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The machine-readable version of *The Engineering Index*<sup>R</sup>, known as COMPENDEX<sup>R</sup> (COMPuterized ENgineering InDEX), and COMPENDEX<sup>R</sup>\*PLUS is available via a number of online vendors or via direct lease or license from Ei. Contact the Marketing Division of Engineering Information, Inc. for details.

*The Engineering Index Annual*—1988 is organized as follows: Parts I, II, III, IV, and V contain the Abstract Section. Parts VI, VII, VIII, and IX contain the Author Index, the Author Affiliation Index and the Subject Index.

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"See" and "See Also" cross-references follow both the main subject headings and subheadings and act as guides to related headings and additional abstracts of interest.

*The Engineering Index Annual* abstract number is found at the beginning of each abstract. Abstract numbers run consecutively, starting with number 000001. It should be noted that the abstract numbers in *The Engineering Index Annual* are not the same as those found in *The Engineering Index*<sup>R</sup> *Monthly*, as these two sets of numbers result from separate sorting processes.

The title of the article (or paper, report, monograph, etc.) follows the abstract number and is printed in boldface upper case. If a title is in a language other than English, an English translation of the title will follow, enclosed in brackets and printed in boldface upper and lower case.

Following the text of the abstract, the bibliographic citation is presented. The citation includes the author(s) name(s), the first author's affiliation and information describing the source document in which the paper appears. The source information is in abbreviated form. The full title of the original source material may be found in Ei's *PIE: Publications Indexed for Engineering*, which is published annually.

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To locate abstract(s) of interest, search under appropriate subject terms, under specific applications of the subject, and under synonymous terminology. For example, if you are interested in the general subject of superconducting materials, search in the abstract section of *The Engineering Index<sup>R</sup> Annual* (Volumes I-V) under SUPERCONDUCTING MATERIALS, which is a valid heading. If you are interested in a specific aspect or application of superconducting materials, such as "microstructure" or "microwaves", search under the main heading SUPERCONDUCTING MATERIALS and the subheading of choice. You will find applicable subheadings arranged in alphabetical order following the main heading.

*The Engineering Index Annual* includes cross-references from many of its subject headings which will lead the searcher to related headings and additional abstracts of interest.

### SAMPLE ENTRY

The following example identifies the elements of a typical record.

Heading → **SUPERCONDUCTING MATERIALS** See  
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Properties; ELECTRIC CONDUCTORS—Materials; ELEC-  
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LINIUM COMPOUNDS—Magnetic Properties; HYDRO-  
GEN—Research; INTERMETALLICS—Synthesis; LAN-  
THANUM COMPOUNDS—Magnetic Properties; LAN-  
THANUM COMPOUNDS—Spectroscopic Analysis;

← Cross-References

Subheading → **Microstructure** See Also FILMS—Superconducting;  
LANTHANUM COMPOUNDS—X-Ray Analysis; NEU-  
TRONS—Diffraction; NIOBIUM TITANIUM ALLOYS  
—Electric Conductivity.

Abstract Number → **108337** **OBSERVATIONS CONCERNING THE** ← Title of Article  
**TWIN MICROSTRUCTURE IN  $\text{YBa}_2\text{Cu}_3\text{O}_x$**  When ob-  
served under the optical microscope using polarized light,  
the grains of the  $90^\circ$  oxide superconductor,  $\text{YBa}_2\text{Cu}_3\text{O}_x$ ,  
display arrays of parallel twin planes. A sample of this  
material was placed in a scanning electron microscope  
(SEM) and imaged using a backscattered electron detec-  
tor. The results present strong evidence that the optical  
twins are transformation twins which form during the  
tetragonal to orthorhombic phase transition. The trans-  
formation occurred at quite low temperatures, around  
 $250^\circ\text{C}$ , probably due to the loss of oxygen in the vacuum.  
12 refs. ← Abstract

← Number of References

Author's Name and Affiliation → Verhoeven, J.D. (Iowa State Univ, Ames, IA, USA);  
Laabs, F.C.; Chumbley, L.S.; Gibson, E.D.; McCallum,  
R.W. *J Mater Sci Lett* v 7 n 9 Sep 1988 p 897-899.

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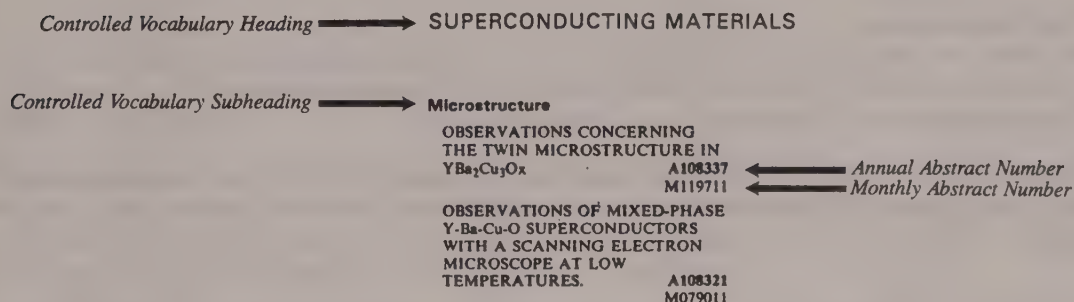
## BY SUBJECT—IN THE SUBJECT INDEX

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Example—



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Verhoeven, J.D., 084375, 026715, 104606, 108337, 070381
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DIALOG Information Services (USA & UK)<sup>1</sup>

ESA-IRS (European Space Agency—Information Retrieval Service)(Italy)

ORBIT Search Service (USA)

STN International (The Scientific & Technical Information Network)(USA, West Germany & Japan)

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# Acronyms, Initials and Abbreviations of Organization Names

The following list is presented to assist the user in identifying the organizations cited by acronym, by initials, or by abbreviation in the current publications of Engineering Information, Inc.

AACE	American Association of Cost Engineers	CDA	Copper Development Association
ACM	Association for Computing Machinery	CEA	Commissariat a l'Energie Atomique (Fr)
ACS	American Chemical Society	CEGB	Central Electricity Generating Board (UK)
AEC	Atomic Energy Commission (US)	CEN	Centre d'Etudes Nucleaires
AECL	Atomic Energy of Canada Limited	CERN	Organisation Europeenne pour la Recherche Nucleaire
AEG	Allgemeine Elektrizitaets Gesellschaft		
AEI	Associated Electrical Industries		
AERE	Atomic Energy Research Establishment (of UKAEA)	CIB	Conseil Europeen pour la Recherche Nucleaire
AFB	Air Force Base		
AFIPS	American Federation of Information Processing Societies	CIBA	Conseil International du Batiment pour la Recherche, l'Etude et la Documentation
AFS	American Foundrymen's Society	CIGRE	Chemical Industry in Basel
AGARD	Advisory Group for Aerospace Research and Development		
AGEN	Arbeitsgemeinschaft fuer Elektrische Nachrichtentechnik der Stiftung Hasler-Werke, Bern	CIM	Conference Internationale de Grands Reseaux Electriques a Haute Tension
		CIRP	Canadian Institute of Mining and Metallurgy
AGMA	American Gear Manufacturers Association	CMERI	College International pour l'Etude Scientifique des Techniques de Production Mecanique
AIA	American Institute of Architects		
AIAA	American Institute of Aeronautics and Astronautics	CNEA	Comision Nacional de Energia Atomica (Argent)
AICHe	American Institute of Chemical Engineers	CNEN	Comitato Nazionale per l'Energia Nucleare (Italy)
AIIE	American Institute of Industrial Engineers	CNET	Centre National d'Etudes de Telecommunications (Fr)
AIME	American Institute of Mining, Metallurgical and Petroleum Engineers		
AIP	American Institute of Physics	CNR	Consiglio Nazionale delle Ricerche (Italy)
AISC	American Institute of Steel Construction	CNRS	Centre National de la Recherche Scientifique
AISI	American Iron and Steel Institute	COMSAT	Communications Satellite Corporation
Alcoa	Aluminum Company of America	CONICET	Consejo Nacional de Investigaciones Cientificas y Tecnicas (Argent)
ANS	American Nuclear Society		
ANSI	American National Standards Institute	CPPA	Canadian Pulp and Paper Association
APCA	Air Pollution Control Association	CRM	Centre de Recherches Metallurgiques
API	American Petroleum Institute	CSIC	Consejo Superior de Investigaciones Cientificas (Spain)
APICS	American Production and Inventory Control Society		
ARCO	Atlantic Richfield Company	CSIR	Council of Scientific and Industrial Research (S Afr)
ASAE	American Society of Agricultural Engineers	CSIRO	Commonwealth Scientific and Industrial Research Organisation (Aust)
ASCE	American Society of Civil Engineers		
ASEA	Allmanna Svenska Elektriska Aktiebolaget	DEW	Deutsche Edelstahlwerke Aktiengesellschaft
ASEE	American Society for Engineering Education	DFVLR	Deutsche Forschungsanstalt und Versuchsanstalt fuer Luft- und Raumfahrt
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers		
		DOE	Department of Energy (US)
ASIS	American Society for Information Science	DOT	Department of Transportation (US)
ASLE	American Society of Lubrication Engineers	DuPont	E. I. Du Pont de Nemours and Company
ASM	American Society for Metals	EBU	European Broadcasting Union
ASME	American Society of Mechanical Engineers	EG&G	Edgerton, Germeshausen and Grier Incorporated
ASNE	American Society of Naval Engineers	EIA	Electronic Industries Association
ASQC	American Society for Quality Control	EPA	Environmental Protection Agency (US)
ASTM	American Society for Testing and Materials	EPRI	Electric Power Research Institute
AT&T	American Telephone and Telegraph Company	ERA	Electrical Research Association
AVS	American Vacuum Society	ERDA	Energy Research and Development Administration (US)
AWS	American Welding Society		
AWWA	American Water Works Association	ESA	European Space Agency
BARC	Bhabha Atomic Research Centre	ESL	Engineering Societies Library
BASF	Badische Anilin und Soda Fabrik	ETH	Eidgenoessische Technische Hochschule (Swiss Federal Institute of Technology)
BBC	British Broadcasting Corporation		
BCIRA	British Cast Iron Research Association	EURATOM	European Atomic Energy Community
BCURA	British Coal Utilization Research Association	FAA	Federal Aviation Administration (US)
BHP	Broken Hill Proprietary	FAO	Food and Agricultural Organization of the United Nations
BHRA	British Hydromechanics Research Association		
BISRA	British Iron and Steel Research Association	FDA	Food and Drug Administration (US)
BP	British Petroleum Company	FEA	Federal Energy Administration (US)
BPO	British Post Office	Fermilab	Fermi National Accelerator Laboratory (US)
CANMET	Canadian Center for Mineral and Energy Technology	FIAT	Fabbrica Italiana Automobile, Torino
CASI	Canadian Aeronautics and Space Institute	FMC	Food Machinery Corporation
		FOM	Stichting voor Fundamenteel Onderzoek de Materie (Neth)

E	General Electric Company	NSF	National Science Foundation (US)
EC	General Electric Company Limited (UK)	NSTL	National Space Technology Laboratory
EM	General Motors	NTG	Nachrichtentechnische Gesellschaft
PO	Government Printing Office (US)	NTIS	National Technical Information Service (US)
TE	General Telephone and Electronics	NTT	Nippon Telegraph and Telephone Public Corporation
MSO	Her Majesty's Stationery Office (UK)	OCLC	Online Computer Library Center Incorporated
AEA	International Atomic Energy Agency	OECD	Organization for Economic Cooperation and Development
BM	International Business Machines Corporation	OMIKK	Országos Muszaki Információs Központ és Könyvtár (National Technical Information Centre and Library, Budapest, Hung)
CE	Institution of Civil Engineers (UK)	ORSTOM	Office de la Recherche Scientifique et Technique Outre-Mer
CHCA	International Cargo Handling Coordination Association	PCA	Portland Cement Association
CSU	International Council of Scientific Unions	PPG Ind Inc	Pittsburgh Plate Glass Industries Incorporated
DIEM	Instituto de Investigaciones y Ensayos de Materiales (Chile)	PTT	Postes, Telegraphes et Telephones
EC	International Electrotechnical Commission	RCA	Radio Corporation of America
EE	Institution of Electrical Engineers (UK)	RILEM	Reunion Internationale des Laboratoires d'Essais et de Recherches sur les Matériaux et les Constructions
EEE	Institute of Electrical and Electronics Engineers	RWTH	Rheinisch-Westfälische Technische Hochschule Aachen
ERE	Institution of Electronic and Radio Engineers (UK)	SAAB	Svenska Aeroplan Aktiebolaget
FAC	International Federation of Automatic Control	SAE	Society of Automotive Engineers
FIP	International Federation for Information Processing	SAM	Society for Advancement of Management
FTOMM	International Federation for the Theory of Machines and Mechanisms	SAMPE	Society for the Advancement of Material and Process Engineering
HI	Ishikawajima-Harima Heavy Industries	SCM	Smith-Corona Marchant Incorporated
NSA	Institut National des Sciences Appliquées de Lyon	SESA	Society for Experimental Stress Analysis
NTELSAT	International Telecommunications Satellite Consortium	SHAPE	Supreme Headquarters Allied Powers Europe (NATO)
RSID	Institut de Recherches de la Siderurgie	SIAM	Society for Industrial and Applied Mathematics
IA	Instrument Society of America	SME	Society of Manufacturing Engineers
II	Iron and Steel Institute (UK)	SMPTE	Society of Motion Picture and Television Engineers
IO	International Standards Organization	SNAME	Society of Naval Architects and Marine Engineers
IT	International Telephone and Telegraph	SNCF	Société Nationale des Chemins de Fer Français
UPAC	International Union of Pure and Applied Chemistry	SPI	Society of the Plastics Industry
VF	Institutet fuer Verkstadsteknisk Forskning (Swed)	SPIE	Society of Photo-optical Instrumentation Engineers
AERI	Japan Atomic Energy Research Institute	SRI Int	Stanford Research Institute International
PL	Jet Propulsion Laboratory	TAPPI	Technical Association of the Pulp and Paper Industry
SAE	Japan Society of Automotive Engineers	3M	Minnesota Mining and Manufacturing Company
SME	Japan Society of Mechanical Engineers	TISCO	Tata Iron and Steel Company
DD	Kokusai Denshin Denwa	TNO	Toegepast Natuurwetenschappelijk Onderzoek
FA	Kernforschungsanlage Juelich GmbH	TRI	Transportation Research Institute
UIT	Massachusetts Institute of Technology	TRW	Thompson, Ramo, Wooldridge, Incorporated
ACE	National Association of Corrosion Engineers	TVA	Tennessee Valley Authority (US)
APE	National Association of Power Engineers	UKAEA	United Kingdom Atomic Energy Authority
AS	National Academy of Sciences (US)	UN	United Nations
AS-NRC	National Academy of Sciences — National Research Council (US)	UNESCO	United Nations Educational, Scientific and Cultural Organization
ASA	National Aeronautics and Space Administration (US)	USDA	United States Department of Agriculture
ATO	North Atlantic Treaty Organization	VDE	Verband Deutscher Elektrotechniker
BS	National Bureau of Standards (US)	VDI	Verein Deutscher Ingenieure
CB	National Coal Board (UK)	VGB	Vereinigung der Grosskraftwerksbetreiber
EC	Nippon Electric Company	WHO	World Health Organization
EMA	National Electrical Manufacturers Association	WMO	World Meteorological Organization
FAIS	National Federation of Abstracting and Indexing Services	WRC	Welding Research Council
GPA	Natural Gas Processors Association	ZIS	Zentralinstitut fuer Schweisstechnik
HK	Nippon Hosokyo Kyokai		
IH	National Institutes of Health		
OAA	National Oceanic and Atmospheric Administration (US)		
PL	National Physical Laboratory (UK)		



# Abbreviations, Units and Acronyms

The following list is presented to assist the user in identifying the meaning of some of the abbreviations, units, symbols or acronyms appearing in the products and services of Engineering Information, Inc.

A	degree Absolute	bpsd	barrels per stream day
Å	Angstrom	BS	British Standard
abs	absolute	Btu	British thermal unit
ABS	acrylonitrile-butadiene-styrene	bu	bushel
ac	alternating current	BWR	boiling water reactor
ADP	ammonium dihydrogen phosphate		
ADP	automatic data processing	C	capacitance
AF	audio frequency	C	degree Centigrade, Celsius
afc	automatic frequency control	CA	cellulose acetate
agc	automatic gain control	cal	calorie
AGR	advanced gas cooled reactor	CATV	community antenna television, cable television
ALGOL	algorithmic language	cc	cubic centimeter
ALS	aircraft landing system	cd	candela
am	amplitude modulation	cf	cubic feet per day
amp	ampere	cfhr	cubic feet per hour
amp hr	ampere hour	cfm	cubic feet per minute
antilog	antilogarithm	cfs	cubic feet per second
ASWG	American steel wire gage	cgs	centimeter-gram-second
ATC	air traffic control	Ci	curie
atm	atmosphere	CI	compression ignition
at. %	atomic percent	cm	centimeter
at. wt	atomic weight	cmil	circular mil
AU	astronomical unit	CN	cellulose nitrate
avc	automatic volume control	CN	cetane number
avdp	avoirduois	COBOL	common business oriented language
avg	average	COD	chemical oxygen demand
		colog	cologarithm
B	magnetic flux density	COMSAT	communications satellite
b	barn	cos	cosine
bbl	barrel	cosh	hyperbolic cosine
bcc	body centered cubic	cot	cotangent
Be	Baume	coul	Coulomb
Bev	billion electron volt	cp	candlepower
bfo	beat frequency oscillator	CPM	critical path method
Bhn	Brinell hardness number	cps	cycles per second
bhp	brake horsepower	c to c	center to center
bhp-hr	brake horsepower-hour	CTOL	conventional takeoff and landing
bil	basic insulation level	cu	cubic
bit	binary digit	*cu ft	cubic foot
bmep	brake mean effective pressure	cu in	cubic inch
bod	biochemical oxygen demand	cu m	cubic meter
BOF	basic oxygen furnace	cusec, cfs	cubic feet per second
bp	between perpendiculars	cu yd	cubic yard
bp	boiling point	cw	continuous wave
bpd	barrels per day	cyl	cylinder
bpi	bits per inch		

DAP	diallyl phthalate	fm	frequency modulation
db	decibel	FORTAN	formula translation
dba	decibels adjusted	fp	freezing point
dbm	decibels referred to 1 mw	fpm	feet per minute
dbv	decibels referred to 1 v	fps	feet per second
dc	direct current	fps	foot-pound-second
DDT	dichlorodiphenyltrichloroethane	FRP	fiberglass reinforced plastic
deg	degrees (angle)	FSK	frequency shift keying
DEW	distant early warning	ft	foot
df	direction finder	ft-c	foot-candle
dia, diam	diameter	ft-l	foot-lambert
dkm	dekameter	ft-lb	foot-pound
dm	decimeter	FWHM	full wave at half maximum
DME	distance measuring equipment	FWP	fiber wound plastics
doz	dozen		
dpdt	double pole double throw	g	gram
dph	diamond pyramid hardness	g	gravitational acceleration
dpst	double pole single throw	G	gauss
DTA	differential thermal analysis	gal	gallon
dwc	deadweight capacity	GCA	ground controlled approach
dwt	deadweight	GCFR	gas cooled fast reactor
		GEM	ground effect machines
EBR	experimental breeder reactor	Gev	gigaelectron volts
EBWR	experimental boiling water reactor	GEV	ground effect vehicles
ECG	electrocardiogram	GFRP	glass fiber reinforced plastic
ECG	electrochemical grinding	GHz	gigahertz
ECM	electrochemical machining	gpd	gallons per day
EDM	electrical discharge machining	gph	gallons per hour
EDP	electronic data processing	gpm	gallons per minute
EDT	ethylenediamine tartrate	gps	gallons per second
EDTA	ethylenediaminetetra-acetic acid	GRP	glass reinforced plastics
EEG	electroencephalogram	GVW	gross vehicle weight
EEM	electron emission microscope	Gw	gigawatt
ehp	effective horsepower	Gwhr	gigawatt-hour
ehv	extra high voltage		
ELF	extra low frequency	h	henry
ELG	electrolytic grinding	H	magnetic field strength
EMC	electromagnetic compatibility	hcp	hexagonal close packed
emf	electromotive force	HDPE	high density polyethylene
emi	electromagnetic interference	hf	high frequency
emu	electromagnetic units	hp	horsepower
EPR	electron paramagnetic resonance	h-p	high pressure
EPR	ethylene propylene rubber	hp hr	horsepower hour
ERP	effective radiated power	hr	hour
ESM	electron scanning microscope	HSS	high speed steel
ESR	electron spin resonance	ht	high tension
esu	electrostatic units	HTGR	high temperature gas cooled reactor
ev	electron volt	HTHW	high temperature hot water
		hv	high voltage
f	farad	Hz	hertz
F	degree Fahrenheit		
fbm	foot board measure (boardfeet)		
fcc	face centered cubic	IC	integrated circuit
FET	field effect transistor	IC	internal combustion
fl oz	fluid ounce	ICBM	intercontinental ballistic missile

icw	interrupted continuous wave	L-C	inductance capacitance
ID	inside diameter	LCL	less than carload lots
if	intermediate frequency	L/D	lift/drag ratio
IGY	International Geophysical Year	lf	low frequency
ihp	indicated horsepower	lm	lumen
ihp-hr	indicated horsepower-hour	LMG	liquefied methane gas
ILS	instrument landing system	ln	natural logarithm
impd	impedance	LNG	liquefied natural gas
in.	inch	log	logarithm
ipm	inches per minute	long.	longitude
ips	inches per second	LOX	liquid oxygen
IR	infrared	l-p	low pressure
IRBM	intermediate range ballistic missile	LPG	liquefied petroleum gas
I-V	current-voltage	LPG	liquefied propane gas
		lv	low voltage
j	joule	$\mu$	$\mu$ micron
JATO	jet assisted takeoff	$\mu$ a	microampere
		$\mu$ f	microfarad
K	degree Kelvin	$\mu$ g	microgram
ka	kiloampere	$\mu$ in.	microinch
kbar	kilobar	$\mu$ m	micrometer
kc	kilocycles per second	$\mu$ sec	microsecond
kcal	kilocalorie	$\mu$ v	microvolt
KDP	potassium dihydrogen phosphate	$\mu$ w	microwatt
kev	kiloelectron volt	$\mu\mu$ f	micromicrofarad
kg	kilogram	m	meter
kG	kilogauss	M	Mach
kgf	kilogram force	M	molar concentration
kgm	kilogram mass	ma	milliampere
kg-m	kilogram-meter	Mamp	megampere
kHz	kilohertz	man-hr	man-hour
kips	thousand pounds	mb	millibar
kliter	kiloliter	mb	millibarn
km	kilometer	Mbit	megabit
koe	kilo oersted	mc	millicurie
kohm	kilo ohm	Mc	megacycles per second
kp	kilopound	Mcf	thousand cubic feet
ksi	kilopounds per square inch	MCM	thousand circular mills
kv	kilovolt	MCR	maximum continuous rating
kva	kilovolt-ampere	mcw	modulated continuous wave
kvar	kilovolt-ampere reactive	mep	mean effective pressure
kvp	kilovolts peak	meq	milliequivalents
kw	kilowatt	Mev	million electron volt
kwe	kilowatts electrical	mf	medium frequency
kwhr	kilowatt-hour	mg	milligram
kwt	kilowatts thermal	mgd	million gallons per day
		MGD	magnetogasdynamic
L	inductance	mh	millihenry
L	lambert	MHD	magnetohydrodynamic
lat.	latitude	MHz	megahertz
lb	pound	mi	mile
lbr	pounds force	MIG	metal inert gas
lb-ft	pound-foot	min	minute
lb-in.	pound-inch	mks	meter-kilogram-second
lbm	pounds mass		



ml	milliliter	OH	open hearth
mL	millilambert	oz	ounce
mm	millimeter		
MMcf	million cubic feet	PA	public address
MMcfd	million cubic feet per day	PABX	private automatic branch exchange
mmf	magnetomotive force	PAM	pulse amplitude modulation
mo	month	PBX	private branch exchange
Mohm	megohm	P/C	printed circuits
mol%	molecular percent	PCM	pulse code modulation
mol. wt	molecular weight	PD	potential difference
MOS	metal oxide semiconductor	Pdb	perceived decibels
MOSFET	MOS field effect transistor	PDF	probability distribution function
MOST	metal oxide semiconductor transistor	pdl	poundal
mp	melting point	PE	polyethylene
Mp	megapond	PERT	program evaluation and review technique
MPD	magnetoplasmdynamic	PETN	pentaerythritol tetranitrate
mph	miles per hour	pf	picofarad
mr	milliroentgen	pf	power factor
Mrad	megarad	PFM	pulse frequency modulation
msec	millisecond	pH	hydrogen ion concentration
MTI	moving target indicator	p-i-n	positive-intrinsic-negative (junctions)
MTR	materials testing reactor	PM	phase modulation
MUF	Maximum usable frequency	PM	powder metallurgy
mv	millivolt	PM	pulse modulation
Mv	megavolt	PMMA	polymethyl methacrylate
Mva	megavolt-ampere	p-n	positive-negative (junctions)
mw	milliwatt	p-n-p	positive-negative-positive (junctions)
Mw	megawatt	PP	polypropylene
Mwd	megawatt day		
MWD	molecular weight distribution	ppb	parts per billion
Mwe	megawatts electrical	PPI	plan position indicator
Mwt	megawatts thermal	ppm	parts per million
μ	millimicron	PPO	polyphenylene oxide
		pps	pulses per second
N	newton	PRF	pulse repetition frequency
N	normal concentration	PS	polystyrene
NBR	nitrile butadiene rubber	psec	picosecond
NC	nitrocellulose	psf	pounds per square foot
N/C	numerical control	psi	pounds per square inch
NDI	nondestructive inspection	psia	pounds per square inch absolute
NDT	nondestructive testing	psig	pounds per square inch gage
nm	nanometer	PSK	phase shift keying
nmi	nautical mile	PSWR	power standing wave ratio
NMR	nuclear magnetic resonance	PTFE	polytetrafluoroethylene
n-p-n	negative-positive-negative (junctions)	PVA	polyvinyl alcohol
NPSH	net positive suction head	PVC	polyvinyl chloride
nsec	nanosecond	PVF	polyvinyl fluoride
NTP	normal temperature and pressure	pvt	pressure volume temperature
nv	neutron flux	PWR	pressurized water reactor
nvt	total integrated neutron flux		
		QC	quality control
oa	overall	qt	quart
od	outside diameter		
oe	oersted	R	degree Rankine, Reaumur
OFHC	oxygen free high conductivity copper	R	resistance

rad	radian	swg	standard wire gage
rad	radiation dose	SWR	standing wave ratio
R	Rockwell hardness (subscript according to scale, e.g., s.b.: R <sub>C</sub> )	sync	synchronization
r	roentgen		
RC	resistance capacitance	t	ton
R & D	research and development	T	Tesla
RDX	cyclotrimethylene trinitramine	tan	tangent
Re	Reynolds number	tanh	hyperbolic tangent
RE	rare earth	tdw	total deadweight
reac	reactance	TE	transverse electric
rem	roentgen equivalent man	TEL	tetraethyl lead
rep	roentgen equivalent physical	TEM	transverse electromagnetic
rf	radio frequency	TEP	thermoelectric power
RH	relative humidity	TFE	tetrafluoroethylene
RIV	radio influence voltage	TFT	thin film transistor
'R-L-C	resistance-inductance-capacitance	TGA	thermogravimetric analysis
rms	root mean square	THz	terahertz
rpm	revolutions per minute	THTR	thorium high temperature reactor
rps	revolutions per second	TIG	tungsten inert gas
		TM	transverse magnetic
SBR	styrene butadiene rubber	TNT	trinitrotoluene
scf	standard cubic feet	tonf	tons force
scfm	standard cubic feet per minute	TPA	terephthalic acid
SCR	silicon controlled rectifier	tpd	tons per day
sec	secant	tph	tons per hour
sec	second	TR	transmitter-receiver
SGHWR	steam generating heavy water reactor	trf	tuned radio frequency
shp	shaft horsepower	TTT	time-temperature-transformation
sin	sine	TV	television
sinh	hyperbolic sine	TWT	traveling wave tube
SMS	semiconductor-metal-semiconductor	TWX	teletype exchange
SNAP	system for nuclear auxiliary power		
snr	signal-to-noise ratio		
sp gr	specific gravity	UHF	ultra-high frequency
spdt	single pole double throw	uhv	ultra high voltage
SPL	sound pressure level	UHV	ultra high vacuum
spst	single pole single throw	ULF	ultra low frequency
sq	square	UV	ultraviolet
sq cm	square centimeter		
sq ft	square foot		
sq in.	square inch	v	volt
sq m	square meter	va	volt ampere
sq mi	square mile	var	volt-ampere reactive
SQC	statistical quality control	vers	verse sine
sr	steradian	vf	voice frequency
SR	silicone rubber	Vh	Vickers hardness
SSB	single sideband	VHF	very high frequency
SST	supersonic transport	V-I	voltage-current
SSU	Saybolt seconds universal	VLF	very low frequency
STOL	short takeoff and landing	vol%	volume percent
STP	standard temperature and pressure	VOR	VHF omnidirectional radio range
SW	short wave	VSWR	voltage standing wave ratio

VTOL	vertical takeoff and landing	wpm	words per minute
VTR	video tape recording	wt%	weight percent
VTVM	vacuum tube voltmeter		
vu	volume unit	YAG	yttrium aluminum garnet
		yd	yard
w	watt	YIG	yttrium iron garnet
Wb	weber	yr	year
wg	water gage		
whr	watt-hour	°	degree (angle)
wk	week	/	per



**Directional** See Also OIL WELL COMPLETION—Offshore Operations; OIL WELL PRODUCTION—Enhanced Recovery.

**072809 DIRECTIONAL DRILLING; THE STATE OF THE ART.** The economics of oil recovery have dictated the necessity of controlled directional drilling, and today it is no longer the dreaded operation that it once was. It is an accepted function of the industry. The most important aspect of controlled directional drilling is that it enables oil producers to develop reservoirs that could not be reached economically in any other way.

Bakke, Steiner (North Sea Drilling Services Ltd, Aberdeen, Scotl). *Q J Tech Pap Inst Pet* Jan-Mar 1986 p 49-54.

**072810 EFFECT OF THE ANGLE OF INCLINATION OF A WELL ON THE READINGS OF A PROFILOMETER.** Even well inclination angles that are not very large ( $\leq 12^\circ$ ) are capable of greatly affecting the nature of profilograms given a stably positioned two-plane well instrument in an inclined well, the larger of its readings is equal to the actual well diameter. For accurate calculation of the volume of a well it is recommended that profilometry be carried out in the well with a single profilometer twice in succession. By so doing, zones of unstable positioning of the instrument on one profilogram are overlapped by intervals of stable positioning on the other, which makes it possible to determine the true shaft diameter as a function of depth with sufficient accuracy. In Russian. 4 refs.

Tavanets, A.I. *Neft Khoz* n 5 Mar 1987 p 17-20.

**072811 DESIGNING WELL PATHS TO REDUCE DRAG AND TORQUE.** A deviated well with an undersection trajectory (i.e., a trajectory lying below the conventional tangent section and constantly building to target) can exhibit lower drag and torque than a conventional well geometry in certain circumstances. The influence of well geometry on drag and torque is discussed, making use of the results of the theoretical model. Although an undersection well may have a reduced overall drag, the side forces in the drill collars will be increased. This can lead to a greater danger of sticking in the bottomhole assembly (BHA). Furthermore, because of the enhanced side forces near the bit, an undersection well may also exhibit greater torque. (Edited author abstract) 3 refs.

Sheppard, M.C. (Schlumberger Cambridge Research); Wick, C.; Burgess, T. *SPE Drill Eng* v 2 n 4 Dec 1987 SPE 15463, p 344-350.

**072812 CONTROLLED DIRECTIONAL DRILLING AS A TOOL OF THE OFFSHORE INDUSTRY.** This article gives an introduction to the basic principles of directional drilling. A new application for directional drilling is Drainhole Drilling. To drill a drainhole means to drill a long section of a well inside the reservoir to increase the productivity. Offshore directional drilling is discussed from the viewpoint of technological advances. A discussion is also presented of borehole surveying and the two basic principles used to determine borehole position. Steering Tools and gyroscopic survey tools are briefly examined.

Kinzel, Holger. *Mar Technol* v 17 n 1 Feb 1986 p 29-31.

**072813 SLANT-HOLE DRILLING FINDS EXPANDING ROLE IN CANADA.** Slant-hole drilling is a method for achieving horizontal displacement at shallow depths to access targets that could not be reached by conventional directional drilling. This article focuses on two projects in western Canada where Sierra acted as drilling contractor. One project was a multiwell drilling program for a drill pad and the other project was a gas well drilled with an extreme horizontal well bore displacement. Steerable downhole motors were used for directional drilling. The motors were oriented to build and maintain drift angle, as well as make minor azimuth adjustments. When both the angle and direction requirements were met to achieve target parameters, the drill string was rotated slowly to negate the effects of the motor's deflecting action. Because BP Canada drilled the

wells from a multiwell drilling pad, the company opted for a central mud system to improve the project's overall economics.

Edwards, R.D. (Sierra Drilling Ltd, Edmonton, Alberta, Can); Strelkov, George. *Pet Eng Int* v 60 n 2 Feb 1988 p 20, 22-23.

**072814 HORIZONTAL-WELL DRILLING DATA ENHANCE RESERVOIR APPRAISAL.** Based on the examples covered in this concluding article of the seven-part series on horizontal well operations it appears that the very perception of the reservoir characteristics and heterogeneities are modified when a well is drilled horizontally. The lateral evolution of the facies, the fractured zones, and the irregularities of the top and bottom of the reservoir are all directly encountered. On the other hand, vertical characterization is more problematic, and will require a new type of logging that enables deep investigation above and below the horizontal well. Elf Aquitaine's horizontal wells in the Lacq and Castera Lou fields were primarily aimed at learning how to drill horizontally. After these tests, the Rospo Mare field was drilled and put into production with horizontal wells. 1 Ref.

de Montigny, Olivier (Elf Aquitaine, Pau, Fr); Sorriaux, Patrick; Louis, Alain J.P.; Lessi, Jacques. *Oil Gas J* v 86 n 27 Jul 4 1988 p 40-48.

**072815 APPLICATION OF RECENTLY DEVELOPED MEDIUM-CURVATURE HORIZONTAL-DRILLING TECHNOLOGY IN THE SPRABERRY TREND AREA.** Recently developed horizontal-drilling techniques have been applied the Spraberry trend area in Midland County, TX. The desired application includes drilling horizontally at a right angle to the naturally occurring vertical fractures in one of three Spraberry zones. The result was 1,180 ft of vertical section within 10° of the planned azimuth of 115°. The W.M. Schrock 38 No. 7 was drilled vertically to 8,620 ft [2627 m] through the Upper Spraberry, Lower Spraberry, and Dean formations. After openhole-log evaluation, the decision was made to attempt horizontal-drilling operations in the lower Spraberry. Seven-inch casing was set 342 ft above the horizontal target of 7,889-ft true vertical depth (TVD), and a cement plug was set and dressed to 7,567-ft TVD. After the curved portion of the hole had been drilled 3- and 1°/100-ft [ $1.7 \times 10^{-3}$  and  $0.57 \times 10^{-3}$  rad/m] motors were used in both rotational and orienting modes to maintain an inclination near 90° and an azimuth of about 115°. During drilling at 8,598-ft measured depth (MD), the motor parted and a fishing job in the near-horizontal portion of the wellbore resulted. The motor and bit were successfully retrieved on the first attempt. (Edited author abstract). 1 Ref.

Edlund, P.A. (Arco Oil & Gas Co, USA). *JPT J Pet Technol* v 40 n 9 Sep 1988 p 1178-1182.

**Drill Pipe** See Also COUPLINGS—Hardening; KEYS AND KEYWAYS—Stresses; OIL FIELD EQUIPMENT—Corrosion Protection; OIL WELL CEMENTING; OIL WELL LOGGING; PIPE JOINTS—Strain; STEEL—Mechanical Properties.

**072816 EXPERIMENTAL AND THEORETICAL STUDY OF A COUPLING MECHANISM BETWEEN LONGITUDINAL AND TORSIONAL DRILLSTRING VIBRATIONS AT THE BIT.** A mechanism that couples longitudinal and torsional drillstring vibrations at the bit was studied. Torsional vibrations are associated with dynamic variations of the rotational bit speed. When a roller bit runs over a multilobed pattern, these speed variations have been shown to affect the input of longitudinal vibrations. The theory for this coupling mechanism is verified experimentally by high-rate data of near-bit accelerations and torque recorded in a 1000-m [3280-ft]-deep well. (Author abstract) 9 refs.

Aarrestad, Thor Viggo (Rogaland Research Inst); Kyllingstad, Age. *SPE Drill Eng* v 3 n 1 Mar 1988 SPE 15563, p 12-18.

**072817 REVERSED BENDING FATIGUE STRENGTH OF DRILL STRINGS SUBJECT TO**

**THE ATTACK OF DRILLING FLUIDS.** Under normal service conditions, drill pipes are frequently exposed to reverse bending stresses. In addition to mechanical loads, corrosion is generated by the circulating medium, which may lead to corrosion fatigue cracking. The paper describes reverse bending fatigue tests on small specimens in order to determine the fatigue strength characteristics. Although small specimens are usually tested at high frequencies, the test series described also includes tests with low load frequencies of 100 min<sup>-1</sup>. The results contain data on nearly all available material grades according to API and give strength characteristics for practical application. (Edited author abstract) 6 refs.

Helbig, R. (Mannesmann Forschungsinstitut GmbH, Duisburg, West Ger); Vogt, G.H. *Oil Gas Eur Mag* v 13 n 2 1987 p 16-20.

**072818 DESIGN, TESTING, AND PLANNING CONSIDERATIONS FOR A 20-IN. RECORD CASING STRING.** During May 1984, a total of 12,455 ft [3800 m] of 20-in., 169-lbf/ft [51-cm, 2.47-N/m] C-95 casing was successfully run and cemented to the surface in L. W. Magoun No. 1, Concordia Parish, LA. The string consisted of 303 joints and required 49 hours to run. The casing weight in 9.7-lbm/gal [1162-kg/m<sup>3</sup>] mud was  $1.8 \times 10^6$  lbm [826 Mg]. This paper discusses the engineering, operational planning, and job execution for this world-record string of 20-in. [51-cm] casing. The topics include casing design, manufacturing, connection testing, and running and cementing procedures. (Author abstract). 3 Refs.

Pejac, R.D. (Sohio Petroleum Co); Fontenot, E.P. *SPE Drill Eng* v 3 n 2 Jun 1988 p 187-194.

**072819 ANALYSIS OF HELICAL BUCKLING.** A new solution to helical buckling is presented yielding real helical shapes of buckled pipes with a varying helix pitch. This solution has been developed with the beam/column equation. The change in length and the bending stress can be computed from the helical-buckling solution. In addition, a new equation for tool clearance in helically buckled pipes is provided. (Author abstract). 8 Refs.

Kwon, Young W. (Univ of Missouri, USA). *SPE Drill Eng* v 3 n 2 Jun 1988 p 211-216.

**072820 CORROSION INVESTIGATION OF DRILLING PIPE IN VARIOUS CONCENTRATIONS OF SALT MIXTURE WITH AND WITHOUT ADDING MUD AT DIFFERENT TEMPERATURES.** In order to evaluate the effect of mud on drilling pipe corrosion in the presence of different salt mixtures, Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup> and HCO<sub>3</sub><sup>-</sup>, different concentrations of salts were used and different temperatures were applied. Addition of mud improved corrosion inhibition only at moderate temperatures 20 and 40°C because the mud composition contained a considerable quantity of sulfate, but at temperatures over 60°C mud had the capability of reducing the sulfate to sulfide and severe attack would occur. (Edited author abstract). 12 Refs.

Habeeb, Hassan S. (Council Scientific Research, Baghdad, Iraq); Matlub, Falah K. *J Pet Res* v 7 n 1 Jun 1988 p 51-62.

**Drilling Fluids** See Also FOAMS—Applications; MARINE BIOLOGY; OIL WELL PRODUCTION—Enhanced Recovery; STEEL—Protective Coatings.

**072821 THERMALLY STABLE INVERTED EMULSION FOR SECONDARY DRILLING OF FORMATIONS.** An inverted emulsion which is thermally stable up to 140°C and is distinguished by low viscosity and high clay content has been developed. This emulsion contains a stabilizer consisting of a highly effective liquid emulsifier and an organosilicon fluid - namely, sodium methyl (ethyl) silicate. The properties of this emulsion, the availability of the reagents, the ease



of producing it under field conditions, and the positive results of tests make it possible to recommend it for wide use in secondary drilling of productive formations.

Loginov, Yu.F.; Kaz'min, A.V.; Kas'yanov, N.M.; Fainshtein, I.Z.; Ovchinskii, K.Sh.; Saunin, V.I.; Balaev, A.A. *Neft Khoz* n 5 Mar 1987 p 57-59.

**072822 AUTOMATED AND MANUAL METHODS FOR THE DETERMINATION OF POLYACRYLAMIDE AND OTHER ANIONIC POLYMERS.** The concentration of polyacrylamides is determined by precipitation with Hyamine 1622 Reagent 1 and by measurement of the amount of light scattered by the resulting turbidity. The analysis can be automated as well as adapted for field trials. The effects of anionic surfactants, changes in polyacrylamide molecular weight, and salinity are discussed. (Author abstract) 6 refs.

Allison, J.D. (Conoco Inc); Wimberly, J.W.; Ely, T.L. *SPE Reservoir Eng* v 2 n 2 May 1987 p 184-188.

**072823 MUD FILTRATE EFFECTS ON THE LATEROLOG IN ALBERTA FOOTHILLS CARBONATES.** This report proposes a new set of invasion correction curves for the laterolog that can be used quantitatively for a variety of mud systems and various diameters of invasion to obtain the true resistivity of the formation. The Resistivity Index (I) was used to develop new invasion corrections. By assigning an I value to each of the flushed, transition and uninvaded zones and establishing the resistivity contribution of each zone to the laterolog reading from published pseudo-geometrical factors, invasion corrections were determined. Open-hole logs of actual field cases are used to demonstrate the invasion corrections for the laterolog. The proposed corrections have resulted in the calculation of more accurate water saturations as substantiated by production test results. (Edited author abstract) 14 refs.

Dziuba, Taras T. (Shell Canada Ltd). *J Can Pet Technol* v 26 n 5 Sep-Oct 1987 p 41-50.

**072824 EVALUATION OF FORMATION DAMAGE CAUSED BY DRILLING FLUIDS, SPECIFICALLY IN PRESSURE-REDUCED FORMATIONS.** This paper describes a method for evaluating formation damage caused by drilling fluids in reservoirs that may have pressure considerably lower than hydrostatic pressure. The problem is of specific interest for EOR and/or underground gas storage projects. The method, which is flexible and practically oriented, allows formation-damage evaluation under the following conditions:  $\leq 1,400$ -psi differential pressure,  $\leq 300^\circ\text{F}$  temperature, 6-ft/sec annular velocity, 0.4- to 1-in. core diameter, and 10-in. length. (Edited author abstract) 9 refs.

Marx, Claus (ITE-TU Clausthal); Rahman, S.S. *JPT J Pet Technol* v 39 n 11 Nov 1987 p 1449-1452.

**072825 USE OF POTASSIUM/LIME DRILLING-FLUID SYSTEM IN NAVARIN BASIN DRILLING.** This paper presents a case history of Amoco Production Co.'s use of potassium-lime mud (KLM) for drilling a series of wells in the Navarin basin. The remote location, logistical concerns, environmental regulations, and the high cost of the operation mandated that the project be carefully planned. This paper describes the planning, implementation, and results of the mud system used to drill the wells. It includes a matrix of tests used to define further the nature of KLM, presents the methods used to run the system while the wells were drilled, and describes the results of using the mud in the basin. Navarin basin experience suggested that KLM should be considered when clay inhibition is needed and moderate bottomhole temperatures (BHT's) are expected. (Edited author abstract) 12 refs.

Holt, C.A. (Amoco Production Co, USA); Brett, J.F.; Johnson, J.B.; Walker, T.O. *SPE Drill Eng* v 2 n 4 Dec 1987 SPE 14755, p 323-330.

**072826 DESIGN CONSIDERATIONS FOR AN INHIBITIVE, STABLE WATER-BASED MUD SYSTEM.** This paper discusses the technique of using

high-molecular-weight organic polymers to stabilize troublesome shales through the adsorption of a protective polymer layer. It specifically covers the performance of a partially hydrolyzed polyacrylamide (PHPA) in respect to shale preservation and in the retardation of cuttings dispersion. Other design factors - e.g., pH control, rheological stability, and lubricity - are also covered. (Author abstract) 6 refs.

Chesser, B.G. (Milpark Drilling Fluids). *SPE Drill Eng* v 2 n 4 Dec 1987 SPE 14757, p 331-336.

**072827 SETTLING VELOCITY OF VARIOUSLY SHAPED PARTICLES IN DRILLING AND FRAC-TURING FLUIDS.** The settling velocities of a variety of shaped particles to simulate drilled cuttings were measured in both Newtonian and non-Newtonian fluids. The results showed that the particle drag coefficient is a function of the particle Reynolds number and, in the case of power-law-model fluids, of the flow behavior index. A new generalized model has been developed for predicting the settling velocities of particles of various shapes in both Newtonian and power-law fluids over a range of flow regimes. (Author abstract) 19 refs.

Peden, James M. (Heriot-Watt Univ, Scotl); Luo, Yuejin. *SPE Drill Eng* v 2 n 4 Dec 1987 SPE 16243, p 337-343.

**072828 DELTA FLOW: AN ACCURATE, RELIABLE SYSTEM FOR DETECTING KICKS AND LOSS OF CIRCULATION DURING DRILLING.** A system to monitor drilling-fluid flow rate has been developed that detects kicks and lost returns in floating, fixed-platform, and land-based drilling operations. The system uses flowmeters that monitor the flow rates of drilling fluids entering the borehole through the standpipe and leaving the well through the return flowline. These readings are processed in a computer-based, data-acquisition system to form a filtered delta-flow signal that identifies the occurrence of downhole fluid gains or losses. The system is designed to trip an alarm when a gain or loss exceeds 25 gal/min [ $1.6 \text{ dm}^3/\text{s}$ ], even in a floating drilling environment. (Edited author abstract) 2 refs.

Speers, J.M. (Exxon Production Research Co, USA); Gehrig, G.F. *SPE Drill Eng* v 2 n 4 Dec 1987 SPE 13496, p 359-363.

**072829 TOXICITY OF SEDIMENT-INCORPORATED DRILLING FLUIDS.** The 24, 96, or 168h  $\text{LC}_{50}$ s of four used drilling fluids or barite incorporated into sediment were determined in toxicity tests with lancelets (*Branchiostoma caribaeum*), a benthic chordate. Concurrent  $\text{LC}_{50}$  determinations,  $\text{EC}_{50}$ s were calculated from the number of lancelets that did not burrow into contaminated sediments. Observations of the burrowing behavior allowed quantitation of effects after 24h exposures to each of the drilling fluids whereas lancelet mortality was sufficient to calculate 24h  $\text{LC}_{50}$ s for only one drilling fluid. Drilling fluids were less toxic to lancelets when incorporated into sediments than to mysids (*Mysidopsis bahia*) or benthic invertebrate communities in water-column exposures. (Author abstract) 14 refs.

Clark, James R. (US EPA, Gulf Breeze, FL, USA); Patrick, James M. Jr. *Mar Pollut Bull* v 18 n 11 Nov 1987 p 600-603.

**072830 STUDY OF THE STATE OF THE BOTTOM-HOLE AREA OF TERRIGENOUS FORMATIONS.** In many wells it is not possible to solve the problem of the presence of infiltration and clogging zones unequivocally from the results of widely used geophysical exploratory methods. The depth of the zone of infiltration of the rinsing fluid filtrate depends in a complex way on the time of contact between the formation and the drilling solution and on the porosity of the formation. The number of formations with a clogging zone increases with an increase in porosity, cracking and depth of occurrence. In addition, a dependence of the clogging zone on the stress state of the well walls and the strength properties of the collector is observed. In Russian. 7 refs.

Khomins, Z.D. *Neft Khoz* n 7 Jul 1987 p 18-22.

**072831 CHARACTERIZATION OF DRILLING MUD FLUID INVASION.** A method for the characterization of drilling mud fluid invasion of porous formations was developed. The oil saturation and resistivity profiles are determined as a function of radial distance from the well and time using a finite difference solution of the radial form of the diffusivity equation. The coefficient of dispersion and its variation with respect to time was determined for five sandstones using long cores. The effluent profile of a step increase of injected sodium chloride concentration is analyzed to determine the value of the coefficient. Values reported in the literature for the dependence of the mud filtration rate on time of filtration were used. The method gives a complete analysis of mud filtrate invasion and can be used for improvement of resistivity well log interpretation. (Author abstract) 14 refs.

Donaldson, Erle C. (Univ of Oklahoma, Norman, OK, USA); Chernoglavov, Valery. *J Pet Sci Eng* v 1 n 1 Aug 1987 p 3-13.

**072832 GREEN CANYON DRILLING - 1: RESEARCH, WELL MONITORING FOCUS ON GUMBO PROBLEM.** Research and continual monitoring during a series of wells produced a cost-effective, deep drilling program for the Green Canyon/Ewing Bank area of the Gulf of Mexico. Drilling problems in this area have historically been attributable to highly reactive shales. The mud system selected as a result of this study and careful drilling cut drilling time and costs while producing in-gage, stable boreholes. This first article covers the study and major considerations. A second will detail the results. 10 refs.

Palumbo, S. (Agip SpA, Milan, Italy); Hawkins, C.D.; Riley, S.M.; Williams, G.J. *Oil Gas J* v 86 n 1 Jan 4 1988 p 35-39.

**072833 DRILLING PROVES KLM SYSTEM WELL-SUITED FOR GULF OF MEXICO'S GREEN CANYON.** A carefully monitored four-well program in the Green Canyon area of the Gulf of Mexico revealed the advantage of a KLM mud employed in the final three wells. This is the second in a series of two papers on drilling with KLM mud. The first article covered the troublesome shale characteristics of this area and other factors for selecting the drilling mud. Excellent borehole stabilization was achieved on all three of the wells drilled with the KLM system. By analyzing monitored data taken at selected depths while drilling 1 Green Canyon 108, it is possible to show that the KLM system effectively stabilized the borehole. Significant improvements in borehole stabilization were also reflected in time savings on each well that the KLM mud system was used.

Palumbo, S. (Agip SpA, Milan, Italy); Hawkins, C.D.; Riley, S.M.; Williams, G.J. *Oil Gas J* v 86 n 2 Jan 11 1988 p 70-72.

**072834 INCREASING PENETRATION RATES WITH HIGH-PRESSURE MUD.** To improve penetration rates of conventional oil and gas drilling rigs by as much as 300%, a high pressure system has been developed. Heart of the system is this trailer-mounted series of pumps that generate 10 gal/minute of mud apiece at 30,000 psi. The high-pressure mud comes off the rear of the trailer through a manifold that sends it to a high-pressure pipe, inside the pipe shown at right, which takes it to the drilling rig. The high-pressure system works with all drilling fluids, but it runs them through this additional centrifuge for extra cleaning.

McNally, Rich (Petroleum Engineer Int, Dallas, TX, USA). *Pet Eng Int* v 59 n 12 Dec 1987 p 46-47.

**072835 EFFECTS OF OIL-BASED DRILL-MUDS IN SEDIMENTS ON THE SETTLEMENT AND DEVELOPMENT OF BIOTA IN A 200-DAY TANK TEST.** Planktonic organisms from natural estuarine waters were allowed to settle in tanks floored with autoclaved natural sediment mixed with oil-based drill-muds to give an initial oil concentration of  $1000\times$  the background total



hydrocarbon content. Over the 200 days of the experiment, there was a marked difference between the biota developing in tanks containing oil-based drill-muds. Differences in effect were found between two drill-muds, based on alternative oils of moderate and low aromatic hydrocarbon content, but there was a greater difference between these two muds and a diesel-based mud. (Edited author abstract) 8 refs.

Blackman, R.A.A. (Ministry of Agriculture, Fisheries & Food, Burnham-on-Crouch, Engl); Fileman, T.W.; Law, R.J.; Thain, J.E. *Oil Chem Pollut* v 4 n 1 1988 p 1-19.

**072836 WILLISTON BASIN: AN ANALYSIS OF SALT DRILLING TECHNIQUES FOR BRINE-BASED DRILLING-FLUID SYSTEMS.** Williston Basin salt intervals, ranging in depth from 5000 to 12,500 ft [1525 to 3810 m], have been responsible for widespread casing collapse because of the plastic movement of evaporites and the subsequent point loading of casing. This phenomenon is attributable to poor cement jobs across excessively eroded salt sections. A 2-year study led to the realization that this erosion is a function of not only salt dissolution but also the mechanical action of turbulent flow in the wellbore. A laminar flow regime can be realized and salt enlargement limited by careful control of annular flow rate, jet velocity, and drilling-fluid rheology. (Author abstract) 11 refs.

Stash, Sandra M. (Arco Oil & Gas Co); Jones, Mark E. *SPE Drill Eng* v 3 n 1 Mar 1988 SPE 15152, p 19-32.

**072837 EXPERIMENTAL STUDY OF GAS SOLUBILITY IN OIL-BASED DRILLING FLUIDS.** Experimental data are provided for the solubility of  $C_1$ ,  $C_2$ ,  $CO_2$ , and a natural gas mixture in base oils and emulsifiers used to prepare oil-based drilling fluids over a range of temperatures. In addition, an empirical correlation for predicting gas solubility in oil-based drilling fluids at low to moderate pressures is presented and a field application is outlined. (Author abstract) 5 refs.

O'Bryan, Patrick L. (Louisiana State Univ); Bourgoynne, Adam T. Jr.; Monger, Teresa G.; Kopcs, Debra P. *SPE Drill Eng* v 3 n 1 Mar 1988 SPE 15414, p 33-42.

**072838 STUDY OF FRICTION FACTOR AND EQUIVALENT DIAMETER CORRELATIONS FOR ANNULAR FLOW OF NON-NEWTONIAN DRILLING FLUIDS.** Published annular pressure drop field data have been compared with values predicted by the Bingham plastic and power law models. Several equivalent diameter equations and friction factor correlations were utilized to estimate the frictional pressure gradients. The estimated frictional pressure drop gradients were then compared with the experimental gradients statistically to determine which combination of friction factor correlation and equivalent diameter equation predicted the experimental data best. New correlations for friction factors predict the field data better than previously published correlations. (Edited author abstract) 14 refs.

Jensen, T.B. (Univ of Wyoming, Laramie, WY, USA); Sharma, M.P. *J Energy Resour Technol Trans ASME* v 109 n 4 Dec 1987 p 200-205.

**072839 DRILLING CEMENT WITH A POLYMER MUD.** Cement contamination of a drilling fluid occurs one or more times during the process of drilling a well. Many polymers are irrevocably altered in the presence of free calcium ions when a pH change occurs. Consequently, the free calcium must be chemically removed before the polymer molecule is altered. Of the several chemicals that can remove free calcium, sodium bicarbonate or potassium bicarbonate instead of a carbonate offers advantages. A bicarbonate will cause a rapid increase in the pH of the polymer system, but the free calcium from the lime is immediately reacted to form the precipitate calcium carbonate. This leaves the polymer unaffected by the calcium ion while the pH increases. The amount of pretreatment chemical should be determined based on the amount of lime to be reacted. Calculations are shown to determine the amount of lime to be treated.

Venus, Tom (Mayco Wellchem, Houston, TX, USA);

Dorsey, Dave. *Oil Gas J* v 83 n 13 Apr 1 1985 p 128, 133.

**072840 WATER MUD GIVES ADVANTAGES WITH PCD BITS.** Operators desire a water-base mud that will yield high penetration rates without downhole trouble when used in conjunction with polycrystalline diamond (PCD) bits. A new water-mud system allows not only high penetration with PCD bits, but maintains a gage hole in the process. The new mud is marketed under the tradename Calx. Calx is a non-dispersed system that contains calcium and potassium. When used in heaving shales, it helps stabilize the well bore, aids in reducing formation damage, and base-exchanges the calcium and potassium for sodium in clay, reducing mud-making. Combined with high temperature deflocculants, which allow the system to function effectively at temperatures to 400°F., the mud permits operators to save on total well costs by replacing conventional water or oil muds in hydratable shales. The drilling fluid uses a polysaccharide as the deflocculant. It acts as a thinning agent and stops hydration of mud-making shales. No lignosulfonates are used. Mud contents are biodegradable. 1 ref.

de Boisblanc, C.W. (Am-Pet Services Inc, Houston, TX, USA). *Oil Gas J* v 83 n 13 Apr 1 1985 p 134, 136-137.

**072841 EFFECT OF A NONCLAYEY SALT-SATURATED SOLUTION OF CARBOXYMETHYL CELLULOSE ON THE QUALITY OF DRILLING INTO PRODUCTIVE FORMATIONS.** According to field data obtained from well testing in eastern Siberia, salt-saturated solutions of carboxymethyl cellulose affect the bottom-hole area of a productive formation in different ways. Cases of partial and complete clogging of this area by the products of drilling into the formation have been noted, as well as cases of recovery and increase in its permeability, prior to well completion. These different states of the bottom-hole area prior to well completion are determined by the nature of the salinization of the rocks, the depth of penetration of the polymer into the productive formation, changes in the conditions of capillary retention of fluid in pores and capillaries of the rocks; and the occurrence of diffuse phase transitions in the solution in the zone penetrated by it. In Russian. 7 refs.

Kazanskii, V.V.; Bragins, O.A.; Nizovtsev, V.P.; Efimova, E.N.; Zakharova, V.A. *Neft Khoz* n 1 Jan 1988 p 21-25.

**072842 DRILLING FLUIDS AND RESERVE PIT TOXICITY.** Drilling fluids are presently classified as exempt under the RCRA hazardous waste laws. However, since last year EPA has been studying reserve pit contents to determine if oilfield wastes should continue under this exemption. Concerns regarding reserve pit contents and disposal practices have resulted in state and local governmental regulations limiting traditional methods of construction, closure and disposal of reserve pit sludge and water. (Edited author abstract) 13 refs.

Leuteran, A.J.J. (M-I Drilling Fluids Co, Houston, TX, USA); Jones, F.V.; Chandler, J.E. *Soc Pet Eng AIME Pap SPE* n 014777 1987 26p.

**072843 EFFECT OF A VACUUM ON THE DRILLING SOLUTION PRESSURE IN A WELL.** A study was made of the effect of a difference in the properties of the drilling solutions filling the pipe space and the annular space of a well on the bottom-hole pressure during regulation of a vacuum in the well. It was found that when the pipe and annular spaces are filled to the well mouth and hermetically sealed, the bottom-hole pressure is always less than the calculated pressure in the annular space but greater than the calculated value in the pipe space. Also, under these conditions the sum of the measured pressures at the bottom hole and at the well mouth in the pipe space is always greater than the calculated pressure in the annular space. A change in the vacuum in the annular space after stabilization of the levels in the pipe and annular spaces has no effect on the bottom-hole pressure. In Russian.

Babayana, E.V.; Bulatov, A.I.; Vidorskii, A.L.; Kuksov, A.K.; Tatarinov, A.V. *Neft Khoz* 3 Mar 1988 p 13-15.

**072844 FLUIDS ARE KEY IN DRILLING HIGH-ANGLE DEVIATED WELLS.** This article investigates some of the key properties and characteristics and suggests adjustments to be made to minimize problems. These include mud selection, mud weight, viscosity and gel strength filtration, and lubricity. The information is based primarily on field experience, basic research, and special studies conducted to solve both local and general problems related to drilling high-angle wells. One internal research and engineering study, involving hole cleaning and related problems with oil-base muds in large-diameter holes in the Gulf of Mexico and North Sea, resulted in the development of new additives as well as improved drilling. 5 refs.

Byrd, Bob (M-I Drilling Fluids Co, Houston, TX, USA); Zamora, Mario. *Pet Eng Int* v 60 n 2 Feb 1988 p 24-26

**072845 COST REDUCTION AND IMPROVEMENT OF DRILLING MUD PROPERTIES BY USING A NOVEL POLYMER.** A novel sulfonated polymer for filtration control in water based drilling fluids is described. Test results demonstrate temperature stability up to 200°C and outstanding electrolyte tolerance of the product. The polymer can be used in NaCl-saturated drilling fluids as well as in muds containing 75,000 ppm of calcium or 100,000 ppm of magnesium ions. Typical applications of this additive are presented. A combination of starch with the mud additive worked successfully in several wells drilled by Preussag AG. The deepest hole was drilled with 11-22 kg/m<sup>3</sup> of pregelatinized starch and 2.5-5.5 kg/m<sup>3</sup> of the polymer to a depth of 4500 m (BHS 133°C). Field experience up to 145°C is discussed. Also reported is a field test in which a CMC mud showing thermal degradation of the cellulosic polymer was successfully stabilized by the polymer. (Edited author abstract) 4 refs.

Ujma, K.-H. (Preussag AG Erdoel und Erdgas, Peine, West Ger); Sahr, M.; Plank, J.; Schoenlinner, J. *Oil Gas Eur Mag* v 13 n 2 1987 p 12-15.

**072846 TRANSPORT RATIO CAN SHOW MUD-CARRYING CAPACITY.** To optimize drill cutting transport, the transport ratio should be maintained as high as possible, although 100% in practice is not possible. Several empirical correlations have been proposed to estimate the cutting slip velocity experienced during rotary drilling operations. Because of the complexity in the flow behavior, these correlations are not expected to yield accurate results. However, they do provide an estimate for selecting drilling fluid properties and pump operating conditions. 4 refs.

Bizanti, Mohamed S. (Louisiana Tech Univ, Ruston, LA, USA); Robinson, Steven W. *Oil Gas J* v 86 n 26 Jun 27 1988 3p.

**072847 PROPER SOLIDS CONTROL: PLANNING IS THE KEY.** This article discusses the concepts of removal efficiency and their effect on well costs. Also included is an example pre-well checklist and schematics of basic solids removal equipment hookups for use with specific circulating fluids under varying conditions that will help in selecting an optimum solids control system. Factors governing choice of a system are also given. 17 refs.

Montgomery, Mike. *World Oil* v 207 n 1 Jul 1988 p 55-61.

**072848 SOFTWARE PREDICTS MUD TOXICITY.** An expert computer system has been developed to approximate expected 'lethal concentration - 50 percent' (LC<sub>50</sub>) values based upon changes in concentrations of the drilling fluid constituents. This program, developed by M-I Drilling Fluids Co. and called ENV, is based upon hundreds of laboratory-generated bioassay values. It reduces both the cost and the time required to get an indication of the LC<sub>50</sub> value expressed as a limited range.

Anon. *Oil Gas J* v 86 n 28 Jul 11 1988 p 85-88.



**072849 DRILLING MUD EVALUATION OF SOUTHWEST QUEENSLAND WELLS.** In a study of 17 exploration and appraisal wells drilled in southwest Queensland, inclusion of all measurable mud related costs radically changed previously held beliefs on mud system cost effectiveness. The study showed a cost advantage of approximately 30 per cent when using KCl-polymer over wells drilled with gellignosulphonate. Mud product consumption cost was shown to be only part of what must be considered when evaluating the overall cost effectiveness of a drilling fluid. Evaluation of a mud system was shown to require a detailed analysis of all drilling and evaluation problems encountered during the course of drilling a well. (Edited author abstract) 1 ref.

Lake, B. (Delhi Petroleum Pty Ltd, Adelaide, Aust); Muecke, N. *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 465-469.

## Economics

**072850 ECONOMICS OF CONTRACT DRILLING - A DILEMMA.** As a result of the downturn in exploration, the Australian contract drilling industry was flooded by an oversupply of rigs resulting in a reduction in rates by up to 35 per cent. This oversupply situation continues today in Australia, and contractors are now facing severe economic difficulties as they attempt to gain a reasonable market share to ensure that their nucleus of highly trained personnel are not lost from the industry. Contractors have implemented cost control programs which if continued for some time will have adverse effects. As maintenance programs have been curtailed, capital expenditure has all but been eliminated and training programs deferred. (Edited author abstract)

Bushell, J.E. (Richter Drilling Pty Ltd, Brisbane, Aust). *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 31-35.

**Electric Drive** See EARTH BORING MACHINES—Electric Drive.

**Equipment** See Also OIL FIELD EQUIPMENT; OIL FIELD EQUIPMENT—Pumps; OIL WELL CASING—Wear.

**072851 NORTH SEA DEVELOPMENT DRILLING, SOUTH EAST FORTIES: A CASE STUDY.** The development of the South East Forties field began in July 1984, when a 16-slot subsea template was transported to location and installed by the semisubmersible drilling vessel (SSDV) Sedco 707. Thereafter, 14 subsea development wells were drilled before the installation of a minimum-facilities jacket, to which the wells would be tied back and completed. This field development was identified as an ideal candidate for the optimization of the drilling operation. The result of this optimization campaign was a significant reduction in well-drilling times and associated costs. (Author abstract) 1 ref.

Denholm, J.M. (BP Petroleum Development Ltd). *SPE Drill Eng* v 2 n 4 Dec 1987 SPE 15448, p 387-392.

**072852 MODERN RIG DESIGN, EQUIPMENT UPS EFFICIENCY.** Increasing rig efficiency would be one way to enable the oil well drilling industry to survive. The efficiency of a drilling rig is increased when the maximum rig time is spent on bottom, making hole at optimum penetration rates. This means that one has to concentrate efforts to minimize rig moving time and increase the percentage of time making hole. This can be achieved by study of the drilling process and designing, selecting, and matching components to it.

Spoerker, Hermann F. (OMV AG, Vienna, Austria). *Oil Gas J* v 86 n 9 Feb 1988 p 51-52, 54, 56.

**072853 DOWNHOLE CONTROL OF DEVIATION WITH STEERABLE STRAIGHT-HOLE TURBO-DRILLS.** Advances in directional drilling have until recently been confined to issues that are peripheral to the central problem of controlling assembly behavior downhole. The steerable straight-hole turbodrill (SST) addresses this problem directly, allowing alteration of the well course without the need to trip. The availability of

such a system radically changes the way in which directional well planning may be approached. This paper describes the equipment used and the equipment's construction and operational requirements. It discusses the capabilities and current limitation of the systems. Field results are presented for some 300,000 ft [91,500 m] of deviated drilling carried out over 2 years in Alaska and the North Sea. A series of four highly deviated wells totaling 35,000 ft [10,700 m] with only three deviation trips is included. (Edited author abstract) 4 refs.

Gaynor, T.M. (Neyfor Ltd, UK). *SPE Drill Eng* v 3 n 1 Mar 1988 SPE 14769, p 50-56.

**072854 USE OF REAMERS FITTED WITH SUPERHARD MATERIALS IN DEEP BORING OPERATIONS.** The field of application and advantages of radial-elastic reamers over rigid reamers or fixed expanding devices is outlined and methods improving them are considered. It is noted that radial-elastic reamers and gages equipped with superhard materials have been used successfully in boring deep boreholes. The number of blades and the forces with which they are presented to the borehole walls are determined from the permissible torque [M] established, using the strength conditions of the boring column on rotary boring or determined from the torque of the face motor. An increase in  $m$  is generally accompanied by a decrease in rigidity of the flexible element under each blade and a decrease in its pressure on the borehole walls. 5 refs.

Gerzhberg, Yu.M. (Ukhtizhmag Industrial Inst, USSR); Vovchanovskii, I.F.; Finkel'shtein, E.M. *Sov J Superhard Mater* v 9 n 6 1987 p 60-63.

**072855 STEERABLE SYSTEM CUTS STRAIGHT HOLE DRILLING COSTS 50%.** The system comprises a bit, bent housing positive displacement motor (PDM), MWD tool, stabilization-bottomhole assembly (BHA) optimization software, and a certified operator. The steerable system drills using either the downhole motor only (sliding mode) or the motor and rotary table (rotary mode) to provide rotational power to the bit. The need to change BHAs is dramatically reduced. Trajectory corrections can be made much more frequently with less changer per correction. The steerable system drills an arc of curvature established by the degree of end in the orienting housing of the motor component of the drilling assembly and stabilizer placement. The bend tilts the bit axis relative to the axis of the hole and creates an offset angle which imparts a lateral, or side force, to the bit.

Nordquist, Darrell (Sun Exploration & Production Co, Valencia, CA, USA); Kerr, Denton; Thomas, Mark. *Pet Eng Int* v 60 n 5 May 1988 p 48-51.

**072856 ELF IMPROVES HORIZONTAL DRILLING AT ROSPO MARE.** Horizontal drilling in the Rospo Mare field, located off the shore of Italy, was enhanced with the use of a remote-controlled bent sub. This new tool allows real-time control and correction of drift angle and azimuth without round trips to modify the bottomhole assembly (BHA). The remote-controlled bent sub, called the T-3000 Telepilot, consists of an upper and lower sub connected by an offset conical swiveling joint. The axis of the conical joint is tilted compared to the main axis of the tool. Rotation of the lower sub around the axis of the swiveling joint gradually induces an increase in the bent sub angle from 0° in the straight position to a maximum angle after five actuations and then back to 0° after a complete revolution (10 actuations). Maximum bent sub angle can be 2°, 2.5°, or 3° depending on the size of the tool. The two main advantages of the remote-controlled bent sub are: Time savings - the standard drilling method would have required three additional round trips. The planned well bore trajectory was followed with greater accuracy and with the same BHA.

Mariotti, Christian (Elf Italiana, Rome, Italy); Kou, Evelyn. *Pet Eng Int* v 60 n 8 Aug 1988 3p.

## Evaluation

**072857 TOP-DRIVE DRILLING SYSTEM EVALUATION.** Three wells were drilled from a platform in Mustang Island, offshore Texas, and the top-drive drilling system was used and tracked for time savings vs. a typical kelly/rotary system. It has been reported that as much as 20 to 25% time savings can be obtained with the top drive. Definite time savings can be expected with the top-drive drilling system, but the magnitude reported was not experienced on the three wells discussed. It was established that roughly 6% of drilling cost or 4% of total well cost could be saved with the top drive, which represents 11% of drilling time or 8% of total well time. (Edited author abstract) 3 refs.

Cavanaugh, James M. (Transco Exploration Co); Adams, David M. *SPE Drill Eng* v 3 n 1 Mar 1988 SPE 16064, p 43-49.

**Exploratory** See Also PETROLEUM PIPELINES—Offshore.

**072858 EFFECTIVE MANAGEMENT KEY TO REMOTE RIG SITE OPERATION.** Remote exploratory drilling operations generally are short-duration projects, but the organization must be developed to provide support before, during and after actual drilling. Five interrelated elements must carefully be considered when developing the organization: goals, organizational structure, decision processes, people and reward systems. Each of these five elements is discussed. In addition, such factors as relationships between participants and support services selection and approvals are also examined in detail. 1 ref.

Goldsmith, Riley (Goldsmith Engineering Inc, Houston, TX, USA). *World Oil* v 205 n 5 Nov 1987 p 55-56, 58.

**072859 IDENTIFYING POTENTIAL PETROLEUM ACCUMULATIONS.** In the course of 'tight money' exploration, explorationists are faced with further reducing the risk of the three parameters of a prospect: trap, reservoir, and the presence of hydrocarbons. Except under very favorable conditions, techniques such as seismic can only provide information on the first two. The latter parameter, the presence of hydrocarbons, has usually been relegated to proximity to production or shows. Predrilling analysis of the near-surface geochemical environment will enable the explorationist to evaluate the potential for hydrocarbon accumulations. A petroleum reservoir will leak various hydrocarbons that rise to the surface via fractures. The article describes electrical and other near-surface exploration techniques. 4 refs.

Indelicato, Gregory J. (Sun Exploration & Production Co, Dallas, TX, USA). *Oil Gas J* v 86 n 13 Mar 28 1988 p 73-74, 76.

**072860 USES OF PRESSURE AND TEMPERATURE DATA IN EXPLORATION AND NEW DEVELOPMENTS IN OVERPRESSURE DETECTION.** Pressure and temperature data from wireline logs and seismic-velocity analysis can be used in deep overpressures to aid in prospect evaluation. Properly interpreted seismic-velocity analysis in deep water can yield maturation and migration information. Use of a modified approach to the  $d$  exponent and use of measurement-while-drilling (MWD) data have proved successful in deepwater pressure detection. (Author abstract) 17 refs.

Pilkington, P.E. (Conoco Inc). *JPT J Pet Technol* v 40 n 5 May 1988 SPE 17101, p 543-549.

**Indonesia** See OIL WELLS—Perforation.

## Mathematical Models

**072861 PREDICTION OF PHYSICO-MECHANICAL PROPERTIES ROCKS TO BE DRILLED BY RELYING ON THE ANALYSIS OF THE TRAJECTORIES OF DRILLED BOREHOLES.** A mathematical model of the process of deflection of inclined-directed boreholes in the course of turbine drillings is described.



An estimation of the values of the load per bit and of the frequency of its rotation is carried out taking into account turbodrill characteristics and assuming that in the course of drilling its mechanical rate is maximized. By using this model and depending on the character of the trajectories of the boreholes drilled it is possible to evaluate the physico-mechanical properties of rocks forming the log of the drilling region. (Translated author abstract) 6 refs. In Russian.

Sdobin, A.I. *Izv Vyssh Uchebn Zaved Neft Gaz* n 2 Feb 1988 p 19-22.

## Measurements

**072862 NEW METHOD OF MEASURING PENETRATION IN WELL DRILLING.** It is proposed to measure the penetration by a bit in accordance with axial load variations. This would utilize the relay character of drilling tool feeding, in which changes in axial load during the drilling with stopped tool feeding are proportionate to the penetration by the bit. Two ways of implementing the method are proposed. Experimental data are presented confirming the theoretical principles. (Translated author abstract) 2 refs. In Russian.

Brazhnikov, V.A.; Andreev, V.A.; Bulushev, V.S. *Izv Vyssh Uchebn Zaved Neft Gaz* n 10 1986 p 23-26.

**072863 MEASUREMENT WHILE-DRILLING ESSENTIAL TO DRILLING.** During the next decade, measurement-while-drilling (MWD) technology will mature and become an essential part of drilling and formation evaluation. Especially in high angle/horizontal wells, more effective drilling and evaluation will be possible. This concluding article in a series that began Jan. 25 focuses on limitations to using MWD that will be overcome. The use of MWD products and services will be expanded to include smaller holes, higher temperature, faster and more frequent signals, more downhole memory, and additional sensors. These advances will lead to better formation evaluation, safer drilling, and increased drilling efficiency. 46 refs.

Fontenot, John E. (Completion Technology Co, Houston, TX, USA); Vikram Rao, M. *Oil Gas J* v 86 n 13 Mar 28 1988 p 52-55, 58.

## Monitoring

**072864 MWD CAN IMPROVE WELL SAFETY, CONTROL.** Measuring while drilling (MWD) can help improve well safety and at the same time reduce trouble and total drilling costs. Detection of geologically over-pressured zones with the technique is now commonplace, but virtually no advance has been made in the art of detection of influx of formation fluids into the wellbore. This third of five articles in a series describes the most recently available MWD techniques of pressure prediction and discusses the need for influx detection and possible means for realizing this in the future. 25 refs.

Fontenot, John E. (Completion Technology Co, Houston, TX, USA); Rao, M. Vikram. *Oil Gas J* v 86 n 7 Feb 15 1988 p 40-41, 44-46, 48.

**Offshore** See Also OCEANOGRAPHY; OIL FIELDS—North Sea; OIL WELL PRODUCTION—Sub-sea Production System; SEMISUBMERSIBLES—Design.

**072865 SUBMERSIBLE RIG/MAT UNIT DRILLS FIRST ARCTIC WELL.** Canadian Marine Drilling Ltd. (Canmar) designed and built the Single Steel Drilling Caisson (SSDC) in 1982, by converting the forward half of a 231,000-dwt tanker to a bottom-founded drilling unit. The SSDC was designed to operate from a specially constructed drillsite berm that required the movement of massive amounts of dredged materials. Although used successfully in 100-ft waters in the Canadian Beaufort, the short work season in the Arctic led Canmar engineers to determine how the system could be used more effectively. The solution focused on the use of a steel base, or mud mat, measuring 561×361×44 ft to support the SSDC. The 44-ft height was needed to provide an operational water depth of 80 ft with no bottom preparation. The large

size of the mat would also increase the footprint of the system to 192,000 sq ft from 75,000 sq ft. This increased base area, together with the incorporation of skirts, would enable the composite unit to operate in relatively weak soils without special bottom preparation. 3 refs.

Anon. *Ocean Ind* v 22 n 7 Jul 1987 p 20-21, 24.

**072866 SYSTEMS APPROACH SPEEDS OFFSHORE DRILLING OPERATIONS.** Five recent drilling technology innovations have been combined into a drilling system that has saved time and money for offshore operators for the past three years. This navigation drilling system combines: the latest in natural and synthetic bit technology, improved performance downhole drilling motors, a unique double-tilted navigation sub that permits both directional and straight-hole drilling, measurement while drilling, and engineered well planning for bit selection, bottomhole assembly optimization and system hydraulic design. Wells drilled with the navigation drilling system typically have been drilled 30% faster than nearby offset wells completed using conventional techniques.

Bitto, Ron (Eastman Christensen Co). *Ocean Ind* v 22 n 7 Jul 1987 p 25-27.

**072867 SUBSURFACE IN SITU STRESS MAGNITUDES FROM OIL-Well DRILLING RECORDS: AN EXAMPLE FROM THE VENTURE AREA, OFFSHORE EASTERN CANADA.** This report describes a method of obtaining information on in situ stress magnitudes at depth in sedimentary basins by using information gathered while drilling oil wells. If we assume that one of the principal stresses is vertical at a well site, principal stress magnitudes can be estimated in the following manner.  $S_v$  is equated with overburden load, which is obtained by integrating density log records.  $S_{Hmin}$  is equated with leak-off test pressures measured over short open-hole intervals and also from selected initial feed-rate pressures. Using this approach, stress magnitudes were estimated for 44 depth intervals in four wells drilled over the Venture structure on the Scotian Shelf, offshore eastern Canada. The information obtained between subsea depths of 815 and 5783 m provides a consistent record and points to a stress regime where  $S_{Hmax} > S_v > S_{Hmin}$ . (Edited author abstract) 39 refs.

Ervine, W.B. (GeoTech Surveys Ltd, Lower Sackville, NS, Can); Bell, J.S. *Can J Earth Sci* v 24 n 9 Sep 1987 p 1748-1759.

**072868 ENVIRONMENTAL EFFECT OF PRODUCED WATER FROM NORTH SEA OIL OPERATIONS.** Produced water from North Sea oil reservoirs contains substantial amounts (about  $1g\ l^{-1}$ ) of non-hydrocarbon organic matter, largely as salts of acetic, propionic and butyric acids, as well as some 20-40  $mg\ l^{-1}$  of dissolved hydrocarbons such as benzene, toluene and xylene. The non-hydrocarbon components originate in water in the oil-bearing formation. All of the organic matter can be accounted for, within analytical accuracy. The water also contains some 20-30  $mg\ l^{-1}$  of ammoniacal nitrogen and a number of inorganic components. At peak water production from production installations in the North Sea some  $1-2 \times 10^5$  tonnes  $yr^{-1}$  of organic acids will be discharged in the U.K. sector of the North Sea. The ready biodegradability of the organic constituents and the low toxicity of produced water have been confirmed by direct measurement; acute toxicity is unlikely at dilutions of greater than 100 fold. Dispersion has been modelled and tested in the laboratory indicating some 1000 fold dilution within less than 50 m of the discharge. (Edited author abstract) Refs.

Somerville, H.J. (Shell UK Exploration & Production, Aberdeen, Scotl); Bennett, D.; Davenport, J.N.; Holt, M.S.; Lynes, A.; Mahieu, A.; McCourt, B.; Parker, J.G.; Stephenson, R.R.; Watkinson, R.J.; Wilkinson, T.G. *Mar Pollut Bull* v 18 n 10 Oct 1987 p 549-558.

**072869 ADVANCE OPEN MARGINAL OFFSHORE SECTORS.** New standards of topsides completion are being achieved on two gas field developments in the Southern basin of the North Sea. The arrival of new

and upgraded heavy duty crane barges has enabled engineers on the Conoco (UK) Ltd. V fields project and BP Petroleum Development's Villages project to design heavy, integrated decks where much of the equipment has been commissioned and tested before floatout. The decks for the two developments both weigh over 5,000 metric tons. The U.K. industry is now moving into a new phase of integrated deck construction with a 7,500 metric-ton unit for Shell/Esso's Kittiwake oil field in the central North Sea. Kittiwake is a relatively small offshore oil project and some of the larger developments now on the drawing board, notably BP's Miller field, will revert to modules and offshore hook-up. These super modules will be the size of some integrated decks. The topsides for V fields and villages have set standards that other fields will need to emulate if they are to achieve the cost savings needed to meet tight development budgets. (Author abstract)

Vielvoye, Roger (Oil & Gas Journal, Tulsa, OK, USA). *Oil Gas J* v 86 n 18 May 2 1988 p 33-35.

**072870 STEERABLE SYSTEM ADDS PRECISION TO GULF DRILLING.** A well bore intersection was achieved ahead of schedule with a steerable drilling system in the Gulf of Mexico. A computer-generated proximity survey comparing the directional surveys of the initial and replacement wells, confirmed that the wells were within 1 ft of each other near the planned intersection depth of 8,890 ft. All objectives for the 9,050-ft replacement well were accomplished 4 days ahead of schedule. This operation illustrates the effectiveness of the steerable drilling system for obtaining better directional control, increased drilling efficiency, and reduced overall drilling time.

Bierschwale, H. (Granstaff Directional Drilling Co, Lafayette, LA, USA); Ridley, R. *Oil Gas J* v 86 n 18 May 2 1988 p 42-44, 47-48, 50.

**072871 TECHNOECONOMIC MODEL FOR OFFSHORE SUPPLY OPERATIONS.** The vital role of logistic support for maintaining uninterrupted drilling operations is well known to offshore petroleum engineers. Moreover, its importance is growing as exploration and production activities are extended to progressively deeper water and harsher weather conditions. However, no systematic approach for ensuring effective logistic support has yet been realized. A method of studying the characteristics of logistic support and of designing a system for securing effective supply to an offshore rig is proposed. It is based on event simulation modeling of offshore supply operations, together with more conventional technical and economic models for yielding economic criteria which take into account a possible interruption of drilling operations. The method has been developed through a detailed investigation of each component of the supply operation and of the inherent problems. To evaluate the feasibility of the approach, an example has been provided. (Author abstract). 5 Refs.

Rahman, S.S. (King Fahd Univ of Petroleum & Minerals, Dhahran, Saudi Arabia). *J Energy Resour Technol Trans ASME* v 110 n 2 Jun 1988 p 102-108.

**072872 DRILLING MODEL FOR YOUNG OFFSHORE LOUISIANA AND TEXAS TRENDS.** A new type of model specifically designed to aid in the planning and drilling of young offshore Louisiana and Texas wells is presented. The model is composed of functions to represent changing drilling mechanics, as well as changing drillabilities with respect to depth, area, and formation type. (Author abstract). 17 Refs.

Smalling, D.A. (Elf Aquitaine Petroleum); Myers R.L. II. *SPE Drill Eng* v 3 n 2 Jun 1988 p 141-152.

**072873 ONBOARD SYSTEM PROVIDES STABILITY, MOORING, AND MOTION ANALYSIS FOR SEMISUBMERSIBLE DRILLING OPERATIONS.** Vessel stability, mooring, and motion-related decisions on semisubmersible drillships have historically been made with a combination of the marine crew's experience and



guidelines documented in the ship's operating manual. This is especially true once the vessel is on location and operations are under way. This situation leaves the operator dependent on contractors to anticipate problems and to take correct remedial action. This paper presents a computer system that combines state-of-the-art marine technology with a simple user interface to provide information useful to operations personnel in making decisions. The purpose of the system is not to take over any of the contractors' responsibilities. It does provide additional information useful in making marine-related decisions. This allows the contractor and the operator to combine experience and analysis and work toward a mutual decision. (Edited author abstract). 6 Refs.

Foreman, Russell D. (Amoco Production Co); Beynet, P.A.; Singhal, S.N.; Seldi, L.H. *SPE Drill Eng* v 3 n 2 Jun 1988 p 153-159.

**072874 OFFSHORE DRILLING AND COMPLETION/WORKOVER RIGS.** In the seventies Deutag in cooperation with Shell started to develop an idea based on the comprehensive conception of simultaneously effecting different operational steps during drilling of offshore production wells. As a result in 1977 we have developed the DUNLIN A platform a conductor driving rig of simple design and lower cost. The experience gained over the past ten years clearly shows that well service or workover rigs, respectively, should be designed to have the highest possible degree of mobility, allowing operation on a variety of platform types.

Eickelberg, H.D. (Deutag Drilling Contractors, Bad Bentheim, West Ger); Wehling, B. *Oil Gas Eur Mag* v 14 n 2 1988 p 18-21.

Oklahoma See PETROLEUM PROSPECTING—Oklahoma.

#### Optimization

**072875 NEW TECHNIQUES IN HORIZONTAL AND DRAIN-HOLE DRILLING OPTIMIZATION: PART 2 - GEORGSDORF 503, HORIZONTAL DRILLING PROJECT.** GEORGSDORF 503 is one of the two drain-hole-wells in the eastern part of the Georgsdorf Oilfield, where the 503 was originally planned to be the production, the 502 to be the injection well. Both wells, located parallel in approx. 250m of lateral distance, should cross the Bentheimer Sandstone over an entire length of 650m from top to bottom. By means of that new technique of development of hydrocarbons in combination with secondary and possibly tertiary recovery, the production of marginal oil and gas fields should become economical in the future. (Edited author abstract)

Prevedel, B. (PREUSSAG Aktiengesellschaft). *Soc Pet Eng AIME Pap SPE Unsolicited Manuscript Sep 1987 SPE* 017080, 18p.

**072876 MULTIPLE REGRESSION APPROACH TO OPTIMIZE DRILLING OPERATIONS IN THE ARABIAN GULF AREA.** This paper reports a successful application of multiple regression analysis, supported by a detailed statistical study to verify the A.T. Bourgoyne and F.S. Young model. The model estimates the optimum penetration rate (ROP), weight on bit (WOB), and rotary speed under the effect of controllable and uncontrollable factors. Field data from three wells in the Arabian Gulf were used and emphasized the validity of this model. The model coefficients are sensitive to the number of points included. The correlation coefficients and multicollinearity sensitivity of each drilling parameter on the ROP are studied. (Edited author abstract) 4 refs.

Al-Betairi, Emad A. (Petromin); Moussa, Mohamed M.; Al-Otaibi, Saud. *SPE Drill Eng* v 3 n 1 Mar 1988 *SPE* 13694, p 83-88.

**072877 MWD AIDS VITAL DRILLING DECISIONS.** Measurements-while-drilling (MWD) sensors can supply much of the critical downhole information needed in a systems approach to improving drilling efficiency. A means of prioritizing the information needed

in a drilling data base has been developed. To be as objective as possible, the following steps are performed: all the decisions made in planning, drilling, evaluating, and completing a well are listed; for each decision, all of the information needed is listed; for each item of information needed, the number of times it is needed in decision making is tabulated; the types of information are rank-ordered, based on the frequency of usage. 27 refs.

Fontenot, John E. (Completion Technology Co, Houston, TX, USA); Rao, M. Vikram. *Oil Gas J* v 86 n 11 Mar 14 1988 p 60, 62-64.

#### Planning

**072878 INTERACTIVE COMPUTER GRAPHICS SYSTEM IMPROVES PLANNING OF DIRECTIONALLY DRILLED WELLS IN THE EAST WILMINGTON FIELD.** The Long Beach Unit of the East Wilmington field contains more than 1,200 wells directionally drilled from four manmade islands and five land-based drilling sites. Planning new wells that avoid interference with existing wells becomes more difficult and time-consuming as the density of wells in the Unit increases. Improvements and modifications in design procedures have culminated in the interactive computer graphics system now in use. The interactive computer graphics system (ICGS) permits the viewing of a proposed new well or redrill well course, together with all existing well surveys and other proposed well courses in the area of interest. Plan, section, and traveling cylinder views can be displayed to allow the identification of design problems. The significance of the problems is then minimized by use of the interactive features of the system to refine the design parameters. The system's interactive features are also used to create, edit, and plot the finalized design. (Edited author abstract). 1 Ref.

Lutz, T.S. (Thums Long Beach Co); Kendle, D.W. *SPE Drill Eng* v 3 n 2 Jun 1988 p 173-176.

#### Pressure Effects

**072879 STUDY OF PRESSURE ATTENUATION OF A SUBMERGED, NONFREE JET AND A METHOD OF CALCULATION FOR BOTTOM-HOLE HYDRAULIC PARAMETERS.** The pressure attenuation of a submerged, nonfree jet has been studied with a simulated wellbore. Equations describing pressure attenuation along the centerline and the cross-sectional pressure distribution of the jet are given. With these equations, bottomhole hydraulic parameters can then be calculated. Also, an optimal design of a jet-drilling hydraulic program based on bottomhole parameters has been developed. (Author abstract) 10 refs.

Shen, Zhonghou (East China Petroleum Inst, China); Sun, Qingxiao. *SPE Drill Eng* v 3 n 1 Mar 1988 *SPE* 14869, p 69-76.

#### Rigs See Also SEMISUBMERSIBLES—Stability.

**072880 DISCUSSION OF MINIMUM-COST CASING DESIGN FOR VERTICAL AND DIRECTIONAL WELLS.** Wojtanowicz and Maidla (1987) suggest cost as a criterion for casing design. This suggestion is misleading because casing cost is usually arrived at after the final selection of casing is made. Casing selection is based on a variety of factors relating to loading conditions arising from drilling and production operations. The availability of casing and logistics are exterior factors that can influence the casing selection and its cost. No company has unlimited access to all grades and types of available casing. If this were the case, then cost would become a criterion after an initial selection of casing is made on the basis of wellbore forces. 3 refs.

Rabla, H. (Univ of Newcastle upon Tyne, Engl). *JPT J Pet Technol* v 40 n 4 Apr 1988 *SPE* 17100, p 504-506.

**072881 DRILLING RIGS DESIGNED FOR EARTHQUAKES.** The key in designing platforms for earthquake-prone areas such as offshore California is to make sure the natural response frequency of the platform

avoids the peak natural frequency of the ground during a seismic event; thus obtaining a dampening effect versus an amplification effect. A significant portion of the drilling structure's loads are live drilling loads. In fact, the drilling loads could equal 75% of the structure's dead load. The setback, hook, and rotary loads are constantly shifting during drilling, tripping, logging, running casing, and various other operations. To compensate for these significant live loads and yet not overdesign, an in-depth time study was performed using maximum loads during a given operation. An earthquake analysis was performed to determine dynamic loads in individual structural members of the drilling rig, as well as a resultant loading of the platform skid beams. Engineers used the ANSYS finite element computer program with the response spectrum method of dynamic analysis.

Cardenas, Jose (Dual Drilling Co, Dallas, TX, USA). *Pet Eng Int* v 60 n 5 May 1988 p 68, 71.

**072882 CASE STUDY EVALUATION OF SUBSEA PREFERENTIAL-WELD HEAT-AFFECTED-ZONE CORROSION.** This paper discusses parameters studied in an attempt to correlate the spread and severity of the corrosion problem with variances in geometry, metallurgy, and cathodic protection. Correlations were found that enabled the successful prediction of location of further corrosion grooves and allowed a new optimum inspection program based on both fatigue prediction and weld corrosion history. The presence of the corrosion grooves in many cases gives spurious crack-like indications with magnetic particle inspection (MPI). This paper also discusses how alternating current potential difference (ACPD) inspection techniques together with profile-molding techniques were used to eliminate spurious readings and to characterize the grooving shape for detailed fracture-mechanics assessment. (Edited author abstract). 4 Refs.

Tyson, J.A.G. (Conoco (UK) Ltd, Engl); Bell, E.R.G. *JPT J Pet Technol* v 40 n 6 Jun 1988 p 779-782.

**Rotary Mud See Also CLAY MINERALS; FLOW OF FLUIDS—Suspensions; MICROSCOPIC EXAMINATION—Scanning Electron Microscopy.**

**072883 CERCETARI PRIVIND POSIBILITATEA OBTINERII DE SUPORTI MINERALI PENTRU NOROIALE DE FORAJ TIP EMULSIE INVERSA DIN ARGILE ROMANESTI: (II).** [Investigations Regarding the Possibility of Obtaining Mineral Supports from Romanian Clays for Inverse Emulsion Type Drilling Muds: (II)]. By applying X-ray crystal diffraction, the chemico-spectral emission analysis and the semi-quantitative method, the chemico-mineralogical breakdown of certain Romanian products used as mineral supports for drilling muds is presented, together with a laboratory methodology worked out for the purpose proposed in the title. (Author abstract) In Romanian. 13 refs.

Nistor, I. (Inst de Petrol si Gaze, Ploiesti, Rom). *Mine Pet Gaze* v 38 n 6 Jun 1987 p 279-285.

**072884 CERCETARI PRIVIND POSIBILITATEA OBTINERII DE SUPORTI MINERALI PENTRU FLUIDELE DE FORAJ TIP EMULSIE INVERSA, DIN ARGILE ROMANESTI: (I).** [Investigation into the Possibility of Obtaining Mineral Supports from Romanian Clays for Inverse Emulsion-Type Drilling Muds]. Two mineral supports and 12 clay samples from several quarries of Romania were investigated by using X-ray crystal diffraction techniques and emission chemico-spectral analysis. It is shown that the clays which are most appropriate for physico-chemical processing in order to obtain data on chemico-mineralogical structures for inverse emulsion type drilling muds are those which include in their structure mostly crystalline lattices of clayed minerals. (Edited author abstract) In Romanian. 9 refs.

Nistor, I. (Inst de Petrol si Gaze Ploiesti, Rom). *Mine Pet Gaze* v 38 n 1 Jan 1987 p 39-45.



**072885 HOW TO COMBAT OIL-BASED MUD LOSSES.** Oil-based muds have proved successful in solving many problems associated with today's complex drilling operations, but their use often is restricted by concerns over possible lost circulation. Among the factors currently being investigated are some important differences between oil-based and water-based systems that affect whether losses will occur and how circulation can be regained. A discussion is presented of lost circulation control, fibrous sealing materials and the field use of oil dispersible wood fiber. It is shown that adequate knowledge of mud system differences, use of a new oil-dispersible wood fiber and application of specific operating guidelines can limit mud losses to reasonable quantities while still permitting fast drilling. 5 refs.

Simpson, J. P. (O'Brien-Goins-Simpson & Associates Inc, Houston, TX, USA); Salisbury, D.P.; Jewell, Richard A. *World Oil* v 206 n 1 Jan 1988 p 30-32, 34, 88.

**072886 PROCESSES AND FACTORS OF ACTIVATION OF CLAY DRILLING MUDS BY PULSED ELECTRIC DISCHARGES. II.** The results of investigating the change in the breakdown voltage during treatment of clay drilling muds by pulsed discharges are given. It is suggested that to take into account this change through the probability of breakdown of the medium a mathematical model is required. A discussion is presented of the proposed mathematical model. (Edited author abstract) 6 refs.

Alekseeva, T.I.; Kalyatskii, I.I.; Kurets, V.I.; Lobanova, G.L.; Filatov, G.P. *Sov Surf Eng Appl Electrochem* n 4 1987 p 38-42.

**072887 ADDITIVE EFFECTIVENESS AND CONTAMINANT INFLUENCE ON FLUID-LOSS CONTROL IN WATER-BASED MUDS.** The proper fluid-loss control of drilling muds becomes more difficult when drilling high-temperature, high-pressure formations. Chemical additives for reducing fluid loss differ considerably in effectiveness; in turn, these differences vary, often unpredictably, with temperature and pressure. This paper discloses the results of static-filtration experiments that compare capabilities of various additives to minimize filtrate invasion at elevated temperatures when the mud contains certain common contaminants. The effects of mud weight, high-temperature aging, and the presence of asphalt on mud fluid loss were also investigated. The additives selected for study were WL-100, carboxymethyl cellulose (CMC), Dextrid, CC-16, Resinex, and several asphalts. (Edited author abstract). 21 Refs.

Nyland, T. (Univ of Tulsa, USA); Azar, J.J.; Becker, T.E.; Lummus, J.L. *SPE Drill Eng* v 3 n 2 Jun 1988 p 195-203.

## Simulation

**072888 POSIBILITATI DE FOLOSIRE A UNOR EMULATORI INDIGENI IN OPERATIILE DE STIMULARE A SONDELOR DE PETROL SI GAZE.** [Employment Possibilities of Indigenous Emulsifiers in the Oil and Gas Well Stimulation]. The paper presents laboratory data obtained in the preparation of acid emulsions with indigenous emulsifiers based on ethoxylated oils. The characteristics of these emulsions and their action upon marble drill cores and steel samples are presented. (Author abstract) In Romanian. 1 ref.

Dinca, Ana (Inst de Petrol si Gaze Ploiesti, Rom); Gheorghitau, M. *Mine Pet Gaze* v 38 n 3 Mar 1987 p 144-146.

## Stresses

**072889 STABILITY OF HIGHLY INCLINED BOREHOLES.** Hole inclination produces alternations in the stress state around the borehole and in the physical properties of the rock. Depending on specific conditions, such effects may lead to collapse of the borehole or a reduction in the fracture-initiation pressure. This paper shows how to determine such effects through the application of stress analysis and rock mechanics. (Author abstract) 17 refs.

Aadnoy, B.S. (Rogaland Regional Coll); Chenevert, M.E. *SPE Drill Eng* v 2 n 4 Dec 1987 SPE 16052, p 364-374.

## Texas

**072890 MODEL CASE HISTORY OF INFELD DRILLING AND COMPLETION IN SOUTH TEXAS.** This group project presented an opportunity to improve overall operations from title clearance to on-stream producing. Changes and improvements in virtually every area of drilling and completion contributed to substantial savings in time and money. These savings resulted in the drilling of twice as many wells as originally proposed, and all improvements are supported by actual field tests. This paper deals primarily with drilling and completion operations in Laredo, TX, area. (Author abstract) 1 ref.

Barnett, K.L. (Chevron USA, Inc, USA); Jeansonne, J.P.; Mitchell, R.K. *SPE Drill Eng* v 3 n 1 Mar 1988 SPE 14424, p 7-11.

## Thermal Effects

**072891 FORMATION TEMPERATURE ESTIMATION BY INVERSION OF BOREHOLE MEASUREMENTS.** The authors describe a new numerical method that uses inverse methods to model thermal stabilization of a borehole after drilling mud circulation has stopped. The following five geophysical parameters can be estimated from the method: (1) true formation temperature ( $T_f$ ); (2) mud temperature ( $T_m$ ) at the time the mud circulation stops; (3) thermal invasion distance ( $R$ ) into the formation before the formation is at the true formation temperature ( $T_f$ ); (4) formation thermal conductivity ( $K$ ) perpendicular to the borehole; and (5) efficiency factor ( $F$ ) for heating mud in the borehole after mud circulation has stopped. Applications of the new inverse procedure to both synthetic data and field data show that the true formation temperature in many cases can be estimated precisely (to within about 0.4 percent); that the mud temperature can be estimated with acceptable accuracy (5 percent or so); while the thermal conductivity ( $K$ ), the thermal invasion distance ( $R$ ), and the efficiency factor ( $F$ ) can be roughly estimated, provided high-quality data are available. (Edited author abstract).

Cao, Song (Univ of South Carolina, Columbia, SC, USA); Lerche, Ian; Hermanrud, Christian. *Geophysics* v 53 n 7 Jul 1988 p 979-988.

## Turbodrills

**072892 MONITORING BOTTOM-HOLE PARAMETERS DURING TURBINE DRILLING.** The results of experiments convincingly confirm the possibility of obtaining bottom-hole information by measuring the pressure of the drilling fluid in the injection line. This information may be used not only to monitor the operation of the turbodrill but also to study the characteristics of the rocks being drilled and the condition of the well shaft and the drill bit. In Russian. 3 refs.

Skoblo, V.Z.; Vasil'ev, Yu.S.; Vlasov, I.A.; Mirakyan, V.I. *Neft Khoz* n 10 Oct 1987 p 14-20.

## Vibrations

**072893 STUDY OF EXCITATION MECHANISMS AND RESONANCES INDUCING BOTTOM-HOLE-ASSEMBLY VIBRATIONS.** This paper presents a study of important excitation mechanisms and resonances that cause bottomhole assembly (BHA) vibrations during drilling operations. The study is based on dynamic vibration data gathered in a test well with our Advanced Drillingstring Analysis and Measurement System (ADAMS) surface measurement system. The data were gathered while three different BHA's were used to drill portions of this well to 800 ft [244 m]. A case study for a large-diameter hole in an actual field well is also presented. The data showed many velocity-dependent excitation mechanisms, including  $1 \times \omega$ ,  $2 \times \omega$ ,  $3 \times \omega$ , a drillstring walk mechanism, and drillstring whipping mechanisms that were dependent on the drillstring and

hole geometries. The data also show important resonances that may be excited, including resonances with strong local contributions, and axial and torsional resonances. When the excitation mechanisms match these resonances, damaging vibrations can be induced. (Edited author abstract) 15 refs.

Besaious, Amjad A. (Arco Oil & Gas Co); Payne, Mike L. *SPE Drill Eng* v 3 n 1 Mar 1988 SPE 15560, p 93-101.

## Waste Disposal

**072894 THERMAL MODELING FOR FREEZE-BACK DISPOSAL OF DRILLING WASTES ON ALASKA'S NORTH SLOPE.** Regulations pertaining to solid waste disposal have recently undergone major revision by the Alaska Department of Environmental Conservation (ADEC) and now include special provisions especially relevant to the disposal of drilling wastes. Among the various options now available to a permittee, the new regulations allow that freezeback containment is an acceptable and perhaps preferable means of disposal in certain permafrost soils. Maximum thaw depth prediction in order to ensure that wastes are buried sufficiently deep to remain frozen is felt to be important. The purpose of this paper is to examine thermal analysis methods which are currently being used, or which might be used to predict thaw depths associated with such disposal sites. The author is particularly concerned with the reason for the widely ranging values of thaw depth arrived at using the modified Berggren equation for what would otherwise appear to be similar soils in similar circumstances. 24 Refs.

Cormack, Richard. *North Eng* v 19 n 2 Summer 1987 p 16-22.

**OIL WELL LOGGING** See Also BOREHOLES—Logging; ELECTRIC NETWORKS—Analysis; OIL FIELDS—Reservoir Evaluation; OIL WELL PRODUCTION—Enhanced Recovery; OIL WELL PRODUCTION—Flooding; OIL WELLS—Corrosion Protection; OIL WELLS—Fracturing.

**072895 DECONVOLUTION OF WELL LOG DATA - AN INNOVATIONS APPROACH.** Modern filtering theory as typified by the Kalman filter has provided a general technique for the design of algorithms that process data to provide optimum estimates of quantities associated with data sets. Additionally, these algorithms make possible the recursive processing of measured data in a computationally efficient manner. Kalman filtering can be and has been applied to inverse filter or deconvolve well log data, but such attempts have met with limited success due to the practical difficulties of accurately modeling the tool output measurement data as the filtered output of a white-noise driven linear system. This paper describes an approach that retains the computational efficiency of the Kalman filter while at the same time avoiding the necessity of modeling the measured data as the filtered output of a white-noise driven linear system. An algorithm is presented which depends only on the measured data, the tool response function, and a procedure for extracting the innovations from the data. Data are processed sequentially, and the data innovations (defined as the new information contained in a measurement that was not in the previously processed data points) are recursively extracted from each data point. Examples using real data from induction, sonic and gamma-ray logs illustrate that practical and reliable deconvolution algorithms are provided using the innovations approach. (Author abstract) 9 refs.

Lyle, W.D. (Mobil Research & Development Corp); Williams, D.M. *Log Anal* v 28 n 3 May-Jun 1987 p 321-328.

**072896 SCALE MODELLING OF THE LATEROLOG USING SYNTHETIC FOCUSING METHODS.** The Laterolog tool is a focused electrode tool used in well logging for the measurement of formation resistivity. The model tool makes use of one of two alternative methods of focusing the current into the formation. One method,



manual focusing, is a manual analog to the focusing method used in the actual tool. The other method, synthetic focusing, uses the principle of superposition to analytically simulate a focusing situation. This method requires the measurement of electrode potentials for separately applied currents. Both methods are used to log a synthetic formation composed of porous concrete suspended in saline water. The logs obtained are equivalent. The synthetic method is simple to apply and avoids the potentially unstable feedback amplifier used in full scale tools. 10 refs.

Shattuck, David P. (Univ of Houston, Houston, TX, USA); Bittar, Michel S.; Shen, Liang C. *Log Anal* v 28 n 4 Jul-Aug 1987 p 357-369.

**072897 WELL LOGGING TECHNOLOGY FOR HIGHLY DEVIATED AND HORIZONTAL WELLBORES.** With the Dresser Atlas pipe-conveyed logging system for highly deviated wells, i.e., the Slant-hole Express, the logging instruments are guided to the bottom of the borehole through the protection of the drillpipe. The significant difference in the Slant-hole Express operation and conventional through-drillpipe pump-down operations is in the use of a sidetrack wireline entry-sub properly placed within the drillstring. A significant advantage of the Slant-hole Express system is that no special 'wet' electrical cable connector is required for mating to the logging instrumentation. The basic concepts, considerations, observations, and field experiences with this technology are discussed and illustrated. (Edited author abstract) 4 refs.

Fertl, Walter H. (Western Atlas Int Inc, Houston, TX, USA); Martin, John R. *J Pet Sci Eng* v 1 n 1 Aug 1987 p 83-90.

**072898 PERENNIAL CBL CENTERING PROBLEM CAN BE MINIMIZED.** The cement bond log (CBL) has been plagued by the problem of poor tool centering since it was introduced to the oil industry. Three case histories are cited to illustrate the problem. General instructions and requirements are given that can produce good-quality CBL logs when used by both the operator representative and logging engineer. The general instructions and requirements can provide guidance during job planning to insure that communication is established and the service company knows what will be required of it on the CBL run. In addition, a check list on location can provide the company representative with some memory joggers that remind him or her of critical factors relating to CBL quality. A general check list is presented. 4 refs.

Pilkington, P.E. (Conoco Inc, Houston, TX, USA). *Oil Gas J* v 85 n 48 Nov 30 1987 p 45-49.

**072899 MULTIPLE DYNAMIC MATCHING: A NEW APPROACH TO WELL LOG CORRELATION.** A new method of nonlinear correlation or matching is presented which overcomes some of the difficulties of other techniques. 'Multiple dynamic matching' is based on a constrained optimization approach but contains some important innovations. Rather than finding only one solution, the present method generates a 'function network' of probable interpretations. These are then ranked by an objective function which quantifies an interpreter's qualitative matching criteria through a similarity and simplicity measure. The top ranking matching function thus determined is used to correlate the zones which are structurally equivalent in sonic well logs, and an example of an automatic structural interpretation is given. (Author abstract) 14 refs.

Leaney, W. Scott P. (Univ of British Columbia, Vancouver, BC, Can); Ulyrch, Tad J. *Geos Exploration* v 24 n 6 Dec 1987 p 503-515.

**072900 RESERVOIR APPLICATIONS OF DIPMETER LOGS.** Reservoir quality indicators can be delivered from the analysis of high-resolution dipmeter records. Changes in the aspect of the dipmeter curves respond primarily to changes in rock texture and sedimentary structure; their analysis can be instrumental in describing the petrophysical and reservoir properties of the forma-

tions. A four-step methodology has been set up: (1) extract dipmeter curve attributes, (2) combine dipmeter-derived data with other logs, (3) compare with core data over key intervals and (4) extrapolate to other intervals and other wells. This approach is illustrated here by three examples. (Author abstract) 6 refs.

Delhomme, Jean-Pierre (Etudes et Productions Schlumberger); Pilenko, Thierry; Cheruvier, Etienne; Cull, Richard. *JPT J Pet Technol* v 40 n 2 Feb 1988 p 180-186.

**072901 DIPMETER HELPS IN SITING SUCCESSFUL WILCOX OFFSETS.** Dipmeter logs can be used to more accurately map subsurface stratigraphic traps. After drilling into a seismically defined target in far south-western Mississippi, R.E. Williams Oil and Gas Co. geologists and their logging advisors were able to site and drill six successful offset locations to a 1984 discovery in a Wilcox point bar sandstone by applying a stratigraphic dipmeter tool. Interpretation steps leading up to the drilling of each of these wells are reviewed. 4 refs.

Anon. *World Oil* v 206 n 3 Mar 1988 p 29-32.

**072902 OBTAINING STRUCTURAL AND STRATIGRAPHIC DIP INFORMATION USING SEGMENTATION TREES AND OPTIMIZATION.** A new method of dipmeter computation is described that is based on formalizing and implementing some of the rules of optical dipmeter correlation. The new techniques used for this are segmentation trees and hierarchical, multilevel optimization. Use of this method results in precise definition of dip information on both structural and stratigraphic levels. (Author abstract) 9 refs.

Kerzner, Mark G. (Walex). *SPE Form Eval* v 3 n 1 Mar 1988 SPE 15539, p 47-54.

**072903 GEOMETRICAL EFFECTS IN THE DIELECTRIC RESPONSE OF PARTIALLY SATURATED SANDSTONES.** Laboratory measurements have been made of the dielectric constant ( $k'$ ) of a tight gas sandstone as a function of water saturation ( $S_w$ ) in the frequency range of 10 kHz to 1 MHz.  $S_w$  was varied through adsorption of water vapor, imbibition, and drying. It was found that  $k'$  of a partially saturated sandstone depends on the geometrical distribution of water and gas in the pore space. The interpretation of the observed change in  $k'$  with  $S_w$  is based on the modified Maxwell-Wagner model in which platy insulating grains surrounded by conducting pore fluid act as capacitors, contributing to the total measured  $k'$ . It has been shown that in the interpretation of in situ measurements of  $k'$  a geometrical parameter is needed to account for the geometry of the grains. Results suggest that the distribution and resulting geometries of the liquid and gas in the pore space must also be accounted for. Alternatively, measurement of  $k'$  could be used to obtain information about the microgeometry of a sandstone and the contained fluid phases. (Edited author abstract) 26 refs.

Knight, Rosemary J. (Stanford Univ, Stanford, CA, USA); Nur, Amos. *Log Anal* v 28 n 6 Nov-Dec 1987 p 513-519.

**072904 TOTAL ORGANIC CARBON LOG FOR SOURCE ROCK EVALUATION.** The method for deriving total organic carbon uses log measurements of carbon: oxygen ratio and density porosity. The model partitions the formation into a solid and a pore space on the basis of density porosity and then treats the solid as minerals and the pore space as water. The environmentally-corrected carbon: oxygen ratio is multiplied by an approximation of the formation oxygen to obtain formation carbon. In formations containing carbonate minerals the inorganic carbon content is estimated and subtracted from the total carbon to provide total organic carbon. This approach is different from the current practice of using some combination of gamma ray, sonic, resistivity, neutron, and density logs to either identify or quantify organic matter in potential source beds. Its advantages are 1) it is sensitive to low amounts of organic carbon, 2) it does not require calibration with core data on either a single well or regional basis, and 3) it does not require extensive log

interpretation to produce an answer. (Edited author abstract) 16 refs.

Herron, Susan L. (Schlumberger-Doll Research, Ridgefield, CT, USA). *Log Anal* v 28 n 6 Nov-Dec 1987 p 520-527.

**072905 HOW WELL LOGS DETECT FRACTURES: PART 1 - TECHNIQUES USED IN IDENTIFICATION.** In a homogeneous formation with uniform borehole size, the detection of open fractures is relatively straightforward. The detection of sealed fractures is much more difficult and may not be possible. In view of this, the authors present two techniques: the secondary porosity index and the cementation factor. Cross plots and resistivity logs are also examined. 1 Ref.

Harvey, A. Herbert (Univ of Missouri-Rolla, Rolla, MO, USA); Honarpour, M.; Koederitz, L.F. *Pet Eng Int* v 60 n 7 Jul 1988 p 45-46, 51.

**072906 HOW WELL LOGS DETECT FRACTURE. PART 2-LOGGING TOOLS.** This work gives an overview of the well logging tools available for use in identifying fractured reservoirs. Equipment examined includes: borehole televiwer; full wave-form log; variable density log; SP log; gamma ray log; caliper log; fracture identification log; temperature log; density log; and, photoelectric density log. Several geophysical techniques are also outlined briefly. 11 Refs.

Harvey, Herbert (Univ of Missouri-Rolla, Rolla, MO, USA); Honarpour, M.; Koederitz, L.F. *Pet Eng Int* v 60 n 8 Aug 1988 4p.

**072907 COMPARISON OF CBL, RBT, AND PET LOGS IN A TEST WELL WITH INDUCED CHANNELS.** A 'logging well' has been constructed by the U.S. Environmental Protection Agency (EPA) to evaluate downhole tool response to cement channels. This test well was constructed with numerous sizes and weights of casings and has specially constructed flaws on the casing circumference to produce channels of variable lengths and widths. A detailed analysis of the ability of the CBL (Cement Bond Logs) RBT, (Ratio Bond Tool) and PET (Pulse Echo Tool) logs to detect these channels is presented. (Edited author abstract) 15 Refs.

Albert, L.E. (Gearhart Industries, USA); Standley, T.E.; Tello, L.N.; Alford, G.T. *JPT J Pet Technol* v 40 n 9 Sep 1988 p 1211-1216.

**072908 DIAGENETICAL TRANSFORMATION OF PORES AND THEIR INFLUENCE ON FLOW PROPERTIES DEPENDING ON LITHOLOGY.** We investigated logs and rock samples from the completely cored well Remlingen 5 located in south-east Lower Saxony. Different wire line logging and computing systems were run to achieve rock parameters over the whole borehole. Logging systems like Gamma-Spectrometry, Sonic and Litho-Density have been verified by laboratory investigations. Through pore size distribution and the study of pore specific internal surface, the very low permeability ( $< 10^{-5}$  mD) of these formations, in spite of their relative high porosity (approx. 10%) could be understood. (Edited author abstract) 10 refs.

Folle, S. (Technological Univ of Clausthal, Clausthal-Zellerfeld, West Ger); Khan, F.A. *Oil Gas Eur Mag* v 14 n 2 1988 p 22-25.

**072909 LOGGING CALIBRATION TECHNOLOGY AND FACILITIES.** Nuclear well-logging instrument calibration is reviewed. Both calibration equipment and concepts are discussed. Emphasis is placed on existing and needed environmental calibration facilities available



to the public. A table identifying location of facilities, operator, and type of calibration available is included with relevant comments on each. 12 refs.

Arnold, Dan M. (Walex, Houston, TX, USA); Butler, John. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 844-846.

**072910 LOGGING WITH A COILED TUBING SYSTEM.** A completion technique has been developed for highly deviated wells which uses a conductor cable placed inside coiled tubing. All conventional cased hole logging and perforating tools can be run. The advantages of this system include a shorter completion time, precise positioning of the downhole tools, the ability to maintain an even logging speed, the ability to circulate fluid while logging, and the elimination of a workover rig. This paper reviews a completion program performed on three gas wells in the Bantry Field of southern Alberta and presents details on open hole logging procedures conducted on two wells in England. Also discussed are the equipment modifications that were necessary and possible future developments of this technique. (Edited author abstract) 10 refs.

Latos, Jeff (Nowco Well Service Ltd, Can); Chenery, Dale. *J Can Pet Technol* v 27 n 2 Mar-Apr 1988, 38th Annu Tech Meet, Pet Soc CIM, Jun 1987 p 81-84.

#### Accident Prevention

**072911 RECOMMANDATIONS ESSENTIELLES DE SECURITE RELATIVES AU TRAVAIL DU PERSONNEL DES LABORATOIRES GEOLOGIQUES DE CHANTIER: PREMIERE PARTIE.** [Essential Safety Recommendations Concerning Work by Personnel in Well Site Mud Logging Units]. These recommendations concern the installation of logging units and the problems created by the diversified equipment in such units, including sensors around the site and the network of cables linking the sensors to the unit. Eight appendixes review the risks inherent in the presence of hydrogen sulfide and the conditions for using protective equipment, the problems linked to any microwave ovens that may be installed, and the problems linked to the presence of radioactive sources. Some of these recommendations are devoted to storage, handling and disposal of chemicals commonly present in such units. (Edited author abstract) In French.

Laporte, J. (Chambre Syndicale de la Recherche et de la Production du Pétrole et du Gaz Naturel); Le Caignec, J.; Mallet, A.; Matern, G.; Thierree, B.; Verdier, M.; Werbrouck, M.; Pasquier, J.; Sadoux, J. *Rev Inst Fr Pet* v 42 n 5 Sep-Oct 1987 p 555-566.

**Acoustic** See Also GEOPHYSICS—Seismic.

**072912 BOREHOLE SEISMIC PROFILES IN THE EKOFISK FIELD.** In October 1983 a major borehole seismic survey was carried out in the Ekofisk oil field in the Norwegian sector of the North Sea on behalf of the Phillips Petroleum Licence 018 group of companies. The processing of the data through to a series of conventional common-midpoint sections has permitted detailed interpretations of the top of the Ekofisk formation and the top of the Tor formation apart from well control. Both formations are producers separated by a tight zone. The Tor formation is the primary horizon to waterflood. Information as to its lateral continuity is important in the location of proposed waterflood injector wells. Prior to the survey, the field was considered effectively unfaulted. An apparent graben lying subparallel to the borehole was detected by the surveys. Reflections from below the reservoir formations are evident. A byproduct of the survey is strong evidence for the existence of lateral velocity gradients or apparent transverse velocity isotropy associated with the overlying gas-charged sediments. (Edited author abstract)

Christie, P.A.F. (E.P. Schlumberger, Clamart, Fr); Dan-gierfield, J.A. *Geophysics* v 52 n 10 Oct 1987 p 1328-1345.

#### 072913 NEW APPLICATIONS IN THE INVERSION OF ACOUSTIC FULL WAVEFORM LOGS - RELATING MODE EXCITATION TO LITHOLOGY.

Existing techniques for the quantitative interpretation of waveform data have been based on one of two fundamental approaches: (1) simultaneous identification of compressional and shear velocities; and (2) least-squares minimization of the difference between experimental waveforms and synthetic seismograms. Techniques based on the first approach do not always work, and those based on the second seem too numerically cumbersome for routine application during data processing. An alternative approach is tested here, in which synthetic waveforms are used to predict relative mode excitation in the composite waveform. Synthetic waveforms are generated for a series of lithologies ranging from hard, crystalline rocks ( $V_p=6.0$  km/sec. and Poisson's ratio=0.20) to soft, argillaceous sediments ( $V_p=1.8$  km/sec. and Poisson's ratio=0.40). The series of waveforms illustrates a continuous change within this range of rock properties. Mode energy within characteristic velocity windows is computed for each of the modes in the set of synthetic waveforms. The results indicate that there is a consistent variation in mode excitation in lithology space that can be used to construct a unique relationship between relative mode excitation and lithology. (Author abstract) 21 refs.

Pailet, F.L. (US Geological Survey, Denver, CO, USA); Cheng, C.H.; Meredith, J.A. *Log Anal* v 28 n 3 May-Jun 1987 p 307-320.

#### 072914 VELOCITY SURVEYS IN DEVIATED WELLS.

Both theory and experience indicate that vertical travel times estimated from slant times that are measured by shooting from the platform to a downhole geophone in a deviated well can be too short, potentially by more than 100 msec. A field experiment confirms this. More importantly, the data show that the error cannot easily be predicted. This uncertainty is too large for most production mapping, and so deviated well velocity surveys shot from the platform are generally not useful. 4 refs.

Goins, Neal R. (Mobil Research & Development Corp, Princeton, NJ, USA). *Oil Gas J* v 85 n 41 Oct 12 1987 p 53-56.

#### 072915 CIRCUMFERENTIAL ACOUSTIC LOG FINDS VERTICAL FRACTURES.

The basic concepts of circumferential acoustic logging are presented and an example demonstrates system application. The authors show that the circumferential acoustic log: detects presence and orientation of vertical and near-vertical fractures, microfractures, and/or stress plane zones, in uncased wellbores, provides excellent thin-bed resolution in highly stratified, laminated reservoir rocks, assisting accurate net pay determination and optimum selection of perforations, assists in multi-well field studies of natural drainage patterns and fracture trends across a reservoir, facilitates optimum selection of offset locations along major fracture trends, assists in whole core orientation via tie-in to oriented log-derived features. 2 refs.

Noblett, Bruce R. (Western Atlas Int Inc, Houston, TX, USA); Fertil, Walter H. *World Oil* v 205 n 5 Nov 1987 p 37-38.

#### 072916 FRACTURE DETECTION USING CIRCUMFERENTIAL ACOUSTIC LOGS.

The Circumferential Acoustilog (CAL) is an excellent method for determining (1) vertical or near-vertical open fracture systems which intersect a wellbore; (2) the directional, lateral, subsurface, trend of the detected fracture system; and (3) the direction of regional stress patterns. A North American field example compares potential fracture identification based on whole core analysis, conventional acoustic (sonic) log responses, and the Circumferential Acoustic log. (Author abstract) 5 refs.

Chilingarian, G. (Univ of Southern California, Los Angeles, CA, USA); Fertil, Walter H. *Energy Sources* v 9 n 3 1987 p 149-160.

#### 072917 CROSSWELL LOGGING FOR ACOUSTIC IMPEDANCE.

Crosswell seismic data are recorded by

placing the seismic source in one well and receivers in a second well to measure physical properties between the two wells. When reflected seismic energy is extracted from the recorded seismograms, the resultant picture is a function of acoustic impedance (density times velocity) between the wells. Previous crosswell seismic studies have predominantly used direct waves and measure only seismic velocities by tomographic techniques. Synthetic crosswell seismic data are generated by a computer to illustrate the concepts and procedures used for crosswell impedance logging in this study. Such synthetics are useful for investigating how the experiment should work, but real data reveal how the experiment does work. (Edited author abstract) 17 refs.

Iverson, William P. (Univ of Wyoming, WY, USA). *JPT J Pet Technol* v 40 n 1 Jan 1988 SPE 15543, p 75-82.

#### 072918 BOREHOLE TELEVIEWER IMPROVES COMPLETION RESULTS IN A PERMIAN BASIN SAN ANDRES RESERVOIR.

The borehole televiewer (BHTV) is an acoustic logging tool that has a fine vertical resolution (1/3 in. [8.5 mm]) that is extremely useful for detecting bedding orientation, thin high-permeability zones, lithology changes, and zones of secondary or vuggy porosity. BHTV logs were acquired from 10 wells during the recent infill drilling of the North Hobbs (Grayburg/-San Andres) Unit. These logs, when correlated with conventional logs and core data, have improved completion strategies, resulting in higher oil and lower water production in new infill wells. (Author abstract) 7 refs.

Clerke, E.A. (Shell Western E&P); Van Akkeren, T.J. *SPE Prod Eng* v 3 n 1 Feb 1988 SPE 15033 p 89-95.

#### 072919 LOW-FREQUENCY TUBE WAVES IN PERMEABLE ROCKS.

Low-frequency tube waves in permeable boreholes are of interest because their propagation depends upon in-situ rock permeability. In this paper, the authors use low-frequency asymptotics to unify two approaches that both describe tube waves. The first approach is due to White, in which the low-frequency tube-wave velocity and attenuation are expressed explicitly as functions of frequency. The expressions include contributions from three factors: the borehole fluid compressibility, the wall rigidity, and the wall impedance due to the permeability of the solid. The second approach is the full solution of tube-wave properties based on Biot theory and the appropriate boundary conditions between the fluid and the porous solid. By taking the low-frequency approximations to the full solution, the authors derive an explicit expression for the tube-wave properties, similar to White's expression. White's formulation is hereby corrected to include the elasticity of the solid frame around the borehole. (Edited author abstract)

Chang, S.K. (Schlumberger-Doll Research, Ridgefield, CT, USA); Liu, H.L.; Johnson, D.L. *Geophysics* v 53 n 4 Apr 1988 p 519-527.

#### 072920 FULL-WAVE SYNTHETIC ACOUSTIC LOGS IN RADIIALLY SEMIINFINITE SATURATED POROUS MEDIA.

The wave field generated by a point source in an axisymmetric fluid-filled borehole embedded in a saturated porous formation is studied in both the spectral domain and time domain. The formation is modeled following Biot theory modified in accordance with homogenization theory. When the borehole wall is permeable, guided waves can be significantly affected by the permeability of the formation. Whatever the formation, fast or slow, Stoneley-wave phase velocity and energy decrease and attenuation (in the sense of  $Q^{-1}$ ) increases with increasing permeability. These effects are more important in the very low-frequency range, where Darcy's law governs the fluid motion and the wave energy at the interface is maximum, than at higher frequencies. The effects increase and persist over a larger frequency range with decreasing viscosity and increasing compressibility of the saturant fluid, with increasing pore-fluid volume, and with decreasing borehole radius. In contrast, the effects



decrease with decreasing stiffness of the formation because of more efficient coupling of the interface wave to the surrounding medium. (Edited author abstract)

Schmitt, Denis P. (Etudes et Productions Schlumberger, Clamart, Fr); Bouchon, Michel; Bonnet, Guy. *Geophysics* v 53 n 6 Jun 1988 p 807-823.

**072921 CIRCUMFERENTIAL ACOUSTIC LOGGING.** A circumferential acoustic logging instrument that operates at a radial mode resonance of 120 kHz utilizes opposing pairs of acoustic transmitters and receivers mounted on pad assemblies, which are pressed against the borehole wall. An important feature of the instrument is a baffle system which effectively minimizes the propagation and reception of the direct fluid wave. The incorporation of the baffle allows both types of boundary waves, the Rayleigh and the guided fluid wave, to be more easily recognized. At present, the primary application of the circumferential acoustic log is in locating natural fracture systems. When run with an orientation section, the instrument is also capable of determining fracture direction. Several field examples are presented here which demonstrate the capabilities and effectiveness of circumferential acoustic logs. (Author abstract) 3 refs.

McDougall, J. (Dresser Industries Inc, Houston, TX, USA); Fertl, W.H.; Chilingarian, G.V.; Yen, T.F. *Energy Sources* v 10 n 1 1988 p 43-53.

**072922 MULTIPLE P-WAVE LOGGING IN FORMATIONS ALTERED BY DRILLING.** Wave trains produced by conventional and multipole sonic logging tools may be expected to depend upon whether the formation has been altered by the drilling process. Such alteration may include invasion by drilling fluids and/or drilling damage. It is shown, by theoretical modeling, that a dipole or quadrupole tool operating at conventional logging frequencies (in the range 10-20 kHz) detects P waves from the virgin formation with a much higher signal-to-noise ratio than does a monopole tool. This permits the multipole tool to measure formation P-wave velocities two to three times farther away from the borehole than a conventional monopole tool. This large radius of investigation typically extends beyond the altered zone for most situations, even for sources and receivers spaced several meters apart. However, this conclusion is valid only if the velocity of the altered zone is less than the velocity of the virgin formation. (Edited author abstract). 22 refs.

Baker, L.J. (Exxon Production Research Co, Houston, TX, USA); Winbow, G.A. *Geophysics* v 53 n 9 Sep 1988 p 1207-1218.

**072923 PHYSICAL MODELING OF THE FULL ACOUSTIC WAVEFORM IN A FRACTURED, FLUID-FILLED BOREHOLE.** Three concrete models were constructed, one each with a fracture oriented at 90, 45, and 10 degrees to the axis of the borehole. These were used to simulate physically the propagation of the full acoustic waveform through a fluid-filled borehole in crystalline rock and to ascertain the effects of fracture aperture and orientation of fluid-filled fractures on the waveform. The tube-wave mode of the waveform is most indicative of the magnitude of fracture aperture. Normalized tube-wave amplitude decreased as a negative exponential function of aperture over the range of fracture apertures studied (closed to 0.66 cm). The 90 degree fracture orientation caused greater tube-wave amplitude reduction than the 45 degree fracture. It is suggested that this reduction can be attributed to the borehole walls guiding the wave across the 45 degree fracture. However, the 10 degree model gave ambiguous results, which are believed to be related to the low ratio of tube-wave wavelength to aperture as measured parallel to the borehole axis, i.e., axial aperture. (Edited author abstract). 8 refs.

Zlatev, Petko (Colorado Sch of Mines, Golden, CO, USA); Poeter, Eileen; Higgins, Jerry. *Geophysics* v 53 n 9 Sep 1988 p 1219-1224.

**072924 ROBUST AND LEAST-SQUARES ESTI-**

**MATION OF ACOUSTIC ATTENUATION FROM WELL-LOG DATA.** Several least-squares attenuation (Q) estimation algorithms are tested on various types of models. These algorithms include the spectral ratio method and methods based upon eigenvector decomposition and Wiener filtering, all of which are unsatisfactory. Hence more robust methods are needed. The errors in Q estimation have an asymptotically Cauchy distribution, with a reasonable noise model and Gaussian input noise. On noise models with Gaussian errors slightly contaminated by Cauchy or Laplacian noise, a maximum-likelihood (ML) estimator based on Gaussian noise performed best. On heavily contaminated models, the ML estimator based on Laplacian noise performed best; but simple, robust estimators such as the median also did well. On more realistic models with noise, the median and alpha-trimmed mean appear to be the best. (Edited author abstract). 15 refs.

Patton, Steven W. (Univ of Oklahoma, Norman, OK, USA). *Geophysics* v 53 n 9 Sep 1988 p 1225-1232.

**072925 IMPROVED INTERFACE DETECTION FOR VERTICAL SEISMIC PROFILE INVERSION.** For VSP inversion prior knowledge of the wavelet obtained from the downgoing wave field is used to locate and constrain the number of interfaces used in the forward model. Grivelet (1985) presented an algorithm to do this constraining based on the extremum in the crosscorrelation of the estimated wavelet and trace. In this paper, an improved detection algorithm is presented which looks at three extrema in the crosscorrelation and then looks one step ahead seeking to minimize trace energy. The procedure can be generalized to looking at more extrema and increasing the depth of the decision-tree search. 3 refs.

Dillon, William G. (Standard Oil Production Co, Dallas, TX, USA); Spencer, Terry W. *Geophysics* v 53 n 9 Sep 1988 p 1244-1247.

**072926 EVALUATION OF FORMATION PROPERTIES FROM PROCESSING AND INTERPRETATION OF THE EVA TOOL LOGS.** A new tool, EVA (Evaluation of Velocity and Attenuation), is a 4-transmitter/12-receiver long spacing tool permitting recording of the complete waveform and processing of all information contained in the acoustic signal. The key point for optimum results is a robust and automatic processing which allows quantitative estimation of different parameters such as velocity, amplitude, and period of all the three main types of waves, i.e. compressional (P), shear (S), and Stoneley (ST) waves. In parallel with the processing phase, the analysis of the raw data leads to a qualitative and very rapid interpretation of the recordings. Once the processing is completed and all parameters obtained, these may be applied to a quantitative interpretation of the EVA data. (Edited author abstract) 4 refs.

Arditty, P.C. (Elf Aquitaine-Operation EVA, Paris-La Defense, Fr); Mathieu, F.; Staron, P. *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 187-191.

## Bibliographies

**072927 GEOLOGICAL APPLICATIONS OF WELL LOGS. AN INTRODUCTORY BIBLIOGRAPHY AND SURVEY OF THE WELL LOGGING LITERATURE, ARRANGED BY SUBJECT, UPDATE, OCTOBER 1986 THROUGH OCTOBER 1987.** This update includes new publications for the period October 1986-October 1987 as well as earlier publications of interest that were omitted from the original due either to oversight or because they had not been received in sufficient time for inclusion. Part A covers basic well logging. Part B covers geological applications. 745 refs.

Premsky, Stephen E. (US Geological Survey, Denver, CO, USA). *Log Anal* v 28 n 6 Nov-Dec 1987 p 558-575.

## Computer Aided Analysis

**072928 LOG ANALYSIS METHODS AND EMPIRICAL DERIVATION OF NET PAY PARAMETERS**

**FOR CARBONATE RESERVOIRS IN THE EASTERN MONTANA PART OF THE WILLISTON BASIN.** The purpose of this petrophysical study is the refinement of previously developed log analysis methods and the determination of empirically derived net pay parameters which can be used by the log analyst in exploration, property enhancement, and acquisition studies. Twenty-one wells were selected in the study area for evaluation based on the availability of 'modern' log suites, multiplicity of tests, and geographic distribution. Significant untested pay potential is indicated in many of the wells evaluated. Most of the untested pay potential is in the Ratcliffe, Mission Canyon, Nisku, Duperow, Winnipegosis, and Interlake formations. The application of these log analysis methods and net pay parameters should improve success rates for those projects in which log analysis is critical. (Edited author abstract) 7 refs.

Teti, M.J. (Yellowstone Associates, Park City, MT, USA); Krug, J.A. *Log Anal* v 28 n 3 May-Jun 1987 p 259-281.

## Computer Simulation

**072929 NEW HIGH-SPEED HYBRID TECHNIQUE FOR SIMULATION AND INVERSION OF RESISTIVITY LOGS.** The inversion of resistivity logs with multiple bed boundaries is of vital interest to log analysts, but previously published methods have been optimized for cases of many radial boundaries with a serious loss of speed when many bed boundaries are considered. This paper describes a hybrid solution (analytic radially and numeric vertically) that can simulate a 100-ft [30.4-m] log with 25 beds in less than 12 minutes on an IBM 3081. The model assumes axial symmetry with no dip and with the tool centered in the borehole. Decomposition of the measured potential into the product of two independent functions describing its radial and axial dependence allows us to choose the best method for evaluating each function. (Edited author abstract) 7 refs.

Gianzero, Stan (Gearhart Industries Inc); Lin, Yih-yih; Su, Shey-Min. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 14189, p 55-61.

**Electric** See Also OIL WELL DRILLING—Blowout Prevention; OIL WELL DRILLING—Exploratory.

**072930 FORMATION IMAGING WITH MICRO-ELECTRICAL SCANNING ARRAYS.** A new Formation MicroScanner Tool (FMS) has been developed for obtaining two-dimensional, high-resolution imagery of microresistivity variations around the borehole wall. The measurement concept is an extension of our dipmeter technology; the imaging capability arises through the use of an array of electrodes distributed azimuthally on a conducting pad. The imaging resolution is on the order of a few millimeters in both vertical and azimuthal directions, thereby allowing core-like characterizations for applications such as stratigraphic analysis, facies identification, fracture and fault description, recognition of zones of secondary porosity, and improved petrophysical modeling of clay distribution (laminated versus dispersed shales). World-wide testing of the tool has confirmed that the measurement is robust, repeatable, and of high quality. Comparison of its electrical imagery with physical cores has been striking. (Edited author abstract) 8 refs.

Ekstrom, M.P. (Schlumberger-Doll Research, Ridgefield, CT, USA); Dahan, C.A.; Chen, M.Y.; Lloyd, P.M.; Rossi, D.J. *Log Anal* v 28 n 3 May-Jun 1987 p 294-306.

**072931 COMPLEX DIELECTRIC INTERPRETATION OF 20-MHz ELECTROMAGNETIC LOGS.** An interpretation technique for the  $20 \times 10^6$ -cycle/sec [20-MHz] dielectric log based on the complex Lichteneker-Rother (LR) equation is proposed. The equation is shown to be an adequate model of quarry rocks and is applied to field logs from the California coastal basins. The results are significantly better than those obtained



with other techniques. The major disadvantage is that core data are required for calibration in each reservoir. (Author abstract) 8 refs.

Sims, J.C. (Texaco); Cox, P.T.; Simpson, R.S. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 15486, p 24-28.

## Electromagnetic

**072932 ANALYTIC MODEL FOR ELECTROMAGNETIC WIRELINE TOOLS.** A mathematical model for electromagnetic tools is presented that accounts for the finite size of the transmitter and receiver coils, tool mandrel, a shielding conductor internal to the tool, and the concentrically stratified media surrounding the tool. The model is applied to various tools in the  $20 \times 10^3$  to  $1 \times 10^9$  cycle/sec [20-kHz to 1-GHz] frequency range, and results indicate that this model will be useful in designing future tools. (Author abstract) 8 refs.

Durgapal, Prabha (Welex). *SPE Form Eval* v 3 n 1 Mar 1988 SPE 14190, p 17-23.

**072933 MODELING OF THE DIELECTRIC LOGGING TOOL AT HIGH FREQUENCIES: THEORY.** The high-frequency dielectric logging tool is analyzed, using first-principle electromagnetic field analysis, to determine characteristics such as tool behavior during measurement in a well logging environment. The theoretical model, a composite boundary value problem, consists of a source backed by an infinite ground plane (the measurement tool) in front of a two-dimensional inhomogeneity (geologic formation) which is divided into regions. The solution in each region is treated analytically in two dimensions, and numerically in one dimension. The one-dimensional problem is solved using the finite-element method, resulting in a conventional eigenvalue problem. This allows the eigenmodes of each region to be found systematically. Once the eigenmodes are found in each region, the solution for the two-dimensional inhomogeneity is obtained by matching boundary conditions at a discontinuity as in the method of mode matching. This gives the reflection and transmission operators characterizing each discontinuity. When the reflection and transmission operators for a single discontinuity are known, the case of more than one discontinuity can be derived. 10 refs.

Chew, Weng Cho (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA). *IEEE Trans Geosci Remote Sens* v 26 n 4 Jul 1988 p 382-387.

**072934 MODELING OF THE DIELECTRIC LOGGING TOOL AT HIGH FREQUENCIES: APPLICATIONS AND RESULTS.** The high-frequency dielectric logging tool is useful in electromagnetic well logging, because, by measuring the dielectric constants of rock formations at high frequencies (1 GHz), the water saturation of rocks can be inferred without knowing the water salinity in the rocks. The results of a theoretical model presented in a previous paper by the author are reported. Use is made of the theoretical model to study the behavior of such a tool across geological sedimentary beds. The effect of using different polarizations on the measurement is considered, along with the standoff and mudcake effects that reflect on the depth of investigation of such a tool. The use of borehole compensation modes in the measurements is also considered. It has been found that the TE polarization is more robust than the TM polarization in terms of mudcake and standoff effects. Also, the standoff effect affects the measurement more severely than the mudcake effect. Shorter receiver spacings give rise to higher resolution in the measurement. Borehole compensation results in a slight loss of resolution, and horns in the logs are removed. 15 refs.

Chew, Weng Cho (Univ of Illinois at Urbana-Champaign, IL, USA). *IEEE Trans Geosci Remote Sens* v 26 n 4 Jul 1988 p 388-398.

## Equipment

**072935 SATELLITE TECHNOLOGY APPLIED AT THE WELL SITE.** The overall system consists of two subnetworks. A well site-to-hub subnetwork consists of

the link from the well site to a large receiving station, the hub, near Denver, Colo. At the well site, a small 4-ft (1.2-m) Ku band transmitter antenna transmits a fairly weak signal via the satellite to the large 30-ft (9-m) receiving antenna at the hub. Once at the hub, the data then is automatically transcribed into a format (either a graphics playback or digital data) and is transmitted via telephone lines to the operator's receiving terminal. The well site unit consists of a 4-ft (1.2-m) transmit-receive antenna and an electronics module which fits in the logging truck. The well site antenna is transportable, consisting of five pieces and can be easily assembled or disassembled in 10 to 15 minutes. Once assembled, the antenna elevation and azimuth are calculated by the software in the logging truck for properly aiming the antenna to acquire synchronization with the satellite. The well site unit can transmit data at various speeds with a maximum of 496 Kbs, providing fast transfer of data from the well site to the hub or to the data center.

Linger, Daniel B. (Forest Oil Corp); Dill, Paul H. *Pet Eng Int* v 60 n 1 Jan 1988 p 32, 34-35.

**072936 COILED-TUBING LOGGING SYSTEM.** Techniques have been developed to use coiled tubing containing a seven-conductor wireline to facilitate logging operations. Equipment has been designed to permit the connection of conventional logging tools to the tubing and the recording of logs. Operating techniques have been developed and applied under various wellbore conditions. The system allows traditional log measurements in a well while wellbore conditions are controlled. The ability of coiled tubing to push tools down highly deviated or horizontal wellbores makes logging or perforating feasible in these wells. Expenses can often be reduced with coiled-tubing logging because a rig is unnecessary during many operations. (Edited author abstract) 4 refs.

Howell, E.P. (Arco Oil & Gas Co); Smith, L.J.; Blount, C.G. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 15489, p 37-39.

**072937 TEST OF A HIGH-RESOLUTION SPECTROSCOPY LOGGING TOOL TO MEASURE CHLORINE IN A LOW-SALINITY RESERVOIR.** A series of tests was conducted to evaluate the usefulness of neutron-induced gamma spectra recorded by a detector cooled to the temperature of liquid nitrogen. These tests were conducted in an oil well that had been evaluated with core and other logging techniques. Results showed that measurements of carbon abundance were not accurate enough to enable useful estimates of oil abundance, but measurements of chlorine abundance could be used to estimate brine saturation if data were accumulated long enough. The commercial logging equipment tested consisted of two different tools that combined a high-resolution detector with both chemical and 14-MeV pulsed neutron sources. Methods were developed to process and display the 4,000-channel spectra recorded. (Edited author abstract) 17 refs.

Neuman, C.H. (Chevron Oil Field Research Co). *SPE Form Eval* v 3 n 1 Mar 1988 SPE 15438, p 40-46.

**072938 BOREHOLE CORRECTION MODEL FOR CAPTURE GAMMA RAY SPECTROSCOPY LOGGING TOOLS.** A borehole correction model, based on more than 1,000 laboratory measurements, has been developed for logging tools that measure gamma ray energy spectra induced by the capture of thermal-energy neutrons. The measurements were made with a field-worthy tool incorporating a pulsed source of 14-MeV neutrons and a NaI(Tl) gamma ray detector. In addition to the obvious geometric dependencies on borehole and casing sizes, the sensitivity of the measurement to elements within the borehole was found to depend just as strongly on the porosity and salinity of the borehole and formation fluids. The model decouples the geometric effects from most of the nuclear physics effects by explicitly including the time decay of the neutron flux in each homogeneous region. (Author abstract) 8 refs.

Grau, James A. (Schlumberger-Doll Research); Roscoe, Bradley A.; Tabanou, Jacques R. *SPE Form Eval* v 3 n

1 Mar 1988 SPE 14462, p 62-68.

## Induction

**072939 CHARTS FOR CORRECTING EFFECTS OF FORMATION DIP AND HOLE DEVIATION ON INDUCTION LOGS.** Computer-simulated deep induction logs show that the apparent resistivity at the center of a dipping bed is affected by the dip of the bed. Generally the apparent resistivity decreases with dip angle. It is not unusual to find that the apparent resistivity decreases by a factor of two or more when the dip angle is varied from 0 to 60 degrees for thin beds. To obtain the true resistivity a correction is needed. Such quantitative correction is available in the form of correction charts. Charts for dip angles of 5, 30, 45, and 60 degrees for shoulder bed resistivities of 1 and 10 ohm-m are presented. (Edited author abstract) 6 refs.

Hardman, R.H. (Univ of Houston, Houston, TX, USA); Shen, L.C. *Log Anal* v 28 n 4 Jul-Aug 1987 p 349-356.

**072940 EFFECT OF DIPPING BEDS ON THE RESPONSE OF INDUCTION TOOLS.** This paper describes a computer model for studying the effect of dipping beds on the response of induction tools. Simulated tool response in an arbitrary number of dipping beds is obtained from calculations of the magnetic fields of an equivalent magnetic dipole with an axis arbitrarily oriented with respect to the direction of stratification. The effects of the borehole and the invaded zone are neglected to solve the problem in a closed form. In addition to describing the model, we also study the effect of dip angle on the apparent resistivity and the apparent bed thickness as read by induction tools in several typical logging configurations. (Author abstract) 9 refs.

Anderson, Barbara (Schlumberger Doll Research); Ali Safinya, Kambiz; Habashy, Tarek. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 15488, p 29-36.

Instruments See Also BOREHOLES—Logging.

**072941 INTERPRETING AN RFT-MEASURED PULSE TEST WITH A THREE-DIMENSIONAL SIMULATOR.** An interpretation procedure has been developed to analyze repeat formation tester (RFT) pressure surveys quantitatively during well-to-well interference tests with a three-dimensional (3D) simulator in which only the pressure equation is solved, while retaining saturation effects on fluid viscosity and relative permeability. This approach accurately and efficiently determines location and transmissibility of faults, horizontal permeability of production zones, and vertical permeability of barriers over length scales comparable to reservoir dimensions. (Author abstract) 7 refs.

Lasseter, T. (Schlumberger-Doll Research); Karakas, M.; Schweitzer, J. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 14878, p 139-146.

Mud See OIL WELL DRILLING—Core.

Neutron See Also BOREHOLES—Logging; GEOPHYSICS—Radioactive Methods; OIL FIELDS—Formations; POROSIMETERS; SCINTILLATION COUNTERS—High Temperature Effects.

**072942 NEW DIGITAL MULTISCALE PULSED NEUTRON LOGGING SYSTEM.** A new multiscale pulsed neutron capture logging system (PDK-100) is discussed. The instrument is a 1 11/16-in. [1.7-cm]-diameter, microprocessor-controlled logging sonde that processes raw data occurring in the short- and long-spaced detectors. The timing spectrum (10  $\mu$ sec per channel and 100 channels for the decay component) of the detector events is accumulated downhole and transmitted to the surface computer logging system upon command by a pulse code modulation data transmission system. This configuration makes use of significantly increased count rates to improve log repeatability greatly. Unique data reduction techniques are also possible with the high-reso-



lution data. The gamma rays during the burst of 14-MeV neutrons are also processed. This unique feature allows derivation of the ratio of inelastic to capture count rates, which is a function of porosity. (Edited author abstract) 8 refs.

Randall, R.R. (Dresser Industries Inc); Gray, T.P.; Craik, G.C.; Hopkinson, E.C. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 14461, p 395-400.

**072943 RESERVOIR MONITORING WITH THE THERMAL MULTIGATE DECAY LOG.** The thermal multigate decay (TMD) logging system, which uses a two-exponential model to isolate borehole and formation  $\Sigma$  effects, can be an effective device for the high-accuracy environment of monitor logging. The minimized influence of borehole parameters on the formation sigma ( $\Sigma^{CORR}_{FM}$ ) results in residual oil saturation (ROS) calculations that compare favorably with expected values. The measurement of borehole parameters enables the user to determine whether proper formation flushing has been achieved and whether borehole fluid contamination of perforated intervals presents a potential interpretation problem. Test pit data and field results indicate that the use of flushing salinities less than approximately 70,000 ppm NaCl can result in significant borehole effects to the observed formation decay rates. (Edited author abstract) 13 refs.

Wyatt, D.F. Jr. (Welex); Smith, H.D. Jr. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 14137, p 401-411.

**072944 MDW GAINS AS FORMATION-EVALUATION TOOL.** A comparison of measuring while drilling (MWD) and wire line methods as alternatives for formation evaluation is now pertinent. The recent addition of neutron porosity and formation density logs to the MWD logging suite has significantly advanced it as a tool for quantitative formation evaluation. Though wire line measurements are far from obsolete, their replacement by MWD is becoming more common, particularly in high-angle holes. This is the second article in a series of MWD. Some topics discussed are these: downhole environment, natural gamma radiation, formation resistivity, neutron porosity, formation density, the bit as a sensor, and MWD applications (thinly bedded pay, time lapse logging, and high angle wells. 25 refs

Vikram Rao, M. (NL Drilling Services, Houston, TX, USA); Fontenot, John E. *Oil Gas J* v 86 n 6 Feb 8 1988 p 44-48.

**072945 ACCELERATOR-BASED COMPENSATED EPITHERMAL NEUTRON POROSITY TOOL.** It is generally considered that a neutron porosity measurement made with 14 MeV neutrons will be inferior to one made with 4 MeV neutrons. This paper demonstrates that the conclusion is invalid. The response characteristics of a new tool are presented as are the results of field tests. The effects of changes in borehole size, standoff and lithology are similar to those for conventional thermal neutron porosity tools (for example, the CNT-K. The statistical uncertainty in the porosity estimate is as good as that of the CNT-K at medium porosities if a  $4 \times 10^8$  n/sec. source is used and smaller than the CNT-K at low porosities. Log examples show that the accelerator-based epithermal porosity estimate is generally close to that of the sidewall epithermal tools (for example, the SNL) and lower than that of the CNT-K. (Edited author abstract) 5 refs.

Gartner, M.L. (Gearhart Industries Inc, Austin, TX, USA); Schnoor, C.; Sinclair, P. *Log Anal* v 28 n 6 Nov-Dec 1987 p 528-537.

**072946 IMPROVED ENVIRONMENTAL CORRECTIONS FOR COMPENSATED NEUTRON LOGS.** The basic openhole responses and environmental correction algorithms for compensated neutron logging (CNL) tools have been updated. The improved processing is based on an extensive set of laboratory formation measurements to which mathematical modeling calculations have been added. In all, the new algorithms include basic responses for the three principal formation matrix

types and corrections for seven environmental effects and formation-fluid salinity. A total of 467 laboratory formation measurements have been augmented with 245 data points generated through mathematical modeling. This data base has been used to define more accurately the effects on the tool response of variations in logging conditions from those considered standard in the laboratory. (Edited author abstract). 11 Refs.

Galford, J.E. (Schlumberger Well Services, Sugar Land, TX, USA); Flaum, C.; Gilchrist, W.A. Jr.; Soran, P.D.; Gardner, J.S. *SPE Form Eval* v 3 n 2 Jun 1988 p 371-376.

**072947 DUAL-BURST THERMAL DECAY TIME LOGGING PRINCIPLES.** The dual-burst thermal-neutron-decay-time (TDT<sup>TM</sup>) tool brings two enhancements to pulsed-neutron capture logging. The first is a realistic physical model of pulsed neutron decay curves that accounts explicitly for the effects of neutron diffusion and decay in both the wellbore and the formation. The second is the dual-burst system itself, which permits excellent statistical precision with minimal dead-time losses. This paper discusses the physics of the model, operation of the tool, important mathematical considerations for optimum use of the tool, and a demonstration of the tool performance in a laboratory simulation of a log-inject-log (LIL) operation. (Author abstract). 11 Refs.

Steinman, D.K. (Schlumberger Well Services); Adolph, R.A.; Mahdavi, M.; Preeg, W.E. *SPE Form Eval* v 3 n 2 Jun 1988 p 377-385.

**072948 MACROSCOPIC THERMAL NEUTRON CAPTURE CROSS SECTION MEASUREMENTS.** The macroscopic thermal neutron-capture cross-section measurement in cased-well bores is discussed. The physical parameter measured is the formation capture cross section which is related to the type of fluid saturating the pore space. This measurement distinguishes between gas and water, gas and oil, and oil and water provided the water is saline. The physics of the measurement and the historical development of the instrumentation are reviewed. Important instrumentation elements are examined. The reasons for the limitation of the measurement to saline connate-water environments of modest to high porosity and simple lithology are listed and quantified. Current hardware and software developments that aim at more-sophisticated data acquisition and reduction are examined in detail. Other important applications such as production monitoring and enhanced-oil-recovery prospects are briefly discussed. 7 refs.

Jacobson, Larry A. (Gearhart Industries Inc, Austin, TX, USA). *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 817-821.

**072949 NEUTRON POROSITY MEASUREMENT WHILE DRILLING.** A measurement-while-drilling (MWD) neutron porosity tool has been designed that is superior to wireline porosity tools in several respects. Longer sample periods and greater porosity sensitivity reduce the statistical uncertainty in the MWD porosity measurement. Most of the borehole effects that perturb the measurement (salinity, mud weight, and borehole size) are reduced or nonexistent because the drill stem virtually fills the hole during drilling. Formation effects, lithology, and salinity changes, are comparable to or less than those for the wireline measurement. A sophisticated computer model was used to develop the initial design for this instrument and to estimate its response characteristics. Simulated response data are compared with experimental data to demonstrate the validity of the model. The response characteristics are superior to those of the wireline device. 4 refs.

Gartner, Michael L. (Gearhart Industries Inc, Austin, TX, USA). *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 839-843.

**072950 He<sup>3</sup> NEUTRON DETECTORS FOR HOSTILE ENVIRONMENTS.** The He<sup>3</sup> proportional counter is widely used for neutron detection in nuclear well-log-

ging tools, where high levels of thermal and mechanical stress are routine. The capabilities of these devices are summarized, and the chief mechanisms related to stable operation in the logging-tool environment are examined to provide some practical guidance to tool designers and users. The discussion covers charge output, He<sup>3</sup> proportional counter spectra, thermal neutron sensitivity, gamma sensitivity, temperature effects, and spurious signals. The use of integral decoupling networks is briefly considered. 3 refs.

Gjesius, Frederick (GE, Twinsburg, OH, USA); Kniss, Timothy. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 867-871.

**072951 SPECIFIC PURPOSE MONTE CARLO MODELLING OF NUCLEAR WELL LOGGING TOOL RESPONSES.** Statistical estimation and direction biasing combined with path-length stretching have been incorporated in special-purpose Monte Carlo codes for modeling pulsed-neutron and dual-spaced neutron well-logging-tool responses. Experimental test-pit results have been simulated with these codes, indicating that they are accurate. The codes are run on a DEC Microvax II computer in very reasonable CPU times and are easy to use. It is estimated that further optimization of the biasing parameters, inclusion of correlated sampling, and other improvements will yield computer codes that are about an order of magnitude faster than the present general-purpose codes. 13 refs.

Gardner, R.P. (North Carolina State Univ, NC, USA); Verghese, K.; Choi, H.K.; Mickael, M. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 882-887.

**072952 APPLICATIONS OF THERMAL MULTIGATE DECAY PULSED NEUTRON LOGS IN UNUSUAL DOWNHOLE LOGGING ENVIRONMENTS.** The Thermal Multigate Decay (TMD) logging system utilizes a pulsed 14 Mev generator and two gamma ray detectors to obtain measurements of the capture cross sections of downhole formations. The composite decay curve from both formation and borehole capture gamma rays is detected, and is separated into the two individual components: sigma formation and sigma borehole. The resulting sigma formation measurement is only minimally affected by borehole conditions, especially in cased wells. The paper briefly reviews the TMD logging system and concentrates on log examples in unusual borehole conditions. (Edited author abstract) 8 refs.

Ajam, Sami O. (Halliburton Ltd, Jakarta, Indones); Rahal, V.E. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 265-274.

**Nuclear** See Also BOREHOLES—Logging; GAMMA RAYS—Detection; GAMMA RAYS—Measurements.

**072953 NML - THE HOPE FOR PRODUCTION PREDICTION.** The nuclear magnetism log (NML) has recently been upgraded to a workable and reasonably trouble-free service. The most important parameter measured by the NML is the free-fluid index (FFI). The initial magnetization of the formation is a function of the number of aligned protons. The FFI can be of great value in estimating the potential productivity of reservoir rocks. It will be of particular value in cases where there are apparent dual-porosity systems with part of the porosity being microporosity that is saturated with immovable water. The FFI of the NML offers a way to determine whether the water saturation calculated from conventional well logs is truly irreducible or higher than irreducible water saturation. In practical terms, it presents a way to determine the productivity of the sandstone reservoirs with well logs. 4 refs.

Hilchie, Douglas W. (Douglas W. Hilchie Inc.). *JPT J Pet Technol* v 40 n 3 Mar 1988 SPE 17092, p 273-275.



**072954 STATISTICAL PRECISION OF NEUTRON-INDUCED GAMMA RAY SPECTROSCOPY MEASUREMENTS.** The statistics of neutron-induced gamma ray measurements performed in the borehole environment are affected by parameters such as borehole size and salinity, formation sigma, neutron-burst timing, and casing. By understanding how these parameters affect the statistical uncertainty, logging conditions can sometimes be optimized to produce better results. For example, the statistical uncertainty of the inelastic carbon-to-oxygen ratio is affected by the salinity in the borehole because of the increased capture background that is associated with the chlorine. The value of the carbon-to-oxygen ratio is not affected; only the precision to which it is determined is. For the capture measurement, the various parameters affect the partitioning of the signal coming from the borehole versus the formation; thus, the statistical uncertainty of the interpretation model is affected by the magnitude of borehole correction required. This paper shows how the statistics in the borehole spectroscopic measurement are propagated and how these statistics affect the interpretation models. (Author abstract) 16 refs.

Roscoe, B.A. (Schlumberger Well Services, Houston, TX, USA); Grau, J.A.; Wraight, P.D. *Log Anal* v 28 n 6 Nov-Dec 1987 p 538-545.

**072955 TOTAL ORGANIC CARBON CONTENT DETERMINED FROM WELL LOGS.** Total organic-carbon (TOC) content present in potential source rocks significantly affects the response of various well logs. This paper discusses and illustrates well-log anomalies caused by TOC as observed on various wireline measurements, including resistivity (or conductivity), acoustic, nuclear (density and neutron), gamma ray, natural gamma ray spectra, and pulsed neutron [sigma and carbon/oxygen (C/O) ratio]. Field examples of these well-log responses in open and/or closed wellbores are presented from several counties. Several correlations between TOC and individual and/or combinations of various logging responses are also reviewed. (Author abstract) 27 Refs.

Fertl, Walter H. (Atlas Wireline Services, Houston, TX, USA); Chilingar, George V. *SPE Form Eval* v 3 n 2 Jun 1988 p 407-419.

**072956 NUCLEAR MODELING TECHNIQUES AND NUCLEAR DATA.** A review of radiation transport techniques, useful in modeling nuclear oil-well logging applications, is presented. These techniques include deterministic and stochastic methods, in addition to sophisticated nuclear databases. Mathematical modeling minimizes design and experiment time and provides information on sensor design, environmental effects, and interpretation questions. Monte Carlo techniques provide energy, time, and spatial information to permit signal partitioning and sensitivity analysis in complex geometries and environments. Three examples of nuclear modeling are given. 49 refs.

Soran, Patrick D. (Lawrence Livermore Natl Lab, Livermore, CA, USA). *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 847-851.

**072957 HIGH TEMPERATURE ELECTRONICS APPLICATION IN WELL LOGGING.** Overall system requirements for high-temperature applications are examined. The current capabilities of each element in a well-logging system are summarized, and persistent problems and directions for future solutions are suggested. The characteristics of the electronic components (active and passive devices, interconnections) used are discussed. Dewatered systems and calibration are considered. 10 refs.

Traeger, R.K. (Sandia Natl Lab, Albuquerque, NM, USA); Lysne, P.C. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 852-854.

**OIL WELL PRODUCTION** See Also OIL FIELDS—Field Development; OIL FIELDS—United Kingdom; OIL WELL DRILLING; OIL WELL LOGGING—Computer Aided Analysis; OIL WELLS—Hydraulic Fracturing; PETROLEUM CRUDE—Processing; PETROLEUM ENGINEERING; PETROLEUM RESERVOIR ENGINEERING.

**072958 ELEMENTE DE CALCUL PRIVIND EFECTELE REALIZATE PRIN INSTALAREA FILTRELOR METALICE SIMPLE IN SONDA IN DREPTUL STRATULUI PRODUCTIV.** [Calculation Elements Regarding the Effects Obtained by Installing Simple Metallic Filters in Wells in the Protective Bed]. Calculation examples are presented regarding the size of the openings in metallic filters with slots and orifices, an evaluation of the factors of the pseudo-skin effect and an estimation of the elements characterizing the modifications taking place in the bed-well system, following the presence of a sand filter in the well. On the basis corresponding conclusions are drawn, applicable in the examined cases, as well as generally applicable ones. (Edited author abstract) 2 refs. In Romanian.

Tocan, I. (Inst de Petrol si Gaze Ploiesti, Rom). *Mine Pet Gaze* v 38 n 5 May 1987 p 229-234.

**072959 OIL RECOVERY IN A LOW-PERMEABILITY, WAVE-DOMINATED, CRETACEOUS, DELTAIC RESERVOIR, BIG WELLS (SAN MIGUEL) FIELD, SOUTH TEXAS.** The Upper Cretaceous Big Wells (San Miguel) reservoir in Dimmit and Zavala Counties, south Texas, produces from a broadly lenticular, wave-dominated deltaic sandstone encased in prodelta and shelf mudstones. The reservoir is subdivided into an upper, nonproductive, transgressive shelf sandstone and a lower, productive, but intensely bioturbated, deltaic sandstone. The northward transition from thicker and cleaner sandstones of the beach-ridge plain to argillaceous sandstones within and adjacent to the distributary system strongly affects oil recovery from the field. Reservoir, permeability and induced-fracture half-lengths decrease dramatically to the north. Consequently, well performance peaks in the beach-plain sediments and decreases northward and updip and downdip into adjacent mudrier sediments. Recovery efficiencies of the original oil in place average 50% in the southern half of the pool and drop to 20-30% in the north. Additional aspects of the subject are discussed. (Edited author abstract) 23 refs.

Tyler, Noel; Gholston, J. Crispin; Ambrose, W.A. *AAPG Bull* v 71 n 10 Oct 1987 p 1171-1195.

**072960 PREDICTING LIQUID GRADIENT IN A PUMPING-WELL ANNULUS.** This work proposes a hydrodynamic model for estimating gas void fraction,  $f_g$ , in the bubbly and slug flow regimes. The model is developed from experimental work, involving an air/water system, and from theoretical arguments. The proposed model suggests that prediction of  $f_g$ , and hence the bottomhole pressure (BHP), is dependent on such variables as tubing-to-casing-diameter ratio, densities of gas and liquid, and surface tension. Available correlations do not include these variables as flexible inputs for a given system. Computation on a field example indicates that slug flow is the most dominant flow mechanism near the top of liquid column at the earliest times of a buildup test. As buildup progresses, transition from slug to bubbly flow occurs in the entire liquid column. (Edited author abstract) 40 refs.

Hasan, A. Rashid (Univ of North Dakota, ND, USA); Kabir, C. Shah; Rahman, Rehana. *SPE Prod Eng* v 3 n 1 Feb 1988 SPE 13638 p 113-120.

**072961 THEORETICAL AND EXPERIMENTAL ANALYSIS OF MINIPERMEAMETER RESPONSE INCLUDING GAS SLIPPAGE AND HIGH VELOCITY FLOW EFFECTS.** This study introduces a geometrical factor which when substituted into a modified form of Darcy's law allows the computation of permeability from steady-state measurements of gas flow rate and injection pressure. This geometrical factor ( $G_p$ ), a function of injection tip-seal size and sample dimensions, is given for two basic flow geometries: (1) half-space flow as encountered

in outcrop measurements and (2) unconfined core plug flow for measurements taken on samples not held in a conventional Hassler sleeve device. Examination of  $G_p$ -factors for both flow patterns can estimate the depth of investigation for typical tip-seal dimensions. Experiments reveal that for certain ranges of sample permeability, the response of ten minipermeameter is affected by gas slippage and high velocity gas flow. The authors demonstrate how to correct for these effects on an example of a vertical sequence of measurements taken from a Page sandstone core. (Edited author abstract). 26 Refs.

Goggin, David J. (Univ of Texas at Austin, Austin, TX, USA); Thrasher, Richard L.; Lake, Larry W. *In Situ Oil Coal Shale Miner* v 12 n 1-2 Mar-Jun 1988 p 79-116.

**072962 DEBLUTUL DE LICHID SI PROCENTUL DE IMPURITATI LICHIDE LA OSONDAPRODUCTIVA CARE TRAVERSEAZA SI UN STRAT DE APA NEIZOLAT.** [Liquid Flow and Liquid Contaminants Percentage at a Productive Well Which Crosses an Unisolated Water Layer.]. After presenting the methodology for the application of the method, an analysis is carried out by illustrating two situations, that is: when the pressure in the water layer is higher than in the oil layer (case 1) and the opposite (case 2). The behavior regarding the inflow of the type  $Q=Q(p)$ , as well as the specific curves for the variation of the contaminants percentage depending on the total flow and pressure are presented. The conclusions, which follow from the two cases are given. (Edited author abstract). 3 Refs. In Romanian.

Tocan, L. (Inst de Petrol si Gaze Ploiesti, Rom). *Mine Pet Gaze* v 39 n 4 Apr 1988 p 197-203.

## Accident Prevention

**072963 SAFETY PERFORMANCE: RESULTS CAN BE ACHIEVED.** With the proper commitment, planning and establishment of priorities, it is entirely possible to handle periods of high work activity and/or major construction in a safe, cost effective manner, on schedule, and with impressive results. This article presents the background leading up to the extremely intensive activities during 1987 on the Ekofisk Area offshore oil and gas production installations, and the comprehensive loss prevention coordination scheme that has led to one of the best safety performances ever achieved in the history of its development.

Lowery, Rock (Phillips Petroleum Co, Odessa, TX, USA); Moore, Steve L.; Thomas, E.J. *Prof Saf* v 33 n 8 Aug 1988 p 11-18.

**Calculations** See Also OIL WELLS—Productivity; PETROLEUM RESERVOIR ENGINEERING—Calculations.

**072964 EMPIRICAL METHOD FOR CALCULATING RECOVERABLE PETROLEUM RESERVES.** In processing the results of oil field investigations, an empirical relation has been established between the preceding and subsequent values of cumulative oil recovery. Based on a transformation of this relation, calculation formulas have been derived for the determination of the drainable and recoverable oil reserves. The sequence of oil field data processing is shown on the example of a deposit. (Translated author abstract) In Russian. 5 refs.

Grigor'ev, S.N. *Izv Vyssh Uchebn Zaved Neft Gaz* n 2 Feb 1987 p 30-34.

## Cameroon

**072965 INSTALLATION OF THE CENTRAL PRODUCTION FACILITIES DECK FOR THE MOKOKO-ABANA FIELD, CAMEROON.** To reduce development costs at the Mokoko-Abana field, all production equipment was installed in deck units during fabrication and the equipment was precommissioned in the contractors' yards before loadout. The 5,000-ton [4500-Mg] central production facilities deck, however, exceeded lifting capabilities of available marine equipment, so a unique installation technique was developed that uses tidal changes and rapid barge ballasting to lower



the completed deck onto a specially designed jacket. (Author abstract)

Gatto, A.W. (Pecten Int Co). *SPE Prod Eng* v 3 n 2 May 1988 SPE 14082, p 238-244.

**Computer Applications** See Also ARTIFICIAL INTELLIGENCE—Expert Systems.

**072966 OPUS: AN INTEGRATED ASSISTANCE SYSTEM FOR OIL PRODUCTION.** Opus is a software package for selecting activation processes that are the best suited for a hydrocarbon field. It integrates an expert system to manage what is known in the field and to organize the application of a set of algorithmic programs for making technico-economic evaluations. This article gives a detailed description of the expert system part as well as an example of how the complete system is used. (Author abstract) 9 refs.

Hoffmann, Frederic C. (Inst Francais du Petrole, Rueil Malmaison, Fr); Valentin, Emmanuel P. *Expert Syst* v 4 n 4 Nov 1987 p 242-250.

**072967 COMPUTER APPLICATIONS IN OIL PRODUCTION: A VIEWPOINT.** This paper reviews selected areas of importance and indicates the growth directions of computer applications in oil production. The key message is that alert petroleum engineers must make a concerted effort to keep abreast of computer applications in the field or else fall behind. Those who want to make the effort may be interested in available software, types of useful applications, and approaches for getting more involved. The paper also offers words of caution on how to obtain proper use and to avoid abuse. (Author abstract) 21 refs.

Aronofsky, Julius S. (Aro Computing Co). *JPT J Pet Technol* v 40 n 2 Feb 1988 p 143-148.

**072968 COMPUTING IN THE UPSTREAM COMES OF AGE.** A discussion is presented of the advances in the use and control of information technology in oil exploration and production. The role played by the computer in oil exploration and production is discussed. The use of computers in electronic mail, seismology and structural engineering are briefly examined.

Mayhew, Geoffrey. *Pet Rev* v 42 n 493 Feb 1988 p 4-7.

**Control**

**072969 STUDY OF SUBCRITICAL FLOW THROUGH MULTIPLE-ORIFICE VALVES.** Increased oil and gas production from offshore areas and hostile environments has led to a greater use of multiple-orifice-valve (MOV) wellhead chokes. Unlike conventional wellhead chokes, MOV's can be adjusted to any given choke area while under pressure, allowing wells in remote locations to be controlled from a central site. Data on the behavior of multiphase flow through MOV chokes have not been available in the past. This study investigated high-pressure (400 to 800 psia [2.8 to 5.5 MPa]), two-phase air/water flow through a 2-in. [5.1-cm] MOV choke. Single-phase air and water data were obtained to determine the valve-sizing coefficient,  $C_v$ . A correlating parameter was determined with two-phase data to predict the subcritical two-phase pressure drop. This parameter was found to be a function of the gas/liquid ratio, upstream pressure, and choke opening. (Edited author abstract) 12 refs.

Surbey, D.W. (Univ of Tulsa, OK, USA); Kelkar, B.G.; Brill, J.P. *SPE Prod Eng* v 3 n 1 Feb 1988 SPE 14285 p 103-108.

**072970 PLC'S ARE NOW PREFERRED IN MANY OIL-FIELD OPERATIONS.** In recent years, programmable logic controllers (PLC's) have evolved to such a point that in small control systems typical of oil field production operations, they are often technologically and economically preferred over hard-wired relays. Advantages of PLC's include reduced development and training time that is possible because of standardized development and documentation. The standardization also simplifies troubleshooting and spare part requirements. 3 refs.

Kowalski, Richard A. (ARCO Oil & Gas Co, Midland, TX, USA). *Oil Gas J* v 86 n 25 Jun 20 1988 p 59-62.

**Control Systems**

**072971 ROUGHING IT IN REAL TIME.** The authors believe it takes a rugged computer to acquire and analyze data in real time when the conditions are as adverse as those in an oil field. In these extreme circumstances, a ruggedized smart computer system can be helpful in resolving difficult problems as they arise. A computer system to accomplish just that, developed for the petroleum industry, is described here, and various other applications are discussed, including the possibility of partial or complete automation of many operational tasks.

Cleary, Michael P. (MIT, Cambridge, MA, USA); Buharali, Ahmet M.; Wright, Timothy B.; Willis, Richard M. Jr. *Mech Eng* v 109 n 12 Dec 1987 p 44-49.

**Costs**

**072972 PACKERLESS SALTWATER DISPOSAL REDUCES OPERATING COSTS.** Since the free fall of oil prices in February 1986, dozens of marginal producing properties offered for sale have been studied. In evaluating these properties one common denominator was discovered—inefficient saltwater disposal systems. As a rule of thumb it costs as much to dispose of a barrel of salt water with pumps as it does to produce it. The answer to lowering operating costs with an improved saltwater system is relatively simple—replace the saltwater disposal pumps with a packerless gravity feed or vessel pressure system. Mastery of saltwater disposal has been hampered by three factors—neglect, costs, and regulatory requirements. The authors discuss tubing selection, swabbing operation, fluid level control, well cleanup and a well's Injunctivity Index.

Herlihy, John D.; Champlin, Lizabeth A.; McGowan, John W. *Pet Eng Int* v 59 n 5 May 1987 p 18-20, 22, 24-25.

**Economics** See Also OIL WELL DRILLING—Directional.

**072973 COST BENEFITS FROM MICROBIAL OIL WELL STIMULATION.** Microbial well stimulation is a technique that offers cost advantages over the conventional chemical treatments and is therefore of particular interest while the price of oil is low. Many classes of oilfield chemicals, including acids and solvents, are produced by micro-organisms grown on a cheap, fermentable sugar substrate. Some of these micro-organisms are capable of growth under the conditions prevailing in oil reservoirs, and the use of porous reservoir rock as a biological reactor offers enormous cost advantages over production of these bio-chemicals in conventional fermentation plants. To be of value for microbial oil-well stimulation, organisms must produce products to dissolve or dislodge metal scale or asphaltenes under reservoir conditions in the well bore region. Since the 1950s there have been some 200 field trials of microbial oil recovery treatments in the USA, Romania, the Soviet Union, Hungary, Poland and the Netherlands.

Brown, M.J. (QMC Industrial Research Ltd, London, Engl). *Oil Gas Eur Mag* v 13 n 1 1987 p 27-28.

**072974 L'IMPACT DES DEVELOPPEMENTS SCIENTIFIQUES SUR LA RESOLUTION DES PROBLEMES TECHNIQUES POSES PAR LA NOUVELLE CONJONCTURE DANS L'EXPLORATION ET LA PRODUCTION DU PETROLE.** [Impact of Scientific Developments on the Solving of Technical Problems Raised by the New Economic Situation in Oil Exploration and Production]. In the difficult circumstances now confronting oil exploration and production, technical know-how combined with cost control will be essential assets for the petroleum and petroleum equipment and service industries. This article considers the foreseeable impact on scientific developments on the solving of technical problems in exploration and production. The principal scientific disciplines involved (geology, geophysics, geochemistry, rock and soil mechanics, fluid mechanics, interface physicochemistry) as well as three basic techniques (modeling, expert systems, new materials) are examined within this context. (Edited author abstract) In French. 1 ref.

Tissot, B. (Inst Francais du Petrole, Rueil-Malmaison, Fr). *Rev Inst Fr Pet* v 43 n 3 May-Jun 1988 p 337-348.

**Enhanced Recovery** See Also COGENERATION PLANTS—California; EMULSIONS—Theory; FLOW OF FLUIDS—Porous Materials; MIXTURES—Phase Equilibria; OIL FIELD EQUIPMENT—Selection; OIL FIELD EQUIPMENT—Tubular Goods; OIL FIELD EQUIPMENT—Valves; OIL FIELDS—Management; OIL FIELDS—North Sea; OIL WELL CASING—Repair; OIL WELL COMPLETION; OIL WELL LOGGING—Acoustic; OIL WELLS—Acid Treatment; OIL WELLS—Fracturing; OIL WELLS—Hydraulic Fracturing; PETROLEUM GEOLOGY; PETROLEUM RESERVOIR ENGINEERING; PETROLEUM RESERVOIR ENGINEERING—Computer Simulation; PETROLEUM RESERVOIR ENGINEERING—Costs; PETROLEUM RESERVOIR ENGINEERING—Mathematical Models; PROPANE—Recovery; SURFACE ACTIVE AGENTS—Applications; SURFACE ACTIVE AGENTS—Solutions.

**072975 DIESEL-BASED GEL CONCENTRATE REDUCES STIMULATION COSTS.** A new liquid gel concentrate based on diesel (LGCD) has helped operators reduce oil well-stimulation costs. The gelled fracture fluid is mixed 'on the fly' from diesel-based liquid concentrate. Procedural changes made possible by use of the LGCD bring more efficiency and versatility, which result in better economy, to the fracturing operation. Examples are major savings due to lower treating pressure and pumping rates. Also, work reported by E.R. Simonson showed that lower treating pressure consistently yielded less fracture height and greater fracture length in formations of all types. 3 refs.

Harms, Weldon M. (Halliburton Services, Duncan, OK, USA); Yeager Randy. *Oil Gas J* v 85 n 44 Nov 2 1987 p 37-39.

**072976 EOR SURFACE FACILITIES FOR THE NORTH SEA.** Maximizing recovery of oil from the North Sea's huge reserves by utilizing enhanced oil recovery techniques is just beginning now that production has peaked and is starting to decline. It is estimated that primary and secondary recovery methods will yield 35 to 42% of the 60 billion barrels of original oil in place, and that tertiary (EOR) methods will recover an additional 5-40% of the original oil in place, depending upon the methods used, economics of production and technological advances. A brief review of EOR methods is presented with comments regarding their use in the North Sea. Descriptions of actual land-based projects for the most likely EOR methods to be used in the North Sea are discussed, and then judgements to applicability are offered. 34 refs.

Jones, W. Tom (Fluor Engineers Inc, Sugar Land, TX, USA); Nolley, Erlene; Houghton, Jim. *Q J Tech Pap Inst Pet* Jul-Sep 1986 p 27-63.

**072977 REVIEW OF THERMAL OIL RECOVERY USING HORIZONTAL WELLS.** This report is a review of the state of the art of thermal oil recovery using horizontal wells for producing heavy oils and tar sands. The review includes a discussion of reservoir engineering, drilling, and completion aspects of horizontal well and drainhole technology. The available field data are also discussed. The review is restricted to the steam-horizontal well combination technology. The available data demonstrate that for tar sand oil recovery, steam assisted gravity drainage using horizontal wells is an efficient oil production mechanism. For heavy oil recovery, steam assisted gravity drainage as well as steam drive employed with horizontal wells seem to give substantially higher recovery than that obtained using vertical wells. In addition, in mature steam drives with significant steam override,



horizontal wells could be used to reduce gravity segregation and produce oil from the bottom layers. (Author abstract) 72 refs.

Joshi, S.D. (Phillips Petroleum Co, Bartlesville, OK, USA). *In Situ Oil Coal Shale Miner* v 11 n 2-3 Jun-Sep 1987 p 211-259.

**072978 EOR WITH PENN STATE SURFACTANTS.** Petroleum sulfonate surfactants were synthesized from C<sub>19</sub>, C<sub>22</sub> and C<sub>26</sub> feedstocks and evaluated in core tests for their ability to enhance oil recovery. All three feedstocks are composed predominantly of saturated paraffinic and naphthenic hydrocarbons. The C<sub>19</sub> feedstock includes about 12% aromatics. The hydrocarbons were vapor-phase oxidized at low temperatures to provide cyclic ethers, which subsequently were sulfonated to form a product mixture of mono-, di-, and trisulfonates. Corefloods were conducted with both sulfonates developed at Pennsylvania State U. and commercial sulfonates in Berea sandstone cores. High oil recovery efficiencies are realized when the Penn State sulfonates are used without cosurfactants to form dilute chemical slugs. (Edited author abstract) 19 refs.

Arf, T.G. (Pennsylvania State Univ, PA, USA); LaBelle, G.; Klaus, E.E.; Duda, J.L.; Nagarajan, R.; Biterge, M.B.; Ertekin, T. *SPE Reservoir Eng* v 2 n 2 May 1987 p 166-176.

**072979 HYDROLYSIS AND PRECIPITATION OF POLYACRYLAMIDES IN HARD BRINES AT ELEVATED TEMPERATURES.** The authors attempt to define some of these limits through an extensive series of cloud-point measurements for commercial polyacrylamides, coupled with data on the rate of hydrolysis as a function of temperature. These are combined to predict precipitation times as a function of hardness level and temperature, thereby providing guidelines for the use of polyacrylamides in EOR. Indications are that these cloudy solutions cause plugging of porous media. Therefore, a polymer solution is potentially useful only below its cloud-point temperature. 30 refs.

Moradi-Araghi, Ahmad (Phillips Petroleum Co); Doe, Peter H. *SPE Reservoir Eng* v 2 n 2 May 1987 p 189-198.

**072980 LABORATORY SEISMIC METHODS FOR REMOTE MONITORING OF THERMAL EOR.** Laboratory measurements of compressional (P) and shear (S) wave velocities and first-arrival amplitudes at ultrasonic frequencies in unconsolidated tar and heavy-oil sands indicate that wave-propagation properties in these materials are sensitive to bitumen content. The results suggest that seismic wave transmission and possibly reflection methods should be highly successful in locating thermal EOR fronts and in monitoring the distribution of heated tar and heavy oils within a reservoir. The application for this technique is evident: because of the potential to track heated oil remotely, field operators may be able to determine optimal placement of future production or injection wells. (Edited author abstract) 10 refs.

Tosaya, Carol (Petrophysical Services Inc); Nur, Amos; Vo-Thanh, Dung; Da Prat, Giovanni. *SPE Reservoir Eng* v 2 n 2 May 1987 p 235-242.

**072981 REMOTE MONITORING OF THE STEAM-FLOOD ENHANCED OIL RECOVERY PROCESS.** Cross-borehole seismic velocity and high-frequency electromagnetic (EM) attenuation data were obtained to construct tomographic images of heavy oil sands in a steam-flood environment. First-arrival seismic data were used to construct a tomographic color image of a 10 m by 8 m vertical plane between the two boreholes. Two high-frequency (17 and 15 MHz) EM transmission tomographs were constructed of a 20 m by 8 m vertical plane. The velocity tomograph clearly shows a shale layer with oil sands above it and below it. The EM tomographs show a more complex geology of oil sands with shale inclusions. The deepest EM tomograph shows the upper part of an active steam zone and suggests steam channeling just below the shale layer. These results show the detailed structure of the entire plane between boreholes and may

provide a better means to understand the process for in-situ heavy oil recovery in a steam-flood environment. (Author abstract) Refs.

Laine, E.F. (Lawrence Livermore Natl Lab, Livermore, CA, USA). *Geophysics* v 52 n 11 Nov 1987 p 1457-1465.

**072982 PRODUCTION FROM HORIZONTAL WELLS AFTER 5 YEARS.** The first of our horizontal wells drilled by Elf Aquitaine during the last 6 years produced its first barrel of oil in Aug. 1980. The others followed between 1981 and 1983. There is now enough production history to draw conclusions. It is found that success in drilling horizontal wells means compensating for additional costs with additional production. Reaching this target means carefully selecting potential candidates, improving the horizontal production, and reducing the additional cost. Selecting the candidates is the key point. The best fields for horizontal drilling might be reservoirs with widely spaced, vertical, permeable heterogeneities (fractures and karsts), tight gas with some fractures, and also severe water/oil or gas/oil interface deformation. Improving horizontal production depends on the lateral heterogeneity. It must be measured adequately and used in the selective completion of horizontal wells. (Edited author abstract) 11 refs.

Reiss, L.H. (Elf Aquitaine). *JPT J Pet Technol* v 39 n 11 Nov 1987 p 1411-1416.

**072983 APPLICATION OF HORIZONTAL WELLS AT PRUDHOE BAY.** This paper reviews production and reservoir engineering aspects of the trial program. It includes the objectives of the test program, the planning and drilling of three wells, the forecasting of production rates and recoveries, and the testing and analysis of actual well performance. In summary, the three wells have been successfully drilled and completed, with each well consisting less than its predecessor. The wells have exhibited productivities two to four times that of conventional comparison wells, and increased oil recovery is anticipated. (Edited author abstract) 13 refs.

Sherrard, Dave W. (Standard Alaska Production Co); Brice, Bradley W.; MacDonald, David G. *JPT J Pet Technol* v 39 n 11 Nov 1987 p 1417-1425.

**072984 DEVELOPMENT AND EVALUATION OF EOR POLYMERS SUITABLE FOR HOSTILE ENVIRONMENTS - PART 1: COPOLYMERS OF VINYL-PYRROLIDONE AND ACRYLAMIDE.** This paper describes the properties of synthetic water-soluble polymer that are stable for extended periods of time in hard brines at very high temperatures. Several copolymers of vinylpyrrolidone (VP) and acrylamide (AM) were prepared and evaluated in our laboratories for EOR application in hostile environments. VP in the copolymer composition protects AM against extensive thermal hydrolysis, which otherwise will result in loss of viscosity and precipitation. A range of VP/AM copolymer compositions was found to tolerate the harsh conditions of 250°F (121°C) in seawater for extended periods of time to be suitable for EOR application under these conditions. The results indicate that these copolymers can easily be injected into porous media and that they can be effective polymers for EOR application in hostile environments. (Edited author abstract) 13 refs.

Doe, Peter H. (Phillips Petroleum Co); Moradi-Araghi, Ahmad; Shaw, James E.; Stahl, G. Allan. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14233, p 461-467.

**072985 CALCULATION OF MINIMUM MISCIBILITY PRESSURE.** An algorithm is presented for the calculation of the thermodynamic minimum miscibility pressure (TMMP) consistent with an equation-of-state (EOS)-based fluid description. This algorithm handles both condensing and vaporizing miscibility mechanisms. TMMP calculations are included for a ternary mixture of pure components, as well as a reservoir-oil/CO<sub>2</sub> system. (Author abstract) 7 refs.

Luks, Kraemer D. (Univ of Tulsa, OK, USA); Turek, Edward A.; Baker, Lee E. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14929, p 501-506.

**072986 KINETIC STUDY OF THE DECOMPOSITION OF SURFACTANTS FOR EOR.** The effect of temperature, pH, surfactant purity, and air on the decomposition rate of two classes of surfactants typically used in steam EOR processes has been investigated. With synthetic alkylaryl sulfonates, isolation and characterization of the hydrocarbon reaction products established that the principal reaction is desulfonation of the surfactant. The kinetics of the decomposition of certain alkylaryl sulfonates under carefully controlled pH and temperature conditions are discussed and compared with the behavior observed for  $\alpha$ -olefin sulfonates (AOS's) under the same conditions. The synthesis and decomposition of key pure isomeric alkylaromatic sulfonates of known structure led to a mechanistic description of the decomposition reaction. (Edited author abstract) 14 refs.

Angstadt, H.P. (Sun Co); Tsao, H. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 12662, p 613-618.

**072987 NUCLEAR STEAM GENERATION FOR A SHENGLI FIELD EOR.** High-temperature nuclear-reactor (HTR) units are being considered to provide energy to generate steam for thermal recovery of oil in China's Shengli area. These reactors are particularly suited because they can be designed in small sizes, and they are extraordinarily safe. A two-phase study to determine the possible application of this technology is now under way. Begun in 1985, the preliminary feasibility study and evaluation of a steam-drive project with an HTR as the steam generator in Shanjasi field are scheduled to be completed in mid-1988. 3 refs.

Froeling, W. (KFA, Juelich, West Ger); Kugeler, K.; Stoll, R.D.; Schwarzkopp, F.; Zhong, Daxin; Ye, Daxin. *Oil Gas J* v 85 n 49 Dec 7 1987 p 49-50, 54-55.

**072988 TECHNOLOGY OF USING CARBON DIOXIDE TO INCREASE THE OIL OUTPUT OF FORMATIONS.** Carbon dioxide can be used to increase the oil output of formations in a wide range of variations of the geological and physical conditions in any stage of development of oil fields. The method is most effectively introduced when the technology for working the field is correctly chosen. This is possible after carrying out laboratory studies, calculations and experiments on a small section of the field involved. Further studies of the method are required concerning ways of controlling the rate of advance of the injected fluids through the formation, preventing premature breakthroughs of CO<sub>2</sub> into the extraction wells, recovering the CO<sub>2</sub> extracted with the oil, and creating the equipment required for successful realization at the process. In Russian. 6 refs.

Gorbunov, A.T.; Ziskin, E.A. *Neft Khoz* n 6 Jun 1987 p 33-38.

**072989 SARAH-DIEZOL: UN SYSTEME DE DIAGNOSTIC EN RECUPERATION ASSISTEE D'HYDROCARBURES.** [Sarah-Diezol: A Diagnosis System for Enhanced Oil Recovery]. This article describes a system for selecting possible enhanced oil recovery (EOR) processes on the basis of reservoir data. The method is based on an expert system shell (DIEZOL) developed by Institut Francais du Petrole (IFP). The reasoning uses backward and forward chaining, confidence factors and procedure attachments. This approach is considered to play a role in establishing a methodology for choosing an EOR process, for improving known-how by checking the criteria used by comparison with practical experience, and for transferring expert's knowledge to users of the system. (Edited author abstract) In French. 23 refs.

Guerillot, D. (Inst Francais du Petrole, Rueil-Malmaison, Fr); Bessis, F. *Rev Inst Fr Pet* v 41 n 6 Nov-Dec 1986 p 759-771.

**072990 FOURTH SPE COMPARATIVE SOLUTION PROJECT: COMPARISON OF STEAM INJECTION SIMULATORS.** Three related steam injection problems are presented along with simulation results for them obtained from six organizations. The problems



selected for comparison were intended to exercise many of the features of thermal models that are of practical and theoretical interest. The first problem deals with three cycles of cyclic steam injection and the other two problems deal with steam displacement in an inverted nine-spot pattern. The first two problems are of 'black-oil' type and the third of compositional type. Complete data are presented for these problems. The comparison of solutions indicates good agreement for most of the results of importance in field operations. (Author abstract) 27 refs.

Aziz, K. (Stanford Univ); Ramesh, A.B.; Woo, P.T. *JPT J Pet Technol* v 39 n 12 Dec 1987 SPE 13510, p 1576-1584.

**072991 HOW CALIFORNIA OPERATORS IMPROVE HEAVY OIL PRODUCTION.** The main attraction at Kern River is the big cogeneration project that sits on 20 acres atop Omar Hill in the center of the field. It produces 300 mw of electricity as well as 131,000 b/d of steam. Another 45 to 50 conventional steam generators will be replaced at Kern River by a second cogeneration facility currently under construction a little more than a mile west of the Omar Hill plant. Another cogeneration facility is being built near the Midway-Sunset oil field in the San Joaquin Valley. Heavy oil production is also being enhanced by the use of the Chaser additive in cyclic steaming applications. Hot water flood is yet another method being used to improve recovery at the Kern River field.

McNally, Rich (Petroleum Engineer Int, Dallas, TX, USA). *Pet Eng Int* v 59 n 11 Nov 1987 p 17-20.

**072992 IMPROVED INTERPRETATION OF THE INACCESSIBLE PORE-VOLUME PHENOMENON.** In laboratory corefloods, polymer solutions used in EOR, such as partially hydrolyzed polyacrylamides (HPHA), often break through at less than 1 PV injected compared to the breakthrough of pure water. The rapid breakthrough is erroneously used to determine the ratio of pores accessible to polymer to total PV (accessible PV). Through numerical simulation and steady-state analysis, we show that the rapid breakthrough of such polymer solutions is not a measure of accessible PV. Our results significantly affect interpretation of polymer flow in porous media. We show two different forms of the same partial differential equation used to describe rapid polymer breakthrough. The finite-difference solutions lead to two different polymer concentrations for each gridblock - a flowing concentration and a bulk (volume-average) concentration. The polymer-concentration-dependent properties required for each formulation must be interpreted correctly. (Edited author abstract) 7 refs.

Gilman, J.R. (Marathon Oil Co); MacMillan, D.J. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 13499, p 442-448.

**072993 GEOLOGIC PROBLEMS RELATED TO CHARACTERIZATION OF CLASTIC RESERVOIRS FOR EOR.** Geologic problems encountered in four U.S. DOE-sponsored EOR projects in clastic reservoirs were analyzed. The reservoir heterogeneities were grouped into four categories: depositional, diagenetic, structural, and formation-fluid composition/distribution. Each category had a variable effect on the performance of the EOR projects. Requirements for developing one static geologic model for each category of heterogeneity are proposed. The interrelationship of geologic factors and the effect of heterogeneities resulting from the origin and timing of geologic events are described. (Edited author abstract) 80 refs.

Szpakiewicz, M. (Nat Inst for Petroleum & Energy Research); McGee, K.; Sharma, B. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 14888, p 449-460.

**072994 ANALYSIS OF AN INTERWELL TRACER TEST IN A DEPLETED HEAVY-OIL RESERVOIR.** This paper presents field data and analyses of an interwell tracer test conducted in the Niitsu oil field, which is a fully depleted heavy-oil reservoir of unconsolidated sand formation. Water containing a chemical tracer was injected

at a constant rate into an injector surrounded by three production wells. Effluent analyses showed very early breakthrough of injected water at two of the producing wells. The test results suggest a strong areal heterogeneity of the tested formation. An appropriate analytic model was used to obtain a preliminary interpretation of the results. A modified three-dimensional (3D) black-oil model developed to simulate the polymer flood process was then used for analyzing the data in more detail. The model treats tracer solution as a fourth component and can also account for adsorption of tracer. (Edited author abstract) 9 refs.

Ohno, Kenji (Japan Natl Oil Co); Nanba, Takao; Horne, Roland N. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 13672, p 487-494.

**072995 WATER CONTENT OF CO<sub>2</sub> IN EQUILIBRIUM WITH LIQUID WATER AND/OR HYDRATES.** Experimentally measured water content in CO<sub>2</sub>-rich fluid in the gaseous or liquid state in equilibrium with liquid water or hydrate is presented for pressures ranging from 100 to 2,000 psia [0.69 to 13.79 MPa] and temperatures from -19 to 77°F [-28.33 to 25.0°C]. The water content of the CO<sub>2</sub>-rich phase along the three-phase equilibria, i.e., liquid water/liquid CO<sub>2</sub>/gas to the three-phase critical endpoint, is also reported. The experimental results from this study on the water content in the CO<sub>2</sub>-rich phases have been combined with earlier research results of the CO<sub>2</sub>/water binary system in the hydrate-free region from 77 to 200°F [25.0 to 93.3°C] and pressures to 3,000 psia [20.69 MPa] to produce a comprehensive plot. (Edited author abstract) 20 refs.

Song, Kyoo Y. (Rice Univ); Kobayashi, Riki. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 15905, p 500-508.

**072996 MATHEMATICAL MODELING OF THE ONE-DIMENSIONAL PROCESSES OF OIL DISPLACEMENT BY AN ACTIVE SOLUTION.** The previously proposed model of oil displacement by an active solution is extended to the case in which the relative phase permeabilities depend on the percolation velocity and interfacial tension as functions of the active agent concentration. For this purpose the phase permeability curves are approximated by functions of two variables - saturation and capillary number. An analytical description of the structure of the displacement zone in an extended stream tube of variable cross section is given for continuous pumping of the active solution and the use of a finite batch (slug). The coefficient of displacement of the oil from the near-well zone and an annular element of the reservoir is calculated by a finite-difference method for various operating conditions. This approach could be useful in analyzing the efficiency of different methods of improving oil recovery. (Author abstract) 20 refs.

Zazovskii, A.F. *Fluid Dyn* v 22 n 3 May-Jun 1987 p 420-430.

**072997 ANALYZING, SOLVING OFFSHORE SEAWATER INJECTION PROBLEMS.** Adma-Opeco injects some 433,000 bpd of treated seawater into 10 reservoirs in the two fields through mostly dual completed wells. Main cause of injectivity deterioration is the treated seawater. Deterioration was initially noted while monitoring injection performance. A study to determine suitability of water quality specifications to the reservoirs showed that removal of particles larger than 2 microns is necessary. Factors relating to completion damage and problem control are discussed. 6 refs.

Al-Rubaie, J.S. (Adma-Opeco, Abu Dhabi); Muhsin, M.A.; Shaker, H.A.; Washash, I. *World Oil* v 206 n 1 Jan 1988 p 67-68, 70.

**072998 FUNDAMENTALS OF OILWELL JET PUMPING.** This paper explains the theory behind the operation of jet pumps, including the effect of density differences between power fluid and produced fluids. By differentiating between the pump intake pressure and the throat-entrance pressure, we provide insight into the factors that affect jet pump performance. A stepwise procedure is given for sizing and selecting a jet pump.

(Author abstract) 9 refs.

Gruppings, A.W. (Delft Univ of Technology, Neth); Coppes, J.L.R.; Groot, J.G. *SPE Prod Eng* v 3 n 1 Feb 1988 SPE 15670 p 9-14.

**072999 SOLUBLE FLUID-LOSS ADDITIVES CAN REDUCE WELL PRODUCTIVITIES AND PREVENT COMPLETE GRAVEL PLACEMENT.** Examples of wells indicating this effect during post-gravel-pack acid treatments are discussed. The theory of why this occurs and calculations of pressure drops through perforations filled with fluid-loss additives are presented. It has also been found that excess fluid-loss additives prevent complete coverage of a zone with gravel, because of either inadequate leakoff to the formation or partial plugging of the screen. Therefore, it is imperative that these additives be removed by acid, water, or solvents preceding the gravel slurry; however, if their removal causes loss of circulation, the results may be equally bad. (Edited author abstract) 7 refs.

Sparlin, D.D. (Int Completion Consultants Inc); Hagen, R.W. Jr. *SPE Prod Eng* v 3 n 1 Feb 1988 SPE 14817 p 63-68.

**073000 UNDERBALANCED PERFORATION CHARACTERISTICS AS AFFECTED BY DIFFERENTIAL PRESSURE.** Underbalanced, tubing-conveyed completions are increasing because of the apparent advantages of cleaner perforations, reduced completion times, and stimulation treatments. Radial-flow Berea sandstone core specimens are used to determine the perforation characteristics resulting from time-dependent pressure differentials between core pressure and wellbore pressure during the completion process. The primary perforation characteristic studied [radial flow ratio (RFR)] is defined as the ratio of the perforated flow rate to the flow rate of the unperforated core. The perforation flow tests included pressure differentials from 500 psi [3450 kPa] overbalanced to 1,000 psi [6900 kPa] underbalanced, with immediate or delayed surging. The RFR was affected most by the 500-psi and 1,000-psi [3450- and 6900-kPa] underbalance. The surged RFR's were from 50 to 58% greater than the no-surge RFR's. (Edited author abstract) 10 refs.

Regalbuto, John A. (Jet Research Cent Inc); Riggs, Robert S. *SPE Prod Eng* v 3 n 1 Feb 1988 SPE 15816 p 83-88.

**073001 RESERVOIR COMPACTION LOADS ON CASINGS AND LINERS.** Pressure drawdown resulting from production causes compaction of the reservoir formation, which induces axial and radial loads on the wellbore. Reservoir compaction loads increase during the production life of a well and are greater for deviated wells. Presented here are casing and liner loads at initial and final reservoir pressures for well deviation angles of 0 to 45° [0 to 0.79 rad]. (Author abstract) 7 refs.

Wooley, Gary R. (Enertech Engineering & Research Co); Prachner, W. *SPE Prod Eng* v 3 n 1 Feb 1988 SPE 13088 p 96-102.

**073002 EXPERIMENTAL INVESTIGATION OF HYDROCARBON RECOVERY FROM A POROUS MEDIUM BY CONTINUOUS STEAM INJECTION.** Experiments were carried out to recover oils by steam flooding a previously waterflooded core maintained at room temperature (21°C), 71.5°C and steam temperature (143°C), using continuous steam injection in an unconsolidated core containing oils of different viscosity. Primol, light paraffin and heavy paraffin, under varying heat loss conditions. In an actual petroleum reservoir, the injection of steam results in heat loss situations represented by all of the conditions used in this investigation on a stage-wise basis. Results indicate that the steamflood residual oil saturation is a highly variable quantity and any estimate of it must take into account the prevailing heat losses. The



overall recoveries of Primol, light paraffin and heavy paraffin were found to be 62, 31 and 65% of the waterflood residual oil saturations. (Author abstract) 13 refs.

Narayan, K.A. (Univ of Sydney, Sydney, Aust); Walsh, B.W. *Fuel* v 67 n 2 Feb 1988 p 215-220.

**073003 MAKING NEW PRODUCTION TECHNOLOGY WORK FOR YOU.** A discussion is presented of trends toward cost effectiveness in all areas of production. Also, the use of innovative technology to exploit marginal properties is examined. Artificial lift costs are discussed and an overview is presented of new production technologies. 5 refs.

Moore, Steven D. (Petroleum Engineer Int, Cleveland, OH, USA). *Pet Eng Int* v 60 n 1 Jan 198 p 20-22.

**073004 DENVER UNIT CO<sub>2</sub> FLOOD: MATERIAL ASPECTS OF THE DESIGN AND OPERATION OF INJECTION AND PRODUCTION FACILITIES.** CO<sub>2</sub> flooding technology in conjunction with the development of large new natural sources of CO<sub>2</sub> has advanced to become a significant factor in the enhanced oil recovery scene. Shell Western E&P Inc. (SWEPI) initiated a large scale tertiary recovery CO<sub>2</sub> project in West Texas at the Denver Unit in April, 1983. The detrimental effects of CO<sub>2</sub> on many non-metallic materials and of carbonic acid on metallic materials has had a significant effect on selection of equipment for CO<sub>2</sub> flooding at the Denver Unit. This article reviews materials selection and the operating performance of these materials in the injection and production facilities at the Denver Unit.

Iken, George (Shell Western E&P Inc, Houston, TX, USA). *Energy Prog* v 7 n 4 Dec 1987 p 193-195.

**073005 FACTORI CARE DECID PRODUCTIVITATEA SONDELOR.** [Decisive Factors for the Productivity of Oil Wells]. The main factors which interfere with the productivity of oil wells are presented. The penetration of solid particles from the drilling slurry into the pores, the penetration of the filtered slurry into the empty spaces and the movement of clay-like minerals into the productive formations are discussed. The necessity for reconsidering the 'small values' of the process of filtering the drilling slurry and the allowed tolerances for the opening of oil wells is discussed. (Edited author abstract) In Romanian. 8 refs.

Manolescu, G. *Mine Pet Gaze* v 38 n 11 Nov 1987 p 526-531.

**073006 CO<sub>2</sub> PRODUCTION IN GASIFICATION-COMBINED-CYCLE PLANTS.** Great reserves of known oil deposits remain in the ground because they cannot be extracted by conventional techniques. Injecting carbon dioxide (CO<sub>2</sub>) into oil reservoirs is one means of recovering some of those deposits when the market price of crude oil warrants the additional production costs. When oil prices were above \$25/bbl, CO<sub>2</sub> was a valued commodity in the oil industry, which looked to electric utilities as a potential supplier. But recent drops in oil prices caused less interest in such recovery methods, particularly at the high cost of CO<sub>2</sub> extracted from conventional power plant stacks. However, CO<sub>2</sub> could be produced most economically by utilities if it were coproduced with electricity at coal gasification-combined-cycle (GCC) power plants. An EPRI study of two GCC plants indicates the costs might make CO<sub>2</sub>-enhanced oil production economical even at today's oil price (about \$20/bbl). (Edited author abstract)

Louks, Bert. *EPRI J* v 12 n 7 Oct-Nov 1987 p 52-54.

**073007 EVALUATION AND COMPARISON OF RESIDUAL OIL SATURATION DETERMINATION TECHNIQUES.** A brief review of available ROS techniques is presented, indicating advantages, limitations, problems, and possible improvements of each technique. Advantages and disadvantages of each ROS-determination technique are summarized. Screening criteria for determining the best ROS technique under certain well-bore or reservoir conditions are presented. This paper also presents results from comparisons of ROS measurements

obtained from the literature as calculated from resistivity logs, pulsed neutron capture (PNC) logs, pressure coring, single-well tracer tests, nuclear magnetism logs (NML), carbon/oxygen (C/O) logs, and electromagnetic propagation tool (EPT) measurements. In this study, the ROS measured by each method is compared with that determined by other methods conducted in the same well. (Edited author abstract) 99 refs.

Chang, M.M. (Nat'l Inst of Petroleum & Energy Research); Maerefat, N.L.; Tomutsa, L.; Honarpour, M.M. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 14887, p 251-262.

**073008 NEW STABILITY THEORY FOR DESIGNING GRADED VISCOSITY BANKS.** This paper presents a newly-developed theory which is based on the small perturbations method. In particular, a dimensionless number which is a function of the dimensions of the porous medium as well as the properties of the fluids and the porous medium and its critical value for the onset of viscous fingering is derived. With the help of this dimensionless number, it is possible to design a graded viscosity solvent bank which is able to resist the adverse effects of viscous fingering. The theory enables the prediction of the minimum size and configuration of a graded viscosity bank so as to maximize recovery by avoiding bank breakdown due to viscous fingering. (Edited author abstract) 19 refs.

Coskuner, G. (Univ of Alberta, Edmonton, Alberta, Can); Bentsen, R.G. *J Can Pet Technol* v 26 n 6 Nov-Dec 1987 p 26-30.

**073009 MULTIPLE CONTACT PHASE BEHAVIOUR IN THE DISPLACEMENT OF CRUDE OIL WITH NITROGEN AND ENRICHED NITROGEN.** Phase behavior tests carried out on a Nisku crude oil (a candidate reservoir for nitrogen flooding) with nitrogen and nitrogen mixed with carbon dioxide or propane. These measurements were carried out in a batchwise multiple contact mode to simulate what occurs when gas displaces oil in a porous medium. None of the mixtures achieved miscibility with the oil in four contacts at pressures up to 35 MPa. Nitrogen and methane were exchanged between the gas and oil phases in an almost 1:1 ratio, while gas enrichment with C<sub>2-5</sub> hydrocarbons proceeded at a much slower pace. The experimental data were matched using the Peng-Robinson equation of state. The largest deviations were in the amount of heavy ends found in the vapor phase. (Edited author abstract) 10 refs.

Sayegh, S.G. (Petroleum Recovery Inst, Calgary, Alberta, Can); Wang, S.T.; Najman, J. *J Can Pet Technol* v 26 n 6 Nov-Dec 1987 p 31-39.

**073010 MOBILITY CONTROL IN WATER-FLOODING OIL RESERVOIRS WITH A BOTTOM-WATER ZONE.** Many oil reservoirs in Alberta and Saskatchewan have a bottom water zone which leads to poor areal and vertical sweeps under a waterflood. Performance in such reservoirs could be improved if an effective method of partially plugging the bottom water zone can be implemented. A possible means of accomplishing this would be to precede the waterflood with a slug of a mobility control agent. This possibility was investigated using a laboratory flow model for polymer, emulsion, biopolymer, and foam mobility control agents in various slug sizes. Core flood experiments were conducted to study the effect of permeability contrast, relative oil-water layer thickness, oil viscosity, injection rate, slug size and the use of an artificial barrier. Oil of viscosities ranging from 1 to 200 mPa.s were used in 42 displacement tests. A qualitative comparison is made to show the relative merits of different mobility control agents. (Edited author abstract) 49 refs.

Islam, M. Rafiqul (Univ of Alberta, Edmonton, Alberta, Can); Ali, S.M. Farouq. *J Can Pet Technol* v 26 n 6 Nov-Dec 1987 p 40-53.

**073011 LABORATORY EVALUATION OF CROSSLINKED POLYMER AND ALKALINE-POLYMER-SURFACTANT FLOOD.** This paper discusses the feasibility of using crosslinked polymer technology

and alkaline-polymer-surfactant technology to improve oil recovery in the Grand Forks Lower Mannville D pool in Alberta. The results of laboratory studies indicate that the alkaline-polymer system can recover incremental oil over waterflooding of approximately 30% of original oil in place. With an addition of 0.1% by weight of surfactant, up to 47% of original oil in place can be recovered. No injectivity and fluid incompatibility problems were detected. The test results also indicate that the residual resistance factor can be increased by crosslinking. This should help improve the vertical sweep efficiency by diverting the subsequent injection fluids into the unswept zones. It is concluded that chemical flood is technically feasible for the pool. (Edited author abstract) 9 refs.

Lin, Frank F.J.; Besserer, George J.; Pitts, Malcolm J. *J Can Pet Technol* v 26 n 6 Nov-Dec 1987 p 54-65.

**073012 ANALYTICAL MODEL OF ONE-DIMENSIONAL MISCIBLE DISPLACEMENT IN POROUS MEDIA.** A mathematical model having an analytical solution that is valid both for stable and unstable one-dimensional first-contact miscible displacement in homogeneous and heterogeneous porous media has not been reported in the literature. This paper's main objective is to present such a model. This model is described by the diffusion-convection equation for which an approximate parametric solution is a one-parameter family of curves. Simple formulae for cumulative oil recovery, solvent effluent concentration and oil cut are derived and matched with published experimental data. (Edited author abstract) 14 refs.

Jankovic, M.S. (Esso Resources Canada Ltd, Can). *J Can Pet Technol* v 26 n 6 Nov-Dec 1987 p 82-95.

**073013 IMPROVED MODEL FOR PREDICTING HEAT LOSSES AND PRESSURE CHANGES IN STEAM INJECTION WELLS - PART 1: MODEL DEVELOPMENT.** An improved model for predicting heat losses and pressure changes in steam injection wells is presented. The model incorporates a two-phase, annular-mist flow pressure change model with heat transfer to the surroundings during wet steam injection. The model requires an iterative procedure which is solved numerically using a fourth-order Runge-Kutta method. (Author abstract) 27 refs.

Yao, S.C. (Univ of Tulsa, Tulsa, OK, USA); Sylvester, N.D. *J Energy Resour Technol Trans ASME* v 109 n 4 Dec 1987 p 218-224.

**073014 IMPROVED MODEL FOR PREDICTING HEAT LOSSES AND PRESSURE CHANGES IN STEAM INJECTION WELLS - PART 2: MODEL EVALUATION.** The improved model developed in Part 1 for predicting heat losses and pressure changes in steam injection wells is evaluated. It shows good agreement with limited field data. The model is used to predict the effects of steam injection time, rate and pressure, well depth and tubing diameter on heat losses, bottomhole pressure and downhole steam quality. A design example is presented to illustrate the solution method for a common field operations problem. (Author abstract) 9 refs.

Yao, S.C. (Univ of Tulsa, Tulsa, OK, USA); Sylvester, N.D. *J Energy Resour Technol Trans ASME* v 109 n 4 Dec 1987 p 225-229.



**073015 EFFECT OF AN INITIAL GAS CONTENT ON THERMAL EOR AS APPLIED TO OIL SANDS.** This paper discusses the results of a number of physical model experiments on thermal EOR. Seven experiments were performed, three in which a 'dead' heavy oil was used, and four in which the oil sand was saturated with methane. For oils without an initial gas content, coinjection of CO<sub>2</sub> with steam was capable of improving oil recovery over that obtained with steam alone. When an initial dissolved gas was present, coinjection of CO<sub>2</sub> was not beneficial. Injection of CO<sub>2</sub> or CH<sub>4</sub> slugs just before steam injection was beneficial in increasing oil recovery for experiments where an initial dissolved gas was present. (Author abstract). 9 refs.

Frauenfeld, T.W.J. (Alberta Research Council, Can); Ridley, R.K.; Nguyen, D.M. *JPT J Pet Technol* v 40 n 3 Mar 1988 SPE 15086, p 333-338.

**073016 ENGINE-EXHAUST GAS OFFERS ALTERNATIVE FOR EOR.** The use of processed engine-exhaust gas as an injection fluid has proven to be an economic success in several site-specific EOR projects. The energy released in producing the inert gas is converted into mechanical energy, and the water in the combustion process is removed by waste heat from the exhaust gas. To provide a noncorrosive gas prior to reaching injection pressure, certain elements, (e.g., water, oxides of nitrogen, oxygen) must be removed. Generally, the air/fuel ratio to the engine is controlled to produce a minimum amount of combustibles and oxygen in the exhaust. Exhaust gas is treated to remove NO<sub>x</sub> and O<sub>2</sub> through a proprietary catalyst system and then dried between stages of compression.

Hlozek, Robert J. (Production Operators Inc, Houston, TX, USA). *Oil Gas J* v 83 n 13 Apr 1 1985 p 75-78.

**073017 NUMERICAL INVESTIGATION OF THE PROCESS OF DISPLACEMENT OF OIL BY STEAM.** A calculation model of the process of displacement of oil by steam, based on the equations of three-phase nonisothermal flow with allowance for phase transitions in the water-steam system, is proposed. This model is used for the numerical investigation of the recovery of oil from water-oil zones by means of steam injection. The extraction of oil from water-oil zones is one of the difficult problems of the theory of exploitation of petroleum deposits. The presence of two zones with sharply different fluid resistances leads to considerable nonuniformity in production rates. It is shown that injecting steam significantly reduces this nonuniformity. (Author abstract) 6 refs.

Bokserman, A.A.; Yakuba, S.I. *Fluid Dyn* v 22 n 4 Jul-Aug 1987 p 559-564.

**073018 POLYMERIZATION IN SUPERCRITICAL CO<sub>2</sub> TO IMPROVE CO<sub>2</sub>/OIL MOBILITY RATIOS.** The purpose of this work is to investigate the use of polymers to enhance the CO<sub>2</sub> phase viscosity. It is, however, different from the of Heller's work in that an attempt will be made to find monomers that are soluble in CO<sub>2</sub> under conditions similar to reservoir conditions. An initiator will then be added to the mixture in an attempt to generate a polymerization reaction. If a monomer can be polymerized and if the resulting polymer is soluble in the CO<sub>2</sub>, then the viscosity of the resulting mixture would be evaluated to determine whether it is higher than that of the pure CO<sub>2</sub> viscosity. If the viscosity can be raised by a factor of 20 to 30, then substantial improvement in sweep efficiency would be achieved. 25 refs.

Terry, Ronald E. (Univ of Wyoming, Laramie, WY, USA); Zaid, Alforji; Angelos, Cris; Whitman, David L. *Energy Prog* v 8 n 1 Mar 1988 p 48-53.

**073019 OIL WELL GAS CONDITIONS IN THERMOALKALINE METHOD OF ENHANCED OIL RECOVERY.** Industrial testing of the thermoalkaline effect on a petroleum-bearing formation has been carried out for the first time in Soviet oil production practice with the purpose of enhancing oil recovery. An analysis of the

atmosphere in different sections of the oil well in the course of the experiments has shown that the concentration of noxious impurities - carbon monoxide and dioxide, alkali, light and heavy hydrocarbons - does not exceed the maximum permissible values. This industrial experiment has demonstrated that it is safe for the servicing personnel to employ the thermoalkaline treatment of a formation to enhance oil recovery. (Translated author abstract) In Russian 7 refs.

Panov, G.E.; Tskhadaya, N.D.; Krupenskii, V.I. *Izv Vyssh Uchebn Zaved Neft Gaz* n 8 1987 p 31-33.

**073020 MATHEMATICAL MODELING ON THE PROCESS OF PETROLEUM DISPLACEMENT BY FLUE GAS.** A system of equations is presented describing the process of displacement of oil by flue gas. The mass exchange between the components of the displaced and displacing fluids is taken into account. A method of calculation of the process of displacement, as well as the method of replacement of the multicomponent mixture of the formation oil and the flue gas by a ternary system is considered. An example of calculation is presented and the results obtained are analyzed. (Translated author abstract) In Russian. 6 refs.

Gurevich, G.R.; Zazovskii, A.F. *Izv Vyssh Uchebn Zaved Neft Gaz* n 8 1987 p 49-54.

**073021 INFLUENCE OF AN ELECTRIC FIELD ON THE INTERFACIAL PARAMETERS OF A WATER/OIL/ROCK SYSTEM: APPLICATION TO OIL ENHANCED RECOVERY.** Experimental work was carried out to determine the influence of electrochemical phenomena on the interfacial tension and wettability parameters of three water/oil/rock systems. The reactions of the electrolysis products of brine on the carboxylic acids of oil were shown to result in the formation of surfactants directly at the water/oil interface. Their effect was to reduce significantly the interfacial tension and, in some cases, to modify the solid-liquid interactions. Applications of this phenomenon have been considered, especially as a method for enhanced oil recovery. (Author abstract) 28 refs.

Fleureau, Jean-Marie (CNRS, Chateau-Malabry, Fr); Dupeyrat, Monique. *J Colloid Interface Sci* v 123 n 1 May 1988 p 249-258.

**073022 DISPLACEMENT OF OIL BY CARBON DIOXIDE AND WATER UNDER VARIOUS GEOLOGICAL AND PHYSICAL CONDITIONS.** It is shown that, depending on the oil viscosity and the degree of inhomogeneity of the formation, alternating injection of CO<sub>2</sub> and water with eight or more cycles yields the same technological indices as combined injection of carbon dioxide and water with the same reagent concentration in the flow. In a homogeneous formation the dependence of the oil output increase on the oil viscosity has a characteristic minimum, in agreement with experimental data. In formations with medium and strong inhomogeneity, the additional oil output is fairly high for low-viscosity oils, but it decreases with an increase in viscosity. In the case of low-viscosity oils the effectiveness of the method is higher when the injected mixture contains a large proportion of CO<sub>2</sub>. With an increase in the oil viscosity the additional oil output in an inhomogeneous formation increases with a decrease in this proportion. In Russian. 6 refs.

Levi, B.I.; Shakirov, Kh.G. *Neft Khoz* n 2 1988 p 33-36.

**073023 TRANSVERSE DISPERSION IN SLUG-MODE CHEMICAL EOR PROCESSES IN STRATIFIED POROUS MEDIA.** Transverse dispersion in multilayered media of moderate permeability contrast has been examined experimentally and theoretically. Continuous and slug-mode displacements at unit and nonunit mobility ratios have been conducted in a layered beadpack model with a permeability contrast of approximately 3:1. Layer-width and residence-time effects have been quantified and scaled to core and reservoir dimensions. Transverse dispersion can be significant for reservoirs with layers less than 100 cm [40 in.] thick and

core material with layers less than 1 cm [0.4 in.] thick. The data can be used for validating simulation packages written for chemical dispersion. (Author abstract) 16 refs.

Wheat, Michael R. (Imperial Coll); Dawe, Richard A. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14890, p 466-478.

**073024 EFFECTS OF RESERVOIR HETEROGENEITY ON CHEMICALLY ENHANCED OIL RECOVERY.** A three-dimensional (3D), multiphase, multi-component micellar/ polymer flooding simulator has been used to investigate the process performance under different conditions of reservoir heterogeneity (stratifications) and mobility ratios. The significance of crossflow has been studied by relating chemical flood recoveries to the effective length-to-thickness ratio and the transverse dispersion number of the reservoir. A long-standing question in micellar/ polymer flooding concerns whether small, high-concentration chemical slugs are preferred to large lower-concentration slugs. This aspect of slug size vs. slug concentration has been studied in 3D in the presence of heterogeneity. (Edited author abstract) 22 refs.

Gupta, Akhil Datta (Standard Alaska Production Co); Pope, Gary A.; Sepehrnoori, Kamy; Shook, Mike. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14889, p 479-488.

**073025 EVALUATION OF MICROBIAL SYSTEMS IN POROUS MEDIA FOR EOR.** The use of microorganisms to enhance oil recovery has become a technically feasible technology for production from stripper wells (those that produce less than 10 B/D [1.6 m<sup>3</sup>/d]). As a result of microbial growth and the production of CO<sub>2</sub> and/or chemicals, oil recovery can be effectively increased in certain reservoirs with temperatures and salinities hospitable to microorganisms. Research at the Natl. Inst. for Petroleum and Energy Research has led to development of laboratory facilities for evaluating microbial systems for microbial enhanced oil recovery (MEOR) applications. Results from microbial core studies using Berea sandstone have shown that bacteria can vary greatly in their ability to recover residual oil after waterflooding, giving from 7.5 to 71% recovery efficiency. (Edited author abstract) 10 refs.

Bryant, Rebecca S. (IIT); Douglas, Jonell. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 16284, p 489-495.

**073026 MINIMUM MISCIBILITY PRESSURE PREDICTION WITH EQUATIONS OF STATE.** Prediction of the minimum miscibility pressure (MMP) of the vaporizing gas drive (VGD) process is modeled by use of an equation of state (EOS) with different mixing rules joined with a newly formulated expression for the unlike three-body interactions between the injection gas and the reservoir fluid. The comparison of the numerical results with the available experimental data indicates that an EOS alone overestimates the MMP. When the EOS is joined with the correct version of the van der Waals mixing rules and the unlike three-body interaction term, however, the MMP will be predicted accurately. (Author abstract) 16 refs.

Benmekki, E.H. (Univ of Illinois, IL, USA); Mansoori, G.A. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 15677, p 559-564.

**073027 INVESTIGATION OF FOAM STABILITY IN POROUS MEDIA AT ELEVATED TEMPERATURES.** A laboratory study is described of the factors controlling the formation and breakdown of foams in porous media at elevated temperatures. The degradation of a foam when gas injection was discontinued involved the gradual transformation of a foam with a noncondensable gas phase (gas foam) to a foam with steam as the gas phase (steam foam). The ability to prevent release of the noncondensable gas phase was strongly influenced by surfactant type and concentration. The formation of steam foams in the absence of noncondensable gas was a critical function of steam velocity and permeability. Surfactant



concentration and chain length, salinity, and the presence of oil were important variables in determining mobility reduction of steam. (Edited author abstract) 24 refs.

Isaacs, E. Eddy (Alberta Research Council, Can); McCarthy, F. Clare; Maund, J. Darol. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 15647, p 265-272.

**073028 MECHANISMS OF FOAM GENERATION IN GLASS-BEAD PACKS.** The fundamental, pore-level mechanisms of foam generation are investigated in mono-disperse bead packs. First, direct visual observations identify the following generation mechanisms: lamella leave-behind, gas-bubble snap-off, and lamella division. Then, to ascertain the relative importance of these mechanisms, quantitative experiments are pursued on the role of bead-pack permeability (bead sizes from 0.25 to 1 mm, gas-phase velocity, gas-phase fractional flow, permeability variations, and surfactant type. A simple model, based on the concept of a 'germination site', is developed to predict the onset of snap-off at higher gas velocities. (Edited author abstract) 26 refs.

Ransohoff, T.C. (Univ of California, CA, USA); Radke, C.J. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 15441, p 573-585.

**073029 LABORATORY INVESTIGATION OF HIGH-TEMPERATURE SURFACTANT FLOODING.** Experiments were conducted to evaluate the use of surfactants for improving heavy-oil recovery from the hot-water zone in a steamflood. Criteria used to screen surfactants for this high-temperature application included thermal stability, interfacial activity, and surfactant flood performance. The thermal stabilities of several classes of sulfonate surfactants were measured. Surfactants exhibiting no thermal decomposition at elevated temperature (500°F) were identified. The phase behavior between heavy crude oil and surfactant solution was determined over a temperature range from 150 to 350°F. Regions of high interfacial activity were generated by the addition of salt to the brine phase. Interfacial tension (IFT) measurements confirmed the high salinity requirement of the selected surfactant/brine/oil system at elevated temperature. (Edited author abstract) 30 refs.

Ziegler, V.M. (Chevron Oil Field Research Co). *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 13071, p 586-596.

**073030 SURFACTANTS FOR EOR: OLEFIN SULFONATE BEHAVIOR AT HIGH TEMPERATURE AND HARDNESS.** The surfactant properties usually required for EOR are investigated with alpha-olefin sulfonates (AOS's), particularly at high temperature, salinity, and hardness, together with their solubility in brine, chemical stability, phase behavior, and adsorption. The use of a cosolvent enables aqueous solutions to be prepared with concentrated brine, even at high divalent cation levels. But the chemical stability of some solutions can be affected by their sensitivity to the oxidation of unsaturated components, resulting in a decrease of the pH. Precautionary measures to stabilize the solutions are stressed - i.e., anaerobic environment, maintenance of an alkaline pH, or addition of alcohol. (Edited author abstract) 26 refs.

Baviere, Marc (Inst Francais du Petrole, Fr); Bazin, Brigitte; Noik, Christine. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14933, p 597-603.

**073031 EFFECT OF WETTABILITY ALTERATION ON WATER/OIL RELATIVE PERMEABILITY, DISPERSION, AND FLOWABLE SATURATION IN POROUS MEDIA.** Wettability alteration was shown to affect strongly water/oil two-phase flow behavior in Berea and Loudon reservoir cores. Two examples of wettability alteration were realized by core aging and core extraction. With a steady-state method coupled with tracer analyses, these changes in wettability were shown to affect relative permeabilities, dispersivities, and flowable saturations in the cores. The changes in wettability were also confirmed by waterfloods and spontaneous-imbibition tests. Dispersion in steady-state two-phase flow was found to be a strong function of saturation and wettability.

ity. Dispersivity of each phase increases with decreasing phase saturation. Flow of the nonwetting phase was dispersed much more than that of the wetting phase. (Edited author abstract) 17 refs.

Wang, F.H.L. (Exxon Production Research Co). *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 15019, p 617-628.

**073032 INVESTIGATION OF THE PARAMETERS OF MECHANICAL STRESS WAVES IN A SATURATED POROUS MEDIA.** The parameters of stress waves occurring during an electrical explosion in a saturated porous medium were investigated. The mechanical stresses in a model of an oil reservoir were recorded, and the regularities of the change in the amplitude of stress in porous medium in comparison with the regularities in the change in the amplitude of pressure in water were evaluated. The effect of an electrical explosion on the change in permeability of the reservoir model was determined. The results of the investigations permit recommending the creation of an electroexplosive device for reservoir stimulation. (Author abstract) 5 refs.

Sizonenko, O.N.; Malyushevskii, P.P.; Gorovenko, G.G.; Golubenko, Yu.G. *Sov Surf Eng Appl Electrochem* n 6 1987 p 69-73.

**073033 STATUS OF ENHANCED RECOVERY BY THERMAL METHODS.** This paper describes the main developments in thermal methods of oil recovery in recent years. Particular attention is devoted to work aimed at improving understanding of the physical and chemical mechanisms involved and at increasing the efficiency of thermal processes. Their preferred domain of application is described and illustrated by typical cases. The contribution of thermal recovery to oil production in the United States and worldwide is discussed. (Author abstract) 55 refs.

Burger, J. (Inst Francais du Petrole, Rueil-Malmaison, Fr). *Rev Inst Fr Pet* v 43 n 3 May-Jun 1988 p 307-322.

**073034 ANALYSIS OF THE LOW-TENSION PILOT AT BIG MUDDY FIELD, WYOMING.** Conoco Inc. initiated a low-tension pilot test in 1973 at the Big Muddy field east of Casper, WY. The process mobilized an oil bank ahead of the slug, reached a peak oil cut of 20 percent, and recovered 36 percent of the residual oil saturation (ROS). Tracers were injected in the preflush and postflush to determine swept volumes and distributions of flow. Tracer responses showed that more than 95 percent of the flow to the center well of the five-spot came from the two northern injection wells. The overall performance of the pilot was analyzed with a numerical simulator. As a result of the pilot and the supporting research, a nearby 90-acre [36.4-ha] commercial demonstration low-tension flood was initiated in 1980 and was operated as an EOR project until July 1985, although oil production still continues. (Author abstract) 13 refs.

Ferrell, H.H. (K&A Energy Consultants Inc, Tulsa, OK, USA); King, D.W.; Sheely, C.Q. Jr. *SPE Form Eval* v 3 n 2 Jun 1988 p 315-321.

**073035 EOR PAYING OFF IN PREMIAIN BASIN.** With five workover rigs running 7 days a week, Chevron U.S.A. is on a schedule that will have 87 water-injection wells at the North Ward Estes field converted for carbon dioxide injection during 1988 as part of Stage 1 of a three-stage enhanced oil recovery project. Additional wells will be converted during 1989. Another major CO<sub>2</sub> project reaching full stride is Amoco Production Co.'s effort to produce more oil from reservoirs in four West Texas units - three in the Slaughter field southwest of Lubbock (Slaughter Estate, Central Mallet, and Frazier) and one in the Wasson field near Denver City (Wasson ODC).

McNally, Rich (Petroleum Engineer Int, Cleveland, OH, USA). *Pet Eng Int* v 60 n 7 Jul 1988 p 34-36.

**073036 DRAINAGE PERFORMANCE AND CAPILLARY-PRESSURE CURVES WITH A NEW CENTRIFUGE.** A new centrifuge has been used to measure the drainage performance and the drainage capillary-pres-

sure function,  $P_c$  of various rock samples. The permeabilities of the rocks used for this study range from 0.1 to 700 md. A unique feature of the apparatus is that the rock sample is always in contact with the wetting phase at the outlet face so that the saturation boundary condition is known at this end. The drainage performance and  $P_c$  data for a variety of reservoir rock samples reported in this paper are expected to provide the basis for added insight into the drainage of oil from porous media. (Author abstract) 14 refs.

Firoozabadi, Abbas (Stanford Univ, USA); Soroosh, Hossein; Hasanpour, Gholambhossein. *JPT J Pet Technol* v 40 n 7 Jun 1988 p 913-919.

**073037 CROSSLINKED GELLED WATER IS OPTIMUM FRACTURE FLUID FOR SPRABERRY TREND IN WEST TEXAS.** Cumulative production data indicate that crosslinked gelled water is the optimum fracturing fluid for the Spraberry trend in West Texas. When different pump rates for crosslinked gelled water are used, lower rates appear to be optimum even though there is no consistency with higher rates. Several different proppant types and concentrations have been used in crosslinked gelled water treatments. It was found that oil production declines as higher proppant concentrations are pumped.

Hoel, Mark (Smith Energy Services, Midland, TX, USA). *Oil Gas J* v 86 n 33 Aug 15 1988 p 60-62,64,69.

**073038 REDUCTION OF POLYMER ADSORPTION ON RESERVOIR ROCKS.** The adsorption properties of polyacrylamides and xanthans on mineral surfaces carrying silanol and aluminol groups such as sand and kaolinite are described. The influence of the main parameters such as the nature of adsorption sites, surface charge, chemical structure and conformation of polymer and interactions of mono- and divalent ions with polymer and mineral surface has been investigated and interpreted. Some operating parameters in polymer flooding such as pH and salinity of the injected solution, the nature of the polymer and its degree of ionicity were found to be determining factors from the adsorption level. The results give key elements for reducing adsorption by a proper choice of the nature and ionicity of the polymer and of injection conditions. (Edited author abstract) 23 refs.

Chauveteau, G. (Inst Francais du Petrole, Rueil-Malmaison, Fr); Lecourtier, J.; Lee, L.T. *Rev Inst Fr Pet* v 43 n 4 Jul-Aug 1988 p 533-543.

**073039 VINYL SULFONATE/VINYL AMIDE COPOLYMERS AND DIFFERENT SURFACTANTS AS SUITABLE SYSTEMS IN EOR AT HIGHER TEMPERATURES AND SALINITIES.** The aim of the present article is to demonstrate the influence of alkylphenol ethoxylates and their corresponding ether sulfonates on VS/VA/AM copolymer solutions. Aqueous solutions of such copolymers were added to varying quantities of nonionic and anionic surfactants at different temperatures using salinity scans. This article discusses the results of experiments with solutions of copolymers and surfactants in terms of compatibility, viscosity yield, flow properties, shear stability, injectability, thermostability, and oil recovery. Solutions of alkylphenol ethoxylates and/or ether sulfonates show nearly the same compatibility within a broad range of temperature and salinity, both with and without polymers. Relatively small amounts of surfactants are able to influence the EOR (Enhanced Oil Recovery) properties of the polymer solutions, giving several interesting aspects for improved oil recovery. (Edited author abstract) 10 refs.

von Halasz, S.P. (Hoechst Aktiengesellschaft, Frankfurt am Main, West Ger). *Rev Inst Fr Pet* v 43 n 4 Jul-Aug 1988 p 545-553.



**073040 EFFECTS OF RELATIVE PERMEABILITY CHARACTERISTICS AND THERMAL CONDUCTIVITY ON IN SITU COMBUSTION PERFORMANCE.** A thermal simulator was used to simulate a laboratory in situ combustion run. Comparison between simulated and laboratory results shows that the simulator is adequate for this study. Results from the simulation study show that in situ combustion performance is sensitive to relative permeability characteristics and to the thermal conductivity of the formation. These parameters affect the amount of fuel available for combustion. This process, in turn, affects the recovery and air requirement for in situ combustion projects. (Edited author abstract). 10 Refs.

Onyekonwu, M.O. (Univ of Port Harcourt, Port Harcourt, Nigeria). *Energy (Oxford)* v 13 n 8 Aug 1988 p 619-624.

**073041 TIRRAWARRA AND MOORARI ENHANCED OIL RECOVERY PROJECTS - 'GETTING MORE OIL OUT FROM DOWN UNDER'.** The Tirrawarra and Moorari oilfields are located in the South Australian portion of the Cooper Basin. Production to date in the fields has been maintained primarily by infill drilling, with individual wells showing substantial declines in productivity. In 1984 pilot gas injection floods were initiated in both the Tirrawarra and Moorari fields to test the effectiveness of pressure maintenance and the miscible process in the Tirrawarra Sandstone. The results of the pilot injection programs have been most promising: production has improved in most offset producing wells with no sign of early injection gas breakthrough. (Edited author abstract) 4 refs.

Brown, D.J. (Santos Ltd, Adelaide, Aust); Barley, M.R. *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 389-396.

**073042 GRIFFITHS MODEL OF TRICRITICAL BEHAVIOR AND ITS APPLICATION, TO THE DESIGN OF ENHANCED OIL RECOVERY PROCESSES.** This paper describes a strategy for the surfactant design based on the relationship between the residual oil saturation and the thermodynamical state of the mixture appearing in the subsurface. More specifically, the suggested approach utilizes the fact that the amount of residual oil is controlled by the thermodynamical distance separating the state of the mixture from a tricritical point. The interfacial tensions between the coexisting phases are derived from a mathematical model combining the van der Waals definition of an interface and the Griffiths thermodynamic model of phase equilibria in the vicinity of a tricritical point. (Edited author abstract) 21 refs.

Winter, A. (Geological Survey of Denmark, Copenhagen, Den). *PCH PhysicoChem Hydrodyn* v 9 n 3-4 1987, 6th Int Conf, Oxford, Engl, Apr 6-8 1987 p 589-603.

**073043 PROCEEDINGS - SPE/DOE SIXTH SYMPOSIUM ON ENHANCED OIL RECOVERY.** This conference proceedings contains 72 papers on recent developments in enhanced oil recovery technology. The major topics include gas flooding, injection, petroleum reservoir engineering, reservoir computer simulation and mathematical modelling, fluid flow in porous media, applications at polymers, gels and foams, miscible displacement, mobility control, corefloods, heterogeneous reservoir characteristics, history matching, and permeability variations. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11299 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Soc of Petroleum Engineers, Mid-Continent Section, USA). *Soc Pet Eng AIME Pap SPE Proc - SPE/DOE Sixth Symp on Enhanced Oil Recovery*, Tulsa, OK, USA, Apr 17-20 1988. Publ by Soc of Petroleum Engineers, Richardson, TX, USA, 1988 936p.

**073044 PROCEEDINGS - 1988 CALIFORNIA REGIONAL MEETING: THE ENGINEERING CHALLENGE OF TODAY'S ECONOMICS.** This conference proceedings contains 69 papers, 16 of which are in

abstract form only. A wide range of topics in petroleum technology are covered. These include enhanced oil recovery (EDR) via steam flooding, water flooding, and core flooding; oil well fracturing and testing, reservoir simulation fluid flow analysis in reservoir, formation damage, logging, history matching, oil prices and marketing, oil well production performance, and completion. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11298 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Soc of Petroleum Engineers, Los Angeles Basin Section, Los Angeles, CA, USA). *Soc Pet Eng AIME Pap SPE* 1988, Proc - 1988 Calif Reg Meet: the Eng Challenge of Today's Econ, Long Beach, CA, USA, Mar 23-25 1988. Publ by Soc of Petroleum Engineers, Richardson, TX, USA, 1988 639p.

## Environmental Impact

**073045 WATER POLLUTION FROM OIL AND GAS RECOVERY IN EASTERN KENTUCKY WATERSHEDS.** The effects of water quality on brine discharged from oil and gas recovery operations are described for surface water and ground water in two small watersheds in eastern Kentucky. The brine, which had salinity that was often several times that of sea water, led to significantly higher concentrations of several minerals in surface water, particularly in the first and second order streams. Concentrations as high as 50,000 mg/l for sodium and 64,000 mg/l for chloride were measured in streams. The differences in chemical concentrations for various chemicals over the period of the study were ascribed to temporal variability, particularly due to differences between wet and dry seasons, and to spatial variability, particularly due to dilution and other chemical decay processes. Additional study results are discussed. (Edited author abstract) 23 refs.

Sidhu, Amarjit (Frankfort Office Park, Frankfort, KY, USA); Mitsch, William J. *Water Resour Bull* v 23 n 5 Oct 1987 p 943-953.

## Estimation

**073046 ESTIMATION OF PRODUCTIVITY OF LOBO 6 SAND, LOWER WILCOX, TEXAS, BY IDENTIFYING DIAGENETIC CLAYS WITH WELL LOG DATA.** The laminated, structural, and grain-coating primary clays in the Lower Wilcox Sand, Lobo 6, tend to be potassium-bearing illite and some smectite, whereas diagenetic clays, the cause of pore-throat plugging, are largely potassium-deficient kaolinite and chlorite. These diagenetic clays largely control reservoir permeability, depending on the degree of pore-throat plugging. This paper presents different methods for qualitative and quantitative evaluation of these diagenetic clays, which are related to productivity of the Lobo 6 sand. Qualitative evaluation consists of crossplot techniques using natural spectral gamma ray and other log data plus selected computed reservoir parameters. For quantitative evaluation, a sophisticated clay-analysis program that uses log-derived cation exchange capacity (CEC) and hydrogen index (HI) values is used. (Edited author abstract).

Berilgen, B.A. (Forest Oil Corp); Sinha, A.K.; Ferti, W.H. *SPE Form Eval* v 3 n 2 Jun 1988 p 393-406.

## Evaluation See OIL WELL DRILLING—Drilling Fluids.

## Filtration

**073047 PROLECTAREA FILTRELOR CU PIETRIS (GRAVEL PACKING), IN VEDEREA INSTALĂRII ÎN SONDA, ÎN DREPTUL STRĂLUTULUI PRODUCTIV. [Gravel-Packed Filter Design for Well Installation in Line with the Productive Bed].** The design method for gravel packing is presented, outlining the criteria taken into account, the step by step solving methodology and an example of design for a given case. In this context the following aspects are pointed out: the mechanism of retaining the sand from the productive bed by the gravel packing; the concept of gravel - sand ratio

and its determination. (Edited author abstract) In Romanian. 4 refs.

Tocan, I. (Inst de Petrol si Gaze, Ploiesti, Rom). *Mine Pet Gaze* v 38 n 6 Jun 1987 p 268-273.

**Flooding** See Also EQUATIONS OF STATE—Liquids; FLOW OF FLUIDS—Porous Materials; OIL SANDS—Calculations; OIL WELL DRILLING—Core; OIL WELLS—Mathematical Models; PETROLEUM RESERVOIR ENGINEERING—Mathematical Models; SANDSTONE—Composition Effects; SILICA—Dissolution; WATER POLLUTION—Marine Pollution.

**073048 SUBZONE REDEVELOPMENT OF THE LONG BEACH UNIT, WILMINGTON OIL FIELD: A CASE STUDY.** A major program of infill subzone redevelopment to improve vertical waterflood conformance has been successful in materially improving oil recovery performance in the Long Beach Unit of the Wilmington oil field, CA. The well completions in individual subzones or layers will result in greatly improved future reservoir management opportunities through individual subzone or layer monitoring and control. (Author abstract) 3 refs.

Robertson, Jack A.; Blesener, Jeffery A.; Soo Hoo, Samuel. *JPT J Pet Technol* v 39 n 10 Oct 1987 SPE 15101, p 1229-1236.

**073049 MALJAMAR CO<sub>2</sub> PILOT: REVIEW AND RESULTS.** This paper presents the results of a CO<sub>2</sub> flood pilot performed in the Permian Age carbonate rock formations of the Maljamar Cooperative Agreement (MCA) Unit. Field background and pilot development are reviewed. Injection and production history are presented, along with an evaluation of the pilot. A summary of the observation well logging results is also given. (Author abstract) 4 refs.

Pittaway, K.R. (Conoco Inc); Albright, J.C.; Hoover, J.W.; Moore, J.S. *JPT J Pet Technol* v 39 n 10 Oct 1987 SPE 14940, p 1256-1260.

**073050 JOBO STEAMFLOOD PROJECT: EVALUATION OF RESULTS.** This paper presents a description and a preliminary evaluation of the Jobo steamflood project, located in eastern Venezuela, from startup in March 1981 through Dec. 1986. The Jobo project consists of a steamdrive at original reservoir pressure conditions (1,300 psia [8.96 MPa]) because an active aquifer supporting this reservoir prevents pressure depletion by primary steam-stimulated production. The primary recovery estimated for this 8.5° API [1.01-g/cm<sup>3</sup>] accumulation of 10% stock-tank original oil in place (OOIP) is expected to increase to above 45% by steamflooding. To date, 36.2% of the project's stock-tank OOIP has been produced, and steam breakthrough is expected to occur during 1988. (Edited author abstract) 7 refs.

McGee, James H. (Lagoven SA). *JPT J Pet Technol* v 39 n 10 Oct 1987 SPE 15649, p 1261-1268.

**073051 PROPOSED TECHNIQUE FOR SIMULATION OF VISCOUS FINGERING IN ONE-DIMENSIONAL IMMISCIBLE FLOW.** Theoretical and experimental results indicate that viscous fingering in one-dimensional oil-water displacement processes, scaled to field conditions in mixed wettability systems with very wide range of unfavorable mobility ratios, may be simulated simply by using one set of relative permeability values. The set may be calculated directly from data obtained on water flooding experiments. (Edited author abstract) 7 refs.

Odeh, Aziz S. (Mobil R&D Corp). *Soc Pet Eng AIME Pap SPE Unsolicited Manuscr Sep 1987 SPE 017087, 25p.*

**073052 MINERAL DISSOLUTION, PRECIPITATION, AND ION EXCHANGE IN SURFACTANT FLOODING.** The transient retention of an anionic surfactant below the critical micellar concentration flowing in an argilo-calcareous sandstone is shown to depend



mainly upon: (1) the dissolution of trace amounts of calcium carbonate contained in the sandstone and (2) precipitation and redissolution of the surfactant with calcium ions due to carbonate dissolution or ion exchange on the clays. The adsorption process on solid surfaces is secondary, due to a high pH resulting from the presence of carbonates. A predictive model is developed. It is compared with typical surfactant breakthrough curves and demonstrates that dissolution of calcite is the main process affecting the transport of surfactant close to the injection point. (Author abstract) 33 refs.

Krebs, R. (CNRS, Nancy, Fr); Sardin, M.; Schweich, D. *AIChE J* v 33 n 8 Aug 1987 p 1371-1378.

**073053 BACTERIA CAN PLUG WATERFLOOD INJECTION WELLS.** Laboratory models were constructed to study the injection conditions frequently found in working bore holes, i.e., through perforations full of sand. Our models have incorporated different combinations of loose sand and sandstone to represent the dirty well conditions and formation rock, respectively. This study has attempted to answer the question, "Does the presence of sand in the bore hole influence formation plugging during water flooding?" The bacterium used in our study was isolated from produced waters and injected through the model cores in concentrations similar to those reported in oil well waters. We conclude that stimulation of an injection well would be more efficient if the dirty well was first cleaned up. In the design of a stimulation program to improve injectivity, we suggest that the loose sand be removed before implementing a series of bleach, or bleach acid treatments. This should reduce some of the bacterial plugging and free the perforations for further treatment. 11 refs.

Cusack, F. (Univ of Calgary, Calgary, Alberta, Can); Lappin-Scott, H.M.; Costerton, J.W. *Oil Gas J* v 85 n 45 Nov 9 1987 p 59-60, 62, 64.

**073054 MISCIBLE DISPLACEMENT OF CRUDE OIL BY CO<sub>2</sub>/SO<sub>2</sub> MIXTURES.** Slim-tube displacement tests on a Pembina Cardium stock-tank oil using CO<sub>2</sub>, SO<sub>2</sub>, and four CO<sub>2</sub>/SO<sub>2</sub> mixtures as the flooding agents demonstrated that the mixtures have lower minimum miscibility pressures (MMP's) than both pure components. More oil was recovered from Berea sandstone cores when CO<sub>2</sub> and a CO<sub>2</sub>/SO<sub>2</sub> mixture were the flooding agents than when SO<sub>2</sub> was used. Carbon dioxide and the CO<sub>2</sub>/SO<sub>2</sub> mixture recovered comparable quantities of oil from Indiana limestone, while a severe loss of permeability was observed in the corresponding SO<sub>2</sub> flood. Rock/fluid interactions characterized by mineral dissolution and precipitation were observed with all flooding agents in both rock types. (Edited author abstract) 19 refs.

Sayegh, S.G. (Petroleum Recovery Inst); Krause, F.F.; Fosti, J.E. *SPE Reservoir Eng* v 2 n 2 May 1987 p 199-208.

**073055 INFILL DRILLING IN A STEAMFLOOD OPERATION: KERN RIVER FIELD.** An infill well program involving 574 wells in previously steamflooded idle reservoirs proved to be economical and increased recovery in some areas from 50 to 58%. These wells were recompleted to zones under active steam drive and showed similar recovery increases in addition to acceleration of reserves. These increases in recovery were attained without additional fuel. (Author abstract) 13 refs.

Restine, J.L. (Texaco Inc); Graves, W.G.; Elias, R. Jr. *SPE Reservoir Eng* v 2 n 2 May 1987 p 243-248.

**073056 EVOLUTION OF THE CARBON DIOXIDE FLOODING PROCESSES.** This paper briefly reviews the evolution of the CO<sub>2</sub> flooding processes as they are most commonly applied today. The important features of CO<sub>2</sub> flooding, which have been defined by extensive laboratory research and field testing, are summarized. Included are summaries of (1) early developments in the use of CO<sub>2</sub>, (2) oil displacement mechanisms of CO<sub>2</sub>, and (3) other factors involved in the design of CO<sub>2</sub> floods, i.e., CO<sub>2</sub> availability, CO<sub>2</sub> injection requirements, mobility control, reservoir conditions, safety, CO<sub>2</sub> reinjection,

corrosion, and solids precipitation. (Edited author abstract) 30 refs.

Holm, L. Wally (Unocal Co). *JPT J Pet Technol* v 39 n 11 Nov 1987 p 1337-1342.

**073057 DESCRIPTION OF AN IMPROVED COMPOSITIONAL MICELLAR/POLYMER SIMULATOR.** A description is given of a micellar/polymer or chemical flood simulator and compare it to experimental data. A three-dimensional version of this simulator has been developed, but in this paper we describe only the one-dimensional (1D) flow equations because we focus on comparisons with linear coreflood data and related physical properties. All physical property models are the same in both versions, however. The property models described in this paper are (1) inaccessible PV, (2) permeability reduction, (3) polymer-phase viscosity, (4) adsorption, (5) residual phase saturations as a function of capillary number, and (6) relative permeabilities. (Edited author abstract) 20 refs.

Camilleri, D. (Univ of Texas, TX, USA); Engelsen, S.; Lake, L.W.; Lin, E.C.; Ohno, T.; Pope, G.; Sepehrmoori, K. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 13967, p 427-432.

**073058 IMPROVEMENTS IN PHYSICAL-PROPERTY MODELS USED IN MICELLAR/POLYMER FLOODING.** Various physical-property models required by chemical flood simulators have been improved and others developed. The most significant development in the use of pseudophases to model phase behavior. The method allows representation of four pseudocomponents. This is made possible by assuming that alcohol is distributed among the other three pseudocomponents, thus forming three pseudophases that are assumed to be in thermodynamic equilibrium. Another improvement relates to the ion-exchange model. Cations are considered to exchange with both surfactant micelles and clays. The model assumes the exchange to be entirely a result of electrostatic association. A model for treating physical dispersion coefficients as a function of saturations has been added. The model is based on experimental evidence and is purely empirical. (Edited author abstract) 25 refs.

Camilleri, D. (Univ of Texas, TX, USA); Fil, A.; Pope, G.A.; Rouse, B.A.; Sepehrmoori, K. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 12723, p 433-440.

**073059 COMPARISON OF AN IMPROVED COMPOSITIONAL MICELLAR/POLYMER SIMULATOR WITH LABORATORY COREFLOODS.** The authors compare numerical simulations made with our previously reported simulator with both our own and literature experiments. The most significant improvement concerns the phase behavior model used in the simulator. The new model approximately represents the phase behavior of pseudoquaternary mixtures containing surfactant, cosurfactant, oil, and brine. The different effects of sodium and calcium cations in the mixtures are accounted for with a new cation exchange model allowing for exchange with both clays and micelles. A tertiary oilflood experiment is reported that includes a more complete analysis of phase compositions and properties than generally available previously. Produced samples were analyzed for surfactant, alcohol, sodium, calcium, polymer, tritium, water, carbon-14-tagged decane, and decane. (Edited author abstract) 27 refs.

Camilleri, Dominic (Univ of Texas, TX, USA); Fil, Andre; Pope, G.A.; Rouse, B.A.; Sepehrmoori, Kamy. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 12083, p 441-451.

**073060 METHOD FOR LABORATORY AND FIELD EVALUATION OF A PROPOSED POLYMER FLOOD.** The relevant components of a proposed polymer flood in the Tensleep reservoir of the Frannie Phosphoria-Tensleep Unit in Park County, WY, were investigated. Laboratory testing consisted of polymer injectivity, stability, retention, and effective viscosity measurements. On the basis of polymer viscosity and retention tests, a polysaccharide polymer was chosen over a polyacrylamide polymer for extensive laboratory evalua-

tion and field pilot tests. Field testing included injectivity, biological stability, and in-situ viscosity measurements. Pressure falloff tests following variable-rate injection of a polysaccharide polymer solution indicated the presence of a non-Newtonian, low-mobility bank. (Edited author abstract) 1 ref.

Castagno, Richard E. (Conoco Inc); Shupe, Russell D.; Gregory, M. Duane; Lescarbourea, Jaime A. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 13124, p 452-460.

**073061 EFFECT OF OIL COMPOSITION ON MINIMUM MISCIBILITY PRESSURE - PART 1: SOLUBILITY OF HYDROCARBONS IN DENSE CO<sub>2</sub>.** This paper examines the effect of oil composition on the phase behavior of CO<sub>2</sub>/hydrocarbon mixtures and, hence, on the development of miscibility in a CO<sub>2</sub> flood. Results of component-partitioning measurements are reported for mixtures of CO<sub>2</sub> with five synthetic oil systems: normal alkanes, branched alkanes, naphthenes, aromatics, and a mixture of all four molecular types. The results of the experiments indicate that unsubstituted ring structures are less soluble in dense CO<sub>2</sub> than branched or normal alkanes with the same number of carbon atoms, but that the addition of alkyl side chains to ring structures improves their solubility. Also reported are component-partitioning measurements for mixtures of CO<sub>2</sub> with three crude oils: Rock Creek (paraffinic), Maljamar (more aromatic), and Rock Creek plus 15 wt% of a mixture of aromatic components. (Edited author abstract) 33 refs.

Silva, M.K. (New Mexico Petroleum Recovery Research Cent, NM, USA); Orr, F.M. Jr. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14149, p 468-478.

**073062 EFFECT OF OIL COMPOSITION ON MINIMUM MISCIBILITY PRESSURE - PART 2: CORRELATION.** A new correlation for CO<sub>2</sub> minimum miscibility pressure (MMP) is proposed and tested. The correlation is based on experimental evidence that extraction of hydrocarbons from a crude oil depends most strongly on the size of the hydrocarbon molecules. Thus, an oil rich in hydrocarbons that are efficiently extracted should show a lower MMP than a heavier oil. The only crude-oil data needed for use of the correlation are a carbon-number distribution, which can be obtained easily by chromatography. The density of CO<sub>2</sub> at the MMP is correlated against a weighted-composition parameter. The proposed correlation produces MMP estimates accurate to within about 10% for most oils. (Edited author abstract) 37 refs.

Orr, F.M. Jr. (Stanford Univ, CA, USA); Silva, M.K. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14150, p 479-491.

**073063 INTERPRETATION OF MISCIBLE DISPLACEMENTS IN LABORATORY CORES.** Results of stable, first-contact miscible displacements are presented for three San Andres carbonate cores from west Texas and eastern New Mexico. All three cores showed evidence of significant heterogeneity at the core scale. Effluent composition measurements were interpreted with two relatively simple models of mixing during flow in heterogeneous porous media: the Coats-Smith (CS) model, which represents the pore space as flowing and stagnant fractions with mass transfer between them, and a porous sphere (PS) model, which describes flow between an assemblage of porous spheres with diffusive interchange of material in the spheres with fluid flowing past them. Parameters for the two models are reported and compared. (Edited author abstract) 24 refs.

Bretz, Robert E. (New Mexico Inst of Mining & Technology, NM, USA); Orr, Franklin M. Jr. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14898, p 492-500.

**073064 DETAILED SIMULATION OF UNSTABLE PROCESSES IN MISCIBLE FLOODING.** This paper describes applications of linear and nonlinear simulations to unstable miscible flooding. The first section describes a method of calculating linear growth of unstable modes by use of finite differences in the direction of flow and Fourier



decomposition perpendicular to flow. The second section describes the numerical scheme for calculations on a fine grid of the nonlinear development of an instability. Results are presented on calculations of nonlinear growth at several mobility ratios and levels of diffusion. (Edited author abstract) 21 refs.

Christie, M.A. (BP Research Cent, Engl); Bond, D.J. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14896, p 514-522.

**073065 RAPID MEASUREMENT OF MINIMUM MISCIBILITY PRESSURE WITH THE RISING-BUBBLE APPARATUS.** The minimum miscibility pressure (MMP) for a gas/oil pair can be measured within 1 hour with the rising-bubble apparatus (RBA). Development of miscibility between a gas bubble and an oil can be observed visually. The measurements of the MMP with the RBA compare favorably with those based on slim-tube experiments and predictions from phase-behavior studies. (Author abstract) 12 refs.

Christiansen, Richard L. (Marathon Oil Co); Haines, Hiemi Kim. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 13114, p 523-527.

**073066 APPLICATION OF GRADIENT THEORY OF INHOMOGENEOUS FLUID TO PREDICTION OF LOW INTERFACIAL TENSIONS IN CO<sub>2</sub>/HYDROCARBON SYSTEMS.** M. Sahimi, H.T. Davis, and L.E. Scriven recently presented predictions of interfacial tensions (IFT's) for CO<sub>2</sub>/hydrocarbon systems using the gradient theory of inhomogeneous fluid (GTIF) model. In the present paper, additional calculations from the GTIF model are presented at low IFT's, and comparisons are made with experimental measurements. The results show that the GTIF model predicts 'classical' scaling behavior at low IFT's, in conflict with experimental observations. Thus, while the GTIF model has been documented by its authors to yield good predictions at high and moderate levels of IFT, it could be inappropriate for use at the low levels of IFT ( $\sigma < 0.1$  mN/m [0.1 dynes/cm]) that may be required to enhance the oil displacement efficiencies in enhanced gas drives. (Author abstract) 28 refs.

Gupta, Mukesh K. (Oklahoma State Univ, OK, USA); Robinson, Robert L. Jr. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14699, p 528-530.

**073067 PREDICTION OF CO<sub>2</sub> FLOOD PERFORMANCE: INTERACTION OF PHASE BEHAVIOR WITH MICROSCOPIC PORE STRUCTURE HETEROGENEITY.** This paper describes simulations of the effects of microscopic heterogeneity present in rock pore structures or resulting from high water saturations on the performance of one-dimensional (1D) CO<sub>2</sub> floods. In the simulations, microscopic heterogeneity was represented by dividing the nonaqueous portion of the pore space into flowing, dendritic, and trapped fractions. A 1D simulator, previously shown to model quantitatively the effects of phase behavior in slim-tube displacements, was modified to include effects of the isolated or trapped fraction unavailable for mixing with injected fluids and the dendritic fraction, which exchanges material with the flowing fraction by mass transfer. Model formulation, numerical solution, and validation tests are described. (Edited author abstract) 27 refs.

Dai, K.K. (New Mexico Inst of Mining & Technology, NM, USA); Orr, F.M. Jr. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 13115, p 531-542.

**073068 DISPLACEMENT OF VISCOUS OIL FROM CONSOLIDATED CORES BY CAUSTIC AT TEMPERATURES ABOVE 257°F.** Laboratory data were obtained to investigate the use of alkaline material with or without a small amount of surfactant as an additive to steam to enhance oil recovery from that portion of a reservoir subjected to a hot waterflood in a conventional steamflood. A series of hot alkaline floods (some containing surfactant) was performed on fired cores previously subjected to a hot waterflood in an isothermal flooding apparatus with temperatures as high as 356°F [180°C]. Floods with no previous waterflood were also

tested. Results show that tertiary recovery increases with increasing temperature, increasing flood rate, increasing salt concentration in the injected caustic, and the addition of surfactant. (Edited author abstract) 18 refs.

Mehdizadeh, Amrollah (Univ of Southern California, CA, USA); Handy, Lyman L. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 12040, p 599-604.

**073069 SURFACTANT FLOODING WITH HARD WATER: A CASE STUDY SOLVED BY HLB GRADIENT.** Surfactant formulations were designed for field application of micellar processes in a salty environment on the basis of a mixture of one synthetic sulfonate with two types of nonionic agents. This formulation led to the required Winsor-III-type phase diagram in the presence of reservoir fluids at reservoir temperature. The main difficulty in this study was the high level of surfactant retention in the reservoir rock. The sacrificial agents tested did not reduce these surfactant losses significantly. The solution found to be efficient consisted of creating a hydrophilic-lipophile balance (HLB) gradient of the additives used in situ by injecting a desorbing agent with high HLB behind the micellar slug containing the nonionic cosurfactants with lower HLB. (Edited author abstract) 19 refs.

Minssieux, Louis (Inst Francais du Petrole, Fr). *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14292, p 605-612.

**073070 SURFACTANT FLOODING CARBONATE RESERVOIRS.** This paper presents data obtained in two well-pair surfactant floods undertaken in the San Andres formation, Bob Slaughter Block, Hockley County, Texas. The data provided by these tests demonstrate (1) low-permeability carbonate reservoirs can be chemically flooded, (2) polymer can be injected and propagated in these reservoirs without any biodegradation, (3) these systems can mobilize tertiary oil effectively at a chemical consumption near that observed in the laboratory, and (4) two-well tests can provide a quick field evaluation of surfactant systems proposed for large-scale use. (Edited author abstract)

Adams, Wilton T. (Texaco Inc); Schievelbein, Vernon H. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 12686, p 619-626.

**073071 GRAVITY EFFECTS IN THE DISPLACEMENT OF OIL BY SURFACTANT SOLUTIONS.** The displacement of isooctane by aqueous surfactant solutions was investigated in model porous media consisting of a thin layer of lightly sintered glass beads. Pre-equilibrated oil/surfactant pairs were prepared that exhibited interfacial tensions (IFT's) in the range 0.06 to 2.08 mN/m [0.06 to 2.08 dynes/cm]. Because aqueous solution viscosity was always higher than that of the isooctane, a stable displacement would normally be expected. While systems with IFT's greater than about 1 mN/m [1 dyne/cm] showed sharp interfaces and generally stable displacements, experiments conducted at lower IFT exhibited a considerable degree of instability. In particular, at lower tensions, the interfaces became fuzzy, and there was distinct evidence of gravity override by the aqueous phase. (Edited author abstract) 13 refs.

Hornof, V. (Univ of Ottawa, Ont, Can); Morrow, N.R. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 13573, p 627-633.

**073072 IN-SITU GEL CALCULATIONS IN COMPLEX RESERVOIR SYSTEMS USING A NEW CHEMICAL FLOOD SIMULATOR.** This paper presents results for a series of calculations on the deep emplacement of a polymer gel in a stratified reservoir model. These calculations were performed with a new chemical flooding simulator that has the facility to describe generalized chemical reactions between components. This code is described, and preliminary calculations on an in-situ gel treatment in a large model reservoir are presented. We find that to obtain significant amounts of incremental oil while avoiding very large pressure buildup, the polymer gel system must have the correct combination of long gelation times and good permeability-reducing

properties in the high-permeability streak (residual resistance factor  $F_R$  approx. 10 to 40 in the cases studied here). (Edited author abstract) 23 refs.

Scott, T. (UKAEA, Engl); Roberts, L.J.; Sharpe, S.R.; Clifford, P.J.; Sorbie, K.S. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14234, p 634-646.

**073073 BIOCIDES EVALUATION AGAINST SESILE XANTHAN POLYMER-DEGRADING BACTERIA.** This paper supports the use of formaldehyde at economically feasible concentrations as a biocide for EOR processes that use xanthan biopolymer. Its biocidal action against anaerobic sessile xanthan-degrading field organisms was clearly superior to three other biocides tested when 100% kill was used as the criterion for effectiveness. These findings are especially significant in conjunction with the earlier report of successful use of formaldehyde to protect xanthan from microbial degradation in a pilot field test. 11 refs.

O'Leary, W.B. (Technical Services Ltd); Boivin, J.W.; Dasinger, B.L.; Beck, D.; Goldman, I.M.; Wernau, W.C. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 13588, p 647-652.

**073074 STUDY OF MINERAL/ALKALI REACTIONS.** A study of the reaction of alkaline chemicals with minerals constituting reservoir rock is presented. Static tests were conducted with high concentrations of NaOH and orthosilicate solutions and minerals (montmorillonite, kaolinite, illite, and quartz sand). The reaction time varied from 10 minutes to 2 months. Solutions were analyzed for hydroxide, Si, and Al, and solids were analyzed by X-ray diffraction (XRD) and other spectroscopic techniques. The loss of useful alkalinity was the highest with kaolinite and the least with quartz sand for high alkali concentration (5 wt%) or temperature (180°F [82°C]). A detailed study of kaolinite/alkali reaction kinetics and quartz/alkali equilibrium is presented. (Author abstract) 54 refs.

Mohnot, S.M. (Gulf R&D Co); Bae, J.H.; Foley, W.L. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 13032, p 653-663.

**073075 VISCOSITY AND PHASE BEHAVIOR OF PETROLEUM SULFONATE SOLUTIONS IN THE LIQUID CRYSTALLINE REGION.** Aqueous solutions of two petroleum sulfonate surfactants, a pure sulfonate surfactant and one mixed with an ethoxylated sulfate surfactant, were studied with polarizing microscopy, polarized light screening (PLS), and viscometry. The same sequence of phases was seen with increasing salinity for the various surfactants - i.e., transformation from an isotropic micellar solution to a lamellar liquid crystalline phase to an isotropic phase that scattered light and exhibited streaming birefringence. Addition of calcium ions to the petroleum-sulfonate/ethoxylated-sulfate mixtures led to the same basic sequence of transformations, but the effect of calcium was about 11.5 times as great as that of sodium on a molar basis. It was found that apparent viscosity decreased with increasing shear rates and was time-dependent at a given shear rate. (Edited author abstract) 32 refs.

Benton, W.J. (Rice Univ, USA); Baijal, S.K.; Ghosh, O.; Qutubuddin, Syed; Miller, C.A. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 12700, p 664-670.

**073076 CYCLING WITH AIR AND OTHER NON-HYDROCARBON GASES.** Injecting lean gas into condensate reservoirs is a practice currently used to increase recovery. The process reduces condensation and increases liquid recovery by revaporization. However, delaying natural gas sales for long periods of time is economically unattractive. The purpose of this paper is to investigate the effectiveness of nonhydrocarbon gases (i.e., air, N<sub>2</sub>, and CO<sub>2</sub>) for improving recovery from retrograde condensate reservoirs. A compositional model that uses the Peng-Robinson equation of state (PR-EOS) was developed to evaluate condensate reservoir performance. A



15-component hydrocarbon system and extensive experimental data were used in the study. The model shows that nonhydrocarbon gases can vaporize hydrocarbon liquids effectively, with CO<sub>2</sub> the most effective nonhydrocarbon for vaporizing heavy fractions. (Edited author abstract) 11 refs.

Striefel, M.A. (Montana Coll of Mineral Science & Technology, MT, USA); Ahmed, T.H.; Cady, G.V. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 13229, p 683-686.

**073077 FOUR-PHASE FLASH EQUILIBRIUM CALCULATIONS USING THE PENG-ROBINSON EQUATION OF STATE AND A MIXING RULE FOR ASYMMETRIC SYSTEMS.** A technique for predicting one- to four-phase flash equilibrium is presented for multicomponent systems containing water, such as CO<sub>2</sub>/crude-oil/H<sub>2</sub>O mixtures that characterize the CO<sub>2</sub> miscible flooding of petroleum reservoirs. The Peng-Robinson equation of state (PR-EOS) is used to describe the aqueous and hydrocarbon phases, and an accelerated and stabilized successive-substitution method is used to obtain convergence, even in the near-critical region. In order to describe accurately multiphase equilibria involving water, a recently developed mixing rule for asymmetric systems is incorporated that permits the solubilities of both CO<sub>2</sub> in H<sub>2</sub>O and H<sub>2</sub>O in CO<sub>2</sub> to be modeled. The equation of state (EOS) is also modified to enable the aqueous-phase density to be predicted accurately. (Edited author abstract) 33 refs.

Enick, Robert M. (Univ of Pittsburgh, PA, USA); Holder, Gerald D.; Mohamed, Rahoma. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14148, p 687-694.

**073078 COMPUTER IMAGE PROCESSING: A NEW TOOL FOR STUDYING VISCOUS FINGERING IN COREFLOODS.** Computer image processing technology was used to study the patterns of viscous fingering in laboratory corefloods. The fingering patterns in unstable immiscible corefloods were captured and photographed with the aid of a fluorescent dye. The photographs were digitized and stored as computer image files for subsequent processing. A program was written to count the fingers, to determine their sizes, to compute the sweep efficiencies at the core cross sections, and to determine the frequency contents of the fingering patterns. Results show that computer image processing technology can be used to study the performance of laboratory corefloods quantitatively. (Edited author abstract) 31 refs.

Peters, Ekwe J. (Univ of Texas, TX, USA); Broman, John A.; Broman, William H. Jr. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 13668, p 720-728.

**073079 POLYMER FLOODING REVIEW.** This paper reviews published results of the use of polymers to improve oil recovery. A discussion of the capabilities of the available types of polymers and where they have been successful is coupled with the principles of the mechanisms of polymer flooding to serve as a guide for future applications. The scope of this review is limited to case histories where full-scale polymer floods were applied, as opposed to near-well treatments. (Author abstract) 16 refs.

Needham, Riley B. (Phillips Petroleum Co); Doe, Peter H. *JPT J Pet Technol* v 39 n 12 Dec 1987 SPE 17140, p 1503-1507.

**073080 PERFORMANCE AND OPERATION OF THE HAMM MINNELUSA SAND UNIT, CAMPBELL COUNTY, WYOMING.** The Hamm Minnelusa Sand Unit was discovered in 1966 and produced from the Minnelusa B sand. The field was under fluid-expansion primary recovery until water injection began in Dec. 1972. Waterflood response peaked at a higher monthly rate than that of primary recovery. Water production indicated channeling through high-permeability zones. This paper details flood performance up to July, 1985. Cumulative water injection is 76.6% of the total PV. A 39.5% PV chemical slug has been injected. Total recovery to date is 48.7% of the original oil in place (OOIP). (Edited author abstract) 5 refs.

Doll, T.E. (Tiorco Inc); Hanson, M.T. *JPT J Pet Technol* v 39 n 12 Dec 1987 SPE 15162, p 1565-1570.

**073081 WETTABILITY LITERATURE SURVEY - PART 6: THE EFFECTS OF WETTABILITY ON WATERFLOODING.** This paper examines the effects of wettability on waterflooding, including the effects on the breakthrough and residual oil saturations (ROS's) and the changes in waterflood behavior caused by core cleaning. Also covered are waterfloods in heterogeneously wetted systems. Waterfloods in fractionally wetted sandpicks, where the size of the individual water-wet and oil-wet surfaces are on the order of a single pore, behave like waterfloods in uniformly wetted systems. In a mixed-wettability system, the continuous oil-wet paths in the larger pores alter the relative permeability curves and allow the system to be waterflooded to a very low ROS after the injection of many PV's of water. (Edited author abstract) 122 refs.

Anderson, W.G. (Conoco Inc). *JPT J Pet Technol* v 39 n 12 Dec 1987 SPE 16471, p 1605-1622.

**073082 DISPLACEMENT OF OIL BY WATER FROM THE PART OF AN OIL-AND-GAS DEPOSIT UNDERLYING THE GAS.** If at the start of the working of an oil-and-gas deposit the gas-saturated part of the formation is characterized by the absence of or very slight presence of an initial oil saturation, then the direction of displacement of oil and gas by water from the zone underlying the gas is of great importance. A relatively high oil output is observed when the oil is displaced in the direction from the inner to the outer contour of the gas-saturated zone. When there is an initial oil saturation equal to or exceeding the residual oil saturation in the gas-saturated part of the formation, then the displacement direction has no effect on the efficiency of the process, i.e., if the oil is displaced from the inner to the outer contour or from the outer to the inner contour of the gas-saturated zone the final oil output is practically the same. In Russian. 6 refs.

Kurbanov, A.K.; Udmov, R.Kh. *Neft Khoz* n 8 Aug 1987 p 29-32.

**073083 EFFECT OF INSTABILITY ON RELATIVE PERMEABILITY CURVES OBTAINED BY THE DYNAMIC-DISPLACEMENT METHOD.** A study was undertaken to investigate how instability would affect the oil/water relative permeability curves obtained by the dynamic-displacement method. In this method, stable Buckley-Leverett displacement theory is used to calculate relative permeability curves from coreflood data. Thus, to obtain the true relative permeability curves by the dynamic-displacement method, the coreflood must be stable. However, the method frequently has been applied to unstable corefloods. The consequence of this application of the method has not been previously reported. We compared oil/water relative permeability curves from steady-state and dynamic-displacement experiments at several levels of instability. The results showed that the dynamic-displacement relative permeability curves deviated significantly from the steady-state curves as the degree of instability increased. (Edited author abstract) 18 refs.

Peters, Ekwe J. (Univ of Texas, USA); Khataniar, Santanu. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 14713, p 469-474.

**073084 FIELD AND LABORATORY STUDIES OF MICROBIAL/FINES PLUGGING OF WATER INJECTION WELLS: MECHANISM, DIAGNOSIS AND REMOVAL.** During a program to improve injection into water injection wells in the East Beverly Hills and San Vicente fields, some empirical observations were made about plugging. Laboratory studies were performed that provided explanations about the nature and formation of microbial/fines plugging and its removal. It is demonstrated that the proper sequence of treatment is bleach first to degrade the organic coating, then the acid to dissolve the inorganic particulates. (Author abstract) 18 refs.

Cusack, F. (Univ of Calgary, Calgary, Alberta, Can); Brown, D.R.; Costerton, J.W.; Clementz, D.M. *J Pet Sci Eng* v 1 n 1 Aug 1987 p 39-50.

**073085 WORKING OF POROUS-TYPE CARBONACEOUS COLLECTORS.** The efficiency of oil extraction from carbonaceous collectors is lower than that from terrigenous collectors. Thus the maximum oil extraction coefficient for the best carbonaceous collectors in the regions studied does not exceed 0.53, while the maximum coefficient for terrigenous collectors amounts to 0.7. Measures for improving the efficiency of working carbonaceous collectors include intensification of the flooding system, increasing the injection pressure, and the use of unsteady flooding methods. The flooding systems and the mutual arrangement of extraction and injection wells in carbonaceous collectors must be established with allowance for the possible occurrence of cracking. In Russian. 5 refs.

Sazonov, B.F.; Koralev, V.S.; Shabanov, V.A.; Gudoshnikov, S.S.; Zhitomirskii, V.M.; Lyubarskaya, N.B.; Shaunova, L.K.; Sopronyuk, N.B.; Pilov, A.A.; Safonov, A.V.; Morgunov, A.P. *Neft Khoz* n 9 Sep 1987 p 25-30.

**073086 WORKING THE DEPOSITS OF THE KRASNOYARSK AND BOBROSSK FIELDS.** The special features of the working of deposits with carbonaceous collectors are related mainly to the pronounced inhomogeneity of their structure and to the presence of a network of cracks and cavities. Under the conditions of this inhomogeneity of the structure of carbonaceous collectors the nature of their working is greatly affected by the flooding system chosen. The most favorable conditions for the displacement of oil by water are created upon the introduction of marginal, focal and block systems or combinations of them. In Russian.

Morganov, A.P.; Chernoshanov, I.F.; Caritskii, I.N.; Kirillov, S.A. *Neft Khoz* n 10 Oct 1987 p 36-39.

**073087 ROCK CREEK OIL FIELD CO<sub>2</sub> PILOT TESTS, ROANE COUNTY, WEST VIRGINIA.** This paper reports on the design and operation of two CO<sub>2</sub> EOR tests conducted in the Rock Creek field in Roane County, WV. The history, fluid properties, and geology of the Rock Creek field are presented first. The test area is then addressed more specifically with an evaluation of the cores and the geophysical logs of the injection, production, and observation wells. Finally, the injection history and the production response are documented. Based on experimental data, it appears that CO<sub>2</sub> miscible flooding is technically successful in Appalachian reservoirs. (Edited author abstract) 9 refs.

Brummert, A.C. (US DOE, Washington, DC, USA); Watts, R.J.; Boone, D.A.; Wasson, J.A. *JPT J Pet Technol* v 40 n 3 Mar 1988 SPE 14941, p 339-347.

**073088 INTERFACIAL SPREADING AGENTS INCREASE WATERFLOOD PRODUCTION.** Use of a novel class of interfacially active compounds when properly selected for a specific oil-water-rock system are effective in mobilizing additional commercial oil after waterflooding. The success of thin film spreading agent (TFSA) applications in cyclic steaming combined with positive laboratory results pointed to the potential benefit of these products in ordinary waterfloods. The effectiveness of these compounds appears to arise from their ability to displace thick films which form at interfaces between crude oils and the higher energy reservoir rock and water phases, thereby replacing them with very thin, mobile films which offer little resistance to coalescence and water-wetting of rock. This article reports the results of the first field application of these new interfacial spreading agents in a previously waterflooded reservoir. 8 refs.

Blair, Charles M. Jr. (Magna Corp, Santa Fe Springs, CA, USA); Stout, Charles A. *Oil Gas J* v 83 n 20 May 20 1985 p 55-59.



**073089 NUMERICAL MODELING OF THE DISPLACEMENT OF OIL BY SLUGS OF A SOLVENT FROM POROUS MEDIA WITH AN INCLUSION.** Numerical modeling of two-dimensional flow of oil, water, and solvent encounters great difficulties, since numerical diffusion, which is inherent in the difference schemes of shock-capturing (through-computation) normally used in the solution of problems on flow in a porous medium, seriously distorts the nature of the motion of the slug. The main purpose of this study was to investigate the principal properties of the two-dimensional motion of liquids with very different mobilities, a number of simplifying assumptions were introduced into the model describing the process of displacement of oil by slugs of a solvent. The flow was assumed to be two-phase and three-component. The capillary, gravitational, and diffusion effects, and also the compressibility of the liquids, were not taken into account. The content of the solvent in the liquid forcing it through (water) was neglected in comparison with the content in the oil phase. 14 refs.

Zaidel', Ya.M.; Levi, B.I. *Fluid Dyn* v 22 n 4 Jul-Aug 1987 p 545-553.

**073090 ALKALINE FLOODING IN THE TREKHOZERNYI FIELD.** Experimental field work on the injection of alkali solutions on two sections of the Trekhozernyi field showed that for a highly water-contaminated formation a process of alkali injection with mobility control is applicable. After using this process the injectivity of the injection wells increased by 20-30%, the portion of the formation affected by the flooding increased by 10-20%, the water contamination of the extraction wells was reduced, and the final oil output increased by 3.1%. 2 refs. In Russian.

Nikolaev, S.S.; Mel'nikov, A.I.; Sofin, R.E.; Popov, V.A.; Tsyml'yanskii, G.K.; Gorbunov, A.G.; Vashurkin, A.I.; Lokhmatov, S.I. *Neft Khoz* n 11 Nov 1987 p 48-52.

**073091 EFFECT OF CAPILLARY PRESSURE ON THE APPROACH TO RESIDUAL SATURATION.** The approach to residual oil saturation during the immiscible displacement of oil as predicted by the multiphase Darcy equations is studied. It is well-known that when the capillary pressure term is neglected, one arrives at the Buckley-Leverett formulation according to which the inlet face attains residual oil saturation instantaneously. This result may, however, be strongly influenced by the inclusion of the capillary pressure term. In this paper it is shown that when the relative permeability and capillary pressure functions have power-law dependencies on the saturation deviation from residual oil condition, the long-time solution exhibits a power-law decay toward residual saturation. Moreover, the power-law decay solution is found to be unique and independent of the initial conditions. The relationship of this solution is found to be unique and independent of the initial condition. The relationship of this solution to the classical Buckley-Leverett result is shown. Finally, generalization to the time-varying flow rate case is addressed. (Edited author abstract)

Ramakrishnan, T.S. (Schlumberger-Doll Research, Ridgefield, CT, USA); Wilkinson, D.; Dias, M.M. *Transp Porous Media* v 3 n 1 Feb 1988 p 51-79.

**073092 EQUATION-OF-STATE STEAM SIMULATOR.** A one-dimensional fully implicit compositional simulator has been developed for the hot water and steam injection processes. This simulator is the first steam simulator reported to date which uses the equation-of-state approach to phase behavior. Because of the equation-of-state phase behavior approach used, numerous displacement mechanism studies become possible. Examples of single hydrocarbon component runs are presented to investigate the various important features peculiar to the steamflood process. A two hydrocarbon distillable component run is presented as an example of the separation of components in the oil. (Author abstract) 12 refs.

Ishimoto, K. (Univ of Texas, Austin, TX, USA); Pope, G.A.; Sepehrnoori, K. *In Situ Oil Coal Shale Miner* v 11

n 1 Mar 1987 p 1-37.

**073093 EFFECTS OF SHEAR HISTORY ON THE GELATION OF POLYACRYLAMIDE-CHROMIUM(VI)-THIOUREA SOLUTIONS.** The influence of shearing on the gelation rate of a polyacrylamide-chromium(VI)-thiourea solution was studied in depth. Gelations were carried out under steady-state shear, oscillatory shear, and programmed shear. For the solution studied, gels formed more slowly at higher constant shear rates than at lower shear rates. This behavior is opposite to that observed with polyacrylamide-chromium(VI)-bisulfite solutions, where increased shear rates led to faster gelations. Since the rate of gelation and strength of the gel formed are strongly influenced by the total shear history, the evaluation of gel characteristics in quiescent bottle tests, as is commonly done, may not be sufficient to determine whether a gel of the desired strength can be obtained in situ. (Edited author abstract) 12 refs.

Bhaskar, R.K. (Univ of Kansas, KS, USA); Stinson, J.A.; Willhite, G.P.; Thiele, J.L. *Soc Pet Eng AIME Pap SPE* n 017472 1987 35p.

**073094 INCREASING THE FLOODING COVERAGE OF A FORMATION.** Under the conditions of a high degree of layer-to-layer inhomogeneity of the productive formations of the Udmurtiya oil fields it is advisable to carry out interval-by-interval acid treatments even in the early stage of exploitation of the wells, and the formations should be worked initially from the low-permeability interlayers. In order to improve the flooding coverage of a formation, the high-permeability sections should be shielded from the action of the acid and leakages of the acid solution into the annular space must be prevented. For this purpose, it is recommended that after the second acid treatment directional acid treatments be carried out interval by interval with prior blocking of the zones of discharge of acid into high-permeability interlayers. 4 refs. In Russian.

Suchkov, B.M.; Kim, M.B.; Vasil'ev, A.A. *Neft Khoz* n 3 Mar 1988 p 37-40.

**073095 CONTROLLING THE PERMEABILITY OF THE WATER-CONDUCTING CHANNELS OF A FORMATION WITH AN AMMONIA SOLUTION.** By reacting a 24% aqueous solution of ammonia with the injected wastewater, it is possible to obtain a complex precipitate consisting of calcium and magnesium hydroxides and also ammonium sulfide. The precipitate formed is easily dissolved in hydrochloric acid, which is important for restoring the permeability of the formation during complete clogging of the water-conducting channels. The introduction of an ammonia solution into the wastewater leads to a decrease in the concentration of hydrogen sulfide, which is an aggressive corrosion component. 3 refs. In Russian.

Gabdrakhmanov, A.G.; Kashapov, O.S.; Alsynbaeva, F.L. *Neft Khoz* n 3 Mar 1988 p 40-44.

**073096 RATE DEPENDENCE OF UNSTABLE WATERFLOODS.** Viscous fingering is part of the flow mechanisms that are operative in waterflooding and in a wide range of EOR methods. A laboratory and computer model analysis is conducted of the viscous-fingering dynamics that develop when a less mobile fluid is immiscibly displaced by a more mobile fluid in a permeable medium. Physical experiments of horizontal fluid displacements conducted in a rectangular bead pack show that the amplitude/frequency character of the wave-like fingers that form depends on flow rate and mobility ratio. The nature of these wave-like features is shown for two viscosity ratios and several displacement rates. Spatial frequency domain analyses of finger shapes at fixed time intervals were conducted on digitized records of the laboratory experiments. (Edited author abstract) 21 refs.

Sigmund, P. (Univ of Calgary, Can); Sharma, H.; Sheldon, D.; Aziz, K. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14368, p 401-409.

**073097 CO<sub>2</sub> DISPLACEMENTS OF RESERVOIR**

**OILS FROM LONG BEREAS CORES: LABORATORY AND SIMULATION RESULTS.** CO<sub>2</sub> displacements of three different reservoir oils from long Berea cores were conducted over a wide range of reservoir conditions with the pressure always above the slim-tube minimum miscibility pressure (MMP). The detailed performance of these displacements is simulated with a fully compositional simulator and the Redlich-Kwong (RK) equation of state (EOS). Oil recovery, GOR, and effluent profiles are compared with experimental results. The EOS is observed to be capable of predicting the phase-behavior transitions that occur in situ when miscibility is generated by multiple contacts. The good comparison between experimental results and the simulation has led to specification of a minimum data set for which an EOS should be able to predict before a priori simulations of displacement experiments can be made. (Edited author abstract) 24 refs.

Kremesec, V.J. Jr. (Amoco Production Co); Sebastian, H.M. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14306, p 496-504.

**073098 PHASE BEHAVIOR OF SEVERAL CO<sub>2</sub>/WEST-TEXAS-RESERVOIR-OIL SYSTEMS.** The design of miscible CO<sub>2</sub> recovery methods and the evaluation of laboratory CO<sub>2</sub> coreflood and pilot field studies require knowledge of the phase behavior encountered in such processes and the ability to make reliable predictions. Because of the complexity of CO<sub>2</sub>/hydrocarbon phase behavior, experimental measurements are necessary as a basis from which to develop an understanding. Measured phase equilibria and volumetric properties are reported for several west-Texas-reservoir-oil/CO<sub>2</sub> systems. Both static (single-contact) and multiple-contact measurements have been conducted in a visual fluid property cell. Static data cover a wide range of CO<sub>2</sub> compositions and provide a general understanding of CO<sub>2</sub>/reservoir-oil phase behavior. (Edited author abstract) 9 refs.

Turek, Edward A. (Amoco Production Co); Metcalfe, Robert S.; Fishback, Robert E. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 13117, p 505-516.

**073099 MECHANISTIC STUDY OF GRAVITY-ASSISTED CO<sub>2</sub> FLOODING.** A series of gravity-assisted vertical core displacements of contact-miscible and multiple-contact-miscible CO<sub>2</sub>/recombined-crude-oil systems was conducted and simulated. Gravity-assisted displacements offer the advantages of eliminating gravity tongues and stabilizing viscous fingers. Although the process has been used successfully in the field, a mechanistic laboratory and modeling study of gravity-assisted multiple-contact-miscible CO<sub>2</sub> flooding has not been described previously. The results from this experimental and computer modeling study elucidate the complex mechanisms acting in gravity-assisted CO<sub>2</sub> flooding. Component transfer, as occurs in multiple-contact-miscible processes, can strongly affect flood-front stability. (Edited author abstract) 31 refs.

Tiffin, D.L. (Amoco Production Co); Kremesec, V.J. Jr. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14895, p 524-532.

**073100 EFFECT OF AN AQUEOUS PHASE ON CO<sub>2</sub>/TETRADECANE AND CO<sub>2</sub>/MALJAMAR-CRUDE OIL SYSTEMS.** The effect of the presence of an aqueous phase on the phase behavior of the CO<sub>2</sub>/tetradecane and the CO<sub>2</sub>/Maljamar-crude-oil systems has been experimentally determined. Both the salinity and the amount of the aqueous phase were varied to test several methods of modeling. In the first technique, the amount of CO<sub>2</sub> 'lost' to the aqueous phase was determined using Henry's law, decreasing the overall ratio of CO<sub>2</sub> to hydrocarbons, while the Peng-Robinson equation of state (PR EOS) was used to determine the phase distribution of the hydrocarbon phases. In the second technique, the equation of state (EOS) was modified to predict the



densities and compositions of not only the hydrocarbon phases, but also the aqueous phase. (Edited author abstract) 26 refs.

Pollack, N.R. (Univ of Pittsburgh, PA, USA); Enick, R.M.; Mangone, D.J.; Morsi, B.I. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 15400, p 533-541.

**073101 DETAILED VALIDATION OF AN EMPIRICAL MODEL FOR VISCOUS FINGERING WITH GRAVITY EFFECTS.** This paper extends to two-dimensional (2D) flows the derivation and validation of an empirical model for viscous fingering previously developed. Fine-scale numerical simulations are used to provide basic data for validating the approximations, and these fingering results are also checked against a range of experiments. The flow rate dependence of gravity segregation in vertical section experiments conducted by C. van der Poel is examined, where the broadly acceptable agreement of the empirical model is limited by some identified additional features. (Edited author abstract) 18 refs.

Fayers, F. John (BP); Newley, Trevor M.J. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 15993, p 542-550.

**073102 APPROXIMATE MODEL WITH PHYSICALLY INTERPRETABLE PARAMETERS FOR REPRESENTING MISCIBLE VISCOUS FINGERING.** An approximate viscous fingering model is derived with physically related parameters. Plausible assumptions are made about some limits on finger fluid mixing, and the use of a fingering function is suggested. It is shown that for the horizontal linear problem, a hyperbolic partial-differential equation governs the solvent fractional flow behavior. Satisfactory agreement with classic miscible displacement experiments is demonstrated for a reasonable choice of parameters. When gravity is introduced into the equation, the same model gives adequate agreement with the rate dependency observed in a vertical displacement experiment. Recommendations are made concerning extension of the model for use in three-dimensional (3D) compositional simulations. (Author abstract) 9 refs.

Fayers, F. John (Sohio Petroleum Co). *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 13166, p 551-558.

**073103 UPDATE OF THE POLYMER-AUGMENTED ALKALINE FLOOD AT THE ISENHOUR UNIT, SUBLETTE COUNTY, WYOMING.** An Almy sand polymer-augmented alkaline flood at the Isenhour Unit, Sublette County, WY, is reviewed. This paper updates process technology, including the use of clay stabilization, sweep improvement, soda ash alkaline agent [to reduce interfacial tension (IFT) and mobilize residual oil], and anionic-polymer-blend mobility buffer. Oil production has been increasing at 20%/yr since the process start. (Author abstract) 5 refs.

Doll, Thomas E. (TIORCO Inc). *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14954, p 604-608.

**073104 EVALUATION OF THE WILMINGTON FIELD MICELLAR/POLYMER PROJECT.** The Long Beach micellar/polymer pilot in the Wilmington field has been evaluated. Actual recovery efficiency is about two-thirds of coreflood and simulation model estimates. This relatively high recovery efficiency represents a technically successful flood. Oil recovery was less than optimal, however, because of problems associated with production from an unconsolidated formation and the presence of *Desulfovibrio* bacteria. (Author abstract) 21 refs.

Fanchi, J.R. (Kepler & Associates); Carroll, H.B. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 12681, p 609-616.

**073105 EXPERIMENTAL INVESTIGATION OF THE INTERACTION OF PHASE BEHAVIOR WITH MICROSCOPIC HETEROGENEITY IN A CO<sub>2</sub> FLOOD.** This paper reports results of an experimental investigation of the effects of microscopic heterogeneity on local displacement efficiency in a CO<sub>2</sub> flood. Flow-visualization experiments for first-contact miscible displacements are described and compared with effluent composi-

tion measurement for the same models. High-pressure flow-visualization experiments for multicontact miscible CO<sub>2</sub> floods are also described. The displacements were performed in two-dimensional (2D) etched glass models made from thin-sections of San Andres carbonate core from the Maljamar field. Techniques used in preparation of the models are described briefly. (Edited author abstract) 25 refs.

Bahralolom, I. (New Mexico Petroleum Recovery Research Cent); Bretz, R.E.; Orr, F.M. Jr. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14147, p 662-672.

**073106 MULTIPLE-CONTACT PHASE BEHAVIOR MEASUREMENT AND APPLICATION WITH MIXTURES OF CO<sub>2</sub> AND HIGHLY ASPHALTIC CRUDE.** The phase behavior relevant to CO<sub>2</sub> flooding for multiple-contact miscible, immiscible, or huff 'n' puff applications is studied. Unique features of this investigation are that the live reservoir oil was highly asphaltic and was modified to resemble the composition likely contacted by injected CO<sub>2</sub>. Single-contact and two types of multiple-contact PVT data are presented, and the usefulness of such data in predicting CO<sub>2</sub> flood performance is discussed. Results show no liquid/liquid/vapor (L/L/V) three-phase region at higher temperatures and no liquid/liquid (L/L) critical point. Large CO<sub>2</sub> concentrations were required before substantial hydrocarbon extraction occurred. A ternary diagram representation of forward multiple-contact compositional results indicates that CO<sub>2</sub> generated miscibility with the oil by the vaporization mechanism. (Edited author abstract) 20 refs.

Bryant, D.W. (Louisiana State Univ, LA, USA); Monger, T.G. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14438, p 701-710.

**073107 OILFIELD MICROORGANISMS AND THEIR ROLE IN DESTRUCTION OF NONIONIC SAS.** The goal of the present investigation was to study microorganisms in stratal waters decomposing nonionic SAS, to isolate them, and to study the possibility of their use for treatment of waste waters. The subjects of the investigation were the strata of the Tuimazy and Arlan oilfields, where in 1967 a 0.05% solution of OP-10 detergent was injected to increase oil output, and where experiments are being carried out to evaluate the degradability of nonionic SAS under the effect of stratal microorganisms. It was shown that the isolated microorganisms exert destructive activity for ethoxylated alcohols, acids, and alkylphenols. Experimental data were obtained demonstrating the possibility of use of these microorganisms to treat waste waters containing nonionic SAS. 10 refs.

Kravchuk, V.N. (Dumanskii Inst of Colloidal Chemistry & Water Chemistry, Kiev, USSR); Udod, V.M.; Gvozdyak, P.I. *Sov J Water Chem Technol* v 9 n 2 1987 p 89-92.

**073108 MOBILITY CONTROL OF CAUSTIC FLOOD.** Displacement tests to date of oil field core with alkaline solutions at reservoir temperature show low tertiary oil recovery. Inadequate mobility control is singled out as the reasons for such poor recovery. To test the validity of this reasoning, a laboratory study was undertaken in which a high heat resistant power was used as the mobility control agent in a hot alkaline solution recover technique. It is observed that polymer injection actually did improve recovery substantially and that there is an optimum concentration and slug size of polymer for a particular reservoir. Higher concentrations of pore volumes injected did not improve recovery significantly. (Edited author abstract) 25 refs.

Alam, M.W. (Univ of Oklahoma, Norman, OK, USA); Tiab, D. *Energy Sources* v 10 n 1 1988 p 1-19.

**073109 EVALUATION OF AN ANALYTIC TECHNIQUE FOR ESTIMATING SWEEP VOLUME FROM THERMAL PRESSURE FALLOFF TESTS IN HETEROGENEOUS SYSTEMS.** Several simulated pressure falloff tests were analyzed to see whether the swept volume estimated by an analytic technique agrees with the swept volume simulated with both a steamflood

model and an in-situ combustion model. Several parameters, such as wellbore gridblock size, nonuniform permeability, layering, flowing noncondensable gas, and oil vaporization, were studied. The analyses of these runs also led to the evaluation of other parameters, such as permeability-thickness, kh, in the swept zone. For steamfloods, the analytically estimated swept volume in relatively homogeneous models is in agreement with the simulated swept volume. The calculated kh reflects the effective gas permeability-thickness at the average gas saturation behind the steam front. (Edited author abstract) 12 Refs.

Fasshi, Mohammad Reza (Amoco Production Co, Tulsa, OK, USA). *SPE Form Eval* v 3 n 2 Jun 1988 p 449-458.

**073110 ANALYSIS OF UNSTEADY-STATE DISPLACEMENT USING A CAPACITANCE-DISPERSION MODEL.** Tracer displacements were performed during both steady state and unsteady state oil and water flow. Chemical and radioactive tracers, partitioning and non-partitioning, were added to both the wetting and non-wetting phases. These experiments were conducted in naturally water-wet and treated neutrally-wet Berea sandstone cores to also investigate the effect of wettability. The mobility ratio was varied from a favorable to an unfavorable one during the unsteady-state waterflood experiment. An existing capacitance-dispersion model, a Coats-Smith type model, was used to fit the effluent tracer profiles from the steady-state experiments. The model is developed to predict the behavior of tracer data during unsteady-state waterflood experiments. This model divides each phase into two parts, flowing and dendritic. Wettability alteration has an effect on the capacitance parameters. (Edited author abstract) 30 Refs.

Smith, Jeffrey C. (Univ of Texas at Austin, Austin, TX, USA); Delshad, Mojdeh; Pope, Gary A.; Anderson, William G.; Marcel, Denis. *In Situ Oil Coal Shale Miner* v 12 n 1-2 Mar-Jun 1988 p 41-78.

**073111 DETERMINATION OF THREE-PHASE RELATIVE PERMEABILITIES UNDER RESERVOIR CONDITIONS BY HOT WATER AND STEAMFLOOD EXPERIMENTS.** In order to help the physical and numerical interpretation of Emeraude's steam pilot, two-phase waterfloods at four temperatures (between 30 and 240°C) and a steamflood were performed in the laboratory using the same porous medium (compacted silt) and under reservoir conditions. Dynamic isothermal displacements were interpreted with a thermal simulator taking into account capillary end effects. The corresponding oil-water relative permeability curves were obtained by matching observed pressure drop and oil production. Results show that temperature influences the end-point saturations but not the shape of the curves. The numerical interpretation of this experiment, by making use of the oil-water relative permeabilities, provided the three-phase oil relative permeability which is an essential datum for numerical interpretation of a steam drive pilot. (Edited author abstract) 7 refs.

Quettier, L. (Elf Aquitaine, Pau, Fr); Corre, B. *Rev Inst Fr Pet* v 43 n 4 Jul-Aug 1988 p 555-566.

**073112 WATER QUALITY CONTROL AND ITS IMPORTANCE IN WATERFLOODING OPERATIONS.** The contaminants primarily responsible for plugging are presented and water quality requirements are discussed. Factor affecting water quality include: suspended solids, corrosion, scale formation, microbiological problems and oil content. Data that should be gathered for system monitoring are given. 12 Refs.

Patton, Charles C. (Patton & Associates, USA). *JPT J Pet Technol* v 40 n 9 Sep 1988 p 1123-1126.

**073113 PERFORMANCE EVALUATION OF THE SALEM UNIT SURFACTANT/POLYMER PILOT.** Injection of a brine-tolerant surfactant formulation gave a projected recovery of 73 percent in the flooded interval of a 12-pattern test at the Salem Unit. Use of tracers enabled



chemical distribution quantification in all 48 quadrants. Different adsorption rates for the surfactant components were confirmed from monitor-well samples. (Author abstract). 5 refs.

Widmyer, R.H. (Texaco Inc); Williams, D.B.; Ware, J.W. *JPT J Pet Technol* v 40 n 9 Sep 1988 p 1217-1226.

**Flow** See Also OIL SHALE—Pressure Effects; OIL WELL CASING.

**073114 MATHEMATICAL MODEL FOR PRESSURE EVALUATION IN AN INFINITE CONDUCTIVITY HORIZONTAL WELL.** In this study a mathematical model is developed to evaluate the transient pressure behavior in a well with an infinite conductivity horizontal drainhole. The physical model includes a fluid of small and constant compressibility flowing through an infinitely large anisotropic reservoir, with upper and lower impermeable boundaries. The analytical solution is obtained by applying the concepts of instantaneous sources and Green's functions. (Edited author abstract) 6 refs.

Rosa, Adalberto Jose; de Souza Carvalho, Renato. *Soc Pet Eng AIME Pap SPE Unsolicited Manuscript Sep 1987 SPE 015967*, 32p.

**073115 THERMODYNAMIC APPROACH TO THE SOLUTION OF PROBLEMS OF OIL PRODUCTION HYDRAULICS.** An unconventional method of integrated consideration of the variations of the dynamic viscosity and hydraulic friction coefficient depending on the parameters of the thermodynamic state of the system (flowrate, hydrostatic pressure, temperature, differences between chemical and electrode potentials, as well as heat exchange with the environment) is proposed. (Translated author abstract) 7 refs. In Russian.

Mochernyuk, D.Yu. *Izv Vyssh Uchebn Zaved Neft Gaz* n 10 1986 p 58-63.

**073116 ANALYSIS OF RESERVOIR CHEMICAL TREATMENTS.** In chemical well treatments, success or failure is often difficult or impossible to anticipate. The near-wellbore pressure drawdown and fines migration contribute to the overall well damage, but the effect of the chemical treatment alone can induce damage by reprecipitation when the spent treatment solution is produced over the treated zone. The identity, amount, and rate of return of this reprecipitation damage are discussed. Our procedure considers the chemical interaction of formation minerals and brine with the treatment solution in the presence of an immiscible phase. Although this analysis contains several simplifying assumptions, the results can be applied, with care, to lend insight and direction to practical problems. (Edited author abstract) 39 refs.

Dria, M.A. (Univ of Texas, TX, USA); Schechter, R.S.; Lake, L.W. *SPE Prod Eng* v 3 n 1 Feb 1988 SPE 13551 p 52-62.

**073117 REVISED BEAN PERFORMANCE EQUATION FOR EAST BAGHDAD OIL WELLS.** A comparison of the existing correlations for the determination of multiphase fluid-flow performance through a wellhead choke is made. The comparison is based on statistical analysis with production data from 155 well tests, 20 of which are from the East Baghdad oil field. The comparison indicates the relative strengths and weaknesses of each correlation and should aid in the selection of a satisfactory correlation for different applications. No one method is found to be most accurate in all ranges of flow variables. The best overall comparison, however, is obtained with the Gilbert correlation that predicted measured production rates within an average error of 6.1%. This correlation is then revised in two forms to fit the observed data from the East Baghdad oil wells best. (Author abstract) 8 refs.

Al-Attar, H.H. (Univ of Baghdad, Iraq); Abdul-Majeed, G.H. *SPE Prod Eng* v 3 n 1 Feb 1988 SPE 13742 p 127-131.

**073118 CORRELATION DEVELOPED TO PREDICT TWO-PHASE FLOW THROUGH WELL-**

**HEAD CHOKES.** The predictive accuracy of eight critical two-phase flow correlations are tested against field measured production data, from 210 well tests, covering broad ranges of production rates, choke sizes, upstream pressures, gas-liquid ratios and oil API gravities. Test data are divided into four selected categories based on choke size (D). The average percent error, absolute average percent error, and standard deviation are computed for each correlation. Due to inconsistency of results obtained by the included correlations, the multiple regression analysis is used to find out correlations that best fit the measured data, as a result, four new correlations are developed (a correlation for each data category). Based on the statistical results, the new correlations clearly outperformed the remaining correlations. (Edited author abstract) 8 refs.

Abdul-Majeed, Ghassan H. (Univ of Baghdad, Baghdad, Iraq). *J Pet Res* v 6 n 2 Dec 1987 p 17-40.

## Flowlines

**073119 PRODUCTION LINES HOUSED IN SYN-TACTIC FOAM.** Buoyancy modules of syntactic foam play a dual role in Placid Oil Co.'s operation of the world's largest floating production system located in Green Canyon block 29, Gulf of Mexico. For the first time, syntactic foam buoyancy modules have been converted to the task of housing flow and service lines in addition to providing vital buoyancy for the riser string. Specially designed Ecofoam syntactic foam modules, suited to the main riser, were made by Grace Syntactics, Canton, Mass.

Anon. *Oil Gas J* v 86 n 32 Aug 8 1988 67p.

**073120 PROCESS SOLVES PARAFFIN BUILDUP IN TUBING.** A patented downhole process has been employed and tested that removes accumulated paraffin and prevents subsequent paraffin buildup in the tubing of flowing or pumping oil wells. Developed by Extractol of Ardmore, Okla., the process involves heating the tubing from the surface down through the paraffin deposition zone by means of a low-voltage electric current. The heated tubing melts the paraffin and allows the well to maintain continuous optimum oil-production rates without the operational constrictions of paraffin accumulation.

Yuki, Edward T. (E.T. Yuki & Associates Inc, Dallas, TX, USA); Marr, Andrew W. Jr. *Oil Gas J* v 86 n 32 Aug 8 1988 p 68, 70.

**Gas Lift** See Also OIL FIELDS—North Sea.

**073121 OPTIMAL LIQUID FLOW RATE IN GAS-LIFT WELLS.** An increase in the liquid viscosity and the surface tension at the liquid-gas boundary and a decrease in the gas density reduce the liquid flow rate for specific pressure differentials less than 0.4. Consequently, effective action on the gas-liquid flow for the purpose of increasing the efficiency of a gas-lift hoist is possible only in the above-mentioned pressure range. The optimal liquid flow rate reaches a maximum value at specific pressure differentials of 0.7-0.8. The maximum efficiency of a gas-lift hoist may be obtained at specific pressure differentials of 0.6-0.8 and at a reduced gas density no less than 0.02. In Russian. 2 refs.

Belogortzev, G.P.; Vasil'ev, V.A.; Guzhov, A.I. *Neft Khoz* n 5 Mar 1987 p 29-31.

**073122 DRAWBACKS OF GASLIFT CAN BE OVERCOME.** The importance of continuous-flow gaslift continues to increase with the number of oil fields, particularly offshore, where deviated wells and sea-bottom completion make application of other lifting methods unattractive or impossible. Although many advances have been made over the years in the design of gaslift strings and valves, there remain a few drawbacks that reduce the attractiveness of the method. The most important of these are the occurrence of heading problems, the expense of wireline/through flow line (TFL) operations, and the cost of well repairs associated with malfunctioning gaslift equipment. These problems, can largely be solved by applying alternative strategies for regulating liftgas injection rates. In offshore fields, it is necessary to eliminate gaslift valves and start the gaslift process with a start compressor. On multiwell platforms, this is feasible because the wells are grouped together. 4 refs.

Gruppung, A.W. (Delft Univ of Technology, Delft, Neth). *Oil Gas J* v 85 n 52 Dec 28 1987 p 113-115.

**073123 OPTIMAL WORKING PRESSURE FOR THE GAS LIFT IN A MULTIFORMATION FIELD.** A method of determining the optimal working fluid injection pressure is proposed which ensures minimum energy consumption in raising the oil in a group of gas-lift wells drilled into inhomogeneous horizons. Maximum accuracy in calculations according to this method may be attained by using adapted mathematical models which describe the relation between the parameters of motion of the gas-liquid mixture. In Russian. 3 refs.

Pronchenko, G.A.; Khonova, E.A.; Lutoshkin, G.S.; Mavrikov, I.G. *Neft Khoz* n 9 Sep 1987 p 46-48.

**073124 HIGH-PRESSURE GAS LIFT FOR DEEP, SOUR PRODUCTION.** An innovative high-pressure N<sub>2</sub> gas-lift design has been used to return several wells to production in the Jay/Little Escambia Creek (LEC) field of northwest Florida. The N<sub>2</sub> was available from a field tertiary injection project and provided the means for the first continuous N<sub>2</sub> lift system, and some of the deepest gas-lifted wells in operation. The design accommodates the unique demands of gas-lifting a deep, sour oil well with high water cuts through the operation of a continuous N<sub>2</sub> lift system. Because the project design was not limited to conventional artificial lift techniques, a solution was achieved with the resources available. The high-pressure N<sub>2</sub> lift enabled wells to return to production that would not have been economically attractive or mechanically feasible with a standard hydrocarbon gas lift or submersible pump design. (Author abstract) 5 refs.

Dickens, R.J. (Exxon Co, USA). *SPE Prod Eng* v 3 n 1 Feb 1988 SPE 14347 p 109-112.

**073125 REGIMUL DE LUCRU AL SONDELOR IN ERUPTIE NATURALA, IN CAZUL CONSIDERARII SISTEMULUI DE ANSAMBLU, ALCATUIT DIN TREI COMPONENTE: STRAT PRODUCTIV-SONDA DE EXTRACTIE-CONDUCTA DE AMESTEC.** [Natural Flow Well Drive, Considering the Overall System Consisting of: Producing Bed-Producing Well-Mixture Pipeline]. The paper presents the principle, the calculation methodology and numerical examples for setting the parameters of the flowing-well drive. The procedures are devised on the basis of the combined interdependent operation principle of the three components of the overall system (producing bed-producing well-mixture pipeline connected to the separator), either with or without a surface nose for the operation control. (Edited author abstract) In Romanian. 5 refs.

Toean, I. (Inst de Petrol si Gaze, Ploiesti, Rom). *Mine Pet Gaze* v 38 n 10 Oct 1987 p 469-475.

**073126 HIGH-RATE ARTIFICIAL LIFT.** This paper summarizes the major considerations in the selection, design, installation, operation, or repair of high-rate artificial-lift systems. The major types of artificial lift-sucker-rod pumps, gas-lift systems, electrical submersible pumps, hydraulic pumps and jets, and hydraulic turbine-driven pumps will be discussed. An extensive bibliography of artificial-lift papers is included. (Author abstract) 68 refs.

Cleg, Joe Dunn (Shell Western E&P Inc, Houston, TX, USA). *JPT J Pet Technol* v 40 n 3 Mar 1988 SPE 17638 p 277-282.

**073127 THEORY OF GASLIFTS.** Under the conditions occurring in practice the gas lift process often appears to be unsteady-state in nature. Unsteadiness occurs in the process of starting up a well, and may also be introduced when the gaslifts are organized to operate batchwise. In addition, the steady-state regime sometimes



proves to be unstable, which leads ultimately to the generation of self-excited oscillations. On the basis of a simplified model, a new method is proposed for analysis of unsteady-state gaslifts, and instabilities of steady-state gaslift processes are demonstrated. (Edited author abstract) 8 refs.

Buevich, Yu.A. (A.M. Gor'skii State Univ of the Urals, Sverdlovsk, USSR). *J Eng Phys* v 53 n 4 Oct 1987 p 1129-1136.

**073128 EXPERIENCE WITH PUMPOFF CONTROL IN THE PERMIAN BASIN.** Shell Western E&P Inc. has installed pumpoff control on more than 2,500 sucker-rod pumping wells in the Permian Basin during the last 12 years. These systems fall into three basic categories: stand-alone analog devices, stand-alone microprocessor units with optional communication capabilities to a central computer, and a centralized system where well data are communicated to a central computer for pumpoff decisions. Evaluation has shown that production can be maintained or slightly increased while energy consumption and maintenance expense are substantially reduced. The pumpoff controllers also provide well data that are beneficial in maintaining good surveillance. (Author abstract) 6 refs.

Neely, A. Buford (Shell Western E&P Inc); Tolbert, H.O. *JPT J Pet Technol* v 40 n 5 May 1988 SPE 14345, p 645-649.

**073129 WHAT'S NEW IN ARTIFICIAL LIFT.** New developments pertaining to electric submersible pumps, beam pumps and gas lift discussed include: cable-suspended submersible pump design testing; measurement of bottom hole pressure in ESP-produced wells; advanced wellheads for submersible lift, hydraulic lift and injection wells; downhole pump protectors; ESP motor design; beam pump motor controller; beam unit monitoring relay; long, slow-stroke pumping unit; portable rod pump analysis system; and wellhead assembly for installation and suspension of coil tubing while under pressure.

Lea, James F. (Amoco Production Research Co, Tulsa, OK, USA). *World Oil* v 206 n 5 May 1988 p 45-51.

**073130 CO<sub>2</sub> HUFF 'N' PUFF PROCESS IN A BOTTOMWATER-DRIVE RESERVOIR.** Two CO<sub>2</sub> huff 'n' puff projects were conducted in the 4,900-ft [1495-m] Reservoir (BA) Sand Unit [4900'R(BA)SU], Timbalier Bay field, Louisiana. This reservoir is a bottomwater-drive reservoir with a 26° API [0.9-g/cm<sup>3</sup>] oil gravity and 18% primary oil recovery. Before CO<sub>2</sub> injection, both project wells were gas lifting more than 1,000 BFPD [160 m<sup>3</sup>/d fluid] with 99% water cuts. After CO<sub>2</sub> injection, the production from each well increased to 200 BOPD [32 m<sup>3</sup>/d oil]. This paper discusses the CO<sub>2</sub> huff 'n' puff process, specific reservoir characteristics, and project evaluation. 14. AA Refs.

Simpson, Marcia Reeves (Chevron USA Inc, USA). *JPT J Pet Technol* v 40 n 7 Jun 1988 p 887-893.

**073131 GAS LIFT IN BASS STRAIT.** Gas lift has proved a most effective artificial lift method for the fields operated by Esso Australia Ltd in Bass Strait for the Esso-BHP joint venture. Gas lift is now used to produce approximately 5 st ML/d of the total crude production from the Strait. It has enabled wells to be produced to water cuts higher than 90 per cent, increasing the oil recovery from the fields by up to 35 per cent. Gas lift work in Bass Strait to date has included the use of special packoff gas lift assemblies for wells with sliding sleeves, the development of a tool to assist the opening of the sleeves, improved operating techniques to limit slugging from gas-lifted wells, and the testing of gas lift performance. (Edited author abstract) 1 ref.

Fagg, Kathryn J. (Esso Australia Ltd, Sale, Aust). *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 107-113.

**Heavy Oil** See Also OIL FIELDS—Computer Simulation; OIL FIELDS—Field Development.

**073132 APPLICATION OF HORIZONTAL WELLS IN THE SIMULATION OF HEAVY OIL RECOVERY PROCESS.** Field experience as well as experimental and numerical modelling have shown that inherent gravity override, poor vertical sweep and low productivity characterize the displacement process in many steamflood and hot waterflood projects. In particular sand bodies, horizontal wells offer the possibility of placing the injected fluid in a specified area of the system. Representation of the horizontal well continuum by appropriate discretised models and analytical expressions for productivity indices allows us to define horizontal wells in a finite difference numerical simulator. The calculation of these productivity indices is achieved through a conformal mapping technique. (Edited author abstract) 18 refs.

Folefac, A.N. (Imperial Coll, London, Engl); Archer, J.S. *Soc Pet Eng AIME Pap SPE Unsolicited Manuscript* Sep 1987 SPE 017078, 33p.

**073133 O.** Without the application of innovative equipment and operating techniques, a reservoir containing an estimated 40 million m<sup>3</sup> (250×10<sup>6</sup> bbl) of heavy oil-in-place would have remained unproductive. Progressive cavity pumps provided the most flexible, cost-effective option to exploit this difficult formation. Through the optimization of this unique equipment and associated operating techniques by both the producing and service companies involved, economic development has been made possible. This paper describes the evolution of the progressive cavity pump system in the development of the Clearwater Formation in the Lindbergh-Elk Point field. Modifications made to the equipment design and techniques to optimize pump sizing and pump run lives are discussed. (Edited author abstract)

Lea, J.F. (Amoco Canada Petroleum Co); Anderson, P.D.; Anderson, D.G. *J Can Pet Technol* v 27 n 1 Jan-Feb 1988 p 58-67.

**073134 D.** The most persistent problem facing heavy oil producers is sand production. Frequent servicing caused by sand may increase the operating cost per barrel of oil dramatically. Disposal of the large volumes of sand produced also continues to be a problem. The oil and gas industry has investigated methods of sand control on primary wells for 25 years. Early attempts were largely unsuccessful and the investigation was not aggressively pursued. In the 1980s Dome's interests and control was stimulated by higher sanding frequencies associated with the start-up of various thermal projects. This paper reviews Dome's experience with sand control for various projects. (Edited author abstract) 6 refs.

Marjerrison, Douglas M. (Dome Petroleum Ltd); Sayre, John A. *J Can Pet Technol* v 27 n 1 Jan-Feb 1988 p 68-72.

**073135 DOWNSTREAM PLANNING AND INNOVATION FOR HEAVY OIL DEVELOPMENT - A PRODUCER'S PERSPECTIVE.** The complexion of the Canadian oil industry will change rapidly in the next ten years as a dramatic increase in heavy oil production replaces dwindling conventional oil reserves. This sharp rise in Canadian heavy oil production will result in unique demands on the downstream sector of the industry. These demands will present a whole new range of technical problems and opportunities for innovation. Downstream concerns specifically include a potential diluent shortage, pipeline capacity restrictions and availability of markets. This paper presents potential solutions including upgrading and others viewed from the producer's perspective. (Edited author abstract) 27 refs.

Todd, C.M. (Amoco Canada Petroleum Co). *J Can Pet Technol* v 27 n 1 Jan-Feb 1988 p 79-86.

**073136 ANALYTIC MODEL FOR ANALYZING THE EFFECTS OF DISSOCIATION OF HYDRATES ON THE THERMAL RECOVERY OF HEAVY OILS.** An analytic model is given that includes the effects of the

presence of hydrates in a thermal recovery process. The model considers continuous injection of steam into a reservoir containing an oil zone overlain by a hydrate zone. Although part of the steam is consumed in dissociation of hydrates to gas and water and dissociated hydrate zone acts as a thief zone for steam, there is a reduction in heat losses to the overburden because of the 'insulation' effect of overlying hydrates. Thus, the net reservoir heat efficiency is not significantly affected by the presence of hydrates. Although the model does not address the effect of gas generated from hydrate dissociation, it is speculated that the dissolution of the gas will cause oil swelling, oil-viscosity reduction, and improved steamflood performance. (Edited author abstract) 23 refs.

Kamath, Vidyadhar A. (Univ of Alaska, AK, USA); Godbole, Sanjay P. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14224, p 449-456.

**073137 EFFECT OF SOLVENT ON STEAM RECOVERY OF HEAVY OIL.** Solvents and light ends of crudes are frequently used as diluents to facilitate pumping and pipeline transportation of heavy crudes. The use of solvent alone for in-situ recovery of heavy oil tends to be limited because of its high cost; however, the use of solvent as an additive to steam processes has been tested both in the laboratory and in the field. The results of these tests are mixed. The authors use numerical experiments to delineate the recovery mechanism of a steam-slug process when solvents are present. A good understanding of the mechanism will help provide an interpretation of the conditions under which solvents can improve steam oil recovery. The study focuses on the use of small quantities of solvent - i.e., no more than 10% of the steam volume. (Author abstract) 14 refs.

Shu, W.R. (Mobil R&D Corp); Hartman, K.J. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14223, p 457-465.

**073138 FLUID FLOW AND SAND PRODUCTION IN HEAVY-OIL RESERVOIRS UNDER SOLUTION-GAS DRIVE.** The production of heavy oil in Canada has led to a number of anomalous results, most of which have been excused as high-permeability channels resulting from sand production. The methods of soil mechanics predict gross formation failure resulting from high fluid compressibility, small cohesion, and high viscosity. Gross failure results in excellent productivity but reduced in-situ stress (and fracture stress). Solution-gas drive in these reservoirs involves simultaneous-mixture flow of gas as very tiny bubbles entrained in heavy oil. Stress, geometry, and permeability alteration resulting from matrix deformation combined with peculiar pressure-dependent multiphase-flow properties result in a new model of reservoir performance. (Edited author abstract) 19 refs.

Smith, Gerald E. (Husky Oil Operations Ltd). *SPE Prod Eng* v 3 n 2 May 1988 SPE 15094, p 169-180.

## In Situ Combustion

**073139 LOW-TEMPERATURE-OXIDATION KINETIC PARAMETERS FOR IN-SITU COMBUSTION: NUMERICAL SIMULATION.** The principal objective of this study was to provide low-temperature-oxidation (LTO) reaction models that are suitable for use in numerical simulators of in-situ combustion for bitumen and heavy-oil reservoirs. A systematic study investigated the LTO reactions of the liquid-phase components of bitumen and heavy oils. Athabasca bitumen, free of water and minerals, was oxidized by use of a laboratory-stirred semiflow batch reactor. Kinetic studies were carried out in the 333 to 423 K [140 to 300°F] temperature range and at an oxygen partial pressure of 50 to 2233 kPa [7.3 to 324 psi]. The total pressures applied in the reactor ranged from 2190 to 4415 kPa [318 to 640 psi]. Experimental data were collected in the kinetic subregime. (Edited author abstract) 21 refs.

Adegbesan, K.O. (Texaco Canada Resources Ltd); Donnelly, J.K.; Moore, R.G.; Bennion, D.W. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 12004, p 573-582.



**073140 OXYGEN FIREFLOODING: COMBUSTION TUBE TESTS WITH LIGHT, MEDIUM, AND HEAVY CRUDE OILS.** Five light, medium, and heavy crude oils were evaluated in a combustion tube, primarily at 750 and 2000 psig [5.2 and 13.8 MPa] and with  $O_2$  concentrations between 21 (air) and 95%. The overall characteristics of combustion with  $O_2$  appear to be superior to those with air. For light and medium crude oils, when the combustion conditions are marginal (e.g., at low temperatures at which the kinetics appears to control coke combustion), the apparent kinetics and the quality of the combustion were substantially improved when  $O_2$  enrichment was used. Three of the crude oils in this study did not burn in air; however, with the same flux of contained  $O_2$ , high levels of  $O_2$  enrichment could sustain combustion. (Edited author abstract) 12 refs.

Shahani, Goutam H. (Air Products & Chemicals Inc); Hansel, James G. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 12726, p 583-590.

**073141 CATALYTIC EFFECT OF HEAVY METAL OXIDES ON CRUDE OIL COMBUSTION.** Differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) were applied to crude oil combustion in the presence and absence of metal oxides. It was found that the effect of titanium oxide was similar to that of silica and alumina. Vanadium, nickel, and ferric oxides behaved similarly in enhancing the endothermic reactions. In the presence of a large surface area such as with silica, the surface reactions are predominant and unaffected by the small amount of metal oxide present. Kinetic analysis of the DSC curves revealed that the activation energies and the frequency factors of the hydrocarbon and the coke combustion reactions, estimated for all the metal oxide additives including silica and alumina, followed the same normal compensation trend. The application significance of this work lies in an EOR process called in-situ combustion. 12 refs.

Drici, Ouarda (Univ of Kansas, KS, USA); Vossoughi, Shapour. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14484, p 591-595.

**073142 SIMPLIFIED PERFORMANCE-PREDICTIVE MODEL FOR IN-SITU COMBUSTION PROCESSES.** A one-dimensional (1D) model to perform rapid calculations of fluid production history for dry and wet forward in-situ combustion processes is presented. The predominantly explicit, discrete timestep formulation divides the reservoir into four zones of constant properties, separated by shock fronts. Model results are compared with a 1D simulator study of a combustion-tube experiment and with field data from the Suplacu de Barcău project. (Author abstract) 26 refs.

Genrich, J.F. (Sohio Petroleum Co); Pope, G.A. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14242, p 410-418.

**073143 FIELD SCALE IN-SITU COMBUSTION SIMULATOR WITH CHANNELING CONSIDERATIONS.** A new and numerically stable algorithm has been developed to achieve the desirable fuel consumption. This algorithm involves an oil-flow-enhancement scheme. Arrhenius-type reactions have been found to be inadequate in field-scale combustion simulation. A new pseudokinetic scheme is introduced to field-scale studies in which the reaction zone is not simulated accurately because of the large size of the gridblocks. In some in-situ combustion projects, viscous fingering and channeling phenomena can affect the efficiency of the combustion process. A new formula of molecular diffusivity of oxygen has been introduced to represent the contact efficiency of the reactants. (Edited author abstract) 21 refs.

Ito, Yoshiaki (Gulf Canada Resources Ltd). *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 13220, p 419-430.

**073144 IN-SITU COMBUSTION IN THE LOWER HOSPAH FORMATION, MCKINLEY COUNTY, NEW MEXICO.** To evaluate the pilot test and to determine the reasons for its performance behavior, a reservoir model of the test site was developed from the historical performance of secondary recovery operations

in conjunction with available log and core data. The result was a three-layer, four-quadrant model of the test site. The volumetric sweep efficiency of the combustion front was estimated from two interior core holes drilled after the project was terminated. This resulted in a postcombustion model of the test site depicting the vertical sweep of the combustion front. Stoichiometric relationships were used to evaluate the combustion performance of each layer of the model. The stoichiometric evaluation provided a means to compare quantitatively the postcombustion reservoir model with actual test performance, thus verifying the model. (Edited author abstract) 7 refs.

Struna, Stephen M. (Tenneco Oil Co); Poettmann, Fred H. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14917, p 440-448.

**073145 EXTRACTION OF LOW-VISCOSITY OILS UNDER ULTRAHUMID COMBUSTION CONDITIONS.** Ultrahumid in situ combustion is one of the promising methods of increasing the efficiency of working light-oil fields. Owing to differences in the reaction characteristics of the oils in the region of low-temperature liquid-phase oxidation, the possibility of carrying out this process must be demonstrated experimentally for each specific case. Variation of the pH of the water obtained from the formation serves as an additional source of information concerning the occurrence of oxidative processes in light oils. In Russian. 7 refs.

Abasov, M.T.; Vezirov, O.Sh.; Orudzhaliyev, F.G.; Khismetov, T.V.; Mamalov, E.N. *Neft Khoz* n 4 Apr 1988 p 42-45.

## Leak Detection

**073146 NITROGEN/HELIUM LEAK DETECTION USED ON NORTH RANKIN 'A' PLATFORM.** In the past, leaks were found by pressuring the process systems first with water and then with hydrocarbons. This low cost but hazardous method of leak detection used gas detectors and soapy water to detect gas leaks. The disadvantage of this method is that large leaks contaminate the environment, risk a possible explosion and fire, and can result in a considerable loss of product. In the last few years, NOWSCO Well Service Ltd has developed a leak test process utilizing nitrogen mixed with helium as a tracer gas. With this innovative technology the industry is now able to eliminate the use of hydrocarbons during leak testing, and detect leakage rates as small as 0.1 cubic foot per year. This nitrogen/helium leak testing method was used on North Rankin 'A' platform. (Edited author abstract) 2 refs.

Albers, B. (NowSCO Well Services Ltd); Rose, H. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 123-128.

## Mathematical Models

**073147 MODELING OIL AND WATER PRODUCTION PROCESSES ON THE BASIS OF VOLTERRA EQUATION.** Based on an evaluation of experimental data concerning the transportation of oil and water via collecting pipes, it is shown that the discharge characteristics can be described qualitatively by the volterra equation. (Translated author abstract) In Russian. 2 refs.

Baikov, V.A.; Baikov, I.R. *Izv Vyssh Uchebn Zaved Neft Gaz* n 1 1987 p 41-43.

**Offshore** See Also MARINE PLATFORMS; MARINE PLATFORMS—Construction; MARINE PLATFORMS—Design; MARINE PLATFORMS—Maintenance; MARINE RISERS; OFFSHORE STRUCTURES—Analysis; OIL FIELD EQUIPMENT—Pumps; OIL FIELDS—Monitoring; OIL RIGS, JACK-UP—Design; PRODUCTION PLATFORMS—Accidents; PRODUCTION PLATFORMS—Design; SHIPS—Design; TANKERS—Loading.

**073148 NOVEL FPSO FACILITY SERVES THREE NIGERIAN OIL FIELDS.** The recently installed Antan floating production, oil storage and offloading (FPSO) facility designed, installed and operated by Single Buoy Moorings Inc, according to Ashland Oil Co. (Nigeria) specifications, is the first such installation to handle

production from more than one offshore oil field. Permanently moored to a conventional fixed platform in 125 ft of water 22 miles off Nigeria, the FPSO vessel is equipped to handle up to 80,000 bpd through parallel process trains of 40,000 bpd each. Currently handling a total output of 25,000 bpd from Adanga and Akam fields in Ashland's offshore concession OPL 98, the facility has the capability of having additional fields connected at a later date. A soft yoke mooring designed to withstand 100-year storms allows the vessel to weathervane about the platform.

Eppley, D.R. (Ashland Oil Co, Houston, TX, USA); Davison, N.J.; Beare, A. *Ocean Ind* v 22 n 1 Jan 1987 p 30, 32-33.

**073149 HOW PENROD PLANS TO DRILL FROM THE BLOCK 29 FPS.** In the fall of 1987, Penrod Drilling Co.'s Penrod 72 semi-submersible will be moored on location over Placid Oil Co.'s Gulf of Mexico Block 29 subsea template in 1,522-ft water to begin a 15-year life both as a permanent floating production system (FPS) and as industry's first-ever MODU that drills and produces simultaneously. Placid and Penrod, in choosing the first-of-a-kind deepwater development scheme, faced the unique challenge of converting a 12-year-old vessel, which has drilled primarily deepwater exploratory wells into a floating platform designed to drill and complete multiple development wells in the most expeditious and economical method. Refs.

Anon. *Ocean Ind* v 22 n 7 Jul 1987 p 17-20.

**073150 SELM/ITALIAN CONTRACTORS READY VEGA A FOR FIRST OIL.** First oil from the giant Vega field, located some 13 miles off the southeastern coast of Sicily in 410-ft water is expected in July. Discovered in 1980, field development has proceeded under the direction of the operator, SELM S.P.A., a subsidiary of the Montedison Group of Milan. This paper details the operations directed by SELM that will allow the first barrel of Vega oil to flow through tied-back template wells, platform production system, subsea lines and single-point mooring to the permanently moored Vega Oil storage tanker, where each participating company will take its oil in kind for shuttle tanker delivery to a refinery of its choice. These operations include: rigging up for platform drilling, tie-back and completion of suspended template wells, commissioning of platform production facilities, special design/installation of seabed lines, and principal storage tanker features. 4 refs.

Snyder, Robert E. (Ocean Industry, Houston, TX, USA). *Ocean Ind* v 22 n 7 Jul 1987 p 40-42, 44, 46-47.

**073151 NEW SYSTEM INSTALLS HEAVY SUBSEA COMPONENTS SAFELY.** The Mobile-Designed Subsea Atmospheric System (SAS), which is presently undergoing final development, comprises three heavy components, two of which must be lowered in deep water, precisely oriented and mated with controlled vertical velocity. A submerged motion compensator and a positive wire rope positioning program are to be used to achieve precise placement of these components on the seafloor.

Anon. *Ocean Ind* v 22 n 8 Aug 1987 p 41-42.

**073152 KITTIWAKE PROJECT WILL PACE GANNET AREA DEVELOPMENT.** After low oil prices forced operators to shelve plans for a \$3.2-billion Gannet area development, engineers came up with a low-cost solution to make Kittiwake field a stand-alone project. After exploring a wide range of options - including a floating production system that was found to offer no significant economic advantage - the optimum solution was identified as a multi-well 15,000-mt slimline fixed platform linked to a Single Buoy Mooring. The resulting \$350 million (\$560-million) development proposal for Kittiwake - now awaiting approval from the UK Department of Energy - is about 40% under initial cost estimates.

Anon. *Ocean Ind* v 22 n 8 Aug 1987 p 49-50.



**073153 ENVIRONMENTAL PROTECTION MANAGEMENT IN OFFSHORE OIL AND GAS FIELDS.** The response of industry to environmental obligations and responsibilities has been an area of heightened debate in recent months stimulated by the European Year of the Environment, publication of the final report of the World Commission on Environment and Development, and the forthcoming Second International Conference on the Protection of the North Sea. These initiatives help to highlight the principle that industry should continue to strive for a preventative approach to the environmental consequences of its activities. The author discusses the principal elements in an environmental impact assessment. 17 refs.

Probert, P.K. (BP Int Ltd). *Pet Rev* v 41 n 489 Oct 1987 p 28, 30-32.

**073154 TELEMETRY AND CONTROL SYSTEM FOR INTERPLATFORM CRUDE LOADING AT THE STAFFJORD FIELD.** A control system for crude loading to tankers at the Staffjord field has been designed to allow tanker loading to take place at all times to prevent production shutdowns caused by loading-buoy problems. This paper discusses how the control system was designed to maximize the flexibility of loading operations and to meet all safety and regulatory requirements. The experience gained from more than 4 years of operation of the system is reviewed. The system has allowed maximum use of total field crude storage capacity while loading to 125,000-DWT [127 000-Mg] tankers nearly every day throughout the year. It has been possible to maintain a high production rate even through the periods of difficult weather conditions experienced in the northern North Sea. (Author abstract)

Malm, P.C. (Mobil Exploration Norway Inc); Lassa, P. *JPT J Pet Technol* v 40 n 4 Apr 1988 SPE 15452, p 453-458.

**073155 COMPOSITE LEG PLATFORMS FOR DEEP U.S. GULF WATERS.** A new fixed platform design, embodying two configurations which simplify and reduce the cost of fabrication and installation and improve structural performance in-place, has been developed by Hudson Engineering, a McDermott Company. Studies indicate the patented Composite Leg Platform (CLP) is more efficient than the conventional fixed platform at 1,600-ft water depths and that the Compliant Composite Leg Platform (CCLP) is economically attractive to at least 3,000 ft in the Gulf of Mexico. Basic configurations of the CCLP and the CLP are very similar, with exception of those features used to produce the desired compliant or non-compliant in-place response. In each configuration, piles are clustered around corner legs, and extend vertically several bays above the mudline. In the non-complaint mode, it is desirable under some circumstances to support the jacket with piles driven through the legs in bottom levels. Once these piles have been grouted to the jacket legs, they form a 'composite leg' section. 8 refs.

Will, Stephen A. (McDermott Co, Houston, TX, USA); Morrison, Denby G.; Calkins, Dennis E. *Ocean Ind* v 23 n 3 Mar 1988 p 23-28.

**073156 MAJOR OFFSHORE WORK READIES PLACID FIELD FOR STARTUP.** Not since Exxon installed the Lena field guyed tower in 1983 has the Gulf of Mexico seen so much innovative offshore work as has taken place in conjunction with Placid Oil's development of the Green Canyon Block 29 area (GC 29). Working in water depths ranging from 550 to 2,300 ft, Placid and its principal contractors have been breaking records and establishing firsts at an impressive pace. The achievements include: installation of the largest and most sophisticated permanent mooring system ever set in the Gulf of Mexico, deployment of the first floating production platform in the Gulf, completion of the deepest production well in the Gulf and the second deepest in the world, running of the world's largest and most technologically advanced production riser, and installation of flowlines by the bottom-tow method for the first time in the Gulf.

McCabe, Charles (Ocean Industry, Houston, TX, USA).

*Ocean Ind* v 23 n 3 Mar 1988 p 36-39, 42-45.

**073157 RISER TESTS MOVE AHEAD ON ADRIATIC PLATFORM.** Agip is proceeding with an extensive research project on a Tension Leg Platform (TLP) for oil production in very deep waters. One of the most challenging problems encountered in designing a TLP is the safe design of the production risers. To acquire reliable experimental data needed for properly designing an array of deepwater risers, a full-scale riser test was organized. The basic approach is to install a single, or a pair of, instrumented risers on a gas production platform newly installed in the Barbara field in the Adriatic Sea at a water depth of about 70 meters. A description is given of the surface and bottom equipment used for the tests, and the test categories planned for a single-riser configuration and for two-riser tests are indicated.

Campelli, P. (Agip SpA); Berta, M.; Basu, A.C. *Ocean Ind* v 23 n 4 Apr 1988 p 103, 105, 107.

**073158 SWOPS: OIL PRODUCTION, STORAGE AND TRANSPORT SYSTEM.** The SWOPS production system has been devised by BP as a means of producing oil from small offshore fields that would be considered uneconomic to develop from fixed platforms or by other more conventional means. The system can also provide a relatively low-cost method of testing a reservoir over a long period to assess if a discovery is worthy of development. SWOPS is to be built for BP, as a joint venture, by Harland and Wolff of Belfast. Matthew Hall Engineering is responsible for design, procurement and installation of the process facilities, riser system and ROV handling facility. BP's Cyrus Field in Block 16/28 in the U.K. North Sea will be the first to be developed using the SWOPS system. (Edited author abstract)

Anon. *Oil Gas Eur Mag* v 13 n 1 1987 p 22.

**073159 DIMOS: DIVERLESS INSTALLABLE AND MAINTAINABLE OIL PRODUCTION SYSTEM.** Starting less than 40 years ago in the coastal swamps of Louisiana, the offshore industry has since progressed into ever deeper waters. Today, production of hydrocarbons in just over 300 metres water depth is a reality. But because exploration for oil and gas continues in even greater depths, beyond the present limit of human intervention by hyperbaric diving, new production systems must be designed which can be installed and maintained without the help of divers. Using the experience gained in a wide variety of offshore situations worldwide, Shell has developed a conceptual production system for a hypothetical oil field in 600 metres water depth and harsh environment in order to meet the challenge offered by successful exploration in such great depths. Some parts of the subsea engineering for the DIMOS project have been carried out in Norway. (Author abstract)

Anon. *Oil Gas Eur Mag* v 13 n 1 1987 p 23.

**073160 SAS: SUBSEA ATMOSPHERIC SYSTEM.** The search for oil and gas around the world has led to oil exploration activities into increasingly deeper waters. As the depth increases, the reserves must be increasingly larger in order to justify field development with fixed platforms. At a depth of 300 meters, the reserves must be very large if a fixed platform is to be installed, and at greater depths it is hardly economical to develop a field with fixed platforms. The alternative is to use subsea production systems, either in connection with a fixed installation, which makes it possible to exploit a greater area, or in combination with a floating platform. Offshore operators can now take advantage of a fully developed subsea production system, the Mobil, Statoil, and Kvern jointly developed hybrid Subsea Atmospheric System (SAS), that bridges the gap between wet and dry systems, following comprehensive final work on proving the concept. (Author abstract)

Anon. *Oil Gas Eur Mag* v 13 n 1 1987 p 25.

**073161 TURRET MOORING COMPLETES WORLD'S LARGEST FSO SYSTEM.** In January 1988,

SOFEC Inc. completed design and construction of a turret mooring system for Yemen Exploration & Production Co. (YEPSCO). The turret mooring was constructed and mounted to the bow of the 409,000 DWT tanker Safer. Safer sailed to location and was installed at YEPSCO's offshore site in the Yemen Arab Republic (formerly North Yemen) where first oil flowed on March 22, 1988. Formerly ESSO Japan, the tanker, and its production facilities, constitute the largest permanently moored floating storage and offloading (FSO) system in the world. Described in this paper are details of the single point mooring turret, how it was designed, built and installed, and how it operates. Also presented is an overview of the FSO storage and offloading system with emphasis on the crude handling risers, swivel, valves and controls.

Anon. *Ocean Ind* v 23 n 6 Jun 1988 p 43-45.

Optimization See Also OIL FIELDS—Management.

**073162 OPTIMIZE PRODUCTION THROUGH BALANCED RESERVOIR DEPLETION: PART 1 - METHODS AND DATA REQUIRED.** A description is presented of the basic reservoir study that describes rock properties, fluid properties, structure, volumetric reserve analysis, material balance, production decline curve analysis, reservoir compositional model, and development of in-flow performance. The three methods for increasing and decreasing production with electric subsurface pumps (ESPs) are discussed. In addition, rate and pressure tests are examined.

Patton, L. Douglas (L.D. Patton & Associates, Aurora, CO, USA). *Pet Eng Int* v 60 n 7 Jul 1988 p 23-25.

Performance

**073163 FAHUD FIELD REVIEW: A SWITCH FROM WATER TO GAS INJECTION.** The water injection schemes implemented in the Fahud field during the early 1970's led to poor recoveries because the reservoirs were both fractured and oil-wet. On the basis of the results of a thorough performance review, it was decided in 1983 to promote gas/oil gravity drainage fully by drilling rows of downip producers and switching completely from water to gas injection. This paper investigates the reasons behind each stage of development and reviews recent efforts to evaluate the future production potential through the use of dual-porosity simulators. (Author abstract) 6 refs.

O'Neill, Niel (Petroleum Development Oman). *JPT J Pet Technol* v 40 n 5 May 1988 SPE 15691, p 609-618.

**073164 PRODUCTION PERFORMANCE ANALYSIS OF HORIZONTAL DRAINAGE WELLS FOR THE DEGASIFICATION OF COAL SEAMS.** The production performances of horizontal drainage wells for the degasification of coal seams have been investigated with a multidimensional, two-phase coal-seam degasification model. The model is written in rectangular coordinates, can handle a number of horizontal wells, and operates in a one-, two-, or three-dimensional (1D, 2D, or 3D) mode. The model accommodates multiple horizontal boreholes originating from a common vertical shaft or horizontal boreholes being drilled from the peripheries of the reservoir. In consideration of the relatively thin but large lateral extent of coal seams, flow dynamics around a horizontal borehole is described in elliptic flow geometry. (Edited author abstract) 14 refs.

Ertekin, Turgay (Pennsylvania State Univ, PA, USA); Sung, Wonmo; Schwerer, Fred C. *JPT J Pet Technol* v 40 n 5 May 1988 SPE 15453, p 625-632.

**073165 NEW APPROACH TO THE HYPERBOLIC CURVE.** An efficient and timesaving approach to hyperbolic-decline-curve analysis has been developed that has made it possible to determine the hyperbolic b exponent characterized by thousands of wells. After extensive use of the technique, the authors concluded that the range of the b exponent previously prescribed by J.J. Arps is too



narrow. The type curves are marked to exhibit instantaneous equivalent annual decline rates. In addition to its simplicity, this technique provides the engineer with a straightforward visual understanding of historical performance and a clear grasp of potentially expected future production trends. (Edited author abstract). 7 refs.

Long, D.R. (Williamson Petroleum Consultants Inc); Davis, M.J. *JPT J Pet Technol* v 40 n 7 Jun 1988 p 909-912.

**Pressure Effects** See OIL WELLS—Hydraulic Fracturing.

**Secondary** See Also OIL WELL COMPLETION; OIL WELL DRILLING—Optimization.

**073166 ANALYTICAL MODEL OF UNSTABLE IMMISCIBLE FLOW.** An analytical method is developed for calculating pseudo relative permeabilities which can be used to describe the average properties of unstable immiscible flow. The predictions of this model are in good agreement with the results of numerical simulations of unstable flow using a Monte Carlo solution technique. (Author abstract) 9 refs.

Hughes, D.S. (UKAEA, Dorchester, Engl); Murphy, P. *Soc Pet Eng AIME Pap SPE* n 017473 1987 15p.

**073167 USE OF A MONTE CARLO METHOD TO SIMULATE UNSTABLE MISCIBLE AND IMMISCIBLE FLOW THROUGH POROUS MEDIA.** A Monte Carlo (statistical) solution technique has been implemented within the framework of a conventional simulator for two phase, or two component, flow. The implicit pressure equation is solved in the usual way. However, the explicit equation, describing the rate of change of saturation or concentration of the invading fluid with time, is interpreted as a probability density function and solved statistically. This method automatically triggers an unstable solution when the mobility ratio is unfavourable. The algorithm has been applied to a series of both linear and quarter five-spot miscible and immiscible problems, and the results are presented and discussed. (Edited author abstract) 7 refs.

Hughes, D.S. (UKAEA, Dorchester, Engl); Murphy, P. *Soc Pet Eng AIME Pap SPE* n 017474 1987 24p.

**073168 MEASUREMENT AND CORRELATION OF DIFFUSION COEFFICIENTS FOR CO<sub>2</sub> AND RICH-GAS APPLICATIONS.** A novel in-situ method for measuring molecular diffusion coefficients of CO<sub>2</sub> and other solvent gases in consolidated porous media at high pressure has been developed and is described. This technique is unique because visual observations and measurements of composition are not required. Experimental diffusion coefficients are reported for CO<sub>2</sub> in decane up to 850 psia [5.86 MPa], for CO<sub>2</sub> in 0.25 N NaCl brine up to 850 psia [5.86 MPa], and for ethane in decane up to 600 psia [4.14 MPa]. All tests were conducted in Berea cores saturated with liquid phase at 100°F [311 K]. Cores were oriented both vertically and horizontally to assess the effects of gravity-induced convection on the observed mass transfer. (Edited author abstract) 28 refs.

Renner, T.A. (Amoco Production). *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 15391, p 517-523.

**Sub-Sea Production System** See Also FLOW OF FLUIDS—Two phase; OIL FIELD EQUIPMENT—Pumps; OIL FIELDS—Field Development; PIPELINES, SUBMARINE—Construction; PRODUCTION PLATFORMS—Design.

**073169 RECORD RELIABILITY FOR THE FIRST SUBSEA PRODUCTION SYSTEM IN THE NORTH SEA.** Since oil was first discovered in the North Sea, operators have been constantly searching for methods which will enable natural reserves to be fully exploited. But because of a health desire to protect their investment the major oil companies view any departure from conventional technology with a critical eye. In this environment Shell in a joint venture with Esso decided to install a subsea production system which threatened to revolutionize automated offshore oil production. Since the first oil

was produced in 1981 from this system a 95% record of availability has been achieved, and the technology has been utilized by many companies to fully exploit natural offshore oil and gas deposits.

Dempster, J. (Ferranti Subsea Systems Ltd). *QJ Tech Pap Inst Pet* Jul-Sep 1986 p 83-84.

**073170 DEEPWATER TECHNOLOGY FOCUSING ON PRODUCTION.** Designed for operation in up to 2,600 ft of water, the Mobil system is said to have a price tag equal to that of a fixed platform system in about 1,300 ft of water. The system provides for total production capability in a severe environment, including full well control, downhole servicing, gas lift, water and gas injection, oil storage, and tanker offloading. It can be used for either gas or oil fields, and seafloor components can be used in conjunction with nearby platforms in shallower water. Although designed for maximum reliability and minimum maintenance the system provides for manned intervention for equipment maintenance and operational changes by oil field technicians. Major components of the system are discussed. Other deepwater production activities and equipment are also briefly examined.

McNally, Rich (Petroleum Engineer Int, Duluth, MN, USA). *Pet Eng Int* v 59 n 4 Apr 1987 p 18-20.

**073171 MAGNUS SUBSEA WELLS: DESIGN, INSTALLATION, AND EARLY OPERATIONAL EXPERIENCE.** This paper describes the subsea aspects of the Magnus field development. The design and installation of the well completions and control systems are described. Problems encountered during this phase and during the early production life of the system are discussed. Some of the longer-term operational aspects are also discussed, and recommendations are made to improve subsequent subsea developments. (Author abstract) 1 ref.

Dawson, A.P. (BP Petroleum Development); Murray, M.V. *SPE Prod Eng* v 2 n 4 Nov 1987 SPE 12973, p 305-312.

**073172 DIMOS PROJECT: TECHNOLOGICAL BREAKTHROUGH.** The DIMOS project, a conceptual development aimed at achieving oil production from deep waters and in harsh environments without the use of divers, has made a major step forward. The multi-bore connector, one of the key elements of the systems seabed manifold, has successfully completed its initial tests. The DIMOS is designed to meet the requirements of a future deepwater oil field, where some twelve subsea satellite completed production wells would flow up to a total of 60,000 barrels per day. To increase hydrocarbon recovery and maintain reservoir pressure, eight water injection and six gas injection wells would also be completed subsea. The system is applicable for the production of oil from fields located in water depths beyond the reach of hyperbaric divers in areas with maximum wave heights of 30 m and surface currents of 1.5 m/s. The system is designed to enable the various components to be arranged in a variety of combinations of type and size in order to meet a wide range of specific field conditions.

Anon. *Mar Technol* v 17 n 4 Nov 1986 p 142-143.

**073173 LAST MAJOR TESTS CLEAR SAS FOR NORTH SEA APPLICATIONS.** Testing of a full-scale flowline connection system in Norway has marked a successful end to four years of intensive work on the hybrid Subsea Atmospheric System (SAS) for oil and gas production. This final series of tests established that the connection system and its built-in safety features will function as intended. The system is a subsea, multiwell assembly that features wet wellheads directly connected to a dry atmospheric chamber, within which oil/gas production is separated. From the chamber, oil and gas streams are transmitted to a pipeline bundle for transfer to a surface handling facility. Personnel can periodically enter the subsea chamber and work in a shirt-sleeve, one atmosphere environment. Present designs make the complex workable in water depths to 800 m (2,600 ft).

Anon. *Ocean Ind* v 23 n 2 Feb 1988 p 43-45.

**073174 ASSESSMENT OF PRODUCTION REGULARITY FOR SUBSEA OIL/GAS PRODUCTION SYSTEMS.** A model for subsea oil/gas production systems, being useful for carrying out production regularity studies, is presented. Formulas for calculating approximate (asymptotic) mean values of interesting reliability parameters within this model are derived. The use of these formulas is exemplified and discussed for a rather simple example. It is argued that the approximate formulas should be used in an interaction with Monte Carlo simulation, giving a powerful approach to the problem of assessing the availability (production regularity) of a subsea production system. (Author abstract) 3 refs.

Hokstad, P. (SINTEF, Trondheim, Norw). *Reliab Eng Syst Saf* v 20 n 2 1988 p 127-146.

**073175 DEVELOPING MARGINAL FIELDS WITH REMOTE SUBSEA SYSTEMS: PART 1 - PRODUCING SYSTEM ALTERNATIVES THAT SHOULD BE CONSIDERED AT PROJECT CONCEPTION TO ATTAIN MAXIMUM OPERATING FLEXIBILITY AT LEAST COST.** This paper is the first of two on development options for marginal offshore reserves using remote systems tied back to a host platform for production handling. In this paper, the advantages, disadvantages and cost implications of available subsea producing facilities are discussed. 2 refs.

Hunt, R.A.M. (Oilfab Group, Aberdeen, Scotl); Lorimer, E.P. *Ocean Ind* v 23 n 4 Apr 1988 p 15-18.

**073176 REMOTE SUBSEA SYSTEM CONTROLS DISTANT WELLS.** The Elf Aquitaine Group has developed and successfully tested a system that remotely controls subsea wellheads at distances to 12.4 miles. Manufactured by the French company ECA under the acronym, 'IRCUS' (Intelligent Remote Controlled Underwater System), it is an electro-hydraulic, multiplexed system based on programmable equipment. Operating from its remote location, IRCUS also monitors data that includes pressures, temperatures, limit switches, pressure switches, etc. The system is self-checking, will compensate for minor faults which may arise, and can switch to pre-programmed safety procedures if serious failures occur.

Anon. *Ocean Ind* v 23 n 4 Apr 1988 p 64.

**073177 PROTOTYPE ACOUSTIC SUBSEA WELL CONTROL INSTALLED.** A research and development project named Subsea Wells Acoustic Control System (SWACS) has been developed. The system can control and monitor up to 15 wells in water depths up to 1,000 m. No umbilicals to the surface are required, either for the electric or hydraulic lines. The system relies on a lithium battery for long-term energy storage and on acoustic telemetry for signal transmission. It also features low power consumption electronics with intrinsic well safety procedures and closed loop hydraulics. The control module can be installed without guidelines, with dedicated positioning, soft landing and orientation systems. It also features remotely operated subsea electrical and hydraulic connectors.

Anon. *Ocean Ind* v 23 n 4 Apr 1988 p 93-94.

**073178 TECHNICAL PROBLEMS SPUR DEEP-WATER R&D ACTION.** Highlights of three ongoing research efforts by ENI companies focus on technical and economical solutions to handle untreated multiphase subsea well fluids, develop a completion system for 3,280-ft water and repair pipelines in ultradeep water. This article summarizes the status of these three programs aimed at providing solutions to develop offshore marginal and deepwater fields beyond conventional water depth levels, with particular emphasis on underwater robotics. 1 ref.

Anon. *Ocean Ind* v 23 n 4 Apr 1988 p 95-96, 101-103.



**073179 NEW SUBSEA TREE DESIGNED FOR NORTH SEA FIELDS.** The Amerada Hess group is using a floating production system and a new universal Christmas tree design with unique features in its subsea development of Ivanhoe and Rob Roy fields in the UK North Sea. In addition, a special dual workover riser package has been provided to facilitate well maintenance via wireline or coiled tubing.

Anon. *Ocean Ind* v 23 n 4 Apr 1988 p 144.

**073180 MULTIBORE MODULE CONNECTS SUBSEA MANIFOLD, PIPELINES.** Kongsberg Subsea Systems has developed a retractable horizontal multibore connector to tie the pipelines, flowlines and service lines into underwater manifolds. The device, manufactured for use on A/S Norske Shell's deepwater production system, is designed to simplify connecting multiple lines to the maze of piping on complex subsea gathering stations. Successful testing of the connector proved the feasibility of using such a connector mechanism in both horizontal and vertical applications, eliminating the requirement for flexibility to be built into connecting pipework.

Luff, Richard (Sheerway Technology Group Ltd, Woking, Engl). *Ocean Ind* v 23 n 4 Apr 1988 p 150, 152.

**073181 PETROBRAS MAINTAINS LEAD IN SUBSEA COMPLETIONS.** Petrobras provided further evidence in January that it is the leader in subsea production technology. The Brazilian national oil company completed well 3-RJS-376D at a depth of 1,614 ft subsea to extend by 240 ft the world water depth record it had set only last November with Albacora-field well 4-RJS-328. RJS-376D is the fourth in a set of Marimba field wells that Petrobras has used to test its diverless completion equipment and methods. All four wells have been successfully brought onstream. Petrobras is presently specifying diverless layaway trees for all wells in water depths between 300 and 600m. Current layaway technology is being pushed step-wise for depths in the 600 to 1,000-m range. Petrobras is working under long-term agreements with suppliers to develop technology for completion systems for water depths to 1,800 m.

Anon. *Ocean Ind* v 23 n 4 Apr 1988 p 5.

**073182 DEVELOPING MARGINAL FIELDS WITH REMOTE SUBSEA SYSTEMS; PART 2.** Part 1 of this series dealt with advantages, disadvantages and cost implications of development with a subsea production center, cluster wells serving a small manifold, and satellite wells producing through a small manifold. This concluding installment discusses operating and economic factors that can help in selecting the most cost-effective pipeline system between subsea facilities and host platform, riser access system to bring production to the platform deck, and platform processing facilities. 2 refs.

Hunt, R.A.M. (Oilfab Group, Aberdeen, Scotl); Lorimer, E.P. *Ocean Ind* v 23 n 5 May 1988 p 40-43.

**073183 SUBSEA WIRELINING INNOVATION OPERATIONAL AT KEPITING.** Conoco Indonesia has developed Kepiting oil field in the Natuna Sea, Indonesia, as a satellite to its larger Udang field located some 5 miles northeast. Kepiting has two subsea wells in 295-ft water which produce into the floating production storage and offloading (FPSO) barge called Production Barge San Jacinto (PBSJ). For economic reasons, Conoco has designed a unique well maintenance/workover system which permits wireline work on the two wells using only a workboat and a portable riser/lubricator base. This surface riser/ buoy system is deployed and attached, as needed, to 240-ft riser and subsea buoy systems permanently mounted on each well. 3 refs.

Kadi, I. (Conoco Indonesia, Indonesia); Wybro, P.G.; Rodriguez, F.H. *Ocean Ind* v 23 n 6 Jun 1988 p 26-27, 30.

**073184 DIVERLESS SUBSEA SYSTEM TO PRODUCE OIL IN DEEP WATERS.** The Diverless Subsea Production System (Disps), British Petroleum Co. plc's entry into the expensive world of deepwater oil produc-

tion, will soon begin the onshore testing phase. A full scale segment of the Disps template, designed to operate in water depths to 1,300 ft, will be fabricated prior to an extensive onshore test program. Disps, BP's biggest single R&D project, is a two part project aimed at providing a system to produce oil from the outer slope of the European continental shelf in the mid 1990s. The most likely locations are in British or Norwegian waters, and the system must be capable of being upgraded for use in 2,500-ft water depths. Disps will follow the broad outlines of other deepwater, diverless systems with the wellhead and various production modules contained within a template with a capability for connecting remote satellite wells. Modules are installed and retrieved by a remote guidance vehicle.

Anon. *Oil Gas J* v 86 n 33 Aug 15 1988 p 52,54.

**073185 WET CONNECTION SYSTEM OF PIPELINE BUNDLE - SUBSEA PRODUCTION SYSTEM.** A subsea production system (SPS) for installation in water depth of over 300 m was researched for seven years under the large-scale technical research and development project of the Agency of Industrial Science and Technology, Ministry of International Trade and Industry. In this project, Nippon Steel was commissioned to perform research and development on the pipeline system. Emphasis was placed on the development of a unique wet connection system for installing pipeline bundles on the sea floor without diver assistance or guidelines. The system thus developed features the capability of repeatedly connecting and disconnecting a bundle of electric power, signal and hydraulic lines in the deepsea environment by remote control from the surface. It successfully demonstrated its functions to attain the objectives of development in various fundamental experiments, surface and underwater tests and in an integrated SPS verification test. (Author abstract) 4 Refs.

Miyake, Toshihiro (Nippon Steel Corp, Jpn); Kitajima, Taishu; Hagihara, Toshio. *Nippon Steel Tech Rep* n 36 Jan 1988 p 15-24.

**073186 OIL EXPLOITATION AT GREATER DEPTHS.** Since the beginning of the exploitation of the North Sea oil and gas reserves two decades ago, the petroleum industry has built up its offshore capabilities in some of the most inhospitable conditions ever encountered by offshore operators anywhere in the world. As a result, petroleum companies and equipment suppliers have developed techniques for exploiting hydrocarbons at great depths - currently well in excess of 350 m - in exceptionally arduous environments and remote areas. (Author abstract).

Ford, E. (Engineering Gazette, London, Engl). *Eng Dig (Toronto)* v 34 n 4 Aug 1988 p 17-18.

**073187 EXTENDING THE INNES FIELD LIFE BY COST-EFFECTIVE SUBSEA TECHNOLOGY.** A description is given of an approach taken to extend the economic life of the Innes field, one of the North Sea's smallest producing oil fields. Emphasis is placed on the importance of minimizing production operating costs for developed fields. In the Innes field case, this was achieved by applying 'low-cost technology' to change the Innes field production mode from a dedicated floating production facility to a subsea satellite manifold producing to a remote floating production facility (FPF). The feasibility study, the Innes field flow test, and the eventual project work leading to the demobilization of the Innes field FPF and the routing of Innes field fluids to the nearby FPF Deepsea Pioneer are described, which emphasizes the cost benefits obtained by using low-cost proven technology wherever possible and limiting the use of high-cost equipment. (Edited author abstract).

Workman, D.M. (Hamilton Brothers Oil & Gas Ltd, USA); Methven, J.O.; Kearns, J. *JPT J Pet Technol* v 40 n 9 Sep 1988 p 1197-1202.

**073188 DEEP OFFSHORE TECHNOLOGY 1985: 3RD INTERNATIONAL CONFERENCE AND EXHIBITION PROCEEDINGS.** This conference proceedings

contains 44 papers. The main topics discussed are: Italian offshore activities in the Mediterranean; U.S. government policies and deep-water technology development; the Montanazo deepwater development project; exploration; installation/ maintenance of sub-sea systems; pipelines in deep water; deepwater drilling; deepwater productions. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10666 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Assoc Scientifique et Technique pour l'Exploitation des Oceans, Paris, Fr). *Deep Offshore Technol 1985: 3rd Int Conf and Exhib Proc, Sorrento, Italy, Oct 21-23 1985* Publ by Deep Offshore Technology, Amsterdam, Neth, 1985 2 vol, var pagings.

Suriname See OIL FIELDS—Suriname.

Taxation See PETROLEUM INDUSTRY—Australia.

Tertiary See Also SURFACE ACTIVE AGENTS.

**073189 SCOPE AND PERSPECTIVE OF ROS MEASUREMENT AND FLOOD MONITORING.** In this paper, we deal only with the scope and perspective of the methodology and how they interrelate with the overall objective of successful supplemental recovery. A discussion is also presented of the remaining oil saturation (ROS) measurements and flood monitoring methods. Factors pertinent to when and where to measure ROS are discussed. 27 refs.

Thomas, E.C. (Shell Oil Co); Richardson, J.E.; Shannon, M.T.; Williams, M.R. *JPT J Pet Technol* v 39 n 11 Nov 1987 p 1398-1406.

**073190 LABARGE PROJECT: AVAILABILITY OF CO<sub>2</sub> FOR TERTIARY PROJECTS.** The LaBarge field in Wyoming is being developed to recover and to sell methane, as well as CO<sub>2</sub>, and helium. As a source of CO<sub>2</sub>, the LaBarge field provides oil producers in the Rocky Mountain area an opportunity to increase production in their mature fields through EOR projects. A 649-mile pipeline is planned to transport up to 650 MMcf/D [18.4 × 10<sup>6</sup> m<sup>3</sup>/d] of CO<sub>2</sub> to users throughout Wyoming and the Williston basin. A CO<sub>2</sub> marketing survey indicates potential CO<sub>2</sub> demand of 4.4 Tcf in the planned marketing area for EOR. About 25% of the CO<sub>2</sub> demand identified is already contracted. LaBarge CO<sub>2</sub> will allow northern Rocky Mountain operators to recover a potential and additional 1 billion bbl of oil reserves. (Edited author abstract) 1 ref.

Hunter, J.K. (Exxon Co, USA); Bryan, L.A. *JPT J Pet Technol* v 39 n 11 Nov 1987 p 1407-1410.

**073191 INVESTIGATION OF UNEXPECTEDLY LOW FIELD-OBSERVED FLUID MOBILITIES DURING SOME CO<sub>2</sub> TERTIARY FLOODS.** Phase behavior, inorganic precipitation, and wettability are investigated as possible reasons for the unexpectedly low field-observed mobilities during some CO<sub>2</sub> floods, in particular, the Denver Unit, Wason field CO<sub>2</sub> pilot. The observed mobility was not a near-wellbore effect and probably played a major role in reservoir sweep: the low effective permeability offset the detrimentally low CO<sub>2</sub> viscosity. Experimental and simulation studies, supplemented by literature data, lead to the conclusion that rock wettability could be the root cause of these low fluid mobilities. (Edited author abstract) 32 refs.

Patel, P.D. (Shell Development Co); Christman, P.G.; Gardner, J.W. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14308, p 507-513.

**073192 EFFECT OF INTERFACIAL VISCOSITIES UPON DISPLACEMENT IN SINUSOIDAL CAPILLARIES.** This quantitative analysis shows the relative effects of interfacial tension, interfacial viscosities, and wetting during displacement in a capillary whose radius is a sinusoidal function of axial position. The effect of the



interfacial viscosities is to increase the resistance to displacement regardless of the wetting condition. The results are consistent with a previous qualitative analysis and with a previous quantitative analysis for displacement in capillaries whose radii are independent of axial position. In screening surfactant systems for potential use in tertiary oil recovery, it is recommended that the interfacial tension be minimized first, since it determines whether oil displacement will occur, and that the interfacial viscosities be minimized second, since they influence the rate of oil displacement. (Author abstract) 41 refs.

Giordano, R.M. (Northwestern Univ, Evanston, IL, USA); Slatery, J.C. *AIChE J* v 33 n 10 Oct 1987 p 1592-1602.

**073193 EFFECT OF THERMAL AGING ON XANTHAN SOLUTIONS.** The viscosity stability of xanthan solutions is crucial to petroleum recovery processes. The effects of oxygen concentration, pH, and temperature on viscosity during aging up to 6 months were studied. The structure modifications of the xanthan (substituent contents, weight-average molecular weights) with aging times were followed and related to viscosity loss. In all cases, the acetyl groups were hydrolyzed. The best stability to thermal aging corresponds to neutral or basic conditions with very low oxygen concentrations. At these conditions the viscosity was stabilized to about 50% of its initial value after 6 months at 80°C. In these cases the private groups were not hydrolyzed. The stabilization of main chain breaks in the ordered xanthan conformation improves the stability results. (Author abstract) 18 refs.

Milas, M. (CNRS, St.-Martin d'Heres, Fr); Linossier, J.L.; Contat, F. *J Appl Polym Sci* v 35 n 4 Mar 1988 p 1115-1122.

**073194 DESIGN OF A TERTIARY HYDROCARBON MISCIBLE FLOOD FOR THE MITUSE RESERVOIR.** A large-scale hydrocarbon miscible flood has been designed and is being conducted in the Mitsue Gilwood Sand Unit No. 1 in Alberta, Canada. This paper reviews the evaluation and design process by use of recently developed methodologies, involving innovative laboratory techniques and simulation processes used in planning the miscible flood. Simulation studies indicate that optimum solvent and chase-gas slug sizes of 15 and 25%, respectively, will yield an incremental 12.2% of original oil in place (OOIP), or 21.3 MMSTB. Solvent and chase-gas recoveries were estimated to be 73 and 44%, respectively. (Edited author abstract) 7 refs.

Frimodig, J.P. (Chevron Canada Resources Ltd); Sankur, V.; Chun, C.K. *JPT J Pet Technol* v 40 n 2 Feb 1988 p 215-222.

**073195 MIDDLE CO<sub>2</sub> FLOOD PILOT.** The Middle oil field is part of a Mississippian carbonate trend in southeastern Saskatchewan. The Middle Unit has been under waterflood since 1962 and is approaching an 80% watercut. In an attempt to increase recovery, Shell Canada Limited and partners have begun piloting a tertiary miscible CO<sub>2</sub> process. This article focuses on the planning and design of the CO<sub>2</sub> pilot which began in 1984. The design integrates techniques from both observation and production-style pilots. The analysis of data from many sources is crucial for timely scale-up of results from the project which will conclude in 1988. (Edited author abstract) 6 refs.

Beliveau, Dennis A. (Shell Canada Ltd, Can). *J Can Pet Technol* v 26 n 6 Nov-Dec 1987 p 66-69.

**073196 RESERVOIR SURVEILLANCE PROGRAM: JUDY CREEK BEAVERHILL LAKE 'A' POOL HYDROCARBON MISCIBLE FLOOD.** In 1985, Esso Resources Canada Limited commenced hydrocarbon solvent injection into the Judy Creek Beaverhill Lake 'A' Pool. This staged miscible flood is forecast to recover an incremental 6% of the original oil in place. To ensure maximum tertiary oil recovery, Esso Resources has initiated a reservoir surveillance program. The program includes a computer system to monitor production, injection, and voidage data; a radioactive tracer program

to track solvent and waterflow; injection and production logs to monitor the zonal distribution of the injected solvent; reservoir pressure surveys to ensure solvent/oil miscibility and solvent containment; solvent injection composition monitoring; and a sampling program to monitor reproduced fluid compositions. (Edited author abstract) 3 refs.

Jonasson, Hans P. (Esso Resources Canada Ltd, Can). *J Can Pet Technol* v 26 n 6 Nov-Dec 1987 p 70-75.

**073197 PERFORMANCE OF SOUTH SWAN HILLS TERTIARY MISCIBLE FLOOD.** A review of the performance of the tertiary hydrocarbon miscible flood which has been operating in the West Waterflood area of the South Swan Hills unit since 1982 is presented. The production trend indicates that the tertiary flood has reversed the steady decline experienced under waterflood to the extent that the oil production has increased from 450 m<sup>3</sup>/day to as high as 1200 m<sup>3</sup>/day in 1986. The ultimate recovery factors for the project area are estimated at 38% original oil in place (OOIP) by waterflood and 59% OOIP by miscible flood. The projected 20% incremental recovery is based on a black oil model simulation and is in line with the incremental recovery predicted for the secondary miscible flood in the South Swan Hills Unit. (Edited author abstract) 4 refs.

Derochie, Lionel J. (Amoco Canada Petroleum Co, Can). *J Can Pet Technol* v 26 n 6 Nov-Dec 1987 p 76-81.

**073198 CHEMICAL AND PHYSICAL APPLICATIONS IN TREATING PRODUCED-FLUID EMULSIONS OF THE BELL CREEK MICELLAR/POLYMER FLOOD.** Unforeseen chemical and physical treating problems arose in obtaining acceptable oil and water quality when produced micellar petroleum sulfonates created unique phase changes in the produced-fluid emulsion. Production facilities had to be modified continuously to adapt to the changing emulsion characteristics. Although the production facilities were adapted to meet the changing phase concentrations of the produced fluid, their undersized capacity would not allow the retention time necessary to break the oil and water emulsions effectively in the presence of sulfonates. Conventional reverse chemicals and demulsifiers proved ineffective in treating the produced-fluid emulsion. New chemicals had to be developed to treat the sulfonated production in an environment conducive to the undersized production facilities. (Author abstract) 8 refs.

Johnson, R.E. (O-Tech Inc); Kennelly, R.G.; Schwarz, J.R. *SPE Prod Eng* v 3 n 2 May 1988 SPE 15175, p 210-216.

**073199 PHASE BEHAVIOUR OF TERTIARY RECOVERY SULFONATES - PETROLEUM FRACTIONS - AQUEOUS SYSTEMS.** The phase behavior of tertiary recovery sulfonates having commercial names TRS-10, TRS-16 and TRS-40 with aqueous phase and light petroleum fractions (non polar kerosene and gasoline) was studied at 20, 40 & 60 degrees C. The adopted pseudo components of the ternary diagram are hydrocarbon, surfactant and aqueous phase. The aqueous phase was composed of bidistilled water in addition to different proportions of pure alcohols and sodium chloride. The tested alcohols included methanol, ethanol, iso-propanol, n-butanol and n-pentanol. It was shown that the higher the affinity of the tested surfactant for hydrocarbon phase, the greater is the solubility of the corresponding optimum co-surfactant in water. (Edited author abstract) 31 refs.

Ghoniem, S.A. (Kuwait Oil Co, Ahmadi, Kuwait); Darwish, T.A.; Salamah, A.O. *Erdoel Kohle Erdgas Petrochem* v 41 n 2 Feb 1988 p 74-80.

## Testing

**073200 OIL RECOVERY METHOD COULD NET MILLIONS OF DOLLARS FOR KANSAS.** The Tertiary Oil Recovery Project (TORP) at the University of Kansas uses a polymer gel to recover barrels of oil. As in water flooding, the polymer will follow the path of least resistance to the most permeable rock layers, the so-called

high-flow regions. Once the gel fills the formerly flooded route, water is introduced again. But now the water is diverted to untapped, oil-rich layers, and the booty can be forced to the surface. The polymer begins as powder mixed in a tank with water, 2000 parts per million. That causes the viscosity to go up, making the polymer thicker than molasses. To get the polymer chain to gel, chromium must be added to the mixture. This year, Kansas is producing 166,000 barrels a day. At 15 dollars a barrel, that's 2.5 million dollars a day - almost one billion dollars for the year.

Anon. *Natl Eng* v 92 n 7 Jul 1988 p 18-19.

**Thermal** See Also OIL SANDS—Thermal Recovery; OIL WELL CASING—Failure; PETROLEUM, CRUDE—Pyrolysis; PETROLEUM RESERVOIR ENGINEERING—Calculations; PETROLEUM RESERVOIR ENGINEERING—Computer Simulation.

**073201 PROBLEM OF APPLICATION OF LOW-WASTE TECHNOLOGY OF SEAWATER TREATMENT IN OIL PRODUCTION.** Results of an investigation of the processes of preliminary purification and preliminary softening of seawater and of the spent brine by sodium cationization are presented. The working capacity of low-waste technology of treatment of highly mineralized waters, designed for water preparation with the purpose of using it for thermally enhanced oil recovery, is determined. (Translated author abstract) 6 refs. In Russian.

Shakhmarov, S.A. *Izv Vyssh Uchebn Zaved Neft Gaz* n 10 1986 p 38-42.

**073202 COMPARISON OF K-VALUE CALCULATION METHODS IN COMPOSITIONAL STEAMFLOOD SIMULATION.** The speed and accuracy of compositional steamflood simulation were compared for four K-value calculation methods: the Antoine equation, table look-up, the Peng-Robinson equation of state (PR-EOS), and the Hong-Makhlouf modification of Wilson's equation. These methods were used with a compositional steamflood simulator to model light-oil steamfloods in three- and one-dimensional (3D and 1D) reservoir models. The results indicate that the table look-up and the Hong-Makhlouf modification of Wilson's equation are the most preferred methods to use in terms of both speed and accuracy of computation. This paper describes how the four methods are used in compositional steamflood simulation and discusses the advantages and disadvantages of each method. (Edited author abstract) 12 refs.

Hong, K.C. (Chevron Oil Field Research Co); Hsueh, Liming. *SPE Reservoir Eng* v 2 n 2 May 1987 p 249-257.

**073203 PILOT STEAM SOAK OPERATIONS IN DEEP WELLS IN CHINA.** Three fields with reservoirs at 1000 to 1300 m [3,281 to 4,265 ft] were almost nonproductive before, but generally a peak production of 100 to 200 Mg/d [100 to 200 tonnes/D] per well was obtained after steamsoak. This paper presents the results of optimization of the steam injection parameters by physical modeling and mathematical simulation studies, e.g., steam quality, injection rate, and amount of steam injected in each cycle. Field pilot tests show that steam injection is feasible in these oil fields under respective reservoir conditions. A feasibility study on the development project of the Gaosheng oil field shows that, for such a deep reservoir, steamdrive is feasible by well bore heat insulation techniques without downhole steam generators. (Edited author abstract)

Liu, Wen-Zhang (Research Inst of Petroleum E&D). *JPT J Pet Technol* v 39 n 11 Nov 1987 p 1441-1448.

**073204 EFFECTIVENESS OF SCREENING TESTS AS PREDICTIVE MODELS FOR STEAMFLOOD ADDITIVES.** The control of fluid mobility has become increasingly important to steamflood applications for oil recovery. Most of the EOR projects in the U.S. use steamflooding techniques. The efficiency of these projects is often reduced because such effects as gravity override



results in poor volumetric sweep through the reservoir. Additives can improve the efficiency of steamflooding, but screening tests must be performed for selection of the most effective additive for individual applications. As potential additives, nine commercially available sulfonate surfactants were tested with the high-temperature/high-pressure foamability (HTHPF) test procedure, and eight of these were tested with the mobility control (MC) procedure. (Edited author abstract) 23 refs.

Strycker, Arden R. (Natl Inst for Petroleum & Energy Research); Madden, Michael P.; Sarathi, Partha. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14904, p 543-548.

**073205 COMPARISON OF STEAMFLOOD STRATEGIES: FIVE-SPOT PATTERN VS. INVERTED NINE-SPOT PATTERN.** This paper describes the use of a black-oil, thermal simulator to compare steamflow development using five-spot and inverted nine-spot patterns. The input data selected were representative of a homogeneous heavy-oil reservoir. This study considered three different development strategies: conventional pattern steamflooding, pattern steamflooding with infill drilling, and steamflooding with infill drilling and pattern realignment. Comparison of pattern steamfloods indicates that at close well spacing (1.25 acres/well [0.5 ha/well]), the inverted nine-spot recovers more oil than the five-spot. Steam breakthrough and oil production are accelerated for the nine-spot relative to the five-spot pattern. At larger well spacing, however, oil recovery from the five-spot pattern exceeds that from the nine-spot. (Edited author abstract) 27 refs.

Ziegler, Victor M. (Chevron Oil Field Research Co). *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 13630, p 549-558.

**073206 EXAMINATION OF THE CONFINED-PATTERN CONCEPT IN STEAMFLOOD SIMULATION.** The confined-pattern concept has been widely used in steamflood simulation for homogeneous reservoirs with negligible dipping. This work found that, for field projects with 9 to 100 repeated patterns, this concept underestimates the actual oil production by 3% at the end of 6 years. The usefulness of the concept has thus been ensured. (Author abstract)

Chu, Chieh (Texaco Inc). *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 13621, p 559-564.

**073207 HIGH-PRESSURE SATURATED-STEAM CORRELATIONS.** This paper reviews literature correlations and compares other predictions with steam-table values. The approach used in developing the new correlations will be presented. The resultant equation for each steam property will then be presented and discussed separately. Advantages of these correlations will be highlighted. Accuracy of all correlations below 500 psia [3.4 MPa] will be compared, in view of recommending the best set for low-pressure applications. 4 refs.

Ejogu, G.C. (BP Resources Canada Ltd); Fiori, M. *JPT J Pet Technol* v 39 n 12 Dec 1987 SPE 15405, p 1585-1590.

**073208 COMPUTERIZED ANALYSIS OF THERMAL RECOVERY WELL TEST DATA.** The thermal recovery of oil requires large investments of time and money. Well tests are a relatively easy way to monitor this expensive process until breakthrough occurs at producers, and they can be used to find the volume (but not the shape) of the swept zone. This paper discusses the application of automated type-curve match to such well tests. A comparison with the best of present methods, i.e., the pseudosteady-state method, shows that automated type-curve match proves to be better in the determination of swept zone radius when mobility ratio is not high or when multiple flow rates have occurred. The application of automated type-curve match to two field examples is demonstrated. (Author abstract) 14 refs.

Barua, Jawahar (Stanford Univ, Stanford, CA, USA); Horne, Roland N. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 12745, p 560-566.

**073209 MULTIBOREHOLE SEISMIC IMAGING**

**IN STEAM INJECTION HEAVY OIL RECOVERY PROJECTS.** Crosshole seismic measurements before and after steam injection were obtained for the purpose of delineating the fluid-invaded zone. The experiment, despite its limited temporal and spatial sampling, showed significant changes in seismic signature after steam injection. The seismic records of the 'before' and 'after' (steam flood) experiments were normalized by using the tube waves. Important results were obtained from power spectral studies which show significant changes after fluid injection. For higher resolution and increased constraints on the determination of the steam-invaded zone, a more sophisticated cross-hole experiment has been designed. Computer simulation of the proposed experiment has been carried out assuming an asymmetrical shape for the steam zone. Inversion via a tomographic approach by solution of an overdetermined system of linear equations produced reconstructions that were in good agreement with the assumed shape and P wave velocity of the steam zone. (Edited author abstract) 18 refs.

Macrides, Costas G. (Univ of Alberta, Edmonton, Alberta, Can); Kanasevich, Ernest R.; Bharatha, S. *Geophysics* v 53 n 1 Jan 1988 p 65-75.

**073210 ROLE OF NONCONDENSABLE GAS IN STEAM FOAMS.** Field tests suggest that a steam-foam drive is more effective when nitrogen, methane, or the like is added to the formulation. A plausible explanation is that foam lifetime is longest when transport of noncondensable gas limits mass transfer between steam bubbles. On the basis of this hypothesis, a method to estimate the amount of noncondensable gas to be included is presented. (Author abstract) 27 refs.

Falls, Andrew H. (Shell Development Co); Lawson, Jimmie B.; Hirasaki, George J. *JPT J Pet Technol* v 40 n 1 Jan 1988 SPE 15053, p 95-104.

**073211 THERMAL CRACKING (SOAKER-VISBREAKING) STUDIES ON QAIYARAH LONG RESIDUES.** Attempts have been made to upgrade Qaiyarah long residue using soaker-visbreaking process as a suitable method to get valuable products and more distillates. The operation was carried out in a continuous laboratory-scale unit at a range of mild condition. Physico-chemical properties of the visbroken products and their activation energy has been reported. The viscosity and pour point are reduced to about 80.5% and 75% by this process. Furthermore, data on the yield and the characteristics of different fractions has been obtained. Atmospheric and vacuum distillation of visbroken products show that about one sixth distilled of visbroken products are as middle distillate, leaving 58.6% on crude base, highly asphaltic material. (Author abstract) 7 refs.

Al-Soufi, Hussain H. (Council of Scientific Research, Baghdad, Iraq); Said, Muwafak A.H.; Naom, Suha S.; Mohammed, Haifaa K. *J Pet Res* v 6 n 2 Dec 1987 p 41-52.

**073212 GEOMETRICAL EFFECT OF STEAM INJECTION ON THE FORMATION OF EMULSIONS IN THE STEAM-ASSISTED GRAVITY DRAINAGE PROCESS.** The production from the in-situ thermal recovery of heavy oils always consists largely of water in oil emulsion. This is much more viscous than the oil itself. In this paper, the production of such emulsions has been studied in a laboratory-scaled reservoir model and it has been found that the degree of in situ emulsification can be changed by altering the geometry of the steam injection. (Edited author abstract) 11 refs.

Chung, K.H. (Univ of Calgary, Calgary, Alberta, Can); Butler, R.M. *J Can Pet Technol* v 27 n 1 Jan-Feb 1988 p 36-42.

**073213 RECENT OBSERVATIONS AT THE GOLDEN LAKE SPARKY FIREFLOOD PILOT.** The Husky operated Golden Lake Sparky fireflood pilot has been in operation since 1968, and the pilot history, field characteristics, and operating results through 1981 have been reported in the literature. During the following four years the pilot was expanded extensively. In 1982, two

additional patterns were ignited and, in 1983, seven wells were drilled to complete one additional pattern and parts of three others. In late 1984/early 1985, fifteen wells were added to complete four patterns, add five offsetting producers, and replace an abandoned well. In late 1985, ignitions were attempted at three of the newly completed patterns. This paper reports the events which occurred between 1981 and 1986 and broadened the understanding of the fireflood process in this reservoir. (Edited author abstract) 20 refs.

Miller, Karl A. (Husky Oil Operations Ltd, Calgary, Alberta, Can); Jaques, Darryl D.; Staniforth, Kenneth R. *J Can Pet Technol* v 27 n 1 Jan-Feb 1988 p 49-57.

**073214 MODIFICATION OF A DOWNHOLE GAS BURNER FOR SUCCESSFUL IGNITION IN A LOW-PRESSURE HEAVY OIL RESEVOIR.** Ignition problems were encountered with a down hole gas burner for initiating a fireflood in a low-pressure depleted heavy oil reservoir. The gas burner design was modified and tested for two air injection rates at the National Research Council of Canada. A better split of the air flow and mixing with the fuel gas, as well as improved flame stabilization, were provided in the modified burners. Successful ignitions were achieved in the Husky Tangleflags Fireflood Project in the Lloydminster area. (Author abstract) 6 refs.

D'Souza, M.V. (Natl Research Council, Ottawa, Ont, Can); Tsang, P.W. *J Can Pet Technol* v 27 n 1 Jan-Feb 1988 p 73-78.

**073215 VISCOELASTIC SYSTEMS FOR CONTROLLING THE STREAM INJECTION DURING THERMOSHIFT WORKING.** The injection of a viscoelastic heat carrier in the late stage of thermoshift working of a field with inhomogeneous cracked collectors is a promising method of reducing the filtration of steam through flushed, worked-out zones and of directing it into sections with a high degree of residual oil saturation. The plugging of the filtration channels forming during the injection of steam in the initial stage of working increases the portion of the formation affected by displacement, i.e., the oil output in the late stage, and reduces the specific consumption of steam and the heat loss to the shaft atmosphere. The ability of a viscoelastic system to plug previously worked zones reduces sand development and water contamination of the oil, thus improving the well working conditions. In Russian. 2 refs.

Tyun'kin, B.A.; Korolev, I.P.; Konopler, Yu.P.; Tsekhe-meistruyk, A.K.; Shchitov, B.V. *Neft Khoz* n 10 Oct 1987 p 47-50.

**073216 ENERGY EXPENDITURES DURING THERMAL STIMULATION OF A FORMATION.** A comparative estimate is made of the energy expenditures related to the working of a formation thermally stimulated either by moist steam or hot water. It is shown that, when hot water is used as the heat-transfer agent, the quantity of it required, depending on its temperature, must be two to five times greater than the quantity of moist steam. Only under this condition is it possible to attain the same rates of introduction of heat into the formation with hot water with moist steam. Moreover, a corresponding quantity of fluid must be removed from the extraction wells, which is not always possible. In Russian. 5 refs.

Zlygostev, E.E. *Neft Khoz* n 1 Jan 1988 p 40-43.

**073217 STEAMFLOOD STRATEGIES FOR A STEEPLY DIPPING RESERVOIR.** A computer simulation study was conducted to determine the best steamflood strategy for a steeply dipping (20°[0.35-rads] reservoir. A compositional steamflood simulator was used with both two-dimensional (2D cross section) and three-dimensional (3D) models of the reservoir. The study showed that gravity drainage of the heated oil is the main production mechanism in steamflooding steeply dipping reservoirs. Consequently, oil production is strongly affected by injector and producer locations. The best steamflood



strategy for this type of reservoir, therefore, involves judicious selection of injector and producer locations, reducing steam injection rate and shutting in wells selectively at appropriate times, and injecting a noncondensable gas to prevent steam cycling in the depleted updip portion of the reservoir. (Edited author abstract) 7 refs.

Hong, K.C. (Chevron Oil Field Research Co). *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 15089, p 431-439.

**073218 DESIGN AND CONSTRUCTION OF A PILOT STEAMDRIVE PROJECT IN A REMOTE DESERT ENVIRONMENT.** A pilot steamdrive test has begun in the Marmul oil field in south Oman. It is intended that 1,774 U.S. tons/D [1610 Mg/d] of dry saturated steam will be injected into the test area for approximately 5 years to test the steamdrive process quantitatively. The surface facilities, consisting of a water treatment plant and steam generators, have been designed for reliable operation in the hot, remote desert environment. (Author abstract) 3 refs.

Halnes, Michael R. (Shell Int Petroleum Mij BV). *SPE Prod Eng* v 3 n 2 May 1988 SPE 13720, p 245-248.

**073219 WAYS OF INCREASING THE OIL OUTPUT OF CARBONACEOUS COLLECTORS SATURATED WITH HIGH-VISCOSITY OIL.** The optimal formation heating temperature during the working of a Permian-Carbonaceous deposit in the USA field by thermal methods amounts to about 200°C. Uniform heating to this temperature makes it possible to increase the oil output to 30-40%. The high oil output of the formation is related to the generation of a large quantity of gas at the contact between the oil and the oil-containing rock of the Permian-Carbonaceous deposit. In Russian.

Ruzin, L.M.; Konovalova, L.V.; Vyborov, V.A. *Neft Khoz* n 4 Apr 1988 p 39-42.

**073220 COMPREHENSIVE SIMULATION STUDY OF STEAMFLOODING LIGHT-OIL RESERVOIRS AFTER WATERFLOOD.** Steamflooding, the most successful among enhanced recovery methods, has been applied mainly to heavy-oil reservoirs. This paper presents a comprehensive simulation study on the use of steamflooding after waterflood in light-oil reservoirs. Some important observations are made on this new application of the process. Guidelines are developed not only for selecting reservoir candidates for steamflooding, but also for designing and operating steamfloods in watered-out reservoirs. Relative importance of key mechanisms to oil recovery is also discussed. (Author abstract) 6 refs.

Chu, Chieh (Texaco Inc). *JPT J Pet Technol* v 40 n 7 Jun 1988 p 894-904.

Waste Disposal

**073221 DEVELOPMENT STUDY OF A CENTRIFUGING TECHNIQUE FOR OILFIELD PRODUCTION PIT CLOSURE.** A study was performed of a centrifuge-based process for dewatering oilfield production waste sludges in order to investigate an application of the process an oilfield production pit closure. The two-stage process tested was primary solids removal by centrifugal classification followed by chemical conditioning and dewatering. Also, tests were run to understand the effects of the fundamental centrifuging parameters (the bowl-scroll differential speed and the centrifugal force) on the composition and quality of the dewatering products. The concentration of metals in the production pit sludge before and after dewatering was analyzed in terms of environmental regulations. The removal of heavy metals from the centrifuge overflow was also evaluated. (Edited author abstract) 13 refs.

Osterman, M.C. (Louisiana State Univ, Baton Rouge, LA, USA); Wojtanowicz, A.K.; Field, S.D. *J Energy Resour Technol Trans ASME* v 109 n 4 Dec 1987 p 191-199.

Well Testing

**073222 WELL TEST ANALYSIS FOR SOLUTION-GAS-DRIVE RESERVOIRS: PART I - DETERMINATION OF RELATIVE AND ABSOLUTE PERMEABILITIES.** This note investigates the transient pressure response at a well draining a solution-gas-drive reservoir. It is shown that estimates of effective permeabilities (absolute permeability times relative permeability) can be obtained directly from the measured flowing wellbore pressure and the flow rates. It is then possible to compute the oil saturation at the wellbore as a function of time, or, as a function of pressure, by solving a simple ordinary differential equation presented in this work. Since the method yields both oil saturation and effective permeabilities as a function of pressure, one also obtains effective permeabilities as a function of oil saturation. (Edited author abstract) 22 refs.

Serra, Kelsen (Univ of Tulsa); Peres, Alvaro; Reynolds, Albert C. *Soc Pet Eng AIME Pap SPE Unsolicited Manuscr Sep 1987 SPE 017020*, 66p.

OIL WELL PUMPING

**073223 ACTIVATION DES PUITES: CRITERES DE SELECTION DES PROCEDES.** [Activation of Wells: Criteria for Process Selection]. There are four main methods for the downhole pumping of crude oil that involve the transfer of the necessary power from the surface to downhole: mechanical, electric, pneumatic, hydraulic. The field equipment raises a difficult problem of choosing among these processes and their different variants. This article first makes a review analysis of techniques now used in this area. It then describes a general method for selecting processes with a view to optimizing equipment. This method is based on an expert system and a model for computing energy efficiencies and cost prices. An example of computing results can be used to make a quantitative comparison of the leading processes. (Edited author abstract) In French. 21 refs.

Corteville, J. (Inst Francais du Pétrole, Rueil-Malmaison, Fr); Hoffmann, F.; Valentin, E. *Rev Inst Fr Pet* v 41 n 6 Nov-Dec 1986 p 739-758.

Design

**073224 CALCULATOR PROGRAM SPEEDS PUMPING UNIT DESIGN.** The program described in this article calculates rod string factors and pumping unit loads in accordance with procedures outlined in API Recommended Practice for Design Calculations for Sucker Rod Systems, API RP11L using the TI-59. The program requires the use of a printer for input prompts and output labels. It can be modified for handheld operation using register numbers. Two programs are actually required due to calculator capacity. Each program requires two cards and a third card for alphanumeric memory. The first program requires input of the basic well data and prints out the non-dimensional variables required for entry to Figures 4.1 through 4.6 of API RP11L (or Lufkin Tables 3 through 7). Program 2 transfers the data from Program 1 to the first eight registers of Program 2, prompts for Register 8, 1/KT and indicates the value calculated by Program 1 in the machine register.

Landry, William E. *World Oil* v 205 n 5 Nov 1987 p 41-44.

Equipment

**073225 PUMPING UP FROM DOWN.** As offshore oil fields become depleted and many new marginal fields have insufficient natural drive to force oil to the surface, artificial lift is being used more extensively. This article reviews important developments which are taking place to improve the effectiveness of subsea downhole pumps.

Anon. *Mar Eng Rev* Apr 1988 p 19, 21.

**073226 WEIGH ADVANTAGES OF FIBERGLASS SUCKER RODS.** Fiberglass rods are subjected to high cyclic stress ranges; that is, wide variation between

minimum and maximum loads. Because of this, their useful life is limited by the fatigue properties of the pultruded composite. For the most highly stressed rods near the top of the string, manufacturers project useful life of about 17 million cycles. For a highly stressed rod string in a typical beam-pumped well, this translates into a useful life of 4 or 5 years. Properly designed fiberglass rods can allow more production from an underproduced well using the same surface equipment. The lighter rod string may allow more strokes per minute, or a larger pump to be installed. In some cases, the same surface stroke has resulted in a much longer effective pump stroke, which increases fluid lifted with no other changes in pumping parameters. API Spec 11C provides quality control and dimensional requirements for manufacture of fiberglass sucker rods. Materials and performance must be qualified by testing as specified in Spec 11C.

Oney, Charles L. (Cities Services Oil & Gas Corp, Tulsa, OK, USA). *Pet Eng Int* v 60 n 7 Jul 1988 p 55.

**073227 ANALIZA ENERGETICA A SONDELOR IN POMPAJ DE ADINCIME CU PRAJINI.** [Energetic Analysis of Wells for Deep Sucker Rods]. A practical method is presented for the determination of the power losses along the transmission of power chain from the engine to the deep pump in installations for the extraction of crude from wells by deep sucker rods. By correlating the technological analysis of the pumping process with an energetic analysis of the pumping installation measures for the improvement of the deep pumping process, low power consumption can be brought about. (Edited author abstract). 3 Refs. In Romanian.

Lonel, A. (Sch de Productie Petroliera, Rom). *Mine Pet Gaze* v 39 n 6 Jun 1988 p 286-291.

Measurements

**073228 DETERMINATION OF CHARACTERISTICS OF WELL BOTTOM ZONE FROM DATA ON CHANGES IN ITS OPERATING CONDITIONS.** A method of determination of the physical parameters of the well bottom zone is presented. It is characterized by a high operational flexibility and is based on the data regarding the changes in the operating conditions of the pumping well, obtained by taking a measurement of the dynamic level in the space outside the pipe by a wavemeter. The method proposed makes it possible to determine the indicated parameters from a comparatively small number of initial data and does not require the lifting of internal well equipment. (Translated author abstract) In Russian.

Bogachev, A.B. *Izv Vyssh Uchebn Zaved Neft Gaz* n 10 1986 p 35-38.

Stability

**073229 PULSE DAMPENER FOR CORE-FLOOD EXPERIMENTS.** A pulse dampener is described which significantly reduces the fluctuations which are frequently present in the flow from reciprocating piston pumps. Frequency response methods are used to design the pulse dampener. A design procedure is presented to enable one to design such a pulse dampener for the particular experimental situation of interest. This pulse dampener is effective when the pressure drop across the experimental system changes with time as well as when it is constant. (Edited author abstract) 9 refs.

Kerig, P.D. (Conoco Inc); Watson, A.T. *Soc Pet Eng AIME Pap SPE* n 17650 1988 17p.

**OIL WELLS** See Also OIL WELL DRILLING—Drilling Fluids; OIL WELL PRODUCTION—Tertiary.

**Acid Treatment** See Also OIL FIELDS—Field Development; OIL WELL PRODUCTION—Flooding.

**073230 HEATED ACIDS FOR IMPROVED STIMULATION.** A simple and practical process has been developed to heat hydrochloric acid to improve its performance as an oil well stimulating agent. Heated acid is used in cold formations such as cold dolomites to



increase the rate at which the formation is dissolved, thus improving flow capacities. The technique heats the acid by causing an exothermic chemical reaction that uses a portion of the HCl as one of the reactants. Heated acid reacts at a faster rate and aids in the removal of acid-retarding materials such as oil, asphaltene and paraffins to give a better acid-to-formation contact. Laboratory and field results illustrate the effectiveness of the heated acid method of stimulation and compare the various methods of bringing the acid to its ideal temperature. (Edited author abstract) 4 refs.

Walker, Michael L. (Halliburton Services Ltd); Fredrickson, Sherman; Norman, Lewis; Hoch, Ottmar. *J Can Pet Technol* v 26 n 5 Sep-Oct 1987 p 57-59.

**073231 FOAM-DIVERTING TECHNIQUE IMPROVED SANDSTONE ACID JOBS.** Advantages and disadvantages of foam diverting as well as treatment design procedures for foam diverting in matrix hydrofluoric acid treatments are presented in this article. It is shown that foam diverted matrix hydrofluoric acid treatments have been successful in removing inorganic damage. Staged 65 quality foam treatments have been used most often in this work with encouraging results. The specific foam diversion technique used in a treatment design is dependent on individual well characteristics as well as the stimulation objective. Proper planning of a tailored Gulf Coast sandstone stimulation job should include mineralogical analysis of core material to aid in selecting proper acids, along with produced fluid testing to minimize paraffin, asphaltene and emulsion problems during and after the work. 11 refs.

Burman, J.W. (Chevron USA Inc, New Orleans, LA, USA); Hall, B.E. *World Oil* v 205 n 5 Nov 1987 p 31-36.

**073232 BUFFER-REGULATED HF ACID FOR SANDSTONE ACIDIZING TO 550°F.** Two earlier papers discussed the suitability of buffer-regulated HF acid (BRHFA) for high-temperature sandstone matrix stimulation treatments. This paper discusses a new, less corrosive BRHFA formulation that has clay-dissolving capacity comparable to 7½% HCl/1½% HF acid. The corrosion rate of carbon steel at 550°F [288°C] is only 330 mils/yr [8.4 mm/a]. The BRHFA systems are also compatible with a variety of corrosion-resistant alloys. This paper presents slurry, core flow, and corrosion data and discusses use guidelines. (Edited author abstract) 5 refs.

Scheurman, R.F. (Shell Development Co). *SPE Prod Eng* v 3 n 1 Feb 1988 SPE 13563 p 15-21.

**073233 EFFECTS OF ACIDS ON GRAVELS AND PROPPANTS.** The effects of acids on the integrity of gravels and proppants should be considered in acid treatments. This paper reports on the influence of acid type, acid concentration, and contact duration on the acid solubility of five sands and bauxitic materials. The effects of the acids on the mechanical strength and the size distribution of the solids are determined. We found that intermediate-density and low-density bauxites (IDB and LDB) are very soluble in HF acid and that sintered bauxite is weakened by HF acid. (Author abstract) 13 refs.

Cheung, S.K. (Chevron Oil Field Research Co). *SPE Prod Eng* v 3 n 2 May 1988 SPE 13842, p 201-204.

**073234 ADSORPTION AND CHLORINATION OF MUTUAL SOLVENTS USED IN ACIDIZING.** Loss of mutual solvents during acidizing can be severe, depending on the type of product. Results showed that some mutual solvents can penetrate deeply into a test formation. Chlorination of mutual solvents by HCl was also considered and was found to be minimal when the treatments were designed properly. (Author abstract) 13 refs.

King, G.E. (Amoco Production Co); Lee, R.M. *SPE Prod Eng* v 3 n 2 May 1988 SPE 14432, p 205-209.

**073235 STATUS REPORT: ACID FRACTURING.** The basic principles and objectives of acid fracturing are the same as for propped fracturing treatments. In both cases, the goal is to produce a conductive fracture with

sufficient length to allow more effective drainage of the reservoir. The major barrier to effective fracture penetration by acid is apparently excessive fluid loss. Fluid-loss control is a greater problem with acid systems due to the constant erosion of fracture faces. Various additives and treating techniques have been developed to control acid fluid loss. Among the earliest were natural materials, such as gum karaya. Multiple stages of viscous pad have been used to control acid fluid loss. In this technique, the fracture is initially created by a gelled pad, after which alternating stages of acid and additional pad are pumped. These additional pad stages are designed to enter and seal wormholes created by the preceding acid. Fine particulate material often is added to the pad stages to aid in fluid-loss control. Acid loss can also be reduced by acid gelling. Surfactant-type thickeners are also used. However, acid forming is one of the most effective methods to control acid loss. A discussion is presented of techniques to control acid reaction rate. 4 refs.

Crowe, Curtis W. (Dowell Schlumberger, Tulsa, OK, USA). *Pet Eng Int* v 60 n 6 Jun 1988 p 39, 41.

**Bottom Hole Pressure** See Also OIL WELL DRILLING—Bits; OIL WELL DRILLING—Drilling Fluids; OIL WELL DRILLING—Pressure Effects; OIL WELL DRILLING—Turbodrills; PETROLEUM RESERVOIR ENGINEERING—Calculations.

**073236 STATIC AND DYNAMIC THREE-DIMENSIONAL BOTTOMHOLE ASSEMBLY COMPUTER MODELS.** This paper presents two three-dimensional (3D) mathematical models to predict the directional behavior of bottomhole assemblies (BHA's). The first model describes BHA dynamic, stepwise, transient behavior. Displacements and lateral forces, computed for each step, account for friction against the borehole wall. The second model computes a static BHA equilibrium whereby simplified friction forces are assumed. The static lateral forces are found to be an average of the highly varying ones computed by the dynamic model, but the static computer run is much faster. The static model is therefore used iteratively to compute an oriented dogleg severity that balances lateral forces. This is used to derive the directional behavior of the BHA. Comparison and calibration against real field cases are performed. (Author abstract) 11 refs.

Birades, Michel (Elf Aquitaine). *SPE Drill Eng* v 3 n 2 Jun 1988 p 160-166.

**Calculations** See Also OIL WELL PRODUCTION—Enhanced Recovery; PETROLEUM RESERVOIR ENGINEERING—Calculations.

**073237 CALCULATE DRAWDOWN THAT WILL CAUSE SAND PRODUCTION.** The approach given in this article makes it possible to calculate the maximum possible sand-free production rate of fluids from perforated casing completions. Most of the required data are obtained from well logs; a reasonable assumption is made for capillary pressure. These calculations made at projected conditions at various stages in the life of a well help to maximize profits in field developments of sand reservoirs. 4 refs.

Stein, Nathan (SANS Co, Boston, MA, USA). *World Oil* v 206 n 4 Apr 1988 p 48-49.

**073238 STUDY OF MULTIPHASE FLOW BEHAVIOR IN VERTICAL WELLS.** This paper presents a physical model for predicting flow pattern, void fraction, and pressure drop during multiphase flow in vertical wells. The hydrodynamic conditions giving rise to various flow patterns are first analyzed. The method for predicting void fraction and pressure drop is then developed. In the development of the equations for pressure gradient, the contribution of the static head, frictional loss, and kinetic energy loss are examined. Laboratory data from various sources show excellent agreement with the model. (Author abstract) 45 refs.

Rashid Hasan, A. (Univ of North Dakota, ND, USA); Shah Kabir, C. *SPE Prod Eng* v 3 n 2 May 1988 SPE 15138, p 263-272.

**Computer Applications** See OIL WELL PRODUCTION—Thermal.

**Computer Simulation** See OIL WELL PRODUCTION—Heavy Oil.

**Contamination** See OIL WELL PRODUCTION.

## Control

**073239 TREE SNUBBING OPERATION SOLVES WELL CONTROL PROBLEM.** A unique method is discussed for removing a Christmas tree under high pressure and install BOPs without a rig. This allowed workover of a gas-condensate well with a shallow tubing break that could not be killed by surface pumping due to casing pressure limitations. The tree-stripping procedure is applicable to wells with Christmas trees that are screwed to the tubing string and equipped with wrap-around tubing hangers. (The method would not be required if the tree were provided with a mandrel hanger that could receive a back-pressure valve). The four steps that should be performed prior to any tree removal operation are outlined.

Gebhardt, Freddy (Wild Well Control Inc, Spring, TX, USA); Thompson, Joe Dean. *World Oil* v 205 n 3 Sep 1987 p 51-53.

**Corrosion** See Also STEEL CORROSION—Electrochemical; STEEL CORROSION—Stress Corrosion Cracking.

**073240 CONTROLLING CORROSION IN DEEP HOT WELLS.** This article makes a broad economic comparison of several of the more common means of completing deep corrosive wells. The five cases presented are for three alloy completions and two continuous inhibition completions. By using the best available data on the cost of corrosive well completions, the economic advantage of one completion method over another - with all else being equal - is a function of the well depth and the discount rate. At high discount rates over the entire depth range, capillary tube injection is favored economically over all CRAs (Corrosion Resistant Alloys) except for 13% Cr. As the discount rate decreases, CRAs are generally more economical than chemically inhibiting steel tubing, except for shallow wells. Annular injection is less economical than CTI (Capillary Tube Injection) under the assumptions used in this study. 10 refs.

Craig, Bruce D. (Metallurgical Consultants Inc, Englewood, CO, USA). *Pet Eng Int* v 59 n 10 Oct 1987 p 35-36, 38, 40.

## Corrosion Protection

**073241 PHASE DIAGRAMS CAN LOCATE GAS-CONDENSATE-WELL CORROSION.** Phase diagrams that show regions where different phase combinations are in equilibrium help answer many questions in a gas-condensate well void of formation water. Typical questions might be: Is there only the vapor phase present or is there really a condensed water-rich liquid in equilibrium with the vapor phase? Are there really two condensed liquid phases in equilibrium with the vapor phase, both a water-rich liquid and a hydrocarbon-rich liquid? If an inhibitor is added, will the inhibitor cause a new hydrocarbon-rich liquid to appear or does it alter the hydrocarbon-rich liquid already present? The phase diagram regions are shown as functions of temperature and pressure; hence, the pressure-temperature profile of the well can be added to the associated phase diagram to see what phase combinations are possible throughout the well string. Deductions can then be made to determine where corrosion problems are likely to occur and what actions are possible to reduce corrosion. (Author abstract) 3 refs.

Reinhardt, James R. (Univ of Southwestern Louisiana, Lafayette, LA, USA). *Oil Gas J* v 86 n 14 Apr 4 1988 p 41, 44-47.



**Drainage** See OIL WELL PRODUCTION—Well Testing.

**Drilling** See GEOTHERMAL WELLS—Drilling.

**Drilling Fluids**

**073242 HOW SYNTHETIC ORGANIC POLYMERS AFFECT DRILLING FLUIDS.** Synthetic organic polymers have been used in water-base drilling muds for more than 40 years. They have been used to control fluid loss, fluid rheology, and for clay beneficiation. Sodium polyacrylate, polyacrylamide, and hydrolyzed polyacrylamide were among the first to be used. A review is presented of polymers in general, and sodium polyacrylate and polyacrylamide in particular. Filtration control agents are also briefly discussed. 9 refs.

Enright, D.P. (Milpark Drilling Fluids, Houston, TX, USA); Perricone, A.C. *Pet Eng Int* v 60 n 4 Apr 1988 p 55-56, 58.

**Environmental Impact** See OIL WELL DRILLING—Drilling Fluids.

**Equipment** See Also OIL WELL DRILLING—Bits.

**073243 NEW SAND-CONTROL FILTER FOR THERMAL RECOVERY WELLS.** A device was designed to solve a severe case of sand inflow into horizontal wells at the Athabasca Tar Sands pilot plant in Fort McMurray, Alberta. The sand problem at this pilot resulted from a combination of three conditions: a fine-grained, cohesionless sand; the cyclic injection of steam; and the production of steam, water, and high-viscosity bitumen. A new type of filter, designed to overcome this problem, has application to the control of solids in wells drilled in a variety of formations producing liquids or gas. It was first designed and tested in the laboratory with a physical simulator; then it was fabricated and tested in vertical wells at the Athabasca pilot plant. (Author abstract) 11 refs.

Toma, Peter (Alberta Research Council, Can); Livesey, Declan; Helderick, Theodore. *SPE Prod Eng* v 3 n 2 May 1988 SPE 15057, p 249-257.

**Evaluation** See PETROLEUM RESERVOIR ENGINEERING—Calculations.

**Filters** See OIL WELL PRODUCTION.

**Fires** See OIL WELL DRILLING—Blowout Prevention.

**Fracturing** See Also OIL FIELD EQUIPMENT—Pumps; OIL FIELDS; OIL WELL LOGGING; OIL WELL LOGGING—Acoustic; OIL WELL PRODUCTION—Enhanced Recovery; PETROLEUM RESERVOIR ENGINEERING—Calculations; PETROLEUM RESERVOIR ENGINEERING—Mathematical Models.

**073244 ANALYTICAL SOLUTIONS FOR VERTICAL FRACTURE IN A COMPOSITE SYSTEM.** A method is proposed to interpret the pressure transient data of injection wells in secondary and tertiary recovery processes. A composite system is considered in which the inner region represents a swept volume and the outer region extends to infinity. The two regions are thus featured by different hydraulic diffusivities and mobilities. The well is vertically fractured and the fracture is assumed to exhibit an infinitely large conductivity. The flow behavior in the system is described by use of elliptical geometry. The model was tested against several cases for which analytical solutions are available and good matches were obtained. (Author abstract) 10 refs.

Stanislaw, J.F.; Easwaran, C.V.; Kokal, S.L. *J Can Pet Technol* v 26 n 5 Sep-Oct 1987 p 51-56.

**073245 HOW TO ENGINEER A FRACTURING TREATMENT.** The author considers the elements that can contribute to a successful hydraulic-fracture-treating program. Not all the elements need to be done in every case. However, they should be considered carefully, because they might affect both the success and the interpretation of the fracture simulation treatment. Inade-

quate evaluation could fail to identify changes and improvements to include in subsequent treatments. A discussion is presented that covers the pretreatment, execution, and evaluation phases of hydraulics fracturing. The key phase in fracture design is the pretreatment analysis. 12 refs.

Economides, Michael J. (Dowell Schlumberger). *JPT J Pet Technol* v 39 n 11 Nov 1987 p 1343-1345.

**073246 MODEL INVESTIGATION OF WELLBORE PRESSURE DISTRIBUTION IN STEM-INDUCED FRACTURING.** This paper describes model testing conducted to investigate pressure variations along the length of a wellbore between a decoupled bottom charge and the stem. Tests were conducted in three-dimensional models made from thick plexiglass sheets that contained small decoupled explosive charges in the bottom of the borehole. Charge sizes varied from 75 to 200 mg, and the open borehole length between the top of the charge and the stem ranged from three to seven times the charge length. Both top and bottom charge initiations were investigated. Multiple pressure transducers were used along the borehole, and pressure/time distributions were determined at several locations. (Edited author abstract) 5 refs.

Fourney, W.L. (Univ of Maryland, USA); Holloway, D.C.; Simha, K.R.Y. *SPE Prod Eng* v 2 n 4 Nov 1987 SPE 12883, p 243-249.

**073247 FRACTURE GEOMETRY AND PROPPANT-TRANSPORT COMPUTATION FOR MULTIPLE-FLUID TREATMENT.** This paper incorporates expressions for changing the flow-behavior index,  $n'$ , and the flow-consistency index,  $K'$ , of fracturing fluids used in any treatment into a dynamic procedure for fracture design to determine simultaneously the temperature profile, viscosity profile, location of each fluid, and location of each proppant in the fracture, together with the resulting geometry. After pumping ceases, the effect of temperature recovery on proppant deposition and fracture closure is also considered. Several examples demonstrate the effective use of this new procedure for better fracture design. These examples will show the effect of temperature on fluid behavior and its influence on proppant deposition in the fracture. (Author abstract) 7 refs.

Lee, W.S. (Halliburton Services, USA); Daneshy, A.A. *SPE Prod Eng* v 2 n 4 Nov 1987 SPE 14511, p 257-266.

**073248 ANALYSIS OF FRACTURED WELLS PRODUCING AT HIGH FLOW RATES USING LATE-TIME DATA.** This paper presents a method for analyzing late-time data for high-flow-rate wells that cause turbulent flow within the fracture. Fracture conductivity has been determined on the basis of early-time pressure data. The pseudoradial flow period, however, can be used to check the fracture conductivity by identifying the semilog straight line and by determining the total skin factor. We have found that early-time correlations cannot be used to correct apparent fracture conductivities obtained in the late-time analysis. This is because the flow regime has changed significantly between the early and late periods. Examples are presented that use either both early- and late-time data or only late-time data for determining the true fracture conductivity. (Edited author abstract) 8 refs.

Guppy, Kern H. (Univ of Southern California, USA). *SPE Form Eval* v 2 n 4 Dec 1987 SPE 11760, p 555-559.

**073249 PRESSURE FALLOFF BEHAVIOR IN VERTICALLY FRACTURED WELLS: NON-NEWTONIAN POWER-LAW FLUIDS.** This paper examines pressure falloff behavior in fractured wells after the injection of a non-Newtonian power-law fluid. Results are presented in a form suitable for field application. Responses at wells intercepting infinite-conductivity and uniform-flux fractures are considered. Procedures to identify flow regimes are discussed. We also examine responses at unfractured wells. This part of our study examines the validity of using the superposition principle to analyze pressure falloff data. (The pressure distribution

for this problem is governed by a nonlinear partial-differential equation.) If the solutions given in the literature are used, then correction factors are needed to analyze pressure falloff data. The results of this phase of our work can also be used to analyze data in fractured wells provided that pseudoradial flow conditions exist. (Edited author abstract) 38 refs.

Vongvuthipornchai, S. (Univ of Tulsa, OK, USA); Raghavan, R. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 13058, p 573-589.

**073250 PRACTICAL APPLICATION OF ECONOMIC WELL-PERFORMANCE CRITERIA TO THE OPTIMIZATION OF FRACTURING TREATMENT DESIGN.** Computerized models of varying complexity have become available that use net-present-value (NPV) calculations. The input is based on the operator's performance goals for each well and on specific reservoir properties. Simpler, noncomputerized approaches also being used include cost performance comparisons and nomographs. Each type of model, including several of the computerized models, will be examined. By use of these models and NPV calculations, optimum fracturing treatment designs have been developed for such low permeability reservoirs as the Prue in Oklahoma. Typical well conditions are used in each of the selection models and the results are compared. (Edited author abstract) 15 refs.

Anderson, Robert W. (Western Co of North America); Phillips, Alice M. *JPT J Pet Technol* v 40 n 2 Feb 1988 p 223-228.

**073251 PRESSURE-DERIVATIVE TYPE CURVES FOR VERTICALLY FRACTURED WELLS.** This paper presents a technique for interpreting pressure-derivative type curves for a vertically fractured well located in an infinite reservoir. These type curves can be used to match pressure test data to determine the formation permeability, the half-length of the fracture, and the nature of the fracture - i.e., uniform-flux fracture or infinite-conductivity fracture. At long producing times, the buildup type curves are identical to the drawdown type curves for both types of fractures. (Author abstract) 5 refs.

Tiab, Djebbar (Univ of Oklahoma); Puthigai, Suresh K. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 11028, p 156-158.

**073252 ANALYSIS OF IN-SITU FRACTURE OF OIL SAND FORMATIONS BY EXPLOSIVES.** An analytical model is proposed for the design and simulation of in-situ fracture of deep oil sand formations. This model is based on the finite element variational principle in conjunction with special empirical modules to characterize in-situ oil sands behavior. A computer code by the name of SANFRAC was developed to handle the dynamic fracture of formations induced by explosives. Simulation of hydraulic fracture processes can be treated by the same code as special cases using the quasi-static analysis. Numerical case studies by the SANFRAC code indicate that extensive horizontal fracture can be achieved by dynamic loads with proper fracture starters configured at the injection well. The unique advantage of the dynamic fracturing technique over the hydraulic fracture methods is also demonstrated by these studies. (Author abstract) 14 refs.

Hsu, T.R. (Univ of Manitoba, Winnipeg, Manit, Can); Pizey, G.; Yu, J.R. *In Situ Oil Coal Shale Miner* v 11 n 1 Mar 1987 p 63-79.

**073253 SIMULATIONS OF NATURALLY FRACTURED RESERVOIRS.** A three-dimensional (3D), three-phase, black-oil model is described which is being used to simulate naturally fractured reservoirs. The program is fully implicit and can perform single-porosity, dual-porosity or dual-permeability computations. Sample simulations are presented to illustrate the differences between the three computational techniques. Single-porosity recoveries are much larger than the recoveries predicted by the dual techniques. The dual-permeability,



primary-depletion recoveries are very similar to the dual-porosity, primary-depletion recoveries, while the dual-permeability waterflood recoveries are significantly larger than the dual-porosity waterflood recoveries. (Edited author abstract) 22 refs.

Dean, R.H. (Arco Oil & Gas Co); Lo, L.L. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14110, p 638-648.

**073254 DISPERSION OF A SOLVENT SLUG INJECTED INTO A COMMUNICATION PATH.** Solvents may be injected into a formation once communication has been achieved between injection and production wells to increase the size of the communication path. However, the solvent disperses into the formation and bitumen flows into the communication path, increasing the viscosity of the flowing phase. As a result, no solvent may ever appear at the producing well. In this paper, the problem is modeled for the one-dimensional case and an analytic solution is obtained from which breakthrough time, outlet concentration of solvent, and other significant parameters can be estimated. (Author abstract)

Schmidt, Teddy (Alberta Research Council, Can); Hel-drick, Ted; Ridley, Rod; Kissel, Gerald. *SPE Prod Eng* v 3 n 2 May 1988 SPE 13602, p 273-279.

**073255 DIESEL-BASED HPG CONCENTRATE IS PRODUCT OF EVOLUTION.** Use of a diesel-based, hydroxypropyl guar (HPG) concentrate as a means of creating aqueous fracturing fluid for operations in the Laredo, Tex., area has evolved from the batch-mixed dry powder type, through water-based gel concentrates (800 lb gel/Mgal) to diesel-based (6,600 lb gel/Mgal) HPG. Conversion to a diesel-based gel concentrate has reduced the concentrate requirement by a factor of six. A job that required 20,000 gal of water-based gel concentrate and a 500-bbl frac storage tank can now be run out of one 4,000 gal transport of diesel-based concentrate. Field results are given for three Wilcox jobs. 3 refs.

Harms, Weldon M. (Halliburton Services); Watts, Mike; Venditto, Jim; Chisholm, Pat. *Pet Eng Int* v 60 n 4 Apr 1988 p 51-54.

**073256 MARKETING AND ECONOMICAL ASPECTS OF HYDRAULIC PROPPANT FRACTURING IN WESTERN AND EASTERN EUROPE.** During the last 10 years since hydraulic proppant fracturing of deep tight reservoirs started to boom with the invention of the first high-strength proppants, various events in the general world economy have had considerable influences on the stimulation market. The discussion reviews and forecasts hydraulic fracturing in Western and Eastern Europe from the marketing and economical points of view. Emphasis is on important factors controlling the general economic situation of the oil and gas industry. 37 refs.

Mader, D. *Oil Gas Eur Mag* v 13 n 2 1987 p 34-41.

**073257 CONTINUOUS MIX TECHNOLOGY ADDS NEW FLEXIBILITY TO FRAC JOBS.** After years of trying, continuous mix technology appears to be a practical method for obtaining better frac jobs. It provides the capability to modify fluid characteristics during a treatment in response to reservoir conditions. For instance, fluid viscosity can be raised or lowered to accommodate apparent viscosity increases caused by proppant and rapid changes in proppant. Polymer concentration can be adjusted in response to downhole pressure changes. This flexibility economizes materials and increases the control over the job. The article discusses the Dowell Schlumberger Inc. development of technology to permit continuous mixing of fracturing fluids. 7 refs.

Constien, V.G. (Dowell Schlumberger Inc, Tulsa, OK, USA); Brannon, H.D.; Bannister, C.E. *Oil Gas J* v 86 n 23 Jun 6 1988 p 49-52, 54.

**073258 L'OUVERTURE DES TROUS DE FORAGES: SYNTHÈSE BIBLIOGRAPHIQUE.** [Borehole Breakout: Bibliographic Synthesis]. Natural borehole breakout (borehole cross-section elongation) due to the fracturing and spalling of well walls has been used in

recent years to determine the direction of stress in the Earth's crust. Its performances and scope of application are compared to those of other methods used in boreholes. An initial selection of information obtained by different logging tools appeared necessary to prevent any contamination of measurements by phenomena independent of deformation under stress. The principal parameters governing the amplitude and frequency of the phenomenon are reviewed. The outlook for the future of the method is examined, including the recent development of research on borehole breakout by the plastic deformation of the surrounding formations. (Author abstract) In French. 51 refs.

Baudemont, D. (Univ Louis Pasteur de Strasbourg, Strasbourg, Fr); Ruhland, M.; Gauer, P.; Janot, P. *Rev Inst Fr Pet* v 43 n 3 May-Jun 1988 p 389-403.

**073259 DISPERSION RADIAL DE TRAZADORES MISCIBLES EN MEDIOS POROSOS FRACTURADOS.** [Radial Dispersion of Miscible Tracers Within Fractured Porous Media]. An analytical solution to the problem of radial displacement of a miscible tracer within a fractured porous medium is presented. It is shown that, within the fracture, the displacement by convection is much more important than the displacement by diffusion, so that the latter process is negligible. Furthermore, the matrix blocks serve as storage elements which exchange fluids with the fractures by a diffusion process. To illustrate the results obtained, graphs of effluent concentration as a function of injected fluid volume are presented. (Edited author abstract) In Spanish. 10 refs.

Perez Cardenas, Fernando C. (Inst Mexicano del Petroleo, Mexico City, Mex). *Rev Inst Mex Pet* v 19 n 1 Jan 1987 p 30-40.

**073260 FRACTURE-GRADIENT PREDICTION FOR OFFSHORE WELLS.** A key parameter required in the design of offshore wells is the fracture gradient of the formations to be penetrated. Existing fracture-gradient correlations have been developed largely on the basis of empirical data gathered on land and in the near-shore marine environment. They have been extended to deepwater areas through an equivalent intergranular stress concept. In this study, offshore data from several operators were obtained and a new fracture-gradient correlation procedure, based on an assumption of an exponential decline in average porosity with depth in normally pressured formations, was applied. The technique is ideally suited for implementation on a hand-held calculator or personal computer. (Author abstract). 5 refs.

Constant, W. David (Louisiana State Univ, USA); Bourgoynne, A.T. Jr. *SPE Drill Eng* v 3 n 2 Jun 1988 p 136-140.

**073261 FRACTURE HEIGHT PREDICTION.** A currently used, simple procedure includes (1) compressional and shear wave velocities from a long-spaced sonic or sonic digital tool to calculate rock elastic properties; (2) a transversely isotropic elastic model to compute minimum horizontal stress using elastic properties and pore pressures; and (3) a linear fracture mechanics model using minimum horizontal stresses to predict fracture height growth. Each of these steps is briefly described. It is shown that continuous sonic logging data, using long-spaced sonic or digital sonic tools, combined with mini- or microfracture data and linear fracture mechanics can allow one to determine the required fracture height parameter. 22 Refs.

Ahmed, Usman (Schlumberger Well Services). *JPT J Pet Technol* v 40 n 7 Jun 1988 p 813-815.

**073262 HOW TO CALCULATE FRACTURE PRESSURES FROM WELL LOGS.** This work improves on the vertical fracturing model and field solution discussed by R.A. Anderson, D.S. Ingram, and A.M. Zanier. They used an empirical method to solve their fracture-pressure equation, and they elected not to consider the tensile strengths of different sands. In the improved procedure discussed in this paper, tensile strength is considered and a theoretical approach is used to evaluate the different factors in this fracture-pressure equation. The problem of

matching physical properties of new sands to the properties of test sands can be avoided. This is accomplished by making the three improvements proposed to the calculation procedure. The improvements are the vertical grain pressure is corrected for tectonic pressure to become the effective vertical grain pressure. Examples of tectonic pressure include salt dome intrusion, folds, faults, or plate movement. Tensile strength is added to the right side of one equation. This strength must be overcome before a fracture could be initiated unless open fractures already exist. It is shown that the maximum estimated fracture pressure corresponds to including tensile strength in the fracture pressure equation; the minimum corresponds to excluding the tensile strength. The average error of all the estimates from reported corresponding minimum and maximum fracture pressures is about 5%; the maximum error is about 11%. 9 Refs.

Stein, Nathan (Boston Coll, Boston, MA, USA). *Pet Eng Int* v 60 n 8 Aug 1988 p 36-38.

**Fracturing Fluids** See Also FLUIDS—Viscosity; OIL WELL DRILLING—Drilling Fluids; OIL WELL PRODUCTION—Enhanced Recovery; OIL WELL PRODUCTION—Flooding; OIL WELL PRODUCTION—Secondary.

**073263 LIQUID CO<sub>2</sub> FRACTURING: ADVANTAGES AND LIMITATIONS.** The concept of fracturing with 100% CO<sub>2</sub> as the sole carrying fluid was first introduced in 1981. Development of this process was an extension of comingling CO<sub>2</sub> with conventional treatment to aid in the recovery of load fluids. Well stimulation with CO<sub>2</sub> has since increased. Knowledge about its advantages and limitations has been acquired from completing over 450 liquid CO<sub>2</sub> hydraulic fracturing treatments. Results from various fields are assessed to demonstrate the success of the liquid CO<sub>2</sub> fracturing process. (Edited author abstract) 12 refs.

Sinal, Mary Lou (Canadian Fracmaster Ltd); Lancaster, Greg. *J Can Pet Technol* v 26 n 5 Sep-Oct 1987 p 26-30.

**073264 NUMERICAL SIMULATION OF HYDRAULIC FRACTURING TREATMENTS WITH LOW-VISCOSITY FLUIDS.** Field experience indicates that some fluids of this type (e.g., liquid CO<sub>2</sub>) may be preferable in sensitive reservoirs where there is a risk of formation damage with conventional treatments. Simulation of the process, which is characterized by low viscosity and temperature effects on fluid PVT, requires consideration of turbulence and its effect on fracture geometry, leak-off, and proppant transport. The model for low-viscosity fluids described was successfully used to match CO<sub>2</sub> field data with short closure times. Simulation results indicate effective propping of the fracture. (Edited author abstract) 22 refs.

Settari, A. (SIMTECH Consulting Services Ltd); Bachman, R.C.; Morrison, D.C. *J Can Pet Technol* v 26 n 5 Sep-Oct 1987 p 31-40.

**073265 FIELD STUDY OF A NEW HIGH-TEMPERATURE FRACTURING FLUID IN SOUTH TEXAS.** Extensive field development of new fracturing system incorporating a temperature-delayed crosslinker was undertaken over a 15-month period in south Texas. Treatments performed at depths from 7,500 to 17,100 ft [2290 to 5210 m] revealed that the new fluid has properties superior to those of high-temperature systems that use conventional organometallic crosslinkers. Treated formation include the Wilcox, Frio, and Vicksburg. The use of this new fluid has resulted in lower and more consistent friction pressures. Average sand concentrations have been a significant decline in the occurrence of screenouts has been observed. (Author abstract) 9 refs.

Walser, D.W. (Dowell Schlumberger Inc). *SPE Prod Eng* v 3 n 2 May 1988 SPE 13813, p 187-191.



**073266 HYDROXYPROPYLATION OF GUAR GUM AND THE EFFECT OF VARIOUS PROCESS PARAMETERS ON THE YIELD AND QUALITY OF HYDROXYPROPYL GUAR GUM.** Unmodified guar gum was used in the past as a fracturing fluid. However, upon degradation, it leaves behind about 15-20 percent insoluble residue which can cause considerable damage to the formation productivity. To overcome this shortcoming the guar gum can be modified to hydroxypropyl guar gum, which has a higher viscosity, better compatibility with electrolyte solutions and, on degradation, the insoluble residue is reduced substantially (approx. 4 percent). The authors report on the hydroxypropylation of guar gum using propylene oxide in an alkaline medium. 2-Propanol was used for the dispersion of the reactants. The reaction conditions were optimized. 6 Refs.

Surana, Asha (Indian Inst of Technology, New Delhi, India); Mirza, Z.B.; Grover, P.D. *Res Ind v 33 n 1 Mar 1988 p 49-54.*

**Hydraulic Fracturing** See Also FLOW OF FLUIDS—Porous Materials; OIL WELL COMPLETION—Offshore Operations; OIL WELL DRILLING; OIL WELL PRODUCTION—Secondary.

**073267 CAUSING ROCK FAILURE FOR ACCELERATED OIL PRODUCTION: SOME THEORETICAL ASPECTS.** The concept of fracturing or formation breakdown, recognized by the oil industry many years ago, played a very important role in accelerating oil production through well stimulation, acidizing, water injection and cementing. Several important theories to predict material failure are reviewed in the present paper. (Author abstract)

Sinha, S.P. (ONGC, Nazira, India). *J Inst Eng India Part T v 66 n 1 Jul 1985 p 18-20.*

**073268 TEMPERATURE ANALYSIS IN HYDRAULIC FRACTURING.** The authors present a thermal analysis of hydraulic fracturing based on variational methods. The purpose is to provide a theoretical method for determining fracturing fluid temperature as a function of time and location during fracture growth. We first develop an expression of the variational principle for the general problem of convective heat transfer in a porous solid. Its accuracy is confirmed by comparisons with exact relations for specific cases. It is then used to develop a partial-differential equation for fluid temperature as a function of time and location. In this development, we treat fracture dimensions and leakoff distributions as known functions. The differential equation is solved by the method of characteristics. An alternative method of successive approximations is also presented. (Edited author abstract) 10 refs.

Biot, M.A. (Mobil R&D Corp); Masse, L.; Medlin, W.L. *JPT J Pet Technol v 39 n 11 Nov 1987 p 1389-1397.*

**073269 LIMITED ENTRY EXTENDED TO MASSIVE HYDRAULIC FRACTURING.** Limited entry techniques have recently been applied in massive hydraulic fracturing (MHF) of the Niobrara/Codell intervals of the Denver-Julesburg basin. Erratic surface treating pressure behavior and partial-to-complete well screenouts were frequently encountered during simultaneous treatment of these zones. This may be indicative of a lack of control of interzonal treatment fluid placement. There are field-proven solutions to this problem of interzonal fluid entry control during limited entry MHF. This first of two articles examines the downhole interactions that occur. The second will present field-proven solutions to the problem of interzonal fluid entry control during MHF. 31 refs.

Cramer, D.D. (BJ Titan Services Co, Denver, CO, USA). *Oil Gas J v 85 n 50 Dec 14 1987 p 40-45.*

**073270 STUDY INDICATES GUIDELINES IMPROVE RESULTS.** Proppant-induced perforation erosion and dynamic fracture extension pressures impose severe complications when applying limited entry techniques in massive hydraulic fracturing (MHF) treatments. Methods to compensate for these phenomena and limited

entry design guidelines are presented in this second of two articles. 14 refs.

Cramer, D.D. (BJ Titan Services Co, Denver, CO, USA). *Oil Gas J v 85 n 51 Dec 21 1987 p 44-50.*

**073271 ENGINEERING OF HYDRAULIC FRACTURES - STATE OF THE ART AND TECHNOLOGY OF THE FUTURE.** A new age is dawning in the application of computers to precise engineering design and analysis for the optimization of petroleum field operations, particularly hydraulic fracturing. This review concentrates on the dramatic changes in technology generated by the power of computer-based analysis and design, based on sound engineering models of the process. Such engineering has gradually replaced guesswork, as research and development have proved their value over the past decade or so. Primary results include more realistic fracture treatment designs, better quality control, and the possibility of largely automatic control for such operations in the near future. (Edited author abstract) 18 refs.

Cleary, Michael P. (MIT, MA, USA). *JPT J Pet Technol v 40 n 1 Jan 1988 SPE 16260, p 13-21.*

**073272 PRINCIPLES FOR FRACTURE DESIGN BASED ON PRESSURE ANALYSIS.** This paper reviews the procedures for interpreting, modeling, and predicting fracturing pressure. This review shows that excessive pressure resulting from fluid flow in the fracture can cause such problems as excessive height growth and screenouts, which reduce the potential fracture penetration. As a result, an important design consideration is to limit the pressure by controlling the fluid viscosity. (Author abstract) 34 refs.

Nolte, K.G. (Amoco Production Co). *SPE Prod Eng v 3 n 1 Feb 1988 SPE 10911 p 22-30.*

**073273 APPLICATION OF FRACTURE DESIGN BASED ON PRESSURE ANALYSIS.** This paper describes case studies of fracturing pressure analysis for the Wattenberg field of the Denver basin and the Cotton Valley sand of east Texas. The studies show the benefits of pressure analysis and controlled pressure designs for fracture treatments. In addition, procedures for measuring fracturing pressures and considerations for the successful execution of minimal viscosity treatments are presented. (Author abstract) 31 refs.

Nolte, K.G. (Amoco Production Co). *SPE Prod Eng v 3 n 1 Feb 1988 SPE 13393 p 31-42.*

**073274 INFLUENCE OF DOWNHOLE CONDITIONS ON THE LEAKOFF PROPERTIES OF FRACTURING FLUIDS.** Fluid loss under dynamic conditions, considering such realistic conditions as low-permeability core samples and extreme shear conditions, has been examined and is reported in this paper. Dynamic data of fluid loss as a function of time, pressure, and temperature have been developed. Laboratory data are presented that describe the effects of shear rate, pressure differential, temperature, and time on the leakoff profiles of complexed gels. The relative effectiveness of fluid-loss additives, such as diesel and silica flour, is also presented. A comparison is made to other dynamically obtained leakoff velocities, as well as static data. Although dynamic data have been available, they have not been applied in field fracture design. In this work, a method of converting dynamic data to an effective  $C_w$  that can be entered into today's fracture simulators is proposed and examples are given. 16 refs.

Ford, William G.F. (Halliburton Services); Penny, Glenn S. *SPE Prod Eng v 3 n 1 Feb 1988 SPE 14016 p 43-51.*

**073275 HYDRAULIC-FRACTURE-TREATMENT DESIGN SIMULATION.** Computer simulation of hydraulic-fracture-treatment design uses a combination of reservoir rock, fluid properties, and process variables to compute the treatment size and volume on the basis of desired fracture geometry and conductivities. 2D, pseudo-3D, and even fully 3D fracture propagation simulators are now in use to simulate fracture geometry while many of the complex phenomena are considered (e.g., fracture

growth and containment) in the fracturing process. Depending on the complexities of the process, the underlying assumptions and the methodology of solution vary considerably from model to model. A fully 3D fracture propagation model requires much detailed information about material properties of the reservoir rock and the flow behavior of the fracturing fluids. 10 refs.

Acharya, Ruma (BJ Titan Services). *JPT J Pet Technol v 40 n 2 Feb 1988 p 139-142.*

**073276 PRESSURE-TRANSIENT ANALYSIS FOR FRACTURED WELLS PRODUCING AT CONSTANT PRESSURE.** Past solutions to many well-test problems considered the wells to be produced at a constant rate. It has become apparent that there are many cases in which constant-pressure production is more common. Gas wells, geothermal wells, and even oil wells are operated at constant pressure during most of their producing life. This paper presents for the first time a technique that analyzes buildup and drawdown data from wells produced at constant pressure with turbulent flow in the fracture. Two example applications, one for buildup and one for drawdown, are included to demonstrate the use of these techniques. (Edited author abstract) 12 refs.

Guppy, K.H. (Univ of Southern California); Kumar, S.; Kagawan, V.D. *SPE Form Eval v 3 n 1 Mar 1988 SPE 13629, p 169-178.*

**073277 FRACTURE CONDUCTIVITY IN HYDRAULIC FRACTURE STIMULATION.** It is shown that proppant-pack conductivity determines the productivity improvement obtained by a hydraulic fracture stimulation treatment. Fracturing-fluid residue may reduce the proppant conductivity by 90% or more, depending on the fracturing-fluid type, quality and effectiveness, particularly of the breaker system. The non-Darcy flow factor increases with damage, thereby reducing the effective gas-well fracture conductivity further. Two-phase flow effects also reduce the effective fracture conductivity significantly. Fracture design, optimization, and proppant/fracturing-fluid selection account for all these factors. In particular, consider wide propped fractures resulting from the use of high proppant concentrations in the fracturing slurry; intermediate- or high-strength, coarse proppant in (relatively) shallow wells to replace the traditional 20/40-mesh sand economically; and fracturing fluids with low damaging characteristics together with an effective (on-site) quality-control program. 8 refs.

Davies, D.R. (Koninklijke/Shell E&P Lab); Kulper, T.O.H. *JPT J Pet Technol v 40 n 5 May 1988 SPE 17655, p 550-552.*

**073278 ABNORMAL TREATING PRESSURES IN MASSIVE HYDRAULIC FRACTURING TREATMENTS.** Abnormal treating pressures were observed during massive hydraulic fracturing (MHF) treatments in the Mesa Verde formation of the Piceance basin, CO. Data from three widely separated wells and in several zones per well showed a pressure increase during MHF treatments that we call 'pressure growth.' This pressure growth was at least semipermanent. The elevated instantaneous shut-in pressures (ISIP's) did not return to initial values over periods of several days. Pressure growth seems to depend on both pumping rate and fluid viscosity. Thus, there is some hope for its mitigation through treatment design. Also, pressure growth appears to correlate negatively with pay-zone quality. This suggests that the phenomenon can be exploited as a fluid-diversion technique. (Edited author abstract) 18 refs.

Medlin, W.L. (Mobil R&D Corp); Fitch, J.L. *JPT J Pet Technol v 40 n 5 May 1988 SPE 12108, p 633-642.*

**073279 PRESSURE DISTRIBUTION IN THREE-DIMENSIONAL HYDRAULIC FRACTURES.** Stress intensity factors, calculated along the edge of an elliptic fracture with a three-dimensional (3D) coupled hydraulic fracturing model, differ significantly from those that arise from a uniform pressure within



the fracture. Interactions between the two branches of a T-shaped fracture are shown to affect the geometry of the overall fracture. Results of 3D model simulations are compared with field and experimental data. (Edited author abstract) 26 refs.

Vandamme, L. (Dowell Schlumberger Technology Cent); Jeffrey, R.G.; Curran, J.H. *SPE Prod Eng* v 3 n 2 May 1988 SPE 15265, p 181-186.

**073280 USE OF LONG-PERIOD SEISMOMETERS TO DETERMINE INDUCED FRACTURE GEOMETRY.** A novel technique to determine the geometry of induced hydraulic fractures has been tried at five shallow (305- to 884-m [1,000- to 2,900-ft] depth) stimulation tests since 1983. Long-period (LP) seismometers with peak ground-motion sensitivities in the period range between 10 and 100 seconds were deployed on the surface at distances 115 to 732 m [377 to 2,402 ft] from the treatment wellbores. Identifiable transient waveforms with reproducible site-specific ground-motion polarizations were recorded during four of the five stimulations. Temporal coincidence of these LP waveforms with treatment-related events [e.g., bottomhole pressure (BHP) passing through the formation closure stress] suggested that the signals may contain useful information about the induced fracture. (Edited author abstract) 27 refs.

Mauk, Frederick J. (Teledyne Geotech); Mahner, K.D. *SPE Prod Eng* v 3 n 2 May 1988 SPE 15214, p 192-200.

**073281 MINIMIZING DAMAGE TO A PROPPED FRACTURE BY CONTROLLED FLOWBACK PROCEDURES.** Severe fracture-conductivity damage can result from proppant crushing and/or proppant flowback into the wellbore. Such damage is often concentrated near the wellbore and can directly affect postfracture performance. Most of the time severe fracture-conductivity damage can be minimized by choosing the correct type of proppant for a particular well. In many cases, however, this is not enough. To minimize excessive crushing or to prevent proppant flowback, it is also necessary to control carefully the flowback of the well after the treatment. Specific procedures can be followed to minimize severe fracture-conductivity damage. These procedures involve controlling the rates at which load fluids are recovered and maximizing backpressure against the formation. These procedures require much more time and effort than is normally spent on postfracture cleanup; however, the efforts could result in better performance. (Author abstract). 16 Refs.

Robinson, B.M. (S.A. Holditch & Assocs Inc); Holditch, S.A.; Whitehead, W.S. *JPT J Pet Technol* v 40 n 6 Jun 1988 p 753-759.

**073282 HUGOTON INFILL PROGRAM USES OPTIMUM STIMULATION TECHNIQUE.** The Mesa Limited Partnership has evaluated its 1987 Kansas Hugoton field infill drilling program to determine the most efficient completion methods for the field. The focus was mainly on optimum stimulation techniques. Of several hydraulic fracturing methods tested, one proved to be the most effective. The results are being incorporated in the company's 1988 infill drilling program. Mesa has 327 existing wells in the Kansas Hugoton and has the opportunity to drill 326 infill wells. Fifty-six of the 66 infill wells completed by the end of 1987 are included in this study. Mesa expects to recover an additional 200 bcf of reserves as a result of the infill drilling program. 5 Refs.

Cottrell, Theodore L. (Mesa Ltd Partnership, Amarillo, TX, USA); Spronz, William D.; Weeks, William C. *Oil Gas J* v 86 n 28 Jul 11 1988 p 88-90.

**073283 FINITE ELEMENT APPROACH OF THE HYDRAULIC FRACTURING TECHNIQUE FOR OIL WELL STIMULATION.** This paper covers the application of the finite element method for stress analysis considering adequate boundary conditions for simulation of underground excavations in an infinite medium, by the application of special elements. The stress distribution analysis is actually the simulator of the effect of well boring taking into account the fluid pressure inside the

rock mass when a penetrating fluid is considered. The material behavior is considered to be elasto-plastic according to the yielding criterion of Mohr-Coulomb. At the elastic region comparisons are made with analytical solutions available. 3 Refs.

Filho, Adolfo, P. (Petrobras SA, Brazil); da Costa, Alvaro Maia; Ebecken, Nelson F.F. *Adv Eng Software* v 10 n 3 Jul 1988 p 131-135.

**073284 IN SITU STRESS PREDICTION AND MEASUREMENT BY HYDRAULIC FRACTURING, WAPITI, ALBERTA.** A combined field and laboratory investigation of the Cardium Formation in the Wapiti Field near Grande Prairie was performed to determine rock mechanical properties and in situ stress magnitude and orientation. An abnormally high minimum horizontal stress gradient, or fracture gradient, close to and exceeding the calculated vertical overburden stress gradient of 24.3 kPa/m is indicated by several pressure decay interpretation techniques. The inferred minimum horizontal in situ stress is between 1 and 4 MPa greater than in the bounding shale units. Regardless of whether laboratory static or sonic log-derived dynamic elastic properties are used, simple predictions of the minimum horizontal in situ stress may be grossly in error in this part of Alberta unless residual and active tectonic stresses are accounted for. The orientations of the major and minor horizontal in situ stresses have been interpreted from wellbore breakouts, differential strain curve analysis, and anelastic strain recovery techniques. The actual induced hydraulic fracture orientation has been determined by monitoring microseismic events downhole during two mini-frac tests. The average predicted fracture orientation of between N35°E and N43°E compares favourably with the average measured N35°E azimuth from these two wells. (Edited author abstract) 36 refs.

McLellan, Patrick (Petro-Canada Resources, Can). *J Can Pet Technol* v 27 n 2 Mar-Apr 1988, 38th Annu Tech Meet, Pet Soc CIM, Jun 1987 p 85-95.

**Maintenance** See OIL WELL PRODUCTION—Heavy Oil; OIL WELL PRODUCTION—Sub-sea Production System.

## Mathematical Models

**073285 NEW SKIN AND WELLBORE STORAGE TYPE CURVES FOR PARTIALLY PENETRATED WELLS.** The purposes of this study are (1) to present an analytic solution that describes the transient pressure behavior of a partially penetrated well flowing at a constant rate in an infinite reservoir, and that takes into account wellbore storage, skin, and permeability anisotropy; (2) to present a set of new type curves for partially penetrated wells in the Gringarten format; (3) to compare the above results with previous studies and to emphasize certain salient differences; and (4) to show by example how the new type curves may be used to estimate the various components of skin in a saturated reservoir. 19 refs.

Kuchuk, Fikri J. (Sohio Petroleum Co); Kirwan, Paul A. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 11676, p 546-554.

**073286 MODELING THE PROCESS OF FORMATION OF A WATER INSULATING SCREEN AROUND AN OIL WELL.** A mathematical model is proposed for the process of oil well insulation from water by using sediment-forming polymers. The problem posed is solved by asymptotic methods. Based on an analysis of the solution and experimental data, a conclusion is drawn about a high efficiency of the method considered in media with high permeability. (Translated author abstract) In Russian. 6 refs.

Poryadin, A.V.; Krupin, S.V.; Garifullin, F.A. *Izv Vyssh Uchebn Zaved Neft Gaz* n 12 Dec 1987 p 66-72.

**Measurements** See OIL WELL DRILLING—Directional; OIL WELL PUMPING—Measurements.

**Offshore** See Also OIL WELL DRILLING—Blowout Prevention; OIL WELL PRODUCTION—Enhanced Recovery; PLATES—Steel; PRODUCTION PLATFORMS—Reviews.

**073287 SEVERE SLUG FLOW IN OFFSHORE FLOWLINE/RISER SYSTEMS.** Small-scale experiments are described that simulate the unstable two-phase flow pattern of severe slugging often found in offshore flowline/riser systems. In particular, the effects of riser-base supplementary gas lift, flowline orientation, and liquid viscosity have been examined. To place the tests in perspective, the physics of severe slugging is discussed, including a method for scaling between model and prototype situations. Test results are compared with a simple hydrodynamic computer model. (Author abstract) 7 refs.

Pots, Bert F.M. (Koninklijke/Shell Lab, Amsterdam, Neth); Bromilow, Ian G.; Konijn, Martin J.W.F. *SPE Prod Eng* v 2 n 4 Nov 1987 SPE 13723, p 319-324.

**073288 Well Control Team Caps Underwater Blowout. Part 1 - Planning Phase.** Planning separated the project into four distinct phases for organizational purposes: Phase I - engineer, fabricate and procure (14 days). Phase II - mobilization, Louisiana to the well site (14 days). Phase III - capping and killing (28 days). Phase IV - demobilization, well site to Houston (14 days). Each well-kill phase finished on schedule. During Phase III, the capping finished in less than scheduled time. Two capping options are discussed. The use of a riser-capping assembly is discussed. 3 refs.

Anon. *Pet Eng Int* v 59 n 11 Nov 1987 p 22-23, 25-26.

**073289 WELL CONTROL TEAM CAPS UNDERWATER BLOWOUT: PART 2 - EXECUTION PHASE.** A discussion is presented of an underwater blowout and capping in Lake Maracaibo, Venezuela. The initial operation was to remove debris that would affect the kill program. Most of the wreckage from the burned rig lay on the lake floor adjacent to the well site or along the area of the fallen derrick. A 50-ton platform provided a work area for crews and support of some equipment such as the choke manifold and hydraulic lines. The BOP-riser assembly weight rested on the guide base and casing at the lake floor. The surface work area was 30 by 30 ft with a 16 by 16 ft opening in the center. The capping plan required direct access to the 7 in. casing for placement of the explosive charges. The exterior 20-, 13 3/8- and 9 5/8-in. strings had to be removed. Due to the delicacy of maintaining the integrity of the 7-in. pipe, caution and careful execution were paramount for removal of the exterior strings. A team-designed guide base fit onto the 20- and 13 3/8-in. casing strings at the lake bed. The guide base served as a bearing plate to transfer the load to the BOP-riser assembly to the casing and also to provide a stable means for guiding the riser assembly over the well. The final casing cut is discussed and the capping and snubbing operations are outlined. 3 refs.

Anon. *Pet Eng Int* v 59 n 12 Dec 1987 p 32-33, 35-36, 38.

## Oklahoma

**073290 OIL FIND BUOYS HOPE IN OKLAHOMA CORNER.** A four well program undertaken by Chevron U.S.A. in Harmon County last year paid off with a small oil discovery. The one out of four hits was 1 Chevron Motley in SE NW NW 20-3n-24w, 3 miles northeast of Gould. Chevron tested 61 b/d of oil last January from the Pennsylvanian Bend conglomerate (Atokan) at 6,562-86 ft. Drilling took place last fall with total depth of 8,350 ft.

McCaslin, John C. (Oil & Gas Journal, Tulsa, OK, USA). *Oil Gas J* v 86 n 25 Jun 20 1988 p 72.

**Paraffin Sedimentation** See OIL FIELD EQUIPMENT—Cleaning.

## Perforation

**073291 TUBING-CONVEYED PERFORATING CUTS COSTS, BOOSTS PRODUCTION.** A discussion



is presented of the determination of proper underbalance, operational aspects of tubing conveyed perforating, cost comparisons between TCP (Tubing Conveyed Perforating) and wireline methods and a comparison of skin factors resulting from underbalanced perforating and overbalanced perforating. Reservoir characteristics for the Attaka field in Jakarta, Indonesia are discussed. A method for determining net pay is also presented. 6 refs.

Sukmadjaja, Tedja (Unocal Indonesia Ltd, Jakarta, Indonesia); Shewchenko, Don; Ajam, Sami O. *World Oil* v 206 n 5 May 1988 p 52-57.

**Performance** See OIL WELL PRODUCTION—Flooding.

**Pressure Effects** See OIL WELL PRODUCTION—Flow.

**Productivity**

**073292 AUGMENTATION OF WELL PRODUCTIVITY WITH SLANT AND HORIZONTAL WELLS.** The paper presents an equation to calculate the productivity of horizontal wells and a derivation of that equation using potential-fluid theory. This equation may also be used to account for reservoir anisotropy and well eccentricity (i.e., horizontal well location other than midheight of a reservoir). The theoretical predictions were used to calculate the effective wellbore radius and the effective skin factors of horizontal wells. Laboratory experiments with an electrical analog were also conducted. These laboratory experimental data and also the laboratory data available in the literature show good agreement with the theoretical equation, indicating its accuracy. (Edited author abstract). 26 Refs.

Joshi, S.D. (Phillips Petroleum Co). *JPT J Pet Technol* v 40 n 6 Jun 1988 p 729-739.

**Reinjection** See POLYMERS—Precipitation.

**Remote Control** See OIL WELL PRODUCTION—Sub-sea Production System.

**Repair**

**073293 EFFICACY ASSESSMENT OF ADDITIONAL VITAMINIZATION OF WORKERS ENGAGED IN UNDERGROUND REPAIR OF OIL WELLS IN THE AZERBAIDZHAN SSR.** Workers engaged in repair of the underground part of oil wells are subject of hazardous chemical factors, meteorological conditions, noise, vibrations and physical and neural stresses. This study analyses industrial hygienic conditions and effects on cardio-vascular and neural system in workers. Efficiency of additional vitaminization is investigated based on the experience in Azerbaidzhan oil well repairing works. In Russian. 4 refs.

Kerimova, M.G.; Iskenderova, T.A. *Gig Tr Prof Zabol* n 12 Dec 1987 p 51-52.

**Rheology** See OIL WELL PRODUCTION—Flooding.

**Sand Consolidation**

**073294 UNELE CONSIDERATII PRIVIND EFECTELE REALIZATE PRIN INSTALAREA FILTRULOR METALICE SIMPLE IN SONDA IN DREPTUL STRATULUI PRODUCTIV.** [Some Considerations Regarding the Effects Obtained by Installing Simple Metallic Filters in the Well in Line with the Producing Horizon]. The main theoretical and practical aspects are presented regarding the effects obtained by installing metallic slot or orifice filters in the well, in line with the horizon consisting of unconsolidated sand. Calculation methods are indicated in order to establish the proper filter slot size for an efficient process of sand retainment in the bed, as well as calculation relations to estimate the pseudoskin effect factors. Also the methodology is outlined for the calculations of elements characterizing the modifications taking place in the system, due to the presence of a sand filter in the well. (Author abstract) In Romanian. 5 refs.

Tocan, I. (Inst de Petrol si Gaze, Ploiesti, Rom). *Mine Pet Gaze* v 38 n 4 Apr 1987 p 173-176.

**073295 HIGH-TEMPERATURE SAND CONSOLIDATION.** A sand consolidation system has been developed that is stable to wellbore temperature of 700°F [371°C]. Two improvements in technique have contributed to this development. First, a controlled quantity of catalyst is adsorbed on the sand. Consequently, consolidation occurs only on or very near sand grains, resulting in a high-permeability consolidation. Second, the reaction is driven to completion by avoiding, insofar as possible, the adverse effect of water. The resin used for the consolidation is a very viscous derivative of furfuryl alcohol that requires a diluent to make it injectable. The diluent used to reduce viscosity is hydrolyzable ester. The diluted fluid, which is still more viscous than water, displaces much of the water present in the pore space. (Edited author abstract)

Friedman, R.H. (Texaco Inc); Suries, B.W.; Kleke, D.E. *SPE Prod Eng* v 3 n 2 May 1988 SPE 14093, p 167-168.

**Scale Problems**

**073296 SATURATION INDEX PREDICTS BRINE'S SCALE-FORMING TENDENCY.** When natural gas or oil wells produce large volumes of brine/water along with the hydrocarbon, precipitation of calcium carbonate (scale) may be a problem. When brine is produced, the pressure and temperature are lowered, carbon dioxide comes out of solution, and the shift in conditions causes calcium carbonate to precipitate as scale on the inside surfaces of tubulars and processing equipment. This article presents a series of nomographs which can be used to predict the scale-forming tendency, based on the results of relatively simple field chemical tests that can be made by the well operator. The nomographs are based upon rigorous chemical theory, but remove the need for a complex computer program. Further, the scale-forming tendency for each independent parameter is individually given such that the most significant parameters can be readily identified. The results provide the operator with a quantitative measure for the scale-forming tendency which can be used to design or operate the scale control system. 9 refs.

Rogers, Leo A. (Gas Research Inst, Chicago, IL, USA); Tomson, Mason B.; Matty, Jane M.; Durrett, Larry R. *Oil Gas J* v 83 n 13 Apr 1 1985 p 97-100, 104-106, 108.

**073297 NEW TWO-STEP XYLENE-SCALE TREATMENT REMOVES CALCIUM SULFATE.** The majority of the workovers in the Mabec San Andres field in West Texas are for the removal of calcium sulfate. A new scale converter treatment is being evaluated there. This new method uses a xylene-scale converter emulsion as the scale converter and requires only a two-step treatment. The currently used treatment is a five-step process. With the new method the well is first treated with the xylene-scale converter emulsion and then stimulated with acid. The xylene-scale converter treatment has been tested in the laboratory and in the field. 6 Refs.

Hoerauf, Ryan C. (Texaco Inc, Midland, TX, USA). *Oil Gas J* v 86 n 34 Aug 22 1988 p 56-59.

**Simulation**

**073298 SIMULADOR NUMERICO PARA OPTIMIZAR LA PRODUCTIVIDAD DE LOS POZOS.** [Computer Program to Optimize Oil Well Productivity]. An interactive computer program was developed in order to optimize oil well productivity by analyzing, in a practical way, the flow of fluids from the reservoir up to superficial facilities. The program offers several operative alternatives of practical interest such as: automatic selection of the optimum combination for the PVT correlation and two-phase flow method that best matches observed pressure drop data; ability to analyze data for either vertical, horizontal, or inclined flow lines; analysis of the effect of perforations on oil well productivity; evaluation of formation damage caused by fluid invasion; and simulation of diverse completion alternatives to predict

the effect on well productivity when varying; tubing string geometry, surface pipeline dimensions, choke size, and perforation density and pattern. (Edited author abstract) In Spanish. 7 refs.

Gonzalez Chion, Maria Andrea (Instituto Mexicano del Petroleo); Diaz Zertuche, Hector; Pobiano Ordenez, Raul. *Rev Inst Mex Pet* v 19 n 4 Oct 1987 p 20-37.

**Stresses**

**073299 MESURES DE CONTRAINTES IN-SITU METHODE DE RELAXATION DES CAROTTES.** [Measuring In-Situ Stresses. Relaxation Method with Core Samples]. This article describes the first results of research on a method for evaluating stresses by measuring the various deformations of a core sample after it has been extracted. The principles of this method and several interpretation aspects published recently in the literature are described in the first part. Then the results of two measurement programs using two SNEA - P wells are described. These tests revealed that the different deformations of a core sample due to the relaxing of stresses can effectively be measured. However, a quantitative interpretation of these measurements requires an improvement to be made in the experimental conditions (thermal stabilization, stabilization of the state of saturation). (Edited author abstract) 6 refs. In French.

Lessi, J. (Inst Francais du Petrole, Rueil-Malmaison, Fr); Kocher, M.; Perreau, Ph. *Rev Inst Fr Pet* v 43 n 1 Jan-Feb 1988 p 17-42.

**Testing** See Also PETROLEUM RESERVOIR ENGINEERING.

**073300 HOW TO ANALYZE INTERFERENCE WELL TESTS.** The authors examine how wellbore storage and skin effects affect interference test data. The discussion will include analytical models, type curves and recommended procedure for designing and analyzing wellbore storage-dominated interference and pulse test data. 10 refs.

Economides, Michael J. (Dowell Schlumberger, Houston, TX, USA); Ogbe, David O. *World Oil* v 205 n 4 Oct 1987 p 71, 73-76.

**073301 HOW TO ANALYZE INTERFERENCE WELL TESTS - PART 2.** The authors discuss linear flow that occurs in predominantly linear-shaped formations. Several depositional environments, such as river meander point bars, oxbow lakes, river channels and tectonic breccias, could result in predominantly linear flow. Linear fractures, bounded by parallel faults, are frequently observed in highly fractured geothermal reservoirs. Wells drilled in these formations drain volumes that are best described as long, narrow channels. Models for both linear-flow interference testing and vertical interference testing are reviewed through actual case histories. 27 refs.

Economides, Michael J. (Dowell Schlumberger, Houston, TX, USA); Ogbe, David O. *World Oil* v 205 n 3 Sep 1987 p 54-57.

**073302 EXTENDED TEST SYSTEMS HELP APPRAISE SUBSEA WELLS.** An extended test and reservoir appraisal system can help an operator get a better handle on a new offshore field's potential with minimal expense. In view of this, the authors recommend a basic system which uses a diving support class vessel, both as the surface platform to support the production equipment, and as the mooring buoy for the offloading tanker. The system is designed so a minimal amount of modifications need to be made to the offload tanker, which can be from 50,000 to 250,000 dwt capacity - the latter being able to hold 700,000 bbl of oil with segregated ballast. Water depth can be from 200 ft to around 1,500 ft. The advantages of an extended test system are given.

O'Sullivan, Jim (Brown & Root, Houston, TX, USA); Smith, Earl. *Pet Eng Int* v 59 n 4 Apr 1987 p 40, 42-44.



**073303 NEW APPROACH TO INTERFERENCE TEST ANALYSIS.** A new approach for interference test analysis is introduced. A semilog plot of  $tp^2$  vs.  $1/t$  gives a straight line from its intercept, and slope reservoir parameters can be estimated. The method can also be applied to two-rate interference tests for which an iterative procedure is used. Data points from the two regions may be analyzed separately or combined. 5 refs.

El-Khatib, Noaman A.F. (King Saud Univ, Saudi Arabia). *SPE Form Eval* v 2 n 4 Dec 1987 SPE 13733, p 609-610.

**073304 SHORT-TERM TRANSIENT-RATE AND PRESSURE-BUILDUP ANALYSIS OF LOW-PERMEABILITY RESERVOIRS.** This paper presents a technique that reduces test time considerably and obtains accurate formation flow properties before any boundary effects are felt. The technique involves measuring transient rate and pressure at the wellbore during the buildup period and a few minutes before the surface shut-in of the well. The technique is called TRAP (transient rate and pressure) analysis. Having the transient rate during the pressure buildup allows the engineer to correct the pressure data collected during the early portion and to perform the analysis for permeability, skin factor, reservoir pressure, and other formation characteristics. A field example is presented to show the effectiveness of the technique in analyzing low-permeability reservoirs. (Edited author abstract) 26 refs.

Ahmed, Usman (Schlumberger Well Services); Kuchuk, Fikri; Avestaran, Luis. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 13870, p 611-617.

**073305 WELL TEST ANALYSIS OF DATA DOMINATED BY STORAGE AND SKIN: NON-NEWTONIAN POWER-LAW FLUIDS.** We examine pressure falloff behavior dominated by storage and skin subsequent to the injection of a non-Newtonian power-law fluid. New solutions to analyze falloff tests are presented in a form suitable for analyzing field data. The effective wellbore concept is used to combine the wellbore storage constant and skin factor. This phase of our work required extensions to the effective wellbore radius concept (for power-law fluids) given in the literature. To improve analysis procedures, we examine the use of the pressure-derivative technique. We discuss the advantages of this method for the problem under consideration. (Author abstract) 23 refs.

Vongvuthipornchai, S. (Univ of Tulsa, OK, USA); Raghavan, Rajagopal. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 14454, p 618-628.

**073306 PRESSURE DRAWDOWN AND BUILDUP ANALYSIS OF HORIZONTAL WELLS IN ANISOTROPIC MEDIA.** An analytic solution is presented for the pressure response during drawdown and buildup of a horizontal well. This method results from solving the three-dimensional diffusion equation with successive integral transforms. Simplified solutions for short, intermediate, and long times that exhibit straight-line sections when pressure is plotted vs. time are presented. The validity of the method is demonstrated by comparing with results generated numerically by a reservoir simulator and with an analogous analytic solution. Methods for analyzing pressure drawdown and buildup data are presented with examples. The method allows reservoir characteristics, including permeability, skin, and distance to boundaries to be determined. The early-time effects, where the well behaves as if it were in an infinite reservoir, are also discussed. (Edited author abstract) 75 refs.

Goode, P.A. (Sohio Petroleum Co); Thambaynagaram, R.K.M. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 14250, p 683-697.

**073307 NEW DEVELOPMENTS IN MULTIPLE-Well TESTING.** Multiple-well tests provide information about reservoir characteristics such as permeability, porosity, communication between wells, and reservoir heterogeneity. A previous paper discussed the state of the art of multiple-well testing. Several developments were

reported over the last few years; most are for fractured wells, double-porosity systems, and vertical permeability testing. Several field applications of multiple-well testing were also published during the last few years. This paper discusses the new developments, summarizes the information that can be obtained from multiple-well tests with current technology, and indicates areas for future developments. (Edited author abstract) 27 refs.

Kamal, Medhat M. (Schlumberger Perforating & Testing Cent); Hegeman, Peter S. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 14100, p 159-168.

**073308 IMPROVED ESTIMATION ALGORITHMS FOR AUTOMATED TYPE-CURVE ANALYSIS OF WELL TESTS.** This study investigates the application of the Newton method (and an important modification, the Newton-Greendstadt method) to automated well-test analysis. It shows that the added expense of the Newton-Greendstadt method is often justified by the improvement in performance achieved. In many cases, the Newton-Greendstadt procedure converges almost as fast as the Gauss-Marquardt method, yet is more reliable in cases where one (or more important, more than one) parameter is ill-defined. (Edited author abstract) 16 refs.

Barua, Jawahar (Stanford Univ); Horne, Roland N.; Greendstadt, John L.; Lopez, Louis. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 14255, p 186-196.

**073309 EPA DEVELOPS INJECTION WELL PRESSURE TEST: PART 1.** A number of wells have open perforations above the packer and cannot be tested by the standard annulus pressure test. To demonstrate mechanical integrity of the wells, the Ada pressure test was designed and developed by the EPA. In the Ada pressure test, the fluid level in a well is measured to determine the height of the water column above the perforations, the pressure required to depress this column of water to the top of the perforations is calculated. Nitrogen then is added to the annulus until the pressure no longer increases. If the test pressure stabilizes at or very close to the calculated pressure and remains constant for 30 minutes after closing the valve to the nitrogen source, there are no leaks in the casing above the perforations and mechanical integrity is demonstrated. The method was used to test 13 wells in Osage County in 1986. All were witnessed by EPA inspectors and the results were conclusive. Five of the wells passed and eight failed. 2 refs.

Wilson, Everett M. (EPA, Pawhuska, OK). *Pet Eng Int* v 60 n 3 Mar 1988 7p.

**073310 DISEÑO DE PRUEBAS DE INCREMENTO DE PRESION CON EFECTOS DE ALMACENAMIENTO Y DANO. [Build-Up Design with Wellbore Storage and Skin Effects].** A simple procedure to design build-up tests is shown. It is based on the diffusion equation solution for homogeneous and infinite acting reservoirs considering wellbore storage and skin effects. In order to get successful tests, important practical aspects are indicated. A computer program was developed to design automatically the build-up tests. Thus hard work in manipulation of the information is avoided, and the reliability of results is increased. The data and results of the procedure are presented and illustrated with several examples. (Edited author abstract) In Spanish. 8 refs.

Martinez, Romero Nestor (Inst Mexicano del Petroleo); Leon, Ventura Raul. *Rev Inst Mex Pet* v 19 n 3 Jul 1987 p 68-81.

**073311 INTERACTIVE WELL-TEST ANALYSIS USING MICROCOMPUTERS.** In spite of the proliferation of well-test analysis literature in recent years, many pressure-transient tests are still being misinterpreted, partly because a logical procedure is lacking and incomplete analysis is performed by nonexpert analysts. The time and difficulty involved in hand-analysis techniques often discourage a complete, consistent analysis. A properly designed computer program that uses interactive graphics can improve the accuracy of test interpretations by enabling the engineer to perform thorough and

consistent analyses quickly and easily. Microcomputers are ideally suited for such a program because of their computing power, portability, and relatively low costs. The development of microcomputers and well-test analysis software places 'expert' interpretive capabilities within the reach of most engineers. (Author abstract). 18 refs.

McVay, D.A. (S.A. Holditch & Associates Inc); Hill, N.C.; Lancaster, D.E.; Lee, W.J.; Holditch, S.A. *JPT J Pet Technol* v 40 n 9 Sep 1988 p 1227-1231.

**Workover** See Also OIL WELL CASING—Repair; OIL WELL PRODUCTION—Enhanced Recovery.

**073312 WHAT TO REMEMBER ABOUT BULL-HEADING.** Key considerations are outlined for bull-heading which calls for pumping into the annulus of a closed well so that mud and the influx of unwanted formation fluids are displaced back downhole into the weakest exposed open hole interval. Guidelines for bull-heading are also presented. Examples are used to demonstrate this technique. 6 refs.

Adams, Neal (Adams Engineering Inc, Houston, TX, USA). *World Oil* v 206 n 3 Mar 1988 p 46-48.

**Yukon** See PETROLEUM RESERVOIR ENGINEERING.

**OILS AND FATS** See Also ALCOHOLS—Extraction; DIESEL FUELS—Contamination; EMULSIONS—Dielectric Properties; EMULSIONS—Phase Diagrams.

**073313 NATURAL FATS AND OILS - RENEWABLE RAW MATERIALS FOR THE CHEMICAL INDUSTRY.** The authors discuss the sources and importance of raw materials for the oleochemical industry. These include animal oils and fats; marine animal oils and fats; vegetable oils and fats; and oil and fats from microorganisms. New sources of vegetable oils are surveyed. An examination is also presented of classical oleochemical reactions at the fatty acid carboxy group and the products which result from them. Biologically catalyzed reactions are also outlined. 223 refs.

Baumann, Horst (Henkel KGaA, Duesseldorf, West Ger); Buehler, Matthias; Fochem, Heinz; Hirsinger, Frank; Zoebelein, Hans; Falbe, Juergen. *Angew Chem (Int Ed Engl)* v 27 n 1 Jan 1988 p 41-62.

**Analysis** See HOLOGRAPHY.

**Chromatographic Analysis** See Also CHROMATOGRAPHIC ANALYSIS—Equipment.

**073314 ON COLUMN INJECTION-DUAL CHANNEL ANALYSIS OF ESSENTIAL OILS.** In this paper a dual channel/on-column injection system is presented. The principle, practical construction of the device, and results of a data elaboration system carried out on a personal computer, are described. A practical application in essential oil analysis is given. 19 refs.

Bicchi, C. (Dipartimento di Scienza e Tecnologia del Farmaco, Turin, Italy); Frattini, C.; Nano, G.M.; D'Amato, A. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 11 n 1 Jan 1988, Eighth Int Symp on Capillary Chromatogr, Riva del Garda, Italy, May 19-21 1987 p 56-60.

**073315 CGC ANALYSIS OF THE ESSENTIAL OILS OF CITRUS FRUITS ON 100  $\mu$ m I.D. COLUMNS.** Narrow bore columns (100  $\mu$ m) have successfully been applied in the analysis of commercial lemon oils. On these columns, high resolution is obtained in a short analysis time. Different Brazilian lemon oils are characterized qualitatively and quantitatively. (Author abstract) 6 refs.

Lancas, F. (Univ of Sao Paulo, San Carlos, Brazil); David, F.; Sandra, P. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 11 n 1 Jan 1988, Eighth Int Symp on Capillary Chromatogr, Riva del Garda, Italy, May 19-21 1987 p 73-75.



Encapsulation See POLYSACCHARIDES.

Health Hazards See AEROSOLS—Analysis.

Heat Transfer

**073316 LAMINAR NATURAL CONVECTION IN VISCOUS OILS.** The laminar, natural convection flow adjacent to a vertical isothermal surface in viscous oils is analyzed. The strong variations of viscosity with temperature is represented by an exponential function. Similarity solutions are found to exist. It is shown that for a heated wall the constant viscosity results underestimate the Nusselt number and overestimate the drag coefficient. For the cooled wall, the opposite is true. The heat transfer results for the heated wall are in very close agreement with the corresponding correlation of previous experimental investigations. A new correlation for the cooled wall is suggested. (Edited author abstract) 7 refs.

Jang, Jiin-Yuh (Nat'l Cheng-Kung Univ, Tainan, Taiwan); Lin, Chien-Nan. *Modell Simul Control B* v 12 n 1 1987 p 19-30.

Heating See FOOD PRODUCTS—Fats.

Hydrogenation

**073317 ESTIMATION OF AMOUNT OF TRANS, TRANS-ISOMERS OF OCTADECADIENOIC ACIDS IN HYDROGENATED OILS AND FATS.** Hydrogenated oils and fats may consist of a complex mixture of fatty acids, since double-bond migration occurs in addition to inversion of geometric configurations during hydrogenation. An efficient method to estimate the amount of trans, trans-isomers of octadecadienoic acids in hydrogenated oils is described. The method consists of the conversion of triacylglycerols into fatty acid methyl esters (FAME), fractionation of methyl esters by HPLC on silica/silver nitrate, followed by separation of the FAME by capillary gas chromatography, using a CP-Sil 88 column. 1 ref.

Mutter, M. (Unilever Research Lab, Vlaardingen, Neth); Homan, H.R. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 10 n 12 Dec 1987 p 672-673.

**073318 MARCHE DES CATALYSEURS D'HYDROGENATION DES CORPS GRAS.** [Market of Hydrogenation Catalysts for Fats and Derivatives]. Since Institut Francais du Petrole (IFP) has a great deal of experience in the field of catalysts, particularly for hydrogenation, the Evaluation Department has made studies at various times to evaluate the potential markets. The analysis discussed in this article was made to determine the possible outlets for catalysts used for the hydrogenation of fats and oils. It covers the food industry, the hydrogenation of fatty acids of animal or vegetable origin, and the production of fatty alcohols and fatty amines. Whereas the consumption of catalysts used in lipochemistry is highly concentrated in the main industrial regions (United States, Western Europe, Japan), that of the food industry is much more scattered. The three regions mentioned above account for less than 64% of world consumption. (Edited author abstract) In French.

Barraque, M. (Inst Francais du Petrole, Rueil-Malmaison, Fr); Stern, R.; Torck, B. *Rev Inst Fr Pet* v 43 n 3 May-Jun 1988 p 423-437.

Hydrolysis See Also ENZYMES—Activity.

**073319 LIPASE-CATALYZED OIL HYDROLYSIS IN THE ABSENCE OF ADDED EMULSIFIER.** The purpose of the current study is to investigate the kinetics of oil hydrolysis catalyzed by Candida lipase in the absence of any added emulsifier. The effects of pH, calcium, and water content on the lipolysis rate are also discussed. 18 refs.

Wang, Y.J. (Nat'l Yang-Ming Medical Coll, Taipei, Taiwan); Sheu, J.Y.; Wang, F.F.; Shaw, J.F. *Biotechnol Bioeng* v 31 n 6 Apr 20 1988 p 628-633.

**073320 HYDROLYSIS OF BEEF TALLOW BY LIPASE FROM PSEUDOMONAS SP.** The lipase produced by *Pseudomonas fluorescens* biotype I was selected for hydrolyzing beef tallow at 50-70°C to more than 90% of reaction ratio. Using an amount of lipase sufficient to reach equilibrium, the final reaction ratio was decreased with increasing temperature and the apparent enthalpy of beef tallow hydrolysis obtained by the final reaction ratio was  $-1.93 \times 10^4$  cal/mol, and the final reaction ratio also decreased with increasing substrate concentration. The rising time, which is the reaction time up to one-half of the final reaction ratio, decreased remarkably with increasing temperature, and was closely related to the value of the maximum velocity by the Michaelis constant of this lipase. The final reaction ratio increased with increasing lipase amount up to equilibrium. The feasibility of using parameters obtained by a hyperbolic simulation of the progress curve is discussed. (Edited author abstract) 19 refs.

Kosugi, Yoshitsugu (Fermentation Research Inst, Tsukuba, Jpn); Suzuki, Hideo; Funada, Tadashi. *Biotechnol Bioeng* v 31 n 4 Mar 1988 p 349-356.

**073321 THERMAL HYDROLYSIS OF VEGETABLE OILS AND FATS. 1. REACTION KINETICS.** A model is proposed to describe the liquid-liquid thermal hydrolysis of vegetable oils and animal fats. Extensive data on hydrolysis equilibrium and rate have been obtained. Results of the present and previous studies have been compared with model predictions. Uniformly excellent agreement is indicated in all the cases. (Author abstract) 16 refs.

Patil, T.A. (Indian Inst of Technology, Bombay, India); Butala, D.N.; Raghunathan, T.S.; Shankar, H.S. *Ind Eng Chem Res* v 27 n 5 May 1988 p 727-735.

**073322 THERMAL HYDROLYSIS OF VEGETABLE OILS AND FATS. 2. HYDROLYSIS IN CONTINUOUS STIRRED TANK REACTOR.** The hydrolysis can be brought about over a batch of oil by a spray of high-pressure water. This scheme could have somewhat poor productivity in relation to continuous countercurrent operations. No work on semicontinuous hydrolysis has been reported so far. The reaction can also be conducted in a continuous stirred tank reactor. This scheme offers advantages with respect to energy integration and productivity in addition to cost advantages in terms of investment. In this scheme, a mixture of water and oil is pumped to a reactor. In this paper, we examine the behavior of this configuration theoretically by using the model developed earlier. The model predictions are then tested experimentally. 1 ref.

Patil, T.A. (Indian Inst of Technology, Bombay, India); Raghunathan, T.S.; Shankar, H.S. *Ind Eng Chem Res* v 27 n 5 May 1988 p 735-739.

**073323 THERMAL HYDROLYSIS OF VEGETABLE OILS AND FATS. 3. AN ANALYSIS OF DESIGN ALTERNATIVES.** An analysis of the oil hydrolysis reactor design alternatives is performed. A model reaction  $t \approx g$  for oil hydrolysis is used to simulate the performance of several reactor configurations. The continuous countercurrent spray column is shown to be superior to others in terms of productivity and conversion. A tubular plug-flow reactor module is shown to have promising features. (Author abstract) 8 refs.

Namdev, P.D. (Indian Inst of Technology, Bombay, India); Patil, T.A.; Raghunathan, T.S.; Shankar, H.S. *Ind Eng Chem Res* v 27 n 5 May 1988 p 739-743.

Manufacture

**073324 USE OF COAGULATING AND POLYMERIC FLOCCULATING AGENTS IN THE TREATMENT OF PALM OIL MILL EFFLUENT (POME).** The reduction of pollution strength in palm oil mill effluent (POME) using five inorganic salts and nine polymers was investigated. Treatment of POME with 80-100 mg litre<sup>-1</sup> of Magnafloc LT22 polymer aided in coagulation and flocculation of Total Suspended Solids,

producing 96%, 63%, 53% and 93-94% reduction in the turbidity, chemical oxygen demand (COD), Total Solids (TS) and Total Suspended Solids (TSS) respectively, of the effluent. The TSS of POME can be substantially reduced by treating with coagulating and flocculating agents before discharging into other treatment systems. (Edited author abstract) 13 refs.

Karim, Mohamed Ismail Abdul (Univ Pertanian Malaysia, Selangor, Malaysia); Hie, Lau Leh. *Biol Wastes* v 22 n 3 1987 p 209-218.

Oxidation

**073325 FORMATION OF CONJUGATED DIENE AND TRIENE PRODUCTS IN LIPOXYGENASE OXIDATION OF C18, C20, C22 PUFA.** In the present study, we investigated the substrate specificity for the formation of conjugated diene and triene products in the oxidation of a series of polyunsaturated fatty acids (PUFA) in oils by the soybean lipoxygenase. In addition, an attempt is made to extend the enzymatic method for measuring cis,cis-methylene interrupted PUFA to a variety of oil and fat products. 13 refs.

Takagi, Toru (Hokkaido Univ, Hokodate, Jpn); Wakasa, Naoko; Miyashita, Kazuo. *JAOCs J Am Oil Chem Soc* v 64 n 9 Sep 1987 p 1320-1323.

Processing

**073326 TREATMENT OF PALM OIL STERILISER CONDENSATE BY AN ANAEROBIC PROCESS.** In a palm oil mill using a decanter, sterilizer condensate is the main liquid effluent generated. The sterilizer condensate was found to be easily treatable by a simple anaerobic process at ambient temperature. A BOD removal efficiency of more than 90% could be achieved. The process seemed to attain optimum operating conditions at a BOD loading of 1.8 kg per cubic meter per day with a hydraulic retention time of 15 to 16 days. The Volatile Fatty Acid to alkalinity ratio was found to be a good control index. It was quick and simple to determine. (Edited author abstract) 17 refs.

Ma, A.N. (Palm Oil Research Inst of Malaysia, Kuala Lumpur, Malaysia); Ong, Augustine S.H. *Biol Wastes* v 23 n 2 1988 p 85-97.

Recovery

**073327 EQUILIBRIUM CHARACTERISTICS FOR EXTRACTIONS IN THE SYSTEM OIL-BEARING MATERIAL-SOLVENT.** The authors have obtained direct experimental data on the equilibrium in the system sunflower petal-oil micelle. In view of the diversity of composition of the extraction benzines used on the oil-seed works, we selected normal hexane as solvent. We have developed the theory of adsorption equilibrium in the system solid body-liquid and carried out a generalization of the experimental data on this basis. This study provides evidence of the essential difference, especially in regions of low concentration, between the equilibrium compositions of pore and external micelles in the extraction of vegetable oil from oil cake. This fact should be taken into account in the design of new and the improvement of existing oil-extraction plants in order to yield extracted meal of low oil content. 7 refs.

Konstantinov, E.N. (Krasnodar Polytechnic Inst, USSR); Fridt, A.I.; Klyuchkin, V.V. *J Appl Chem USSR* v 60 n 9 pt 1 Sep 1987 p 1840-1844.

Removal See Also TEXTILES—Laundering.

**073328 EVALUATION OF GREASE MANAGEMENT ALTERNATIVES FOR ARMY WASTEWATER COLLECTION AND TREATMENT SYSTEMS.** A survey determined that over two-thirds of the installations responding experienced problems with grease and oil accumulation. Research was conducted by the U.S. Army Construction Engineering Research Laboratory (USA-CERL) to: (1) determine the nature and extent of grease and oil problems at fixed Army installations,



identify the installations' current oil and grease control practices, and evaluate these methods' effectiveness and cost, (2) identify, from published information, commercially available grease and oil control methods (including chemical and biological additives) and establish their properties and applications, (3) collect and evaluate case histories, and (4) provide guidance for determining whether use of an alternative method would be cost-effective at military installations. (Edited author abstract) 46 refs.

Bandy, John T.; Marlatt, Richard M.; Lang, Lynn E.; Poon, Calvin; Skov, Kenneth; Prakash, Temkar M. *Tech Rep US Army Corps Eng Constr Eng Res Lab* 87-15 May 1987 48p.

## Thermal Properties

**073329 THERMAL AND COMPOSITIONAL PROPERTIES OF COCOA BUTTER DURING STATIC CRYSTALLIZATION.** Studies were conducted using differential scanning calorimetry (DSC) and high performance liquid chromatography (HPLC) to determine the thermal properties and glyceride composition of cocoa butter crystals formed under static conditions. In addition to these studies, visual characterization of the crystallites was obtained with polarized light microscopy (PLM). (Edited author abstract) 16 refs.

Dimick, Paul S. (Pennsylvania State Univ, University Park, PA, USA); Manning, Douglas M. *JAOCs J Am Oil Chem Soc* v 64 n 12 Dec 1987 p 1663-1669.

**OLEFINS** See Also CHEMICAL REACTIONS—Fischer-Tropsch Synthesis; PHENOLS—Alkylation; PHOTO-RESISTS—Materials.

## Carbocation

**073330 DIRECT SYNTHESIS OF 1,3-BENZODI-OXOL-2-ONE FROM STYRENE, DIOXYGEN AND CARBON DIOXIDE PROMOTED BY Rh(I).** In view of the diverse synthetic utility of the direct carbocation reaction, this paper investigates the use of metal systems as catalysts in the direct conversion of olefins into carbonates, and reports on the synthesis of 1,3-benzodioxol-2-one starting from styrene, dioxygen and carbon dioxide. This reaction was attempted under different conditions. Several Rh(I) complexes were used, namely RhCl(PET<sub>3</sub>Ph)<sub>3</sub>, RhCl(diphos) [diphos=1,2-bis(diphenylphosphino)ethane], RhCl(diphos)<sub>2</sub>, RhCl(dipy), RhCl(dipy) and (dipy) (molar ratio equal to 1). The influence of the temperature, solvent and ligand-to-rhodium ratio was also studied. 15 refs.

Aresta, M. (CNR-MISO, Bari, Italy); Quaranta, E.; Ciccarese, A. *J Mol Catal* v 41 n 3 Aug 1987 p 355-359.

**Catalysis** See Also CATALYSTS—Synthesis.

**073331 PHOTOINDUCED METATHESIS OF OLEFIN CATALYZED BY W(CO)<sub>5</sub>L-AX<sub>n</sub> SYSTEM.** In the photocatalytic system containing tungsten compounds of the type W(CO)<sub>5</sub>L (L=CO, py, PPh<sub>3</sub>, Cl<sup>-</sup>) and Group IIIb and IVab element halides (AX<sub>n</sub>) the metathesis of internal and terminal olefins was investigated. The terminal olefin metathesis reaction is accompanied by double bond migration yielding the internal olefins, which undergo co-metathesis with the initial olefins. Substitution of tungsten by molybdenum or chromium favors the isomerization reaction. (Author abstract) 21 refs.

Szymanska-Buzar, T. (Univ of Wroclaw, Wroclaw, Pol); Ziolkowski, J.J. *J Mol Catal* v 43 n 2 Dec 1987 p 161-170.

**Chemical Reactions** See Also CATALYSTS—Activity; POLYMERS—Reactions.

**073332 MEERWEIN ARYLATION REACTIONS OF OLEFINS WITH ANTHRAQUINONE DIAZONIUM HYDROGEN SULFATES: FORMATION OF NEW CARBON BONDS AT THE CARBON ATOMS C-1 AND AT C-1,5 OF THE ANTHRAQUINONE SYSTEM.** A survey is presented of Meerwein arylation reactions involving the arylation of olefins with anthraqui-

none diazonium hydrogen sulfate. These reactions comprise an experimentally limited and special section of the otherwise broad applicability and scope of Meerwein reactions. The combinations of the anthraquinone system with olefins having from two to five carbon atoms are attained by using experimental conditions which differ markedly from those patterned after the general performance of Meerwein reactions. The best results are obtained in using diazonium hydrogen sulfates, in contrast to the generally and most conveniently used hydrogen chloride salts. Many further ring-closure reactions of the intermediates thus obtained are reported, yielding condensed heterocyclic aromatic compounds. (Edited author abstract) 30 refs.

Weis, Claus D. (Ciba-Geigy Ltd, Basel, Switz). *Dyes Pigm* v 9 n 1 1988 p 1-20.

## Chromatographic Analysis

**073333 DETAILED GAS CHROMATOGRAPHY/MASS SPECTROMETRIC STRUCTURAL DETERMINATION OF OLEFIN OLIGOMERIZATION PRODUCTS.** Reaction gas chromatography/mass spectrometry methods have been applied in determining the molecular structure of individual C<sub>7</sub> olefins present in a complex mixture of isomers formed by the cooligomerization of C<sub>3</sub> and C<sub>4</sub> olefins. It is shown that gas chromatography/chemical ionization/mass spectrometry (GC/CI/MS), using reagent gases such as dimethyl ether and vinyl methyl ether, can also be used to determine the presence of specific structural features of isomeric alkenes. Where applicable, these techniques provided support for the structural assignments given. (Edited author abstract) 15 refs.

Chaffee, Alan L. (CSIRO, Menai, Aust); Cavell, Kingsley J.; Masters, Anthony F.; Western, Robert J. *Ind Eng Chem Res* v 26 n 9 Sep 1987 p 1822-1824.

**Composition Effects** See ETHYLENE—Polymerization.

**Cracking** See Also ETHANE—Pyrolysis.

**073334 EFFECT OF HYDROTHERMAL TREATMENT ON THE ACIDITY, ACTIVITY AND OLEFIN SELECTIVITY OF ULTRASTABLE Y ZEOLITE.** The effect of hydrothermal treatment on the activity and acidity of zeolites, apparent activation energy of n-hexane cracking, and hydrogen transfer reaction have been studied by means of n hexane cracking with pyridine poisoning over USY, using pulse catalytic chromatograph branch-flow and TPD technique. The regularity of olefin formation have also been investigated. A close relationship exists between the activity of n-hexane cracking and the acidic property. It has been found that the hydrothermal stability and catalytic cracking activity of REH-USY after high temperature treatment are much higher than those of H-USY. (Edited author abstract) In Chinese. 6 refs.

Li Dongfan (Acad Sinica, China); Tao Longxiang; Zhan Yingzhen; Li Shiyao; Zheng Lubin. *Shiyou Xuebao Shiyou Huagong* v 3 Mar 1987 p 56-64.

## Desorption

**073335 THERMAL DESORPTION OF C<sub>6</sub>-C<sub>9</sub> n-ALKENES FROM THE SURFACE OF ZEOLITE HY.** The nature of the species formed during the adsorption and thermal desorption of 1-hexene, 1-heptene, 1-octene and 1-nonene from HY zeolite was studied by temperature-programmed desorption coupled with mass spectrometry. Various transient species desorbed include alkenes, dienes, trienes, alkanes and aromatics. From the identification of these species, the mechanism of the formation of aromatics and the nature of carbonaceous deposits formed during alkene conversion are proposed. (Author abstract) 13 refs.

Jasra, R.V. (Indian Petrochemicals Corp, Baroda, India); Bhatt, B.D.; Garg, V.N.; Bhat, S.G.T. *Appl Catal* v 39 n 1-2 May 1988 p 49-60.

## Esterification

**073336 RUTHENIUM-CATALYZED ESTERIFICATION OF OLEFIN WITH METHYL FORMATE.** On the basis of previous findings, we attempted a reaction of methyl formate activated by metal complex with olefin to produce ester, and found that the reaction took place using the ruthenium dihydride complex catalyst, RuH<sub>2</sub>(PPh<sub>3</sub>)<sub>4</sub>. We will discuss this novel synthetic reaction which has not previously been reported. A catalyst screening was made first by using many kinds of transition metal complexes, in order to discover an effective catalyst for the reaction. As a result, RuH<sub>2</sub>(PPh<sub>3</sub>)<sub>4</sub> was found to be a unique effective catalyst among the complexes tested, although the reaction conditions used may not have been adequate for catalyst screening. Other catalysts, for example RuH-(CO)(PPh<sub>3</sub>)<sub>3</sub>, showed some activity but gave very poor results, mainly catalyzing the decomposition of methyl formate. 7 refs.

Ueda, W. (Tokyo Inst of Technology, Yokohama, Jpn); Yokoyama, T.; Morikawa, Y.; Moro-Oka, Y.; Ikawa, T. *J Mol Catal* v 44 n 2 Feb 29 1988 p 197-200.

**Forming** See Also METHANOL—Processing.

**073337 FUNCTIONAL MONOMERS AND POLYMERS. 145. SYNTHETIC APPLICATION BASED ON THE TAUTOMERISM OF POLYMER-BOUND PURINE AND PYRIMIDINE BASES.** Polymer-bound alkylthiopyrimine and -pyrimidine bases were prepared and used as the polymeric reagents for the reactions of nitrile, olefin, and enone formation. The corresponding low molecular weight compounds were also prepared for comparison. Differences in the reactivity of these reagents were related to the change in tautomerism of the purine and pyrimidine moieties. (Author abstract) 11 refs.

Koshiba, Hiroshi (Osaka Univ, Suita, Jpn); Kondo, Koichi; Takemoto, Kiichi. *J Macromol Sci Chem* v A24 n 11 Nov 1987 p 1303-1314.

## Heating

**073338 PREDICTION OF OLEFIN BOILING POINTS FROM MOLECULAR STRUCTURE.** The normal boiling points for olefins are predicted by use of exclusively topological descriptors derived from molecular structure. Predictive equations having from one to eight independent variables were obtained by applying multiple linear regression analysis to a set of topological descriptors (independent variables and the observed boiling point of 123 C<sub>2</sub>-C<sub>10</sub> olefins (dependent variable). The best model found, which included eight descriptors, yielded a correlation coefficient of 0.999 and an estimated standard deviation of 1.78°C. (Author abstract) 23 refs.

Hansen, Peter J. (Pennsylvania State Univ, University Park, PA, USA); Jurs, Peter C. *Anal Chem* v 59 n 19 Oct 1 1987 p 2322-2327.

## Hydration

**073339 HIGH PRESSURE CATALYTIC HYDRATION OF OLEFINS OVER VARIOUS PROTON-EXCHANGED ZEOLITES.** The catalytic hydration of ethylene, propylene and 1-butene to alcohols was investigated using proton-exchanged zeolites at high pressure in a flow reactor. All the zeolites exhibited hydration activity. Pentasil- and ferrierite-type zeolites were the most active. (Author abstract) 15 refs.

Eguchi, Koichi (Kyushu Univ, Fukuoka, Jpn); Tokiai, Takeo; Arai, Hiromichi. *Appl Catal* v 34 n 1-2 Oct 15 1987 p 275-287.

**Hydrogenation** See Also CATALYSTS—Performance; ORGANIC COMPOUNDS—Hydrogenation; PETROLEUM PRODUCTS—Chemical Analysis.



**073340 HOMOGENEOUS HYDROGENATION OF CYCLOHEXENE CATALYZED BY Ru(II) AND (III) AND THEIR TRICHLOROSTANNATO COMPLEXES: PROTON NMR AND RATE STUDIES.** A study was undertaken of metal hydrides of chloro- and trichloro-stannato complexes of Ru(II) and (III) with a mixed donor  $\text{NP}_2$  as primary ligand and  $\text{PPH}_3$  or DMSO as the secondary ligand. The comparative study of rates of hydrogenation of cyclohexene by all these complexes is reported, and a mechanism of hydrogenation catalyzed by these complexes proposed. 24 refs.

Taqi Khan, M.M. (Central Salt & Marine Chemicals Research Inst, Bhavnagar, India); Siddiqui, M. Rafiq H. *J Mol Catal* v 42 n 2 Oct 1987 p 161-171.

**073341 SHAPE SELECTIVE HYDROGENATION BY RUTHENIUM-HECTORITE CATALYSTS WITH VARIOUS INTERLAYER DISTANCES.** Ru- Hectorite catalysts with various interlayer distances have been prepared and characterized by X-ray diffraction (XRD), infrared spectroscopy and temperature programmed desorption (TPD). It was found that the interlayer distance depended on the  $\text{H}_2$ -treatment temperature of the catalysts. Hydrogenation of various olefins was studied using these catalysts. The catalytic activity was shown to depend on the interlayer distances. (Author abstract) 6 refs.

Shimazu, Shogo (Chiba Univ, Chiba, Jpn); Hirano, Tomoaki; Uematsu, Takayoshi. *Appl Catal* v 34 n 1-2 Oct 15 1987 p 255-261.

**073342 THERMODYNAMICS OF HOMOGENEOUS HYDROGENATION. PART IV. SYNTHESIS, CHARACTERIZATION AND HYDRIDE FORMATION OF THE Pd(II) COMPLEXES CHLORO-BIS(DIPHENYLPHOSPHINOETHYL)AMINEPALLADIUM(II) CHLORIDE AND CHLORO-TRIS(DIPHENYLPHOSPHINOETHYL)AMINEPALLADIUM(II) CHLORIDE AND THEIR CATALYSIS IN THE HOMOGENEOUS HYDROGENATION OF CYCLOHEXENE.** The synthesis and characterization of  $[\text{Pd}(\text{DPEA})\text{Cl}]\text{Cl}$  1 and  $[\text{Pd}(\text{TPEA})\text{Cl}]\text{Cl}$  2, where DPEA and TPEA are bis(2-diphenylphosphinoethyl)amine  $\text{NH}(\text{CH}_2\text{CH}_2\text{PPh}_2)_2$  and tris(2-diphenylphosphinoethyl)amine  $\text{N}(\text{CH}_2\text{CH}_2\text{PPh}_2)_3$ , respectively, are reported. The catalytic activity of 1 and 2 in the homogeneous hydrogenation of cyclohexene over the temperature range 10-40°C and 0.4 to 1 atm of hydrogen partial pressure has been investigated. The rate of hydrogenation of cyclohexene catalyzed by 1 and 2 is found to be first order with respect to the catalyst, fractional order with respect to the substrate concentration and independent of  $\text{H}_2$  partial pressure. (Edited author abstract) 23 refs.

Taqi Khan, M.M. (Central Salt & Marine Chemicals Research Inst, Bhavnagar, India); Taqi Khan, Badar; Begum, Safia. *J Mol Catal* v 45 n 3 May 30 1988 p 305-317.

**073343 HYDROGENATION REACTIONS WITH  $\text{RuCl}_2(\text{TRIPHOS})$ ,  $\text{RuCl}_2(\text{TRIPHOS})$  ( $\text{TRIPHOS} = \text{PhP}(\text{CH}_2\text{CH}_2\text{PPh}_2)_2$ ) CATALYZES THE HOMOGENEOUS HYDROGENATION AND ISOMERIZATION OF OLEFINS, HYDROGENATION OF ALKYNES, ALDEHYDES, KETONES AND NITRILES, UNDER MODERATE REACTION CONDITIONS IN DIFFERENT ORGANIC SOLVENTS.** The hydrogenation of 1-hexene shows a rate increase with higher temperature and pressure. The system shows high selectivity in the reduction of phenylacetylene to the corresponding alkene. The system can also reduce  $\alpha,\beta$ -unsaturated aldehydes to the corresponding saturated aldehyde and unsaturated alcohol. Likewise, the reduction of aldehydes and ketones to alcohols and nitriles to a mixture of primary, secondary and tertiary amines has been observed. (Author abstract) 13 refs.

Suarez, Trino (Univ de Los Andes, Merida, Venez); Fontal, Bernardo. *J Mol Catal* v 45 n 3 May 30 1988 p 335-344.

**073344 AB INITIO MO STUDY OF THE FULL CATALYTIC CYCLE OF OLEFIN HYDROGENATION BY THE WILKINSON CATALYST  $\text{RhCl}(\text{PPh}_3)_3$**

. The potential energy profile for the full catalytic cycle of olefin hydrogenation by the Wilkinson catalyst has been studied with the ab initio MO method. The geometries of the transition states as well as the intermediates have been determined with the RHF energy gradient method for each step of the model Halpern mechanism. The energetics for some critical steps has been calculated also with the second-order Moller-Plesset perturbation theory. The first two steps, exothermic without significant barrier, should take place easily. The olefin migratory insertion has a high barrier. (Edited author abstract) 50 refs.

Daniel, C. (Inst for Molecular Science, Okazaki, Jpn); Koga, N.; Han, J.; Fu, X.Y.; Morokuma, K. *J Am Chem Soc* v 110 n 12 Jun 8 1988 p 3773-3787.

**073345 EFFECT OF THE HEAT TREATMENT OF Pd THIN FILM ALLOY ON THE HYDROGENATION OF OLEFINS.** Pd-(B, P) thin film alloys have been prepared by an RF sputtering method. Before heat treatment, the selectivity for the partial hydrogenation of olefins increased with the increase in the B or P concentration in the Pd-(B, P) films. After the heat treatment, on the other hand, the selectivity for the partial hydrogenation was reduced over the Pd films with a low B or P concentration. However, in the case of the Pd films with a high B or P concentration, the selectivity was enhanced by the heat treatment. The high selectivity after the heat treatment was explainable in terms of the small ensemble size, the low electron density of Pd, and the appearance of a  $\text{Pd}_3\text{B}$ ,  $\text{Pd}_4\text{P}$ , or  $\text{Pd}_3\text{P}_2$  phase in the Pd films with a high B or P concentration. A sputtered film is known to have a columnar structure. (Edited author abstract) 23 Refs.

Tamaki, Jun (Osaka Univ, Osaka, Jpn); Yamamura, Masashi; Imanaka, Toshinobu. *Bull Chem Soc Jpn* v 61 n 5 May 1988 p 1725-1729.

#### Isomerization

**073346 HOMOGENEOUS NICKEL-CATALYZED OLEFIN HYDROCYANATION.** In this paper, the authors discuss the chemistry of the du Pont adiponitrile process from a mechanistic viewpoint. The review is restricted to homogeneous nickel-catalyzed hydrocyanation of olefins and depends primarily on du Pont studies. Before discussing hydrocyanation chemistry the authors explore the interaction of zero-valent nickel phosphite complexes with various independent components of the catalytic system. A summary of the mechanism as it is now understood is presented. 73 refs.

Tolman, C.A. (DuPont, Wilmington, DE, USA); McKinney, R.J.; Seidel, W.C.; Druliner, J.D.; Stevens, W.R. *Adv Catal* v 33. Publ by Academic Press Inc, Orlando, FL, USA, 1985 p 1-46.

**073347 ISOMERIZATION OF OLEFINS CATALYZED BY SILICA-POLYALUMAZINE-PALLADIUM COMPLEXES.** A silica-supported polyalumazine-palladium complex (abbreviated Al-N-Pd) has been found to be an effective isomerization catalyst for olefins. It can catalyze pentene-1 to pentene-2 in 72% yield and hexene-1 to hexene-2 and hexene-3 in yields of 88 and 12%, respectively, at 0°C and under atmospheric pressure. In investigating the solvent effects on the isomerization of hexene-1 catalyzed by Al-N-Pd, it was found that alcohol probably plays a role as promoter. The results show that the inorganic polymer-supported metal complex Al-N-Pd is more active, selective, and stable than other catalysts for isomerization of  $\alpha$ -olefins. (Edited author abstract) 5 refs.

Yuan, Y.X. (Acad Sinica Zhongguancun, Beijing, China); Huang, M.Y.; Jiang, Y.Y. *J Macromol Sci Chem* v 24 n 3-4 1987, Macromol-Met Complexes: Sel Pap from the US-China-Jpn Jt Semin, Beijing, China, Oct 20-24 1985 p 261-268.

#### Oxidation See Also CATALYSIS; ETHERS—Synthesis.

**073348 PHOTOCHEMICALLY INDUCED OLEFIN OXIDATION BY TITANYL AND VANADYL PORPHYRINS.** This work reports the photocatalytic properties of some titanyl and vanadyl meso-tetraphenyl-

porphyrin monomers and dimers. In each case, cyclohexene was converted to cyclohexene-1,2-epoxy, 6,2-cyclohexen-1-ol 7 and 2-cyclohexen-1-one. Kinetic study shows the reaction to be first order with respect to cyclohexene, and first order with respect to oxygen. In the light of the results, a mechanism for the photocatalytic oxidation of cyclohexene induced by titanyl or vanadyl porphyrins (P) is suggested, which implies singlet oxygen as the oxidizing agent. 31 refs.

Mansour, E.M.K. (CNRS, Gif-sur-Yvette, Fr); Maillard, P.; Krausz, P.; Gaspard, S.; Giannotti, C. *J Mol Catal* v 41 n 3 Aug 1987 p 361-366.

**073349 REGIO- AND STEREOSELECTIVITY OF THE EPOXIDATION REACTION OF ETHYLIDENENORBORNENE.** Epoxidation of ethylenenorbornene, a mixture of E- and Z-stereoisomers, with an equimolecular amount of per acid (peracetic, monoperphthalic) occurs regiospecifically at the extracyclic strained double bond and stereoselectively predominately from the exo-direction of the norbornene fragment. In the case of monoperphthalic acid the reaction is complicated by isomerization of the monoepoxide to endo-2-acetyl-bicyclo[2,2,1]hept-5-ene. Stereoisomeric diepoxides of ethylenenorbornene were isolated by reaction of per acids and the monoepoxides. Spectra of the synthesized compounds were studied using IR and PMR spectral parameters. (Author abstract) 10 refs.

Kas'yan, L.I.; Galafeeva, M.F.; Kovalenko, V.V.; Dryuk, V.G. *Sov Prog Chem* v 53 n 9 1987 p 69-73.

**073350 USE OF SOLVENTS IN THE LOW-PRESSURE PLASMA OXIDATION OF OLEFINS.** The oxidation of n-octene has been studied in mixtures with dimethylbutane, 1,4-dimethylcyclohexane, ethylcyclohexane, and dibutyl ether. Except for dimethylbutane, total yields increase on addition of a solvent, and the fraction of epoxide among the products is higher than in reactions with neat octene. The main constituents of oxygen plasmas are ground-state molecules  $\text{X}^3\Sigma^-$ , singlet oxygen molecules  $^1\Delta_g$ , and ground-state oxygen atoms  $^3\text{P}$ . Ozone can be neglected in the low-pressure range. Singlet oxygen may react with allylic hydrogens to form hydroperoxides; toward other hydrogens, it is inert. (Edited author abstract) 12 refs.

Suhr, H. (Univ of Tuebingen, Tuebingen, West Ger); Pfreundschuh, H. *Plasma Chem Plasma Process* v 8 n 1 Mar 1988 p 67-74.

**073351 KINETICS OF THE LIQUID-PHASE OXIDATION OF TRI- AND TETRA-CHLOROETHYLENES.** Studies have been made concerning the kinetic mechanism of the liquid-phase oxidation of tri- and tetra-chloroethylene initiated by azodiisobutyronitrile. The kinetic parameters of the reactions have been calculated. The rate constants of chain propagation and termination reactions ( $k_2$  and  $k_6$ ) obtained and also the ratio  $k_2/k_6^{1/2}$  may be used to calculate cooxidation curves of organic compounds, in other words, to obtain crossed rate constants of reactions and solve theoretical and practical problems in the field of liquid-phase oxidation. (Edited author abstract) 6 refs.

Kucher, R.V. (Acad of Sciences of the Ukrainian USSR, L'vov, USSR); Flyunt, R.I.; Timokhin, V.I. *Kinet Catal* v 28 n 4 pt 2 Jul-Aug 1987 p 860-862.

**073352 OXIDATION OF OLEFINS WITH  $\text{O}_2$  AND  $\text{NaBH}_4$  CATALYZED BY MANGANESE meso-TETRAKIS(p-SULFONATOPHENYL)PORPHIN.** The oxidations of olefins with molecular oxygen and a reducing agent couple catalyzed by metal meso-tetrakis(p-sulfonatophenyl)porphyrins  $[\text{Me}(\text{TPPS})]$  in methanol solvent was studied and compared with that by metal meso-tetraphenylporphyrin  $[\text{Me}(\text{TPP})]$ . In the oxidation of cyclohexene by  $\text{Me}(\text{TPPS})$ ,  $\text{Mn}(\text{TPPS})$  coupled with  $\text{NaBH}_4$  was the most effective for producing cyclohexanol as a main product, and its activity was higher than that of  $\text{Mn}(\text{TPP})\text{Cl}$ . On comparing its activity with that of the



Mn(TPPS)/iodosobenzene system capable of producing a high-valent metal oxo-type active species, it was deduced that the Mn(TPPS)/O<sub>2</sub>/NaBH<sub>4</sub> system catalyzed the olefin oxidation by forming a non-metal oxo-type active species. (Author abstract) 12 refs.

Shimizu, Masao (Tsukuba Research Cent, Yatabe, Jpn); Orita, Hideo; Hayakawa, Takashi; Takehira, Katsuomi. *J Mol Catal* v 45 n 1 Apr 18 1988 p 85-90.

**073353 REACTIVITY OF UNSATURATED COMPOUNDS IN REACTION WITH PEROXY RADICALS.** This article is devoted to an analysis of the reactivity of unsaturated compounds in reaction with peroxy radicals, and the relation between reactivity and the rate and selectivity of epoxidation. In the reaction of hydrogen atom detachment from olefins and addition by a double bond, the peroxy radical exhibits electrophilic properties, and the molecule nucleophilic properties. The reaction passes through a polar transition state. The introduction of a double bond into a cycloalkane and n-alkane molecule leads to an increase in the rate constant of detachment of the hydrogen atom by the peroxy radical by a factor of 10<sup>3</sup>, and of the two double bonds by a factor of 10<sup>5</sup>. For olefins with a rigid skeleton, the α-C-H bonds are completely passive. 45 refs.

Kucher, R.V. (Ukrainian Acad of Sciences, USSR); Timokhin, V.I. *Pet Chem USSR* v 26 n 4 1986 p 205-214.

**073354 D<sup>0</sup> METAL PEROXIDES AS HOMOLYTIC AND HETEROLYTIC OXIDATIVE REAGENTS. MECHANISM OF THE HALCON EPOXIDATION PROCESS.** The role of d<sup>0</sup> metal peroxides as intermediates in catalytic oxidations involving H<sub>2</sub>O<sub>2</sub> and ROOH as the oxygen source is studied through the stoichiometric oxidizing properties of the isolated d<sup>0</sup> metal peroxidic complexes. Whereas heterolytic epoxidation of olefins requires the coordination of olefins as a prerequisite for a cyclic or a pseudocyclic peroxymetalation mechanism, homolytic oxidation of hydrocarbons involves a bimolecular mechanism with radical intermediates, and is less selective. A complete elucidation of the mechanism of the Halcon epoxidation process has been made possible by studying the reactivity of the complexes VO(OPhSal)-(OOtBu) towards olefins. (Author abstract) 17 refs.

Mimoun, Hubert (Inst Francais du Petrole, Rueil-Malmaison, Fr). *Catal Today* v 1 n 3 Jun 1987, New Dev in Sel Oxid, Proc of the Eur Workshop Meet, Louvain-la-Neuve, Fr, Mar 17-18 1986 p 281-295.

**073355 NOVEL WACKER ROUTE BASED ON RUTHENIUM(III) ION FOR OLEFIN OXIDATION TO KETONES.** The oxidation of 1-hexene to the end ketone 2-hexanone by molecular oxygen is catalyzed by Ru(III) ion, [RuCl<sub>2</sub>(H<sub>2</sub>O)<sub>4</sub>]<sup>+</sup> at 35°C (μ = 0.1 M) in 1:1 (v/v) water-dioxane solution at pH 2.00. The reaction shows a first-order dependence in catalyst and substrate concentrations and a one-half-order dependence with respect to molecular oxygen concentration. A mechanism involving a combination of a peroxometalacycle and the Wacker oxidation route to ketone formation is proposed. Finally, on the basis of kinetics and the mechanism proposed, a rate law for the oxidation reaction was derived and the corresponding rate constants evaluated. (Edited author abstract) 31 refs.

Taqi Khan, M.M. (Central Salt & Marine Chemicals Research Inst, Bhavnagar, India); Prakash Rao, A. *J Mol Catal* v 44 n 1 Feb 15 1988 p 95-105.

**Polymerization** See Also CATALYSTS—Materials; HYDROCARBONS—Rheology; POLYMERIZATION—Addition Reactions.

**073356 CYCLOALKENES AND BICYCLOALKENES.** The paper considers the various types of catalyst that can bring about ring-opening polymerization of cycloalkenes, and some thermodynamic aspects of the reaction including ring-chain equilibria. A brief account is given of the reactions of acetylenes, monocyclic monenes, and monocyclic dienes listed according to ring size, followed by bicyclic alkenes. Finally, the paper deals with copolymer formation and industrial applications. 211 refs.

Ivin, K.J. (Queen's Univ of Belfast, North Irel). *Ring-Opening Polym* v 1. Publ by Elsevier Applied Science Publ, London, Engl and New York, NY, USA, 1984 p 121-183.

**073357 THEORETICAL INTERPRETATION OF REACTIVITY RATIO PRODUCTS IN COPOLYMERS FORMED FROM TWO FRACTIONS DIFFERING IN COMPOSITION.** Reactivity ratio products for ethylene-propylene copolymerization over catalysts with two sites differing in incorporation and/or reactivity ratio product have been theoretically derived. It is shown that combination of the polymer fractions resulting from two sites can lead to large dyadic reactivity ratio products as determined by nuclear magnetic resonance. The dyadic reactivity ratio product is calculated at several different monomer ratios in the reactor, and compared to the reactivity ratio product obtained from a least-squares fit of the copolymerization equation. When the polymers are compositionally heterogeneous, the reactivity ratios derived from kinetic measurements are not meaningful. (Author abstract) 10 refs.

Floyd, S. (Exxon Chemical Co, Linden, NJ, USA). *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2559-2574.

**073358 THERMODYNAMICS OF THE CATALYTIC POLYMERIZATION OF ALKENES IN THE GAS PHASE.** The polymerization of alkenes is catalyzed by zeolite catalysts in the temperature range 450-800 K. As expected from thermodynamics the degree of polymerization is higher at lower temperatures and higher pressures. Equilibrium distributions of alkene isomer groups in the ideal gas phase have been calculated over a range of temperatures and pressures. The use of isomer groups greatly reduces the number of species that have to be considered in an equilibrium calculation and provides a means for extrapolating to higher carbon numbers. Since ZSM-5 is selective, equilibrium distributions have also been calculated for three restricted isomer groups from which certain bulky isomers have been excluded. Comparison of theory and experiment provides a means for learning about the nature of isomers excluded by the catalyst. (Author abstract) 25 refs.

Alberty, Robert A. (MIT, Cambridge, MA, USA). *Chem Eng Sci* v 42 n 10 1987 p 2325-2330.

**073359 Ring-Opening Polymerization of Cyclo-Olefin. II. The Activator in the Catalytic System.** Effects of activators in the catalytic system used for ring-opening polymerization of cyclopentene were investigated. The activators reported in the literature are classified. (Edited author abstract) 15 refs.

Kriza, Angela; Negoiu, Maria. *Bul Inst Politeh Bucuresti Ser Chim* v 48 1986 p 93-101.

**073360 RING-OPENING POLYMERIZATION OF CYCLO-OLEFINS - III. SYNTHESIS OF NEOPEN-TYL LITHIUM.** The mechanism on carbene chain process of ring-opening polymerization of cycloolefins can be illustrated by cycloolefin's polymerization with neopentyl-lithium as an organo-metallic compound. This article reports the method of synthesis of neopentyl lithium. (Edited author abstract) 8 refs.

Hu, Bingyong; Li, Tianyi; Opreacu, C.; Tomescu, Margareta. *Bul Inst Politeh Bucuresti Ser Chim* n 49 1987 p 97-100.

**073361 TRANSIENT RESPONSE OF CONTINUOUS-FLOW STIRRED-TANK POLYMERIZATION REACTORS.** The transient behavior of polymer properties following a step change in feed conditions during copolymerization in a continuous-flow stirred-tank reactor has been investigated by both modeling and experiment. For kinetics appropriate to Ziegler catalyzed olefin polymerization, the dynamic response of polymer molecular weight and composition is predicted to be relatively slow; four to six reactor turnovers could be required to reach steady state. In addition, response time depends on the direction and magnitude of change and is generally shorter when a property value is decreased. These model

predictions were confirmed by measurement of the transient response of copolymer composition and molecular weight for ethylene-propylene-ethylidene norbornene terpolymerization. The model equations also were used to simulate reactor startups, and it was found that steady state following a startup can be reached in about three reactor turnovers. The initial absence of polymer in the reactor causes the dynamic response to be faster for a startup than for reactor control. (Author abstract) 7 refs.

Cozewith, Charles (Exxon Chemical Co, Linden, NJ, USA). *AIChE J* v 34 n 2 Feb 1988 p 272-282.

**073362 POLYMERIZATION OF ISOPRENE, INITIATED WITH HYDROGEN PEROXIDE.** Polymerization of isoprene, initiated with hydrogen peroxide, was investigated in alcohol solutions. The yield of oligomers, molecular mass, and their functionality with respect to hydroxyl groups were determined by chemical reaction of the alcohol with initiator and its effect on the phase state of the polymerization systems. (Author abstract) 18 refs.

Grischenko, V.K.; Pakirbaeva, V.; Tkach, V.P.; Boiko, V.P.; Svistova, E.I.; Laevskaya, L.I. *Sov Prog Chem* v 53 n 7 1987 p 106-109.

**073363 FORMATION AND GROWTH OF POLY-PROPYLENE AND POLYETHYLENE PARTICLES DURING THE POLYMERIZATION OF OLEFINS ON DEPOSITED CATALYSTS.** The laws governing the formation and growth of polymeric particles obtained in the polymerization of propylene and ethylene on TiCl<sub>3</sub> deposited on the surface of microspherical mesoporous copolymers of styrene and divinylbenzene have been investigated in the present work. It has been found that, during polymerization, the catalyst undergoes replication leading to the formation of polymers in the form of coarse granules 1.5-4.5 mm in diameter and spherical in shape, whose structures are similar to that of the carrier particles. It is shown that the carrier's pore size and the polymerization rate have the decisive effect on the regime under which the deposited catalyst operates. (Edited author abstract) 21 refs.

Mkrtychyan, S.A. (USSR Acad of Sciences, USSR); Uvarov, B.A.; Tsvetkova, V.I.; Tovmasyan, Yu.M.; Chistyakov, S.O.; Rchinskii, G.F.; D'yachkovskii, F.S. *Polym Sci USSR* v 28 n 10 1986 p 2343-2350.

**073364 HIGH ACTIVITY MIXED METAL ALKYL COCATALYSTS FOR α-OLEFIN POLYMERIZATION.** High activity α-olefin polymerization catalysts are generally obtained by mixing MgCl<sub>2</sub>-supported TiCl<sub>4</sub> (MgCl<sub>2</sub>/TiCl<sub>4</sub>) with aluminum trialkyl cocatalyst. Surprisingly, AlEt<sub>2</sub>Cl, which is the preferred cocatalyst in polymerization employing nonsupported Ti compounds, is a poor cocatalyst when used with MgCl<sub>2</sub>/TiCl<sub>4</sub>. It was found that in propylene and 1-butene polymerizations, using different MgCl<sub>2</sub>/TiCl<sub>2</sub>/TiCl<sub>4</sub> catalysts, the cocatalyst activity of AlEt<sub>2</sub>Cl can be greatly improved by the addition of a magnesium or lithium alkyl. The mixed metal alkyl obtained from AlEt<sub>2</sub>Cl and MgBu<sub>2</sub> is a particularly effective cocatalyst always yielding more polymer, of about the same stereospecificity, than the conventional aluminum trialkyls. The exact nature of the mixed metal alkyl cocatalysts is not known, but the available evidence argues against in situ aluminum trialkyl formation resulting from the alkylation of AlEt<sub>2</sub>Cl by the second metal alkyl. (Author abstract) 7 refs.

Bacska, R. (Chevron Research Co, Richmond, CA, USA). *J Appl Polym Sci* v 35 n 2 Feb 5 1988 p 321-326.

**073365 KINETIC STUDY OF THE PHOTOSENSITIZED CYCLOPOLYMERIZATION OF N,N'-METHYLENEBISACRYLAMIDE.** This work on the photopolymerization of this monomer using uranyl ion as photosensitizer was undertaken with a view to finding out whether cyclization of the radical occurs under these conditions or not, and also to establish the mechanism. The evidence for cyclization of the radical prior to propagation was obtained from the IR spectrum of the



polymer. If cyclization had not occurred, the polymer should have a double bond, yet no peak corresponding to a double bond was observed in the spectrum. The absence of double bonds could also be due to the formation of crosslinked polymers. However, the polymer obtained was soluble in pyridine-water mixtures and, hence, cannot be crosslinked appreciably. 6 refs.

Suresh Babu, B. (Osmania Univ, Hyderabad, India); Nageswar Rao, K.; Sethuram, B.; Navaneeth Rao, T. *J Macromol Sci Chem* v A25 n 1 1988 p 109-113.

**073366 CHEMISTRY OF OLEFIN OLIGOMERIZATION OVER ZSM-5 CATALYST.** Light olefins ( $C_3$ - $C_6$ ) can be converted to a mixture of higher molecular weight olefins via a sequence of acid-catalyzed-shape-selective polymerization and isomerization reactions over the ZSM-5 zeolite catalyst. The composition and molecular weight of the product are very dependent on reaction temperature and pressure through both thermodynamic and kinetic constraints. Distillate-range olefins having an almost petrochemical-type structure with high-quality fuel properties are produced at relatively high pressure (30-100-bar) and lower temperature (200-300°C) conditions. At lower pressure and higher temperature, lower molecular weight products are formed, including aromatics and saturates from olefin condensation and hydrogen-transfer reactions. (Author abstract) 15 refs.

Quann, Richard J. (Mobil Research & Development Corp, Paulsboro, NJ, USA); Green, Larry A.; Tabak, Samuel A.; Krambeck, Frederick J. *Ind Eng Chem Res* v 27 n 4 Apr 1988 p 565-570.

**073367 METALLOCENE-METHALUMINOXANE CATALYST FOR OLEFIN POLYMERIZATION. II. BIS- $\eta^5$ -(NEOMETHYL CYClopentadienyl) ZIRCONIUM DICHLORIDE.** Bis(neomethyl cyclopentadienyl)zirconium dichloride/methyl aluminumoxane ( $\eta^5\text{-C}_5\text{Me}_5\text{ZrCl}_2/\text{MAO}$ ) catalyze investigation for ethylene polymerization. About 51% of the Zr forms active sites more or less instantaneously according to quenching with tritiated methanol. There is an initial drop of rate of polymerization,  $R_p$ , of about 30% which remains constant thereafter. The  $\text{TiCl}_3/\text{MgCl}_2$  and  $(\text{NMCp})_2\text{MAO}$  catalysts have nearly the same activation energy for propagation (ca. 7 kcal/mol $^{-1}$ ). The higher activity of the latter is due to its larger preexponential factor in  $k_p$ . (Edited author abstract) 15 refs.

Chien, James C. W. (Univ of Massachusetts, Amherst, MA, USA); Razavi, Abbas. *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2369-2380.

**073368 MASS TRANSFER PROCESSES DURING POLYMERIZATION OF OLEFINS ON HIGH EFFICIENCY SOLID CATALYSTS.** The distribution of monomer concentration along the radius of a growing polymer particle is analyzed for various polymerization times, and different values of the coefficients of diffusion and dimensions of the micro- and macroparticles of the catalyst, in the case of the polymerization of ethylene on highly active catalysts. A model for the growth of the polymer particle based on the results of electron microscopy is selected. It is shown that the diffusion of the monomer affects the rate of the process only during the initial stage of polymerization; with increase in yield the effect of diffusion is abruptly decreased. (Edited author abstract) 12 refs.

Skomorokhov, V.B. (USSR Acad of Sciences, USSR); Zakharov, V.A.; Bukatov, G.D.; Kirillov, V.A.; Kryukova, G.N. *Polym Sci USSR* v 29 n 4 1987 p 979-986.

**Processing.** See Also BUTANE—Alkylation; CATALYSIS: CATALYSTS—Materials; CATALYSTS—Rhodium Compounds; HYDROCARBONS—Processing; MOLYBDENUM COMPOUNDS—Encapsulation.

**073369 INDUSTRIAL HYDROFORMYLATION OF OLEFINS WITH RHODIUM-BASED SUPPORTED LIQUID PHASE CATALYST (SLPC) - PART V. THE FORMATION OF 2-ETHYL-2-HEXENE**

**NAL AND PROPANE: EXTRINSIC CATALYST POISONING.** Hydridocarbonyltris(triphenylphosphine)-rhodium(I) dissolved in liquid triphenylphosphine and capillary condensed into the pores of a porous support is studied as a possible heterogeneous catalyst for the industrial hydroformylation of olefins. The extent of the side reactions, hydrogenation to propane and aldolization to 2-ethyl-2-hexenal, is studied. The hydrogenation does not occur in the temperature range 90-120°C with hydrogen/carbon monoxide ratios equal to or below 3. The danger of aldolization and consequently leaching of the catalyst is negligible under practical conditions. This is certainly the case if the degree of liquid loading of the catalyst is 0.20. (Edited author abstract) 13 refs.

Herman, J.M. (Delft Univ of Technology, Delft, Neth); van Krugten, P.J.; van den Berg, P.J.; Scholten, J.J.F. *Chem Eng J Biochem Eng J* v 35 n 1 May 1987 p 25-35.

**073370 DISPROPORTIONATION OF HEX-1-ENE ON AN ALUMINO-COBALT-MOLYBDENUM CATALYST.** The activity, selectivity and stability of aluminocobalt-molybdenum catalysts in the disproportionation of olefins were demonstrated to depend on olefin composition, the method of preparation and conditions of heat treatment. A catalyst containing molybdenum and cobalt oxides in a proportion of 15.7 and 4.5% respectively was shown to be for disproportionation of hex-1-ene. Replacement of cobalt oxide additive by nickel oxide in an aluminocobalt-molybdenum catalyst for olefin disproportionation is ineffective. Scanning electron spectroscopy established that a catalyst having a dense and ordered structure with pore size of 0.5-1.5  $\mu\text{m}$ , isomeric particle size of 0.3  $\mu\text{m}$  has the highest activity; these particles accumulate in lamellar units (1.5-4  $\mu\text{m}$ ). 15 refs.

Ignatov, V.M. (I.M. Gubkin Inst of Petrochemical & Gas Industry, Moscow, USSR); Belov, P.S.; Usacheva, G.A.; Bochkov, R.A. *Pet Chem USSR* v 26 n 1 1986 p 28-34.

**073371 ELECTROCHEMICAL BROMINATION OF c-HEXENE ON A Pt ELECTRODE IN NITROMETHANE SOLUTION.** In this process a complex intermediate forms between the olefin and  $\text{Br}_2$  evolved and it transforms to dibromo-c-hexane. At higher potential values the electrochemical oxidation of this complex results bromo-c-hexane, the formation of which is hindered by oxide layer on the electrode surface. On the basis of the experimental results it can be concluded that the electrochemical oxidation of the complex intermediate leads partly to a new product as  $\text{BrCHOH}$ . At higher water concentration this process is hindered assumingly by the formation of an oxide layer. (Edited author abstract) 20 refs.

Visy, Cs. (Univ of Szeged, Szeged, Hung); Novak, M. *Electrochim Acta* v 32 n 12 Dec 1987 p 1757-1759.

**073372 STUDIES OF THE MECHANISM OF THE OLEFIN METATHESIS REACTION AND THE PROCESS OF ACTIVE SITE FORMATION ON PHOTOREduced MOLYBDENUM-SILICATE CATALYSTS. 1. MECHANISM OF FORMATION OF MOLYBDENUM-CARBENE INTERMEDIATES.** The products of the initial stages of the reaction of ethylene and propylene with  $\text{Mo}^{4+}$  ions in photoreduced molybdenum-silicate olefin metathesis catalysts have been studied by mass spectroscopy. The reaction of  $\text{C}_2\text{H}_4$  with  $\text{Mo}^{4+}$  has been found to yield propylene, whereas interaction of  $\text{C}_3\text{H}_6$  with  $\text{Mo}^{4+}$  gives a superequilibrium concentration of butenes and a small amount of pentenes. A significant kinetic isotope effect for the metathesis reaction was observed upon substitution of  $\text{C}_3\text{H}_6$  by  $\text{C}_3\text{D}_6$ . The results can be interpreted in terms of a stepwise mechanism involving carbene intermediates, which are formed via isomerization of surface-bound  $\pi$ -complexes of olefins with  $\text{Mo}^{4+}$  ions as a result of intramolecular 1,2-H atom transfer. (Author abstract) 17 refs.

Elev, I.V. (Acad of Sciences of the USSR, USSR); Shelimov, B.N.; Kazanskii, V.B. *Kinet Catal* v 28 n 2 pt 2 Mar-Apr 1987 p 357-362.

**073373 STUDIES OF THE MECHANISM OF THE**

**OLEFIN METATHESIS REACTION AND THE PROCESS OF ACTIVE SITE FORMATION ON PHOTOREduced MOLYBDENUM-SILICATE CATALYSTS. 2. 'PRODUCTIVE' AND 'DEGENERATIVE' METATHESIS OF  $\text{C}_2\text{H}_4$ - $\text{C}_2\text{D}_4$  AND  $\text{C}_2\text{H}_4$ - $\text{C}_3\text{D}_6$  MIXTURES.** The specific catalytic activity of photoreduced  $\text{Mo}^{4+}/\text{SiO}_2$  samples has been compared for 'productive' and 'degenerate' metathesis reactions of  $\text{C}_3\text{H}_6$ - $\text{C}_3\text{D}_6$  and  $\text{C}_2\text{H}_4$ - $\text{C}_2\text{D}_4$  mixtures. It has been found that, under comparable conditions, the rate of 'degenerate' metathesis of ethylene is 4-5 times slower than the rate of 'productive' metathesis of propylene, although the rate of 'degenerate' metathesis of propylene is  $5.10^3$ - $10^4$  times greater than its rate of 'productive' metathesis. Based on these results, it is concluded that 'degenerate' metathesis of propylene occurs via the involvement of secondary (ethylidene) carbenes. (Author abstract) 8 refs.

Elev, I.V.; Shelimov, B.N.; Kazanskii, V.B. *Kinet Catal* v 28 n 2 pt 2 Mar-Apr 1987 p 363-365.

**073374 IRON-PHTHALOCYANINE CATALYZED EPOXIDATION OF OLEFINS BY  $\text{KHSO}_5$ .** Because of the high efficiency of potassium hydrogen persulfate,  $\text{KHSO}_5$ , in catalytic epoxidation of olefins or hydroxylation of alkanes, we decided to investigate the epoxidation by  $\text{KHSO}_5$  and metallophthalocyanines. We report the epoxidation of cyclohexene, styrene and tetramethylethylene. It is shown that phthalocyaninato-iron complexes are able to catalyze the oxygen transfer from  $\text{KHSO}_5$  to an olefin, but rather low catalytic activities are obtained due to a fast oxidative intramolecular destruction of the catalyst. One way to improve its activity is to create a cage around the high-valent metal-oxo species by increasing the steric constraints along the axis perpendicular to the macrocycle plane, as observed for metalloporphyrin-catalyzed oxygenations. 21 refs.

Belal, Rachid (CNRS, Toulouse, Fr); Meunier, Bernard. *J Mol Catal* v 44 n 2 Feb 29 1988 p 187-190.

**073375 STUDIES OF THE EFFECT OF BRONSTED ACIDS AND THE FORM OF THE SECOND TRANSITION METAL ON A ZIEGLER-TYPE CATALYTIC SYSTEM FOR OLEFIN DIMERIZATION.** Studies have been carried out concerning the effect of Bronsted acids on the catalytic activity of  $\text{Ni}(\text{C}_5\text{H}_7\text{O}_2)_2(\text{C}_2\text{H}_5)_2\text{AlCl}(\text{C}_6\text{H}_5)_3\text{P}$  with respect to dimerization of lower olefins. Strong acids have been found to improve, and weak acids to diminish, the catalytic activity of this system. The direction of insertion of propylene into the Ni-H-bond can also vary, depending on the acidity. The use of transition metal additives can significantly enhance the catalytic activity of the system, by acting as an oxidant in the activation process. (Author abstract) 7 refs.

Dobrev, D. (A.S. Zlatarov Higher Chemical Technological Inst, Burgas, Bulg); Kurtev, K. *Kinet Catal* v 28 n 4 pt 2 Jul-Aug 1987 p 872-875.

**073376 MECHANISM OF THE HYDROCARBOXYLATION AND HYDROCARBOMETHOXYLATION OF OLEFINS AND DIOLEFINS IN THE PRESENCE OF PYRIDINE.** The adequacy of the reaction mechanisms for the case of the use of cobalt carbonyls as catalysts is discussed. It is shown that the carbocation mechanism does not correspond to the reaction kinetics and the composition of the products. The mechanism according to which  $\text{HCO}(\text{CO})_4$  is bonded to the olefin according to a molecular pathway or with the participation of ions, but synchronously, while pyridine accelerates hydrocarboxylation and hydrocarbomethoxylation through the formation of an acylpyridinium salt, is free of these short-comings. Such a mechanism explains the specifics of the action of pyridine in comparison with other Lewis bases. (Author abstract) 42 refs.

Imyanitov, N.S. (Leningrad Petrochemistry Scientific-Industrial Assoc, Leningrad, USSR). *Kinet Catal* v 28 n 4 pt 1 Jul-Aug 1987 p 722-727.



**073377 PHASE AND VOLUME-DEPENDENT RELATIONSHIPS IN HYDROGEN-1 HEXENE, HYDROGEN-1-OCTENE, AND HYDROGEN-C<sub>15</sub>-C<sub>18</sub> OLEFIN SYSTEMS.** In the study and development of hydroformylation and hydrocarboxylation processes of olefins, data are required on the liquid-gas phase equilibria for several systems, including the hydrogen-olefin system. The authors determined the composition of the equilibrium gas and liquid phases and the volume-dependent behavior of the latter in the hydrogen-1-hexene and hydrogen-1-octene systems in the temperature range 313-453°K and at pressure of up to 30 MPa, and in the hydrogen-C<sub>15</sub>-C<sub>18</sub> olefin system in the temperature range 313-553°K and a pressure also of 30 MPa. The volatility of hydrogen in the gas phase was calculated according to the additivity rule, from the data on the volatility of pure hydrogen and the composition of the gas phase. The results of the thermodynamic analysis showed that one of the authors' equations satisfactorily describes the experimental data of the systems studied at temperatures up to approximately 393°K and at pressures up to 20 MPa only. 10 refs.

Vasil'eva, I.I.; Naumova, A.A.; Polyakov, A.A.; Tyvina, T.N.; Fokina, V.V. *J Appl Chem USSR* v 59 n 6 1 Jun 1986 p 1180-1183.

**073378 HYDROSILYLATION CHEMISTRY AND CATALYSIS WITH cis-PtCl<sub>2</sub>(PhCH=CH<sub>2</sub>)<sub>2</sub>.** The precursor cis-PtCl<sub>2</sub>(PhCH=CH<sub>2</sub>)<sub>2</sub> is shown to catalyze (i) the hydrosilylation of various terminal olefins and acetylenes, (ii) the reduction of carbonyl functions with silanes in the presence of pyridine or aniline as cocatalyst, and (iii) the formation of R<sub>3</sub>SiOR<sup>2</sup> from R<sub>3</sub>SiH and R<sup>2</sup>OH. The hydrosilylation of styrene is shown to proceed via reduction of PtCl<sub>2</sub>(PhCH=CH<sub>2</sub>)<sub>2</sub> to Pt(PhCH=CH<sub>2</sub>)<sub>3</sub> with concomitant formation of 2 equiv of R<sub>3</sub>SiCl and 1 equiv of PhCH<sub>2</sub>CH<sub>3</sub>. Extensive <sup>195</sup>Pt measurements together with <sup>13</sup>C studies on complexed styrene selectively enriched at the β-carbon support the formation of the Pt(0) complex. The precursor cis-PtCl<sub>2</sub>(PhCH=CH<sub>2</sub>)<sub>2</sub> is suggested to arise from the trans isomer which is identified by <sup>195</sup>Pt NMR and its reaction chemistry. (Author abstract) 19 refs.

Caseri, Walter (ETH, Zurich, Switzerland); Pregosin, Paul S. *Organometallics* v 7 n 6 Jun 1988 p 1373-1380.

**073379 EPOXIDATION OF OLEFINS USING cis-DIOXOMOLYBDENUM COMPLEXES AS CATALYSTS.** Cis-dioxomolybdenum complexes, having tetradentate and tridentate ligands, as catalyst with t-butylhydroperoxide gave epoxides from olefins in good yield. The catalysts, except MoO<sub>2</sub>(apac), have been found to withstand the oxidative conditions. The steric environment due to the ligand around the metal center plays a significant role in the epoxidation of substituted olefins, viz., isoprene and 1,2-dimethyl-1,4-cyclohexadiene and cis- and trans-2-hexene. The steric effect due to nonporphyrin ligands is much less than that observed with catalysts having porphyrin ligands. (Author abstract) 28 refs.

Agarwal, D.D. (Jiwaji Univ, Gwalior, India). *J Mol Catal* v 44 n 1 Feb 15 1988, Int Workshop on Homogen Catal: Act of Mol Oxygen and Catal Oxid by Dioxigen Compd, Bhavnagar, India, Oct 3-6 1986 p 65-72.

**Production** See Also CATALYSIS; CHEMICAL EQUIPMENT—Heat Transfer; PARAFFINS—Pyrolysis.

**073380 PROCESO OLIMP TECNOLOGIA IMP PARA PRODUCCION DE OLEFINAS. [OLIMP Process IMP Technology for Olefin Production].** Olefin production technology (OLIMP) has been developed that involves basic cracking furnace design and separation equipment and scheme for the whole process, which can be designed for both gaseous (ethane and propane) and liquid (naphtha or gas-oils) feedstocks. The development technology requirements for this process are described, mainly for the reaction system, the phase equilibria involved, and basic equipment sizing. The tools that have been used for basic engineering development and applied and adapted successfully in the OLIMP process are

described. Technological developments specifically for this process, concerning mainly modeling for the mass and energy balance and geometry and sizing analysis for the furnaces, are discussed. Finally results are presented which compare predicted behavior of the furnaces with those for other designs and plants. (Edited author abstract) In Spanish.

Aguilar Rodriguez, Enrique (Inst Mexicano del Petroleo, Mexico City, Mex); Salazar Sotelo, Daniel; Sanchezllanes Machuca, Ma. Teresa; Perez Garcia, Ana Lilia; Arzate Barbosa, Elva. *Rev Inst Mex Pet* v 19 n 1 Jan 1987 p 67-76.

**Pyrolysis** See FLUOROHYDROCARBONS—Pyrolysis.

## Recovery

**073381 ADSORPTIVE RECOVERY OF OLEFINS FROM MIXTURES WITH PARAFFINS.** The largest source of linear olefins is the process of dehydrogenation of high-molecular-weight paraffins. However, the dehydrogenated products obtained in a single pass will contain no more than 8-12% n-olefins by weight. The authors are reporting on a study of the recovery of olefins from mixtures with paraffins by adsorption on synthetic zeolites; this work has been aimed at obtaining experimental data as a basis for developing a mathematical model of the process of recovery of higher n-olefins from the products of n-paraffin dehydrogenation, by means of pseudocontinuous adsorption. 6 refs.

Zhuravlev, A.M. (Scientific-Industrial Assoc 'Lenneftkhim', Krasnodar, USSR); Alekseeva, R.V.; Gerasimenko, E.G.; Alekseev, Yu.A. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 189-191.

**Solubility** See Also CHEMICAL OPERATIONS—Solvent Extraction.

**073382 SOLUBILITIES OF PROPENE, BUTANE, ISOBUTANE AND ISOBUTENE GASES IN n-OC-TANE, CHLOROBENZENE AND n-BUTANOL SOLVENTS.** Solubilities are reported for atmospheric pressure and temperatures of 298.15, 323.15 and 343.15 K for the gases propene, butane, isobutane and isobutene in the solvent n-octane, chlorobenzene and n-butanol. The solvents were chosen to investigate the effect of the nature of the solvent on gas solubility. The solvents range from the non-polar (octane) to slightly polar (chlorobenzene) and to polar and associating (butanol). The order of gas solubilities in the slightly polar chlorobenzene is found to be closely related to the normal boiling points of the dissolving gases. A method for relating solubilities at various temperatures in similar polar and associating solvents is examined. (Author abstract) 23 refs.

Hayduk, W. (Univ of Ottawa, Ottawa, Ont, Can); Asatani, H.; Miyano, Y. *Can J Chem Eng* v 66 n 3 Jun 1988 p 466-473.

## Synthesis

**073383 SYNTHESIS OF OLEFINS FROM METHANOL ON SiO<sub>2</sub> SUPPORTED Ag<sub>4</sub> (SiW<sub>12</sub>O<sub>40</sub>) CATALYSTS.** The conversion of methanol to hydrocarbons was investigated to Aerosil supported Ag<sub>4</sub> (SiW<sub>12</sub>O<sub>40</sub>) catalysts. It was shown that the support has a stabilizing effect on catalytic activity. Three patterns of activity/running-time behaviour of the catalysts were found according to the surface concentration of the active component. Results indicated that the deposition of coke causing catalytic deactivation takes place predominantly at the exterior surface of the catalyst, whereas active sites within the pore system remain untouched by deactivation. Best results with respect to the production of olefins and other hydrocarbons were obtained in the medium range of surface concentrations of the active component. (Edited author abstract) 12 refs.

Ehwald, H. (Acad Sciences of the GDR, Berlin-Adler-shof, East Ger); Fiebig, W.; Jerschke, H.-G.; Lischke, G.; Parltz, B.; Schreier, E.; Oehlmann, G. *Appl Catal* v 34 n 1-2 Oct 15 1987 p 13-22.

**073384 SYNTHESIS OF OLEFINS FROM METHANOL ON ALUMINA-SUPPORTED H<sub>4</sub>(SiW<sub>12</sub>O<sub>40</sub>) CATALYSTS.** The conversion of methanol to hydrocarbons was investigated on alumina-supported H<sub>4</sub>(SiW<sub>12</sub>O<sub>40</sub>) catalysts. Depending on the concentration of the heteropoly compound, two different types of [SiW<sub>12</sub>O<sub>40</sub>]<sup>4-</sup> anions exist on the surface of the catalysts. Increasing the H<sub>4</sub>(SiW<sub>12</sub>O<sub>40</sub>) concentration from 5 to 40 wt% of W results mainly in an increase in the surface density of Bronsted centres, whereas the distribution of their acidic strength is only slightly shifted towards higher values. From the dependence of the yield of the hydrocarbon on the H<sub>4</sub>(SiW<sub>12</sub>O<sub>40</sub>) content of catalysts, it is concluded that under the conditions applied hydrocarbon synthesis from methanol occurs only on adjacent acid groups, the density of which is evaluated to be approximately 1 μmol/m<sup>2</sup>. (Author abstract) 6 refs.

Ehwald, H. (Acad Sciences of the GDR, Berlin-Adler-shof, East Ger); Fiebig, W.; Jerschke, H.-G.; Lischke, G.; Parltz, B.; Reich, P.; Oehlmann, G. *Appl Catal* v 34 n 1-2 Oct 15 1987 p 23-38.

**073385 SYNTHESIS OF POLYALCOHOLS VIA ZIEGLER-NATTA POLYMERIZATION.** Functional polymers are normally difficult to prepare by Ziegler-Natta polymerization because of catalyst poisoning and other side reactions. This paper describes the synthesis of functional α-olefins via the intermediacy of novel borane monomers and polymers. Borane monomers, derived from monohydroboration of appropriate dienes with dialkylborane, have been found to be stable to titanium-based Ziegler-Natta catalysts. In turn, the borane polymers are easily converted to a variety of other functionalities, under mild reaction condition. This paper focuses on the preparation and molecular structure characterization of polyalcohols prepared according to this route. Moreover, some physical properties, such as high-temperature stability of these materials, are mentioned in this content. (Author abstract) 13 refs.

Chung, T.C. (Exxon Research & Engineering Co, Annandale, NJ, USA). *Macromolecules* v 21 n 4 Apr 1988 p 865-869.

**OLIGOMERS** See Also ELECTROLYTES—Materials; ORGANIC COMPOUNDS—Oxidation; POLYETHYLENE TEREPHTHALATE; POLYETHYLENES; POLYMERS—Stabilizers; POLYSTYRENES.

## Applications

**073386 CHARACTERISTICS OF FORMATION OF NETWORK STRUCTURE IN EPOXY-OLIGOESTER MIXTURES.** By using mixtures of oligomers as binders in production of various materials it is possible to bind the range of their properties considerably in comparison of products made from pure oligomers. Binders of this kind include, for example, epoxy-oligoester mixtures (EPOEM). Knowledge of the temperature-time sequence of these reactions is needed for active regulation of the hardening process and production of materials having specified properties. The EPOEM studied by us differ from known compositions not only in chemical structure and component ratio but also by the presence of phosphazenes. We used IR spectroscopy and DTA for investigating the kinetics of formation of network polymers based on the EPOEM studied. Study of the character of hardening of EPOEM containing OPC and PNA showed that the activating energy of hardening at 50-100° in both cases is 67 kJ/mole, which differs little from the value for EPOEM. This indicates once again that the initial stage of formation of a network polymer is basically the same for all the EPOEM studied. Introduction of initiators of radical processes into EPOEM has virtually no influence on the general course of hardening. 14 refs.

Vashevko, D.S. (Lensovet Technological Inst, Leningrad, USSR); Volkov, T.I.; Trizno, M.S. *J Appl Chem USSR* 60 n 2 pt 2 Feb 1987 p 358-361.



**Chromatographic Analysis** See CHROMATOGRAPHIC ANALYSIS—Applications; MELAMINE FORMALDEHYDE RESINS—Chromatographic Analysis.

## Curing

**073387 RHEOKINETICS OF CURING OF AN EPOXYORGANOSILICON OLIGOMER BY AGENTS OF VARIOUS FUNCTIONALITY.** The process of curing of an epoxyorganosilicon oligomer by metal-organic curing agents of various functionality - tetrabutyltitanium, and polybutoxytitanium phosphoroxane - was studied by several rheological methods. Phenomenological models of the curing rheokinetics were constructed and compared with known equations for curing agents of different type. The results conclusively indicate that the functionality of the curing agent, at identical chemical nature of the participating reactive groups, has a profound influence on the type of kinetic equation describing the curing process. An increase in the functionality of the curing agent and thus of the reaction system as a whole leads to the transformation of the most general equation for curing processes, with autoacceleration, into an equation reflecting the possibility of autoinhibition of the process in its course. (Edited author abstract) 17 refs.

Kulichikhin, S.G. (Research & Production Unit 'Plastmassy', USSR); Astakhov, P.A.; Chernov, Yu.P.; Kozhina, V.A.; Golubenkova, L.I.; Malkin, A.Ya. *Polym Sci USSR* v 28 n 10 1986 p 2350-2359.

**073388 CURING EPOXY-OLIGOMERS BY CYANURATE COMPLEXES OF IRON.** This work reports the investigation of  $\alpha$ -oxide rings (OR) of diglycidyl ester of diphenylolpropane (DEPD) with CC (Cyanurate Complexes). It is shown that the  $\alpha$ -epoxy rings of the epoxides react with CC in three stages: with the liberation of ammonia, and then at the O-M and C-O-C bonds, followed by the isomerization of cyanurate fragments into isocyanurates. Under conditions of an excess of the  $\alpha$ -oxide rings, the reaction of the epoxides with CC at temperatures above 100°C leads to the formation of oxazolidone fragments. 11 refs.

Zaplishnyi, V.N. (Acad of Sciences of the Armenian SSR, USSR); Khachatryan, M.A.; Kinoyan, F.S.; Balyan, A.A.; Gavalyan, V.B.; Nikogosyan, S.S.; Poghosyan, G.M. *J Appl Chem USSR* v 60 n 6 pt 2 Jun 1987 p 1303-1308.

**Decomposition** See SILICON COMPOUNDS—High Temperature Effects.

## Electric Conductivity

**073389 CHARGE-TRANSFER COMPLEXES OF A CONJUGATED OLIGOMER WITH IODINE: EVIDENCE FOR POLARON, BIPOLARON, AND IONIZED BIPOLARON FORMATION.** This paper describes the results of electron spin resonance experiments on the charge-transfer complexes that are formed when the conjugated oligomer poly(4,4'-dibromobiphenyl-co-1,4-diethynylbenzene)-dibromobiphenyl-co-1,4-diethynylbenzene is doped with iodine. The dependence of the spin susceptibility on the iodine content is interpreted in terms of the formation of polarons (radical cations with) bipolarons (cations  $S = 0$ ), and ionized bipolarons (radical trications  $S = \frac{1}{2}$ ). The dependences of the effective  $g$  value and the line-shape parameters on the iodine content are explained in terms of an equilibria scheme involving different stoichiometric forms of these two types of radical cations. A dependence of the line-shape parameters on the radical concentration is also identified and is explained in terms of intermolecular spin-spin interactions. (Author abstract) 11 refs.

Brown, I.M. (McDonnell Douglas Research Lab, St. Louis, MO, USA); Wilbur, J.M. *Macromolecules* v 21 n 6 Jun 1988 p 1859-1863.

## Electrodeposition

**073390 INVESTIGATION OF ELECTRODEPOSITION OF A MODIFIED ALKYD-EPOXY OLIGO-**

**MER.** The combined electrodeposition of an alkyd-epoxy oligomer and siloxane lacquer was investigated. It is shown that the colloid-chemical modification of the water soluble oligomer makes it possible to considerably improve the electrical insulation and anticorrosion properties of coatings. The parameters of the electrodeposition process were determined. (Edited author abstract) 10 refs.

Tertykh, L.I.; Deinega, Yu.F. *Sov Surf Eng Appl Electrochem* n 5 1987 p 60-65.

**Esterification** See POLYETHYLENE TEREPHTHALATE.

## Flammability

**073391 FLAMMABILITY OF OLIGOISOBUTENES WITH OXYGEN-CONTAINING END GROUPS.** The behaviour of oligoisobutenes under combustion conditions has not been studied before. Accordingly, the authors carried out a comparative study of the stages of ignition and steady combustion of OIB and polyisobutene (PIB). It is shown that there is an experimental linear relationship between the mass combustion rate of the oligomers and the oxygen content in the atmosphere and with the same oxidant content the rate of combustion of oligoisobutene is appreciably lower than that of polyisobutene. However, oligoisobutenes are less flammable than polyisobutene owing to incomplete combustion of gasification products and to dilution with carbon dioxide evolved from carboxyl groups. 7 refs.

Nasybullin, Sh.A.; Khakimullin, Yu.N.; Zaripov, I.N. *J Appl Chem USSR* v 60 n 1 pt 2 Jan 1987 p 228-230.

**Forming** See MONOMERS—Polymerization; POLYMERIZATION.

**Heat Treatment** See LUBRICANTS—Wear Resisting.

**Measurements** See POLYMERS—Measurements.

**Melting** See POLYMERS—Melting.

**Molecular Structure** See Also POLYMETHYL METHACRYLATE—Synthesis.

**073392 STATISTICAL CONFORMATIONS OF CYCLIC DIMETHYLSILOXANES.** Rotational-isomer-state models have been used to describe the statistical conformations of cyclic oligomers of dimethylsiloxane possessing 8-20 skeletal bonds. The results are compared with similar calculations made on linear-chain molecules of dimethylsiloxane. Cyclic dimethylsiloxanes,  $[(CH_3)_2SiO]_x$ , with  $x=4-10$ , appear to be relatively rigid, compared with their linear-chain counterparts, and their average shape is disc-like. For cyclic molecules possessing  $\geq 50$  skeletal bonds, the directional correlations between pairs of skeletal bonds approach those calculated for the corresponding open-chain molecules. (author abstract) 19 refs.

Mumby, S.J. (Univ of Aston, Birmingham, Engl); Beevers, M.S. *Polymer* v 29 n 1 Jan 1988 p 14-17.

**Molecular Weight** See CHROMATOGRAPHIC ANALYSIS—Calibration; POLYMERS—Molecular Structure; POLYMERS—Molecular Weight.

## Oxidation

**073393 STERIC EFFECTS ON THE CONTROLLED POTENTIAL ELECTRO-OXIDATION OF 3-METHYLTHIOPHENE AND THIOPHENE OLIGOMERS AND THE PROPERTIES OF THEIR POLYMER FILMS.** This investigation is concerned with the effect of thiophene monomer structures on the electrochemical behavior and physical characteristics of electropolymerized poly(thiophenes) and various poly(3-methylthiophenes). These variations in polymer structure were achieved by employing thiophene and 3-methylthiophene oligomers of different unit sizes and substitution patterns as the starting 'monomers'. The relative redox characteristics of the 'monomers' were deduced from the measured current maximum values of the electro-oxidation potentials. Electrochemical oxida-

tion of the monomer yields electrically conducting polymers that exhibit internal redox properties unique for each type of starting 'monomer.' Scanning electron micrographs of the oxidized films are shown. (Author abstract) 14 refs.

Laguren-Davidson, Laarni (Univ of Cincinnati, Cincinnati, OH, USA); Van Pham, Chiem; Zimmer, Hans; Mark, Harry B. Jr. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1406-1414.

## Permeability

**073394 DIFFUSION OF SOLVENT VAPORS IN POLYMER NETWORKS BASED ON EPOXY OLIGOMERS.** The penetrability of polymer coatings by different aggressive reagents is one of the more important characteristics determining their effectiveness for anticorrosion protection. Coatings based on epoxy and phenol-formaldehyde oligomers have found wide application for the protection of metals from corrosion because of their strong adhesion to different surfaces, good deformation strength properties, and chemical resistance to aggressive reagents. Despite the high practical value of the protective epoxy phenol-formaldehyde coatings, data are practically unavailable in the literature on the influence of crosslink density on the sorption and diffusion of aggressive reagents in polymer networks. The authors, therefore, carried out an investigation of the kinetics of sorption of vapors of low-molecular-weight liquids in crosslinked polymers with different crosslink densities. 13 refs.

Markevich, M.A. (Acad of Sciences of the USSR, Moscow, USSR); Sakhonenko, L.S. *Mech Compos Mater* v 23 n 1 Jan-Feb 1987 p 112-116.

## Physical Properties

**073395 OLIGOMERIC CARBONOTHIOIC DIHYDRAZIDES FROM DIALDEHYDES AND CARBONOTHIOIC DIHYDRAZIDE.** This report describes the acid-catalyzed preparation of oligomeric ( $n=8$  to 10) (diylidene)carbonothioic dihydrazides from equimolar quantities of selected dialdehydes and carbonothioic solvents. The elemental analyses agree with carboxy/hydrazide termination. This is consistent with termination by traces of carboxyaldehyde in the dialdehyde or with terminal oxidation during isolation of the product, or both. 8 refs.

Wiley, Richard H. *J Macromol Sci Chem* v A25 n 2 1988 p 231-233.

**073396 AB INITIO CONFORMATION AND IONIZATION POTENTIALS OF POLYSILANE OLIGOMERS.** Ab initio results indicate no significant difference in total energy between the anti and gauche conformers in tetrasilane and the anti-anti and gauche-gauche conformers in pentasilane when basis set and electron correlation improvements are made. Our calculated EPT vertical ionization energies are in good agreement with experimental photoelectron spectra assuming an approximately equal mix of anti and gauche rotamers. Furthermore, these results support the idea that the highest occupied MO energy level of the larger silane oligomers will decrease as the backbone is transformed from an all-anti conformation to one with a larger gauche population. 22 refs.

Mintmire, J.W. (US Naval Research Lab, Washington, DC, USA); Ortiz, J.V. *Macromolecules* v 21 n 4 Apr 1988 p 1189-1191.

**Polymerization** See Also CHEMICAL REACTIONS—Reaction Kinetics; POLYMERS—Calculations

**073397 DI-STYRENE-ETHERS, A NOVEL CLASS OF CATIONICALLY POLYMERIZABLE OLIGOMERS.** A novel class of cationically polymerizable oligomers is reported. The system is based on di-styrene-ethers, a series of which were synthesized and characterized. The synthesized compounds were thermally polymerized by a cationic mechanism. Bisphenol-A die-thoxy vinyl ether, which is known readily to undergo cationic polymerization was used as a reference com-



pound. By comparison it was shown that this new class of oligomer reacts much more rapidly in thermally initiated cationic polymerization. (Author abstract) 10 refs.

Ericsson, Jan (Royal Inst of Technology, Stockholm, Sweden); Hult, Anders. *Polym Bull (Berlin)* v 18 n 4 Oct 1987 p 295-302.

**073398 FEATURES OF POLYCONDENSATION OF TRICYCLODECENE TETRACARBOXYLIC DIANHYDRIDE WITH DIAMINODIPHENYL OXIDE IN PRESENCE OF POLY-4-VINYLPYRIDINE.** The features of polycondensation of tricyclodecene tetracarboxylic dianhydride with diaminodiphenyl oxide in the presence of poly-4-vinylpyridine have been studied. It has been established that the oligomer molecules of the polyamic acid formed in the course of polycondensation react with poly-4-vinylpyridine with formation of polycomplexes: only the highest molecular weight part of the polyamic acid enters into the complexation reaction. Composition of the polycomplex poly-4-vinylpyridine: polyamic acid = 3:1. IR and <sup>1</sup>H-NMR spectroscopy are used to study the structure of the polycomplex and demonstrate the possibility of rapid imidization of the carboxamide units in complex with poly-4-vinylpyridine at room temperature. (Author abstract) 12 refs.

Zhubanov, B.A. (Kazakh SSR Acad of Sciences, USSR); Solomin, V.A.; Lyapunov, V.V. *Polym Sci USSR* v 28 n 8 1986 p 1840-1846.

**073399 ELECTROCHEMICAL POLYMERIZATION OF AN UNSATURATED ISOCYANATE-CONTAINING OLIGOMER.** The authors investigate the electrochemical polymerization of an unsaturated isocyanate-containing oligomer in solvents with different donor capacity (dimethylacetamide and acetonitrile) as a function of the concentration of the starting product, temperature and density of current. It is shown that in dimethylacetamide the polymerization of such an oligomer is accompanied by simultaneous conversion of the free isocyanate groups and unsaturated bonds with formation of an insoluble network polymer. (Edited author abstract) 3 refs.

Lipatova, T.E. (Acad of Sciences of the Ukrainian SSR, USSR); Matyushova, V.G.; Narazhaiko, L.F. *Polym Sci USSR* v 28 n 8 1986 p 1867-1873.

**073400 CYCLIZATION AND OXIDATION OF ISOPRENE OLIGOMERS DURING POLYMERIZATION ON KAOLINITE.** The structure of isoprene oligomers prepared by cationic polymerization on kaoline acid centers was studied by PMR and IR spectroscopic methods. It was shown that during polymerization the oligomer undergoes cyclization, forming two- and three-cycle structures by an intramolecular chain transfer reaction. The oligoisoprene is easily oxidized, with additional cyclization taking place simultaneously with oxidation. Oxidation leads to the formation of a great variety of oxygen containing groups. A system of PMR signal assignment is cyclized and oxidized oligoisoprene was developed. A method for the calculation of the structure of cyclized low-molecular weight oligoisoprenes from PMR spectroscopic data is presented. (Author abstract). 16 Refs.

Cheshchevoi, V.N. (Central Paper Research Inst, USSR); Diner, V.A.; Polushkin, V.A. *Polym Sci USSR* v 29 n 4 1987 p 868-874.

**Processing** See Also CATALYSTS—Materials; POLYURETHANES—Synthesis.

**073401 SORPTION AND DIFFUSION IN POLYMER NETWORKS PREPARED FROM EPOXIDE OLIGOMERS.** Sorption and diffusion of chloroform vapor in crosslinked epoxide polymers used as protective layers was investigated. The free energy of mixing, diffusion coefficients, and coefficients of self-diffusion have been determined. Self-diffusion coefficient of chloroform in the network increases with the degree of swelling and, for networks in the elastic state, also with decreasing crosslink density. (Author abstract) 9 refs.

Markevich, M.A. (USSR Acad of Sciences, USSR); Sakhonenko, L.S. *Polym Sci USSR* v 28 n 10 1986 p 2392-2397.

**Production** See STYRENE—Structure.

**Reinforcing** See COMPOSITE MATERIALS—Fiber Reinforced.

## Research

**073402 OLIGOMER COMPATIBILITY BY CONTINUOUS THERMODYNAMICS.** In this paper the concept of continuous thermodynamics is applied to establish a simple calculation procedure for the number-average segment number. Instead of the well-known sums with respect to the species, integrals occur which, in the case of Schulz-Flory distributions, may be calculated analytically, leading to simple formulas for the cloud-point curve and the shadow curve. The method is applied to model calculations showing that the chosen Gibbs free energy function may account for the details of the liquid-liquid equilibrium of oligomer mixtures and to a real oligomer system taken from the literature. (Edited author abstract) 14 refs.

Raetzsch, Margit T. ('Carl Schorlemmer' Technical Univ, Merseburg, East Ger); Kehlen, Horst; Thieme, Detlef. *J Macromol Sci Chem* v A24 n 8 1987 p 991-1004.

**073403 FORMATION OF RADICALS IN THERMOCHEMICAL TRANSFORMATIONS OF EPOXY OLIGOMERS FILLED WITH CARBON FIBERS.** The surface groups of the ECF not only have an important effect on the character of the processes which take place in the interphase region but also actively participate in them. The mechanism of the chemical reactions has not been definitively elucidated. Industrial 4,4'-isopropylidenediphenol (ED-20) and cycloaliphatic (UP-612) epoxy oligomers were studied. It is shown that although acceleration of the decomposition of the oligomer was observed in the early stages of heating, further heat treatment results in its slowing is also confirmation of the participation of Pb or its oxide in the formation of the structural network of the epoxy composite. This type of thermal decomposition is characteristic of composites with a disperse filler in the case of the reaction of the components and inclusion of heteroatoms in the polymer chain. 13 refs.

Ermolenko, I.N. (Acad of Sciences of the BSSR, USSR); Ugolev, I.I.; Dubkova, V.I.; Savitskaya, E.I. *J Appl Chem USSR* v 60 n 4 pt 2 Apr 1987 p 858-861.

**073404 REACTIONS OF  $\alpha$ -OXIDES IN THE PRESENCE OF HEXAMETHYLENETETRAMINE AND GLYCERINE DIPHENYL ETHER.** Without a knowledge of the chemical processes taking place in systems containing  $\alpha$ -oxide compounds, HMTA, and alcohols it is difficult to suggest a structure for the hardened composition and to evaluate the actual activities in the condensation and hardening process. To provide objective information about the reaction scheme and the kinetics of reactions in which epoxide oligomers participate we studied a model reaction system. The model epoxide oligomer selected was phenyl glycidyl ether (PGE) and the  $\alpha,\gamma$ -diphenyl ether of glycerine (GDPE). Results of the isolation of reaction products and the establishment of the reaction scheme provided evidence of the predominance of oligoalkylation in the system examined. Semilogarithmic anamorphoses of the kinetic curves of  $\alpha$ -oxide consumption, obtained during determination of the concentration of PGE are presented. 9 refs.

Nikolaev, P.V. (Ivanovo Chemical Technology Inst, USSR); Sveshnikova, N.F.; Ignatov, V.A. *J Appl Chem USSR* v 60 n 6 pt 1 Jun 1987 p 1243-1247.

**073405 MOLECULAR-MASS DISTRIBUTION OF LINEAR FORMALDEHYDE OLIGOMERS IN THE SYSTEM FORMALDEHYDE-WATER-ORGANIC SOLVENT.** The <sup>13</sup>C NMR method has been used to investigate the MD of linear formaldehyde oligomers in mixed solvents containing in addition to water an organic

component - DMSO, sulfolane or dimethylsulphone (up to 60 wt.%). The values of the equilibrium constants K<sub>j</sub> of formation of the j-mers (j = 2, 3, 4) have been determined. Addition of an organic component chemically inert in relation to formaldehyde to an aqueous solution of formaldehyde practically had no influence on the equilibrium between the oxymethylene glycols. (Author abstract) 9 refs.

Slonim, I.Ya. (Plastmassy Scientific-Production Assoc, USSR); Gruznov, A.G.; Oreshenkova, T.F.; Klyuchnikov, V.N.; Romanov, L.M.; Pavlikov, R.Z. *Polym Sci USSR* v 29 n 2 Feb 1987 p 310-315.

## Rheology

**073406 RHEOLOGY OF HARDENED OLIGOMERS. ROLE OF WALL SLIDING.** A new problem in the rheology of polymers, i.e. flow of the hardened polymer with the appearance of sliding in the tube is analysed theoretically. The statement of the problem is discussed, the pressure-flow characteristic is calculated (in dimensionless variables), and the boundaries of stability and the conditions for the appearance of discontinuous hysteresis transitions are considered. A model case of isothermal steady-state motion of a hardened oligomer in a circular tube (channel) of radius R<sub>0</sub> is considered. Experimental data indicate that when the flow changes from large to small values the system passes consecutively through steady-states from the right hand branch of the curve  $\kappa(\omega)$  up to the extreme left hand point of the intermediate branch. On attaining this point, with further decrease in flow, a further abrupt transition occurs on the left hand branch corresponding to the piston flow. (Edited author abstract) 14 refs.

Vaganov, D.A. (USSR Acad of Sciences, USSR); Zhirkov, P.V.; Malkin, A.Ya. *Polym Sci USSR* v 29 n 2 Feb 1987 p 461-468.

## Solutions

**073407 ACYLATION OF TERMINAL AMINO GROUPS IN THE SYNTHESIS OF POLY-M-PHENYLENEISOPHTHALAMIDE.** The reaction between terminal amino groups and dimethylacetamide in acid reaction solutions of PMPIA oligomers (or polymer) at elevated temperatures (80-90°C) has been investigated. The process takes place quantitatively and is catalyzed by the presence of hydrogen chloride. Similar relationships were obtained with m-phenylenediamine. The occurrence of the acylation reaction via decomposition of dimethylacetamide has been confirmed by polarographic analysis of the accumulation of dimethylamine in the system and by potentiometric titration of the consumption of hydrogen chloride in building up the dimethylamine which is liberated. 4 refs.

Vladimirova, M.P.; Zhigulin, A.G.; Zhizdyuk, B.I. *Fibre Chem* v 19 n 5 Sep-Oct 1987 p 319-321.

**Spectroscopic Analysis** See Also POLYMERS—Spectroscopic Analysis.

**073408 PHENOL-ACETALDEHYDE OLIGOMERS. 2. ONE- AND TWO-DIMENSIONAL <sup>13</sup>C NMR AND PHOTOCHEMICALLY INDUCED DYNAMIC NUCLEAR POLARIZATION <sup>1</sup>H NMR STUDIES IN DIMETHYL SULFOXIDE.** A number of oligomers with different stereoregularity, related to novolac resins from phenol-acetaldehyde, are investigated by one- and two-dimensional <sup>1</sup>H and <sup>13</sup>C NMR and by photochemically induced dynamic nuclear polarization (photo-CIDNP) <sup>1</sup>H NMR spectroscopy in dimethyl sulfoxide. For the racemic trimer designated IIIr complete assignment of proton and carbon signals is achieved by homonuclear carbon-carbon (INADEQUATE) and heteronuclear carbon-proton correlated spectra. For the dimer and for trimer IIIr apparent pK<sub>a</sub> values are obtained from the pH dependence of <sup>13</sup>C chemical shifts and discussed in terms of stability of the anionic groups formed during pH titration. (Edited author abstract) 8 refs.



Zetta, Lucia (CNR, Milan, Italy); De Marco, Antonio; Cornia, Mara; Casiraghi, Giovanni. *Macromolecules* v 21 n 4 Apr 1988 p 1170-1173.

**073409 FAST ATOM BOMBARDMENT MASS SPECTROMETRY IDENTIFICATION OF OLIGOMERS CONTAINED IN POLYSULFIDES AND THEIR COMPLEXES WITH HEAVY METALS.** Fast atom bombardment mass spectrometry (FABMS) was used to identify cyclic oligomers formed in polycondensation reactions leading to aromatic, aliphatic, and aliphatic-aromatic polysulfides. Compounds with a molecular weight up to about 1500 daltons present in the crude polymers were detected without separation. Furthermore, the FABMS technique showed the formation of complexes between the cyclic sulfides contained in the extracted fraction from crude polymers and salts of heavy metals (Ag, Hg, and Cu). In some cases a selectivity of the  $\text{AgNO}_3$  toward cyclic sulfides of particular size was also observed. (Author abstract) 11 refs.

Montaudou, G. (Univ di Catania, Catania, Italy); Scamporrino, E.; Puglisi, C.; Vitalini, D. *Macromolecules* v 21 n 6 Jun 1988 p 1594-1598.

**073410 SEGMENTED OLIGO-ETHERURETHANE-UREAS WITH END AND INTRA-CHAIN URETHANE-UREA BLOCKS.** X-ray diffraction, differential scanning calorimetry and IR spectroscopy have been used to study segmented oligo-etherurethane-ureas, incorporating intra-chain and end rigid blocks of various lengths, as well as compounds modeling these blocks. It has been established that the oligomers are amorphous with a characteristic domain structure formed as a result of the microsegregation of the flexible and rigid blocks. The process of de-glassification of the associates of the different rigid blocks is accompanied by the appearance of corresponding endothermic peaks on the DSC curves. More intense endothermic peaks at higher temperatures are typical of the model compounds. (Edited author abstract) 10 Refs.

Lipatov, Yu. S. (USSR Acad of Sciences, USSR); Matyushov, V.F.; Krolenko, A.V.; Tantsyura, T.P. *Polym Sci USSR* v 29 n 4 1987 p 942-948.

## Stability

**073411 GAS-PHASE REACTIONS OF OCTAVINYLSILASESQUIOXANE IN VACUO.** When sensitive films are sprayed in vacuo, varying amounts of residual gases ( $\text{O}_2$  and  $\text{H}_2\text{O}$ ), adsorbed by the support to which the film is being applied, are present, depending on the residual pressure. The reactions of these gases with the film of vinyl- $\text{T}_3$  can result during subsequent development in distortion of the resulting topological relief. For this reason, it is important to study the thermal stability of vinyl- $\text{T}_3$  in vacuo and its reactions with water and oxygen and to establish the conditions for its GLC analysis. The reaction of glass with vinyl- $\text{T}_3$  results in the formation of volatile gaseous products, corresponding to ion currents with  $m/z = 28, 31, 45, 62, 64, 78$ . It was found that the intensities of these ions are temperature-dependent. These results therefore enable conditions for the chromatography of oligoorganosilasesquioxane to be established. 10 refs.

Semyannikov, P.P.; Martynova, T.N. *J Appl Chem of USSR* v 59 n 12 pt 1 Dec 1986 p 2435-2440.

**Structure** See Also ESTERS—Synthesis; POLYMERS—Stability; POLYMERS—X-Ray Analysis.

**073412 STRUCTURAL ORGANIZATION IN EPOXIDE OLIGOMERS AND POLYMERS.** A study of structure formations in epoxydiane oligomers of MM 340-10<sup>4</sup> by means of X-ray diffraction and IR spectroscopy has shown that bands sensitive to structure formations are present in oligomers. Low molecular weight epoxide oligomers with a high content of diphenylolpropanediglycidyl ether crystallize on holding for a long period. Ordering occurs in epoxide polymers of MM up to 10<sup>4</sup> with formation of micro-crystallites. The characteristic dimensions of the ordered regions are 100-150 Å.

(Author abstract) 14 refs.

Markevich, M.A. (USSR Acad of Sciences, USSR); Rytov, B.L.; Vladimirov, L.V.; Shashkin, D.P.; Shiryayev, P.A.; Solov'yev, A.G. *Polym Sci USSR* v 28 n 8 1986 p 1773-1782.

**Synthesis** See Also ION EXCHANGE RESINS—Industrial Applications; MONOMERS—Polymerization; PEROXIDES—Synthesis; POLYMERS—Chemical Reactions.

**073413 POLY(DI-1,2-DIAZINEDIETHYLENE-1,2-DIOLS).** Oligomers of 2 to 9 units having a diazinediethylene-1,2-diol repeating unit have been prepared by a cyanide ion-catalyzed self-condensation of pyridazine-3,6-, pyrazine-2,5-, or pyrimidine-4, 6-dialdehyde. These are the first known representatives of a class of conjugated polymeric enediol materials derivable specifically from these three structurally related diazine dialdehydes. The oligomers, isolated as their potassium salts, are soluble in acid and base with an isoelectric point at pH 6.5. Of several possible methods evaluated for the preparation of the free dialdehydes, only that involving ozonization of the distyryldiazines was found to be of preparative value. (Edited author abstract) 18 refs.

Wiley, Richard H. *J Macromol Sci Chem* v A24 n 10 Oct 1987 p 1183-1190.

**073414 STRUCTURAL STUDIES OF SEMI-FLUORINATED n-ALKANES. 3. SYNTHESIS AND CHARACTERIZATION OF  $\text{F}(\text{CF}_2)_n(\text{CH}_2)_m(\text{CF}_2)_n\text{F}$ .** A series of semifluorinated triblock oligomers of the form  $\text{F}(\text{CF}_2)_n(\text{CH}_2)_m(\text{CF}_2)_n\text{F}$  have been synthesized and characterized by thermal analysis and low-frequency Raman measurements. Only a single endotherm is observed for the series of F12HmF12 molecules corresponding to the crystalline melting point. In the limit of vanishing m, the melting point of  $\text{F}(\text{CF}_2)_{24}\text{F}$  has been predicted by extrapolation and compared with that which recently appeared in the literature. Low-frequency (30-330  $\text{cm}^{-1}$ ) Raman measurements revealed the presence of two bands attributable to the longitudinal acoustical mode oscillations (LAM) of the extended molecule. (Edited author abstract) 21 refs.

Twieg, R.J. (IBM Research, San Jose, CA, USA); Rabolt, J.F. *Macromolecules* v 21 n 6 Jun 1988 p 1806-1811.

**073415 SYNTHESIS OF REACTIVE OLIGOMERS AND THEIR USE IN BLOCK POLYCONDENSATION.** The authors examine the following topics: synthesis of reactive oligomers by radical processes, polycondensation, chemical modification, and degradation. The use of reactive oligomers in macromolecular synthesis; in particular, block polycondensation is also studied. Examples are also presented of oligomers which were polycondensed to form block copolymers are presented in tabular form. 359 Refs.

Nguyen, Hung Anh (Univ Pierre et Marie Curie, Paris, Fr); Marechal, Ernest. *J Macromol Sci Rev Macromol Chem Phys* v C28 n 2 1988 p 187-291.

**Thermal Properties** See POLYMERS—Synthesis.

**Thermodynamic Properties** See MOLECULES—Thermodynamic Properties.

**X-Ray Analysis** See BLOCK COPOLYMERS—Synthesis.

**OLIVINE** See Also IRON ORE PELLETS—Additives.

**073416 NORWEGIAN OLIVINE.** Norwegian olivine production has risen remarkably from barely 100,000 mt at the beginning of the 1970s to 2.8 million mt in 1986, primarily due to the success of A/S Olivin, the major producer, in researching and promoting new uses for the mineral. Norwegian olivine producers now account for 60% of Western world production, and they are the dominant suppliers to the world market. The traditional uses of olivine are for blast cleaning and in foundry sands, where its high melting point, good thermal conductivity, high heat capacity, and low coefficient of expansion make

it ideal as a casting medium. During the past decade, use of olivine as a slag conditioner in iron and steel making has been responsible for the huge growth in demand. In steel making, dolomite or limestone are the usual fluxing agents, with silica to lower the melting point. Olivine contains both magnesia and silica, so when used as a conditioner, it reduces the melting point of the charge and lowers the viscosity of the slag. It is an excellent substitute for dolomite when treating low silica ores.

Suttil, Keith. *Eng Min J* v 188 n 9 Sep 1987 p 34-39.

**Chemical Analysis** See CERAMIC MATERIALS—Phase Diagrams.

## OPERA HOUSES

### Construction

**073417 L'OPERA DE LA BASTILLE - UN GRAND PROJET EN COURS DE REALISATION.** [Paris Opera at the Bastille - A Major Project Under Way]. Construction work on Paris' second Opera at the Bastille has gone into cruising speed after the completion of the major excavation and foundation phases requiring the use of special methods to be able to work in a dense urban area. Everything is now in order to allow compliance with the target completion date of 14 July 1989 set for this modern, popular opera. (Author abstract) In French.

Lemonnier, G. (EPOB, Fr); Antoine, J.P.; Polissadoff, M.; Boissin, M. *Travaux* n 624 Sep 1987 p 26-37.

**OPERATIONS RESEARCH** See Also BUDGET CONTROL—Management; COMPUTER AIDED MANUFACTURING; COMPUTER GRAPHICS—Interactive; DECISION THEORY AND ANALYSIS; ECONOMICS; ECONOMICS—Computer Simulation; ECONOMICS—Management; FREIGHT HANDLING; INDUSTRIAL MANAGEMENT; INVENTORY CONTROL; INVENTORY CONTROL—Mathematical Models; MANAGEMENT; MANAGEMENT—Information Systems; MANAGEMENT SCIENCE; MATHEMATICAL PROGRAMMING, DYNAMIC; MATHEMATICAL PROGRAMMING, LINEAR; MATHEMATICAL TECHNIQUES—Graph Theory; PROBABILITY—Queueing Theory; PRODUCTION CONTROL—Management; PRODUCTION ENGINEERING—Analysis; RELIABILITY; SCHEDULING; SEWAGE TREATMENT PLANTS—Performance; SOCIETIES AND INSTITUTIONS; SONAR—Design; TRANSPORTATION—Route Analysis; WAREHOUSES—Inventory Control; WASTE DISPOSAL.

**073418 MINIMIZING THE MAXIMUM DEVIATION OF JOB COMPLETION TIME ABOUT A COMMON DUE-DATE.** Given a set of n jobs with deterministic processing times and the same ready times, the problem is to find the optimal common due-date  $k^*$  and the optimal job sequences  $\sigma^*$  to minimize the maximum deviation of job completion time about the common due-date. It is shown that the problem can be formulated as an equivalent linear programming (LP) minimization problem. Using the strong duality property of LP, we derive the optimal due-date by considering the dual of the LP problem. When the optimal due-date is determined the optimal job sequence is readily available. After the theoretical treatment numerical examples are presented to demonstrate the validity of the theories. (Author abstract) 11 refs.

Cheng, T.C.E. (Univ of Manitoba, Winnipeg, Manit, Can). *Comput Math Appl* v 14 n 4 1987 p 279-283.

**073419 STOCHASTIC LEADTIMES IN TWO-LEVEL DISTRIBUTION-TYPE NETWORKS.** The paper analyzes a simple three-location, two-level distribution-type system with stochastic leadtimes with the objective of determining planned leadtimes which minimize the sum of expected inventory-holding and tardiness costs. In a manufacturing context, the system can be viewed as one in which common processing or procurement is done first, whereupon another manufacturing stage differentiates this common product. Within a distribution framework, the system is one in which material is transported to a central facility and subsequently transported to smaller local distributors or retailers. Two



heuristic policies are investigated which are simple adjustments to optimal solutions for serial systems resulting from a decoupling of the distribution network. Additional study results are discussed. (Edited author abstract) 8 refs.

Yano, Candace Arai (Univ of Michigan, Ann Arbor, MI, USA). *Nav Res Logist* v 34 n 6 Dec 1987 p 831-843.

**073420 OR IN GOVERNMENT.** The paper presents 2 initiatives where operations research (OR) has proven to play a key role. The idea in the Financial Management Initiative (FMI) is that government business will be improved by importing sound management principles and methods from the best in private sector business. The second initiative is the application of information technology.

Trumpington (Dep of Health & Social Security, Engl). *J Oper Res Soc* v 38 n 10 Oct 1987 p 907-912.

**073421 DISCRETE LOCATION MODEL WITH FUZZY ACCESSIBILITY MEASURES.** In many location problems especially those associated with social policies, non-crisply defined criteria are used such as, how 'near' or 'accessible' a facility is, or how 'important' certain issues are, etc. In these cases a fuzzy sets approach is more appropriate. This paper presents an application of the set partitioning (set covering with equality constraints) type of integer programming formulation to a discrete location problem with fuzzy accessibility criteria. (Edited author abstract) 6 refs.

Darzentas, J. (Polytechnic of the South Bank, London, Engl). *Fuzzy Sets Syst* v 23 n 1 Jul 1987 p 149-154.

**073422 INTERNATIONAL PUBLISHING IN OPERATIONAL RESEARCH.** The primary literature in OR, as defined in International Abstracts in Operations Research, has grown by 47 per cent between 1975 and 1985. EURO and North-America together account for 85 percent of the primary literature. The USA is more than three times as productive per capita as EURO. English has become the standard language; its share in the primary literature increased from 86 to 93 per cent. Most primary journals are nationalist and many cannot be called international. These and more detailed results are presented in this cross-section analysis of the OR primary literature. (Author abstract) 5 refs.

Rutten, W.G.M.M. (Eindhoven Univ of Technology, Eindhoven, Neth); Tilanus, C.B. *Eur J Oper Res* v 33 n 1 Jan 1988 p 114-125.

**073423 MIXED PLANAR/NETWORK FACILITY LOCATION PROBLEMS.** Location problems that arise in real-world context often require the use of a modeling framework which has a mixture of planar and network components. Examples include: (i) the general plant layout problem, in which the plant consists of several arbitrarily shaped departments connected to each other via doors; (ii) warehouse location in cities and village, in which the Manhattan travel metric applies within cities, but networks of roads connect cities and villages; and (iii) facility location in older cities, in which older, unplanned sections are best modeled by a network representation, whereas newer, planned sections are best modeled via a Manhattan travel metric. The purpose of this article is to examine such a modeling framework for facility location. Properties of this new representation are developed, and the p-median problem is analyzed in this context. (Edited author abstract) 10 refs.

Batta, Rajan (State Univ of New York at Buffalo, Buffalo, NY, USA); Palekar, Udatia S. *Comput Oper Res* v 15 n 1 1988 p 61-67.

**073424 ESTIMATION OF DISTRIBUTION PARAMETERS ASSOCIATED WITH FACILITIES DESIGN PROBLEMS INVOLVING FORWARD AND BACKTRACKING OF MATERIALS.** The facilities design problem is one of the important cases of general quadratic assignment problems which involve the assignment of  $n$  facilities to  $n$  locations with the objective of minimizing total cost of the design. All  $n$  feasible solutions for a given problem of size  $n$  yield a frequently distribution

of total costs between lower and upper bounds. The estimation of distribution parameters, viz. mean and variance, allow the checking of the optimality of the different solutions. The methods used to calculate these parameters consider only forward movement of material. However in actual functional layouts the cost of transportation should include costs of both forward as well as backflow of material. This paper deals with the development of a general expression for determining the distribution parameters associated with the facilities design problems involving both forward and backflow of materials. (Edited author abstract) 22 refs.

Khare, V.K. (Univ of Roorkee, Roorkee, India); Khare, M.K.; Neema, M.L. *Comput Ind Eng* v 14 n 1 1988 p 63-75.

**073425 GENERALIZED DISCOUNT STRUCTURE AND SOME DOMINANCE RULES FOR SELECTING THE PRICE-BREAK EOQ.** This paper introduces a generalized discount structure that combines the features of incremental and all-units quantity discount policies. General properties of the EOQ model under this discount structure are studied, and dominance rules for comparing order quantity intervals under either type of discount policy are established. In addition, procedures for developing an iso-cost function and the minimal feasible set for optimal order quantity are proposed. (Author abstract) 8 refs.

Das, Chandrasekhar (Univ of Northern Iowa, Cedar Falls, IA, USA). *Eur J Oper Res* v 34 n 1 Feb 1988 p 27-38.

**073426 GEOMETRICAL REPRESENTATIONS FOR MCDA.** In this paper geometrical representations for multicriteria decision problems are proposed. This new approach provides assistance to understand the conflictual aspects of the criteria and to tackle the problem of the weights associated to them. A generalized criterion, including a preference function, is first generated for each criterion. This allows to define unicriterion preference flows for which a geometrical representation can be obtained by using the Principal Components Analysis. This technique provides the decision-maker with a considerable enrichment for the understanding of his problem: clusters of actions can be considered, the importance of the criteria can be evaluated, conflictual criteria are immediately detected, incomparability between actions is emphasized and explained. (Edited author abstract) 7 refs.

Mareschal, Bertrand (Univ of Brussels, Brussels, Belg); Brans, Jean-Pierre. *Eur J Oper Res* v 34 n 1 Feb 1988 p 69-77.

**073427 IMPROVING FEASIBLE DIRECTIONS FOR A CLASS OF NONDIFFERENTIABLE FUNCTIONS.** This paper describes a method to obtain improving feasible directions for the problem of minimizing a convex, nondifferentiable function subject to linear constraints. The method requires the knowledge of the subgradient of the function at each point and its projection on the null space of the gradients of the binding constraints. We also report the results obtained by applying this method to the optimization of some piecewise linear functions. (Author abstract) 10 refs.

Manuel, Jose (Univ of Valencia, Valencia, Spain); Goerlich, Tamarit. *Eur J Oper Res* v 34 n 1 Feb 1988 p 99-104.

**073428 FORECASTING DEMAND FOR MAIL ORDER CATALOGUE LINES DURING THE SEASON.** Most mail order catalogues include a large number of new lines. Forecasting demand is therefore not easy, and the forecasts for all lines are typically up-dated every week of the catalogue season. The forecasts for each line are usually obtained by determining how the demand for similar lines built up in the corresponding season of the previous year, and then grossing up the demands received accordingly. Using data for one particular mail order company, the sources of error in this trend profile method of forecasting are explored, and some simple ways of improving its accuracy are suggested. (Edited author abstract) 10 refs.

Chambers, M.L. (Univ of Lancaster, Lancaster, Engl); Egles, R.W. *Eur J Oper Res* v 34 n 2 Mar 1988 p 131-138.

**073429 DB2 AND DB2A: TWO USEFUL TOOLS FOR CONSTRUCTING HAMILTONIAN CIRCUITS.** The paper presents a procedure, called DB2A, for constructing a Hamiltonian circuit (HC) in a general directed graph. Application examples and a completely developed example problem are included. An appendix recalls the features of DB2, used here as a subprocedure of DB2A, and finding a Hamiltonian Cycle in undirected graphs. (Author abstract) 10 refs.

Brunacci, Francesco A. (Univ di Firenze, Florence, Italy). *Eur J Oper Res* v 34 n 2 Mar 1988 p 231-236.

**073430 SAVINGS ALGORITHM FOR THE VEHICLE ROUTING PROBLEM.** A survey is presented concerning the savings method for the vehicle routing problem. Results for several methods and data sets are compared. Furthermore, modifications of the savings method are presented which show less CPU time and reduced storage requirements. Therefore, the savings method can be implemented on microcomputers. (Edited author abstract) 34 refs.

Paessens, H. (Fachhochschule Flensburg, Flensburg, West Ger). *Eur J Oper Res* v 34 n 3 Mar 1988 p 336-344.

**073431 LAGRANGIAN RELAXATION APPROACH TO SOLVE THE SECOND PHASE OF THE EXAM SCHEDULING PROBLEM.** In this paper, we present new integer programming formulations for the second phase of the scheduling problem. We present an integer program with a single objective of minimizing the number of students with two or more exams per day. We present a Lagrangian relaxation based solution procedure to solve this problem. Further, we present a bicriterion integer programming formulation to minimize the number of students with two exams per day and the number of students with three exams per day. Finally, we present some computational experience using randomly generated problems as well as real world data obtained from the State University of New York at Buffalo. (Edited author abstract) 21 refs.

Arani, Taghi (State Univ of New York at Buffalo, Buffalo, NY, USA); Karwan, Mark; Lotfi, Vahid. *Eur J Oper Res* v 34 n 3 Mar 1988 p 372-383.

**073432 OR IN PRACTICE: RESULTS OF A SURVEY IN GREECE.** This paper presents results of a survey on the utilization of OR in tackling complex organizational and operational problems in the public and private sectors in Greece. The survey was addressed to the qualified OR and computer personnel, members of the corresponding scientific societies, and replies to questions concerning users, application areas, techniques used, results and related problems. The results of the survey presented in this paper show that, although OR utilization is expanding in Greek operational units, problems are often encountered which tend to minimize its pace of expansion. On the other hand it was shown that, wherever OR is utilized, practitioners are usually equipped with micros and the programming languages mostly used are COBOL, BASIC and FORTRAN, whereas a considerable number of OR studies, mostly in project planning, are carried out without any use of computer. (Edited author abstract) 17 refs.

Pappis, Costas P. (Hellenic Operational Research Society, Athens, Greece); Nikitas, Grigoris D.; Patrikalakis, Gianis S. *Eur J Oper Res* v 34 n 3 Mar 1988 p 405-410.

**073433 REDUCTION OF PARADOXES IN SUBJECTIVELY JUDGED COMPETITIONS.** In competitions where a number of judges choose with some subjectivity among three or more alternatives, a wide variety of undesirable effects can occur. Examples of such effects are presented, with emphasis on figure skating and dance competitions, where the rule traditionally used



allows for the existence of dictator situations, dependence on irrelevant alternatives, and intransitivity. Although not all paradoxes can be removed (as proven by K.J. Arrow), we propose an improved rule which alleviates many of the difficulties, and is superior to any weighted summation rule. (Edited author abstract) 7 refs.

Frederiksen, Jesper S. (DIKU, Copenhagen, Den); Machol, Robert E. *Eur J Oper Res* v 35 n 1 Apr 1988 p 16-29.

**073434 FROM PROBLEM-STRUCTURING TO IMPLEMENTATION.** This paper is intended to encourage operations research/management sciences (OR/MS) practitioners to take seriously the notion that the implementation of their work deserves as much attention as do the technical aspects that underlie their recommendations. It focuses on the similarities between problem-structuring and implementation, and argues that an exploration approach can be used in both. It is now accepted that successful structuring must involve deliberate exploration of tangible and intangible issues, and the same is true of implementation. (Edited author abstract) 10 refs.

Pidd, Michael (Univ of Lancaster, Engl). *J Oper Res Soc* v 39 n 2 Feb 1988 p 115-121.

**073435 REOPTIMIZATION ALGORITHM FOR THE SHORTEST PATH PROBLEM WITH TIME WINDOWS.** The shortest path problem with time windows (SPPTW) occurs in the construction of vehicle routes and schedules for which time window constraints must be satisfied. The SPPTW is repeatedly solved to produce routes with disjoint schedules which form the solution of the original problem. The cost of repeatedly solving the SPPTW can be reduced by reusing part of the solution of the preceding problem. A primal-dual reoptimization method which runs in pseudo-polynomial time is proposed. It can solve problems with up to 2500 nodes. (Author abstract) 14 refs.

Desrochers, Martin (Univ de Montreal, Can); Soumis, Francois. *Eur J Oper Res* v 35 n 2 May 1988 p 242-254.

**073436 BATCH ACCEPTANCE COMPLEMENT METHOD FOR GENERATING RANDOM VARIABLES.** We present a new method called the 'batch acceptance-complement method for generating random variables' from a given density function. Some guidelines for application of this method are discussed. The authors also introduce an algorithm which is based on both M-2 on the MAC (Modified Acceptance Complement) method. This algorithm uses a truncated form of the geometric distribution and generated the random variables in batches. (Edited author abstract) 6 refs.

Rubinstein, Reuven Y. (Technion, Haifa, Isr); Kreimer, Joseph. *Eur J Oper Res* v 35 n 2 May 1988 p 278-285.

**073437 PRESIDENT'S SYMPOSIUM: THE CURRENT MISSIONARY ROLE OF OR/MS.** A major role of operations research and management science has always been to provide 'missionaries' to bring system perspectives, modeling, and analysis to those 'heathen' professions that have not yet been 'converted'. Since many of our traditional fields have already become self-sufficient, in the future our future attention should be directed at the more complex fields of organization theory and public policy, which have considerable needs and thus offer rich opportunities. The author provides some perspectives on these views 10 years later, at a time when rather dramatic changes are taking place in the structure and activities of the field. (Edited author abstract) 4 refs.

Blumstein, Alfred (Carnegie Mellon Univ, Pittsburgh, PA, USA). *Oper Res* v 35 n 6 Nov-Dec 1987 p 926-929.

**073438 DYNAMIC EXPANSION AND RELOCATION OF CAPACITATED PUBLIC FACILITIES: A MULTI-OBJECTIVE APPROACH.** This paper presents an interactive fuzzy goal programming model that will aid the public administrator in determining the dynamic relocation and expansion of capacitated public facilities. Since the general public usually views a public facility as a service institution, the proposed model explicitly considers multiple competing objectives includ-

ing the service-related qualitative objective. To demonstrate the practicality of the model, the model has been applied to an actual two period expansion and relocation problem of Columbus public library facilities. (Author abstract) 29 refs.

Min, Hokey (Univ of New Orleans, New Orleans, LA, USA). *Comput Oper Res* v 15 n 3 1988 p 243-252.

**073439 ON THE ACCURACY OF DEMAND POINT SOLUTIONS TO THE PLANAR, MANHATTAN METRIC, p-MEDIAN PROBLEM, WITH AND WITHOUT BARRIERS TO TRAVEL.** This article examines the accuracy of a frequently made assumption by urban planners in location analysis, namely, to restrict facility location to demand points. Theoretical, computational and empirical analysis reveal that in the absence of barriers to travel this is an excellent approximation for a well studied planar location problem which has wide applicability in an urban environment. In the presence of barriers to travel, our findings suggest that the set of demand points should be augmented with the set of barrier intersection candidate points to yield an approximation of the same overall quality. 2 refs.

Batta, Rajan (State Univ of New York at Buffalo, Buffalo, NY, USA); Leifer, Lloyd A. *Comput Oper Res* v 15 n 3 1988 p 253-262.

**073440 SYSTEM DYNAMICS AND MICROWORLDS FOR POLICYMAKERS.** The paper reviews four major developments in the subject that have brought about this change. There have been improvements in the symbols and software used to map and model system structure. New ideas have been adopted from behavioral decision theory which help to transfer policymakers' knowledge into computer models. There have been improvements in methods of simulation analysis that enable modelers and model users to gain better insight into dynamic behavior. Greater emphasis has been placed on small transparent models, on games and on dialogue between 'mental models' and computer simulations. Together these developments allow modelers to create computer-based learning environments (or microworlds) for policymakers to 'play-with' their knowledge of business and social systems and to debate policy and strategy change. (Edited author abstract) 75 refs.

Morecroft, John D.W. (London Business Sch, London, Engl). *Eur J Oper Res* v 35 n 3 Jun 1988 p 301-320.

**073441 MINIMIZING EXPECTED MAKESPAN IN A TWO-MACHINE STOCHASTIC OPEN SHOP WITH POISSON ARRIVAL.** Longest expected processing time (LEPT) policy is a machine loading rule where out of all the jobs waiting to be processed by a machine, with their processing times following given probability distributions, the one with the largest expected processing time is chosen first. Using a method based on Markov process and dynamic programming, we show that a LEPT policy will minimize the expected makespan for a two-machine stochastic open shop with Poisson arrival for jobs. Processing time of any job at any machine is exponential. We assume that all jobs are identical but the two machines are not. (Author abstract) 21 refs.

Chung, Chia-Shin (Cleveland State Univ, Cleveland, OH, USA); Mohanty, Bidhu B. *J Math Anal Appl* v 133 n 2 Aug 1 1988 p 498-508.

**073442 INSTITUTE FOR OPERATIONAL RESEARCH: AN INITIATIVE TO EXTEND THE SLOPE OF OR.** One of the aims in forming the Institute for Operational Research (IOR) in 1963 was to expand the fields of application of OR and to reverse the tendency, then evident, for it to settle down as a mainly in-house, industrial activity deriving its strength from mathematics and the hard sciences, with little research content of its own. The paper outlines the early work done at IOR in pursuit of this mission, especially in multi-organizational settings such as city and regional planning, health services and the building industry. This leads into discussion of the conditions under which the work was done, the style of 'action-research' that evolved, its influence at the time,

and its relevance to the different circumstances of the present day. (Author abstract). 35 Refs.

Friend, John K. (Tavistock Inst of Human Relations, Engl); Norris, Michael E.; Stringer, John. *J Oper Res Soc* v 39 n 8 Aug 1988 p 705-713.

**073443 SOME METHODOLOGIES FOR COMMUNITY OPERATIONAL RESEARCH.** As experience of conducting community OR projects grows and learning accrues, new approaches will be developed offering guidance on how best to proceed in alleviating the problems of community organizations. In the interim, it is sensible to consider which, if any, among the existing OR and systems methodologies might prove useful for this kind of work. In this paper it is argued that there already exist, within what might be described as 'enhanced OR', a number of approaches which are suitable for guiding community OR practice. This is demonstrated by outlining some of these methodologies, giving examples of their use with community organizations and showing their particular strengths in the community context. Some conclusions are drawn about the community OR enterprise. (Author abstract). 34 Refs.

Jackson, M.C. (Univ of Hull, Hull, Engl). *J Oper Res Soc* v 39 n 8 Aug 1988 p 715-724.

**073444 PROCEDURE FOR LOCATING EMERGENCY-SERVICE FACILITIES FOR ALL POSSIBLE RESPONSE DISTANCES.** The problem of locating emergency-service facilities involves the assignment of a set of demand points to a set of facilities. One way to formulate the problem is to minimize the number of required facilities, given that the maximum distance between the demand points and their nearest facility does not exceed some specified value. We present a procedure for determining the numbers of such facilities for all possible values of the maximum distance. Computational results are presented for a microcomputer implementation. (Author abstract). 15 Refs.

Neebe, Alan W. (Univ of North Carolina, USA). *J Oper Res Soc* v 39 n 8 Aug 1988 p 743-748.

**073445 ON THE DISTRIBUTION OF ACTIVITY TIME IN PERT.** In PERT analysis the activity-time distribution is assumed to be a beta distribution, and the mean and variance of the activity time are estimated on the basis of the 'pessimistic', 'most likely' and 'optimistic' completion times, which are subjectively determined by an analyst. In this paper, on the basis of the study of the PERT assumptions, we present an improvement of these estimates. It is also shown that, by means of additional reasonable assumptions, the activity-time distribution in PERT analysis may be essentially simplified. (Author abstract). 24 Refs.

Golenko-Ginzburg, Dimitri (Ben-Gurion Univ of the Negev, Beer Sheva, Isr). *J Oper Res Soc* v 39 n 8 Aug 1988 p 767-771.

**073446 STRUCTURAL PROPERTIES OF THE COMPATIBILITY MATRIX: EXISTENCE OF MATHEMATICAL RELATIONSHIPS.** A project network consists of activities that have many alternatives and pairwise compatibility relationships. This paper employs the compatibility matrix approach and derives statistical relationships for the estimation of the mean and standard deviation number of feasible alternatives plans. (Author abstract). 6 Refs.

Katz, Joseph L. (Georgia State Univ, Atlanta, GA, USA); Singhal, Jaya. *INFOR* v 26 n 3 Aug 1988 p 163-169.

**073447 ASYMPTOTICALLY EFFICIENT ALLOCATION RULES FOR THE MULTIARMED BANDIT PROBLEM WITH MULTIPLE PLAYS - PART I: I.I.D. REWARDS.** The authors address a version of the multiarmed bandit problem with multiple plays. At each instant of time it is necessary to sample a fixed number  $m \geq 1$  out of  $N$  i.i.d. (independent and identically distributed) processes whose distributions belong to a family



suitably parameterized by a real number  $\theta$ . The objective is to maximize the long-run total expected value of the samples. Following T.L. Lai and H. Robbins (1985), the learning loss of a sampling scheme corresponding to a configuration of parameters  $C = (\theta_1 \times \theta_N)$ ,  $N$  being the number of the machine's arms, is quantified by the regret  $R_n(C)$ . This is the difference between the maximum expected reward at time  $n$  that could be achieved if  $C$  were known and the expected reward actually obtained by the sampling scheme. A lower bound is provided for the regret associated with any uniformly good scheme, and a scheme which attains the lower bound for every configuration  $C$  is constructed. The lower bound is given explicitly in terms of the Kullback-Liebler number between pairs of distributions. 7 refs.

Anantharam, Venkatachalam (Univ of California, Berkeley, CA, USA); Varaiya, Pravin; Walrand, Jean. *IEEE Trans Autom Control* v AC-32 n 11 Nov 1987 p 968-976.

**073448 ASYMPTOTICALLY EFFICIENT ALLOCATION RULES FOR THE MULTIARMED BANDIT PROBLEM WITH MULTIPLE PLAYS - PART II: MARKOVIAN REWARDS.** The multiarmed bandit problem is studied when the reward statistics are Markovian and given by a one-parameter family of stochastic transition matrices  $P(\theta) = [P(x, y, \theta)]$ ,  $\theta \in R$ , and  $x, y, \in X$ , where  $X$  is contained in  $R$  is a finite set of rewards. There are  $N$  arms with parameter configuration  $C = (\theta_1 \times \theta_N)$ . Successive plays of arm  $j$  result in  $X$ -valued random variables  $Y_{j1}, Y_{j2}, \dots$ , whose statistics are given by  $P(\theta)$ . The first play of an arm has a reward distribution which need not be the invariant distribution. It is necessary at each stage to play  $m$  arms. The aim is to maximize in some sense the total expected reward for every parameter configuration. 8 refs.

Anantharam, Venkatachalam (Univ of California, Berkeley, CA, USA); Varaiya, Pravin; Walrand, Jean. *IEEE Trans Autom Control* v AC-32 n 11 Nov 1987 p 977-982.

## Analogies

**073449 ANALYSIS OF VALVE MODELS FOR SOLUTION OF DISCRETE OPTIMIZATION PROBLEMS IN OPERATIONS RESEARCH.** The author considers a class of circuits consisting only of diodes, voltage sources, current sources and ideal transformers and used as models of discrete optimization problems which are solved in operations research. An analysis is made of the electric processes in these circuits. An analytic method is proposed for their design. The methods are of practical interest since they avoid the need to set up electric models and measure the voltages and currents in them. They also enable the prerequisites to be created for a search for more effective computer algorithms. Modeling of the general linear programming problem is treated by an example covering valve converter schemes. (Edited author abstract) 6 refs.

Berkovich, Ye.I. *Electr Technol USSR* n 1 1987 p 59-75.

**Applications** See RAPID TRANSIT—Operations Research.

**Calculations** See OPTIMIZATION.

**Computer Applications** See Also ARTIFICIAL INTELLIGENCE—Expert Systems; COMPUTER SOFTWARE—Applications; PRODUCTION ENGINEERING—Scheduling.

**073450 SUPERCOMPUTERS AND OR.** As supercomputers become more accessible to the operations research (OR) community (both here and in the USA), their influence on OR is expected to grow. Increased availability of supercomputers could be the single factor that would have the greatest impact upon research into large-scale systems. Using supercomputers could be classified as: near-term: increasing the scale size of current models; experimenting with parallel computing steps in current solution procedures; improving the accuracy of current computations; trying larger Monte Carlo and simulation runs on current models; and long-term: developing genuinely parallel models and using parallel solu-

tion techniques on them; developing parallel simulation models; developing parallel algorithmic techniques; developing real-time models. 55 refs.

Beasley, J.E. (Imperial Coll, London, Engl). *J Oper Res Soc* v 38 n 11 Nov 1987 p 1085-1089.

**073451 PRESIDENTS' SYMPOSIUM: GEORGE E. KIMBALL, A PIONEERING GIANT IN OPERATIONS RESEARCH.** These remarks, adapted from a talk given at the April 1985 TIMS/ORSA meeting in Boston, are aimed at sustaining the memory of George Elbert Kimball, one of the operations research's influential pioneers, who himself was president of the Society from 1964 to 1965. George Kimball's contributions to operations research were diverse and fundamental. The sophistication he displayed in developing method or problem analysis was usually characterized by its simplicity, by his capacity to get to the heart of the question. When George Kimball died in 1967, at age 61, he was already working on computer games and self-learning systems. (Edited author abstract) 3 refs.

Magee, John F. (Arthur D. Little Inc, Cambridge, MA, USA). *Oper Res* v 35 n 4 Jul-Aug 1987 p 622-624.

**073452 USER-ORIENTED OPERATIONS RESEARCH SOFTWARE.** Significant advances in computer hardware and software have prompted the accelerated development of operations research (OR) software. Recently, a widespread interest has emerged in the design of user-oriented model-user interfaces that make existing OR methodologies readily available to practitioners. The feasibility of these systems has created new dimensions in the development of model generators that facilitate the use of OR techniques. This paper describes several programs that take advantage of some of the features of the microcomputer to assist the user of data input and editing, error detection in data entry, as well as model generation. The software illustrates different levels of ease of learning and use, modeling flexibility, and assistance to the user in the modeling effort as well as in interactive decision making. It also illustrates different levels of user-program interaction. (Author abstract) 7 refs.

Haddock, Jorge (Rensselaer Polytechnic Inst, Troy, NY, USA). *Appl Math Modelling* v 12 n 3 Jun 1988 p 268-272.

**Economics** See AIR CONDITIONING—Equipment.

**Education** See Also PRODUCTION CONTROL—Management.

**073453 TEACHING OPERATIONAL RESEARCH USING IBM-PC COMPATIBLES.** This paper compares the IBM-PC microcomputer and compatibles against the mainframe computing facilities, and discusses specifically the use of software in the areas of spreadsheets, simulation, forecasting and textbook floppies. A comprehensive set of references is given. (Author abstract). 14 Refs.

James, Jim (Ealing Coll of Higher Education). *J Oper Res Soc* v 39 n 8 Aug 1988 p 779-789.

**Industrial Applications** See MACHINE SHOP PRACTICE—Scheduling.

**Management** See PRODUCTION ENGINEERING—Management.

**Mathematical Models** See Also COMPUTER SOFTWARE: MATHEMATICAL PROGRAMMING, DYNAMIC; TRANSPORTATION—Route Analysis.

**073454 MODELING AND SOLVING ILL-STRUCTURED PROBLEMS IN OPERATIONS RESEARCH.** Three major functions of fuzzy set theory in operations research are considered. They are: 1. fuzzy sets as a modeling language for problem situations which contain vague, i.e., nondichotomous, components; 2. fuzzy set theory as an algorithmic tool; and 3. fuzzy sets as a tool to improve and facilitate the communication and interaction between models or EDP-systems and users (human

beings). 44 refs.

Zimmermann, H.-J. *Anal of Fuzzy Inf Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 217-240.*

**073455 GRAPHICAL-STRUCTURE-BASED MODELS FOR ROUTING PROBLEMS.** This paper presents an approach to the modelling of routing problems, focusing on the manner in which circuitous flow and conservation of flow are defined. The new modelling approach employs graphical constructs to define circuit requirements and allows a better description of real-world problems. Graphical constructs allow greater latitude than do existing modelling constructs, which can be inadequate and computationally inefficient. The flexibility and adaptability of graphical-structure-based models allows inclusion of balance constraints for typical routing problems. A hierarchical development, which makes use of the graphical structures employed in the model, is outlined for obtaining exact solutions. (Author abstract). 18 refs.

Ali, Agha Iqbal (Univ of Massachusetts at Amherst, Amherst, MA, USA); Huang, Chung-Hsing. *Int J Syst Sci* v 19 n 9 Sep 1988 p 1667-1686.

## Medical Applications

**073456 PREDICTING THE IMPACT OF INSTITUTING A PRIORITY READMISSION POLICY IN NURSING HOMES.** This paper utilizes a computer simulation model written in FORTRAN to predict the impact of changing a nursing home policy regarding the reservation of beds for Medicaid patients sent to the hospital for a stay of up to 20 days. The model assumes that the policy would be eliminated (beds would not be held open) and that what were formerly bed reservation patients would have priority over all others seeking admission to the nursing home. The output variables of primary interest are the average waiting time in the hospital to return to the nursing home, the average queue size for patients waiting to return, and the maximum number of days such that at least 95%(90%) of the patients will have been able to return within that time period. (Author abstract) 11 refs.

Hannan, Edward L. (New York State Dep of Health, USA); Gimbrone, Christopher J. *Comput Oper Res* v 14 n 6 Oct 1987 p 493-505.

## Military Applications

**073457 SOME ASPECTS OF OPERATIONAL ANALYSIS IN THE MINISTRY OF DEFENCE.** The paper starts by describing what types of operational analysis (OA) are undertaken, and goes on to discuss the management of this OA, in terms of the coordination of the many studies, the types of expertise sought in the personnel who undertake the work, and the balance between intramural and extramural activity. It then addresses more technical matters: the problems of coping with many potential scenarios, the problems associated with data uncertainty, the problems of selecting output measures, the problems of choosing between OA methods, the problems of validating studies of a postulated major war, and the problems associated with generating cost data. (Edited author abstract)

Murray, M.T. (Ministry of Defence, Engl). *J Oper Res Soc* v 38 n 10 Oct 1987 p 875-882.

**Military Purposes** See Also MILITARY EQUIPMENT—Control; SUBMARINES—Computer Simulation.

**073458 FIELD STUDY OF URBAN COMBAT.** The paper describes an example of how practical field trials are used to provide data bases for analytical models of combat. The general requirement for data is explained, followed by a description of how the requirement for the current study of urban combat arose. The methods of planning and carrying out the field trials to meet the requirement are described, highlighting some of the



problems and how they were solved. Finally the paper describes how the data obtained during the trials are being analysed and interpreted. (Author abstract)

Thody, J. (Defence Operational Analysis Establishment, Engl.). *J Oper Res Soc* v 38 n 10 Oct 1987 p 883-889.

**073459 LINEAR PROGRAMMING IN AIR DEFENCE MODELLING.** The paper describes the use of an optimizing model, together with a simulation model, to determine the most effective mix and deployment of air defence weapons to defend a given set of assets against a range of air threats. The advantages of using an optimizing model in such studies are discussed. These are that it: gives more consistent results by reducing player variance, can generate solutions that are robust to variations in threat and environment, ensures that good solutions are not overlooked, reduces the total processing time required to complete the study. (Author abstract)

Beare, G.C. (UK Ministry of Defence, Engl.). *J Oper Res Soc* v 38 n 10 Oct 1987 p 899-905.

**073460 U.S. OPERATIONS RESEARCH IN WORLD WAR II.** This article is the third in a series on the early history of operations research. It offers an overview of American military operations research during World War II. The first and second articles (Operations Research 35, pp. 143-152 and 453-470) traced the scattered beginnings of operations research from World War I through the British experience of World War II. (Edited author abstract)

McCloskey, Joseph F. (California State Univ, Carson, CA, USA). *Oper Res* v 35 n 6 Nov-Dec 1987 p 910-925.

**Reviews** See MATHEMATICAL PROGRAMMING, LINEAR.

## Scheduling

**073461 SCHEDULING JOBS WITH FIXED START AND END TIMES.** We analyze a scheduling problem in which each job has a fixed start and end time and a value. We describe an algorithm which maximizes the value of jobs completed by  $k$  identical machines. The algorithm runs in time  $O(n^2 \log n)$ , where  $n$  is the number of jobs. We also show that the problem is NP-complete under the following restriction: Associated with each job is a subset of the machines on which it can be processed. For a fixed number of machines  $k$ , an  $O(n^{k+1})$  time algorithm is presented. (Author abstract) 13 refs.

Arkin, Esther M. (Stanford Univ, Stanford, CA, USA); Silverberg, Ellen B. *Discrete Appl Math* v 18 n 1 1987 p 1-8.

**073462 ONE-MACHINE SCHEDULING WITH ALLOCATION OF CONTINUOUSLY-DIVISIBLE RESOURCE AND WITH NO PRECEDENCE CONSTRAINTS.** The efficiently solved one-machine scheduling problems with no precedence constraints are generalized to the case with allocation of continuously-divisible constrained nonrenewable resource. Models of operation are assumed to be duration versus resource amount linear functions. The following optimality criteria are considered: maximum completion time, maximum lateness, maximum cost and weighted sum of completion times. For the problems discussed polynomial-time algorithms are found. (Author abstract) 3 refs.

Janiak, Adam. *Kybernetika* v 23 n 4 1987 p 289-293.

**073463 POLYNOMIAL ALGORITHMS FOR PROBLEMS IN THE THEORY OF SCHEDULING ON 'NARROW' NETWORKS.** An acyclic network, the vertices of which are covered by a small number of oriented chains will be called 'narrow with respect to the vertices' or simply 'narrow.' The minimum number of such oriented chains is identical to the number  $n$  of chains in Dilworth's minimum expansion for vertex comparability. We consider problems of constructing an optimal schedule for a narrow network  $G$  with vertices-operations  $E_i$ . 11 refs.

Al'berton, I.B. *Sov J Comput Syst Sci* v 25 n 3 May-Jun 1987 p 82-92.

**073464 INTEGRATION OF PRIORITY DISPATCHING AND DUE-DATE ASSIGNMENT IN A JOB SHOP.** A simulation study to investigate the effect on missed due-dates and job flow-time is discussed by combining the job dispatching and due-date assignment decisions in job shop scheduling. A 'semi-local' due-date-oriented dispatching rule is designed which is able to monitor the progress of jobs closely. The performance of the dispatching rule is enhanced by a rational due-date assignment procedure which takes account of both job content and shop status information in determining due-dates. The simulation results show that the combined scheduling procedure performs better than some common simple dispatching rules which are used with the total-work-content (TWK) due-date assignment method. (Author abstract). 11 refs.

Cheng, T.C.E. (Univ of Manitoba, Winnipeg, Manit, Can.). *Int J Syst Sci* v 19 n 9 Sep 1988 p 1813-1825.

**073465 JOB SHOP SCHEDULING WITH UNIT TIME OPERATIONS UNDER RESOURCE CONSTRAINTS AND RELEASE DATES.** We consider the problem of job shop scheduling with  $m$  machines and  $n$  jobs  $J_i$ , each consisting of  $l_i$  unit time operations. There are  $s$  distinct resources  $R_h$  and a quantity  $q_h$  available of each one. The execution of the  $j$ -th operation of  $J_i$  requires the presence of  $u_{ijh}$  units of  $R_h$ ,  $1 \leq i \leq n$ ,  $1 \leq j \leq l_i$ , and  $1 \leq h \leq s$ . In addition, each  $J_i$  has a release date  $r_i$  that is  $J_i$  cannot start before time  $r_i$ . We describe algorithms for finding schedules having minimum length or sum of completion times of the jobs. Let  $l = \max\{l_i\}$  and  $u = \max\{u_{ijh}\}$ . If  $m$ ,  $s$ ,  $u$  and  $l$  are fixed, then both algorithms terminate within polynomial time. (Author abstract) 5 refs.

Szwarcfiter, Jayme Luiz (Univ Federal do Rio de Janeiro, Rio de Janeiro, Braz). *Discrete Appl Math* v 18 n 2 Nov 1987, Rio Conf on Comb Optim, Rio de Janeiro, Braz, Jul 8-19 1985 p 227-233.

**Theory** See STATISTICAL METHODS—Regression Analysis.

**OPTICAL COATINGS** See Also COATINGS—Antireflection Coatings; GLASS—Coatings; LASER BEAMS—Effects; PHOTODETECTORS—Electronics Packaging; SOLAR RADIATION—Collectors; WAVEGUIDES, OPTICAL.

**073466 CRYOPUMPS: CURE FOR IR COATING HEADACHES.** The advantages of using cryopumps in producing infrared coatings are discussed. Cryopumps are constructed of materials resistant to most acids and have no moving parts exposed to particulate contaminants. Compared to a turbomolecular pump of the same size, the cryopump's much higher pumping speed enables it to reach process pressure in far less time, and to hold a lower process pressure. Problems with backing mechanical pumps are eliminated entirely because the cryopump is a 'hold-up' pump that does not require a backing pump. Other topics include cost-saving features, stopping toxic gases, and regeneration.

Blais, John; Grandinetti, Michael. *Photonics Spectra* v 21 n 7 Jul 1987 p 107-108, 110, 112.

**073467 SPECTRALLY SELECTIVE PROPERTIES OF CHEMICALLY-DEPOSITED  $Ag_2S$  ON ALUMINIUM.** Silver sulfide coatings were chemically deposited on aluminum substrates using spray pyrolysis techniques. These techniques were used for the first time to prepare  $Ag_2S$ . Various combinations of the spraying solution were controlled to give higher solar selectivity. Absorbance and emittance measurements were made to discern the spectral selectivity for their application in photothermal conversion. The structure of the  $Ag_2S$  coatings was characterized by X-ray diffraction. The coatings are stable and have good adhesive properties. The costs of one square meter of  $Ag_2S$  layer is approximately 1.0 US dollars. (Author abstract). 8 Refs.

Abass, A.K. (Univ of Basrah, Basrah, Iraq). *Sol Energy Mater* v 17 n 5 Aug 1988 p 375-378.

**Abrasion Resistance** See Also GLASS—Coatings.

**073468 ABRASION OF OPTICAL COATINGS AND ITS ASSESSMENT.** An abrasion machine using wiper blade action with a slurry of fine silica particles in water is described and the optimum conditions for producing uniform and reproducible damage over the rubbed area are discussed. The machine has been applied to assuming the durability of a range of optical coatings, examining the abraded films by a combination of techniques, including interference microscopy, profilometry transmittance and scatter measurements. The method has been shown to provide information both on the adhesion of coatings and on their resistance to scratching and roughening. (Author abstract) 14 refs.

King, R.J. (NPL, Teddington, Engl); Putland, D.E.; Talim, S.P. *J Phys E* v 21 n 1 Jan 1988 p 39-46.

**Antireflection Coatings** See Also OPTICAL FILTERS—Components.

**073469 POLARISATION-INDEPENDENT ANTIREFLECTION COATINGS FOR SEMICONDUCTOR OPTICAL AMPLIFIERS.** A new, simple and accurate method to compute the TM reflectivity of multilayer coatings deposited on laser diodes is presented. This is applied to the optimization of antireflection coatings. With two-layer coatings it is possible to have near-zero reflectivity for both TE and TM polarizations at some wavelength, and to maintain it below  $10^{-4}$  over 100 nm. (Edited author abstract) 4 refs.

Vassallo, C. (CNET, Lannion, Fr). *Electron Lett* v 24 n 1 Jan 7 1988 p 61-62.

**073470 ANTIREFLECTION COATINGS FOR OPTICAL SEMICONDUCTOR AMPLIFIERS: JUSTIFICATION OF A HEURISTIC ANALYSIS.** A rigorous mathematical basis is presented for a highly accurate heuristic analysis (previously published) of the reflection coefficient of the TE<sub>0</sub> mode in an abruptly terminated slab dielectric waveguide, with or without coating. The role of the weak guiding approximation is clarified. (Author abstract) 2 refs.

Vassallo, C. (CNET, Lannion, Fr). *Electron Lett* v 24 n 1 Jan 7 1988 p 62-64.

**073471 TWO-LAYER DIELECTRIC AR FILM AND ITS APPLICATION IN SEMICONDUCTOR OPTO-ELECTRONIC DEVICES.** This paper gives a theoretical study on the design method of the anti-reflection (AR) film for traveling wave semiconductor laser amplifiers (TWSLA). A two-dimensional digital integration is used to calculate the optimum film parameters and their allowable errors for  $TiO_2/SiO_2$  AR film coated on the facets of the 1.3  $\mu m$  GaAsP lasers. Such films are successfully fabricated by using the vacuum coating and two-wavelength control technique. The reflectivity of the film is lower than  $3.9 \times 10^{-4}$ . By means of the AR film, we succeeded in achieving the direct amplification for the optical signal and in increasing the sensitivities of PIN & APD detectors. (Author abstract) In Chinese. 4 refs.

Huang Dexiu (Huazhong Univ of Science & Technology, China); Liu Deming; Fan Chengjun. *Guangxue Xuebao* v 7 n 11 Nov 1987 p 1036-1040.

**Bonding** See GLASS—Coatings.

## Ceramics

**073472 PREPARATION OF WAVELENGTH-SELECTIVE REFLECTORS BY SOL-GEL PROCESSING.** The present letter reports attempts to prepare, by the sol-gel method, a multilayer, relatively narrow band reflector. A wavelength of 650 nm was chosen for the reflector. Multilayer stacks (up to 13 layers) were built up of alternating  $TiO_2$  and  $SiO_2$  coatings. Individual sols serving as sources of  $SiO_2$  and  $TiO_2$  were prepared from



silicon tetraethoxide and titanium isopropoxide. The layers were deposited (alternately) on thoroughly cleaned soda-lime glass discs by the spin-coating technique. Each layer, after deposition, was heat-treated at 450°C for 10 min. 6 refs.

Biswas, P.K. (Central Glass & Ceramic Research Inst, Calcutta, India); Kundu, D.; Ganguli, D. *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1481-1482.

## Chemical Vapor Deposition

**073473 STUDY ON THE OPTICAL AND ELECTROCHROMIC PROPERTIES OF POLYCRYSTALLINE WO<sub>3</sub> THIN FILMS PREPARED BY CVD.** Polycrystalline WO<sub>3</sub> thin films were prepared by annealing, under various conditions, of black or reflective tungsten layers produced by CVD on fused quartz or SnO<sub>2</sub> coated substrates. The optical gap was investigated and found to depend on film thickness. It varies from approx. 2.5 eV for the thicker films to 3.1 eV for the thinner films. The values of the electrochromic efficiency, using protons as inserted ions, varies between 30 and 40 cm<sup>2</sup>/C for all kinds of films and depends on the film preparation and the coloring-bleaching cycle. Coloring and bleaching times and response of the films are also found to be enhanced with cycling and influenced by the preparation conditions. (Author abstract) 38 Refs.

Davazoglou, D. (CNRS, Montpellier, Fr); Leveque, G.; Donnadieu, A. *Sol Energy Mater* v 17 n 5 Aug 1988 p 379-390.

## Contamination

**073474 APPLYING CRYOGENIC PUMPS TO OPTICAL COATING SYSTEMS.** One of the methods of improving film quality in general is to reduce contamination in the coating system, and one of the possible sources of contamination in any coating system is the pumping system. Many pump technologies involve the use of hydrocarbons, which in turn can be the source of contamination in a deposition process. The author examines various pump technologies in common usage and discusses the various factors which enter into the selection of pumps to reduce contamination during deposition.

Christeler, Jean-Claude (Balzers High Vacuum Products, Hudson, NM, USA). *Lasers Optonics* v 7 n 4 Apr 1988 p 116-118, 120, 122.

## Diffusion Coatings

**073475 CHANGES IN THE DIFFUSIVE PROPERTIES OF REFLECTIVE COATING THROUGHOUT ITS LIFE.** The paper describes the experimental studies concerning the aging of various specular reflective coatings. A luminance indicatrix change throughout the life of the material was determined. Empirical dependences for variations of the factors describing the indicatrix in time are proposed. (Edited author abstract) 6 refs. In Russian.

Kazakova, T.I. *Svetotekhnika* n 3 1988 p 12-14.

## Fabrication

**073476 STUDY OF NEAR-IR TRANSPARENT, HIGH CONDUCTIVE Si-Ag-Si COATINGS PREPARED BY DC MAGNETRON SPUTTERING USING TWO S-GUN.** Near-IR transparent, high conductive Si-Ag-Si coatings are deposited by dc magnetron sputtering using two S-gun. The parameters of multilayer are designed and optimized. Si-Ag-Si coatings with arbitrary thicknesses are sputtered-deposited by means of a simple control method. The optical, electrical and mechanical properties of samples are given. (Author abstract) 3 Refs. In Chinese.

Ye, Zhizheng (Zhejiang Univ, Hangzhou, China); Tang, Jinfa. *Hongwai Yanjiu A-Ji* v 7A n 4 1988 p 259-266.

**Leaching** See GLASS—Chemical Attack; GLASS—Coatings.

**Luminous** See ELECTROLUMINESCENCE—Thin Films.

## Mathematical Models

**073477 WAVELENGTH-INDEPENDENT ANTI-INTERFERENCE COATING FOR THE FAR-INFRARED.** The transmission and reflection of radiation at an interface between two dielectrics with a thin conducting film is analyzed under conditions appropriate to the far-infrared. When the transmission is from a more dense to a less dense optical medium it is demonstrated that the reflectivity can be made arbitrarily small for a wide range of wavelengths by selecting the appropriate sheet resistance for the conducting film. This property can be exploited to produce a coating that drastically reduces the interference fringes in a flat plane-parallel dielectric substrate or window. The condition depends only on the film resistance which can be monitored precisely during deposition. (Edited author abstract) 9 refs.

McKnight, S.W. (Northeastern Univ, Boston, MA, USA); Stewart, K.P.; Drew, H.D.; Moorjani, K. *Infrared Phys* v 27 n 5 Sep 1987 p 327-333.

**073478 NEAR-IR SURFACE IMPEDANCE OF THIN METALLIC FILMS WITH UNLIKE SURFACES.** A simple formula is proposed for the near-IR surface impedance of thin metallic films with unlike surfaces. It is derived from a previous N-directional model based on the Reuter and Sondheimer anomalous skin effect theory. The relative precision on the surface resistance thus calculated is found to be a few times 0.1% at wavelengths smaller than or about 2 μm. Anisotropy may easily be introduced into the electron relaxation time to treat the polycrystalline case or (and) into the Fuchs electron-surface scattering parameters. (Author abstract) 25 refs.

Dudek, J.C. (Conservatoire Natl des Arts et Metiers, Paris, Fr). *Thin Solid Films* v 152 n 3 Sep 28 1987 p 411-431.

## Monitoring

**073479 OPTICAL MONITORING OF NONQUARTERWAVE STACKS.** Three methods of monitoring nonquarterwave stacks are investigated: the turning value method, the inflection point method, and the second-harmonic method. The advantages of these methods are that they are monochromatic and that they do not rely on any absolute measurements of transmittance during monitoring. Computer simulations of the deposition process are performed for different nonquarterwave stacks to check the accuracy of the three methods, and we investigate whether these methods can compensate for errors in thickness occurring during deposition. (Author abstract) 6 refs.

Skettrup, T. (Technical Univ of Denmark, Lyngby, Den). *Opt Eng* v 26 n 11 Nov 1987 p 1175-1181.

## Performance

**073480 DIAMOND-TOUGH COATINGS: HAS THE SPARKLE DULLED?** Early in the '80s, there was excitement over the prospect of applying film layers that transmit perfectly and could protect their substrates from physical or chemical abuse. It would be the ideal film for optical as well as mechanical applications. Over 20 years earlier there was some excitement generated by the occasional occurrence of CVD films of carbon forms that possessed unusual hardness and chemical resistance. These films, based on forms of carbon, have been described according to their structure or deposition process as diamond-like carbon (DLC), i-carbon (for ion-processed), hard carbon, and transparent carbon. More recent developments and improvements are reported. 3 refs.

Pellicori, Samuel F. *Photonics Spectra* v 21 n 10 Oct 1987 p 165-166, 168.

## Radiation Effects

**073481 NONLINEAR BEHAVIOUR OF OPTICAL COATINGS SUBJECTED TO INTENSE LASER IRRADIATION.** Optical filters subjected to intense laser irradiation can experience changes in their optical properties due to nonlinearities in the optical constants of their materials. The origin of the nonlinearity can be due to the dependence of refractive index on temperature or electric field. A simulation of both cases has been developed and is presented here. The model is then applied to two particular designs, showing that reflecting components can be turned into transmitting devices if sufficient input power is used. The result is relevant to the case of high-energy laser mirrors to rugate filters. (Author abstract) 9 Refs.

Bovard, Bertrand G. (Univ of Arizona, Tucson, AZ, USA); Macleod, H. Angus. *Opt Acta* v 35 n 7 Jul 1988 p 1151-1168.

**Spectroscopic Analysis** See GLASS—Surfaces.

**Spectrum Analysis** See MAGNESIUM COMPOUNDS—Thin Films.

## Stability

**073482 ELECTRIC-FIELD-ASSISTED DEPOSITION OF OPTICAL COATINGS.** It is possible to improve the stability of optical coatings if an electric field is applied during deposition. A.c. and d.c. electric fields have been used in the preparation of narrow-band filters consisting of ZnS and cryolite layers and edge filters of ZnS and MgF<sub>2</sub>. As a result, the shift in the wavelength of prominent features in the spectral transmittance is reduced considerably even for coatings subjected to 100% relative humidity. (Author abstract) 5 refs.

Gu, P.F. (Zhejiang Univ, Hangzhou, China). *Thin Solid Films* v 156 n 1 Jan 15 1988 p 153-160.

## Testing

**073483 REAL-TIME INTERFEROMETRIC TESTING OF OPTICAL SURFACES.** Various methods for precise testing of the surface geometries are reviewed. Integrating modern microcomputer and laser technology, a computer-linked Twyman-Green interferometer with real-time processing of the digitized interferogram data was conceived. For visual inspection, this instrument can easily be switch-converted to a Fizeau interferometer. Phase sampling interferometry proved to be of particular advantage. It is a method of establishing surface topology from the intensities for several values of the reference phase through the determination of the sample phases. 10 refs.

Merkel, Klaus. *Jena Rev* v 32 n 2 1987 p 60-64.

**073484 FEL OPTICS COATING TEST DEVICE.** A crucial issue concerning FEL is the resistance of the mirrors to high flux. In the example of the ACO storage ring the high X-ray flux of spontaneous emission sets a limit to the shortest wavelength. A detailed analysis of the resistance of multilayer dielectric TiO<sub>2</sub>/SiO<sub>2</sub> mirrors has been carried out. Several degradation processes have been identified occurring at different energies of incident photons leading to either surface or bulk absorption. This data was very important for the operation of the FEL at wavelength above 460 nm. (Edited author abstract) 4 refs.

Velghe, M.F. (CNRS, Orsay, Fr); Elleaume, P. *Nucl Instrum Methods Phys Res Sect A* v A259 n 1-2 Sep 1 1987 p 83-87.

**Thin Films** See Also OPTICAL FILTERS; WAVEGUIDES, OPTICAL.

**073485 STABILISATION SPECTRALE DES DEPOTS OPTIQUES EN COUCHES MINCES.** [Spectral Stabilization of Thin Film Optical Coatings]. Knowledge of the spectral derivatives of the reflectance R of a thin film optical coating permits a better understanding of their influence on the reflectance. Consequently, one can



modify these derivatives to change the shape of the spectral reflective curve. In particular, the canceling of successive spectral derivatives determines a coating with a flat broad band reflectance. In this paper, general equations are given to calculate the first and second spectral derivatives whatever the optical thicknesses of the layers. Derivatives with higher orders are also obtained when the coating is antireflective or when the layers are in  $\lambda/4$  configuration. Conditions relating thicknesses and indices are given to achieve broad-band coatings. Simple  $\lambda/4$  coatings up to four layers are studied; explicit equations are obtained linking the reflectance  $R_0$  and the indices of the layers for a given value of  $R_0$ . (Author abstract) In French. 13 refs.

Mouchart, J. (Cent de Recherches de la Compagnie Generale d'Electricite, Marcoussis, Fr); Begel, J.; Chalot, S. *J Mod Opt* v 34 n 10 Oct 1987 p 1297-1325.

**073486 INCREASING THE EFFECTIVENESS OF COMMERCIAL LASER DAMAGE TESTING.** Failure of the thin-film coatings on the optical elements of high-power production laser systems frequently limits achievable performance. Laser manufacturers now require optics with the most durable coatings; as a result, routine laser damage testing has become an essential tool for production and procurement of reliable optics. A demand for fast turnaround and low unit-test cost paced the emergence of such testing from the research laboratory into the high-volume production environment. Conventional manual damage testing methods are labor intensive and slow, therefore, test automation is the key to effective high-volume testing. 19 refs.

Seitel, Steven C. (Montana Laser Optics Inc, Bozeman, MT, USA). *Lasers Optonics* v 6 n 10 Oct 1987 p 67-69.

**073487 AUTOMATIC DESIGN OF OPTICAL COATINGS WITH CALCULATED RATE OF FINISHED PRODUCTS AS THE END MERIT INDEX.** A new automatic design method of optical thin film systems is presented, in which the effect of the errors in monitoring of optical multilayer coatings on the performance is considered. The merit function in the design involves not only the optical properties but also the rate of finished products of the multilayer coatings by computer simulation, and the highest rate of finished products is taken as the end optimization goal. The thin film systems designed by this method not only satisfy the requirement of optical properties but also have larger manufacture tolerance. Hence, this method will be very effective in production. Some examples of the designs of broad-band and double-band antireflection coatings are given. The results of such designs are satisfactory. (Author abstract) In Chinese. 11 refs.

Zheng, Yanfei (Zhejiang Univ, Hangzhou, China); Tang, Jinfa. *Guangxue Xuebao* v 7 n 9 Sep 1987 p 818-823.

**073488 BROADBAND OPTICAL MONITORING APPARATUS.** The apparatus described in this paper consists of a minicomputer coupled to a rapid-scanning spectrometer that continuously measures the spectral profile during deposition of each layer for monitoring film thickness. The apparatus is demonstrated in the monitoring of a beam splitter made of three layers. Performance of the apparatus: measuring band width: 333 nm; spectral wavelength point: 50 point; transmittance accuracy: 1% spectral transmittance; scan period: 12 sweep/sec. (Author abstract) In Chinese. 5 refs.

Yang, Benqi (Acad Sinica, China); Xu, Shaoji; Jin, Linfa; Zhang, Hongfen; Jin, Honghou. *Guangxue Xuebao* v 7 n 7 Jul 1987 p 612-617.

**073489 OPENING NEW DOORS TO OPTICAL CONDUCTIVE COATINGS.** Optically transmitting and electrically conductive (EC) coatings have become an important product of the thin film industry. Many thousands of square feet of indium tin oxide (ITO) coatings and optically enhanced noble metal thin films are produced annually for many diverse applications. This article reviews the recent developments in optical conductive coatings and some of its new areas and applications.

4 refs.

Bright, Clark. *Photonics Spectra* v 22 n 3 Mar 1988 p 131-132.

**073490 ION-ASSISTED DEPOSITION: IAD IS SLOWLY MOVING TOWARD LIMITED PRODUCTION.** While researchers have studied ion-assisted deposition (IAD) of thin films for more than a decade, IAD for coating commercial laser optics has only recently moved into limited production use. Commercially, the addition of IAD to the coating process for laser optics has only peaked the interest of the optical coating industry within the last year or two. Perhaps a handful of optical coating firms are now using the process for production. Interest in IAD for commercial use is keen, however, because the process promises to improve many of the characteristics of optical coatings at very little added cost. 50 refs.

Iscoff, Ron. *Lasers and Optonics* v 7 n 2 Feb 1988 p 53-56.

**073491 VAPOR-PHASE MIXED DEPOSITION OF OPTICAL COATINGS.** Two thin-film materials are evaporated simultaneously from respective sources in vacuum where vapor-phase mixed thin films will be formed. Experimental methods are described for the vapor-phase mixed deposition, and three programs for controlling deposition are presented. The experimental results of two broad-band antireflection coatings are given as practical examples. Experiments show that vapor-phase mixed deposition is a promising technique for application. (Author abstract) In Chinese. 4 refs.

Duan Ziping (Pingyuan Optical Instrument Plant, Jiaozuo, China); Zhou Jiulin. *Guangxue Xuebao* v 8 n 3 Mar 1988 p 261-265.

**073492 DESIGN AND TEST OF COATINGS DEPOSITED ON WINDOW GLASS FOR ENERGY EFFICIENCY.** Coatings for energy efficiency is one of functional thin films which is developing vigorously. In this paper, requirements of the coatings are analysed wholly while the design of the coatings is discussed and some appropriate layer systems are given. Also the calculation method of spectral properties of layer which is absorptive and dispersive is proposed. The paper shows the test results of spectral properties, firmness, and reducing and maintaining temperature respectively for summer and winter films, which indicate that the deposited coatings have fulfilled the basic requirements of coatings for energy efficiency. (Author abstract) 9 refs.

De, Ling Shi (Shanghai Inst of Mechanical Engineering, Shanghai, China); Weiming, Cheng. *Optik (Stuttgart)* v 78 n 3 Feb 1988 p 87-90.

**073493 RAMAN CHARACTERIZATION OF OPTICAL THIN FILM COATINGS.** A simple oblique-incident method for suppressing substrate interference and enhancing Raman sensitivity is discussed. Using this method, Raman spectroscopy on different types of titania films is shown to be a sensitive technique for probing the microscopic structures of thin films and characterizing submicron thin film coatings. With Raman spectroscopy, ion-beam-sputtered and electron-beam-evaporated coatings, when exposed to heat or laser light, are found to crystallize into different polycrystalline structures. The rate of crystal growth may be investigated with in situ Raman scattering. Using zirconia films as an example, polarization analysis of Raman scattered light can be used to discern the state of crystallinity of the film and to enhance the sensitivity of detection of low-frequency Raman modes. (Edited author abstract) 12 refs.

She, C.Y. (Colorado State Univ, Fort Collins, CO, USA). *Thin Solid Films* v 154 n 1-2 Nov 12 1987, Pap Presented at the Int Conf on Metall Coat - Part II, San Diego, CA, USA, Mar 23-27 1987 p 239-247.

**OPTICAL COMMUNICATION** See Also COMPUTER NETWORKS; COMPUTER NETWORKS—Local Networks; COMPUTER SYSTEMS, DIGITAL—Distributed; COMPUTER SYSTEMS, DIGITAL—Multiprocessing; DATABASE SYSTEMS; DIGITAL COMMUNICATION SYSTEMS—Voice/Data Integrated Services; ELECTROMAGNETIC WAVES—Scattering; FIBER OPTICS; FIBER OPTICS—Applications; FIBER OPTICS—Sensors; LASERS, GAS—Stability; LASERS, SEMICONDUCTOR; LASERS, SEMICONDUCTOR—Design; LASERS, SEMICONDUCTOR—Measurements; LASERS, SEMICONDUCTOR—Noise, Spurious Signal; LASERS, SEMICONDUCTOR—Performance; LIGHT—Polarization; MATHEMATICAL TECHNIQUES—Vectors; MULTIPLEXING EQUIPMENT—Design; OPTICAL DATA PROCESSING; OPTICAL DEVICES—Analysis; OPTICAL DEVICES—Switching; OPTICAL FIBERS—Analysis; OPTICAL FIBERS—Fracture; OPTICAL FIBERS—Optical Properties; OPTICAL FIBERS—Performance; OPTICAL FIBERS—Stresses; OPTOELECTRONIC DEVICES—Design; OPTOELECTRONIC DEVICES—Performance; PHASE MODULATION—Phase Shift Keying; RAILROADS; SIGNAL DETECTION; SIGNAL INTERFERENCE—Crosstalk; SIGNAL PROCESSING; SIGNAL RECEIVERS—Noise, Spurious Signal; SIGNAL RECEIVERS—Performance; SWITCHING SYSTEMS; TELECOMMUNICATION; TELECOMMUNICATION CABLES—Submarine; TELECOMMUNICATION SYSTEMS; TELEPHONE EXCHANGES, AUTOMATIC—Performance; TELEVISION SYSTEMS, CABLE—Geneva, Switzerland; WAVEGUIDES, OPTICAL; WAVEGUIDES, OPTICAL—Laser Applications.

**073494 GENERAL CHARACTERISTICS OF THE PLESSEY 565 MBIT/S OPTICAL FIBRE SYSTEMS.** The design of the Melbourne-Canberra-Sydney optical fiber route called for the highest bit rate systems available. The Plessey equipment operating at 565 Mbit/s and developed in the United Kingdom and redeveloped in Australia to comply with Telecom Australia's requirements is scheduled to be installed early in 1988. (Author abstract)

Anon. *Telecommun J Aust* v 37 n 3 1987 p 75-76.

**073495 MID-INFRARED OPTICAL TRANSMISSION SYSTEMS.** Fluoride optical fibers offer great potential for future ultra-long span optical transmission systems. Much work has recently been centered on developing a new class of ultra-low loss fiber operating in the mid-infrared wavelength region. This paper reviews mid-infrared system aspects and describes some of the ongoing work in this area. (Author abstract) 16 refs.

Walker, S.D.; Garnham, R.A. *Br Telecom Technol J* v 5 n 3 Jul 1987 p 5-8.

**073496 CUT-OFF RATE PERFORMANCE FOR PHASE SHIFT KEYING MODULATED COHERENT STATES.** Cut-off rate performance for phase modulated coherent states in a noiseless optical channel, using a phase measurement operator is calculated. The results obtained deviate significantly from those given by the upper bound, shown previously to be close to the optimal in several practical cases. (Author abstract) 5 refs.

Helstrom, C.W. (CNRS, Gif-sur-Yvette, Fr); Charbit, M.; Bendjaballah, C. *Opt Commun* v 64 n 3 Nov 1 1987 p 253-255.

**073497 APPLICATION OF RECEIVED QUANTUM STATE CONTROL FOR COHERENT OPTICAL COMMUNICATIONS.** It is well known that energy loss brings a serious problem in the optical information transmission systems with the quantum state control at transmitter. We have proposed a new system using the two photon coherent state applicable to the long distance transmission fiber systems, and shown the numerical properties of the advantage of using the received quantum state control. As a result, the merit of our system remarkably increases when one requires high reliability. (Edited author abstract) 12 refs.

Hirota, Osamu (Tamagawa Univ, Machida, Jpn); Kagami, Osamu; Takahara, Mikio. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 9 Sep 1987 p 801-803.



**073498 COMPARISON BETWEEN PHOTON COMMUNICATION SYSTEMS AND QUANTUM COHERENT COMMUNICATION SYSTEMS.** This paper clarifies properties of the quantum state control communication systems such as the quantum coherent communication systems (QCCS) and the photon communication systems (PS). We compare properties of these two systems in the case of uncoded and coded schemes. In the former case, the energy-information efficiencies of both systems are given, taking into quantum state control account, and the Fano factor of PCS which corresponds to the same performance to the ideal QCCS is given. In the latter case, the reliability functions of both systems are considered. As a result, it is shown that effects of error correcting code in the PCS are much larger than that in the QCCS. (Author abstract) 18 refs.

Yamazaki, Kouichi (Keio Univ, Yokohama, Jpn); Hirota, Osamu; Nakagawa, Masao. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 9 Sep 1987 p 835-840.

**073499 OPTISCHER UEBERLAGERUNGSEMPFANG - EINE UEBERSICHT.** [Coherent Optical Transmission - a General View]. In contrast to conventional optical direct receivers, coherent optical receivers enable a basically novel scheme for optical transmission techniques. By evaluating until now almost neglected coherence properties of light sources, it is possible to increase the receiver sensitivity of an optical transmission link up to a factor of 1000, which enables a drastic increase of the repeater spacing. Furthermore, it is possible to introduce coherent frequency division multiplexing similar to the well-known broadcasting techniques. This allows a substantial improvement of the transmission capacity in future optical transmission systems. In German. 38 refs.

Strobel, Otto (Standard Elektrik Lorenz AG, Stuttgart, West Ger); Schmuck, Harald. *Frequenz* v 41 n 8 Aug 1987 p 201-208.

**073500 60-CHANNEL FM VIDEO SUBCARRIER MULTIPLEXED OPTICAL COMMUNICATION SYSTEM.** A subcarrier multiplexed (SCM) optical communication system is described which transmits 60 frequency-modulated (FM) video channels over 18 km of single-mode fibre with a 56db weighted SNR. (Author abstract) 9 refs.

Olshansky, R. (GTE Lab, Waltham, MA, USA); Lanzisera, V.A. *Electron Lett* v 23 n 22 Oct 22 1987 p 1196-1198.

**073501 2.2-Gbit/s TRANSMISSION WITH A 1550-nm DFB LASER.** A 2.2-Gbit/s optical transmission system, based on 1550-nm DFB lasers and fast PIN photodiodes, has been developed and produced at the Research Institute of the Deutsche Bundespost. The electronic circuitry consists of fast GaAs integrated components. A transmission experiment made on a 60 km long standard monomode fiber with a bit error rate of better than  $10^{-10}$  showed that such a system can be used to upgrade the transmission capacity of already installed fiber lines with regenerator spacings of 36 km. (Author abstract) 8 refs.

Hein, Bernhard (Deutsche Bundespost, West Ger). *Frequenz* v 41 n 9 Sep 1987 p 225-227.

**073502 CONTRIBUTION OF RESONANCE MEDIUM AMPLITUDE AND PHASE MODULATION TO THE EFFECTIVENESS OF PHASE CONJUGATION BY DEGENERATE FOUR-WAVE MIXING.** The contribution of amplitude and phase modulation to the energetic efficiency of wavefront conjugation (WFC) under degenerate four-wave mixing is studied in resonant media simulated by a two- or a three-level scheme. It is shown that a WFC-mirror of reflectivity  $R$  higher than unity may be achieved only in the presence of the medium phase modulation. Optimum conditions for obtaining high-efficiency ( $R > 1$ ) WFC are defined. (Author abstract) 18 refs.

Kabanov, V.V. (BSSR Acad of Sciences, Minsk, USSR);

Rubanov, A.S.; Tolstik, A.L.; Chaley, A.V. *Opt Quantum Electron* v 19 n 6 Nov 1987 p 351-359.

**073503 RAY PROPAGATION AND COMPRESSION IN A STRICTLY ADIABATIC TAPER.** In this paper we construct the exact ray paths for a strictly adiabatic taper. Ray invariants are given and explicit formulae for the components of the ray path are found. We investigate the characteristics of the bound and leaky rays and compare them with the behavior of the exact bound and radiating modal fields. The compression of rays within the taper is discussed from the viewpoint of concentrator theory. (Author abstract) 14 refs.

Bertlone, Derek (Australian Natl Univ, Canberra, Aust). *Opt Quantum Electron* v 19 n 6 Nov 1987 p 361-375.

**073504 FDDI AND INTEGRATED PACKAGING CAST NEW LIGHT ON FUTURE OF FIBEROPTICS.** Within the last several years, the use of fiberoptic technology for certain communications-oriented applications has gone from being an alternative to a necessity. From its widespread use in telecommunications, the technology is rapidly being propelled into data communications applications within and between computers. The main topics are state of the art in fiberoptic technology and technology evolution, system components, and applications and standards.

Barron, Janet J. (Computer Design, Littleton, MA, USA). *Comput Des* v 27 n 2 Jan 15 1988 p 46, 48-50, 52.

**073505 OPTICAL COMPUTING.** In principle, optical fibers can carry signals with bandwidth in excess of one terahertz over a 1 km distance. In practice, however, the bandwidth of fiber optic communication systems is much less than this because of the bandwidth restrictions of optoelectronic interfaces and electronics for signal processing. This is evident in three related types of fiber optic communication systems: a simple point-to-point fiber optic link, a fiber optic network and a photonic switch. In each case, an electronic or optoelectronic bottleneck exists that is unrelated to the fiber's transmission capacity.

Anon. *Photonics Spectra* v 22 n 1 Jan 1988 p 107-108, 110.

**073506 TIME CHARACTERISTICS OF AN OPTICAL SIGNAL IN A COMMUNICATIONS CHANNEL WITH SCATTERING.** The scattering processes that accompany the propagation of light pulses in open information channels lead to time blurring of a signal. Here in a direct channel (the optical axis of the radiator is directed toward the receiver) the time blurring of a pulse results from the influence of multiply scattered radiation; in over-the-horizon communications channels, where information is transmitted precisely through scattering, the principal contribution to time blurring is introduced by singly scattered radiation. 8 refs.

Sinyavskii, A.V. *Radioelectron Commun Syst* v 30 n 7 1987 p 84-86.

**073507 TERABIT LIGHTWAVE NETWORKS: THE MULTIHOPE APPROACH.** For multiuser communications networks, lightwave technology offers the potential to supply a pool of capacity- to be shared among users - far above that provided by any alternative technology. However, the bandwidth limitation of the electro-optic converters needed to attach each user to the optical medium prevents any one user from accessing more than a tiny fraction of the overall capacity. This paper discusses the problems with conventional approaches for tapping the capacity contained within the optical communications band. It then proposes a new network architecture that permits tapping lightwave's vast capacity potential without requiring a technological breakthrough. With this approach, it becomes possible to create networks that offer hundreds of thousands of gigabits-per-second total capacity, to be shared among users, each limited to a peak rate of 1Gb/s. (Author abstract) 12 refs.

Acampora, Anthony S. (AT&T, Bell Lab, Holmdel, NJ, USA); Karol, Mark J.; Hluchyj, Michael G. *AT&T Tech*

*J* v 66 n 6 Nov-Dec 1987 p 21-34.

**073508 AUTOMATIC OPTICAL FIBRE BREAK LOCATION SCHEME FOR DUPLEX AND DUPLEX TRANSMISSION SYSTEMS.** The continued trend towards longer reach optical systems for both terrestrial and undersea applications is posing significant problems for fiber break location using conventional optical time domain reflectometry (OTDR) techniques. In the case of single fiber working with duplex or simplex systems it can be shown that this can, to varying degrees of accuracy, be achieved automatically by observing the nature of data arrival at the terminal stations. (Author abstract) 3 refs.

Rosher, P.A.; Fenning, S.C.; Cochrane, P.; Hunwicks, A.R. *Br Telecom Technol J* v 6 n 1 Jan 1988 p 54-59.

**073509 IMPLICATION OF VERY WIDE FIBER BANDWIDTH FOR NETWORK ARCHITECTURE.** The basic premise of this article is that at some point in the future all the transmission facilities of the public (telephone) network will be fiber-optic, i.e., end-to-end fiber connectivity will be provided to each subscriber. With the advent of coherent transmission systems the available bandwidth will become enormous, and thus the question we address is: given the availability of 'infinite' bandwidth to every subscriber in the relatively near future, what does this imply for the network architecture? Having discussed advantages and disadvantages of architectures based on different switching technologies, we conclude that an architecture based on circuit-switched, fixed-bandwidth channels for the transport of user information is the most appropriate for a network in which there are no constraints on the transmission bandwidth. The standard channel capacity should be determined by the service having the greatest bandwidth requirement. (Edited author abstract) 13 refs.

O'Reilly, Peter (GTE Lab Inc, Waltham, MA, USA). *Fiber Integr Opt* v 7 n 2 1988 p 159-171.

**073510 HIGHSPEED OPTICAL BUS AND ITS DESIGN.** In a large scale multiprocessor system, a bus which has large communication bandwidth is necessary for an information exchange among elements. For this purpose, authors have developed a bus system which does not use electric transmission through wire but uses optical transmission with a cylindrical mirror, the broadcasting optical bus. This paper presents the principle and design method of the broadcasting optical bus. (Edited author abstract) In Japanese. 12 refs.

Tajima, H.; Suzuki, M.; Hamazaki, Y.; Sanechika, N.; Okada, Y.; Tamura, K. *Denshi Gijutsu Sogo Kenkyusho Iho* v 52 n 1 1988 p 29-46.

**073511 FIBRES, PHOTONS AND THE FUTURE.** The optical fibre transmission systems enjoying widespread application today are very simple in form and are basically limited to transmitting information over large distances. The electrical information, in whatever form it is available, is fed into a suitable transducer, which could be a light-emitting diode or a semiconductor laser, to produce a modulated optical output which is launched into the optical fibre. The optical part of the system is rather simple and primitive, consisting of a light source, fibre transmission line and a detector. The bandwidth available depends on details of the fibre structure. The launched beam normally comprises rays at all angles within the acceptance cone, with the result that the geometrical path travelled by a ray depends on its angle to the axis. The effect of multipath, or multimode, dispersion can be greatly reduced by introducing an appropriate variation of refractive index in the core. These are discussed in the paper, along with optical fibre cables, optical signal processing, fibre lasers, and other aspects of the subject.

Gambling, Professor. *J Soc Eng (London)* v 78 n 4 1987 p 15-37.



**073512 DIGITALE UEBERTRAGUNG VON ANALOGSIGNALEN UEBER LWL-STRECKEN.** [Digital Transmission of Analog Signals over Optical Waveguides]. The advantages of using optical fibers for signal transmission over long distances are pointed out, particularly the low level of noise and interference. A practical realization is described for the transmission of two channels in the form of digital data at 8 bit resolution using a module. 3 refs. In German.

Goettlicher, Gerhard; Bender, Rolf; Selb, Michael. *Elektronik* v 37 n 1 Jan 8 1988 p 64-68.

**073513 OPTICAL PAM-TO-PDM CONVERSION: AN APPLICATION OF OPTICAL CRITICAL SLOWING-DOWN EFFECT.** In this paper, a new function that converts optical pulse amplitude modulation (PAM) to light pulse duration modulation (PDM) for a bistable optical system is proposed and observed experimentally. This PAM-to-PDM conversion is based on the optical critical slowing-down effect. (Author abstract) 7 refs. In Chinese.

Zhong, Lichen (Tsinghua Univ, Beijing, China); Guo, Yili. *Guangxue Xuebao* v 8 n 4 Apr 1988 p 374-378.

**073514 CROSSTALK IN A TWO-CHANNEL COHERENT FIBRE-OPTIC ASK SYSTEM USING AN OPTICAL AMPLIFIER AND NON-NEGLECTIBLE LINEWIDTH LASERS.** We present measurements of crosstalk penalties in a two-channel ASK system using 1.55  $\mu\text{m}$  DFB lasers and a semiconductor laser amplifier. The amplifier was operated well below gain saturation. No additional receiver sensitivity penalty due to the amplifier was observed for single channel operation. However, the additional crosstalk in the amplifier required a 10% increase of the channel spacing compared to the spacing in the nonamplifier system. (Author abstract) 8 refs.

Park, Y.K. (AT&T Bell Lab, Allentown, PA, USA); Granlund, S.W.; Tzeng, L.D.; Olsson, N.A.; Dutta, N.K. *Electron Lett* v 24 n 8 Apr 1988 p 475-477.

**073515 565-MBIT/S FIBER-OPTIC SYSTEMS FOR THE LONG HAUL.** The installation of fiber-optic transmission systems operating at high bit rates to upgrade long-haul routes in national and international telecommunication networks is proceeding on-schedule. Siemens has installed and handed over a number of its LA565LWL systems for the transmission of 565-Mbit/s signals. The authors describe the 565-Mbit/s fiber-optic equipment installed and give the first results of the function and performance tests performed on the Karlsruhe-Stuttgart route. (Author abstract) 3 refs.

Frech, Ludwig (Siemens AG, Munich, West Ger); Grallert, Hans-Joachim. *Telecom Rep* v 11 n 2 Mar-Apr 1988 p 54-57.

**073516 SANDS OF TIME.** The short article reviews the history of fiber optic communication developments and outlines the current activities of British Telecom in this area. They include manufacture of optoelectronic components, drastic reduction in repeaters, synchronous multiplexing, and a totally passive optical fiber system development.

Anon. *Comput Bull (London 1986)* v 4 pt 2 Jun 1988 p 9.

**073517 MICROWAVE-MULTIPLEXED WIDE-BAND LIGHTWAVE SYSTEMS USING OPTICAL AMPLIFIERS FOR SUBSCRIBER DISTRIBUTION.** A lightwave systems analysis shows that microwave-multiplexed wideband services can be distributed to large numbers of subscribers by using optically amplified multiplexed lightwave distribution networks. (Author abstract).

Olshansky, R. (GTE Lab Inc, Waltham, MA, USA); Eichen, E. *Electron Lett* v 24 n 15 Jul 21 1988 p 922-923.

**073518 SYSEME DE TRANSMISSION OPTIQUE ATMOSPHERIQUE A 0,8  $\mu\text{m}$ .** [0.8  $\mu\text{m}$  Optical Atmospheric Transmission System]. A 0.8  $\mu\text{m}$  optical atmo-

spheric system for video and sound transmission is described. After a brief summary on the propagation medium, system specifications are considered. The different parameters involved in the constitution of the system are examined before its description. (Edited author abstract). 3 Refs. In French.

Bordas, Michel (CILAS-ALCATEL, Marcousis, Fr); Delaplanche, Hugues. *Onde Electr* v 68 n 2 Feb 1988 p 62-68.

**073519 AVAILABILITY REQUIREMENT FOR FIBER OPTIC TRANSPORT SYSTEMS IN DISTRIBUTION FEEDER APPLICATIONS.** This paper contains a discussion of Bellcore's proposed channel availability requirement for fiber optic transport systems used in distribution feeder applications. A representative model of the distribution network is first constructed which includes a high capacity fiber optic system running to a distribution hub. An overall availability requirement, consistent with present availability requirements, is applied to this model. The allocation to the fiber system is determined by truncation of the current interface channel availability requirement which is prorated with distance. Further allocation of downtime to the electronic hardware reliability failures yields an objective that can be directly compared with the results of electronic hardware reliability models. This requirement is now included in Bellcore's proposed 'Generic Reliability Assurance Requirements for Fiber Optic Transport Systems.' (Author abstract). 7 Refs.

Lewin, B.R. (Bell Communications Research, Red Bank, NJ, USA). *Fiber Integr Opt* v 7 n 3 1988 p 197-204.

**073520 WAVEFORM DISTORTION EVALUATION FOR OPTICAL CPFSK HETERODYNE TRANSMISSION.** Waveform distortion of a continuous-phase frequency-shift keyed (FSK) signal due to fiber chromatic dispersion is measured. The transmission spacing is estimated to be 100 km at 5 Gb/s with 1.55- $\mu\text{m}$  wavelength. The results of a 2-Gb/s optical CPFSK heterodyne detection transmission experiment is reported. Since there is no chirping degradation, it is possible to transmit the signal through a 200-km single-mode fiber. 4 refs.

Iwashita, Katsushi (NTT, Yokosuka, Jpn); Takachio, Noboru. *J Lightwave Technol* v LT-5 n 9 Sep 1987, Opt Fiber Conf/Sixth Biannual Int Conf on Integr Opt and Opt Fiber Commun, Reno, NV, USA, Jan 19-22 1987 p 1188-1191.

**073521 TECHNIQUES FOR MULTIGIGABIT COHERENT OPTICAL TRANSMISSION.** It has been anticipated that the main roles for coherent optical techniques will be to provide increased capacity both for long-haul transmission and wideband signal distribution. This could be achieved by the combination of high-data-rate transmission and fine-grain wavelength-division multiplexing. To this end, heterodyne detection experiments have recently been extended into the gigabit regime, but difficulties not present at lower data rates have been encountered. A range of technical solutions to these problems are discussed, including broadband receivers, homodyne detection, and phase-diversity reception, and the current status of each of these is reviewed. 59 refs.

Smith, David W. (British Telecom, Ipswich, Engl). *J Lightwave Technol* v LT-5 n 10 p 1466-1478.

**073522 LONG-DISTANCE GIGABIT-RANGE OPTICAL FIBER TRANSMISSION EXPERIMENTS EMPLOYING DFB-LD'S AND INGAAS-APD'S.** High-speed and long-distance transmission characteristics have been examined at 1.2, 2, and 4 Gb/s using mesa structure DFB-DC-PBH LD (laser diode) transmitters and planar InGaAs APD (avalanche photodiode) receivers. High receiver sensitivities, -40 dBm at 1.2 Gb/s, -37.4 dBm at 2 Gb/s, and -32.4 dBm at 4 Gb/s, have been obtained with high-speed and low-noise InGaAs APD/FET receiver circuits. Long-span transmissions, 1.2-Gb/s over 170 km, 2-Gb/s over 141 km, and 4-Gb/s over 120

km at 1.55  $\mu\text{m}$ , and 4-Gb/s over 74 km at 1.3  $\mu\text{m}$ , have been performed. Power penalties caused by the LD wavelength chirping in the 1.5- $\mu\text{m}$  wavelength region and error-rate flooring caused by the LD side-mode oscillation in the 1.3- $\mu\text{m}$  wavelength region are discussed. 18 refs.

Shikada, Minoru (NEC, Kawasaki, Jpn); Fujita, Sadao; Henmi, Naoya; Takano, Isamu; Mito, Ikuro; Taguchi, Kenkou; Minemura, Kouichi. *J Lightwave Technol* v LT-5 n 10 p 1488-1497.

**073523 OVERVIEW OF VERY HIGH CAPACITY TRANSMISSION TECHNOLOGY FOR NTT NETWORKS.** A description is given of very-high-capacity optical transmission system technology that is useful for long-haul trunk lines and has been used to implement a Gb/s transmission system. The various devices and circuits required for the development of such systems are examined. Future research areas and trends in advanced lightwave communication systems are discussed. 14 refs.

Nakagawa, Kiyoshi (NTT, Yokosuka, Jpn); Nosu, Kiyoshi. *J Lightwave Technol* v LT-5 n 10 p 1498-1504.

**073524 ANALYSIS OF CHIRP POWER PENALTY IN 1.55- $\mu\text{m}$  DFB-LD HIGH-SPEED OPTICAL FIBER TRANSMISSION SYSTEMS.** In a 1.55- $\mu\text{m}$  high-speed transmission system using a distributed-feedback laser diode (DFB LD), the chirp effect in the LD is a factor limiting transmission span length. In order to evaluate the chirp effect, expressions for the chirp power penalty are derived for two cases: the chirp occurring in both edges of the pulse and in the whole time of the pulse. The calculations based on the results of the LD chirp measurement predict that the chirp effect will be significant above 2 Gb/s even if the zero dispersion wavelength of fiber is shifted to the 1.55- $\mu\text{m}$  band. Transmission experiments performed at 1.2 Gb/s and 2.4 Gb/s verify this prediction. 18 refs.

Yamamoto, Shu (KDD, Tokyo, Jpn); Kuwazuri, Masakuni; Wakabayashi, Hiroharu; Iwamoto, Yoshinao. *J Lightwave Technol* v LT-5 n 10 p 1518-1524.

**073525 HIGH-SPEED PICOSECOND OPTICAL PULSE COMPRESSION FROM GAIN-SWITCHED 1.3- $\mu\text{m}$  DISTRIBUTED FEEDBACK-LASER DIODE (DFB-LD) THROUGH HIGHLY DISPERSIVE SINGLE-MODE FIBER.** Picosecond optical pulse compression characteristics of chirped pulses from gain-switched distributed-feedback laser diodes (DFB-LD) transmitting through highly dispersive media are studied theoretically and experimentally. It is clarified theoretically that gain-switched chirped pulses can be compressed to about a 0.7-time-bandwidth product by normal dispersion of the dispersive media and that the optimum dispersion value to obtain a minimum compressed pulse is proportional to the square of original pulsewidth. Through a dispersion-shifted single-mode fiber with -48 ps/nm normal dispersion at a 1.3- $\mu\text{m}$  wavelength, gain-switched 30-ps (full width half maximum) pulses from a directly modulated 1.3- $\mu\text{m}$  DFB-LD at a 4.4-GHz repetition rate have been successfully compressed to 6.4-ps optical pulses with a 0.8 time-bandwidth product. Experimental results agree with the theoretical analysis. 42 refs.

Takada, Atsushi (NTT, Kanagawa, Jpn); Sugie, Toshio; Saruwatari, Masatoshi. *J Lightwave Technol* v LT-5 n 10 p 1525-1533.

**073526 THEORETICAL PERFORMANCE OF DIRECT DETECTION OPTICAL COMMUNICATION WITH ALGAS LASER TRANSMITTERS, AVALANCHE PHOTODIODE DETECTORS, AND COLOR-CODED PPM SIGNALING.** Theoretical performance characteristics are presented for a direct detection optical communication system that has peak-power-limited laser diode transmitters and avalanche photodiode photodetectors. The signal format consists of the transmission of a group of L binary source digits as a single light pulse at one of N nonoverlapping optical center frequencies (colors) in one of M possible time slots.



The system achieves a given received symbol error probability at lower peak signal intensities with a less complicated receiver structure than can be obtained with an ordinary pulse position modulation system of the same alphabet size and source data rate. 31 refs.

Davidson, Frederic M. (Johns Hopkins Univ, Baltimore, MD, USA); Bayoumi, Mohamed. *J Lightwave Technol* v LT-5 n 11 p 1574-1583.

**073527 MAXIMUM ENTROPY METHOD FOR LIGHTWAVE SYSTEM PERFORMANCE EVALUATION.** A constrained maximum entropy criterion is used to approximate the cumulative distribution function of the photocurrent generated by an avalanche photodiode in response to an incident information-bearing optical signal. The approximate distribution, derived from known moments of the photocurrent, is used to evaluate the probability of error in direct detection lightwave systems. In this application, the results of the maximum entropy method are equivalent to those of a Gauss quadrature rule method. However the maximum entropy method exhibits a relative efficiency in terms of the required number of moments of the photocurrent. 15 refs.

Cartledge, John C. (Queen's Univ, Kingston, Ont, Can). *J Lightwave Technol* v LT-5 n 11 p 1613-1617.

**073528 IMPROVED ERROR PROBABILITY EVALUATION METHODS FOR DIRECT DETECTION OPTICAL COMMUNICATION SYSTEMS.** The problem of average error probability evaluation for direct-detection binary optical communications in the presence of avalanche gain, intersymbol interference, and colored additive Gaussian noise is considered. Tight new upper and lower bounds, together with a modified Gaussian quadrature rule based on approximate moments, are derived and evaluated. The bounds are found to be much tighter than the Chernoff bound though only slightly more complex to evaluate, and can be used as approximations to the error probability in most cases of practical interest. Taken together the new bounds and the modified Gaussian quadrature rule form a comprehensive set of performance evaluation tools offering a judicious balance between complexity and accuracy. 33 refs.

O'Reilly, John J. (Univ Coll of North Wales, Gwynedd, Wales); da Rocha, Jose R.F. *IEEE Trans Inf Theory* v IT-33 n 6 p 839-848.

**073529 SYSTEM DESIGN FOR OPTICAL PPM COMMUNICATIONS WITH DIODE COMBINING.** The most efficient way to encode laser diodes for maximum data rate is studied. Three different system architectures are considered, with combining achieved by dichroic mirrors operating in conjunction with a pulse-position-modulated (PPM) format. The basic criterion is to maximize the data rate with increasing number of diodes, while maintaining diode power constraints and decoding bit error probability. The three systems are: (1) power combining into a single pulse, followed by PPM encoding; (2) parallel channels, in which each diode is separately PPM encoded; and (3) color coding, in which diodes are encoded over a common wavelength-time slot alphabet. Data rate equations are presented as a function of the number of diodes, mirror combining losses, PPM alphabet size, and the operating optical signal-to-noise ratio. 14 refs.

Gagliardi, Robert M. (Univ of Southern California, Los Angeles, CA, USA); Kim, Youngky. *IEEE Trans Commun* v 36 n 2 Feb 1988 p 186-190.

**073530 CIRCULATING LOOP EXPERIMENTAL TECHNIQUE TO SIMULATE THE JITTER ACCUMULATION OF A CHAIN OF FIBER-OPTIC REGENERATORS.** A circulating-loop experimental technique to simulate the jitter accumulation of a chain of fiber-optic regenerators is described. This technique allows system designers to establish the jitter accumulation characteristics of systems without the need for many test regenerators. An analytic description of how well the loop technique simulates a chain of identical fiber-optic regenerators is presented along with a comparison of calculated

and simulated jitter accumulation. 15 refs.

Trischitta, Patrick R. (AT&T, Holmdel, NJ, USA); Sannuti, Peddappaiah; Chamzas, Christodoulos. *IEEE Trans Commun* v 36 n 2 Feb 1988 p 205-213.

**073531 ADVANCED COHERENT LIGHTWAVE TECHNOLOGIES.** The present state of optical coherent communication technologies, covering optical heterodyne/homodyne detection and optical frequency division multiplexing (optical FDM), is discussed. Included is a description of the development history of coherent lightwave communication technology followed by a discussion of heterodyne detection for future long-haul high-speed systems. A description of optical coherent transmission systems using heterodyne/homodyne detection is presented along with a review of optical FDM technology and its applications. Future trends are examined. 8 refs.

Nosu, Kiyoshi (NTT, Yokosuka, Jpn). *IEEE Commun Mag* v 6 n 2 Feb 1988 p 15-21.

**073532 FACTORS AFFECTING FIBER-OPTIC TRANSMISSION QUALITY.** Important factors related to further improvement and extension of optical-fiber transmission system performance are discussed, focusing on repeater spacing, data rate, and optical frequency utility. Relevant progress in optical-fiber loss, semiconductor laser properties (such as output power, spectrum, and modulation speed), low-noise broad-band photodetectors, and optical-frequency multiplexers/demultiplexers are reviewed. 61 refs.

Kimura, Tatsuya (NTT, Tokyo, Jpn). *J Lightwave Technol* v 6 n 5 May 1988 p 611-619.

**073533 INFLUENCE OF DIRECTLY MODULATED DFB LD SUB-MODE OSCILLATION ON LONG-SPAN TRANSMISSION SYSTEM.** Error-rate floors have been observed in several long-span transmission experiments at 500 Mb/s, using 1.5- $\mu$ m distributed-feedback laser diodes (DFB LDs) and 1.3- $\mu$ m zero dispersion optical fibers. It is proposed that for the threshold gain difference between main and submode (for DFB LDs),  $\Delta\alpha$  is a good parameter to specify the submode oscillation characteristics. It is experimentally and theoretically confirmed that the threshold gain difference  $\Delta\alpha$  must be greater than 5-6 cm<sup>-1</sup>, to avoid the error rate floor at 500 Mb/s. It was also confirmed that  $\lambda/4$  phase-shifted DFB LDs can easily satisfy this condition. 9 refs.

Henmi, Naoya (Opto-Electron Research Lab, Kawasaki, Jpn); Koizumi, Yoshihiro; Yamaguchi, Masayuki; Shikada, Minoru; Mito, Ikuro. *J Lightwave Technol* v 6 n 5 May 1988 p 636-642.

**073534 FORWARD ERROR CORRECTION IN DISPERSION-LIMITED LIGHTWAVE SYSTEMS.** A rate 0.964 forward error correcting (FEC) code is integrated into the low-speed tributaries of a 565-Mb/s lightwave system as an exploratory system design approach toward relaxing requirements on laser sources in dispersion-limited operation. Experimental and simulation studies show that FEC can increase allowed spectral width up to 70% and wavelength offset up to 60%, at 565 and 1200 Mb/s. FEC is shown to qualify a mode-hopping, nearly single-mode laser for use at 1200 Mb/s, under conditions that otherwise prohibit use of this laser due to a severe error-rate floor. By virtually removing error rate floors, regardless of their cause, FEC is shown to provide an increasing advantage in conditions of greater degradation and to be effective against mode partition noise (MPN), mode jumping, and reflection impairments. The experimental FEC code is implemented in a standard gate array. The FEC code is described and its performance is analyzed. A new system design strategy is suggested for low-cost gigabit lightwave systems using FEC. 26 refs.

Grover, Wayne D. (Alberta Telecommunications Research Cent, Edmonton, Alberta, Can). *J Lightwave Technol* v 6 n 5 May 1988 p 643-654.

**073535 BAUD RATE RESPONSE: CHARACTER-**

**IZING MODAL DISPERSION FOR DIGITAL FIBER OPTIC SYSTEMS.** A method of characterizing modal dispersion in optical fibers, for baseband digital applications, is developed. Pulse distortion due to modal dispersion is simulated using modal transfer functions and pseudorandom pulsetrains. The extent of the distortion at given baud rates is identified with eye diagrams. Received optical power penalties are calculated from eye diagrams for a spectrum of baud rates, resulting in a penalty-versus-baud rate function called a baud rate response (BRR). Three useful parameters are derived from the BRR. The BRR magnitude parameter and shape parameter are used to accurately calculate a fiber's modal-dispersion power penalty for any given baud rate. The maximum baud-rate length product provides a mechanism for specifying modal dispersion quality among fibers. Together, these three parameters provide a means of characterizing modal dispersion for digital applications. The BRR method appears to be more accurate, and provides greater insight into fiber performance, than conventional methods. 10 refs.

Harris, Dan O. (North Carolina State Univ, Raleigh, NC, USA); Jones, J. Richard. *J Lightwave Technol* v 6 n 5 May 1988 p 668-677.

**073536 NEW METHOD ANALYZING EYE PATTERNS AND ITS APPLICATION TO HIGH-SPEED OPTICAL TRANSMISSION SYSTEMS.** An advanced method of analyzing eye patterns is proposed which plots the eye pattern as a function of the error rate. This eye-pattern analysis method can reveal low-probability phenomena accurately and presents information on the eye margin. The method is applied to high-speed optical-transmission systems and its usefulness is confirmed. Degradation of eye opening due to noise and intersymbol interference is investigated quantitatively using the 10<sup>-10</sup> BER eye. An automatic gain-control system is evaluated from a viewpoint of eye margin, and a gain control system having an improved eye margin performance is proposed. Low-probability abnormal phenomena, such as turn-on fluctuations and mode partitioning in directly modulated distributed feedback (DFB) lasers, are observed using this method. Transmission characteristics for a directly modulated DFB laser and an externally modulated DFB laser using a Ti:LiNbO<sub>3</sub> Mach-Zehnder modulator are also investigated at a bit rate of 4 Gb/s. It was discussed that there is no degradation for the 10<sup>-11</sup> BER eye opening after transmission over 580-ps/nm dispersive fiber, using external modulation. The eye margin design guide using the 10<sup>-11</sup> BER eye is also presented. 12 refs.

Nishimoto, Hiroshi (Fujitsu Lab Ltd, Kawasaki, Jpn); Okiyama, Tadashi; Kuwata, Naoki; Arai, Yasunari; Miyauchi, Akira; Touge, Takashi. *J Lightwave Technol* v 6 n 5 May 1988 p 678-685.

**073537 CONSIDERATION OF FACTORS AFFECTING FUTURE COHERENT LIGHTWAVE COMMUNICATION SYSTEMS.** The performance limitations of coherent lightwave communication technologies are examined. Their practical device requirements, with emphasis on optical heterodyne/homodyne detection and optical frequency-division multiplexing (optical FDM) are also discussed. 29 refs.

Nosu, Kiyoshi (NTT, Yokosuka, Jpn); Iwashita, Katsushi. *J Lightwave Technol* v 6 n 5 May 1988 p 686-694.

**073538 INPUT POWER LIMITS OF SINGLE-MODE OPTICAL FIBERS DUE TO STIMULATED BRILLOUIN SCATTERING IN OPTICAL COMMUNICATION SYSTEMS.** Stimulated Brillouin scattering (SBS) limits the optical power that can be transmitted through a single-mode fiber in long-distance optical communication systems, the authors have investigated SBS gain and threshold characteristics with amplitude-shift-keying (ASK), frequency-shift-keying (FSK), and phase-shift-keying (PSK) modulated lights, to estimate the input power limitation set by SBS. It was shown that maximum fiber-input powers or the SBS thresholds for fixed-pattern (1010 ...) ASK, FSK, and PSK modu-



lated lights are 2, 4, and 2.5 times higher, respectively, than the threshold for unmodulated light. Theoretical predictions were experimentally verified by SBS gain measurements with FSK and PSK modulated lights. The first direct observation of SBS with FSK modulated light pumping is also described. 25 refs.

Aoki, Yasuhiro (NEC, Kawasaki, Jpn); Tajima, Kazuhito; Mito, Ikuo. *J Lightwave Technol* v 6 n 5 May 1988 p 710-719.

**073539 SIGNAL PROCESSING FOR AN OPTICAL WIDE BAND DATA TRANSMISSION SYSTEM.** The signal processing for an optical wideband transmission system using gallium arsenide (GaAs) digital integrated circuits and optical fibers has been investigated. Multiplexing, coding, synchronization, demultiplexing, and error checking at 780-Mb/s data rates are described. Data storage in memory for linking to a computer is also considered. The design uses available GaAs and silicon components. The reliability of GaAs components is discussed as well as the layout and thermal considerations required for a high-speed system. 7 refs.

Nakamura, M. (Lawrence Berkeley Lab, Berkeley, CA, USA); Leskovar, B.; Turko, B. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 197-204.

**073540 12TH EUROPEAN CONFERENCE ON OPTICAL COMMUNICATION: TECHNICAL DIGEST.** Proceedings incorporates 141 papers that are grouped into 28 sessions. These deal with: materials and processes of optical fibers; semiconductor lasers; fabrication and measurements of optical fibers; LED (light-emitting diodes); integrated optics; components and splices of optical fibers; special fibers; nonlinear optics in optical communications; optical bistability; polarization-preserving fibers; fiber components; optical amplification; measurements; photodiodes and photoreceivers; mid- and far-infrared fiber and systems, coherent optical systems technology; fiber-optic devices and architectures for applications; fiber sensor; switching; nonlinearities; and guided-wave multi/demultiplexers. Topics covered include: semiconductor diodes, glass fibers, single-mode fibers, interferometers, BHT lasers, optical couples and isolators, optical links, filters, connectors, injection lasers, submarine optical cables, monolithic circuitry, and subscriber loops. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10432 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Convention of Natl Soc of Electrical Engineers of Western Europe). *12th Eur Conf on Opt Commun - Tech Digest, Barcelona, Spain, Sep 22-25 1986* Publ by Telefonica, Spain, 1986 3 vol, 722p.

**073541 OFC/IOOC'87 CONFERENCE.** This issue contains 30 conference papers dealing with various aspects of optical transmission and communication systems based on optical fibers and cables, passive and active components, optical switching and midinfrared fiber technology. Considered are integrated optics and optoelectronic devices, coherent systems, fiber fabrication, and various light sources including laser diodes. National and international standards are also discussed. All papers are abstracted and indexed separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10623 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Kaiser, Peter (Ed.) (Bell Communications Research, Red Bank, NJ, USA); Schultz, Peter (Ed.). *J Lightwave Technol* v LT-5 n 9 Sep 1987, OFC/IOOC'87 Conf, Reno, NV, USA, Jan 19-22 1987 p 1139-1332.

**073542 IOOC-ECOC '85: 5TH INTERNATIONAL CONFERENCE ON INTEGRATED OPTICS AND OPTICAL FIBRE COMMUNICATION - 11TH EUROPEAN CONFERENCE ON OPTICAL COMMUNICATION.** This three-volume conference proceedings contains 248 papers covering the following major sub-

jects: new materials and processes DFB laser diodes, integrated optical waveguide fabrication, fiber fabrication, DFB-DBR laser diodes, optical waveguide devices, polarization in single mode fibers, optical amplifiers, integrated optical waveguide components dispersion optimized fibers, laser diodes, nonlinear and nonreciprocal integrated optical devices, fiber characterization, system technology, optoelectronic integrated circuits, single mode fiber properties, coherent optical systems, waveguide optical switches, optical cables, coherent transmission technology, optical interconnects and switching, wideband subscriber loop, multiquantum well structures, environmental effects and fiber coating, single mode fibers in subscriber loop, photodetectors, sensors and special applications, single mode systems, linewidth in single mode lasers, high speed systems, linewidth in single mode lasers, high speed systems, frequency control of laser diodes, noise in semiconductor lasers, future optical communications, optical networks, advanced laser diode structures, coupling and WDM devices and subscriber loop and LAN technology. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10504 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Natl Soc of Electrical Engineers of Western Europe Convention). *IOOC-ECOC '85: 5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun, Venice, Italy, Oct 1-4 1985* Publ by Istituto Int delle Comunicazioni, Genoa, Italy, 1985 3 vol, 1217p.

**073543 HIGH FREQUENCY OPTICAL COMMUNICATIONS.** This conference proceedings contains 24 papers covering the subjects of optical systems and applications, integrated optical devices, photodetectors, light sources (lasers) and coherent communications. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10977 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Ramer, Glenn O. (Ed.) (Hughes Aircraft Co); Sierak, Paul (Ed.). *Proc SPIE Int Soc Opt Eng* v 716, High Freq Opt Commun, Cambridge, MA, USA, Sep 23-24 1986. Publ by SPIE, Bellingham, WA, USA, 1987 166p.

**073544 IOOC-ECOC '85 (5TH INTERNATIONAL CONFERENCE ON INTEGRATED OPTICS AND OPTICAL FIBRE COMMUNICATION - 11TH EUROPEAN CONFERENCE ON OPTICAL COMMUNICATION).** This conference proceedings contains 14 papers. The subjects covered include: optical fiber distribution networks, broadband services, wideband optical loops, design of an optical fiber LAN, optical cables, —optical island— in the Milano Fair, single-mode optical fibers, fast heterodyne interferometer for real-time fiber polarimetry, hydrogen-induced effects on optical cables, the effect of water vapor on refractive index in optical planar waveguides, and MCVD method with inner pressure control for optical fiber manufacturing. All papers are indexed and abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11313 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *CSELT Tech Rep* v 13 n 5 Oct 1985, IOOC-ECOC '85 (5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun), Venice, Italy, Oct 1-4 1985 p 267-330.

**073545 INTRODUCTION TO TECHNICAL PROGRAM.** First some relevant data concerning the Program of the Conference are reported. In the rest of the paper the technical content of the Conference is discussed, pointing out highlights, advances, new trends and emerging areas, that may experience major developments in future years. (Author abstract)

Costa, B. (CSELT, Turin, Italy). *CSELT Tech Rep* v 13 n 5 Oct 1985, IOOC-ECOC '85 (5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun), Venice, Italy, Oct 1-4 1985 p 275-278.

**Amplification** See RAMAN SCATTERING—Applications.

## Analysis

**073546 NEW POLARISATION-INSENSITIVE DETECTION TECHNIQUE FOR COHERENT OPTICAL FIBRE HETERODYNE COMMUNICATIONS.** A new technique for overcoming polarization-induced fading in coherent optical fiber communications is described. The technique generates two IFs, which fade in antiphase, by mixing the signal light with orthogonally polarized local oscillator modes which have been separated in the frequency domain. (Author abstract) 7 refs.

Kersey, A.D. (US Naval Research Lab, Washington, DC, USA); Yurek, A.M.; Dandridge, A.; Weller, J.F. *Electron Lett* v 23 n 18 Aug 27 1987 p 924-926.

**073547 POWER PENALTY IN BIT ERROR RATE DUE TO LIMITED TRANSMISSION BANDWIDTH.** Power penalties in bit error rate due to limited transmission bandwidth are studied theoretically and experimentally. For less than a 0.5 db penalty, a transmission bandwidth of 1.25 times the bit rate is required. If there are  $n$  components contributing equally to the transmission bandwidth, each of these components should have a bandwidth  $1.25/\sqrt{n}$  times the bit rate. (Author abstract) 4 refs.

Shen, T.M. (AT&T, Murray Hill, NJ, USA). *Electron Lett* v 23 n 18 Aug 27 1987 p 927-928.

**073548 EVALUATION OF CROSSTALK PENALTY IN MULTICHANNEL ASK HETERODYNE OPTICAL COMMUNICATION SYSTEMS.** The bit error rate (BER) of a two-channel ASK heterodyne lightwave system employing envelope detection is evaluated analytically. The result is used to calculate the power penalty resulting from intrachannel crosstalk. The theory predicts a minimum channel spacing of three times the bit rate if the design criterion is to keep the crosstalk penalty below 0.1 db. The minimum channel spacing increases to five times the bit rate for multichannel systems when crosstalk from the nearest neighbors on both sides is included. (Edited author abstract) 5 refs.

Agrawal, G.P. (AT&T, Murray Hill, NJ, USA). *Electron Lett* v 23 n 17 Aug 13 1987 p 906-908.

**073549 IMPROVEMENT OF POLARIZATION DIVERSITY METHOD FOR HETERODYNE/COHERENT OPTICAL TRANSMISSION SYSTEMS.** This letter proposes an improved polarization diversity method for heterodyne/coherent optical transmission systems. It is theoretically clarified that this method can reduce the noise caused by polarization fluctuations and can receive a binary FSK or PSK modulated signal with high sensitivity. (Author abstract) 11 refs.

Tsushima, Hideaki (Hitachi Ltd, Kokubunji, Jpn); Takasaki, Yoshitaka; Maeda, Minoru. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 7 Jul 1987 p 608-610.

**073550 OPTICAL HOMODYNE RECEIVER WITH A SIX-PORT FIBRE COUPLER.** The performance of a PSK optical homodyne system based on a six-port fiber coupler, which avoids the need for an optical 90° hybrid device, is determined. Depending on the actual receiver implementation using the coupler, the receiver sensitivity is shown to be about 0.5-3 db from ideal and local laser excess intensity noise can be cancelled. (Author abstract) 7 refs.

Stephens, T.D. (Telecom Australia Research Lab, Clayton, Aust); Nicholson, G. *Electron Lett* v 23 n 21 Oct 8 1987 p 1106-1108.

**073551 APPLICATION OF COHERENT OPTICAL TECHNIQUES TO BROADBAND NETWORKS.** The potential advantages of applying coherent optical fiber techniques to broadband networks are reviewed, and a



number of system types are described to illustrate the operating principles. Particular consideration is given to networks that rely on the use of optically tunable lasers either to define a source frequency or to select a channel from a frequency-multiplexed transmission using the heterodyne receiver technique. (Author abstract) 11 refs.

Hill, G.R. (British Telecom Research Lab, Ipswich, Engl); Stanley, I.W. *Opt Eng* v 26 n 4 Apr 1987 p 349-353.

**073552 CHIRP-INDUCED PENALTY IN OPTICAL FIBRE SYSTEMS.** Using the output light intensity and wavelength chirp waveforms obtained with a SPICE2 equivalent circuit laser model, together with a computer model for chirp-dispersion interaction, the chirp-induced power penalty is estimated. In contrast with previously published theoretical estimates, the results obtained show good agreement with reported experiments. (Author abstract) 7 refs.

O'Rielly, J.J. (Univ Coll of North Wales, Bangor, Wales); Silva, H.J.A. *Electron Lett* v 23 n 19 Sep 10 1987 p 992-993.

**073553 INTERMODULATION DISTORTION IN OPTICAL AMPLIFIERS FROM CARRIER-DENSITY MODULATION.** We present a theoretical model describing the generation of intermodulation products (IMPs) in semiconductor optical amplifiers by signal-induced carrier-density modulation. The IMPs depend strongly on the linewidth-enhancement factor and the ratio of output intensity to the saturation intensity of the amplifier. Calculation of the total intermodulation penalty for multichannel amplifier applications is possible using the expressions presented. (Author abstract) 8 refs.

Darcie, T.E. (AT&T Bell Lab, Holmdel, NJ, USA); Jopson, R.M.; Tkach, R.W. *Electron Lett* v 23 n 25 Dec 3 1987 p 1392-1394.

**073554 SIMPLE FORMULA FOR BIT-ERROR RATE IN OPTICAL HETERODYNE DPSK SYSTEMS EMPLOYING POLARISATION DIVERSITY.** A simple bit-error rate (BER) formula for DPSK optical heterodyne systems employing polarisation diversity is presented. It is shown by this formula that the power penalty at BER =  $10^{-9}$  owing to the polarisation diversity is only 0.4 db, showing good agreement with previous computer-simulation results. The effect of the laser phase noise can also be considered. (Author abstract) 6 refs.

Okoshi, T. (Univ of Tokyo, Tokyo, Jpn); Ishida, O.; Kikuchi, K. *Electron Lett* v 24 n 2 Jan 21 1988 p 120-122.

**073555 NONLINEAR INTERACTIONS IN OPTICAL AMPLIFIERS FOR MULTIFREQUENCY LIGHTWAVE SYSTEMS.** Nonlinear interactions that occur in an optical amplifier between the carrier density and multiple optical signals, are described using a small-signal analysis. In multifrequency lightwave systems with channel separations less than 1 GHz, the ratio of the signal power to the total intermodulation interference may be less than 25 db, for total output intensities 10 db below the amplifier saturation intensity. (Author abstract) 10 refs.

Darcie, T.E. (AT&T Bell Lab, Holmdel, NJ, USA); Jopson, R.M. *Electron Lett* v 24 n 10 May 12 1988 p 638-640.

**Applications** See ANTENNAS—Phased Arrays; COMPUTERS—Data Communication Equipment; ELECTRIC POWER SUPPLIES TO APPARATUS—Control.

## Australia

**073556 GENERAL FEATURES OF THE ROUTE.** The growing need for telecommunications services and the emerging of digital transmission as an economic preference are being satisfied to an increasing extent by the use of optical fibers. The first Australian intercapital route to employ this technique is the Melbourne-Canberra-Sydney route. This short article outlines the history of long distance telecommunication in Australia and gives a

general description of this latest optical communication project.

Reynolds, Rodney (Telecom Australia, Aust). *Telecommun J Aust* v 37 n 3 1987 p 3.

**073557 TELECOMMUNICATION REQUIREMENTS - THE DECISION ENVIRONMENT AND OUTCOMES.** Few technologies have gained acceptance and grown faster in sophistication and application than that of optical technology. The capacity times distance product of optical systems has been doubling each year and future upgradability is now estimated to be some 50 to 100 times that of today's systems. This however was not so clear early in the 1980s. The author describes the research studies which resulted in selection of optical fiber technology for the Australian national telecommunication infrastructure.

Burton, J.; Mount, R.; Nowotny, G. *Telecommun J Aust* v 37 n 3 1987 p 5-10.

**073558 PLANNING FOR THE DEVELOPMENT OF THE ROUTE.** In early 1984, a Telecom Planning Committee was set up to examine the options available for the next phase of development for the Melbourne-Sydney route. The Committee found that optical fiber cable equipped with high capacity digital systems operating at 140 Mbit/s and 565 Mbit/s provided the most economic and technologically appropriate solution. (Author abstract)

Burton, J.; Piltz, D. *Telecommun J Aust* v 37 n 3 1987 p 11-14.

**073559 SYSTEM DESIGN AND EQUIPMENT SPECIFICATION.** The system design of the Melbourne-Canberra-Sydney SMOF route took place over the period 1984 to 1987 during which dramatic advances in cable and equipment performance occurred. The final savings in reduced equipment quantities were substantial. The design stages are outlined. (Edited author abstract)

Dempsey, R.; Faulks, B. *Telecommun J Aust* v 37 n 3 1987 p 65-67.

## Computer Simulation

**073560 COMPUTER SIMULATION OF HIGH-BIT-RATE OPTICAL FIBER TRANSMISSION USING SINGLE-FREQUENCY LASERS.** Chirp-induced dispersion penalties in high-bit-rate optical fiber transmission are assessed using numerical integration of laser rate equations and a Fourier transform fiber dispersion routine. The roles of the imposed modulation waveform and laser design parameters are evaluated from computer generated eye diagrams and simple analytical observations. Consistent with experimental data, the authors find device-dependent optimum laser extinction ratios. In addition, they address the delicate balance between nonlinear chirp-induced dispersion penalties and the speed limitations imposed by linear current filtering on both the laser transmitter and the receiver. These considerations become increasingly important at higher bit rates such as 8 Gb/s. 11 refs.

Corvini, P.J. (AT&T Bell Lab, Holmdel, NJ, USA); Koch, Thomas L. *J Lightwave Technol* v LT-5 n 11 p 1591-1595.

**073561 CHROMATIC DISPERSION LIMITATIONS IN COHERENT LIGHTWAVE TRANSMISSION SYSTEMS.** Computer simulation is used to evaluate the chromatic dispersion limitations for both various coherent lightwave transmission systems and direct-detection on-off keying (OOK) systems. The results show that for a 2-dB dispersion penalty the maximum modulation rate ranges from 5 to 9 Gb/s for systems operating at 1.55  $\mu\text{m}$  with 15 ps/km-nm of chromatic dispersion and 100 km of fiber. The effect is less severe for OOK systems and most severe in coherent detection systems. Simulation results are in agreement with available experimental data. 13 refs.

Elrefaie, Aly F. (Bell Communications Research, Red

Bank, NJ, USA); Wagner, Richard E.; Atlas, Dogan A.; Daut, David G. *J Lightwave Technol* v 6 n 5 May 1988 p 704-709.

## Control

**073562 ENDLESS POLARISATION STATE MATCHING CONTROL EXPERIMENT USING TWO CONTROLLERS OF FINITE CONTROL RANGE.** The experimental results of a new, endless polarisation state matching (PSM) control scheme which requires only two finite control range controllers are presented. Only one controller is required to maintain PSM conditions. The second controller is only utilised during the reset procedure. The simplified control protocol can maintain PSM conditions even during resets. (Edited author abstract) 9 refs.

Mahon, C.J. (Philips Research Lab, Eindhoven, Neth); Khoe, G.D. *Electron Lett* v 23 n 23 Nov 5 1987 p 1234-1235.

## Costs

**073563 ECONOMIC IMPACT OF OPTICAL TRANSMISSION TECHNOLOGY ON WIDEBAND OPTICAL LOOPS.** Different structures of optical distribution network are presented in which optical fibres carry digital video signals originated by broadcast or interactive services. Several options are examined from a technical and economic point of view. (Author abstract) 1 ref.

De Bortoli, M. (CSELT, Turin, Italy); Moncalvo, A. *CSELT Tech Rep* v 13 n 5 Oct 1985, IOOC-ECOC '85 (5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun), Venice, Italy, Oct 1-4 1985 p 285-287.

## Design

**073564 700 Mbit/s PSK OPTICAL HOMODYNE SYSTEM WITH BALANCED PHASE LOCKED LOOP.** An optical PSK homodyne system has been established in the laboratory. The highest transmitted bit rate, limited by the BER measurement equipment, is 700 Mbit/s. The required number of effective photons per bit is 18, at a bit rate of 140 Mbit/s, and a BER of  $10^{-9}$ . The balanced optical phase locked loop shows high stability, even in a very noisy environment. (Author abstract) 4 refs.

Fischer, Georg (Technische Univ Muenchen, Munich, West Ger). *J Opt Commun* v 9 n 1 Mar 1988 p 27-28.

**073565 USING SPREAD-SPECTRUM IN A HIGH-CAPACITY FIBER-OPTIC LOCAL NETWORK.** A local fiber-optic communications network capable of supporting tens of thousands of simultaneous users, each requiring on the order of 10-Mb/s continuous data rate, is proposed. The system uses coherent optical techniques to fully utilize the vast bandwidth offered by single-mode optical fibers (tens of thousands of GHz) a spread-spectrum technique is used to circumvent the problem caused by the instabilities of present-day semiconductor lasers. These include difficulty in reliably setting a laser's frequency with an accuracy better than several hundred GHz, and phase noise in the laser output, which would otherwise result in excessive amounts of interference among the various users. The method proposed is a variant of code-division multiple access (CDMA) that is called random-carrier (RC) CDMA, since the modulated carriers can be assumed to be completely randomly placed in the available optical band. 14 refs.

Foschini, Gerard J. (AT&T Bell Lab, Holmdel, NJ, USA); Vannucci, Giovanni. *J Lightwave Technol* v 6 n 3 Mar 1988 p 370-379.

**Federal Republic of Germany** See TELECOMMUNICATION CABLES—Submarine.



**Industrial Applications** See OPTICAL FIBERS—Environmental Testing.

**Italy** See TELECOMMUNICATION SYSTEMS—Optimization.

**Laser Applications** See Also LASERS, SEMICONDUCTOR—Applications; LASERS, SEMICONDUCTOR—Resonators.

**073566 PRECISE OPTICAL HETERODYNE BEAT FREQUENCY FROM LASER DIODES LOCKED TO ATOMIC RESONANCES.** Semiconductor lasers locked to atomic resonances provide precise optical frequencies with very good long-term stability. This property can be used in coherent optical communications for obtaining a well defined IF frequency (or frequencies) at the receiver. The letter deals with the optical heterodyne detection of a precise 6.54 GHz frequency offset derived from the hyperfine structure of rubidium 87. (Author abstract) 5 refs.

Villeneuve, B. (Laval Univ, Ste.-Foy, Que, Can); Cyr, N.; Tetu, M. *Electron Lett* v 23 n 20 Sep 24 1987 p 1082-1084.

**073567 313 km TRANSMISSION EXPERIMENT AT 1 Gbit/s USING OPTICAL AMPLIFIERS AND A LOW CHIRP LASER.** The use of four in-line semiconductor laser amplifiers is reported in an optical fiber transmission experiment. Using direct detection at 1 Gbit/s, a transmission distance of 313 km of non-dispersion-shifted fiber was achieved. This is 142 km longer than previous experiments at similar data rates. It is claimed to be first time optical amplifiers have been used to improve transmission distance for fiber-optic communication systems. (Edited author abstract) 6 refs.

Oberg, M.G. (AT&T Bell Lab, Murray Hill, NJ, USA); Olsson, N.A.; Koszi, L.A.; Przybylek, G.J. *Electron Lett* v 24 n 1 Jan 7 1988 p 38-39.

**073568 EFFECT OF LASER PHASE NOISE ON A CLASS OF BIT-RATE LIMITER.** Serious bit-error-rate limitations arise due to laser phase fluctuations in a class of all-fibre bit-rate limiters. Polarisation-sensitive error-rate floors exceeding  $10^{-6}$  have been observed in the passbands of these devices when driven by intensity-modulated GaInAsP lasers using non-return-to-zero signalling and direct detection. A similar decline in performance is anticipated in other fibre systems containing multiple paths. (Author abstract) 4 refs.

Tur, M. (Tel-Aviv Univ, Tel-Aviv, Isr); Goldstein, E.L.; Brackett, C.A. *Electron Lett* v 24 n 2 Jan 21 1988 p 126-128.

**073569 SELF-SWITCHING OF OPTICAL RADIATION FROM ONE FREQUENCY TO ANOTHER.** The possibility is shown of switching radiation power from one frequency to another on the output of a quadratically nonlinear medium with cubic nonlinearity by changing the input power. A method for shortening the duration of laser pulses to  $10^{-14}$  sec is proposed on the basis of this, and the possibility is shown of realizing it for a specific case of synchronous frequency doubling in a potassium dideuterium phosphate crystal. (Author abstract) 11 refs.

Maier, A.A. *Sov Phys Lebedev Inst Rep* n 6 1987 p 84-87.

**073570 1.5  $\mu$ m  $\lambda$ /4-SHIFTED DFB LD FILTER AND 100 Mbit/s TWO-CHANNEL WAVELENGTH SIGNAL SWITCHING.** A 1.5  $\mu$ m tunable wavelength filter was studied. A 1.5  $\mu$ m  $\lambda$ /4-shifted distributed feedback laser diode (DFB LD) was applied as an effective single wavelength selective filter. A wavelength switching experiment in a 100 Mbit/s two-channel wavelength multiplexed system was successfully demonstrated by using the tunable  $\lambda$ /4 shifted DFB LD filter. (Author abstract) 7 refs.

Numai, T. (NEC, Kawasaki, Jpn); Fujiwara, M.; Shimosaka, N.; Kaede, K.; Nishio, M.; Suzuki, S.; Mito, I. *Electron Lett* v 24 n 4 Feb 18 1988 p 236-237.

**073571 8 Gbit/s TRANSMISSION OVER 76 km OF OPTICAL FIBRE USING A DIRECTLY MODULATED 1.3  $\mu$ m DFB LASER.** We report an optical transmission experiment at a data rate of 8 Gbit/s over an unrepeatable distance of 76 km. The transmitter was a directly modulated, 1.3  $\mu$ m-wavelength, distributed-feedback laser. The receiver employed an avalanche photodiode and a high-impedance GaAs MESFET preamplifier. (Author abstract) 9 refs.

Gnauck, A.H. (AT&T, Holmdel, NJ, USA); Kasper, B.L.; Dutta, N.K.; Cella, T. *Electron Lett* v 24 n 9 Apr 28 1988 p 510-512.

**073572 CASCADED INLINE SEMICONDUCTOR LASER AMPLIFIERS IN A COHERENT OPTICAL FIBRE TRANSMISSION SYSTEM.** A coherent optical transmission system with two broadband inline optical amplifiers was investigated. The main cause of system degradation was the generation of an interfering signal owing to backward scattered waves in the amplifier chain. The perturbation was eliminated by an isolator or sufficient attenuation between both amplifiers. It is possible to convert the effective 30 db gain of both amplifiers fully into an increase of the transmission span. (Author abstract) 6 refs.

Grosskopf, G. (Nachrichtentechnik Berlin GmbH, Berlin, West Ger); Ludwig, R.; Weber, H.G. *Electron Lett* v 24 n 9 Apr 28 1988 p 551-552.

**073573 CPFSK COHERENT OPTICAL RECEIVERS: IMPACT OF IF BANDWIDTH AND LASER PHASE NOISE.** A theoretical model for narrowband CPFSK receivers is presented. It accounts for the influence of if bandwidth on the signal voltage, non-Gaussian statistics of the output noise, correlation between noise samples stemming from limited if bandwidth, and the impact of laser phase noise. It is found that the if bandwidth needed to avoid intersymbol interference is 2.2 times the bit rate for a modulation index of 1; it is higher for other modulation index values. The bit error ratio is within 1 db of the shot noise limit for the modulation index of 1. (Edited author abstract) 6 refs.

Jacobsen, G. (Telecommunications Research Lab, Copenhagen, Den); Kazovsky, L.G. *Electron Lett* v 24 n 11 May 26 1988 p 715-717.

**073574 USE OF LASER DIODES LOCKED TO ATOMIC TRANSITIONS IN MULTI-WAVELENGTH.** The possibility of building multiwavelength coherent communication systems based on low-cost semiconductor lasers in the 0.8  $\mu$ m range locked to rubidium linear absorption is investigated. The values of frequency offset between the resonances of the  $D_2$  (780nm) and  $D_1$  (794.7nm) lines are considered. A simple two-carrier FDM set-up using three resonances of the  $D_2$  line is presented and the optical frequency offsets are measured. (Edited author abstract). 4 refs.

Villeneuve, B. (Laval Univ, Ste.-Foy, Que, Can); Cyr, N.; Tetu, M. *Electron Lett* v 24 n 12 Jun 9 1988 p 736-737.

## Mathematical Models

**073575 VIDEO TRANSMISSION IN OPTICAL FIBER COMMUNICATION SYSTEMS USING PULSE FREQUENCY MODULATION.** A design procedure has been developed to determine the required operating conditions for a pulse-frequency modulation (PFM) system (modulation index, required system bandwidth, and receiver carrier-to-noise ratio (CNR) for a specified receiver SNR (signal-to-noise ratio) and number of clicks per second. The PFM processing gain (= SNR/CNR) was measured to be 40 dB for a modulation index of  $\beta = 2.5$ , which agrees closely with the theory. The theoretical processing gain advantage of PFM over FM is 15.9 dB for a modulation index of  $\beta = 2.5$  with receiver bandwidth  $B_{rx} = 50$  MHz. 9 refs.

Heker, Sergio F. (Stevens Inst of Technology, Hoboken, NJ, USA); Herskowitz, Gerald J.; Grebel, Haim; Wichansky, Howard. *IEEE Trans Commun* v 36 n 2 Feb 1988 p 191-194.

## Microwaves

**073576 . FIBER-OPTIC TRANSMISSIONS OF MICROWAVE 8-PHASE-PSK AND 16-ARY QUADRATURE-AMPLITUDE-MODULATED SIGNALS AT THE 1.3- $\mu$ m WAVELENGTH REGION.** Transmissions of a 6-GHz 8-phase phase-shift-keyed (8 $\phi$ -PSK) signal over a 12.5-km single-mode fiber with a 5-dB power margin and bit-error-rate (BER) of  $10^{-10}$  and a 6-GHz 16-ary quadrature-amplitude-modulated (QAM) signal over the same distance with a 2-dB power margin and BER of  $10^{-12}$  were demonstrated. The 8 $\phi$ -PSK digital modem operated at 78 Mb/s and the 16-QAM digital modem operated at 90 Mb/s. A high-speed multimode InGaAsP laser diode and a high-speed p-i-n diode were used in both fiber-optic transmission systems. Floor characteristics and power penalties observed in the BER performances of both systems were found to be caused by the intensity noise of the laser diode, particularly the reflection-induced intensity noise. 25 refs.

Way, Winston Ingshih (Bell Communications Research, Red Bank, NJ, USA). *J Lightwave Technol* v 6 n 2 Feb 1988 p 273-280.

**Multiplexing** See Also DIGITAL COMMUNICATION SYSTEMS—Voice/Data Integrated Services; OPTICAL FIBERS—Applications; WAVEGUIDE COMPONENTS—Couplers.

**073577 CROSSCONNECTION OF WAVELENGTH-DIVISION-MULTIPLEXED HIGH-SPEED CHANNELS.** The letter describes a wavelength-division-multiplexing structure to establish point-to-point connectivity of high-speed channels between network nodes. The information-handling capacity of the network exceeds 1 Tbit/s, which can only be duplicated otherwise by a complete fiber mesh structure. A small-scale experimental system with two transmitting nodes and two receiving nodes, each with two wavelengths, is reported. (Author abstract) 8 refs.

Kobrinski, H. (Bell Communications, Morristown, NJ, USA). *Electron Lett* v 23 n 18 Aug 27 1987 p 974-976.

**073578 OPTICAL TIME-DIVISION MULTIPLEXED TRANSMISSION SYSTEM EXPERIMENT AT 8 Gbit/s.** We describe the design and performance of an experimental two-channel optical time-division multiplexed fiber transmission system operating at a wavelength of 1.3  $\mu$ m and a bit rate of 8 Gbit/s. Transmission over 8 km of single-mode fiber with low crosstalk and transmission error rates as low as  $10^{-10}$  is demonstrated. (Author abstract) 6 refs.

Eisenstein, G. (AT&T Bell Lab, Holmdel, NJ, USA); Tucker, R.S.; Korotky, S.K.; Raybon, G.; Veselka, J.J.; Buhl, L.L.; Gnauck, A.H.; Kasper, B.L.; Alfness, R.C. *Electron Lett* v 23 n 21 Oct 8 1987 p 1115-1116.

**073579 150 km OPTICAL FIBRE TRANSMISSION NETWORK EXPERIMENT WITH 2 Gbit/s THROUGHPUT.** Optical time-division multiplexing is considered for synchronous gigabit/s long-distance transmission networks. Experimental results are presented for a 150 km fiber network of 2 Gbit/s capacity. The problem of differential fiber propagation delay variations is addressed with signal processing developed for the implementation of closed-loop feedback control. (Author abstract) 4 refs.

Blank, L.C. (British Telecom Research Lab, Ipswich, Engl); Bryant, E.G.; Lord, A.; Boggs, J.M.; Stallard, W.A. *Electron Lett* v 23 n 19 Sep 10 1987 p 977-978.

**073580 SAMPLED OPTICAL TIME-DIVISION MULTIPLEXING OF ASYNCHRONOUS DATA.** A simple and novel sampling technique for optical time-division multiplexing circuit and packet switched data is proposed using a gain-switched distributed feedback semiconductor laser and lithium niobate modulators. System error rate measurements on a two-channel system



multiplexing data at 140 Mbit/s and 50 Mbit/s are given and operating penalties analysed. (Author abstract) 7 refs.

Chidgey, P.J. (British Telecom Research Lab, Ipswich, Engl); Smith, D.W. *Electron Lett* v 23 n 23 Nov 5 1987 p 1228-1229.

**073581 FREQUENCY STABILIZATION OF FDM OPTICAL SIGNALS ORIGINATING FROM DIFFERENT LOCATIONS.** Frequency stabilization of FDM optical signals to a comb of equally spaced frequencies has been demonstrated for optical signals originating from different locations. The results was achieved by locking each optical source to a resonance of a separate fibre Fabry-Perot cavity. The Fabry-Perot's comb of resonances was synchronised by locking all these devices to a master reference. Implementation of the frequency stabilisation circuit requires, at each location, a tunable fibre Fabry-Perot resonator, a photodetector and simple electronics. Such a simple circuit provides the means to frequency-stabilise a large number of FDM optical sources originating from different locations, as in a star network. (Author abstract) 4 refs.

Glance, B. (AT&T Bell Lab, Holmdel, NJ, USA); Stone, J.; Fitzgerald, P.J.; Pollock, K.J.; Burrus, C.A.; Stulz, L.W. *Electron Lett* v 23 n 23 Nov 5 1987 p 1243-1245.

**073582 WDM EXPERIMENT USING 1300/1500 nm DUAL-WAVELENGTH LED FOR SINGLE-MODE FIBRE TRANSMISSION SYSTEMS.** A wavelength-division-multiplexing transmission experiment using a 1300/1500 nm dual-wavelength LED modulated at 140/560 Mbit/s over 10 km of single-mode fiber has been demonstrated. This dual-LED device has a 9  $\mu$ m emitter spacing between the active facets with a coupling loss of 2.3 db through a lens/fiber coupler. The chromatic dispersion penalty for the 1500 nm channel at 560 Mbit/s was about 6.5 db and the electrical crosstalk penalty was 2.5 db. (Author abstract) 9 refs.

Chang, G.-K. (Bell Communications Research, Red Bank, NJ, USA); Reith, L.A.; Leblanc, H.P.; Chin, A.K. *Electron Lett* v 23 n 24 Nov 19 1987 p 1267-1268.

**073583 16 Gbit/s FIBRE TRANSMISSION EXPERIMENT USING OPTICAL TIME-DIVISION MULTIPLEXING.** An experimental four-channel optical time-division multiplexed transmission system is described, and the first demonstration of fiber transmission at a bit rate of 16 Gbit/s is reported. In this experiment, data at 16 Gbit/s have been transmitted over 8 km of fiber with a bit error rate below  $10^{-9}$ . (Author abstract) 9 refs.

Tucker, R.S. (AT&T Bell Lab, Holmdel, NJ, USA); Eisenstein, G.; Korotky, S.K.; Buhl, L.L.; Veselka, J.J.; Raybon, G.; Kasper, B.L.; Alfiness, R.C. *Electron Lett* v 23 n 24 Nov 19 1987 p 1270-1271.

**073584 TWO-CHANNEL SYSTEM DEMONSTRATION OF DIFFERENTIAL FREQUENCY-DEVIATION MULTIPLEXING.** A two-channel lightwave system using differential frequency-deviation multiplexing (DFDM) is presented. Both 90 Mbit/s channels are differentially detected using a fiber interferometer. The performance is independent of the absolute optical frequencies and received state of polarization. Interchannel interference results in a 1 db penalty for channel separations of 700 MHz. (Author abstract) 4 refs.

Darcie, T.E. (AT&T Bell Lab, Holmdel, NJ, USA); Burrus, C.A.; Gnauck, A.H.; Kasper, B.L.; Talman, J.R. *Electron Lett* v 23 n 24 Nov 19 1987 p 1278-1280.

**073585 THEORY OF CONTROL MECHANISM FOR AN OPTICALLY TIME-DIVISION-MULTIPLEXED SYSTEM.** The problem of phase control in a synchronous bit interleaved optical transmission system network is addressed theoretically and a practical implementation demonstrated. Control information is derived from the amplitude and phase of a discrete frequency component of the interleaved data spectrum, and it is shown that control is possible with a system penalty of less than 0.2 db. (Author abstract) 3 refs.

Lord, A. (British Telecom Research Lab, Ipswich, Engl); Blank, L.C.; Boggis, J.M.; Bryant, E.; Stallard, W.A. *Electron Lett* v 24 n 1 Jan 7 1988 p 29-31.

**073586 SIMPLE MULTIPLEXING METHOD FOR PULSED ANALOG SIGNAL AND DIGITAL SIGNAL IN OPTICAL COMMUNICATIONS.** There is a need for simultaneous optical transmission of two distinct signals, broadband analog video signal, and digitalized PCM voice signal or digital data signal, such as in TV transmission. Conventional multiplexing methods such as FDM, TDM, and WDM, can be applied, but some problems remain to be solved. This paper proposes a simple multiplexing method for a pulse analog signal and digital signal, which are multiplexed in different directions, time and amplitude. The proposed method is analyzed both by theory and simulation, and it is shown that with very slight deterioration of the analog signal, the multiplex transmission of digital signals with good quality can be obtained. (Edited author abstract) 11 refs.

Kusakabe, Hiroyuki (Keio Univ, Yokohama, Jpn); Nakagawa, Masao. *Electron Commun Jpn Part 1* v 71 n 2 Feb 1988 p 81-88.

**073587 FDM OPTICAL FIBER TRANSMISSION FOR HDTV IN BROADCASTING STATION.** We researched transmission of HDTV signals as YC-components through an optical fiber. A frequency allocation method for frequency-multiplexing has been developed. It has been found that a single-mode fiber is better for high quality transmission. An optical fiber transmission system for four HDTV channels was constructed using the FDM and WDM techniques. This model is good enough to use in a broadcasting station. 1 ref.

Oyamada, Kimiyuki (NHK, Tokyo, Jpn); Maeda, Mikio; Utsumi, Yozo. *NHK Lab Note* n 345 Apr 1987 10p.

**073588 EXPERIMENTAL DEMONSTRATION OF A PASSIVE OPTICAL SUBSCRIBER LOOP ARCHITECTURE.** We report the experimental demonstration of a new passive optical subscriber loop architecture employing 20 channel WDM with 2nm channel spacings. The experiment includes the demonstration of LED transmission in a dense, multi-wavelength single-mode fiber network. The experiment also features simultaneous, bidirectional transmission with both LEDs (384 kb/s) and DFB lasers (up to 1.2 Gb/s). (Author abstract) 5 refs.

Wagner, S.S. (Bell Communications Research, Morristown, NJ, USA); Kobrinski, H.; Robe, T.J.; Lemberg, H.L.; Smoot, L.S. *Electron Lett* v 24 n 6 Mar 17 1988 p 344-346.

**073589 WIDEBAND GUIDED-WAVE PERIODIC MULTI/DEMULTEPLEXER WITH A RING CAVITY FOR OPTICAL FDM TRANSMISSION SYSTEMS.** A guided-wave periodic multi/demultiplexer with a ring cavity for optical frequency-division-multiplexing (FDM) transmission systems is demonstrated. The frequency spacing is 5 GHz at the 1.55  $\mu$ m wavelength region and the bandwidth is 1.8 times as wide as that of conventional periodic filters with simple Mach-Zehnder interferometer structure. (Author abstract) 6 refs.

Oda, K. (NTT, Yokosuka, Jpn); Takoto, N.; Toba, H.; Nosu, K. *Electron Lett* v 24 n 4 Feb 18 1988 p 210-212.

**073590 TECHNIQUE DE MULTIPLEXAGE POUR RESEAU OPTIQUE DE VIDEOCOMMUNICATION.** [Multiplexing Techniques for Fiber Optic Video-communication Networks]. The paper describes the building of the subscriber equipment for a fiber optic local cable network. Three signals are multiplexed on the user access: video, digital audio and an ISDN channel. The multiplexing procedure is matched to a video signal in an analogue format likely to evolve towards the digital format of the future. This procedure is based on the properties of the video signal: the periodicity of a line structure and the availability of a time slot between active sections of the video lines. (Author abstract) In French. 11 refs.

Duret, Christian (CNET, Issy-les-Moulineaux, Fr). *Ann Telecommun* v 42 n 7-8 Jul-Aug 1987 p 398-403.

**073591 15 MHz CHANNEL SPACING OF TWO FREQUENCY DIVISION MULTIPLEXED OPTICAL CARRIERS INTENSITY-MODULATED WITH ANALOGUE VIDEO SIGNALS.** An experimental coherent fibre-optic system has been demonstrated using heterodyne detection of analogue intensity-modulated NTSC colour television video signals of two optical carriers frequency division multiplexed (FDM) with 15 MHz channel spacing. (Author abstract) 5 refs.

Stone, S.M. (GTE, Waltham, MA, USA). *Electron Lett* v 24 n 9 Apr 28 1988 p 526-528.

**073592 BIDIRECTIONAL MULTICHANNEL 1.44 Gbit/s LIGHTWAVE DISTRIBUTION SYSTEM USING SUBCARRIER MULTIPLEXING.** We demonstrate a bidirectional lightwave distribution system that uses subcarrier multiplexing to transmit data to eight nodes from a single head-end laser. Data for each node (180 Mbit/s) and return data (45 Mbit/s digital video) are transmitted as FSK subcarriers, between 2.5 and 5.0 GHz. Penalties from laser nonlinearities, interchannel interference or bidirectional transmission are negligible. (Author abstract) 8 refs.

Darcie, T.E. (AT&T Bell Lab, Holmdel, NJ, USA); Iannone, P.P.; Kasper, B.L.; Talman, J.R.; Burrus, C.A.; Baker, T.A. *Electron Lett* v 24 n 11 May 26 1988 p 649-650.

**073593 NOVEL SINGLE-MODE, GRATING WDM DEVICE BASED NETWORK.** Experiments on a commercial grating WDM device show that it can be used as the core element in a passive, complete routing network, allowing secure communication between all system users. A system is configured to demonstrate this potential use. (Author abstract) 4 refs.

Lord, A. (British Telecom Research Lab, Ipswich, Engl); Boggis, J.M. *Electron Lett* v 24 n 11 May 26 1988 p 672-674.

**073594 TWENTY CHANNEL FSK SUBCARRIER MULTIPLEXED OPTICAL COMMUNICATION SYSTEM FOR VIDEO DISTRIBUTION.** A two Gbit/s subcarrier multiplexed optical communication system suitable for video distribution is presented where 20 microwave subcarriers are modulated at 100 Mbit/s using a frequency shift keyed format. (Author abstract) 8 refs.

Hill, P. (GTE, Waltham, MA, USA); Olshasky, R. *Electron Lett* v 24 n 14 Jul 7 1988 p 892-894.

## Noise, Spurious Signal

**073595 INTERFEROMETRIC CONVERSION OF LASER PHASE NOISE TO INTENSITY NOISE BY SINGLE-MODE FIBRE-OPTIC COMPONENTS.** The intrinsic phase noise of semiconductor lasers is interferometrically converted into high levels of intensity noise by reflections at single-mode connectors and other fiber-optic components. This noise can have significant adverse impact on both direct detection and coherent transmission systems, causing bit-error-rate floors in extreme cases. (Author abstract) 7 refs.

Choy, M.M. (Bell Communications Research Inc, Red Bank, NJ, USA); Gimlett, J.L.; Welter, R.; Kazovsky, L.G.; Cheung, N.K. *Electron Lett* v 23 n 21 Oct 8 1987 p 1151-1152.

**073596 EFFECT OF MODAL NOISE ON SINGLE MODE FIBER OPTIC NETWORKS.** Modal noise may arise in single mode fiber optic networks from the random coupling of the fundamental mode LP<sub>01</sub> and the higher order mode LP<sub>11</sub>. The higher mode LP<sub>11</sub> is generated in the fiber optic link from imperfect connectors. A model for the modal noise generated in a single mode fiber optic network consisting of a number of connectors or splices is presented. The effect of modal noise on the link is



discussed and expression for signal to noise ratio has been obtained. Suggestions for the reduction of modal noise are given. (Author abstract) 11 refs.

Shankar, P. Mohana (Drexel Univ, Philadelphia, PA, USA). *Opt Commun* v 65 n 5 Mar 1 1988 p 347-350.

**073597 CALCULATION OF ERROR PROBABILITY FOR OPTICAL FIBER COMMUNICATION SYSTEMS BY EDGEWORTH SERIES EXPANSION.** The exact calculation of error probability for a direct-detection optical fiber communication system is difficult because of the formidable characteristics of the shot noise induced by a filtered doubly stochastic Poisson process. This paper applies Edgeworth expansion method to calculate the exact error rate in the presence of shot noise and thermal noise. Numerical examples are given by using typical system parameters. Also, the calculations of this method are compared with the results obtained by the previously proposed Gram-Charlier series expansion method and the simple Gaussian Approximation. (Author abstract). 12 Refs.

Wu, Jingshown (Nat'l Taiwan Univ, Taipei, Taiwan); Wu, I-fan; Lee, San-Liang. *J Opt Commun* v 9 n 2 Jun 1988 p 67-71.

**073598 EVALUATION OF POWER PENALTY DUE TO BEAT NOISE INDUCED BY CONNECTOR REFLECTION.** Power penalties caused by beat noise in a received optical signal beam were evaluated experimentally and theoretically. It was found that power penalties could be suppressed when the beam relative intensity noise was reduced to less than  $+MIN@135$  dB/Hz below 2.4 Gbit/s. This goal can be satisfied using a commercially available physical contact optical connector, which has less than  $-20$  dB reflection. (Author abstract). 4 Refs.

Shikada, M. (NEC Corp, Kawasaki, Jpn); Henmi, N. *Electron Lett* v 24 n 18 Sep 1 1988 p 1126-1128.

## Optimization

**073599 COMPARATIVE SENSITIVITY OF OPTIMAL DIGITAL OPTICAL COMMUNICATIONS SYSTEMS.** The optimal-design problem has been solved for digital optical communications systems (DOCS). The parameter of the optical signal of the transmitting device (spectrum width, radiation pulse duration) and a graded optical waveguide (profile shape and difference  $\Delta$  between indices of refraction of core and sheath) are considered as the system parameters to be varied. The length of a repeater section of the DOCS is taken as the optimality criterion. Optimal values are obtained for the varied parameters and the comparative sensitivity of the optimality criterion has been investigated in the presence and absence of intersymbol interference at the receiver for two wavelength bands, 0.85 and 1.3  $\mu$ m. (Author abstract) 5 refs.

Makkaveev, V.I.; Petrova, N.N. *Radioelectron Commun Syst* v 30 n 9 1987 p 1-5.

**073600 OPTIMIZATION OF COHERENT OPTICAL HOMODYNE SYSTEMS.** In the present paper coherent optical transmission systems (ASK and PSK) with homodyne detection will be optimized in regard to a minimum bit-error-rate (BER). By calculating the BER the laser phase noise, the additive Gaussian noise, the influence of the baseband filter on both noise terms and the intersymbol interferences are accounted for. The optimizable system parameters are identified as the PLL bandwidth, the bandwidth of the baseband filter and the decision threshold. It will be shown that the optimal filter bandwidth and the optimal threshold in ASK systems, in contrast to PSK systems, are dependent on the laser phase noise. The calculation of the optimal system parameters will be done exactly and by useful approximations. (Author abstract). 5 Refs.

Fleischmann, Michael (Technische Univ Muenchen, Munich, West Ger); Franz, Juergen. *J Opt Commun* v 9 n 2 Jun 1988 p 72-77.

## Performance

**073601 OPTICAL FSK TRANSMISSION SYSTEM USING A PHASE-DIVERSITY RECEIVER.** A coherent optical transmission system has been demonstrated using commercial DFB lasers as both transmitter and local oscillator. A receiver sensitivity of  $-51.8$  dbm was measured at a data rate of 140 Mbit/s. The system employs FSK modulation and a three-port, phase-diversity receiver. The effect of source linewidth on receiver bandwidth requirements has been examined. (Author abstract) 7 refs.

Pettitt, M.J. (STC Technology Ltd, Harlow, Engl); Remedios, D.; Davis, A.W.; Hadjifotiou, A.; Wright, S. *Electron Lett* v 23 n 20 Sep 24 1987 p 1075-1076.

**073602 OPTICAL SELF-HOMODYNE DPSK TRANSMISSION AT 1 AND 2 GBIT/S OVER 86 KM OF FIBRE.** Optical self-homodyne DPSK transmission has been achieved at 1 and 2 Gbit/s data rates with respective receiver sensitivities of  $-34.4$  dbm and  $-32.4$  dbm at  $10^{-9}$  BER. No dispersion penalty was observed after transmission through 86 km of optical fibre with 17 ps/ $\mu$ m/km dispersion at the operating wavelength of 1.53  $\mu$ m. (Author abstract) 7 refs.

Giles, R.C. (AT&T Bell Lab, Holmdel, NJ, USA); Reichmann, K.C. *Electron Lett* v 23 n 22 Oct 22 1987 p 1180-1181.

**073603 OPTICAL FIBRE LINE SYSTEM FOR  $4 \times 140$  MBIT/S, A NEW 565 MBIT/S APPLICATION.** Optical fiber systems offer an economically advantageous alternative in cases where large amounts of information have to be transmitted. In order to meet the need for high-capacity transmission systems within the CEPT hierarchy Ericsson has adapted its optical fiber line system for 56 Mbit/s to the requirements of the CEPT market. The system is designed for traditional telecommunications transmission with a capacity of 7680 telephone channels or one-way distribution of up to eight cable-TV channels and is entirely in accordance with the CCITT recommendation for 140 Mbit/s standard interface. Transmission takes place over single-mode fibers at a wavelength of 1300 or 1500 nm. 26 db system attenuation can be bridged, which corresponds to a repeater spacing of 40 and 70 km, respectively. The authors describe the design, construction and performance of the system. (Author abstract) 5 refs.

Hansson, Anna-Karin (Ericsson Telecom); Linden, Kjell. *Ericsson Rev (Engl Ed)* v 64 n 3 1987 p 102-109.

**073604 NOVEL ALL-ELECTRICAL SCHEME FOR DYNAMIC SEMICONDUCTOR LASER-TO-FIBRE COUPLING CONTROL.** An all-electrical scheme to maintain the optimum coupling condition in semiconductor laser-to-fiber coupling is described. A small deviation ( $\epsilon$ ) of the optimum laser-to-fiber distance severely degrades the laser performance in terms of, for example, output power, longitudinal mode spectrum and pulse response. The scheme employs the electrical noise of the laser as a distance sensor in a control loop that maintains the optimum laser-to-fiber distance in the presence of thermal or mechanical disturbances. (Author abstract) 7 refs.

Andrekson, P.A. (Chalmers Univ of Technology, Goteborg, Swed); Alping, A. *Electron Lett* v 23 n 24 Nov 19 1987 p 1275-1277.

**073605 PRESERVATION OF POLARIZATION ORTHOGONALITY THROUGHOUT A LINEAR OPTICAL SYSTEM.** When two orthogonally polarized optical waves are launched into an optical medium they may experience a loss in orthogonality. We derive a simple bound on this loss. Our result predicts that orthogonality is virtually preserved for many common single-mode optical components (for example, long lengths of fibers, directional couplers and filters). (Edited author abstract) 4 refs.

Cimini, L.J. (AT&T Bell Lab, Holmdel, NJ, USA); Habbab, I.M.I.; John, R.K.; Saleh, A.A.M. *Electron Lett*

v 23 n 25 Dec 3 1987 p 1365-1366.

**073606 400 Mbit/s, 372 km COHERENT TRANSMISSION EXPERIMENT USING IN-LINE OPTICAL AMPLIFIERS.** We report on an optical transmission experiment using four in-line optical amplifiers. With a net gain of 58,000 (47.7 db) from the amplifiers, we were able to increase the longest non-regenerated transmission distance to 372 km. The system penalty associated with amplifiers was only 1.5 db. (Author abstract) 11 refs.

Olsson, N.A. (AT&T Bell Lab, Murray Hill, NJ, USA); Oberg, M.G.; Koszi, L.A.; Przybylek, G. *Electron Lett* v 24 n 1 Jan 7 1988 p 36-38.

**073607 COMPENSATION OF FIBRE CHROMATIC DISPERSION IN OPTICAL HETERODYNE DETECTION.** Compensation of fibre chromatic dispersion in coherent optical fibre transmission is demonstrated. The chromatic dispersion of a 70 km single-mode fibre with 1.3  $\mu$ m zero dispersion wavelength is compensated for using a microstrip line equaliser in the intermediate frequency band. Amplitude distortion due to fibre chromatic dispersion at 1.55  $\mu$ m wavelength is reduced to below 2.5% with the equaliser. (Author abstract) 6 refs.

Takachio, N. (NTT Lab, Yokosuka, Jpn); Iwashita, K. *Electron Lett* v 24 n 2 Jan 21 1988 p 108-109.

**073608 EXPERIMENTAL OPTICAL FIBRE DIGITAL PULSE-POSITION MODULATION SYSTEM.** Practical measurements on a digital PPM system handling 8 Mbit/s PCM data show good correlation with theoretical results obtained from a computer model of the system. It is confirmed that there exists an optimum number of time slots which maximises the receiver sensitivity, and that a digital PPM system can offer an improvement of 4.2 db over an equivalent binary PCM system when the fibre bandwidth is several times that required by PCM. (Author abstract) 4 refs.

Calvert, N.M. (The Polytechnic, Huddersfield, Engl); Sibley, M.J.N.; Unwin, R.T. *Electron Lett* v 24 n 2 Jan 21 1988 p 129-131.

**073609 OPTICAL TELEMONITORING AND TRANSMISSION NETWORK FOR LARGE TRANSPORTATION SYSTEMS.** The safe and efficient operation of motorways, railways and pipelines calls for centralized monitoring and control, requiring reliable transmission of data, images, and control signals over large distances. Optical fiber is well suited to this task. The authors describe a system installed on the A40 autoroute between Lyon (France) and Geneva (Switzerland) that uses a two-level star structure for video transmission and processing, and a bus structure for the transmission of telemonitoring and control signals. (Edited author abstract)

Lecomte, J. (Compagnie Lyonnaise de Transmissions Optiques, Bezons, Fr); Seguin, M. *Electr Commun* v 61 n 4 1987 p 422-427.

**073610 400 MBIT/S OPTICAL HETERODYNE DPSK SYSTEM EXPERIMENT WITH IN-LINE 1.5  $\mu$ m AMPLIFIERS.** We report a 400 Mbit/s differential phase shift keying (DPSK) heterodyne optical transmission system experiment using two inline packaged resonant type amplifiers. The optical amplifier gave a 14.5 db net gain from fiber to fiber at  $\lambda=1.488$   $\mu$ m with no significant system penalty. (Author abstract) 4 refs.

Delavaux, J.-M.P. (AT&T, Allentown, PA, USA); Rice, T.C.; Tzeng, L.D.; Ku, R.T.; Salko, S.J. *Electron Lett* v 24 n 6 Mar 17 1988 p 305-306.

**073611 150 Mbit/s PHASE DIVERSITY ASK HOMODYNE RECEIVER WITH A LINEWIDTH-BIT RATE RATIO OF 0.5.** A 150 Mbit/s ASK phase-diversity homodyne receiver was constructed with



a DFB laser emitting at 1550 nm. At a BER of  $10^{-9}$ , a sensitivity of  $-55$  dbm, corresponding to 77 photoelectrons/bit, was measured. (Author abstract) 5 refs.

Welter, R. (Bell Communications Research, Red Bank, NJ, USA); Kazovsky, L.G. *Electron Lett* v 24 n 4 Feb 18 1988 p 199-201.

**073612 1.2 Gbit/s, 201 km OPTICAL DPSK HETERODYNE TRANSMISSION EXPERIMENT USING A COMPACT, STABLE EXTERNAL FIBRE CAVITY DFB LASER MODULE.** An optical DPSK heterodyne transmission experiment was performed at a bit rate of 1.2 Gbit/s using a compact, stable external fibre cavity DFB laser module and a high-electron-mobility transistor (HEMT) front end. A receiver sensitivity of  $-46.9$  dbm and a transmission length of 201.4 km were achieved. (Author abstract) 4 refs.

Chikama, T. (Fujitsu Lab Ltd, Kawasaki, Jpn); Naitou, T.; Onaka, H.; Kiyonaga, T.; Watanabe, S.; Suyama, M.; Seino, M.; Kuwahara, H. *Electron Lett* v 24 n 10 May 12 1988 p 636-637.

**073613 NEW FSK PHASE-DIVERSITY RECEIVER IN A 150 Mbit/s COHERENT OPTICAL TRANSMISSION SYSTEM.** We present a coherent FSK phase-diversity system with a novel delay-and-cross-multiply frequency discriminator that allows reception of the FSK signals in the baseband. The measured sensitivity is  $-52$  dbm at 150 Mbit/s after 52 km of fibre. (Author abstract) 7 refs.

Noe, R. (Bellcore, Red Bank, NJ, USA); Sessa, W.B.; Welter, R.; Kazovsky, L.G. *Electron Lett* v 24 n 9 Apr 28 1988 p 567-568.

**073614 JITTER ACCUMULATION IN A SIMULATED 591.2 Mbit/s, 6000 km OPTICAL TRANSMISSION SYSTEM.** An equivalent-time jitter synthesis experiment is described which allows laboratory evaluation of transoceanic regenerated optical transmission systems. Results are reported for the timing jitter accumulation obtained over a 591.2 Mbit/s, 6000 km route derived from the simulated concatenation of 60 regenerated sections. (Edited author abstract) 6 refs.

McNally, B.I. (British Telecom Research Lab, Engl); Carter, S.F.; Walker, S.D. *Electron Lett* v 24 n 11 May 26 1988 p 676-678.

**073615 COMPENSATION OF 202km SINGLE-MODE FIBRE CHROMATIC DISPERSION IN 4 Gbit/s EXPERIMENT.** Compensation for fiber chromatic dispersion in a coherent transmission system is demonstrated. A 4Gbit/s optical CPFSK signal at 1.55  $\mu$ m is transmitted through a 202 km conventional single-mode fiber. There is 1.8 db degradation in transmission caused by fiber chromatic dispersion. This degradation has been compensated for using a delay equaliser with optical heterodyne detection. (Edited author abstract). 5 Refs.

Iwashita, K. (NTT, Yokosuka, Jpn); Takachio, N. *Electron Lett* v 24 n 12 Jun 9 1988 p 789-790.

**073616 1.4 Gbit/s OPTICAL DPSK HETERODYNE TRANSMISSION SYSTEM EXPERIMENT.** We report the performance of a 1.4 Gbit/s differential phase shift keying (DPSK) coherent fiber system experiment using a balanced receiver. We show that the detection sensitivity as a function of local oscillator (LO) power follows the same functional dependence as the theoretical prediction. (Author abstract). 9 Refs.

Delavaux, J.-M.P. (AT&T Bell Lab, Allentown, PA, USA); Tzeng, L.D.; Dixon, M. *Electron Lett* v 24 n 15 Jul 21 1988 p 941-942.

**073617 PHASE-INSENSITIVE ZERO-F COHERENT OPTICAL SYSTEM USING PHASE SWITCHING.** We present a simple technique wherein phase-insensitive zero-IF coherent optical detection is achieved by imposing a periodic phase modulation on the transmitted signal. With differential phase shift keying (DPSK), this

can be achieved by adding a square wave to the phase modulator drive voltage. A single branch receiver is used, avoiding the doubling of receiver hardware needed with conventional phase diversity techniques. The performance of this scheme is analysed and compared to that of heterodyne DPSK. (Author abstract). 5 Refs.

Habbab, I.M.I. (AT&T Bell lab, Holmdel, NJ, USA); Kahn, J.M.; Greenstein, L.J. *Electron Lett* v 24 n 15 Jul 21 1988 p 974-976.

**073618 POLARISATION DIVERSITY RECEIVER USING A SIMPLE WEIGHT CONTROLLER FOR COHERENT FSK COMMUNICATIONS.** A polarisation diversity receiver using a simple baseband weight controller is demonstrated. A measured receiver sensitivity degradation of less than 0.3 db has been obtained in a 600 Mbit/s FSK lightwave system. It is also shown that the performance of this receiver is hardly affected by the nonideality of the controller characteristics. (Author abstract). 6 Refs.

Imai (NTT Lab, Yokosuka-shi, Jpn). *Electron Lett* v 24 n 15 Jul 21 1988 p 979-980.

**073619 DIRECT TIMING EXTRACTION IN A MODIFIED-MANCHESTER CODED PICOSECOND OPTICAL PULSE FIBRE OPTIC TRANSMISSION SYSTEM.** Direct timing extraction in a modified-Manchester-coded fiber optic transmission system is demonstrated. The presence of the clock signal in the received data is used to injection lock an electronic oscillator thus generating a large timing signal. The technique is also suitable for optical injection locking for timing extraction. (Author abstract). 8 Refs.

Izadpanah, H. (Bell Communications Research, Morristown, NJ, USA). *Electron Lett* v 24 n 18 Sep 1 1988 p 1151-1153.

**073620 OPTICAL AMPLIFICATION IN A MULTI-CHANNEL FSK COHERENT SYSTEM.** We report the crosstalk degradation caused by an optical amplifier in a densely spaced four-channel heterodyne FSK system. A maximum receiver sensitivity of 250 photons/bit is obtained for an optimum input signal level. This result is 5 db poorer than the sensitivity obtained in the absence of an optical amplifier. (Author abstract). 9 Refs.

Glance B. (AT&T Bell lab, Holmdel, NJ, USA); Eisenstein, G.; Fitzgerald, P.J.; Pollock, K.J.; Raybon, G. *Electron Lett* v 24 n 18 Sep 1 1988 p 1157-1159.

## Reviews

**073621 OPTICAL COMMUNICATION: THE DOORWAY TO THE INFORMATION ERA.** After some preliminary historical remarks about the origin and the itinerancy of the IOOC, some technical issues concerning the outstanding progress of optical communications are reported. This progress will soon involve not only the transmission links, but also other fields such as optical amplification, switching, data processing. So the optical communications are changing the present telecommunication network in a -Integrated Broadband Communication- (IBC) system, as it is called in Europe. In fact, the close cooperation among telecoms, broadcasters and computers is likely to give rise to the -Information Society- in which all kinds of sources, networks, user terminals and service will be encompassed. The various implications this transformation will have in human life are also illustrated. (Author abstract)

Catania, B. (CSELT, Turin, Italy). *CSELT Tech Rep* v 13 n 5 Oct 1985, IOOC-ECOC '85 (5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun), Venice, Italy, Oct 1-4 1985 p 267-274.

## Sensors

**073622 INTEGRATED COMMUNICATION AND SENSING SYSTEM USING ONE SINGLE-MODE OPTICAL FIBRE.** A novel technique to integrate communication and sensing in one single-mode optical fibre by wavelength division multiplexing is described. Its principle

of sensing is based on the modulation of the interference pattern projected from the output end of a multimode optical fibre when the fibre is subjected to an external disturbance which changes its optical properties. It is demonstrated that the communication performance will not be degraded by the simultaneous sensing operation. (Edited author abstract). 6 Refs.

Chen, K.Y. (Telecommunication Lab, Chung-li, Taiwan); Leung, C.Y.; Chang, I.F. *Electron Lett* v 24 n 13 Jun 23 1988 p 790-792.

## Space Applications

**073623 OPTICAL TECHNOLOGIES FOR SPACE COMMUNICATION SYSTEMS.** This conference proceedings contains 24 articles on developments in the field of optical technology for space communication. Among the topics covered are: Diode laser transmitters; Lasercom link transmission characteristic; Lasercom systems and technologies; High frequency optical components; Optically controlled phased array antennas; Polarization controlling coatings; and Multiplexing/demultiplexing system for optical intersatellite links. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11554 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Bhasin, Kul (Ed.) (NASA, Cleveland, OH, USA); Koepf, Gerhard A. (Ed.). *Proc SPIE Int Soc Opt Eng* v 756, Opt Technol for Space Commun Syst, Los Angeles, CA, USA, Jan 15-16 1987. Publ by SPIE, Bellingham, WA, USA, 1987 184p.

**Standards** See COMPUTER NETWORKS—Local Networks.

**Switching** See Also OPTICAL DEVICES—Switching.

**073624 SATURATION ABSORPTION AND KERR SUSCEPTIBILITY IN POLYDIACETYLENE LANGMUIR-BLODGETT FILM.** Direct measurements of the saturation from Langmuir-Blodgett films of a polydiacetylene have been carried out in picosecond time domain. Using a photoacoustic technique, we have obtained directly the imaginary part of Kerr susceptibility. Its magnitude is found to be in excess of  $10^{-8}$  esu and the associated ground state recovery time is less than the laser pulse width of 3 ps. These results are discussed in terms of a phase space filling model for a one dimensional exciton. (Author abstract) 13 refs.

Kajzar, F. (CEN Saclay, Gif sur Yvette, Fr); Rothberg, L.; Etamad, S.; Chollet, P.A.; Grec, D.; Boudet, A.; Jedju, T. *Opt Commun* v 66 n 1 Apr 1 1988 p 55-58.

**073625 POLARISATION-INSENSITIVE COHERENT LIGHTWAVE SYSTEM USING WIDE-DEVIATION FSK AND DATA-INDUCED POLARISATION SWITCHING.** We present a technique where polarization-insensitive heterodyne detection is achieved through data-induced polarization switching. The polarization switching is brought about by inserting a passive, birefringent optical device in the path of the transmitted FSK signal. The experimental results show that this technique suffers a power penalty of 3-4 db when compared with a conventional FSK system with perfectly matched polarizations. This compares well with the expected penalty of 3 db. This approach uses a single optical receiver and no additional receiver electronics, which could be a significant advantage for local area networks. (Author abstract) 8 refs.

Cimini, L.J. (AT&T, Holmdel, NJ, USA); Habbab, I.M.I.; Yang, S.; Rustako, A.J.; Liou, K.Y.; Burrus, C.A. *Electron Lett* v 24 n 6 Mar 17 1988 p 358-360.

**073626 PHOTONIC SPACE-DIVISION SWITCHING SYSTEM UTILISING COHERENT OPTICAL TRANSMISSION TECHNOLOGIES.** Integration of photonic switching and coherent transmission was studied



ied. A photonic space-division (SD) switching system with a line capacity exceeding 500 is expected, taking advantage of the receiver sensitivity improvement and crosstalk rejection capability of coherent optical detection. SD switching experiments in a 100 Mbit/s optical FSK transmission system were carried out with a  $\text{LiNbO}_3$  photonic switch matrix. The crosstalk component was shown to be rejected by introducing channel separation greater than 3 GHz. (Author abstract). 6 Refs.

Fujiwara, M. (NEC Corp, Kawasaki, Jpn); Suzuki, S.; Emura, K.; Kondo, M.; Manome, K.; Mito, I.; Kaede, K.; Shikada, M.; Sakaguchi, M. *Electron Lett* v 24 n 14 Jul 7 1988 p 882-883.

**073627 CROSSOVER MINIMIZATION IN DIRECTIONAL-COUPLER-BASED PHOTONIC SWITCHING SYSTEMS.** Methods to design directional-coupler-based switching networks with minimum number of crossovers are presented. Also presented is a modular construction scheme that allows large switching networks (with minimum of crossovers) to be built using identical chips containing smaller networks of the same type. The total number of crossovers and the maximum number of crossovers between an inlet-outlet pair have been analyzed in three major self-routing networks. Since many networks are based on these topologies, the results can be applied extensively to the study of many other switching networks. 26 refs.

Lea, Chin-Tau (Georgia Inst of Technology, Atlanta, GA, USA). *IEEE Trans Commun* v 36 n 3 Mar 1988 p 355-363.

## Synchronization

**073628 TRANSPONDER FOR SYNCHRONIZATION OF OPTICAL SIGNALS.** A version of a delay device with optical triggering and an optical output signal is described. The sync-pulse delay range is 15-1500 nsec, and the accuracy and instability of the delay are  $\leq 2$  nsec. (Author abstract) 4 refs.

Apollonov, V.V. (Acad of Sciences of the USSR, Moscow, USSR); Brytkov, V.V.; Zienko, S.I.; Murav'ev, S.V.; Shakir, Yu.A. *Instrum Exp Tech* v 30 n 4 pt 2 Jul-Aug 1987 p 892-893.

## Testing

**073629 5 Gbit/s TRANSMISSION SYSTEM EXPERIMENT OVER 111 km OF OPTICAL FIBRE.** A 5 Gbit/s optical transmission system experiment is reported over 111 km of single-mode optical fiber using a 1.5  $\mu\text{m}$  directly modulated DFB laser and a ternary APD. Full clock recovery as well as frequency division equipment is provided for demultiplexing purposes. (Author abstract) 6 refs.

Heidemann, R. (Standard Elektrik Lorenz AG, Stuttgart, West Ger); Scholz, U.; Wedding, B. *Electron Lett* v 23 n 19 Sep 10 1987 p 1030-1031.

**073630 COLLOQUIUM ON TESTING EQUIPMENT FOR OPTICAL COMMUNICATIONS SYSTEMS.** Proceedings incorporates seven papers. Topics covered include: fiber optics, optical communication equipment, computer-aided measurement techniques, single- and multimode fibers, optical cables, use of semiconductor lasers, dispersion measurements, installed optical fibers, field measurements, reflectometers, commercial fibers, and measurement of optical variables. Technical and professional papers from this conference are indexed and abstracted from the conference code no. 09352 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig* n 1986/85, Colloq on Test Equip for Opt Commun Syst, London, Engl, May 28 1986. Publ by IEE, London, Engl, 1986 var pagings.

**Theory** See Also OPTICS—Theory.

**073631 ERROR MECHANISMS IN A FOUR-LEVEL PULSE WIDTH MODULATED OPTICAL FIBRE SYSTEM.** The error mechanisms in a four-level PWM optical fiber communication system are investigated. The error mechanisms are related to the noise variance and amplitude of the received signal at the sampling instants. This theory, referred to as the 'amplitude theory', is shown to be more generally applicable than an earlier theory, referred to as the 'slope theory'. The slope theory is an extension of the noise analysis for an analog PWM system. Theoretical and experimental results show that the slope theory generally underestimates the BER and that the amplitude theory gives a more accurate evaluation. (Author abstract) 7 refs.

Teo, K.H. (Univ of Alberta, Edmonton, Alberta, Can); Goud, P.A.; Dai, X.D.; Englefield, C.G. *Can Electr Eng J* v 12 n 4 Oct 1987 p 142-146.

**073632 PROPERTIES OF QUANTUM COMMUNICATION WITH RECEIVED QUANTUM STATE CONTROL.** The advantage of nonstandard quantum states such as two-photon coherent state (or squeezed states) and photon number state as transmitter state is strongly degraded by transmission loss in quantum communications. To cope with such a problem, a new application of these states is proposed, and it is shown that its system has infinite capacity. (Author abstract). 18 Refs.

Hirota, Osamu (Tamagawa Univ, Machida, Jpn). *Opt Commun* v 67 n 3 Jul 1 1988 p 204-208.

**073633 SOLITON PROPAGATION IN OPTICAL FIBERS WITH RANDOM PERTURBATIONS.** Effects of randomly varying parameters of optical fibers on soliton propagation are studied numerically by using the propagating beam method. The results show that  $N=3$  and higher order solitons are strongly influenced by the random perturbations in dispersion and nonlinearity of the fibers. The lowest two order solitons, however, can stably transmit in such fibers and should be used for communication applications. (Author abstract). 6 Refs.

Zhao, Yang (Pennsylvania State Univ, University Park, PA, USA). *Opt Commun* v 68 n 1 Sep 1 1988 p 21-24.

## United Kingdom

**073634 INSTALLATION OF DISPERSION-SHIFTED FIBRE IN THE BRITISH TELECOM TRUNK NETWORK.** Measurements are presented from the first installation of dispersion-shifted fibre into the British Telecom network. The cabled fibre performance is compared to that obtained in laboratory trials and analyzed with respect to the fibre structure before and after installation. (Author abstract) 7 refs.

Hunwicks, A.R. (British Telecom Research Lab, Ipswich, Engl); Rosher, P.A.; Bickers, L.; Stanley, D. *Electron Lett* v 24 n 9 Apr 28 1988 p 536-537.

## Venezuela

**073635 OPTICAL COMMUNICATION SYSTEM FOR SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA).** Sumitomo received an order to build a supervisory control and data acquisition (SCADA) system using a fiber optic communication system and has successfully completed the system. This system is for a 230 kv power transmission network. The function of this system is: (1) automatic computer control of the pumping plant for a 9 km long 230 kv submarine OF cable and its monitoring; (2) signal transmission for control and monitoring of two switch yards and two substations; (3) protection signal transmission; and (4) communication network among four stations. The principal elements of this system can be divided into communication equipment such as PCM and MUX, the terminal equipment used in the SCADA system, the computer which controls the pumping plant, and the communication paths composed of OPGW, etc. To ensure high reliability, an integrated dual system, composed of a fiber

optic communication system linked by an optical submarine cable combining an OPGW and a wireless UHF communication system, is used. (Edited author abstract)

Itaka, Koshi; Matsuoka, Noriyuki; Fujieda, Keishi; Kawamura, Takeshi. *Sumitomo Electr Tech Rev* n 27 Jan 1988 p 58-66.

## OPTICAL COMMUNICATION EQUIP-

**MENT** See Also ACOUSTOOPTICAL DEVICES; AMPLIFIERS, MICROWAVE—Performance; COMPUTERS, PERSONAL—Data Communication Equipment; DATA TRANSMISSION EQUIPMENT; DIGITAL COMMUNICATION SYSTEMS; DIGITAL COMMUNICATION SYSTEMS—Switching; ELECTRIC CONNECTORS; ELECTRO-OPTICAL DEVICES; FIBER OPTICS—Applications; FIBER OPTICS—Equipment; IMAGE SENSORS—Performance; INTEGRATED CIRCUITS—Applications; INTEGRATED CIRCUITS, DIGITAL; INTEGRATED OPTICS—Components; LASERS, SEMICONDUCTOR; LASERS, SEMICONDUCTOR—Mode Locking; LASERS, SEMICONDUCTOR—Noise, Spurious Signal; LASERS, SEMICONDUCTOR—Performance; LASERS, SEMICONDUCTOR—Tuning; LIGHT—Amplifiers; OPTICAL DEVICES; OPTICAL DEVICES—Applications; OPTICAL FIBERS; OPTICAL FIBERS—Mathematical Models; SEMICONDUCTING CADMIUM COMPOUNDS—Chemical Vapor Deposition; SEMICONDUCTOR DIODES, PHOTODIODE; SEMICONDUCTOR DIODES, PHOTODIODE—Performance; SIGNAL RECEIVERS—Mathematical Models; SIGNAL RECEIVERS—Measurements; TELECOMMUNICATION; TELECOMMUNICATION CABLES—Laying; TELECOMMUNICATION CABLES—Submarine; TELECOMMUNICATION LINES—Submarine; TELEVISION EQUIPMENT.

**073636 DESIGN AND CHARACTERISTICS OF AN OPTICAL FIBER CABLE FOR EMERGENCY USE.** Communication lines damaged during a disaster must be restored quickly since this seriously affects society. This paper examines the applications of optical cables to restore communication lines quickly in a large-scale disaster area where mechanical tools cannot be used. The paper also offers the conditions required for the structure design of the cable. Based on these examinations, an optical cable for emergency use was developed which contains four optical fibers, and weighs about 25 kg (including its reel), and can be carried by one man. The unit piece of the cable is 1 km; the numbers of pieces can be connected as required. Disaster cases where damaged cable sections are scattered on interoffice lines were examined, and the number of the sections which can be restored was estimated. (Author abstract) 12 refs.

Mihara, Katsumi (NTT, Ibaraki, Jpn); Tanaka, Chihaya; Uesugi, Naoshi. *Electron Commun Jpn Part 2* v 70 n 8 Aug 1987 p 22-30.

**073637 NEC 140 MBIT/S SINGLE MODE OPTICAL FIBRE TRANSMISSION EQUIPMENT - DEVELOPMENT AND MANUFACTURE.** Australia's harsh environment and special operational needs were among the design considerations in the development of the Optical Fibre Equipment used on the Melbourne-Canberra-Sydney route. The result was the production by NEC Australia, of an Australian designed and manufactured 140 Mbit/s system. The design phases of the single mode optical fiber equipment are outlined. (Edited author abstract)

Faulks, Boyd; Del Papa, John. *Telecommun J Aust* v 37 n 3 1987 p 69-74.

**073638 THREE-CHANNEL WAVELENGTH-DIVISION-MULTIPLEXING TRANSCIVER MODULE USING LEDS FOR MULTIMODE FIBER TRANSMISSION SYSTEMS.** This paper describes the design and performance of a 3-channel wavelength-division-multiplexing (WDM) transceiver module for a broadband distribution system in the subscriber loops. The module incorporates WDM optical emitters, detectors and filters for compactness and ease of handling. Moreover, the emitter, the detector and input/output fibers are packaged



each with a collimating or focusing lens in order to enable mounting on the module substrate without adjustment. (Edited author abstract) 11 refs.

Tachikawa, Yoshiaki (NTT, Jpn); Oguchi, Taisuke; Kato, Kuniharu. *Rev Electr Commun Lab (Tokyo)* v 35 n 5 Sep 1987 p 521-528.

**073639 HIGH PERFORMANCE PUSH-PULL COUPLING SINGLE FIBER CONNECTORS AND PLUG-IN FIBER-OPTIC CONNECTORS.** This paper presents the development of compact, high performance and low cost single fiber connectors. They feature push-pull coupling connectors with rectangular connector housings and plug-in circuit-pack connectors with four plugs and four jacks mounted on the back panel and circuit board to realize high-density packaging of optical transmission equipment for subscriber loop systems. Actual field installed connectors with 50/125 GI fibers produced a satisfactory insertion loss of 0.06-0.10 db and a return loss of 26.9-27.8 db. (Author abstract) 7 refs.

Sugita, Etsuji; Shintaku, Toshihiro; Sasakura, Kunihiko. *Rev Electr Commun Lab (Tokyo)* v 35 n 5 Sep 1987 p 529-534.

**073640 THEORY FOR HETERODYNE OPTICAL ASK RECEIVERS USING SQUARE-LAW DETECTION AND POSTDETECTION FILTERING.** We present an approximate but comprehensive theoretical model for heterodyne ASK receivers relevant to optical communication systems where the transmitter and local oscillator have significant linewidths. The ASK receiver modeled here uses square-law detection and post-detection filtering. As a consequence of this detection scheme a key issue in the theory is to account for the very different noise statistics associated with receiving ONE and ZERO symbols. The theory also takes into account receiver noise and nonideal intermediate frequency (IF) filter characteristics and permits an evaluation of optimum threshold setting. Detailed numerical results for receiver sensitivity for a typical 140 Mbit/s pin-FET front end are presented. (Edited author abstract) 15 refs.

Jacobsen, G. (Telecommunications Research Lab, Copenhagen, Den). *IEEE Proc Part J* v 134 pt J n 5 Oct 1987 p 303-312.

**073641 LES LIAISONS OPTIQUES SUR LES LIGNES AERIENNES.** [Optical Links on Overhead Lines]. New developments in optical fiber communication technology will soon allow E.D.F. to establish high quality telecommunication links on high voltage overhead lines. Being intrinsically immune to electromagnetic interference, optical fibers also bring a very high data rate capability. Special optical cables have recently been successfully field tested on a power line. These cables will support communications used for real time supervision and operation of the E.D.F. generation and transmission system. (Author abstract) In French.

Kouteynikoff, Pierre (Electricite des Ouvrages, Clamart, Fr). *Epure* n 10 Apr 1986 p 11-21.

**073642 HIGH BIT RATE FIBRE-OPTIC TRANSMISSION USING BIPOLAR PULSING AND DUO-BINARY SIGNALLING.** Schemes for high bit rate transmission of fibre-optic signal using LEDs with bipolar pulsing and duo-binary signalling have been discussed. The reverse pulsing together with preshaping of driving pulses has been found to increase the LED modulation bandwidth by a factor of four while with duo-binary signalling the bit-rate can be increased by a factor of two with 4-5 dB power penalty. A combination of the two techniques can thus lead to significant improvement in the bit-rate of transmission. (Author abstract) 8 refs.

Rakshit, S. (Indian Inst of Technology, Kharagpur, India); Maulik, A. *J Inst Electron Telecommun Eng* v 32 n 6 Nov-Dec 1986 p 438-441.

**073643 DESIGN AND PERFORMANCE OF THE TAT-8 OPTICAL RECEIVER.** The development of low loss optical fiber and reliable opto-electronic devices has

led in recent years to the installation of a new generation of undersea communication links - optical fiber systems. Compared with their metallic counterparts, optical systems afford significantly greater transmission capacities and repeater spacings, the combined effect of which drives down the effective installation and running costs. This paper describes the design and performance of an optical receiver which has been developed and manufactured at the British Telecom Research Laboratories (BTRL) for the latest in this new generation of undersea systems - the TAT-8 digital transatlantic cable link. (Author abstract) 13 refs.

Brockbank, R.G.; Calton, R.L.; Mottram, S.W.; Hunter, C.A.; Heatley, D.J.T. *Br Telecom Technol J* v 5 n 4 Oct 1987 p 26-33.

**073644 POLARIZATION DIVERSITY RECEIVERS USING ERROR-CONTROL CODES FOR HETERODYNE DETECTION LIGHTWAVE TRANSMISSION SYSTEMS.** In a coherent optical fiber communication with a single-mode fiber and an optical heterodyne detection for improved receiver sensitivity, degradations of the receiving sensitivity due to fluctuation of the polarization condition of the received light are a problem. As a possible solution to this problem, this paper proposes a polarization diversity system with an error-detecting code or an error-correcting code. Its characteristics are analyzed and optimum design values are obtained. (Edited author abstract) 9 refs.

Yamaguchi, Haruo (NTT, Yokosuka, Jpn). *Electron Commun Jpn Part I* v 71 n 1 Jan 1988 p 77-86.

**073645 BASIC EQUIPMENT OF THE 140-MBIT/S FIBER-OPTIC TRANSMISSION SYSTEM.** For the transmission of digital information signals at 140 Mbit/s over optical cable routes, Siemens has developed the line equipment LA140LWL of 19 in. design. Initially used in the Australian national network, this system will later be launched on the world market. The basic system of the new transmission equipment is described. (Author abstract) 7 refs.

Bruckboeck, Peter (Siemens AG, Munich, West Ger); Doerner, Josef; Lazarou, Paul. *Telecom Rep* v 11 n 1 Jan-Feb 1988 p 12-17.

**073646 SUPERVISION AND ADDITIONAL SERVICES OF THE 140-MBIT/S FIBER-OPTIC TRANSMISSION SYSTEM.** The new line equipment LA140LWL of 19" design has been jointly developed by Siemens Ltd., Melbourne and Siemens AG, Munich. It transmits digital information signals at 140 Mbit/s over optical cable routes. Initially used in the Australian national network, this system will later be launched on the world market. The service system of the new transmission equipment is described. (Author abstract) 3 refs.

Bruckboeck, Peter (Siemens AG, Munich, West Ger); Doerner, Josef; Lazarou, Paul. *Telecom Rep* v 11 n 1 Jan-Feb 1988 p 18-21.

**073647 50-Mbaud OPTICAL TRANSMISSION SYSTEM OPERATING AT 860 NM.** A description is given of a competitively priced and efficient transmission system which operates at an optical wavelength of 860 nm and is capable of transmitting data at well over 50 Mbit/s which has now been developed, using integrated circuits of a 200-Mbaud transmission system. The system's transmitter and receiver are both ECL-compatible. There is also a TTL-compatible transmitter, and a matching receiver is currently being developed. (Edited author abstract) 2 refs.

Ruegenberg, Gervin (Siemens AG, Munich, West Ger); Schroedinger, Karl. *Siemens Compon* v 23 n 1 Feb 1988 p 22-24.

**073648 100Mb/sec CMI OPTICAL TRANSMITTER/RECEIVER.** This paper describes an optical transmitter/receiver at a transmission rate of 100 Mb/sec. It employs the CMI coded mark inversion format with a constant mark ratio ( $= 1/2$ ), allowing stable clock extraction and data regeneration. The format is applicable to

optical loop LAN systems in which the input data mark ratio changes transitionally. Two ICs, a wide-band amplifier IC and a CMI CODEC IC have been newly developed. The minimum received optical power is  $-27.5$  dBm and the optical dynamic range is 25 dB by the use of a BTRS (buried twin-ridge substrate) laser in the  $0.8 \mu\text{m}$  wavelength region and a Si-pin photodiode. This implies that transmission through more than 3 km optical fiber of the GI (graded index) type with 500MHz-km bandwidth is possible. (Author abstract) 5 refs. In Japanese.

Kitaji, Seiko (Matsushita Communication Industrial Co, Jpn); Kawashima, Seichiro; Sanada, Takeshi; Kato, Osamu; Miwa, Makoto. *Natl Tech Rep Matsushita Electr Ind Co* v 33 n 6 Dec 1987 p 35-39.

**073649 100Mb/sec OPTICAL LOOP NETWORK.** A 100Mb/sec optical loop network system based on the high-speed optical transmission technology has been developed. The loop network consists of node equipments which are connected to one another with double optical fibers in a loop configuration. On the optical highway, circuit switched data and packet switched data are multiplexed by the TDMA (time division multiple access) method. Every time-slot is dynamically assigned to circuit switched data or packet switched data depending on the traffic conditions so that the highway is efficiently used. Each of the node equipment has 80kb/sec, 1.5Mb/sec and 32Mb/sec subscriber line interfaces for circuit switching. The loop network also operates as a bridge among the packet switching bus networks. The loop network provides a general-purpose data highway which can integrate various media, such as voice, text, image and video media. (Author abstract) 4 refs. In Japanese.

Iwaoka, Atsushi (Matsushita Communication Industrial Co, Jpn); Morozumi, Masahide; Itoh, Harumine; Hikokubo, Tsuneo; Iwakiri, Takuya; Yamada, Takaki. *Natl Tech Rep Matsushita Electr Ind Co* v 33 n 6 Dec 1987 p 114-121.

**073650 KOPPLUNG VON LASERDIODE UND POLARISATIONSERHALTENDER GLASFASER DURCH KLEBEN.** [Coupling of Laserdiode and Polarization-Maintaining Fiber by Gluing]. In a wideband communications system with optical switching a space division switching unit based on lithium-niobate matrices is used. Such matrices need light of a defined state of polarization that will be provided via polarization maintaining fibers. These fibers are directly glued to the laser crystal so that the linearly polarized light of the laser matches one of their principal axes as exactly as possible. The influence of an angular mismatch on this coupling is calculated and a criterion for adjustment is determined. This gluing will alter the power balance of the laser and its P-I-characteristic, which is calculated in an appendix. With these formulas the laser-fiber coupling loss will be determined. (Author abstract) In German. 2 refs.

Buenning, Helmut; Werner, Wolfgang. *NTZ Arch* v 10 n 4 Apr 1988 p 101-105.

**073651 DETECTOR FOR SUBNANOSECOND OPTICAL PULSES.** A detector for subnanosecond optical pulses which uses GaAs power field-effect transistors and an avalanche photodiode is described. This detector makes it possible to obtain a voltage pulse with an amplitude of 1.5 V across an active load of  $50 \Omega$  at a pulse length of about 250 ps at the half-maximum level. There is provision for adjustment of the initial sensitivity of the photodiode. The height of the output pulses can be controlled electronically. (Author abstract) 6 refs.

Adamov, P.G.; Vaksenburg, V.Ya. *Optoelectron Instrum Data Process* n 6 1987 p 108-110.

**073652 POSSIBILITY OF DEVELOPING COMMUTATOR SWITCHES FOR OPTICAL COMMUNICATION CHANNELS FROM BULK ACOUSTO-TOPTIC DEFLECTORS.** The physical limitations which arise in the use of acoustooptic deflectors to switch optical communication channels, including optical-fiber



channels, have been studied experimentally. The number of channels which can be switched by a single device is shown to be limited by the magnitude of the crosstalk between channels. When single-coordinate deflectors are used, the number of channels can be more than 10; when two-coordinate deflectors are used, the number of channels can be more than 100. The typical expenditure of control energy per connection is approx. 1.5 W at a switching time approx. 1.5  $\mu$ sec. and at a radiative loss less than 10 db. (Author abstract) 4 refs.

Mirgorodskii, V.I. (Fryazino Moskovskoi, USSR); Peshin, S.V. *Optoelectron Instrum Data Process* n 6 1987 p 114-116.

**073653 OPTICAL RECEIVER EMPLOYING 850 nm FEEDBACK.** Optical feedback (OFB) transimpedance receivers have recently been shown to offer considerably better sensitivity than resistive feedback designs at low (1-2 Mbit/s) bit rates. We demonstrate an OFB receiver with a high sensitivity of  $-64.0$  dBm at 2.048 Mbit/s without the need for high-quality optoelectronic and electronic components. (Author abstract). 6 Refs.

Methley, S.G. (British Telecom Research Lab, Ipswich, Engl). *Electron Lett* v 24 n 13 Jun 23 1988 p 778-779.

**073654 FIBRE-OPTIC GRATING COUPLER FOR USE AS COMBINED POWER DIVIDER AND WAVELENGTH DEMULTIPLEXER.** A new design method is presented for step-structured phase-only gratings, which integrate two system functions (power divider and wavelength demultiplexer) in one single grating structure. Calculations based on simple Fourier transform techniques yield diffraction efficiencies between 75% and 83% for these structures. Because the depth is too large ( $> 10 \mu\text{m}$ ) for Fourier transform to be perfectly valid, these results cannot be considered to be reliable enough. Therefore the approximate results are verified by exact calculations based on Maxwell's equations, also considering polarization effects. By generalizing the algorithm, calculations can be carried out for almost any deep, stepped transmission and reflection grating. (Author abstract). 11 Refs.

Noll, J. (Philips GmbH Forschungslab Hamburg, Hamburg, West Ger); Schmitt, H.J. *Philips J Res* v 43 n 2 1988 p 152-184.

**073655 SIMULATION STUDIES ON NONLINEAR BIT SYNCHRONIZERS IN APD-BASED OPTICAL RECEIVERS.** The problem of self-bit-synchronization utilizing nonlinear timing extraction schemes is examined in optical receivers with avalanche photodetectors (APD) through digital computer simulation. A direct algorithm is developed for the simulation of sample functions of the APD output process with due consideration to intersymbol interference. Simulation of all the functional blocks used for synchronization is carried out in the discrete time domain. Detailed performance results are given for a linear and four types of nonlinear timing recovery schemes for exponential and trapezoidal pulse shapes. Performances of the nonlinear timing recovery schemes are evaluated in terms of the rms timing jitter for nonreturn-to-zero as well as return-to-zero signaling formats. 16 refs.

Datta, Debasis (Indian Inst of Technology, Kharagpur, India); Gangopadhyay, Ranjan. *IEEE Trans Commun* v COM-35 n 9 Sep 1987 p 909-917.

**073656 COMPARATIVE STUDY OF EASILY INTEGRABLE PHOTODETECTORS.** Three different 800-nm photodetectors were fabricated using an ion-implanted GaAs MESFET technology. No modifications to the MESFET process were necessary, making these detectors among the most easily integrable reported. The three detectors are a photoconductor with an ion-implanted active region and a high photocurrent gain, a fast photodiode (FWHM (full width half maximum)  $< 53$  ps), and a zero-bias photodiode. Accurate comparisons of reported detectors are sometimes difficult because results are influenced by differences in the processing, material, device dimensions, active area, and testing.

These factors are identical for the three detectors reported, making possible a fair comparison among detector types. 18 refs.

Wojtczuk, Steven J. (Cornell Univ, Ithaca, NY, USA); Ballantyne, Joseph M.; Wanuga, Stephen; Chen, Young-Kai. *J Lightwave Technol* v LT-5 n 10 p 1365-1370.

**073657 PLANAR EMBEDDED INP/GAINAS P-I-N PHOTODIODE FOR VERY HIGH-SPEED OPERATION.** Planar embedded InP/GaInAs p-i-n photodiodes have been fabricated by using preferential ion-beam etching for planarizing and embedding the p-i-n photodiode structure in a semi-insulating InP substrate. The stray capacitances caused by a bonding pad and an interconnection have been markedly reduced, which resulted in extremely low capacitance of less than 0.08 pF for a diameter of 20  $\mu\text{m}$  of photosensitive area. It has been demonstrated by an optical heterodyne technique that the photodiode exhibits a maximum cutoff frequency of 14 GHz. This result was analyzed taking the depletion layer thickness into account and has been found to be dominated by the carrier transit time. The demonstrated low capacitance and high-speed response result indicates the suitability of the p-i-n photodiodes not only for a discrete p-i-n photodiode but also for optoelectronic integration. 17 refs.

Miura, Shuichi (Fujitsu Ltd, Atsugi, Jpn); Kuwatsuka, Haruhiko; Mikawa, Takashi; Wada, Osamu. *J Lightwave Technol* v LT-5 n 10 p 1371-1376.

**073658 ALGAS OEIC TRANSMITTERS.** The state of the art of AlGaAs optoelectronic integrated-circuit (OEIC) transmitters is discussed, covering the concept, their history, examples, designs, fabrication, materials, and future possibilities. Experimental results in the Gb/s regime are demonstrated. 66 refs.

Matsueda, Hideaki (Hitachi Ltd, Kokubunji, Jpn). *J Lightwave Technol* v LT-5 n 10 p 1382-1390.

**073659 TWO AND THREE LEVEL OPTICAL PCM TRANSMITTER DESIGN FOR MULTIGIGABIT SYSTEMS USING A RELAXATION OSCILLATION TECHNIQUE.** A theoretical method based on gain switching of semiconductor lasers is described which optimizes the bandwidth and modulated output power from a given laser for application in optical PCM (pulse-code-modulation) systems. Both two-level and three-level systems are considered. The type of laser used to demonstrate the technique is typical of an AlGaAs buried heterostructure laser. A three-level optical system based on only two electrical drive levels is evaluated. Numerical results based on the single-mode rate equations, including a diffusion term, predict bit rates of 5 Gb/s for a two-level system and 8 Gb/s for the three level system. The technique was also applied to short cavity and quaternary lasers. 18 refs.

Byrne, Donal M. (Univ Coll, Dublin, Irel); O'Dowd, Ronan F. *J Lightwave Technol* v LT-5 n 10 p 1412-1425.

**073660 GIGABIT-PER-SECOND DUAL-GATE MESFET SWITCHING AND MULTIPLEXER OPERATION FOR HIGH-SPEED FIBER-OPTIC SYSTEMS.** The operation of dual-gate GaAs MESFETs in Gb/s switching applications for high-speed fiber-optic systems is investigated, and a full nonlinear modeling procedure is presented for general switching simulations. The model is characterized by an efficient technique that only requires two-port s-parameter measurements to determine the nonlinear element variations. Circuit simulations implemented on SPICE 2 have been applied to evaluate the transient switching response of dual-gate MESFETs in several circuits involving 1-Gb/s pulse conversion and synchronization, pulsewidth reduction, and 2-Gb/s multiplexing. The results show good agreement between predicted and experimental switching waveforms. 18 refs.

Scott, James R. (Univ of Melbourne, Parkville, Aust); Minasian, Robert A. *J Lightwave Technol* v LT-5 n 10 p 1459-1465.

**073661 INGAASP/INP LONG WAVELENGTH OPTOELECTRONIC INTEGRATED CIRCUITS (OEIC'S) FOR HIGH-SPEED OPTICAL FIBER COMMUNICATION SYSTEMS.** A description is given of long-wavelength InP-based OEICs in which optical components and electrical components are monolithically integrated on a single chip. Recent progress in the InP-based OEIC technologies is reviewed. Results obtained from transmission experiments using long-wavelength OEICs are described, and applications for optical systems are discussed. 41 refs.

Suzuki, Akira (NEC, Kawasaki, Jpn); Kasahara, Kenichi; Shikada, Minoru. *J Lightwave Technol* v LT-5 n 10 p 1479-1487.

**073662 8-BIT/S TRANSMISSION EXPERIMENT OVER 68 KM OF OPTICAL FIBER USING A Ti:LiNbO<sub>3</sub> EXTERNAL MODULATOR.** The performance of an experimental 1.5- $\mu\text{m}$  lightwave transmission system operating at 8 Gb/s over 68.3 km of single-mode fiber is described. The dispersion penalty is limited to 1 dB by means of external modulation and is attributable to the intrinsic information bandwidth.

Korotky, Steven K. (AT&T Bell Lab, Holmdel, NJ, USA); Gnauck, Alan H.; Kasper, Byron L.; Campbell, Joe C.; Veselka, John J.; Talman, J.R.; McCormick, Alfred R. *J Lightwave Technol* v LT-5 n 10 p 1505-1509.

**073663 1.13-GBIT/LIGHTWAVE TRANSMISSION SYSTEM.** A high-capacity lightwave transmission system, developed using GaAs semicustom logic arrays and a DFB (distributed feedback) single-mode laser, is presently in production. The architecture of this product is designed for in-service upgrade of a 565-Mb/s product. The technical characteristics and design considerations of the system are reviewed. 5 refs.

Maxham, Kenneth Y. (Rockwell Int, Dallas, TX, USA); Dugan, J. Michael; McDonald, Mark A.; Hogge, Charles R. Jr. *J Lightwave Technol* v LT-5 n 10 p 1510-1517.

**073664 GIGABIT SINGLE-MODE FIBER TRANSMISSION USING 1.3- $\mu\text{m}$  EDGE-EMITTING LEDS FOR BROAD-BAND SUBSCRIBER LOOPS.** Gigabit single-mode fiber transmission using 1.3- $\mu\text{m}$  edge-emitting LEDs for broadband subscriber loops is described, focusing on a method of calculation for maximum transmission distance and 1.2-Gb/s and 600-Mb/s transmission experiments. The maximum transmission distance is estimated by taking into account the wavelength dependence for both chromatic dispersion and loss of the single-mode fiber. The possibility of gigabit transmission near the dispersion-free wavelength 1.3  $\mu\text{m}$  is confirmed. The 1.3- $\mu\text{m}$  edge-emitting LED and a driver circuit with a simple response compensation circuit has been developed for this application.

Ohtsuka, Tonoyuki (Fujitsu Ltd, Kawasaki, Jpn); Fujimoto, Nobuhiro; Yamaguchi, Kazuo; Taniguchi, Atsuki; Naitou, Hidetoshi; Nabeshima, Yoichiro. *J Lightwave Technol* v LT-5 n 10 p 1534-1541.

**073665 ROBUST MATCHED FILTERS FOR OPTICAL RECEIVERS.** The design of optical receivers that are robust against uncertainty in the statistics of the observation process in photodetection is investigated. A modification in the design of the postdetection matched filter is proposed to account for possible uncertainty in the rate function of the incident light, the rate of the dark current, and in the statistics of the additive noise present at the input to the optical receiver. The design is based on a game-theoretic approach in which a filter is sought that has the maximum worst-case output signal-to-noise ratio possible over the class of allowable statistics; that is, the design criterion is maximin signal-to-noise ratio. A general characterization of maximin robust matched filters for observed Poisson processes is presented, and solutions for



several useful uncertainty models are obtained. Numerical results for a specific example illustrate the performance of the technique. 23 refs.

Geraniotis, Evangelos A. (Univ of Maryland, College Park, MD, USA); Poor, H. Vincent. *IEEE Trans Commun* v COM-35 n 12 p 1289-1296.

**073666 JITTER TOLERANCE OF FIBER OPTIC REGENERATORS.** The effect of accumulated jitter on the decision-making process inside the Nth fiber-optic regenerator of a long chain of fiber optic regenerators is analyzed. The criteria for a correct bit decision in the presence of receiver noise, static phase offset, and accumulated input jitter are derived, and the bit-error-rate penalties caused by the presence of known distributions of accumulated input jitter are calculated. It is shown that excessive bit-error-rate penalties will not occur if the accumulated input jitter does not exceed the regenerator's measured jitter tolerance template. The jitter tolerance measurement technique is used to find the optimum sampling time inside a fiber-optic regenerator, resulting in a regenerator that is optimized for use in long-haul systems. 22 refs.

Trischitta, Patrick R. (AT&T Bell Lab, Holmdel, NJ, USA); Sannuti, Peddapullaiah. *IEEE Trans Commun* v COM-35 n 12 p 1303-1308.

**073667 COMPUTING THE PERFORMANCE OF OPTICAL RECEIVERS WITH AVALANCHE DIODE DETECTORS.** A method is described for exactly computing the probability distribution of the sum of the output of an avalanche diode and Gaussian noise using the Personick-McIntyre model of the random electron multiplication in the diode. A saddlepoint approximation is also presented. Both are incorporated in an optimization procedure for efficiently calculating the minimum input signal strength and the decision level that are needed to attain a preassigned error probability when the diode is embodied in a binary optical communication receiver. 13 refs.

Helstrom, Carl W. (Univ of California at San Diego, La Jolla, CA, USA). *IEEE Trans Commun* v 36 n 1 Jan 1988 p 61-66.

**073668 THICK-FILM CRYSTAL GROWTH OF HIGHLY B<sub>1</sub>%-SUBSTITUTED GARNET FOR OPTICAL ISOLATORS.** The melt composition needed to obtain pit-free, highly Bi-substituted (BiLu)<sub>3</sub>Fe<sub>5</sub>O<sub>12</sub> crystals by the LPE method was investigated. It was confirmed that adding B<sub>2</sub>O<sub>3</sub> to the melt increases the equilibrium segregation coefficient of Bi,  $K_{O(Bi)}$ . It was found that a decrease in garnet composition ratio  $R_4$  acts to increase the growth-rate dependence of the normalized effective segregation coefficient of Bi  $K_{eff(Bi)}/K_{O(Bi)}$ . Crystals with mirror-smooth surfaces were obtained by adding Gd<sub>2</sub>O<sub>3</sub> to the melt. Using a melt with Gd<sub>2</sub>O<sub>3</sub>/Lu<sub>2</sub>O<sub>3</sub> ≥ 1, the pits that usually appear in LPE growth of (BiLu)<sub>3</sub>Fe<sub>5</sub>O<sub>12</sub> were eliminated and pit-free, highly Bi-substituted (BiLuGd)<sub>3</sub>Fe<sub>5</sub>O<sub>12</sub> crystals were obtained. The optical properties of 250-μm-thick (BiLuGd)<sub>3</sub>Fe<sub>5</sub>O<sub>12</sub> crystals were measured in order to evaluate their applicability to optical isolators for use at 1.3 μm. A sufficient Faraday rotation of  $\theta_F = -1800$  deg/cm and an extinction ratio of -40 dB were obtained. 4 refs.

Matsuda, K. (Matsushita Electric Industrial Co, Jpn); Kamada, O.; Ishizuka, S. *IEEE Transl J Magn Jpn* v TJM-2 n 8 Aug 1987, Contrib from the Ninth Annu Conf on Magn in Jpn, Jpn, Nov 26-29 1985 p 674-679.

**073669 OPTICAL AND OPTOELECTRONIC DEVICES FOR OPTICAL FIBER TRANSMISSION SYSTEMS.** The present status and research trends in light sources, detectors, and various optical components are described, focusing mainly on those for single-mode fiber systems. Laser-diode and light-emitting-diode sources are described, and their problems and advantages are examined. The features of optical detectors, namely, avalanche and p-i-n photodiodes are discussed. A method of comparing the performance of optical receivers with different detectors, by examining the minimum detectable

power at a specified error probability for the received pulses, is presented. Optical components such as optical filters, couplers, dividers; isolators, connectors, and switches are considered briefly. The potential of optoelectronic integrated circuits is discussed. 16 refs.

Nakagami, Takakiyo (Fujitsu Lab, Kawasaki, Jpn); Sakurai, Teruo. *IEEE Commun Mag* v 26 n 1 Jan 1988 p 28-33.

**073670 VERY SMALL SINGLE-MODE TEN-FIBER CONNECTOR.** A small plastic molded single-mode ten-fiber connector has been developed for high-count optical subscriber cables. The connector ferrule alignment mechanism is designed with a sufficient factor of safety to allow rough handling during connection. The ferrules are precisely aligned by alignment pins and guide sleeve. The fabricated connector, which has a cross section of just 4 mm × 6 mm, exhibited an average loss of 0.4 dB and reconnection time of less than 0.5 min. Connection loss does not change after over 1000 reconnections. 9 refs.

Satake, Toshiaki (NTT, Tokai, Jpn); Kashima, Norio; Oki, Masayuki. *J Lightwave Technol* v 6 n 2 Feb 1988 p 269-272.

**073671 DISPERSION PENALTY FOR 1.3-μm LIGHTWAVE SYSTEMS WITH MULTIMODE SEMICONDUCTOR LASERS.** The effect of fiber dispersion on the performance of lightwave systems is analyzed for the case where multimode semiconductor lasers operating near the zero-dispersion wavelength of the single-mode fiber are used as sources. Both the intersymbol interference and the mode-partition noise are considered in the discussion of dispersion-induced power penalties. The theory is in agreement with an experiment in which the bit error rate is measured for lasers at various bit rates. The tolerable limits on the deviation of the laser wavelength from the zero-dispersion wavelength are obtained for a 1.3-μm system operating at 1.7 Gb/s. Monte Carlo simulations are used to predict the effect of mode-partition noise on the performance of such high-speed lightwave communication systems. 11 refs.

Agrawal, Govind P. (AT&T Bell Lab, Murray Hill, NJ, USA); Anthony, Philip J.; Shen, Tek-Ming. v 6 n 5 May 1988 p 620-625.

**073672 PERFORMANCE IMPLICATIONS OF MODE PARTITION FLUCTUATIONS IN NEARLY SINGLE LONGITUDINAL MODE LASERS.** A statistical model of mode partition fluctuations is developed for semiconductor laser diodes with a single dominant lasing mode and one vestigial side mode. It is the basis of a rigorous analysis of the influence of partition fluctuations on the performance of digital lightwave transmission systems. A Gauss quadrature rule is used to evaluate the average probability of error in the presence of mode-partition-dependent shot noise, photodetector multiplication noise, circuit noise, and intersymbol interference. This methodology permits the determination of reliable performance estimates enabling the establishment of permissible degrees of mode partition fluctuations. 32 refs.

Cartledge, John C. (Queen's Univ, Kingston, Ont, Can). *J Lightwave Technol* v 6 n 5 May 1988 p 626-635.

**073673 ANALYSIS OF SENSITIVITY DEGRADATION CAUSED BY THE FLICKER NOISE OF GaAs-MESFET'S IN FIBER-OPTIC RECEIVERS.** The total input noise current and sensitivity of the fiber-optic receiver was calculated. The flicker noise source was included by adopting a pertinent flicker noise model. Power penalties caused by the flicker noise were calculated for various fiber-optic receivers using the calculated noise current. It has been found that the flicker noise affects the sensitivity over the whole range of the bit rates, and that the total input capacitance is an important parameter affecting the power penalty which is serious in the case of a high-impedance-type p-i-n FET receiver. The optimum feedback resistance for practical p-i-n FET receiver design is also suggested. 27 refs.

Park, Moon-Soo (Electronics & Telecommunications Re-

search Inst, Chungnam, South Korea); Shim, Chang-Sup; Kang, Min-Ho. *J Lightwave Technol* v 6 n 5 May 1988 p 660-667.

**073674 TRANSMISSION QUALITY AND PERFORMANCE OF ILL REPEATERS USED IN OPTICAL FSK COMMUNICATIONS.** The use of injection-locked laser diodes as nonregenerative repeaters for optical frequency-shift keying (FSK) transmission systems is considered, with emphasis being placed on potential impairments which may limit performance. Nonlinear phase distortion associated with the amplification of FSK signals by injection-locked lasers (ILLs) is considered, as are the effects of intensity fluctuations on the locking bandwidth, the influence of laser phase noise, ILL frequency stability requirements, and the number of repeaters that can be cascaded before loss of lock occurs. How these factors combine to influence overall system performance is also examined. 20 refs.

O'Byrne, Vincent (Univ of Coll of North Wales, Bangor, North Wales); O'Reilly, John J. *J Lightwave Technol* v 6 n 5 May 1988 p 695-703.

**073675 OPTIMIZATION OF AN OPTICALLY PULSED PHOTOCELL ARRAY AS A SENSOR POWER SOURCE.** A method for improving the efficiency of the conversion of pulsed optical power to electrical power by photovoltaic cells is presented. A fiber-optic echo sensor being developed requires a pulsed power source with a storage capacitor to hold energy for a time after the optical power is turned off. By charging capacitors from each cell individually with a switching transistor control, a higher efficiency is obtained than when the common method of series charging is used. 8 refs.

Trisno, Yudhi S. (State Univ of New York at Buffalo, Amherst, NY, USA); Wobschall, Darold. *IEEE Trans Instrum Meas* v 37 n 1 Mar 1988 p 142-144.

**073676 OPTIMIZATION OF THE OPTICAL SENSITIVITY OF p-i-n FET RECEIVERS.** The optimization of the input stage of a p-i-n FET receiver is discussed, with emphasis on the implications for an integrated InP/InGaAs p-i-n FET technology. In the early stages of development of this technology, it is necessary to keep the design simple, which implies that the device will consist of a single-stage, low-gain amplifier. Design criteria for such an amplifier are presented, and it is shown that the transimpedance configuration provides better sensitivity than a voltage amplifier, even when the gain of the amplifier is very small. It is also shown that the gate capacitance (i.e., width) of the input FET which optimizes the sensitivity is much smaller when the amplifier gain is low than it is in the high-gain limit. 9 refs.

Vella-Coleiro, G.P. (AT&T, Murray Hill, NJ, USA). *IEEE Electron Device Lett* v 9 n 6 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 269-271.

**073677 FIVE YEARS S.I.P. EXPERIENCE IN AERIAL OPTICAL CABLES.** In the experimentation on optical cables carried out by SIP (Italian Telephone Operating Company) an important role is played by cables for aerial installation. The main activity (grouped under the name COS 4) has been carried out on a line along a valley of Italian Alps, where three different cables have been installed. The characteristics of the experimented cables, the measuring and monitoring systems and the collected results are reviewed. (Author abstract) 2 refs.

Esposito, F. (SIP DG, Rome, Italy); Galliano, G.; Giavelli, A.; Lanzillotti, D. *CELT Tech Rep* v 13 n 5 Oct 1985, IOOC-EOC '85 (5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun), Venice, Italy, Oct 1-4 1985 p 293-295.

**073678 COLLOQUIUM ON HIGH CAPACITY FIBRE OPTIC SYSTEMS.** This conference proceedings contains 14 papers covering the following major subjects:



long haul optical transmission system, low power multiplexer/demultiplexer for 2.4 Gb/s fiber optic systems, 1.53  $\mu$ m DFB laser for transmission systems, bipolar integrated circuits for digital optical links, crosstalk penalties in WDM optical transmission systems, PIN-FET receiver coherent transmission system using DFB lasers, tolerant wavelength multiplexing of high capacity optical fiber systems, passive fiber optic components using dispersion shifted fiber, methods for fine tuning the wavelength response of optical fiber taper filters and lithium niobate digital switching. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11338 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig n* 1987/23, Colloq on High Capacity Fibre Opt Syst, London, Engl, Feb 19 1987. Publ by IEE, London, Engl, 1987 var pagings.

Analysis See MULTIPLEXING EQUIPMENT—Analysis.

Applications See Also COMPUTER NETWORKS—Local Networks.

**073679 LIGHT-LINK OPTOCOUPERS ARE FASTER.** Optocouplers are versatile devices used in modern microelectronic applications. Siemens has developed new devices called light-link components for constructing optocouplers with features superior to those of standard coupling elements. The new light-link components are ideal for constructing coupling elements with features so far only provided by standard couplers. High isolation voltage and improved high-frequency characteristics are important features. Three circuits capable of handling 50 kHz, 200 kHz and 1 MHz are described in the article. The devices are also suitable for use in light-sensing applications. 2 refs.

Hirschmann, Guenther (Siemens AG, Munich, West Ger). *Siemens Compon v* 22 n 3 Jun 1987 p 96-99.

**073680 OPTICAL TRANSMISSION SYSTEMS OF TWIN-21 BUILDING.** Construction of intelligent buildings equipped with optical communication systems has been promoted these years. For the purpose of practical application and verification of the optical transmission systems to be introduced in future high buildings, various optical transmission systems using optical communication techniques have been built in the Twin-21 Building in Osaka Business Park. The systems include the following: (1) Building control and monitoring system using a 1Mb/sec optical loop network; (2) ITV monitoring and control system in elevators for preventing fire and crimes; (3) OA systems using a 100Mb/sec optical LAN as the trunk line; (4) Visual information system for AV information service in the buildings; and (5) TV periscope system applying a camera control system. The paper describes the setup of these systems and the details of the visual information system. (Author abstract) 4 refs. In Japanese.

Kishi, Shuichiro (Matsushita Electronic Components Co, Jpn); Ando, Kaoru; Kurata, Noboru. *Natl Tech Rep Matsushita Electr Ind Co v* 33 n 6 Dec 1987 p 83-91.

Components

**073681 OPTICAL CABLES, SWITCHES AND LOGIC (OR MADNESS).** Optical fibres are well established as the preferred long and medium distance communications medium. Optical interconnect technology, deeply embedded down to wafer level in otherwise electronic processors, seems likely to allow electronics to push to higher speed-complexity product values. In networks, it is extremely attractive to look forward to 'all optical networks' as an elegant concept. Will it be a hybrid assembly, an all III-V opto-electronic system or a new combination such as III-V grown on silicon, using silicon as the prime electronic medium? These issues have yet to be resolved, but represent a fascinating challenge for those interested in pushing still further the scope for opto-electronics within communications.

Midwinter, J.E. (Univ Coll London, London, Engl). *Int J Digital Analog Cabled Syst v* 1 n 2 Apr-Jun 1988 p55.

Computer Integrated Manufacturing

**073682 MACHINE-VISION-ASSISTED WORKSTATIONS FOR LIGHTWAVE DEVICE MANUFACTURE.** Three lightwave production workstations are a part of the optical data link production line at the AT&T Reading Works. Although they perform different production tasks, each is an example of the manufacturing advantages that can be achieved when computer-controlled robotic positioners are coupled with visual feedback. The potential benefits include reduced operator errors due to fatigue, increased product quality and consistency, and increased manufacturing efficiency. (Author abstract) 6 refs.

Berk, Donald A. (AT&T Bell Lab, Morristown, NJ, USA); Judd, Frank F.; Wisniewski, Stanley C. II. *AT&T Tech J v* 67 n 2 Mar-Apr 1988 p 35-46.

Costs

**073683 INCREASING THE VALUE/COST RATIO FOR THE INTRODUCTION OF BROADBAND SERVICES.** The paper examines the architecture, system and component aspects related to the introduction of broadband service on an optical fibre distribution network, addressing in particular the cost issue. (Author abstract) 7 refs.

Tosco, F. (CSELT, Turin, Italy). *CSELT Tech Rep v* 13 n 5 Oct 1985, IOOC-ECOC '85 (5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun), Venice, Italy, Oct 1-4 1985 p 279-284.

Design

**073684 WAVELENGTH-DIVISION-MULTIPLEXING TRANSCIEVER MODULE.** This paper describes the design and performance of a 3-channel wavelength-division-multiplexing (WDM) transceiver module for a broadband distribution system in subscriber loops. The module incorporates WDM optical components such as emitters, detectors and filters for compactness and ease of handling. Moreover, the emitter, the detector and the input/output fiber are packaged each with a collimating or focusing lens in order to enable mounting without adjustment on the substrate of the module. Good performance and high stability were confirmed for the module through tests. (Author abstract) 9 refs. In Japanese.

Oguchi, Taisuke (NTT Electronics & Mechanics Technology Lab, Jpn); Tachikawa, Yoshiaki; Nishi, Isao; Ikeda, Masahiro. *Denki Tsushin Kenkyusho Kenkyu Jitsuyoku Hokoku v* 36 n 7 1987 p 909-917.

**073685 MDF FOR OPTICAL SUBSCRIBER SYSTEMS.** This paper describes the design concept and hardware of an optical MDF (main distribution frame) developed to meet the needs of optical subscriber systems, such as fiber-optic broadband distribution systems which provide both video distribution services and 64kb/s data services. A two-connector system is employed for easier jumper changes. A high density terminal block is attained by adopting the newly developed push-pull singlefiber connector. The structure is designed considering ease of handling and the attributes peculiar to fiber-optic code. (Author abstract) 5 refs. In Japanese.

Magaki, Yohtarō (NTT Electronics & Mechanics Technology Lab, Jpn); Watanabe, Tamotsu; Imori, Yasutaka; Kanai, Tsuneo. *Denki Tsushin Kenkyusho Kenkyu Jitsuyoku Hokoku v* 36 n 7 1987 p 927-934.

**073686 OPTICAL-ACTUATOR-MULTIPLEXED, SERIAL TRANSMISSION FIBER ENCODER.** An optically-driven, electro-mechanical actuator is described, which can sequentially connect a single multimode input fiber to each fiber of a 12-fiber array. The optical drive is effected remotely over a long fiber cable, and only 16  $\mu$ W received optical power is required for resonant scanning of the array. The output array fibers are configured to read

ten tracks of a reflective absolute encoder disc, and to transmit the digital word to a readout station. The inherent serial, digital code format conveys the readout with a high level of transmission-path independence. (Author abstract) 6 refs.

Johnson, Mark (York Harburg Sensor GmbH, Hamburg, West Ger). *Opt Commun v* 65 n 2 Jan 15 1988 p 87-90.

Electric Properties

**073687 CURRENT CROWDING EFFECTS IN GAAS/ALGAAS HETEROJUNCTION PHOTOTRANSISTORS.** The heterojunction phototransistor (HPT) has applications as an optical detector/amplifier in receivers for fiber optic communications systems. It is well known that the provision of an external bias, either optically or electrically, via a third (base) terminal, can enhance the performance of the HPT in terms of gain, a speed of response and signal to noise ratio. This is due principally to an increase in emitter efficiency and a reduction in the RC time constant of the emitter base junction. In the paper we show that crowding of the bias current and the signal current can affect very significantly the high frequency performance of phototransistors and will limit the advantage given by the external bias in three-terminal devices but improve the performance of two-terminal devices. The implications for the design of high speed phototransistors are discussed. (Author abstract) 12 refs.

Twynam, J.K. (Univ of Sheffield, Sheffield, Engl); Woods, R.C. *IEE Proc Part J v* 135 n 1 Feb 1988 p 52-55.

Electronics Packaging

**073688 GIGABIT RECEIVER IC'S FOR OPTICAL COMMUNICATIONS.** The authors discuss gigabit receiver ICs for optical communications, focusing on their circuit and package design, the performance of receivers that were fabricated, and their application to a 1.6 Gb/s optical receiver. The key technologies for the receivers are discussed, and a design based on these key technologies is proposed. The proposed design is used to fabricate six receiver ICs (eight chips) using an ultra-high-speed bipolar process with transistors having a unity gain bandwidth of 6-8 GHz. The receivers are suitable for long-haul optical transmission at bit rates up to 1.6 Gb/s. Experimental results show that the 1.6-Gb/s receiver has an optical dynamic range of more than 23 dB without any adjustment, and the received average optical power required to maintain a  $10^{-11}$  error rate is less than -dBm. 6 refs.

Yamaguchi, Kazuo (Fujitsu Lab Ltd, Kawasaki, Jpn); Kitagami, Hiroo; Kawai, Masaaki; Amemiya, Izumi; Touge, Takashi; Tamada, Haruo; Kokado, Masayuki; Sugimoto, Masahiro. *IEEE J Sel Areas Commun v* 6 n 3 Apr 1988 p 460-467.

Exhibitions

**073689 —OPTICAL ISLAND— IN THE MILANO FAIR.** The paper presents the —optical island— recently implemented in the Milano Fair. This area has been fully wired with optical fibres and new video services have been given to a number of users from a Service Centre at the Spring '85 Exhibition. The general organization and the main characteristics of the system are briefly highlighted. (Author abstract) 2 refs.

Bigi, F. (SIP DG, Rome, Italy); Giorgetti, F.; Melindo, F. *CSELT Tech Rep v* 13 n 5 Oct 1985, IOOC-ECOC '85 (5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun), Venice, Italy, Oct 1-4 1985 p 297-299.

Laser Applications

**073690 IMPACT OF LASER INTENSITY NOISE ON ASK TWO-PORT OPTICAL HOMODYNE RECEIVERS.** The letter describes experimental results obtained with a multipoint optical homodyne receiver employing a DFB laser. The receiver performance is found to be limited by the intensity noise of the local oscillator



rather than by the phase noise, even when the product of the IF linewidth and the bit duration is as large as 0.56. A relative intensity noise level of at least  $-140$  dB/Hz will be required for a satisfactory receiver performance with  $-15$  dbm local oscillator power. (Author abstract) 6 refs.

Kazovsky, L.G. (Bell Communications Research, Red Bank, NJ, USA); Elreifaie, A.F.; Meissner, P.; Welter, R.; Crespo, P.; Gimlett, J.; Smith, R.W. *Electron Lett* v 23 n 17 Aug 13 1987 p 871-873.

**073691 810M OPTICAL TRANSMISSION SYSTEM.** A single-mode 810M optical transmission system has been developed. The system operates at  $1.3$   $\mu$ m wavelength and a large capacity of 12096 telephone channels can be transmitted over a distance of 6400 km with a repeater spacing of 40 km. Development of this system is the result of progress in technologies concerning optical modules, DFB laser-diode and InGaAs avalanche photodiode modules, and high speed semiconductors. This system is suitable for application on long-haul high capacity trunk lines and microwave access. (Edited author abstract) 10 refs.

Mori, Masakazu; Fujimoto, Naonobu; Fukushima, Takeo. *Fujitsu Sci Tech J* v 23 n 3 Autumn 1987 p 177-186.

## Maintenance

**073692 EQUIPMENT SUPERVISION, OPERATION AND MAINTENANCE.** Continuous supervision of the optical fiber equipment along the route is an essential requirement for proper operation and maintenance. On the Melbourne-Canberra-Sydney route, two distinct equipment types and two state administrations having different maintenance organizations are involved. The authors describe maintenance and supervision philosophy, supervisory equipment, arrangements, handling of internal plant faults, electrostatic discharge precautions, and routine tests. 1 ref.

D'Alessi, F.; Lierse, K.; Hollo, P.. *Telecommun J Aust* v 37 n 3 1987 p 83-88.

**Manufacture** See Also LASERS, SEMICONDUCTOR—Reliability.

**073693 HIGH-SPEED GaInAsP/InP BURIED-HETEROSTRUCTURE OPTICAL INTENSITY MODULATOR WITH SEMI-INSULATING InP BURYING LAYERS.** GaInAsP/InP buried-heterostructure (BH) optical intensity modulators have been fabricated by the use of Fe-doped semi-insulating InP burying layers. The reduction of a parasitic capacitance due to the semi-insulating burying layers realised a wide modulation bandwidth of 11.2 GHz. At a wavelength of  $1.53$   $\mu$ m, an attenuation ratio of 20 db at 26°C was achieved with an applied voltage of  $-8.5$  v. (Author abstract) 3 refs.

Soda, H. (Fujitsu Lab Ltd, Atsugi, Jpn); Nakai, K.; Ishikawa, H.; Imai, H. *Electron Lett* v 23 n 23 Nov 5 1987 p 1232-1234.

**073694 DEVELOPMENT OF A COMPACT FUSION SPLICER WITH DIRECT CORE MONITORING SYSTEM SUMIOFAS TYPE 34.** A new generation of compact fusion splicers with a direct core monitoring system has been developed. It is called SUMIOFAS TYPE 34. It is more compact, lighter, and consumes less power than TYPE 33. Its controller is incorporated in the main body, unlike its predecessor where it was separated. Its splicing characteristics and reliability have been tested and good results achieved. With its high performance, the TYPE 34 has an important role to play in the installation of long optical transmission lines. (Edited author abstract) 8 refs.

Hakamata, Naoshi; Awai, Hiromitsu; Usui, Yuichi; Asano, Yasuo; Ide, Takashi; Watanabe, Kazuo; Kawachi, Koji; Furuya, Shuji. *Sumitomo Electr Tech Rev* n 27 Jan 1988 p 37-41.

## Mathematical Models

**073695 ASK HOMODYNE SYSTEM RECEIVER USING A 6-PORT FIBER COUPLER.** The transmission performance of an ASK optical homodyne system is investigated, which uses a 6-port optical fiber coupler at the receiver. The effect of phase imbalance in the fiber coupler outputs is considered and shown not to be a significant factor, provided the path delays in the receiver are equalised. In this case, the system has a similar receiver sensitivity and allowable laser linewidth as that for conventional ASK heterodyne systems using nonsynchronous demodulation techniques. (Author abstract) 7 refs.

Nicholson, Grant (Telecom Australia Research Lab, Clayton, Aust). *J Opt Commun* v 9 n 1 Mar 1988 p 13-16.

## Measurements

**073696 MEASUREMENT OF CARRIER-DENSITY MEDIATED INTERMODULATION DISTORTION IN AN OPTICAL AMPLIFIER.** We measured intermodulation distortion (IMD) generated by the presence of two optical tones separated by up to 1 GHz in a  $1.3$   $\mu$ m near-traveling-wave optical amplifier. The measured distortion agrees with calculations of third-order nonlinearity caused by carrier-density modulation. The third-order intercept of 5 dbm may be more restrictive in closely spaced frequency-multiplexed systems than gain saturation. (Author abstract) 11 refs.

Jopson, R.M. (AT&T Bell Lab, Holmdel, NJ, USA); Darcie, T.E.; Gayliard, K.T.; Ku, R.T.; Tench, R.E.; Rice, T.C.; Olsson, N.A. *Electron Lett* v 23 n 25 Dec 3 1987 p 1394-1395.

**073697 FIBER OPTIC APPLICATION. A SMARTER TEST SET FOR FIBER OPTIC MEASUREMENTS.** The design of test equipment for optical fiber installations is discussed. A wavelength-division-multiplex concept is described that meets the design goals. The use of the test set is shown.

Parikh, Rutesh (Photodyne Inc, Newbury Park, CA, USA); Wendland, Brad; Halpern, Hal. *Eval Eng* v 27 n 3 Mar 1988 p 110-112.

**Multiplexing** See Also WAVEGUIDES, OPTICAL—Mathematical Models.

**073698 HIGH-PERFORMANCE GUIDED-WAVE MULTI/DEMULTIPLEXER BASED ON NOVEL DESIGN USING EMBEDDED GRADIENT-INDEX WAVEGUIDES IN GLASS.** A guided-wave multi/demultiplexer which comprises low-loss gradient-index ion-exchange waveguides embedded in a glass substrate and optimized interference filters was fabricated. Around  $-1$  db insertion losses for demultiplexing and less than 2 db insertion losses for multiplexing with sufficient transmission bandwidth as wide as 66 nm were achieved. (Author abstract) 7 refs.

Seki, M. (Nippon Sheet Glass Co, Tsukuba, Jpn); Sugawara, R.; Hanada, Y.; Okuda, E.; Wada, H.; Yamasaki, T. *Electron Lett* v 23 n 18 Aug 27 1987 p 948-949.

**073699 OPTICAL INTERFERENCE IN LIGHTWAVE SUBCARRIER MULTIPLEXING SYSTEMS EMPLOYING MULTIPLE OPTICAL CARRIERS.** It is shown that when multiple optical carriers are used in a subcarrier multiplexing system, the mixing of the optical fields in the photodetector leads to interference which may impose a limitation on the system bandwidth or the number of available channels. (Author abstract) 6 refs.

Desem, C. (Telecom Australia Research Lab, Clayton, Aust). *Electron Lett* v 24 n 1 Jan 7 1988 p 50-52.

**073700 5 GHz-SPACED, EIGHT-CHANNEL OPTICAL FDM TRANSMISSION EXPERIMENT USING GUIDED-WAVE TUNABLE DEMULTIPLEXER.** A 5 GHz-spaced, eight-channel optical FDM transmission experiment using a guided-wave tunable demultiplexer is

presented. 400 Mbit/s intensity-modulated optical carriers are multiplexed and transmitted through 13 km single-mode fibre. One of the carriers is selected by the tunable demultiplexer and directly detected. (Author abstract) 7 refs.

Toba, H. (NTT Lab, Yokosuka, Jpn); Oda, K.; Nosu, K.; Takato, N.; Miyazawa, H. *Electron Lett* v 24 n 2 Jan 21 1988 p 78-80.

**Peoples Republic of China** See OPTOELECTRONIC DEVICES—Performance.

**Performance** See Also LASERS, SEMICONDUCTOR—Modulation; SIGNAL RECEIVERS—Performance.

**073701 34 MBIT/S OPTICAL FIBRE TRANSMISSION SYSTEM EXPERIMENT AT A WAVELENGTH OF 2.4  $\mu$ m.** Data transmission at 34 Mbit/s has been performed over a fluoride glass fiber at a wavelength close to the 2.55  $\mu$ m minimum-loss wavelength of the fiber, using an externally modulated He-Ne laser and a graded-composition GaInAs photodiode with spectral response optimized for 2.55  $\mu$ m operation. (Author abstract) 6 refs.

Garnham, R.A. (British Telecom Research Lab, Ipswich, Engl); Cunningham, D.G.; Stallard, W.A. *Electron Lett* v 23 n 20 Sep 24 1987 p 1063-1064.

**073702 ELECTRONIC DESIGN REPORTS ISSCC SPECIAL PURPOSE.** Fast ICs for optical communications and image sensing and processing are reported. Topics discussed include: a fiber-optic link, a three-stage source follower and a CCD imager.

Allan, Roger. *Electron Des* v 34 n 4 Feb 20 1986 p 119-123.

**073703 POLARISATION-INSENSITIVE COHERENT RECEIVER USING A DOUBLE BALANCED OPTICAL HYBRID SYSTEM.** A prototype polarisation-insensitive double balanced receiver for coherent lightwave communication is demonstrated and described. This receiver has been tested in a 40 Mbit/s DPSK self-heterodyne system. The maximum variation in the amplitude of the recovered data is only about 0.8db under random variation of the signal polarisation. The cause of this variation is discussed. (Author abstract) 4 refs.

Tzeng, L.D. (AT&T Bell Lab, Allentown, PA, USA); Emkey, W.L.; Jack, C.A.; Burrus, C.A. *Electron Lett* v 23 n 22 Oct 22 1987 p 1195-1196.

**073704 POLARIZATION-INSENSITIVE OPERATION OF COHERENT FSK TRANSMISSION SYSTEM USING POLARIZATION DIVERSITY.** Dynamic operation of an optical polarization diversity receiver with a square-law baseband combining technique is avoided with use of configurations in which two amplifiers are combined. We describe experiments with a series and a parallel arrangement of two optical amplifiers. The experiments demonstrate a polarization-insensitive amplification for both configurations over a spectral range of at least 80 GHz. (Author abstract) 5 refs.

Kyu, S. (KDD, Tokyo, Jpn); Yamamoto, S.; Mochizuki, K. *Electron Lett* v 23 n 25 Dec 3 1987 p 1382-1384.

**073705 OPTICAL AMPLIFIER CONFIGURATIONS WITH LOW POLARIZATION SENSITIVITY.** The sensitivity of optical amplifiers to signal polarization is avoided with use of configurations in which two amplifiers are combined. We describe experiments with a series and a parallel arrangement of two optical amplifiers. The experiments demonstrate a polarization-insensitive amplification for both configurations over a spectral range of at least 80 GHz. (Author abstract) 5 refs.

Grobkoste, G. (Nachrichtentechnik Berlin GmbH, Berlin, West Ger); Ludwig, R.; Waarts, R.G.; Weber, H.G. *Electron Lett* v 23 n 25 Dec 3 1987 p 1387-1388.



**073706 SEMICONDUCTOR MATERIALS AND STRUCTURES FOR OPTICAL-COMMUNICATION DEVICES.** We outline the present and advanced optical-communication-system trends and identify the important components and materials required. The appropriate preparation and assessment techniques are considered. Some materials properties particularly relevant for optical-communication devices are discussed. 18 refs.

Goodfellow, R.C. (Plessey Research (Caswell) Ltd, Twycross, Engl.). *Cryst Semicond Mater and Devices, Trieste, Italy, 1984* Publ by Plenum Press, New York, NY, USA, 1988 p 549-590.

**073707 DEVELOPMENT OF MULTICORE OPGW WITH TAPE-COATED FIBERS.** To ensure stable and efficient supply of power, electric power companies are now promoting the use of composite fiber-optic overhead ground wire (OPGW) as a highly reliable medium for the transmission of a variety of data in large volume. As the volume of data to be transmitted continues to grow larger and larger, the need has arisen for multi-core OPGW capable of holding even more optical fiber. The authors have developed a multi-core OPGW with a new fiber unit construction which doubles the number of fiber cores without making any changes in the basic construction of conventional OPGW. This has been accomplished by replacing the fluorocarbon polymer sheath, which was previously used for the secondary sheath of the optical fibers, with an overlapping wrapping of thin heat-resistant tape. This new construction not only makes it possible to achieve optical multi-core fiber cable with an extremely small diameter, but it also improves the heat resistance and other thermal characteristics. (Edited author abstract) 7 refs.

Amamiya, Masatoshi; Ozawa, Akio; Okumura, Tetsuo; Sanai, Masao; Kitayama, Yoshinobu; Ona, Atsuhiko; Kimura, Yuji. *Sumitomo Electr Tech Rev* v 27 Jan 1988 p 52-57.

**073708 IMPACT OF REFLECTIONS ON PHASE-DIVERSITY OPTICAL HOMODYNE RECEIVERS.** Reflections as small as  $-35$  db in the local oscillator path can cause deterioration in the performance of two-branch phase-diversity optical homodyne receivers, even when optical isolators protect the laser. The impact of reflections can be alleviated through the use of balanced receivers. (Author abstract) 6 refs.

Kazovsky, L. (Bell Communications Research, Red Bank, NJ, USA). *Electron Lett* v 24 n 9 Apr 28 1988 p 522-524.

**073709 FIBEROPTIC TRANSMITTERS AND RECEIVERS TACKLE LOCAL LINKS.** A growing array of lower cost, off-the-shelf transmitter and receiver modules is accelerating the move to fiber optics. Covering a broad range of data rates, these transmitter and receiver modules provide increasingly extended transmission capability with a minimum of electromagnetic and radio-frequency interference. Many higher performance devices use a 1,300-nm wavelength light source capable of communicating over a few tens of kilometers without requiring a repeater. Bit error rates commonly run in excess of  $10^{-9}$ .

Mayer, John H. (Computer Design, Littleton, MA, USA). *Comput Des* v 27 n 12 Jun 15 1988 p 66, 69-72, 74-75.

**073710 ALL-OPTICAL REGENERATOR.** An all-optical regenerator has been demonstrated using two self-electric-optic effect devices (SEED) and a local pump laser. The regenerator's optical signal processing included clock recovery, data retiming and signal amplification. A 2 db optical gain was attained at a 5 kbit/s data rate. (Author abstract). 5 Refs.

Giles, C.R. (AT&T, Holmdel, NJ, USA); Li, T.; Wood, T.H.; Burrus, C.A.; Miller, D.A.B. *Electron Lett* v 24 n 14 Jul 7 1988 p 848-850.

**073711 NOVEL COPLANAR THREE-WAVE MIXER FOR COHERENT AND HETERODYNE DETECTION OF OPTICAL SIGNALS.** A novel three-wave mixer is described in which two optical beams

are mixed with an rf signal to provide another rf signal. These devices can be used for coherent/heterodyne detection of optical signals with gigahertz frequency offsets. The device consists of a photoconductor embedded in a coplanar microwave circuit. (Author abstract). 5 Refs.

Everard, J.K.A. (King's Coll London, London, Engl.). *Electron Lett* v 24 n 14 Jul 7 1988 p 883-885.

**073712 SELF-ALIGNED FLAT-PACK FIBRE-PHOTODIODE COUPLING.** We report on a novel fibre-photodiode coupling assembly on a silicon chip, which is characterised by negligible coupling loss, simple (passive) prealignment and low fabrication cost. (Author abstract). 3 Refs.

Hillerich, B. (AEG AG, Ulm, West Ger); Geyer, A. *Electron Lett* v 24 n 15 Jul 21 1988 p 918-919.

**073713 WIDE BANDWIDTH LOW NOISE PIN FET RECEIVER FOR HIGH-BIT-RATE OPTICAL PREAMPLIFIER APPLICATIONS.** A wide bandwidth low noise pinFET receiver has been fabricated and characterized for optical preamplifier applications. The receiver uses a low capacitance planar pin diode as the photodetector. A bandwidth of 7.08 GHz was measured. The measured input noise current for the receiver front-end is lower than  $12 \text{ pA}/\sqrt{\text{Hz}}$ . Using a  $1.3 \text{ } \mu\text{m}$  DFB laser as the transmitter, at a data rate of 4 Gbit/s, the measured receiver sensitivity is  $-25.5 \text{ dbm}$  with a bit-error-rate of  $1 \times 10^{-9}$ . A set of two such receivers has been tested in a  $1.3 \text{ } \mu\text{m}$  polarization-insensitive optical preamplifier system experiment. The measured receiver sensitivity, including an optical insertion loss of 1.5 db, is  $-29.3 \text{ dbm}$ . (Edited author abstract). 3 Refs.

Tzeng, L.D. (AT&T, Allentown, PA, USA); Frahm, R.E. *Electron Lett* v 24 n 18 Sep 1 1988 p 1132-1134.

**Radiation Effects** See OPTICAL FIBERS—Radiation Effects.

## Reliability

**073714 RELIABILITY OF LEDs AND QUATERNARY PHOTODIODES.** This paper outlines the investigation into the reliability of GaAlAs and InGaAsP LEDs, and InGaAsP photodiodes, which have been used in the fiber-optic video distribution system. All devices are found to be sufficiently reliable. The study also showed that: (a) GaAlAs LEDs with an Al content as high as 0.78  $\mu\text{m}$  band-gap, have reliability comparable to the usual 0.8  $\mu\text{m}$  band-gap LEDs, (b) Homogeneous degradation of InGaAsP LEDs is caused by electrode migration, (c) InGaAsP photodiodes do not endure electrical-surge as well as Ge photodiodes, and (d) Discontinuous bias application improves device reliability. (author abstract) 10 refs.

Fukuda, Mitsuo (NTT, Jpn); Sudo, Hiromi; Kaizu, Katsumi. *Rev Electr Commun Lab (Tokyo)* v 35 n 6 Nov 1987 p 747-751.

**Research** See Also OPTICAL FIBERS—Physical Properties.

**073715 HIGH PERFORMANCE PUSH-PULL COUPLING SINGLE FIBER CONNECTORS AND PLUG-IN FIBER-OPTIC CONNECTORS.** This paper presents the development of compact, high performance and low cost single fiber connectors. They feature push-pull coupling connectors with rectangular connector housings and plug-in circuit-pack connectors with four plugs and four jacks mounted on the back panel and circuit board to realize high-density packaging of optical transmission equipment for subscriber loop systems. Actual field installed connectors with 50/125 GI fibers produced a satisfactory insertion loss of 0.06 approximately 0.10db and a return loss of 26.9 approximately 27.8db. (Author abstract) 11 refs. In Japanese.

Sugita, Etsuji (NTT Electronics & Mechanics Technology Lab, Jpn); Iwasa, Kyouichi; Inagaki, Shuichiro; Sasakura, Kunihiko. *Denki Tsushin Kenkyusho Kenkyu Jitsuyoku Hokoku* v 36 n 7 1987 p 919-925.

## Stability

**073716 RECEIVER FOR OPTICAL TRANSMISSION LINE.** The receiver ensures high stability with various types of modulation and coding of the transmitted signals. The maximum modulation frequency is 1 MHz, and the minimum pulse duration is 200 nsec. (Author abstract) 3 refs.

Bochkar, E.P. (Moscow State Univ, USSR). *Instrum Exp Tech* v 30 n 4 pt 2 Jul-Aug 1987 p 996-998.

**Switching** See Also OPTICAL DEVICES—Switching.

**073717 OPTICAL SWITCHING NETWORKS USING TREE-STRUCTURED WAVEGUIDE OPTICAL SWITCHES.** To make a large-sized optical matrix is an important subject in realizing optical switching systems. This paper offers optical switching networks using tree-structured  $N \times 1$  waveguide switches as fundamental elements. Approximated equations for the insertion loss and the multiple crosstalk are given and it is shown that those in the proposed networks are approximately proportional to the number of stages in the tree structure. A  $4 \times 4$  optical highway switch using  $\text{Ti:LiNbO}_3$  tree-structured directional couplers was tested to confirm its switching capability. (Edited author abstract) 20 refs.

Habara, Keishi (NTT, Musashino, Jpn); Kikuchi, Katsumi. *Electron Commun Jpn Part 1* v 70 n 11 Nov 1987 p 118-128.

**073718 32-LINE OPTICAL SPACE-DIVISION SWITCHING SYSTEM USING  $8 \times 8$  OPTICAL MATRIX SWITCHES.** This paper describes the world's first trial of a 32-line optical space-division switching system which can be used in future broadband private networks and also in broadband ISDN.  $\text{LiNbO}_3$   $8 \times 8$  optical matrix switches with 64 switch elements integrated on one chip have been developed for this system. An improved folded optical switching network, which has the advantage of low insertion loss, has been used. The influence of crosstalk in the optical switching network has also been discussed. Finally, the design of an experimental optical switching system, using the  $8 \times 8$  optical matrix switches, is explained. The system has been successfully operating in exchanging 800-Mbps optical signals. (Author abstract) 3 refs.

Suzuki, Syuji (NEC, Jpn); Kondo, Michikazu; Nagashima, Kunio; Mitsuhashi, Masashige; Nishimoto, Hiroshi; Miyakawa, Tosiya; Iwasaki, Masaaki; Ohta, Yoshinori. *NEC Res Dev* n 87 Oct 1987 p 44-50.

**073719 OPTISCH NICHTLINEARE MOLEKULKRISTALLE ALS OPTISCHE SCHALTER.** [Nonlinear Organic Molecular Crystals as Optical Switches]. A particular class of organic molecular crystals is presented which possesses large nonlinear optical properties. Applying high package densities with small nonlinear molecules (e.g. iodoform), a large nonlinearity can be achieved macroscopically. These molecular crystals are promising candidates for optical data processing systems. The application of this new class of materials as optical switches is discussed. (Author abstract) In German. 8 refs.

Staehelein, M.; Kohler, D. *Mitt AGEN* n 47 May 1988 p 33-37.

**Testing** See Also SPECTRUM ANALYZERS; TELECOMMUNICATION LINKS, OPTICAL—Testing.

**073720 INSTALLATION AND TESTING OF THE TRANSMISSION EQUIPMENT.** The installation of the Melbourne-Canberra-Sydney optical fiber system was performed by the Victorian and New South Wales State administrations. The equipment was installed in existing buildings which required a high level of reorganization of the existing material. The installation and testing procedures are outlined.

Clark, J.; Douglas, M.; Lette, M. *Telecommun J Aust* v 37 n 3 1987 p 77-81.



**OPTICAL DATA PROCESSING** See Also ELECTRIC FILTERS—Design; HOLOGRAMS; IMAGE PROCESSING; IMAGE PROCESSING—Control; INTEGRATED CIRCUIT MANUFACTURE; INTEGRATED OPTICS—Applications; LIGHT—Modulators; LOGIC DEVICES—Gates; OPTICAL FILTERS; PATTERN RECOGNITION SYSTEMS—Design; PHOTOELASTICITY—Theory; SENSORS—Performance.

**073721 COORDINATE TRANSFORMATIONS WITH MULTIPLE COMPUTER-GENERATED OPTICAL ELEMENTS.** An afocal system for coherent optical coordinate transformation using computer-generated holograms is presented. The afocal geometry allows cascading of transformations and simple incorporation into optical systems. A two-element afocal transformation system from Cartesian to log-polar coordinates, and a three-element cascaded afocal transformation system from polar to Cartesian coordinates, are presented for simple objects. 30 refs.

Hossack, W.J. (King's Coll London, London, Engl); Darling, A.M.; Dahdouh, A. *J Mod Opt* v 34 n 9 Sep 1987 p 1235-1250.

**073722 REAL TIME OPTICAL LOGIC PROCESSING.** A real time optical logic processor is described. The logic states (zero or one) are encoded by two gratings with different frequencies and the logic operations are performed by spatial filtering. The processor has two output channels. Experimental results are presented. (Author abstract) 8 refs.

Yang, Xiangyang (Tsinghua Univ, Beijing, China); Chin, Kuo-fan; Wu, Minxian. *Opt Commun* v 64 n 5 Dec 1 1987 p 412-416.

**073723 THRESHOLD PROCESSING OF OPTICAL SIGNALS IN ANGLE-CODE CONVERTERS WITH SCANNING.** The author proposes a structural implementation of threshold processing of optical signals in angle-code converters that enables elimination of the error owing to the finite dimensions of the light beam. A knife edge is used as a convenient base for aligning and operating the angle-code converter. It 'materializes' the direction of the beam, and its absolute position in space can be easily controlled by well-known measurement techniques. The proposal procedure was tested in an X-Y ADC of displacements for an encoder of graphical images with scanning of a laser beam. It is shown that the maximum absolute area of the angular measurements equalled 8 inches in the entire range of angles and was independent of the specific photodetector: the angle was reliably measured between the edges of the knives. 7 refs.

Bogatyrenko, K.I. *Meas Tech* v 29 n 9 Sep 1986 p 832-835.

**073724 DIGITAL OPTICAL MATRIX MULTIPLICATION BASED ON A SYSTOLIC OUTER-PRODUCT METHOD.** A hybrid optical architecture for digital matrix-matrix multiplication is discussed. The proposed system requires less hardware than outer-product optical matrix multipliers and offers a higher processing speed than systolic array matrix multipliers. The throughput and hardware requirements of the proposed architecture are discussed with reference to the availability of various electro-optic devices. The performance of the proposed system is compared to existing systolic array optical matrix multipliers and to outer-product-based optical matrix processors. The accuracy and error rate of the proposed architecture are evaluated. (Author abstract) 16 refs.

Yu, Francis T.S. (Pennsylvania State Univ, University Park, PA, USA); Cao, M.F. *Opt Eng* v 26 n 12 Dec 1987 p 1229-1233.

**073725 REQUIREMENTS ON THE DEGREE OF COHERENCE OF THE EMISSION FROM THE SOURCE IN AN OPTICAL CORRELATOR WHICH INCORPORATES A FOURIER TRANSFORMATION.** Optical data processing systems, particularly correlators, using injection lasers have recently attracted increased interest because of the practical need for processing devices with small dimensions, a low weight,

and a low power consumption. As the object of the present study we selected a correlator which incorporates a Fourier transformation. Such devices have recently been adopted widely and have several well-known practical advantages. 12 refs.

Zolotarev, A.I. *Optoelectron Instrum Data Process* n 3 1987 p 106-111.

**073726 AMPLITUDES SYNTHESIS OF COMPLEX SPATIAL-FREQUENCY FILTERS WITH TWO PULSED RESPONSES.** The article describes a computer synthesis of a complex spatial-frequency filter for a coherent optical processor. The transfer function of the filter is digitized and subjected to a stepped approximation. The synthesized filter is represented by a matrix of cells, each containing 16 slits. 2 refs.

Golubkova, M.N.; Ochinnikov, E.F. *Optoelectron Instrum Data Process* n 3 1987 p 122-124.

**073727 OPTICAL BINARY ADDER USING LIQUID CRYSTAL TELEVISION.** This paper describes the methods of implementing an optical half-adder and a full adder utilizing programmable liquid crystal televisions (LCTV). The concept of constructing an optical full adder is based upon the realization of an optical read-only-memory (OROM). An experimental demonstration of binary number addition performed by an optical half-adder is given. (Author abstract) 4 refs.

Jin, Yong (Pennsylvania State Univ, University Park, PA, USA); Yu, Francis T.S. *Opt Commun* v 65 n 1 Jan 1 1988 p 11-16.

**073728 MEASUREMENT OF PHASE FUNCTIONS OF 1-D AND 2-D FOURIER SPECTRA.** By using a coherent optical information processing system with two orthogonal polarization channels we have measured the Fourier phases experimentally for one and two dimensional real objects. For a shifted slit and a shifted square, the Fourier phase values measured by experiment are in agreement with the calculated phase value quite well. Another object is a binary alphabet, the real and imaginary part of its Fourier spectrum has been investigated. (Author abstract) In Chinese. 4 refs.

Xu Keshu (Fudan Univ, Shanghai, China); Ji Rongcai; Zhang Zhiming. *Guangxue Xuebao* v 7 n 11 Nov 1987 p 1013-1020.

**073729 LA LECTURE OPTIQUE. [Optical Reading].** Although paper documents will be forever necessary today we also need electronic documents. The purpose of optical reading is to transform the paper documents into electronic documents. To overcome the present limits of current optical readers, it is worth studying the human reading process. This process indeed makes use of successive interdependent analysis and synthesis levels. The strategy adopted is inspired by this study and aims at realising, then integrating the main functions that will be required in tomorrow's optical readers. (Author abstract) In French.

Lefevre, Philippe (ESE). *Epure* n 17 Jan 1988 p 43-53.

**073730 DIRECT FINITE ELEMENT SOLUTION OF AN OPTICAL LABORATORY MATRIX-VECTOR PROCESSOR.** The first optical laboratory system results employing a direct LU decomposition solution of a system of linear algebraic equations are presented for a finite element problem solution. This also represents the first laboratory demonstration of the use of sign-magnitude negative number representation as well as new bit partitioning techniques to increase the accuracy of an optical encoded processor beyond the number of bit channels available. (Author abstract) 11 refs.

Casasent, David (Carnegie Mellon Univ, Pittsburgh, PA, USA); Riedel, Steven. *Opt Commun* v 65 n 5 Mar 1 1988 p 329-333.

**073731 COMPLETE 2D-SHUFFLE/EXCHANGE-STAGE FOR LARGE 1D DATA ARRAYS.** A Perfect Shuffle network for (optical) parallel computers

is proposed. The network uses the full 2D space of optics for the 1D permutation. The control part of the network is based on symbolic substitution. (Author abstract) 5 refs.

Stucke, Gregor (Univ Erlangen-Nuernberg, Erlangen, West Ger). *Optik (Stuttgart)* v 78 n 2 Jan 1988 p 84-85.

**073732 TIME DIFFERENTIATION OF IMAGES BY MEANS OF OPTICALLY CONTROLLABLE TRANSPARENCIES WITH A (METAL-INSULATOR-SEMICONDUCTOR)-(LIQUID CRYSTAL) STRUCTURE.** A time differentiation of images of transparencies with a (metal-insulator-semiconductor)-(liquid crystal) structure is described. Experimental results are reported on the use of this operation on optical and television images. A physical mechanism explaining the effect is examined. (Author abstract) 3 refs.

Dumarevskii, Yu.D.; Kovtonyuk, N.F.; Petrovicheva, G.A.; Savin, A.I. *Optoelectron Instrum Data Process* n 4 1987 p 62-66.

**073733 OPTICAL METHOD FOR CODING AND PROCESSING DATA.** The idea, suggested in previous papers, of using a multilayer interference filter as a processor for processing data in the solution of nonlinear equations is developed. First, arguments are presented for the case that an interference filter has advantages over other systems. A theorem describing the properties of this filter is formulated. Second, a new approach for using an interference filter is proposed. In this approach, the device works in monochromatic light. The effect is to simplify practical implementations. Third, a hybrid data processing system, which combines a digital computer with an optical processor, is proposed. (Author abstract) 2 refs.

Stolov, E.G. *Optoelectron Instrum Data Process* n 4 1987 p 91-93.

**073734 OPTICAL-ELECTRONIC SYSTEM FOR TECHNICAL VISION OF ROBOTS.** The use of a hybrid optical-electronic complex for data processing for pattern recognition is discussed. Such a system is shown to be useful in robotics as a system of technical vision. A high analysis rate is achieved thanks to a preliminary data processing in a coherent processor, which carries out the mathematically most laborious operations. Experimental results are reported. Algorithms for a digital processing of correlation-field images are described. (Author abstract) 4 refs.

Makarovskii, A.P.; Ostrovskii, A.S.; Paslen, V.N.; Slavgorodskii, V.K. *Optoelectron Instrum Data Process* n 4 1987 p 103-105.

**073735 DIFFRACTION CALCULATION FOR AN OPTICAL ELEMENT WHICH FOCUSES INTO A RING.** The Kirchhoff diffraction integral is used to calculate the spatial distribution of the optical field in the focal region of an optical element which focuses into a ring. The width of the ring in the diffraction limit is found. The energy efficiency of the optical element is also found. The range of applicability of the geometric-optics formulas for the phase function of the optical element is determined. (Author abstract) 7 refs.

Golub, M.A. (Kuibyshev-Moscow, USSR); Kazanskii, N.L.; Sisakyan, N.I.; Soifer, V.A.; Kharitonov, S.I. *Optoelectron Instrum Data Process* n 6 1987 p 7-14.

**073736 OPTICAL PROCESSING OF RANGE IMAGERY FOR SEGMENTATION.** Using multi-sensor image information aids in the interpretation of a represented scene. By segmenting the scene into meaningful parts, we can analyze each individual component and create a description of the scene. Range data is useful for segmenting an image into objects based on the distance relationships between pixels. In this paper, we demonstrate a hybrid optical/digital technique for segmenting range data into object and non-object regions. The object



regions found are used as masks to be ANDed with other sensor imagery for identification of the regions. (Author abstract). 8 Refs.

Liebowitz, Suzanne (Carnegie Mellon University, Pittsburgh, PA, USA); Casasent, David. *Opt Commun* v 67 n 5 Aug 1 1988 p 331-334.

**073737 OPTICAL COMPONENTS FOR DIGITAL OPTICAL CIRCUITS.** The present status of all-optical computing for digital logic and information processing is reviewed briefly. Computing architectures that take advantage of the parallelism and interconnect freedom that optics offers are addressed. In particular demonstrator circuits employing optically bistable components are described. (Author abstract). 17 Refs.

Wherrett, Brian S. (Heriot-Watt Univ, Edinburgh, Scotl); Smith, S. Desmond; Tooley, Frank A.P.; Walker, Andrew C. *Future Gener Comput Syst* v 3 n 4 Dec 1987 p 253-259.

**073738 IMPLEMENTATION OF CARRY LOOK-AHEAD ADDER WITH SPATIAL LIGHT MODULATORS.** An implementation of a carry look-ahead adder using commercial spatial light modulators is presented. The speed of these devices is compared with that of electronic devices. Based on the comparison, future requirements of such devices for digital optical computing are suggested. (Edited author abstract). 9 refs.

Golsban, R. (Wayne State Univ, Detroit, MI, USA); Bedi, J.S. *Opt Commun* v 68 n 3 Oct 1 1988 p 175-178.

**073739 HYBRID OPTICAL COMPUTING.** The technology base of digital optical computing is briefly described. An electrooptical processor that utilizes the inherent parallelism of optical processing is shown and applied to matrix-matrix multiplication. Symbolic logic processing is examined. Discrete linear transformations using optical processors are described. 2 refs.

Yu, Francis T.S. (Pennsylvania State Univ, University Park, PA, USA). *IEEE Potentials* v 6 n 4 p 34-37.

**073740 USING COINCIDENT OPTICAL PULSES FOR PARALLEL MEMORY ADDRESSING.** A memory structure is proposed that provides for parallel access in a multiprocessor environment. The proposed system has two advantages. First, it distributes the address-decoding circuitry to each of the requesting units on a common bus, thus eliminating the bottleneck of centralized decoding of encoded memory addresses. Second, it allows for parallel fetches of memory data with a level of parallelism limited only by the ratios of optical to electronic bus bandwidths and the dimensionality of the memory array. Both 1-D and 2-D structures are considered. 12 refs.

Chiarulli, Donald M. (Univ of Pittsburgh, PA, USA); Melhem, Rami G.; Levitan, Steven P. *Computer* v 20 n 12 Dec 1987 Dec 1987 p 48-57.

**073741 TOPICAL MEETING ON OPTICAL COMPUTING, SUMMARIES OF PAPERS PRESENTED (TECHNICAL DIGEST SERIES V 11).** Proceedings incorporates 70 papers that are grouped in 11 sessions dealing with progress made in the development of optical data processing. Nine papers are presented in the form of either summaries or abstracts only. Topics considered include: systolic arrays, programmable optical processors, digital design, symbolic substitution, optical architectures, binary image algebra, cellular image processors, bit serial optical computers, optical crossbar, holographic interconnections, integrated optics, optical beam shaping, optical interconnects, electron-beam lithography, computer-generated holograms, combinatorial logic, look-up table processing, residue number theory, matrix-vector multipliers, matrix-vector multiplication, matrix inversion, Monte Carlo methods, CAD, adders, matched filtering, CCD image sensors, brain-style computation, neural networks, volume holograms, optical learning networks, adaptive learning, pattern recognition, artificial intelligence, SAR (Synthetic Aperture Radar), logic gates, bistable devices, and spatial light modulators. Technical

and professional papers from this conference are indexed and abstracted with the conference code no. 11472 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Optical Soc of America, Washington, DC, USA). *Top Meet on Opt Comput, Summ of Pap Presented, Incline Village, NV, USA, Mar 16-18 1987* Publ by Optical Soc of America, Washington, DC, USA, 1987 264p.

## Analysis

**073742 OPTICAL LOGICAL OPERATION AND MOIRE PATTERN.** Based on optical logical operations, a new approach to extract a specific beat pattern from superposed periodic structures is proposed. Gratings are first periodically encoded and then processed by logical operation. Experimental results are presented. (Author abstract) 11 refs.

Zhang, Jiajun (Shanghai Inst of Optics & Fine Mechanics, Shanghai, China); Liu, Liren. *Opt Commun* v 66 n 4 May 1 1988 p 179-182.

## Calculations

**073743 PYRAMIDICAL PIPELINING OF AO CELLS FOR COMPUTING SUCCESSIVE MATRIX POWERS.** The paper describes an optical implementation for successive matrix powers, using an optical processor as a basic component for matrix/matrix multiplication with unidirectional data flow. Then, a series of optical processors are lined up to produce a pyramidical pipeline for successive matrix squarings. Suitable applications which would benefit include, besides the calculation of matrix powers, the evaluation of matrix polynomials, iterative solutions of linear equations, iterative matrix inversion, and the calculation of matrix functions, i.e. matrix exponential. (Author abstract) 13 refs.

Margaritis, K. (Loughborough Univ of Technology, Loughborough, Engl); Bekakos, M.P.; Evans, D.J. *IEE Proc Part J* v 135 n 3 Jun 1988 p 276-280.

## Design

**073744 FAST PARALLEL OPTICAL DIGITAL MULTIPLICATION.** A parallel optical binary multiplication scheme is proposed in which parallel convolution preprocessing is performed using a parallel-input optical outer-product processor together with a one dimensional either space or time integrator. Using a theta-modulation based optical A/D converter and a carry look-ahead adder array, the resulting mixed-binary partial product can be reduced to the final multiplication result. (Author abstract) 25 refs.

Li, Yao (City Coll of New York, New York, NY, USA); Eichmann, George; Alfano, R.R. *Opt Commun* v 64 n 2 Oct 15 1987 p 99-104.

**073745 REAL-TIME OPTICAL PARALLEL PROCESSOR FOR BINARY ADDITION WITH A CARRY.** A bichannel optical shadow casting (OSC) technique has been proposed for logic operation and addition of multi-bit binary numbers. In case of addition the 'carry' is accommodated by spatial placement of channels. Optoelectronic half and full adders, using spatial light modulators (SLM), optical to electrical converters, beam splitters and mirrors, form additional building blocks in the proposed processor, where operations are performed in parallel. Limitations are discussed. (Author abstract) 16 refs.

Mukhopadhyay, S. (Calcutta Univ, Calcutta, India); Basuray, A.; Datta, A.K. *Opt Commun* v 66 n 4 May 1 1988 p 186-190.

## Equipment

**073746 OPTICAL CONSIDERATIONS IN THE DESIGN OF DIGITAL OPTICAL COMPUTERS.** This paper spells out the computational requirements and limitations for non-linear optical devices and optical

interconnects. Relationships between the optical properties of devices (transmission and contrast) and their potential computational properties (fanin and fanout) are derived. The accuracy of the intensity levels required in the system are estimated. The requirements for a minimal device useful for digital optical computing are stated. The 'volume' of a device in phase-space limits fanin, switching energy and the degree of space variance in the interconnections. Space-invariant and space-variant interconnections are compared. Limits of random interconnects by volume holograms are discussed. (Edited author abstract) 37 refs.

Prise, M.E. (AT&T Bell Lab, Holmdel, NJ, USA); Streibl, N.; Downs, M.M. *Opt Quantum Electron* v 20 n 1 Jan 1988 p 49-77.

## Mathematical Models

**073747 OPTICAL COMPUTATION OF DETERMINANTS.** We have presented a new algorithm for the determinant computation, which is suitable for optical realization. N systems of simultaneous equations are solved in order to find a value of the determinant (N is a dimension of determinant). The algorithm is devised to be used in a hybrid opto-electronic setup, that essentially solves a system of simultaneous linear equations by an iterative procedure. (Author abstract) 15 refs.

Pantelic, Dejan V. (Inst of Physics Belgrade, Belgrade, Yugosl). *Opt Commun* v 64 n 5 Dec 1 1987 p 421-424.

## Noise, Spurious Signal

**073748 FILTRATION OF PHASE NOISES OF IMAGES USING HOLOGRAMS.** A method for filtering phase noises in a system of optical information processing with passage through a transparency, which fixes the image of a wave and its complexly adjoint transmission function, is investigated. (Author abstract) 4 refs.

Volyak, K.I.; Malyarovskii, A.I.; Sidorov, A.R. *Sov Phys Lebedev Inst Rep* n 3 1987 p 15-19.

**Switching** See LASERS, SEMICONDUCTOR—Switching.

**OPTICAL DEVICES** See Also COMPARATORS; COMPUTER SYSTEMS, DIGITAL—Parallel Processing; ELECTRONIC CIRCUITS, VOLTAGE STABILIZING—Costs; EXTRUSION—Inspection; FIBER OPTICS—Applications; GONIOMETERS—Design; LASERS, SEMICONDUCTOR—Accessories; LASERS, SEMICONDUCTOR—Electrodes; LASERS, SEMICONDUCTOR—Oscillations; LASERS, SEMICONDUCTOR—Performance; LASERS, SEMICONDUCTOR—Resonators; LASERS, SEMICONDUCTOR—Tuning; LASERS, SOLID STATE—Garnets; LIGHT—Optical Resonators; LIGHT—Propagation; LOGIC DEVICES—Gates; OPTICAL COMMUNICATION—Laser Applications; OPTICAL COMMUNICATION—Noise, Spurious Signal; OPTICAL COMMUNICATION EQUIPMENT—Performance; OPTICAL COMMUNICATION EQUIPMENT—Stability; OPTICAL DATA PROCESSING—Equipment; OPTICAL FIBERS—Analysis; SEMICONDUCTING CADMIUM COMPOUNDS—Plasmas; SENSORS—Optical Properties; SIGNAL INTERFERENCE—Crosstalk; SIGNAL RECEIVERS—Performance; SOLAR RADIATION—Concentrators; SPECTROSCOPY, ABSORPTION—Accessories; WAVEGUIDES, OPTICAL—Optimization; WAVEGUIDES, OPTICAL—Performance.

**073749 BEHAVIOUR OF POLARIZATION BEAM SPLITTERS MADE FROM DIFFERENT TYPES OF FIBER.** In the paper, polarization beam splitters are studied. Our theoretical study reveals that the coupling length and modulation period of a polarization beam splitter made from the depressed cladding fiber are shorter compared with that made from the matched fiber. Thus the former is characterized by a short interaction length. On the other hand, a polarization beam splitter made from the raised cladding fiber has a longer coupling length and a longer modulation period than those made from the matched fiber. (Author abstract) 10 refs.

Chen Yijiang (Shanghai Univ of Science & Technology, Shanghai, China). *Appl Phys B* v B45 n 1 Jan 1988 p 17-20.



**073750 ABSOLUTE-TYPE OPTICAL FIBER ROTARY ENCODER FOR NATIONAL AEROSPACE LABORATORY SCIENCE AND TECHNOLOGY AGENCY.** The rotary encoder, which measures the angle of rotation, was planned as part of the research on the future technology of the STOL plane developed by National Aerospace Laboratory of the Science and Technology Agency. IHI manufactured the encoder as part of the component development of the FBL (Fly By Light) of the flight control system of the aircraft. The encoder detects the control surface angle and converts it into digital signals of absolute code. It increases the reliability of the flight control system and enables highly accurate control through adoption of the resistance against lighting interference, electromagnetic interference, and electrical insulation. This article presents the specifications of this device and describes its configuration and features.

Yasuo, Ehara (IHI, Jpn); Yamanoi, Takashi; Hoshikawa, Masayuki. *IHI Eng Rev (Engl Ed)* v 20 n 4 Oct 1987 p 160-161.

**073751 OPTICAL ISOLATOR.** An optical isolator using the Faraday effect is used for preventing noise generation and transmission characteristic degradation caused by the light feedback to the laser diode (LD) from the refractive surface in an optical transmission path. A composite film of  $(\text{BiLuGd})_3\text{Fe}_2\text{O}_{12}/(\text{BiGd})_3(\text{FeGa})_5\text{O}_{12}$  has been developed by the 2-step LPE method as a Faraday rotator which has a temperature dependence derivative of Faraday rotation angle of  $\beta \leq 0.01$ . By the use of this film, an optical isolator and an LD module have been trially fabricated for evaluation. As a result, the degradation of the isolation ratio ( $-34$  db) of the isolator is less than 1 db in the temperature range of 20 to 60°C. No periodic noise occurs in this temperature range even when a feedback light is applied from the fiber farthest end. Thus, a stable optical isolation effect is obtained against temperature change. (Author abstract) In Japanese. 13 refs.

Matsuda, Kaoru (Matsushita Electric Industrial Co, Jpn); Minemoto, Hisashi; Kamata, Osamu; Ishizuka, Satoshi. *Natl Tech Rep Matsushita Electr* v 34 n 1 Feb 1988 p 41-49.

**073752 OPTICAL STAR COUPLER.** Optical star couplers (of the 6×6 port type and 9 port type) which make possible simultaneous intercommunication among a plurality of terminals have been developed. The star couplers are of the outer reflection mirror type employing graded index fibers and composed of a 0.25-pitch slab lens and a reflection mirror. The 6×6 port type and the 9 port type have an average insertion loss of 15.6 db and 16.3 db, respectively, and a variation in the loss among terminals of within  $\pm 1$  db. They have the following features: (1) simple structure by using a slab lens; and (2) easy handling with both input and output terminals positioned on the same end. The paper describes the structure, production method and characteristics of these optical star couplers, as well as an example of applications, a network which allows simultaneous communication of digital data and audio-video signals. (Author abstract) In Japanese. 6 refs.

Ishino, Yuko (Information Systems Research Lab); Ohkawa, Yasuhito; Okamura, Noboru; Kishi, Shuichiro; Soda, Hironori. *Natl Tech Rep Matsushita Electr* v 34 n 1 Feb 1988 p 56-65.

**073753 CONICAL ZONE PLATE.** The phase contribution obtained by the superposition of two tilted wavefronts, one cylindrical and the other plane, is considered in this paper. It is shown that the obtained transmittance is equivalent to the conical lens transmittance. In the particular case when the superposed wavefronts are collinear, the resulting hologram becomes an on-axis conical zone plane, and the loci of the points on the registration plane where the intensity is maximal will be parabolas. The effect of the diffraction on the obtained holograms is calculated (including nonlinear processing of the plate). Additionally, the technique of conical zone plate production is described. (Author abstract) 17 refs.

Jaroszewicz, Zbigniew (Central Optical Lab, Warsaw,

Pol). *Opt Commun* v 66 n 1 Apr 1988 p 9-14.

**073754 ANALYSIS OF THE OPERATION OF SURFACE-EMITTING-TYPE OPTICAL THRESHOLD DEVICE.** This paper proposes a surface-emitting-type optical threshold device and analyzes its characteristics. For a surface-emitting laser resonator with a saturable absorber, its static characteristics and small signal analysis with a current or light injection are obtained from rate equations. As a result, the possibility of an optical threshold device which operates with a practical optical energy of approximately 30 kW/cm<sup>2</sup> has been shown. Furthermore, it has been shown that the optical threshold varies by controlling an injection current, and that AND and OR logics are possible with one device. As a result of small signal analysis, the device is shown to have a bandwidth of approximately 1 GHz. (Author abstract) 20 refs.

Nitta, Jun (Keio Univ, Yokohama Univ, Jpn); Iga, Kenichi. *Electron Commun Jpn Part 2* v 71 n 3 Mar 1988 p 73-81.

**073755 DEVELOPMENT OF A FIBROSCOPE MANIPULATOR FOR DUNGENESS 'B' POWER STATION.** The two advanced gas cooled reactors (AGRs) at Dungeness 'B' each have 408 channels containing the fuel. Each fuel assembly is attached to a plug unit which seals the channel opening and supports the fuel during refueling. The plug units also contain a piston valve known as a 'gag' which is used to regulate the gas flow up the fuel channel. In May 1986 it was discovered that incorrect materials had been used in some of the fasteners holding up the gag pistons. A decision was then taken to inspect all the gags to assess the extent of the problem. Removing the gags from the reactor to inspect would be a costly and time consuming process so effort was concentrated on an in-situ inspection. The Barnwood Remote Inspection Group (RIG) were asked to design a manipulator which would inspect gag fasteners under remote control from the reactor charge floor, and to procure it in minimum time. This article discusses a fibroscope manipulator for this purpose.

Crackett, J. (CEGB, Barnwood, Engl); Ewen, R.O.; James, D.W. *Nucl Eng J Inst Nucl Eng* v 29 n 1 Jan-Feb 1988 p 8-11.

**073756 SIMPLIFIED LASER TO FIBRE COUPLING VIA OPTICAL FIBRE UP-TAPERS.** A new method for coupling single-mode fiber to laser diodes employing a spherical ruby lens and a single-mode optical fiber up-taper is demonstrated. High coupling efficiency and greatly reduced alignment sensitivities are attained. (Author abstract) 3 refs.

Presby, H.M. (AT&T, Holmdel, NJ, USA); Amitay, N.; Scotti, R.; Benner, A. *Electron Lett* v 24 n 6 Mar 17 1988 p 323-324.

**073757 OPTO-ACOUSTIC POWER MONITOR WITH HIGH SENSITIVITY.** A new type of laser power monitor based on opto-acoustic effect is described in this paper. The spectral response ranges from UV to IR. In visible spectral region, the responsibility of the monitor is about 26  $\mu\text{V}/\mu\text{W}$ , the minimum detectable power is 0.2  $\mu\text{V}/\mu\text{W}$ , and the linear dynamic range is over 10<sup>4</sup>. (Author abstract) 4 refs. In Chinese.

Wu, Jihua (South China Normal Univ, Guangzhou, China); Wu, Hongyue. *Guangxue Xuebao* v 8 n 4 Apr 1988 p 354-358.

**073758 FUSED COUPLER SWITCH USING A THERMO-OPTIC CLADDING.** An optical switch based on a single-mode fused coupler has been fabricated. The switching is achieved by a thermal refractive index change of a silicone resin cladding material in the coupling region. Fabrication details and device characteristics are described. (Author abstract) 5 refs.

Diemeer, M.B.J. (Dr. Neher Lab (PTT), Leidschendam, Neth); De Vries, A.J.; Benoist, K.W. *Electron Lett* v 24 n 8 Apr 1988 p 457-458.

**073759 ALL-SINGLE-MODE-FIBRE INTERFEROMETRIC POLARISATION BEAM SPLITTER.** A novel all-fibre polarisation beam splitter based on an all-fibre Mach-Zehnder interferometer (MZI) is reported. The device symmetrically separates orthogonally polarised components of an incoming optical signal with isolations between these components of greater than 17 dB at each output. (Author abstract) 4 refs.

Shipley, S.P. (Hirst Research Cent, Wembley, Engl). *Electron Lett* v 24 n 8 Apr 1988 p 478-479.

**073760 TOLERANZANFORDERUNGEN BEI OPTISCHEN STECKVERBINDERN.** [Tolerance Requirements For Optical Connectors]. Tolerance requirements cannot be discussed in total isolation from a real product, so an attempt is made to point out the major problems by referring to the family of connectors defined in DIN with a nominal diameter of 2.5 mm. (Author abstract). 2 Refs. In German.

Ludolf, Wilhelm S. *F&M Feinwerktech Messtech* v 96 n 6 Jun 1988 p 243-244.

**073761 ALL-OPTICAL LOGIC IN FIBER SYSTEMS USING NONLINEAR REFRACTION.** We describe the realization of a nonlinear all-optical logic gate and modulator for use in fiber-optics communication systems. The physical mechanisms for the optical nonlinearities and their influences on device operation and design are considered. Results are presented for the AND, NOR, NOT, and XOR logic functions with a better than 20 dB contrast ratio. The gates and modulators exhibit exceptional stability, because no resonator, feedback, or stringent wavelength control are needed. Silicon at  $\lambda = 1.06 \mu\text{m}$  has been used for these 'proof-of-concept' experiments. The feasibility of picosecond operation, multiplexing, and wavelength translation is discussed. (Author abstract) 17 refs.

Normandin, R. (Natl Research Council of Canada, Ottawa, Ont, Can). *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 913-918.

**073762 OPTICAL CAVITIES FOR VISIBLE FREE ELECTRON LASER EXPERIMENTS.** Visible FEL oscillator experiments require optical cavities of unusual size and configuration. This paper examines optical cavities for current and future visible oscillator experiments. (Author abstract) 1 ref.

Shemwell, D.M. (Spectra Technology Inc, Bellevue, WA, USA); Robinson, K.E.; Gellert, R.I.; Quimby, D.C.; Ross, J.; Slater, J.M.; Vetter, A.A.; Zumdick, J. *Nucl Instrum Methods Phys Res Sect A* v A259 n 1-2 Sep 1 1987 p 56-61.

**073763 OPTICAL CAVITY ALIGNMENT AND MIRROR DAMAGE IN THE LELA FEL EXPERIMENT.** The alignment of the LELA optical cavity 17.5 m long, is described. The procedure to attain a close alignment of the undulator radiation axis and the cavity axis using an external laser is reported. Measurements of Q from stored light spectra are presented. Mirror degradation at increasing integrated electron currents is considered. (Author abstract) 5 refs.

Patteri, Piero (Lab Nazionali di Frascati INFN, Italy); Preger, Miro Andrea; Ambrosio, Michelangelo; Barbarino, Giancarlo; Castellano, Michele; Cavallo, Nicola; Cevenini, Francesco; Masullo, Maria Rosaria. *Nucl Instrum Methods Phys Res Sect A* v A259 n 1-2 Sep 1 1987 p 88-93.

Amplification See LASERS, SEMICONDUCTOR—Computer Simulation.

Analysis See Also LASERS, SEMICONDUCTOR—Analysis.

**073764 BIREFRINGENT-FIBRE POLARISATION SPLITTERS.** A simple analytical study on fused tapered couplers composed of birefringent fibers is presented. It is shown that the polarization splitting property of the



coupler can remain almost constant over a wide range of wavelengths when the geometrical birefringence and the stress-induced birefringence in the coupler are properly balanced. (Author abstract) 8 refs.

Chiang, K.S. (CSIRO, Lindfield, Aust). *Electron Lett* v 23 n 17 Aug 13 1987 p 908-909.

**073765 OPTICAL WIGNER DISTRIBUTION AND AMBIGUITY FUNCTION FOR COMPLEX SIGNALS AND IMAGES.** Using a degenerate optical phase conjugation device, a new real-time coherent optical Wigner distribution and ambiguity function implementation method for both one- and two-dimensional complex signals is suggested. (Author abstract). 20 Refs.

Li, Yao (City Univ of New York, New York, NY, USA); Eichmann, George; Conner, Michael. *Opt Commun* v 67 n 3 Jul 1 1988 p 177-179.

Anisotropy See INTEGRATED OPTICS.

**Applications** See Also DIESEL ENGINES—Maintenance; INTEGRATED CIRCUIT MANUFACTURE; INTEGRATED OPTICS—Components; OPTICAL COMMUNICATION EQUIPMENT—Design; OPTICAL INSTRUMENTS—Selection.

**073766 OPTICAL SHAFT POSITION SENSOR.** An optical shaft position sensor provides an analog output which is a function of the relative displacement of a shaft. The shaft, which is translucent, includes a hollow region formed at one end thereof and a light mask formed on its outer surface proximate to its end region. Operational details and an alternate implementation are outlined.

Brown, V.O.; Newman, W.S. *Tech Dig AT&T Technol* n 78 Jul 1986 p 5.

**073767 1×6 OPTICAL SWITCH FOR SINGLE-MODE FIBERS.** Optical communication systems using single-mode fibers, which feature a large capacity and low loss, are expected to have a large future demand. A 1×6 optical switch has been developed for the systems. The optical switch employs parallelogram prisms for switching optical paths in order to decrease the fluctuation of insertion losses. The prism combination and the proper length of the parallelogram prisms allow low difference of insertion losses and low crosstalk between channels. The insertion loss is less than 1 db. The fluctuation and difference of the insertion losses are less than 0.04 db and 0.3 db, respectively. The crosstalk is less than -72 db. The optical switch makes it possible to build various optical communication systems, and its application to optical measuring instruments is expected. (Author abstract) In Japanese. 8 refs.

Ieda, Tomoaki (Matsushita Electronic Components Co, Jpn); Kurata, Noboru; Soda, Hironori; Komatsu, Seiji. *Natl Tech Rep Matsushita Electr* v 34 n 1 Feb 1988 p 50-55.

**073768 OPTICAL COUPLER AND MULTI/DEMULTIPLEXER FOR SINGLE-MODE FIBERS.** An optical coupler and a multi/demultiplexer both for single-mode fibers have been developed. The optical coupler is used to branch an optical signal from one optical fiber to two optical fibers. It is composed of a non-randomly polarized light beam splitter and a graded index rod lens. With a laser diode (LD) as the optical source, it has an insertion loss of less than 3.5 db, a loss variation of 0.1 db, and a channel isolation of more than 30 db. The optical multi/demultiplexer is used for wavelength division multiplex transmission, and has a function of multiplexing or demultiplexing different optical wavelength. It is composed of a flat parallel surface prism, a graded index rod lens, and an optical interference filter. In 2-wavelength division multiplex transmission using a LD, it has a pair of transmission losses of less than 2.5 db, a channel isolation of more than 30 db, and near-end crosstalk of less than -40 db. The optical coupler and the multi/demultiplexer feature high performance, and good reproducibility thanks to their simple construction. A preferable result has been obtained in various reliability tests. (Author abstract) In Japanese. 12 refs.

Kishi, Shuichiro (Information Systems Research Lab); Ishino, Yuko; Soda, Hironori. *Natl Tech Rep Matsushita Electr* v 34 n 1 Feb 1988 p 66-72.

**073769 OPTICAL REPEATER FOR 32Mb/sec LOOP LAN.** A highly-reliable, compact, low-power optical repeater has been developed for 32Mb/sec loop LAN. It is composed of an optical transmitter/receiver, coder/decoder, and RAS (reliability, availability and serviceability) control. For the light source and the detector, a 1.3μm band LED and a Ge-APD are used. The pre-amplifier and the amplifier are composed of two new monolithic ICs. The clock recovery module employs a crystal filter. The coder/decoder circuit, where a coded mark inversion (CMI) coding scheme is applied as the transmission code, uses a TTL gate array, being integrated in a SDIP 28-pin package. The RAS circuit, which detects bit errors and constitutes loop-back, bypass, etc., uses a CMOS gate array, being integrated in a SDIP 48-pin package. The repeater system has a required receiving optical power of -44 dbm (bit error rate=10<sup>-9</sup>), and a level margin of 22 db between the transmitter and the receiver. The repeater makes it possible to build a high-performance and low-cost optical LAN system. (Author abstract) In Japanese. 7 refs.

Morikura, Susumu (Information Systems Research Lab); Tanaka, Tsutomu; Kubo, Kiyoshi. *Natl Tech Rep Matsushita Electr* v 34 n 1 Feb 1988 p 94-100.

Calibration See OPTICAL VARIABLES MEASUREMENT.

Cleaning See OPTICAL MATERIALS—Glass.

Components

**073770 PRECISION OPTICAL FABRICATION THROUGH HYBRID PROCESSING.** The optical community uses several methods for fabricating precision optics. By using a combination of these techniques, we can produce many state-of-the-art parts at significantly less than state-of-the-art prices. This economy is achieved by combining the valuable features of one manufacturing technique with the otherwise unavailable but valuable features of an alternative method. The final product benefits from the efficiency and advantages of each technique. The techniques we have found particularly well suited for hybrid processing are precision machining with diamond tools and conventional pitch-and-polish techniques.

DeCew, Alan (Diamond Electro-Optics, Wilmington, MA, USA). *Lasers Optonics* v 6 n 6 Jun 1987 p 105-106.

Design See Also INFRARED DEVICES—Accessories.

**073771 CHARACTERISTICS AND DESIGN OF MERCURIOS HALIDE BRAGG CELLS FOR OPTICAL SIGNAL PROCESSING.** Mercurous halide crystals (Hg<sub>2</sub>Cl<sub>2</sub>, Hg<sub>2</sub>Br<sub>2</sub>, and Hg<sub>2</sub>I<sub>2</sub>) possess unique acoustooptic properties, including low acoustic velocities and high figures of merit. These properties make mercurous halide Bragg cells desirable for optical signal processing applications that are not possible with other acoustooptic materials. This paper discusses the crystal properties and optimum operating conditions and identifies the implications for certain signal processing applications. A discussion of device design for both isotropic and anisotropic configurations is presented. (Edited author abstract) 14 refs.

Goutzoulis, Anastasios P. (Westinghouse Research & Development Cent, Pittsburgh, PA, USA); Gottlieb, Milton. *Opt Eng* v 27 n 2 Feb 1988 p 157-163.

Efficiency

**073772 EFFICIENT N×N STAR COUPLER BASED ON FOURIER OPTICS.** A technique for constructing an efficient N×N star coupler suitable for mass production in integrated form for large N at optical frequencies is discussed. The coupler can be realised using Si technology by means of two arrays of strip waveguides

and a dielectric slab formed on a glass substrate. Power transfer between the two arrays is accomplished through radiation in the dielectric slab with theoretical efficiency exceeding 30% under optimised conditions. (Author abstract). 9 Refs.

Dragone, C. (AT&T Bell Lab, Holmdel, NJ, USA). *Electron Lett* v 24 n 15 Jul 21 1988 p 942-944.

Electric Properties

**073773 EFFECTS OF FABRICATION OF AGING ON THE XEROGRAPHIC PROPERTIES OF SQUARINE PHOTORECEPTOR DEVICES.** The effects of a number of fabrication variables on the electrical properties of bilayer squaraine photoreceptor devices have been studied. Our results show that primary squaraine particles, which are 0.1-0.2 μm in size are usually agglomerated in the coating dispersion and the carrier generation layer (CGL). Of the sixteen binders examined, five of them contain mainly aromatic functionalities. The aging characteristics of squaraine devices as a function of binder, CGL thickness, and pigment concentration have also been investigated. Seasonal fluctuations in dark decay and charge acceptance are seen for all devices. This seasonal fluctuation is shown to be a humidity effect and is found to be sensitive to CGL binder, pigment concentration, and CGL thickness. (Edited author abstract) 18 refs.

Law, Kock-Yee (Xerox, Webster Research Cent, Webster, NY, USA). *J Imaging Sci* v 31 n 3 May-Jun 1987 p 83-93.

Fabrication See Also WAVEGUIDE COMPONENTS—Couplers.

**073774 COLOR ELECTROLUMINESCENT DEVICES PREPARED BY METAL ORGANIC CHEMICAL VAPOR DEPOSITION.** This paper discusses the preparation of ac thin film ZnS:Tb (green), Sm (red) and Tm (blue) color electroluminescent devices by metal organic chemical vapor deposition, using dimethylzinc and H<sub>2</sub>S as source gases. A new doping method for luminescent centers was used. This was accomplished by evaporating TbF<sub>3</sub>, SmF<sub>3</sub>, SmCl<sub>3</sub> and TmF<sub>3</sub> after they had been heated to their melting points during the growth of ZnS in a MOCVD reactor. The maximum brightness of ZnS:TbF<sub>3</sub>, ZnS:SmCl<sub>3</sub> and ZnS:TmF<sub>3</sub> are 5000, 1000 and 10 cd/m<sup>2</sup>. The ZnS:SmCl<sub>3</sub> EL devices showed a deeper red chromaticity than the ZnS:SmF<sub>3</sub> EL ones. (Author abstract) 14 refs.

Hirabayashi, Katsuhiko (NTT Electrical Communications Lab, Tokai-mura, Jpn); Kozawaguchi, Haruki; Tsujijima, Bunjiro. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1472-1476.

Laser Applications

**073775 DENSELY SPACED WDM COHERENT OPTICAL STAR NETWORK.** An optical WDM star network consisting of three lasers transmitting at about 234,000 GHz, spaced by 300 MHz, has been used to demonstrate dense packing of WDM signals. The three optical signals, FSK-modulated at 45 Mbit/s, are multiplexed by a 4×4 star coupler and demultiplexed by a balanced heterodyne receiver. Receiver sensitivity is -61 dbm for a BER of 10<sup>-9</sup> or 113 photons/bit, which is 4.5 db from the shot noise limit. The results indicate that 100,000 users in a 10 km radius could be interconnected with such a system. (Edited author abstract) 8 refs.

Glance, B. (AT&T, Holmdel, NJ, USA); Pollock, K.; Burrus, C.A.; Kasper, B.L.; Eisenstein, G.; Stulz, L.W. *Electron Lett* v 23 n 17 Aug 13 1987 p 875-876.

**073776 LASER SCANNER USING STACKED PIEZOELECTRIC CERAMIC ACTUATOR.** A laser scanner using the displacement of two stacked piezoelectric ceramic actuators (Piezo-Stacks) has been developed. This scanner is capable of simultaneously scanning both X and Y axes up to 4.0 mrad at frequencies as high as 1.0



kHz. Possible uses include automated precise positioning of optics and lasers for LSI applications. (Author abstract) 2 refs.

Okuda, Makoto (NGK Spark Plug Co, Nagoya, Jpn); Wakita, Naomasa; Ohya, Kanji; Banno, Hisao; Hattori, Shuzo. *Jpn J Appl Phys Suppl* v 25 suppl 25-1 1986, Proc 6th Symp on Ultrason Electron, Tokyo, Jpn, Dec 10-12 1985 p 223-225.

## Low Temperature Effects

**073777 SIMPLE CHAMBER FOR LOW-TEMPERATURE OPTICAL STUDIES.** A chamber of experiments in the temperature range of 90-340 K is described. The use of Teflon and foil-coated textolite ensures thermal isolation of the optical window. External vapor-liquid cooling permits low-temperature studies at a chamber pressure of  $5 \cdot 10^{-4}$  torr. (Author abstract) CX

Vasil'ev, I.A. (Saratov State Univ, USSR). *Instrum Exp Tech* v 30 n 2 pt 2 Mar-Apr 1987 p 493-494.

**Manufacture** See FIBER OPTICS—Fabrication; INTERFEROMETERS—Applications; OPTICAL FIBERS—Analysis.

**Materials** See LOGIC DEVICES—Materials.

**Mathematical Models** See LIGHT—Amplifiers.

**Measurements** See Also OPTICAL VARIABLES MEASUREMENT.

**073778 MEASUREMENT METHOD FOR DETERMINATION OF OPTICAL PHASE SHIFTS IN  $3 \times 3$  FIBRE COUPLERS.** The phase characteristics of  $3 \times 3$  fibre couplers are investigated with a self-homodyne experiment at 1.3 and 1.5  $\mu\text{m}$ . A  $2 \times 2$  fibre coupler, a fibre delay line and the  $3 \times 3$  fibre coupler under test form a Mach-Zehnder interferometer. The measurement results are compared with values from S-matrix theory for lossy couplers. (Author abstract) 4 refs.

Gottwald, E. (Siemens AG, Munich, West Ger); Pietzsch, J. *Electron Lett* v 24 n 5 Mar 3 1988 p 265-266.

**073779 THROUGH-WAFER OPTICAL INTERCONNECTION COUPLING CHARACTERISTICS.** Both the optical coupling and resulting optical crosstalk characteristics for LED-based through-wafer optical interconnections have been measured within a simulated stacked wafer environment. Using integrated  $\text{SiO}_2$  Fresnel phase plate lens arrays, a nearly 4:1 improvement in received signal was noted over the configuration without lenses. Interchannel crosstalk measurements indicate that from an optical standpoint, high interconnect densities (250  $\mu\text{m}$  pitch) are obtainable with reasonable noise margins over a range of distances of interest for stacked wafer architectures. (Author abstract) 7 refs.

Hornak, L.A. (AT&T Bell Lab, Holmdel, NJ, USA). *Electron Lett* v 24 n 11 May 26 1988 p 714-715.

## Microwaves

**073780 10 GHz OPTICAL RECEIVER USING A TRAVELLING-WAVE SEMICONDUCTOR LASER PREAMPLIFIER.** A 1.5  $\mu\text{m}$  optical receiver with a bandwidth of 10 GHz has been demonstrated. The receiver used a travelling-wave semiconductor laser preamplifier and had an equivalent input noise of 1  $\text{pA}/\sqrt{\text{Hz}}$  with a 3 db bandwidth of 10 GHz. The estimated sensitivity at 15 Gbit/s was -27 dbm. (Author abstract) 6 refs.

Marshall, I.W. (British Telecom Research Lab, Ipswich, Engl); O'Mahony, M.J. *Electron Lett* v 23 n 20 Sep 24 1987 p 1052-1053.

## Military Application

**073781 ADVANCED OPTICS IN GOVERNMENT USE.** The prospect of laser defense systems, deep-space telescopes, interference-immune optical computers and

communications based on optical systems has made optics a crucial technology for the government. Industry is stepping up to the challenge of satisfying unique requirements of the high-precision optical devices that are needed. (Author abstract)

Kelley, Robert A. *Photonics Spectra* v 21 n 8 Aug 1987 p 101-102, 104, 106.

## Multiplexing

**073782 SINGLE MODE FUSED COUPLERS INSENSITIVE TO EXTERNAL REFRACTIVE INDEX.** Wavelength multiplexers produced using the fused taper technique have been fabricated to be insensitive to variations in the external refractive index, allowing them to be potted in silicone for environmental protection. The technique exploits two opposing dependencies by fabrication at a particular coupler cross-section. (Author abstract) 2 Refs.

Fielding, A. (STC Technology Ltd, Harlow, Engl); Brichen, T. *Electron Lett* v 24 n 14 Jul 7 1988 p 851-853.

**Optical Beam Splitters** See Also INTERFEROMETERS—Performance; PICKUPS—Performance.

**073783 MINIATURE INTEGRATED OPTICAL BEAM-SPLITTER IN  $\text{AlGaAs/GaAs}$  RIDGE WAVEGUIDES.** Typical directional couplers in semiconductor waveguides require long (several millimetre) interaction lengths, potentially limiting their use in future optoelectronic integrated circuits (OEICs). We report the fabrication and operation of a newly designed integratable waveguide beam-splitter device only micrometres in size, consisting of a groove at the intersection of two perpendicular  $\text{AlGaAs/GaAs}$  ridge waveguides which was milled with a microfocused gallium ion beam. Single-mode propagation of both transmitted reflected beams was observed, and the power ratio between both beams was adjustable by varying the groove depth. (Author abstract) 5 refs.

Osinski, J.S. (Bell Communications Research Inc, Red Bank, NJ, USA); Zah, C.E.; Bhat, R.; Contolini, R.J.; Beebe, E.D.; Lee, T.P.; Cummings, K.D.; Harriott, L.R. *Electron Lett* v 23 n 21 Oct 8 1987 p 1156-1158.

**073784 QUANTUM THEORY OF THE LOSSLESS BEAM SPLITTER.** The electromagnetic fields associated with a beam splitter having two input arms and two output arms are quantized in terms of the spatial modes of the complete optical system. The continuum mode operators employed conveniently describe the flow of light through the beam splitter from sources to detectors. The formalism is used to determine the photocount fluctuations in difference detection of the two outputs, the effect of beam splitting on squeezed input light, and the distribution of output photocounts for a definite number of input quanta. (Author abstract) 20 refs.

Fearn, H. (Essex Univ, Colchester, Engl); Loudon, R. *Opt Commun* v 64 n 6 Dec 15 1987 p 485-490.

**073785 RELATION BETWEEN INPUT AND OUTPUT STATES FOR A BEAM SPLITTER.** The state of the optical field at the output of a beam splitter is expressed directly in terms of the state at the input via the diagonal coherent state representation. The conclusion is illustrated for a two-photon Fock state, and it is shown that an output having some features of the two-photon singlet state can be produced. (Author abstract) 6 refs.

Ou, Z.Y. (Univ of Rochester, Rochester, NY, USA); Hong, C.K.; Mandel, L. *Opt Commun* v 63 n 2 Jul 15 1987 p 118-122.

## Optical Properties

**073786 POLARIZATION BISTABILITY IN A HYBRID DEVICE SIMULATING A NONLINEAR BIREFRINGENT CAVITY.** Polarization bistability can be achieved in a resonant cavity containing a nonlinear birefringent material. A hybrid opto-electronic device was constructed in order to simulate the behavior of such a

system and to study its response in terms of a number of system parameters. Intensity driven polarization switching as well as polarization driven intensity switching are demonstrated as examples. (Author abstract) 7 refs.

Indebetouw, G. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA). *Opt Commun* v 65 n 4 Feb 15 1988 p 311-314.

## Performance

**073787 SINGLE-MODE FIBRE Y-JUNCTION BEAM-SPLITTER.** The fabrication operation and performance of a wavelength-independent single-mode fiber beam-splitter is discussed. Equal power splitting over an indefinitely broad spectral range is possible with this device, which has a tapered Y-junction configuration. (Author abstract) 7 refs.

Minelly, J.D. (Univ of Southampton, Southampton, Engl); Hussey, C.D. *Electron Lett* v 23 n 20 Sep 24 1987 p 1087-1088.

**073788 PERFORMANCE OF GALLIUM PHOSPHIDE BRAGG CELLS.** The design, fabrication and evaluation of efficient wideband Bragg cells in gallium phosphide is reported. The devices were fabricated using the  $<110>$  and  $<111>$  longitudinal modes of acoustic propagation with design bandwidths of 500 MHz centered on 1.2 GHz. Very high diffraction efficiencies of 115%/W and 210%/W, respectively, were obtained. The devices were characterized in terms of two tone third order intermodulation products, which are shown to be consistent with being caused by acoustic mixing. Other results reported include measurements of acoustic attenuation, the acoustic anisotropy factor and optical scatter. (Edited author abstract) 10 refs.

Bagshaw, J.M.; Lowe, S.E.; Willats, T.F. *GEC J Res* v 5 n 3 1987 p 171-175.

**073789 PERFORMANCE OF OPTICAL RECEIVERS INCORPORATING MULTIEMISSION SUPERLATTICE AVALANCHE PHOTODIODES.** Recently interest has been expressed in superlattice avalanche photodiodes (SAPDs) in which the initiating carrier can impact more than one ionisation per stage, as a further step towards the solid-state photomultiplier. This letter indicates that these advanced SAPDs are likely to offer improved receiver sensitivity, compared with normal SAPDs, only if the residual hole ionisation is kept to an extremely low value. (Author abstract) 8 refs.

Fyath, R.S. (Univ Coll of North Wales, Bangor, Wales); O'Reilly, J.J. *Electron Lett* v 24 n 4 Feb 18 1988 p 234-235.

**073790 DELAY LINES FOR OPTICAL PULSE SEQUENCE FORMATION.** The problem of forming two or several series of a sequence of pulses, including forming an optical vernier, occurs in the development of pulse, pulse-phase, and phase-pulse range-finder technique. To assure strict phase pinpointing it is expedient to form these series of sequential multiple division operations of the original pulse into direct and delayed. In this case the instrumental component of the measurement error can be removed because of assurance of the equality of the amplitudes and stability of the pulse repetition rate in the series or sequences formed. This effect can be achieved by using the physical features of certain optical delay lines. The proposed method for investigating such delay lines is based on a representation of the original signal and the individual signal components at the delay line output by  $\delta$ -functions of the corresponding delay times governed by the geometric pathlength which the signal traverses. 4 refs.

Andrusenko, A.M.; Ganchin, V.V.; Golenkova, N.V.; Prokopov, A.V. *Meas Tech* v 30 n 9 Sep 1987 p 873-878.

## Physical Properties

**073791 PROPERTIES OF MULTILAYERS FOR SOFT X-RAY OPTICS.** An appropriate physical description of multilayer structures to be used as soft x-ray optical elements is necessary to ensure agreement of



predicted and actual performance. Deviations of the fabricated structures from an ideal design (interfacial roughness and diffusion, microvoids, impurities, thickness errors) degrade the reflectance properties. Deviations of the physical properties of very thin films from those of the bulk materials can limit the validity of reflectance calculations. We describe these difficulties and how a particular fabrication-characterization procedure can help solve them. Characterization techniques used include a variety of x-ray diffraction techniques, Rutherford backscattering spectroscopy and Transmission Electron Microscopy. Results obtained for samples prepared by triode magnetically confined dc sputtering are given. The implication of these results for other multilayer materials is discussed. (Edited author abstract) 10 refs.

Falco, Charles M. (Univ of Arizona, Tucson, AZ, USA); Fernandez, Felix E.; Dhez, P.; Khandar-Shahabad, A. *Superlattices Microstruct* v 4 n 1 1988, Chicago Conf, Pap, Chicago, IL, USA, 1987 p 51-53.

## Protection

**073792 TEFLON FILMS FOR PROTECTION OF OPTICAL SYSTEMS IN LASER PROCESSING OF METALS.** In processing of metals by pulsed neodymium lasers, it is necessary to protect the focusing objectives—especially the short-focus objectives—as well as the entrance windows of the chambers from sputtered and evaporated material, which can contaminate or damage the elements of the optical system. Teflon films are used for effective protection of the elements of the optical systems of pulsed neodymium lasers from contamination in metals processing. (Edited author abstract) 4 refs.

Nikitin, A.A. (Central Scientific-Research Inst of Ferrous Metallurgy, Moscow, USSR); Mukomel, E.A.; Safonov, E.V. *Instrum Exp Tech* v 30 n 4 pt 2 Jul-Aug 1987 p 1004-1005.

**Research** See ELECTROOPTICAL DEVICES—Research; OPTICAL COMMUNICATION EQUIPMENT—Research; OPTICS—Research.

## Reviews

**073793 OPTICAL FIBRE-GRATING PULSE COMPRESSIONS.** The article reviews the current state-of-the-art of optical pulse compressors based on the optical fiber-grating pair. As this technique has become a standard laboratory procedure providing pulses with duration shorter than those directly generated from mode-locked lasers, we review the basic mechanism of the method, the role played by additional non-linear effects (such as stimulated Raman scattering), describe the current results, with emphasis to our own work, and point out the limitations of the technique. (Author abstract) 94 refs.

Gomes, A.S.L. (Imperial Coll, London, Engl); Gouveia-Neto, A.S.; Taylor, J.R. *Opt Quantum Electron* v 20 n 2 Mar 1988 p 95-112.

## Selection

**073794 SELECTING SUPPORT EQUIPMENT.** The rapidly expanding areas of application for lasers, electro-optical systems, imaging equipment and fiber optics have brought with them an unprecedented growth in the optical support equipment industry. Today the researcher in photonics-related fields can select support equipment from as many as 20 different suppliers. Photonics system designers have a wide variety of support equipment to select from today. However, this bonanza also complicates the problem of picking the right components for the job at hand.

Spiegel, Gary. *Photonics Spectra* v 21 n 12 Dec 1987 p 82, 84, 86.

## Space Applications

**073795 WIDEBAND 150  $\mu$ S OPTICAL DELAY LINE FOR SATELLITE ALTIMETRIC RADAR CHECKING.** A 1.3  $\mu$ m optical delay line providing a 150

$\mu$ s delay time in the spectral range 200-600 MHz has been realized using a 30 km-long single-mode fiber. The aim of this delay line is the ground test of an altimetric radar to be implemented in the oceanographic satellite Topex-Poseidon, whose launch is scheduled for the end of 1991. (Author abstract) 5 refs.

Maignan, M. (CGE Research Cent, Marcoussis, Fr); Bernard, J.J.; De Chateau-Thierry, P. *Electron Lett* v 24 n 14 Jul 7 1988 p 902-904.

**Stability** See Also LASERS, SEMICONDUCTOR—Stability; LIGHT—Nonlinear Optical Effects.

**073796 NOVEL QUANTUM-WELL OPTICAL BISTABILITY DEVICE WITH EXCELLENT ON/OFF RATIO AND HIGH SPEED CAPABILITY.** A novel optical bistability device is proposed and analyzed in which the Stark effect of a multiple quantum well is used in combination with a negative resistance device. The device is found to possess an excellent on/off ratio (19:1) and high speed capability ( $\tau < 10$ ps), while the required optical power P is as small as 1 mW or less with a bias voltage of 5V, giving a Pr product of 1 to approximately 10 fJ. (Author abstract) 3 refs.

Sakaki, H. (Univ of Tokyo, Tokyo, Jpn); Kurata, H.; Yamanishi, M. *Electron Lett* v 24 n 1 Jan 7 1988 p 1-2.

**073797 OPTICAL BISTABILITY.** This chapter provides an introduction to and an overview of optical bistability. The steady-state characteristics and modes of operation of optically bistable and multistable devices are examined. The theory of passive nonlinear absorptive and dispersive ring and Fabry-Perot cavities is developed and compared with experimental results. Hybrid electro-optic devices and systems which display intrinsic bistability without resonant cavities are surveyed. The complex dynamic behavior of bistable systems is investigated, including: questions of stability, critical slowing down in state switching, overshoot, alternate, and phase switching, self-pulsing due to hysteresis cycling and to positive slope instabilities, and optical chaos. (Author abstract) 380 refs.

Goldstone, J.A. (Univ of Southern California, Los Angeles, CA, USA). *Laser Handb* Publ by North-Holland, Amsterdam, Neth and New York, NY, USA p 487-558.

**Switching** See Also ELECTROOPTICAL DEVICES—Thermal Effects; GLASS—Optical Quality; LASERS, SEMICONDUCTOR—Electrodes; LASERS, SEMICONDUCTOR—Switching; OPTICAL FIBERS—Switching; WAVEGUIDE COMPONENTS—Couplers; WAVEGUIDES, OPTICAL—Components.

**073798 IMPLEMENTATION OF MULTISTAGE SPACE-SWITCH INTERCONNECTIONS VIA THE PERFECT SHUFFLE.** Multistage space-switch interconnection configurations involving  $2^m$  links can be implemented by m sequential applications of the perfect shuffle operator, with potential applicability in optical switching systems. (Author abstract) 5 refs.

Kirkby, C.J.G. (Plessey Research Caswell Ltd, Towcester, Engl). *Electron Lett* v 23 n 18 Aug 27 1987 p 971-973.

**073799 NEW TYPE OF OPTICAL SWITCH WITH A PLASTIC-MOLDED FERRULE.** This letter proposes a novel type of 1x2 optical switch with a plastic-molded ferrule where an alignment mechanism is formed. Discussing the errors in ferrule fabrication, the insertion loss of the switch has been evaluated. The switch for multimode fibers has shown an insertion loss of 0.7 db and a switching time of 4 msec. (Edited author abstract) 3 refs.

Nagasawa, Shinji (NTT, Jpn); Furukawa, Hiroshi; Satake, Toshiaki; Kashima, Norio. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 8 Aug 1987 p 696-698.

**073800 POLARIZATION BISTABILITY WITH A MIRRORLESS HYBRID DEVICE.** A bistable device driven by the incident light polarization is created on the basis of a phase electrooptical modulator from LiNbO<sub>3</sub>. The light transmitted through the device does not vary its intensity. The switching takes place between states with different polarization. The device action at different

parameters is experimentally investigated. (Author abstract) 7 refs.

Zartov, G.D. (Bulgarian Acad of Sciences, Sofia, Bulg); Panajotov, K.P.; Pejewa, R.A. *Appl Phys B* v 44 n 3 Nov 1987 p 181-184.

**073801 LOW-LOSS LARGE-SCALE 1xN OPTICAL SWITCH.** The feasibility of a 1x600 mechanical optical switch is demonstrated. The maximum insertion loss is 0.2 db and the loss variation throughout 500 switching cycles is less than 0.1 db for both multimode and single-mode fibers at wavelength of 0.85, 1.3, and 1.53  $\mu$ m. The maximum switching time is 3.4 seconds. (Author abstract) 11 refs.

Tateda, Mitsuhiro (NTT Electrical Communications Lab, Ibaraki, Jpn); Furukawa, Shin-ichi; Miyokawa, Hiromichi. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 10 Oct 1987 p 890-892.

**073802 PERFORMANCE OF AN 8x8 LiNbO<sub>3</sub> SWITCH MATRIX AS A GIGAHERTZ SELF-ROUTING SWITCHING NODE.** The performance of an LiNbO<sub>3</sub> integrated-optic crossbar switch is a node in a gigahertz self-routing network is measured. Switch throughput supports 12.5 Gbit/s signals with a measured switching speed of 1.33 GHz. Crosstalk due to RF/acousto-optic coupling and modulation depth are reported at 1.33 GHz. Optical self-routing of 100 Mbit/s information using the 8x8 switch is demonstrated. (Author abstract) 7 refs.

Blumenthal, D.J. (Columbia Univ, New York, NY, USA); Prucnal, P.R.; Thylen, L.; Granstrand, P. *Electron Lett* v 23 n 25 Dec 3 1987 p 1359-1360.

**073803 PHOTOPHYSICAL AND PHOTOCHEMICAL SWITCHES BASED ON TWISTED INTRAMOLECULAR CHARGE TRANSFER (TICT) STATES.** TICT states, accessible in twisted multichromophoric systems, are nonradiative funnels to the ground state in many dyes. By controlling these funnels, faster saturable absorbers for subpicosecond laser pulses can be developed. Oriented assemblies of TICT molecules, as in liquid crystalline polymers, are expected to exhibit light-induced macroscopic charge separation. Chemical approaches to supramolecular bistable species are also shown. (Author abstract) 30 refs.

Rettig, W. (Technische Univ Berlin, Berlin, West Ger). *Appl Phys B* v B45 n 3 Mar 1988 p 145-149.

**073804 SWITCHING DYNAMICS OF OPTICAL BISTABLE DEVICES.** The switching dynamics of optical bistable devices is studied and some recent results are reviewed. It is shown that it is relatively easy to switch rapidly a bistable pixel monitored by a cw beam by adding the exact amount of energy. This switching time can be much faster than the relaxation time  $\tau_r$  of the nonlinear material. However, when the device is switched, the characteristic time which drives the system is  $\tau_p$ , so that the reverse switching time should be of the order of this relaxation time. This reverse switching is obtained by a decrease of the holding intensity which can be achieved by cutting the holding cw beam. 63 refs.

Daunois, A. (CNRS, Strasbourg, Fr); Bigot, J.Y. *Appl Phys B* v B45 n 3 Mar 1988 p 157-162.

**073805 ROOM-TEMPERATURE SINGLE-WAVELENGTH OPTICAL LATCHING CIRCUITS USING GaAs BISTABLE DEVICES AS LOGIC GATES.** Room-temperature two-element latching circuits are experimentally demonstrated using GaAs multiple-quantum-well (MQW) nonlinear etalons under single-wavelength bistable operation. Signal power gains of up to 4 and contrast ratios of 10 have been achieved at milliwatt power levels with 1- $\mu$ s pulses, which will allow the construction of more complicated digital optical circuits using diode lasers as the light sources. The problems of applying these nonlinear etalons to fast optical signal processing are also discussed. Numerical simulations



show that the gain vanishes as the pulse duration decreases and approaches the carrier lifetime. (Author abstract) 24 refs.

Jin, R. (Univ of Arizona, Tucson, AZ, USA); Hanson, C.; Warren, M.; Richardson, D.; Gibbs, H.M.; Peyghambarian, N.; Khitrova, G.; Koch, S.W. *Appl Phys B* v B46 n 1 May 1988 p 61-67.

**073806 REARRANGEABLY NONBLOCKING  $8 \times 8$  GUIDED WAVE OPTICAL SWITCH.** The design and construction of a lithium niobate  $8 \times 8$  optical switch with a rearrangeably nonblocking architecture is described. The design is compared with the more familiar strictly nonblocking architecture. The switch has 29 elements, a switching voltage of 26 V and a loss of 5.5 db at 1.3  $\mu$ m wavelength. (Author abstract) 7 refs.

Duthie, P.J. (Plessey Research Caswell Ltd, Towcester, Engl); Wale, M.J. *Electron Lett* v 24 n 10 May 12 1988 p 594-596.

**073807 INTERACTION COEFFICIENT IN DETUNED NONLINEAR COUPLERS.** By including a field interaction coefficient we give a complete treatment of a nonlinear coupler which is 'detuned' in the sense that two unequal guides are used. This generalizes earlier work in this area. (Author abstract) 8 refs.

Ankiewicz, Adrian (Australian Natl Univ, Aust). *Opt Commun* v 66 n 5-6 May 1988 p 311-314.

**073808 ALL-OPTICAL FLIP-FLOP OPERATIONS IN A COUPLED ELEMENT BISTABLE DEVICE.** An optical bistable device composed of coupled nonlinear elements is proposed. This device features optical bistability without hysteresis. It is shown theoretically that a set-reset type (S-R) flip-flop operation can be easily achieved on an all-optical basis by utilizing nonhysteretic bistable characteristics. (Author abstract) 4 refs.

Otsuka, K. (NTT, Musashino, Jpn). *Electron Lett* v 24 n 13 Jun 23 1988 p 800-801.

**073809 POLARISATION-INDEPENDENT  $\text{LiNbO}_3$   $4 \times 4$  MATRIX SWITCH.** A polarization-independent  $\text{LiNbO}_3$  strictly nonblocking  $4 \times 4$  matrix switch has been developed. This matrix switch has a 4.6 db insertion loss at any incident polarization with 1.3  $\mu$ m wavelength and about 30 V switching voltage. (Edited author abstract) 9 refs.

Nishimoto, H. (NEC Corp, Kawasaki, Jpn); Suxuki, S.; Kondo, M. *Electron Lett* v 24 n 18 Sep 1 1988 p 1122-1123.

**073810  $1 \times 2$  OPTICAL SWITCH FOR WDM TRANSMISSION SYSTEMS.** A  $1 \times 2$  optical switch, which also functions as wavelength demultiplexer is designed and experimentally fabricated utilizing a phase plate and a twisted nematic liquid crystal. Measured insertion loss, crosstalk attenuation, and transit time are < 1.5 db, > 17.6 db, and < 80 ms, respectively. (Author abstract) 2 refs.

Fujii, Y. (NTT Lab, Kanagawa, Jpn). *Electron Lett* v 24 n 18 Sep 1 1988 p 1153-1154.

**073811 WAVELENGTH-DIVISION-MULTIPLEXING OPTICAL SWITCH USING ACOUSTOOPTIC DEFLECTOR.** A wavelength-division-multiplexing (WDM) optical switch that requires minimal hardware and is applicable in high-speed signal switching has been developed. Theoretical calculations based on Gaussian beam approximation show that up to a  $20 \times 20$  switch is possible using present technology. As a preliminary study, a  $3 \times 3$  WDM switch was constructed. Crosstalk of this switch is found to be less than -20 dB, and a 500 Mb/s return-to-zero signal is successfully switched with a 4- $\mu$ s switch access time. A large-capacity switching network using this WDM optical switch is proposed. 11 refs.

Shimazu, Yoshihiro (NTT, Kanagawa, Jpn); Nishi, Shigeto; Yoshikai, Noriaki. *J Lightwave Technol* v LT-5 n 12 p 1742-1747.

**073812 GUIDED-WAVE OPTICAL GATE MATRIX SWITCH.** An optical gate matrix switch that is made by integrating InGaAsP laser diode gates with high-silica guided-wave splitter and combiner circuits in a hybrid fashion is proposed and demonstrated. It provides point-to-multipoint switching. A preliminary experiment for a  $4 \times 4$  matrix switch shows that the switch is capable of more than 400-Mb/s bandwidth signal switching. 11 refs.

Himeno, Akira (NTT, Tokai, Jpn); Terui, Hiroshi; Kobayashi, Morio. *J Lightwave Technol* v 6 n 1 Jan 1988 p 30-35.

**073813 TRANSIENT-GRATING STUDIES IN GaAs/GaAlAs MULTIPLE QUANTUM WELLS.** We report degenerate four-wave mixing experiments at room temperature, using a three-beam geometry and sub-picosecond laser to study GaAs/GaAlAs multiple quantum well material. Diffraction efficiencies and grating decay times for two samples of different carrier lifetimes have been measured in the spectral region corresponding to excitonic resonances. The measurements provide values of the nonlinear refractive index per carrier pair ( $n_{2h}$ ) deriving from the excitonic saturation, and also the recombination times and diffusion coefficients for the samples. (Author abstract) 13 refs.

Manning, R.J. (Royal Signals & Radar Establishment, Malvern, Engl); Crust, D.W.; Craig, D.W.; Miller, A.; Woodbridge, K. *J Mod Opt* v 35 n 3 Mar 1988, Eighth Natl Quantum Electron Conf, St. Andrews, Scotl, Sep 21-25 1988 p 541-551.

#### Telemetry

**073814 ANALOG-DIGITAL OPTICAL TELEMETRY LINE.** A line for transmission of analog and digital data through a single optical channel is described. Pulse-duration modulation is used for transmission of analog signals. The bandwidth for analog signals is 0-25 kHz, and digital data are transmitted in bytes at a speed of up to 100 kbaud. (Author abstract) 2 refs.

Bochkar', E.P. (Moscow State Univ, USSR); Zakharov, A.I.; Polyakov, S.N.; Samorodov, V.A. *Instrum Exp Tech* v 30 n 1 pt 2 Jan-Feb 1987 p 148-151.

#### Testing See INTERFEROMETRY.

#### Transients

**073815 TRANSIENT RESPONSE OF AN ELECTRICALLY ADDRESSABLE NONLINEAR BISTABLE OPTICAL DEVICE.** This note describes an experimental study of the transient response of this device when it was subject to square wave voltage pulses and identifies the mechanisms dominating the overall switching time at varying values of driving voltage, initial dc biasing and optical input power. The device consisted of a Fabry-Perot etalon containing the nematic liquid crystal mixture 3/5/7 PCH. Results are presented which show that the transient characteristic is composed of three regions, a purely electro-optic part where the cavity intensity does not change (region 1), followed by a slow change in cavity intensity brought about by the electro-optic and nonlinear effects (region 2), with a final fast switch up to the high transmission state (region 3). 14 refs.

Staromlynska, J. (Royal Signals & Radar Establishment, Great Malvern, Engl); Clay, R.A. *Opt Commun* v 64 n 5 Dec 1 1987 p 474-480.

**OPTICAL FIBERS** See Also ACOUSTOOPTICAL DEVICES—Analysis; ATMOSPHERIC HUMIDITY—Measurements; DIELECTRIC MATERIALS—Radiation Effects; DIGITAL COMMUNICATION SYSTEMS—Analysis; ELECTRIC DELAY LINES—Performance; ELECTRONIC CIRCUITS, FREQUENCY MULTIPLYING—Performance; ELECTROOPTICAL DEVICES; FIBER OPTICS; FIBER OPTICS—Mathematical Models; FILMS—Dielectric; GLASS—Optical Quality; GLASS FIBER; INTERFEROMETERS; INTERFEROMETERS—Laser Applications; LASER PULSES; LASER PULSES—Mathematical Models; LASER PULSES—Spectrum Analysis; LASERS—Accessories; LASERS, GAS—Mode Locking; LASERS, SEMICONDUCTOR; LASERS, SEMICONDUCTOR—Per-

formance; LASERS, SOLID STATE; LASERS, SOLID STATE—Performance; LASERS, SOLID STATE—Q Switching; LENSES; LENSES—Analysis; LIGHT—Nonlinear Optical Effects; LIGHT—Polarization; LIGHT—Pulse Generators; MAGNETOMETERS—Performance; OPTICAL COMMUNICATION; OPTICAL COMMUNICATION—Analysis; OPTICAL COMMUNICATION—Australia; OPTICAL COMMUNICATION—Computer Simulation; OPTICAL COMMUNICATION—Design; OPTICAL COMMUNICATION—Theory; OPTICAL COMMUNICATION EQUIPMENT; OPTICAL COMMUNICATION EQUIPMENT—Costs; OPTICAL COMMUNICATION EQUIPMENT—Exhibitions; OPTICAL DEVICES—Analysis; OPTICAL MATERIALS—Plastics Applications; RAMAN SCATTERING; REFLECTOMETERS; RESONATORS—Multiplexing; RESONATORS—Performance; SEMICONDUCTOR DIODES, LIGHT EMITTING; SENSORS—Design; SIGNAL INTERFERENCE—Crosstalk; TELECOMMUNICATION CABLES; TELECOMMUNICATION CABLES—Design; TELECOMMUNICATION CABLES—Joining; TELECOMMUNICATION CABLES—Laying; TELECOMMUNICATION CABLES—Manufacture; TELECOMMUNICATION CABLES—Protection; TELECOMMUNICATION CABLES—Submarine; TELECOMMUNICATION CABLES—Telemetry; TELEVISION TRANSMISSION—Performance; TELEVISION TRANSMISSION—Spectrum Analysis; WAVEGUIDE COMPONENTS—Couplers; WAVEGUIDES, DIELECTRIC—Analysis; WAVEGUIDES, OPTICAL; WAVEGUIDES, OPTICAL—Components; WAVEGUIDES, OPTICAL—Imaging Techniques; WAVEGUIDES, OPTICAL—Manufacture; WAVEGUIDES, OPTICAL—Materials; WAVEGUIDES, OPTICAL—Performance.

**073816 LASING SPECTRUM OF P CO-DOPED  $\text{Nd}^{3+}$  SILICA FIBERS.** Co-doping effects for the fluorescence and lasing spectrum of  $\text{Nd}^{3+}$ -doped silica fibers have been studied. Alternating the concentration ratio between  $\text{Nd}^{3+}$  and P atoms, the peak lasing wavelength can be changed from 1.064  $\mu$ m to 1.092  $\mu$ m. A fiber laser configuration which can increase the laser tuning range up to 93 nm at  $^4F_{3/2}$ - $^4I_{11/2}$  transition is proposed. (Author abstract) 7 refs.

Kimura, Yasuo (NTT, Jpn); Nakazawa, Masataka. *Jpn J Appl Phys Part 2* v 26 n 8 Aug 1987 p 1253-1254.

**073817 MODIFIED SZ STRANDING OF OPTICAL FIBRE CABLE CONDUCTORS.** Analysis of all well-known stranding methods revealed that SZ stranding with synchronous pulleys in modified form best satisfies all product-specific and production requirements in the stranding of optical fiber cable conductors. A length compensator mounted between the unwinding bobbins and the SZ infed synchronously counteracts the non-uniform speeds of the individual conductors in stranding machines operating on this principle. The production speeds are higher with this method than with the conventional ones. (Author abstract) 4 refs.

Schmitz, Hans-Joachim. *Wire World Int* v 29 n 1 Jan-Feb 1987 p 10-12.

**073818 DRUM TWISTER FOR STRANDING OF OPTICAL FIBRE CABLES.** For the stranding of sensitive products such as optical fiber cables the manufacturer can make a choice between cage machines, single twist cablers, SZ stranders, and drum twisters. The outstanding advantages of the drum twister include extensive flexibility on the pay-off side, low-deflection guiding and the possibility of disruption-free backtwisting of the sensitive stranded product. Optical splicing units such as a TV camera built into the rotating take-up permit the accurate observation of the winding quality at the stranding point. With the aid of various handling devices and different drive solutions a drum twister can be built into a computer-controlled stranding plant. (Edited author abstract) 5 refs.

Bruns, Klaus H. *Wire World Int* v 29 n 1 Jan-Feb 1987 p 13-16.

**073819 EFFECTIVE SPLICING FOR OPTICAL COMMUNICATION.** The capability to splice fibers with minimal loss is fundamental to fiber optics. The 'Placotic' splicing system uses a rectilinear section alignment block rather than the conventional V-groove. This ensures more accurate alignment in the y-plane. Alignment in the x-plane is assured by the elastomeric material with which



the block is made. This centers the two fibers whatever their outside diameter may be. The fibers are automatically aligned by the reactive forces which result from distortion of the elastomer.

Kidd, Trevor (K-Tech Micro Precision); Smith, Dave. *New Electron* v 20 n 15 Jul 21 1987 p 25-26.

**073820 ADVANCES IN BLOWN FIBER INSTALLATION METHODS.** The blown fiber method has recently been introduced into British Telecom operating districts as a means of providing optical point-to-point cable links. This paper, describes some laboratory advances in the blown fiber installation technique which will enable the system to be applied across the whole range of local network applications, including connecting the customer directly to the exchange. The first part of the paper examines the duct utilization of blown fiber tubing; recommendations are made on the use of smaller bore blowing tubes to improve heads in series, and single head blowing with fiber unit delivered from toroidal pans rather than drums. Route lengths in excess of 2 km are now possible using either of these methods. (Author abstract) 6 refs.

Freeman, R.A.; Jenkins, P.D.; Stockton, D.J.; Wiltshire, B. *Br Telecom Technol J* v 5 n 3 Jul 1987 p 19-24.

**073821 BEHAVIOUR OF  $EH_{11}$  AND  $HE_{11}$  WAVE MODES IN A THREE-LAYER OPTICAL FIBRE.** Many guided-wave optical transmission systems employ fibers having a slight depression of the refractive index along the axis of the core. This has been shown to have comparatively little effect on the  $HE_{11}$  mode normally used for propagation but, according to the present paper, any slight axial depression of the refractive index permits the appearance of an anomalous  $EH_{11}$  mode at the lower end of the frequency spectrum. The behavior of this anomalous wave is examined and described; it is found to disappear completely when the core remains homogeneous. (Author abstract) 7 refs.

Barlow, H.M. (Penrith, Epsom, Engl). *J Phys D* v 20 n 10 Oct 14 1987 p 1232-1236.

**073822 CHARACTERISTICS OF DISPERSION-SHIFTED FIBERS.** The bending properties of dispersion-shifted fibers with dual shape cores are theoretically and experimentally investigated. A bend-optimized dual shape core fiber is achieved for a large mode field diameter of 8.6  $\mu\text{m}$ . It is clarified that its dispersion controllability is better in dual shape core fibers than in  $\alpha$ -index dispersion-shifted fibers. (Author abstract) 10 refs.

Ohashi, Masaharu (NTT, Jpn); Kuwaki, Nobuo; Uesugi, Naoshi. *Rev Electr Commun Lab (Tokyo)* v 35 n 5 Sep 1987 p 535-539.

**073823 FLUORINE IN MCVD OPTICAL FIBERS.** Fluorine incorporation in silica glass network has been investigated using  $\text{CCl}_2\text{F}_2$  (Freon-12) as a source. Considerations on the stoichiometry of the reactions involved in CVD processes and experimental results on the refractive index are detailed. The data are collected in a ternary diagram that is proposed as a useful graphic representation in order to identify iso-index curves. (Author abstract) 8 refs.

Cocito, G. (CSELT, Turin, Italy); Cognolato, L.; Modone, E.; Parisi, G. *J Non Cryst Solids* v 93 n 2-3 Sep 1987 p 296-302.

**073824 FIBRE OPTIC SENSORS.** Apart from their use in communication links, optical fibers can be used as sensors for the measurement of various physical properties. This is because of the dependence of the refractive index of the fibre on physical parameters like temperature, pressure, strain, etc. Some topics discussed are these: a classification of fibre optics sensors (amplitude modulation, phase modulation, polarisation modulation, time resolved, and wave length modulation); components for the FOS systems; applications; and the optical phenomenon and the modulation of light. 23 refs.

Babu Reddy, C (SVU Coll of Engineering, Tirupati, India). *J Inst Eng India Part T* v 66 pt 3 Jan 1986 p 62-64.

**073825 EFFECTIVE CUTOFF FREQUENCY OF LP<sub>11</sub> MODE IN UNIFORMLY CURVED STEP-INDEX OPTICAL FIBERS.** This paper evaluates the field distribution and the propagation constant of the  $LP_{11}$  mode propagated in circularly bent step-index optical fibers by considering these quantities as perturbations from those in the straight fiber. By using these results, the field distributions and the curves of solutions of the eigenvalue equations for the bent fiber are studied in detail based on numerical and physical considerations. On the basis of this study, a reasonable method is proposed for defining the effective cut-off frequency of the  $LP_{11}$  mode in a circularly bent section of a step-index fiber. (Edited author abstract) 16 refs.

Tanaka, Toshiaki (Osaka Univ, Suita, Jpn); Morita, Nagayoshi; Kumagai, Nobuaki. *Electron Commun Jpn Part 2* v 70 n 10 Oct 1987 p 77-86.

**073826 MEASUREMENT OF MODE FIELD RADIUS USING EQUIVALENT VARIABLE APERTURE METHOD IN FAR-FIELD OF SINGLE MODE FIBERS.** An equivalent variable aperture method for mode field radius measurement of single mode fibers is proposed. It involves measurement of the integrated far-field distribution with a circular aperture moved axially in the far-field of the fiber. In addition, calculation method of the mode field radius, which is also suitable for non-Gaussian field distributions, is derived by using Petermann's new definition of mode field radius. Experiments have shown that this method is simple and reliable. The typical deviation of repeated measurements of the mode field radius of a given fiber with different ends is less than 0.04  $\mu\text{m}$ . (Author abstract) In Chinese. 6 refs.

Bai, Aimin (Wuhan Research Inst of Post & Telecommunications, China). *Guangxue Xuebao* v 7 n 6 Jun 1987 p 530-533.

**073827 BENDING LOSS CHARACTERIZATION IN SINGLE-MODE FIBRES.** An experimental characterization of bending sensitivity in single-mode fibres has been carried out by means of two distinct approaches. In the former the first measurement technique for the spot-size  $w_0$ , that describes both macro- and microbending losses, is proposed. In the second approach the microbending loss has been measured directly in a realistic configuration, determining the statistical properties of the phenomenon. (Author abstract) 9 refs.

Artiglia, M. (CSELT, Turin, Italy); Coppa, G.; Di Vita, P.; Kalinowski, H.J.; Potenza, M. *CSELT Tech Rep* v 15 n 6 Oct 1987 p 411-415.

**073828 SPECTRAL AND TEMPORAL INVESTIGATION OF SELF-PHASE MODULATION AND STIMULATED RAMAN SCATTERING IN A SINGLE-MODE OPTICAL FIBRE.** An investigation of the spectral and temporal characteristics of the self-phase modulated pulses exiting from a germania-doped fused-silica-core single-mode optical fibre has been undertaken at 1.064  $\mu\text{m}$ . For peak powers below the stimulated Raman scattering threshold the spectral data were in excellent agreement with a simple theory developed for negligible fibre group-velocity dispersion and symmetrical chirp-free input pulses. For elevated peak-power levels a complementary study of the temporal and spectral features of the first-order Stokes Raman and pump pulses has been carried out. It was observed that the onset of stimulated Raman scattering leads to both spectral and temporal pump-pulse asymmetry and hence to deviation from the theoretical spectral predictions. In addition, a simple fibre Raman oscillator was constructed and its characteristics are described in some detail. (Author abstract) 19 refs.

Kean, P.N. (Univ of St. Andrews, St. Andrews, Scotl); Smith, K.; Sibbet, W. *IEE Proc Part J* v 134 n 3 Jun 1987 p 163-170.

**073829 OPTICAL PULSE COMPRESSION OF**

**RAMAN-DEPLETED PICOSECOND PULSES AND SPECTRALLY WINDOWED SELF-PHASE MODULATED PULSES AT 1.06  $\mu\text{m}$ .** Two pulse-shortening schemes based on the nonlinear propagation of picosecond pulses from a Nd: YAG laser in single-mode optical fibres are described. In the first experiment, a spectral-windowing technique was employed to compress self-phase modulated pulses exiting 100m of optical fibre, and compression factors of 2.5 were recorded in good agreement with theoretical predictions. In the second experiment, cascaded stimulated Raman generation, occurring when a high-power pump pulse propagated in 4 m of fibre, was studied. Lower-order components in the cascade were severely depleted through generation of higher-order Stokes signals, leaving negatively chirped pulse fragments. These were compressed with a dispersion-tunable Gires-Tournois interferometer and compression ratios of times 4 were obtained. (Edited author abstract) 34 refs.

Gomes, A.S.L. (Imperial Coll of Science & Technology, London, Engl); Gouveia-Neto, A.S.; French, P.M.W.; Avramopoulos, H.; New, G.H.C.; Taylor, J.R. *IEE Proc Part J* v 134 n 3 Jun 1987 p 171-179.

**073830 INVESTIGATION OF NONLINEAR POWER TRANSMISSION LIMITS IN OPTICAL-FIBRE DEVICES.** An experimental investigation of nonlinear power transmission limits in short lengths of single-mode fibre is described. Nonlinearities have been observed at peak optical power levels of a few hundred watts, and these thresholds have been compared with theoretical predictions. The consequences of these power transmission limits for the development and characterisation of nonlinear fibre waveguide devices are discussed. (Author abstract) 13 refs.

Edge, C. (Plessey Research (Caswell) Ltd, Towcester, Engl); Goodwin, M.J.; Bennion, I. *IEE Proc Part J* v 134 n 3 Jun 1987 p 180-182.

**073831 CONCATENATED, TAPERED COAXIAL COUPLER FILTERS.** Fabrication of successive tapered coaxial couplers is investigated as a means for producing all-fibre wavelength filters. Narrowband filters are reported from a cascade of tapered coaxial couplers of broad wavelength response. (Author abstract) 9 refs.

Boucoulvas, A.C. (GEC, Wembley, Engl); Georgiou, G. *IEE Proc Part J* v 134 n 3 Jun 1987 p 191-195.

**073832 HIGH-REFLECTIVITY SURFACE-RELIEF GRATINGS IN SINGLE-MODE OPTICAL FIBRES.** The design, fabrication and experimental characterisation of surface-relief gratings in single-mode optical fibres are described. Novel structures employing high-refractive-index overlayers are discussed with which reflectivities up to 98% and linewidths down to 0.8 nm at the first-order Bragg wavelength have been achieved. Applications of these structures are described. (Author abstract) 15 refs.

Rowe, C.J. (Plessey Research (Caswell) Ltd, Towcester, Engl); Bennion, I.; Reid, D.C.J. *IEE Proc Part J* v 134 n 3 Jun 1987 p 197-202.

**073833 COMPACT ALL-FIBRE MACH-ZEHNDER DEVICES.** A single-mode optical-fibre switch which is electrically activated has been fabricated. This device is achieved by forming two couplers in series on a pair of single-mode optical fibres to provide a compact Mach-Zehnder interferometer (MZI). Power switching in the output arms is achieved by introducing a phase shift or path difference in the MZI by various means. The application of the device as a wavelength-selective switch is also considered. (Author abstract) 9 refs.

Shipley, S.P. (GEC, Wembley, Engl); Georgiou, G.; Boucoulvas, A.C. *IEE Proc Part J* v 134 n 3 Jun 1987 p 203-207.



**073834 ZUGKRAFT-REGELUNGSSYSTEME FUER DIE LWL-VERSEILUNG.** [Tensile Force Control Systems for Stranding Optical Fibers]. Stringent requirements are imposed on braking systems when stranding optical fibers. The sensitive stranding stock requires braking forces to be as small as possible (0.3 to 1.5 N) and maintained with a tolerance of  $\pm 10\%$ . This is possible only by employing suitable tensile force controllers. Systems of this type do exist. They consist of sensitive braking equipment, components for continuous and precise measurement of the actual value of tensile stress in the core, and attendant actuating and control equipment. (Edited author abstract) In German.

Meerkamm, Harald (Univ Erlangen, Nuremberg, West Ger); Freund, Gerd. *Drahtwelt* v 73 n 10 Oct 1987 p 169-173.

**073835 EFFECT OF A REFRACTIVE-INDEX GRADIENT ON THE CHARACTERISTICS OF A SINGLE-MODE OPTICAL FIBER.** Single-mode lightguides with a large difference in the refractive indices of the core and cladding ( $\Delta n$  approximately 3%) and a small core radius ( $R$  approximately 1.5  $\mu\text{m}$ ) can provide a first-order dispersion that is close to zero over a wide range of wavelengths. It is of interest to investigate methods of reducing the modulus  $501 S_1$  of the first-order dispersion at one wavelength for lightguides that are more feasible to manufacture with  $\Delta n \leq 0.5\%$  and  $R$  approximately 5  $\mu\text{m}$ ; this will make it possible to transmit information at a rate of hundreds of Gbits/sec. The effect of the variation of the refractive index along the radius of a lightguide on its dispersion characteristic was investigated earlier i.e., the above problem can be solved by choosing an appropriate variation of the refractive index. We will show this for the case of a lightguide, the cladding of which is made from pure  $\text{SiO}_2$  while the core has a diameter of  $2R = 10 \mu\text{m}$  and is made from  $\text{SiO}_2$  with a maximum concentration of 3.1% for a  $\text{GeO}_2$  impurity. 6 refs.

Frenkel, L.A. *Sov J Commun Technol Electron* v 32 n 1 Jan 1987 p 186-188.

**073836 CALCULATION OF RADIATION LOSS IN SINGLE MODE FIBERS BY EQUIVALENT CURRENT METHOD.** Taking a non-ideal waveguide as an ideal waveguide in the presence of polarization currents giving rise to electric and magnetic fields, we can directly solve the problems of mode coupling and radiation loss of an optical waveguide. By using this method, we have calculated the radiation loss of single mode fibers caused by periodical and random non-uniformities of the core index. It is an alternative method of coupled mode theory, but is mathematically simpler and physically more intuitive than the coupled mode theory. At last, taking bending and microbending loss for single mode fibers as an example, we see that this method also applied to problems which can be solved by generalized coupled mode theory. (Author abstract) In Chinese. 7 refs.

Wang, Zihua (Shanghai Univ of Science & Technology, China). *Guangxue Xuebao* v 7 n 10 Oct 1987 p 923-928.

**073837 MONOMODE FIBRE COMPONENTS FOR DYNAMIC LIGHT SCATTERING.** The design, construction and evaluation of monomode optical fibre components for miniaturised laser velocimetry and photon correlation spectroscopy experiments is described. It is shown that 21 refs.

Brown, R.G.W. (Royal Signals & Radar Establishment, Malvern, Engl); Jackson, Ann P. *J Phys E* v 20 n 12 Dec 1987 p 1503-1507.

**073838 HYDROGEN INTERACTION IN HIGH Ge-DOPED SILICA OPTICAL FIBERS.** Paramagnetic defects are observed in high Ge-doped silica fibers. Particularly the E'(Ge) centers and the drawing induced E'(Si) centers are tested with hydrogen at room temperature and at 100°C. An E'(Si) center bleaching occurs after hydrogen adsorption-desorption cycle at room temperature. A decrease in the E'(Ge) center EPR signal during  $\text{H}_2$  adsorption-desorption cycle at 100°C is noted. At same

time the increase of OH peaks and background loss in the attenuation curves is observed. (Author abstract) 4 refs.

Cocito, G. (CSELT, Turin, Italy); Ferraris, M.; Modone, E.; Sordo, B. *Alta Freq* v 56 n 6 Aug 1987 p 301-303.

**073839 ALIGNMENT OF POLARISATION-MAINTAINING FIBRES BY TEMPERATURE MODULATION.** High birefringence polarization-maintaining optical fibers only preserve polarization if all the light is launched into one or other of the two principal propagation modes. At present, the most widely used alignment technique is time-consuming and can give ambiguous results for narrow linewidth sources. A novel non-destructive technique for rapidly aligning stress effect high birefringence polarization-maintaining fiber is described. Temperature modulation is applied to a short length of fiber, giving alignment to better than  $0.5^\circ$ , and enabling the fast and slow axes to be identified. The technique is best suited to narrow linewidth sources, but it is also applicable for the tailing of short lengths of fiber to most laser sources. (Author abstract) 21 refs.

Walker, G.R.; Walker, N.G. *Br Telecom Technol J* v 6 n 1 Jan 1988 p 60-69.

**073840 PULSE BROADENING IN SINGLE-MODE FIBERS.** An approximate theory is presented which involves the broadening of propagated Gaussian pulses in single-mode optical fibers by the first-order dispersion. The light source is assumed to have a Lorentz spectral distribution. Formulas are derived for the ensemble average of the pulse power and the rms pulse width. The approximate expressions are quite precise in comparison with the numerical calculations with deviations between the approximate expressions and the numerical calculations smaller than 5%. (Author abstract) In Chinese. 4 refs.

Cao, Zhangqi (Shanghai Jiao-tong Univ, China); Yang, Fuzi; Chen, Yingli; Fang, Junxing. *Guangxue Xuebao* v 8 n 1 Jan 1988 p 62-66.

**073841 SELF-SUPPORTING AERIAL FIBER OPTIC CABLE.** The Fibrespan optical cable design is based on a single rod of fiber reinforced plastic (FRP) with a tensile strength of 65 kN, which is three times the design maximum for operation of 22.5 kN. The FRP rod has a longitudinal slot in which ribbons containing up to 24 fibers are laid in a thixotropic gel to cushion them, a polyethylene slot cap which restores the circular profile, and the whole is covered by a binder yarn and outer sheath. The single mode fibers used in this cable operate at 1300 nm with 0.5 dB/km attenuation or better and a pulse dispersion factor of not more than 3.5 dB/km. The nm/cable with an outer diameter of 13 mm weighs 220 kg/km and has an operating temperature of  $-40^\circ\text{C}$  to  $70^\circ\text{C}$ . Two types of Translite cable self-supported by FRP rod are manufactured, a 250 kg/km long span circular section cable, and a 240 kg/km short span version.

Pressdee, B. *Eng Dig (Toronto)* v 34 n 2 Apr 1988 p 49-50.

**073842 SOLITARY WAVES OF STEADY STATE SRS IN OPTICAL FIBER.** The equations of SRS in optical fiber are given. The equations are discussed and a conclusion that the solitary waves can exist in the process of steady state SRS is obtained. This theory gives a new way to produce ps pulses. (Author abstract) In Chinese. 3 refs.

Xu Zhongde (Shanghai Jiao Tong Univ, Shanghai, China); Yang Fuzi; Fang Junxin. *Guangxue Xuebao* v 8 n 3 Mar 1988 p 200-204.

**073843 LED-UEBERTRAGUNGSSYSTEME MIT 1,3 $\mu\text{m}$ -SM-GLASFASER.** [LED/1.3 $\mu\text{m}$  Single-Mode Fiber Transmission Systems]. The article describes the performance of optical short-distance transmission systems with light-emitting diodes and single-mode fiber. The different types of LEDs are classified and their most important parameters with respect to applications in the distribution local network are discussed. The limits and the feasibility of LED single-mode fiber transmission

systems are discussed. (Author abstract) In German. 17 refs.

Staubli, R. *Mitt AGEN* n 47 May 1988 p 39-47.

**073844 FIBRES UNIMODALES EFFILEES.** [Tapered Single-Mode Fibers]. Oscillatory transmission of tapered single-mode fibers is explained. Several realized or proposed applications are also described. (Author abstract) 9 refs. In French.

Lacroix, Suzanne (Ecole Polytechnique, Montreal, Que, Can); Gonthier, Francois; Bures, Jacques. *Ann Telecommun* v 43 n 1-2 Jan-Feb 1988 p 43-47.

**073845 OPTICAL AND MECHANICAL PROPERTIES OF FLUORIDE GLASS FIBERS FOR INFRARED TRANSMISSION SYSTEMS.** Heavy-metal fluoride glasses are attractive candidates for infrared transmitting fibers due to their ultra-low intrinsic losses. The glasses must be prepared under strict thermal process control to avoid growth of scattering crystallites. We used DSC measurements to calculate the optimum process design. With the present fluorozirconate glasses extremely low losses can only be realized with relatively small preform dimensions. Marked progress has been achieved with respect to increased fiber strength, mean bending test values as high as 1400 MPa being measured. Drawing in a reactive  $\text{NF}_3$  atmosphere suppresses surface crystallization. (Author abstract) 26 refs.

Schneider, H.W. (Siemens AG, West Ger); Schobert, A.; Staudt, A.; Gerndt, Ch. *Siemens Forsch Entwicklungsber* v 17 n 3 1988 p 147-153.

**073846 MODAL FIELD TRANSFORMING QUARTZ SINGLE-MODE FIBRE.** We have made modal field transforming fibres, in which the cross-section of the core changes continuously from circular to elliptical within a few metres. The fabrication method is based on the deformation of a quartz tube during collapse. (Author abstract) 3 refs.

Tammela, S. (Technical Research Cent of Finland, Espoo, Finl); Kiiveri, P.; Pohjonen, P. *Electron Lett* v 24 n 8 Apr 1988 p 500-501.

**073847 BLOWING A NETWORK.** This novel technique from a British research laboratory simplifies optical fibre installation for in-building and local area networks.

Anon. *Electron Wireless World* v 94 n 1626 Apr 1988 p 399.

**073848 OPTICAL FIBRE: PROGNOSIS AND ECONOMIC IMPACT.** The prognosis for optical fibre is bright. As we progress into the post-industrial-revolution era we turn towards an information-intensive society where optical fibre is an essential component. Just as the motorways, autobahns or inter-state highways permitted the development of the modern transportation system, optical fibre will become our information arterial highway, providing the transport system for our information traffic.

Kao, Charles R. *Electron Wireless World* v 94 n 1626 Apr 1988 p 395-396.

**073849 COUPLING BETWEEN AN ABRUPTLY TERMINATED OPTICAL FIBER AND A DIELECTRIC PLANAR WAVEGUIDE.** The coupling between an optical fiber and a dielectric planar waveguide is analyzed when both guides are terminated abruptly and are facing each other. Mixed spectrum eigenwave representations of fields are utilized inside the waveguides while Fourier integrals are utilized to describe the field in the space between the two guides. A coupled system of integral equations is derived by satisfying the boundary conditions on the terminal planes of both waveguides. A weak guidance approximation is assumed to facilitate the



analysis. Numerical results are presented for several coupling geometries. Misalignment losses and coupling optimization phenomena are investigated. 12 refs.

Capsalis, Christos N. (Natl Technical Univ of Athens, Greece); Uzunoglu, Nikolaos K. *IEEE Trans Microwave Theory Tech* v MTT-35 n 11 p 1043-1051.

**073850 OPTICAL FIBER SENSORS USING THE METHOD OF POLARIZATION-ROTATED REFLECTION.** The method of polarization-rotated reflection is applied to sensors with polarization-maintaining optical fibers. By the use of this scheme, stable measurement can be realized because the fluctuation of the light propagation characteristics in the fiber is canceled automatically without any additional active phase-compensation techniques. Several kinds of sensors were designed for the measurement of different physical values. A magnetic field sensor and a temperature sensor were built and the performances were tested to confirm their basic features experimentally. 7 refs.

Enokihara, Akira (Osaka Univ, Toyonaka, Jpn); Izutsu, Masayuki; Sueta, Tadasi. *J Lightwave Technol* v LT-5 n 11 p 1584-1590.

**073851 POLARIZATION CHARACTERISTICS OF SIDE-PIT AND SIDE-TUNNEL FIBERS USING THE EFFECTIVE INDEX METHOD.** The effective index method has been used to determine the polarization characteristics of side-pit and side-tunnel fibers. The results obtained by this method compare quite well with those reported by using the finite-element method. 7 refs.

Kaul, A.N. (Indian Inst of Technology, New Delhi, India); Kumar, Arun; Thyagarajan, K. *J Lightwave Technol* v LT-5 n 11 p 1610-1612.

**073852 THEORY OF LED COUPLING TO SINGLE-MODE FIBERS.** A theory is developed to estimate the coupling efficiency and sensitivity of an LED coupled to a single-mode fiber (SMF). The theory uses electromagnetic theory, but avoids the issue of coherence by considering the LED to be totally incoherent. Specific equations are derived for butt coupling surface-emitting and edge-emitting LEDs to SMFs, and lensed coupling is considered. The authors' analysis is found to be in good agreement with experimental results. 22 refs.

Christodoulides, D.N. (Bell Communications Research, Red Bank, NJ, USA); Reith, Leslie A.; Saifi, M.A. *J Lightwave Technol* v LT-5 n 11 p 1623-1629.

**073853 MULTIMODE OPTICAL FIBER SPLICE LOSS: RELATING SYSTEM AND LABORATORY MEASUREMENTS.** An examination is made of the splice loss occurring along a multimode fiber regenerator and the results are compared to a 'standard' laboratory test condition. Large variations in the splice loss sensitivity to transverse offset of a reference splice were seen (1) at the ends of five different 8.9-km fiber concatenations and (2) at various locations along one 8.9-km path. These data indicate that significant variations in the modal power distribution exist even at the receiver end of a regenerator span. This is explained by the long coupling lengths (long compared to splice spacing) of low-loss fibers and the random amount of mode coupling introduced by the concatenation splices. 18 refs.

Peckham, David W. (AT&T Bell Lab, Norcross, GA, USA); Lovelace, Charles R. *J Lightwave Technol* v LT-5 n 11 p 1630-1636.

**073854 LIGHT CONVERSION IN NONLINEAR MONOMODE OPTICAL FIBERS.** A complementary analysis of the four-wave mixing phenomenon in monomode optical fibers is undertaken. Its central aspect is the interdependence between the amplitudes and the relative phase of the four waves. An expression for the spontaneous emission in terms of the pump power is derived. Investigating the pump depletion, it is shown that for short fibers a certain degree of total phase mismatch can be advantageous to the amplification of weak Stokes and anti-Stokes signals. Also, the optimal fiber length depends on the initial relative phase. 24 refs.

Vatarescu, Andrei (Australian Natl Univ, Canberra, Aust). *J Lightwave Technol* v LT-5 n 12 p 1652-1659.

**073855 AUTOMATIC POLARIZATION SPECTRAL RESPONSE MEASUREMENT SYSTEMS FOR OPTICAL FIBER COUPLERS.** By using cooled Ge-PIN photodiode to 77 K ( $-196^{\circ}\text{C}$ ) with liquid nitrogen and lock in amplification technique, automatic polarization spectral response measurement systems with measuring dynamic range of about 36 db have been developed. From the experimental results, it is confirmed that the spectral response of polarization beam splitting ratios of fused-taper fiber couplers are slightly dependent on the incident polarization angle. (Author abstract) 5 refs.

Namihira, Yoshinori (KKD Co, Tokyo, Jpn); Horiuchi, Yukio; Wakabayashi, Hiroharu. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 11 Nov 1987, Pap from the 1987 Natl Conf on Semicond Devices and Mater IEICE, Kumamoto, Jpn, Nov 1-4 1987 p 1080-1082.

**073856 MULTICORE FIBER CONNECTOR WITH A PLASTIC-MOLDED FERRULE.** This letter describes design and performance of a multicore fiber connector with a plastic-molded ferrule. Discussing ferrule fabrication errors, the connector loss and crosstalk were evaluated. The constructed connector for joining and fanouting multimode two-core fibers showed an insertion loss of 0.4 db and a crosstalk of less than  $-35$  db. (Author abstract) 5 refs.

Nagasawa, Shinji (NTT Electrical Communications Lab, Jpn); Furukawa, Hiroshi; Kashima, Norio. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 11 Nov 1987 p 1101-1103.

**073857 DESIGN CONSIDERATION FOR FERRULE HOLE DIAMETER IN A SINGLE MODE MULTI-FIBER CONNECTOR.** Design of ferrule hole diameters in a ferrule-type single mode fiber connector has been investigated to achieve a low-loss multi-fiber connection. Based on the theory of the connection loss statistics, connection losses for various designs of ferrule hole diameters are evaluated and discussed. (Author abstract) 3 refs.

Kashima, Norio (NTT Electrical Communications Lab, Jpn). *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 11 Nov 1987 p 1116-1119.

**073858 RELATION BETWEEN CONNECTION LOSS AND SINGLE MODE OPTICAL FIBER DIAMETER IN A MULTI-FIBER CONNECTOR.** The relation between connection loss and fiber diameter is investigated for a ferrule-type single mode multi-fiber connector. The theory for the connector loss statistics is derived taking the centering effect in a ferrule-type connector into account. Five-fiber connectors for single mode fibers are manufactured. Their connection losses are measured and compared to the theory. (Author abstract) 4 refs.

Kashima, Norio (NTT Electrical Communications Lab, Jpn); Satake, Toshiaki. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 11 Nov 1987 p 1120-1124.

**073859 SPATIAL IMAGE TRANSMISSION CHARACTERISTICS IN THE GRADED-INDEX OPTICAL FIBER.** The two-dimensional spatial image transmission characteristics of the optical graded-index fiber with a refractive index distribution including fourth and sixth order terms in the core region are investigated. Since the GRIN fiber for image transmission has a large core radius, the most field is tightly confined to the center of the core. The effect of the core-clad interface on the image transmission characteristics is approximately evaluated. The electric field distributions and the propagation constants of the modes which carry the optical images, are discussed and the image transmission characteristics of the GRIN fibers such as the focusing properties and the impulse response, i.e., the point spread function and the coherent transfer function are evaluated. (Edited author abstract) 15 refs.

Kalantari, Khalil (Nagoya Univ, Nagoya, Jpn); Miyazaki, Yasumitsu; Ito, Masami. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 11 Nov 1987 p 1140-1149.

**073860 MODULAR APPROACH TO BROADBAND ISDN OVER OPTICAL FIBRES.** This paper describes a digital architecture supporting broadband channels for video services with special emphasis on the physical level (layer 1). The proposed system is fully digital and makes use of optical fibers. Moreover, adopting modularity and flexibility concepts, it takes into account the future evolutions of the wideband networks, either for residential or business subscribers. This proposal will be the base of a field experience that will contribute, as 'open laboratory', to a future Italian trial of wideband network foreseen in Rome at the end of 80's. (Author abstract) 10 refs.

Brosio, A. (CSELT, Turin, Italy); Gagliardi, F.; Moncalvo, A.; Rocchi, O. *CSELT Tech Rep* v 16 n 2 Mar 1988, GLOBECOM '87 - IEEE/IECI Global Telecommun Conf, Tokyo, Jpn, Nov 15-18 1987 p 111-114.

**073861 TUNABLE BACKSCATTERING FOR SINGLE-MODE OPTICAL FIBRES IN 1.1 TO 1.6  $\mu\text{m}$  SPECTRAL REGION.** A tunable backscattering apparatus for single mode fibres is described, operating from 1.06 to 1.6  $\mu\text{m}$ . A Raman source fibre is filtered by a special concept imaging (folded path) monochromator, with good launching efficiency into test fibre, while Fresnel reflection is suppressed by an acousto-optic device. Applications to spectral attenuation, cut-off phenomena and spot-size propagation are discussed. (Author abstract) 7 refs.

Cisternino, F. (CSELT, Turin, Italy); Costa, B.; Mukunda Rao, M.; Sordo, B. *CSELT Tech Rep* v 13 n 5 Oct 1985, IOOC-ECOC '85 (5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun), Venice, Italy, Oct 1-4 1985 p 301-304.

**073862 SELF-IMAGING OFFSET MEASUREMENTS IN SINGLE-MODE OPTICAL FIBRES.** A new technique for offset losses and spot-size measurement in single-mode fibres is proposed. It consists in coupling the fibre with its image from a spherical mirror and overcomes the problems of the traditional offset techniques. (Author abstract) 3 refs.

Calzavara, M. (CSELT, Turin, Italy); Coppa, G.; Di Vita, P. *CSELT Tech Rep* v 13 n 5 Oct 1985, IOOC-ECOC '85 (5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun), Venice, Italy, Oct 1-4 1985 p 305-307.

**073863 MEASUREMENTS OF MODE FIELD RADIUS IN SINGLE-MODE FIBRES BY MEANS OF HARMONIC ANALYSIS.** A new technique for mode field radius measurement of easy implementation is presented. It is based on a dynamical filtering of the output radiation and a suitable harmonic evaluation. The preliminary results are exposed. (Author abstract) 5 refs.

Coppa, G. (CSELT, Turin, Italy); Di Vita, P.; Potenza, M. *CSELT Tech Rep* v 13 n 5 Oct 1985, IOOC-ECOC '85 (5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun), Venice, Italy, Oct 1-4 1985 p 309-311.

**073864 FAST HETERODYNE INTERFEROMETER FOR REAL-TIME FIBRE POLARIMETRY.** A fast polarimeter operating in heterodyne mode is presented, for single mode fibre characterization. The polarization measurement is achieved with an original interferometric arrangement, placed at the output of the fibre. To demonstrate the excellent performance of the system, two different kinds of applications are illustrated: polarization



changes due to mechanical stresses and spectral measurements of polarization noise produced by acoustical vibrations impressed to the fibre. (Author abstract) 9 refs.

Calvani, R. (CSELT, Turin, Italy); Caponi, R.; Cisternino, F. *CSELT Tech Rep* v 13 n 5 Oct 1985, IOOC-ECOC '85 (5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun), Venice, Italy, Oct 1-4 1985 p 313-316.

**073865 COLLOQUIUM ON NONLINEAR OPTICAL WAVEGUIDES.** This colloquium proceedings contains 12 papers, of which one appears in abstract-only form. Of the topics included, most involve optical fibers in some way, and are as follows: nonlinear propagation effects in silica glass fibers; nonlinear power transmission limit in single-mode optical fibers; laser pulse compression due to self-phase modulation (SPM); nonlinear optical waveguides; including organic polymer; Soliton; Raman, and Neodymium-doped fiber lasers; the application of stimulated Raman scattering for optical amplification in Germanium-doped silica optical fibers; laser pump pulse depletion and compression; and a capillary waveguide laser. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 09349 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig* n 1986/81, Colloq on Nonlinear Opt Waveguides, London, Engl, May 21 1986. Publ by IEE, London, Engl, 1986 var pagings.

## Aging

**073866 HYDROGEN IN FIBERS: A COMPARISON BETWEEN THE AGING AND THE SIMULATED AGING.** The optical attenuation caused by interaction between hydrogen and optical fibers, at a constant pressure in the temperature range 20°-100°C, has been studied to verify the simulation of aging by temperature increase. Relations between percentual differences in time and temperatures were obtained, and were compared with measurements on a high Ge-doped multimode fiber. Only one of three observed effects seems to be correctly predicted by simulation. (Author abstract) 7 refs.

Cocito, G. (Centro Studi e Lab Telecomunicazioni SpA, Turin, Italy); Cognolato, L.; Modone, E.; Sordo, B. *J Opt Commun* v 9 n 1 Mar 1988 p 2-4.

**073867 MODEL FOR HYDROGEN AGING IN MULTIMODE FIBERS.** In order to explain the variation of initial aging rate on the square root of the hydrogen pressure observed in two other studies, a model based on the production of hydrogen atoms by some defect site in the glass is developed. The model is then successfully tested against the detailed temporal behavior that was reported for fibers containing high levels of phosphorus as well as those containing low levels. 6 refs.

Araujo, R.J. (Corning Glass Works, Corning, NY, USA). *J Lightwave Technol* v 6 n 2 Feb 1988 p 197-202.

**Analysis** See Also LIGHT—Polarization; WAVEGUIDES, OPTICAL—Analysis.

**073868 TABLES OF INTEGRALS: MISPRINT IN A CONVOLUTION-TYPE INTEGRAL WITH GAUSS-LAGUERRE FUNCTIONS.** The solution of a convolution-type integral with Gauss-Laguerre functions has turned out to be wrong due to a misprint. So far as we know this error appears in the tables of Gradstein and Ryzik, Magnus et al., Oberhettinger and Prudnikov et al. We did not succeed in proving the correct formula in all generality, but we have demonstrated with four special cases the correct structure of the solution. Gauss-Laguerre functions are of interest when treating fiber-optic problems theoretically or experimentally. (Edited author abstract) 10 refs.

Chen, He-Ming (Univ Karlsruhe, Karlsruhe, West Ger); Freude, W. *Electron Lett* v 23 n 18 Aug 27 1987 p 966-967.

**073869 EFFECT OF HIGHER ORDER MODES ON PULSE WAVEFORM IN A MULTIMODE OPTICAL FIBER.** A Gaussian pulse propagated through a multimode optical fiber is explained by introducing a weighting function of higher order modes into the theoretical formula, being consistent with experimental results. Extending the equation of the pulse propagation in a single mode fiber into that for the multimode fiber, the calculated waveform with several weighting functions is compared with the experimental pulse of a He-Ne fiber. Consequently, the most appropriate weighting function is found to be hyperbolic function  $W(l)=1-0.7$ , which depends only on the radial mode  $l$  and is independent of the azimuthal mode  $m$ . The physical interpretation about the obtained weighting function is discussed. (Edited author abstract) 15 refs.

Azumai, Yuji (Natl Defense Acad, Yokosuka, Jpn); Sato, Heibachi. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 7 Jul 1987 p 652-660.

**073870 BIREFRINGENCE IN STRESS-APPLIED POLARISATION-MAINTAINING OPTICAL FIBRES.** Simple, analytical expressions are presented for the calculation of the birefringence in stress-applied polarization-maintaining optical fibers. The method is based on the vector analysis of propagation constants in dielectric waveguides with perturbed refractive-index profile. It is shown that present results agree with the results obtained using the finite-element method. (Author abstract) 4 refs.

Chen, Zhihao (Fujian Normal Univ, Fuzhou, China); Yao, Huihai. *Electron Lett* v 23 n 20 Sep 24 1987 p 1081-1082.

**073871 NEW BENDING LOSS FORMULA EXPLAINING BENDS ON LOSS CURVE.** A new bending loss formula for single-mode fibers is presented. Comparison with measurements and conventional theory shows good agreement. Reported bends on the loss curves for matched- and depressed-clad fibers are explained. (Author abstract) 6 refs.

Andreasen, S.B. (Technical of Univ of Denmark, Lyngby, Den). *Electron Lett* v 23 n 21 Oct 8 1987 p 1138-1139.

**073872 SPOT SIZE, ADIABATICITY AND DIFFRACTION IN TAPERED FIBERS.** A simple formula is given for the maximum spot size achievable by down tapering a single-mode fiber, regardless of core profile. When the fundamental-mode field is approximately Gaussian, the maximum taper angle associated with minimal loss of spot-size power on a finite-length taper is the classical diffraction angle for a beam passing through a circular aperture. (Author abstract) 7 refs.

Love, J.P. (Australian Natl Univ, Canberra, Aust). *Electron Lett* v 23 n 19 Sep 10 1987 p 993-994.

**073873 FAST ALGORITHM FOR TRANSVERSELY INHOMOGENEOUS OPTICAL FIBERS USING POWER METHOD AND FAST FOURIER TRANSFORM.** A scalar-field integral equation is employed to find the propagation characteristics of guided modes of an inhomogeneous optical fiber of arbitrary transverse shape. Two facts make the proposed method quite efficient. First, by employing the scalar-field integral equation, the propagation problem is reduced to a standard eigenvalue problem, where the lower-order modes correspond to the larger eigenvalues. Hence, the eigenproblem can be manipulated efficiently by variants of the power method. Further, the major computation in the associated power method can be arranged into the form of a convolution, which in turn can be performed using the fast Fourier transform (FFT). (Author abstract) 16 refs.

Su, Ching-Chuan (Natl Tsinghua Univ, Taiwan). *IEE Proc Part J* v 134 pt J n 5 Oct 1987 p 276-280.

**073874 CONSIDERATIONS ON GROUP DELAY FITTING EQUATIONS FOR DISPERSION-SHIFTED FIBRES.** Chromatic dispersion measurement accuracy was examined experimentally for four kinds of group delay fitting equations which have been proposed to

date. It was found that the five-term Sellmeier equation is appropriate for dispersion-shifted fibers with various refractive index profiles. It was demonstrated that the maximum difference in zero dispersion wavelength among the four equations is less than 0.67 nm by selecting six measuring wavelengths between 1.49  $\mu$ m and 1.59  $\mu$ m using the LD phase-shift method. (Edited author abstract) 5 refs.

Miyajima, Y. (NTT Transmission Systems Lab, Tokai, Jpn); Kawata, T.; Negishi, Y. *Electron Lett* v 23 n 25 Dec 3 1987 p 1381-1382.

**073875 STATISTICAL CHARACTERISTICS OF THE NONLINEAR EVOLUTION OF A RANDOM PULSE IN A FIBER LIGHTGUIDE.** The evolution of the correlation function of a random pulse, transmitted along a lightguide in a nonlinear regime, is investigated and the laws governing the variation of its intensity, duration and other parameters along the lightguide as a function of the degree of nonlinearity, coherence interval of the input pulse and modulation frequency, are determined in a Gaussian approximation. The boundaries of the nonlinear stabilization and pulse compression regimes are determined. (Author abstract) 11 refs.

Klovskiy, D.D.; Sisakyan, I.N.; Shvartsburg, A.B.; Shirokov, S.M. *Sov J Commun Technol Electron* v 32 n 6 Jun 1987 p 112-117.

**073876 METHOD OF DETERMINING THE EQUIVALENT STEP PARAMETERS OF GRADED SINGLE-MODE LIGHTGUIDES.** The diffraction method of measuring the equivalent step parameters (ESP) of graded single-mode fiber lightguides (SFL) is known. A modification of the diffraction method is proposed for measuring the ESP in order to simplify it and to determine measures for making the field distributions of the modes of the graded SFL and the equivalent step SFL identical. 5 refs.

Klevitskiy, B.G.; Sedykh, D.A.; Sokolovskiy, A.A. *Sov J Commun Technol Electron* v 32 n 6 Jun 1987 p 129-131.

**073877 ON THE PROPAGATION OF SOLITONS IN COUPLED OPTICAL FIBERS.** Solitons - envelope pulses for which the effects of group dispersion and nonlinearity of the refractive index on accuracy are counterbalanced - have been suggested for use in high-speed transmission of information along optical fibers. In the development of communication systems using solitons it is necessary to build information branching devices. The directional coupler is one such traditionally used device. The operation of such a coupler in the soliton regime is investigated. 2 refs.

Andrushko, L.M.; Karplyuk, K.S.; Ostrovskiy, S.B. *Sov J Commun Technol Electron* v 32 n 6 Jun 1987 p 161-163.

**073878 LOCAL FIELD IN A BENT STEP INDEX FIBRE.** The local field and field shift in a bent step index single mode fiber are investigated by using local field theory. A simple approximate expression for the local field in a bent fiber is given. The expressions for local field and field shift in the bent fiber are compared with numerical results. (Author abstract) 5 refs.

Cheng, Y.H. (Chengdu Inst of Radio Engineering, Chengdu, China); Lin, W.G. *Electron Lett* v 24 n 6 Mar 17 1988 p 332-333.

**073879 THEORY OF TAPERING SINGLE-MODE OPTICAL FIBRES BY CONTROLLED CORE DIFFUSION.** The feasibility of tapering the core of a fluorine-doped monomode fibre by controlled thermal diffusion is investigated. Numerical calculations suggest that operating temperatures of 1100-1600°C for heating times of less than one hour should produce substantial broadening of the fundamental mode field. Experimental



measurements have confirmed the effect. Implications for optical connector technology are discussed. (Author abstract) 8 refs.

Botham, C.P. (British Telecom Research Lab, Ipswich, Engl). *Electron Lett* v 24 n 4 Feb 18 1988 p 243-245.

**073880 TAPERS IN SINGLE-MODE OPTICAL FIBRE BY CONTROLLED CORE DIFFUSION.** A method of obtaining tapered single mode fibre cores by controlled thermal diffusion of the dopant is described. The mechanical fibre dimensions are maintained during this process. Extended tapers have been produced, which show an increased tolerance to longitudinal and transverse offsets. Such tapers will prove useful for a range of optical fibre components. (Author abstract) 8 refs.

Harper, J.S. (British Telecom Research Lab, Ipswich, Engl); Botham, C.P.; Hornow, S. *Electron Lett* v 24 n 4 Feb 18 1988 p 245-246.

**073881 MODE-FIELD RADIUS OF NONCIRCULAR FIELD SINGLE-MODE FIBRE: NEW DEFINITION AND APPLICATION TO CALCULATION OF SPICE LOSS AND WAVEGUIDE DISPERSION.** A new definition of the mode-field radius (MFR) of a non-circular field single-mode fibre (NCSMF) is proposed, based on the quadratic moment of far-field distribution. Relations between MFR and splice loss, propagation constant and waveguide dispersion of the NCSMF are derived, which will reduce to known results under cases of circular and Gaussian-elliptic field distribution. (Author abstract) 7 refs.

Liang, A. (Tsinghua Univ, Beijing, China); Fan, C.-C. *Electron Lett* v 24 n 10 May 12 1988 p 646-647.

**073882 MODE EFFECTS OF VIBRATION ON THE COMPLEX DEGREE OF TRANSVERSE SPATIAL COHERENCE IN A MULTIMODE OPTICAL FIBER.** The effects of vibration on the complex degree of transverse spatial coherence at the exit face of multimode optical fiber are investigated by utilizing a quasi-homogeneous source with a time-varying spatial stationary phase factor of mode-averaging. Both theoretical and experimental results show that the coherence at the end face of multimode optical fiber is sensitive to the interference and coupling between the modes caused by vibration. (Author abstract) 6 refs.

Qin, Ke-Qi (Shanghai Inst of Optics & Fine Mechanics, Shanghai, China); Wang, Run-Wen. *Opt Commun* v 67 n 1 Jun 1 1988 p 5-10.

**073883 TRANSMISSION OF A SURFACE PROFILE THROUGH A SINGLE OPTICAL FIBER.** An optical method which allows the transmission of a 2-D surface profile through a single optical fiber is presented. The system performs a double encoding of the surface: in a first step a white light interferogram is used to store the relief. In a second step a chromatic encoding is used to introduce, in real time, the 2-D interferogram in a single multimode fiber. The number of transmitted pixels is limited by the luminosity of the image. (Edited author abstract) 11 refs.

Tagliaferri, A.A. (Univ Federal Fluminense, Niteroi, Jpn); Calatroni, J.; Froehly, C. *Opt Commun* v 67 n 3 Jul 1 1988 p 180-184.

**073884 EXACT RELATIONSHIPS BETWEEN FIELD AND DISPERSION OF SINGLE-MODE FIBRES IN PRESENCE OF MATERIAL AND LINEAR PROFILE DISPERSION.** Exact explicit relationships relating the Petermann spot size to the propagation constant and its wavelength derivatives are derived including the effect of material and profile dispersion. An explicit expression for the propagation constant in terms of an integral of the spot size over wavelength is obtained. (Author abstract) 9 refs.

Sharma, A. (Indian Inst of Technology, New Delhi, India); Sharma, E.K. *Electron Lett* v 24 n 14 Jul 7 1988 p 873-874.

**073885 OPTICAL FIBRE-GRATING PULSE COMPRESSION.** Numerical simulation is used to consider nonlinear pulse propagation in fibres and subsequent pulse compression in a dispersive delay line. It is shown that for small initial pulse powers the conventional non-linear Schroedinger equation (NSE) is accurate to describe the process of pulse propagation in fibres. In this case initially symmetrical pulses undergo squaring and spectral broadening in fibres, and frequency chirp is linearized over most of the pulse, while shapes of the pulse, spectrum and frequency chirp remain symmetrical at the output of the fibre. There is a certain optimum fibre length  $Z_{opt}$  which is determined by the initial pulse parameters and fibre characteristics for pulse compression in the dispersive delay line. Spectral windowing of the extreme Stokes components of the pulse spectrum permits significant improvement in the quality of the compressed pulse. The main features of the compression of pulses with asymmetrical initial shape are considered. (Edited author abstract) 27 Refs.

Golovchenko, E.A. (Acad of Sciences of the USSR, Moscow, USSR); Dianov, E.M.; Mamyshev, P.V.; Prokhorov, A.M. *Opt Quantum Electron* v 20 n 4 Jul 1988 p 343-355.

**073886 EVALUATION OF MODE-FIELD-DIAMETER DEFINITIONS AND CONDITIONS FOR SINGLE-MODE FIBERS BY TRANSMITTED FIELD PATTERN METHODS.** This paper investigates the relative effectiveness of three different definitions of mode-field diameter in evaluation of splice losses of current and dispersion-shifted fibers. As a result, it is shown that the difference in splice losses, due to various definitions, increases with decreasing V value. Further, it is confirmed theoretically and experimentally that by using Petermann's new definition, it is possible to estimate the splice loss very well. Next, using near-field pattern (NFP) and far-field pattern (FFP) methods, the measurement conditions of mode field diameter are also investigated. As a result, it is shown theoretically and experimentally that to keep the measurement error below 1 percent, it is necessary for the dynamic ranges of NFP and FFP methods to be larger than 25 and 35 dB, respectively. Under these conditions, it is shown that the measured results of both methods are in good agreement. (Edited author abstract) 8 Refs.

Kuwaki, Nobuo (NTT, Jpn); Ohashi, Masaharu; Tanaka, Chihaya; Uesugi, Naoshi. *Electron Commun Jpn Part 2* v 71 n 5 May 1988 p 40-47.

**Applications** See Also ATMOSPHERIC HUMIDITY—Sensors; COMPUTER NETWORKS—Local Networks; COMPUTER NETWORKS—Standards; DIGITAL COMMUNICATION SYSTEMS; ELECTRIC GENERATORS—Vibrations; ELECTRIC WAVEFORMS—Measurements; LASER PULSES; LASERS, CARBON DIOXIDE—Accessories; LASERS, RING—Research; MICROWAVE DEVICES; OPTICAL COMMUNICATION; OPTICAL COMMUNICATION—Noise, Spurious Signal; OPTICAL COMMUNICATION EQUIPMENT—Applications; OPTICAL DEVICES; OPTICAL INSTRUMENTS; PARTICLE SIZE ANALYSIS—Performance; PRESSURE MEASUREMENT—Sensors; PROBES—Fabrication; PYROMETERS; SENSORS; TELECOMMUNICATION CABLES—Design; TELECOMMUNICATION CABLES—Laying; TELECOMMUNICATION CABLES—Lightning Protection; TELECOMMUNICATION CABLES—Sheathing; TELECOMMUNICATION SYSTEMS—Biarritz, France; TELECOMMUNICATION SYSTEMS—Reviews; TELECOMMUNICATION SYSTEMS—United Kingdom; TEMPERATURE MEASUREMENT; TEMPERATURE MEASURING INSTRUMENTS—Sensors; TRANSDUCERS—Design; TRANSDUCERS—Temperature Measurement; VELOCIMETERS—Laser Doppler.

**073887 FEMTOSECOND ALL-FIBRE COMPRESSOR.** An all optical fiber pulse compressor operating in the femtosecond regime is presented for the first time. Commencing with 100 ps pulses from a cw mode locked Nd:YAG laser operating at 1.3  $\mu$ m, pulses of 130 fs were generated in a standard single mode fiber through a single pass multi-soliton Raman compression. These pulses were further compressed in a two-stage dispersion shifted fiber arrangement. Pulses as short as 65 fs were generated. (Author abstract) 20 refs.

Gouveia-Neto, A.S. (Imperial Coll, London, Engl);

Gomes, A.S.L.; Taylor, J.R. *Opt Commun* v 64 n 2 Oct 15 1987 p 163-166.

**073888 SECOND GENERATION FIELD TEST EQUIPMENT.** As optical fiber moves steadily toward a wider installed base in a variety of applications, pointing toward the subscriber loop, the requirements for test equipment to be used in outside-plant and maintenance operations present many new challenges to test instrumentation designers. This article discusses some of the requirements for a second generation of optical fiber field test equipment. The article asserts that a field test instrument should be compact, portable, and capable of doing more work in less time with a minimum of operator background and training.

Parikh, Rutesh; Wendland, Brad; Halpern Hal. *Photonics Spectra* v 22 n 2 Feb 1988 p 103-104.

**073889 FIBER OPTIC HETERODYNE DISPLACEMENT DETECTION IN WIDE DYNAMIC RANGE.** The dynamic range of displacement measurements was experimentally estimated for the case of laser heterodyne technique with fiber optics. Even using flexible fiber optics, a wide dynamic range of  $10^5$  order, i.e. from 100  $\mu$ m to 10 A displacement, was obtained. (Author abstract) 7 refs.

Suemoto, Yoshiro (Kagoshima Univ, Kagoshima, Jpn); Takeishi, Yasuyuki. *Opt Commun* v 65 n 2 Jan 15 1988 p 67-69.

**073890 DISTRIBUTED FLUID SENSOR USING ECCENTRICALLY CLADDED FIBERS.** By using optical fibers as liquid sensors, it is possible to monitor the leakage of oil tanks, pipelines, etc., safely and reliably because it is nonexplosive and chemically inactive. In this paper, the eccentrically clad fiber is proposed as a means to increase the sensitivity without the need to reduce its diameter. The theoretical analysis and its experimental verification are carried out. As a result, it is shown that if the eccentricity is increased, the sensitivity will not decrease remarkably, even at large cladding diameters. Further, as experimental evidence of liquid detection, optical losses of a few decibels per centimeter were observed by attaching a liquid to the fiber. This indicated the possibility of highly sensitive distributed-type sensors. (Edited author abstract) 14 refs.

Yoshikawa, Hiroshi (Nihon Univ, Funabashi, Jpn); Sugata, Akihiko; Watanabe, Minoru; Ohno, Yutaka. *Electron Commun Jpn Part 2* v 71 n 2 Feb 1988 p 89-97.

**073891 OBSERVED SINGLE-MODE RESONANCE IN A MULTIMODE FIBER GENERATOR.** Single mode excitation of multimode fibers is of great interest for the measurement of individual or mutual mode fiber parameters. We give here some experimental results concerning the resonance properties of a weakly multimode fiber generator, where a photorefractive BGO crystal is used as a light amplifier within an optical fiber ring resonator. (Edited author abstract) 8 refs.

de Bougrenet de la Tocnaye, J.-L. (ENST de Bretagne, Brest, Fr); Pellat-Finot, P.; Bondiou, M.; Alger, M. *Opt Commun* v 66 n 2-3 Apr 15 1988 p 97-99.

**073892 DEVELOPMENT OF INTERFEROMETRIC OPTICAL FIBER ACOUSTIC SENSORS.** In this paper, the pressure sensitivity of an optical fiber acoustic sensor has been described theoretically and its sensitivity under inhomogeneous pressure has been analyzed and evaluated. An optical fiber interferometric acoustic sensor system with dc phase tracking homodyne detection has been established. The threshold of the detectable acoustic pressure is about 200  $\mu$ Pa with an optical fiber 5 m long. (Author abstract) In Chinese. 8 refs.

Tang, Mingung (Chengdu Inst of Radio Engineering, China); Liao, Bofan; Liu, Shuqi; Fan, Junhong. *Guangxue Xuebao* v 8 n 1 Jan 1988 p 67-74.



**073893 FIBER FINDS A NICHE IN PROCESS CONTROL.** Since it first found commercial use in measurement and control applications, optical fiber has managed to keep a foot in the door of the process-control market. Applications have been concentrated in areas of sensing and transmitting the status and values of process variables and communicating this information to operators and management. However, while the potential has been large, realization has been small. This article discusses the essence of industrial process control and some fiber optics applications to this field.

Moore, John A. *Photonics Spectra* v 21 n 12 Dec 1987 p 57-58, 60.

**073894 USE OF OPTICAL FIBER IN SAFETY-SYSTEM DESIGN.** This paper summarizes the design, installation, and performance of an optical-fiber safety system installed for testing purposes on a production platform in the Gulf of Mexico. This system was installed on a chemellectric treater to monitor five end devices and to determine the feasibility of using fiber optics rather than pneumatics or an electrical system in a harsh environment. Included with a performance summary is a brief history of optical fiber and the potential for these types of safety systems in oilfield applications. (Author abstract). 4 Refs.

Kugler, B.A. (Tenneco Oil Co). *JPT J Pet Technol* v 40 n 7 Jun 1988 p 906-908.

**073895 CALIBRATED OPTICAL FIBER POWER METERS: ERRORS DUE TO VARIATIONS IN CONNECTORS.** We discuss potential errors in the measurement of optical fiber power when using a calibrated power meter with connectors of various types and from different vendors. Data are given on the error and standard deviation due to biconic connectors from a limited number of vendors. We speculate that the error is due to reflecting surfaces on the connector end. To confirm the hypothesis, we tested two connectors whose reflective ends have noticeable differences. The data illustrate the variability seen among connectors. Our data indicate that a user should expect measurement error in most cases. We issue a call for caution based on the results. (Author abstract). 1 Ref.

Li, Xiaoyu (NBS); Gallawa, R.L. *Fiber Integr Opt* v 7 n 3 1988 p 241-248.

**073896 FIBRE LASER WITH ADJUSTABLE FIBRE REFLECTOR FOR WAVELENGTH TUNING AND VARIABLE OUTPUT COUPLING.** Fibre-loop reflectors are applied to Nd<sup>3+</sup> doped fibre lasers operating in the  $^4F_{3/2} - ^4I_{11/2}$  transition. The splitting ratio of the fused fibre coupler used in a loop reflector is varied thermo-optically, giving rise to a spectral variation in the reflectivity of the device. Using the fibre loop in a configuration with a broadband dielectric mirror to form a resonant cavity, we demonstrate wavelength tuning of the fibre laser and continuously variable power output for a constant pump power. (Author abstract). 14 Refs.

Millar, Colin A. (British Telecom Research Lab, Ipswich, Engl); Miller, Lain D.; Mortimore, David B.; Ainslie, B. James; Urquhart, Paul. *IEE Proc Part J* v 135 n 4 Aug 1988 p 303-309.

**073897 WDM COHERENT OPTICAL STAR NETWORK.** The results obtained with a fiber-optical star network using densely-spaced wavelength division multiplexing (WDM) and heterodyne detection techniques are reported. The system consists of three lasers transmitting at optical frequencies around 234,000 GHz, spaced at a frequency interval of 300 MHz. The lasers are frequency-shift-key (FSK) modulated at 45 Mb/s. A  $4 \times 4$  optical star coupler combines the three optical signals. The WDM signals received from one of the four outputs of the star coupler are demultiplexed by a heterodyne receiver. The minimum received optical power needed to obtain a bit-error rate of  $10^{-9}$  is -61 dBm or 113 photon/bit, which is 4.5 dB from the shot noise limit. The degradation caused by co-channel interference was measured and found to be negligible when the channels,

modulated at 45 Mb/s, are spaced by more than 130 MHz in the IF domain. These results indicate that a WDM coherent optical star network of this type has a potential throughput of 4500 Gb/s. 17 refs.

Glance, Bernard S. (AT&T Bell Lab, Holmdel, NJ, USA); Pollock, K.; Burrus, Charles A.; Kasper, Bryon L.; Eisenstein, Gadi; Stulz, Lawrence W. *J Lightwave Technol* v 6 n 1 Jan 1988 p 67-72.

**073898 STOICHIOMETRIC LiNbO<sub>3</sub> SINGLE-CRYSTAL FIBERS FOR NONLINEAR OPTICAL APPLICATIONS.** A vapor transport equilibration technique has been used to improve the homogeneity and adjust the Li/Nb ratio in small LiNbO<sub>3</sub> single crystal rods and fibers grown by the laser heated pedestal growth method. When equilibrated with a Li-rich powder, containing a mixture of LiNbO<sub>3</sub> and Li<sub>2</sub>NbO<sub>4</sub>, crystals of stoichiometric composition can be obtained. This treatment was used to raise the phase-matching temperature of congruent LiNbO<sub>3</sub> for second harmonic generation of 1064 nm radiation from 4 to 238°C. The 238°C phase-matching temperature is above the annealing temperature for photorefractive damage. This property, along with the good optical homogeneity, should allow efficient conversion of cw laser sources. We also, for the first time, demonstrated the doubling of 954 nm radiation in a LiNbO<sub>3</sub> crystal. (Author abstract) 31 refs.

Luh, Y.S. (Stanford Univ, Stanford, CA, USA); Fejer, M.M.; Byer, R.L.; Feigelson, R.S. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 264-269.

**073899 OPTICAL FIBRES AND THEIR APPLICATIONS - IV.** The proceedings contains 52 papers. The papers are grouped under the following headings: technology and theory of optical fibers; optoelectronic devices; optoelectronic and optical metrology; optical fiber sensors; applications in professional equipment; optical fiber communications; and integrated optoelectronics. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10924 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Szstakowski, Mieczyslaw (Ed.) (Inst of Technical Physics, Pol); Romaniuk, Ryszard S. (Ed.). *Proc SPIE Int Soc Opt Eng* v 670, Opt Fibres and Their Appl IV, Warsaw, Pol, Feb 11-13 1986. Publ by SPIE, Bellingham, WA, USA, 1986 256p.

## Attenuation

**073900 LIQUID CRYSTAL SIGNAL ATTENUATION DEVICE FOR OPTICAL FIBERS.** This paper presents a few results regarding the variation of transmission through silica optical fibers introduced in cells with compensated nematic and cholesteric liquid crystals having refractive indexes which could be varied either with temperature or by means of an applied steady electric field. The analysis of the way in which the transmission varies with temperature and the applied electric field leads to conclusions on the way a coupling device using liquid crystals could be built. 3 refs.

Bena, Rodica (Inst Politehnic Bucuresti, Bucharest, Rom); Guculescu, Iuliana; Opran, M.; Plosceanu, Carmina. *Bul Inst Politeh Bucuresti Ser Electroteh* v 46-47 1984-1985 p 58-64.

## Calculations

**073901 APPLICATION OF CONFORMAL MAPPING IN FIBRE OPTICS.** Conformal mapping is used to find the exact cut-off frequency of optical fibres with a dip in the refractive index. The exact mode field at cut-off is found to be a Bessel function of fractional order in the fibre core. The wider the dip is, the smaller the order. (Author abstract) 6 refs.

Zheng, Xue-Heng (Australian Natl Univ, Canberra, Aust). *Opt Quantum Electron* v 20 n 3 May 1988 p 273-278.

## Chemical Vapor Deposition

**073902 OPTICAL FIBRES TAILORED FOR SINGLE MODE PROPAGATION IN THE 600-850 NM WAVELENGTH RANGE.** Optical fibers exhibiting single mode transmission in the 600-850 nm wavelength range have been designed. Using MCVD method with inner pressure control and adopting an unusual procedure, optical fibers with cut-off wavelength at 575 nm have been obtained. The core was doped only with Ge, devoting particular attention to the index profile. The resulting fiber has a 4.2 µm core diameter, a numerical aperture of 0.102 and an optical window between 575-900 nm, in which the fiber is single mode. (Author abstract). 8 Refs.

Cocito, Giuseppe (CSELT, Turin, Italy); Cognolato, Livio; Modone, Eros. *Alta Freq* v 57 n 2 Feb-Mar 1988 p 153-156.

**Coatings** See Also ELECTRIC LAMPS, ULTRAVIOLET—Energy Conservation.

**073903 LIQUID CRYSTAL POLYESTERS FOR OPTICAL FIBER JACKETING.** A new coating material with a thermal expansion coefficient ( $\alpha$ ) of approximately  $10^{-6}K^{-1}$  and a Young's modulus ( $E$ ) of approximately 10 GPa has been developed for optical fiber. The low  $\alpha$ , high  $E$  coating layer is obtained as a result of the molecular orientation of a thermotropic liquid-crystal polyester (LCP) during extrusion-coating of the fiber. The LCP material also has adequate flexibility because within one polymer chain the length of the rigid and/or flexible segments is optimized. The LCP-coated fiber exhibits a slight fiber-strain change of approximately  $10^{-4}K^{-1}$  and no excess loss in the temperature range of -60 to 80°C. (Author abstract) In Japanese. 10 refs.

Shuto, Yoshito (NTT, Jpn); Takeuchi, Yoshiaki; Yamamoto, Fumio. *Denki Tsushin Kenkyusho Kenkyu Jitsuyoku Hokoku* v 36 n 9 1987 p 1295-1301.

**073904 POLYMER COATINGS FOR OPTICAL FIBERS.** Coating materials for optical fibers must be chosen with close attention to the manner in which their properties affect fiber performance. The ability to protect fiber strength and to provide resistance to excess transmission losses caused by microbending are the most important functions of the coating. Two basic considerations that govern fiber strength are the avoidance of damage to the glass surface during coating application and the quality of the applied coating. There are several factors related to the quality of the coating: coating concentricity, incomplete coatings, coating mechanical integrity, and particle contaminants in the coating. An examination is also made of microbending loss and its effect on fiber performance, microbending loss related to coating properties, and microbending in fiber cables. 28 refs.

Blyler, Lee L. Jr.; Aloisio, Charles J. *CHEMTECH* v 17 n 11 Nov 1987 p 680-684.

## Components

**073905 CONVENIENT FIELD-INSTALLABLE ANTIREFLECTION COATING FOR OPTICAL FIBER CONNECTORS AND OTHER COMPONENTS.** Disc-shaped pellicles 15 microns thick are antireflection coated and cemented to the polished ends of optical fiber connectors. Excess loss due to increased fiber separation is a maximum of 10 percent (.46 dB), typically 3.8 percent (.16 dB) in graded index fibers; Fresnel back-reflections are reduced by a factor of more than 10. (Author abstract). 6 Refs.

Lightstone, A.W. (RCA, Vaudreuil, Que, Can). *Fiber Integr Opt* v 7 n 3 1988 p 249-254.

## Computer Aided Analysis

**073906 MICROSCOPIC COMPUTER TOMOGRAPHY MEASUREMENT OF NONAXISYMMETRICALLY DISTRIBUTED OPTICAL FIBER REFRACTIVE INDEX.** A nonaxisymmetrically distributed method for measuring the refractive index of an optical



fiber is described. The light intensity distribution is observed with a microscope when an optical fiber is laterally illuminated by collimated light. The integrated refractive-index difference along the projective line is obtained by performing two integrations of the light intensity. The fiber is rotated, and the observation and calculations are repeated at each angle of rotation. The refractive-index pattern over the fiber cross section is reconstructed by computer tomography. 10 refs.

Toiga, Kenji (Tokyo Univ of Agriculture & Technology, Tokyo, Jpn); Amano, Nobuo; Noda, Ken-Ichi. *J Lightwave Technol* v 6 n 1 Jan 1988 p 73-79.

## Computer Aided Design

**073907 UN OUTIL DE CAD POUR FIBRES OPTIQUES MONOMODES. [A CAD Tool for Monomode Optical Fibers].** The applications of monomode optical fibers in telecommunication are increasing. The main characteristics of such fibers are determined by the refractive index distribution of its core fibers. This article describes a tool for the dimensioning of monomode fibers that is based on the numerical solution of vectorial wave function. (Translated author abstract) In French. 17 refs.

Kotrotsios, G. (CSEM, Neuchatel, Switz); Parriaux, O. *Bull Assoc Suisse Electr* v 78 n 15 Aug 8 1987 p 921-925.

## Connectors

**073908 ROBOT ASSEMBLES FIBER-OPTIC CONNECTORS.** When AT&T chose to automate its production of fiber-optic connectors, it turned to Com-Tal, a St. Paul company that specializes in flexible automation. An automated robotic workcell uses an Adept robot for a high speed, three-piece connector assembly. The end effector transports each connector body to a final assembly station where fiber optics and retroreflective sensors scan the assembly for proper alignment.

Anon. *Automation (Cleveland)* v 35 n 1 Jan 1988 p 56-57.

## Cooling

**073909 COOLING RATE IN FIBER DRAWING PROCESS GOVERNS THE STRENGTH OF THE 630 nm-ABSORPTION.** The effect of a forced or delayed fiber cooling on the Drawing Induced Absorption (DIA) at 630 nm in pure silica-core fibers is investigated. The cooling rate only, not the drawing tension as assumed generally before, determines the intensity of the DIA and explains the draw speed and fiber diameter dependence, too. (Author abstract) 7 refs.

Hack, H. (Schott Glaswerke, Mainz, West Ger); Kersten, R.Th.; Weingaertner, Th. *J Opt Commun* v 9 n 1 Mar 1988 p 29-30.

## Defects

**073910 HYDROGEN INTERACTION IN HIGH GE-DOPE SILICA OPTICAL FIBRES.** Paramagnetic defects are observed in high Ge-doped silica fibres. Particularly the E'(Ge) centres and the drawing induced E'(Si) centres are tested with hydrogen at room temperature and at 100 °C. An E'(Si) centre bleaching occurs after hydrogen adsorption-desorption cycle at room temperature. A decrease in the E'(Ge) centre EPR signal during H<sub>2</sub> adsorption-desorption cycle at 100 °C is noted. At same time the increase of OH peaks and background loss in the attenuation curves is observed. (Author abstract) 4 Refs.

Cocito, G. (CSELT, Turin, Italy); Ferraris, M.; Modone, E.; Sordo, B. *CSELT Tech Rep* v 16 n 4 Jun 1988 p 405-407.

**073911 CONSOLIDATION-ATMOSPHERE INFLUENCE ON DRAWING-INDUCED DEFECTS IN PURE SILICA OPTICAL FIBERS.** Drawing-induced paramagnetic defects (E' centers and oxygen-associated hole centers (OHCs)) and optical absorption bands at 630 nm and in the UV region are investigated for optical fibers.

These fibers are drawn from pure silica glass preforms consolidated in atmospheres containing O<sub>2</sub> and Cl<sub>2</sub> of various contents. UV absorption bands at 245 nm and 275 nm are clearly observed through deconvolution of the absorption spectra of optical fibers. The defects and absorption bands are influenced by the atmosphere in the consolidation process: (1) the OHCs and the absorption bands at 630 nm and 275 nm increase the intensity with increasing O<sub>2</sub> content and with decreasing Cl<sub>2</sub> content; (2) the E' centers decrease under the same conditions; and (3) the absorption band at 245 nm is independent of the atmosphere. These results reveal that O<sub>2</sub> incorporated into the preforms plays a vital role in the formation of the drawing-induced defects and absorption bands. The analysis of the O<sub>2</sub> dependencies indicates that the defect formation is due to diffusion of O<sub>2</sub> in the drawing process. It is also suggested that Cl<sub>2</sub> suppresses the reaction with O<sub>2</sub> in silica glass. 29 refs.

Hibino, Yoshinori (NITT, Tokai, Jpn); Hanafusa, Hiroaki. *J Lightwave Technol* v 6 n 2 Feb 1988 p 172-178.

**073912 SUBTHRESHOLD FLAWS AND THEIR FAILURE PREDICTION IN LONG-DISTANCE OPTICAL FIBER CABLES.** A study of surface defects and static fatigue data is presented to support the view that subthreshold surface defects are responsible for failure in proof-tested optical fibers. For this type of defect, crack initiation, as opposed to crack growth, is the rate-limiting step. Classical crack propagation theory does not describe this process sufficiently well for lifetime prediction, but semiempirical techniques indicate that this popular treatment may be pessimistic. A more conventional reliability treatment, similar to that used for other system components, appears to offer the best available approach to the task of failure lifetime prediction in proof-tested fibers. 24 refs.

Donaghy, Frank A. (Overseas Telecommunications Commission, Sydney, Aust); Dabbs, Tim P. *J Lightwave Technol* v 6 n 2 Feb 1988 p 226-232.

**Degradation** See Also TELECOMMUNICATION CABLES—Design.

**073913 ESTIMATION OF LONG-TERM TRANSMISSION LOSS INCREASE IN SILICA-BASED OPTICAL FIBERS UNDER HYDROGEN ATMOSPHERE.** The irreversible loss increase in silica-based optical fibers due to hydrogen is discussed on the basis of results of various high-temperature tests. The results show that germanium-doped-core fibers have different behavior with respect to irreversible loss increase, and that a pure-silica-core fiber fabricated under optimum conditions is very stable against irreversible loss increase. The estimation of long-term transmission loss stability is also discussed, and high-temperature testing is certified to be effective for estimating the long-term loss stability under low temperature. 20 refs.

Kuwazuru, Masakuni (Kokusai Denwa Co, Tokyo, Jpn); Namihira, Yoshinori; Mochizuki, Kiyofumi; Iwamoto, Yoshino. *J Lightwave Technol* v 6 n 2 Feb 1988 p 218-225.

## Design

**073914 DESIGN METHOD FOR TRIPLE-CLAD SILICA CORE OPTICAL FIBERS WITH ZERO TOTAL DISPERSION AT WAVELENGTHS OF 1.3 AND 1.55 μm.** This paper describes the design method for triple-clad silica core optical fibers with zero total dispersion at wavelengths of 1.3 and 1.5 μm. The total dispersion is computed by the differentiation formula for determinant. Therefore the significant digits of the total dispersion in our results are more than four. (Edited author abstract) 14 refs.

Furukawa, Shinichi (Amano Corp, Yokohama, Jpn); Nakazawa, Kazushige; Hinata, Takashi; Hosono, Toshio. *Electron Commun Jpn Part 2* v 70 n 11 Nov 1987 p 1-13.

**073915 PRACTICAL UPPER LIMITS TO CUTOFF WAVELENGTH FOR DIFFERENT SINGLE-MODE**

**FIBER DESIGNS.** A practical upper limit to cutoff wavelength in single-mode fiber is investigated. Based on the relationship between the attenuation of the LP<sub>11</sub> mode and the length dependence of cutoff wavelength, a formula is developed to predict this limit from four fiber designs commonly seen in commercially available fibers. It is found that, depending on fiber design, the upper limit of factory-measured fiber cutoff wavelength is anywhere from 20 to 60 nm above the system operating wavelength, even for a worst-case straight fiber layout. Under actual field layout conditions, however, the limits converge to approximately 65 nm above the system wavelength for all four fiber designs. The practical upper limit predicted here is confirmed through an experimental evaluation of modal noise effects in a 1.2-Gbit/s single-mode fiber system. 12 refs.

Wei, Leping (Northern Telecom, Nepean, Ont, Can); Lowe, Richard S.; Saravanos, Costas. *J Lightwave Technol* v 1T-5 n 9 Sep 1987, Opt Fiber Conf/Sixth Biannual Int Conf on Integr Opt and Opt Fiber Commun, Reno, NV, USA, Jan 19-22 1987 p 1147-1155.

**Doping** See Also REFLECTOMETERS—Infrared.

**073916 FLUORINE DOPING IN MCVD OPTICAL FIBRES.** Fluorine incorporation in silica glass network has been already investigated using CCl<sub>2</sub>F<sub>2</sub> (Freon-12) as a source. Considerations on the stoichiometry of the reactions involved in CVD processes and experimental results on the refractive index are detailed. The data are collected in a ternary diagram that is proposed as a useful graphic representation in order to identify iso-index curves. A value of  $4.9 \times 10^{-3}$  for the refractive index difference has been obtained. This value has been achieved with a flow composition very far from usual CVD conditions. (Author abstract) 8 Refs.

Cocito, G. (CSELT, Turin, Italy); Cognolato, L.; Modone, E.; Parisi, G. *CSELT Tech Rep* v 16 n 4 Jun 1988 p 369-372.

**Efficiency** See SUBMARINES—Remote Sensing.

## Environmental Testing

**073917 ENVIRONMENTAL EFFECTS ON THE STATIC FATIGUE OF SILICA OPTICAL FIBER.** The static fatigue properties of silica optical fiber are measured in 90°C aqueous environment for various pHs in the range 0 to 14 and for distilled water. The effect of a UV-curable urethane acrylate protective coating is evaluated by directly comparing coated and bare fiber. It is found that both higher pH and (at long times) the presence of the protective coating increase the fatigue rate. (Edited author abstract) 38 refs.

Matthewson, M. John (Bell Lab, Murray Hill, NJ, USA); Kurkjian, Charles R. *J Am Ceram Soc* v 71 n 3 Mar 1988 p 177-183.

**073918 FIBER OPTICS IN ADVERSE ENVIRONMENTS III.** This conference proceedings contains 18 papers. The main subjects are environmental effects on optical fiber components, environmental effects on optical fibers, measurement and characterization of optical fiber components, optical fiber power delivery system, and low dispersion glass for optical fiber industrial applications. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11051 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Greenwell, Roger A. (Ed.) (Science & Engineering Associates Inc). *Proc SPIE Int Soc Opt Eng* v 721, Fiber Opt in Adverse Environ III, Cambridge, MA, USA, Sep 25 1986. Publ by SPIE, Bellingham, WA, USA, 1987 132p.

## Fabrication

**073919 HIGH-RATE FABRICATION OF OPTICAL FIBER PREFORMS BY THE MULTI-FLAME VAD METHOD.** A new type of burner with a multi-flame structure is proposed for high-rate fabrication of



optical fiber preforms by the vapor-phase axial deposition method (VAD). Fine glass particles synthesized using the double-flame burner under a variety of conditions are observed with a SEM and their deposition rates are measured. Then, this technique is applied to several types of preform fabrications. As a result, the deposition rate for one double-flame burner is increased by as much as 5 g/min. The multi-flame VAD method enables obtaining whole synthesis for single-mode optical fiber preforms at a high deposition rate of 10.2 g/min. (Author abstract) 17 refs. In Japanese.

Suda, Hiroyuki (NTT Ibaraki Electrical Communications Lab, Jpn). *Denki Tsushin Kenkyusho Kenkyu Jitsuyoku Hokoku* v 36 n 7 1987 p 949-955.

**073920 HIGH FREQUENCY PLASMA DEPOSITION IN FABRICATION OF OPTICAL GUIDE FIBRES.** The aim of this work was to calculate the electromagnetic fields in the high-frequency induction discharge at atmospheric pressure on oxygen during deposition of layers of silica glass on a pipe 19 mm in diameter and 2.5 mm wall thickness, and develop a general method of calculating several parameters of the process of formation of SFL blanks with small losses (thickness of the deposited  $\text{SiO}_2$  shell, radius of the  $\text{SiO}_2 + \text{GeO}_2$  core, S/a parameter). The proposed method of calculations can be used for selecting pipes of various diameter and wall thickness in designing the process of formation of SFL blanks using the hf plasma at atmospheric pressure. 6 refs.

Blinov, L.M.; Obukhov, A.V.; Rykalin, N.N.; Sorokin, L.M.; Shilov, I.P. *Phys Chem Mater Treat* v 21 n 3 May-Jun 1987 p 231-234.

**073921 FIBER-PREFORM FABRICATION USING PLASMA TECHNOLOGY: A REVIEW.** This paper gives a review on the state-of-the-art of the application of plasmas for the preparation of optical waveguides. Both high and low pressure plasmas initiating a homogeneous or a heterogeneous reaction are used for the fabrication of high quality low-loss optical fibers. Both inside and outside deposition processes are presented and compared. Among these the Plasma Impulse CVD (PICVD-process) is discussed in more detail. (Author abstract) 24 refs.

Huenlich, Th. (SCHOTT Glaswerke Central Research, Mainz, West Ger); Bauch, H.; Kersten, R.Th.; Paquet, V.; Weidmann, G.F. *J Opt Commun* v 8 n 4 Dec 1987 p 122-129.

**073922 CHEMICAL VAPOUR DEPOSITION IN MICROWAVE PRODUCED PLASMAS FOR FIBER PREFORMS.** The plasma impulse chemical vapor deposition technique (PICVD) is used to deposit pure and doped silica in quartz tubes. The time dependent chemical composition of the vapor is measured spectroscopically. Microwave measurements clarify the axial distribution of the microwave power. Theoretical results for the kinetics of reaction are in good agreement with experimental observations. (Author abstract) 8 refs.

Bauch, H. (SCHOTT Glaswerke, Mainz, West Ger); Krause, D.; Kersten, R.Th.; Paquet, V.; Weidmann, G.; Mentges, J.; Janzen, G.; Rauechle, E. *J Opt Commun* v 8 n 4 Dec 1987 p 130-135.

**073923 FIBERS WITH PURE  $\text{SiO}_2$ -CORE MADE BY PICVD.** Recent results of single- and multimode fibers with a pure or partially doped  $\text{SiO}_2$  core and a depressed cladding fabricated by the Plasma-Impulse-CVD (PICVD) process are presented. Fibers with good radiation resistance have been realized. Losses as low as 1.3 dB/km at 860 nm have been achieved. (Author abstract) 6 refs.

Bauch, H. (SCHOTT Glaswerke, Mainz, West Ger); Paquet, V. *J Opt Commun* v 8 n 4 Dec 1987 p 136-139.

**073924 POSSIBILITIES FOR MANUFACTURING OPTICAL FIBRES.** The process for manufacturing optical fibres for optical communication systems has been developed over the last few years into a reliable technique. Elaborate machines and sensitive operations for the

production of the preforms and drawing of the fibres themselves have been mastered. The future belongs to the monomode fibre, which with an optical wavelength of 1300  $\mu\text{m}$  can be used for lines with repeater spacings of over 30 km. (Edited author abstract) 2 refs.

Freidinger, Robert. *Wire World Int* v 29 n 5 Sep-Oct 1987 p 107-110.

**073925 OPTICAL FIBER FABRICATION BY THE OUT-DIFFUSION METHOD.** Single-mode optical fibers with triangular index profile are successfully fabricated by a new fabrication technique, the 'out-diffusion method'. Evaporation and diffusion of fluorine by heating and subsequent collapsing of the fluorine-doped silica glass tubes result in formation of the core in the center of the collapsed preforms. Optical fibers with refractive index difference of 0.67% are obtained with an optical loss of 0.40 dB/km at 1.57  $\mu\text{m}$  wavelength. (Author abstract) 7 refs.

Kitagawa, Takeshi (NTT Opto-Electronics Lab, Tokai, Jpn); Shibata, Shuichi; Horiguchi, Masaharu. *Jpn J Appl Phys Part 2* v 26 n 12 Dec 1987 p 2044-2045.

**073926 INNER PRESSURE CONTROL METHOD IN OPTICAL FIBER PREFORM FABRICATION BY VAPOR-PHASE AXIAL DEPOSITION.** A method to control inner pressure variation in a vapor-phase axial-deposition (VAD) apparatus is developed. It uses a flame-detection technology to explain temperature fluctuations. Primary causes of the inner pressure fluctuations are analyzed, and suppression techniques are described. They include the adoption of a large buffer-tank and bias gas addition. An inner pressure-feedback control mechanism operates by adjusting the bias gas flow, keeping fluctuations of the inner pressure to less than half of that with no control. 6 refs.

Imoto, Katsuyuki (Hitachi Ltd, Kokubunji, Jpn); Sumi, Masao. *J Lightwave Technol* v 6 n 4 Apr 1988 p 574-581.

## Failure

**073927 FIBRE OPTIC DAMAGE DETECTION IN COMPOSITE STRUCTURES.** A system of thin, light-conducting fibres, integrated into a composite structure during its manufacturing process, can serve as a reliable, automatic and remote working long-term monitoring device for structural damage. Fractures, cracks, or delaminations in a structure area can destroy the optical fibres installed there and thus interrupt the light flow. Various examples of applications in GFRP aircraft components are described. The outline of a complete fibre optic nervous system (FONS) for large Airbus CFRP components shows how fibre optic damage detection can contribute to future aircraft maintenance and inspection philosophies. (Edited author abstract) 8 refs.

Hofer, B. (Messerschmitt-Boelkow-Blohm GmbH, West Ger). *Composites* v 18 n 4 Sep 1987 p 309-316.

**073928 FAILURE OF OPTICAL FIBRES EMBEDDED IN COMPOSITE MATERIALS.** This paper shows the use of an available 'fiber in matrix' model to represent optical fiber embedded in a composite three-point bend specimen. The model was used to predict the optical fiber stress level while embedded in the loaded structure, and experimental failure of such embedded fiber was compared with the failure stress of similarly treated non-embedded fiber. Indications are that knowledge of optical fiber strength combined with use of the model will permit prediction of embedded optical fiber failure. (Author abstract). 18 Refs.

Waite, S.R. (City Univ, London, Engl); Sage, G.N. *Composites* v 19 n 4 Jul 1988 p 288-294.

## Fatigue

**073929 STATIC FATIGUE OF OPTICAL FIBERS IN BENDING.** A two-point bending technique for making static fatigue measurements on optical fibers is described which allows large quantities of data to be rapidly and conveniently gathered. Statistical analysis is

used to compare the times to failure of the method with those of the commonly used mandrel and tensile methods. Direct experimental comparison of the two-point bend and tensile method shows that while the times to failure are generally longer for two-point bend than tension, the essential fatigue behavior is identical for the two methods. (Author abstract) 13 refs.

Matthewson, M. John (AT&T Bell Lab, Murray Hill, NJ, USA); Kurkjian, Charles R. *J Am Ceram Soc* v 70 n 9 Sep 1987 p 662-668.

## Focusing

**073930 OBSERVATION OF CATASTROPHIC SELF-PROPELLED SELF-FOCUSING IN OPTICAL FIBRES.** Observation of what appears to be a new guided-wave phenomenon which causes optical damage to the entire optical fiber transmission path at relatively low optical power levels is reported. Damage to the core manifests itself as periodic restructuring of the region, similar to that seen in self-focusing. (Author abstract) 11 refs.

Kashyap, R. (British Telecom Research Lab, Ipswich, Engl); Blow, K.J. *Electron Lett* v 24 n 1 Jan 7 1988 p 47-49.

## Fracture See Also OPTICAL COMMUNICATION.

**073931 CLEAVAGE OF OPTICAL FIBRES FOLLOWING DIAMOND-WEDGE INDENTATION.** A major problem in the fiber-optics and communications area is the coupling of two fiber ends with the minimum of transmission loss across the interface. The fiber end faces need to be flat, smooth and at right angles to the fiber axes. A method of achieving this is described. It involves first adding a short precursor crack to the fiber by indentation with a diamond wedge under carefully controlled conditions and then pulling the fiber along its axis until it fractures. The angle of the diamond wedge is important if it is to produce a good precursor crack and be capable of repeated use without suffering damage. Experiments are described which optimize the diamond wedge angle and the loads. A model is developed relating the length of the precursor crack formed by wedge indentation and the applied load and wedge angle. (Edited author abstract) 33 refs.

Field, J.E. (Cavendish Lab, Cambridge, Engl); Samuels, B.; Townsend, D.; Hagan, J.T. *Philos Mag A* v 57 n 2 Feb 1988 p 151-171.

## Impurities

**073932 BEHAVIOR OF ALKALI IMPURITIES AND THEIR ADVERSE EFFECT ON GERMANIA-DOPED SILICA FIBERS.** Alkalis, such as sodium and potassium, were found to migrate from over-jacketing natural silica tubes into germania-doped cores forming defects leading to hydrogen-induced loss in the infrared wavelength region. These impurities were found to be removed from the same kind of natural silica tubes during the MCVD process. Results strongly point out that the absence of impurities is essential for 1.55- $\mu\text{m}$  transmission systems based on germania-doped silica fiber. 8 refs.

Ogai, Mikio (Furukawa Electric Co, Chiba, Jpn); Iino, Akio; Matsubara, Kunihiro. *J Lightwave Technol* v LT-5 n 9 Sep 1987, Opt Fiber Conf/Sixth Biannual Int Conf on Integr Opt and Opt Fiber Commun, Reno, NV, USA, Jan 19-22 1987 p 1214-1218.

## Ionization

**073933 OBNIZANIE ZAWARTOSCI JONOW  $\text{OH}^-$  W SWIATLOWODACH JEDNOMODOWYCH.** [Reduction of  $\text{OH}^-$  Ions Content in Monomode Optical Fibers]. Considered are reduction problems of  $\text{OH}^-$  ions content in monomode optical fibers, which is far more serious, because a considerable part of modal power propagates in the cladding. A series of methods of solving this problem was proposed. Dehy-



dration processes for VAD (Vapor Axial Deposition) preforms were debated. (Edited author abstract) In Polish. 9 refs.

Romaniuk, Ryszard (Politechniki Warszawskiej, Pol). *Elektronika* v 27 n 10-11 1986 p 8-11.

**Laser Applications** See REFLECTOMETERS.

**Low Temperature Effects** See TELECOMMUNICATION CABLES—Performance.

**Manufacture** See Also GLASS—Optical Quality; WAVEGUIDES, OPTICAL—Manufacture.

**073934 ENVIRONMENTAL ASPECTS OF THE MCVD PROCESS.** The MCVD process for making optical fibers involves the high temperature oxidation of halides of silicon, germanium, and phosphorus. This reaction generates both solid and gaseous by-products which have to be scrubbed. This paper describes a system to treat the MCVD effluents and also recover the unused germanium. (Author abstract) 12 refs.

Bohrer, M.P. (AT&T Bell Lab, Murray Hill, NJ, USA); Amelse, J.A.; Narasimham, P.L. *AIChE Symp Ser* v 83 n 258 1987, Fiber Opt Eng: Process and Appl (Pap from Natl AIChE Meet Held 1984-1986) p 12-16.

**073935 OPTICAL FIBER DRAWING AND COATING.** The optical fiber drawing and coating process plays a very important role in determining the performance properties of fibers used in telecommunications. Among the performance properties of concern are strength, dimensional precision and transmission loss. This article shows a schematic of a state-of-the-art fiber drawing and coating operation and depicts the ways in which the fiber performance properties are influenced by the drawing and coating process.

Blyler, L.L. Jr. (AT&T Bell Lab, Murray Hill, NJ, USA); Williams, J.C. *AIChE Symp Ser* v 83 n 258 1987, Fiber Opt Eng: Process and Appl (Pap from Natl AIChE Meet Held 1984-1986) p 27-28.

**073936 RECENT ADVANCES IN FIBER DRAWING AND COATING TECHNOLOGY.** The large predicted increase in demand for a lightwave communication system is now being realized, and in response to this manufacturing technologies of high quality optical fibers have advanced rapidly in the past ten years. This paper reviews the evolution of the fiber drawing and coating processes, discussing the various sources and coating materials which can be used. Subsequently, the latest results obtained from the very high speed coating technique (draw speed greater than 10 m/sec) are presented. (Edited author abstract) 13 refs.

Paek, U.C. (AT&T, Princeton, NJ, USA). *AIChE Symp Ser* v 83 n 258 1987, Fiber Opt Eng: Process and Appl (Pap from Natl AIChE Meet Held 1984-1986) p 38-41.

**073937 OPTICAL FIBRE MANUFACTURE IN AUSTRALIA.** The Melbourne-Sydney optical fiber cable project was the instigator for the 'all-Australian' optical fiber cable. Cable with Australian-made fiber became a reality when two optical fiber manufacturing plants, became operational in 1986. Mass production of silica-based optical fibers by vapor deposition methods have dominated the fiber manufacturing industry over the past decade. Several techniques have emerged which are widely used throughout the world, namely the modified chemical vapor deposition (MCVD), the vapor-phase axial deposition (VAD), the outside vapor deposition (OVD), and the plasma activated chemical vapor deposition (PCVD) processes. The authors describe two of these methods - the VAD and OVD. (Edited author abstract) 11 refs.

Consiglio, G.; Croft, T.; Lloyd, R.; Long, P.; Sasagawa, M. *Telecommun J Aust* v 37 n 3 1987 p 22-30.

**073938 DIGITAL HAND-HELD TENSIO METER - A QUALITY IMPROVEMENT.** Manufacturing fiber optic cable is a delicate and precise process operation. Siecor Corp., a manufacturer of fiber optic cable and

related equipment, has a philosophy of 'Total Quality'. In order to meet this philosophy, key process parameters are monitored and controlled to produce a quality product. Several processes in the manufacturing of fiber optic cable require measuring fiber tensions. The article describes a tensiometer for this purpose.

Daily, Michael A. *Wire J Int* v 20 n 10 Oct 1987 p 31-34, 36, 39-41.

**073939 MANUFACTURING PROCESSES FOR FLUOROZIRCONATE GLASS PREFORMS AND OPTICAL FIBERS.** Fluoride glasses, in the system composed by  $ZrF_4$ - $BaF_2$ - $LaF_3$ - $AlF_3$ - $NaF$ , are investigated as potential low loss materials for optical fibers, operating in the wavelength range of 2-5  $\mu$ m. The minimum loss of these glasses is predicted to be less than 0.01 db/km based on the precise evaluation for intrinsic loss factors. At present, among several optical fibers manufacturing techniques, the 'Rotational casting' method seems to be the most suitable for preform preparation and it has been developed in CSELT. The paper describes all the phases of this method, and the conditions adopted to obtain preforms for optical fibers. Several preforms were manufactured and some of their physical characteristics were investigated. Moreover the techniques developed, all over the world, for making optical fibers operating in the middle infrared region and comparison among them, are also discussed. (Author abstract) 15 refs.

Abollino, Ornella (Cent Studi e Lab Telecomunicazioni, Turin, Italy); Braglia, Marco; Cocito, Giuseppe; Ferraris, Monica; Grego, Giorgio; Parisi, Giuseppe. *Alta Freq* v 57 n 1 Jan 1988 p 15-19.

**073940 FLUORINE-DOPING MECHANISM BY VAD METHOD.** A fluorine doping mechanism for fine glass particles is investigated. Fluorine doping and dissipating properties of fine glass particles are measured during heat-treating experiments. Fluorine doping and dissipating amounts are dependent on particle-size,  $SF_6$  partial pressure and temperature. The experimental results are interpreted and a possible fluorine-doping model for fine glass particles is presented. (Author abstract). 13 Refs. In Japanese.

Hanawa, Fumiaki (NTT, Jpn); Ohmori, Yasuji; Horiguchi, Masaharu. *Denki Tsushin Kenkyusho Kenkyu Jitsuyoka Hokoku* v 37 n 4-5 1988 p 313-320.

**073941 DESIGN AND IMPLEMENTATION OF AN INDUSTRIAL-PROCESS ADAPTIVE CONTROL SYSTEM.** To satisfy the requirements of optical communication, it is necessary to control the factors affecting fiber performance. Considering these factors, the authors have developed a high speed Optical Fiber Drawing Process Microcomputer Adaptive Control System (OFDPMACS). The design and implementation with a dual-microcomputer of OFDPMACS is discussed. Aimed at the requirements of high precision and high speed on the drawing of optical fiber, the authors propose a new self-tuning control algorithm based on output prediction. The fiber diameter can be controlled within the range of 125 + 0.5  $\mu$ m with such an algorithm. (Edited author abstract). 6 Refs. In Chinese.

Zhu, Zhixiang (Northwestern Polytechnical Univ, China); Wei, Jiangou; Li, Yongxi; Tang, Xinghui. *Xibei Gongye Daxue Xuebao* v 6 n 3 Jul 1988 p 263-270.

**073942 MCVD METHOD WITH INNER PRESSURE CONTROL FOR OPTICAL FIBRE MANUFACTURING.** The MCVD process with inner pressure control allows an easy fabrication of a wide variety of compositions and fiber designs, using only  $GeO_2$  and/or F as silica dopants. Very low loss monomode and high numerical aperture multimode fibres have been made with a high reproducibility degree and good geometrical characteristics. (Author abstract) 6 refs.

Chigo, G. (CSELT, Turin, Italy); Grego, G.; Parisi, G.; Roba, G. *CSELT Tech Rep* v 13 n 5 Oct 1985, IOOC-ECOC '85 (5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun),

Venice, Italy, Oct 1-4 1985 p 327-330.

## Marine Applications

**073943 UPON EMPLOYING FIBER OPTICS AT SEA.** While optical fibers are rapidly finding great acceptance on land every day, they are only recently beginning to be used in marine applications. Like on land, they offer certain advantages over electrical methods of transmission, such as small size and larger bandwidth. Optical fiber systems are, however, not a total replacement for electrical systems since they carry information rather than power, which still needs to be transmitted over wires. But when the power level is low enough, energy can be transmitted in the form of light to be transformed at destination into electricity.

Giannini, Gabriel M. (Giannini Petro-Marine). *Sea Technol* v 28 n 9 Sep 1987 p 41, 43-44.

**Materials** See Also GLASS; GLASS—Chemical Reactions; GLASS—Spectroscopic Analysis; LIGHT—Scattering.

**073944 REMOVAL OF WATER ADSORBED ON FLUORIDE GLASS SURFACES BY  $NF_3$  PLASMA PROCESSING.** A new method to remove water adsorbed on fluoride glass performs is reported. This method, using  $NF_3$  plasma, can remove surface water on fluoride glasses. (Author abstract) 4 refs.

Nakai, T. (KDD Research & Development Lab, Tokyo, Jpn); Norimatsu, N.; Noda, Y. *Opt Laser Technol* v 19 n 5 Oct 1987 p 271-272.

**073945 NEW PLASTIC OPTICAL FIBER USING POLYCARBONATE CORE AND FLUORESCENCE-DOPED FIBER FOR HIGH TEMPERATURE USE.** This article describes the development of a plastic optical fiber composed of a polycarbonate core with a glass transition temperature of 150°C, and a cladding of newly developed poly-4-methyl penten-1, which softens at 173°C. This cladding is suitable for use at temperatures up to 130°C. The minimum optical attenuation is 0.8 dB/m at 765 nm in the near-infrared region. The cause of the attenuation of the PC-core fiber was analyzed and the intrinsic loss limit was estimated to be 0.4 dB/m at 765 nm. The fiber has excellent characteristics, including thermal stability up to 125°C, high flexibility, high strength, and self-extinguishing properties. The polycarbonate core fiber, of doped organic fluorescing materials, has also been developed for automotive uses such as light guide and illuminator. (Edited author abstract) 12 refs.

Tanaka, Akira (Fujitsu Ltd, Kawasaki, Jpn); Sawada, Hisashi; Takoshima, Takehisa; Wakatsuki, Noboru. *Fiber Integr Opt* v 7 n 2 1988 p 139-158.

**073946 LOW-LOSS FLUORIDE OPTICAL FIBERS FOR MIDLINFRARED OPTICAL COMMUNICATION.** Optical loss in current fibers is dominated by two major extrinsic loss factors, defect scatterers and impurities. Scatter analysis using a Raman microprobe has revealed that the majority of them are  $ZrO_2$  crystallites. These crystallites dominate the fiber scattering characteristics, having both wavelength independent and Rayleigh wavelength<sup>4</sup> dependencies according to their size. Excess loss due to OH groups which causes absorption at around 2.9  $\mu$ m is quantified as 2000-5000 dB/km/ppm, depending on glass composition. These results suggest that further efforts in glass synthesis should concentrate on eliminating oxide and hydroxide impurities, and on the further purification of the raw materials. The key for realizing high-quality, low-loss, and long-length fluoride fibers is currently related to whether or not oxide scatterers can be completely eliminated. 38 refs.

Sakaguchi, Shigeki (NTT, Tokai, Jpn); Takahashi, Shiro. *J Lightwave Technol* v LT-5 n 9 Sep 1987, Opt Fiber Conf/Sixth Biannual Int Conf on Integr Opt and Opt Fiber Commun, Reno, NV, USA, Jan 19-22 1987 p 1219-1228.



**073947 MECHANICAL AND OPTICAL PROPERTIES OF THE CHALCOGENIDE GLASS SYSTEM  $As_2Se_{3-x}Te_x$ .** Chalcogenide glasses of  $As_2Se_{3-x}Te_x$  ( $0 \leq x \leq 3$ ) were fabricated with special care to avoid traces of oxygen, using very pure raw materials. From part of these materials, special plates were made, and fibers were pulled from the rest. From transmittance measurements, the existence of absorption bands was shown, corresponding to the presence of small crystallites of  $As_2O_3$ . The attenuation in the infrared of these plates increased from 14 dB/m for  $As_2Se_3$  to 29 dB/m for  $As_2Se_{0.5}Te_{2.5}$ . Conversely, a decrease of microhardness  $V_H$  was observed. The attenuation of  $CO_2$  laser light ( $\lambda = 10.6 \mu m$ ) transmitted through the pulled fibers was measured as a function of the  $Te(x)$  content, and an increase of the attenuation was observed from 18.1 dB/m for  $As_2Se_3$  to 66.7 dB/m for  $As_2Se_{1.5}Te_{1.5}$ . 22 refs.

Croitoru, Natan (Tel-Aviv Univ, Tel-Aviv, Isr); Shamir, Noam. *J Lightwave Technol* v LT-5 n 11 p 1637-1641.

**073948 OPTICAL FIBER MATERIALS AND PROPERTIES.** This symposium proceedings contains 28 papers. The symposium included talks on new methods of preparation and characterization of these materials, new material systems, composition-property relationships and process effects on properties. Topics include polymer fiber and coatings; oxide glasses, processing and characterization; heavy metal halide glasses; non-silicate lightguide materials; and defects in optical fibers. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11593 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Nagel, Susanne R. (Ed.) (AT&T, Murray Hill, NJ, USA); Fleming, James W. (Ed.); Sigel, George H. (Ed.); Thompson, David A. (Ed.). *Mater Res Soc Symp Proc* v 88, Opt Fiber Mater Prop, Boston, MA, USA, Dec 3-5 1986. Publ by Materials Research Soc, Pittsburgh, PA, USA, 1987 239p.

**Mathematical Models** See Also ACOUSTIC WAVES—Propagation; LIGHT—Birefringence; OPTICAL COMMUNICATION—Theory; TELECOMMUNICATION CABLES—Oscillations.

**073949 CALCULATIONS TO DETERMINE THE EFFECTIVE CUTOFF-WAVELENGTH OF SINGLE-MODE FIBERS.** The effective cutoff of circularly symmetric weakly guiding single-mode fibers is calculated from the spectral attenuation of the  $LP_{11}$ -mode, which we assume to be caused by frustrated total reflection. We use a semiclassical model which is applicable to inhomogeneous fiber profiles also. A comparison with the results of the leaky-mode-approach for step-index-fibers shows that the approximations made in our model are tolerable. We then present a new criterion for a 'mathematical' cutoff. It is defined for inhomogeneous fiber claddings as well, where the mathematical cutoff criterion fails. In contrast to the mathematical cutoff, our criterion takes into account fiber length and provides a quickly computed estimation of the effective cutoff if measured at fiber pieces of some meters in length. (Edited author abstract) 4 refs.

Fotheringham, U. (SCHOTT Glaswerke, Mainz, West Ger); Krause, D.; Kunstmann, R. *J Opt Commun* v 8 n 4 Dec 1987 p 143-147.

**073950 ADIABATIC MODEL FOR CALCULATING THE PULSE RESPONSES OF MULTIMODE FIBER LIGHTGUIDES.** A method is proposed for calculating the pulse response of multimode fiber lightguides in which the refractive index profile changes slowly along the fiber length. Preliminary estimates confirm the fact that within the framework of the adiabatic model it is possible to explain a number of special features of the preceding measurements of the pulse response in actual optical fibers. (Edited author abstract) 5 refs.

Tutubalin, V.N.; Shatrov, A.D. *Sov J Commun Technol Electron* v 32 n 4 Apr 1987 p 137-143.

**073951 SOLUTIONS OF NONAXISYMMETRIC FIELDS IN SELFOC FIBERS WITH LONGITUDINAL IMPERFECTIONS.** The refractive index is assumed to be of the form  $K = \epsilon/\epsilon_0 - K_2(z)r^2$  ( $K_2(z)$  is a gradually varying function of  $z$ ). The analytic solution is obtained. When  $K_2$  is a constant, the solution is reduced to that of perfect SELFOC fibers, which is well known. The solution of the imperfect fiber is expanded in terms of that of perfect fibers so that the mode conversion in imperfect fiber is obtained. 7 refs.

Kang, Shouwan (Northern Jiaotong Univ, Beijing, China). *J Lightwave Technol* v LT-5 n 12 p 1690-1694.

**073952 MULTIMODE CONCATENATION MODAL GROUP ANALYSIS.** A multimode concatenation model is derived using the link-mode power distribution and fiber-mode group delay times. The model is used deterministically to predict the bandwidth length exponent  $\gamma$  for seven concatenations.  $\gamma$  depends directly on the amount of correlation existing among the fibers' mode group delays. Under the assumption that the fiber ensemble is stationary and satisfies ergodicity conditions, it is possible to evaluate an ensemble- $\gamma$ . It can be used statistically to estimate the concatenation- $\gamma$ . 12 refs.

Nolan, D.A. (Corning Glass Works, Corning, NY, USA); Hawk, Robert M.; Keck, D.B. *J Lightwave Technol* v LT-5 n 12 p 1727-1732.

**073953 WAVELENGTH DEMULTIPLEXING USING BENDS IN A SINGLE-MODE OPTICAL FIBER.** A method of wavelength demultiplexing is developed that makes use of the wavelength and bend-radius dependence of the pure bend loss at single radius bends in a single-mode fiber. The light leaving the fiber at a bend forms one output of the demultiplexer. Equations are derived that predict the bend radii for the most-efficient operation of the demultiplexer and the power extracted from the fiber at each wavelength. The demultiplexer operates over the wavelength range corresponding to  $V$  numbers from 2.4 to 1.6. A two-wavelength demultiplexer formed from  $90^\circ$  bends is constructed and tested. Collection efficiencies of 70% and insertion losses of less than 2 dB are shown to be possible. Crosstalk isolation in excess of 40 dB can be achieved with the aid of optical wavelength filters. The performance of a three-wavelength demultiplexer is also considered. 10 refs.

Harris, Alun J. (Univ of Newcastle-upon-Tyne, Engl); Shrubshall, Paul A.; Castle, Peter F. *J Lightwave Technol* v 6 n 1 Jan 1988 p 80-86.

**073954 PHASE INDUCED INTENSITY NOISE IN CONCATENATED FIBER-OPTIC DELAY LINES.** A fiber-optic differential-delay-line structure converts the phase noise of its short coherence source to intensity noise at its output. If this structure is followed by a similar system, intensity noise is generated as well as filtered by each of the two systems. The power spectrum of the noise at the output of concatenated systems built of Mach-Zehnder and the recirculating delay lines is theoretically studied. The spectral structure of phase-induced intensity noise at the output of these concatenated systems is analyzed, taking into account polarization effects and emphasizing the physical interpretations of the results. An experimental verification is presented for the case of two recirculating delay lines in series. 19 refs.

Tur, Moshe (Tel-Aviv Univ, Ramat Aviv, Isr); Arie, Ady. *J Lightwave Technol* v 6 n 1 Jan 1988 p 120-130.

**073955 BUTTERFLY MODEL OF SINGLE-POLARIZATION FIBERS.** An exact analysis of propagation along practical single-mode single-polarization fibers is difficult and involves extensive numerical analysis. The authors present a simple refractive-index profile - the butterfly profile - which exhibits the key features of single-polarization operation, but possesses exact analytical solutions of the scalar wave equation for its modes, enabling such quantities as fundamental-mode cutoff and birefringence to be readily evaluated. The accuracy of perturbation solutions based on axisymmetric profiles can also be determined. By incorporating stress anisotropy, the relative values of cutoff for the two polarizations of each mode are shown to be in quantitative agreement with

measured values for the bow-tie fiber. 18 refs.

Skinner, Iain M. (Australian Natl Univ, Canberra, Aust); Love, John D. *J Lightwave Technol* v 6 n 3 Mar 1988 p 419-427.

**073956 BIREFRINGENCE IN BENT SINGLE-MODE FIBERS.** Changes to field properties when an optical fiber is bent are considered. A formula is obtained for the geometrical birefringence in a single-mode fiber due to bending, and is explicitly evaluated for a Gaussian field approximation, giving a simple analytic expression; it is also evaluated for more exact fields. Scalar theory is not sufficient to describe this birefringence, as reported previously, and vector or polarization corrections must be included in the theory. This birefringence is several orders of magnitude less than stress-induced bending birefringence. 15 refs.

Garth, Steve J. (Australian Defence Force Acad, Campbell, Aust). *J Lightwave Technol* v 6 n 3 Mar 1988 p 445-449.

**Measurements** See Also INTERFEROMETERS; INTERFEROMETRY; RADIOMETERS—Calibration; REFLECTOMETERS—Performance.

**073957 DIRECT INTERFEROMETRIC MEASUREMENT OF NONLINEAR REFRACTIVE INDEX OF OPTICAL FIBRES BY CROSSPHASE MODULATION.** We have computed the nonlinear refractive index of optical fibers from the phase shift resulting from crossphase modulation between a probe signal and a pulsed pump. This phase shift is obtained with a Mach-Zehnder interferometer. Values of  $0.92 \times 10^{-13}$  esu for silica and  $0.80 \times 10^{-13}$  esu for fluorozirconate glasses have been measured. (Author abstract) 10 refs.

Monerie, M. (CNET, Lanion, Fr); Durteste, Y. *Electron Lett* v 23 n 18 Aug 27 1987 p 961-963.

**073958 INTERFERENCYJNE POMIARY DYS-PERSJI SWIATLA WE WLOKNACH OPTYCZNYCH.** [Interferometric Measurements of Optical Fibre Spectral Dispersion]. The author studied the behavior of spectral dispersion of cladged, 'step-index' type optical fibers: thin-core type 2wBc, thick-core 2wBg, high-aperture 2wLS and 'gradient-index' type, four-layer 4wHB fibers. Refractive indices of every layer was found by transversal interferometry method with 'shearing' type interferometer. The influence of various dispersions of immersion environment and fiber material on measurements of difference in optical paths was also studied in interferometric fringe field. The results thus obtained were compared with dispersion curves of glasses used in technology of the said fibers. (Author abstract) In Polish. 17 refs.

Bozyk, Mirosława (Politechniki Białostockiej, Pol). *Elektronika* v 27 n 10-11 1986 p 3-7.

**073959 MODULATION FREQUENCY-SHIFT TECHNIQUE FOR DISPERSION MEASUREMENTS IN OPTICAL FIBRES USING LEDS.** Reliable phase-shift measurements in optical fibers were performed by downshifting the modulation frequency of the optical signal to the low-frequency range before detection. This technique maintains the full resolution of the high-frequency modulation and increases the sensitivity allowing accurate group delay measurements in single-mode fibers over a 300 nm spectral range using a single LED. (Author abstract) 3 refs.

Thevenaz, L. (Univ of Geneva, Geneva, Switz); Pellaux, J.-P. *Electron Lett* v 23 n 20 Sep 24 1987 p 1078-1079.

**073960 LIGHT POWER FLUCTUATIONS AT THE OUTPUT END OF A FIBER IN PARTIAL COUPLING WITH A DETECTOR IN COHERENT LIGHT.** Fluctuations of intensity located in the intersection of the end-face image of a graded-index fiber and a circular diaphragm are studied in coherent light. The



curve of the signal to noise ratio against the misalignment  $\delta$  shows a discontinuity when the fiber is motionless. To explain this phenomenon, this intensity is calculated by proposing a Gaussian representation of the end-face intensity. (Edited author abstract) 11 refs.

Verrier, Isabelle (Univ de Saint-Etienne, St.-Etienne, Fr); Goure, Jean-Pierre. *J Opt Commun* v 8 n 4 Dec 1987 p 151-154.

**073961 CORE DOPANT PROFILES IN WEAKLY FUSED SINGLE-MODE FIBRES.** Core dopant profiles have been measured in weakly fused single-mode fibres. The results show that the peak refractive index of the core decreases and the core size increases during fusing, contrary to previously proposed models. This suggests that the field is still guided by the cores and that the coupling mechanism model should include the effects of the cores for weakly fused fibres. (Author abstract) 3 refs.

McLandrich, M.N. (US Naval Ocean Systems Cent, San Diego, CA, USA). *Electron Lett* v 24 n 1 Jan 7 1988 p 8-10.

**073962 FIBRE PROBE FAR-FIELD TECHNIQUE FOR MODE-FIELD DIAMETER MEASUREMENT OF SINGLE-MODE FIBRES.** A far-field pattern (FFP) technique using an optical fibre probe to measure the mode-field diameters of single-mode fibres is described. The endface separation between the test fibre and the probe fibre can be reduced to a tenth of the fibre/detector separation in the conventional scanning detector method. (Author abstract) 5 refs.

Yamashita, K. (NTT Transmission Systems Lab, Tokai, Jpn); Tateda, M. *Electron Lett* v 24 n 2 Jan 21 1988 p 84-85.

**073963 GAUGE FOR MEASURING THE GEOMETRIC CHARACTERISTICS OF FIBERS BASED ON A SEMICONDUCTOR EMISSION SOURCE.** An important OF characteristic is its diameter, on whose constancy the spatial resolution of the fiber braids and faceplate with regular stacking depends. The deviation from the given OF diameter should not exceed 0.8-2%. Consequently, the development of a highly accurate compact apparatus to measure OF diameters during its drawing is a very urgent problem. The OF (Optical Fibers) diameter was estimated by the comparison method, i.e., by determining the distance between the minima of the diffraction patterns from the fiber being checked and an orthogonally located —standard— fiber. The resultant cruciform diffraction pattern, recorded on the screen of the television installation, carries information about the deviation of the diameter being checked relative to the —standard.— Utilization of a semiconductor laser as radiation source in a measuring installation permits a significant reduction in the overall dimensions and supply voltage while maintaining high stability and low response to vibrations and external illumination. 5 refs.

Lazarev, L.P.; Mirovitskaya, S.D. *Meas Tech* v 30 n 7 Jul 1987 p 643-645.

**073964 TWO-SIDED OTDR MEASUREMENTS FROM SAME FIBER END.** Monitoring fiber splices by OTDR requires measurements from both sides of the fiber link. Using a chemically prepared highly reflective end face at the far end of a fiber optic link permits two-sided OTDR displays to be made from one end only. The method presented is readily applicable for field-use. Practical results are presented. (Author abstract) 3 refs.

Faltin, L. (Kabel-und Drahtwerke AG, Vienna, Austria). *J Opt Commun* v 9 n 1 Mar 1988 p 24-26.

**073965 CALCULATION AND MEASUREMENT OF MODE TRANSITION MATRICES FOR DIFFERENTIAL MODE ATTENUATION AND DIFFERENTIAL MODE DELAY CHARACTERIZATION OF OPTICAL FIBERS.** A method is described to characterize multimode fiber-optic devices in terms of differential mode attenuation (DMA), differential mode delay (DMD), and mode coupling. It is important to describe these properties with only a few data. This is accomplished

by the mode transition matrix method, in which each fiber optic component is characterized by one or more  $3 \times 3$  matrices. Certain trade-offs between simplicity and precision are unavoidable, but it has already been demonstrated that the matrix method yields results that are precise enough to calculate system responses poorly. Mode or pulse transition matrices are defined for the DMD characterization of fibers. Measurements have been carried out. (Edited author abstract) 17 refs.

Evers, Gert (Technische Univ Braunschweig, Braunschweig, West Ger). *Opt Eng* v 27 n 2 Feb 1988 p 179-186.

**073966 LAUNCHING AND RECEIVING CONDITIONS FOR OPTICAL FIBER LOSS MEASUREMENTS USING AN OTDR.** Optical pulse measuring instruments (OTDRs) are very useful in locating broken areas and assessing the homogeneity of optical fibers. This study investigates the backscattering mode distribution of graded-index optical fibers using geometrical optics. The launching condition of the light pulse and the receiving condition of backscattering, and their relation to the measured optical and splicing losses, are determined. The theoretical and experimental relation between the measured values of backscattering by OTDR and cut-back methods is also discussed. It is shown that the steady-state condition of the received backscattering light is necessary when measuring the losses of steady-state mode distribution by the OTDR method. We propose the possibility of estimating the splicing loss values of the cut-back method from the difference of the splicing loss measurements under varied launching conditions of OTDR method. The correctness of this method is confirmed experimentally. (Edited author abstract) 16 refs.

Furukawa, Shin-ichi (NTT, Ibaraki, Jpn); Koyamada, Yaei. *Electron Commun Jpn Part 2* v 71 n 3 Mar 1988 p 10-22.

**073967 SHORT W-TUNNELLING FIBRE POLARIZERS.** There are several types of inline fiber polarizers of interest for applications in single-mode fiber systems. We demonstrate that the so-called W-tunnelling polarizers are capable of excellent performance in extremely short lengths of fiber. We present results on a polarizer with 39 db of polarization extinction at 633 nm with a 4% usable bandwidth in only 4.8 cm of fibre which is essentially lossless for the favoured polarization. 7 refs.

Stolen, R.H. (AT&T, Holmdel, NJ, USA); Pleibel, W.; Simpson, J.R.; Ree, W.A.; Mitchell, G. *Electron Lett* v 24 n 9 Apr 28 1988 p 524-525.

**073968 COMPARISON OF REFRACTIVE INDEX MEASUREMENTS OF OPTICAL FIBRES BY THREE METHODS.** The work of the National Physical Laboratory on the measurement of refractive index profiles of optical fibres is aimed at providing fibres with calibrated refractive index steps accurate to  $\pm 1\%$ , and assessing the accuracy of near-field techniques. Axial interferometry and refracted and transmitted near-field techniques (RNF and TNF) are being employed for profiling, and differences in the measurements examined. 14 refs.

Raine, K.W. (NPL, Teddington, Engl); Baines, J.G.; King, R.J. *IEE Proc Part J* v 135 n 3 Jun 1988 p 190-195.

**073969 RESOLUTION MODEL FOR MEASUREMENT OF OPTICAL FIBRE PREFORMS BY FOCUSED LASER TRANSVERSE ILLUMINATION TECHNIQUE.** A model has been developed to describe the spatial resolution function of a focussed laser transverse illumination technique for the measurement of the refractive index profile of an optical fibre preform. The resolution function is shown to have similar Gaussian characteristics to that of the sampling beam at the centre plane of the preform, and this has been tested by measurements made on different preforms and with different beam diameters. The results show that the model predicts both the quantitative and qualitative behaviour of the resolution function correctly, which enables the comparison of the resolutions of different preform profil-

ing techniques, as well as assisting in the study of measurement anomalies. (Author abstract) 9 refs.

Svensen, D.A. (York Technology Ltd, Chandler's Ford, Engl). *IEE Proc Part J* v 135 n 3 Jun 1988 p 196-201.

**073970 (E)ESI DETERMINATION FROM MODE-FIELD DIAMETER AND REFRACTIVE INDEX PROFILE MEASUREMENTS ON SINGLE-MODE FIBRES.** We show, both experimentally and theoretically, that for single-mode fibres, the (E)ESI and MFD methods are interrelated in a self-consistent model with the theoretical cutoff wavelength playing a pivotal role. Three independent measurement approaches are examined: mode-field diameter measurements, preform profile measurements and fibre profile measurements. (Author abstract) 23 refs.

Martinez, F. (Univ of Southampton, Engl); Hussey, C.D. *IEE Proc Part J* v 135 n 3 Jun 1988 p 202-210.

**073971 EXPERIENCE WITH MODE-FIELD RADIUS MEASUREMENTS.** The transverse offsets, and variable-aperture far-field methods have been applied to the measurements of the mode-field radii of two types of single mode optical fibre. Comparison with the results of calculations based on the measured refractive index profiles shows that discrepancies between the experimental results by the two methods may be confidently attributed to the deviation of the electromagnetic field in the fibre from a Gaussian form. A possible alternative test method for measuring the numerical aperture of a parabolic-index multimode fibre is described. The paper includes a number of comments on the technical problems associated with the measurement methods. (Author abstract) 10 refs.

Fox, M. (BICC Systems Development Cent, Hemel Hempstead, Engl). *IEE Proc Part J* v 135 n 3 Jun 1988 p 211-214.

**073972 MEASUREMENT OF CHROMATIC DISPERSION IN INSTALLED SINGLE-MODE FIBRE.** The measurement of chromatic dispersion in single-mode fibres using a 1300 nm edge-emitting LED, a 1550 nm laser diode, and the phase shift method are described. The approach is insensitive to fibre temperature change throughout the measurement, and may enable dispersion in single-mode fibre optimised for 1300 nm operation to be characterised in the 1550 nm region, as well as in the 1300 nm region. The influence of the edge-emitting LED on the measurement is also considered, in that error can arise through selecting narrow wavelength regions of its output, and matching its wavelength coverage to the fibre zero dispersion region is important for long length characterisation. Measurements on installed SM fibres are discussed. (Author abstract) 11 refs.

Boothroyd, S.A. (Nat'l Research Council Canada, Ottawa, Ont, Can). *IEE Proc Part J* v 135 n 3 Jun 1988 p 215-219.

**073973 INTERMODAL AND INTRAMODAL DISPERSION MEASUREMENTS ON 1.3  $\mu$ m SINGLE-MODE FIBRE FOR USE AT 0.85  $\mu$ m.** Intermodal dispersion at 0.85  $\mu$ m, and intramodal dispersion in the range 0.75 to 1.5  $\mu$ m has been measured on single-mode fibres for use at 1.3  $\mu$ m. Results in good agreement with theoretical predictions show the fibres to be undercompensated at 0.85  $\mu$ m. The pulse spreading at 0.85  $\mu$ m in such fibres owing to intramodal dispersion is 0.24 ns/km for a 3 nm linewidth source. (Author abstract) 4 refs.

Byron, K.C. (STC Technology Ltd, Harlow, Engl); Ashworth, D.M. *IEE Proc Part J* v 135 n 3 Jun 1988 p 220-222.

**073974 1.55  $\mu$ m WAVELENGTH REGION HIGH-STABILITY OPTICAL FIBRE LOSS VARIATION MEASUREMENT USING FIBRE COUPLER.** In the development of an optical fibre submarine cable, high measurement accuracy is necessary to extrapolate the loss variation of a long optical fibre from the loss variation of a short fibre under testing in various environmental



conditions, such as tensile force, hydraulic pressure and ambient temperature variations. To evaluate a small loss variation in a short-length optical fibre cable of the order of 100-200 m<sup>2</sup> a measurement accuracy of 0.001 dB is necessary. A 1.55  $\mu$ m-wavelength high-stability optical fibre loss variation measurement system, using a comparison method with an optical fibre coupler, was developed. Long-term stability within  $\pm 0.001$  dB over a 120 hour period at a room temperature variation of  $\pm 2.2^\circ\text{C}$  has been achieved. (Edited author abstract). 5 Refs.

Namihira, Y. (KDD Meguro Research & Development Lab, Tokyo, Jpn); Horiuchi, Y.; Wakabayashi, H. *Electron Lett* v 24 n 13 Jun 23 1988 p 794-796.

**073975 DIRECT OBSERVATION OF OPTICAL WAVE BREAKING OF PICOSECOND PULSES IN NONLINEAR SINGLE-MODE OPTICAL FIBRES.** The combined use of a streak camera attached to a spectrograph allows the direct measurement of induced frequency modulation experienced by picosecond pulses during propagation through a single-mode fibre. Complete information is available in a single-shot event. As a result, optical wave breaking was observed. (Author abstract). 10 Refs.

Hamaide, J.P. (Univ Libre de Bruxelles, Brussels, Belg); Emplit, P. *Electron Lett* v 24 n 13 Jun 23 1988 p 818-819.

**073976 FIBER BIREFRINGENCE MEASUREMENTS WITH AN EXTERNAL STRESS METHOD AND HETERODYNE POLARIZATION DETECTION.** Precise birefringence measurements on polarization-maintaining fibers have been obtained with external pressure scanning along a fiber axis. Output detection has been performed through heterodyne interferometric polarimetry, which allows the use of a simplified technique (avoiding pressure modulation and fiber eigenaxis search). Beat-length evaluation is achieved directly through multiple counting of periodical variations of the two radio-frequency output signals provided by the polarimeter. A theoretical model for the behavior of the fiber output polarization on the Poincare sphere as a function of pressure scanning has been developed and experimentally tested and the results are in good agreement with the theory. 11 refs.

Calvani, Riccardo (CSELT, Turin, Italy); Caponi, Renato; Cisternino, Francesco; Coppa, Gianni. *J Lightwave Technol* v LT-5 n 9 Sep 1987, Opt Fiber Conf/Sixth Biennu Int Conf on Integr Opt and Opt Fiber Commun, Reno, NV, USA, Jan 19-22 1987 p 1176-1182.

**073977 TECHNIQUE FOR DIRECT MEASUREMENT OF SINGLE-MODE FIBER CHROMATIC DISPERSION.** The technique uses wavelength modulation to provide a differential fiber chromatic delay signal from which chromatic dispersion is obtained directly. The system is described in detail and practical measurement results shown to illustrate the high accuracy of the technique and its versatility in use with all fiber types. 14 refs.

Barlow, Arthur J. (EG&G, Bracknell, Engl); Jones, Roger S.; Forsyth, Keith W. *J Lightwave Technol* v LT-5 n 9 Sep 1987, Opt Fiber Conf/Sixth Biennu Int Conf on Integr Opt and Opt Fiber Commun, Reno, NV, USA, Jan 19-22 1987 p 1207-1213.

**073978 SPLICE LOSS MEASUREMENT USING LOCAL LAUNCH AND DETECT.** A method for measuring absolute splice loss using a local launch and detect technique is discussed. The theory of the procedure and the calibration routine are described. Results with single-mode fiber splices are presented and compared with the cutback measurements. 10 refs.

So, Vincent C.Y. (Bell Northern Research, Ottawa, Ont, Can); Hughes, Richard Pierre; Lamont, Jason Bentley; Vella, Paul Joseph. *J Lightwave Technol* v LT-5 n 12 p 1663-1666.

**073979 SUITABLE DEFINITION OF MODE FIELD DIAMETER IN VIEW OF SPLICE LOSS EVALUATION.** The definition of the mode field diameter

is investigated theoretically and experimentally from the practical viewpoint of the splice loss estimation. The difference of mode field diameter defined by various definitions becomes larger as the V number decreases. This tendency agrees with the experimental result. As a result, the definition of mode field diameter obtained from the rms width of far-field intensity is found to be useful. 7 refs.

Ohashi, Masaharu (NTT, Tokai, Jpn); Kuwaki, Nobuo; Uesugi, Naoshi. *J Lightwave Technol* v LT-5 n 12 p 1676-1679.

**073980 DISPERSION STATISTICS IN CONCATENATED SINGLE-MODE FIBERS.** Dispersion measurement data from two sets of fiber cable lengths were employed to determine the histograms of slope and wavelength of zero chromatic dispersion in concatenated single-mode fibers. A Monte Carlo technique was used under two concatenating scenarios, depending whether those fibers being concatenated are or are not manufactured by the same process. Results show that the variances of slope and wavelength of zero dispersion are inversely proportional to the number N of fiber cable lengths being concatenated. The average and standard deviation of zero-chromatic dispersion wavelength change less than 0.005% or 1%, respectively, when the actual dispersion slopes of individual fiber lengths being concatenated are replaced by random quantities distributed with uniformity within 0.08-0.1 ps/km-nm<sup>2</sup>. 22 refs.

Diaz de la Iglesia, Raimundo (Telefonica, Madrid, Spain); Tobias Azpitarte, Enrique. *J Lightwave Technol* v LT-5 n 12 p 1768-1772.

**073981 COLLOQUIUM ON OPTICAL FIBRE MEASUREMENTS.** This colloquium proceedings contains 14 papers, of which one appears in abstract form only. The papers are concerned with the measurement of various optical properties of optical fibers. Specific topics included are single mode optical fibers; refractive index profiles; optical fiber chromatic and inter modal dispersion; Fourier Transform Spectroscopy; rare-earth-doped optical fibers; Equivalent Step Index; Variable Aperture Far Field method; mode field determination; Equivalent Tube Index; non reciprocity; Effective Mode Indices; and Second harmonic generation in a second order susceptibility grating written into an optical fiber. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11368 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig* n 1987/55, Colloq on Opt Fibre Meas, London, Engl, May 1 1987. Publ by IEE, London, Engl, 1987 var pagings.

## Mechanical Properties

**073982 FIBRE OPTICS IN DYNAMIC STRAIN CABLES.** This article examines the development of a load carrying electro-optic cable assembly typically used for naval towed applications. As a full scale research and development exercise, different arrangements and positions of fiber optics were incorporated into the design to allow the evaluation of manufacturing parameters in order to determine suitability for long term operational use. Coupled with the design and manufacturing program was a series of land based and sea trials which have proven that an adequately ruggedized fiber optic element, if correctly positioned within the structure, is capable of withstanding all the rigors of operational service.

Smith, T.R. (STC Defence Systems, Newport, Wales); Carter, D.R. *Wire Ind* v 55 n 655 Jul 1988 p 477-485.

**Medical Applications** See Also BIOMEDICAL ENGINEERING—Remote Sensing.

**073983 MEDICAL NEEDS DRIVE IR FIBER DEVELOPMENT.** The major force behind today's IR fiber development is the urgent need for an IR fiber for medical laser applications. In general, it is desirable to have an

appropriate fiber for each type of laser used in medicine and surgery. In this article, the author discusses the fibers that can be used as delivery systems for IR lasers, and also gives some examples of IR fiber endoscopes that have been fabricated for use with CO<sub>2</sub> lasers. 7 refs.

Harrington, James A. *Photonics Spectra* v 21 n 7 Jul 1987 p 61-62, 64.

**Multiplexing** See OPTICAL COMMUNICATION EQUIPMENT—Design.

**Noise, Spurious Signal** See OPTICAL COMMUNICATION—Noise, Spurious Signal.

**Optical Properties** See Also GLASS—Optical Properties; GLASS—Optical Quality; WAVEGUIDE COMPONENTS—Couplers.

**073984 OPTIMUM FIBRE PARAMETERS OF LOW-LOSS SINGLE-MODE OPTICAL FIBRES FOR USE IN 1.55  $\mu$ m-WAVELENGTH REGION.** Design considerations are discussed for the structural optimization of 1.3  $\mu$ m zero-dispersion single-mode fibers for use in the 1.55  $\mu$ m-wavelength region. The ranges of optimum fiber parameters for mode field diam 2W and effective cutoff wavelength  $\lambda_{cc}$  are determined as  $2W = 10.5 \pm 1.0 \mu\text{m}$  and  $1.35 \mu\text{m} \leq \lambda_{cc} \leq 1.60 \mu\text{m}$ , respectively. A mean test fiber loss of 0.185 dB/km has been achieved. (Author abstract) 7 refs.

Namihira, Y. (KDD Research & Development Lab, Tokyo, Jpn); Horiuchi, Y.; Kuwazuru, M.; Nunokawa, M.; Iwamoto, Y. *Electron Lett* v 23 n 18 Aug 27 1987 p 963-964.

**073985 MODAL CALCULATIONS FOR OPTICAL FIBERS AND THEIR IMPACT ON PROCESSING.** A computer program has been developed that computes the propagation modes of an optical fiber from its index profile. The calculation is described briefly and then several examples illustrate its use in fiber design. The examples show how various processing decisions, such as whether or not to etch the center of the fiber, can be resolved. (Edited author abstract) 5 refs.

Lenahan, T.A. (AT&T Bell Lab, Norcross, GA, USA). *AIChE Symp Ser* v 83 n 258 1987, Fiber Opt Eng: Process and Appl (Pap from Natl AIChE Meet Held 1984-1986) p 17-20.

**073986 GENERATION OF SHORT PULSES FROM CW LIGHT BY INFLUENCE OF CROSS-PHASE MODULATION (CPM) IN OPTICAL FIBRES.** We demonstrate that crossphase modulation, imposed by a train of pulses on a weak cw signal in the wavelength region of anomalous fiber dispersion can induce the generation of short pulses (approximately 1 ps) at the signal wavelength. (Author abstract) 5 refs.

Schadt, D. (Inst of Optical Research, Stockholm, Swed); Jaskorzynska, B. *Electron Lett* v 23 n 20 Sep 24 1987 p 1090-1091.

**073987 SECOND-HARMONIC GENERATION IN SINGLE-MODE OPTICAL FIBRES.** We consider the origin of frequency-doubling in single-mode optical fibres. We show that the presence of nonlinear electric quadrupole and magnetic dipole moments can explain the initial formation of frequency-doubled light, and present the results of analysis of these effects which is in good agreement with experiment. (Edited author abstract) 7 refs.

Payne, F.P. (Univ of Cambridge, Cambridge, Engl). *Electron Lett* v 23 n 23 Nov 5 1987 p 1215-1216.

**073988 NONLINEAR POLARIZATION CHANGES IN A BIREFRINGENT FIBER.** The nonlinear evolution of the polarization state along a birefringent fiber has been numerically investigated using the Poincare sphere representation. The polarization changes of intense light in a birefringent fiber are governed by a competition between intrinsic and intensity-induced bire-



fringe. When the intrinsic birefringence is cancelled by the intensity-induced birefringence, the evolution of the polarization state along the fiber is sensitive to a small perturbation, i.e., a fluctuation of the birefringence. The trajectories of the polarization state exhibit a complex behavior. (Author abstract) 16 refs.

Kimura, Yasuo (NTT Electrical Communications Lab, Tokai, Jpn); Nakazawa, Masataka. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1503-1508.

**073989 DETERMINATION OF NONDIAGONAL COMPONENT  $n_{2B1}$  OF NONLINEAR REFRACTIVE INDEX IN POLARISATION-MAINTAINING FIBRES UTILISING OPTICAL KERR MODULATION SCHEME.** The nondiagonal component  $n_{2B1}$  of the nonlinear refractive index is measured relative to the diagonal component  $n_{2B1}$  in polarization-maintaining fibers utilizing optical Kerr modulation properties in the presence of chromatic and polarization dispersion. The ratio  $n_{2B1}/n_{2B1}$  is determined to be 0.34 and is in good agreement with the theoretical prediction of 1/3, which assumes isotropic media and a pure electronic contribution. (Author abstract) 5 refs.

Morioka, T. (NTT Lab, Yokosuka, Jpn); Saruwatari, M. *Electron Lett* v 23 n 24 Nov 19 1987 p 1330-1332.

**073990 PROPERTIES OF PICVD-FIBERS WITH PURE  $\text{SiO}_2$ -CORE: THE INFLUENCE OF THE PREFORM COLLAPSE PROCESS.** Collapsing of preforms with low OH-content and pure  $\text{SiO}_2$  core oxygen rich atmosphere generates characteristic losses after fiber drawing. The losses consist of additional attenuation at 630 nm and 850 nm and an additional wavelength independent attenuation correlated to the value of both other attenuations. Using an appropriate collapsing technique allows for the preparation of low-loss fibers with pure  $\text{SiO}_2$  core. (Author abstract) 4 refs.

Bauch, H. (SCHOTT Glaswerke, Mainz, West Ger); Paquet, V.; Siefert, W. *J Opt Commun* v 8 n 4 Dec 1987 p 140-142.

**073991 LENGTH AND CURVATURE EFFECTS ON THE EFFECT CUTOFF WAVELENGTH OF MONOMODE OPTICAL FIBERS.** On the basis of experimental results, the combined effects of length and curvature on the monomode fiber effective cutoff wavelength  $\lambda_{cc}$  is analyzed and discussed. Prediction of  $\lambda_{cc}$  in conditions different from the experimental ones is also shown as feasible. (Author abstract) 6 refs.

Bassi, Paolo (Univ di Bologna, Bologna, Italy); Zoboli, Maurizio. *Opt Commun* v 65 n 3 Feb 1 1988 p 189-192.

**073992 REFLECTIONS FROM POLISHED SINGLE MODE FIBER ENDS.** When the end of a single mode fiber is polished and placed in an index-matching liquid, a reflection will occur. Its amplitude depends on two factors: (1) the difference between the liquid's refractive index and that of the fiber, and (2) the polishing procedure used. By proper choice of both, the end-reflection can be reduced to below -60 db. When two well-polished fiber ends are joined together with a small, liquid-filled gap between them, the resulting reflection will be coherent addition of the two individual end-reflections. By adjusting the gap, this reflection can be made greater than or less than the individual end-reflections. (Author abstract) 10 refs.

Judy, A.F. (AT&T Bell Lab, Norcross, GA, USA); Neysmith, H.E.S. *Fiber Integr Opt* v 7 n 1 1988 p 17-26.

**073993 CHARACTERISTICS OF PURE SILICA CORE SINGLE-MODE FIBER.** There are two types of the  $\text{SiO}_2$  core single-mode fiber. Type I fiber is fabricated by MCVD process and has a silica jacket in its outer cladding layer. Type II fiber is fabricated by VAD process. This fiber has a pure silica core and a cladding layer which consists of silica with fluorine uniformly added throughout the entire cladding region, achieves a 'matched cladding structure,' and has nearly the same fiber structural parameters as the conventional  $\text{GeO}_2$ - $\text{SiO}_2$  core fibers. This fiber is designed for use in both 1.3  $\mu\text{m}$  and

1.55  $\mu\text{m}$  wavelength. Some characteristics of practical use of the Type II fiber which we have developed are reviewed. 12 refs.

Tanaka, Gotaro (Yokohama Research Lab, Yokohama, Jpn); Watanabe, Minoru; Yano, Koji. *Fiber Integr Opt* v 7 n 1 1988 p 47-56.

**073994 TIME DOMAIN MEASUREMENT OF DISPERSION IN OPTICAL FIBRES.** A time domain dispersion measurement apparatus was successfully built and tested at the Indian Institute of Technology, Madras. This instrument can measure directly the pulse broadening in a multimode optical fiber. The basic dispersion mechanisms in optical fibers and the design of the system are discussed. (Author abstract) 7 refs.

Vivek, S. (TIFR, Bangalore, India); Raina, J.P. *Opt Laser Technol* v 20 n 1 Feb 1988 p 39-44.

**073995 INFLUENCE OF PHASE FLUCTUATIONS ON OPTICAL-SOLITON PARAMETERS IN FIBER LIGHTGUIDES.** The dynamics of propagation of the envelope of an optical pulse of picosecond duration in a fiber lightguide in analytically and numerically investigated. On the basis of the inverse-problem method, the influence of phase noise on the soliton parameters in the remote region of the lightguide is considered. The statistical characteristics of the soliton ensemble are analyzed. (Author abstract) 12 refs.

Ivanov, A.V.; Matveev, A.N. *Moscow Univ Phys Bull* v 42 n 5 1987 p 89-93.

**073996 WAVELENGTH DEPENDENCE OF BRILLOUIN-GAIN SPECTRA FOR SINGLE-MODE OPTICAL FIBRES.** Brillouin-gain profiles are measured for fused-silica core and  $\text{GeO}_2$ -doped core fibres at wavelengths of 1286 nm and 1550 nm. The intrinsic Brillouin linewidth is found to vary as the square of optical frequency, as predicted for bulk fused-silica. However, the experimentally evaluated Brillouin line-widths at both wavelengths are broader by a factor of 2.5 than those predicted for the bulk glass. (Author abstract) 9 refs.

Azuma, V. (NTT Transmission Systems Lab, Tokai-mura, Jpn); Shibata, N.; Horiguchi, T.; Tateda, M. *Electron Lett* v 24 n 5 Mar 3 1988 p 250-252.

**073997 SINGLEMODE-LICHTWELLENLEITER. GRUNDLEGENDE EINFUEHRUNG IN PHYSIK UND ANWENDUNG.** [Single-Mode Optical fibers. Basic Introduction into Physics and Application]. The fundamental characteristics of single-mode optical fibers are considered, and a comparison is made with multimode fibers. It is pointed out that in certain applications, such as long-distance data transmission, multimode fibers are being avoided in preference of their single-mode counterparts. In German. 4 refs.

Winkelmann, Helmut. *Elektronik* v 37 n 3 Feb 5 1988 p 102-106, 108-109.

**073998 FIBER OPTIC TRENDS: POLARIZATION PRESERVING FIBER AND SENSORS.** As the demand for fiber optic sensors grows, polarization preserving fiber is coming into its own. Polarization preserving fiber is the name given to a type of single-mode fiber that provides a medium for the transmission of stable linear polarized light. This article looks at polarization preserving (pp) fibers - what they are and their applications.

Brambley, Roger J. *Photonics Spectra* v 22 n 4 Apr 1988 p 99-100, 102.

**073999 PHOTOCROMIC BEHAVIOUR OF THULIUM-DOPED SILICA OPTICAL FIBRES.** There has been a recent increase in interest in optical fibres which exhibit enhanced nonlinear behavior by virtue of the inclusion of rare-earth ions in the silica host glass. Photochromic behavior in optical fibres has been observed previously, and photorefractive effects have been noted in rare-earth doped silicate and phosphate glasses. We report the observation of the photochromic effect in thulium ( $\text{Tm}^{3+}$ )-doped silica optical fibres. 6 refs.

Millar, C.A. (British Telecom Research Lab, Ipswich, Engl); Mallinson, S.R.; Ainslie, B.J.; Craig, S.P. *Electron Lett* v 24 n 10 May 12 1988 p 590-591.

**074000 RESULTS OF EXPERIMENTAL INVESTIGATION INTO THE BIREFRINGENCE OF POLARIZATION-MAINTAINING FIBERS WITH STRESS-APPLYING PARTS BY MEANS OF PHOTOELASTICITY.** Regular configurations of stress-applied polarization-maintaining fibers are divided into four groups according to the shape of stress-applying parts on both sides of a fiber core. By means of a photoelastic method mechanical stresses inside these fibers are analysed. Stress patterns and graphs of induced birefringence of representative types are shown. Ultrasonic drilling is proposed to be a convenient technique for fabrication of new types of polarization-maintaining fibers. (Author abstract). 6 refs.

Stadnik, B. (Czechoslovak Acad of Sciences, Prague, Czech); Berka, L.; Kratena, J.; Doupovec, J. *J Opt Commun* v 9 n 2 Jun 1988 p 59-63.

**074001 SINGLE-MODE FIBRES WITH EXTREMELY HIGH- $\Delta$  AND SMALL-DIMENSION PURE  $\text{GeO}_2$  CORE FOR EFFICIENT NONLINEAR OPTICAL APPLICATION.** Single-mode fibres with 8.2 percent  $\Delta$  and a 1.4 minimum diameter- $\text{GeO}_2$  core have been prepared for efficient stimulated Raman effect. When pumping a 2.7 m-long fibre by a Q-switched and mode-locked Nd:YAG laser ( $\lambda = 1.064 \mu\text{m}$ ), the first Stokes light ( $\lambda = 1.114 \mu\text{m}$ ) and second Stokes light ( $\lambda = 1.169 \mu\text{m}$ ) have been observed at the input peak power levels of 24 W and 40 W, respectively. These results indicate that the above critical power levels are approximately  $10^{-2}$  to  $10^{-3}$  smaller than those for the high-silica single-mode fibre. (Author abstract). 5 refs.

Hosaka, T. (NTT, Atsugi, Jpn); Sudo, S.; Itoh, H.; Okamoto, K. *Electron Lett* v 24 n 13 Jun 23 1988 p 770-771.

**074002 DISPERSION-FLATTENED SINGLE-MODE FIBRES WITH MINIMISED DOPANT EXPENDITURE.** The fibre profile which meets certain requirements concerning chromatic dispersion, mode field diameter, attenuation and cut-off at minimal dopant expenditure is defined as natural refractive index profile. In the case of a dispersion-flattened single-mode fibre, this profile is of the QC-type, with interesting further structures. (Author abstract). 7 refs.

Fotheringham, U. (Schott Glaswerke, Mainz, West Ger). *Electron Lett* v 24 n 13 Jun 23 1988 p 801-803.

**074003 NONLINEAR OPTICAL PROPERTIES FOR HIGH- $\Delta$ , SMALL-CORE SINGLE-MODE FIBRES.** Nonlinear optical properties of high- $\Delta$ , small-core single-mode fibers were investigated. Results indicated that such fibers have low stimulated Raman scattering critical powers and large frequency chirping. Forty-three percent coupling efficiency was achieved in direct coupling between high- $\Delta$  fibers and an edge-emitting LED. (Edited author abstract). 8 refs.

Itoh, H. (NTT Optoelectronics Lab, Atsugi, Jpn); Sudo, S.; Hosaka, T.; Okamoto, K. *Electron Lett* v 24 n 14 Jul 7 1988 p 870-872.

**074004 FREQUENCY-DOUBLING BY MODAL PHASE MATCHING IN POLED OPTICAL FIBRES.** We induce a permanent second-order nonlinearity in phosphorous and germania doped optical fibers via simultaneous excitation and orientation of defect centers. Modal phase matching is used for frequency-doubling of 1.208  $\mu\text{m}$  radiation and we investigate the effect of nonuniform nonlinearities on the second-harmonic conversion efficiency. (Author abstract). 5 refs.

Fermann, M.E. (Univ of Southampton, Southampton, Engl); Li, L.; Farries, M.C.; Payne, D.N. *Electron Lett* v 24 n 14 Jul 7 1988 p 894-895.



**074005 TWO-PHOTON ABSORPTION IN SILICA OPTICAL FIBERS MEASURED WITH A XeBr EXCIMER LASER.** Two-photon absorption in ultraviolet-grade silica optical fibers is measured with a 282-nm XeBr excimer laser. The two-photon absorption coefficient is  $5 \times 10^{-6} \pm 20\%$  cm/MW. The two-photon absorption is not resonance-enhanced but intrinsic at this wavelength. The calculated value based on Keldysh formula is also presented and compared with the measured one. (Author abstract). 17 refs.

Mizunami, Toru (Kyushu Inst of Technology, Kitakyushu, Jpn); Takagi, Keiji. *Opt Commun* v 68 n 3 Oct 1 1988 p 223-227.

**074006 LONG-LENGTH LOW-LOSS POLARIZATION-MAINTAINING FIBERS.** Long-length low-loss polarization-maintaining fibers are useful for coherent optical transmission systems, active transmission lines with optical nonlinear effects, and other long-length optical transmission systems, such as those for bidirectional optical transmission. Design, fabrication, and characteristics of highly birefringent polarization-maintaining fibers with long length and low loss, especially polarization-maintaining and absorption-reducing (PANDA) fibers, are reviewed and discussed. Application of the fibers is also discussed. 28 refs.

Sasaki, Yutaka (NTT, Tokai, Jpn). *J Lightwave Technol* v LT-5 n 9 Sep 1987, Opt Fiber Conf/Sixth Biannual Int Conf on Integr Opt and Opt Fiber Commun, Reno, NV, USA, Jan 19-22 1987 p 1139-1146.

**074007 SINGLE-MODE FIBER COMPONENTS.** A review is presented of a variety of optical components made directly from single-mode fibers. The review first treats both ordinary and polarization-preserving fibers. The discussion of components is divided into passive and active components. Passive components include polarizers and directional couplers, as well as a discussion of splicing of polarization-preserving fibers. Active components require some external control or optical power. These components include polarization transformers, modulators, and optical amplifiers. It is noted that these components can be combined to construct inline all-fiber systems such as fiber gyroscopes, fiber Raman lasers, local area networks, or coherent lightwave systems. 122 refs.

Stolen, Roger H. (AT&T Bell Lab, Holmdel, NJ, USA); De Paula, Ramon P. *Proc IEEE* v 75 n 11 p 1498-1511.

**074008 COUPLED MODES OF ANISOTROPIC POLARIZATION MAINTAINING FIBERS.** Wave coupling between the fundamental vector modal fields of two identical, polarization-maintaining, weakly guiding fibers is analyzed. An improved coupled-mode theory is used that also applies to anisotropic materials. Coupling coefficients that are the elements of a coupling matrix are calculated and presented as functions of the relative tilt angle between the two fiber principal axes. Exact analytical expressions for the eigenvalues and their associated eigenvectors are given in terms of the elements of this coupling matrix, for any relative tilt angle. Symmetry relations that are found between elements of the coupling matrix much simplify the presentation of the eigenvectors. A weak-coupling approximation of the eigenvector expressions, which is also given, retains their qualitative properties. 9 refs.

Shafir, Ehud (Soreq Nuclear Research Cent, Yavne, Isr); Hardy, Amos; Tur, Moshe. *J Lightwave Technol* v 6 n 1 Jan 1988 p 58-63.

**074009 RADIATION RESISTIVITY IN SILICA OPTICAL FIBERS.** Hydrogen treatment of optical fiber waveguides with pure silica cores and boron, fluorine codoped silica claddings was found to effectively reduce the  $\gamma$ -ray induced loss increases in visible wavelength region. Germanium-doped core fibers free from metal impurities had good resistance against  $\gamma$ -rays. The induced losses were shown to be dependent on the dose rate, a similar behavior to that of pure silica core fibers. Metal impurities such as phosphorus or alkalis added to germanium doped silica core were found to change the glass

structure significantly, producing the precursors of a defect center related to the  $\gamma$ -ray-induced loss and increasing sensitivity to  $\gamma$ -irradiation. 11 refs.

Iino, Akira (Furukawa Electric Co, Ichihara, Jpn); Tamura, Junich. *J Lightwave Technol* v 6 n 2 Feb 1988 p 145-149.

**074010 OPTICAL AND MECHANICAL PROPERTIES OF INFRARED FIBERS.** Optical and mechanical properties have been investigated for  $As_2S_3$  and  $As_2Se_3$  glass fibers and a KRS-5 polycrystalline fiber. A bending effect was serious for a KRS-5 fiber but not for chalcogenide fibers. In an aging test, a KRS-5 fiber showed a deterioration of transmissivity due to adsorption of moisture as well as plastic deformation of the crystal. Optical loss spectra of chalcogenide fibers were observed to change characteristically due to environmental factors such as humidity, high temperature, and ultraviolet radiation. The potential usefulness of these fibers is discussed. 17 refs.

Saito, Mitsunori (Tohoku Univ, Sendai, Jpn); Takizawa, Masaya; Miyagi, Mitsunobu. *J Lightwave Technol* v 6 n 2 Feb 1988 p 233-239.

**074011 PROPAGATION CONSTANT AND WAVEGUIDE DISPERSION OF SINGLE-MODE FIBERS MEASURED FROM THE FAR-FIELD.** Wave-length-dependent measurements of the far-field pattern can be evaluated to yield a mode-field radius. It was recently proposed to fit these data to a formula that contained all the parameters necessary to construct an empirical relation for the wavelength dependence of the propagation constant. The authors report on the feasibility of this technique, using actual measurement data. They discuss the calculation of the waveguide dispersion from the measured mode-field radius. In both cases the choice of the empirical fitting function proves to be of great importance. 5 refs.

Freude, Wolfgang (Shanghai Univ of Science & Technology, China); Yao, Hui-hai; He, Zhi-jian. *J Lightwave Technol* v 6 n 2 Feb 1988 p 318-321.

**Performance** See Also FIBER OPTICS—Applications.

**074012 VECTOR MODES OF SIX-PORT COUPLERS.** The polarization patterns for the first six vector modes of six-port couplers with either ideal equilateral or nonideal isosceles cross-sections are determined using formal perturbation theory. They are shown to bear a close similarity with the corresponding modal patterns of a circularly symmetric fiber or an elliptical fiber, respectively. (Author abstract) 3 refs.

Stevenson, A.J. (Australian Natl Univ, Canberra, Aust); Love, J.D. *Electron Lett* v 23 n 19 Sep 10 1987 p 1011-1013.

**074013 FEMTOSECOND SINGLE-PASS CASCADE RAMAN SOLITON GENERATION AT 1.5  $\mu$ M.** High efficiency generation of 130 fs pulses at 1.5  $\mu$ m, through a single-pass cascade Raman soliton-like compression-amplification process in a single-mode fiber is described. The dispersion-shifted fiber with a zero-dispersion wavelength at 1.46  $\mu$ m, was pumped by the 100 ps pulses from a cw mode-locked Nd:YAG laser operated at 1.32  $\mu$ m. (Author abstract) 10 refs.

Gouveia-Neto, A.S. (Imperial Coll, London, Engl); Gomes, A.S.L.; Taylor, J.R.; Ainslie, B.J.; Graig, S.P. *Electron Lett* v 23 n 19 Sep 10 1987 p 1034-1035.

**074014 BIREFRINGENCE AND POLARIZATION CHARACTERISTICS OF SOLITON IN A SINGLE-MODE OPTICAL FIBER UNDER ELASTIC DEFORMATION.** The influences of elastic deformation on the soliton propagation characteristics in a single-mode optical fiber are studied by treating the deformation as perturbations. It is indicated that the deformation also can cause polarization, dispersions and birefringences in soliton propagations, as in conventional propagation. (Author abstract) In Chinese. 3 refs.

Zhou, Guosheng (Shangxi Univ, Taiyuan, China); Li, Xuenong. *Guangxue Xuebao* v 7 n 7 Jul 1987 p 656-661.

**074015 LIGHT PROPAGATION IN ACTIVE FIBERS.** In this paper we deduce the equations of motion for both cw and long-pulse light in active fibers. We then solve the equations under zero-order and first-order perturbations by using the quantum theory about the polarization of an active material. We give a quantitative description of the evolutions of amplitudes and phases of the cw and long-pulse light, and discuss the influence of the active material on the group velocity of the long pulse light. (Author abstract) 10 refs. In Chinese.

Weng Tingdun (Shanxi Univ, Taiyuan, China); Zhong Guosheng. *Guangxue Xuebao* v 7 n 12 Dec 1987 p 1106-1111.

**074016 LIMITATION OF TRANSMISSION DISTANCE AND CAPACITY DUE TO POLARISATION DISPERSION IN A LIGHTWAVE SYSTEM.** The length dependence of group delay differences between orthogonally polarized modes has been investigated experimentally for real single-mode fibers ranging from 0.1 km to 100 km. The mean group delay difference is a constant value of 0.67 ps, over a length of more than 1 km. The mode coupling coefficient of random mode mixing which causes pulse broadening has been estimated to be  $6.13 \times 10^{-3} \text{ m}^{-1}$ . A light pulse will broaden by 17 ps after traversing a 100 km-long fiber. This may restrict single-mode fiber systems to a bit rate of 10GHz for lengths over 150 km. (Author abstract) 10 refs.

Tsubokawa, M. (NTT, Tokai, Jpn); Sasaki, Y. *Electron Lett* v 24 n 6 Mar 17 1988 p 350-352.

**074017 MAGNETOOPTIC EFFECT OF SINGLE-MODE FIBERS.** In investigating the polarization property and magneto-optic effect of single-mode fiber, we need to consider not only its Faraday effect but also its birefringence. In this paper, the theory of the magneto-optic effect of the single-mode fiber is described with the Jones matrix. The Jones matrix expressing the birefringence and magneto-optic effect of the single-mode fiber is derived. And the relation between the output light intensity and Faraday rotation angle of current sensor system is presented using Mueller matrix. (Author abstract) In Chinese. 9 refs.

Chen Xikun (Shanghai Univ of Science & Technology, China); Zong Weiyong. *Guangxue Xuebao* v 8 n 3 Mar 1988 p 276-280.

**074018 COUPLING BETWEEN TWO DOUBLY CLADDING SINGLE MODE FIBERS.** An accurate analytic expression of coupling coefficient between two parallel doubly cladding single mode fibers is given in this paper. The coupling coefficients as a function of normalized frequency parameter  $V$  are calculated for fibers with raised, matched, and depressed inner cladding indices. The coupling coefficients as a function of normalized distance  $D/a$  are also given with different  $V$ . The formula can be used to compute both the coupling coefficients for both x-polarized modes and the coupling of y-polarized modes further. It can also be used to analyze the coupling between two fibers with their large refractive-index difference, as well as polarization characteristics of optical fiber couplers. (Author abstract) 7 refs. In Chinese.

Chen, Zhihao (Fujian Teachers Univ, China); Yao, Huihai. *Guangxue Xuebao* v 8 n 4 Apr 1988 p 379-384.

**074019 POLARISATION-MAINTAINING FIBRE COUPLES WITH MISALIGNED BIREFRINGENT AXES.** A recently developed formulation of the coupling between polarisation maintaining fibers is applied to the study of the dependence of the properties of tunable polarisation maintaining couplers on the angular misalignment between the transversal principal axes of the two individual fibers. When the cores are close enough it is shown that while the same coupling ratio can be obtained at several transversal settings of the coupler,



different behaviour is exhibited by the extinction ratio. For a transversely tunable coupler made of 3 mm beat-length fibers with a 5° misalignment, two 3 dB settings result in polarisation isolations of 18 dB and 40 dB. (Edited author abstract) 9 Refs.

Shafir, E. (Soreq Nuclear Research Cent, Yavne, Isr); Hardy, A.; Tur, M. *Electron Lett* v 24 n 12 Jun 9 1988 p 754-756.

**074020 UNIVERSAL SINGLE-MODE DISPERSION-FLATTENED FLUORIDE FIBRE DESIGNED FOR OPTIMUM PERFORMANCE FROM 1.5 TO 2.9  $\mu\text{m}$ .** A simple step-index with depressed-cladding single-mode fluoride fiber gives excellent dispersion flattening over a broad spectral range, 1.5-2.9  $\mu\text{m}$ . The extrinsic losses due to macrobending, microbending and splicing are minimized. This design enables the use of fluoride fibers at about 1.55  $\mu\text{m}$  and later can be upgraded to 2.55  $\mu\text{m}$ , where predicted losses are significantly less than those of silica fibers at 1.55  $\mu\text{m}$ . (Edited author abstract) 9 Refs.

Sunak, H.R.D. (Univ of Rhode Island, Kingston, RI, USA); Bastien, S.P. *Electron Lett* v 24 n 14 Jul 7 1988 p 879-880.

**074021 SINGLE-MODE FIBRES OPERATING AT FEW-MODE WAVELENGTHS.** There are communication systems where the initial requirement is for moderate bit-rates and transmission distances, but where the ability to upgrade for future applications is important. One way of designing such a system may be to combine readily available low-loss, high-bandwidth single-mode fibres, designed for optimum performance at  $\lambda = 1.3 \mu\text{m}$ , with economical and reliable LEDs that emit light at  $\lambda = 0.85 \mu\text{m}$ . Such a system would no longer be single-mode; the consequences for fibre loss and dispersion of allowing the second mode to propagate are examined and used to predict the performance limits for a two-mode fibre system. (Edited author abstract) 10 Refs.

Garth, S.J. (Univ Coll, Campbell, Aust); Pask, C.; Sammut, R.A. *Opt Quantum Electron* v 20 n 4 Jul 1988 p 301-312.

**074022 DEMODULATION SCHEME FOR POLARIMETRIC OPTICAL FIBRE SENSORS USING DERIVATIVE TECHNIQUE.** A demodulation method for polarimetric optical fibre sensors is described and demonstrated. Two signals with a  $\pi/2$  phase difference are generated from the sensor output signal and its first derivative with respect to the phase. This method does not require strict modulation conditions for the laser source. (Author abstract) 8 Refs.

Tsuchida, H. (Electrotechnical Lab, Tsukuba, Jpn); Mitsuhashi, Y.; Ishihara, S. *Electron Lett* v 24 n 15 Jul 21 1988 p 938-940.

**074023 THERMO-OPTICAL INTERACTIONS IN OPTICAL FIBRES CAUSED BY AXIAL HEAT-FLUX PROPAGATION.** Mode distribution changes were observed when fiber cladding was locally heated by a focused C.W. laser. The time-evolution of mode-coupling was experimentally obtained with the help of a linear photodiode array. A simplified theoretical model of fiber axial temperature flow gave a good agreement with experiment. (Author abstract) 7 Refs.

Tankovsky, N.S. (Sofia Univ, Sofia, Bulg); Yordanov, B.L. *Opt Acta* v 35 n 7 Jul 1988 p 1245-1250.

**074024 CHARACTERIZATION OF SINGLE MODE FIBRES FOR COHERENT SYSTEMS.** In the last few years the use of single-mode fibers has grown and the relevant parameters of interest in the system design have been identified and measured. At the same time the values achieved for attenuation and dispersion coefficient have nearly reached theoretical limits so that the future improvement of system performances will rely only on transmitted power increase and/or coherent detection use. A further step will be the use of WDM or FDM systems to increase the information carrying capacity of the single fiber. In view of these developments further characteriza-

tion of the fiber will be needed, mainly dealing with polarization properties and nonlinear effects. (Author abstract) 44 Refs.

Costa, B. (CSELT, Turin, Italy); De Marchis, G. *CSELT Tech Rep* v 16 n 2 Mar 1988, GLOBECOM '87 - IEEE/IEICE Global Telecommun Conf, Tokyo, Jpn, Nov 15-18 1987 p 79-85.

**074025 ULTRAVIOLET PULSE TRANSMISSION IN OPTICAL FIBRES.** This paper explores the limitations of silica fibers for pulsed u.v. transmission and reports photodegradation limits and power density performance characteristics. Technical innovations to extend the operating capabilities of optical fibers for the u.v. are described. These include the use of special designs of input fiber taper sections, to change the damage threshold from that of the surface to that of the bulk, and the design and performance of flexible fluid-filled fibers of increased cross-sectional area. (Edited author abstract) 29 Refs.

Whitehurst, C. (Manchester Univ, Manchester, Engl); Dickinson, M.R.; King, T.A. *J Mod Opt* v 35 n 3 Mar 1988, Eighth Natl Quantum Electron Conf, St. Andrews, Scotl, Sep 21-25 1988 p 371-385.

**074026 EVOLUTION OF CIRCULARLY POLARIZED PULSES IN NONLINEAR OPTICAL FIBRES.** The discussion in this paper is centered upon the evolution of circularly polarized pulses for a length of optical fiber in which the beat length and pulse height remain constant, but the size of the group velocity dispersion is varied. The paper essentially contains a preview of work in progress on a penetration into a rather difficult parameter space. It begins with an overview of the concept of critical power and stability and then follows a route from the existing body of c.w. work on nonlinear birefringence into the soliton regime. Although this is a difficult area, the general aim is to test the validity of certain critical power conclusions that have arisen in the c.w. case, as a transition from c.w. propagation to pulse mode is made. The preliminary calculations reported here seem to indicate that the clear-cut features of the c.w. case are not maintained. (Author abstract) 14 Refs.

Boardman, A.D. (Univ of Salford, Salford, Engl); Cooper, G.S. *J Mod Opt* v 35 n 3 Mar 1988, Eighth Natl Quantum Electron Conf, St. Andrews, Scotl, Sep 21-25 1988 p 407-417.

**074027 INVESTIGATION ON HYDROGEN INDUCED EFFECTS ON OPTICAL CABLES AND POSSIBLE COUNTERMEASURES.** Several multi-mode and monomode fibres have been tested under hydrogen exposition in order to identify the three mechanisms contributing to the fibres' loss increase and to quantitatively characterize their effects as a function of composition, structure, time,  $\text{H}_2$  pressure and temperature. As a possible countermeasure hydrogen chemical absorber materials have been developed. (Author abstract) 6 Refs.

Anelli, P. (Soc Cavi Pirelli, Milan, Italy); Esposto, F.; Grasso, G.; Modone, E.; Sordo, B. *CSELT Tech Rep* v 13 n 5 Oct 1985, IOOC-ECOC '85 (5th Int Conf on Integr Opt and Opt Fibre Commun - 11th Eur Conf on Opt Commun), Venice, Italy, Oct 1-4 1985 p 317-321.

## Physical Properties

**074028 CHARACTERISTICS OF DISPERSION-SHIFTED FIBERS.** This paper describes the bending property and dispersion controllability of dual shape core (DSC) and  $\alpha$ -index core fibers that have zero dispersion at 1.55  $\mu\text{m}$ . The bending characteristics are examined at constant splice loss. DSC fiber has a smaller bending loss than  $\alpha$ -index core fiber, and better bending characteristics than with the 1.3  $\mu\text{m}$ -optimized fiber can be expected. Dispersion controllability of a DSC fiber is also superior to that of an  $\alpha$ -index core fiber. (Author abstract) 13 Refs. In Japanese.

Ohashi, Masaharu (NTT Ibaraki Electrical Communications Lab, Jpn); Kuwaki, Nobuo; Tanaka, Chihaya; Uesugi, Naoshi. *Denki Tsushin Kenkyusho Kenkyu*

*Jitsuyoka Hokoku* v 36 n 7 1987 p 935-941.

**074029 BEND LOSSES OF HIGHER-ORDER MODES IN DISPERSION-FLATTENED MULTIPLE-CLAD OPTICAL FIBRES.** The bending losses and effective cutoff wavelengths of the disturbing  $\text{LP}_{11}$  and  $\text{LP}_{02}$  modes in dispersion-flattened, multiple-clad, quasi-single-mode fibers have been evaluated numerically. Even when the theoretical cutoff wavelengths of the  $\text{LP}_{11}$  and  $\text{LP}_{02}$  modes are within the usual interval of operating wavelengths ( $1.3 < \lambda < 1.7 \mu\text{m}$ ), because of the extremely large bending losses of these modes, the effective cutoff wavelength can be below 1.3  $\mu\text{m}$ . These fibers are thus effectively single-mode. (Author abstract) 9 Refs.

Schwierz, H. (Bergische Univ Wuppertal, Wuppertal, West Ger); Neumann, E.-G. *Electron Lett* v 23 n 24 Nov 19 1987 p 1296-1298.

**074030 KERR MODULATION OF SIGNALS AT 1.3 AND 1.5  $\mu\text{m}$  IN POLARISATION-MAINTAINING FIBRES PUMPED AT 1.06  $\mu\text{m}$ .** Optically induced high-speed modulation of the output of semiconductor lasers at 1.3 and 1.5  $\mu\text{m}$  has been achieved in polarization-maintaining fibers pumped with the output from an Nd:YAG laser. (Author abstract) 8 Refs.

Byron, K.C. (STC Technology Ltd, Harlow, Engl). *Electron Lett* v 23 n 24 Nov 19 1987 p 1324-1326.

**074031 WORLDWIDE STATUS OF DISPERSION-MODIFIED SINGLE-MODE FIBRES.** The state of the art in the field of dispersion-flattened and dispersion-shifted fibers is reviewed with emphasis on the preparation of dispersion-flattened fibers by means of the low pressure plasma activated chemical vapor deposition process. Dispersion data, loss characteristics and, where available, coupling, splicing, and bending performance of fibers with various refractive index profiles are compared to the corresponding data of conventional single-mode fibers. (Edited author abstract) 38 Refs.

Bachmann, P.K. (Philips GmbH, Forschungslaboratorium, Aachen, West Ger). *Philips J Res* v 42 n 4 Nov 23 1987 p 435-450.

**074032 OPTICAL FIBRE AS SENSORS.** The temperature, refractive index, concentration and other environmental conditions surrounding the fiber is being sensed in terms of loss characteristics of different conditions of fiber. The loss characteristics of fiber by liquid over unclad fiber or tapered fiber (with or without clad) and also liquid over core clad behaving as three region fiber in the leaky ray zone are analyzed and verified with experimental results. The simplicity and the sensitivity of the liquid characteristics for the different systems are shown. (Author abstract) 9 Refs.

Das, A.K. (Jadavpur Univ, Calcutta, India); Banerjee, S.; Mandal, A.K. *J Inst Eng India Part ET* v 68 pt 1 Aug 1987 p 24-28.

## Polishing

**074033 NEW APPROACHES TO TERMINATION.** Efficient light transmission via fiber requires minimal losses at each termination - those breakable or nonbreakable connections used to mate fibers, transmitting and receiving equipment, and other active and passive devices. Currently, there are three prevalent fiber optic termination applications: telecommunications, data communications and medicine. Polishing of fiber ends requires different techniques for different applications. And the requirements are growing along with a host of new applications. This paper discusses the use of polishing as a means of producing efficient low-light-loss terminations.

Drexel, R. Patrick; Nelson, James A.; Schneckner, John. *Photonics Spectra* v 22 n 3 Mar 1988 p 101-102, 104, 106.

**074034 OPTICAL FIBRE POLISHING WITH A MOTOR-DRIVEN POLISHING WHEEL.** A whole range of optical fibre components-from couplers to modu-



lators and switches—can be achieved by interacting with the evanescent field of an optical fibre. The polishing of optical fibres is demonstrated using an abrasive polishing wheel. The approach requires that only the fibre itself is polished and allows arbitrarily long interaction lengths to be generated with losses of less than 0.1 dB. (Edited author abstract). 3 Refs.

Hussey, C.D. (Univ of Southampton, Southampton, Engl); Minelly, J.D. *Electron Lett* v 24 n 13 Jun 23 1988 p 805-807.

## Production

**074035 HIGH-SPEED DRAWING AND COATING SYSTEM FOR OPTICAL FIBERS.** Kobe Steel has recently put on the market a high-speed optical fiber drawing system. This report describes the details of the components including the high-performance drawing furnace, pressurized coating die, and high-precision fiber diameter control apparatus. This system makes possible the low-cost production of optical fibers with high quality. (Author abstract) 1 ref. In Japanese.

Akita, Toshiaki; Nagaoka, Tatsuo. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 25-27.

**074036 OPTICAL FIBRE PRODUCTION AND MEASUREMENT.** Excellent quality graded-index and single-mode fibres can be produced by the MCVD method that allows high production efficiency, high automation of the process, high production yield, and flexibility for all common types of optical fibres. Introduction of the sleeving techniques has made it possible to produce large preforms. Low OH substrate tubes will further increase the efficiency of single-mode fibre production. High quality loose tube and multifibre cables have been produced using fibres primary coated using the dual pressure coater method, and secondary-coated with a horizontal extrusion line facilitating fibre overlength control with the bias capstan. 19 Refs.

Kurki, J. (Nokia Cable Machinery, Helsinki, Finl). *Wire Ind* v 55 n 654 Jun 1988 p 421-429,433.

**074037 DISPERSION LIMITED PRODUCTION TOLERANCES OF SINGLE-MODE FIBERS.** Based on profile-independent expressions, optimum values of the dispersion slope at the zero-dispersion wavelength for single-mode fibers are given, as a function of production tolerances. These optimum values minimize the spread in dispersion or maximize the usable wavelength interval of the fiber. Maximum allowable tolerances for dispersion-flattened fibers are found. 9 refs.

Andreasen, Svend Bank (Technical Univ of Denmark, Lyngby, Den). *J Lightwave Technol* v LT-5 n 9 Sep 1987, Opt Fiber Conf/Sixth Biennu Int Conf on Integr Opt and Opt Fiber Commun, Reno, NV, USA, Jan 19-22 1987 p 1183-1187.

**Protection** See ELECTRIC CABLES—Submarine; TELECOMMUNICATION CABLES—Protection.

## Protective Coatings

**074038 POLYMER COATINGS FOR LIGHT-GUIDE FIBERS.** In order to protect their surface from damage caused by abrasion, optical fibers must be coated with a polymer as they are drawn. The properties of the coating are crucial to the performance of the fiber. Two commonly used types of fiber coating geometries are illustrated. Three types of primary coating materials have been commercially used: thermally-curable silicones, UV-curable prepolymers, and thermoplastic rubber compounds. Typical modulus-temperature characteristics for these materials are displayed.

Blyler, L.L. Jr. (AT&T Bell Lab, Murray Hill, NJ, USA); Hart, A.C. *AICHe Symp Ser* v 83 n 258 1987, Fiber Opt Eng: Process and Appl (Pap from Natl AICHe Meet Held 1984-1986) p 29-31.

**074039 TEMPERATURE DEPENDENCE OF OPTICAL FIBER COATINGS FOR SINGLE-MODE**

**FIBER.** The physical properties of a coating material can greatly influence the extent of microbending losses in single-mode optical fiber. Therefore the reduction of microbending sensitivity is important to the operation of very low-loss fiber in open-channel cable for temperatures between  $-40^{\circ}$  and  $+60^{\circ}\text{C}$ . This paper describes the microbending sensitivity of various single-layer and composite acrylate coatings. (Author abstract) 5 refs.

White, J.S. (CELWAVE-VALTEC, Roanoke, VA, USA); Geyer, T.W. *AICHe Symp Ser* v 83 n 258 1987, Fiber Opt Eng: Process and Appl (Pap from Natl AICHe Meet Held 1984-1986) p 42-52.

**074040 HIGH STRENGTH HERMETICALLY COATED OPTICAL FIBERS.** Optical fibers prepared by a high strength MCVD process are coated online in the fiber puller with a thin ceramic film to preserve their pristine strength in high temperature and/or chemically reactive environments such as oil well bore holes and undersea cables. Mechanical and optical measurements indicate orders of magnitude improvement in reliability of these fibers in such environments. (Author abstract) 5 refs.

Hiskes, R. (Hewlett Packard Lab, Palo Alto, CA, USA); Narbut, M.; Mittelstadt, L.; Schantz, C.; Scott, C.; Hanson, E.; Nel, A.; Joiner, S.; Mannheimer, P. *AICHe Symp Ser* v 83 n 258 1987, Fiber Opt Eng: Process and Appl (Pap from Natl AICHe Meet Held 1984-1986) p 53-54.

**074041 EFFECT OF PROTECTIVE POLYMER COATING ON THE STRENGTH OF FIBER OPTICAL LIGHT GUIDES OF CHALCOGENIDE GLASSES.** Strength and crack resistance of fiber light guides of IR-range of chalcogenide glasses of the  $\text{Ge}_3\text{As}_{38}\text{Se}_{57}$  and  $\text{Ge}_5\text{As}_{38}\text{S}_{57}$  composition with protective polymeric shell of fluoroplastic-42 and without it are investigated. It is shown that polymeric coating with the surface protection essentially strengthens the light guide. The main reasons of strengthening are analyzed and possibility of an essential rise in the mechanical strength and reliability of no-failure operation of light guides made of chalcogenide glasses is registered. (Author abstract) 5 refs. In Russian.

Shchurov, A.F.; Shiryayev, A.M.; Skripachev, I.V.; Shipunov, V.A.; Tseloval'nikova, M.A. *Probl Prochn* n 2 Feb 1988 p 109-111.

**074042 RECENT DEVELOPMENTS IN HERMETICALLY COATED OPTICAL FIBER.** Recent progress on the development of hermetically coated optical fiber is presented. This fiber provides improved fatigue resistance; high usable strength; and excellent resistance to hydrogen permeation,  $25\text{-}90^{\circ}\text{C}$  water, and corrosive chemicals such as hydrofluoric acid and boiling sodium hydroxide. These attributes make the hermetically coated fiber an excellent candidate for use in undersea cables and other special applications where a harsh environment prevails. 17 refs.

Lu, K.E. (Corning Glass Works, Corning, NY, USA); Glaesemann, G.S.; VanDewoestine, Robert V.; Kar, G. *J Lightwave Technol* v 6 n 2 Feb 1988 p 240-244.

## Quality Control

**074043 ZASTOSOWANIE ZOGNISKOWANEJ WIAZKI SWIATLA DIODY KRAWEDZIOWEJ DO POMIARU SREDNIEJ CIENKICH WLOKNIEN.** [Use of a Focused Light Beam of an Edge Diode for Measuring the Diameters of Thin Fibers]. Experimental studies confirm the possibility of constructing relatively simple systems for measuring the diameters of thin optical fibers with the aid of a semiconductor light source, in particular, an edge diode. The particular system studied by the authors is characterized by a total measurement error of  $\pm 0.8\text{ }\mu\text{m}$  with an admissible range of Transverse displacements of the fiber of  $\pm 1\text{ mm}$  and a displacement measurement error of the scanner of about  $0.1\text{ }\mu\text{m}$ . 4 refs. In Polish.

Dobosz, Marek (Politechnika Warszawska, Pol); Tomasiak, Jan. *Mech Mies Nauk Tech* v 60 n 4 Apr 1987 p 169-172.

**074044 QUALITY CONTROL OF LONG FIBRE OPTIC CABLES.** This article shows that routine quality testing of fibre optical cables is best done through the OTDR technique. A computer-assisted system has been developed for this purpose. Improved production methods now enable fibre manufacturers to supply fibres with lengths up to 12 km or more on a regular basis. To take full advantage of this development, it is not only necessary to process these fibres as one unit but also to measure them as one single cable production length in such a manner that after dividing into individual sections, these do not need further measurement. 2 Refs.

Klar, R. (Kabelmetal Electro GmbH, Hanover, West Ger); Schoenfeld, H. *Wire Ind* v 55 n 654 Jun 1988 p 412-414,420.

## Radiation Damage

**074045 INDUCED THERMAL DAMAGES TO FIBER LIGHTGUIDES.** The dynamics of melting of a lightguide under the effects of radiation propagating in it are investigated. Estimations are found for the rate of a melting wave in different modes, along with the critical radiation power. (Author abstract) 7 refs.

Romanovskii, M.Yu. *Sov Phys Lebedev Inst Rep* n 5 1987 p 29-33.

**074046 FUSION NEUTRON DAMAGE IN OPTICAL FIBERS.** There have been many papers on radiation damage in optical fibers. However, most papers have described irradiation experiments utilizing a  $\gamma$ -source and applications to nuclear power plants, fuel reprocessing plants and others. Insufficient data seem to be available for fusion neutron damage. Irradiation experiments by a D-T neutron source are essential, and data on fusion neutron damage are directly useful for fiber optics in fusion reactor diagnostic systems. The purpose of the present paper is to show the data on fusion neutron response of optical fibers which have been recently developed and to determine how long they can be effectively used in the fusion neutron environments. 3 refs.

Iida, Toshiyuki (Osaka Univ, Suita, Jpn); Ie, Shinichiro; Sumita, Kenji; Heikkinen, Dale W.; Short, David W. *J Nucl Sci Technol* v 24 n 12 Dec 1987 p 1073-1075.

**Radiation Effects** See Also FIBER OPTICS—Radiation Effects.

**074047 RADIATION FROM SINGLE-MODE HELICAL FIBRES.** The fundamental mode of a helical fiber is not strictly bound and radiates at all wavelengths. For practical purposes, radiation is negligible unless the pitch angle is sufficiently large or the pitch length short enough. The loss edge is mainly due to pure bending loss for the former, and to helical ripple loss for the latter. A simple loss expression is presented. (Author abstract) 4 refs.

Love, J.D. (Australian Natl Univ, Canberra, Aust); Snyder, A.W. *Electron Lett* v 23 n 21 Oct 8 1987 p 1109-1110.

**074048  $\gamma$ -RAY IRRADIATION CHARACTERISTICS OF PURE SILICA CORE SINGLE MODE FIBER AND ITS LIFE TIME ESTIMATION.** Investigations of induced loss of single mode optical fiber under  $\gamma$ -ray irradiation are described and an estimation method of induced loss at low dose rate and long time  $\gamma$ -ray irradiation is proposed. The induced loss of pure silica core SM fiber was estimated to be 50 times lower than that of  $\text{GeO}_2$  added core SM fiber after irradiated with  $1\text{ R/h}$  for 25 years. 3 refs.

Kyoto, Michihisa; Chigusa, Yoshiki; Ooe, Masaharu; Watanabe, Minoru; Yamamoto, Takao; Okamoto, Siniichi. *Sumitomo Electr Tech Rev* n 27 Jan 1988 p 30-36.



**074049 RADIATION PERFORMANCE OF PCVD SM FIBRES.** Radiation induced loss recovery and saturation data are presented and discussed for PCVD production and experimental pure silica core single-mode fibers. (Author abstract). 9 refs.

Lambrichs, R.L.M. (Hokkaido Univ, Sapporo, Jpn); Yoshida, N.; Fukai, I. *Electron Lett* v 24 n 18 Sep 1 1988 p 1166-1167.

**074050 FIBER OPTIC SIGNAL ATTENUATION BY SECONDARY IONIZING RADIATION IN NUCLEAR ENVIRONMENTS.** Irradiation of optical fiber waveguides by ionizing radiation can cause an increased loss in optical transmission. The effect of the loss was measured on several commercially available pure silica-core boron-doped clad fibers irradiated with thermal neutrons from a nuclear reactor. Optical absorption was measured over the 400-1100-nm range during neutron irradiation. It was found that the attenuation of optical transmission by thermal neutrons is caused by defects produced by alpha particles produced in boron-neutron reactions.

Karasawa, Shigeru (Musashi Inst of Technology, Tokyo, Jpn); Hatori, Yoshinori; Takada, Tatsuo; Sakai, Takao; Shibuya, Kiyoshi. *IEEE Trans Nucl Sci* v NS-34 n 5 p 1105-1109.

**074051 ASSESSMENT OF RADIATION-INDUCED LOSS FOR AT&T FIBER-OPTIC TRANSMISSION SYSTEMS IN THE TERRESTRIAL ENVIRONMENT.** Environmental radiation dose rate estimates are provided for both outdoor terrestrial and indoor environments. Laboratory radiation sensitivity measurements are reported for the AT&T standard single-mode fiber and standard and radiation-hardened multimode fibers. These are used to estimate typical system losses for long-haul, trunk, feeder, local area network, and optical data environments. It is reported that radiation-induced loss in unusually harsh environments can be minimized by using the radiation hardened 62.5/125- $\mu$ m multimode fiber, which has sensitivities roughly an order of magnitude lower than the standard product at 0.85  $\mu$ m and almost two orders of magnitude lower at 1.3  $\mu$ m. 7 refs.

Haber, Janice B. (AT&T Bell Lab, Norcross, GA, USA); Mies, Eric W.; Simpson, Jay R.; Wong, Sweet F. *J Lightwave Technol* v 6 n 2 Feb 1988 p 150-154.

**074052 INTERLABORATORY COMPARISON OF RADIATION-INDUCED ATTENUATION IN OPTICAL FIBERS - I: STEADY-STATE EXPOSURES.** A comparison of the losses induced at 0.85  $\mu$ m in three all glass-pure silica core optical fibers by steady-state radiation exposures has been made among five laboratories. Both the growth of the attenuation during irradiation and the recovery following exposures of 3000 and 10<sup>5</sup> rads have been measured. Although a standard set of parameters was attempted by all laboratories, the slight divergences (0.45  $\leq \sigma \leq$  0.99 dB/km) observed in some data indicate sensitivity of the results to factors such as photobleaching, injection conditions, and sample coil diameter. 15 refs.

Friebele, E. Joseph (US Naval Research Lab, Washington, DC, USA); Taylor, Edward W.; Turguet de Beauregard, Guy; Wall, James A.; Barnes, C.E. *J Lightwave Technol* v 6 n 2 Feb 1988 p 165-171.

**074053  $\gamma$ -RAY AND NEUTRON IRRADIATION CHARACTERISTICS OF PURE SILICA CORE SINGLE MODE FIBER AND ITS LIFE TIME ESTIMATION.** The investigation of the induced loss for a single-mode (SM) optical fiber under  $\gamma$ -ray irradiation and neutron irradiation is described. An estimation method for induced loss with low dose rate and long-term  $\gamma$ -ray irradiation is proposed. The induced loss of pure-silica-core SM fiber is estimated to be 50 times lower than that of germanium containing silica-core SM fiber after irradiation with 1 R/h for 25 years. 1 ref.

Chigusa, Y. (Sumitomo Electric Industries Ltd, Yokohama, Jpn); Watanabe, M.; Kyoto, M.; Ooe, M.; Matsubara, T.; Okamoto, S.; Yamamoto, T.; Iida, T.; Sumita,

K. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 894-897.

**074054 FUSION NEUTRON DAMAGE ON OPTICAL FIBERS AND OPTOELECTRONIC DEVICES.** Radiation-resistant optical fibers fabricated with purified silica glass were irradiated at room temperature with 14-MeV neutrons from the RTNS-II. The induced loss in light transmission was measured in situ during irradiation. It was found that the fusion neutron response of the optical fibers can be approximately classed in three types as follows: (1) a large induced loss with little recovery; (2) a large induced loss with a quick recovery; and (3) a small induced loss with a saturated tendency. The induced-loss rate has been calculated on the basis of damage components that depend mainly on neutron fluence and show little recovery. Fusion neutron irradiation effects on related optoelectronic devices and their hardness levels are shown. These are the neutron fluences at which important performance parameters of the devices begin to degrade. The data are useful for fiber-optics design for fusion diagnostic systems. 2 refs.

Iida, T. (Osaka Univ, Osaka, Jpn); Ire, S.; Sumita, K.; Matsubara, T.; Heikinen, D.W.; Short, D.W. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 898-902.

**Reliability** See Also TELECOMMUNICATION CABLES—Submarine.

**074055 TOUGHER FIBER FOR THE FOG-M.** Military applications such as the fiber-optic guided missile (FOG-M) require long-length, highly reliable optical fibers that usually are proof stressed after manufacture to insure reliability. This article describes a new approach to producing long length, highly reliable optical fibers. This involves modifying the composition of fibers produced by the outside vapor deposition (OVD) process. Change in the chemistry of glass has been shown to increase fiber resistance to fatigue. 14 refs.

Ritter, J.E.; Helfinstine, J.D. *Photonics Spectra* v 21 n 8 Aug 1987 5p between p 90 and 98.

**074056 LONG-TERM RELIABILITY OF TRANSMISSION LOSS IN OPTICAL FIBER CABLES.** Increased optical-fiber cable losses due to hydrogen are discussed. A mathematical model is developed to predict the growth of hydrogen concentration in the cable, which is determined by the evolution from organic cable materials and permeation through the cable sheath. This cable model, together with the measured parameters for the cable materials, explains the measured results. Design criteria for the allowable hydrogen evolution from cable materials and for the cable sheath structure are established on the basis of the model. 7 refs.

Tanaka, Shigeru (Sumitomo Electric Industries Ltd, Yokohama, Jpn); Honjo, Makoto. *J Lightwave Technol* v 6 n 2 Feb 1988 p 210-217.

**074057 RELIABILITY CONSIDERATIONS IN FIBER OPTIC APPLICATIONS.** This conference proceedings contains 20 papers. The topics covered are: optical fibers and cables; light sources and detectors; optical transceivers and high-speed ICs; fiber-optic components and interconnects; and long- and short haul systems. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10975 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Paul, Dilip K. (Ed.) (COMSAT, Clarksburg, MD, USA). *Proc SPIE Int Soc Opt Eng* v 717, Reliab Consid in Fiber Opt Appl, Cambridge, MA, USA Sep 25-26 1986. Publ by SPIE, Bellingham, WA, USA, 1987 168p.

## Repair

**074058 LOW-LOSS FUSION SPLICING OF PCVD-DFSM FIBERS.** Fusion splicing of dispersion-flattened single-mode (DFSM) fibers results in wave-

length-independent average repair splice losses of 0.05 dB. These losses are as low as for conventional single mode (SM) fibers and field application is not limited. Splices between DFSM fibers and conventional SM fibers showed surprisingly low splice losses in spite of the large difference in spot size. This is caused by internal diffusion processes which result in a steady transition of the spot sizes. 9 refs.

Zell, Werner (Philips Communications Industrial AG, Cologne, West Ger); Becker, Johann A.; Bachmann, Peter K.; Hermann, W.G. *J Lightwave Technol* v LT-5 n 9 Sep 1987, Opt Fiber Conf/Sixth Biannual Int Conf on Integr Opt and Opt Fiber Commun, Reno, NV, USA, Jan 19-22 1987 p 1192-1195.

## Robotic Assembly

**074059 MICROROBOT PERFORMS TASK OF PIGTAILING OPTICAL FIBERS.** The Microrobotics Division of Dukane Corp., St. Charles, Ill., has designed the AL5010 Microrobot System, an assembly robot for the challenging task of pigtailing single-mode optical fibers. By automating the manufacture of semiconductor lasers and other optoelectronic devices, the AL5010 makes obsolete the manual alignment of optical fibers to active components. Replacing manual operation reduces rework demands and cycle times. (Edited author abstract)

Anon. *Rob World* v 6 n 4 Apr 1988 p 28.

**Scintillation** See ELECTRON TUBES, PHOTOMULTIPLIER.

**Sensors** See Also FIBER OPTICS—Applications.

**074060 OPTICAL FIBER SENSOR FOR THE MEASUREMENT OF PRESSURE.** This paper describes the design, construction and testing of a fiber optic pressure sensor based on a reflecting Fabry-Perot etalon. The etalon comprised one fixed mirror and a second mirror designed to flex under the action of the pressure being monitored. A single multimode fiber was used to connect the passive, remote sensor to the transmitter/receiver section, and dual wavelength referencing was used to eliminate the effects of bending-induced attenuation in the fiber. (Author abstract) 1 ref.

Dakin, J.P. (Plessey Research Roke Manor Ltd, Romsey, Engl); Wade, C.A.; Withers, P.B. *Fiber Integr Opt* v 7 n 1 1988 p 35-46.

## Spectroscopic Analysis

**074061 NEW TECHNIQUE FOR SPECTROSCOPIC ANALYSIS OF INSULATING SINGLE CRYSTAL FIBERS.** A new technique for determining the optical properties of insulating single crystal fibers is presented and applied to Titanium-doped Sapphire, Spinel and YALO. The fibers were grown at the Stanford University Center for Materials Research by a laser heated pedestal growth method and were about 1 mm in diameter and 5 cm long. We introduce a statistical treatment of radiation transport through fibers to account for multiple scattering and interference. In this analysis, the effects of multiple scattering are treated as a length dependent reflection from the bulk and combined with Fresnel surface reflection allow the prediction of absorption and emission characteristics. (Edited author abstract) 4 refs.

Buoncrisiani, A.M. (Christopher Newport Coll, Newport, News, VA, USA); Byvik, C.E. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 869-870.

**Spectrum Analysis** See Also OPTICAL GRATINGS—Mathematical Models.

**074062 EXPERIMENTAL STUDY OF THE EVOLUTION OF CHIRPED SOLITON PULSES IN SINGLE MODE OPTICAL FIBERS.** The evolution of chirped soliton pulses relaunched into single mode fibres in the region of anomalous dispersion has been examined experimentally under conditions where the bandwidth of



the launched soliton pulse was up to seven times that of the transform limit. After relaunch, the soliton rapidly broadened approaching the condition where further broadening was solely due to transmission losses. The results are in good qualitative agreement with recent theoretical predictions. (Author abstract) 26 refs.

Gouveia-Neto, A.S. (Imperial Coll of Science & Technology, London, Engl); Gomes, A.S.L.; Taylor, J.R. *Opt Commun* v 64 n 4 Nov 15 1987 p 383-386.

**074063 STIMULATED BRILLOUIN SCATTERING EXCITED BY A MULTIMODE LASER IN SINGLE-MODE OPTICAL FIBERS.** A steady state solution for stimulated Brillouin (SBS) in single-mode optical fibers when excited by a pump wave having discrete spectral components is derived. This solution is valid for any arbitrary ratio of the spontaneous Brillouin linewidth to the frequency separation of the adjacent modes. The solution can be extended to include a quasi-continuous spectrum for the pump wave. (Author abstract) 16 refs.

Lichtman, E. (Weizmann Inst of Science, Rehovot, Isr); Friessman, A.A. *Opt Commun* v 64 n 6 Dec 15 1987 p 544-548.

**074064 ABSORPTION AND FLUORESCENCE SPECTRA OF RARE EARTH IONS IN SILICA-BASED MONOMODE FIBER.** Rare-earth ions have been systematically incorporated into the cores of silica-based optical fibers, and the absorption and fluorescence spectra have been measured. The results provide basic data for a wide range of possible future fiber-based devices. For specific telecommunications applications, ions that could be useful for sources in the 1.3- $\mu$ m and 1.5- $\mu$ m low-loss windows are identified. It is suggested that  $\text{Er}^{3+}$ ,  $\text{Nd}^{3+}$ , and  $\text{Tm}^{3+}$  are the most promising ions for semiconductor pumping with GaAs-based laser diodes. 19 refs.

Ainslie, B. James (British Telecom Research Lab, Ipswich, Engl); Craig, Susan P.; Davey, Steven T. *J Lightwave Technol* v 6 n 2 Feb 1988 p 287-293.

**074065 BANDWIDTH OF A SINGLE-MODE OPTICAL FIBER IN PSK COHERENT OPTICAL TRANSMISSION SYSTEMS.** The author examines propagation characteristics of PSK modulated signal light under the influence of the group velocity dispersion (GVD), the higher-order dispersion (HOD), and the nonlinear refractive index of a single-mode fiber. Emphasis has been placed on behavior at and near the zero-dispersion wavelength (ZDWL), where the HOD as well as the GVD would be important. It is found that propagation at the ZDWL is similar to that away from the ZDWL; the effect of the nonlinear refractive index can be comfortably ignored. The effect of HOD is found to induce self-amplitude modulation (SAM) at the ZDWL; the amplitude of PSK-modulated light becomes modulated as the light travels down the fiber. The SAM considered produces a power penalty in the PSK coherent fiber transmission, and determines the dispersion limit of such systems. As the operating wavelength moves away from the ZDWL, the effect of GVD becomes important relative to that of HOD. The significance of the results is examined. 23 refs.

Tajima, Kazuhito (NEC Corp, Kanagawa, Jpn). *J Lightwave Technol* v 6 n 2 Feb 1988 p 322-328.

**074066 1.55- $\mu$ m FIBER-OPTIC TRANSMISSION EXPERIMENTS FOR LONG-SPAN SUBMARINE CABLE SYSTEM DESIGN.** Results of 1.55- $\mu$ m transmission experiments at 140, 280, and 565 Mb/s involving conventional and dispersion-shifted single-mode fibers along the Fabry-Perot laser diode (FP-LD) and distributed-feedback laser diode (DFB-LD) optical sources are discussed. The results show which combination of optical fiber and optical source best meet the requirement of long repeater spacing for each bit rate. The results indicate that to achieve repeater spacing more than 100 km with dispersion-shifted fibers and FP-LD optical sources will impose strict requirements on both the optical fibers and

the optical sources even at 280 Mb/s. Alternatively, systems using DFB-LD optical sources will not degrade the transmission performances and will considerably loosen requirements on the fibers and optical sources. A combination of dispersion-shifted fibers and DFB-LD optical sources can further loosen the requirements on the fibers and optical sources in 560-Mb/s systems. 17 refs.

Yamamoto, Shu; Sakaguchi, Haruo; Nunokawa, Makoto; Iwamoto, Yoshinao. *J Lightwave Technol* v 6 n 3 Mar 1988 p 380-391.

## Standardization

**074067 DEVELOPMENT OF PROPOSED FEDERAL STANDARD 1070: 62.5/125- $\mu$ m GRADED-INDEX, MULTIMODE OPTICAL FIBER WAVEGUIDES FOR ON-PREMISES APPLICATIONS.** This paper describes a process that has been successful in generating a specification to guide the user community in the procurement of single-size, multimode optical fiber for on-premises applications. This process began with an attempt to adopt an industry standard as a federal standard that would eliminate a multiplicity of choices available from the marketplace. The initial EIA-458-A Standard contained four 'preferred' sizes. Discussions both in a government standards committee and in an applications-oriented industry (EIA) working group indicated the desirability of recommending a single fiber size. The process by which the industry committee selected the 62.5- $\mu$ m core diameter/125- $\mu$ m cladding diameter multimode fiber is presented. The next element of the process was that of selecting the appropriate standard performance measures and attributes that would assure minimum performance of graded parameters such as attenuation and bandwidth, as well as a uniform specification of the product. (Edited author abstract). 3 Refs.

Hanson, A. Glenn (US Dep of Commerce, Boulder, CO, USA); Hull, Joseph A. *Fiber Integr Opt* v 7 n 3 1988 p 173-179.

**Strain** See Also TELECOMMUNICATION CABLES—Gas Filled; TELECOMMUNICATION CABLES—Laying.

**074068 DETERMINATION OF THE INDIVIDUAL STRAIN-OPTIC COEFFICIENTS IN SINGLE-MODE OPTICAL FIBERS.** A method to determine the individual strain-optic coefficients in single-mode fibers is described. It is based on two photoelastic experiments, namely, the polarimetric measurement of optical activity induced by mechanical twist and the interferometric measurement of optical-path-length change induced by static longitudinal strain. For fibers with pure silica core and  $\text{B}_2\text{O}_3$  doped cladding, the optical activity per unit twist rate and the phase change per unit fiber elongation have been measured to be 0.1472 and  $1.150 \times 10^7$  rad/m, respectively. The strain-optic coefficients have been measured to be  $p_{11} = 0.113$  and  $p_{12} = 0.252$ , 7% lower than those of bulk silica. 15 refs.

Bertholds, Axel (Univ of Neuchatel, Switz); Dandliker, Rene. *J Lightwave Technol* v 6 n 1 Jan 1988 p 17-20.

**Stresses** See Also MATERIALS TESTING; TELECOMMUNICATION CABLES—Submarine.

**074069 STRESS-APPLIED OPTICAL FIBER HAVING INHOMOGENEOUS CORE.** To extend the freedom in the design of polarization-maintaining single-mode optical fiber, a stress-applied fiber with inhomogeneous core has been investigated. The refractive index in the core has an  $\alpha$ -power profile, and the refractive index of the stress-applying parts is decreased by doping. The fiber characteristics are evaluated by stress analysis and modal analysis, using the finite-element method useful for arbitrary refractive-index profile. For modal analysis, a new scalar variational expression useful for the analysis of weakly guiding birefringent fibers is presented. Using this expression, the polarization-mode properties of the fiber are studied in detail. (Edited author abstract) 12 refs.

Hayata, Kazuya (Hokkaido Univ, Sapporo, Jpn); Koshiiba, Masanori; Suzuki, Michio. *Electron Commun Jpn Part 2* v 70 n 9 Sep 1987 p 74-81.

## Structure

**074070 OPTICAL AND STRUCTURAL INVESTIGATION OF  $\text{Nd}^{3+}$  IN SILICA-BASED FIBRES.** We have previously reported the fabrication and properties of  $\text{Nd}^{3+}$ -doped silica-based optical fiber in concentrations kept low in order to avoid clustering effects. This letter furthers this study and reports the optical and structural properties of  $\text{Nd}^{3+}$ -doped silica-based optical fiber in concentrations which extend well into the clustered phase. The behavior of the lanthanides in silica is similar, hence inferences can be made for all these ions from this work. Silica-based optical fibers contain clusters when doped with  $\text{Nd}^{3+}$  at concentrations above  $10^3$  ppm. Fluorescence spectra and time-resolved measurements have shown that these clusters are  $\text{Nd}^{3+}$ -rich crystalline phases. 7 refs.

Ainslie, B.J. (British Telecom Research Lab, Martlesham Heath, Engl); Craig, S.P.; Davey, S.T.; Barber, D.J.; Taylor, J.R.; Gomes, A.S.L. *J Mater Sci Lett* v 6 n 11 Nov 1987 p 1361-1363.

**074071 LIGHT SCATTERING MEASUREMENT IN PMMA OPTICAL FIBERS.** A new light scattering measuring system was developed to investigate the heterogeneous structure in plastic optical fibers (POF). Measurements were conducted on commercial PMMA POF of different diameters. The results showed that the correlation length, which characterizes the size of a heterogeneous structure, is substantially larger in POF than in a bulk PMMA specimen, and increases with decreasing fiber diameter. These facts suggest that some structural changes such as molecular orientation and residual stress might be induced during POF formation, resulting in an additional scattering loss. (Author abstract) 9 refs.

Yamashita, Tomoyoshi (Kyushu Univ, Fukuoka, Jpn); Shichijyo, Shiro; Takemura, Tetuo; Matsushige, Kazumi. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1797-1799.

**Substrates** See WAVEGUIDE COMPONENTS—Couplers.

**Surfaces** See GLASS MANUFACTURE—Ion Exchange.

## Switching

**074072 WAVELENGTH DEPENDENCE OF A D-FIBRE OPTICAL SWITCH.** Fully transparent optical networks require both highly wavelength-selective devices and wavelength-independent devices to transmit, switch and select bandwidth. Coupled waveguide devices in various forms have been fabricated to meet many of these network functions. We present a wavelength-independent space switch realized with D-fibers. (Edited author abstract) 6 refs.

Cassidy, S.A. (British Telecom Research Lab, Ipswich, Engl); Yennadmiou, P. *Electron Lett* v 23 n 25 Dec 3 1987 p 1385-1387.

**074073 4×4 ALL-FIBRE OPTICAL SWITCHING MATRIX.** This letter describes the fabrication and performance of a 4×4 nonblocking optical switching matrix for use with single-mode optical fiber systems. The configuration adopted uses individual 2×2 all-fiber switching units interconnected by fusion splices to form a 4×4 nonblocking matrix with a mean path insertion loss of 2.3 db and a channel isolation better than -15 db when operating at a wavelength of 1300 nm. (Author abstract) 5 refs.

El Fatatry, A. (GEC, Wembley, Engl); Shipley, S.P.; Tyson, R. *Electron Lett* v 24 n 6 Mar 17 1988 p 339-340.

**Testing** See Also TELECOMMUNICATION CABLES—Testing.

**074074 DETECTION OF FAULTS IN OPTICAL FIBERS BY THE PHASE COMPENSATED REFLECTOMETER.** The Fresnel reflection is influenced strongly by defects in the optical fiber. As the fiber attenuation is decreased, the Fresnel reflection becomes useful for fault detection if it is measured accurately. This paper proves theoretically that the phase-compensated



reflectometer can be the optimum detection system of the Fresnel reflection when it is used for fiber-defect detection. In addition, the results of computer simulations for some typical operating conditions for defect detection are shown. (Author abstract) 14 refs.

Hangai, Seichiro (Science Univ of Tokyo, Tokyo, Jpn); Kosaka, Yoshihiro; Taki, Yasuo. *Electron Commun Jpn Part 2* v 70 n 11 Nov 1987 p 103-115.

**Theory** See Also WAVEGUIDES, DIELECTRIC—Mathematical Models.

**074075 COUPLED-MODE THEORY FOR HELICAL FIBRES.** A set of coupled-mode equations for helical fibers is formulated. These equations are then used to analyse the helical single-mode fibers with intrinsic linear birefringence. The eigenmodes and the resultant birefringence of the whole waveguides are obtained. The effect of the external perturbation on these waveguides is also considered. (Author abstract) 16 refs.

Qian, Jing-ren (Univ of Science & Technology of China, Hefei, China). *IEE Proc Part J* v 135 n 2 Apr 1988 p 178-182.

## Thermal Effects

**074076 OPTICAL-FIBER THERMAL MODULATOR.** A device which utilizes temperature sensitivity of optical fibers to modulate the light in an optical-fiber interferometer is described. Desired temperature changes are accomplished by passing current through a thin conductive coating on the surface of a short length of the fiber in the interferometer. Modulation rates up to tens of kilohertz have been achieved with an optical fiber which has had a gold coating deposited directly onto the silica fiber. Fiber temperature changes of over 200 K were easily attained and resulted in a phase difference of many radians between the two arms of the interferometer. 13 refs.

White, Barbara J. (US Naval Air Development Cent, Warminster, PA, USA); Davis, Jon P.; Bobb, Lloyd C.; Krumholtz, Howard D.; Larson, Donald C. *J Lightwave Technol* v LT-5 n 9 Sep 1987, Opt Fiber Conf/Sixth Biannual Int Conf on Integr Opt and Opt Fiber Commun, Reno, NV, USA, Jan 19-22 1987 p 1169-1175.

**074077 TEMPERATURE DEPENDENCE OF PULSE WAVEFORM DISTORTION IN A STEP-INDEX TYPE MULTIMODE INFRARED OPTICAL FIBER.** Introducing temperature-dependent terms into the propagation constant and its derivatives, and extinction coefficient of a core material of optical fiber, the equation of pulse propagation in a multimode fiber is derived, allowing us to evaluate the temperature dependence of a pulse waveform such as the peak-intensity, the pulse duration or width and the pulse delay-time at the peak as a function of ambient temperature. Using the weighting function for higher order modes in the above equation, the theoretically calculated waveforms are compared with the mode-locked He-Ne 3.39  $\mu$ m laser pulses propagated through As-S fiber over the range from room temperature to  $-220^\circ\text{C}$ , being in good agreement each other. (Author abstract) 12 refs.

Azumai, Yuji (Natl Defence Acad, Yokosuka, Jpn); Sato, Heihachi. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 11 Nov 1987 p 1150-1154.

**Thin Films** See WAVEGUIDES—Thin Films.

## Vapor Deposition

**074078 HIGH-RATE FABRICATION OF OPTICAL FIBER PREFORMS BY THE MULTI-FLAME VAD METHOD.** A new type of burner with a multi-flame structure is proposed for high-rate fabrication of optical fiber preforms in the vapor-phase axial deposition method (VAD). Fine glass particles synthesized using the double-flame burner under various conditions were characterized by SEM and the BET method. It was confirmed that particle size and deposition rate could be increased by using the new burner. The multi-flame VAD method

makes it possible to synthesize whole fiber preforms for single-mode optical fibers at a high deposition rate of more than 10 g/min. (Author abstract) 17 refs.

Suda, Hiroyuki (NTT, Jpn). *Rev Electr Commun Lab (Tokyo)* v 35 n 5 Sep 1987 p 547-552.

## Vibration

**074079 POLARIZATION FLUCTUATION CHARACTERISTICS OF A HIGHLY BIREFRINGENT FIBER SYSTEM UNDER FORCED VIBRATION.** Polarization characteristics in environmental disturbance are evaluated, in terms of the signal-to-noise ratio (SNR), which is defined as the ratio of a mean to a standard deviation of time-varying signals. The SNR is computer-simulated, assuming a Gaussian probability distribution for the random variables, i.e., birefringent axis, linear retardance, and polarization mode-coupling. These parameters are assumed to fluctuate owing to the force vibration of a loudspeaker. A comparison of the numerical results with the experimental SNR provides a direct connection between fluctuations of the state of polarization (SOP) and SNR of received signals modulated by polarization noise in highly birefringent fiber systems. 19 refs.

Imai, Masaaki (Hokkaido Univ, Sapporo, Jpn); Terasawa, Yoshiaki; Ohtsuka, Yoshihiro. *J Lightwave Technol* v 6 n 5 May 1988 p 720-727.

**Vibrations** See Also FIBER OPTICS—Mathematical Models.

**074080 CORRELATION PROCESSING OF FLUCTUATING OPTICAL WAVES GUIDED IN AN EXTERNALLY PERTURBED BIREFRINGENT SINGLE-MODE FIBER BY OPTICAL HETERODYNE INTERFEROMETRY.** A description is given of experimental studies on the correlation processes for the optical waves guided in a birefringent single-mode fiber exposed to random vibrations. A laser beam with orthogonally polarized two-frequency components is launched into the fiber in such a way that the polarization directions of the two-frequency components coincide with the birefringent axes of the fiber. On leaving the fiber, its orthogonal components, modulated at random in phase and amplitude, are superimposed with a reference laser beam with two-frequency components; two-beat photocurrents are produced from the combination of different frequency components of the signal and reference laser beams. The beat photocurrents can yield the fluctuating phase and amplitude components of the guided optical waves, which are statistically processed by use of a signal analyzer. Autocorrelation and cross-correlation functions for the fluctuation components are given together with their corresponding power spectra. Characteristic features extracted from the measured results are explained. 7 refs.

Ohtsuka, Yoshihiro (Hokkaido Univ, Sapporo, Jpn); Tsukada, Masato; Imai, Yoh. *J Lightwave Technol* v 6 n 2 Feb 1988 p 191-196.

**OPTICAL FILTERS** See Also ACOUSTOOPTICAL DEVICES; ACOUSTOOPTICAL DEVICES—Performance; HOLOGRAPHY; IMAGE PROCESSING—Enhancement; LASERS, DYE—Mode Locking; LASERS, GAS; LIGHT—Modulation; OPTICAL FIBERS; OPTICAL INSTRUMENTS—Accessories; PATTERN RECOGNITION; PATTERN RECOGNITION SYSTEMS; PRINTING—Offset.

**074081 PHASE-ONLY FILTER AS MATCHED SPATIAL FILTER WITH ENHANCED DISCRIMINATION CAPABILITY.** The optical and digital analysis of the discrimination capability of the phase-only filter is presented. The comparison between the discrimination capability for this filter and high-pass matched spatial filter of different kinds is realized. (Author abstract) 20 refs.

Chlaskinska-Macukow, K. (Warsaw Univ, Warsaw, Pol); Nitka, T. *Opt Commun* v 64 n 3 Nov 1 1987 p 224-228.

**074082 FILTERS AND GRATINGS: NOT ALWAYS A SIMPLE CHOICE.** Historically, the optical engineer has had three choices for defining the response of an

optical system to a narrow band of wavelengths: filters, diffraction gratings or prisms. In recent years we have witnessed exciting developments in grating and filter technology. Where we could make our choices so easily in the past, we now need to rethink what is 'few' and what is 'many.' New capabilities make the optical engineer rethink the boundary between filters and gratings in design.

Pierson, Arthur H. (Pierson Associates, Andover, MA, USA). *Lasers Optonics* v 6 n 8 Aug 1987 p 63-67.

**074083 PHOTON INTENSITY CONTROL WITHOUT FILTERS.** The authors have demonstrated an alternative technique to control light intensity adjusting direct light source brightness instead of employing filters. This allows a computer to directly control a pulse generator through a D-A converter. The precision of photon intensity control can be improved to less than 1%. Since the technique does not require any filter replacement, a tube can be isolated in a light tight box perfectly. The technique is at least as simple as that using filters and would be probably more simple in most practical situations.

Omori, Masaharu (Univ of Sydney, Aust). *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 463-467.

**074084 MESURE DES TAUX DE REJECTION ELEVES DANS LES FILTRES INTERFERENTIELS. APPLICATION AU DEMULTIPLEXAGE OPTIQUE.** [Measurement of High Rejection Rates in Interference Filters. Application to Optical Demultiplexing.] High performance interference filters are usually used for multiplexing or demultiplexing in optical telecommunications. It is necessary to characterize these filters for implementation in a demultiplexer. Particularly in the rejection bands, transmission values which do not exceed  $10^{-4}$ , or even  $10^{-5}$  are aimed at values. Generally, these values cannot be obtained with a classical spectrophotometer. Therefore, a special equipment had to be developed and built. This equipment makes it possible to master measurement conditions (aperture, incidence, resolution, ...) and particularly it has the high spectral purity required for this type of application. It is shown that actual performances of these interference filters are very close to theoretical previsions. This applies as well to the transparency band shape as to the transmission values in rejection bands. This result is confirmed by computer simulation of the effect of realization errors and measurement conditions on the optical properties of multilayers stacks. (Author abstract). 4 Refs. In French.

Galernau, Anne-Sophie (CNRS); Fornier, Andre; Hamel, Andre. *Ann Telecommun* v 43 n 3-4 Apr-May 1988 p 123-134.

**074085 OPTICAL COATINGS FOR LARGE AREA INTERFERENCE FILTERS.** The appearance of optical filters on a large scale as heat reflecting coatings on domestic windows heralds the advent of techniques and materials for a range of applications which are far removed from the ultra-high performance, and cost, of multilayer filters used hereto. These new coatings use interference anti-reflection layers on either side of a thin metal layer. They are prepared by high rate reactive planar magnetron sputtering onto a large area of glass or plastic substrate. This technique is critically assessed and materials considered which will allow more complex filters to be made. In particular the preparation of a high index dielectric film of  $\text{SnO}_2$  and a low index film of aluminum oxyfluoride is described. Illustrations of some applications of these are given. (Author abstract) 9 refs.

Lewin, R. (Loughborough Univ of Technology, Loughborough, Engl); Howson, R.P.; Bishop, C.A. *Vacuum* v 37 n 3-4 1987 p 257-260.

## Applications

**074086 ZUR KOMPLEXEN PHASENFILTERUNG IM KOHAERENT OPTISCHEN PROZESSOR.** [Method for a Complex Phase Filter Procedure in a



**Coherent Optical Processor.** The holographic filter process developed by G.W. Stroke and R.G. Zech is often applied to electron microscopical phase contrast images. This matter is a real filter procedure. The present paper describes the development and application of analog optical filters for a complex filter process. The test object is a radial test bar chart. (Author abstract) 4 refs. In German.

Block, H. (Univ Bremen, Bremen, West Ger). *Optik (Stuttgart)* v 78 n 3 Feb 1988 p 108-110.

## Design

**074087 OPTIMISED DESIGN OF ODD-ORDER OPTICAL LOWPASS AND HIGHPASS MULTILAYER FILTERS BY METHOD OF COEFFICIENT MATCHING.** An algorithm is developed to design optimized lowpass multilayer filters by equating the coefficients of the multilayer transmittance with those of the Chebyshev transmittance. Results obtained for a 17th-order, lowpass multilayer show that it has optimized Chebyshev-like performance in the passband. Its transmittance characteristic falls short of optimum performance in that the ripples at low frequencies are less than the specified value. Nonetheless, its performance compares favorably with other well-established methods of design. By contrast, a high-pass multilayer, designed using the same approach, has a performance which falls short of the accepted norm. Evidence leads us to conclude that coefficient matching with Chebyshev polynomial is more suited to the design of lowpass multilayers than highpass multilayers. (Author abstract) 20 refs.

Chen, T.C. (Hong Kong Polytechnic, Hong Kong). *IEE Proc Part J* v 135 n 2 Apr 1988 p 166-177.

## Efficiency

**074088 INVESTIGATION OF LIGHT FILTER THERMAL CONDITIONS.** Thermal conditions and radiation flux density distribution on the traditional and double filters consisting of two components, viz., a main film and an auxiliary/protective glass with air separation were studied. Radiation losses were calculated for the filters. Temperature dependence for the transmittance of the glass in-bulk painted filters is given. The dependence is responsible for a nearly two-fold drop in floodlight efficiency in the sensitivity range of a multislit photocathode receptor. The temperature properties and cost of the double filters render them advantageous over the traditional ones. (Author abstract) 6 refs. In Russian.

Rakviashvili, A.G.; Sysun, V.V. *Svetotekhnika* n 1 1988 p 18-21.

## Laser Applications

**074089 EXPERIMENTAL DEMONSTRATION OF A DIODE LASER-EXCITED OPTICAL FILTER IN ATOMIC Rb VAPOR.** A narrow-bandwidth optical filter using diode-laser-pumped atomic Rb vapor has been demonstrated. Excellent rejection of off-resonant laser photons has been achieved. The measured detection bandwidth was 1.18 GHz at the Rb cell temperature of 150°C, which shows a good agreement with the calculated detection bandwidth of 1.02 GHz. The quantum efficiency of the atomic Rb vapor laser-excited optical filter is linearly dependent on the diode laser pumping power. 8 refs.

Chung, Yun C. (Utah State Univ, Logan, UT, USA); Shay, T.M. *IEEE J Quantum Electron* v 24 n 5 May 1988 p 709-711.

## Materials

**074090 NEAR MILLIMETRE WAVELENGTH OPTICAL CONSTANTS OF FLUOROSINT.** The near millimeter wavelength optical constants of Fluorosint have been determined and shown to be suitable for use in low pass transmission filter applications. The optical properties are found to be isotropic, an important advantage over some materials used in such applications.

(Author abstract) 6 refs.

Birch, J.R. (NPL, Teddington, Engl); Lesurf, J. *Infrared Phys* v 27 n 6 Nov 1987 p 423-424.

## Mathematical Models

**074091 ROTATION AND SCALE SENSITIVITIES OF THE BINARY PHASE-ONLY FILTER.** The scaling and rotation sensitivity of a binary phase-only correlator is studied and compared to that of continuous phase-only correlator, classical correlator, and edge-enhanced classical correlator. Computer simulation of the optical system is used to determine values of the correlation peak intensity versus scale and rotation changes of the input signal for the four filter types. The results show that the binary phase-only filter is slightly less sensitive to such input variations than is the continuous phase-only filter. (Author abstract) 8 refs.

Javidi, B. (Michigan State Univ, East Lansing, MI, USA); Odeh, S.F.; Chen, Y.F. *Opt Commun* v 65 n 4 Feb 15 1988 p 233-238.

## Measurements

**074092 TUNABLE SINGLE-MODE FIBER REFLECTIVE GRATING FILTER.** A single-mode fiber tunable reflective filter is demonstrated by translating a fan-shaped grating structure through the evanescent field of a side-polished fiber. Filter linewidths of about 1 nm were measured over tuning ranges in excess of 65 nm. Reflectivities as high as 88% were observed. Using the fiber filter as a feedback element, a multimode semiconductor laser was observed to oscillate in a single mode which could be discretely tuned over a wavelength range of 26 nm. 5 refs.

Sorin, Wayne V. (Hewlett-Packard Lab, Palo Alto, CA, USA); Zorabedian, Paul; Newton, Steven A. *J Lightwave Technol* v LT-5 n 9 Sep 1987, Opt Fiber Conf/Sixth Biannual Int Conf on Integr Opt and Opt Fiber Commun, Reno, NV, USA, Jan 19-22 1987 p 1199-1202.

## Multiplexing

**074093 FDM-FSK STAR NETWORK WITH A TUNABLE OPTICAL FILTER DEMULTIPLEXER.** An optical frequency-division-multiplexed star network is analyzed and demonstrated experimentally using two 45 Mbit/s frequency-shift-keyed laser channels at 1.5  $\mu$ m. A tunable fiber Fabry-Perot filter is used as demultiplexer. The analysis predicts and experiment supports a minimum channel spacing of about six times bit rate B for a single FFP and 3B for a tandem FFP. (Author abstract) 3 refs.

Kaminow, I.P. (AT&T Bell Lab, Holmdel, NJ, USA); Iannone, P.P.; Stone, J.; Stulz, L.W. *Electron Lett* v 23 n 21 Oct 8 1987 p 1102-1103.

**Performance** See Also PATTERN RECOGNITION SYSTEMS—Components.

**074094 RELAXATION METHOD OF COMPENSATION IN AN OPTICAL CORRELATOR.** An iterative method is proposed for the sharpening of programmable filters in a 4-f optical correlator. Continuously variable spatial light modulators (SLMs) permit the fine adjustment of optical processing filters so as to compensate for the departures from ideal behavior of a real optical system. Although motivated by the development of continuously variable phase-only SLMs, the proposed sharpening method is also applicable to amplitude modulators and, with appropriate adjustments, to binary modulators as well. A computer simulation is presented that illustrates the potential effectiveness of the method: an image is placed on the input to the correlator, and its corresponding phase-only filter is adjusted (allowed to relax) to produce a progressively brighter and more centralized peak in the correlation plane. The technique is highly robust against the form of the system's departure from ideal behavior. (Author abstract) 4 refs.

Juday, Richard D. (NASA, Johnson Space Cent, Houston, TX, USA); Daiuto, Brian J. *Opt Eng* v 26 n 11 Nov

1987 p 1094-1101.

**074095 CARBON AND BERYLLIUM EXTREME ULTRAVIOLET FILTERS: FAR-ULTRAVIOLET PERFORMANCE.** Designs for extreme-ultraviolet filters using thin carbon and beryllium foils are presented and their far-ultraviolet performance summarized. The transmission data yield values for the linear-absorption coefficients of beryllium and carbon in the wavelength range 1200-2000 Å which are compared with other published data in this and in the adjacent extreme-ultraviolet wavebands. Use of multiple foils is demonstrated to be an effective means of eliminating pin-holes, which may contribute significantly to the far-ultraviolet transmission. (Author abstract) 18 refs.

Barstow, M.A. (Univ of Leicester, Leicester, Engl); Kent, B.J.; Whiteley, M.J.; Spurrett, P.H. *J Mod Opt* v 34 n 11 Nov 1987 p 1491-1500.

**074096 RECENT DEVELOPMENTS IN THE PRODUCTION OF NARROWBAND POSITION TUNED INTERFERENCE FILTERS FOR WAVELENGTH MULTIPLEXED OPTICAL FIBRE SYSTEMS.** The performance of position tuned multilayer interference filters for use in the 1250-1600 nm wavelength range is described and analysed. These new filters have an improved performance with a wider tuning range (> 250 nm) and reduced fwhm (< 10 nm) compared with earlier samples. These devices could find application for single channel selection in wavelength multiplexed single-mode optical fibre systems. (Author abstract) 9 refs.

McCartney, D.J. (British Telecom Research Lab, Ipswich, Engl); Lissberger, P.H.; Roy, A.K. *Opt Commun* v 64 n 4 Nov 15 1987 p 338-342.

## Stability

**074097 WAVELENGTH DEPENDENCE OF OPTICAL BISTABILITY IN MOLECULAR-BEAM-DEPOSITED ZnSe INTERFERENCE FILTERS.** Complete ZnS interference filters exhibiting optical bistability have been fabricated using ultrahigh-vacuum molecular-beam techniques. The wavelength dependence of the critical switching power was measured at five wavelengths between 521 and 676 nm for a filter with two-period ZnSe/BaF<sub>2</sub> multilayer reflectors and an initial assessment has been made of their long-term operational stability. (Author abstract) 19 refs.

Miller, A. (Royal Signals & Radar Establishment, Malvern, Engl); Staromlynska, J.; Muirhead, I.T.; Lewis, K.L. *J Mod Opt* v 35 n 3 Mar 1988, Eighth Natl Quantum Electron Conf, St. Andrews, Scotl, Sep 21-25 1988 p 529-540.

**Thin Films** See ORGANIC COMPOUNDS—Thin Films.

**OPTICAL GRATINGS** See Also DOMES AND SHELLS—Vibrations; FIBER OPTICS—Multiplexing; HOLOGRAPHY; HOLOGRAPHY—Computer Applications; INTERFEROMETERS; INTERFEROMETRY—Imaging Techniques; LASER PULSES; LASERS, CARBON DIOXIDE—Modes; LASERS, RING—Research; LASERS, RING—Stability; LASERS, SEMICONDUCTOR—Accessories; LASERS, SEMICONDUCTOR—Modes; LIGHT—Scattering; OPTICAL COMMUNICATION—Multiplexing; OPTICAL COMMUNICATION EQUIPMENT; OPTICAL FIBERS; OPTICAL FIBERS—Analysis; OPTICAL FILTERS; OPTICAL FILTERS—Measurements; SPECTROMETERS—Resolving Power; SPECTROSCOPY—Theory; TELECOMMUNICATION LINES—Analysis; WAVEGUIDES, OPTICAL—Components.

**074098 NUMERICAL ANALYSIS OF DIFFRACTION FROM A SINUSOIDAL METAL GRATING.** Diffraction of plane waves by a metal grating of a sinusoidal cross section is investigated theoretically by considering a finite conductivity of the material. The analysis is based on the mode-matching method with a smoothing operation. The numerical results of the diffracted power from a sinusoidal gold grating are presented with sufficient accuracy for both P-polarization and



S-polarization. The results have been compared with those for perfectly conducting gratings. (Edited author abstract) 13 refs.

Yasuura, Kamenosuke (Kyushu Univ, Fukuoka, Jpn); Murayama, Masanao. *Electron Commun Jpn Part 1* v 70 n 8 Aug 1987 p 70-78.

**074099 IMPROVEMENT OF A DIFFERENTIAL METHOD FOR METALLIC DIFFRACTION GRATINGS BY MEANS OF AN INTEGRAL METHOD.** It is shown how a result from the integral method for calculating the diffraction from a metallic grating can be used to improve the differential method. The result from the integral formalism can be regarded as a vigorous theoretical basis for those methods that employ surface impedance boundary conditions. (Author abstract) 9 refs.

Depine, Ricardo A. (Univ de Buenos Aires, Buenos Aires, Argent). *J Mod Opt* v 34 n 9 Sep 1987 p 1135-1139.

**074100 NON-UNIFORMITIES IN THICK DICHROMATED GELATIN TRANSMISSION GRATINGS.** The angular characteristics of transmission gratings are studied for the case when three parameters, namely the dielectric-constant modulation, the average dielectric constant and the grating vector vary with distance in the grating. The diffraction efficiency is worked out with the aid of a coupled-wave theory for linear and quadratic variation of the parameters. Gratings recorded in thick (~60 μm) dichromated gelatin plates are measured. The spatial variations of the parameters are deduced by comparing the experimental and theoretical results. (Author abstract) 20 refs.

Au, L.B. (Univ of Oxford, Oxford, Engl); Newell, J.C.W.; Solymar, L. *J Mod Opt* v 34 n 9 Sep 1987 p 1211-1225.

**074101 ROTATING GRATINGS REVEAL THE TEMPORAL TRANSFER FUNCTION OF THE OBSERVING SYSTEM.** It is shown that a rotating sinusoidal grating is a useful sweep signal for the analysis of the temporal behavior of linear imaging systems. For a suitably chosen angular velocity and spatial frequency, the spatial a.c. component of the grating appears modulated in one dimension at the output of the system. The profile of this modulation is the temporal transfer function (TTF) of the system. A quantitative analysis of this effect is presented, and results from experiments with a photographic camera are shown. It is proposed to use this method in the field of vision research since it is presently the only way to demonstrate the complex-valued TTF of the visual system for suprathreshold grating stimuli. The main consequence of the first psycho-physical investigations was the discovery of a phase reversal at the origin of the TTF of the human visual system for gratings of low spatial frequency. (Author abstract) 16 refs.

Gluender, Helmut (Technische Univ Muenchen, Munich, West Ger). *J Mod Opt* v 34 n 10 Oct 1987 p 1365-1374.

**074102 FINITE-ELEMENT ANALYSIS OF PLANE WAVE DIFFRACTION FROM DIELECTRIC GRATINGS.** A method for analysis based on the finite element method has been presented as a procedure that enables analysis of a dielectric grating with an arbitrary profile. A systematic formulation has been presented from both TE and TM wave incidences. The analysis has been carried out for groove grating with rectangular, sinusoidal and trapezoidal profile as well as for a holographic grating actually fabricated. From the comparison with the results computed with other methods and with the experimental data, the validity and usefulness of the present method have been confirmed. 21 refs.

Nakata, Yasunori (Hokkaido Univ, Sapporo, Jpn); Koshiba, Masanori; Suzuki, Michio. *Electron Commun Jpn Part 2* v 70 n 11 Nov 1987 p 42-52.

**074103 EFFECTS OF TAPER IN NONLINEAR DISTRIBUTED FEEDBACK GRATINGS.** The effects of taper in a nonlinear slab waveguide with a distributed feedback grating are studied. The role of taper in the operation of the bistable gate is analyzed with regard to switching intensity and transmission for various detunings from the Bragg condition. A comparison is made between three different functional forms of taper, namely linear, quadratic and triangular, which could occur in the preparation of a working device. (Author abstract). 12 Refs.

Assanto, G. (CRES, Montreale, Italy); Zononi, R.; Stegeman, G.I. *J Mod Opt* v 35 n 6 Jun 1988 p 871-883.

**074104 "ANTI-BLAZING" OF GRATINGS.** A general property of diffraction gratings is established numerically: at a certain value of the groove depth a grating supporting only two orders acts like a plane mirror - the efficiency of the non-specular order does not exceed 0.1 percent in a large angular region. This property is shown to be a direct consequence of the reciprocity theorem. (Author abstract). 7 Refs.

Mashev, L. (Bulgarian Acad of Science, Sofia, Bulg); Popov, E. *Opt Commun* v 67 n 5 Aug 1988 p 321-324.

**074105 DIFFRACTION CHARACTERISTICS OF METALLIC REFLECTION GRATINGS.** Plane-wave diffraction by metallic reflection gratings with finite conductivity of arbitrary profile is analysed by a new analytical-numerical technique. The obliquely incident radiation is of linear polarisation with either its fields parallel to the rulings. The solution method is simple, general and numerically efficient. It involves expansion by a Fourier series of the periodic permittivity function in the inhomogeneous grating region, and application of finite differences to numerically solve the inhomogeneous vector-wave equation in this region. Numerical results are presented for several gratings to demonstrate the convergence, reliability and accuracy of the method. They also show effect of the finite conductivity of metal on the diffraction characteristic of gratings. (Author abstract). 12 refs.

Moaveni, Mahmood K. (New Zealand Ltd, Wellington, NZ). *IEE Proc Part J* v 135 n 4 Aug 1988 p 318-324.

**074106 DYNAMICS OF TWO-WAVE MIXING WITH RUNNING GRATINGS IN PHOTOREFRACTIVE CRYSTALS.** In this study we extend previous works of the dynamics of two-wave mixing in photorefractive crystals in respect of two points: (i) We allow different frequencies of the two beams. (ii) We calculate both hologram buildup and erasure, where the writing time may be arbitrary. The introduction of a running grating leads to a complex effective response time  $\tau_{eff}$ . With this the behavior of a drift dominated photorefractive material can be forced upon a diffusion dominated material and vice versa. This effect has been used to enhance the steady state amplification. (Edited author abstract). 5 Refs.

Goltz, J. (Technische Hochschule Darmstadt, Darmstadt, West Ger); Tschudi, T. *Opt Commun* v 67 n 6 Aug 15 1988 p 414-416.

**074107 THE DIFFRACTION NEAR FIELDS AND LAU EFFECT OF A SQUARE-WAVE MODULATED PHASE GRATING.** The intensity distribution in the near field of a square-wave modulated phase grating is calculated. It is found that the Talbot images as well as the Fresnel images of this phase grating are similar to the object structure. The Lau effect for the case of square-wave modulated phase grating is studied with reference to diffraction theory. (Author abstract). 10 Refs.

Jinhong, Tu (Shanghai Jiao Tong Univ, Shanghai, China). *J Mod Opt* v 35 n 8 Aug 1988 p 1399-1408.

**074108 VOLUME HOLOGRAPHIC GRATINGS: MODELLING THEIR OPTICAL PROPERTIES.** Numerical studies of non-sinusoidal holographic gratings are reported. It is assumed that losses are present during the hologram recording process. At reconstruction the structures are treated as pure-phase volume gratings. The photo induced changes in the refractive index of the material are described by an exponential saturation law. Angular and wavelength selectivities of unsaturated transmission and reflection gratings are evaluated. (Author abstract). 5 Refs.

Shaarlandjiev, P. (Cent Lab of Optical Storage & Processing of Information, Sofia, Bulg); Markovski, P.; Todorov, T. *J Mod Opt* v 35 n 8 Aug 1988 p 1409-1415.

**074109 PICOSECOND PHOTOREFRACTIVE AND FREE-CARRIER TRANSIENT ENERGY TRANSFER IN GAAS AT 1 μm.** The strength, formation, and decay of photorefractive and free-carrier gratings written in GaAs by 43-ps pulses at a wavelength of 1 μm are investigated using picosecond-time-resolved two-beam coupling, transient grating, and degenerate-four-wave-mixing techniques. Photorefractive weak-beam gains of a few percent are measured at fluences of a few pJ/μm<sup>2</sup> (0.1 mJ/cm<sup>2</sup>), and gain from transient energy transfer is observed at fluences larger than 10 mJ/cm<sup>2</sup> in the beam-coupling experiments. The roles of saturation and two-photon absorption in determining the final electron, hole, and ionized-donor populations and the roles of drift and diffusion in determining the quasi-steady-state photorefractive and free-carrier index modulations are discussed. 27 refs.

Smirl, Arthur L. (Hughes Research Lab, Malibu, CA, USA); Valley, George C.; Bohnert, Klaus M.; Bogges, Thomas F. Jr. *IEEE J Quantum Electron* v 24 n 2 Feb 1988 p 289-303.

**Analysis**

**074110 COUPLED BEAM ANALYSIS OF CURVED PLANAR BRAGG GRATINGS.** When a laser or a fiber is butt joined to a single mode film waveguide it launches a two-dimensional nearly Gaussian beam in the fundamental film mode. A curved Bragg grating may deflect and even refocus such an incident Gaussian beam. A coupled beam analysis has shown that the distortions of the refocused field may be kept low if the distance between the beam waists and the curved grating is sufficiently long. The greater this distance, the more the curved grating behaves like a concentrated reflector, which has the same wavelength dependence of reflectivity as would result for a plane wave incident upon a corresponding plane grating with straight lines. (Author abstract) 6 refs.

Jacob, J. (Technische Univ Braunschweig, West Ger); Lange, J. *Radio Sci* v 22 n 6 Nov 1987, Int Symp on Electromagn Theory, Budapest, Hung, Aug 25-29 1986 p 1003-1007.

**Applications** See LASERS, DYE; MECHANICAL VARIABLES MEASUREMENT—Laser Applications.

**Construction**

**074111 INTERFEROMETRIC METHOD FOR MAKING EQUISPACED CIRCULAR GRATINGS.** A simple interferometric method is proposed for constructing equispaced circular gratings. This method uses only a cylindrical mirror and a collimating lens, and the radial spatial frequency of the gratings thus constructed is a function of the focal length of the collimating lens. A change of radial spatial frequency of the grating can be performed by changing the focal length of the collimator. A continuous change of the frequency can be obtained by using a zoom lens. (Author abstract). 9 Refs.

Ru, Qing-Shin (Tokyo Inst of Technology, Yokohama, Jpn); Ohyama, Nagaaki; Honda, Toshio; Tsujiuchi, Junpei. *Opt Commun* v 67 n 3 Jul 1 1988 p 195-198.

**Design** See Also POLARIMETERS—Design.

**074112 DIFFRACTION BY DYNAMIC GRATINGS INDUCED BY OPTICALLY GENERATED CARRIERS IN InGaAsP.** Dynamic interferometric amplitude gratings are generated in an InGaAsP epitaxial layer of 2 μm thickness. The pump beams have a wavelength of 514 nm and a light power of approximately 0.3 w each. The diameter of the grating pattern amounts to 440 μm. The average pumping intensity is 400 w/cm<sup>2</sup>. A maximum absorption difference in the sample between the bright and dark grating lines of 160cm<sup>-1</sup> is introduced via dynamic band filling. A test beam at 1.30 μm wavelength corre-



sponding to the band gap wavelength of the epilayer is diffracted and thus modulated by the grating at grating constants of about 20  $\mu\text{m}$ . The diffraction efficiency of the first order at normal incidence amounts to about  $1 \times 10^{-4}$ . The 3 db corner frequency of the modulation is about 80 MHz. Carrier diffusion diminishes grating contrast. (Author abstract). 6 Refs.

Kowalsky, W. (Technical Univ of Braunschweig, Braunschweig, West Ger); Fouckhardt, H.; Ebeling, K.J. *Opt Commun* v 67 n 3 Jul 1 1988 p 199-203.

**074113  $\lambda/4$  SHIFTED 1ST AND 2ND ORDER DFB-GRATINGS FOR InGaAs/InP LASERS.** First and second order DFB-gratings for InGaAs/InP double heterostructures have been developed using high resolution electron beam lithography (EB) and dry etching. The lasing characteristics of the structures are investigated by gain spectroscopy. In contrast to the unmodified gratings which show laser spectra dominated by two competing modes the inclusion of a  $\lambda/4$  phase-shift leads reproducibly to single mode emission. (Author abstract) 4 refs.

Korn, M. (Univ Stuttgart, Stuttgart, West Ger); Forchel, A.; Moehle, M.; Germann, R.; Streubel, K.; Scholz, F. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microlithogr, Jouy-en-Josas, Fr, Sep 22-25 1987 p 571-574.

**Fabrication** See Also LASERS, SEMICONDUCTOR.

**074114 NOVEL FABRICATION METHOD OF QUARTER-WAVE-SHIFTED GRATINGS USING ECR-CVD  $\text{Si}_3\text{N}_4$  FILMS.** Quarter-wave-shifted gratings were fabricated by novel methods using ECR-CVD  $\text{Si}_3\text{N}_4$  films.  $\text{Si}_3\text{N}_4$  films deposited on photoresist and grooves have a higher etching rate than those deposited on the flat substrate. We made good use of this difference to fabricate the quarter-wave-shifted gratings with a 240 nm period, about 150 nm depth and narrow transient regions. (Author abstract) 9 refs.

Sugimoto, H. (Mitsubishi Electric Corp, Amagasaki, Jpn); Abe, Y.; Matsui, T.; Ogata, H. *Electron Lett* v 23 n 24 Nov 19 1987 p 1260-1261.

**074115 FABRICATION OF BLAZED GRATING BY SLOPING V-GROOVE STRUCTURES ON SILICON.**  $\langle 113 \rangle$  oriented silicon is used as substrate and the  $\langle 113 \rangle$  surface is at an angle of  $25.24^\circ$  with  $\langle 111 \rangle$  planes. A 36  $\mu\text{m}$  period diffraction grating as a mark during the anisotropic etching of silicon was generated on  $\langle 113 \rangle$  Si by thermal oxidation and photo-etching technology. Subsequently silicon wafers are etched in the conventional anisotropic etching solution. Continuously slanted V-groove structures on silicon have been fabricated which are used for a 36  $\mu\text{m}$  groove distance blazed grating with 69% diffraction efficiency at wavelength of 6328 Å. Useful blazed gratings can be obtained by further reducing the groove distance. (Author abstract) In Chinese. 3 refs.

Huang, Xinfan (Nanjing Univ, China); Li, Liangzhu; Gao, Wenqi; Ye, Quanshu. *Guangxue Xuebao* v 8 n 1 Jan 1988 p 89-92.

**074116 NOVEL FABRICATION METHOD OF 120nm PERIOD GRATINGS USING ECR-CVD  $\text{Si}_3\text{N}_4$  FILMS.** 120 nm period gratings were fabricated by a novel method using ECR-CVD  $\text{Si}_3\text{N}_4$  films.  $\text{Si}_3\text{N}_4$  films deposited on the photoresist having a higher etching rate than that on the flat semiconductor substrate. Good use of this difference was made to fabricate gratings whose period is one-half that of the original, formed by a holographic exposure technique. (Author abstract). 8 Refs.

Sugimoto, H. (Mitsubishi Electric Corp, Hyogo, Jpn); Abe, Y.; Matsui, T.; Ogata, H. *Electron Lett* v 24 n 14 Jul 7 1988 p 842-843.

## Manufacture

**074117 ETCHING TECHNIQUE OF DIFFRACTION GRATINGS IN InP AND InGaAsP.** A technique is described for the manufacture of gratings by wet

chemical etching through a photoresist mask that has been patterned by laser interference exposure. First-order as well as second-order gratings in InP or InGaAsP for 1.55  $\mu\text{m}$  DFB lasers with high uniformity and reproducibility have been fabricated. (Edited author abstract) In Chinese. 3 refs.

Zheng Yuhong (Acad Sinica, China); Miao Yubo; Tian Huiliang; Si Yuancheng; Zhang Jingyuan. *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 305-307.

**Mathematical Models** See Also OPTICAL DATA PROCESSING—Analysis.

**074118 DIFFRACTION REGIMES OF PHASE GRATINGS.** The occurrence of Raman-Nath regime and Bragg regime diffraction by planar phase gratings is rigorously analyzed. It is shown that the published indicators for a Raman-Nath regime are unsatisfactory. An attempt to redefine the Raman-Nath region is given in this paper. (Author abstract) 5 refs.

Jaaskelainen, T. (Univ of Kuopio, Kuopio, Finl); Hytonen, T. *Opt Commun* v 64 n 1 Oct 1 1987 p 19-22.

**074119 CALCULATION ON THE RESOLUTION AND THE DIFFRACTION INTENSITY OF ONE DIMENSIONAL LINE GRATINGS WITH ABERRATIONS.** The resolution and the diffraction intensity are calculated on the one-dimensional gratings which have positional errors of the lines. Two types of errors are investigated. One is a random error represented by a certain probability distribution. The other is a systematic one which is a function of the line position and can be denoted with a polynomial expression of the line position. As the result it is shown that the random error hardly decreases the resolution, but the systematic error decreases the resolution significantly. It is also shown that in the systematic error case, the scattering energy is localized around the maximum intensity of diffraction so that the product of the maximum value and the width of half maximum of diffraction intensity distribution becomes almost constant. In the random error case, the product is not a constant and the scattering energy diffuses widely along the diffraction angle. (Author abstract) In Japanese. 3 refs.

Hibino, Ken-ichi; Matsuda, Kiyofumi. *Kikai Gijutsu Kenkyusho Shoho* v 41 n 5 Sep 1987 p 227-235.

**074120 NATURAL MODES OF TWO-DIMENSIONAL RECTANGULAR GRATINGS.** The properties of the roots of the dispersion equation for the electromagnetic field of a grating with two-dimensional rectangular sinusoidal modulation are analyzed in the four-wave approximation. The regions of real and imaginary roots and their dependence on the grating periods and modulation amplitudes along both coordinates are determined. It is shown that as one of the modulation amplitudes tends to zero the roots of the dispersion equation change into the roots of the equations of a grating with one-dimensional modulation. The presence of important special features of the roots compared with one-dimensional modulation is pointed out. (Author abstract) 4 refs.

Gudzenko, A.I.; Sotin, V.Ye. *Sov J Commun Technol Electron* v 32 n 4 Apr 1987 p 22-28.

**074121 COMPENSATION OF NONLINEAR CHIRP GENERATED BY SELF-STEEPENING USING THIRD ORDER DISPERSION OF A GRATING PAIR.** The cubic term of a response function of a grating pair can be changed by varying the angle of incidence to the gratings, while the quadratic term is controlled by varying the distance between the gratings. With this cubic term, the self-steepening (optical shock) and third order dispersion in single-mode fibers, which produce a nonlinearly chirped pulse, can be successfully compensated for optical pulse compression. (Author abstract) 8 refs.

Kubota, Hirokazu (NTT, Tokai, Jpn); Nakazawa, Masataka. *Opt Commun* v 66 n 2-3 Apr 15 1988 p 79-82.

**074122 COUPLING COEFFICIENTS FOR TRAPE-**

**ZOIDAL GRATINGS.** Using coupled-mode theory, the coupling coefficient was calculated for a trapezoidal grating, and it was shown that it is possible to adjust its shape to obtain a high coupling coefficient. This is one of the advantages offered by the ion beam etching technique. 7 refs.

Correc, P. (CNET, Fr). *IEEE J Quantum Electron* v 24 n 1 Jan 1988 p 8-10.

**Spectrum Analysis** See Also WAVEGUIDES, OPTICAL—Sensors.

**074123 PLASMON SURFACE POLARITON FIELDS VERSUS TIR EVANESCENT WAVES FOR SCATTERING EXPERIMENTS AT SURFACES.** Dielectric phase gratings have been employed to directly compare the diffraction efficiencies of total internal reflection (TIR) evanescent waves and plasmon surface polariton (PSP) fields. It is demonstrated that the latter couple more effectively to surface layer heterogeneities. The use of PSP is proposed for static and dynamic scattering experiments at interfaces and in thin films. (Author abstract) 17 refs.

Rothenhauser, Benno (Technische Univ Muenchen, Munich, West Ger); Knoll, Wolfgang. *Opt Commun* v 63 n 5 Sep 1 1987 p 301-304.

**074124 BACK-SIDE DIFFRACTION BY RELIEF GRATINGS.** A comparison is made between the efficiency of bare and aluminum coated dielectric diffraction gratings supporting only two propagating orders utilizing substrate side light incidence. A large dissimilarity between the two types of gratings is observed and a possibility to achieve a 100% value of the absolute diffraction efficiency in Littrow mount is discussed. An almost constant value of 80% of efficiency is preserved for the aluminum grating nearly in the entire visible region. (Author abstract) 8 refs.

Popov, E. (Bulgarian Acad of Sciences, Sofia, Bulg); Mashev, L.; Maystre, D. *Opt Commun* v 65 n 2 Jan 15 1988 p 97-100.

## Theory

**074125 AMBIGUITY FUNCTION AND GENERAL TALBOT-LAU EFFECTS.** The Talbot and Lau effects of Ronchi gratings are treated by the ambiguity function in this paper. Furthermore, both effects fit any optical system. Because of quasi-ray-optical operation of the AF, two general formulas directly describing the patterns of the Talbot and Lau fringes respectively are derived in a quite simple form. All the variables in the formulas depend only on the transfer matrices of the optical system used. The Talbot and Lau effects of complex gratings are also discussed. (Author abstract) In Chinese. 23 refs.

Liu, Liren (Acad Sinica, China). *Guangxue Xuebao* v 7 n 6 Jun 1987 p 501-510.

**OPTICAL INSTRUMENTS** See Also ACCELEROMETERS; FILMS—Measurements; GYROSCOPES; LASERS, CARBON DIOXIDE—Tuning; LIGHT—Polarization; OPTICAL FIBERS—Measurements; OPTICAL VARIABLES MEASUREMENT; PHOTOGRAMMETRY—Instruments; PRESSURE MEASUREMENT; SOLUTIONS—Measurements; SPECTROMETERS—Performance; SURFACES—Roughness Measurement.

**074126 PRECISION DIGITAL PHOTO-ELECTRIC CENTERING INSTRUMENT.** The working principles of a digital photoelectrical centering instrument, its completed construction project, optical system, mechanical design, circuit principles and the results of testing and using the instrument are described in this paper. This instrument can be used for centering during edging and cementing and testing centering error of lenses. We can measure deviation of spherical center with an accuracy as small as 1  $\mu\text{m}$ . (Author abstract) 4 refs. In Chinese.

Zhou, Changxin (Acad Sinica, China). *Guangxue Xuebao* v 7 n 8 Aug 1987 p 738-742.



**074127 STUDY OF OPTICAL FIBER INSTRUMENT FOR DISPLACEMENT MEASUREMENT.** The article presents the construction and measuring process of an optical fiber instrument for measuring micro-meter displacement. The instrument can also be used to measure roundness, micro-deflection, surface roughness, small vibration amplitude as well as the thickness error of silicon plate and film. (Edited author abstract) In Chinese. 6 refs.

Anon. *Ji Chuang* n 10 1987 p 30-33.

**074128 VARIABLE ANGLE SPECTROSCOPIC ELLIPSOMETRY.** Null ellipsometry and automated ellipsometry at a single wavelength are established technologies but limited in their range of application. In comparison, spectroscopic ellipsometry at fixed angle and, in the past few years, variable angle spectroscopic ellipsometry (VASE) are powerful analytical tools for the investigation of surfaces, chemical interfaces, semiconductor heterojunctions, quantum well structures, and optoelectronic materials. (Author abstract) 27 refs.

Alterovitz, Samuel A. (NASA, Lewis Research Center, OH, USA); Woollam, John A.; Snyder, Paul G. *Solid State Technol* v 31 n 3 Mar 1988 p 99-102.

**074129 TOWARD A GENERAL-PURPOSE OPTICAL OSCILLOSCOPE.** For years, researchers and product developers have had to assemble some sort of jury-rigged apparatus to make critical optical measurements with conventional oscilloscopes. All this has changed with the introduction, by Tektronix, of a new oscilloscope capable of measuring optical signals directly. Users can quickly and consistently analyze data from a wide variety of applications, ranging from high-energy physics and nuclear research to high-voltage transmission and communications systems.

Trent, Bill (Tektronix, Beaverton, OR, USA). *Lasers Optonics* v 6 n 12 Dec 1987 p 52-54.

**074130 INSIGHTS ON MOIRE DEFLECTOMETRY.** A phase-measuring interferometer uses the interference phenomenon between two temporally coherent light waves to form a fringe-contour map. Both reflective and phase objects can be tested, and the resulting map is fully quantitative. This technique has long been the most popular method of optical diagnostics, although it suffers four drawbacks that lead to difficult operation and (generally) high-cost instrumentation. Moire deflectometry inherently solves these problems of interferometry and adds many benefits. It is insensitive to tilt, relative height is observed directly, mechanical stability requirements are only ten times the desired sensitivity, and sensitivity is tunable. Deflectometry can be used to test all objects that are tested by interferometry, plus other objects whose distortions are beyond the range of interferometry. A Moire deflectometer maps ray deflections caused by refractive-index gradients in phase objects, or height gradients of reflective surfaces. The technique is based on the Moire effect, a phenomenon that causes a Moire fringe to appear when two gratings are placed at a small angle to each other. 21 Refs.

Kreske, Kathi; Keren, Eliezer; Kafri, Oded. *Lasers Optonics* v 7 n 10 Oct 1988 p 63-66.

Accessories

**074131 AUTOMATIC APPARATUS BASED ON ACOUSTOOPTIC FILTER FOR RECOGNITION OF SURFACE COLOR SHADE.** Automatic apparatus for recognition of surface color shade is described that is based on a programmable polarizing acoustooptic visible spectrophotometer. The operating modes and the possibilities for data processing and output are described. An algorithm is given for color-shade recognition and determination of chromatic coordinates. (Author abstract) 5 refs.

Bezdenzhnykh, S.V. (All-Union Scientific-Research Inst of Physicotechnical & Radio-Engineering Measurements, Mendeleevo, USSR); Gazarov, Kh.V.; Zhogun, V.N.; Kostin, N.S.; Latyshev, V.M.; Skobelev, I.Yu.; Pustovoi,

V.I.; Faenov, A.Ya.; Shekhovtsov, V.N. *Instrum Exp Tech* v 30 n 4 pt 2 Jul-Aug 1987 p 937-940.

Aerospace Applications

**074132 PERFORMANCE OF OPTICAL SENSORS IN HYPERSONIC FLIGHT.** Hypersonic flight through the atmosphere presents unique environmental conditions that significantly affect the performance of a vehicular optical sensor. Knowledge of high-speed optical conditions and of the resulting effects on sensor performance is important in the design of optical instruments used in space shuttles, high-speed aircraft, and guided missiles. This article reports on recent work to quantify the transmissive and radiative effects of complex flow and heated windows caused by hypersonic flight in order to predict sensor performance and investigate the effect of film cooling of windows. (Author abstract) 12 refs.

Tropf, William J.; Thomas, Michael E.; Harris, Terry J.; Lutz, Steven A. *Sol Cells* a2 p 370-385.

**Applications** See FILMS—Imaging Techniques; FLOW OF FLUIDS—Turbulent; SURFACES—Roughness Measurement; TOOLS, JIGS AND FIXTURES—Calibration.

**Assembly** See ROBOTS, INDUSTRIAL—Grippers.

**Calibration** See OPTICAL FIBERS—Measurements; PARTICLE SIZE ANALYSIS—Instruments.

**Computer Applications** See DUST—Monitoring; MINE DUST—Measurements; SEMICONDUCTING FILMS—Optical Properties.

Computer Simulation

**074133 ACCURACY OF DIGITAL FOURIER TRANSFORMATION DETECTION SYSTEMS FOR HIGH SPEED ROTATING ANALYSER ELLIPSOMETERS.** Computer simulations have been performed in order to assess the accuracy of a fast Fourier transformation detection system for a high speed rotating analyser ellipsometer with a data acquisition time of the order of 10 ms for an entire measurement. The effect of mechanical imperfections of the analyser assembly and of electrically and optically generated periodic and random noise was studied. (Author abstract) 5 refs.

Riedling, K. (Technische Univ Wien, Vienna, Austria). *Thin Solid Films* v 155 n 1 Dec 15 1987 p 151-163.

Design

**074134 OPTICAL MULTICHANNEL RECORDER AND ITS APPLICATION IN STUDYING A PICO-SECOND DYE LASER.** We created and applied an optical multichannel recorder with a PZS matrix detector for investigating the parameters of laser radiation. The instrument, called an OMR (optical multichannel recorder), records the spatial intensity distribution of a radiation pulse incident on the detector, memorizes it, reproduces it in the form of a semitone map on a television display, and outputs the signal intensity at any point, the intensity distribution over a given cross-section (line), and the integral over the cross section to a digital display. 2 refs.

Vinogradov, S.V.; Kuznetsov, V.V.; Lyutinskii, V.V.; Nazarov, V.N.; Neporent, B.S.; Nikolaev, G.E.; Poznyak, R.I.; Revinskii, V.V.; Sokolov, A.V.; Tovmasyan, S.K.; Chernyavskii, A.F.; Shilov, V.B. *J Appl Spectrosc* v 46 n 3 Mar 1987 p 322-325.

**Errors** See Also MECHANICAL VARIABLES MEASUREMENT—Angles; PARTICLE SIZE ANALYSIS—Equipment.

**074135 METHOD OF RECOGNIZING THREE-DIMENSIONAL POSITION OF A RIGID BODY USING ITS SHAPE. ERROR ANALYSIS AND AN OPTIMIZATION OF OBSERVATION SYSTEM.** In the problem of measuring three-dimensional positions and motion of a rigid body, methods to determine the three-dimensional position from its optical projection data

on a two-dimensional plane have been widely used. We have proposed a method using positional relations among the marked points and applied it to three-dimensional movement measurement of the human jaw. This paper analyzes the effect of error associate with measurement on estimating the position of marked points at implementation. Error propagation equations are derived effective for design of measuring instruments. The optimum measuring method is obtained from the viewpoint of error propagation using the result. (Edited author abstract) 8 refs.

Hayashi, Toyohiko (Niigata Univ, Niigata, Jpn); Iijima, Taizo. *Syst Comput Jpn* v 18 n 10 Oct 1987 p 68-78.

Evaluation

**074136 PROFILE OF SIRA LTD.** Previously known as the British Scientific Instrument Research Association, Sira has continued, since its formation in 1918, to offer a service to users and manufacturers of instruments that involves the application of new developments in optics to serve the needs of industry. The two operating divisions provide multidisciplinary teams to work on a variety of different problems, including instrument evaluation and calibration, conference and course organization, and the application of measurement science to solve new industrial problems. Two recent projects described include the use of the principle of thermoelasticity to display the distribution of stress on the surface of a structure subjected to periodic loading, and a TV-imaging technique that enables a surface flaw to be quantified objectively in relation to a standard. (Edited author abstract) 5 refs.

Baker, L.R. (Sira Ltd, Chislehurst, Engl). *Opt Lasers Eng* v 7 n 4 1986-1987 p 243-251.

Gratings

**074137 APPROXIMATE ANALYSIS OF DIELECTRIC GRATINGS WITH BOUNDARY REFLECTION.** Approximate two-wave analysis of planar dielectric gratings with boundary reflection is presented. The analysis is derived from our previous rigorous theory by neglecting the higher-order waves and the second derivatives of the field amplitudes but taking into account of the boundary reflection. The pulsation phenomena of the diffraction efficiency due to the multiple reflection which are usually ignored in most of the approximate analysis can be given clearly by simple  $2 \times 2$  matrix calculations for practical gratings of small index-modulation type. The numerical results are given for TE wave incidence and are compared with rigorous results. (Author abstract) 9 refs.

Mori, Shizuo; Teraguchi, Hirofumi; Yamakita, Jiro; Rokushima, Katsu. *Bull Univ Osaka Prefect Ser A* v 36 n 2 1987 p 119-139.

**Infrared** See Also OPTICAL PROPERTIES—Measurements.

**074138 OFF-AXIS IR COLLIMATOR.** An off-axis IR collimator has been developed for the wavelength interval  $\lambda = 3.0 - 12.0 \mu\text{m}$ . The meniscus parameters have been optimized on the basis of a Herschel-Maksutov arrangement. Analysis of the wavefront distortions at the exit from the collimator shows that they do not exceed  $\lambda/5$ . A method for centering the optical parts of the collimator has been developed in detail. (Author abstract) 4 refs.

Anokhovskii, V.N.; Moskalenko, V.I. *Optoelectron Instrum Data Process* n 6 1987 p 23-27.

Ionization

**074139 REGISTRATION OF IONIZATION CLUSTERS BY ELECTROLUMINESCENT DRIFT CHAMBER.** The possibility of registration of ionization clusters by a drift chamber with luminous data acquisition is investigated. Light is collected by a reemitter-containing light guide, which views two photomultipliers connected in coincidence. For registration of clusters, a mixture of  $\text{Ar} + 15\% \text{CH}_4$  is blown through the chamber, which operates in the proportional mode. The duration of a



signal from a single electron is 5-7 nsec. The average density of clusters registered from beta particles is 12 or 9.5 cm<sup>-1</sup> for a drift field of 40 or 100 v/cm in transverse-drift geometry for a digitization time of 2 nsec. (Author abstract) 13 refs.

Volkov, A.D. (Joint Inst for Nuclear Research, Dubna, USSR); Grebenyuk, V.M.; Zalikhanov, B.Zh.; Komissarov, E.V.; Serdyuk, V.Z.; Sidorkin, V.V.; Filimonov, P.S.; Jani, J. *Instrum Exp Tech* v 30 n 3 pt 1 May-Jun 1987 p 531-537.

**Laser Applications** See LASER BEAMS—Applications.

**Lenses** See Also MICROSCOPES—Computer Aided Design.

**074140 TRENDS DER OPTIKENTWICKLUNG.** [Trends in Optical System Development]. In an evaluation of the future development of image-forming optical systems significant trends are cited and explained. These include extension of the usable spectral range, self-focusing systems, variable-focus lenses, high-resolution large-field lenses, improved achromatic lenses, diffraction-limited high-performance aplanatic lenses, mini-lenses, and Fourier-transformation optical systems. (Edited author abstract) In German. 14 refs.

Emmerich, W. (Kombinat VEB Carl Zeiss JENA, East Ger); Hofmann, C. *Feingeraetetechnik* v 36 n 11 1987 p 488-492.

**074141 INJECTION MOUNTING: A LENSE ASSEMBLY INNOVATION.** This article introduces an innovative technique used for mounting lens elements and assembling optical systems which has been developed at Kodak. Known as Injection Mounted Assembly (IMA), this unique process forms a molded cell around an uncentered glass lens element. The molded cell is an optical subassembly with the lens element's optical axis aligned to secondary mounting features that are created during injection molding. 3 refs.

Pollicove, Harvey; Aquilina, Thomas. *Photonics Spectra* v 21 n 12 Dec 1987 p 109-114.

**074142 LENS CORRECTION FOR OPTICAL SYSTEMS.** The range of optical diameter gauges designed and manufactured by Beta Instrument Company Ltd. have been upgraded to include computer generated lens correction routines, giving the gauges an improved accuracy and a greater tolerance to movement of the measured product. In the wire, fibre and extrusion industries, dimensional measurement will often have to be performed by non-contact techniques using optical methods. These methods enable the product size to be determined immediately after the extrusion, so that process control can be applied to maintain the size between strict limits. To gain a high resolution of measurement, laser scanning can be used whereby a thin beam of monochromatic light is passed over the product in a linear scan and is arranged to fall on a photo-cell.

Anon. *Wire* v 38 n 3 May 1988 p 339-340.

**Manufacture** See Also CAMERAS—Manufacture.

**074143 PROCESS ENGINEERING ASPECTS OF OPTICAL SCALE MANUFACTURE.** This paper gives some insight into the variety and complexity of influences that have to be minded and technically controlled in optical scale manufacture. The high optical quality of image transfer, say, with quasi-diffraction-limited objectives and ultraprecise positioning systems cannot be fully exploited unless that quality is matched by that of all the processes involved, of which exposure is but one step. 12 refs.

Proeger, Hans-Juergen. *Jena Rev* v 31 n 2 1986 p 86-91.

**074144 EFFECT OF FABRICATION ERRORS OF DIFFRACTION LENSES ON THE QUALITY OF THE RESULTING IMAGE.** The effect of errors in alignment and in the etching depth on the quality of the

image formed by diffraction lenses with a line with a stepped profile is analyzed. Expressions are given for the pupil function of diffraction optical elements fabricated by means of sets of three phototemplates in a case in which there are two alignment errors. The alignment requirements in the use of various sets of phototemplates to fabricate lenses are compared. (Author abstract) 2 refs.

Bobrov, S.T. *Optoelectron Instrum Data Process* n 5 1987 p 64-68.

**Materials** See Also ALUMINUM AND ALLOYS—Metallic Matrix Composites.

**074145 RECENT APPLICATIONS OF METAL MATRIX COMPOSITES IN PRECISION INSTRUMENTS AND OPTICAL SYSTEMS.** This paper describes three unique metal matrix composite (MMC) material systems that have been developed for use in dimensionally stable platforms, precision mechanical systems, and lightweight reflective optics. These materials, consisting of aluminum alloys reinforced with fine particles of silicon carbide, offer performance advantages over conventional metals, including greater specific stiffness, higher strength, and better resistance to compressive microcreep. Weighing about the same as aluminum, certain grades of these MMC materials are isotropic and have excellent thermal conductivity, and they can be tailored to match the coefficients of thermal expansion of other materials, including beryllium, stainless steel, and electroless nickel. Such flexibilities in establishing material properties and characteristics present new opportunities in producing weight-critical, precision hardware. Practical applications of MMC materials in advanced guidance equipment and lightweight optical assemblies are discussed. (Edited author abstract) 15 refs.

Mohn, Walter R. (Advanced Composite Materials Corp, Greer, SC, USA); Vukobratovich, Daniel. *Opt Eng* v 27 n 2 Feb 1988 p 90-98.

**Medical Applications**

**074146 THIN FILMS: NEW MEDICAL DETECTIVES.** The body reacts to injury or disease by producing specific molecular antibodies form the immune system that assist in healing or rectifying the biochemical imbalance. In the medical world, immunoassay is a branch of diagnostics that attempts to identify and quantify these molecular complexes for the purpose of identifying both the cause and the severity of the problem. This article discusses new optical immunoassay techniques which increase sensitivity and simplify procedures. The main topics are optical immunoassay (OIA) interference slide, quantification of the interference slide, and current areas of research.

Hanlin, John. *Photonics Spectra* v 22 n 2 Feb 1988 p 113-114, 116, 118.

**Monitoring** See OPTICAL SYSTEMS—Monitoring.

**Performance** See Also AEROSOLS—Measurements; LASERS, SEMICONDUCTOR—Optical Pumping; MIRRORS—Thermal Effects; PLANETARIUMS—Instruments.

**074147 INTEGRATION OF PRECISION OPTICS, MECHANICS AND MICROELECTRONICS - THE BASIS OF INTELLIGENT MEASURING INSTRUMENTS AND SYSTEMS.** Modern production requires testing and measuring instruments that relieve man of certain intellectual working routines. For creating intelligent measuring systems, it is necessary to integrate computer technology, programming and storage facilities into modules, instruments and systems, to enable them to take up human knowledge, experience and intuition. The development and use of intelligent measurement instruments and systems is inseparably tied to advances in the field of opto-electronics. 6 refs.

Muetze, Klaus. *Jena Rev* v 32 n 1 1987 p 7-10.

**074148 HIGH-TRANSMISSION POLYCHROMATOR WITH LARGE ENTRANCE-SLIT HEIGHT.** A

stigmatic polychromator is described that is implemented by the component base of an MDR-2 monochromator with an entrance-slit height of 50-60 mm. The polychromator is designed for measurement of the spatially resolved spectra of weakly luminescent objects. (Author abstract) 3 refs.

Kotsubanov, V.D. (Acad of Sciences of the USSR, USSR); Nikol'skii, I.K.; Kovalenko, V.I. *Instrum Exp Tech* v 30 n 4 pt 2 Jul-Aug 1987 p 935-937.

**074149 IP-400 METER FOR WEAK OPTICAL ABSORPTION.** The IP-400 instrument is described, which is designed for local measurement of absorption in large plates made of isotropic, polycrystalline, and crystalline materials of the cubic system. The instrument employs the induction of thermoelastic birefringence, which is linearly related to the absorption coefficient, under the local influence of continuous laser radiation of medium power at the point of analysis. A photoelectric polariscope system with a rotary analyzer is used for automatic recording of the absorption coefficient. Measurements are made in the wavelength region of 10 μm with a sensitivity of 10<sup>-3</sup>·10<sup>-4</sup> + U 5 cm<sup>-1</sup>, the maximum linear dimension of the plates is 500 mm for a thickness of up to 40 mm, the resolution is approx. 1 mm<sup>2</sup>, and the measurement time for one point is 1-2 min. (Author abstract) 4 refs.

Kudryashov, I.A. (Acad of Sciences of the USSR, Moscow, USSR); Lifshits, I.E.; Prave, G.G.; Chudakov, V.S.; Nosov, V.B. *Instrum Exp Tech* v 30 n 4 pt 2 Jul-Aug 1987 p 962-965.

**074150 MICROWAVE ENERGY FLUX DIVIDER OF QUASIOPTICAL TYPE.** An energy flux divider in quasioptical measuring channels performs the function of a separator of the signal from a microwave generator into signals directed to the measuring and heterodyne channels, the adder of these signals in a balanced bolometric mixer, the directional coupler of a reflexometer, splitting in an interferometer. To perform the functions mentioned, the energy flux divider should satisfy a number of requirements, the most important of which are high directivity and controllability of the coefficient of energy flux division in a given 80-180 GHz frequency band. The directivity requirement is satisfied mainly by selecting the construction and quality of fabrication of the divider. Controllability of the division coefficient is realized by constructing the divider in the form of two plane-parallel dielectric plates between which the spacing can be changed smoothly. Questions of material selection and plate thickness and the spacing between them in order to satisfy the mentioned requirement are considered analytically and numerically. 2 refs.

Kistovich, A.V.; Gol'ba, V.A. *Meas Tech* v 30 n 9 Sep 1987 p 911-913.

**Reflectors** See Also SOLAR CELLS—Thermal Effects.

**074151 THREE-PLATE OPTICAL RESONANT REFLECTORS AND THEIR DESIGN.** This paper describes characteristics of frequency and space reflection spectra of multilayer resonant reflectors. We mainly analyze the effects of thicknesses of glass and air gap on reflection spectra and the space reflection spectra due to each optical plane not being parallel in the degenerate resonant reflectors. The requirements for designing the resonant reflectors are provided and some methods to solve the problems are shown. Non-degenerate resonant reflectors are also discussed. (Author abstract) In Chinese. 7 refs.

He Weiming (Acad Sinica, China); Chen Shaohe; You Nangchang; Deng Ximing. *Guangxue Xuebao* v 7 n 11 Nov 1987 p 976-982.

**074152 DESIGN AND PREPARATION OF THIN FILM QUARTER-WAVE PLATES.** At non-normal incidence multilayer reflectors have different phase shifts for two polarization components. Therefore the design of reflectors with specific phase retardation can be carried



out by computer optimization. The purpose of this paper is to design coatings with 90° phase difference between the s and p polarization components. The effect of such a reflector is like a quarter-wave plate. Its advantages are that they may be used on whole light spectrum, may have higher precision of phase retardation and larger apertures. The two design methods, experimental techniques and results are presented. (Author abstract) 5 Refs.

Gu, Pei-Fu (Zhejiang Univ, Hangzhou, China); Tang, Jin-Fa. *Instrumentation in China* Instrumentation in China, Technical Papers. English Language Edition of Selected Articles Originally Published in the Chinese Journal of Scientific Instrument 1987. Publ by ISA, Research Triangle Pk, NC, USA, 1987 p 217-222.

**Resolving Power See MICROSCOPES, ELECTRON: OPTICAL SYSTEMS—Optimization.**

## Selection

**074153 COMPARING BEAM DEFLECTING SYSTEMS.** Light-beam deflection has become an important mechanism in a number of useful products. Current applications include computer printers, point-of-sale scanners, IR imagers, optical inspection machines, laser displays, facsimile systems and barcode readers, to name a few. With the growing use of beam-deflecting devices in commercial applications, choosing system components hinges on application-specific parameters. This article introduces the systems and their commercial applications.

Sherman, Randy J. *Photonics Spectra* v 22 n 3 Mar 1988 p 89-90, 92.

## Space Applications

**074154 OPTICAL MONITOR FOR SPACE OPERATIONS.** An Optical Monitor for Space Operations (OMSO) is being developed at Officine Galileo S.p.A. under ESTEC contract. It consists of three main units: video camera; preprocessing unit; and illuminator unit. The OMSO is intended to meet a range of requirements. There are three main areas of application: 1) As an inspection system for satellites. 2) As a locating and docking aid in RVD operations in orbit. 3) As an imaging unit for robotic vision. The OMSO general configuration includes one or two cameras integrated with an illuminator, a preprocessing and control system, and an interface unit. (Author abstract) 6 refs.

Borghini, G. (Officine Galileo, Florence, Italy); Buccheri, A.; Carboncini, M. *ESA J* v 11-12 n 4-1 1987-1988 p 37-46.

**Standards See COMPARATORS—Testing.**

**OPTICAL MATERIALS** See Also ADHESIVES; CRYSTALS—Growing; LASERS, SOLID STATE; LASERS, SOLID STATE—Materials; OPTICAL FIBERS—Analysis; OPTICAL FILTERS—Materials; OPTICS—Geometrical; SEMICONDUCTING GERMANIUM; SOLIDS—Optical Properties.

**074155 BBO'S NONLINEAR OPTICAL PHASE-MATCHING PROPERTIES.** Beta barium borate (BBO), a major contributor in the development of the field of nonlinear optics, will find its niche in ultraviolet generation. While efforts to improve the size as well as optical quality are continuing, BBO crystals as large as  $10 \times 10 \times 6 \text{ mm}^3$  are already available. This is adequate for most dye-laser needs. BBO has an impressive performance for the generation of intense UV radiation. BBO may replace all currently used materials including potassium pentaborate, lithium formate, and urea, as well as ADP and KDP, for UV generation in the region from 205 to 360 nm. The usefulness of BBO is enhanced by the low temperature dependence of its index of refraction. Because of this property, laser-induced heating does not significantly affect the conversion efficiency. This results in a significant increase in the stability of the final output and an increase in the ease of alignment of the crystal. 9 refs.

Adhav, R.S. (Quantum Technology Inc, Sanford, FL, USA); Adhav, S.R.; Pelaprat, J.M. *Laser Focus (Littleton*

Mass) v 23 n 9 Sep 1987 7p between p 88 and 100.

**074156 OPTICAL PROPERTIES OF  $\text{Ce}^{3+}$  IN YTTRIUM GALLIUM GARNET PHOSPHOR.** The diffuse reflection, excitation and fluorescence spectra of  $\text{Ce}^{3+}$  ions in  $\text{Y}_3\text{Ga}_5\text{O}_{12}$  garnet phosphor have been studied and discussed at room temperature for the first time. It has been found that the YGG- $\text{Ce}^{3+}$  shows the optical properties of the allowed 5d-4f transition of  $\text{Ce}^{3+}$  ions whether under UV radiation or visible blue light or cathode ray excitation. The broad emission band extending from 430 to near 670 nm results from the transition of the lowest 5d level to  $^2F_1$  ( $J = 5/2, 7/2$ ) terminal state. In YGG, the optical behaviour of  $\text{Ce}^{3+}$  is very similar to that of  $\text{Ce}^{3+}$  in YAG, but the positions of absorption and emission bands of  $\text{Ce}^{3+}$  shift toward shorter wavelength. (Author abstract) 8 refs. In Chinese.

Liu Xingren (Acad Sinica, China); Wang Xiaojun; Ma Long. *Guangxue Xuebao* v 7 n 12 Dec 1987 p 1118-1121.

**074157 PHASE-MATCHED OPTICAL SECOND-HARMONIC GENERATION IN THE ORGANIC CRYSTAL MBA-NP, (—)2-( $\alpha$ -METHYLBENZYLAMINO)-5-NITROPYRIDINE.** Large ( $5 \times 3 \times 3 \text{ cm}^3$ ) crystals of the organic nonlinear optical material MBA-NP have been prepared by growth from solution, in an optically and structurally highly perfect state. Oriented cut and polished specimens were examined by the Maker fringe technique at a wavelength of 1.064  $\mu\text{m}$ . Analysis of the data yielded  $d_{22}$  as  $69 \times d_{11}$  quartz with a corresponding coherence length of 2  $\mu\text{m}$ . A large rotation of the X and Z dielectric axes with wavelength ( $30^\circ$  over 200 nm) was observed. Type I phase-matched second-harmonic generation (SHG) was recorded for the 1.064  $\mu\text{m}$  dielectric axis set and a (010) faced crystal, phase matched SHG was observed for rotation about X to an angle of incidence of  $45^\circ$ . This angle is very sensitive to the correct alignment of dielectric axes and the effect of its misalignment was investigated. (Author abstract) 5 refs.

Bailey, R.T. (Univ of Strathclyde, Glasgow, Scotl); Cruickshank, F.R.; Guthrie, S.M.G.; McArdle, B.J.; Morrison, H.; Pugh, D.; Shepherd, E.A.; Sherwood, J.N.; Yoon, C.S.; Kashyap, R.; Nayar, B.K.; White, K.I. *J Mod Opt* v 35 n 3 Mar 1988, Eighth Natl Quantum Electron Conf, St. Andrews, Scotl, Sep 21-25 1988 p 511-516.

**Absorption See LASERS—Mathematical Models.**

## Adhesion

**074158 OPTICAL STRESS FORMED IN ADHESION OF OPTICAL COMPONENTS WITH ADHESIVES.** Ultraviolet-curing adhesive is widely used for effective adhesion of optical components. However, the optical stress formed in the adhesion process has an important role in the optical performance of the product. This optical stress was studied in a series of adhesion experiments using epoxy adhesives, ultraviolet-curing adhesives, and modified adhesives, by means of a Fizeau interferometer and a polarizing light microscope. The optical stress formation was governed by adhesive properties, curing conditions, the structure and dimensions of the assembly, and an external thermal effect after curing. (Author abstract) In Japanese. 7 refs.

Seo, Naoyuki (Olympus Optical Co, Tokyo, Jpn); Shiga, Naohito; Iwabuchi, Junichi; Shirai, Michio. *Kobunshi Ronbunshu* v 44 n 10 Oct 1987 p 717-728.

**Composition Effects See GLASS—Physical Properties.**

**Films See CERAMIC MATERIALS—Optical Properties; FILMS—Electric Properties; SELENIUM—Thin Films.**

**Glass** See Also GLASS—Mechanical Properties; GLASS—Optical Properties; GLASS—Polishing; GLASS—Spectroscopic Analysis.

**074159 ANALYSIS OF FATIGUE FAILURE OF OPTICAL GLASS FIBRES.** The author has proposed a new modified Weibull distribution function for the analysis of strength data of optical glass fibers. The main

purpose of this letter is to analyze the fatigue failure of optical fibers in terms of this equation along with fracture mechanics theory. There is good agreement between the predicted and measured distributions indicating that fatigue failure of polymer-coated optical glass fibers occurs by slow growth of pre-existing flaws and that fracture mechanics theory together with the proposed distribution function can be used in making fatigue-failure predictions of these materials. 13 refs.

Phani, K.K. (Central Glass & Ceramic Research Inst, Calcutta, India). *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1389-1391.

**074160 SURFACE FLAWS IN  $\text{ZrF}_4$ -BASED FLUORIDE OPTICAL FIBRES WITH IMPROVED TENSILE STRENGTH.** Fluoride glass is widely recognized as the most promising material for ultra-low loss optical fibers. This letter reports surface flaw formation in  $\text{ZrF}_4$ -based fluoride fibers. Discussions are based on the effect of preform surface treatment on the tensile strength and fiber surface analysis using electron spin resonance (ESR) measurements. Tensile strengths were uniformly raised to 500 MPa by surface treatment. Based on sub-critical crack growth data in which a growth parameter of 66.5 was obtained, existing flaw sizes were estimated to be around 0.1  $\mu\text{m}$ . In addition, ESR measurement revealed that the fiber surface consists of inherent fluoride. These results suggest that crystalline oxide islands, which act as flaws, are dispersed on the fluoride surface. 8 refs.

Sakaguchi, S. (NTT Electrical Communications Lab, Tokai, Jpn); Hibino, Y.; Ohishi, Y.; Takahashi, S. *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1440-1442.

**074161 DESIGNING A UNIFIED SET OF TEST GLASSES FOR CHECKING SPHERICAL SURFACES IN OPTICAL COMPONENTS.** It has been proposed to set up a unified (basic) set of glasses and use these in the centralized manufacture and distribution of sets of working glasses for optical manufacturers and other organizations concerned with making optical components having spherical surfaces. An important feature here is that there is no need to make up new pairs of trial glasses, as it is possible to use the best ones available at the organization, which correspond to the first conjugation group in GOST 2786-76, as such pairs can be selected by one's own efforts. When the radii of these have been measured with the highest accuracy (error of measurement not more than 0.005%), they can be used for making working glasses for the industry. Factor relating to implementation of a unified set of glasses for manufacturers are briefly discussed. 1 ref.

Strakun, G.I. *Meas Tech* v 30 n 7 Jul 1987 p 658-659.

**074162 REMOVAL OF GYPSUM AND PORTLAND CEMENT FROM THE SURFACE OF OPTICAL COMPONENTS.** In order to establish the optimum method of removing the residual gypsum mass, a study was made with a number of reagents that can dissolve, soften, or destruct it and facilitate its removal from the surface of the component. The effectiveness of the solution was evaluated on the basis of the time required for removing the gypsum mass and the surface quality of the glass specimen. Superior surface cleaning was obtained when using sodium carbonate with subsequent treatment of the specimen with acetic acid; the best cleaning was achieved under the action of sodium bicarbonate.

Bakhteva, L.A.; Mamonov, S.K.; Yabluchanskaya, N.N. *Glass Ceram* v 44 n 7-8 Jul-Aug 1987 p 363-365.

## Ion Exchange

**074163 ION EXCHANGE TECHNIQUE FOR LI GLASS SELF-FOCUS LENS MANUFACTURING.** In this paper, the law of radial index distribution in the lithium glass self-focus lens manufactured by one-step ion exchange technique has been analyzed. The optical distribution obtained with this method and its technical conditions have been derived. A new way of using molten salt with some  $\text{Li}^+$  and exchanging ions in more than one step has been proposed. Calculation shows that the self-focus lens



manufactured with this new method has a greatly improved index distribution. (Author abstract) In Chinese. 4 refs.

Yi, Youmin (Anhui Univ, Hefei, China); Huang, Weitong; Gao, Yongchun. *Guangxue Xuebao* v 8 n 1 Jan 1988 p 57-61.

**Light Sensitive Materials** See LUMINESCENCE—Measurements; PHOTOCROMISM—Mathematical Models.

## Magnetic Properties

**074164 GALVANOMAGNETIC EFFECTS IN MnSb FILMS.** Materials possessing a large magneto-optic effect and suitable magnetic properties are of great interest for many optical memory applications. In this letter, we report on the galvanomagnetic effects, i.e. transverse magnetoresistance (TMR) and Hall effect in MnSb films in the Thickness range 35 to 400 nm. The galvanomagnetic effects are studied for films deposited at different substrate temperatures. MnSb films were prepared by an electron-beam evaporation, on glass substrates held at different substrate temperatures, and in a vacuum of  $10^{-4}$  Pa. MnSb films exhibit both negative and positive TMR and Hall coefficients, depending on the substrate temperature. 23 refs.

Angadi, M.A. (Univ of the West Indies, Trinidad, West Indies); Angadi, Ravi. *J Mater Sci Lett* v 7 n 4 Apr 1988 p 380-382.

**Mathematical Models** See Also OPTICAL FIBERS—Aging.

**074165 ASYMPTOTIC REGIME IN THE PROBLEM OF RADIATION TRANSFER IN SPATIALLY BOUNDED MEDIA.** The purpose of this study is to investigate the formation of the asymptotic regime in bounded media, to refine our understanding of the asymptotic regime, and to establish its boundaries. Our consideration will be made on the basis of a method for solving the radiation transfer problem in spatially bounded media [10]. We make a comparative analysis of the asymptotic parameter  $\gamma$  and the function  $K(A, \tau_y, \tau_z, \chi)$ . It is shown that the radiation field in bounded scattering media can be characterized by the function  $K(A, \tau_y, \tau_z, \chi)$ , which is equal to the asymptotic regime parameter for unbounded media. It was found that the rate of decrease in the photometric quantities is greater for smaller transverse dimensions, where a large fraction of the radiation exiting the medium does not take part in the transfer. The transfer of the remaining energy is characterized exponentially. 15 refs.

Goryachev, B.V.; Larionov, V.V.; Mogil'nitskii, S.B.; Savelev, B.A.; Kutlin, A.P. *J Appl Spectrosc* v 46 n 5 May 1987 p 536-538.

**074166 43 m PHOTOREFRACTIVE MATERIALS IN ENERGY TRANSFER EXPERIMENTS.** The photorefractive effect in 43 m crystals shows specific symmetries in its dependence upon wave polarizations and crystal orientation. Theoretical predictions and experimental verification in semi-insulating gallium arsenide in the nanosecond regime at 1.06  $\mu\text{m}$  given. (Author abstract) 7 refs.

Fabre, J.C. (Centre Univ, Orsay, Fr); Jonathan, J.M.C.; Roosen, G. *Opt Commun* v 65 n 4 Feb 15 1988 p 257-260.

**074167 OPTICAL BISTABILITY IN PHOTOREFRACTIVE FOUR-WAVE MIXING.** The coupled wave equations for four-wave mixing (FWM) in a cubic, non-optically-active photorefractive crystal are solved for the case of orthogonally polarized pumping beams. For certain values of the pump and probe beam intensity ratios, the solutions exhibit a multi-valued branching behavior. If the different branches are assumed to be stable, bistability of the phase conjugate reflectivity is predicted. Furthermore, it is shown that this solution is valid for the case where the pump beams are parallel-polarized if the geometry of the four-wave mixing configuration is modified slightly. Our results are therefore applica-

ble to crystals of other symmetry groups, such as barium titanate, using the modified FWM configuration. (Author abstract) 4 refs.

Shaw, Kenneth D. (Tufts Univ, Medford, MA, USA); Cronin-Golomb, Mark. *Opt Commun* v 65 n 4 Feb 15 1988 p 301-305.

**Measurements** See ELECTRODYNAMICS; INTERFEROMETERS—Automation; OPTICAL INSTRUMENTS—Performance.

## Performance

**074168 QUALITY AND PERFORMANCE OF THE ORGANIC NON-LINEAR OPTICAL MATERIAL (-)-2-( $\alpha$ -METHYLBENZYLAMINO)-5-NITROPYRIDINE (MBA-NP).** Large ( $7 \times 4 \times 4 \text{ cm}^3$ ) crystals of the organic, nonlinear optical material NBA-NP have been prepared by growth from solution, in an optically and structurally highly perfect state. Oriented, cut and polished specimens were examined by the Maker fringe technique. Analysis of the data yielded a coherent length of 2  $\mu\text{m}$  (cf. MNA 0.7  $\mu\text{m}$  and quartz 20  $\mu\text{m}$ ). Type I, phase-matched second harmonic generation (efficiency 0.5% at 58.8 MW  $\text{cm}^{-2}$ ; comparable with lithium iodate) was observed for 1.05  $\mu\text{m}$  radiation incident at 28.8° to the y-axis on the y-z incident plane. There was no evidence of type II phase matching. (Author abstract) 12 refs.

Bailey, R.T. (Univ of Strathclyde, Glasgow, Scotl); Cruickshank, F.R.; Guthrie, S.M.G.; McArdle, B.J.; Morrison, H.; Pugh, D.; Shepherd, E.A.; Sherwood, J.N.; Yoon, C.S.; Kashyap, R.; Nayar, B.K.; White, K.I. *Opt Commun* v 65 n 3 Feb 1 1988 p 229-232.

**074169 STRENGTHENING OF SOME COMMERCIAL OPHTHALMIC AND FILTER GLASSES BY ION EXCHANGE.** The strengthening of various glasses by ion exchange at different temperatures in molten  $\text{KNO}_3$  or a solution of molten  $\text{KNO}_3$  and  $\text{NaNO}_3$  is examined. After ion exchange the glass is sectioned and examined with a polarizing microscope to measure the magnitude, depth, and type of surface stress. The results show that the  $\text{KNO}_3$  bath provides the greatest strengthening. (Edited author abstract). 22 Refs.

Stroud, J.S. (Schott Glass Technologies Inc, Duryea, PA, USA). *Glass Technol* v 29 n 3 Jun 1988 p 108-114.

## Plastics Applications

**074170 BRIGHT OUTLOOK FOR OPTICAL POLYMERS.** Optical polymers - basically ultrapure polycarbonates, polyacrylates and polystyrenes - are witnessing a boom in demand, as companies move to exploit their rare qualities (great clarity, excellent processability, high heat-stability) in a range of new products, such as fiber optics, optoelectronic components, and optical disks for storing information. Various investment activities by worldwide companies are covered. Some of the companies are General Electric, Bayer AG, Dow Chemical, and Japanese companies.

Chowdhury, Jayadev; Ushio, Shota. *Chem Eng (New York)* v 94 n 7 May 11 1987 p 14-15, 17.

## Polishing

**074171 POLISHING OF LITHIUM NIOBATE BY ION-BEAM ETCHING.** Ion-beam etching has previously been used to enable coupling of light from an optical fiber to a titanium indiffused waveguide on  $\text{LiNbO}_3$ . The fiber diameter was reduced so that the fiber could be placed in an ion-etched groove in the  $\text{LiNbO}_3$  coaxial with the waveguide. Here, an alternative use of ion etching, as a non-contact polishing method, is reported. The etching geometry is shown. 2 refs.

Venables, M.A. (British Aerospace plc, Bristol, Engl); Makh, S.S. *J Mater Sci Lett* v 6 n 11 Nov 1987 p 1254-1256.

## Quartz Applications

**074172 ESR CENTERS IN FUSED QUARTZ EXPOSED TO GLOW-DISCHARGE PLASMAS OF Ar AND  $\text{H}_2$ .** Fused quartz was exposed to glow-discharge plasmas of Ar and  $\text{H}_2$  gases. The ESR centers,  $\text{E}_\text{p}$  and the impurity-associated hyperfine structure (HF) centers were found in the incovered quartz as well as in the quartz covered with a glassplate having an absorption-edge  $\text{E}_\text{c}$  of 150 nm which prevented directed exposure to the plasmas. However, these centers were not found in the quartz covered with a glass-plate having a  $\text{E}_\text{c}$  of 220 nm. Both centers are created predominantly by UV-light of wavelengths between 150 and 220 nm radiated from the plasmas rather than by the plasma particles. It is suggested that the heating effect by the plasma particles on the directly exposed surface enhances the creation of the HF center. (Author abstract). 8 Refs.

Endo, Tamio (Mie Univ, Tsu, Jpn); Taniguchi, Shizuo; Inaba, Ichiro; Katoh, Masayuki; Sugiyama, Koichi. *Jpn J Appl Phys Part 1* v 27 n 5 May 1988 p 710-714.

**Radiation Effects** See OPTICS—Mathematical Models.

## Spectrum Analysis

**074173 MULTIPLE REFLECTIONS IN AN OPTICAL RETARDER INVESTIGATED BY SPECTROSCOPIC TRANSMISSION ELLIPSOMETRY.** The response of the ellipsometric parameters as a function of wavelength has been derived for an optical retarder. Experimental results in the wavelength region 400-1000 nm are given, these are in agreement with the derived formalism. (Author abstract) 4 refs.

Hanekamp, L.J. (Univ of Twente, Enschede, Neth). *Opt Commun* v 65 n 4 Feb 15 1988 p 261-263.

**Stability** See SEMICONDUCTING GALLIUM COMPOUNDS—Optical Properties.

## Surfaces

**074174 SURFACE CHARACTERIZATION AND TESTING.** This conference proceedings contains 23 papers. They cover the subjects of interferometry, optical testing, and techniques and measurements for assessment of surface quality. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10903 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Creath, Katherine (Ed.) (WYKO Corp). *Proc SPIE Int Soc Opt Eng* v 680, Surf Character and Test, San Diego, CA, USA, Aug 21-22 1986. Publ by SPIE, Bellingham, WA, USA, 1986 174p.

## Synthesis

**074175 FUSED SALT SYNTHESIS OF MATERIALS FOR IR WINDOWS.** A fused salt technique for preparing nearly spherical, narrow size distribution particles of  $\text{NaLaS}_2$  is discussed. The method, a one-step synthesis and Ostwald ripening, appears to have great potential for complex, nonoxide materials. (Author abstract) 18 refs.

Morgan, P.E.D. (Rockwell Int Science Cent, Thousand Oaks, CA, USA); Koutsoutsis, M.S. *Mater Res Bull* v 22 n 5 May 1987 p 617-621.

**Testing** See PHENOLS—Optical Properties.

## Thin Films

**074176 VACUUM EVAPORATION TECHNOLOGY FOR OPTICAL THIN FILMS.** The general proliferation of high-quality optical instruments in the last two decades has created an increased demand for better thin-film coatings on optical components. This is especially true for those coatings used in laser and aerospace applications. Many of these coatings are applied by



evaporative vacuum deposition. Contaminants of all kinds, including atmospheric, have to be eliminated before and during film deposition to achieve the necessary quality. This requires thorough cleaning of substrates and processing equipment, the use of ultrapure cleaning agents and source materials, and maintenance of highly controlled vacuum conditions, minimizing outgassing and backstreaming.

Welch, Michael (Leybold-Heraeus, San Jose, CA, USA). *Lasers Optonics* v 6 n 7 Jul 1987 p 69-73.

**OPTICAL PROJECTORS** See Also DISPLAY DEVICES—Liquid Crystal; IMAGING TECHNIQUES; MOTION PICTURES.

## Automation

**074177 AUTOMATIC CONTROL SYSTEM FOR PLANETARIUM PROJECTORS.** A unified control system for the planetarium projectors COSMORAMA and SPACEMASTER has been developed, which employs modern computer engineering. Its heart is a microcomputer system and a number of power interfaces for controlling all dimming and switching functions as well as the six main drives of the planetarium projector. The control system meets a number of user requirements resulting from the daily work with the projector.

Weniger, Klaus; Steuding, Guenther. *Jena Rev* n 3 1986 Suppl p 16-19.

## Performance

**074178 SPACEMASTER RFP-DP3 - THE LATEST VERSION OF THE WORLD'S FIRST AUTOMATIC PLANETARIUM PROJECTOR.** The SPACEMASTER with its fully automatic control and real-time programming is an ideal tool for teaching and show programs. The system allows retrofitting of other automatic devices via standardized interfaces. The task of the SPACEMASTER is the projection of a most natural starry sky, brilliantly and accurately positioned, with magnitude levels as close as possible to the impression we have in nature. This applies, apart from fixed stars up to magnitude 6.5<sup>m</sup>, especially to bright stars, the Milky Way, nebulae and galaxies. 9 refs.

Koehler, Peter. *Jena Rev* n 3 1986 Suppl p 14-16.

**OPTICAL PROPERTIES** See Also BORON COMPOUNDS—Coatings; BORON COMPOUNDS—Thin Films; CARBON—Thin Films; COPPER COBALT ALLOYS—Structure; COPPER OXIDE—Thin Films; GLASS—Electronic Properties; GLASS—Radiation Effects; HEAT TRANSFER—Radiation; INDIUM COMPOUNDS—Electric Properties; LASERS—Materials; LI THOGRAPHY—Equipment; MATERIALS—Anisotropy; MOLECULAR CRYSTALS—Electronic Properties; NITRIDES—Structure; ORGANIC COMPOUNDS—Thin Films; OSCILLATORS, TUNNEL DIODE—Analysis; PLATINUM COMPOUNDS—Electric Properties; POLYMERS—Electric Conductivity; POLYMERS—Film; RADIOMETERS; SEMICONDUCTING BISMUTH COMPOUNDS—Doping; SEMICONDUCTING GALLIUM ARSENIDE—Oxidation; SEMICONDUCTING GALLIUM COMPOUNDS—Electronic Properties; SEMICONDUCTING GLASS—Thin Films; SEMICONDUCTING INDIUM COMPOUNDS—Electronic Properties; SEMICONDUCTING LEAD COMPOUNDS—Thin Films; SEMICONDUCTING ORGANIC COMPOUNDS—Physical Properties; SEMICONDUCTING SILICON—Ion Implantation; SEMICONDUCTING SILICON—Radiation Effects; SEMICONDUCTING SILICON—Thin Films; SEMICONDUCTING ZINC COMPOUNDS—Electric Conductivity; SEMICONDUCTOR DEVICES, MIS—Semiconductor Insulator Boundaries; SEMICONDUCTOR MATERIALS—Electric Properties; SEMICONDUCTOR MATERIALS—Impurities; SILICON COMPOUNDS—Thin Films; SILICON NITRIDE—Ion Implantation; SILVER AND ALLOYS—Thin Films; TUNGSTEN AND ALLOYS—Anodic Oxidation; X-RAYS—Diffraction; YTTRIUM COMPOUNDS—Thin Films; ZINC SULFIDE—Thin Films.

## Analysis

**074179 MIRROR WITH AN INTENSITY-DEPENDENT REFLECTION COEFFICIENT.** A device exhibiting a power-dependent reflection coefficient with fast time response and no frequency shift is proposed and analyzed. It utilizes combination of a nonlinear crystal for second harmonic generation and a dichroic mirror with

high reflectivity for the second harmonic and partial transmission for the fundamental wavelength. This device has been successfully used in a preliminary experiment to mode-lock a Nd:YAG laser. (Author abstract) 9 refs.

Stankov, K.A. (Max-Planck-Inst Fuer Biophysikalische Chemie, Goettingen, West Ger). *Appl Phys B* v B45 n 3 Mar 1988 p 191-195.

**Anisotropy** See SUPERCONDUCTING MATERIALS—Thin Films.

**Calculations** See ALKALINE EARTH COMPOUNDS—Optical Properties; ARSENIC COMPOUNDS—Optical Properties.

**Electric Field Effects** See SALTS—Optical Properties.

**Mathematical Models** See MATERIALS—Amorphous.

**Measurements** See Also CELLULOSE—Solutions; COATINGS—Reflective; DIAMONDS—Synthetic; REMOTE SENSING—Equipment.

**074180 VIBRATIONAL CIRCULAR DICHROISM MEASUREMENT IN THE FREQUENCY RANGE OF 800 TO 650  $\text{cm}^{-1}$ .** The development of dispersive instrumentation for the measurement of vibrational circular dichroism (VCD) with a lower frequency limit of approx.  $650 \text{ cm}^{-1}$  is reported. VCD spectra of 3-methylcyclohexanone,  $\alpha$ -pinene, and 3-bromocamphor in the frequency range of 800 to  $650 \text{ cm}^{-1}$  are presented to illustrate instrumental performance. The spectra obtained are superior to earlier spectra obtained with the use of a Fourier transform spectrometer. Significant extension of the lower frequency limit for VCD measurement will require the replacement of the ZnSe PEM by a device whose transmission limit is lower than that of ZnSe and the introduction of yet more powerful light sources. (Edited author abstract) 15 refs.

Devlin, F. (Univ of Southern California, Los Angeles, CA, USA); Stephens, P.J. *Appl Spectrosc* v 41 n 7 Sep-Oct 1987 p 1142-1144.

**074181 SOME METHODS OF OPTICAL PROPERTIES OF BIREFRINGENT MEDIA MEASUREMENT.** Since Sciarski described his general matrix of birefringent media it has been possible to express some general laws: i) general Malus law, ii) general method of Poincare sphere usage, and iii) general theory of polariscopes. In this paper some methods of measurement of birefringent media properties are given. (Edited author abstract) 1 Ref.

Ratajczyk, Florian (Technical Univ of Wroclaw, Wroclaw, Pol); Urbanczyk, Wacław. *Optik (Stuttgart)* v 79 n 4 Jul 1988 p 183-187.

**Radiation Effects** See VANADIUM COMPOUNDS—Radiation Effects.

**Thermal Effects** See COPOLYMERS—Optical Properties.

**Thin Films** See OPTICS—Mathematical Models.

**OPTICAL PUMPING** See Also ATOMS—Magnetic Field Effects; ATOMS—Spectrum Analysis; BARIUM AND ALLOYS—Spectroscopic Analysis; LASER BEAMS—Nonlinear Optical Effects; LASERS—Efficiency; LASERS—Mathematical Models; LASERS—Stability; LASERS, SEMICONDUCTOR; LASERS, SOLID STATE—Modes; LASERS, SOLID STATE—Q Switching; LASERS, SOLID STATE—Thermal Effects; LIGHT—Scattering; OSCILLATORS, MICROWAVE—Design; SODIUM AND ALLOYS—Magnetic Field Effects.

**074182 DIODE PUMPING OF LNA LASER FOR HELIUM OPTICAL PUMPING.** Neodymium-doped LNA laser crystals ( $\text{La}_{1-x}\text{Nd}_x\text{MgAl}_2\text{O}_9$ ) have been pumped by laser diode arrays emitting around 800 nm. With longitudinal pumping using two 200 mW diode arrays focused on the crystal end, 10 mW of power was obtained at  $1.054 \mu\text{m}$ . With the insertion of a Lyot filter and a thin etalon, tuning across the  $1.082 \mu\text{m}$  band was

possible. Tuning the LNA laser output to the resonance transition of helium-4 ( $2^3\text{S}_1-2^3\text{P}_1$ ) at  $1.083 \mu\text{m}$  enabled us to optically pump the metastable helium atoms in a discharge cell and record magnetic resonance signals. Transverse pumping of the LNA crystals by a high-power, quasi-cw array was also successfully demonstrated. (Author abstract) 17 refs.

Hamel, Joseph (Univ de Caen, Fr); Cassimi, Amine; Abu-Safia, Hassan; Luduc, Michele; Schearer, L.D. *Opt Commun* v 63 n 2 Jul 15 1987 p 114-117.

**074183 DYNAMIC STARK EFFECT IN THE  $4p^2 \text{P}_{3/2}^o \rightarrow 2s$  TRANSITION OF SODIUM BY INTENSE TWO-PHOTON PUMPING.** In this paper the measurements of the dynamic Stark shift and splitting in the transition  $\text{Na } 4p^2 \text{P}_{3/2}^o \rightarrow 2s^2 \text{S}_{1/2}$  by intense near resonant two-photon pumping of the  $5s^2 \text{S}_{1/2}$  transition of sodium are described. The influence of laser detuning, input power and vapour pressure on the output u.v. parametric signal wave are studied. The measurements are in qualitative agreement with a theoretical model previously developed. 12 refs.

Dinev, S.G. (Sofia Univ, Sofia, Bulg). *Opt Quantum Electron* v 20 n 3 May 1988 p 263-272.

**Theory** See Also LASERS—Optical Pumping.

**074184 ANALYSIS OF RAMAN GAIN FOR FOCUSED GAUSSIAN PUMP BEAMS.** Several theoretical and numerical models have been published which describe the evolution of a Stokes beam in a Raman medium excited by a focused pump beam. Generally, the published theoretical departures from the plane-wave theory of Raman scattering are based on assumptions about the power of the pump beam. In this paper we present a theoretical model which is shown to be in excellent agreement with an exact numerical treatment, and which is valid without restrictions on the pump power. Its predictions are used to indicate the range of validity of earlier theories. (Author abstract) 13 refs.

Ibison, M.C. (Univ of Southampton, Southampton, Engl); Hanna, D.C. *Appl Phys B* v B45 n 1 Jan 1988 p 37-44.

**074185 COLLISION-ASSISTED OPTICAL FIELD INDUCED CIRCULAR BIREFRINGENCE IN SODIUM VAPOR.** Collision-assisted optical field induced circular birefringence has been observed in the  $3^2\text{S}_{1/2} \rightarrow 3^2\text{P}_{1/2}$  transition an Na atom. The experimental results are explained in terms of collision-assisted transverse optical pumping as well as collision-induced Zeeman coherence in four-wave mixing. (Edited author abstract) 12 refs.

Gong, Qihuang (Peking Univ, Beijing, China); Zou, Y.H. *Opt Commun* v 66 n 5-6 May 15 1988 p 294-298.

**OPTICAL SYSTEMS** See Also ACCELERATORS, SYNCHROTRON—Accessories; GAGES; GLASS—Absorption; HOLOGRAMS—Computer Aided Analysis; INSPECTION—Automation; INTERFEROMETRY; INTERFEROMETRY, HOLOGRAPHIC; LASERS—Performance; LENSES—Mathematical Models; LIGHT—Reflection; LIGHT—Refraction; OPTICAL DEVICES—Military Application; PRISMS; RANGE FINDERS; SOLAR RADIATION—Collectors.

**074186 POLYFOCAL SYSTEMS - METHOD OF MATCHED IMAGES.** The problem of determining N surfaces of an optical system, which provides for aberration-free focusing of the fields of N sources at N foci, is solved. In the first part this method is described by the example of a bifocal system. The method is then generalized to polyfocal systems. The last section illustrates the application of MMI to the construction of a symmetrical trifocal system (two-dimensional problem), providing aberration-free focusing in the directions  $-\alpha, 0, +\alpha$  ( $\alpha=5^\circ$ ). (Edited author abstract) 4 refs.

Vaaz, I.L.; Kimber, B.Ye. *Sov J Commun Technol Electron* v 31 n 12 Dec 1986 p 58-65.



**074187 METHOD FOR PERFORMING N-DIMENSIONAL FOURIER TRANSFORMATIONS IN COHERENT OPTICAL SYSTEMS.** A method for performing N-dimensional Fourier transformation in coherent optical Fourier-transform systems is studied. The method involves a special arrangement of readings of the functions in the entrance and exit planes of the optical system. (Author abstract) 9 refs.

Smirnov, V.V. *Optoelectron Instrum Data Process* n 5 1987 p 26-29.

**074188 SLIT AS SPATIAL FILTER, ITS APPLICATION TO THE ALIGNMENT OF OPTICAL SYSTEMS.** The influence of the size and position of a narrow slit on the intensity distribution produced on a screen by light which passes through an optical system and through the mentioned slit is shown. It is also shown how these distributions may be of use in controlling the alignment of optical systems. (Author abstract). 5 Refs.

Mattei, Guillermo O. (Univ de Buenos Aires, Buenos Aires, Argent); Gil, Mirta A. *Optik (Stuttgart)* v 79 n 3 Jun 1988 p 128-134.

**074189 INFLUENCE OF THE EXTENDED LINEAR INHOMOGENEITIES ON THE STREHL DEFINITION OF THE OPTICAL SYSTEMS CONTAINING PRISMS.** A method is described of calculating the optimal aberration function, the optimal Strehl definition, and parameters of the optimal reference sphere conditioned only by the small extended non-birefringent linear inhomogeneities of the refractive index in prisms. (Edited author abstract). 2 Refs.

Sciarski, Ireneusz (Technical Univ of Wroclaw, Wroclaw, Pol); Ratajczyk, Florian. *Optik (Stuttgart)* v 79 n 4 Jul 1988 p 159-164.

**074190 SPONTANEOUS SPATIAL PATTERN FORMATION IN LASERS AND COOPERATIVE FREQUENCY LOCKING.** We discuss aspects of laser dynamics that are connected with transverse effects. We show that a laser capable of operating simultaneously in more than one transverse mode can develop temporal instabilities and pulsations at gain values close to the lasing threshold and within experimental reach, and also approach steady state configurations in which several transverse resonances develop synchronized oscillation (cooperative frequency locking). We suggest a practical scheme for the experimental verification of our predictions. (Author abstract). 13 Refs.

Lugiato, L.A. (Politecnico di Torino, Turin, Italy); Oppo, G.L.; Pernigo, M.A.; Tredice, J.R.; Narducci, L.M.; Bandy, D.K. *Opt Commun* v 68 n 1 Sep 1 1988 p 63-68.

**074191 STRUCTURAL MECHANICS OF OPTICAL SYSTEMS II.** This conference proceedings contains 25 papers which cover the following subjects: astronomical observatories, optical system design and construction, special techniques and devices, applications of control systems and advanced technology mirror construction. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11166 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Hatheway, Alson E. (Ed.) (Alson E. Hatheway Inc). *Proc SPIE Int Soc Opt Eng* v 748, Struct Mech of Opt Syst II, Los Angeles, CA, USA, Jan 13-15 1987. Publ by SPIE, Bellingham, WA, USA, 1987 236p.

**074192 ELECTROMECHANICAL SYSTEM INTERACTION WITH OPTICAL DESIGN.** This conference proceedings contains 13 papers one of which appears in abstract only form. The topics included address the various aspects of adaptive optics with emphasis on the electromechanical components. The first session deals with all the system level considerations in designing an adaptive optical system. The papers range from how to select the actuators in a deformable mirror to control algorithm implementation for wave front compensation. Technical and professional papers from this conference are indexed and abstracted with the conference code no.

11617 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Gowrinathan, Sankarian (Ed.) (Perkin-Elmer Corp, Danbury, CT, USA). *Proc SPIE Int Soc Opt Eng* v 779, Electromech Syst Interact with Opt Des, Orlando, FL, USA, May 21-22 1987. Publ by SPIE, Bellingham, WA, USA, 1987 102p.

## Analysis

**074193 DYNAMIC CHARACTERISTICS OF PREDICTIVE ADAPTIVE OPTICAL SYSTEMS.** An adaptive optical system is treated as a linear dynamic system with delay. Using a variety of means for the statistical prediction of random phase distortions, we calculate the errors involved in estimating the mean field and mean intensity in an adaptive optical system with constant time delay. We assess the improvement in correction quality in a system with 'prediction' as compared with a constant-delay system. (Author abstract) 13 refs.

Lukin, V.P. *Sov J Commun Technol Electron* v 32 n 3 Mar 1987 p 49-53.

**074194 PARALLEL N<sup>2</sup> WEIGHTED RECONFIGURABLE NETWORKS FOR OPTICAL NEURON AND CHIP-TO-CHIP INTERCONNECTS.** Various N<sup>2</sup> weighted reconfigurable optical networks for the optical free-space either neural network (ONN) or other chip-to-chip interconnections are proposed. With these new schemes, the large number of either electronic or optical delay lines, that were used in the previous ONN implementations, are minimized, so that the massive interconnections among monolithically integrated either optical neurons or computing chips can be implemented. Both linearly- and circularly-distributed optical neuron (chip) interconnect models are presented. A comparison between the two interconnect models is included. (Edited author abstract). 14 Refs.

Li, Yao (City Univ of New York, New York, NY, USA); Eichmann, George. *Opt Commun* v 67 n 4 Jul 15 1988 p 251-255.

**Applications** See Also OPTICAL INSTRUMENTS—Errors.

**074195 METHOD OF RECOGNIZING THREE-DIMENSIONAL POSITION OF A RIGID BODY USING ITS SHAPE - FORMULATION OF THE PROBLEM AND ITS SOLUTION BY AN ITERATION METHOD.** In this paper, the problem formulated is of three marked points (the least necessary number to estimate the position of a rigid body). The solution is given by an iterative approximation. Furthermore, the relation between the measurement method and the convergence of the iterative approximation is analyzed. Observation is best obtained from this point of view. An instrument to measure three-dimensional movement of the human jaw is introduced (Edited author abstract) 10 refs.

Hayashi, Toyohiko (Niigata Univ, Niigata, Jpn); Iijima, Taizo. *Syst Comput Jpn* v 18 n 10 Oct 1987 p 58-67.

**Components** See LASERS, SEMICONDUCTOR; OPTICS—Exhibitions.

## Computer Aided Design

**074196 RECENT TRENDS IN OPTICAL SYSTEMS DESIGN: COMPUTER LENS DESIGN WORKSHOP.** This conference proceedings contains 45 papers. In the first session, Design Philosophy, the general principles involved in optical design are discussed. This topic is expanded on further in Session 2, Special Methods and Theory in Lens Design, where specific techniques for tolerancing and analyzing systems are presented. Session 3, Computer-Aided Lens Design, addresses the contributions made by the use of computers in the design process. The application of artificial intelligence to the design of optical systems is also considered. The next two sessions are oriented more toward applications. The design of telescopes, integrated optical circuits, electronic still video

systems, and anamorphic Fourier transform relays are examined along with many others. In interactive Computer Lens Design Workshop, the latest developments and/or new optical design programs are formally reviewed and demonstrated. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11519 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Londono, Carmino (Ed.) (Polaroid Corp); Fischer, Robert E. (Ed.). *Proc SPIE Int Soc Opt Eng* v 766, Recent Trends in Opt Syst Des; Comput Lens Des Workshop, Los Angeles, CA, USA, Jan 13-15 1987. Publ by SPIE, Bellingham, WA, USA 301p.

## Computer Applications

**074197 ILLUMINATION AND OPTICS FOR AUTOMATIC OPTICAL INSPECTION.** Automatic optical inspection (AOI) systems typically consist of three fundamental parts: the image acquisition module, the segmentation processor and the image analysis processor. With today's demand for increased resolution, accuracy and consistency, the segmentation processor often faces unnecessary burdens brought about by neglect of illumination and transmitter/receiver optics. The price for such design shortcomings is incorrect inspection decisions. This article explores various facets of AOI front ends and shows that object-material properties and inspection-system performance requirements rigidly dictate system architecture - usually to a more complicated degree than lens-and-vidicon combinations.

Donahue, Joseph P. *Photonics Spectra* v 21 n 7 Jul 1987 p 49-50, 52.

**Computer Simulation** See Also OPTICAL FILTERS—Mathematical Models.

**074198 SUPER-RESOLUTION USING THE GERCHBERG ALGORITHM.** A modified version of the Gerchberg iterative super-resolution algorithm has been applied in two dimensions to computer simulations of a two point object and a finite portion of its spectrum, and successful extrapolation has been attained. The modified algorithm exhibits a considerably faster rate of convergence, thus overcoming the well known drawback of the original algorithm - the slow and to some extent stagnant convergence. Results are given for both the noise-free case and for the case when signal dependent additive noise is present on the image. (Author abstract). 8 Refs.

Kani, L.M. (Imperial Coll, London, Engl); Dainty, J.C. *Opt Commun* v 68 n 1 Sep 1 1988 p 11-17.

## Control

**074199 NOVEL METHOD FOR ULTRA-FINE CONTROL OF AN OPTICAL PATH.** A novel method for ultra-fine tuning of a Fabry-Perot resonator is shown, in which the evanescent waves existing at the back of a totally-reflecting prism are perturbed by a plate located a few  $\mu\text{m}$  apart. Extremely precise control of the optical path is possible. So that the noise level of the resonance frequency is suppressed to such a low level as that of a stable cavity without control unit. (Author abstract). 5 Refs.

Shishido, Fumio (Kanagawa Inst of Technology, Atsugi, Jpn). *Opt Commun* v 68 n 1 Sep 1 1988 p 1-6.

**Cooling** See ACCELERATORS, SYNCHROTRON—Storage Rings.

**Design** See HOLOGRAPHY—Imaging Techniques; LENSES—Design; MICROSCOPES—Focusing; SOLAR RADIATION—Heliostats; TELESCOPES—Stability.

## Economics

**074200 ON THE ECONOMIC TOLERANCE OF OPTICAL SYSTEM.** This paper tries to analyze the economic benefits of an optical system, and to make a



proposal in the estimating and calculating formulae for making optical tolerance with probability-statistical method. In the equations which are used to find the solution of tolerance, the target function is minimum cost, while the restraint conditions are the permitted variation of MTF value and manufacturing ability. Its feasibility is proved by a practical example. (Author abstract) In Chinese.

Jiang Huilin (Acad Sinica, China). *Guangxue Xuebao* v 7 n 12 Dec 1987 p 1127-1132.

**Focusing** See Also MICROSCOPES—Laser Applications.

**074201 FOCAL SHIFT IN LENS LIKE MEDIA WITH GAIN OR LOSS.** Focal shift in lenslike systems having loss or gain is evaluated. The results obtained show a shift in the geometrical focus with respect to the lossless case. The best focus is determined for uniform plane and Gaussian illumination. (Author abstract) 15 refs.

Linares, J. (Univ de Santiago, Galiza, Spain); Gomez-Reino, C.; Flores, J.R.; Acosta, E. *J Mod Opt* v 35 n 4 Apr 1988 p 679-691.

**Laser Applications** See CRYSTALS, LIQUID—Optical Properties; ELECTRIC CIRCUIT BREAKERS.

**Mathematical Models** See Also INFRARED IMAGING; OPTICAL GRATINGS—Theory.

**074202 POLARIZATION INVESTIGATION OF THE RELAXATION OF MEDIUM EXCITATION BY THE METHOD OF DELAY OF ULTRASHORT LIGHT PULSES.** The method is considered to measure the relaxation parameters of optically oriented resonant systems by the polarization change of ultrashort probe pulses. It is shown that in the general case the change of the probe pulse polarization does not occur in exponential dependence of the excitation relaxation. It is seen that the law of decrease of change of the probe pulse polarization in accordance with time delay is exponential too, when the medium is sufficiently thin and rare. (Author abstract) 11 refs.

Arutunyan, V.M. (Yerevan State Univ, Yerevan, USSR); Muradyan, A.Zh.; Petrosyan, L.S. *Opt Commun* v 64 n 1 Oct 1 1987 p 72-74.

**074203 DISSIPATION IN MIXED OPTICAL BISTABLE SYSTEMS.** The dissipation problem of a mixed (absorptive and dispersive) optical bistable system (MOBS) is discussed in detail. The main results are as follows: (i) A general rule describing the energy dissipation of the atom-field coupled open systems is derived from the rate equations of the populations of two-level atoms, and it is proved that the energy dissipation of MOBS associated with active atoms in stationary states obeys strictly the above general rule. (ii) The entropy production rate of MOBS is derived from the fundamental principle of the non-equilibrium thermodynamics. (Author abstract) 6 refs.

Ou, Fa (South China Inst of Technology, Guangzhou, China); Cai, Yongqiang; Wu, Tingwan; Zhang, Xiadong. *Opt Commun* v 65 n 3 Feb 1 1988 p 221-224.

**074204 LENSLESS DISPLAY OF PHASE-SPACE FUNCTIONS FOR 1-D SIGNALS.** A coherent lensless processor for displaying a 1-D Fourier transform is proposed. It is shown that under appropriate conditions the diffraction produced by certain 2-D objects can be approximated to a 1-D Fourier transformer. In particular we show that this processor is useful in order to display phase-space functions of 1-D signals, which involves in their definitions a 1-D Fourier transform, like the Wigner distribution function, ambiguity function, and local spectrum. (Author abstract) 15 refs.

Furlan, W.D. (Centro de Investigaciones Opticas, La Plata, Argent); Grosz, S.I.; Zerbino, L.M. *Opt Commun* v 65 n 2 Jan 15 1988 p 110-114.

**074205 CALCULATION OF COMA OF UNSYM-**

**METRIC OPTICAL SYSTEM.** In this paper, we studied the characteristics of the coma of a toroid surface. A formula for calculating the coma produced by itself is derived. Another formula for calculating the coma which accompanies the input light beam and is amplified by the toroid is also derived. Some examples are discussed. (Author abstract) In Chinese.

Zao, Bing (Acad Sinica, China); Li, Yuankang. *Guangxue Xuebao* v 8 n 1 Jan 1988 p 34-38.

## Measurements

**074206 MEASUREMENTS OF THE PHASE DISPERSION OF OPTICAL COMPONENTS BY HETERODYNE INTERFEROMETRY.** We describe the use of a heterodyne Michelson interferometer to measure the wavelength-dependent phase shift of a Gires-Tournois interferometer. A comparison of the experimental and the calculated phase characteristics reveals significant deviations indicating, in particular, a different group velocity dispersion of the device under test. The results show that the heterodyne interferometer in combination with a tunable laser is well for the measurement of the phase characteristic of optical components. (Author abstract) 10 refs.

Bonkhofer, T. (Univ-GHS-Essen, Essen, West Ger); Kuehlke, D.; von der Linde, D. *Opt Commun* v 65 n 3 Feb 1 1988 p 167-169.

**074207 DISSIPATIVITY OF AN OPTICAL CHAOTIC SYSTEM CHARACTERIZED VIA GENERALIZED MULTISTABILITY.** We present experimental evidence of three different kinds of collisions in a laser with modulated losses and we show that the existence of them is related to the relative overlap of coexisting attractors in the parameter space. The generalized multistability is a quantitative indicator of the dissipativity of a dynamical system and we use it to determine the behavior of the dissipation as a function of the parameters. (Author abstract) 12 refs.

Meucci, R. (Istituto Nazionale di Ottica, Florence, Italy); Poggi, A.; Arecchi, F.T.; Tredicce, J.R. *Opt Commun* v 65 n 2 Jan 15 1988 p 151-156.

## Monitoring

**074208 ENGINEERING APPLICATIONS OF OPTICAL MULTIPARAMETER MONITORING FACILITIES.** There have recently been papers on optimizing parameter monitoring sequences. There is an optimum approach that minimizes the monitoring time on account of the different rejection probabilities and different parameter monitoring times. Multiparameter monitoring is also important in testing components under conditions of varying atmospheric pressure, temperature, or static and dynamic loading. The mass multidimensional monitoring facility (MMF) is given to a device for rapid size-set monitoring. We consider only facilities that have the most numerous functions and the highest throughput. 23 refs.

Birnirk, Yu.I. *Meas Tech* v 30 n 9 Sep 1987 p 863-867.

## Optical Properties

**074209 NONCRITICAL SLOWING DOWN IN OPTICAL BISTABILITY.** We have experimentally studied by dynamics of a bistable system prepared in an initial state, close to the unstable intermediate branch of the bistability curve but far from the turning points. Our observations are indicative of a divergence of the switching times in  $-\log \epsilon$ , characterizing the departure of the initial state from the unstable branch. This result, contrasting with the  $\epsilon^{-1/2}$  standard law in critical slowing down, is well interpreted by a simple model involving a single dynamical variable. (Author abstract) 17 refs.

Segard, Bernard (CNRS, Villeneuve d'Ascq, Fr); Zemmouri, Jaoud; Macke, Bruno. *Opt Commun* v 63 n 5 Sep 1 1987 p 339-343.

## Optimization

**074210 STUDY ON THE OPTIMIZATION OF APERTURES IN AN ABERRATED PROBE FORMING SYSTEM.** The effects of aperture size on the maximum resolving power of a probe forming system have been studied carefully in terms of the optical transfer function. It is found that for a system which has significant chromatic aberration and small spherical aberration, we can achieve a better resolving power than the one given by simple optimization by using slightly larger apertures. However, for a system suffering only from spherical aberration, the gain in the resolving power is marginal by using larger apertures. This result could be of value in the design of low voltage probe forming systems, especially in a low voltage SEM. (Author abstract). 13 Refs.

Shao, Zhifeng (Univ of Chicago, Chicago, IL, USA); Crewe, A.V. *Optik (Stuttgart)* v 79 n 3 Jun 1988 p 105-110.

**Oscillations** See OPTICS—Nonlinear.

## Performance

**074211 OPTICAL SYSTEM FOR NIGHT VISION DEVICES AND THEIR APPLICATIONS.** Optical systems for different passive night vision devices for observation and aiming for fire control have been considered. The main points regarding different designs of objective systems like dioptric and catadioptric including 'Mangin Mirror' have been described. It has been emphasized that the choice of system, its design, thin film coating play crucial role in arriving at a system, which would give optimum performance for particular application. (Edited author abstract). 3 Refs.

Gupta, S.D. (Instruments Research & Development Establishment, Dehradun, India); Banerjee, K.K.; Musla, A.K.; Gupta, G.P.; Beri, V.K. *IETE Tech Rev* v 5 n 1 Jan 1988 p 9-13.

## Stability

**074212 EXPERIMENTS AND THEORY OF CAVITY-FREE SELF-DEFOCUSING OPTICAL BISTABLE SYSTEM.** A new cavity-free optical bistable system with negative logical operating character based on aberrational self-defocusing in absorbing medium was designed. The experimental methods and results are presented, and the analytical formulas for this system are given. Theoretical calculations are in good agreement with the experimental curves. (Author abstract) In Chinese. 5 refs.

Xie, Changde (Shanxi Univ, Taiyuan, China); Wu, Dongdong; Gao, Jiangrui; Peng, Kunchi. *Guangxue Xuebao* v 8 n 1 Jan 1988 p 1-6.

**Standards** See OPTICAL MATERIALS—Glass.

## Theory

**074213 TV OPTICS.** A color television camera contains an optical system that separates light into its component colors. This system is of key importance: besides determining the faithfulness with which the camera reproduces color, it influences the arrangement of the image pick-up tubes, and therefore the camera design itself. Topics discussed include spectral characteristics, bins light, ghosts and techniques for removing them.

Kanie, Chiomi (Ed.). *Image Technol (London)* v 68 n 11 Nov 1986 p 538-546.

**074214 PROPAGATION AND IMAGING EXPERIMENTS WITH GAUSSIAN SCHELL-MODEL BEAMS.** We report results of experiments dealing with the effects of partial spatial coherence on the propagation and focusing of Gaussian Schell-model beams. The measured coherence-dependences of the beam profile in free



space, and of the focal shift and image spot size in optical systems, are in good agreement with recent theoretical predictions. (Author abstract). 19 Refs.

He, Qingsheng (Helsinki Univ of Technology, Espoo, Finl); Turunen, Jari; Friberg, Ari T. *Opt Commun* v 67 n 4 Jul 15 1988 p 245-250.

Vibrations See ACCELERATORS, SYNCHROTRON—Performance.

## OPTICAL VARIABLES MEASUREMENT

See Also AEROSOLS—Optical Properties; ATMOSPHERIC OPTICS—Visibility; BIOLOGICAL MATERIALS—Blood; ELECTRIC LAMPS, DISCHARGE—Efficiency; ELECTRIC LIGHTING—Glare; ELECTRIC MEASUREMENTS—Power; ELECTROOPTICAL DEVICES—Measurements; FIBER OPTICS—Applications; FIBER OPTICS—Measurements; FIBER OPTICS—Plastics Applications; HALOGEN COMPOUNDS—Spectroscopic Analysis; HIGHWAY SIGNS, SIGNALS AND MARKINGS—Visibility; IMAGE PROCESSING—Performance; INTERFEROMETERS; INTERFEROMETRY—Performance; LASER PULSES—Measurements; LASERS—Measurements; LASERS, SEMICONDUCTOR—Performance; LENSES—Testing; LIGHT—Diffraction; LIGHT—Reflection; LIGHT—Scattering; LIGHT—Speckle; LIQUIDS—Optical Properties; MICROSCOPIC EXAMINATION; OPTICAL COMMUNICATION EQUIPMENT—Measurements; OPTICAL FIBERS—Analysis; OPTICAL FIBERS—Measurements; OPTICAL FIBERS—Optical Properties; OPTICAL INSTRUMENTS—Evaluation; PAPER—Surface Properties; PARTICLE SIZE ANALYSIS—Measurements; POLYMERS—Phase Transitions; PROSTHETICS—Measurements; PYROMETERS; SEMICONDUCTING LEAD COMPOUNDS—Optical Properties; SILICA—Optical Properties; SOLAR CELLS—Spectrum Analysis; STRESSES—Analysis; WAVEGUIDES, OPTICAL—Measurements.

**074215 HIGH-QUALITY CLEAVES FOR BETTER FIBER SPLICES.** A good fiber cleave is one that produces a completely flat end with an angle (between the cleaved plane and a plane perpendicular to the fiber axis) of less than one degree. A useful tool in the evaluation of cleave quality is the interference microscope which provides a view of the patterns that reveal the contours of the fiber. A perfectly flat cleave that nonetheless has an end angle greater than zero will display a series of parallel fringes. Curved fringes or nonparallel fringes show that the surface is nonplanar. An interference pattern alone will not differentiate between roll-off and lip. Pertinent measurement techniques are discussed.

Johnson, Keith. *Photonics Spectra* v 21 n 10 Oct 1987 5p between p 135 and 142.

**074216 APPARATUS FOR CALIBRATION TESTING OF MEANS OF AVERAGE LASER EMISSION POWER MEASUREMENTS.** The apparatus for calibration testing of average power means of measurements (ACTAP) is designed for transferring the dimension of the unit of the average laser emission power from the standard means of measurement (SMM) to the operational means of measurement (OMM) in accordance with the State Standard GOST 8.275-78. The main metrological characteristic of the ACTAP is the error with which the average laser emission power at the OMM input can be measured. This error consists of the error of the SMM used on the ACTAP, the diffraction divider error, and the error caused by the emission instability. This paper discusses the components of the ACTAP error. These components are SMM errors, diffraction divider error, and laser emission power instability error. 3 refs.

Kaufman, S.A.; Knyupfer, A.P.; Liberman, A.A. *Meas Tech* v 29 n 11 Nov 1986 p 1029-1031.

**074217 COMPLEX AND ELEMENTAL CERTIFICATION OF DEVICES FOR MEASURING DAMPING IN FIBER LIGHTGUIDES.** The prospects for the development and employment of standard-optical attenuators for the metrological provisions of measurement devices (MD) for measuring damping require the development of setups for measuring damping in these attenuators with the required accuracy. Analysis of methods for measuring damping in fiber lightguides (FLG) shows that from the standpoint of raising the measurement accuracy and the simplicity of the technological realization the two-point method employing two methods is preferable:

truncation and matched injection. 9 refs.

Nikolaev, N.V.; Surodin, M.P.; Tikhomirov, S.V. *Meas Tech* v 29 n 11 Nov 1986 p 1036-1040.

**074218 MEASURING APPARATUS TO DETERMINE THE ABSORPTION FACTOR OF PLANE SPECIMENS.** Plane surfaces are used as receiving elements in many calorimetric measuring converters of medium power laser radiation. A rise in the accuracy in determining the value of the absorption factor of plane receiving elements in a broad spectrum band in fixed wave-length radiation contributes to a reduction in the fundamental error of the measuring transducer being used. This article examines an installation permitting significant reduction in the error in measuring the absorption factor of plane receiving elements. 2 refs.

Liberman, A.A.; Yankevich, E.M. *Meas Tech* v 29 n 11 Nov 1986 p 1041-1043.

**074219 SPECTRAL RESPONSE MEASUREMENTS ON POLARISATION SPLITTING RATIO OF FUSED-TAPER SINGLE-MODE FIBRE COUPLERS.** Using a Ge PIN photodiode cooled to 77K (−196°C) with liquid nitrogen and the lock-in amplification technique, an automatic polarisation spectral response measurement system with a measuring dynamic range of about 36db has been developed. It has been confirmed experimentally that the spectral response of polarisation beam-splitting ratios of fused-taper fibre couplers depend on the incident polarisation angle. (Author abstract) 6 refs.

Namihira, Y. (KDD Meguro Research & Development Lab, Tokyo, Jpn); Horiuchi, Y.; Wakabayashi, H. *Electron Lett* v 23 n 22 Oct 22 1987 p 1204-1206.

**074220 SYNCHRONOUS SINGLE-PHOTON COUNTING USING AN SI AVALANCHE PHOTO- DIODE AT ROOM TEMPERATURE.** We have demonstrated photon counting using an Si APD at room temperature. A wide dynamic range of 43 db has been achieved with the synchronous single-photon counting (SSPC) technique. (Edited author abstract) 5 refs.

Shimizu, K. (KDD Meguro R&D Lab, Tokyo, Jpn); Fujise, M.; Nunokawa, M. *Electron Lett* v 23 n 24 Nov 19 1987 p 1307-1308.

**074221 RADIUS-OF-CURVATURE METER FOR REFLECTING SURFACES.** Curvature is determined by the change of direction of a laser beam reflected by the surface being measured as it moves perpendicular to the beam. The measurement error is  $\pm 1\%$  for a radius of curvature of not over 30 m. (Author abstract) 5 refs.

Gromov, A.N. (Acad of Sciences of the USSR, Novosibirsk, USSR); Schulyat'ev, V.B. *Instrum Exp Tech* v 30 n 2 pt 2 Mar-Apr 1987 p 489-490.

**074222 REGULARIZATION IN ELLIPSOmetry. NEAR-SURFACE DEPTH PROFILES OF THE REFRACTIVE INDEX.** The continuous variation of the refractive index with the depth in the vicinity of surfaces can be determined by ellipsometry without destroying the object of measurements. The presented method does not impress any given structure to the profile and is applicable to just the range of layer thicknesses interesting to optics (about  $\lambda/4$  to  $\lambda/2$ ). The theoretical approach to interpret the measured data leads to an integral equation that is numerically inverted by regularization to filter out the destabilizing effects of measurement errors. The regularizing operator and regularization parameter responsible for this 'filtering' are founded on physical arguments and experiment, respectively. These results can be transferred to other regularization problems based on quantities related to volume (e.g. density, temperature). (Author abstract) 16 refs.

Kaiser, J.H. (Univ of Duesseldorf, Duesseldorf, West Ger). *Appl Phys B* v B45 n 1 Jan 1988 p 1-5.

**074223 HIGH RESOLUTION MEASUREMENT OF JET STREAM THICKNESS BY OPTICAL**

**RANGING.** A non-contact, high resolution (2  $\mu\text{m}$ ) measurement of jet stream thickness has been performed using an optical ranging technique. By measuring the coherent spike displacement of the non-linear autocorrelation function of partially mode-locked picosecond light pulses, a complete characterization of jet stream profiles has been achieved. (Author abstract) 14 refs.

Bulloni, M. (CNR, Milan, Italy); De Silvestri, S.; Laporta, P.; Zaraga, F.; Liu, Yupu; Magni, V. *Opt Commun* v 66 n 5-6 May 15 1988 p 280-284.

## Applications

**074224 DEFORMATION MEASUREMENT USING HIGH RESOLUTION MOIRE PHOTOGRAPHY.** By installing a slotted mask inside the lens of a 35 mm camera the response can be tuned to resolve 300 lines/mm. The camera is used to record changes in fine grid patterns applied to engineering structures and by analyzing the processed negatives in a spatial filtering system, moire fringe maps are generated representing the separate x and y displacements that have occurred. Measurements have been obtained from materials ranging from concrete to soft plastics and a variety of patterns is described for treating most surfaces. (Edited author abstract). 11 Refs.

Forno, C. (NPL, Middlesex, Engl). *Opt Lasers Eng* v 8 n 3-4 1988 p 189-212.

Automation See INTERFEROMETRY, HOLOGRAPHIC—Applications.

Computer Applications See LIGHT—Reflection.

Estimation See MICROSCOPES, ELECTRON—Resolving Power.

Imaging Techniques See LIGHT—Measurements.

## Industrial Applications

**074225 APPLICATIONS OF MOIRE TOPOGRAPHY MEASUREMENT METHODS IN INDUSTRY.** Moire topography is able to determine the shape of an object, by pattern measuring, in a short time. Recently moire topography has been used in various industrial fields because it has superior features that point measurement does not have. As it becomes popular, various related techniques that fit specific needs have been developed and there is the prospect that moire topography will become a more important measurement method and strengthen its position in the near future. This paper explains the grid irradiation method and the grid projection method as the basis of the moire topography measurement method and describes the existing status and prospects of utilizing moire topography measurement in the applied fields of shape measurement, flatness measurement and detection of abnormality. (Author abstract). 13 Refs.

Suzuki, Masane (Fuji Photo Optical Co, Omiya, Jpn); Kanaya, Motonori. *Opt Lasers Eng* v 8 n 3-4 1988 p 171-188.

Laser Applications See Also CARBON DIOXIDE—Optical Properties; OPTICAL FIBERS—Measurements.

**074226 AUTOMATIC ANALYSIS OF YOUNG'S FRINGES IN SPECKLE PHOTOGRAPHY AND PARTICLE-IMAGE VELOCIMETRY.** Laser-speckle photography (LSP) and particle-image velocimetry (PIV) are two related optical techniques for the measurement of two-dimensional in-plane displacement. LSP is primarily used for the measurement of solid-surface motion, whereas PIV is used in fluid-flow applications. In both cases, data are obtained from the optical-power spectrum of a double-exposure recording of the moving object by measuring the wavelength and orientation of Young's-type fringes corresponding to the displacement magnitude and direction, respectively. Typically, in any



single experiment, of the order of  $10^4$  fringe patterns must be analyzed, and this would be tedious to perform manually. A number of schemes have been reported in the literature for automated analysis of Young's fringes. We examine two techniques, 1-D integration and 2-D autocorrelation, and discuss their application to LSP and PIV. A unified theoretical model is used to show important differences between the two techniques, and resulting implications with respect to analysis procedures are discussed. (Edited author abstract) 16 refs.

Pickering, C.J.D. (Univ of Southampton, Southampton, Engl); Halliwell, N.A. *Opt Lasers Eng* v 7 n 4 1986-1987 p 227-242.

**074227 NEW LASER MEASUREMENT SYSTEM FOR PRECISION METROLOGY.** Laser measurement systems, based on optical heterodyne interferometry, have been a valuable tool for precision metrology for almost two decades. During this period measurement requirements have steadily increased without an accompanying improvement in system capabilities. This paper describes a new laser head, electronics and interferometers that satisfy present needs and have the attributes to meet future requirements. (Author abstract) 3 refs.

Sommargren, G.E. (Zygo Corp, Middlefield, CT, USA). *Precis Eng* v 9 n 4 Oct 1987 p 179-184.

**074228 INTERFEROMETRIC OPTICAL PATH DIFFERENCE MEASUREMENT USING SINUSOIDAL FREQUENCY MODULATION OF A DIODE LASER.** We describe a technique applicable to interferometric systems illuminated by a laser diode. In this system, the optical path difference is recovered by means of sinusoidal modulation of the laser emission frequency. (Edited author abstract) 11 refs.

Webb, D.J. (Univ of Canterbury, Canterbury, Engl); Taylor, R.M.; Jones, J.D.C.; Jackson, D.A. *Opt Commun* v 66 n 5-6 May 15 1988 p 245-248.

**Mathematical Models** See LIGHT—Scattering.

**Nondestructive Examination**

**074229 NON-DESTRUCTIVE TESTING.** Since they are inherently noncontact, optical test methods are nondestructive and interferometry has become one of the most widely used of such methods. Fringe observation and analysis, however, are highly subjective: Digitization of fringe centers, while providing accuracy to about one-tenth of a wave, is time consuming and not accurate enough to meet demanding testing requirements. It is pointed out that by more precisely measuring the fringe patterns, much higher accuracy can be achieved.

Mittelstaedt, Mark. *Photonics Spectra* v 21 n 10 Oct 1987 7p between p 121 and 132.

**Performance**

**074230 DIFFERENTIAL INTERFERENCE CONTRAST SYSTEM INCORPORATING A MURTY INTERFEROMETER AND HOLOGRAPHIC CORRECTION.** The Differential Interference Contrast (DIC) method, is useful for the observation of phase gradients in objects which have phase variations of less than one quarter of a wavelength. A description of an optical system in which the DIC method is realised through the use of a Murty-type shearing interferometer consisting of a plane parallel glass plate is given. This is followed by a description of a modified version of this system, in which a holographic element is used to compensate for lens aberrations, and to modulate the output fringes in order to allow their easy detection. The application of this system to the measurement of film thickness is described. Results are given which are in reasonably good agreement with measurement made on a Talysurf. (Edited author abstract) 6 refs.

Matsuda, K. (Mechanical Engineering Lab, Sakura-mura, Jpn); Namiki, M.; Barnes, T.H. *Opt Lasers Eng* v 9 n 1 1988 p 35-46.

**Sensors** See OCEANOGRAPHY—Salinity Measurements.

**Spectroscopic Analysis**

**074231 DEVELOPMENT OF A HIGH-SPEED TIME-RESOLVED SPECTROSCOPE AND ITS APPLICATION TO ANALYSIS OF TIME-VARYING OPTICAL SPECTRA.** The authors have developed a spectroscopic measuring system that is controlled by a microcomputer to analyze a time-varying optical spectrum. A charge-coupled-device (CCD) linear image sensor, which has 128 pixels, is used as an optical detector, so that the optical spectrum can be measured quickly in a parallel way. The spectrum to be measured ranges from about 350 to 700 nm in wavelength. All data are digitized and transferred to a microcomputer for storage on a floppy disk, and they can be processed for display in various forms. This system has been applied to the spectrum analysis of light emitted due to a contact arc discharge. 5 refs.

Sato, Kiminori (Tohoku Univ, Sendai, Jpn); Sato, Tomohiko; Sone, Hideaki; Takagi, Tasuku. *IEEE Trans Instrum Meas* v IM-36 n 4 Dec 1987, IMTC/1987: The Fourth IEEE Instrum and Meas Technol Conf, Boston, MA, USA, Apr 27-29 1987 p 1045-1049.

**Spectrum Analysis** See COLOR—Measurements; OPTICAL FIBERS—Measurements.

**Standards** See UNITS OF MEASUREMENT—Standards.

**OPTICS** See Also ACCELERATORS, SYNCHROTRON—Design; ACCELERATORS, SYNCHROTRON—Performance; AEROSOLS—Thermal Effects; ANTENNAS—Reflectors; HOLOGRAPHY—Analysis; LASERS; LASERS, FREE ELECTRON; LASERS, X-RAY—Research; LIGHT—Polarization; LIGHT—Scattering; LIGHT—Transmission; LITHOGRAPHY—Performance; MIRRORS—Applications; OPTICAL SYSTEMS—Mathematical Models; PATTERN RECOGNITION—Analysis; PHOTOGRAPHY, COLOR; SPECTROSCOPY, EMISSION—Imaging Techniques; VISION; VISION—Mathematical Models.

**074232 BISTABILITE, MULTISTABILITE ET CHAOS EN LONGUEUR D'ONDE.** [Bistability, Multistability and Chaos in Wavelength]. Unstable and chaotic phenomena have led to a number of studies in the area of optics which allows easy experimental verifications owing to the use of optical sources and feedback, and optically-induced nonlinearities. Most of those studies have dealt with hybrid or all-optical systems working in monochromatic light and whose dynamic variable of concern was the energy. The work presented here deals with chaotic phenomena linked to the wavelength variable. The latter opens up new possibilities inherent to the high flexibility in inducing wavelength nonlinearities and their control, and to the greater dynamic excursion of the signals. Wavelength bistable and multistable devices are presented, together with a discussion of the various routes to chaos they can generate. The prospects given in the conclusion deal with the use of the wavelength variable in a chaos generator, the multi-valued coding in wavelength of signals, and the chaos that would be generated by a system with a feedback featuring a signal-dependent optical delay. In French. 14 refs.

Duvernoy, Jacques (Univ de Franche-Comte, Besancon, Fr); Goedgebuer, Jean-Pierre; Porte, Henri. *Ann Telecommun* v 42 n 5-6 May-Jun 1987 p 315-323.

**074233 PROJECTION OF OPTICAL FOCUSING ELEMENTS WITH RELIEF PECULIARITIES.** Mathematical problems that arise in the evaluations of optical elements that focus radiation into a smooth plane curve were studied. The situation is considered where the surface of a phase element is not smooth and includes a discontinuity. An algorithm for calculation of the profile of optical elements is suggested. (Author abstract) 2 refs.

Goncharskii, A.V.; Kashirina, Z.V.; Stepanov, V.V. *Moscow Univ Comput Math Cybern* n 3 1987 p 10-15.

**074234 REFLECTIVE OPTICS (HELD AT SPIE'S O-E/LASE '87 SYMPOSIUM ON OPTOELEC-**

**TRONICS AND LASER APPLICATIONS IN SCIENCE AND TECHNOLOGY).** Proceedings in cooperation 16 papers that are subdivided into four sessions dealing with: large reflective optics, precision machining of optics, and reflective systems design. Emphasis is on: large ground-based and space-based optical systems; progress in the area of diamond-turned mirrors and mirror systems; and use of new and advanced fabrication methods. Topics considered include: unobscured reflective systems, collimators, afocal telescopes, two-mirror collimator, multimirror systems, visible and IR interferometry, copper mirrors, star exploration, phased arrays, aperture-synthesis interferometry, cohered lidar wind measurements, two-mirror three-surface telescope, and astrophysics space observatories during the next 25 years. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11570 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Korsch, Dietrich (Ed.) (Korsch Optics Inc). *Proc SPIE Int Soc Opt Eng* v 751, Reflective Opt, Los Angeles, CA, USA, Jan 15-16 1987, Publ by SPIE, Bellingham, WA, USA, 1987 151p.

**Absorption**

**074235 BAND TAILS, PATH INTEGRALS, INSTANTONS, POLARONS, AND ALL THAT.** This paper reviews the explanations recently developed by the authors and their collaborators of how disorder leads to exponential band tails and to Urbach tails in optical absorption. It starts with the simplest single-potential-well models which, despite their simplicity, are remarkably successful in accounting for the experimental facts. It then identifies the weaknesses, hidden or explicit, in these models and shows, step by step, how they can be corrected by increasing the sophistication of the procedures used. Exact results are finally achieved through use of field-theoretic techniques, and appropriately formulated single-potential-well models are shown to reproduce these quite accurately. It is also shown that the probability distribution of the random potential must be close to Gaussian, with an autocorrelation function which cuts off fairly rapidly with distance for there to be a well-defined, broad energy range in which there are exponential band tails in the density of states and Urbach tails in the optical absorption. (Author abstract)

Cohen, M.H.; Chou, M.Y.; Economou, E.N.; John, S.; Soukoulis, C.M. *IBM J Res Dev* v 32 n 1 Jan 1988 p 82-92.

**Analysis**

**074236 INVESTIGATION OF THE FOURIER-TRANSFORM METHOD OF FRINGE PATTERN ANALYSIS.** The tolerance of the Fourier-transform method of fringe pattern analysis to increasing levels of signal-independent random additive noise and increasingly complicated phase functions is investigated. It is shown that the condition that the phase must be a slowly varying function compared to the variation introduced by the carrier frequency is flexible. (Edited author abstract) 5 refs.

Green, R.J. (King's Coll London (KQC), London, Engl); Walker, J.G.; Robinson, D.W. *Opt Lasers Eng* v 8 n 1 1988 p 29-44.

**Applications** See HOLOGRAPHY—Applications; HOLOGRAPHY—Research; MATHEMATICAL TRANSFORMATIONS—Applications; RADIO SYSTEMS, MOBILE—Performance.

**Exhibitions**

**074237 FACHAUSSTELLUNG PRAEZISIONSOPTIK.** [Special Exhibition on Precision Optics]. In the beginning of November, 1987, a small but worthwhile special exhibition was held, where 20 enterprises exhibited optical machinery and operating means, measuring and testing units, precision optical components and ultrasonic cleaning plants. This report provides a general survey for



our readers. (Author abstract) In German.

Stoeckermann, Thomas. *F&M Feinwerktech Messtech* v 96 n 1-2 Jan-Feb 1988 p 29-30.

**Geometrical** See Also ANTENNAS—Reflectors.

**074238 SUCCESSIVE GEOMETRIC-OPTICAL ITERATION FOR WEDGE DIFFRACTION.** Successive iterative solutions of the geometrical optics are explicitly obtained for a conducting wedge of arbitrary wedge angle. Their convergence to the exact edge diffraction pattern is shown numerically. Only one iteration is needed to give a better approximation for edge diffraction than the physical optics approximation. (Author abstract) 4 refs.

Hwang, Churl-Kew (Korea Advanced Energy Research Inst, Chung-nan, South Korea); Kim, Se-Yun; Ra, Jung-Woong. *Electron Lett* v 24 n 1 Jan 7 1988 p 41-42.

**074239 REFINED HEURISTIC CRITERIA FOR THE APPLICABILITY OF GEOMETRICAL OPTICS.** The heuristic criteria for the applicability of geometrical optics extend the results of numerous investigations, beginning with the classical investigations of Fresnel. The first (basic) requirement reduces to the fact that within the limits of the first Fresnel zone the variations of the parameters of the wave and medium would be quite small. It is advisable to refine the Fresnel zone concept in order to avoid an erroneous interpretation of the heuristic criteria in the case of saddle-type stationary points. The second (or auxiliary) criterion of the applicability of geometrical optics - the beams must not cross the Fresnel volumes - also needs to be refined: this condition must refer only to Fresnel zones belonging to one and the same phase front, i.e., the beams must belong to one and the same congruency. This follows directly from the meaning of the stationary phase method, by means of which the geometrical optics approximation can be derived on the basis of the Kirchhoff integral. 12 refs.

Kravtsov, Yu.A. *Sov J Commun Technol Electron* v 32 n 7 Jul 1987 p 133-134.

**074240 SYMMETRY AND GEOMETRICAL RELATIONS DERIVED FROM REAL AND COMPLEX ABCD LAW FOR GAUSSIAN BEAMS.** The symmetry of the complex radius of curvature is analyzed, and a definition for the local divergence of the gaussian beam is given also. By the use of the ABCD law we deduce expressions for the conjugate point distances, matching beam waist problem and lateral magnification, including new definitions for the angular and axial magnification. An extension of the ABCD law is given including complex matrix elements, and an application on lenslike media with loss or gain variation is made as a characteristic example. (Edited author abstract). 7 Refs.

Bernabeu, Eusebio (Univ Complutense, Madrid, Spain); Alda, Javier. *Optik (Stuttgart)* v 79 n 3 Jun 1988 p 94-98.

**074241 GEOMETRICAL OPTICS METHODS FOR MODE CONVERSION IN ANISOTROPIC MEDIA.** Mode conversion can occur if two (or more) solutions of the dispersion equation coalesce. If the corresponding polarization vectors do not coincide (e.g., in lossless media) and the group velocities are finite and parallel, a coupled system of transport is derived for the amplitudes of the coinciding modes, valid in a small 'conversion region'. (Author abstract) 8 refs.

Suchy, K. (Univ of Duesseldorf, West Ger). *Radio Sci* v 22 n 6 Nov 1987, Int Symp on Electromagn Theory, Budapest, Hung, Aug 25-29 1986 p 1018-1022.

**Imaging Techniques** See IMAGE PROCESSING—Image Analysis.

**Magnetic Field Effects** See LIGHT—Polarization.

**Mathematical Models** See Also ELECTROMAGNETIC WAVES—Propagation; ELECTRONS—Scattering; IMAGING TECHNIQUES—Mathematical Models; LENSES—Measurements; LIGHT—Acoustic Wave Effects; LIGHT—Coherent; LIGHT—Mathematical Models; LIGHT—Propagation; LIGHT—Reflection; LIGHT

—Refraction; LIGHT—Scattering.

**074242 SOLUTION OF THE FOKKER-PLANCK EQUATION WITH ZERO OR NEGATIVE DIFFUSION COEFFICIENTS IN QUANTUM OPTICS.** We obtain the solution of the Fokker-Planck equation for a nonlinear optical system with negative or zero diffusion coefficients and introduce its application to the analysis of the generation of a squeezed state in the parametric amplification. (Author abstract) 6 refs.

Tan, Weihai (Acad Sinica, China); Li, Yufang; Zhang, Weiping. *Opt Commun* v 64 n 2 Oct 15 1987 p 195-199.

**074243 MEASURING THE PHASE OF SLOW KERR-TYPE NONLINEARITIES: THE ROLE OF PHASE MODULATION.** We show theoretically and verify experimentally how the phase modulation of the laser pulse affects the phase of the various contributions to the nonlinear polarization in the optical phase conjugation geometry. This provides an explanation for the apparent sum rule violation observed by Jain and Lind in semiconductor-doped glasses. It also allows to define the conditions which must be fulfilled when one wants to measure the phase of a slow Kerr-type nonlinearity. (Author abstract) 12 refs.

Hache, F. (CNRS, Palaiseau, Fr); Roussignol, P.; Ricard, D.; Flytzanis, C. *Opt Commun* v 64 n 2 Oct 15 1987 p 200-204.

**074244 NEARLY DEGENERATE FOUR-WAVE MIXING IN PHOTOREFRACTIVE CRYSTALS, AN ANALYTICAL TREATMENT.** We extend the standard model of four-wave mixing in photorefractive crystals to the case where the Bragg-condition is broken by a slight departure from degeneracy. Our analytical treatment shows that for this conditions an increased phase conjugate reflectivity can be obtained. (Author abstract) 7 refs.

Goltz, J. (Technische Hochschule Darmstadt, Darmstadt, West Ger); Laeri, F.; Tschudi, T. *Opt Commun* v 64 n 1 Oct 1 1987 p 63-66.

**074245 COMPUTATION OF THE OPTICAL PROPERTIES AND THEIR FIRST ORDER DERIVATIVES FOR MULTILAYER STRUCTURES.** An elaborate computer program has been established for calculating the optical properties and their first order derivatives for arbitrary multilayer structure systems. The method employs Chebyshev polynomials. The optical properties that may be calculated include reflectivity R, transmissivity T, absorptivity A and their derivatives R', T' and A' with respect to wavelength. The advantages of the present program reside in the reduction of the computer time by almost a factor of m, the total number of inentity periods, and the advantage of calculating the derivatives of R, T and A with respect to wavelength. The basic formulas which are utilized in these calculations are given together with the essential details of the program, including a block diagram. (Edited author abstract) 13 refs.

Abu El-Hajja, A.J. (Int Cent for Theoretical Physics, Trieste, Italy); Omari, H.Y. *Appl Phys Commun* v 7 n 3 Sep 1987 p 157-172.

**074246 OPTICAL QUANTUM NONDEMOLITION DETECTION SCHEMES IN  $\chi^{(2)}$  MEDIA.** Two quantum nondemolition (QND) measurement schemes using second order optical nonlinearities are proposed and shown to fulfil the criteria for back-action evasion in a measurement of optical amplitude. The first scheme, based on optical rectification, is very simple in principle, but yields extremely small signals with available materials. The second scheme is based on optical parametric amplification with type II phase matching. The interactions necessary for back-action evasion are provided by polarization mixing using Faraday rotation. (Author abstract) 18 refs.

Shelby, R.M. (IBM, San Jose, CA, USA); Levenson, M.D. *Opt Commun* v 64 n 6 Dec 15 1987 p 553-559.

**074247 GAUSSIAN BEAM-MODE OPTICS AND**

**THE DESIGN OF MILLIMETER-WAVE MARTIN-PUPPLETT INSTRUMENTS.** The Martin-Puplett Interferometer is a polarising version of the Michelson two-beam interferometer. Optical systems of this type are widely used in the millimeter-wave spectral region. This paper details some ways in which the technique of Gaussian beam-Mode optics may be employed to assist in the design of compact, high performance systems for use as spectrometers, diplexers, filters, or general four-port networks. (Author abstract) 13 refs.

Lesurf, J.C.G. (Univ of St. Andrews, St. Andrews, Scotl). *Infrared Phys* v 28 n 2 Mar 1988 p 129-137.

**Measurements** See HARMONIC GENERATION—Spectrum Analysis; LIGHT—Polarization.

**Moire Fringes** See Also AIRCRAFT—Failure; ELECTRON OPTICS; INTERFEROMETRY; INTERFEROMETRY—Analysis; INTERFEROMETRY—Applications; INTERFEROMETRY—Performance; OPTICAL INSTRUMENTS; OPTICAL VARIABLES MEASUREMENT—Applications; OPTICAL VARIABLES MEASUREMENT—Industrial Applications; PHYSICS—Education.

**074248 MOIRE FRINGE MULTIPLICATION OF SUPERIMPOSED GRATINGS IN COHERENT FILTERING SYSTEM.** In this paper the principle of Fourier optics is used in treating the problem of moire fringe multiplication formed by two contact gratings. A continuous relationship between displacement and light intensity is obtained. The gratings may be amplitude type, phase type, or amplitude and phase type. Moire fringe multiplication under coherent illumination for both homogeneous and inhomogeneous deformation-field is considered. The resulting formulas have universal significance and agree fairly well with the experimental results obtained by D. Post. (Author abstract) In Chinese 9 refs.

Gu, Jie (Suzhou Univ, China); Shen, Yongzhao; Jiang, Jinhu; Chen, Binquan. *Guangxue Xuebao* v 7 n 6 Jun 1987 p 519-523.

**074249 MIRROR MOIRE TOPOGRAPHY.** We propose a scheme of optical layout for the mirror Moire topography. A theory has been furnished to derive the reckoning formula of the mirror Moire topography. Several inclining and cylindrical mirror Moire fringe photos are given and compared with the results which are reckoned according to the theory. (Author abstract) In Chinese.

Yuan, Yulin (Zhejiang Univ, Hangzhou, China); Xu, Qizhem; Yu, Hong. *Guangxue Xuebao* v 7 n 7 Jul 1987 p 642-650.

**074250 COMBINING OPTICAL FRINGE ANALYSIS AND THE FINITE-ELEMENT METHOD.** A method has been developed to fit Zernike polynomials to surface deformations computed during finite-element structural analysis. This procedure uses a preprocessor to the finite-element code and allows the polynomial fit to be calculated during both static and dynamic computations. (Author abstract) 1 ref.

Bella, David F. (MacNeal-Schwendler Corp, Los Angeles, CA, USA). *Opt Eng* v 27 n 2 Feb 1988 p 111-114.

**074251 BINARIZATION OF SCANNING MOIRE FRINGE PATTERN.** This paper describes a digital picture processing method to obtain a binary scanning moire pattern. A bias component due to the illumination light distribution is eliminated from the scanning moire fringe pattern to detect the zero-crossing points of the moire profile. The binary fringe pattern is then obtained from the zero-crossing points. Experiments indicate that the method is useful for facilitating three-dimensional automatic measurement using moire topography. (Edited author abstract). 6 Refs.

Arai, Y. (Kansai Univ, Suita, Jpn); Kurata, T. *Opt Lasers Eng* v 8 n 3-4 1988 p 263-275.



**Nonlinear** See Also ACETYLENE—Optical Properties; CARBON DISULFIDE—Measurements; CRYSTALS—Electric Field Effects; CRYSTALS—Optical Properties; CRYSTALS, LIQUID—Nematic; FIBER OPTICS; FLUORESCENCE—Mathematical Models; INTERFEROMETERS—Stability; LASER BEAMS—Nonlinear Optical Effects; LASER PULSES; LASERS—Materials; LASERS—Optical Pumping; LASERS, SOLID STATE—Thermal Effects; OPTICAL COMMUNICATION—Switching; OPTICAL COMMUNICATION EQUIPMENT—Switching; OPTICAL FIBERS; OPTICAL FIBERS—Applications; OPTICAL GRATINGS; OPTICAL MATERIALS; OPTICAL MATERIALS—Performance; POLYMERS—Optical Properties; RESONATORS—Stability; SEMICONDUCTING CADMIUM COMPOUNDS—Optical Properties; SEMICONDUCTOR DIODES, PHOTODIODE—Applications; WAVEGUIDES, OPTICAL; WAVEGUIDES, OPTICAL—Mathematical Models.

**074252 CHAOS DANS DES SYSTEMES OPTIQUES A REACTION RETARDEE.** [Chaos in Delayed Feedback Optical Systems]. Optical systems which display bistability in the stationary regime may exhibit high-dimensional chaos. The Lyapunov dimension of chaotic attractors is found to be almost equal to the delay time divided by the autocorrelation time of the feedback for two optical systems, the nonlinear ring cavity and the hybrid system, and for the Mackey-Glass model for white-cell production. This simple relationship will enable experimentalists to easily estimate the complexity of a high-dimension system. (Author abstract) In French. 11 refs.

Le Berre, Martine (Univ Paris-Sud, Orsay, Fr); Ressayre, Elisabeth; Tallet, Andree. *Ann Telecommun* v 42 n 5-6 May-Jun 1987 p 324-327.

**074253 ORGANIC MATERIALS FOR NONLINEAR OPTICAL DEVICES.** Nonlinear optical effects offer devices which allow the control of a light beam with another light beam or an applied electric field. After a brief introduction to some nonlinear optical effects various organic materials and their applications in this area are discussed. (Author abstract) 11 refs.

Blau, W. (Trinity Coll, Dublin, Ire). *Phys Technol* v 18 n 6 Nov 1987 p 250-257, 268.

**074254 SURFACE-GUIDED NONLINEAR TM WAVES IN PLANAR WAVEGUIDES.** The propagation of strongly nonlinear TM surface-guided waves in media controlled by a self-focusing third-order optical, unsaturated nonlinearity is analysed theoretically. In this theory both the amplitude and the wave number of the guided wave are power dependent. The reasons for studying these waves are explained and it is emphasised that strong nonlinearity can lead to a number of device applications. Although such devices are not simulated here, a number of planar structures that are of potential device interest are discussed. A mathematical theory is presented that is both free of previous approximations and capable of dealing with many types of nonlinear mechanisms. The waveguide structures that are considered are a single interface between semi-infinite linear and nonlinear media, a linear guide symmetrically bounded by self-focusing nonlinear media and two linear waveguides coupled through a nonlinear medium. The exact theory quickly leads to equations that can only be solved numerically but some degree of analytical progress is reported here for the single-interface case. Two methods of solution are presented, one based on the first integral of the nonlinear wave equation and the other based on a spline collocation numerical method. (Edited author abstract) 31 refs.

Boardman, A.D. (Univ of Salford, Salford, Engl); Twardowski, T.; Shivarova, A.; Stegeman, G.I. *IEEE Proc Part J* v 134 n 3 Jun 1987 p 152-160.

**074255 DUAL-FREQUENCY Nd:YAG LASER FOR THE STUDY AND APPLICATION OF NONLINEAR OPTICAL CRYSTALS.** We have devised and demonstrated a technique that allows the simultaneous (in space and time) generation of two independent and well-separated Nd:YAG laser lines. We use this system to study three-wave mixing in nonlinear optical crystals. Application of this laser system coupled with suitable nonlinear optical crystals permitted us to simultaneously generate

frequencies extending throughout the visible (including the three primary colors) and into the near-UV. (Author abstract) 7 refs.

Morgan, R.A. (Univ of Arizona, Tucson, AZ, USA); Hopf, F.A.; Peyghambarian, N. *Opt Eng* v 26 n 12 Dec 1987 p 1240-1244.

**074256 NONLINEAR OPTICAL PHASE CONJUGATION.** The real-time information processing and manipulation of electromagnetic waves using nonlinear optical techniques has results in a myriad of new insights and applications in diverse fields such as quantum electronics, real-time adaptive optics, image processing and optical computing. The field had also motivated basic study in such areas as nonlinear laser spectroscopy, coherent and quantum optical motivated basic study in such areas as nonlinear laser spectroscopy, coherent and quantum optical phenomena, and in essence, has unified many classes of nonlinear optical interactions, occurring in most natural and synthesized states of matter. In this chapter, we review and explore the field, provide a historical perspective, analyze several of the nonlinear interactions useful for the generation of phase-conjugate replies, and conclude with a brief survey of potential applications and suitable nonlinear media. (Author abstract) 103 refs.

Pepper, David M. (Hughes Research Lab, Malibu, CA, USA). *Laser Handb* Publ by North-Holland, Amsterdam, Neth and New York, NY, USA p 333-485.

**074257 ENHANCEMENT OF PHASE CONJUGATION BY STIMULATED BRILLOUIN SCATTERING IN FLOWING AND NON-FLOWING GASES.** A theoretical analysis of optical phase conjugation (PC) in four-wave mixing is made for gases in which the driving force is proportional to the gradient of the square of the electric field. The enhancement mechanism for PC in nearly degenerate four-wave mixing (NDFWM) by Stimulated Brillouin Scattering (SBS) is treated, in the present work, by making the analysis for degenerate four-wave mixing (DFWM) in a flowing fluid, at nearly sonic velocity, and transforming the equations to the fluid frame of reference. The equations derived in the present work give a relation between the frequency shifts of the pump and the probe fields which would give maximal enhancement of PC. (Author abstract) 19 refs.

Ben-Aryeh, Y. (Technion-Israel Inst of Technology, Haifa, Isr); Postan, A. *Opt Commun* v 66 n 1 Apr 1 1988 p 47-51.

**074258 WEHRL'S ENTROPY AS A MEASURE OF SQUEEZING.** In quantum optics, the most important quantum states are the coherent states first introduced by Schroedinger in 1926. For more than a decade, people have speculated about the possibility of generating radiation with the uncertainty in one quadrature component reduced below the symmetrical lower limit set by the coherent state. This of course can only be achieved at the expense of increased uncertainty in the other quadrature component so that the Heisenberg Principle is not violated. The quantum states of this kind of unusual radiation field are called squeezed states. In this paper Wehrl's entropy is adopted to be a measure of uncertainties of quantum states and used to characterize the degree of squeezing of squeezed states in quantum optics. (Author abstract) 16 refs.

Lee, C.T. (Alabama A&M Univ, Normal, AL, USA). *Opt Commun* v 66 n 1 Apr 1 1988 p 52-54.

**074259 PICOSECOND INFRARED GENERATION FROM Nd:YAG AND A VISIBLE, SHORT CAVITY DYE LASER.** We report infrared conversion of picosecond, visible dye laser pulses and picosecond 1.064  $\mu\text{m}$  by a sequence of difference frequency generations in  $\text{LiIO}_3$  and  $\text{AgGaS}_2$  crystals. The dye laser was a short cavity design and was pumped by the second harmonic of a mode-locked Nd:YAG laser to give 23 ps pulses. The design can span 4-11  $\mu\text{m}$  in the infrared, and we tested the efficiencies between 5.2-6.4  $\mu\text{m}$  with a single dye. Conversion efficiencies of the dye laser were 16%, while the

resulting near infrared was converted to infrared at 35% efficiency. (Author abstract) 20 refs.

Spears, Kenneth G. (Northwestern Univ, Evanston, IL, USA); Zhu, Xinming; Yang, Xueyu; Wang, Liang. *Opt Commun* v 66 n 2-3 Apr 15 1988 p 167-171.

**074260 OPTICAL PULSE SMOOTHING BY DEGENERATE FOUR-WAVE MIXING.** By the investigation of the transient characteristics of degenerate four-wave mixing, we found that an optical pulse can be smoothed by relatively delaying the three incident pulses. The experimental results showed that the incident pulses with modulation larger than 50% can be reduced to a modulation less than 5%. (Author abstract) 4 refs.

Lan, Guang (Shanghai Inst of Optics & Fine Mechanics, Shanghai, China); Zhao, Suwei; Fan, Dianyan. *Opt Commun* v 66 n 4 May 1 1988 p 235-237.

**074261 COMMENT ON NONLINEAR OPTICS USING SURFACE PLASMON-POLARITONS.** Theories of nonlinear effects associated with the surface plasmon-polariton (SPP) mode have centered on the enhanced electric field localized at the metal/dielectric interface. Although SPPs do indeed present potentially large field enhancements without the need for a Fabry-Perot resonator, the primary nonlinear effect will almost invariably be thermally induced. Unlike a resonant cavity arrangement, the SPP resonance is a resonant absorption of the incident power into Joule heating of the metal. (Author abstract) 10 refs.

Sambles, J.R. (Univ of Exeter, Exeter, Engl); Innes, R.A. *J Mod Opt* v 35 n 5 May 1988 p 791-797.

**074262 PHASE CONJUGATION BY DEGENERATE FOUR-WAVE MIXING IN INVERTED DYE SOLUTIONS.** Phase conjugation has been observed in an amplifying medium of rhodamine 6/g dye molecules in solution, excited either by flashlamps or by a laser. It is found that the mechanism involved in phase conjugation is degenerate four-wave mixing through gain saturation, and reasonable agreement obtained with the theory of saturable amplifiers. A phase-conjugate signal was observed over the tuning range of the dye system (580-605 nm) and a reflectivity up to a maximum of 25% was obtained. (Author abstract) 6 refs.

Routledge, P.A. (Univ of Manchester, Manchester, Engl); King, T.A. *J Mod Opt* v 35 n 5 May 1988 p 799-805.

**074263 FORCED OSCILLATION MODEL OF OPTICAL BISTABILITY.** This paper presents a new model of optical bistability (OB). In view of the ideas of the mean field approximation, the slow envelope approximation and the adiabatic approximation, the OB system can be regarded as a 'box'. Compared with the theory of nonlinear oscillation, we find that the courses in different OBS's - including different substances and different cavities (E-P.C. or R.C.) - can be described consistently, in both steady state and temporal respect, with an appropriate nonlinear forced oscillation equation, in which the coefficients are measurable macroscopic parameters. Using the method of slowly changing phase and amplitude in oscillation theory, we develop the equation into a coupling and autonomous dynamic equation set of phase and amplitude. The general solutions of the equation set for OB steady state and transient behavior are obtained conveniently from this form. Several concrete results in literature are compared as the examples for the verification of the wide applicability of this model. (Author abstract) In Chinese. 6 refs.

Ou Fa (South China Inst of Technology, China); Wu Tingwan; Zhang Xiaodong. *Guangxue Xuebao* v 8 n 3 Mar 1988 p 205-211.

**074264 ULTRAFAST OPTICAL NONLINEARITY BY VIRTUAL CHARGE POLARIZATION IN DC-BIASED QUANTUM WELL STRUCTURES.** An optical nonlinearity due to virtual charge polarization in a quantum-well structure biased by a DC electric field is



proposed and discussed. The switching time of the nonlinearity is expected to be extremely short, on the order of 100 fs. An effective degenerative four-wave  $\chi^3$  parameter is estimated to be  $1.0 \times 10^{-9}$  [esu] for a graded gap AlGaAs quantum well and a detuning energy of pump light, 35 meV. The nonlinearity is observable and quite useful for designing an all-optical and ultrafast optical gate. 22 refs.

Yamanishi, Masamichi (Hiroshima Univ, Higashihiroshima, Jpn); Kurosaki, Masami. *IEEE J Quantum Electron* v 24 n 2 Feb 1988 p 325-331.

**074265 EFFECT OF AXIAL INHOMOGENEITY ON SOLITONS NEAR THE ZERO DISPERSION POINT.** It is shown both numerically and analytically that solitons emerge from initial pulses in the neighborhood of the zero dispersion point even when axial inhomogeneity causes large fluctuations in the zero dispersion point's location. The criterion for soliton propagation in this regime is that the correlation length of the variations is much shorter than the second-order and the third-order dispersion lengths. 14 refs.

Wai, P.K.A. (Univ of Maryland, College Park, MD, USA); Menyuk, C.R.; Chen, H.H.; Lee, Y.C. *IEEE J Quantum Electron* v 24 n 2 Feb 1988 p 373-381.

**074266 PROCEEDINGS OF THE TWELFTH ALL-UNION CONFERENCE ON COHERENT AND NONLINEAR OPTICS.** This conference proceedings contains 13 papers. All of the papers are abstracted and indexed separately. Papers cover among other subjects such as coherent atomic scattering spectroscopy, multifrequency solitons, optical sound generation, optical nonlinearity measurement, picosecond fluorescence spectroscopy, and laser-induced phase transition. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10652 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *Bull Acad Sci USSR Phys Ser* v 51 n 2 1987, Proc of the Twelfth All-Union Conf on Coherent and Nonlinear Opt, Moscow, USSR, Aug 26-29 1985 p 1-57.

**074267 PARAMETRIC MULTIFREQUENCY SOLITONS: GENERATION, COLLISION, AND DECAY.** The paper discusses the formation and interaction of a new class of stationary waves: multifrequency parametrically coupled solitons. (Author abstract) 12 refs.

Azimov, B.S.; Sukhorukov, A.P.; Trukhov, D.V. *Bull Acad Sci USSR Phys Ser* v 51 n 2 1987, Proc of the Twelfth All-Union Conf on Coherent and Nonlinear Opt, Moscow, USSR, Aug 26-29 1985 p 19-23.

**074268 THIRD-ORDER OPTICAL NONLINEARITY MEASUREMENT FOR A NEMATIC LIQUID CRYSTAL BY SURFACE ELECTROMAGNETIC-WAVE EXCITATION.** There is considerable interest in exciting surface electro-magnetic waves SEW in nonlinear systems such as boundaries of semi-infinite media and layered structures. The interest relates to topics such as bistability and SEW excitation at a planar interface between two semi-infinite media. SEW in nonlinear systems have some applications such as in nonlinear optical spectroscopy. We have used SEW excitation in a Kretschman system: prism, metal plate, and optically nonlinear nematic liquid crystal NLC in order to measure the cubic nonlinearity of the NLC at the fundamental. The measurements have been interpreted from the dispersion law for p-polarized SEW in a nonlinear anisotropic three-layer systems. 11 refs.

Arakelyan, S.M.; Grigoryan, G.L.; Kocharyan, L.M.; Nersisyan, S.Ts.; Chilingaryan, Yu.S. *Bull Acad Sci USSR Phys Ser* v 51 n 2 1987, Proc of the Twelfth All-Union Conf on Coherent and Nonlinear Opt, Moscow, USSR, Aug 26-29 1985 p 24-27.

**074269 NONLINEAR OPTICS: MATERIALS AND DEVICES, PROCEEDINGS OF THE INTERNATIONAL SCHOOL OF MATERIALS SCIENCE AND TECHNOLOGY.** Proceedings incorporates 13 papers

that are grouped into four parts. These deal with nonlinear optics in guided structures, ultrafast charge carrier dynamics in semiconductors, nonlinear optical materials, and optical bistability and instabilities in nonlinear optical devices. Topics discussed include: chaos in nonlinear optical beams, bixcitons, excitons, optical computing, nonlinear optics in composite materials, optical fibers, organic crystalline cores, photorefractive materials for optical processing, nonlinear organic materials, picosecond luminescence, electron-hole dynamics, femtosecond and picosecond lasers, and optical waveguides. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11274 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Flytzanis, C. (Ed.) (CNRS, Palaiseau, Fr); Oudar, J.L. (Ed.). *Nonlinear Opt: Mater and Devices, Proc of the Int Sch of Mater Sci and Technol, Erice, Italy, Jul 1-14 1985* Publ by Springer-Verlag (Springer Proc in Phys v 7), Berlin, West Ger and New York, NY, USA, 1986 249p.

**074270 PHASE CONJUGATION.** The background mechanisms responsible for the production of phase-conjugate waves are presented in a unified way. One set of wave equations can be used to describe both four-wave mixing and stimulated backscattering phase-conjugate mirrors. The nonlinear-optical mechanism of photorefractive is described in detail and several of the most exciting potential applications of phase-conjugate mirrors are highlighted. (Author abstract) 24 refs.

Gower, M.C. (Rutherford Appleton Lab, Didcot, Engl). *J Mod Opt* v 35 n 3 Mar 1988, Eighth Natl Quantum Electron Conf, St. Andrews, Scotl, Sep 21-25 1988 p 449-472.

**074271 PHOTOCONDUCTIVE ENHANCEMENT OF DEGENERATE FOUR-WAVE MIXING REFLECTIVITY IN BSO.** A method of enhancing the degenerate four-wave mixing (DFWM) conjugate reflectivity in photorefractive BSO is described, which uses an auxiliary beam of different wavelength to modify the local conductivity inside the crystal. With an applied external electric field of 6 kV cm<sup>-1</sup>, and small diameter DFWM beams, the auxiliary enhancing beam is used to increase local conductivity and hence drop essentially the entire voltage across the small DFWM region producing local fields of approx. 30 kV cm<sup>-1</sup>. A simple model is derived for three separate experimental configurations, and the predictions are compared with experimental results using yellow and blue beams for DFWM and enhancing beams respectively. (Author abstract) 8 refs.

Eason, R.W. (Univ of Essex, Colchester, Engl); Vainos, N.A. *J Mod Opt* v 35 n 3 Mar 1988, Eighth Natl Quantum Electron Conf, St. Andrews, Scotl, Sep 21-25 1988 p 491-503.

**074272 MAGNETIC FIELD GRADIENTS AND PARTICLE DENSITY EFFECTS IN SECOND-HARMONIC GENERATION IN SODIUM VAPOUR.** A single-frequency c.w. dyelaser has been used to study the properties of second-harmonic generation in sodium vapor induced by a magnetic field. Theoretical modeling shows that the phase as well as the magnitude of the generated second harmonic depends on the magnetic field strength. By using an appropriate magnetic field gradient it is thus possible to reduce the effects of phase-velocity mismatching, and this has been demonstrated experimentally. The effects of buffer gas pressure on second-harmonic generation have also been studied. (Author abstract) 11 refs.

Sinclair, B.D. (Univ of St. Andrews, St. Andrews, Scotl); Dunn, M.H. *J Mod Opt* v 35 n 3 Mar 1988, Eighth Natl Quantum Electron Conf, St. Andrews, Scotl, Sep 21-25 1988 p 517-528.

**074273 REPRESENTATIONS OF SQUEEZED STATES WITH THERMAL NOISE.** Some of the possible representations of squeezed states with thermal noise are discussed and their various physical interpretations elucidated. Both thermofield techniques and a density operator description are employed, and their

results related to one another where possible. (Author abstract) 15 refs.

Fearn, H. (Univ of Essex, Colchester, Engl); Collett, M.J. *J Mod Opt* v 35 n 3 Mar 1988, Eighth Natl Quantum Electron Conf, St. Andrews, Scotl, Sep 21-25 1988 p 553-564.

**074274 BERRY'S PHASE IN THE COHERENT EXCITATION OF ATOMS.** The adiabatic variation of a Hamiltonian can cause the wavefunction, governed by the Hamiltonian, to acquire an unexpected phase. The existence of this phase (Berry's phase) is an additional element in the well-known quantum adiabatic theorem. Berry's phase is observable in the interference between two identically prepared systems only one of which is adiabatically varied. We show that a single quantum system prepared in a superposition of the eigenstates of its Hamiltonian leads to observable Berry phase effects at all times. We examine this principle within the context of two-level optical resonance. (Author abstract) 31 refs.

Barnett, S.M. (Research Inst for Theoretical Physics, Helsinki, Finl); Ellinas, D.; Dupertuis, M.A. *J Mod Opt* v 35 n 3 Mar 1988, Eighth Natl Quantum Electron Conf, St. Andrews, Scotl, Sep 21-25 1988 p 565-574.

## Research

**074275 EXPERIMENTAL OBSERVATION OF OPTICAL BISTABILITY BASED ON SELF-DEFOCUSING.** The authors report what they believe is the first experimental observation of self-defocusing bistability. This kind of bistable system may have some interesting device applications due to the negative logical operation. Although the response time of thermal defocusing is quite long (hundreds of milliseconds) and the solution is not ideal for logical devices, this kind of bistable system can undoubtedly be used for other self-defocusing media with faster response times. 7 refs.

Xie, Chang-De (Shanxi Univ, Taiyuan, China); Wu, Dong-Dong; Gao, Jiang-Rui; Peng, Kun-Chi. *Opt Quantum Electron* v 19 n 5 Sep 1987 p 268-271.

## Synthesis

**074276 OBSERVATION OF OPTICAL REDSHIFTS AND BLUESHIFTS PRODUCED BY SOURCE CORRELATIONS.** Frequency shifts of the optical spectra emitted by a pair of suitably correlated small sources have been recently predicted by E. Wolf and demonstrated experimentally in the acoustic domain by Bocko, Douglass and Knox. We show that a small modification in the form of the correlation functions used by Wolf leads to a model of the correlated pair that can be synthesized in the optical domain. The results of experimental tests exhibiting redshifts and blueshifts are presented. (Edited author abstract) 9 refs.

Gori, F. (Univ di Roma La Sapienza, Rome, Italy); Guattari, G.; Palma, C.; Padovani, C. *Opt Commun* v 67 n 1 Jun 1 1988 p 1-4.

**Theory See Also ELECTROMAGNETIC WAVES—Theory; LIGHT—Diffraction; LIGHT—Spectrum Analysis; OPTICAL SYSTEMS—Mathematical Models.**

**074277 LOCAL FREQUENCY DESCRIPTION OF OPTICAL SIGNALS AND SYSTEMS.** Two types of local frequency spectra are presented: the Wigner distribution function and the sliding-window spectrum; the latter function is the Fourier transform of the signal after having been multiplied by a slided window function. The Wigner distribution function can provide a link between Fourier optics and geometrical optics. The sliding-window spectrum leads to Gabor's expansion of a signal into a discrete set of properly shifted and modulated versions of an elementary signal; the latter description leads, by its discrete nature, directly to the concept of the number of degrees of freedom of a signal. Applications of Gabor's expansion to optical signals (completely coherent and



partially coherent) as well as a way to generate Gabor's expansion coefficients of a time signal by optical means, are described. (Edited author abstract) 113 refs.

Bastiaans, M.J. (Eindhoven Univ of Technology, Eindhoven, Neth). *EUT Rep Eindhoven Univ Technol Dep Electr Eng* n 88 E-191 Apr 1988 124 p.

**Waves** See ATMOSPHERIC OPTICS—Analysis.

**OPTIMIZATION** See Also AERODYNAMICS—Wings and Airfoils; AIR ENGINES—Performance; AIRCRAFT—Landing; ANTENNAS—Feed Systems; ANTENNAS, CYLINDRICAL—Arrays; ANTENNAS, DIPOLE—Design; ANTENNAS, DIRECTIVE—Synthesis; AUTOMATA THEORY; BEAMS AND GUIDES—Structural Design; BEARINGS—Gas Lubrication; BOILERS—Components; CAMS—Design; CAST IRON—Additives; CHEMICAL EQUIPMENT—Reactors; CHEMICAL OPERATIONS—Computer Applications; CHEMICAL PLANTS—Computer Simulation; CHEMICAL REACTIONS—Phase Equilibria; COAL MINES AND MINING—Costs; COLLUMNS—Buckling; COMPUTER METATHEORY; COMPUTER OPERATING SYSTEMS—Program Compilers; COMPUTER PERIPHERAL EQUIPMENT—Plotters; COMPUTER PROGRAMMING—Algorithms; COMPUTER PROGRAMMING—Reviews; COMPUTER SIMULATION—Applications; COMPUTER SYSTEMS, DIGITAL—Parallel Processing; CONTROL SYSTEMS—Design; CONTROL SYSTEMS, ADAPTIVE—Theory; CONTROL SYSTEMS, OPTIMAL—Analysis; CONTROL SYSTEMS, OPTIMAL—Design; CONTROL SYSTEMS, OPTIMAL—Theory; DATA PROCESSING—Analysis; DATA TRANSMISSION—Packet Switching; DATA TRANSMISSION EQUIPMENT—Performance; DATABASE SYSTEMS—Distributed; DATABASE SYSTEMS—Relational; DECISION THEORY AND ANALYSIS; DIESEL ENGINES—Design; DISKS—Design; DISTILLATION—Mathematical Models; DISTILLATION EQUIPMENT—Calculations; ELECTRIC POWER DISTRIBUTION—Fault Location; ELECTRIC POWER DISTRIBUTION—Maintenance; ELECTRIC POWER GENERATION—Scheduling; ELECTRIC POWER SYSTEMS—Load Flow Analysis; ELECTRIC UTILITIES—Contracts; ELECTRONIC CIRCUITS—Computer Aided Design; ELECTRONIC EQUIPMENT—Synthesis; ELECTRONIC EQUIPMENT MANUFACTURE—Monitoring; FLYWHEELS—Design; GLASS—Stresses; HEAT EXCHANGERS; HEAT PUMP SYSTEMS—Optimization; HYDROELECTRIC POWER PLANTS—Mathematical Models; IMAGE PROCESSING; INTEGRATED CIRCUITS—Computer Aided Design; INTEGRATED CIRCUITS, VLSI—Computer Aided Design; INTERNAL COMBUSTION ENGINES—Fuel Injection; INTERNAL COMBUSTION ENGINES—Performance; INVENTORY CONTROL; IRON MOLYBDENUM ALLOYS—Thermodynamic Properties; MACHINE TOOLS—Laser Applications; MACHINE TOOLS—Mathematical Models; MACHINE TOOLS—Structural Analysis; MAGNETS—Design; MAINTENANCE—Reliability; MARKETING; MATERIALS—Creep; MATHEMATICAL MODELS; MATHEMATICAL PROGRAMMING; MATHEMATICAL PROGRAMMING, LINEAR; MATHEMATICAL PROGRAMMING, NONLINEAR; MATHEMATICAL TECHNIQUES; MATHEMATICAL TECHNIQUES—Algebra; MATHEMATICAL TECHNIQUES—Algorithms; MATHEMATICAL TECHNIQUES—Approximation Theory; MATHEMATICAL TECHNIQUES—Combinatorial Mathematics; MATHEMATICAL TECHNIQUES—Convergence of Numerical Methods; MATHEMATICAL TECHNIQUES—Differential Equations; MATHEMATICAL TECHNIQUES—Eigenvalues and Eigenfunctions; MATHEMATICAL TECHNIQUES—Finite Element Method; MATHEMATICAL TECHNIQUES—Graph Theory; MATHEMATICAL TECHNIQUES—Interpolation; MATHEMATICAL TECHNIQUES—Matrix Algebra; MATHEMATICAL TECHNIQUES—Numerical Methods; MATHEMATICAL TECHNIQUES—Variational Techniques; MECHANICAL VARIABLES MEASUREMENT—Forces; MECHANISMS—Design; MOLYBDENUM AND ALLOYS—Thermodynamic Properties; MOTOR TRUCKS—Springs and Suspensions; MOTORCYCLES—Springs and Suspensions; NUCLEAR FUELS—Reprocessing; NUCLEAR REACTORS—Containment Vessels; OPERATIONS RESEARCH; OPERATIONS RESEARCH—Scheduling; OPTICAL FIBERS—Measurements; OPTICAL FIBERS—Production; ORDNANCE—Mathematical Models; ORE TREATMENT—Crushing and Grinding; PERSONNEL; PLATES—Stresses; PROBABILITY—Game Theory; PROBABILITY—Queueing Theory; PRODUCTION ENGINEERING—Automation; PRODUCTION ENGINEERING—Efficiency; PRODUCTION ENGINEERING—Mathematical Models; PRODUCTION ENGINEERING—Planning; PUMPS, JET—Performance; ROADS AND STREETS—Construction; ROADS AND STREETS—Repair; ROTORS—Balancing; SCHEDULING; SEMICONDUCTOR DEVICES, MOSFET—Degradation; SEWAGE TREATMENT PLANTS—Management; SEWERS—Design; SOLIDS—Stresses; STEAM—Thermodynamics; SURFACES—Measurements; SWITCHING SYSTEMS—Analysis; SYSTEMS SCIENCE AND CYBERNETICS; TECHNOLOGICAL FORECASTING—Mathematical Models; TRANSPORTATION—Operations Research; TURBOMACHINERY—Blades; VALVES AND VALVE GEAR—Design; VIBRATIONS—Absorption; VIBRATIONS—Damping; WATER—Quality Control; WATER DISTRIBUTION SYSTEMS—Control; WATER SUPPLY—Economics; ZIR-

CONIUM BORON ALLOYS—Thermodynamic Properties.

**074278 DIRECT SOLUTIONS TO SOME CONSTRAINED TRANSPORTATION PROBLEMS.** Some methodology available for estimating the regression coefficient matrix of a multivariate normal linear regression model  $Y = \beta X + E$ , subjected to the double linear restrictions  $F\beta = W_1$ ,  $\beta H = W_2$ ,  $\beta L = W_3$ , is used to derive a direct solution to a three-dimensional constrained transportation problem, and a classical quadratic programming technique is used to derive a direct solution to a two-dimensional constrained transportation problem. (Author abstract) 8 refs.

Scobey, P. (St. Mary's Univ, Halifax, NS, Can); Kabe, D.G. *Ind Math* v 34 pt 2 1984 p 109-121.

**074279 OPTIMIZATION THEORY FOR n-SET FUNCTIONS.** An optimization theory is developed for functions of n sets. Optimality conditions are established, and a Lagrangian duality is obtained. (Author abstract) 14 refs.

Corley, W.H. (Univ of Texas, Arlington, TX, USA). *J Math Anal Appl* v 127 n 1 Oct 1987 p 193-205.

**074280 SEQUENTIAL STOPPING RULES FOR THE MULTISTART ALGORITHM IN GLOBAL OPTIMIZATION.** In this paper a sequential stopping rule is developed for the Multistart algorithm. A statistical model for the values of the observed local maxima of an objective function is introduced in the framework of Bayesian non-parametric statistics. A suitable a-priori distribution is proposed which is general enough and which leads to computationally manageable expressions for the a-posteriori distribution. Sequential stopping rules of the k-step look-ahead kind are then explicitly derived, and their numerical effectiveness compared. (Author abstract) 12 refs.

Betro, Bruno (CNR, Milan, Italy); Schoen, Fabio. *Math Program* v 38 n 3 Aug 1987 p 271-286.

**074281 SECOND ORDER NECESSARY AND SUFFICIENT CONDITIONS FOR CONVEX COMPOSITE NDO.** The author considers a minimization problem that arises in nondifferentiable optimization. This problem model has a wide range of application in mathematical programming since many important problem classes can be cast within its framework, e.g. convex inclusions, minimax problems, and penalty methods for constrained optimization. In the present work we extend the second-order theory developed by A.D. Ioffe to arbitrary finite valued convex functions. A discussion of the second order regularity conditions is given that illuminates their essentially geometric nature. (Edited author abstract) 23 refs.

Burke, James V. (Univ of Washington, Seattle, WA, USA). *Math Program* v 38 n 3 Aug 1987 p 287-302.

**074282 RELAXATION METHODS FOR PROBLEMS WITH STRICTLY CONVEX SEPARABLE COSTS AND LINEAR CONSTRAINTS.** We consider the minimization problem with strictly convex, possibly nondifferentiable, separable cost and linear constraints. The dual of this problem is an unconstrained minimization problem with differentiable cost which is well suited for solution by parallel methods based on Gauss-Seidel relaxation. We show that these methods yield the optimal primal solution and, under additional assumptions, an optimal dual solution. To do this it is necessary to extend the classical Gauss-Seidel convergence results because the dual cost may not be strictly convex, and may have unbounded level sets. (Author abstract) 16 refs.

Tseng, Paul (MIT, Cambridge, MA, USA); Bertsekas, Dimitri P. *Math Program* v 38 n 3 Aug 1987 p 303-321.

**074283 TRUST REGION ALGORITHM FOR NONLINEARLY CONSTRAINED OPTIMIZATION.** We present a trust region-based method for the general nonlinearly equality constrained optimization problem. The method works by iteratively minimizing a

quadratic model of the Lagrangian subject to a possibly relaxed linearization of the problem constraints and a trust region constraint. The model minimization may be done approximately with a dogleg-type approach. We show that this method is globally convergent even if singular or indefinite Hessian approximations are made. A second-order correction step that brings the iterates closer to the feasible set is described. (Edited author abstract) 15 refs.

Byrd, Richard H. (Univ of Colorado, Boulder, CO, USA); Schnabel, Robert B.; Shultz, Gerald A. *SIAM J Numer Anal* v 24 n 5 Oct 1987 p 1152-1170.

**074284 GLOBAL CONVERGENCE OF A CLASS OF QUASI-NEWTON METHODS ON CONVEX PROBLEMS.** We study the global convergence properties of the restricted Broyden class of quasi-Newton methods, when applied to a convex objective function. We assume that the line search satisfies a standard sufficient decrease condition and that the initial Hessian approximation is any positive definite matrix. We show global and superlinear convergence for this class of methods, except for DFP. The analysis gives us insight into the properties of these algorithms; in particular it shows that DFP lacks a very desirable self-correcting property possessed by BFGS. (Edited author abstract) 19 refs.

Byrd, Richard H. (Univ of Colorado, Boulder, CO, USA); Nocedal, Jorge; Ya-Xiang, Yuan. *SIAM J Numer Anal* v 24 n 5 Oct 1987 p 1171-1190.

**074285 EFFICIENCY OF A GLOBAL OPTIMIZATION ALGORITHM.** An algorithm for determining the global minimum of an unconstrained function  $f$  is considered. The method is applicable to functions  $f$  having so-called inclusion functions. Such inclusion functions are easily found using some simple features of interval arithmetic. Sharp estimates for the convergence order are presented. The order depends polynomially on the size of the domain of  $f$  and exponentially on the order of the inclusion function chosen and the dimension of the problem. (Edited author abstract) 19 refs.

Ratschek, H. (Univ of Duesseldorf, Duesseldorf, West Ger); Rokne, J.G. *SIAM J Numer Anal* v 24 n 5 Oct 1987 p 1191-1201.

**074286 USE OF PSEUDO-POLYNOMIAL ALGORITHMS FOR SOME PROBLEMS OF COMBINATORIAL OPTIMIZATION WITH CONSTRAINTS.** There are algorithms for the solution of problems of finding assignments, pair-combinations, or extremal-weight trees, and their operation time is polynomial with respect to the dimensionality of the problem and the length of the binary representation of its numerical parameters. If extremality is replaced in these problems by the requirement of finding a solution of given weight, then the problem become NP-complete, though not in the strong sense. Algorithms for finding solutions of given weight, which are polynomial in dimensionality and magnitude of the numerical parameters, are described. They are probabilistic and, when repeated, yield a solution to the indicated problems which has an arbitrary degree of reliability. (Author abstract) 2 refs.

Smetanin, Yu.G.; Khachiyan, L.G. *Sov J Comput Syst Sci* v 25 n 2 Mar-Apr 1987 p 161-165.

**074287 CHARACTERIZATION OF SEMICONTINUITY OF SOLUTIONS TO ABSTRACT OPTIMIZATION PROBLEMS.** The author investigates the upper semicontinuity of a multifunction that arises in an abstract minimization problem. 12 refs.

Bednarczuk, Ewa (Polish Acad of Sciences, Warsaw, Pol). *Numer Funct Anal Optim* v 9 n 7-8 Jul-Aug 1987 p 685-708.

**074288 HOW GOOD ARE THE PROXIMAL POINT ALGORITHMS?** We consider a simple idealized proximal point algorithm using gradient minimization on  $C^2$  convex functions. This is compared to the direct use of



the same gradient method with an appropriate mollifier. Our object is to assess the potential efficiency of these algorithms. We find that for distant starting values, proximal point algorithms are considerably less laborious than a direct method. However there is no essential improvement in the complexity, only in the numerical factors. This negative conclusion holds for the entire family of proximal point algorithms based on the gradient methods of this paper. The algorithms considered may be important for large scale optimization problems. (Edited author abstract) 6 refs.

Goldstein, A.A. (Univ of Washington, Seattle, WA, USA); Russak, I.B. *Numer Funct Anal Optim* v 9 n 7-8 Jul-Aug 1987 p 709-724.

**074289 STRUCTURAL ANALYSIS OF LOCAL SEARCH HEURISTICS IN COMBINATORIAL OPTIMIZATION.** Neighborhood, or local, search is a popular and practical heuristic for many combinatorial optimization problems. We examine the neighborhood structures of two classes of problems, 0-1 integer programming and the mean tardiness job sequencing problem - from the viewpoint of state-space graphs in artificial intelligence. Such analysis is shown to provide fundamental insights into the nature of local search algorithms, and provides a useful framework for evaluating and comparing such heuristics. Computational results are presented to support these observations. (Author abstract) 15 refs.

Evans, James R. (Univ of Cincinnati, Cincinnati, OH, USA). *Comput Oper Res* v 14 n 6 Oct 1987 p 465-477.

**074290 OPTIMAL PORTFOLIO AND CONSUMPTION DECISIONS FOR A 'SMALL INVESTOR' ON A FINITE HORIZON.** A general consumption/investment problem is considered for an agent whose actions cannot affect the market prices, and who strives to maximize total expected discounted utility of both consumption and terminal wealth. Under very general conditions on the nature of the market model and on the utility functions of the agent, it is shown how to approach the above problem by considering separately the two more elementary ones of maximizing utility of consumption only and of maximizing utility of terminal wealth only, and then appropriately composing them. The optimal consumption and wealth processes are obtained quite explicitly. In the case of a market model with constant coefficients, the optimal portfolio and consumption rules are derived very explicitly in feedback form (on the current level of wealth). (Author abstract) 14 refs.

Karatzas, Ioannis (Columbia Univ, New York, NY, USA); Lehoczky, John P.; Shreve, Steven E. *SIAM J Control Optim* v 25 n 6 Nov 1987 p 1557-1586.

**074291 INFINITE HORIZON OPTIMIZATION FOR FINITE STATE MARKOV CHAIN.** We consider the infinite horizon optimal control of a finite state Markov chain from the point of view of overtaking optimality and the long-run average cost. The stochastic model is cast into a deterministic framework by considering the distribution of the original state as a new state. Using known results about deterministic control systems we obtain short proofs of existence and characterization of stationary overtaking optimal strategies for the stochastic problem. We characterize and prove existence of stationary strategies which have a minimal cost growth rate in the class of all nonanticipative strategies. Restricting our attention only to stationary strategies we show that for every given initial state there exists an overtaking optimal strategy. Finally, under more restrictive conditions, we establish the existence of a stationary overtaking optimal strategy for all the initial values. (Author abstract) 10 refs.

Leizarowitz, Arie (Carnegie-Mellon Univ, Pittsburgh, PA, USA). *SIAM J Control Optim* v 25 n 6 Nov 1987 p 1601-1618.

**074292 DUAL TECHNIQUES FOR CONSTRAINED OPTIMIZATION.** Algorithms to solve constrained optimization problems are derived. These schemes combine an unconstrained minimization scheme like the conjugate gradient methods, an augmented

Lagrangian, and multiplier updates to obtain global quadratic convergence. Since an augmented Lagrangian can be ill conditioned, a preconditioning strategy is developed to eliminate the instabilities associated with the penalty term. A criterion for deciding when to increase the penalty is presented. (Author abstract) 41 refs.

Hager, W.W. (Pennsylvania State Univ, University Park, PA, USA). *J Optim Theory Appl* v 55 n 1 Oct 1987 p 37-71.

**074293 MINIMIZING MULTIMODAL FUNCTIONS OF CONTINUOUS VARIABLES WITH THE 'SIMULATED ANNEALING' ALGORITHM.** A new global optimization algorithm for functions of continuous variables is presented, derived from the 'Simulated Annealing' algorithm recently introduced in combinatorial optimization. The algorithm is essentially an iterative random search procedure with adaptive moves along the coordinate directions. It permits uphill moves under the control of a probabilistic criterion, thus tending to avoid the first local minima encountered. The algorithm has been tested against the Nelder and Mead simplex method and against a version of Adaptive Random Search. The new method proved to be more reliable than the others, being always able to find the optimum, or at least a point very close to it. It is quite costly in term of function evaluations, but its cost can be predicted in advance, depending only slightly on the starting point. (Edited author abstract) 18 refs.

Corana, A. (CNR, Genoa, Italy); Marchesi, M.; Martini, C.; Ridella, S. *ACM Trans Math Software* v 13 n 3 Sep 1987 p 262-280.

**074294 GENERALIZED DESCENT METHODS FOR ASYMMETRIC SYSTEMS OF EQUATIONS.** We consider generalizations of the steepest descent algorithm for solving asymmetric systems of equations. We first show that if the system is linear and is defined by the matrix  $M$ , then the method converges if  $M^2$  is positive definite. We also establish easy to verify conditions on the matrix  $M$  that ensure that  $M^2$  is positive definite, and develop a scaling procedure that extends the class of matrices that satisfy the convergence conditions. In addition, we establish a local convergence result for nonlinear systems defined by uniformly monotone maps, and discuss a class of general descent methods. All of the methods that we consider reduce to standard nonlinear programming algorithms. (Edited author abstract) 25 refs.

Hammond, Janice H. (Harvard Univ); Magnanti, Thomas L. *Math Oper Res* v 12 n 4 Nov 1987 p 678-699.

**074295 ON THE CONVERGENCE OF PROJECTED GRADIENT PROCESSES TO SINGULAR CRITICAL POINTS.** The projected gradient methods treated here generate iterates by the rule  $X_{k+1} = P_\Omega(X_k - S_k \nabla F(X_k))$ ,  $X_1$  an element of  $\Omega$ , where  $\Omega$  is a closed convex set in a real Hilbert space  $X$ ,  $S_k$  is a positive real number determined by a Goldstein Bertsekas condition,  $P_\Omega$  projects  $X$  into  $\Omega$ ,  $F$  is a differentiable function whose minimum is sought in  $\Omega$ , and  $\nabla F$  is locally Lipschitz continuous. Asymptotic stability and convergence rate theorems are proved for singular local minimizers in the interior of  $\Omega$ , or more generally, in some open facet in  $\Omega$ . (Edited author abstract) 14 refs.

Dunn, J.C. (North Carolina State Univ, Raleigh, NC, USA). *J Optim Theory Appl* v 55 n 2 Nov 1987 p 203-216.

**074296 THEOREMS OF THE ALTERNATIVE FOR MULTIFUNCTIONS WITH APPLICATIONS TO OPTIMIZATION: GENERAL RESULTS.** Theorems of the alternative for systems of multifunctions are studied, some general properties are stated, and connections with known results investigated. It is shown how the present approach can be used to analyze extremum problems, where the image of the domain of the constraining functions belongs to a functional space. (Edited author abstract) 29 refs.

Giannessi, F. (Univ of Pisa, Pisa, Italy). *J Optim Theory Appl* v 55 n 2 Nov 1987 p 233-256.

**074297 DIRECT METHOD OF LINEARIZATION FOR CONTINUOUS MINIMAX PROBLEMS.** We consider the problem of minimizing a nondifferentiable function that is the pointwise maximum over a compact family of continuously differentiable functions. We suppose that a certain convex approximation to the objective function can be evaluated. An iterative method is given which uses as successive search directions approximate solutions of semi-infinite quadratic programming problems calculated via a new generalized proximity algorithm. Inexact line searches ensure global convergence of the method to stationary points. (Author abstract) 16 refs.

Kiwiel, K.C. (Polish Acad of Sciences, Warsaw, Pol.). *J Optim Theory Appl* v 55 n 2 Nov 1987 p 271-287.

**074298 ON THE EXACT SOLUTION OF RANDOM TRAVELLING SALESMAN PROBLEMS WITH MEDIUM SIZE INTEGER COEFFICIENTS.** Let edge weights for the complete graph on vertex set  $\{1, 2, \dots, n\}$  be chosen independently and uniformly from  $\{0, 1, \dots, B(n)-1\}$  where  $B(n) = o(n/\log \log n)$ . We show that there exists a polynomial time ( $O(n^3 \log n)$ ) algorithm which solves the associated travelling salesman problem with probability tending to 1 as  $n$  tends to  $\infty$ . (Author abstract) 17 refs.

Frieze, A.M. (Carnegie-Mellon Univ, Pittsburgh, PA, USA). *SIAM J Comput* v 16 n 6 Dec 1987 p 1052-1072.

**074299 SIMULATED ANNEALING METHODS WITH GENERAL ACCEPTANCE PROBABILITIES.** Heuristic solution methods for combinatorial optimization problems are often based on local neighborhood searches. These tend to get trapped in a local optimum and the final result is often heavily dependent on the starting solution. Simulated annealing methods attempt to avoid these problems by randomizing the procedure so as to allow for occasional changes that worsen the solution. In this paper we provide probabilistic analyses of different designs of these methods. (Author abstract) 22 refs.

Anily, S. (Univ of British Columbia, Vancouver, BC, Can); Federgruen, A. *J Appl Probab* v 24 n 3 Sep 1987 p 657-667.

**074300 DISCRETE MAXIMUM PRINCIPLE FOR COLLOCATION METHODS.** A discrete maximum principle for collocation approximations is formulated. For the cases of piecewise cubic and piecewise quartic  $C^1$  approximations, sufficient conditions for the placement of the collocation points are derived which ensure that resulting collocation approximation satisfy the discrete maximum principle. (Author abstract) 12 refs.

Greenwell Yanik, E. (Virginia Commonwealth Univ, Richmond, VA, USA). *Comput Math Appl* v 14 n 6 1987 p 459-464.

**074301 ON NONCONVEX OPTIMIZATION WITH INTEGRAL CONSTRAINTS.** We consider the problem of minimizing  $\int f(y) \, dy$  with  $\int y \, dy = c$ ,  $c$  fixed. The function  $f$  is assumed to be continuous, but need not be convex. For this problem, we give necessary and sufficient conditions for the existence of solutions. We also give conditions under which uniqueness in a certain sense holds, and we show a relation which holds between the minimizers of two different problems and the corresponding values of the constraints  $c$ . (Author abstract) 7 refs.

Patino, J.G.S. (Pontificia Univ Catolica, Rio de Janeiro, Brazil). *J Optim Theory Appl* v 55 n 3 Dec 1987 p 391-401.

**074302 CONTINUOUS DEPENDENCE OF SOLUTIONS ON A PARAMETER IN A SCALARIZATION METHOD.** This paper studies a certain behavior of maximal values, solutions, and local solutions in a scalarization method under variation of parameters. It is



shown that, for a large class of vector optimization problems, this dependence is continuous. (Author abstract) 22 refs.

Sterna-Karwat, A. (Univ of Newcastle, Aust). *J Optim Theory Appl* v 55 n 3 Dec 1987 p 417-434.

**074303 APPROXIMATE SADDLE-POINT THEOREMS IN VECTOR OPTIMIZATION.** The paper contains definitions of different types of nondominated approximate solutions to vector optimization problems and gives some of their elementary properties. Then, saddle-point theorems corresponding to these solutions are presented with an application relative to approximate primal-dual pairs of solutions. (Author abstract) 11 refs.

Valyi, I. (Int Inst for Applied Systems Analysis, Laxenburg, Austria). *J Optim Theory Appl* v 55 n 3 Dec 1987 p 435-448.

**074304 ORDER STATISTICS AND THE LINEAR ASSIGNMENT PROBLEM.** Under mild conditions on the distribution function  $F$ , we analyze the asymptotic behavior in expectation of the smallest order statistic, both for the case that  $F$  is defined on  $(-\infty, +\infty)$  and for the case that  $F$  is defined on  $(0, \infty)$ . These results yield asymptotic estimates of the expected optimal value of the linear assignment problem under the assumption that the cost coefficients are independent random variables with distribution function  $F$ . (Author abstract) 8 refs.

Frenk, J.B.G.; van Houweninge, M.; Rinnooy Ken, A.H.G. *Computing (Vienna/New York)* v 39 n 2 1987 p 165-174.

**074305 SUBMODULAR SET FUNCTIONS AND MONOTONE SYSTEMS IN AGGREGATION PROBLEMS. I.** A relationship is established between two types of set functions - submodular functions and functions determining the extremal properties of monotone systems. It is shown that this relationship may be utilized in applied combinatorial optimization problems, in particular, for identifying the structure of empirical information. These results are directly related to the development of effective extremum-seeking algorithms for these functions. (Edited author abstract) 21 refs.

Muchnik, I.B.; Shvartser, L.V. *Autom Remote Control* v 48 n 5 pt 2 May 1987 p 679-689.

**074306 REGULARIZED METHOD OF LINEARIZATION FOR MINIMIZING A CONVEX FUNCTION ON A POLYHEDRAL SET WITH ERRORS IN THE INPUT DATA.** The problem of minimization of a convex function on a polyhedral set is considered without the assumption of Slater's condition. A regularized method of linearization is suggested, assuming that the function being minimized, the functions defining the set, and their gradients are given with an error. The convergence of a sequence of Lagrange multipliers of the minimization of Tikhonov's function is demonstrated, as well as a strong convergence of the method to a normal solution. (Author abstract) 5 refs.

Chirich, N.T. *Moscow Univ Comput Math Cybern* n 2 1987 p 25-30.

**074307 ON THE VARIATIONAL PROCESS IN PARAMETER OPTIMIZATION.** The simplest constrained optimization problem is used to investigate the concept of variations of variations. It is shown that variations of dependent variations are nonzero whereas variations of independent variations are zero. The existence of these variations adds to the second variation a term which vanishes because of first-variation conditions but which contributes directly to the third and higher variations. These variations are needed in particular if the second variation vanishes and in general if the whole process is to be done correctly. Finally, the same results are derived using the Taylor series expansion. (Author abstract) 4 refs.

Hull, D.G. (Univ of Texas, Austin, TX, USA). *J Optim Theory Appl* v 56 n 1 Jan 1988 p 31-38.

**074308 APPROXIMATION OF SOLUTION FOR LOCATION PROBLEMS.** This paper is devoted to a class of location problems with polyhedral norms. The objective function is shown to be a piecewise convex function which has to be maximized. We prove that the optimal locations belong to a finite set of intersection points, and we present an efficient method operating upon this finite set and providing a strict local maximum with few computational efforts. (Edited author abstract) 11 refs.

Idrissi, H. (Univ de Dijon, Dijon, Fr); Loridan, P.; Michelot, C. *J Optim Theory Appl* v 56 n 1 Jan 1988 p 127-143.

**074309 GMANOVA MODEL ANOVA AND ANCOVA THEORY.** Some elementary aspects of ANOVA and ANCOVA theories of the MANOVA model are extended to parallel aspects for a certain restricted MANOVA model. The GMANOVA model is a particular case of this restricted MANOVA model, and hence the results for the restricted MANOVA model hold for the GMANOVA model. The main purpose of the paper is to demonstrate that the MANOVA experimental designs theory may be generalized to a somewhat similar theory for the GMANOVA model. (Author abstract) 4 refs.

Kabe, D.G. (St. Mary's Univ, Halifax, NS, Can). *Ind Math* v 37 pt 1 1987 p 37-51.

**074310 SUBMODULAR SET FUNCTIONS AND MONOTONE SYSTEMS IN AGGREGATION PROBLEMS.** The relationship from Part I between submodular functions and functions determining the extremal properties of monotone systems is applied to prove that, on the chain of any set-theoretical interval, the submodular function varies more slowly than the linear function of the cardinality of ordered sets. Branch-and-bound algorithms are developed for unconstrained and constrained extremization with optimal tree traversal. Some standard examples of aggregation of empirical data are solved by applying the apparatus of combinatorial optimization of submodular functions. (Author abstract) 13 refs.

Muchnik, I.B.; Shvartser, L.V. *Autom Remote Control* v 48 n 6 pt 2 Jun 1987 p 821-828.

**074311 STOCHASTIC GLOBAL OPTIMIZATION METHODS. PART I: CLUSTERING METHODS.** In this stochastic approach to global optimization, clustering techniques are applied to identify local minima of a real valued objective function that are potentially global. Three different methods of this type are described; their accuracy and efficiency are analyzed in detail. (Author abstract) 40 refs.

Rinnooy Kan, A.H.G. (Univ of California, Berkeley, CA, USA); Timmer, G.T. *Math Program* v 39 n 1 Sep 1987 p 27-56.

**074312 STOCHASTIC GLOBAL OPTIMIZATION METHODS. PART II: MULTI LEVEL METHODS.** Two stochastic methods for global optimization are described that, with probability 1, find all relevant local minima of the objective function with the smallest possible number of local searches. The computational performance of these methods is examined both analytically and empirically. (Author abstract) 17 refs.

Rinnooy Kan, A.H.G. (Univ of California, Berkeley, CA, USA); Timmer, G.T. *Math Program* v 39 n 1 Sep 1987 p 57-78.

**074313 VARIABLE TRANSFORMATION METHOD FOR SOLVING LINEAR ABSOLUTE-VALUE OBJECTIVE-FUNCTION PROBLEMS WITH LINEAR CONSTRAINTS.** In practice, especially in engineering, we often encounter the linear absolute-value objective-function problems with linear constraints, such as  $\sum |X_i - C_i|$ . Using powerful simplex algorithm, we derive a variable transformation method to solve it. (Author abstract) 3 refs.

Lu, Lin Chao (Beijing Inst of Technology, Beijing, China);

Wang, Yan. *J Comput Appl Math* v 21 n 1 Jan 1988 p 111-113.

**074314 FRACTIONAL PROGRAMMING REVISITED.** A new format is proposed for fractional programming problems. This format gives full expression to the fact that the parametric approach to fractional programming problems is rooted in a first-order necessary and sufficient optimality condition. It is thus shown that although traditionally it has not been construed as such, the parametric approach is in fact classical par excellence. (Author abstract) 13 refs.

Snjedovich, Moshe (CSIR, Pretoria, S Afr). *Eur J Oper Res* v 33 n 3 Feb 1988 p 334-341.

**074315 SUCCESSIVE PROJECTION METHOD.** It is of both theoretical and practical interest to find the projection of a point to the intersection of a finite number of closed convex sets by a sequence of projections to the individual sets successively. In this paper we study such a method and analyze its convergence properties. A main feature of the method is its capability to decompose the projection problem into several small ones. For some structured sparse problems these small subproblems can be solved independently and the presented method has a potential use in parallel computation. (Author abstract) 7 refs.

Han, Shih-Ping (Univ of Illinois, Urbana-Champaign, IL, USA). *Math Program* v 40 n 1 Jan 1988 p 1-14.

**074316 CONVEX TWO-LEVEL OPTIMIZATION.** A model for a two-level planning problem is presented in the form of a static Stackelberg game. By assumption, play is sequential and noncooperative; however, the leader can influence the actions of the followers through a set of coordination variables while the followers' responses may partly determine the leader's payoff. Under certain convexity assumptions, it is shown that the feasible region induced by the leader is continuous in the original problem variables. This observation, coupled with two corollary results, is used as a basis for a hybrid algorithm which clings to the inducible region until a local optimum is found. A branching scheme is then employed to locate other segments of the region, eventually terminating with the global optimum. (Edited author abstract) 13 refs.

Bard, Jonathan F. (Univ of Texas, Austin, TX, USA). *Math Program* v 40 n 1 Jan 1988 p 15-27.

**074317 SECOND-ORDER NECESSARY CONDITIONS IN SEMISMOOTH OPTIMIZATION.** First- and second-order conditions are given which are necessary for a function  $f$  to have a local minimal value at  $x^*$  in  $R^n$ . It is assumed that  $f$  is locally Lipschitzian near  $x^*$  and semismooth at  $x^*$ . The necessary conditions are expressed in terms of the generalized gradients of nonsmooth analysis and certain second-order directional derivatives. The method of proof bears no resemblance to standard methods. Three special cases are discussed here, but applications to constrained problems are made elsewhere. (Author abstract) 13 refs.

Chaney, Robin W. (Western Washington Univ, Bellingham, WA, USA). *Math Program* v 40 n 1 Jan 1988 p 95-109.

**074318 STATE-OF-THE-ART IN PARALLEL NONLINEAR OPTIMIZATION.** This survey is concerned with variants of nonlinear optimization methods designed for implementation on parallel computers. First, we consider a variety of methods for unconstrained minimization. We consider a particular type of parallelism (simultaneous function and gradient evaluations). We focus on promising approaches for solving large, well-structured constrained problems: dualization of problems with separable objective and constraint functions, and decomposition of hierarchical problems with linking variables (typical for Bender's decomposition in



the linear case). Finally, we outline the key issues in future computational studies of parallel nonlinear optimization algorithms. (Edited author abstract) 66 refs.

Lootsma, F.A. (Delft Univ of Technology, Delft, Neth); Ragsdell, K.M. *Parallel Comput* v 6 n 2 Feb 1988 p 133-155.

**074319 USING TABU SEARCH TECHNIQUES FOR GRAPH COLORING.** Tabu search techniques are used for moving step by step towards the minimum value of a function. A tabu list of forbidden movements is updated during the iterations to avoid cycling and being trapped in local minima. Such techniques are adapted to graph coloring problems. We show that they provide almost optimal colorings of graphs having up to 1000 nodes and their efficiency is shown to be significantly superior to the famous simulated annealing. (Author abstract) 6 refs.

Hertz, A.; de Werra, D. *Computing (Vienna/New York)* v 39 n 4 1987 p 345-351.

**074320 NUMERICAL EXPERIENCE WITH THE TRUNCATED NEWTON METHOD FOR UNCONSTRAINED OPTIMIZATION.** The truncated Newton algorithm was devised by R. Dembo and T. Steihaug for solving large sparse unconstrained optimization problems. When far from a minimum, an accurate solution to the Newton equations may not be justified. Dembo's method solves these equations by the conjugate direction method, but truncates the iteration when a required degree of accuracy has been obtained. We present favorable numerical results obtained with the algorithm and compare them with existing codes for large-scale optimization. (Author abstract) 6 refs.

Dixon, L.C.W. (Hatfield Polytechnic, Hatfield, Engl); Price, R.C. *J Optim Theory Appl* v 56 n 2 Feb 1988 p 245-255.

**074321 STOCHASTIC ALGORITHM FOR OPTIMIZATION PROBLEMS WITH CONTINUA OF INEQUALITIES.** Optimization algorithms for solving mathematical programming problems involving continua of inequalities are presented. The algorithms use an outer-approximation method, by which they attempt to approximate, at each point, the maxima of sets of inequality constraints. They do so by performing random experiments, resulting in a finite number of points, over which the maximum is taken. They use constraint-dropping schemes, by which they eliminate points from the constraint set at hand, which are felt to be irrelevant. At each point that the algorithms construct, they evaluate a measure of optimality, which indicates the distance of the point from the set of solutions of the optimization problem. They use this measure to determine the number of random experiments performed. Thus, the number of such experiments tends to be small initially, when the points at hand are far from optimal, and they tend to increase when an optimal point is approached. (Author abstract) 6 refs.

Wardi, Y. (Georgia Inst of Technology, Atlanta, GA, USA). *J Optim Theory Appl* v 56 n 2 Feb 1988 p 285-311.

**074322 INTERVAL ALGORITHMS AND THEIR APPLICATION TO DISCRETE OPTIMIZATION OF MULTISTEP PROCESSES.** The authors describe a class of discrete optimization problems for multistep processes with piecewise-constant Bellman functions. The algorithms proposed for the solution of these problems are a modification of dynamic programming and approximating combinatorial algorithms. 6 refs.

Kovalenko, A.G. *Cybernetics* v 23 n 3 May-Jun 1987 p 409-414.

**074323 METHOD OF RESIDUES FOR SOLUTION OF UNSTABLE MINIMIZATION PROBLEMS.** Unstable minimization problems are studied where the function being minimized and the set in which the minimum is sought are given with an error. The residue method is extended to a broader class of problems than those studied previously; a regularizing operator is

constructed. (Author abstract) 9 refs.

Vasil'ev, F.P. *Moscow Univ Comput Math Cybern* n 4 1987 p 1-6.

**074324 SOLUTION OF MULTICRITERIAL DISCRETE OPTIMIZATION PROBLEMS USING A UNIVERSAL GENERATING FUNCTION.** A method is given for solving discrete multi-criterial optimization problems using universal generating functions. The exposition is done using the terminology of optimal redundancy problems. A numerical example is included illustrating the application of the method proposed. (Author abstract) 3 refs.

Ushakov, I.A. *Sov J Comput Syst Sci* v 25 n 5 Sep-Oct 1987 p 21-27.

**074325 METHOD OF LINEARIZATION.** A presentation is given of basic theoretical results associated with the construction and justification of one of the most popular and universal numerical methods of nonlinear optimization, the method of linearization. The method of linearization was first described in 1970, as a method of numerical solution of systems of nonlinear equations and inequalities. Over the years passed, the method of linearization was analyzed theoretically, the class of problems that it could solve was broadened, modifications were proposed, and rules for changing the parameters in the algorithm were perfected. The purpose of the present article is to give a compressed review of all these changes and peculiarities, emphasizing the finer and more typical features of the method. (Edited author abstract) 23 refs.

Pshenichnyy, B.N. *Sov J Comput Syst Sci* v 25 n 5 Sep-Oct 1987 p 48-60.

**074326 METHOD OF HALF-DIVISIONS FOR GLOBAL OPTIMIZATION OF A FUNCTION OF MANY VARIABLES.** A new method of minimizing multiextremum functions of many variables that is based on a nonuniform covering of an admissible set with parallelepipeds converging to the optimal solution is described. The method combines the ideas of nonuniform coverings with an approach based on the use of estimates obtained with the aid of interval analysis. The solution of nonlinear programming problems is considered. (Edited author abstract) 8 refs.

Yevtushenko, Yu.G.; Rat'kin, V.A. *Sov J Comput Syst Sci* v 25 n 5 Sep-Oct 1987 p 75-84.

**074327 NOTE ON ESSENTIAL SPECTRA AND NORMS OF MIXED HANKEL-TOEPLITZ OPERATORS.** In this brief, Hankel-Toeplitz operators which occur in feedback theory, e.g., in the minimization of mixed  $H^\infty$  sensitivity and complementary sensitivity, will be considered. A method of computing their spectra, eigenvectors, and norms will be presented for infinite-dimensional systems subject to continuous weightings. (Author abstract) 13 refs.

Zames, G. (McGill Univ, Montreal, Que, Can); Mitter, S.K.; Safonov, M.G. *Syst Control Lett* v 10 n 3 Mar 1988 p 159-165.

**074328 ON THE CONVERGENCE OF STATIONARY DISTRIBUTIONS IN SIMULATED ANNEALING ALGORITHMS.** Simulated annealing is a randomized optimization algorithm which accepts deterioration of the objective function with a probability depending on a control parameter  $t$  in each iteration. Under general assumptions we show that the equilibrium distributions with respect to the parameter levels converge to the distribution which selects a global optimum with probability one. This result may be taken as an explanation for the observed good performance of simulated annealing implementations which prefer many iterations on relatively few parameter levels to relatively few iterations at many parameter levels. (Author abstract) 17 refs.

Faigle, Ulrich (Rheinische Friedrich-Wilhelms Univ, Bonn, West Ger); Schrader, Rainer. *Inf Process Lett* v 27 n 4 Apr 8 1988 p 189-194.

**074329 QUADRATIC OPTIMIZATION PROBLEMS.** An examination is made of numerical methods associated with external problems with quadratic objective functional with constraints. It is shown that, in the multiextremal case, lower bound estimates of the optimal value of the objective functional that are necessary for application of methods of the branch-and-bound type can be obtained by duality methods with solution of a convex optimization problem with constraints requiring that certain matrices be nonnegative-definite. Methods of solving estimation problems are examined. The application of the approach described to certain discrete optimization problems is described. (Author abstract) 21 refs.

Shor, N.Z. *Sov J Comput Syst Sci* v 25 n 6 Nov-Dec 1987 p 1-11.

**074330 RECURRENT SEARCH OPTIMIZATION ALGORITHMS IN THE PRESENCE OF RELATIVE NOISE. II. OPTIMAL SEARCH PROCEDURES.** This paper discusses the solution of search optimization problems in the presence of 'diminishing' noise intensity. Algorithms that provide the maximum possible convergence rate as established in part I are proposed. Realizable versions of such algorithms are presented. (Edited author abstract) 6 refs.

Murtazin, D.A.; Poznyak, A.S. *Autom Remote Control* v 48 n 10 Pt 2 Oct 1987 p 1343-1349.

**074331 APPROXIMATE SOLUTION OF THE TRUST REGION PROBLEM BY MINIMIZATION OVER TWO-DIMENSIONAL SUBSPACES.** The trust region problem, minimization of a quadratic function subject to a spherical trust region constraint, occurs in many optimization algorithms. In a previous paper, the authors introduced an inexpensive approximate solution technique for this problem that involves the solution of a two-dimensional trust region problem. They showed that using this approximation in an unconstrained optimization algorithm leads to the same theoretical global and local convergence properties as are obtained using the exact solution to the trust region problem. This paper reports computational results showing that the two-dimensional minimization approach gives nearly optimal reductions in the  $n$ -dimension quadratic model over a wide range of test cases. (Edited author abstract) 15 refs.

Byrd, Richard H. (Univ of Colorado, Boulder, CO, USA); Schnabel, Robert B.; Shultz, Gerald A. *Math Program* v 40 n 3 Apr 1988 p 247-263.

**074332 CHORDAL PRECONDITIONER FOR LARGE-SCALE OPTIMIZATION.** We propose an automatic preconditioning scheme for large sparse numerical optimization. The strategy is based on an examination of the sparsity pattern of the Hessian matrix: using a graph-theoretic heuristic, a block-diagonal approximation to the Hessian matrix is induced. The blocks are submatrices of the Hessian matrix; furthermore, each block is chordal. That is, under a positive definiteness assumption, the Cholesky factorization can be applied to each block without creating any new nonzeros (fill). Therefore the preconditioner is space efficient. We conduct a number of numerical experiments to determine the effectiveness of the preconditioner in the context of a linear conjugate-gradient algorithm for optimization. (Author abstract) 25 refs.

Coleman, Thomas F. (Cornell Univ, Ithaca, NY, USA). *Math Program* v 40 n 3 Apr 1988 p 265-287.

**074333 SCHEDULING TWO IRREGULAR POLYGONS.** Let  $A$  and  $B$  be irregular polygons with  $m$  and  $n$  vertices ( $m \geq n$ ) on some circle line. How should polygon  $A$  be moved relative to polygon  $B$  in such a way that the maximum (minimum) distance between adjacent vertices



on the circle line is minimized (maximized)?  $O(m \log m)$  algorithms are given which solve these problems. (Author abstract) 3 refs.

Brucker, Peter (Univ Osnabrueck, Osnabrueck, West Ger); Meyer, Wolfgang. *Discrete Appl Math* v 20 n 2 Jun 1988 p 91-100.

**074334 GLOBAL CONVERGENCE AND STABILIZATION OF UNCONSTRAINED MINIMIZATION METHODS WITHOUT DERIVATIVES.** In this paper, acceptability criteria for the stepsize and global convergence conditions are established for unconstrained minimization methods employing only function values. On the basis of these results, the convergence of an implementable line search algorithm is proved and some global stabilization schemes are described. (Author abstract) 11 refs.

Grippio, L. (Natl Research Council, Rome, Italy); Lampariello, F.; Lucidi, S. *J Optim Theory Appl* v 56 n 3 Mar 1988 p 385-406.

**074335 SENSITIVITY ANALYSIS IN MULTIOBJECTIVE OPTIMIZATION.** Sensitivity analysis in multiobjective optimization is dealt with. Given a family of parametrized multiobjective optimization problems, the perturbation map is defined as the set-valued map which associates to each parameter value the set of minimal points of the perturbed feasible set in the objective space with respect to a fixed ordering convex cone. The behavior of the perturbation map is analyzed quantitatively by using the concept of contingent derivatives for set-valued maps. Particularly, it is shown that the sensitivity is closely related to the Lagrange multipliers in multiobjective programming. (Author abstract) 10 refs.

Tanino, T. (Int Inst for Applied Systems Analysis, Laxenburg, Austria). *J Optim Theory Appl* v 56 n 3 Mar 1988 p 479-499.

**074336 ALGORITHM FOR GLOBAL OPTIMIZATION OF LIPSCHITZ CONTINUOUS FUNCTIONS.** An algorithm is presented which locates the global minimum or maximum of a function satisfying a Lipschitz condition. The algorithm uses lower bound functions defined on a partitioned domain to generate a sequence of lower bounds for the global minimum. Convergence is proved, and some numerical results are presented. (Author abstract) 11 refs.

Meewella, C.C. (Imperial Coll of Science & Technology, London, Engl); Mayne, D.Q. *J Optim Theory Appl* v 57 n 2 May 1988 p 307-322.

**074337 FARKAS' THEOREM OF NONCONVEX TYPE AND ITS APPLICATION TO A MIN-MAX PROBLEM.** This note is concerned with the generalization of Farkas' theorem and its application to derive optimality conditions for a min-max problem. Farkas' theorem is generalized to a system of inequalities described by sup-min type positively homogeneous functions. This generalization allows us to deal with optimization problems consisting of objective and constraint functions whose directional derivatives are not necessarily convex with respect to the directions. As an example of such problems, we formulate a min-max problem and derive its optimality conditions. (Author abstract) 12 refs.

Ishizuka, Y. (Sophia Univ, Tokyo, Jpn). *J Optim Theory Appl* v 57 n 2 May 1988 p 341-355.

**074338 ON POLJAK'S IMPROVED SUBGRADIENT METHOD.** Poljak has suggested an improved subgradient method and provided a lower bound on the improvement of the Euclidean distance to an optimal solution. In this paper the authors provide a stronger lower bound and show that the direction of movement in this method forms a more acute angle with the direction toward the set of optimal solutions than that in the subgradient method. (Author abstract) 7 refs.

Kim, S. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Koh, S. *J Optim Theory Appl* v 57 n 2 May 1988 p 355-360.

**074339 ABSTRACT SUBDIFFERENTIALS AND SOME CHARACTERIZATIONS OF OPTIMAL SOLUTIONS.** The authors introduce and study the subdifferential of a function at a point, with respect to a primal-dual pair of optimization problems, which encompasses, as particular cases, several known concepts of subdifferential. They give a characterization of optimal solutions of the primal problem, in terms of abstract Lagrangians, and a simultaneous characterization of optimal solutions and strong duality, with the aid of abstract subdifferentials. They give some applications to unperturbational Lagrangian duality and unperturbational surrogate duality. (Author abstract) 9 refs.

Singer, I. (Natl Inst for Scientific & Technical Creation & Inst of Mathematics, Bucharest, Romania). *J Optim Theory Appl* v 57 n 2 May 1988 p 361-368.

**074340 TWO APPROACHES TO THE SOLUTION OF PROBABILISTIC OPTIMIZATION PROBLEMS.** Probabilistic optimization problems in which a quantile of the objective function serves as quality criterion in the presence of supplementary constraints are examined. Two approaches are considered. The first assumes the use of gradient methods. A formula for the gradient of the quantile function is derived for this purpose. The results can be used not only for the realization of gradient methods, but also in the form of necessary optimality conditions for the search for an optimal strategy, for testing a strategy suspected to be optimal, and for investigating the convergence of various numerical procedures. The second is the generalized minimax approach which consists of reducing the original probabilistic problem to some equivalent minimax problem in which supplementary optimization is performed over sets in the realization space of the random factors. An iterative method which realizes this approach is developed. Provides means for implementing such double optimization on strategies and indicated sets. Its convergence is proven for a broad class of problems. (Edited author abstract) 7 refs.

Malyshev, V.V. (Moscow Aviation Inst, Moscow, USSR); Kibzun, A.I.; Chernov, D.E. *Sov J Autom Inf Sci* v 20 n 3 May-Jun 1987 p 20-25.

**074341 OPTIMUM WATCHMAN ROUTES.** In this paper we consider the problem of finding shortest routes from which every point in a given space is visible (watchman routes). We show that the problem is NP-hard in polygons with holes and we present an  $O(n \log \log n)$  algorithm to find a shortest route in simple rectilinear polygons. (Author abstract) 8 refs.

Chin, Wei-pang (Univ of Texas, Dallas, TX, USA); Ntafos, Simeon. *Inf Process Lett* v 28 n 1 May 30 1988 p 39-44.

**074342 MORSE THEORY FOR SOME LOWER- $C^2$  FUNCTIONS IN FINITE DIMENSION.** Using inf-regularization methods, we prove that Morse inequalities hold for some lower- $C^2$  functions. For this purpose, we first recall some properties of the class of lower- $C^2$  functions and of their Moreau-Yosida approximations. Then, we establish, under some qualification conditions on the critical points, that it is possible to define a 'Morse' index for a lower- $C^2$  function  $f$ . This index is preserved by the Moreau-Yosida approximation process. We prove in particular that the Moreau-Yosida approximations are twice continuously differentiable around such a critical point which is shown to be a strict local minimum of the restriction of  $f$  and of its approximations to some affine space. In a last step, Morse inequalities are written for Moreau-Yosida approximations and with the aid of deformation retractions we prove that these inequalities also hold for some lower- $C^2$  functions. (Author abstract) 27 refs.

Bougard, Mireille L. (Univ Paris-X, Paris, Fr). *Math Program* v 41 n 2 Jul 1988 p 141-159.

**074343 CONVERGENCE AND RESTART IN BRANCH-AND-BOUND ALGORITHMS FOR GLOBAL OPTIMIZATION.** APPLICATION TO

CONCAVE MINIMIZATION AND D.C. OPTIMIZATION PROBLEMS. A general branch-and-bound conceptual scheme for global optimization is presented that includes along with previous branch-and-bound approaches also grid-search techniques. The corresponding convergence theory, as well as the question of restart capability for branch-and-bound algorithms used in decomposition or outer approximation schemes are discussed. As an illustration of this conceptual scheme, a finite branch-and-bound algorithm for concave minimization is described and a convergent branch-and-bound algorithm, based on the previous one, is developed for the minimization of a difference of two convex functions. (Author abstract) 35 refs.

Tuy, Hoang (Inst of Mathematics, Hanoi, Vietnam); Horst, Reiner. *Math Program* v 41 n 2 Jul 1988 p 161-183.

**074344 APPROXIMATION AND DECOMPOSITION PROPERTIES OF SOME CLASSES OF LOCALLY D.C. FUNCTIONS.** We study the connection between local and global decompositions of some important subclasses of locally dc functions (functions which locally split as a difference of two convex functions). Then we tackle the problem of regularizing such functions by the Moreau-Yosida process and prove in particular that the class of lower- $C^2$  functions fits well this approximation procedure. (Author abstract) 52 refs.

Penot, J.P. (Faculte des Sciences, Pau, Fr); Bougeard, M.L. *Math Program* v 41 n 2 Jul 1988 p 195-227.

**074345 DESIGN CENTERING PROBLEM AS A D.C. PROGRAMMING PROBLEM.** The following problem is studied: Given a compact set  $S$  in  $R^n$  and a Minkowski Functional  $p(x)$ , find the largest positive number  $r$  for which there exists  $x$  belonging to  $S$  such that the set of all  $y$  belonging to  $R^n$  satisfying  $p(y-x) \leq r$  is contained in  $S$ . It is shown that when  $S$  is the intersection of a closed convex set and several complementary convex sets (sets whose complements are open convex) this 'design centering problem' can be reformulated as the minimization of some dc function (difference of two convex functions) over  $R^n$ . In the case where, moreover,  $p(x) = (x^T A x)^{1/2}$ , with  $A$  being a symmetric positive definite matrix, a solution method is developed which is based on the reduction of the problem to the global minimization of a concave function over a compact convex set. (Author abstract) 15 refs.

Thach, Phan Thien (Inst of Mathematics, Hanoi, Vietnam). *Math Program* v 41 n 2 Jul 1988 p 229-248.

**074346 NOTE ON THE SOLUTION OF BILINEAR PROGRAMMING PROBLEMS BY REDUCTION TO CONCAVE MINIMIZATION.** We present a new algorithm for solving the bilinear programming problem by reduction to concave minimization. This algorithm is finite, does not assume the boundedness of the constraint set, and uses an efficient procedure for checking whether a concave function is bounded below on a given halfline. Some preliminary computational experience with a computer code for implementing the algorithm on a microcomputer is also reported. (Author abstract) 26 refs.

Thieu, Tran Vu (Inst of Mathematics, Hanoi, Vietnam). *Math Program* v 41 n 2 Jul 1988 p 249-260.

**074347 CONCAVE DUALITY: APPLICATION TO PROBLEMS DEALING WITH DIFFERENCE OF FUNCTIONS.** In this paper a duality obtained from the marginal function is introduced in a concave sense and its relationship with J.F. Toland's duality is studied along with several formulas dealing with the conjugates of differences of convex functions. (Author abstract) 28 refs.

Volle, M. (U.E.R. des Sciences, Limoges, Fr). *Math Program* v 41 n 2 Jul 1988 p 261-278.



**074348 USE OF AUTOMATIC CLASSIFICATION ALGORITHMS FOR ADJUSTING PARAMETERS OF AN INTERACTIVE PROCEDURE FOR FINDING EXTREMA.** Machine experiments to investigate the possibility of using automatic classification algorithms for adjustment of parameters in an iterative procedure for finding a global extrema are described. (Edited author abstract). 12 Refs.

Bordetskiy, A.B.; Khavronina, M.A. *Sov J Comput Syst Sci* v 26 n 2 Mar-Apr 1988 p 178-181.

**074349 INCLUSION FUNCTIONS AND GLOBAL OPTIMIZATION II.** This paper discusses algorithms of R.E. Moore, S. Skelboe, K. Ichida and Y. Fujii, and E. Hansen for solving the global unconstrained optimization problem. These algorithms have been tried on computers, but a thorough theoretical discussion of their convergence properties has been missing. In part I the convergence to the global minimum was studied. The present paper is concerned with the different behaviors of these algorithms when they are used for the determination of global minimum points,  $G$ , a superset of  $G$ , or exactly  $G$ . The algorithms are applicable to a very general class of functions: functions which are continuous, and have suitable inclusion functions. The number of global minimum points can be infinite. (Edited author abstract). 14 Refs.

Moore, R.E. (Ohio State Univ, Columbus, OH, USA); Ratschek, H. *Math Program* v 41 n 3 Sep 1988 p 341-356.

**074350 TRACING STRUCTURAL OPTIMA AS A FUNCTION OF AVAILABLE RESOURCES BY A HOMOTOPY METHOD.** Optimization problems are typically solved by starting with an initial estimate and proceeding iteratively to improve it until the optimum is found. The design points along the path from the initial estimate to the optimum are usually of no value. This work proposes a strategy for tracing a path of optimum solutions parameterized by the amount of available resources. The paper specifically treats the optimum design of a structure to maximize its buckling load. Equations for the optimum path are obtained using Lagrange multipliers, and solved by a homotopy method. The solution path has several branches due to changes in the active constraint set and transitions from unimodal to bimodal solutions. The Lagrange multipliers and second-order optimality conditions are used to detect branching points and to switch to the optimum solution path. (Edited author abstract). 15 Refs.

Shin, Yung S. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Haftka, Raphael T.; Watson, Layne T.; Plaut, Raymond H. *Comput Methods Appl Mech Eng* v 70 n 2 Sep 1988 p 151-164.

**074351 ENVELOPE APPROACH FOR MULTIOBJECTIVE OPTIMIZATION PROBLEMS.** A multiobjective optimization problem is usually solved by finding the set of all noninferior solutions to the problem. A methodology termed the envelope approach is presented for generating the set of noninferior solutions. The relationship between the envelope approach and multiobjective optimization is explored. Investigation of the use of the envelope approach in multiobjective dynamic programming and in the parametric decomposition method shows that this approach is very suitable for solving certain classes of multiobjective optimization problems by decomposition and coordination.

Li, Duan (Univ of Virginia, Charlottesville, VA, USA); Haimes, Yacov Y. *IEEE Trans Syst Man Cybern* v SMC-17 n 6 1987 p 1026-1038.

**074352 LOCATING THE MAXIMUM OF A SIMPLE RANDOM SEQUENCE BY SEQUENTIAL SEARCH.** Consider a stationary Gaussian process with  $EX_i X_j = \sigma^2 \rho(|i-j|)$ , where  $0 < \rho < 1$ , and let  $0 < r < 1$ . It is shown that to locate the maximum of  $X_1, X_2, \dots, X_N$  for large  $N$  with probability  $r$ , roughly  $-rN \log a / \log \log n$  observations at sequentially determined locations are sufficient and necessary. 1 ref.

Hajek, Bruce (MIT, Cambridge, MA, USA). *IEEE Trans*

*Inf Theory* v IT-33 n 6 p 877-881.

**074353 EFFICIENT OPTIMIZATION WITH INTEGRATED GRADIENT APPROXIMATIONS.** A flexible and effective algorithm is proposed for efficient optimization with integrated gradient approximations. It combines the techniques of perturbations, the Broyden update, and the special iterations of Powell. Perturbations are used to provide an initial approximation as well as regular corrections. The approximate gradient is updated using C.G. Broyden's formula (1965) in conjunction with the special iterations of M.J.D. Powell (1970). A modification to the Broyden update is introduced to exploit possible sparsity of the Jacobian. Utilizing this algorithm, powerful gradient-based nonlinear optimization tools for circuit CAD can be used without the effort of calculating exact derivatives. Applications of practical significance are demonstrated. The examples include robust small-signal FET modeling using the  $I_1$  techniques and simultaneous processing of multiple circuits, worst-case design of a microwave amplifier, and minimax optimization of a five-channel manifold multiplexer. Computational efficiency is greatly improved over estimating derivatives entirely by perturbations. 19 refs.

Bandler, John W. (McMaster Univ, Hamilton, Ont, Can); Chen, Shao Hua; Daijavad, Shahrokh; Madsen, Kaj. *IEEE Trans Microwave Theory Tech* v 36 n 2 Feb 1988 p 444-455.

**074354 RIO CONFERENCE ON COMBINATORIAL OPTIMIZATION.** This issue contains 11 conference papers. The topics covered include: dual methods; Lagrangean relaxation; matching problems; process planning; traveling salesman problem; switching center network problem; quadratic assignment problem; job shop scheduling; and the knapsack problem. All of the papers are abstracted and indexed separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10606 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Campello, R.E. (Ed.); Finke, G. (Ed.). *Discrete Appl Math* v 18 n 2 Nov 1987, Rio Conf on Comb Optim, Rio de Janeiro, Braz, Jul 8-19 1985 139p.

**074355 CONSTRUCTIVE DUAL METHODS FOR DISCRETE PROGRAMMING.** This paper gives a general theory for constructive dual methods in discrete programming. These techniques are concerned with the reduction of the feasibility set in order to obtain a dual problem which is easy to solve and has no duality gap. If a particular dual problem fails to solve the primal problem, then a stronger dual problem is constructed and the analysis continued. The relaxation approximation is made progressively tighter until, in a finite number of iterations, an optimal solution is reached. (Edited author abstract) 10 refs.

Barcia, Paulo (Univ Nova de Lisboa, Lisbon, Port). *Discrete Appl Math* v 18 n 2 Nov 1987, Rio Conf on Comb Optim, Rio de Janeiro, Braz, Jul 8-19 1985 p 107-117.

**074356 ADDING ACTIVITIES TO THE DUAL INSTEAD OF CUTS TO THE PRIMAL PROBLEM.** When solving a problem by appending cuts the dimension of the corresponding simplex tableau and the basic inverse oscillates, it becomes difficult to implement a cutting plane algorithm based on a standard LP code. Moreover, it is complicated to express a cut in the original variables. In this paper we show that by formulating the dual to the problem and adding activities, these adverse effects can be circumvented. It is shown that the set of activities which can be added is the same as the set of cuts which can be appended and that it is easy to exhibit an activity in the original primal variables. As a consequence of this a new formulation of a cut in the original primal variables is given. (Author abstract) 4 refs.

Holm, Soren (Odense Univ, Den). *Discrete Appl Math* v 18 n 2 Nov 1987, Rio Conf on Comb Optim, Rio de Janeiro, Braz, Jul 8-19 1985 p 167-174.

**074357 TELEPHONIC SWITCHING CENTRE NETWORK PROBLEM: FORMALIZATION AND COMPUTATIONAL EXPERIENCE.** The switching center network problem consists of looking for a topology on the urban street network that minimizes the total cost of cables and subterranean piping infrastructure necessary to link a telephonic center and its subscribers. A simple version of the real model can be viewed as a mixture of Steiner's problem on graphs and a transshipment problem with a single source. We show that a very good initial solution for the problem can be obtained using Dijkstra's minimum distance algorithm. We discuss the theoretical background and the computational experience concerning a software for microcomputers that uses such initialization strategy and that is running quite well in practice. We present the heuristic that looks for scale economies provenient from trajectory coincidences, a local optimum strategy, and also discuss global optimum strategies which should be tested following recent experience concerning Steiner's problem. (Author abstract) 14 refs.

Luna, Henrique Pacca L. (Univ Federal de Minas Gerais, Belo Horizonte, Braz); Ziviani, Nivio; Cabral, Regina Helena B. *Discrete Appl Math* v 18 n 2 Nov 1987, Rio Conf on Comb Optim, Rio de Janeiro, Braz, Jul 8-19 1985 p 199-210.

**074358 PARALLEL BRANCH AND BOUND ALGORITHM FOR THE QUADRATIC ASSIGNMENT PROBLEM.** We propose a parallel branch and bound algorithm for the quadratic assignment problem; this algorithm has been implemented on an asynchronous multiprocessor machine with shared memory (the Cray X-MP). For problems with size  $n \geq 10$ , the improvement in using  $n$  processors is very close to  $n$ , and moreover very good results are obtained for a classical example from the literature with size 12. (Author abstract) 18 refs.

Roucairol, Catherine (Univ Paris 6, Paris, Fr). *Discrete Appl Math* v 18 n 2 Nov 1987, Rio Conf on Comb Optim, Rio de Janeiro, Braz, Jul 8-19 1985 p 211-225.

**074359 NEW ENUMERATION SCHEME FOR THE KNAPSACK PROBLEM.** This paper presents a new enumeration scheme to solve the one-dimensional knapsack problem motivated by some observations on number theory, more specifically on the determination of the number of solutions of linear diophantine equations. This new algorithm is pseudopolynomial and its special features provide a reduction in running time and in the computational memory requirements as compared with other exact (dynamic programming) methods. (Author abstract) 35 refs.

Yanasse, Horacio Hideki (Inst de Pesquisas Espaciais, Sao Jose Dos Campos, Braz); Soma, Nei Yoshihiro. *Discrete Appl Math* v 18 n 2 Nov 1987, Rio Conf on Comb Optim, Rio de Janeiro, Braz, Jul 8-19 1985 p 235-245.

**074360 CONCURRENT FUNCTION EVALUATIONS IN LOCAL AND GLOBAL OPTIMIZATION.** This paper discusses some basic opportunities for the use of multiprocessing in the solution of optimization problems. We consider two fundamental optimization problems, unconstrained optimization and global optimization, in the important case when function evaluation is expensive and gradients are evaluated by finite differences. First we discuss some simple parallel strategies based upon the use of concurrent function evaluations to evaluate the finite difference gradient. These include the speculative evaluation of the gradient concurrently with the evaluation of the function before it is known whether the gradient value at this point will be required. We present examples that indicate the effectiveness of these parallel strategies for unconstrained optimization. We also give experimental results that show the effect of using these strategies to parallelize each of the multiple local minimizations within a recently proposed concurrent global optimization algorithm. We briefly discuss several parallel optimization strategies that are related to these



approaches but make more fundamental changes to standard sequential optimization algorithms. (Author abstract) 14 refs.

Schnabel, Robert B. (Univ of Colorado, Boulder, CO, USA). *Comput Methods Appl Mech Eng* v 64 n 1-3 Oct 1987, Proc of the First World Congr on Comput Mech, Austin, TX, USA, Sep 22-26 1986 p 537-552.

**074361 ON THE CONSTRUCTION OF MINIMIZATION METHODS OF QUASI-NEWTON TYPE.** The secant equation, which underlies all standard 'quasi-Newton' minimization methods, arises from the use of a linear function to model the gradient along a chosen direction. We present new minimization algorithms, derived by replacing this linear model with a more general one involving a free parameter, which is determined by using information contained in the current approximate Hessian. The use of such a model can give more flexibility in the criteria to be satisfied during the line-search. The new methods can operate as soon as a reasonable approximation to the Hessian has been accumulated and may, in one sense, be viewed as acceleration techniques for quasi-Newton methods. (Author abstract) 11 refs.

Ford, John A. (Univ of Essex, Colchester, Engl); Saadallah, Adel F. *J Comput Appl Math* v 20 Nov 1987, Proc of the 2nd Int Conf on Comput and Appl Math, Louvain, Belg, Jul 21-26 1986 p 239-246.

**074362 GEOMETRIC OPTIMIZATION AND THE POLYNOMIAL HIERARCHY.** We illustrate two techniques of accurately classifying the optimization versions of geometric problems in the polynomial hierarchy. We show that if  $NP \neq Co-NP$ , then there are interesting natural geometric optimization problems (location-allocation problems under minsum) in  $\Delta_2^P$  that are in neither  $NP$  nor  $Co-NP$ . Hence, all these problems are shown to belong properly to  $\Delta_2^P$ , the second level of the polynomial hierarchy. We also show that there are some interesting geometric optimization problems (location-allocation problems under minmax) complete for a class  $D^P$  (which is contained in  $\Delta_2^P$  and contains  $NP$  union  $Co-NP$ ). (Author abstract) 17 refs.

Bajaj, Chandrjit (Purdue Univ, West Lafayette, IN, USA). *Theor Comput Sci* v 54 n 1 Sep 1987, Fifth Conf on Found of Software Technol and Theor Comput Sci, New Delhi, India, Dec 16-18 1985 p 87-102.

## Analogies

**074363 SIMULATED ANNEALING WITH CONSTANT THERMODYNAMIC SPEED.** Arguments are presented to the effect that the optimal annealing schedule for simulated annealing proceeds with constant thermodynamic speed, i.e., with  $dT/dt = -(\nu T)/(e\nu/C)$ , where  $T$  is the temperature,  $e$  is the relaxation time,  $C$  is the heat capacity,  $t$  is the time, and  $\nu$  is the (constant) thermodynamic speed. Experimental results on a graph partitioning problem which can be solved exactly are shown to be consistent with this conjecture. (Author abstract) 24 Refs.

Salamon, Peter (San Diego State Univ, San Diego, CA, USA); Nulton, James D.; Harland, John R.; Pedersen, Jacob; Ruppener, George; Liao, Luby. *Comput Phys Commun* v 49 n 3 Jun 1988 p 423-428.

**Applications** See Also COMPUTER NETWORKS—Design; ELECTRIC FILTERS, LOW PASS—Design; INTEGRATED CIRCUITS—Layout; MATHEMATICAL TECHNIQUES—Algorithms; MATHEMATICAL TECHNIQUES—Optimization; MICROSTRIP DEVICES—Computer Aided Design; ROBOTS, INDUSTRIAL—Grippers.

**074364 STABILITY OF SOLUTIONS OF COMBINATORIAL OPTIMIZATION PROBLEMS.** A method of analysis of the sensitivity of optimal and approximate solutions of combinatorial optimization problems with a linear goal function is suggested, measuring the response of the goal function to changes in the values of the input parameters in terms of which the goal function is expressed. Formulas are defined for the stability radius for the quality estimates of approximate

solutions of the problem; the admissible variation intervals of the input parameters are identified. The practical applications of this approach are illustrated by an optimal routing of requests for nonsharable resources in a computer network. (Author abstract) 9 refs.

Karas, V.M. *Autom Control Comput Sci* v 21 n 2 1987 p 40-46.

**074365 COLLOQUIUM ON THE APPLICATION OF OPTIMISATION TECHNIQUES TO REAL-ENGINEERING PROCESSES.** This conference proceedings contains 11 papers. The main subjects are unconstrained and constrained optimization methods, integrated system optimization and parameter optimization, optimization of project control using heuristic techniques, optimal satellite trajectories, optimal engine performance, and water system optimization. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 09355 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Computing & Control Div, London, Engl). *IEE Colloq Dig* n 1986/89, Colloq on Appl of Opt Tech to Real Eng Processes, York, Engl, Jul 8-9 1986. Publ by IEE, London, Engl, 1986 var pagings.

**Calculations** See CHEMICAL REACTIONS—Precipitation.

## Computer Aided Analysis

**074366 SEARCH PROCEDURE FOR SOLVING SMALL NONLINEAR PROGRAMS ON SMALL COMPUTERS.** This work describes a brute-force procedure for solving small nonlinear optimization problems. The scheme will work on any micro, or larger, computer on which it is possible to express the functions appearing in the problem. Sample problems are included, along with the code, in C, used to solve two of them. The code is derived from a procedure used to find the curve of intersection of three-dimensional surfaces. (Author abstract) 10 refs.

Millham, C.B. (Washington State Univ, Pullman, WA, USA). *Adv Eng Software* v 9 n 2 Apr 1987 p 74-76.

**Computer Applications** See Also ELECTRIC TRANSFORMERS—Computer Aided Engineering; MACHINERY—Automation.

**074367 USING A MICROPROCESSOR FOR THE ON-LINE DETECTION OF A BOUNDARY OPTIMUM.** This paper describes optimisation techniques which can be implemented under steady state to a function possessing its optimum feasible value on the boundary line of the allowable operating region. Consideration is given to soft boundary constraints and the associated difficulties when a microcomputer is used to achieve the optimisation. Methods are presented which if included in the algorithm would allow the use of a simple low-cost microcomputer and would result in a fast and successful convergence. Such techniques are implemented on-line for the steady state minimisation of the current supplied to the stator of an inverter-driven induction motor. Both the operation of the system and the implementation of the minimisation algorithm were achieved under the control of a single eight-bit microprocessor (INTEL 8085). (Author abstract) 8 refs.

Mustafa, M.A. (Portsmouth Polytechnic, Portsmouth, Engl). *Syst Sci* v 12 n 1-2 1986 p 109-121.

**074368 SAMURAI: A GENERAL AND EFFICIENT SIMULATED-ANNEALING SCHEDULE WITH FULLY ADAPTIVE ANNEALING PARAMETERS.** This paper describes a novel simulated annealing procedure with a general scope. New concepts have been derived for dynamically and efficiently updating the essential annealing parameters. These have allowed speeding up the convergence and saving a lot of objective function evaluations compared to other methods which have been published. Our most important contribution is the introduction of a generally applicable and adaptive

'inner-loop criterion'. The quality of the results obtained with this general optimization routine has been demonstrated for the accurate characterization of worst-case limit-cycle behavior and other finite word-length effects in digital filters. The general applicability of our approach is substantiated with some promising results for the solution of clustered TSP problems with many cities. Hierarchical partitioning is established as an important property for distinguishing applications which are well-suited for simulated annealing from those which are not. (Edited author abstract) 34 Refs.

Catthoor, Francky (IMEC VZW, Heverlee, Belg); de Man, Hugo; Vandewalle, Joos. *Integr VLSI J* v 6 n 2 Jul 1988 p 147-178.

**Computer Simulation** See Also MATERIALS HANDLING—Manipulators.

**074369 COMPUTER EXPERIMENTS WITH THE SEMI-INFINITE OPTIMIZATION PROGRAM SUITABLE FOR THE CACSD.** An application of the semi-infinite optimization program (SIOP) to the computer-aided control system design (CACSD) is considered to show how the appropriate software tools can be applied to form the proper CACSD environment. As an example of the micro CACSD application to the optimum transient response design, the dc positional control system of the third order is considered. Different performance indices are used as the objective function to be minimized. The optimum gain of controller is considered as one of the design parameters to be found. Different techniques of the semi-infinite optimization which can be applied to the general unconstrained optimization methods to handle with the semi-infinite constraints (patterns) are discussed. The results of the semi-infinite optimization for the example chosen are given for six different performance indices and the efficiency of such an approach is discussed. It is also shown how the patterns can be used to control the way of getting the desired values of some parameters. (Author abstract) 7 refs.

Slepov, N.N. *Adv Modell Simul* v 9 n 3 1987 p 25-38.

**Mathematical Models** See CHEMICAL PLANTS—Optimization; SURFACE WAVES—Reflection.

**Models** See RAILROAD TRANSPORTATION—Route Analysis.

## Theory

**074370 SCALARIZATION OF VECTOR OPTIMIZATION PROBLEMS.** We investigate the scalar representation of vector optimization problems in close connection with monotonic functions. We show that it is possible to construct linear, convex, and quasiconvex representations for linear, convex, and quasiconvex vector problems, respectively. For finding all the optimal solutions of a vector problem, it suffices to solve certain scalar representations only. The question of the continuous dependence of the solution set upon the initial vector problems and monotonic functions is discussed. (Edited author abstract) 11 refs.

Luc, D.T. (Hungarian Acad of Sciences, Budapest, Hung). *J Optim Theory Appl* v 55 n 1 Oct 1987 p 85-102.

**074371 LEXICOGRAPHICAL ORDER AND DUALITY IN MULTIOBJECTIVE PROGRAMMING.** This paper studies the applications of lexicographical order relation for vectors in the mathematical theory of multiobjective programming. We show that any Pareto minimum of an unconstrained convex problem is the lexicographical minimum for the problem associated to a matrix multiplier having lexicographical positive columns. A similar result is also obtained for inequality constrained problems. Our approach to the theory of duality follows the pattern of J. Jahn but we substitute vectors by matrices in the formulation of the dual problem and the usual scalar order relation by the lexicographical order relation. This



allows us to state the Strong Duality Theorem in terms of Pareto minima and to eliminate some regularity assumptions. (Author abstract) 13 refs.

Martinez-Legaz, Juan Enrique (Univ de Barcelona, Spain). *Eur J Oper Res* v 33 n 3 Feb 1988 p 342-348.

**OPTOELECTRONIC DEVICES** See Also ANTENNAS; DIPOLES; BAR CODES; DEMODULATORS—Performance; DISPLAY DEVICES; ELECTRONIC CIRCUITS, MIXER—Performance; ELECTRONIC CIRCUITS, PULSE SHAPING—Performance; FERROELECTRIC MATERIALS—Thin Films; IMAGE PROCESSING; IMAGE SENSORS; INTEGRATED OPTICS; LASER BEAMS—Applications; LASERS, SEMICONDUCTOR—Mathematical Models; LASERS, SEMICONDUCTOR—Switching; MERCURY COMPOUNDS—Crystallization; OPTICAL COATINGS—Antireflection Coatings; OPTICAL COMMUNICATION EQUIPMENT; OPTICAL FIBERS—Applications; OXIDES—Thin Films; POLYACETYLENES—Dielectric Properties; POLYMERS—Curing; ROBOTS, INDUSTRIAL—Proximity Sensors; SEMICONDUCTING CADMIUM COMPOUNDS—Growth; SEMICONDUCTING CADMIUM COMPOUNDS—Thin Films; SEMICONDUCTING GALLIUM ARSENIDE—Thin Films; SEMICONDUCTING SILICON—Thin Films; SEMICONDUCTOR DIODES, PHOTODIODE; SEMICONDUCTOR MATERIALS—Charge Carriers; SENSORS—Design; SOILS—Surveys; TRANSISTORS, BIPOLAR—Tunneling; WAVEGUIDES—Radiation Effects; WAVEGUIDES, OPTICAL—Fabrication.

**074372 OPTOELECTRONIC DEVICES BASED ON QUANTUM WELL STRUCTURES AND SUPERLATTICES GROWN BY MOLECULAR BEAM EPITAXY: SINGLE QUANTUM WELL LASERS AND ELECTROABSORPTION DEVICES.** This thesis deals with the fabrication and characterization of optoelectronic devices based on GaAs/AlGaAs quantum-well structures and superlattices grown by molecular beam epitaxy. These devices, which all utilize the quantum-size-effects in ultra-thin semiconductor layers, can be divided into two categories: single quantum well lasers and electroabsorption devices. (Edited author abstract) 154 refs.

Larsson, Anders. *Chalmers Tek Hogsk Doktorsavh* n 624 1987 30p.

**074373 OPTOELECTRONIC MEASURING DEVICE WITH NEURISTOR DISPLAY.** One of the important advances in modern electronics is the design of optoelectronic measuring devices (OED) which have many advantages over regular electromechanical pointer-type meters and are intended to replace them. This article discusses some experimental tests that were carried out using an optoelectronic measuring device with neuristor display. 5 refs.

Gaitan, V.V.; Gurin, N.T. *Meas Tech* v 29 n 11 Nov 1986 p 1088-1090.

**074374 NOVEL APPROACH TO THE DESIGN OF OPTICALLY ACTIVATED WIDEBAND SWITCHING MATRICES.** High-speed switching matrices for wideband synchronous data are difficult to fabricate using purely optical or electronic techniques. A new approach is proposed with electronic logic and intimate optical interconnection to exploit the best features of each technology. (Author abstract) 20 refs.

Midwinter, J.E. (Univ Coll London, London, Engl). *IEE Proc Part J* v 134 pt J n 5 Oct 1987 p 261-268.

**074375 OPTO-ELEKTRONISCHE SIGNAL-VERARBEITUNG. TEIL II: ARITHMETIK-LOGIK, DATENRANGIER- UND SPEICHEREINHEITEN.** [Opto-electronic Signal Processing. Part II: Arithmetic-Logic, Data Ranging and Memory Units]. The paper briefly reviews opto-electronic processor subsystems, their most important specifications, and their tasks. In part I spatial light modulators and bus systems are considered. Part II describes the remaining subsystems with major attention given to the arithmetic logic units. Many of the references presented are reviews. (Author abstract) In German. 74 refs.

Laws, Peter (Univ Duisburg, West Ger). *Frequenz* v 41 n 8 Aug 1987 p 182-188.

**074376 OPPORTUNITY KNOCKS FOR NEW OP-**

**TOCOUPLERS.** The move to aluminum gallium arsenide light-emitting diodes (AlGaAs LEDs) has much relaxed the chief constraint on optocoupler performance—the net gain-bandwidth product value. Optocoupler gain is strongly affected by the efficiency with which an LED produces light from a given current. Bandwidth is significantly limited by the LED's response time. The use of AlGaAs for the LED emitter has increased the gain-bandwidth value. AlGaAs LEDs are brighter, faster, more linear, and slower to degrade than their predecessors. They enable optocouplers to operate either at very high speeds (40 Mbaud) or at relatively high speeds (5 Mbaud) but with low input currents (0.5 mA) ideal for low-power applications. Several ways of using the new optocouplers are presented.

Jamison, Richard (Hewlett-Packard Co, San Jose, CA, USA); Fraser, Sharon; James, Chris. *Electron Prod (Garden City NY)* v 30 n 11 Nov 1 1987 p 57-60, 62.

**074377 OPTICAL ENCODERS FOR CUSTOM REQUIREMENTS.** Custom optical encoders can use a variety of different photodetectors to translate the light from the emitter into photocurrent. These include PIN and PN silicon diodes, photo-transistors, photo-Darlington and photo-resistors. Each of these offers benefits and could be used as a viable solution. The author discusses the size, resolution and performance requirements for a custom optical encoder design.

Wiesner, Werner (Hewlett-Packard Components); Lewis, Chris. *New Electron* v 20 n 17 Sep 1 1987 p 26-27.

**074378 DEVELOPMENTS IN FIBRE OPTIC SENSORS.** For sensing applications, an optical fibre can be used in two ways: either purely as a light carrier (extrinsic) or it can be involved in the sensing process itself (intrinsic). The latter relies on inhomogeneities of a fibre which cause transmission loss. The main mechanisms for transmission loss are: coupling; absorption; scattering; radiation; and jointing. The article reviews several fiber optic sensor examples, including Schlieren, cantilever, microbending, and interferometric strain sensors. Temperature and current sensing devices using optical fibers are described.

Hickleton, Andrew. *New Electron* v 20 n 17 Sep 1 1987 p 39-40.

**074379 OPTOELECTRONICS AND COMPUTING.** The article reviews the present and future use of optoelectronics in data storage, communications, switching systems, parallel processors, ultrafast large chips for communications and timing. A major future role for optoelectronics seems as certain in computing as it already is in communications.

Midwinter, J.E. (Univ Coll London, Engl). *Comput Bull (London 1986)* v 4 pt 1 Mar 1988 p 12-13, 15.

**074380 DAUERJUSTIERTES DIODENZEILEN-SIMULTANSPEKTROMETER: EINE OPTOELEKTRONISCHE GERAETEBAU-PROBLEMLÖSUNG.** [Permanently Adjusted Simultaneous Spectrometer with a Diode Line: The Solution for Designing an Opto-Electronic Unit]. The MCS simultaneous spectrometer is extremely compact and can be universally used for routine analyses in the laboratory and in industrial practice. Its special feature is the amazingly simple setup using a minimum of functional elements. This concentration is obtained by using a high-resolution photo-diode line, highly integrated digital electronics, the holographic production of diffraction grids, special fibre optics and advanced ceramic engineering. (Author abstract) 10 refs. In German.

Maechler, Meinrad. *F&M Feinwerktech Messtech* v 96 n 1-2 Jan-Feb 1988 p 13-17.

**074381 OPTICAL SWITCHES BUILD HIGH SPEED ARRAYS.** Integrated optical switching is being developed by Plessey, AT&T and many others as a method for communications and digital signal processing. Operational principles and potential uses of optical switches are outlined. (Edited author abstract)

Judge, Peter. *New Electron* v 21 n 2 Feb 1988 p 39-40.

**074382 GENERATION AND STATISTICAL PROPERTIES OF OPTICAL DEAD-TIME EFFECTS.** An optoelectronic device that can generate either the non-paralyzable or the paralyzable dead-time effect has been constructed using a feedback scheme in conjunction with the acousto-optic deflector. 'Semi-classical' experiments show good agreement with the theory, which predicts antibunching and sub-Poissonian statistics. An expression for the correlation function of an arbitrary order is obtained for a general renewal process. From this general result, exact expressions for autocorrelation functions for both the non-paralyzable and the paralyzable counters are derived when the dead-time is greater than twice the sample time. The Fano factor is considered for both the non-paralyzable and the paralyzable counters. It is seen that the Fano factor for the paralyzable counter can be smaller than that for the non-paralyzable counter for a certain range of the input count rate. (Author abstract) 15 refs.

Cho, Doo Jin (Univ of Rochester, Rochester, NY, USA); Morris, G. Michael. *J Mod Opt* v 35 n 4 Apr 1988 p 667-677.

**074383 GUIDES D'ONDES ENFOUIS DANS DES SUPERRESEAUX GaAs-AlGaAs CREES PAR INTERDIFFUSION INDUITE PAR DES IMPURETES.** [Buried Waveguides in GaAs-AlGaAs Superlattices by Impurity Induced Layer Disorder]. Heterostructures comprised of  $Al_xGa_{1-x}As-Al_yGa_{1-y}As$  superlattices or quantum wells are compositionally stable up to very high temperatures but may become unstable with the introduction of particular impurities. The resulting layer interdiffusion leads to a compositionally averaged material. Since the introduction of impurities can be controlled by standard photolithographic masking techniques, the material properties can be modified in unmasked region. The disordered region has a wider bandgap and a lower index of refraction. This property has been used to fabricate delineated buried waveguides which exhibit very low propagation losses. Experimental results show that the index step between the layered and disordered region is at least 2.3%. While not large in magnitude, this index difference is sufficient to allow complex waveguide structures to be made in the same materials used for other high performances opto-electronic devices. (Author abstract) 28 refs. In French.

Julien, Francois (Univ Paris XI, Orsay, Fr); Swanson, P.; Tang, T.; Deppe, D.G.; Emanuel, M.; Detemple, T.A.; Coleman, J.J.; Holonyak, N. Jr. *Ann Telecommun* v 43 n 1-2 Jan-Feb 1988 p 66-72.

**074384 DETECTORS FOR MONOTILIC OPTOELECTRONICS.** In this paper, we present data on the electrical characteristics and the optical response of photodetectors integrated on GaAs substrates with FET devices. We compare the differences between devices fabricated on globally implanted areas versus the undoped semi-insulating regions of the same wafer. (Author abstract) 8 refs.

Jackson, D.J. (Hughes Research Lab, Malibu, CA, USA); Josefowicz, J.Y.; Rensch, D.B.; Persechini, D.L. *Fiber Integr Opt* v 7 n 3 1988 p 229-233.

**074385 IMPROVED PHOTOACTIVITY OF MELT-GROWN GROUP VI TRANSITION METAL DICHALCOGENIDES PREPARATION FROM SE AND SE-TE MELTS.** The preparation of group VI layered crystals from Se and mixed Se-Te melts is described. The rectification behavior and photoactivity is analyzed by photoelectrochemical measurements. Best results are obtained for  $MoSe_2$  crystals prepared from 1:1 Se-Te melts. The I-V characteristics in  $I^{-1/2}/HI$  redox electrolytes are superior to those of all crystals grown from other fluxes. They approach the behavior of selected CVT grown samples but are probably restricted by the presence of p-type conducting areas on mostly n-type samples. The



influence of electrolyte constituents on the output power characteristic is additionally investigated. (Author abstract). 17 refs.

Hofmann, W.K. (Hahn-Meitner-Inst Berlin, Berlin, West Ger); Lewerenz, H.J. *Sol Energy Mater* v 17 n 5 Aug 1988 p 369-374.

**074386 ION IMPLANTATION INTO InP FOR OPTOELECTRONIC DEVICES.** In comparison to the widespread use of ion implantation for the fabrication of Si and GaAs devices, doping of InP crystals via ion implantation is still in its infancy. Nevertheless, ion implantation as well as epitaxial techniques are the key technologies for future optoelectronic integrated circuits. It is shown that n- and p-type regions in InP can be implanted reproducibly under suitable annealing conditions. Profiles of the implanted impurities are compared with the resultant carrier profiles. The high quality of implanted pn junctions in InP is demonstrated by presenting results of diode measurements. (Author abstract). 28 refs.

Haessler, W. (Siemens AG, Munich, West Ger); Roemer, D.; Plibhal, M. *Siemens Forsch Entwicklungsber* v 17 n 4 1988 p 177-183.

**074387 NOVEL SINGLE QUANTUM WELL OPTOELECTRONIC DEVICES BASED ON EXCITON BLEACHING.** Planar high-speed optoelectronic devices offering advantages for optoelectronic integration are proposed. Exciton-resonant light propagates along a single-mode rib waveguide containing a single quantum well (SQW), the only absorbing medium in the waveguide. The two-dimensional excitonic optical absorption is controlled by the bleaching effect induced by free carriers, whose electrical conduction simultaneously makes possible optical detection and high-speed transistor action. Three such optical modulating devices are: (1) a gate-controlled single-quantum-well field-effect transistor optical modulator (FETOM); (2) an optically readable memory element; and (3) an optically switched charge storage device. The FETOM, in which the free-carrier density in the SQW is controlled by the gate voltage, offers high speed (22 ps), small size (125  $\mu\text{m}$ ), and unique potential for optoelectronic integration. 11 refs.

Abeles, Joseph H. (Bell Communications Research, Red Bank, NJ, USA); Kastalsky, Alexander; Leheny, R.F. *J Lightwave Technol* v LT-5 n 9 Sep 1987, Opt Fiber Conf/Sixth Biennu Int Conf on Integr Opt and Opt Fiber Commun, Reno, NV, USA, Jan 19-22 1987 p 1296-1300.

**074388 SEMICONDUCTOR OPTOELECTRONIC DEVICES BASED ON INTERFERENCE-INDUCED CARRIER MODULATION.** Transport of carriers generated under the influence of optically induced spatial modulation is investigated theoretically and experimentally in semiconductors. The resulting transient photocurrent is studied under varied degrees of optical interference. It is shown that strong anisotropic properties describable by an interaction tensor are suitable for device applications. Device properties are characterized analytically and are seen to be useful for the processing of optical signals with picosecond and femtosecond features. Accurate modeling demonstrates the formation of strong nodal fields whose effect is detrimental to the achievement of high current extinction. The manifestation of interference-induced carrier modulation is demonstrated with high-contrast recordings of autocorrelation of picosecond laser pulses in homogeneous materials. In other experiments, monitoring of laser coherence ranging from picoseconds to tens of femtoseconds is shown. 39 refs.

Merkelo, Henri (Univ of Illinois, Urbana, IL, USA); McCredie, Bradley D.; Veatch, Mark S.; Zocher, Andrew G.; Spanos, Ted. *IEEE J Quantum Electron* v 24 n 2 Feb 1988 p 245-254.

**074389 INTEGRATION AND PACKAGING OF OPTOELECTRONIC DEVICES.** This conference proceedings contains 21 papers, one of which is in abstract form only. Among the topics covered are: Optoelectronics packaging; Fiber-optoelectronic interfaces; Integrated op-

toelectronics; Systems/subsystems architectures; Materials/processes for devices; VLSI Optical interconnection; Small optical components; and Multiple quantum well devices. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10954 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Hartman, Davis H. (Ed.) (Bell Communications Research Inc); Holman, Robert L. (Ed.); Skinner, Doyle P. (Ed.). *Proc SPIE Int Soc Opt Eng* v 703, Integr and Packag of Optoelectron Devices, Cambridge, MA, USA, Sep 18-19 1986. Publ by SPIE, Bellingham, WA, USA, 1986 181p.

**074390 InP BASED INTEGRATED OPTOELECTRONICS: ACTIVITY IN THE FRAMEWORK OF THE ESPRIT PROGRAMME.** The main objective of this paper is to give an overview of the aims and achievements of the Esprit project 'InP based integrated optoelectronics', focusing in particular the attention on the activity carried out by CSELT regarding the realization of a monolithic integrated demultiplexer at two wavelengths in InGaAlAs material system grown by MBE technique. In this project, involving nine European research laboratories, two sub-projects 'A' and 'B' are carried out. For each sub-project the operative tasks and their chronological developments and milestones are shown, together with common activities of the two complementary sub-projects. The final part of the paper concerns the potential applicability of the results of the projects in terms of broadband communications, together with an overview of integrated optoelectronic impact on future fibre optic systems in Europe. (Author abstract) 15 refs.

Ghergia, V. (CSELT, Turin, Italy); Cinguino, P.; Genova, F.; Tosco, F. *CSELT Tech Rep* v 16 n 2 Mar 1988, GLOBECOM '87 - IEEE/IEICE Global Telecommun Conf, Tokyo, Jpn, Nov 15-18 1987 p 105-110.

## Analysis

**074391 SPATIAL FREQUENCY MULTICHANNELING IN ACOUSTICAL OPTOELECTRONIC DEVICES WITH TIME INTEGRATION.** Ways of providing spatial frequency multichanneling in acoustical optoelectronic devices with time integration are determined. An acoustical optoelectronic delay line and a correlator are considered. Utilization in these devices of weight processing of space spectra of received signals makes it possible to obtain multichanneling with respect to frequency and delay time simultaneously. (Author abstract) 4 refs.

Katkov, B.G.; Sinegubov, N.N. *Radioelectron Commun Syst* v 30 n 3 1987 p 27-32.

**Applications** See Also DATA STORAGE, OPTICAL—Inspection; DATA TRANSMISSION EQUIPMENT; INTEGRATED CIRCUITS, MONOLITHIC—Manufacture; OPTICAL DATA PROCESSING—Design.

**074392 OPTOELECTRONIC ICs FOR HIGH-SPEED PARALLEL PROCESSING.** In light of the increase in the number of interconnections between pairs of chips and between various systems, one would expect a decrease in the number of required interconnections at higher levels. However, current applications of intelligent interconnection structures in the design of next-generation computers prove the opposite. High-performance computing, it seems, also requires a high-performance communication structure. Unlike conventional electrical designs, optical interconnection techniques yield many advantages. Beyond the well-known advantages of reduced crosstalk and electromagnetic interference, optical connections also yield much wider bandwidths, larger fanouts and lower system power, and allow greater system complexity. Next-generation computers will likely use optoelectronic interconnections.

Frietman, Edward E.E. (Delft Univ of Technology, Delft, Neth); van Nifterick, Wim. *Lasers Optonics* v 6 n 8 Aug 1987 p 69-71.

**Components** See SEMICONDUCTING GALLIUM COMPOUNDS—Research.

**Computer Aided Design** See OPTICAL DATA PROCESSING.

**Computer Applications** See COMPUTERS.

**Design** See Also SEMICONDUCTOR DIODES, PHOTODIODE—Design.

**074393 ELECTRON-BEAM VALVE FOR A CURRENT OF 50 A, VOLTAGE OF 160 kV.** The electron-beam valves (EBV) possessing full controllability, high efficiency resulting from slowing-down the electron beam at the anode at a high instrument capacity may be utilized for devising high-voltage commutators. The results of numerical and experimental analysis of electron-beam forming in an optoelectronic valve system at various operating conditions and also its performance curves are presented. (Edited author abstract) 4 refs.

Kuklinskii, B.D.; Naguchev, O.Yu.; Perevodchikov, V.I.; Shapenko, V.N.; Yakovlev, A.N. *Sov Electr Eng* v 58 n 9 1987 p 24-27.

**074394 GaAs MONOLITHIC INTEGRATED PHOTORECEIVER FOR 0.8  $\mu\text{m}$  WAVELENGTH: ASSOCIATION OF SCHOTTKY PHOTODIODE AND FET.** We report the fabrication and the characterization of a GaAs planar monolithic integrated photoreceiver. It consists of a semiplanar Schottky photodiode, associated with a field-effect transistor. Static, dynamic and noise properties have been investigated and interpreted, taking into account the particular characteristics of the material and the design of the integrated circuit. For example, sensitivity up to  $-30$  dBm can be achieved at 250 Mbits/s for a 1E-9 bit error rate. (Author abstract) 9 refs.

Verrielle, H. (CNRS, Villeneuve d'Ascq, Fr); Lorriaux, J.L.; Legry, P.; Gouy, J.P.; Vilcot, J.P.; Decoster, D. *IEEE Proc Part J* v 135 n 2 Apr 1988 p 92-95.

**074395 NEW APD-BASED RECEIVERS PROVIDING TOLERANCE TO ALIGNMENT JITTER FOR BINARY OPTICAL COMMUNICATIONS.** Receiver signal processing which leads to signal element waveforms satisfying Nyquist's first and second criteria (with respect to the depressed optimum decision threshold encountered with high performance avalanche photodiode receivers is considered. This results in an eye pattern for binary optical communications, which is well disposed around the depressed threshold. These new signal design targets are thus well suited to untimed transmission while also offering improved tolerance to alignment jitter when used in conventional fully retimed optical receivers. The practical realization is considered to consist of signal shaping networks with responses closely approximating these new designs, and receiver performance is evaluated. (Author abstract) 8 refs.

O'Reilly, J.J. (Univ Coll of North Wales, Bangor, Wales); Fyath, R.S. *IEEE Proc Part J* v 135 n 2 Apr 1988 p 119-125.

**074396 NOVEL WAVELENGTH-RESONANT OPTOELECTRONIC STRUCTURE AND ITS APPLICATION TO SURFACE-EMITTING SEMICONDUCTOR LASERS.** An optimized design for optoelectronic devices which depends on the interaction between an electromagnetic standing wave and the carrier population is described. The structure consists of quantum well layers spaced at one half the wavelength of a selected optical transition in quantum wells. This spatial periodicity allows the amplifying or absorbing medium quantum wells to coincide with the peaks of the standing wave optical field in the Fabry-Perot cavity. In such a periodic medium, the gain or absorption for the selected wavelength is enhanced by a factor of two compared to a uniform medium. This concept was applied to fabricate a surface-emitting semiconductor laser in the GaAs/Al-



GaAs system. It is claimed that lasing was achieved with the shortest gain medium length (320 nm) ever reported. (Edited author abstract). 4 Refs.

Raja, M.Y.A. (Univ of New Mexico, Albuquerque, NM, USA); Brueck, S.R.J.; Osinski, M.; Schaus, C.F.; McInerney, J.G.; Brennan, T.M.; Hammons, B.E. *Electron Lett* v 24 n 18 Sep 1 1988 p 1140-1142.

**074397 DESIGN AND PERFORMANCE OF AN OPTOELECTRONIC MATRIX SWITCH USING SI-P-I-N PHOTODIODES.** Switching speed, isolation, optical-source requirements, and attainable matrix dimensions of an optoelectronic matrix switch using Si p-i-n photodiodes are discussed. By charging the internal capacitance of the diode with a photocurrent, forward bias voltages are attained that establish off-states. The novel features of the matrix switch are that the switch elements have high output impedance at off-states, and no electrical power is required to establish the off-states. This leads to advantages in fabricating large-dimension matrix switches. 8 refs.

Aida, Kazuo (NTT, Yokosuka, Jpn); Matsuno, Kimio; Toyoshima, Motoyoshi. *J Lightwave Technol* v 6 n 1 Jan 1988 p 131-138.

**074398 5.2-GHz BANDWIDTH MONOLITHIC GaAs OPTOELECTRONIC RECEIVER.** A high-speed monolithic optoelectronic receiver consisting of a photodetector, a transimpedance amplifier and a 50- $\Omega$  output buffer stage has been fabricated using an enhancement/depletion 0.35- $\mu$ m recessed-gate GaAs MESFET process. The interdigitated metal-semiconductor-metal (MSM) photodetector has a dark current of 0.8 nA, a responsivity of 0.2 A/W, and a capacitance of 12 fF. The bandwidth of the receiver is 5.2 GHz with an effective transimpedance of 300  $\Omega$  into a 50- $\Omega$  load, which corresponds to a transimpedance bandwidth product of 1.5 THz- $\Omega$ . 12 refs.

Harder, Christoph S. (IBM, Rueschlikon, Switz); Van Zeghbroeck, Bart; Meier, H.; Patrick, William; Vettiger, Peter. *IEEE Electron Device Lett* v 9 n 4 Apr 1988 p 171-173.

**Electric Properties** See LASERS, SEMICONDUCTOR—Performance.

## Etching

**074399 NOVEL PROCESS FOR INTEGRATION OF OPTOELECTRONIC DEVICES USING REACTIVE ION ETCHING WITHOUT CHLORINATED GAS.** A new process for RIE of III-V compound semiconductors using mixtures of  $\text{CH}_4$ , Ar and  $\text{H}_2$  as the etching gas is presented. This process can be successfully applied to most III-V materials used in micro-optoelectronic technology. (Author abstract) 9 refs.

Henry, L (CNET, Lannion, Fr); Vaudry, C.; Granjoux, P. *Electron Lett* v 23 n 24 Nov 19 1987 p 1253-1254.

**Fabrication** See Also LOGIC CIRCUITS—Fabrication; SEMICONDUCTING INDIUM COMPOUNDS—Etching; SEMICONDUCTOR MATERIALS—Growing.

**074400 LONG-WAVELENGTH PINFET RECEIVER OEIC ON A GaAs-ON-InP HETEROSTRUCTURE.** A long-wavelength PINFET OEIC has been fabricated on a GaAs-on-InP heterostructure. A receiver sensitivity as high as -31 dbm for 600 Mbit/s NRZ has been obtained. The potential of the GaAs-on-InP heterostructure for high-performance, long-wavelength OEIC applications has been demonstrated. (Edited author abstract) 6 refs.

Suzuki, A. (NEC Corp, Kawasaki, Jpn); Itoh, T.; Terakado, T.; Kasahara, K.; Asano, K.; Inomoto, Y.; Ishihara, H.; Torikai, T.; Fujita, S. *Electron Lett* v 23 n 18 Aug 27 1987 p 954-955.

**074401 PLANAR MONOLITHIC INTEGRATION OF LED AND FET DEVICES ON A CONDUCTIVE SUBSTRATE.** Results of a study on the monolithic integration of AlGaAs light-emitting diodes with GaAs

field-effect transistors (FETs) on a conductive p-GaAs substrate are described. Using a selective growth technique, a horizontal configuration is fabricated that allows separate optimization of the two types of devices and provides a quasiplanar surface. This approach is compatible with standard GaAs integrated-circuit technology. By inserting an undoped layer and a p-n junction between the active layer of the FET and the substrate, leakage currents below 500  $\mu$ A for bias voltage up to 9 V are obtained. The emitted light intensity of the LED, connected in series with the FET, exhibits a nearly linear dependence on the diving gate potential. Fall and rise times around 20 ns are determined from the measured pulse-response characteristics. This switching time is limited by the LED; the FET and isolation layers do not affect the switching behavior of the circuit in this time frame. 21 refs.

Deschler, Marc (RWTH, Aachen, West Ger); Heyen, Meino; Roentgen, Peter; Narozny, Peter; Beneking, Heinz; Balk, Pieter. *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2043-2048.

**074402 OPTOELECTRONIC INTEGRATED CIRCUITS.** The demand for optoelectronic integrated circuits (OEICs) is argued to be driven by the need for more sophisticated, second-generation photonic systems such as optical interconnects, optical computing, and optical communications. All of these systems require certain generic, or building-block components, which include optical transmitters, receivers, modulators, and arrays of all of these various devices. In the hierarchical arrangement of systems and devices considered, it is pointed out that the foundation of the hierarchy is the materials growth technology. Therefore, a brief description is also given of the materials growth techniques which are used in OEIC structures. 35 refs.

Forrest, Stephen R. (Univ of Southern California, Los Angeles, CA, USA). *Proc IEEE* v 75 n 11 p 1488-1497.

**074403 INTEGRATED WAVEGUIDE P-I-N PHOTODETECTOR.** A p-i-n photodetector in  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}/\text{InP}$  integrated at the end of a ridge waveguide in n<sup>+</sup>-InP/n<sup>-</sup>-InP is reported. In the waveguide, an average propagation loss of 3 dB/cm at 1.15  $\mu$ m was measured with a coupling loss of 2 dB and a reflection loss of 3 dB. For optical evaluation of the waveguide-detector, 1.15- $\mu$ m light from a He-Ne laser was coupled into the waveguide and the detected photocurrent was measured as a function of the input light intensity with reverse bias as a parameter. The response of the detector was linear with intensity. Typically, a photocurrent of 11  $\mu$ A was measured for an input light intensity of 56  $\mu$ W falling on the waveguide. Taking into account coupling, reflection and propagation losses, it is estimated that 85% of the guided light was absorbed by the photodetector. The device had a 3-dB bandwidth of 500 MHz when light from a 1.3- $\mu$ m semiconductor laser source was coupled into the waveguide. 1 ref.

Chandrasekhar, S. (AT&T Bell Lab, Holmdel, NJ, USA); Campbell, J.C.; Dentai, A.G.; Qua, G.J. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2364-2365.

**074404 MONOLITHICALLY INTEGRATED RECEIVER FRONT-END:  $\text{In}_{0.53}\text{Ga}_{0.47}\text{AS PIN-AMPLIFIER}$ .** A monolithically integrated  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$  p-i-n-amplifier fabricated on n-InP substrates is discussed. The structure utilizes a vertical integration of p-i-n-diode and recessed-gate InP MISFETs, yet with a planar surface for fine-line photolithography. The preamplifier consists of a gain stage and a buffer stage, both made of InP MISFETs with aluminum phosphorus oxide as gate insulator. This is by far the most complex integrated optoelectronic circuit on InP ever reported. At 400 Mb/s, the receiver sensitivity is better than -27 dBm for 1  $\times$  10<sup>-9</sup> bit-error rate.

Cheng, Chu-Liang (AT&T Bell Lab, Murray Hill, NJ, USA); Chang, R.P.H.; Tell, B.; Zima, S.M.; Ota, Y.; Vella-Coleiro, G.P.; Miller, R.C.; Zilko, J.L.; Kasper, B.L.; Brown-Goebele, K.F.; Mattera, V.D. Jr. *IEEE*

*Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2365.

## Imaging Techniques

**074405 BILDVERARBEITENDE, OPTOELEKTRONISCHE SENSOREN FUER DIE FLEXIBLE MONTAGE.** [Image-Processing Optoelectronic Sensors for Flexible Assembly]. Efficient image-processing systems with gray-scale processing open new possibilities for the design of flexible industrial robot assembly units. Past developments and the present status of the technological trends are reported. Present activities aim at developing faster processors, more efficient recognition algorithms and 3-D pattern recognition. 15 refs. In German.

Rummel, Peter (Siemens AG, Munich, West Ger); Simon, Johannes. *E&I Elektrotech Informationstech* v 105 n 4 Apr 1988 p 169-175.

## Japan

**074406 RESEARCH ACTIVITIES OF RADIO-AND OPTO-ELECTRONICS DIVISION.** The research activities in Radio- and Opto-Electronics Division are reviewed. The technological basis of the Division lies in handling coherent waves including laser light and microwaves. The activities in the field of laser technology extend from the generation of laser light to their application in material processing and optical information handling. In the field of microwave technology, activities have centered around standardization of measurements (Author abstract). 183 Refs. In Japanese.

Shimada, J. *Denshi Gijutsu Sogo Kenkyusho Iho* v 52 n 6 1988 p 122-157.

## Laser Applications

**074407 GaAs/AlGaAs ROOFTOP REFLECTOR LASER FOR OPTOELECTRONIC INTEGRATED CIRCUITS.** A GaAs/AlGaAs laser, consisting of a cleaved facet and a chemically etched total-internal-reflecting rooftop reflector, is fabricated and tested. The results show that the rooftop reflector with the reflectivity exceeding 0.9 can be readily obtained and the laser is suitable for optoelectronic integrated circuits. (Author abstract) 12 refs.

Chae, Chang-Joon (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Kwon, Young-Se. *Electron Lett* v 23 n 21 Oct 8 1987 p 1118-1120.

**Materials** See Also SEMICONDUCTING CADMIUM COMPOUNDS—Oxidation; SEMICONDUCTOR MATERIALS—Optical Properties; SEMICONDUCTOR MATERIALS—Temperature Measurement; SOLAR CELLS—Materials.

**074408 HIGH-SPEED OPERATION OF 1.5  $\mu$ m GaInAsP/InP OPTOELECTRONIC INTEGRATED LASER DRIVERS.** A 1.5  $\mu$ m-wavelength high-speed self-aligned constricted-mesa laser diode and an InP MESFET have been integrated monolithically without deterioration in the performance of either device, by using a gate projection process. A broad 3dB bandwidth of 6.6 GHz was demonstrated for the first time. (Author abstract) 5 refs.

Suzuki, N. (Toshiba Research & Development Cent, Kawasaki, Jpn); Furiyama, H.; Hirayama, Y.; Morinaga, M.; Eguchi, K.; Kushibe, M.; Funamizu, M.; Nakamura, M. *Electron Lett* v 24 n 8 Apr 1988 p 467-468.

**074409 DIFFUSION-INDUCED DISORDERING OF  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}/\text{InP}$  MULTIPLE QUANTUM WELLS WITH ZINC.** Diffusing zinc into  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}/\text{InP}$  MQW layers is found to cause strong intermixing of the group III elements which changes the composition in the quantum wells and barriers. As a result of this disordering



the MQW bandgap is reduced in energy and the photoluminescence emission peak moves to longer wavelength. (Author abstract) 7 refs.

Pape, I.J. (Univ of Sheffield, Sheffield, Engl); Li Kam Wa, P.; David, J.P.R.; Claxton, P.A.; Robson, P.N.; Sykes, D. *Electron Lett* v 24 n 15 Jul 21 1988 p 910-911.

**074410 ADVANCED MATERIALS FOR TELECOMMUNICATION 1986 (PAPERS PRESENTED AT SYMPOSIUM XIII AT THE EUROPEAN MATERIALS RESEARCH SOCIETY MEETING).** The proceedings contains 58 papers dealing with bulk crystal growth, bulk material characterization, heterostructures, materials for optical transmitters, materials for optoelectronic integration, and materials for contacts, interconnects, insulation and passivation. The proceedings is a valuable information source for materials scientists and technologists developing signal source, transmission and receiver systems of telecommunication networks. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11290 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Glasow, P.A. (Ed.) (Siemens AG, Erlangen, West Ger); Nissim, Y.I. (Ed.); Noblanc, J.P. (Ed.); Speight, J. (Ed.). *Adv Mater for Telecommun 1986*, Strasbourg, Fr, Jun 17-20 1986 Publ by Les Editions de Physique, Les Ulis, Fr, 1986 509p.

## Millimeter Waves

**074411 OPTOELECTRONIC MILLIMETRE-WAVE SWITCHING USING A FINLINE-ON-SILICON SUBSTRATE.** A finline-on-silicon substrate has been realized showing small insertion loss. Illuminating the slot region by an infra-red-emitting diode, considerable attenuation has been achieved. This demonstrates the high optoelectronic sensitivity of a finline structure, which is due to the high field concentration in the slot. Experimental results in the 26.5-40 GHz range are given. (Author abstract) 8 refs.

Uhde, K. (Technische Univ Hamburg-Harburg, Hamburg, West Ger). *Electron Lett* v 23 n 21 Oct 8 1987 p 1155-1156.

## Packaging

**074412 OPTOELECTRONIC PACKAGING.** By adding the capability of photons to electrical devices (i.e., optoelectronics), a number of performance advantages may be obtained in existing products and new applications may be developed. Exploiting this potential is not simple, however, since optoelectronic packaging must overcome a number of complexities which are not inherent in silicon devices. As a result, considerable progress must still be made in developing optoelectronic packaging technology. (Author abstract) 15 refs.

Wen, Sherree H. (IBM, Yorktown Heights, NY, USA). *J Met* v 40 n 6 Jun 1988 p 14-17.

**Performance** See Also MECHANICAL VARIABLES MEASUREMENT—Position; OPTICAL DEVICES—Stability; SEMICONDUCTOR DIODES, PHOTODIODE—Analysis.

**074413 MONOLITHIC PHOTORECEIVER INTEGRATING GaInAs PIN/JFET WITH DIFFUSED JUNCTIONS.** A new integrated PIN/JFET using an original three-layer GaInAs structure has been developed in order to optimize both devices separately. Thanks to the good performances and high reliability of individual components, the sensitivity of such monolithic photoreceivers is  $-33.7$  dbm for a  $10^{-9}$  bit error rate at 140 Mbit/s. (Author abstract) 7 refs.

Renaud, J.C. (CNET, Bagneux, Fr); N'guyen, L.; Alloven, M.; Heliot, F.; Lugiez, F.; Scavennec, A. *Electron Lett* v 23 n 20 Sep 24 1987 p 1055-1056.

**074414 OPTOELECTRONIC IMAGE CONVERTER BASED ON MF-14 INTEGRATED-CIR-**

**CUIT PHOTODIODE ARRAY.** An optical-to-electrical converter based on an MF-14 photodiode array is described. The input and output electrical signals of the converter have TTL levels. The readout time for one row of the array is approx. 150 nsec. The readout time for the entire field of the array does not exceed 11  $\mu$ sec. (Author abstract) 3 refs.

Gorodilov, V.D. *Instrum Exp Tech* v 30 n 1 pt 2 Jan-Feb 1987 p 142-143.

**074415 ADVANCE OF OPTOELECTRONIC DEVICES FOR LONG WAVELENGTH OPTICAL FIBER COMMUNICATION IN CHINA.** The advances of optoelectronic devices for long wavelength optical fiber communication in China is reviewed. The main features of the long wavelength semiconductor lasers and photodetectors are presented. (Author abstract) 30 refs.

Wang, C.M. (Chinese Acad of Sciences, Beijing, China); Peng, H.D.; Wang, S.T. *Fiber Integr Opt* v 6 n 4 1987 p 255-277.

**074416 DYNAMIC RESPONSE OF AN INTEGRATED OPTOELECTRONIC LOGIC DEVICE.** A monolithically integrated form of optoelectronic logic device, based on a GaAs/AlGaAs multiple-quantum-well modulator, has been fabricated using MOVPE and tested. The Dynamic response of the device is modelled theoretically and tested experimentally, and good agreement is found over a substantial range. (Author abstract) 6 refs.

Wheatley, P. (Univ of Coll London, London, Engl); Parry, G.; Midwinter, J.E.; Hill, G.; Mistry, P.; Pate, M.A.; Roberts, J.S. *Electron Lett* v 23 n 23 Nov 5 1987 p 1249-1250.

**074417 OPTOELECTRONIC SEMICONDUCTOR DEVICES.** In recent years fiberoptic communication has become one of the most expanding fields in telecommunication. Optoelectronic semiconductor devices, play a important role in this new technology. This article attempts to provides an overview of optoelectronic devices for fiberoptic applications in the market today and in the near future. (Author abstract)

Heister, Gerd (Siemens AG, Munich, West Ger). *Telcom Rep* v 10 n 5 Sep-Oct 1987 p 328-332.

**074418 ANALYSIS OF THE INFLUENCE OF DARK CURRENT ON THE PERFORMANCE OF OPTICAL RECEIVERS EMPLOYING SUPERLATTICE APDs.** Formulas are derived for the effective mean value and effective excess-noise factor associated with dark-current induced hole-electron pairs and these are used to study the influence of dark current, and residual hole ionization on device and receiver performance for superlattice avalanche photodiodes (APDs). The analyses should provide useful guidelines for the design of high performance superlattice APDs and receivers. (Author abstract) 51 refs.

O'Reilly, J.J. (Univ Coll of North Wales, Bangor, Wales); Fyath, R.S. *IEE Proc Part J* v 135 n 2 Apr 1988 p 109-118.

**074419 HETEROSTRUCTURES IN III-V OPTOELECTRONIC DEVICES.** Heterojunctions are used in most III-V optoelectronic devices. Through their use a number of additional degrees of freedom are introduced as compared with homojunction devices. New effects, not possible with homojunctions, appear and are applied in many new devices. A classification of heterojunctions is made and their advantages are discussed. The application of heterojunctions in laser diodes is described. (Edited author abstract) 16 refs.

Baets, R. (IMEC-Rijksuniversiteit Gent, Ghent, Belg). *Solid State Electron* v 30 n 11 Nov 1987, New Dev in the Phys of Homo- and Heterojunctions, US-Belg Jt Semin, Louvain, Belg, May 28-30 1986 p 1175-1182.

## Reviews

**074420 R&D IN III-V OPTO TECHNOLOGY.** Advanced solid-state lasers, photo-detectors, optoelectronic integrated circuits (OEICs) and microwave communication links are exploiting the unique electronic and optical properties of Group III-V semiconductor materials. Multi-layer structures necessary for creation of layers (eg GaAs/GaAlAs), photodiodes (eg InGaAs/InP) or more complex devices which combine opto and digital functions within a single package are achieved using epitaxial growth processes such as metal organic chemical vapour deposition (MOCVD), vapour phase epitaxy (VPE) or molecular beam epitaxy (MBE). Significant development work associated with III-V semiconductor materials for use in optoelectronic components has already been undertaken by the major American and Japanese corporate research laboratories. The article is a short review of developments in optoelectronic technology.

Baker, P. (ERA Technology); Carey, J. *New Electron* v 20 n 17 Sep 1 1987 p 25.

**074421 INTEGRATED OPTOELECTRONICS FOR OPTICAL TRANSMISSION SYSTEMS.** A brief overview is given of research on optoelectronic integrated circuits (OEICs). Their performance, design, and manufacturing advantages are discussed. Device approaches and state-of-the-art OEICs are described. Future prospects for OEICs are considered. 23 refs.

Maeda, Minoru (Hitachi Ltd, Kokubunji, Jpn); Nakano, Hiroyuki. *IEEE Commun Mag* v 26 n 5 May 1988 p 45-51.

**Spectrum Analysis** See SEMICONDUCTOR DEVICES—Ultrasonic Effects.

**Stability** See LASERS, SEMICONDUCTOR—Optical Pumping.

**Switching** See Also TELEPHONE SWITCHING EQUIPMENT—Crossbar Equipment.

**074422 OPTOELECTRONIC PULSE COMPRESSION OF MICROWAVE SIGNALS.** Optically switched transmission line resonators are shown to generate short microwave pulses of higher output peak power than the CW input signal. This kind of pulse compression is achieved by using the resonator as a storage element and an optoelectronic switch as the output mirror. A theoretical analysis of the efficiency of this device is presented. Experimentally, a peak power enhancement of 14 has been observed at a frequency of 1 GHz. A comparison with numerical results is finally carried out. 12 refs.

Paulus, Peter (Univ Muenster, West Ger); Stoll, Lothar; Jager, Dieter. *IEEE Trans Microwave Theory Tech* v MTT-35 n 11 p 1014-1019.

**Theory** See LASERS, SEMICONDUCTOR—Mathematical Models; SEMICONDUCTOR DIODES, PHOTODIODE—Mathematical Models.

**OPTOMETERS** See Also VISION—Eye Movements.

## Performance

**074423 NEW DIAGNOSTIC POSSIBILITIES WITH A RETINAL MEASURING SYSTEM.** Clinical experimental studies on retinal circulation have proved that blood circulation measurements on the retina substantially expand the ophthalmologist's potential for differential diagnosis. These studies suggest that the use of corresponding measuring instruments will make possible substantial advancements in the therapy of retinal circulatory disturbances. The microcomputer-controlled retinal measuring system is part of the overall effort to develop a comprehensive circulatory measuring station. A computer-controlled measuring attachment to the RCS-310 Retinal Camera was developed. The heart of the measuring system is an optoelectronic CCD sensor arranged in one of the image planes of the measuring path of rays. 3 refs.



Vilser, Waltherd (Friedrich Schiller Univ of Jena, East Ger). *Jena Rev* v 32 n 2 1987 p 76-78.

## ORCHARDS

### Frost Protection

**074424 DETERMINATION OF THE EFFECTIVE EMISSIVITY AND TEMPERATURE UNDER VERTICAL OBSERVATION OF A CITRUS ORCHARD. APPLICATION TO FROST NOWCASTING.** In this work Becker's model for the determination of the effective temperature and emissivity under vertical observation of a citrus orchard was used. This model was applied to the particular case of a typically radiative night cooling condition (completely clear sky and calm wind), under which radiation frosts are normally produced. This is damaging to the fruit and, consequently, to the Valencian economy. The authors determined that a citrus orchard under normal observation can, in practice, be considered as a homogeneous system as far as the emissivity is concerned and that the orange tree's influence on the effective temperature is approximately three times that of the ground. (Edited author abstract) 22 refs.

Caselles, V. (Univ of Valencia, Burjassot, Spain); Sobrino, J.A.; Becker, F. *Int J Remote Sens* v 9 n 4 Apr 1988 p 715-727.

Productivity See SOILS—Chemistry.

## ORDNANCE See Also GUNS.

**074425 EXPERIMENTAL INVESTIGATION FOR THE AXIAL DISTRIBUTION OF INITIAL VELOCITY OF SHELLS.** Initial velocity of steel shells with various charge structures have been measured by using flash x-ray photography system. As the result of data processing, an engineering analysis for the distribution of initial velocities along the shell axis is presented. This approach applies to fragment warhead with general charge structures under three different initiation patterns. (Author abstract) In Chinese. 3 refs.

Feng, Shunshan; Cui, Bingui. *Bingong Xuebao* n 4 Nov 1987 p 60-63.

**074426 EXTERIOR BALLISTIC OPTIMUM DESIGN FOR ANTI-AIRCRAFT PROJECTILES OF SMALL CALIBERS.** The design for an anti-aircraft projectile, provided with ample power and precision, to attain a given slant distance with the shortest possible spent time, is a problem of much practical interest. This paper gives a mathematical model for such an optimum design of anti-aircraft projectiles and, applying methods of mathematical programming, suggests a computer software for the design. Selected examples proved the practicability of the optimum design. (Author abstract) In Chinese. 7 refs.

Wang, Zhongyuan. *Bingong Xuebao* n 4 Nov 1987 p 64-68.

**074427 MOMENT EXERTED ON A CONING PROJECTILE BY A SPINNING LIQUID IN A SPHEROIDAL CAVITY.** Motion of a rotating inviscid liquid in a spheroidal container has been studied for some time. This inviscid theory for spheroids has been modified here by a boundary-layer correction. The resulting pressures and velocity profiles can then be used to compute liquid in-plane and liquid side-moment coefficients for various eccentricities, coning frequencies, and Reynolds numbers. In this paper, these results are discussed and compared with similar results for cylinders. 16 refs.

Murphy, Charles H. (US Army Ballistic Research Lab, Aberdeen Proving Ground, MD, USA). *AIAA J* v 25 n 12 Dec 1987 p 1631-1633.

**074428 SUBSONIC SINGLE-PHASE FLOW IN A GUN SIMULATOR.** Reported here are the time-resolved and ensemble mean and rms fluid velocities obtained by laser Doppler anemometry in a subsonic gun simulator with an inert single-phase flow and a projectile exit

velocity of 40 m/s. The results presented also include the time-resolved measurements of the projectile velocity and breech pressure. The results show that, based on measured breech-pressure record, the calculated projectile velocities are almost exactly equal to the measured values and confirm that the friction of the system is negligible. Fluid velocity traces, together with ensemble mean and rms velocity profiles, indicate the presence of a wall boundary layer occupying up to 20% of the tube radius and having a growth rate similar to that of steady turbulent boundary layers. (Edited author abstract) 12 refs.

Bicen, A.F. (Imperial Coll of Science & Technology, London, Engl); Khezziar, L.; Whitelaw, J.H. *AIAA J* v 26 n 1 Jan 1988 p 47-51.

**074429 DYNAMIC STABILITY CRITERIA OF FREE FLIGHT NO-SPINNING MORTAR PROJECTILES.** The effects of linear yawing, nonlinear damping and pitching moments on free flight no-spinning mortar projectiles are discussed in this paper. A yawing stability factor and a damping stability factor are introduced first. By these factors are described criteria that determine unexpected falling-down of free flight mortar projectiles. (Author abstract) 6 refs. In Chinese.

Dong, Liang. *Bingong Xuebao* n 1 Feb 1988 p 42-51.

**074430 RAM ACCELERATOR: A NEW CHEMICAL METHOD FOR ACCELERATING PROJECTILES TO ULTRAHIGH VELOCITIES.** A new method for accelerating projectiles from velocities of approximately 0.7 km/s up to approximately 12 km/s using chemical energy is presented in this paper. The concept, called the 'ram accelerator', is based on gasdynamic principles similar to those of an airbreathing ramjet but operates in a different manner. The projectile, which resembles the center body of a ramjet, travels through a tube filled with a premixed gaseous fuel and oxidizer mixture. The tube becomes the outer cowl of the ramjet, and the energy release process travels with the projectile. By tailoring the propellant mixture along the tube, a nearly constant acceleration can be achieved. In principle, the ram accelerator can be scaled for projectile masses ranging from grams to hundreds of kilograms and is capable of ballistic efficiencies as high as 30%. A straightforward, quasisteady, one-dimensional approach is used to model the acceleration process. (Edited author abstract) 15 refs.

Hertzberg, A. (Univ of Washington, Seattle, WA, USA); Bruckner, A.P.; Bogdanoff, D.W. *AIAA J* v 26 n 2 Feb 1988 p 195-203.

**074431 NUMERICAL EVALUATION OF WHITHAM'S F-FUNCTION FOR SUPERSONIC PROJECTILES.** Reference is made to a nonlinear analysis accurate to first-order for determination of the complete supersonic flowfield around slender and smooth bodies of revolution, presented previously by Whitham which has then been used extensively to obtain flowfields about supersonic projectiles, missiles, and aircraft. This paper presents an accurate and efficient numerical method for evaluating  $F(y)$ . The method presents no computational difficulties, and reveals physical insight on how particular body shape features contribute to the  $F(y)$ . 4 refs.

Ritzel, David V. (Defence Research Establishment Suffield, Ralston, Alberta, Can); Gottlieb, James J. *AIAA J* v 26 n 2 Feb 1988 p 244-247.

**074432 SEA LANCE WEAPON DEVELOPMENT - SYSTEM AND NAVAL ENGINEERING ASPECTS OF THE CAPSULE.** The developmental Sea Lance Weapon System is an encapsulated supersonic standoff ant submarine warfare missile, launched from an attack submarine torpedo tube. The buoyant capsule rises to the surface, broaches, the forward closure separates, and the rocket motor ignites, powering the missile and payload from the capsule to the target coordinates. This paper emphasizes the system engineering and naval engineering aspects of the Sea Lance capsule, a lightweight high strength composite material pressure hull. Performance, environmental and interface requirements were identified

to which analyses and comparisons were made. (Edited author abstract) 5 refs.

Booth, Ronald (Boeing Aerospace Co, Seattle, WA, USA). *Nav Eng J* v 100 n 3 May 1988 p 204-214.

Accident Prevention See ROCKETS AND MISSILES—Accident Prevention.

Computer Aided Analysis See MATHEMATICAL TECHNIQUES—Harmonic Analysis.

## Design

**074433 SHOCK AND VIBRATION PROBLEMS OF FUZE AND PROJECTILE SYSTEMS.** This paper deals with the in-bore-environment measuring technique of fuze-projectile systems and its spectral and model analysis. It is shown that the shock and vibration measurement and analysis are significant in the design of fuze strength, dynamic response problems of fuze mechanisms, and safety problems of gun and ammunition systems. (Edited author abstract) 6 refs. In Chinese.

Chen, Qingsheng; Qiao, Kun. *Bingong Xuebao* v 2 n 3 Aug 1987 p 17-23.

Fire Protection See INDUSTRIAL PLANTS—Fire Protection.

Manufacture See GAGES—Automation.

Materials See Also GLASS FIBER—Applications.

**074434 DIAMOND DICED CERAMIC ARMOUR.** High velocity ballistics trials on a recently developed glass-ceramic armour material suggest that it is competitive with alumina and boron carbide. Developed by Ceramic Developments (Midlands) Ltd., the material can be diced into tile form by a diamond slitting wheel at twice the stock removal rate achieved when slitting alumina. The article gives background on development and testing.

Herbert, Stan. *Ind Diamond Rev* v 46 n 513 Feb 1986 p 55-56.

**074435 RECOMMENDED REPLACEMENTS FOR TETRYL IN AUSTRALIAN PRODUCTION FUZES AND RELATED ORDNANCE.** The final phase of study into RDX-based formulations suitable for replacement of tetryl in Australian ordnance is described. 24 refs.

Spear, Robert J. (Materials Research Lab, Ascot Vale, Aust); Nanut, Victor; Redman, Lance D.; Dagley, Ian J. *Rep Mater Res Lab Aust* 1089 Nov 1987 32p.

**074436 COMPARATIVE ASSESSMENT OF US AND UK EXPLOSIVES QUALIFIED AS REPLACEMENTS FOR TETRYL.** Three UK and seven US production formulations qualified as replacements for tetryl in fuzes have been obtained through TTCP WTP-1. Characterization of powders - Rotter impact sensitiveness, temperature of ignition, vacuum thermal stability and electrostatic spark sensitivity - and of pressed charges - shock sensitivity - has been carried out at MRL. Our results are compared with UK and US published data, to produce probably the most complete comparative set published for production booster explosives. (Author abstract) 32 refs.

Spear, Robert J. (Materials Research Lab, Ascot Vale, Aust). *Rep Mater Res Lab Aust* 1094 Nov 1987 28p.

## Mathematical Models

**074437 ON THE OPTIMAL BURST HEIGHT AND BURST HEIGHT DISPERSION OF ANTIPERSONNEL HE PROJECTILES.** Based on an analysis of quantity relations between the burst height, high burst dispersion and the lethal area, this paper develops a mathematical model for determining the optimal burst height of HE projectiles and the high burst dispersion. Air burst HE projectiles are mainly used to fire at personnel in trenches. A formula for calculating the impact area of an infantryman in standing position in a trench is



presented, the method to calculate the lethal area is discussed, and results of a number of projectile types are obtained. (Author abstract) 2 refs. In Chinese.

Peng, Jicheng; Cheng, Yunmen. *Bingong Xuebao* n 1 Feb 1988 p 26-35.

**074438 OPTIMIZATION PROBLEM OF MORTAR BARREL AND BOMB CLEARANCES.** Optimum mortar windage to achieve maximum accuracy and required velocity for impacting the firing stud under two conditions of constraint is considered. These control constraints are considered to be bounded and the extremes have been studied. (Author abstract) 2 refs.

Sirpal, J.P. (Terminal Ballistics Research Lab, Chandigarh, India); Kapoor, Ashok. *Def Sci J* v 37 n 3 Jul 1987 p 305-317.

## Nondestructive Examination

**074439 NAVAL WEAPONS CENTER'S LIVE-ORDNANCE ENVIRONMENTAL, SAFETY AND NONDESTRUCTIVE TEST AND EVALUATION FACILITIES.** The live-ordnance environmental, safety and nondestructive test and evaluation facilities at the Naval Weapons Center are described. These facilities are unique for performing tests on all-up weapons containing explosive material during development programs. (Author abstract)

Parmenter, W.W. (US Naval Weapons Cent, China Lake, CA, USA). *J Environ Sci* v 30 n 5 Sep-Oct 1987 p 26-30.

## Testing

**074440 PENETRATION DYNAMICS OF EARTH PENETRATION WARHEAD INTO COMPOSITE TARGET MEDIA.** Attempts have been made to develop a suitable computer code that can find solutions to the axis-symmetric penetration of an Earth Penetrating Warhead yielding complete space-time histories of the resistive force offered by the target medium. The consequent warhead deceleration and velocity reduction, and the resulting axial compressive stress developed in the warhead casing as the penetration process progresses into the composite target media consisting of hard concrete of a specified thickness backed by soil have been discussed. (Edited author abstract) 4 refs.

Roy, P.K. (Armament Research & Development Establishment, Poona, India); Rama Rao, K.; Patkar, M.R. *Def Sci J* v 37 n 3 Jul 1987 p 347-360.

**ORE ANALYSIS** See Also FLUORSPAR—Chemical Analysis; GOLD AND ALLOYS—Chemical Analysis; LEAD MINES AND MINING; PHOSPHATE DEPOSITS—Africa; SILVER DEPOSITS—Peoples Republic of China; TANTALUM AND ALLOYS—Chemical Reactions.

**074441 DETERMINATION OF TRACE AND LOWER CONTENT OF Nb<sub>2</sub>O<sub>5</sub> AND Ta<sub>2</sub>O<sub>5</sub> IN ORES BY ICP-AES.** In order to meet the needs of rapid determination for a large number of samples in ore concentration, the step of chemical enrichment is omitted. Work for improvement apparatus has been done and effective measures for the chemical pretreatment of samples have been adopted. The lower limit of detection is 0.05 µg/cm<sup>3</sup>. Determination range is from 0.0003% to 2.5%. (Edited author abstract) 2 refs. In Chinese.

Lu Ming-xin (Research Inst of Non-ferrous Metals, China); Yu Gui-xiang. *Xi You Jin Shu* v 5 n 4 Nov 1986 p 292-296.

**074442 SPECTROPHOTOMETRIC DETERMINATION OF MICRO AMOUNTS OF MOLYBDENUM WITH THIOCYANATE-MALACHITE GREEN.** A simple selective method has been developed for photometric determination of molybdenum. The formation conditions of Mo(V)-SCN<sup>-</sup>-R<sup>+</sup> were studied. A green ternary complex of molybdenum (V) with reagents is formed at 0.15-0.3 mol/dm<sup>3</sup> with molar ratio 1:5:2. This method has been applied to the determination of micro amounts of molybdenum in ore samples. (Edited author abstract) In

Chinese.

Zhang, Xiao-yan (Research Inst of Non-ferrous Metals, Xian, China). *Xi You Jin Shu* v 6 n 1 Feb 1987 p 71-73.

**074443 SPECTROPHOTOMETRIC DETERMINATION OF MICROAMOUNTS OF GERMANIUM WITH ORTHO-NITROPHENYLFLUORONE AND TRITON X-100.** A simple and rapid method for spectrophotometric determination of germanium using o-nitrophenylfluorone (9-ortho-nitrophenyl-2,3,7-trihydroxyfluorone, o-NPF) in the presence of nonionic surfactant (Triton X-100) has been developed. In a mixed acid medium (0.5 mol/dm<sup>3</sup> of HCl + 0.5 mol/dm<sup>3</sup> of H<sub>3</sub>PO<sub>4</sub>) germanium can form an orange color ternary complex with the reagents. The complex exhibits a maximum absorption of 511 nm and the value of apparent molar absorption coefficient is 1.45 × 10<sup>5</sup>. The constituent of the complex is also established as Ge:o-NPF=1:4 in the presence of Triton X-100. This method has been used for the rapid determination of microamounts of germanium in ore. (Edited author abstract) In Chinese. 6 refs.

Wang, Zhen-qing (Nankai Univ, China); Xu, Guang-hui; Shen, Han-xi. *Xi You Jin Shu* v 6 n 2 May 1987 p 149-152.

**074444 SPECTROPHOTOMETRIC DETERMINATION OF TRACE GERMANIUM WITH UNDECYLFLUORONE IN THE PRESENCE OF CETYLTRIMETHYLAMMONIUM BROMIDE.** A new analytical agent, 2,3,7-trihydroxy-9-n-undecylfluorone (UF) was synthesized for the first time. The authors studied the color reaction of UF with germanium (IV) in the presence of cetyltrimethylammonium bromide (CTMAB). Trace germanium in ore was determined. (Edited author abstract) In Chinese. 8 refs.

Zhen, Yung-xi (Tsinghua Univ, China); Li, Xiao-qiang. *Xi You Jin Shu* v 6 n 3 Aug 1987 p 222-226.

**074445 QUANTITATIVE DETERMINATION OF HEMATITE AND GOETHITE IN LATERITIC BAUXITES BY THERMODIFFERENTIAL X-RAY POWDER DIFFRACTION.** An X-ray thermodifferential powder diffraction method for the quantitative determination of goethite and hematite in lateritic bauxites has been developed and consists of measuring the integrated intensities of the 012 line of hematite before and after heating the sample at 900°C and of correcting the obtained values by the X-ray mass absorption coefficient of either the untreated or heated matrix. From the corrected line intensities and the chemical analyses, the amounts of iron to be allocated to goethite and hematite in the untreated samples can be estimated. The actual content of goethite and hematite in a sample is calculated by taking into account the degree of Al substitution in each of these minerals. The method was tested on artificial mixtures of goethite and hematite and subsequently used to analyze 98 auger drill samples from lateritic bauxites of Guinea Bissau. The estimated precision of the determination of goethite and hematite content was ±2% (absolute). The method can not be applied to samples containing <10% Fe<sub>2</sub>O<sub>3</sub> (on a whole weight basis) unless preconcentration is carried out. (Author abstract) 14 refs.

Boski, T. (Vrije Univ Brussels, Brussels, Belg); Herbillon, A.J. *Clays Clay Miner* v 36 n 2 Apr 1988 p 176-180.

**074446 CORRELATION BETWEEN THE CONTENTS OF A USEFUL COMPONENT IN THE ORE STREAM AND ITS INFLUENCE ON THE RESULTS OF EXTRACTED ORE TESTING AND SORTING.** Studies with large-portion testing (LT) and large-portion sorting (LS) of extracted ore of radioactive, rare, and nonferrous metals by radiometric and nuclear physical methods have been done to determine the source of substantial discrepancies between the calculated and actual LT errors and to determine the complex relationship between the yield of tails in LS and the principal factors. The author has developed a simple and transparent technique which evaluates the degree of a trend in the contents and at the same time estimates the ore enrichability by large-portions sorting and the dependency of its

characteristics on the volume of the portions being sorted. 7 refs.

Shilov, A.S. *Sov Min Sci* v 23 n 1 Jan-Feb 1987 p 55-64.

Iron Determination See COAL—Chemical Analysis.

Radium Determination See RADIUM—Spectroscopic Analysis.

## Spectroscopic Analysis

**074447 ELECTRON PARAMAGNETIC RESONANCE STUDY OF CRYSTAL LATTICE SILVER IN GALENA.** The authors studied the silver in galena by means of electron paramagnetic resonance (EPR) for the first time. The results show that there is a fine structure line of the Gauss type in the spectrum. It is demonstrated that crystal lattice silver occurs in galena. In addition, the authors explained why this line had been generated and computed the concentration of lattice silver by contrasting this line with the intensity of the fine structure line. A new method has been provided for studying the occurrence of lattice silver in galena or in other sulfides. (Edited author abstract) 3 refs. In Chinese.

Luo, Xianchang (Central South Univ of Technology, China); Wang, Zengrun; Luo, Xianguo. *Zhongnan Kuan-gye Xueyuan Xuebao* v 18 n 6 Dec 1987 p 599-604.

**074448 NEAR-INFRARED REFLECTANCE ANALYSIS OF IRON ORES.** Near-infrared reflectance analysis (NIRA) has been applied to the rapid characterization of mineral samples. A suite of 82 West Australian iron ores was used to carry out the work. Approximately half the samples, chosen randomly, were used as a calibration set, while the remaining samples formed a prediction test set. Correlations were sought for eight of the significant practical properties of the samples. These properties were major element analysis, combined water, relative density, and goethite concentration. Reasonably close correlations were obtained for most of the properties, except silicon, although the estimated prediction errors were worse than those obtained with conventional methods. (Edited author abstract) 12 refs.

Fredericks, Peter M. (BHP, Walsend, Aust); Tattersall, Alan; Donaldson, Ralph. *Appl Spectrosc* v 41 n 6 Aug 1987, Fourteenth Annu Meet of the Fed of Anal Chem and Spectrosc Soc, Detroit, MI, USA, Oct 4-9 1987 p 1039-1042.

ORE DEPOSITS See Also ENVIRONMENTAL PROTECTION; MINERALOGY—Chlorites.

**074449 PROSPECTING IN AREAS OF GLACIATED TERRAIN 1986 (PAPERS PRESENTED AT THE SEVENTH INTERNATIONAL SYMPOSIUM).** This symposium proceedings contains 23 papers. The topics discussed are: geochemical exploration for gold deposits in areas of glaciated overburden; glacial transport distance as indicators of ore mineralization; geophysical surveys of auriferous moraine; lead-zinc exploration; digital image analysis applications in mineral exploration; tungsten exploration in glaciogenic deposits; litho-geochemistry of zinc-copper-pyrite deposits; gold transport in till; exploration for sediment-hosted exhalative mineralization; electromagnetic exploration methods; gold exploration in komatite complex; geophysical surveys in Finland; geochemical data interpretation through statistical analysis; anomaly enhancement using catchment basin analysis on surficial geochemical data; prospecting in Antarctica; stream-sediment geochemical survey of carbonate/alkaline complex; gold, molybdenum and tungsten tracing; length of boulder transport in Finland; drift prospecting for gold in Canada; copper-lead-zinc geochemistry; glacial dispersion of barite. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10942 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *Prospect in Areas of Glaciated Terrain 1986, Kuopio, Finl, Sep 1-2 1986* Publ by Int of Mining &



Metallurgy, London, Engl, 1986 269p.

**074450 CHANGES IN DISPERSION VARIANCE CONSEQUENT UPON INACCURATELY MODELLED SEMI-VARIOGRAMS.** The semi-variogram function which describes the spatial variation of samples as a function of their distance apart is an intermediary in geostatistical calculations. It is used in the calculation of several variances: the estimation variance which quantifies the accuracy of block estimates and the dispersion variance which measures the variability of blocks in the deposit. However the semi-variogram must be accurately modeled if these variances are to be well-known. The changes in dispersion variance calculated here when a spherical semi-variogram is estimated inaccurately show the need for care in its estimation, especially in the selection of the correct nugget effect. (Author abstract) 7 refs.

Brooker, Peter I. (Univ of Adelaide, Adelaide, Aust). *Math Comput Simul* v 30 n 1-2 1988, Simul Soc of Aust 1987 Conf, Melbourne, Aust, May 11-13 1987 p 11-16.

## Alaska

**074451 GEOLOGY, GEOCHEMISTRY, AND TECTONIC SETTING OF THE KHAYYAM AND STUMBLE-ON MASSIVE SULFIDE DEPOSITS, PRINCE OF WALES ISLAND, ALASKA.** The purpose of this study is to define the nature and origin of the massive sulfide deposits, including their tectonic setting within the Wales metamorphic suite. The study is based on reconnaissance mapping in the Wales metamorphic suite of central Prince of Wales Island and on detailed mapping at scales of 1:5,000 in the vicinity of the deposits and 1:500 at the mine sites. The mapping concentrated on host-rock lithologies south of the deposits where there is excellent exposure. The petrology and geochemistry of the host rocks, including the unusual wall-rock lithologies, have been studied using standard petrographic, microprobe, X-ray fluorescence, and neutron activation techniques, and the ore mineralogy has been investigated using reflected light microscopy, X-ray diffractometry, and the scanning electron microscope. 60 refs.

Barrie, C. Tucker (Univ of Toronto, Toronto, Ont, Can); Kyle, J. Richard. *Econ Geol Bull Soc Econ Geol* v 83 n 1 Jan-Feb 1988 p 182-196.

**074452 MINERAL AND WHOLE-ROCK COMPOSITIONS OF SEAWATER-DOMINATED HYDROTHERMAL ALTERATION AT THE ARCTIC VOLCANOGENIC MASSIVE SULFIDE PROSPECT, ALASKA.** The Arctic volcanogenic massive sulfide prospect, located in the Ambler mineral district of northwestern Alaska, includes three types of hydrothermally altered rocks overlying, underlying, and interlayered with semimassive sulfide mineralization. Hydrothermal alteration of wall rocks and deposition of sulfide and gangue minerals were contemporaneous with Late Devonian or Early Mississippian basalt-rhyolite volcanism. Whole-rock analyses of altered rocks surrounding the prospect indicate that strong chemical gradients exist in major and minor oxides and volatiles. Alteration developed asymmetrically around a linear fissure, suggesting fracture control of ore fluids rather than a point source. Microprobe analyses of phyllosilicates from the Arctic area indicate two discrete mineral populations. Magnesian chlorite, barian white mica, and barian fluorophlogopite in hydrothermally altered rocks have compositions distinct from similar minerals (chlorite, phengite, biotite) developed during high-pressure metamorphism in metapelitic and metavolcanic lithologies. These differences in mineral chemistry are the result of differences in protolith composition caused by hydrothermal alteration-metasomatism. (Edited author abstract). 36 Refs.

Schmidt, Jeanine M. (US Geological Survey, Anchorage, AK, USA). *Econ Geol Bull Soc Econ Geol* v 83 n 4 Jun-Jul 1988 p 822-842.

## Analysis

**074453 GENETIC AND EXPLORATION SIGNIFICANCE OF THE ZINC RATIO (100 Zn/(Zn+Pb)) IN MASSIVE SULFIDE SYSTEMS.** Comparison of the 100 Zn/(Zn+Pb) ratio ('zinc ratio') of various styles of mineralization in the Mount Read Volcanics of Tasmania indicates that volcanogenic massive sulfide deposits have a restricted range of mean values (60-77) and low standard deviations (less than 15) whereas other mineralization styles have a broader but lower range of mean values (39-61) and higher standard deviations (greater than 26). Thermochemical calculations on lead and zinc transport in saturated ore solutions show that the solution zinc ratio is controlled only by temperature and salinity and is independent of pH,  $I_{O(2)}$ , and activity of dissolved sulfur. Variations in the zinc ratio between individual massive sulfide deposits in the Mount Read Volcanics indicate that lead-zinc saturation of the ore solution rather than lead-zinc content in the footwall volcanic source rocks was the major control on the zinc ratio of the deposits. The characteristics zinc ratio of volcanogenic massive sulfide-style mineralization can be used to distinguish these deposits from other mineralization types in the Mount Read Volcanics. Effective use of this simple technique requires a reasonable number of anomalous samples and an unoxidized sample medium. Additional aspects of the subject and its application significance are discussed. (Edited author abstract) 40 refs.

Huston, David L. (Univ of Tasmania, Hobart, Aust); Large, Ross R. *Econ Geol Bull Soc Econ Geol* v 82 n 6 Sep-Oct 1987 p 1521-1539.

**074454 UNDERGROUND MAPPING AND COMPUTER ESTIMATION OF ORE RESERVES.** This paper traces the involvement of the mine surveyor with ore estimation procedures from the days when the art was simply a matter of sample lengths and assays being converted into tonnage and grade to the present time where an apparently highly sophisticated program approach is used. The author suggests that there is a tendency to accept that these computer-based methods have resolved all the problems of resource evaluation. It is easy to gain the impression that such programs have already taken into account errors in geological input, drill core data, sampling methods, volumes, assays, etc. (Author abstract)

Cooper, Graham H. (DDIAE, Aust). *Aust Surv* v 33 n 8 Dec 1987 p 718-730.

**074455 TIME OF MINERALIZATION IN THE EVOLUTION OF THE McDERMITT CALDERA COMPLEX, NEVADA-OREGON, AND THE RELATION OF MIDDLE MIOCENE MINERALIZATION IN THE NORTHERN GREAT BASIN TO COEVAL REGIONAL BASALTIC MAGMATIC ACTIVITY.** This paper focuses on the relationship between Neogene hydrothermal activity and mineralization in the northern Great Basin and coeval magmatic activity. New data show that mineralization at the McDermitt mercury mine is closely related to major stages of evolution of the McDermitt caldera complex. On a regional scale, the authors emphasize the very close association in time between mineralization and a major pulse of middle Miocene basaltic and basalt-related volcanism. The spatial and temporal associations in conjunction with evidence for elevated initial gold contents of mafic rocks and their intermediate composition differentiates suggest that such rocks must be considered as possible sources for the gold in the various epithermal and hot springs deposits of the region. 52 Refs.

Noble, Donald C. (Univ of Nevada-Reno, Reno, NV, USA); McCormack, John K.; McKee, Edwin H.; Silverman, Miles L.; Wallace, Andy B. *Econ Geol Bull Soc Econ Geol* v 83 n 4 Jun-Jul 1988 p 859-863.

## Arizona

**074456 STRUCTURAL REINTERPRETATION OF THE AJO MINING DISTRICT, PIMA COUNTY, ARIZONA, BASED ON PALEOMAGNETIC AND**

**GEOCHRONOLOGIC STUDIES.** The Ajo mining district of southern Arizona is divided into two main structural blocks by the Gibson Arroyo fault. Paleomagnetic and geologic evidence indicates that the ore deposit has been tilted to the south a total of approximately 120°: 68° before and another 55° after emplacement of the overlying Locomotive Ganglomerate and Ajo Volcanics. Paleomagnetic directions are consistent with the southward tilting of the volcanic rocks, but they suggest that the remanent magnetization and perhaps the K-Ar dates of the western intrusion were reset by the emplacement of dikes younger than the Locomotive Ganglomerate and Ajo Volcanics. These and other geologic relations indicate a sequence of mid-Tertiary events in the district, which the paper discusses. (Edited author abstract) 22 refs.

Hagstrum, Jonathan T. (US Geological Survey, Menlo Park, CA, USA); Cox, Dennis P.; Miller, Robert J. *Econ Geol Bull Soc Econ Geol* v 82 n 5 Aug 1987 p 1348-1361.

**074457 RELATIONSHIPS BETWEEN A PORPHYRY Cu-Mo DEPOSIT, BASE AND PRECIOUS METAL VEINS, AND LARAMIDE INTRUSIONS, MINERAL PARK, ARIZONA.** In the Wallapai mining district, porphyry-style copper-molybdenum mineralization occurs within and near Laramide granitoid stocks at the center of an elongate zone of polymetallic quartz veins. The principal mineralized veins form a well-defined paragenetic sequence, with a simplified mineralogy progressing through a variety of minerals. The coexistence of vapor- and liquid-rich fluid inclusions in vein quartz shows that the molybdenite-bearing anhydrite and quartz veins formed at 360 to 410°C from boiling, low-salinity brines. Copper and molybdenum mineralization occurred in a lithocap environment above a progenitor intrusion but was not directly related to the exposed Ithaca Peak stocks. The evolution from hypersaline fluids in the anhydrite-chalcocopyrite veins to low-salinity, lower temperature fluids in the quartz-pyrite veins suggests an influx of meteoric water. Brines up to 100°C hotter appeared during the formation of the paragenetically later polymetallic quartz veins and constituted a new, and much larger, hydrothermal system. (Edited author abstract). 50 Refs.

Lang, James R. (Univ of Arizona, Tucson, AZ, USA); Eastoe, Christopher J. *Econ Geol Bull Soc Econ Geol* v 83 n 3 May 1988 p 551-567.

## Australia

**074458 DISTRICT-SCALE ALTERATION ASSOCIATED WITH MASSIVE SULFIDE DEPOSITS IN THE MOUNT READ VOLCANICS, WESTERN TASMANIA.** The distribution of secondary mineral assemblages in six mineralized areas of the Mount Read Volcanics defines a district-wide zonation which is sub-conformable with massive sulfide host horizons and the contacts of sill-like granitoids where present. The relationships between alteration patterns and elements of Cambrian geology strongly suggest that the alteration is related to Cambrian hydrothermal circulation responsible for massive sulfide mineralization. There is a later greenschist facies metamorphic overprint. Chlorite compositions preserve local patterns due to Cambrian hydrothermal processes, but they do not vary systematically with alteration assemblages throughout the province. Chlorite Mg to Fe ratios appear to have been preserved through metamorphism. A combination of structural and alteration data is useful to mapping in the Mount Read volcanics. Study results are discussed. 54 refs.

Eastoe, C.J. (Univ of Arizona, Tucson, AZ, USA); Solomon, M.; Walshe, J.L. *Econ Geol Bull Soc Econ Geol* v 82 n 5 Aug 1987 p 1239-1258.

## California

**074459 PERMIAN KUROKO-TYPE HYDROTHERMAL SYSTEM, AFTERTHOUGHT-INGOT AREA, SHASTA COUNTY, CALIFORNIA: LATERAL AND VERTICAL SECTIONS, AND GEOCHEMICAL EVOLUTION.** The Afterthought and smaller kuroko deposits in the East Shasta mining district formed at the culmination of a late Permian mafic to felsic



volcanic cycle. They were succeeded by Triassic clastic sediments and reworked tuff in a presumed rifting environment with local evidence of renewed mafic volcanism and large-scale slumping. The Afterthought host horizon is repeated in an outcrop by folding. The kuroko deposits comprise three ore types: A: banded, fine-grained sulfides and gangue; B: recrystallized, coarser grained sulfides and gangue with a consistent paragenetic sequence; and C: coarse-grained pyrite and barite. B and C appear to replace type A. A further type of mineralization, type D, consists of fine-grained pyrite occurring locally within silicified dacite on the Afterthought host horizon. The paragenetic sequence of type B implies a sequential introduction of metals in a fluid evolving toward higher  $H_2S$  activity. Cu was introduced early as chalcopyrite and bornite; later fluids altered preexisting Cu minerals rather than introducing significant new Cu. The last type B fluids dissolved much base metal sulfide and deposited calcite, quartz, and sericite. (Edited author abstract). 43 Refs.

Eastoe, C.J. (Univ of Arizona, Tucson, AZ, USA); Nelson, S.E. *Econ Geol Bull Soc Econ Geol* v 83 n 3 May 1988 p 588-605.

## Chile

**074460 GEOLOGIC AND METALLOGENIC SIGNIFICANCE OF THE ISOTOPIC COMPOSITION OF LEAD IN GALENAS OF THE CHILEAN ANDES.** Galenas from deposits hosted by pre-Jurassic to Jurassic rocks are relatively enriched in radiogenic Pb, reflecting the involvement of old crustal Pb. Galenas from Lower Cretaceous-hosted deposits are less radiogenic and may reflect a mantlelike component. Those from Tertiary rocks are isotopically more variable, reflecting the influence of a more evolved crust. There is no obvious correlation between the isotopic composition of the galena leads and the age of the hydrothermal event that gave rise to the particular mineral deposit (when such ages can be determined from independent geologic evidence). It is concluded that the galena leads were derived from a mixture of different lead reservoirs. The correlation of isotopic composition with age of host rocks suggests either that the concentration of lead to form galena was more or less contemporaneous with the formation of the host rock or that the galena lead was essentially derived from the country rocks and inherited their original isotopic signature. (Edited author abstract). 48 Refs.

Puig, Alvaro (Servicio Nacional de Geología y Minería, Santiago, Chile). *Econ Geol Bull Soc Econ Geol* v 83 n 4 Jun-Jul 1988 p 843-858.

**Classification** See MANGANESE DEPOSITS; PLATINUM METALS—Geochemistry.

## Colorado

**074461 GENESIS OF ACID-SULFATE ALTERATION AND Au-Cu-Ag MINERALIZATION AT SUMMITVILLE, COLORADO.** The Summitville Au-Cu-Ag deposit occurs within a porphyritic quartz latite, primarily in a zone of 'vuggy silica' alteration characterized by leaching of all major elements except silica and iron. Vuggy silica is best developed between an elevation of 3,700 and 3,500 m where it occurs in irregular pipes and lenticular pods up to 70 m wide and is enclosed by up to 30 m of intense quartz-alunite alteration. Sulfide mineralization occurs primarily within the vuggy silica. Consideration of alunite, kaolinite, and pyrite stability relations and of aluminum speciation at 250°C indicates that a pH of 2 or below and a  $\log f_{O_2}$  of  $-31 \pm 1$  (at 250°C) were necessary to produce vuggy silica alteration. Textural and geochemical relationships indicate that sulfide and gold mineralization postdate the formation of vuggy silica alteration in the deposit and are not directly related to the highly acidic solutions necessary for this early acid-leaching event. Additional study results and conclusions are discussed. (Edited author abstract) 60 refs.

Stoffregen, Roger (Univ of California, Berkeley, CA, USA). *Econ Geol Bull Soc Econ Geol* v 82 n 6 Sep-Oct 1987 p 1575-1591.

**Estimation** See MINERAL INDUSTRY AND RESOURCES—Evaluation.

## Exploration

**074462 EVALUATING THE MORPHOLOGICAL CHARACTERISTICS OF ORE DEPOSITS IN PROSPECTING CROSS SECTIONS.** The results of the studies described in this paper have made it possible to establish a dependence of the errors of the main metric characteristics of contours determined from a relatively sparse network of intersections on the distance between the intersections and the methods of contour mapping employed. The presence of this dependence precludes the use of the ratio of the ore contour perimeter to the ore area to estimate the morphological features of mineralization in prospecting cross sections when it is determined from a sparse prospecting network. Therefore, it is advisable to use only data obtained on sampling detailization sections where the distances between the cross sections are no less than 20 m. In Russian. 5 refs.

Yaskovskii, P.P.; Fireiskii, D.M. *Razved Okhr Nedr* n 9 Sep 1987 p 16-19.

**074463 DETERMINATION OF W AND Mo IN NATURAL SPRING WATERS BY ICP-AES (INDUCTIVELY COUPLED PLASMA ATOMIC EMISSION SPECTROMETRY) AND ICP-MS (INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY): APPLICATION TO SOUTH NAHANNI RIVER AREA, N.W.T., CANADA.** The relative merits of analyzing fresh and saline waters for W and Mo by inductively coupled plasma-atomic emission spectrometry (ICP-AES) and ICP-mass spectrometry (ICP-MS) have been examined. A preconcentration step via adsorption of Cretaceous the analysis onto activated charcoal is mandatory in analysis by ICP-AES in order to achieve practical detection limits of  $1.2 \mu\text{g L}^{-1}$  for W and  $0.4 \mu\text{g L}^{-1}$  for Mo. This step is also necessary in analysis by ICP-MS for water high in total dissolved salts ( $> 1000 \text{ mg L}^{-1}$ ). Application of this procedure results in detection limits of  $0.06 \mu\text{g L}^{-1}$  for both elements, based on a 100-mL sample volume. The above methods were applied to 41 samples of waters taken from thermal, cold and iron-rich springs in the South Nahanni River area. Four distinctly anomalous sites (22  $15 \mu\text{g L}^{-1}$  W) are hot springs spatially associated with Cretaceous granites, and three of these are in the vicinity of known scheelite-bearing skarns or wolframite occurrences. The remainder of the sites, located in folded and faulted sedimentary rocks as well as granites, produced waters with W and Mo abundances at or below detection limits. (Edited author abstract) 52 refs.

Hall, G.E.M. (Geological Survey of Canada, Ottawa, Ont, Can); Jefferson, C.W.; Michel, F.A. *J Geochem Explor* v 30 n 1 Mar 1988 63-84.

**074464 INTEGRATING SPATIAL AND FREQUENCY INFORMATION IN THE SEARCH FOR KUROKO DEPOSITS OF THE HOKUROKU DISTRICT, JAPAN.** A new method (FINDER) that uses the area of influence and Bayesian statistics to aid in selection of target areas on the basis of one or more variables and multiple observations was tested with drill hole data. A previously defined bimodal distribution of  $\text{Na}_2\text{O}$  with the low sodium group confined to a  $1.5 \times 3.0\text{-km}$  zone beneath the cluster of deposits at Fukazawa was used as a control area for one test of FINDER. Using the  $\text{Na}_2\text{O}$  means and standard deviations for the control area and minimum  $\text{Na}_2\text{O}$  values from 174 drill holes, a probability map of centers of sodium depletion is produced for the Hokuroku district. High probability areas correspond to the known deposits that should have been rediscovered and to several areas without known deposits. Use of X-ray data from 165 drill holes, some of which also have chemical analyses, led to the identification of two additional variables, sericite and gypsum plus anhydrite, that allow more drill holes to be used and that expand the areas of influence around drill holes. (Edited author abstract) 22 refs.

Singer, Donald A. (US Geological Survey, Menlo Park, CA, USA); Kouda, Ryoichi. *Econ Geol Bull Soc Econ*

*Geol* v 83 n 1 Jan-Feb 1988 p 18-29.

**074465 FIELD, ISOTOPIC, AND CHEMICAL STUDIES OF TOURMALINE-BEARING ROCKS IN THE BELT-PURCELL SUPERGROUP: GENETIC CONSTRAINTS AND EXPLORATION SIGNIFICANCE FOR SULLIVAN TYPE ORE DEPOSITS.** The Sullivan Pb-Zn-Ag massive sulphide deposit (located in the mid-Proterozoic Belt-Purcell Supergroup near Kimberley, British Columbia) is associated with a large tourmalinite alteration zone. A petrologically similar, but barren, alteration zone has recently been discovered at Trestle Creek, Idaho. Because of the importance of the Sullivan deposit, several methods of exploration involving tourmaline have recently been proposed in the literature. To test these proposals, the authors compared the alteration zone at Sullivan (using literature data) with that at Trestle Creek. The two areas can clearly be distinguished using Mg content in tourmaline and  $\delta^{18}\text{O}$  in albite, can probably be distinguished using  $\delta^{18}\text{O}$  in tourmaline-bearing rocks, but cannot be distinguished using alteration mineralogy alone. In addition we found that tourmaline occurs in at least eight different geologic settings in the Belt-Purcell Supergroup. Additional aspects of the subject are discussed. (Edited author abstract) 35 refs.

Beatty, David W.; Hahn, Gregory A.; Threlkeld, William E. *Can J Earth Sci* v 25 n 3 Mar 1988 p 392-402.

**074466 ORE DEPOSIT MODELS #14. VOLCANOGENIC MASSIVE SULPHIDE DEPOSITS. PART 2: GENETIC MODELS.** Characteristics of volcanogenic massive sulphide VMS deposits were described in Part 1 of this article. Discussion here is limited to those processes and related geological aspects that have been of the most concern in the recent literature. These include: (i) processes of sulphide accumulation which form the massive sulphide lens and which in turn control the morphology, texture, mineralogical zonation, etc. of the sulphide body; (ii) processes in the immediate footwall of proximal VMS deposits that give rise to the hydrothermal alteration pipe and stockwork ore; (iii) reasons for fluid flow in the hydrothermal system, which in turn help explain the geological setting and distribution of VMS deposits; and (iv) origin and nature of the hydrothermal fluids, which in turn determine the source of the ore constituents and the chemistry of the sulphide ores. 197 Refs.

Lydon, John W. (Geological Survey of Canada, Ont, Ottawa, Can). *Geosci Can* v 15 n 1 Mar 1988 p 43-65.

## Finland

**074467 GEOMETRY OF SHEATH FOLDS AND RELATED FABRICS AT THE LUIKONLAHTI MINE, SVEVOKARELIDES, EASTERN FINLAND.** The Luikonlahti Cu-Co-Zn sulfide ore deposit is hosted by metasediments associated with serpentinites in the 1.97 Ga old Outokumpu assemblage in the Svevokarelidides of eastern Finland. Polyphase deformation of the host rocks, a history shared by the ore body, includes a phase of sheath fold propagation. A modified vergence rule, utilizing only the intersection geometry of planar fabric elements, permits recognition of these extremely curvilinear folds in poorly exposed terrain. The detailed geometry of these rocks is independently resolved from borehole and underground stope records. Sheath fold propagation occurred during D<sub>2</sub>, the second phase of regional deformation. In the Kaavi district D<sub>2</sub> major structures are either thrusts or thrust-related. The Luikonlahti sheaths are located in a steeply dipping shear zone formed during this deformation episode. (Author abstract). 20 Refs.

Park, Adrian F. (Univ of Glasgow, Glasgow, Scotl). *J Struct Geol* v 10 n 5 1988 p 487-498.

## France

**074468 EVOLUTION MINÉROLOGIQUE ET ISOTOPIQUE (Pb) DU FILON SULFURE COMPLEXE DES BORDERIES (MASSIF CENTRAL FRANÇAIS) — IMPLICATIONS MÉTALLOGÉNIQUES.** [Mineralogical and Isotopic (Pb) Evolution



tion of a Polymetallic Vein at Les Borderies (French Central Massif) - Metallogenetic Implications]. The polymetallic vein (Sb, Pb, Zn, Ag, Cu) of Les Borderies (Puy de Dome, France) results from a succession of four stages of mineralization. Each has its own mineralogical, geochemical and isotopic (Pb) characteristics. This study shows that mineralogical studies combined with lead isotope analysis for specific sulfides allow determination of the genesis of complex ore deposits. (Edited author abstract) In French. 27 refs.

Marcoux, E. (BRGM, Orleans, Fr); Moelo, Y.; Picot, P.; Baubron, J.-C. *Miner Deposita* v 23 n 1 1988 p 58-70.

## Geochemistry

**074469 COMPOSITION AND ACTIVITY OF SULFUROUS SPECIES IN QUENCHED MAGMATIC GASES ASSOCIATED WITH PYRRHOTITE-BEARING SILICIC SYSTEMS.** Study of pyrrhotite-bearing volcanic units such as the El Chichon, St. Helens, and Fish Canyon tuffs demonstrates that the activity of sulfurous gases in calc-alkaline systems is often quite high. Oxidizing systems have especially high activities of  $\text{SO}_2$  in early volatile phases. Upon cooling, oxidized compositions react to form sulfate-rich solutions through the reactions  $4\text{SO}_2 + 4\text{H}_2\text{O} = 3(\text{H}_2\text{SO}_4) + \text{H}_2\text{S}$  whereas reduced compositions from hydrogen sulfide-rich solutions by the reaction  $\text{SO}_2 + 3\text{H}_2 = \text{H}_2\text{S} + 2\text{H}_2\text{O}$ . In both cases, the quenched magmatic component is high in total sulfur content and possesses high oxygen and sulfur fugacities. The high sulfate content, either inherited directly from the reaction of magmatic gases or derived from the oxidation of magmatic  $\text{H}_2\text{S}$  by meteoric waters, may be an important component for the transport of certain ore-forming elements. The conditions derived from these calculations duplicate those determined from natural magmatic-dominated systems such as Summitville, Colorado. (Edited author abstract) 31 refs.

Whitney, James A. (Univ of Georgia, Athens, GA, USA). *Econ Geol Bull Soc Econ Geol* v 83 n 1 Jan-Feb 1988 p 86-92.

**074470 SULFUR ISOTOPE VARIABILITY IN SEDIMENT-HOSTED MASSIVE SULFIDE DEPOSITS AS DETERMINED USING THE ION MICROPROBE SHRIMP: I. AN EXAMPLE FROM THE RAMMELSBERG OREBODY.** Ores from weakly or unmetamorphosed stratiform or strata-bound massive sulfide deposits such as Rammelsberg, Kuroko, or Mount Isa, are fine grained and texturally complex, containing multiple generation of minerals. Understanding the timing of and process involved in, their formation has remained a formidable task. In situ ion microprobe analytical techniques have been developed to circumvent some of the difficulties involved in sample purification necessary for conventional sulfur isotope determinations and allow concurrent examination of ore textural and isotopic characteristics on a scale as small as  $20\ \mu\text{m}$ . Though the interpretation of the nature and timing of ore depositional processes at Rammelsberg has not been aided by the ambiguous morphological characteristics of individual clasts, the sulfur isotope signatures of the minerals, as well as inter- and intraclast textural relationships which remain undisturbed through in situ analyses, may be quite useful as guides to key issues as the dependence of ore formation on the presence of biogenic sulfide. 28 refs.

Eldridge, C.S. (Australian Natl Univ, Canberra, Aust); Compston, W.; Williams, I.S.; Both, R.A.; Walshe, J.L.; Ohmoto, H. *Econ Geol Bull Soc Econ Geol* v 83 n 2 Mar-Apr 1988 p 443-449.

**074471 CHEMICAL CONTROLS ON THE SOLUBILITY, TRANSPORT, AND DEPOSITION OF PLATINUM AND PALLADIUM IN HYDROTHERMAL SOLUTIONS: A THERMODYNAMIC APPROACH.** Thermodynamic calculations of the solubility of Pt and Pd up to  $300^\circ\text{C}$  using isocoulombic extrapolation, the correspondence principle, linear free energy relationships, and the theory of stepwise ligand replacement indicate that, depending on physicochemical conditions, complexation by either  $\text{OH}^-$ ,  $\text{HS}^-$ , or  $\text{Cl}^-$  can

contribute to the transport of these metals in hydrothermal solutions. These calculations suggest that Pt and Pd may be mobile in a variety of environments. In kupferscheifer-type ore-forming fluids they could be transported as chloride complexes. The lack of acidic alteration and oxidized mineral assemblages in hydrothermal Pt and Pd occurrences in shear zones in metagabbroic rocks, such as those at New Rambler, Wyoming, and Rathbun Lake, Ontario, preclude Pt and Pd transport as chloride complexes during formation of these deposits. In these cases, bisulfide and/or hydroxide complexes are more likely responsible for precious metal transport. (Edited author abstract). 86 refs.

Mountain, Bruce W. (McGill Univ, Montreal, Que, Can); Wood, Scott A. *Econ Geol Bull Soc Econ Geol* v 83 n 3 May 1988 p 492-510.

## Greece

**074472 GENESIS OF NICKEL LATERITES AND BAUXITES IN GREECE DURING THE JURASSIC AND CRETACEOUS, AND THEIR RELATION TO ULTRABASIC PARENT ROCKS.** Nickel laterites and bauxites, including their proposed parent rocks from the Mesozoic of Greece, have been investigated by means of mineralogical and geochemical methods. The results are discussed in order to recognize the genetic sequence which comprises: pre-lateritic alteration and reworking of ophiolites and associated rocks, lateritic in-situ weathering, reworking and redeposition of the alteration products in a epicontinental transition environment, and post-depositional events affecting the mineralogical and geochemical properties. The ultramafic massifs of the Euboea and Locris area, i.e., the parent rocks of the Ni-Fe deposits, are primarily harzburgites which represent the erosional outliers of a probable 'complete' ophiolitic nappe that were transformed to a monomineralic lizardite. Xenoliths of basic and sedimentary rocks are included in the serpentine matrix of the basal tectonic melange. (Edited author abstract) 66 refs.

Valeton, I. (Univ Hamburg, Hamburg, West Ger); Biermann, M.; Reche, R.; Rosenberg, F. *Ore Geology Rev* v 2 n 4 Aug 1987 p 359-404.

## Illinois

**074473 STRONTIUM ISOTOPE GEOCHEMISTRY OF FLUORITE, CALCITE, AND BARITE OF THE CAVE-IN-ROCK FLUORITE DISTRICT, ILLINOIS.** In this study, strontium isotopes have been used to constrain the number and possible sources of the ore-forming fluid(s) at the Cave-in-Rock district. Because minerals like fluorite, calcite, and barite have very low Rb/Sr ratios and there is no fractionation in the strontium isotopes during mineral precipitation, the  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios of these hydrothermal minerals should be a measure of the isotopic composition of the mineralizing fluids. Previous work sets a framework for the strontium isotope signatures of deposits that are also thought to be formed by basinal brines. 30 refs.

Ruiz, Joaquin (Univ of Arizona, Tucson, AZ, USA); Richardson, Catherine K.; Patchett, P. Jonathan. *Econ Geol Bull Soc Econ Geol* v 83 n 1 Jan-Feb 1988 p 203-210.

## Japan

**074474 PALEOMAGNETIC EVIDENCE FOR THE TIMING OF FORMATION OF THE CHICHIBU PYROMETASOMATIC DEPOSITS, JAPAN.** The timing of formation of the Chichibu pyrometasomatic deposits is given chronologically: (1) intrusion of the quartz diorite A body in the normal polarity chron; acquisition of a normal polarity magnetization by the A body; (2) intrusion of the quartz diorite C body after the change of the geomagnetic field from normal to reversed; acquisition of a reversed polarity magnetization by the C body; (3) skarn formation, mineralization, and hydrothermal alteration in the reversed chron; acquisition of reversed polarity magnetization by hematite and pyrrhotite ores; (4) intrusion of dike rocks just after the main

mineralization during the reversed polarity chron; acquisition of a reversed magnetization by dike rocks; and (5) extremely strong alteration with pyritization after the change of the geomagnetic field from reversed to normal; acquisition of normal polarity magnetization by the quartz diorite B body and a part of the quartz diorite A body. (Edited author abstract) 30 refs.

Ueno, Hirotomo (Tohoku Univ, Sendai, Jpn); Tonouchi, Shoji. *Econ Geol Bull Soc Econ Geol* v 82 n 7 Nov 1987 p 1723-1731.

Leaching See MINES AND MINING—Solution Mining.

## Mathematical Models

**074475 GENERALIZED FILTERING AND THE AUTOMATION OF ESTABLISHING A MATHEMATIC MODEL OF ORE BODIES.** Generalized filtering and a Yang Chizhong functions have been found, and their application results in establishing the mathematic model of an ore body, automatically carried out. This indicates that the development of the statistical theory of geologic variables of an ore deposit is at a new stage. (Edited author abstract) 5 refs.

Yang, Shanci. *Zhongnan Kuangye Xueyuan Xuebao* v 18 n 4 Aug 1987 p 392-396.

## Microanalysis

**074476 APPLICATIONS OF PROTON AND NUCLEAR MICROPROBES IN ORE DEPOSIT MINERALOGY AND METALLURGY.** The micro-PIXE technique usefully complements the analytical capabilities of the electron microprobe in many investigations of ore deposit mineralogy and metallurgy. Unfortunately, micro-PIXE has not been widely used, largely because of a paucity of accessible proton/nuclear microprobes designed with sample- and data-handling facilities suitable for mineralogical targets. Ore deposit mineralogy studies are performed to achieve a wide range of objectives: from the identification of parameters useful for mineral exploration through an understanding of the genesis of ore deposits to a complete characterization of the minerals, necessary to provide guidance for mineral beneficiation and metal extraction. The specific requirements for an ideal proton microprobe for mineral analyses are discussed. In addition, new analytical data are presented for sulfide minerals (troilite and entlandite), an oxide mineral (chromite), and for copper anodes. (Edited author abstract) 36 refs.

Cabri, Louis J. (CANMET, Ottawa, Ont, Can). *Nucl Instrum Methods Phys Res Sect B* v B30 n 3 Mar II 1988, Nucl Microprobe Technol and Appl, Proc of the First Int Conf, Oxford, Engl, Sep 1-4 1987 p 459-465.

## Missouri

**074477 DISTRIBUTION OF SELECTED ELEMENTS IN THE SHALE OF THE DAVIS FORMATION, BUICK MINE AREA, VIBURNUM TREND, SOUTHEAST MISSOURI.** Ninety-five shale samples from drill holes that intersected the base of the Davis shale as well as a drill hole that cored the entire section of the formation were collected and analyzed for 26 elements by neutron activation. It was found that ore-forming and related solutions had produced a broad zone of enrichment at the base of the Davis shale that, for some elements, extends up to 0.5 and 1.0 km west and east of the ore zones, respectively. These data suggest that the shale of the Davis Formation may have acted as a sink and subsequently a source for Na, K, Mn, Fe, and Zn, as well as a sink for As. Episodic mineralization and leaching are believed to be responsible for the initial enrichment and subsequent removal of these elements in the Davis shale. The enrichment zone at the 'base of the Davis shale, best delineated by Fe and Zn, is laterally extensive and could prove to be a useful guide to ore mineralization in this and other Mississippi Valley-type districts. Arsenic may be of use as an indicator of pathways taken by ore-forming and/or related solutions. (Edited author abstract) 27 refs.



Panno, Samuel V. (Brookhaven Natl Lab, Upton, NY, USA); Harbottle, Garman; Sayre, Edward V. *Econ Geol Bull Soc Econ Geol* v 83 n 1 Jan-Feb 1988 p 140-152.

## Morocco

**074478 APERCU SUR LES AMAS SULFURES MASSIFS DES HERCYNIDES MAROCAINES.** [Massive Sulfide Deposits of Moroccan Hercynian Islets]. Massive sulfide deposits located on Hercynian islets of northwestern Morocco exhibit four main characteristics. They are strata bound massive pyrrhotite deposits mined for sulfur and/or base metals occasionally occurring as sulfides of workable grade. Volcanic rocks with which these massive sulfide orebodies are associated are scarce, although always present as acid flows of submarine emissions of either rhyolitic or more often quartz-keratophytic nature. Stockworks underlying the massive sulfide orebodies are common, but not systematic. Associated alterites and exhalites belong to three types, i.e., sericitite (or biotite-rich rock), chloritite, and/or chert (jasper). These volcano-sedimentary deposits exhibit distal features with regard to the volcanism coeval with their sedimentation. They are mostly linked with strongly reducing environmental properties entailing pyrrhotite and/or magnetic syngenetic deposition, whatever the iron activity. (Edited author abstract) In French. 23 refs.

Bernard, A.J. (Ecole Natl Supérieure de Géologie, Nancy, Fr); Maier, O.W.; Mellal, A. *Miner Deposita* v 23 n 2 Apr 1988 p 104-114.

## New Brunswick

**074479 STOCKWORK TUNGSTEN (SCHEELITE)-MOLYBDENUM MINERALIZATION, LAKE GEORGE, SOUTHWESTERN NEW BRUNSWICK.** Scheelite-molybdenite stockwork mineralization constitutes one component of the Lake George polymetallic (Sb-W-Mo-Au-base metal) deposit, a complex hydrothermal center of Late Silurian (ca. 412 m.y.) age in the Fredericton trough of the northern Appalachians. The W-Mo deposit comprises three different scheelite-and/or molybdenite-bearing veinlet types. In both type 1 and 2 systems, scheelite and molybdenite deposit appears to have been controlled by decreasing temperature and increasing pH. Temperature was a function of distance from the cupola for both veinlet types, but the controls on pH were specific to each. Thus, the pH of type 1 fluids was controlled by wall-rock interaction (H metasomatism), whereas that of type 2 fluids was controlled by CO<sub>2</sub> effervescence. The economic stibnite-quartz veins occupy fractures which transect, and therefore, postdate all stages of W-Mo mineralization. (Edited author abstract) 76 refs.

Seal, Robert R. II (Queen's Univ, Kingston, Ont, Can); Clark, Alan H.; Morrissy, Charles J. *Econ Geol Bull Soc Econ Geol* v 82 n 5 Aug 1987 p 1259-1282.

## New Mexico

**074480 STRATIGRAPHY, AGE, AND RATES OF DEPOSITION OF THE DATIL GROUP (UPPER EOCENE-LOWER OLIGOCENE), WEST-CENTRAL NEW MEXICO.** The Datil Group, formerly called the Spears Formation, comprises a series of volcanoclastic rocks, lava flows, and ash-flow tuffs that crops out in a broad, west-trending swath of discontinuous exposures in west-central New Mexico. The Datil Group is the oldest unit in the northern Mogollon-Datil volcanic field, and ranges in thickness from more than 1 km to about 300 m where it overlies late Laramide uplifts. This report summarizes part of a doctoral dissertation on the Datil Group and incorporates 15 new radiometric dates. 39 refs.

Cather, Steven M. (New Mexico Bur of Mines & Mineral Resources, Socorro, NM, USA); McIntosh, William C.; Chapin, Charles E. *NM Geol* v 9 n 3 Aug 1987 p 50-54.

## Newfoundland

**074481 ISLE AUX MORTS PROSPECT: THE FIRST SIGNIFICANT BASE METAL DISCOVERY IN THE PORT AUX BASQUES COMPLEX OF**

**SOUTHWEST NEWFOUNDLAND.** The Isle aux Morts Prospect is the first polymetallic, sulfide mineralization reported from the Port aux Basques Complex of southwest Newfoundland, Zn-Pb-Cu-Ba-Ag mineralization hosted by quartz-muscovite semipelitic occurs at the contact between a quartzofeldspathic unit and pelitic unit with intercalated amphibolite. Ore minerals comprise sphalerite-galena-chalcocopyrite in order of decreasing abundance. The principal gangue minerals are quartz, muscovite, feldspar and barite. Three morphologic types of mineralization are present: massive with more than 50% sulfide, flanked on one or both sides by disseminated and/or banded types. (Edited author abstract) 55 refs.

O'Neill, Pat P. (Dep of Mines and Energy, St. John's, Newfoundland, Can); Strong, D.F. *CIM Bull* v 18 n 910 Feb 1988 p 59-68.

## Nonmetallic

**074482 ORIGIN OF DIASPORE AND PYROPHYLLITE IN THE FOXTRAP PYROPHYLLITE DEPOSIT, AVALON PENINSULA, NEWFOUNDLAND: A REINTERPRETATION.** The Foxtrap pyrophyllite mine is the only commercial source of pyrophyllite in Canada. It is situated on the Avalon peninsula of Newfoundland within a belt of late Precambrian rocks of the Avalon zone. The rocks in which the pyrophyllite deposit occurs belong to the Harbour Main Group and consist predominantly of a northerly trending belt of rhyolitic flows and pyroclastics (the Harbour Main volcanics), with a minor sedimentary component. In the central part of the Avalon peninsula the Harbor Main volcanics have been intruded by a shallow-level composite granitoid pluton, the Holyrood batholith. This paper presents a new interpretation for the origin of diaspore and pyrophyllite in the Foxtrap deposit, consistent with the textures and assemblages of minerals documented by V.S. Papezik and H.F. Keats (1976). 12 refs.

Bryndzia, L. Taras (Univ of Chicago, Chicago, IL, USA). *Econ Geol Bull Soc Econ Geol* v 83 n 2 Mar-Apr 1988 p 450-453.

**074483 GEOLOGY AND ORIGIN OF THE YOGO SAPPHIRE DEPOSIT, MONTANA.** The Yogo sapphire deposit is located in central Montana approximately 72 km southwest of Lewistown. The deposit was discovered by gold prospectors and became an important source of sapphires in the early part of this century. Despite its long history and periods of active mining, little has been published on the geology of the deposit. This paper presents a brief summary of the occurrence, properties, and possible origins of the Yogo sapphire. 29 refs.

Brownlow, Arthur H. (Boston Univ, Boston, MA, USA); Komorowski, Jean-Christophe. *Econ Geol Bull Soc Econ Geol* v 83 n 4 Jun-Jul 1988 p 875-880.

## North Carolina

**074484 OXYGEN ISOTOPE AND GEOCHEMICAL STUDY OF METEORIC-HYDROTHERMAL SYSTEMS AT PILOT MOUNTAIN AND SELECTED OTHER LOCALITIES, CAROLINA SLATE BELT.** This paper provides a detailed isotopic and geochemical study of an Au-bearing porphyry system associated with high alumina alteration at Pilot Mountain, Randolph County, North Carolina. It is shown that low <sup>18</sup>O meteoric waters played an important role in this ancient hydrothermal system and that a large and controllable <sup>18</sup>O anomaly is preserved in the metamorphosed volcanic host rocks. Subsequent sections of the paper also provide brief discussions of <sup>18</sup>O relationships in several other mineral deposits of the Carolina slate belt. 108 refs.

Klein, T.L. (US Geological Survey, Reston, VA, USA); Criss, R.E. *Econ Geol Bull Soc Econ Geol* v 83 n 4 Jun-Jul 1988 p 801-821.

## Ontario

**074485 GENERATION OF A MAGMATIC H<sub>2</sub>O-CO<sub>2</sub> FLUID ENRICHED IN Mo, Au, AND W**

**WITHIN AN ARCHEAN SODIC GRANODIORITE STOCK, MINK LAKE, NORTHWESTERN ONTARIO.** The 1.5×3.25-km Mink Lake intrusion located approx. 110 km northeast of Red Lake, northwestern Ontario in the Uchi-Conederation Lakes greenstone belt is an unmetamorphosed and postductile deformation Archean stock. The most important MoS<sub>2</sub> mineralization (grab samples with approx. 0.1-0.3%Mo) occurs in a 1,000×350-m zone completely contained within the south end of the intrusion and spans a silicate melt-hydrothermal fluid transition. Spatially distributed Rb, TiO<sub>2</sub>, Zr, and Li data (n=47) show that the main MoS<sub>2</sub>-mineralized zone is located in moderately differentiated material immediately adjacent to the principal internal zone of crystal fractionation, and in part, laterally continuous with it. It is concluded that the Mink Lake MoS<sub>2</sub> fluids were magmatically derived from the host sodic granodiorite stock. These and other aspects of the subject are discussed. 90 refs.

Burrows, D.R. (Univ of Toronto, Toronto, Ont, Can); Spooner, E.T.C. *Econ Geol Bull Soc Econ Geol* v 82 n 7 Nov 1987 p 1931-1957.

**074486 OXYGEN ISOTOPE STUDY OF THE KIDD CREEK, ONTARIO, VOLCANOGENIC MASSIVE SULFIDE DEPOSIT: EVIDENCE FOR A HIGH <sup>18</sup>O ORE FLUID.** The hydrothermally altered rhyolites (<sup>18</sup>O = 10-16‰) at the Kidd Creek Cu-Zn-Ag-Pb volcanogenic massive sulfide deposit (Archean, Abitibi greenstone belt) are all markedly enriched in <sup>18</sup>O compared to almost all other massive sulfide deposits. A chalcocopyrite stockwork zone, forming a concordant 'keel' stratigraphically below the massive sulfide, typically has whole-rock <sup>18</sup>O = 10 to 12 per mil. Beneath the stockwork keel, rhyolite <sup>18</sup>O values systematically increase stratigraphically downward for about 50 m. Below this level, all of the footwall rhyolites in the Kidd Creek area display exceptionally high <sup>18</sup>O values of 13 to 16 per mil. Petrographically, all of the Kidd Creek footwall rhyolites are intensely altered (typically containing 76-90 wt% SiO<sub>2</sub>), indicating that the high <sup>18</sup>O characteristics are not primary magmatic features but are the result of hydrothermal alteration. These and other aspects of the subject are discussed. (Edited author abstract) 40 refs.

Beatty, David W. (California Inst of Technology, Pasadena, CA, USA); Taylor, Hugh P. Jr.; Coad, Paul R. *Econ Geol Bull Soc Econ Geol* v 83 n 1 Jan-Feb 1988 p 1-17.

**074487 PHYSICAL VOLCANOLOGY OF THE FOOTBALL ROCKS NEAR THE MATTABI MASSIVE SULPHIDE DEPOSIT, STURGEON LAKE, ONTARIO.** Subaerial and shallow subaqueous mafic hyalotuffs, lava flows, and flow breccias, felsic lava flows, and pyroclastic flows and falls form a 2 km thick succession beneath the Mattabi massive sulphide deposit. Amygdaloidal felsic lavas overlie the mafic flows and are locally capped by coarse explosion breccia. This breccia is believed to represent the start of mafic hydrovolcanism, which produced ash falls, surges, and flows. In the Mattabi area, pyroclastic flow deposits form the immediate mine footwall strata and include (i) massive basal beds and overlying bedded ash tuffs and (ii) massive pumiceous units. These deposits overlie and, to the west in the Darkwater Lake area, are intercalated with the mafic hyalotuff sequence. The morphology of the footwall volcanic rocks indicates that the Mattabi and the F-zone massive sulphide deposits formed in a shallow subaqueous environment. (Edited author abstract) 40 refs.

Groves, D.A. (Univ of Minnesota-Duluth, Duluth, MN, USA); Morton, R.L.; Franklin, J.M. *Can J Earth Sci* v 25 n 2 Feb 1988 p 280-291.

## Oregon

**074488 PRELIMINARY STUDY OF THE TURNER ALBRIGHT Zn-Cu-Ag-Au-Co MASSIVE SULFIDE DEPOSIT, JOSEPHINE COUNTY, OREGON.** The Turner Albright Zn-Cu-Ag-Au-Co deposit represents an important ophiolite-hosted (Cyprus-type) massive sulfide occurrence in the West Coast accreted terranes of the



United States. Recent exploration efforts have located an estimated 3,300,000 tons of mineralization with an average grade of 3.33 percent Zn, 1.46 percent Cu, 0.44 oz/ton Ag, 0.11 oz/ton Au, and 0.06 percent Co. The deposit occurs as a series of pods in the basal basaltic pillow lava sequence within the Josephine ophiolite complex. The mineralized horizons, known as the Main Upper and Lower zones and the Upper High-Grade pods, consist (in order of abundance) of pyrite, sphalerite, chalcopyrite, marcasite, and native gold, with minor to trace amounts of tetrahedrite, galena, arsenopyrite, and pyrrhotite. The Turner Albright deposit was formed by metal-bearing fluids generated by the circulation of seawater through a pillow basalt and sheeted dike complex within a back-arc rifting environment. These and other aspects of the subject are discussed. (Edited author abstract) 42 refs.

Kuhns, Roger J. (Univ of Minnesota, Minneapolis, MN, USA); Baitis, Hart W. *Econ Geol Bull Soc Econ Geol* v 82 n 5 Aug 1987 1362-1376.

**Pacific Ocean** See Also MANGANESE DEPOSITS—Pacific Ocean; MINERAL INDUSTRY AND RESOURCES—Subaqueous.

**074489 HYDROTHERMAL OXIDE AND NON-TRONITE DEPOSITS ON SEAMOUNTS IN THE EASTERN PACIFIC.** Deposits of Fe oxide mud, nontronite, and Fe-Mn crusts were sampled from the summits of two seamounts in the eastern Pacific. Where low temperature (0-15°C) hydrothermal fluids are issuing, the deposits consist of X-ray amorphous Fe oxyhydroxide and are rich in Fe (43 wt.%), contain minor Si and P (4% and 3.5%, respectively), and have very low Mn (<0.01%) and other trace element contents. Other deposits, where no current hydrothermal activity was observed, consist of mud and crusts composed of amorphous material and poorly crystalline hematite, goethite, and smectite. Nontronite deposits, capped by Fe-Mn oxides, were sampled from one of the seamounts. These deposits have compositions similar to other seafloor nontronite deposits, and formed at low temperatures (30°C) during mixing of low temperature hydrothermal fluids with seawater. The oxide deposits consist almost entirely of long, delicate filaments, remarkably similar in morphology to genera of Fe oxidizing bacteria. (Edited author abstract). 34 Refs.

Alt, Jeffrey C. (Washington Univ, St. Louis, MO, USA). *Mar Geol* v 81 n 1 pt 4 Jun 1988 p 227-239.

**Peoples Republic of China** See GEOLOGY—Peoples Republic of China; ORE TREATMENT—Beneficiation.

## Peru

**074490 OLIGOCENE MAGMATIC ACTIVITY AND ASSOCIATED MINERALIZATION IN THE POLYMETALLIC BELT OF CENTRAL PERU.** Various volcanic and intrusive rocks were dated at the Institut Dolomieu (Grenoble, France) as part of a research program. This paper deals with the part of this new data which has already been partly published that refers to metallogenetic aspects; it allows the conclusion that there have been at least two distinct periods of polymetallic mineralization in central Peru during the Oligocene and Miocene epochs. Data on two polymetallic districts are presented. The economically important Milpo-Atacocha district, located a few kilometers northeast of Cerro de Pasco near to the eastern edge of the polymetallic belt, is shown to be of middle Oligocene age and the now economically marginal Chungara district, located in the middle part of the belt southwest of Cerro de Pasco near the top of the western cordillera, appears to be of normal middle Miocene age. 30 Refs.

Soler, Pierre (ORSTOM, Paris, Fr); Bonhomme, Michel G. *Econ Geol Bull Soc Econ Geol* v 83 n 3 May 1988 p 657-663.

## Quebec

**074491 SYSTEMATICS OF CHLORITE ALTERATION AT THE PHELPS DODGE MASSIVE SULFIDE DEPOSIT, MATA GAMI, QUEBEC.** Hydrother-

mal alteration at the Phelps Dodge Archean volcanogenic massive sulfide deposit has converted rhyodacite and rhyolite footwall rocks into the following mineral assemblages: quartz-chlorite-albite-epidote±sericite, quartz-chlorite±sericite, chlorite±sericite, and chlorite-talc±stilpnomelane. Chlorites in the Si-Al-Mg-Fe system form a rectangular solid solution plane with limited substitution of Al for Si and extensive substitution of Fe for Mg. In Si-Al space the solid solution plane is outlined by Al saturation (presence of other Al-rich mineral) and Al undersaturation (presence of Al-poor or Al-free mineral) boundaries. Chlorites on the Al-saturated boundary of the solid solution field form a potentially useful geothermometer. The Fe/Fe+Mg ratios of bulk rock and contained chlorite correlate well. Birefringence colors of the chlorite change from green to brown, violet, and Berlin Blue as Fe/Fe+Mg changes from 0.18 to 0.64. The Fe/Fe+Mg variation apparently depends largely on the proportions of Mg-rich seawater and Fe-rich hydrothermal fluid in the altering brine. (Edited author abstract) 28 refs.

Kranidiotis, P. (McGill Univ, Montreal, Que, Can); MacLean, W.H. *Econ Geol Bull Soc Econ Geol* v 82 n 7 Nov 1987 p 1898-1911.

**Remote Sensing** See Also MINERAL EXPLORATION—Japan.

**074492 SPECTRAL LUMINESCENCE PROPERTIES OF NATURAL SPECIMENS IN THE SCHEELITE-POWELLITE SERIES, AND AN ASSESSMENT OF THEIR DETECTIVITY WITH AN AIRBORNE FRAUNHOFER LINE DISCRIMINATOR.** Spectral luminescence analysis, using a laboratory fluorescence spectrometer, of 85 scheelite-powellite specimens from 50 localities in the western United States shows that 46 specimens are within the sensitivity limits of a Fraunhofer line discriminator, an airborne electro-optical device for the detection of materials stimulated to luminescence by the sun. Three-dimensional perspective plots of excitation and emission spectra of the natural specimens are markedly similar in shape to perspective plots of 21 artificial scheelite-powellite specimens. Natural specimens show wider range in luminescence intensity than the synthetics. Luminescence intensity has been shown by other workers in the fabrication of artificial tungstate phosphors to be controlled by varying the amount of calcium, tungsten, rare earth element and trace element impurities, and temperature. (Edited author abstract). 28 Refs.

Hemphill, William R. (US Geological Survey, USA); Tyson, R. Michael; Theisen, Arnold F. *Econ Geol Bull Soc Econ Geol* v 83 n 3 May 1988 p 637-646.

## Saudi Arabia

**074493 METALLIFEROUS SUB-MARINE SEDIMENTS OF THE ATLANTIS-II-DEEP, RED SEA.** The Atlantis II Deep is a stratified metalliferous deposit located along the medium valley of the Red Sea at a water depth of about 2200 m. The metal-bearing mud contains sulfides of zinc, copper and iron with significant amounts of silver, gold and cobalt. Mining geostatistics was applied to estimate the Red Sea offshore mineral resources. Kirging estimates indicated that 696.330 million t of bulk sediments contain 1.891 million t of zinc, 0.425 million t of copper and 3.75 thousand t of silver. Gold and cobalt contents were calculated from the analysis of solids in flotation concentrates as 47 t and 5368 t respectively. 10 refs.

Guney, Mehmet (K.F. Univ of Petroleum & Minerals, Dhahran, Saudi Arabia); Al-Marhoun, Muhammad A.; Nawab, Zuhair A. *CIM Bull* v 18 n 910 Feb 1988 p 33-39.

## South Australia, Australia

**074494 ZIRCON U-PB DATING IN THE VICINITY OF THE OLYMPIC DAM CU-U-AU DEPOSIT, ROXBY DOWNS, SOUTH AUSTRALIA.** Isotopic data are presented for granitoids and felsic volcanics from the Stuart shelf of South Australia, some of which are spatially associated with the Olympic Dam Cu-U-Au deposit.

Close to the Olympic Dam deposit, the zircon U-Pb system of Olympic Dam suite quartz syenite was contaminated by barite precipitated from hydrothermal fluids associated with the mineralization. The abraded zircons have U-Pb ages similar to uncontaminated Olympic Dam suite zircons. Deformed and altered basement granitoids on the Stuart shelf have complex zircons with discrete cores and overgrowths which yield complicated U-Pb isotope systematics. Comparable apatite U-Pb and biotite Rb-Sr isotope dates from all the granitoids and from thin veins in the Acropolis prospect suggest regional cooling through the respective blocking temperatures. The Acropolis apatite date suggests at least some Stuart shelf mineralization was emplaced at, or before, about 1602 m.y. (Edited author abstract). 36 Refs.

Mortimer, G.E. (Univ of Adelaide, Adelaide, Aust); Cooper, J.A.; Paterson, H.L.; Cross, K.; Hudson, G.R.T.; Uppill, R.K. *Econ Geol Bull Soc Econ Geol* v 83 n 4 Jun-Jul 1988 p 694-709.

## Spain

**074495 HYDROTHERMAL FLUID EVOLUTION OF THE SN-W MINERALIZATION IN THE PARRILLA ORE DEPOSIT (CACERES, SPAIN).** The Parrilla orebody, located on the southern border of the Caceres province, is a stockwork of quartz veins with scheelite and cassiterite. The Sn-W ore fills fractures in the Greylake Schist Complex, intruded in this area by Hercynian granites. Most of the veins strike N30°E and dip 45°SE. The mineral association includes scheelite and cassiterite, which are the most important economic minerals, and arsenopyrite, wolframite, sphalerite, chalcopyrite, pyrite, bismuth sulphosalts, pyrrhotite, quartz, muscovite and tourmaline. (Edited author abstract) 23 refs.

Mangas, J. (Facultad de Ciencias del Mar, Las Palmas, Spain); Arribas, A. *J Geol Soc London* v 145 pt 1 Jan 1988 p 147-155.

**074496 SILVER AND LEAD MINERALOGY IN GOSSAN-TYPE DEPOSITS OF SIERRA DE CARTAGENA, SOUTHEAST SPAIN.** Two strata-bound Pb-Zn-Ag orebodies (mantos) are currently being worked by the Sociedad Minera y Metalurgia Penarroya-Espana in the Sierra de Cartagena, southeast Spain. Associated with the primary ores are gossan-type oxidation zones; these supergene ores, which comprise two distinct mineral associations that were formed from the two primary manto assemblages under different pH conditions, are locally enriched in lead and/or silver. A preliminary evaluation of the gossan ores at two of the open-pit mines was undertaken to investigate the distribution of Pb and Ag in the different magnetic fractions of the ore. The results indicate that magnetic separation as a first-stage preconcentration method after crushing could be used successfully prior to beneficiation of silver by heap leaching. 19 Refs.

Garcia, J.A. Lopez; Lunar, R.; Oyarzun, R. *Trans Inst Min Metall Sect B* v 97 May 1988 p b82-b88.

## Structural Analysis

**074497 SIZE DETERMINATION OF SLAB-LIKE ORE BODIES - AN INTERPRETATION SCHEME FOR SINGLE-HOLE MISE-A-LA-MASSÉ ANOMALIES.** Theoretical borehole mise-a-la-masse profiles are generated using the integral equation method for the case of a thin slab-like conductor and an analytical method for a thin disk-like conductor. It is shown that the potential gradient on intersection of the conducting body is related to the lateral extent of the body. A characteristic curve is presented showing the potential gradient on intersection as a function of the surface area of the body. A correction may be made if the borehole is not perpendicular to the conductor. The use of the scheme is illustrated with a field case. (Edited author abstract) 7 refs.

Bowker, Annabel (Univ of Leicester, Leicester, Engl). *Geoexploration* v 24 n 3 Oct 1987 p 207-218.



# Taiwan

**074498 STUDY ON PURIFICATION OF SERICITE ORE IN SHIANG-YANG, TAIWAN.** There are large reserves of sericite in the Shiang-Yang area of Taiwan. Due to the lack of beneficiation technology, these resources have not been effectively utilized. A series of investigations including mineral identification and analysis, attrition grinding, flotation, and settling were conducted on the ore. Flotation and settling procedures can obtain sericite which meets the industrial welding specification requirements and pyrophyllite suitable for refractory use. In Japanese. 8 refs.

Tsai, Min-Shing (Cheng-Kung Univ, China). *Nippon Kogyo Kaishi* v 103 n 1192 Jun 1987 p 389-394.

# Tasmania, Australia

**074499 TIGHTLY FOLDED, GOLD-RICH, MASSIVE SULFIDE DEPOSIT: QUE RIVER MINE, TASMANIA.** The Que River deposit in western Tasmania is a high-grade, gold-rich, Cambrian volcanogenic sulfide deposit, comprising two major subvertical ore lenses hosted by andesitic lavas and volcanoclastics of the Mount Read Volcanics. The major orebodies are considered to lie at the same stratigraphic level and be folded into a tight asymmetric syncline which has been sheared along its western limb. Copper, lead, and zinc distribution within the lenses provides evidence of a stratigraphic younging direction around the fold structure. Gold grades of 5 to 30 ppm are concentrated toward the interpreted stratigraphic top of the folded lens. A conspicuous fuchsite-bearing horizon of altered coarse-grained polymict volcanoclastic immediately overlies the major ore lenses, and it is in turn overlain by flow-banded dacite lavas and lava breccias which lack significant hydrothermal alteration. (Edited author abstract). 31 Refs.

Large, Ross R. (Univ of Tasmania, Hobart, Aust); McGoldrick, Peter J.; Berry, Ron F. *Econ Geol Bull Soc Econ Geol* v 83 n 4 Jun-Jul 1988 p 681-693.

# Tennessee

**074500 STRONTIUM ISOTOPIC GEOCHEMISTRY OF MISSISSIPPI VALLEY-TYPE DEPOSITS, EAST TENNESSEE: IMPLICATIONS FOR AGE AND SOURCE OF MINERALIZING BRINES.** Strontium isotopic ratios of wall-rock, ore, and gangue minerals from the Mascot-Jefferson City, Copper Ridge, and Sweetwater Mississippi Valley-type (MVT) districts and from the Lost Creek barite deposit in East Tennessee were measured in an effort to determine the age of this mineralization and its relation to the tectonic evolution of the Appalachian orogen. Of the three possible source basins for the MVT brines, the Late Proterozoic Ocoee, Cambrian Luttrell, and Ordovician Sevier basins, the Sevier basin appears to be the only one that could have supplied brines of the appropriate composition at geologically reasonable times. The maximum ages of the Lost Creek, Sweetwater, Copper Ridge, and Mascot-Jefferson City mineralization are 520, 460, 405, and 395 m.y., respectively. The Lost Creek barite mineralization formed as an exhalative deposit in the Sevier basin and that the Sweetwater fluorite-barite mineralization formed during the later part of the Taconic orogeny. The Copper Ridge and Mascot-Jefferson City mineralization could have formed either prior to or during the Alleghanian orogeny. (Edited author abstract). 65 Refs.

Kesler, Stephen E. (Univ of Michigan, Ann Arbor, MI, USA); Jones, Lois M.; Ruiz, Joaquin. *Geol Soc Am Bull* v 100 n 8 Aug 1988 p 1300-1307.

**Theory** See Also TUNGSTEN DEPOSITS—Composition Effects; ZINC COMPOUNDS—Geochemistry.

**074501 ACTIVE ORE FORMATION AT A BRINE INTERFACE IN METAMORPHOSSED DELTAIC LACUSTRINE SEDIMENTS: THE SALTON SEA GEOTHERMAL SYSTEM, CALIFORNIA.** The Salton Sea geothermal system is an area of active hydrothermal metamorphism of Pliocene to Pleistocene deltaic, lacustrine, and evaporitic sediments deposited in a modern continental rift zone. Base metal ore mineralization occurs in vertical fractures that comprise the major form of fluid permeability at 1 to 3 km in the modern geothermal system. Fluid inclusions record an apparent steep, progressive salinity increase in the vein systems in the upper 2 km of the system. However, fluid production data from Salton Sea geothermal wells indicate that reduced, metaliferous hypersaline brine averaging 23 wt percent total dissolved solids is overlain by more oxidized, metal-poor fluid averaging 5 wt percent total dissolved solids. A model is developed for type 2 vein ore formation involving mixing at the interface between the two fluids. Ore formation in the system is caused by the coincidence of transaxial entry of a major river into an active rift zone, deposition of metal-bearing deltaic sediments to form a closed-basin sedimentary environment, episodic lacustrine evaporite formation, and injection of heat and elements by rift-related magmatic intrusions at depth. (Edited author abstract). 47 Refs.

McKibben, Michael A. (Univ of California, Riverside, CA, USA); Andes, Jerry P. Jr.; Williams, Alan E. *Econ Geol Bull Soc Econ Geol* v 83 n 3 May 1988 p 511-523.

**Turkey** See ORE TREATMENT—Beneficiation.

**United Kingdom** See GEOLOGY—United Kingdom.

**Wall Rock Alteration** See Also COPPER DEPOSITS—Zaire; GOLD DEPOSITS—Indonesia; GRAPHITE—Sri Lanka.

**074502 QUIRUVILCA, PERU: MINERAL ZONING AND TIMING OF WALL-ROCK ALTERATION RELATIVE TO Cu-Pb-Zn-Ag VEIN-FILL DEPOSITION.** Wall-rock alteration types from the vein margin outward and from most intense to least intense are intense sericitic, strong sericitic, moderate sericitic, strong argillic, weak argillic, and propylitic. Petrographic observations indicate that at any given location, propylitic alteration is oldest, followed by argillic, and then sericitic alteration. The zoned alteration halos formed as each inner assemblage advanced, overprinted, and replaced its adjacent outer precedent. Correlation between paragenetic stages of vein fill and wall-rock alteration is based upon the mineralogy and wall-rock alteration of single-stage veinlets that are zoned about major veins. Temperatures of ore deposition, deduced from the stability of various mineral assemblages, decreased through time from >320° to <230°C. Additional study results are discussed. (Edited author abstract) 52 refs.

Bartos, Paul J. (ASARCO Inc, Lakewood, CO, USA). *Econ Geol Bull Soc Econ Geol* v 82 n 6 Sep-Oct 1987 p 1431-1452.

**074503 ROCK ALTERATION, MERCURY TRANSPORT, AND METAL DEPOSITION AT SULPHUR BANK, CALIFORNIA.** The hydrothermal alteration at Sulphur Bank, Lake County, California, is characterized by the phases alunite, kaolinite, and amorphous silica. Comparison between the observed mineralogical zonation and theoretical simulation of the water-rock interaction reveals that the alteration process at Sulphur Bank may be described on a broad scale in terms of an irreversible thermodynamic model based on the assumption of local equilibrium. However, this theoretical model alone fails to explain the details of the mineralogical zonation of the veins and alteration halos at Sulphur Bank. The zonation may be the result of a coupled reaction-fluid transport system in which two solute transport mechanisms - advective flow through open veins and diffusion - build superimposed alteration sequences. As a result of aqueous mercury-complex stability studies, it is inferred that mercury is transported as sulfide complexes at Sulphur Bank. Both boiling and oxidation are effective depositional processes for cinnabar according to theoretical calculations presented. (Edited author abstract). 46 Refs.

Wells, James T. (Univ of Washington, Seattle, WA, USA); Ghiorsio, Mark S. *Econ Geol Bull Soc Econ Geol* v 83 n 3 May 1988 p 606-618.

# Wisconsin

**074504 VOLCANIC HISTORY, MINERALIZATION, AND ALTERATION OF THE CRANDON MASSIVE SULFIDE DEPOSIT, WISCONSIN.** This paper presents a detailed description and discussion of the distribution and origin of the subaqueous volcanoclastic and chemical sedimentary rocks which occur at the Crandon deposit. A detailed discussion of the sulfide mineralogy, the distribution of mineralization, and the silicate alteration mineralogy of the deposit follows. A genetic model of ore deposition is then developed based on these observations. 50 refs.

Lambe, Robert N. (Exxon Co, Houston, TX, USA); Rowe, Roger G. *Econ Geol Bull Soc Econ Geol* v 82 n 5 Aug 1987 p 1204-1238.

# Yukon

**074505 GOLD-COPPER-BISMUTH MINERALIZATION IN HEDENBERGITE SKARN, TOMBSTONE MOUNTAINS, YUKON.** Gold mineralization on the Marn property, Yukon, occurs in two pyroxene skarn bodies, which are adjacent to the Mount Brenner Stock in the Ogilvie Mountains. The skarns are separated by a 600 m wide monzonite intrusion and show contrasting mineralogical and geochemical characteristics in addition to quite different metal values. Significant but uneconomic Au, Ag, W, and Cu mineralization is found in skarn on the north side of the intrusion, while very low Au grades (0.052 g/t) occur at the southern contact. The mineral assemblages of both skarns are dominated by iron-rich pyroxenes. The iron content of the pyroxenes varies between Hd<sub>40</sub> and Hd<sub>80</sub> in the northern location and Hd<sub>60</sub> and Hd<sub>100</sub> in the southern skarn. A well-developed sequence of retrograde alteration affected only the northern skarn. The relationship of this type of skarn to the hedenbergite skarn is ambiguous, since there is no large-scale mineralogical zoning. (Edited author abstract) 27 refs.

Brown, Isobel J. (Oxford Polytechnic, Oxford, Engl); Nesbitt, Bruce E. *Can J Earth Sci* v 24 n 12 Dec 1987 p 2362-2372.

# ORE HANDLING

**074506 OPTIMIERTE HYDRAULISCHE FÖRDERUNG VON ERZEN. [Optimized Hydraulic Ore Transport].** Different transporting methods for ores can be compared only after optimization. To avail oneself of a large number of possibilities for designing a hydraulic transporting system, a computer should be used to determine the optimal solution. (Author abstract) 4 refs. In German.

Beckmann, Uwe (TU Berlin, West Ger). *Erzmetall* v 41 n 5 May 1988 p 297-301.

# Mechanization

**074507 MECHANIZATION OF LABOR-INTENSIVE WORK AT THE WEST SIBERIAN METALLURGICAL COMBINE.** Ore is broken up by grates when it is unloaded from railcars at the car dumper. A number of workers are needed to clean grates. To eliminate this deficiency, spring-opposed vibrating grates was installed in the hoppers of the car dumper. A layer of grease is left on the walls and bottom of the container after unloading. To mechanize this unproductive operation, save grease, and improve safety and working conditions, the authors developed a manipulator with a vibrating table.

Kryukov, Yu.V. (West Siberian Metallurgical Combine, USSR); Rastorguev, A.V.; Naumov, A.S. *Metallurgist (USSR)* v 31 n 5-6 May-Jun 1987 p 149-151.



**ORE SAMPLING** See Also COAL—Quality Control; GOLD MINES AND MINING—France; TIN ORE TREATMENT—Flotation.

**074508 RELATIONSHIP BETWEEN OBSERVED MINERAL LIBERATIONS IN SCREENED FRACTIONS AND IN COMPOSITE SAMPLES.** An investigation was conducted to determine the minimum number of samples that must be studied by image analysis of polished sections to characterize a mill product and determine the apparent mineral liberation. It was found that a representative polished section cannot be prepared from an unscreened sample that has a wide size range of particles. Similarly, individual screened fractions are not representative of the sample because minerals are partitioned during screening and the quantities of soft brittle minerals are increased in fine grained fractions, whereas the quantities of hard minerals are increased in coarse grained fractions. Results obtained by combining data for a series of narrow size range screened fractions (one Tyler size range) are representative of the sample, and relatively accurate data can be obtained by analyzing each fraction and combining the data. (Edited author abstract) 4 refs.

Petrak, W. (CANMET, Ottawa, Ont, Can); Pinard, R.G.; Finch, J. *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt B 1986 p 60-62.

**074509 CHARACTERIZATION PROBLEMS IN COMMINUTION - AN OVERVIEW.** The problems of sampling particulate materials and characterizing the distribution of particle size and composition are reviewed. Requirements for sampling from comminution systems are discussed, and a simple formula is presented for estimating the minimum sample size needed. The limitations and errors associated with the techniques available for particle size analysis are evaluated, and guidelines are suggested for the selection of appropriate methods. The use of microscopic and macroscopic approaches to the characterization of particle composition is discussed. (Author abstract) 13 refs.

Hogg, R. (Pennsylvania State Univ, University Park, PA, USA). *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 25-40.

**ORE TREATMENT** See Also MINERALS—Processing; MINES AND MINING; SEPARATORS—Magnetic.

**074510 FLOWSHEET AUDITING FOR IMPROVED METALLURGICAL PERFORMANCE.** This paper discusses the need for periodic auditing of mineral processing flow sheets and the potential benefits a company can gain from a study of this nature. A carefully designed flowsheet audit can have a significant impact on the metallurgical performance in the plant. Several case studies illustrating the potential benefits that can be attained from flowsheet auditing are discussed. (Edited author abstract) 6 refs.

Malhotra, D. (AMAX Extractive Research & Development Cent, Golden, CO, USA). *Miner Metall Process* v 4 n 4 Nov 1987 p 203-206.

**074511 MOTION OF PARTICLES IN ACCELERATED FLUIDS WITH SPECIAL REFERENCE TO PROBLEMS IN MINERAL DRESSING.** The functions of velocity-time, acceleration-time and distance-time of a particle moving in an accelerated fluid are determined in this paper. The problem is solved for the unhindered motion of the particle and for that hindered by a sieve. An example is shown in which the problem is solved both analytically and numerically assuming the validity of Stokes's law. A suggestion is made for a numerical solution which holds over the entire range of velocity of practical importance. (Author abstract) 8 refs.

Pethoe, Sz. (Technical Univ of Heavy Industry, Miskolc-Egyetemvaros, Hung); Szarka, Z.; Goenczi, I. *Min Sci Technol* v 6 n 2 Jan 1988 p 171-177.

**074512 ESTIMATION OF MODEL PARAMETERS FOR LIBERATION AND SIZE REDUCTION.** In previous work at Virginia Tech, a population balance

model describing the simultaneous processes of size reduction and mineral liberation has been developed. Experimental verification of this model, however, has been limited to a binary mineral system containing only one composite particle class. When considering multiple classes of composite particles, estimation of model parameters becomes more difficult. In the present work, a procedure for estimating model parameters for a multiple composite class model has been developed. Emphasis is placed on direct experimental determination of these parameters. The physical significance of the breakage rate function and the liberation function in characterizing the liberation process is also discussed. (Author abstract) 17 refs.

Choi, W.Z. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Adel, G.T.; Yoon, R.H. *Miner Metall Process* v 5 n 1 Feb 1988 p 33-39.

**074513 ACTIVITIES OF WATER AND HCl IN AQUEOUS SOLUTION SYSTEMS OF HCl-MCL<sub>n</sub> INCLUDING CuCl<sub>2</sub>, NiCl<sub>2</sub> AND FeCl<sub>3</sub>.** Activities of HCl in the HCl-CuCl<sub>2</sub>, HCl-NiCl<sub>2</sub> and HCl-FeCl<sub>3</sub> aqueous solution systems which cannot be determined by the emf method were calculated at 298 K by applying the McKay-Perring method based on the measured water activities. The water activities of these solutions and those of HCl-NaCl solutions were determined by a transpiration method and the b values involved in the corrected Zdanovskii equation were evaluated as a function of water activity. The calculated values of a(HCl) of the aqueous solution system of HCl-NaCl agreed well with those determined by the emf method at both dilute and concentrated HCl levels. The change in a(HCl) with an increase in chloride concentration is attributable to the change in ionic strength of the solution, and thus the concentration of the chemical species present in the solution. (Edited author abstract) 35 refs.

Awakura, Yasuhiro (Kyoto Univ, Kyoto, Jpn); Kawasaki, Yukio; Uno, Akito; Sato, Koji; Majima, Hiroshi. *Hydrometallurgy* v 19 n 2 Dec 1987 p 137-157.

**074514 ISOIONIC POINT AND MINIMUM SOLUBILITY OF CARBONATE MINERALS.** The isoionic point is defined as the pH of an aqueous solution in equilibrium with a solid and the atmosphere. Mineral-/aqueous solution equilibria on magnesite suspensions open to the atmosphere show that the pH of minimum solubility of carbonate minerals is not equivalent to the isoionic point of the mineral suspension. For magnesite suspensions, the isoionic point occurs at pH 8.4, whereas the minimum solubility of the mineral occurs at pH values higher than 10.4. (Edited author abstract) 11 refs.

Lopez-Valdivieso, A. (Univ of California, Berkeley, CA, USA). *Min Eng* v 1 n 1 1988 p 85-87.

**074515 RECENT MINERAL PROCESSING DEVELOPMENT AT BOLIDEN.** The Swedish Boliden group, the largest Scandinavian industrial group in the fields of sulphide ore mining, non-ferrous metal smelting and the production of inorganic chemicals is faced with the same difficulties as in other industrial countries - dwindling deposits of high-grade ore, growing requirements of environmental protection, rising energy costs and a high cost situation. The pressure of having to continuously adapt processing technique to the poorer and more strongly growing deposits determines the current activities in the area of preparation technique. The programs of development have recently been focused on the particularly pressing problem areas of autogenous grinding, recovery of precious metals, dewatering and process control. The work carried out to this time is reported on and an outlook is given on future developments. (Author abstract)

Hultqvist, J. *Aufbereit Tech* v 29 n 4 Apr 1988 p 179-185.

**074516 REACTION BETWEEN SPODUMENE AND TACHYHYDRITE.** The reaction between spodumene Li<sub>2</sub>O·Al<sub>2</sub>O<sub>3</sub>·4SiO<sub>2</sub> and tachyhydrite (CaCl<sub>2</sub>·2MgCl<sub>2</sub>·12H<sub>2</sub>O) at temperatures above 1270 K, when the spodumene has transformed from the unreactive

γ-form to the β-form, was studied by varying the reaction temperature and the relative proportions of the two minerals in the reaction mixtures. Mass balances as well as X-ray diffraction to identify the reaction products indicate that the reactions that occur are: decomposition of the tachyhydrite, losing at first some of its water of crystallization, followed by MgCl<sub>2</sub> hydrolyzing to MgO; transformation of the γ-spodumene into β-spodumene; a reaction between the β-spodumene, MgO produced from tachyhydrite, and CaCl<sub>2</sub> of the tachyhydrite according to the equation Li<sub>2</sub>O·Al<sub>2</sub>O<sub>3</sub>·4SiO<sub>2</sub> + CaCl<sub>2</sub> + 8MgO = 2LiCl + CaO·MgO·SiO<sub>2</sub> + 3SiO<sub>2</sub>·2MgO + Al<sub>2</sub>O<sub>3</sub>·MgO. X-ray diffraction confirmed the presence of all the phases in the products except the phase containing alumina. Considerations of the quaternary phase diagram Al<sub>2</sub>O<sub>3</sub>-SiO<sub>2</sub>-MgO-CaO show that the phases indicated as reaction products are the ones expected under equilibrium conditions at the reaction temperature. Calculated standard free energy change of the suggested reaction is -211926 Joules at 1423 K, indicating that under standard conditions the reaction is possible. (Author abstract). 11 Refs.

El-Naggar, M.M.A. (Federal Univ of Rio de Janeiro, Brazil); Medina, L.F.; Espinola, A. *Metall Trans B* v 19 n 4 Aug 1988 p 663-668.

**074517 VALIDATION DES MESURES PAR EQUILIBRAGE HIERARCHISE DE BILANS-MATIERE. [Data Validation and Hierarchical Mass Balance Equilibration].** Flow rate measurements under a steady state condition of a process are usually reconciled by weighted least squares so that the mass balance law is conserved. However, in the case of a large-scale system, the classical approach must be adapted. In this paper the proposed algorithm uses a clustering analysis of the balance equations and a hierarchical equilibration. (Author abstract). 7 Refs. In French.

Maquin, D. (E.R.A., Vandoeuvre, Fr); Ragot, J.; Darrouach, M.; Fayolle, J. *Int J Miner Process* v 23 n 3-4 Jul 1988 p 241-252.

**074518 PACE OF CHANGE IN MINERAL PROCESSING.** The author considers some past prognosticians of future changes in mineral processing technology and concludes that although technological change is inevitable, predicting the direction of these changes is fraught with difficulty. The author advances his own forecasts of some major changes which may come about in methods of liberation and treatment of ores of tin, tungsten, gold, diamonds, copper and other base metals in coming decades. The article identifies the liberation and separation methods in use at the time of Agricola (1550), R.H. Richards (1900), the years 1960 and 1980 and the forecast for the year 2000. 5 Refs.

Chaston, Ian R. *Aust Min* v 80 n 6 Jun 1988 5p.

**074519 EXTRACTION METALLURGY '85.** This conference proceedings contains 57 papers. Among the subjects covered are ore treatment processes, hydrometallurgy, smelting, refining, mineral chemistry, waste utilization, mercury removal, oxygen smelting, refinery slimes, ore sampling, pollution control, thermal plasma technology, reduction chlorination, direct smelting, laterites and solvent extraction. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11038 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Inst of Mining & Metallurgy, London, Engl). *Extr Metall '85, London, Engl, Sep 9-12 1985* Publ by Inst of Mining & Metallurgy, London, Engl, 1985 1124p.

**074520 RECENT ADVANCES IN COMMINUTION, CONFERENCE PAPERS.** This issue of the journal contains 26 papers presented at a conference. Some of the subjects covered are comminution, crushing and grinding, liberation modeling, scale-up considerations, tracer studies, flotation chemistry, size reduction,



rheological effects, hydrocyclones, optimal control, autogenous grinding, grinding balls, abrasion testing, centrifugal milling and stirred ball milling. All papers are abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11516 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Rajamani, K. (Ed.) (Univ of Utah, Salt Lake City, UT, USA); Herbst, J.A. (Ed.). *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 444p.

## Agglomeration

**074521 CONSIDERATIONS ON AGGLOMERATE GROWTH PROCESSES: STUDIES ON AGGLOMERATION IN WATER (2ND REPORT).** Agglomeration experiments were carried out using BaSO<sub>4</sub> as model particles, sodium oleate (NaOl) as the surface active reagent and kerosene as the bridging liquid agglomerate growth processes are classified into three patterns. The pattern 1) agglomerates were formed immediately after the experiment started and they gradually grew to certain sizes after which agglomerate growth slowed down. In pattern 2) micro-agglomerates were formed and after a certain aging time they grew to large agglomerates with intermediate size agglomerates also present. In pattern 3) micro-agglomerates were formed and after a certain aging time they grew to large agglomerates with almost no intermediate size agglomerates. Simulations of these patterns were conducted using population balance equations. (Edited author abstract) In Japanese. 10 refs.

Hirajima, Tsuyoshi (Hokkaido Univ, Jpn); Takamori, Takakatsu; Tsunekawa, Masami; Tsurui, Masao. *Nippon Kogyo Kaishi* v 103 n 1195 Sep 1987 p 577-585.

Australia See GOLD ORE TREATMENT—Leaching.

**Beneficiation** See Also COAL MINES AND MINING—United States; COAL PREPARATION—Agglomeration; COAL PREPARATION—Flotation; FLOW OF FLUIDS—Channel Flow; OIL SHALE—Processing; PHOSPHATES—Processing; REFRACTORY MATERIALS—Separation.

**074522 ULTRAFINE PARTICLE PROCESSING: A METHOD FOR ALUNITE BENEFICIATION.** Alunite has been used as raw material for producing alumina and potassium sulfate fertilizer in Russia for many years. In the United States, this mineral has not been commercially processed though reserves of 5 to 10 billion tons of alunite ore have been estimated. A new method for the beneficiation of alunite ore utilizes a small amount of fine magnetite upon which the liberated quartz is selectively flocculated. The co-flocculated magnetite and quartz are then separated from the alunite in a high gradient magnetic separator. An alunite concentrate of 90% grade with 80% recovery has been obtained from Utah ore. (Edited author abstract) 22 refs.

Hwang, J.Y. (Michigan Technological Univ, Houghton, MI, USA); Kullerud, G.; Friedlaender, F.J.; Takayasu, M. *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt A 1986 p 1961-1964.

**074523 VORSCHLAG FUER EIN AUFBEREITUNGSTECHNISCHES CODE-SYSTEM.** [Proposal for a Beneficiation Code System]. A code system of abbreviations to identify material flows, mineral dressing apparatus and transport lines is described. It is based on groups of two letter codes each. The codes derive from English identification of material flow and apparatus. The advantages of applying the code system are described. (Edited author abstract) In German.

Papacek, Herbert G. (Exploration und Bergbau GmbH, Duesseldorf, West Ger); Flegel, Erich. *Erzmetall* v 40 n 9 Sep 1987 p 462-465.

**074524 CONTRIBUTION TO THE BENEFICIATION OF A TANTALUM/NIOBIUM ORE FROM CHINA.** The Federal Institute of Geosciences and Natu-

ral Resources (of the Federal Republic of Germany) has been exploring for niobium and tantalum in weakly greisenized and albitized pegmatites in the Guangdong province of southern China. In so doing, it has discovered mineralization there of approximately 230 ppm Ta and 80 ppm Nb. By means of a test program incorporating several stages and involving both small specimens and also a large sample, investigations were carried out concerning the possibility of concentrating these ores. It was demonstrated that <0.2 mm and 50% <0.07 mm could be concentrated with a good Nb/Ta recovery level by adopting a process of grinding/high-intensity magnetic separation/table grading and flotation of middlings. This produces a columbite concentrate with approximately 30% Ta and a valuable metal recovery of 70-75%. (Edited author abstract) In German and English. 3 refs.

Burghardt, O.; Mertins, E. *Aufbereit Tech* v 28 n 12 Dec 1987 p 704-710.

**074525 BENEFICIATION OF CELESTITE: ORE STRIPA APPLICATION IN TURKEY.** The paper describes some laboratory concentration studies made on rejects from hand picked celestite ore by attrition tumbling and wet screening. The -25mm + 1mm fraction is taken as coarse concentrate or alternatively a concentrate can be obtained by jigging of this fraction. The -1mm fraction is further treated on shaking tables to produce a concentrate. A celestite beneficiation plant is described which includes a jaw crusher, attrition tumbler and a Stripa unit to upgrade the -25mm fraction. The Stripa product is treated on jigs and shaking tables to obtain a concentrate. Finally, examples are given of the Stripa used as pre-concentration step with respect to iron ore, chromite, and barytes. 3 refs.

Onal, Guven (Istanbul Technical Univ, Turk); Dogan, M. Zeki. *Ind Miner (London) Suppl* Mar 1988 p 44-46.

**074526 AUTOMATIC IMAGE ANALYSIS FOR MINERAL BENEFICIATION.** Mineral recoveries from a concentrator can often be improved by determining mineralogical characteristics that affect mineral behavior during beneficiation. Classic mineralogical studies provide qualitative information but do not define mineral behavior when quantitative data are needed. In contrast, image analysis provides quantitative mineralogical data. One image analysis system, MP-SEM-IPS, developed in the CANMET laboratories of the Department of Energy, Mines and Resources at Ottawa, Canada, consists of an electron microprobe to produce an image, an energy dispersive x-ray analyzer (EDXA) to identify the minerals, and a Kontron SEM-IPS image analyzer to determine mineral characteristics. The article describes the technique and gives several examples of applications. 4 refs.

Petrak, William (CANMET, Can). *J Met* v 40 n 4 Apr 1988 p 29-31.

**074527 TENDINTE MODERNE IN VALORIFICAREA SUPERIOARA A MINERURILOR, CONCENTRATORUL SI SUBPRODUSELOR DIN METALURGIE.** [Modern Trends in Upgrading Ores, Concentrates and By-Products in Metallurgy]. Under current conditions, the technologies of upgrading ores, concentrates and byproducts in metallurgy have experienced radical transformations. These include process combination (preconcentration, selective concentration, treatment in the presence of chemical reagents, pyrometallurgical treatment), operation improvements (crushing, grinding, classifying, calcining, dissolution, extraction and changes in the process flows. These transformations have led to the creation of several specific versions for each raw material category. (Edited author abstract). 6 Refs. In Romanian.

Ienciu, M. (Inst Politehnic Bucuresti, Bucharest, Rom); Moldovan, P.; Panait, N. *Metalurgia (Bucharest)* v 40 n 2 Feb 1988 p 70-73.

Biodegradation See GOLD ORE TREATMENT—Leaching.

## Chelation

**074528 APPLICATIONS OF CHELATING AGENTS IN MINERAL PROCESSING.** Because of their metal specificity chelating agents can function as effective mineral processing reagents. A brief review of work carried out in this area is presented. Some of the features of mineral flotation and flocculation with chelating-type reagents such as bulk vs. surface chelation, the role of pH, mineral solubility, solution chemistry of reagents, and temperature are illustrated with examples. The problems associated with the commercialization of chelating reagents for ore beneficiation and the research efforts required in this area are also discussed. (Edited author abstract) 120 refs.

Pradip (Tata Research Development & Design Cent, Pune, India). *Miner Metall Process* v 5 n 2 May 1988, Spec Top in Miner Process Semin, Pune, India, Dec 30 1987-Jan 1 1988 p 80-89.

## Chlorination

**074529 TRAPPING AND TREATMENT OF GOLD-RICH CHLORIDE SUBLIMATES.** A basic scheme for trapping and treating chloride sublimate of resistant gold-containing ash is proposed. The scheme includes wet trapping of chlorides in a recirculating-solution system, filtration of the trapped sludge, smelting of the filter cake into a gold-silver alloy, and additional extraction of silver from the trapping solutions by cementation. The scheme provides for extraction of noble metals into the end product - the gold-silver alloy. The expected extraction by this scheme is 96.8-97.5% for gold and 88.3-90.0% for silver. 4 refs. In Russian.

Bardik, N.V.; Zyryanov, M.N.; Khlebnikova, G.A. *Izv Vyssh Uchebn Zaved Tsvetn Metall* n 5 1987 p 66-69.

Classifiers See Also COPPER ORE TREATMENT—Classifiers.

**074530 SAND PROCESSING, PRODUCT OPTIMIZATION AND WASTE TREATMENT. PART 2 - CLASSIFICATION.** In considering classification and classifiers, it is useful to understand the terms 'overflow' and 'underflow' which can be applied to all processes and types of equipment. The overflow contains the finest of the product/waste fractions. The coarser underflow may be in one or several fractions and often exists in a partially dewatered state. All these factors can be engineered into a sand classification system. The article discusses the physical processes involved and the equipment designed around these processes. 2 refs.

Littler, A. (ARC Southern Ltd). *Quarry Manage* v 14 n 8 Aug 1987 p 25-31.

**074531 ZUR BEDEUTUNG DER PULSATION BEI DER AUFBEREITUNG FESTER MINERALISCHER ROHSTOFFE.** [Importance of Pulsation for Preparation of Solid Mineral Raw Materials]. Examples are given of pulsating preparation processes employing mechanical vibrations. The mechanisms by which the pulses generated are transmitted to the particles or particle collectives are described. The effects of pulsation on particle collectives are discussed. The characteristic features of pulsating processes for the preparation of solid mineral raw materials are explained. In German and English. 24 refs.

Rolf, L. *Aufbereit Tech* v 28 n 3 Mar 1987 p 156-162.

**074532 USEFUL GENERAL TWO-MILL CIRCUIT MODEL.** A circuit is proposed which consists of two mills, four classifiers and three stream splitters. It is shown that this circuit reduces to a number of simpler circuits of industrial interest. A program was written to compute the steady state performance of this general circuit assuming first order mill and classifier models. The overfilling correction was appropriately incorporated. This program enables the effect of different ways of connecting two mills



to be investigated as a function of make-up feed size distribution and desired product specifications. (Edited author abstract) 8 refs.

Austin, Leonard G. (Pennsylvania State Univ, University Park, PA, USA); Luckie, Peter T.; Yildirim, Kemal. *Int J Miner Process* v 21 n 3-4 Dec 1987 p 205-215.

**074533 EFFECT OF TEMPERATURE ON HYDROCYCLONE EFFICIENCY.** Plant investigations and laboratory experiments have been conducted in order to study the effects of temperature on the classification efficiency of a cyclone. It is demonstrated that under otherwise constant operating conditions, alterations in temperature produced a nearly linear change in  $d_{50(c)}$  size. However, the sharpness of the separation, as defined by the reduced efficiency curve, shows no dependence on temperature. The mineral used for the experiments was pure silica. The investigations were carried out in an iron ore processing plant located in the northern U.S. which experiences substantial seasonal temperature variations. (Edited author abstract). 10 refs.

Kawatra, S.K. (Michigan Technological Univ, Houghton, MI, USA); Eisele, T.C.; Zhang, D.; Rusesky, M. *Int J Miner Process* v 23 n 3-4 Jul 1988 p 205-211.

**074534 PHENOMENOLOGICAL MODEL OF THE HYDROCYCLONE: MODEL DEVELOPMENT AND VERIFICATION FOR SINGLE-PHASE FLOW.** Hydrocyclone models hitherto reported in the literature are empirical expressions that relate device dimensions and inlet flow conditions with separation parameters. Therefore, the applicability of such models is limited. Phenomenological models can cover a broader range and incorporate the geometry of the device in the model expressions. The first step in this effort is to solve the fluid-dynamic equations for single-phase flow before solving the actual two-phase flow problem. Experimental measurements of velocity profiles made in a 75-mm hydrocyclone and their prediction by solving the Navier-Stokes equation are shown. (Author abstract) 24 refs.

Hsieh, K.T. (Univ of Utah, Salt Lake City, UT, USA); Rajamani, K. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 223-237.

## Computer Applications

**074535 BUMP AND GRIND. HOW A COMPUTER CAN REDUCE MILL COSTS.** The system can manipulate all of the variables which affect the outcome quickly enough to eliminate the impact of large differences in the feed. Process control consists of continuous monitoring of the streams, comparison with selected setpoints or ratios, control of the flow or reagent addition rates, logging data, and the compiling of data into reports. Computers were introduced to the system in the early 1960s and have speeded up all of the functions. The system can manipulate all of the variables which affect the outcome quickly enough to eliminate the impact of large differences in the feed. The article gives nine examples of computer applications in Canadian ore treatment mills.

Werniuk, Jane. *Can Min J* v 109 n 8 Aug 1988 p 27-30.

## Computer Simulation

**074536 TREATMENT OF POLISHED SECTION DATA FOR DETAILED LIBERATION ANALYSIS.** A transformation equation can be used to describe the relationship between the one, two and three dimensional information regarding the composition of mineral particles of specified size. Linear or areal grade distribution ( $f_g$ ) can be transformed to an estimate of the volumetric grade distribution  $p(g)$  via a transformation function  $H(g, |g, N_n, \dots)$ , a conditional probability function. The effects of the external particle structure (shape) and internal grain characteristics (grade, dispersion density, and grain size distribution) on the transformation matrix have been evaluated by computer simulation of randomly oriented, irregularly shaped multiphase particles. Volumetric grade and dispersion density (number of grains per particle) are

the most important variables which influence the transformation matrix. Least square minimization of fitted functions and the Phillips-Twomey inversion technique have been used to solve the transformation equation. Three examples, a computer simulated volumetric grade distribution and two experimental depth profiles of different monosize particle samples (iron ore and copper ore), provide evidence that such an approach can be useful for liberation analysis. (Author abstract) 12 refs.

Miller, J.D. (Univ of Utah, Salt Lake City, UT, USA); Lin, C.L. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 41-58.

**Concentration** See Also GOLD ORE TREATMENT—Leaching.

**074537 PUTTING LA CARIDAD RIGHT.** These are just some of the problems faced at La Caridad and some of the solutions. Some of the solutions, the reclining cyclones and the reversible lifter bars in the mills, are particularly notable and may find useful application in other concentrators. The La Caridad flotation plant has been essentially rebuilt, and the crushing and screening plants have been substantially modified. The remaining materials handling problems relate to the intermediate and fine ore storage, but satisfactory solutions will require money not currently available. The pressure will now be on the mine to produce the 90,000 mt/d of ore required to feed the plant to capacity.

Suttill, Keith R. (Engineering & Mining Journal, New York, NY, USA). *Eng Min J* v 188 n 10 Oct 1987 p 46-51.

**074538 STUDY OF THE MOVEMENT OF PARTICLES ON THE TABLE WITH NON-HARMONIC MOTION.** According to the principles of incompressible viscous fluid flow, the velocity equation of particles on a table with non-harmonic motion is obtained through strict mathematical derivation. The velocity equation shows that, in addition to the non-harmonic motion, the particle possesses a uniform motion term and the velocity of the particle increases with the amplitude and the frequency of the non-harmonic motion. This equation is applicable in film-type gravity concentrators. (Edited author abstract). 11 refs. In Chinese.

Wang, Wexing (Central South Univ of Technology, China). *Zhongnan Kuangye Xueyuan Xuebao* v 19 n 2 1988 p 140-147.

## Control

**074539 FUZZY LOGIC: A POTENTIAL CONTROL TECHNIQUE FOR MINERAL PROCESSING.** Recent advances in the theory of fuzzy sets have led to application of this science to process control. Fuzzy logic can be used to develop heuristic or rule-of-thumb controllers with the strategy based on the actual operating practice of experienced plant operators. A heuristic controller has been designed and tested with a computer simulation model of a secondary crushing plant. The results are discussed and future applications of this control technique to other mineral processes are suggested. (Edited author abstract) 8 refs.

Harris, C.A. (Queen's Univ, Kingston, Ont, Can); Meech, J.A. *CIM Bull* v 80 n 905 Sep 1987 p 51-59.

## Costs

**074540 BUREAU OF MINES COST ESTIMATING SYSTEM HANDBOOK (IN TWO PARTS): 2. MINERAL PROCESSING.** This Bureau of Mines report and its companion report (Information Circular 9142) have been prepared to assist in the preparation of prefeasibility type estimates for capital and operating costs of beneficiation of various types of mineral occurrences using current technology. The handbook provides a convenient costing procedure based on the summation of the costs for the unit processes required in any particular mining or mineral processing operation. The unit process sections may be used to generate, in January 1984 dollars, costs through

the use of either costing curves or formulae representing the prevailing technology. The mineral processing handbook includes individual cost estimation sections for unit operations associated with comminution, beneficiation, solid-liquid separation, hydrometallurgy, and special applications as well as infrastructure and plant general and administrative costs.

Anon (US Bur of Mines, USA). *Inf Circ US Bur Mines* 9143 1987 577p.

**074541 IMPACT OF CHANGING ENERGY ECONOMICS ON MINERAL PROCESSING.** The cost per energy unit has shown the single greatest cost increase in the mineral industries. Thus, the potential for savings in operating costs are significant. Comminution is the major consumer of energy in mineral processing plants. As shown, there are at least six areas in comminution where significant energy reductions should be possible. Flotation energy reduction is already possible by using larger cells. New liquid-solids separation methods are available that offer potential energy savings as well as other cost reductions. 12 refs.

Dahlstrom, D.A. (Univ of Utah, Salt Lake City, UT, USA). *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt A 1986 p 45-48.

**Crushing and Grinding** See Also GRINDING MILLS—Ball Milling; GRINDING MILLS—Modification; GRINDING MILLS—Simulation; GRINDING MILLS—Testing; SILVER MINES AND MINING—British Columbia.

**074542 CLOSED GRINDING CIRCUIT RESIDENCE TIME DISTRIBUTION ANALYSIS.** Knowledge of the amount of time material spends in a continuous mill in a closed grinding circuit is essential for circuit performance analysis and scale-up design. A convenient method for acquiring this information involves the use of pulse tracers in residence time distribution (RTD) experiments. In typical grinding circuit experiments, RTD measurements are done by injecting a pulse tracer into the mill inlet and detecting it in the circuit exit. In this article, an easy mathematical method for calculating mean residence time and the degree of mixing of material in a closed grinding circuit is developed. The analysis of impulse response data obtained from several commercial grinding circuits using this method is presented. (Edited author abstract) 13 refs.

Rogovin, Z. (3M Co, St. Paul, MN, USA); Lo, Y.C.; Herbst, J.A.; Rajamani, K. *Miner Metall Process* v 4 n 4 Nov 1987 p 207-214.

**074543 ENERGY SAVING IN VERTICAL SHAFT IMPACTORS.** Although considered to be a newcomer, the principle of the VSI crusher has been in existence for many years. This article discusses the use of Vertical Shaft Impact Crushers in the field of tertiary and quaternary crushing, and more recently in the coarser fractions of the milling operation. A description of the machine is given.

Hill, H.E. *Mine Quarry* v 16 n 12 Dec 1987 p 27-31.

**074544 MODELING OF COMMINUTION IN HAMMER MILLS - PART 1.** This paper is a continuation of the efforts to install a mathematical model for the comminution in hammer mills. Here, in opposition to known models the solid mass flow rates inside the grinding chamber are taken into account. The model describes the comminution in a sieve hammer mill as a general case of comminution split into two steps. The first comminution step is the one time stress by the first impact at the hammers. The second comminution step realizes the continuous comminution of particles which move in a platen-roller formed between hammer tops and sieve cylinder. The particles fly off the roller and are stressed by the hammers. The equations presented describe the development of mass flows of single fractions inside the platen roller in dependency on the position at the sieve circumference at steady state. The possibility of an experimental determination of the necessary classifier and



selection coefficients is determined by experiments at a sieve hammer mill of small industrial scale, as described in part 2 of this work. (Edited author abstract) In German and English. 9 refs.

Tschorbadjiski, I. (Hochschule fuer Maschinenbau und Elektrotechnik, Sofia, Bulg); Schallnus, H.; Schwedes, J. *Aufbereit Tech* v 28 n 10 Oct 1987 p 555-562.

**074545 DETERMINATION OF OPTIMUM IMPACT-BREAKAGE ROUTES FOR AN ORE.** Single ore particles of various sizes were broken in an impact breakage device at varying levels of impact energy. It is shown that an optimum impact energy can be determined for the breakage of an ore particle of a given size to a specified product size and that the optimum usage of impact energy is often obtained by the use of a number of breakage steps for the size reduction of a particle. The optimum level of the impact energy is dependent on the size of the particle to be broken and is influenced by the size of the final product required and the efficiency of secondary breakage. The significance of these results in relation to the optimization of breakage events in grinding mills is discussed. (Edited author abstract) 10 refs.

Pauw, O.G. (Council for Mineral Technology, Randburg, S Afr); Mare, M.S. *Powder Technol* v 54 n 1 Jan 1988 p 3-13.

**074546 ANALYSIS OF DYNAMIC RESPONSES IN AN INDUSTRIAL GRINDING CIRCUIT.** The dynamic behavior of grinding circuits is an important consideration in the development of process automation. The influences of the feed rate, sump water addition and circulating load on some important process variables, such as product particle size, pulp flow rate and density, have been investigated with the aid of a large amount of dynamic data from an industrial closed grinding circuit collected by a microcomputer sampling system. The results showed that the fresh feed rate was the main manipulating variable governing the dynamic behavior. The control of circulating load is one of the feasible approaches in process optimization of closed grinding circuits. (Edited author abstract) 6 refs.

Xiong, Weiping (Central South Univ of Technology, China); Zhang, Guoxiang; Li, Songren; Su, Zhen; Hu, Weibai. *Yu Se Chin Shu* v 39 n 3 Aug 1987 p 29-37.

**074547 EFFECTS OF MILL SPEED AND FILLING ON THE BEHAVIOUR OF THE LOAD IN A ROTARY GRINDING MILL.** The dynamics of the ball load within a wet-grinding mill are examined. Both variables tested - mill filling and rotational speed - influence the position of the load, and hence the torque. An increase in mill speed and filling causes the torque to increase to a maximum value, after which further increases in speed or filling cause the torque to decrease. The position of the load toe is influenced only by the filling up to speeds of approximately 80 per cent of critical, whereas the speed and filling both cause the load shoulder to rise as their magnitudes are increased. The power drawn by the mill is predicted by the use of equations and these values are compared with the measured power draw. (Edited author abstract) 12 refs.

Liddell, K.S. (Council for Mineral Technology, Randburg, S Afr); Moys, M.H. *J S Afr Inst Min Metall* v 88 n 2 Feb 1988 p 49-57.

**074548 SIZE REDUCTION OF MAGNETITE SAND TO NANOMETRE POWDER IN A LABORATORY VIBRATION MILL.** A size reduction of a magnetite sand (300 - 425µm) to the extreme ultra-fine sizes ( $D_{50}$  = 10.7 nm), designated as a nanometre (sub-domain) powder, was accomplished in a vibration mill. On the basis of average particle size and grinding time, five stages of size reduction can be recognized, namely fine sand, micrometre (single domain) powder, and nanometre (subdomain) powder. The operating conditions and powder characteristics were determined for each stage. Micrographs of the products are presented. The mode of comminution for the different stages differ as a result of several predominant factors, namely micro-

structure of the test material, rheology of the pulp and magnetic agglomeration. (Edited author abstract) 37 refs.

Wen, S.B. (Nat'l Cheng-Kung Univ, Tainan, Taiwan); Chen, C.K.; Liu, H.S. *Powder Technol* v 55 n 1 May 1988 p 11-17.

**074549 ESTIMATION OF BREAKAGE PARAMETERS IN GRINDING OPERATIONS USING A DIRECT SEARCH METHOD.** The breakage parameters S and B of individual particle size intervals can be obtained from size distributions at different grind times by using direct search optimization. The parameters for both batch and continuous grinding operations are considered and the effectiveness of the search method is demonstrated. The direct search optimization method of R. Luus and J.H.I. Jaakola is easy to program and exhibits good convergence of the optimal values even if the initial estimates are far from the optimal values. (Author abstract) 28 refs.

Koka, V.R. (Univ of Toronto, Toronto, Ont, Can); Trass, O. *Int J Miner Process* v 23 n 1-2 May 1988 p 137-150.

**074550 WEAR AND CHIPPING OF COARSE PARTICLES IN AUTOGENOUS GRINDING: EXPERIMENTAL INVESTIGATION AND MODELLING.** The surface mechanisms of loss of mass for coarse particles in wet autogenous grinding was investigated in batch experiments using tumbling mills of 0.75 and 1.75 m diameter. Measurements of wear were carried out by following the mass of individual particles. The effect of percentage of fines present in the mill, load volume, particle roundness and mill diameter on breakage rate was established. A simple model based on a population balance analysis similar to the one used for the prediction of ball size distribution in ball mills was used to compare predicted and actual load size distribution in continuous autogenous and semi-autogenous pilot plant tests in the 1.75 m diameter mill. (Author abstract) 13 refs.

Goldman, M. (Univ Laval, Can); Barbery, G. *Min Eng* v 1 n 1 1988 p 67-76.

**074551 RAPID METHOD FOR MEASUREMENT OF FINENESS OF GRIND.** The method involves no drying of screened products and results can be obtained within a few minutes. Although the rapid method is less accurate than the conventional method of drying screened products, in certain cases this lack of accuracy may be of less importance than the increased speed of assessment. The accuracy of assessment can be reliably forecast from a simple expression provided measurement errors can be estimated. (Edited author abstract) 1 ref.

Wills, B.A. (Camborne Sch of Mines, Redruth, Engl). *Min Eng* v 1 n 1 1988 p 81-84.

**074552 EFFICIENCY OF GRINDING HARD AND ABRASIVE INDUSTRIAL MINERALS IN A ROLLER-AND-PLATE MILL.** Data received from commissioning a Loesche roller-and-plate mill and operational data over a 6 months period show very satisfying results with regard to power consumption and production as compared to previous results obtained by operating an autogenous air-swept tumbling mill of large diameter. Operational data of a conventional ball mill, installed in a German commercial grinding plant utilizing an identical mineral, show interesting results regarding the energy efficiency of the roller-and-plate mill. The mill had been installed in Bikita, Zimbabwe, to grind primarily petalite, a lithium-aluminum silicate, as well as other minerals like spodumene and feldspar. (Author abstract)

Loesche, Th. *Aufbereit Tech* v 29 n 4 Apr 1988 p 203-207.

**074553 CLASSIFICATION EFFECTS IN WET BALL MILLING CIRCUITS.** The concept of classification in wet closed circuit ball milling is expanded beyond the performance of the classifying equipment to include all aspects of the fines removal system of the grinding circuit. The fines removal effectiveness of ball milling circuits is closely related to the residence time characteristics of the mill as well as the performance of the classification equipment. Material breakage characteristics and lengthy

retention time for at least some of the solids limit the extent to which the classification characteristic of the equipment influences the overall fines removal process and the grinding efficiency of the circuit. (Edited author abstract) 34 refs.

McIvor, R.E. (McGill Univ, Montreal, Que, Can). *Min Eng (Littleton Colo)* v 40 n 8 Aug 1988 p 815-820.

**074554 ANALYSIS OF JOINT DISTRIBUTION OF NUMBER OF CYCLES AND RESIDENCE TIME IN A SELECTIVE RECYCLE SYSTEM.** The first two equations of central moments of the residence time distribution (RTD) derived from the transfer function of a selective recycle system are given. Analysis of the joint distribution of number of cycles distribution (NCD) and RTD and total regional residence time distribution (TRRTD) in a selective recycle comminution system has been analyzed using gamma distribution. General mathematical models showing the relationship between the NCD, RDT, and TRRTD have been given in terms of the covariances and correlation coefficients of pairs of those variables. The example concerns a ball mill used to grind sulfide ore at Vammala mine in Finland. (Author abstract) 12 refs.

Nkonde, Glasswell K. (Helsinki Univ of Technology, Espoo, Finl). *Acta Polytech Scand Chem Technol Metall Ser* n 183 1988 16p.

**074555 ENERGY SPLIT IN MULTICOMPONENT GRINDING.** An energy split factor is defined as the ratio of energies expended when unit-mass of a mineral is ground in a mixture environment and ground alone for the same time interval. Provided the grinding path of a mixture component remains invariant in the two grinding modes and the mill power-breakage rate function correlation holds, the energy split factor can be computed from breakage rate functions or initial rates of production of fines or from data for top-size feed particles remaining unbroken as a function of time. For illustration and verification, three sets of mixture grinding data have been employed, namely, calcite-quartz and hematite-quartz, both in 1:1 volume ratio, and dolomite-hematite in four different compositions. (Edited author abstract) 11 refs.

Kapur, P.C. (Univ of California, Berkeley, CA, USA); Fuerstenau, D.W. *Int J Miner Process* v 24 n 1-2 Sep 1988 p 125-142.

**074556 EFFECTS OF LIFTER BARS ON THE MOTION OF en-MASS GRINDING MEDIA IN MILLING.** Cinematographic films were analysed in the quantitative assessment of the effects of rectangular lifter bars on the motions of en-masse grinding elements in an experimental mill. It was found that, while lifter bars eliminate the slip of the grinding charge against an otherwise smooth liner, they increase the dynamic pressure and the intensity of abrasive interactions in the bulk of the en-masse grinding charge. They also increase the intensity of the impactive interactions in a mill as a result of their lifting action, which promotes cataracting of the grinding charge, and their keying-in action, which increases the kinetic energies and the rates of transport of grinding elements through the en-masse regime. (Author abstract) 15 refs.

Vermeulen, L.A. (MINTEK, Council for Mineral Technology, S Afr); Howat, D.D. *Int J Miner Process* v 24 n 1-2 Sep 1988 p 143-159.

**074557 CORRELATION BETWEEN PROBABILITY OF BREAKAGE AND FRAGMENT SIZE DISTRIBUTION OF MINERAL PARTICLES.** The energy consumption in industrial grinding depends considerably on the particle size. This phenomenon has been described by well known comminution laws. It is now explained quantitatively for spherical particles using Weibull statistics for the flaw size distribution, Hertz theory of the stresses, and fracture mechanics for the crack propaga-



tion. The resulting simple equations are applied for the description of several experiments with spherical and non-spherical particles. (Author abstract) 17 refs.

Weichert, Reiner (Univ of Karlsruhe, Karlsruhe, West Ger). *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 1-8.

**074558 PREDICTION OF PARTICLE COMPOSITION DISTRIBUTION AFTER FRAGMENTATION OF HETEROGENEOUS MATERIALS.** A review of problems encountered in developing prediction models for composition distribution for particles obtained by the breakage of multiphase materials is presented. The need to characterize texture by image analysis, describe particle production by similar methods, relate particle production and texture, and use integral geometry methods and stochastic geometrical processes to solve the complex probability equations in three-dimensional space is stressed. A presentation is made of a model which incorporates the required elements. A special case of the model, combining a description of texture based on a Boolean model with primary Poisson polyhedra grains of particle production calibrated on screen fractions extracted from ground ores, is presented. Applications to data of other researchers give evidence of its value in predicting particle composition distribution at sizes similar or coarser than grain sizes. (Edited author abstract) 37 refs.

Barbery, G. (Laval Univ, Quebec, Que, Can); Leroux, D. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 9-24.

**074559 LIBERATION MODELING USING AUTOMATED IMAGE ANALYSIS.** A population balance model describing the combined processes of size reduction and mineral liberation has been developed for batch grinding. Important model parameters including breakage distribution functions, breakage rate functions, and liberation functions have been determined experimentally by examining the mill product using a Zeiss SEM-IPS image analyzer. Areal assays obtained from image analysis of monosized particle mounts correspond closely to the actual chemical assays. As a result of the model parameter analysis, breakage distribution functions have been found to be independent of the grinding environment, while breakage rate functions appear to be sensitive to it. The model has been validated by simulating the batch grinding of a sphalerite ore from Tennessee. Excellent agreement between the model predictions and the experimental results is observed for both monosized and multisized feed materials. (Edited author abstract) 21 refs.

Choi, W.Z. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Adel, G.T.; Yoon, R.H. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 59-73.

**074560 DESIGN CONSIDERATIONS FOR LARGE DIAMETER BALL MILLS.** Large mill ( $D > 5.0$  m (16.5 ft)) performance has been predicted from small scale batch experiments for grinding kinetics and residence time distribution correlation for transport using population balance models. The effect of ball size must be properly taken into account in the scale-up. A design method that combined the kinetic scale-up findings and the transport of material through the mill has been developed. A computer program involving kinetic and transport considerations has been tested and found to be satisfactory for mill design purposes. (Author abstract) 26 refs.

Lo, Y.C. (Univ of Utah, Salt Lake City, UT, USA); Herbst, J.A.; Rajamani, K.; Arbiter, N. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 75-93.

**074561 COMMINATION OF MULTICOMPONENT FEEDS UNDER BATCH AND LOCKED-CYCLE CONDITIONS: KINETICS, SIMULATION AND ENERGY DISTRIBUTION.** The results of an

investigation of batch and locked-cycle dry grinding of quartz-calcite mixtures in a laboratory ball mill are presented. Batch grinding tests showed that the breakage rate function of the components is time-independent but composition-dependent and is normalizable with specific energy. Locked-cycle tests revealed that approximately 25 2-min cycles are required before the composition of the circuit product and the recycle material attains a steady state. The circulating load, after steadily increasing during the first 15 cycles, continued to fluctuate over a narrow range. These findings indicate that industrial-scale grinding circuits may also have long transient periods as the grindability of the ore changes and that circuits might be in transience perpetually. (Author abstract) 9 refs.

Fuerstenau, D.W. (Univ of California, Berkeley, CA, USA); Venkataraman, K.S. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 105-118.

**074562 MULTICOMPONENT MODELS OF GRINDING AND CLASSIFICATION FOR SCALE-UP FROM CONTINUOUS SMALL OR PILOT SCALE CIRCUITS.** A multicomponent model of grinding and classification circuits as a scaling-up method is described. Steady-state test results of an ore are presented for continuously operated ball mills ranging from 0.6 to 4.4 m diameter. Simple translation of the specific breakage rates in the breakage rate-particle size ( $k-x$ ) plane enables an excellent estimate of the largest mill performance to be made from the smaller full scale mill and fair to reasonable estimates to be made from the two pilot scale mills. Ball size is the major, if not sole, cause for the variation in size interval for which the breakage rate was a maximum. A simple method for incorporating this effect into a scale-up procedure is presented. It is concluded that the functional form for the  $k-x$  relationship based on batch grinding tests is inadequate for testing heterogeneous ores under grinding conditions. The results are otherwise consistent with the scale-up relation of L.G. Austin. (Author abstract) 28 refs.

Weller, K.R. (CSIRO, Clayton, Aust); Sterns, U.J.; Artone, E.; Bruckard, W.J. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 119-147.

**074563 TRACER STUDY OF MASS TRANSPORT AND GRINDING IN A ROD MILL.** Residence time distribution experiments using radioactive tracers have shown strong particle size dependence of material transport in a continuous wet overflow rod mill. A new method for the determination of the size-dependent velocities and dispersion coefficients of the material has been developed. Earlier studies have shown that non-linear grinding kinetics prevail in rod milling operations, and a mathematical method to handle it has been previously suggested. By using these two methods, a non-linear distributed parameter model has been solved analytically and has been fitted to experimental size distribution data. The predictive capability of this model has been demonstrated. (Edited author abstract) 26 refs.

Rogovin, Zvi (Univ of Utah, Salt Lake City, UT, USA); Casali, Aldo; Herbst, John A. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution Conf Pap, Salt Lake City, UT, USA, 1987 p 149-167.

**074564 POTENTIAL ENERGY SAVINGS IN COMMINATION BY TWO-STAGE CLASSIFICATION.** Comminution normally consumes a large amount of energy in any mineral processing plant. One of the areas that appears to enable an appreciable saving of energy is the classification step in a closed ball mill circuit. Hydrocyclones are the major method for closing comminution circuits but employ only a single stage of classification. Thus, in each pass through the hydrocyclones, only 70-78% of the extreme fines are sent to product. A computer program named MODSIM permitted determination of results for the ball mill and hydrocyclone circuit as they influence each other. Energy consumption in kilowatt hours/ton of product was plotted against the product grind with parameters of circulating load. Grind utilized was percent +100 mesh. The flow-sheet employed

for two-stage classification was repulping of first-stage underflow with second-stage underflow returned as ball mill feed. Product was taken from both cyclone overflows. The feed was an ore similar to Kennecott's Utah operation for copper production with a rod mill discharge size distribution as feed to the circuit. All cyclone feeds were at 54% solids with hydrocyclone underflow maintained at 75 wt.% solids. As the grind increased in fines, the energy savings increased. As the circulating load increased, energy savings decreased. Energy savings ranged from 6% to over 30%. (Edited author abstract) 6 refs.

Dahlstrom, Donald A. (Univ of Utah, Salt Lake City, UT, USA); Kam, Wai-Ping. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 239-250.

**074565 RHEOLOGICAL EFFECTS IN GRINDING CIRCUITS.** The grinding efficiency of circuits using tumbling media mills in closed circuits with hydrocyclone classifiers may be improved by control of the mill slurry rheology. The rheology affects both the rate of fine material production by the grinding mill and the separation performance of the hydrocyclone. In addition, the manner in which rheology changes are produced will affect hydrocyclone performance. This parameter is neglected in process control situations due to the difficulty of making rheological measurements of dense slurries on-line. In recent years, a number of new viscometers have been developed which may be useful for this purpose. (Author abstract) 14 refs.

Kawatra, S.K. (Michigan Technological Univ, Houghton, MI, USA); Eisele, T.C. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 251-259.

**074566 STOCHASTIC SIMULATION OF FILTERING AND CONTROL STRATEGIES FOR GRINDING CIRCUITS.** Random variations in the grinding circuit operating variables and their measured values complicate the dynamic analysis and automatic control of the circuit operation. A stochastic-dynamic simulator is presented for the purpose of testing various data filtering and circuit control strategies under actual noisy plant conditions. The simulator is flexible with respect to the circuit flowsheet and versatile for the implementation of additional noises, filters and control loops. It is applied to the evaluation of a conventional control strategy for a two-stage industrial grinding circuit and to the design of an adaptive Kalman filter for a closed laboratory grinding circuit. (Author abstract) 8 refs.

Hodouin, Daniel (Univ Laval, Que, Can); Dube, Yves; Lanthier, Robert. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 261-274.

**074567 OPTIMAL CONTROL OF COMMINATION OPERATIONS.** Optimal control theory has had limited application in mineral processing practice. The reason for this has been the lack of accurate on-line models, the complicated nature of the mathematics and a lack of inexpensive computing power. In recent years progress has been made, especially in comminution. This paper reviews work at the Utah Comminution Center concerned with the application of optimal control theory to crushing, semiautogenous grinding and rod/ball mill grinding. The state of development ranges from computer-simulated to plant-tested. In all instances, the potential for improving upon classical control strategies is exceptional. (Author abstract) 18 refs.

Herbst, J.A. (Univ of Utah, Salt Lake City, UT, USA); Alba J., F.; Pate, W.T.; Oblad, A.E. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 275-296.

**074568 PROGRESS IN ABRASION-RESISTANT MATERIALS FOR USE IN COMMINATION PROCESSES.** The wide range of materials used to resist wear in comminution processes is reviewed under the main



categories of special steels, non-metals, and alloyed white cast irons. Those process areas leading to the highest levels of wear are discussed in conjunction with the mechanism of abrasion and type of machinery and equipment utilized. Progress in the metallurgical development of high chromium white cast irons is highlighted. The physical properties in resisting wear are related to chemical composition and microstructure. Successful application and the financial benefits arising from the use of these alloys are demonstrated by reference to specific applications. An insight is given into the ongoing areas of research and practical aspects of development of high chromium cast irons with the emphasis on minimizing the cost of consumable wear parts. (Edited author abstract) 23 refs.

Durman, R.W. (Bradley & Foster Ltd, Wednesbury, Engl.). *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 381-399.

**074569 FIRST SURVEY OF GRINDING WITH HIGH-COMPRESSION ROLLER MILLS.** The special feature of high-compression roller mills is that a bed of particles is compressed between two rollers to a high solid density more than 70% of volume. The size reduction occurs by interparticle crushing. The milling force must be adjusted to a level so that the particle bed is loaded by a compressive force per unit area exceeding at least 50 N/mm<sup>2</sup> and in most practical cases being within the range between 100 and 300 N/mm<sup>2</sup>. The material leaves the mill as flakes which have to be deagglomerated in a succeeding operation. Nevertheless, both operations consume less energy than a ball mill. HC roller mills have less wear and reduce overgrinding. (Edited author abstract) 9 refs.

Schoenert, Klaus (Technische Univ Clausthal, Clausthal-Zellerfeld, West Ger.). *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 401-412.

## Effluent Treatment

**074570 TECHNO-ECONOMIC EVALUATION OF THIOSALT TREATMENT PROCESSES.** Numerous processes for the treatment of thiosalts in base metal milling effluents have been examined in the past decade. Flowsheets for thirteen processes are outlined and cost estimates are presented for a base case of a 720 m<sup>3</sup>/h effluent flow containing 1400 mg/L thiosalts. The processes are ranked on the basis of capital and operating costs and chance of technical success. All costs are high and none of the methods has yet been proven to be consistently effective for large-scale treatment of actual effluents on a continuous basis. (Author abstract) 8 refs.

Wasserlauf, M. (Gionet, Mellor, Liebich Associates Ltd, Dorval, Que, Can); Condy, A.A.; Wheeland, K.G.; Dutrizac, J.E. *CIM Bull* v 81 n 909 Jan 1988 p 82-86.

## Electric Breakdown

**074571 MECHANISM OF ELECTRIC DISCHARGE WEAKENING OF ORES.** The results of optical investigations of the surface of rare-metal ores weakened by electrical discharges are presented. It is shown that weakening of ore specimens by discharges is found in the development and broadening of existing microcracks and chips and in the formation of new ones. Furthermore, as a result of the effect of the pressure wave on the rock, shearing occurs with the formation of new surfaces, on which microparticles of the minerals are constantly present. (Edited author abstract)

Yashchenko, A.V.; Blaznina, D.N.; Belyaevskii, A.T.; Rakaev, A.I. *Sov Surf Eng Appl Electrochem* n 5 1987 p 33-37.

## Electrochemistry See Also METALLIC COMPOUNDS—Electric Conductivity.

**074572 DETERMINATION OF THE DIFFUSION COEFFICIENTS OF CuSO<sub>4</sub>, ZnSO<sub>4</sub>, AND NiSO<sub>4</sub> IN AQUEOUS SOLUTION.** The diffusion coefficients of

CuSO<sub>4</sub>, ZnSO<sub>4</sub>, and NiSO<sub>4</sub> in the aqueous solution systems of MSO<sub>4</sub> and MSO<sub>4</sub>-H<sub>2</sub>SO<sub>4</sub> were measured at 298 K using a diaphragm cell method and are listed as a function of molar concentrations of MSO<sub>4</sub> and H<sub>2</sub>SO<sub>4</sub>. It was found that the concentration dependencies of the diffusion coefficients in each single metal sulfate solution are similar. The presence of H<sub>2</sub>SO<sub>4</sub> generally causes a less significant concentration dependency of the diffusion coefficients of MSO<sub>4</sub>. The concentration dependencies of the diffusion coefficients of CuSO<sub>4</sub> in aqueous solutions of CuSO<sub>4</sub> and CuSO<sub>4</sub>-H<sub>2</sub>SO<sub>4</sub> are attributed to changes in the mean activity coefficient of CuS 4 and the viscosity of the solutions. (Edited author abstract) 14 refs.

Awakura, Yasuhiro (Kyoto Univ, Kyoto, Jpn); Doi, Toshiya; Majima, Hiroshi. *Metall Trans B* v 19B n 1 Feb 1988 p 5-12.

## Environmental Impact See AIR POLLUTION—Particulate Emissions; SILICA.

## Equipment See Also CHEMICAL EQUIPMENT—Cyclones; IRON ORE TREATMENT—Sintering.

**074573 CYCLONE MODELLING: A REVIEW OF PRESENT TECHNOLOGY.** Since the publication of empirical cyclone models by Lynch and Rao in 1975 and by Plitt in 1976, the technical literature on this subject has consisted primarily of reports of applications, with only a few articles discussing basic modifications or enhancements in model form. This paper presents a review of empirical cyclone modelling technology, with an emphasis on developments since the mid 1970s. The topics addressed include homogeneous and heterogeneous ores, parameter estimation techniques, parameter confidence intervals, and a new conceptual model of cyclone operation. (Edited author abstract) 38 refs.

Flintoff, B.C. (Univ of Alberta, Can); Plitt, L.R.; Turak, A.A. *CIM Bull* v 80 n 905 Sep 1987 p 39-50.

## Filtration

**074574 REDUCTION OF THE ENERGY REQUIRED FOR THE DEWATERING OF FINE-GRAINED ORE CONCENTRATES.** The separation of fine-grained solids from ore, coal and mineral concentrates is commonly accomplished with vacuum filters on a continuous basis. The desired residual moisture of the filter cake thus built, is however, frequently not achieved, so that additional energy-consuming accessory units are often required. Based on research work which has been carried out, engineering solutions leading to a more economical dewatering of difficult-to-filter beneficiation concentrates are presented. The mechanical dewatering of a filter cake by means of continuous pressure filtration is substantially more advantageous than the use of a combination of inadequate vacuum filtration and subsequent thermal drying. In addition to ascertaining the optimal operational conditions, new methods for avoiding shrinkage cracks in filter cakes have also been developed, and questions regarding the design of disk and drum filters have been investigated. (Edited author abstract) In German and English. 7 refs.

Anlauf, H.; Stahl, W. *Aufbereit Tech* v 28 n 6 Jun 1987 p 308-313.

**074575 VARIATION OF FILTER CAKE PERMEABILITY WITH MEAN PORE DIAMETER OF THE CAKE.** It is shown that most particles in a filter cake have more than only point contact with each other. Therefore, the Kozeny-Carmen equation is modified by relating permeability to porosity and a mean pore diameter as measured by automatic image analysis in horizontal cross sections of the cake. In filter cakes of chalcopryrite and magnetite, the permeability increases stepwise with the product of porosity and square mean pore diameter. (Author abstract) 22 refs.

Banda, S.M. Herath (Lulea Univ of Technology, Lulea, Swed); Forsberg, K.S. Eric. *Scand J Metall* v 17 n 2 1988 p 67-72.

## Flocculation See KAOLIN—Flocculation.

**Flotation** See Also ALUMINA—Flotation; COAL PREPARATION—Flotation; COPPER LEAD ORE TREATMENT—Flotation; FERROALLOYS—Applications; FLOTATION—Computer Simulation; FLOTATION—Equipment; FLUORSPAR DEPOSITS—German Democratic Republic; MAGNESIUM COMPOUNDS—Processing; ORE DEPOSITS—Taiwan; PHOSPHATES—Separation; SURFACE ACTIVE AGENTS—Adsorption; ZINC ORE TREATMENT—Leaching.

**074576 EFFECT OF THE LENGTH OF THE HYDROCARBON CHAIN OF FATTY ACID POTASSIUM SOAP ON THE KINETICS OF FLOTATION SEPARATION OF POLYVALENT METAL IONS COLLECTED WITH THEIR AID.** The results of experiments concerning the effect of the length of the hydrocarbon chain of fatty-acid collectors on the kinetics of process of flotation separation of ions collected by them are presented. An attempt is made to explain these results from the standpoint of the theory of stability of hydrophobic colloids. In Russian. 18 refs.

Skypylev, L.D.; Sazonova, V.F.; Skryleva, T.L. *Izv Vyssh Uchebn Zaved Tsvetn Metall* n 1 1987 p 16-21.

**074577 RAW-MATERIAL-RELATED INFLUENCES ON BARITE FLOTATION.** The influences of specific surface and mineral composition on the flotation of primary and secondary barite raw materials are quantified. By the introduction of equivalent surfaces, which are determined by using X-ray diffractometry, the indirect technical measurement of the specific surfaces of the mineral phases and mineral groups involved is possible. A regression model for the evaluation of raw materials is derived which makes it possible to calculate the separation quality in advance. The influence of the absolute solids surface per unit volume of slurry on the flotation result is demonstrated and discussed. (Edited author abstract) In German and English. 34 refs.

Heinrich, G. (Technische Univ Berlin); Gock, E. *Aufbereit Tech* v 28 n 6 Jun 1987 p 301-307.

**074578 IMPROVEMENT OF THE FLOTATION BEHAVIOR OF QUARTZ AND KAOLINITE BY ADSORPTION OF Ca IONS.** The adsorption of Ca ions on finely ground quartz and kaolinite particles has been measured over a wide pH range at a concentration of 100 ppm of Ca in the slurry. A distinct parallelism was found between the pH-dependent adsorption of the Ca ions and the flotation recovery of quartz by using various fatty acids as anionic collectors. The adsorption of hydrolyzed CaOH<sup>+</sup> on Na-kaolinite causes coagulation. The coagulation occurs preferably under conditions where hydrolysis is observed. The zeta potential of Na-kaolinite was reversed at a pH of about 13. (Edited author abstract) In German and English. 7 refs.

Atesok, G. (Istanbul Technical Univ, Istanbul, Turk); Acarkan, N. *Aufbereit Tech* v 28 n 6 Jun 1987 p 314-321.

**074579 METHOD OF AUTOMATING SEMI-BATCH FLOTATION.** The present report describes a relatively simple, low-cost method of automation that can readily be implemented. A standard stainless-steel cell, which is operated in conjunction with a Denver flotation machine, has been modified by opening a narrow slot on one side and attaching a vertical glass tube 22 mm in diameter via a copper elbow. A length of plastic tubing is suspended with one end in the glass tube by hanging it from a vertical Plexiglass cylinder 150 mm in diameter, which is, in turn, connected to a 25-l polyethylene tank that serves as a reservoir for make-up water. The discharge from the tank flows into a spray nozzle that consists of a length of Plexiglass tubing with several small holes. Additional aspects of the experimental apparatus, test procedure and results are discussed. 7 refs.

Yalcin, T.; Reilly, A.M. *Trans Inst Min Metall Sect C* v 96 Sep 1987 p 163-164.



**074580 DEVELOPMENT OF CONTACT ANGLES ON HEAZLEWOODITE.** There has been considerable controversy over the relative roles of adsorbed xanthate, metal xanthates and dioxanthogen in the flotation of sulfide minerals. The results of the electrochemical experiments reported here help to resolve this position as regards the flotation of heazlewoodite ( $\text{Ni}_3\text{S}_2$ ) by ethyl xanthate. The present work forms part of a wider study on the flotation response of nickel-bearing sulfide minerals. The separation of  $\text{Cu}_2\text{S}$  and  $\text{Ni}_3\text{S}_2$  is carried out industrially in the Inco separation process, the former being selectively floated with the use of diphenylguanidine; however, other than the observation that  $\text{Ni}_3\text{S}_2$  is floated by butyl xanthate over the narrow pH range 7-10, there appear to be no published data on the flotation of this mineral. 9 refs.

Critchley, J.K.; Hunter, C.J. *Trans Inst Min Metall Sect C* v 96 Sep 1987 p 165-168.

**074581 TESTS OF A NEW COLLECTOR FOR ORE FLOTATION.** A new reagent - a synthetic fatty acid amidoamine (BP-3) - is proposed as a collector for ore flotation. Data are presented concerning the selectivity of BP-3 on pure minerals, the separation of a quartz-feldspar product and the flotation of columbite and cassiterite from real process slurries. (Translated author abstract) In Russian.

Kurkov, A.V.; Molodkina, I.A.; Uskov, S.M. *Tsvet Met* n 5 May 1987 p 101-102.

**074582 PARTICLE SIZE DEPENDENCE IN FLOTATION DERIVED FROM A FUNDAMENTAL MODEL OF THE CAPTURE PROCESS.** A flotation model is described wherein particle collection is considered to occur by particle-bubble collision followed by the particle sliding over the bubble during which attachment may occur. Collisions are quantified by a collision efficiency  $E_C$ . The existing model for  $E_C$  is extended by including particle inertia. Attachment is quantified by an attachment efficiency  $E_A$  calculated as the fraction of particles which reside on the bubble for a time greater than the induction time. The model is examined and shown to agree with much experimental data. (Edited author abstract) 28 refs.

Dobby, G.S. (Univ of Toronto, Toronto, Ont, Can); Finch, J.A. *Int J Miner Process* v 21 n 3-4 Dec 1987 p 241-260.

**074583 EFFECT OF TRACE METAL ION IMPURITIES ON THE HYDROXAMATE FLOTATION OF QUARTZ.** Hydroxamates are chelate-forming organic compounds that show selectivity for certain metal cations. The results reported in this communication illustrate how the presence of impurities, even trace quantities, can affect the flotation behavior of quartz when potassium octyl hydroxamate is used as the collector. Surface chemistry studies must be performed under conditions in which the absence of trace impurities can be guaranteed, otherwise interpretation of the results could ensue. 4 refs.

Herrera-Urbina, R. (Univ of California, Berkeley, CA, USA); Fuerstenau, D.W. *Int J Miner Process* v 21 n 3-4 Dec 1987 p 307-310.

**074584 STUDIES WITH A DERIVATOGRAF OF THE PROPERTIES OF A WATER FILM ON A MARBLE SURFACE MODIFIED BY TETRACYCLAMMONIUM CHLORIDE (TDACl).** In mechanical mineral enrichment processing in aqueous media, mainly a flotation method is used. More than 60% of the minerals are concentrated by this method. The properties of water layers on bare marble and on marble samples covered with various amounts of tetracyclammonium chloride TDACl after flotation were investigated by thermal analysis methods. The dependence of the layer thickness, activation energy, enthalpy and entropy of the bonded water vs. the amount of TDACl previously deposited on the marble surface were determined. The results obtained and the literature data were used to propose an interpretation of the changes caused in these parameters by the coverage of the marble surface with

TDACl molecules. A correlation between these parameters and the changes in the water structure and marble flotability is also presented. 29 refs.

Staszczuk, P. (Marie Curie-Sklodowska Univ, Lublin, Pol); Bilinski, B. *J Therm Anal* v 32 n 5 Sep-Oct 1987 p 1457-1470.

**074585 EFFECT OF COLUMN HEIGHT ON FLOTATION COLUMN PERFORMANCE.** The question is posed as to why columns typically have a collection zone 10 m high (H) by 1 m in diameter (D). Three geometry dependent factors are considered: degree of mixing,  $N_p$ ; volumetric bias rate, B; and volumetric gas rate, G. Increasing H:D decreased  $N_p$  and B which improves performance but decreases G which causes the column to approach overloading. Taking typical column operating conditions, it is concluded that a collection zone H:D of 10:1 is a reasonable compromise. (Author abstract) 10 refs.

Yianatos, J.B. (McGill Univ, Montreal, Que, Can); Espinosa-Gomez, R.; Finch, J.A.; Laplante, A.R.; Dobby, G.S. *Miner Metall Process* v 5 n 1 Feb 1988 p 11-14.

**074586 BUBBLE DIAMETER ESTIMATION IN A MECHANICALLY AGITATED FLOTATION MACHINE.** The photographic measurement of bubble diameter is tedious and restricted to vessels with transparent walls and relatively low bubble concentrations. A new method for predicting bubble diameter in a flotation column has been developed and confirmed by comparison with measured mean bubble diameter (Yianatos et al., 1987). Flotation columns are not mechanically agitated. This note describes an extension of this method to a mechanically agitated flotation machine. A recent publication by Szatkowski (1987) provided sufficient data to calculate bubble diameter by the proposed method and compare the estimates with values determined photographically. 4 refs.

Xu, M. (McGill Univ, Montreal, Que, Can); Finch, J.A. *Miner Metall Process* v 5 n 1 Feb 1988 p 43-44.

**074587 NEW CONCEPT IN FLOTATION COLUMN DESIGN.** A column flotation cell is described in which the contact between the feed and the air stream is made in a mixing device at the top of a vertical downcomer. The air-liquid mixture flows downward to discharge into a shallow pool of pulp in the bottom of a short cylindrical column. The bubbles disengage and rise to the top of the column to overflow into a concentrate launder while the tails are discharged from the bottom of the vessel. The main advantages of the device are that the overall height of the column is reduced to about 1 m (3 ft) and the column can be self-inducing with respect to the air supply. Experimental results are given from tests on a feed stream to a conventional zinc cleaner circuit. Using wash water to reduce gangue entrainment, the column gave high concentrate grades and high recoveries. (Author abstract) 4 refs.

Jameson, G.J. (Univ of New Castle, Newcastle, Aust). *Miner Metall Process* v 5 n 1 Feb 1988 p 44-47.

**074588 ADSORPTION VON OLEAT AN CHROMIT UND OLIVIN.** [Adsorption of Oleate on Chromite and Olivine]. Oleate adsorption on chromite and olivine is an important phenomenon, since oleate is one of the leading surfactants used in chromite flotation. Adsorption studies were conducted to determine the effects of oleate concentration, solution, pH, and concentration of some modifiers, such as sodium fluorosilicate and carboxymethyl cellulose, on oleate adsorption of both minerals. The relationship between oleate adsorption and the electrokinetic potential of the minerals was also investigated under the above-mentioned conditions. Finally, the concentrations of dissolved ions in chromite and olivine solutions were determined to explain oleate adsorption and electrokinetic phenomenon. (Edited author abstract) In German and English. 11 refs.

Atak, S. v 28 n 12 Dec 1987 p 727-733.

**074589 CLEANING ACTION IN COLUMN FLO-**

**TATION FROTHERS.** Hydraulic entrainment of fine particles into the froth decreases concentrate grade in mechanical flotation cells. Flotation columns prevent hydraulic entrainment by maintaining a net downward flow of water through the froth. A study is presented of feed water penetration into the froth, a state that corresponds to the boundary (worst) condition of fine particle entrainment. Laboratory and plant scale tracer tests were performed to measure the amount of feed water entrained at different levels in the froth as a function of gas rate, bias (net downward water) rate and froth depth. The results show that the main cleaning action occurs close to the interface (< 10 cm) at moderate superficial gas rates (< 1 cm/s). The effects of gas rate and froth depth on the cleaning of the froth are more significant than that of the bias rate. Feed water is completely rejected at superficial gas rates of less than 1.5 cm/s with froth depths greater than 1 m. 14 refs.

Yianatos, J.B.; Finch, J.A.; Laplante, A.R. *Trans Inst Min Metall Sect C* v 96 Dec 1987 p 199-205.

**074590 PRINCIPLE AND APPLICATION OF RAMIFICATION CARRIER FLOTATION.** In this paper, the ramification-carrier flotation (RCF) of seven kinds of different ores, including wolframite, hematite, refractory copper ore, lead-zinc ore oxide, low-grade Cu-Mo sulfide ore, and Sb-As sulfide, are investigated. It has been shown that much higher recovery and better separation efficiency are achieved with RCF than with conventional flotation. In addition, for the RCF technology as compared with conventional carrier flotation (CCF), the overall reagent consumption is reduced and the difficulties of subsequent separation of the carried valuable ultrafine particle from the coarse carrier particles and the recovery of the carrier are obviated. The mechanism of the RCF process named the 'collision adhesion' model is suggested. In the model, the parameters influencing the RCF process are classified into the geometrical, physical and chemical factors. (Edited author abstract) 9 refs.

Hu, Weibai; Wang, Dianzuo; Qu, Guanzhou. *Zhongnan Kuangye Xueyuan Xuebao* v 18 n 4 Aug 1987 p 408-414.

**074591 FREE JET FLOTATION OF OXIDE AND SULFIDE ORES IN THE ULTRA-FINE PARTICLE RANGE.** For flotation of fine particles with 100% approx. > 10  $\mu\text{m}$ , difficulties are experienced which, among others, can be attributed to adhering particles and the formation of agglomerates. Due to the density and character of the charges at the surfaces of these collectives, the equalizing of charges between the surfaces of the coarser and finer particles results in the formation of adhering particles which leads to a reduced ability of the surface of the solid to react. This results in product losses and/or a decrease in the selectivity of the sorting process. At the Technical University of Berlin, a free jet flotation cell has been developed for the flotation of ores of the finest particle ranges. The objective of the project is to test this cell for flotation of ores. The matrices floated were baddeleyite rough concentrate, sulphide lead-zinc ore, mercury ores containing graphite and sulfides, iron ore and tailings containing chromite. Concentrates of the required standard for further processing were produced in multi stage preflotation and cleaning flotation. (Edited author abstract) 9 refs. In German and English.

Atmaca, T.; Simonis, W. *Aufbereit Tech* v 29 n 2 Feb 1988 p 88-94.

**074592 COMPUTER SIMULATION OF STEADY-STATE FLOTATION FLOWSHEET.** A general steady-state flotation flowsheet simulator SIMFLOT based on the discrete distribution of the rate coefficient with low and high values presented by Kelsall is developed by the authors. Three basic modules, i.e. the mixer MIXER, the splitter SPLITR and the flotation bank FLBANK consisting of several modules ONECEL, are connected by the flowsheet topology matrix in SIMFLOT. So any flotation flowsheet with a random arrangement can be simulated by it. It is also developed that a program ESTIFLOT is used to estimate the parameters of models



in the SUMT method taking weighting square sums of differences between simulated and experimental values as the objective function. The data collected from the Dexing Copper Mine are taken as the normal condition of simulation. Then the parameters of models are estimated from data balanced by the material balance package CSIMBAL. The results of simulation are very satisfactory: The simulated and observed values for the recovery of copper in the final concentrate are 91.102% and 91.155%, respectively. (Edited author abstract) 9 refs. In Chinese.

Yin Di; Zhang Guoxiang; Hu Weibai. *Zhongnan Kuangye Xueyuan Xuebao* n 5 Oct 1986 p 14-20.

**074593 SURFACE CHEMISTRY AND APPLICATIONS OF ALKYL HYDROXAMATE COLLECTORS IN MINERAL FLOTATION.** The published results of mineral flotation with alkyl hydroxamate collectors as investigated through adsorption studies and microflotation tests have been critically reviewed. Hydroxamate reagents chemisorb at the mineral/water interface, forming chelate complexes with the metal ions on the surface. The flotation response as a function of concentration and pH correlates with adsorption data. There exists a characteristic peak at pH 9 for both adsorption and flotation. This peak appears to be a result of two mechanisms of chemisorption, namely, the co-adsorption of adsorbate ions and molecules on the surface near the pK of the collector and the surface reaction between hydroxamate species and the cationic metal hydroxycomplexes at the mineral interface. (Edited author abstract) 55 refs.

Anon (Tata Research Development & Design Cent, Poona, India). *Trans Indian Inst Met* v 40 n 4 Aug 1987 p 287-304.

**074594 AEROSOL FROTHER ADDITION IN COLUMN FLOTATION.** The objective of the laboratory work described in this paper has been to develop a method for producing small gas bubbles at moderate to high gas rates in a flotation column. Small bubbles are particularly important for attaining reasonable flotation rates of fine particles. An ultrasonic aerosol generator has been employed to add frother solution directly to the gas stream. Using porous glass and filter cloth spargers, aerosol frother addition has produced bubbles at  $\frac{1}{2}$  to  $\frac{2}{3}$  the diameter of those produced by conventional frother addition to the liquid, at a lower frother consumption. (Author abstract)

Flint, I.M. (Univ of Toronto, Toronto, Ont, Can); MacPhail, P.; Dobby, G.S. *CIM Bull* v 81 n 913 May 1988 p 81-84.

**074595 FLOTATION ACTIVITY AND THERMODYNAMIC ADSORPTION FUNCTION OF AROMATIC HYDROCARBONS.** A detailed study has been made of the flotation activity and thermodynamic adsorption functions of alkylated and polymethylated benzenes, with mono- and diisomeric substituents containing various functional groups (particularly halogens) in the benzene ring. The data shows that benzene is a poor flotation reagent for graphite, has the lowest adsorption capacity and is the least strongly adsorbed of all the hydrocarbons examined. Alkylation and polymethylation of the benzene improves its flotation activity, increasing both the adsorption capacity and the strength of attachment, and the differential heat of adsorption, free energy and entropy. Polymethylbenzene has the greatest flotation and adsorption capacities. Xylene and trimethylbenzene are more active than ethylbenzene or propylbenzene. 10 refs.

Chizhevskii, V.B. *Sov Min Sci* v 23 n 3 May-Jan 1987 p 270-273.

**074596 ELECTROKINETIC POTENTIAL OF FLOTATION PULPS.** The electrokinetic potential is a parameter which can be used to characterize the flotation properties of pulps. Equations for determining this potential from the results of measuring sedimentation potential were derived. Two types of pulps were considered, namely

stable pulps and unstable pulps. 6 refs.

Mis'nik, V.A. (Siberian Nonferrous Metals Research & Planning Inst, Krasnoyarsk, USSR). *Sov Min Sci* v 23 n 3 May-Jan 1987 p 275-280.

**074597 MISE A L'ECHELLE DES CIRCUITS DE FLOTATION.** [Scaling of Flotation Circuits]. This article presents an analysis of the possibilities of scaling the mechanically agitated flotation cells (agitation froth machines), by making use of the volume of the flotation cells as the only scaling factor. The assumptions made are described in detail. The proposed method is based on an analysis of the kinetic behaviour of the different species in flotation, such as the hydrophobic phases, the hydrophilic phases and water. The behavior of the hydrophilic phases is described in accordance with kinetics of the first order with distributed constants; that of the hydrophilic phases is an entrainment mechanism by the water; that of the water is attributed to two mechanisms, one associated with a maximum solids concentration in the froth which overflows and the other with a kinetic behaviour of the first order. The authors present the methodology which was used to effect the experimental calibration measurements. (Edited author abstract) 17 refs. In French.

Barbery, Gilles (Univ Laval, Ste-Foy, Que, Can); Bousarra, Michel; Dionne, Lucien. *Ind Miner Mines Carrieres Tech* v 70 n 1 Jan-Feb 1988 p 8-14.

**074598 INFLUENCE OF PARTICLE SIZE AND CONTACT ANGLE IN MINERAL FLOTATION.** The flotation behaviour of quartz particles whose surfaces have been hydrophobized to varying extents with an organosilane compound has been studied over the particle size range from 15 to 125  $\mu$ m in diameter under conditions of known bubble size and relative turbulent velocity. For a given particle size, there is a unique contact angle below which the particle will not float. This leads to the concept of a flotation domain, within which flotation is possible. Coarse particle behaviour is predicted by the kinetic theory of flotation proposed by H.J. Schulze, whereas there is only a qualitative agreement with A. Scheuldo's theory of fine particle flotation. Calculated induction times indicate that the attachment process is most efficient for particles of about 38  $\mu$ m in diameter under the experimental conditions. The dependence of rate constant on particle size was essentially linear. (Edited author abstract) 45 refs.

Crawford, Russell (Swinburne Inst of Technology, Hawthorn, Aust); Ralston, John. *Int J Miner Process* v 23 n 1-2 May 1988 p 1-24.

**074599 MODEL OF FLOTATION SELECTIVITY.** A mathematical model of the flotation process was developed having at least two features which can make it a useful tool for flotation analysis. First, the model includes physically meaningful descriptions of the inter-relationships between bubbles and particles in the flotation process. This makes the model a more reliable predictor of flotation result changes than a regression curve fitted to experimental data but having no causal meaning. Second, once the model is fitted to a given process, it simplifies a search for physical conditions optimizing that process. Computer simulations can be used instead of experiments or can be employed as screening tests before commencing an experimental program. The model can indicate where the process conditions are located with respect to the optimum conditions. 6 refs.

Szatkowski, Marian (Michigan Technological Univ, Houghton, MI, USA). *Int J Miner Process* v 23 n 1-2 May 1988 p 25-31.

**074600 FROTH STABILITY, PARTICLE ENTRAINMENT AND DRAINAGE IN FLOTATION - A REVIEW.** The froth stability, entrainment and drainage of particles in flotation have been recognised as important factors which affect recovery and grade. A too stable froth is difficult to handle but an unstable froth is least desirable. Therefore, a froth of correct stability is of importance. However, the question is whether this phe-

nomenon is related to the frothing properties of a frother or to the physical, chemical and geometrical conditions of a system. The entrainment and drainage of particles in flotation are concerned with the pulp/froth phases. The paper deals with the current aspects on froth stability, particle entrainment and drainage based on a literature review. (Author abstract) 73 refs.

Subrahmanyam, Y.V. (Lulea Univ of Technology, Lulea, Swed); Forsberg, Eric. *Int J Miner Process* v 23 n 1-2 May 1988 p 33-53.

**074601 COLLECTORLESS FLOTATION AND SEPARATION OF SULPHIDE MINERALS BY  $E_h$  CONTROL.** The flotation of galena, chalcopyrite, and sphalerite has been studied singly and as mixtures in the absence of collector by  $E_h$  control. The collectorless floatability of each sulphide is directly linked to its ease of oxidation as well as to the stability of the hydrophobic surface state which is produced. The hydrophobic surface species may be elemental sulphur or a sulphur-rich metal-deficient surface. The ease of collectorless flotation follows the order chalcopyrite > galena > sphalerite. Measures of galena and chalcopyrite may be separated by  $E_h$  control provided that they are ground in a reducing environment. Under such conditions, their floatability is enhanced compared with the response of the minerals studied singly. (Edited author abstract) 42 refs.

Hayes, Robert A. (South Australian Inst of Technology, Aust); Ralston, John. *Int J Miner Process* v 23 n 1-2 May 1988 p 55-84.

**074602 INTERACTION OF GLYCINE AND A GLYCINE-BASED POLYMER WITH XANTHATE IN RELATION TO THE FLOTATION OF SULFIDE MINERALS.** The interaction between the amino acid glycine, a polymer (BA/13) with a glycine functional group incorporated into its backbone structure, and three sulfide minerals (chalcocite, galena and pyrite) was investigated using settling tests, electrokinetic measurements, and dissolution studies. The resulting increase in pulp stability and changes in zeta potential are related to the adsorption of metal glycinate complexes that form in aqueous solutions of the minerals. Chalcocite exhibited the greatest interaction with glycine due to the high stability of the copper glycinate complexes as compared to those of lead and iron. In flotation with xanthate as collector, glycine increased the floatability while BA/13 completely depressed all three minerals. (Edited author abstract) 10 refs.

Hanson, J.S. (Univ of California, Berkeley, CA, USA); Barbaro, M.; Fuerstenau, D.W.; Marabini, A.; Barbucci, R. *Int J Miner Process* v 23 n 1-2 May 1988 p 123-135.

**074603 COLUMN FLOTATION OF VERY FINE PARTICLES.** This work presents plant-site evaluations of six feeds comprising very fine particles (80% passing sizes 8-23  $\mu$ m). Five of the streams contained mainly sulphides (Mount Isa Mines Ltd, Australia) and one contained oxide minerals (Niobec, Canada). All the testwork was performed using pilot-scale columns. Column results were better than plant and laboratory results, giving concentrate grades up to 6% higher (in absolute terms) at the same recoveries. Entrainment into the column concentrate was measured by the recovery of the -10  $\mu$ m non-sulphide gangue fraction and recovery of feed water. Entrainment was lower in the column than for the mechanical cells and accounted for most of the improved performance. Some evidence of improved selectivity in the column was found. (Edited author abstract) 23 refs.

Espinosa-Gomez, R. (McGill Univ, Montreal, Que, Can); Finch, J.A.; Johnson, N.W. *Min Eng* v 1 n 1 1988 p 3-18.

**074604 FROTH CHARACTERISTICS AND GRADE-RECOVERY RELATIONSHIPS IN THE FLOTATION OF LEAD-ZINC AND COPPER ORES.** Froth forms an important phase in flotation upon which the final yield parameters are dependent. Flotation froths



are three-phase froths and the solid particles exercise an influence in stabilizing or destabilizing the froths depending on the degree of hydrophobicity, size and concentration of fines. This paper deals with froth characteristics in flotation tests carried out on lead-zinc and copper ores with four different frothers. The results are analysed by grade-recovery relationships. (Edited author abstract) 22 refs.

Subrahmanyam, T.V. (CCE/UFRN, Natal, Braz); Forssberg, E. *Min Eng* v 1 n 1 1988 p 41-52.

**074605 FLOTATION COLUMN CARRYING CAPACITY: PARTICLE SIZE AND DENSITY EFFECTS.** The capacity of a flotation column can be limited by the rate of concentrate removal. There is a maximum rate at which solids can be removed related to individual bubble loading (surface coverage by solids (e.g. g/cm<sup>2</sup>)) and the bubble surface area rate (e.g. cm<sup>2</sup>/min). The maximum solids concentrate rate is referred to as the carrying capacity. A tentative model is presented to predict column carrying capacity ( $C_a$ ) as a function of particle size ( $d_{90}$ ) and particle density ( $\rho_p$ ):  $C_a = 0.068 (d_{90} \times \rho_p)$ . Evidence is presented suggesting  $C_a$  is independent of column diameter. (Edited author abstract) 7 refs.

Espinosa-Gomez, R. (McGill Univ, Montreal, Que, Can); Finch, J.A.; Yianatos, J.B.; Dobby, G.S. *Min Eng* v 1 n 1 1988 p 77-79.

**074606 REAGENT USAGE IN MINERAL PROCESSING.** The author reviews the wide variety of 'reagents' consumed in the production of metals and concentrates from mineral ores, ranging from the well-known highly specific flotation collectors with no other significant uses, to reagents 'borrowed' from the chemical, paper-making, dyestuff, detergent, fertilizer, fuel and other industries. The reagents are discussed under the headings of flotation, hydrometallurgy, solid-liquid separation, and water treatment, together with a few other 'miscellaneous', reagents. (Author abstract) 11 refs.

Smith, Mike (Royal Sch of Mines, London, Engl). *Min Mag* v 158 n 6 Jun 1988 7p.

**074607 REAGENT USAGE IN MINERAL PROCESSING.** The author reviews the wide variety of reagents consumed in the production of metals and concentrates from mineral ores, the reagents range from the highly specific flotation collectors with no other significant uses to reagents borrowed from the chemical, paper-making, dyestuff, detergent, fertilizer, fuel and other industries. The reagents are discussed under the headings of flotation, hydrometallurgy, solid-liquid separation, and water treatment together with other miscellaneous reagents. 11 Refs.

Smith, Mike (Royal Sch of Mines, London, Engl). *Min Mag* v 158 n 6 Jun 1988 p 472-481.

**074608 CHOOSING A CATIONIC COLLECTOR.** Cationic collectors are used to float minerals that have a negative surface charge - primarily silica and silicates. Sometimes the material floated is the one being recovered as with feldspar, vermiculite and glass sands. Sometimes the material floated is a major impurity contaminating the ore being recovered as when silica is floated away from phosphates and from iron ore. In the flotation of potash from saturated brines, a cationic collector is used to float a sylvite (KCl) from halite (NaCl). The article examines each of these recovery situations.

Gefvert, David (Sherex Chemical Co). *Min Mag* v 158 n 6 Jun 1988 p 513-517.

**074609 HOLD-UP VOLUME AND MEAN RESIDENCE TIME MEASUREMENTS IN THE AIR-SPARGED HYDROCYCLONE.** In order to provide more information regarding flow characteristics in the air-sparged hydrocyclone, experiments were designed to determine the hold-up volumes of water and air inside the unit under typical operating conditions. The parameters of slurry flow, air flow, annular opening, and frother concentration were varied and the hold-up volumes of water and air and the corresponding residence times were

determined by collection of the cyclone's contents. In addition, the residence time distributions were measured using radioactive tracer and dye tracer techniques. The results indicate that the air-sparged hydrocyclone operates under choked conditions, at least half-filled with water. Such a situation arises when the annular opening is ten percent of the radius which corresponds to the swirl layer thickness developed for unrestricted swirl flow in a right-vertical cylinder. The measured mean residence time of water reporting to the underflow is in the range 0.5 to 1.0 seconds. (Author abstract). 7 Refs.

Baker, M.W. (I.M.I. Inst for Research & Development Ltd, Haifa, Isr); Gopalakrishnan, S.; Rogovin, Z.; Miller, J.D. *Part Sci Technol* v 5 n 4 1987 p 409-420.

**074610 DEVELOPMENT IN THE CONTROL OF FLOTATION COLUMNS.** The major deficiency of present methods is that they rely on inaccurate and indirect measurements of the slurry-froth interface level and bias flowrate (the net downward flowrate of water through the froth phase). This generally means that excess wash water is added, with reduction in slurry residence time and column capacity. More accurate measurement of the temperature distribution in the froth phase are described. Control schemes based on these measurements are discussed. (Edited author abstract). 14 Refs.

Moys, M.H. (McGill Univ, Montreal, Que, Can); Finch, J.A. *Int J Miner Process* v 23 n 3-4 Jul 1988 p 265-278.

**074611 COUNTER-FLOW FLOTATION CELLS (FLOTATION COLUMNS) - PRESENT STATE AND CURRENT TRENDS.** Since the beginning of the eighties flotation columns have been increasingly employed in industry, because, in general, the counterflow mode ensures a higher selectivity in comparison with conventional flotation machines. In addition, there are further advantages: the lower specific energy consumption, the lower floor space required, the lower investment and operating costs. In this paper, first of all, the performance and the essential operational parameters are characterized. Next, the present state of process modeling, performance of pilot tests as well as scale-up and process control are briefly discussed. Finally, industrial applications are presented, and new concepts and design variations of the equipment are considered. (Edited author abstract). 36 Refs.

Schubert, H. (Bergakademie Freiberg, Freiberg, East Ger). *Aufbereit Tech* v 29 n 6 Jun 1988 p 307-315.

**074612 INCO-VOLTAMMETRIC CELL: A NEW APPROACH TO FLOTATION MODELLING.** A new electrochemical cell was developed so that the impact of conditions during liberation could be related to mineral hydrophobicity. Mineral electrodes were polished in situ in the test electrolyte and allowed to achieve their rest potentials after aeration of the electrolyte. The procedure was designed to represent a grinding-flotation system and the hydrophobicity of chalcopryrite, pentlandite and pyrrhotite electrodes was found to be dependent on the following factors: (1) rate of increase in anodic potential following cleaning of the electrode; (2) presence of iron which causes galvanic coupling effects; and (3) pH variations during electrode cleaning; as well as other relevant variables (e.g. xanthate dosage). The observations made using the new cell favourably compared with flotation data. Mineral selectivity was a function of polarization of the particle surfaces and the rate of increase in the anodic potential of the pulp. (Edited author abstract). 17 refs.

Hodgson, M. (INCO Ltd, Mississauga, Ont, Can); Agar, G.E. *Int J Miner Process* v 24 n 1-2 Sep 1988 p 27-45.

**074613 INFLUENCE OF DIFFERENT GRINDING METHODS ON FLOATABILITY.** Investigations have been in progress since the middle of 1981 to prove and explain differences in the influence of conventional and autogenous grinding on the floatability of sulphide minerals. Techniques for liberation and particle shape studies under the microscope, and measurement of pulp chemistry as to redox potential and contents of free oxygen and

various sulphur-carrying ions were tested on samples from batch tests, pilot plant runs and commercial practice. The phenomena observed can partly be explained in terms of liberation and chemical characteristics of the pulp. (Author abstract) 10 refs.

Forssberg, Eric (Technical Univ of Lulea, Lulea, Swed); Sundberg, Stellan; Zhai, Hongxin. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Communication, Conf Pap, Salt Lake City, UT, USA, 1987 p 183-192.

Grinding See GRINDING MILLS—Ball Milling.

Heating

**074614 MICROWAVE HEATING CHARACTERISTICS OF SELECTED MINERALS AND COMPOUNDS.** Naturally occurring minerals and reagent-grade compounds were tested to determine their receptivity to microwave heating. The maximum temperature achieved for the samples and the time required to reach temperature are reported. A description of the microwave oven and a thermocouple technique that accurately measures and continuously records the temperature of samples during irradiation are reported. Extractive applications using the generated microwave data were investigated. Stress fracturing at mineral grain boundaries in a gangue matrix was shown. This should affect grinding energy requirements and liberation properties. A method to produce a magnetic phase on pyrite surfaces, a method of using microwave heating to retort cinnabar concentrate, and a roast leaching microwave treatment of chalcopryrite ore are described. (Author abstract) 8 refs.

Walkiewicz, J.W. (Bur of Mines, Reno, NV, USA); Kazonich, G.; McGill, S.L. *Miner Metall Process* v 5 n 1 Feb 1988 p 39-42.

Impurities

**074615 DAS EISENPROBLEM IN DER METALLURGIE DER NICHTEISENMETALLE (II). [Iron Problem in the Extractive Metallurgy of Non-Ferrous Metals (part II)].** The role of iron in the extractive hydrometallurgy of copper, zinc and aluminium; the influence on metallurgical operations and the resulting energy, quality and environmental problems are discussed. The distribution of iron in products during processing is demonstrated by metal balances. Pyrometallurgical and hydrometallurgical processes are compared concerning the iron problem. (Edited author abstract) 29 refs. In German.

Koeck, Wolfgang (Montanuniv Leoben, Leoben, Austria); Paschen, Peter. *Erzmetall* v 40 n 9 Sep 1987 p 473-481.

In Situ See Also COPPER ORE TREATMENT—Leaching.

**074616 ESTIMATING THE VERTICAL FLARING IN IN SITU LEACHING.** Flaring, the vertical excursion of leachant from an ore zone, is an economic and environmental detriment to all in situ leaches. Two measures characterize flaring: the rate of vertical fluid migration from the mineralized or ore zone and the volume of the barren zone swept at a given amount of injection. In this paper we investigate both aspects, the first through an analytical method and the second by numerical solution. The rate of fluid migration outside the ore zone increases with decreasing thickness of the ore zone and with flowpath length. To a lesser extent, it also depends on the location of the ore zone within the hydrologic zone. More centered ore zones show more excursion. The barren zone swept volume, which depends on these quantities, increases with the cumulative volume of leachant injected and with ore zone permeability. From these numerical results we develop a simplified procedure for estimating barren zone swept volume based on a sensitivity coefficient approach. The procedure yields answers that are generally within 10% agreement of numerical simulation, an accuracy that is within the precision of the variables upon which the barren zone swept volume depends. (Author abstract) 7 refs.



Lake, Larry W. (Univ of Texas, Austin, TX, USA); Zapata, Vito J. *In Situ Oil Coal Shale Miner* v 11 n 1 Mar 1987 p 39-62.

**Leaching** See Also ACIDS—Separation; CATALYSTS—Waste Utilization; CORROSION—Electrochemical; IRON COMPOUNDS—Dissolution; MANGANESE ORE TREATMENT—Ion Exchange; MANGANESE ORE TREATMENT—Waste Utilization; MEMBRANES—Testing; MERCURY AND AMALGAMS—Recovery; MINES AND MINING—Patents and Inventions.

**074617 OXIDATION OF Fe(II) BY OXYGEN IN CONCENTRATED NaCl SOLUTIONS: PREDICTION OF STIRRED GAS-LIQUID REACTOR PERFORMANCE FROM HOMOGENEOUS KINETIC DATA.** Two kinds of experimental data have been used to identify separately: the kinetics of homogeneous reaction between the liquid reactant (ferrous chloride) and the dissolved gas (oxygen), the mass-transfer characteristics of a gas-liquid stirred reactor. The first set of data was obtained with a batch single phase reactor and very low ferrous concentrations; the second set, i.e. the product  $k_L a$  (mass-transfer coefficient times specific interfacial area) in the gas-liquid stirred reactor, was inferred from previous work using the same reactor and the system  $\text{Cu(I)/O}_2$ , and checked for our physical and chemical conditions. The results demonstrate that ferrous chloride oxidation by air or pure oxygen flow in a stirred reactor occurs in the regime of very slow or homogeneous reaction, according to the theory of absorption with chemical reaction: oxygen immediately reaches its solubility in the bulk of the aqueous phase, and the oxidation is far slower than the oxygen transfer. Gathering homogeneous and gas-liquid oxidation data lead the authors to propose an expression of the rate of homogeneous reaction. 22 refs.

Bouboukas, Georges (CNRS, Fontainebleau, Fr); Gaudand, A.; Renon, H. *Hydrometallurgy* v 19 n 1 Oct 1987 p 25-35.

**074618 METHOD FOR THE ACCURATE DETERMINATION OF THE VIABLE MINERAL LEACHING BACTERIA THIABACILLUS FERROOXIDANS, USING RADIOISOTOPIC  $^{14}\text{C}$  AND AUTORADIOGRAPHY.** A novel method for determining viable cells of *Thiobacillus ferrooxidans* has been developed. The cells were collected on cellulose acetate filters, washed with artificial minewater, and incubated in the presence of ferrous ion at pH 3 in an atmosphere containing radioactive ( $^{14}\text{C}$ ) carbon dioxide. Colonies of bacterial growth were detected by the image formed on X-ray photographic paper (autoradiography). The method was compared with three conventional techniques and shown to detect three orders of magnitude more cells in cultures of *Thiobacillus ferrooxidans* in the late exponential phase of growth. 13 refs.

Ragusa, Santo (Univ of New South Wales, Aust); Madgwick, John. *Bull Proc Australas Inst Min Metall* v 292 n 7 Sep 1987 p 51-53.

**074619 SPECIATION AND REDUCTION POTENTIALS OF METAL IONS IN CONCENTRATED CHLORIDE AND SULFATE SOLUTIONS RELEVANT TO PROCESSING BASE METAL SULFIDES.** The speciation, Eh-pH and Eh-log  $a_{\text{Cl}^-}$  dependence of  $\text{Fe(III)}$ ,  $\text{Fe(II)}$ ,  $\text{Cu(II)}$ ,  $\text{Cu(I)}$ ,  $\text{Ag(I)}$ ,  $\text{Pb(II)}$ ,  $\text{Zn(II)}$ ,  $\text{Ni(II)}$ ,  $\text{As(III)}$ ,  $\text{Sb(III)}$ , and  $\text{Bi(III)}$  ions in practical (high ionic strength) sulfate and chloride solutions are discussed. The emphasis is placed on those ions which form strong sulfato-, chloro-, and hydroxo-complex species. Measured potentials are compared with potentials calculated from reported association and stability constants to test the applicability of these constants in non-ideal solutions and to characterize predominant species. (Author abstract) 35 refs.

Senanayake, G. (Nugegoda); Muir, D.M. *Metall Trans B* v 19B n 1 Feb 1988 p 37-45.

**074620 GEOTECHNICAL ASPECTS OF HEAP LEACH DESIGN.** This volume contains 12 papers. Geotechnical engineers can assist significantly in the

development, design, and operation of heap leach projects. They can assist in the site investigation and foundation preparation design, pad and liner design, heap material characterization, heap stability analysis, analysis of solution flow through the heap and its collection, design of monitoring systems, and the design of collection ponds. This volume presents a collection of papers on most all of the foregoing topics. The papers are all written by practitioners and operators and represent significant practical experience.

van Zyl, Dirk (Colorado State Univ, Fort Collins, CO, USA). *Geotech Asp of Heap Leach Des* Publ by Soc of Mining Engineers of AIME, Littleton, CO, USA, 1987 85p.

**074621 OPTIMIZATION TECHNOLOGY FOR LEACH PAD LINER SELECTION.** Minimizing the loss of pregnant solution through the leach pad liner is obviously of paramount importance to the economic efficiency and environmental compliance of the heap leach operation. Losses through the liner are a function of the hydraulic conductivity of the liner material and the hydraulic gradient across the liner. This applies to both natural and synthetic materials. The hydraulic gradient across the liner is a function of the build-up of solution above the liner, which in turn is determined by the permeability of the heap material, the slope of the liner, the drainage path length and the leachate infiltration rate. A relationship incorporating each of these parameters and their effect on the hydraulic head acting on the liner has been developed in terms of the Dupuit criterion, assuming one-dimensional flow with vertical accretion. (Edited author abstract) 2 refs.

East, Donald R. (Knight Piesold & Co, Denver, CO, USA); Haile, Jeremy P.; Beck, Richard V. *Geotech Asp of Heap Leach Des* Publ by Soc of Mining Engineers of AIME, Littleton, CO, USA, 1987 p 1-6.

**074622 TOMOGRAPHIC COMPUTER PROGRAM WITH CONSTRAINTS TO IMPROVE RECONSTRUCTIONS FOR MONITORING IN SITU MINING LEACHATE.** The Bureau of Mines is investigating possible applications of geophysics to monitor leachate during in situ mining. Tomographic reconstruction of seismic or electromagnetic crosshole data appears applicable. The tomographic program BOMTOM (Bureau of Mines tomography) was used to investigate reconstructions with synthetic travel time data. The calculations confirmed that without constraints, crosshole data do not provide unique solutions. The solution is not determined solely by the data, but is also influenced by the velocity guesses starting the iterative solution procedure. BOMTOM uses the simultaneous iterative reconstruction technique (SIRT) with straight ray paths. The program is efficient in use of memory and can be run on a personal computer. A source code in FORTRAN is listed. A source code in BASICA and compiled executable codes in both languages are available from the Bureau's Twin Cities (MN) Research Center. (Edited author abstract) 15 refs.

Tweeton, Daryl R. (Bur of Mines, Minneapolis, MN, USA). *Rep Invest US Bur Mines* 9159 1988 70p.

**074623 STUDY BY SEM-EDS OF THE IN SITU DYNAMIC LEACHING OF MERCURY ORES.** The present work studies the surface evolution of cinnabar, when it is leached with HBr acid for different conditions. The dynamic in situ test has been studied by scanning electron microscopy and EDS techniques. According to the acid condition, time, and temperature, the HgS presents different mechanisms of dissolution, and the results prove that the cinnabar does not present 'memory effect', as proposed by other authors. (Author abstract) 16 refs.

Calvo, F.A. (Complutense Univ of Madrid, Madrid, Spain); Guilemany, J.M.; Gomez de Salazar, J.M.; Urena, A. *Metall Trans B* v 19 n 2 Apr 1988 p 165-170.

**074624 PRECIPITATE FORMATION IN THE OXIDATION OF FERROUS IONS IN THE PRESENCE**

**OF THIABACILLUS FERROOXIDANS.** This report discusses the mechanism involved in the process of ferrous sulfate biooxidation in aqueous solutions. The main chemical reactions involved in the production of soluble and insoluble species have been investigated during growth of the culture. The work focuses on the times at which the principal reactions begin, how long they last and the relationship between various precipitates. A material balance has been made to verify the proposed mechanism. (Author abstract) 12 refs.

Toro, L. (Univ dell'Aquila, L'Aquila, Italy); Paponetti, B.; Cantalini, C. *Hydrometallurgy* v 20 n 1 Mar 1988 p 1-9.

**074625 MICROBIAL ECOLOGY OF SOME INDIAN SULPHIDIC MINES.** In this paper, the physico-chemical characteristics of various Indian sulphidic mine waters are brought out. Various types of micro-organisms present in different mineral occurrences are discussed. Such microbial associations are discussed from the viewpoint of microbial ecology and the contribution of microbes in the conversion and oxidation of various sulphide minerals. (Author abstract) 33 refs.

Dave, S.R. (Gujarat Univ, Ahmedabad, India); Nataraajan, K.A. *Trans Indian Inst Met* v 40 n 4 Aug 1987 p 315-327.

**074626 BACTERIAL LEACHING OF A SULFIDE ORE BY THIABACILLUS FERROOXIDANS AND THIABACILLUS THIOOXIDANS: I. SHAKE FLASH STUDIES.** Bacterial leaching of a sulfide ore containing pyrite, chalcopyrite, and sphalerite was studied in shake flask experiments using *Thiobacillus ferrooxidans* and *thiobacillus thiooxidans* strains isolated from mine sites. The  $\text{Fe}^{2+}$ -grown *T. ferrooxidans* isolates solubilized sphalerite preferentially over chalcopyrite leaching 7-10% Cu, 68-76% Zn, and 10-22% Fe from the ore in 18 days. The sulfur-grown *T. thiooxidans* isolates leached Zn much more slowly and very little Fe, with a Cu-Zn extraction ratio twice the value obtained with *T. ferrooxidans*. The ore-adapted *T. ferrooxidans* started solubilizing Cu and Zn without a lag period. The ore-adapted *T. thiooxidans* extracted Cu as well as *T. ferrooxidans*, but the extraction of Zn or Fe was still much slower in the low-phosphate medium, while in the high-phosphate medium it approached the value obtained with *T. ferrooxidans*. A high Cu-Zn extraction ratio of 0.34 was obtained with *T. thiooxidans* in the low-phosphate medium. (Edited author abstract) 8 refs.

Lizama, Hector M. (Univ of Manitoba, Winnipeg, Manit, Can); Suzuki, Isamu. *Biotechnol Bioeng* v 32 n 1 Jun 1988 p 110-116.

**074627 LINER DESIGN FOR HEAP-LEACH PADS.** Heap leaching of low-grade precious metal ores can be profitable. However, although the ore may be friable, the gold-bearing mineral leachable and the heaped ore permeable, if the pad on which the leaching is to take place leaks, sags or slides, there may be no returns. With this in mind, the authors discuss the various factors involved in designing a precious metal heap leach pad. 20 refs.

Worstell, Jonathan H. (Shell Development Co); Worstell, Sinta L. *Min Mag* v 158 n 5 May 1988 p 382-383, 385, 387.

**074628 HDPE GEOMEMBRANES FOR HEAP-LEACH PADS AND TAILINGS PONDS.** The proper construction of heap leach pads is important in ensuring the profitability of this method of treating low-grade ores. One of the materials used successfully to provide the necessary leak-proof membrane is high density polyethylene (HDPE). The author describes a number of operations where this material has been used.

Cadwallader, Mark (Gundle Lining Systems Inc, Houston, TX, USA). *Min Mag* v 158 n 5 May 1988 p 388-389.



**074629 RECUPERACION DE COMPUESTOS DE CALCIO Y DE MAGNESIO DE ALTA PUREZA A PARTIR DE DOLOMITAS ARGENTINAS.** [Recovery of High-Purity Calcium and Magnesium Compounds from Argentine Dolomites]. From an Argentine dolomite of average composition  $\text{CaO} = 30.65$  percent;  $\text{MgO} = 20.18$  percent,  $\text{SiO}_2 = 1.97$  percent,  $\text{Fe}_2\text{O}_3 = 1.18$  percent,  $\text{Al}_2\text{O}_3 = 0.42$  percent, loss on ignition = 45.50 percent, calcium and magnesium compounds with a purity higher than 99 percent were produced. An excellent recovery was obtained using a hydrometallurgical route with selective dissolution of calcium with ammonium chloride, and then of magnesium, with carbon dioxide leaching. In practice, the dolomite carrier of calcium and magnesium is the only raw material required by the procedure, inasmuch as the reagents ammonium chloride and carbon dioxide are recovered during the process. (Edited author abstract). 18 Refs. In Spanish.

Hipeding, N.E. (CONICET, Buenos Aires, Argent); Tedesco, P.H. *Rev Metal (Madrid)* v 24 n 2 Mar-Apr 1988 p 77-83.

**074630 BIOLIXIVIACION DE MENAS NATURALES. POSIBILIDADES ACTUALES DE UTILIZACION.** [Bioleaching of Natural Ores. Present Possibility of Use]. During the last few years, the industry related to metal extraction has been suffering a very important crisis the immediate cause of which lies in growing process costs, in lower metal prices, in problems related to atmospheric pollution, in poorer and poorer ores, in energy problems and in reserve exhaustion. So, in some particular cases, bioleaching may be an alternative to the classical hydrometallurgical process in view of the present difficult situation. A summary of the bioleaching situation is made in the present review. In the first place, the principal microorganisms used in both direct and indirect mechanisms through which reactions occur are described. Among these microorganisms, some mesophiles like *Tiobacillus* genus and some thermophiles like *Sulfolobus* genus stand out. Finally, after mentioning both the advantages and disadvantages of these processes, its more important industrial applications (copper and uranium bioleaching) and the ones with a more promising future (coal desulfurization and pre-oxidation of refractory pyrite ores containing gold and silver) are reviewed. (Edited author abstract). 60 Refs. In Spanish.

Ballester, A. (Univ Complutense, Madrid, Spain); Gonzalez, F.; Blazquez, M. *Rev Metal (Madrid)* v 24 n 2 Mar-Apr 1988 p 91-102.

**074631 MICROBIOLOGICAL EFFECTS ON METALLURGICAL PROCESSES (HELD AT THE 1985 AIME ANNUAL MEETING).** This conference proceedings contains 10 papers. Topics presented include microbial leaching of complex sulfides; chalcopirite leaching by *thiobacillus ferrooxidans*; biotechnology of gold recovery; biological ferrous iron oxidation; biotankleach process for the treatment of refractory gold/silver concentrates and coal desulfurization bacteriology. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10404 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Clum, J.A. (Ed.) (Thomas J. Watson Sch of Engineering, Binghamton, NY, USA); Haas, L.A. (Ed.). *Microbiol Eff on Metall Processes*, New York, NY, USA, Feb 24-28 1985 Publ by Metallurgical Soc of AIME, Warrendale, PA, USA, 1985 165p.

**074632 FUNDAMENTAL AND APPLIED BIOHYDROMETALLURGY. PROCEEDINGS OF THE SIXTH INTERNATIONAL SYMPOSIUM ON BIOHYDROMETALLURGY.** This conference proceedings contains 43 papers arranged in 10 sections. Topics presented include Base Metal Leaching; Gold and Silver Leaching; Coal Desulfurization; In-Situ Leaching; Engineering Fundamentals; Biosorption; Environmental Aspects; Alternative Bacteria and Bacterial Strain Improvement and Genetic Engineering and Immunological Studies. Technical and professional papers from this conference are indexed and abstracted with the conference code

no. 10634 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Lawrence, Richard W. (Ed.) (BC Research, Vancouver, BC, Can); Branion, Richard M.R. (Ed.); Ebner, Hans G. (Ed.). *Fundam and Appl Biohydrometall, Proc of the Sixth Int Symp on Biohydrometall*, Vancouver, BC, Can, Aug 21-24 1985 Publ by Elsevier (Process Metall 4), Amsterdam, Neth and New York, NY, USA, 1986 501p.

**074633 GEOTECHNICAL ASPECTS OF HEAP LEACH DESIGN.** This conference proceedings contains 12 papers on geotechnical aspects of heap leach design. Topics discussed include site investigation and foundation preparation design, leach pad and liner design, heap material characterization, heap stability analysis, geomembrane soil interfaces, and geotextiles applications. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10974 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Van Zyl, Dirk (Ed.) (Colorado State Univ, Fort Collins, CO, USA). *Geotech Asp of Heap Leach Des* Publ by Soc of Mining Engineers of AIME, Littleton, CO, USA 1987 86p.

**074634 SPECIAL TOPICS IN MINERAL PROCESSING SEMINAR.** This issue of the journal contains seven of the papers presented at a conference. Some of the subjects covered are biotechnology in the mining industry, advances in microbial leaching, electrochemical aspects of microbial leaching, isolation and preservation of leaching cultures, advances in spectroscopic characterization of adsorbed layers and surface compounds, applications of chelating agents in mineral processing and synthesis of polyelectrolytes for mineral separation. All papers are abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11476 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Pradip (Ed.) (Tata Research Development & Design Cent, Pune, India); Somasundaran, P. (Ed.). *Miner Metall Process* v 5 n 2 May 1988, Spec Top in Miner Process Semin, Pune, India, Dec 30 1987-Jan 1 1988 p 49-96.

**074635 TECHNOLOGY IN THE MINING AND METAL PROCESSING INDUSTRIES: CHALLENGES AND OPPORTUNITIES.** Recent progress in genetic engineering promises to revolutionize the existing biological process and expedite the adoption of new biological applications. Before it can do so effectively, progress must be made in many areas of fundamental research and biochemical engineering. These issues are addressed with reference to the biotechnology of semi-enclosed containers (bioreactors), dumps, heaps, in situ and underground leaching, and metal concentration. Certain biological considerations for bacterial strain improvement are discussed. (Edited author abstract) 21 refs.

Holmes, D.S. (Rensselaer Polytechnic Inst, Troy, NY, USA). *Miner Metall Process* v 5 n 2 May 1988, Spec Top in Miner Process Semin, Pune, India, Dec 30 1987-Jan 1 1988 p 49-56.

**074636 RECENT ADVANCES IN MICROBIAL LEACHING OF ORES.** Processes involving biological solubilization of metal values from ores or removal of mineral constituents that interfere with metal value recovery from ores by abiological means are reviewed. Many of them, though promising, have yet to be tested on a pilot scale or applied industrially. (Edited author abstract) 59 refs.

Ehrlich, H.L. (Rensselaer Polytechnic Inst, Troy, NY, USA). *Miner Metall Process* v 5 n 2 May 1988, Spec Top in Miner Process Semin, Pune, India, Dec 30 1987-Jan 1 1988 p 57-59.

**074637 ELECTROCHEMICAL ASPECTS OF BIOLEACHING MULTISULFIDE MINERALS.** This paper deals with the various electro- and biochemical mechanisms involved in the bioleaching of multisulfide

minerals such as those containing copper-lead-zinc and copper-nickel-iron. The galvanic series for sulfide minerals consisting of pyrite, chalcopirite, galena, sphalerite, pentlandite, and pyrrhotite in an acid bacterial leaching system is illustrated and the role of relative electrochemical activity on selective dissolution is discussed. Typical leaching results are shown to illustrate the practical applicability of galvanic effects. Attachment of *Thiobacillus ferrooxidans* onto chalcopirite and sphalerite mineral substrates is illustrated through scanning electron micrographs. The role of high metal tolerant strains in the leaching of multimetal concentrates is also outlined. (Edited author abstract) 6 refs.

Natarajan, K.A. (Indian Inst of Science, Bangalore, India). *Miner Metall Process* v 5 n 2 May 1988, Spec Top in Miner Process Semin, Pune, India, Dec 30 1987-Jan 1 1988 p 61-65.

**Magnetic Separation** See Also TUNGSTEN ORE TREATMENT—Separation.

**074638 SUPERCONDUCTING MAGNETIC SEPARATOR AND ITS APPLICATIONS IN MINERAL PROCESSING.** In mineral processing, conventional magnetic separators are equipped with magnetic circuits (magnetic iron yoke with copper coils or iron clad solenoid) that develop magnetic fields of less than 2 T. For minerals of low magnetic susceptibility, use of these circuits has disadvantages. This paper describes a magnetic separator having a superconducting magnet with integrated closed circuit for helium liquefaction. The system generator and maintenance are simplified by automation realized by a programmable autocontrol unit. A comparative study of the results on concentration and purification of different raw materials with the new and with conventional separators is described. (Edited author abstract) 12 refs.

Gillet, G. (Ecole Natl Supérieure de Geologie, Nancy, Fr); Houot, R.; Leschevin, C. *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt B 1986 p 246-251.

**074639 FUNDAMENTALS OF HIGH-INTENSITY MAGNETIC SEPARATION AS APPLIED TO INDUSTRIAL MATERIALS.** Either wet or dry separation has application in both the recovery and concentration of minerals and in removing deleterious mineral constituents. The various types of magnetic separators along with the design and operating parameters relative to separation response are characterized. The characteristics of specific minerals to magnetic collection and the production of high-grade concentrates are described. Laboratory, pilot-scale, and plant studies have demonstrated the effectiveness of magnetic separation as either a primary or a secondary unit operation to achieve product quality. (Edited author abstract) 4 refs.

Norrgran, D.A. (Eriez Magnetics, Erie, PA, USA); Orlich, J.N. *Miner Metall Process* v 5 n 1 Feb 1988 p 1-11.

**074640 FUNDAMENTAL STUDY ON CONTINUOUS HIGH GRADIENT MAGNETIC SEPARATION.** A ferromagnetic wire charged with alternating current in magnetic field ( $H_0$ ) perpendicular to an axis and with the overall gradient along its axis ( $dH/dx$ ) is horizontally vibrated by electromagnet force. The wire and the magnetic particles captured on it move relatively and the friction between them are reduced. The magnetic particles are transported to the place of the strongest magnetic field by magnetic force ( $F_{mx}$ ) and deposited there. When the upward magnetic force ( $F_{my}$ ) acting the particles becomes weaker than gravity ( $F_g$ ), the particles fall apart from the wire. On the basis of the above-mentioned principle, single wire experiments were conducted. The results obtained were as follows: As particles were transported in state of blocks, the moving velocity ( $V_p$ ) was larger than the value calculated about one particle. The moving velocity of particles were proportional to wire amplitude ( $Y$ ). When the wire fixed on both sides, therefore, is vibrated in first mode the particles are



transported more rapidly in central part than in the side. Wire amplitude is proportional to current; therefore the moving velocity of the particles is also proportional to it. The results of calculation indicated that the thickness of deposit layers ( $r$ ) which the particles fall apart from the wire could be predicted by the deposit layer model. (Edited author abstract) 10 refs. In Japanese.

Hasuda, Tetsuhiko (Nat'l Research Inst for Pollution & Resources, Jpn); Ogawa, Katsumi; Kitora, Yoshihisa. *Nippon Kogyo Kaishi* v 104 n 1200 Feb 1988 p 83-88.

**074641 SUPERCONDUCTING HIGH GRADIENT MAGNETIC SEPARATION.** Separation of materials by means of their differing magnetic properties has been used for many years in mineral dressing and waste processing. However, the technique's applicability has been limited by its inability to deal with small particles or weakly magnetic materials. The CSIRO Division of Applied Physics uses magnets operating at a temperature of  $-269^{\circ}\text{C}$  which offer a five-fold increase in magnetic field strength over conventional electromagnets. Such magnets extend the range of magnetic separation into the colloidal size range and to weakly magnetic materials at a reduced operating cost compared to ordinary electromagnets. The technique has been applied to recover fine particles of tantalite  $[(\text{Fe}, \text{Mn})(\text{Ta}, \text{Nb})_2\text{O}_6]$  as a concentrate from feed with a grade below 0.1 percent  $\text{Ta}_2\text{O}_5$ . Other applications are removing colored impurities in kaolin clays, separating blood components and cleaning effluent gases.

Anon. *Aust Min* v 80 n 5 May 1988 p 3p.

**074642 SELECTIVITY AND PRODUCTIVITY OF OGMS WITH ALLOWANCE FOR TWO FLOWS IN THE SEPARATION ZONE.** The separator extraction curves are discussed in the common reduced coordinates, which permits the selectivities of different open gradient magnetic separators (OGMS) to be compared. It is shown that in the real separators  $0.2 \leq S_{10} \leq 0.65$  for OGMS with wet separation process and  $0.2 \leq S_{10} \leq 0.83$  with dry process. The maximum selectivity is reached in the system with the constant of forces (isodynamical). The work also considers operation of the separators with two flows in the separation zone, i.e. when the pulp is introduced not close to the wall nearest to the magnetic system but at some distance from it. 6 refs.

Dmitrievskaya, T.V. (Inst of Atomic Energy, USSR); Fedorov, V.K.; Cheremnykh, P.A. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1684-1687.

**Mathematical Models** See Also COPPER ORE TREATMENT—Flotation.

**074643 MODELLING AND SIMULATION OF THE BOND WORK INDEX TEST.** In this paper, the Bond grindability test was systematically analyzed and studied by means of mathematical modelling and computer simulation. A rapid and accurate computer simulation method has been worked out for the determination of the Bond work index. Comparison of the test results of six ore samples showed that the simulation values of the Bond Work index of these ore samples were well approximated to the actual values. The simulation process printed out by the computer was consistent with the actual grindability test process. It generally takes about two minutes to complete the simulation process with the computer. This new method not only improves the accuracy of determination but also reduces a good deal of test time and work load for determining the Bond work index. (Edited author abstract) 10 refs.

Xiong, Weiping; Weng, Weixiong; Zhou, Zhongshang. *Zhongnan Kuangye Xueyuan Xuebao* v 18 n 4 Aug 1987 p 415-421.

**Optimization** See KAOLIN—Processing.

## Oxidation

**074644 INFLUENCE OF TEMPERATURE AND MOLAR RATIO OF  $\text{PbSO}_4:\text{ZnS}$  ON THE RATE OF CHEMICAL REACTION BETWEEN LEAD SULPHATE AND ZINC SULPHIDE.** The chemical reaction between  $\text{ZnS}$  and  $\text{PbSO}_4$  at various molar ratios was studied by the thermogravimetric method. It was found that the reaction is multistage. Products of the first stage of the reaction contain mainly  $\text{ZnO}:\text{PbS}$  and  $\text{PbSO}_4$  in different amounts depending on the molar ratio of the substrates. The next stages consist in the action of  $\text{PbS}$  formed in the first stage with  $\text{PbSO}_4$ . It was found that the reaction rate depends on temperatures and on the  $\text{PbSO}_4:\text{ZnS}$  molar ratio (up to 3:1). The activation energy of the reaction was also determined. The value of the activation energy slowly increases with an increase in the  $\text{PbSO}_4:\text{ZnS}$  molar ratio. (Edited author abstract) 11 refs.

Malinowski, Czeslaw (Akad Gorniczno-Hutnicza, Cracow, Pol). *Arch Hutn* v 32 n 2 1987 p 203-212.

**Pelletizing** See GOLD ORE TREATMENT—Leaching.

## Physical Chemistry

**074645 SOLUBILITIES OF BROMIDE SALTS OF ALUMINUM, COBALT, LEAD, MANGANESE, POTASSIUM, AND SODIUM WHEN SPARGED WITH HYDROGEN BROMIDE.** The effects of HBr concentration and temperature on the solubility and hydration state of  $\text{AlBr}_3$ ,  $\text{CoBr}_2$ ,  $\text{PbBr}_2$ ,  $\text{MnBr}_2$ ,  $\text{KBr}$ , and  $\text{NaBr}$  were investigated by the Bureau of Mines. Saturated aqueous solutions of the Al, Pb, K, and Na bromides were sparged with HBr gas at 20, 40, and  $60^{\circ}\text{C}$ , and saturated solutions of Co and Mn bromides were sparged at  $20^{\circ}\text{C}$ . Increased HBr concentration caused decreased salt solubility because of the common ion effect for all the investigated bromides except  $\text{PbBr}_2$ . Aqueous solubilities at  $20^{\circ}\text{C}$  were, in percent, 51.7 for  $\text{AlBr}_3$ , 53.2 for  $\text{CoBr}_2$ , 1.1 for  $\text{PbBr}_2$ , 59.6 for  $\text{MnBr}_2$ , 39.5 for  $\text{KBr}$ , and 47.4 for  $\text{NaBr}$ . At  $60^{\circ}\text{C}$ , the solubilities were, in percent, 53.3 for  $\text{AlBr}_3$ , 2.2 for  $\text{PbBr}_2$ , 46.0 for  $\text{KBr}$ , and 53.8 for  $\text{NaBr}$ . Solubilities in solutions sparged to HBr saturation at  $20^{\circ}\text{C}$  were in percent, 0.5 for  $\text{AlBr}_3$ , 42.0 for  $\text{Co}_2$ , 32.2 for  $\text{PbBr}_2$ , 21.0 for  $\text{MnBr}_2$ , 0.6 for  $\text{KBr}$ , and 0.3 for  $\text{NaBr}$ . At  $60^{\circ}\text{C}$ , the solubilities at HBr saturation were, percent, 1.8 for  $\text{AlBr}_3$ , 41.4 for  $\text{PbBr}_2$ , 1.3 for  $\text{KBr}$ , and 0.4 for  $\text{NaBr}$ .  $\text{PbBr}_2$  precipitated out to a minimum solubility of 27.2 pct at 28.7-pct-HBr concentration. Further increases in HBr concentration increased  $\text{CoBr}_2$  solubility because of the formation of bromide complexes.  $\text{PbBr}$  increased in solubility as HBr concentration increased. (Author abstract) 9 refs.

Noble, E.G. (Bur of Mines, Reno, NV, USA); Shanks, D.E. *Rep Invest US Bur Mines* n 9156 1988 19p.

**074646 PHYSICAL CHEMISTRY OF THE PRECIPITATION STRIPPING PROCESS FOR REMOVING IRON (III) FROM CARBOXYLATE SOLUTIONS WITH DILUTE SULPHURIC ACID.** Precipitation stripping is a single-stage process for stripping a metal from a loaded liquid cation exchanger with dilute mineral acid while simultaneously precipitating a hydrolyzed phase. Iron(III) can be stripped from carboxylate solutions with dilute  $\text{H}_2\text{SO}_4$  (10-40 g/l) at  $100^{\circ}\text{C}$  under atmospheric pressure to give goethite or basic sulfates. The thermodynamics of the process are examined and equilibrium constants are estimated at  $25^{\circ}\text{C}$  and  $100^{\circ}\text{C}$ . For the formation of goethite and hematite, these constants are high at both temperatures. This indicates that iron(III) can only be extracted in reasonable concentrations by carboxylic acids before precipitates have nucleated or when the metastable phase  $\text{Fe}(\text{OH})_3$  is present. The sluggish kinetics of hydrolysis and precipitation favor extraction at  $25^{\circ}\text{C}$ . At  $100^{\circ}\text{C}$ , goethite and hematite precipitate more rapidly, which drives the precipitation stripping process to near completion. The structure of the iron carboxylate complexes within the organic phase is discussed along with the influence of these structures on the kinetics of stripping and the nature of the hydrolysis products. (Edited author abstract) 40 refs.

Doyle, F.M. (Univ of California, Berkeley, CA, USA). *Hydrometallurgy* v 20 n 1 Mar 1988 p 65-85.

**Process Control** See NICKEL ORE TREATMENT—Reduction.

## Reduction

**074647 CARBOTHERMIC REDUCTION USING LIQUID METAL SOLVENTS.** The use of liquid metal solvents has broadened the application-potential of carbothermic reduction in the areas of ore reduction reactions and reactive separations. A properly chosen solvent permits pyrometallurgical reductions at temperatures far below those possible with processes that do not employ a solvent metal. Product contamination is inhibited as well. Further, solvated carbothermic reduction appears to consume substantially less energy than conventional electrochemical and metallothermic processes. (Author abstract). 69 refs.

Howell, Wayne J.; Eckert, Charles A.; Anderson, Robert N. *J Met* v 40 n 7 Jul 1988 p 21-23.

**Research** See COPPER ORE TREATMENT—Flotation; PYRITES—Flotation.

**Reviews** See HYDROMETALLURGY—Reviews.

## Screening

**074648 PRINCIPLES OF SCREENING IN THE RANGE 0.5MM TO 20MM.** In spite of numerous attempts to master the complexity of screening machines, the old saying that screening is an art, not a science, still holds very true. However, this does not imply that the correct choice of screen and/or screening media for a screening application is still a matter of guesswork - far from it. To date, so much experience has been gained that it is more a question of how many trials are needed before it performs to specifications than anything else. Today, polymer screen media - rubber or polyurethane - are, with rare exceptions, standard on metal mining screens worldwide, and on hard rock and sand and gravel screens in Western and Eastern Europe, Australia and South Africa. The only major market place yet to realise fully the benefits of polymer screen media is, curiously enough, the United States.

Goldkuhl, A. (Trellex Products, Trelleborg, Swed). *Mine Quarry* v 16 n 11 Nov 1987 p 39-43.

**074649 MODELLING OF SCREENING OPERATIONS.** This paper reviews the Ferrara-Preti screening model and shows that recent laboratory and pilot plant data validate this approach. The model predicts the partition curve (selectivity function) and therefore the product size distributions, given the feed size distribution. Some improvement in the application of the model concerning numerical solution of the equations and parameter estimation are indicated. Information is given on the influence of some operating conditions on screen performance. Some applications of the model to improvement of screening operations, sizing of screens, simulation of screening and integrated plant operations are discussed. (Edited author abstract) 19 refs.

Ferrara, G. (Univ of Trieste, Trieste, Italy); Preti, U.; Schena, G.D. *Int J Miner Process* v 22 n 1-4 Apr 1988, Recent Adv in Comminution, Conf Pap, Salt Lake City, UT, USA, 1987 p 193-222.

## Sedimentation

**074650 NUMERICAL MODELLING OF MULTI-PHASE PARTICULATE FLOW AND ITS APPLICATION TO SEDIMENTATION.** A numerical model has been developed to simulate the batch settling of a suspension of a particulate size distribution initially with a uniform concentration in a host fluid. The various particle size fractions are represented as separate phases with distinct concentration and velocities. This permits the larger particles to move to the bottom of the vessel and pack. As the particles settle, all but the smallest will not



penetrate the lower levels of the vessel. The packing behaviour is represented in detail via the approach of N. Ouchiya and T. Tanaka. The numerical implementation is based upon the control volume techniques elucidated by S.V. Patankar, although the algorithm contains a number of original features. The model is compared favourably with the experimental results of R.G. Holdich. (Author abstract). 28 refs.

Bailey, C. (Thames Polytechnic, London, Engl); Cross, M.; Edwards, D. *Part Sci Technol* v 5 n 4 1987 p 357-370.

**Separation** See Also COPPER ORE TREATMENT—Concentration; ORE ANALYSIS; SEPARATORS—Magnetic.

**074651 DESIGN AND APPLICATION OF A MODERN SOLID/LIQUID SEPARATION PLANT.** The industrial practice of concentration of solids and production of clear solids by gravity sedimentation (thickening) is an old technology and the most widely applied dewatering technique in mineral processing. The authors cover the basic theory of settling as well as the development of thickeners. They indicate applications of the Neyrtex high-rate thickener (Clariflux) and sludge compactor (Tasster) for the Southern African market. 3 refs.

Harries, Gavin (Neyrtex, S Afr); Jones, Colin; Milotte, Gerard. *S Afr Mech Eng* v 37 n 10 Oct 1987 p 481-485.

**074652 INDIUM RECOVERY FROM SULPHURIC SOLUTIONS BY SUPPORTED LIQUID MEMBRANES.** A supported liquid membrane (SLM) process was developed for indium recovery from industrial copper cross leach solutions up to a pre-pilot scale level (0.5 m<sup>2</sup> of membrane surface). The values of the separation factor for In/Cu (10<sup>4</sup>-10<sup>6</sup>) and the concentration factor for indium (400) are high. The order of magnitude of the indium flux through the membrane (g/m<sup>2</sup> h) can be favorably compared to those reported in the literature for other chemical systems. With regard to the life-time of the liquid film, the result relative to a feed solution containing only Cu, In and H<sub>2</sub>SO<sub>4</sub> show that it is stable enough to perform pilot runs of several weeks. In the case that the industrial solution is used, the extraction efficiency decreases with time. Some possible causes for this behavior were investigated; the use of a more selective extractant would probably minimize the problem. (Edited author abstract) 8 refs.

Guerriero, R. (Nuova SAMIM, Venice/Mestre, Italy); Meregalii, L.; Zhang, X. *Hydrometallurgy* v 20 n 1 Mar 1988 p 109-120.

**074653 OPTIMAL DESIGN OF MINERAL SEPARATION CIRCUITS BY USE OF LINEAR PROGRAMMING.** A model is proposed for the simulation of mineral separation plants using linear programming. A mineral separation plant is described here by two linear models, one being a subset of the other. These models are solved in succession, the first producing the total flow rates between the banks and the circuit configuration, and the second the flow rates of mineral species. Circuit configurations produced by the simulation model are similar to those encountered in industry. This suggests the feasibility of applying the model in the design of separation plants in practice. The grades and recoveries obtained also closely resemble those of similar separation plants in industry. The only data required by the simulation models are the separation characteristics, tailings grade constraints and the feed rates. (Author abstract) 13 refs.

Reuter, M.A. (Univ of Stellenbosch, Stellenbosch, S Afr); Van Deventer, J.S.J.; Green, J.C.A.; Sinclair, M. *Chem Eng Sci* v 43 n 5 1988 p 1039-1049.

**074654 SYNTHESIS AND CHARACTERIZATION OF POLYELECTROLYTES FOR MINERAL SEPARATION.** The paper is concerned with polymers used as flocculation aids. Preparation of functionalized polymers from the polymerization of monomers and preformed polymers are discussed with a few illustrative examples. The methods of their characterization are described. (Edited author abstract) 24 refs.

Gundiah, S. (Nat'l Chemical Lab, Pune, India). *Miner*

*Metal Process* v 5 n 2 May 1988, Spec Top in Miner Process Semin, Pune, India, Dec 30 1987-Jan 1 1988 p 90-96.

**Separators** See SEPARATORS—Magnetic.

## Simulation

**074655 PROCESS AND PROCESS CONTROL DESIGN USING DYNAMIC FLOWSHEET SIMULATION.** The development of a mathematical description of a process plant requires coordination of information from conceptual design to operation management. The activities required to build and operate a process plant are divided into four basic chronological activities or phases. The activities are conceptual and flowsheeting; detailing around the P&ID; building and commissioning; and plant operation. The CAD system described provides a design tool to be used for each of these activities, as well as providing continuity between the activities and the disciplines involved. The heart of the system is dynamic simulation of the flowsheet. As an example, a series of carbon in pulp tanks for the adsorption of gold in solution has been chosen.

Garner, K.C. (Kenwalt (Pty) Ltd, Sandton, S Afr); Peberdy, N.J.; Moreton, C.N. *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt B 1986 p 41-45.

**Sintering** See ALUMINUM METALLURGY.

**Smelting** See Also FLOW OF FLUIDS—Vortex Flow; TITANIUM ORE TREATMENT—Reduction.

**074656 INITIAL TECHNOLOGICAL CONSUMPTION OF IMPERIAL SMELTING PROCESS AT HARIMA WORKS AND ITS LATER DEVELOPMENTS.** Harima Works was commissioned in 1966, introducing the Imperial Smelting Process (simultaneous zinc and lead smelting process) in Japan. Most part of the plant, however, was designed by Sumitomo utilizing accumulated technologies of its long and extensive experience in copper and nickel smelting operations. It was built as a smelter complex consisting of not only a sinter and ISF plant but also a zinc and lead refinery. The SO<sub>2</sub> gas is sent to the acid plant of a neighbouring chemical company. The ISF has a shaft area of 15.3 m<sup>2</sup> which is smaller than the standard one of 17.2 m<sup>2</sup> and the initial capacity was designed to produce 3000 T/M of zinc and 1500 T/M of bullion. The operation has been smooth and stable since the start-up. The production capacity has been stepped up to 6600 T/M of zinc and 2500 T/M of bullion with accumulation of various modifications and improvements through twenty years' operation. As a result, Harima Works has established its position as one of the most successful among the thirteen ISP factories in eleven countries in the world. (Author abstract)

Fujimori, Masamichi (Sumitomo Metal Mining Co, Jpn). *Metal Rev MMJ* v 4 n 2 Nov 1987 p 1-14.

## Solvent Extraction

**074657 EXTRACTION OF METAL IONS FROM AMMONIACAL SOLUTION WITH VARIOUS EXTRACTANTS.** Extraction of Cu, Ni, Co(II) and Co(III) from ammoniacal solution was carried out using Versatic Acid 10, D2EHPA, PC-88A, LIX64N, SME529 and KELEX100 as extractants in order to investigate the difference in extraction suppression by the extractants used. When acidic extractants such as Versatic Acid 10, D2EHPA and PC-88A were applied to the solution containing ammonia at high concentration, the strong extraction suppression was caused by the formation of stable metal-ammine complexes. Metal ions of Cu, Ni and Co were not extracted in the pH region of 7-9.5. On the other hand, the extraction suppression was weak and the extraction of Cu and Co(II) occurred in the pH range over 10 when chelating extractants such as LIX64N, SME529 and KELEX100 were used. (Edited author abstract) In Japanese. 15 refs.

Shibata, Junji (Kansai Univ, Suita, Jpn); Sawai, Hiroshi; Sano, Makoto; Nishimura, Sanji. *Nippon Kinzoku Gak-*

*kaishi* v 51 n 8 Aug 1987 p 743-748.

**074658 EFFECTS OF VARIOUS ADDITIVES ON THE EXTRACTION OF Pr AND Nd WITH D2EHPA.** The extraction of Pr and Nd was carried out using D2EHPA as an extractant and by adding the additives TBP, TOPO and amine to the organic phase or the additives dimethylsulfoxide and dimethylformamide to the aqueous phase. The separation factor increases in D2EHPA/LIX63 and D2EHPA/BEHAA systems, while the additives except LIX63 and BEHAA cause a decrease in the separation factor. When the water soluble additives acetonitrile, dimethylformamide and dimethylsulfoxide are added to the aqueous phase, the extraction is strongly affected. The separation factor increases up to 5.06 in the extraction from a feed solution containing 70 vol% acetonitrile. (Edited author abstract) In Japanese. 8 refs.

Shibata, Junji (Kansai Univ, Suita, Jpn); Sano, Makoto; Ohmori, Hiroshi; Nishimura, Sanji. *Nippon Kinzoku Gakkaishi* v 51 n 8 Aug 1987 p 749-754.

**074659 SOLVENT EXTRACTION OF METALS WITH CARBOXYLIC ACIDS - THEORETICAL ANALYSIS OF EXTRACTION BEHAVIOUR.** This paper describes a new theoretical method for analyzing the behavior of metals during solvent extraction with carboxylic acids. A general solvent extraction equation which allows for extraction of partially hydrolyzed species solvation of the metal within the carboxylate complex and polymerization of the organic species is used. A general expression for the distribution coefficient is derived, taking into account complexation of the metal in the aqueous phase by inorganic ligands. This general expression is then used to generate sets of theoretical log D/pH curves for different parameters in the extraction equation. For a given set of experimental log D/pH data, the most probable values of the different parameters are deduced by curve-matching. The equilibrium constant for extraction is then found from the position of the experimental curve. Examples of the technique are given for Fe(III), Cu(II) and Zn(II). (Edited author abstract) 45 refs.

Pouillon, D. (Univ of California, Berkeley, CA, USA); Doyle, F.M. *Hydrometallurgy* v 19 n 3 Jan 1988 p 269-288.

**074660 SOLVENT EXTRACTION OF METALS WITH CARBOXYLIC ACIDS - COEXTRACTION OF BASE METALS WITH Fe(III) AND CHARACTERIZATION OF SELECTED CARBOXYLATE COMPLEXES.** The solvent extraction behavior of Fe(III) and various divalent metals with neo-decanoic acid, a tertiary C<sub>10</sub> monocarboxylic acid, has been examined in nitrate, chloride and sulfate solutions at 25°C and 60°C. Ni, Zn and Cu were coextracted with Fe, especially at relatively low pH; this effect was increasingly pronounced on going from nitrate to chloride and sulphate media. Co, Mn and Mg were also coextracted with Fe in sulfate solutions. UV/visible spectrophotometry indicated that Fe(III) forms mixed carboxylate complexes with Mn, Co and Ni, having Fe:M(II) ratios of 3:2, 2:1 and 2:1+3:1, respectively. Infrared spectrophotometry also gave evidence of these complexes along with a mixed Fe-Zn complex. Mass spectrometry suggested the existence of a dimeric Ni carboxylate complex, a trimeric Fe complex and a trinuclear mixed Fe<sub>2</sub>Ni complex. Thus, there appears to be a strong correlation between coextraction and the formation of mixed carboxylate complexes. (Author abstract) 23 refs.

Doyle, F.M. (Univ of California, Berkeley, CA, USA); Pouillon, D.; Villegas, E.A. *Hydrometallurgy* v 19 n 3 Jan 1988 p 289-308.

**074661 SEPARATION OF D2EHPA AND M2EHPA.** D2EHPA and M2EHPA were separated using selective precipitation and solvent extraction. When the precipitation technique was employed, M2EHPA was precipitated as its barium salt from the mixture, followed by regeneration of the alkyl phosphoric acids by contacting each component separately with acid. In the solvent



extraction method, many binary solvent systems were tested; of them, the ethylene glycol-kerosene system was found to be most suitable. The distribution coefficients of D2EHPA and M2EHPA in various solvent systems are reported and the selectivity of solvents for the alkyl phosphoric acids is discussed. (Author abstract) 11 refs.

Acharya, S. (CSIR, Orissa, India); Nayak, A. *Hydrometallurgy* v 19 n 3 Jan 1988 p 309-320.

**074662 VERFAHREN ZUR GEWINNUNG VON TANTAL, NIOB, URAN, YTTRIUM UND SELTENERDEN AUS KOMPLEXEN ERZEN.** [Process for the Recovery of Tantalum, Niobium, Uranium, Yttrium and Rare Earths from Complex Ores]. Using samples with samarskite and uranium containing micro-lite a process has been developed in which tantalum and niobium are dissolved by treatment with hydrofluoric acid under reducing conditions while uranium, thorium, yttrium and the radionuclides are enriched as difficultly soluble fluorides in the solution residues. The residual radium traces in the fluoride solution can be eliminated by barium sulphate collector precipitation. By means of subsequent solvent extraction, radiation-free tantalum and niobium products are obtained. Protactinium traces remain in the raffination residue or in the lime neutralisation product. In order to obtain a largely radiation-free yttrium/rare earth master product from the solution residues enriched with radionuclides, a process has been developed using sulfuric acid digestion, solvent extraction and oxalate precipitation. (Edited author abstract) 9 refs. In German.

Albrecht, Wolf-Wigand (Hermann C. Starck Berlin GmbH & Co, Goslar, West Ger); Schroeder, Klaus; Wolf, Ruediger. *Erzmetall* v 41 n 1 Jan 1988 p 36-39.

**074663 EFFECTS OF NON-AQUEOUS SOLVENTS ON THE EXTRACTION OF METAL ION WITH D2EHPA.** Extraction of metal ions from the aqueous phase containing non-aqueous solvents such as dimethyl formamide (DMF), dimethyl sulfoxide (DMSO) and acetonitrile (AN) was investigated by using di-2-ethylhexylphosphoric acid (D2EHPA) as an extractant. Extraction of Cu, Ni and Co increases by adding DMSO and DMF of less than 50 vol% and then decreases by the addition of more than 50 vol%. Extraction of Ag, Cr and Fe decreases with an increasing addition of DMSO and DMF, irrespective of its amount. Extraction of Mg and Al increases with an increasing addition of DMSO and DMF, regardless of its amount. The addition of AN does not cause a great change in the extraction except for Al and Ag, but extraction of Ag is decreased by the addition of AN. (Edited author abstract) 8 refs.

Kamitani, Masaya (Kansai Univ, Suita, Jpn); Shibata, Junji; Sano, Makoto; Nishimura, Sanji. *Nippon Kinzoku Gakkaishi* v 52 n 3 Mar 1988 p 303-309.

## Surfaces

**074664 ADVANCES IN CHARACTERIZATION OF ADSORBED LAYERS AND SURFACE COMPOUNDS BY SPECTROSCOPIC TECHNIQUES.** Spectroscopic techniques are becoming increasingly popular for characterizing the interior of adsorbed layers of surfactants and polymers at the solid-liquid interface as well as the identification of compounds on mineral surfaces. This review encompasses the application of fluorescence and ESR spectroscopic techniques to reveal the microscopic environment of the adsorbed layers with special reference to the adsorption of anionic surfactants (sodium dodecyl sulfate) and polyelectrolytes (polyacrylic acid) at positively charged alumina - water interfaces. The utility of XPS and auger techniques to identify the surface elemental composition of different mineral species is related to their flotation efficiency. (Edited author abstract) 33 refs.

Somasundaran, P. (Columbia Univ, New York, NY, USA); Kunjappu, J.T. *Miner Metall Process* v 5 n 2 May 1988, Spec Top in Miner Process Semin, Pune, India, Dec 30 1987-Jan 1 1988 p 68-79.

Sweden See MINES AND MINING—Sweden.

**Tailings Disposal** See Also GOLD ORE TREATMENT—Leaching.

**074665 USE OF DILATOMETER AND PIEZOCONE TESTING IN DESIGN OF TAILINGS RECLAMATION PLANS.** The design of cover systems for reclamation schemes in tailings requires estimation or determination of tailings properties such as compressibility, shear strength, and consolidation characteristics. The piezocene and flat plate dilatometer methods provide a rapid means of material identification in a nearly continuous fashion. The equipment is described and typical data from a uranium tailings impoundment is presented. The results are compared and the advantages and disadvantages of these methods are discussed. (Edited author abstract) 12 refs.

van Zyl, D. (Colorado State Univ, Ft. Collins, CO, USA); Nelson, J.D.; Wardwell, R.E. *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt A 1986 p 1882-1886.

**074666 PROFILE PREDICTION OF HYDRAULICALLY DEPOSITED TAILINGS.** An empirical investigation was conducted to formulate a design criteria for predicting the beach profile of hydraulically deposited tailings. Field data were obtained from mining operations producing gold sulfides, silver, molybdenum, copper, platinum, and uranium. Site-specific parameters were collected that included the beach slopes, tailings soil properties, slurry properties, and the slurry distribution system characteristics. Each of the beach profiles were dimensionlessly plotted and regression expressions were computed. It was determined that either a power expression or an exponential expression closely predicted each beach slope. A slope designation chart was developed as a function of the discharge, the tailings critical tractive shear stress, and the inertial forces exerted by the slurry on the beach. (Edited author abstract) 6 refs.

Smith, G.M. (Sergeant, Hauskins & Beckwith Inc, Albuquerque, NM, USA); Abt, S.R.; Nelson, J.D. *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt A 1986 p 2024-2027.

**074667 SIGNIFICANCE OF NATURAL GROUNDWATER RECHARGE IN SITE SELECTION FOR MILL TAILINGS DISPOSAL.** Assessing the occurrence of natural groundwater recharge at mine and mill waste disposal sites may be crucial to addressing regulatory agency concerns regarding the potential impact of waste seepage on groundwater resources. Recharge has been shown to occur even in semi-arid areas where annual lake evaporation exceeds precipitation. Permanent storage of waste seepage in the unsaturated zone is not to be expected if recharge occurs under natural conditions. Establishing the direction and rate of fluid movement in the vadose zone by field measurements is an important element that should be included in the site selection process. (Author abstract) 23 refs.

Stephens, D.B. (New Mexico Inst of Mining & Technology, Socorro, NM, USA). *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt A 1986 p 2064-2068.

**074668 ENVIRONMENTAL IMPACTS OF AN OLD MINE TAILINGS DEPOSIT - MODELLING OF WATER BALANCE, ALKALINITY AND pH.** A diversity of hydrological and hydrochemical data is the foundation for an integrated modeling study of a leaching tailing deposit at Bersbo in southern Sweden. A distributed conceptual water balance model system combined with empirical hydrochemical subroutines are used to describe the variation pattern in runoff, alkalinity and pH of the outlet of the drainage basin. Examples of the sensitivity of the model output to perturbations of some of the model parameters are shown. (Author abstract) 6 refs.

Brandt, M. (Swedish Meteorological & Hydrological Inst, Norrköping, Sweden); Bergstrom, S.; Sanden, P. *Nord Hydrol* v 18 n 4-5 1987 p 291-300.

**074669 ENVIRONMENTAL IMPACTS OF AN OLD MINE TAILINGS DEPOSIT - METAL CONCENTRATIONS AND WATER PATHWAYS.** Variations in metal concentrations in a heavily polluted stream receiving acidic leachates from an old mine tailings deposit are analyzed from a hydrological perspective. From an extensive data material, collected during three years, the variations in concentrations of four metals (copper, zinc, cadmium and lead) are discussed. The deposit is the principal source for these metals in the watershed. The variation in metal concentrations in the vicinity of the deposit can to a large extent be explained by simple dilution of contaminated water with uncontaminated water from the surrounding area. Further downstream the deposit, other processes become increasingly important for the metal concentrations in the water bodies. (Author abstract) 17 refs.

Sanden, P. (Linköping Univ, Sweden); Karlsson, S.; Lohm, U. *Nord Hydrol* v 18 n 4-5 1987 p 301-312.

**074670 ENVIRONMENTAL IMPACTS OF AN OLD MINE TAILINGS DEPOSIT - METAL ADSORPTION BY PARTICULATE MATTER.** The distribution of metals (aluminum, manganese, iron, copper, zinc, cadmium and lead) between suspended particles and solution phase has been studied by analysis of time series data in a stream receiving leachates from a mine tailings deposit. A precipitation of aluminum and iron takes place when the acidic effluents are neutralized by unpolluted groundwater, while the other dissolved elements never reach saturation. The particulate fraction is largely amorphous. A transfer of dissolved elements from the solution phase to the particle phase, increasing in the order zinc < cadmium < copper < lead with increasing pH, is observed. This removal of metals from the aqueous phase appears to be due to sorption processes rather than to coprecipitation. (Edited author abstract) 20 refs.

Karlsson, S. (Linköping Univ, Sweden); Sanden, P.; Allard, B. *Nord Hydrol* v 18 n 4-5 1987 p 301-312.

**074671 BEACH CHARACTERISTICS OF MINE WASTE TAILINGS.** The Bureau of Mines surveyed waste disposal sites at 18 metal and nonmetal mines and conducted laboratory and full-scale field tests to determine the effects of tailings deposition techniques on physical properties of tailings pond beaches. Survey data included measurements of beach slopes, descriptions of deposition techniques, and measurements of beach physical properties taken at various distances from the point of discharge. Laboratory tests involved depositing two types of tailings, each with different grain size distributions, into a settling trough and determining the physical properties of settled materials along the length of the beach. Side confinement and the closeness of the water pool to the point of deposition caused the laboratory results to be inconclusive. Full-scale field deposition tests showed that there were similarities in relationships between exit velocities of tailings slurry and physical properties of the settled tailings. (Edited author abstract) 5 refs.

Boldt, C.M.K. (Bur of Mines, Spokane, WA, USA). *Rep Invest US Bur Mines* 9171 1988 24p.

**Thermodynamics** See TUNGSTEN ORE TREATMENT—Chlorination.

**Ultrasonic Applications** See IRON ORE TREATMENT—Flocculation.

**Waste Utilization** See Also MINES AND MINING—Roof Control.

**074672 METAL, MINERAL WASTE PROCESSING AND SECONDARY RECOVERY.** Throughout 1987, significant emphasis was placed on the processing of wastes. Better awareness of the environmental problems of waste disposal and a zeal to develop technology for recovering the valuables contained therein contributed to the global interest. Reflecting this expanded interest, the field was prominently featured in more than sixteen symposia or conferences as well as a variety of papers in leading journals. The review covers developments in 1987.



214 refs.

Reddy, Ramana G. (Univ of Nevada-Reno, NV, USA). *J Met* v 40 n 4 Apr 1988 p 46-51.

**Wastes** See MINES AND MINING—Land Reclamation.

## Water Supply

**074673 STUDIES ON WATER RECYCLING IN MINERAL PROCESSING (3RD REPORT).** In previous papers, it was reported that a pilot plant was constructed to test for recovery of pure kaolin with a closed water recycling system, using kaolin ore of the Minami-shiraoi mine, Hokkaido. In the present paper, the authors carried out experiments to compare the results between the continuous operations of an open circuit system and operations of approximately 50% and 90% recycling ratio with a closed circuit system. The changes in the accumulated materials in the closed circuit system and the influence of these accumulations on performance was measured and examined. This report proposes simple models of the mass balance of materials and the flow pattern of the flows in each apparatus. (Edited author abstract) In Japanese. 14 refs.

Shimokawa, Katsuyoshi (Government Industrial Development Lab, Hokkaido, Jpn); Sekiguchi, Itsuma; Yamaguchi, Yoshiaki; Takamori, Takakatsu. *Nippon Kogyo Kaishi* v 103 n 1192 Jun 1987 p 383-388.

**ORGANIC CHEMICALS** See Also BIOMEDICAL ENGINEERING—Cytology; CLAY—Physical Properties; COAL—Solvent Extraction; DYES AND DYEING; FLOW OF FLUIDS.

**Adsorption** See Also CLAY MINERALS—Adsorption; HAZARDOUS MATERIALS—Waste Disposal; POLYMERS—Adsorption; WATER TREATMENT—Chemicals Removal.

**074674 EQUILIBRIUM ADSORPTION OF CHEMICAL VAPORS ON SURFACE SOILS, LANDFILLS AND LANDFARMS—A REVIEW.** The equilibrium adsorption of Volatile Organic Chemicals (VOCs) onto soils, such as occurring in surface soils, landfills and landfarms, is reviewed. On the basis of moisture content, soils can be classified into the 'dry', 'damp' and 'wet' categories. Increasing moisture content in dry soils is known to lead to displacement of adsorbed nonpolar VOCs. This review addresses adsorption models for the three soil moisture regimes. An extended Brunauer, Emmet, Teller (BET) adsorption theory is used and simplified isotherms are developed from it that enable the estimation of partial pressures of VOCs above soils. Available experimental data on VOC adsorption in the present context are also reviewed. (Author abstract). 56 Refs.

Valsaraj, K.T. (Louisiana State Univ, Baton Rouge, LA, USA); Thibodeaux, L.J. *J Hazard Mater* v 19 n 1 Jul 1988 p 79-99.

**Applications** See WOOLEN AND WORSTED FABRICS—Wrinkle Recovery.

## Bioconversion

**074675 ABIOTIC AND BIOTIC TRANSFORMATIONS OF 1,1,1-TRICHLOROETHANE UNDER METHANOGENIC CONDITIONS.** This study confirms that 1,1,1-trichloroethane (TCA) can be biotransformed by reductive dehalogenation to 1,1-dichloroethane (1,1-DCE) and chloroethane (CE) under methanogenic conditions. Also, reductive dehalogenation of 1,1-DCE to vinyl chloride (VC) is confirmed. This study demonstrates that these transformations can occur stoichiometrically. In addition,  $[^{14}\text{C}]\text{TCA}$ ,  $[^{14}\text{C}]\text{-1,1-DCE}$ ,  $[^{14}\text{C}]\text{-1,1-DCE}$ ,  $[^{14}\text{C}]\text{CA}$ , and  $[^{14}\text{C}]\text{VC}$  were at least partially mineralized to  $^{14}\text{CO}_2$ , under similar methanogenic conditions. (Edited author abstract) 23 refs.

Vogel, Timothy M. (Michigan State Univ, East Lansing, MI, USA); McCarty, Perry L. *Environ Sci Technol* v 21 n 12 Dec 1987 p 1208-1213.

**074676 BIOMINERALIZATION RATES OF  $^{14}\text{C}$**

**C-LABELLED ORGANIC CHEMICALS IN AEROBIC AND ANAEROBIC SUSPENDED SOIL.** The formation of  $^{14}\text{CO}_2$  from 13  $^{14}\text{C}$ -labelled organic chemicals in aerobic and anaerobic suspended soil was determined. After 5 days at 35°C,  $^{14}\text{CO}_2$  was between 70.1% (urea, anaerobic) and < 0.1% (2,6-dichlorobenzonitrile and hexachlorobenzene, aerobic and anaerobic) of the  $^{14}\text{C}$  initially applied. (Author abstract) 37 refs.

Scheunert, I. (Gesellschaft fuer Strahlen- und Umweltforschung mbH Muenchen, West Ger); Vockel, D.; Schmitzer, J.; Korte, F. *Chemosphere* v 16 n 5 1987 p 1031-1041.

**Biodegradation** See Also INDUSTRIAL WASTES—Biodegradation; WATER BACTERIOLOGY; WATER POLLUTION—Pesticide Effects.

**074677 MICROBIAL DEGRADATION OF GUANIDINIUM ION.** Degradation of the cation was characterized by long and variable periods prior to enhanced microbial activity and was considerably slower than the degradation of the amino acid arginine. A carbon source could potentiate the degradation of guanidinium ion, in which case its carbon was mineralized and its nitrogen could be used for growth; but at nutrient levels in surface water, only slight mineralization of the cation's carbon was demonstrated and was considerably slower than that of urea carbon. Degradation of guanidinium ion by microorganisms capable of growing on it as a sole carbon source was estimated to be slow relative to two xenobiotic compounds. (Edited author abstract) 25 refs.

Mitchell, Wayne R. (US Army Medical Bioengineering Research & Development Lab, Frederick, MD, USA). *Chemosphere* v 16 n 5 1987 p 1071-1086.

**Chemical Analysis** See Also WATER ANALYSIS.

**074678 2-CHLOROETHYLSTEARATE: AN IN VIVO FATTY ACID CONJUGATE OF 2-CHLOROETHANOL.** 2-Chloroethanol is used as a solvent and an intermediate in the production of organic chemicals. It has been shown that compounds containing hydroxyl function can be retained in the body for a longer time as a fatty acid conjugate. Recently, the authors have shown the presence of pentachlorophenol conjugate of palmitic acid in human fat which possesses selective toxicity to pancreas. The present study was undertaken to examine if the reported retained radioactivity of 2-chloroethanol in the rat liver is associated with the formation of fatty acid conjugates. The isolation and characterization of 2-chloroethylstearate from the liver of rats treated with 2-chloroethanol is reported. 22 refs.

Kaphalia, B.S. (Univ of Texas, Galveston, TX, USA); Ansari, G.A.S. *Bull Environ Contam Toxicol* v 39 n 5 Nov 1987 p 835-842.

## Chemical Reactions

**074679 ACETALDEHYDE/ETHYL-ALCOHOL REACTION FOR A MEDIUM-LEVEL HEAT TRANSPORT SYSTEM.** An acetaldehyde/ethyl-alcohol reversible hydrogenation and dehydrogenation reaction is proposed for a medium-level heat transport system. Under atmospheric pressure the dehydrogenation converts heat at a temperature of 350-400°C to chemical energy. At another location chemical energy may be converted back, by the hydrogenation, to thermal energy at 200-250°C. For both reactions, the same silica-supported copper catalysts, particularly of ion-exchange type, have high activities and selectivities. A small amount of ethyl acetate is produced. However, the reaction producing ethyl acetate is also exothermic, so that the acetate only slightly decreases the amount of heat to be transported with this system. (Author abstract) 10 refs.

Wakao, N. (Yokohama Natl Univ, Yokohama, Jpn); Smith, J.M.; Ogasawara, S. *Int J Energy Res* v 12 n 1 Jan-Mar 1988 p 165-174.

**074680 ATMOSPHERIC REACTIONS OF A SERIES OF DIMETHYL PHOSPHOROAMIDATES AND DIMETHYL PHOSPHOROTHIOAMIDATES.**

The kinetics of the atmospherically important gas phase reactions of a series of dimethyl phosphoroamidates and dimethyl phosphorothioamidates with OH and NO<sub>3</sub> radicals and O<sub>3</sub> were investigated at 296±2 K and approximately 740 Torr total pressure of air. Rate constants obtained for the OH radical, NO<sub>3</sub> radical, and O<sub>3</sub> reactions are given. These data show that for the dimethyl phosphorothioamidates both the OH and NO<sub>3</sub> radical reactions are important atmospheric loss processes, with calculated lifetimes ranging from 1 h to 1 day. The mechanistic implications of these data are discussed. (Edited author abstract) 26 refs.

Goodman, Mark A. (Univ of California, Riverside, CA, USA); Aschmann, Sara M.; Atkinson, Roger; Winer, Arthur M. *Environ Sci Technol* v 22 n 5 May 1988 p 578-583.

**074681 GENERAL ACID CATALYSIS OF MONOCHLORAMINE DISPROPORTIONATION.** This paper presents experimental results showing that monochloramine disproportionation, which results in the formation of dichloramine, involves a general acid catalyzed reaction pathway. Rate constants characterizing the effect of hydrogen ion, phosphate, and sulfate were determined by measuring the rate of monochloramine disappearance under pH conditions, which simplified interpretation of results. These rate constants were used to develop a linear free energy relationship that was used to predict the effect of carbonate and silicate. Predictions indicate that carbonate, and possibly silicate, may significantly increase the rate of acid-catalyzed disproportionation at concentrations and pH values typical of many drinking waters. Study conclusions are discussed. (Edited author abstract) 17 refs.

Valentine, Richard L. (Univ of Iowa, Iowa City, IA, USA); Jafvert, Chad T. *Environ Sci Technol* v 22 n 6 Jun 1988 p 691-696.

**074682 HUMIC ACID COMPLEXATION OF CALCIUM AND COPPER.** High-affinity metal binding by isolated humic acids has been observed for both copper and calcium in metal titration experiments. Results of titrations of humic acids with a single metal (either calcium or copper) are consistent with a discrete ligand site model of humate-metal binding. However, copper titrations in the presence of excess calcium do not show competitive effects predicted excess calcium do not show competitive effects predicted by such a model. Hence, different ligand sites must be involved in calcium and copper binding, or a binding mechanism other than discrete ligand binding must be operative. (Author abstract). 31 Refs.

Hering, Janet G. (MIT, Cambridge, MA, USA); Morel, Francois M.M. *Environ Sci Technol* v 22 n 10 Oct 1988 p 1234-1237.

**Concentration** See CLAY—Compaction; INDUSTRIAL HYGIENE.

**Control** See LAKES; WATER TREATMENT—Activated Carbon.

## Desorption

**074683 REEXAMINATION OF THE KINETICS OF THE THERMAL DESORPTION OF DIMETHYLSULFOXIDE AND N-METHYL FORMAMIDE FROM A GREENSLATT KAOLIN.** The kinetics of the thermal decomposition of the kaolin: dimethylsulfoxide (kaolin: DMSO) and the kaolin:N-methylformamide (kaolin:NMF) intercalates have been reexamined. All sample configurations for the kaolin:DMSO intercalate (2 mg, <45 µm; 2 mg, 45-63 µm; 8 mg, <45 µm; 8 mg, 45-63 µm) followed the rate law  $-\ln(1 - \alpha) = kt$  to a value for  $\alpha$ , the reaction fraction complete, of .6, yielding activation energies and standard deviations at the 99% confidence level of 85.5 ± 3.79 and 71.75 ± 8.75 kJ/mole for the isothermal and dynamic runs, respectively. The kaolin:NMF intercalate (2 mg, <45 µm) also followed the same rate law for  $\alpha$  < .8, with activation energies and standard deviations at the 99% confidence level of 89 ±



5.05 and  $79.25 \pm 6.47$  kJ/mole for the isothermal and dynamic studies, respectively. Additional aspects of the study are discussed. (Edited author abstract) 15 refs.

Breen, Christopher (Nat'l Inst for Higher Education, Dublin, Ire); Lynch, Sean. *Clays Clay Miner* v 36 n 1 Feb 1988 p 19-24.

## Electronic Properties

**074684 CHEMICAL MODIFICATION OF SURFACES.** Bifunctional organic molecules that form bonds with a surface with one functional group give new properties to the surface with the other functional group. Adhesion to a surface or release from a surface can be improved by using this method. Preconditions for such chemical surface modification are the presence of reactive sites at the surface, the absence of impurities at these sites, and the possibility of stress relaxation on expansion and shrinkage. Subjects discussed include improvement of the adhesion between a photosensitive resist based on 'novolac' and silicon with an aminosilane, improved adhesion between noble metals and glass with a mercaptosilane, improved adhesion of silver reflecting coatings on Laser-Vision discs with tannin, an improvement of both adhesion and release in the replication method used for making aspheric lenses, using a methacryloxysilane and a trialkylsilane. The chemical surface modifications described for the replication method have been investigated by IETS and TOF-SIMS. The principles of these methods are discussed and results are presented. (Edited author abstract) 6 refs.

Ponjee, J.J. (Philips Research Lab, Eindhoven, Neth); van Velzen, P.N.T. *Philips Tech Rev* v 44 n 3 Jul 1988 p 81-88.

## Environmental Impact See Also MARINE BIOLOGY.

**074685 PREDICTION OF ORGANIC CHEMICAL FATES IN BIOLOGICAL TREATMENT SYSTEMS.** A coupled mechanism equation and related fate equations provide a basis for estimating organic compound fates from a single or a group of biological wastewater treatment systems. This approach can be used to correct existing treatability data for stripping and sorption processes and, in new treatability experiments, can provide for an indirect measure of the biotransformation rate mechanism. Use of existing data in the proposed equations suggests strong ecological subpopulation control and enzyme regulation effects resulting in major variations in biotransformation rates. Biotransformation rates are the most sensitive parameters in the fate prediction model. 14 refs.

Blackburn, James W. (Univ of Tennessee, Knoxville, TN, USA). *Environ Prog* v 6 n 4 Nov 1987 p 217-223.

**074686 CARCINOGENIC RISK OF SOME ORGANIC VAPORS INDOORS: A THEORETICAL SURVEY.** This exploratory report examines the risk of selected organic air pollutants measured in homes in the United States and the Netherlands. After several theoretical assumptions, estimates are made for the carcinogenic potency of each chemical; combined with the exposure measurements these give estimates of cancer risk. These estimates are compared with risks of these same pollutants outdoors and in drinking water and also with other well known indoor air pollutants: cigarette smoke, radon gas and formaldehyde. These comparisons indicate priorities for action. Some suggestions are made for future studies. (Author abstract) 60 refs.

Tancredi, M. (Harvard Univ, Cambridge, MA, USA); Wilson, R.; Zeise, L.; Crouch, E.A.C. *Atmos Environ* v 21 n 10 1987 p 2187-2205.

**074687 DIETHYLHEXYLPHTHALATE AS AN ENVIRONMENTAL CONTAMINANT - A REVIEW.** Di(2-ethylhexyl)phthalate (DEHP) is a priority pollutant in several countries; annual production amounts to 3-4 million tons. Approximately 95% is used as a plasticizer in polyvinylchloride (PVC). DEHP is emitted to the environment during the production of plastics and plastic

products, during their use and after disposal. In the environment, physico-chemical degradation of DEHP is practically non-existent. Biodegradation occurs readily under aerobic conditions ( $t_{1/2} = 2-4$  weeks), but not under anaerobic conditions. The acute toxicity of DEHP to mammals is low. Many subchronic and chronic effects have, however, been identified. With respect to carcinogenicity the situation is uncertain, especially for some risk groups. The ecotoxicology of DEHP is especially relevant for aquatic communities where data are contradictory. Emissions of DEHP can be reduced by the biological treatment of wastewater and waste gas, the use of alternative plasticizers in PVC or the substitution of other plastics for PVC. (Edited author abstract) 89 refs.

Wams, T.J. (Vereniging Milieudefensie, Amsterdam, Neth). *Sci Total Environ* v 66 1987 p 1-16.

**074688 CHEMISTRY AND PHOTOCHEMISTRY OF LOW-VOLATILITY ORGANIC CHEMICALS ON ENVIRONMENTAL SURFACES.** Hydrophobic organic xenobiotics such as polychlorinated dibenzodioxins (PCDDs) and polycyclic aromatic hydrocarbons (PAHs) have strong tendencies to sorb on environmental surfaces. Little is known about the heterogeneous chemistry and physical processes that affect the fate of organics on environmental surfaces. Because chemicals sorbed on soil surfaces or atmospheric particles are strongly exposed to sunlight, photochemical reactions are likely to be an important reaction pathway. This article discusses subjects covered in a recent two-day workshop in Alexandria, Va., on soil or sediment surfaces and on atmospheric particles. The workshop, which was sponsored by the EPA's Environmental Research Laboratory at Athens, Ga., and by the University of Nevada, Reno, brought together 20 scientists to discuss a wide variety of topics with a major emphasis on the environmental fate of chlorinated dioxins. 2 refs.

Miller, Glenn C.; Hebert, Vince R.; Zepp, Richard G. *Environ Sci Technol* v 21 n 12 Dec 1987 p 1164-1167.

## Environmental Testing

**074689 DEVELOPMENT OF A METHOD FOR DETERMINATION OF METHYLENE CHLORIDE EMISSIONS AT STATIONARY SOURCES.** Prior to source sampling, laboratory experiments were conducted to determine the best sample container in which to collect an integrated sample. It was found that  $\text{CH}_2\text{Cl}_2$  remained stable in Tedlar bags for at least four weeks. The analytical method selected was gas chromatography with flame ionization detection (GC/FID). The range of concentrations from the sources was 100 ppm to 27,000 ppm  $\text{CH}_2\text{Cl}_2$ . A statistical analysis of samples collected simultaneously showed no difference in the samples, proving good precision in both sampling and analysis. Some of the sample bags returned from the test sites developed leaks indicating that immediate on-site analysis is best. A comparison of results obtained in the field and the two laboratories showed that inter- and intra-laboratory precision was within 10 percent. (Edited author abstract) 8 refs.

Butler, F.E. (US EPA, Research Triangle Park, NC, USA); Coppedge, E.A.; Suggs, J.C.; Knoll, J.E.; Midgett, M.R.; Sykes, A.L.; Hartman, M.W.; Steger, J.L. *JAPCA* v 38 n 3 Mar 1988 p 272-277.

**074690 METABOLIC CONVERSION OF TOLUENE AND ETHYLBENZENE BY PACIFIC SALMON MICROSOMAL PREPARATIONS.** The aromatic fraction from crude oil has a substantial solubility in water and as a result makes up the major hydrocarbon components of processed ballast water. The purpose of this study was to investigate the metabolism of several of the major components of this processed water by Chinook salmon, *Oncorhynchus tshawytscha*, liver microsomes. The metabolic products of toluene and ethylbenzene in this microsomal system, as determined by gas chromatography-mass spectrometry, were benzyl alcohol and 1-phenylethanol, respectively. The conditions for the microsomal incubations were 20°C, pH 7.5, and an ionic strength of 0.126. A linear rate of benzyl alcohol and 1-phenylethanol formation is observed during the first 30

to 60 min followed by a decrease in the rate between 60 and 90 min. (Author abstract) 5 refs.

Kennish, John M. (Univ of Alaska, Anchorage, AK, USA); Gillis, Debora; Hotaling, Krystal. *Mar Environ Res* v 24 n 1-4 1988, Fourth Int Symp on Responses of Mar Org to Pollut, Woods Hole, MA, USA, Apr 22-24 1987 p 69-71.

## Estimation See RESERVOIRS—Analysis.

## Evaporation

**074691 VALIDATION OF MAXIMUM ALLOWABLE CONCENTRATIONS FOR O-METHYLETHYLCHLORTIOPHOSPHATE IN THE WORK ZONE AIR.** The o-methyl-ethylchlortriophosphate vapors in the work zone air are monitored and toxic effects at high concentrations are investigated. The evaporation of this organic chemical is possible through the non-hermetic joints in industrial piping systems. The maximum allowable concentration of o-methyl-ethylchlortriophosphate in the work zone air is assessed. In Russian. 2 refs.

Gzhegotsky, M.I.; Kuzminov, B.P.; Szarova, T.I.; Kokot, V.R.; Zhuk, S.Sh.; Vus, M.M. *Gig Tr Prof Zabol* n 6 Jun 1987 p 57-58.

**074692 SULFUR HEXAFLUORIDE AS A SURROGATE FOR VOLATILIZATION OF ORGANICS FROM INDOOR WATER USES.** Sulfur hexafluoride ( $\text{SF}_6$ ) was used as a surrogate to characterize the releases from a full-size shower system.  $\text{SF}_6$  has been used widely as an indoor air tracer for air exchange and source dissemination measurements because of its low toxicity, low reactivity, and ease of measurement. This paper describes a system for delivering controlled concentrations of  $\text{SF}_6$  into water devices and presents initial results of  $\text{SF}_6$  volatilization studies with a full-size shower. 9 refs.

Giardino, Nicholas J. (Univ of Pittsburgh, Pittsburgh, PA, USA); Andelman, Julian B.; Borrazzo, John E.; Davidson, Cliff I. *JAPCA* v 38 n 3 Mar 1988 p 278-280.

## Health Hazards See Also OCCUPATIONAL DISEASES—Monitoring; PIGMENTS—Chemistry.

**074693 OCCUPATIONAL ASTHMA CAUSED BY HIMIC ANHYDRIDE.** Twenty workers with exposure to himic anhydride power used for the manufacture of a synthetic flame retardant were questioned about respiratory symptoms. Three of the seven symptomatic workers who reported wheezing at work exhibited elevated specific immunoglobulin E (IgE) to two or more acid anhydride-human serum albumin conjugates. Radioallergosorbent inhibition studies performed with sera containing high levels of himic anhydride-human serum albumin specific IgE from a symptomatic worker demonstrated cross-allergenicity between himic anhydride-human serum albumin and hexahydrophthalic anhydride-human serum albumin allergenic determinants. This study demonstrated that himic anhydride can elicit IgE-mediated sensitization in the workplace. (Edited author abstract) 9 refs.

Rosenman, Kenneth D. (New Jersey Dep of Health, Trenton, NJ, USA); Bernstein, David I.; O'Leary, Kathleen; Gallagher, Joan S.; D'Souza, Leo; Bernstein, I. Leonard. *Scand J Work, Environ Health* v 13 n 2 Apr 1987 p 150-154.

**074694 STATE OF SOME PHYSIOLOGIC INDICES IN THOSE EXPOSED TO DMFA.** Physiologic studies showed that DMFA-exposed practically healthy workers experienced a number of changes as to the central and peripheral nervous systems, some hemodynamic characteristics and elasticity of peripheral vessels. The earliest and most distinct signs of fatigue were noted among the men in charge of apparatus applying outer layers and through skin exposed to DMFA concentrations greatly exceeding MACs. Changes in a number of characteristics were noted earlier in men than in women.



Proceeding from the research results, the recommendations on the work/rest regulations were developed, short-term intervals for rest substantiated, and the sign 'dangerous for skin contact' introduced into normative documents. (Author abstract) In Russian. 3 refs.

Aldyeva, M.V.; Bortsevich, S.V.; Ivanova, N.Yu.; Turbin, E.V. *Gig Tr Prof Zabol* n 5 May 1988 p 20-22.

**Manufacture** See MICROORGANISMS—Biodegradation.

## Measurements

**074695 MEASUREMENT OF ELECTRON DRIFT MOBILITY AND LIFETIME IN SPECIMENS OF DOMESTIC TETRAMETHYLSILANE.** The results of measurements of electron drift mobility and lifetime in specimens of domestic tetramethylsilane are discussed. The drift mobility was  $90 \text{ cm}^2/\text{sec} \cdot \text{V}$ ; the lifetime constant is approximately  $7 \cdot 10^{-6} \text{ sec}$ , which is sufficient for use in detectors of ionizing radiation. (Author abstract) 5 refs.

Babaev, A.I. (Inst of Theoretical & Experimental Physics, Moscow, USSR); Balakin, A.A.; Gorbakto, L.G.; Endovin, Yu.P.; Epifantsev, A.V.; Mazurina, N.I.; Novikova, L.I.; Salakhutdinov, G.Kh.; Starodubtsev, E.S.; Shatalov, P.B.; Yakovlev, B.S. *Instrum Exp Tech* v 30 n 4 pt 1 Jul-Aug 1987 p 831-832.

**Molecular Structure** See PROTEINS—Chemistry; PROTEINS—Computer Aided Analysis.

**Oxidation** See WATER TREATMENT, INDUSTRIAL—Chemicals Removal.

**Production** See BIOMASS—Production; HYDROGEN PEROXIDE—Production.

## Purification

**074696 PURIFICATION OF ORGANIC CHEMICALS BY ZONE MELTING.** Purification of naphthalene and stearic acid by zone melting was studied. The effects of the crystallization velocity and mixing intensity of the melt on the purity of the crystal were investigated by applying the solution of the diffusion equation where the necessary boundary layer thickness was calculated from correlations in the literature. The calculated values are compared with experimental values. The results can be used for estimation of the optimum mixing intensity and crystallization velocity. (Author abstract). 13 refs.

Louhi, Marjatta (Lappeenranta Univ of Technology, Lappeenranta, Finl); Silventoinen, Ilpo; Palosaari, Seppo. *Acta Polytech Scand Chem Technol Metall Ser* n 182 1988 24p.

**Removal** See INDUSTRIAL PLANTS—Effluents; WATER POLLUTION—Control.

## Separation

**074697 SEPARATION OF DILUTE AQUEOUS BUTANOL AND ACETONE SOLUTIONS BY PERVAPORATION THROUGH LIQUID MEMBRANES.** A simultaneous extraction-stripping process is proposed for separating volatile products from fermentation broths. It is based on pervaporation through a liquid membrane supported with a hydrophobic porous membrane. The liquid membrane prepared with oleyl alcohol was selected as the most suitable for separating volatile products resulting from acetone-butanol fermentation. Using the oleyl alcohol liquid membrane, the dilute aqueous butanol solutions of around  $4 \text{ g/L}$  obtained in acetone-butanol fermentation could be concentrated up to 100 times. The stability of this liquid membrane was also quite good as long as the surface tension of the feed solution was less than the critical surface tension of the support membrane. (Edited author abstract) 22 refs.

Matsumura, Masatoshi (Univ of Tsukuba, Sakura-mura, Jpn); Kataoka, Hiroshi. *Biotechnol Bioeng* v 30 n 7 Nov 1987 p 887-895.

## Solubility

**074698 COMPARISON OF WATER SOLUBILITY ENHANCEMENTS OF ORGANIC SOLUTES BY AQUATIC HUMIC MATERIALS AND COMMERCIAL HUMIC ACIDS.** Water solubility enhancements of 1,1-bis(p-chlorophenyl)-2,2,2-trichloroethane (p,p'-DDT), 2,4,5,2',5'-pentachlorobiphenyl (2,4,5,2',5'-PCB), and 2,4,4'-trichlorobiphenyl (2,4,4'-PCB) by dissolved organic matter have been studied with the following samples: (1) acidic water samples from the Suwannee River, Georgia, and the Sopchoppy River, Florida; (2) a humic extract of a nearly neutral pH water from the Calcasieu River, Louisiana; (3) commercial humic acids from the Aldrich Chemical Co. and Fluka-Tridom Chemical Corp. The calculated partition coefficients on a dissolved organic carbon basis ( $K_{DOC}$ ) for organic solutes with water samples and aquatic humic extracts from this and earlier studies indicate that the enhancement effect varies with the molecular composition of the aquatic humic materials. Additional study results are discussed. (Edited author abstract) 14 refs.

Chiou, Cary T. (US Geological Survey, Denver, CO, USA); Kile, Daniel E.; Brinton, Terry I.; Malcolm, Ronald L.; Leenheer, Jerry A.; MacCarthy, Patrick. *Environ Sci Technol* v 21 n 12 Dec 1987 p 1231-1234.

**074699 PREDICTION OF AQUEOUS SOLUBILITY OF ORGANIC CHEMICALS BASED ON MOLECULAR STRUCTURE.** Correlations for aqueous solubility of a range of 200 environmentally relevant chemicals are derived from molecular connectivity indexes and a polarizability factor, calculated solely from molecular structure. The quality and reliability of the correlations are shown to be high enough for environmental applications, even with the minimum number of variables in the equations and without excluding any data to improve the correlations. The robustness and validity of these correlations are demonstrated by use of appropriate statistical techniques. A generalized predictive equation for aqueous solubility is recommended, which employs easily calculable molecular descriptors. (Author abstract) 20 refs.

Nirmalakhandan, Nagamany N. (Drexel Univ, Philadelphia, PA, USA); Speece, Richard E. *Environ Sci Technol* v 22 n 3 Mar 1988 p 328-338.

**074700 LINEAR SOLVATION ENERGY RELATIONSHIPS. 44. PARAMETER ESTIMATION RULES THAT ALLOW ACCURATE PREDICTION OF OCTANOL/WATER PARTITION COEFFICIENTS AND OTHER SOLUBILITY AND TOXICITY PROPERTIES OF POLYCHLORINATED BIPHENYLS AND POLYCYCLIC AROMATIC HYDROCARBONS.** Methods are presented for estimation of  $V_1$  (intrinsic molar volume),  $\pi^*$ , and  $\beta$  of polychlorinated biphenyls and polycyclic aromatic hydrocarbons. Taken with the equation reported recently by D.J. Leahy, these parameter estimation rules allow prediction of  $\log K_{ow}$  with a precision that is better than the usual reproducibility of the measurements between laboratories. (Edited author abstract) 31 refs.

Kamlet, Mortimer J. (Advanced Technology & Research Inc, Laurel, MD, USA); Doherty, Ruth M.; Carr, Peter M.; Mackay, Donald; Abraham, Michael H.; Taft, Robert W. *Environ Sci Technol* v 22 n 5 May 1988 p 503-509.

**Sorption** See Also AQUIFERS—Chemistry.

**074701 SORPTION OF 8-HYDROXYQUINOLINE BY SOME CLAYS AND OXIDES.** The sorption of 8-hydroxyquinoline onto some clays and oxides was studied as a function of concentration, pH, and time. The sorption reaction reached equilibrium in about 5 hr, was irreversible, and reached a maximum at pH 5. The decrease in sorption on both sides of the maximum was attributed to electrostatic interactions of charged molecules with similarly charged surfaces and/or neighbors as well as solvent and proton competition. X-ray powder diffraction of dried clays showed that a one-layer complex formed in which the molecules lay flat between the clay interlayers. The sorption onto the clays included physical

and exchange sorption and was accompanied by exchangeable cation hydrolysis. At high surface coverage the silicate structure deteriorated in the direction of the Z-axis due to chemical aggressiveness of the reagent. (Author abstract) 13 refs.

Ferreiro, E.A. (Univ Nacional del Sur, Bahia Blanca, Argent); de Bussetti, S.G.; Helmy, A.K. *Clays Clay Miner* v 36 n 1 Feb 1988 p 61-67.

**Synthesis** See Also BIOMEDICAL EQUIPMENT—Radionuclides; ETHERS—Synthesis; POLYMERS—Chemical Reactions.

**074702 SYNTHESIS OF DL-[3-<sup>11</sup>C]VALINE USING [2-<sup>11</sup>C]ISOPROPYL IODIDE, AND PREPARATION OF L-[3-<sup>11</sup>C]VALINE BY TREATMENT WITH D-AMINO ACID OXIDASE.** DL-[3-<sup>11</sup>C]Valine, synthesized by phase-transfer alkylation of N-(diphenylmethylene)glycine t-butyl ester with [2-<sup>11</sup>C]isopropyl iodide, followed by acidic hydrolysis, was obtained in 20-30% radiochemical yield (decay corrected and calculated on the amount of [<sup>11</sup>C]carbon dioxide used) and with 93-99% radiochemical purity with a total synthesis time of 50 min. Following treatment with immobilized D-amino acid oxidase, L-[3-<sup>11</sup>C]valine was obtained in 90-99% enantiomeric excess with a total synthesis time of 85 min. [2-<sup>11</sup>C]isopropyl iodide was obtained in 40 and 90% radiochemical yield and purity respectively, within 12 min calculated from [<sup>11</sup>C]carbon dioxide. In a typical experiment starting with 150 mCi of [<sup>11</sup>C]carbon dioxide, 7 mCi of DL-[3-<sup>11</sup>C]valine and 0.8 mCi of L-[3-<sup>11</sup>C]valine were obtained. (Author abstract) 18 refs.

Antoni, Gunnar (Univ of Uppsala, Uppsala, Swed); Langstrom, Bengt. *Appl Radiat Isot* v 38 n 8 1987 p 655-659.

**074703 KINETIC STUDY ON THE FORMATION OF METHYL CHLORIDE FROM METHANOL AND HYDROGEN CHLORIDE BY CATALYTIC GAS-LIQUID REACTION.** The gas-liquid phase reaction of the formation of methyl chloride from gaseous methanol and hydrogen chloride with 75-79% aqueous zinc chloride solution as catalyst in a bubble agitated reactor was studied. The influence of diffusion was eliminated by enhanced agitation and the intrinsic reaction rates with different amounts of feedings were measured at 413, 418 and 423 K respectively. An empirical kinetic equation was established from the experimental data obtained and its parameters were evaluated. (Author abstract) 6 refs. In Chinese.

Zhou, Jipping (Nanjing Inst of Chemical Technology, China); Li, Shan; Zeng, Chongyu; Qiao, Xu; Dai, Xing. *Huaxue Fanying Gongcheng Yu Gongyi* v 2 n 3 Sept 1986 p 1-7.

## Thermodynamic Properties

**074704 CALORIMETRIC MEASUREMENTS AT 318.15 K FOR THE MALEIC ANHYDRIDE/DIOXANE AND 2-METHYLFURAN/DIOXANE BINARYS AND THEIR CORRELATION WITH A MODIFIED GMEHLING EQUATION OF STATE.** Partial molar enthalpies for the binary systems 2-methylfuran/p-dioxane and maleic anhydride/p-dioxane were measured via titration, isoperibol calorimetry at 318.15 K. The behavior of both binaries was correlated within experimental uncertainty with a three-parameter version of the Gmehling equation of state. Two-parameter models could successfully correlate the 2-methylfuran/p-dioxane binary but not the maleic anhydride/p-dioxane binary. (Author abstract) 13 refs.

Nagy, Paul E. (Univ of Missouri - Rolla, Rolla, MO, USA); Bertrand, Gary L.; Poling, Bruce E. *J Chem Eng Data* v 32 n 4 Oct 1987 p 439-443.

**Toxicity** See Also ALUMINUM COMPOUNDS; BIOMEDICAL ENGINEERING—Living Systems Studies; EPOXY RESINS—Synthesis; FUNGICIDES; MARINE BIOLOGY; PAPER PRODUCTS—Health Hazards; REFUSE INCINERATORS—Environmental Impact; SEWAGE TREATMENT—Sludge Digestion; WATER POLLUTION—Canada.



**074705 IN VITRO AND IN VIVO TOXICITY: A COMPARISON OF ACRYLAMIDE, CYCLOPHOSPHAMIDE, CHLORDECONE, AND DIETHYLSTILBESTROL.** Four chemicals that had been tested in an *in vivo* toxicological screen were tested in a Chinese hamster ovary (CHO) cytotoxicity assay. Cell density, viability, ATP concentration, rate of protein synthesis, and cellular protein concentration were decreased by exposure to acrylamide (AC), chlordane (CHL), cyclophosphamide (CYC), and diethylstilbestrol (DES). Based on the *in vitro* toxicity rankings, DES and CHL were more toxic than AC or CYC. *In vivo*, the four chemicals were toxic following 10 daily treatments. While CYC was the least toxic chemical *in vitro*, it was one of the most toxic *in vivo*. Implications of the study results are discussed. (Edited author abstract) 45 refs.

Simmons, Jane Ellen (US EPA, Research Triangle Park, NC, USA); Berman, Ezra; Jackson, Marcus; Lewtas, Joellen. *J Environ Sci Health Part A* v A22 n 7 1987 p 639-664.

**074706 PHARMACOKINETICS OF ORGANIC SOLVENT VAPORS IN RELATION TO THEIR TOXICITY.** The volatility and lipophilicity by which organic solvents are distinct from other chemicals constitute a characteristic pharmacokinetic feature. They enter a living body by inhalation, preferentially distribute in the adipose tissue, and are eliminated by both expiration and metabolic degradation. This review article is centered on experimental studies conducted by the authors and their co-workers, and it deals with (i) pharmacokinetic principles, (ii) partition coefficients in relation to toxicity, (iii) significance of metabolism in the development of organic solvent toxicity, and (iv) environmental factors that alter the metabolism and toxicity of solvents. (Author abstract) 64 refs.

Sato, Akio (Medical Univ of Yamanashi, Yamanashi, Jpn); Nakajima, Tamie. *Scand J Work, Environ Health* v 13 n 2 Apr 1987 p 81-93.

**074707 EXPERIMENTAL DATA FOR THE SUBSTANTIATION OF MAC FOR META-AMINOPHENOL IN THE WORK ZONE AIR.** Meta-aminophenol is an organic chemical used in paint manufacture and as a basic product in herbicide synthesis. Meta-aminophenol toxicity is investigated. The limit of meta-aminophenol concentration in the work zone air is assessed in rat and guinea pig experiments described in this paper. In Russian. 3 refs.

Markaryan, K.L.; Babayan, E.A. *Gig Tr Prof Zabol* n 1 Jan 1988 p 49-50.

**074708 EFFECTS OF ETHANOL ON THE HEMATOTOXICITY OF TWELVE PHARMACEUTICAL AND ENVIRONMENTAL AGENTS.** The ability of ethanol (5%) to potentiate the oxidant stressor effects of twelve well-known hematotoxic agents was investigated *in vitro* using human erythrocytes. Human whole blood was incubated with one of the following agents with and without ethanol for one hour at 37°C: o-aminophenol (0.05 mM); p-benzoquinone (4.0 mM); butyl nitrite (1.0 mM); p-hydroxyacetophenone (3.0 mM); hydroxylamine (0.5 mM); O,N-dimethylhydroxylamine (7.0 mM); 1,2-naphthoquinone (0.4 mM); 1,4-naphthoquinone (0.5 mM); p-phenylenediamine (5.0 mM); phenylhydrazine (1.0 mM); potassium nitrite (1.0 mM) and primaquine (8.0 mM). Methemoglobin (METHB) and reduced glutathione (GSH) levels were subsequently measured. Synergistic increases in METHB levels occurred for primaquine, 1,2-naphthoquinone and p-phenylenediamine incubated with ethanol ( $p < 0.05$ ). (Author abstract) 13 refs.

Calabrese, Edward J. (Univ of Massachusetts, Amherst, MA, USA); Tili, Frank; Horton, Holly M.; Stoddard, Anne. *J Environ Sci Health Part A* v A23 n 4 May 1988 p 359-367.

**ORGANIC COMPOUNDS** See Also ACIDS—Extraction; AEROSOLS—Atmospheric; AIR POLLUTION—Paris, France; ALGAE; AQUACULTURE—Fish Ponds; BIOLOGICAL MATERIALS—Blood; BIOLOGICAL MATERIALS—Blood Vessels; BORON COMPOUNDS—Purification; BUTADIENE—Polymerization; CELLULOSE DERIVATIVES—Production; CHEMILUMINESCENCE—Applications; CLAY MINERALS—Thermal Properties; COPOLYMERS—Chemical Reactions; CORROSION PROTECTION—Inhibitors; CRYSTALS—Radiation Effects; DIALYSIS; DUST—Flammability; ELECTRIC BATTERIES, SECONDARY—Materials; ELECTROLESS PLATING—Nickel; EMULSIONS—Stabilizers; ESTERS—Thermodynamic Properties; ETHERS—Phase Equilibria; FILMS—Preparation; FLUORESCENCE—Laser Applications; FORMALDEHYDE—Structure; GASES—Solubility; GELS—Structure; GRAPHITE; HAZARDOUS MATERIALS—Wastes; KETONES—Manufacture; LIGNIN; LIQUID FUELS—Ignition; LUMINESCENCE—Magnetic Field Effects; MAGNETIC MATERIALS—Ferromagnetism; MIXTURES—Phase Equilibria; MIXTURES—Thermodynamic Properties; MIXTURES—Viscosity; MOLEBENIUM COMPOUNDS—Synthesis; NITROGEN COMPOUNDS—Molecular Structure; OIL SANDS; PAPER AND PULP MILLS—Health Hazards; POLYELECTROLYTES—Synthesis; POLYETHYLENES—Crosslinking; POLYMERS—Dielectric Properties; POLYMERS—Synthesis; POLYMETHYL METHACRYLATE—Molecular Structure; PULP—Leaching; SALTS—Structure; SEMICONDUCTOR MATERIALS—Testing; SHALE OIL—Structure; SILICA—Modification; SOILS—Analysis; SOLID STATE DEVICES—Materials; SOLUTIONS—Thermal Effects; SPECTROSCOPY, EMISSION; STEEL—Anodic Protection; STEEL CORROSION—Pitting; STYRENE—Polymerization; SUPERCONDUCTING MATERIALS—Electronic Properties; SUPERCONDUCTING MATERIALS—Pressure Effects; SURFACES—Thermodynamic Properties; VAPORS—Thermodynamic Properties; ZIRCONIUM COMPOUNDS.

**074709 HYDROGENACE DICYKLOPENTADIEN V TRUBKOVEM REAKTORU SE ZKRAPENYM LOZEM KATALYZATORU.** [Hydrogenation of Dicyclopentadiene in a Tubular Reactor with Sprinkled Catalyst Bed]. Hydrogenation of dicyclopentadiene has been studied in a tubular reactor with sprinkled bed of a nickel-chromium catalyst. Values of the apparent activation energy have been deduced from experimental data. A power-law kinetic equation, supplemented by a correlation formula which respects the efficiency of catalyst wetting, was used in the design of a reactor and development of technology for hydrogenation of dicyclopentadiene to tricyclo-(5,2,1,0<sup>2,6</sup>)decane, an intermediate in the production of adamantane. The developed mathematical model of hydrogenation of dicyclopentadiene in a tubular reactor was used in a design of a plant-scale tubular reactor and in the development of technology for hydrogenation of dicyclopentadiene in the adiabatic regime. (Edited author abstract) In Czech. 29 refs.

Kysilka, Vladimir (Lachema op, Brno, Czech); Hanika, Jiri; Sporka, Karel; Macoun, Petr. *Chem Prum* v 37 n 7 1987 p 360-364.

**074710 ALUMINOSILOXANE AS A CERAMIC PRECURSOR.** Aluminosiloxane  $Al(OPr)_2(OSiMe_3)$  can be used as an organic precursor of gels and ceramics. Polymerization has been followed by SAXS and <sup>27</sup>Al NMR. The gelation results first from the formation of chain polymeric units with Al-O-Al linkages and secondly from the formation of mass-fractal clusters by aggregation of the chain units. During the ageing of the gel and the removal of the solvent, the chain structure turns into a three-connective polymer network. The heat treatment of the gels leads, after removal of volatile siloxanes, to transparent glass ceramics with a molar composition of about 92Al<sub>2</sub>O<sub>3</sub>-8SiO<sub>2</sub>. (Author abstract) 16 refs.

Pouxviel, J.C. (Ecole Polytechnique, Palaiseau, Fr); Boilot, J.P.; Poncelet, O.; Hubert-Pfalzgraf, L.G.; Lecomte, A.; Dauger, A.; Beloeil, J.C. *J Non Cryst Solids* v 93 n 2-3 Sep 1987 p 277-286.

**074711 ON THE REMOVAL OF METALLIC MIRRORS BY FREE RADICALS.** Large radicals can be formed by passing chlorinated organic compounds at pressures of a few mm., through a furnace containing a pellet of sodium and heated to 350-400°C. It is found that the only radicals that will remove metallic mirrors (of tellurium or antimony, etc., previously deposited beyond the furnace) are those that can decompose into methyl or ethyl radicals plus an unsaturated molecule, without

undergoing any transmigration of atoms. The authors also found, especially in the case of larger monochlorinated molecules, that there was some decomposition, approximately half, even in the absence of metallic sodium. (Edited author abstract)

Rice, Francis Owen (Chemical Research Lab, Mishawaka, IN, USA); Tweedell, Joan. *Ber Bunsenges Phys Chem* v 91 n 10 Oct 1987 p 995-997.

**074712 ELECTRO-ORGANIC REACTIONS - XXX. CLEAVAGE AND COUPLING OF SOME BIOMASS-DERIVED ORGANIC COMPOUNDS.** The oxalate cathodic cleavage reaction has been applied to several biomass-derived organic substrates. Furfuryl alcohols and hydrofuroin undergo the expected deoxygenation reactions, but butane-2,3-diol is only deoxygenated by prior conversion into butane-2,3-dimethanesulfonate. The one-pot cathodic conversion of furfural into hydrofuroin, and thence into 1,2-difurylthene is described. (Author abstract)

Ellis, Keith G. (Univ of London, London, Engl); Nazari-ul-Islam; Sopher, David W.; Utley, James H.P. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3058-3062.

**074713 DETERMINATION OF THE IONIC CHARGE OF SEMIQUINONES BY PULSED CONDUCTIVITY AND ESR TECHNIQUES.** Microsecond pulsed conductivity and ESR techniques have been used for unambiguous determination of the ionic charge on semiquinones derived from one-electron reduction of hydroxyquinones such as juglone, naphthazarin, sodium quinizarin-2-sulfonate and adriamycin. Irrespective of the presence of other charges elsewhere in the molecule, the radical centers of all the semiquinones have been shown to be mono-anionic at around neutral pH. The importance and significance of strong intramolecular H-bonding have been highlighted. Results on one-electron oxidation of naphthazarin have also been briefly discussed. (Author abstract) 18 refs.

Mukherjee, T. (BARC, Bombay, India); Cercek, B.; Dodd, N.J.F.; Swallow, A.J. *Radiat Phys Chem* v 30 n 4 1987 p 271-277.

**074714 EFFECTS OF BENZOTRIAZOLE AND 1,2,4-TRIAZOLE ON THE FORMATION OF ROUGH COPPER DEPOSITS UNDER REPETITIVE DOUBLE-PULSE ELECTRODEPOSITION CONDITIONS.** It was the aim of this work to study the effect of two organic compounds, benzotriazole (BTA) and 1,2,4-triazole (TA), on the surface morphology of copper deposits produced under repetitive double-pulse conditions. Copper adhesion coatings were electrodeposited on flat copper samples obtained by copper electrodeposition from sulfate bath with dc. It is shown that dendritic deposit growth ceases during the even pulses, since under these conditions the deposition rate is practically the same at all microprofile section. In repetitive odd pulses higher-order branching occurs. The rapid growth of the dendrites initially nucleated on top of the substrate microprojections leads to a fast redistribution of the mean rate of copper deposition away from the surface sections screened by dendrites; this is readily seen in transverse sections of the deposits. 1 ref.

Vesilevich, L.M. (D.I. Mendeleev Chemical Engineering Inst, Moscow, USSR); Kruglikov, S.S.; Yarlykov, M.M.; Morozov, V.A. *Sov Electrochem* v 23 n 7 Jul 1987 p 920-923.

**074715 PREPARATION OF HOMO- AND HETEROBIMETALLIC  $\mu$ - $\eta^2$ -(C,C)-KETENE COMPLEXES,  $FpCH_2COML_n$ , AND TRANSFORMATION OF THE BRIDGING KETENE LIGAND INTO VARIOUS C2 FUNCTIONAL GROUPS.** Eight examples of homo- and heterobimetallic  $\mu$ -ketene complexes,  $FpCH_2COML_n$ , are prepared by acylation of an iron-substituted acetyl chloride with various transition-metal anions. IR studies reveal the significant contribution of a  $\pi$ -complex  $Fp+[CH_2=C(O^-)Fp]$  in addition to an



oxycarbene structure  $\text{FpCH}_2\text{C}(\text{O})=\text{Fp}^+$  which is well-established for mononuclear acyl complexes. As a typical example,  $\text{FpCH}_2\text{COFp}$  is subjected to chemical transformations relevant to catalytic CO hydrogenation. (Edited author abstract) 59 refs.

Akita, Munetaka (Tokyo Inst of Technology, Yokohama, Jpn); Kondoh, Atsuo; Kawahara, Takashi; Takagi, Takenobu; Moro-oka, Yoshihiko. *Organometallics* v 7 n 2 Feb 1988 p 366-374.

**074716 INSERTION REACTIONS OF NITRILES IN CATIONIC ALKYLBI(CYCLOPENTADIENYL) TITANIUM COMPLEXES: THE FACILE SYNTHESIS OF AZAALKENYLIDENE TITANIUM COMPLEXES AND THE CRYSTAL AND MOLECULAR STRUCTURE OF  $[(\text{IDENYL})_2 \text{Ti}(\text{N-CMePh})(\text{NCPb})\text{BPh}_4]$ .** The cationic methylbis(cyclopentadienyl)titanium nitrile complexes are readily converted to the azaalkenylidene complexes as the products of a migratory insertion of nitriles into the Ti-methyl bond. The kinetics of the insertion reactions show a first-order dependence on the titanium alkyl and zero-order in the concentration of free nitrile. The reaction rates increase in the order  $\text{Me} < \text{t-Bu} < \text{Ph} < \text{n-Pr}$ . Bi(idenyl) complexes are more reactive than their cyclopentadienyl analogs, with reaction rates increasing for  $\text{R} = \text{t-Bu} < \text{Me} < \text{Ph}$ . The role of these complexes as models for the mechanism of the  $\text{Cp}_2\text{TiCl}_2/\text{AlR}_3$ -catalyzed polymerization of ethylene is discussed. (Edited author abstract) 42 refs.

Bochmann, Manfred (Univ of East Anglia, Norwich, Engl); Wilson, Ladislav M.; Hursthouse, Michael B.; Motevalli, Majid. *Organometallics* v 7 n 5 May 1988 p 1148-1154.

**074717 CONTROL OF  $\pi$ -RADICAL ANION STATE OF PORPHYRIN WITH A POLYMER MATRIX.** The photoredox and electrochemical behavior of cationic porphyrins immobilized on Nafion was investigated using flash and continuous photolyses and modified electrode techniques. Porphyrin  $\pi$ -radical anions generated by photochemical and electrochemical reduction are stabilized by immobilization on Nafion. In a polymer matrix, the disproportionation of the  $\pi$ -radical anion is inhibited because of lowered mobility of the porphyrin. (Author abstract). 10 Refs.

Segawa, Hiroshi (Kyoto Univ, Kyoto, Jpn); Shimidzu, Takeo; Honda, Ken-ichi. *Polym J* v 20 n 6 1988 p 441-446.

**074718 PICOSECOND STUDY ON EXCIMER FORMATION IN PYRENE SINGLE CRYSTALS II. THE EXCIMER PRECURSOR STATE IN THE HIGH-TEMPERATURE PHASE.** Temperature dependent measurements of transient fluorescence spectra and fluorescence rise and decay times were performed in the high temperature phase of pyrene (155-300 K) with experimental response down to 15 ps. These prove the two-step excimer formation process via the precursor B-state as suggested in part I. The residual vibronic substructure in the B-fluorescence spectra indicates moderate electron-phonon coupling and partial self-trapping in the B-state. The B-state can be excited directly. Experiments with variable excess excitation energy show that this is not needed for excimer formation. There are good reasons that the B-state is the S<sub>1</sub>-state of pyrene. A kinetic scheme for the coupled energy relaxation processes has been applied providing kinetic rates and activation energies. (Author abstract). 18 refs.

Seyfang, R. (Univ Stuttgart, Stuttgart, West Ger); Port, H.; Wolf, H.C. *J Lumin* v 42 n 3 Sep 1988 p 127-135.

**074719 ISOMERIC EFFECT OF EXCIPLEX FORMATION.** As well known, Weller proposed that the condition of  $I_A < I_D$  and  $E_A < E_D$  must be satisfied for the formation of exciplex. The interaction between the donor and acceptor are contributed by two parts. One is electrostatic force and the other is dispersion. In the case of  $I_D < I_A$ ,  $E_D < E_A$ , the former is very strong and the latter is weak. In this paper we report how to extract the latter interaction from a very strong electron transfer

system. Only the systems composed of ethylcarbazole-isomers of phthalate and carbazole derivatives-dimethyl-terephthalate are discussed in detail.

Chen, Shangxian (Inst of Chemistry, Beijing, China); Chen, Zhanchi. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 241.

**Absorption** See Also CLAY MINERALS—Surface Properties; SODIUM COMPOUNDS—Solutions.

**074720 QUALITATIVE IR SPECTRAL ANALYSIS OF PRODUCTS ABSORBED FROM DITOLYLMEthane COOLANT BY SILICA GEL AND THE ABSORPTION ISOTHERMS.** In reactors with an organic coolant, as the energy output increases the pressure drop in the active zone increases as a result of impurities of harmful substances which enter the coolant during uptake and when the first loop is opened as well as because of the formation of harmful substances with the radiation-chemical transformation of the coolant. It is pointed out that the rate at which pressure drop increases decreases substantially when the organic coolant is filtered through a layer of attapulgus - an adsorbent, prepared from aluminosilicate clay. Because of this it was of interest to study qualitatively the products absorbed from an organic fuel. 6 refs.

Ermakov, V.A.; Benderskaya, O.S. *Sov At Energy* v 62 n 4 Apr 1987 p 320-322.

**074721 REMOVAL OF HUMIC SUBSTANCE DISSOLVED IN WATER - I.** This study is concerned with the absorption properties of a fractionated humic substance at varying pHs on surface-treated carbon adsorbents. Activated carbon fiber (PF) made from phenol resin, Pittsburgh activated carbon (AC), and electronic conductive carbon black (EC) are used. The lower- (mol wt 100 to 1000 as polyethylene glycol (PEG)) and higher- (mol wt 1000 to 5000 as PEG) molecular-weight components are adsorbed well on PF and AC, having a large volume of micropores, and EC, being rich in mesopores, respectively. After the removal of surface polar substances from the adsorbents, we correlate the adsorptive capacity and the pore-size distribution. These results suggest that pore-size distribution is an important factor in removing humic substances effectively. (Edited author abstract) 28 refs.

Ogino, Keizo (Science Univ of Tokyo, Noda, Jpn); Kaneko, Yukihiro; Minoura, Tomoyasu; Agui, Wataru; Abe, Masahiko. *J Colloid Interface Sci* v 121 n 1 Jan 1988 p 161-169.

**Adsorption** See Also AEROSOLS—Atmospheric; AMMONIA—Adsorption; BLOCK COPOLYMERS—Structure; CATALYSTS—X-Ray Analysis; CHEMICAL OPERATIONS—Diffusion; CHLORINE COMPOUNDS; ELECTRODES, ELECTROCHEMICAL—Chemical Modification; IONS—Emission; IRON AND ALLOYS—Surfaces; LEAD COMPOUNDS—Surfaces; METALS AND ALLOYS—Corrosion; POLYMERS—Chemical Reactions; SALTS—Adsorption; SOLUTIONS—Dielectric Properties; WASTEWATER—Activated Carbon; WATER TREATMENT—Activated Carbon; WATER TREATMENT—Coagulation.

**074722 INFLUENCE OF POTENTIAL ON THE ADSORPTION PARAMETERS OF ANILINE ON MERCURY.** The parameters for the adsorption of aniline molecules from neutral sodium sulfate solutions were calculated. The adsorption energies of the molecules were estimated for the first time over a wide range of potentials for each of the orientations assumed to be jointly present in the adsorbed layer. The influence of potential on coefficient B<sub>2</sub> of the isotherm for flat orientation can be described satisfactorily in terms of the Frumkin theory. Changes in base-electrolyte concentration could be accounted for, merely by taking into account the change in activity coefficient of the organic material which occurs due to the salting-out effect. (Author abstract) 22 refs.

Ershler, A.B. (Acad of Sciences of the USSR, Moscow, USSR); Kuminov, E.M. *Sov Electrochem* v 23 n 1 Jan 1987 p 54-59.

**074723 INFLUENCE OF AN ELECTRIC FIELD ON ADSORPTION OF ORGANIC SUBSTANCES AT ELECTRODES - I. GENERALIZATION OF THE FRUMKIN'S THEORY FROM THE MODIFIED MODEL OF TWO PARALLEL CONDENSERS.** The modified model of two parallel condensers based on a new demonstration of the Helmholtz formula provides a consistent electrostatic interpretation of the influence of an electric field on adsorption of organic substances. Following the procedure proposed by the soviet school, deviations, with respect to congruence, due to variations in coverage of the inner properties of the surface layers, are treated for some molecular examples in the frame of the modified model. (Edited author abstract) 27 refs.

Schuhmann, D. (Lab de Physico-Chimie des Systemes Polyphases, Montpellier, Fr). *Electrochim Acta* v 32 n 9 Sep 1987 p 1331-1336.

**074724 INTERACTIONS OF COMPOUNDS ADSORBED ON AN 80%  $\alpha$ -CYCLODEXTRIN-SODIUM CHLORIDE MIXTURE INVESTIGATED BY DIFFUSE REFLECTANCE AND LUMINESCENCE SPECTROMETRY.** The interactions of  $\alpha$ -cyclodextrin-analyte responsible for the luminescence phenomenon observed from compounds adsorbed on an 80%  $\alpha$ -cyclodextrin-sodium chloride mixture were compared with the interactions of the prepared solid-phase  $\alpha$ -cyclodextrin complexes of the compounds. The diffuse reflectance spectra of several compounds adsorbed on an 80%  $\alpha$ -cyclodextrin-sodium chloride mixture and on NaCl were compared. Some of the compounds showed a red shift in their reflectance band maximum, and other compounds showed well-resolved vibronic bands on the 80%  $\alpha$ -cyclodextrin mixture. (Edited author abstract) 28 refs.

Bello, J.M. (Univ of Wyoming, Laramie, WY, USA); Hurtubise, R.J. *Anal Chem* v 59 n 19 Oct 1 1987 p 2395-2400.

**074725 DISCUSSION OF THE BEHAVIOR OF 2-ACETYL-5-BROMOTHIOPHENE AT THE MERCURY/AQUEOUS SOLUTION INTERFACE IN TERMS OF PHASE TRANSITIONS IN MULTISITE ADSORPTION OF FLAT LATTICES.** In the discussion of experimental adsorption isotherms of 2-acetyl-5-bromothiophene on mercury which consist of two steps, model concepts involving a phase transition in an adsorbed layer of molecules in flat positions without reorientation are used. Results obtained when measuring adsorption values, electrode capacitance, and electroreflectance spectra and estimates obtained with the aid of molecular models are in harmony with these concepts. Apparently for the first time we have experimentally detected the transition of organic molecules from a chaotic arrangement to an orderly arrangement in an adsorbed layer at the metal/solution interface. (Edited author abstract) 8 refs.

Ershler, A.B. (Acad of Sciences of the USSR, Moscow, USSR); Levinson, I.M. *Sov Electrochem* v 23 n 3 Mar 1987 p 330-337.

**074726 RELATION BETWEEN ADSORPTION PARAMETERS AND ELECTRONIC STRUCTURE OF ORGANIC ADSORBATES.** The authors have made an attempt to correlate the energy parameters of the molecules with the adsorption properties, and to analyze certain adsorption parameters of organic substances on this basis. The calculations were performed with the Huckel method. It is shown that the acid molecules contain two oxygen atoms, one hydroxylic and one of the ester-type. Here the electron density is more highly concentrated at the ester oxygen atom. It increases with increasing length of the carbon chain, but that at the hydroxylic, oxygen decreases, i.e., the hydrophilicity of



the ester atom increases. The molecules of all the acids considered have an excess of electrons, and this excess decreases with increasing chain length. 7 refs.

Nesterenko, A.F. (F.E. Dzerzhinskii Chemical Engineering Inst, Dnepropetrovsk, USSR); Burykina, V.S.; Aprasyukhin, A.I.; Loshkarev, M.A. *Sov Electrochem* v 23 n 3 Mar 1987 p 395-397.

**074727 ADSORPTION OF GLUTARIC, ADIPIC, AND PIMELIC ACIDS ON ACTIVATED CARBON.** Experimental data are reported for the adsorption of three dicarboxylic acids onto activated carbon from dilute aqueous solutions. Glutaric, adipic, and pimelic acids were studied at 278 and 313 K over a concentration range of  $10^{-1}$  to  $10^{-4}$  (kg mol)/m<sup>3</sup>. A single generalized characteristic curve for the dicarboxylic acids was obtained by using the potential theory. (Author abstract) 13 refs.

Lee, Chia-Yuan C. (Oklahoma State Univ, Stillwater, OK, USA); Hines, Anthony L. *J Chem Eng Data* v 32 n 4 Oct 1987 395-397.

**074728 POTENTIAL- AND pH-DEPENDENT ADSORPTION OF ANILINE ON SILVER AS EVIDENCED WITH SURFACE ENHANCED RAMAN SPECTROSCOPY.** The potential- and pH-dependent adsorption of aniline on silver has been studied using Surface Enhanced Raman Spectroscopy. Different orientations of the adsorbed aniline depending on the composition of the electrolyte solution and the potential of the electrode have been identified based upon occurrence and band-shift of characteristic Raman bands corresponding to modes of the adsorbed molecule related to the molecule-electrode interaction. In neutral electrolyte aniline is adsorbed via Ag-N interaction at potentials positive to the potential of zero charge, at potentials negative to the pzc this coordination is changed to a more edge-on one. In acidic solutions the anilinium-cation is adsorbed flat by interaction of the aromatic electron system and the electrode as well as edge-on. (Author abstract) 31 refs.

Holze, Rudolf (Univ of Bonn, Bonn, West Ger). *Electrochim Acta* v 32 n 10 Oct 1987 p 1527-1532.

**074729 UNTERSUCHUNGEN ZUR ADSORPTION BI- UND POLYFUNKTIONELLER ORGANISCHER SAEUREN AN ALUMINIUMOXID.** [Investigation of the Adsorption of Bi- and Polybasic Organic Acids by Alumina]. This paper deals with the adsorption of citric acid, tartaric acid, lactic acid and oxalic acid, resp. as well as malic acid and hydrochloric acid on  $\gamma$ -Al<sub>2</sub>O<sub>3</sub>. Errors, which arise from the analytical determination of the loading in consequence of the adsorbent porosity are adjusted by a pore correction. The adsorption of the first four acids can be described best by the Langmuir isotherm equation and that of the last two acids by a three-parameter equation. Relations between the parameters of the Langmuir isotherm and the composition of the appropriate aluminium complexes in aqueous solution are discussed and proposals for the structure of the formed complexes are given. (Edited author abstract) In German. 22 refs.

Engels, Siegfried (Technische Hochschule 'Carl Schorlemmer', Leuna-Merseburg, East Ger); Lausch, Hartmut; Schwokowski, Rainer. *Chem Tech (Leipzig)* v 39 n 9 Sep 1987 p 387-391.

**074730 ADSORPTION AND FILM FORMATION OF CAMPHOR-10-SULFONATE AT THE MERCURY-SOLUTION INTERFACE.** The adsorption behavior of camphor-10-sulfonate at the mercury-solutions interface was studied by means of double layer capacity and electrocapillary measurements. A remarkable effect of the anion of the supporting electrolyte on film formation was observed. In order to determine adsorption parameters of camphor-10-sulfonate the temperature dependence of the double layer capacity was measured and evaluated. Inhibition investigations show, that the reduction of Cu<sup>2+</sup> in the presence of camphor-10-sulfonate in dependence on surfactant concentration follows two distinct reaction paths. (Author abstract) 31 refs.

Philipp, R. (Paedagogische Hochschule, Halle, East Ger); Retter, U.; Dittrich, J.; Mueller, E.; Kuschel, F. *Electrochim Acta* v 32 n 12 Dec 1987 p 1671-1677.

**074731 COMPARISON OF ADSORPTION PARAMETERS IN DIFFERENT ISOTHERMS.** The objective of this work is to provide a method of interconversion for the isotherm parameters and to propose a unified, rational scale for the standard free energies of adsorption. The authors report adsorption parameters for certain compounds on bismuth which were calculated with the use of different isotherms. The method proposed in this work for expressing the free energies of adsorption calculated via different isotherms proves to be a most appropriate method for obtaining comparable data, since the adsorption energies can be compared under the condition of identical standard states. 8 refs.

Past, U. (Tartu State Univ, USSR); Alumaa, A.; Palm, U. *Sov Electrochem* v 23 n 4 Apr 1987 p 527-530.

**074732 ADSORPTION OF THIOPHENE AND THIOPHENYLAMINE ON BISMUTH.** The adsorption of thiourea (TU) and its derivatives is characterized by strong interaction of their molecules with the electrode surface. It is of interest in this connection to elucidate the importance of a sulfur atom in the ring of an organic molecule. To this end we studied the adsorption of thiophene (TP) and thiodiphenylamine (TDPA) on the bismuth electrode in this work. It is shown that the adsorption of TDPA (thiodiphenylamine) from butanol, like that of aromatic hydrocarbons from alcohols is characterized by the presence of two adsorption regions. A comparison of the shape of the (C - C<sub>0</sub>) vs E curves obtained in TDPA and anthracene adsorption reveals a number of differences in their adsorption behavior. On the negatively charged surface where adsorption chiefly occurs on account of a displacement of the adsorbate molecules from the bulk solution, the adsorption effect of the saturated TDPA solution owing to its higher concentration is larger than that of the saturated anthracene solution. 13 refs.

Past, U. (Tartu State Univ, USSR); Alumaa, A.; Palm, U. *Sov Electrochem* v 23 n 4 Apr 1987 p 531-534.

**074733 SPECIFIC ADSORPTION OF CYCLOHEXANE AND BENZENESULFONATE ANIONS AT A MERCURY ELECTRODE.** The specific adsorption of cyclohexane and benzenesulfonate anions has been studied from mixed electrolyte solutions at constant ionic strength at a mercury electrode. The adsorption can be described by a virial adsorption isotherm. The role of the  $\pi$ -electrons in the adsorption process and the charge dependence of the standard Gibbs energy is discussed. The influence of conformational properties of cyclohexanesulfonate anion on the structure of the inner double layer is also considered. (Author abstract) 23 refs.

Dutkiewicz, Edward (Univ im. A. Mickiewicza, Poznan, Pol); Stuczynska, Jolanta. *Electrochim Acta* v 33 n 1 Jan 1988 p 19-23.

**074734 ADSORPTION OF THIOUREA AT THE POLYCRYSTALLINE SILVER ELECTRODE FROM AQUEOUS KF SOLUTIONS - II.** The Frumkin adsorption isotherm parameters and the virial isotherm parameters are determined from the earlier published experimental data on double layer differential capacity measurements of polycrystalline silver electrode in aqueous KF solutions containing thiourea using the Parsons analysis. Thiourea is also used as the probe dipole to evaluate the electrostatic parameters of the inner layer. (Edited author abstract) 11 refs.

Milkowska, Magdalena (Univ of Warsaw, Warsaw, Pol). *Electrochim Acta* v 33 n 1 Jan 1988 p 161-163.

**074735 ON APPLYING THE IDEAL ADSORBED SOLUTION THEORY ON MULTICOMPONENT ADSORPTION EQUILIBRIA OF DISSOLVED ORGANIC COMPONENTS ON ACTIVATED CARBON.** Multicomponent adsorption equilibria of organic components from aqueous solutions on activated carbons were

measured and the applicability of the ideal adsorbed solution (IAS) theory was tested. Systematic deviations between experiments and theory were observed. Adsorbed phase activity coefficients which account for these deviations proved to be thermodynamically inconsistent. However, the calculation of spreading pressure in the IAS theory requires extrapolation of single solute isotherms to zero concentration. A correction of extrapolation errors was determined by fitting binary equilibrium data to the IAS theory. For a mixture of N components, N-1 constants have to be obtained from binary mixtures of N-1 components with a reference component. This work is pertinent to the treatment of industrial waste-waters and for the purification of the effluents. (Edited author abstract) 25 refs.

Seidel, A. (Acad of Sciences of GDR, Berlin, East Ger); Gelbin, D. *Chem Eng Sci* v 43 n 1 1988 p 79-89.

**074736 ADSORPTION, ORIENTATION, AND POLYMERIZATION OF 1-OCTYNE-3-ol ON IRON. AN ELLIPSOMETRIC STUDY.** The initial adsorption, structural transition, and polymeric growth of 1-octyne-3-ol on iron electrode from sulfuric acid solutions have been examined by using time-resolved in situ automatic ellipsometry. The adsorption occurs in two different configurations, flat and partly upright. The structural transition of the adsorbed octynol molecules is characterized by a large time constant indicating adsorption-reorientation mechanism. The linear growth of the polymer layer together with the current oscillations for hydrogen evolution reaction suggests a thin porous loosely bonded structure. The optical properties are related to the small conjugated units within the compact domains of the film. (Author abstract) 20 refs.

Jovancicevic, V. (Texas A&M Univ, College Station, TX, USA); Yang, B.; Bockris, J.O'M. *J Electrochem Soc* v 135 n 1 Jan 1988 p 94-98.

**074737 SORPTION OF PHOSPHINE FROM ACETYLENE BY ACTIVE CARBONS.** The results of the authors' experiments, in which 11 brands of domestic and foreign active carbons were tested during purification of phosphine, hydrogen sulfide, and arsine from acetylene, are in agreement with the data in the literature on the whole. The experiments were conducted in a dynamic column containing 11 cm<sup>3</sup> of carbon bypassing acetylene through the column at the rate of 0.25-0.71 m/min. It is found that SKT carbons, on contrast to other types of carbons, exhibit elevated adsorption-catalytic activity with respect to phosphine, converting it into nonvolatile and nontoxic phosphoric acid. A high concentration of water in the carbons and preliminary treatment with acids, particularly sulfuric acid, stabilizes the properties of SKT carbons. 8 refs.

Bogdanov, V.M. (D.I. Mendeleev Chemical Technology Inst, Moscow, USSR); Moiseichuk, O.V.; Shumyatskii, Yu.I. *J Appl Chem USSR* v 60 n 5 pt 2 May 1987 p 1055-1058.

**074738 STUDY OF SORPTION OF MONOETHANOLAMINE AND ITS COMPLEXES WITH COPPER(II) AND CADMIUM(II) IONS ON HYDRATED ZIRCONIUM DIOXIDE AND ITS MODIFIED FORMS.** Study of sorption of monoethanolamine on H and Me forms of hydrated zirconium dioxide in relation to the pH of the equilibrium solution and the nature of the modifier cation and of the outer-sphere anion showed that HZD is sorbed on Me forms of HZD both by ion exchange and by ligand-exchange mechanisms. Sorption of MEA is greater on HZD in the Me form than in the H form, and depends on the content and nature of metal ions in the sorbent. Sorption of MEA and of its complexes with copper(II) ions on the CuSO<sub>4</sub>(4) form of HZD was



accompanied by desorption of copper(II); this suggested the possibility of separating monoethanoamine complexes of copper(II) and cadmium(II). 13 refs.

Boichinova, E.S. (Lensovet Leningrad Technological Inst, USSR); Palitsyna, A.I.; Zonkheva, E.L.; Brovko, N.V. *J Appl Chem USSR* v 60 n 6 pt 1 Jun 1987 p 1183-1186.

**074739 ADSORPTION BEHAVIOUR OF ISOMERIC COMPOUNDS AT MERCURY/AQUEOUS 0.1 M KCl INTERFACE AT 25°C.** Adsorption of 1,4-butanediol and ethyl cellosolve (isomers) at mercury/0.10 M KCl aq. interface has been studied through double layer capacity measurements. Surface excess, standard free energy of adsorption and the anodic shift of  $E_{pzc}$  are greater while the charge corresponding to maximum adsorption ( $\sigma_{max}^m$ ) is more negative, for ethyl cellosolve than for the diol. Nevertheless, both the compounds obeyed Langmuir's adsorption isotherm, quadratic dependence of  $\Delta G^\circ$  on E and single, stable orientation with the hydrocarbon chain facing the electrode and functional group in solution throughout the coverage region. (Author abstract) 8 refs.

Apparao, B.V. (Gandhigram Rural Univ, Gandhigram, India). *J Electrochem Soc India* v 36 n 4 Oct 1987 p 237-240.

**074740 MODELING ACTIVATED CARBON ADSORPTION OF TARGET ORGANIC COMPOUNDS FROM LEACHATE-CONTAMINATED GROUNDWATERS.** A relatively straightforward mathematical modeling technique employing a modified homogeneous surface diffusion version of the Michigan Adsorption Design and Applications Model was used to simulate and predict fixed-bed adsorber behavior with respect to two target organic compounds in a complex background water contaminated by leachate from a hazardous waste landfill. The unspecified dissolved organic matter in the leachate reduced granular activated carbon adsorption capacities and rates for both target compounds relative to their respective values in waters containing no other organic species. A short-bed adsorber technique was employed for estimation of system-specific rate parameters. (Edited author abstract) 31 refs.

Smith, Edward H. (Univ of Michigan, Ann Arbor, MI, USA); Weber, Walter J. Jr. *Environ Sci Technol* v 22 n 3 Mar 1988 p 313-321.

**074741 INFLUENCE OF AN ELECTRIC FIELD ON ADSORPTION OF ORGANIC SUBSTANCES - II. APPLICATION OF THE MODIFIED MODEL OF TWO PARALLEL CONDENSERS TO ETHYLENE GLYCOL SOLUTIONS.** The data for ethylene glycol (EG) solutions containing normal alcohols recently reported are analyzed in the light of the model presented in recent papers. The effective dipole moment of an adsorbed molecule at vanishing and at maximum coverage is evaluated. The previous assumption of a flat orientation of the adsorbed molecules is strongly supported by a correlation between the variations of the interaction coefficient with potential and other adsorption parameters. Another correlation is found between the effective dipole moment and the dielectric constant of the surface layer at maximum coverage. The results are explained by hydrogen bonding between the polar heads reducing the effective dipole moment. (Edited author abstract) 15 refs.

Schuhmann, D. (CNRS, Montpellier, Fr); Vanel, P. *Electrochim Acta* v 33 n 3 Mar 1988 p 425-432.

**074742 REACTIONS OF ORGANONITROGEN MOLECULES WITH Ni(100).** The adsorption and reaction of a variety of organonitrogen compounds on a Ni(100) surface have been examined with temperature-programmed reaction, Auger electron spectroscopy, and infrared spectroscopy. Monomethylamine adsorbs via the nitrogen lone pair of electrons and then undergoes C-N bond scission yielding adsorbed carbon, dihydrogen, and ammonia. Aniline  $\pi$ -bonds to the surface and polymerizes to form a thermally stable poly(aniline) surface film. Pyridine undergoes a temperature-induced orientational transformation. At low temperatures pyri-

dine adsorbs with its ring parallel to the surface. At higher temperatures it appears to form an  $\alpha$ -pyridyl species with an activation barrier of 85 kJ/mol. Methyl groups on 2,6-lutidine sterically hinder this reaction. (Edited author abstract) 55 refs.

Schoofs, Gregory R. (Princeton Univ, Princeton, NJ, USA); Benziger, Jay B. *J Phys Chem* v 92 n 3 Feb 11 1988 p 741-750.

**074743 COMBINED USE OF POTENTIODYNAMIC METHODS AND OF RADIOTRACER MEASUREMENTS IN EXAMINING THE NATURE OF ADSORPTION OF ORGANIC SUBSTANCES ON PLATINUM.** A method for studying the nature of the adsorption products of organic substances on platinum electrodes which is based on simultaneous radiotracer and electrochemical sweep measurements is proposed and tested with model substances (methanol and formaldehyde). The method is such that adsorption can be studied under steady-state conditions, i.e., when adsorbate is present in the solution and when electrochemical processes occur, and that assumptions which cannot be verified experimentally need not be used. In the adsorption of methanol on platinum electrodes, the species were shown to have an average composition of COH (or HCO). (Edited author abstract) 26 refs.

Khazova, O.A. (Acad of Sciences of the USSR, Moscow, USSR); Andreev, V.N.; Vasil'ev, Yu.B.; Kazarinov, V.E. *Sov Electrochem* v 23 n 9 Sep 1987 p 1091-1096.

**074744 FTIR STUDY OF THIONOCARBAMATE ADSORPTION ON SULFIDE MINERALS.** The adsorption of O-isopropyl-N-ethylthionocarbamate (IPETC) and O-isobutyl-N-ethoxycarbonylthionocarbamate (IBECTC) on chalcocite, chalcopyrite and pyrite has been studied in situ by FTIR spectroscopy using the ATR technique. Thionocarbamates adsorb most strongly on chalcocite at pH 4-10, while on chalcopyrite and pyrite, adsorption continues to increase with decreasing pH. Except at very low pH values, adsorption on chalcocite is 3-20 times higher than on chalcopyrite and pyrite. IPETC chemisorbs on chalcocite through sulfur below pH 6 and through both sulfur and oxygen above pH 6. (Edited author abstract) 18 refs.

Leppinen, J.O. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Basilio, C.I.; Yoon, R.H. *Colloids Surf* v 13 n 1-2 Jun 1988 p 113-125.

**074745 HEATS OF SORPTION OF ACRYLONITRILE INTO 6-NYLON FIBRES.** The sorption of acrylonitrile into a 6-nylon fibre at 22°C has been studied by calorimetry. It is shown that with change in the concentration of sorbed acrylonitrile from 0.1-1.0 wt.% the integral heat of sorption falls from 52 to 45 kJ/mole for the initial fibre and from 50 to 35 kJ/mole for the fibre modified by radiation grafting of PAN which points to the presence in the fibres studied, as on the surface of solids, of a quite wide distribution of the site of sorption over the heats of sorption. From comparison of the heats of sorption, the equilibrium concentrations and the coefficients of diffusion into the initial and grafted 6-nylon fibres it is concluded that a loose PAN layer forms on the surface of the grafted fibre. (Author abstract) 10 refs.

Pilyugin, V.V. (USSR Acad of Sciences, USSR); Kritskaya, D.A.; Ponomarev, A.N. *Polym Sci USSR* v 29 n 2 Feb 1987 p 259-264.

**074746 ELECTROSORPTION ON HETEROGENEOUS SURFACES - A STATISTICAL MECHANICAL TREATMENT.** A statistical mechanical treatment for electrosorption of neutral organic compounds on heterogeneous surfaces is presented. A continuous-solvent model and a discrete-solvent one with and without lateral dipolar interactions are developed and discussed within the frame of lattice statistics and under mean field approximation. The adsorption isotherms obtained on the basis of the uniform distribution of the energy of sites may be considered as generalized Temkin isotherms. (Author abstract) 19 refs.

Nikitas, P. (Univ of Thessaloniki, Thessaloniki, Greece).

*Electrochim Acta* v 33 n 5 May 1988 p 647-653.

**074747 THEORETICAL APPROACH TO THE ELECTROSORPTION KINETICS.** The kinetics of the adsorption process of neutral organic compounds on electrodes is studied from a theoretical point of view. Adopting simple kinetic arguments and within the frame of lattice statistical thermodynamics rate equations for electrosorption on homogeneous and random heterogeneous surfaces are developed when diffusion effects are negligible. The case where diffusion predominates is also studied. The Fick diffusion equation under constraints corresponding to an initially clean electrode surface is solved numerically. Adopting various adsorption isotherms, the influence on the electrosorption kinetics of a number of parameters, like the lateral particle-particle interactions, the field-dipole ones, as well as the adsorbent heterogeneity is investigated. (Author abstract) 24 refs.

Nikitas, P. (Univ of Thessaloniki, Thessaloniki, Greece); Papoutsis, A. *Electrochim Acta* v 33 n 5 May 1988 p 683-692.

**074748 ROWNOWAGI ADSORPCYJNE TROJSK-LADNIKOWYCH MIESZANIN PAR ZWIAZKOW ORGANICZNYCH NA WEGLU AKTYWNYM.** [Adsorption Equilibria of Tricomponent Vapor Mixtures of Organic Compounds on Active Carbon]. Adsorption equilibria of acetone, benzene, ethyl acetate, methanol, ethanol, propanol and their ternary mixtures were obtained. The experimental data was compared with theoretical results predicted by the Langmuir, Huettig, BET, Freundlich, Jovanovic as well as Peterson and Redlich equations. (Author abstract) 16 refs. In Polish.

Jablonski, Maciej (Politechnika Szczecińska, Pol); Paderewski, Mscislaw. *Inz Chem Procesowa* v 8 n 4 1987 p 551-558.

**074749 ADSORPTION THERMODYNAMICS OF CARBOFURAN ON FLY ASH.** Adsorption of carbofuran on fly ash was studied at 25 and 50°C. The data were analyzed in terms of isotherm, Freundlich equation and various thermodynamic parameters. The data fit in close agreement with the Freundlich equation and yield 'S' type isotherms. The degree of adsorption of carbofuran was determined and found to be in accordance with the partial molar free energies and  $K_d$  values. The thermodynamic constants ( $K_d$ ) and standard free energy ( $\Delta G^\circ$ ), enthalpy ( $\Delta H^\circ$ ) and entropy changes ( $\Delta S^\circ$ ) were calculated for predicting the nature of adsorption. (Author abstract).

Kumari, K. (Aligarh Muslim Univ, Aligarh, India); Saxena, S.K. *Colloids Surf* v 33 n 1-2 Aug 1988 p 55-61.

**074750 ADSORPTION OF NONIONIC POLYACRYLAMIDE ON SODIUM MONTMORILLONITE: RELATION BETWEEN ADSORPTION,  $\zeta$  POTENTIAL, TURBIDITY, ENTHALPY OF ADSORPTION DATA AND  $^{13}\text{C}$ -NMR IN AQUEOUS SOLUTION.** The adsorption of nonionic polyacrylamide on sodium montmorillonite is studied using different molecular weight macromolecules (mol wt =  $4.40 \times 10^4$ ,  $1.20 \times 10^5$ ,  $3.70 \times 10^5$ ,  $3 \times 10^6$ ), with the monomeric unit represented by the isobutyramide molecule. All of the adsorption runs are completed by turbidimetric, electrokinetic, X-ray scattering, and calorimetric data. The adsorption of isobutyramide reveals the nature of the different adsorption sites (broke edge faces and external basal faces). The  $^{13}\text{C}$ -nuclear magnetic resonance of the C=O groups in the adsorbed phase and in aqueous solution corroborate the conformation variations along the isotherms. It is demonstrated that the broadening is due to a chemical shift dispersion arising from the surface site heterogeneity or the rotational isomerism hindrance accompanying a change of macromolecular structure near the surface. (Edited author abstract). 43 Refs.

Bottero, J.Y. (CNRS, Vandoeuvre, Fr); Bruant, M.; Cases, J.M.; Canet, D.; Fiessinger, F. *J Colloid Interface Sci* v 124 n 2 Aug 1988 p 515-527.



**074751 FOURIER TRANSFORM INFRARED AND RAMAN SPECTRA OF DIMETHYL METHYLPHOSPHONATE ADSORBED ON MONTMORILLONITE.** FTIR and Raman spectroscopic analyses were used to determine the adsorption interaction between the highly polar organophosphonate dimethyl methylphosphonate (DMMP) and a standard montmorillonite clay (SAZ-1). The polar DMMP molecular appears to interact with the interlamellar exchangeable cation in the montmorillonite clay and to displace water from the clay mineral interlamellar spaces. This was confirmed by XRD observation of a primary lattice distance expansion of about 3.3 Å during the adsorption process. Some evidence for a secondary interaction of DMMP with the natural organic matter associated with the clay mineral was obtained. (Author abstract). 24 Refs.

Bowen, John M. (Oklahoma State Univ, Stillwater, OK, USA); Powers, C. Ray; Ratcliffe, Ann E.; Rockley, Mark G.; Hounslow, Arthur W. *Environ Sci Technol* v 22 n 10 Oct 1988 p 1178-1181.

**074752 LANGMUIR-BLODGETT FILMS OF D-NOR-URETHANE-TCNQ AND RELATED MOLECULES.** New molecules of the type D- $\sigma$ -A have been shown to form Pockels-Langmuir monolayers at the air-water interface and Langmuir-Blodgett films over glass or Al substrates (D, one-electron donor;  $\sigma$ , covalent bridge (urethane); A, strong one-electron acceptor BHTCNQ or weak two-electron acceptor HMTCAQ). Assemblies  $M_1$  | D- $\sigma$ -A |  $M_2$  ( $M_1$ ,  $M_2$ , conventional metallic thin films; D, strong one-electron donor; A, strong one-electron acceptor) had been predicted to be one-molecule-thick rectifiers of electrical current. Greasy tails are found to be generally helpful in orienting D- $\sigma$ -A molecules in monolayers (even though they may slow down electron conduction through the molecules). (Edited author abstract) 51 refs.

Metzger, R.M. (Univ of Alabama, Tuscaloosa, AL, USA); Schumaker, R.R.; Cava, M.P.; Laidlaw, R.K.; Panetta, C.A.; Torres, E. *Langmuir* v 4 n 2 Mar-Apr 1988, Mol Process at Solid Surf: Spectrosc of Interm and Adsorbate Interact, Denver, CO, USA, Apr 6-8, 1987 p 298-304.

**074753 STUDIES OF ADSORPTION PROCESSES IN THE ABSENCE OF ADDED ELECTROLYTE: PHASE CHANGES IN COUMARIN ADSORBED AT CONVENTIONAL AND MICRO MERCURY ELECTRODES.** In this work alternating and direct current polarographic and voltammetric techniques for studying adsorption processes in the absence of added electrolyte have been investigated at conventional sized electrodes and at microelectrodes. The model system chosen was an examination of the effect of decreasing the added sodium fluoride concentration from 0.9 M to zero on the adsorption of coumarin onto mercury electrodes from its saturated solution at 15°C. At all electrolyte concentrations the adsorbed monolayer of the neutral coumarin molecule formed three surface phases in the relevant potential ranges, and data are consistent with those predicted by theory. (Edited author abstract) 28 refs.

Bond, A.M. (Deakin Univ, Waurn Ponds, Aust); Thomas, F.G. *Langmuir* v 4 n 2 Mar-Apr 1988, Mol Process at Solid Surf: Spectrosc of Interm and Adsorbate Interact, Denver, CO, USA, Apr 6-8, 1987 p 341-345.

**074754 MONOLAYER FILMS PREPARED BY THE SPONTANEOUS SELF-ASSEMBLY OF SYMMETRICAL AND UNSYMMETRICAL DIALKYL SULFIDES FROM SOLUTION ONTO GOLD SUBSTRATES: STRUCTURE, PROPERTIES, AND REACTIVITY OF CONSTITUENT FUNCTIONAL GROUPS.** Exposure of evaporated gold films supported on silicon wafers to solutions of dialkyl sulfides or alkanethiols in methanol or ethanol results in rapid formation of a monolayer of the organosulfur compound adsorbed onto the gold. The resulting films have been characterized by using a number of techniques, including X-ray photoelectron spectroscopy, infrared spectroscopy, ellipsometry, and wetting. These self-assembled, supported organic monolayer films are systems that can be used to study problems in the physical-organic chemistry

and materials science of organic surfaces, especially the relation between the molecular-level structure of the film constituents and the macroscopic properties of the assembled monolayers. The films are relatively robust: examples formed from both dialkyl sulfides and alkanethiols withstand washing and prolonged soaking in neutral water, but films containing dialkyl sulfides are destroyed by contact with aqueous base at pH 8-13. (Edited author abstract) 68 refs.

Troughton, Ernest B. (Harvard Univ, Cambridge, MA, USA); Bain, Colin D.; Whitesides, George M.; Nuzzo, Ralph G.; Allara, David L.; Porter, Marc D. *Langmuir* v 4 n 2 Mar-Apr 1988, Mol Process at Solid Surf: Spectrosc of Interm and Adsorbate Interact, Denver, CO, USA, Apr 6-8, 1987 p 365-385.

**074755 ORIENTATION OF MOLECULAR MONOLAYERS AT THE LIQUID-LIQUID INTERFACE AS STUDIED BY OPTICAL SECOND HARMONIC GENERATION.** The study of molecular monolayers at the liquid-liquid interface has attracted attention from researchers in a variety of disciplines. Interface-active monolayers are of interest in studying interfacial mass transfer and micellar structure, and as model membrane structures. In this paper we report the use of optical second harmonic generation to determine the orientation of monolayers of sodium 1-dodecylphthalene-4-sulfonate at the aqueous/decane and aqueous/carbon tetrachloride interfaces. The results show that the molecular orientation depends on the nature of the nonaqueous phase. 18 refs.

Grubb, S.G. (Exxon Research & Engineering Co, Annandale, NJ, USA); Kim, Mahn Won; Rasing, Th.; Shen, Y.R. *Langmuir* v 4 n 2 Mar-Apr 1988, Mol Process at Solid Surf: Spectrosc of Interm and Adsorbate Interact, Denver, CO, USA, Apr 6-8, 1987 p 452-454.

**Alkylation** See Also DYES AND DYEING—Synthesis.

**074756 ALKYLATION OF PHTHALIMIDE WITH HIGHER ALKYL BROMIDES UNDER CONDITIONS OF PHASE-TRANSFER CATALYSIS.** N-alkylphthalimides, used as intermediates for synthesis of primary amines, are obtained in good yields by heating potassium phthalimide with alkyl halides in dimethylformamide (DMFA) and other polar solvents. Phthalimide is alkylated by higher alkyl bromides, RBr, where R = C<sub>4</sub>H<sub>9</sub>, C<sub>12</sub>H<sub>25</sub>, C<sub>16</sub>H<sub>33</sub>, in toluene (at 95°) in high yields in presence of solid K<sub>2</sub>CO<sub>3</sub> and a phase-transfer catalyst, methyl triethylammonium sulfate. The reaction of phthalimide with dodecyl bromide under the usual conditions of phase-transfer catalysis (organic phase-50% NaOH) is accompanied by hydrolysis of phthalimide and formation of a complex mixture of products, from which N-dodecylphthalimide, dodecylamine, 1-dodecanol, dodecyl ether, and 1-dodecene were isolated. 10 refs.

Vasilevskaya, T.N.; Grineva, N.I.; Chernousova, G.A.; Grankina, Z.A.; Andrievskii, V.N. *J Appl Chem USSR* v 60 n 1 pt 2 Jan 1987 p 220-222.

**074757 ALKYLATION OF p-CRESOL WITH ISOBUTENE CATALYZED BY CATION-EXCHANGE RESINS: A KINETIC STUDY.** In this paper the kinetics of the reactions occurring in the alkylation of p-cresol with isobutene, catalyzed by cation-exchange resins, have been studied. These reactions are the monoalkylation, the successive dialkylation, and the dimerization and trimerization of isobutene. The kinetics have been studied in a slurry reactor, completely mixed and operating under batch conditions for the liquid phase and continuous conditions for the gas phase. The influence of mass transfer on reaction rates has been carefully considered with experiments independent of kinetic runs. Vapor-liquid equilibrium of isobutene, in the reaction mixture, has also been studied for determining the gas-liquid interface concentration of this reagent. A second-order kinetic law has been found suitable to describe the behavior of all mentioned reactions. (Edited author abstract) 16 refs.

Santacesaria, E. (Politecnico di Milano, Milan, Italy); Silvani, R.; Wilkinson, P.; Carra, S. *Ind Eng Chem Res*

v 27 n 4 Apr 1988 p 541-548.

**074758 ALKYLATION OF AZOLES USING  $\beta$ -FUNCTIONAL ALKYL HALIDES UNDER CONDITIONS OF PHASE TRANSFER CATALYSIS.** The objective of this study was to develop a convenient synthetic method for direct N-alkylation of pyrazole (I), 3(5)-methylpyrazole (II), 3,5-dimethylpyrazole (III), 1,2,4-triazole (IV), and tetrazole (V) using  $\beta$ -functional alkyl halides under conditions of two-phase catalysis and with high product yields. This investigation was stimulated by the fact that the desired reaction products are intermediates in the synthesis of an important class of compounds, vinylazoles, as well as of various pharmaceutical agents. It is found that depending on the acidity of the azole, alkylation with dichloroethane can be accompanied by  $\beta$ -elimination. The effect of solvent on the course of alkylation reactions using dichloroethane has also been studied, and revealed that the reactions occur via the intermediacy of ion pairs rather than free anions. 21 refs.

Asratyan, G.V. (Acad of Sciences of the Armenian SSR, USSR); Attaryan, O.S.; Pogossyan, A.S.; Eliazan, G.A.; Darbinyan, E.G.; Matsoyan, S.G. *J Appl Chem USSR* v 59 n 6 1 Jan 1986 p 1202-1206.

**Analysis** See Also COAL—Testing.

**074759 DETERMINATION OF AVIDIN AND BIOTIN BY FLUORESCENCE POLARIZATION.** Assays for avidin and biotin are presented which combine high sensitivity with short assay times. Minimum detectable concentrations are 5 ng/mL avidin and 100 pg/mL biotin and assay time is under 10 min. The fluorescence polarization of a biotin-fluorescein conjugate is monitored. Polarization varies as a function of avidin concentration and, at fixed avidin levels, as a function of competing biotin concentrations. This simple, rapid assay has a detection limit about 1000-fold lower than the commonly used 4-hydroxyazobenzene-2-carboxylic acid dye binding method. (Author abstract) 23 refs.

Schray, Keith J. (Lehigh Univ, Bethlehem, PA, USA); Artz, Pamela G.; Hevey, Richard C. *Anal Chem* v 60 n 9 May 1 1988 p 853-855.

**Applications** See Also ACIDS—Organic; CERAMIC MATERIALS; CORROSION PROTECTION—Inhibitors.

**074760 NEW CW FIR LASING MEDIUM: METHYL FLUOROFORM.** CW lasing action is reported for the first in methyl fluoroform (1,1,1-trifluoroethane). Fifty four lines covering the 1.6 mm-370  $\mu$ m wavelength range have been detected by infrared pumping by CO<sub>2</sub> and N<sub>2</sub>O lasers. (Author abstract) 10 refs.

Fourier, M. (CNRS, Paris, Fr); Redon, M. *Opt Commun* v 64 n 6 Dec 15 1987 p 534-536.

**Aromatization**

**074761 CONVERSION OF ORGANIC OXYGEN COMPOUNDS AND THEIR MIXTURES ON H-ZSM-5.** The conversion of a number of alcohols, ethers, ketones, aldehydes, carboxylic acids, esters, and cyclic compounds and their mixtures on H-ZSM-5 at 673 K was investigated. These compounds can be easily converted to aromatic hydrocarbons if the C/H ratio of the molecule fragment, remaining after elimination of oxygen as water, is less than 0.62. At higher C/H ratios, coking of the catalyst increases, thus reducing its lifetime, a difficulty which can be overcome by hydrogenation of these compounds prior to their conversion over H-ZSM-5. A procedure is proposed for converting at least a part of organic waste chemicals to valuable products instead of burning them. (Author abstract) 30 refs.

Fuhse, Juergen (Univ Essen, Essen, West Ger); Bander-mann, Friedhelm. *Chem Eng Technol* v 10 n 5 Oct 1987 p 323-329.



**Biodegradation** See Also AROMATIC COMPOUNDS—Ozonization; INSECTICIDES—Environmental Impact; REFUSE DISPOSAL—Composting; SOILS—Denitrification; WASTEWATER—Treatment.

**074762 EFFECT OF CULTURE HISTORY ON THE DETERMINATION OF BIODEGRADATION KINETICS BY BATCH AND FED-BATCH TECHNIQUES.** A pure bacterial culture was grown in continuous culture at four dilution rates with 2-chlorophenol (2-CP) as the carbon source. During the steady state the Monod kinetic parameters ( $\mu_m$  and  $K_S$ ) characterizing 2-CP biodegradation were determined under batch and fed-batch conditions. The values of both parameters were influenced by the dilution rate: the higher the dilution rate the larger the value of  $\mu_m$  and the smaller the value of  $K_S$ . Parameter values determined under batch conditions were influenced more than those determined under fed-batch conditions. These effects were consistent with the physiological adaptation of cells to their previous growth environment. (Author abstract) 26 refs.

Templeton, Laura L. (Engineering Science, Atlanta, GA, USA); Grady, C.P. Leslie Jr. *J Water Pollut Control Fed* v 60 n 5 May 1988 p 651-658.

**074763 BIODEGRADATION STUDIES OF ANILINE AND NITROBENZENE IN ANILINE PLANT WASTE WATER BY GAS CHROMATOGRAPHY.** A gas chromatographic (GC) method has been developed for studying the biodegradation of aniline and/or nitrobenzene in aniline plant waste water. The effects of various parameters have been reported and critically discussed. The results are precise and afford simultaneous determinations of aniline and nitrobenzene. (Author abstract) 20 Refs.

Patil, Sampat Rao S. (Shinde, Vijay M., Inst of Science, Bombay, India). *Environ Sci Technol* v 22 n 10 Oct 1988 p 1160-1165.

**Biosynthesis** See Also BIOLOGICAL MATERIALS—Chromatographic Analysis.

**074764 ENZYMATIC SYNTHESIS OF L-CYSTEINE.** For L-cysteine production, the authors chose a reaction catalyzed by O-acetylserine sulphydrase (OASS). An enzymatic process to synthesize L-serine from glycine and formaldehyde has recently been described. L-O-Acetylserine (OAS) can be produced in high yield by reacting L-serine with acetic anhydride under acidic conditions. The second substrate, sulfide, is widely available. Therefore, the availability and cost of the substrates, which are normally the limiting factors for the successful development of enzymatic production processes, are under control. However, OAS was known to be readily isomerized to N-acetylserine (NAS) at alkaline pH. This article reports on the study of the OASS reaction and the development of an automatic feeding system to control the addition of substrates that gives a high concentration of L-cysteine with a good yield. 18 refs.

Hsiao, Hung-Yu (Genex Corp, Gaithersburg, MD, USA); Wei, Tena. *Biotechnol Bioeng* v 30 n 7 Nov 1987 p 875-881.

**Calculations** See RUBBER, SYNTHETIC—Synthesis.

**Carbonylation** See Also CATALYSTS—Testing.

**074765 COBALT-CATALYZED AMINOCARBONYLATION OF FORMALDEHYDE DIETHYL ACETAL.** N-Aryl glycine esters were synthesized from formaldehyde diethyl acetal, aniline derivatives and CO by use of cobalt catalyst; this is the first example of aminocarbonylation of acetal. (Author abstract) 5 refs.

Murata, Kazuhisa (Nat'l Chemical Lab for Industry, Tsukuba, Jpn); Matsuda, Akio; Masuda, Takashi. *Chem Express* v 2 n 10 Oct 1987 p 603-606.

**074766 CARBONYLATION OF BENZYL CHLORIDE TO PHENYLACETIC ACID AND ITS ESTER USING WATER-SOLUBLE Ru(III)-EDTA COMPLEX CATALYST.** The authors have examined the

carbonylation of benzyl chloride in ethanol-water mixed solvent system. The reaction proceeds at 80°C and 20 atm of CO to yield phenylacetic acid and its ester, with a turnover frequency of 44 mol product per hour. The reaction gave 100% conversion to the desired products phenylacetic acid and ethylphenyl acetate in 9 h. A possible mechanism of the reaction, based on our observations, is given. 14 refs.

Taqi Khan, M.M. (Central Salt & Marine Chemicals Research Inst, Bhavnagar, India); Halligudi, S.B.; Abdi, S.H.R. *J Mol Catal* v 44 n 2 Feb 29 1988 p 179-181.

**Chemical Analysis** See Also PHOSPHORESCENCE; REFUSE DISPOSAL—Leachate Treatment; SOILS—Chemical Analysis; WATER—Sampling; WATER ANALYSIS.

**074767 COMPOSITION DEPTH INFORMATION IN ORGANIC MATERIALS BY MEASUREMENT OF XPS BACKGROUND SIGNAL.** Tougaard's technique for extracting depth information from a single XPS spectrum was examined in the case of organic materials. The A/B ratio between the XPS peak area and the increase in background signal associated with the peak was measured for homogeneous organic materials with unmonochromated and monochromated X-rays. The A/B values were similar to those obtained with metallic samples. Polymers with a fluorinated surface layer were covered with polymeric overlayers, and the A/B ratio for F 1s was measured. This ratio may be used to monitor the overlayer thickness. (Author abstract) 29 refs.

Zeggane, Samia (CNRS, Paris, Fr); Delamar, Michel. *Appl Surf Sci* (1985) v 29 n 4 Dec 1987 p 411-417.

**074768 HAZARDOUS ORGANIC COMPOUND ANALYSIS.** The assessment of the source, extent, and nature of hazardous-waste contamination relies on sophisticated chemical analyses to identify and quantify a wide range of pollutants. For organic compounds, these analyses are most often performed using combined gas chromatography/mass spectroscopy (GC/MS). In an effort to obtain high-quality chemical data on a national scale, regulatory agencies have developed standardized methods for sample handling and preparation as well as standardized instrument-operating conditions. Elaborate quality assurance and quality control (QA/QC) procedures specify and require the use of field blanks, laboratory blanks, surrogate spikes, matrix spikes, duplicate samples, and internal standards to assure that performance standards are met (quality control). In addition, comprehensive documentation and scientific review are required. This article discusses fundamentals of analysis, analysis problems, quantitation, and other aspects of the subject. 9 refs.

Swallow, Kathleen C. (Gradient Corp, Cambridge, MA, USA); Shifrin, Neil S.; Doherty, Philip J. *Environ Sci Technol* v 22 n 2 Feb 1988 p 136-142.

**074769 APPLICABILITY OF POTASSIUM PERIODATE METHOD FOR ESTIMATION OF MANGANESE IN SOLID WASTE SAMPLES.** Plants do not grow well unless certain trace elements like manganese, copper, zinc, molybdenum are available in sufficient quantities. While their presence in higher concentrations becomes toxic to the plants, the total absence also affects the growth and yield of the plants. This paper deals with the suitability of the 'Periodate Method' to determine manganese, one of the trace elements, in city refuse compost. (Author abstract) 9 refs.

Dixit, R.C. (NEERI, Nagpur, India); Bhide, A.D. *J Inst Eng India Part EN* v 68 pt 1 Oct 1987 p 1-4.

**074770 INTERCOMPARISON STUDY OF LIQUID-LIQUID EXTRACTION AND ADSORPTION ON POLYURETHANE AND AMBERLITE XAD-2 FOR THE ANALYSIS OF HYDROCARBONS, POLYCHLOROBIPHENYLS, AND FATTY ACIDS DISSOLVED IN SEAWATER.** The application of these methods sampling in parallel the same body of water has resulted in significant differences related to the proportion of higher molecular weight components in the complex mixtures of aliphatic and aromatic hydrocarbons. These

occur irrespective of the operating conditions and are attributed to selective interactions of these hydrophobic species with macromolecular organic matter such as fulvic and humic acids and to the resulting effects on adsorbent properties. In contrast, the quantitative results for most hydrocarbons and fatty acids depend on the total sampled volume, resulting in major losses when volumes larger than 300-400 L are collected with the adsorption systems (3000 bed volumes for the Amberlite XAD-2. Additional study results are discussed. (Edited author abstract) 65 refs.

Gomez-Belinchon, Josep I. (CSIC, Barcelona, Spain); Grimalt, Joan O.; Albaiges, Joan. *Environ Sci Technol* v 22 n 6 Jun 1988 p 677-685.

**074771 EVALUATION OF METHOD 25 NONMETHANE ORGANIC ANALYZER DESIGN.** Under contract to the U.S. Environmental Protection Agency, Research Triangle Institute has been conducting research to improve the precision, accuracy and limit of detection attainable with the EPA Method 25 nonmethane organic (NMO) analyzer. In Method 25, volatile organic carbon (VOC) samples are collected by drawing gas from an emitting source through a dry ice cooled sample trap and into an evacuated collection tank. The hydrocarbon concentration emitted from the source is determined on a per-carbon basis by catalytically converting the trap and tank sample fractions to CO<sub>2</sub> and quantitating the amount of CO<sub>2</sub> produced using the NMO analyzer. A reduction catalyst evaluation led to the selection of an NMO analyzer reduction catalyst which operates at a moderate temperature and displays no appreciable effect on peak shape. A gas chromatographic column system which provides better permanent gas separation and hydrocarbon quantitation was also selected for use in the NMO analyzer. (Author abstract) 3 Refs.

Howe, G.B. (Research Triangle Inst, Research Triangle Park, NC, USA); Jayanty, R.K.M.; Jackson, M.; Riley, C.E.; McAlister, G.D. *JAPCA* v 38 n 7 Jul 1988 p 907-913.

**Chemical Reactions** See Also ALUMINUM COMPOUNDS—Chemical Reactions; CHEMICAL REACTIONS—Friedel-Crafts Reaction; COAL BY-PRODUCTS—Separation; COPPER AND ALLOYS—Extraction; LIGNIN; MONOMERS—Synthesis; NITROGEN OXIDES—Chemical Reactions; POLYAMIDES—Synthesis; POLYCHLORINATED BIPHENYLS—Chemical Reactions; POLYMERIZATION; POLYMERS—Chemical Reactions; POLYMERS—Conductive; POLYSACCHARIDES—Chemical Reactions; POLYSTYRENES—Chemical Reactions; POLYURETHANES—Forming; SODIUM COMPOUNDS—Chemical Reactions; WASTEWATER—Chlorination.

**074772 ABIOTIC TRANSFORMATIONS OF HALOGENATED ORGANICS. 1. ELIMINATION REACTION OF 1,1,2,2-TETRACHLOROETHANE AND FORMATION OF 1,1,2-TRICHLOROETHENE.** The abiotic homogeneous aqueous-phase elimination reaction of 1,1,2,2-tetrachloroethane to 1,1,2-trichloroethene has been studied. The reaction has been carried out in 0.100 M phosphate buffer in the pH range 5-9 and at 11 temperatures. In all cases, quantitative conversion of the 1,1,2,2-tetrachloroethane to 1,1,2-trichloroethene was observed. The reaction is second order overall and fits the equation  $\log k_e = (15.87 \pm 0.54) \exp[-91.1 \pm 3.4 \text{ kJ/mol}/RT]$ . (Author abstract) 8 refs.

Cooper, William J. (Florida Int Univ, Miami, FL, USA); Mehran, Mostafa; Riusech, David J.; Joens, Jeffrey A. *Environ Sci Technol* v 21 n 11 Nov 1987 p 1112-1114.

**074773 INVESTIGATION OF THE REACTION OF SOME UNSATURATED DICARBOXYLIC ACID ANHYDRIDES WITH CYCLIC CARBONATES.** This work reports attempts to extend to unsaturated anhydrides the rapid reaction of dicarboxylic acid anhydrides with ethylene carbonate to form polymer directly. The reaction of unsaturated diacid anhydrides with two cyclic carbonates, ethylene and propylene carbonate, leads to gelled products whenever the anhydride is capable of Michael addition, while an anhydride without such



unsaturation gave linear polymer instead. The GC/MS results, along with efforts to trap radical reactions, support Michael addition as an explanation of gelation in these systems. (Author abstract) 5 refs.

Fagerburg, D.R. (Eastman Kodak Co, Kingsport, TN, USA). *J Macromol Sci Chem* v A24 n 8 1987 p 853-858.

**074774 ADDITION REACTIONS OF 1-ARENE-SULFONYL-2-SUBSTITUTED AZIRIDINES.** Ring-opening reactions of asymmetric aziridines were studied. It was shown that in aziridines with electronegative substituents the mutual and opposite effect of polar and steric factors leads to a decrease in regioselectivity of addition reactions. (Author abstract) 3 refs.

Markov, V.I.; Danileiko, D.A.; Doroshenko, V.A. *Sov Prog Chem* v 53 n 2 1987 p 94-97.

**074775 INFLUENCE OF THE SOLVENT ON THE INTERACTION OF PHENYL ISOCYANATE WITH PROTON DONORS, CATALYZED BY COPPER(II) ACETYLACETONATE.** The influence of the medium on the noncatalytic and copper(II)-acetylacetonate-catalyzed interaction of phenyl isocyanate with *n*-butanol under conditions of an excess of isocyanate was investigated. It was shown that the product of super-equimolar conversion of isocyanate is *n*-butyl- $\alpha$ ,  $\gamma$ -diphenylallophanate. The kinetic and thermodynamic peculiarities of the process of formation of urethane and allophanate in various solvents are discussed. (Author abstract) 12 refs.

Bakalo, L.A. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Rakhlevskii, L.V. *Kinet Catal* v 28 n 2 pt 1 Mar-Apr 1987 p 300-304.

**074776 EFFECT OF ELECTROLYTE CONCENTRATION ON THE INTERACTION OF HUMIC ACID AND HUMATE WITH MONTMORILLONITE.** The present study examines the dependence of the interaction of montmorillonite with a brown-coal humic acid on the pH and electrolyte concentration. The effects of these two factors were studied separately. The interaction was always measured by decrease of concentration of humic substances in the solution. The adsorption isotherms of humic acid on H-montmorillonite and of Na-humate on Na-montmorillonite were measured, and results based on electrolyte and pH variations are given. To interpret these effects, the surface charge, potential and the interaction energy of montmorillonite and humic substances were calculated on the basis of a simple model concerning two, mostly different, intrinsic dissociation constants. As a result of these calculations, it is most likely that joint coagulation, i.e., coaggregation, of the components takes place. (Edited author abstract) 40 refs.

Tombacz, Etelka (Attila Jozsef Univ, Szeged, Hung); Gilde, Maria; A'braham, Imre; Szanto, Ferenc. *Appl Clay Sci* v 3 n 1 Jan 1988 p 31-52.

**074777 AIR-WATER PARTITIONING COEFFICIENTS OF ORGANICS IN DILUTE AQUEOUS SOLUTIONS.** Henry's Law constants were measured for 45 chemicals spanning a wide range of chemical structures and volatilities. A static headspace method, Equilibrium Partitioning in Closed Systems (EPICS), was used to measure Henry's Law constant, and the batch air stripping method was used as a check. Measurements were conducted over a temperature range of 10-30°C, and the data were correlated with a temperature regression equation. An average precision of 10% was obtained for the EPICS runs, and the Henry's constants agreed well with the batch air stripping results and other reported values. (Author abstract) 14 refs.

Ashworth, Richard A. (HQ AFESC/RDWW, Tyndall AFB, FL, USA); Howe, Gary B.; Mullins, Michael E.; Rogers, Tony N. *J Hazard Mater* v 18 n 1 Apr 1988 p 25-36.

**074778 PRODUCTION OF TOXIC EQUIVALENTS TO 2, 3, 7, 8-TCDD IN MUNICIPAL-WASTE INCINERATORS (MWIS).** We have modified the model of W.M. Shaub and W. Tsang to calculate dioxin formation from precursors in the gas phase and on fly ash,

by estimating congener-specific parameters from measurements of dioxin production over 2 h time periods on fly ash performed by H. Vogt et al. The resulting kinetic data have been combined with a previously determined temperature-time history in a municipal waste incinerator (MWI) and with relative EPA toxicity estimates to determine toxic equivalents to 2,3,7,8-TCDD obtained in a representative MWI. If toxic inputs producing precursors were measured, together with the toxic equivalents of the outputs, then our model could be used to define furnace destruction factors for the inputs. (Edited author abstract) 9 refs.

Li, C.P. (Univ of California, La Jolla, CA, USA); Wiesenbahn, F.; Penner, S.S. *Energy (Oxford)* v 13 n 3 Mar 1988 p 217-223.

**074779 SIMPLIFIED MODEL FOR DIOXIN AND FURAN FORMATION IN MUNICIPAL-WASTE INCINERATORS.** The authors have used the temperature-time profile derived from a one-dimensional energy-balance model, in conjunction with the kinetic estimates of W.M. Shaub and W. Tsang, to estimate the production of dioxins from chlorinated precursors in the gas phase and on fly ash. In agreement with earlier studies, it is found that dioxin production on particulates is much larger than gas-phase formation. The scaling relation for dioxin production on fly ash shows that the absorbed concentration in ng/g is proportional to the square of the gas-phase precursor concentration and inversely proportional to the particulate radius. Calculated dioxin outputs for flue-gas-fly-ash mixtures and for bottom ash fall in the general range observed for some of the available municipal-waste incinerator data. Modifications needed in the model parameters are suggested to obtain agreement with the best of the new incinerators. Additional study results are discussed. (Edited author abstract) 28 refs.

Weisenbahn, D.F. (Univ of California, La Jolla, CA, USA); Li, C.P.; Penner, S.S. *Energy (Oxford)* v 13 n 3 Mar 1988 p 225-237.

**074780 SOLID-STATE REACTION BETWEEN p-PHENYLENEDIAMINE AND p-BENZOQUINONE.** p-Phenylenediamine reacts with p-benzoquinone in solution as well as in the solid state forming a 1:1 molecular complex which may be polymeric or agglomeric in nature. When the two components are mixed in the solid state in an agate mortar first a blue color develops which ultimately (after a few minutes) changes to dark brown. Differential scanning calorimetric studies show that the reaction products obtained from solution and by solid-state reactions are the same. Spectroscopic studies reveal that charge transfer stabilized by hydrogen bonding is involved in the formation of the complex. UV and visible spectroscopic studies in solution show that the complex either is unstable in solution or requires some time for stabilization. Magnetic measurements and ESR spectroscopy show the presence of an unpaired electron in the complex. (Author abstract) 25 refs.

Singh, N.B. (Univ of Gorakhpur, Gorakhpur, India); Singh, R.J. *J Solid State Chem* v 76 n 2 Oct 1988 p 375-390.

**074781 INTERACTION OF XENOBIOTICS WITH MERCURY-ADSORBED PHOSPHOLIPID MONOLAYERS.** This study examines the following groups of toxic compounds: polycyclic aromatic hydrocarbons (PAH), DDT and other chlorinated pesticides, and the phenothiazines. The effect of these substances on the monolayer is measured by monitoring the capacitance-potential curves of the adsorbed phospholipid. The response to these compounds is manifested as a change in the potential and height of two capacitance peaks. PAH penetrate the film without disrupting its fundamental structure. The extent of interaction is dependent on the hydrophobicity and aromaticity of the PAH. DDT interacts with the layer depressing the capacitance peaks. The heterocyclic 3-ringed phenothiazines also affect the membrane; the response depends on the N- and ring substituents on these compounds. (Edited author abstract) 10 refs.

Nelson, A. (Inst for Marine Environmental Research,

Plymouth, Engl); Auffret, N. *Mar Environ Res* v 24 n 1-4 1988, Fourth Int Symp on Responses of Mar Org to Pollut, Woods Hole, MA, USA, Apr 22-24 1987 p 51-56.

## Chemical Vapor Deposition

**074782 CONSTRUCTION OF AN ADIABATIC CALORIMETER FOR A VAPOR-DEPOSITED SAMPLE AND THERMAL CHARACTERIZATION OF AMORPHOUS BUTYRONITRILE.** An adiabatic calorimeter for a vapor-deposited sample was newly constructed, and thermal properties of amorphous butyronitrile were studied in detail. The cryostat was cooled down to 10 K with a built-in refrigerator. The sample vapor was introduced through a filling tube into a calorimeter cell. A special device was made in order to minimize the heat flow from the tube to the cell. Butyronitrile vapor was deposited at 67 and 40 K in the first and the second experiments, respectively. Another kind of vitreous sample was prepared by rapidly cooling the liquid in comparison with the vapor-deposited vitreous samples. Heat capacities of the samples were measured in the temperature range from 15 to 175 K with an imprecision of about  $\pm 0.5\%$ . Both the vapor-deposited and the liquid-quenched samples exhibited heat capacity jump characteristic of the glass transition of the same temperature, viz. 97 K. (Edited author abstract) 20 refs.

Hikawa, Hideaki (Osaka Univ, Toyonaka, Jpn); Oguni, Masaharu; Suga, Hiroshi. *J Non Cryst Solids* v 101 n 1 Apr 1988 p 90-100.

**Chlorination** See PAPER AND PULP MILLS—Effluents; WATER POLLUTION—Underground.

**Chromatographic Analysis** See Also ALDEHYDES—Chromatographic Analysis; AMINES—Chromatographic Analysis; AMINO ACIDS—Chromatographic Analysis; BIOLOGICAL MATERIALS—Chromatographic Analysis; BIOLOGICAL MATERIALS—DNA; CHROMATOGRAPHIC ANALYSIS—Gas; CHROMATOGRAPHIC ANALYSIS—Liquid; COAL TAR—Chromatographic Analysis; DRUG PRODUCTS—Antibiotics; DRUG PRODUCTS—Chromatographic Analysis; DRUG PRODUCTS—Spectroscopic Analysis; FLUOROMETERS—Applications; HORMONES—Chromatographic Analysis; HYDROCARBONS—Chromatographic Analysis; OLEFINS—Chromatographic Analysis; PESTICIDES—Chromatographic Analysis; POLYMERS—Chemical Reactions; RESERVOIRS—Algae; SHALE OIL—Chromatographic Analysis; SILICONES—Chemical Reactions; VITAMINS—Chromatographic Analysis; WATER ANALYSIS; WATER ANALYSIS—pH Effects.

**074783 REVERSED-PHASE HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY OF SUBSTITUTED ANILINES UTILIZING MOLECULAR-RECOGNIZING ABILITY OF CROWN ETHER: COMPARISON WITH ION-PAIR CHROMATOGRAPHY.** Host-guest interaction between crown ether and protonated amino group has been applied to the specific separation of positional isomers of mono- and disubstituted anilines by reversed-phase high-performance liquid chromatography with mobile phase containing 18-crown-6. The retention of these amines on a hydrophobic stationary ligand was enhanced by association with 18-crown-6, and the degree of the enhancement reflected the molecular structure of the guest. (Edited author abstract) 22 refs.

Shibukawa, Akimasa (Kyoto Univ, Kyoto, Jpn); Nakagawa, Terumichi; Kaihara, Atsunori; Yagi, Kumiko; Tanaka, Hisashi. *Anal Chem* v 59 n 20 Oct 15 1987 p 2496-2501.

**074784 DIRECT LIQUID CHROMATOGRAPHIC SEPARATION OF RACEMATES WITH AN  $\alpha$ -CYCLODEXTRIN BONDED PHASE.** To date there have been no reports on the resolution of any enantiomers on  $\alpha$ -cyclodextrin bonded liquid chromatography phases. In this work 22 compounds, including racemic tryptophan, phenylalanine, tyrosine, and analogues are quickly separated with aqueous or hydroorganic mobile phases. The  $\alpha$ -cyclodextrin bonded phase linkage is hydrolytically stable and completely analogous to that of the successful  $\beta$ -cyclodextrin bonded phase. The retention behavior and



the effect of structure on chiral recognition are discussed. None of the compounds reported in this work can be resolved easily with the  $\beta$ -cyclodextrin bonded phase. (Edited author abstract) 27 refs.

Armstrong, Daniel W. (Texas Tech Univ, Lubbock, TX, USA); Yang, Xiufeng; Han, Soon M.; Menges, Randy A. *Anal Chem* v 59 n 21 Nov 1 1987 p 2594-2596.

**074785 INFRARED EMISSION FROM A FLAME AS THE BASIS FOR CHROMATOGRAPHIC DETECTION OF ORGANIC COMPOUNDS.** The feasibility of using infrared emission from a combustion flame as a means of detection for chromatography was investigated. Over the wavelength interval from 1 to 5  $\mu$ m, two strong emission bands were observed with a PbSe detector when organic compounds were introduced into an hydrogen/air flame. The band at 4.3  $\mu$ m ( $2326\text{ cm}^{-1}$ ) was due to the asymmetric stretch of carbon dioxide while the band at 2.7  $\mu$ m was due to both water and carbon dioxide emission. The carbon dioxide emission at 4.3  $\mu$ m was found to be most intense at the tip of the flame and to increase with the amount of organic compound introduced into the flame. (Edited author abstract) 16 refs.

Hudson, M. Keith (Baylor Univ, Waco, TX, USA); Busch, Kenneth W. *Anal Chem* v 59 n 21 Nov 1987 p 2603-2609.

**074786 APPLICATION OF FAST LC TO PHARMACEUTICAL ANALYSIS: DOPAMINE · HCl.** A reversed-phase HPLC method for the determination of the dopamine hydrochloride content of pharmaceutical intravenous solutions is developed using short (3-cm) columns packed with 3- $\mu$ m particles. Total analysis time for the stability indicating assay, which is capable of separating the analyte from all its common degradates and formulation matrix components, is 2 min. The assay is equivalent in performance (accuracy, precision, separation behavior, ruggedness) to a standard method recommended by the United States Pharmacopeia (USP). Common components of conventional HPLC systems are evaluated with respect to their utility for this application of fast LC. (Author abstract) 12 refs.

Brown, David S. (Travenol Lab Inc, Morton Grove, IL, USA); Jenke, Dennis R. *J Chromatogr Sci* v 25 n 11 Nov 1987 p 494-500.

**074787 DETERMINATION OF OXALATE IN PHARMACEUTICAL MATRICES BY INDIRECT PHOTOMETRIC CHROMATOGRAPHY.** An indirect photometric ion chromatography method is developed for the quantitation of oxalate in typical pharmaceutical matrices. The column/mobile phase conditions used represent a trade off between resolving power and sensitivity and results in an assay with a total analysis time of less than 9 minutes. Method response is linear between concentrations of 10 to 80 ppm oxalate. The limit of quantitation is roughly 5 ppm. Precision in the range of 30 to 80 ppm is better than 1.0% RSD of replicate injections, and the accuracy in a variety of matrices is  $100 \pm 2\%$ . The method is quite rugged and meets rigorous suitability requirements even after 500 injections. (Edited author abstract) 11 refs.

Downey, Brian P. (Travenol Lab Inc, Morton Grove, IL, USA); Jenke, Dennis R. *J Chromatogr Sci* v 25 n 11 Nov 1987 p 519-527.

**074788 REVERSED-PHASE LIQUID CHROMATOGRAPHY WITH MIXED ELUENTS: PARTITION MODEL OF RETENTION FOR IONOGENIC SOLUTES.** Based on the pure partition model of solute retention new theoretical equations for ionogenic solutes are discussed. These equations define dependence of the capacity ratio on the mobile phase composition, which is characteristic for the reversed-phase liquid chromatography. The treatment presented in this paper facilitates the description of solute dissociation effects in the RPLC with mixed eluents and forms a background for further studies in this field. 21 refs.

Borowko, M. (M. Curie-Sklodowska Univ, Lublin, Pol); Jaroniec, M.; Piotrowska, J. *J Liq Chromatogr* v 10 n 10

Aug 1987 p 2033-2045.

**074789 MICROPREPARATIVE HPLC PURIFICATION PROCEDURE FOR (G-<sup>3</sup>H)-BENZO(a)PYRENE AND 3-(6-<sup>14</sup>C)-METHYLCHOLANTHRENE.** This paper describes a micropreparative purification method of (<sup>3</sup>G)-benzo(a)pyrene and 3-(6-<sup>14</sup>C)-methylcholanthrene employing high pressure reversed phase chromatography. The method can be used immediately prior to the use of these compounds as exposure agents in metabolism studies. This assures the highest possible degree of purity during exposure and thereby eliminating the need for batch purification and repetitive sampling from the purified material. (Author abstract) 2 refs.

Rosier, Jan A. (Harvard Sch of Public Health, Boston, MA, USA). *J Liq Chromatogr* v 10 n 10 Aug 1987 p 2105-2114.

**074790 IDENTIFICATION OF URIDINE IN CACAO EXTRACTS.** Uridine has been identified as a minor component of defatted Ecuadorian cacao liquor through reverse phase HPLC of aqueous extracts. The nucleoside was identified by comparison of its behavior in a variety of mobile phases and column types as well as its absorbance ratios at 245 and 270 nm. This work has extended the previously reported methodology to include pyrimidine nucleosides. (Author abstract) 5 refs.

Quintero, Enid-Noemi (Dickinson Coll, Carlisle, PA, USA); Sheeley, Richard M.; Hurst, W. Jeffrey; Martin, Robert A. Jr. *J Liq Chromatogr* v 10 n 10 Aug 1987 p 2145-2150.

**074791 DETERMINATION OF ETHINYLESTRADIOL AND NORETHINDRONE IN A SINGLE SPECIMEN OF PLASMA BY AUTOMATED HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY AND SUBSEQUENT RADIOIMMUNOASSAY.** A method is described for the specific determination of ethinylestradiol and norethindrone in the same specimen of plasma at concentrations of 20 and 50 pg/ml, respectively. The method is based on fully automated high-performance liquid chromatography for separation of the analytes from one another and from coextracted extraneous components and on radioimmunoassay using antisera of high specificity for the quantification. Validation of the method included demonstration of low procedural blanks, recoverability of added hormones and low intra-assay and inter-assay variability. (Author abstract) 11 refs.

Lee, George Jia-Long (Syntex Research, Palo Alto, CA, USA); Oyang, Miin-Huey; Bautista, Jeanette; Kushinsky, Stanley. *J Liq Chromatogr* v 10 n 10 Aug 1987 p 2305-2318.

**074792 MICELLAR LIQUID CHROMATOGRAPHY OF ADENOSINE IN CACAO.** A rapid isocratic micellar HPLC procedure for the separation of adenosine from theobromine in cacao was developed. The adenosine peak was identified by using the enzymatic peak shift technique with adenosine deaminase (ADA). Separation was performed on a polyvinyl alcohol (PVA) column using a mobile phase containing 0.012 M sodium dodecyl sulfate (SDS) and 0.005 M phosphate buffer (pH 11.5). Quantitation and detection limits were determined. In addition the separations obtained on a PVA column with the micellar mobile phase were compared to separations obtained on a C<sub>18</sub> column using both isocratic and gradient elution. (Author abstract) 18 refs.

Kim, Yong-Nam (Univ of Rhode Island, Kingston, RI, USA); Brown, Phyllis R. *J Liq Chromatogr* v 10 n 11 1987 p 2411-2422.

**074793 SIMULTANEOUS HPLC ANALYSIS OF CATECHOLAMINES AND INDOLEAMINES IN MOUSE BRAIN TISSUE FOLLOWING ACETATE EXTRACTION AND TREATMENT WITH ASCORBATE OXIDASE.** A refined HPLC Method for the determination of monamine levels in six brain regions is presented. Analyses are made for the olfactory tubercles,

prefrontal cortex, septum, striatum, amygdala and hypothalamus of adult male ICR mice. This system permits the simultaneous analysis of norepinephrine, dopamine, serotonin and their major metabolites during a single run of approximately twenty-five minutes without prior clean-up of samples. (Author abstract) 9 refs.

Hadfield, M. Gary (Virginia Commonwealth Univ, Richmond, VA, USA); Mili, Christine; Narasimachari, Nedathur. *J Liq Chromatogr* v 10 n 11 1987 p 2439-2446.

**074794 SEPARATION OF BUFOTALIN AND CINOBUFOTALIN BY PREPARATIVE LIQUID CHROMATOGRAPHY.** Complete resolution of bufadienolides by traditional column chromatography, or by thin-layer chromatography (TLC), is quite difficult. Separation of various bufadienolide conjugates by high performance liquid chromatography (HPLC) has been described, but not for resolution of the corresponding genins. A preparative HPLC procedure has been developed for resolving the difficultly separable bufotalin (1) and cinobufotalin (2). A Lobar B column packed with LiChromrep Si-60 was used to separate these bufadienolides employing a recycling procedure. (Author abstract) 10 refs.

Inoue, Masuo (Arizona State Univ, Tempe, AZ, USA); Kamano, Yoshiaki; Pettit, George R.; Smith, Cecil R. *J Liq Chromatogr* v 10 n 11 1987 p 2453-2460.

**074795 LIQUID CHROMATOGRAPHY-PHOTOLYSIS-ELECTROCHEMICAL DETECTION FOR ORGANOIODIDES. 1. OPTIMIZATION AND APPLICATION.** An improved high-performance liquid chromatographic detection method has been applied for the trace determination of iodinated organic compounds. The method, which incorporates postcolumn, on-line UV irradiation prior to oxidative electrochemical (EC) detection, exploits the facile photochemical dissociation of the C-I bond to form anionic iodide and a number of solvolyzed products. Following bond cleavage, iodide is readily detected amperometrically at moderate oxidative potentials, allowing for the determination of a number of organoiodides at the 25-75 pg level. (Edited author abstract) 30 refs.

Selavka, Carl M. (Northeastern Univ, Boston, MA, USA); Krull, Ira S. *Anal Chem* v 59 n 22 Nov 15 1987 p 2699-2703.

**074796 LIQUID CHROMATOGRAPHY-PHOTOLYSIS-ELECTROCHEMICAL DETECTION FOR ORGANOIODIDES. 2. OPERATIVE MECHANISMS.** An improved high-performance liquid chromatographic detection method has been characterized for the trace determination of iodinated organic compounds. The method, which incorporates postcolumn, on-line UV irradiation prior to oxidative electrochemical (EC) detection, exploits the facile photochemical dissociation of the C-I bond to form anionic iodide and a number of solvolyzed products. (Edited author abstract) 23 refs.

Selavka, Carl M. (Northeastern Univ, Boston, MA, USA); Krull, Ira S. *Anal Chem* v 59 n 22 Nov 15 1987 p 2704-2709.

**074797 VYSOKOUCINNA KAPALINOVA CHROMATOGRAPHIE DERIVATU PYRIDIMU. [High-Performance Liquid Chromatography of Pyridine Derivatives].** Conditions are described for the separation of pyridine derivatives by high-performance liquid chromatography on chemically bonded sorbents and on silica. A method is presented for the separation of pyridine mono- and dicarboxylic acids, amides and nitriles, the dependences of the capacity-factors on the mobile phase composition are presented. (Edited author abstract) In Czech. 18 refs.

Kralovsky, Josef (Vyskumny Ustav Organickych Syntex, Pardubice, Czech); Kalhousova, Marta; Placek, Karel. *Chem Prum* v 37 n 10 1987 p 537-540.



**074798 COMPARING ELECTROCHEMICAL, FLUORESCENCE, AND ULTRAVIOLET DETECTORS FOR HPLC ANALYSIS OF THE DECAPEPTIDE, NAFARELIN.** This report describes a reverse-phase HPLC technique to determine the concentration of nafarelin (a decapeptide luteinizing hormone-releasing hormone analog) in aqueous solutions for intranasal administration. Pursuant to the method development we evaluated three different detectors with respect to sensitivity, linearity, specificity and reliability. The three detector types investigated were: spectrophotometric (225 nm), electrochemical (at +1.2 v), and fluorescence (excitation = 282 nm, emission = 332 nm). All three detectors gave satisfactory linear response, and gave equivalent results for nafarelin samples assayed in parallel. (Edited author abstract) 16 refs.

Lockhart, Karen L. (Inst of Pharmaceutical Sciences, Palo Alto, CA, USA); Kenley, Richard A.; Lee, M.O. *J Liq Chromatogr* v 10 n 13 1987 p 2999-3013.

**074799 CHROMATO-MASS SPECTROMETRY OF HEAVY PYRIDINE BASES.** Crude heavy pyridine bases (CHPB) constitute a complex mixture of heterocyclic nitrogen-containing compounds, isolated from coal tar fractions. The data presented in the literature on the composition of heavy pyridine bases from coal are very limited. For analysis of the CHPB we used a Finnigan-4021 chromat-mass spectrometer equipped with a computer. The separation of the bases was carried out on a quartz capillary column with OV-101. The carrier gas was hydrogen. The results of quantitative analysis of the CHPB showed that the proportion of the basic components (quinoline, isoquinoline, quinaldine, and lepidine) was about 60%. In addition, the CHPB contain more than 10 components with a concentration of over 1%. Thus over 70 components were found in the CHPB, most of which were identified. 20 refs.

Berlizov, Yu.S.; Nabivach, V.M.; Linberg, L.F. *Coke Chem (USSR)* n 1 1987 p 62-67.

**074800 LIGAND EXCHANGE CHROMATOGRAPHY SEPARATIONS OF SOME PHENOLIC COMPOUNDS ON ZINC SILICATE IN Fe(III) FORM.** The high sorption capacity of zinc silicate for Fe(III) has been utilized for the separation of phenolic compounds on the basis of ligand exchange. The coordination of ligands with the central metal ion occurs through oxygen. Ligand sorption capacity, rate of sorption and break-through capacity have been studied. The distribution coefficients ( $K_d$  values) of 21 phenols have been determined in five different systems. Selectivity has been determined on the basis of  $K_d$  values of these phenols. On the basis of differences in  $K_d$  values various analytically important quantitative binary and ternary separations on columns of zinc silicate in Fe(III) form have been achieved. (Author abstract) 12 refs.

Singh, D.K. (Harcourt Butler Technological Inst, Kanpur, India); Darbari, Anjana. *J Liq Chromatogr* v 10 n 14 1987 p 3235-3248.

**074801 AMPEROMETRIC DETECTION OF CATECHOLS IN CAPILLARY ZONE ELECTROPHORESIS WITH NORMAL AND MICELLAR SOLUTIONS.** A recently introduced system for interfacing capillary zone electrophoresis with off-column amperometric detection is demonstrated on small-bore columns with normal and micellar solutions. The use of smaller inner diameter columns with a carbon-fiber electrochemical detector allows for increased separation efficiency and decreased detection limits. On a 26- $\mu$ m-i.d. column, separation efficiencies of greater than 400,000 theoretical plates and subfemtomole detection limits have been obtained for several catechols. (Edited author abstract) 42 refs.

Wallingford, Ross A. (Pennsylvania State Univ, University Park, PA, USA); Ewing, Andrew G. *Anal Chem* v 60 n 3 Feb 1988 p 258-263.

**074802 HPL CHARACTERIZATION OF THE GRAMICIDIN A DIMER-MONOMER CONFOR-**

**MATIONAL EQUILIBRIUM IN ETHANOL AND STUDY OF THE EFFECT OF CALCIUM ION.** The usefulness of size-exclusion high-performance liquid chromatography for the study of gramicidin A (GA) dimer-monomer conformational equilibrium in polar organic solvents is demonstrated for the first time. The monomerization process of GA in ethanol has been analyzed using an Ultrastaygel 1000 Angstrom column isocratically equilibrated with tetrahydrofuran, which has allowed the determination of kinetic and thermodynamic constants. (Edited author abstract) 26 refs.

Braco, Lorenzo (Univ de Valencia, Burjassot, Spain); Del Carmen Bano, Maria; Chillaron, Francisco; Abad, Concepcion. *J Liq Chromatogr* v 10 n 15 Nov 1987 p 3463-3480.

**074803 INVESTIGATION OF THE COMPOSITION OF IMPURITIES IN PURIFIED PYRIDINE.** Gas-liquid chromatography was used to identify the impurities present in purified pyridine. A method was developed for quantitative determination of benzene, toluene, and 2- and 3-methylthiophenes in pyridine. Impurities determining the quality of the final product were determined. The limit allowable concentrations were determined for the impurities determining the light transmittance of pyridine. It was shown that production of pyridine of the especially pure grade required a combination of various treatment methods. 8 refs.

Krasavin, V.Yu.; Egorenko, G.A.; Kanaeva, O.A.; Zel'venskii, V.Yu.; Samolyuk, S.I.; Zhadanov, B.V.; Olikova, V.A.; Parkhaeva, G.N.; Stepanova, A.G. *Coke Chem (USSR)* n 7 1987 p 50-53.

**074804 HPLC SEPARATION AND FT-IR ISOMER DIFFERENTIATION OF THE 1,2,4,7/1,2,4,8-TETRACHLORODIBENZODIOXIN ISOMER PAIR - A THEORETICAL/EMPIRICAL APPROACH TO DIBENZODIOXIN ISOMER ASSIGNMENT.** The 1,2,4,7- and 1,2,4,8-tetrachlorodibenzodioxin (TCDD) isomers were separated by reversed-phase high-performance liquid chromatography (HPLC) with the use of a pyrene column. Fourier transform infrared (FT-IR) matrix isolation and vapor-phase spectra of the individual isomers were recorded. The spectra of the HPLC-separated isomers correlate well with spectral subtraction results and were found to be distinct in three spectral regions - one of which allows for isomer structural assignment. Ambiguities and differences in published TCDD isomer FT-IR assignments are discussed in terms of a qualitative valence-bond approach and empirically derived estimates of ether linkage asymmetric stretching frequencies. (Author abstract) 11 refs.

Grainger, James (US Dep of Health & Human Services, Atlanta, GA, USA); Barnhart, Elizabeth; Patterson, Donald G. Jr.; Presser, David. *Appl Spectrosc* v 42 n 2 Feb 1988 p 321-326.

**074805 ANALYSIS OF FLAVOR AND FRAGRANCE COMPOUNDS USING SUPERCRITICAL FLUID EXTRACTION COUPLED WITH GAS CHROMATOGRAPHY.** A method has been developed for the extraction and analysis of flavor and fragrance compounds of natural products by supercritical fluid extraction (SFE) with  $\text{CO}_2$  combined with capillary gas chromatography (GC). Extracted compounds were transferred from the supercritical fluid extraction cell directly into the gas chromatographic column for cryogenic focusing by inserting the extraction cell outlet restrictor into the chromatographic column through a standard on-column injection port. Following the extraction, the gas chromatographic analysis was performed in a normal manner by using either flame ionization or mass spectral detection. (Edited author abstract) 14 refs.

Hawthorne, Steven B. (Univ of North Dakota, Grand Forks, ND, USA); Krieger, Mark S.; Miller, David J. *Anal Chem* v 60 n 5 Mar 1988 p 472-477.

**074806 DETERMINATION OF COUMARIN IN VANILLA FLAVORINGS BY QUANTITATIVE HIGH PERFORMANCE THIN LAYER CHROMA-**

**TOGRAPHY.** High performance silica gel TLC was used to qualitatively and quantitatively determine coumarin in real and artificial vanilla flavorings. Coumarin was detected as a fluorescent or colored zone and quantified by scanning with a densitometer. Recoveries and reproducibility values are reported for fortified samples. The method was applied to a qualitative survey of domestic vanilla samples and quantification of coumarin in an adulterated foreign sample. The result of this determination was verified by standard addition analysis. (Edited author abstract) 11 refs.

Sherma, Joseph (Lafayette Coll, Easton, PA, USA); Schafer, Susan L.; Morris, Kristen. *J Liq Chromatogr* v 10 n 16 1987 p 3585-3593.

**074807 OVERPRESSURED LAYER CHROMATOGRAPHIC (OPLC) SEPARATION OF CLOSELY RELATED FUROCUMARINS.** An OPLC method for the analytical separation of eight furocoumarins is described. Of the eight compounds investigated, four are linear furocoumarins (psoralen, bergapten, 8-methoxypsoralen, iso-pimpinellin) and four are angular furocoumarins (angelicin, sphondin, iso-bergapten, pimpinellin). In preliminary experiments, optimization of the mobile phase was made using the 'PRISMA' model on TLC plates in unsaturated chambers. Evaluation of the final optimization steps for OPLC separations on HPTLC plates was done densitometrically. (Edited author abstract) 23 refs.

Zogg, G. (ETH, Zurich, Switz); Nyiredy, Sz.; Sticher, O. *J Liq Chromatogr* v 10 n 16 1987 p 3605-3621.

**074808 APPLICATION OF COUNTERCURRENT CHROMATOGRAPHY/THERMOSPRAY MASS SPECTROMETRY FOR THE ANALYSIS OF NATURAL PRODUCTS.** The versatility and high resolving power of countercurrent chromatography (CCC) has been demonstrated with a newly developed analytical high speed planet centrifuge system. Interfacing countercurrent chromatography with mass spectrometry (MS) provides a new analytical methodology which integrates the advantages of countercurrent chromatography with the low detection limit and identification capability of mass spectrometry. The technique proved useful in identifying an unknown impurity and in validating the presence of a specific compound in a mixture. (Edited author abstract) 20 refs.

Lee, Y.W. (Research Triangle Inst, Research Triangle Park, NC, USA); Voyksner, R.D.; Fang, Q.-C.; Cook, C.E.; Ito, Y. *J Liq Chromatogr* v 11 n 1 Jan 1988 p 153-171.

**074809 LARGE SCALE PURIFICATION OF APOCAROTENOIDS FROM COCHLOSPERMUM TINCTORIUM BY COUNTER-CURRENT CHROMATOGRAPHY.** Carotenoids are well-known for their instability so usual analytical methods such as HPLC or preparative TLC applied to the separation of the constituents of *Cochlospermum tinctorium* failed in the isolation of pure pigments for further chemical characterization. Thus high-speed CCC using a horizontal flow-through coil planet centrifuge was used to conveniently and efficiently achieve this separation for quantities up to 500mg of the crude plant extract. (Author abstract) 5 refs.

Diallo, B. (Inst de Pharmacie, Brussels, Belg); Vanhaelen, M. *J Liq Chromatogr* v 11 n 1 Jan 1988 p 227-231.

**074810 SEPARATION OF FLAVONOIDS IN CRUDE EXTRACT FROM SEA BUCKTHORN BY COUNTERCURRENT CHROMATOGRAPHY WITH TWO TYPES OF COIL PLANET CENTRIFUGE.** Flavonoid constituents in a crude ethanol extract from dried fruits of sea buckthorn (*Hippophae rhamnoides*) were subjected to countercurrent chromatography with a two-phase solvent system. Separations were performed with two different types of the coil planet centrifuge: one is called the multilayer coil planet centrifuge and the other, the horizontal flow-through coil planet centrifuge. Although the horizontal flow-through coil



planet centrifuge produced efficient peak resolution for five flavonoid components, the multilayer coil planet centrifuge yielded much superior results in terms of partition efficiency, separation time and sample loading capacity. (Edited author abstract) 10 refs.

Zhang, Tian-you (New Technology Application Inst of Beijing, Beijing, China); Hua, Xiang; Xiao, Rong; Kong, Shan. *J Liq Chromatogr* v 11 n 1 Jan 1988 p 233-244.

**074811 ANALYSIS OF FLAVONOIDS BY HPLC: AN UPDATE.** The innovative technological developments in HPLC use in recent years has provided the researcher with extremely rapid procedures for the qualitative and quantitative analysis of flavonoids. The current sensitivity of this technique allows for the use of extremely small amounts of material—nanogram or picogram quantities that can easily be used. The initial cost of HPLC instrumentation is still high, but small-scale, solid-phase extraction clean-up techniques coupled with inexpensive guard columns have extended the life of expensive analytical columns. As it becomes practical to resolve the more complex phenolic mixtures in plants by various combinations of these rapid, sensitive methods, HPLC may become the technique of choice for flavonoid analysis. 123 refs.

Daigle, D.J. (USDA, New Orleans, LA, USA); Conker-ton, E.J. *J Liq Chromatogr* v 11 n 2 Feb 1988 p 309-325.

**074812 LIQUID CHROMATOGRAPHIC-ELECTROCHEMICAL TECHNIQUE FOR DETERMINATION OF ETHYLENETHIOREA RESIDUES.** A high performance liquid chromatographic-electrochemical (HPLC-EC) technique was developed to selectively determine ethylenethioarea (ETU) at residue levels without derivatization. ETU was eluted from a C-8 column with water, a phosphoric acid electrolyte solution was added to the column eluate, and the ETU was detected with an electrochemical detector containing a Au/Hg working electrode. The HPLC-EC system produced a sharp chromatographic peak for ETU that was detected by the Au/Hg electrode at an applied potential of  $\pm 36$  v. (Edited author abstract) 22 refs.

Krause, Richard T. (Food & Drug Administration, Washington, DC, USA); Wang, Yi. *J Liq Chromatogr* v 11 n 2 Feb 1988 p 349-362.

**074813 DETERMINATION OF POLYCYCLIC AROMATIC COMPOUNDS BY HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY WITH SIMULTANEOUS MASS SPECTROMETRY AND ULTRAVIOLET DIODE ARRAY DETECTION.** A major problem in the determination of polycyclic aromatic compounds (PACs) in environmental samples is the extreme complexity of the extracts, even after extensive fractionation. The combination of high-performance liquid chromatography (HPLC) with simultaneous mass spectrometry (MS) and ultraviolet diode array detection (DAD) is a powerful tool for the identification and quantitation of such species with a high degree of confidence. HPLC allows the selective separation of a wide variety of PACs, including thermally labile and high molecular weight compounds. Electron ionization MS with the moving belt interface provides high sensitivity and selectivity, as well as structural information such as molecular weight, functional groups, and elemental composition. (Edited author abstract) 17 refs.

Quilliam, M.A. (Natl Research Council of Canada, Halifax, NS, Can); Sim, P.G. *J Chromatogr Sci* v 26 n 4 Apr 1988 p 160-167.

**074814 ENHANCED FLUORESCENCE DETECTION OF DANSYL DERIVATIVES OF PHENOLIC COMPOUNDS USING A POSTCOLUMN PHOTO-CHEMICAL REACTOR AND APPLICATION TO CHLOROPHENOLS IN RIVER WATER.** Photochemical decomposition by ultraviolet (UV) irradiation of dansyl derivatives of phenolic compounds in methanol-water mixtures leads to the formation of highly fluorescent dansyl-OH and dansyl-OCH<sub>3</sub>. With substituted phenols as model compounds, it is demonstrated

that inductive effects, caused by the substituents, play a major role in the gain in fluorescence signal (up to 8000-fold) that is obtained after postcolumn UV irradiation of the dansyl derivative, compared to that of the nonirradiated derivative. The optimal irradiation time for the dansyl derivatives is about 5.5 s. (Edited author abstract) 23 refs.

de Ruiter, Cornelis (Free Univ, Amsterdam, Neth); Bohle, Jan F.; de Jong, Gerhardus J.; Brinkman, Udo A.Th.; Frei, Roland W. *Anal Chem* v 60 n 7 Apr 1 1988 p 666-670.

**074815 GLASS CAPILLARY GAS CHROMATOGRAPHY-MASS SPECTROMETRY AT HIGH TEMPERATURES. DIRECT ANALYSIS OF FREE BASE PORPHYRINS AND METAL PORPHYRIN COMPLEXES EXTRACTED FROM THE SERPANO OIL SHALE.** This study describes GC/MS analysis of natural petroporphyrin extracts containing alkylporphyrins either as vanadyl complexes or as demetallated free bases. The combination of high temperature glass capillary gas chromatography with mass spectrometry allows, for the first time, direct determination of electron impact mass spectra of separated alkylporphyrins, making additional purification and derivatization unnecessary. The authors also give detailed working directions for the preparation of the high temperature GC/MS-interface, and of the high temperature stable OV-225-OH columns (max. working temperature 390°C). (Edited author abstract) 37 refs.

Blum, W. (Ciba-Geigy AG, Basel, Switz); Richter, W.J.; Eglinton, G. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 11 n 2 Feb 1988 p 148-156.

**074816 SELECTIVE DETERMINATION OF OXYGENATES IN COMPLEX SAMPLES WITH THE O-FID ANALYZER.** A gas-chromatographic analyzer allowing the selective detection of individual oxygenates in complex organic mixtures, such as gasolines, is described. The analyzer is based on the oxygen-specific response flame ionization detection (O-FID) method. The system operates with capillary columns and includes a cracking reactor to convert any oxygenate to carbon monoxide and a special FID equipped with a microreactor for the catalytic hydrogenation of CO and detection as methane. Hydrocarbons give no signal. The selectivity of the method is better than  $1:10^7$  and the linear range approaches  $10^5$ . (Edited author abstract) 9 refs.

Verga, G.R. (Carlo Erba Strumentazione, Milan, Italy); Sironi, A.; Schneider, W.; Frohne, J.Ch. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 11 n 3 Mar 1988 p 248-252.

**074817 OXYGEN-SELECTIVE MICROWAVE-INDUCED PLASMA GAS CHROMATOGRAPHY DETECTOR FOR PETROLEUM-RELATED SAMPLES.** An atmospheric-pressure, microwave-induced, helium plasma system for oxygen-selective gas-chromatographic detection of petroleum-related samples is presented. Using the various precautions outlined, the authors report that the oxygen-to-carbon selectivity is  $10^3$ . This is the best oxygen selectivity reported in the literature to date for a microwave-induced plasma detector system. The system is sensitive down to 2 ppm<sub>w</sub> (parts per million by weight) oxygen for narrow-boiling range distillates and simple mixtures and 500 ppm<sub>w</sub> oxygen for wide-boiling range, complex samples. (Edited author abstract) 21 refs.

Bradley, Cherylavaughn (Amoco Corp, Naperville, IL, USA); Carnahan, Jon W. *Anal Chem* v 60 n 9 May 1 1988 p 858-863.

**074818 HYDROPHOBIC SELECTIVITY IN MICELLAR AND HYDRO-ORGANIC REVERSED-PHASE LIQUID CHROMATOGRAPHY.** Selectivity for homologous series in reversed-phase liquid chromatography (RPLC) using micelles and organic solvents as the modifiers for the aqueous mobile phase was studied. Significant differences were observed between micellar and hydro-organic RPLC systems. With hydro-organic mobile phases, methylene group(s) selectivity depends only on the eluant composition for a given stationary phase chain

length. For micellar eluants, however, the selectivity for homologous series is a function of the solute type. (Edited author abstract) 34 refs.

Khaledi, Morteza G. (Univ of New Orleans, New Orleans, LA, USA). *Anal Chem* v 60 n 9 May 1 1988 p 876-887.

**074819 HIGH PERFORMANCE LIQUID CHROMATOGRAPHIC DETERMINATION OF (-)-N-FORMYLNOREPHEDRINE IN PLASMA.** An HPLC procedure for the detection and quantitative estimation of (-)-N-formylnorephedrine in rabbit plasma has been developed. The procedure involved the extraction of (-)-N-formylnorephedrine from plasma spiked with the internal standard (phenacetin), using ethyl acetate. The ethyl acetate extract is evaporated under nitrogen and the residue is reconstituted in water and injected onto the column. A u-Bondapak-C18 column 30 cm  $\times$  3.9 mm ID was used. The procedure allows the measurement of (-)-formylnorephedrine in concentrations as low as 150 ng/ml of plasma with total procedure time of about 10 min. The applicability of the procedure to pharmacokinetic studies is illustrated and metabolites are shown not to interfere with the assay procedure. (Edited author abstract) 5 refs.

Morad, A.M. (King Saud Univ, Riyadh, Saudi Arabia); Al-Meshal, I.A.; El-Ferali, F.S.; Matar, Kamal M. *J Liq Chromatogr* v 11 n 3 1988 p 713-724.

**074820 ION EXCHANGE HIGH PERFORMANCE LIQUID CHROMATOGRAPHY OF LEUKOTRIENES.** A novel anion exchange liquid chromatographic system has been developed for isocratic separation of leukotrienes. Hydrophobic as well as ionic forces were found to influence the separation. By optimization of solvent strength, ionic strength and pH, amphoteric peptidoleukotrienes could be separated simultaneously with hydroxy fatty acids such as leukotriene B<sub>4</sub> and its  $\omega$ -oxidized metabolites. To obtain a good buffering capacity of the mobile phase at optimum pH, a multicomponent buffer was developed. (Author abstract) 25 refs.

Steffenrud, S. (Univ Laval, Que, Can); Borgeat, P.; Salari, H. *J Liq Chromatogr* v 11 n 4 1988 p 849-862.

**074821 DETERMINATION OF ATENOLOL AND ITS RELATED COMPOUNDS BY ION PAIR HIGH PERFORMANCE LIQUID CHROMATOGRAPHY.** A rapid, simple, accurate, and stability-indicating ion pair high performance liquid chromatography (IP HPLC) procedure is presented for the determination of atenolol in pharmaceutical tablets. The related compounds of atenolol were separated, making the determination specific for atenolol. The detection was carried at 225 nm. The relative standard deviations are less than 1.0% for the two commercial products analyzed. The method was tested for linearity, recovery, and specificity. (Edited author abstract) 7 refs.

Isa Sa'sa', Suleiman (Yarmouk Univ, Irbid, Jordan). *J Liq Chromatogr* v 11 n 4 1988 p 929-942.

**074822 SELECTIVE DETERMINATION OF ORGANOFLOURINE COMPOUNDS BY CAPILLARY COLUMN GAS CHROMATOGRAPHY WITH AN ATMOSPHERIC PRESSURE HELIUM MICROWAVE-INDUCED PLASMA DETECTOR.** Fluorinated analogs of compounds typical of those found in metabolic and other biological studies are detected with high selectivity using a gas chromatograph/microwave-induced plasma detector (GC-MIPD), which permits fluorine-selective detection by monitoring the emission at 685.6 nm. Using the described atmospheric pressure helium-sustained plasma detector, the minimum detectable level, fluorine selectivity (relative to carbon),



and linear dynamic range of this GC-MIPD system were determined to be 4.8 pg-F/s, 1060, and 5000, respectively. (Edited author abstract) 32 refs.

Brill, J.H. (Univ of Missouri, Columbia, MO, USA); Narayanan, B.A.; Doom, J.P.; McCormick, J.P. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 11 n 5 May 1988 p 368-374.

**074823 CHARACTERIZATION AND DYNAMICS OF ORGANIC COMPOUNDS IN FOREST HUMUS STUDIED BY PYROLYSIS-GAS CHROMATOGRAPHY/ELECTRON IMPACT MASS SPECTROMETRY AND PYROLYSIS-(HIGH RESOLUTION) FIELD IONIZATION MASS SPECTROMETRY.** The study of macromorphologically differentiated horizons from three forest humus types (mull, moder, mor) demonstrated the suitability of pyrolysis-mass spectrometry to characterize, differentiate and identify organic compounds in humic soil horizons at different stages of humification. Besides lower molecular pyrolysis products the combination of high-resolution pyrolysis-field ionization mass spectrometry and pyrolysis-gas chromatography/electron impact mass spectrometry also enabled the characterization of higher molecular subunits from forest humus that cannot be accounted for by wet chemical methods. (Edited author abstract) 10 refs.

Hempfling, R. (Univ of Bayreuth, Bayreuth, West Ger); Schulten, H.-R. *J Anal Appl Pyrolysis* v 13 n 4 Jun 1988 p 319-325.

**074824 LIQUID CHROMATOGRAPHIC SEPARATION OF ENANTIOMERS USING CHIRAL ADDITIVES IN THE MOBILE PHASE.** Addition of an optically active compound to the mobile phase is an attractive method for resolving enantiomers in liquid chromatography. The technique is practical, easy to use and allows rapid screening for new chiral complexing agents as well as for optimal separation conditions. (Author abstract) 25 refs.

Pettersson, Curt (Uppsala Univ, Uppsala, Swed). *TrAC Trends Anal Chem (Pers Ed)* v 7 n 6 Jun-Jul 1988 p 209-217.

**074825 PENTACHLORODIBENZO-p-DIOXIN ISOMER DIFFERENTIATION BY CAPILLARY GAS CHROMATOGRAPHY FOURIER TRANSFORM INFRARED SPECTROSCOPY.** Reference infrared vapor-phase spectra of the 14 pentachlorodibenzo-p-dioxin (PnCDD) isomers were recorded at low microgram concentrations. A unique infrared spectrum corresponding to each chromatographically separated or spectrally subtracted mixture component was observed. The structures for individual isomers in each isomer pair were assigned by qualitative valence-bond evaluations and empirically derived quantitative estimations of ether linkage asymmetric stretching frequencies [ $\nu_{\text{COC(asy)}}$ ]. Correlations between calculated linkage (C-O-C) bond angles and  $\nu_{\text{COC(asy)}}$  indicate existence of buttressed 1,6 and 1,9 nonbonded interactions not observed in tetrachlorodibenzo-p-dioxin (TCDD) isomers. (Author abstract) 21 refs.

Grainger, James (Dep of Health & Human Sciences, Atlanta, GA, USA); Reddy, V. Vikram; Patterson, Donald G. Jr. *Appl Spectrosc* v 42 n 5 Jul 1988 p 800-806.

**074826 EVIDENCE FOR THE FORMATION OF 2,4-IMIDAZOLIDINEDIONES AND PYRROLIDINO[1,2a]-3,6-PIPERAZINEDIONES IN HUMAN HAIR PYROLYZATE BY PYROLYSIS-GAS CHROMATOGRAPHY-MASS SPECTROMETRY.** The formation of 5-substituted pyrrolidino[1,2a]-3,6-piperazinediones by a similar mechanism is proposed. Due to the complexity of the hair pyrolyzate, even with separation by capillary gas chromatography, few single-component peaks were obtained with pyrolysis-gas chromatography-mass spectrometry. The use of capillary pyrolysis-gas chromatography-tandem mass spectrometry overcame this problem. Electron impact and chemical ionization collisionally activated dissociation experiments provided data which support the

proposed formation of 5-substituted 2,4-imidazolidinediones and 5-substituted pyrrolidino[1,2a]-3,6-piperazinediones during the anaerobic pyrolysis of human hair. (Edited author abstract) 4 refs.

Munson, T.O. (FBI Acad, Quantico, VA, USA); Fetterolf, D.D. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 15-24.

**074827 CHARACTERISATION OF SUBFOSSIL SPAGNUM LEAVES, ROOTLETS OF ERICACEAE AND THEIR PEAT BY PYROLYSIS-HIGH-RESOLUTION GAS CHROMATOGRAPHY-MASS SPECTROMETRY.** A silicon from an oligotrophic peat and handpicked subfossil plant fragments from this peat were studied by pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS). The Py-GC-MS data consist of evaporation products of adsorbed compounds and a large number of pyrolysis products from remnants of the plant macromolecular systems. The Sphagnum pyrolysate consists mainly of compounds derived from polysaccharides, including anhydro sugars from xylose, mannose, galactose and glucose. Only a few phenolic compounds were observed in the peat moss sample. (Edited author abstract) 52 refs.

Van Smeerdijk, Dirk G. (FOM, Amsterdam, Neth); Boon, Jaap J. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 377-402.

**074828 QUANTITATIVE STRUCTURE-ACTIVITY RELATIONSHIPS USING HYDROPHOBICITY CONSTANTS MEASURED BY HIGH-PRESSURE LIQUID CHROMATOGRAPHY: A COMPARISON WITH OCTANOL-WATER PARTITION COEFFICIENTS.** Capacity ratios ( $k'$ ) for a set of small organic compounds of miscellaneous structure were measured under a variety of reversed-phase liquid chromatographic conditions. The capacity ratios from these experiments were correlated with the binding of these solutes to bovine serum albumin (BSA). Hydrophobic binding of small molecules to BSA is considered to be a nonspecific process (i.e., requiring no special orientation or restriction of movement of the solute molecules) and serves as a model for the hydrophobic binding of small molecules to other macromolecules, such as hemoglobin and ribonuclease. (Edited author abstract) 22 refs.

Minick, D.J. (Wellcome Research Lab, Research Triangle Park, NC, USA); Sabatka, J.J.; Brent, D.A. *J Liq Chromatogr* v 10 n 12 1987, Seventh Annu Res Triangle Park Liq Chromatogr Symp, Research Triangle Park, NC, USA, Oct 15 1987 p 2565-2589.

**074829 ISOMER-SPECIFIC SEPARATION AND QUANTITATION OF TETRACHLORODIBENZO-p-DIOXINS BY HRGC AND HRGC/MS.** A method is described for the determination of 22 tetrachlorodibenzo-p-dioxin isomers at the low part-per-trillion (ppt) level. High resolution, narrow bore, open tubular columns (OTCs) with 100  $\mu\text{m}$  i.d. can achieve better separations than presently used 320 or 250  $\mu\text{m}$  i.d. columns in about half the total time. Relative retention times and response factors for all 22 TCDD isomers are presented for the electron capture detection and for the molecular ion mass of individual isomers under electron impact ionization with selected ion monitoring (SIM). (Author abstract) 12 refs.

Onuska, F.I. (Nat'l Water Research Inst, Burlington, Ont, Can); Wilkinson, R.J.; Terry, K. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 11 n 1 Jan 1988, Eighth Int Symp on Capillary Chromatogr, Riva del Garda, Italy, May 19-21 1987 p 9-12.

**074830 SYNCHRONIZED TEMPERATURE/DENSITY PROGRAMMING IN CAPILLARY SUPERCRITICAL FLUID CHROMATOGRAPHY.** The theoretical and practical implications of simultaneous temperature/pressure and synchronized density/temperature programming are considered. Examples are shown for separations of dimethylpolysiloxanes where these tech-

niques provide superior separation over their analogous isothermal programming methods. From the theoretical considerations presented in this paper, it is evident that density, pressure and temperature influence separations performed by capillary SFC. The route by which these parameters effect the chromatographic process is through modulation of the diffusion properties of the mobile phase as expressed by the binary diffusion coefficient,  $D_m$ , terms of the Golay equation. 12 refs.

Later, D.W. (Lee Scientific Inc, Salt Lake City, UT, USA); Campbell, E.R.; Richter, B.E. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 11 n 1 Jan 1988, Eighth Int Symp on Capillary Chromatogr, Riva del Garda, Italy, May 19-21 1987 p 65-69.

**074831 CYCLODEXTRINS AND THEIR DERIVATIVES AS STATIONARY PHASES IN GC CAPILLARY COLUMNS.** In previous work the authors demonstrated application of the permethylated beta-CD as stationary phase in glass capillary columns. In this work, the authors report somewhat more extensive work; several original and derivatized CDs were tried as stationary phases, and the possibilities and limitations of the various types studied. 11 refs.

Alexander, G. (Hungarian Acad of Sciences, Budapest, Hung); Juvancz, Z.; Szejtli, J. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 11 n 1 Jan 1988, Eighth Int Symp on Capillary Chromatogr, Riva del Garda, Italy, May 19-21 1987 p 110-113.

**074832 HIGH PERFORMANCE MICROCOLUMN EXCLUSION CHROMATOGRAPHY OF PROTEINS AND PEPTIDES.** A new method for the determination of the molecular weight of proteins and peptides has been developed. It is based on micro-column exclusion chromatography in trifluoroacetic acid on silica gel sorbents of different porosities with a linear molecular-weight calibration dependence in the range of  $5 \times 10^2$  -  $7 \times 10^4$  Da. It was shown that in this eluent proteins and peptides adopt the random-coil conformation and do not undergo hydrolysis for 2-3 days at room temperature. (Author abstract) 7 refs.

Gankina, E.S. (Acad of Sciences of the USSR, Leningrad, USSR); Kever, J.J.; Kostuk, I.O.; Saminsky, A.E.; Belenki, B.G. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 11 n 1 Jan 1988, Eighth Int Symp on Capillary Chromatogr, Riva del Garda, Italy, May 19-21 1987 p 119-121.

## Coagulation

**074833 HETEROGENEOUS COAGULATION OF ORGANIC COLLOID AND POWDERED ACTIVATED CARBON.** For the treatment of wastewaters containing both dissolved and suspended organics, powdered activated carbon may well be applied to remove dissolved organics by adsorption, and suspended solid organics by heterogeneous coagulation, at the same time. The condition for this heterogeneous coagulation was studied here. First, control of surface charge of activated carbon by heat treatment was examined. It was found that it is possible to shift the surface charge of the powdered activated carbon in a positive direction. Secondly, heterogeneous coagulation of organic colloid by heat-treated carbon or carbon black was attempted. Coagulation was found to be successful. Stoichiometry of the coagulation was well explained by charge neutralization using surface charge density determined by colloid titration. (Author abstract) 6 refs.

Suzuki, Motoyuki (Univ of Tokyo, Tokyo, Jpn); Chihara, Kazuyuki. *Water Res* v 22 n 5 May 1988 p 627-633.

**Combustion** See COAL—Processing; FUELS—Combustion; HYDROCARBONS—Thermodynamics; POLY-VINYL CHLORIDE—Pyrolysis.

**Composition Effects** See COAL—Petrography; PEAT—Drying; PEAT—Geochemistry; SOILS—Sampling.



**Concentration** See POLYBUTADIENES—Physical Properties; SURFACE ACTIVE AGENTS—Solubility; ZINC ORE TREATMENT—Leaching.

**Control** See WATER TREATMENT PLANTS—By-products.

**Cooling** See CRYSTALS, LIQUID—Phase Transitions.

**Crystallization** See CRYSTALS—Design; DRUG PRODUCTION—Crystallization.

**Decomposition** See Also AGRICULTURAL WASTES—Processing; ELECTRIC DISCHARGES—Research; ETHANE—Pyrolysis; SOILS—Microbiology; SOILS—Sampling; WASTE UTILIZATION; WATER TREATMENT—Ozone.

**074834 DECAY OF m-CRESOL IN WATER BY OZONIZATION STUDIED BY MEANS OF ELECTRON TUNNELING.** In this paper we report a study of the decomposition of m-cresol in a 1% aqueous solution during ozonization. The results can be explained by the process that involves the gradual decomposition of m-cresol. In this process the benzene rings are damaged. The decomposition products clearly contain carboxylic acid or acids. Such a result would be expected in the decomposition of aqueous phenol and phenol-like solutions. 11 refs.

Czajka, Ryszard (Poznan Technical Univ, Poznan, Pol); Szuba, Stanislaw; Rauluszkiewicz, Jerzy. *Appl Spectrosc* v 41 n 7 Sep-Oct 1987 p 1254-1256.

**074835 THERMAL CONVERSIONS OF  $\alpha$ -PROPYLENE CHLOROHYDRIN.** The purpose of the authors' work was to determine the principal relationships of thermal decomposition of anhydrous PCH in the liquid phase. Preliminary experiments showed that appreciable decomposition of PCH begins only at 130°. Therefore thermal conversions of PCH were studied at higher temperatures than in the case of ethylene chlorohydrin in the range 140-170°. It is shown that acetone, 1-(1-chloroisopropoxy)-2-propanol, 2-chloro-1-propanol, hydrogen chloride, and 1,2-dichloropropane are formed during liquid-phase thermal decomposition of 1-chloro-2-propanol in the temperature range 140-170°. Isomerization of 1-chloro-2-propanol to 2-chloro-1-propanol is accelerated by the hydrogen chloride formed during its thermal decomposition. 10 refs.

Kolesnikov, V.A. (A.A. Zhdanov Polytechnic Inst, Gor'kii, USSR); Zil'berman, I.E.; Danov, S.M.; Eftremov, R.V. *J Appl Chem USSR* v 59 n 11 pt 2 Nov 1986 p 2384-2386.

**074836 STUDY ON THE REACTION MECHANISM OF THE DECOMPOSITION OF PEROXYACETYL NITRATE BY SPIN-TRAPPING METHOD.** Peroxyacetyl radical was directly observed in the thermal decomposition of peroxyacetyl nitrate in benzene by spin-trapping method using PBN and MNP. The rate constant of the decomposition of PAN was in a good agreement with the rate constant of the formation of peroxyacetyl radical. This result shows that the main path of the decomposition of PAN is via the formation of peroxyacetyl radical. (Author abstract) 6 refs. In Japanese.

Maeda, Yasuaki (Univ of Osaka Prefecture, Sakai, Jpn); Masaoka, Hitonari; Suetaka, Tohru; Munemori, Makoto. *Chem Express* v 2 n 10 Oct 1987 p 591-594.

**074837 EVIDENCE FOR RATE-DETERMINING C-C BOND HETEROLYSIS IN THE CONDENSED PHASE THERMAL DECOMPOSITION OF POLYNITROETHYL COMPOUNDS.** Thermal stability data for a number of cyanodinitroethyl compounds and some new trinitroethyl compounds are presented. Interpretation of this data in terms of the molecular structures present requires the assumption of a new mechanism for the thermal decomposition of such compounds, involving C-C rather than C-N bond scission. The scope of the new mechanism is discussed briefly. (Author abstract) 7 refs.

Adolph, Horst G. (US Naval Surface Weapons Cent,

Silver Spring, MD, USA). *Combust Flame* v 70 n 3 Dec 1987 p 343-347.

**074838 PHOTODECOMPOSITION OF N-ARYL N',N'-DIMETHYLUREA IN AQUEOUS SOLUTIONS.** The photodecomposition process of N-aryl-N',N'-dimethylurea was investigated in aqueous solutions in the presence of oxidizing and reducing additives. Quantum yields of photodecomposition of herbicides were found, and it was shown that monuron undergoes photoreduction more easily; the herbicide diuron is most easily oxidized. (Author abstract) 6 refs.

Svezhentsova, A.A.; Krasnova, V.A.; Vysotskaya, N.A. *Sov Prog Chem* v 53 n 2 1987 p 103-106.

**074839 PHOTODEGRADATION OF TRICHLOROETHYLENE IN MICROHETEROGENEOUS AQUEOUS SYSTEMS.** Hydrogen generated in situ from a water-splitting process was used to reduce trichloroethylene (TCE) to ethane in water. Two hundred and eighty-five  $\mu$ mol of TCE were reduced to less than 8.96  $\mu$ mol within 12 hours of irradiation in a platinum catalyzed water-photolysis system. Zinc was added to the system to enhance the degradation rate. The degradation of 285  $\mu$ mol TCE was completed within 2 and 5 hours with 2 and 1 g. of zinc added, respectively. The hydrogen molecule is not an effective reactive reagent for the degradation of TCE. By the addition of a catalyst such as platinum particle, the hydrogen molecule may be transformed into active hydrogen atoms or the metal bonded hydride form. The hydrogen atoms are then able to reduce TCE to hydrocarbons. (Author abstract) 15 refs.

Wang, T.C. (Harbor Branch Oceanographic Inst Inc, Fort Pierce, FL, USA); Tan, C.K. *Environ Int* v 13 n 4-5 1987 p 359-362.

**074840 KINETICS OF THERMAL DECOMPOSITION OF DI-TERT-BUTYL PEROXALATE IN THE PRESENCE OF SILOCHROME.** It was found that the thermal decomposition of di-tert-butyl peroxalate in a solution in carbon tetrachloride is catalyzed by silochrome. Equations are proposed for homogeneous and nonhomogeneous surfaces of the catalyst, linking the effective rate constant of the decomposition of di-tert-butyl peroxalate with the rate constants of spontaneous decomposition of the peroxide, and of the catalytic decomposition in an adsorbed state. A higher correlation of the experimental data with the model of a nonhomogeneous surface of the catalyst has been established. (Author abstract) 6 refs.

Dodonov, V.A. (Gor'kii State Univ, USSR); Dregich', A.I.; Grigor'ev, A.V. *Kinet Catal* v 28 n 2 pt 2 Mar-Apr 1987 p 429-431.

**074841 GENERATION AND LOSS OF RADICALS FROM THE DECOMPOSITION OF METHYL IODIDE, DIALLYL, AND BUTYL HALIDES ON A SILVER CATALYST.** The stages of the generation of the loss of various radicals in the decomposition of methyl iodide, diallyl and butyl halides have been studied in the presence of oxygen on Ag/pumice. Effective energies of activation for generation of these radicals have been calculated. It has been found that heterogeneously catalyzed decomposition of these compounds begins on the silver surface at low temperatures (400-590 K) and is accompanied by desorption of the radicals from the surface of the catalyst to the gas phase. (Edited author abstract) 9 refs.

Garibyan, T.A. (Acad of Sciences of the Armenian SSR, Erevan, USSR); Grigoryan, R.R.; Muradyan, A.A.; Nalbandyan, A.B. *Kinet Catal* v 28 n 3 pt 2 May-Jun 1987 p 638-640.

**074842 THERMAL DECOMPOSITION OF ENERGETIC MATERIALS 27. SYNTHESIS, CHARACTERIZATION, AND THERMOLYSIS OF Cu(II)-DOPED 'BLUE RDX'.** A Cu(II) complex was incorporated in RDX with copper at about the 400 ppm level giving distinctly blue crystals of RDX. Despite exhaustive attempts to determine the identity of the Cu(II)

species, we were able to conclude only that RDX or an RDX fragment is present in the coordination sphere of the metal. By DSC copper-doped RDX exhibits a small exotherm at 175°C which is below the decomposition temperature of pure RDX. By using high-rate thermolysis and rapid-scan FTIR spectroscopy we found that copper-doped RDX liberates more N<sub>2</sub>O and CH<sub>2</sub>O and less NO<sub>2</sub> than does pure RDX suggesting that, consistent with the DSC data, the extent of condensed phase chemistry is enhanced when the lattice is doped with this Cu(II) species. (Author abstract) 18 refs.

Palopoli, Stephen F. (Univ of Delaware, Newark, DE, USA); Brill, Thomas B. *Combust Flame* v 72 n 2 May 1988 p 153-158.

**074843 DECOMPOSITION OF 1-PHENYLETHYL HYDROPEROXIDE BY METHYL(PYRIDINE)-BIS(DIMETHYLGLYOXIMATE)-COBALT(III).** The decomposition of 1-phenylethyl hydroperoxide (HROOH) catalyzed by methylcobaloxime (Co(III)) at 70°C has been investigated in oxygen-free chlorobenzene-acetonitrile solvent. A simple mechanism has been suggested which describes the kinetics of the overall reaction and explains (i) the linear dependence of the maximal decomposition rate of the hydroperoxide on the initial substrate concentration, (ii) the relation between  $d[\text{Co(III)}]/dt$  and  $[\text{HROOH}]_0$ , as well as between  $(d[\text{HROOH}]/dt)_{\text{max}}$  and  $[\text{Co(III)}]_0$ , observed experimentally. Deactivation of the catalytically active species takes place with participation of the hydroperoxide. (Edited author abstract) 11 refs.

Hajdu, I.P. (Hungarian Acad of Sciences, Budapest, Hung); Vetchinkina, V.N.; Lukacs, J.; Gal, D. *J Mol Catal* v 45 n 1 Apr 1988 p 17-23.

**074844 THERMAL DECOMPOSITION OF CYCLOHEXANE AT APPROXIMATELY 810°C.** In order to determine the behavior of cycloparaffins in steam cracking reactions, a study of the thermal decomposition of cyclohexane in the presence of n-decane has been carried out at ca. 810°C by using the technique of plug flow reactor. Cyclohexane chiefly decomposes into ethylene, hydrogen, 1,3-butadiene, and small amounts of cyclohexene. We propose a primary mechanism of the decomposition of cyclohexane initiated by n-decane. This mechanism leads to three main primary stoichiometries which account for the whole range of reaction products. (Author abstract) 45 refs.

Billaud, F. (CNRS, Nancy, Fr); Chaverot, P.; Berthelin, M.; Freund, E. *Ind Eng Chem Res* v 27 n 5 May 1988 p 759-764.

**074845 'REAL' SINGLE CRYSTALS OF THE ORGANIC CONDUCTOR (FLUORANTHENE)<sub>2</sub> PF<sub>6</sub>: AN N.M.R. STUDY.** A report is presented on extensive n.m.r. investigations of the quasi-one-dimensional organic conductor (fluoranthene)<sub>2</sub>PF<sub>6</sub>. N.m.r. signatures of sample aging and decomposition were established. The authors analyzed the frequency dependence of proton spin-lattice relaxation of individual, well-characterized single crystals. These data could be described quantitatively based on parameters that were independently derived earlier. It is concluded that the intrinsic anisotropy of the conduction electron scattering times  $\tau_{1\parallel}/\tau_{1\perp}$  for (fluoranthene)<sub>2</sub>PF<sub>6</sub> must be larger than  $3 \times 10^4$ , i.e., more than one order of magnitude larger than for TTF-TCNQ and its derivatives. (Edited author abstract) 19 Refs.

Sachs, Gunter (Univ Bayreuth, Bayreuth, West Ger); Dormann, Elmar. *Synth Met* v 25 n 2 Aug 1988 p 157-170.

**074846 KINETICS OF DECOMPOSITION OF HCHO, HCOOH, CH<sub>3</sub>OH, AND N<sub>2</sub>H<sub>4</sub> ON Pt AND Rh SURFACES.** The decomposition kinetics of formaldehyde, formic acid, methanol, and hydrazine on polycrystalline Pt and Rh wires are examined and compared in a differential flow reactor for reactant pressures between



0.02 and 1.0 Torr and temperatures between 400 and 1800 K. HCHO decomposes mostly to CO and H<sub>2</sub> with less than 2% CH<sub>4</sub> formed. Formic acid decomposes CO, CO<sub>2</sub>, H<sub>2</sub>, and H<sub>2</sub>O with identical rates of CO and CO<sub>2</sub> formation on both metals. Methanol decomposes primarily to CO and H<sub>2</sub> although a few percent of HCHO and traces of CH<sub>4</sub> and H<sub>2</sub>O are also formed. Hydrazine decomposes to N<sub>2</sub>, NH<sub>3</sub>, and H<sub>2</sub>. Below 800 K rates of nitrogen and ammonia formation are comparable, while nitrogen predominates above 800 K. It is shown that all rates of formation can be fit quantitatively with simple Langmuir-Hinshelwood (LH) unimolecular rate expressions with an accuracy of  $\pm 30\%$ . These reactions are compared with decomposition of NO, N<sub>2</sub>O, NO<sub>2</sub>, and NH<sub>3</sub>, which were reported previously. (Edited author abstract) 32 refs.

Papapolymerou, G.A. (Univ of Minnesota, Minneapolis, MN, USA); Schmidt, L.D. *Langmuir* v 3 n 6 Nov-Dec 1987 p 1098-1102.

**074847 DECOMPOSITION OF METHANOL, ACETALDEHYDE, AND ACETONE ON SUPPORTED RHODIUM CATALYSTS.** The decomposition processes for methanol, acetaldehyde, and acetone over supported rhodium catalytic films have been investigated by infrared spectroscopy. An interesting support effect was observed for methanol decomposition with methane being the primary product over Rh/TiO<sub>2</sub> and dimethyl ether being formed over Rh/Al<sub>2</sub>O<sub>3</sub>. In the latter case the Al<sub>2</sub>O<sub>3</sub> support was the active catalyst. For acetaldehyde decomposition the principal products were methane and acetone for both supported rhodium catalysts. Acetone decomposition produced only inactive carbon with no other infrared-detectable surface species. It is possible that a metallic rhodium gem-dicarbonyl adsorbate was produced during the decomposition of acetaldehyde over Rh/Al<sub>2</sub>O<sub>3</sub>. Previous observations of the rhodium gem-dicarbonyl species have referred to dispersed Rh<sup>+</sup> ions. (Author abstract) 22 refs.

Dai, C.H. (Auburn Univ, Auburn, AL, USA); Worley, S.D. *Langmuir* v 4 n 2 Mar-Apr 1988, Mol Process at Solid Surf: Spectrosc of Intermed and Adsorbate Interact, Denver, CO, USA, Apr 6-8, 1987 p 326-329.

**Degradation** See Also AGRICULTURAL WASTES—Degradation; COAL HYDROGENATION.

**074848 BIOLOGICKA ROZLOZITELNOST AROMATICKYCH SLOZENIN.** [Biological Degradability of Aromatic Compounds]. Reasons for the differences in biodegradability of benzene derivatives are discussed on the basis of own and literature data. The relationship between structure and biodegradability is discussed from the point of view of electronic and steric effects and also in connection with the type, position, and number of substituents on the benzene ring. (Author abstract) In Czech. 16 refs.

Pitter, Pavel (Vysoka Skola Chemickotechnologicka, Prague, Czech). *Chem Prum* v 37 n 7 1987 p 374-377.

## Dehalogenation

**074849 ACCELERATED DEBROMINATION OF BIPHENYLS BY PHOTOLYSIS WITH SODIUM BOROHYDRIDE.** The photochemical debromination of a series of bromobiphenyls was examined in the presence and absence of sodium borohydride. In both cases the photoreduction proceeded cleanly to give the corresponding debrominated biphenyls, but the photolyses in the presence of borohydride were accelerated up to a 100-fold. A free radical chain mechanism is involved. (Author abstract) 10 refs.

Epling, Gary A. (Univ of Connecticut, Storrs, CT, USA); McVicar, William; Kumar, Anil. *Chemosphere* v 16 n 5 1987 p 1013-1020.

## Dehydration

**074850 PREPARATION AND DEHYDRATION OF 1-BENZYLCLYCICCARBINOLS.** In this study, the

dehydration products of some 1-Benzylcycliccarbinols were obtained by using H<sub>3</sub>PO<sub>4</sub> in toluene. The products were identified with GLC and NMR and the results were listed. One of the used Benzylcycliccarbinols (1-Benzylcycloclodecanol) is made first in this work. (Author abstract) 3 refs.

Gunaydin, Keriman (Istanbul Technical Univ, Istanbul, Turk); Oymen, Ulku. *Bull Tech Univ Istanbul* v 38 n 3 1985 p 329-332.

**Dehydrogenation** See Also CATALYSTS—Materials; CATALYSTS—Rhodium Compounds; HYDROCARBONS—Reforming; HYDROGEN—Adsorption.

**074851 CATALYTIC DEHYDROGENATION OF CYCLOHEXENE ON SILICA OVERLAYER FILMS.** The preparation of noble-metal catalysts resistant to poisoning is a possibility opened up by the following experiment: On SiO<sub>2</sub>/Pt/Si layer catalysts (shown schematically below) in the presence of H<sub>2</sub>, cyclohexene undergoes reaction to give benzene and cyclohexane. The same is true when Pt/Si catalysts are used except that the activity is lower by a factor of 100. SiO<sub>2</sub> overlayers of 0 to 30 nm lower the activity exponentially, after which the value remains constant up to 2200 nm. The results indicate that, instead of the transition-metal surface, 'active hydrogen' (atomic hydrogen) is the true catalytic species. (Author abstract) 14 refs.

Cogen, Jeffrey M. (Univ of California, Berkeley, CA, USA); Ezaz-Nikpay, Khosro; Fleming, Ronald H.; Baumann, Scott M.; Maier, Wilhelm F. *Angew Chem (Int Ed Engl)* v 26 n 11 Nov 1987 p 1182-1184.

## Desorption

**074852 DYNAMICS OF DESORPTION OF CYANOCOBALAMIN FROM MACROPOROUS STYRENE-DIVINYLBENZENE COPOLYMER AND FROM THE CARBOXYLIC CATION-EXCHANGERS SG-1 AND KMT.** In this paper we report the results of studies of desorption of cyanocobalamin from macroporous styrene-divinylbenzene copolymer and from SG-1 and KMT carboxylic cation-exchangers in relation to the grain size of the sorbent, flow rate of the eluant, and the height of the sorbent bed in the column. Cyanocobalamin was desorbed from the macroporous copolymer by percolation in a column of the usual type by dilute solutions of an organic solvent in sorbent beds of various heights and at various eluant flow rates. The results were presented in the form of breakthrough curves for the dependence of the cyanocobalamin concentration in the eluate fractions on the volume of solution passed. Study of the influence of the grain size of the sorbent on desorption of cyanocobalamin from the macroporous copolymer showed that the effectiveness of the process increases substantially with decrease of the grain size. 8 refs.

Bogdanova, M.E. (Leningrad Inst of Pharmaceutical Chemistry, USSR); Momot, N.N. *J Appl Chem USSR* v 59 n 11 pt 2 Nov 1986 p 2406-2409.

**074853 DESORPTION OF BENZOPHENONE OXIME MONOLAYERS AT THE AIR/WATER INTERFACE.** The interfacial behavior of 2-hydroxy-5-nonylbenzophenone oxime (HBPO) at the air/water interface has been investigated with Langmuir trough techniques. The dissolution kinetics of HBPO followed a diffusion-controlled model from which the aqueous solubility of HBPO was estimated. Because of deprotonation of the hydroxyoxime group, the aqueous solubility of HBPO was pH dependent. At pH 2.0, the solubility was 0.1  $\mu\text{mole dm}^{-3}$  and increased to 4.0  $\mu\text{mole dm}^{-3}$  at pH 12. From the influence of pH on the dissolution rate, the surface pK<sub>a</sub> for HBPO was estimated to be 11.5. At surface pressures greater than the equilibrium spreading pressure of HBPO (23 mN m<sup>-1</sup>), simultaneous dissolution and monolayer collapse were observed. (Author abstract) 38 refs.

Chaiko, D.J. (Pennsylvania State Univ, University Park, PA, USA); Osseo-Asare, K. *J Colloid Interface Sci* v 121 n 1 Jan 1988 p 13-21.

**074854 DESORPTION OF ETHYL ACETATE**

**FROM ACTIVATED CARBON BY SUPERCRITICAL CARBON DIOXIDE.** The regeneration of activated carbon loaded with ethyl acetate by supercritical carbon dioxide was investigated in this study. It was found that the adsorption capacities after several regeneration cycles were still close to that of virgin carbon and remained stable. The effects of temperature, pressure, and flow rate on regeneration efficiency were also investigated. Regeneration was more favorable at higher pressures, but optimal temperatures were found to depend on pressure. A one-parameter mathematical model assuming linear desorption kinetics was proposed which agreed well with the experimental data. (Author abstract) 11 refs.

Tan, Chung-Sung (Nat'l Tsing Hua Univ, Hsinchu, Taiwan); Liou, Din-Chung. *Ind Eng Chem Res* v 27 n 6 Jun 1988 p 988-991.

**Desulfurization** See Also CATALYSTS—Cobalt; IRON COMPOUNDS.

**074855 THIOPHENE ON Si(111)2x1: SYNCHRONTRON RADIATION STUDY OF A DESULFURIZATION PROCESS.** The adsorption and desulfurization of thiophene on cleaved silicon was studied at different temperatures. For substrate temperatures of 60-85 K, we found the co-existence of two different adsorption states at low exposures, which yield to a condensed thiophene multilayer at high exposures. For room-temperature substrates, we observed a desulfurization process. The process is probably followed by further fragmentation, and the fragmentation path depends on the substrate preparation process. (Author abstract) 14 refs.

Pincastelli, M.N. (Univ of Rome, Rome, Italy); Zanonì, R.; Kelly, M.K.; Kilday, D.G.; Chang, Y.; McKinley, J.T.; Margaritondo, G.; Perfetti, P.; Quaresima, C.; Capozzi, M. *Solid State Commun* v 63 n 2 Jul 1987 p 85-89.

## Dielectric Properties

**074856 EXPERIMENTAL INVESTIGATION ON PYROELECTRIC PROPERTIES OF m-NITROANILINE CRYSTALS (m-NA).** Experimental studies of dielectric constant, ac- and dc-conductivity, loss angle tangent, pyroelectric coefficient in the o-orientation, P-E curve, transparency and other relevant properties of the organic m-Nitroaniline crystal are presented. (Author abstract) In Chinese. 4 refs.

Shi, Zikang (Acad Sinica, China); Huang, Gongfan; Su, Genbo. *Hongwai Yanjiu A-JI* v 6 n 5 1987 p 395-398.

**Diffusion** See Also POLYELECTROLYTES—Chemical Reactions.

**074857 BIDIRECTIONAL COUPLED DIFFUSION OF GLYCINE DRIVEN BY pH GRADIENTS.** Stokes magnetically-stirred diaphragm cells have been used to determine multicomponent diffusion coefficients for aqueous glycine + hydrochloric acid + sodium hydroxide solutions at 25°C. In acidic solutions, pH gradients drive coupled flows of glycine toward the low-pH region of the solution, countercurrent to the flow of H<sup>+</sup> ions. In alkaline solutions, the coupled flow of glycine travels in the opposite direction, 'up' the pH gradient. The diffusion measurements also show that gradients in concentration of glycine can produce large coupled flows of H<sup>+</sup> and OH<sup>-</sup> ions. Equations are developed to predict multicomponent transport coefficients for glycine and related ampholytes in acid-base solutions. (Author abstract) 19 refs.

Leaist, Derek G. (Univ of Eastern Ontario, London, Ont, Can). *Ber Bunsenges Phys Chem* v 91 n 10 Oct 1987 p 1059-1064.



**074858 BINARY GASEOUS DIFFUSION COEFFICIENTS. 7. TETRACHLOROETHENE AND 1,1,1-TRICHLOROETHANE WITH METHANE AND TETRAFLUOROMETHANE AT 100 kPa AND 283-343 K.** Binary gaseous diffusion coefficients  $D_{12}$  for tetrachloroethene diffusing in methane and tetrafluoroethane and for 1,1,1-trichloroethane diffusing in tetrafluoroethane were measured at about 283, 298, 313, 328, and 343 K and at 100 kPa by the capillary-tube method of Stefan. In addition,  $D_{12}$  for tetrachloroethane in methane and in tetrafluoroethane were determined at 283 and 298 K, respectively. The experimental results are compared with diffusion coefficients calculated via the first-order Chapman-Enskog approximation. For the gases, effective Lennard-Jones [6, 12] pair potential parameters were taken from recent literature; for the heavy chlorinated hydrocarbons the parameters were obtained from semitheoretical extended-corresponding-states correlations. Agreement is satisfactory throughout. (Author abstract) 31 refs.

Tominaga, Toshihiro (Okayama Univ of Science, Okayama, Jpn); Park, Tracy; Rettich, Timothy R.; Battino, Rubin; Wilhelm, Emmerich. *J Chem Eng Data* v 33 n 4 Oct 1988 p 479-481.

## Distillation

**074859 ANALYSIS OF THE DISTILLATION RESIDUE FROM DITOLYLEMETHANE COOLANT.** Ditolylemethane (DTM) is used in heat exchangers as a transmitting liquid. DTM is subject to radiolysis, pyrolysis, and oxidation, and carbonaceous deposits appear on the transfer surfaces, which shorten the working life. The components capable of forming deposits in the transmitting surfaces in the core have been identified and the optimum purification technology has been selected from measurements on the compositions of the high-molecular and non-volatile products from DTM. These substances are usually identified by liquid chromatography and molecular spectroscopy, where the mixtures are first separated into fractions having simple compositions. Here the authors give methods of separating the residue into narrow fractions and determination of the main components of these by IR spectroscopy and liquid adsorption chromatography at high pressures. 15 refs.

Nevaeva, V.E.; Sokolov, E.I.; Tebelev, L.G. *Sov At Energy* v 63 n 3 Sep 1987 p 676-680.

## Doping See NICKEL COMPOUNDS—Electric Properties.

**Electric Conductivity** See Also CRYSTALS—Electric Conductivity; ELECTRIC CONDUCTORS—Electric Conductivity; MOLECULAR CRYSTALS—Electric Conductivity; POLYMERS—Conductivity; SALTS—Electric Properties; SALTS—X-Ray Analysis; SUPERCONDUCTING MATERIALS—Physical Properties; SUPERCONDUCTING MATERIALS—Pressure Effects; SUPERCONDUCTING MATERIALS—Transport Properties.

**074860 POSSIBLE DEVIL'S STAIRCASE IN TTF-CHLORANIL AT THE NEUTRAL-IONIC TRANSITION OBSERVED BY ELECTRIC CONDUCTIVITY MEASUREMENTS.** The electric conductivity of TTF-Chloranil single crystals of different origins has been measured close to the quasi-neutral of quasi-ionic transition. Assuming the results as intrinsic properties of TTF-CA, a devil's staircase behavior has been evidenced at the N-I transition in a small temperature range. (Author abstract) 30 refs.

Bartholin, H. (Univ de Toulon, La Garde, Fr); Baudour, J.L.; Breandon, C.; Tchepoutian, R.; Cailleau, H.; Perrin, D. *Solid State Commun* v 63 n 3 Jul 1987 p 223-225.

**074861 EFFECT OF DISORDER ON THE CONDUCTION ELECTRON SPIN RESONANCE LINEWIDTH OF THE  $\alpha$  AND  $\beta$  PHASES OF (BEDT-TTF) $_2$ I $_3$ .** We present the electron spin resonance linewidth of  $\alpha$  and  $\beta$  phases of the organic conductor di-bis (ethylenedithiolo) tetrathiafulvalene dtriiodide [(BEDT-TTF) $_2$ I $_3$ ] disordered by fast electron irradiation. In the high temperature metallic phase the linewidth decreases in both phases with defect concentration in

contrast to the predictions of the Elliott mechanism for spin relaxation in metals. (Author abstract) 14 refs.

Forro, L. (Section d'Etude des Solides Irradies, Fontenay-aux-Roses, Fr); Schweitzer, D.; Keller, H. *Solid State Commun* v 64 n 5 Nov 1987 p 771-774.

**074862 FORMATION OF INTERMOLECULAR CHARGE-TRANSFER COMPLEXES BETWEEN TETRAAMINOANTHRAQUINONE AND ACCEPTORS.** The intermolecular charge-transfer complexes are interesting in their high electrical conductivity as "organic metals" and superconductivity materials, and in their third optical nonlinearity. Intermolecular charge-transfer complexes composed of equimolecular amounts of 1,4,5,8-tetraaminoanthraquinone and several acceptors were isolated, and their characteristics such as spectroscopic properties and electrical conductivity were determined. 8 refs.

Matsuoka, Masaru (Univ of Osaka Prefecture, Sakai, Jpn); Han, Liyuan; Oka, Hidetaka; Kitao, Teijiro. *Chem Express* v 3 n 8 Aug 1988 p 491-494.

**074863 VERY SHORT MEAN FREE PATH IN ORGANIC METALS.** Organic metals exhibit relatively high resistivity at ambient temperature and the mean free path  $l$  may be less than the molecular spacing. In one-dimensional metals like TTF-TCNQ, TMTSF $_2$ X, and even doped polyacetylene, a symmetry argument prevents linear coupling between the low-frequency librations and the electrons. In the two-dimensional organic metal NBEDT-TTF $_2$ I $_3$  linear coupling with the librations is possible, resulting in much greater resistivity. A very strong coupling with a very soft phonon of frequency meV has been observed experimentally. The conductivity of the metallic state can be considerably less than N.F. Mott's minimum value, because of interband scattering. (Author abstract) 30 refs.

Weger, M. (Hebrew Univ, Jerusalem, Isr). *Philos Mag B* v 56 n 6 Dec 1987, Second Bar-Ilan Conf on the Phys of Disordered Syst, Ramat-Gan, Isr, Jan 5-7 1987 p 889-899.

**Electric Properties** See Also ELECTRIC CONDUCTORS—Transport Properties.

**074864 ORGANIC  $\pi$ -ELECTRON METAL SYSTEM WITH INTERACTION THROUGH MIXED-VALENCE METAL CATION: ELECTRONIC AND STRUCTURAL PROPERTIES OF RADICAL SALTS OF DICYANO-QUINODIIMINE, (DM $_2$ DCNQI) $_2$ Cu AND (MeCl-DCNQI) $_2$ Cu.** The structural and electrical properties of new radical anion salts of dicyanoquinodimimine derivatives have been investigated (R $_1$ R $_2$ -DCNQI) $_2$ M (R $_1$ , R $_2$  = CH $_3$ , Cl, M = Cu). The Cu atom is coordinated in tetrahedral fashion to the N atoms of N-cyano groups. The molecular stacking of DCNQI molecules and the temperature dependence of the resistivity suggest that the electronic structure of the system is one-dimensional. X-Ray diffraction experiments and XPS revealed the formal oxidation state of copper is Cu $^{+1.3}$ . This may be the first evidence of the molecular metal, having the mixed-valent transition metal atom interacting with  $\pi$  conduction band of organic molecules. The electronic structures of these systems were examined by the tight-binding band calculation to elucidate the relation between the mixed-valent state of Cu and the instability of the metallic state. (Author abstract) 8 refs.

Kobayashi, A. (Univ of Tokyo, Tokyo, Jpn); Kato, R.; Kobayashi, H.; Mori, T.; Inokuchi, H. *Solid State Commun* v 64 n 1 Oct 1987 p 45-51.

**074865 CONDUCTING POLYMERS FROM 3,4-DISUBSTITUTED POLYPYRROLES.** Pyrrole derivatives, which were substituted in the 3,4-position by a fused alkyl ring have been synthesized and their electrochemical and electrical properties have been investigated. Compounds with a five, six, seven and twelve membered ring fused to the pyrrole moiety were obtained by means of a 3+2 cycloaddition of tosylmethylisocyanide to an  $\alpha$ ,  $\beta$ -unsaturated ketone. Electrooxidation in acetonitrile/tetrabutylammonium perchlorate led to the deposition of

brittle, black, conducting polymer films on the anode, which could be reversibly reduced and reoxidized. The polypyrrole derivative containing the twelve membered ring showed a strong frequency dependence of the conductivity at 100 K. (Edited author abstract) 13 refs.

Ruehe, J. (Max-Planck-Institut fuer Polymerforschung, Mainz, West Ger); Kroehnke, C.; Ezquerro, T.A.; Kremer, F.; Wegner, G. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem, of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 885-888.

**074866 IN SITU OBSERVATION OF A PHASE TRANSFORMATION IN  $\alpha$ -(BEDT-TTF) $_2$ I $_3$  USING A CONTACTLESS TECHNIQUE.** We describe a novel apparatus for contactless measurement of the conductivity of small platelet-shaped charge transfer crystals from above room temperature down to helium temperatures. This technique is employed to study the temperature dependence of the conductivity in the quasi two-dimensional organic conductor  $\alpha$ -(BEDT-TTF) $_2$ I $_3$  both in its pristine form and after annealing at 360 K. The low temperature behavior is found to change from insulating (metal-to-insulator transition at 135 K) to metallic. (Author abstract) 13 refs.

Spaeth, K. (Walther-Meissner-Institut, Garching, West Ger); Gross, F.; Heidmann, C.P.; Andres, K. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem, of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 909-911.

## Electrochemistry

**074867 ELECTROCHEMICAL BEHAVIOUR OF POTASSIUM FERRICYANIDE, HYDROQUINONE, CATECHOL AND p-AMINOPHENOL AT POLYPYRROLE FILM ELECTRODES.** The electrochemical behavior of potassium ferricyanide, hydroquinone, catechol and p-aminophenol was investigated on a polypyrrole (PPy) film electrode in H $_2$ SO $_4$  electrolyte solution. The voltammograms of these electroactive materials at the PPy film electrode are not controlled by the doping and redoping processes of electrolytes, but by mass transfer or reaction, and their electrochemical reversibility increases to a certain extent on the PPy film electrode compared with that on platinum electrodes. The experiment implies that the PPy film functions as the electron transfer medium in the electrode reaction process of the materials; in this case, PPy acts as both a mediator and an electron conductor. (Author abstract) 19 refs.

Dong, Shaojun (Chinese Acad of Sciences, Changchun, China); Ding, Jie. *Synth Met* v 24 n 4 Jun 1988 p 273-281.

**Electronic Properties** See Also FILMS—Optical Properties; HYDROCARBONS—Electronic Properties; POLYMERS—Electronic Properties.

**074868 ORGANIC MATERIALS IN RELATION WITH ELECTRONICS.** It is now estimated that there are 3 million or 6 million kinds of organic substances. They have been found out to show wide properties from insulating to superconducting until quite recently. In spite of those various properties, there are few organic materials used for electronics. The present article considers the properties and structures of organic molecules, van der Waals and coulomb force interactions between the molecules, structures and properties of molecular crystals, molecular electronics and electronics of organic materials, material design and comparison between organic and inorganic substances. In Japanese. 216 refs.

Anzai, H. *Denshi Gijutsu Sogo Kenkyusho Iho* v 51 n 11 1987 p 825-882.

**074869 NEW EFFECT FOR THE ORGANIC CONDUCTORS: THE NEGATIVE MAGNETORESISTANCE IN SALT OF THE (DMTTF) $_2$ X SERIES.** We have studied the electronic properties of a recent series of organic conductors: the (DMTTF) $_2$ X, with X being anions such as PF $_6$ , AsF $_6$ , BF $_4$ , ClO $_4$ , by magnetotran-



sport up to 40 T and down to 2 K. We observed the stability of the metallic state in the whole field and temperature range explored, and discovered, for the first time in the field of organic conductors, effects of negative magnetoresistance. (Author abstract). 11 Refs.

Ulmet, J.P. (CNRS, Toulouse, Fr); Bachere, L.; Askenasy, S. *Solid State Commun* v 67 n 2 Jul 1988 p 145-149.

**074870 ELECTRON DONORS AND CYANOIMIDAZOLE ACCEPTORS: CYCLIC VOLTANNETRY AND MOLECULAR ORBITAL STUDY.** Voltammetric measurements on a series of cyanoimidazoles and their metal complexes are reported and compared with those for various donors and acceptors measured under the same conditions. LUMO (Lowest Unoccupied Molecular Orbitals) energies from extended Huckel calculations correlate well with reduction potentials of cyanoimidazoles. Extended Huckel calculations also give insights into the interaction of the metal complexes of tetracyanoimidazole and the nature of molecular stacking. (Edited author abstract). 41 Refs.

Allan, David S. (Univ of Michigan, Ann Arbor, MI, USA); Bergstrom, Debora F.; Rasmussen, Paul G. *Synth Met* v 25 n 2 Aug 1988 p 139-155.

**Encapsulation** See POLYMERS—Chemical Reactions.

**Environmental Impact** See Also AIR POLLUTION—Analysis; AIR POLLUTION—Indoor; ATMOSPHERIC COMPOSITION—Chemical Reactions; CONTAINERS—Heating; MARINE BIOLOGY; WATER POLLUTION—Analysis; WATER POLLUTION—Marine Pollution; WATER POLLUTION—Monitoring.

**074871 POLYCHLORINATED DIBENZOFURANS AND DIBENZO-p-DIOXINS AND OTHER CHLORINATED CONTAMINANTS IN COW MILK FROM VARIOUS LOCATIONS IN SWITZERLAND.** Six samples of cow milk from various locations in Switzerland were analyzed for polychlorinated dibenzofurans (PCDFs), polychlorinated dibenzo-p-dioxins (PCDDs), and other chlorinated contaminants. Sub parts per trillion levels of 2,3,7,8-substituted PCDFs and PCDDs were found in all samples. The levels were higher in samples collected in the vicinity of incinerators. Non-2,3,7,8-substituted PCDDs and PCDFs were not found in the milk samples. (Author abstract) 21 refs.

Rappe, Christoffer (Univ of Umea, Umea, Swed); Nygren, Martin; Lindstrom, Gunilla; Buser, Hans Rudolf; Blaser, Otto; Wuethrich, Claude. *Environ Sci Technol* v 21 n 10 Oct 1987 p 964-970.

**074872 COMPARISON OF THE RESIDUE LEVELS OF SOME ORGANOCHLORINE COMPOUNDS IN BREAST MILK OF THE GENERAL AND INDIGENOUS CANADIAN POPULATIONS.** Numerous studies have shown polychlorinated biphenyls (PCB) and other organochlorine residues to be present in mothers' milk of the general Canadian population, but there has been little work done with respect to Canada's native population. A small survey was therefore undertaken to determine organochlorine residues in breastmilk of Canadian Indian and Inuit mothers. Analyses were conducted for 14 individual isomers of PCBs, photo-mirex, four hexachlorocyclohexane isomers, heptachlor epoxide, dieldrin, oxychlorodane,  $\alpha$ - and  $\gamma$ -chlorodane, trans-nonachlor, four analogs of DDT and five isomers of chlorobenzenes. The results were compared to those of the national survey. 6 refs.

Davies, D. (Health & Welfare Canada, Ottawa, Ont, Can); Mes, J. *Bull Environ Contam Toxicol* v 39 n 5 Nov 1987 p 743-749.

**074873 CONCENTRATIONS OF DDT, PCBs, HCB, AND HCH ISOMERS IN THE LIVER AND ADIPOSE TISSUE OF NEWBORN MICE RECEIVING AN EXTRACT OF HUMAN MILK.** Persistent organic chlorine compounds, such as DDT and its metabolites, hexachlorobenzene (HCB) and polychlorinated biphenyls (PCBs) circulate in the food chain of the ecosystems. The purpose of the present study was to investigate the degree

of accumulation of these compounds in the liver and adipose tissue after long-standing feeding them with an extract of human milk with added organic chlorine compounds in doses received by human newborns with milk. In the assessment of the relationship between the degree of accumulation of various compounds in the tissues of newborn mice and the daily dose concentrations were used similar to those found in human milk. 8 refs.

Sitarska, Ewa (Agricultural Acad, Warsaw, Pol); Gorski, Tadeusz; Ludwicki, Jan K. *Bull Environ Contam Toxicol* v 39 n 5 Nov 1987 p 756-761.

**074874 FIELD STUDY OF THE URINARY EXCRETION OF ETHOXYACETIC ACID DURING REPEATED DAILY EXPOSURE TO THE ETHYL ETHER OF ETHYLENE GLYCOL AND THE ETHYL ETHER OF ETHYLENE GLYCOL ACETATE.** The urinary excretion of ethoxyacetic acid (EAA) was studied in a group of five women daily exposed to the ethyl ether of ethylene glycol (EGEE) and the ethyl ether of ethylene glycol acetate (EGEE-Ac) during 5 d of normal production and 7 d after a 12-d production stop. The mean combined exposure concentration of EGEE and EGEE-Ac (expressed in equivalent weight of EGEE) was 14.0 mg/m<sup>3</sup> with occasional slight excursions above the current Belgian occupational exposure limit. The daily combined exposure profiles for EGEE and EGEE-Ac were rather constant during the first observation period, but they tended to decrease during the last week. The urinary EAA excretion clearly increased during the work week. Over the weekends the elimination was far from complete. Additional study results are discussed. (Edited author abstract) 15 refs.

Veulemans, Hendrik (KU Leuven, Leuven, Belg); Groeseneken, Dominique; Masschelein, Raphael; Van Vlem, Eduard. *Scand J Work, Environ Health* v 13 n 3 June 1987 p 239-242.

**074875 HUMAN EXPOSURE TO VOLATILE ORGANIC COMPOUNDS IN HOUSEHOLD TAP WATER: THE INDOOR INHALATION PATHWAY.** This paper addresses the quantification of human exposure to volatile organic compounds (VOC's) as a result of mass transfer from tap water to indoor air. A three-compartment model is developed and used to simulate the 24-h concentration profile within the shower, bathroom, and remaining household volumes of a dwelling. Mass transfers from water to air are derived from measured data for radon and adjusted to account for the difference in mass-transfer properties for VOC's. A preliminary data base for household parameters is used to calculate a range of concentrations and human exposures in U.S. dwellings. The model is used to estimate exposure factors for seven compounds - chloroform, ethylene dibromide, dibromochloropropane, methylchloroform, perchloroethylene, trichloroethylene, and carbon tetrachloride. (Edited author abstract) 21 refs.

McKone, Thomas E. (Lawrence Livermore Natl Lab, Livermore, CA, USA). *Environ Sci Technol* v 21 n 12 Dec 1987 p 1194-1201.

**074876 NEW SOLVENT-RECOVERY TECHNOLOGY.** The Environmental Protection Agency's EPA's volatile-organic-compound emission standards are becoming stiffer, and smaller sources are expected to come under increasing scrutiny. This article reviews conventional removal processes. It also describes a new system that recovers a wide variety of organic compounds, including single and mixed solvents, at high levels of collection efficiencies.

Ehrler, A.J. (Ceilcote Co, Berea, OH, USA). *Plast Compd* v 10 n 7 Nov-Dec 1987 p 36-37, 40, 42.

**074877 BIOCONCENTRATION OF ORGANICS IN BEEF, MILK, AND VEGETATION.** Biotransfer factors for organic chemicals in beef and milk were found to be directly proportional to octanol-water partition coefficients, while bioconcentration factors for vegetation were inversely proportional to the square root of octanol-water partition coefficients. (Author abstract) 68

refs.

Travis, Curtis C. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Arms, Angela D. *Environ Sci Technol* v 22 n 3 Mar 1988 p 271-274.

**074878 EVALUATION OF POTENTIAL MECHANISMS GOVERNING DIOXIN CONGENER PROFILES IN SOILS NEAR COMBUSTION SOURCES.** Non isomer-specific photochemical attack and thermal equilibration are identified as plausible dioxin removal mechanisms from the surface of flyash. A first-order congener ratio decay model is used to generate tentative removal rates that range from 41 h<sup>-1</sup> for T<sub>4</sub>CDD/OCDD to 5 h<sup>-1</sup> for H<sub>7</sub>CDD/OCDD. These rates may be compared against predictions of candidate removal mechanisms. Differential settling of particulates of various sizes may also contribute to the shift in congener ratios observed in the vicinity of combustion sources, and it is likely that a combination of processes should be considered in future work. (Edited author abstract) 27 refs.

Edulee, G.H. (Rechem Int Ltd, Southampton, Engl); Townsend, D.I. *Chemosphere* v 16 n 5 1987 p 1095-1104.

**074879 CHLORINATED DIOXINS AND DIBENZOFURANS IN PERSPECTIVE (PAPERS PRESENTED AT THE 189TH NATIONAL MEETING OF THE AMERICAN CHEMICAL SOCIETY).** This conference proceedings contains 37 papers which are organized into six sections with the following areas of interest: human exposure; incineration emissions; soil contamination; bioassays; analytical methods; and synthesis and destruction. Some of the topics discussed by the papers are here cited as examples; chlorinated dioxin and dibenzofuran levels in human adipose tissues from exposed and control populations; thermal combustion of octachlorodibenzofuran to form lower PCDFs; solubility of 2,3,7,8-TCDD in contaminated soils; studies on the molecular basis of TCDD-caused changes in proteins associated with the liver plasma membrane; dioxin residues in fish and other foods; mathematical and statistical methods in modeling the Seveso dioxin episode; preparation of dioxin standards for chemical analysis; and destruction of dioxin-containing wastes in a mobile incinerator system. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11077 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Rappe, Christoffer (Ed.) (Univ of Umea, Umea, Swed); Choudhary, Gangadhar (Ed.); Keith, Lawrence H. (Ed.). *Chlorinated Dioxins and Dibenzofurans in Perspective, Miami Beach, FL, USA, Sep 1985* Publ by Lewis Publ Inc, Chelsea, MI, USA, 1986 570p.

**Environmental Testing** See Also AIR POLLUTION—Analysis; AIR POLLUTION—Environmental Testing; AIR POLLUTION—Indoor; AIR POLLUTION—Japan; ICE—Environmental Testing; RAIN AND RAINFALL—Bermuda; SNOW AND SNOWFALL—Environmental Impact; SOIL POLLUTION—Analysis; WATER POLLUTION—Analysis.

**074880 ISOMER-SPECIFIC DETERMINATION OF POLYCHLORINATED DIBENZO-p-DIOXINS AND DIBENZOFURANS IN INCINERATOR-RELATED ENVIRONMENTAL SAMPLES.** Polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) ranging from tetra- to octachloro congeners in ash and fly ash from incinerators, river water, effluent water from incinerators, groundwater, soil, and sediment were determined isomer specifically by high-resolution gas chromatography-mass spectrometry in order to manifest an environmental situation polluted with those compounds in Japan. The most toxic 2,3,7,8-tetrachlorodibenzo-p-dioxin was detected only in fly ash. In many samples, octachlorodibenzo-p-dioxin had the highest abundance in PCDDs, and heptachlorodibenzofurans had the highest abundance in PCDFs. Gas chromatography-mass spectrometry was used to identify the



graphic patterns of PCDDs and PCDFs in all samples were compared with each other, and results are discussed. (Edited author abstract) 33 refs.

Yasuhara, Akio (Nat'l Inst for Environmental Studies, Tsukuba, Jpn); Ito, Hiroyasu; Morita, Masatoshi. *Environ Sci Technol* v 21 n 10 Oct 1987 p 971-979.

**074881 MUTAGENIC ACTIVITY OF PARTICULATE ORGANIC MATTER COLLECTED WITH A DILUTION SAMPLER AT COAL-FIRED POWER PLANTS.** Stack and ambient samples of particulate matter were collected with a dilution sampler at three coal-fired power plants in West Virginia. Samples were sequentially extracted with cyclohexane (CX), dichloromethane (DCM) and acetone (ACE) and tested for mutagenicity in the Ames Salmonella/microsome assay using TA98 (-S9). The cyclohexane- and dichloromethane-soluble fractions of the stack samples from all locations exhibited mutagenicity when tested in the plate incorporation assay. No significant response was observed with the acetone fraction. When tested with Kado's modification of the preincubation assay, the acetone-soluble fraction did exhibit mutagenic activity comparable to that of the other fractions when expressed in units of revertants per milligram of particulate matter. Chemical analyses of one of the acetone-soluble fractions indicated that half of the mass was sulfuric acid while the remainder consisted of C, H and O. Additional aspects of the study are discussed. (Edited author abstract) 39 refs.

Souza, J.A. (New York Univ Medical Cent, New York, NY, USA); Houck, J.E.; Cooper, J.A.; Daisey, J.M. *JAPCA* v 37 n 12 Dec 1987 p 1439-1444.

**074882 PERFORMANCE AUDIT RESULTS FOR VOLATILE POHC MEASUREMENTS.** Audit materials containing principal organic hazardous constituents (POHCs) have been developed by EPA for use by federal, state, and local agencies or their contractors to assess the accuracy of measurement methods used during RCRA trial burn tests. Audit materials are currently available for 27 gaseous organics in five, six, seven, and nine-component mixtures at parts-per-billion levels in compressed gas cylinders in a balance gas of nitrogen. Subsequent to completion of the stability studies, 89 performance audits have been conducted with the audit materials to assess the accuracy of the Volatile Organic Sampling Train (VOST) and bag measurement methods during or prior to RCRA trial burn tests. A summary of the audits conducted for each POHC and the measurement system audited is shown in this paper. (Edited author abstract) 5 refs.

Jayanty, R.K.M. (Research Triangle Inst, Research Triangle Park, NC, USA); Von Lehmden, D.J. *JAPCA* v 38 n 6 Jun 1988 p 823-827.

**074883 SEASONAL AND TEMPORAL CHANGES OF ORGANIC COMPOUNDS IN RAIN AND SNOW.** Alkylbenzenes, polycyclic aromatic hydrocarbons and chlorinated hydrocarbons were determined in rain and snow collected during 1985 at an urban site in Switzerland. Although great variations in concentrations were found for each season and type of precipitation event, concentrations and wet depositions of the investigated compounds were significantly lower in summer than in winter precipitation. Snow contained the highest concentrations of alkylbenzenes, i.e. total concentrations of up to  $10 \mu\text{g l}^{-1}$ . Non-polar organic chemicals, measured sequentially during three rain events, exhibited a variety of temporal trends which can best be explained by changing sources and moving air masses. (Author abstract) 25 refs.

Czuczwa, Jean (Swiss Federal Inst of Water Resources and Water Pollution Control, Dübendorf, Switz); Leuenberger, Christian; Giger, Walter. *Atmos Environ* v 22 n 5 1988 p 907-916.

**074884 DEVELOPMENT AND EVALUATION OF A NOVEL GAS AND PARTICLE SAMPLER FOR SEMIVOLATILE CHLORINATED ORGANIC COMPOUNDS IN AMBIENT AIR.** A prototype annular diffusion denuder inlet has been adapted to a dichot-

mous sampler for the collection of organic compounds which occur in both the gas and particulate phase. The inlet selectivity removes and efficiently preconcentrates atmospheric vapor-phase components by molecular diffusion prior to the collection of the particulate phase (coarse and fine fractions) by filtration. Backup adsorbent cartridges collect any vapor-phase constituents which might volatilize from the collected particulate matter and submicron particles which might penetrate the filter media. Special techniques were developed for coating the annular denuder with solid adsorbents. Laboratory tests with lindane and hexachlorobenzene have demonstrated better than 98 percent trapping efficiency over a 24-h sampling period at contaminant concentrations representative of ambient air and under most simulated atmospheric conditions. (Author abstract) 36 refs.

Lane, Douglas A. (Environment Canada, Downsview, Ont, Can); Johnson, N. Douglas; Barton, Sydney C.; Thomas, Gordon H.S.; Schroeder, William H. *Environ Sci Technol* v 22 n 8 Aug 1988 p 941-947.

## Esterification

**074885 INFLUENCE OF REACTION CONDITIONS ON MAIN AND SIDE REACTIONS DURING THE TRANSESTERIFICATION OF DIMETHYL TEREPHTHALATE WITH 1, 4-BUTANEDIOL.** The transesterification of dimethyl terephthalate (DMT) with 1, 4-butanediol (BD) has been studied by measuring the amount of methanol and tetrahydrofuran formed during the reaction. Investigation of various catalyst systems revealed that titanium isopropoxide was a better catalyst than conventional transesterification catalysts such as manganese and cobalt acetates. Increases in the temperature, BD/DMT ratio, and catalyst concentration led to higher production of methanol. (Edited author abstract) 4 refs.

Yurramendi, L. (Univ del Pais Vasco, San Sebastian, Spain); Barandiaran, M.J.; Asua, J.M. *J Macromol Sci Chem* v A24 n 11 Nov 1987 p 1357-1367.

## Etching

**074886 Ar<sup>+</sup> PLASMA ETCHING OF PALMITIC ACID MULTILAYERS: DIFFERENTIAL EROSION RATES OF EXPOSED AND PROTECTED LAYERS.** The degree of spatial resolution obtainable by ion etching was examined by analyzing palmitic acid multilayers, of the type originally described by Langmuir and Blodgett, after erosion in a low-energy Ar<sup>+</sup> plasma. Etching of multilayers revealed that the rate of loss (by sputtering) of the reference bilayer depended critically on the number of protecting, nonradioactive layers. More protection was afforded by four than by two bilayers and more by two than by one. Similar experiments involving multilayers containing a reference (radioactive) monolayer revealed significant protection when the reference layer was covered by a single palmitic acid monolayer. Chemical analysis after etching of exposed and covered bilayers demonstrated that a single bilayer was able to protect a reference layer from significant covalent chemical damage by the Ar<sup>+</sup>-beam. Together the results indicate that plasma etching techniques may be employed to resolve structures in biological materials if they are separated by distances comparable to one to two palmitic acid monolayers. (Edited author abstract) 15 refs.

Newcomb, William W. (Univ of Virginia Medical Cent, Charlottesville, VA, USA); Johnston, Troy A.; Brown, Jay C. *Langmuir* v 3 n 6 Nov-Dec 1987 p 1000-1004.

## Evaluation

**074887 COMPUTATIONAL EVALUATION AND COMPARISON OF SOME NITRAMINE PROPERTIES.** A computational study of six nitramines, R<sub>1</sub>R<sub>2</sub>NNO<sub>2</sub>, has been carried out with the objective of gaining a better understanding of how the properties of the NNO<sub>2</sub> group are affected by the natures of R<sub>1</sub> and R<sub>2</sub>. An ab initio SCF procedure was used, with the initial step being the determination of each molecule's optimized geometry. This was subsequently used to compute its bond orders,

dipole moment, and electrostatic potential. In most instances, the NNO<sub>2</sub> portions of the molecules are planar, due to the strong electron-withdrawing effect of the nitro group; the amino-type nitrogen can better respond to this when in a planar configuration. (Edited author abstract) 31 refs.

Politzer, Peter (Univ of New Orleans, New Orleans, LA, USA); Sukumar, Nagamani; Jayasuriya, Keerthi; Ranganathan, Shoba. *J Am Chem Soc* v 110 n 11 May 25 1988 p 3425-3430.

**Evaporation** See SEWAGE TREATMENT PLANTS—Environmental Testing; WATER ANALYSIS; WATER TREATMENT—Chemicals Removal.

**Extraction** See Also AGRICULTURAL WASTES—Processing; DRUG PRODUCTS—Antibiotics; EXTRACTION; FOOD PRODUCTS—Fruits; RAIN AND RAINFALL—Sampling; SOILS—Chemical Analysis.

**074888 ORGANICS IN WATER: SOLID PHASE EXTRACTION ON A SMALL SCALE.** Octadecyl (C-18) bonded to porous silica has been evaluated for the solid-phase extraction (SPE) of organic compounds from water. Excellent performance was deduced from average recovery of >85% for pesticides and polycyclic organic materials present in contrived water samples at 1-10 ng/mL. Extraction results showed effective performance of the SPE when 1-100 mL of water was passed through small columns containing 40-100 mg of 40- $\mu\text{m}$  C-18 bonded porous silica at flow rates as high as 250 bed volumes/min. (Edited author abstract) 23 refs.

Junk, G.A. (USDOE, Ames, IA, USA); Richard, J.J. *Anal Chem* v 60 n 5 Mar 1 1988 p 451-454.

**074889 EXTRACTION OF RESORCINOL BY SULFOXIDES.** Extraction by alcohols has received the greatest amount of attention [2-7]. Information on the extraction of resorcinol by neutral organophosphorus extractants is scanty, and there have been no reports of the extraction of resorcinol by sulfoxides. The authors have examined the extraction of resorcinol by sulfoxides, and obtained information on the mechanism of extraction. It is shown that sulfoxides are efficient extractants for resorcinol. It is found that under the conditions of extraction by sulfoxides a nonhydrated disolvate and a monosolvate-monohydrate of resorcinol are formed. 13 refs.

Egutkin, N.L.; Malaya, I.P.; Nikitin, Yu.E. *J Appl Chem USSR* v 59 n 6 1 Jun 1986 p 1193-1196.

**074890 NEW APPROACH TO THE EXTRACTION OF PROSTAGLANDINS 6-KETO-F<sub>1</sub>  $\alpha$ , F<sub>2</sub>  $\alpha$ , E<sub>2</sub>, AND E<sub>1</sub> FROM GASTRIC MUCOSA WITH QUANTITATIVE ANALYSIS BY REVERSE PHASE LIQUID CHROMATOGRAPHY.** A simple and reliable method is presented for the extraction of Prostaglandins 6-Keto-F<sub>1</sub>  $\alpha$ , F<sub>2</sub>  $\alpha$ , E<sub>2</sub> and E<sub>1</sub> from gastric mucosa with quantitation by Reverse Phase Liquid Chromatography. Extraction is accomplished without the need for the harsh chemicals normally associated with tissue extraction. The efficiency of prostaglandin extraction is demonstrated utilizing radiolabeled prostaglandins. Quantitation of these compounds is compared to measurement by radioimmunoassay. (Author abstract) 13 refs.

Palm, C.D. (Univ of Texas Health Science Cent, San Antonio, TX, USA); Levine, B.A. *J Liq Chromatogr* v 11 n 4 1988 p 811-826.

**074891 FLUORESCENCE QUENCHING AND COPPER COMPLEXATION BY A CHESTNUT LEAF LITTER EXTRACT: SPECTROSCOPIC EVIDENCE.** Fluorescence quenching on addition of Cu(II) to aqueous solutions of chestnut (*Castanea sativa* L.) leaf litter extract (LLE) has been interpreted previously in terms of Cu complexation by LLE organic ligands. In order to provide direct evidence for the existence of these complexes, as well as information about their coordination structures, infrared (IR) and electron spin resonance



(ESR) spectroscopy were applied to investigate Cu/LLE mixtures that showed increasing fluorescence quenching with increasing pH. The Cu/LLE mixtures were prepared with approximately equimolar concentrations of Cu and LLE binding sites (200 mmol m<sup>-3</sup>) at pH values in the range 4 to 7. The IR spectra indicated the existence of Cu complexes involving carboxylate groups, even at pH 4. (Edited author abstract) 19 refs.

Sposito, Garrison (Univ of California, Riverside, CA, USA); Senesi, Nicola; Holtzclaw, Kenneth M. *Soil Sci Soc Am J* v 52 n 3 May-Jun 1988 p 632-636.

**074892 THE EXTRACTION BY N,N'-TETRAHYDROGLUTARAMIDES. I. HNO<sub>3</sub> AND OTHER INORGANIC ACIDS EXTRACTION.** Extraction of HNO<sub>3</sub> into 0.5M TBGA ((C<sub>4</sub>H<sub>9</sub>)<sub>2</sub>NCO(CH<sub>2</sub>)<sub>3</sub>CON(C<sub>4</sub>H<sub>9</sub>)<sub>2</sub>) toluene takes place via the formation of the following species: (TBGA)<sub>2</sub>HNO<sub>3</sub>, TBGA HNO<sub>3</sub> and TBGA(HNO<sub>3</sub>)<sub>2</sub> for which extraction constants values: 0.74 ± 0.04, 0.50 ± 0.02 and 0.032 ± 0.002 have been found. Water does not play a role in this extraction. IR investigations show that only one of the two C = O of TBGA is bonded to HNO<sub>3</sub>. (Edited author abstract). 10 Refs.

Charbonnel, M.C. (CEN, Fontenay-Aux-Roses, Fr); Musikas, C. *Solvent Extr Ion Exch* v 6 n 3 1988 p 461-478.

**074893 SUPERCRITICAL EXTRACTION OF CROTALARIA SPECTABILIS IN THE CROSS-OVER REGION.** Previous experimental results indicated that a single-stage supercritical extraction process could not be used to isolate monocrotaline since the lipid material is always extracted with the monocrotaline. A study was conducted to examine the feasibility of isolating pure monocrotaline from a complex extract using cross-over phenomena. It differs from the work of E.H. Chimowitz and K.J. Pennisi in that the solute is a multicomponent system consisting of the polar monocrotaline and a series of nonpolar lipids. It is shown that utilization of the temperature-solubility cross-over region exhibited by solutes in supercritical fluids is a promising isolation technique in multicomponent separations. However, when the substrate is a complex biological material consisting of a large number of components, multiple separations may be necessary to isolate pure components. 3 refs.

Schaeffer, Steven T. (Georgia Inst of Technology, Atlanta, GA, USA); Zalkow, Leon H.; Teja, Aryn S. *AIChE J* v 34 n 10 Oct 1988 p 1740-1742.

**074894 PERVAPORATION: IMPORTANCE OF CONCENTRATION POLARIZATION IN THE EXTRACTION OF TRACE ORGANICS FROM WATER.** The extraction of trichloroethylene in dilute aqueous solutions by pervaporation was studied using silicone tubing as a membrane. In this process, the feed water solution flows over the surface of the membrane while a portion of the solution, enriched in contaminant, is transported through the membrane and emerges as vapor. The vapor is then condensed in a cold trap. The aqueous feed solution was fed through the fiber bores of a hollow fiber membrane module. Analysis at the inlet and the outlet of the bundle was performed with a gas chromatograph using an electron capture detector. The reduction in contaminant level at outlet of the module was evaluated as a function of different inlet feed concentrations and axial Reynolds numbers. (Edited author abstract) 13 refs.

Psaume, R. (INSA, Toulouse, Fr); Aptel, Ph.; Aurelle, Y.; Mora, J.C.; Bersillon, J.L. *J Membr Sci* v 36 Mar 1988, Fifth Int Symp on Synth Membr in Sci and Ind, Sel Pap, Tuebingen, West Ger, Sep 2-5 1986 p 373-384.

**Fermentation** See SEWAGE TREATMENT—Sludge Digestion.

**Films** See ELECTRODES, ELECTROCHEMICAL—Coatings.

## Flammability

**074895 APPLICATION DU PROGRAMME CHETAH A L'ETUDE DE LSA SENSIBILISATION DE COMPOSES OXYGENES ET A L'ESTIMATION DES LIMITES INFERIEURES D, DINFLAMMABILITE.** [Application of the CHETAH Program to the Study of Sensitization of Oxygenated Compounds and to the Estimation of Lower Limits of Inflammability]. The use of an appropriate (K) parameter, resulting from the ponderation of four energy hazard potential criteria of the CHETAH program, enables to study more easily a reactive chemical system with multiple components. Moreover, this parameter provides a satisfactory estimation of lower limits of inflammability of organic compounds mixed with air. (Author abstract). 9 Refs. In French.

Ducros, M. (Ecole Natl Supérieure de Techniques Avancées, Palaiseau, France); Sannier, H. *J Hazard Mater* v 19 n 1 Jul 1988 p 33-49.

**Forming** See Also CATALYSTS—Aluminum Compounds; CHEMICAL EQUIPMENT—Reactors; OLEFINS—Forming; POLYSTYRENES—Oxidation.

**074896 KINETICS OF FORMATION OF METHANE AND ETHANE GAS HYDRATES.** An intrinsic kinetic model with only one adjustable parameter is proposed for the formation of methane and ethane gas hydrates. Experimental formation data were obtained in a semi-batch stirred tank reactor. The experiments were conducted at four temperatures from 274 to 282 K and at pressures ranging from 0.636 to 8.903 MPa. The kinetic model is based on the crystallization theory, while the two-film theory model is adopted for the interfacial mass transfer. Experiments were performed at various stirring rates to define the kinetic regime. The study reveals that the formation rate is proportional to the difference in the fugacity of the dissolved gas and the three-phase equilibrium fugacity at the experimental temperature. This difference defines the driving force which incorporates the pressure effects. (Edited author abstract) 24 refs.

Englezos, P. (Univ of Calgary, Calgary, Alberta, Can); Kalogerakis, N.; Dholabhai, P.D.; Bishnoi, P.R. *Chem Eng Sci* v 42 n 11 1987 p 2647-2658.

**074897 KINETICS OF GAS HYDRATE FORMATION FROM MIXTURES OF METHANE AND ETHANE.** Experimental data on the kinetics of formation of gas hydrates from three mixtures of gaseous methane and ethane are reported. The experiments were conducted in a semi-batch stirred tank reactor at temperatures from 273 to 284 K and of pressures from 0.68 to 5.60 MPa. An intrinsic kinetic model for the growth of the gas hydrate is proposed. It is extension of the model for pure component hydrate formation. The model is based on the crystallization theory coupled with the two-film theory for the gas absorption into the liquid phase. The model does not contain any adjustable parameters. The kinetic rate constants which appear in the model are those obtained previously from pure component formation data. The results indicate that the formation rate is proportional to a linear combination of the differences in the fugacities of the dissolved gases and their three-phase equilibrium fugacities at the experimental temperature. (Edited author abstract) 27 refs.

Englezos, P. (Univ of Calgary, Calgary, Alberta, Can); Kalogerakis, N.; Dholabhai, P.D.; Bishnoi, P.R. *Chem Eng Sci* v 42 n 11 1987 p 2659-2666.

**074898 DIOXINS SOURCES, COMBUSTION THEORIES AND EFFECTS.** The author explains what dioxins (PCDDs) and the closely related furans (PCDFs) are, their dangers, where they are principally found and how they can be controlled. Of particular concern are the emissions from incinerator plants, especially those burning household, industrial and clinical waste. It is shown that from a regulatory viewpoint, greater attention must be directed towards the standardisation of methods used for sampling and analysis of gaseous and particulate emissions, especially when relating the results obtained to

the incinerator operation. (Edited author abstract) 13 refs.

Oakland, D. (London Scientific Services, Engl). *Filtr Sep* v 25 n 1 Jan-Feb 1988 p 39-41.

**074899 FORMATION OF 2-ETHYL ACRYLEIN BY GAS PHASE ALDOL CONDENSATION.** The gas phase aldol condensation between n-butyraldehyde and formaldehyde to give 2-ethyl acrolein, CH<sub>2</sub>=C(C<sub>2</sub>H<sub>5</sub>)-CHO, over a silica supported tungsten oxide catalyst, by feeding formaldehyde as hemiformal or trioxane, over a wide range of operating conditions has been studied. A maximum selectivity of about 95% to 2-ethyl acrolein based on n-butyraldehyde at 275-300°C, by using a feeding molar ratio of formaldehyde (supplied as hemiformal) to n-butyraldehyde of about 2 to 1, with 50% n-butyraldehyde conversion, was found. The reaction studied could provide a viable alternative to the usual liquid phase process for the synthesis of 2-ethyl acrolein. (Author abstract) 22 refs.

Albanesi, Giancarlo (Parma Univ, Parma, Italy); Moggi, Pietro. *Appl Catal* v 37 n 1-2 Feb 15 1988 p 315-322.

**074900 FORMATION OF HCN AND ACETYLENE OLIGOMERS BY PHOTOLYSIS OF AMMONIA IN THE PRESENCE OF ACETYLENE: APPLICATIONS TO THE ATMOSPHERIC CHEMISTRY OF JUPITER.** HCN is formed by the photolysis of ammonia in the presence of acetylene at room temperature. There is a 70% decrease in the yield of HCN when the temperature is lowered to 178 K and two new reaction products, acetonitrile and acetaldehyde ethylenedihydrazide (6), are formed. Photolysis of 6 yields acetonitrile, and the hydrogen atom initiated decomposition of acetonitrile yields HCN. Aziridine, a predicted reaction intermediate, was not detected at 298 or 178 K. Oligomers of acetylene are also formed. Oligomers formed by the photolysis of ammonia in the presence of acetylene were shown by Fourier transform infrared spectroscopy to contain NH groupings and to differ from those produced by the direct photolysis of acetylene. The possible role of these photochemical processes on the formation of HCN and chromophores on Jupiter, Titan, and comets is discussed. (Author abstract) 70 refs.

Ferris, James P. (Rensselaer Polytechnic Inst, Troy, NY, USA); Ishikawa, Yoji. *J Am Chem Soc* v 110 n 13 Jun 22 1988 p 4306-4312.

**074901 FORMATION OF ANISOTROPIC MESOPHASE OF PHOSPHATIDYLCHOLINE IN ALKANE/ WATER SYSTEM BY THE ACTION OF ELECTRIC FIELD.** The formation of a phosphatidylcholine anisotropic mesophase in n-heptane induced by the action of weak electric fields has been observed. It is shown that the produced phase is homogeneous and differs in refractive index from the environmental solution. The phase bears a close resemblance to a gel. With the electric field switched-off, the gel is no longer retained in the interelectrode space and is seen to deposit on the immiscible liquid interface and to gradually dissipate therefrom. (Edited author abstract). 10 Refs.

Shchipunov, Yrii A. (Acad of Sciences of the USSR, Vladivostok, USSR); Kolpakov, Alexander F. *J Dispersion Sci Technol* v 9 n 3 Jun 1988 p 259-267.

**Geochemistry** See PEAT—Geochemistry.

## Grafting

**074902 GRAFTING OF MALEIC ANHYDRIDE TO n-EICOSANE.** Maleic anhydride was grafted to the linear hydrocarbon, n-eicosane, at 165°C in the presence of the free radical initiator, 2,5-dimethyl-2,5-di(t-butylperoxy)-3-hexyne. The anhydride has a low solubility in eicosane and a multiple addition procedure was adopted. Grafted product which separated from the reaction mixture was fractionated and analyzed. The fractions contained on average 2-5.5 anhydride units/eicosane residue. <sup>1</sup>H- and <sup>13</sup>C-NMR studies show that the grafts consist of single succinic anhydride rings. At the concentrations of maleic anhydride chosen for homogeneous reaction (<0.02 M) and at 165°C, poly(maleic anhydride) is above its ceiling



temperature, so that succinic anhydride radicals cannot add maleic anhydride to form polymer side chains. (Edited author abstract). 11 refs.

Russell, K.E. (Queen's Univ, Kingston, Ont, Can); Kelsky, E.C. *J Polym Sci Part A* v 26 n 8 Aug 5 1988 p 2273-2280.

**Grain Size and Shape** See EXPLOSIVES—Detonation.

**Grinding** See COAL—Heating; COAL—Mechanical Properties.

**Halogenation** See FLUORINE CONTAINING POLYMERS—Chemical Reactions.

**Health Hazards** See LEAD COMPOUNDS—Health Hazards.

**Hydration** See Also CATALYSTS—Materials; ZEOLITES—Physical Properties.

**074903 HYDRATION OF p-ALKOXY- $\alpha$ - $\alpha$ -TRIFLUOROACETOPHENONE AND WATER ACTIVITY AT A MICELLAR SURFACE.** Equilibrium hydration of p-methoxy- $\alpha$ - $\alpha$ -trifluoroacetophenone (MTFA) in water and anionic micelles of sodium dodecyl sulfate (SDS) has been followed by  $^{19}\text{F}$  NMR and UV spectrometry. Comparison of hydration equilibria obtained by UV and NMR measurements provides a test of the assumptions about extinction coefficients which are involved in the estimation of hydration equilibria by UV spectrometry. Attainment of hydration equilibria can be followed by UV spectrometry without making assumptions regarding extinction coefficients. We also examined hydration in aqueous MeCN and compared effects of micelles and organic solvents. (Edited author abstract) 14 refs.

Angell, Alida D. (Univ of Perugia, Perugia, Italy); Cipiciani, Antonio; Germani, Raimondo; Savelli, Gianfranco; Cerichelli, Giorgio; Bunton, Clifford A. *J Colloid Interface Sci* v 121 n 1 Jan 1988 p 42-48.

**Hydrocracking** See ZEOLITES—Synthesis.

**Hydrogenation** See Also ACIDS—Hydrogenation; CATALYSTS; CATALYSTS—Manufacture; CATALYSTS—Selectivity; CATALYSTS—Spectroscopic Analysis.

**074904 REACTION ANALYSIS OF CATALYTIC HYDROGENATION OF 1,4-BUTYNE-2,3-DIOL.** The hydrogenation of 1,4-butyne-2,3-diol over Raney nickel catalyst for butynediol synthesis has been investigated. The optimum operating conditions with proper catalyst concentrations, agitation intensities, hydrogen pressures and reaction temperature sequences have been verified under the guidance of the basic reaction engineering principles. It has been proved that the reaction rates and the selectives are greatly influenced by the concentration of hydrogen on catalyst surface. (Author abstract) 8 refs. In Chinese.

Zhu, Yumin (UNILAB Research Cent of Chemical Reaction Engineering, China); Gu, Chungen; Zhao, Jingling; Gu, Qiwei. *Huaxue Fanying Gongcheng Yu Gongyi* v 1 n 4 1985 p 18-24.

**074905 COPPER-CATALYZED DECHLORINATION/HYDROGENATION OF POLYCHLORINATED DIBENZO-P-DIOXINS, POLYCHLORINATED DIBENZOFURANS, AND OTHER CHLORINATED AROMATIC COMPOUNDS.** The recent discovery that fly ash samples from different waste incineration facilities catalyze a dechlorination/hydrogenation of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) at temperatures below 300°C prompted the authors to test metals and metal oxides for such a catalytic activity. Copper was found to catalyze the dechlorination/hydrogenation of octaCDD and octaCDF at low temperatures, leading either to mixtures of chlorinated dibenzodioxin or dibenzofuran congeners or to the disappearance of PCDD or PCDF below limits of detection. The time dependence and temperature dependence of the copper-catalyzed dechlori-

nation of octaCDD and octaCDF were studied in detail, and results are discussed. Polychlorinated biphenyls (PCBs) and chlorobenzenes as well as brominated dibenzo-p-dioxins and brominated dibenzofurans were found to undergo decomposition in the presence of copper powder. (Edited author abstract) 7 refs.

Hagenmaier, Hanspaul (Univ of Tuebingen, Tuebingen, West Ger); Brunner, Hermann; Haag, Roland; Kraft, Michael. *Environ Sci Technol* v 21 n 11 Nov 1987 p 1085-1088.

**074906 HYDROGENATION OF ANILINE IN PRESENCE OF  $\text{Ru}(\text{OH})\text{Cl}_3$ .** Hydrogenation of aniline in the presence of  $\text{Ru}(\text{OH})\text{Cl}_3$  was carried out without preliminary saturation of the catalyst with hydrogen. The solvent, ruthenium salt, aniline, and oxide (if added) were put into the reaction vessel simultaneously. Experimental evidence indicates that during hydrogenation of aniline in the presence of  $\text{Ru}(\text{OH})\text{Cl}_3$  the reaction order with respect to hydrogen decreases from close to 1 to zero with increase of pressure to 10 MPa. The reaction order with respect to the substrate is fractional. The total apparent activation energy is 66.1 kJ/mole and remains unchanged with increase of the hydrogen pressure from 2 to 8 Pa. Conversion of aniline is complete; the catalyze consists of a mixture of only two products, cyclohexylamine and cyclohexanol. The cyclohexylamine yield increases with increase of the hydrogen pressure from 2 to 10 MPa, and of the temperature from 363 to 393 K. The catalyst obtained from  $\text{Ru}(\text{OH})\text{Cl}_3$  is more stable in the course of the reaction than metallic or supported catalysts prepared by the usual methods. 4 refs.

Sokol'skii, D.V. (Acad of Sciences of the Kazakh SSR, USSR); Ualikhanova, A.; Temirbulatova, A.E. *J Appl Chem USSR* v 59 n 7 pt 2 Jul 1986 p 1530-1533.

**074907 CORRELATION OF RATES OF ALKENE HYDROGENATION CATALYZED BY RHODIUM COMPLEXES.** The application of linear free energy relationships (LFER) to rate and equilibrium data of organic reactions yields important information on the mechanism and allows prediction of the reactivity of related compounds. It has been shown that the LFER are useful also in the field of heterogeneous catalysis. As substituent parameters for the LFER, the  $\sigma$  constants for polar effects and various constants for steric effects have been tested; their numerical values were taken from a critical compilation. The most successful correlation, based on standard steric  $E_s$  constants, is given. It confirms quantitatively and specifies the qualitative conclusion of the authors that the predominant structural influence upon reactivity is steric hindrance. All the correlations mentioned establish a link between homogeneous and heterogeneous catalysis; the common features of alkene hydrogenation are thus manifested. 10 refs.

Kraus, M. (Czechoslovak Acad of Sciences, Prague, Czech). *J Mol Catal* v 43 n 1 Nov 2 1987 p 27-29.

**074908 INFLUENCE OF CONDITIONS ON THE ELECTROCATALYTIC HYDROGENATION OF ORGANIC MOLECULES.** The electrocatalytic hydrogenation of several functional groups has been studied at high surface area nickel, palladium, platinum and rhodium cathodes in methanol as a function of pH and current density. It is demonstrated that syntheses may be designed where good current efficiency and selectivity are possible at reasonable current densities and that the product can depend both on the choice of cathode metal and the solution conditions. (Author abstract) 17 refs.

Casadei, M. Antonietta (Univ La Sapienza, Rome, Italy); Pletcher, D. *Electrochim Acta* v 33 n 1 Jan 1988 p 117-120.

**074909 SPECIFICITY OF THE CATALYTIC ACTION OF Pt AND Ni IN THE HYDROGENATION OF p-BENZOQUINONE.** It was shown for the first time that in the presence of Ni and Pt, p-benzoquinone is hydrogenated with the formation not only of hydroquinone but also of 1,4-cyclohexanediol. The rate of formation of 1,4-cyclohexanediol is approximately 1/20 of the

rate of formation of hydroquinone. Small additions of alkali (0.001 M) to the reaction system lead to a change in the selectivity of the process on Pt; the only hydrogenation product is hydroquinone; in the case of Ni, the direction of the reaction is unchanged. (Author abstract) 7 refs.

Lunin, V.V. (M.V. Lomonosov Moscow State Univ, USSR); Bogdan, V.I.; Kuznetsova, N.N.; Dobrosodova, N.B. *Kinet Catal* v 28 n 2 pt 2 Mar-Apr 1987 p 440-442.

**074910 EFFECT OF CHEMICAL COMPOSITION OF SUPPORTED METAL CATALYSTS ON THEIR ACTIVITY AND SELECTIVITY IN THE HYDROGENATION REACTION OF ACETONITRILE.** The catalytic properties of transition metals on various supports in the gas phase hydrogenation reaction of acetonitrile have been studied at atmospheric pressure. The specific catalytic activity with respect to the total process is determined mainly by the chemical nature of M and decreases as the energies of the M-nitrile and M-H bonds increase. The selectivity with respect to primary amine decreases as the surface acidity of the catalyst increases, while the selectivity increases for secondary amine and reaches a maximum for tertiary amine. (Author abstract) 15 refs.

Golodets, G.I. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Pavlenko, N.V.; Prokhorenko, E.V. *Kinet Catal* v 28 n 3 pt 1 May-Jun 1987 p 544-550.

**074911 SELECTIVITY IN NITRILE HYDROGENATION CATALYZED BY GROUP VII METALS.** This work is devoted to an analysis of the factors which affect the selectivity of this process in the direction of obtaining primary amines and which are connected primarily with the strength of adsorption of intermediate reaction products on transition metals. Experimental data on the hydrogenation of acetonitrile over various catalysts are given. They show that both the activity of metals of group VIII and also the proportion of hydrogenation products observed for them vary within a wide range. Thus, over cobalt, a more than 90% yield of primary amine is attained, while on Pd it is not formed at all. This difference may be caused by a different ability of the metals to adsorb the intermediate reaction products. Although the results of the calculations performed and the conclusions drawn from them relate primarily to the catalytic hydrogenation of aliphatic nitriles, it may be assumed that the same catalyst properties determined their selectivity in the other process of aldehyde hydrogenation, which is related to hydrogenation in mechanism also. 12 refs.

Dobrotvorskii, A.M. (All-Union Scientific-Research Inst of Petrochemical Processes, USSR); Yakushkin, M.I.; Smaeva, T.P. *J APPL Chem USSR* v 60 n 5 pt 1 May 1987 p 1026-1030.

**074912 ELEMENTARY MODELLING OF HYDROGENATION KINETICS ON THE WORKING CATALYST SURFACE: A STUDY OF GAS PHASE AND LIQUID PHASE HYDROGENATION IN THE PRESENCE OF SUPPORTED Ni, NiS AND Pd CATALYSTS.** The hydrogenation of 2-ethyl-hexenal to observed products has been extensively studied. The hydrogenation kinetics were examined at low pressure gas phase conditions as well as intermediate pressure liquid phase conditions, in the presence of commercial as well as model catalysts with Pd, Ni or NiS as active components. In addition, the kinetics of aldehyde (2-ethyl-hexenal and 2-ethyl-hexanal) adsorption and desorption in presence and absence of hydrogen have been investigated. Qualitative aspects concerning the structures of adsorbed aldehydes and kinetics of hydrogen adsorption were studied and the kinetics of liquid phase hydrogenation of 2-ethyl-hexenal and 2-ethyl-hexanal were examined. An extraordinarily high selectivity for 2-ethyl-hexanal formation was observed when Pd or NiS catalysts were employed. On nickel catalysts, on the other hand, the



further hydrogenation of 2-ethyl-hexanal to 2-ethyl-hexanol was readily catalyzed. (Edited author abstract) Refs. Smedler, Gudmund (Chalmers Univ of Technology, Goteborg, Sweden). *Chalmers Tek Hogsk Doktorsavh* 646 1987 265p.

**074913 EFFECT OF SOLVENT AND REACTION MEDIUM ON THE KINETICS AND MECHANISM OF THE CATALYTIC HYDROGENATION OF VARIOUS AROMATIC COMPOUNDS ON GROUP VIII METALS. VIII. HYDROGENATION OF BENZYLIDENEACETONES ON RHODIUM BLACK AT DIFFERENT pH VALUES.** The catalytic hydrogenation of benzylideneacetone and its derivatives has been studied on rhodium black catalyst in aqueous alcohol buffer solutions in the pH range 2-11. The pH dependence of the hydrogenation rate constants has been found to consist of two separate lines which intersect at pH = ca. 7.5, for all compounds studied. The data obtained in this paper are thus in excellent agreement with the electrochemical model for the catalytic hydrogenation of organic compounds in electrolyte solutions. (Edited author abstract) 6 refs.

Finkel'shtein, A.V. (Siberian Technological Inst, Krasnoyarsk, USSR); Rybintsev, V.V. *Kinet Catal* v 28 n 4 pt 2 Jul-Aug 1987 p 875-877.

**074914 HYDROGENATION OF 2-ETHYL-1,4-DIHYDROANTHRAQUINONE IN THE PRESENCE OF PALLADIUM CATALYST.** The hydrogenation reaction of 2-ethyltetrahydroanthraquinone has been studied in a slurry reactor, in the presence of a palladium-supported catalyst. This chemical reaction is very fast, and a mass-transfer regime is always operative. Gas-liquid and liquid-solid mass-transfer coefficients have been determined by experiments performed both in the presence and in the absence of the reaction. The values obtained are quite the same in both cases. Kinetic runs show that, if the catalyst holdup is changed, a critical catalyst concentration exists at which any additional amount of catalyst is ineffective in promoting the reaction rate. (Edited author abstract) 16 refs.

Santacesaria, E. (Univ di Napoli, Naples, Italy); Wilkinson, P.; Babini, P.; Carra, S. *Ind Eng Chem Res* v 27 n 5 May 1988 p 780-784.

**074915 STOICHIOMETRIC HYDROGENATION AND HYDROFORMYLATION OF CYCLOPENTENE WITH COBALT TETRACARBONYL HYDRIDE IN THE PRESENCE OF HYDROGEN OR DEUTERIUM.** The authors investigated the transformation of  $\text{HCo}(\text{CO})_4$  (1) to  $\text{Co}_2(\text{CO})_8$  (2) and  $\text{H}_2$  under 100 bar  $\text{D}_2$  at 25°C in n-heptane. By carrying out the same experiment in the presence of equimolar amounts of  $\text{HCo}(\text{CO})_4$  (1) and cyclopentene, the following facts were established. (1) The rate of disappearance of 1 is much faster in the presence than in the absence of the olefin. (2) The rate of formation of 2 is much faster in the presence than in the absence of cyclopentene, and the amount of 2 formed is greater than that predicted by equilibrium (1). (3) Both cyclopentane and formylcyclopentane are formed. (4) Deuterium is partially incorporated into the reaction products, showing that, under the conditions used, activation of  $\text{D}_2$  takes place. 12 refs.

Major, Arpad (ETH-Zentrum, Zurich, Switz); Horvath, Istvan T.; Pino, Piero. *J Mol Catal* v 45 n 3 May 30 1988 p 275-280.

**074916 SELECTIVE HYDROGENATION OF NEAT ISOQUINOLINE I. ACTIVITIES OF SOME COMMERCIAL CATALYSTS AND EFFECTS OF COEXISTING SULPHUR-CONTAINING COMPOUNDS IN THE SUBSTRATE.** Isoquinoline obtained from coal-tar was hydrogenated over several commercial catalysts to tetrahydroisoquinolines and decahydroisoquinolines without any solvent or acid. 1,2,3,4-Tetrahydroisoquinoline exclusively is obtained with Raney nickel and ruthenium on carbon from isoquinoline containing a sulphur compound which is identified as thieno [3,2-b]pyridine. The same compound was also obtained

with copper-chromite or platinum on carbon from sulphur-free isoquinoline. When Raney nickel was employed with sulphur-free isoquinoline under relatively high temperature and low pressure (205-210°C and 15-25 kg/cm<sup>2</sup>), 5,6,7,8-tetrahydroisoquinoline and trans-decahydroisoquinoline could be selectively prepared at 90 percent and 80 percent yields, respectively, by adjusting the reaction time. (Edited author abstract) 26 Refs.

Okazaki, Hiroshi (Nippon Steel Chemical Co, Kitakyushu, Jpn); Soeda, Mahito; Onishi, Kiyotaka; Tamura, Ryuzi. *Appl Catal* v 41 n 1-2 Jul 15 1988 p 99-108.

**074917 INTERACTION OF MOLECULES WITH MOLYBDENUM DISULPHIDE CATALYSTS: AN EXPERIMENTAL AND MOLECULAR GRAPHICS STUDY. ISOPRENE.** The interaction of isoprene with molybdenum disulphide has been studied by computer-assisted modelling of the binding of the molecule at active sites. Possible structures of intermediate-active-site complexes were evaluated by the method of molecular mechanics. For isoprene hydrogenation the preferred catalytic sites, according to energy minimisation calculations, proved to be corner molybdenum atoms having threefold unsaturation. This conclusion agrees with deductions from experimental studies of isoprene hydrogenation. The modelling studies are valuable for revealing the steric relationships between active sites and substrate molecules, for calculating the most likely structures, and for revealing non-bonded interactions. (Author abstract) 7 refs.

Drew, M.G.B. (Univ of Reading, Reading, Engl); Edmondson, S.J.; Forsyth, G.A.; Hobson, R.J.; Mitchell, P.C.H. *Catal Today* v 2 n 5 Apr 1988, New Methods of Catal Prep and Character, Proc of the Surf React and Catal Meet, Uxbridge, Engl, Sep 14-16 1987 p 633-641.

**Hydrolysis** See Also AEROSOLS—Atmospheric; INSECTICIDES—Synthesis.

**074918 HYDROLYSIS OF ACRYLONITRILE TO ACRYLAMIDE OVER AN ION-EXCHANGED COPPER ON SILICA CATALYST.** The deactivation of a copper on silica catalyst prepared by the ion-exchange technique for the hydrolysis of acrylonitrile (AN) to acrylamide (AA) has been studied at temperatures below 350 K. Initial deactivation is attributed to a polymer network coating the outer particle surface and originating from the product. Due to the nature of the polymer and the fine catalyst support pore structure, a major part of the active copper sites remains accessible and the catalyst retains its activity over a long time and broad range of reactant and product concentrations, but undergoes very slow and constant deactivation by copper oxidation from oxygen dissolved in the reactant mixture. (Edited author abstract) 25 refs.

Kohler, M.A. (Univ of New South Wales, Kensington, Aust); Lee, J.C.; Wainwright, M.S.; Trimm, D.L. *Appl Catal* v 35 n 2 Dec 15 1987 p 237-248.

**074919 HYDROLYSIS OF CARBONYL SULFIDE IN A GAS-LIQUID REACTOR.** The purpose of this study was to examine the hydrolysis of COS (Carbonyl Sulfide) in solutions of tertiary amines and an acid gas solvent. We studied DABCO (1,4-diazabicyclo[2.2.2]octane) and several compounds that were reported in the patent literature to catalyze COS hydrolysis. Most of the compounds examined have about the same base strength. Large differences in catalytic activity may indicate steric effects. 24 refs.

Ernst, W.R. (Georgia Inst of Technology, Atlanta, GA, USA); Chen, M.S.K. *AIChE J* v 34 n 1 Jan 1988 p 158-162.

**074920 CARBON TETRACHLORIDE-PROMOTED STEREO SELECTIVE HYDROLYSIS OF METHYL-2-CHLOROPROPIONATE BY LIPASE.** The present report deals with interesting observations made during the kinetic studies of lipase-catalyzed hydrolysis of methyl-2-chloropropionate (MCP) when an organic solvent, carbon tetrachloride, was used as a diluent

for the substrate. 4 refs.

Dahod, Samun K. (Eastern Research Cent, Dobbs Ferry, NY, USA); Siuta-Mangano, Patricia. *Biotechnol Bioeng* v 30 n 8 Dec 5 1987 p 995-999.

**074921 KINETIC MODEL OF THE HYDROLYSIS OF p-NITROPHENYL ACETATE IN FROZEN SUSPENSIONS OF SILICA GEL.** A kinetic model of the hydrolysis of p-nitrophenyl acetate in frozen suspensions of silica gel based on the experimental results of a study of the reaction kinetics, the phase state of the frozen suspensions, and the absorption of p-nitrophenyl acetate on the surface of silica gel has been proposed. Theories concerning the existence in frozen multicomponent heterogeneous systems of reaction zones differing in composition and with respect to the concentrations of the components of the mixture have been introduced. It has been shown that highly dispersed insoluble additions influence the rates of chemical reactions in frozen systems, altering not only their phase state, but also the properties of the reaction medium, particularly the ionic composition. (Author abstract) 4 refs.

Sergeev, G.B. (M.V. Lomonosov Moscow State Univ, USSR); Sergeev, B.M.; Konstantinova, N.R. *Kinet Catal* v 28 n 4 pt 1 Jul-Aug 1987 p 716-722.

**074922 EFFECT OF A SUBSURFACE SEDIMENT ON HYDROLYSIS OF HALOALKANES AND EP-OXIDES.** Neutral and base-catalyzed hydrolyses of isopropyl bromide, 1,1,2,2-tetrachloroethane, 1,1,1-trichloroethane, and ethylene dibromide were studied in pure water and in barely saturated subsurface sediment at 25-60°C. Half-lives in sediment at 25°C were 2.1, 29, 450 (measured), and 1500 days (calculated), respectively. No significant differences in the kinetics or products were observed in the sediment pores compared to those in water at the same pH, indicating that the effects of ionic strength, surface catalysis, and adsorption are unimportant for the low-carbon sediment studied. Thus, kinetic and product data for haloalkanes obtained in pure water are applicable to such groundwater systems. On the other hand, epoxide hydrolysis can be affected by the presence of sediments; styrene oxide (acid catalyzed below pH 7) hydrolyzed 4 times faster in sediment than in buffered water and also formed benzaldehyde by oxidation. (Author abstract) 27 refs.

Haag, Werner R. (SRI, Menlo Park, CA, USA); Mill, Theodore. *Environ Sci Technol* v 22 n 6 Jun 1988 p 658-663.

**074923 KINETICS OF THE HYDROLYSIS OF TRICHLOROMETHYLBENZENE IN WATER-ACETONE MIXED SOLVENTS.** The kinetics of the hydrolysis of trichloromethylbenzene in water-acetone solutions have been studied over the temperature range 30-45°C. The rate of the reaction have been followed by conductance measurements. The rate is first order with respect to the trichloromethylbenzene and is independent of the concentration of water. When the concentration of water in the solvent is increased, the hydrolysis rate constant first decreases to a minimum at about 0.5 water mol fraction, then increases. The influence of solvent variation on reaction rates has been examined in terms of changes in activation parameters. The results are discussed in terms of the electrostatic theory, polarity of the medium and on the change in the solvent structure. (Author abstract) 22 refs.

Moussa, Mahmoud A. (Benha Univ, Benha, Egypt); Diefallah, El-Hussieny M.; Shaaban, Abd Elfattah F.; Azab, Mohamed A. *Chem Ser* v 28 n 2 Jun 1988 p 207-209.

## Ignition

**074924 STUDIES ON THE SYNERGISTIC HYPERGOLIC IGNITION OF HYBRID SYSTEMS.** A variety of solid organic compounds, such as Schiff bases, azines, hydrazones, thiocarbonohydrazones, thiosemicarbazones, and hydroxy compounds, on mixing with metal powders, especially with magnesium, become synergistic



cally hypergolic with white fuming nitric acid (WFNA). In the absence of magnesium powder, these compounds are either nonhypergolic or have longer ignition delays, when WFNA is used as oxidizer. The synergistic ignition behavior has been explained in terms of increased exothermicity of the system, primarily due to the heat evolving chemical reactions occurring between the fuels (organic compound and magnesium) and the oxidizer in the preignition stage. (Author abstract) 21 refs.

Jain, S.R. (Indian Inst of Science, Bangalore, India); Rao, Rama; Murthy, K.N. *Combust Flame* v 71 n 3 Mar 1988 p 233-243.

## Impurities

**074925 EFFECTS OF SELECTED ALCOHOLS ON CYCLODEXTRIN INCLUSION COMPLEXES OF PYRENE USING FLUORESCENCE LIFETIME MEASUREMENTS.** This study focuses on the inclusion complexes of  $\gamma$ -cyclodextrin with pyrene as indicated by fluorescence lifetime measurements and the effects of alcohols on these systems. The pyrene complex has a longer lifetime than free pyrene, yet quenching is observed in the presence of  $\gamma$ -cyclodextrin. This apparent conflict is discussed. Also, short-chain alcohols participate in the pyrene/ $\gamma$ -cyclodextrin inclusion complexes producing a longer lifetime of the pyrene complex. This participation is described through evaluation of the lifetime data. (Edited author abstract) 22 refs.

Nelson, Gregory (Emory Univ, Atlanta, GA, USA); Patony, Gabor; Warner, Isiah M. *Anal Chem* v 60 n 3 Feb 1 1988 p 274-279.

## Ionization See Also PLATINUM COMPOUNDS—Adsorption.

**074926 IONIZATION EFFICIENCIES OF  $C_3H_6$ ,  $C_4H_8$ ,  $C_5H_{12}$ ,  $C_2H_6O$ , AND  $C_3H_8O$  ISOMERS.** Ionization efficiencies of 14 organic compounds have been measured in the wavelength region from 105 to 134 nm using an ionization chamber. The compounds examined are cyclopropane, propylene, 1-butene, isobutene, cis- and trans-2-butenes, cyclohexane, 1-hexane, tetramethylethylene, ethyl alcohol, dimethyl ether, n-, and iso-propyl alcohol, and ethyl methyl ether. The ionization efficiencies of cyclopropane and cyclohexane monotonically increase with increasing photon energy, but those for the others show a peak or a shoulder in the wavelength region of the present work. (Author abstract) 16 refs.

Koizumi, H. (Hokkaido Univ, Sapporo, Jpn); Shinsaka, K.; Yoshimi, T.; Hironaka, K.; Arai, S.; Ukai, M.; Morita, M.; Nakazawa, H.; Kimura, A.; Hatano, Y.; Ito, Y.; Zhang, Y.; Yagishita, A.; Ito, K.; Tanaka, K. *Radiat Phys Chem* v 32 n 1 1988 p 111-115.

**074927 POSTIONIZATION OF LASER-DESORBED ORGANIC AND INORGANIC COMPOUNDS IN A TIME OF FLIGHT MASS SPECTROMETER.** A new time-of-flight mass spectrometer for UV-excimer-laser desorption of neutrals, followed by resonant - or nonresonant postionization with a second excimer laser or excimer-dye-laser combination is described. The advantages of the technique are discussed. The performance of the instrument is demonstrated for a number of nonvolatile organic compounds. (Edited author abstract) 23 refs.

Spengler, B. (Univ Muenster, Muenster, West Ger); Bahr, U.; Karas, M.; Hillenkamp, F. *Anal Instrum (New York)* v 17 n 1-2 Mar-Jun 1988 p 173-193.

**074928 SURFACE IONIZATION OF ORGANIC COMPOUNDS AND ITS APPLICATIONS.** Surface ionization of organic compounds in a weak external electric field involving the formation of many-atomic positive ions is considered (including specific features of the phenomenon, its major characteristics, experimental techniques used and possible applications). Information is presented on the adsorption of compounds of complex composition which was obtained in studying the phenomenon. A detailed analysis is made of the reactions of

particles in the adsorbed layer, as well as of the methods of determining the binding energies of the particles undergoing ionization to the surface, and of their lifetimes on the surface against thermal desorption in the charged and neutral states. (Edited author abstract). 187 Refs.

Rasulev, U. K.H. (Acad of Sciences of Uzb.SSR, Tashkent, USSR); Zandberg, E. Y.A. *Prog Surf Sci* v 28 n 3-4 1988 412p.

## Isomerization See Also CATALYSTS—Evaluation; ION EXCHANGE RESINS—Chemical Reactions.

**074929 PHOTSENSITIZED ISOMERIZATION OF NORBORNADIENE FOR SOLAR ENERGY STORAGE AND SUPPRESSION OF SIDE REACTION.** Photosensitized isomerization of norbornadiene to quadricyclene was investigated by using several photosensitizers such as toluene, acetone, acetophenone, benzophenone and  $\alpha$ -naphthoquinone. The effect of wavelength on the quantum yield of quadricyclene and on the energy conversion efficiency was measured by using spectroirradiator. The formation of byproduct polymer in the presence of photosensitizers was also studied. The formation of polymers during irradiation, which prevents the repeated use of energy storage material, was effectively suppressed by the addition of several phenolic substances into norbornadiene. (Author abstract) 32 refs.

Taoda, Hiroshi (Government Industrial Research Inst, Nagoya, Jpn); Hayakawa, Kiyoshi; Kawase, Kaoru. *J Chem Eng Jpn* v 20 n 4 Aug 1987 P 335-338.

**074930 HYDROFORMYLATION AND ISOMERIZATION REACTIONS OF HEX-1-ENE CATALYZED BY RHODIUM COMPLEXES.** The hydroformylation of hex-1-ene (at 1 atm and 40°C) with various rhodium compounds as catalysts has been studied. Catalytic activity of both catalysts is comparable with that found for the  $Rh(acac)[(OPh)_3]_2 + nP(OPh)_3$  systems, however, an induction time was not observed. The effect of  $H_2/CO$  ratio on the yield of hydroformylation reaction products was investigated.  $HRh[P(OPh)_3]_4$  as well as  $Rh(acac)[P(OPh)_3]_2 + nP(OPh)_3$  gave optimal yields of aldehyde (ca. 70%) when  $H_2/CO = 1$ . (Author abstract) 9 refs.

Trzeciak, A.M. (Univ of Wroclaw, Wroclaw, Pol); Ziolkowski, J.J. *J Mol Catal* v 43 n 3 Jan 1988 p 335-341.

**074931 ISOMERIZATION OF METHYL LINOLEATE ON SUPPORTED RUTHENIUM-NICKEL CATALYST.** Isomerization of methyl linoleate on supported ruthenium catalyst is studied with the aid of an unsteady-state mathematical model. The model developed is found to describe the observed behavior well. The rate constants and the activation parameters in the model are estimated by fitting the simulation to the experimental data. The effects of the ruthenium-nickel ratio, support, catalyst activation temperature, and preparation conditions on the selectivity for conjugation, polymerization, hydrogenation, and geometric isomer distribution are discussed in detail. It is noted that isomerization precedes hydrogenation, while polymerization is a competing parallel reaction. (Edited author abstract) 20 refs.

Mukesh, Doble (Alchemie Research Cent, Maharashtra, India); Narasimhan, Chakravarthula S.; Deshpande, Vinayak M.; Ramnarayan, K. *Ind Eng Chem Res* v 27 n 3 Mar 1988 p 409-414.

## Labeling See SURFACES—Spectroscopic Analysis.

## Low Temperature Effects

**074932 LOW-TEMPERATURE (23 K) STUDY OF L-ALANINE.** From a spherical crystal of L-alanine an extensive set of X-ray diffraction data has been measured at 23 (1) K. No phase transition has been observed on cooling, and the cell parameters of the orthorhombic crystals (space group  $P2_12_12_1$ ) are, at the temperature of data collection,  $a = 5.928$  (1) Angstrom,  $b = 12.260$  (2) Angstrom,  $c = 5.794$  (1) Angstrom. The contraction of the cell volume, with respect to the room temperature

value, amounts to 2.2%. Intensity data, carefully corrected for scan-truncation losses, have been analyzed with various models. The best fit was reached by interpreting the electron density function in terms of pseudatoms (multipoles). The analysis of the correlation coefficients has shown that the quality and quantity of the data set allowed a reliable deconvolution of thermal motion from the charge density. (Edited author abstract) 36 refs.

Destro, Riccardo (California Inst of Technology, Pasadena, CA, USA); Marsh, Richard E.; Bianchi, Riccardo. *J Phys Chem* v 92 n 4 Feb 25 1988 p 966-973.

## Low Temperature Properties

**074933 ANALYSIS OF THE LOW-TEMPERATURE PHASE OF THE ORGANIC CONDUCTOR (FLUORANTHENE) $_2PF_6$  WITH MAGNETIC RESONANCE.** In order to clear up the electronic structure of the low-temperature phase of the organic conductor (fluoranthene) $_2PF_6$ , we combined the knowledge available from the electrical conductivity and the static magnetic susceptibility with the information accessible by different magnetic resonance techniques: ESR of defects and conduction electrons (intensity, g-tensor, linewidth,  $T_2$ , diffusion constant and  $T_1$ ) and proton-NMR (linewidth), all measured for different qualities of (FA) $_2PF_6$ -single crystals in dependence of the sample orientation, the temperature and the Larmor frequency. Thus we report on comprehensive results for a model system of the organic conductor. (Author abstract) 27 refs.

Sachs, G. (Univ Bayreuth, Bayreuth, West Ger); Poehlmann, E.; Dormann, E. *J Magn Magn Mater* v 69 n 2 Oct II 1987, Sel Pap from the 1987 Arbeitsgem Magn Meet, Freudenstadt, West Ger, Mar 9-13 1987 p 131-143.

## Magnetic Field Effects

**074934 DIFFERENTIAL THERMAL ANALYSIS OF THE FIELD INDUCED PHASE TRANSITIONS OF (TMTSF) $_2ClO_4$  ABOVE 1.2 K.** We present results of a differential thermal analysis of the magnetic field induced phase transitions in the organic conductor (TMTSF) $_2ClO_4$  above 1.2 K. This study shows that transitions between different spin density wave states are first order and that the total entropy change involved in the two detected transitions (in the temperature range 1.2-2 K) is close to that of the quasi-one-dimensional electron gas. Above 2 and 4.2 K, only a single transition has been detected in our measurements. The entropy of that transition decreases and extrapolates to zero near 5 K. We present some arguments suggesting that if longitudinal nesting ( $2k_F$ , 0, 0) is to take place in the semi-metallic SDW phase at high fields it exists only above 2 K or so. (Edited author abstract) 26 refs.

Piveteau, B. (CNRS, Orsay, Fr); Cooper, J.R.; Jerome, D. *Solid State Commun* v 62 n 4 Apr 1987 p 313-317.

## Magnetic Properties See Also POLYMERS—Conductive.

**074935 C\*-MAGNETORESISTANCE OF  $\beta$ -(BEDT-TTF) $_2I_3$  IN THE HIGH- $T_c$  STATE: KOHLER'S RULE.** We report a study of Kohler's rule for  $\beta$ -(BEDT-TTF) $_2I_3$  in the high- $T_c$  state (obtained by pressure cycling, i.e. cooling under pressure and removing the pressure at low temperature) in the temperature range 8-22 K and fields up to 9.4 T for  $c^*$  current flow, perpendicular to the highly conducting ab plane. It is observed that magnetoresistance  $\Delta\rho/\rho_0$  is a universal function of  $H/\rho_0$  (Kohler's rule), and we give an estimation of the interchain overlap integral, the mean free paths in the chain direction ( $l_{||}$ ) and along  $c^*$  ( $l_{||}$ ), as well as the relaxation time  $\tau$ . (Author abstract) 15 refs.

Hamzic, B. (Univ de Paris-Sud, Orsay, Fr); Creuzet, G.; Lenoir, C. *J Phys F Met Phys* v 17 n 11 Nov 1987 p 2267-2272.



**074936 MAGNETIC AND SPECTROSCOPIC PROPERTIES OF**  $[\text{Co}(\text{AGIH})_{2\text{py}2}][\text{Cr}(\text{NH}_3)_2\text{NCS}]_4$  AND  $[\text{Co}(\text{AGIH})_{2\text{py}2}][\text{Co}(\text{NH}_3)_2(\text{NO}_2)_4]\text{COMPLEXES}$ . The magnetic and spectroscopic (UV, visible-IR and electron paramagnetic resonance spectra) properties of the molecular complexes  $[\text{Co}(\text{AGIH})_{2\text{py}2}][\text{Cr}(\text{NH}_3)_2\text{NCS}]_4$  and  $[\text{Co}(\text{AGIH})_{2\text{py}2}][\text{Co}(\text{NH}_3)_2(\text{NO}_2)_4]$  (where  $\text{AGIH}_2$  is diamonoloxoyne) have been examined in solid state. The molecular structure of the complexes and the nature of the interaction in the crystals has been considered. (Author abstract) 13 refs.

Starosta, Jan (Technical Univ of Wroclaw, Wroclaw, Pol); Karczynski, Feliks; Wojciechowski, Walter. *J Less Common Met* v 136 n 1 Dec 1987 p 155-160.

**074937 ELECTRIC-FIELD-DEPENDENCE OF THE SMALL-PERIOD OSCILLATION OF THE MAGNETORESISTANCE IN  $(\text{TMTSF})_2\text{ClO}_4$** . The electric field effects on the small-period oscillation of the magnetoresistance in  $(\text{TMTSF})_2\text{ClO}_4$  were investigated in high magnetic fields. It was found that the oscillation amplitude decreased with increasing electric fields and was smeared out at sufficiently high electric fields. The present results suggest a possibility of some kind of tunneling effect as the mechanism of the small-period oscillation and are analyzed on the basis of the recent tunneling theory by Yamaji. (Author abstract) 18 refs.

Osada, T. (Univ of Tokyo, Tokyo, Jpn); Miura, N.; Oguro, I.; Saito, G. *Solid State Commun* v 64 n 1 Oct 1987 p 133-136.

**074938 PARTIALLY DEUTERATED TETRAMETHOXYDIBENZOFURAN-HEXAFLUOROPHOSPHATE: AN ELECTRON SPIN RESONANCE STUDY**. The susceptibility of the compound is large,  $\chi(300\text{ K}) = 3.8 \times 10^{-4}$  emu/mol, and the temperature dependence of the susceptibility is explained by the random exchange Heisenberg antiferromagnetic chain model. The localization of the electrons in an antiferromagnetic order is proved by the angular dependence of the ESR linewidth, which corresponds to dipole-dipole interaction. A comparison of the spin properties between the title compound and a non-deuterated compound exhibits only minor differences. 11. AA Refs.

Soderholm, S. (Royal Inst of Technology, Stockholm, Sweden); Hellberg, J.; Ahlgren, G.; Krebs, M.; Von Schuetz, J.U. *Synth Met* v 26 n 1 Oct 1 1988 p 61-67.

**074939 HIGH FIELD MAGNETIC SUSCEPTIBILITY OF INDIVIDUAL SINGLE CRYSTALS OF THE ORGANIC CONDUCTOR (FLUORANTHENE) $_2\text{PF}_6$** . Using single crystals of a sufficient size (4-7 mg) and a high quality (about  $5 \times 10^{-4}$  paramagnetic defects per formula unit) we measured the anisotropic static magnetic properties of the quasi-1d organic conductor  $(\text{FA})_2\text{PF}_6$  in external fields of up to 70 kOe. Thus the strong anisotropy of the molecular diamagnetism was determined for the first time. The contribution of the conduction electrons to the static susceptibility of  $(\text{FA})_2\text{PF}_6$  was separated. We analyzed the influence of fluctuations (pseudogaps) in the metallic high temperature phase and we derived the temperature dependence of the energy gap in the low-temperature ( $T > 185\text{ K}$ ) semiconducting phase of  $(\text{FA})_2\text{PF}_6$ . (Author abstract) 27 refs.

Koehler, U. (KFA, Juelich, West Ger); Gmeiner, J.; Dormann, E. *J Magn Magn Mater* v 69 n 2 Oct II 1987, Sel Pap from the 1987 Arbeitsgem Magn Meet, Freudenstadt, West Ger, Mar 9-13 1987 p 189-198.

**Mathematical Models** See SOILS—Composition Effects.

**Measurements** See Also LIPIDS—Phase Transitions.

**074940 FLUORESCENCE LIFETIME STUDY OF CYCLODEXTRIN COMPLEXES OF SUBSTITUTED NAPHTHALENES**. The interactions of  $\alpha$ ,  $\beta$ , and  $\gamma$ -cyclodextrins and selected naphthalene derivatives as observed through fluorescence lifetime measurements are discussed in detail. These systems can be quickly

characterized with the use of the parameters obtained from experimental fluorescence decay curves. The formation of inclusion complexes can be followed with the appearance of a long-lived fluorophore which contributes to the total fluorescence according to the cyclodextrin concentration. This fluorophore is determined to be an inclusion complex between a naphthalene and cyclodextrin. (Author abstract) 15 refs.

Nelson, Gregory (Emory Univ, Atlanta, GA, USA); Patonay, Gabor; Warner, Isiah M. *Appl Spectrosc* v 41 n 7 Sep-Oct 1987 p 1235-1238.

**074941 FLUORESCENCE-DETECTED LOW FIELD RESONANCES IN T-T ANNIHILATION IN THE A-TCNB SINGLE CRYSTAL: LINESHAPE AND DYNAMIC PARAMETERS**. An investigation is made of the line shape of the low field resonances observed in the dependence of the fluorescence of a single A-TCNB CT crystal on the external magnetic field. It is shown that the resonance is caused by avoided crossing of magnetic sublevels of a single T-exciton arising when the direction of the field is close to the axis of the fine interaction tensor. An analytic expression for the resonance line shape is obtained. The spin-lattice relaxation rate of T-excitons,  $\tau^{-1} = (1.0 \pm 0.3) \times 10^7\text{ s}^{-1}$  as well as the rate of jumps between the planes of fast exciton migrations,  $\omega_1 = (5 \pm 2) \times 10^7\text{ s}^{-1}$ , are determined. (Author abstract) 15 refs.

Konyaev, S.N. (Acad of Sciences of the USSR, Moscow, USSR); Shushin, A.I.; Kolesnikova, L.I.; Tribel, M.M.; Frankovich, E.L. *Phys Status Solidi B* v 142 n 2 Aug 1987 p 461-471.

**074942 TIME-DEPENDENCE OF THE GROWTH OF THIN ORGANIC LIQUID LAYERS ON A GOLD SURFACE, STUDIED BY SURFACE-PLASMON POLARITON TECHNIQUES**. The novel use of surface-plasmon polaritons to study the build-up thin organic liquid films onto a planar gold surface by vapor deposition has recently been reported. We extend the work here by studying the time-dependent nature of this process in greater detail. We report, for the first time, the coexistence of two SPP features at the same interface; the first corresponding to a SPP between the gold and a thin organic film; and the second to a SPP between the gold and bulk-liquid. This observation is reconciled with the model to thin fluid films on a solid planar surface attached by van der Waals bonding. (Author abstract) 2 refs.

Pollard, J.D. (Univ of Exeter, Exeter, Engl); Sambles, J.R. *Opt Commun* v 64 n 6 Dec 15 1987 p 529-533.

**074943 ACOUSTIC AND PHYSICO-CHEMICAL BEHAVIOUR OF DIMETHYLFORMAMIDE WITH BENZENE AND TOLUENE AT 30, 35 AND 40°C**. This paper deals with the study of ultrasound velocity, isotropic compressibility, molar volume, available volume and free length of the binary systems: I. Dimethylformamide (Dmf) + benzene, II. Dmf + toluene at 30, 35 and 40°C. Ultrasound velocity of these above liquid mixtures was measured with a single crystal variable path interferometer operating at 2 MHz. The transducer used was a quartz crystal plated with gold. The accuracy in the measurement of velocity has been found to be  $\pm 0.1\%$ . 9 refs.

Prakash, S. (Allahabad Univ, Allahabad, India); Singh, J.; Srivastava, S. *Acustica* v 65 n 5 Apr 1988 p 263-265.

## Melting

**074944 ULTRASONIC METHOD FOR THE ACCURATE DETERMINATION OF THE MELTING LINE: DATA FOR CYCLOHEXANE AND BENZENE**. The p-T melting curves of cyclohexane and benzene were measured accurately at pressures up to 85 MPa and 175 MPa respectively using an ultrasonic method. Important features of this new method are that the phase transition is studied by monitoring changes in the attenuation of ultrasonic echoes and that the measurements start in a non-equilibrium two-phase region, the partially solidified liquid, created by superpressing the liquid sample. The accuracy of the experimental melting temperatures for both liquids is about 0.03 K. The

Simon-Glatzel equation, fitted to the experimental data, can be extrapolated to 500 MPa without introducing large errors. (Author abstract) 12 refs.

Sun, T.F. (Univ of Amsterdam, Amsterdam, Neth); Kortbeek, P.J.; Biswas, S.N.; Trappeniers, N.J.; Schouten, J.A. *Ber Bunsenges Phys Chem* v 91 n 10 Oct 1987 p 1013-1017.

**Methanation** See REFUSE DISPOSAL—Fermentation.

## Microscopic Examination

**074945 RESULTS OF LASER-INDUCED FLUORESCENCE OF ORGANIC MATERIALS**. A new laser-induced fluorescence microscopy system has been developed to significantly broaden the analytical scope of the characterization of organic materials. The system uses a pulsed tunable dye laser interfaced to a Leitz MPV3 fluorescence microscope. The fluorescence of the organic materials is excited with ultraviolet radiation in the range of 260-450 nm and analyzed between 300 and 800 nm. The temporal decay of the fluorescence induced by the pulsed laser is studied. The anode pulses from a fast photomultiplier detecting the fluorescence are digitized by a fast waveform digitizer, and the information is then processed by a desk-top computer to obtain the decay curves and the corresponding decay times. The technique of pulse counting is employed for greater sensitivity in detecting weakly fluorescing materials. Results of this technique from the fluorescence of coal macerals and dispersed organic material in sedimentary rocks indicate that characterization in the time domain is an expansion of conventional fluorescence analysis.

Landis, Charles R. (Univ of Kentucky, Lexington, KY, USA); Crelling, John R.; Sullivan, Gregory W.; Pleil, Matthias W.; Borst, Walter L. *Org Geochem* v 11 n 5 1987, Sel of Pap from the 2nd Annu Meet of the Soc for Org Petrol, Houston, TX, USA, Nov 7-9 1985 p 423.

## Mixing

**074946 ELECTROLYTIC PROPERTIES OF  $\text{LiClO}_4$ -PROPYLENE CARBONATE MIXED WITH AMIDE-SOLVENTS FOR LITHIUM BATTERIES**. The electrolytic properties of propylene carbonate (PC) mixed with amide-solvents incorporating  $\text{LiClO}_4$  as the solute were examined for application to lithium (Li) batteries. The amide-solvents used were N,N-dimethylformamide (DMF), N,N-dimethylacetamide (DMA) and N,N-dimethylacetamide (DMAA). Conductivities for PC mixed with amide-solvents were higher than that for PC alone. For example, 1M  $\text{LiClO}_4$ -PC/DMA (mixing volume ratio = 1/1) showed 2.7 times higher conductivity of  $1.64 \times 10^{-2}\text{ Scm}^{-1}$  at 25°C than PC. This higher conductivity is due mainly to the lowered viscosity which results from mixing amide-solvent with PC. The selective solvation of DMA with  $\text{Li}^+$  ion in  $\text{LiClO}_4$ -PC/DMA was clearly apparent in  $^{13}\text{C}$ -NMR spectra. (Edited author abstract) 19 refs.

Tobishima, Shin-Ichi (NTT, Tokai-mura, Jpn); Arakawa, Masayasu; Yamaki, Jun-Ichi. *Electrochim Acta* v 33 n 2 Feb 1988 p 239-244.

**Molecular Structure** See Also EXPLOSIVES—Detonation; ORGANIC CHEMICALS—Solubility; PETROLEUM PRODUCTS—Degradation; PHOSPHORUS COMPOUNDS—Molecular Structure; POLYCHLORINATED BIPHENYLS—Solubility; SUPERCONDUCTING MATERIALS—Molecular Structure.

**074947 STRUCTURE OF LIGNANS FROM PAPAN MACE (*MYRISTICA ARGENTEA* WARB)**. Two lignans were isolated from papuan mace (*Myristica argentea* Warb.) and their structures were determined to be 2-(3',4'-methylenedioxybenzyl)-3-(4'-hydroxy-3'-me-



thoxybenzyl)-butane and meso-dihydroguaiaretic acid on the basis of chemical and spectroscopic evidence. (Edited author abstract) 8 refs.

Nakatani, Nobuji (Osaka City Univ, Osaka, Jpn); Ikeda, Kayo. *Chem Express* v 2 n 10 Oct 1987 p 627-630.

**074948 1H-IMIDAZO(2,1-A)ISOINDOLE DERIVATIVES.** Representative of a 14- $\pi$  electronic heteroaromatic system, 1H-imidazo(2,1-a)-isoindole derivatives, were obtained upon treatment of 2R-5H-imidazo(2,1-a)-isoindole salts with bases. It was shown that electrophilic substitution reactions occur at position 5 of the system. (Author abstract) 6 refs.

Kovtunen, V.A.; Demchenko, A.M.; Tyltin, A.K.; Babichev, F.S.; Voitenko, Z.V. *Sov Prog Chem* v 53 n 2 1987 p 90-93.

**074949 NEW ALGORITHM FOR SELECTION OF SYNTHETICALLY IMPORTANT RINGS. THE ESSENTIAL SET OF ESSENTIAL RINGS FOR ORGANIC STRUCTURES.** The concept of tied rings, multi-tied rings, and dependent rings is introduced, wherein transannular bonds and heterogeneity and abnormality of a ring are key classifiers. The essential set of essential rings (ESER) is defined as a set of rings other than tied, multi-tied, and dependent rings. An algorithm for detection of the ESER and its scope and limitations are discussed. (Author abstract) 19 refs.

Fujita, Shinsaku (Fuji Photo Film Co, Minami-Ashigara, Jpn). *J Chem Inf Comput Sci* v 28 n 2 May 1988 p 78-82.

**074950 LIPID-BASED TUBULE MICROSTRUCTURES.** Hollow tubule-shaped microstructures have been fabricated by self-organization of polymerizable diacetylenic phospholipid molecules. These microstructures have potential applications in a number of areas in materials science. A wide range of positional isomers of the diacetylenic lipids have been synthesized and all form tubules. A process for the deposition of thin metal coatings onto the exterior surfaces of the tubules has been developed. Results of spectroscopic and microscopic investigations of the lipids and microstructures are presented. Future issues important to the assessment of the ultimate utility of these materials are also presented. (Author abstract) 55 refs.

Schnur, J.M. (US Naval Research Lab, Washington, DC, USA); Price, R.; Schoen, P.; Yager, P.; Calvert, J.M.; Georger, J.; Singh, A. *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 181-206.

## Molecular Weight

**074951 SOLUTION AND SOLID-STATE STRUCTURES OF Di-n-BUTYLtin 3-THIOPROPIONATE. X-RAY CRYSTAL STRUCTURE DETERMINATION OF THE CYCLIC HEXAMER.** Molecular weight and  $^{13}\text{C}$  and  $^{119}\text{Sn}$  NMR data for di-n-butyltin 3-thiopropionate indicate that monomer and at least two oligomers are in equilibrium in solution. The  $^{119}\text{Sn}$  chemical shift and tin-carbon coupling constants indicate that the associative interaction gives rise to five-coordinate tin. Complicated concentration and temperature effects on the  $^{119}\text{Sn}$  NMR spectra are rationalized by postulating the existence of a third oligomeric form at high concentration; solution viscosity measurements suggest that this species may be a linear polymer. Full structural analysis of the monoclinic modification reveal the presence in the unit cell of two crystallographically independent cyclic hexamers in which the carboxylate group bridges between tin atoms. (Edited author abstract) 26 refs.

Lockhart, Thomas (DuPont, Wilmington, DE, USA). *Organometallics* v 7 n 6 Jun 1988 p 1438-1443.

**074952 ON THE MOLECULAR WEIGHT OF PECTIC SUBSTANCES AND ITS RELATION TO THEIR GEL STRENGTHS.** A study has been made on the possibility of determining the molecular weight  $M_w$ , the second virial coefficient  $A_2$  and the radius of gyration by measuring the light scattering of pectin aqueous solutions.

The experimental data were processed on a computer by using an algorithm, accounting for the effect of microgel formations in the pectic solution. A tendency towards a decrease in  $M_w$  when decreasing the degree of esterification for a certain type of pectin was established and was confirmed by the change in the intrinsic viscosity. This fact is explained by degradation during deesterification. (Edited author abstract). 32 Refs.

Panchev, I.N. (Higher Inst for Food & Flavour Industries, Plovdiv, Bulg); Kirtchev, N.A.; Kratchanov, Chr.G.; Proichev, T. *Carbohydr Polym* v 8 n 4 1988 p 257-269.

Monitoring See SEWERS—Monitoring.

Nitration See DIESEL ENGINES—Exhaust Gases.

**Optical Properties** See Also LUMINESCENCE; OPTICS—Nonlinear; PEAT—Geochemistry; SALTS—Electronic Properties; WATER ANALYSIS.

**074953 REFRACTIVE INDICES OF 2-METHYL-4-NITROANILINE (MNA).** We report on the results of ellipsometric measurements of refractive indices and their dispersion over the wavelength range 500 nm-1100 nm on a single-crystal thin film of 2-methyl-4-nitroaniline (MNA). The refractive indices show large anisotropy attributable to the orientation of the molecular dipole moment. (Author abstract) 8 refs.

Morita, Ryuji (Univ of Tokyo, Tokyo, Jpn); Ogasawara, Nagaatsu; Umegaki, Shinsuke; Ito, Ryoichi. *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1711-1713.

**074954 COMPARISON OF THE ELECTRONIC STRUCTURE OF DISUBSTITUTED FERROCENES.** We have measured the optical absorption of gaseous ferrocene, 1,1'-dimethylferrocene, 1,1'-dibromoferrocene, and 1,1'-dichloroferrocene using synchrotron radiation. From these data we have estimated the ligand field parameters and noted increasing  $e_2(d)$  to  $\text{Cp}(\pi)$  overlap with increasing charge transfer from the Cp ring to the substitution. The optical absorption spectra for ferrocene, dibromoferrocene, and dichloroferrocene are remarkably similar. The halogen substitutions result in greater  $\text{Cp}(\pi)$  to  $e_2(d(x^2-y^2))$  hybridization. The  $e_2g$  orbitals become more bonding while the  $a_{1g}$  and  $e_{1g}$  orbitals become more non-bonding or antibonding. This change is reflected in a change of the ligand field parameters. (Edited author abstract) 22 refs.

Dowben, P.A. (Syracuse Univ, Syracuse NY, USA); Driscoll, D.C.; Tate, Ranjeet S.; Boag, N.M. *Organometallics* v 7 n 2 Feb 1988 p 305-308.

**074955 INFLUENCE OF THE RING-SUBSTITUTION ON THE SECOND HARMONIC GENERATION OF CHALCONE DERIVATIVES.** Several nonlinear chalcones have been prepared by selecting appropriate substituents. Second harmonic generation up to 5 times that of urea under IR-excitation has been observed. The determining role of the substituents in the symmetry of the molecular packing is pointed out. (Edited author abstract) 6 refs.

Fichou, Denis (CNRS, Thiais, Fr); Watanabe, Toshiyuki; Takeda, Takeshi; Miyata, Seizo; Goto, Yoshitaka; Nakayama, Masaharu. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 429-430.

**074956 ORGANIC CRYSTALS FOR NONLINEAR OPTICS.** Materials with nonlinear optical properties can be used in devices which process information very efficiently indeed. Typically they are used as fast switches, to modulate waves carrying information and to amplify signals. Chemists are now finding that organic materials may have as much - or more - to offer than the more conventional inorganic materials. (Author abstract) 5 refs.

Pugh, D. (Univ of Strathclyde, Glasgow, Scotl); Sherwood, J.N. *Chem Br* v 24 n 6 Jun 1988 p 544-545, 547-548.

**074957 QUANTUM YIELD AND FLUORESCENCE LIFETIME MEASUREMENTS OF NEU-**

**TRAL AND CATIONIC SPECIES OF SIX  $\beta$ -CARBOLINE DERIVATIVES.** A study of some emission parameters (quantum yield and fluorescence lifetime) for six alkaloid derivatives of  $\beta$ -carboline is presented. Depending on pH value, various species can exist in solution. In this work we have studied only two of them: cationic and neutral species. The variation of quantum yield and fluorescence lifetime has been analysed for different substituted  $\beta$ -carboline rings and for some derivatives which do not present the aromatic character on the pyrimidinic nucleus. (Author abstract). 10 refs.

Pardo, A. (Univ Autonoma de Madrid, Madrid, Spain); Reyman, D.; Martin, E.; Poyato, J.M.L.; Camacho, J.J.; Hidalgo, J.; Sanchez, M. *J Lumin* v 42 n 3 Sep 1988 p 163-168.

**Oxidation** See Also AEROSOLS—Production; CATALYSTS—Coatings; CATALYSTS—Copper Compounds; CATALYSTS—Silver; CATALYSTS—Structure; CATALYSTS—Vanadium Compounds; CHEMILUMINESCENCE; GLYCOLS—Oxidation; HYDROCARBONS—Oxidation; NUCLEAR FUELS—Reprocessing; OLEFINS—Oxidation; OXYGEN—Recovery; PHENOLS—Oxidation; SULFUR COMPOUNDS—Oxidation; WASTEWATER—Water Reclamation.

**074958 ELECTRO-OXIDATION BEHAVIOUR OF SOME METHOXYANTHRACENES IN BENZONITRILE.** Electro-oxidation behavior of 9,10-dimethoxy- and 9-cyano-10-methoxyanthracenes on a Pt electrode was investigated in benzonitrile containing tetra-n-butylammonium perchlorate using controlled potential electrolysis, cyclic voltammetry and ESR spectroscopy. The concentration of protons produced during electro-oxidation was determined spectroscopically. Anthraquinone was found to be the major product of electro-oxidation of these two compounds. (Author abstract) 18 refs.

Ozyoruk, Haluk (Hacettepe Univ, Ankara, Turk); Yildiz, Atilla. *Electrochim Acta* v 32 n 9 Sep 1987 p 1311-1314.

**074959 OLIGOMERIZATION OF 4-CHLOROANILINE BY OXIDOREDUCTASES.** Oxidation of aromatic amines by oxidoreductases can result in the formation of polyaromatic products. We incubated 4-chloroaniline with horseradish peroxidase and with a laccase from the fungus *Trametes versicolor*. Qualitative and quantitative analyses were performed on the oligomeric products. Both enzymes generated eight oligomers, which were isolated and identified. On the basis of their structures and rates of formation, a reaction scheme for the oxidative oligomerization of 4-chloroaniline was proposed. The scheme shows that, once the substrate was enzymatically oxidized, free-radical coupling followed, and three dimeric intermediates were produced. Each of the dimers initiated a nonenzymatic reaction pathway, and the combined pathways accounted for the formation of the first eight stable 4-chloroaniline-derived oligomers. (Author abstract) 16 refs.

Simmons, Kathleen E. (Pennsylvania State Univ, University Park, PA, USA); Minard, Robert D.; Bollag, Jean-Marc. *Environ Sci Technol* v 21 n 10 Oct 1987 p 999-1003.

**074960 LIQUID PHASE OXIDATION OF CYCLOHEXENE WITH ALCOHOLIC PALLADIUM(II) SALTS.** The oxidation of cyclohexene to cyclohexanone with alcoholic palladium(II) salts has been investigated. The best result in the catalyst system studied was obtained with the  $\text{PdCl}_2\text{-CuCl}_2\text{-2H}_2\text{O}$  couple. However, further oxidations of cyclohexanone significantly occurred, i.e., cyclohexanone was oxidatively dehydrogenated to 2-cyclohexen-1-one, which then afforded 3-ethoxy-2-cyclohexen-1-one by an oxipalladation mechanism, resulting in a decrease in the cyclohexanone selectivity. (Author abstract) 11 refs.

Takehira, Katsuomi (Tsukuba Research Cent, Yatabe, Jpn); In Hwan Oh; Martinez, Victor C.; Chavira, Rodolfo S.; Hayakawa, Takashi; Orita, Hideo; Shimidzu, Masao; Ishikawa, Toshio. *J Mol Catal* v 42 n 2 Oct 1987 p 237-246.



**074961 PALLADIUM(II)-CATALYZED OXIDATION OF CYCLOPENTENE IN THE PRESENCE OF COPPER(II) CHLORIDE AND MOLECULAR OXYGEN.** The oxidation of cyclopentene to cyclopentanone with alcoholic palladium(II) salt has been investigated. PdCl<sub>2</sub> coupled with CuCl<sub>2</sub> or FeCl<sub>3</sub> as co-catalyst afforded cyclopentanone with high yield in alcoholic solvents at moderate temperatures. Under atmospheric pressure of oxygen, use of FeCl<sub>3</sub> as co-catalyst resulted in high selectivity to cyclopentanone, >90%, at approx. 50% cyclopentene conversion. An increase in oxygen pressure to 490.3 kPa favored the selective oxidation with PdCl<sub>2</sub>-CuCl<sub>2</sub> catalyst, to afford the almost complete conversion of cyclopentene to cyclopentanone. The PdCl<sub>2</sub>-CuCl<sub>2</sub> couple catalyzed the mono-oxygenation of cyclopentene to cyclopentanone with dioxygen, the reaction rate depending greatly on the oxygen pressure. These results cannot be accounted for by the conventional Wacker-type catalysis; a hydroperoxopalladium(II) species coupled with Cu(II) is most likely the active species. (Author abstract) 10 refs.

Takehira, Katsuomi (Tsukuba Research Cent, Yatabe, Jpn); Orita, Hideo; In Hwan Oh; Leobardo, Corona O.; Martinez, Gudelia C.; Shimidzu, Masao; Hayakawa, Takashi; Ishikawa, Toshio. *J Mol Catal* v 42 n 2 Oct 1987 p 247-255.

**074962 DETERMINATION OF THE PARAMETERS OF ELECTROCHEMICAL FURFURAL OXIDATION AT A CARBON ELECTRODE IN A CONTINUOUS CELL.** It was the task of this investigation to find the optimum conditions of electrochemical furfural oxidation to  $\beta$ -formylacrylic acid in the cell proposed. The solution concentration of furfural and the qualitative and quantitative composition of the reaction products were determined in these investigations by the procedures developed previously. The results obtained when investigating the influence on the FAA yields of current density, furfural starting concentration, and contact time between anode and solution to be oxidized are reported. It is shown that at the different starting concentrations and current densities, a certain time of contact between anolyte and electrode must not be exceeded for maximum FAA yields, since otherwise the FAA is oxidized to maleic acid. At a given current density, the contact times required for maximum FAA yield increased when the furfural starting concentration is increased. 7 refs.

Mil'man, V.I. (Krasnodar Polytechnic Inst, USSR); Sycheva, G.M. *Sov Electrochem* v 22 n 12 Dec 1986 p 1539-1540.

**074963 PREPARATION OF 2-SUBSTITUTED BENZOXAZOLES FROM PHENOLIC SCHIFF BASES BY COPPER(II) CHLORIDE-CATALYZED OXIDATION WITH DIOXYGEN IN PYRIDINE.** N-alkylidene-2-hydroxyanilines are oxidized by dioxygen to 2-substituted benzoxazoles in good yields when initiated by copper(I) chloride in pyridine. The overall rate of dioxygen consumption obeys second-order kinetics. The reaction rate is independent of the substrate concentration, indicating that the oxidation of Cu(I) is rate-limiting. (Author abstract) 39 refs.

Speier, Gabor (Veszprem Univ of Chemical Engineering, Veszprem, Hung). *J Mol Catal* v 41 n 3 Aug 1987 p 253-260.

**074964 ELECTROCHEMICAL OXIDATION OF 1,3-CYCLOHEXADIENE.** The electroinitiated cation radical Diels-Alder reaction was attempted for 1,3-cyclohexadiene in methylene chloride with tetrabutylammonium tetrakisfluoroborate as the supporting electrolyte. The expected end o/exo adducts (4:1) were formed in very low yields. The major product was characterized by <sup>1</sup>H and <sup>13</sup>C NMR as polycyclohexadiene with mainly 1,4-addition mode segments. Different voltages, supporting electrolytes, electrode materials, and concentrations were used in an effort to optimize reaction results. Polymerization was still a major competing reaction, but the use of tetrabutylammonium hexafluorophosphate as supporting electrolyte was still a major competing reaction, but the use of tetrabutylammonium hexafluorophos-

phate as supporting electrolyte and of graphite electrodes instead of platinum, improved the Diels-Alder adduct yield. (Edited author abstract) 24 refs.

Nigenda, S.E. (Polytechnic Univ, Brooklyn, NY, USA); Schleich, D.M.; Narang, S.C.; Keumi, T. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2465-2470.

**074965 OXIDATION OF ANTHRACENE IN THE LIQUID-PHASE.** Various processes for the oxidation of anthracene in the liquid-phase have been reviewed with special consideration to the mechanistic pathways involved. The prospect of the processes with crude anthracene/less pure anthracene as feed-stock has been emphasized. (Author abstract) 119 refs.

Das, C.K. (Central Fuel Research Inst, Dhanbad, India); Das, N.S. *J Chem Technol Biotechnol* v 39 n 3 1987 p 183-199.

**074966 VAPOUR PHASE OXIDATION OF 2,6-LUTIDINE TO 2,6-PYRIDINEDICARBOXYALDEHYDE. III: KINETIC STUDY.** The oxidation reaction of lutidine (LUT) was carried out at 390-450°C over V-Mo-oxide catalyst, in presence of excess steam. A much simplified, but still significant kinetic model was obtained, useful for the design of a pilot plant, in view of a possible practical development of the process. The apparent  $\Delta E_a$  for the main reactions of the model range from ca. 111 to ca. 198 kJ mol<sup>-1</sup>, except for the formation of the heterocyclic byproducts from the lutidine-mono- and di-carboxaldehydes, for which a  $\Delta E_a$  of only 54 kJ mol<sup>-1</sup>, was found. LUT seems to absorb on the catalyst more strongly than the partially oxidised products. (Author abstract) 13 refs.

Forni, Lucio (CNR, Milan, Italy); Casalone, Gianluigi. *Appl Catal* v 34 n 1-2 Oct 15 1987 p 317-328.

**074967 COMPLETE CATALYTIC OXIDATION OF VOLATILE ORGANICS.** Heterogeneous catalytic oxidation of organic compounds is an important and intensely studied area. However, most reported research deals with the partial oxidation of petrochemical feedstocks to make products of economic value (e.g., ethylene oxide from ethylene), automotive exhaust catalysts, or CO oxidation. Complete (or —deep—) catalytic oxidation of low molecular weight volatile organic compounds (VOCs) in air has received relatively little attention. This review of heterogeneous catalytic oxidation focuses on its application to control of VOCs at operating conditions typical of field applications. The parameters for this review are low to moderate temperatures (25-400°C), atmospheric pressure, high space velocity (10<sup>3</sup>—10<sup>5</sup> h<sup>-1</sup>), and low organic reactant concentration (roughly 10<sup>2</sup>—10<sup>3</sup> ppm) in air. (Author abstract) 125 refs.

Spivey, James J. (Research Triangle Inst, Research Triangle Park, NC, USA). *Ind Eng Chem Res* v 26 n 11 Nov 1987 p 2165-2180.

**074968 PARALLEL AND SERIAL NETWORKS IN THE MECHANISM OF THE OSCILLATING BELOUSOV-ZHABOTINSKY REACTION. THE TANDEM OSCILLATOR.** After some historical introduction the problem of non-bromide controlled oscillations is discussed. An experimental proof for a fast  $\text{Ag}^+ + \text{Br}^- \rightarrow \text{AgBr}$  precipitation reaction is presented. This proves that in the presence of silver ions bromide cannot play the role of the control intermediate; it must be another chemical species. For the role of the second control intermediate an organic free radical is proposed. It is shown that while bromide is a part of a serial (Explosor type) network the organic free radical is a part of a parallel (Oregonator type) network. Finally, a combination of the two networks the Tandem oscillator is presented. (Author abstract) 61 refs.

Noszticzius, Zoltan (Univ of Texas at Austin, Austin, TX, USA); Swinney, Harry L.; Schelly, Zoltan A.; McCormick, William D. *Acta Polytech Scand Chem Technol Metall Ser* n 178 1987 p 57-77.

**074969 KINETICS AND MECHANISM OF THE OXIDATION OF N,N-DIETHYL-P-PHENYLENE-**

**DIAMINE BY 12-TUNGSTOCOBALTATE(III).** The almost irreversible oxidation of N,N-diethyl-p-phenylenediamine by 12-tungstocobaltate(III) was studied by means of a multi-mixing, stopped-flow apparatus with optical detection. Both unprotonated and simple protonated p-phenylenediamine are oxidized rapidly to form p-semiquinonediimine. The reaction rate is dependent on the concentration of all ions present in the solution, as well as on the choice and concentration of the buffer. The rate constant varies from  $3 \cdot 10^4 \text{ M}^{-1} \text{ s}^{-1}$  to  $1.4 \cdot 10^6 \text{ M}^{-1} \text{ s}^{-1}$  at 25°C. The activation energy in all cases is very small. (Author abstract) 39 refs.

Nickel, Ulrich (Univ Erlangen-Nuernberg, Erlangen, West Ger); Klein, Boris; Jen Hsin-min. *Ber Bunsenges Phys Chem* v 91 n 10 Oct 1987 p 997-1002.

**074970 SYNTHESIS OF AROMATIC NITRILES BY VAPOUR PHASE CATALYTIC AMMOXIDATION.** V/Ti/O catalysts, active for the mild oxidation of o-xylene, were tested in the ammoxidation of different alkylaromatics. The presence of substituents on the aromatic ring was found to slightly influence the reactivity of the hydrocarbon; both electron donor and acceptor groups showed an activating effect with respect to toluene. This was taken as an indication that the slow step of the reaction consists in a homolytic scission of the C-H bond, thus involving a radical intermediate species. (Edited author abstract) 30 refs.

Cavani, Fabrizio (Dep of Industrial Chemistry & Materials, Bologna, Italy); Parrinello, Fiorenzo; Trifiro, Ferruccio. *J Mol Catal* v 43 n 1 Nov 2 1987 p 117-125.

**074971 KINETICS AND MECHANISM OF Ru(III)-EDTA CATALYZED OXIDATION OF cis-CYCLOOCTENE BY MOLECULAR OXYGEN.** The homogeneous oxidation of cis-cyclooctene with molecular oxygen catalyzed by potassium chloro(ethylene)diaminetetraacetato)ruthenium(III),  $\text{K}[\text{Ru}(\text{H}_2\text{EDTA})\text{Cl}] \cdot 2\text{H}_2\text{O}$ , was investigated in the temperature range 310-335 K,  $\mu = 0.1 \text{ M KCl}$  in 1:1 water-dioxane mixture. The rate of oxidation of cis-cyclooctene was found to be first order with respect to catalyst and cyclooctene concentrations, and one-half order in molecular oxygen concentration. Based on the kinetic data, a  $\mu$ -peroxoruthenium(IV) cyclooctene complex is suggested as an active intermediate for the formation of cyclooctene oxide as a major product. (Edited author abstract) 23 refs.

Khan, M.M. Taqui (Central Salt and Marine Chemicals Research Inst, Bhavnagar, India); Mirza, Shaikat A.; Bajaj, H.C. *J Mol Catal* v 42 n 3 Nov 2 1987 p 323-329.

**074972 CATALYZED OXIDATION KINETICS OF ANTHRACENE WITH OXYGEN IN ETHYLENE GLYCOL.** The kinetics of liquid-phase oxidation of anthracene to anthraquinone by gaseous oxygen, with  $\text{CuBr}_2$  as a catalyst and ethylene glycol as the solvent, has been studied. The oxidation kinetics, without an induction period, is interpreted by considering an analyzed intermediate compound, and the kinetic constants are evaluated over the temperature range 120-160°C. One mechanism for the reaction which conforms with the experimental results is also proposed. (Author abstract) 16 refs.

Cepeda, Emilio A. (Colegio Universitario de Alava, Vitoria, Spain); Diaz, Mario. *Ind Eng Chem Res* v 26 n 12 Dec 1987 p 2401-2403.

**074973 ASSESSMENT OF CONDITIONS UNDER WHICH THE OXIDATION OF FERROCENE CAN BE USED AS A STANDARD VOLTAMMETRIC REFERENCE PROCESS IN AQUEOUS MEDIA.** The one-electron oxidation process for ferrocene (Fc),  $\text{Fc} \rightleftharpoons \text{Fc}^+ + e^-$ , has been studied extensively by cyclic, normal pulse, and differential pulse voltammetry and chronocoulometry to determine the conditions under which this reaction can be used as a voltammetric standard in aqueous media. In water, the oxidation of ferrocene is not a simple reversible one-electron process as is the case in organic solvents. Rather, weak reactant



adsorption is exhibited, which is electrode and electrolyte dependent. The oxidation of a saturated solution corresponds to considerably less than a monolayer of coverage. (Edited author abstract) 59 refs.

Bond, A.M. (Deakin Univ, Warrn Ponds, Aust); McLennan, E.A.; Stojanovic, R.S.; Thomas, F.G. *Anal Chem* v 59 n 24 Dec 15, 1987 p 2853-2860.

**074974 CHANGES IN THE STEADY ELECTROOXIDATION RATES OF ORGANIC SUBSTANCES ON PLATINUM AND PALLADIUM INDUCED BY THALLIUM MONOLAYER FORMATION ON THESE METALS.** The data show that an accelerating effect of thallium adatoms is displayed at Pt/Pt, only in the oxidation of HCOOH and HCHO at  $E_c$  which are not too high, i.e., precisely in those cases where the contribution of currents due to the oxidation of products of a catalytic decomposition ( $i_c$ ) to the measured values of  $i_a$  is quite large. Two reasons for an increase of  $i_c$  are possible: an acceleration of catalytic decompositions itself and (or) a more difficult removal of the decomposition products from the surface without consumption of charge. The results obtained also show, at the time, that thallium adatoms influence not only  $i_c$  but also - directly - the electrooxidation rate of the chemisorbed species; it follows directly from the data for CH<sub>3</sub>OH that they lower it. Tin adatoms accelerate this process. The data obtained in the polarization measurements of this work allow the basic tasks in mechanistic studies of electrocatalysis by adatoms to be defined, and optimum systems and processes for their experimental accomplishment to be selected. 15 refs.

Tsirlina, G.A. (Acad of Sciences of the USSR, Moscow, USSR); Andreev, V.N.; Vasil'ev, Yu.B.; Kazarinov, V.E. *Sov Electrochem* v 23 n 4 Apr 1987 p 515-519.

**074975 CATALYTIC OXIDATION OF THIOCYANATES AND CYANIDES WITH OZONE.** Oxidation of thiocyanates and cyanides with ozone can be used to purify wastewaters from metallurgical plants. To investigate the effect of catalysts of oxidation of thiocyanates and cyanides we used industrial catalysts based on metal oxides. Data are presented that show the relation between concentration of thiocyanate and the cyanide formed during ozonation without a catalyst and with a catalyst. During oxidation of thiocyanate without a catalyst accumulation of cyanide occurs first in the solution. The amount of cyanide then diminishes, since its oxidation to cyanate begins to predominate. In the presence of catalysts SNM-1 and NTK the rate of cyanide oxidation increases sharply. We also investigated the effect of temperature on catalytic oxidation of cyanides. It was found that when catalyst SNK-1 was used with increasing temperature from 25 to 37°C, the rate of oxidation of cyanides increases. These investigations enable us to significantly improve the industrial method for purifying wastewaters from metallurgical plants. This study enables us also to propose an effective and economical catalyst (copper oxide) during oxidation of thiocyanates and cyanides with ozone. The principles of this process will be of assistance in designing new industrial facilities for wastewater purification. 4 refs.

Alibekov, G.Ya.; Kashcheev, I.N.; Starodubtsev, D.S.; Tupitsyn, V.P. *Coke Chem (USSR)* n 3 1987 p 72-74.

**074976 OXIDATIVE TRANSFORMATIONS OF 4-PICOLINE IN THE GAS PHASE IN THE PRESENCE OF A VANADIUM OXIDE CATALYST.** The basic principles of the gas-phase oxidative transformations of 4-picoline in the presence of a vanadium oxide catalyst were investigated. High catalytic activity and selectivity of vanadium pentoxide in the synthesis of 4-cyanopyridine were demonstrated. Some kinetic principles of the oxidative ammonolysis of 4-picoline were studied in a flow apparatus with a gradientless reactor. (Author abstract) 13 refs.

Suvorov, B.V. (Acad of Sciences of the Kazakh SSR, Alma-Ata, USSR); Tolmacheva, T.P.; Afanas'eva, T.A.; Vorob'ev, P.B. *Kinet Catal* v 28 n 2 pt 2 Mar-Apr 1987 p 344-349.

**074977 FORMATION MECHANISM FOR A CATALYST FOR THE SELECTIVE OXIDATION OF ETHYLBENZENE IN THE PRESENCE OF NICKEL BIS-ACETYLACETONATE AND AN ELECTRON-DONOR LIGAND. 1. OXIDATION OPTIMIZATION.** It has been found that there is a considerable increase in the degree of oxidation of ethylbenzene to hydroperoxide as catalyzed by Ni(AcAc)<sub>2</sub>-D complexes (D is hexamethylphosphoramide) when Ni(AcAc)<sub>2</sub> is added. It is suggested that the mechanism involves an increase in the concentration of the oxidation product from the initial Ni(AcAc)<sub>2</sub>-D, which is responsible for the selectivity. Experimental evidence has been obtained that the O<sub>2</sub> is attached in the oxidation of Ni(AcAc)<sub>2</sub>-D on the C-H methine bond in the acetylacetonate ligand. (Author abstract) 13 refs.

Mosolova, L.A. (Acad of Sciences of the USSR, Moscow, USSR); Matienko, L.I.; Skibida, I.P. *Kinet Catal* v 28 n 2 pt 2 Mar-Apr 1987 p 421-425.

**074978 FORMATION MECHANISM FOR A CATALYST FOR THE SELECTIVE OXIDATION OF ETHYLBENZENE IN THE PRESENCE OF NICKEL BIS-ACETYLACETONATE AND AN ELECTRON-DONOR LIGAND. 2. COMPOSITION OF THE CATALYTICALLY ACTIVE COMPLEX.** This study concerns the structure of the oxidation product from Ni(AcAc)<sub>2</sub>-D. Various physicochemical methods have been used together with elemental analysis to show that the oxidation of Ni(AcAc)<sub>2</sub>-MP (MP is N-methylpyrrolid-2-one) gives rise to a binuclear complex of composition Ni<sub>2</sub>(AcAc)(AcO)<sub>3</sub>-MP·2H<sub>2</sub>O (P). Kinetic methods show that this complex P catalyzes the selective oxidation of ethylbenzene to 1-phenylethylhydroperoxide. (Edited author abstract) 9 refs.

Mosolova, L.A. (Acad of Sciences of the USSR, Moscow, USSR); Matienko, L.I.; Skibida, I.P. *Kinet Catal* v 28 n 2 pt 2 Mar-Apr 1987 p 425-428.

**074979 MASS TRANSFER AND SOLUBILITY IN AUTOCATALYTIC OXIDATION OF CYCLOHEXANE.** Mass transfer coefficients for the solution, without reaction, of oxygen in cyclohexane over a wide range of temperature and pressure have been measured in a flat interface reactor (FIR) and a gas sparged stirred-tank reactor (STR). Solubilities have also been measured and it is suggested that a modified Henry's law coefficient of  $1.09 \times 10^{-2}$  kmol/m<sup>3</sup>·bar can be regarded as constant over the temperature range 293-435 K. The physical mass transfer coefficient in the STR shows very little variation over this temperature range and a value of  $3.5 \times 10^{-4}$  m/s can be assumed for 423-435 K. (Edited author abstract) 50 refs.

Suresh, A.K. (Monash Univ, Clayton, Aust); Sridhar, T.; Potter, O.E. *AIChE J* v 34 n 1 Jan 1988 p 55-68.

**074980 AUTOCATALYTIC OXIDATION OF CYCLOHEXANE - MODELING REACTION KINETICS.** Liquid phase oxidation of hydrocarbons is a major source of organic chemicals. This paper concerns itself with the oxidation of cyclohexane. In this paper attention is given to the kinetics and to the interaction of kinetics and mass transfer, showing that in this autocatalytic system the dissolved oxygen level rises to saturation and falls as the rate of reaction increases. Initially zero order in oxygen, the reaction becomes first order at low oxygen levels. (Edited author abstract) 10 refs.

Suresh, A.K. (Monash Univ, Clayton, Aust); Sridhar, T.; Potter, O.E. *AIChE J* v 34 n 1 Jan 1988 p 69-80.

**074981 AUTOCATALYTIC OXIDATION OF CYCLOHEXANE-MASS TRANSFER AND CHEMICAL REACTION.** In an industrial gas-liquid reactor both mass transfer and kinetics have, in principle, a role to play. This paper describes studies on the oxidation of cyclohexane in two-phase, gas-liquid reactors. Regimes of absorption have been clarified by measurements of dissolved oxygen concentrations. The behavior is found to be complex, arising from the fact that no reaction is autocatalytic kinetics, enhanced physical mass transfer rates arise.

(Edited author abstract) 20 refs.

Suresh, A.K. (Monash Univ, Clayton, Aust); Sridhar, T.; Potter, O.E. *AIChE J* v 34 n 1 Jan 1988 p 81-93.

**074982 ANODIC OXIDATION OF O-TOLUENESULPHONAMIDE TO SACCHARINE ON A NiO(OH)-COATED NICKEL ANODE.** O-Toluenesulphonamide has been electrolytically oxidized at low current density to saccharine in aqueous solutions of alkali carbonates on anodes coated with NiO(OH). This electrolytic oxidation led to a 40% yield of saccharine. The application of carbon and glassy-carbon counter electrodes or of various supports for the working electrodes did not result in improved saccharine yield. Moreover, the choice of a different potential and a different current density or the use of organic co-solvents did not substantially affect the course of the electrolytic oxidation. (Edited author abstract) 12 refs.

Hlavaty, Jaromir (Czechoslovak Acad of Sciences, Prague, Czech); Bakos, Viktor; Volke, Jiri. *J Appl Electrochem* v 17 n 6 Nov 1987 p 1228-1233.

**074983 ROLE OF FIRST- AND SECOND-ORDER REACTIONS WITH RESPECT TO Pd(II) IN THE OXIDATION OF THIOPHENE BY PALLADIUM(II) SALTS IN AQUEOUS SOLUTIONS.** The authors report results concerning the kinetics and mechanism of reaction in aqueous solutions containing HClO<sub>4</sub> or H<sub>2</sub>SO<sub>4</sub> at a 10-fold excess of Pd<sup>II</sup> relative to thiophene. New data have been obtained concerning the effects of Pd<sup>II</sup> concentration, medium acidity, and salt additives on the reaction kinetics. It is shown that under the conditions of this study Pd<sup>II</sup> reacts in its Pd<sup>2+</sup> aqua ion form with thiophene; in H<sub>2</sub>SO<sub>4</sub> solutions it is also active in the form of the bisulfate complex Pd(HSO<sub>4</sub>)<sub>2</sub>. 2-Thienylpalladium (II) is an intermediate in this reaction; it is formed via an electrophilic substitution mechanism. Evidence has also been obtained for the reversibility of this reaction. 19 refs.

Rudakov, E.S. (Acad of Sciences of the Ukrainian SSR, Donetsk, USSR); Ignatenko, V.M. *Kinet Catal* v 28 n 3 pt 1 May-Jun 1987 p 510-517.

**074984 CATALYTIC OXIDATION OF 1-OCTENE IN THE PRESENCE OF Mn<sub>2</sub>O<sub>4</sub>.** A study has been made of the initial stages in the liquid-phase oxidation of 1-octene in the presence of Mn<sub>2</sub>O<sub>4</sub>. It has been established that the process is initiated by catalytic decomposition of hydroperoxide. The orders of reaction with respect to olefin, hydroperoxide, and catalyst have been determined. Critical quantities of catalyst have been detected. It is suggested that the catalyst surface contains two kinds of active centers on which hydroperoxide is decomposed through radical and molecular paths. It is shown that critical phenomena set in when the rate of hydroperoxide decomposition is greater than the rate of its formation. (Edited author abstract) 9 refs.

Kotur, M.G. (Lenin Komosomol L'vov Polytechnic Inst, USSR); Kozak, S.I.; Nikipanchuk, N.V.; Chernyak, B.I. *Kinet Catal* v 28 n 3 pt 1 May-Jun 1987 p 523-528.

**074985 KINETICS OF OXIDATION OF CYANIDE IONS WITH OZONE IN AN ALKALINE MEDIUM.** The authors investigated the kinetics of oxidation of CN<sup>-</sup> ions in alkaline solutions with ozone. They demonstrated that the process occurs under diffusion conditions. They also determined the factors that influence the rate of oxidation with ozone. They refined the values incorporated in the equation of diffusion kinetics which satisfactorily describes the process. 5 refs.

Medvedev, A.S.; Alibekov, G.Ya.; Kashcheev, I.N. *Coke Chem (USSR)* n 4 1987 p 64-68.

**074986 INTRADIFFUSION INHIBITION IN THE ETHYL CHLORIDE OXIDATION PROCESS ON A COPPER-COBALT-CHROME CATALYST.** A determination of the role of intradiffusion inhibition in the catalytic oxidation process of ethyl chloride, the basis of purification of waste gases from this toxic impurity, was



carried out in the present research. The porous structure was investigated of a copper-cobalt-chrome catalyst, deposited in  $\gamma\text{-Al}_2\text{O}_3$ , used in the ethyl chloride oxidation process. It was established that a bidispersed structure is characteristic for this catalyst with a predominance of micropores and macropores. Degrees of use of the internal surface were calculated from structural characteristics of the catalyst and data on kinetics of reaction and were compared with experimentally determined values. A kinetic equation was obtained, expressing the rate of ethyl chloride oxidation on the copper-cobalt-chrome catalyst in the intradiffusion region. (Edited author abstract) 7 refs.

Chernitskii, O.G.; Vlasenko, V.M.; Chernobrivets, V.L.; Denisov, A.A. *Sov Prog Chem* v 53 n 3 1987 p 34-38.

**074987 OXIDATION OF 1-ACETOXYCYCLOHEXENE CATALYZED BY  $\text{VO}^{2+}$ ,  $\text{MoO}_2^{2+}$ , AND  $\text{Cr}^3$  ACETYLACETONATES.** We studied the possibility of obtaining acetoxyketones more selectively during catalytic oxidation of ACH-1 (1-Acetoxy-cyclohexene) in the presence of metal compounds of varying valence: vanadyl, molybdenyl, chromium, and chromium stearate acetylacetonates, which have been shown to be effective catalysts for hydroperoxide decomposition and olefin epoxidation. It is shown that during oxidation of ACH-1 in the presence of  $\text{MoO}_2(\text{acac})_2$ , the concentration of ACHanone-2 (1-Acetoxy-cyclohexane-2-one) and CHenone-1 (2-Cyclohexene-1-one) increases. The increase in the relative content of these compounds is due primarily to a decrease in the amount of ACHenone-3 (1-Acetoxy-cyclohex-3-one). Moreover, at the same oxidation level, the concentration of ACHanone-2 is almost two times higher and that of HP two times lower than in the uncatalyzed oxidation. 11 refs.

Gudimenko, Yu.I. (Acad of Sciences of the Belorussian SSR, USSR); Agabekov, V.E.; Shibaeva, L.V.; Mitskevich, N.I. *JAPPL Chem USSR* v 60 n 5 pt 1 May 1987 p 1018-1021.

**074988 BIOMIMETIC OXIDATION WITH MOLECULAR OXYGEN. SELECTIVE CARBON-CARBON BOND CLEAVAGE OF 1,2-DIOLS BY MOLECULAR OXYGEN AND DIHYDROPYRIDINE IN THE PRESENCE OF IRON-PORPHYRIN CATALYSTS.** The selective carbon-carbon bond cleavage of 1,2-diols in the presence of an iron-porphyrin complex, molecular oxygen, and 1-benzyl-3-carbamoyl-1,4-dihydropyridine is reported. The C-C bonds of aryl-substituted ethane-1,2-diols were cleaved exclusively to aldehydes or ketones as the oxidation products at room temperature. The reaction rates were influenced by the steric hindrance of the substituents both in the catalysts and diols, but no differences in the reactivities were observed between the two stereo isomers (meso and dl) of diols. A kinetic analysis of this bond cleavage reaction is consistent with the reaction mechanism consisting of the initial binding of diol on the active catalyst forming an intermediate complex and its subsequent breakdown in the rate-determining step of the catalytic cycle. (Edited author abstract) 68 refs.

Okamoto, Tadashi (Kyoto Univ, Uji, Jpn); Sasaki, Ken; Oka, Shinzaburo. *J Am Chem Soc* v 110 n 4 Feb 1988 p 1187-1196.

**074989 ELECTROCATALYTIC OXIDATION OF GLYOXALATE IN ALKALINE MEDIUM ON PLATINUM ADAMANT ELECTRODES.** The influence of the foreign metal adatoms deposited at underpotentials on the oxidation of glyoxalate on platinum was studied in alkaline medium. Pronounced catalytic effects caused by underpotential submonolayers of Pb, Ti, Cd, Cu and Cr were observed. The enhancement of the oxidation processes by underpotential submonolayers has been interpreted according to the bifunctional theory of the electrocatalysis. (Author abstract) 33 refs.

Ocon, P. (Univ Autonoma de Madrid, Madrid, Spain); Gonzalez Velasco, J. *J Appl Electrochem* v 18 n 1 Jan 1988 p 43-53.

**074990 LIQUID-PHASE OXIDATION OF P-ISOPROPYLPHENYL ACETATE.** The kinetics and products of the initiated liquid-phase oxidation of p-isopropylphenyl acetate (IPPA) in the temperature range 80-115°C have been studied. Yields of hydroperoxide are >90% at low temperature and low conversion. The composite rate constants determined at the different temperatures predict an overall energy of activation of 7.8 kcal/mol. The oxidation is self-retarding, and conversions of about 35-38% are the upper practical limit. The product hydroperoxide is readily rearranged by acid catalysis to hydroquinone monoacetate (and acetone) in ca.90% yield. Computer simulation of the reaction has been accomplished by numerical integration of a 15-step mechanism. (Edited author abstract) 32 refs.

Sickle, Dale E. Van (Eastman Kodak Co, Kingsport, TN, USA). *Ind Eng Chem Res* v 27 n 3 Mar 1988 p 440-447.

**074991 ELECTROCHEMICAL FORMATION OF THE  $\text{PyO}^+$  CATION RADICAL AND ITS REACTION WITH CYCLOHEXANE.** The oxidation of PyO was studied in  $\text{CH}_3\text{CN}$  solution containing 0.2 mole/liter  $\text{LiClO}_4$  on a rotating disk electrode made from carbon glass, using linear and cyclic voltammetry. The half-wave potential  $E_{1/2}$  observed in the irreversible oxidation of PyO to  $\text{PyO}^+$  was  $+1.72 \pm 0.01$  V (relative to SCE). The limiting current  $I_d$  appeared to be diffusion (controlled). Introduction of cyclohexane to this solution resulted in a decrease in  $I_d$ ; the higher the concentration of  $\text{C}_6\text{H}_{12}$ , the more pronounced the decrease in  $I_d$ . The decrease in  $I_d$  can possibly be associated with adsorption of pyridine on the anode, the pyridine being formed in the chemical reaction of  $\text{PyO}^+$  with cyclohexane which occurs after the electrode process. 3 refs.

Kulakovskaya, S.I. (Acad of Sciences of the USSR, Chernogolovka, USSR); Geletii, Yu.V.; Kushch, L.A.; Shamaev, S.N.; Shilov, A.E. *Kinet Catal* v 28 n 4 pt 2 Jul-Aug 1987 p 899-900.

**074992 KINETIC FEATURES OF THE OXIDATION OF  $\text{C}_2\text{H}_5\text{CHO}$  IN THE REGION OF THE NEGATIVE TEMPERATURE COEFFICIENT OF THE MAXIMUM REACTION RATE. II. INFLUENCE OF THE RATIO OF SURFACE AREA OF VOLUME OF THE REACTION VESSEL.** EPR has been used to study the influence of the surface-to-volume ratio (S/V) of the reaction vessel on the kinetics of the gas-phase oxidation of  $\text{C}_2\text{H}_5\text{CHO}$  in the region of the negative temperature coefficient of the maximum reaction rate. It has been shown that increasing S/V leads to a shift of the region of the negative temperature coefficient toward lower temperatures in a reactor treated with boric acid, while in reactors treated with KCl no negative temperature coefficient is observed. The dependence of the boundary of the region in which the negative temperature coefficient depends on S/V is explained by the breakdown of the radicals  $\text{RCO}$ ,  $\text{RCO}_2$ , and  $\text{RCO}_2\text{H}$  at the surface. (Edited author abstract) 9 refs.

Lusparian, A.P. (Acad of Sciences of the Armenian SSR, Erevan, USSR); Oganessian, E.A.; Vardanyan, I.A.; Nalbandyan, A.B. *Kinet Catal* v 28 n 4 pt 1 Jul-Aug 1987 p 673-677.

**074993 OXIDATION OF PHOSPHINE BY OXYGEN CATALYZED BY COPPER (II) CHLORIDE COMPLEXES SUPPORTED ON SILICA GEL.** The authors report on a study of phosphine oxidation by oxygen in the presence of  $\text{Cu(II)}$  chloride complexes supported on MSM silica gel. This study includes a determination of the composition of the complexes responsible for catalysis. On the basis of kinetic and potentiometric studies, it has been shown that maximum catalytic activity in the oxidation of phosphine by oxygen is manifested by complexes with the composition  $\text{CuFCl}_3$  (-aq) and  $\text{CuCl}_4^{2-}$  (-aq) supported on MSM silica gel. (Edited author abstract) 14 refs.

Rakitskaya, T.L. (I.I. Mechnikov Odessa State Univ, USSR); Abramova, N.N.; Poklad, N.S.; Red'ko, T.D. *Kinet Catal* v 28 n 4 pt 1 Jul-Aug 1987 p 762-765.

**074994 REACTIVITY OF RING-SUBSTITUTED DERIVATIVES OF ALKYL BENZENES IN REACTIONS WITH PEROXY RADICALS.** The reaction of hydrogen atom detachment by peroxy radicals is studied in detail for two reasons. First, it is an important elementary stage of reactions of chain continuation during oxidation of many substances (products of petroleum and carbon chemistry) by oxygen. Second, experimental methods for kinetic measurements have now reached such a level that they enable the rate constants of reactions to be measured with the wide variation in structure of both the molecules and the peroxy radicals for reaction series where the radical is the same but the molecular structure varies and also for reactions of different radicals with the same molecule. In view of this derivatives of alkyl-aromatic compounds have been investigated. Analysis of available data relating to the dependence of the rate constants of ring-substituted alkylarenes on the properties of substituents makes it possible to conclude that the reactivity of particles here is determined on the one hand by the energy factor (the energy of the rupturing and forming bonds), and on the other hand by the polar factor, indicated by the ability of a particle to give and receive electrons. 25 refs.

Opeida, I.A. (Ukrainian Acad of Sciences, USSR). *Pet Chem USSR* v 26 n 4 1986 p 214-223.

**074995 ROUTE OF AUTOOXIDATION OF ORGANIC COMPOUNDS THROUGH A METAL ION AND BROMIDE CATALYSIS.** Liquid-phase oxidation of organic compounds is normally an autocatalytic process and proceeds by a branched-chain mechanism through intermediate formation of peroxides. Decomposition of peroxides into free radicals ensures branching of the chain and consequently autoacceleration of the reaction. It is found that when bromine ions are present, the reduction of organic compounds takes place readily in several redox stages, which ensures high effectiveness of the route of autooxidation through a metal ion. The use of this route and the latent catalytic possibilities of metal ions is promising in the development of new effective systems of complete and selective oxidation of organic compounds. 25 refs.

Zakharov, I.V. (USSR Acad of Sciences, USSR); Geletii, Yu.V. *Pet Chem USSR* v 26 n 4 1986 p 234-246.

**074996 WET OXIDATION CATALYZED BY RUTHENIUM SUPPORTED ON CERIUM(IV) OXIDES.** The activity of precious metal catalysts in the wet oxidation of organic compounds was investigated. Ruthenium was the most active catalyst among the precious metals examined, and cerium(IV) oxide was the most effective support. The Ru/Ce catalyst rivaled homogeneous copper catalyst, which is used in the practical wastewater treatment, for the oxidation of n-propyl alcohol, n-butyl alcohol, phenol, acetamide, poly(propylene glycol), and acetic acid. In addition, it was especially effective for the oxidation of some compounds with high oxygen content such as poly(ethylene glycol), ethylene glycol, formaldehyde, and formic acid. (Author abstract) 13 refs.

Imamura, Seichiro (Kyoto Inst of Technology, Kyoto, Jpn); Fukuda, Ikumi; Ishida, Shingo. *Ind Eng Chem Res* v 27 n 4 Apr 1988 p 718-721.

**074997 ANALYTICAL AND MECHANISTIC ASPECTS OF THE ELECTROCHEMICAL OXIDATION OF KETO STEROIDS DERIVATIZED WITH PHENYLHYDRAZINE, (4-NITROPHENYL)HYDRAZINE, AND (2,4-DINITROPHENYL)HYDRAZINE.** The electrochemical oxidation of biologically important 3- and 17-keto steroids derivatized with phenylhydrazines has been investigated at platinum and glassy carbon electrodes in aqueous methanol. The oxidation process has been used in the amperometric detection of keto steroids in nonmammalian biological fluids after separation by reverse-phase liquid chromatography. The derivatization was shown to be quantitative, and the



response linear with the detection limit of 1-5 ng for injection volumes of 20  $\mu$ L. (Edited author abstract) 34 refs.

Bond, Alan M. (Deakin Univ, Waurin Ponds, Aust); Hollenkamp, Anthony F.; Thompson, Stephen B.; Bourne, Anthony R.; Huf, Peter A.; Watson, Thomas G. *Anal Chem* v 60 n 10 May 15 1988 p 1023-1027.

**074998 THERMOOSCILLATIONS DURING THE COMPLETE OXIDATION OF ETHYLENE OXIDE OVER A SUPPORTED SILVER CATALYST.** The aim of the present letter is to describe briefly the conditions and the form of these thermooscillations, which were observed for the first time during the catalytic oxidation of ethylene oxide. The catalyst studied contains about 20 wt.% of silver, supported on  $\alpha$ -alumina. Silica was used as a binding compound. 5 refs.

Eliyas, A. (Bulgarian Acad of Sciences, Sofia, Bulg); Petrov, L. *Appl Catal* v 39 n 1-2 May 16 1988 p L1-L5.

**074999 STUDY OF THE REACTION OF ALKYL CHLOROFORMATES WITH SODIUM PEROXIDE.** The reaction of peroxidation of CFT with a  $C_7$ - $C_9$  alkyl radical by hydrogen peroxide in alkaline medium, determination of the possible side reactions which decrease the yield of the target product, and substantiation of the methods of transformation of the starting reagents as a function of the conditions of synthesis were studied. The results obtained on peroxidation of chloroformates with a number of carbon atoms of  $C_7$ - $C_9$  show that the rate of formation of dialkyl peroxydicarbonates and the occurrence of side reactions of hydrolysis of CFT and peroxydicarbonate in the presence of an emulsifier is a function of the ratio of the starting reagents to a significant degree, primarily the excess of the alkaline component ( $Na_2O_2$ , NaOH), the presence of an organic phase, and to a lesser degree, the temperature. 9 refs.

Fomin, V.A.; Govlovnenko, V.N. *J Appl Chem USSR* v 60 n 7 pt 2 Jul 1987 p 1486-1490.

**075000 HOMOGENEOUS CATALYZED AUTOXIDATION OF C-3-ene.** The liquid-phase autoxidation of car-3-ene in the presence of cobalt acetyl acetonate has been studied kinetically. The desired product, car-3-en-5-one, is an intermediate in one of the routes for the manufacture of synthetic pyrethroid. Several side products are formed, of which the principal is the peroxide. Lower temperature and pressure, higher catalyst usage and a less polar solvent medium each improves the selectivity for the desired ketone. A mathematical model of the reaction is developed after it has been broken down into several basic steps. The rate constants and activation energies for the various steps in the model are estimated by fitting the simulation to the experimental data. (Edited author abstract) 21 refs.

Mukesh, Doble (Alchemie Research Cent, Maharashtra, India); Bhaduri, Sumit; Khanwalkar, Vinod. *Chem Eng J Biochem Eng J* v 38 n 3 Jul 1988 p 153-160.

**075001 STUDY OF THE ELECTROOXIDATION OF 1,3-PROPANEDIOL ON A GOLD ELECTRODE IN BASIC MEDIUM.** A study of the mechanism of electrooxidation of 1,3-propanediol on a gold electrode in basic medium has been made. The kinetic parameters measured, together with other experimental data, allow the formulation of a mechanism in which both 1,3-propanediol and  $OH^-$  ions adsorb on the gold surface and the rate determining step is an interaction between both coverages with the result of the formation of an adsorbed radical, whose oxidation leads to the formation of 3-hydroxypropanoic acid which has been identified by nuclear magnetic resonance (NMR). (Author abstract) 10 refs.

Alonso, C. (Univ Autonoma de Madrid, Madrid, Spain); Gonzalez-Velasco, J. *J Appl Electrochem* v 18 n 4 Jul 1988 p 538-545.

**075002 OXIDATION OF FORMIC ACID AT POLYANILINE-COATED AND MODIFIED-POLYANILINE-COATED ELECTRODES.** The oxida-

tion of formic acid at polyaniline-coated electrodes has been studied. It was found that the oxidation rates at polyaniline are comparable to the rate at a platinized platinum electrode at low over-potentials. Modification of the polymer by cycling on 0.01%  $H_2PtCl_6$  results in a 10-fold increase in activity as compared to platinum. The dependence of oxidation rate on polymer thickness and platinum loading has been investigated. The promoter action of  $PtCl_6^{2-}$  may be related to the exchange of these ions into the polymer or the formation of microparticles of Pt dispersed in the polymer matrix. This study shows that conducting polymers may have interesting applications as fuel cell electrodes. (Author abstract) 16 refs.

Gholamian, M. (IIT, Bombay, India); Sundaram, J.; Contractor, A.Q. *Langmuir* v 3 n 5 Sep-Oct 1987 p 741-744.

**075003 THERMODYNAMICS OF Ru(III)-EDTA CATALYZED OXIDATION OF SATURATED ORGANIC COMPOUNDS BY MOLECULAR OXYGEN.** The thermodynamics of Ru(III)-EDTA catalyzed oxidation of cyclohexane to cyclohexanol and of cyclohexanol to cyclohexanone by molecular oxygen in acidic medium has been investigated in the temperature range 288-318 K,  $\mu = 0.1$  M  $KNO_3$  in a 1:1 water: 1,4-dioxane mixture (v/v). The dependence of the rate of oxidation on factors such as temperature (288-318 K), catalyst, substrates, molecular oxygen concentrations and pH was studied. The mechanisms proposed on the basis of the kinetic data are discussed in terms of thermodynamic stability and reactivity. The activation energy for the oxidation of cyclohexane is 7.3 kcal  $mol^{-1}$  higher than that of cyclohexanol. Thermodynamic factors are more favorable for the oxidation of cyclohexanol, which proceeds by a rate higher than that of cyclohexane. (Edited author abstract) 21 refs.

Taqi Khan, M.M. (Central Salt & Marine Chemicals Research Inst, Bhavnagar, India); Shukla, R.S. *J Mol Catal* v 44 n 1 Feb 15 1988, Int Workshop on Homogen Catal: Act of Mol Oxygen and Catal Oxid by Dioxigen Compd, Bhavnagar, India, Oct 3-6 1986 p 85-93.

**075004 HOMOGENEOUS OXIDATION OF CYCLOHEXANE BY A Ru(III) ANALOGUE OF THE MODEL PEROXIDASE SYSTEM Ru(III)-EDTA-ASCORBATE- $H_2O_2$ .** A ruthenium(III) analogue of the model peroxidase system Ru(III)-EDTA-ascorbic acid- $H_2O_2$  is an efficient catalyst for the oxidation of cyclohexane. The kinetics of the oxidation of cyclohexane to cyclohexanol by hydrogen peroxide catalyzed by the Ru(III)-EDTA-ascorbate system was investigated by spectrophotometric techniques. The kinetic parameters of the oxidation of cyclohexane to cyclohexanol were determined by potentiometric, spectrophotometric and gas chromatographic methods. On the basis of the kinetic and experimental results, a rate law for the reaction was derived and the mechanism discussed. (Edited author abstract) 22 refs.

Taqi Khan, M.M. (Central Salt & Marine Chemicals Research Inst, Bhavnagar, India); Shukla, R.S. *J Mol Catal* v 44 n 1 Feb 15 1988, Int Workshop on Homogen Catal: Act of Mol Oxygen and Catal Oxid by Dioxigen Compd, Bhavnagar, India, Oct 3-6 1986 p 73-83.

**Ozonization** See Also PIGMENTS—Optical Properties.

**075005 OZONATION OF ORGANIC REFRACTORY COMPOUNDS IN WATER IN COMBINATION WITH UV RADIATION.** The ozonation rates of organic refractory compounds such as aliphatic carboxylic acids and alcohols were determined in water at 293 K. The experiment was carried out by recirculating a solution between an ozone absorption column and a rectangular ozone/UV reactor, and the time-dependent changes in concentration of organic substances were directly measured. In the presence of UV radiation of about  $30 W \cdot m^{-2}$ , the initial ozonation rate of organic substances was increased by  $10 \cdot 10^4$  times. The total organic carbon was effectively decreased in the presence of UV radiation. This was explained by the destruction of acetic and oxalic acid by  $HO^\cdot$  radicals which were produced in the ozone/UV

system. The ozone/UV oxidation rate of acetic and oxalic acid was roughly proportional to the degree of dissociation. (Author abstract) 19 refs.

Ikemizu, Kiyoshi (Kyushu Univ, Fukuoka, Jpn); Orita, Masafumi; Sagiike, Masahiko; Morooka, Shigeharu; Kato, Yasuo. *J Chem Eng Jpn* v 20 n 4 Aug 1987 p 369-374.

**075006 OZONOLYSIS OF ORGANIC COMPOUNDS IN A TWO-PHASE FLUOROCARBON-WATER SYSTEM.** The ozonation process may be more efficiently carried out in a two-phase system. The second phase consists of a reusable, fluorinated hydrocarbon, with an ozone solubility of 12-14 times that of water. The fluorinated solvent serves as both an ozone source and a non-aqueous phase in which the oxidation occurs. With this novel two-phase process, it is also possible to perform selective oxidation. The experimental results are presented for organic compounds such as phenol, naphthol, etc. The extent of degradation is measured in terms of pH changes, HPLC, and TOC. (Edited author abstract) 19 refs.

Stich, Frank A. (Univ of Kentucky, Lexington, KY, USA); Bhattacharyya, D. *Environ Prog* v 6 n 4 Nov 1987 p 224-229.

**Permeability, Mechanical** See COAL—Porosity.

**Phase Diagrams** See SUPERCONDUCTING MATERIALS—Impurities.

**Phase Equilibria** See Also HYDROCARBONS—Solubility; MIXTURES—Phase Equilibria.

**075007 SOLID-LIQUID PHASE EQUILIBRIA OF ( $\alpha$ -METHYLNAPHTHALENE +  $\beta$ -METHYLNAPHTHALENE) AND (CHLOROBENZENE + BROMOBENZENE) SYSTEMS UNDER HIGH PRESSURES.** The freezing pressures of the  $\alpha$ -methylnaphthalene +  $\beta$ -methylnaphthalene system and the chlorobenzene + bromobenzene system were measured at temperatures from 278 to 343 K and pressures up to 500 MPa. In the former system the solid components are soluble partially, and in the latter system completely. Based on the results, the pressure effect on the phase diagrams of these systems is discussed and coexistence curves are expressed by polynomial equations of pressure. 9 refs.

Nagaoka, K. (Kobe Univ, Kobe, Jpn); Makita, T. *Int J Thermophys* v 8 n 6 Nov 1987 p 671-680.

**075008 LIQUID-VAPOR EQUILIBRIUM IN THE HEXAMETHYLENETETRAMINE-WATER SYSTEM.** The study of vapor pressure in the  $(CH_2)_6N_4 \cdot H_2O$  system is of interest for the production of hexamethylenetetramine (HMTA) and mineral fertilizers based on it. It was found that the gas phase consists of ammonia, formaldehyde, and water vapor. Empirical equations have been derived with which the vapor pressures over aqueous solutions of HMTA could be calculated at different concentrations over the range studied. 7 refs.

Narkulov, A.N. (Tashkent Inst of Railway Transport Engineers, USSR); Yunusov, D.Kh.; Kim-Lin-Zu, V.A. *J Appl Chem USSR* v 60 n 4 pt 2 Apr 1987 p 836-839.

**075009 MEASUREMENTS OF VLE,  $V^E$ , AND  $h^E$  FOR BINARY MIXTURES OF 1-CHLOROHXANE WITH THREE n-ALKYLBENZENES: TOLUENE, ETHYLBENZENE, n-PROPYLBENZENE.** Results of a series of experimental investigations of three binary mixtures of 1-chlorohexane with toluene, ethylbenzene, and n-propylbenzene are reported: T, p, x, y data of vapor-liquid equilibria (VLE),  $h^E$ , T, x data of calorimetric measurements, and v, T, x data of volumetric measurements. VLE data are checked for thermodynamic consistency by performing the test of Fredenslund and used to fit parameters of several  $g^E$  models. UNIFAC predictions



and experimental data are compared.  $h^E$  and  $v^E$  data were correlated with Redlich-Kister polynomials. (Author abstract). 18 refs.

Paul, Hanns-Ingolf (Technical Univ, Berlin, West Ger); Krug, Josef; Knapp, Helmut. *J Chem Eng Data* v 33 n 4 Oct 1988 p 453-460.

**Phase Transitions** See Also CRYSTALS—Growth.

**075010 KINETICS OF THE SUBTRANSITION OF MULTILAMELLAR DIPALMITOYLPHOSPHATIDYLCHOLINE.** An X-ray diffraction method was used to study the kinetics of the conversion between two phases in 1,2-dipalmitoyl-L-phosphatidylcholine (DPPC) dispersions. The time course of conversion after a rapid temperature change did not follow a simple monotonic function. The conversion occurred in three stages. In the first stage, rapid changes in the hydrocarbon chain packing and the repeat period of lamellar stacking were observed. In the second stage, remarkable changes could not be observed. In the third stage, gradual changes were observed. Except for the first stage, the process traced a sigmoid curve. This suggests the existence of a cooperative interaction in the arrangement of lipid molecules. A tentative theory of transition kinetics based on lenient cooperativity is proposed. (Edited author abstract) 13 refs.

Akiyama, Morio (Sapporo Medical Coll, Sapporo, Jpn); Matsushima, Norio; Terayama, Yoshio. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1587-1591.

**075011 NUCLEATION KINETICS OF POLYMORPHIC TRANSITION FROM PHASE II TO PHASE III OF HEXACHLOROETHANE: METASTABILITY/UNSTABILITY.** The conversion of the transition from phase II to III of  $C_2Cl_6$  were measured for the range between 38.81 and 41.15°C (the transition point: 43.64°C). A simple model was devised appropriate to the present mononuclear transition. Using this, the induction periods, that are inversely proportional to the nucleation rates, were extracted from the observed curves. The resulting induction periods varied from 0.07 to 1500 h. In terms of the classical nucleation theory, though its applicability for such a wide variation is questionable, it was shown that there are two temperature regions bounded at about 40.8°C in which nucleation behaviors are different. As shown in the previous papers, the growth rates of the same transition were too fast to measure below a certain threshold temperature which was lower than 41.9°C. These threshold behaviors in nucleation and growth were tentatively attributed to the changeover from metastability to instability. (Author abstract) 24 refs.

Koga, Yoshikata (Univ of British Columbia, Vancouver, BC, Can). *Physica B & C* v 146 n 3 Oct 1987 p 408-415.

**075012 STRUCTURES AND PHASE TRANSITIONS IN PIPERAZINIUM HEXACHLOROMETALLATES,  $(C_4H_{12}N_2)[MCl_6]$ ,  $M = Te, Pb, Pt$ , AND  $(C_4H_{12}N_2)[MCl_6] \cdot 3H_2O$ ,  $M = Sn$ . AN X-RAY DIFFRACTION AND  $^{35}Cl$  NQR STUDY.** Crystal structures and the nature of the chemical bond in piperazinium hexachlorometallates were studied by X-ray diffraction and  $^{35}Cl$  NQR spectroscopy. Piperazinium hexachlorostannate trihydrate shows a solid-solid phase transition at  $T_c = 256$  K. A disorder of the piperazinium ring and of one of the three water molecules appears in the high temperature phase. The disorder affects the  $^{35}Cl$  NQR spectrum. (Edited author abstract) 11 refs.

Borchers, Dirk (Technische Hochschule Darmstadt, Darmstadt, West Ger); Weiss, Alarich. *Ber Bunsenges Phys Chem* v 91 n 11 Nov 1987 p 1182-1189.

**075013 PYROELECTRIC CHARACTERISTIC OF PHASE TRANSITION OF TAM SINGLE CRYSTAL.** Using the measuring method of pyroelectric effect, the characteristic of phase transition along the C axis in TAM (Tris (hydroxymethyl) amine methane) single crystal, a new type of polar crystal material, is studied. No trace of phase transition in TAM single crystal is found when the method of electric charge integral measurement is used at

temperatures of  $20^\circ C \leq T \leq 128^\circ C$ , whereas the phase transition is found to be accompanied by a reversion of pyroelectric current at a temperature near  $135^\circ C$ , when measured in the range of  $100^\circ C \leq T$  with an equal-rate heating method. The phase transition temperature  $T_c$  established above has demonstrated the result of  $T_c = 134.3^\circ C$  presented by N. Doshi, et al. (Author abstract) In Chinese. 6 refs.

Shi Zhikang (Acad Sinica, China). *Hongwai Yanjiu, A-jì* v 6 n 6 1987 p 445-449.

**075014 STRUCTURAL AND PHOTOCHEMICAL TRANSFORMATIONS IN ANTHRACENES.** The phase transformation in both anthracene and 9-cyanoanthracene photodimer (9 CNAD) has been studied using X-ray powder diffraction and molecular emission spectroscopy. The increased photoreactivity of the recently reported anthracene new phase has also been studied. The first exothermic calorigram peak appearing at ca 420 K during 9 CNAD solid-state monomerization is assigned to two exothermic processes, namely the phase transformation of 9 CNAD crystals and the separation of 9-cyanoanthracene (9 CNA) microcrystallites inside the photodimer matrix as supported by emission spectroscopy. (Author abstract) 27 refs.

Ebeid, El-Zeiny M. (Tanta Univ, Tanta, Egypt); Donia, Ahmed M. *J Phys Chem Solids* v 49 n 3 1988 p 263-266.

**075015 POLYMORPHISM IN THE BIS(PHENALKYLAMMONIUM)TETRACHLOROMETALLATES.** Compounds of the general formula,  $(C_6H_5C_nH_{2n-1}NH_3)_2MCl_4$ , where  $n = 1$  to 10;  $M = Cd, Cu, Zn$ , and  $Co$ ; were prepared and characterized by differential scanning calorimetry. All of the compounds prepared with  $n > 1$  were observed to undergo solid-solid phase transitions and the high entropies of the solid-solid phase transitions indicate that there is a considerable amount of disorder in the high-temperature phase. Similarity of the thermodynamic results divides the compounds into two groups: the  $Cd$  and  $Cu$  derivatives, and the  $Co$  and  $Zn$  derivatives. Trends within each group and between groups can be attributed to the influence that phenyl group packing has on the thermodynamic behavior. (Author abstract). 39 Refs.

Van Oort, Michiel J.M. (Dalhousie Univ, Halifax, NS, Can); White, Mary Anne. *J Solid State Chem* v 75 n 1 Jul 1988 p 113-123.

**Photochemical Reactions** See Also POLYELECTROLYTES.

**075016 PHOTOADDITION OF THIOCARBOXYLIC ACID TO 3,4-DIALLYL-1,6-PROPANO-1H, 6H-3A-THIA(S<sup>IV</sup>)-1,3,4,6-TETRAAZAPENTALENE-2,5(3H,4H)-DITHIONE.** Irradiation of 3,4-diallyl-1,6-propano-1H,6H-3a-thia(S<sup>IV</sup>)-1, 3,4,6-tetraazapentale-2,5(3H,4H)-dithione in the presence of excess thiocarboxylic acid in acetone gave photoaddition products, 3,4-bis(3-acylthioxypropyl)-1,6-propano-1H, 6H-3a-thia(S<sup>IV</sup>)-1,3,4,6-tetraazapentale-2,5(3H, 4H)-dithiones. (Edited author abstract) 2 refs.

Matsumura, Noboru (Univ of Osaka Prefecture, Sakai, Jpn); Mori, Osamu; Tomura, Masaaki; Yoneda, Shigeo. *Chem Express* v 2 n 10 Oct 1987 p 631-634.

**075017 ELECTRON PARAMAGNETIC RESONANCE MEASUREMENTS OF PHOTOCHEMICAL RADICAL PRODUCTION IN HUMIC SUBSTANCES - 1. EFFECTS OF  $O_2$  AND CHARGE ON RADICAL SCAVENGING BY NITROXIDES.** Electron paramagnetic resonance spectroscopy (EPR) was employed to measure the ability of Aldrich humic acid (HA) to photosensitize the consumption of a series of cationic, neutral, and anionic nitroxides. These stable organic radicals react rapidly with a suite of inorganic and organic radicals to form diamagnetic products. In the presence of  $250 \mu g/mL$  HA and under near-natural light conditions, easily detectable rates of nitroxide consumption are observed in both air- and Ar-equilibrated samples. However, at a given nitroxide concentration, signifi-

cantly lower rates of nitroxide loss are observed in the presence of air, consistent with the view that  $O_2$  and nitroxides compete for a substantial portion of the total radical pool. Additional study results and significance of the overall results are discussed. (Edited author abstract) 43 refs.

Blough, Neil V. (Woods Hole Oceanographic Inst, Woods Hole, MA, USA). *Environ Sci Technol* v 22 n 1 Jan 1988 p 77-82.

**075018 FORMATION AND REACTION OF POLYENESULFONIC ACID. II. PHOTOREACTION OF POLYENESULFONIC ACIDS.** Conjugated polyenesulfonic acids were found to be sensitive not only to UV but also to visible light, affording stable radical species. The photoreaction included the cleavage of C-S bonds to eliminate sulfonic acid groups. The resulting polyene radicals either reacted with oxygen in the air to form ketone compounds or released hydrogen atom to give more conjugated polyenes on the average under reduced pressure. 10 refs.

Ihata, Jyoji (Asahi Chemical Industry Co, Fuji, Jpn). *J Polym Sci Part A* v 26 n 1 Jan 1988 p 177-185.

**Photolysis** See Also CHEMICAL REACTIONS—Photochemical Reactions.

**075019 PHOTOLYSIS OF S-PHENYL THIOBENZZOATES AND THEIR USE AS PHOTOINITIATORS.** Photolysis of S-phenyl thiobenzoates (1) in benzene produced benzaldehyde, diphenyl disulfide, and biphenyl as major products. This indicates that 1 underwent CO-S bond fission upon photoexcitation. Among the various aryl-substituted S-phenyl thiobenzoates, 4-benzoyl and 4-acetylbenzoate derivatives were photolyzed most efficiently, probably because of involvement of the triplet excited state in the photocleavage of 1. When 1 was irradiated in phenyldiethyleneglycol acrylate, polymer was formed. The efficiency of the photopolymerization was greatly enhanced by the introduction of 4-benzoyl group on the benzoate phenyl ring. It also increased with decreasing its initial concentration. (Edited author abstract) In Japanese. 8 refs.

Tomioka, Hideo (Mie Univ, Mie, Jpn); Takeuchi, Sigeru; Kurimoto, Hideshi; Takimoto, Yasuyuki; Kawabata, Masaki; Harada, Masahiko. *Kobunshi Ronbunshu* v 44 n 10 Oct 1987 p 729-734.

**075020 CHLOROPHYLL-SENSITIZED PHOTOLYSIS OF DIAZONIUM COMPOUNDS.** The chlorophyll-sensitized photolysis of diazonium salts has been investigated in methyl ethyl ketone solution. The experimental data on the quantum yield of fluorescence and the difference spectrum between chlorophyll A in the presence and in the absence of diazonium salt were explained in terms of an electron transfer sensitization. It is shown by these spectra that chlorophyll A made a complex with diazonium salt in the ground state of which the binding constant was estimated to be  $2.7 \text{ mol}^{-1} \cdot \text{dm}^3$ . (Author abstract) 19 refs.

Enmanji, Koe (Mitsubishi Electric Corp, Amagasaki, Jpn). *J Imaging Sci* v 31 n 4 Jul-Aug 1987 p 169-171.

**075021 PULSED PHOTOLYSIS OF p-AZIDOANILINE IN APROTIC SOLVENTS.** A detailed mechanism of dark transformations of p-aminophenylnitrene in a triplet state in the presence of  $O_2$ , in toluene and in hexane was studied by the pulsed photolysis method. It was shown that in the course of the reaction of p-amino-phenylnitrene with  $O_2$ , an adduct is formed and the rate constant of this process has been determined. It was proved that the adducts then disappear by a second order reaction to form dimers, and the rate constant of this



reaction is equal to  $(1.4 \pm 0.4) \cdot 10^9$  liters/mole in toluene and  $(0.7 \pm 0.2) \cdot 10^{10}$  liters/mole-sec in hexane. (Edited author abstract) 11 refs.

Pritchina, E.A. (Acad of Sciences of the USSR, Novosibirsk, USSR); Gritsan, N.P. *Kinet Catal* v 28 n 5 pt 1 Sep-Oct 1987 p 905-909.

**075022 CHARACTERISTICS OF THE PHOTOLYSIS OF  $\text{CH}_3\text{CHO}$  ADSORBED ON POROUS VYCOR GLASS.** Photolysis of  $\text{CH}_3\text{CHO}$  adsorbed on Vycor glass has been investigated. The characteristic formation of  $\text{C}_2\text{H}_4$  was found to arise from the intramolecular photodissociation of chemisorbed crotonaldehydes which are formed through the adsorption of acetaldehydes on Vycor glass. (Author abstract) 5 refs.

Anpo, Masakazu (Univ of Osaka Prefecture, Sakai, Jpn); Shindo, Takashi. *Chem Express* v 3 n 6 Jun 1988 p 327-330.

**Physical Chemistry** See PETROLEUM GEOLOGY; POLYMERS—Physical Properties.

**Physical Properties** See ALSO CRYSTALS—Phase Transitions; ELECTROCHROMISM—Measurements; POLYETHYLENES—Physical Properties; POLYMERS—Synthesis.

**075023 ELECTROLUMINESCENCE AND CHARGE CARRIER TRANSPORT IN POTASSIUM-DOPED ANTHRACENE.** The increase in the electroluminescence (EL) intensity in potassium-doped anthracene crystals (K-Ant) was investigated in relation to the mechanism of EL. Carrier drift mobilities  $\mu_{e+h}$  and transient EL were measured by the doubly-injected impulse method. The drift mobility of K-Ant along the c-axis was larger by a factor of 1.5 than in an undoped anthracene single crystal for electric fields larger than  $1.9 \times 10^4 \text{ V} \cdot \text{cm}^{-1}$ . An analysis of the transient EL showed that recombination through recombination centers in K-Ant crystals occurs more efficiently than in anthracene single crystals. These results reveal that the potassium atoms in K-Ant crystals do not act as carrier traps but, rather, act as recombination centers. (Author abstract) 26 refs.

Okii, Hironori (Keio Univ, Yokohama, Jpn); Ohba, Yujiro. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1477-1481.

**075024 CONTROL OF THE ELECTRONIC STRUCTURE OF ORGANIC CONDUCTORS AS EXEMPLIFIED BY [NMP][TCNQ] CHARGE-TRANSFER COMPLEXES.** Through replacement of cations with neutral molecules of similar shape and polarizability in a highly conducting 'metal-like' charge-transfer organic conductor, the deliberate control of the electronic structure from a quarter to a half-filled band is possible. This goal has been achieved with the N-methylphenazinium (NMP) salt of the tetracyanoquinodimethane (TCNQ) anion by partial replacement of the cation with phenazine. A detailed study of the optical, electrical, and magnetic properties of these conducting molecular solids has led to the evolution of a broad understanding of the physics of one-dimensional organic conductors and a reinterpretation of the mechanism of electron transport in such solids. (Edited author abstract) 41 refs.

Miller, Joel S. (DuPont, Wilmington, DE, USA); Epstein, Arthur J. *Angew Chem (Int Ed Engl)* v 26 n 4 Apr 1987 p 287-293.

**075025 CHARACTERISTICS OF THERMO-CHEMICAL CONVERSIONS OF ORGANIC MATTER OF BITUMINOUS COALS IN THE PRESENCE OF MESOGENIC HYDROCARBON SUBSTANCES.** The authors investigated the characteristics of thermochemical conversions of binary mixtures of additives with coals of different stages of metamorphism. We investigated four coals during combined heat treatment with x mesogenic hydrocarbon substances, characterized by a different degree of condensation of the structures and a different capacity to form a mesophase. Derivatographic

studies confirmed the presence of physicochemical reaction of the organic matter of coal and the additive, including reactions that occur with intense liberation of hydrogen and methane, which are differentiated as a function the nature of the coals and the mesogenic substances. 10 refs.

Ol'fert, A.I.; Enik, G.I.; Arzaeva, L.A. *Coke Chem (USSR)* n 3 1987 p 6-12.

**075026 METAL LIKE  $^{13}\text{C}$  AND  $^{63}\text{Cu}$  KNIGHT SHIFTS IN THE ORGANIC CONDUCTOR (2,5-DIMETHYL-DICYANOQUINONEDIIMINE) $_2\text{Cu}$ .** Metal-like Knight shifts and relaxation times have been observed for  $^{63}\text{Cu}$  and  $^{13}\text{C}$  at different carbon positions in (DM-DCNQI) $_2\text{Cu}$ . The following Knight shift data were obtained at room temperature:  $^{63}\text{Cu}$ : 1995 ppm; N- $^{13}\text{C}$ :  $\text{C}=\text{N}$ : -287 ppm and -7 ppm to -47 ppm for the different ring carbons. As a reference for the Knight shift we used the spectra of CuCl and of pure DM-DCNQI crystals, respectively. (Author abstract) 17 refs.

Koengeter, D. (Univ Stuttgart, Stuttgart, West Ger); Hentsch, F.; Seidel, H.; Mehring, M.; von Schuetz, J.U.; Wolf, H.C.; Erk, P.; Huenig, S. *Solid State Commun* v 65 n 6 Feb 1988 p 453-456.

**075027 PHYSICAL-CHEMICAL PROPERTIES OF CHLORINATED DIBENZO-p-DIOXINS.** Reported and newly determined experimental data for aqueous solubility, octanol-water partition coefficient, vapor pressure, and Henry's law constants of the polychlorinated dibenzo-p-dioxins are presented and reviewed. Correlation equations are derived for these properties as a function of chlorine number and molar volume, which enable the solubility and octanol-water partition coefficients of most congeners to be estimated with an accuracy within a factor of 2 and vapor pressure and Henry's law constant with a factor of 5. It is suggested that properties of homologous series are best correlated by a two-stage process. In the first stage, treated here, simple correlations are developed to establish approximate values as a function of molar volume and chlorine number. This should be followed by a more rigorous second stage treating isomer differences and using more refined molecular descriptors. (Edited author abstract) 53 refs.

Shiu, Wan Ying (Univ of Toronto, Toronto, Ont, Can); Doucette, William; Gobas, Frank A.P.C.; Andren, Anders; Mackay, Donald. *Environ Sci Technol* v 22 n 6 Jun 1988 p 651-658.

**075028 PHYSICAL PROPERTIES OF COMPOUNDS USED IN VITAMIN SYNTHESIS.** Some physical properties, namely vapor pressure, surface tension, density, heat capacity, and heat conductivity, were measured for 20 organic compounds that are used in the synthesis of A and E vitamins. (Author abstract). 40 refs.

Baglay, Alexander K. (S.M. Kirov Byelorussian Inst of Technology, Minsk, USSR); Gurariy, Lyubov L.; Kuleshov, Gennadiy G. *J Chem Eng Data* v 33 n 4 Oct 1988 p 512-518.

## Polarographic Analysis

**075029 POLAROGRAPHIC EXAMINATION OF LUPININE SURFACE PROTONATION IN BORATE SOLUTIONS.** The authors examined the height ( $i_{\text{lim}}$ ) of the catalytic surface wave in borate buffer solutions of lupinine as a function of solution pH and buffering capacity, in order to determine the kinetic parameters of lupinine surface protonation under the effect of acid components of the borate buffer solutions. The overall rate constant of lupinine surface protonation (i.e., that reflecting the effect of all proton donors,  $p_s$ ) was found using the authors' equation. The partial rate constants of lupinine surface protonation are more than an order of magnitude lower than the analogous constants for pachycarpine. 13 refs.

Mairanovskii, S.G. (Acad of Sciences of the USSR, Moscow, USSR); Seilova, K.S.; Glubokovskaya, T.V.; Loshkarev, Yu.M. *Sov Electrochem* v 23 n 7 Jul 1987 p 926-929.

**Polymerization** See ALSO CRYSTALS—Phase Transitions; LIPIDS—Polymerization; POLYAMIDES—Synthesis; POLYMERIZATION—Reaction Kinetics; POLYMERS—Synthesis.

**075030 POLYMERIZATION OF METHYL PROPIONATE WITH PALLADIUM CHLORIDE, TRIPHENYLPHOSPHINE, AND PALLADIUM CHLORIDE TRIPHENYLPHOSPHINE COMPLEX.** Some results of the bulk polymerization of methyl propionate in the presence of  $\text{PdCl}_2$ , triphenylphosphine, and  $[(\text{C}_6\text{H}_5)_3\text{P}]_2\text{PdCl}_2$  complex are presented. From the polyconjugated polymers obtained, fractions based on their solubility in various solvents were separated. Subsequently, these products were characterized by IR and  $^1\text{H}$  NMR spectroscopies and by thermal analysis. The data obtained indicate that polymerization assisted by  $[(\text{C}_6\text{H}_5)_3\text{P}]_2\text{PdCl}_2$  proceeds faster, giving products with a lower cyclic oligomers content. The polymers possess good thermal stability and semiconducting properties. (Author abstract) 17 refs.

Simionescu, C.I. (Polytechnic Inst of Jassy, Iasi, Rom); Bulacovschi, V.; Grovu-Ivanouiu, Maria; Stanciu, A. *J Macromol Sci Chem* v A24 n 6 1987 p 611-622.

**075031 POLYMERIZATION AND OXIDATION OF PYRROLE BY HALOGENS IN ORGANIC SOLVENTS.** Simultaneous chemical polymerization and oxidation of pyrrole have been initiated by a halogenic electron acceptor, bromine or iodine, in various organic solvents. The polypyrrole (PPY)-halogen charge transfer (CT) complexes obtained from polymerization in acetonitrile are of particular interest. Both the PPY-I $_2$  and PPY-Br $_2$  CT complexes are granular in nature and have an electrical conductivity in the order of 1 to 10 ohm $^{-1}$  cm $^{-1}$ . Both complexes show remarkable stability in the atmosphere and in the presence of moisture. The PPY-I $_2$  and PPY-Br $_2$  CT complexes in the form of thin, coarse films have also been synthesized on a  $\text{SnO}_2$  electrode by electrochemical polymerization in acetonitrile. (Edited author abstract) 26 refs.

Kang, E.T. (Nat'l Univ of Singapore, Singapore); Neoh, K.G.; Tan, T.C.; Ong, Y.K. *J Macromol Sci Chem* v A24 n 6 1987 p 631-644.

**075032 CYCLIC COMPOUNDS CONTAINING TWO OR MORE OXYGEN ATOMS IN THE RING.** Monocyclic compounds containing two or more hetero oxygen atoms which undergo polymerization by ring opening are described in this paper. The saturated systems which involve 5- to 17-membered rings are listed; besides the systematic names, the abbreviations which are in common use in the literature for these compounds are also given. Monomers with considerably larger ring size are also known; most of these compounds form cyclic oligomers which are again polymerizable. The macrocyclic compounds which are formed in this way are treated along with the corresponding monomers. With the exception of trioxane, the basic structures in all cases involve cyclic formaldehyde acetals. These compounds are mostly prepared by the acid-catalyzed reaction of a diol with formaldehyde. 263 refs.

Schulz, R.C. (Univ of Mainz, West Ger); Hellermann, W.; Nienburg, J. *Ring-Opening Polym* v 1. Publ by Elsevier Applied Science Publ, London, Engl and New York, NY, USA, 1984 p 369-460.

**075033 CYCLIC 1,3-OXAZA COMPOUNDS.** This paper deals with the ring-opening polymerization of cyclic 1,3-oxaza compounds which have an O-C-N linkage in the cyclic structure. More than ten compounds of this category have hitherto been polymerized or copolymerized. 2-Substituted oxazolines have become important, and recently the commercial production has begun of 2-ethyl- and 2-isopropenyl-2-oxazolines as intermediate



materials for polymers and for fine chemicals. Therefore, work on 2-oxazolines constitutes the major part of the paper. 168 refs.

Kobayashi, S. (Kyoto Univ, Jpn); Saegusa, T. *Ring-Opening Polym* v 2. Publ by Elsevier Applied Science Publ, London, Engl and New York, NY, USA, 1984 p 761-807.

**075034 LACTAMS AND CYCLIC IMIDES.** This paper is concerned principally with the polymerizations of lactams, and with some close relatives, namely thiolactams and cyclic imides. They are all nitrogen-containing heterocyclic compounds, and are characterized respectively by NH-CO, NH-CS and CO-NH-CO functional groups constituting a part of the ring. Substituted lactams and those containing one or more extra heteroatoms in the ring, as well as cyclic diamides are also included. 627 refs.

Sekiguchi, H. (Univ Pierre et Marie Curie, Paris, Fr). *Ring-Opening Polym* v 2. Publ by Elsevier Applied Science Publ, London, Engl and New York, NY, USA, 1984 p 809-918.

**075035 GRAFT EMULSION COPOLYMERIZATION OF ACRYLONITRILE AND POLYVINYL ALCOHOL IN PRESENCE OF A CHAIN-GROWTH REGULATOR.** The authors studied emulsion polymerization of AN (Acrylonitrile) in presence also of isopropyl alcohol, used as a molecular-weight regulator. The data show some decrease of AN conversion and of the contents of dry solids in the latex formed; this is presumably due to decrease of the concentration of  $Mn^{3+}$ , which is partially consumed in interaction with isopropyl alcohol. The data reveal significant changes in the picture of emulsion polymerization of AN when it is conducted in presence of isopropyl alcohol. The PVA content in the copolymer is considerably lower, as is its content relative to the maximum possible amount in the copolymer. It can be concluded that isopropyl alcohol, which is presumably a more powerful chain-transfer agent than PVA (Polyvinyl Alcohol) alters substantially the picture of emulsion polymerization of PAN conducted with the use of PVA as stabilizer. 4 refs.

Basok, M.O.; Gladikh, A.F.; Kiselev, G.A.; Roskin, E.S. *J Appl Chem USSR* 60 n 2 pt 2 Feb 1987 p 361-364.

**075036 SPECTROSCOPIC STUDIES OF BIPOLARONS FROM OLIGOMERIZED 3-METHOXYTHIOPHENE IN SOLUTION.** 3-Methoxythiophene was anodically polymerized, then cathodically reduced to provide a neutral oligomeric product (I) composed of 3-methoxythiophene units. I and its oxidation product 2 were soluble in N,N-dimethylformamide, acetonitrile and benzonitrile and the solution phase redox process was studied as a model for reactions of insoluble polythiophenes. Oxidation to form 2 was accomplished using iodine or electrochemistry. The strong acids, nitric, perchloric or trifluoroacetic also oxidized I to 2. Rereduction of 2 to I used triethylamine. Quantitative studies showed that  $I_2$  or anodic oxidation at 0.6 V gave 2 with the same extent of oxidation. Ultraviolet-visible spectroscopy showed that 2 was composed of at least two different types of species, each type showing a pair of absorption bands between 630 and 860 nm. E.s.r. showed that 2 was mainly diamagnetic, and it is proposed that soluble dications (bipolarons) are produced. (Author abstract) 15 refs.

Chang, An-Cheng (Univ of Minnesota, Minneapolis, MN, USA); Miller, Larry L. *Synth Met* v 22 n 1 Nov 1987 p 71-78.

**075037 ROLE OF WATER IN CHAIN INITIATION BY THE SYSTEM BENZOYL PEROXIDE-TERTIARY AMINOALCOHOL IN THE POLYMERIZATION OF ACRYLONITRILE IN DIMETHYLFORMAMIDE.** An investigation was conducted of the kinetics of the polymerization of acrylonitrile (AN) in a solution of dimethylformamide (DMF), initiated by the redox system benzoyl peroxide (BP) - tertiary aminoalcohol (A). In conjunction with BP we used triethanolamine (T), ethyldiethanolamine (E), diethylethanolamine (D), and phenyldiethanolamine (P). In this work we discuss the

influence of additions of water as a second cosolvent. It is shown that additions of  $H_2O$  to DMF accelerate chain initiation by increasing the initiation efficiency. (Edited author abstract) 5 refs.

Simonyan, G.S. (Erevan State Univ, USSR); Sogomonyan, B.M.; Beiranyan, N.M. *Kinet Catal* v 28 n 1 pt 2 Jan-Feb 1987 p 176-179.

**075038 POLYMERIZATION OF HEXACHLOROCHLOROTRIPHOSPHAZENE IN THE PRESENCE OF TIN TETRAPHENYL.** The polymerization of hexachlorochlorotriphosphazene in the presence of tin tetraphenyl has been investigated. It was found as a result of gamma-resonance (GR), IR and NMR investigations that the phenylation of growing macroradicals is accompanied by simultaneous chlorination of tin tetraphenyl. The feasibility of controlling the MW and the yield of polydichlorophosphazene has been demonstrated. (Author abstract) 12 refs.

Kireyev, V.V. (Lomonosov Inst of Fine Chemical Technology, Moscow, USSR); Milashvili, M.V.; Rochev, V.Ya.; Kosova, G.N.; Mitropol'skaya, G.L.; Korshak, V.V. *Polym Sci USSR* v 28 n 8 1986 p 1766-1773.

**075039 STRUCTURE OF THE ALUMINOXANE-ACETYLACETONATO CATALYTIC COMPLEX FOR POLYMERIZATION OF EPOXIDES.** The authors determined cryoscopically the average molecular masses of catalytic complexes obtained from triethylaluminum (TEA) and triisobutylaluminum (TIBA) at temperatures from  $-3$  to  $20^\circ$  in the toluene solution. Aluminosiloxane-acetylacetonato complexes, characterized by molecular mass, alkyl-group contents, and IR-spectroscopic data, were prepared from triethyl- and triisobutylaluminum. A model of the structure of these complexes, consisting mainly of three to five units containing alkylaluminosiloxane and acetylacetonato groups, is proposed. 7 refs.

Gorin, Yu.A. (S.V. Lebedev All-Union Scientific-Research Inst of Synthetic Rubber, USSR); Rodina, Z.I.; Silina, N.A.; Ikonitskii, I.V.; Marasanova, N.N. *J Appl Chem USSR* v 60 n 3 pt 2 Mar 1987 p 629-631.

**075040 ELECTROCHEMICAL POLYMERIZATION OF THIONAPHTHENE-INDOLE.** The polymer derived from thionaphthene-indole has been prepared by electrochemical oxidation of the monomer in methylene chloride on platinum electrode. The oxidized polymer obtained has been reduced on the same electrode to a neutral polymer, which is processable and soluble in several solvents. Both oxidized and neutral polymers have been characterized by UV, IR and mass spectrometry. The electrical conductivity of the oxidized material has been found to be nine orders of magnitude greater than that of the reduced product. (Author abstract) 20 refs.

Casalbore Miceli, G. (CNR, Bologna, Italy); Beggiato, G.; Daolio, S.; Di Marco, P.G.; Emmi, S.S.; Giro, G. *J Appl Electrochem* v 17 n 6 Nov 1987 p 1111-1117.

**075041 OPTIMUM REACTION CONDITIONS FOR THE POLYMERIZATION OF ANILINE IN AQUEOUS SOLUTION BY AMMONIUM PERSULFATE.** The polymerization of aniline by persulfate anion in aqueous solution was studied as a function of oxidant/monomer initial mole ratio (r). For values of r less than about 1.15, the conductivity, yield, elemental composition and degree of oxidation of the resulting polyaniline product are essentially independent of r. However, higher oxidant/monomer initial mole ratios result in over-oxidation of the polyaniline, with a concomitant decrease in conductivity and yield. (Author abstract) 29 refs.

Armes, S.P. (Univ of Bristol, Bristol, Engl); Miller, J.F. *Synth Met* v 22 n 4 Feb 1988 p 385-393.

**075042 ELECTROCHEMICAL POLYMERIZATION OF AN UNSATURATED ISOCYANATE ON THE SURFACE OF CARBON FIBRES.** Electrochemical polymerization of an unsaturated isocyanate as a function of its concentration, current density and the temperature of electrolysis has been investigated using as

cathode a graphitized monofiber with a high degree of purity. In the course of electrochemical polymerization of the unsaturated isocyanate the carbon fiber is covered with polymer some of which after extraction with acetone remains on the fiber in the form of local outgrowths. From the electron micrographs of the carbon fiber samples obtained after electrolysis of unsaturated isocyanate and extraction with acetone it is postulated that grafting of the polymer on the surface of the carbon fiber is associated with the energy inhomogeneity of this surface. (Author abstract) 12 refs.

Lipatova, T.E. (UkrSSR Acad of Sciences, USSR); Matyushova, V.G.; Narazhaiko, L.F. *Polym Sci USSR* v 28 n 10 1986 p 2267-2275.

**075043 RADICAL POLYMERIZATION OF DIETHYLENE GLYCOL-BIS-ALLYL CARBONATE.** The structure of polyethylene glycol-bis-allyl carbonate has been studied and its parameters within the model of overlapping statistical coils determined. A kinetic scheme of the synthesis of the polymer is proposed. The quantitative characteristics of the rates of the elementary stages have been found by the method of solving the back kinetic problem. The results satisfactorily describe the rate of polymerization of diethylene glycol-bis-allyl carbonate. (Author abstract) 20 refs.

Nikiforenko, V.S. (Ukrainian Plastics Research Inst, USSR); Alekseyev, N.N.; Zaitsev, Yu.S. *Polym Sci USSR* v 28 n 10 1986 p 2290-2297.

**075044 GRAFT ANIONIC COPOLYMERIZATION OF OCTAMETHYL CYCLOTETRASILOXANE WITH OLIGOSTYRENE CARBOCYCLOSILOXANE.** A study was made of the formation of graft copolymers in the anionic copolymerization of octamethyl cyclotetrasiloxane with oligostyrene carboxycyclosiloxanes that have cyclotrisiloxane substituents in the organic framework surrounding the carbon-carbon backbone. Investigations based on GLC, gel chromatography and also NMR were used to determine the extent to which copolymerization conditions may influence the character of the reactions and the structure and composition of the products. If appears from the experimental data that the part played by reactions of chain transfer and interchain interaction increases with the increase in grafting density, in the length of the polysiloxane branches, and in line with depletion of the monomer. (Edited author abstract) 20 refs.

Zhdanov, A.A. (USSR Acad of Sciences, USSR); Zavin, B.G.; Blokhina, O.G. *Polym Sci USSR* v 28 n 10 1986 p 2428-2434.

**075045 INVESTIGATION OF THE CATIONIC COPOLYMERIZATION OF GLYCOLIDE WITH OPTICALLY ACTIVE AND RACEMIC LACTIDE UNDER THE ACTION OF  $SnCl_4 \cdot 2H_2O$ .** The kinetics and mechanism of cationic copolymerization of glycolide with L- and D, L-lactide under the action of  $SnCl_4 \cdot 2H_2O$  in the melt at  $140-180^\circ C$  is studied by PMR spectroscopy and gravimetric methods. The kinetics of the consumption of comonomers for various compositions of the initial monomer mixture are studied. The reactivities of L- and D, L-lactides are shown to be almost equal. The copolymerization constants as calculated from the Feinmann-Ross equation are found to be  $r_1 = 2.70$  and  $r_2 = 0.35$  for glycolide and lactide respectively. The activation energies are identical for both monomers ( $67 \pm 3$  kJ/mole), and the order of the polymerization rate for the two monomers is also the same, i.e. 0.5. (Edited author abstract) 13 refs.

Khomyakov, A.K. (L.Ya Karpov Physicochemical Research Inst, USSR); Vlasova, T.V.; Lyudvig, Ye.B. *Polym Sci USSR* v 28 n 10 1986 p 2464-2471.

**075046 GAS PERMEABILITY OF POLY(ORGANOPHOSPHAZENES).** The poly(organophosphazenes) have many useful properties. For example, one of these had good fuel, acid and base resistance. There are no



available data about the gas permeability and selectivity of poly(organophosphazenes). This letter describes the gas permeability of poly(organophosphazene) membranes. The gas permeabilities were determined over the temperature range 20 to 100°C. 9 refs.

Kajiwara, Meisetsu (Nagoya Univ, Nagoya, Jpn). *J Mater Sci Lett* v 7 n 2 Feb 1988 p 102-104.

**075047 EFFECT OF WATER ON THE ANIONIC POLYMERIZATION OF  $\alpha$ -METHYL- $\alpha$ -N-PROPYL- $\beta$ -PROPIOLACTONE.** The effect of water on the anionic polymerization of  $\alpha$ -methyl- $\alpha$ -n-propyl- $\beta$ -propiolactone was studied by performing kinetic measurements in THF with different amounts of water, at 38.6°C, with tetramethylammonium benzoate as the initiator. The data were treated by assuming that the propagation occurs through free ions, ion pairs, and the corresponding water-solvated species. Analysis of the results leads to the conclusion that the hydrated ion pairs do not contribute to propagation and that the free ions which are in small amounts are less reactive than the ion pairs. Thus the role of water introduced into the medium is to remove a large fraction of the ion pairs from the propagation reaction by hydration. (Author abstract) 13 refs.

Camps, M. (Univ de St.-Etienne, Fr); Ait-Hamouda, R.; Boileau, S.; Hemery, P.; Lenz, R.W. *Macromolecules* v 21 n 4 Apr 1988 p 891-894.

**075048 CHAIN TRANSFER BY 2-IODOPROPANE AND PROPIONIC ACID CHLORIDE IN THE POLYMERIZATION OF TETRAHYDROFURAN.** The polymerization of tetrahydrofuran was initiated by the addition of silver hexafluoroantimonate and an excess of 2-iodopropane or propionic acid chloride. Rapid chain transfer to the acid chloride was observed. Chain transfer to 2-iodopropane was slow and occurred with the incorporation of the 2-propyl group at the end of the chain. A mechanism is proposed which involves an iodonium ion intermediate. (Author abstract) 9 refs.

Buese, M.A. (CRM, Strasbourg, Fr); Franta, E. *Macromolecules* v 21 n 5 May 1988 p 1202-1204.

**075049 FREE-RADICAL POLYMERIZATION OF MALEIMIDE DERIVATIVES IN THE PRESENCE OF CHIRAL SUBSTANCES.** Free-radical homo- and copolymerizations of substituted maleimide derivatives in the presence of chiral substances have been reinvestigated. Optically active copolymers were obtained from the copolymerizations of styrene with N-t-butylmaleimide and N-phenylcitracrimide. Optically active homopolymers were obtained from N-t-butyl-, N-isopropyl-, N-benzyl-, and N- $\alpha$ -phenethylmaleimides, but not from N-p-tolyl- and N-triphenylmethylmaleimides. The  $[\alpha]$  values of poly-N-benzylmaleimide increase both with increasing chiral substance concentration and monomer concentration. (Author abstract) 7 refs.

Fujita, Tsunehisa (Kinki Univ, Higashi, Jpn); Okuda, Yoshihiro; Yoshihara, Masakuni; Maeshima, Toshihisa. *J Macromol Sci Chem* v A 25 n 3 Mar 1988 p 327-336.

**075050 POLYMERIZATION OF METHYL METHACRYLATE USING THIOCRESOLS.** In order to examine the initiating function of thiols for radical polymerization, the polymerization of methyl methacrylate (MMA) was investigated in the presence of thiocresols (Tere). It was found that the rate of polymerization increased by the addition of formic acid (FA), although the initiating activity of Tere was weak. The kinetic study was made and the following rate equation was obtained in a certain range of Tere and FA concentrations;  $R_p = k[MMA]^{1.5}[Tere]^{0.5}[FA]^{0.5}$ . This equation suggested that initiating radical was produced as a result of the reaction among MMA, Tere, and FA. The rate of polymerization initiated by Tere-FA system was found to decrease in the following order: o-Tere > m-Tere > p-Tere-FA system. (Edited author abstract). 3 Refs. In Japanese.

Okada, Yukio (Himeji Inst of Technology, Jpn). *Kobunshi Ronbunshu* v 45 n 5 1988 p 449-451.

**075051 POLY-1,2-azEPINES BY THE PHOTOPOLYMERIZATION OF PHENYL AZIDES. PRECURSORS FOR CONDUCTING POLYMER FILMS.** The authors report experimental evidence for the formation of poly-1,2-azepines as the primary product of the polymerization of secondary amines. The ease of oxidation of these polymers is investigated in view of the formation of conducting polymers. On the basis of the evidence presented, poly-1,2-azepines are established to be the primary products of the photopolymerization of phenyl azides. The polymers are easily oxidized to delocalized charged species, yielding conducting polymers that can be formed in films with pattern structures. 24 Refs.

Meijer, E.W. (Philips Research Lab, Eindhoven, Neth); Nijhuis, S.; van Vroonhoven, F.C.B.M. *J Am Chem Soc* v 110 n 21 Oct 12 1988 p 7209-7210.

## Preprocessing

**075052 STUDY OF THE MECHANISM OF HYDROGENOLYSIS OF THIOPHENE ON AN ALUMINUM-COBALT-MOLYBDENUM CATALYST AND MOLYBDENUM DISULFIDE USING  $^{35}\text{S}$ .** The hydrogenolysis of thiophene has been studied on a sulfurized aluminum-cobalt-molybdenum catalyst and molybdenum disulfide containing the  $^{35}\text{S}$  radioisotope. It has been found that in both cases formation of  $\text{H}_2\text{S}$  occurs via the participation of sulfur on the catalyst, which, in turn, is replaced by sulfur cleaved from thiophene. It has also been established that two types of sulfide sulfur are found on the aluminum-cobalt-molybdenum catalyst, and that these have different reactivities. A large portion of sulfur on the catalyst (ca. 60%) is not involved in  $\text{H}_2\text{S}$  formation. (Edited author abstract) 10 refs.

Isagulyants, G.V. (Acad of Sciences of the USSR, Moscow, USSR); Greish, A.A.; Kogan, V.M.; V'yunova, G.M.; Antoshin, G.V. *Kinet Catal* v 28 n 3 pt 1 May-Jun 1987 p 550-555.

**Processing** See Also BENZENE—Synthesis; BIOTECHNOLOGY—Applications; BUTENES; CATALYSTS—Materials; CHEMICAL EQUIPMENT—Research; COAL LIQUEFACTION; COAL TAR—Pyrolysis; COPOLYMERS—Materials; DRUG PRODUCTS—Electrochemistry; ESTERS—Processing; HYDROGEN—Production; ION EXCHANGE RESINS; OLEFINS—Processing; SULFUR COMPOUNDS—Desulfurization; WASTEWATER—Treatment.

**075053 COPOLYMERIZATION KINETICS OF N-CARBOXYANHYDRIDES OF  $\epsilon$ -BENZYL-OXYCARBONYL-L-LYSINE AND L-VALINE.** The authors report the kinetics of copolymerization of  $\epsilon$ -benzyloxycarbonyl-L-lysine NCA and L-valine NCA in two solvents, dioxane and benzene/methylene chloride. The intrinsic viscosity in dichloroacetic acid, and hence the MW, increased only slightly with conversion in dioxane (0.60-0.65 dL/g) or in the mixed solvent (2.00-2.40 dL/g). The systems satisfy the conditions laid down by F.T. Wall for analysis of data by the copolymerization kinetics theory. 9 refs.

Kumar, Ajay (Cent for Cellular & Molecular Biology, Hyderabad, India). *J Macromol Sci Chem* v A24 n 6 1987 p 707-710.

**075054 STUDIES OF THE MECHANISM OF COPOLYMERIZATION OF ELECTRON-DONOR DIENES AND ACRYLONITRILE.** In the copolymerizations of acrylonitrile with 1-ethoxy-1,3-butadiene and 1-diethylamino-1,3-butadiene, the resulting copolymers were found to have a highly alternating structure. Their monomer reactivity ratios were determined by the Fineman-Ross and Kelen-Tudos methods. A mechanism for this alternating copolymerization system is suggested on the basis of chemical shift differences between the head-to-tail and head-to-head monomer sequence distributions. (Author abstract) 31 refs.

Butler, George B. (Univ of Florida, Gainesville, FL, USA); Chen, Jen-Chi. *J Macromol Sci Chem* v A24 n 7 1987 p 813-828.

**075055 POLYKETOEETHERESTERS FROM**

**4,4'-DICHLOROACETYLDIPHENYL ETHER AND THEIR CHARACTERIZATION.** As phenacyl chloride is more reactive than benzyl chloride is more reactive than benzyl chloride, 4,4'-dichloroacetyldiphenyl ether (DADE) should prove even more reactive than a dichloride of the  $\text{Ar}(\text{CH}_2\text{Cl})_2$  type. The work presented here comprises a study of the polycondensation of DADE with sodium adipate (ADP), sebacate (SEB), or terephthalate (TER). This study has revealed that a dichloride monomer like DADE can afford polyesters on reaction with sodium diolate monomers. The infusibility and insolubility which appears at the lower stage of  $\text{M}_n$ , even when an aliphatic diol acid is employed as monomer, seem to suggest strong intermolecular interaction between the vicinal flat and planar biphenylene moieties of the repeat units of polymer chains since simple intermolecular attractive dipolar interaction cannot account for these properties. 14 refs.

Patel, H.G. (Sardar Patel Univ, Vallabh Vidyanagar, India); Patel, R.M.; Patel, S.R. *J Macromol Sci Chem* v A24 n 7 1987 p 835-840.

**075056 CATALYTIC CONVERSIONS OF METHYLTETRAHYDROPHthalic ANHYDRIDE.** Methyltetrahydrophthalic anhydride (MTHPA) and mixtures of its isomers are among the widely used intermediates for production of polyester and epoxy resins. Information on methods of production of MHPA and MPA (methylphthalic anhydride) is confined to a few patents. The possibility of obtaining them from MTHPA by hydrogenation and dehydrogenation respectively is of interest. Experimental evidence shows that alumina-palladium catalyst with a palladium content of 5.0 mass % has the highest activity and selectivity in synthesis of 4-MPA. The yield of 4-MPA under the optimal conditions found is 60-61% on the converted feed, with 100% conversion. Alumina-palladium catalyst with a palladium content of 3.0 mass % has the highest activity and selectivity in synthesis of 4-MHPA. Under the optimal conditions found the yield of 4-MHPA is 75-80% on the converted feed, with 100% conversion. 5 refs.

Lezdin, S.Yu. (Lensovet Leningrad Technological Inst, USSR); Dokuchaeva, T.G.; Sibarov, D.A.; Panfilova, N.N.; Proskuryakov, V.A. *J Appl Chem USSR* v 60 n 1 pt 2 Jan 1987 p 136-138.

**075057 THERMODYNAMIC CHARACTERISTICS OF SOLVATION OF ORGANIC COMPOUNDS IN SULFONES.** In addition to saturated cyclic sulfides, middle-distillate fractions of sulfurous and high-sulfur petroleum contain considerable amounts of organosulfur compounds of the thiophene and benzothio-phenes series, oxidation of which gives the corresponding sulfones (TPSO), having a combination of useful properties. It is therefore necessary to devise methods for their isolation and effective utilization in the national economy. This was the purpose of the work. Examination of the data reported in this paper shows that compounds containing hydroxyl groups enter into stronger specific interaction with sulfones than with compounds of other classes (cf. the  $\Delta H_{sp}^{\text{in}}$  values for methyl alcohol, nitromethane, and acetonitrile). In order to determine the specific values of  $\Delta H_{sp}^{\text{sol}}$  and  $\Delta G_{sp}^{\text{sol}}$  per OH group, we studied the dependence of these thermodynamic characteristics on the number (n) of C-H bonds in aliphatic alcohols of normal structure. It can be concluded that the extraction efficiency of most of the organic compounds included in this study is approximately the same with respect to CPSO as with respect to TPSO. 7 refs.

Kozin, V.G. (S.M. Kirov Inst of Chemical Technology, Kazan, USSR); Okruzchnov, M.A.; Diyarov, I.N.; Mazitova, F.N. *J Appl Chem USSR* v 59 n 7 pt 2 Jul 1986 p 1431-1435.

**075058 KINETICS AND MECHANISM OF THE REACTION OF DIFLUOROCARBENE WITH MOLECULAR BROMINE.** The results are cited from an investigation of the kinetics and mechanism of the reaction of difluorocarbene with molecular bromine, proceeding with the formation of  $\text{CF}_2\text{Br}_2$ , by the method of compet-



ing reactions using the reaction of difluorocarbene with hydrogen chloride proceeding with the formation of  $\text{CF}_2\text{HCl}$  as the standard. On the basis of the data obtained, a mechanism of the formation of the reaction product is proposed, and the Arrhenius parameters of the reaction of  $\text{CF}_2$  with  $\text{Br}_2$  are proposed. (Edited author abstract) 9 refs.

Mel'nikov, S.V.; Moin, F.B. *Kinet Catal* v 28 n 1 pt 2 Jan-Feb 1987 p 159-162.

**075059 DEVELOPMENT OF A PROCESS FOR WASHING ABSORPTION OIL WITH WATER.** The authors selected the optimum conditions for washing oil with separator water. For this purpose we used a 2000 ml column with three plates, filled it with separator water and supplied from the top recycled oil that was withdrawn from the bottom of the column. We analyzed samples of oil and separator water. We also determined the content of thiocyanates, cyanides, sulfides, sulfates, chlorides, salts of organic bases according to a previously developed method. To determine the salt composition of the absorption oil we carried out alkaline extraction. The results of the experiments conducted showed that an increase in temperature during washing of the oil above  $80^\circ\text{C}$  had no significant effect on reducing the corrosive components and the optimal ratio oil: water was 1:10. The content of corrosive components diminished by 65%. We also conducted experiments to find the most effective equipment layout for oil washing. It is proposed that washing be conducted under industrial conditions in a  $45\text{ m}^3$  vessel with a built-in distributing ring with holes on the top. 4 refs.

Taskina, M.F.; Zhuravleva, L.A.; Muzychuk, V.D. *Coke Chem (USSR)* n 3 1987 p 85-88.

**075060 STUDY OF THE MECHANISM OF HYDROGENOLYSIS OF THIOPHENE ON AN ALUMINUM-COBALT-MOLYBDENUM CATALYST USING TRITIUM.** Use of  $^3\text{H}$  has shown that adsorption of hydrogen occurs irreversibly on a sulfurized ACM catalyst, and that this hydrogen reacts with sulfide sulfur found on the catalyst to form hydrogen sulfide, but that this hydrogen does not take part in isotope exchange reactions or hydrogenation of the hydrocarbon fragment of thiophene. A proposal has been made, namely, that in the decomposition of thiophene on a sulfurized ACM catalyst  $\text{H}_2\text{S}$  is formed via SH groups on the catalyst. A reaction scheme has also been suggested. (Author abstract) 10 refs.

Isagulyants, G.V. (Acad of Sciences of the USSR, Moscow, USSR); Greish, A.A.; Kogan, V.M. *Kinet Catal* v 28 n 3 pt 1 May-Jun 1987 p 555-559.

**075061 EXAMPLE OF CATALYTIC SELECTIVITY INDUCED BY CHELATION: THE HYDROFORMYLATION OF CYCLODODECATRIENES.** The hydroformylation of (E,E,Z)-1,5,9-cyclododecatriene with a rhodium catalyst gave selective monohydroformylation of a trans double bond. Dimethyl-substituted cyclododecatrienes reacted similarly. This unusual selectivity is attributed to chelation. (Author abstract) 9 refs.

Chalk, A.J. (Givaudan Corp, Clifton, NJ, USA). *J Mol Catal* v 43 n 3 Jan 1988 p 353-358.

**075062 KINETIC STUDY OF THE AMMOXIDATION OF METHYLPYRAZINE TO CYANOPYRAZINE.** The kinetic study of the ammoxidation of methylpyrazine to cyanopyrazine was carried out at 583-643 K and atmospheric pressure, in excess steam. Apparent partial reaction orders were -0.4, 0.7, 0.02 and 0.2, with respect to methylpyrazine, oxygen, ammonia and water, respectively. A pseudo-first order model fitted experimental data satisfactorily. However, low values (50 kJ/mol or less) of the apparent activation energy indicate that the kinetics are probably controlled by internal diffusion. (Author abstract) 4 refs.

Forni, Lucio (Univ di Milano, Milan, Italy). *Appl Catal* v 37 n 1-2 Feb 15 1988 p 305-314.

**075063 ESR SPIN RADICAL TRAPPING IN DEHYDROHALOGENATION OF ALKYL HALIDES CATALYZED BY MOLYBDENUM HEXACARBONYL.** The dehydrohalogenation of some aliphatic alkyl halides catalyzed by molybdenum hexacarbonyl produces organic free radicals in solution. These transient radical species were trapped by using spin-trapping techniques and formed stable organic compounds whose structures were elucidated. Based on the structures of these spin-radical adducts, a dehydrohalogenation mechanism was proposed for each reaction system. (Author abstract) 19 refs.

Hwang, James S. (King Fahd Univ of Petroleum & Minerals, Dhahran, Saudi Arabia); Tsonis, Christos P. *J Mol Catal* v 44 n 2 Feb 29 1988 p 259-267.

**075064 TPSR STUDY OF 1-BUTANOL OVER A Zn-Cr-O CATALYST.** In a previous work the interaction of n-butanol with a Zn-Cr-O catalyst was studied by Temperature-Programmed Surface Reaction (TPSR) methods. In this study the investigation is extended to the functionalities involved in the interaction of the corresponding alcohol, 1-butanol, with a Zn-Cr-O catalytic system. This aspect is of particular relevance for the direct synthesis of methanol and higher alcohols from CO and  $\text{H}_2$ , since it can help to establish whether alcohols are actually terminal reaction products or can be further involved in successive reactions, including e.g. condensation, dehydration, dehydrogenation. The results of this study confirm that some of the chemical functionalities of the Zn-Cr-O catalyst previously assessed for TPSR of n-butanol are effective also in the interaction of 1-butanol with Zn-Cr-O. 6 refs.

Lietti, Luca (Chimica G. Natta del Politecnico, Milan, Italy); Tronconi, Enrico; Forzatti, Pio. *J Mol Catal* v 44 n 2 Feb 29 1988 p 201-206.

**075065 CATALYTIC DIMERIZATION OF MONOETHANOLAMINE TO N-(2-AMINOETHYL)-ETHANOLAMINE.** The authors report that AEEA (Aminoethylethanolamine) is obtained in high selectivity by dimerization of ethanolamine in the presence of a lanthanum phosphate catalyst. It is shown that conversion of ethanolamine to AEEA is directly proportional to temperature and pressure and increases as either or both are raised. The highest yields of AEEA are obtained at 300 psig with reaction temperatures between 245 and  $255^\circ\text{C}$ . Phosphate-catalyzed dimerization of ethanolamine, while a low conversion process, provides AEEA in high selectivity under relatively mild conditions of temperature and pressure. Moreover, cyclic polyamines, the major by-products of this process, are also useful industrial chemicals. 23 refs.

Ford, Michael E. (Air Products & Chemicals, Allentown, PA, USA); Johnson, T.A.; Premecz, J.E.; Cooper, C.A. *J Mol Catal* v 44 n 2 Feb 29 1988 p 207-211.

**075066 PALLADIUM COMPLEX-CATALYZED CARBOALKOXYLATION OF BIS(CHLOROMETHYL)ARENES.** Palladium complex-catalyzed carboalkoxylation of bis(chloromethyl)-arenes was studied for use in the synthesis of bis(alkoxycarbonylmethyl)-arenes. Reaction parameters, such as auxiliary base, palladium complex catalyst and solvent in the reaction of 1,4-bis(chloromethyl)benzene, were found to significantly affect the selectivity for the formation of 1,4-bis(alkoxycarbonylmethyl)benzene, which was almost quantitatively obtained under optimum conditions without side reactions, such as quaternization of amine and alcoholysis of the benzylic chloride. The procedure with optimized conditions was applied to various other bis(chloromethyl)-arenes. (Author abstract) 35 refs.

Kobayashi, Toshi-Aki (Nat'l Chemical Lab for Industry, Yatabe, Jpn); Abe, Fujio; Tanaka, Masato. *J Mol Catal* v 45 n 1 Apr 18 1988 p 91-109.

**075067 KINETIC RELATIONSHIPS IN CONVERSION OF 3-METHYL-1,3-BUTANEDIOL ON PHOSPHORIC ACID CATALYST WITH ADDED SODIUM PHOSPHATE.** By means of pulse chromatography on a phosphoric acid catalyst consisting of a mixture

of phosphoric acid and sodium phosphates supported on quartz, a study has been made of the acid-catalyzed conversions of 3-methyl-1,3-butanediol (MBD) at  $120\text{--}150^\circ\text{C}$ . It has been established that the principal products are isoprene and isopropenylethyl alcohol; at long contact times, the alcohol is also dehydrated to isoprene. It has been shown that the reaction of MBD conversion is irreversible and is first-order with respect to the reactant. Rate constants have been determined for individual stages of the process. (Author abstract) 8 refs.

Malinskii, V.S. (Acad of Sciences of the USSR, Moscow, USSR); Vinnik, M.I. *Kinet Catal* v 28 n 4 pt 1 Jul-Aug 1987 p 766-771.

**075068 CONVENIENT METHOD OF SYNTHESIZING THE METHYL ETHER OF BENZOIN.** The authors propose a convenient method of synthesizing the methyl ether of benzoic acid, which makes possible an appreciable reduction in the total volume of organic solvents, quickens the process and delivers a product with high yield and high purity. Benzoic acid was synthesized by condensing benzaldehyde in a water-alcohol medium at  $50\text{--}70^\circ\text{C}$  with an equimolar mixture of acetone cyanohydrin and an alkali being used as the catalyst at the rate of 8-12% of the benzaldehyde. The reaction takes 1 h to give a 90-92% yield of benzoic acid. It is shown that the best results were obtained when 1,4-dioxane was used as the solvent, the optimum being the use of 1 mole of dioxane to 0.1 mole of benzoic acid with a methanol:benzoic acid molar ratio of 1:30, whereupon, at  $60^\circ\text{C}$ , the compound is formed in 3.5 h with the maximum yield and purity. To purify the product a single recrystallization from hexane is sufficient, whereas one of the disadvantages of the Fischer method is the complication of isolating compound (I) by repeated crystallization from nonane. 9 refs.

Etlis, V.S.; Shomina, F.N. *J Appl Chem USSR* v 60 n 8 Pt 2 Aug 1987 p 1770-1772.

**075069 PHOSPHORESCENCE QUENCHING OF BENZYL BY POLYSTYRENE IN DILUTE AND SEMIDILUTE SOLUTIONS.** In this study, we have investigated the quenching of benzyl phosphorescence by polystyrene in dilute and semidilute solutions, this time employing cyclohexane and toluene as solvents. In addition to measuring phosphorescence lifetimes as a function of polymer concentration, phosphorescence intensities were also measured. A comparison of values of  $I_0/I$  and  $\tau_0/\tau$ , clearly shows that they are not equivalent. The higher values of  $I_0/I$  indicate that significant static quenching is present in addition to dynamic quenching. 18 refs.

Yu, Daniel H.S. (Northwestern Univ, Evanston, IL, USA); Torkelson, John M. *Macromolecules* v 21 n 3 Mar 1988 p 852-853.

**075070 TRANSITION STRUCTURES OF PERICYCLIC REACTIONS. ELECTRON CORRELATION AND BASIS SET EFFECTS ON THE TRANSITION STRUCTURE AND ACTIVATION ENERGY OF THE ELECTROCYCLIZATION OF CYCLOBUTENE TO BUTADIENE.** Cyclobutene (1), s-trans-butadiene (2), and the conrotatory transition structure 3 of the electrocyclic ring opening of 1 have been located at the ab initio RHF and MP2 levels of theory and with semiempirical techniques. Geometries of all three structures are reasonably insensitive to changes in basis set or inclusion of electron correlation. At the RHF level and with MNDO and MINDO/3, activation energies and heats of reaction are overestimated, while at the AM1, MP2/6-31G\*, MP2/6-31G\*\*/RHF/3-21G, and MP4SDTQ/6-31G\*\*/MP2/6-31G\* levels they are in good agreement with the experimental values. (Author abstract) 29 refs.

Spellmeyer, David C. (Univ of California at Los Angeles, Los Angeles, CA, USA); Houk, K.N. *J Am Chem Soc* v 110 n 11 May 25 1988 p 3412-3416.



**075071 POLYMERIC PHOSPHOLIPID ANALOGS. XXIV. POLYMERIC PHOSPHOLIPID ANALOGS WITH URIDINE UNITS.** The authors synthesize polymeric phospholipid analogs containing nucleosides, e.g., uridine. The starting material, 2',3'-O-isopropylideneuridine, was commercially obtained and reacted with 2-chloro-2-oxo-1,3,2-dioxaphosphatane in THF in the presence of triethylamine to give 2',3'-O-isopropylidene-5'-O-(2-oxo-1,3,2-dioxaphospholan-2-yl)-uridine (I). The product, obtained as a white solid in nearly quantitative yield, was characterized by IR spectroscopy. 16 refs.

Furukawa, Akio (Osaka City Univ, Osaka, Jpn); Nakaya, Tadao; Imoto, Minoru. *J Macromol Sci Chem* v A 25 n 3 Mar 1988 p 337-343.

**075072 OLIGOMERIZATION OF PIPERYLENE AND PIPERYLENE FRACTION IN THE PRESENCE OF COMPLEX CATALYSTS BASED ON ALUMINIUM CHLORIDE.** An investigation was made of the oligomerization of industrial piperylene fraction in the presence of homogeneous catalysts (monoethyl aluminum chloride and a Gustavson complex) with the use of different solvents. It was shown that, by changing the nature of the catalyst or the nature of the solvent (heptane, mesitylene, methylene chloride), soluble products with a molecular weight of 1600-1400 and containing di- and trisubstituted cyclohexene groups and linear chain sections containing conjugated double bonds can be obtained. The possibility of oligomerizing piperylene (with an 80 percent yield) in a reaction mass on heterogenized catalysts based on aluminum halides applied to silica gel is discussed. 14 refs.

Atamanenko, O.P. (USSR Acad of Sciences, USSR); Nel'kenbaum, E.M.; Yasman, Yu.B.; Sangalov, Yu.A.; Sokolova, N.P.; Taits, S.Z.; Dumskii, Yu.V.; Vasserberg, V.E. *Pet Chem USSR* v 27 n 1 1987 p 32-39.

**075073 SIDE REACTIONS IN QUINOLINE HYDRODINITROGENATION.** The mechanism for hydrodinitrogenation (HDN) of quinoline to propylbenzene, propylcyclohexene and propylcyclohexane is well established. The formation of substantial amounts of species formed from HDN intermediates is reported for a cobalt-molybdenum/alumina catalyst. As many as eighteen species were found in reaction mixtures at concentration levels greater than 1 percent, with indoline and hydrindane being the most significant. The results suggest that Bronsted acidity may be responsible for the formation of indoline and hydrindane. (Edited author abstract). 11 refs.

Collins, Dermot J. (Univ of Louisville, Louisville, KY, USA); Lloyd, Edward C.; Miranda, Raul. *Appl Catal* v 41 n 1-2 Jul 15 1988 p 81-88.

**075074 LUMPED KINETIC MODEL FOR PROPENE-BUTENE MIXTURES OLIGOMERIZATION ON A SUPPORTED PHOSPHORIC ACID CATALYST.** A lumped kinetic model for the oligomerization of propene-butene mixtures on a supported phosphoric acid catalyst was developed. The model was based on four lumping criteria, stemming from the chemical properties of the reacting system. An automatic procedure for self-dimensioning of the model, in terms of the number of considered lumped reactions, was derived. Finally, the model reliability was tested by comparison with experimental data, reported in the literature. (Author abstract). 12 refs.

Cao, Giacommo (Univ degli Studi di Cagliari, Cagliari, Italy); Viola, Antonio; Baratti, Roberto; Morbidelli, Massimo; Sanseverino, Luigi; Cruicu, Mario. *Appl Catal* v 41 n 1-2 Jul 15 1988 p 301-312.

**075075 REACTION PRODUCTS OF TRIGLYCIDYL ISOCYANURATE WITH ORTHOPHOSPHORIC AND POLYPHOSPHORIC ACIDS: THERMAL BEHAVIOUR AND PYROLYSIS STUDIES.** Triglycidyl isocyanurate reacts with orthophosphate or polyphosphoric acid, under suitable experimental conditions, to give polycondensates which are flame-retardant

additives for polypropylene. These additives have been studied by means of thermogravimetry and pyrolysis. The polycondensates undergo different rearrangements at different temperatures. A probable structure of the polycondensates and of the residue char, obtained by heating them, are described. The reaction that produces char is also responsible for the formation of CO<sub>2</sub>, the swelling gas of the polymeric material during the combustion. (Author abstract) 8 refs.

Audisio, Guido (CNR, Milan, Italy); Rossini, Alessio; Severini, Febo; Gallo, Raffaele. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 263-275.

**Production** See Also BIOLOGICAL MATERIALS—Genes.

**075076 ELECTROREDUCTION OF 4-AMINO-5-CYANO-2-PROPYLPYRIMIDINE.** The possibilities of electrochemical production of 4-amino-5-hydroxymethyl-2-propylpyrimidine have been studied, which is an intermediate in the manufacture of Tiakotsid, a compound helping to increase livestock productivity. Starting material for synthesis of the hydroxy derivative was 4-amino-5-cyano-2-propylpyrimidine, for which the electrochemical behavior is not known. Data is given for the electroreduction of 4-amino-5-cyano-2-propylpyrimidine at electrodes with developed surfaces area. The most negative potential at the start of electrolysis is attained at nickel cathodes covered with copper sponge. At the palladium electrode with palladium sponge where the least negative potentials are seen, amine is found in low yields while no hydroxy derivative is formed. It is shown that by using a palladized nickel electrode which is stable in sulfuric acid solution one can obtain 4-amino-5-hydroxymethyl-2-propylpyrimidine in a chemical yield of 84% and a current yield of 56%. 1 ref.

Antonova, T.L. (D.I. Mendeleev Chemical Engineering Inst, Moscow, USSR); Savushkina, N.N.; Ivanovskaya, L.N.; Avrutskaya, I.A.; Maksimova, O.V.; Fioshin, M.Ya. *Sov Electrochem* v 23 n 2 Feb 1987 p 272-275.

**075077 PRODUCTION OF HIGH-PURITY INDOLE FROM COAL TAR.** Data were obtained on the liquid-vapor phase equilibria under isobaric conditions in a monoethanolamine-indole system and satisfactory agreement was shown between the experimental results and the results of calculation by the Wilson and NRTL equations. These equations may be used as a model in the design of a system for separation of indole from the extract. The process of rectification with production of technical indole was carried out under conditions of a large-scale continuous laboratory system. It was shown possible to obtain indole of high purity (not less than 99.5%) by rectification of technical indole on a batch-process column. 7 refs.

Zaretskii, M.I.; Golub, V.B.; Chartov, E.M.; Taits, S.Z. *Coke Chem (USSR)* n 12 1986 p 47-51.

**075078 PRODUCTION OF PROPENE OXIDE IN AN ORGANIC LIQUID-PHASE IMMOBILIZED CELL REACTOR.** Some major restrictions of the production of propene oxide in an organic liquid-phase immobilized cell packed-bed reactor were quantified, and techniques were investigated to enhance the epoxide production rates. Propene-epoxidizing *Mycobacterium* cells were entrapped in calcium alginate gel and contacted with the substrates, propene and oxygen, which were dissolved in a continuous organic phase, n-hexadecane. The effects of product inhibition by the toxic epoxide - microbial consumption of propene oxide and immobilized cell deactivation - restricted severely the accumulation of the epoxide in the recirculation reactor system and could be predicted using a simple mathematical model. (Edited author abstract) 19 refs.

Brink, L.E.S. (Agricultural Univ Wageningen, Wageningen, Neth); Trampler, J. *Enzyme Microb Technol* v 9 n 10 Oct 1987 p 612-618.

**075079 PREPARATION OF D-VALINE FROM**

**D,L-5-ISOPROPYLHYDANTOIN BY STEREOSELECTIVE BIOCATALYSIS.** The synthesis of D-valine has been optimized starting from isobutyraldehyde, sodium cyanide and ammonium carbonate. The intermediate hydantoin was converted by a bienzymatic system to D-valine. The specific consumption of *Agrobacterium radiobacter* resting cells, which are high producers of hydantoinase and N-carbamoyl-D-amino acid amidohydrolase, has been evaluated and the optimum reaction conditions were obtained by using a 10% solution of the hydantoin and a hydantoin/cells w/w ratio equal to 5, at 40°C for 48 h. Several methods have been optimized to recover the amino acid from the hydrolysate. (Edited author abstract) 15 refs.

Battilotti, M. (ENIricerche SpA, Rome, Italy); Barberini, U. *J Mol Catal* v 43 n 3 Jan 1988 p 343-352.

**075080 PRODUCTION OF MESITYLENE AND PSEUDOCUMENE FROM C<sub>9</sub> AROMATIC FRACTIONS OF DIFFERENT ORIGIN.** The authors demonstrated high activity of the proposed vanadium-containing catalyst during catalytic purification of mesitylene and pseudocumene from ethyltoluenes by dehydrogenation. The most suitable feedstock for producing pure mesitylene and pseudocumene by dehydrogenation of impurities (ethyltoluenes) with subsequent rectification isolation of the pure products is the byproduct coke solvent. In addition to producing mesitylene and pseudocumene, the proposed method of processing provides for the possibility of isolating pure vinyltoluenes by extractive rectification by known methods using n-methylpyrrolidone as extractant which permits broadening the variety of commercial products from the C<sub>9</sub> aromatic fractions. 8 refs.

Zolotarev, O.V.; Petrov, I.Ya.; Tryasunov, B.G.; El'bert, E.I. *Coke Chem (USSR)* n 8 1987 p 50-53.

**075081 DEVELOPMENT OF ACRYLAMIDE MANUFACTURING PROCESS USING MICROORGANISM.** There is a growing interest in the synthesis of useful organic compounds by biological process for its specificity and moderate reaction condition. Therefore, the author attempted to produce acrylamide from acrylonitrile using microbial enzyme and found a bacterium having a high acrylamide producing enzyme (nitrile hydratase). This paper describes the details and merits of the development of microbial production of acrylamide. (Edited author abstract) In Japanese. 20 refs.

Watanabe, Ichiro (Nitto Chemical Industry Co, Yokohama, Jpn). *Yuki Gosei Kagaku Kyokaiishi* v 46 n 2 Feb 1988 p 169-176.

**075082 METHYL ACETATE: BYPRODUCT IN THE TEREPHTHALIC ACID PRODUCTION PROCESS. MECHANISMS AND RATES OF FORMATION AND DECOMPOSITION IN OXIDATION.** Methyl acetate is one of the main byproducts in the terephthalic acid process. This investigation has been aimed to shed more light on particular aspects concerning this byproduct: the relationship between the ester production and the process variables, methyl acetate behavior in the oxidation vessel, and recycle of the ester to the oxidation. The effect of some parameter variations on the ester formation is reported. Ester formation rate and the decomposition rate constant have been also calculated for operating conditions adopted in our oxidation. The ester decomposition preferably occurs through a hydrolysis reaction. The recycle of the ester to the oxidation appears then to be a valid solution to recover selectively acetic acid from this byproduct and to reduce solvent makeup, while CH<sub>3</sub>OH decomposes to CO<sub>x</sub>. (Author abstract) 17 refs.

Roffia, Paolo (Montedipe SpA, Bollate MI, Italy); Calini, Pierangelo; Tonti, Sergio. *Ind Eng Chem Res* v 27 n 5 May 1988 p 765-770.

**Purification** See Also RARE EARTH COMPOUNDS.

**075083 BEHAVIOR OF A NOVEL THERMOSTABLE β-AMYLASE ON RAW STARCH.** The first extremely thermostable β-amylase from *Clostridium thermosulfurogenes* was partially purified to 98-fold. It readily



and strongly adsorbed onto raw starch. p-Chloromercuribenzoate treated  $\beta$ -amylase lost its activity toward raw or gelatinized starch but the ability to be adsorbed onto raw starch was preserved. Adsorbed  $\beta$ -amylase was gradually released from starch in the liquid phase during hydrolysis at 75°C. The degradation of raw starch by  $\beta$ -amylase was greatly stimulated by pullulanase addition. The optimum pH for raw starch hydrolysis by  $\beta$ -amylase was pH 4.5 to 5.5, whereas that of soluble starch hydrolysis was at pH 5.5 to 6.0. (Edited author abstract) 12 refs.

Saha, Badal C. (Michigan Biotechnology Inst, Lansing, MI, USA); Shen, Gwo-Jenn; Zeikus, J. Gregory. *Enzyme Microb Technol* v 9 n 10 Oct 1987 p 598-601.

**075084 PURIFICATION OF LIQUID ETHYLENE DICHLORIDE BY ADSORPTION.** The separation of acidic contaminants from liquid ethylene dichloride has been examined. Through the use of a chemically modified alumina specifically designed for this application, it was found that packed bed adsorption could remove hydrochloric acid and ferric chloride to below one ppm in the effluent. Residual water is also significantly reduced. Kinetics and thermodynamics of the adsorption process for each adsorbate are examined. Both dynamic columns and batch cells were evaluated in order to characterize the separation as a function of various process parameters. Some definition of process reversibility and potential regeneration schemes are given. (Author abstract) 2 refs.

Sood, Ajay (Alcoa, Alcoa Center, PA, USA); Fleming, Hubert L. *AIChE Symp Ser* n 259 v 83, Rec Progr in Adsorpt and Ion Exch. Publ by AIChE, New York, NY, USA, 1987 p 40-51.

**075085 ISOLATION OF PHENANTHRENE FROM CRUDE ANTHRACENE.** The purpose of this study is to select a solvent that displays high selectivity with respect to phenanthrene and inertness with respect to sulfuric acid so that phenanthrene can be purified without replacing the solvent. The solvent must meet industrial health and fire safety standards. It was found that treatment of phenanthrene and the accompanying substances in  $\text{CCl}_4$  with 96% sulfuric acid effectively removes almost all the impurities and hardly entrains the phenanthrene at all. The phenanthrene solution in  $\text{CCl}_4$  separated from the resinous lower layer, neutralized with alkali and washed with water is colorless and transparent. After distillation of the solvent the phenanthrene remains in the form of a yellowish molten mass with mp 94-95°C. According to data from chromatographic analysis the product contains 10% fluorene. UV spectroscopic analysis ( $\lambda = 375 \text{ nm}$ ) indicates the absence of anthracene in the product. 3 refs.

Kachurin, O.I.; Okhrimenko, Z.A.; Frolova, I.B. *Coke Chem (USSR)* n 4 1987 p 49-50.

**075086 PURIFICATION OF ORGANIC MATERIALS FOR ELECTRICAL AND OPTICAL STUDIES.** The purification steps for a given crystalline organic solid which is to be evaluated for electrical, magnetic, or optical properties are very dependent on the origins and reactivity of the materials involved. With particular reference to conductive ion-radical solids and monomeric precursors to crystallographically ordered conjugated polymers, examples are chosen to illustrate origins of impurities, selective purification methods, and alternative synthetic procedures. Building on this background, detailed materials characterization can provide not only materials of improved quality for physical study but also furnish insights to interpretation of observed physical phenomena. (Author abstract) 37 refs.

Sandman, Daniel J. (GTE Lab Inc, Waltham, MA, USA). *J Cryst Growth* v 89 n 1 Jun 1988, Purif of Mater for Cryst Growth and Glass Process - Proc of the Second Workshop, Champion, PA, USA, Sept 28-Oct 1 1987 p 111-116.

**075087 PURITY AND PURIFICATION OF SOURCE MATERIALS FOR III-V MOCVD.** The major factors that affect the quality of MOCVD-grown

III-V electronic materials are reviewed. Of prime importance is the purity of the source compounds, for example, trimethylgallium (TMG), trimethylindium (TM), arsine and phosphine. Generally, we find that the quality of these compounds is good, commercially available sources are good, as evidenced by the relatively good electronic quality of the product compounds, GaAs and InP. Newer or less commonly used sources such as cyclopentadienylmagnesium ( $\text{Cp}_2\text{Mg}$ ) or diethylarsine may still require further purification. A simple apparatus for the laboratory-scale vacuum distillation of MOCVD source materials is presented. The utility and efficacy of this purification technique is demonstrated by its application to the purification of silicon- and oxygen-contaminated trimethylindium. (Author abstract) 24 refs.

Olson, J.M. (Solar Energy Research Inst, Golden, CO, USA); Kurtz, S.R.; Kibbler, A.E. *J Cryst Growth* v 89 n 1 Jun 1988, Purif of Mater for Cryst Growth and Glass Process - Proc of the Second Workshop, Champion, PA, USA, Sept 28-Oct 1 1987 p 131-136.

**Pyrolysis** See Also CARBON—Manufacture; COAL RESEARCH; HYDROCARBONS—Aromatic; HYDROCARBONS—Processing; MICA—Thermal Effects; SUPERCONDUCTING MATERIALS—Thin Films.

**075088 TOPOGRAPHY AND MORPHOLOGY OF THE CARBON DEPOSIT OBTAINED BY PYROLYSIS OF METHYLENE CHLORIDE ON A SILICA GEL SURFACE.** Structural and morphological studies of carbons produced by the thermal pyrolysis of methylene chloride on the surface of Merck Si 100 silica gel were carried out by transmission electron microscopy. The results suggest that during this pyrolysis the carbon is deposited in the form of globules of various size (100-7500 Ångström). The dimensions of these globules depend on the temperature of pyrolysis and the reaction conditions. This globular character of the deposit was confirmed by the use of the globular model of A.P. Karnaukhov. (Edited author abstract) 15 refs.

Gierak, Andrzej (Maria Curie Skłodowska Univ, Lublin, Pol); Lebeda, Roman; Tracz, Elzbieta. *J Anal Appl Pyrolysis* v 13 n 1-2 Jan 1988 p 89-101.

**075089 VACUUM PYROLYSIS OF  $\text{CCl}_3\text{COCl}$ : MATRIX-IR AND MASS SPECTROMETRIC STUDIES OF THE INTERMEDIATES.** Vacuum pyrolysis of trichloroacetyl chloride was studied at 970-1370 K by mass spectrometry and matrix isolation-IR spectroscopy. The pyrolysis experiments were performed in a quartz flow reactor directly connected to the ion source of a quadrupole mass spectrometer or to an optical helium cryostat. The IR spectra of the pyrolysis products, condensed at 12 K in an argon matrix, have revealed the intermediate species: radicals  $\text{CCl}_3$  and  $\text{COCl}$ , carbene  $\text{CCl}_2$  and unstable ketene  $\text{Cl}_2\text{C}=\text{C}=\text{O}$ . It has also been established that the  $\text{COCl}_2$ ,  $(\text{COCl})_2$  and  $\text{C}_2\text{Cl}_4$  detected are formed in secondary reactions. On the basis of the experimental data obtained, two possible routes for the thermal dissociation of  $\text{CCl}_3\text{COCl}$  are proposed, including molecular and radical mechanisms. (Author abstract) 11 refs.

Khabashesku, V.N. (Acad of Sciences of the USSR, Moscow, USSR); Maltsev, A.K.; Nefedov, O.M. *J Anal Appl Pyrolysis* v 13 n 1-2 Jan 1988 p 135-140.

**075090 KINETICS AND MECHANISM OF THE VAPOR PHASE PYROLYSIS OF 1,3-DIOXOLANE IN STEAM.** The kinetics and mechanism of 1,3-dioxolane pyrolysis were determined in atmospheric pressure steam between 963 K and 1093 K with reactant concentrations of  $6.28 \cdot 10^{-7}$  to  $1.36 \cdot 10^{-4} \text{ mol/l}$  using a flow reactor. The reaction was found to be first order. The temperature dependence of the rate constant is given by  $\ln k = 27.6 \pm 3.2 - (51,300 \pm 6,500)/RT$  which agrees well with previous literature data. Some mechanistic aspects of levoglucosan pyrolysis are considered in light of these dioxolane results and recently published results on the pyrolysis of glycerol. (Author abstract) 34 refs.

Cutler, Andrew H. (Univ of Hawaii at Manoa, Honolulu, HI, USA); Antal, Michael J. Jr. *J Anal Appl Pyrolysis* v

12 n 3-4 Nov 1987 p 223-242.

**075091 KINETICS OF THE PYROLYSIS OF CYCLOHEXANE USING THE PULSE TECHNIQUE.** The kinetics and product distributions of the thermal cracking of cyclohexane were investigated in a stainless steel annular reactor using the pulse method. Experiments were conducted at 1-atm pressure and with excessive nitrogen dilution. Data were obtained at temperatures of 700-860°C and space times of 0.40-1.14 s. A kinetic analysis of the conversion-space time data revealed that conversion was autocatalytic at 700-800°C, while at higher temperatures (820-860°C) it was governed by first-order kinetics. The activation energies for the two kinetic regimes were 192.5 and 240.0 kJ mol<sup>-1</sup>, respectively. The autocatalysis was ascribed to the participation of methylallyl radicals in a new bimolecular propagation sequence. (Edited author abstract) 25 refs.

Aribike, D. Stan (Univ of Lagos, Lagos, Nigeria); Susu, Alfred A. *Ind Eng Chem Res* v 27 n 6 Jun 1988 p 915-920.

**075092 TRANSFORMATIONS OF PIPERYLENE IN THE PRESENCE OF A HETEROGENEOUS CATALYST AND HOMOGENEOUS INITIATOR AT HIGH TEMPERATURES.** It was shown that, with pyrolysis of piperylene in the presence of an indium oxide catalyst and the introduction of HBr and hydrogen into the reaction zone, the yield of divinyl and CPD is increased by a factor of 1.5-2 compared with the thermal process. A study was made of the kinetic laws governing the pyrolysis of piperylene on a unit with a nongradient reaction vessel. It was shown that, on transition from a thermal to a catalytic process, there is an increase in the rate constant and a reduction in the activation energy of piperylene decomposition. The observed effect is greater when HBr is introduced into the zone of catalytic pyrolysis. It is assumed that HBr has a modifying effect on the surface of the heterogeneous catalyst and thereby increases the A-factor of the bimolecular reactions of chain nucleation and continuation. 14.

Yegiazarov, Yu.G. (Belorussian SSR Acad of Sciences, USSR); Savon'kina, M.G.; Bobchenok, N.S. *Pet Chem USSR* v 27 n 1 1987 p 48-56.

**075093 CHARACTERIZATION OF THE ALIPHATIC NATURE OF KEROGENS ISOLATED FROM MARINE SEDIMENTS BY VACUUM PYROLYSIS.** Vacuum pyrolysis followed by saponification and fractionation of the pyrolysis products made it possible to determine hydrocarbons, fatty acids and alcohols responsible for the aliphatic polymethylene structures in kerogen. The pyrolysis study using consecutive kerogen samples from a well stratified homogeneous surface sediment core (Tokyo Bay; ca. 150-200 years) revealed that the pyrolytic lipid compounds were practically conserved during the earliest stage of diagenesis. Pyrolysis of samples from Sagami Bay sediments showed that the yields and the compositions of the lipid compounds were sufficiently variable to provide evidence for the heterogeneity of sediments caused by turbidite intercalation or subaqueous gliding. (Author abstract) 22 refs.

Fukushima, Kazuo (Tokyo Metropolitan Univ, Tokyo, Jpn); Ishiwatari, Ryoshi. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 109-124.

**075094 INDICATIONS FROM ANALYTICAL PYROLYSIS ON THE EVOLUTION OF ORGANIC MATERIALS IN THE TEMPERATURE ENVIRONMENT.** Within the carbon cycle, organic carbon circulates mostly between the atmosphere and the biomass. Smaller amounts of organic carbon however separate out into more slowly cycled pools characterized by dark colored polymers, the humic substances, while arrested bioconversion leads to the accumulation of organic deposits as peats or aquatic sediments. This paper examines from the standpoint of their pyrolysis characteristics, examples from the main groups of organic matter taken from these pools, including peat, freshwater and marine



sediments, soils with developed humus, eluviated materials and organic matter which has undergone diagenesis in the wider geochemical cycle. It represents an initial attempt to coordinate widely ranging data which may not be strictly representative in some of these areas. (Edited author abstract) 20 refs.

Bracewell, J.M. (Macaulay Inst, Aberdeen, Scotl); Robertson, G.W. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 355-366.

#### Radiation Effects See Also ELECTRON BEAMS.

**075095 STUDY OF DYNAMICS AND SPIN LATTICE RELAXATION MECHANISM IN THE TRIPHENYLMETHYLPEROXY RADICAL USING PEROXY SPIN PROBES.** The stable triphenylmethylperoxy radical  $\text{Ph}_3\text{COO}^\cdot$  is obtained by gamma irradiation of triphenylacetic acid  $\text{Ph}_3\text{CCOOH}$  in vacuum followed by exposure to oxygen. ESR spectra of the peroxy radicals were measured at X-band in the temperature range 77-300 K. The averaging of the g-anisotropy has been interpreted using the modified Bloch equations. Good agreement with experimental results is obtained by assuming a C-O bond rotation mechanism with 120° jumps. The simulated spectra are very sensitive to the value used for the COO bond angle. The angle deduced from the simulations is  $129 \pm 1^\circ$ . (Edited author abstract) 14 refs.

Schlick, Shulamith (Univ of Detroit, Detroit, MI, USA). *Radiat Phys Chem* v 30 n 1 1987 p 33-38.

**075096 ABSORPTION AND CONDUCTIVITY STUDIES ON THE TRANSIENTS GENERATED IN THE GAMMA-RADIOLYSIS OF PERFLUOROBENZENE IN RIGID MATRICES.** Absorption spectrum of the transient produced on gamma-radiolysis of  $\text{C}_6\text{F}_6$  in 3-methylpentane (3MP) matrix at 77 K has bands at 370 and 460 nm. Studies using electron and hole scavengers in 3MP matrix have shown that the species responsible for the above absorption is indeed due to electron attachment to  $\text{C}_6\text{F}_6$ . However, electron attachment to  $\text{C}_6\text{F}_6$  could be dissociative or nondissociative. Conductivity measurement of a gamma-irradiated  $\text{C}_6\text{F}_6$  in 3MP show a peak thermostimulated current of  $500 \times 10^{-12}\text{A}$  as the temperature was raised above 77 K. The thermostimulated current measured for irradiated  $\text{C}_6\text{F}_6$  in 3MP was reduced to  $50 \times 10^{-12}\text{A}$  when the absorption bands were photobleached. The decrease in the thermostimulated current correlates with the depletion of species having absorption bands at 370 and 460 nm on photobleaching, indicating that the spectrum is due to the molecular anionic species and hence electron attachment to  $\text{C}_6\text{F}_6$  is nondissociative. (Author abstract) 45 refs.

Shoute, Lian C.T. (BARC, Bombay, India); Mittal, Jai P. *Radiat Phys Chem* v 30 n 2 1987 p 105-111.

**075097 AMPLITUDE AND PHASE ANISOTROPY OF PHTHALIMIDE SOLUTIONS DURING PICOSECOND EXCITATION.** In the study of optical properties of dye solutions during high power excitation, the examination of phase anisotropy (related to a change in the refractive index) deserves special attention. We studied the induced anisotropy of solutions of technical phthalimides, 3,6-tetramethyl-diamino-N-methylphthalimide in ethanol and toluene, and also of 3-monomethylamino-6-monomethylphthalimide in ethanol. The irradiation of the solution by a high power light flux in the absorption band of the compound leads to a considerable decrease in the population of the ground state. Therefore, not only the absorption (amplification) coefficient increases, but also the refractive index of the excited solution. Because of the anisotropy of the excitation (a directed polarized light flux), the refractive index of the excited solution is characterized by a given anisotropy, which leads to the occurrence of a birefringence phenomenon. It is desirable (from the experimental point of view) to characterize the induced optical anisotropy (amplitude and phase) as being due to a change in the population of the molecules in the ground state, by a dimensionless value  $\gamma = 4\pi\Delta n/\lambda\Delta\alpha$ , representing the ratio of the phase

anisotropy to the amplitude anisotropy. 13 refs.

Gul'binas, V.B.; Kabelka, V.I.; Pikulik, L.G.; Rudik, K.I.; Chernyavskii, V.A. *J Appl Spectrosc* v 46 n 5 May 1987 p 515-518.

**075098 LYOLUMINESCENCE STUDIES OF PERSISTENCE OF GAMMA-RAY INDUCED FREE RADICALS IN THE MOLTEN STATE OF IRRADIATED SACCHARIDES.** Lyoluminescence (LL) measurements of radiation-induced free radicals, which are presumed to be trapped in the matrix of organic solids, show them to be extremely stable even during storage at high temperatures. To investigate their behavior in liquid phase,  $\gamma$ -ray irradiated saccharides were melted and kept liquid for different periods of time before resolidification. An appreciable LL yield was found to remain in the solids which are once-melted and resolidified, even over periods of minutes while held at melting temperatures. Such persistence of free radicals and the possibility of use of LL-dosimetry from these once-melted samples are discussed. (Author abstract) 13 refs.

Kundu, H. (Bose Inst, Calcutta, India); Mitra, B. *Appl Radiat Isot* v 39 n 2 1988 p 179-180.

**075099 MODIFYING EFFECTS OF CYSTEINE AND AROMATIC SULFHYDRYL AND DISULFIDE AGENTS ON THE RADIATION-INDUCED DECOMPOSITION OF THYMIDINE.** Steady-state  $\gamma$  radiolysis of oxygen-free aqueous solution of thymidine has been carried out in the presence of cysteine and five aromatic sulfhydryl and disulfide agents. The common major mode of action of these compounds is their ability to scavenge water radiolysis species including OH radicals of solvated electrons. In addition, cysteine and the two compounds with a free SH group were found to act as hydrogen donor leading to an increase in the formation of the 5R and 5S diastereoisomers of 5,6-dihydrothymidine and 5-hydroxy-5,6-dihydrothymidine. Two sulfhydryl agents including cysteine were also found to chemically repair the radiation-induced oxidic radicals through efficient hydrogen donation mechanisms. It should be noticed that hydrogen atom transfer to hydroxyl and electron thymidine adducts leads to the decomposition of the thymine moiety. (Edited author abstract) 34 refs.

Cadet, J. (CEN de Grenoble, Grenoble, Fr); Berger, M.; Demonchaux, P.; Lhomme, J. *Radiat Phys Chem* v 32 n 2 1988 p 197-202.

**075100 THERMOLUMINESCENCE 155-1611N CRYSTALLINE PHENANTHRENE.** Charge carrier photogeneration in crystalline phenanthrene has been studied by monitoring the UV-induced thermoluminescence (UVTL) as a function of external electric field for the excitation quanta at energies lower than the band gap. The electric field effect on the UVTL is discussed in terms of Poole-Frenkel- and Onsager-type dissociation of the defect-trapped geminate electron-hole pairs produced under low-temperature excitation. Quantitative agreement with the experiment is obtained with the Onsager-type model, indicating that the average distance between hole and electron in the trapped geminate pairs amounts to 7 nm. (Author abstract). 29 refs.

Kalinowski, J. (Technical Univ, Gdansk, Pol); Dreger, Z. *J Lumines* v 42 n 3 Sep 1988 p 155-161.

#### Reaction Kinetics See Also SURFACE ACTIVE AGENTS—Reaction.

**075101 KINETICS OF THE RADIOLYTIC PROCESSES IN TRI-n-BUTYL PHOSPHATE.** Tri-n-butyl phosphate is widely used in radiochemistry. The main products of its radiolysis are di-n-butyl phosphate (DBP), monobutyl phosphate (MBP),  $\text{H}_3\text{PO}_4$ , and a polymer (P). It has been shown that the yield from the decomposition of TBP is equal to the sum of the yields from the formation of these products. The kinetics of the formation of DBP from TBP, MBP from DBP,  $\text{H}_3\text{PO}_4$  from MBP in a 30% TBP-n-dodecane system has been examined by a mathematical method. In this article it is included in the schemes for the decomposition of TBP. 2 refs.

Vladimirova, M.V.; Kulikov, I.A.; Bulkin, V.I.; Sosnovskii, O.A. *Sov At Energy* v 62 n 4 Apr 1987 p 329-331.

**075102 KINETICS OF REACTION OF CYCLOPENTADIENE WITH SODIUM.** The kinetics of the topochemical reaction of cyclopentadiene with metallic sodium were studied in a toluene medium. It was found that the observed rate of the first-order reaction is proportional to the surface of sodium and the cyclopentadiene concentration. The values of the energy of activation and reaction-rate constants are:  $E=31\text{ kJ/mole}$ ;  $k=7.4 \cdot 10^{-4}\text{ liter/m}^2\cdot\text{sec}$  at  $40^\circ\text{C}$ . (Author abstract) 6 refs.

Koshkina, S.B. (M.V. Lomonosov Inst of Fine Chemical Technology, Moscow, USSR); Krylov, A.V.; Rozovskii, V.Ya.; Zhitkov, I.V. *Kinet Catal* v 28 n 1 pt 2 Jan-Feb 1987 p 170-173.

**075103 SOLID STATE REACTION BETWEEN  $\alpha$ -NAPHTHOL AND p-BENZOQUINONE.** The solid state reaction between  $\alpha$ -naphthol and p-benzoquinone yields a red crystalline 1:1 adduct; in very concentrated solutions the red color can be seen, but it may be due either to Mulliken charge transfer or hydrogen bonding interactions. Kinetic studies of the solid state reaction by a capillary technique indicate that p-benzoquinone is the diffusing species, and that either surface migration or vaporphase diffusion plays an important role in the rate of complex formation. Microscopic examination of a single crystal of  $\alpha$ -naphthol in the presence of p-benzoquinone vapor suggests that the reaction occurs only at defect centers on the  $\alpha$ -naphthol surface. (Edited author abstract) 43 refs.

Singh, N.B. (Univ of Gorakhpur, Gorakhpur, India); Singh, N.N.; Laidlaw, R.K. *CHEMTECH* v 17 n 8 Aug 1987 p 530-539.

**075104 CALORIMETRIC STUDIES OF ORGANIC SOLID-STATE REACTIONS. THE CONVERSION OF METHYL P-DIMETHYLAMINOBENZENESULFONATE TO P-(TRIMETHYLAMMONIUM)-BENZENESULFONATE.** The thermal conversion of methyl p-dimethylaminobenzenesulfonate to p-(trimethylammonium)benzenesulfonate in the solid state has been investigated using temperature-scanning and isothermal calorimetry. An enthalpy of  $-65.2\text{ kJ/mole}$  for the reaction at  $50.2^\circ\text{C}$  and an average of  $-62.6\text{ kJ/mole}$  over the temperature range  $27-109^\circ\text{C}$  have been obtained. Unusual kinetics were observed. Evidence for a physical process partially coincident with the chemical transformation in the bulk materials and for slow chemical reaction on the surface was also observed. (Author abstract) 11 refs.

Boerio-Goates, J. (Brigham Young Univ, Provo, UT, USA); Artman, Johanne I.; Gold, Dianne. *J Phys Chem Solids* v 48 n 12 1987 p 1185-1189.

**075105 SIDE REACTIONS IN THE PHENOL-/ACETONE PROCESS. A KINETIC STUDY.** The reaction of dimethylphenylcarbinol in the presence of phenol, acetone, and sulfuric acid to give  $\alpha$ -methylstyrene and byproducts as well as the reverse reactions was considered. The treatment of the experimental data was performed within a suitable mathematical model by using an optimization procedure. The kinetic parameters governing the different steps of the process and their dependence on temperature and phenol, water, and acid concentrations were determined. Useful indications for the attainment of the best working conditions were obtained. (Author abstract) 6 refs.

Beltrame, Pier Luigi (Univ di Milano, Milan, Italy); Carniti, Paolo; Gamba, Aldo; Cappellazzo, Oscar; Lorenzoni, Lorenzo; Messina, Giuseppe. *Ind Eng Chem Res* v 27 n 1 Jan 1988 p 4-7.



**075106 KINETIC PRINCIPLES AND MECHANISM OF THE REACTION OF POLYCONJUGATED SYSTEMS WITH ARYLDIAZONIUM SALTS.** The rates of the reactions of oligohydroquinone and oligophenol with aryldiazonium ion derivatives at pH 7-8 are known to decrease with the identity of the para substituent. A linear correlation has been established between the logarithmic reaction rate and  $E_{1/2}$ , the one-electron reduction potential of the diazo compound, as well as between the logarithm of the effective rate constant for the reaction and Hammett  $\sigma^+$  constants for the para-substituents in the diazonium ion. It is concluded that para-substituents influence the quantitative characteristics of these reactions and that in this reaction series one-electron transfer takes place between the donor (oligomeric anion or ion-radical) and the diazonium ion. (Edited author abstract) 12 refs.

Aleksanyan, R.Z. ('Polimerkley' Scientific-Industrial Union, Kirovakan, USSR); Avanesova, N.R.; Liogon'kii, B.I. *Kinet Catal* v 28 n 4 pt 2 Jul-Aug 1987 p 868-872.

**075107 ELECTROCHEMICAL EXPERIMENTS ON THE KINETICS OF THE COUPLING REACTION OF QUINONEDIIMINES.** The rotating ring-disk electrode (RRDE) and the spectroelectrochemical method (SEC) were employed for the kinetic study of the coupling reaction of quinonediimines (QDI) with a water-soluble coupler. The reaction rates were obtained by the measurement of the disappearance rate of QDI with RRDE and by the formation rate with SEC, respectively. The rate constants obtained by these two methods were in good agreement with each other. This suggests that the formation of the leuco dye is the rate determining step. (Author abstract) 7 refs.

Kobayashi, Hiroyuki (Chiba Univ, Chiba, Jpn); Yoshida, Kazuaki; Takano, Hiroki; Ohno, Takashi; Mizusawa, Shinya. *J Imaging Sci* v 32 n 2 Mar-Apr 1988 p 90-94.

**075108 KINETIC AND MECHANISTIC STUDIES ON THE FORMATION AND REACTIONS OF EARLY-TRANSITION-METAL-KETENE COMPLEXES.** A series of complexes of vanadocene or molybdenocene with unsymmetrical ketenes were prepared, either by reaction of the various ketenes with vanadocene itself or by reaction with the molybdenocene phosphine complex  $(C_5H_5)_2Mo(PEt_3)$ . All of the complexes exhibited the expected ketene C=O bonding mode, and all reactions were very specific in their formation of the facial isomer with metalocene fragment located on the side of the smaller ketene substituent. Kinetic studies were used to assess the sensitivity of the incoming vanadocene to steric and electronic effects, with the latter found to dominate. Kinetic studies and activation parameters for reaction of  $Cp_2Mo(PET_3)$  with  $EtPhC=C=O$  indicated a second-order associative mechanism, proposed to involve a nucleophilic attack of the metal center on the ketene central carbon in the rate-limiting step. (Edited author abstract) 57 refs.

Galante, Julianne M. (Wesleyan Univ, Middletown, CT, USA); Bruno, Joseph W.; Hazin, Paulette N.; Folting, Kirsten; Huffman, John C. *Organometallics* v 7 n 5 May 1988 p 1066-1073.

**075109 HEXANE-CARBON DIOXIDE REACTION CATALYZED BY ALKALINE EARTH METAL OXIDES II. REACTION NETWORK.** The catalytic properties of alkaline earth metal oxides and the reaction sequences in the hexane-carbon dioxide reaction were investigated at 1173 K and atmospheric pressure. The catalytic activity for the decomposition of hexane to give deposited carbon increased with increase in the surface area of the catalyst, but the order of the activity for gasification of the deposited carbon was not parallel with either that for the decomposition of hexane or that for the hexane-carbon dioxide reaction. The catalytic activity for the hexane-carbon dioxide reaction was determined from the balance between the activity for the decomposition of hexane to produce the intermediate and that for the gasification of the deposited intermediate carbon. (Edited author abstract). 14 refs.

Matsukata, Masahiko (Waseda Univ, Tokyo, Jpn); Sekine, Shinya; Kobayashi, Kenichiro; Kikuchi, Eiichi; Morita, Yoshiro. *Appl Catal* v 41 n 1-2 Jul 15 1988 p 199-211.

## Recovery

**075110 RECOVERY OF VOLATILE ORGANICS FROM SMALL INDUSTRIAL SOURCES.** The recovery of volatile organic compounds (VOCs) from contaminated air generated by small industrial operations such as coating operations and spray painting is an important alternative to other air cleaning techniques such as thermal or catalytic incineration. Three technologies - adsorption, absorption, and condensation - are discussed herein. The focus of this article is activated carbon adsorption. General design parameters and costs, along with their application to example cases, are given for VOC recovery by activated carbon adsorption and condensation. No commercial systems specifically for VOC recovery by absorption have yet been reported, though this technology is extremely important for other air pollution control needs. (Edited author abstract) 17 refs.

Spivey, James J. (Research Triangle Inst, Research Triangle Park, NC, USA). *Environ Prog* v 7 n 1 Feb 1988 p 31-40.

**Reduction** See Also CATALYSTS—Osmium; PLATINUM COMPOUNDS—Hydrogenation.

**075111 ELECTROREDUCTION OF SOME ARYLAZOMETHINE PYRAZOLONES.** DC polarography measurements with some 2,3-dimethyl-1-phenyl-4-(phenylazomethine)-3-pyrazolin-5-one and some of its derivatives show a single 4e, diffusion-controlled, irreversible wave in 30% ethanolic B.R. buffer, (pH < 8) while in strongly alkaline solutions (pH ≥ 10) a single 2e wave is observed. For m- and p-chloro derivatives, two single-electron waves are obtained. The voltammograms of these compounds of different sweep rates show two peaks in the cathodic scan in neutral or alkaline media, corresponding to two reduction steps. (Author abstract) 12 refs.

Mabrouk, E.M. (Tanta Univ, Tanta, Egypt); Elmorisi, M.A.; Moharram, Y.I. *J Electrochem Soc India* v 36 n 3 Jul 1987 p 185-188.

**075112 ELECTRODIMERIZATION OF QUINOLINE DERIVATIVES. 5-CHLORO- AND 5, 7-DI-CHLORO-8-HYDROXYQUINOLINE.** The electrochemical reduction of 5-chloro- (I) and 5,7-dichloro-8-hydroxyquinoline (II) in basic media has been studied using polarography, voltammetry and macroscale electrolysis. The experimental results show a clear influence of chlorine atoms present in the benzene ring, on the electrochemical parameters of quinoline derivatives. This can be seen from the data in Table I. A shift to lower pK and reduction potential values is observed when the number of chlorine atoms is increased. This result is in good agreement with the chemical behavior of quinoline derivatives and is due to the so-called electron attracting effect of the chlorine group. (Edited author abstract) 12 refs.

Claret, J. (Univ de Barcelona, Barcelona, Spain); Mueller, C.; Feliu, J.M.; Alcalde, J. *Electrochim Acta* v 32 n 10 Oct 1987 p 1431-1433.

**075113 CARBANION AND RADICAL INTERMEDIACY IN THE ELECTROCHEMICAL REDUCTION OF BENZYL HALIDES IN ACETONITRILE.** The electrochemical reduction of benzyl iodide, benzyl bromide, and benzyl chloride was studied in acetonitrile on platinum and glassy carbon electrodes. The reductions of benzyl chloride, benzyl bromide, and benzyl iodide all occur as a single wave at  $E_p = -2.20, -1.85, \text{ and } -1.7V$  vs. SCE, respectively, on freshly polished platinum. Reduction of benzyl iodide in the presence of either diethyl malonate or carbon dioxide at  $-1.7V$  produces >40% yields of the diethyl ester of benzyl malonate and benzyl phenylacetate, respectively. (Edited author abstract) 31 refs.

Koch, Del A. (Univ of North Dakota, Grand Forks, ND, USA); Henne, Bruce J.; Bartak, Duane E. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3062-3067.

**075114 INFLUENCE OF THE SOLVENT ON SELECTIVITY OF REDUCTION OF N-OXIDE 2-(2-OXY-5-METHYLPHENYL)-BENZOTRIAZOL BY HYDROGEN ON RANEY NICKEL.** An investigation has been made of the kinetics of reduction by hydrogen of N-oxide 2-(2-oxy-5-methylphenyl)-benzotriazol of Raney nickel in solvents of propanol-2, 1 M aqueous solution of sodium hydroxide and in the same solvent with pyridine addition. It has been shown that the selectivity of the process is determined by the nature of the liquid phase, which is related to the changes of the adsorption states of hydrogen and the N-oxide benzotriazol on the nickel surface under the influence of the solvent. (Author abstract) 14 refs.

Gostikin, V.P. (Ivanovsk Chemical Engineering Inst, USSR); Lefedova, O.V.; Ulitin, M.V. *Kinet Catal* v 28 n 2 pt 1 Mar-Apr 1987 p 305-310.

**075115 ELECTROREDUCTION OF NITRILES.** Existing electrochemical methods for the reduction of nitriles to the corresponding amines have a number of indisputable advantages. Reduction occurs at normal pressure and near room temperature, and pyrophoric catalysts are not present (or, when they are present as additives the medium is not flammable). However, the number of papers discussing the electroreduction of nitriles is small. It is the aim of work to generalize the results and reveal general trends in work concerning nitrile electroreduction that has not been discussed in review or has been published after the review appeared. It is concluded that aromatic nitriles can be reduced to amines in sufficiently high chemical and current yields at electrodes made of metals with low or intermediate hydrogen overpotential or of graphite which are coated with a layer of spongy catalyst (chiefly palladium). Here the reduction evidently follows the catalytic hydrogenation mechanism. Using low temperatures (10-20°C) and current densities (1-5 A/dm<sup>2</sup>) one can obtain near-quantitative yields of primary amines in hydrochloric and sulfuric acid solutions. 31 refs.

Antonova, T.L. (D.I. Mendeleev Chemical Engineering Inst, Moscow, USSR); Ivanovskaya, L.N.; Fioshin, M.Ya.; Savushkina, N.N. *Sov Electrochem* v 23 n 5 May 1987 p 560-566.

**075116 ELECTRODE REACTIONS OF FORMYL RADICALS ADSORBED ON MERCURY.** Laser-pulse electron photoemission was used to measure the rate constants for oxidation ( $W_2$ ) and reduction ( $W_3$ ) of formyl radicals  $HC(OH)_2$  which are formed upon capture of solvated electrons by formic acid and then become adsorbed on the mercury electrode. The transfer coefficients characterizing the dependence of  $W_2$  and  $W_3$  on electrode potential are 0.45 and 0.27, respectively (determined to ±0.05). The results are compared with the energy changes involved in the one-electron steps of the reduction of formic acid to formaldehyde where  $HC(OH)_2$  is an intermediate. (Edited author abstract) 16 refs.

Benderskii, V.A. (Acad of Sciences of the USSR, Moscow, USSR); Krivenko, A.G.; Kurmaz, V.A. *Sov Electrochem* v 23 n 5 May 1987 p 577-583.

**075117 ELECTROCHEMICAL REDUCTION OF 7,7-DICHLORONORCARANE AT COPPER, PYROLYTIC GRAPHITE, AND LEAD IN DIGLYME AND DIGLYME-ETHANOL MIXTURES.** Preparative electrolysis of DCNC 7,7-dichloronorcarane at mercury in diglyme or diglyme-ethanol mixture yields hydrocarbon. An investigation was conducted to determine whether DCNC can be reduced electrochemically in diglyme and diglyme-ethanol mixtures at cathodes made of other materials. Electrodes of copper ('specially pure' grade), pyrolytic graphite (MPG-6, of 'specially pure 6-4' grade) and lead (99.999%) were used as the cathodes. Electrolysis in a solution of 75% diglyme and 25% ethanol (by volume)



with 0.1 M (C<sub>4</sub>H<sub>9</sub>)<sub>4</sub>NBF<sub>4</sub> as the base electrolyte, at copper, pyrolytic graphite and lead only yields CNC, (7-chloronorcaradiene), which is produced by detachment of one chlorine atom (only traces of the hydrocarbon were detected). Here the current yields were only 1-2%. This result is in harmony with the data concerning the influence of added ethanol on the background currents under the conditions studied. 7 refs.

Girina, G.P. (Acad of Sciences of the USSR, Moscow, USSR); Kokorekina, V.A.; Feoktistov, L.G.; Alpatova, N.M. *Sov Electrochem* v 23 n 5 May 1987 p 656-658.

**075118 KINETICS AND MECHANISM OF REDUCTION OF 4p-DIMETHYLAMINO-BENZYLIDENE-3-METHYL-1-PHENYL-2-PYRAZOLIN-5-ONE BY BISULPHITE IONS IN AQUEOUS ETHANOLIC MEDIA.** The kinetics of the reduction has been studied in aqueous ethanolic media spectrophotometrically. The effect of hydrogen ion concentration on the reduction rate was investigated in a buffer solution at constant ionic strength of 1.0. The reaction was found to be first order in both of the reactants and inverse first order with respect to the hydrogen ion. The rate of reaction decreased with increasing ethanol as well as hydrogen ion concentrations. Pseudo-first-order rate constant,  $k_{obs}$ , was obtained by monitoring the disappearance of the dye. The activation parameters have been evaluated and a tentative reaction mechanism is discussed. (Edited author abstract) 14 refs.

Girgis, M.M. (Assiut Univ, Assiut, Egypt); Hassan, R.M.; Khalil, Z.H. *Indian J Technol* v 25 n 7 Jul 1987 p 334-338.

**075119 KINETICS OF ANTHRAQUINONE REDUCTION WITH SODIUM DITHIONITE IN ALKALINE MEDIUM.** The aim of this work is to study the heterogeneous solid-liquid reaction kinetics between AQ and sodium dithionite in an alkaline medium. The dithionite was chosen because of its high reduction power at low temperatures. Runs with different size particles of AQ and sodium dithionite/hydroxide mixtures of several strengths were carried out in a stirred batch reactor under atmospheric pressure and temperatures ranging from 303 to 323 K. The analysis of the results was made according to an isothermal SCM for spherical particles with no ash layer formation. It was shown that the influence of sodium dithionite concentration over the process rate agreed well with that predicted by the proposed model in the range studied. The average solid particle size effect is in agreement with the model only in the 22-50  $\mu$ m particle radius interval. 22 refs.

Burillo, J.C. (Univ Complutense, Madrid, Spain); Rodriguez, Francisco; Adrados, L.F.; Tijero, J.F. *AIChE J* v 34 n 5 May 1988 p 865-869.

**075120 REACTION ENTROPY FOR THE ELECTROREDUCTION OF AROMATIC AZO COMPOUNDS IN ACETONITRILE.** The reaction entropy for the one-electron reduction of azobenzene, naphthalene-1-azobenzene, 1,1'-azonaphthalene and 2,2'-azonaphthalene has been measured using a non-isothermal cell. Effects of the reactant size and the spin density at nitrogen atom of a radical anion are discussed. For spherical transition-metal redox couples it was found that reaction entropies depend on the difference in squares of charge numbers of both redox species and on the reciprocal of a reactant radius estimated on the basis of molecular models. (Edited author abstract) 13 refs.

Jaworski, Jan S. (Univ of Warsaw, Warsaw, Pol). *Electrochim Acta* v 33 n 5 May 1988 p 717-718.

**075121 PHOTOREDUCTION OF ALKYL VIOLOGENS AND POLYVIOLOGENS IN 2-PROPANOL AQUEOUS SOLUTION.** In order to study the effect of alkyl chain length and the polymer effect on the photoreduction behavior of some viologens, a series of alkyl viologen, polyviologen and bisviologen compounds have been synthesized. In the presence of excess 2-propanol, the initial photoreduction of alkyl viologens and polyviologens follow the pseudo-second-order reaction, the calcu-

lated rate constants are related to the alkyl chain length. In addition, the intramolecular association of radical cations of polyviologens has been found even in dilute solution. However the extent of association is varied with the alkyl chain length. The observed polymer effect of polyviologens in the photoreduction is significant which can be explained in terms of the nature of second order reaction. (Author abstract) 8 refs.

Liang, Zhaoxi (Zhongshan Univ, Guangzhou, China); Li, Wen; Li, Manfu. *Chin J Polym Sci (Engl Ed)* v 5 n 3 1987 p 254-260.

**Removal** See Also REFUSE DISPOSAL—Leachate Treatment; SEWAGE TREATMENT—Adsorption; SEWAGE TREATMENT—Aeration; SEWAGE TREATMENT—Biological Treatment; SEWAGE TREATMENT—Stabilization Ponds; WASTEWATER—Biological Treatment; WATER TREATMENT; WATER TREATMENT—Costs.

**075122 INFLUENCE OF SURFACTANTS ON REMOVAL OF TRIBUTYL PHOSPHATE FROM AQUEOUS SOLUTIONS BY FLOTATION.** The authors have examined the possibility of removal of molecularly dissolved TBP by flotation in the presence of surfactants. It is found that wastewaters containing TBP may differ in pH and may contain surfactants of different classes. If surfactants are already present in the wastes, their TBP content may be lowered significantly by selection of pH in accordance with the results of this investigation, followed by purification using the flotation method. In the absence of surfactants in the wastewaters, the TBP content can be lowered by addition of an appropriate surfactant (in accordance with the pH), followed by flotation treatment. 4 refs.

Brayalovskii, B.S. (Moscow Physical-Engineering Inst, USSR); Lutoshkin, S.A.; Kovalev, N.V. *J Appl Chem USSR* v 60 n 1 pt 2 Jan 1987 p 195-196.

**075123 CATALYTIC OXIDATION OF GROUNDWATER STRIPPING EMISSIONS.** Air stripping has been shown to be an efficient and cost effective method of removing volatile organic contaminants from groundwater and soil. Unfortunately, these contaminants are transferred to the air where they may continue to pose an environmental and health threat. Vapor phase carbon adsorption and thermal incineration are the two treatment methods which have been applied most often, but these technologies have some disadvantages. A new alternative is appearing in the form of catalytic oxidation. Like thermal incineration, it is an ultimate disposal method, but since it operates at much lower temperatures, the energy costs are also lower. This paper reviews the applicability of catalytic oxidation to control groundwater air stripping gaseous effluents with special attention given to system designs and case histories. The variety of contaminants and catalyst poisons encountered in stripping operations are also reviewed. (Edited author abstract) 14 refs.

Kosusko, Michael (US EPA, Research Triangle Park, NC, USA). *Environ Prog* v 7 n 2 May 1988 p 136-142.

**075124 REMOVAL OF REFRACTORY ORGANICS BY AERATION. VII. AIR STRIPPING OF BENZENE DERIVATIVES.** The removal of several benzene derivatives from water was carried out by bubble column aeration. The presence of NaCl enhanced removal rates, while the presence of alcohols decreased them. Mixtures of two hydrophobic solutes are removed by aeration as if each were present alone. The use of the equilibrium assumption for mass transport between phases seems to be reasonably (but not perfectly) satisfactory. Henry's law constants calculated from aeration data are in fairly good agreement with those calculated from vapor pressure and solubility data. Toluene, ethylbenzene, p-xylene, chlorobenzene, p-dichlorobenzene, styrene, benzene, and 3-pentanone were studied. As predicted, the ketone is not removed by aeration at a significant rate. Removal rates of the other compounds are reasonably rapid, with Henry's law constants in the range of roughly 0.1 to 0.3 (dimensionless). (Author abstract) 26 refs.

Harkins, Bonnie (Vanderbilt Univ, Nashville, TN, USA);

Boehm, Tom L.; Wilson, David J. *Sep Sci Technol* v 23 n 1-3 1988 p 91-104.

**Research** See Also MONOMERS—Research.

**075125 GAS-PHASE PHOTOINDUCED NUCLEATION OF OCTAORGANYL SILSESQUIOXANES.** We have investigated the nucleation of octaorganyl silsesquioxanes induced by UV light. In order to create the conditions for the formation of nuclei, we have applied a technique based on mutual heat exchange processes and diffusion of laminar flows of vapor at different temperatures. We have established the multiphoton character of the photonucleation process. We have isolated the region of the UV spectrum responsible for induction of nucleation. We propose ionic and radical mechanisms for photonucleation. We give an estimate of the effective size of the photoinduced condensation nuclei. (Author abstract) 25 refs.

Mikheev, V.B. (Acad of Sciences of the USSR, Novosibirsk, USSR); Kostrovskii, V.G.; Nadolinnii, V.A.; Moralev, V.M.; Kovrigin, V.M. *Colloid J USSR* v 49 n 1 Jan-Feb 1987 p 146-151.

**075126 EFFECT OF LIPOSOMIZATION ON REACTION CHARACTERISTICS OF PROSTAGLANDIN SYNTHETASE.** In this work the effect of liposomization of PG-synthetase derived from sheep seminal vesicular glands on the rate of prostaglandin E<sub>2</sub> (PGE<sub>2</sub>) biosynthesis was studied. It is found that the rates of PGE<sub>2</sub> synthesis showed no appreciable change in a pH range from 7.5 to 8.5, and proceeded to a plateau above a sodium arachidonate concentration of 0.5 mg/cm<sup>3</sup> for the cases of both free and liposomized enzyme. Therefore, in these experiments, the rates were measured at pH 8.0 and 1 mg/cm<sup>3</sup> of sodium arachidonate as the optimal conditions. 5 refs.

Sada, Eizo (Kyoto Univ, Kyoto, Jpn); Katoh, Shigeo; Terashima, Masaaki; Kheirulomoom, Azadeh; Sawai, Hiroyuki. *J Chem Eng Jpn* v 20 n 5 Oct 1987 p 531-533.

**075127 QUENCHING OF THE FLUORESCENCE OF ORGANIC LUMINOPHORES BY OXYGEN IN THIN POLYMER FILMS.** The anomalously high quenching of the luminescence of 9,10-bis-(phenylethynyl)-anthracene in thin films of PMMA by oxygen at pressures 0-25 atm is due to the structural inhomogeneity of the objects and the migration of the energy of electron excitation over the molecules of the luminophore. The apparatus of the theory of non-radiation energy transfer is used for the quantitative evaluation of the local mobility of oxygen in the regions of the polymer closest to the luminophore. Comparison of the local and volume-average diffusion coefficients of oxygen determined from experiments on the quenching of fluorescence may be an effective express method for structural investigations of polymer films. (Author abstract) 12 refs.

Lashkov, G.I. (Vavilov State Optical Inst, USSR); Kavret, A.F. *Polym Sci USSR* v 28 n 8 1986 p 1885-1891.

**075128 CYCLIC VOLTAMMETRIC STUDIES ON SOME MULTICENTRE BIPYRIDILUM COMPOUNDS.** Cyclic voltammograms of some multicentre bipyridilum compounds were recorded and analyzed. From the electrochemical data various disproportionation constants and interaction energies are calculated. For all the compounds studied two cathodic and two anodic waves were obtained. Cyclic voltammetric data for specific compounds 1-IV (fig. 1) and the two alkyl viologens are collected. These data refer to acetonitrile with tetrabutylammonium perchlorate as supporting electrolyte. These data can be analyzed with regard to (a) electron transfer to multiple non interacting system (b) electron transfer to interacting system (c) disproportionation constants and (d) the interaction energies between various redox centres. (Edited author abstract) 13 refs.

Mohammad, M. (Quaid-i-Azam, Islamabad, Pak). *Electrochim Acta* v 33 n 3 Mar 1988 p 417-419.



**075129**  $^{19}\text{F}$  N.M.R. STUDY OF GRAPHITE FLUOROSULFATES. Graphite fluorosulfates,  $\text{C}_6\text{SO}_3\text{F}$ , with  $n=7$  for stage-one materials, are ideally suited for  $^{19}\text{F}$  n.m.r. studies due to the unambiguous identity of the intercalate and its axially symmetric nature. The intensity of the signal shows a clear dependence on the orientation of the  $c$  axis with respect to the oscillating radio-frequency field  $H_1$ . The chemical shift value, however, is affected by the orientation of the  $c$  axis with respect to  $H_0$ . The powder spectrum of the stage-one material  $\text{C}_6\text{SO}_3\text{F}$  extends from 10 to 100 ppm at low temperatures, while motional narrowing at room temperature contributes to a sharp signal at the lower field end of the powder spectrum, corresponding to an axially symmetric chemical shift tensor. Angular dependence studies on  $\text{C}_7\text{SO}_3 + \text{D}_2\text{O}$  samples made from HOPG indicate that the majority of the intercalated  $\text{SO}_3\text{F}^-$  ions are oriented with their molecular  $\text{C}_3$  symmetry axis parallel to the  $c$  axis of graphite, or normal to  $H_0$ . Multi-staged samples made from HOPG demonstrate the stage dependence of the chemical shift of intercalated  $\text{SO}_3\text{F}^-$  ions. The chemical shift of the stage-one material is observed in the region of 10–12 ppm, while higher-staged materials show resonances at less shielded regions. (Author abstract) 15 refs.

Karunaniy, S. (Univ of British Columbia, Vancouver, BC, Can); Willis, J.M.; Aubke, F. *Synth Met* v 24 n 4 Jun 1988 p 379-389.

**075130** INTERCALATION AND PARTIAL DEINTERCALATION OF TETRAHYDROFURAN IN  $\text{CsC}_{24}$ : A NEUTRON POWDER DIFFRACTION STUDY. Real time neutron powder diffraction has been used to study the intercalation of tetrahydrofuran (THF) in the second stage caesium graphite intercalated compound  $\text{CsC}_{24}$ . According to the Daumas-Herold's model, the reaction proceeds as follows: first, THF intercalates in the binary leading to a second stage ternary; second, the THF concentration increases up to  $\text{Cs}(\text{THF})_{1.75}\text{C}_{24}$  as simultaneously the compound becomes first stage. Deintercalation leads to the 2nd stage  $\text{Cs}(\text{THF})_{\approx 1}\text{C}_{24}$ . In both cases, the  $I_c$  parameter indicates THF molecules lying parallel to the graphene plane. Diffraction patterns show that the intercalated layer is liquid in the 1st stage  $\text{Cs}(\text{THF})_{1.75}\text{C}_{24}$  at room temperature but solid and structured in the 2nd stage  $\text{Cs}(\text{THF})_{\approx 1}\text{C}_{24}$  due to higher constraints. This agrees well with steric considerations using the molecular volume of THF. (Edited author abstract) 9 refs.

Goldmann, M. (ILL, Grenoble, Fr); Pannetier, J.; Beguin, F.; Gonzalez, B. *Synth Met* v 23 n 1-4 Mar 1988, Graphite Intercalation Compd, Proc of the Fourth Int Symp, Jerusalem, Isr, May 24-29 1987 p 133-138.

**Rheology** See HYDROCARBONS—Structure.

## Sampling

**075131** DESIGN AND OPERATION OF A VOLATILE ORGANIC COMPOUND CANISTER SAMPLER. This paper discusses the operation of a Volatile Organic Compound Canister Sampler (VOCCS) for collection of trace level volatile organic compounds in the ambient air. Volatile organic compound sampler design and operation was reviewed. Historically, collection of volatile organic compounds has been done by integrated sample bag collection or collection on chromatographic resins, both of which are a matter of great uncertainty. A new sampler and procedure was developed for collection of volatile organic compounds and the accuracy with which volatile organic compounds can be determined is being studied. 1 ref.

Merrifield, T.M. (Andersen Samplers Inc, Atlanta, GA, USA). *J Aerosol Sci* v 18 n 6 Dec 1987, Aerosols in Sci, Med and Technol with Spec Emphasis on Urban and Environ Air Pollut, Hanover, West Ger, Sep 9-11 1987 p 881-883.

**Separation** See Also ARSENIC—Recovery; CHROMATOGRAPHIC ANALYSIS—Liquid; COAL TAR—Processing; DISTILLATION EQUIPMENT—Research; MIXTURES—Azeotrope; ORGANIC COMPOUNDS—Chromatographic Analysis.

**075132** AUTOMATED EQUILIBRIA SYSTEM FOR MODELING LIQUID-VAPOR SEPARATION PROCESSES. The automated EQUILIBRIA system, designed for modeling systems for separation of non-ideal mixtures of organic and some basic inorganic substances ( $\text{H}_2$ ,  $\text{H}_2\text{O}$ ,  $\text{SO}_2$ ,  $\text{NH}_3$ ,  $\text{N}_2$ ,  $\text{CO}_2$ , etc.) in very wide ranges of changes in the temperature and pressure, including the regions close to (or above) the critical region, is examined. EQUILIBRIA is written in Fortran and runs in the dialog mode. It can be used as a functional part of programs for modeling or designing CES or as a totally independent system. The flow duct of the data macrostructure of the EQUILIBRIA system is presented. It consists of four types of interacting program units (combining more than 100 separate program units): modeling, executing, auxiliary, and mathematical. We will briefly examine the structure, organization, and purpose of each of them. The 'modeling' unit has two hierarchical levels. The first includes the program realizations of the basic separation processes: isothermal evaporation, multicomponent distillation, and absorption: IFLASH, SHTCUT, ABSMD. 12 refs.

Bancheva, I.V.; Stateva, R.; Boyadzhiev, Khr. *J Appl Chem USSR* v 59 n 9 pt 1 Sep 1986 p 1776-1781.

**075133** INVESTIGATION OF TWO HOMOLOGOUS SERIES OF CARBOXYLIC ACIDS IN BLACK TRONA WATER FROM THE GREEN RIVER BASIN. Two series of carboxylic acids were identified in the dialysate from a sample of Black Trona Water from the Green River Basin of Wyoming. One of the series consists of straight-chain dicarboxylic acids ranging in carbon number from four to fourteen. This series had been observed by previous workers. The other series, much less abundant than the dicarboxylic acids, appears to be a series of homologous tricarboxylic acids that are derivatives of succinic acid. The structures of these compounds were determined by analysis of the mass spectra of their methyl esters and trideuteromethyl esters. (Edited author abstract) 16 refs.

Branthaver, J.F. (Western Research Inst, Laramie, WY, USA); Thomas, K.P.; Logan, Eugenia R.; Barden, R.E. *Fuel Sci Technol Int* v 6 n 5 Oct 1988 p 525-539.

**075134** ADMICELLAR CHROMATOGRAPHY: SEPARATION AND CONCENTRATION OF ISOMERS USING TWO-DIMENSIONAL SOLVENTS. Immobilized surfactant aggregates at a solid/liquid interface can act as two-dimensional solvents to increase the interfacial concentrations of organic compounds selectively. This phenomenon is the basis for a new separation process presented here, admicellar chromatography. The technique offers certain advantages over conventional chromatographic separations. Batch and column separations of isomers of heptanol are used to illustrate the concepts of the process. Equilibrium calculations with single component data are found to give reasonable predictions for the batch separation of the isomers. (Author abstract). 18 Refs.

Barton, J.W. (Univ of Oklahoma, Norman, OK, USA); Fitzgerald, T.P.; Lee, C.; O'Rear, E.A.; Harwell, J.H. *Sep Sci Technol* v 23 n 6-7 1988 p 637-660.

## Soldering

**075135** ORGANIC SOLDER. A new type of organic-based conductive product to replace metallic solders and eliminate much of their accompanying processes is presented. Conventional metal materials are being replaced more and more with lower cost, lighter weight, more with lower cost, lighter weight, more versatile and easier-to-use polymer-based materials. Thermoplastic-based materials are used where the thermal characteristics of the final product would more closely duplicate those of metallic solder.

King, Harry A. (Emerson & Cuming Inc, Lexington, MA, USA). *Circuits Manuf* v 27 n 11 Nov 1987 p 33, 35-36.

**Solubility** See Also ALUMINUM COMPOUNDS—Adsorption; CRYSTALS, LIQUID—Solubility; MIXTURES; PARAFFINS—Solubility.

**075136** SOLUBILITY IN BINARY MIXTURES AT THE IMMISCIBILITY CRITICAL POINT. It is shown that solubility of organic solids in binary mixtures of partially miscible liquids is singular at the immiscibility critical point. The theoretically predicted maximum of solubility in the vicinity of the critical point is found experimentally. The effect is similar to the phenomenon observed near the gas-liquid critical point. The similarity of these two critical phenomena may have interesting technical applications and may provide guidelines for identifying promising new solvents for separation processes. (Author abstract) 18 refs.

Ludmer, Z. (City Coll of CUNY, New York, NY, USA); Shinnar, R.; Yalkot, V. *AIChE J* v 33 n 11 Nov 1987 p 1776-1780.

**075137** INTENSIFICATION OF HETEROGENEOUS REACTIONS THROUGH HYDROTROPY: ALKALINE HYDROLYSIS OF ESTERS AND OXIMATION OF CYCLODODECANONE. Hydrotropic substances are capable of increasing the solubility of sparingly soluble organic compounds in aqueous solutions and can thus enhance the rates of two-phase reactions substantially. The increase in the solubility of sparingly soluble organic substances due to hydrotropes has been found to be an exponential function of the hydrotrope concentration over a wide range. A study of the rates of solid-liquid and liquid-liquid alkaline hydrolysis of esters and solid-liquid oximation of cyclododecanone, in the presence of different hydrotropes, was carried out. The potassium salts of different hydrotropes, such as, butyl monoglycol sulfonate, p-cumyl phenol, cumene sulfonic acid were found to be more effective than the corresponding sodium salts. In some cases intensification factors as high as 1000 were observed. (Author abstract) 23 refs.

Pandit, A. (Univ of Bombay, Matunga, India); Sharma, M.M. *Chem Eng Sci* v 42 n 11 1987 p 2517-2523.

**075138** SOLUBILIZATION OF ANTHRAQUINONE DERIVATIVES IN SOLUTIONS OF NON-IONOGENIC SURFACTANTS. A study has been made of the solubilization of anthraquinone,  $\alpha$ -aminoanthraquinone, and 1,4-diaminoanthraquinone in solutions of the nonionogenic surfactant Sintanol DS-10 at various concentrations. It is shown that the solubilization increases with increasing polarity of the molecules of the solubilize. The relative increase of the micellar volume with the inclusion of molecules of the solubilize within the micelle has been demonstrated viscometrically. (Author abstract) 5 refs.

Kovtun, L.G. (Textile Inst, Moscow, USSR); Korchagin, M.V.; Lazareva, N.V. *Colloid J USSR* v 49 n 4 Jul-Aug 1987 p 679-681.

**075139** SOLUBILIZATION OF n-HEXANOL IN MIXED MICELLES. The solubilization of n-hexanol by mixed anionic/nonionic and cationic/nonionic micelles was measured throughout a wide range of hexanol activities. The solubilization equilibrium constant for both kinds of mixed micelles is less than that predicted by assuming that the equilibrium constant varies linearly with nonionic/total surfactant mole ratio in the micelle. This effect is more pronounced for the anionic/nonionic mixture than for the cationic/nonionic mixture. The results are attributed to the decrease in micellar surface charge density upon insertion of nonionic surfactant in the micelle. This results in a decrease in ion-dipole attractive forces between the ionic surfactant hydrophilic group and the alcohol hydroxyl group. (Author abstract) 33 refs.

Nguyen, Cuong M. (Univ of Oklahoma, Norman, OK, USA); Scamehorn, John F.; Christian, Sherril D. *Colloids Surf* v 30 n 3-4 Apr 1988 p 335-344.



**075140 SOLUBILITIES OF FIFTEEN ORGANIC SUBSTANCES IN POLY(VINYL CHLORIDE), POLY(VINYL ACETATE), AND VINYL CHLORIDE-VINYL ACETATE COPOLYMER.** The solubilities of 15 organic solvents (benzene, fluorobenzene, ethylbenzene, chlorobenzene, toluene, p-xylene, vinyl acetate, styrene, acrylonitrile, carbon tetrachloride, chloroform, acetone, methyl ethyl ketone, n-nonane, and n-decane) in poly(vinyl acetate) [100 - 200°C], poly(vinyl chloride) [115 - 150°C] and vinyl chloride(90%)-vinyl acetate(10%) copolymer [115 - 150°C] were measured at atmospheric pressure by using a gas chromatographic technique. For these systems, Henry's constants are reported on a mass fraction basis. Bonner's equation was applied at infinite dilution and the binary interaction parameters of each homopolymer were determined from the experimental results. Furthermore, it was found that the interaction parameters for copolymer could be represented by the average segment fraction of each homopolymer parameter. (Edited author abstract) 8 refs. In Japanese.

Sato, Yoshio (Hachinohe Natl Coll of Technology, Hachinohe, Jpn); Inomata, Hiroshi; Arai, Kunio. *Kobunshi Ronbunshu* v 45 n 3 Mar 1988 p 287-289.

**Solutions** See Also ACIDS—Isomerization; CARBON DIOXIDE—Absorption; CATALYSIS; CLAY—Shrinkage; ELECTRODES—Palladium; IRON AND ALLOYS—Chemical Reactions.

**075141 POLAROGRAPHIC CATALYTIC HYDROGEN WAVES IN LUPININE SOLUTIONS; DETERMINATION OF THE ADSORPTION CHARACTERISTICS OF LUPININE AT THE MERCURY ELECTRODE.** In an effort to find new catalysts or inductors the authors looked at lupinine, the molecules of which have a quinolizidine nucleus (the pachycarpine molecule can be regarded as consisting of two similar, fused nuclei) with a hydroxymethyl group in the 1-position. In lupinine solutions, catalytic hydrogen waves can only be observed over the pH range from 7.5 to 10 in borate buffer solutions. When small amounts of lupinine are added to more acidic borate buffer solutions or to acetate solutions the polarograms are shifted appreciably (by some 60 mV) past the base curve, i.e., discharge of the base electrolyte occurs at more negative potentials. In borate solutions of pH 7.5 to 10.0 one can see distinct catalytic hydrogen waves. It is pointed out above that in alkaline solutions one cannot observe catalytic waves, but desorption steps are distinctly noticeable under these conditions in the curves of the changing currents in lupinine solutions. 12 refs.

Mairanovskii, S.G. (Acad of Sciences of the USSR, Moscow, USSR); Seilova, K.S.; Alashev, F.D.; Zhurinov, M.Zh. *Sov Electrochem* v 23 n 2 Feb 1987 p 254-257.

**075142 FEATURES OF ULTRAFILTRATION SEPARATION OF SOLUTIONS OF ORGANIC SUBSTANCES.** The features of ultrafiltration separation of 1% aqueous solutions of polyoxyethylene of varying molecular weight (1000, 3000, 15,000 and 40,000), saccharose, and urea through UAM-500, UAM-300, UAM-150, and UAM-100 acetylcellulose membranes when the working pressure was varied within the limits of 200-3000 kPa were experimentally investigated. (Edited author abstract) 10 refs.

Tsapyuk, E.A. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Bryk, M.T. *Colloid J USSR* v 49 n 2 Mar-Apr 1987 p 349-353.

**075143 TRIPLET-STATE KINETICS OF 2,5-DIPHENYLOXAZOLE (PPO).** Time-resolved excited-state triplet-triplet absorption spectra were measured for solutions of 2,5 diphenyloxazole (PPO) in various solvents, with the use of a pump and probe technique. The rate constants for intersystem crossing, triplet deactivation by oxygen, and triplet-triplet self-quenching are obtained. The latter two rate constants are substantially larger than the corresponding rate constants for 2-(1-naphthyl)-5-phenyloxazole- $\alpha$ -NPO. (Author abstract) 10 refs.

Dharamsi, A.N. (Old Dominion Univ, Norfolk, VA, USA); Jong, Shawpin. *Appl Spectrosc* v 42 n 1 Jan 1988 p 27-31.

## Solvent Extraction

**075144 FATE OF INTERFACIAL ADSORBATES IN SOLVENT EXTRACTION SYSTEMS.** The recent introduction of the microporous Teflon phase separator (MTPS) in the study of solvent extraction processes has had a positive significant impact on increased understanding of such separations. Adsorbed extractants are quantitatively stripped from a liquid-liquid interface when the organic phase is removed from a rapidly stirring two-phase mixture through a microporous Teflon phase separator. A method is described which enables the determination of interfacial excess from more dilute solutions than was possible heretofore. (Edited author abstract) 8 refs.

Chamupati, V.G. (Univ of Arizona, Tucson, AZ, USA); Freiser, H. *Langmuir* v 4 n 1 Jan-Feb 1988 p 49-51.

**Sorption** See Also CLAY—Ion Exchange; WASTEWATER—Treatment.

**075145 SORPTION OF 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN TO SOILS FROM WATER/METHANOL MIXTURES.** Sorption of  $^{14}$ C-labeled 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) to soils from water/methanol mixtures has been evaluated by batch shake testing. Uncontaminated soils from Times Beach, MO, were used in these experiments and ranged in fraction organic carbon ( $f_{oc}$ ) from 0.0066 to 0.077. Volume fraction methanol in the liquid phase ( $f_L$ ) was varied between 0.25 and 1.0. Contact times ranging from 1 to 90 days were employed. Sorption kinetics were influenced by soil type and  $f_L$ . Sorption isotherms were linear, and when sorption partition coefficients ( $K_D$ , mL/g) were converted to  $K_m$  (mol/g), these latter values were log-linearly related to  $f_L$ . Study results are discussed. (Edited author abstract) 21 refs.

Walters, Richard W. (Univ of Maryland, Philadelphia, PA, USA); Guiseppe-Elle, Annette. *Environ Sci Technol* v 22 n 7 Jul 1988 p 819-825.

**Specific Heat** See Also FERTILIZERS—Thermal Properties.

**075146 CALORIMETRIC STUDY OF PURE AND KOH-DOPED TETRAHYDROFURAN CLATHRATE HYDRATE.** The heat capacity of pure tetrahydrofuran (THF) clathrate hydrate was measured by an adiabatic calorimeter in the temperature range of 12-300 K. A glass transition having a heat capacity jump of 1.1 J K $^{-1}$  (H $_2$ O-mol) $^{-1}$  was newly observed at 85 K. Combined with previous dielectric data, this was shown to be related to proton configurational motion in the host hydrogen-bonded lattice. The experimental heat capacity of KOH-doped THF-hydrate previously reported in the was converted to the molar one of the hydrate by measuring its eutectic melting and making appropriate correction for unreacted ice and THF. Comparison of the heat capacities and entropies of the pure and KOH-doped samples gave new information on the mechanism of the transition observed in the KOH-doped sample. (Author abstract) 29 refs.

Yamamuro, O. (Osaka Univ, Toyonaka, Jpn); Oguni, M.; Matsuo, T.; Suga, H. *J Phys Chem Solids* v 49 n 4 1988 p 425-434.

**Spectroscopic Analysis** See Also AMINO ACIDS—Chromatographic Analysis; AMINO ACIDS—Spectroscopic Analysis; BIOLOGICAL MATERIALS—Chromatographic Analysis; COAL—Pyrolysis; DRUG PRODUCTS—Antibiotics; DRUG PRODUCTS—Spectroscopic Analysis; ETHERS—Chromatographic Analysis; FLUORESCENCE; IONS—Spectroscopic Analysis; PETROLEUM PRODUCTS—Desulfurization; PROTEINS—Research; SPECTROSCOPY, RAMAN—Laser Applications; WATER ANALYSIS—Spectroscopic Analysis.

**075147 EXAMINATION OF THE MATRIX ISOLATION FOURIER TRANSFORM INFRARED**

**SPECTRA OF ORGANIC COMPOUNDS: PART II.** Matrix-isolated (MI) Fourier transform infrared spectra have been collected on a series of aliphatic ketones. The values for the carbonyl absorptions maxima are intermediate between vapor-phase (VP) and solid-state solution (SS) phases. The data reveal a stereochemical influence on the position of the ketone carbonyl absorption when the carbons that are in the alpha position with respect to the carbonyl group contain alkyl substituents vs. protons. Steric bulk causes the frequency of the absorption to decrease. The position of the ketone carbonyl absorption was also shown to decrease as the carbonyl group migrated toward the center of a long straight-chain hydrocarbon backbone. (Edited author abstract) 15 refs.

Coleman, W.M. III (R.J. Reynolds Tobacco Co, Winston-Salem, NC, USA); Gordon, Bert M. *Appl Spectrosc* v 41 n 7 Sep-Oct 1987 p 1159-1162.

**075148 EXAMINATION OF THE MATRIX ISOLATION FOURIER TRANSFORM INFRARED SPECTRA OF ORGANIC COMPOUNDS: PART III.** Matrix-isolated (MI) Fourier transform infrared spectra (FT-IR) have been collected on a series of esters and ketones. The values for the carbonyl absorption are intermediate between the values for vapor-phase (VP) and solid-state (SS) phases. The spectra reveal a splitting or broadening of the carbonyl absorption in the majority of cases for both compound types. The splitting, on the order of 5 to 10 cm $^{-1}$ , does not appear to be a function of concentration at  $\leq 20$  ng on the cryogenic disk. The splitting is also not unequivocally due to steric hindrance about the carbonyl group. (Edited author abstract) 14 refs.

Coleman, W.M. (R.J. Reynolds Tobacco Co, Winston-Salem, NC, USA); Gordon, Bert M. *Appl Spectrosc* v 41 n 7 Sep-Oct 1987 p 1163-1169.

**075149 DETERMINATION OF METHYLENE GROUPS IN OXYGEN-CONTAINING COMPOUNDS BY IR SPECTROSCOPY.** The methylene groups of saturated hydrocarbons are represented in the infrared spectrum by the absorption bands of swinging vibrations in the region 780-720 cm $^{-1}$ , the intensity of which is proportional to the content of these groups. This region is used for the quantitative determination of -CH $_2$ - in open chains of different lengths. It was considered of interest to determine the content of CH $_2$ -groups in  $\alpha$ -oxides, alcohols, and acid esters, since such data have not been found in the literature. The present work used methyl ester of stearic acid, C $_{12}$  and C $_{14}$  monoxides, and C $_{13}$  and C $_{14}$  alcohols, for which the specific extinction coefficients were obtained. 3 refs.

Danilova, A.S. (Yaroslavl Polytechnical Inst, USSR); Yulina, V.I.; Kyukova, G.G. *Ind Lab (USSR)* v 53 n 2 Feb 1987 p 151-152.

**075150 ELECTRON SPIN RESONANCE AND POLARISATION REVERSAL ON ELECTROTHERMALLY ANNEALED X-RAY IRRADIATED TGS.** The polarization reversal of electrothermally annealed x-ray irradiated TGS crystals is studied. After annealing the switching times are shorter and the asymmetry of the switching behavior relative to the direction of the switching field becomes more pronounced. Electron spin resonance measurements show that electrothermal annealing causes a marked amplification of the recombination of the NH $_3$ CHCOOH radical. On the basis of the experimental results the microscopic mechanism of electrothermal annealing is discussed. (Author abstract) 17 refs.

Schlemmbach, H. (Karl-Marx-Univ, Leipzig, East Ger); Volk, T.R.; Windsch, W.; Moebius, M.; Shuvalov, L.A. *J Phys D* v 20 n 10 Oct 14 1987 p 1297-1301.

**075151 SPECTROSCOPY OF ACID-BASE INTERACTION OF SUBSTITUTED TETRAAZAPORPHIN DERIVATIVES IN NONAQUEOUS MEDIA.** We used the method of electronic spectroscopy to study the influence of the functional substitution in H $_2$ TAP on its



properties as a base. Analysis of the present data and the published data shows that for such complex conjugated multicenter bases as tetraazaporphyrins, the influence of the substituent is not confined to simple quantitative changes. The possibility must be considered that the formation of each of the forms depends not only on the internal factors, i.e., the electronic structure of the molecule, but also on external factors, such as the composition and properties of the medium, playing an active role in acid-base interactions. 12 refs.

Berezin, B.D.; Khelevina, O.G.; Stuzhin, P.A. *J Appl Spectrosc* v 46 n 5 May 1987 p 510-515.

**075152 SPECTROSCOPIC INVESTIGATION OF INTERMOLECULAR INTERACTION IN THE N-METHYLPYRROLIDONE-WATER SYSTEM.** IR spectra were studied of the N-methylpyrrolidone (MP)-water and MP-CCl<sub>4</sub> two-component systems in the region of stretching vibrations of the MP C=O and water O-H. It was shown that a chemical compound of composition C<sub>5</sub>H<sub>9</sub>NO·2H<sub>2</sub>O is formed in the MP-water system. (Author abstract) 6 refs.

Afanasenko, L.D.; Yarym-Agaev, N.L.; Bilobrov, V.M. *Sov Prog Chem* v 53 n 2 1987 p 46-48.

**075153 FT-IR MICRO-SPECTROSCOPIC STUDIES OF SEVERAL CHARGE-TRANSFER ORGANIC ELECTRICAL CONDUCTORS.** A series of infrared reflectance measurements using FT-IR Micro methods were conducted on bis(ethylenedithio)tetrathiafulvalene (ET') and bispropylenedithio)tetrathiafulvalene (PT') salts. The technique is useful for characterizing, at room temperature, differences between  $\beta$ -,  $\beta'$ - and  $\alpha'$ -type structures vs.  $\alpha$ -structures. The  $\beta$ -,  $\beta'$ -, and  $\alpha'$ -type structures show a vibrational feature at approximately 1280 cm<sup>-1</sup> which has been assigned as the -C-C-H bending vibrations and is absent in the spectrum of the  $\alpha$ -type salts. This vibration shifts toward higher frequency in going from the PT to the ET salts, and the results indicate stronger hydrogen bonding and harder lattices in the ET salts as opposed to the PT salts. (Edited author abstract) 38 refs.

Ferraro, John R. (Loyola Univ, Chicago, IL, USA); Wang, Hau H.; Ryan, John; Williams, Jack M. *Appl Spectrosc* v 41 n 8 Nov-Dec 1987 p 1377-1382.

**075154 EXAMINATIONS OF THE MATRIX ISOLATION FOURIER TRANSFORM INFRARED SPECTRA OF ORGANIC COMPOUNDS. PART V.** MI/FT-IR spectral data have been collected on selected types of organic compounds containing the carbonyl group. By the varying of the ratio of the matrix gas to the compound (M/E) as well as the matrix gas (Ar vs. Xe), the observed splitting of the carbonyl absorption band was attributed to both conformer isolation and aggregation in the matrix. The splitting of the carbonyl group of methyl acetate was attributed to aggregation, while conformer isolation was found to exist for phenyl acetate and trimethylacetaldehyde. (Edited author abstract) 28 refs.

Coleman, W.M. III (R.J. Reynolds Tobacco Co, Winston-Salem, NC, USA); Gordon, Bert M. *Appl Spectrosc* v 41 n 8 Nov-Dec 1987 p 1431-1438.

**075155 EXAMINATION OF THE MATRIX ISOLATION FOURIER TRANSFORM INFRARED SPECTRA OF ORGANIC COMPOUNDS: PART VI.** Matrix isolation Fourier transform spectral evidence is presented that documents the isolation of rotational isomers in an argon matrix. The spectral evidence is based on the presence of split carbonyl absorption bands in the spectra of selected derivatives of methyl acetate which do not vary in intensity with changes in the matrix-to-eluate ratios. The results compare very favorably with FT-IR data on the identical compounds obtained in the vapor phase. The low temperature of the matrix isolation experiment (10 K) allows for the observation of rotational isomers not seen at the high temperatures of the vapor-phase experiment (500 K). (Edited author abstract) 20 refs.

Coleman, W.M. III (R.J. Reynolds Tobacco Co, Winston-Salem, NC, USA); Gordon, Bert M. *Appl Spectrosc* v 42 n 1 Jan 1988 p 101-108.

**075156 EXAMINATION OF THE MATRIX ISOLATION FOURIER TRANSFORM INFRARED SPECTRA OF ORGANIC COMPOUNDS: PART VII.** A series of lactones and lactams have been examined by matrix isolation Fourier transform infrared spectrometry. The values for the carbonyl absorption bands fall between those reported for the same compounds in the vapor phase and solid state. Multiple absorption bands are found in the region of carbonyl absorption for compounds examined under the matrix isolation phase. Ring strain has a dramatic effect on simplifying the complexity of the spectra. Little or no aggregation effects are observed for either the lactones or lactams under accepted operating parameters. The effects of substituents on these systems are comparable to those found in the vapor-phase and solid-state data. (Author abstract) 19 refs.

Coleman, W.M. III (R.J. Reynolds Tobacco Co, Winston-Salem, NC, USA); Gordon, Bert M. *Appl Spectrosc* v 42 n 1 Jan 1988 p 108-113.

**075157 SPECTROFLUOROMETRIC DETERMINATION OF PESTICIDE RESIDUE MIXTURES BY ISODIFFERENTIAL DERIVATIVE SPECTROSCOPY.** A synchronous derivative spectrofluorometric method has been developed for quantitative residue determination of thiabendazole (TBZ) and 2-benzimidazol-2-ylcarbamic acid methyl ester (MBC) in various crops. This paper also reports the testing of a graphical model to measure derivative amplitudes which is based on the interference-free character of the isodifferential points in the derivative calibration graphs. (Edited author abstract) 20 refs.

Garcia Sanchez, F. (Malaga Univ, Malaga, Spain); Cruces Blanco, C. *Anal Chem* v 60 n 4 Feb 1988 p 323-328.

**075158 ELECTROCHEMICAL AND SPECTROSCOPIC STUDIES OF 1,4-BENZOQUINONE IN AMBIENT TEMPERATURE CHLOROALUMINATE IONIC LIQUIDS.** The chemical, electrochemical, and spectroscopic properties of 1, 4-benzoquinone (Q) have been studied in the aluminum chloride: 1-ethyl-3-methylimidazolium chloride (ImCl) ionic liquid. In basic melts (AlCl<sub>3</sub>:ImCl mole ratio <1.0), fast scan voltammetry (up to 1000 V s<sup>-1</sup>) shows that Q reduces to Q<sup>2-</sup> in a fast two-electron step, probably followed by solvation of the dianion. Infrared and visible spectroscopic data, and electrochemical measurements show that Q reacts with Cl<sup>-</sup> in basic melts producing the dianion of monochlorohydroquinone. Q shows no electrochemical response in acidic melts. However, it reacts with the solvent and eventually generates HCl which is electrochemically detected at a Pt electrode. (Edited author abstract) 15 refs.

Uribe, Francisco A. (State Univ of New York at Buffalo, Buffalo, NY, USA); Osteryoung, Robert A. *J Electrochem Soc* v 135 n 2 Feb 1988 p 378-381.

**075159 ANGULAR DEPENDENCE OF DIFFUSE REFLECTANCE INFRARED SPECTRA. PART III: LINEARITY OF KUBELKA-MUNK PLOTS.** The linearity of plots of the Kubelka-Munk function against concentration is investigated for weak and strong absorption bands in the spectrum of a typical organic analyte, caffeine. The linear region is extended when measurements are made with an off-axis optical geometry, in comparison to an in-line configuration. For the latter configuration, the linearity is improved when crossed polarizers are placed before and after the sample. (Author abstract) 12 refs.

Brimmer, Paul J. (Univ of California, Riverside, CA, USA); Griffiths, Peter R. *Appl Spectrosc* v 42 n 2 Feb 1988 p 242-247.

**075160 EXAMINATIONS OF THE MATRIX ISOLATION FOURIER TRANSFORM INFRARED SPECTRA OF ORGANIC COMPOUNDS: PART**

**VIII.** Matrix isolation Fourier transform infrared (MI/FT-IR) data has been presented that documents the presence of discrete conformers in an argon matrix for a series of ketones. The distribution of conformers in the matrix was related to the structure of the molecule, in that rigid structures (i.e., small rings, bicyclic systems, and unsaturated systems) displayed simple carbonyl absorption patterns relative to those of their less rigid counterparts. Also, conformer isolation was seen for halosubstituted ketones. These results are in agreement with previous findings concerning the vapor-phase (VP) spectra of these molecules. (Author abstract) 22 refs.

Coleman, W.M. III (R.J. Reynolds Tobacco Co, Winston-Salem, NC, USA); Gordon, Bert M. *Appl Spectrosc* v 42 n 2 Feb 1988 p 304-309.

**075161 SPECTROSCOPIC INVESTIGATION (INS, FIR) OF STRUCTURAL PHASE TRANSFORMATIONS OF FERROELECTRIC CH<sub>3</sub>NH<sub>3</sub>HgCl<sub>3</sub>.** The mechanism of the structural phase transformation from the ferroelectric room temperature to the paraelectric high temperature phase at T=333(2)K in methylammonium trichloromercurate was investigated by inelastic neutrons scattering and FIR-measurements. Energies for an internal torsional mode of CH<sub>3</sub> and an external librational mode of NH<sub>3</sub><sup>+</sup> are derived from the inelastic part of neutron time of flight spectra. The evaluation of the quasielastic intensity revealed a jump rotation at T approximately 100 K and a rotational diffusion at T approximately 295 K for the CH<sub>3</sub>NH<sub>3</sub>-group around the C-N axis. For CH<sub>3</sub>- this rotational diffusion still exists in the paraelectric phase. It is however, strongly reduced for NH<sub>3</sub> at the phase transition where an end over end libration for the whole CH<sub>3</sub>NH<sub>3</sub>-group is activated. (Edited author abstract) 11 refs.

Koerfer, M. (Inst fuer Kristallographie und Mineralogie der Univ, Frankfurt am Main, West Ger); Fuess, H.; Prager, M.; Zehnder, E.-J. *Ber Bunsenges Phys Chem* v 92 n 1 Jan 1988 p 68-73.

**075162 SURFACE-ENHANCED RAMAN SPECTROSCOPY OF THE CATECHOLAMINE NEUROTRANSMITTERS AND RELATED COMPOUNDS.** The surface-enhanced Raman spectra (SERS) of dopamine, norepinephrine, epinephrine, epinine, isoproterenol, 3-methoxytyramine, and catechol in pH 7.2 buffers on a silver electrode are reported. Catechol and the catecholamines are shown to be coordinated to silver through both oxygens. The methoxylated derivative is a monodentate complex. Intensities maximize near -0.9 V vs saturated calomel electrode. The strongest bands in the spectra are phenolic carbon-oxygen stretches and the  $\nu_{196}$  modes around 1270 and 1480 cm<sup>-1</sup> respectively. (Edited author abstract) 28 refs.

Lee, Nam-Soo (Univ of Michigan, Ann Arbor, MI, USA); Hsieh, You-Zung; Paisley, Richard F.; Morris, Michael D. *Anal Chem* v 60 n 5 Mar 1988 p 442-446.

**075163 TIME RESOLVED ELECTRON PARAMAGNETIC RESONANCE SPECTROSCOPY OF ANTHRACENE IN FROZEN AQUEOUS MICELLAR SOLUTIONS: TRIPLET YIELDS AND LIFETIMES.** Anthracene in frozen aqueous micellar solutions of n-alkyltrimethylammonium halides, C<sub>n</sub>TAX(n=10, 12, 14, 16, 18; X=I, Br, Cl), was subjected to laser pulse excitation in the cavity of an EPR-spectrometer. Decaying triplet signals were recorded with a signal processing unit designed for time resolution in the ms-range. Measured triplet lifetimes  $\tau_T$  at 80 K were lowest in C<sub>10</sub>TAI-solutions, highest in C<sub>16</sub>TAI-solutions, and varied with n; relative triplet quantum yields  $\phi_T$  were lowest in C<sub>16</sub>TAI and highest in C<sub>16</sub>TAI-solutions. Relative fluorescence quantum yields  $\phi_F$  were also higher in C<sub>16</sub>TAI than in C<sub>16</sub>TABr-solutions. (Edited author abstract) 24 refs.

Meling, H. (Univ Siegen, Siegen, West Ger); Wolff, T.; von Buena, G. *Ber Bunsenges Phys Chem* v 92 n 2 Feb 1988 p 200-204.



**075164 XPS STUDY OF ORIENTED ORGANIC MOLECULES. VESICLES OF AZOBENZENE-CONTAINING ALKYL AMMONIUM AMPHIPHILES.** We have observed the N 1s spectral change by aggregation of azobenzene-containing ammonium amphiphiles  $C_{12}AzoC_MN+Br^-$  ( $M=2, 10$ ) in water by utilizing the freezing method. By comparing the calculated intensity ratio of azo-group nitrogen to ammonium nitrogen with that experimentally observed, the N 1s spectral change has been successfully correlated with various aggregate's model structures of the amphiphiles, such as the lamella, tube, and globule. With the assumption that the N 1s photoelectron (about 850 eV in kinetic energy) mean free path is about 30 Å, the bilayer lamella model has proved to be most probable for both  $M=2$  and  $M=10$  compounds. This paper has successfully demonstrated that XPS (X-ray photoelectron spectroscopy) has the potential for use in analyzing molecular orientation in addition to conventional elemental and functional group analyses. (Edited author abstract) 19 refs.

Nakayama, Youichi (Toray Research Cent Inc, Otsu, Jpn); Takahagi, Takayuki; Soeda, Fusami; Ishitani, Akira; Shimomura, Masatsugu; Kunitake, Toyoki. *J Colloid Interface Sci* v 122 n 2 Apr 1988 p 464-474.

**075165 OVERTONE VIBRATIONAL PHOTO-CHEMISTRY OF QUADRICYCLANE.** The photochemistry of quadricyclane (Q) was explored by single-photon excitation to high vibrational levels. Spectra of the  $\nu = 4-7$  carbon-hydrogen overtones were recorded by using intracavity absorption and photoacoustic detection. These spectra were compared to the infrared fundamental spectrum and assigned. Excitation of the  $\nu = 5$  and  $\nu = 6$  bands of cyclopropanoid and methylenic hydrogens leads to reaction. At least one intermediate, probably a vibrationally excited form of norbornadiene (N), must be involved because partitioning among various reaction channels is pressure dependent. Apparent rate constants were measured and correlated with variations in pressure according to the Stern-Volmer relationship. (Edited author abstract) 41 refs.

Lishan, David G. (Allied-Signal Corp, Morristown, NJ, USA); Reddy, K. V.; Hammond, George S.; Leonard, Jack E. *J Phys Chem* v 92 n 3 Feb 11 1988 p 656-660.

**075166 SURFACE-ENHANCED RAMAN SPECTRA OF PYRAZINE, PYRIMIDINE, AND PYRIDAZINE ADSORBED ON SILVER SOLS.** Raman spectra of pyrazine, pyrimidine, and pyridazine adsorbed on silver sols have been obtained and compared with existing data from corresponding experiments on Ag electrode. These two techniques give similar results except for pyrazine for which strong bands, observed only in the SER Surface Enhanced Raman spectrum on the electrode, may be due to reduction products coadsorbed on the Ag surface. Chemisorption plays a role in the absorption of diazines as evidence of Ag-N bond formation was found in the SERS Scattering of all three molecules. Both N atoms of pyridazine are bound to the substrate and this explains an enhancement, for the latter molecule, of 2 orders of magnitude larger than for the other two compounds. The presence of low-frequency Ag-N modes and predictions of surface selection rules support 'edge on', rather than flat, orientation of diazines on the colloidal particles. (Author abstract) 23 refs.

Muniz-Miranda, Maurizio (Univ Degli Studi di Firenze, Florence, Italy); Neto, Natale; Sbrana, Giuseppe. *J Phys Chem* v 92 n 4 Feb 25 1988 p 954-959.

**075167 QUANTITATIVE DETERMINATION OF ORGANIC COMPOUNDS BY DIFFUSE REFLECTANCE FOURIER TRANSFORM INFRARED SPECTROMETRY.** Diffuse reflectance Fourier transform infrared spectrometry can successfully be used for the quantitative determination of small amounts of organic compounds, e.g. fractions from liquid chromatography. The relation between sample concentration and reflectance is - at first approximation - described by the Kubelka-Munk equation. For a correct application of the Kubelka-Munk equation, the absolute reflectance of the matrix material used as reference also has to be known. A

method is described that permits an accurate calculation of the absolute reflectance of the matrix material from experimental values obtained with conventional FTIR equipment. (Edited author abstract) 7 refs.

Reinecke, Dietmar (Fachhochschule Muenster, Steinfurt, West Ger); Jansen, Anton; Fister, Friedrich; Schernau, Ulrich. *Anal Chem* v 60 n 11 Jun 1 1988 p 1221-1224.

**075168 ATOMIZATION OF ORGANIC COMPOUNDS IN THE INDUCTIVELY COUPLED PLASMA.** The problem of incomplete atomization when nonmetals are being determined in aspirated organic solutions was studied. Abel inverted spatial profiles of  $C_2$ , CN, C(I) and Si(I) emission were acquired at several heights. It was found that molecular emission caused by the analyte is restricted to the lower aerosol channel. Nonmetal atomic emission is found in the toroidal region and higher up in the aerosol channel. Compounds that contained nonmetals comprised of either oxygen, nitrogen, or sulfur, which were dissolved in xylene, exhibited nonmetal emission intensities independent of the structure of the compound. (Author abstract) 17 refs.

Hause, P.C. (Univ of British Columbia, Vancouver, BC, Can); Blades, M.W. *Appl Spectrosc* v 42 n 4 May-Jun 1988 p 595-598.

**075169 EXAMINATIONS OF THE MATRIX ISOLATION FOURIER TRANSFORM INFRARED SPECTRA OF ORGANIC COMPOUNDS; PART IX.** A series of  $\beta$ -diketones and alkenes have been examined by matrix isolation Fourier transform infrared spectroscopy. The matrix experiment detects the presence of extensive keto-enol tautomerization in selected  $\beta$ -diketones. Certain absorption bands in the IR could be used to estimate the extent of the tautomerization. The data gathered on the alkenes found their absorption bands to occur in the same regions ( $\pm 5 \text{ cm}^{-1}$ ) as those found for VP and SS phases. Minimal nearest-neighbor (aggregation) interactions were found. These results are in contrast to those found for aldehydes, ketones, and acids of similar chain lengths. (Author abstract) 31 refs.

Coleman, W.M. III (RJ Reynolds Tobacco Co, Winston-Salem, NC, USA); Gordon, Bert M. *Appl Spectrosc* v 42 n 4 May-Jun 1988 p 666-670.

**075170 EXAMINATION OF THE MATRIX ISOLATION FOURIER TRANSFORM INFRARED SPECTRA OF ORGANIC COMPOUNDS; PART X.** The characteristics of the OH stretching absorptions in a series of catechols, resorcinols, hydroquinones, and diols have been documented with the use of matrix isolation Fourier transform infrared spectroscopy. Steric and electronic effects were described and found to agree with published results on the vapor-phase studies on the same compounds. The positions of the OH absorptions were shown to fall within a window set on the high energy side by the vapor-phase results and on the lower energy side by solid-state/solution results. The low full width at half-height values unique to the matrix experiment allowed for the observance of absorption bands not yet seen before in the vapor-phase or solid-state studies. These new bands confirm the presence of intramolecular interactions not previously documented. The data indicate that extensive intermolecular interactions occur at low loadings on the cryogenic disk (10 ng) for compounds containing polar substituents. (Edited author abstract) 18 refs.

Coleman, W.M. III (RJ Reynolds Tobacco Co, Winston-Salem, NC, USA); Gordon, Bert M. *Appl Spectrosc* v 42 n 4 May-Jun 1988 p 671-674.

**075171 OPTICAL LINEWIDTHS AND DEPHASING OF ORGANIC AMORPHOUS AND SEMI-CRYSTALLINE SOLIDS STUDIED BY HOLE BURNING.** The experiments described here have been performed on the  $0-0 \text{ S}_1 \leftarrow \text{S}_0$  transitions of a large variety of amorphous and semi-crystalline systems at temperatures between 0.3 and 20 K. It was found that, independent of the hole-burning mechanism,  $\Gamma_{\text{hom}}$  follows a  $T^{1.3}$  temperature law, and extrapolates to or in fact attains the fluorescence lifetime-limited value of the guest

for  $T \rightarrow 0$ . From a study of the holewidth dependence on laser power, burning time, sample preparation and detection method, conditions could be established for the determination of  $\Gamma_{\text{hom}}$  and the study of spectral diffusion. The results show that hole burning is a very sensitive technique to prove the amount of disorder of the environment directly surrounding the guest molecule. An interpretation of the experiments in terms of various theoretical models for dephasing in glasses is presented. (Edited author abstract) 56 refs.

Volker, Silvia (Univ of Leiden, Leiden, Neth). *J Lumin* v 36 n 4-5 Jan-Feb 1987 p 251-262.

**075172 QUENCHING OF EXCITED STATES OF XYLENOLS DUE TO HYDROGEN BONDING WITH TRIETHYLAMINE IN DIFFERENT SOLVENTS.** Hydrogen bonding between xyenols in the ground state and triethylamine (TEA) brings about red shift and increase of intensity of the absorption bands of the xyenol molecules. TEA quenches fluorescence of the xyenols at 300 K in varying degrees, possibly through a very short-lived CT species formed by strong hydrogen bonding interaction between excited xyenols and TEA, which leads to large charge transfer. At 77 K, restricted solvent relaxation or orientation impedes formation of such CT complex and consequently impedes the quenching process. Quenching is weak and absent in polar aprotic and alcoholic solvents, respectively. The monoexponential nature of phosphorescence decay of xyenols indicates establishment of very rapid equilibrium between hydrogen-bonded complexes in the triplet state and free molecules. (Author abstract) 26 refs.

Pal, T.K. (Indian Assoc for the Cultivation of Science, Calcutta, India); Mallik, G.K.; Ganguly, T.; Banerjee, S.B. *J Lumin* v 36 n 6 Mar 1987 p 339-346.

**075173 KINETIC AND THERMODYNAMIC STUDIES ON NEW INTRAMOLECULAR MIXED EXCIMERS IN ANTHRACENE-PHENANTHRENE AND ANTHRACENE-PYRENE LINKED SYSTEMS.** An analysis of the intramolecular mixed excimer formation in (9-anthrylmethyl) (9-phenanthrylmethyl) ether (I) in methylcyclohexane (MCH) and methanol (MeOH) was carried out, based on spectral data and time-dependent fluorescence intensities at different temperatures and wavelengths. The rate constants for formation and deactivation of the mixed excimer and the values of  $\Delta H$  and  $\Delta S$  were determined under stationary and dynamic conditions for I. The study on (9-anthrylmethyl) (1-pyrenylmethyl) ether (II) was limited to Stevens-Ban analysis due to the closeness of the first-singlet excited states of the anthracene and pyrene chromophores. These new intramolecular mixed excimers display no significant solvent polarity effect and their thermodynamic data are similar to those of homoeexcimers. Consequently their stabilization seems to originate more from exciton resonance than from charge transfer states. (Author abstract) 24 refs.

Desvergne, J.P. (CNRS, Talence, Fr); Bitit, N.; Castellan, A.; Bouas-Laurent, H.; Soullignac, J.C. *J Lumin* v 37 n 3 Jun-Jul 1988 p 175-181.

**075174 HINDRANCE OF THE ROTATIONAL RELAXATION IN THE EXCITED SINGLET STATE OF BIPHENYL AND PARA-TERPHEYL IN COOLED SOLUTIONS BY METHYL SUBSTITUENTS.** The measured fluorescence spectra of biphenyl (BP) and para-terphenyl (PTP) in solution reveal with decreasing temperature first an increasing structure and a slight red shift and below the glass transition a loss in structure and a strong blue shift. The effect is discussed using a torsional potential scheme in agreement with QCFF/PI calculations. Comparison of the experimental blue shifts with the results of CNDO calculations suggest an incomplete hindrance of the relaxation process of the unsubstituted



molecules. A nearly perfect hindrance could be detected for the tetra-methyl substituted BP and PTP molecules. (Author abstract) 24 refs.

Swiatkowski, Gernot (Technical Univ Berlin, Berlin, West Ger); Menzel, Ralf; Rapp, Werner. *J Lumin* v 37 n 3 Jun-Jul 1988 p 183-189.

**075175 INFLUENCE OF STRUCTURAL RELAXATION ON THE FLUORESCENT PROPERTIES OF N-NAPHTHYL-SUBSTITUTED PYRIDINIUM CATIONS.** N-naphthyl-substituted pyridinium cations fluoresce in liquids at 293 and 77 K and have an unusually large Stokes shift  $(9-15) \times 10^3 \text{ cm}^{-1}$ . The Stokes shift is a result of the torsional relaxation of different aromatic groups. Characteristic fluorescence spectra demonstrate dependence of the Stokes shift on the solvent viscosity. (Author abstract) 9 refs.

Knyazhanskii, M.I. (Rostov State Univ, Rostov-on-Don, USSR); Feigelman, V.M.; Tymyanski, Ya.R.; Druzhinin, S.I.; Uzhinov, B.M. *J Lumin* v 37 n 4 Aug 1987 p 215-218.

**075176 INTRAMOLECULAR EXCITED STATE CHARGE TRANSFER AND FLUORESCENCE DECA-Y OF p-CYANO-N,N-DIMETHYLANILINE IN MIXED HYDROCARBON/HALOCARBON SOLVENTS.** Fluorescence spectra, quantum yields and lifetimes of p-cyano-N,N-dimethylaniline (CDMA) were studied in various binary mixtures of n-hexane with chlorinated hydrocarbons. Solvent effects on the equilibrium between normal emission and fluorescence originating from the highly dipolar twisted internal charge transfer (TICT) state arise predominantly from non-specific solute-solvent interactions. The non-radiative deactivation rate of the TICT state is affected primarily by the solvent composition and slows down with the stabilization of the TICT state in environments of high polarity. (Author abstract) 22 refs.

Rotkiewicz, Krystyna (Polish Acad of Sciences, Warsaw, Pol); Koehler, Gottfried. *J Lumin* v 37 n 4 Aug 1987 p 219-225.

**075177 STUDY ON EXCITED STATES DIPOLE MOMENTS OF 9,9-BIANTHRYL.** The influence of an external electric field on the fluorescence intensity of 9,9-bianthryl in non-polar and medium polar solvents and solvent mixtures is studied experimentally. The results show that the single fluorescence band observed in these solvents is not due to a homogeneous transition between two states. (Author abstract) 26 refs.

Baumann, wolfram (Univ of Mainz, Mainz, West Ger); Spohr, E.; Bischof, H.; Liptay, W. *J Lumin* v 37 n 4 Aug 1987 p 227-233.

**075178 CHARGE-TRANSFER EXCITONS IN MIXED-STACK DONOR-ACCEPTOR COMPOUNDS: A VARIETY OF SOLITONIC STATES.** Charge-transfer excitons (CTEs) strongly coupled to lattice phonons in quasi-1-d neutral mixed-stack compounds may self-trap, forming various large-radius solitonic states. Two types of symmetric solitons (denoted by  $S_0^-$ ,  $S_n^+$ ) and dimerized ones (D) are described together with the areas of crystal parameters at which they exist. The exact discrete spectra  $\Omega_n$ ,  $n=0,1,\dots$ , of local optical vibrations bound to S-solitons are found. A general problem of several exciton states mixing in quasi-1-d systems in the presence of the strong exciton-phonon interaction is also discussed for the examples of site excitations in coupled-chain-composed substances and mixed CTE-Frenkel excitons. Known estimates and experimental data distinguish CTEs as the most appropriate candidate for soliton formation compared to other molecular excitations in quasi-1-d. (Edited author abstract) 34 refs.

Gartstein, Yu.N. (UzSSR Acad of Sciences, Tashkent, USSR); Zakhidov, A.A. *J Lumin* v 37 n 5 Sep 1987 p 275-286.

**075179 PICOSECOND SPECTROSCOPY OF POLARITONS IN ANTHRACENE CRYSTALS II. LUMINESCENCE.** The low-temperature luminescence

spectrum of anthracene crystals is investigated by applying simultaneous time and frequency resolution. The complicated kinetics of the emission in the polariton bottleneck region reflects directly the evolution and relaxation of the polariton distribution in the crystal. Three distinct relaxation stages are distinguished: (1) the ultrafast decay of initial vibronic excitations, mediated by optical phonons and resulting in a broad distribution of polaritons near the band bottom; (2) the formation of a narrow distribution of polaritons with a characteristic time of 30 ps, which is caused by scattering on acoustic phonons; (3) relaxation through the bottleneck region on a subnanosecond time scale. It is suggested that the polaritons immediately below the resonance frequency are responsible for the observed excitonic energy transfer in anthracene crystals. (Author abstract) 41 refs.

Aaviksoo, J. (Estonian SSR Acad of Sciences, Tartu, USSR); Freiberg, A.; Lippmaa, J.; Reinot, T. *J Lumin* v 37 n 6 Oct 1987 p 313-322.

**075180 SOLID STATE ROOM-TEMPERATURE FLUORESCENCE OF p-OLIGOPHENYLENES AND OF POLY (PARAPHENYLENE) FILMS PREPARED ELECTROCHEMICALLY.** Fluorescence excitation and emission spectra of p-terphenyl, p-quaterphenyl and p-quinquephenyl were measured in sodium chloride pressed pellets at room temperature (293 K). Significant red-shifts of fluorescence spectra are found, upon increasing the number of phenyl rings in the oligomer chain. Polyparaphenylene (PPP) films were prepared by a new method of electro-oxidation of p-terphenyl in dichloromethane. Their solid-state fluorescence excitation and emission spectra were determined at room temperature. The excitation wavelength-dependent changes of fluorescence emission bands as well as their highly structured components are attributed to the occurrence in the excited singlet state of a variety of planar or nearly planar configurations of PPP films with relatively long chains. (Author abstract) 21 Refs.

Aaron, J.J. (CNRS, Paris, Fr); Aciyach, S.; Lacaze, P.C. *J Lumin* v 42 n 1 Jun-Jul 1988 p 57-60.

**075181 STRUCTURAL INFORMATION ON PROBE SOLUBILIZATION IN MICELLES BY FT-IR SPECTROSCOPY.** The carbonyl stretching vibration of n-(9-anthroyloxy)stearic acid probes was monitored in Triton X-100 and SDS micelles, and it was concluded that (i) the radial distribution function is more displaced to the micellar core when the alkyl chain between the terminal acid group and the chromophore increases and (ii) in SDS micelles a large fraction of probes is in all cases at the micellar interface. (Author abstract) 30 Refs.

Villalain, Jose (Univ de Murcia, Spain); Gomez-Fernandez, Juan C.; Prieto, J.E. *J Colloid Interface Sci* v 124 n 1 Jul 1988 p 233-237.

**075182 DATA SYSTEM FOR IMAGING ORGANIC ANALYSIS WITH A SECONDARY ION MASS SPECTROMETER.** A data system is described for a custom-built secondary ion mass spectrometer assembled with a microcomputer, plug-in data acquisition and control cards, and a commercial scientific software system. Capabilities and limitations of this system are described. (Author abstract) 5 Refs.

Flurer, R.A. (Indiana Univ, Bloomington, IN, USA); Busch, K.L. *Anal Instrum (New York)* v 17 n 3 1988 p 255-276.

**075183 FLUORESCENCE INVESTIGATION OF THE CHROMATOGRAPHIC INTERACTIONS OF NITROGEN HETEROCYCLES WITH DEACTIVATED SILICA.** Solid-surface fluorescence spectroscopy was used to study the chromatographic interactions of benzo[f]quinoline (B[f]Q) and benzo[h]quinoline (B[h]Q) with water-deactivated silica gel. The results indicated that some of the water was adsorbed on sites in silica that were incapable of proton donation to B[h]Q in the excited singlet state. It was also found that solute localization became more important on the water-deactivated silica.

By combination of the luminescence data and the chromatographic data, the mass balance was calculated for three B[h]Q species responsible for the chromatographic bands. Spectral evidence was also obtained that supported a displacement-type of chromatographic mechanism for the systems investigated. (Author abstract) 22 refs.

Burrell, G.J. (Univ of Wyoming, Laramie, WY, USA); Hurtubise, R.J. *Anal Chem* v 60 n 20 Oct 15 1988 p 2178-2182.

**075184 ENHANCED ROOM-TEMPERATURE PHOSPHORESCENCE OF ANTHRACENE ON CYCLODEXTRIN-TREATED FILTER PAPER.** This study investigates the enhancement of room-temperature phosphorescence (RTP) for anthracene when the compound is adsorbed on cyclodextrin (CD)-treated filter paper. The results show that  $\beta$ -CD treatment induces a significant increase in anthracene RTP emission, which is normally extremely weak. The  $\alpha$ -CD does not produce any strong RTP enhancement, while  $\gamma$ -CD produces relatively lower enhancement than does  $\beta$ -CD. The CD treatment procedure is very simple and improves the analytical usefulness of the RTP method. (Edited author abstract) 34 refs.

Vo-Dinh, Tuan (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Alak, Ala. *Appl Spectrosc* v 41 n 6 Aug 1987, Fourteenth Annu Meet of the Fed of Anal Chem and Spectrosc Soc, Detroit, MI, USA, Oct 4-9 1987 p 963-966.

**075185 KNIGHT SHIFT IN THE ORGANIC CONDUCTOR (FLUORANTHENYL)<sub>2</sub>AsF<sub>6</sub>.** Proton and <sup>13</sup>C NMR knight shift investigations performed in the organic conductor F<sub>2</sub>AsF<sub>6</sub> provide locally resolved information on the electronic states of the conducting band. From single crystal measurements, the principal axis values of the proton hyperfine tensor for two positions are determined. A comparison of <sup>13</sup>C Knight shift spectra with spectra simulated from HMO/McLachlan spin density data shows a fair agreement supporting the theoretical values. Taking <sup>1</sup>H Knight shift experiments and HMO/McLachlan theory together results in a spin density map of the fluoranthene molecule. 11 refs.

Hentsch, F. (Univ Stuttgart, Stuttgart, West Ger); Helmle, M.; Koenigter, D.; Mehring, M. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem, of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 911-913.

**075186 LOCAL STRUCTURE OF COPPER-ALBUMIN COMPLEXES: INVESTIGATIONS BY EPR AND EXAFS SPECTROSCOPY.** The atomic short-range order of copper-albumin complexes in the freeze-dried form has been investigated by EPR and EXAFS spectroscopy using synchrotron radiation. The superhyperfine structure of EPR spectra of these complexes testifies to the fact, that the copper atom is surrounded by four ligand atoms of nitrogen. The radial distribution function of Cu-N, found from the EXAFS spectrum of these complexes using the regular algorithm for solution of inverse ill-defined problems, is characterized by a narrow symmetrical peak with a maximum at  $0.204 \pm 0.001 \text{ nm}$ . (Author abstract) 13 refs.

Asaturian, R.A. (Yerevan Physics Inst, Yerevan, USSR); Avakian, Ts.M.; Ershov, N.V.; Ageev, A.L.; Kozlov, M.A. *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 187-189.

**075187 TEMPERATURE PROGRAMMED PYROLYSIS-MASS SPECTROMETRY.** Temperature programmed pyrolysis performed close to the ion source of a mass spectrometer is a rapid and sensitive method for the analysis of involatile organic materials. The pyrolysis products directly enter the source as they are evolved and are rapidly analyzed so that both temporal and temperature resolution are possible. The technique requires little sample preparation and be used to characterize complex



mixtures of materials. The method can be simply used in the fingerprinting mode or the evolution of species can be related to the rate of thermal degradation. Applications of temperature programmed pyrolysis-mass spectrometry to the analysis of materials of interest in defense quality assurance will be described together with the instrumentation available. The advantages of temperature resolution in the analysis of samples such as polymers, lubricants and their additives is demonstrated. (Edited author abstract) 16 refs.

Westall, W.A. (Ministry of Defence, London, Engl); Pidduck, A.J. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 3-14.

**075188 LUMINESCENCE OF NEUTRAL AND PROTONATED AMINOQUINOXALINES.** Stationary and time-resolved luminescence methods were used to investigate various protonated forms of 2-aminoquinoxaline and 2,3-diaminoquinoxaline. Proton attachment to 2-aminoquinoxaline monocation was discovered in the first excited singlet electronic state. Three different protonated structures of 2,3-diaminoquinoxaline were observed. (Author abstract) 4 refs.

Waluk, Jacek (Polish Acad of Sciences, Warsaw, Pol). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 211-212.

**075189 PHOTOCHEMICALLY INDUCED INTERMOLECULAR EXCHANGE OF BROMINE AND CHLORINE OBSERVED BY OPTICALLY DETECTED NQR ON CHLOROCCUMARIN IN DIBROMOBENZENE SINGLE CRYSTALS.** On uv irradiation at low temperatures 7-chlorocoumarin exhibits a solid state reaction in single crystals of p-dibromobenzene, which includes a chlorine abstraction followed by a temperature activated bromine addition. The structure of the reactive crystalline site is investigated by ODNQR. (Author abstract) 5 refs.

Schneider, T. (Freie Univ Berlin, Berlin, West Ger); von Borzyskowski, C. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 213-214.

**075190 N,N'-BIS-(2-NAPHTHYLMETHYL) PIPERAZINE: A COMPOUND EXHIBITING INTRAMOLECULAR EXCIPLEX AND EXCIMER FORMATION IN MIXED SOLVENTS.** The fluorescence spectra of N,N'-bis-(2-naphthylmethyl) piperazine in pure and mixed solvent have been determined. The mechanism of the process for the formation of intramolecular exciplex and excimer have been proposed. It is indicated that intramolecular exciplexes are formed in benzene, chloroform, ethyl acetate, tetrahydrofuran, dichloromethane. 2 refs.

Zhou, Qingfu (Acad Sinica, Beijing, China); Xu, Huijun. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 239-240.

**075191 NEW PHENOMENA OF EMISSION DEPENDENCE OF INTRAMOLECULAR EXCITED STATE COMPLEXES OF DMNP IN POLAR SOLVENTS ON EXCITATION WAVELENGTH.** The photophysical properties of the intramolecular excited state complexes (ESC) of N,N'-Di- $\beta$ -naphthylmethyl-piperazine (DMNP) have been studied in solvents of different polarities. New phenomena of excitation dependent fluorescence were observed. (Author abstract) 4 refs.

Ge, Guangyuan (Acad Sinica, Changchun, China); Li, Duolu; Tian, Nailiang; Xiong, Guangnan; Xu, Xurong; Zhou, Qingfu; Xu, Huijun. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 248-249.

**075192 ENHANCING AFFECTION OF EXCIMER FORMATION OF PHENYL PROPIONATE BY  $\beta$ -CYCLODEXTRIN.** In this paper, the promoted ex-

cimer formed by interaction of phenyl propionate with the cavity of  $\beta$ -cyclodextrin and effects of the excimer on the catalyst photorearrangement reaction have been studied. Dependence of  $\beta$ -cyclodextrin concentrations of adding to the system on equilibria of inclusion have been discussed. In addition, the probable structure of excimer formed by  $\beta$ -cyclodextrin promotion was postulated. (Author abstract) 3 refs.

Zhang, Limin (Acad Sinica, Beijing, China); Chen, Shangxian. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 266-267.

**075193 TOTAL LUMINESCENCE SPECTROSCOPY.** The low temperature total luminescence spectra of pyrene in a single crystal of n-heptane, in a n-heptane Shpol'skii matrix and in an ethanol glass, were compared. Characteristic patterns of a single-site spectrum, a multi-site spectrum, and a strongly inhomogeneously broadened spectrum were identified. (Author abstract) 6 refs.

Wild, Urs P. (ETH-Zentrum, Zurich, Switz); Luond, Markus; Meister, Erich; Suter, Georg W. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 270-271.

**075194 EXCIMER LUMINESCENCE OF ANTHRACENE DERIVATIVES AT HIGH PRESSURE.** The excimer luminescence of 9-cyano-,  $\beta$ -9-chloro- and  $\beta$ -9, 10-dichloro-anthracene has been studied up to approximately 10 GPa. Comparative results are discussed in terms of the relationship between type of emission and excimer geometry in different pressure regimes. (Author abstract) 3 refs.

Brillante, A. (Univ di Bologna, Bologna, Italy); Della Valle, R.G.; Stroessner, K.; Syassen, K. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 278-279.

**075195 LUMINESCENCE PROPERTIES OF SOME DIFFERENTLY SUBSTITUTED INDOLES.** Solutions of some differently substituted indoles have been spectroscopically characterized and the experimental spectra have been interpreted on the basis of CNDO calculation. All the examined compound  $C_{22}H_{13}N$  (N-methyl, 2,3 diphenyl, 5-methyl indole),  $C_{20}H_{14}O$  (O-2phenyl, 3 methyl benzofuran) and  $C_{20}H_{14}N$  (N- 2,3 diphenyl indole) have been analyzed by means of X-ray diffraction measurements in order to determine the crystal structure. 4 refs.

Girlanda, R. (Univ di Messina, Italy); Martino, G.; Mezzasalma, A.M.; Mondio, G.; Saitta, G. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 284-285.

**075196 PHASE TRANSITION AND LUMINESCENCES IN p-TERPHENYL CRYSTALS.** We have investigated the effect of phase transition on the fluorescence spectra and decay times of p-terphenyl crystals in the range of 12-300 K. The temperature dependences of the spectrum and the decay time are interpreted by the libration of the central ring of p-terphenyl molecules. (Author abstract) 2 refs.

Uchida, Kenji (Fukui Inst of Technology, Fukui, Jpn); Takahashi, Yoshihiro. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 292-293.

**075197 ONE-AND TWO-PHOTON FLUORESCENCE EXCITATION SPECTRA OF MULTICHROMOPHORIC MOLECULES.** The splittings in  $S_1$  states of molecules containing weakly coupled  $\pi$ -chromophoric groups have been determined through one- and two-photon fluorescence excitation (OPF and TPF) spectroscopy. The  $1_{B_{2u}}$  state of benzene splits by about  $140\text{ cm}^{-1}$  in the dimer, dihydroanthracene (DHA) and by about  $2500\text{ cm}^{-1}$  in the strained trimer, triptycene (TR). While the exciton splitting in the trans-dimer of

acenaphthylene (TDA), in which the two naphthalene moieties are linked by two ethylene bridges, is only  $130\text{ cm}^{-1}$ , no such near degeneracies are noticed in two-methylene-bridge-linked dihydrodibenzanthracene (DBA) or dihydropentacene (DHP). (Author abstract) 4 refs.

Samanta, Anunay (Indian Assoc for the Cultivation of Science, Calcutta, India); Kundu, Tapanendu; Chowdhury, Mihir. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 437-438.

**075198 CHANGES OF THE SITE DISTRIBUTION INDUCED BY HOLE BURNING.** In this work we propose a different method to determine the distribution of energy shifts during holeburning. It proceeds in several steps: First, we excite the sample with white light and measure the resulting broad band fluorescence spectrum. White light excitation ensures, that all molecules are excited with equal probability. Then we start the holeburning with the laser, constantly measuring the resulting site-selection fluorescence spectrum. Finally, we excite the sample again with white light and measure the fluorescence spectrum, which is now changed due to the holeburning. 1 ref.

Fuenschilling, J. (Inst fuer Physik, Basel, Switz); Glatz, D.; Zschokke-Graenacher, I. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 511-512.

**075199 HOLE BURNING WITH EXCITATION INTO THE TRIPLET STATE.** Nonphotochemical hole burning (NPHB) of organic molecules imbedded in amorphous solids has been the subject of many recent investigations. But attention has been paid only to the hole burning in the singlet absorption system. We have observed very efficient NPHB in the inhomogeneously broadened  $S_0-T_1$  absorption of coronene in 1-bromobutane and in a mixture of 1-bromobutane and 1-iodonaphthalene. 1 ref.

Lin, Shixiong (Univ of Basel, Basel, Switz); Fuenschilling, J.; Zschokke-Graenacher, I. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 513-514.

**075200 STUDY ON PHOTOSENSITIZED TRIPLET-TRIPLET ABSORPTION OF NAPHTHYLALKANES.** The photosensitized triplet energy transfer and photochemistry processes from Benzophenone to naphthylalkanes are studied by laser flash photolysis and calculated relative constants. It seems the molecular structure affects the energy levels of the excited state. When the two naphthalene rings of bis-(2-naphthyl)propane are coplanar and close to each other, the interaction of the electron clouds stabilizes the excited state. When the hydrogen is substituted for the acetoxy group in 1-position of the alkane (in the case of ANP or AMN), the coplanar conformation is preferred. 2 refs.

Yu, Qun (Acad Sinica, Beijing, China); Ye, Jianping; Guo, Shiyang; Shou, Hansen. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 579-580.

**075201 CHARACTERIZATION OF AGGREGATES AND THEIR IMPORTANCE FOR ENERGY TRANSPORT IN CHEMICALLY MIXED CRYSTALS.** Chemically mixed crystals of dichlorobenzene (DCB) in dibromobenzene have been investigated over the concentration range from 0.01 to 10%. DCB guest molecules induce energy funnels for triplet energy transport. Phosphorescence excitation spectroscopy reveals that guest aggregates formed at higher concentrations induced the same kind of energy funnels as monomers. Optical shifts of DCB aggregates relative to monomers are



mainly determined by crystal field effects whereas changes in ODMR frequencies are due to exchange interactions. (Author abstract) 8 refs.

Grimm, J. (Freie Univ Berlin, Berlin, West Ger); von Borczyskowski, C. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 645-646.

**075202 ENERGY TRANSFER BY TWO KINDS OF EXCIMERS IN PYRENE CRYSTALS.** The decay curves of the host and guest fluorescence in perylene doped pyrene crystals were nearly equal in each concentration and fitted with two exponential functions in high concentration. From the dependence of the two decay times on the temperature and doped concentration, we propose that the fast decay component is due to the energy transfer from host to guest through a different excimer. (Author abstract) 2 refs.

Takahashi, Yoshihiro (Aichi Inst of Technology, Yakusa, Jpn); Kitamura, Takashi; Uchida, Kenji. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 671-672.

**075203 SHORT RANGE EFFECTS ON PYRENE-EXCIMER ENERGY TRANSFER TO 9,10-DIPHENYLANTHRACENE.** The rate constants for the energy transfer process between the pyrene-excimer and 9,10-diphenylanthracene (DPA) in solvents of different viscosities were obtained from the excimer decay curves of pyrene. The results were analysed in terms of a short-range and a long-range energy transfer processes. (Author abstract) 7 refs.

Martinho, J.M.G. (UTL, Lisbon, Port); Pereira, V.R. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 673-675.

**075204 ELECTRON TRANSFER OF SOME COVALENTLY LINKED TETRAPHENYLPORPHYRIN-NITROBENZENE MODEL COMPOUNDS.** Here we wish to report the photophysical properties of a series of new model compounds: covalently linked tetraphenylporphyrin-nitrobenzene compounds in which the relative orientation between the donor and the acceptor varies from one porphyrin-nitrobenzene molecule to another. A systematic study of absorption spectra, fluorescence spectra and lifetimes has been carried out. 2 refs.

Zhu, Hesun (Beijing Inst of Technology, Beijing, China); Guo, Chu; Yu, Lian; Zhang, Jun; Feng, Yangbo. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 680-681.

**075205 DIFFUSE REFLECTANCE LASER PHOTOLYSIS STUDIES OF ENERGY TRANSFER AT INTERFACES.** Static and dynamic mechanisms of electronic energy transfer from triplet benzophenone to 1-methyl naphthalene have been investigated on microcrystalline surfaces of silica and cellulose. Energy transfer at these surfaces show substantial 'static' quenching which approaches a 'Perrin' type behaviour, which contrasts with the situation in homogeneous solution where dynamic quenching yields 'Stern-Volmer' kinetics and a quenching constant of  $1.1 \times 10^{10} \text{ M}^{-1}\text{s}^{-1}$ . (Author abstract) 4 refs.

Wilkinson, F. (Loughbrough Univ of Technology, Loughbrough, Engl); Ferreira, L.F.V. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 704-705.

**Spectrum Analysis** See Also FLUORESCENCE—Spectrum Analysis.

**075206 IR SPECTRA STUDY OF THE HYDROGEN BONDS IN OXIMES.** The spectral parameters of the  $\nu(\text{OH}\cdots)$  bands of oximes when hydrogen bonds (HB) are formed with bases have not been measured previously. In order to determine the spectral parameters of  $\nu(\text{OH})$

bands of a complex containing a HB and a self-associate of oximes it is necessary to take into account the complex structure of the entire band. Taking this into account we have measured in this investigation the integrated intensities and first moments (centers of gravity) of the  $\nu(\text{OH}\cdots)$  absorption bands of the oximes of acetone (I) and cyclohexanone (II). 12 refs.

Gurkchi, G.A.; Zimina, L.M.; Mel'nikova, D.N.; Kuskushina, M.L. *J Appl Spectrosc* v 46 n 2 Feb 1987 p 172-176.

**075207 SPECTROCHROMATOGRAPHIC ANALYSIS OF ORGANIC COMPOUNDS USING cw TUNABLE CO AND CO<sub>2</sub> LASERS.** Selective analysis of multicomponent mixtures, organic compounds is studied using the combined system of 'gas chromatograph - laser optoacoustic spectrometer' (GC-LOAS). The spectral range was widened by using a cw CO laser (5.3-6.3  $\mu\text{m}$  output range). This permitted to make the composition of the mixtures being analyzed more complex, in particular, by adding carbonyl containing compounds. 7 refs.

Gorokhov, Yu.A.; Ogurok, D.D.; Tumanova, L.M. *J Appl Spectrosc* v 46 n 3 Mar 1987 p 241-244.

**075208 ELECTRON TRANSITIONS IN THE SPECTRA OF DIARYL-SUBSTITUTED.** The present work outlines the results of quantum-chemical calculation of the excited electron states of 2,5-diaryl-substituted 1,3,4-oxadiazole, containing phenyl and naphthyl radicals in various combinations. Analysis of the transitional density matrices allow the following quantitative interpretation to be given for the spectra of diaryl-substituted oxadiazole. The lowest intense transition is of whole-molecule type and is due both to excitation of P-electron systems of individual fragments and to significant charge transfer between them. In the short-wave region, low-intensity transitions  $B_2$  and  $N_2$  appear, overlapping the long-wave band. The bands of compounds II, III, and V observed experimentally in the region 36,000-38,000  $\text{cm}^{-1}$  [7] are due to  $N_p$  transitions. The lack of pronounced absorption in the given region for compound IV is due to the low intensity of the transitions  $H_p(S_0 \rightarrow S_4^*, S_0 \rightarrow S_6^*)$ . 8 refs.

Pedash, V.F.; Pedash, Yu.F. *J Appl Spectrosc* v 46 n 4 Apr 1987 p 403-406.

**075209 VIBRATIONAL SPECTRA AND ROTATIONAL ISOMERISM OF ETHYL DICHLOROTHIOPHOSPHITE  $\text{C}_2\text{H}_5\text{SPCl}_2$  AND TRIETHYL TRITHIOPHOSPHITE  $(\text{C}_2\text{H}_5\text{S})_3\text{P}$ .** In order to accumulate further data on the internal rotation around the  $\text{P}(\text{III})\text{S}$  bond and to study how it is affected by the sizes of the alkyl radicals at the S atom we studied the vibrational spectra and rotational isomerism of the molecules  $\text{C}_2\text{H}_5\text{SPCl}_2$  (IV) and  $(\text{C}_2\text{H}_5\text{S})_3\text{P}$  (V). We also derived a transferable set of force constants of the fragment  $\text{C}_2\text{H}_5\text{SP}(\text{III})$ . 12 refs.

Filippova, E.A.; Katsyuba, S.A.; Shagidullin, R.R.; Sinyashin, O.G. *J Appl Spectrosc* v 46 n 5 May 1987 p 467-471.

**075210 CONCENTRATION QUENCHING OF THE TRIPLET STATE OF Pd-TETRAPHENYLCHLORIDE IN LIQUID SOLUTIONS.** We measured the dependence of the rate constant of the deactivation of the lowest triplet state of Pd-TPhC on its concentration in toluene and dioxane at room temperature. We conclude that the observed concentration quenching of the triplet state of Pd-TPhC is due to the formation of a complex from molecules in the triplet and ground states. Comparison of the experimental data with the analysis results confirms the realization of this mechanism of concentration quenching. 9 refs.

Sapunov, V.V.; Egorov, G.D. *J Appl Spectrosc* v 46 n 5 May 1987 p 519-522.

**075211 IR SPECTRA OF IRRADIATED ORGANIC MATERIALS.** We present IR spectra (4400-400  $\text{cm}^{-1}$ ) of organic materials, both commercial and newly produced in the laboratory, and their changes due to fast ion

bombardment. The results indicate in particular: a preferential loss of hydrogen, darkening, amorphization, a rearrangement in the molecular structure. Some astrophysical applications and observations from space missions are suggested. (Author abstract) 16 refs.

Strazzulla, G. (Citta Univ, Catania, Italy); Massimino, P.; Spinella, F.; Calcagno, L.; Foti, A.M. *Infrared Phys* v 28 n 3 May 1988 p 183-188.

**075212 IR AND/OR NMR SPECTRA-STRUCTURE CORRELATIONS FOR ORGANONITROGEN-CONTAINING COMPOUNDS.** IR and/or NMR spectra-structure correlations have been developed which aid in the elucidation of molecular structure of organonitrogen-containing compounds. (Author abstract) 10 refs.

Nyquist, Richard A. (Dow Chemical Co, Midland, MI, USA). *Appl Spectrosc* v 42 n 4 May-Jun 1988 p 624-634.

**075213 FT-IR AND FT-NMR STUDY OF ORGANOPHOSPHORUS SURFACE REACTIONS.** Fourier transform infrared (FT-IR) and Fourier transform nuclear magnetic resonance (FT-NMR) methods were used to examine the adsorption and reaction of diisopropyl fluorophosphate (DFP) on various solid adsorbents. Static and flow system experiments were monitored with the use of FT-IR to determine DFP adsorption rates and isotherms on silica, coated silicas,  $\gamma$ -alumina, coated aluminas, and activated charcoal. The adsorption of DFP(g) onto the solid adsorbents was generally rapid, with a half-life of 20 s for 1 mg DFP onto 25 mg of 350  $\text{m}^2/\text{g}$  silica. The DFP adsorption isotherm on silica indicated chemisorption to a monolayer at  $P/P_0 < 0.6$ , followed by increased coverage that appears to be physical adsorption. Diffuse reflectance infrared Fourier transform (DRIFT) spectroscopy, photoacoustic spectroscopy (PAS), and solidstate  $^{31}\text{P}$  NMR of adsorbed DFP showed chemisorption on silica and on alumina. Bonding at the  $\text{P}=\text{O}$  of DFP was indicated by a  $-41 \text{ cm}^{-1}$  shift in the  $\nu(\text{P}=\text{O})$  and a 1-ppm upfield shift in the  $^{31}\text{P}$  resonance. DRIFT, PAS kinetics, and  $^{31}\text{P}$  NMR showed that DFP hydrolyzed after the initial adsorption on alumina and some coated materials but not on silica or activated charcoal. The rate of hydrolysis increased on alumina with addition of water and varied with different aluminas and coated silicas. (Edited author abstract) 19 refs.

Nadler, Melvin P. (Naval Weapons Cent, China Lake, CA, USA); Nissan, Robin A.; Hollins, Richard A. *Appl Spectrosc* v 42 n 4 May-Jun 1988 p 634-642.

**Stability** See Also CATALYSIS; DYES AND DYEING—Stability.

**075214 STABILITY OF ADSORPTION COMPLEXES FORMED BY ALCOHOLS ON H-ZSM-5.** The stability of adsorption complexes formed by alcohols in H-ZSM-5 has been investigated by using a titration/displacement technique. In this experiment, the ability of probe molecules to displace a given adsorbate from a complex at a zeolite hydroxyl site is examined. TPD and  $^{13}\text{C}$  NMR are used to measure the coverages of the alcohols following sequential or competitive adsorption experiments. The results show that there is a clearly defined ordering in the ability of alcohol molecules to displace one another at the adsorption site, and this ordering appears to follow the relative strengths of the zeolite/adsorbate interactions. Displacement orders correlate with the gas-phase proton affinities for alcohols with three or fewer carbon atoms in the hydrocarbon chain. However, as the carbon chain length increases, interactions between the carbon backbone and the zeolite channel walls become increasingly important in directing the course of the displacement reactions. (Author abstract) 18 refs.

Aronson, M.T. (Univ of Pennsylvania, Philadelphia, PA, USA); Gorte, R.J.; Farneth, W.E.; White, David. *Langmuir* v 4 n 3 May-Jun 1988 p 702-706.



## Standards

**075215 PROCEDURES FOR DEFINING FSE STANDARDS.** Formal steric enthalpies (FSE's) of a given class of molecules are defined in terms of FSE values assigned to standards. As an aid to selecting standard molecules and in determining appropriate FSE values for them, a procedure has been developed for the systematic generation of molecules that incorporate specific structural groups, for identifying all heavy atom torsions of the conformer (usually) of minimum energy, and for assigning gauche enthalpies to the torsions. The estimates of gauche enthalpies are derived by an interpolation procedure which provides a consistent set of values. Three programs FSEUNITA.BAS, FSEUNITB.BAS AND FSEUNITC.BAS together with a data set of TORSION.DAT define the procedures. (Edited author abstract) 11 refs.

DeTar, DeLos F. (Florida State Univ, Tallahassee, FL, USA). *Comput Chem* v 12 n 1 1988 p 1-14.

**Structure** See Also BIOCHEMISTRY; DRUG PRODUCTS—Antibiotics; DRUG PRODUCTS—Chromatographic Analysis; DYES AND DYEING—Chemistry; INFORMATION SCIENCE—Information—Retrieval; LIQUIDS—Surface Tension; PIGMENTS—Synthesis; POLYSACCHARIDES—Spectroscopic Analysis; PROTEINS—Chromatographic Analysis; SALTS—Structure; SUPERCONDUCTING MATERIALS—Structure; SURFACE ACTIVE AGENTS—Spectroscopic Analysis.

**075216 SIDEBRANCH STRUCTURE OF CONSTRAINED DENDRITES.** The authors present in situ observation and measurement results and theoretical analyses that deal with the non-steady-state development of constrained dendritic sidebranch structures in succinonitrile-acetone during directional solidification. The results provide further insights into the fundamental problems and show that the evolution of the sidebranch is dominated by the coupled effects of dynamic diffusion, the capillary effect, and the anisotropy in solid-liquid interfacial energy. Three regions in the metamorphosis of the sidebranch are reported and discussed. (Edited author abstract) In Chinese. 6 refs.

Huang, Tao; Lu, Deyang; Zhou, Yaohe. *Xibei Gongye Daxue Xuebao* v 6 n 1 Jan 1988 p 41-51.

**075217 FURTHER DEVELOPMENT OF STRUCTURE GENERATION IN THE AUTOMATED STRUCTURE ELUCIDATION SYSTEM CHEMICS.** The automated structure elucidation system CHEMICS has been expanded to allow the compound with all or any of the elements C, H, O, N, S, and the halogens to be analyzed. To realize the improvement, a new set of primary, secondary, and tertiary components to be used commonly for both spectral analyses and structure construction was established. Twelve attributes of the components were prepared for the determination of the bonding priorities between the components. This makes it possible to construct a tertiary component by giving an attribute of bonding partner to a secondary component. A new structure generator for the improved system has been developed on the basis of the established components set, using the authors' connectivity stack method. (Edited author abstract) 9 refs.

Funatsu, Kimito (Toyoashi Univ of Technology, Toyohashi, Jpn); Miyabayashi, Nobuyoshi; Sasaki, Shin-ichi. *J Chem Inf Comput Sci* v 28 n 1 Feb 1988 p 18-28.

**075218 CRYSTAL STRUCTURE, SOLID-STATE NMR SPECTRA, AND OXYGEN REACTIVITY OF FIVE CRYSTAL FORMS OF PREDNISOLONE TERT-BUTYLACETATE.** The crystal structures of five crystalline forms of prednisolone tert-butylacetate were determined. The crystal packing is different in each crystal form. One crystal form is unsolvated while the other four contain various solvents of crystallization. The unsolvated crystal form belongs to space group  $P2_12_12_1$ , three of the solvated forms belong to space group  $P2_1$ , and the fourth solvated form belongs to space group  $P6_1$ . The prednisolone tert-butylacetate molecules are in different conformations in the different crystal forms. (Edited author abstract) 37 refs.

Byrn, Stephen R. (Purdue Univ, West Lafayette, IN, USA); Sutton, Paul A.; Tobias, Brian; Frye, James; Main, Peter. *J Am Chem Soc* v 110 n 5 March 1988 p 1609-1614.

**075219 STRUCTURE ELUCIDATION AND ARTIFICIAL INTELLIGENCE.** The author examines the facilities and problems of automation from the viewpoint of a modern spectroscopy laboratory, and above all, surveys the tools which permit an 'intelligent' evaluation of the raw data. A discussion is presented of automatic sample changers; automatic sample preparation; the flow of information in the laboratory; recording spin-spin interactions; and, intelligent evaluation of spectra. 29 refs.

Bremser, Wolfgang (BASF AG, Ludwigshafen, West Ger). *Angew Chem (Int Ed Engl)* v 27 n 2 Feb 1988 p 247-260.

**075220 STRUCTURAL PROPERTIES OF ADSORBED LAYER OF ALBUMIN ON SURFACE OF HEMOSORBENT.** A study has been made of the adsorption of serum albumin on particles of activated carbon that are used for sorptive purification of blood. The properties of the adsorbed layers have been investigated by means of viscometric and electrophoretic measurements. The possibilities for application of these methods in adsorption studies have been examined critically. The geometric character of the protein molecule location in the adsorbed layer has been determined. An interpretation of a microelectrophoretic experiment is proposed, through which the structural aspect of protein adsorption on solid surfaces can be examined quantitatively. (Author abstract) 38 refs.

Sigal, V.L. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Osadchii, P.V. *Colloid J USSR* v 49 n 5 Sep-Oct 1987 p 830-835.

**075221 SOLID STATE CHARACTERIZATION AND X-RAY CRYSTAL STRUCTURE OF A 1,1 COMPLEX OF TETRATHIAFULVALENE AND META-DINITROBENZENE (TTF-mDNB).** The preparation, properties and crystal structure of an insulating complex formed between TTF and meta-dinitrobenzene (mDNB) are described. This acceptor has an aromatic ground state, rather than the quinonoid ground-state structure of TCNQ and the halobenzoquinones, which are the established acceptors that form crystalline TTF complexes. This neutral complex has low conductivity,  $\sigma_{300} = 2.7 \times 10^{-9} \text{ S cm}^{-1}$ , and a mixed stack structure. (Edited author abstract) 17 refs.

Bryce, Martin R. (Univ of Durham, Durham, Engl); Davies, Stephen R. *Synth Met* v 25 n 1 Jul 1988 p 25-28.

**075222 STRUCTURE OF N-(n-PROPYL)-QUINOLINIUM-(TCNQ)<sub>2</sub> AT 100 K.** The structure of  $(C_{12}H_{14}N)(C_{12}H_4N_4)_2$ ,  $(NPrQn)(TCNQ)_2$ , has been determined at 120 K. TCNQ molecules are stacked along the b axis in tetramers containing two inequivalent molecules. The NPrQn molecules are situated between the TCNQ stacks. The geometry of TCNQ molecules does not change significantly in comparison with room-temperature values. There is an increased tetramerization in the low-temperature phase, thermal contraction taking place within tetramers only and not affecting inter-tetramer distances. The latter may be explained assuming a lattice distortion originating in exciton-exciton interactions, competing with thermal effects. (Edited author abstract) 12 refs.

Rindorf, Grethe (Technical Univ of Denmark, Lyngby, Den); Thorup, Niels; Kamaras, Katalin. *Synth Met* v 25 n 2 Aug 1988 p 189-195.

## Sulfonation

**075223 DETERMINATION OF THE AMOUNT AND FORM OF ADDED SULFUR IN MODIFIED HUMATES.** The amount of sulfur introduced into modified humates has been determined. A method for determining sulfate in mixtures containing modified humic acids, sodium sulfite, and hydroxides has been developed on model mixtures. It has been shown by IR spectroscopy that the introduced sulfo groups are at-

tached to the aliphatic parts of the humic acid molecules. (Author abstract) 18 refs.

Sharanova, I.E.; Girina, L.V.; Rybachenko, V.I.; Dulenko, V.I.; Dumbai, I.N. *Solid Fuel Chem* v 21 n 3 1987 p 33-37.

**Surfaces** See CLAY—Surfaces; ORGANIC CHEMICALS—Electronic Properties; SPECTROSCOPY—Applications.

**Suspensions** See SOILS—Separation.

**Synthesis** See Also ACETYLENE—Processing; AMINES—Alkylation; BIOMEDICAL EQUIPMENT—Radionuclides; CARBON DIOXIDE—Applications; CATALYSIS—Theory; COAL RESEARCH; DRUG PRODUCTS—Antibiotics; ENZYMES; ESTERS—Polymerization; ETHYLENE—Processing; GRAPHITE—Ion Implantation; HYDROCARBONS—Structure; ION EXCHANGE RESINS—Chemical Reactions; MATHEMATICAL TECHNIQUES—Graph Theory; PETROLEUM REFINING—Modification; POLYESTERS—Forming; POLYMERS; POLYMERS—Chemical Reactions; POLYMERS—Electric Conductivity; POLYMERS—Synthesis; POLYSTYRENES—Chemical Reactions.

**075224 SYNTHESIS OF CARBON-11 LABELLED DIAZOMETHANE.** This work describes a method of synthesis of  $[^{11}\text{C}]$ diazomethane from  $[^{11}\text{C}]$ methane.  $[^{11}\text{C}]\text{CH}_4$  produced by irradiation of a  $\text{N}_2$ -5%  $\text{H}_2$  mixture with 20 Mev protons is converted into  $[^{11}\text{C}]\text{chloroform}$  by chlorination on pumice stone impregnated with  $\text{CuCl}_2$  at  $310^\circ\text{C}$ . The  $[^{11}\text{C}]\text{chloroform}$  reacts with hydrazine and potassium hydroxide in ethanol. The yield of the synthesis and the specific activity of  $[^{11}\text{C}]$ diazomethane are measured by formation of the methyl ester of 3-nitrobenzoic acid. Thirty percent of  $[^{11}\text{C}]$ methane is transformed into diazomethane 10 min after the end of bombardment. The specific radioactivity is 92-130 GBq/ $\mu\text{mol}$  (2.5-3.5 Ci/ $\mu\text{mol}$ ). (Author abstract) 5 refs.

Crouzel, C. (CEA, Orsay, Fr); Amano, R.; Fournier, D. *Appl Radiat Isot* v 38 n 8 1987 p 669-670.

**075225 MICHAEL ADDITION OF  $\beta$ -DICARBONYLS TO  $\alpha,\beta$ -UNSATURATED KETONES CATALYZED BY MIXED SPHERE  $\beta$ -CARBONYLENO-LATE DIPHOSPHINO METAL COMPLEXES.** The addition reaction of  $\beta$ -dicarbonyls to Michael acceptors is catalyzed by  $[\text{M}(\text{acac})_2]$  and  $[\text{M}(\text{acac})(\text{diphosphine})]^+$  complexes ( $\text{M} = \text{Ni}, \text{Cu}, \text{Pd}$ ) in the 60-120°C temperature range. The catalysts exhibit yields and selectivities towards the relevant Michael adduct generally superior to those given by the usual basic catalysts. The catalytic activity depends on the nature of M, and decreases in the order  $\text{Ni} > \text{Cu} > \text{Pd}$ . Catalytic activity of  $[\text{Ni}(\text{acac})(\text{dppe})]^+$  is maintained when the catalyst is anchored to an insoluble polymeric matrix. (Edited author abstract) 16 refs.

Basato, M. (CNR, Padua, Italy); Corain, B.; de Roni, P.; Favero, G.; Jaforte, R. *J Mol Catal* v 42 n 1 Sep 1987 p 115-125.

**075226 MOLECULAR MECHANISMS OF MTBE SYNTHESIS ON A SULPHONIC ACID ION EXCHANGE RESIN.** Molecular mechanisms of methyl t-butyl ether (MTBE) synthesis by methanol addition to isobutene in the gaseous and liquid phases are presented as an example of general and specific acid catalysis by sulfonated ion exchange resins, respectively. As an example of general acid catalysis, a concerted mechanism with a cyclical intermediate of six centers is proposed for this reaction in gaseous phase. It is based on the LHHW kinetic model determined for the reaction that explains rate data in a statistically significant fashion. Analysis of the significance of the LHHW model shows that it is thermodynamically consistent. Therefore, we can assume that the kinetic model is a simplified picture of the molecular process. (Edited author abstract) 39 refs.

Tejero, J. (Univ of Barcelona, Barcelona, Spain); Cunill, F.; Iborra, M. *J Mol Catal* v 42 n 2 Oct 1987 p 257-268.



**075227 SYNTHESIS OF AMINOANTHRAQUINONES BY HYDROGENATION OF THE CORRESPONDING NITRO DERIVATIVES.** In this work hydrogenation of nitroanthraquinones was studied in the presence of a palladium complex with an aminated chloromethylated copolymer of styrene with divinylbenzene (A), with palladium content of 1 mass %. Experimental data indicate that the rate of NAQ hydrogenation in ethanol is practically independent of the ratio. Thus, the influence of solvent adsorption on the hydrogenation of nitroanthraquinones to a first approximation can be disregarded. It is shown that the most suitable solvents for NAQ hydrogenation are alcohols and DMF. The reaction proceeds much more poorly in nonpolar aromatic hydrocarbons. A catalyst was also found which is capable of reducing all nitrogroups in nitroanthraquinones was obtained, substantially simplifying purification and isolation of 1-AAQ, since the separation and purification of aminoanthraquinones is substantially easier than nitroanthraquinones. 10 refs.

Nasibulin, A.A. (Ivanovo State Univ, USSR); Klyuev, M.V. *J Appl Chem of USSR* v 59 n 12 pt 1 Dec 1986 p 2417-2420.

**075228 VAPOR-LIQUID EQUILIBRIUM IN BINARY SYSTEMS FORMED BY PRODUCTS OF THE SYNTHESIS OF EPICHLOROHYDRIN BY THE EPOXIDATION OF ALLYL CHLORIDE BY tert-BUTYL HYDROPEROXIDE.** To determine the possibility of isolating epichlorohydrin from the reaction mixture by the usual fractional distillation, we studied the vapor-liquid equilibrium in binary systems formed by epichlorohydrin with di-tert-butyl peroxide, isopropylbenzene, and isobutyric acid at  $P_{\text{still}} = 15.996$  kPa (120.0 mm Hg) and in the methanol-epichlorohydrin system at  $P = 101.308$  kPa (760.0 mm Hg). The experimental data on phase equilibrium in binary systems formed by epichlorohydrin with methanol, di-tert-butyl peroxide, isopropylbenzene, and isobutyric acid, checked according to the Van Ness method are presented. The experiments have established that all the indicated systems possess positive deviations from Raoult's law. In the di-tert-butyl peroxide-epichlorohydrin system, the presence of an azeotrope with minimum boiling point 51.15°C ( $P = 15.996$  kPa), containing 59.0% mole % of di-tert-butyl peroxide and preventing the isolation of epichlorohydrin in pure form under these conditions, was established. 13 refs.

Denisova, I.V. (Yaroslavl Polytechnic Inst, USSR); Karavaeva, A.P.; Bobylev, B.N.; Remyantseva, T.K. *J Appl Chem of USSR* v 59 n 12 pt 1 Dec 1986 p 2456-2459.

**075229 COBALT-CATALYZED SYNTHESIS OF PYRIDINES FROM 1-ALKYNES AND NITRILES: SUBSTRATE STRUCTURE AND REGIOSELECTIVITY.** A 3,5-trisubstituted pyridine has been carried out of the influence exerted by the substrate structure on the regioselectivity of the synthesis of trisubstituted pyridines by cycloaddition of 1-alkynes (R-CCH) and nitriles (R'-CN) catalyzed by the complexes  $[\text{CoCp}^*(\text{C}_2\text{H}_4)_2]$ , (IVa) ( $\text{Cp}^* = \eta^5\text{-C}_5\text{H}_5$ ) and (IVb) ( $\text{Cp}^* = \eta^5\text{-C}_5\text{Me}_5$ ). In most cases two isomers, i.e., the 2,4,6- and 2,3,6-trisubstituted pyridines, form, whose distribution depends upon the steric and electronic effects induced by R and R'. From highly sterically hindered alkynes and nitriles only the 2,4,6-trisubstituted isomer is formed. When R is a strong electron-withdrawing group (COOMe), the 2,3,5-trisubstituted pyridine is formed in addition to the 2,4,6- and 2,3,6-trisubstituted ones, whose distribution can be varied by altering the steric features of nitriles. (Author abstract) 12 refs.

Diversi, Pietro (Univ di Pisa, Pisa, Italy); Ingrosso, Giovanni; Lucherini, Antonio; Vanacore, Dario. *J Mol Catal* v 41 n 3 Aug 1987 p 261-270.

**075230 ELECTROSYNTHESIS OF ORGANIC COMPOUNDS: XII. SYNTHESIS OF SOME ARYLACETYLACETONE DERIVATIVES.** Electrosynthesis of some arylacetylacetone derivatives was carried out via the anodic oxidation of acetylacetone in absolute methanol containing 0.8 gm atom/e-v sodium metal in the

presence of selected aromatic compounds (benzene, toluene, o-xylene, naphthalene and anthracene) on platinum anode under controlled anodic potential value of  $+1.1 \pm 0.03$  v vs SCE at 20°C. The synthesized compounds were 3-phenyl 2,4-pentanedione, 3-(p-tolyl) 2,4-pentanedione, 3-(o-xylol) 2,4-pentanedione, 3-( $\alpha$ -naphthyl) 2,4-pentanedione and 3-(9-anthryl) 2,4-pentanedione. In addition, a small amount of dimerised and polymerized products was obtained. (Edited author abstract) 14 refs.

Ismail, M.T. (Assiut Univ, Assiut, Egypt). *J Electrochem Soc India* v 36 n 3 Jul 1987 p 161-164.

**075231 SYNTHESIS AND POLAROGRAPHIC BEHAVIOUR OF BENZOTHIAZOLYLAZOPYRIMIDINES.** The present paper deals with the synthesis and polarographic behavior of some benzothiazolylazopyrimidines. Synthesis of these compounds have been achieved by the condensation of 2-ABT(s) with 4-methyl-2-thiouracil and 6-hydroxy-4-methyl-2-methylthiopyrimidine. Their structures have been established on the basis of IR and NMR spectral studies. Polarographic studies were carried out in N,N-dimethylformamide. This work is of interest to biochemistry. (Edited author abstract) 15 refs.

Jain, Rajeev (Jiwaji Univ, Gwalior, India); Pandey, Pratibha. *J Electrochem Soc India* v 36 n 3 Jul 1987 p 179-183.

**075232 SYNTHESIS AND BIOLOGICAL ACTIVITY OF DICHLOROMALEIC ACID DERIVATIVES.** Dichloromaleic acid and its anhydride are widely used in production of herbicides and fungicides. In this investigation the authors used dichloromaleic anhydride (I) for synthesizing 2,3-dichloro-N-cyclohexylmaleamic acid (II) and its derivatives for evaluation of the biological activity of compounds of this series. The characteristics of the synthesized compounds are given and their structures were confirmed by IR and NQR  $^{35}\text{Cl}$  spectroscopy. A characteristic feature of the NQR  $^{35}\text{Cl}$  spectra of compounds (IV)-(VIII) is the lower region of the resonance frequencies of the  $^{35}\text{Cl}$  nucleus in comparison of the maleamic acid (II) itself; this is evidently due to the excess electron density on the anion and increase of the ionic character of the C-Cl bond. It was found that all the synthesized compounds acted as disinfectants. 3 refs.

Shagas, G.G.; Valitov, R.B.; Zlot-skii, S.S.; Davletshina, A.M. *J Appl Chem USSR* v 60 n 1 pt 2 Jan 1987 p 214-216.

**075233 BISACETALS OF AROMATIC DIOLS WITH TERMINAL ETHNYL GROUPS.** The authors have synthesized bisacetals of aromatic diols with ethynyl terminal groups by selective addition of hydroxy- and bisphenols at the double bond of the vinyl 2-propynyl diether of ethylene glycol (I). The synthesized ethynyl bisacetals (II)-(VI) are nondistillable liquids of moderate or low viscosity, ranging from colorless to dark, and capable of spontaneous hardening during prolonged storage, with formation of cross-linked polymers. Their physicochemical characteristics and the experimental conditions are given. Because of the quantitative yields of the products and the technological effectiveness and high selectivity of the process, it can be regarded as a promising route to synthesis of various ethynyl monomers from the readily available vinyl 2-propynyl diethers of glycols and various hydroxy compounds. This work is pertinent to polymer synthesis. 11 refs.

Trofimov, B.A. (Acad of Sciences of the USSR, USSR); Parshina, L.N.; Nedolya, N.A.; Lavrov, V.I. *J Appl Chem USSR* v 60 n 1 pt 2 Jan 1987 p 225-227.

**075234 STUDY OF PRODUCTION OF ALKYL-PYRIDINES BY HETEROGENEOUS-CATALYTIC CONDENSATION OF ACETYLENE AND AMMONIA.** The purpose of this work was to study the principal kinetic relationships of formation of 2- and 4-methylpyridines from acetylene and ammonia under atmospheric pressure on a supported zinc-cadmium catalyst, intended for use in formulation of a mathematical model of the action of a displacement reactor with a fixed catalyst bed. The authors kinetic data were used for formulating the

mathematical model of acetylene conversion, taking into account deactivation of the catalyst with time. The model consists of the material-balance equation for acetylene and an equation describing deactivation of the catalyst. Operation of the apparatus in which 2-methylpyridine is produced can be represented by a steady-state model with ideal displacement, as its length is much greater than its diameter ( $L/D > 20$ ), and back-mixing through the catalyst bed does not occur. The condensation reaction is accompanied by decrease of volume, which leads to change of velocity of the gas phase along the reactor. Deactivation of the catalyst occurs during the process as the result of deposition of macromolecular and carbonaceous products on its surface. 9 refs.

Vasil'ev, L.P. (Acad of Sciences of the USSR, USSR); Pechatnikov, E.L.; Popov, E.A.; Shatunova, E.N.; Sheshtakov, G.K. *J Appl Chem USSR* v 60 n 2 pt 2 Feb 1987 p 339-342.

**075235 SYNTHESIS AND PROPERTIES OF N-( $\beta$ -ALKYLTHIOETHYL) SUCCINIMIDES.** The authors have synthesized and characterized N-( $\beta$ -alkylthioethyl) succinimides and studied their inhibiting activity against hydrogen sulfide corrosion of steel oil-well equipment. They first synthesized the corresponding alkyl  $\beta$ -hydroxyethyl sulfides by the reactions of thiols with 2-chloroethanol in presence of alkali. Alkyl  $\beta$ -chloroethyl sulfides were then synthesized by the reactions of alkyl  $\beta$ -hydroxyethyl sulfides with thionyl chloride. N-( $\beta$ -alkylthioethyl)succinimides were synthesized by the reaction of sodium succinimide with alkyl  $\beta$ -chloroethyl sulfides in presence of isopropyl alcohol. The structures of the synthesized compounds were examined by IR spectroscopy while the purity was verified by elemental analysis and thin-layer and gas-liquid chromatography. The authors' investigation showed that they inhibit hydrogen sulfide corrosion of steel considerably, and that their inhibiting activity depends significantly on their structure. 9 refs.

Allakhverdiev, M.A. (S. Agamaliogly Agricultural Inst, USSR); Kurbanov, K.B.; Omarov, Sh. M.; Guseinova, Ya.T. *J Appl Chem USSR* v 60 n 2 pt 2 Feb 1987 p 422-425.

**075236 LIQUID CHROMATOGRAPHIC OPTIMIZATION OF REACTION CONDITIONS FOR THE SYNTHESIS OF 2,2-DIMETHYL-N-BENZYL-MALONAMIDE, A NEW ANTICONVULSANT.** Reversed-phase liquid chromatographic (RP/LC) procedures are used to optimize the reaction conditions for the large scale preparation of 2,2-dimethyl-N-benzylmalonamide, 1. In acute studies using mice and rats, compound 1 is a very effective anticonvulsant agent. Large quantities of 1 (ca. 300 g) are needed for detailed studies of its chronic effects. LC monitoring of the synthesis of intermediate products and 1 result in the optimum use of reagents, increased product yields, and decreased reaction times. (Author abstract) 5 refs.

McMillian, Carl L. (Auburn Univ, Auburn, AL, USA); DeRuiter, Jack; Clark, C. Randall. *J Chromatogr Sci* v 25 n 11 Nov 1987 p 510-513.

**075237 MALEIC ANHYDRIDE CONVERSION BY V-P-O CATALYSTS.** The vapor phase conversion of maleic anhydride was studied using two model vanadium-phosphorus-oxygen (V-P-O) catalysts,  $\beta$ -VOPO<sub>4</sub> and (VO)<sub>2</sub>P<sub>2</sub>O<sub>7</sub>, and a series of industrial-type catalysts having P-to-V ratios of 0.9, 1.0, 1.1 and 1.2. Maleic anhydride was fed directly to an integral flow reactor using a molten maleic anhydride saturator system. Direct evidence for the combustion of maleic anhydride has been observed with the simultaneous production of maleic acid. The conversion of maleic anhydride increased with temperature, oxygen partial pressure, and residence time. The



incorporation of 'excess' phosphorus in industrial catalysts suppressed maleic anhydride combustion by stabilizing the  $(VO)_2P_2O_7$  phase. (Author abstract) 8 refs.

Moser, T.P. (US DOE, Ames, IA, USA); Wenig, R.W.; Schrader, G.L. *Appl Catal* v 34 n 1-2 Oct 15 1987 p 39-48.

**075238 SYNTHESIS OF HYDROXYAPATITE FROM RICE BRAN AS STARTING MATERIALS.** A hydroxyapatite (Hap) has been synthesized using as a P-source phytin contained in rice bran. Phytin was extracted from oilseed rice bran of 10g by a NaOH solution of 0.01N and 60°C. CaO of 2.0g was then added to the filtrate containing phytin to obtain precipitate. After rinsing and drying, the precipitate was finally fired in an electric furnace of 1000°C for 3 hours to obtain Hap powder of 0.8g. (Edited author abstract) 6 refs. In Japanese.

Matsumoto, Yoshitaka (Ritsumeikan Univ, Kyoto, Jpn); Yamagishi, Jun-ichi; Yamada, Fumiaki; Kaneko, Yasunari; Iwasaki, Hiromichi. *Chem Express* v 2 n 10 Oct 1987 p 655-658.

**075239 COMPLEXES WITH SUBSTITUTED 2,5-DIHYDROXY-P-BENZOQUINONES: THE INCLUSION COMPOUNDS  $[Y(H_2O)_3]_2(C_6Cl_2O_4)_3 \cdot 6H_2O$  AND  $[Y(H_2O)_3]_2(C_6Br_2O_4)_3 \cdot 6H_2O$ .** Single crystals of  $[Y(H_2O)_3]_2(C_6Br_2O_4)_3 \cdot 6H_2O$  and  $[Y(H_2O)_3]_2(C_6Cl_2O_4)_3 \cdot 6H_2O$  were grown in aqueous. The compounds are in principle isostructural. In Y chloranilate one additional water site is occupied as verified by X-ray single crystal structure analysis.  $Y^{3+}$  is nine-coordinated by three water molecules and six oxygen atoms of the bischelating  $(C_6X_2O_4)^{2-}$  ions ( $X=Cl, Br$ ). The coordination polyhedron is an only slightly distorted tri-capped trigonal prism. The connection of  $Y^{3+}$  with the dianions leads to infinite, corrugated layers. The layer stacking yields cage-like cavities in which water molecules are accommodated. Hydrogen bonds interlink adjacent layers. Further hydrogen bonds involve the entrapped water molecules. Differential scanning calorimetry measurements indicated a complicated dehydration process which caused destruction of the single crystals right from the start. (Edited author abstract) 17 refs.

Robl, Christian (Univ Muenchen, Munich, West Ger). *Mater Res Bull* v 22 n 11 Nov 1987 p 1483-1491.

**075240 SYNTHESIS OF ANISOLE BY LEWIS ACID CATALYZED DECARBOXYLATION OF METHYL PHENYL CARBONATE.** The authors report that methyl phenyl carbonate (MPC) can be decarboxylated to anisole using a Lewis acid catalyst. Dimethyl carbonate and diphenyl carbonate, resulting from disproportionation of MPC,  $CO_2$  and sometimes a small amount of phenol were also produced and characterised. The nature of the substituent on aluminum plays a vital role in both the conversion and selectivity of this reaction. The fact that diphenyl carbonate is formed with 45% selectivity when  $AlCl_3$  is used as a catalyst emphasizes the versatility of the new aluminum-based systems reported. 5 refs.

Braunstein, Pierre (CNRS, Strasbourg, Fr); Lakkis, Mohammed; Matt, Dominique; Lecolier, Serge. *J Mol Catal* v 42 n 3 Nov 2 1987 p 353-355.

**075241 SYNTHESIS OF RACEMIC, OPTICALLY PURE AND PARTIALLY OPTICALLY ACTIVE 2-(2-METHYL-3-OXO-3-PHENYLPROPYL)BENZALDEHYDE AND DETERMINATION OF ITS ABSOLUTE CONFIGURATION.** Racemic and optically active 2-(2-methyl-3-oxo-3-phenylpropyl)benzaldehyde 1 has been synthesized. Starting from 2-benzylpropanoic acid with known optical purity, optically pure 1 was prepared and the maximum rotation and absolute configuration of 1 were determined. Partially optically active 1 was prepared, starting with an asymmetric synthesis, using a 1,4-addition of benzylmagnesium chloride to methyl crotonate, in a optical yield of 30%. (Edited author abstract) 20 refs.

Meurling, Anita (Univ of Uppsala, Uppsala, Swed). *Chem Scr* v 27 n 3 Sep 1987 p 349-354.

**075242 CHLORINE-SUBSTITUTED PYRIMIDINYL-FORMAZANES.** The reaction of 4-chloropyrimidinyl-6-hydrazines of acetaldehyde, benzaldehyde, and p-chlorobenzaldehyde with arylidiazonium salts yielded 1-(4-chloropyrimidinyl-6)-3-methyl(aryl)-5-arylformazanones. Some of their properties, structure, and electronic and IR spectra were studied. (Author abstract) 7 refs.

Nasyr, I.A.; Ovchinnikov, V.G.; Bobrova, O.B.; Cherkasov, V.M. *Sov Prog Chem* v 53 n 2 1987 p 98-100.

**075243 PREPARATION OF A CARBON-11 LABELLED NEUROHORMONE -  $[^{11}C]$ MELATONIN.** Melatonin, a hormone of the pineal gland, has been labelled with the positron-emitting radionuclide, carbon-11 ( $t_{1/2}=20.4$  min), for study in vivo by positron emission tomography. Thus a novel labelling agent,  $[^{11}C]$ acetyl chloride, was prepared by the carbonation of methylmagnesium bromide with cyclotron-produced  $[^{11}C]$ carbon dioxide followed by treatment with phthaloyl dichloride. Acylation of 5-methoxytryptamine then affords  $[^{11}C]$ melatonin, which is purified by HPLC and formulated for intravenous injection. The preparation requires 35 min from the end of radionuclide production. It provides  $[^{11}C]$ melatonin in 13% radiochemical yield (decay-corrected from  $^{11}CO_2$ ) and in high specific activity. Radiochemical and chemical purity were demonstrated by HPLC and TLC. The validity of the radiosynthesis was also confirmed by a parallel synthesis of  $[^{13}C]$ melatonin and examination of the product by  $^{13}C$ -NMR spectroscopy and mass spectrometry. (Author abstract) 20 refs.

Le Bars, D. (Hammersmith Hospital, London, Engl); Luthra, S.K.; Pike, V.W.; Luu Duc, C. *Appl Radiat Isot* v 38 n 12 1987 p 1073-1077.

**075244 CATALYTIC REARRANGEMENT OF TRIS-(2-SUBSTITUTED-2-PROPENYL) CYANURATES.** Allyl esters of cyanuric and isocyanuric acids are widely used as cross-linking additives in order to confer thermal stability and heat resistance on polymeric materials. This paper is concerned with the synthesis and rearrangement of tris-(2-methyl-2-propenyl) (I), tris-(2-fluoro-2-propenyl) (II) and tris-(2-chloro-2-propenyl) (III) cyanurates. Experiments show that introduction of a substituent in position 2 of the allyl group retards the rearrangement reaction in comparison with triallyl cyanurate. 10 refs.

Klenovich, S.V.; Pashkina, E.P.; Likhterov, V.P.; Tsareva, L.A.; Etlis, V.S. *J Appl Chem USSR* v 60 n 3 pt 2 Mar 1987 p 621-623.

**075245 CURRENT EFFICIENCY LOSSES IN INDIRECT ELECTROCHEMICAL PROCESSING.** There is considerable industrial interest in the indirect two-stage electrochemical process ('ex-cell' process) for the synthesis of organic compounds. One reason why this process has not become common is the loss in current efficiency observed in working processes due to organic matter present in the recycled electrolyte. In previous work it has been found that the loss in current efficiency using the  $Mn^{2+}/Mn^{3+}$  system in 88%  $H_2SO_4$  was due to the oxidation of the organic compounds (mainly to  $CO_2$ ) carried over with the electrolyte back to the electrochemical cell. In this work we extend the study in 50% w/w  $H_2SO_4$  and a simple relation is proposed which permits the calculation of the loss in current efficiency from the total organic carbon present in the recycled electrolyte. 6 refs.

Comninellis, Ch. (ETH, Lausanne, Switz); Plattner, E. *J Appl Electrochem* v 17 n 6 Nov 1987 p 1315-1318.

**075246 SYNTHESIS AND THERMAL CHARACTERISTICS OF NEW SULPHUR-CONTAINING BIS-MALEIMIDES.** New sulphur-containing aromatic bis-maleimides were synthesized, with various spacing between the reactive maleimide groups, and their thermal characteristics were determined in dependence on the length of the phenylsulphide fragment. By the methods of dynamic thermal analysis and of dynamic mechanical analysis it was found that the polymerization of the bis-maleimide double bonds occurs above  $T_m$  of the

crystalline and above  $T_g$  of the amorphous oligomeric bis-maleimides. In studies of the temperature dependences of  $E'$ ,  $E''$  and  $\tan \delta$  with bis-maleimides in a cardiac polyimide matrix, alignment of the bis-maleimides in a cardiac polyimide matrix, alignment of the bis-maleimide with the polymer matrix was revealed. (Edited author abstract) 20 refs.

Sergeyev, V.A. (USSR Acad of Sciences, USSR); Nedel'kin, V.I.; Yufarov, Ye.A.; Nikol'skii, O.G.; Askadskii, A.A.; Slonimskii, G.L.; Yorz, B.V. *Polym Sci USSR* v 28 n 9 1986 p 2141-2151.

**075247 SYNTHESIS AND REACTIONS OF SUBSTITUTED ACROLEINS.** In this work we examined methods for obtaining 2-alkylacroleins and their derivatives that would render these compounds as cheap and readily available products of organic synthesis. Using aldehydes we show that ethylene glycol, glycerin, and pentaerythritol in the presence of acid catalysts react primarily at the carbonyl group. Maximal yields (50-80%) were obtained when using the cation exchanger KU-2 as the acid catalyst, which also simplified the isolation of the desired products. The 2-alkyl-1,3-dioxacyclanes obtained are of particular interest as monomers, comonomers, and intermediate products of organic synthesis. 14 refs.

Saprygina, V.N.; Zlot'skii, S.S.; Rakhmankulov, D.L. *J Appl Chem USSR* v 60 n 4 pt 2 Apr 1987 p 862-866.

**075248 KONTROLLE DER PROZESSPARAMETER BEI DER ALLYLCHLORIDSYNTHESE. [Control of Allyl Chloride Synthesis Parameters].** Theoretical equation of the thermal-material balance of an allyl chloride synthesis reactor is derived and its solutions are given. The method of theoretical balance adjustment to measured values of process parameters is described, as well as simple correlations of basic process parameters that permit easy control of measuring instrument indications and the synthesis process. (Edited author abstract) In German. 10 refs.

Stajczyk, Manfred (Inst fuer Organische Synthese 'Blachownia', Kedzierzyn-Kozle, Pol); Spadlo, Marian; Wasilewski, Jerzy; Madej, Wladyslaw. *Chem Tech (Leipzig)* v 39 n 11 Nov 1987 p 484-487.

**075249 CONTINUOUS METHOD FOR PREPARATION OF  $C_{14}$ - $C_{18}$  AND  $C_{17}$ - $C_{20}$  SYNTHETIC FATTY ACID NITRILES.** The aim of this investigation was to develop a highly efficient catalytic process for the synthesis of synthetic fatty acid nitriles which would enable us to completely automate the engineering process and to obtain the desired end product in a high yield while avoiding the vacuum distillation stage. Experiments indicate that nitriles obtained from  $C_{14}$ - $C_{18}$  and  $C_{17}$ - $C_{20}$  fractions of synthetic fatty acids do not require vacuum distillation. The rate of nitrilation reaction is determined by the rate of desorption of the reaction water from active centers on the catalyst. 6 refs.

Bizhanov, F.B.; Ayazbaev, E.Kh.; Shubin, V.P.; Prnazarov, Zh. *J Appl Chem USSR* v 60 n 5 pt 2 May 1987 p 1110-1112.

**075250 PREPARATION OF NEW INTERCALATION COMPLEXES OF n-ALKYLAMINES WITH  $FeMoO_4Cl$  AND ELECTROCHEMICAL LITHIATION OF  $FeMoO_4Cl$ .** Organic derivatives of  $FeMoO_4Cl$  have been synthesized by reaction of n-alkylmonoamines on  $FeMoO_4Cl$ . The n-alkylmonoamine molecules form bilayers at room temperature with average chemical composition  $FeMoO_4Cl \cdot 1.7C_nH_{2n+1}NH_2$  ( $4 \leq n \leq 18$ ). The basal spacing depends upon the alkyl chain length and can be represented by a linear regression. From electrochemical lithium intercalation in  $FeMoO_4Cl$ ,  $LiFeMoO_4Cl$  has been obtained, it is consistent with the  $FeMoO_4Cl$  structure. Correlation between reduction rate,



structural phase transformation (tetragonal  $\rightarrow$  monoclinic) and variation of Fe-site symmetry ( $C_{4v} \rightarrow D_{4h}$ ) is discussed. (Edited author abstract) 23 refs.

Choy, Jin-Ho (Seoul Natl Univ, Seoul, South Korea); Noh, Dong-Youn; Park, Jung-Chul; Chang, Soon-Ho; Delmas, Claude; Hagemuller, Paul. *Mater Res Bull* v 23 n 1 Jan 1988 p 73-86.

**075251 SYNTHESIS OF ETHYLAMINE WITH A cw TUNABLE CO<sub>2</sub> LASER.** The successful synthesis of ethylamine with a cw tunable CO<sub>2</sub> laser is reported. This action occurs at normal pressure ( $\approx 5.32 \times 10^4$  Pa) and temperature ( $< 100^\circ\text{C}$ ). No catalyst is used. The experiment shows a high directionality of this reaction. No other product except ethylamine is yielded. A possible mechanism for this reaction is discussed. (Author abstract) 9 refs.

Sun, Mengjia (Shanxi Univ, Taiyuan, China); Yu, Weng-qian; Li, Mingjian; Feng, Xiaopeng. *Appl Phys B* v B45 n 2 Feb 1988 p 83-86.

**075252 KINETICS OF THE SYNTHESIS OF BISPHENOL A.** The kinetics of the synthesis of bisphenol A from acetone and phenol on an ion-exchange catalyst promoted by partial neutralization of acid groups with 2-mercaptoethyl amine was investigated in the temperature range 50-85°C. A Langmuir-Hisheewood type rate equation was used for treatment of the experimental data. The rate constant and the adsorption coefficient of water as the reaction product are temperature dependent, while the adsorption coefficient of phenol and acetone can be regarded as constants within the given range of temperatures. The effect of adsorption of bisphenol A need not be included in the kinetic equation. The effect of the reverse reaction is apparent at temperatures higher than 70°C. The equation thus obtained may be used in a description of integral data up to high conversions. (Author abstract) 7 refs.

Jerabek, K. (Czechoslovak Acad of Sciences, Prague, Czech); Odnova, J.; Setinek, K. *Appl Catal* v 37 n 1-2 Feb 15 1988 p 129-138.

**075253 STUDY OF THE SYNTHESIS OF FLUORESCAMINE.** A shortened and improved route to the synthesis of fluorescamine is presented in this paper. Starting with diethylphthalate as raw material, the authors have prepared fluorescamine and its derivative, p-chlorofluorescamine, through condensation, epoxidation, ring cleavage, and spirocyclization in six steps instead of seven. The yield of the former has been raised to 15.8%, thus bringing about a two-fold increase over that reported in the literature and a considerable reduction in its production cost. (Edited author abstract) In Chinese. 9 refs.

Wang Fan; Chen Yangsan; Dong Lifan. *Huadong Huagong Xueyuan Xuebao* v 14 n 1 1988 p 53-58.

**075254 CYCLOBUTANEDIYLS: A NEW CLASS OF LOCALIZED BIRADICALS. SYNTHESIS AND EPR SPECTROSCOPY.** Nine triplet cyclobutanediyls (I) have been synthesized and observed by matrix isolation EPR spectroscopy. The zero-field splitting (zfs) parameters provide detailed information on the spin densities in these structures. The observed zfs values can be quantitatively modeled by using a straightforward semiempirical scheme, as long as one explicitly incorporates the spin polarization effects known to be important in radicals such as allyl and benzyl. In addition, interpretable hyperfine coupling (hfc) has been observed in many cyclobutanediyls. Spectral simulation produces the hfc constants, which provide further information on spin distribution and indicate that the four-membered ring in I is planar. (Edited author abstract) 56 refs.

Jain, Rakesh (California Inst of Technology, Pasadena, CA, USA); Sponsler, Michael B.; Coms, Frank D.; Dougherty, Dennis A. *J Am Chem Soc* v 110 n 5 March 1988 p 1356-1366.

**075255 PREPARATION AND DETERMINATION OF THE COMPLEXING ABILITY OF N-BENZYL**

**DERIVATIVES OF METHIONINE.** To study the possibility of their use as passivators of metals in polyolefins, we synthesized a series of N-benzyl derivatives of methionine (I) and studied their complexing ability in the presence of Cu<sub>2</sub>Cl<sub>2</sub>. The data show that the synthesized compounds can react with copper ions with complexation, and, therefore, these compounds can be used as passivators of copper in a polymer. In a test in polypropylene films in the presence of 10% copper filings the synthesized compounds behaved as passivators. Thus, the time to onset of brittleness during aging at 150° in a thermal hood was 8-10 h for the film without the passivator additive and 29, 37, 31, and 46 h for films with 0.5% additions of products Ia-Ic, respectively. 2 refs.

Kiro, Z.B. (Scientific-Research Inst of Chemicals for Polymer Materials, USSR); Volkotrub, M.N.; Markushkevskaya, K.V.; Nazarov, A.A.; Paramonov, V.I. *J Appl Chem USSR* v 60 n 6 pt 2 Jun 1987 p 1353-1354.

**075256 INSPECTION OF CORROSION IN EQUIPMENT FOR THE SYNTHESIS OF HYDROXYLAMINE SULFATE.** In connection with the need to build domestic plants for the synthesis of hydroxylamine sulfate and to choose corrosion-resistant construction materials perfected by production for their manufacture, a series of research studies was carried out, including repeated inspections of operating equipment. After eighteen months of operation of the reactors, the condition of the body metal and internally installed systems was satisfactory. The corrosion rate of control samples made of 03Kh21N21M4GB sheet steel of different casts installed in the first reactors was not more than 0.001 mm/year. The change in thickness of the walls of the coil was not recorded. The results of the inspection confirm the correctness in choosing steel as the main construction material for the bodies of reactors for the synthesis of hydroxylamine sulfate and the feasibility of using 10Kh17 N13M2T steel for the internal systems of the reactors. 9 refs.

Flerova, N.G.; Chizhenko, D.L.; Shishkin, A.V.; Pryatnikova, T.V.; Yakovlev, V.P. *Chem Pet Eng* v 23 n 5-6 May-Jun 1987 p 236-237.

**075257 NEAR-INFRARED ELECTROPHOTOGRAPHIC PHOTORECEPTOR INCORPORATING A HYDROXY SQUARINE.** The synthesis and xerographic evaluation of bis(4-dimethylamino-2-hydroxy-6-methylphenyl) squaraine (HMS) is described. Significant photosensitivity enhancement is observed upon addition of certain phenols during the synthesis of the squaraine. Negatively charged dual layer photoreceptor devices incorporating doped HMS are characterized by excellent xerographic properties such as low dark decay ( $< 50$  V/sec), high white light and IR sensitivity ( $E_{70} \approx 5$  ergs/cm<sup>2</sup> at 830 nm) and good short-term cycling stability. The effect of charge generator layer thickness, pigment loading and nature of the polymer binder are discussed. (Author abstract) 14 refs.

DiPaola-Baranyi, G. (Xerox Research Cent of Canada, Mississauga, Ont, Can); Hsiao, C.K.; Kazmaier, P.M.; Burt, R.; Loutfy, R.O.; Martin, T.I. *J Imaging Sci* v 32 n 2 Mar-Apr 1988 p 60-64.

**075258 NOVEL SYNTHESIS OF ISOTHIOCYANATES FROM AMINES USING TRIPHENYLPHOSPHINE/CARBON TETRACHLORIDE.** The authors describe an efficient and simple method for conversion of amines into isothiocyanates via dithiocarbamates, which are readily available from carbon disulfide and amines under mild condition. Two procedures, a one-pot method and a two-step method including the isolation of the dithiocarbamates, were examined to convert amines into isothiocyanates. Triethylammonium dithiocarbamate (RNHC(S)/S-HNEt<sub>3</sub>), which we prepared from aliphatic and/or aromatic amines, carbon disulfide and triethylamine, were treated with triphenylphosphine/carbon tetrachloride reagent in acetonitrile at room temperature to give the corresponding isothiocyanates in good yields. (Edited author abstract) 8 refs.

Furukawa, Isao (Doshisha Univ, Kyoto, Jpn); Abe,

Noboru; Hashimoto, Shizunobu. *Chem Express* v 3 n 4 Apr 1988 p 215-218.

**075259 KINETIC STUDY OF THE SUBSTITUTION REACTION OF BENZYL CHLORIDE WITH TRIPHENYLPHOSPHINE TO SYNTHESIZE BENZYLTRIPHENYLPHOSPHONIUM CHLORIDE. SOLVENT EFFECTS.** Triphenylphosphine (TP) and benzyl chloride (BC) undergo S<sub>N</sub>2 substitution reaction to produce benzyltriphenylphosphonium chloride (BTTPC). The effects of solvent, reactant concentration, agitation rate, and temperature on the conversion rate are investigated in order to find the optimum operating conditions for this reaction. It is found that no agitation effect is observed when the agitation rate exceeds 700 rpm. The order of relative activities of solvents is methanol > acetic acid > dichloromethane > acetone > ether > benzene > toluene. In methanol, the conversion can be as high as 100% with respect to TP when BC is in great excess. The second-order rate constant at 30°C for the BC-TP reaction in methanol is 0.135 M<sup>-1</sup> h<sup>-1</sup>. (Edited author abstract) 14 refs.

Wang, Maw-Ling (Natl Tsing Hua Univ, Hsinchu, Taiwan); Liu, An-Hong; Jwo, Jing-Jer. *Ind Eng Chem Res* v 27 n 4 Apr 1988 p 555-559.

**075260 STRATEGY AND ALGORITHMS IN THE THERMODYNAMIC ANALYSIS OF THE EQUILIBRIUM IN THE INDUSTRIAL SYNTHESIS OF CARBAMIDE.** The authors present a strategy for calculating the equilibrium constants in the synthesis if the melt is considered as a nonideal solution. Wilson's equation has been used in an algorithm for calculating the phase-equilibrium constants for free ammonia and water over the liquid. The new relationships for these quantities as functions of temperature agree much better with experiment than those derived previously on the assumption that the molten mixture is ideal. The relationship for the phase-equilibrium constants can be used in calculating the optimum pressure and temperature, as well as for determining the composition of the vapor-gas mixture in the synthesis. 10 refs.

Stateva, R.P.; Kafarov, V.V.; Meshalkin, V.P. *J Appl Chem USSR* v 59 n 6 1 Jun 1986 p 1171-1176.

**075261 SYNTHESIS OF DITHIO(THIO)CARBAMATES OF ACYCLIC DI- AND POLYAMINES.** Alkali and heavy metal dithio(thio)carbamates of polyethylene polyamines were obtained and studied. These carbamates are of interest as complex forming agents, fungicides and stabilizers for polymeric materials. It was found that alkali metal dithio(thio)carbamates of acyclic polyethylenepolyamines form polymeric metal complexes with heavy metal salts. 4 refs.

Zagidullin, R.N. *J Appl Chem USSR* v 60 n 8 pt 2 Aug 1987 p 1706-1714.

**075262 RUTHENIUM-CATALYZED SYNTHESIS OF PIPERAZINES.** An alternate approach to the synthesis of the piperazine ring would be to consider the simple condensation of a 1,2-diol with a 1,2-diamine. In view of the potential pharmaceutical interest of piperazines, we decided to study this reaction in more detail. In a first stage, the catalyst effect on the synthesis of piperazine ( $R_1 = R_2 = R_3 = R_4 = H$ ) from the condensation of ethylene glycol and ethylenediamine was established. It is clear that ruthenium catalysis is essential to the reaction. The best catalyst is Ru<sub>3</sub>(CO)<sub>12</sub>. The presence of a suitable phosphine helps the reaction, the basic uncrowded tri-n-butylphosphine being the most efficient. 8 refs.

Jenner, G. (Univ Louis Pasteur, Strasbourg, Fr); Bitsi, G. *J Mol Catal* v 45 n 2 May 9 1988 p 165-168.

**075263 ACETYLENIC TELLURIDES: SYNTHESIS AND REACTIVITY.** Acetylenic tellurides were prepared by the reaction of lithium phenylacetylide with (p-methoxyphenyl)tellurium bromide or with elemental



tellurium, followed by alkylation of the intermediate lithium phenylacetylenetellurolate with primary or secondary alkyl halides. The acetylenic tellurides can function as either nucleophilic or electrophilic tellurium centers. Reaction of these intermediates with reducing agents, followed by air oxidation, gives dialkyl ditellurides in high yields, along with the tellurium-free phenylacetylene. Reaction of these intermediates with reducing agents under nitrogen, followed by reaction with alkyl halides, furnishes symmetrical and unsymmetrical dialkyl tellurides in high yields. The reaction of acetylenic tellurides with alkyl Grignard or alkyllithium reagents led to the formation of symmetrical or unsymmetrical dialkyl tellurides in good yields. (Author abstract) 24 refs.

Dabdoub, Miguel J. (Univ de Sao Paulo, Sao Paulo, Braz); Comassetto, Joao V. *Organometallics* v 7 n 1 Jan 1988 p 84-87.

**075264 PREPARATION AND POLYMERIZATION OF A NEW TYPE OF STABLE QUINODIMETHANES WITH CAPTODATIVE SUBSTITUENTS: 7,8-BIS(ETHYLTHIO)-, 7,8-BIS(PHENYLTHIO)-, AND 7,8-BIS(TERT-BUTYLTHIO)-7,8-DICYANOQUINODIMETHANES.** The three compounds were successfully prepared as stable crystals at room temperature. Their first reduction potential values were measured in dichloromethane containing tetrabutylammonium perchlorate (0.1 mol/L) by cyclic voltammetry to be  $-0.76$ ,  $-0.61$ , and  $-0.70$  V, respectively. Homopolarizability results are reported. 13 refs.

Iwatsuki, Shouji (Mie Univ, Tsu, Jpn); Itoh, Takahito; Miyashita, Ikuhiro. *Macromolecules* v 21 n 3 Mar 1988 p 557-560.

**075265 SYNTHESIS AND BIODISTRIBUTION OF AN  $^{123}\text{I}$  LABELLED FLUNITRAZEPAM DERIVATIVE: A POTENTIAL IN VIVO TRACER FOR BENZODIAZEPINE RECEPTORS.** A method for the synthesis of no-carrier-added of 7-[ $^{123}\text{I}$ ]iodo-1,3-dihydro-5-(2-fluorophenyl)-1-methyl-2H-1, 4-benzodiazepine-2-one with a radiochemical yield of 25-30% has been developed. This benzodiazepine was prepared by reaction of [ $^{123}\text{I}$ ]iodide with the corresponding piperidyl-triazene in acid medium and the reaction has been optimized for solvent, time and temperature. The triazene was synthesized by reduction of flunitrazepam to the amine, diazotisation and coupling with piperidine. Biodistribution studies of this radioligand in rats showed a maximum brain uptake of 0.35% of the injected dose at 15 min, which decline to 0.02% at 120 min. (Author abstract) 12 refs.

Zecca, Luigi (CNR, Milan, Italy); Ferrario, Paolo. *Appl Radiat Isot* v 39 n 4 1988 p 353-356.

**075266 SYNTHESIS OF 1-PHENYL-2-(4-PYRIMIDINYL)ETHANONE AND RELATED ETHANONES.** Eleven 1-phenyl-2-(4-pyrimidinyl)ethanones were synthesized by the condensation of 4-methylpyrimidine and the requisite methyl benzoate ester with sodium hydride as the condensing agent. Substituents in the 3- and 4-position of the phenyl ring were chloro, dimethylamino, methoxy, methyl, and trifluoromethyl. (Author abstract) 4 refs.

Sund, Eidon H. (Midwestern State Univ, Wichita Falls, TX, USA); Strickland, Stuart Kent. *J Chem Eng Data* v 33 n 2 Apr 1988 p 216-217.

**075267 SYNTHESIS AND CHARACTERIZATION OF FERROCENE BONDING AGENTS.** New bonding agents, viz., 1,1'-(1,1'-ferrocenediyl-diethylidene)bis(thiocarbonylhydrazide) (DAFT), 1,1'-diacetylferrocene dicarbonylhydrazide (DAFS), 1,1'-diacetylferrocene benzoylhydrazide (FDBAH), and 1,1'-diacetylferrocene p-nitrobenzoylhydrazide (FDNBH), have been synthesized and characterized by IR,  $^1\text{H}$  NMR,  $^{13}\text{C}$  NMR, and UV spectroscopic techniques. (Author abstract) 5 refs.

Iyanar, K. (Indian Inst of Science, Bangalore, India); Prema, S.; Kishore, K. *J Chem Eng Data* v 33 n 2 Apr 1988 p 220-221.

**075268 INDIRECT ELECTROCHEMICAL EPOXIDATION OF HEXENE IN A LIQUID-LIQUID ELECTROLYTE.** Preliminary experiments have been carried out on the mediated electrolytic synthesis of 1,2-epoxy-hexane from 1-hexene. The electrochemical cell was an undivided parallel-plate reactor under galvanostatic operation at  $25^\circ\text{C}$  and 1 atm. The electro-active  $\text{Br}_2/\text{Br}^-$  couple acted as the mediating species. A dispersion of 1-hexene droplets in aqueous sodium bromide solution was generated by use of a static mixer. Current efficiency for organic species and chemical yield of epoxide were determined in order to investigate qualitatively the dependence of the overall electrolyzer performance upon flow rate, organic volume fraction, dispersed droplet size, and current density. (Edited author abstract) 17 refs.

Alkire, Richard (Univ of Illinois, Urbana, IL, USA); Koehler, Juergen. *J Appl Electrochem* v 18 n 3 May 1988 p 405-409.

**075269 CONVENIENT SYNTHESIS OF 2,4,6-TRICHLOROHEPTANE, THE TRIMER MODEL OF POLY(VINYL CHLORIDE).** The authors have developed a convenient synthesis of the stereoisomers of trichloroheptane. The starting material is inexpensive and readily available. The method avoids most of the complications of previous procedures and improves the yield of the product. Therefore, the mixture of trichloroheptane stereoisomers and the individual isomers separated by GC are made readily available for use as the model trimers in studies of the physical properties of PVC. 15 refs.

Schilling, F.C. (AT&T Bell Lab, Murray Hill, NJ, USA); Schilling, M.L. *Macromolecules* v 21 n 5 May 1988 p 1530-1532.

**075270 MATHEMATICAL MODELING OF THE PAIRED ELECTRO-ORGANIC SYNTHESIS IN PACKED BED FLOW REACTORS.** A mathematical model for paired syntheses of 2-butanone from 2,3-butanediol in a packed bed flow reactor has been constructed. Model equations have been solved with a modified Shooting-Runge Kutta numerical technique. Model calculations of current efficiencies and species concentrations are in good agreement with the experimental results. Calculations show that anodic reactions occur mainly in the front end of the anode. Bromine and bromate formation at the anode and acetoin reduction and hydrogen evolution at the cathode are charge-transfer controlled. Rates of bromine and bromate reduction at the cathode are mass-transfer controlled. (Author abstract) 21 refs.

Yu, Jimmy C. (Univ of California, Los Angeles, CA, USA); Baizer, M.M.; Nobe, Ken. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1392-1400.

**075271 MATHEMATICAL MODELING OF THE PAIRED ELECTRO-ORGANIC SYNTHESIS IN PACKED BED FLOW REACTORS.** The mathematical model has been applied to the paired synthesis of gluconic acid and sorbitol from glucose in a packed bed flow reactor. Good agreement between experimental results obtained previously and model predictions has been obtained. Model calculations show anode current efficiency is not a function of current density, whereas sorbitol current efficiency is strongly dependent on current density. Surface coverages of hydrogen on the Raney nickel powder cathode range from 0.7 to 0.8 at 1.75 mA/cm $^2$ ; glucose electrohydrogenation at  $60^\circ\text{C}$  is charge-transfer controlled. For a fixed quantity of Raney nickel, an increase in the cathode diameter results in increased sorbitol current efficiencies. (Author abstract) 12 refs.

Yu, Jimmy C. (Univ of California, Los Angeles, CA, USA); Baizer, M.M.; Nobe, Ken. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1400-1406.

**075272 KINETIC MODEL FOR THE SYNTHESIS OF MONOCHLOROACETIC ACID.** A kinetic model was derived for the homogeneous catalytic liquid phase chlorination of acetic acid in a semibatch reactor. The model is based on a reaction mechanism with a single

rate-determining step: the acid catalyzed enolization of the catalyst, acetyl chloride. The model parameters were determined by stepwise regression analysis and the model was used for batch reactor simulation. (Author abstract) 9 refs.

Salmi, Tapio (Abo Akad, Turku, Finl); Martikainen, Paivi; Paatero, Erkki; Hummelstedt, Leif; Damen, Henrik; Lindroos, Torsten. *Chem Eng Sci* v 43 n 5 1988 p 1143-1151.

**075273 NOVEL COMPUTER-AIDED DESIGN SYSTEM FOR ORGANIC SYNTHESIS - GENERATION OF OVERALL REACTION MATRICES BETWEEN A GIVEN STARTING COMPOUND AND A TARGET MOLECULE.** Computational procedures have been developed for generation of overall reaction matrices between a given starting compound and a target molecule. The selection of correspondence of atoms between a starting compound and a target molecule is based upon minimum bond exchange and maximum atom overlapping. The preliminary results of trial execution of the program are briefly described. (Author abstract) In Japanese. 6 refs.

Uchimar, Tadaumi (Nat'l Chemical Lab for Industry, Ibaraki, Jpn); Tanabe, Kazutoshi; Ouchi, Akihiko; Hayashi, Teruyuki. *Chem Express* v 3 n 5 May 1988 p 299-302.

**075274 ROUTINE SYNTHESIS OF N- $^{11}\text{C}$ -METHYLSCOPOLAMINE BY PHOSPHITE MEDIATED REDUCTIVE METHYLATION WITH  $^{11}\text{C}$  FORMALDEHYDE.** A synthesis of [ $^{11}\text{C}$ ]scopolamine capable of clinical delivery of this agent in high specific activity is described. The precursor [ $^{11}\text{C}$ ]formaldehyde was produced by catalytic oxidation of [ $^{11}\text{C}$ ]CH $_3$ OH over metallic silver and was used to N- $^{11}\text{C}$ -methylate nortropine using aqueous neutral potassium phosphite as the reducing agent. The labeling reaction was complete after 5 min at  $75-80^\circ\text{C}$  and the [ $^{11}\text{C}$ ]scopolamine (99% radiochemical purity) was isolated by preparative HPLC. Total synthesis time is less than 45 min. Decay corrected radiochemical yields from [ $^{11}\text{C}$ ]CO $_2$  are presently 20-43%. (Author abstract) 20 refs.

Mulholland, G. Keith (Univ of Michigan Medical Sch, Ann Arbor, MI, USA); Jewett, Douglas M.; Toorngian, Steven A. *Appl Radiat Isot* v 39 n 5 1988 p 373-379.

**075275 SYNTHESIS OF  $^{18}\text{F}$ -LABELLED 2-FLUORO-1,4-QUINONES USING ACETYLHYPOFLUORITE.** The fluorination of 1,4-benzo- and naphthoquinones using [ $^{18}\text{F}$ ]acetylhypofluorite is described. For compounds with electron-donating substituents fair to good radiochemical yields have been reached. (Author abstract) 25 refs.

Herscheid, Jacobus D.M. (Free Univ, Amsterdam, Neth); Wedzinga, Rinny; Verboom, Willem; Visser, Gerard W.M. *Appl Radiat Isot* v 39 n 5 1988 p 397-400.

**075276 CAPTIVE SOLVENT METHOD FOR RAPID N- $^{11}\text{C}$  METHYLATION OF SECONDARY AMIDES: APPLICATION TO THE BENZODIAZEPINE, 4'-CHLORODIAZEPAM (RO5-4864).** [ $^{11}\text{C}$ ]4'-Chlorodiazepam (RO5-4864), for PET studies of peripheral benzodiazepine receptors, was synthesized by alkylation of 1-desmethyl-4'-chlorodiazepam, in a small volume of acetone adsorbed on acrylic yarn, with [ $^{11}\text{C}$ ]methyl iodide in the injection loop of a liquid chromatograph. The reaction mixture was introduced directly onto a small, disposable alumina chromatographic column. Elution with pentane:ethanol gives a product of high chemical and radiochemical purity. A simple heating and cooling device for the injection loop is described. (Author abstract) 6 refs.

Watkins, G. Leonard (Univ of Michigan Medical Sch, Ann Arbor, MI, USA); Jewett, Douglas M.; Mulholland, G. Keith; Kilbourn, Michael R.; Toorngian, Steven A. *Appl Radiat Isot* v 39 n 5 1988 p 441-444.



**075277 MECHANISTIC ASPECTS OF MALEIC ANHYDRIDE SYNTHESIS FROM C<sub>4</sub> HYDROCARBONS OVER PHOSPHORUS VANADIUM OXIDE.** The subject of this review is a critical analysis of data published in recent years concerning the mechanism of the oxidation of n-butane with vanadium phosphorus oxide catalysts. We will present an overall general picture of this mechanism and clarify issues related to the nature of the active site involved, including the importance of P:V ratio, oxidation state, structural characteristics of the vanadium phosphorus oxide system, and the detection and formation of intermediates. The authors review the experimental work relevant to determination of the forms of selective and nonselective oxygen in the reaction, addressing the question of whether the Mars and van Krevelen redox mechanism common to olefin oxidation applies equally well to this saturated system. 188 refs.

Centi, Gabriele (Univ of Bologna, Bologna, Italy); Trifiro, Ferruccio; Ebner, Jerry R.; Franchetti, Victoria M. *Chem Rev* v 88 n 1 Jan-Feb 1988 p 55-80.

**075278 SYNTHESIS AND CHARACTERIZATION OF 1,2-CYCLOBUTENEDICARBOXAMIDES: THERMALLY GENERATED POLYMERS AND DI-ELS-ALDER ADDUCTS.** A series of model diamides were synthesized from mono- and disubstituted amines with the diacid chloride of cyclobutene-1,2-dicarboxylic acid. Yields ranged from 30 to 70 percent. Melting points of the purified diamides ranged from less than 23°C for N-alkyl and N,N-dialkyl species to 204°C for the N-phenyl model. Relative rates of thermolysis (by DSC) with maxima from 208-224°C at 10°C/min were dependent on the number and type of substituents and on intramolecular hydrogen bonding. Thermolysis products were Diels-Alder dimers for N-monosubstituted materials and for bulky tetrasubstituted models and spontaneously formed polymers for two tetrasubstituted models with at least one methyl group on each nitrogen. (Edited author abstract). 15 Refs.

Powell, Douglas G. (Univ of Southern Mississippi, Hattiesburg, MS, USA); Mathias, Lon J. *Macromolecules* v 21 n 7 Jul 1988 p 1911-1915.

**075279 AMIDES AND THIOAMIDES OF  $\beta$ -DIETHYLAMINOPROPIONIC ACID ADDITIVES TO LUBRICATING OILS.** The new series of amides and thioamides of  $\beta$ -diethylaminopropionic acid was synthesized. It was established that thioamides of  $\beta$ -diethylaminopropionic acid are effective anticorrosion additives to oil M-11 and in this respect are superior to similar amides, but equivalent to isobutylthioacetopiperidine and isobutylthioacetothiopiperidine. Thioamides of  $\beta$ -diethylaminopropionic acid have an equivalent scuff index to isobutylthioacetothiopiperidine but a better scuff index than corresponding amides and isobutylthioacetopiperidine. 7 Refs.

Kuliyev, A.B. (Azerbaijani SSR Acad of Sciences, USSR); Akhadov, N.O.; Abdullayeva, M.I. *Pet Chem USSR* v 27 n 1 1987 p 66-71.

**075280 NEW HIGHLY-CONJUGATED TTF ANALOGUE: SYNTHESIS, ELECTROCHEMISTRY AND A CONDUCTING TCNQ COMPLEX OF 9,10-ANTHRACENEDIYLIDENE-2,2'-bis(4,5-DIMETHYL-1,3-DITHIOLE).** The authors report the synthesis of the 9,10-anthracenediylidene-2,2'-bis(4,5-dimethyl-1,3-dithiole) system. Both the dication and neutral species have been isolated, and are stable in the solid state. A charge-transfer complex with TCNQ has also been prepared. (Edited author abstract). 6 Refs.

Bryce, Martin R. (Univ of Durham, Durham, Engl); Moore, Adrian J. *Synth Met* v 25 n 2 Aug 1988 p 203-205.

**075281 SYNTHESIS, STRUCTURE, AND EXCIMER FORMATION OF CHOLESTERIC LIQUID CRYSTALS CONTAINING CARBAZOLYL GROUPS COVALENTLY LINKED TO A CHOLESTEROL GROUP.** Cholesteryl 3-(9-carbazolyl)propanoate (9Cz-2) and cholesteryl 3-[3-(9-ethylcarbazolyl)]propanoate (3Cz-2) were synthesized. They did not show a cholesteric

mesophase by themselves, but their 1:1 mixture with other cholesteryl arylpropanoates showed cholesteric mesophases near room temperature. The average orientation of the two types of carbazoyl groups in the quasinematic layer were determined by circular dichroism and circularly polarized fluorescence spectroscopy. Their fluorescence spectra showed a monomer fluorescence with a small contribution of excimer. The intensity ratio of the excimer to monomer fluorescence of 3Cz-2 was larger than that of 9Cz-2 and reached the minimum value at the cholesteric-isotropic transition temperature. (Edited author abstract). 22 Refs.

Kawaguchi, Koji (Kyoto Univ, Kyoto, Jpn); Sisido, Masahiko; Imanishi, Yukio. *J Phys Chem* v 92 n 16 0811 1988 p 4806-4811.

**075282 METAL CATALYZED DEMETHYLATION OF N,N-DIMETHYLANILINE.** The demethylation of N,N-dimethylaniline (DMA) was examined over activated charcoal supported metal catalysts such as palladium, ruthenium, rhodium, and platinum. The palladium catalyst was the most effective for the formation of aniline (AN). The demethylation occurred to form aniline via N-methylaniline (MAN) by the stepwise degradation. A possible mechanism involving an iminium cation was proposed. TT Metal Catalyzed Demethylation of N,N-Dimethylaniline. (Author abstract). 10 refs. In Japanese.

Sugi, Yoshihiro (Nat'l Chemical Lab for Industry, Tukuba, Jpn); Hanaoka, Takamasa; Takeuchi, Kazuhiko; Arakawa, Hironori; Matsuzaki, Takehiko; Bando, Ken-Ichiro; Watanabe, Hiroki. *Chem Express* v 3 n 8 Aug 1988 p 511-514.

**075283 REDUCTION AND HYDROGENATION WITH THE SYSTEM HYDROCARBON/CARBON.** Hydrocarbon/carbon systems can be readily used instead of molecular hydrogen and expensive metal catalysts for the hydrogenation of compounds containing, for example, CC-, CO-, or NO-double bonds. Furthermore, these systems can be used for carrying out reductions which hitherto required strong reducing agents such as zinc, tin, alkali metals and hydrides. Especially suitable as economic sources of hydrogen are refinery products such as vacuum gas oil, fuel oil S or vacuum residue oil. Hydrocarbons are dehydrogenated to unsaturated systems and finally to carbon. (Edited author abstract). 6 Refs.

Dockner, Toni (BASF Aktiengesellschaft, Ludwigshafen, West Ger). *Angew Chem (Int Ed Engl)* v 27 n 5 1988 p 679-682.

**075284 NOVEL CATALYTIC REACTIONS USING RUTHENIUM AND PLATINUM COMPLEXES.** The following novel organic synthesis catalyzed by ruthenium or platinum complexes are reviewed: (1) activation of alcohols which provides novel synthetic methods for alkylamines and N-heterocycles such as piperidines, pyrrolidines, quinolines and indoles, (2) hydroamidation of olefins, (3) addition of carboxylic amides to olefins, (4) addition of aldehydes to olefins to give unsymmetric ketones. Reactions 3 and 4 involve the activation of carbon-hydrogen bond of formyl groups, (5) [2+2] cross cycloaddition of norbornenes with acetylene which provides the synthetic tool for linear polycyclic compounds, (6) linear codimerization of acetylenes with 1,3-dienes, (7) addition of carboxylic acids to acetylenes to give enol esters, (8) reductive carbonylation of nitroarenes to amides, urethanes and ureas, and (9) thermal and photo-chemical carbonylation of alkyl iodides to esters or aldehydes. (Edited author abstract). 55 Refs. In Japanese.

Watanabe, Yoshihisa (Kyoto Univ, Kyoto, Jpn); Mitsudo, Take-aki; Tsuji, Yasushi. *Yuki Gosei Kagaku Kyokaiishi* v 46 n 8 Aug 1988 p 789-800.

**075285 ORGANIC ELECTROCHEMISTRY IN THE SOLID STATE-OVEROXIDATION OF POLYPYRROLE.** Anodic overoxidation of polypyrrole in the presence of nucleophiles such as H<sub>2</sub>O, OH<sup>-</sup>, CH<sub>3</sub>OH, CH<sub>3</sub>O<sup>-</sup>, Br<sup>-</sup> and CN<sup>-</sup> has been studied in detail. At potentials up to 2.1 V (vs. SCE), irreversible anodic peaks

are observed with 200 nm layers on Pt. In most of the cases, a total of z=4-6 f/mol monomer unit initially oxidized in the reversible potential region to the radical cation has been evaluated. Only every third ring is involved in this way. Characteristic products in aqueous systems are pyrrolinones (with a keto group in 3-position), z=4, and product of further hydroxylation in 4-position (z=6). (Edited author abstract) 50 refs.

Beck, Fritz (Univ-GH-Duisburg, Duisburg, West Ger); Braun, Petra; Oberst, Manfred. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem, of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 967-974.

**075286 ORGANIC SYNTHESIS WITH RADICALS VIA ORGANOTIN COMPOUNDS.** Trialkyltin hydrides and allyl trialkyltin compounds are precursors of alkyl radicals in chain reactions. Their main application is in the formation of carbon-carbon and carbon-hydrogen bonds. Several syntheses of target molecules including pheromones, antibiotics and carbohydrate derivatives are described. The decisive radical steps occur via intermolecular reactions, cyclizations and rearrangements. (Author abstract) 14 refs.

Giese, Bernd (TH Darmstadt, Darmstadt, West Ger). *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometal and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 99-111.

**075287 RECENT DEVELOPMENTS IN THE CHEMISTRY OF  $\alpha$ -ALKOXY AND  $\alpha$ -AMINOSUBSTITUTED ORGANOTINS DIRECTED TOWARDS ORGANIC SYNTHESIS.**  $\alpha$ -Heterosubstituted organotins are potentially interesting synthetic tools. New efficient and versatile routes to these reagents are presented. The syntheses involve the stannylation of organic substrates (orthoformates, aldehydes, aminoacetals or immonium salts) as well as the modification of doubly functionalized organotin compounds (e.g. diethoxymethyltributyltin or  $\alpha$ -chloro- $\alpha$ -ethoxymethyltributyltin) with organoaluminum reagents or Grignard reagents. The new organotins are shown to be efficient tools for organic synthesis after transmetalation with butyllithium or after direct (or catalyzed) reactions with various organic substrates. (Edited author abstract) 72 refs.

Quintard, Jean-Paul (CNRS, Talence, Fr); Duchene, Alain; Dumartin, Gilles; Elisondo, Bernard; Verlhac, Jean-Baptiste. *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometal and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 241-262.

**075288 SIMULATION OF THE OPERATIONAL CHARACTERISTICS OF THE LARGE-SCALE MULTITUBULAR REACTOR FOR MALEIC ANHYDRIDE PRODUCTION.** The paper presents an analysis of the operational behavior of the industrial reactor for maleic anhydride synthesis. The kinetic model of the process carried at the elevated benzene concentrations (within the explosivity range) is proposed. The analysis is carried out on the base of the mathematical model of multitubular reactor taking account of thermal interaction between heat carrier flowing through the intertubular space and the reactants inside variously positioned catalytic tubes. The influence of process parameters as well as the effect of co-current and counter-current flow configurations on the operational characteristics of the industrial reactor is examined by means of numerical simulation. (Author abstract) 9 refs.

Adamska-Rutkowska, D. (Industrial Chemistry Research Inst, Warsaw, Pol); Stankiewicz, A.; Leszczynski, Z. *Comput Chem Eng* v 12 n 2-3 Feb-Mar 1988, MATCHEM, Sel Pap from the Conf on Math Methods in Chem Eng, Balatonfured, Hung, May 5-8 1986 p 171-175.

Testing See Also HORMONES—Insulin; MUTAGEN—Testing.

**075289 ELECTROANALYTICAL STUDY OF SUL-**



**PHADIAZINE AT SOLID ELECTRODES. DETERMINATION IN PHARMACEUTICAL PREPARATIONS.** An electroanalytical study of the sulphadiazine oxidation process at solid electrodes using different voltammetric techniques was carried out. Limiting current is diffusion-controlled in the concentration range studied. DPV at a glassy carbon electrode allows the determination of sulphadiazine within the range  $1.5 \times 10^{-5}$ – $6.0 \times 10^{-5}$  mol l<sup>-1</sup>. The dpv was applied to determine sulphadiazine in a commercial pharmaceutical preparation. (Author abstract) 17 refs.

Pingarron Carrazon, J.M. (Complutense Univ of Madrid, Madrid, Spain); Corona Corona, P.; Polo Diez, L.M. *Electrochim Acta* v 32 n 11 Nov 1987 p 1573-1575.

**Thermal Effects** See Also HYDROCARBONS—Stability; POLYCHLORINATED BIPHENYLS—Oxidation.

**075290 TEMPERATURE DEPENDENCE OF THE LEAKAGE OF CARBOXY FLUORESCIN FROM AN INNER AQUEOUS PHASE OF LIPOSOMES OR MIXED LIPOSOMES.** Small unilamellar liposomes with an average diameter of about 500 Å containing carboxy fluorescein in an inner aqueous phase were prepared by 20 min sonication (60 W) of the aqueous dispersions of dimyristoyl-, dipalmitoyl-, or distearoyl phosphatidylcholine. The excess carboxy fluorescein in an outer aqueous phase was expelled by a Sepharose CL4B column. The leaked carboxy fluorescein was analyzed successively by fluorescence spectroscopy at different temperatures. A rapid leakage was observed at the main phase transition temperature. On the other hand, little leakage was recorded below and above the phase transition temperature. (Edited author abstract) 21 refs.

Ohno, Hiroyuki (Waseda Univ, Tokyo, Jpn); Ukaji, Kazuo; Tsuchida, Eishun. *J Colloid Interface Sci* v 120 n 2 Dec 1987 p 486-494.

**075291 THERMALLY INDUCED REARRANGEMENT OF  $\alpha$ -ZIRCONOCENYL THIOETHERS: CARBON-CARBON BOND FORMATION VIA A TRANSITION-METAL HYDROXYMETHYL OR METALLOXIRANE ANALOGUE.** The authors examined the thermolysis of  $\alpha$ -zirconocenyl thioethers to gain insight into the basic reactivity patterns of  $\alpha$ -heteroatom-substituted alkyl groups in highly oxophilic transition-metal complexes. In recent preliminary reports, we have shown that  $\alpha$ -zirconocenyl thioethers undergo carbon-carbon bond-forming reactions 1 and 2, which are potentially good models for carbon-carbon bond formation via a hydroxymethyl metal or metalloxirane complex. In this work the authors report on studies of one particular bond-forming reaction. Based on experimental data, the authors conclude that the rearrangement proceeds by intramolecular nucleophilic attack (migration) of the aryl group to the methylene carbon with commensurate breaking of the C-S bond. (Edited author abstract) 20 refs.

Ward, A. Steven (West Virginia Univ, Morgantown, WV, USA); Mintz, Eric A.; Kramer, Michael P. *Organometallics* v 7 n 1 Jan 1988 p 8-12.

## Thermal Properties

**075292 ESTIMATION OF THE BOILING TEMPERATURE AT NORMAL PRESSURE FOR ORGANIC COMPOUNDS FROM THEIR CHEMICAL FORMULA AND A KNOWN BOILING TEMPERATURE AT LOW PRESSURE.** A simple and accurate method to predict the normal boiling temperature  $T_b$  of organic compounds from their chemical formula and a known boiling temperature at low pressure is proposed. The bases of the method are Clausius-Clapeyron's equation, Lydersen's group contribution correlations and a statistical decrement  $\Delta T_b$ . From a known boiling temperature under a known low pressure (which is a common case), a predictive method is thus provided to estimate the unknown normal boiling temperature of such compounds, which cannot be experimentally measured. The observed standard error for compounds with known normal boiling temperature is  $\pm 3$  K. (Author abstract) 15 refs.

Pailhes, Francis (Cent de l'Industrialisation de Decines, Decines-Charpieu, Fr). *Fluid Phase Equilib* v 41 n 1-2 Jun 1988 p 97-107.

**075293 THERMAL PROPERTIES OF TETRAKIS (ALKYLTHIO)TETRATHIAFULVALENES.** Thermal properties have been investigated for a series of tetrakis (alkylthio)tetrathiafulvalenes which consist of a TTF  $\pi$  system and four alkylthio substitutional groups with n carbon atoms (abbreviated TTC<sub>n</sub>-TTFs (n=1-18), by means of differential scanning calorimetry. The linear dependence of the enthalpy and entropy changes at the melting point,  $\Delta H_m$  and  $\Delta S_m$ , is observed, which is consistent with the behavior of flexible molecules reflecting the contribution from the configurational change in alkyl chains of TTC<sub>n</sub>-TTFs to the entropy change at the melting point. The n dependence of the melting point, in addition to that of  $\Delta H_m$  and  $\Delta S_m$ , suggests that the series of TTC<sub>n</sub>-TTFs are divided into two subgroups depending on n. (Edited author abstract). 16 Refs.

Shi, Zurong (Inst for Molecular Science, Okazaki, Jpn); Enoki, Toshiaki; Imaeda, Kenichi; Seki, Kazuhiko; Wu, Peiji; Inokuchi, Hiroo; Saito, Gunzi. *J Phys Chem* v 92 n 17 Aug 25 1988 p 5044-5048.

## Thermoanalysis

**075294 COMMON THERMOANALYTICAL CHARACTERISTICS OF DURABLE PRESS REACTANTS BASED ON CYCLIC UREAS.** Thermal analyses, including differential scanning calorimetry (DSC), thermogravimetry (TG), and differential thermogravimetry (DTG), were performed on a series of derivatives of cyclic ureas under nitrogen. Such compounds are used extensively for durable press finishing of cotton textiles. Three common features were discovered in 15 compounds analyzed. The amount of residue produced in TG analyses was related to structure and indicated that thermally induced polycondensations were occurring. (Edited author abstract) 15 refs.

Trask-Morrell, B.J. (Textile Finishing Chemistry Research, New Orleans, LA, USA); Kottes Andrews, B.A. *J Appl Polym Sci* v 35 n 1 Jan 1988 p 229-245.

**Thermodynamic Properties** See Also HYDROCARBONS—Chromatographic Analysis; HYDROCARBONS—Mixing; HYDROCARBONS—Thermodynamic Properties; MIXTURES—Thermodynamic Properties; PARAFFINS—Thermodynamic Properties; SALTS—Thermodynamic Properties.

**075295 VAPOR-LIQUID EQUILIBRIUM IN BINARY SYSTEMS FORMED BY DI-tert-BUTYL PEROXIDE WITH tert-BUTYL AND ALLYL ALCOHOLS.** The authors report a study of vapor-liquid equilibrium in binary systems formed by di-tert-butyl peroxide with tert-butyl and allyl alcohols at P = 120.0 and 760 mm. Experimental data on liquid-vapor equilibrium in binary systems formed by di-tert-butyl peroxide with tert-butyl and allyl alcohols, verified by the Van Ness method, are presented. Studies of liquid-vapor equilibria in binary systems formed by di-tert-butyl peroxide with tert-butyl and allyl alcohols showed the existence of homogeneous positive azeotropes, whose compositions and properties, corrected by the rectification method, are also given. 9 refs.

Denisova, I.V. (Yaroslavl' Polytechnic Inst, USSR); Karavaeva, A.P.; Bobylev, B.N.; Rumyantseva, T.K.; Demidova, M.V. *J Appl Chem USSR* v 59 n 11 pt 2 Nov 1986 p 2378-2380.

**075296 OSMOTIC COEFFICIENTS OF TRIORGANOPHOSPHORUS COMPOUNDS IN n-OC-TANE AND BENZENE.** Osmotic and activity coefficients are reported for a number of organophosphorus compounds dissolved at low concentrations in n-octane and in benzene. In both solvents, the most polar compound, tri-n-octylphosphine oxide, was the most nonideal, whereas the least polar compound, tri-n-octyl phosphate, was the most ideal. All the organophosphorus compounds were more ideal in benzene than in n-octane. (Author abstract) 8 refs.

Sagert, Norman H. (Whiteshell Nuclear Research Establishment, Pinawa, Manit, Can); Bangu, Kiran; Lau, Danny W.P. *J Chem Eng Data* v 32 n 4 Oct 1987 p 460-461.

**075297 MODIFIED UNIFAC GROUP-CONTRIBUTION MODEL FOR PREDICTION OF PHASE EQUILIBRIA AND HEATS OF MIXING.** The Modified UNIFAC model for predicting activity coefficients presented in this work is based on the well-known UNIFAC model. Two changes are introduced in Modified UNIFAC: (1) the group-interaction parameters have been made temperature-dependent and (2) the combinatorial term is slightly modified. Group-interaction parameters have been determined for 21 different main groups. It is shown that Modified UNIFAC gives somewhat better predictions of vapor-liquid equilibria than does UNIFAC, while the predictions of excess enthalpies are much improved. (Edited author abstract) 32 refs.

Larsen, Bent L. (DECHEMA, Frankfurt am Main, West Ger); Rasmussen, Peter; Fredenslund, Aage. *Ind Eng Chem Res* v 26 n 11 Nov 1987 p 2274-2286.

**075298 ALDEHYDE-BISULFITE ADDUCTS: PREDICTION OF SOME OF THEIR THERMODYNAMIC AND KINETIC PROPERTIES.** Stability constant ( $K_1$ ) for the reaction of acetaldehyde and hydroxyacetaldehyde with NaHSO<sub>3</sub>, determined spectrophotometrically in aqueous solution, were found to be  $(6.90 \pm 0.54) \times 10^5$  M<sup>-1</sup> and  $(2.0 \pm 0.5) \times 10^6$  M<sup>-1</sup>, respectively, where  $K_1$  (corrected for aldehyde hydration) =  $[RCH(OH)SO_3^-]/[RCHO][HSO_3^-]$  ( $\mu=0.2$  M; 25°C). Acid dissociation constants ( $pK_{a3}$ ) of a series of  $\alpha$ -hydroxyalkanesulfonate salts,  $RCH(OH)SO_3^-$ , were found to be 11.46 (CH<sub>3</sub>-), 11.28 (H-), 10.30 (HOCH<sub>2</sub>-), 10.33 (C<sub>6</sub>H<sub>5</sub>-), 10.31 (CH<sub>3</sub>CO-), and 7.21 (Cl<sub>3</sub>C-) ( $\mu=0$  M; 25°C). Simple straight-line relationships were found to exist between Taft's  $\sigma^*$  parameter and a number of thermodynamic and kinetic properties of some aldehydes. Additional aspects of the subject are discussed. (Edited author abstract) 47 refs.

Betterton, Eric A. (California Inst of Technology, Pasadena, CA, USA); Erel, Yigal; Hoffmann, Michael R. *Environ Sci Technol* v 22 n 1 Jan 1988 p 92-99.

**075299 DIPOLE MOMENTS OF SOME DIAZARENES.** The electric dipole moments of 1,8-naphthyridine, 1,8-diazabiphenylene, and pyrido[3,2-g]quinoline have been determined experimentally. The measured values in benzene are 4.10, 4.23, and 4.02 D, respectively. The larger value for 2 is attributed to its distorted molecular geometry. (Author abstract) 16 refs.

Markgraf, J. Hodge (Williams Coll, Williamstown, MA, USA); Skinner, James F.; Marshall, G. Thomas. *J Chem Eng Data* v 33 n 1 Jan 1988 p 9-10.

**075300 SIMULTANEOUS OPTIMIZATION OF BINARY PHASE EQUILIBRIUM AND THERMODYNAMIC DATA FOR ORGANIC SYSTEMS.** A technique is proposed which permits the simultaneous optimization of all available VLE, LLE, excess enthalpy, and other liquid excess property data for binary systems. The method permits the analysis of the complete range of experimental temperatures, pressures, and compositions. The result is a single set of self-consistent parameters for a power-series expression for the excess Gibbs energy which will reproduce experimental data with precision and can be used for extrapolations with confidence. The method is illustrated by examples including the following systems: hexane + acetone; 2,3-dimethylbutane + acetone; ethylbenzene + 2-ethoxyethanol; ethanol + ethyl acetate; hexane + hexadecane; water + 1,4-dioxane; benzene + toluene; and water + 2-butanone. (Author abstract) 68 refs.

Talley, Paul K. (Ecole Polytechnique de Montreal, Montreal, Que, Can); Bale, Christopher W.; Pelton, Arthur D. *Ind Eng Chem Res* v 26 n 9 Sep 1987 p 1774-1781.



**075301 THERMODYNAMIC PROPERTIES OF 1-CHLORO-1,2,2,2-TETRAFLUOROETHANE (R124).** The critical temperature and pressure, vapor pressure, and PVT relations for gaseous and liquid 1-chloro-1,2,2,2-tetrafluoroethane (R124) were determined experimentally. The vapor pressure was measured in the temperature range from 278.15 K to the critical temperature. The PVT measurements were carried out using two types of volumeters in the temperature range from 278.15 to 423.15 K, at pressure up to 100 MPa. The numerical PVT data of gaseous state are fitted as a function of density to a modified Benedict-Webb-Rubin equation. The pressure-volume relations of the liquid at each temperature are correlated satisfactorily as a function of pressure by the Tait equation. The critical density and saturated vapor and liquid densities are also determined and some of the thermodynamic properties are derived from the experimental results. (Author abstract) 5 refs.

Kubota, H. (Kobe Univ, Kobe, Jpn); Tanaka, Y.; Makita, T.; Kashiwagi, H.; Noguchi, M. *Int J Thermophys* v 9 n 1 Jan 1988 p 85-101.

**Thin Films** See Also FILMS—Preparation; IONS—Emission; MOLECULAR CRYSTALS—Growth; SURFACES—Molecular Structure; TRANSITION METALS—Surfaces; VAPORS—Condensation.

**075302 DIRECT PATTERNING AND ELECTRICAL PROPERTIES OF PHTHALOCYANINES THIN FILMS PREPARED BY LANGMUIR-BLODGETT AND SPIN CAST TECHNIQUES.** The patterning and electrical properties of thin films based on two new highly soluble nickelphthalocyanines involving four long alkyl amides (AmPc1 and AmPc2) have been examined. The films were prepared using the Langmuir-Blodgett and spin cast techniques. The film conductivities increased by 2-4 orders of magnitude upon iodine vapor exposure and reached ca.  $10^{-6}$  S  $\text{cm}^{-1}$ . Both the AmPc1 and AmPc2 thin films showed negative patterning features to electron beam (EB) dose, and excellent resistance to plasma-assisted dry etching. The AmPc2 possesses high contrast in a LB film ( $\gamma=3.8$ ) and high reactivity ( $D_0=3.5$   $\mu\text{C cm}^{-2}$ ) in a spin cast film. The fine patterns in the AmPc2 spin cast film have been fabricated down to lines with widths of 0.8  $\mu\text{m}$  (with a 0.8  $\mu\text{m}$  spacing) using EB irradiation and wet etching, while (probably) maintaining the semiconducting properties of the Pc ring moieties without decomposition. (Author abstract) 38 refs.

Fujiki, Michiyo (NTT, Tokai-mura, Jpn); Tabei, Hisao; Imamura, Saburo. *Jpn J Appl Phys Part 1* v 26 n 8 Aug 1987 p 1224-1229.

**075303 STRUCTURE-DEPENDENT DIELECTRIC RESPONSE OF p-TERPHENYL THIN FILMS.** The dielectric properties of large-grained and small-grained p-terphenyl layers are reported. The dielectric responses of the two kinds of p-terphenyl polycrystalline structures differed significantly. The dielectric losses of the small-grained layers were found to be of injected carrier origin. The loss peak found in the small-grained films is associated with traps about 0.65 eV deep and interpreted in terms of the Dissado-Hill theory. (Author abstract) 10 refs.

Bak, G.W. (Technical Univ of Lodz, Lodz, Pol); Lipinski, A. *Thin Solid Films* v 151 n 3 Aug 17 1987 p 289-295.

**075304 OPTICAL PROBES OF ORGANIC THIN FILMS: PHOTONS-IN AND PHOTONS-OUT.** This monograph attempts to present a comprehensive review of the current applications and characteristics of photon-in, photon-out optical techniques used to characterize organic thin solid films and their interfaces. The optical probes are grouped according to their common origins within the point dipole approximation and both theoretical aspects and experimental capabilities and limitations are discussed. Emphasis is given to describing how information about the surface and interface characteristics, the thin film microscopic physical structure and the macroscopic optical properties derives from nine basic optical approaches used in some two dozen different

experimental configurations. The level of presentation is directed at nonexperts in the multidisciplinary research and technology fields which utilize organic thin films in the submonolayer to micron thickness range. (Edited author abstract) 638 refs.

Debe, M.K. (3M, St. Paul, MN, USA). *Prog Surf Sci* v 24 n 1-4 1987 282p.

**075305 ABSORBING ORGANIC LIGHT FILTERS FOR THE VISIBLE PART OF THE SPECTRUM.** Absorbing light filters on the basis of organic film-forming compounds and chromophors are promising for mass production. Such filters are characterized by high reproducibility of the spectral characteristics, they are subtractive and therefore are free of secondary interference phenomena which cause uncontrollable changes in chromaticity, and they can be manufactured at low cost. We have developed absorbing light filters of the cut-off type with  $\lambda_{\text{lim}} = 490 \pm 10$  and  $600 \pm 20$  nm transmitting the long-wave part of the spectrum, and band filters with  $\Delta\lambda_{1/2}$  approximately 80 nm for the green ( $\lambda_{\text{max}} = 530 \pm 10$  nm) and blue ( $\lambda_{\text{max}} = 450 \pm 10$  nm) parts of the spectrum on the basis of thin (up to 2  $\mu\text{m}$ ) gelatine layers having good color contrast. 6 refs.

Zyat'kov, I.P.; Zubareva, M.M.; Matveitseva, M.S.; Sagaidak, D.I.; Semenova, V.A. *J Appl Spectrosc* v 46 n 5 May 1987 p 477-479.

**075306 PHOTOCURRENT SPECTRA OF PHTHALOCYANINE FILMS IN RELATION TO EXCITED STATE PROPERTIES.** Photocurrent spectra of thin-film sandwich cells for vacuum-deposited phthalocyanines (Pc's) have been investigated and compared with their optical absorption spectra. A close resemblance was found between the two spectra for H<sub>2</sub>Pc and ZnPc, but peaks in the photocurrent spectra of CuPc and NiPc have been found to be considerably shifted compared with those in the absorption spectra. These photocurrent peaks in CuPc and NiPc correspond well to structures in the recently reported electroabsorption spectra of phthalocyanines. Direct charge-transfer excitation is suggested to play a role in the photocurrent generation in phthalocyanine films. The absorption spectrum of VOPc is considerably dependent on the deposition conditions of thin films, unlike other planar phthalocyanines. (Author abstract) 14 refs.

Minami, Nobutsugu (Research Inst for Polymers & Textiles, Tsukuba, Jpn); Asai, Michihiko. *Jpn J Appl Phys Part 1* v 26 n 10 Oct 1987 p 1754-1758.

**075307 INFRARED SPECTROSCOPY OF THIN ORGANIC FILMS ON METAL SURFACES.** The principles of external reflection infrared spectroscopy for obtaining spectra of thin films on surfaces by reflecting infrared radiation from the surface at large, almost grazing angles, are reviewed and new applications are described. Infrared spectra of monomolecular films formed by myristic acid adsorbed from dilute solutions in nitrobenzene onto aluminum and chromium were obtained. Adsorption onto both substrates involved dissociation of the acid groups to form carboxylate species, but undissociated monomer was retained in the films formed on aluminum. Myristic acid was adsorbed onto aluminum with a vertical conformation in which the twofold symmetry axes of the carboxylate groups were nearly perpendicular to the surface of the substrate. The twofold axes of the carboxylate groups were more inclined with respect to the normal to the surface for the chromium substrates. Terephthalic acid and terephthalic acid-*d*<sub>4</sub> were adsorbed onto aluminum from dilute solutions in ethanol with a vertical conformation in which one acid group was dissociated to form a salt with a metal ion in the substrate, while the other acid group may have formed hydrogen bonds with neighboring molecules. (Edited author abstract) 16 refs.

Boerio, F.J. (Univ of Cincinnati, Cincinnati, OH, USA); Boerio, J.P.; Bozian, R.C. *Appl Surf Sci* (1985) v 31 n 1 Jan 1988 p 42-58.

**075308 IR STUDIES OF PYROELECTRIC LANGMUIR-BLODGETT FILMS.** Alternate-layer

Langmuir-Blodgett (LB) assemblies, consisting of 22-tricosenoic acid with three different amine derivatives, have been fabricated. The pyroelectric activity in the films has been assessed and correlated with their structures determined using Fourier transform IR (FTIR) spectroscopy. Two of the acid/amine systems are pyroelectric but differ in that one exhibits proton transfer from the acid to the amine whilst the other retains discrete acid and amine units. For one of these systems, a pyroelectric coefficient of  $1.9$  nC  $\text{cm}^{-2}\text{K}^{-1}$  has been attained, representing the largest reported value, to date, for an LB film. The third type of film is not pyroelectric, and FTIR spectroscopy studies have revealed that this is due to a rearrangement of the molecules to produce a centrosymmetric structure in which pyroelectricity is precluded. (Author abstract) 13 refs.

Jones, C.A. (Univ of Durham, Durham, Engl); Petty, M.C.; Roberts, G.G.; Davies, G.; Yarwood, J.; Ratcliffe, N.M.; Barton, J.W. *Thin Solid Films* v 155 n 2 Dec 30 1987 p 187-195.

**075309 X-RAY DIFFRACTION AND OPTICAL STUDIES OF LANGMUIR-BLODGETT FILMS FORMED FROM AZOBENZENE DERIVATIVES.** X-ray diffraction data were used to construct the electron density profiles of Langmuir-Blodgett films formed from two azobenzene derivatives, before and after annealing at moderate temperatures. The annealing process caused phase changes to occur that were apparent in the changes in optically observed textures and X-ray diffraction patterns. Considerations of these changes led us to conclude that, before annealing, the Langmuir-Blodgett films possessed smectic liquid crystal A phases and, after annealing, one compound had a tilted, layered crystal phase and the other a tilted liquid crystal phase. (Author abstract) 8 refs.

Tredgold R.H. (Univ of Lancaster, Lancaster, Engl); Allen, R.A.; Hodge, P. *Thin Solid Films* v 155 n 2 Dec 30 1987 p 343-352.

**075310 DRAWING FINE PATTERNS ON N-OCTADECYLACRYLAMIDE LANGMUIR-BLODGETT MULTILAYERS: A NEW CLASS OF ULTRATHIN RESISTS.** Recently the authors found that the N-octadecylacrylamide (ODA) monomer forms a stable condensed monolayer and that the multilayers deposited onto solid supports were polymerized completely by UV irradiation. The polymerized ODA LB film is a uniform thin film having a high stability against solvents. Fine negative resist patterns due to the polymerized LB film could be drawn. This letter describes preliminary results on the application of the LB film to a deep UV-sensitive negative resist. 8 refs.

Miyashita, Tokuji (Tohoku Univ, Sendai, Jpn); Yoshida, Hiroshi; Matsuda, Minoru. *Thin Solid Films* v 155 n 2 Dec 30 1987 p L11-L14.

**075311 CHARACTERIZATION OF ASYMMETRICAL MOLECULAR ORIENTATION IN LANGMUIR-BLODGETT FILMS BY THE STARK EFFECT.** Three types of Langmuir-Blodgett film of an azobenzene derivative were prepared by hetero Y-type, Y-type and Z-type deposition methods. The molecular orientations in the films were determined from the analysis of the linear Stark effect (electroabsorption) spectra. Molecules in the hetero Y-type film were proved to align asymmetrically. However, molecular orientations in the Z-type films showed very small asymmetry. Investigation of the long spacing determined from x-ray diffraction supported the conclusion from the Stark effect. (Author abstract) 6 refs.

Era, Masanao (Kyushu Univ, Kasuga, Jpn); Fukuda, Makoto; Tsutsui, Tetsuo; Saito, Shogo. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1809-1811.



**075312 NEW EVALUATION METHOD OF EVAPORATED ORGANIC THIN FILMS BY ENERGY DISPERSIVE X-RAY DIFFRACTOMETER.** A new method was developed to obtain clear diffraction patterns of organic thin films evaporated on substrates such as Au. In this method, total reflection on substrates was utilized to most efficiently collect the diffracted x-rays from organic thin films. The x-rays were detected with a pure Ge solid-state detector set at a constant scattering angle and analyzed with a multichannel analyzer. Excellent performance of this system was demonstrated for a thin stearic acid film evaporated on Au and Cu-phthalocyanine on glass. (Author abstract) 4 refs.

Horiuchi, Toshihisa (Kyushu Univ, Fukuoka, Jpn); Fukao, Koji; Matsushige, Kazumi. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1839-1841.

**075313 NEW LANGMUIR-BLODGETT FILMS BUILT UP FROM A COPPER HALOGENIDE SEMI-AMPHIPHILIC SALT.** The aim of the present work is to show the feasibility of true LB films built up from a semi-amphiphilic salt in which the anion is a paramagnetic transition metal halogenide. For this purpose, we have chosen bis(octadecylammonium)/tetrachlorocuprate,  $(C_{18}H_{37}NH_3)_2CuCl_4$ . This salt was prepared by mixing a hot solution of copper chloride in ethanol with a boiling solution of the corresponding ammonium chloride also in ethanol. Perovskite-type yellow crystals were obtained by cooling the solution to room temperature. 15 refs.

Lequan, M. (CNRS, Paris, Fr); Lequan, R.M.; Vandevyver, M.; Richard, J.; Barraud, A.; Roullay, M.; Jaquinot, J.F. *Thin Solid Films* v 156 n 2 Jan 30 1988 p L27-L30.

**075314 CHEMICAL DEGRADATION OF GAS-SENSING MESO-TETRA-ARYLPORPHIN THIN FILMS BY HIGH LEVELS OF DINITROGEN TETROXIDE.** Thin solid films of free base meso-tetra-arylporphins and their zinc, copper, platinum and palladium complexes have been exposed to high levels of dinitrogen tetroxide (NOX). The optical spectra (300-850 nm) were recorded in transmission before and after exposure to NOX. On the basis of the foregoing spectroscopic evidence, films resistant to permanent chemical damage by high levels of NOX (>10,000 ppm) are identified. Reaction schemes are presented for those molecules that can be regenerated after chemical attack by NOX. The relevance of these observations to the selection of solid organic films suitable as industrial gas sensors is highlighted. (Author abstract) 24 refs.

Honeybourne, Colin L. (Bristol Polytechnic, Bristol, Engl); Hill, Callum A.S. *J Phys Chem Solids* v 49 n 3 1988 p 315-321.

**075315 ORIENTATION-CONTROLLED IMMOBILIZATION OF PROTEIN MOLECULES ON THIN ORGANIC FILMS DEPOSITED BY THE PLASMA TECHNIQUE.** The technique for the fabrication of protein-immobilized organic films was studied. A thin organic film 100 nm thick was deposited on the surface of substrates by the plasma polymerization technique, then the surface of the film was treated with a glow discharge in  $NH_3$  gas. Surface characterization by x-ray photoelectron spectroscopy was performed. The results indicated that a thin organic film with amino groups on its surface was formed on the substrates. Rabbit anti-human serum albumin IgG was immobilized on the surface of the film. The Fab'-SH domains were separated from the protein molecules and purified. The sulfhydryl groups of the molecules and the amino groups on the surface of the film were cross-linked by a bifunctional reagent. Using this method, binding sites of the molecules with the supporting material can be uniquely specified. The density of the immobilized protein molecule was estimated from the enzyme immunoassay measurement, and the results suggested that a high immobilization density (approximation  $6 \times 10^{11} \text{ cm}^{-2}$ ) could be achieved by this method. (Author abstract) 15 refs.

Jimbo, Yasuhiko (Univ of Tokyo, Tokyo, Jpn); Saito,

Masao. *J Mol Electron* v 4 n 2 Apr-Jun 1988 p 111-118.

**075316 SYNTHESIS OF ELECTRICALLY CONDUCTIVE ORGANIC THIN FILM BY PLASMA POLYMERIZATION OF 3,4,9,10-PERYLENETET-RACARBOXYLIC DIANHYDRIDE.** The first synthesis of electrically conductive organic thin film by plasma polymerization (glow-discharge chemical vapor deposition) is reported. The monomer specifically employed is 3,4,9,10-perylenetetracarboxylic dianhydride consisting of five-condensed aromatic rings attached by carboxylic groups outside the rings. The film is air-stable and hard enough not to be scratched out. Electrical conductivity of the samples measured is more than  $1.0 \times 10^5 \text{ cm}^{-1}$  with n-type carriers at room temperature. Preliminary spectroscopic data are also to be shown. (Author abstract). 7 Refs.

Tanaka, K.; Murashima, M.; Yamabe, T. *Solid State Commun* v 67 n 2 Jul 1988 p 159-161.

**075317 HALL EFFECT IN CONDUCTING LANGMUIR-BLODGETT FILMS OF A TERNARY TETRACYANOQUINO-DIMETHANE SALT.** In the present work, the first successful Hall effect measurements in these conducting LB films are reported. These measurements appear as a strong argument in favor of a semiconductor band model rather than a hopping model. The key point in measuring the Hall effect is to design a suitable sample shape and to use an operating procedure, which makes it possible to keep the two Hall probes at the same potential before applying a magnetic field. The substrates are optically polished glass slides. In order to improve the transfer rate, substrates are systematically precoated with a few LB layers of the classical dipping-withdrawing method and the films are exposed to iodine vapor. This iodination process results in stable, homogeneous, conducting films. 20 Refs.

Richard, J. (CEA, Yvette, Fr); Vandevyver, M.; Barraud, A.; Delhaes, P. *Thin Solid Films* v 161 Jul 1988 p L73-L78.

**075318 EXPERIMENTAL CRITERIA FOR MONOLAYER STUDIES IN RELATION TO THE FORMATION OF LANGMUIR-BLODGETT MULTILAYERS.** Langmuir-Blodgett (LB) multilayers are formed by the dynamic transfer of molecules to a solid support from a preformed monolayer, usually at the air-water interface. Control of this process depends in part on knowing the properties of the air-water monolayer. These properties are discussed in terms of the variables defining equilibrium reference states and of the several rate processes which govern the transport and transfer of the monolayer substance to the solid support. The need for agreed reference states and new rheological studies to support further advances in LB technology is evident. (Author abstract) 17 refs.

Pethica, Brian A. (Electro-Biology Inc, Parsippany, NJ, USA). *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 3-8.

**075319 EXPERIMENTAL CONSIDERATIONS IN INSOLUBLE SPREAD MONOLAYERS.** When lipid multilayers are prepared by the Langmuir-Blodgett method their quality depends on the deposition process and the condition of an insoluble monolayer spread at the air-water interface. It is shown how trace impurities can drastically alter the properties of this monolayer. Several sources of impurities are identified and methods of reducing their level are reviewed. Attention is focused on water purification and the preparation of surface chemically pure, virtually ion-free water is described. Methods for the elimination of particles and at the same time maintaining this standard do not seem to be established. A major error in surface pressure vs. area isotherms arises from monolayer losses on spreading which can be substantial and the checks described for quantitative spreading are advocated. The two main methods of measuring surface pressure are assessed and possible sources of error are explored. (Author abstract) 34 refs.

Mingins, J. (Norwich Lab, Norwich, Engl); Owens, N.F. *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 9-28.

**075320 PRE-LANGMUIR-BLODGETT MONOLAYERS.** We focus on simulation techniques that use brownian dynamic algorithms. It is possible to define molecular interactions well enough to yield detailed pictures of monolayer states along the entire isotherm. While providing difficulties for the simulation, phase transitions can be observed. Useful thermodynamic quantities can be estimated including the surface pressure tensor, elastic moduli and various distribution functions. We show the evolution of a simulation from the initial state (perfect crystal) to the equilibrium state for  $\pi = 37.5 \text{ mN m}^{-1}$ . A systematic tilt is observed for the molecules in the equilibrium state. Aggregation is observed in simulations of more expanded films. New X-ray diffraction methods for determining monolayer structure are summarized. Experimental methods for determining viscoelastic moduli using capillary waves are summarized. We discuss the integration of these methodologies in developing an understanding of Langmuir-Blodgett deposition. (Edited author abstract) 30 refs.

Adin Mann, J. (Case Western Reserve Univ, Cleveland, OH, USA); Tjattopoulos, George J.; Azzam, Mohammed-Osama J.; Boggs, Karl E.; Robinson, Karl M.; Sanders, John N. *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 29-48.

**075321 PHYSICAL PROPERTIES OF ORDERED ULTRATHIN ORGANIC FILMS.** This review is a presentation of the state of the art and research needs required for the study of the physical properties of ordered ultrathin organic films. For many properties of ultrathin films the topic of electronic transport is central. Drawing on the conclusion of a previous review of non-linear transport in organic materials, the present review is placed within the context of attempting to understand the physical mechanisms underlying ultrathin organic films, and a physical model is provided with this view in mind. The topics addressed are (a) general aspects of electrical conductivity, (b) the optical properties of organic thin films, (c) the physics of macroscopic or collective phenomena, (d) the physics of critical phenomena, (e) band gap engineering, and (f) capillarity and wetting. (Edited author abstract) 171 refs.

Barrett, Terence W. (W.J. Schafer Associates Inc, Arlington, VA, USA). *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 67-98.

**075322 STRUCTURE OF LANGMUIR-BLODGETT FILMS.** In a series of experiments involving IR spectroscopy, Raman spectroscopy, scanning tunneling microscopy and measurements of the near-edge X-ray fine structure, many new details of the structure of Langmuir-Blodgett films have been obtained. The methods and the results giving orientation of the chains, their packing and the head group attachment are described, as well as other properties such as phase transitions. (Author abstract) 31 refs.

Swalen, J.D. (IBM, San Jose, CA, USA). *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 151-154.

**075323 DEFECT CHARACTERIZATION AND DETECTION IN LANGMUIR-BLODGETT FILMS.** The Langmuir-Blodgett technique enables the production of ultrathin organic films. These layers are known for their high quality and well-organized structure. However, defects are present in them. In the present paper a review is given of the different types of defects together with their electrical characterization and their visualization by optical or electron microscopy. Several examples of decoration



techniques and the importance of the defects for various applications are also presented. (Author abstract) 37 refs.

Lesieur, Pierre (CEN, Gif sur Yvette, Fr); Barraud, Andre; Vandevyver, Michel. *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 155-164.

**075324 CHARACTERIZATION OF THE STRUCTURE OF LANGMUIR-BLODGETT FILMS BY SHORT-WAVELENGTH RADIATIONS.** A review is given of the methods of determining the structure of organic thin films using short-wavelength radiations. These include X-rays, electrons and neutrons. Most of the methods involve diffraction and interference effects, of either traveling or standing waves. In addition, direct imaging techniques are also mentioned. Particular emphasis is given to the structure of Langmuir-Blodgett films but the applicability extends to thin polymer films as well. Some trends of the research in this field are identified. (Author abstract) 54 refs.

Pomerantz, M. (IBM, Yorktown Heights, NY, USA). *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 165-179.

**075325 ORGANIC FILMS IN NON-LINEAR INTEGRATED OPTICS STRUCTURES.** Organic films with specifically engineered optical properties hold considerable promise for applications in integrated optics. Light can be propagated for up to centimeter distances in waveguides to interact with organic films of thicknesses 1-5000 nm which are either deposited onto the waveguide or form the guiding medium, depending on the application. The potential advantage of using organic materials is that the molecules can be optimized for their optical response, e.g. second- and/or third-order optical non-linearities for efficient modulation, harmonic generation, all-optical signal processing etc. The basic concepts of integrated optics, non-linear guided wave interactions, material requirements for various applications and progress to date are reviewed. (Author abstract) 106 refs.

Stegeman, George I. (Univ of Arizona, Tucson, AZ, USA); Seaton, Colin T.; Zononi, R. *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 231-263.

**075326 LANGMUIR-BLODGETT FILMS AND NON-LINEAR OPTICS.** Recent work on the non-linear optical and electro-optical properties of Langmuir-Blodgett monolayers and multilayers is reviewed. The fundamental theory of non-linear optical susceptibilities and interactions is discussed, as well as their relationship to molecular hyperpolarizabilities. Among the non-linear optical experiments discussed are second and third harmonic generation, d.c. electric field induced second harmonic generation and the Pockels linear electro-optic effect. It is shown that surface second harmonic generation is a powerful tool for studying the orientation of molecules and their hyperpolarizabilities. The interactions between monolayers and metallic surfaces are also studied by surface-plasmon-enhanced second harmonic generation. Finally, third harmonic generation is used to study the electronic spectra and resonances (two- and three-photon absorption) on very thin multilayers of polydiacetylenes. It is concluded that non-linear optics is a powerful and useful tool for the study of Langmuir-Blodgett films, and that there is a good understanding of fundamental theoretical and experimental problems. (Edited author abstract) 44 refs.

Khanarian, Garo (Hoechst-Celanese Corp, Summit, NJ, USA). *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 265-274.

**075327 NON-LINEAR OPTICAL EFFECTS IN THIN ORGANIC POLYMERIC FILMS.** In this paper a comprehensive account is presented of research work carried out in the author's laboratory in the areas of design of polymeric thin films, investigation of their ultrastruc-

ture and studies of non-linear optical effects. Thin film design and fabrication involve two approaches: electrochemical polymerization and the Langmuir-Blodgett technique. Application of laser Raman optical wave-guides, inelastic electron tunneling, picosecond transient gratings and surface plasmon coupling techniques for the study of ultrastructure is discussed. Results are presented from picosecond and subpicosecond degenerate four-wave mixing, time-resolved coherent Raman spectroscopy, surface plasmon non-linear optics and optical bistability behavior at a non-linear interface to elucidate the nature of third-order non-linear optical effects in thin films of  $\pi$  electron conjugated polymeric systems. (Author abstract) 29 refs.

Prasad, Paras N. (State Univ of New York at Buffalo, Buffalo, NY, USA). *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 275-294.

**075328 THIN ORGANIC FILMS OF PROTEINS.** Biological applications of protein films, machines and devices are briefly reviewed. A brief discussion of protein structure and properties is given. Needs and opportunities in the field include the following: (a) better potential functions to model and predict protein structure, denaturation and adsorption and the assembly of protein films and devices; (b) better methods to characterize protein films, particularly two-dimensional structures and ordering; (c) better means to assemble and stabilize protein machines, such as in lipid or polymer films; (d) means to modify protein stability, binding and enzymatic properties. About 5000 different proteins exist, each 'designed' for a specific function: they can serve to stimulate and aid scientists and engineers in the design and development of new generations of molecular machines and devices. (Author abstract) 52 refs.

Andrade, J.D. (Univ of Utah, Salt Lake City, UT, USA). *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 335-343.

**Toxicity** See Also AIR POLLUTION—Computer Aided Analysis; CHLORINE COMPOUNDS—Chemical Analysis; COAL LIQUEFACTION—Environmental Testing; GASOLINE—Additive Compounds; ORGANIC CHEMICALS—Solubility; PAINT—Removal; POLYCHLORINATED BIPHENYLS—Environmental Impact; REFUSE INCINERATORS—Environmental Impact; WASTEWATER—Activated Sludge; WASTEWATER—Treatment; WATER POLLUTION—Marine Pollution; WATER SUPPLY—Contamination; WATER, UNDERGROUND—Decontamination.

**075329 EFFECTS OF SODIUM PENTACHLOROPHENATE ON THE ECOLOGY OF A FRESHWATER MODEL ECOSYSTEM.** An outdoor model ecosystem was designed for the ecotoxicological evaluation of xenobiotics. Two years were necessary before the artificial pond reached a steady state. During this time the composition of the community and its functions were investigated. A short time before the application of sodium pentachlorophenate (Na-PCP) the ecosystem was divided into three identical subunits. One of these was used as an internal control, the others were contaminated with two different concentrations of Na-PCP (0.1 and 0.3 mg litre<sup>-1</sup>). One year after application of the chemical, the remineralization of nutrients was disturbed. This resulted in a diminution of the phytoplankton and the aquatic fauna. (Edited author abstract) 28 refs.

Feind, Doris (Technische Univ Muenchen-Weihenstephan, Freising, West Ger); Zieris, Franz-Joachim; Huber, Wilfried. *Environ Pollut* (1987) v 50 n 3 1988 p 211-223.

**075330 IMPACT OF PARA-NITROCHLOROBENZENE AND 2,4-DINITROCHLOROBENZENE ON THE STATE OF CARBOHYDRATE AND ENERGY METABOLISM IN RATS.** Para-nitrochlorobenzene and 2,4-dinitrochlorobenzene are used in the dye and drug industries and in chemical synthesis. This study is aimed to assess the toxicity of these benzene compounds and their effect on energy metabolism in experimental animals. Rat experiment results are described. 4 refs. In Russian.

Kashkald, D.A.; Kolodub, F.A. *Gig Tr Prof Zabol n 2* Feb 1988 p 48-49.

**075331 POLYCHLORINATED BIPHENYLS AND POLYCHLORINATED DIBENZOFURANS IN THE TISSUES OF PATIENTS WITH YUSHO OR YU-CHEN; TOTAL TOXICITY.** The most serious incident of polychlorinated biphenyls (PCBs) and polychlorinated dibenzofurans (PCDFs) poisoning in humans, referred to as Yusho, occurred in Western Japan in 1968 and involved the ingestion of rice oil contaminated with these compounds. A second similar mass food poisoning, Yu-Chen, took place in central Taiwan in 1979. It is presently impossible to assess, directly from high resolution capillary gas chromatographic (GC) data, the total toxicity resulting from a mixture of these toxic substances in a particular tissue. It is the objective of this study to provide a method for determining the relative toxicity of each of these congeners and isomers in terms of an equivalent toxic concentration of TCDD so that the overall toxicity of the mixture may be evaluated. The applicability of this approach is then demonstrated by the direct conversion of available Yusho and Yu-Chen GC data to total equivalent toxicities of TCDD. 21 refs.

Olafsson, P.G. (Xenobiotics Corp, Albany, NY, USA); Bryan, A.M.; Stone, W. *Bull Environ Contam Toxicol* v 41 n 1 Jul 1988 p 63-70.

**075332 EFFECTS OF NITRILACETIC ACID, Cd AND Hg ON THE MARINE ALGAE, DUNALIELLA TERTIOLECTA AND ISOCHRYSIS GALBANA.** Microalgae *Dunaliella tertiolecta* and *Isochrysis galbana* were cultured in the presence of: (i) NTA (1, 5 and 10 mg l<sup>-1</sup>) or (ii) metals: Cd<sup>2+</sup> (13.8 mg l<sup>-1</sup> for *D. tertiolecta*; 0.2 mg l<sup>-1</sup> for *I. galbana*), and Hg<sup>2+</sup> (0.96 mg l<sup>-1</sup> for *D. tertiolecta*; 0.02 mg l<sup>-1</sup> for *I. galbana*); (iii) metal (above dose) with the addition of NTA in 1:1, 1:2, 1:3 molar ratios. Population growth data show the absence of toxicity of NTA and the absence of interaction of NTA with the toxic effects of metals. (Author abstract) 31 refs.

Bressan, Monica (Univ of Padua, Padua, Italy); Brunetti, Riccardo. *Water Res* v 22 n 5 May 1988 p 553-556.

**Trace Analysis** See Also AIR POLLUTION—Sampling; BIOLOGICAL MATERIALS—Trace Analysis; FLUE GASES—Chromatographic Analysis; PEAT—Testing; WATER POLLUTION—Analysis; WATER POLLUTION—Underground.

**075333 DERIVATIZATION AS AN APPROACH TO TRACE ANALYSIS BY GAS CHROMATOGRAPHY WITH ELECTRON-CAPTURE DETECTION.** The unsurpassed sensitivity and selectivity of the electron-capture detector to compounds of environmental and biomedical importance has maintained widespread interest in its application to all aspects of organic trace analysis. In this review, the characteristics of the reagents used for trace analysis are discussed. The subject is treated in general terms to provide an overview of the techniques involved, present some considerations for reagent selection, and discuss those aspects of the detector's response that influence the quality of quantitative data measured at trace levels. (Edited author abstract) 83 refs.

Poole, Colin F. (Wayne State Univ, Detroit, MI, USA); Poole, Salwa K. *J Chromatogr Sci* v 25 n 10 Oct 1987 p 434-443.

**075334 TRACE ANALYSIS OF VOLATILE POLAR ORGANICS: PROBLEMS AND PROSPECTS.** Existing approaches to the trace analysis of volatile polar organics by gas chromatography are reviewed. Problems are noted, and the prospects for solving these problems and developing protocols that are suitable for routine use are discussed. It is shown that one of the more promising techniques for the further development of trace analysis of volatile polar organics employs an uncoated capillary column to concentrate analytes from water. The organics are removed from aqueous solution merely by passing the



sample through an uncoated capillary. They are subsequently desorbed thermally or by the use of an appropriate solvent. 38 refs.

Middleditch, Brian S. (Univ of Houston, Houston, TX, USA); Zlatkis, Albert; Schwartz, Robert D. *J Chromatogr Sci* v 26 n 4 Apr 1988 p 150-152.

**075335 SAMPLING AND ANALYSIS TECHNIQUES FOR TRACE VOLATILE ORGANIC EMISSIONS FROM CONSUMER PRODUCTS.** Comparisons are made of two techniques for the trace analysis of volatile organic compound (VOC) emissions from consumer products: direct on-line sampling and analysis and on-line solid sorbent collection followed by off-line analysis. Two types of direct analyses are examined. The first consists of direct injection of emissions from a sample loaded environmental chamber into a gas chromatograph equipped with a flame ionization detector (FID) for compound identification. Direct injection of headspace collected emissions into a gas chromatograph equipped with a mass selective detector is the second direct method scrutinized. The more traditional technique of solid sorbent collection of the volatile organic emissions followed by thermal desorption (TD)/gas chromatographic (GC)/mass spectrometric desorption analysis is compared to both direct on-line methods. (Author abstract) 14 refs.

Bayer, Charlene W. (Georgia Tech Research Inst, Atlanta, GA, USA); Black, Marilyn S.; Galloway, Linda M. *J Chromatogr Sci* v 26 n 4 Apr 1988 p 168-173.

## Viscoelasticity

**075336 INFLUENCE OF ADDED SALT ON DYNAMIC VISCOELASTICITY OF CARBOXYMETHYLCELLULOSE AQUEOUS SYSTEMS.** Using three series of sodium carboxymethylcellulose (NaCMC) in the range of the degree of substitution (the average number of carboxymethyl groups/glucose unit) from 0.5 to 1.3, weight-average molecular weight  $M_w$  was determined by light scattering in solution of triethylenediamine cadmium hydroxide (cadoxene). It was found that the relation between  $M_w$  and the limiting viscosity number  $[\eta]$  in 0.1 N sodium chloride (NaCl) aqueous solution can be represented by Staudinger's equation. Dynamic viscoelasticity of aqueous disperse systems of NaCMC with various added salts was measured by means of a cone-and-plate rheometer. If the concentration of added salt is less than the concentration at which polymer begins to salt out, frequency dependence curves of the dynamic modulus, which is measured at various salt concentrations, can be superposed into a master curve by horizontal shift only. (Edited author abstract) 12 refs.

Matsumoto, Takayoshi (Kyoto Univ, Kyoto, Jpn); Mashiko, Kimio. *Polym Eng Sci* v 28 n 6 Mar 1988 p 393-402.

**Viscosity** See Also OIL WELL PRODUCTION—Tertiary; POLYSACCHARIDES—Viscosity.

**075337 DENSITIES AND VISCOSITIES OF THE BINARY MIXTURES METHANOL-ETHYLBENZENE AND CUMENE-1-BUTANOL.** Densities and viscosities of two binaries, viz., methanol-ethylbenzene, and cumene-1-butanol, were measured at 25 and 35°C. The excess values of molar volume, viscosity and Gibbs free energy for the activation of flow were evaluated. The Grunberg-Nissan parameter was calculated. The viscosity data were fitted to the semitheoretical equations of R.L. McAllister, E.L. Heric and a polynomial. The results indicate the presence of molecular interactions between unlike molecules in both the binaries with the strength of interaction being greater in methanol-ethylbenzene. (Author abstract) 16 refs.

Rattan, V.K. (Panjab Univ, Chandigarh, India); Singh, Sukhmehar; Sethi, B.P.S.; Raju, K.S.N. *Indian J Technol* v 25 n 6 Jun 1987 p 253-258.

**075338 VISCOSITIES OF BINARY MIXTURES OF CYCLOPENTANE AND n-ALKANES AT 298.15 K.** Viscosities of binary mixtures of cyclopentane +

n-hexane, + n-octane, + n-decane, + n-dodecane, + n-tetradecane and + n-hexadecane have been measured at 298.15 K. The excess viscosity and the excess Gibbs energy of activation of viscous flow have been calculated from the experimental data. The predicted excess viscosity from the absolute rate and free volume theories of viscosities is in poor agreement with the experimental. The differences may be attributed to the orientational order effect in the long chain n-alkanes. (Author abstract) 17 refs.

Awad, Alk M. (Council of Scientific Research, Baghdad, Iraq); Salman, Muna A. *J Pet Res* v 6 n 2 Dec 1987 p 117-129.

**075339 ISOBARIC VAPOUR-LIQUID EQUILIBRIA AND VISCOSITIES OF (1, 2-DICHLOROETHANE + METHYLCYCLOHEXANE).** Isobaric vapor liquid equilibria for the mixtures of 1,2-dichloroethylene and methylcyclohexane measured using a vapor recirculating equilibrium still at 100.5 kPa are reported. The system is found to form a minimum boiling azeotrope. Wilson equation gave the best fit of the experimental activity coefficients, whose thermodynamic consistency have been tested by the methods of E.F.G. Herrington, C. Black, R. Norrish and G.H. Twigg, and B.C.-Y. Lu. Viscosities at 308.15 K have been measured using a modified Ubbelohde viscometer. The excess viscosity, excess molar Gibbs free energy for the activation of flow, and Grunberg and Nissan parameter derived from the mixture viscosity data are also presented. The study indicates dipole-induced dipole type interactions in the system. This data is essential for the design of equipment for separation processes. (Edited author abstract). 35 Refs.

Rattan, V.K. (Panjab Univ, Chandigarh, India); Sethi, B.P.S.; Singh, Sukhmehar; Raju, K.S.N. *Indian J Technol* v 26 n 4 Apr 1988 p 197-200.

**Waste Utilization** See WASTE DISPOSAL—Composting.

**X-Ray Analysis** See CRYSTALS—X-Ray Analysis.

**ORGANOMETALLICS** See Also ALCOHOLS—Synthesis; CATALYSTS—Materials; CATALYSTS—Supported; CATALYSTS—Synthesis; COPPER COMPOUNDS—Synthesis; CRYSTALS—Molecular Structure; GRAPHITE; ION EXCHANGERS—Synthesis; MANGANESE COMPOUNDS—Chemical Vapor Deposition; MANGANESE COMPOUNDS—Synthesis; OLIGOMERS—Curing; ORGANIC COMPOUNDS—Molecular Weight; ORGANIC COMPOUNDS—Optical Properties; ORGANIC COMPOUNDS—Synthesis; POLYBUTADIENE—Microstructure; POLYVINYL CHLORIDE—Heat Stabilizers; SEMICONDUCTING CADMIUM COMPOUNDS—Surfaces; SEMICONDUCTING GALLIUM ARSENIDE—Defects; SEMICONDUCTING ORGANIC COMPOUNDS; SEMICONDUCTOR MATERIALS—Vapor Deposition; SODIUM COMPOUNDS; SOLID STATE DEVICES—Materials; SUPERCONDUCTING MATERIALS; TRANSITION METALS—Optical Properties.

**075340 TRANSFORMATION OF OXO RHENIUM COMPLEXES USED AS CATALYSTS IN METATHESIS REACTION.** For a better understanding of the role of oxo complexes in olefin metathesis reaction, we examined the following Re(III) compounds:  $\text{ReCl}_3(\text{PMePh}_2)_3$ ,  $\text{ReCl}_3[\text{P}(\text{OEt})_3]_3$ ,  $\text{ReCl}_3\text{py}_3$  and related Re(V) oxo complexes:  $\text{ReOCl}_3(\text{PPh}_3)_2$ ,  $\text{ReOCl}_3[\text{P}(\text{OEt})_3]_2$  and  $\text{ReOCl}_3\text{py}_2$  as precatalysts in metathesis reaction. It was found that the formation of ethane was shown by means of  $^1\text{H}$  NMR for solution and by mass spectroscopy for vapour phase samples taken from over a solution. One of the most significant changes in the  $^1\text{H}$  NMR spectrum was the appearance of a broadened quartet at  $\delta$  6.70 ppm most likely due to alkylidene  $\alpha$ -proton. Moreover, complicated changes in the methylene and methyl group resonating regions were observed. 16 refs.

Rybak, Witold K. (Univ of Wroclaw, Wroclaw, Pol); Ziolkowski, Jozef J. *J Mol Catal* v 42 n 3 Nov 2 1987 p 347-352.

**075341 ZUR CHEMISCHEN BINDUNG IN DER ERSTEN ORGANOMETALLCLUSTERVERBINDUNG MIT EINEM INTERSTITIELLEN SI-ATOM**

**IM CLUSTERANION  $[\mu_8\text{-SiCo}_9(\text{CO})_{21}]^{2-}$ .** [Chemical Bonding in the First Organometallic Cluster Compound with an Interstitial Si-Atom in the Cluster Anion  $[\mu_8\text{-SiCo}_9(\text{CO})_{21}]^{2-}$ ]. The aim of this work is to calculate the electronic structure of the cluster anion  $[\mu_8\text{-SiCo}_9(\text{CO})_{21}]^{2-}$  using a combination of EHMO and SW-X $\alpha$ -methods. Energies and correlation diagrams (including geometry optimization), as well as charge distribution (population analysis) and bonding properties, are discussed in detail. (Edited author abstract) In German. 23 refs.

Mueller, H. (Friedrich-Schiller-Univ, Jena, East Ger); Fuehr, U.; Opitz, Ch.; Fritsche, H.-G. *J Less Common Met* v 137 Feb 1 1988 p 195-210.

**075342 CHIRAL SYNTHESIS VIA ORGANOBORANES. 13. A HIGHLY DIASTERESELECTIVE AND ENANTIOSELECTIVE ADDITION OF  $[(Z)\text{-}\gamma\text{-ALKOXYALLYL}]\text{DIISOPINOCAMPHEYLBORANES TO ALDEHYDES}$ .** Isomerically pure  $[(Z)\text{-}\gamma\text{-methoxyallyl}]\text{diisopinocampheylboranes}$  have been prepared from 8-methoxydiisopinocampheylborane and lithiated allyl methyl ether. These enantiomeric  $[(Z)\text{-}\gamma\text{-methoxyallyl}]\text{diisopinocampheylboranes}$ , the first such derivatives to be synthesized, retain their stereochemical identity under the reaction conditions. They have been successfully condensed with various aldehydes, such as acetaldehyde, propionaldehyde, 2-methylpropionaldehyde, and benzaldehyde in a regioselective and stereoselective manner to yield the corresponding three- $\beta$ -methoxyhomoallyl alcohols in  $\geq 99\%$  diastereoselectivities and  $\geq 95\%$  enantioselectivities. This work is of interest to the synthesis of carbohydrates and antibiotics. (Edited author abstract) 22 refs.

Brown, Herbert C. (Purdue Univ, West Lafayette, IN, USA); Jadhav, Prabhakar K.; Bhat, Krishna S. *J Am Chem Soc* v 110 n 5 Mar 1988 p 1535-1538.

**075343 EFFECT OF CAVITY SIZE ON THE CHARGE DISTRIBUTION IN CARBIDO-METAL CARBONYL CLUSTERS AND ITS POSSIBLE CATALYTIC IMPLICATIONS.** Molecular orbital calculations on carbido-transition-metal carbonyl cluster compounds where the carbon atom lies in a large cavity indicate a substantial buildup of negative charge on the carbon atom. Besides making the carbon more susceptible to protonic attack the large cavity assists the stabilization of interstitial C-H fragments. Experimental evidence suggests that a carbon atom within a large cavity bears a substantial negative charge and should be very susceptible to electrophilic reagents. The results of the molecular orbital calculations on model carbido clusters with 4-12 metal atoms are summarized. (Edited author abstract) 18 refs.

Halet, Jean-Francois (Univ of Oxford, Oxford, Engl); Evans, David G.; Michael, D.; Mingos, P. *J Am Chem Soc* v 110 n 1 Jan 6 1988 p 87-90.

**075344 CARBON-METAL HYDROGEN INTERCHANGE IN ORGANOMETAL CLUSTERS ON RUTHENIUM AND OSMIUM.** Facile carbon-metal hydrogen exchange is demonstrated by the scrambling of deuterium into the hydrocarbon ligand at 110°C in a sample initially 80% enriched in deuterium at the hydride position by  $^1\text{H}$ -NMR techniques. Deuterium was incorporated into the allenic hydrogen position and the methylene hydrogens but not into the methyl groups. These studies demonstrate that reversible carbon-metal hydrogen interchange at  $\alpha\text{-C-H}$  bonds can be a facile process in trinuclear organometallic complexes of ruthenium and osmium containing  $\eta^3\text{-hydrocarbon}$  ligands. (Edited author abstract) 12 refs.

Skinner, David M. (California State Univ, Northridge, CA, USA); Rosenberg, Edward; Bracker-Novak, Julia; Aime, Silvio; Osella, Domenico; Gobetto, Roberto. *Organometallics* v 7 n 4 Apr 1988 p 856-858.



**075345 ORGANOMETALLIC COMPLEXES OF OSMIUM WITH SULFUR-CONTAINING LIGANDS: SYNTHESIS OF**  $\text{cis}[\text{Os}(\text{N}(\text{CH}_2\text{SiMe}_3)_2)(\text{SCH}_2\text{CH}_2\text{S})^-]$  **AND**  $\text{cis}[\text{Os}(\text{N}(\text{CH}_2\text{SiMe}_3)_2)(\text{SCN})_2]^-$  **AND THE SYNTHESIS AND X-RAY CRYSTAL STRUCTURE OF**  $\text{cis}[\text{Os}(\text{N}(\text{CH}_2\text{SiMe}_3)_2)(2\text{-S-NC}_5\text{H}_4)_2]$ . Osmium (VI) complexes with 1,2-ethanedithiolato, pyridine-2-thiolato, and thiocyanato ligands can be prepared in good yield by substitution of halide in the dihalide complex  $[\text{N-n-Bu}_4][\text{Os}(\text{N}(\text{CH}_2\text{SiMe}_3)_2)_2]$ . These complexes are thermally stable and stable to air and water. Analysis of IR spectra shows that in the major isomer of  $[\text{N-n-Bu}_4][\text{Os}(\text{N}(\text{CH}_2\text{SiMe}_3)_2)(\text{SCN})_2]$  both thiocyanate groups are bonded to osmium through nitrogen, while the minor isomer contains both S-bonded and N-bonded thiocyanate groups. The 1,2-ethanedithiolato and pyridine-2-thiolato ligands are strongly electron-donating to the osmium center. 24 refs.

Zhang, Naijie (Univ of Illinois, Urbana, IL, USA); Wilson, Scott R.; Shapley, Patricia A. *Organometallics* v 7 n 5 May 1988 p 1126-1131.

**075346 NEW FERROCENYL SULFIDES AND SELENIDES: PREPARATION AND APPLICATION AS EFFICIENT SELECTIVE HYDROGENATION CATALYSTS.** In this work we report the preparation of new ferrocenyl sulfide and selenide complexes such as  $\text{C}_5\text{H}_5\text{Fe}(\text{C}_5\text{H}_4\text{-1-CH}_2\text{NMe}_2\text{-ER})\text{PdCl}_2$  ( $\text{E}=\text{S}, \text{Se}; \text{R}=\text{Pr}, \text{n-Bu}, \text{s-Bu}, \text{t-Bu}, \text{Bz}, 4\text{-tolyl}, 4\text{-ClPh}$ ). These chiral complexes have been used in selective hydrogenation of conjugated dienes to monoenes at ambient temperatures.  $^1\text{H}$  and  $^{13}\text{C}$  NMR spectra were obtained, and IR, MS, melting point, and elemental analysis data of these bimetallic complexes are presented. The palladium(II) ferrocenyl sulfide complexes are good selective homogeneous and heterogeneous hydrogenation catalysts for the reduction of conjugated dienes to monoenes at room temperature. (Edited author abstract) 59 refs.

Okoroafor, Michael O. (Michigan State Univ, East Lansing, MI, USA); Shen, Lei-Hang; Honeychuck, Robert V.; Brubaker, Carl H. Jr. *Organometallics* v 7 n 6 Jun 1988 p 1297-1302.

**075347  $^{29}\text{Si}$  NMR ACCESS TO STEREOCHEMISTRY OF ORGANOSILICON COMPOUNDS. 3. VINYLIC SILANES.**  $^{29}\text{Si}$  NMR data are reported for a series of vinyllic and acetylenic silanes. Chemical shifts were measured and  $^{29}\text{Si}$ ,  $^1\text{H}$  coupling constants were determined by using the selective polarization transfer (SPT) technique. It was found in particular that there is a relationship between  $^3J$  and the stereochemistry of the molecules. (Author abstract) 17 refs.

Grignon-Dubois, Micheline (CNRS, Talence, Fr); Laguerre, Michel. *Organometallics* v 7 n 6 Jun 1988 p 1443-1446.

**075348 THEORY OF JAHN-TELLER INTERACTION IN METALLOCEENES: I. COBALTOCENE AND FERRICENIUM CATION.** A canonical transformation and variational approach is used to treat the Jahn-Teller problem in an effective one-electron or hole case in  $D_{5h}$  symmetry. The Jahn-Teller spin-orbit and orthorhombic field interactions are treated on equal footing. The variational wavefunctions are used to calculate the magnetic and EPR behavior of cobaltocene and ferricenium cation. In cobaltocene the orthorhombic interaction is found to be small and whether it is treated on equal footing with the other two interactions or as a perturbation the values of the variational parameters remain nearly the same. In ferricenium cation the covalency effects are found to be negligible. Along with the linear (JT) term the third order term in the vibrational potential also plays an important role in this case. (Author abstract) 10 refs.

Rai, R. (Natl Physical Lab, New Delhi, India). *Physica B & C* v 150 n 3 Jun 1988 p 414-418.

**075349 THEORY OF JAHN-TELLER INTERACTION IN METALLOCEENES: II. CHROMOCENE.** The  $^3E_g(e^3_2g^1_1g)$  ground state of chromocene is treated

as a system consisting of two holes, one in the  $e_{2g}$  and the other in the  $a_{1g}$  orbital. By a suitable choice of the basis vectors the vibronic eigenvalue equations of this case are transformed into isomorphic forms to the corresponding equation for the one electron case. The method of canonical transformation and variational approach developed in part I therefore is applied to chromocene also. The variational wavefunctions and energies are used to explain the EPR and Raman spectroscopy results on the complex. (Author abstract) 7 refs.

Rai, R. (Natl Physics Lab, New Delhi, India). *Physica B & C* v 150 n 3 Jun 1988 p 419-422.

**075350 FIFTH INTERNATIONAL CONFERENCE ON THE ORGANOMETALLIC AND COORDINATION CHEMISTRY OF GERMANIUM, TIN AND LEAD.** This issue contains 12 conference papers, of which 2 are given in abstract form only. All of the papers are abstracted and indexed separately. Topics covered include: organotin compounds; organic synthesis; amorphous semiconducting germanium; coordination compounds; electronic stabilized stannyls; stereoselective synthesis; hydrogen bonding; and organogermanium compounds. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10224 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Int Tin Research Inst, London, Engl). *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 87-305.

Adsorption See STEEL—Surfaces.

Applications See PLASTICS—Antistatic Agents; RUBBER, SYNTHETIC—Stabilizers.

Bibliographies See GRAPHITE—Bibliographies.

Chelation See POLYMERS—Chemical Reactions.

Chemical Reactions See Also LUBRICATING OILS—Additives; POLYSACCHARIDES—Crosslinking; SEMICONDUCTING GALLIUM COMPOUNDS—Growth; SEMICONDUCTING GALLIUM COMPOUNDS—Vapor Deposition.

**075351 STUDIES OF REACTIONS BETWEEN GASEOUS ORGANO-SILICON COMPOUNDS AND METAL SURFACES.** A procedure for modifying the surface composition of catalytically active metals with silicon-containing gaseous reactants has been developed. This new gas-solid reaction method is unique in that it can be used for the in situ synthesis of catalytically interesting materials, which cannot be done by conventional solid-solid reaction techniques. This treatment can readily be accomplished in situ in the catalytic reactor. The above reactions may well result in a new class of metallic catalysts, with one of the components being silicon. Furthermore, gas-phase compounds containing the elements aluminum, boron, and germanium are known to react with metals in an analogous manner, which further extends the range of possibilities for the synthesis of new catalytic materials. (Edited author abstract). 20 Refs.

Yates, D.J.C. (Exxon Research & Engineering Co, Annandale, NJ, USA); Behal, S.K.; Kear, B.H. *J Mater Sci* v 3 n 4 Jul 8 1988 p 714-722.

**075352 SILICON COMPOUNDS WITH STRONG INTRAMOLECULAR STERIC INTERACTIONS: XXIII. FORMATION AND REACTIONS OF STERICALLY CONGESTED ACYCLIC TRISILANES AND OF A TETRASILOXANE.** Ring opening reactions of hexa-tert-butylcyclotrisilane with halogens ( $\text{Cl}_2$ ,  $\text{Br}_2$ ,  $\text{I}_2$ ) or with halides lead to sterically crowded 1,3-dihalo-hexa-tert-butyltrisilanes which are easily converted into the corresponding 1,3-dihydrotrisilane. Reaction of the dihalotrisilanes with methylolithium regenerates the cyclotrisilane in moderate yield. Irradiation of the three-membered cycle and dimethylsulfide in the presence of water affords 1,7-dihydro-1,1,3,3,5,5,7,7-octa-tert-butyl-tetrasiloxane. (Author abstract) 11 refs.

Weidenbruch, Manfred (Univ of Oldenburg, Oldenburg, West Ger); Flintjer, Bolko; Schaefer, Annemarie. *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 19-23.

Chemical Vapor Deposition See ZINC COMPOUNDS—Thin Films.

Chromatographic Analysis

**075353 GAS CHROMATOGRAPHIC SEPARATION OF  $\text{PF}_3$  SUBSTITUTED GROUP 6 METAL CARBONYL COMPLEXES USING SERIALY-COUPLED CAPILLARY COLUMNS.** The retention of group 6 metal trifluorophosphine carbonyl compounds in serially-coupled gas capillary columns has been studied as a function of different column configurations. For the trifluorophosphine-substituted Mo, W, and Cr carbonyls, as well as the analogous Fe compounds, it was observed that the maximum resolution achievable by the coupled column technique was dependent on the order in which the nonpolar (DB-1) and moderately polar (DB-1701) columns were connected. (Edited author abstract) 17 refs.

Hwang, Wen-Huan (Florida State Univ, Tallahassee, FL, USA); Clark, R.J.; Cooper, W.T. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 10 n 9 Sep 1987 p 504-509.

Concentration See WATER POLLUTION—Monitoring.

Decomposition See Also SEMICONDUCTING GERMANIUM—Chemical Vapor Deposition; SILANES—Thermal Effects.

**075354 LASER DECOMPOSITION OF PLATINUM METALLO-ORGANIC FILMS FOR ELECTROLESS COPPER PLATING.** Micron-size platinum features are patterned by focusing the output of a CW argon ion laser (514.5 nm) onto a scanning quartz substrate coated with a spun-on platinum metallo-organic film. The platinum is used as a seed layer for electroless copper plating. The role of laser power, scan speed, and film thickness on the thermal decomposition of the film is discussed. In addition, the electrochemical activity and composition of the platinum features, as well as their use as seed layer for electroless copper plating, is reported. (Author abstract) 11 refs.

Sausa, Rosario C. (IBM, Yorktown Heights, NY, USA); Gupta, Arunava. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2707-2713.

**075355 DECOMPOSITION OF  $\text{CH}_3\text{TiCl}_3$  COMPLEXES WITH PYRIDINE-BASED LIGANDS.** The kinetics and mechanisms of the reactions of  $\text{CH}_3\text{TiCl}_3$  with pyridine,  $\gamma$ -picoline, and 4-vinylpyridine were investigated. It was found that a homolytic break of the Ti-C bond takes place in  $\text{CH}_3\text{TiCl}_3$  complexes with pyridine. It was established that, as a consequence of the decomposition of the Ti-C bond in  $\text{CH}_3\text{TiCl}_3$  complexes with 4-vinylpyridine and with  $\gamma$ -picoline the pyridine ring is metallized. The rate constants of this process were determined. (Author abstract) 9 refs.

Serebryanaya, I.V. (Acad of Sciences of the USSR, Chernogolovsk, USSR); Krushch, N.E.; D'yachkovskii, F.S. *Kinet Catal* v 28 n 2 pt 1 Mar-Apr 1987 p 266-270.

Doping

**075356 ELECTROCHEMICAL DOPING OF ( $\mu$ -PYRAZINE)-PHTHALO-CYANINATOIRON(II). G. alvanostatic doping of  $[\text{PcFe}(\text{pyz})_2]_n$  ( $\text{Pc}$ =phthalocyaninato,  $\text{pyz}$ =pyrazine) using several anions leads to well characterized compounds with the stoichiometry  $[\text{PcFe}(\text{pyz})_2X]_n$  ( $X=\text{BF}_4^-$ ,  $\text{PF}_6^-$ ,  $\text{ClO}_4^-$ ,  $\text{HSO}_4^-$ ,  $\text{SCN}^-$  and  $\text{BPh}_4^-$ ). The stoichiometry of the doped samples was established by elemental analyses, thermogravimetric analyses (TG/DTA) and charge quantity measurements. Magnetic measurements and  $^{57}\text{Fe}$  Mossbauer data show that the oxidation is mainly ligand centered. Four-probe conductivity measurements reveal**



increases in conductivity of up to four orders of magnitude. The increase in conductivity was accompanied with a broad electronic absorption in the infrared spectra.  $^{13}\text{C}$  CP-MAS solid-state n.m.r. spectra and X-ray powder diffraction data are also recorded. (Author abstract) 14 refs.

Hanack, Michael (Univ Tuebingen, Tuebingen, West Ger); Leverenz, Andreas. *Synth Met* v 22 n 1 Nov 1987 p 9-14.

## Electric Conductivity

**075357 STRUCTURAL AND ELECTRICAL PROPERTIES OF (BEDT-TTF) $_2\text{Hg}_3\text{Br}_{11}$ .** New organic conductors (BEDT-TTF) $_2\text{Hg}_3\text{Br}_{11}$  and (BEDT-TTF) $\text{HgBr}_3$  (BEDT-TTF: bis(ethylenedithio)tetrathiafulvalene) are prepared, and their crystal structures, transport properties, and ESR are investigated. In the former complex, 3/10 of the BEDT-TTF molecules are incorporated in the anion sheet as BEDT-TTF $^{2+}$ . This complex shows, in spite of its complicated 7-fold periodicity, metallic conductivity down to 120 K. (Author abstract) 10 refs.

Mori, T. (Inst for Molecular Science, Okazaki, Jpn); Wang, P.; Imaeda, K.; Enoki, T.; Inokuchi, H. *Solid State Commun* v 64 n 5 Nov 1987 p 733-737.

**075358 SUPERCONDUCTIVITY AT 10 K AND AMBIENT PRESSURE IN THE ORGANIC METAL (BEDT-TTF) $_2\text{Cu}(\text{SCN})_2$ .** The authors confirm the observation of superconductivity at ambient pressure above 10 K in the metal (BEDT-TTF) $_2\text{Cu}(\text{SCN})_2$  as reported recently by Urayama et al. The authors have measured ESR, ac-susceptibility and thermopower in crystals of (BEDT-TTF) $_2\text{Cu}(\text{SCN})_2$  and have shown that in contrast to other organic superconductors a relatively sharp superconducting transition even in the ac-susceptibility can be observed which saturates already around 8 K. The thermopower measurements indicate a clear metal-metal phase transition at 100 K and a possible second phase transition at around 50 K, while from the temperature dependence of the and susceptibility (ESR) these phase transitions cannot be observed. (Edited author abstract) 17 refs.

Gaertner, S. (Max Planck-Inst fuer Medizinische Forschung, Heidelberg, West Ger); Gogu, E.; Heinen, I.; Keller, H.J.; Klutz, T.; Schweitzer, D. *Solid State Commun* v 65 n 12 Mar 1988 p 1531-1534.

**075359 TEMPERATURE AND PRESSURE DEPENDENCE OF THE RESISTIVITY OF  $\beta(\text{BEDT-TTF})_2\text{X}(\text{X}=\text{I}_3, \text{I}_2, \text{Au})$  AND  $\alpha\text{T}(\text{BEDT-TTF})_2\text{I}_3$ .** The temperature dependence of the resistivity of the organic metals and superconductors  $\beta(\text{BEDT-TTF})_2\text{I}_3$ ,  $\beta(\text{BEDT-TTF})_2\text{I}_2$  and  $\alpha\text{T}(\text{BEDT-TTF})_2\text{I}_3$  was measured at ambient and at several isotropic pressures (up to 2.5 kbar). By the application of a relatively low pressure, it is possible to measure the term in the resistivity that is linear in temperature. This term is masked by the larger  $T^2$  term at ambient pressure. It is shown that in the temperature range below 120 K, the external modes are mainly responsible for the resistivity, while above this temperature the flipping of the  $\text{CH}_2$  groups becomes important. (Edited author abstract). 18 Refs.

Weger, M. (Hebrew Univ, Jerusalem, Isr); Bender, K.; Klutz, T.; Schweitzer, D.; Gross, F.; Heidmann, C.P.; Probst, CH.; Andres, K. *Synth Met* v 25 n 1 Jul 1988 p 49-58.

## Electric Properties

**075360 ELECTRICAL CONDUCTIVITY AND THERMOPOWER STUDIES ON  $\text{Fe}_x[\text{Pt}(\text{C}_2\text{O}_4)_2] \cdot 6\text{H}_2\text{O}$  (WHERE  $x=0.8$ ).** The electrical conductivity (dc and 35 GHz) and thermopower of  $\text{Fe}_x[\text{Pt}(\text{C}_2\text{O}_4)_2] \cdot 6\text{H}_2\text{O}$ , Fe-OP, are presented and compared with those of other partially oxidized bis(oxalato)platinate salts of divalent cations. At room temperature Fe-OP is metallic with a conductivity of  $6\text{ S cm}^{-1}$  and a thermopower of  $15\text{ } \mu\text{V/K}$ . Below room temperature there is a structural transition, which has little influence on transport proper-

ties. Below 160 K Fe-OP is a semiconductor with an activation energy of 55 meV. (Author abstract) 11 refs.

Kaye, B. (Univ Coll of North Wales, Gwynedd, Wales); Underhill, A.E.; Mortensen, K.; Carneiro, K.; Yuequiang, Shen; Jacobsen, C.S.; Bertinotti, A. *Synth Met* v 22 n 1 Nov 1987 p 35-40.

**075361 ELECTRIC AND MAGNETIC PROPERTIES OF ORGANOMETALLIC TCNQ SALTS.** Three salts  $[(\eta^5\text{-C}_5\text{H}_5)\text{FeAr}]^+[(\text{TCNQ})_2]^-$  ( $\text{Ar}=\text{2, 4, 6-C}_6\text{H}_3\text{Me}_3$ ,  $\text{C}_6\text{Me}_6$ ,  $\text{C}_6\text{Et}_6$ ) have been characterized by dc conductivity, thermoelectric power and esr measurements. Quasi-semiconducting properties of electric transport have been found, with a temperature-dependent energy gap in the case of the first two salts and a constant gap for the third salt. The magnetic properties have been shown to be determined by the non-paired electrons of TCNQ. The angular dependences of the g factor and the esr linewidth have been analyzed with regard to the crystal structure. The spin interactions and localization of electrons have been found to be dependent on the ligand size in the aromatic ring of the cation. (Author abstract) 9 refs.

Pukacki, W. (Polish Acad of Sciences, Poznan, Pol); Graja, A. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 137-143.

**075362 SPECTRAL PROPERTIES OF THE NEW SERIES OF ORGANOMETALLIC TCNQ SALTS WITH METALLOCENE STACKS.** Infrared measurements of a new series of organometallic TCNQ salts with metallocene donors were performed in the out-of-plane vibrational region ( $880\text{-}800\text{ cm}^{-1}$ ) of a TCNQ molecule. Thermal evolution of the spectra has been used as an indicator of the electron localization in the TCNQ chains. (Author abstract) 6 refs.

Pawlak, M. (Polish Acad of Sciences, Poznan, Pol); Graja, A. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 145-149.

**075363 E.S.R. AND ELECTRICAL PROPERTIES OF THE ORGANIC METAL (BEDT-TTF) $_4\text{Hg}_3\text{Cl}_8$ .** (BEDT-TTF) $_4\text{Hg}_3\text{Cl}_8$  is a new ion-radical salt in which superconductivity has been observed at 1.7 K under a pressure of 12 kbar. The angular dependences of the g factor and the linewidth,  $\Delta H$ , at room temperature, for three perpendicular crystal orientations have been studied. The angular study of g and  $\Delta H$  indicated strong two dimensionality of the spin ordering of the crystals. The temperature dependences of the spin susceptibility  $\chi$  of monocrystals of (BEDT-TTF) $_4\text{Hg}_3\text{Cl}_8$  were analyzed. Above 220 K, a temperature-independent spin susceptibility seems to characterize the Pauli spin susceptibility;  $\chi$  of (BEDT-TTF) $_4\text{Hg}_3\text{Cl}_8$  was about  $2.1 \times 10^{-4}\text{ emu/mole}$ . The e.s.r. study has been complemented by thermopower, S, measurements along the a and b axes. (Edited author abstract) 7 refs.

Sekretarczyk, G. (Polish Acad of Sciences, Poznan, Pol); Graja, A.; Goldenberg, L.M. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 161-166.

**Electrodeposition** See DIE CASTINGS—Protective Coatings.

## Electronic Properties

**075364 ELECTRONIC STATE OF METALLOPORPHYRINS.** The electronic states of the oxidized and reduced metalloporphyrins were studied to provide a basis for electronic device applications of the molecules. The effective energy level of the d electron in the metal ion has been found to be approximately 1 eV higher than the HOMO level of the  $\pi$  electron in the porphyrin ring. Fe ions in the Fe porphyrin were found to be irreducible when the temperature was much higher than approximately 280 K. (Author abstract) 23 refs.

Sugahara, Masanori (Yokohama Natl Univ, Yokohama, Jpn); Haneji, Nobuo; Imamura, Kimitake; Niki, Katsumi; Takano, Wataru; Kaneda, Hisayoshi. *Jpn J Appl Phys Part 1* v 27 n 1 Jan 1988 p 109-116.

**Environmental Impact** See FUNGICIDES—Agricultural Applications.

## Forming

**075365 KINETIC FEATURES OF THE PROCESS OF OLIGOMERIZATION OF DIENE HYDROCARBONS UNDER THE ACTION OF METALLIC SODIUM IN PRESENCE OF TRI-ISOBUTYL ALUMINIUM.** General rules have been determined for the formation of homogeneous organosodium aluminum compounds, capable of initiating anionic polymerization of diene hydrocarbons. It was shown to be possible to regulate the oligomer chain length and the active sodium content in the product by changing the triisobutyl aluminum concentration. In addition, an analysis of the kinetic data showed that the nature of the oligomerization process in presence of TIBA (Tri-Isobutyl Aluminum) differs significantly from the formation of organosodium compounds, without TIBA. (Edited author abstract) 12 refs.

Skornyakov, A.S. (S.V. Lebedev All-Soviet Synthetic Rubber Research Inst, USSR); Krol, V.A. *Polym Sci USSR* v 28 n 9 1986 p 2085-2091.

## Ionization

**075366 INVESTIGATION OF FRAGMENTATION PROCESSES FOLLOWING CORE PHOTOIONIZATION OF ORGANOMETALLIC MOLECULES IN THE VAPOR PHASE.** Ionic fragmentation processes following  $(n-1)d$  core level photoionization of organometallic molecules have been studied in the vapor phase using synchrotron radiation. Results on tetramethyllead, tetramethyltin and tetramethylgermanium are reported. The threshold electron spectra and the photoionization efficiency curves of these molecules are presented and discussed. It is concluded that the  $(n-1)d^9$  core-hole state of  $\text{M}(\text{CH}_3)_4$  ( $\text{M} = \text{Pb, Sn or Ge}$ ) is split into five sublevels owing to both the spin-orbit coupling and the electrostatic perturbations by the methyl groups, and that the  $\text{M}^+$  ions are predominantly produced following  $(n-1)d$  photoionization. (Author abstract) 15 refs.

Nagaoka, Shin-ichi (Inst of Molecular Science, Okazaki, Jpn); Suzuki, Shinzo; Koyano, Inosuke. *Nucl Instrum Methods Phys Res Sect A* v A266 n 1-3 Apr 1 1988, Synchrotron Radiat Instrum, Proc of the Fifth Natl Conf, Madison, WI, USA, Jun 21-25 1987 p 699-703.

## Isomerization

**075367 SILENE STEREOCHEMISTRY: 5. AN EXPERIMENTAL DETERMINATION OF THE ACTIVATION ENERGY FOR A SILENE TRANS-CIS ISOMERIZATION.** The E- and Z-isomers of 1-methyl-1-phenyl-2-neopentylsilene, generated by the sealed tube thermolyses of their anthracene adducts are stereospecifically trapped by methoxytrimethylsilane to give diastereomeric adducts. Under isomerizing conditions the ratio of the two diastereomers obtained when the silene formed from the pure E-anthracene adduct is trapped is a linear function of the concentration of the trapping reagent. The temperature dependence of permitted the first experimental determination of the activation energy for a silene E- to Z-isomerization of  $43 \pm 6\text{ kcal/mole}$ . (Author abstract) 6 refs.

Jones, Paul Ronald (North Texas State Univ, Denton, TX, USA); Lee, Myong Euy. *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometal and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 11-18.



**075368 METHANOL-INDUCED ISOMERISATION OF SOME 5-ALKYLCYCLOHEX-2-ENYLSTANNANES.** Predominantly cis-5-methylcyclohex-2-enyltrimethylstannane experiences clean methanol induced isomerization to predominantly (65%) the trans isomer. Approach to equilibrium is first order in stannane and  $^2\text{H}$  labelling indicates a symmetric intermediate is involved. The trans isomer is calculated to be ca 0.4 kcal/mole more stable than the cis such energy difference reflecting a stabilizing  $\sigma-\pi$  interaction (C-Sn bond with  $\pi$  system) in the trans isomer, as well as relief of allylic strain (between  $\text{Sn}(\text{CH}_3)_3$  and  $\text{H}_2$ ) in the cis. The trans-5-*t*-butyl analogue also predominates at equilibrium (c. 79%). (Author abstract) 9 refs.

Young, David (Univ of Queensland, Brisbane, Aust); Kitching, William. *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 67-70.

## Magnetic Properties

**075369 STATIC MAGNETIC SUSCEPTIBILITIES OF POLY(PHENYLETHYNYLCOPPER) DOPED WITH IODINE.** Static magnetic susceptibilities of poly(phenylethynylcopper), doped with iodine, are reported and analysed in view of a simple 'dilute' system of paramagnetic centres in a diamagnetic matrix, the unpaired electron concentration being generated by a thermal activation process. The resulting diamagnetism,  $-3.3 \times 10^{-9} \text{ m}^3 \text{ kg}^{-1}$ , is low suggesting the presence of a temperature independent paramagnetism of  $\geq 0.6 \times 10^{-9} \text{ m}^3 \text{ kg}^{-1}$ . The maximum concentration of unpaired electrons accounted for by the data, taken above 160 K, is  $3.1 \times 10^{-2}$  per mole. The 4.2 K concentration is  $1.8 \times 10^{-3}$  unpaired electrons per mole. The field dependence of the low temperature susceptibility indicates the occurrence of ferromagnetic coupling between unpaired electrons, showing that the 'dilute' model does not hold in the low temperature region. (Author abstract) 6 refs.

Krikor, H. (Univ of Antwerp, Antwerp, Belg); Nagels, P.; Vansummen, J.; Van den Bosch, A. *Phys Status Solidi A* v 107 n 2 Jun 1988 p 639-646.

## Optical Properties

**075370 OPTICALLY ACTIVE ORGANOIRON COMPLEXES. PREPARATION AND CHEMISTRY.** The achiral and optically active  $\text{Fp}(\text{dioxene})\text{BF}_4$  complexes 2a and 2b ( $\text{Fp}$  = dicarbonylcyclopentadienyliron) are readily prepared from  $\text{Fp}(1,2\text{-dimethoxyethylene})\text{BF}_4$  by glycol exchange reactions. The barrier to ring inversion in these compounds is estimated to be 7.6 kcal/mol from low-temperature  $^{13}\text{C}$  NMR spectral measurements. A crystal structure determination of 2a shows significant distortions due to transannular steric interactions between the  $\text{Fp}$  carbonyl groups and an axial ring proton. Lateral displacement of the  $\text{Fp}$  group along the C-C double-bond axis is also suggested by the X-ray data and is supported by  $^{13}\text{C}$  and  $^1\text{H}$  NMR spectral analyses. (Edited author abstract) 28 refs.

Turnbull, Mark M. (Brandeis Univ, Waltham, MA, USA); Foxman, Bruce M.; Rosenblum, Myron. *Organometallics* v 7 n 1 Jan 1988 p 200-210.

**075371 RUTHENIUM(II)-POLYPYRIDINE CAGE COMPLEXES: LUMINESCENCE AND PHOTO-CHEMICAL PROPERTIES.** The first noncryptand type, spacered tris-bpy-ligand and the first closed cage ruthenium(II)-polypyridine complex have been synthesized. Data are reported concerning the photophysical and photochemical behavior of that cage complex and some related species. The most interesting result is the extraordinary stability of the cage complex toward photodecomposition, about  $10^4$  times higher than that of  $\text{Ru}(\text{bpy})_3^{2+}$ . It is generally agreed that for  $\text{Ru}(\text{bpy})_3^{2+}$  the ligand photosubstitution reaction proceeds via a thermally activated radiationless transition from the luminescent metal-to-ligand charge-transfer ( $^3\text{CT}$ ) level to a distorted metal-centered ( $^3\text{MC}$ ) level, with subsequent cleavage of one Ru-N bond and formation of an intermediate contain-

ing a monodentate bpy ligand. 14 Refs.

De Cola, Luisa (CNR, Bologna, Italy); Barigelletti, Francesco; Balzani, Vincenzo; Belser, Peter; von Zelewsky, Alex; Voegtli, Fritz; Ebmeyer, Frank; Grammenudi, Smaragda. *J Am Chem Soc* v 110 n 21 Oct 12 1988 p 7210-7212.

## Oxidation See Also IRON OXIDES—Manufacture.

**075372 ELECTROCHEMICAL OXIDATION OF CYCLOPOLYSILANES USING CYCLIC VOLTAMMETRY.** A series of 28 cyclopolysilanes were studied by cyclic voltammetry in dichloromethane and shown to undergo irreversible oxidation at potentials from 0.54 to 1.6 v. Oxidation potentials increase with ring size from  $\text{Si}_3$  to  $\text{Si}_6$ , with the lowest value, 0.54 v, found for the highly strained compound  $[(t\text{-Bu})_2\text{Si}]_3$ . For the dimethyl compounds, potentials decrease again above  $\text{Si}_9$ ; the differences parallel those for the electronic excitation energies of the same compounds. (Author abstract) 28 refs.

Shafiee, Fathieh (Univ of Wisconsin, Madison, WI, USA); West, Robert. *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 1-10.

## Performance See LUBRICATING OILS—Additives.

## Phase Transitions See Also SOAP—Metallic.

**075373 GROUP-THEORETICAL ANALYSIS OF THE SYMMETRY CHANGES IN  $\text{R}_2\text{MX}_4$  COMPOUNDS.** Commensurate subgroups of  $\text{Pnma}$  are obtained by a group-theoretical method started from the Landau theory of continuous phase transitions. The investigated high symmetry points are  $\Gamma$ , X, Y, Z, R, T, S, U,  $\Sigma$ ,  $\Delta$ , and A. These points belonging to the first Brillouin zone, are the most involved ones according to literature experimental data. The selected order parameter is defined in the basis associated with the corresponding irreducible representation of  $\text{Pnma}$ , so it may represent any physical property. The results are given in table form together with some useful information concerning the low symmetry structure. A particular interest is devoted to  $\text{R}_2\text{MX}_4$  compounds ( $\text{R}$ =organic cation;  $\text{M}=\text{Cu}$ ,  $\text{Cd}$ ,  $\text{Hg}$ ,  $\text{Zn}$ , ...;  $\text{X}=\text{Cl}$ ,  $\text{Br}$ ) where the parent structure has  $\text{Pnma}$  symmetry. (Author abstract) 18 refs.

Abdi, S. (Ecole Natl d'Ingenieurs, Sfax, Tunisia); Mlik, Y.; Ben Ghazlen, M.H. *Phys Status Solidi B* v 142 n 1 Jul 1987 p 27-34.

**075374 CALORIMETRIC STUDY OF THE PHASE TRANSITION IN DEUTERATED METHYLAMMONIUM HEXACHLOROSTANNATE.** The heat capacity of methylammonium- $\text{d}_6$  hexachlorostannate has been measured between 13 and 300 K. A peak due to the phase transition occurred at  $(154.96 \pm 0.06)$  K. Critical properties of the transition were characterized by detailed measurement around  $T_c$ . Models of disorder that carry large enough entropy to explain the experimental transition entropy  $21.8 \text{ J K}^{-1} \text{ mol}^{-1}$  are proposed, with particular attention paid to the symmetry of the two phases. (Author abstract) 18 refs.

Matsuo, Takasuke (Osaka Univ, Toyonaka, Jpn); Yan, Hai-Kai; Suga, Hiroshi. *J Phys Chem Solids* v 49 n 1 1988 p 85-90.

## Physical Properties See Also GOLD COMPOUNDS—Physical Properties; SEMICONDUCTOR MATERIALS—Growth.

**075375 INITIAL STUDIES ON A NEW TELLURIUM CONTAINING ORGANIC METAL: TETRATELLURAFULVALENE-TETRACYANOQUINODIMETHANE (TTef-TCNQ).** Experimental conditions for the growth of acicular crystals of the new organic conductor tetratellurafulvalene-tetracyanoquinodimethane (TTef-TCNQ) are reported. The room temperature conductivity along the needle axis was found to be  $1800 \pm 300 (\Omega\text{-cm})^{-1}$ . dc conductivity studies down to 77

K displayed metallic behavior and microwave conductivity studies showed the compound to still be highly conducting at 5 K. EPR studies down to 8 K were performed but no measurable resonances were recorded. Preliminary x-ray scattering studies indicate a segregated stack structure with a stacking distance of  $3.95 \pm 0.01 \text{ \AA}$ . The charge transfer was found to be  $0.71 \pm 0.03 e^-$  from infrared spectroscopy data. In most respects the physical properties of TTef-TCNQ are similar to those of HMTSF-TCNQ. (Author abstract) 10 refs.

Mays, M.D. (Johns Hopkins Univ, Baltimore, MD, USA); McCullough, R.D.; Cowan, D.O.; Poehler, T.O.; Bryden, W.A.; Kistenmacher, T.J. *Solid State Commun* v 65 n 10 Mar 1988 p 1089-1092.

## Polarographic Analysis

**075376 POLAROGRAPHIC STUDY OF MIXED COMPLEXES OF  $\text{Mn(II)}$  WITH PYRIDINE AND FORMATE.** The polarographic behavior of manganese(II)-pyridine-formate system has been reported. Rather starting results are obtained upon comparison of the equilibrium constants for the addition of formate anion or pyridine molecule to the various bis ligand complexes. Addition of either a pyridine molecule or a formate anion to  $\text{Mn}(\text{py})_2^{2+}$  would be hindered, despite the opposite charges of the latter two species, while addition of either ligand to  $\text{Mn}(\text{formate})_2$  would proceed more readily. It is possible to explain the observed trends on the assumption that the negatively charged formate anions, each with two oxygen atoms, repel and loosen the coordinated water molecule to a greater extent than do pyridine molecule. 5 refs.

Sharma, Jyoti (Delhi Univ, Delhi, India); Kumar, Arvind; Rao, A.L.J.; Puri, B.K. *J Electrochem Soc India* v 36 n 3 Jul 1987 p 191-192.

**075377 POLAROGRAPHIC STUDY OF COPPER WITH  $\delta$ -VALEROLACTAM AND ITS ANALYTICAL APPLICATIONS.** This work deals with the determination of the thermodynamic parameters and the stability constants of the complexes formed by copper with  $\delta$ -valerolactam at different temperatures i.e. 303, 313 and 323 K. It is found that in most of these cases mixed electrolytes have been used and in certain cases a maximum suppressor is also required. Thus, the sensitivity and accuracy in the measurement of the diffusion-current tend to decrease. 4 refs.

Kumar, Ashok (D.A. Univ of Indore, Indore, India); Katal, M.; Puri, B.K. *J Electrochem Soc India* v 36 n 3 Jul 1987 p 195-197.

**075378 MIXED LIGAND COMPLEXES OF COPPER ION WITH L-TYROSINE.** The mixed ligand complex formation by copper ion with L-trosine and some bicarboxylic acids have been investigated by employing polarographic technique of W.B. Schaap and D.L. McMasters. The reduction of all the six systems under investigation: (copper-tyrosine-oxalate, copper-tyrosine-maleate, copper-tyrosine-tartrate, copper-tyrosine-maleate, copper-tyrosine-malonate, copper-tyrosine-succinate) has been found to involve a two electron reversible diffusion controlled wave. The stability constants are discussed from the point of view of steric, electrostatic and statistical considerations. (Author abstract) 10 refs.

Saxena, R.K. (Univ of Rajasthan, Jaipur, India); Rajanikumari, Chandel, C.P.S.; Gupta, C.M. *Trans SA-EST* v 22 n 3 Jul-Sep 1987 p 169-172.

**075379 POLAROGRAPHIC BEHAVIOUR OF CADMIUM, IRON, COBALT, NICKEL AND ZINC IONS AS PIPERIDINE COMPLEXES AND THEIR SIMULTANEOUS DETERMINATION IN BINARY MIXTURES.** Using piperidine as complexing agent, the authors have undertaken the analysis of few metal ions individually and in their binary mixtures and the results are presented. It is found that the shift in half wave-poten-



tials of the ions indicate the formation of stable complexes with piperidine. Linear plots of diffusion current vs concentration 0.5 to 2 mM indicated the feasibility of this method for the quantitative determination of the metal ions. 3 refs.

Saraswathi, K. (S.V. Univ, Tirupati, India); Rao, B. Srinivasa. *J Electrochem Soc India* v 36 n 4 Oct 1987 p 287-288.

**Polymerization** See Also NEODYMIUM COMPOUNDS—Chelation; UREA FORMALDEHYDE RESINS—Synthesis.

**075380 ORGANOSILYLENES AND THEIR DIMERIZATION TO DISILENES.** By photolysis of cyclosilanes or linear trisilanes, 22 different organosilylenes have been isolated in 3-methylpentane glass at 77K. The wavelengths of the principal electronic transitions of the silylenes are reported; these range from 368 to 577 nm. Upon annealing of the glass the silylene absorption is lost and new absorption bands appear, assigned to disilenes formed by dimerization of the silylenes. (Author abstract) 17 refs.

Michalczyk, Michael J. (Univ of Wisconsin, Madison, WI, USA); Fink, Mark J.; De Young, Douglas J.; Carlson, Corey W.; Welsh, Kevin M.; West, Robert; Michl, Josef. *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 75-80.

## Processing

**075381 CARBON SORPTION METHOD FOR REMOVAL OF ORGANOTIN-COMPOUND VAPORS FROM WASTE GASES.** Investigations on the adsorption of organotin-compound vapors were carried out on AR-3-type activated carbon at 25°C under dynamic conditions with synthetic vapor-air mixtures at a flow rate of 0.2 m/sec (adsorber diameter of 20 mm) with TET and TBT as the adsorbate. Experimental results show that for concentrations of 7.5 mg/m<sup>3</sup> organotin compounds, 21.5 g/m<sup>3</sup> benzene, and 41.5 g/m<sup>3</sup> ether in the gas before cleaning, the degree of their removal from the gas was 99.1, 99.2, and 91.0%, respectively. After regeneration of the activated carbon by water vapor (at 300°C for 2 h with a vapor consumption of 5-7 kg/kg of the mixture of collected organic substances), the degree of gas cleaning did not decrease, at least in the first two or three adsorption-regeneration cycles. 12 refs.

Stepanov, A.S.; Batrakov, G.N. *J Appl Chem USSR* v 59 n 8 pt 1 Aug 1986 p 1575-1577.

**Pyrolysis** See CERAMIC MATERIALS—Fibers; FERRITES—Synthesis; NICKEL COMPOUNDS—Synthesis; SUPERCONDUCTING MATERIALS—Film; TITANIUM OXIDES—Synthesis.

## Radiation Effects

**075382 RADIOLYTIC REDUCTION OF FERRICETHYLENEDIAMINETETRAACETATE IN AQUEOUS SOLUTION.** Aqueous solution of ferricethylenediaminetetraacetate (F) was radiolyzed in deaerated medium and in the presence of HCOO<sup>-</sup>, 2-propanol, t-butanol, N<sub>2</sub>O and O<sub>2</sub>. The G[Fe(II)] was found to be equal to G(-F). Apart from e<sup>-</sup>(aq) and H atom, CO<sub>2</sub><sup>-</sup>, (CH<sub>3</sub>)<sub>2</sub>C-OH, O<sub>2</sub><sup>-</sup> and HO<sub>2</sub> radicals directly reduced Fe(III) of the chelate; the OH radical did so indirectly through hydrogen abstraction from ligand and reacted more readily with Fe(II) than with F. (Author abstract) 14 refs.

Sahul, K. (Jamal Mohamed Coll, Tiruchirappalli, India). *Radiat Phys Chem* v 30 n 1 1987 p 51-53.

**Research** See Also HYDROCARBONS—Fischer-Tropsch Synthesis; VANADIUM COMPOUNDS—Electronic Properties.

**075383 NaBH<sub>4</sub> REDUCTION OF CO IN THE CATIONIC IRON CARBONYL COMPLEXES [C<sub>5</sub>Me<sub>2</sub>Fe(CO)<sub>2</sub> L]<sup>+</sup>PF<sub>6</sub><sup>-</sup> (L = CO OR PHOSPHINE).**

In recognition of the limited petroleum reserves of the world, interest has grown in the conversion of coal to a synthetic fuel. An experiment has been carried out on reducing CO in a cationic iron carbonyl complex with the use of NaBH<sub>4</sub>. The studies effected using neutral transition-metal hydrides indicate that they are less efficient than NaBH<sub>4</sub>, especially in the reduction of hydroxymethyl to methyl. 100 Refs.

Lapinte, Claude (CNRS, Rennes, Fr); Catheline, Daniel; Astruc, Didier. *Organometallics* v 7 n 8 Aug 1988 p 1683-1691.

**075384 HEAVY ATOM MAIN GROUP 4 ANALOGUES OF CARBENES, RADICALS, AND ALKENES: THE USE OF BULKY TRIMETHYLSILYL-SUBSTITUTED LIGANDS.** This paper deals with compounds of general formula MX<sub>2</sub>, MX<sub>3</sub> (briefly), and R<sub>2</sub>M=MR<sub>2</sub> (where M=Ge, Sn, or Pb). The ligands X<sup>-</sup> and R<sup>-</sup> are bulky groups containing trimethylsilyl substituents and may be C-, N-, O-, or S-centered. Among the ligands X<sup>-</sup> investigated were the following: R<sup>-</sup>, N<sup>-</sup>(SiMe<sub>3</sub>)<sub>2</sub>, <sup>-</sup>CB<sub>3</sub>, O<sup>-</sup>Ar, S<sup>-</sup>C(SiMe<sub>3</sub>)<sub>3</sub>, and S<sup>-</sup>Ar[R=CH(SiMe<sub>3</sub>)<sub>2</sub>, Ar=C<sub>6</sub>H<sub>2</sub>Bu<sup>-</sup><sub>2</sub>-2,6-Me-4, Ar=C<sub>6</sub>H<sub>2</sub>Bu<sup>-</sup><sub>3</sub>-2,4,6], and stable compounds belonging to each of these classes MX<sub>2</sub>, MX<sub>3</sub>, and R<sub>2</sub>M=MR<sub>2</sub> (where M=Ge and Sn; and for MX<sub>2</sub>, M also=Pb) have been obtained. The author discusses the role of the carbene analogs MX<sub>2</sub> [especially for the case of X=N(SiMe<sub>3</sub>)<sub>2</sub>] in transition metal chemistry. Various classes of reactions have been identified. (Edited author abstract) 41 refs.

Lappert, Michael F. (Univ of Sussex, Brighton, Engl). *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 129-154.

**075385 RECENT DEVELOPMENTS IN THE CHEMISTRY AND APPLICATIONS OF ORGANOTIN COMPOUNDS.** Organotin compounds have become large-scale industrial chemicals. Formulated products are being used in applications as diverse as catalysts, heat and light stabilizers for PVC, antifouling point biocides, agrochemicals, wood preservatives, in the treatment of glass surfaces and others. Industrial aspects of organotin chemicals are briefly reviewed and some highlights from the chemistry of organotin compounds are discussed with emphasis on their use in organic synthesis. (Edited author abstract)

Noltes, J.G. (Netherlands Organization for Applied Scientific Research, Utrecht, Neth). *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 211.

## Reviews

**075386 ORGANO-GERMANIUM, -TIN AND -LEAD CHEMISTRY WITH SULPHUR LIGANDS.** The author presents a brief review of the chemistry of organo-germanium, -tin and -lead derivatives with a few selected sulfur ligands like thiols, dithiols, dialkyldithiophosphates, alkylenedithiophosphates, monothio-β-diketones, β-aminothionates, benzothiozoles and xanthates. A convenient route for synthesis of tin tetracarboxylates from the reaction of tin tetrathiolates with acid anhydrides is highlighted. Tin tetracetate, thus obtained, has been used for the synthesis of a variety of sulfur ligand derivatives of tin. Work has been initiated on some other sulfur ligands like thiocarboxylates and thiocarbamates, including monothiocarbamates are also covered. (Edited author abstract) 125 refs.

Mehrotra, R.C. (Univ of Rajasthan, Jaipur, India). *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 185-210.

**Specific Heat** See CHROMIUM COMPOUNDS—Specific Heat.

**Spectroscopic Analysis** See Also ORGANIC COMPOUNDS—Chromatographic Analysis; POLYACRYLO-NITRILE—Electronic Properties.

**075387 SPECIATION OF METHYL- AND BUTYL-TIN COMPOUNDS AND INORGANIC TIN IN OYSTERS BY HYDRIDE GENERATION ATOMIC ABSORPTION SPECTROMETRY.** This paper describes speciation of inorganic tin, methyltin compounds, and butyltin compounds from oyster samples. We validated the hydride generation atomic absorption spectrophotometric technique by demonstrating ca. 100% recovery from spiked samples and by the absence of any organotin decomposition products. Absolute detection limits (3 σ) are 1.1-2.5 ng for 0.1-g oyster samples (wet weight). This method is superior to published techniques because of careful validation, low limits of detection, and minimal sample manipulation. (Edited author abstract) 19 refs.

Han, Jennie S. (Univ of New Hampshire, Durham, NH, USA); Weber, James H. *Anal Chem* v 60 n 4 Feb 1988 p 316-319.

**075388 VARIABLE TEMPERATURE FTIR SPECTROSCOPY OF ORGANOTIN THIOCYANATES.** The position of the C-N stretch band center and the temperature dependence of this frequency have been determined for a number of organotin (IV) thiocyanates, including compounds in which the metal atom shows four-, five-, six-, and seven-coordination. A detailed comparison is made between structures involving both bridging and terminal thiocyanate groups of related molecular systems. In compounds in which the SCN group acts as a terminal ligand by bonding through the N atom, the band center is observed in the range 2050 to 2066 cm<sup>-1</sup> and has a temperature dependence of ca. (2.5+1) × 10<sup>-2</sup> cm<sup>-1</sup> K<sup>-1</sup>. In contrast, organotin (IV) compounds in which the ligand acts as a bridging moiety, the band center is observed in the range 2096 to 2116 cm<sup>-1</sup> and shows a wide range of band center temperature dependencies which are related to the molecular level architecture of the metal atom environment. (Edited author abstract) 35 refs.

Herber, R.H. (Rutgers Univ, New Brunswick, NJ, USA). *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 113-128.

**075389 <sup>119</sup>Sn AND <sup>31</sup>P NMR STUDIES OF COORDINATION COMPOUNDS OF TETRAVALENT TIN WITH MONO- AND BIDENTATE PHOSPHINES.** Complexation of SnHal<sub>4</sub> and RSnHal<sub>3</sub> (R=Me, Et, Ph; Hal=Cl, Br) with mono- and bidentate tertiary phosphines has been studied in detail by means of <sup>119</sup>Sn and <sup>31</sup>P NMR spectroscopy in solutions in dichloromethane within the wide intervals of temperatures and ratios of donor to acceptor. NMR parameters have been obtained for fifty complexes. Phosphines have been chosen as ligands. Principal efforts were concentrated on obtaining the spectral parameters of <sup>119</sup>Sn and <sup>31</sup>P, and maximal attention has been focused on the <sup>119</sup>Sn-<sup>31</sup>P couplings. (Edited author abstract) 7 refs.

Petrosyan, V.S. (Moscow State Univ, Moscow, USSR); Yashina, N.S.; Gefel, E.I. *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 213-239.

## Stability

**075390 5-ELEMENT-STANNA(II)BICYCLOOTANES - ELECTRONIC STABILIZED STANNYLENES.** It is shown that in 5-element-stanna(II)bicycloclootanes and in certain structures the stannylenes can be stabilized by intramolecular donor-acceptor interactions. The stannylene properties of the compounds studied are evidenced from dynamic NMR measurements. The 1,5-donor-acceptor interactions in the first are proved by



X-ray analysis. The reactivity of all three stannylens with electrophilic and nucleophilic reagents and their ability to form complexes with transition metals are discussed. (Edited author abstract) 41 refs.

Tzschach, Alfred (Martin Luther Univ, Halle, East Ger); Jurkschat, Klaus. *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 263-278.

**Structure** See Also PLATINUM AND ALLOYS—Research.

**075391 COMPLEXES WITH SUBSTITUTED 2,5-DIHYDROXY-P-BENZOQUINONES:**  $AE[C_6(C_2H_5)_2O_4] \cdot 3H_2O$  ( $AE = Ca, Sr, Ba$ ). Single crystals of  $AE[C_6(C_2H_5)_2O_4] \cdot 3H_2O$  belonging to space group  $P2_1 2_1 2_1$  were grown in aqueous silicagel ( $AE = Ca, Sr$ ) and in aqueous solution ( $AE = Ba$ ), respectively.  $AE^{2+}$  is coordinated by four oxygen atoms of two bis-chelating  $[C_6(C_2H_5)_2O_4]^{2-}$  ions, thus forming infinite, corrugated chains extending along [010]. The coordination polyhedron is completed by additional water molecules. The coordination sphere is different for the three different  $AE^{2+}$  ions. Adjacent chains are interlinked by hydrogen bonds between water molecules of the coordination sphere and the oxygen atoms of the  $[C_6(C_2H_5)_2O_4]^{2-}$  ion. (Edited author abstract) 15 refs.

Robl, Christian (Univ Muenchen, Munich, West Ger). *Mater Res Bull* v 22 n 10 Oct 1987 p 1395-1403.

**075392 NONCLASSICAL UREA OLIGOMERS. IX. PHOTO-REDUCING NATURE OF BINUCLEAR COPPER COMPLEXES OF NONCYCLIC PENDANT-TYPE UREA OLIGOMERS.** The octametric oligomers of 1-(N-substituted-carbamoyl)-aziridine, i.e., N-ureanized-oligo-ethylenimines, form  $Cu(II)$  complexes. When the N-substituents are phenyl(1, 3), methyl(2), and p-tolyl(4) groups, the main portions of the  $Cu(II)$  complexes are binuclear. The binuclear oligomer- $Cu(II)$  complexes showed characteristic properties of photo-reduction of  $Cu(II)$  species, giving rise to stable yellow  $Cu(I)$  species. The ease of photo reduction strongly depends on the oligomer structures, especially on the nature of the pendant-urea groups, i.e.,  $4 > 1,3 > 2$ . In the series of aromatic type urea-oligomers, highly stable photo-radicals were observed in ESR. By using an optically active oligomer (3) the molecular requirements for these characteristic properties were investigated with circular dichroism and cyclic voltammetry. And one of the plausible structures was deduced as the model of binuclear  $Cu(II)$  sites surrounded by oligomeric environments. (Author abstract) 19 refs.

Araki, Takeo (Shimane Univ, Matsue, Jpn); Kubo, Yasuo; Hino, Atsushi; Yasuda, Yokho; Kamachi, Mikiharu. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 285-299.

**075393 STRUCTURE - ACTIVITY RELATIONSHIP AND MOLECULAR BONDING PARAMETERS FROM ROOM-TEMPERATURE MULTIFREQUENCY ESR SPECTRA OF ANITUMOR COPPER(II) COMPLEXES.** A rigorous unambiguous way to extract all the necessary magnetic parameters for copper complexes in the fluid phase, by a combination of multifrequency ESR spectroscopy and computer simulation, is presented. By this method, which has the obvious advantage of not changing the physical state of the system, homologue copper complexes with very different cytotoxic and pharmacological activities ( $CuKTS$  and  $CuKTSm_2$ ) were examined. Having extracted the spin Hamiltonian parameters and the rotational correlation time from the room-temperature ESR spectra of the two complexes at multiple frequencies, small differences were found in the isotropic nitrogen coupling constants. This was never appreciated before because of the aggregation occurring in the samples at low temperature. (Edited author abstract) 45 refs.

Basosi, Riccardo (Univ of Siena, Siena, Italy). *J Phys Chem* v 92 n 4 Feb 25 1988 p 992-997.

**075394 CLUSTER SYNTHESIS. 17. SYNTHESIS AND STRUCTURAL CHARACTERIZATIONS OF  $Ru_5(CO)_{15}(\mu_4-S)$ ,  $Ru_6(CO)_{18}(\mu_4-S)$ , AND  $Ru_7(CO)_{21}(\mu_4-S)$ .** The authors have investigated the preparation and structural character of a new series of higher nuclearity ruthenium carbonyl clusters that contain only one sulfido ligand. As with the previous series similarities and differences to the osmium system were observed again. Three new compounds with the formulas  $Ru_5(CO)_{15}(\mu_4-S)$  (2),  $Ru_6(CO)_{18}(\mu_4-S)$  (3), and  $Ru_7(CO)_{21}(\mu_4-S)$  (4) were obtained in yields which varied depending on the amount of  $Ru(CO)_5$  that was initially present, the temperature, and the duration of the reaction period. When heated to  $68^\circ C$  for 10 min in the presence of a 3/1  $Ru(CO)_5/1$  molar ratio, the yields of 2, 3, and 4 were 62%, 9%, and 0%, respectively, but when heated to  $98^\circ C$  for 15 min in a 10/1  $Ru(CO)_5/1$  molar ratio, the yields were 8%, 55%, and 23%, respectively. 16 refs.

Adams, Richard D. (Univ of South Carolina, Columbia, SC, USA); Babin, James E.; Tasi, Miklos. *Organometallics* v 7 n 2 Feb 1988 p 503-513.

**075395 STRUCTURAL STUDIES OF ORGANOTIN COMPOUNDS.** Results are reported of studies by n.m.r. spectroscopy on the solid and solution states, and of single crystal X-ray diffraction of various types of Sn-O and Sn-S bonded compounds. These include 1,3,2-dioxastannolanes, oxathiastannolanes, dithiastannolanes, and trimethyltin hydroxide. (Author abstract) 17 refs.

Davies, Alwyn G. (Univ Coll London, London, Engl); Slater, Sean D. *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 87-98.

**075396 IMPORTANCE OF HYDROGEN BONDING OF ORGANOTIN IN WATER.** We have been studying organotin in situations in which hydrogen bonding is possible, and we conclude that information from non-aqueous phases is largely irrelevant to the situation in water. We review results on the solid-state structures of a number of organotins. We find that in all situations in which hydrogen bonding is possible, it is this feature that predominates in determining the structure, with the organotin moiety accommodating as best it can, relinquishing favored for less-favored bonding partners, adopting lower than maximum possible coordination numbers, forming lattices of ions delocalized by hydrogen bonding rather than expected covalent condensation products and adjusting crystal habits to those determined by the propagation of hydrogen bonds rather than by tin bonds. (Edited author abstract)

Zuckerman, J.J. (Univ of Oklahoma, Norman, OK, USA). *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 305.

**Synthesis** See Also BIOMEDICAL EQUIPMENT—Radionuclides; INDIUM COMPOUNDS—Synthesis; MAGNETIC MATERIALS—Ferromagnetism.

**075397  $(\eta^3\text{-PHOSPHAALLYL})\text{IRON COMPLEXES: SYNTHESIS AND PRELIMINARY CHEMICAL STUDY.}$**  Vinylchlorophosphine  $P-W(CO)_5$  complexes react in boiling toluene with  $[CpFe(CO)_2]_2$  to give  $\mu_2$ -vinylphosphido complexes whose phosphorus atom bridges a  $W(CO)_5$  and a  $Fe(CO)_2Cp$  unit. Upon short irradiation, these  $\mu_2$ -complexes yield  $(\eta^3\text{-1-phosphaallyl})Fe(CO)Cp$  complexes as mixtures of two isomers. These two series of isomers undergo a slow equilibration in solution. This equilibration takes place via the decoordination and the upside-down rotation of the vinyl unit followed by a recomplexation of this unit by the iron atom. These two series of isomers differ mainly in the magnitude of the  $^2J(P-C-H)$  coupling constants within the phosphoallyl unit. The constant is high (ca. 30 Hz) when the  $W-P-C-H$  dihedral angle is close to  $0^\circ$  and low (ca. 0 Hz) when this angle is close to  $180^\circ$ . (Edited author abstract) 28 refs.

Mercier, Francois (DCPH-Ecole Polytechnique, Palai-

seau, Fr); Hugel-Le Goff, Catherine; Mathey, Francois. *Organometallics* v 7 n 4 Apr 1988 p 955-963.

**075398 SYNTHESIS AND CHARACTERIZATION OF NEOPENTYL GALLIUM COMPOUNDS.** The authors report the synthesis and characterization of a series of organogallium compounds that incorporate the neopentyl ( $CH_2CMe_3 = Np$ ) group including  $GaNp_3$ ,  $GaNp_2Cl$ ,  $GaNp_2Br$ ,  $GaNpCl_2$ , and  $GaNpI_2$ . These neopentylgallium derivatives are of chemical interest because the bulky neopentyl substituent with no  $\beta$ -hydrogen atoms might introduce unusual chemical properties. A comparison of the properties of the neopentyl- and (trimethylsilyl)methylgallium derivatives suggest that the neopentyl group has larger steric effects and stronger electron-withdrawing properties than the corresponding (trimethylsilyl)methyl substituents. 13 refs.

Beachley, O.T. Jr (State Univ of New York at Buffalo, Buffalo, NY, USA); Pazik, J.C. *Organometallics* v 7 n 7 Jul 1988 p 1516-1519.

**075399 PREPARATION OF 1,2,4,5-TETRASTANNACYCLOHEXANES CONTAINING DIMETHYLBUILDING BLOCKS.** A series of 1,2,4,5-tetrastannacyclohexanes has been prepared from precursors of the type  $BrSnMe_2CRR'SnMe_2Br$ . In contrast to hexaalkylditins these are air-stable molecules, but the tin-tin bonds in both exhibit similar reactivity. (Edited author abstract) 12 refs.

Mitchell, T.N. (Univ Dortmund, Dortmund, West Ger); Fabisch, B.; Wickenkamp, R. *Silicon Germanium Tin Lead Compd* v 9 n 2-3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7-11 1986 p 57-65.

**075400 NEW DEVELOPMENTS IN THE CHEMISTRY OF PEROXO-METAL AND CHROMIUM(VI)-OXIDANT SYSTEMS.** The importance of syntheses and studies of reactivity of peroxo-metal compounds, which provide a heuristic approach in this field for an understanding of catalytic oxidation reactions, has been highlighted. Innovative approaches and their scope in the synthesis of new heteroligand peroxo-metal compounds are described. The oxidations of organic substrates involving a new  $Cr(VI)$  reagent, pyridinium fluorochromate,  $C_5H_5NHCrO_3F$  (PFC), are described. PFC in dichloromethane oxidizes primary and secondary alcohols to the corresponding aldehydes and ketones. (Edited author abstract) 62 refs.

Chaudhuri, Mihir K. (North-Eastern Hill Univ, Shillong, India). *J Mol Catal* v 44 n 1 Feb 15 1988, Int Workshop on Homogen Catal: Act of Mol Oxygen and Catal Oxid by Dioxigen Compd, Bhavnagar, India, Oct 3-6 1986 p 129-141.

## Testing

**075401 INTERACTION OF TRIALKYLALUMINUM REAGENTS WITH METAL-BOUND ETHYLENE AND CARBON MONOXIDE. THE MOLECULAR STRUCTURE OF  $(\eta^5-C_5Me_5)_2Ta(H)(C_2H_4 \cdot AlEt_3)$ .** The compounds  $(\eta^5-C_5Me_5)_2M(H)(C_2H_4)$  and  $(\eta^5-C_5Me_5)_2M(H)(CO)$  ( $M = Nb, Ta$ ) reversibly bind trialkylaluminum reagents to give 1:1 adducts in which the aluminum is bonded to the metal-bound ethylene or carbonyl oxygen in preference to the hydride ligand. The mixed-ring compound  $(\eta^5-C_5Me_5)(\eta^5-C_5H_5)Ta(H)(CO)$ , in contrast, binds aluminum at the hydride ligand. This structure displays an unusual ethylene bridge between the aluminum and tantalum centers. The significance of these adducts in the context of Ziegler-Natta catalysis and migratory insertion is discussed. (Edited author abstract) 34 refs.

McDade, Christine (California Inst of Technology, Pasadena, CA, USA); Gibson, Vernon C.; Santarsiero, Bernard D.; Bercau, John E. *Organometallics* v 7 n 1 Jan 1988 p 1-7.



## Thermodynamic Properties

**075402 KINETICS, MECHANISM, AND THERMODYNAMIC ASPECTS OF THE INTERCONVERSION OF COMPLEXES OF PLANAR AND NON-PLANAR METALLO-AMIDO-N GROUPS.** In this report we discuss the first mechanistic study of facile isomerizations of diastereomeric complexes in which planar and nonplanar amido-N ligands are interconverted. The accumulated evidence consistently suggests that the T mechanism most reasonably describes the isomerizations of the systems studied. While the focus here has been upon processes occurring at a transition-metal center, the isomerization reactions interconvert cis- $\alpha$  and trans diastereomers where the enthalpy difference is primarily a result of the presence of nonplanar amido-N ligands in the former and planar amido-N ligands in the latter. 15 refs.

Collins, Terrence J. (California Inst of Technology, Pasadena, CA, USA); Keech, John T. *J Am Chem Soc* v 110 n 4 Feb 1988 p 1162-1167.

Thin Films See GASES—Sensors.

## Transport Properties

**075403 TRANSPORT OF COPPER AMINES THROUGH A CATION-EXCHANGE MEMBRANE DURING ELECTRODIALYSIS.** Extraction of copper amine complexes from wastewaters in electroplating technology and in production of cuprammonium fibers is an important problem, and electrodialysis with ion-exchange membranes is the most promising method of solving it. Our aim was to study transport of copper(II) amines through a commercial cation-exchange membrane of the MK-40 type. These experiments lead to the conclusion that electrodialysis of copper(II) amine complexes is possible only at current densities below the limiting values and that the transport is accompanied by decrease of the formation function of the complexes both in the membrane and in the solution of the concentrate receiving compartment. 5 refs.

Kireeva, L.D. (N.N. Burdenko State Medical Inst, Voronezh, USSR); Shaposhnik, V.A.; Sorokina, V.I. *J Appl Chem USSR* v 60 n 3 pt 2 Mar 1987 p 589-592.

## Vapor Pressure

**075404 DETERMINATION OF VAPOUR PRESSURES AND DIFFUSION COEFFICIENTS OF BIS- $\mu$ -(DIISOPROPYLLAMIDO) TETRAMETHYL DI-ALUMINIUM (III) AND BIS- $\mu$ -(DITERTIARYBUTYLPHOSPHIDO) TETRAMETHYL DI-INDIUM (III).** Vapor pressures of the two title compounds were measured using Knudsen mass loss effusion and the modified entrainment method. From this data the enthalpies and entropies of sublimation were calculated, in addition to the binary diffusion coefficient in nitrogen. Plots of  $\log P$  vs.  $1/T$  were linear: i.e.  $\log P(\text{Torr}) = -A/T + B$ ; where for bis- $\mu$ -(diisopropylamido) tetramethyl di-aluminum (III),  $A=5180$  and  $B=13.2$ , and for bis- $\mu$ -(ditertiarybutylphosphido) tetramethyl di-indium (III),  $A=6790$  and  $B=14.2$ . The binary diffusion coefficients in nitrogen at 373 K were calculated to be  $6.4 \times 10^{-6} \text{ m}^2 \text{ s}^{-1}$  and  $4.7 \times 10^{-6} \text{ m}^2 \text{ s}^{-1}$  respectively. (Author abstract) 12 refs.

Bradley, D.C. (Queen Mary Coll, London, Engl); Faktor, M.M.; Young K.V.; Frigo, D.M. *Chemtronics* v 3 n 1 Mar 1988 p 50-53.

## ORTHOTICS

**075405 GENERIC SHOE: A PRESCRIPTION TOOL.** A multiple-use testing shoe capable of various orthotic modifications has been developed. Its use in predicting prescription performance and patient compliance is presented. Patient compliance is enhanced by understanding gained through the testing procedure. (Author abstract) 13 refs.

McDermott, John E. (Univ of Washington Hospital,

Seattle, WA, USA); Lippert, Frederick G. III; Hayes, Shane; Kalivas, Thomas L. *Bull Hosp Jt Dis Orthop Inst* v 47 n 2 1987 p 228-234.

Computer Aided Manufacturing See PROSTHETICS—Computer Aided Design.

## Functional Electric Stimulation

**075406 FUNCTIONAL ELECTRICAL STIMULATION IN THE USA. RESEARCH VISIT OF DR. I.D. SWAIN (OCTOBER 1986).** This report describes visits to a number of centres in the United States in which research on functional electrical stimulation and related topics is in progress. Many projects are discussed in some detail.

Swain, I.D. (Odstock Hospital, Salisbury, Engl). *J Med Eng Technol* v 12 n 2 Mar-Apr 1988 p 61-71.

**075407 REHABILITATION OF MUSICIANS WITH UPPER LIMB AMPUTATIONS.** Three saxophone players with upper limb amputations have been successfully rehabilitated to play their musical instruments using skin-conductivity touch control. Each attained a standard of musicianship sufficient to perform the standard repertoire of the instrument in a concert setting. The mechanical and electrical modifications to the saxophone are described, as well as the principles of operation of the skin-conductivity touch control module. The touch control module is commercially available for prosthetists who wish to fit musicians or others with upper extremity amputations who require rapid accurate control of a number of channels of powered prosthetic function. (Author abstract). 3 Refs.

Charles, Dean (Univ of Alberta, Edmonton, Alberta, Can); James, Kelvin B.; Stein, Richard B. *J Rehabil Res Dev* v 25 n 3 Summer 1988 p 25-32.

**075408 ROBUST CLOSED-LOOP CONTROL OF ISOMETRIC MUSCLE FORCE USING PULSE-WIDTH MODULATION.** The design of feedback controllers to accurately and robustly regulate the properties of electrically stimulated muscle is considered. Reliable, precise control is necessary for the development of neuroprosthetic devices to improve gradation and repeatability of force. A digital closed-loop controller has been developed which regulates muscle force by modulating the pulsewidth of a constant-amplitude electrical stimulation pulse train. This controller has been evaluated in slow- and fast-twitch muscles (cat soleus and plantaris) in acute experiments. In isometric tests, it was found to regulate muscle force with low sensitivity to modeling errors and disturbances while satisfying stability, repeatability, linearity, and step/ramp response criteria over a wide range of commands. 18 refs.

Chizeck, Howard J. (Case Western Reserve Univ, Cleveland, OH, USA); Crago, Patrick E.; Kofman, Leon S. *IEEE Trans Biomed Eng* v 35 n 7 Jul 1988 p 510-517.

**075409 PRACTICAL LOW COST STAND/SIT SYSTEM FOR MID-THORACIC PARAPLEGICS.** The use of functional electrical stimulation (FES) to enable paraplegics to stand is not new or indeed difficult to undertake under laboratory conditions. However, there are substantial problems to overcome before such systems can be used routinely by patients without professional supervision. The overriding consideration has to be one of safety, i.e. the system must be 'fail safe'. Second, the system must be quick and easy to use in a wide variety of locations, otherwise it will not provide any increase in function. Finally, it must be inexpensive enough to be available to a large number of paraplegics. The primary aim of our work was to provide such a system to enable mid-thoracic lesion paraplegics to stand wherever they wish. This involved the development of a microprocessor-based simulator to enable the stimulating envelope to be individually tailored to a given patient's requirements and the provision of closed loop control to minimize fatigue. A folding standing frame was also designed which replaces the arm rests on a standard wheelchair. Using this system, the user is able to stand within 30 s of stopping

and can remain standing up to 10 min. Cosmic calipers (knee-ankle-foot orthoses) are also being used for paraplegics who require to stand for longer periods. (Edited author abstract) 11 refs.

Ewins, D.J. (Bath Univ, Engl); Taylor, P.N.; Crook, S.E.; Lipczynski, R.T.; Swain, I.D. *J Biomed Eng* v 10 n 2 Apr 1988, Pap Presented at the 27th Annu Sci Meet of the Biol Eng Soc, Oxford, Engl, Sep 2-4 1987 p 184-188.

**075410 HYBRID FES ORTHOSIS INCORPORATING CLOSED LOOP CONTROL AND SENSORY FEEDBACK.** A hybrid functional electrical stimulation (FES) orthosis is described, comprising a rigid ankle-foot brace, a multi-channel FES stimulator with surface electrodes, body mounted sensors, a 'rule-based' controller and an electro-cutaneous display for supplementary sensory feedback. The mechanical brace provides stability, without FES activation of muscles, for standing postures normally adopted by patients. This avoids incurring muscle fatigue during prolonged upright activity. However, stability is conditional upon the position of the ground reaction vector (GRV) relative to the knee joint. The finite state FES controller reacts automatically to destabilizing shifts of the GRV by stimulating appropriate anti-gravity musculature to brace the leg. The FES system also features a control mode to initiate and terminate flexion of the leg during forward progression. A simple mode of supplementary sensory feedback was used during the laboratory standing tests to assist the patient in maintaining a set posture. Preliminary results of laboratory tests for two spinal cord injured subjects are presented. (Author abstract) 7 refs.

Andrews, B.J. (Univ of Strathclyde, Scotl); Baxendale, R.H.; Barnett, R.; Phillips, G.F.; Yamazaki, T.; Paul, J.P.; Freeman, P.A. *J Biomed Eng* v 10 n 2 Apr 1988, Pap Presented at the 27th Annu Sci Meet of the Biol Eng Soc, Oxford, Engl, Sep 2-4 1987 p 189-195.

**075411 REDUCTION OF MUSCLE FATIGUE IN MAN BY CYCLICAL STIMULATION.** In order to develop a control system for electrical stimulation of paralyzed muscle and improve muscle resistance to fatigue, it is useful to investigate the possibility of stimulating the control systems of the normal body. One way is the periodic shifting of stimulation from one muscle to another. This technique is called sequential stimulation and allows sufficient rest time for each muscle to reduce fatigue and consequently prolong muscle strength. It can also be seen to improve the muscle recovery time. In the following study, the muscles rectus femoris, vastus lateralis, and vastus medialis were used to keep the knee locked and extended during stimulation. Several experiments were carried out using a three-channel computer controlled stimulator. The results for three-phase sequential stimulation (33% duty cycle per muscle) were most effective and significantly improved the muscle fatigue characteristics. (Author abstract) 6 refs.

Pournezam, M. (Univ of Strathclyde, Glasgow, Scotl); Andrews, B.J.; Baxendale, R.H.; Phillips, G.F.; Paul, J.P. *J Biomed Eng* v 10 n 2 Apr 1988, Pap Presented at the 27th Annu Sci Meet of the Biol Eng Soc, Oxford, Engl, Sep 2-4 1987 p 196-200.

**075412 BASIC MODULE FOR AN ADAPTIVE CONTROL SYSTEM BASED ON NEURONE INFORMATION PROCESSING.** The design of such devices as robotic aids for handicapped people, powered prostheses and manipulative aids such as page turners would benefit from the use of an adaptive system. Much recent work on adaptive networks has been based on simplified models of the information processing capabilities of neurons. Neurons are known to be capable of association learning and memory and this study incorporates these features in a neurone model. A single neuronal input system, the NMDA-type glutamate receptor, is modeled by deriving finite difference equations from its reaction dynamics so that the concentration of several molecules in the receptor can be plotted as a function of time. The model shows association learning taking place



at the glutamate receptor. A whole neurone with ten glutamate receptor regions is also modeled and shows that a neurone should be capable of recognizing patterns of inputs. As the neurone model is complicated and slow to run, a much simplified form of the model is described which embodies the basic features of neurone information processing in a simple algorithm. (Author abstract) 9 refs.

Orpwood, R.D. (St. Martin's Hospital, Bath, Engl.) *J Biomed Eng* v 10 n 2 Apr 1988, Pap Presented at the 27th Annu Sci Meet of the Biol Eng Soc, Oxford, Engl, Sep 2-4 1987 p 201-205.

**Functional Neural Stimulation** See Also BIOMEDICAL ENGINEERING—Electromyography; ELECTROTHERAPEUTICS—Medical Applications.

**075413 CHARACTERIZATION AND CONTROL OF MUSCLE RESPONSE TO ELECTRICAL STIMULATION.** The maintenance of upright posture in neurologically intact human subjects is mediated by two major nervous pathways. The first, leading from the cerebral cortex through the spinal cord to motor neurons, activates muscles which produce postural movements. The second, leading from various sensory organs to higher centers, provides sensory feedback regarding the postural state. The path through the spinal cord is no longer intact in victims of spinal cord injury and loss of normal control of muscle activity results. Functional neuromuscular stimulation (FNS) has been shown as a feasible method for obtaining muscle contraction in paraplegics and has been proposed as a means for control of antero-posterior sway to make upright posture possible for these individuals. (Edited author abstract) 18 refs.

Bajzek, T.J. (Illinois Inst of Technology, IL, USA); Jaeger, R.J. *Ann Biomed Eng* v 15 n 5 1987 p 485-501.

**075414 CLINICAL ELECTROEJACULATION.** Anejaculation is a disorder that occurs infrequently in the general population, but it occurs in some cases of spinal cord injury and dissection of retroperitoneal lymph nodes for testicular cancer. It is associated with multiple sclerosis, transverse myelitis, and diabetes mellitus. Electro-ejaculation, which involves electrodes in a probe placed in the rectum, electrically stimulates emission of seminal fluid. Semen thus obtained can be used for artificial insemination if a patient and his spouse wish to become natural parents. (Author abstract) 31 refs.

Shaban, Stephen F. (Baylor Coll of Medicine, Houston, TX, USA); Seager, Stephen W.J.; Lipschultz, Larry I. *Med Instrum* v 22 n 2 Apr 1988 p 77-81.

**075415 RF POWERING OF MILLIMETER- AND SUBMILLIMETER-SIZED NEURAL PROSTHETIC IMPLANTS.** The size of the transducers for neural stimulation has shrunk steadily with application of thin-film techniques to electrode design. The feasibility is examined of designing millimeter- and submillimeter-sized power sources based on RF coupling that could be integrated into these implants to provide power without a tethering power cable. The coupling between a transmitter coil and receiver coil when the coil diameters are markedly different is analyzed, and for these circumstances, a simple Thevenin equivalent model is developed to describe the power transmission between the transmitter and receiver. The equivalent circuit developed gives insight into the way that coil diameters, frequency, and turns affect coupling between large and small coils. Several examples demonstrate that milliwatt range power sources can be implemented with millimeter- and submillimeter-diameter receivers.

Heetderks, William J. (Nat'l Inst of Health, Bethesda, MD, USA). *IEEE Trans Biomed Eng* v 35 n 5 May 1988 p 323-327.

**075416 SPECTRAL ANALYSIS INTERPRETATION OF ELECTRO-SURGICAL GENERATOR NERVE AND MUSCLE STIMULATION.** The frequency spectra of two commercial electrosurgical generators were examined during stimulated tissue cutting and compared to radio-frequency animal nerve and muscle stimulation curves generated from high-frequency sinusoi-

dal current. During electrosurgical cutting, significant energy can exist at the fundamental frequency, as well as at frequencies lower and greater than the fundamental, which may be stimulatory to both nerve and muscle tissue. Different types of biological loads did not seem to significantly affect the spectra of each individual electrosurgical unit (ESU). However, the interaction of a specific ESU output with the biological load when compared to a pure resistive load accounts for varying impedances and resultant modulations of the fundamental frequency. Reducing electrosurgical side effects and hazards may depend, in part, on a better understanding of these underlying mechanisms. 13 refs.

LaCourse, John R. (Univ of New Hampshire, Durham, NH, USA); Vogt, Marc C.; Miller, W. Thomas; Selikowitz, Stuart M. *IEEE Trans Biomed Eng* v 35 n 7 Jul 1988 p 505-509.

**OSCILLATORS** See Also AMPLIFIERS, OPERATIONAL—Applications; BAND STRUCTURE—Measurements; CONTROL SYSTEMS, NONLINEAR—Stability; CRYOGENICS; DIGITAL COMMUNICATION SYSTEMS—Equipment; ELECTRIC MEASUREMENTS—Capacitance; ELECTRONIC CIRCUITS, PULSE SIGNAL—Performance; LASERS, FREE ELECTRON; LASERS, FREE ELECTRON—Theory; LIGHT—Coherent; MASERS; OPTICAL COMMUNICATION EQUIPMENT—Performance; PARTICLE BEAMS—Mathematical Models; RESONATORS, CAVITY—Performance; SEMICONDUCTOR DEVICES, MOSFET; SEMICONDUCTOR DEVICES, MOSFET—Materials; SENSORS—Design; SUPERCONDUCTING DEVICES—Josephson Junctions; TELEVISION RECEIVERS—Tuners; VIBRATIONS—Analysis; VIDEO RECORDING—Equipment.

**075417 EXPERIMENTAL STUDY OF A SYNCHRONOUSLY PUMPED FIBRE RAMAN OSCILLATOR.** A synchronously pumped fiber Raman oscillator has been constructed employing a mode-locked C.W. Nd:YAG laser as a pump source and 150 m of single-mode optical fiber as the Raman-active medium. A detailed spectral and temporal study of the laser has been undertaken. Time-dispersion tuning offered an operating spectral range of 1.0725-1.1220  $\mu\text{m}$  for the first Stokes oscillation and 1.149-1.179  $\mu\text{m}$  for the associated second Stokes component. Pulse durations  $\approx 100$  ps were generated with average output powers of about 40 and 9 mW for the first and second Stokes Raman pulses respectively. (Author abstract) 8 refs.

Smith, K. (Univ of St. Andrews, St. Andrews, Scotl); Kean, P.N.; Crust, D.W.; Sibbett, W. *J Mod Opt* v 34 n 9 Sep 1987 p 1227-1233.

**075418 TWO-MINIMUM-COMPONENT SINGLE CURRENT CONVEYOR RC OSCILLATORS.** Two minimum-component RC-sinusoidal oscillator circuits using current conveyors are presented. Each circuit uses a single current conveyor, two resistors and two capacitors. The two circuits enjoy low sensitivities. (Author abstract) 11 refs.

Abuelma'atti, Muhammad Taher (Univ of Bahrain, Isa Town, Bahrain). *Int J Electron* v 63 n 4 Oct 1987 p 509-512.

**075419 NONLINEAR OSCILLATOR LANCHES-TER DAMPER.** The method of multiple scales is used to investigate the effect of a nonlinear spring in the main system on the performance of Lanchester-type absorbers. A second-order uniform expansion is obtained for the response of the system to a harmonic excitation. Numerical results for steady-state solutions illustrating the influence of the nonlinearity and damping factors on the response are presented. A softening-type effective nonlinearity dominates the system and considerably improves its damping. (Author abstract) 10 refs.

Asfar, K.R. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Nayfeh, A.H.; Barrash, K.A. *J Vib Acoust Stress Reliab Des* v 109 n 4 Oct 1987 p 343-347.

**075420 IMPACT DAMPED HARMONIC OSCILLATOR IN FREE DECAY.** The impact-damped oscillator in free decay is studied by using time history solutions. A large range of oscillator amplitude is covered. The

amount of damping is correlated with the behavior of the impacting mass. There are three behavior regimes: a low-amplitude range with less than one impact per cycle and very low damping; a useful middle amplitude range with a finite number of impacts per cycle; and a high-amplitude range with an infinite number of impacts per cycle and progressively decreasing damping. The system exhibits jump phenomena and period doublings. An impactor with 2 percent of the oscillator's mass can produce a loss factor near 0.1. (Edited author abstract) 9 refs.

Brown, G.V. (NASA, Cleveland, OH, USA); North, C.M. *NASA Tech Memo* 89897 Sep 1987 22p.

**075421 MINIMAL REALIZATION OF RC OSCILLATORS - A SYNTHESIS APPROACH.** A systematic synthesis of sinusoidal minimal RC oscillators is presented. Basically, it is shown that the realization of a single (ideal) operational amplifier oscillator calls for the realization of a passive notch filter. Minimal RC realization of this notch filter is then obtained by various known synthesis procedures. Additional oscillators are obtained through horizontal and/or vertical rotatory transformations on this notch network. Thus, in all 16 minimal oscillators are derived out of which 3 are believed to be new. (Author abstract) 9 refs.

Rathore, T.S. (Indian Inst of Technology, Bombay, India); Bhattacharyya, B.B. *J Inst Electron Telecommun Eng* v 32 n 6 Nov-Dec 1986 p 435-437.

**075422 CLOCK OSCILLATOR AND CLOCK RECOVERY CIRCUIT FOR DIGITAL TRANSMISSION UP TO 200 Mbit/s.** A clock oscillator and clock recovery circuit have been developed for synchronous transmission at high data rates. The frequency of the oscillator determines the modulation rate of the transmit section of a transmission system while the clock recovery circuit extracts the clock from the received data and regenerates the data signal. The compact design of the clock recovery circuit and the high quality of its signal processing despite small dimensions are the chief attractions of this unit as a system module. (Author abstract) 2 refs.

Schroedinger, Karl (Siemens AG, Munich, West Ger). *Siemens Compon* v 22 n 6 Dec 1987 p 225-229.

**075423 ON THE METHOD OF CALCULATING FRANCK-CONDON FACTORS (I): THE CASE OF HARMONIC OSCILLATORS.** The authors derive a simple formula for Franck-Condon factors in the harmonic oscillator approximation using an addition theorem for Hermite polynomials. One of the most important characteristics of the formula is that the parameters do not take any imaginary values irrespective as to whether or not  $f$  (being the ratio of the frequency in the excited state to that in the ground state) is larger than unity. The formula is simpler than Forsch's in a case of absorption or emission where a thermally equilibrated vibrational state plays an important role at the initial level. In Japanese. 6 refs.

Suzuki, Hideo (Waseda Univ, Tokyo, Jpn); Umezaki, Keisho. *Waseda Daigaku Rikogaku Kenkyusho Hokoku* n 119 1987 p 56-60.

**075424 LOW NOISE mm-WAVE TRANSMITTER TUBE OSCILLATORS.** Recent developments in extended interaction oscillators (EIOs) have produced low noise mm-wave radar-transmitter-tube oscillators suitable for use in coherent radar systems. This article focuses on the methods of generating power in the frequency range from 30 to 300 GHz and at power levels from 1 kW to 1 W of CW power using a bi-periodic ladder slow-wave circuit in the EIO. It also discusses the measurement of the phase noise exhibited by these oscillators. 2 refs.

Nilsen, Chris (Varian Canada, Georgetown, Ont, Can); Viant Maurice; Wong, Man. *Microwave J* v 31 n 7 Jul 1988 5p.



**075425 CURRENT-TUNABLE SINUSOIDAL OSCILLATOR.** A high-performance integrable current-tunable sinusoidal oscillator is proposed and experimentally investigated. A current-tunable bandpass filter is used as the frequency-determining network. Practical frequency-sweep ranges of approximately three orders of magnitude have been obtained. The maximum useful frequency of oscillation is in excess of 20 MHz, and the total harmonic distortions can be adjusted easily to be less than 0.5%. The measured temperature coefficient of the oscillation frequency is less than -30 ppm/°C. The circuit technique is simple enough for use in the construction of practical instrumental oscillators using only a few off-the-shelf integrated circuit packages. 15 refs.

Pookaiyaudom, Sithichai (King Mongkut's Inst of Technology, Bangkok, Thailand); Srisuchinwong, Banlue; Kurutach, Werasak. *IEEE Trans Instrum Meas* v IM-36 n 3 Sep 1987 p 725-729.

**075426 LINEAR VOLTAGE CONTROLLED OSCILLATOR.** A description is given of a sinusoidal oscillator having a frequency of oscillation that can be controlled by a controlling voltage. The circuit gives ultralow distortion and stable output by virtue of an automatic gain control (AGC) loop. The oscillator is useful for the VLF (3-30 kHz) and LF (30 kHz-300 kHz) ranges of operation. The circuit uses all grounded capacitors, which are suitable for large-scale integration. 6 refs.

Saha, Sisir K. (G.B. Pant Univ of Agriculture & Technology, Pantnagar, India); Jain, Lakhmi C. *IEEE Trans Instrum Meas* v 37 n 1 Mar 1988 p 148-150.

**075427 VOLTAGE CONTROLLED OSCILLATOR WITH SINE-WAVE OUTPUT.** An RC oscillator with sinusoidal output is presented. The frequency of oscillation can be controlled by varying a voltage. The circuit incorporates an AGC loop for amplitude stabilization with ultralow distortion output. The realization of the basic configuration uses two grounded capacitors, which are suitable for LSI implementation. 8 refs.

Singh, Ved Prakash (G.B. Pant Univ, Pantnagar, India); Saha, Sisir K. *IEEE Trans Instrum Meas* v 37 n 1 Mar 1988 p 151-153.

**075428 PANORAMA OF THE VISIBLE WAVELENGTH FEL OSCILLATOR.** The current status of the Boeing Aerospace Company and Spectra Technology, Inc. rf linac-driven 0.5  $\mu$ m FEL oscillator is reported. The final installation of this FEL oscillator is nearly completed as of this writing (September 1986). The purpose of this experiment is to demonstrate that high extraction and short wavelength operation are simultaneously achievable. (Author abstract) 15 refs.

Robinson, K.E. (Spectra Technology Inc, Bellevue, WA, USA); Churchill, T.L.; Quimby, D.C.; Shemwell, D.M.; Slater, J.M.; Valla, A.S.; Vetter, A.A.; Adamski, J.; Doering, T.; Gallagher, W.; Kennedy, R.; Robinson, B.; Shoffstall, D.; Tyson, E.; Vetter, A.; Yeremian, A. *Nucl Instrum Methods Phys Res Sect A* v A259 n 1-2 Sep 1 1987 p 49-55.

**075429 BENDING AND FOCUSING EFFECTS IN AN FEL OSCILLATOR I: SIMPLE MODELS.** The combination of wiggler, electron beam, and optical beam produces not only gain, but also refractive effects. These effects have been modeled for an oscillator configuration with a simple prism and lens. An instability is found to occur whenever the focal strength of the electron beam is sufficiently large. An estimate has been made of the magnitude of these effects and the authors present a discussion of the likely consequences. (Author abstract) 15 refs.

Warren, R.W. (Los Alamos Natl Lab, Los Alamos, NM, USA); McVey, B.D. *Nucl Instrum Methods Phys Res Sect A* v A259 n 1-2 Sep 1 1987 p 154-157.

**075430 BENDING AND FOCUSING EFFECTS IN AN FEL OSCILLATOR II: NUMERICAL SIMULATIONS.** Bending and focusing of the optical beam by the electron beam is investigated for an FEL oscillator

configuration. Numerical calculations are performed with the simulation code, FELEX. (Author abstract) 6 refs.

McVey, B.D. (Los Alamos Natl Lab, Los Alamos, NM, USA); Warren, R.W. *Nucl Instrum Methods Phys Res Sect A* v A259 n 1-2 Sep 1 1987 p 158-162.

**075431 TAPERED WIGGLER ANALYSIS OF HIGH GAIN FREE ELECTRON LASER OSCILLATORS.** The development of lasers in which the active medium is a relativistic stream of free electrons has evoked much interest. The prospect of operating these continuously tunable, high gain devices at high efficiencies by appropriately tapering the wiggler field parameters has significantly increased the interest in these devices. Variable parameter wiggler free electron lasers have been previously considered for operation in the amplifier configuration and also in the micropulse, low gain operation in the oscillator configuration. The present analysis extends the range of application to the case of intense, long pulsed electron beams in which the self-consistently derived space charge potential (arising from the axial bunching of the particles in the beat wave) is not negligible. Also included in this analysis are arbitrarily relativistic beams (i.e. no ultrarelativistic beam approximation). We have obtained theoretical expressions for the nonlinear efficiency and present a comparison of these results with a fully nonlinear simulation. (Author abstract) 6 refs.

Marable, W.P. (US Naval Research Lab, Washington, DC, USA); Tang, C.M.; Sprangle, P. *Nucl Instrum Methods Phys Res Sect A* v A259 n 1-2 Sep 1 1987 p 210-218.

**075432 THEORETICAL STUDY OF A HIGH-EXTRACTION EFFICIENCY UNDULATOR FOR A FREE ELECTRON LASER OSCILLATOR.** To design a high-extraction efficiency undulator, the authors explore a parabolically tapered undulator and a buncher device that almost doubles the efficiency and gain by prebunching the electron micropulse into subpulses peaked at every laser wavelength. The design of the prebuncher, which is placed upstream from the undulator is discussed. The effects are studied using progressively more complex computer codes. 5 refs.

Takeda, Harunori (Los Alamos Natl Lab, Los Alamos, NM, USA); McVey, Brian D.; Goldstein, John C. *Nucl Instrum Methods Phys Res Sect A* v A259 n 1-2 Sep 1 1987 p 295-303.

**075433 ACCURATE OSCILLATOR STRENGTHS.** Accurate multiconfiguration Hartree-Fock (MCHF) f-values are compared with the most reliable theoretical values obtained by other theories and recent laser beam experiments. For the  $2^3S-2^3P$  transition in Li II, MCHF results are in excellent agreement with those of Schiff et al. For the resonance transitions of Li I, Na I, and K I, particular attention is given to core effects. It is shown that in core-polarization calculation, the theoretical ionization energy of the valence electron is larger than the observed ionization, that the inclusion of radial correlation in the core decreases the theoretical ionization energy and brings length and velocity forms of the f-values into better agreement. The effect on the oscillator strength was to increase the length form and the discrepancy with the experimental values of Gaupp et al. (Author abstract) 18 refs.

Froese Fischer, Charlotte (Vanderbilt Univ, Nashville, TN, USA). *Nucl Instrum Methods Phys Res Sect B* v B31 n 1-2 Apr II 1988, Proc of the Symp on At Spectrosc and Highly Ionis At, Lisle, IL, USA, Aug 16-21 1987 p 265-272.

**Analysis** See Also AMPLIFIERS—Switching.

**075434 EIGENPROPERTIES OF NONCLASSICALLY DAMPED PRIMARY STRUCTURE AND OSCILLATOR SYSTEMS.** The calculation of the combined eigenproperties of a nonclassically damped structure and a supported equipment is of practical interest. Herein an approach is developed whereby these properties

can be obtained, in terms of the eigenproperties of the structure and equipment, without a conventional eigenvalue analysis of the combined system. The eigenvalues are obtained as the solutions of a nonlinear characteristic equation, easily solvable by a simple Newton-Raphson scheme. Once the eigenvalues are known, the corresponding eigenvectors can be obtained from closed-form expressions. The approach can also be used effectively to obtain exact eigenproperties for very light as well as very heavy equipment supported on structures. (Author abstract)

Suarez, L.E. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Singh, M.P. *J Appl Mech Trans ASME* v 54 n 3 Sep 1987 p 668-673.

**075435 SIGNAL AMPLITUDE ESTIMATION IN SELF-EXCITED OSCILLATORS.** A new estimate of signal amplitude in self-excited oscillations which use second-order tuned circuits is proposed. (Author abstract) 8 refs.

Gil, M.I.; Shargorodskaya, L.L. *Sov J Commun Technol Electron* v 32 n 3 Mar 1987 p 58-62.

**075436 MULTIMODE OSCILLATOR ANALYSIS VIA INTEGRAL MANIFOLDS. PART I: NON-RESONANT CASE.** This article represents Part I of a two-part paper which provides a rigorous mathematical foundation of the mode-analysis method for analyzing the periodic and quasi-periodic oscillations observed in various types of coupled oscillators. Although the results predicted by this method had been confirmed by experiments to some extent, the crucial assumptions used to derive the averaged equations are based on engineering intuition. This paper resolves the theoretical ambiguities of the mode analysis method by using the theory of integral manifolds. In particular, we recalculate the averaged equations in a rigorous way, and show that they coincide with those obtained before. Therefore, the theory of integral manifolds guarantees the existence of an integral manifold in the original system that corresponds to a steady-state periodic or quasi-periodic solution, provided the equilibrium point of the averaged equation has no eigenvalues with a zero real part (i.e., hyperbolic). This rigorous analysis proved that all our previous results obtained from the mode analysis method, i.e., averaged equations and stability analysis, were correct. (Edited author abstract) 20 refs.

Chau, Leon O. (Univ of California, Berkeley, CA, USA); Endo, Tetsuro. *Int J Circuit Theory Appl* v 16 n 1 Jan 1988 p 25-58.

**075437 MULTIMODE OSCILLATOR ANALYSIS VIA INTEGRAL MANIFOLDS. PART II: RESONANT CASE.** By using the theory of integral manifolds, we give a rigorous derivation of the average equations of multimode oscillators, which we previously derived by intuitive method. In this part II, two kinds of weakly-non-linear multimode oscillators in the resonant frequency case are rigorously investigated: namely, a ring array with a third-power non-linearity, and a square array with a third-power non-linearity. Moreover, we proved the existence of integral manifolds associated with non-resonant single modes, non-resonant double modes as well as resonant double modes of each array of oscillators. We also prove that there exist two kinds of resonant double modes: a phase-determinate type and a phase-indeterminate type. In coupled oscillator systems, there exist various equilibrium points in the averaged equations. They correspond physically to a variety of oscillations with different frequencies, including both periodic and quasi-periodic oscillations. From our rigorous stability analysis, we prove that all non-resonant single modes, all phase-determinant resonant double modes, and all phase-indeterminant resonant double modes are stable for the ring array. Moreover, we prove



that there exist two non-resonant single modes, three non-resonant double modes, and one resonant double mode for the ( $\# \times 4$ ) square array. 21 refs.

Chua, Leon O. (Univ of California, Berkeley, CA, USA); Endo, Tetsuro. *Int J Circuit Theory Appl* v 16 n 1 Jan 1988 p 59-92.

**075438 SYMMETRY, LOCAL SYMMETRY AND ASYMPTOTIC PAUSES OF THE STEADY-STATE CURRENT RESPONSE OF SOME OSCILLATORY CIRCUITS TO PERIODIC RECTANGULAR VOLTAGE WAVES.** Steady-state current response of some passive oscillatory circuits to a periodic rectangular (r.) voltage wave is analysed with the requirement that the set of the voltage jump points (j.p.) be included in the set of the current zero-points (z.p.). The latter states a correspondence between the circuit and the r. wave which is not associated directly with a resonance phenomenon. The analysis reveals some interesting properties of the current response; for instance, possible pauses (the intervals where the current is identically zero) and a strong sensitivity of the current function waveform to small changes in some positions of the j.p. of the r. wave. Conclusions are derived also for nonperiodic input voltage waves. The basic results are associated mainly with a symmetry of the r. wave and (or) with a symmetry of a circuit response function to a shock, which makes the analysis relevant for linear and nonlinear circuits. (Author abstract) 10 refs.

Gluskin, Emanuel (Ben-Gurion Univ of the Negev, Beer-Sheva, Isr). *Int J Electron* v 64 n 4 Apr 1988 p 563-586.

**075439 RESONANCE FREQUENCIES AND BEHAVIOUR OF THE IMPATT CAP OSCILLATOR.** The oscillation frequency of impatt cap oscillators is close to the frequency of the resonator formed by the cap and the diode capsule. In the design of the oscillator or interpretation of its behavior, knowledge of the cap resonance frequencies and of their dependence upon the geometry and characteristics of the diode is desirable. Assuming radial wave propagation beneath the cap with either shunt or 'cross' connection of the diode, good agreement between the measured and estimated resonance frequencies was obtained. Including the cap representative circuit in that for the oscillator, the tuning characteristics were derived assuming a capacitive reactance for the diode. (Edited author abstract) 8 refs.

Twisleton, J.R.G (English Electric Valve Co, Lincoln, Engl). *IEE Proc Part H* v 135 n 3 Jun 1988 p 196-204.

**075440 ON THE ANALYSIS OF INTERNALLY RESONANT OSCILLATORS.** A method for investigating both global and local dynamics of internally resonant oscillators of any order is presented. It rests mainly on a first-approximation mode separation technique, which makes it possible derive, from the starting time-domain model, a set of differential equations in the amplitudes and phases of the predominant signal spectral components. The steps in the procedure for the actual application to particular cases are rather straightforward, as illustrated by the example worked out (a 1:3 two-resonator oscillator). 25 refs.

Sommariva, Antonino M. (Univ of Palermo, Italy). *IEEE Trans Circuits Syst* v 35 n 2 Feb 1988 p 221-229.

Applications See SIGNAL GENERATORS.

Components See Also SUPERCONDUCTING DEVICES—Josephson Junctions.

**075441 SINEWAVE OSCILLATOR USING C-MOS INVERTERS.** This article describes a simple and inexpensive circuit using inverters instead of amplifiers. It easily covers the whole range of audio frequencies from 20Hz to 20kHz and can produce far lower sinewaves as well. Frequency is determined almost entirely by the RC constants and it can be very stable if stable resistors and capacitors are used. The influence of the inverters is negligible thanks to their high input resistance. 3 refs.

Damljanovic, Dragoljub (Boris Kidric Inst of Nuclear

Sciences, Belgrade, Yugosl). *Electron Wireless World* v 94 n 1624 Feb 1988 p 187, 191.

Computer Aided Analysis See ELECTRIC HEATING—Electric Power Supplies.

Computer Aided Design

**075442 COMPUTER PROGRAM AIDS DIELECTRIC RESONATOR FEEDBACK OSCILLATOR DESIGN.** A fast and accurate FORTRAN routine that determines the optimum position of the dielectric resonator in a dielectric resonator feedback oscillator is presented. The relative simplicity of the program and its associated design technique provide a good starting point for oscillator design. (Author abstract). 8 Refs.

Murphy, Aidan C. (Univ Coll, Cork, Irel); Murphy, Patrick J. *Microwave J* v 31 n 9 Sep 1988 9p.

Control

**075443 POWER LEVEL CONTROLLED OPTICAL SWEEP OSCILLATOR USING A GAAS SEMICONDUCTOR LASER.** A frequency-tunable semiconductor laser having a power level controller has been developed. The laser frequency is locked to a piezoelectrically modulated interferometer having a free spectral range of 5 GHz and tuned by varying its mirror gap. A servoloop for this purpose is connected to the injection current source of the laser diode. The level of the output power is stabilized by a second servoloop connected to the temperature controller of the laser diode. The relations between the parameters of the servoloops and the characteristic of the laser diode to get a good system response are discussed. 17 refs.

Yamaguchi, Shizuo (Tokyo Inst of Polytechnics, Atsugi, Jpn); Suzuki, Masao. *IEEE Trans Instrum Meas* v IM-36 n 3 Sep 1987 p 789-796.

Design

**075444 ACTIVE-R MULTIPHASE OSCILLATORS.** A multiphase active-R oscillator circuit is presented. The oscillator can produce m signals equal in amplitude and equally spaced in phase. The circuit uses one operational amplifier for each phase. Experimental results are included. (Author abstract) 5 refs.

Abuelma'atti, M.T. (Gulf Polytechnic, Isa Town, Bahrain); Almansoury, W.A. *IEE Proc Part G* v 134 n 6 Dec 1987 p 292-294.

**075445 TWO NEW MINIMUM-COMPONENT WIEN-BRIDGE OSCILLATORS USING CURRENT-CONVEYORS.** Two new Wien-bridge oscillator circuits are presented. The circuits use the minimum number of active and passive components. The circuits enjoy low sensitivities, and are attractive for integration. Experimental results are included. (Author abstract) 11 refs.

Abuelma'atti, M.T. (Univ of Bahrain, Isa Town, Bahrain); Humood, N.A. *Int J Electron* v 63 n 5 Nov 1987 p 669-672.

**075446 SINUSOIDAL RC-OSCILLATOR WITH AMPLITUDE CONTROL BY CURRENT SPLITTING.** The paper describes a method of amplitude control in a sinusoidal RC-oscillator. The oscillator includes an amplifier of current with differential output and the amplitude control is achieved by insertion of a current splitter in the positive feedback path. The current splitter is realized as a bipolar transistor differential pair with control of emitter tail current splitting from an amplitude detector. The approach is suitable for design of RC-oscillators operating with a low voltage power supply (an example of the oscillator for a 3V power supply is given. (Author abstract) 12 refs.

Filanovsky, I.M. (Univ of Alberta, Edmonton, Can); Piskarev, V.A.; Kothapalli, G. *Int J Electron* v 64 n 2 Feb 1988 p 199-211.

**075447 REALIZATION OF ACTIVE-R VOLTAGE-CONTROLLED OSCILLATOR.** A new active-R circuit which implements voltage-controlled oscillator function is presented. The circuit generates sinusoidal oscillations over a fairly good frequency range. The circuit obviates the need for external capacitors by utilizing the single-pole model of the operational amplifier. The frequency of oscillation is tunable through a grounded resistor independent of oscillation condition. (Author abstract) 10 refs.

Shah, N.A. (Univ of Kashmir, Srinagar, India). *Indian J Pure Appl Phys* v 25 n 5-6 May-Jun 1987 p 245-246.

**075448 4GHz SYNTHESIZED LOCAL OSCILLATOR DESIGN.** The radio-frequency spectrum analyzer, like its relative the communications receiver, has to meet ever more demanding requirements as communication technology advances. The signals to be analyzed can cover a very large range of amplitudes (dynamic range), and be closely-spaced in frequency, making it difficult to resolve the individual spectral components. Accuracy and resolution is essential to make high quality measurements. The analyzer's local oscillator system is crucial to obtaining good resolution, and forms the subject of this article. Some of the design considerations and building blocks are reviewed, with a high performance 100Hz-4.2GHz spectrum analyzer used as an example of a practical design.

Braithwaite, Ian (Marconi Instruments). *Electron Wireless World* v 94 n 1625 Mar 1988 p 251-255.

**075449 DESIGN OF GENERATORS OF SINUSOIDAL OSCILLATIONS WITH TRANSIENT PROCESSES THAT ARE OPTIMUM IN TERMS OF DURATION.** The control function, for which transient processes have minimum duration, is found by means of the Pontryagin maximum principle for the system of differential equations describing processes in generators of sinusoidal oscillations. The form of the optimum switching line, corresponding to the found control function for all possible ratios of the amplitude of the stationary regime and control, is obtained in the phase plane. An approximation is suggested for the optimum switching line that simplifies considerably the technical implementation of the generator. (Author abstract) 7 refs.

Rybin, Yu.K.; Groshev, B.L. *Sov J Commun Technol Electron* v 32 n 7 Jul 1987 p 109-114.

**075450 VOLTAGE-CONTROLLED OSCILLATOR USING DIELECTRIC RESONATOR.** A simple type of voltage-controlled oscillator using a dielectric resonator is presented for MIC applications, operating at 1.69 GHz. This gives a 0.5 percent tuning range, for  $-104$  dBc/Hz FM noise. Two design strategies have been utilised to investigate the optimum approach for a 0.5 percent tuning range: first, a conventional one-port design, and secondly, a two-port transmission type based on a shunt feedback approach. Finally, their performance is compared. (Edited author abstract). 7 Refs.

Chan, O.Y. (Univ of Bradford, Bradford, Engl); Kazeminejad, S. *Electron Lett* v 24 n 13 Jun 23 1988 p 776-777.

**075451 WIEN BRIDGE OSCILLATOR INCORPORATING AN OP, AMP AS THE ACTIVE ELEMENT.** A Wien bridge oscillator circuit is analysed, taking into account the finite gain-bandwidth product of the op. amp. Expressions for the oscillation frequency and its sensitivity to the op. amp gain-bandwidth product are obtained. (Author abstract). 4 Refs.

Vosper, J.V. (Manchester Polytechnic, Engl). *Int J Electron Educ* v 25 n 2 Apr 1988 p 125-139.

**075452 ON THE ASYMPTOTIC PAUSE STEADY STATE CURRENT RESPONSE OF A NONLINEAR OSCILLATORY CIRCUIT TO RECTANGULAR VOLTAGE WAVES.** With respect to the possible existence of some pause current states of a nonlinear oscillatory circuit driven by rectangular voltage waves (Gluskin



1988 a) it is noted that for small amplitude current oscillations which occur in certain time intervals, the oscillations are very close to sinusoidal. This makes the results of (Gluskin 1988 a) and the preceding work (1988 b) specifically interconnected. (Author abstract). 5 Refs.

Gulskin, Emanuel (Ben-Gurion Univ of the Negev, Beer-Sheva, Isr). *Int J Electron* v 65 n 2 Aug 1988 p 251-254.

**075453 VAN DER POL REALIZATION OF TORUS KNOT OSCILLATORS.** Van der Pol type nonlinear oscillators are used for the design of a torus knot oscillator. This involves replacing the structurally unstable linear oscillators of previous theories by nonlinear Van der Pol ones that can designed using an op-amp-realized piecewise-linear negative resistor. The resulting five design cases are then conveniently treated, using piecewise-linear theory, to yield limit cycles from which the torus knots are formed. The resulting equations are used to obtain computer-generated torus knot trajectories. 10 refs.

Rassai, Rassa (Univ of Maryland, College Park, MD, USA); Newcomb, Robert W. *IEEE Trans Circuits Syst* v 35 n 2 Feb 1988 p 215-220.

**075454 SUBMILLIMETER BACKWARD WAVE OSCILLATORS.** NASA Lewis Research Center is engaged in a program to develop a series of backward wave oscillators (BWO's) for the frequency range 500 to 2000 GHz. Generically BWO's are electron beam traveling wave tubes operating in a dispersive regime in which the group velocity and the phase velocity of the induced electromagnetic wave are in opposite directions. Such tubes because of their frequency tunability, phase locking capability, and large bandwidth are ideal local oscillators for heterodyne receiver/spectrometers. The design of the BWO's is discussed with emphasis on the etched slow wave structure, zero compression electron beam, long life cathode, and moderate operating voltages. (Edited author abstract) 11 refs.

Dayton, J.A.; Heinen, V.O.; Stankiewicz, N.; Walleit, T.M. *Int J Infrared Millim Waves* v 8 n 10 Oct 1987, Pap Presented at the Submillimeter (Terahertz) Receiver Technol Conf, Lake Arrowhead, CA, USA, Apr 7-8 1987 p 1257-1268.

## Electric Conductivity

**075455 STARTING PHENOMENON IN NEGATIVE RESISTANCE FET OSCILLATORS.** The letter provides a study and an explanation of the starting phenomenon in an FET oscillator. It has been shown that the behaviour of the negative resistance with the amplitude of the signal leads to a lag effect in the response of the oscillator. This effect is due to the nonlinearity of the transconductance of the active device. Simulations have been made using accurate large signal models included in a time domain analysis software package. (Author abstract). 1 Ref.

Gamand, P. (Lab d'Electronique et de Physique Appliquee, Limeil-Brevannes, Fr); Pauker, V. *Electron Lett* v 24 n 15 Jul 21 1988 p 911-913.

**Finite Difference Method** See VIBRATIONS—Analysis.

**Laser Applications** See Also LASERS, DYE.

**075456 EFFICIENCY AND SIDEBAND OBSERVATIONS OF A RAMAN FEL OSCILLATOR WITH A TAPERED UNDULATOR.** Power and spectral measurements are reported from the Columbia Raman free-electron laser (FEL) oscillator experiment. High-power radiation pulses (approx. 12 MW, 100 ns) are generated at a wavelength of approx. 2.5 mm, using a 750-kV electron beam injected into a helical undulator. The undulator is made up of a 40-cm long constant-period (1.45 cm) section followed by an equal length of tapered undulator. The period is decreased by 7.6% in such a way that the on-axis field remains constant. It is reported that the taper allows an increase in total power efficiency from

approx. 4 to approx. 12%. Most noteworthy is that the tapered undulator reduces the sideband radiation compared with a constant-period undulator FEL which was studied in the same configuration. The power was measured calorimetrically and compared with the results of a 1-D Raman code. The reduction of sideband power observed in the experiment was consistent with computational results obtained with a 2-D sideband code. 14 refs.

Yee, F.G. (Columbia Univ, New York, NY, USA); Marshall, T.C.; Schlesinger, S.P. *IEEE Trans Plasma Sci* v 16 n 2 Apr 1988 p 162.

## Mathematical Models

**075457 CHARACTERISTICS OF NUMERICAL SIMULATIONS OF CHAOTIC SYSTEMS.** A generalized form of Duffing's Equation is examined in order to gain insight into the characteristics and properties of chaotic motions. It is shown that variations in the forcing function parameters as well as variations in the system's initial conditions can lead to a chaotic response. The incidence of chaos is presented in the form of chaos maps and the structure of these maps is discussed. The influence of linear spring force on these maps is also examined. Finally, it is shown that an improper choice of time step can cause spurious results with regard to the existence of chaotic motion. (Author abstract) 19 refs.

Tongue, B.H. (Georgia Inst of Technology, Atlanta, GA, USA). *J Appl Mech Trans ASME* v 54 n 3 Sep 1987 p 695-699.

**075458 MATHEMATICAL MODEL OF A QUASI-PERIODIC OSCILLATOR.** A method for constructing mathematical models of quasi-periodic oscillators is developed. The signal is represented by the sum of an arbitrary number of harmonic components with specified amplitudes and frequencies. A computer model of a generator of the sum of two harmonic oscillations is constructed as an example. (Author abstract) 10 refs.

Sinitskiy, L.A.; Felyshtyn, O.I. *Sov J Commun Technol Electron* v 31 n 12 Dec 1986 p 144-150.

**075459 LOEB'S CRITERION AND 'LATCH-UP' EFFECT IN SECOND ORDER OSCILLATORS WITH SINGLE OA.** The aim of this paper is to show that Loeb's criterion in 2nd-order oscillators with a single operational amplifier enables a linear interpretation. The 'latch-up' effect in these systems can be also predicted by a linear theory. (Author abstract) 13 refs.

Martinez, P.A. (Univ de Zaragoza, Spain); Carlosena, A.; Barquillas, J. *Int J Electron* v 63 n 5 Nov 1987 p 655-660.

**075460 NONLINEAR NEGATRON MODEL OF ACTIVE THREE-ELECTRODE DEVICES WITH FEEDBACK.** Different three-electrode oscillators (triode, transistor circuits) may be considered from a common viewpoint due to the fact that their output characteristics are quite similar. Analysis of the behavior of such oscillators is ordinarily based on approximation of the characteristics by broken-line curves and on introduction of two or even three cutoff angles. The optimal regime is taken to be the critical regime for which the current impulse at the output is largest and there is no dip in the pulse. We attempt a simple determination of the parameters of a negatron model for a three-electrode self-excited oscillator with an active device (triode, transistor, field-effect transistor) operating in undervoltage and overvoltage modes. 5 refs.

Malyshev, I.V.; Obolenskii, A.S. *Radioelectron Commun Syst* v 30 n 3 1987 p 82-84.

**075461 CURRENT-CONVEYOR SINE-WAVE OSCILLATORS.** The current-conveyor has attracted the attention of many researchers in the field of active filters and oscillators. Over the past few years, a number of schemes have been developed for realizing single current-conveyor active-RC sinusoidal oscillators. But papers available on this subject are concerned only with one new circuit in each paper. Our objective in this article is therefore to provide a unified treatment for single cur-

rent-conveyor active-RC sinusoidal oscillator circuits. Apart from the obvious advantage of unifying the analysis of this class of oscillator, this treatment leads to the systematic discovery of numerous single current-conveyor active-RC sinusoidal oscillators. 10 refs.

Abuelma'atti, Muhammad Taher; Humood, Nouria Abdullah. *Electron Wireless World* v 94 n 1625 Mar 1988 p 282-284.

**075462 RELATING THE ALLAN VARIANCE TO THE DIFFUSION COEFFICIENTS OF A LINEAR STOCHASTIC DIFFERENTIAL EQUATION MODEL FOR PRECISION OSCILLATORS.** Models of clock errors are of interest in understanding the NAVSTAR Global Position System Control Segment as well as in the design and simulation of user equipment. In these practical situations, the question of how the clock model's noise properties relate to the Allan variance is important. In particular, the relationship between the diffusion coefficients or so-called process noise parameters for the stochastic differential equation often used in Kalman filters to model the behavior of oscillators, and the Allan variance, must be understood. The relationship is stated and derived using integrals of stochastic processes as the natural tool.

Chaffee, James W. (Systems Control Technology Inc, Palo Alto, CA, USA). *IEEE Trans Ultrason Ferroelectr Freq Control* v UFFC-34 n 6 p 655-658.

## Medical Applications

**075463 SINE-QUADRATURE OSCILLATOR FOR CELLULAR SPIN RESONANCE UP TO 120 MHZ.** Living or dead cells influenced by a rotating electric field can be observed to spin. This phenomenon is called cellular spin resonance or CSR (Mischel et al., 1982; Arnold et al., 1982). This behavior depends on the electrical properties of the cell and of the surrounding medium and also on the amplitude and frequency of the rotating field. Around 100 kHz, living cells spin against the field's sense of rotation, whilst beyond 1 MHz they spin with the field. So far, experimental results exist only up to 10 MHz (Gimsa et al., 1985). Calculations (Fuhr et al., 1985) predict a spinning resonance somewhat below 100 MHz. The author describes a circuit which provides rotating fields up to 120 MHz at amplitudes of  $2 \mu\text{p-p}$  (at 50Ω). With this instrument it has been possible for the first time to prove that the predicted resonance is correct. The circuit diagram is provided. 5 refs.

Hoelzel, R. (Freie Univ Berlin, Berlin, West Ger). *Med Biol Eng Comput* v 26 n 1 Jan 1988 p 102-105.

**Millimeter Waves** See Also OSCILLATORS, MICRO-WAVE—Transients; SEMICONDUCTOR DEVICES, TRANSIT TIME—Mathematical Models.

**075464 FREQUENCY-CHIRP IN SOLID-STATE mm-WAVE SOURCES.** The frequency chirp phenomenon of IMPATT oscillators and the capability of injection synchronization in removing it are examined. Simultaneous use of injection locking and bias tuning, help in the generation of dechirped mm-wave oscillations with IMPATT diodes. Computer simulation confirms the theoretical predictions. (Author abstract) 9 refs.

Sarkar, S. (Burdwan Univ, Burdwan, India); Chatterjee, S.; Biswas, B.N. *J Inst Electron Telecommun Eng* v 33 n 4 Jul-Aug 1987 p 116-121.

**075465 MONOLITHIC MILLIMETRE-WAVE OSCILLATOR USING A TRANSMISSION LINE PERIODICALLY LOADED BY QWITT DIODES.** A small-signal analysis of a travelling-wave structure implemented by periodically loading a parallel-plate waveguide with either resonant tunnelling or QWITT diodes is presented. A small-signal equivalent circuit is used to determine the diode impedance as a function of frequency. The periodicity of the structure, i.e. the distance between adjacent diodes, determines the oscillation (resonant) frequency of the circuit. The analysis shows that change



in the oscillation frequency through variation in the design width and thickness of the waveguide is minimal. The physical dimensions of the waveguide facilitate monolithic fabrication of the oscillator circuit. (Author abstract) 8 refs.

Kesan, V.P. (Univ of Texas at Austin, Austin, TX, USA); Mortazawi, A.; Neikirk, D.P.; Itoh, T. *Electron Lett* v 24 n 11 May 26 1988 p 666-667.

## Monitoring

**075466 USING A MICROCOMPUTER IN AUTOMATIC MONITORING OF THE PARAMETERS OF VACUUM-TUBE OSCILLATORS.** A system is described for automatic monitoring of the electrical and energy parameters of self-excited vacuum-tube oscillators that uses a microcomputer; it has been developed for matching to loads and adjustment of industrial vacuum-tube oscillators to an optimal energy regime. (Author abstract) 2 refs.

Vologdin, V.V.; Litman, E.H.; Sazonov, L.V. *Sov Electr Eng* v 58 n 2 1987 p 105-107.

## Noise See OSCILLATORS, GUNN.

## Noise, Spurious Signal

**075467 ON THE RESPONSE OF THE VAN DER POL OSCILLATOR TO WHITE NOISE EXCITATION.** The response of the Van der Pol oscillator to white noise excitation has been investigated by R.L. Stratonovich, T.K. Caughey, K. Piszczek and others using different approximate methods. It is shown that in certain ranges of non-linearity and noise intensity Stratonovich's stochastic averaging method yields reasonable results while Caughey's and Piszczek's techniques give incorrect results. It is also shown that the Gaussian closure technique is inapplicable to this problem. (Edited author abstract) 9 refs.

Zhu, W.-Q. (Zhejiang Univ, Hangzhou, China); Yu, J.-S. *J Sound Vib* v 117 n 3 Sep 22 1987 p 421-431.

## Performance

**075468 HIGH-POWER FET GENERATOR.** The generator is designed to supply loaded piezoelectric transducers in the frequency range of 0.5-3 MHz. The output power is  $\leq 200$  W, the dynamic range with a working frequency for the entire range is set by a single external resistor. The frequency instability is  $\leq 1\%$  for an ambient temperature of 20-50°C. Operation without a load is permissible. The generator withstands brief short circuits. (Author abstract) 3 refs.

Ageev, A.A. (Acad of Sciences of the USSR, Moscow, USSR). *Instrum Exp Tech* v 30 n 1 pt 2 Jan-Feb 1987 p 127-128.

**075469 VOLTAGE-CONTROLLED BIPOLAR-MOS (VCBM) RING OSCILLATOR.** 17-stage VCBM ring oscillators have been fabricated. The VCBM device is an SOI device which operates both as a lateral bipolar and as a MOS transistor. Ring oscillators operated at supply voltage as low as 0.7 V and power-delay products per gate as low as 2.9 fJ are observed. (Author abstract) 2 refs.

Colinge, J.P. (Hewlett-Packard Co, Palo Alto, CA, USA). *Electron Lett* v 23 n 19 Sep 10 1987 p 1023-1025.

**075470 CHARACTERISATION OF A FIBRE RAMAN OSCILLATOR USING FIBRE GRATING REFLECTORS.** We have constructed a completely integrated fibre Raman oscillator using two fibre grating reflectors. This was synchronously mode-locked using a cw mode-locked Nd: YAG laser operating at 1.06  $\mu$ m. Spectral and temporal characteristics of the Raman oscillator are presented. (Author abstract) 8 refs.

Kean, P.N. (Univ of St. Andrews St. Andrews Scotl); Smith, K.; Sinclair, B.D.; Sibbert, W.; Rowe, C.J.; Reid, D.C.J. *Electron Lett* v 23 n 23 Nov 5 1987 p 1241-1243.

**075471 MEASURING VCO TIME VARYING FREQUENCY CHARACTERISTICS.** Many time-dependent characteristics of high frequency VCOs, such as settling time and post-tuning drift, traditionally have been difficult to measure. This technique, using an EIP model 588 pulsed frequency counter and a delaying pulse generator, facilitates accurate measurements of time varying frequencies. This concept may be used for any application where the frequency varies with time, such as settling time and post-tuning drift. The technique can be automated using the GPIB (IEEE 488) bus.

Beers, Ray (EIP Microwave Inc, San Jose, CA, USA); Hughes, Andy. *Microwave J* v 30 n 11 Nov 1987 p 201-203.

**075472 VCO TECHNIQUES FOR EW SYSTEMS.** Improvements in technology and design have yielded VCO and LO components with reduced size and power consumption and improved overall electrical performance. Steadily increasing complexity of next-generation EW systems, resulting from a dynamic threat environment, has placed added burdens on the VCO and LO designer to provide more complex subsystems. Wider frequency coverage, faster tuning response, improved stability over frequency and temperature, and reduced volume and input power budgets have been necessary. Future trends include predictive jamming techniques, 'smart' control circuitry with real time adjustments, integration of battlefield ECM systems with other EW and command functions, and utilization of active decoys and expendables. (Author abstract) 6 refs.

Boyd, David A. (Litton Electron Devices, San Jose, CA, USA). *Microwave J* v 31 n 2 Feb 1988 6p between p 129 and 137.

**075473 LINEAR SINUSOIDAL VCO.** This paper presents a sinusoidal oscillator whose frequency of oscillation bears a linear relationship with the controlling voltage  $V_x$ . The basic configuration incorporates two four-quadrant analogue multipliers in conjunction with an RC network of which two capacitors are grounded. The circuit is found to show an ultra-low distortion output. The realization of the basic configuration uses two grounded capacitors which are suitable for LSI implementation of the oscillator circuit. (Author abstract) 5 refs.

Prakash Singh, Ved (G.B. Pant Univ, Pantnagar, India); Saha, S.K. *Int J Electron* v 65 n 2 Aug 1988 p 243-247.

**075474 LOWER LIMIT FOR BIAS TERMINATION CONDUCTANCE OF A MULTIPLE-DEVICE OSCILLATOR.** It is shown that for oscillations to occur, the bias termination conductance of a multiple-device oscillator must exceed a critical value. This is dependent on the susceptibility of an individual active device. (Author abstract) 4 refs.

Sarkar, S. (Univ of Roorkee, Roorkee, India). *Int J Electron* v 65 n 2 Aug 1988 p 255-256.

## Quartz Applications

**075475 ACCELERATION SENSITIVITY OF QUARTZ CRYSTAL OSCILLATORS: A REVIEW.** A tutorial on navigation, radar, and identification systems is presented. The topics discussed are the consequences of acceleration sensitivity in crystal oscillators on the Allan variance, including the effects of sinusoidal and random vibration, phase noise and integrated phase jitter; the vector nature of quartz resonator sensitivity; the theoretical description of the cause of the acceleration sensitivity of quartz resonators; techniques for the measurement of acceleration sensitivity; and the effect of frequency multiplication on acceleration effect. Various techniques currently being used or developed for reducing the effective acceleration sensitivity are considered. The techniques fall into three general categories: reduction of the acceleration sensitivity of the resonator; passive techniques that use compensating elements in the oscillator feedback loop, e.g., a second resonator or an acceleration sensitivity capacitor; and active acceleration compensation schemes that sense the acceleration and feedback a compensating

signal to a tuning network. 60 refs.

Filler, Raymond L. (US Army Electronics Technology & Devices Lab, Fort Monmouth, NJ, USA). *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 297-305.

## Research

**075476 STUDY OF DIFFRACTION RADIATION OSCILLATION.** The theoretical and experimental study of a Diffraction Radiation Oscillator (DRO) is reported. The sphere-cylindrical open cavity used in the DRO has been analyzed, the method for testing the field profile and the cold measurement of the open cavity have been worked out. The experimental device was manufactured in the authors' laboratory, and the theoretical analysis and experimental study of the device have been carried out. The main experimental results are: from 2000 V to 4000 V, the tube operates in the 60-87 GHz band, and the maximum output power is about 800 mW. (Edited author abstract) 12 refs.

Liu, Shenggang (Chengdu Inst of Radio Engineering, China); Chen, Jiayu; Yu, Shanfu; Zou, Wenlu; Duan, Yuxiang; Zhang, Fuxin; Lin, Chongwen. *Int J Infrared Millim Waves* v 8 n 8 Aug 1987 p 885-900.

## Spectrum Analysis

**075477 ELECTROSTATIC CALIBRATION OF MECHANICAL OSCILLATORS.** An accurate calibration method for mechanical oscillators is proposed that can measure small forces and moments yet does not require a measurement of geometrical parameters on the calibrating capacitor. The method depends on a mechanical oscillator with a sufficiently high quality factor and the fact that the charged calibrating capacitor introduces negative stiffness in the oscillatory system. 5 refs.

Maksimov, V.N. *Meas Tech* v 30 n 5 May 1987 p 497-500.

**075478 COMPARATIVE ANALYSIS OF NATURAL FLUCTUATIONS IN TWO CLASSES OF SELF-EXCITED OSCILLATORY SYSTEMS.** Using the spectral-time method a comparative analysis is made of the natural fluctuations in the amplitude and phase of self-excited oscillatory systems of the Thomson type and of self-excited oscillatory systems with delay. A system of stochastic differential equations describing the fluctuation motion of the spectral components of the stationary process is set up. Analytic expressions for determining the intensities of fluctuations in amplitude, and phase and their cross correlation are obtained. Results of an analysis of the fluctuations as of function of the relative delay time are presented. (Author abstract) 11 refs.

Vladimirov, S.N.; Maydanovskiy, A.S. *Sov J Commun Technol Electron* v 32 n 4 Apr 1987 p 69-75.

## Stability See Also RESONATORS—Design.

**075479 ON A DRIVEN NONLINEAR CIRCUIT AND CHAOTIC BEHAVIOUR.** The results for nonlinear RLC circuits driven by a sinusoidal voltage is first summarized. Then, the chaotic behavior of the sinusoidally driven nonlinear circuit proposed by E.R. Hunt is investigated. The results are compared with those from other driven nonlinear circuits. 20 refs.

Steeb, W.H. (Rand Afrikaans Univ, Johannesburg, S Afr). *Chung kuo Kung Ch'eng Hsueh K'an* v 10 n 6 Nov 1987 p 717-720.

**075480 INTERNAL RESONANCES IN NONLINEARLY-COUPLED OSCILLATORS.** The present paper gives an analytical perturbation theory to treat the problem of internal resonances of higher orders in systems of nonlinearly-coupled oscillators. The problem of two nonlinearly-coupled oscillators is treated first. It is found even for higher-order internal resonances that whereas the



actions of the individual oscillators are nearly constant when the system does not show an internal resonance, the total action of the uncoupled system is nearly constant when the system undergoes an internal resonance. (Edited author abstract). 22 Refs.

Shivamoggi, B.K. (Univ of Central Florida, Orlando, FL, USA); Varma, Ram K. *Acta Mech* v 72 n 1-2 May 1987 p 111-130.

**075481 SYSTEM OF 2N SELF-EXCITED OSCILLATORS WITH TWO TYPES OF RESISTIVE COUPLING.** The conditions for local stability of synchronous oscillations in a system of two ensembles of self-excited oscillators, in which two types of resistive coupling that are opposite in their action exist between the self-excited oscillators, are examined. An approach, which represents the stability problem as an eigenvalue problem, is used in the analysis. (Author abstract). 6 Refs.

Novikov, S.S.; Maydanovskiy, A.S. *Sov J Commun Technol Electron* v 32 n 10 Oct 1987 p 158-162.

**075482 STABILITY AND DISTORTION IN TUNEABLE LOW FREQUENCY SINUSOIDAL OSCILLATORS.** The theoretical principles involved in the design of tuneable oscillators are presented in the context of a practical design which generates a sinusoidal output with a constant amplitude and low harmonic content over the range 7-2500 Hz in three overlapping bands, each with a continuous tuning range exceeding 20:1. We introduce a figure of merit  $\zeta$ , the product of the fractional amplitude variation on tuning and the fractional harmonic content, and show that  $\zeta = \lambda \delta L / L$  where  $L$  is the insertion loss at the resonant frequency  $\omega$ , (essentially  $L = Q^{-1}$ ) of the frequency selective element,  $\delta L / L$  its fractional variation on tuning and  $\lambda$  is a constant depending on the structure of the oscillator and of the amplitude control system. When a subsidiary low-pass control loop characterized by a time constant  $T$ , which influences the settling time, is used,  $\lambda$  is inversely proportional to  $\omega_0 T$ . (Author abstract). 5 Refs.

Robinson, F.N.H. (Univ of Oxford, Oxford, Engl). *Int J Electron* v 65 n 5 Nov 1988 p 971-982.

## Synchronization

**075483 OSCILLATOR SYNCHRONIZATION POWER AS A FUNCTION OF REGENERATION IN BIAS CIRCUITS.** Investigation of synchronization processes in self-excited oscillators with allowance for bias-circuit parameters is of scientific and practical interest. In the literature the energy characteristics of the synchronizing signal are considered with no allowance for this influence. In systems designed on the basis of devices having natural negative resistance (tunnel diodes (TD) or Gunn diodes (GD)), this influence may be substantial, however, owing to regeneration in the bias circuit. We examine the influence of regeneration qualitatively for the example of a TD oscillator. 3 Refs.

Grunenkov, A.A.; Zubov, P.T.; Khotuntsev, Yu.L. *Radiotekhnika i Elektronika* v 30 n 10 1987 p 76-79.

## Synthesis

**075484 SYNTHESIS OF ACTIVE-R OSCILLATORS WITH ADDITIONAL NOTES ON PARTIALLY ACTIVE-R APPLICATIONS.** General oscillation requirements for two operational amplifier active-R circuit implementations are stated. A procedure for minimizing oscillation frequency sensitivities is described. Many oscillator realizations are also derived. The steps for finding partially active-R oscillator circuits are shortly outlined. It has been shown that especially in IC-technology non-minimum sensitivity oscillator structures may be preferable. (Author abstract) 11 Refs.

Valtonen, Pekka (Tampere Univ of Technology, Tampere, Finl). *AEU Arch Elektron Uebertrag Electron Commun* v 41 n 6 Nov-Dec 1987 p 325-329.

## Testing

**075485 ANALYTICAL AND EXPERIMENTAL STUDY OF INJECTION-LOCKED TWO-PORT OSCILLATORS.** A Ku-band IMPATT oscillator with two distinct output power ports was injection-locked alternately at both ports. The transmission locking bandwidth was nearly the same for either port. The lower free running power port had a reflection locking bandwidth that was narrower than its transmission locking one. Just the opposite was found at the other port. A detailed analytical model for two-port injection-locked oscillators is presented, and its results agree quite well with the experiments. A detailed critique of the existing literature on this topic is included. It is concluded that two-port injection-locked oscillators may prove useful in certain communication systems. (Edited author abstract) 14 Refs.

Freeman, Jon C. (NASA, Cleveland, OH, USA); Downey, Alan N. *NASA Tech Memo* 110119 1987 38p.

**Theory** See LASERS, FREE ELECTRON—Components; MATHEMATICAL TECHNIQUES—Differential Equations.

## Transients

**075486 NUMERICAL METHOD FOR ANALYZING TRANSIENT AND STEADY STATES OF SINE WAVE OSCILLATOR CIRCUIT WITH STIFFNESS.** This paper proposes a method for analyzing the transient and steady states of a sine wave oscillator circuit with reactive elements which have large differences in their values. The circuit equation is represented by an autonomous nonlinear differential equation with the values of these elements. First, we describe the method for solving numerically the differential equation regardless of the stiffness by the asymptotic method developed by Krylov, Bogolyubov and Mitropolskiy. Second, we present the method for obtaining solutions of the differential equation with regard to the stiffness by combining the asymptotic method with numerical integration. (Edited author abstract) 9 Refs.

Okumura, Kohshi (Kyoto Univ, Kyoto, Jpn); Kishima, Akira; Yasuda, Hisashi. *Electron Commun Jpn Part 1* v 70 n 10 Oct 1987 p 1-11.

**075487 AMPLITUDE TRANSIENTS IN THE TWIN-T BRIDGE RC-OSCILLATOR WITH A MULTIPLIER AMPLITUDE CONTROL SYSTEM.** This paper considers the amplitude transients in the twin-T bridge RC-oscillator with an amplitude control system employing multipliers. The application of such a control system is feasible because this oscillator has two nodes where the sinusoidal steady-state voltages are shifted by 90°. The voltages at these nodes are squared and summed and the resulting dc voltage is compared with the reference voltage. The difference is amplified and is applied to the voltage control resistor (VCR) which is able to control the displacement of the poles on  $j\omega$  axis. Restricting ourselves to the case of step modulation of the reference voltage we obtain the solution for the amplitude transients in a closed form. This result is obtained without recurring to the linearization of the transfer function relating the oscillator output to the displacement of the above-mentioned  $j\omega$  axis poles. The effect of a loop filter for further reducing total harmonic distortions (THD) in a practical oscillator is analyzed. The nonlinearity of the VCR realized with a (FET) is taken into consideration by the piece-wise linearization of the FET control characteristic. All calculations were verified experimentally. (Author abstract) 19 Refs.

Filanovsky, I.M. (Univ of Alberta, Edmonton, Alberta, Can); Fortier, G.J.; Taylor, L.F. *Int J Electron* v 64 n 4 Apr 1988 p 547-561.

## Variable Frequency

**075488 ISOCHRONIZATION OF PENDULUM OSCILLATORS.** The problem of securing isochronism in pendulum-type oscillatory systems retains its interest when designing single-harmonic systems of measuring

technology. An outline is given of the design criteria for oscillatory devices that have multiple-fiber suspensions for checking angular accelerometers or moments of inertia of bodies. 4 Refs.

Smirnov, V.N. *Meas Tech* v 30 n 5 May 1987 p 438-441.

## Vibrations

**075489 PRESSURE DEPENDENT DYNAMIC CHARACTERISTICS OF MINIATURE SILICON OSCILLATOR.** The theoretical analysis of the dynamic behavior of a miniature silicon oscillator consisting of a cantilever beam and a rectangular paddle was presented. The calculated results are in good agreement with the experimental data. Within the range of  $10^{-1}$  to  $10^5$  Pa, the dynamic characteristics of the oscillator are seen to depend on the air pressure. The effects of the air damping force acting on the miniature oscillator can be explained by the kinetic theory of gases in the lower pressure region. In the lower pressure region, vibrational amplitude increases with decreasing air pressure, but saturates at a critical pressure. In the higher pressure region, the air damping force increases in proportion to the acceleration, as well as in proportion to the velocity of the paddle tip. 5 Refs.

Terasawa, Tsuneo (Hitachi Ltd, Kokubunji, Jpn); Kawamura, Yoshio; Sato, Kazuo; Tanaka, Shinji. *Bull Jpn Soc Precis Eng* v 22 n 1 Mar 1988 p 49-54.

## OSCILLATORS, CRYSTAL See Also RESONATORS, CRYSTAL.

**075490 PACKAGED FREQUENCY SOURCES USING SPECIALISED PRECISION CRYSTALS.** High precision frequency sources are readily accessible due to the availability of quartz crystals. Frequencies can be measured and generated to accuracies many order of magnitude better than 50 ppm. The available packages range from the SPXO through TCXO (temperature compensated crystal oscillator), OXCO (oven controlled crystal oscillator) to miniature atomic standards able to generate frequency reliably to a precision of  $1 \times 10^{-11}$  in a package only a few centimeters in each dimension. The paper discusses the undesirable crystal characteristics, such as aging and susceptibility to mechanical and thermal stresses, and the measures to be taken to overcome these properties.

Heaviside, John (HCD Research). *New Electron* v 20 n 19 Sep 29 1987 p 39-42.

**075491 QUARTZ CRYSTAL UNITS FOR TEMPERATURE COMPENSATED CRYSTAL OSCILLATORS.** Quartz crystal units in the frequency range of 2.48 MHz to 5.0 MHz were designed and fabricated for use in Temperature Compensated Crystal Oscillators (TCXOs). Their dynamic and state behavior of frequency and resistance with respect to temperature changes from  $-45^\circ\text{C}$  to  $+85^\circ\text{C}$  were studied. The geometry of the resonator namely, the resonator diameter, planoconvex contour, electrode thickness and size were properly selected to make them free from activity dips and frequency discontinuities in the desired temperature range. The resonator quality factor [Q] was estimated with different amount of etching in  $\text{NH}_4\text{HF}_2$  solution and an optimum level of etch was determined. (Edited author abstract) 8 Refs.

Acharya, P. Kumara (Bharat Electronics Ltd, Bangalore, India). *IETE Tech Rev* v 4 n 9 Sep 1987 p 345-348.

**Acceleration** See OSCILLATORS—Quartz Applications.

**Applications** See SEMICONDUCTOR DEVICES, MOS—Design.

## Design

**075492 DESIGN OF CRYSTAL OSCILLATORS WITH FUNDAMENTAL FREQUENCIES IN THE UHF AND MICROWAVE REGIONS.** A negative resistance approach is used to design a crystal oscillator



whose fundamental resonance is at  $F_0 = 842.911$  MHz. The SSB phase noise measurements of the crystal oscillator show great potential for the development of stable frequency sources in the UHF and microwave regions. (Author abstract) 4 refs.

Gonzalez, G. (Univ of Miami, Coral Gables, FL, USA); Avanic, B. *Electron Lett* v 23 n 25 Dec 3 1987 p 1379-1381.

**075493 DESIGN METHOD YIELDS LOW-NOISE, WIDE-RANGE CRYSTAL OSCILLATORS.** A characterization technique allows you to design frequency-determining networks for tunable crystal oscillators. The method yields oscillators that provide a wide tuning range and exhibit low-noise performance. The design methodology accurately quantifies all effects relevant to oscillator performance. (Author abstract)

Hillstrom, Tim L. (Hewlett-Packard Co). *EDN* v 33 n 6 Mar 17 1988 p 141-144, 146.

**075494 RUBIDIUM-CRYSTAL OSCILLATOR (RBXO).** The rubidium-crystal oscillator (RBXO) is a voltage-controlled crystal oscillator (VCXO) that is periodically synchronized by a rubidium (Rb) reference. The RBXO uses a digital tuning memory to hold the VCXO frequency-control voltage while the Rb reference is off. The RBXO design and test results are described, including a 180-day design verification test, during which four RBXOs were cycled on and off 20 times/day while being subjected to a -62-to-+68°C temperature cycle. This test successfully verified that the design is capable of the desired 20-year life. Of particular interest is the low synchronization energy (2 Wh at +25°C) and low drift of the synchronized frequency ( $< 5 \times 10^{-13}$ /day) during many thousands of on-off cycles. The long-term stability of the RBXO is essentially identical to that of the rubidium frequency standard operating continuously. 5 refs.

Riley, William J. Jr. (EG&G, Salem, MA, USA); Vaccaro, John R. *IEEE Trans Ultrason Ferroelectr Freq Control* v UFFC-34 n 6 p 612-618.

## Electric Field Effects

**075495 EFFECTS OF AN APPLIED FIELD ON THE STEADY STATE CHARACTERISTICS OF A UNIDIRECTIONAL PHOTOREFRACTIVE RING OSCILLATOR.** Steady state oscillation in a unidirectional photorefractive ring oscillator is examined in the presence of a dc electric field. For small applied field strengths, there is a shift in the origin of the linear curve for the frequency difference between the oscillating field and the pump beam versus the cavity detuning. Consequently, the resonator field oscillates at a different frequency from the pump beam, even when the cavity is tuned to exact resonance. This frequency difference is determined by the dc electric field and the characteristic fields of the photorefractive medium. For large applied fields, the frequency difference becomes an asymmetric function of the cavity detuning due to the dominance of the drift motion of the liberated charge carriers in one preferred direction. The range of cavity detuning over which oscillation will occur for a given set of parameters is enhanced when large electric fields are applied to the photorefractive medium; this effect may best be observed in resonators with high finesse. (Edited author abstract) 17 refs.

Saxena, R. (NBS, Boulder, CO, USA); Anderson, D.Z. *Opt Commun* v 66 n 2-3 Apr 15 1988 p 172-178.

## Quartz Applications

**075496 HIGH-PERFORMANCE CRYSTAL OSCILLATOR CIRCUITS: THEORY AND APPLICATION.** A general theory that allows the accurate linear and nonlinear analysis of any crystal oscillator circuit is presented. It is based on the high Q of the resonator and on a very few nonlimiting assumptions. The special case of the three-point oscillator, that includes Pierce and one-pin circuits, is analyzed in more detail. A clear insight into the linear behavior, including the effect of losses, is

obtained by means of the circular locus of the circuit impedance. A basic condition for oscillation and simple analytic expressions are derived in the lossless case for frequency pulling, critical transconductance, and start-up time constant. The effects of nonlinearities on amplitude and on frequency stability are analyzed. As an application, a 2-MHz CMOS oscillator which uses amplitude stabilization to minimize power consumption and to eliminate the effects of nonlinearities on frequency is described. The chip, implemented in a 3- $\mu$ m p-well low-voltage process, includes a three-stage frequency divider and consumes 0.9  $\mu$ A at 1.5 V. The measured frequency stability is 0.05 ppm/V in the range 1.1-5 V of supply voltage. Temperature effect on the circuit itself is less than 0.1 ppm from -10 to +60°C. 28 refs.

Vittoz, Eric A. (Cent Suisse d'Electronique et de Microtechnique, Neuchatel, Switzerland); Degrauwe, Marc G.R.; Bitz, Serge. *IEEE J Solid State Circuits* v 23 n 3 Jun 1988, Thirteenth Eur Solid-State Circuits Conf 87, Bad Soden, West Ger, Sep 1987 p 774-783.

## Stability

**075497 FREQUENCY STABILITY OF EMITTER FOLLOWER TYPE CRYSTAL OSCILLATORS.** Adjustment-free crystal oscillators with only a few circuit elements are used widely since they are suited for ICs. The simplest emitter-follower-type crystal oscillator made of a transistor, a quartz crystal, a capacitor, and three resistors is studied in terms of its frequency stability. It is found that the oscillation frequency is more stable against the change of an external capacitance if larger values are chosen for the collector capacitance  $C_c$ , the grounded base current gain  $\alpha$ , and the cutoff frequency  $f_c$ . Against the change of the power supply voltage, the optimum value of  $f_c$  can be determined after  $C_c$  is selected from the forementioned condition. The oscillation frequency deviation is smaller for a larger equivalent inductance regardless of the Q value of the crystal. Based on these results, it is found that the improvement is more than sixfold against the variation of the power supply voltage, and more than elevenfold against that of the circuit capacitance. (Edited author abstract)

Nakamura, Kohei (Nihon Univ, Narashino, Jpn). *Electron Commun Jpn Part 2* v 71 n 1 Jan 1988 p 32-40.

## Thermal Effects

**075498 300-MHZ DIGITALLY COMPENSATED SAW OSCILLATOR.** A method for compensating for the inherent temperature sensitivity of surface-acoustic-wave (SAW) oscillators is described. Results for a 300-MHz digitally compensated SAW oscillator (DCSO) show a reduction of temperature-induced frequency variation from  $\pm 125$  parts per million to  $\pm 1.4$  parts per million over the temperature range of -23 to 75°C. This is accomplished using simple digital circuitry and microprocessor control. The temperature-sensing scheme, using a SAW structure with two delay paths of different temperature sensitivity on the same AT-cut quartz substrate, virtually eliminates thermal resistance and time-constant problems. Advantages over ovenized systems include fast warmup; reduced size, weight, and power dissipation; low cost potential; and the ability to compensate for other sources of frequency drift. 20 refs.

Cowan, William D. (Rome Air Development Cent, Hanscom AFB, MA, USA); Slobodnik, Andrew J. Jr.; Roberts, George A.; Silva, Jose H. *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 May 1988 p 380-385.

## Variable Frequency

**075499 FREQUENCY TEMPERATURE COMPENSATION OF CMOS CRYSTAL CONTROLLED OSCILLATOR IN ELECTRONIC WATCHES.** This paper describes the compensation of frequency temperature with double crystals: the principle of compensation, the method of calculation, the relationship between the frequency character curve after compensation and the single crystal character, and the relationship between the frequency character curve and the load capacity. (Author abstract)

In Chinese. 3 refs.

He, Yongjian (Tianjin Univ, China); Zhang, Daxu; Yao, Wan; Sun, Zhanli. *Tianjin Daxue Xuebao* n 4 1987 p 21-30.

## OSCILLATORS, GUNN

**075500 AM-PM CONVERSION IN AN X-BAND INJECTION-LOCKED GUNN OSCILLATOR.** The paper presents a systematic analysis of the AM-to-PM conversion performance of an X-Band Gunn Oscillator injection-locked to an AM signal. The analysis shows that with a proper choice of the system parameters, it is possible to obtain a complete conversion of the amplitude modulation of a given carrier into the phase modulation of the same carrier with the least possible modulation-distortion. (Edited author abstract) 12 refs.

Chattopadhyay, Taraprasad (Burdwan Univ, Burdwan, India). *J Inst Electron Telecommun Eng* v 33 n 2 Mar-Apr 1987 p 52-57.

**075501 EFFICIENT FM-AM CONVERSION THROUGH INJECTION-LOCKING OF AN X-BAND GUNN OSCILLATOR.** This paper describes experimental observations on the amplitude modulation of a 9.347 GHz Gunn oscillator when it is injection-locked by an FM signal. The dependence of both the FM-AM conversion efficiency and the harmonic distortion of the detected signal on the system parameters is discussed in detail. Numerical analysis for the system is also presented. The investigations carried out indicate that an injection-synchronized microwave oscillator can be used as an efficient FM-AM converter so that together with an AM detector, it can serve the purpose of a faithful FM demodulator, especially for low-index FM signals. (Author abstract) 14 refs.

Chattopadhyay, T.P. (Burdwan Univ, Burdwan, India). *J Inst Electron Telecommun Eng* v 32 n 6 Nov-Dec 1986 p 428-434.

**075502 SECOND HARMONIC OPERATION OF X-BAND GUNN DEVICES.** GaAs Gunn devices are being increasingly used in the harmonic mode to deliver appreciable power in the mm-wave band. In this paper, the second harmonic response of indigenously developed X-band Gunn devices are treated. The circuit requirements and experimental results obtained in a conventional resonant disc type oscillator circuit are discussed in detail. (Author abstract) 10 refs.

Aggarwal, A.K. (Solid State Physics Lab, Delhi, India); Ray, U.C.; Gulati, R.; Chandra, Ishwar. *J Inst Electron Telecommun Eng* v 32 n 6 Nov-Dec 1986 p 451-452.

**075503 PROPER BIAS CUTS NOISE, SELECTS FREQUENCY.** Part 1 of this article covered Gunn diode and oscillator fundamentals, and the basic design concepts and temperature-compensation methods of a cavity oscillator. This part advances the study by analyzing problems in starting the oscillations at low temperatures and maintaining power stability at all temperatures. It also covers noise performance and frequency tuning in the Gunn oscillator. 3 refs.

Howell, Charles M. (Semiconductor Products Inc, Burlington, MA, USA). *Microwaves RF* v 26 n 5 May 1987 8p.

## Analysis

**075504 AUTODYNE DETECTION EFFECT IN GUNN-DIODE OSCILLATORS AND ITS UTILIZATION FOR MONITORING THE THICKNESS AND DIELECTRIC CONSTANT OF MATERIALS.** We use a numerical analysis as the basis for describing the autodyne detection effect in oscillators using Gunn diodes and to investigate the features of its utilization for checking the parameters of materials. The calculations, carried out for the actual parameters of the active element and load, make it possible to evaluate the magnitude of a detected signal, to determine the region of values of



monitored material parameters in which the sensitivity of the autodyne to variation is greatest, and to indicate ways of optimizing the oscillator design. 5 Refs.

Usanov, D.A.; Skripal, A.V. *Radioelectron Commun Syst* v 30 n 10 1987 p 80-82.

**075505 VARACTOR-TUNED GUNN-DIODE OSCILLATOR.** It is possible to tune Gunn-diode oscillators electrically by means of bias voltage, by utilization of p-i-n diodes, with utilization of a YIG sphere, and by means of a varactor. Oscillators controlled in accordance with the frequency of a resonator with yttrium iron garnet ferrite have good linearity (better than 1% in the centimeter band) but have a low rate of tuning; oscillators tuned by means of varactors, which have a high rate of tuning, most frequently are provided with good linearity by utilization of special measures. The required linearity of an oscillator modulation characteristic, the dependence of the oscillation frequency on the control voltage, is determined for generation of signals with linear frequency modulation (LFM). It is pointed out that such signals improve the information level of radio systems, for example, the range and velocity resolving power of a radar system. 4 Refs.

Vorob'ev, Yu.P.; Naumovich, N.M. *Radioelectron Commun Syst* v 30 n 10 1987 p 102-104.

## Design

**075506 DESIGN AND FABRICATION OF A 35 GHz, 100 mW LOW PHASE NOISE GUNN DIODE OSCILLATOR.** A low phase noise of between  $-125$  and  $-132$  dBc/Hz is obtained for a 35 GHz, 100 mW Gunn diode oscillator using the van der Hyden approach. This low phase noise was accomplished by making the coupling between the terminated coaxial line Gunn diode oscillator and the stabilizing cavity resonator as large as possible, while making the coupling to the output as weak as practical for sufficient measurement of output power. The design data and test results for the oscillator are given. 13 Refs.

Strangeway, Robert A. (Marquette Univ, Milwaukee, WI, USA); Ishii, T. Koryu; Hyde, James S. *Microwave J* v 31 n 7 Jul 1988 p 107-112.

**075507 LOW-PHASE-NOISE GUNN DIODE OSCILLATOR DESIGN.** Low-phase-noise Gunn diode oscillators with an operating frequency of 35 GHz and an output power of 100 mW are designed, fabricated, and tested. The phase noise is  $-132$  dBc/Hz to  $-125$  dBc/Hz at 100-kHz offset from the center frequency. This low phase noise is obtained by closely coupling the stabilizing transmission cavity resonator and the Gunn-diode-oscillator coaxial line while loosely coupling the transmission cavity to the output waveguide following van der Heyden's approach. 13 Refs.

Strangeway, Robert A.; Ishii, T. Koryu; Hyde, James S. *IEEE Trans Microwave Theory Tech* v 36 n 4 Apr 1988 p 792-794.

## Millimeter Waves

**075508 EFFECT OF A HIGH ENERGY INJECTION ON THE PERFORMANCE OF MM WAVE GUNN OSCILLATORS.** The 'dead zone' existing in conventional  $n^{+}nn^{+}$  GaAs Gunn diodes was eliminated by the addition of a cathode structure which launches electrons into the active region at nearly the energy required for interval transfer. The experimental efficiency and output power from devices made with the launcher were up to three times higher at 80-100 GHz than from conventional  $n^{+}nn^{+}$  devices designed for these frequencies. The launcher was realized by the energy discontinuity at the interface of a  $n$ -AlGaAs/ $n$ -GaAs heterojunction, where the transport is perpendicular to the interface. (Author abstract) 9 Refs.

Greenwald, Z. (Cornell Univ, Ithaca, NY, USA); Woodard, D.W.; Calawa, A.R.; Eastman, L.F. *Solid State Electron* v 31 n 7 Jul 1988 p 1211-1214.

## Stability

**075509 MODE STABILITY OF RADIATION-COUPLED INTERINJECTION-LOCKED OSCILLATORS FOR INTEGRATED PHASED ARRAYS.** An analysis is presented of a two-element, 10-GHz array consisting of two oscillators coupled solely by means of the free-space interaction between their respective antenna elements. The oscillators are modeled as energy-storing L-C tank circuits in parallel with voltage-dependent negative conductances. A simplified far-field slot antenna model is used to derive the mutual admittance of the two antennas. Even-odd mode analysis yields the normal modes of the system, and a theorem from averaged potential theory is used to determine which mode is stable. Two microstrip Gunn diode oscillators were built to verify the essential features of the model. Oscillator frequencies, relative phases, and radiation patterns were measured as functions of the interantenna distance, and the periodic alternation of modes with distance predicted by theory was confirmed quite well. 7 Refs.

Stephan, Karl D. (Univ of Massachusetts, Amherst, MA, USA); Young, Song-Lin. *IEEE Trans Microwave Theory Tech* v 36 n 5 May 1988 p 921-924.

Testing See SEMICONDUCTOR DIODES, GUNN—Testing.

**OSCILLATORS, MICROWAVE** See Also LASERS, FREE ELECTRON—Microwaves; MICROWAVE DEVICES, Military Applications; OSCILLATORS, CRYSTAL—Design; OSCILLATORS, GUNN; RESONATORS, CAVITY; TRANSISTORS, FIELD EFFECT—Efficiency.

**075510 MODE JUMPING AND PHASE LOCKING IN IMPATT OSCILLATORS.** The effect of package parasitics on the behavior of an IMPATT diode oscillator whether it is in a free-running or in injection-synchronized state is studied in detail. Appearance of mode jumping phenomenon in such oscillators, hitherto unknown, has been critically examined and how to get rid of this phenomenon has been predicted. Computer simulation results have been presented to corroborate the theoretical findings. (Author abstract) 3 Refs.

Biswas, B.N.; Chatterjee, S.; Sarkar, S.; Bhattacharya, A.K. *J Inst Electron Telecommun Eng* v 33 n 1 Jan-Feb 1987 p 16-22.

**075511 HIGH-POWER MICROWAVE EMISSION FROM A VIRTUAL CATHODE OSCILLATOR.** Pinched electron beams emit high power microwaves by formation of a virtual cathode. Radiation occurs simultaneously with pinching or slightly thereafter. Observations of strong electrostatic fields and the partitioning of current into reflexing and transmitting populations at the same time that microwaves are emitted indicate virtual cathode formation. Microwaves originate mainly from the virtual cathode side of the anode. A two-dimensional model for the electron flow in the presence of a virtual cathode is presented. The model allows for electron reflexing and velocity distribution spread. Solutions with strong radial flow agree closely with microwave measurements, and result in the microwave frequency scaling linearly with diode current. (Author abstract) Refs.

Sze, H. (Physics Int Co, San Leandro, CA, USA); Benford, J.; Woo, W. *Laser Part Beams* v 5 pt 4 Nov 1987 p 675-681.

**075512 SELF-CONSISTENT FIELD THEORY AND CALCULATION FOR GYROMOTRON.** A self consistent field large signal theory of gyromotron is studied in this paper. The rf field profile function satisfies a wave equation. The field is determined by cavity geometry and ac electron beam current. The rf field not only satisfies the boundary conditions at the ends of the cavity but also obeys conservation of energy for steady state interaction between electron beam and field. The parameters of a particular gyrotron are calculated numerically using present theory. Effect of some factors on gyrotron characteristic is discussed. Comparison is made between the results of the self consistent field calculations

with and without conservation of energy. (Author abstract) 7 Refs.

Hongfu, Li (Dinzhang, Du); Zhonglin, Xie. *Int J Infrared Millim Waves* v 9 n 2 Feb 1988 p 135-148.

**075513 TWO-SPHERE YIG MULTIPLIER/FILTER ENSURES PURITY.** Frequency multiplication is an economical and time-proven technique for generating microwave outputs from low-frequency inputs. However, inherent in this technique is the generation of both desired and unwanted harmonics. A new, two-sphere YIG-tuned multiplier/filter guarantees spectral purity of better than  $-50$  dBc in harmonics and subharmonics over a 2-to-20-GHz frequency range. (Author abstract) 4 Refs.

Rhymes, Lynn (Hewlett-Packard Co, Santa Rosa, CA, USA). *Microwaves RF* v 27 n 4 Apr 1988 5p between p 109 and 116.

**075514 SYNCHRONOUS AND STOCHASTIC SELF-EXCITED OSCILLATIONS IN A TRANSISTOR MICROWAVE OSCILLATOR WITH DELAYED FEEDBACK, SUBJECTED TO THE PARAMETRIC ACTION OF AN EXTERNAL FORCE.** Results of an experimental investigation of nonautonomous operating modes of a transistor microwave oscillator with delay are presented. It is shown that random oscillations can be stimulated parametrically by applying an external signal, and processes of derandomization are examined. Randomization and derandomization processes are studied in a mathematical model of a nonautonomous multimodal system. (Author abstract) 12 Refs.

Kal'yanov, E.V. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 131-137.

**075515 OPERATION OF CUSPTRON AT FUNDAMENTAL AND HARMONIC CYCLOTRON FREQUENCIES.** The authors report microwave radiation at the fundamental and harmonic electron cyclotron frequencies generated by a cusptron oscillator. A low-energy, axis-rotating beam of 28-30 kV, 0.8-3.5 A, 4  $\mu$ s, and 60 pps interacts with a single RF mode, both in a circular cavity and in a six-vane circuit by the negative mass instability. In fundamental and second-harmonic frequency generation with a circular circuit, the independently excited modes are  $TE_{11s}$  and  $TE_{21s}$  with radiation power of more than 1.8 kW and an electronic efficiency of approximately 7.5%. Employing a six-vane circuit, microwave radiation of 6.0 GHz (sixth harmonic) and 3.9 GHz (fourth harmonic) is also independently generated with more than 10.4 and 4.0 kW, respectively. Corresponding electronic efficiencies are approximately 10.0 and 9.5%. 12 Refs.

Namkung, Won (US Naval Surface Weapons Cent, Silver Spring, MD, USA); Choe, Joon Y.; Uhm, Han S.; Ayres, Virginia. *IEEE Trans Plasma Sci* v 16 n 2 Apr 1988 p 149-154.

## Analysis

**075516 COUPLING COEFFICIENTS AND INJECTION-LOCKING CHARACTERISTICS OF MICROWAVE OSCILLATORS.** Injection-locking phenomena are often studied for the purpose of application to synchronous operation and parallel operation of multiple oscillators. With respect to the coupling of multiple oscillators, synchronization stability, mode control and long-time effects are problems. It is pointed out that the difference in the locking characteristics at low frequencies and at microwave frequencies is caused by treatment of the incident signal as the voltage and current or as the traveling wave. It is shown that use of the wave concept is more practical and rational in the microwave region. In such cases, the strength of the coupling between oscillators should be considered in two separate aspects: magnitude of the coupling ( $C \geq$  or  $\leq 1$ ) between the oscillator and the coupling transmission line, and coupling efficient  $r$  of the oscillator coupling circuit. As a result, it is found that a symmetric coupling with a rather weak coupling factor ( $r < 1$ ) or, if coupling is strong, an asymmetric



coupling is desirable for power combining of Van der Pol oscillators. (Edited author abstract) 10 refs.

Fukumoto, Katsumi (Sharp Corp, Tenri, Jpn); Nakajima, Masamitsu. *Electron Commun Jpn Part 1* v 70 n 12 Dec 1987 p 75-83.

**075517 ELECTRODYNAMIC ANALYSIS OF DIODE GENERATORS MOUNTED IN A RIDGE WAVEGUIDE RESONATOR.** A theoretical analysis is given of microwave diode generators connected in a ridge waveguide resonator, and their parameters are calculated. An algorithm for carrying out the calculation on a BESM-6 computer is given. (Author abstract) 9 refs.

Sinel'nikov, Yu. M.; Sinyavskii, G.P.; Tikhov, Yu.I. *Radioelectron Commun Syst* v 30 n 5 1987 p 18-22.

**075518 CONDITIONS FOR THE APPEARANCE OF MULTIFREQUENCY GENERATION IN A DISTRIBUTED RESONANT SELF-EXCITED BACKWARD-WAVE SYSTEM.** The physics of processes leading, in a resonance backward-wave self-excited oscillator with an extended electron beam, to the appearance of multifrequency oscillations and concomitant hysteresis phenomena is studied. The analysis is limited to stationary states. It is shown that a number of stationary generation states can exist at frequencies close to the resonance frequencies of the electrodynamic system, a transition between the stationary states can occur, accompanied by hysteresis of the amplitude and frequency characteristics, and both single-frequency and multifrequency generation of oscillations can be realized. The results of the theory are confirmed by experiments. (Edited author abstract). 8 Refs.

Golant, M.B.; Gulyayev, Yu. A.; Yefimov, V.N.; Zakharchenko, Yu. F.; Sinitsyn, N.I. *Sov J Commun Technol Electron* v 32 n 9 Sep 1987 p 46-56.

**075519 THEORY OF HIGH-HARMONIC GYROTRON OSCILLATORS WITH SLOTTED CROSS-SECTION STRUCTURE.** A linear-theory analysis of gyrotron oscillators with slotted cross section is used to calculate the net change in beam energy. In this formalism, geometric factors are clearly distinguished from the geometry-independent harmonic resonance terms due to the fundamental electron cyclotron maser and peniotron interactions. This separation of the interaction terms from the geometric factors simplifies the physical analysis, and leads to a very compact form for the net change in beam energy. The theory is applied to slotted rectangular oscillators and to slotted cylindrical oscillators to show that a unified expression can be obtained for the start-oscillation condition. In sample applications of the theory, it is demonstrated that slots lower the start-oscillation condition in both cylindrical and rectangular geometries, and can lead to a decrease in this condition as harmonic number is increased in the rectangular geometry. It is also found that the peniotron interaction, which is easily identified in this formalism, may be very strong in slotted cavities. 25 refs.

Vitello, P. (Science Applications Int Corp, McLean, VA, USA); Menyuk, C. *IEEE Trans Plasma Sci* v 16 n 2 Apr 1988 p 105-115.

**075520 CUBIC DISPERSION RELATION FOR A RELATIVISTIC BACKWARD-WAVE OSCILLATOR.** The cubic approximation to the dispersion relation for a relativistic backward-wave oscillator is obtained, and the utility and limits of the approximation are presented. The approximation is obtained by Taylor series expansion of the wave admittance in the dispersion relation for the transverse-magnetic and free-streaming modes of a relativistic, thin, hollow, cylindrical electron beam moving along the axis of a disc-loaded waveguide in a strong axial magnetic field. The resulting cubic dispersion relation yields instability growth rates and frequencies which fall off beyond their maximum more sharply with increasing wavenumber than for the complete dispersion relation. The approximation is found to be quite good near the operating points of contemporary high-power relativistic backward-wave oscillators, namely, for relatively long

wavelength and small ratio of Budker's parameter to the relativistic gamma factor of the beam. 4 refs.

Brandt, Howard E. (Harry Diamond Lab, Adelphi, MD, USA); Uhm, Han S. *IEEE Trans Plasma Sci* v 16 n 2 Apr 1988 p 264-269.

**Applications** See Also SPECTRUM ANALYZERS—Components.

**075521 MAGNETICALLY TUNED MICROWAVE OSCILLATOR USING THE YIG FILM AND ITS APPLICATIONS.** Based on the fact that the magneto-static mode in a YIG thin film depends on the direction of a dc magnetic field, a frequency-controllable oscillator is proposed. First, the dispersion and delay characteristics are analyzed theoretically for the magnetostatic wave in a YIG thin film magnetized in an arbitrary angle. Next, on both sides of a YIG thin film with a thickness of 13.6  $\mu\text{m}$  and a size of  $5 \times 15 \text{ mm}^2$ , ten metal strips are evaporated at a pitch of 1 mm. The filtering characteristics of this Bragg reflection reflection filter are then evaluated. Subsequently, this filter and an FET amplifier are combined to form an oscillator for 2 to 4 GHz. Measured results for the oscillation characteristics, output power and spectrum for different magnetic field directions are compared with theoretical results. Finally, as an application of this oscillator, a correlator is proposed and its operation is explained. (Edited author abstract). 8 Refs.

Tsutsumi, Makoto (Osaka Univ, Suita, Jpn). *Electron Commun Jpn Part 2* v 71 n 5 May 1988 p 33-39.

**Computer Aided Design** See Also SEMICONDUCTOR DIODES—Millimeter Waves.

**075522 PC PROGRAM CUTS OSCILLATOR DESIGN TIME.** Even at UHF frequencies, oscillator design is a trial-and-error process. Using a standard 'cookbook' model, the components are scaled to the desired values, and optimization is achieved by tuning the circuit. This requires hours of manual labor. The alternative method described in this article uses a negative-resistance model and a FORTRAN program for MS-DOS computers to accurately predict the performance of UHF oscillators. This program can dramatically reduce the time necessary to design and optimize these components. (Edited author abstract) 3 refs.

Belkerdidi, Madjid A. (Univ of Central Florida, Orlando, FL, USA); Shenfelt, Pher W. *Microwaves RF* v 27 n 3 Mar 1988 5p between p 101 and 108.

**Design** See Also INTEGRATED CIRCUITS, MONOLITHIC—Design.

**075523 DEVELOPMENT OF A COMPACT, HIGHLY RELIABLE Rb-3100 RUBIDIUM ATOMIC OSCILLATOR.** Rubidium atomic oscillator (Rb OSC), that is physically compact and exhibits excellent frequency stability, has become available for various applications as a secondary frequency standard. Compared to XL OSC, Rb OSC is more complex in construction and more expensive. Also, Rb OSC generally is dependent on the lifetime of the optical device, particularly Rb lamp. However, NEC has succeeded in developing a compact Rb OSC called the Rb-3100 oscillator. Along with the excellent frequency stability displayed by this oscillator, it is both reliable and durable enough to be used in various commercial applications. The MTBF of the Rb-3100 has been doubled, and the resistance to vibration and shock has been increased by 20 times as compared with NEC's conventional Rb OSC. Furthermore, the size of the Rb-3100 has been reduced to 1/8 and the cost has been reduced to 1/2 that of the conventional Rb OSC. (Edited author abstract) 3 refs.

Ishihara, Naoki (NEC Corp, Jpn); Oyama, Hitoshi. *NEC Res Dev* n 86 Jul 1987 p 37-44.

**075524 PRINCIPLES OF THE DESIGN OF OPTIMIZED BIPOLAR TRANSISTOR MICROWAVE SELF-EXCITED OSCILLATORS.** A system of three nonlinear algebraic equations are obtained, which describe the stationary mode of operation of a microwave transis-

tor self-excited oscillator, taking into account the actual nonlinearities of the current-voltage and charge-voltage characteristics of the bipolar transistor, the effect of automatic bias, and the mutual nonlinear effect of the input and output circuits. Optimization is carried out by the local method of direct search (rotating coordinates). The theoretical and experimental data for self-excited oscillators based on the 2T634A-2 and 2T640A-2 transistors, designed at frequencies of 4 GHz and 6.5 GHz, are found to be in satisfactory agreement, and methods for optimizing the circuit and constructional parameters to obtain maximum power into the useful load are determined. (Author abstract) 10 refs.

Ganzii, D.D.; Malyshev, V.A. *Radioelectron Commun Syst* v 30 n 5 1987 p 7-12.

**075525 OCTAVE BANDWIDTH VARACTOR-TUNED OSCILLATORS.** This paper describes the design of a new range of voltage-controlled oscillators covering octave bandwidths between 6 and 18 GHz. These oscillators are varactor-tuned and, as such, are inherently faster tuning and more efficient than YIG-tuned oscillators; the other advantages of the new VCOs are small size and low weight. These oscillators use a single control voltage for the tuning even though they use two varactors. 2 refs.

Kitchen, John (Plessey Microwave Electronics Ltd, Towcester, Engl). *Microwave J* v 30 n 5 May 1987 p 347-348, 350, 352-353.

**075526 15.6 GHz HBT MICROSTRIP OSCILLATOR.** This letter describes the design and performance of a Ku-band HBT oscillator. The circuit was implemented in microstrip on an alumina substrate. The device used was a fully self-aligned AlGaAs/GaAs HBT using side wall technology. An output power of +6.5 dbm was achieved at 15.6 GHz with a collector efficiency of 11%. The phase noise was -60 dbc/Hz at 10 kHz offset, which is comparable to that of a silicon bipolar oscillator, and 20 dB less than that for a GaAs FET oscillator at the same frequency band. (Edited author abstract) 6 refs.

Lesage, S.R. (NEC, Kawasaki, Jpn); Madhian, M.; Hayama, N.; Honjo, K. *Electron Lett* v 24 n 4 Feb 1988 p 230-232.

**075527 MICROWAVE SOURCES FOR DIGITAL RADIO.** Digital radio applications represent a rapidly growing area in communications technology. A key component in digital radio system design is the microwave local oscillator, which is used to up- and down-convert the digital signal. Important considerations in the design of these sources are performance criteria, frequency stabilization and mechanical requirements. Some test methods and two examples of digital radio local oscillators are discussed. (Author abstract) 3 refs.

Hwan, Eugene J. (Harris Corp, San Carlos, CA, USA); Brown, Robert E. *Microwave J* v 31 n 1 Jan 1988 p 151-152, 154-156.

**075528 GENERALIZED APPROACH TO THE DESIGN OF MICROWAVE OSCILLATORS.** A generalized two-port method for the design of microwave oscillators and the associated theory are proposed. The method overcomes the difficulties associated with one-port techniques, where the passive elements connected to the active device to obtain a negative-impedance one-port are often chosen empirically, constraining the design and sometimes making the prespecification of parameters impossible. Using the proposed method, both frequency and power output can be predicted. The main feature of this technique is that it allows the optimum performance to be obtained from the active device. This is achieved by means of a generalized substitution theorem, which is described and mathematically proven. A design example and experimental results are given for a 12-GHz MESFET oscillator. The experimental results were found



to be within 9% of the predicted values for both frequency and power, without any experimental adjustment. 24 refs.

Xuan, Yongnan (Univ of Leeds, Engl); Snowden, Christopher M. *IEEE Trans Microwave Theory Tech* v MTT-35 n 12 Dec 1987, 1987 MTT-S Int Microwave Symp, Las Vegas, NV, USA, Jun 9-11 1987 p 1340-1347.

**075529 COLLOQUIUM ON ELECTRONICALLY TUNABLE MICROWAVE OSCILLATORS.** This colloquium proceeding contains six papers. Topics included are: broad band varactor turning of M.I.C. oscillators; wideband voltage controlled oscillators (VCOs) with good linearity; the design and realization of fully monolithic GaAs VCOs; the design and performance of an integrated Y16-Oscillator-Filter; the design of a multi-frequency I-Band source using a phase loaded VCO; and the controlled tuning of microwave VCOs for synthesizer applications. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11317 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig* n 1987/2, Colloq on Electr Tunable Microwave Oscillators, London, Engl Jan 7 1987. Publ by IEE, London, Engl var pagings.

## Efficiency

**075530 HIGH-PEAK POWER  $K_A$ -BAND GYROTRON OSCILLATOR EXPERIMENTS WITH SLOTTED AND UNSLOTTED CAVITIES.** A  $K_A$ -band gyrotron oscillator powered by a compact pulsed-line accelerator has been operated using oscillator cavities with and without axial slots. The oscillator was operated at high voltage (approx. 900 keV) and high current (approx. 500 A) in the approximate frequency range of 20-50 GHz. The use of axial slots has been shown to suppress low-starting-current whispering-gallery modes, in particular, modes of the  $TE_{m2}$  type, allowing stable operation in a linearly polarized  $TE_{13}$  mode. A peak power of 35 MW has been observed at 6% efficiency. 11 refs.

Gold, S.H. (US Naval Research Lab, Washington, DC, USA); Filiflet, A.W.; Manheimer, W.M.; McCowan, R.B.; Lee, R.C.; Granatstein, V.L.; Hardesty, D.L.; Kinkad, A.K.; Suci, M. *IEEE Trans Plasma Sci* v 16 n 2 Apr 1988 p 142-148.

## Fabrication

**075531 70 GHz INTEGRATED SILICON OSCILLATOR.** Planar oscillators on highly insulating silicon substrate with a disc resonator were fabricated. The active element was an IMPATT diode made from Si MBE material. A maximum cw output power of 200 mw with an efficiency of 4.5 percent at 73 GHz has been obtained. (Author abstract). 7 Refs.

Buechler, J. (Technische Univ Muenchen, Munich, West Ger); Kasper, E.; Luy, J.F.; Russer, P.; Strohm, K.M. *Electron Lett* v 24 n 15 Jul 21 1988 p 977-978.

## Millimeter Waves

**075532 OSCILLATOR PRIMING AND PREOSCILLATION NOISE IN A GYROTRON.** Phase control is achieved in a pulsed gyrotron oscillator both by applying an external priming signal directly to the oscillator and by applying the signal to a prebunching cavity. A pulse-to-pulse phase jitter of greater than  $2.5^\circ$  is achieved in the gyrotron at drive-to-oscillator power ratios of  $-36.6$  dB (drive signal-to-noise power ratio of 36 dB) in the direct injection case and  $-71$  dB (drive signal-to-noise power ratio of 22 dB) in the prebunched case. A lumped-element theory is compared to the experimental results. The theoretical description seems valid when the drive frequency is within about 5 MHz of that of the oscillator. Preoscillation noise in the gyrotron is about 10  $\mu$ W, larger than expected from either shot noise or thermal noise but in the vicinity of spontaneous cyclotron emission. Convective radio-frequency noise growth is investigated. No evidence of the electrostatic cyclotron

instability was seen. All growth observed is attributed to the gyrokystron amplification mechanism. However the noise growth per unit length is not as large as that of a narrow-band drive signal. 22 refs.

McCurdy, Alan H. (US Naval Research Lab, Washington, DC, USA); Armstrong, Carter M. *IEEE Trans Microwave Theory Tech* v 36 n 5 May 1988 p 891-901.

## Optimization

**075533 MODELISATION ET REALISATION D'OSCILLATEURS ATT DE FORT PUISSANCE DANS LA FENETRE DES 94 GHz EN REGIME D'OSCILLATIONS CONTINUES.** [Modeling and Implementation of CW High Power ATT Oscillators in the 94 GHz Window.] This paper is to present the main results of both a theoretical and experimental study concerning CW high power and high efficiency oscillators in the 94 GHz window using flat doping profile silicon IMPATT diodes. Firstly, the IMPATT oscillator model is presented. Then the main results of the technological parameters optimization yields the optimum devices. Lastly, the theoretical predictions and experimental findings obtained from diodes made by Thomson DSG are compared. (Author abstract). 14 Refs. In French.

Dalle, Christophe (Univ de Lille, Villeneuve-d'Ascq, Fr); Lleti, Georges; Goral, Didier; Rolland, Paul-Alain. *Ann Telecommun* v 43 n 5-6 May-Jun 1988 p 287-298.

## Performance

**075534 DIELECTRIC RESONATORS FOR MICROWAVE INTEGRATED OSCILLATORS.** Dielectric resonators can be used to stabilize the frequency of the output signal of microwave integrated oscillators. Oscillators of this kind will be widely used in the near future in microwave receivers for satellite-television broadcasts. The required high Q-factor, low temperature-dependence and small dimensions of dielectric resonators only became feasible with the availability of mixed ceramics of  $Ba_2Ti_9O_{20}$  and  $BaTi_4O_9$  or  $TiO_2$ . These materials can be evaluated for their usefulness by generating microwave resonances in cylindrical samples and measuring the frequency spectra. In practice, dielectric resonators are disks. They are mounted in a metal case and can be mechanically tuned to the required frequency. The resonators have a small positive temperature coefficient to compensate for the negative temperature coefficients of other elements in the oscillator circuit. A locus for the impedance of coupling line, resonator and load of the active element in the oscillator circuit as a function of oscillation frequency can be drawn on the Smith chart. The intersection of this locus with the line for the input impedance of the active element gives the operating point. The position of the operating point may be stable or unstable. The oscillator circuits are designed for operation with reaction-type, transmission-type, reflection-type or feedback resonators. Stable oscillator circuits have been designed for transponders used in radiosondes. The use of dielectric resonators in oscillators for direct frequency synthesizers has also been investigated. (Author abstract) 15 refs.

Lutke, G. (Philips GmbH Apparatefabrik Krefeld); Hennings, D. *Philips Tech Rev* v 43 n 1-2 Dec 1986 p 35-46.

**075535 BROAD TUNING RANGE VCOs FOR MICROWAVE SYSTEMS.** VCOs are important components in such microwave applications as local oscillators in frequency agile radars, instrumentation, missile seeker heads and other ESM/ECM systems where rugged units are required to operate in hostile environments. The widest tuning ranges are needed for EW in particular. The system engineer who requires a wideband electronically turned oscillator (ETO) will need to compare the relative advantages and disadvantages of the available oscillator types. The important parameters include linearity, modulation rate, noise and temperature stability, along with size, mass and total power consumption. Performance trade offs and some miniaturised oscillators are discussed. 2 refs.

Parkinson, Graham (Ferranti). *Electron Eng (London)* v 59 n 730 Oct 1987 p 85, 89-90, 93-94.

**075536 COMPARISON OF THE ENERGY EFFICIENCY OF MULTIDIODE MICROWAVE OSCILLATORS.** One way of increasing the output power of radioelectronic devices is to combine the powers of individual sources in a common load. This approach finds particularly extensive application at microwave frequencies where the development of high-power active elements (AE) encounters several difficulties (primarily ensuring reliable cooling). The design of combiner devices is based on utilization of equivalent circuits whose complexity and ramification rise sharply as the number of sources goes up. If we consider only the most desirable case from the practical viewpoint, where the active elements employed are identical, the design of the complete circuit of a device may be simplified to design of a reduced circuit with a single energy source. An appropriate analysis is presented. 2 Refs.

Bovsunovskii, A.Yu.; Tkachenko, L.A. *Radioelectron Commun Syst* v 30 n 10 1987 p 92-94.

**075537 HIGH-PERFORMANCE GAAS MMIC OSCILLATORS.** A number of monolithic single-ended and push-pull oscillator chips were developed for C-band through Ku-band applications. The chips were used to build both dielectric resonator oscillators and voltage-controlled oscillators in these frequency bands. These monolithic microwave ICs (MMICs) also have an integrated buffer amplifier at the oscillator output to provide better load isolation and power output stability. The oscillators demonstrated performance similar to conventional hybrid circuitry; however, the MMIC provided circuit simplicity with improved reliability, decreased size, and reduced manufacturing cost. 5 refs.

Moghe, Sanjay B. (Pacific Monolithics Inc, Sunnyvale, CA, USA); Holden, Thomas J. *IEEE Trans Microwave Theory Tech* v MTT-35 n 12 Dec 1987, 1987 MTT-S Int Microwave Symp, Las Vegas, NV, USA, Jun 9-11 1987 p 1283-1287.

## Selection

**075538 LOCAL OSCILLATOR SELECTION FOR DIGITAL SATELLITE COMMUNICATIONS.** A microwave local oscillator (LO) subsystem is one of the most costly subsystems used in these stations. Dielectric resonator oscillator (DRO) technology, crystal oscillator-multiplier technology, and microwave device technology have made a number of different LO choices available to the system designer. A comparative study of different LO designs and their suitability for digital communications is presented. A step-by-step procedure is given for specifying the LO phase noise, which is the most important LO specification. 3 Refs.

Kumar, Surinder (Univ of Saskatchewan, Saskatoon, Sask, Can). *Microwave J* v 31 n 7 Jul 1988 p 129-135.

## Space Charge

**075539 ALLOWING FOR THE INFLUENCE OF SPACE CHARGE ON THE IMPEDANCE CHARACTERISTICS OF AN IMPATT DIODE IN DESIGNING MULTIDIODE MICROWAVE OSCILLATORS.** A promising way of combining the powers of individual solid-state microwave radiation sources is the method of combining power at the chip level. This involves the series connection into the resonant system of a multidiode oscillator of solid-state sources of microwave radiation in caseless configuration. This not only provides the possibility of 10% summation of the powers of the individual sources but also improves the noise characteristics of oscillators, all other conditions being equal. A comparison has been made of such an approach with a multidiode IMPATT oscillator using varicap tuning (and containing an arbitrary number of IMPATT diodes and varicaps in caseless configuration, connected in series into the resonant system of the oscillator). The IMPATT diode impedance characteristics obtained elsewhere were used without allowance for the influence of space charge; they



were reduced to a given equation. 5 Refs.

Kashtanov, S.F. *Radioelectron Commun Syst* v 30 n 10 1987 p 86-88.

## Stability

**075540 STABILIZING THE FREQUENCY OF DIODE MICROWAVE OSCILLATORS.** Relationships have been obtained permitting targeted selection of the structure of stabilized diode microwave oscillators and optimization of their parameters. A generalized optimal-adjustment algorithm is proposed. A method for oscillator synthesis is presented. (Author abstract). 5 Refs.

Machusskii, E.A. *Radioelectron Commun Syst* v 30 n 10 1987 p 25-31.

**075541 FREQUENCY STABILITY OF L-BAND, TWO-PORT DIELECTRIC RESONATOR OSCILLATORS.** Dielectric resonator oscillators operating at 1.5 GHz and 2.0 GHz were evaluated and show state-of-the-art, close-to-carrier phase noise performance. The oscillators are based on a two-port resonator design incorporated into a basic feedback-loop oscillator configuration. Typically, at 1-kHz carrier offset frequency the single-sideband phase noise levels were -130 dBc/Hz and -120 dBc/Hz for the 1.5-GHz and 2.0-GHz oscillators, respectively. Vibration sensitivity was also investigated and the resonators show fractional frequency changes per g in the range of  $10^{-7}$  to  $10^{-9}$  for the 1.5-GHz and 2.0-GHz designs. Measurements were also performed to characterize both the static and dynamic temperature sensitivities of the 2.0-GHz design. The static temperature coefficient was found to be approximately -1.40 ppm/°C, while the dynamic temperature coefficient was nominally -3000 ppm/°C/s, at 27.5°C. 12 refs.

Loboda, Mark J. (Raytheon Co, Lexington, MA, USA); Parker, Thomas E.; Montress, Gary K. *IEEE Trans Microwave Theory Tech* v MTT-35 n 12 Dec 1987, 1987 MTT-S Int Microwave Symp, Las Vegas, NV, USA, Jun 9-11 1987 p 1334-1339.

## Synchronization

**075542 SYNCHRONIZATION OF A SOLID-STATE MICROWAVE OSCILLATOR WHICH OPERATES SIMULTANEOUSLY IN THE REFLECTION AND TRANSMISSION MODES.** Differences between the power spectra at the two outputs of a microwave oscillator are explained qualitatively. Results of an experimental investigation of the synchronization of millimeter-wave Gunn diode oscillators with quasi-optical resonant circuits are given. (Author abstract) 5 refs.

Andreyev, V.S.; Borodkin, A.I.; Bulgakov, B.M.; Svet, I.V. *Sov J Commun Technol Electron* v 32 n 6 Jun 1987 p 1-6.

**075543 SYNCHRONIZED SELF-EXCITED OSCILLATOR USING POWER KLYSTRON.** The self-excited oscillator, which is implemented by a power klystron, is synchronized by an external low-power microwave oscillator, which substantially increases the frequency stability of the output signal. For a Q of the synchronizing resonator in the feedback loop of 500, a ratio of klystron input power to synchronizing oscillator power of 31.2, and an output pulse power of 9 Mw, the capture bandwidth is 600 kHz. (Author abstract) 2 refs.

Beloglazov, V.I.; Kushnir, V.A.; Sdobnova, L.N.; Zavada, L.M. *Instrum Exp Tech* v 30 n 5 Pt 1 Sep-Oct 1987 p 1125-1126.

## Theory

**075544 ANALYSIS OF LONG-TERM FREQUENCY DRIFT IN FET OSCILLATORS.** The authors analyze the long-term frequency drift observed in 11-GHz GaAs FET dielectric resonator oscillators. The analysis is based on device modeling. It is found that the dominant contributor to the long-term frequency drift is the gate-to-source channel capacitance of the GaAs FET. Results agree with the trends observed on dielectric

resonator oscillators, and good correlation between theory and measured data has been achieved. The observations are general and applicable to all oscillators with GaAs FETs as active devices. 5 refs.

Agarwal, Krishna K. (Rockwell Int Corp, Dallas, TX, USA); Ho, Ching. *IEEE Trans Microwave Theory Tech* v MTT-35 n 12 Dec 1987, 1987 MTT-S Int Microwave Symp, Las Vegas, NV, USA, Jun 9-11 1987 p 1328-1333.

## Transients

**075545 IMPROVED TRANSIENT CHARACTERIZATION OF THREE TERMINAL MICROWAVE OSCILLATORS.** This paper gives an easy and powerful method for the transient analysis of microwave oscillators that use three terminal active devices such as FET or bipolar transistors. Nonlinearities of active devices are assumed to be described by their nonlinear transfer functions at the fundamental. Fast computer simulations of large signal operation, transient oscillations and nonlinear time constants rigorously define the actual quality performance. (Author abstract) 3 refs.

Mediavilla, A. (Univ Cantabria Santander, Santander, Spain); Tazon, A.; Garcia, J.L. *Int J Electron* v 63 n 4 Oct 1987 p 533-540.

**075546 TRANSIENTS IN A MILLIMETER WAVELENGTH SURFACE-WAVE OSCILLATOR.** A millimeter wavelength, relativistic surface-wave oscillator (RSWO), operating in the short-pulse (approximately 5 ns) mode, is analyzed theoretically and experimentally. The characteristics of the device are investigated as functions of the beam current, the length and the period of the slow-wave structure, and of its input and output boundary conditions. The excitation of high-order modes is estimated. Theoretical and experimental results are compared. (Author abstract) 10 refs.

Afonin, A.M.; Vdovin, V.A.; Kanavets, V.I.; Poyezd, A.D.; Sokolov, S.A.; Cherepenin, V.A. *Sov J Commun Technol Electron* v 32 n 6 Jun 1987 p 6-13.

**075547 SIMULATION OF TRANSIENT BEHAVIOR IN A PULSE-LINE-DRIVEN GYROTRON OSCILLATOR.** Results are reported for a set of slow-time-scale single-mode and fast-time-scale single-mode and multimode simulations of the transient-mode excitation phenomena in a short-pulse high-peak-power Ka-band gyrotron oscillator experiment. Both the slow- and fast-time-scale single-mode simulations are generally in good agreement with each other and, within experimental uncertainties, with the experimental observations of the time dependence and magnetic-field dependence of 35-GHz emission in the TE<sub>62</sub> mode. However, the multimode simulations suggest the presence of mode suppression, mode beating, and other nonlinear multimode phenomena that could not easily be observed in the experiment, and generally agree less well with the experimental measurements than the single-mode simulations. The multimode simulations also suggest that steady-state behavior may not be obtainable with the highly time-dependent voltage waveform employed in the experiment, and indicate the importance of carrying out future high-voltage gyrotron experiments with less highly transient voltage waveforms. 18 refs.

Lin, A.T. (Univ of California, Los Angeles, CA, USA); Lin, Chih-Chien; Yang, Z.H.; Chu, K.R.; Fliflet, A.W.; Gold, Steven H. *IEEE Trans Plasma Sci* v 16 n 2 Apr 1988 p 135-141.

## Vibrations

**075548 DESIGN A DRO FOR AIRBORNE APPLICATIONS.** Vibration-induced phase noise and size must be minimized to enhance the effectiveness of dielectric resonator oscillators (DROs) used in airborne applications. If these oscillators are designed for vibration, they can be used aboard airborne platforms with surprisingly good results. One of the keys is to maintain good mechanical integrity throughout the design. The design stages of airborne DROs are presented.

Talwar, A.K. (American Nucleonics Corp, Westlake Village, CA, USA); Poole, W.E. Jr.; Steinkolk, R.B. *Microwaves RF* v 27 n 4 Apr 1988 p 123-124, 126-127.

## OSCILLATORS, PARAMETRIC See Also ELECTRIC MOTORS, LINEAR.

## Modulation

**075549 INVESTIGATION OF RANDOM MODULATION OF THE OSCILLATIONS OF A GENERATOR WITH AN INERTIAL NONLINEARITY UNDER PARAMETRIC EXTERNAL ACTION.** Random oscillatory modes often appear in physically diverse dynamic systems. Such motions can be described quantitatively using the following characteristics: the spectra and the correlation functions associated with them, Lyapunov indicators, Kolmogorov's metrical entropy, and attractors of different dimension. Significant amounts of computer time are used to determine these characteristics from the experimental data. It is suggested that the threshold of synchronization, measured experimentally in real time, can be used as a quantitative characteristic and criterion of randomness for self-excited oscillatory systems. The relationship between the synchronization threshold and Kolmogorov's entropy was determined based on numerical experiments with a number of systems. This paper is devoted to an experimental study of the random modulation of oscillations in a generator with an inertial nonlinearity under parametric external action, leading to modulation of the gain of the active element. The synchronization threshold is used as one of the characteristics of the degree of randomness. 7 refs.

Bezayeva, L.G.; Kaptsov, L.N.; Landa, P.S. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 169-171.

## Synchronization

**075550 SYNCHRONOUSLY PUMPED OPTICAL PARAMETRIC OSCILLATION IN BETA-BARIUM BORATE.** Optical parametric oscillation in beta-barium borate has been demonstrated using synchronous pumping by the frequency doubled output train from an actively mode-locked and Q-switched Nd:YAG laser. The parametric oscillator converts up to about 30% of the pump train to produce broadly tunable pulses (0.68 to 2.4 μm) of about 75 ps duration, with peak idler powers of up to about 1.6 Mw. The tuning range has been extended up to 0.53 μm by frequency doubling the idler output with up to about 3% efficiency. (Author abstract). 13 Refs.

Bromley, L.J. (Univ of Southampton, Southampton, Engl); Guy, A.; Hanna, D.C. *Opt Commun* v 67 n 4 Jul 15 1988 p 316-320.

## OSCILLATORS, RELAXATION See Also ELECTRIC NETWORKS, NONLINEAR—Analysis; OPTICAL COMMUNICATION EQUIPMENT.

## Analysis

**075551 SINGULAR PERTURBATION APPLIED TO THE RELAXATION OSCILLATIONS OF THE VAN DER POL OSCILLATOR.** Using a singular perturbation technique, the non-sinusoidal (relaxation) oscillations of the Van der Pol nonlinear oscillator are investigated. For high frequency and large transconductance and mutual inductance, a small parameter  $\epsilon$  is found to be the multiplication factor to the highest order term in the nonlinear equation. When  $\epsilon \rightarrow 0$  the equation and its solution become singular. The oscillation and its period can be calculated by proper matching at the voltage jump where the singularity occurs. The method is also applicable to relaxation problems of other nonlinear oscillators. (Author abstract) 4 refs.

Wang, Yen-Chu (Howard Univ, Washington, DC, USA). *Int J Electron* v 63 n 4 Oct 1987 p 489-498.



**OSCILLATORS, SOLID STATE** See Also LASERS, SOLID STATE—Tuning; MICROWAVE DEVICES—Millimeter Waves; OSCILLATORS, MICRO-WAVE—Synchronization.

**075552 PHASE REGENERATION CHARACTERISTIC OF A THREE-MODE OSCILLATOR WITH SECOND AND THIRD HARMONIC RESONATORS.** This paper considers the three-mode oscillator which is composed of the resonators for the fundamental, second and third harmonic frequencies, and a negative resistor. It discusses the phase regeneration of the oscillator when an external signal with frequency equal to the second harmonic is injected. A three-mode oscillator is constructed which oscillates at the fundamental frequency of 3.5 MHz. (Edited author abstract) 9 refs.

Umeda, Hiroyuki (Fukui Univ, Fukui, Jpn). *Electron Commun Jpn Part 1* v 70 n 10 Oct 1987 p 107-116.

**075553 INVESTIGATION OF THE KEYING MODE OF A TRANSISTOR OSCILLATOR CONTAINING A PARALLEL SHAPING LINE.** A keyed transistor oscillator is investigated in which the mean-shaped collector voltage is formed by a quarter-wavelength short-circuited line. Energy characteristics and generalized circuit parameters are determined at high frequencies, at which the collector capacitance smears out the fronts of the collector voltage considerably. (Author abstract) 7 refs.

Borisov, V.A.; Voronovich, V.V. *Sov J Commun Technol Electron* v 31 n 12 Dec 1986 p 136-143.

## Analysis

**075554 INFLUENCE OF TRANSIT-TIME EFFECTS ON THE OPTIMUM DESIGN AND MAXIMUM OSCILLATION FREQUENCY OF QUANTUM WELL OSCILLATORS.** A small-signal analysis of quantum-well oscillators is presented. The analysis includes the transit-time effects associated with a depleted spacer layer outside the quantum well. These transit-time effects are found to dominate device characteristics and to lead to dramatic increases in achievable negative resistance. Closed-form expressions are derived for specific negative resistance and cutoff frequency, and a universal curve relating maximum transit-time negative resistance, quantum-well current-voltage characteristics, and frequency is found. Design considerations to maximize the oscillation frequency threshold are discussed. The analysis also shows that the effective limit on the maximum oscillation frequency of practical quantum-well oscillators is determined by a combination of impedance matching constraints and minimum-achievable contact resistance. 37 refs.

Kesan, Vijay P. (Univ of Texas, Austin, TX, USA); Neikirk, Dean P.; Blakey, Peter A.; Streetman, Ben G.; Linton, Thomas D. Jr. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 405-413.

## Design

**075555 DESIGN OF TUNABLE SOLID-STATE OSCILLATORS.** Algorithms are considered which have formed the basis for an applications-program package developed for parametric synthesis of tunable oscillators. The distinguishing feature of these algorithms is calculation of the initial approximation by means of an original algorithm for the parametric synthesis of a nontunable oscillator. 2 refs.

Kotserzhinskii, B.A. *Radioelectron Commun Syst* v 30 n 10 1987 p 108-110.

**Fabrication** See Also ACOUSTIC SURFACE WAVE DEVICES—Fabrication; RESONATORS—Thin Films.

**075556 30-MHZ LOW-JITTER HIGH-LINEARITY CMOS VOLTAGE-CONTROLLED OSCILLATOR.** A fully monolithic voltage-controlled oscillator (VCO) with an on-chip timing capacitor and a maximum oscillation frequency of 30 MHz is reported. Using a novel on-chip servo loop, the VCO displays less than 0.17% nonlinearity

in its voltage-frequency transfer function from 1 to 15 MHz without trimming. An improved circuit topology that provides a large swing on the timing capacitor allows the VCO to obtain a cycle-to-cycle jitter of less than 100 ppm. The circuit operates on a 5-V supply with a die size of 104 mil  $\times$  154 mil. 6 refs.

Wakayama, Myles H. (Univ of California, Los Angeles, CA, USA); Abidi, Asad A. *IEEE J Solid State Circuits* v SC-22 n 6 Dec 1987, 1987 Int Solid-State Circuits Conf (ISSCC), New York, NY, USA, Feb 1987 p 1074-1081.

**Mathematical Models** See Also SIGNAL RECEIVERS—Mathematical Models.

**075557 DEVELOPMENT OF A NEW THREE-PHASE TRIANGULAR WAVE OSCILLATOR.** The present paper is another one in a series of papers on the development of models of precisely stabilized three-phase oscillators. A new model of a three-phase triangular wave oscillator is developed by considering its expected analogy to previously suggested models of sinusoidal and triangular wave oscillators in two and three phases. The development is validated by solving the nonlinear model equations on a digital computer. The expected advantages of the new model and its envisaged applications are considered in the conclusion section. The paper possesses a further value in serving as a tutorial review in the field of precisely stabilized oscillators. The review is carried out with the aid of a relatively new concept of 'invariants' associated with the damping stabilization forces in the oscillator systems. (Author abstract) 16 refs.

Kaplan, B.Z. (Ben Gurion Univ of the Negev, Beer Sheva, Isr); Yardeni, N.D. *Comput Methods Appl Mech Eng* v 63 n 3 Aug 1987 p 305-312.

**075558 INVESTIGATION OF THE CHAOTIC DYNAMICS OF A RING-TYPE SELF-EXCITED OSCILLATOR WITH AN ASYMMETRIC CHARACTERISTIC OF THE NONLINEAR ELEMENT.** The stochastic dynamics of a ring-type self-excited oscillator, consisting of RC and RLC filters and an inertialess nonlinear amplifier, is investigated. The characteristics of the appearance and evolution of strange attractors (SA) are studied experimentally. The special features of the mathematical model, related to the nonlinear element asymmetry, are analyzed. It is shown that a model with a symmetric characteristic is structurally unstable with respect to asymmetric perturbations. Experimental and calculated diagrams of the oscillatory modes of operation in the oscillator are given. (Author abstract) 12 refs.

Dmitriyev, A.S.; Starkov, S.O. *Sov J Commun Technol Electron* v 32 n 4 Apr 1987 p 60-69.

**075559 ANALYSIS OF MOS TRANSFORMER-COUPLED OSCILLATORS.** Techniques for estimating the steady-state voltage amplitudes of MOS transformer-coupled oscillators are presented. A noniterative procedure based on equations and graphical data is used and no simulations are required. By appropriate normalization of variables the graphical data can be applied to arbitrary transistor sizes and bias conditions. Both single-ended and source-coupled configurations are analyzed. A simple analysis is presented for the squegging phenomenon which exists in single-ended stages. This analysis is used to determine the condition for avoiding squegging. Comparisons are made with SPICE2 simulations and good agreement is achieved over a wide range of operation. 6 refs.

Mayaram, Kartikeya (Univ of California, Berkeley, CA, USA); Pederson, Donald O. *IEEE J Solid State Circuits* v SC-22 n 6 Dec 1987, 1987 Int Solid-State Circuits Conf (ISSCC), New York, NY, USA, Feb 1987 p 1155-1162.

**Millimeter Waves** See Also RESONATORS, CAVITY—Applications.

**075560 SOLID-STATE OSCILLATORS WITH QUASIOPTICAL RESONANT SYSTEMS.** Experience in the development and investigation of solid-state oscillators using open cavities is generalized. Oscillator designs

are proposed together with equivalent circuits for tuned and oscillatory systems that take into account coupling with free space. (Author abstract). 30 Refs.

Kotserzhinskii, B.A.; Machusskii, E.A.; Pershin, N.A.; Taranenko, V.P. *Radioelectron Commun Syst* v 30 n 10 1987 p 11-20.

## Spectrum Analysis

**075561 ON THE SPECTRUM OF PULSED OSCILLATIONS OF INTERCOUPLED SELF-EXCITED OSCILLATORS.** The radio oscillation spectrum of an ensemble of many intercoupled single-loop self-excited oscillators, operating in the pulse regime for the condition that the self-excited oscillators are coupled at the fundamental tone, is analyzed. Experimental results are given. (Author abstract) 9 refs.

Dvornikov, A.A.; Prokof'yev, V.A.; Utkin, G.M. *Sov J Commun Technol Electron* v 32 n 7 Jul 1987 p 115-118.

**Ultrasonic Applications** See SENSORS—Ultrasonic Applications.

## Vibrations

**075562 MODE SELECTION IN A MULTIMODE SAW OSCILLATOR USING FM CHIRP MIXING SIGNAL INJECTION.** Mode-selection control of a multimode surface-acoustic-wave (SAW) oscillator has been obtained using SAW linear FM chirp signal injection. The prototype 60-100-MHz SAW oscillator design employed a single-phase unidirectional transducer (SPUDT) low-loss comb filter in the feedback loop, with minimum insertion loss of  $\approx 3.7$  dB. Mode selection was achieved using an injection signal derived from the mixed output of two 27.5-52.5-MHz up- and down-chirp SAW filters. Mode switching times of  $\leq 2$   $\mu$ s were obtained. The device could be useful as a local oscillator on frequency-agile radars, where hopping is required over a moderate number of frequencies. 11 refs.

Saw, C.B. (McMaster Univ, Hamilton, Ont, Can); Smith, Peter M.; Edmonson, Peter J.; Campbell, C.K. *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 May 1988 p 390-395.

## OSCILLATORS, TUNNEL DIODE

### Analysis

**075563 OPTICAL MODEL OF DOUBLE-BARRIER RESONANT TUNNELING OSCILLATORS.** An optical model is applied to a quantum well resonant tunneling diode, in which the effect of scattering can be taken into account by introducing an absorption coefficient  $\alpha$ . In the limit of an opaque barrier the transient time and peak-to-valley current ratio are determined by  $\alpha$  and the width of the quantum well. The numerical estimates of these quantities are shown to be consistent with the experimental values obtained by Sollner and co-workers. (Author abstract) 5 refs.

Hu, Yuming (Univ of California, Los Angeles, CA, USA). *J Phys C Solid State Phys* v 21 n 2 Jan 20 1988 p L23-L29.

## OSCILLOGRAPHS

**075564 DIGITAL STORAGE OSCILLOSCOPE WITH 100 MSAMPLES/S.** While digital storage oscilloscopes are increasingly being preferred, their high cost has compelled many engineers to manage with an analogue instrument. However, a new dual-channel oscilloscope eliminates this remaining disadvantage while still incorporating virtually all the features of the expensive models.

Burgess, G. *Electron Wireless World* v 94 n 1626 Apr 1988 p 366-369.



**Applications** See WAVEFORM ANALYSIS—Equipment.

**Errors** See MEASUREMENT ERRORS—Analysis.

**Medical Applications** See BIOMEDICAL EQUIPMENT—Testing.

**OSCILLOSCOPES, CATHODE RAY** See Also CAMERAS—Applications; ELECTRIC MEASUREMENTS—Voltage; OPTICAL INSTRUMENTS; PROBES—Microwaves.

**075565 DSOs CAN MAKE TESTING EASIER.** Digital storage oscilloscopes (DSOs) are becoming the best choice for some test and measurement applications. The types of waveforms being dealt with determine whether or not a particular application is better served by a DSO. Waveforms difficult to see on conventional scopes can be digitally saved with the DSO to produce clear, stable displays. The annoying display flicker common when viewing low-repetition index marks and strobing also is eliminated. Other important advantages like waveform digitizing and storage, peak detection sampling, and built-in-processing are described.

McMullen, Kim (Tektronix Inc, Beaverton, OR, USA). *Eval Eng v 26 n 11 Nov 1987 p 60, 63-65.*

**075566 PRECISION DIGITAL OSCILLOSCOPES AND WAVEFORM RECORDERS.** The author discusses a precision instrument family consisting of five digitizing oscilloscopes based on three waveform recorders and an analysis, display, and I/O section. He focuses on the HP 5183A waveform recorder, the precision digital trigger, the time base system, and the memory system. 2 refs.

Sorden, James L. *Hewlett Packard J v 39 n 1 Feb 1988 p 6-11, 14.*

**075567 WAVEFORM RECONSTRUCTION TECHNIQUES FOR PRECISION DIGITIZING OSCILLOSCOPES.** The maximum sample rate, dynamic performance, and reconstruction strategy of a digitizing oscilloscope determine its bandwidth. The dynamic performance specification determines the sampling accuracy near the Nyquist rate. Waveform reconstruction allows signals sampled near the Nyquist limit to be displayed with accuracy approaching the sampler-imposed limits. The reconstruction algorithm accuracy can be specified as a design parameter. Speed of operation, reconstruction filter impulse response length, and reconstruction accuracy are interrelated. Reconstruction is also useful when memory constraints dictate sampling slower than the minimum digitizer rate. A good reconstruction algorithm allows the user to take maximum advantage of the digitizing oscilloscope's memory by allowing sampling near the Nyquist limit. 1 ref.

Page, Richard W.; Foster, Allen S. *Hewlett Packard J v 39 n 1 Feb 1988 p 26-31.*

**075568 PRECISION DIGITIZING OSCILLOSCOPE WAVEFORM ANALYSIS, DISPLAY, AND INPUT/OUTPUT.** The author describes the HP 5180T/U, HP 5183T/U, and HP 5185T precision digitizing oscilloscopes, each consisting of a waveform recorder and an analysis, display, and I/O module. The waveform recorder is the HP 5180A, the HP 5183A, or the HP 5185A. The display is a 9-inch-diagonal 2048×2048-point addressable vector CRT display that generates high-resolution text and waveform images. System control is managed by a real-time multitasking operating system that simultaneously handles multiple processes such as keyboard entry, data analysis, and waveform display. A 6803 microprocessor manages all front-panel inputs including hardkey and data entry knob control firmware and scanning control for the touchscreen display. 4 refs.

Nichols, Douglas C. *Hewlett Packard J v 39 n 1 Feb 1988 p 53-64.*

**075569 ONE-GIGASAMPLE-PER-SECOND DIGITIZING OSCILLOSCOPE.** A brief description is given

of the HP 54111D oscilloscope. This instrument's high sampling rate makes it particularly useful for analyzing high-speed, one-shot occurrences. A blend of state-of-the-art designs was required to achieve this performance. (Edited author abstract)

Millard, Joe K. *Hewlett Packard J v 39 n 3 Jun 1988 p 58-59.*

## Applications

**075570 HARDWARE SYSTEM DESIGN FOR A VECTOR ANALYZER.** The HP 8980A Vector Analyzer is designed to measure instantaneous amplitude and phase of wideband RF and microwave signals by analyzing their I and Q components in the time domain. It is a fully programmable HP-IB (IEEE 488/IEC 625) instrument designed for R&D and production applications. The amplitude and phase of a signal can be analyzed visually by plotting the Q component versus the I component graphically in Cartesian coordinates. The amplitude is then represented by the distance from the center of the plot and the phase is represented simply by the angle thereon. The polar displays of vector network analyzers work on this same principle. 3 refs.

Naegeli, Andrew H.; Grau, Juan. *Hewlett Packard J v 38 n 11 Dec 1987 p 6-17.*

**075571 FIRMWARE SYSTEM DESIGN FOR A VECTOR ANALYZER.** The HP 8980A Vector Analyzer is an example of this substantial change in the importance of software in electronic instrumentation. It uses a 32-bit 68000 microprocessor for overall control, in addition to a keyboard processor, an HP-IB (IEEE 488/IEC 625) interface processor, and a CRT display processor. A half megabyte of software used is written in C and, where optimization for speed was critical, in assembly language.

Messenger, Brian S.; Fisher, Peter H.; Woods, Stanley P. *Hewlett Packard J v 38 n 11 Dec 1987 p 17-24.*

## Circuits

**075572 NEW KIND OF OSCILLOSCOPE FOR WIDEBAND SAMPLING.** A new kind of oscilloscope for digital and pulsed-rf testing is introduced, one that combines a wideband repetitive-sampling capability with a time-domain network analyzer. The 20-GHz HP 54120T is tailored for such work as characterizing very high-speed digital circuits and nonlinear microwave devices and tuning their computer-aided-design models; developing transmission-line designs for printed-circuit boards, computer backplanes, and hybrid integrated circuits; and analyzing data communications channels. The new sampling scope can analyze repetitive waveforms with rise times as short as 17.5 ps. Just as important for precision work, it is designed for very high transient response, measurement resolutions to 0.25 ps and 32  $\mu$ V, and virtually drift-free operation.

Sideris, George. *Electronics v 60 n 14 Jul 9 1987 p 72-74.*

**Components** See DATA CONVERSION, ANALOG TO DIGITAL; SIGNAL FILTERING AND PREDICTION—Digital Techniques.

## Computer Applications

**075573 DAS DSO ALS INTELLIGENTES MESSSYSTEM.** [Digital Storage Oscilloscope (DSO) as Intelligent Measurement System]. The combination of computer and oscilloscope furnishes two possibilities. These are: the integration of the computer in the oscilloscope or the measuring instrument in the computer. A computer-type oscilloscope is presented. It is pointed out why this is the most viable method to extend the applications of the DSO. In German.

Westenberger, Heinz. *Elektronik v 37 n 1 Jan 8 1988 p 83-84.*

**Design** See Also ELECTRONICS PACKAGING.

**075574 FRONT-END SIGNAL CONDITIONING FOR A HIGH-SPEED DIGITIZING OSCILLOSCOPE.** The design of the front-end signal conditioning stages of the HP 54111D oscilloscope is discussed. The design was particularly difficult because of the HP 54111D's 500-MHz required signal bandwidth. Key elements in the design are the attenuator, the switch assembly, the hybrid circuit upon which the attenuator is fabricated, and the preamplifier.

Bohley, Thomas K.; Mathews, Mark E.; Dove, Lewis R.; Millard, Joe K.; Bigelow, David W.; Skarke, Donald D. *Hewlett Packard J v 39 n 3 Jun 1988 p 67-69.*

## Digital Devices

**075575 DIGITAL STORAGE OSCILLOSCOPES.** Whether one uses them for single-shot storage, taking measurements, or troubleshooting, the latest digital storage oscilloscopes (DSO) provide a number of measurement features that can help you work faster and more accurately. The available DSOs now include models with 1-GHz bandwidths and digitizing rates to 1 G samples. (Edited author abstract)

Conner, Doug (EDN, Newton, MA, USA). *EDN v 32 n 21 Oct 15 1987 p 90-98, 100, 102.*

**Digital Readout** See Also WAVEFORM ANALYSIS—Automatic Testing.

**075576 AMPLITUDEAUFLÖSUNG UND -MESSFEHLER VON DIGITAL-OSZILLOSKOPEN.** [Amplitude Resolution and Measurement Errors of Digital Oscilloscopes]. The amplitude resolution of a digital oscilloscopes can be made equal to the theoretical resolution of the analog-to-digital converter only in the ideal case. The realistically attainable resolution depends on a multiplicity of factors which are discussed. In German. 2 refs.

Hancock, Johnie. *Elektronik v 36 n 25 Dec 11 1987 p 72-74, 76-78.*

**075577 DIGITAL SCOPES MAKING WAVES IN TEST, MEASUREMENT WORLDS.** Today's designer must deal with all kinds of circuitry - digital and analog - not to mention the inherent firmware and interface problems when he integrates all these into a system or product. During the past five years, digitizing oscilloscopes have evolved to respond to those needs. Because these instruments enhance the traditional tasks of an analog oscilloscope with microprocessor control, they can make significant contributions in all areas of electronic test and measurement. The power and versatility of the latest digitizing scopes can be seen by considering their role in such design and test areas as power supplies, analog circuits, digital circuits, and system integration. Triggering, pulse isolation, and worst-case delay measurements are discussed.

Schade, Sylvia (Hewlett Packard Co, Colorado Springs, CO, USA); Kushnir, Ray. *Electron Des v 36 n 14 Jun 19 1986 p 117-120, 122, 124.*

**075578 ZEITINTERVALL-MESSGENAUIGKEIT VON DIGITAL-OSZILLOSKOPEN.** [Measurement of Accuracy of Time Interval in Digital Oscilloscopes]. It is pointed out that the measurement accuracy associated with the acquisition of single pulses is higher in digital oscilloscopes than in analog storage oscilloscopes. It is limited only by the characteristics of the quartz crystal. 2 refs. In German.

Hancock, Johnie. *Elektronik v 37 n 1 Jan 8 1988 p 94-97.*

## Performance

**075579 DIGITAL SCOPES.** To make the engineer's job easier, a lot of emphasis is being placed on improving the fundamentals of waveform capture in digital scopes. Advances in charge-coupled devices (CCDs) and flash



converters are pushing analog-to-digital conversion speeds to 100 to 200 MHz, extending the usable bandwidth for single-shot measurements to 50 MHz or so. For repetitive signals, digital scopes with a 1-GHz bandwidth are now a reality, and special glitch detection circuitry today captures transient spikes beyond the limitations imposed by basic a-d converter speeds. Additional features are described.

Milne, Bob. *Electron Des* v 34 n 3 Feb 6 1986 p 98-102, 104, 106.

**075580 EVALUATING THE PERFORMANCE OF PULSE AND OSCILLOSCOPE MEASURING INSTRUMENTS BY THE ACCURACY OF INSTANTANEOUS SIGNAL MEASUREMENTS.** Metrological properties of pulse and oscilloscope measuring instruments (MI), such as cathode-ray tube (CRT) oscilloscopes, pulse generators, and instantaneous-value voltmeters, are regulated by GOST 8.009-84, GOST 8.256-77, GOST 22261-82, GOST 22737-77, and GOST 11113-82 standards. The basic standards (GOST 8.009-84 and GOST 8.256-77) establish the need for separate static and dynamic specifications for all MIs. These demands have been published as specific lists of MI parameters and values. The drawbacks seriously impede the improvement of the speed of response of measuring instruments. One of the possible ways to optimize the system of rated parameters and to reduce their number is to evaluate the performance of pulse and oscilloscope measuring instruments by their error of measuring (setting, in the case of pulse generators) instantaneous values of voltages. 4 refs.

Manevich, V.Z.; Khamadulin, E.F. *Meas Tech* v 30 n 2 Feb 1987 p 191-193.

**075581 OSCILLOSCOPE ARCHITECTURE: A CASE OF REVOLUTION RATHER THAN EVOLUTION.** The development of the Tektronix 11400 series of digitizing oscilloscopes is discussed. The radically new architecture of these instruments, which is based on three Intel microprocessors, is described. Their performance is examined.

Anon (Tektronix UK Ltd, Globe Park, Engl). *Electron Wireless World* v 94 n 1624 Feb 1988 p 156-158.

**075582 PORTABLE ANALOG SCOPE BARES SIGNALS HIDDEN EVEN FROM DIGITAL STORAGE UNITS.** Fleeting responses like aberrant signals, unseen jitter, the one-in-a-thousand switching fault, and the random glitch have often eluded design troubleshooters. Conventional scopes usually cannot reveal signals that occur too infrequently to sustain display-phosphor excitation. A new scope is reported which features a high visual writing rate, greater than 4 div/ns, due to the microchannel-plate (MCP) CRT that shows even the most fleeting signals. In addition to more revealing displays, it also has a bandwidth of 350 MHz and sweep rates of 500 ps/div.

Bristol, Rod (Tektronix Inc, Beaverton, OR, USA); Hillman, Alfred K. *Electron Des* v 33 n 7 Mar 20 1986 p 125-128, 130.

## Reviews

**075583 SPECIAL REPORT: DIGITAL SCOPES ARE SET TO CHALLENGE ANALOG UNITS.** Digital oscilloscopes are discussed and compared with their analog counterparts. Their new capabilities are emphasized, such as higher sampling speed, deeper acquisition memories, laser screen update rates, and improved user interfaces. However their higher prices, aliasing, control, and sequential sampling discourages potential users. A list of representative high-frequency digital oscilloscopes and their characteristics is finished.

Riezenman, Mike (Electronics, New York, NY, USA). *Electronics* v 61 n 6 Mar 17 1988 p 107-108, 111-112, 118.

**Sampling** See SIGNAL GENERATORS.

## OSMIUM AND ALLOYS

**Electrolytic Analysis** See PLATINUM AND ALLOYS—Electrolytic Analysis.

## Spectroscopic Analysis

**075584 DETERMINATION OF Os ISOTOPES AND Re/Os RATIOS USING AMS.** We report here results of recent determinations of osmium isotope ratios and rhenium/osmium ratios measured with AMS. Because Re forms negative atomic ions with a considerably lower efficiency than Os, Os isotopes can be determined with minimal isobaric interference at mass 187. Detection limits for AMS measurements of osmium are 20 ppb in chemically untreated samples and 0.01 ppb in samples where Os has been preconcentrated with a nickel sulfide method. The fact that Re and Os each form negative ions as oxides at a comparable rate has been used to determine Re/Os ratios in untreated meteorite samples. (Author abstract) 22 refs.

Teng, R.T.D. (Univ of Rochester, Rochester, NY, USA); Fehn, U.; Elmore, D.; Hemmick, T.K.; Kubik, P.W.; Gove, H.E. *Nucl Instrum Methods Phys Res Sect B* v B29 n 1-2 Nov II 1987, *Accel Mass Spectrom, Proc of the Fourth Int Symp, Niagara-on-the-Lake, Ont, Can, Apr 27-30 1987* p 281-285.

## OSMIUM COMPOUNDS

**Decomposition** See CATALYSTS—Materials.

**Synthesis** See Also ORGANOMETALLICS.

**075585 SYNTHESSES OF INTERLAMELLAR MONTMORILLONITEDIPHENYLPHOSPHINE T-RIOSMIUM CLUSTER COMPLEXES.** In our study, we chose the  $H_2O_3(CO)_{10}$  complex for anchoring on the support, since the cluster is an active isomerization catalyst and isomerization is an important transformation in organic chemistry. We report in this communication the synthesis and characterization of montmorillonite-diphenylphosphine- $H_2O_3(CO)_{10}$  (B) and  $H_2O_3(CO)_9$  (C) complexes for the first time. In addition, these complexes are examined in the alkene isomerization reactions. It is shown that catalyst B is inactive isomerization of hex-1-ene. This is ascribed to its coordinative saturation. Catalyst C is active in isomerization of hex-1-ene affording 76% of hex-2-ene compared which its homogeneous analogue  $H_2O_3(CO)_9PPh_3$  which gave poor yields due to its decomposition. This is another indication that anchored cluster complexes are more stable. 9 refs.

Choudary, B.M. (Regional Research Lab, Hyderabad, India); Ravikumar, K. *Appl Catal* v 35 n 1 Nov 16 1987 p 177-180.

## OSMIUM VANADIUM ALLOYS

### Phase Diagrams

**075586 OS-V (OSMIUM-VANADIUM) SYSTEM.** This review is the result of a literature search through March 1986. A preferred phase diagram is shown. Phase relationships, crystallography and thermodynamic properties are discussed. 9 Refs.

Smith, J.F. (Iowa State Univ, Ames, IA, USA). *J Alloy Phase Diagrams* v 4 n 2 May 1988 p 122-126.

## OSMOSIS

**075587 ELECTROKINETIC PHENOMENA AT THE IONIC SURFACTANT SOLUTION-AIR INTERFACE. ELECTROOSMOSIS ALONG A PLANE INTERFACE. EXPERIMENTAL METHODS.** The results of an experimental check of an earlier developed theory of a method of measuring the rate of electroosmosis along a plane solution-air interface are presented. Methods of experimental investigations based on the use of this method are discussed. To increase the accuracy of the experiment the position of the liquid-gas interface was

recorded with respect to the first indicator particles, as which poorly sedimenting particles of monodisperse polystyrene latex with a diameter of 1.27  $\mu m$  were used, visible in the field of view of the reading microscope. To avoid the error related to possible sedimentation of the indicator particles, this procedure was carried out both after pouring the investigated solution into the cell and after the end of the measurement. 3 refs.

Poberezhnyi, V.Ya.; Sotskova, T.Z.; Kul'skii, L.A. *Sov Surf Eng Appl Electrochem* n 6 1987 p 41-44.

**Electric Field Effects** See SEWAGE TREATMENT—Sludge Drying; SUGAR—Mass Transfer; SUSPENSIONS—Drying.

### Filters

**075588 SIMULTANEOUS ACTION OF HYDROSTATIC AND OSMOTIC PRESSURE GRADIENTS ON CELLOPHANE MEMBRANES.** Measurements were made of volume flows generated by the simultaneous application of hydrostatic and osmotic pressure gradients. When the osmotic pressure gradient across the membrane was maintained constant, there was a linear relationship between the observed flows and the applied hydrostatic pressure differences. Examination of the results using the asymmetric membrane model proposed by Lee, Baker and Lonsdale showed good agreement between calculated and observed flows. The solvent (sucrose) molecular radius and the potential causing the steric exclusion by the pore wall were calculated from the observed flows. (Edited author abstract) 19 refs.

Serrano, F. (Univ of Malaga, Malaga, Spain); Fernandez-Pineda, C. *J Non Equilib Thermodyn* v 13 n 2 1988 p 147-159.

**Phase Transitions** See MEMBRANES—Phase Equilibria.

**Pressure Measurement** See POLYMERS—Solutions.

**OSMOSIS, REVERSE** See Also DESALINATION—India; DESALINATION—Waste Heat Utilization; FOOD PRODUCTS—Fruit Juices; MEMBRANES; MEMBRANES—Applications; MEMBRANES—Performance; MEMBRANES—Ultrafiltration; SEAWATER—Analysis; SEPARATION; SOLUTIONS—Separation; SYNTHETIC FUELS—Processing; WATER FILTRATION—Equipment.

**075589 DEVELOPMENT OF WET-DRY REVERSIBLE REVERSE OSMOSIS MEMBRANES WITH HIGH PERFORMANCE FROM CELLULOSE ACETATE AND CELLULOSE TRIACETATE BLENDS.** Wet-dry reversible membranes were prepared by a two-step coagulation procedure. A cast film containing a blend of cellulose acetate and cellulose triacetate as polymers, dioxane and acetone as solvents and maleic acid and methanol as additives was immersed consecutively in two aqueous coagulation baths, the first bath being kept at 0°C and the second at 60°C. The effects of casting solution composition and coagulation conditions on reverse osmosis performance and membrane morphology were examined. Light transmission measurements and demixing experiments have been carried out to investigate phase separation. High performance membranes have been obtained with salt rejections of more than 99% and permeation rates in the range of 10-12 l/m<sup>2</sup> h. These desalination properties, combined with a good wet-dry reversibility, make our membranes superior to reverse osmosis membranes hitherto produced. (Edited author abstract) 23 refs.

Vasarhelyi, K. (Twente Univ of Technology, Enschede, Neth); Ronner, J.A.; Mulder, M.H.V.; Smolders, C.A. *Desalination* v 61 n 3 Oct 1987 p 211-235.

**075590 FLOW PATTERNS IN RADIAL FLOW HOLLOW FIBER REVERSE OSMOSIS SYSTEMS.** In the past, mathematical models describing the separation characteristics of radial flow hollow fiber reverse osmosis units have used ideal plug-flow models. Recently,



Soltanieh and Gill have developed a model based on the assumption of complete mixing on the shell side of these modules. The purpose of this study is to determine by independent experiments which flow model best described these units, and describe radial flow packed bed systems in general. Experimentally obtained tracer-response curves are compared to theoretical response curves based on the plug-flow and complete-mixed models. A theoretical model which is based on Darcy's law for time variable flow, the complete-mix time variable (CMTV) flow model, was found to fit the experimental data well. (Author abstract) 10 refs.

Gill, William N. (State Univ of New York at Buffalo, NY, USA); Matsumoto, Mark R.; Gill, Alison L.; Lee, Yong-Tack. *Desalination* v 68 n 1 Jan 1988 p 11-28.

**075591 SIGNIFICANCE OF COLOUR CHANGES IN SOME REVERSE OSMOSIS PERMEATORS.** The apparent irrelevance of color to reverse osmosis permeators is discussed in the light of accumulating evidence for the need to prevent light translucency in water retaining vessels to minimize biological growth. (Author abstract)

Walton, N.R.G. (Chemical Engineering & RO Consultant, Oxford, Engl). *Desalination* v 68 n 1 Jan 1988 p 29-33.

**075592 ANNEALING EFFECT OF CELLULOSE ACETATE MEMBRANES ON ETHANOL AND GLUCOSE REVERSE OSMOSIS SEPARATION.** Annealing profiles are determined for two sets of cellulose acetate membranes originating from two different casting solution compositions under different casting conditions. The two sets of membranes are characterized by two normal pore size distributions. Membranes exhibiting a narrower gap between the average pore radius of the two distributions yield a better reverse osmosis performance for the fractionation of glucose-ethanol aqueous solutions. (Author abstract) 10 refs.

de Pinho, Maria Norberta (Inst Superior Tecnico, Lisbon, Port). *Desalination* v 68 n 2-3 Mar 1988, Proc of the 5th Symp on Synth Membr in Sci and Ind, Tuebingen, West Ger, Sep 2-5 1986 p 211-221.

**Applications** See Also SEAWATER—Salt Removal; WASTEWATER—Treatment.

**075593 REMOVAL OF RADIONUCLIDES FROM LIQUID STREAMS BY REVERSE OSMOSIS.** Separation of radionuclides in trace concentrations by cellulose acetate membranes has been under investigation in this laboratory, and the behavior of some important radionuclides such as  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  under reverse osmosis has been reported earlier. The present work deals with a few other typical radionuclides such as  $^{60}\text{Co}$ ,  $^{103}\text{Ru}$  and  $^{131}\text{I}$  which are not fully amenable to conventional methods for their removal. Separation of these radionuclides from liquid streams by the reverse osmosis process was studied using a small reverse osmosis test cell. Various parameters like membrane porosity, applied pressure and feed activity levels were investigated. (Edited author abstract) 21 refs.

Deshmukh, Usha A. (BARC, Bombay, India); Ramachandran, V.; Misra, B.M. *Appl Radiat Isot* v 38 n 11 1987 p 971-974.

**075594 SEPARATION OF MIXTURES OF ORGANIC SUBSTANCES USING REVERSE OSMOSIS MEMBRANES.** A concentration of various aqueous and nonaqueous solutions by the reverse osmosis process is interesting from its energy saving nature. However, there is a barrier due to the osmotic pressure and it has been very difficult to overcome. In this work a membrane cascade system, which used an effective osmotic pressure difference, was developed to cope with this problem. For this purpose reverse osmosis separation data of aqueous ethanol and isopropanol solutions were obtained. (Edited author abstract). 2 Refs. In Japanese.

Kimura, Shoji; Tanimura, Shinobu; Nakao, Shin-ichi. *J Fac Eng Univ Tokyo Ser A* n 25 1987 p 64-65.

**Efficiency** See FEEDWATER TREATMENT.

**Equipment** See Also DESALINATION; MEMBRANES—Materials.

**075595 ANALYTICAL DESIGN EQUATIONS FOR MULTISOLUTE REVERSE OSMOSIS SYSTEMS.** Analytical equations are developed for tubular, spiral-wound, and plate-and-frame reverse osmosis (RO) modules to predict the membrane channel length for achieving a given fractional solvent recovery for a dilute feed with two highly rejected solutes. Extension to a large number of noninteracting solutes is straightforward. Analytical equations to predict the permeate solute concentrations are also developed. These design equations are simple to use and can be applied for both laminar and turbulent flow conditions. On the basis of these design equations, some approximate design equations are also derived. The predicted dimensionless length of the module and the average permeate concentrations are compared with the results obtained by numerical integration and found to be in excellent agreement. (Edited author abstract) 6 refs.

Palanki, Srinivas (Indian Inst of Technology, New Delhi, India); Gupta, Sharad K. *Ind Eng Chem Res* v 26 n 12 Dec 1987 p 2449-2454.

**075596 REVERSE OSMOTIC CONCENTRATION OF AQUEOUS 2-BUTANONE (METHYL ETHYL KETONE), TETRAHYDROFURAN AND ETHYL ACETATE SOLUTIONS.** Reverse osmotic concentration of aqueous MEK, THF and EAc solutions was carried out using five composite membranes (PEC-1000, FT-30 BW, FT-30 SW, NS-100 P1700, NS-100 P3500) and cellulose acetate membrane. Separation of solute and permeation through the membranes were measured under the following conditions: concentration of MEK, 1-8.2 wt%; concentration of THF, 0.7-6.3 wt%; concentration of EAc, 0.8-3.9 wt%; operating pressure, 4-6 MPa. PEC-1000 gave the best solute separation for each system. Its separation was above 97.5% for MEK system, above 99% for THF system and above 97% for EAc system. Membrane constants were calculated by the Spiegler-Kedem membrane transport model. The deviation from this model was corrected by compaction coefficients. (Edited author abstract) 23 refs.

Niwa, Masahiro (Yokohama Natl Univ, Yokohama, Jpn); Ohya, Haruhiko; Kuwahara, Emiko; Negishi, Youichi. *J Chem Eng Jpn* v 21 n 2 Apr 1988 p 164-171.

## Evaluation

**075597 REVERSE OSMOSIS FOR THE PRODUCTION OF BOILER FEED WATER TO POWER PLANTS.** An evaluation of reverse osmosis-cum-demineraliser (RO-DM) process is reported for the production of boiler feed water based on the operating experience of a small reverse osmosis demonstration plant. Cost estimates have been made for a 200 m<sup>3</sup>/h RO-DM plant. The results indicate that RO-DM process would be better than demineralisers alone, even for raw water feed concentrations of about 500-600 ppm of total dissolved solids. (Author abstract) 1 ref.

Prabhakar, S. (BARC, Bombay, India); Misra, B.M.; Ramani, M.P.; Sethuraman, V.; Thangaswamy, John B.; Raghavan, S.K. *Indian J Technol* v 25 n 9 Sep 1987 p 405-410.

## Filters

**075598 OSMOSIS AND THERMO-OSMOSIS THROUGH CELLULOSE ACETATE MEMBRANES.** Osmotic experiments have been carried out by using aqueous solutions of sucrose and cellulose acetate membranes. Two coupling phenomena between the processes of osmosis and of thermosmosis have been considered. In the first a variable thermosmotic flow was opposite to a fixed osmotic flow. The analysis of the results permits to obtain a temperature difference which is equivalent to a concentration difference. In the second, the evolution towards steady states was obtained, when a

temperature difference and a concentration difference were acting simultaneously across the membrane. (Edited author abstract) 33 refs.

Mengual, J.I. (Univ Complutense de Madrid, Madrid, Spain); Garcia-Lopez, F.; Fernandez-Pineda, C. *J Non Equilib Thermodyn* v 13 n 2 1988 p 177-191.

## Industrial Applications

**075599 REVERSE OSMOSIS FOR THE SEPARATION OF ORGANICS FROM AQUEOUS SOLUTIONS.** The properties of modern polymer membranes with respect to organic aqueous solutions are discussed to some extent. The potential of reverse osmosis for the treatment of organics-contaminated waste water is demonstrated by a discussion of two examples - landfill-drainage water and 'desorbate'. It is shown that in the case of partial immiscibility, a combination of reverse osmosis and phase separation allows operation at very high recovery rates without exceeding tolerable concentrations of organics within the reverse osmosis modules. Furthermore, it is shown that a purification of the organic phase by pervaporation is economically feasible. (Author abstract) 15 refs.

Rautenbach, Robert (RWTH Aachen, Aachen, West Ger); Janisch, Ingo. *Chem Eng Process* v 23 n 2 Mar 1988 p 67-75.

## Mathematical Models

**075600 DESIGN AND ANALYSIS OF A RADIAL-FLOW HOLLOW-FIBER REVERSE-OSMOSIS SYSTEM.** The mathematical analysis of a radial-flow hollow-fiber module is carried out by assuming that the solution-diffusion model is applicable for the transport across the membrane wall. Two analytical equations are developed which can be used for the design and analysis of a radial-flow hollow-fiber system. The characteristics of a B-9 hollow fiber module of Du Pont are determined by using these equations. The predicted values of dimensionless parameters, mass-transfer coefficient and solute diffusivity, are compared with the values obtained from numerical analysis, and the agreement between the two predictions is found to be excellent. It is also shown that the design equations simplify considerably when the solute rejection is high and the dimensionless mass-transfer coefficient is large. (Author abstract) 7 refs.

Gupta, Sharad K. (Indian Inst of Technology, New Delhi, India). *Ind Eng Chem Res* v 26 n 11 Nov 1987 p 2319-2323.

**075601 CALCULATING MEMBRANE SELECTIVITY IN REVERSE OSMOSIS SEPARATION OF MULTICOMPONENT ELECTROLYTE SOLUTIONS WITH CONSIDERATION OF THE INTERPHASE POTENTIAL JUMP.** The mechanism of appearance of the interphase potential jump is qualitatively described. A method is proposed for calculating selectivity in multicomponent systems. The results of such calculations for a number of mixtures are presented, together with the experimental selectivity values obtained in a series of cellulose acetate membranes produced by the VNISS Institute (in Vladimir). The agreement between experimental and calculated values is quite satisfactory. 11 refs.

Dukhin, S.S. (Dumanskii Inst of Colloid Chemistry & Water Chemistry, Kiev, USSR); Kocharov, R.G.; Gutierrez, L.E.R. *Sov J Water Chem Technol* v 9 n 2 1987 p 1-6.

## Theory

**075602 REVERSE OSMOSIS SYSTEM FOR AN ADVANCED SEPARATION PROCESS LABORATORY.** This paper focuses on the development of a small pilot unit for use in an advanced separations process laboratory. The end goal is to develop experiments with advanced separation processes such as reverse osmosis, ultrafiltration, adsorption, chromatography, etc. This paper presents one step in that direction. The system that was developed for an advanced separations laboratory



was based on using small spiral wound membranes and can operate at feed rates to 10 gpm and pressures to 1000 psi. Feed flow, solute concentration, temperature, pressure, and recovery can all be independently varied. The system can operate in various flow schemes. Experiments investigate simple operational parameters and mass transfer characteristics. Permeate production and solute rejection are studied. More detailed experiments involving organic separation, concentration polarization and fouling and other membrane configurations can be performed. 8 refs.

Slater, C.S. (Manhattan Coll, Riverdale, NY, USA); Paccione, J.D. *Chem Eng Educ* v 21 n 3 Summer 1987 p 138-143.

## OVENS, INDUSTRIAL See Also ELECTRON TUBES, MAGNETRON—Applications; SILICATES—Heat Treatment; SOILS—Moisture Determination.

**075603 IS THIS NOW EUROPE'S LARGEST MEDIUM WAVE INFRA-RED OVEN?** Europe's largest medium wave infrared curing tunnel (nearly 100ft. long) has been designed, manufactured and installed for Austin Rover. The paint sealant used is a thermosetting material and when applied to the vehicle under ambient conditions will remain tacky for a considerable period of time. The curing oven design is described.

Anon. *Finishing* v 11 n 9 Sep 1987 p 18-19.

**075604 OVENS: ALL SET FOR A RADIANT FUTURE?** The article describes Maywick radiant ovens. The application mentioned is aluminum castings coated with nylon powder. The internal surfaces of the oven are clad in polished stainless steel, enabling radiant energy from the 850°C surface temperature burners to be employed to its maximum. The fuel is natural or LP gas.

Anon. *Finishing* v 12 n 6 May 1988 p 35-36.

**075605 GENTLER DRYING WITH VACUUM OVENS.** A new range of industrial vacuum ovens has been announced by Heraeus Equipment Ltd. Called VHT, the ovens overcome the problems associated with conventional drying processes using radiation or hot air recirculation, in which the solvent is shielded from the energy source, as with the drying of powders. There is also the tendency of some materials to oxidize at high temperatures in air circulation ovens which is not the case with vacuum models.

Anon. *Finishing* v 12 n 6 May 1988 p 40-41.

## Control

**075606 USE OF THE ELEKTRONIKA MK-64 CALCULATOR FOR CONTROLLING AN ELECTRIC OVEN.** A description is given of a temperature stabilizer and program control consisting of an Elektronika MK-64 microcomputer, V7-28 digital voltmeter, and control device. The temperature is stabilized with an accuracy of 0.1°K. (Author abstract) 6 refs.

Yunusov, M.S. (Tashkent Electrotechnical Communications Inst, USSR); Abdurakhmanov, Yu.Yu.; Kim, V.M.; Ob'edkov, E.V. *Instrum Exp Tech* v 30 n 3 pt 2 May-Jun 1987 p 748-749.

## Convection

**075607 FORCED CONVECTION CURING OVENS FOR POWDER COATING.** The forced convection curing oven is the most popular curing equipment in use in the powder coating industry. The most popular method of heating is a direct gas fired heating system. The advantages of forced convection curing are: (1) Running costs; (2) flexibility of storing temperature and curing cycle; (3) a forced convection oven is capable of processing a wide range of weight, size and complexity of components. Most plant users feel these advantages outweigh the only major disadvantage, which is floor space occupied by the oven, in comparison to infrared curing systems.

Stordy, Michael (United & General Engineering Co,

Leatherhead, Engl). *Prod Finish (London)* v 41 n 5 May 1938 p 16, 18.

Design See PRINTED CIRCUITS—Testing.

## Electric

**075608 ELECTRIC OVENS FOR PAINT DRYING AND POWDER CURING.** Electric ovens are widely used by product finishers for the drying of spray-painted and powder-coated items. One reason for their selection is the variety of equipment available, which means that there is an electric option for almost every drying requirement. Controllability is often another key factor in the decision to 'dry electric'. Two examples of companies who have benefitted from the installation of electric ovens are described.

Anon. *Prod Finish (London)* v 41 n 5 May 1938 p 15.

Evaluation See AGRICULTURAL PRODUCTS—Moisture Determination.

## Microwaves

**075609 SECURITE ELECTRIQUE ET NORMALISATION DES FOURS A MICRO-ONDES.** [Electrical Safety and Microwave Oven Standardization]. Based on IEC publications, European bodies established standards to assure safety and the required characteristics of microwave ovens. The paper discusses the main points of the French standard and the changes being prepared. (Edited author abstract) In French.

Castagnoni, A. (Lab Central des Industries Electriques,). *RGE Rev Gen Electr* n 5 May 1988, Appl Energ des Micro-ondes, Fr, Oct 19-22 1987 p 38-39.

Sensors See BAKERIES—Ovens.

## Standards

**075610 IEC PERFORMANCE MEASUREMENT STANDARD FOR MICROWAVE OVENS - BACKGROUND AND RELEVANCE.** The International Electrotechnical Commission (IEC) will soon publish a new performance measurement standard. The work is described and analyzed, as is the current continuing work. The microwave power output measurement as a problem of method and relevance is dealt with. (Edited author abstract)

Risman, Per O. (Microtrans AB, Landvetter, Swed); Ohlsson, Thomas. *J Microwave Power Electromagn* v 22 n 3 1987, Radio Freq Ind Appl, 1987 p 181.

## Temperature Control

**075611 IMPROVEMENT IN THE RELIABILITY OF STANDARD CELL ENCLOSURES.** A description is given of the design of a new temperature-regulation circuit, which is used as an outer oven controller for new standard cell enclosures, with the emphasis on improving the reliability of the temperature control. A redundant protection circuit is used to prevent loss of temperature control caused by component failures in the controller. The temperature control of the outer oven of the enclosure is better than 0.4 mK per °C change in ambient temperature. When used with the additional inner controller the sensitivity of the cell temperature to the ambient temperature is improved to 20 µK/°C. The authors describe in detail the new circuit, summarizes the enclosure construction, and presents data on the performance of the system. (Edited author abstract). 2 Refs.

Field, Bruce F. (NBS, Gaithersburg, MD, USA); Ruimin, Liu. *J Res Natl Bur Stand (US)* v 93 n 4 Jul-Aug 1988 p 533-537.

Temperature Measurement See HEAT TREATMENT—Annealing.

## Vacuum Applications

**075612 HIGH-TEMPERATURE FURNACE WITH FIELD-EMISSION ELECTRON HEATING.** A high-temperature tubular oven is described that works under vacuum and is heated by electrons emitted by field-emission annular cathodes made of carbon fibers. The heating zone is indicated by the length of the luminous annular region in the wall as 3.5-7.0 mm long at 800-2200°C, power drawn 2.9-30 w. (Author abstract) 7 refs.

Pribytkov, V.A.; Matveev, O.I.; Dibrova, A.K. *Instrum Exp Tech* v 30 n 3 pt 2 May-Jun 1987 p 746-747.

**OVERCURRENT PROTECTION** See ELECTRIC CONTACTS—Protection; ELECTRIC POWER SYSTEMS—Control; ELECTRIC TRANSFORMERS—Protection; THYRISTORS—Protection; ELECTRIC FUSES—Computer Simulation.

**OVERVOLTAGE PROTECTION** See Also ELECTRIC LINES—Carrier Transmission; ELECTRIC POWER DISTRIBUTION—Surge Protection; ELECTRIC POWER SYSTEMS—Testing; SURGE PROTECTION.

**075613 CALCULATION OF THE DISTRIBUTION OF VOLTAGE AND CURRENT ALONG THE ELEMENTS OF AN OVERVOLTAGE LIMITER WITH CONTAMINATED AND WET COVERING.** A method is given for calculating the distribution of electric field strength and current along a column of nonlinear resistors in an overvoltage limiter with contaminated and wet cover. It is shown that the structural parameters of the apparatus substantially influence the currents flowing through the nonlinear resistors. (Author abstract) 6 refs.

Kizebeter, V.E.; Sergeev, A.S.; Firsov, A.V. *Sov Electr Eng* v 58 n 3 1987 p 21-27.

## Applications

**075614 APPLYING SURGE SUPPRESSORS.** Protecting electric power systems from overvoltages caused by lightning, switching surges and other disturbances is an increasingly important concern among design professionals. Without proper protection, overvoltages can result in serious damage to equipment and loss of power supply. By applying properly selected surge suppressors to electric power systems, transformers and other apparatus can be protected. A review of suppressors in use today along with design fundamentals and guidelines for their use are presented.

Breeze, Frank (Tilden, Lobnitz & Cooper Inc, Orlando, FL, USA). *Consult Specif Eng* v 3 n 2 Feb 1988 p 82-85.

## Equipment

**075615 CONSIDERAZIONI SUI CRITERI PER LA VERIFICA DELL'AFFIDABILITA' DEGLI SCARICATORI AD OSSIDO DI ZINCO.** [Considerations on the Criteria for Verifying the Reliability of Zinc Oxide Surge Arresters]. The use of zinc-oxide surge arresters, as a device to protect plant components against overvoltages, imposes nowadays the requirement to set-up checks to guarantee high reliability of this apparatus. The zinc-oxide resistors represent the components that can prejudice considerably the reliability of surge arresters; therefore it is very important to pay particular attention to the checks that are carried out on the above mentioned elements during the construction and assembly phases. The paper, after a concise description of the construction phases of zinc-oxide surge arresters, and particularly of nonlinear resistors, discusses the main manufacturing defects of the arresters. The critical examination of the routine and acceptance tests of the IEC standard under preparation are able to evidence only a part of the above mentioned defects. Therefore user actions are described which may be undertaken to prevent the presence of defective components within each supply. (Edited author abstract) In Italian. 7 refs.

Bargigia, A.; Stevanato, F. *Energ Elettr* v 64 n 9 Sep 1987 p 365-372.



Evaluation See ELECTRIC POWER SYSTEMS—Computer Simulation.

**OXIDES** See Also BOILERS—Measurements; CATALYSTS—Materials; CERAMIC MATERIALS; GLASS; GLASS—Oxidation; GLASS—Porosity; IRON BORON ALLOYS—Amorphous; MAGNETIC MATERIALS—Thin Films; METALLIC COMPOUNDS; METALLIC COMPOUNDS—Mathematical Models; POWDERS—Pyrolysis; RARE EARTH COMPOUNDS; RARE EARTH COMPOUNDS—Elasticity; RUBBER, SYNTHETIC—Vulcanization; SEMICONDUCTING SILICON COMPOUNDS—Radiation Effects; SLABS—Analysis; SOLIDS—Defects; STEEL—Protective Coatings; SUPERCONDUCTING MATERIALS; SUPERCONDUCTING MATERIALS—Crystallization; SUPERCONDUCTING MATERIALS—Gravimetric Analysis; SUPERCONDUCTING MATERIALS—Research; SUPERCONDUCTING MATERIALS—Synthesis; SUPERCONDUCTIVITY; TANTALUM COMPOUNDS—Radiation Effects; TUNGSTEN COMPOUNDS; ZINC COMPOUNDS.

**075616 EINE NEUE DARSTELLUNGSMETHODE FUER MONOKLINISCHES SILBER(I,II)OXID (AgO), EINKRISTALLZUECHTUNG UND ROENTGEN-STRUKTURANALYSE.** [New Method of Describing Monoclinic Silver(I,II)Oxide (AgO), Single Crystal Growing and X-ray Structural Analysis]. A new route for the synthesis of monoclinic AgO has been developed, yielding, for the first time, coarse crystalline samples which apparently do not show deviations from the ideal composition. On electrolysis of aqueous AgF solutions, AgO forms at the anode as crystals of  $1.0 \times 0.2 \times 0.05$  mm in size. The crystal structure has been refined using single-crystal diffractometer data. The thermal stability recorded by differential thermal and thermogravimetric analysis techniques is improved over samples prepared previously by chemical oxidation. (Edited author abstract) In German. 9 refs.

Jansen, M. (Inst fuer Anorganische Chemie, Hanover, West Ger); Fischer, P. *J Less Common Met* v 137 Feb 1 1988 p 123-131.

**075617 SYNTHESIS, STRUCTURE AND THERMAL REDUCTION BEHAVIOUR OF DELAFOS-SITE-TYPE  $\text{CuRh}_2\text{Al}_{1-x}\text{O}_2$ .** Delafossite-type oxides  $\text{CuRh}_2\text{Al}_{1-x}\text{O}_2$  with  $0 \leq x \leq 1$  have been synthesized and structurally characterized. The temperature range and the mechanistic course of the thermal reduction have been found to be strongly dependent on the composition of the initial materials. As products, elemental copper, thermally metastable Cu-Rh alloys and  $\text{Al}_2\text{O}_3$  are formed. These products represent not only interesting metallic but also potential bimetallic catalysts. (Author abstract) 13 refs.

Kuhn, P. (Univ of Zurich, Zurich, Switz); Reller, A.; Oswald, H.R. *J Less Common Met* v 137 Feb 1 1988 p 231-239.

**075618 ELECTRONIC BEHAVIOR AND CATIONIC DEFECTS IN CUBIC TRANSITION METAL OXIDES.** A comparison study has been made between the cubic monoxides and oxide spinels of iron, manganese, and cobalt in terms of cation defect structures and electrical properties. Although all six oxides share close-packed oxygen sublattices and have similar point-defect structures, there are considerable differences between conduction processes. Whether or not an octahedral/tetrahedral cation exchange reaction occurs may play a central role in governing conduction. In the iron oxides, n-type small polaron conduction takes place with small hopping energies (0.11-0.16 eV) between octahedral  $\text{Fe}^{2+}$  and  $\text{Fe}^{3+}$ , with the cation inter-site reaction playing a dominant role. Very different behaviors are observed in the spinels and monoxides of manganese and cobalt. Inter-site exchange is highly unlikely in these materials. Instead, disproportionation on the octahedral sites results in p-type small polaron conduction with larger hopping energies (0.25, 0.79 eV) between octahedral  $\text{M}^{4+}$  and  $\text{M}^{3+}$  in the spinels of cobalt and manganese. (Edited author abstract) 26 refs.

Mason, T.O. (Northwestern Univ, Evanston, IL, USA). *Physica B & C* v 150 n 1-2 May 1988, Proc of the Int Conf on Electr Struct and Phase Stab in Adv Ceram, Argonne, IL, USA, Aug 17-19 1987 p 37-43.

**Adhesion** See IRON CHROMIUM NICKEL NIOBIUM ALLOYS—Oxidation; METALS AND ALLOYS—Oxidation; NICKEL AND ALLOYS—Oxidation; NICKEL CHROMIUM ALLOYS—Oxidation.

**Amorphous** See MOLYBDENUM COMPOUNDS—Synthesis; SEMICONDUCTING GLASS—Electric Conductivity.

**Chemical Analysis** See NICKEL CHROMIUM ALLOYS—Oxidation.

**Chemical Reactions** See ALKALI METAL COMPOUNDS—Chemical Reactions; CERAMIC MATERIALS—Structure; FLUORINE COMPOUNDS—Ionic Conduction; GALLIUM AND ALLOYS—Isotopes.

**Chemical Vapor Deposition** See CATALYSTS—Synthesis.

**Chlorination**

**075619 CARBOCHLORINATION OF DISPERSED OXIDES IN A MOLTEN SALT REACTOR.** Reaction mechanism and rates were determined from 803 to 1,073 K for the carbochlorination of  $\text{Al}_2\text{O}_3$  and of Al, Si and Fe-mixed oxides using  $\text{Cl}_2$  and C slurried in a stirred melt of  $\text{NaCl-AlCl}_3$ . Alumina chlorination rates of  $0.33-2.0 \times 10^{-8}$  kmol/s were obtained using C-melt weight ratios between 1:21 and 1:42. The reaction rate was proportional to C loading at temperatures below 923 K, while gas-liquid mass transfer was rate-controlling at higher temperatures. Carbochlorination of the combined oxides in coal fly ash at 923 K and oxide conversion less than about 50 percent was also gas-liquid mass-transfer-controlled. At higher conversions, dissolution became the rate-controlling factor. A 40 percent (molar)  $\text{AlCl}_3$  melt was more effective than a 48 percent  $\text{AlCl}_3$  melt for the selective chlorination of  $\text{Al}_2\text{O}_3$  over  $\text{SiO}_2$ . (Author abstract). 16 Refs.

Dobbins, Michael S. (Iowa State Univ, Ames, IA, USA); Burnet, George. *AIChE J* v 34 n 7 Jul 1988 p 1086-1093.

**Composition Effects** See FUEL CELLS—Components; SUPERCONDUCTING MATERIALS—Microscopic Examination.

**Crystalline**

**075620 HIGH-TEMPERATURE CHARGE-DENSITY STUDIES OF  $\text{CeO}_{2-x}$  USING X-RAY AND NEUTRON DIFFRACTION TECHNIQUES.** High-resolution Bragg scattering experiments have been used to study the structure of polycrystalline  $\text{CeO}_{2-x}$ . The in-situ experiments were carried out as a function of temperature ( $300 < T < 1500$  K). The composition was controlled by flowing gases ( $\text{CO}/\text{CO}_2$  or  $\text{Ar}/\text{O}_2$  mixtures) over the sample. The results of both X-ray and neutron scattering experiments are used to define the principle atomic defects responsible for nonstoichiometry in  $\text{CeO}_{2-x}$ . Large lattice relaxation effects are observed whose magnitudes increase with increasing defect concentration. Temperature-dependent studies of the stoichiometric state ( $x = 0$ ) show that lattice anharmonic interactions are important. The symmetry of the lattice anharmonic interactions is the same as the static displacements observed in the nonstoichiometric state. Thus, we propose that lattice anharmonic interactions are the fundamental driving force for the complex strain interactions observed in the nonstoichiometric state. (Author abstract) 44 refs.

Faber, J. Jr. (Argonne Natl Lab, Argonne, IL, USA). *Physica B & C* v 150 n 1-2 May 1988, Proc of the Int Conf on Electr Struct and Phase Stab in Adv Ceram, Argonne, IL, USA, Aug 17-19 1987 p 241-249.

**Crystallization**

**075621 SPECIAL FEATURES OF THE CRYSTALLIZATION OF  $\text{CaLaAlO}_4$ .** On the basis of an analysis of the processes occurring at the crystal/melt interface, it is shown that ahead of the crystallization front in the melt a diffusion layer enriched with calcium oxide or lanthanum oxide forms as a result of the kinetic processes in the

adsorption and diffusion layers. A theoretical fusibility diagram of the  $\text{CaO-La}_2\text{O}_3\text{-Al}_2\text{O}_3$  system is constructed on the basis of a model of regular and ideal solutions. A comparison of the fusibility diagram and the maximum deviations from stoichiometry of  $\text{CaLaAlO}_4$  at the crystallization front of this compound shows that they correspond to the eutectic line bounding its primary-crystallization field. 7 refs. In Russian.

Brach, B.Ya.; Glazacheva, E.N.; Kostromina, N.A.; Rakhmankulov, R.M.; Romanov, A.Yu.; Udalov, Yu.P. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 977-981.

**075622 ANISOTROPY OF COLOUR PROPERTIES IN  $\gamma\text{-Mo}_4\text{O}_{11}$ .** It is known that  $\gamma\text{-Mo}_4\text{O}_{11}$  with orthorhombic structure in a quasi-two-dimensional conductor exhibits a charge-density-wave transition at 95K. We were able to prepare a  $\gamma\text{-Mo}_4\text{O}_{11}$  single crystal of fairly large size by a process of crystal growth in the Cu-Mo-O system, and found that it had two types of cleavage plane with different colors. In this letter, we report the preparation method and anisotropic color properties of  $\gamma\text{-Mo}_4\text{O}_{11}$  single crystal. The reflection spectrum of  $\gamma\text{-Mo}_4\text{O}_{11}$  for linearly polarized light depends on the orientation of crystal. The anisotropy is probably due to the anisotropy of the inter-band transition probability. 5 refs.

Shimoda, M. (Natl Research Inst for Metals, Tokyo, Jpn); Yagisawa, K.; Okochi, M.; Yoshikawa, A. *J Mater Sci Lett* v 6 n 11 Nov 1987 p 1331-1332.

**Decomposition** See Also CARBIDES—Synthesis; GRAPHITE—Oxidation.

**075623 WUESTIT IN OXIDSCHICHTEN AUF NIEDRIG-LEGIERTEN STAELHEN IN WASSERDAMPF. II: WUESTITZERSETZUNG.** [Wuestite in Oxide Layers on Low-Alloy Steels in Water Vapour. II. Decomposition of Wuestite]. The decomposition of wuestite in oxide layers on low-alloy steels formed in water steam at  $T > 600^\circ\text{C}$  was investigated. The mechanism of the decomposition reaction was analysed by studying the microstructure and phase composition of differently quenched wuestite samples and of samples which had been treated at a constant temperature below  $600^\circ\text{C}$ . The decomposition of wuestite into the stable phases magnetite and  $\alpha$ -iron lead to a characteristic decomposition microstructure which makes the identification of originally present wuestite clearly possible, even after the complete transformation of this wuestite into the stable phases. (Author abstract) 6 refs. In German.

Punge-Wittler, Barbara (Univ Dortmund, Dortmund, West Ger). *Werkst Korros* v 39 n 5 May 1988 p 204-207.

**Defects**

**075624 DIFFUSION OF OXIDE ION VACANCIES IN PEROVSKITE-TYPE OXIDES.** In order to elucidate the diffusion of oxide ion vacancies in perovskite-type oxides, we determined the tracer diffusion coefficient of oxide ions,  $\text{D}_\text{O}^*$ , in  $\text{La}_{1-x}\text{Sr}_x\text{CoO}_{3-\delta}$  ( $x = 0.1$ ) and  $\text{La}_{1-x}\text{Sr}_x\text{FeO}_{3-\delta}$  ( $x = 0.1, 0.25$ , and  $0.4$ ) single crystals. The correlation factor,  $f$ , for a vacancy diffusion mechanism in a perovskite-type anion sublattice was calculated to be  $f = 0.69$  using this value and the nonstoichiometry data, the diffusion coefficient of oxide ion vacancies,  $\text{D}_\text{V}$ , was estimated. It was found that  $\text{D}_\text{V}$  in  $\text{La}_{1-x}\text{Sr}_x\text{MO}_{3-\delta}$  ( $\text{M} = \text{Co, Fe}$ ) take similar values in their magnitude and activation energy. It was concluded that a point defect model holds for the vacancy diffusion in these oxides. The diffusivity of oxide ions in the perovskite-type oxides was comparable to that in fluorite-type oxides. (Author abstract) 38 refs.

Ishigaki, Takamasa (Univ of Tokyo, Tokyo, Jpn); Yamachi, Shigeru; Kishio, Kohji; Mizusaki, Junichiro; Fueki, Kazuo. *J Solid State Chem* v 73 n 1 Mar 1988 p 179-187.



**Degradation** See LITHIUM COMPOUNDS—Synthesis.

**Density** See SEMICONDUCTOR DEVICES, MOSFET—Transport Properties.

**Dielectric Properties** See SEMICONDUCTOR MATERIALS—Doping.

**Diffusion** See Also CERAMIC MATERIALS—Sintering.

**075625 INTERDIFFUSION IN A QUASI-BINARY  $\text{Al}_2\text{O}_3\text{-Mn}_3\text{O}_4$  SYSTEM IN AIR.** Interdiffusion coefficients of the quasi-binary  $\text{Al}_2\text{O}_3\text{-Mn}_3\text{O}_4$  system in air have been studied at temperatures from 1573 to 1773K. The diffusion couple consisted of a single crystal  $\text{Al}_2\text{O}_3$  whose (012) plane of trigonal lattice was placed in contact with a sintered polycrystalline  $\text{Mn}_3\text{O}_4$ . Master curves of concentration penetrations in the direction of diffusion were obtained at each experimental temperature. Interdiffusion coefficients were calculated by the Matano-Boltzmann method. The reaction mechanism in this system and the crystal structure of diffusion layer are discussed. (Edited author abstract) 10 refs.

Atarashiya, Koji (Hokkaido Univ, Sapporo, Jpn); Nagasaki, Ryukichi; Nishida, Keizo. *Trans Jpn Inst Met* v 28 n 12 Dec 1987 p 966-970.

**Dissolution** See Also NITRATES—Electrolysis.

**075626 ELECTROLYTIC GROWTH AND DISSOLUTION OF OXIDE LAYERS ON SILICON IN AQUEOUS SOLUTIONS OF FLUORIDES.** The growth and dissolution of oxide layers on silicon has been studied under illumination and in the dark by analyzing current transients at different voltages in solutions of  $\text{NH}_4\text{F}$  of various concentrations at pH values between 1 and 4.5. When the oxidation rate of the silicon at high enough anodic bias and, for n-type specimens, high enough illumination intensity exceeds the rate of oxide dissolution in the fluoride, the film grows until it has reached a thickness where the dissolution is rate-determining for the net process. At higher voltages the current begins to oscillate. The data give some insight into the composition of the oxide layers and their electronic and ionic properties. (Author abstract) 11 refs.

Gerischer, H. (Max-Planck-Gesellschaft, Berlin, West Ger); Luebke, M. *Ber Bunsenges Phys Chem* v 92 n 5 May 1988 p 573-577.

**075627 INFLUENCE OF OXIDE BOND ENERGIES ON THE KINETICS OF CHEMICAL DISSOLUTION OF ANODIC OXIDES ON VALVE METALS.** The influence of M-O bond energies on the kinetics of the chemical dissolution of anodic oxide films on valve metals was analyzed and the different profiles of atomic defects in these oxides were deduced. Four different equations describing the dissolution behavior of such oxides were derived and the respective examples justifying each equation were also introduced. For many oxides, M-O bond energy was found to vary linearly with the activation energy of the dissolution. It was also found that the dissolution rate increases with increase of the initial thickness of the oxide. The dissolution processes were followed by using potential and capacitance measurements. (Author abstract). 23 Refs.

Gad-Allah, A.G. (Univ of Cairo, Giza, Egypt); Abd El-Rahman, H.A.; Abou-Romia, M.M. *J Appl Electrochem* v 18 n 4 Jul 1988 p 532-537.

**Doping** See Also SUPERCONDUCTING MATERIALS—Structure.

**075628 DECOMPOSITION BEHAVIOURS OF DOPANT-FREE AND DOPED SOLID SOLUTIONS IN THE  $\text{TiO}_2\text{-SnO}_2$  SYSTEM.** Decomposition behaviours, including phase separation by the spinodal mechanism, were investigated for selected compositions of  $x = 0.7, 0.5$  and  $0.3$  in  $\text{Ti}_x\text{Sn}_{1-x}\text{O}_2$  alloy. Inside the coherent spinodal, an equimolar alloy was found to decompose most rapidly at 1100°C and the decomposition rate decreased as the annealing temperature increased. The

difference in the rate of decomposition outside the spinodal between  $x = 0.7$  and  $x = 0.3$  alloys suggested that the ionic mobility of diffusing tin was much slower than that of titanium in the alloy system. The effect of some dopants on the decomposition rate was also examined. Doping with tungsten or antimony atoms strongly suppressed the phase separation both inside and outside the spinodal, especially resulting in a prolonged stabilization of  $x = 0.7$  alloy. The role of the dopants in affecting the decomposition rate is discussed in relation to selective substitution of the doping atoms in the tin or titanium sublattice. (Author abstract) 16 refs.

Takahashi, J. (Nagoya Inst of Technology, Nagoya, Jpn); Kuwayama, M.; Kamiya, H.; Takatsu, M. *J Mater Sci* v 23 n 1 Jan 1988 p 337-342.

**Electric Breakdown** See SEMICONDUCTOR DEVICES, MOS—Etching.

**Electric Conductivity** See Also CERAMIC MATERIALS—Electric conductivity; SENSORS—Materials; SUPERCONDUCTING MATERIALS; SUPERCONDUCTING MATERIALS—Composition Effects; SUPERCONDUCTING MATERIALS—Electric Properties; SUPERCONDUCTING MATERIALS—Magnetic Field Effects; SUPERCONDUCTING MATERIALS—Stresses; SUPERCONDUCTING MATERIALS—Synthesis; SUPERCONDUCTING MATERIALS—Testing.

**075629 ALTERNATING CURRENT ELECTRICAL PROPERTIES OF EVAPORATED CERUM DIOXIDE FILMS.** Alternating current measurements are described for amorphous  $\text{CeO}_2$  thin film metal-insulator-metal samples prepared by vacuum evaporation. The behavior of the ac conductivity  $\sigma(\omega)$  is similar to the earlier observations for many other types of amorphous semiconductors, which obey an equation of the form  $\sigma(\omega) = A\omega^s$ ,  $\omega$  being the radial frequency and the index  $s$  having different values at different temperatures. The conduction process involves the hopping of electrons or polarons. The Elliott (1977) model satisfactorily accounts for the frequency dependence of conductivity and the temperature dependence of  $s$ . The capacitance of the sample shows an increase with increasing temperature certainly in the lower frequency range. (Author abstract) 13 refs.

Al-Dhhan, Z.T. (Brunel Univ, Uxbridge, Engl); Hogarth, C.A. *Int J Electron* v 63 n 4 Oct 1987 p 573-585.

**075630 MIXED IONIC-ELECTRONIC CONDUCTIVITY OF  $\text{La}_{1-x}\text{Sr}_x\text{Co}_{1-y}\text{Fe}_y\text{O}_{3-\delta}$  PEROVSKITE-TYPE OXIDES.** The ionic ( $\sigma_i$ ) and electronic ( $\sigma_e$ ) conductivities of mixed conductive  $\text{La}_{1-x}\text{Sr}_x\text{Co}_{1-y}\text{Fe}_y\text{O}_{3-\delta}$  were separately measured by means of the four-probe ionic dc and ordinary four-probe dc techniques, respectively. At 1073 K, for instance,  $\sigma_i$  ranged from  $1$  to  $10 \cdot 2 \text{ S cm}^{-1}$ , while  $\sigma_e$  was around  $10^2 \text{ S cm}^{-1}$ , indicating that these oxides were good mixed conductors with ionic transport numbers  $10^{-2}$  -  $10^{-4}$ .  $\sigma_i$  increased as the contents of Sr and Co increased although the Sr content had a greater effect. The apparent activation energy for oxide ion conduction, as well as the dependences of  $\sigma_i$  on oxide composition and oxygen partial pressure, suggested that oxide ion conduction occurred via a vacancy mechanism. The relation of mixed conductivity to the oxygen semipermeability was also discussed. (Edited author abstract) 16 refs.

Teraoka, Y. (Kyushu Univ, Kasuga, Jpn); Zhang, H.M.; Okamoto, K.; Yamazoe, N. *Mater Res Bull* v 23 n 1 Jan 1988 p 51-58.

**075631 ELECTRICAL PROPERTIES AND CATION VALENCIES IN  $\text{Mn}_3\text{O}_4$ .** The electrical conductivity and thermopower of  $\text{Mn}_3\text{O}_4$  were measured in the temperature range 920° to 1530°C. Electrical conduction in cubic  $\text{Mn}_3\text{O}_4$  is explained by the small polaron hopping of electron holes between  $\text{Mn}^{4+}$  and  $\text{Mn}^{3+}$  on octahedral sites. The concentrations of  $\text{Mn}^{4+}$  and  $\text{Mn}^{3+}$  are governed by the disproportionation equilibrium  $2\text{Mn}_{\text{Oct}}^{3+} \rightleftharpoons \text{Mn}_{\text{Oct}}^{4+} + \text{Mn}_{\text{Oct}}^{2+}$ . This model also explains the electrical behavior of  $\text{NiMn}_2\text{O}_4$  and  $\text{CuMn}_2\text{O}_4$ . (Author abstract) 50 refs.

Dorris, S.E. (Northwestern Univ, Evanston, IL, USA); Mason, T.O. *J Am Ceram Soc* v 71 n 5 May 1988 p 379-385.

**075632 EFFECT OF ATMOSPHERE ON THE CRYSTAL STRUCTURE AND ELECTRIC CONDUCTIVITY OF Mn-Co-Ni OXIDE IN THE ANNEALING PROCESS OF A THERMISTOR.** This investigation was carried out to elucidate the influence of oxidizing atmosphere in the annealing process for making thermistor. A starting sample was prepared by mixing the nitrates of Mn, Co, Ni with molar ratio of 3.0:1.9:1.1. After fixing at 1400°C, the sample was cooled to room temperature in the furnace. The oxide thus obtained was annealed in different atmospheres at 310° and 370°C. Electric conductivity change during the annealing process was followed for 15 days in argon, air, and oxygen atmospheres. Electric conductivities changed depending on the type of atmospheres. (Edited author abstract) 11 refs. In Japanese.

Meguro, Takeshi (Yokohama Natl Univ, Yokohama, Jpn); Sasamoto, Tadashi; Yokoyama, Takashi; Shiraishi, Kouichi; Abe, Yoshiaki; Torikai, Naohika. *Yogyo Kyokai Shi* v 96 n 3 1988 p 338-341.

**Electric Properties** See Also LIQUIDS—Suspensions; THERMISTORS—Materials.

**075633 SUPERCONDUCTIVITY IN Bi-Cu-Sr-Ca-O.** Indications for new phases with superconducting properties are reported in Bi-Cu-Sr-Ca oxides. One of these is a tetragonal compound of approximate composition of  $\text{CaSr}_2\text{Bi}_2\text{Cu}_2\text{O}_x$  with  $a=b=3.82 \text{ \AA}$ ,  $c=30.7 \text{ \AA}$ . It shows onset of diamagnetism near  $T_s=110 \text{ K}$ . The strength of the signal increases with annealing near the melting temperature (approx. 880°C). Titration gives a composition near  $x=8.25$ . Somewhat different structures are obtained at different compositions and heat treatment. (Author abstract) 8 refs.

Oesterreicher, H. (Univ of California, San Diego, CA, USA); Higgins, B.E. *Mater Lett* v 6 n 8-9 May 1988 p 254-256.

**075634 ELECTRICAL AND PHYSICAL CHARACTERISTICS OF THIN NITRIDED OXIDES PREPARED BY RAPID THERMAL NITRIDATION.** Ultrathin oxides (5-12 nm) were nitrided by lamp-heated rapid thermal annealing in ammonia at temperatures of 900-1150°C for 5-300 s. Elemental depth profiles were measured by Auger electron spectroscopy (AES) and secondary ion mass spectroscopy (SIMS). Both the nitrogen concentration, measured by AES, and that hydrogen, measured by SIMS, for a nitrided oxide, are found to increase monotonically as nitridation proceeds. The AES depth profiles of oxygen show that the Si-SiO<sub>2</sub> interface does not move during nitridation. Dependences of midgap interface state density ( $D_{\text{itm}}$ ) and fixed charge density ( $N_f$ ) on nitridation temperature and on oxide thickness were studied. For a given temperature, both  $D_{\text{itm}}$  and  $N_f$  are found to show turnarounds as nitridation time increases in a similar manner: at first both increase, reach respective maxima at a certain nitridation time  $t_{\text{max}}$ , and then decrease gradually. The maximum of  $D_{\text{itm}}$  increases as the oxide film is thinner. A two-step model is newly proposed to explain the turnaround behaviors of  $D_{\text{itm}}$  and  $N_f$ : the first step is defect formation as a result of nitrogen incorporation, and the second step is reduction of the defects by an annealing-type process. The simulation reproduces the turnaround behaviors very well. 23 refs.

Hori, Takashi (Matsushita Electric Industrial Co, Osaka, Jpn); Iwasaki, Hiroshi; Naito, Yasushi; Esaki, Hideya. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2238-2245.

**Electrochemistry** See ELECTROLYTES; RUTHENIUM COMPOUNDS—Electrochemistry.



## Electronic Properties

**075635 LATTICE DISTORTION AND ELECTRONIC STRUCTURE OF  $\text{La}_2\text{CuO}_4$  AS HOST LATTICE FOR ITS HIGH- $T_c$  SUPERCONDUCTING DERIVATIVES.** Results of electrical transport and magnetic measurements obtained on cold-pressed compacts of  $\text{La}_2\text{CuO}_4$  are reported. The p-type metallic and Pauli paramagnetic behaviour between 300 and approximately 85 K is attributed to the existence of low density-of-states oxygen-2p valence band holes induced by ground state monovalent copper  $[\text{Cu}(\text{I}), 3d^{10}, S = 0]$ .  $\text{La}_2\text{CuO}_4$  exhibits an electronic phase transition at approximately 85 K and transforms to a p-type polaron-mediated incommensurate CDW state. A valence band structure with split-off antibonding is depicted, both for 'native', copper deficient, metallic  $\text{La}_2\text{Cu}_{1-\delta}\text{O}_4$  and 'ideal' stoichiometric insulating  $\text{La}_2\text{CuO}_4$ . (Edited author abstract) 23 refs.

van Bruggen, C.F. (Materials Science Cent, Groningen, Neth); Druiven, H.C.G.; Haange, R.J.; van Woerden, R.A.M.; Wieggers, G.A. *Mater Res Bull* v 22 n 10 Oct 1987 p 1427-1437.

**075636 EXCELLENT CHARGE-TRAPPING PROPERTIES OF ULTRATHIN REOXIDIZED TRITRIDE OXIDES PREPARED BY RAPID THERMAL PROCESSING.** 7.7-nm-thick oxide nitrided at 950°C and 1150°C for 60 s were reoxidized by rapid thermal processing in dry oxygen at 900-1150°C for 15-200 s. The nitridation-condition and reoxidation-condition dependences of charge to breakdown ( $Q_{BD}$ ), flat-band voltage shift ( $\Delta V_{FB}$ ), and increase of midgap interface state density ( $\Delta D_{itm}$ ) under high-field stress were studied. Rapid reoxidation achieves striking improvement of dielectric integrity: the  $Q_{BD}$  is improved by about 16 times and both the  $\Delta V_{FB}$  and  $\Delta D_{itm}$  are reduced by more than two orders of magnitude compared with those of thermal oxides. A correlation between the improvement and a reduction of hydrogen concentration by reoxidation is found. 13 refs.

Hori, Takashi (Matsushita Electric Industrial Co, Moriguchi, Jpn); Iwasaki, Hiroshi. *IEEE Electron Device Lett* v 9 n 4 Apr 1988 p 168-170.

**Forming** See Also SEMICONDUCTING INDIUM COMPOUNDS—Oxidation.

**075637 SATELLITE STRUCTURES IN THE X-RAY PHOTOELECTRON SPECTRA OF SURFACE OXIDES FORMED ON FeTi ALLOYS.** Satellite structures have been observed adjacent to the main peaks in the X-ray photoelectron spectra of metal core levels, Ti(2p) and Fe(2p), as well as in the ligand core level, O(1s), of the surface oxides present on the FeTi alloys. These satellites have been interpreted in terms of charge transfer transitions (shake-up process). The satellites of the metal and ligand tend to be mutually exclusive, a behavior that can be understood on the basis of metal-ligand overlap; this behavior gives valuable clues to the nature of metal-ligand bonding. Based on this information, the deactivation and the difficulties involved in the reactivation of FeTi alloy toward better hydrogen sorption characteristics have been considered. (Author abstract) 54 refs.

Selvam, P. (Indian Inst of Technology, Madras, India); Viswanathan, B.; Swamy, C.S.; Srinivasan, V. *Indian J Technol* v 25 n 12 Dec 1987 p 639-648.

## Friction

**075638 TRIBOLOGICAL PERFORMANCE OF  $\text{MoS}_2$  COMPACTS CONTAINING  $\text{MoO}_3$ ,  $\text{Sb}_2\text{O}_3$  OR  $\text{MoO}_3$  AND  $\text{Sb}_2\text{O}_3$ .** Selected oxides and sulfides have been previously investigated as bulk additives to enhance the tribological performance of  $\text{MoS}_2$  in air from ambient temperature to about 315°C.  $\text{Sb}_2\text{O}_3$ , in particular, has been identified as a superior additive for high temperature aerospace applications. In experiments designed to investigate a hypothesis that the superior tribological performance of  $\text{MoS}_2$ - $\text{Sb}_2\text{O}_3$  formulations results from formation of an  $\text{Sb}_2\text{O}_3$ - $\text{MoO}_3$  eutectic, compacts of  $\text{MoS}_2$  with

$\text{MoO}_3$ ,  $\text{Sb}_2\text{O}_3$  or  $\text{MoO}_3$  and  $\text{Sb}_2\text{O}_3$ , were prepared and tribologically evaluated at 316°C. Formulations containing  $\text{Sb}_2\text{O}_3$  or  $\text{MoO}_3$  resulted in higher friction but much less wear than  $\text{MoS}_2$  compacts, with the wear volume of  $\text{MoS}_2$ - $\text{MoO}_3$  compacts at about half that of compacts containing  $\text{Sb}_2\text{O}_3$ . (Edited author abstract) 10 refs.

Centers, Phillip W. (US Air Force Wright Aeronautical Lab, Wright-Patterson AFB, OH, USA). *Wear* v 122 n 1 Feb 15 1988 p 97-102.

**Grain Boundaries** See SUPERCONDUCTING MATERIALS—Electric Conductivity.

**Heat Treatment** See Also SEMICONDUCTING ZINC COMPOUNDS—Electric Conductivity.

**075639 HIGH-TEMPERATURE TREATMENT OF SILICA-CONTAINING OXIDES.** Experimental data on the effect of thermal and thermal-vapor treatment on the texture and phase composition of coprecipitated  $\text{SiO}_2$ - $\text{TiO}_2$ ,  $\text{SiO}_2$ - $\text{ZrO}_2$ ,  $\text{SiO}_2$ - $\text{SnO}_2$  compositions of varying composition are presented and discussed. The difficulty crystallizing component, silicon dioxide, hinders the texture and phase transformations of  $\text{TiO}_2$ ,  $\text{ZrO}_2$ , and  $\text{SnO}_2$ , as a result of which coprecipitated materials retain high dispersion up to higher temperatures than do pure titanium, zirconium, and tin dioxides, the crystallization temperature of which also significantly increases. The accelerating effect of water vapor on aging of the examined complex oxides was shown. (Author abstract) 15 refs.

Sidorchuk, V.V.; Chertov, V.M. *Sov Prog Chem* v 53 n 7 1987 p 15-19.

**Hydrogenation** See HYDROGEN INORGANIC COMPOUNDS—Synthesis.

**Hydrolysis** See GELS—Microstructure.

**Ionic Conduction** See Also BISMUTH COMPOUNDS—Doping; CALCIUM COMPOUNDS—Ionic Conduction; CERAMIC MATERIALS—Electric Conductivity; ELECTROLYTES, SOLID—Defects; FLUORINE COMPOUNDS—Ionic Conduction.

**075640 ELECTRICAL TRANSPORT PROPERTIES OF CALCIUM AND BARIUM ALUMINATES.** Electrical conductivity and ionic transport numbers have been measured of barium and calcium aluminates. At room temperature these compounds are insulators, but at high temperatures mixed conductivity is observed. Ionic transport numbers depend on partial oxygen pressure and doping. The electrical properties are dominated by impurities. A discussion is given of the underlying defect mechanism in the different compounds. (Edited author abstract) 26 refs.

Metselaar, R. (Eindhoven Univ of Technology, Eindhoven, Neth); Hoefsloot, A.M. *Solid State Ionics* v 24 n 4 Sep 1987 p 305-314.

**075641 INFLUENCE OF WATER ON STRUCTURE AND IONIC CONDUCTION OF PHYLLOMANGANATES (IV).** The variation of cell parameters and ac conductivity with hygrometry and temperature were measured on powders of the layered manganates  $\text{Na}_4\text{Mn}_{14}\text{O}_{27} \cdot z\text{H}_2\text{O}$ ,  $\text{KMn}_5\text{O}_{10} \cdot z\text{H}_2\text{O}$  and  $\text{Mn}_{14}\text{O}_{25} \cdot z\text{H}_2\text{O}$ . They all lose quantitatively water below approximately 120°C with lattice concentration in the direction normal to the layers. DTG (differential thermogravimetry) shows that samples kept in air contain adsorbed and structural (interlayer) water. The conductivity is strongly dependent on the water partial pressure below 80°C. Above 100°C, the conductivity is probably electronic with activation energies 0.32-0.40 eV, in agreement with their mixed-valence character. (Edited author abstract) 24 refs.

Charenton, Jean-Claude (CNRS, Grenoble, Fr); Strobel, Pierre. *Solid State Ionics* v 24 n 4 Sep 1987 p 333-341.

**075642 NONLINEAR ELECTRICAL PROPERTIES OF GRAIN BOUNDARIES IN AN OXYGEN-ION CONDUCTOR ( $\text{CeO}_2$ - $\text{Y}_2\text{O}_3$ ).** The ceria-yttria solid solution is a good anionic conductor. In polycrystalline ceramics, the complex impedance spectroscopy

copy shows clearly the existence of a significant additional resistance associated with the grain boundaries. In this paper a theoretical analysis of the ac response in the nonlinear regime is developed. In particular the current-voltage and capacitance-voltage characteristics of the grain boundaries are derived. For the material investigated the former is well fitted by the Poole-Frenkel law while the capacitance is voltage independent. (Author abstract) 14 refs.

Tanaka, Junzo (Nat'l Inst for Research in Inorganic Materials, Niihari, Jpn); Baumard, Jean-Francois; Abelard, Pierre. *J Am Ceram Soc* v 70 n 9 Sep 1987 p 637-643.

**075643  $\text{HfNbWO}_6$  AND  $\text{HTaWO}_6$ : NOVEL LAYERED OXIDES RELATED TO THE RUTILE STRUCTURE. SYNTHESIS AND INVESTIGATION OF ION-EXCHANGE AND INTERCALATION BEHAVIOUR.** New protonated layered oxides,  $\text{HMWO}_6 \cdot 1.5\text{H}_2\text{O}$  ( $M = \text{Nb}$  or  $\text{Ta}$ ), have been synthesized by topotactic exchange of lithium in trirutile  $\text{LiMWO}_6$  with protons by treatment with dilute  $\text{HNO}_3$ . Partially hydrated compounds,  $\text{HMWO}_6 \cdot 0.5\text{H}_2\text{O}$  and anhydrous compounds,  $\text{HMWO}_6$  retain the layered structure. The structure of these oxides consists of  $\text{MWO}_6$  sheets built up of M/W-oxygen octahedra with rutile type corner- and edge-sharing. Interlayer protons in  $\text{HMWO}_6$  are exchanged with  $\text{Li}^+$ ,  $\text{Na}^+$ ,  $\text{K}^+$  and  $\text{Ti}^+$ .  $\text{HMWO}_6$  exhibit Bronsted acidity intercalating n-alkylamines and pyridine. (Edited author abstract) 25 refs.

Bhat, Vasudeva (Indian Inst of Science, Bangalore, India); Gopalakrishnan, J. *Solid State Ionics* v 26 n 1 Jan 1988 p 25-32.

**075644 ELECTRICAL PROPERTIES AND MICROSTRUCTURE IN THE SYSTEM CERIA-ALKALINE EARTH OXIDE.** Solid electrolytes with a high ionic conduction of oxygen have been attracting great interest for application in high-temperature fuel cells and oxygen sensors. In the present paper, the electrical conductivity and ionic transference number of the ceria-alkaline earth oxide systems are investigated and discussed in terms of the crystal structure, density, and microstructure. Undoped ceria and its solid solution with alkaline earth oxides have a cubic fluorite structure. The ionic conductivity of ceria is greatly enhanced by additions of ceria and strontia, even when they are added in excess of the solubility limit. The conductivities of ceria-calcia and ceria-strontia were much higher than those of ceria- and yttria-stabilized zirconia. Up to the limit of ceria and strontia, the ionic transference number was nearly unity in the temperature range between 600 and 900°C. With an increase in ceria and strontia content, the ionic conductivity was little affected by the presence of a second phase of  $\text{CaO}$  and  $\text{SrCeO}_3$ . (Edited author abstract) 18 refs.

Yahiro, Hidenori (Kyushu Univ, Kasuga-shi, Jpn); Ohuchi, Tatsuya; Eguchi, Koichi; Arai, Hiromichi. *J Mater Sci* v 23 n 3 Mar 1988 p 1036-1041.

**Magnetic Properties** See Also MAGNETIC MATERIALS—Amorphous; MAGNETIC MATERIALS—Thin Films.

**075645 MAGNETIC PROPERTIES OF  $\text{EuO}$  THIN FILMS DOPED WITH TRANSITION METAL.**  $\text{EuO}$  films were doped with Co, Ag, or Au and their characteristics studied. The results were compared with  $\text{EuO}$  films containing either additional Fe or Eu. It was found that films containing a transition metal had a higher Curie temperature than those containing additional Eu. The magnetization of films doped with Ag or Fe had similar temperature dependence (a nearly linear decrease at  $T^{3/2}$ ). Two Curie temperatures were observed in films doped with Co or Au, indicating two magnetic phases. 2 refs.

Kikuda, S. (Nagoya Univ, Jpn); Tsunashima, S.; Uchiyama, S. *IEEE Trans J Magn Jpn* v TJMJ-2 n 5 May 1987, Contrib from the 9th Annu Conf on Magn in Jpn, Jpn, Nov 26-29 1985 p 434-435.



## Manufacture

**075646 NEW COBALT-NICKEL OXIDE SPINEL PREPARED UNDER HIGH PRESSURE IN AN OXYGEN ATMOSPHERE.** The present letter contains results from experiments on the high-temperature preparation of a new cobalt-nickel oxide spinel with unusually high nickel content under a high pressure in the presence of oxygen. The resulting products were subjected to X-ray diffraction (XRD) and quantitative chemical analyses. XRD measurements were carried out with a powder diffractometer using monochromatic  $\text{CuK}\alpha$  radiation and a scintillation counter. The changes in phase composition of the oxide products obtained under different conditions are presented. 10 refs.

Petrov, K. (Bulgarian Acad of Sciences, Sofia, Bulg); Will, G. *J Mater Sci Lett* v 6 n 10 Oct 1987 p 1153-1155.

**075647 INNOVATIONS AND DEVELOPMENTS IN OXIDE PRODUCTION FOR LEAD/ACID BATTERIES.** The lead oxide manufacturing process has been known since the second half of the nineteenth century. After the lead/acid battery ceased to be a mere scientific curiosity at the turn of the century, the fast-growing demands for storage batteries by industry in general, and by the automotive industry in particular, motivated further development of the traditional process for lead oxide production. Nowadays, over 30% of the total world production of lead oxide is converted into plate material for lead/acid batteries. Of the numerous patented processes, only three basic methods have survived, and these have been further developed by various companies worldwide. These processes are reviewed in this paper.

Brockmann, K.H. (Heubach & Lindgens Engineering GmbH, Langelshelm, West Ger). *J Power Sources* v 23 n 1-3 May-Jun 1988, Pap Presented at the Second Asian Battery Conf, Singapore, Aug 17-19 1987 p 87-91.

## Mathematical Models

**075648 SOME ASPECTS IN PREDICTING THE POINT OF ZERO CHARGE OF A COMPOSITE OXIDE SYSTEM.** Discrepancies exist among several recently published correlations between the point of zero charge (PZC) of a composite oxide system and those of its component oxides. In this paper, theoretical background and physical meaning for the PZC of a composite oxide were given. Plausible explanations were provided to clarify the differences among the publications. A set of experiments was also carried out for comparison, to determine the PZC of a mechanical mixture of alumina and silica oxides. Suggestions regarding prediction of PZC of a composite oxide system were made. (Author abstract) 12 refs.

Kuo, Jih-Fen (Univ of Southern California, Los Angeles, CA, USA); Yen, Teh Fu. *J Colloid Interface Sci* v 121 n 1 Jan 1988 p 220-225.

**Measurements** See AIR POLLUTION—Nitrogen Oxides.

**Melting** See LEAD COMPOUNDS.

**Microscopic Examination** See Also CERAMIC MATERIALS—Quality Control; PRASEODYMIUM AND ALLOYS—Radiation Effects.

**075649 THICKNESS OF INTERFACES BETWEEN TWINS, GLIDE DOMAINS, AND GRAIN BOUNDARIES IN OXIDES FROM HREM STUDIES ( $\text{Sm}_2\text{O}_3$ ,  $\text{Nd}_2\text{O}_3$ ,  $\text{Pr}_2\text{O}_3$ ,  $\text{Th}_2\text{O}_3$ , AND  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ ).** High-resolution electron microscope images (lattice or atomic row images) of planar interfaces can provide a precise measurement of interface thicknesses defined as the total width of the region where the atomic arrangement is different from that in the bulk. All the interfaces that are studied (A.P.B., twin and grain boundaries) are at most a few reticular distances thick, but great differences can occur between the different cases. (Author abstract). 32 Refs.

Boulesteix, C.; Salem, M. Ben; Yangui, B.; Kang, Z.

Eyring, L. *Phys Status Solidi A* v 107 n 2 Jun 1988 p 469-480.

**Microstructure** See CERAMIC MATERIALS—Phase Equilibria; CERAMIC MATERIALS—Sintering; SUPERCONDUCTING MATERIALS—Synthesis; ZINC COMPOUNDS—Decomposition.

**Morphology** See IRON AND ALLOYS—Oxidation; IRON CHROMIUM ALUMINUM YTTRIUM ALLOYS—Oxidation; TITANIUM ALUMINUM ALLOYS—Oxidation.

**Optical Properties** See Also LASERS, SOLID STATE—Materials.

**075650 SELECTIVE SOLAR ABSORPTION OF OXIDE FILMS GROWN IN SITU ON Fe-, Ni-, AND Cu-BASE ALLOYS.** In situ films were formed over a range of temperature, time, and oxygen pressure on two iron-base alloys, and nine copper-base alloys. A variety of oxide scales were obtained which included single-phase oxides doped with the alloying additions, multiple oxides of the base metal, and duplex oxides of either the base metal and mixed oxides of the base metal a solute-metal oxides. Solar absorbance, hemispherical-spectral reflectance, and emittance were measured. Oxides on iron-base alloys had absorbances  $> 0.80$  and high emittances ( $> 0.50$ ) and were relatively insensitive to doping effects. Elimination of the outer layer of  $\text{Fe}_2\text{O}_3$  by low-pressure oxidation of Fe-Mn alloys had little effect on spectra selectivity. The emittance of oxides on nickel-base alloys was markedly decreased by doping, but absorbances were virtually unchanged and still too low, i.e., 0.80-0.84, for selective absorption. Copper-base alloys formed very low emittance oxides but absorbances were also low ( $< 0.80$ ). The efficacy of the films as selective absorbers and the mechanism of spectral selectivity are discussed. The tandem-stack model appears to best fit the observations. (Author abstract) 13 refs.

Wu, M.Z. (Monolithic Memories Inc, Santa Clara, CA, USA); Douglass, D.L. *Sol Energy Mater* v 17 n 2 Feb-Mar 1988 p 119-136.

## Oxidation

**075651 VOLTAMMETRIC INVESTIGATIONS OF THE OXYGEN ELECTROCHEMICAL SYSTEMS IN MOLTEN SODIUM NITRATE AT 420°C.** A reaction pathway for the electrochemical oxidation of oxide anions at a platinum electrode in molten  $\text{NaNO}_3$  was deduced from the analysis of cyclic voltammograms. The mechanism involves one diffusion step followed by a charge transfer step, leading to a primary intermediate adsorbed oxygen species  $[\text{O}(-1)]$  which, in another step, disproportionates into a second intermediate adsorbed oxygen species  $[\text{O}_{\text{ads}}]$ , which further desorbs as  $\text{O}_2(\text{g})$ , and oxide ions. These latter are thus regenerated by catalytic process. (Author abstract) 15 refs.

Villard, Veronique (CNRS, Paris, Fr); Lefebvre, Hervé; Ferry, Daniel; Picard, Gerard. *Electrochim Acta* v 33 n 4 Apr 1988 p 545-549.

**Oxygen Determination** See SLAGS—Oxygen Determination.

**Phase Diagrams** See Also CERAMIC MATERIALS—High Temperature Effects; CRYSTALS—Reduction; SUPERCONDUCTING MATERIALS—Crystallization; SUPERCONDUCTING MATERIALS—Thermal Effects.

**075652 SPECIFIC POINTS ON SPINEL PHASE DIAGRAMS.** On phase diagrams of some oxides there exist isolated transition points in the vicinity of which  $N$  ( $N > 3$ ) phases are in equilibrium. A typical description of phase transitions in the vicinity of an N-phase point is confined to the analysis of some non-equilibrium thermodynamic potential invariants in relation to the group of high-symmetry phase transformations. Minima of this potential correspond to possible low-symmetry phases. The note suggests a new method of qualitative construction of phase diagrams containing N-phase points. 21 Refs.

Talanov, V.M. (Novocherkassk Polytechnical Inst,

USSR). *Phys Status Solidi A* v 106 n 2 Apr 1988 p k129-k133.

**075653 ON THE DETERMINATION OF THE  $\text{CuO-BaCuO}_2$  AND  $\text{CuO-YCuO}_{2.5}$  BINARY PHASE DIAGRAMS.** The phase relations in the  $\text{CuO-BaCuO}_2$  and  $\text{CuO-YCuO}_{2.5}$  systems were investigated by means of DTA and X-ray diffraction analysis. Decomposition of  $\text{CuO}$  into  $\text{Cu}_2\text{O}$  and mutual reaction of the melt containing  $\text{BaO}$  complicated the phase diagrams determination. (Author abstract). 8 Refs.

Nevriva, M. (Czechoslovak Acad of Sciences, Prague, Czech); Pollert, E.; Matejkova, L.; Triska, A. *J Cryst Growth* v 91 n 3 Aug 1988 p 434-438.

**075654 CALCULATION OF PHASE DIAGRAMS OF SOME OXIDE SYSTEMS USING THE CLUSTER VARIATION METHOD.** For calculating phase diagrams of mineral/ceramic systems, the cluster variation method CVM is a useful tool. The CVM is a hierarchy in which the approximations based on point- and pair-clusters correspond to the Bragg-Williams and Bethe approximations, respectively. The  $\text{CaCO}_3\text{-MgCO}_3$  system was successfully treated as a trigonally distorted fcc-based system, in an anisotropic tetrahedron approximation. The  $\text{Fe}_2\text{O}_3\text{-FeTiO}_3$  system was treated as a derivative of the simple hexagonal lattice in which permanent vacant sites occupy 1/3 of the lattice sites; a triangular prism was used as the basic cluster. Although the CVM was originally developed to study alloy systems, we find that it yields quite reasonable results for these more complicated mineral/ceramic systems, even though we use highly simplified ad hoc parameterizations for the internal energy. (Edited author abstract) 20 refs.

Kikuchi, Ryoichi (Univ of Washington, Seattle, WA, USA); Burton, Benjamin P. *Physica B & C* v 150 n 1-2 May 1988, Proc of the Int Conf on Electr Struct and Phase Stab in Adv Ceram, Argonne, IL, USA, Aug 17-19 1987 p 132-141.

**Phase Equilibria** See Also VANADIUM ORE TREATMENT—Thermodynamics.

**075655 PHASE EQUILIBRIUM DIAGRAM OF THE SYSTEM - Ni-Mn-O.** Using the available published experimental data on phase equilibria in the system Ni-Mn-O, we have constructed 'oxygen pressure-composition' and 'temperature-composition' (in air) projections, with largely hypothetical boundaries, of the phase equilibrium diagram of this system and the projection of this diagram on the composition triangle. Having compared these data within the framework of one diagram we discovered a number of phase equilibria not revealed experimentally. (Author abstract) 13 refs.

Golikov, Yu.V. (USSR Acad of Sciences, Sverdlovsk, USSR); Balakirev, V.F. *J Phys Chem Solids* v 49 n 4 1988 p 329-332.

**Phase Transitions** See GARNETS—Crystallization; GLASS—Crystallization; IRON OXIDES—Physical Properties; PHOTOCONDUCTING MATERIALS—Synthesis; RARE EARTH COMPOUNDS—Microstructure; SUPERCONDUCTING MATERIALS—Structure; SUPERCONDUCTING MATERIALS—Synthesis.

## Photochemical Reactions

**075656 PHOTOELECTROCHEMICAL PROPERTIES OF  $\text{Zr}_x\text{Ti}_{1-x}\text{Nb}_2\text{O}_7$  MIXED OXIDES.** The suitability of  $\text{Zr}_x\text{Ti}_{1-x}\text{Nb}_2\text{O}_7$  mixed oxides as photoanodes in photoelectrochemical cells is investigated. The mixed oxides are not as suitable as the end members.  $\text{ZrNb}_2\text{O}_7$  can be expected to be a promising candidate from the point of view of stability. (Author abstract) 13 refs.

Gopalakrishnan, R. (Indian Inst of Technology, Madras, India); Viswanathan, B.; Ramakrishnan, V.; Kuriaose, J.C. *Mater Chem Phys* v 18 n 1-2 Oct 1987 p 171-179.



## Physical Chemistry

**075657 PHYSICO-CHEMICAL PROPERTIES AND CATALYTIC BEHAVIOR OF MANGANESE OXIDES.** Two series of manganese oxides have been prepared by the thermal decomposition of manganese carbonate and oxalate under vacuum (300-900°C temperature). The kinetics of aqueous  $H_2O_2$  decomposition on these oxide surfaces have been studied. The reaction was found to be first order with respect to  $[H_2O_2]$ . Catalytic activities were found to be decreasing with the increasing temperature of decomposition. X-ray diffraction studies of the powdered samples show that the samples contain mainly two types of structures,  $NaCl(MnO)$  and calcinite ( $Mn_3O_4$ ). Infrared spectra show a characteristic band at  $796\text{ cm}^{-1}$  for the sample obtained by the decomposition of both Mn oxalate and Mn carbonate at 750 and 900°C. Samples prepared at other temperatures show similar characteristic bands. (Edited author abstract) 14 refs.

Ahuja, L.D. (Indian Inst of Technology, New Delhi, India); Rajeshwer, D.; Nagpal, K.C. *J Colloid Interface Sci* v 119 n 2 Oct 1987 p 481-490.

**Physical Properties** See COATINGS—Sputtering; DISPLAY DEVICES—Materials; ELECTRODES—Nickel; SUPERCONDUCTING MATERIALS; SUPERCONDUCTING MATERIALS—Synthesis.

## Polymerization

**075658 POLYMERIZATION OF EPOXIDES CATALYZED BY THE TITANIUM TETRAISOPROPOXIDE/PHENOL SYSTEM AND ITS MECHANISM.** Although the polymerization of epoxides catalyzed by titanium alkoxides has been reported, the mechanism is still unknown. The authors' examination of this process revealed that cyclohexene oxide gave a polymer in a very low yield in the presence of a catalytic amount of titanium tetraisopropoxide. This result is probably because the Lewis basicity of the epoxide is too weak to facilitate its coordination to the metal center of the weak Lewis acid titanium tetraisopropoxide. They now find that the addition of phenol to titanium tetraisopropoxide causes a remarkable effect on the polymerization of epoxides and that the phenoxy and isopropoxy groups play distinct roles for initiating the polymerization. 1 Ref.

Fukuchi, Yoshihisa (Univ of Tokyo, Tokyo, Jpn); Takahashi, Tamotsu; Noguchi, Hiromichi; Saburi, Masahiko; Uchida, Yasuzo. *J Polym Sci Part C* v 26 n 9 Aug 20 1988 p 401-403.

**Porosity** See GASES—Adsorption.

**Precipitation** See ELECTROLYTES, SOLID—Synthesis; ZIRCONIUM COMPOUNDS—Precipitation.

## Processing

**075659 SOL-GEL PROCESSING OF METAL OXIDES.** The sol-gel process offers new approaches to the synthesis of glasses and ceramics. Starting from molecular precursors such as alkoxides, a macro-molecular oxide network is obtained via inorganic polymerization reactions. A real understanding of the hydrolysis-condensation reactions, together with the role of the chemical modifications will lead to a better control of the process and the synthesis of 'tailor-made' materials. Completely new compounds, such as mixed organic-inorganic polymers have recently been obtained. (Edited author abstract) 23 refs.

Livage, J. (Univ Pierre et Marie Curie, Paris, Fr). *Chem Scr* v 28 n 1 Mar 1988, Adv in Prep and Prop Charact of Cryst Inorg Mater, St. Leonard des Bois, Fr, Sep 26-28 1987 p 9-13.

**Radiation Effects** See Also BERYLLIUM COMPOUNDS—Radiation Effects; TIN COMPOUNDS—Radiation Effects.

**075660 INCONGRUENT SPUTTERING IN METAL OXIDES.** Incongruent sputtering of  $NiO(100)$

and  $CoO(100)$  single crystals is observed for elevated substrate temperatures and 2 keV  $Ar^+$ . The sputtering process, which is three dimensional in nature, involves a balancing of oxygen diffusion into the near-surface region with that of oxygen and metal sputtering yields. Evidence is given that diffusion is ion enhanced and that defect or interstitial oxygen species participate in the preferential sputtering process. Based on the data reported, a mechanism is proposed that does not rely upon thermal sputtering and treats the incident ion as the initiator of typical linear cascade events. 36 refs.

Langell, M.A. (Univ of Nebraska, Lincoln, NE, USA). *Nucl Instrum Methods Phys Res Sect B* v B28 n 4 Nov 1 1987 p 502-508.

**075661 REACTOR IRRADIATION EFFECTS ON SUPERCONDUCTIVITY IN Y-Ba-Cu OXIDES.** Recent discoveries of the oxide compounds having high superconducting transition temperature  $T_c$  offered a possibility of operating of the superconducting devices at a liquid nitrogen temperature. In this note, the authors show the results of inplane resistivity measurement of Y-Ba-Cu oxide specimens (S-1 and S-2) together with the results of following another week of irradiation at 360 K, and discuss tentatively the loss of superconductivity (transition from superconductor to semiconductor or metallic conductor). 16 refs.

Atobe, Kozo (Kyoto Univ, Osaka, Jpn); Yoshida, Hiroyuki; Okada, Moritami; Nakagawa, Masuo. *J Nucl Sci Technol* v 25 n 4 Apr 1988 p 410-412.

**Reaction Kinetics** See Also METALS AND ALLOYS—Oxidation; OLIGOMERS—Research.

**075662 CALCULATION OF ACTIVITIES ON TWO-PHASE REGION BOUNDARIES IN  $CaO-Al_2O_3-SiO_2$  TERNARY SYSTEM.** Calculation of activities on the two-phase region boundaries in  $CaO-Al_2O_3-SiO_2$  ternary system has been carried out. Relationships between the activities of components and the composition of intersection of tie-line and composition edges along two-phase boundaries have also been presented, upon which the activities may easily be read. This method can also be used in other ternary systems. (Author abstract) In Chinese. 7 refs.

Cai Wenjuan (Beijing Univ of Iron & Steel Technology, China); Zhou Guozhi. *Chin Shu Hsueh Pao* v 23 n 5 Oct 18 1987 p B248-B253.

**Reduction** See Also CATALYSTS—Cobalt; CERAMIC MATERIALS—Synthesis; GLASS—Synthesis; MANGANESE COMPOUNDS—Dissolution; TUNGSTEN CARBIDE—Synthesis; TUNGSTEN COMPOUNDS—Reduction.

**075663 MECHANISM OF COMBINED REDUCTION OF IRON AND CHROMIUM IN A QUASI-BINARY OXIDE SYSTEM.** Combined reduction of chromium and iron in a quasi-binary oxide system occurs via the formation of a carbide phase and its subsequent destruction as a result of a reaction with chromium oxide prior to the formation of a solid solution of chromium in iron. Chromium oxide is reduced to a complex trigonal carbide simultaneously with the reduction of wustite. The reduction of ferrochromite with the formation of chromium carbides occurs without prior decomposition of  $FeCr_2O_4$  into individual oxides. The start of the reduction of chromium to the metal and its dissolution in iron is characterized by the reduction of a considerable part of the iron. An increase in the period of the iron lattice confirms the formation of a solid iron-chromium solution of interstitial type. In Russian. 5 refs.

Popov, A.A.; Ostrik, P.N.; Popov, A.N.; Proshchinskii, V.S. *Izv Vyssh Uchebn Zaved Chern Metall* n 6 1987 p 73-77.

**075664 KINETICS OF THE REDUCTION OF Fe-Cr AND Fe-Cr-Ni OXIDE SYSTEMS BY TWO REDUCING AGENTS.** A study was made of the kinetic patterns of the reduction of Fe-Cr and Fe-Cr-Ni oxide systems by

hydrogen and solid carbon simultaneously. The theoretical possibility of attaining a high degree of reduction and decarburization of iron-chromium-nickel alloys with chromium contents up to 23 wt.% by reducing the oxides with two reducing agents at a temperature of 1573 K is shown. In Russian. 12 refs.

Popov, A.A.; Ostrik, P.N.; Popov, A.N.; Volkov, I.V. *Izv Vyssh Uchebn Zaved Chern Metall* n 8 1987 p 1-4.

**075665 USE OF  $^{18}O$ /SIMS AND ELECTROCHEMICAL TECHNIQUES TO STUDY THE REDUCTION AND BREAKDOWN OF PASSIVE OXIDE FILMS ON IRON.** Secondary ion mass spectrometry (SIMS) has been used to study the cathodic removal and open-circuit breakdown of passive oxide films formed on Fe in  $^{18}O$ -enriched borate buffer solution. For film removal by galvanostatic cathodic reduction, the initial stage of reduction resulted in a layer by layer thinning of the film. The rates of film removal with cathodic charge passed were determined to be 1.56 and  $0.30\text{ nm/MC cm}^{-2}$  during the two distinct stages of reduction. These results are analyzed in terms of the various models for the passive film on Fe. Immersion of the passivated Fe electrodes in acidic sulfate solutions on open circuit resulted in a distinct potential arrest followed by a very rapid potential decrease. (Edited author abstract) 15 refs.

Bardwell, Jennifer A. (Natl Research Council of Canada, Ottawa, Ont, Can); MacDougall, B.; Graham, M.J. *J Electrochem Soc* v 135 n 2 Feb 1988 p 413-418.

**075666 XPS AND REDUCTION STUDY OF  $PrCoO_3$ .**  $LaCoO_3$  exhibits the highest catalytic activity for oxidation of CO, propene and isobutene within the series of  $LaMO_3$  oxides (M, first-row transition metal). This catalytic activity should be higher for  $PrCoO_3$  since the oxygen binding energy in this oxide is lower than that for  $LaCoO_3$ . In this work attention is paid to the reactivity of oxygen in the praseodymium-cobalt perovskite. By means of X-ray photoelectron spectroscopy (XPS), two different types of oxygen were identified and their evolution in the reduced sample was studied. Also gravimetric measurements of reduction at programmed temperature and in isothermal conditions were carried out. These results are compared with those of  $LaCoO_3$  and some considerations about the role of the cation in the A position of the perovskite structure are made. 25 refs.

Fierro, J.L.G. (CSIC, Madrid, Spain); Pena, M.A.; Tejuca, L. Gonzalez. *J Mater Sci* v 23 n 3 Mar 1988 p 1018-1023.

**075667 KINETIC STUDY OF COBALT OXIDES REDUCTION BY HYDROGEN.** In spite of the wide utilization of cobalt as an active phase in various heterogeneous catalytic systems, some aspects related to the preparation stages of these metal catalysts have not been given much attention. Such is the case of the kinetics and mechanisms of reduction of the oxides to metal. The kinetics of  $Co_3O_4$  and  $CoO$  reduction with hydrogen was studied in a fixed bed differential reactor under temperatures ranging from 600 to 800 K and hydrogen partial pressures ranging from 0.25 to 0.6 atm. Kinetic parameters were calculated from thermal conductivity variations measured in the gaseous phase during reaction. The results obtained were analyzed in relation to the kinetic models existing in current literature and it was found that in all cases the system has a first order behaviour in relation to hydrogen partial pressure according to an interlocked straight cylindrical pore geometry in the solid phase. 12 refs.

Gallegos, N.G. (CONICET, La Plata, Argent); Porto Lopez, J.M. *Mater Chem Phys* v 19 n 5 Jun 1988 p 431-446.

**075668 EFFECT OF CRYSTALLITE SIZE ON OXIDATION AND REDUCTION BEHAVIOR OF A MANGANESE-SUBSTITUTED MAGNETITE OF COMPOSITION  $Mn_{0.67}Fe_{2.33}O_4$ .** Thermogravimetry and electrical conductivity were used to determine the



effect of crystallite size on oxidation and reduction behavior of a manganese substituted magnetite  $Mn_{0.67}Fe_{2.33}O_4$  containing several oxidizable cations. We have found that within the single-phase region of the spinel (below 550°C) oxidation and reduction temperatures increase with increase of particle size. A quantitative analysis of cations suggests that there exists a grain size of 45 nm above which the oxidation characteristics of three oxidizable cations ( $Fe^{2+}$ ,  $Mn^{3+}$ ,  $Mn^{2+}$ ) change. Above 600°C, the temperature of structural change spinel  $\rightarrow$  corundum increases with decrease in particle size owing to stresses at the crystal lattice level. (Author abstract) 9 refs.

Gillot, B. (Lab de Recherches sur la Reactivite des Solides, Dijon, Fr); Laarj, M.; Tailhades, P.; Rousset, A. *Mater Chem Phys* v 19 n 5 Jun 1988 p 485-495.

**075669 REDUCTION OF TITANIUM-ANTIMONY OXIDES IN HYDROGEN AND IN CARBON MONOXIDE.** The reduction of coprecipitated titanium-antimony oxides by hydrogen and carbon monoxide has been investigated. The results show that the selective oxidation of hydrogen or carbon monoxide by antimony in titanium-antimony oxides is dependent on the temperature, the nature of the matrix and the extent of catalyst reduction. The oxidation of hydrogen, as compared to carbon monoxide, at moderate temperatures is strongly favoured by solids composed of low concentrations of antimony in the rutile lattice and subjected to limited overall reduction. The results may be associated with the use of such materials as selective hydrocarbon oxidation catalysts. (Author abstract). 4 Refs.

Berry, Frank J. (Univ of Birmingham, Birmingham, Engl); Gogarty, Patricia M.; Jenkins, John W. *Appl Catal* v 40 n 1-2 Jun 15 1988 p 151-156.

## Solubility

**075670 SOLUBILITY OF BARIUM OXIDE IN ZINC OXIDE.** The ZnO-BaO system is a potential electronic material; a sintered body shows a varistor characteristic and large grains prepared in this system can be applied for the production of low-voltage varistors. Apart from this application, very little is known of its basic characteristics. This letter reports the solubility of BaO in ZnO which is important for further development of the system. Chemical analysis was used to determine solubility. The method is based on the unique two-phase microstructure of the system. 5 refs.

Uematsu, K. (Nagaoka Inst of Technology, Nagaoka, Jpn); Morimoto, T.; Kato, Z.; Uchida, N.; Sa'to, K. *J Mater Sci Lett* v 6 n 11 Nov 1987 p 1285-1286.

**075671 TERMINAL SOLID SOLUBILITIES AT 1313K IN THE SYSTEM CALCIUM OXIDE-NICKEL OXIDE USING A SOLID STATE GALVANIC CELL.** The present work was undertaken to determine the terminal solid solubilities at 1313K using  $CaF_2$  as the solid electrolyte. The solid solubilities of CaO in NiO and NiO in CaO are found to be 2.0 and 1.3 mol%, respectively. X-ray powder patterns of the samples quenched from 1313K confirmed the phase changes obtained from the e.m.f. work. The very high positive deviation from ideality exhibited in the isostructural system CaO-NiO is to be expected in view of the appreciable cationic size disparity leading to positive strain energy in the crystal structure. 8 refs.

Raghavan, S. (Indian Inst of Technology, Madras, India). *J Mater Sci Lett* v 7 n 4 Apr 1988 p 402-404.

**Spectroscopic Analysis** See Also CERAMIC MATERIALS—Doping; IRON AND ALLOYS—Oxidation; NICKEL AND ALLOYS—Anodic Oxidation; PALLADIUM COMPOUNDS—Thin Films; X-RAYS—Diffraction.

**075672 OXYGEN AUGER SPECTRA OF SOME TRANSITION-METAL OXIDES: RELAXATION ENERGIES AND d-BAND SCREENING.** A number of transition-metal oxides have been investigated by ESCA and special attention has been paid both to the valence band and to the oxygen Auger spectra. Lang and Williams' Auger parameters have been calculated and the

results show that large screening effects, attributable to the metal d band, take place provided the d band is not separated from the actual valence band. In spite of this important extra-atomic relaxation, there is a strong evidence for hole localization in the oxygen Auger final states. Both hole localization and screening effects explain the quasi-atomic nature of the O KLL transitions. (Author abstract) 29 refs.

Humbert, P. (CNRS, Strasbourg, Fr); Deville, J.P. *J Phys C Solid State Phys* v 20 n 28 Oct 10 1987 p 4679-4687.

**075673 X-RAY AND SPECTROSCOPIC STUDIES OF MECHANICALLY TREATED FOR IRRADIATED OXIDES.** Results on the kind and distribution of structural defects in quartz ( $SiO_2$ ) and periclase ( $MgO$ ) after mechanical treatment have been presented. Zero-, one-, two- and three-dimensional defects are generated. Mainly surface near regions are distorted, where interactions of the induced defects with the atmosphere are possible. The mechanical energy causes a stronger structural distortion in quartz than in periclase, but the depth of penetration of the distortions is larger in the latter compound. The distribution of the defects depends mainly on the mechanism of treatment; kind, concentration and penetration depth depend on the material-specific features of the substances. (Author abstract) 71 refs.

Steinike, U. (Akad der Wissenschaften der DDR, Berlin, East Ger); Kretschmar, U.; Ebert, I.; Hennig, H.-P. *React Solids* v 4 n 1-2 Oct 1987 p 1-21.

**075674 X-RAY PHOTOELECTRON SPECTROSCOPY STUDY OF PEROVSKITE-TYPE MIXED OXIDES ( $La_{1-x}A_xCoO_3$ ).** The surface states of the perovskite-type cerium-, thorium- and strontium-doped lanthanum cobalt oxides ( $La_{1-x}Ce_xCoO_3$ ,  $La_{1-x}Th_xCoO_3$ ,  $La_{1-x}Sr_xCoO_3$ ,  $x = 0$  to 0.03) have been investigated using X-ray photoelectron spectroscopy (XPS). From the results, it is expected that the bonding state between the surface cobalt and lattice oxygen is mostly ionic at this point. The valence band (VB) spectra change greatly at  $x = 0.02$  on both cerium- and thorium-doped samples. The change of the VB spectra for  $La_{1-x}Sr_xCoO_3$  near the Fermi level can be explained by the formation of the impurity level. (Edited author abstract) 15 refs.

Tabata, Kenji (Matsushita Housing Products Co, Yamato-Koriyama, Jpn); Kohiki, Shigemi. *J Mater Sci* v 23 n 1 Jan 1988 p 343-346.

**075675 AUGER LINE RELATIVE INTENSITIES AS A TOOL FOR THE CHARACTERIZATION OF OXIDES FORMED DURING THE OXIDATION OF SINGLE CRYSTALS OF DILUTE Cu-Mn ALLOYS.** A chemical effect affecting the shape of the copper, manganese and oxygen Auger lines provides a very useful tool for characterization of the oxides formed during high temperature and low pressure oxidation of dilute Cu-Mn alloys. The state of oxidation of these elements changes the electron distribution in the valence bands, and the relative amplitudes of the Auger transitions involving one or two valence levels have been used as a measure of this effect. (Author abstract). 7 Refs.

Van Steene, G. (Univ Libre de Bruxelles, Brussels, Belg); Jardinier-Offergeld, M.; Bouillon, F. *Surf Interface Anal* v 11 n 12 Sep 1988 p 599-604.

**075676 STRUCTURE OF NICKEL AND INDIUM OXIDE THIN FILMS FROM EXAFS DATA.** The structure of nickel oxide and indium doped by tin thin films prepared by reactive magnetron sputtering has been studied by the EXAFS method. It has been found that the nickel oxide thin film has a microcrystalline structure with significant disorder proved by the increase of the Debye-Waller factor and the sharp decrease of peak amplitudes. The indium oxide thin film has a noticeable structural disorder due to 8% tin doping. (Author abstract) 4 refs.

Bets, V. (Latvian State Univ, Riga, USSR); Zamozdiks, T.; Lusis, A.; Purans, J.; Bausk, N.; Sheromov, M. *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR

Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 173-174.

**075677 OXIDATION OF  $Ni_3Al$  AT LOW AND HIGH OXYGEN PRESSURES.** Oxidation of stoichiometric  $Ni_3Al$  performed at elevated temperatures in low oxygen partial pressure and in atmospheric oxygen has been studied by x-ray photoelectron spectroscopy, auger electron spectroscopy and x-ray diffraction. At low oxidation pressure only the aluminum oxide is found although there is evidence for a phase change at temperatures above 600°C. At atmospheric pressure,  $NiO$ ,  $NiAl_2O_4$  and  $Al_2O_3$  are obtained. The different behavior is discussed in terms of the relative standard free energy of formation of the oxides. (Author abstract) 20 refs.

Venezia, A.M. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Loxton, C.M. *Surf Interface Anal* v 11 n 6 Apr 1988, Proc of the 9th Symp on Appl Surf Anal, Dayton, OH, USA, Jun 3-5 1987 p 287-290.

Stability See CATALYSTS—Supported.

Stresses See IRON ALUMINUM ALLOYS—Oxidation.

**Structure** See Also CATALYSTS—Physical Chemistry; CERAMIC MATERIALS—Thermal Expansion; CRYSTALS—Structure; MOLYBDENUM COMPOUNDS—Synthesis; TUNGSTEN COMPOUNDS—Ionic Conduction.

**075678 NOVEL DEFICIENT PYROCHLORES  $A(MoSb)O_6$  ( $A = Rb, Cs$ ).** In their work on antimony-containing pyrochlores, the authors tried to prepare the hypothetical oxides  $A^I(MoSb)O_6$  ( $A^I =$  sodium, potassium, rubidium, caesium), that would be the first pyrochlores constituted by molybdenum. Their results, and a method for calculating  $u$  and  $x$  positional parameters in  $AB_2O_6$  pyrochlores from the sums of ionic radii,  $A-O_c$  and  $B-O_c$ , are reported in this paper. 6 refs.

Castro, A. (CSIC, Madrid, Spain); Rasines, I.; Sanchez-Martos, M.C. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1001-1003.

**075679 NEW ORDERED SOLID SOLUTION WITH A BIXBYITE STRUCTURE: THE COMPOUNDS  $Cu_{2+x}Ti_{2-x}Fe_{2-x}Sb_xO_9$  ( $0 \leq x \leq 1.4$ ).** A new solid solution with the formula  $Cu_{2+x}Ti_{2-x}Fe_{2-x}Sb_xO_9$  was prepared by solid state reaction in air at 900°C. A rather large homogeneity range is observed:  $0 \leq x \leq 1.4$ . The X-ray powder diffraction shows a  $(Fe, Mn)_2O_3$  bixbyite type structure with a cubic elementary cell. The octahedral distortion is discussed in terms of two parameters: the bond length deviation and the bond angle variance. The purpose of the results, described here, is to show the occurrence of the bixbyite type structure in mixed oxides containing together the  $Cu^{+2}$  and  $Sb^{+3}$  cations. (Edited author abstract) 8 refs.

Mouron, P. (Univ d'Orleans, Orleans, Fr); Choynet, J. *Mater Res Bull* v 23 n 10 Oct 1987 p 1355-1362.

**075680 NOVEL STRUCTURAL TYPE OF HEXAGONAL CLOSEST PACKING: THE TERNARY OXIDE,  $\beta$ -Mn  $Sb_2O_6$ .** Single crystals of a new manganese antimony oxide,  $\beta$ -Mn $Sb_2O_6$ , are obtained by heating a mixture of  $Sb_2O_3$  and  $Mn_2O_3$  in a molar ratio of 5:2 up to 1000°C. Crystal structure is determined by single crystal X-ray diffraction methods. The cell parameters are given. Thermal stability is studied by means of thermogravimetric analysis. (Edited author abstract) 22 refs.

Vincent, H. (CNRS, Grenoble, Fr); Turrillas, X.; Rasines, I. *Mater Res Bull* v 23 n 10 Oct 1987 p 1369-1379.

**075681 MIXED OXIDES OF THE SYSTEM  $M^V$ - $Te^{IV}$ - $O_2$  ( $M = Nb, Ta, Sb$ ); II. CRYSTAL STRUCTURE OF  $Ta_2Te_2O_9$ .** Single crystals of a  $Ta^V$  and  $Te^{IV}$  mixed oxide of composition  $Ta_2Te_2O_9$  have been obtained by transport reaction of  $TeO_3$  and  $Ta_2O_5$  at 700°C. The crystal structure of this material has been determined by single crystal X-ray diffraction technique. The compound has monoclinic symmetry. The structure is discussed on



the basis of the coordination polyhedra of the central atoms and the effect of the 'lone pair' characteristic of  $\text{Te}^{\text{IV}}$ . (Edited author abstract) 25 refs.

Martinez-Carrera, S. (CSIC); Sanz, J.; Pico, C.; Gaitan, M.; Jerez, A.; Veiga, M.L. *Mater Res Bull* v 22 n 10 Oct 1987 p 1405-1412.

**075682 REASSESSMENT OF  $\text{Ba}_2\text{Fe}_2\text{O}_5$ .** Electron diffraction of samples of pure  $\text{Ba}_2\text{Fe}_2\text{O}_5$  shows this phase to be monoclinic with cell parameters which are multiples of a perovskite basic cell parameter. Chemical analysis of the oxide indicated that the iron was in the trivalent state. X-ray powder diffraction data are given. (Edited author abstract) 8 refs.

Parras, M. (Univ Complutense, Madrid, Spain); Vallet-Regi, M.; Gonzalez-Calbet, J.M.; Alario-Franco, M.A.; Grenier, J.C.; Hagemuller, P. *Mater Res Bull* v 22 n 10 Oct 1987 p 1413-1419.

**Substrates** See COPPER AND ALLOYS—Thin Films; SILICA—Chemical Vapor Deposition.

**Surface Properties** See Also CATALYSTS—Activity; PHENOLS—Desorption; TOLUENE—Adsorption.

**075683 NATURE OF CHEMISORBED SPECIES ON METAL OXIDE SURFACES: ELECTRON TRANSFER AND BOND-BREAKING PROCESSES.** Highly ionic insulator oxides, in particular  $\text{MgO}$ , can be prepared by high surface area form possessing many surface defect sites. The nature of these thermally robust defects are either structural (edges, planes, kinks, cation and anion vacancies) or electronic (electron excess or deficient sites). Extremely basic, electron rich sites are capable of strongly interacting with chemisorbing molecules. Proton abstraction, electron transfer, molecular oligomerization, base condensation, and radical trapping reactions have been observed with various adsorbing organic molecules. Adsorbed species can be readily detected with appropriate spectroscopic tools. Further technological use of thermally activated  $\text{MgO}$  and other oxides appear promising, especially in such areas as selective hydrocarbon H-D exchange catalysts, and destructive adsorbents for air purification purposes. (Author abstract) 46 refs.

Nieves, I. (Kansas State Univ, Manhattan, KS, USA); Klabunde, K.J. *Mater Chem Phys* v 18 n 5-6 Jan-Feb 1988 p 485-498.

**075684 SURFACE REACTIVITY OF POWDERS IN THE SYSTEM IRON OXIDE-ALUMINUM OXIDE ON SOLID SOLUTION FORMATION BY EMANATION THERMAL ANALYSIS.** The surface reactivity of oxide powders in the systems iron oxide-aluminum oxides (1:1 molar ratio) was studied by means of emanation thermal analysis (ETA) using a surface impregnation method, in the temperature range 25-1450°C under a controlled temperature program of 10°C/min and in a nitrogen flow atmosphere. The ETA results provided useful information on the processes of solid solution formation at the near-surface of aluminum oxide in the initial step. (Edited author abstract) 16 refs.

Ishii, Tadao (Hokkaido Univ, Sapporo, Jpn). *React Solids* v 4 n 4 Feb 1988 p 327-340.

**Surfaces** See ALUMINUM COMPOUNDS—Forming; SEMICONDUCTING INDIUM COMPOUNDS—Surfaces; SURFACE ACTIVE AGENTS—Adsorption.

## Suspensions

**075685 EFFECT OF WATER ON THE ZETA POTENTIAL OF CHROMIUM DIOXIDE IN TETRAHYDROFURAN.** This work is aimed at investigating one component of the magnetic ink which is commonly overlooked, namely water. Experiments have been performed to determine the effect of water on dilute suspensions of  $\text{CrO}_2$  in tetrahydrofuran (THF). The effect of water in the solvent as well as on the particle surface has been investigated using electrokinetic and dispersion stability measurements. Results of these investigations

have shown that the zeta potential of dried  $\text{CrO}_2$  (physically adsorbed water removed) in THF is positive and is dependent on the water content in THF. The zeta potential exhibits a maximum at about 1,800 ppm water. Good correlation also exists between the electrokinetic and dispersion stability measurements. (Edited author abstract) 14 refs.

Hudson, G.F. (Univ of Arizona, Tucson, AZ, USA); Raghavan, S. *Colloid Polym Sci* v 266 n 1 Jan 1988 p 77-81.

**Synthesis** See Also CATALYSTS—Iron; CERAMIC MATERIALS—Synthesis; SODIUM COMPOUNDS—Synthesis; SUPERCONDUCTING MATERIALS—Synthesis.

**075686 NEW ASPECTS OF PHASE FORMATION IN  $\text{HfO}_2\text{-Ln}_2\text{O}_3$  SYSTEMS.** Using a high-temperature Raman scattering method, a phase-transformation scheme is constructed for the  $\text{HfO}_2\text{-Ln}_2\text{O}_3$  system, where Ln = rare earth element, under various synthesis conditions. It is established that the tetragonal structure in solid solutions of  $\text{HfO}_2$  with a comparatively high impurity concentration is unstable at room temperature and is capable of being transformed into the monoclinic form in stages via the  $\gamma_2$ - and  $\gamma_1$ -structures. 14 refs. In Russian.

Voron'ko, Yu.K.; Zufarov, M.A.; Osiko, V.V.; Sobol', A.A. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 958-963.

**075687 PREPARATION AND PROPERTIES OF GLASSY FILMS IN THE  $\text{V}_2\text{O}_5\text{-ZnO}$  SYSTEM.** Rapidly quenched films in a given system were prepared using a twin-roller type apparatus. It was found that glassy films were obtained in a wide range of 0-75 mol% ZnO content, except for the vicinity of 60ZnO-40V<sub>2</sub>O<sub>5</sub> composition. Of four binary compounds, glassy films of  $\text{ZnV}_2\text{O}_6$  and  $\text{Zn}_2\text{V}_2\text{O}_7$  crystallized directly without changing the composition. The other glassy films showed a complicated process. The first crystallization temperature rose with an increase in ZnO content. In addition, the IR-spectral and electrical properties of quenched films were investigated. On the basis of the data, the structural aspect of Zn-vanadate glasses was discussed. (Author abstract) 15 refs.

Tsuzuki, A. (Government Industrial Research Inst, Nagoya, Jpn); Kawakami, S.; Sekiya, T.; Torii, Y.; Ishii, E. *Mater Res Bull* v 22 n 10 Oct 1987 p 1315-1320.

**075688 VANADATE (V) OXIDE WITH PEROVSKITE STRUCTURE:  $\text{La}_2\text{LiVO}_6$ , COMPARISON WITH HOMOLOGOUS  $\text{La}_2\text{LiMO}_6$  PHASES (M = Fe, Nb, Mo, Ru, Ta, Re, Os, Ir).** The  $\text{La}_2\text{LiVO}_6$  oxide with perovskite structure has been prepared under high oxygen pressure. A structural comparison with analogous  $\text{La}_2\text{LiMO}_6$  phases reveals a smaller unit cell than that expected from the variation of the parameters with ionic radii. Such a phenomenon can be accounted for by the  $d^0$  electronic configuration of vanadium (V) and the resulting high ionization potential. (Author abstract) 15 refs.

Demazeau, Gerard (CNRS, Talence, Fr); Oh-Kim, Eunok; Choy, JinHo; Hagemuller, Paul. *Mater Res Bull* v 22 n 6 Jun 1987 p 735-740.

**075689 NEW MODIFICATION OF  $\text{ReO}_3$ -TYPE  $\text{MoO}_3$  AND THE DEUTERATED INTERCALATION COMPOUND FROM WHICH IT IS DERIVED:  $\text{D}_{0.99}\text{MoO}_3$ .** The synthesis of the perovskite form of pure  $\text{MoO}_3$  has opened the door to crystallochemical studies of this compound and its intercalates. Thus far two intercalates (hydrogen/deuterium and lithium), analogous to those found in the  $\text{WO}_3$  and  $(\text{W},\text{Mo})\text{O}_3$  systems, have been prepared. In addition, a second modification, produced via the decomposition of the deuterium bronze, has been identified.  $\beta\text{-MoO}_3$  promises a structural and intercalation chemistry at least as rich and varied as has been described for  $\text{WO}_3$ . 12 refs.

Parise, John B. (DuPont, Wilmington, DE, USA); McCarron, Eugene M. III; Sleight, Arthur W. *Mater Res Bull* v 22 n 6 Jun 1987 p 803-811.

**075690 LOW-TEMPERATURE PREPARATION**

**OF NICKEL AND ZINC COBALTITES.** Solid solutions of metal acetate hydrazines,  $\text{M}_{1/3}\text{Co}_{2/3}(\text{CH}_3\text{COO})_2(\text{N}_2\text{H}_4)_2$ , where M = Ni or Zn, have been investigated as precursors of nickel and zinc cobaltites. These precursors decompose exothermically in the temperature range 165-345°C to yield the corresponding cobaltites. The formation of cobaltites has been confirmed by thermogravimetric weight loss and x-ray diffraction patterns of the decomposition residues. (Author abstract) 15 refs.

Mahesh, G.V. (Indian Inst of Science, Bangalore, India); Patil, K.C. *React Solids* v 4 n 1-2 Oct 1987 p 117-123.

**075691 USE OF THE ALKOXY METHOD TO OBTAIN OXIDE PHASES OF THE  $\text{Fe}_2\text{O}_3\text{-Y}_2\text{O}_3$  SYSTEM.** It is established that the synthesis of oxide powders of the  $\text{Y}_2\text{O}_3\text{-Fe}_2\text{O}_3$  system by the alkoxy method makes it possible to greatly decrease the reaction volumes, the number of operations and their duration in comparison with the method of coprecipitation of oxide hydrates from aqueous solutions of inorganic salts. During heat treatments of the products of hydrolysis of ferric alcohols it is  $\gamma\text{-Fe}_2\text{O}_3$  which crystallizes first, in contrast to what usually forms during precipitation from  $\alpha\text{-FeOOH}$  solutions. Further heat treatment of  $\gamma\text{-Fe}_2\text{O}_3$  leads to the appearance of  $\alpha\text{-Fe}_2\text{O}_3$ . The conditions of crystallization of  $\text{Y}_2\text{Fe}_2\text{O}_{12}$  and  $\text{YFeO}_3$  phases prepared by the two methods and the average size of their crystallites are very similar, but the powders precipitated from alcoholates are more homogeneous. In Russian. 16 refs.

Yanovskaya, M.I.; Rogova, T.V.; Ivanov, S.A.; Kolganova, N.V.; Turova, N.Ya. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 8 Aug 1987 p 1343-1346.

**075692 ZINC-COBALT OXIDE SPINELS WITH PRECURSOR-CONTROLLED DEGREE OF INVERSION.** Zinc-cobalt oxide spinels,  $\text{ZnCo}_2\text{O}_4$ , have been prepared by thermal decomposition of three different precursors: (I) coprecipitated zinc-cobalt hydroxide nitrate; (II) coprecipitated zinc-cobalt hydroxide, and (III) zinc-cobalt hydroxide nitrate prepared by isomorphous replacement of the tetrahedrally coordinated  $\text{Co}^{2+}$  ions in the double-layered parent cobalt hydroxide nitrate by  $\text{Zn}^{2+}$  ions. It has been shown that the cationic distribution in the oxide product is predetermined by the cationic distribution of the precursor. The coprecipitated precursors (I) and (II) decompose to statistical spinels, whereas precursor (III) decomposes to a normal  $\text{Zn}[\text{Co}_2]\text{O}_4$  spinel. The oxide spinels show a significant catalytic activity in processes of low-temperature oxidation and hydrogenization of hydrocarbons. 24 refs.

Petrov, K. (Bulgarian Acad of Sciences, Sofia, Bulg); Markov, L.; Ioncheva, R.; Rachev, P. *J Mater Sci* v 23 n 1 Jan 1988 p 181-184.

**075693 CHARACTERIZATION OF NIOBIUM PENTOXIDE PREPARED BY FLAME REACTION.** Recently, interest in the catalytic properties of niobium pentoxide as an active phase or as part of a complex system has appeared. The oxidation and/or hydrolysis of niobium pentachloride in a hydrogen-oxygen flame results in niobium pentoxide formation. Particles thus formed are well crystallized, pseudospherical, non-porous and approximately homodispersed. According to the reaction conditions, the average diameter is either close to 30 or to 40 nm. By UV, visible and near-infrared absorption study, the samples are shown to be stable under oxygen or vacuum up to 673K whereas modifications are brought about by hydrogen treatment at temperatures higher than 573 K. 22 refs.

Guenin, M. (CNRS, Villeurbanne, Fr); Frety, R.; Garbowski, E.; Vergnon, P. *J Mater Sci* v 23 n 3 Mar 1988 p 1009-1013.

**075694 SYNTHESIS AND IONIC CONDUCTIVITY OF MIXED OXIDES  $(\text{H}_2\text{ONH}_4)_m\text{MTeO}_{6.5}$  (M = Cr, W).** Mixed oxides  $(\text{H}_2\text{ONH}_4)_m\text{MTeO}_{6.5}$  (M = Cr, W) were prepared by solid-state reaction from orthotelluric acid and ammonium dichromate or pentahydrated ammo-



nium paratungstate, respectively. These compounds were characterized by powder X-ray diffraction, thermogravimetric analysis and IR absorption spectroscopy. Conductivity measurements were made in the 298-523 K temperature range by the complex impedance method. (Author abstract). 18 Refs.

Garcia-Martin, S. (Univ Complutense, Madrid, Spain); Veiga, M.L.; Iborra, E.; Jerez, A.; Pico, C. *Mater Res Bull* v 23 n 8 Aug 1988 p 1107-1117.

**075695 PRECURSORS FOR SOL-GEL PREPARATIONS.** Precursors used for the synthesis of oxide systems by the sol-gel method are reviewed and their role in the various stages of the process is discussed. Emphasis is given to alkoxide precursors and to their physical and chemical properties. In particular, the following topics are discussed: degree of oligomerization, volatility, viscosity, reactions with alcohol, molecular association between alkoxides, hydrolysis, and stabilization against hydrolysis. Some information about preparation methods, commercial products and availability is also given. Among non-alkoxide precursors, nitrates, carboxylates, acetylacetonates, chlorides and other inorganics are described from the point of view of their use in sol-gel preparations. They are compared, when possible, with the corresponding alkoxides. (Author abstract) 89 refs.

Guglielmi, M. (Univ di Padova, Padua, Italy); Carturan, G. *J Non Cryst Solids* v 100 n 1-3 Mar 1988, Glasses and Glass Ceram from Gels, Kyoto, Jpn, Jul 13-15 1987 p 16-30.

**Testing** See AMINES—Testing; CADMIUM COMPOUNDS—Electric Conductivity.

## Thermal Conductivity

**075696 DETERMINATION OF THERMAL CONDUCTIVITY AND ESTIMATION OF SPECIFIC HEAT FOR HIGH-TEMPERATURE OXIDES.** A method is proposed for the simultaneous determination of thermal conductivity, thermal diffusivity and specific heat by use of a hot strip. The principle of this method is based on two solutions of the Fourier partial differential equation solved under different time measurement. The slope of this straight line gives thermal conductivity ( $\lambda$ ). On the other hand, the response curve for short time measurement is proportional to the square root of time. The slope of this straight line gives thermal diffusivity ( $k$ ). The specific heat ( $C_p$ ) can be estimated by  $pC_p = \lambda/k$  ( $p$ : density). Using this method, thermal conductivity, gives thermal diffusivity and specific heat of a 30(mol%) $\text{Na}_2\text{O}$ -70( $\text{SiO}_2$ ) sample have been determined over the temperature range 300 to 1500 K in the liquid and glassy states. The thermal diffusivity is nearly constant at low temperatures but decreases with increasing temperature. The specific heat increases with increasing temperature but the absolute values are 1.1-1.2 times higher than those obtained by the laser flash method. (Edited author abstract) 25 refs.

Susa, M. (Tokyo Inst of Technology, Tokyo, Jpn); Nagata, K.; Goto, K.S. *Trans Jpn Inst Met* v 29 n 2 Feb 1988 p 133-142.

## Thermal Effects

**075697 POLARITY ASYMMETRY OF OXIDES GROWN ON POLYCRYSTALLINE SILICON.** The quality of oxide thermally grown on polycrystalline silicon, commonly referred to as polyoxide, is strongly dependent on polysilicon doping processes and polyoxide growth conditions. The electrical properties of polyoxides using different polysilicon doping processes (in situ, ion implanted, and  $\text{POCl}_3$ ) and different oxidation processes (dry, wet, and LPCVD) have been studied. The emphasis is on the dependence of the polarity asymmetry of leakage current, critical electric field histogram, electron trapping rate, and charge to breakdown. Polyoxides with in situ doped polysilicon exhibit an unusual polarity asymmetry, i.e., higher field enhancement and charge to breakdown are observed when the upper electrode is biased negative. This is the opposite of the asymmetry reported for

polyoxides before. High-temperature annealing of the polysilicon films prior to oxidation reduces this asymmetry. 14 refs.

Lee, Jack C. (Univ of California, Berkeley, CA, USA); Hu, Chenming. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1063-1070.

## Thermal Expansion

**075698 THERMAL EXPANSION DATA XII. COMPLEX OXIDES:  $\text{AB}_2\text{O}_6$ ,  $\text{AB}_2\text{O}_7$ ,  $\text{A}_2\text{B}_2\text{O}_7$  PLUS COMPLEX ALUMINATES, SILICATES AND ANALOGOUS COMPOUNDS.** The first paper in this series gave a brief introduction to the effects of temperature on crystalline compounds, the analysis of thermal expansion data and the treatment of data in this series of papers. This paper continues the compilation with other complex oxides having general formulae  $\text{AB}_2\text{O}_6$ ,  $\text{AB}_2\text{O}_7$  and  $\text{A}_2\text{B}_2\text{O}_7$  as well as complex aluminates, ferrites, germanates, silicates and titanates. Regression data and percentage expansion data are given for various compounds. 117 refs.

Taylor, Derek (Fairey Tecramics Ltd, Stone, Engl). *Br Ceram Trans J* v 87 n 2 Mar-Apr 1988 p 39-45.

**Thermal Properties** See SUPERCONDUCTING MATERIALS—Synthesis.

## Thermodynamic Properties

**075699 APPLICATION OF THE HOCH-ARPSHOFEN MODEL TO THE  $\text{SiO}_2$ - $\text{CaO}$ - $\text{MgO}$ - $\text{Al}_2\text{O}_3$  SYSTEM.** The Hoch-Arpschofen model was applied to the  $\text{SiO}_2$ - $\text{CaO}$ - $\text{MgO}$ - $\text{Al}_2\text{O}_3$  system. First the binary interaction coefficients, obtained from the six binary systems, were used to calculate the Gibbs energy of formation of the ternary compounds present in the four ternary systems; then the calculated activities of  $\text{SiO}_2$ ,  $\text{CaO}$ , and  $\text{Al}_2\text{O}_3$  were compared with the measured activities. The calculated Gibbs energies of formation of anorthite, gehlenite, and cordierite agree with the measured energies; the measured enthalpies of formation of akermanite, diopside, merwinite, and monticellite must be multiplied by formation of akermanite, diopside, merwinite, and monticellite must be multiplied by 0.568 $\pm$ 0.031 to obtain agreement. The Gibbs energy of formation of  $3\text{CaO}$ - $\text{MgO}$ - $2\text{Al}_2\text{O}_3$  was also calculated. The calculated activity data agree with some authors' measurements and not with others. (Author abstract) 15 refs.

Hoch, Michael (Univ of Cincinnati, Cincinnati, OH, USA). *Calphad* v 12 n 1 Jan-Mar 1988 p 45-58.

**075700 THERMODYNAMIC AND CONDUCTIVITY STUDIES OF NONSTOICHIOMETRIC CERIUM DIOXIDE BY COULOMETRIC TITRATION: A SIMULTANEOUS MEASUREMENT.** The partial molar thermodynamic quantities which consist mainly of variations in oxygen chemical potential with changing temperature and composition, can best be used in support of, and in conjunction with, a proposed defect model. Together they provide insight, understanding, and a concise description of the non-stoichiometric behavior. In previous studies of metal oxides (e.g.,  $\text{CeO}_{2-x}$ ), the electron mobility ( $\mu$ ) has been determined by combining separate experimental measurement of  $x$  and  $\sigma$ . In this study, the electrochemical, constant-composition technique is used as a fast and direct method for obtaining thermodynamic data and simultaneous measurements of the electrical conductivity. (Edited author abstract) 14 refs.

Park, Jong-Hee (Argonne Natl Lab, Argonne, IL, USA). *Physica B & C* v 150 n 1-2 May 1988, Proc of the Int Conf on Electr Struct and Phase Stab in Adv Ceram, Argonne, IL, USA, Aug 17-19 1987 p 80-85.

**Thermodynamics** See BLAST FURNACE PRACTICE—Physical Chemistry; SOLID SOLUTIONS—Phase Equilibria.

**Thickness Measurement** See SCANDIUM AND ALLOYS—Oxidation; SEMICONDUCTOR DEVICES, MOS—Measurements; ZIRCONIUM AND ALLOYS—Nondestructive Examination.

**Thin Films** See Also COBALT COMPOUNDS—Magnetic Properties; CRYSTALLIZATION—Thin Films; FILMS—Dielectric; FILMS—Thermal Effects; SEMICONDUCTING GERMANIUM—Oxidation; SEMICONDUCTOR DEVICES, BIPOLAR—Electric Properties; SEMICONDUCTOR DEVICES, MOSFET—Electric Properties; SEMICONDUCTOR DEVICES, MOSFET—Low Temperature Effects; SEMICONDUCTOR MATERIALS—Thin Films; TITANIUM AND ALLOYS—Anodic Oxidation.

**075701 COMPOSITION CONTROL OF SOME OXIDE FILMS BY MEANS OF A TRI-POLE MAGNETRON SPUTTERING SYSTEM.** This paper describes the newly developed Tri-Pole Magnetron Sputtering System, which has the third magnetic pole of an electric magnet, or the control pole, in addition to the conventional N and S poles between them. The system can switch the polarity of the control pole through the direction of the coil current so that it can shift the target-eroded region by the magnetic field configuration. Therefore, film composition can easily be controlled by an appropriate composite target of coaxial disks corresponding to magnetic field configuration, at the same time changing the duty ratio of the current flowing through the control-pole coil to adjust the sputtering time of each target-component. (Edited author abstract) 11 refs.

Fukami, Tatsuo (Shimshu Univ, Nagano, Jpn); Teshima, Osamu. *Electron Commun Jpn Part 2* v 70 n 12 Dec 1987 p 102-109.

**075702 TANTALUM OXIDE FILMS BY PHOTO-PROCESSING.** Tantalum oxide films with high dielectric constant and high dielectric breakdown strength (5-6 MV/cm) have been obtained at relatively low temperatures by a photo-CVD method using  $\text{TaCl}_5$  as a source material, followed by an annealing with UV-irradiation in an oxygen ambient. These films are promising for application to highly integrated MOS DRAMs or high-performance TFTs. (Author abstract)

Tarui, Yasuo (Tokyo Univ of Agriculture & Technology, Jpn); Matsui, M.; Oka, S.; Yamagishi, K.; Kuroiwa, K. *JEE J Electron Eng* v 25 n 254 Feb 1988 p 90-93.

**075703 EFFECT OF RTA ON THIN THERMAL OXIDE.** The authors look at the effect of a source/drain RTA on the gate oxide quality by measuring the oxide parameters of breakdown voltage, bias-temperature-stress C-V shifts, leakage, and defect density. Use of RTA to activate implants, form silicides, and reflow dielectrics does not degrade 150 Å thermal oxide as long as the temperature is less than or equal to 975°C for 10s. Beyond this temperature, while breakdown and C-V shifts are unaffected and leakage decreases, defect densities become excessive. Since the material adjacent to the oxide during the anneal may be significant in determining the effect of anneal, any application of RTA to processes involving 150 Å gate oxides should be evaluated in terms of effect on gate oxide, most importantly the defect density. 1 ref.

Cosway, Richard G. (Motorola Inc, Mesa, AZ, USA); Hodel, Michael W. *J Electrochem Soc* v 135 n 2 Feb 1988 p 533-534.

**075704 EFFECT OF ANALYTICAL METHOD OF THICKNESS MEASUREMENTS OF THIN OXIDE FILMS.** The thickness of thin natural oxide films formed on silicon, nickel, aluminum, iron, tantalum and zirconium has been measured using nuclear reaction analysis (NRA) and Auger electron spectroscopy (AES) in combination with ion beam sputtering. It is shown that ion beam effects severely limit the use of AES and ion beam sputtering in measuring thin oxide thicknesses. Relatively



non-destructive techniques such as NRA or angle-resolved x-ray photoelectron spectroscopy (XPS) provide more reliable information. (Author abstract) 27 refs.

Tapping, R.L. (Chalk River Nuclear Lab, Chalk River, Ont, Can); Davidson, R.D.; Jackman, T.E.; Davies, J.A. *Surf Interface Anal* v 11 n 8 May 1988 p 441-446.

**075705 EFFECT OF HYDROGEN PLASMA ON THE PROPERTIES OF INDIUM-TIN OXIDE FILMS.** The effect of hydrogen plasma exposure on the properties of transparent conducting indium-tin oxide films has been studied. The exposure reduces the film surface to elemental indium. The thickness of the reduced layer increases with increasing exposure and finally saturates to a thickness of about 100 nm. The reduced surface is rough and decreases the visible transmittance of these films drastically due to increased absorbance and reflectance. The reduced metal layer decreases the sheet resistance of the films. Annealing of the plasma-exposed film in oxygen recovers the visible transmittance except in the case of the severely damaged films. (Author abstract). 5 Refs.

Major, S. (Indian Inst of Technology, New Delhi, India); Bhatnagar, M.C.; Kumar, S.; Chopra, K.L. *J Mater Sci* v 3 n 4 Jul 8 1988 p 723-728.

**075706 ELECTRICAL CONDUCTION IN THIN FILMS OF  $\text{CeO}_2/\text{GeO}_2$ .** A.c. and d.c. conduction in MIM sandwich structures based on  $\text{CeO}_2/\text{GeO}_2$  as a dielectric prepared by the co-evaporation technique has been investigated for samples having different compositions. A transition of electrical conductivity from amorphous semiconductor to metallic behaviour as the temperature increased is reported. The electroformed samples show a voltage-controlled negative resistance (VCNR) at high values of bias voltage. (Author abstract). 21 Refs.

Al-Dhhan, Z.T. (Brunel Univ, Uxbridge, Engl); Hogarth, C.A. *J Mater Sci* v 23 n 6 Jun 1988 p 2205-2212.

**075707 MODIFICATION OF OXIDE FILMS BY ION IMPLANTATION:  $\text{TiO}_2$ -FILMS MODIFIED BY X-RAY.** Oxide films can be modified by ion implantation. Changes in the electrochemical properties of the films are due to the deposition profile of the implanted ion, i.e. doping and stoichiometric changes, as well as to the radiation damage. The latter is due to the formation of Frenkel defects and at high concentrations to a complete amorphization of the oxide film.  $\text{TiO}_2$ -films with  $1 < x < 2.5$  were produced by implantation of  $\text{Ti}^{+}$  and  $\text{O}^{+}$ -ions into anodic oxide films on titanium. The electrode capacity shows always the behaviour of an n-type semiconductor with an almost constant flatband potential but a strong maximum donor concentration at about 3 percent  $\text{Ti}^{+}$  concentration. Oxygen implantation, on the other hand, causes a small increase of donor concentration only at high concentration of  $\text{O}^{+}$ . (Edited author abstract). 38 Refs.

Schultze, J.W. (Univ Duesseldorf, Duesseldorf, West Ger); Elfenthal, L.; Leitner, K.; Meyer, O. *Electrochim Acta* v 33 n 7 Jul 1988 p 911-925.

**075708 CHARGE-TRAPPING PROPERTIES OF ULTRATHIN NITRIDED OXIDES PREPARED BY RAPID THERMAL ANNEALING.** Ultrathin (8-nm) oxides were nitrided by lamp-heated rapid thermal annealing in ammonia at 900-1150°C for 5-300 s. Measurements indicate that both the nitrogen concentration near the Si-SiO<sub>2</sub> interface  $[\text{N}]_{\text{int}}$  and the hydrogen concentration in nitrided oxides  $[\text{H}]$  increase monotonically as nitridation proceeds. The flat-band voltage shift  $\Delta V_{\text{FB}}$  and the increase of the midgap interface state density  $\Delta D$  induced by the constant-current stress were investigated. While  $\Delta V_{\text{FB}}$  increases monotonically as nitridation proceeds,  $\Delta D$  is found for the first time to show a turnaround with nitridation time: it increases, reaches a maximum at a certain nitridation time, and then decreases gradually to a value that is lower, in some cases, by more than one order of magnitude than that of a thermal oxide. It is found for the first time that  $\Delta V_{\text{FB}}$  increases in proportion to  $[\text{H}]$ . Based on the turnaround behavior of  $\Delta D$ , a

two-factor model is proposed in which one factor,  $[\text{H}]$ , increases  $\Delta D$  and the other one,  $[\text{N}]_{\text{int}}$ , reduces it. 30 refs.

Hori, Takashi (Matsushita Electric Industries Co Ltd, Moriguchi, Jpn); Iwasaki, Hiroshi; Tsuji, Kazuhiko. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 904-910.

**075709 STUDIES OF TUNGSTEN OXIDE ELECTROCHROMIC THIN FILMS AND POLYCRYSTALS BY THE EXAFS METHOD.** The structure of thermally evaporated tungsten trioxide ( $\alpha\text{-WO}_3$ ), amorphous thin films and a number of tungsten oxide polycrystals ( $\text{c-WO}_3$ ,  $\text{c-WO}_{2.96}$ ,  $\text{c-WO}_{2.72}$ ,  $\text{c-WO}_2$ ) have been studied by EXAFS method along the L<sub>III</sub>-edge of tungsten and by electron diffraction. The distances of W-O and W-W in the first and second tungsten coordinate spheres have been determined. (Author abstract) 9 refs.

Bets, V. (Latvian State Univ, Riga, USSR); Veispals, A.; Lusis, A.; Purans, J.; Ramans, G.; Sheromov, M.; Kochubei, D.; Fedorov, V. *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 175-177.

**075710 OXIDE THICKNESS DETERMINATION IN  $\text{Cr-SiO}_2$ -Si STRUCTURES BY CURRENT-VOLTAGE PAIRS.** A recently proposed method for obtaining the oxide thickness based in current-voltage pairs in the Fowler-Nordheim regime is analyzed in the  $\text{Cr-SiO}_2$ -Si(p) structures with oxide thickness in the range 50-60 Å. After measuring the capacitance-voltage, and current-voltage characteristics, the Fowler-Nordheim plot is obtained, yielding the  $\text{Cr-SiO}_2$  barrier height. Then, applying an iterative technique the oxide thickness is obtained for each I-V pair. The results show that in spite of the oscillatory structure exhibited in the Fowler-Nordheim regime the accuracy in the oxide thickness obtained in this way is much greater than in other electrical methods. (Author abstract) 8 refs.

Aymerich-Humet, X. (Univ Autonoma de Barcelona, Barcelona, Spain); Campabadal, F.; Serra-Mestres, F. *Vacuum* v 37 n 5-6 1987, VI Span Conf on Vac and Its Appl, Madrid, Spain, Dec 1985 p 403-405.

## Transport Properties

**075711 COMMENT ON 'EXPERIMENTAL PROCEDURE FOR DETERMINING TRANSPORT PROPERTIES OF OXIDE SCALES' AND 'DETERMINATION OF TRANSPORT PROPERTIES OF ALUMINA OXIDE SCALE'.** In two previous papers, a procedure and an associated formalism were developed for determining the transport properties ( $i$ ,  $\sigma$ ) of alumina scales formed by oxidation of metallic materials. In agreement with most of the literature data at that time, one of the assumptions was that the predominant moving species consisted of oxygen  $\text{O}^{2-}$  ions. It now appears that  $\text{Al}_2\text{O}_3$  scales can grow either by oxygen- or aluminum-predominant diffusion or by diffusion of both species making it necessary to develop a more general formalism. 3 refs.

Ben Abderrazik, Ghazi (Univ de Paris-Sud, Orsay, Fr); Millot, Francis; Moulin, Gerard; Huntz, Anne Marie. *J Am Ceram Soc* v 70 n 12 Dec 1987 p C374-C375.

**075712 TRANSPORT IN CHEMICAL POTENTIAL GRADIENTS OF MULTICOMPONENT OXIDES.** The ultimate goal of the investigation of solid state reactions in materials science is understanding of the atomistic reaction mechanisms. Therefore, all the complicated conditions at the phase boundaries and the complex phenomenological formalisms in any non-steady state only obscure the atomistic processes. Recent investigations have therefore studied transport in multicomponent nonmetallic solid phases, preferentially in multicomponent oxides, under the action of only the metalloid (oxygen) potential gradient in true steady state in order to clarify the atomistic interpretation. Model investigations of this kind are also of practical importance in view of the fact that nonmetallic, high-temperature ceramics are often multicomponent systems that normally operate under the

action of chemical potential gradients. Oxygen potential gradients are of particular interest. In order to systematize the relevant phenomena described (e.g. crystal shift, demixing, decomposition, external and internal oxidation, morphological instability), the author begins this review with a discussion of binary oxides ( $\text{AO}_n$ ), then progresses to ternary and higher oxides ( $[\text{A}_x\text{B}_y\text{O}_n]$ ). Similar considerations can be applied to sulfides, halides, etc. 47 refs.

Schmalzried, H. (Univ of Hannover, Hannover, West Ger). *Annu Rev Mater Sci* v 17 1987 p 149-160.

## Vacuum Applications

**075713 SOLID STATE OXYGEN SOURCE FOR UHV.** The principle of a solid state oxygen source is based on heating thermally decomposable metal oxides. In this procedure extremely pure oxygen is generated by variation of the heating temperature. The small size of the solid state oxygen source permits different applications and makes it easy to install in UHV systems. In this paper the features of this newly developed oxygen source and its application to thermal field emission are reviewed. (Author abstract) 5 refs.

Speidel, R. (Univ Tuebingen, Tuebingen, West Ger); Weidlich, E-R. *Vacuum* v 38 n 2 1988 p 89-92.

## Vaporization

**075714 MASS SPECTROMETRIC STUDY OF VAPORIZATION IN THE  $\text{SrO-B}_2\text{O}_3$  O<sub>3</sub> SYSTEM.** Vaporization in the  $\text{SrO-B}_2\text{O}_3$  system has been studied by a mass spectrometric Knudsen effusion method in the temperature range of 1281-1572 K. The vapor species  $\text{Sr(g)}$ ,  $\text{SrBO}_2(\text{g})$ ,  $\text{BO(g)}$ ,  $\text{B}_2\text{O}_2(\text{g})$ , and  $\text{B}_2\text{O}_3(\text{g})$  have been identified. On the basis of the partial pressures, the enthalpy of formation and the dissociation energy for  $\text{SrBO}_2(\text{g})$  have been determined and are compared with the values obtained for other alkaline earth metaborates and oxides and further alkali metaborates and monoxides. (Edited author abstract). 39 Refs.

Kou, Tomoyuki (Kyoto Univ, Uji, Jpn); Asano, Mitsuru. *High Temp Sci* v 24 n 1 Aug 1987 p 1-19.

## Wetting

**075715 WETTABILITY OF SOLID OXIDES BY LIQUID PURE METALS.** In this work, the wettabilities of solid oxides ( $\text{Al}_2\text{O}_3$ ,  $\text{MgO}$ ,  $\text{CaO}$ ,  $\text{ZrO}_2$  and  $\text{SiO}_2$ ) by liquid pure metals (Sn, Ag, Au and Cu) have been measured over a wide temperature range by the sessile drop method. Surface tension can be expressed by equations. Contact angles and work of adhesion between liquid pure metals and solid oxides are closely related to the standard free energy change of formation of oxides. Values of contact angle and work of adhesion change linearly with temperature. The wettability depends not only on the stability of solid oxides which can be expressed by the standard free energy change of oxide formation but also on the ionic radii of metals which compose the oxides. (Edited author abstract) In Japanese. 44 refs.

Nogi, Kiyoshi (Osaka Univ, Suita, Jpn); Oishi, Keiichiro; Ogino, Kazumi. *Nippon Kinzoku Gakkaishi* v 52 n 1 Jan 1988 p 72-78.

X-ray Analysis See ZINC ORE TREATMENT—Reduction.

**OXYGEN** See Also ACIDS—Oxidation; ALCOHOLS—Oxidation; ALUMINA; ALUMINUM SILICON MAGNESIUM ALLOYS—Oxidation; AMINES—Oxidation; ANTI-OXIDANTS—Spectroscopic Analysis; BIOCHEMISTRY; BIOMEDICAL EQUIPMENT; BIOREACTORS—Fermenters; BOILER CORROSION AND DEPOSITS; CARBON MONOXIDE—Oxidation; CATALYSTS—Bismuth Compounds; CATALYSTS—Supported; CELL CULTURE—Immobilization; CHEMICAL EQUIPMENT—Reactors; CHEMICAL REACTIONS—Oxidation; CHEMICAL REACTIONS—Reaction Kinetics; COAL—Chemical Reactions; COBALT COMPOUNDS—Solutions; CRYSTALS, LIQUID—Structure; DIAMONDS—Synthesis; ELECTRIC BATTERIES—Research; FLOW OF FLUIDS—Supersonic; GEOTEXTILES—Permeability; Mechanical; GERMANIUM AND ALLOYS—Electronic Properties; GLASS; GRAPHITE—Radiation Effects; INTERMETALLICS;



MANGANESE CHROMIUM ALLOYS—Phase Equilibria; MANGANESE COMPOUNDS—Leaching; MANGANESE COMPOUNDS—Synthesis; METHANE—Combustion; METHANE—Oxidation; MOLYBDENUM AND ALLOYS—Radiation Effects; MOLYBDENUM COMPOUNDS—X-Ray Analysis; MONOMERS—Polymerization; OLEFINS—Oxidation; ORGANIC COMPOUNDS—Oxidation; PHENOLS; POLYPROPYLENE—Decomposition; SEMICONDUCTING CADMIUM COMPOUNDS—Electrochemistry; SEMICONDUCTING GALLIUM ARSENIDE—Ion Implantation; SEMICONDUCTING GALLIUM ARSENIDE—Surfaces; SEMICONDUCTING GERMANIUM—Charge Carriers; SEMICONDUCTING SILICON—Fracture; SEMICONDUCTING SILICON—Impurities; SEMICONDUCTING SILICON—Ion Implantation; SENSORS—Materials; SILANES—Oxidation; SILICA—Thin Films; SILVER AND ALLOYS—Corrosion; STEELMAKING—Physical Chemistry; SUPERCONDUCTIVITY; TITANIUM AND ALLOYS—Mechanical Properties; TITANIUM COMPOUNDS—Surfaces; TRITIUM—Concentration; WATER POLLUTION—Agricultural Runoffs; XYLENE—Oxidation.

**075716 ANOMALOUS LUMINESCENCE OF SINGLET OXYGEN  $O_2(^1\Delta)$  IN MEDIUM WITH A CONDENSED DISPERSE PHASE.** The physical and chemical properties of long-lived electron-excited molecules are extensively studied. The present work theoretically predicts a new physical phenomenon, namely an increase in luminescence intensity (LI) of the singlet oxygen in DM as compared to that in a gas. 11 refs.

Kochelap, V.A. (Acad of Sciences of the Ukr SSR, Kiev, USSR); Izmailov, I.A.; Datzuk, V.V. *Opt Commun* v 66 n 4 May 1 1988 p 195-197.

**075717 INVESTIGATION OF THE PERMEABILITY OF OXYGEN THROUGH SILVER DURING A COMBINED DISCHARGE.** Results of experimental investigations of the permeability of oxygen through a silver polycrystal under the conditions of a high frequency discharge are described. The effect of a substantial increase in the permeability of oxygen within the temperature range of 473-873 K depending on the parameters of the electrodeless discharge is established. An increase in the permeability of oxygen through silver under the combined discharge, i.e., under the simultaneous effect of glow- and high frequency discharges is found. A theoretical justification of the gas permeability processes is presented. (Translated author abstract) In Russian. 8 refs.

Makhamov, T.M.; Radzhabov, T.D.; Suyarov, N.Yu. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 18 1987 p 69-71.

**075718 ADDITIONS OF SINGLET OXYGEN TO ALKOXY-SUBSTITUTED DIENES. THE MECHANISM OF THE SINGLET OXYGEN 1,2-CYCLOADDITION REACTION.** The reactions of singlet oxygen with (E,E)-, (E,Z)-, and (Z,Z)-1,4-dimethoxy-1,3-butadienes are reported. These compounds react to give dioxetanes as the major oxidized products. All three compounds are suggested to react via zwitterions, which collapse to dioxetanes before rotational equilibrium is reached. The zwitterions are stabilized in the more polar solvents, and as a result their rotation competes more effectively than in less polar solvents with closure to the dioxetanes. (Author abstract) 40 refs.

Clennan, Edward L. (Univ of Wyoming, Laramie, WY, USA); Nagraba, Krzysztof. *J Am Chem Soc* v 110 n 13 Jun 22 1988 p 4312-4318.

**Absorption** See Also IRON AND ALLOYS—Molten; SUPERCONDUCTING MATERIALS—Thermodynamics; WATER TREATMENT.

**075719 OXYGEN TRANSFER INTO NEWTONIAN AND NON-NEWTONIAN FLUIDS IN MECHANICALLY AGITATED VESSELS.** Oxygen transfer into Newtonian and non-Newtonian fluids was studied in stirred tank vessels. Emphasis was given to the rheological effects of the pseudoplastic medium on the volumetric oxygen transfer coefficient,  $K_L a$ . Results indicate that  $K_L a$  is a strong function of gassed power input per unit volume ( $P_g/V$ ) for the Newtonian fluid, but a weak function of  $P_g/V$  for the non-Newtonian fluid, and a strong function of superficial gas velocity ( $V_g$ ) for both fluids for paddle-type impellers.  $K_L a$  is found to decrease rapidly with an increase in apparent viscosity for values of

$\mu_a$  greater than 2.0 Pa · s. In addition to various correlations, a dimensionless correlation including the impeller Reynolds number, impeller Weber number, and the aeration number is presented for the prediction of  $K_L a$  in a gas-liquid non-Newtonian system. (Author abstract) 17 refs.

Ogut, Ali (Univ of Maryland, College Park, MD, USA); Hatch, Randolph T. *Can J Chem Eng* v 66 n 1 Feb 1988 p 79-85.

**075720 KINETICS OF ABSORPTION OF OXYGEN IN AQUEOUS ALKALINE SOLUTIONS OF POLYHYDROXYBENZENES.** Kinetics of oxygen absorption in aqueous alkaline solutions of polyhydroxybenzenes (PHBs) such as pyrogallol (PG), p-tert-butylcatechol (PTBC), tert-butylhydroquinone (TBHQ), 2,3,5-trimethylhydroquinone (TMHQ), and gallic acid (GA) was studied in a jet apparatus, a stirred cell, and a model stirred reactor, at  $29 \pm 1^\circ\text{C}$ . In the cases of PTBC and TBHQ, the reaction was found to be first order in oxygen as well as PTBC or TBHQ. The intrinsic second-order rate constants were in the range of  $1 \times 10^3$ – $1 \times 10^5 \text{ m}^3/(\text{kmol} \cdot \text{s})$ . In the case of PG, GA, and TMHQ, the system conformed to the instantaneous reaction regime. The theory of gas absorption with an instantaneous reaction was used to calculate the diffusivity of dissolved PG and GA. (Edited author abstract) 22 refs.

Patwardhan, Anand V. (Univ of Bombay, Bombay, India); Sharma, Man Mohan. *Ind Eng Chem Res* v 27 n 1 Jan 1988 p 36-41.

**075721 ACTIVATION OF MOLECULAR OXYGEN BY COPPER SALTS IN ACETIC ACID AND APPLICATION TO OXIDATION OF 1,4-DIPHENYLBUTADIENE AND OF 2,6-DI-T-BUTYLPHENOL: A 2,4-DIPHENYLFURAN SYNTHESIS.** The stoichiometry and the kinetics of molecular oxygen absorption by the  $\text{Cu}(\text{OAc})_2\text{-LiBr}$  system in solution in acetic acid-acetic anhydride (1:1) mixture has been investigated in the presence respectively of 1,4-diphenyl-1,3-butadiene (3) and of phenols as substrates. The former affords 2,5-diphenylfuran (5), whereas 2,6-di-t-butylphenol (10) leads to the formation of quinoid derivatives (12). The results are discussed on the basis of a duality of mechanism: the copper-LiBr catalyst used acts both as a dioxygen activation catalyst and as a halogenation system, this last aspect receiving further support from the copper halide-catalyzed oxidation of indene. (Author abstract) 20 refs.

Mamalis, I. (Univ de Liege, Liege, Belg); Noels, A.F.; Tihange, G.; Warin, R.; Teyssie, P.; Hubert, A.J. *J Mol Catal* v 45 n 3 May 30 1988 p 327-333.

**075722 MASS TRANSFER COEFFICIENT FOR OXYGEN ABSORPTION INTO A SOLID PARTICLE SUSPENSION IN A STIRRED TANK ABSORBER.** The influence of suspended solid particles on the volumetric mass transfer coefficient in the liquid phase ( $k_L a$ ) has been examined experimentally with the absorption of oxygen into slurries of various concentrations and sizes of glass beads and limestone particles by using a stirred tank reactor. The value of  $k_L a$  first decreases with an increase in the solid concentration, and then locally increases in a certain range of the solid concentration. It is considered that the decrease in  $k_L a$  is due to a decrease in the value of A and that the increase is mainly due to an increase in the value of  $k_L$ . The effect of temperature is considered to be caused mainly by the difference in the diffusivities of oxygen at different temperatures employed in this study. (Edited author abstract) 13 refs.

Uchida, Shigeo (Shizuoka Univ, Hamamatsu, Jpn); Matsumoto, Keiji; Kageyama, Shizuo; Seno, Tadachika. *J Chin Inst Chem Eng* v 19 n 3 May 1988 p 187-191.

**075723 PREDICTION OF  $K_L a$  IN CONVENTIONAL STIRRED FERMENTERS.** In this work values of the volumetric oxygen transfer coefficients ( $k_L a$ ) were determined (by means of the sulphite oxidation technique) in a series of 8- to 1000-dm<sup>3</sup> stirred fermenters

over a wide range of superficial air velocities and impeller rotational speeds. In spite of the great scale-up ratios, very different operating conditions and geometric dissimilarity, it was possible to develop an acceptable correlation of data (the average error being 17.5 percent) utilizing the gassed power consumption and aeration rate per unit volume as key parameters. Since such a correlation succeeded in reconstructing mass transfer rates even in 2.25-m<sup>3</sup> stirred fermenters, it would seem possible to rely on it to allow approximate, but acceptable prediction of  $k_L a$  values in large size multiple-impeller fermenters even when geometric similarity in scaling-up is not maintained. (Author abstract) 30 refs.

Moresi, Mauro (Univ of Basilicata, Potenza, Italy); Patete, Michele. *J Chem Technol Biotechnol* v 42 n 3 1988 p 197-210.

**Adsorption** See Also CATALYSIS; CATALYSTS—Copper; CATALYSTS—Intermetallics; CATALYSTS—Surfaces; ELECTRODES—Platinum; HYDROGEN—Adsorption; LITHIUM AND ALLOYS—Adsorption; MOLECULAR SIEVES—Physical Properties; NICKEL COMPOUNDS—Surfaces; NITROGEN—Adsorption; SOOT—Porosity; TUNGSTEN AND ALLOYS—Surfaces.

**075724 EVIDENCE FOR TWO OXYGEN CHEMISORPTION SITES ON THE Cr (100) SURFACE AT ROOM TEMPERATURE.** The interaction of oxygen with the clean Cr (100) surface has been investigated by work function measurements angle resolved photoemission spectroscopy and low energy electron diffraction. At low coverages (approx. 0.15 monolayer (ML)) the adsorbed oxygen is characterized by a work function decrease, a feature at 6.8 eV binding energy in UPS and a weak diffuse  $C(2 \times 2)$  diffraction pattern. This form of oxygen labeled form a is quite stable at temperatures below 500°C. Upon further exposure at room temperature ( $> 0.20 \text{ ML}$ ) a second form of oxygen labeled form b and characterized by a work function increase and peaks at 3.8 and 5.9 eV at normal photo-emission is identified. It is proposed that oxygen in forms a and b is chemisorbed in the fourfold hollow and on-top sites respectively. (Author abstract) 22 refs.

Peruchetti, J.C. (Univ de Haute Alsace, Mulhouse, Fr); Pirri, C.; Bolmont, D.; Gewinner, G. *Solid State Commun* v 59 n 7 Aug 1986 p 517-519.

**075725  $O_2$  AND  $N_2$  GAS PERMESELECTIVITY OF ALTERNATING COPOLY(VINYLIDENE CYANIDE-VINYL ACETATE).** The sorption and permeation of oxygen and nitrogen in and through alternating copoly(vinylidene cyanide-vinyl acetate) membranes annealed for different periods just below  $T_g$ , 160°C, were investigated over the pressure range from 100 to 1000 cmHg. The dual-mode sorption and mobility models were used to analyze the results. A sub- $T_g$  annealing of copoly(VDCN-VAc) caused a slight decrease in the amount of sorption in the membranes. This decrease in the amount of oxygen and nitrogen sorption can be attributed to a decrease in the Langmuir sorption capacity term,  $C_H$ , with increasing sub- $T_g$  annealing period. The densification of copoly(VDCN-VAc) membranes caused simultaneously by the annealing remarkably reduced diffusion coefficients for both gases. (Edited author abstract) 10 refs.

Hachisuka, Hisao (Nagoya Inst of Technology, Nagoya, Jpn); Kito, Hitoshi; Tsujita, Yoshiharu; Takizawa, Akira; Kinoshita, Takatoshi. *J Appl Polym Sci* v 35 n 5 Apr 1988 p 1333-1340.

**075726 TPD AND XPS STUDIES OF  $O_2$ ,  $CO_2$ , AND  $H_2O$  ADSORPTION ON CLEAN POLYCRYSTALLINE GRAPHITE.** Temperature programmed desorption (TPD) and X-ray photoelectron spectroscopy (XPS) studies on clean polycrystalline graphite under ultra-high vacuum conditions are described. The same three strongly bound oxygenated species are formed after  $O_2$ ,  $CO_2$ , and  $H_2O$  adsorption. They decompose to give CO at 973, 1093, and 1253 K. Small amounts of  $CO_2$  are also produced after adsorption of these gases, with desorption



temperatures at 463, 573, 693, and 793 K. Attempts are made to ascribe these TPD features more precisely. After  $H_2O$  adsorption, some  $H_2$  is evolved at ca. 1300 K. Hydrocarbons ( $C_1$ - $C_6$ ) are also produced but in smaller amounts. A general mechanism is proposed for the gasification reactions of graphite with  $O_2$ ,  $CO_2$ , and  $H_2O$ . (Edited author abstract). 33 Refs.

Marchon, B. (Lawrence Berkeley Lab, Berkeley, CA, USA); Carrazza, J.; Heinemann, H.; Somorjai, G.A. *Carbon* v 26 n 4 1988 p 507-514.

**075727 KINETICS OF ABSORPTION OF OXYGEN INTO AQUEOUS SODIUM SULFITE: ORDER IN OXYGEN.** The kinetics of oxidation of sodium sulfite, which is catalyzed by cobalt ions, has received considerable attention in the chemical engineering literature. Ahmad et al. report that order in oxygen is first order for the oxygen partial pressure range of 0.2 to 1 atm for ammonium sulfite oxidation. Botton et al. also concluded first-order dependency for the same pressure range. When the experimental results are extrapolated to zero oxygen concentration, they do not yield zero absorption rate, indicating that the order in oxygen is higher than one at low oxygen concentrations. This investigation provides accurate substantial data. 12 Refs.

Alper, E. (King Fahd Univ of Petroleum & Minerals, Dhahran, Saudi Arabia); Sbu-Sharkh, B. *AIChE J* v 34 n 8 Aug 1988 p 1384-1386.

**075728 ATOMIC SCALE CHARACTERIZATION OF OXYGEN ADSORBATES ON Al(111) BY SCANNING TUNNELING MICROSCOPY.** We present atomic scale STM pictures of clean and oxygen containing Al(111) surfaces. Little influence of the surface oxygen on the topography of the surfaces is found. Three different oxygen species can be distinguished. One of them is associated with adsorbed oxygen and found to grow in small islands upon adsorption at 300 K. Characteristic hexagonal nuclei, created upon annealing of a dilute oxygen adlayer, represent the second one. By comparison with existing spectroscopic data these are assigned to nuclei of a surface oxide. (Author abstract). 9 Refs.

Wintterlin, J. (Max-Planck-Gesellschaft, Berlin, West Ger); Brune, H.; Hoefel, H.; Behm, R.J. *Appl Phys A* v 47 n 1 Sep 1988 p 99-102.

**Applications** See GLASS FURNACES; PULP MANUFACTURE—Bleaching.

**Bonding** See GLASS; SEMICONDUCTING SILICON—Adsorption.

**Chemical Reactions** See Also FLOW OF FLUIDS—Nozzles; MOLYBDENUM COMPOUNDS—Chemical Attack; SEWAGE TREATMENT—Activated Sludge.

**075729 HIGH TEMPERATURE RATE COEFFICIENT FOR THE REACTION OF  $O(^3P)$  WITH  $H_2$  OBTAINED BY THE RESONANCE ABSORPTION OF O AND H ATOMS.** The reaction of  $O(^3P)$  with  $H_2$  has been studied behind reflected shock waves in the temperature range of 1713-3532K at total pressures of about 1.4-2.0 bar by Atomic Resonance Absorption Spectroscopy using mixtures of  $N_2O$  and  $H_2$  highly diluted in Ar. The O atoms were generated by the fast thermal decomposition of  $N_2O$  and the reaction with  $H_2$  was followed by monitoring the time dependent O and H atom concentrations in the postshock reaction zone. For the experimental conditions chosen, the measured O and H atom concentrations were primarily sensitive to the well-known  $N_2O$  dissociation and to the studied reaction and hence its rate coefficient could be deduced. (Edited author abstract) 24 refs.

Natarajan, K. (Univ Duisburg, Duisburg, West Ger); Roth, P. *Combust Flame* v 70 n 3 Dec 1987 p 267-279.

## Compressors

**075730 HIGH PRESSURE OXYGEN CENTRIFUGAL COMPRESSOR FOR UBE INDUSTRIES, LTD.** IHI-SULZER developed a high-pressure oxygen centrifugal compressor indispensable for coal gasification plants

with paramount emphasis on safety through vigorous theoretical and experimental studies to cope with the various problems involved in compressor engineering. In July 1984, IHI delivered to Ube Industries, Ltd., of Ube, Yamaguchi Prefecture, the world's largest oxygen compressor rated as a discharge pressure of 60 kgf/cm<sup>2</sup> (5.9 MPa) and a flow rate of 40,000 m<sup>3</sup> (normal)/h driven by a 9,150 kW steam turbine for the world's first ammonia plant using gasified coal. The features, specifications and construction of this oxygen compressor are described in this article.

Shimada, Yoshihiro (IHI, Tokyo, Jpn); Kimura, Yasuo. *IHI Eng Rev (Engl Ed)* v 19 n 3 Jul 1986 p 141-142.

**Concentration** See CALORIMETERS—Applications; CATALYSTS—Cobalt Compounds; CATALYSTS—Regeneration; CATALYSTS—Ruthenium Compounds; GLOW DISCHARGES; OIL WELL PRODUCTION—In Situ Combustion; POLYPROPYLENE—Oxidation; RUTHENIUM COMPOUNDS—Synthesis.

**Desorption** See Also SUPERCONDUCTING MATERIALS—Composition Effects; SUPERCONDUCTING MATERIALS—Oxides.

**075731 THERMODYNAMIC DESORPTION OF OXYGEN IN HIGH  $T_c$  SUPERCONDUCTING OXIDES.** We measure as a function of temperature and composition the equilibrium pressure of desorbed oxygen from superconducting oxides  $MBa_2Cu_3O_{6+x}$  ( $M=Eu, Y$ ). Using the Lacher model we determine the enthalpy of formation of the excess oxygen  $x$  ( $-0.7$  eV/atom) as well as the repulsive O-O interaction energy (0.11 eV). We also observe that there is a spontaneous reabsorption of the oxygen above about 600°C with formation of more stable oxides. (Author abstract) 5 refs.

Burger, J.P. (Lab Hydrogene et Defauts dans les Metaux, Orsay, Fr); Lesueur, L.; Nicolas, M.; Daou, J.N.; Dumoulin, L.; Vajda, P. *J Phys (Paris)* v 48 n 9 Sep 1987 p 1419-1422.

**Diffusion** See Also COAL COMBUSTION—Spontaneous; LIQUID METALS—Diffusion; NIOBIUM VANADIUM ALLOYS—Gases; PLASTICS FILMS—Molecular Structure; SEMICONDUCTING LEAD COMPOUNDS—Thin Films; SUPERCONDUCTING MATERIALS—Physical Chemistry; SUPERCONDUCTING MATERIALS—Spectroscopic Analysis; VARISTORS; WASTEWATER—Treatment.

**075732 OXYGEN DIFFUSIVITY IN ELLIS LIQUIDS.** The objective of present study was to determine the oxygen diffusivity in polyacrylamide solutions whose rheological behavior was described by the Ellis flow model. It is found that in polymer solutions values of oxygen diffusivity greater than those in water at the same temperature have been established. However, the diffusivity of oxygen in polymer solutions was of the same order of magnitude as that in water. For more synoptical comparison the ratio of the oxygen diffusivity in polyacrylamide solutions to that in water at the same temperature,  $D/D_w$ , is also reported. 7 refs.

Potucek, F. (Inst of Chemical Technology Pardubice, Pardubice, Czech); Stejskal, J. *Chem Eng Sci* v 42 n 11 1987 p 2793-2795.

**075733 THEORY OF OXYGEN DIFFUSION IN 1, 2, 3 HIGH- $T_c$  SUPERCONDUCTORS.** Results of a theoretical model of the oxygen diffusion in 1,2,3 high- $T_c$  superconductors are given and compared to experimental data. The model discussed in this paper gives an indication for values of the activation energy to be expected under different experimental conditions. 10 refs.

Bakker, H. (Univ van Amsterdam, Neth); Westerveld, J.P.A.; Welch, D.O. *Physica B & C* v 147 n 2-3 Jan-Feb 1988 p 161-165.

**075734 MEASUREMENT OF OXYGEN SELF-DIFFUSION IN SOLID BY A DIRECT COMBINATION OF DIFFUSION-ANNEALING FURNACE AND MASS-SPECTROMETER.** A new system has been designed for the direct introduction of gas from the diffusion-annealing furnace into a mass-spectrometer. A

variable leak valve was used as an interface between the furnace and mass-spectrometer. Using this apparatus, a large number of data were obtained about 100 times as many as those from batch analysis. Some test data of powder materials are presented and compared with those of a sintered material. (Author abstract) 17 refs. In Japanese.

Haneda, Hajime (Nat'l Inst for Research in Inorganic Materials, Tsukuba, Jpn); Matsuda, Shin-ichi; Shirasaki, Shin-ichi. *Yogyo Kyokai Shi* v 96 n 3 1988 p 330-335.

**075735 ANOMALY OF OXYGEN DIFFUSION IN AQUEOUS XANTHAN SOLUTIONS.** A membrane-covered polarographic oxygen electrode was used to measure oxygen diffusion coefficients in aqueous polyelectrolyte solutions of xanthan gum, sodium alginate, and sodium carboxymethylcellulose (CMC). In sodium alginate solutions, dilute xanthan solutions, and solutions containing more than 0.3 wt% CMC, oxygen diffusion coefficients decrease with increasing polymer concentrations. Interestingly, in dilute CMC solutions and concentrate xanthan solutions containing more than 0.5 wt% xanthan gum, oxygen diffusion coefficients increase with increasing polymer concentrations, and values exceeding that in pure water are generally observed. (Author abstract) 49 refs.

Ho, Chester S. (State Univ of New York at Buffalo, Buffalo, NY, USA); Ju, Lu-Kwang; Baddour, Raymond F. *Biotechnol Bioeng* v 32 n 1 Jun 1988 p 8-17.

**075736 SIMULTANEOUS MEASUREMENTS OF OXYGEN DIFFUSION COEFFICIENTS AND SOLUBILITIES IN FERMENTATION MEDIA WITH POLAROGRAPHIC OXYGEN ELECTRODES.** A membrane-covered oxygen electrode was used to measure oxygen diffusion coefficients and solubilities in aqueous glucose solutions and various fermentation media following a newly developed methodology. The fermentation media studied were tryptic soy broth and those for fermentations of *Penicillium chrysogenum*, *Saccharomyces cerevisiae* and *Micrococcus glutamicus*. The experimental results of oxygen diffusion coefficients and solubilities in glucose solutions were in good accord with the literature data. As for the fermentation media, both oxygen diffusion coefficients and solubilities were found to decrease with an increased fractional composition of these media, and log-additive behaviors of the oxygen diffusion coefficients and solubilities in fermentation media were observed. (Author abstract) 47 refs.

Ju, Lu-Kwang (State Univ of New York, at Buffalo, Buffalo, NY, USA); Ho, Chester S.; Baddour, Raymond F. *Biotechnol Bioeng* v 31 n 9 Jun 5 1988 p 995-1005.

**075737 COMMENTS ON VALIDITY OF MEASURING OXYGEN DIFFUSION COEFFICIENTS WITH POLAROGRAPHIC OXYGEN ELECTRODES.** A basic feature of the arrangements already developed for measuring oxygen diffusion coefficients with polarographic oxygen sensors by T.K. Goldstick and I. Fatt and K. Akita is that a liquid film of small volume is situated in precisely defined geometric shapes between the membrane and the surrounding atmosphere. As a result, the effect of side oxygen diffusion can correctly be eliminated by calibration, since its effect in the actual measurement is the same as in the calibration measurements. Owing to this, the oxygen side diffusion may exert different effects in their measurements, depending on the uncontrolled variable, which is the absolute distance between the membrane and the gas-liquid interface. 10 refs.

Linek, V. (Prague Inst of Chemical Technology, Prague, Czech); Vacek, V. *Biotechnol Bioeng* v 31 n 9 Jun 5 1988 p 1010-1011.



**075738 EFFECTS OF MICROORGANISMS ON EFFECTIVE OXYGEN DIFFUSION COEFFICIENTS AND SOLUBILITIES IN FERMENTATION MEDIA.** Effective oxygen diffusion coefficients and solubilities were measured for submerged cultures of *Saccharomyces cerevisiae*, *Escherichia coli*, and *Penicillium chrysogenum*. Both effective oxygen diffusion coefficients and solubilities were found to decrease with increasing cell concentrations in the fermentation media. Comparison of the experimental results of effective oxygen diffusion coefficients in fermentation media with values theoretically predicted on the assumption of unpenetrable microbial cells indicates that oxygen molecules diffuse through the cells during the diffusion process. Within the cell concentration range of typical submerged fermentations, the effective oxygen diffusion coefficient of the fermentation media can be described as  $D_e/D_1 = 1 + A_1f + A_2f^2$ . In this equation,  $f$  is the cell volume fraction and both  $A_1$  and  $A_2$  are functions of the shape of the shape of the cells and the ratio of effective oxygen diffusion coefficient in microbial cells to that in the medium. (Author abstract). 59 Refs.

Ho, Chester S. (State Univ of New York at Buffalo, Buffalo, NY, USA); Ju, Lu-Kwang. *Biotechnol Bioeng* v 32 n 3 Jul 20 1988 p 313-325.

**Dissolved Oxygen Sensors** See Also CELL CULTURE—Immobilization.

**075739 FLEXIBLE APPROACH TO AMPEROMETRIC OXYGEN DETERMINATION.** In vitro and in vivo results obtained from a novel flexible amperometric oxygen sensor are reported. The sensor is fabricated using thin film deposition techniques and is operated by the application of a pulsed waveform. Development of the sensor was undertaken in order to produce a device that is capable of being sited at the interface of a wound and an overlying wound dressing. Oxygen determinations in such an environment would aid in gaining an understanding of the role of oxygen in wound healing and the type of wound dressing that would provide an environment conducive towards wound healing. In vitro data indicate that linearity of response is good although other performance characteristics are irreproducible. In vivo response to oxygen has been observed 50 h after insertion into a porcine sham wound. Expected trends were followed when changes to the oxygen regime of the wound space were effected, but absolute values of oxygen tension are difficult to state with certainty. This may be due to poor calibration stability and inadequate sealing of the sensor from the surrounding environment. (Author abstract) 10 refs.

Hutchings, M. (Univ of Oxford, Headington, Engl); Dewey, I.; Cherry, G.W.; Rolfe, P. *J Biomed Eng* v 10 n 2 Apr 1988, Pap Presented at the 27th Annu Sci Meet of the Biol Eng Soc, Oxford, Engl, Sep 2-4 1987 p 149-154.

**Electrolysis** See HYDROGEN PEROXIDE—Production.

## Encapsulation

**075740 ENCAPSULATION OF OXYGEN AND NITROGEN BY ZEOLITES FOR THEIR STORAGE.** The authors conducted experimental studies of nitrogen and oxygen encapsulation by the synthetic zeolite KNaA containing 68% K<sup>+</sup> and 32% Na<sup>+</sup> in the pressure range 10-100 MPa and temperature range 450-600°K, as well as of nitrogen encapsulation by the commercial zeolite KNaA which contains approx. 20 wt.% clay as binder. The experimental results for nitrogen and oxygen encapsulation by zeolites are given. The results of the studies of nitrogen and oxygen encapsulation by the zeolite KNaA with various degrees of ion exchange are presented. It is shown that the volume of the gas encapsulated by the zeolite depends not merely on the temperature and pressure of the gas in encapsulation process. 5 refs.

Kalinnikova, I.A.; Muchaidze, N.N.; Nikiforov, V.S.; Pribylov, A.A.; Serpinski, V.V.; Tishin, I.V. *Chem Pet Eng* v 22 n 5-6 May-Jun 1986 p 271-273.

**Environmental Testing** See WATER POLLUTION—Water Quality.

**Forming** See PHOSPHATES—Electrolysis.

**Industrial Applications** See PULP MANUFACTURE—Bleaching.

## Ionic Conduction

**075741 OXYGEN ION CONDUCTIVITY OF THE CERIA-SAMARIUM OXIDE SYSTEM WITH FLUORITE STRUCTURE.** Ionic conduction of oxygen in the ceria-samarium oxide system was investigated as a function of temperature, partial pressure of oxygen and the oxide composition, together with its crystal structure, density and defect structure. The ionic conductivity of  $(\text{CeO}_2)_{1-x}(\text{SmO}_{1.5})_x$  was the highest in  $\text{ZrO}_2$ ,  $\text{ThO}_2$  and  $\text{CeO}_2$ -based oxide systems. The system  $\text{CeO}_2\text{-SmO}_{1.5}$  consisted of the solid solution with a fluorite structure at  $x < 50$  at. percent. The ionic transference number was nearly unity between 600 and 900°C. With an increase in  $\text{Sm}_2\text{O}_3$  content, the ionic conductivity gradually decreased due to a decrease in mobility of oxygen ions. The samarium oxide-doped ceria was less reducible than pure and alkaline earth oxide-doped ceria. (Author abstract). 17 Refs.

Yahiro, Hidenori (Kyushu Univ, Kasuga, Jpn); Eguchi, Yukari; Eguchi, Koichi; Arai, Hiromichi. *J Appl Electrochem* v 18 n 4 Jul 1988 p 527-531.

**Ionization** See ELECTRIC BATTERIES—Performance; IONS—Velocity Analyzers; NITROGEN—Ionization.

**Isotopes** See Also GLACIERS; ORE DEPOSITS—Ore; SUPERCONDUCTING MATERIALS.

**075742 CURRENT METHODOLOGY FOR OXYGEN-15 PRODUCTION FOR CLINICAL USE.** The radionuclide oxygen-15, half-life 2.05 min, is used in simple chemical forms to study oxygen metabolism, blood flow and blood volume in man, using the technique of positron emission tomography (PET). The production of  $^{15}\text{O}$  and the preparation of  $[^{15}\text{O}]\text{O}_2$ ,  $[^{15}\text{O}]\text{CO}_2$ ,  $[^{15}\text{O}]\text{CO}$  and  $[^{15}\text{O}]\text{H}_2\text{O}$  is now well established in several PET centers in Europe, North America and Japan. In order to provide a practical design and operational data base for others intending to make use of these techniques an EEC task group representing four European laboratories routinely using  $^{15}\text{O}$  in PET studies was set up to review the current practice of  $^{15}\text{O}$  production purification and quality control of the clinically useful products. (Author abstract) 17 refs.

Clark, J.C. (Hammersmith Hospital, London, Engl); Crouzel, C.; Meyer, G.J.; Strickmans, K. *Appl Radiat Isot* v 38 n 8 1987 p 597-600.

## Magnetic Properties

**075743 MAGNETIC STRUCTURE OF  $\beta$  OXYGEN: A NEUTRON POLARIZATION ANALYSIS STUDY.** We have performed a differential polarization analysis neutron scattering experiment on  $\beta$  oxygen to measure the magnetic part of the scattering and determine its magnetic structure. We have checked all the models proposed for  $\beta$  oxygen and all those compatible with crystal symmetry. The model which fits the experimental neutron profile best is a two dimensional short range order, a helix propagating perpendicularly to the three fold axis with an angle close to 140° between neighboring molecules and with a correlation length of 5 Å. (Author abstract) 18 refs.

Dunstetter, F. (CEN-Saclay, Gif-sur-Yvette, Fr); Plakhti, V.P.; Schweizer, J. *J Magn Magn Mater* v 72 n 3 Apr 11 1988 p 258-266.

**Manufacture** See Also COMPRESSORS—Design.

**075744 PROCESS DESIGN AND EVALUATION OF A CONTINUOUS CHEMICAL PLANT FOR THE SINGLET OXYGEN-IODINE LASER.** Process designs were evaluated for the continuous, large-scale generation of a singlet delta oxygen for use in a chemical oxy-

gen-iodine laser. The excited singlet oxygen is generated from the chemical reaction of chlorine gas with basic hydrogen peroxide. The chemical reaction also produces a large waste brine stream that can be controlled by recycling through a chlor-alkali cell, which regenerates the reactants  $\text{Cl}_2$  and  $\text{NaOH}$ . To prevent deactivation of this excited oxygen, a large excess of hydrogen peroxide is typically used to change the reaction mechanism. This use of excess hydrogen peroxide or nonstoichiometric generation leads to substantial increases in capital and operating costs when compared with theoretical stoichiometric (no excess) generation. (Edited author abstract) 13 refs.

Demyanovich, Robert J. (TERA Corp, Berkeley, CA, USA); Lynn, Scott. *Fusion Technol* v 12 n 3 Nov 1987 p 488-501.

**Mass Transfer** See Also PULP MANUFACTURE—Bleaching; VITAMINS—Fermentation.

**075745 GAS HOLDUP AND VOLUMETRIC OXYGEN TRANSFER COEFFICIENT IN A THREE-PHASE FLUIDIZED BED BIOREACTOR.** The gas-liquid volumetric oxygen transfer coefficient in a three-phase fluidized bed bioreactor was studied using Ca-alginate gels as the solid phase. The coefficient,  $k_{L,a}$ , in three-phase fluidized beds was smaller than that in bubble columns, regardless of gel diameter. This result was a new finding, and was shown to be characteristic of low-density gel beds. The value of  $k_{L,a}$  decreased with decreasing gel diameter and with increasing particle concentration in the liquid suspension. This indicates that an optimal gel diameter and particle concentration exist in application of gels to the bioreactor. Dimensionless correlations are proposed for  $k_{L,a}$  and  $C_G$ . (Author abstract) 14 refs.

Sun, Yan (Univ of Tokyo, Tokyo, Jpn); Nozawa, Taihei; Furusaki, Shintaro. *J Chem Eng Jpn* v 21 n 1 Feb 1988 p 15-20.

**075746 MEAN BUBBLE DIAMETER AND OXYGEN TRANSFER COEFFICIENT IN A THREE-PHASE FLUIDIZED BED BIOREACTOR.** The volume-surface mean diameter of bubbles  $d_{v,s}$  was measured using the electroresistivity probe method. From the mean bubble diameter and volumetric mass transfer coefficient  $k_{L,a}$ , interfacial area  $a$  and mass transfer coefficient  $k_L$  were obtained. The solid phase, Ca-alginate gels, had almost no effect on bubble breakup, and a decrease in  $k_{L,a}$  with decreasing gel diameter was found to be caused by the corresponding decrease in  $k_L$ . The mean bubble diameter increased significantly with increasing particle concentration. The value of  $k_L$  was not affected by particle concentration. Thus, a decrease in  $k_{L,a}$  with increasing particle concentration was mainly attributed to the corresponding decrease in interfacial area. Dimensionless correlations were proposed for  $d_{v,s}$ ,  $a$  and  $k_L$ . (Author abstract) 7 refs.

Sun, Yan (Univ of Tokyo, Tokyo, Jpn); Furusaki, Shintaro. *J Chem Eng Jpn* v 21 n 1 Feb 1988 p 20-24.

**075747 MASS TRANSFER OF OXYGEN IN POLY(2-HYDROXYETHYL METHACRYLATE).** The diffusion coefficient of oxygen in poly(2-hydroxyethyl methacrylate) has been explicitly measured using an optical technique based on fluorescence quenching. This measurement represents the first explicit determination of  $D_{O_2}$  in PHEMA. A diffusion coefficient of oxygen in PHEMA of  $1.36 \times 10^{-7} \text{ cm}^2/\text{s}$  at 20°C was obtained from this measurement. This value is shown to agree well with permeability data for PHEMA, the free volume theory of diffusion, and with values of  $D_{O_2}$  that have been explicitly measured in other methacrylate hydrogels. (Author abstract) 17 refs.

Parker, J.W. (Univ of California, Los Angeles, CA, USA); Cox, M.E. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 1179-1188.

**Measurements** See Also BOILER CONTROL—Combustion; PACKAGING MATERIALS—Testing; SEWAGE TREATMENT—Aeration.



**075748 CONTACT-FREE MEASUREMENTS OF OXYGEN CONCENTRATION IN INDUSTRIAL FLAMES BY RAMAN SCATTERING.** Spatially resolved oxygen concentration measurements were performed in premixed hydrocarbon flames by using laser induced spontaneous Raman scattering. The measurements demonstrate the performance of a relatively simple pulsed laser Raman probe for fundamental combustion studies and also for the control of the equivalence ratio in flames (best spatial resolution: 0.2 mm<sup>3</sup>; theoretical detection limit: 0.8% of O<sub>2</sub>). Comparison of the results with those obtained by a mechanical suction probe (Magnos 2 T) confirmed a good agreement. At present, control of different stoichiometric conditions is possible at a minimum O<sub>2</sub> concentration of 1.3%. (Author abstract) 29 refs.

Leipertz, Alfred (Ruhr-Univ Bochum, Bochum, West Ger); Haumann, Juergen; Fiebig, Martin. *Chem Eng Technol* v 10 n 3 Jun 1987 p 190-203.

**075749 IMPROVED METHOD FOR DETERMINATION OF THE VOLUMETRIC OXYGEN TRANSFER COEFFICIENT IN FERMENTATION PROCESSES.** The volumetric oxygen transfer coefficient,  $K_L a$ , is one of the most important parameters in the scale-up of aerobic fermentation processes. It is a measure of the gas-liquid-oxygen transfer performance of a given fermentor. Because of the involvement of oxygen in the metabolic energy supply, the  $K_L a$  value may play a key role in the synthesis of products and biomass. This report intends to present a quick, convenient, and reliable method for determination of  $K_L a$  values in fermentation processes without difficulties encountered in the previous methods. In the previous communication, some preliminary considerations were discussed. Both theoretical considerations and experimental results in detail has been provided here. 8 refs.

Yang, Xiao-Ming (Acad Sinica, Beijing, China); Mao, Zhuo-Xiong; Yang, Shou-Zhi; Mao, Wei-Ying. *Biotechnol Bioeng* v 31 n 9 Jun 5 1988 p 1006-1009.

## Microanalysis

**075750 SOLID STATE EFFECTS ON CORE ELECTRON CROSS-SECTIONS USED IN MICROANALYSIS.** In quantitative electron energy loss spectroscopy, there has been some controversy as to whether fine structure due to solid state effects leads to errors in quantitative analysis. We consider the oxygen K edges in MnO and MnO<sub>2</sub>, which are different environments for the oxygen fine structure. We show that the partial cross-sections as a function of energy window for the oxygen K edge oscillate about the isolated atom partial cross-section. For an energy window larger than 20 eV, the worst-case error is of the order of 5%. (Author abstract) 11 refs.

Weng, Xudong (Arizona State Univ, Tempe, AZ, USA); Rez, Peter. *Ultramicroscopy* v 25 n 4 1988 p 345-348.

**Mixing** See COAL DUST—Detonation.

## Monitoring

**075751 OXYGEN MONITORING IN ENVIRONMENTAL CHAMBERS PAYS SAFETY DIVIDENDS.** At Hughes Aircraft Co., continuous oxygen monitoring systems are providing an extra level of worker protection in facilities where advanced electronic components for radar, defense and communications systems are tested. A comprehensive monitoring system is used in confined space applications due to the safety needs in and around the environmental chambers used for testing electronic components used in satellites and other aerospace applications.

Long, Stephen E. (Mine Safe Appliance Co, Pittsburgh, PA, USA). *Eval Eng* v 26 n 11 Nov 1987 p 154-156.

## Partial Pressure Sensors

**075752 SIMPLE ZERO CALIBRATOR FOR TRANSCUTANEOUS OXYGEN ELECTRODES.** The authors have developed a simple 'zero calibrator' which requires no gas bottles or chemical solutions. The calibrator essentially consists of an uncovered polarographic oxygen electrode having a large cathode 1 cm in diameter. This is mounted in a plastic chamber into which the transcutaneous oxygen electrode can be fitted. In the chamber, the thin gap between the oxygen electrode cathode and the face of the transcutaneous sensor is filled with water containing a small amount of salt (NaCl). When the calibrator is switched on, the large cathode rapidly consumes the oxygen present in the thin layer of water trapped between it and the transcutaneous sensor membrane. As a result, the oxygen reading from the transcutaneous sensor drops exponentially to zero. Oxygen replenishment from the atmosphere is prevented by the liquid seal between the transcutaneous sensor membrane ring and the circumference of the calibration chamber. 2 refs.

Delpy, D.T. (Univ Coll London, London, Engl); Halsall, D.N.; Parker, D. *Med Biol Eng Comput* v 26 n 1 Jan 1988 p 110-111.

## Permeability, Mechanical

**075753 EFFECTS OF NONVOLATILE ADDITIVES ON PERMEABILITIES OF O<sub>2</sub> AND N<sub>2</sub> THROUGH WATER-SWOLLEN POLY(VINYL ALCOHOL) MEMBRANES.** Effects of various nonvolatile additives on the permeabilities of O<sub>2</sub> and N<sub>2</sub> through water-swollen poly(vinyl alcohol) membranes were investigated. It was found that the addition of substances with a high affinity for the polymer chain altered significantly the permselectivity to O<sub>2</sub> over N<sub>2</sub>. For such solution/membrane systems, the permeability ratio of O<sub>2</sub> to N<sub>2</sub> ranged from 4 to 14, higher than that of any previously reported polymer membrane. To examine the mechanism of permeation of the gases, a dual path model is presented to account for the variation of diffusivity with swelling ratio. The enhanced permselectivity to O<sub>2</sub> over N<sub>2</sub> is attributed to the presence of a polymer-perturbed solution in the membrane rather than the bulk solution. (Author abstract) 13 refs.

Zhang, Wei-Zhong (Tokyo Inst of Technology, Tokyo, Jpn); Nodera, Akio; Satoh, Mitsuru; Komiya, Jiro. *J Membr Sci* v 35 n 3 Feb 1988 p 311-324.

## Photolysis See OZONE—Production.

**Precipitation** See SEMICONDUCTING SILICON—Growth; SEMICONDUCTING SILICON—Impurities.

**Production** See Also ANODES—Dissolution; ELECTRODES—Materials; METALS AND ALLOYS—Amorphous; STEELMAKING—Waste Heat Utilization.

**075754 INDUSTRIAL OXYGEN PRODUCTION—PRESENT STATE AND FUTURE PROSPECTS.** The paper describes principal methods of separating oxygen from air. Discussion focuses on (1) Cryogenic process, (2) Pressure swing adsorption (PSA) process and (3) Membrane process. Other developing technologies such as the chemical absorption process using molten alkali salts and the liquid membrane process are also briefly discussed. The cryogenic process is the best way to produce high purity oxygen at a rate of over 5,000 m<sup>3</sup>/h while the PSA process is suitable for producing oxygen of relatively high purity up to 5,000 m<sup>3</sup>/h at the moment. The use of gaseous oxygen supplies by PSA plants is expanding while the liquid oxygen market is shrinking. Polymeric membranes are used for medical purposes and also oxygen-enriched air production for efficient combustion. The method using molten salts absorption and the liquid membrane method are still under development but are expected to significantly reduce power consumption for high purity oxygen separation in the near future. (Author abstract) In Japanese. 17 refs.

Matsuoka, Takashi (Nippon Sanso KK, Tokyo, Jpn).

Nenryo Kyokai Shi v 66 n 9 Sep 1987 p 763-769.

**075755 OXYGEN EVOLUTION AT PASSIVATED METAL SURFACES.** The problem of oxygen evolution at the surface of an anodically dissolving, passivated metal is discussed. This process is shown to be a concomitant process that can occur, both at potentials more negative and at potentials more positive than the transpassivation potential  $E_p$ . Transpassivation occurs since at  $E \approx E_p$  the point defect concentration of the passivating oxide attains its highest admissible value. (Author abstract) 2 refs.

Alekseev, Yu.V. (L.Y. Karpov Physicochemical Scientific-Research Inst, Moscow, USSR); Popov, Yu.A. *Sov Electrochem* v 23 n 7 Jul 1987 p 880-885.

**075756 ELECTROCATALYSIS BY AMORPHOUS NiCoZr ALLOYS OF OXYGEN EVOLUTION IN 30 W/O KOH AT 70°C.** In this present communication, amorphous alloys NiZr<sub>2</sub>, (Ni<sub>0.4</sub>Co<sub>0.6</sub>Zr<sub>2</sub>), (Ni<sub>0.4</sub>Co<sub>0.6</sub>Zr) and pure Ni and Co are investigated as anodes for O.E.R. (Oxygen Evolution Reaction) from 30 w/o KOH at 70°C. The authors conclude that the addition of cobalt is beneficial for O.E.R. The difference between Co and (Ni<sub>0.4</sub>Co<sub>0.6</sub>Zr) amorphous alloy as far as the electrocatalytic activity is concerned is due mainly to the lower Tafel slope observed for the Co anode. For all materials investigated, holding the potential at +0.7 V<sub>Hg/HgO</sub> for 1 h before scanning results in higher  $\eta_{250}$  values. 6 refs.

Brossard, L. (Inst de recherche d'Hydro-Quebec, Valence, Que, Can); Schulz, R.; Huot, J.Y. *Int J Hydrogen Energy* v 13 n 4 1988 p 251.

**075757 OXYGEN EVOLUTION REACTION ON THICK HYDROUS NICKEL OXIDE ELECTRODES.** The electrocatalytic characteristics of thick hydrous oxide films obtained by repetitive square-wave potential perturbations for the oxygen evolution reaction in alkaline solutions are studied. Two kinds of films, fresh and aged, which can be related to the  $\alpha$  and  $\beta$  nickel oxide structures respectively were used. The results show a marked difference between their Tafel slopes. Besides, a linear dependence of the apparent electrocatalytic activity upon the amount of oxide present in the film is obtained, which is explained on the basis of an increase in the roughness factor. (Author abstract) 32 refs.

Gennero de Chialvo, M.R. (Programa de Electroquímica Aplicada e Ingeniería Electroquímica, Santa Fe, Argent); Chialvo, A.C. *Electrochim Acta* v 33 n 6 Jun 1988 p 825-830.

**Radiation Effects** See DYES AND DYEING—Radiation Effects; IONS—Spectrum Analysis; NEUTRONS—Emission.

## Recovery

**075758 RECOVERY OF USED OXYGEN IN THE COURSE OF OXYGEN-SODA COOKING OF CELLULOSE PULP.** It is shown that in pure oxygen at 350° and a space velocity of 10,000 m<sup>3</sup>·h<sup>-1</sup>/m<sup>3</sup> the degree of oxidation of the organic substances is 76%. The degree of oxidation increases if the oxygen is diluted with an inert compound to concentrations characteristic of waste gases from the digester. On the basis of the results of model tests the following principal technological parameters for catalytic purification of oxygen-containing gas from production of cellulose pulp by the oxygen-soda process may be recommended with adequate reliability: temperature 350°, space velocity 30,000 m<sup>3</sup>·h<sup>-1</sup>/m<sup>3</sup>, content of inert components not less than 8%. If the content of inert components in the original gaseous mixture is less than 8% the process temperature must be raised to 400-450°. The results of investigations of purification by the potash method are given. It is evident from the experimental results that at a constant overall process pressure, which depends on the conditions of pulp cooking (2.0 MPa), accumulation of CO<sub>2</sub> in the gas to be treated improves the operating conditions of the potash treatment stage. 5 refs.

Nikitina, A.K.; Dobromyslova, T.M.; Bryukhanova, L.A.; Ogurtsova, T.A. *J Appl Chem USSR* v 59 n 11 pt 2 Nov 1986 p 2398-2401.



**Reduction** See Also CATALYSTS—Heat Treatment; ELECTROCHEMISTRY; ELECTRODES—Research; STAINLESS STEEL—Corrosion.

**075759 MECHANISM OF CATHODIC OXYGEN REDUCTION IN A CARBON SUPPORT-LACCASE ENZYME SYSTEM.** The effects of solution pH, oxygen pressure, laccase inhibitors, and temperature on the electroreduction of molecular oxygen were studied in a carbon support-immobilized laccase system over a wide potential range. On the basis of the functions obtained, a reaction mechanism was proposed which includes electron transfer from the enzyme's active site to an oxygen molecule as the slow step at low values of polarization. Formation of an enzyme-substrate (laccase-oxygen) complex is the slow step in the limiting-current region. (Author abstract) 10 refs.

Bogdanovskaya, V.A. (Acad. of Sciences of the USSR, Moscow, USSR); Kuznetsov, A.M.; Tarasevich, M.R.; Gavrilova, E.F. *Sov Electrochem* v 23 n 3 Mar 1987 p 344-349.

**075760 OXYGEN ELECTROREDUCTION IN PERFLUORINATED SULFONYL IMIDES.** The electroreduction of oxygen in perfluorinated sulfonyl imides has been studied with the emphasis on the identification of alternate acid electrolytes which could replace the presently used phosphoric acid as an electrolyte in  $H_2$ - $O_2$  fuel cells. The activity for oxygen reduction on smooth platinum and gas-fed, high surface area platinum-catalyzed electrodes (10% platinum loading on XC-72 carbon support) has been examined. The polarization of the air cathode in the micro-fuel cell in bis(trifluoromethanesulfonyl)imide is 40 mV more positive compared to phosphoric acid at 100 mA  $cm^{-2}$ , presumably due to the increased solubility of oxygen and lower tendency of bis(trifluoromethanesulfonyl)imide to adsorb on the platinum catalyst. (Edited author abstract) 16 refs.

Razaq, M. (Case Western Reserve Univ., Cleveland, OH, USA); Razaq, A.; Yeager, E.; Desmarreau, Darryl D.; Singh, S. *J Appl Electrochem* v 17 n 5 Sep 1987 p 1057-1064.

**075761 KINETICS OF OXYGEN REDUCTION IN MOLTEN PHOSPHORIC ACID AT HIGH TEMPERATURES.** The solubility and diffusivity of oxygen in concentrated (98%) phosphoric acid, and the kinetics of its reduction on platinum within the 25°-150°C temperature interval have been investigated utilizing glass insulated Pt microelectrodes with radii of 12.7 and 250  $\mu m$ . The enthalpy of solution of oxygen in phosphoric acid was found to be  $2.2 \pm 0.3$  kcal  $mol^{-1}$ , and the entropy of solution is  $-12.6 \pm 0.8$  cal  $K^{-1} mol^{-1}$ . Fundamental entropy calculations indicate that the large negative entropy change upon solution is due to the loss of three degrees of freedom in translation (free translation becoming hindered) and two degrees of freedom in rotation (only libration occurs in solution). This work is of interest to fuel cells. (Edited author abstract) 44 refs.

Scharifker, B.R. (Texas A&M Univ., College Station, TX, USA); Zelenay, P.; Bockris, J.O'M. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2714-2725.

**075762 OXYGEN REDUCTION KINETICS AT ACTIVE CARBONS WITH DIFFERENT SURFACE PROPERTIES IN SOLUTIONS OF INTERMEDIATE pH VALUES.** The model floating electrode was used to investigate the kinetics of oxygen reduction at KM-2 active carbons in simple and mixed solutions of NaCl,  $NH_4Cl$ , and  $NaH_2PO_4$ ; the carbons had been subjected to different surface treatments. The kinetic features of the reaction are found to be the same as in alkaline and acidic electrolytes. By variation of the surface group composition on the carbon the electrocatalytic activity can be varied by more than an order of magnitude in unbuffered neutral solutions, and by a factor of 3 to 4 in buffered solutions. (Edited author abstract) 7 refs.

Kukushkina, I.A. (Acad. of Sciences of the USSR, Moscow, USSR); Shteinberg, G.V. *Sov Electrochem* v 23 n 5 May 1987 p 583-588.

**075763 ELECTROCHEMICAL REDUCTION OF OXYGEN ON SMALL PLATINUM PARTICLES SUPPORTED ON CARBON IN CONCENTRATED PHOSPHORIC ACID - I. EFFECTS OF PLATINUM CONTENT IN THE CATALYST LAYER AND OPERATING TEMPERATURE OF THE ELECTRODE.** Electrochemical reduction of oxygen on small platinum particles supported on carbon in 105 wt% phosphoric acid at 190°C was investigated by means of a half-cell apparatus. Effects of platinum content in the catalyst layer and operating temperature of the electrode on this reaction were examined. The flooded agglomerate model was supported as the operation mode of the porous gas diffusion electrode. From temperature dependence study of the reaction, apparent activation energy on the electrode was estimated to be about 113 kJ  $mol^{-1}$  at equilibrium potential. This work is pertinent to fuel cells. (Edited author abstract) 36 refs.

Maoka, T. (Toshiba Corp., Kawasaki, Jpn). *Electrochim Acta* v 33 n 3 Mar 1988 p 371-377.

**075764 ELECTROCHEMICAL REDUCTION OF OXYGEN ON SMALL PLATINUM PARTICLES SUPPORTED ON CARBON IN CONCENTRATED PHOSPHORIC ACID - II. EFFECTS OF TEFLON CONTENT IN THE CATALYST LAYER AND BAKING TEMPERATURE OF THE ELECTRODE.** A relation between hydrophobicity (or wettability) of a porous gas diffusion electrode for use in a phosphoric acid fuel cell and its cathode performance (activity toward electrochemical oxygen reduction) was examined. The hydrophobicity of the gas diffusion electrode was regulated by changing either the amount of Teflon (PTFE) content in the catalyst layer or baking temperature of the electrode. The Tafel slope for electrochemical oxygen reduction became twice as high as that of the ordinary electrode when the wettability of electrode toward phosphoric acid was high. This fact supports a flooded agglomerate model as the operation mode of this type of porous gas diffusion electrode. (Author abstract) 14 refs.

Maoka, T. (Toshiba Corp., Kawasaki, Jpn). *Electrochim Acta* v 33 n 3 Mar 1988 p 379-383.

**075765 OXYGEN REDUCTION ON THE Au (311) ELECTRODE SURFACE IN ALKALINE ELECTROLYTE.** Oxygen reduction was studied for the first time using a single crystal electrode in a rotating disc-ring arrangement. The Au (311) surface shows a complex behavior, with a very high activity in certain potential regions. The first electron transfer is rate determining in the region of 4-electron reduction. As with Au (100), a 4  $e^-$  reduction changes into a 2  $e^-$  process, which reverts back to a 4  $e^-$  reaction at very negative potentials. Based on a general reaction scheme of  $O_2$  reduction, a map of the operating potential dependent reaction pathways was constructed. Nearly 60% of the mass flux of  $O_2$  undergoes a direct reduction to  $OH^-$  in the region of mixed control. The high activity of Au (311) was ascribed to a high step density and  $AuOH$  present on its surface. (Author abstract) 23 refs.

Anastasijevic, N.A. (Univ. of Belgrade, Belgrade, Yugosl.); Strbac, S.; Adzic, R.R. *J Electroanal Chem Interfacial Electrochem* v 240 n 1-2 Jan 25 1988 p 239-252.

**075766 SIMPLEX OPTIMIZATION OF ELECTROREDUCTION OF OXYGEN MEDIATED BY METHYL VIOLOGEN SUPPORTED ON ZEOLITE-MODIFIED CARBON PASTE ELECTRODE.** By using the methyl viologen-oxygen system as a model, zeolites Y and A were shown to be promising as supports for electrocatalysts, and perhaps as sites for preconcentration of substrates as well. Simplex optimization was used to reach a maximum catalytic peak current for the reduction of oxygen using a modified electrode consisting of carbon paste mixed with the sodium form of zeolite Y. The electrochemistry was carried out in aqueous lithium perchlorate solution buffered at pH 7.00. Four parameters were varied to give a maximum peak current due to oxygen reduction. The optimal response was obtained when the carbon paste electrode containing 49 wt% zeolite Y was immersed in a 32 mM solution of methyl viologen

in aqueous electrolyte solution saturated with oxygen. (Edited author abstract) 36 refs.

Creasy, Kenneth E. (Univ. of Connecticut, Storrs, CT, USA); Shaw, Brenda R. *Electrochim Acta* v 33 n 4 Apr 1988 p 551-556.

**075767 ELECTROCATALYSIS OF  $O_2$  REDUCTION TO WATER IN DIFFERENT ACID MEDIA BY IRON NAPHTHALOCYANINES.** The oxygen reduction kinetics have been investigated in different acid media by the RRDE and voltammetric techniques on iron naphthalocyanines. Better activity and stability were found in perchloric acid solutions. In most cases indirect four-electron pathway was shown. The reaction mechanism appears to be associated with a redox couple which should involve the central iron. Correlations can be established between the potential of the redox couple and the activity as seen by the RRDE technique. (Author abstract) 20 refs.

Coowar, F. (CNRS, Meudon Principal, Fr); Contamin, O.; Savy, M.; Scarbeck, G. *J Electroanal Chem Interfacial Electrochem* v 246 n 1 May 10 1988 p 119-138.

**075768 OXYGEN REDUCTION AT  $Pt_{0.65}Cr_{0.35}$ ,  $Pt_{0.2}Cr_{0.8}$  AND ROUGHENED.** Oxygen reduction in 0.5M  $H_2SO_4$  has been investigated at  $Pt_{0.65}Cr_{0.35}$ ,  $Pt_{0.2}Cr_{0.8}$  and at surfaces produced from them by selective dissolution of the Cr component. Rotating disk electrodes (RDE) were used to examine the oxygen reduction reaction (ORR). The published (1-2) surface analysis using x-ray photoelectron spectroscopy (XPS) combined with sputter profiling and Rutherford backscattering spectrometry (RBS) convincingly demonstrated that the surface region can be selectively depleted of the Cr component by electrochemical excursions to potentials positive of approximately +1.25V vs. RHE. For the more Cr-rich alloy very severe depletion (>500 Angstrom) occurs upon prolonged potential excursions above +1.25V. For the  $Pt_{0.65}Cr_{0.35}$  sample, the surface depletion extends about 2-3 monolayers into the surface. (Edited author abstract) 28 refs.

Paffett, Mark T. (Los Alamos Natl Lab., Los Alamos, NM, USA); Beery, Jerome G.; Gottesfeld, Shmshon. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1431-1436.

**075769 CATALYSIS OF DIOXYGEN REDUCTION AT GLASSY CARBON AND CARBON FIBRE ELECTRODES COATED WITH POLY-COBALT(II)-AMINOPHENYL-PORPHYRIN FILM.** Electrooxidation of tetra(O-aminophenyl)porphyrin ( $H_2Co$ -TAPP) in acetonitrile results in the formation of a polymer film on glassy carbon (GC) and carbon fiber (CF) surfaces. These films can be made electrocatalytically active toward dioxygen by metallization with Co (II). The polymer film electrodes are stable in organic and aqueous solution under various acidic and basic conditions and catalyze dioxygen reduction to produce hydrogen peroxide. (Edited author abstract) 23 refs.

Dong, Shaojun (Acad Sinica, China); Kuwana, Theodore. *Electrochim Acta* v 33 n 5 May 1988 p 667-674.

**075770 ELECTROCHEMICAL REACTION OF OXYGEN BY NAPHTHALOCYANINE COMPOUNDS.** Electrochemical reduction of oxygen with fluoroaluminum and metal-free naphthalocyanines and a few phthalocyanines has been examined using cyclic voltammetry and RRDE (rotating ring-disk electrode) method and 4-electron mechanism of the reaction is suggested for the naphthalocyanine materials. (Author abstract) 12 refs.

Shimura, Michiko; Sakagami, Masayoshi; Shimura, Yukio. *Mem Fac Technol Tokyo Metropol Univ* n 37 1987 p 3861-3870.

**Removal** See COPPER OXIDE—Defects; FEEDWATER TREATMENT—Catalysis; GASES, INERT—Purification; IRON AND STEEL METALLURGY—Physical Chemistry.



Research See Also NICKEL AND ALLOYS—Research.

**075771 OXYGEN ENRICHMENT BY PRESSURE SWING ADSORPTION.** An automated experimental apparatus was built to study the PSA oxygen enrichment process. Mass flux and concentration of all streams connected to the adsorption bed were continuously monitored so that the transient behavior of the process could be examined. In particular, a four-step process operated under various production, pressurization, and blowdown rates was studied in detail. The experimental data were then compared with the simulation results of a simple, isothermal model. The adsorption isotherm and the mass-transfer rate constants used in the model were taken directly from literature data. The simulated and the experimental transient results were in reasonable agreement. (Edited author abstract) 21 refs.

Chiang, Anthony S.T. (Nat'l Central Univ, Chung-Li, Taiwan); Hwang, Mau-Yueh; Lee, Ting-Yueh; Cheng, Tsao-Wen. *Inf Eng Chem Res* v 27 n 1 Jan 1988 p 81-85.

Sensors See Also GASES—Sensors; SEMICONDUCTOR DEVICES, MIS—Applications; SENSORS—Electrochemical.

**075772 INORGANIC SOLID STATE CHEMICALLY SENSITIVE DEVICES: ELECTROCHEMICAL OXYGEN GAS SENSORS.** The principles of operation of potentiometric, amperometric, coulometric and impedance-based oxygen gas sensors are reviewed. Factors influencing the speed of response are considered in detail and related to the information obtainable from impedance measurements. The response of a sensor to gaseous mixtures not in equilibrium is discussed, particularly in relation to measurements in gases generated by the combustion of fossil fuels. (Author abstract) 50 refs.

Maskell, W.C. (Middlesex Polytechnic, London, Engl.) *J Phys E* v 20 n 10 Oct 1987 p 1156-1168.

**075773 CHARACTERISTICS OF LIMITING CURRENT-TYPE OXYGEN SENSOR.** Characteristics of oxygen sensors based on limiting current behavior of zirconia pumping cells have been investigated. To limit oxygen transport from ambient gas to the cathodes of the zirconia pumping cells, a drilled cover and a porous layer were examined. For the sensor with a diffusion hole of the drilled cover, the limiting current showed a considerable nonlinearity to oxygen concentration in a high oxygen concentration and a temperature dependence as  $T^{0.8}$  in oxygen-nitrogen mixtures. This behavior is in good agreement with that expected from a model in which the oxygen transport rate is limited by the diffusion hole. For the sensor with the porous layer, the sensor output indicated a weak temperature dependence and good linearity to oxygen concentration compared with the former sensor. This work is pertinent to automatic exhaust emissions. (Edited author abstract) 21 refs.

Saji, Keiichi (Toyota Central Research & Development Lab Inc, Aichi-gun, Jpn). *J Electrochem Soc* v 134 n 10 Oct 1987 p 2430-2435.

**075774 OUTPUT CHARACTERISTICS OF A GAS-POLAROGRAPHIC OXYGEN SENSOR USING A ZIRCONIA ELECTROLYTE IN THE KNUDSEN DIFFUSION REGION.** Output characteristics of a gas-polarographic oxygen sensor using a zirconia electrolyte have been investigated at 450°C and low pressures (approx. 1 mmHg) in  $O_2$ - $N_2$  gas mixtures with the aim of clarifying those in the Knudsen diffusion region. The limiting current obtained at 1 mmHg of the total pressure increased linearly with the oxygen concentration up to 100% in the ambient atmosphere as expected from the theoretical consideration on the output characteristics of the sensor in the Knudsen diffusion region. (Author abstract) 9 refs.

Usui, Toshio (Fujikura Ltd, Tokyo, Jpn); Nuri, Kenji; Nakazawa, Mitsuhiro; Osanai, Hiroshi. *Jpn J Appl Phys Part 2* v 26 n 12 Dec 1987 p 2061-2064.

**075775 RESPONSE RATE TECHNIQUES FOR ZIRCONIA-BASED NERNSTIAN OXYGEN SEN-**

**SORS.** Several techniques are described to determine the rate of response of electrodes used in Nernstian sensors to oxygen concentration changes in various environments. These techniques are related to combustion control and automotive applications as well as laboratory testing of electrodes. The response behavior of the electrodes used in the  $SiO_2$  low temperature sensor has been characterized and comparison made with several other electrodes used conventionally in oxygen sensors. (Author abstract) 14 Refs.

Badwal, S.P.S. (CSIRO, Clayton, Aust); Bannister, M.J.; Ciaccio, F.T.; Hooshmand, G.A. *J Appl Electrochem* v 18 n 4 Jul 1988 p 608-613.

**075776 SOLID-STATE OXYGEN METER EQUIPPED WITH  $Co_{2-x}$  THICK-FILM ELECTRODE: DETERMINATION OF COMPOSITION OF  $CO/CO_2$  GAS MIXTURES.** The properties of a thick film of non-stoichiometric cerium dioxide, used as an oxygen electrode in a high-temperature solid-state oxygen meter, have been investigated. Experiments were carried out in a wide range of temperature (650-1000°C) and  $CO/CO_2$  gas mixture composition (75 percent-9 percent  $CO$ ). Results are reported and compared with those obtained, in the same conditions, with a porous platinum electrode made from Hanovia 6082 platinum paste. (Author abstract) 3 Refs.

Mari, C.M. (Univ Degli Studi, Milan, Italy); Terzaghi, G. *Sens Actuators* v 15 n 1 Sep 1988 p 19-24.

**075777 COMMERCIALIZATION OF AN INTRAVASCULAR OXYGEN SENSOR.** The article discusses the development and commercialization of a neonatal catheter oxygen sensor. The neonatal device itself has been successively improved so that it also carries sensors giving  $pCO_2$  and pH, as well as more subtle changes to the products which include improved heparinization processes for the intravascular devices. Subjects covered include design objectives, funding, marketing, clinical testing, performance, and others. 3 refs.

Howse, Merrick T. (MH Associates, London, Engl.) *J Med Eng Technol* v 11 n 5 Sep-Oct 1987, Technol Transfer - The Br Health Serv and Ind Proc of a Conf, Uxbridge, Engl, May 27-28 1987 p 259-262.

**075778 POTENTIOMETRIC SOLID-STATE OXYGEN SENSOR USING LANTHANUM FLUORIDE OPERATIVE AT ROOM TEMPERATURE.** A solid electrolyte oxygen sensor using an  $LaF_3$  single crystal was examined for detection of oxygen at room temperature. The potential of the sensing electrode relative to that of the reference electrode (e.m.f.) varied almost logarithmically with the oxygen partial pressure,  $P_{O_2}$ . While newly fabricated elements showed a very slow response, exposing them to water vapour at 150°C for 12 h followed by repetition of exposure to high and low  $P_{O_2}$  decreased the 90% response time to about 2 min even at room temperature. Both XPS and infrared spectra suggested the formation of a partially hydroxylated surface with the pretreatment. It was also found that the same sensor could respond sensitively to oxygen dissolved in water. (Author abstract) 15 refs.

Yamazoe, N. (Kyushu Univ, Fukuoka, Jpn); Hisamoto, J.; Miura, N.; Kuwata, S. *Sens Actuators* v 12 n 4 Nov-Dec 1987, Pap Presented at the 2nd Int Meet on Chem Sens, Bordeaux, Fr, Jul 7-10 1986 p 415-423.

**075779 OXYGEN SENSOR FOR THE TEMPERATURE RANGE 300 TO 500 K BASED ON FLUORESCENCE QUENCHING OF INDICATOR-TREATED SILICONE RUBBER MEMBRANES.** A silicone rubber membrane treated with the  $O_2$ -sensitive indicator pyrene butyric acid (PBA) was used as a fluorescence sensor layer within a temperature range 300 to about 500 K. Measurements performed with a light fibre fluorescence photometer show that: first, the fluorescence quantum efficiency of PBA does not decrease more than about 20% within the range 300-500 K compared to that at room temperature; secondly, the oxygen sensitivity of the sensor increases significantly with temperature; thirdly, the

long-term stability of the measurement at 500 K remains practically unchanged compared to that at room temperature. (Author abstract) 9 refs.

Opitz, N. (Max-Planck-Inst fuer Systemphysiologie, Dortmund, West Ger); Graf, H.-J.; Luebbes, D.W. *Sens Actuators* v 13 n 2 Feb 1988, Pap Presented at the 2nd Int Meet on Chem Sens, Bordeaux, Fr, Jul 7-10 1986 p 159-163.

**075780 OXYGEN SENSORS.** Recent progress in the development of oxygen sensors mainly for automotive use is reviewed, together with a description of our research. Three types of oxygen sensors, i.e., concentration cell (zirconia sensors), oxide semiconductor ( $TiO_2$  sensors) and electrochemical pumping oxygen sensors (limiting current sensors) are now available for control of the air-fuel ratio of engines. Introduction of thin-film and micromachining technology to the fabrication of oxygen sensors is now in progress and will aid the development of a new generation of sensors. (Author abstract) 51 refs.

Takeuchi, Takashi (Toyota Central Research & Development Lab Inc, Aichi-gun, Jpn). *Sens Actuators* v 14 n 2 Jun 1988, Pap Presented at the 2nd Int Meet on Chem Sens, Bordeaux, Fr, Jul 7-10 1986 p 109-124.

## Separation

**075781 MOLECULAR DESIGN OF POLYMERIC SYSTEMS FOR OXYGEN PERMSELECTIVE MEMBRANE MATERIALS.** Approaches to the molecular design of polymers for selective oxygen-permeable membrane materials are reviewed. The approaches using polymers of semirigid main chain with oligodimethylsiloxanyl substituents and utilization of surface modification by accumulation of surface-active graft copolymers seem to be quite promising for this purpose. (Edited author abstract) 42 refs.

Kawakami, Yuhsuke (Dep of Synthetic Chemistry, Jpn); Yamashita, Yuya. *Mem Fac Eng Nagoya Univ* v 39 n 1 1987 p 62-91.

Solubility See AQUIFERS—Recharging; POTASSIUM AND ALLOYS—Molten; SEMICONDUCTING SILICON—Oxidation; STEELMAKING—Physical Chemistry.

## Spectroscopic Analysis

**075782 TIME-DEPENDENT STUDY ON THE ABSORPTION AND EMISSION SPECTRA OF  $O_2$ .** We use a time-dependent theory to investigate the absorption spectrum to the  $B^3\Sigma_u^-$  state. Also investigated is the emission spectrum corresponding to laser excitation to  $v'=4$  of the  $B^3\Sigma_u^-$  state of the  $O_2$  molecule. We present detailed discussion of the relationship between the dynamics and the resulting spectra and correlate our results with experimental data. (Edited author abstract) 18 refs.

Williams, Stewart O. (Univ of Washington, Seattle, WA, USA); Imre, Dan G. *J Phys Chem* v 92 n 12 Jun 16 1988 p 3374-3386.

**075783 VIBRATIONAL TO ELECTRONIC ENERGY TRANSFER FROM  $CO$  TO  $O_2$  IN RARE GAS MATRICES.** We reported recently the first clear evidence for intermolecular V-E transfer between molecular defects in RG matrices: a modulated low power IR color center laser pumps the first vibrational overtone of  $^{13}C^{18}O$  diluted in solid argon at 4.2K. Highly vibrationally excited CO molecules are produced by the fusion of vibrational excitations (anharmonic V-V pumping). Our previous work was concerned with  $CO/Ar$  samples where  $O_2$  was present as an impurity. New results are reported here after a systematic study on  $CO/O_2/Ar$  samples. 4 refs.

Galaup, J.P. (Lab de Photophysique Moleculaire, Orsay, Fr); Charneau, R.; Dubost, H. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 250-251.



**075784 SPATIAL COHERENCE IN LARGE-SAMPLE SUPERFLUORESCENCE OF  $O_2$  CENTERS IN KCl.** Superfluorescence resulting from  $O_2$  centers at temperatures below 30 K contained in an excitation volume with Fresnel numbers  $F > 1$  exhibits characteristic interference patterns indicating self-organization of spatially coherent states. Experimental studies of this phenomenon are presented. (Author abstract) 3 refs.

Schiller, Achim (Univ Duesseldorf, Duesseldorf, West Ger); Schwan, Lothar O.; Schmid, H. Dankward. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 541-542.

## Spectrum Analysis

**075785 FTIR-SPECTRA OF SOLID  $O_2$ ,  $N_2$  AND CO.** FTIR measurements of thin films of  $N_2$ ,  $O_2$  and CO at about 20 K contain a line due to the allowed or induced fundamental transition and a broad structure shifted to higher frequencies. This phonon sideband is explainable by coupling of lattice vibrations to the molecular fundamental vibration, and mirrors the weighted one phonon density-of-states. This IR-derived density-of-states can be compared with those from other experimental studies (neutron-scattering, Raman) and from theoretical models. (Author abstract) 17 refs.

Jodl, H.J. (Univ Kaiserslautern, Kaiserslautern, West Ger); Loewen, W.; Griffith, D. *Solid State Commun* v 61 n 3 Feb 1987 p 503-506.

**Temperature Measurement** See NITROGEN—Temperature Measurement.

**Transport Properties** See Also MEMBRANES—Permeability, Mechanical.

**075786 TRANSPORT PROPERTIES OF OXYGEN IN AQUEOUS BORATE SOLUTIONS.** The solubility and diffusivity of oxygen in borate buffer solutions were studied on a Pt  $\mu$  electrode under diffusion-controlled conditions. The solubility of oxygen in diluted borate solution is unusually high ( $4.2 \times 10^{-3}$  Ml $^{-1}$ ), whereas its diffusion coefficient is lower ( $5 \times 10^{-6}$  cm $^2$  s $^{-1}$ ) than in other aqueous solutions. The decrease in oxygen solubility at higher ionic strengths is due to the salting-out effect. The results are consistent with the formation of 'oxygen-borate' complex whereby the stability of  $BO_3$  containing polymeric anions is enhanced. (Author abstract) 14 refs.

Jovancevic, V. (Texas A&M Univ, College Station, TX, USA); Zelenay, P.; Scharifker, B.R. *Electrochim Acta* v 32 n 11 Nov 1987 p 1553-1555.

**Transportation** See LAKES—Sampling.

**OXYGEN CUTTING** See Also WELDING.

**075787 BRENNSCHNEIDBARKEIT DER STAHL-GUSSWERKSTOFFE.** [Flame Cuttability of Cast Steels]. Results of investigations into the flame cuttability of selected cast steels are presented. The results of structural examinations, microhardness measurements, and cracking tests were used to assess changes in material structure. Flame cutting without preheating is recommended for special grades of cast steel. (Author abstract) 9 refs. In German.

Herold, Horst (Ingenieurhochschule Koethen, East Ger); Bollmann, Thomas; Irmer, Werner. *Schweisstechnik (Berlin)* v 37 n 9 1987 p 394-396.

**075788 CODE OF PRACTICE FOR MACHINE OXYCUTTING THICKNESSES RANGE 100 TO 400 mm: (CODICE DI BUONA PRATICA PER L'OS-SITAGLIO A MACCHINA DI SPESSORI DA 100 A 400 mm).** The paper offer guidelines for the practice of machine oxycutting of high thicknesses (100-400 mm) of mild steel materials under the following conditions: square edge cut, straight cut on a track, room temperature. The items considered are: properties of the gases equipment

and systems needed, operator know-how, preparation of material to be cut, gas pressure adjusting flame lighting and adjusting, cutting practice, test and inspection, safety precautions. (Edited author abstract).

Anon. (Italy). *Riv Ital Saldatura* v 39 n 2 Mar 4 1988 p 161-163.

**Computer Applications** See PIPE—Cutting.

## Control Systems

**075789 NUMERICALLY CONTROLLED FLAME CUTTING MACHINE CAN PAY FOR ITSELF, EVEN IN SMALL AND MEDIUM SIZED COMPANIES.** Numerically controlled flame cutting machines have been known for several years. Major companies building ships, machines, containers or other steel products use the 'NC technique' (NC = Numerical Control) for controlling flame cutters. But can small and medium sized works also use this technique? An impressive example of the successful introduction of a numerically controlled flame cutter is that of a company with some fifty employees in the central Neckar conurbation. With its long tradition the company still calls itself an 'iron-works'; it is a member of the Chamber of Trade and was once the first user of flame cutting machines in this region. Today, as a manufacturer of welded constructions, it is an important subcontractor for companies dealing in specialized machinery. Part of the work-force is still used for flame cutting, not only for the company's own purposes but also carrying out flame cutting for others. Its long experience in the flame cutting of high-carbon steels (eg C 45, 42 CrMo 4 and 16 MnCr 5) and boiler-grade plate is particularly useful in this content. (Author abstract)

Aichele, Guenter. *Schweissen Schneiden* v 40 n 3 Mar 1988 p 46-48.

**Theory** See MATHEMATICAL TECHNIQUES—Graph Theory.

## OXYGEN CUTTING MACHINES

### Reviews

**075790 PIERCING TECHNIQUES IN OXYGEN CUTTING MACHINES.** The majority of the industrial applications of oxygen cutting necessitate piercing. However, this can damage the equipment and even risk destroying the nozzle and the blowpipe if the operation is not correctly carried out. Piercing is also an operation which takes time and uses gas and should therefore be avoided in so far as possible. However, piercing is often necessary because of the shape of the workpiece, for example a pipe collar. The purpose of this paper is to provide some general information on the piercing techniques to be adopted if one is to avoid ruining both the equipment and the material to be cut. In English and French.

Anon. *Weld World Soudage Monde* v 25 n 3-4 1987 p 54-59.

**OZONE** See Also AIR POLLUTION—Air Quality; AIR POLLUTION—London, England; ATMOSPHERIC COMPOSITION; ATMOSPHERIC COMPOSITION—Chemical Reactions; GRAPHITE—Surfaces; ORGANIC COMPOUNDS—Oxidation.

**Absorption** See Also WATER TREATMENT—Ozone.

**075791 ON OZONE ABSORPTION IN ALKALINE SOLUTIONS IN PACKED TRICKLE BED.** In this communication a different explanation of the underestimation is presented. The data of L. Rizzuti et al. are reviewed by taking into account the kinetic equation for the absorption of carbon dioxide in buffer carbonate-bicarbonate-arsenite aqueous solutions that has been recently proposed by V. Augugliaro and L. Rizzuti. Based on a discussion of experimental results from the work of others, the authors concluded that the procedure used by L. Rizzuti et al. (1976) for the determination of the  $O_3$ -OH $^-$  reaction rate constant, with the revision reported in this paper, leads to the correct value of the kinetic

constant. 10 refs.

Rizzuti, L. (Univ di Palermo, Palermo, Italy); Augugliaro, V.; Marrucci, G. *Chem Eng Sci* v 42 n 12 1987 p 2976-2977.

**Applications** See Also ALCOHOLS—Oxidation; SEWAGE TREATMENT—Activated Sludge; WATER TREATMENT—Chemicals Removal; WATER TREATMENT—Disinfection; WATER TREATMENT—Ozone; WATER TREATMENT—Ozonization.

**075792 1986 WORKSHOP ON OZONE & ULTRAVIOLET RADIATION WATER TREATMENT.** This conference proceedings contains 6 papers, all of which are indexed and abstracted separately. Various aspects of the manufacture and application of ozone in water treatment processes are covered. Some of the topics discussed are water disinfection, wastewater treatment; desulfurization; and chemicals removal. Other topics cover the use of ozone in combination with ultraviolet radiation and hydrogen peroxide in water treatment processes. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10995 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *Ozone Sci Eng* v 9 n 4 1987, 1986 Workshop on Ozone & Ultraviolet Radiat Water Treat, Amsterdam, Neth, 1986 p 299-418.

**Chemical Reactions** See AIR POLLUTION—Air Quality; PHENOLS—Oxidation.

**Concentration** See AIR POLLUTION—Mathematical Models; ATMOSPHERIC COMPOSITION—Measurements; ORGANIC COMPOUNDS—Oxidation.

## Decomposition

**075793 MECHANISM OF OZONE DECOMPOSITION IN WATER. THE ROLE OF TERMINATION.** The radical-chain mechanism of ozone decomposition in water is suggested. Addition of an extra chain termination step, i.e., reaction between superoxide and ozonide radicals, allowed the author to account for various reaction kinetic orders with respect to ozone and hydroxide ion concentrations reported in the literature, in particular the transition from 1.5 to 1 kinetic order for  $[O_3]$  at neutral pH. The rate constant of the proposed new termination reaction has been estimated to be between  $2 \times 10^2$  and  $1 \times 10^4$  dm $^3$ .mol $^{-1}$ .s $^{-1}$ . (Author abstract) 16 refs.

Nadezhdin, A.D. (Domtar Inc, Senneville, Que, Can). *Ind Eng Chem Res* v 27 n 4 Apr 1988 p 548-550.

**075794 CHEMICAL REACTIONS OF OZONE AND THEIR ROLE IN DEVELOPING IMPROVED ANALYTICAL METHODS.** Most methods for the determination of ozone have been developed by utilizing, with or without modifications, existing methods for chlorine determination. The problem with this approach is that ozone chemistry is very different from chlorine chemistry. We believe that a detailed understanding of the mechanism of ozone decomposition and the chemistry of the byproducts is essential in order to develop selective methods for ozone. This paper briefly describes the ozone decomposition mechanism and introduces the concept of an 'Ideal Method'. The indigo method is examined as an 'Ideal method' and the automation of this method by Flow Injection is discussed. (Author abstract) 32 refs.

Gordon, G. (Miami Univ, Oxford, OH, USA); Pacey, G.E.; Cooper, W.J.; Rice, R.G. *Ozone Sci Eng* v 10 n 1 Winter 1988 p 89-102.

**Efficiency** See WATER TREATMENT—Disinfection.

**Environmental Impact** See Also AGRICULTURAL PRODUCTS—Radiation Effects; BIOMASS; BIOMECHANICS—Respiratory Mechanics; FORESTRY—Environmental Testing.



**075795 ESTIMATING THE IMPACT OF OZONE ON CROPS.** Several factors contribute to uncertainties in assessments of crop damage caused by exposure to ozone and other air pollutants. This study pinpointed some of these factors and developed a crop loss assessment model capable of providing more realistic damage estimates. Estimates of loss to soybean crops from ambient ozone levels were developed, using scenarios that considered combinations of various years, regions, varieties, and planting practices. In addition, eight dose-response functions related percent reductions in crop yields to ozone exposure. Estimates of soybean losses caused by  $O_3$  ranged from 1 to 7%, considerably lower than values of 11-16% obtained in previous research. The study attributes variations in results to several factors, including the dose-response equation selected for the analysis, the year and location examined, the agricultural practices, and the type of exposure statistics used. Double cropping produced smaller estimated losses than full-season production, and the use of total dose-exposure statistics yielded higher losses than the use of mean or percentile exposures. (Edited author abstract)

Anon. *Electr Power Res Inst Rep EPRI EA 5335 Jul 1987 192p.*

**075796 URBAN OZONE AND ITS PRECURSORS.** In urban areas, man-made emissions are overwhelmingly dominant over natural ozone sources. This article addresses the ozone problems of urban areas, emphasizing three important issues. The first concerns the form and level of the National Ambient Air Quality Standard (NAAQS); which directly affects the achievability of the standard, as well as confidence in its attainment. The second issue encompasses the trend in ozone concentrations, which is a measure of the effectiveness of existing ozone control strategies. The third entails the control strategies whose failure may reflect a deficiency in the understanding of the ozone problem or in the implementation of the strategies themselves. 38 refs.

Chock, David, P. (GM, Warren, MI, USA); Heuss, Jon M. *Environ Sci Technol* v 21 n 12 Dec 1987 p 1146-1153.

**075797 PULMONARY RESPONSE TO OZONE EXPOSURES IN HEALTHY INDIVIDUALS AGED 55 YEARS OR GREATER.** Ten female and nine male subjects were exposed for 60 minutes in random order to one of the following  $O_3$  concentrations: 0.0, 0.2, or 0.3 ppm. The following pulmonary function tests (PFT) were recorded before exposure, and at periods immediately following and 20 minutes post-exposure: total respiratory resistance ( $R_T$ ), thoracic gas volume at functional residual capacity (FRC), and forced expiratory volume in one second ( $FEV_1$ ). Baseline PFT mean values and air exposure PFT mean values were compared through the use of repeated measure two-way analysis of variance to detect any significant effect of exposure on these parameters. Following 60 minutes of exposure at light intermittent exercise, there were no statistically significant pulmonary functional changes observed in male subjects. However, in female subjects, a statistically significant increase in  $R_T$  was observed. (Edited author abstract) 22 refs.

Reisenauer, Christopher S. (Univ of Washington, Seattle, WA, USA); Koenig, Jane Q.; McManus, Michael S.; Smith, Michael S.; Kusic, Greg; Pierson, William E. *JAPCA* v 38 n 1 Jan 1988 p 51-55.

**075798 ATMOSPHERIC OZONE: FORMATION AND EFFECTS ON VEGETATION.** There is evidence to suggest that there are losses in the stratospheric  $O_3$  due to the updraft of  $O_3$  destroying pollutants generated by both natural processes and by human activity. Such a loss in stratospheric  $O_3$  can result in alterations of incidence in the ultraviolet (UV) radiation to the earth's surface. Tropospheric  $O_3$  is known to be highly phytotoxic. A number of experimental techniques are available to evaluate the chronic effects of  $O_3$  on plants. Among all field evaluation techniques, open-top chambers are the most frequently used method for evaluating the chronic effects of  $O_3$  on crops. Acute effects can be evaluated with less complexity through the use of biological indicator plants. Confounding the acute or chronic responses of plants to

$O_3$  is the presence of other kinds and forms of pollutants in the ambient atmosphere and the incidence of pathogens and pests. The resulting complex interactions and joint effects on plants are poorly understood. (Edited author abstract) 100 refs.

Krupa, Sagar V. (Univ of Minnesota, St. Paul, MN, USA); Manning, William J. *Environ Pollut* (1987) v 50 n 1-2 1988 p 101-137.

**075799 CFC/OZONE/GREENHOUSE ISSUES.** Chlorofluorocarbons (CFCs) play a major role in determining our standard of living. They are used in a number of essential applications, including refrigeration and air conditioning, medical instrumentation, and the production of insulating materials. One particular chlorofluorocarbon, CFC-113, is used as a high performance cleaning and drying agent in the electronics industry. CFCs are involved in two environmental debates: one concerning the protective layer of ozone which filters ultraviolet radiation from sunlight before it reaches the earth's surface and the other, the greenhouse effect and global warming controversy. This paper provides background information on these environmental issues and describes the current status of the regulation of CFC. (Author abstract) 4 refs.

Subar, Robert L. (DuPont, Willington, DE, USA); Cohen, Robert L. *Int J Hybrid Microelectron* v 11 n 1 1988 p 1-3, 22.

**075800 SCIENTIFIC AND TECHNICAL ISSUES FACING POST-1987 OZONE CONTROL STRATEGIES: A CONFERENCE SUMMARY.** This paper summarizes the presentations given at an APCA International Specialty Conference on tropospheric ozone and ozone control strategies. The conference was held in Hartford, Connecticut on November 16-19, 1987. Subjects covered include control techniques, compliance monitoring, atmospheric studies, and others. (Edited author abstract). 64 Refs.

Wolff, George T. (GM, Warren, MI, USA); Hanisch, John L.; Schere, Kenneth L.; Cahaly, Richard. *JAPCA* v 38 n 7 Jul 1988 p 895-900.

**075801 EVALUATION OF THE EFFECTS OF OZONE INJURY ON RADIAL GROWTH OF PONDEROSA PINE (PINUS PONDEROSA) IN THE SOUTHERN SIERRA NEVADA.** Growth of ponderosa pines with visible symptoms of ozone injury was compared with that of asymptomatic trees in the southern Sierra Nevada, California. Time series analysis indicated that there was no significant reduction in annual radial increment of symptomatic trees during recent years compared to past growth of asymptomatic trees. First order autocorrelation and climatic variables accounted for a large proportion of the variance in growth index, and winter precipitation was positively correlated with growth for all size and age classes. Although ozone concentrations are high enough to cause chlorosis and premature needle senescence in ponderosa pine, there has been no significant change in growth associated with ozone injury. (Author abstract). 41 Refs.

Peterson, David L. (USDA, Riverside, CA, USA); Arbaugh, Michael J. *JAPCA* v 38 n 7 Jul 1988 p 921-927.

**075802 CALIFORNIA STATEWIDE ASSESSMENT OF THE EFFECTS OF OZONE ON CROP PRODUCTIVITY.** The California Air Resources Board (CARB). Initiated a Crop Loss Assessment program to develop a process whereby all available information could be put into a format usable for a statewide assessment of yield losses to crops from ozone. The yield loss information was used in conjunction with economic analysis to determine the impacts of different ozone/ambient air quality standards. The results to date indicate the usefulness of the process for general assessments of the effects of ozone on crop productivity, not only for California but potentially for other areas. Modifications in these projected loss estimates will be made as new information becomes available concerning loss equations, air monitoring sites, and growing seasons on a county and crop basis,

and for data collected after 1984. 32 Refs.

Olczyk, David M. (Univ of California, Riverside, CA, USA); Cabrera, Homero; Thompson, C. Ray. *JAPCA* v 38 n 7 Jul 1988 p 928-931.

**075803 COMPARISON OF INDICES THAT DESCRIBE THE RELATIONSHIP BETWEEN EXPOSURE TO OZONE AND REDUCTION IN THE YIELD OF AGRICULTURAL CROPS.** The objective of this study is to compare the use of several indices of exposure in describing the relationship between  $O_3$  and reduction in agricultural crop yield. Hourly mean  $O_3$  concentration data, based on two-three measurements per hour, were used to develop indices of exposure from soybean and winter wheat experiments conducted in open-top chambers at the Boyce Thompson Institute, Ithaca, New York. None of the exposure indices consistently provided a best fit with the Weibull and linear models tested. The selection of the model appears to be important in determining the indices that best describe the relationship between exposure and response. The focus of selecting a model should be on fitting the data points as well as on adequately describing biological responses. The investigator should be careful to couple the model with data points derived from indices relevant to the length of exposure. Additional aspects of the study are discussed. (Edited author abstract).

Lefohn, Allen S. (A.S.L. & Associates, Helena, MT, USA); Laurence, John A.; Kohut, Robert J. *Atmos Environ* v 22 n 6 1988 p 1229-1240.

**075804 IMPACT OF OZONE ON THE GROWTH AND YIELD OF TREES: A REVIEW.** Data from 25 experiments on seedlings of 43 tree species and hybrids show that ozone ( $O_3$ ) can reduce growth and photosynthesis at concentrations common in many areas of the USA. Seedlings have been primarily employed for such studies for logistic reasons, and will likely provide the greatest breadth of information for some time to come. However, a number of impediments limit application of seedling response studies to assessment of impacts on regional timber production. Large trees differ from seedlings in a number of ways, including C allocation and canopy structure, and methods must be developed to account for these differences if information from seedling studies is to prove useful to forest impact assessment. Understanding how competition mediates individual tree responses require investigation of whether systematic differences of microclimate leaf morphology that exist across canopies affects foliage sensitivity to  $O_3$ , and whether the maximum growth rates of genotypes are correlated with susceptibility to  $O_3$ . (Edited author abstract). 90 Refs.

Pye, John M. (USDA, Research Triangle Park, NC, USA). *J Environ Qual* v 17 n 3 Jul-Sep 1988 p 347-360.

**Environmental Testing** See Also AIR POLLUTION—Athens, Greece; AIR POLLUTION—Atlanta, Georgia; AIR POLLUTION—Baghdad, Iraq; AIR POLLUTION—Ontario; AIR POLLUTION—St. Louis, Missouri.

**075805 PULMONARY FUNCTION AND SYMPTOM RESPONSES AFTER 6.6-HOUR EXPOSURE TO 0.12 ppm OZONE WITH MODERATE EXERCISE.** Ten nonsmoking males (18-33 yr) were exposed once to clean air and once to 0.12 ppm  $O_3$  for 6.6 h. Exposures consisted of six 50-min exercise periods, each followed by 10-min rest and measurement; a 35-min lunch period followed the third exercise period. Exercise ventilation averaged approximately 40 L/min. Forced expiratory and inspiratory spirometry and respiratory symptoms were measured prior to exposure and after each exercise. Airway reactivity to methacholine was determined after each exposure.  $FEV_{1.0}$  was found to decrease linearly during the  $O_3$  exposure and was decreased by an average of 13.0 percent (591 mL) at the end of exposure. On forced inspiratory tests, the FIVC and FIV05 were decreased 12.6 and 20.7 percent, respectively. Increases in the symptom ratings of cough and pain on deep inspiration were observed with  $O_3$  exposure but not with clean air.



Airway reactivity to methacholine was approximately doubled following O<sub>3</sub> exposure. Additional aspects of the study are discussed. (Edited author abstract) 27 refs.

Folinsbee, Lawrence J. (Environmental Monitoring & Services Inc, Chapel Hill, NC, USA); McDonnell, William F.; Horstman, Donald H. *JAPCA* v 38 n 1 Jan 1988 p 28-35.

**075806 ALTERNATIVE OZONE DOSE METRICS TO CHARACTERIZE OZONE IMPACT ON CROP YIELD LOSS.** Previous studies of the National Crop Loss Assessment Network (NCLAN) relating the impact of ozone (O<sub>3</sub>) on agricultural crops have used the seasonal arithmetic average of O<sub>3</sub> for either a 7- or 12-h daily period as the measure of dose in the dose response relationships. This study investigated the use of alternative dose metrics that gave differential weighting to hourly O<sub>3</sub> concentrations according to level of O<sub>3</sub>, period of day, or total hourly solar radiation. Data were used from two NCLAN studies in which two different methods of O<sub>3</sub> addition were used for 7 h/d. In addition, one study included 12 h/d exposure for one method of O<sub>3</sub> addition. The residual sums of squares from fitting a common Weibull response model to each experiment were compared over the range of dose metrics. The results suggested that the dose metrics using equal weighting of peaks and valleys closely reflected plant reaction to O<sub>3</sub>, but the fit of the dose-response models improved if relatively little weight was given to the final 5-h component (1700-2200 h EDT) of the 12-h exposure period. Weighting by total hourly solar radiation gave results very similar to the best obtained from differential peak-valley weighting and 7 h:5 h weighting. (Author abstract) 12 refs.

Rawlings, J.O. (North Carolina State Univ, Raleigh, NC, USA); Lesser, V.M.; Heagle, A.S.; Heck, W.W. *J Environ Qual* v 17 n 2 Apr-Jun 1988 p 285-291.

Estimation See ATMOSPHERIC COMPOSITION.

## Manufacture

**075807 OZONHERSTELLUNG.** [Production of Ozone]. Ozone is one of the most powerful oxidizing agents. It is benign to the environment because when ozone is caused to react with other substances nothing but molecular oxygen is evolved apart from the oxidation products. This is a considerable advantage in comparison with other industrial oxidizing agents. The paper presents an outline of the use and production of ozone. (Author abstract) In German. 3 refs.

Kogelschatz, U. (Brown Boveri Forschungszentrum, Baden, Switz). *Elektrowaerme Int Ed B* v 45 n 3-4 Jun-Aug 1987 p 162-164.

**075808 OZONE GENERATION DURING PULSED BREAKDOWN OF GAS-LIQUID SYSTEMS.** The generation of ozone during pulsed breakdown of gas-liquid systems consisting of water and an oxygen-containing gas was investigated. The characteristics of the water and gas, parameters of the pulses, design of the electrodes, and methods of introducing the gas into the liquid were varied. The maximum yield of ozone was obtained with jet introduction of the gas from the zone of the maximum electric field strength. In this case energy expenditures for obtaining ozone from oxygen were 9 kWh/kg and from air 13 kWh/kg. The technical-economic expediency of ozonization of water by pulsed breakdown of gas-liquid systems is shown. (Author abstract) 8 refs.

Greisukh, M.A.; Zubrilov, S.P.; Kosovskii, V.I.; Monastyrskii, A.E. *Sov Surf Eng Appl Electrochem* n 2 1987 p 65-68.

**075809 MAGNETIC FREQUENCY CONVERTOR IN AN OZONE GENERATING SYSTEM.** The paper presents an analysis of an ozone generating system energized by a magnetic frequency tripler. On the basis of the proposed equivalent circuit of the ozonizer, which takes into consideration the nonlinear conductance of the discharge gap, the mathematical model of the system is formulated. This model, which consists of seven nonlinear

first-order differential equations, has been solved numerically by means of the Gear algorithm and permits analyzing all the various operating conditions of the system for a wide range of supply and load parameters. 6 refs.

Janowski, Tadeusz (Lublin Technical Univ, Pol); Stryczewski, Henryk. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3762-3764.

**075810 PHOTOCHEMICAL GENERATION OF OZONE: PRESENT STATE-OF-THE-ART.** This paper reflects an investigation of the feasibility of photochemical generation of ozone by irradiating gases containing oxygen with Hg lamps of the highest performance and emitting the 185 nm line. Besides the expected photostationary equilibrium, determining factors for practical yields in ozone generation by the 185 nm wavelength are the reactor and gas temperature, the reactor geometry, and the gas composition, as well as the pressure. Further developments are expected in the field of lamp construction and also improvement of reactor geometry. A better knowledge of the aging of the lamps is required, as well as of the photochemical reactions of oxygen in the technologies applied. Systems presently available are most promising for application on small scale or in areas of public water distribution which have no developed structures. (Edited author abstract) 20 refs.

Dohan, J.M. (Brussels Waterboard, Brussels, Belg); Maschelein, W.J. *Ozone Sci Eng* v 9 n 4 1987, 1986 Workshop on Ozone & Ultraviolet Radiat Water Treat, Amsterdam, Neth, 1986 p 315-334.

Measurements See Also ATMOSPHERIC COMPOSITION—Remote Sensing.

**075811 SATELLITE REMOTE SENSING AND OZONESONDE OBSERVATION OF OZONE VERTICAL PROFILE AND SEVERE STORM DEVELOPMENT.** Two year ozonesonde data, January 1981 to December 1982, observed at four Canadian stations, two-and-a-half year backscattered ultraviolet experiment data on the Nimbus-4 satellite, April 1970 to August 1972, observed over five U.S. stations, were used to study the relationship between the total ozone, vertical distribution of the ozone mixing ratio, height of half the total ozone, and the variation of local tropopause height. In view of the correlation between the variation of the tropopause height and the possible development of severe storms, a better understanding of the effect of the vertical distribution of the local ozone profile on the variation of the tropopause height can give considerable insight into the development of severe storms. (Author abstract) 25 refs.

Hung, R.J. (Univ of Alabama in Huntsville, Huntsville, AL, USA); Liu, J.M. *Int J Remote Sens* v 9 n 3 Mar 1988 p 469-475.

Monitoring See Also IMAGE SENSORS—Calibration.

**075812 CHARACTERIZATION OF OZONE DATA FOR SITES LOCATED IN FORESTED AREAS OF THE EASTERN UNITED STATES.** Six years (1978-1983) of ozone monitoring data from sites located within six forested areas were examined. Areas that experienced the lowest to the highest ozone exposures were located in (1) northern New England/New York and upper Great Lakes, (2) New York/Pennsylvania/Maryland, (3) southeastern/southern, and (4) New Jersey pinelands. Recommendations for additional ozone monitoring sites are made. A concentrated effort should be made to examine ozone monitoring data from subsequent years (1984, 1985, and 1986) to explore whether the 6-year period 1978 through 1983 is representative of the annual variability of ozone concentrations over eastern forested areas. To better understand the relationship between ozone exposure and possible forest effects, we recommend that the temporal distributions of elevated ozone concentrations over a growing season be examined. The occurrence of elevated ozone levels during specific growth periods during a season may be an important aspect that

biologists may wish to explore. (Edited author abstract) 22 refs.

Pinkerton, John E. (Nat'l Council of the Paper Industry for Air & Stream Improvement Inc, New York, NY, USA); Lefohn, Allen S. *JAPCA* v 37 n 9 Sep 1987 p 1005-1010.

Photochemical Reactions See ATMOSPHERIC COMPOSITION.

Photolysis See POLYPROPYLENE—Stability; WATER TREATMENT—Ozone.

Production See Also ACCELERATORS; SYNCHROTRON—Storage Rings.

**075813 ANALYSE DES REGIMES ET DES ZONES DE LA DECHARGE COURONNE EN TERMES DE PRODUCTION D'OZONE.** [Analysis of Regimes and Zones of Corona Discharge from the Point of View of Ozone Production]. Ozone production by corona discharge in air is analyzed as a function of current pointing out the characteristic current ranges with relation to the discharge regimes. Taking into account the temporal evolution of the discharge, microscopic parameters are analyzed for each range and correlated with the elementary processes of ozone formation. The study allows an interpretation of experimental results for ozone production in the various discharge regimes. The conclusions may also be used as starting points for designing more efficient reactors. (Author abstract) In French. 23 refs.

Leculier, M. (CNRS, Gif-sur-Yvette, Fr); Goldman, M. *J Phys D* v 21 n 1 Jan 14 1988 p 51-56.

**075814 OZONE GENERATION IN THE 214-nm PHOTOLYSIS OF OXYGEN AT 25°C.** Ozone formation in the 214-nm photolysis of oxygen at pressures ranging from 380 to 1300 Torr was investigated. The rates of ozone formation increase with the square of oxygen pressure mirroring the pressure dependence of the absorption cross sections of oxygen. This observation demonstrates the importance of the collision-induced changes in oxygen absorbance and points to a need to examine the role of oxygen dimer (O<sub>2</sub>)<sub>2</sub> in reactions initiated by its photodissociation. Because of the high dilution of ozone, its formation was found to be linear with time even though, on the average, its rate of photolysis exceeded the rate of its generation from oxygen. The quantum yield of ozone formation was 1.86±0.17 independent of O<sub>2</sub> pressure. (Edited author abstract). 38 Refs.

Horowitz, A. (Max-Planck-Inst fuer Chemie, Mainz, West Ger); Von Helden, G.; Simon, F.G.; Crutzen, P.J.; Moortgat, G.K. *J Phys Chem* v 92 n 17 Aug 25 1988 p 4956-4960.

Radiation Effects See INFRARED RADIATION—Absorption.

Spectroscopic Analysis See WATER TREATMENT—Ozone.

Standards See AIR POLLUTION—Air Quality.

## Synthesis

**075815 USE OF THE THERMAL AND ELECTRONIC EFFECT IN A COLD PLASMA REACTOR FOR OZONE SYNTHESIS.** Air or pure oxygen flowing into the discharge gap of a cold plasma reactor is the primary method for ozone production on commercial scale. The modelling of the conversion of oxygen into ozone has been set up by means of a kinetic scheme in which opposite reactions are considered. The forward reaction occurs via electronic activation, while the reverse reaction is temperature-dependent. Experimental results are in accord with this scheme, and lead to the following primary conclusions: the plasma temperature is a linear function of the applied power, while isothermal operation is preferable from an economic point of view. The ozone molecule formed and destroyed in the cold plasma is suggested to be O<sub>3</sub>(<sup>3</sup>B<sub>2</sub>), i.e., the first electronic excited state of ozone (triplet state). (Edited author abstract) 11 refs.



Bes, R.S. (CNRS, Toulouse, Fr); Mora, J.C.; Ouederni, A.; Coste, C.; Benas, J.M. *Ozone Sci Eng* v 9 n 3 Summer 1987 p 247-258.

**075816 OZONE SYNTHESIS FROM OXYGEN IN DIELECTRIC BARRIER DISCHARGES.** A comprehensive model of ozone generation in dielectric barrier discharges is presented. The model combines the physical processes in the micro-discharges with the chemistry of ozone formation. It is based on an extensive reaction scheme including the major electronic and ionic processes. The importance of excited atomic and molecular states is demonstrated. Theoretical limits are given for the ozone production efficiency and the attainable ozone concentration. The most important parameters influencing the performance of ozonizers are identified. All theoretical predictions are compared to measured data. (Author abstract) 53 refs.

Eliasson, B. (Brown Boveri Research Cent, Baden, Switz); Hirth, M.; Kogelschatz, U. *J Phys D* v 20 n 11 Nov 1987 p 1421-1437.

## P

**PACKAGING** See Also **FOOD PRODUCTS**—Packaging; **RADIOACTIVE MATERIALS**—Transportation.

**Automation** See **BOTTLES**—Glass.

**Decoration** See **LABELS**—Adhesion.

## Design

**075817 SPECIALIST PACKAGING.** It is no good winning and completing an important contract if the finished product reaches the client in a damaged state. Product packaging must be correctly designed to withstand the rigors of transportation and storage. One of the pace-setters in the field of specialist packaging in the U.K. has been the Ministry of Defence (MoD) which lays down rigorous standards for products packaged, transported and stored on its behalf. The article discusses these, along with design requirements, packaging materials, and other aspects of the subject.

Anon. *Engineering (London)* v 228 n 5 May 1988 Tech. File No. 166, 2p.

**075818 STRUCTURAL ANALYSIS OF VISUAL FORM ON PACKAGING GRAPHICS AND ITS USE IN AN AUTOMATED DESIGN SYSTEM.** The objective of the paper is to construct a computer system which automates the design procedure in the field of commercial graphics of packaging boxes. To automate the design process a structural analysis of the graphics has been done. It is found that there is a name region of the product and a picture region which indicates somehow the packaged content. The sample graphics which have already been printed are gathered. Their structures are converted into numerical forms which are stored in the files of the computer system as a data base. In the design phase a designer gives a few key words to the computer. Then, it draws an appropriate number of samples from the data base which cover the key words. Using an arithmetic averaging operation and a majority decision rule the computer proposes a composed graphics on a color graphic display. Starting from this graphics, the designer is able to correct or change parts of the graphics in a man-machine interactive manner. (Author abstract). 5 Refs.

Okawa, Yoshikuni (Gifu Univ, Gifu, Jpn). *Comput Vision Graphics Image Process* v 43 n 2 Aug 1988 p 265-278.

**075819 MECHANICAL STRESSES ON PRODUCTS DURING AIR CARGO TRANSPORTATION.** A field study was conducted on board a Boeing 747 Combi (freight and passenger) aircraft on the route Stockholm (Arlanda) via Oslo (Gardermoen) to New York (John F. Kennedy Airport) and return to Stockholm (Arlanda). Shock and vibration, acting on the cargo,

during air transportation were measured and analyzed. The study encompassed all phases of the flight, including taxiing, climb, cruise during both calm and turbulent conditions, descent and approach, landing including touchdown and taxiing to apron. The field data were analyzed by conventional frequency analysis and modeling techniques. In order to generalize the results, flight recorder data from the field trial and from other flights are included. A. 14 Refs.

Trost, Thomas (Swedish Packaging Research Inst, Stockholm, Swed). *Pack Technol Sci* v 1 n 3 Jul-Sep 1988 p 137-155.

## Efficiency

**075820 GILLETTE: EFFICIENCY UP, REJECTS DOWN.** A unique process improvement project has triggered major increases in output and decreases in reject percentages on one high-volume line in the St. Paul manufacturing facility of the Personal Care Div. of the Gillette Co. Prior to the project, the efficiency of this line was approximately 45 per cent. The project has increased line efficiency to 72 per cent, with individual shift results as high as 92 per cent. With eight machines in-line, operating at these high efficiencies is no mean feat. Another accomplishment has been a drastic reduction in defects produced. The major reason for the improvement in the line's performance is a change in the attitude of the people who worked on the line. A number of specific machinery and operational improvements took place - and at some cost.

Holmgren, R. Bruce (Packaging, Newton, MA, USA). *Packaging (Boston)* v 33 n 1 Jan 1988 p 50-52, 54.

## Materials

**075821 PLASTICS AND METALS: CHOICES IN PACKAGING.** In packaging, there has been a drive towards convenience products, particularly in food. More recently, the development of microwave cooking has served to accelerate this process. This paper explores some of the ways in which choices have been established. Following an initial discussion on the package requirements for both food and non-food products, examples have been drawn from recent Metal Box developments to illustrate how desired objectives are achieved, at the same time setting new standards.

Heathcoat, M.J. (Metal Box, Wantage, Engl). *Sheet Met Ind* v 65 n 5 May 1988 p 251-252.

**Operations Research** See **PROBABILITY**—Random Processes.

**Optimization** See **MECHANICAL ENGINEERING**—Computer Aided Design; **PACKAGING MACHINES**—Efficiency.

**Pneumatic Drive** See **SOLIDS**—Fluidization.

## Quality Assurance

**075822 MILITARY PACKAGING IN THEUK TODAY.** Equipment for the Defence Services is daily becoming more expensive and more sophisticated and it therefore has to have a high reliability to enable the serviceman to have confidence in it. Therefore the quality and design of packaging coupled with its cost effectiveness is everyone's business whether he be in design, development, production, purchasing, supply management, operational maintenance, storage, distribution or quality assurance and the aim must be that 'packaging is as important as the material it contains'. The paper outlines the way in which the packaging needs of the British Army, Navy and Air Force are met by the Central Packaging Unit (CPU) of the Ministry of Defence (MOD). The equipment for testing is briefly described and the main R&D projects outlined. (Author abstract).

Slate, P.M.B. (Ministry of Defence, London, Engl); Freeman, R.S. *Pack Technol Sci* v 1 n 3 Jul-Sep 1988 p 161-167.

**Quality Control** See **FOOD PRODUCTS**—Packaging.

**Recycling** See **PACKAGING MATERIALS**—Plastics.

**Seals** See **POLYBUTENE**—Blending.

## Shock Problems

**075823 APPLICATION OF PRODUCT FRAGILITY INFORMATION IN PACKAGE DESIGN.** An overview is given of a six step product and package test and development procedure which has become standardised in recent years. A case history is presented. An electronic product, a blood pressure analyser, encountered failure rates of 40% in shipment. Application of the six step procedure reduced damage in shipment to 0.1% over the next year. This averted potential warranty replacement costs of 2,000,000 dollars over the next year. The steps include: shipping environment definition; product fragility assessment; shock; vibration; product redesign, cushion material evaluation, package system design; prototype package system testing.

Bresk, Frank C. (Lansmont Corp); Irving, Kevin. *J Soc Environ Eng* v 27-2 n 117 Jun 1988 p 3-10.

**Structural Design** See **VIBRATIONS**—Analysis.

**Tamper Resistant** See Also **FOOD PRODUCTS**—Packaging.

**075824 TAMPER-RESISTANT YET CONVENIENT: SOLVING A DESIGN DILEMMA.** Manufacturers of Over-the-Counter (OTC) drugs and some consumer products are in a quandary. On the other hand, they must make packaging, containers, and closures secure enough to be tamper-resistant and child safe. At the same time, the Consumer Product Safety Commission has challenged them to create packaging that is easy for the elderly and handicapped to open. Tampering indications based on sight, sound and smell are the latest developments.

Huckins, Linda. *Des News (Boston)* v 43 n 12 Jun 22 1987 p 20-21.

## Trademarks

**075825 DER GEWERBLICHE RECHTSSCHUTZ IM BEREICH DES VERPACKUNGSWESENS: 1. TEIL: EINORDNUNG UND KENNZEICHNUNG-SRECHE.** [Protection of Industrial Property in the Field of Packaging. I. Classification and Marking Laws]. The legal norms described by the concept of the protection of industrial property protect commercial-intellectual work and the related, particularly economic, interests. In this paper, following a correlation of industrial protection laws with design concepts in the packaging industry, a survey is made of a group of property protection laws, i.e., marking laws. In this context the trademark law, protection of the product format and protection of the firm are discussed. An attempt is made to provide criteria concerning the selection of the right marking law for the user. (Edited author abstract) In German. 5 refs.

Laufhütte, Dieter. *Verpack Rundsch* v 38 n 12 Dec 1987 p 89-92.

**PACKAGING MACHINES** See Also **SUGAR HANDLING**—Packaging.

**075826 NEW LINE HITS PEAK OUTPUT.** An all-new line for the blister packaging and cartoning of physicians' samples at Stuart Pharmaceuticals, Newark, DE, now consolidates in one place a series of operations previously spread around the plant or performed by outside contractors. The central feature of the new line is its use of two Uhlmann cartoners, with a distinctive cartoner-to-cartoner transfer. The latter has a vertical storage magazine that provides a 40-second reserve, to keep feeding the second cartoner if the first cartoner makes a momentary stop. This helps assure a sustained output of 200 blisters cards a minute.



Holmgren, R. Bruce (Packaging, Denver, CO, USA). *Packaging (Boston)* v 32 n 12 Oct 1987 p 52-54.

**075827 CARTONING MACHINES: HOW MUCH HIGH-TECH?** Most packagers interpret the traditional view of state of the art as a high-speed cartoner, rugged enough for round-the-clock operation, with electronic adjustments and changeovers, as well as a diagnostic system that fits into a full-scale management information system. Implicit in this description is the use of latest carton handling and product collation techniques, among others, including a magazine of maximum capacity.

Holmgren, R. Bruce (Packaging, Denver, CO, USA). *Packaging (Boston)* v 32 n 12 Oct 1987 p 60-63.

**075828 CUT-SIZE PAPER PACKAGING OF THE '80S AND BEYOND.** A new design concept has been developed for each piece of equipment in the packaging line. The traditional gearhead motors have given way to direct-drive dc and ac servo motors, and the old relay panels have been replaced by the more versatile programmable logic controllers. The packaging line has also been reconfigured. Product flow patterns have become straighter, keeping abrupt changes in direction at a minimum. All of these improvements raise productivity by increasing efficiencies, decreasing maintenance, and improving product flow. Finally, precision sheeters and high-speed packaging lines are linked by an 'electronic' lineshaft that matches the ream wrapper speed to the discharge speed of the sheeter. (Edited author abstract).

Lutzke, T. (ECH WILL/PEMCO, Sheboygan, WI, USA). *Tappi J* v 71 n 10 Oct 1988 p 83-86.

**Automation** See GLASS—Packaging; PAPER—Sheeting.

**Control** See Also PACKAGING MATERIALS—Manufacture.

**075829 PC MAKES PACKAGER INDEPENDENT OF MECHANICAL CYCLE.** Use of an onboard programmable controller in conjunction with a microprocessor permits the functions of a vertical form, fill, and seal machine independent of one another. Thus, the sequence of each function can be optimized on a time basis for increased filled-bag output, bag-style flexibility, and simplicity of changeover from one bag variety to another. Designed to handle a variety of packaging materials, these SVB 2500/3600 machines can produce medium to large size pillow bags with or without gussets as well as block-bottom bags using heat sealable or weldable roll stock.

Stull, N.R. (Hydraulics & Pneumatics, Cleveland, OH, USA). *Hydraul Pneum* v 41 n 5 May 1988 p 45-47.

## Efficiency

**075830 DOSIERGENAUIGKEIT VOLUMETRISCH ARBEITENDER FUELLSYSTEME IN VERTIKALEN SCHLAUCHBEUTELMASCHINEN.** [Dosing Accuracy of Volumetric Filling Systems in Vertical-Pouch Machines]. Manufacturers of packaging machines try to reach a maximum dosing accuracy with the highest possible number of cycles. This requires good knowledge of the filling behavior of the product and the way in which it is influenced by the machine. Therefore, the factors influencing the dosing accuracy in vertical-pouch forming, filling and sealing machines using both cup dosing and auger filling equipment are investigated. The identified dosing inaccuracy was caused in most of the cases by fluctuations of the bulk density of the filling product. This may result from compression of the product in the supply container and in the dosing cups or from particle breakage in the auger feeder due to a grinding effect. This effect can be avoided only if the filling product is stable enough against grinding or if the particle size is fine enough compared to the dimensions of the auger feeder. The homogeneity of the filling product is also of great importance. An improvement in the dosing accuracy in an auger filler can be achieved mainly by a narrow particle size distribution of the product. In cup dosing

equipment, however, it can also be achieved by structural changes. (Edited author abstract) 2 refs. In German.

Vogelpohl, H. (Technische Univ Muenchen, Munich, West Ger); Hohmann, H.J. *Verpack Rundsch* v 39 n 1 Jan 1988 p 1-6.

**075831 FILLING CHARACTERISTICS AND DOSING ACCURACY OF VOLUMETRIC DOSING DEVICES IN VERTICAL-FORM-FILL-SEAL MACHINES.** Filling from cups with different opening mechanisms and filling systems using an auger have been examined, and the dosing accuracy found in all instances to be more dependent on variations in the bulk density, general particle shape and size etc. of the product being filled than on the dimensions etc. of the filling device. Results are reported on many of the possible characteristics in an attempt to find the relevant one(s) but it is concluded that our knowledge of product characteristics is insufficient and that more research is required. (Edited author abstract). 1 Ref.

Hohmann, H.J. (Fraunhofer Inst for Food Technology & Packaging, Munich, West Ger). *Pack Technol Sci* v 1 n 3 Jul-Sep 1988 p 123-135.

**Reliability** See LABELING—Equipment.

## PACKAGING MATERIALS

### Adhesion

**075832 ASSURING SUCCESSFUL BONDING TO CARTON BOARDS.** This paper considers the factors that will influence successful adhesive bonding to carton-boards. Although the paper assumes the use of carton-board within the packaging industry, the majority of the arguments may be applied to other bonding applications. The commonest adhesive types used within the packaging industry for carton-boards are PVA-type emulsion and hot-melts. Other adhesives used will include animal glues, starches and dextrines, acrylics etc. Although these adhesives vary considerably in properties they share the majority of requirements for successful bonding. The paper firstly considers bond structure and the basic modes of bond failure. The paper then discusses the properties required of boards, board surfaces (be they printed, varnished, coated or otherwise) and adhesives for the successful manufacture of bonds. Techniques for evaluating trial bond performance and, finally, the need for good 'housekeeping' are considered. (Edited author abstract) 6 refs.

Shires, D.A. (Pira, Leatherhead, Engl). *Pack Technol Sci* v 1 n 2 Apr-Jun 1988 p 67-71.

**Aluminum** See CONTAINERS—Seals; ELECTRIC APPLIANCES—Ovens.

### Classification

**075833 PACKAGING AND ASSEMBLY MATERIALS SPECIFICATION GUIDE.** In Electronic Manufacturing's Packaging and Assembly Materials Specification Guide, contributing companies have described their products used in assembling through hole printed wiring boards. These include epoxy, silicone, urethane, acrylic, and parylene conformal coatings; solders in a wide range of formulations; and heat sink compounds in liquid and pad form. Details are given in the conformal coating section about both one and two component coatings, their primary function, application and curing method, and how they can be removed. Bar, core, and preform solders are featured in the guide to solders, for wavesoldering, reflow, ultrasonic, drag, dip, etc. Heat sink compounds described include both unfilled and mineral filled greases; those in pad form include adhesive and non-adhesive elastomers, treated papers and fabrics, and polyimide films, among others.

Anon. *Electron Manuf* v 33 n 17 Nov 1987 p 38-44.

### Coatings

**075834 CHEMICAL PRIMING FOR EXTRUSION COATING.** During extrusion coating, a 100%-solids molten polymer is applied on a substrate. Most substrates require priming to promote adhesion of the extrudate. The discussion in this article focuses on the use of chemical primers. While chemical priming enhances adhesion, it can also improve package performance under unusual conditions. Such conditions can arise either from the outside environment or from the product inside the package. A given chemical primer can also provide some special property of its own to the total package, such as improved barrier performance or better heat resistance.

Isbister, Roger (Morton Thiokol Inc, Chicago, IL, USA). *Tappi J* v 71 n 5 May 1988 p 101-104.

### Composite Materials

**075835 COMPOSITES OFFER NEW OPPORTUNITIES.** The author describes some of the latest developments in composite packages - those which make use of paper and board products in association with plastics and metal foils. (Edited author abstract)

Wolpert, Vladimir. *PPI Pulp Pap Int* v 29 n 12 Dec 1987 p 52-53.

**Laminated Products** See ADHESIVES—Water Borne.

### Manufacture

**075836 PPS-EINSATZ IN EINER MASCHINEN-FABRIK.** [PPS (Production, Planning and Control Systems) Used in an Engineering Plant]. The engineering plant in Braunschweig with its 360 employees belongs to a corporation which is a worldwide leader in the packaging industry. It develops and makes products both for corporate manufacturing plants and for external customers. Its complex range of production comprises a variety of products from high-precision transfer and multiple follow-up composite tools for tin can and lid production to spare parts for tools and machines. A range of products is manufactured with tools made by this company, from stamped and formed parts for the electric appliances and automotive industries and glass jar closure products such as twist-off covers, flip and tear-up systems for beverage tins, metal packaging products from aluminum and tin sheet, to container production. (Edited author abstract) In German.

Querfurt, Klaus-Peter; Hammer, Klaus. *Werkstatt Betr* v 121 n 1 Jan 1988 p 31-34.

**Paper** See Also ALUMINUM AND ALLOYS—Corrosion; PACKAGING MACHINES.

**075837 OPTIMIERUNG DES KLEBSTOFFAUFTRAGS IM SACKBODENLEGER. TEIL 1: KONTINUIERLICHER AUFTRAG AUF UNGEFALTETE PAPIERBAHN MIT GLATTEN MODELLWALZEN.** [Optimization of Glue Application in a Paper Sack Bottomer. I: Continuous Application on Flat Paper Web, Using Smooth Application Rolls]. The mechanism of application of a commercial cold water soluble starch glue on stepped and folded sack papers has been studied on a pilot gluing bottom machine. The machine was equipped with a conventional, gluing system. The influence of the relevant process parameters, e.g. the paper speed, velocity and velocity-ratio of the rolls, the roll distances, the material and the surface characteristics of the stereotypes, the glue viscosity, etc., on the time- and position-related glue thickness uniformity has been evaluated. The relations between the parameters has been quantified and from the data the glue thickness uniformity during the application has been optimized. The results make possible the determination of suitable parameter ranges for the thickness control systems. In this article, the results of the investigations of a continuous glue application with smooth, interrupted application rolls on unstepped papers are discussed. (Edited author abstract) 21 refs. In German.

Korn, Von M. (Technische Univ, Munich, West Ger).



Verpack Rundsch v 39 n 4 Apr 1988 p 25-33.

## Permeability

**075838 MEASUREMENT OF ORGANIC VAPOR MIGRATION IN THIN FILMS.** Time-lag permeation and sorption experiments can be used to determine diffusion and solubility parameters that become the data input to computer programs for modeling packaging. (Author abstract) 18 refs.

Gillette, P.C. (Hercules Inc, Wilmington, DE, USA). *Tappi J* v 71 n 3 Mar 1988 p 193-198.

**075839 BARRIER EXPECTATIONS FOR POLYMER COMBINATIONS.** Modern, sophisticated barrier packaging materials are often composites. While there are many possible configurations, two-phase blends often make the best barriers. Multilayer structures offer the lowest permeance; however, blends in which the barrier polymer remains as the continuous phase are also good. Orientation of the phases helps the barrier of a blend. The viscosities of the components help control the important phase inversion, and it is best if the barrier phase has the lowest viscosity. (Author abstract) 14 refs.

DeLassus, Phillip T. (Dow Chemical USA, Midland, MI, USA). *Tappi J* v 71 n 3 Mar 1988 p 216-219.

**Plastics** See Also BIOMEDICAL EQUIPMENT—Sterilization; COMPUTER PERIPHERAL EQUIPMENT—Packaging; FOOD PRODUCTS—Mechanical Properties; FOOD PRODUCTS—Packaging; NYLON POLYMERS—Applications; PLASTICS—Coextrusion; PLASTICS—Extrusion; PLASTICS—Physical Properties; PLASTICS FILMS—Coextrusion; PLASTICS, FOAMED—Extrusion; POLYETHYLENE TEREPHTHALATE—Applications; POLYMERS—Blending; POLYMERS—Degradation; POLYOLEFINS—Physical Properties.

**075840 ODOR BARRIER PROPERTIES OF MULTI-LAYER PACKAGING FILMS AT DIFFERENT RELATIVE HUMIDITIES.** A permeation cell method was developed for the determination of transmission rates of organic vapors through flexible packaging materials. The permeation rates at 23°C of some compounds for several composite films at 0% and 75% relative humidity (RH) indicated that the polyethylene vinyl alcohol and nylon combinations exhibited superior barrier properties even at elevated RH, provided that moisture barrier films were present in the laminate construction. (Author abstract) 9 refs.

Hatzidimitriu, E. (Rutgers Univ, New Brunswick, NJ, USA); Gilbert, S.G.; Loukakakis, G. *J Food Sci* v 52 n 2 Mar-Apr 1987 p 472-474.

**075841 MOCOVINOFORMALDEHYDOVA PRYSKYRICE JAKO OBALOVY MATERIAL K PRIPRAVE POZVOLNE PUSOBICICH PRUMYSLOVYCH HNOJIV - IV.** [Urea-Formaldehyde Resins as Packaging Materials for Industrial Fertilizers with Protracted Action - IV]. The plasticizer content and the ratio of the basic components were investigated as the factors affecting mechanical properties and permeability of urea-formaldehyde resins as packaging materials for granulated urea. The permeability was characterized by values of the effective diffusion coefficient determined from the experimentally measured diffusion flux of urea across planar polymeric membranes. (Edited author abstract) 27 refs. In Czech.

Glaser, Vladimir (Vysoka Skola Chemicko technologicka, Prague, Czech); Stajer, Pavel; Vidsensky, Jan; Svandova, Pavla; Knor, Vaclav. *Chem Prum* v 37 n 11 1987 p 577-581.

**075842 LE CONDITIONNEMENT POLYETHYLENE: UNE AFFAIRE D'INNOVATION.** [Polyethylene Packaging: A Question of Innovation]. The world market for polyethylene should continue to increase by about 4-5% per year. This progression will mainly concern technical and special products, in particular films for packaging. The Finnish group Neste Oy has specialized in this new sector, and placed on the market polyethylenes and EVA copolymers adapted for traditional packaging

applications, while improving on classical polymers. The firm has produced barrier HDPE, whose impermeability is twice that of standard HDPE. This group has also developed a transparent grade of HDPE, which directly competes with normal HDPE and bi-oriented polypropylene. Composite production has also benefited from research and the various grades of LLDPE, MDPE and EVA, EVA copolymers comply particularly well with specifications for packaging. (Edited author abstract) In French.

Anon. *Rev Gen Caoutch Plast* v 64 n 674 Dec 1987 p 47-49.

**075843 SPECIALTY POLYOLEFINS USE IN FLEXIBLE PACKAGING APPLICATIONS.** In 1985, flexible packaging applications consumed some 5.2 billion pounds of polyolefin resins. This marked an increase of almost 300 million pounds over usage in 1984, and is an increase of 1.7 billion pounds from 1980. This growth came as a result of polyolefins replacing traditional packaging materials. Discussion in this paper is limited to three groups of specialty polyolefins: reactive tie-layer materials; very low density polyethylene (LDPE); and specialty polyethylene copolymer materials.

Harvan, Robin G. (Phillip Townsend Associates Inc, Houston, TX, USA). *J Plast Film Sheeting* v 3 n 3 Jul 1987 p 198-206.

**075844 NEW CRYSTALLIZABLE COPOLYESTER FOR ELEVATED TEMPERATURE USE.** Eastman Chemical Products, Inc. is marketing this new Copolyester 6761 for dual-ovenable use - a resin which can be used in food reconstitution, cooking and baking at temperatures 50 to 75°F above those now recommended for CPET trays. The new copolyester is based on chemistry which permits manufacture of a crystallizable product with a crystalline melting permits manufacture of a crystallizable product with a crystalline melting point of 545°F. Trays made from the resin, properly nucleated and stabilized, can be frozen and stored at temperatures of -20°F without embrittlement and can be used for cooking at oven settings of 450°F without concern for tray distortion and thermal variations in an oven.

Stras, Joseph (Eastman Chemical Products Inc, Kingsport, TN, USA); Weaver, James C. *J Plast Film Sheeting* v 3 n 3 Jul 1987 p 207-214.

**075845 EFFECT OF RELATIVE HUMIDITY ON THE PERMEABILITY OF TOLUENE VAPOUR THROUGH A MULTI-LAYER COEXTRUDED FILM CONTAINING HYDROPHILIC LAYERS.** The effect of relative humidity on the diffusion of toluene vapour through a multi-layer coextrusion film structure containing moisture sensitive hydrophilic barrier layers (nylon and EVAL) was evaluated. Two experimental test methods were employed. In Method I, the effect of relative humidity on the diffusion of toluene vapour was evaluated, where the test film was preconditioned to a fixed water activity prior to test. In Method II, the effect of water vapour as a co-permeant was evaluated. Studies carried out by Method I showed the concentration dependency of the diffusion process and the importance of relative humidity on the diffusion of organic vapour through barrier structures. Water vapour was found to exhibit strong interactive effects with the moisture sensitive polymer layers of the laminate, which resulted in an increase in the diffusion of toluene vapour through the barrier structure. (Edited author abstract) 25 refs.

Liu, K.J. (Michigan State Univ, East Lansing, MI, USA); Giacini, J.R.; Hernandez, R.J. *Pack Technol Sci* v 1 n 2 Apr-Jun 1988 p 57-65.

**075846 RECYCLING OF PLASTIC PACKAGING IN THE UNITED STATES.** The manner in which a recycling of plastic packaging is developing in the USA is outlined and the probable changes in the next decade are discussed. Suggestions as to how packaging professions should deal with the subject are made. (Author abstract) 14 refs.

Selke, Susan E. (Michigan State Univ, East Lansing, MI,

USA). *Pack Technol Sci* v 1 n 2 Apr-Jun 1988 p 93-98.

**075847 WIRTSCHAFTLICHES FERTIGEN VON WARMGEFORMTEN VERPAKKUNGEN.** [Economic Manufacture of Thermoformed Packaging]. Like almost all plastics mouldings, packaging are subject to heavy cost pressures and must, therefore, be manufactured economically. High-efficiency automatic thermoforming units are mainly used for this, which require low-manning. Units of this type are described here. (Author abstract) In German and English.

Hartmann, Karl-Hans (Adolf Illing Maschinenbau GmbH & Co, Heilbronn, West Ger). *Kunstst Ger Plast* v 78 n 5 May 1988 p 398-401.

**075848 IN-LINE-PRODUKTION WARMGEFORMTER VERPAKKUNGEN.** [In-Line Production of Thermoformed Packaging]. Now that in-line plants have proved themselves for thermoforming, primarily of tubs and similar parts, this process is also being employed for thin-walled packages. The necessary technical equipment and the economic advantages are described. (Author abstract) In German and English.

Bratsch, Kurt (Kiefel Thermoform-Maschinen, Freilassing, West Ger). *Kunstst Ger Plast* v 78 n 5 May 1988 p 402-406.

**075849 PACKAGING GOES PLASTIC INTO THE 21ST CENTURY.** Among the many promising markets for plastics, packaging may top the list. Growth projection for plastic packaging vary a bit from one source to the next. SPI forecasts an average annual volume growth rate of 4 percent through the year 2000. Future economic factors will favor plastics. By the year 2000, the use of plastic packaging will hit about 50 percent of the total market. Plastics will replace competitive packaging materials at an annual rate of 10 percent. According to Du Pont's Jenkins, the general category of foodstuffs that may convert to plastics by the year 2000 are oxygen-sensitive foods and beverages. Retortables may soon take off. Environmental concerns are the most formidable obstacle for future growth.

Fitzgerald, Kevin R. (Plastics World, Newton, MA, USA). *Plast World* v 45 n 10 Sep 1987 5p.

**075850 DEVELOPMENTS AND APPLICATIONS OF RECYCLED PLASTICS.** The problems associated with the growing proportion of plastic packaging materials in community domestic refuse have generated public concerns. Furthermore, an increasing number of laws are being proposed to address the solid waste - many targeted at plastic packaging. This was the background for the conference 'Recycled Plastics: Developments and Applications'. Speakers examined the latest developments and discussed recycling methodologies, marketing approaches, social and environmental implications. This report summarizes the main points made. (Edited author abstract).

Lai, Christopher C. (Michigan State Univ, East Lansing, MI, USA); Lai, C.; Selke, Susan E. *Pack Technol Sci* v 1 n 3 Jul-Sep 1988 p 157-160.

**075851 MULTILAYER PACKAGING CONTAINERS.** The author discusses the production of multilayer bottles in the United States, as this technology is likely to grow most rapidly during the next five years. The four major classes of products that are packaged in bottles or other rigid forms are: polypropylene, polyvinyl chloride, high-density polyethylene (HDPE) and, polyethylene terephthalate (PET). Nearly all multilayer bottles used commercially combine backbone structural layers of HDPE or polypropylene for strength and rigidity with a thinner barrier layer of a different polymer. The polymers that are strong barriers to oxygen permeation also tend to be efficient barriers to permeation by hydrocarbon liquids. Bottles made by the laminar-blend process have nylon arranged as many discontinuous and overlapping platelets dispersed within a matrix of HDPE resin that also



contains a compatibilizing polymer to promote adhesion of HDPE to nylon. The laminar-blend extrusion blow molding process is discussed. 11 Refs.

Sacks, William (Stevens Inst of Technology, Hoboken, NJ, USA). *CHEMTECH* v 18 n 8 Aug 1988 p 480-483.

**075852 PLASTICS IN PACKAGING.** A discussion is presented of Indian standards for plastics. An examination is made of the different packaging modes where plastics are being used: rigid containers, flexible packs and fabric packs. Their common applications and the relevant Indian Standards available are discussed. Flexible packaging is discussed. It is shown that the present trend in packaging is towards a changeover to plastics from the traditional packaging materials. In plastics also, flexible packs (up to 1 litre size) have an edge over rigid containers, being lighter, which results in cost reduction. Besides being functional in protecting the contents of a container from moisture, oxygen and loss of aroma, packaging in plastics has the ability to improve the aesthetics due to variety of colours and ease of decoration of packs through modes like multicolour printing.

Dorairaj, V. (Polyolefins Industries Ltd, Thane, India). *Chem Age India* v 39 n 3 1988 p 165-167.

**075853 PVC: PACKAGING ISSUES AND REGULATIONS.** A review is presented of the FDA's revised proposal for the regulation of PVC food packaging issued in 1986 and some recent developments that have further delayed FDA's issuance of a rule that would lead to the use of PVC in liquor bottles. Despite significant technological improvements in the manufacture of rigid PVC, which has led to drastic reduction of residual vinyl chloride monomer (RVCM) to safe levels, FDA action on PVC has remained stalled. It is concluded that final action by FDA may well depend not on scientific principles, but on the Agency's ability to effectively reconcile the correct scientific, health and legal solutions with the political pressure being exerted by environmentalist groups. (Edited author abstract). 10 refs.

de la Cruz, Peter L. (Keller & Heckman, Washington, DC, USA). *J Vinyl Technol* v 10 n 3 Sep 1988 p 117-120.

**075854 PVC PACKAGING RECYCLING.** This study examines the recyclability of PVC bottles into other PVC products. Post consumer bottles can potentially be granulated and used, without further treatment, in the production of these products. Washing will allow the granulate to recover most of the properties of the original bottle compound, by removing paper labels and residual product contamination. Plastic contaminants, such as those from caps and other plastic bottles, show little effect on several physical properties at levels up to 3%. This granulate can thus be used as a significant portion of the raw material feed for a number of PVC products including DWV (drain/waste/vent) pipe, pipe fittings, rigid sheet, bottles, etc. (Edited author abstract). 10 refs.

Pazur, A.S. (BF Goodrich Technical Cent, Avon Lake, OH, USA). *J Vinyl Technol* v 10 n 3 Sep 1988 p 154-157.

**Selection** See HAZARDOUS MATERIALS—Packaging.

**Standards** See ELECTRONIC EQUIPMENT—Packaging.

## Steel

**075855 ECCS EXPANDS HOOGOVENS' PACKAGING STEEL COMMITMENT.** Hoogovens IJmuiden has recently commissioned a new electrolytic chromium/chromium-oxide coating line to further increase its strength in the packaging steel sector. The line uses high current density (HCD) technology for the first time in Europe and represents an investment of £17M. Hoogovens has three electrolytic tinning lines, which process more than 500,000t of packaging steel every year. The contribution of packaging steel to the turnover of Hoogovens IJmuiden amounts to about 24%, indicating the high added value on these products.

Anon. *Steel Times* v 216 n 4 Apr 1988 p 208, 210.

**Testing** See Also NUCLEAR FUELS—Packaging.

**075856 DATABASE OF PACKAGING LABORATORY TEST EQUIPMENT.** The paper reports a recent data base produced for, and available to, National Packaging Centres in developing countries. The ITC in Geneva hold the material which is updated regularly. It should enable enquirers to ascertain details of the equipment they require and to choose between several alternatives. (Author abstract)

Salisbury, John. *Pack Technol Sci* v 1 n 2 Apr-Jun 1988 p 73-75.

**075857 MEASURING OXYGEN TRANSMISSION RATES OF PACKAGING FILMS UNDER HUMID CONDITIONS.** Producers of highly water-sensitive materials being used in food packaging, such as the ethylene vinyl alcohol copolymers, have had to devise methods for measuring gas transmission rates, particularly that of oxygen, under humid conditions. Some of the in-house procedures being used include some form of humidifying the gas streams, a technique taken from the standard methods used to specify dry gases. Other methods are the so-called 'sandwich' technique and the new H-system by Modern Controls. Currently, only limited data are available for comparing the techniques. When enough data can be collected with good precision between laboratories, a method can be supported for approval as a standard. (Edited author abstract). 5 Refs.

Pike, LeRoy (W.R. Grace & Co, Duncan, SC, USA). *Tappi J* v 71 n 10 Oct 1988 p 163-165.

## Trace Analysis

**075858 SCHNELLMETHODE ZUR BESTIMMUNG VON CADMIUMSPUREN IN KARTON NACH DEM MIKROWELLENAUFSCHLUSS.** [Fast Method for Determining Cadmium Traces in Cardboard after Microwave Digestion with HNO<sub>3</sub>]. Cadmium in cardboard was determined by means of Zeeman atomic absorption spectroscopy after digestion with HNO<sub>3</sub> in a microwave oven. It is shown that the cadmium content in cardboard can be quickly and reliably determined by this method. The values obtained by this method are equivalent to those obtained by pressurized digestion in an autoclave or by open wet digestion in a Kjeldahl flask. 4 Refs. In German.

Knezevic, G. (Technischen Univ Muenchen, Munich, West Ger). *Verpack Rundsch* v 39 n 7 Jul 1988 P 62.

## PACKING

### Accident Prevention

**075859 GEFAHRENERMITTLUNG AM BEISPIEL DES ASEPTISCHEN ABPACKENS.** [Determination of Risks with Aseptic Packing Procedures as an Example]. The starting point to take precautions against risks is the determination of hazards. A company utilizing aseptic packing equipment is obliged to determine the hazards emanating from these devices in order to take precautions for the health protection of employees. The measuring procedure presented in this study assists companies to meet this requirement, i.e. to perform measurements. This strategic conception enables companies to maintain limit values characterizing health protection by the performance of a few specific measurements only. Furthermore, an analysis method which can be carried out without difficulties is described. Thus, the expenditure of measurements ascertaining that maximum workplace concentrations are not exceeded is low. (Author abstract) In German. 4 refs.

Schutz, Albrecht. *Staub Reinhalt Luft* v 47 n 9-10 Sep-Oct 1987 p 223-226.

### Calculations

**075860 CALCULATION OF STUFFING BOX SEALS HAVING AN EXPANDING CHAMBER.** The authors examine the effect on the computation character-

istics of static friction along the two surfaces limiting the packing under the assumption that no friction occurs between the packing and one limiting surface (chamber). Experiments were performed to check the validity of the theory. It is shown that for optimum utilization of the properties of the packing and its shrinkage upon tightening of the stuffing box, the chamber should have two cylindrical sections. The studies show that the procedure for calculating stuffing box seals with different sealing materials can also be used for calculating stuffing box seals of a modified design. 5 refs.

Tret'yakov, A.M.; Timoshuk, A.S.; Mil'chenko, A.I. *Chem Pet Eng* v 22 n 9-10 Sep-Oct 1986 p 439-441.

**Materials** See Also SEALS—Materials.

**075861 PACKING OPTIONS FOR ROTATING EQUIPMENT.** A variety of new packing materials has been developed as a result of the potential loss of asbestos. Presented are some packing selection guidelines. Some of the topics discussed include compression packing design, synthetic fiber utilization, packing ratings in various media, and fiberglass alternatives.

Ferland, R.H. (Robco Inc, Pittsburgh, PA, USA). *Hydrocarbon Process* v 67 n 4 Apr 1988 p 39-41.

**075862 NEW COMPRESSION PACKINGS AIM TO REPLACE ASBESTOS.** Material development for compression packings is the key to the solution of critical sealing problems in pumps, especially now that asbestos - formerly the material of choice - can no longer be considered. This article reviews the performance of a variety of compression-packing materials operating in various gases, liquids, and solvents. The materials discussed include braided Teflon ribbon, Teflon yarn, Kevlar yarn and texturized fiberglass.

Ferland, R.H. (Robco Inc, Pittsburgh, PA, USA). *Power Eng (Barrington Ill)* v 92 n 7 Jul 1988 p 28-31.

**Physical Properties** See HEAT EXCHANGERS—Components.

## PACKING PLANTS

### Effluent Treatment

**075863 TREATMENT OF SLAUGHTERHOUSE WASTEWATERS IN STABILIZATION PONDS.** A sampling program was devised to assess in terms of 5-day biochemical oxygen demand (BOD<sub>5</sub>), chemical oxygen demand (COD) and suspended solids (SS) removal the performance of one anaerobic, one facultative and two maturation ponds in series, for treating the wastewater resulting from a slaughterhouse killing approximately 625 pigs/week. The results show that, in spite of poor maintenance, which has been causing bank erosion and macrophyte infestation, the system has coped with large variations in flow and organic load, reducing to a minimum the impact of the effluent discharge on the receiving creek. (Author abstract) 2 refs.

Duarte, A.C. (Univ of Aveiro, Aveiro, Port); Arroja, L.M.; Diegues, P.F.; Rosada, I.; Hall, A.; Oliveira, J.B. *Water Sci Technol* v 19 n 12 1987, Waste Stab Ponds, Proc of an IAWPRC Spec Conf, Lisbon, Port, Jun 29-Jul 2 1987 p 85-91.

**PAINT** See Also BRIDGES, STEEL—Protective Coatings; HEAT TRANSFER—Convection; PHYSICAL CHEMISTRY—Mathematical Models; PIGMENTS—Grinding; STEEL SHEET—Painting; VALVES AND VALVE GEAR—Plastics Applications.

**075864 METHOCCEL AND COLOR ACCEPTANCE OF LATEX PAINTS.** In this study, 30 interior flat paint formulations thickened with hydroxypropyl methylcellulose were made. Each paint contained a different latex. The paints were tested for color acceptance at 120 degrees F with several universal colorant systems. Excellent color acceptance was observed even with the time-honored



'finger rub up' test. Color difference values 'E' were less than one. The latexes evaluated are commercially available acrylics, vinyl acrylics and polyvinyl acetates from eight different manufacturers. (Edited author abstract) 2 refs.

Blake, Donald (Dow Chemical USA). *J Water Borne Coat* v 10 n 4 Nov 1987 p 17, 20.

**075865 ELECTRICAL INDUCTION OF PATTERNS IN METALLIC PAINTS.** A technique for electrically orienting metallic flakes in a wet paint layer using a corona current has been developed. The flakes are oriented perpendicular to the substrate, and a substantial color variation results. The resolution of the affected area is limited by the size of the flake, beam spreading due to space charge, and diffusion of the ions that constitute the corona current. Lines of 1-mm width are easily obtained. No contact with the wet paint layer is required, and the technique is fast and easily automated. The orientation is a result of competition between an induced electric torque and a viscoelastic torque. (Edited author abstract) 7 refs.

Inkpen, Stuart L. (MIT, Cambridge, MA, USA); Melcher, James R.; Jeganathan, Pradeep K. *Ind Eng Chem Res* v 27 n 1 Jan 1988 p 58-64.

**075866 APPLICATION OF THE COULOSTATIC IMPULSE TECHNIQUE FOR THE EVALUATION OF METALLIC SUBSTRATES WITH PAINT COATINGS IN ARTIFICIAL SEA WATER.** A coulостatic impulse technique used as an accelerated, nondestructive, and repetitive test to determine the anticorrosive properties of systems made up of a metal substrate, paint scheme, and electrolytic solution was implemented, together with an equivalent electric circuit representing the interface studied. The systems employed were several dummy cells and a steel sheet which was coated with two types of paints and submerged in sea water. Experimental results obtained for both systems perturbed by equivalent, minimum electric charges were quite similar and reproducible. In addition, they conformed with the results arrived at from calculus using the theoretical resolution of the equivalent electric circuit. By means of a simple, rapid, and nondestructive electrochemical method, the technique provides the ability to differentiate the corrosion protective properties of different organic coatings protecting a metallic substrate from contact with an aggressive electrolytic medium. (Author abstract) 27 refs.

Di Sarli, A.R. (CIDEPI, La Plata, Argent); Aldasoro, R.M.; Paus, G.F.; Podesta, J.J. *J Coat Technol* v 60 n 760 May 1988 p 41-46.

**075867 SALT CONTENT AND ITS TRANSPORT THROUGH EPOXY-POLYAMIDE HYDROPHOBIC FREE FILMS.** The influence of the external salt concentration on the salt content and flux was determined for a normal ratio resin curing agent. These data showed an independence of the salt content and flux on the external concentration, pointing out the existence of a salt exclusion phenomenon. From experiments on permeation for different ratio resin curing agents it was possible to analyse its influence on the salt flux. This data showed an increase of the salt flux with increase of the polyamide content. (Edited author abstract) 18 refs.

D'Alkaine, C.V. (Grupo de Eletroquímica DQ-UFScar, Sao Carlos, Brazil); Ruvoilo Filho, A.; Ribeiro da Silva, D. *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 2, p 1207-1212.

## Additives

**075868 NEW GENERATION OF WATER-BASED THICKENER.** A unique water-based thickener, an organophilic clay produced by the surface treatment of bentonite clay with proprietary organic chemicals, has been developed. It is in the form of an aqueous slurry and can be used in a wide range of pH. In contrast to cellulosic thickener, it is not subjected to microbial degradation. Its rheological properties (pseudoplasticity and thixotropy) make it an excellent rheological additive for controlling application properties in aqueous coating systems. When used in latex paint it suspends pigment, imparts good flow

and leveling, improves sag control, and improves spatter resistance. It also improves hiding which will result in less consumption of TiO<sub>2</sub>. Comparisons against paints thickened with HEC and several associative thickeners are presented. (Edited author abstract) 3 refs.

Tso, Su C. (United Catalysts Inc); Beall, Gary W.; Gordon, John. *J Water Borne Coat* v 10 n 3 Aug 1987 p 3-8.

**075869 EIGENSCHAFTEN VON ALUMINIUMOXID C UND SEINE WIRKUNGEN IM PULVERLACK.** [Properties of Aluminum Oxide C and its Effects in Powder Paint]. Aluminum oxide C is a highly dispersive product used, among other things, as a flowing aid and for increasing the positive electrostatic charge in powder. The effect on the electrostatic charge is of special significance in powder paints which can be applied by triboelectrically. (Edited author abstract) In German. 11 refs.

Ettinger, M. *Metalloberflache* v 41 n 9 Sep 1987 p 429-431.

**075870 INTRODUCTION OF A NOVEL, NONMETALLIC FUNGICIDE FOR THE COATINGS INDUSTRY.** Paint films are subject to fungal attack, which leads to cosmetic disfigurement, deterioration of the paint itself, and possible loss of adhesion. Fungicides are incorporated into coatings to prevent these deleterious effects and to prolong the life and usefulness of the paint. After many years of development work, a new fungicide based on novel chemistry specifically designed for use in coatings to protect against mildew defacement has been introduced. This paper reveals the chemistry of this new compound, the developmental history, and the superior performance characteristics through the presentation of both laboratory and field evaluation data. Comparisons with fungicides currently on the market are shown. The form in which the compound will be commercially available is reviewed, as well as its favorable toxicity profile. (Edited author abstract) 5 refs.

Dalton, Dennis L. (Cosan Chemical Corp, Carlstadt, NJ, USA). *J Coat Technol* v 60 n 761 Jun 1988 p 45-53.

**075871 VISCOELASTIC MEASUREMENT OF ORGANOCCLAY RHEOLOGICAL ADDITIVES FOR LATEX PAINT.** Rheological additives contribute to the viscoelasticity of an aqueous paint composition. In this study with organoclay thickeners and other commercially available thickeners, a correlation of spatter resistance and elastic moduli was observed. The improved spatter resistance of sagging, and flow and leveling organoclay-thickened paint can best be interpreted by the elastic moduli. The article relates viscoelastic parameters, storage modulus, loss modulus and complex viscosity to spatter, sagging, and flow and leveling of two types of paints. One is an acrylic latex enamel and the other is an interior latex wall paint. (Edited author abstract).

Tso, Sue C. (United Catalysts Inc); Rohn, Charles. *J Water Borne Coat* v 11 n 2 May 1988 p 15-17, 20.

**Adhesion** See Also ADHESION; COATINGS—Testing; GALVANIZED METAL—Painting.

**075872 ADHESION OF PAINTS. IS THIS YOUR PROBLEM?** A discussion is presented of phosphating and chromating as techniques for treating surfaces to improve adhesion of paint. Coating application techniques are also discussed. Film drying is examined.

Brown, Lawrie. *Finishing* v 12 n 6 Jun 1988 40p.

**Antifouling** See Also COPPER COMPOUNDS—Desorption; TIN COMPOUNDS—Environmental Impact; TIN COMPOUNDS—Toxicity.

**075873 SEARCH FOR ANTIFOULANT ALTERNATIVES.** There is little doubt that tributyl tin (TBT)-based paints will be the subject of severe restrictions, if not complete elimination. The questions of appropriate alternatives and time of action, however, still remain. It is shown that antifoulants capable of replacing

the organotin biocide tributyl tin are available. The author cited, in particular, a copper-based ablative, tin-free antifoulant which equals and, in some cases, exceeds the performance of the TBT copolymer. Another antifoulant cited is an antibiotic called Compound-X, the advocates of which speak highly of its present performance and also of potential contributions.

Clark, Michael K. (Sea Technology, Arlington, VA, USA). *Sea Technol* v 28 n 10 Oct 1987 p 37-40.

**075874 NONTOXIC ALTERNATIVES TO ANTI-FOULING PAINTS.** All antifouling paints in use today are effective because toxic ingredients based on heavy metals are included in their formulation. The dominant toxins are cuprous oxide and triphenyl of tributyl derivatives of tin. The steady accumulation of these metals in the marine environment has adversely affected marine life, and restrictions on the use of tin-based antifouling paints now exist in the United Kingdom and France, and are under consideration in the United States. An alternative to a toxic coating is a nontoxic fouling release coating which weakens or eliminates the adhesive bond between fouling organisms and the coating. The fouling would then be dislodged by relatively weak mechanical forces, such as those arising from the motion of the ship through the water. This paper describes the formulations of the coatings, their application to five vessels, and their performance to date. (Edited author abstract) 26 refs.

Brady, R.F. (US Naval Research Lab, Washington, DC, USA); Griffith, J.R.; Love, K.S.; Field, D.E. *J Coat Technol* v 59 n 755 Dec 1987 p 113-119.

**075875 USE OF CALCIUM RESINATE IN THE FORMULATION OF SOLUBLE MATRIX ANTI-FOULING PAINTS BASED ON CUPROUS OXIDE.** Antifouling paints based on calcium resinate, calcium resinate/chlorinated rubber and WW rosin/chlorinated rubber were formulated and made in a laboratory ball mill of 3.3-l capacity. The experimental results of immersion raft trials (26 months) were statistically treated (factorial design 2×2×2×3×4, 96 samples prepared and tested in duplicate) and the conclusions then correlated with binder acid values obtained from laboratory analysis. The study showed the influence of composition variables (type of soluble resinous material, resinous material/chlorinated rubber ratio and binder content) and also the importance of some manufacturing variables (order of incorporation of the resinous material and toxicant, and cuprous oxide dispersion time) on the biocidal characteristics of the paints. (Edited author abstract). 17 refs.

Giudice, Carlos A. (CONICET, La Plata, Argent); Del Amo, Beatriz; Rascio, Vicente J.D. *Prog Org Coatings* v 16 n 2 Aug 1 1988 p 165-176.

**075876 ANTIFOULING PAINTS OF THE EMULSION TYPE BASED ON CUPROUS OXIDE.** Forty eight emulsified antifouling paints based on cuprous oxide were tested using oleoresinous binders constituted by bleached linseed oil-ester gum/rosin plus alkyl resin. Studies were made on the influence of binder composition, type of protective colloids and extenders, cuprous oxide content and film thickness on antifouling efficiency. Antifouling paints were applied over sandblasted steel protected by a vinyl wash primer and three coats of anticorrosive paint and tested in the sea during 18 months (including two periods of intense fouling). Trials gave encouraging results due to the good bioactivity with binders constituted by linseed oil-ester gum/rosin and corn starch as protective colloids. (Edited author abstract) 5 refs.

Caprari, J.J. (CIDEPI, La Plata, Argent); Slutsky, O. *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 2, p 1133-1138.

**Applications** See PLASTICS—Painting.

**Chlorinated Rubber** See Also STEEL—Painting; TRAFFIC SIGNS, SIGNALS AND MARKINGS.

**075877 WATER CONTENT AND TRANSPORT**



**THROUGH CHLORINATED RUBBER HYDROPHOBIC FREE FILMS.** As the result of observations using scanning, transmission and contrast phase microscopies as well as mercury porosimeter measurements and a porosity technique using  $\text{CuSO}_4$  in an acid medium, it is possible to propose a model in which the chlorinated rubber films are described as constituted by two phases,  $\alpha$  and  $\beta$ . The  $\alpha$  phase corresponds to the surface cured in contact with air and is continuous and homogeneous. The  $\beta$  phase contains void zones. The flux data showed that the water transport is dependent of film thickness, independent of the substrate and independent of the water activity outside the film. These results are discussed. 9 refs.

Ruvolo-Filho, A. (Univ Federal de Sao Carlos, Sao Carlos, Brazil); D'Alkaine, C.V. *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 2, p 1199-1205.

**Components** See Also STEEL STRUCTURES—Protective Coatings.

**075878 ISOPARAFFINS IMPART BENEFICIAL PROPERTIES TO COATINGS.** Synthetically produced isoparaaffins possess lower surface tensions than most other solvents. Employment of these isoparaaffinic solvents in solvent blends and in paint formulations reduces their surface tensions, which enhances their ability to wet substrates. In water-borne coatings, foam generation is reduced when isoparaaffins are used at low concentrations, alone or together with conventional antifoam agents, with no sacrifice in odor or performance. Higher-boiling isoparaaffins offer the added benefit of extending wet-edge time for these water-borne coatings. (Author abstract) 7 refs.

Storfer, S.J. (Exxon Corp, Linden, NJ, USA); DiPiazza, J.T.; Moran, R.E. *J Coat Technol* v 60 n 761 Jun 1988 p 37-43.

**Composition Effects** See PROTECTIVE COATINGS—Powder.

**Corrosion** See Also STEEL—Painting.

**075879 STUDY OF DIFFERENT PRIMERS IN NATURAL ENVIRONMENTS.** Six primers were exposed in natural environments. The primers studied were zinc chromate (chlorinated rubber), zinc chromate (alcydic), cold galvanized, aluminum rich epoxy amine, iron oxide (chlorinated rubber) and inorganic zinc silicate. The time of exposure was one year. Physical and electrochemical impedance measurements were made. The results show good agreement between the traditional and the electrochemical techniques. The only exception is the aluminum rich epoxiamine primer. (Edited author abstract)

Espada, L. (Univ of Santiago de Compostela, Vigo, Spain); Gonzalez, A.; Sanchez, A.; Merino, P. *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 2, p 1129-1131.

**Corrosion Protection** See PROTECTIVE COATINGS—Organic.

**Curing** See Also OVENS, INDUSTRIAL; STEEL—Painting.

**075880 MEASURING PAINT CURE QUANTITATIVELY.** Evaporative rate analysis is an analytical technique which provides the user with a rapid, quantitative instrumental test method for determining the state of cure of a painted surface. Using a microcomputer based analytical instrument, the technique performs the measurement in less than two minutes. The technique is based on solvent/swell diffusion phenomena resulting from a small droplet of a preformulated test solution which the instrument deposits onto the surface to be tested. A commercially available epoxy paint was chosen to demonstrate the applicability of the technique. 3 refs.

Slover, Charles C. (Meseran Co, Chattanooga, TN, USA). *Met Finish* v 85 n 10 Oct 1987 p 27-29.

**075881 KAWASAKI HEATS UP PRODUCTION.**

Motorcycles, all-terrain vehicles and Jet Ski recreational watercraft are produced by the Lincoln, Nebraska manufacturing plant that was established in 1974 as part of Kawasaki Motors Corporation, USA. When the popularity of Jet Ski watercraft led to larger sales, a production bottleneck was traced to paintcuring. In order to bring parts to required temperatures faster, the company installed a catalytic flameless infrared oven. In catalytic flameless infrared heating systems, natural gas is brought into contact with a catalyst in the presence of oxygen. The resulting reaction oxidizes the natural gas into water vapor and carbon dioxide, generating heat at the same time.

Anon. *Prod Finish (Cincinnati)* v 52 n 9 Jun 1988 p 115-116.

**075882 ANWENDUNGEN INDUSTRIELLER ELEKTRONENSTRAHLHARTUNG VON LACKEN.** [Applications of Industrial Electron Beam Curing of Paints]. In the course of more than 20 years of industrial use, the range of application of beam-cured paint has widened considerably. Its extension into UV curing, for example, can hardly be overlooked any longer. Given the scope of this article, it is neither possible nor intended to present a complete overview of the use of beam curing in coating systems. Instead, a number of examples serve to demonstrate that electron beam cured paints have made low-emission painting possible in certain applications for several years already. (Edited author abstract). 2 Refs. In German.

Haring, Ernst. *Metaloberflaeche* v 42 n 7 Jul 1988 p 331-332.

**Degradation**

**075883 TITANIUM DIOXIDE'S CONTRIBUTION TO THE DURABILITY OF PAINT FILMS.** Several aspects of titanium dioxide's contribution to durability are reviewed in this paper. This picture is one of mixed successes and failures. Industrial efforts to make titanium dioxides less reactive have been successful, but ability to measure the durability of  $\text{TiO}_2$  and paint films is inadequate and may limit further progress. 9 refs.

Braun, Juergen H. (DuPont, Wilmington, DE, USA). *Prog Org Coatings* v 15 n 3 Dec 31 1987, Pap Presented at the Symp: The Meas and Predict of Durability in Org Coatings, Chicago, IL, USA, Sep 4-5 1986 p 249-260.

**075884 INVESTIGATION OF DEGRADATION PROCESSES IN PRIMER COATINGS.** Degradation processes in oil-alkyd, alkyd and polyurethane paint coatings have been investigated. The coatings with active or inert pigments applied on steel were exposed to wet air containing  $\text{SO}_2$  in a cabinet and to an urban atmosphere in an open space. Differences in behaviour have been established, but in general there are three periods during the exposure. In the first period the coating is stable, in the second period the degradation takes place, and in the third period the coating is broken down. (Edited author abstract) 6 refs.

Kunst, M. (Faculty of Mechanical Engineering & Naval Architecture, Zagreb, Yugoslavia); Esih, I. *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 2, p 1139-1150.

**Drying** See OVENS, INDUSTRIAL—Electric.

**Electric Conductivity**

**075885 INVESTIGATION OF ELECTRICAL RESISTIVITY-PIGMENT VOLUME CONCENTRATION RELATIONSHIP IN CARBON BLACK FILLED CONDUCTIVE PAINT.** Carbon black filled conductive paints are very useful for antistatic and EMI shielding applications. However, there is a certain limit to the conductivity that can be achieved. In this work, the relationship between electrical resistivity and carbon black loading of dry paint films was investigated. It is shown that the volume resistivity of these paints is proportional to the cube root of the volume concentration of the carbon black pigment and that the upper limit of

the volume conductivity attainable corresponds to the CPVC of the formulation. Beyond this point, conductivity decreases due to void formation in the dry paint film. (Edited author abstract) 19 refs.

Calahorra, Arie (RAFAEL-Armament Development Authority, Haifa, Israel). *J Coat Technol* v 60 n 757 Feb 1988 p 25-30.

**Electrodeposition** See Also PAINTING—Electrodeposition.

**075886 ELECTRODEPOSITION OF PAINT IN CARBON BLACK FILLED SYSTEMS.** Electrodeposition of paint (EDP) has been investigated with the aid of electrochemical methods using four various binders pigmented with five various carbon blacks (c.b.) in the concentration range of 0-25 weight percent (w/o) (in the solid). Electrodeposition itself is not influenced at low to medium c.b. concentrations, where ionic wet films resistivity is even slightly enhanced by single particles dispersed in the binder. At a relatively high critical c.b. concentration  $C_w$ , where strong electronic conductivity in the wet film is initiated due to the formation of linear agglomerates of c.b. particles, heavily deteriorated deposits are produced with warts at the surface. In the stoved film, electronic conductivities are in the range of  $10^{-9}$ - $10^{-5}$   $\text{cm}^{-1}$ . Percolation sets in at extremely low c.b. concentrations in the order of 1 W/O. (Edited author abstract) 35 refs.

Beck, Fritz (Univ of Duisburg, Duisburg, West Germany); Guder, Harald. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2416-2424.

**Failure** See Also COATINGS—Adhesion.

**075887 MODERN TECHNIQUES FOR THE ANALYSIS OF PAINT FAILURES.** The investigation of paint failures is important for a number of reasons. Identification of the cause of failure can determine the liability, if any, for repair or recoating and can provide a guide to the most effective remedial treatment. In addition, study of many failures can lead to a deeper insight into the mechanisms by which coatings adhere to and protect the underlying substrate. In this paper, several paint failure investigations are described, showing how in some cases the cause of failure may become obvious using low magnification optical microscopy, while in others a more advanced technique, Scanning Electron Microscopy (SEM) with Energy Dispersive X-ray (EDX) analysis, has proved extremely effective.

Clewes, W.D. (BP Research Cent). *J Prot Coat Linings* v 3 n 12 Dec 1986 p 56-63.

**Latex** See Also PIGMENTS—Agglomeration.

**075888 HEAT AND MASS TRANSFER IN LATEX PAINTS DURING DRYING.** Latex paint apparently dries in two stages. The first, when the evaporation rate of water is largely constant, occurs while an evaporative surface, separating the 'dried' layer from the still wet layer, moves towards the substrate. Evaporation during this stage depends on ambient conditions and can be modeled well by heat and mass transfer calculations. The drying slows to zero in the second stage, when the water supply for evaporation is depleted. A simple model for the second stage, that links evaporation rate with decreasing concentration of water, completes a good representation of the whole drying curve. (Author abstract) 15 refs.

Croll, Stuart G. (Sherwin-Williams Co, Chicago, IL, USA). *J Coat Technol* v 59 n 751 Aug 1987 p 81-92.

**075889 METHOCCEL AND COLOR ACCEPTANCE OF LATEX PAINTS.** 30 interior flat paint formulations thickened with hydroxypropyl methylcellulose were made. Each paint contained a different latex. The paints were tested for color acceptance at 120 degrees F with several universal colorant systems. Excellent color acceptance was observed even with the time-honored 'finger rub



up' test. Color difference values 'E' were less than one. The latexes evaluated are commercially available acrylics, vinyl acrylics and polyvinyl acetates from eight different manufacturers. 2 refs.

Blake, Donald (Dow Chemical USA). *J Water Borne Coat* v 11 n 3 Aug 1988 p 2-9, 12-13.

**Luminous** See TRAFFIC SIGNS, SIGNALS AND MARKINGS—Coatings.

## Manufacture

**075890 FLOW AND FILM PROPERTIES OF COATINGS CONTAINING MICROGELS.** Microgels have been prepared via an emulsion polymerization process involving the use of the amphiphilic oligosulfate, ZEO. The particle sizes of these microgels were < 100 nm and particle properties such as crosslink density, copolymer composition and functionality could be varied over a wide range. Their versatility and usefulness as coating modifiers has been demonstrated. Dispersions of the microgels are stable in both aqueous and organic media. Furthermore, solid powdered microgels can be produced by drying the emulsions. These powdered microgels are generally added to photoreactive coatings or can be redispersed in the above media. Such microgels may be applied in various other fields besides coatings because of the diversity of their form and properties. (Author abstract) 4 refs.

Ishikura, Shinichi (Nippon Paint Co, Osaka, Jpn); Ishii, Keizou; Midzuguchi, Ryuzo. *Prog Org Coatings* v 15 n 4 Feb 29 1988 p 373-387.

**075891 QUALITY CONNECTION IN PAINT MANUFACTURING.** Quality is more than just a trendy word at Rockford Coatings; it is a way of life. Quality is emphasized throughout all operations, from checking incoming raw materials to testing paints before shipment. Rockford Coatings approaches quality in two ways, according to Mel Meyer, vice-president and general manager. 'First, we emphasize quality throughout the plant. Second, we design quality standards around end-user requirements. Our testing is designed to check the coatings against whatever processes the customer is using.'

Bailey, Jane M. (Industrial Finishing, Wheaton, IL, USA). *Ind Finish (Wheaton III)* v 64 n 4 Apr 1988 p 22-24.

**075892 HAZARDOUS WASTE MINIMIZATION: PART III. WASTE MINIMIZATION IN THE PAINT AND ALLIED PRODUCTS INDUSTRY.** This paper looks at waste minimization practices available to the paint and coatings industry. The paper begins with an introduction to the industry and a description of the products. The steps involved in the manufacture of paints and coatings are then described. The paper then identifies the wastes generated. Source reduction and recycling techniques are the predominant means of minimizing waste in this industry. Equipment cleaning wastes are the largest category of wastes, and the paper concentrates on equipment and techniques available to reduce or eliminate these wastes. Techniques are described to reduce the other wastes from manufacturing operations. The paper concludes with a discussion of changing industry product trends and the effect that these trends will have on the generation of waste. (Author abstract) 6 refs.

Lorton, Gregory A. (Jacobs Engineering Group, Pasadena, CA, USA). *JAPCA* v 38 n 4 Apr 1988 p 422-427.

## Mixing

**075893 PAINT MIXERS FOR DILUTING ANTI-BURN-ON DRESSINGS.** Anti-burn-on pastes are usually diluted to the necessary consistency in paint mixers with a shaft speed of about 60 rpm and a frame-type agitator. This sets up a tangential flow pattern in the mixer; the mixture rotates in a mainly horizontal circular path with little vertical or radial mixing. For the more efficient dilution and mixing of pastes in the foundry, one should use a bladed paint mixer with reflection

surfaces and raise the shaft speed to about 200 rpm.

Davydov, N.I.; Rebel'skii, M.B. *Sov Cast Technol* n 4 1986 p 53-54.

**Optical Properties** See PIGMENTS—Optical Properties.

**Organic** See PLASTICS—Coloring.

## Plastic Applications

**075894 NEW RESINS MEET APPLICATION DEMANDS.** Today a coating resin is usually a synthetic polymer. This film-forming substance binds together all the coating materials. Each synthetic resin is designed with a specific molecular structure to do a particular job. This article briefly comments on several new resins.

Bailey, Jane M. (Industrial Finishing, Wheaton, IL, USA). *Ind Finish (Wheaton III)* v 64 n 2 Feb 1988 p 28, 30-31.

**Plastics** See Also CHEMICAL PLANTS—Painting; FOOD PRODUCTS PLANTS—Painting.

**075895 KINETICS OF THE RELEASE OF 2,3,5,6-TETRACHLORO-4-METHYLSULFONYL PYRIDINE (TMP) FROM UNPIGMENTED FILMS.** The rate of the loss of 2,3,5,6-tetrachloro-4-methylsulfonyl pyridine (TMP) from unpigmented acrylic films was studied using kinetic equations developed for the release of a soluble material from a planar controlled-release device. For unencapsulated TMP, the rate of solution was greatly reduced when incorporated into the films which were cast from an acrylic latex and dried for 24 hr. Additional dry times, up to three weeks, did not significantly reduce the release rate. The 95% confidence interval for the release of unencapsulated TMP was found to be  $17.71 \pm 10.33$  percent/min<sup>1/2</sup>. The 95% confidence interval for the release rate of the microencapsulated TMP was  $4.42 \pm 2.40$  percent/min<sup>3/4</sup>. The F ratio was used to demonstrate that the reduction of the release rate by microencapsulation was statistically significant. The rate of release of TMP was also found to vary in proportion to the solubility of the TMP in the extraction solvent. Based on these results, the unpigmented acrylic latex film was characterized as a porous, monolithic controlled-release device. (Author abstract) 14 refs.

Noren, G.K. (DeSoto Inc, Des Plaines, IL, USA); Clifton, M.F. *J Coat Technol* v 60 n 759 Apr 1988 p 31-35.

## Production

**075896 THEORY FOR THE DEAGGLOMERATION OF PIGMENT CLUSTERS IN DISPERSION MACHINERY BY MECHANICAL FORCES. I.** An equation quantifying the total probability,  $P_T$ , for an agglomerate of pigment or filler particles to be dispersed in a dispersion medium is derived. This total probability is shown to be the product of two separate, partial probabilities: the probability  $p_p$ , with which the agglomerates encounter a potentially active dispersion site, and the probability  $p_e$ , that enough energy per unit volume (energy density  $E/V$ ) is available to overcome the forces holding the agglomerates together. The total probability,  $P_T$ , is brought into connection with measurable paint properties, i.e., tinting strength development. (Author abstract) 13 refs.

Winkler, J. (Sachtleben Chemie GmbH, Duisburg, West Ger); Klinker, E.; Dulog, L. *J Coat Technol* v 59 n 754 Nov 1987 p 35-41.

**075897 THEORY FOR THE DEAGGLOMERATION OF PIGMENT CLUSTERS IN DISPERSION MACHINERY BY MECHANICAL FORCES. II.** An equation quantifying the probability for agglomerates to be dispersed in a dispersion machine from a previous paper is applied quantitatively to a continuously operated bead mill and a high-speed impeller. The effective volume per time unit is computed for various dispersion conditions in these devices. In addition, the fraction of energy used for dispersion is estimated. Effective volumes per second were found to be in the order of a magnitude of 1%

of the total volume filled with paint. The transfer of the energy onto the agglomerates takes place with an efficiency of approximately 1%. (Author abstract) 5 refs.

Winkler, J. (Sachtleben Chemie GmbH, Duisburg, West Ger); Klinker, E.; Sathyanarayana, M.N.; Dulog, L. *J Coat Technol* v 59 n 754 Nov 1987 45-53.

**075898 THEORY FOR THE DEAGGLOMERATION OF PIGMENT CLUSTERS IN DISPERSION MACHINERY BY MECHANICAL FORCES. III.** The effects of temperature and viscosity on the colloidal and mechanical aspects of pigment dispersions are viewed. The total amount of work mediated onto the mill bases during dispersions is not suitable to characterize the degree of deagglomeration. There is evidence that, in most dispersion machinery, the deagglomeration is governed by the shear stress within the mill base. This suggests that shearing type mechanisms are far more important than smashing type stresses for dispersions. Examples for the qualitative utilization of the total probability function,  $P_T$ , describing the dispersion process are given. (Author abstract) 39 refs.

Winkler, J. (Sachtleben Chemie GmbH, Duisburg, West Ger); Dulog, L. *J Coat Technol* v 59 n 754 Nov 1987 p 55-60.

## Quality Control

**075899 FILTERING KEY TO PERFECT CAR FINISH.** Paint manufacturing cleanliness and housekeeping standards must ensure that paint mixing equipment, piping, drums, tanks and transportation systems are free of contamination. Closed systems are used to the greatest extent possible, and all containers are tightly shut during transportation. Containers must be 'super clean.' Purchase specifications for drums or tote tanks are to medical standards. Cleaning procedures for the containers are explicit and demanding. Filtration is often used throughout paint-making. The choice of filtration is based on the nature and volume of the contaminant to be removed.

Ponchick, Alan R. (Cuno Inc, Meriden, CT, USA). *Ind Finish (Wheaton III)* v 64 n 4 Apr 1988 p 27-28.

**Radiation Effects** See NUCLEAR REACTORS—Coatings.

**Removal** See Also COATINGS—Repair.

**075900 KRYOGEN-ENTLACKUNG MIT TITELN.** [Cryogenic Paint Removal by Means of Titelen]. Cryogenic paint removal possesses interesting features both from the ecological and economical viewpoints for removing paint from metal parts. This technique is used with various methods for conventional alkyd melamine stoving systems and air-dried synthetic resin or nitrocellulose lacquers. None of these methods, however, can be used with powder paint coatings. A suitable procedure was obtained by developing a primer called Titelen, which consists of natural proteins and is capable of swelling, thus making it possible to separate the paint coat from the part. (Edited author abstract). In German.

Morgenstern, Norbert. *Metaloberflaeche* v 41 n 8 Aug 1987 p 369-370.

**075901 REDUCTION OF TOTAL TOXIC ORGANIC DISCHARGES AND VOC EMISSIONS FROM PAINT STRIPPING OPERATIONS USING PLASTIC MEDIA BLASTING.** Three depainting methods were compared for their ability to strip Army communications shelters: chemical stripping, sandblasting, and plastic media blasting (PMB). Each process was studied with respect to the economics, the environmental impact, and the quality of the product. The purpose of this study was to determine if the PMB method is applicable to Army communications shelters and whether it would be advantageous for the Army to convert to this procedure both from the perspective of process efficiency and pollution reduction. The PMB process was determined



superior to the chemical stripping process and marginally better than sandblasting based upon the evaluation criteria. This report presents study results of the three methods evaluated and compares their respective efficiencies, processing costs, and waste generation. (Edited author abstract)

Wolbach, C.D.; McDonald, C. *J Hazard Mater* v 17 n 1 Dec 1987 p 109-113.

**075902 DILEMMA OF REMOVING LEAD-BASED PAINT.** This article describes the problems associated with removal of lead-based paints from bridges, the range of solutions being considered, research and Federal regulations. Two general strategies can be employed in an attempt to comply with hazardous waste disposal regulations. One involves using abrasive blasting together with capture and containment techniques. The other involves alternate surface preparation techniques without abrasive where the volume of waste that must be disposed of is diminished. 13 refs.

Hower, Harold E. (Journal of Protective Coatings & Linings, Pittsburgh, PA, USA). *J Prot Coat Linings* v 5 n 1 Jan 1988 p 30-37.

**075903 LEAD-PIGMENTED PAINTS-THEIR IMPACT ON BRIDGE MAINTENANCE STRATEGIES AND COSTS.** The removal, containment, recovery, and disposal of lead-pigmented paints is fast becoming one of the most critical cost items in steel bridge maintenance. The article examines the problems associated with the removal of lead-based paint and assess impacts on maintenance strategies and cost. It is concluded that for the majority of bridges, lead-paint debris does not pose a significant threat, but for certain urban bridges, it is necessary to carefully monitor and control the wastes. There is no proven cost-effective technology for the removal and containment of lead-based paint. Further equipment development is recommended. The Federal Highway Administration (FHWA) designated the removal of lead-containing bridge paint as a High Priority National Program Area. The immediate result of this was a symposium/workshop organized on the removal of lead-based paint, held February 29-March 1, 1988, and March 2-3, 1988, respectively. The main findings of the symposium/workshop are summed up. 7 refs.

Peart, John W. *Public Roads* v 52 n 2 Sep 1988 p 47-51.

## Selection

**075904 1988 PAINT AND COATINGS SELECTION AND COST GUIDE.** This paper updates and expands the authors' previous papers designed to assist the coatings engineer or specifier in identifying suitable paint and coating systems for specific industrial atmospheric environments, calculating current approximate installed costs and life for each, and establishing economic justification for their selections. In addition to cost factors for new construction and its normal maintenance, the 1988 edition includes maintenance painting conditions and cost factors covering varying degrees of rusting, pitting, and old paint breakdown. Generic classes of products and systems have been updated and expanded from 74 to 98 of the most commonly used protective coating systems, with particular emphasis on surface-tolerant coatings and those containing high-solids, volatile organic compound (VOC)-conforming products. Top-coated galvanized, and zinc metallized systems are included for comparison. 8 refs.

Brevoort, Gordon H. (Brevoort Consulting Associates Inc, Ridgewood, NJ, USA); Roebuck, A.H. *Mater Perform* v 27 n 6 Jun 1988 p 29-41.

**075905 SELECTING COATINGS FOR INDUSTRIAL PAINTING.** Selecting coatings is an important and critical aspect in the corrosion protection of structural facilities. The first part of this paper describes some of the general considerations for selection of a coating. Many agencies, both private and public, have developed coating selection schemes which enable the owner's representative to systematically select coatings for specific structures.

These guidelines, called engineering standards, are based upon the types of structures at the agency's facilities. Development of such standards is discussed in the second part of this paper. 4 refs.

Appleman, Bernard R. (Journal of Protective Coatings & Linings, Pittsburgh, PA, USA). *J Prot Coat Linings* v 5 n 6 Jun 1988 p 30-41.

**075906 GENERIC COATING TYPES: THEIR CHARACTERISTICS AND USES.** This article describes liquid-applied (usually by brush, roller, or spray) coating and lining materials that are commonly used for corrosion protection in atmospheric or immersion service. The coating systems discussed are categorized by generic type of binder or resin and grouped according to the curing or hardening mechanism inherent with that generic type. While the resin or organic binder of the coating material is most influential in determining the resistances and properties of the paint, the type and amount of pigments, solvents, and additives such as rheological aids, etc., may also influence the application properties and protective capability of the applied film. Hybridized systems can be formulated that are crosses between the categories. 7 refs.

Tator, Kenneth B. (KTA-Tator Inc, USA). *J Prot Coat Linings* v 5 n 6 Jun 1988 p 42-53.

**Spectroscopic Analysis** See SPECTROMETERS, INFRARED—Accessories.

## Synthesis

**075907 USE OF SMALL POLYMERIC MICROVOIDS IN FORMULATING HIGH PVC PAINTS.** Since the introduction of opaque polymers to the coatings industry, many paint manufacturers have successfully used this small polymeric microvoid technology to lower their total raw material costs, while maintaining the quality of their paint formulation. This trend has recently accelerated due to increased prices for titanium dioxide, improvement in opaque polymer technology, and the move to uniform sales of paint by volume rather than weight. In the highly competitive interior paint market, these key properties include color, hiding, and washability. (Edited author abstract) 6 refs.

Fasano, David M. (Rohm & Haas Co, Spring House, PA, USA). *J Coat Technol* v 59 n 752 Sep 1987 p 109-116.

**Testing** See PIGMENTS—Testing.

## Thermal Effects

**075908 THERMOCHROMIC PAINTS AND PRINTING INKS.** Major advances in liquid crystal technology have made thermochromic paints and printing inks suitable for a wide range of industrial and commercial uses. The chiral nematic thermochromic crystals now produced are said to be sufficiently stable and reproducible for uses on a wider scale than any previous product of this type. Available as a 33% by weight micro-encapsulated liquid crystal suspension in water using gelatin/gum arabic coacervate walls crosslinked with an aldehyde, a thermochrome is, for the first time, available as a raw material for easy incorporation into any waterbased paint or ink. Chiral nematic thermochromes are micro-encapsulated using the well-known and available National Cash Register (NCR) oil process. The chiral nematics available from BDH Ltd. overcome the problems associated with cholesteryl esters. Once micro-encapsulated, the chiral nematics have far superior ultraviolet light resistance, although they remain vulnerable to attack by solvents.

Slade, S. *Eng Dig (Toronto)* v 33 n 2 Feb 1987 p 24-25.

**Thickness Measurement** See Also PROTECTIVE COATINGS—Quality Control.

**075909 MAGNETIC PARTICLE TESTING OF PAINTED PARTS.** Based on the principle of Faraday-Maxwell, the electromagnetic force acting on magnetic particle by leakage flux is analyzed, on which the sensitivity of magnetic testing is depended. The relation-

ship between the paint thickness and leakage flux distribution is also analyzed by means of finite element method (FEM). It comes to the conclusion that the magnetic particle inspection is feasible for the parts with paints of certain thickness. It has the advantage of high contrast and clear displaying. (Author abstract) In Chinese.

Zhang, Qi (Xian Jiaotong Univ, China); Yu, Lunyuan; Gou, Zhongxin. *Wusun Jiance* v 9 n 6 Jun 1987 p 151-155.

**075910 MAGNETIC PARTICLE INSPECTION OF FERROMAGNETIC PARTS PAINTED.** The feasibility of magnetic inspection of ferromagnetic parts painted is described. And the relationship between the thickness of a paint and the depth of a crack is determined by experiments. (Author abstract) In Chinese.

Ding, Guantang; Miao, Shouren. *Wusun Jiance* v 9 n 6 Jun 1987 p 156-157.

## Thinners

**075911 INFLUENCE OF THINNER ADDITION ON BRUSHABILITY AND SAGGING OF HIGH BUILD ANTICORROSIVE PAINTS.** The objective of this paper was to establish rheologically the influence of thinner addition on the workability and sagging of high build anticorrosive paints of the same composition but with different thixotropic agent content (castor oil). Anticorrosive paints were prepared with a binder based on chlorinated rubber and, plasticized with 42% and 70% chlorinated paraffin. Zinc tetroxochromate, red iron oxide and barytes were employed as pigments. After pigment dispersion, castor oil gel was incorporated. The results of a rheological test allowed the viscosity calculation at an infinite shear rate. Thinning with 10% xylene did not affect workability. The influence of dilution on sagging is that modifies the shear stress and build up kinetics. The thinned samples with castor oil showed lower dry film thickness without sagging. (Edited author abstract) 10 refs.

del Amo, Beatriz (CIDEPI, La Plata, Argent); Rascio, Vicente J.D.; Guidice, Carlos A. *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 2, p 1063-1070.

**Toxicity** See Also ORGANOMETALLICS—Spectroscopic Analysis.

**075912 SOLVENT REFORMULATION-THE SUBSTITUTION FOR ETHYLENE-BASED GLYCOL ETHERS AND ACETATES.** Ethylene-based glycol ethers and acetates have been identified as significant health hazards, and alternate solvents must be selected to replace them. This article describes the toxicology of glycol ethers, their physical properties and appropriate substitute solvents and formulations. It is organized according to three categories where reformulation is required: solvent-based glycol ether formulations, water-reducible glycol ether formulations and solvent-based glycol ether acetate formulations. 7 Refs.

Heckman, Roger A. (ARCO Chemical Co). *J Water Borne Coat* v 11 n 2 May 1988 p 2-11, 14.

**Viscosity** See Also ACRYLICS—Latex.

**075913 CONTROLLING VISCOSITY OF HIGH-SOLIDS COATINGS.** With the shift from solvent-based coatings to high-solids high-performance coatings, products finishers are facing many production problems that didn't exist five years ago. Driven by EPA requirements for the reduction of volatile organic compounds (VOCs), coating producers are introducing highly viscous finishes to manufacturers. Fluid heaters improve the application characteristics of high-solids coatings, resulting in higher quality finishes.

Soderstrom, Ric (Graco Inc, Minneapolis, MN, USA). *Prod Finish (Cincinnati)* v 52 n 7 Apr 1988 p 98-103.



## Weathering

**075914 ACCELERATED WEATHERING OF AUTOMOTIVE PAINTS MEASURED BY GLOSS AND INFRARED SPECTROSCOPY.** The purpose of this study was to determine how much faster automotive paints weathered by accelerated programs than by Florida exposure, and which accelerated program best simulated the effects of Florida exposure. Nine automotive paints, each in white and light blue colors, were weathered by five exposure programs. Three of these exposure programs used sunlight in Florida, Florida and Caracas, and in Arizona using EMMA (Equatorial Mount with Mirrors for Acceleration). The two other exposure programs used laboratory conditions and illumination (xenon-arc and quartz-filtered ultraviolet). The effect of surface weathering was measured by loss of gloss. Spearman ranking correlation coefficients of rates of gloss loss showed xenon-arc weathering correlated with Florida weathering slightly better than QUV, but both were greater than 0.9. (Edited author abstract) 23 refs.

McEwen, D.J. (GM, Warren, MI, USA); Verma, M.H.; Turner, R.O. *J Coat Technol* v 59 n 755 Dec 1987 p 123-129.

**PAINT SPRAYING** See Also ELECTROPLATING SHOPS—Quality Control; ROBOTS, INDUSTRIAL—Manipulators.

**075915 NEW PRETREATMENT AND SPRAY PLANT FOR VAUXHALL'S CAVALIER.** A new pretreatment and spray painting plant built by Durr Ltd, Warwick, for finishing the saloon, hatch-back, and estate models of the popular Cavalier car, has been integrated into the production line at Vauxhall Motors Ltd's factory in Luton. Costing £20m, the Durr plant went into full production at the end of last year (1986). It is one of the most modern in Europe, and forms part of a new extension to the AC Block of Luton, which including the building and services represents a total investment by Vauxhall of £93m. Finishing capacity has increased from 40 to 52 bodies per hour. In addition to designing and manufacturing the finishing plant, Durr acted as consultants for the design of all the services in the AC Block extension.

Anon. *Prod Finish (London)* v 40 n 10 Oct 1987 p 15.

**075916 NEW STEELCASE HIGH-SOLIDS DISK LINE.** A new high-speed rotary disk line at Steelcase is improving quality, reducing operating costs, cutting energy use and minimizing the emission of volatile organic compounds (VOCs). The line was installed at the company's computer furniture plant in Grand Rapids, MI, to coat computer housings and lighting fixtures. Reduced operating costs stem from low manpower operating and maintenance requirements. One person operates the lines.

Anon. *Ind Finish (Wheaton Ill)* v 63 n 11 Nov 1987 p 37-38.

**075917 HON RECYCLES HIGH-SOLIDS OVER-SPRAY.** High solids solventborne coatings tend to be more costly than conventional low solids coatings. With this extra cost in mind, finishers applying high solids tend to be interested in transfer efficiency. Paint that doesn't reach the part to be coated becomes lost overspray. At the HON Co. plant in Cedartown, GA, the overspray is being recovered and recycled. The operation is allowing the plant to use nearly 95% of the paint that is sprayed.

Gardner, Charles L. (HON Co, Muscatine, IA, USA). *Ind Finish (Wheaton Ill)* v 63 n 12 Dec 1987 p 30-31.

**075918 EB/UV CURE OF 100%-SOLIDS 'WET-LOOK' PIGMENTED COATINGS.** High-gloss 'wet look' pigmented finishes have increased in popularity in various markets in the last few years. To meet consumer demand for durable high gloss products, technological advances were introduced during the 1970s which involved multiple applications, cures and sandings of ultraviolet-curable polyester resins. Universal Woods (Louisville, KY) has developed a UV and electron beam system for curing 100% solids pigmented coatings to

create high gloss finishes on flat stock for furniture and cabinet components. This process eliminates the shortcomings of the Italian method.

Anon. *Ind Finish (Wheaton Ill)* v 63 n 12 Dec 1987 p 34-35.

**075919 SOME RECENT ADVANCES IN AUTOMATIC SPRAY PAINTING SYSTEMS.** The article briefly reviews developments in automatic systems. Several installations in England are cited. The equipment includes horizontal traverse spraying machines, robots, camera recognition systems and two-component systems. 2 refs.

Eaton, Mike. *Prod Finish (London)* v 41 n 2 Feb 1988 p 10, 12-13.

**075920 PAINTING WITH A GENTLE TOUCH.** Low pressure high volume turbine spray equipment employs essentially an air turbine and a spray gun. The turbine generates atomizing air at a pressure of 7 to 10 psi at high-cfm volumes. The frictional action of the turbine's stages generates atomizing air at 200°F. The system can be used with specially designed manual or automatic guns. Robotic use also is possible.

Bunnell, Mike H. (CAN-AM Engineered Products Inc, Livonia, MI, USA). *Ind Finish (Wheaton Ill)* v 64 n 5 May 1988 p 28.

**075921 KOMATSU'S NEW PAINTING SYSTEM.** Large construction equipment is painted with an air-dry high-solids coating at Komatsu American Manufacturing Corp. in Chattanooga, Tennessee. Painters use air-assisted airless guns, both electrostatic and non-electrostatic. A trench in the spray booth permits spraying of the underside of the equipment.

Anon. *Prod Finish (Cincinnati)* v 52 n 9 Jun 1988 p 66-68.

## Automation

**075922 ENGINEERING DESIGN.** Today's high-performance military aircraft typically are built with bonded combinations of machined extruded aluminum sections, aluminum honeycomb, and aluminum skin. Pound for pound, the resulting structure is up to 39 times stronger than solid aluminum. Thermwood Corp. (Richardson, TX, and Dale, IN) has applied this same technology in the design of its new PR Series spray painting robots. Three different models are included in the line. All are six-axis units, incorporate the same basic construction details, and differ only in size and working envelope.

Stauffer, Robert N. (Robotics Today, Dearborn, MI, USA). *Rob Today* v 7 n 3 Jun 1985 p 75-76.

**075923 FINISHING THE JOB - AUTOMOTIVE-WISE.** Haden Drysys claims that keeping pace with the changing technology in paint finishing systems is something it has got down to a fine art. This is particularly so in the automotive industry where the company's continuous investment and research program has produced a range of new systems and equipment that solve the problems of air pollution, noise, energy conservation, corrosion and, increasingly have an emphasis on automation. (Author abstract)

Anon. *Prod Finish (London)* v 40 n 10 Oct 1987 p 12, 14.

**075924 CAD-BASED OFF-LINE PROGRAMMING OF PAINTING ROBOTS.** The progress of CAD/CAM methods and the growing interest in an off-line approach in robot programming supplied an idea for applying this technique to the programming of a painting robot. This would result in a better quality of coating and in a decrease of paint loss. There is also a possibility of interactive design of optimal spray gun trajectories for various workpieces. 7 refs.

Klein, Alexandr (Hungarian Acad of Science, Budapest, Hung). *Robotica* v 5 pt 4 Oct-Dec 1987 p 267-271.

## Control

**075925 CONTROLLING SPRAY BOOTHS WITH CHEMICALS.** Booth control chemicals have been developed primarily for treating unwanted overspray paint in both manual and automatic spray booths. They can be classified into two types. One type is chemicals for treating and neutralising the overspray paint to render it non-tacky and thus facilitate its eventual removal. These find their widest use in continuous, large volume production lines where a large amount of unwanted overspray paint is generated. The second type is temporary coatings which are applied to surfaces likely to be covered by the overspray paint and then subsequently removed. This type of booth control chemical would typically be used in intermittent production, manual spray booths or on exposed structural areas liable to contamination by the overspray paint.

Zoltowski, Z. (Pyrene Chemical Services); Brooks, M.E. *Finishing* v 11 n 8 Aug 1987 p 27-28.

**Efficiency** See Also PROTECTIVE COATINGS—Flame Spraying.

**075926 CALCULATING ON-LINE COATING TRANSFER EFFICIENCY.** The capability of coating application equipment to coat a product with a minimum of waste is a measure of its efficiency. Coating equipment transfer efficiency (CETE) can be evaluated on an operating chemical coating line with relatively good accuracy. The overall coating process efficiency (OCPE) is largely dependent on the CETE, and the difference between the two reflects losses in handling, spillage and clean-up. In the experiments reported, the paint material used was a two-coat, high-performance release coating.

Yotti, Brad A. (Univ of Minnesota, Minneapolis, MN, USA); McComas, Cindy A. *Prod Finish (Cincinnati)* v 52 n 3 Dec 1987 p 91-96.

**Electrostatic** See CONTROL EQUIPMENT, ELECTRIC—Applications.

**Environmental Impact** See AUTOMOBILE MANUFACTURE—Finishing.

## Equipment

**075927 SELECTING AUTOMATIC SPRAY GUNS.** Finishing plants relying solely on manual spray guns should investigate the possibility of switching to automatic guns. The upgrading can improve quality, reduce labor overhead, lower volatile organic compound (VOC) emissions, cut paint waste and lessen the likelihood of health and safety claims. Automatic (and manual) spray guns are of three basic atomizing types: air, airless and air-assisted airless. Each type is available with an electrostatic option.

Ehrenhofer, Kenneth R. (Kremlin Inc, Addison, IL, USA). *Ind Finish (Wheaton Ill)* v 63 n 11 Nov 1987 p 31-32, 34-35.

**075928 APPLYING HIGH-SOLIDS AND WATER-BORNE ELECTROSTATICALLY.** Several years ago the demand for the development of industrial coatings that would comply with pending environmental legislation led to interest in water-borne and high-solids coatings. It soon became apparent that in order to spray these coatings efficiently, some modifications to the application equipment would be required. High-speed rotational atomizers coupled with system modules and automatic control can apply hard-to-atomize coatings with high-quality results.

Scharfenberger, Jim (Ransburg-Gema Inc, Indianapolis, IN, USA). *Prod Finish (Cincinnati)* v 52 n 8 May 1988 p 50-55.

**075929 TODAY'S POWER-AND-FREE CONVEYORS.** Planners of finishing systems are continually searching for ways to increase finish quality, improve product



flow, reduce handling and lower costs. Many have discovered that an improved material handling system can help meet those goals. For applications in the finishing industry, a popular choice is the power-and-free conveyor. Today these conveyors are particularly valuable to highly automated painting facilities. The article discusses application to painting automobiles.

Tylaman, Theodore (Jervis B. Webb Co, Framington, MI, USA). *Prod Finish (Cincinnati)* v 52 n 11 Aug 1988 p 88-95.

**Fire Protection** See AUTOMOBILE MANUFACTURE—Painting.

**Optimization** See Also WOOD PRODUCTS—Finishing.

**075930 AIR-CLEANED FLAT-JET NOZZEL.** This paper is concerned with the problems of powder coating complex structural shapes using an automatic system. A short discussion of the physical principles involved demonstrates that the solution to these problems must be of both aerodynamic and electrical nature. A flat-jet nozzle with an air-cleaned electrode is proposed as a solution. The flat-jet nozzle produces the desired flow conditions and the air-cleaned electrode system supplies a consistent high-voltage charge. It is the combination of these two components that ensures both uniformity and consistency in powder coating the most difficult structures.

Welte, Urs J. (Ransburg-Gema Inc, St. Gallen, Switz). *Met Finish* v 86 n 8 Aug 1988 p 33-34, 36.

## Planning

**075931 PLANUNG UND REALISIERUNG NEUER LACKIERLINIEN FUER PULVERBESCHICHTUNG UND NASSLACK.** [Planning and Implementation of New Painting Lines for Powder Coating and Wet Paint]. This article presents a case from actual practice where the assets of powder coating are used as far as possible, although wet painting cannot be dispensed with. The problem solution, whose planning and implementation is described in detail, covers a total of three painting lines for powder and wet paint in combination. (Edited author abstract) In German.

Haupt, Helmut. *Metallberflaeche* v 41 n 9 Sep 1987 p 421-425.

**Robot Applications** See Also AUTOMOBILES—Painting.

**075932 AUTOMATIC PAINT PLANT SPEEDS PRODUCTION AND INCREASES FINISH QUALITY AT CROWN CONTROLS.** Crown Controls of Galway, Eire had several painting problems in the production of pallet fork trucks. The problems ranged from inconsistent coverage to excessive overspraying. An automatic robot paint shop was installed to alleviate the problems.

Anon. *Prod Finish (London)* v 40 n 11 Nov 1987 p 14, 16.

**075933 ROBOTIC SPRAY PAINTING OF AUTOMOTIVE PARTS.** Highly automated finishing systems and an unusual method of handling parts throughout the operation are used at Windsor plastics. Major industries served include business machines, consumer electronics, appliances and automotive. Windsor recently installed Wizard PartPainter Automation Cells for two of its spray painting stations. The Wizard robots are set up for high-volume parts.

Wesson, Jeffery. *Prod Finish (Cincinnati)* v 52 n 8 May 1988 p 58-64.

## Wastes

**075934 ABWASSEREINIGUNG - EIN BEITRAG ZUM UMWELTSCHUTZ.** [Wastewater Treatment - A Contribution to Environmental Protection]. Companies are under unmistakable pressure to deal more intensely

with the subject of wastewater engineering. This article focuses in particular on wastewater from painting shops and plants for its pretreatment. Readers are informed about practically oriented solutions, and consideration is given to dumping suitability. (Edited author abstract). In German.

Tschacher, Ulrich (Morgenstern Anlagen- und Maschinenbau GmbH). *Metallberflaeche* v 42 n 6 Jun 1988 p 297-298.

**PAINTING** See Also MOTOR TRUCKS—Painting; ORGANIC COMPOUNDS—Recovery; SOLVENTS—Applications; STEEL—Finishing; STEEL SHEET—Protective Coatings.

**075935 PULVERLACKERING - TEKNIK OCH ARBETSMILJO.** [Powder Coating - Technology and Work Environment]. This report is intended for people who participate in the choice of painting methods. The intention is to provide information about powder coating in such a way that the reader can decide whether it is a method that is suitable for the type of production concerned. The most usual method of applying powder to the object concerned is by spraying, but fluidized bed coating is also utilized. There are two different principles whereby each grain of powder is given a charge: through ionization or through friction. Conventional electrostatic charging, also known as corona charging, is based on the principle of ionization. (Edited author abstract) In Swedish. 67 refs.

Klinton-Kamark, Birgitta. *Inst Verkstadstek Forsk IVF Resultat* 86502 Apr 1986 66p.

**075936 THIRTY PATHS TO A PAINTED FINISH.** Advanced Machine Co. needed a conveyor system to move parts through its various painting and powder coating operations. When the Plymouth, Minnesota manufacturer of floor care and cleaning machines built a new facility to house its painting system, the selection of the right conveyor system was a high-priority item. The article describes the overhead power and free conveyor chosen.

Anon. *Prod Finish (Cincinnati)* v 52 n 6 Mar 1988 p 116-117.

**075937 PAINT BOOTH VOC EMISSION REDUCTION THROUGH AIR RECIRCULATION.** The continued reduction in allowable volatile organic compound (VOC) emissions embodied in the Clean Air Act has required operators of paint shops to search for new methods to limit VOC emissions from their finishing processes. One available method to reduce the exhaust volumes from paint spray booths while increasing the concentration of VOCs in the exhaust stream is air recirculation. This involves recirculating most of the exhaust air back to the booth with only a small stream being drawn off so as to keep the solvent concentration in the recirculating stream at any desired level. This article covers design, capital investment and operating costs.

Bhushan, Dinesh (Durr Industries Inc, Plymouth, MI, USA). *Met Finish* v 86 n 5 May 1988 p 51-55.

**075938 JIT DELIVERY HELPS PLASTICS FINISHER.** Just-in-time delivery of paint is bringing a number of advantages to a North Carolina molder and finisher of structural foam and other plastic products. The company is the Cashiers Structural Foam Div. of Consolidated Metco Inc. (Cashiers, NC). Under the principles of just-in-time (JIT) delivery, most paint is brought to the plant as it is needed. This has allowed Cashiers to free up most of the former paint storage area in the 10,000-sq-ft plant.

Anon. *Ind Finish (Wheaton Ill)* v 64 n 6 Jun 1988 p 33.

## Automation

**075939 CUSTOM COATER INSTALLS AUTODEPOSITION LINE.** A Detroit company has become the first custom coating plant to install an autodeposition painting system. Autodeposition deposits a low-gloss black coating on a ferris substrate by means of a

dipping process (without the use of electricity). The coating is deposited through autophoretic chemical reaction in a waterborne bath that contains only about 5% solids. The bath generates no volatile organic compounds. The company is Crown Enameling Products Inc. of Warren, MI. The autodeposition line is coating suspension leaf springs for General Motors pickup trucks.

Schranz, Joe (Industrial Finishing, Wheaton, IL, USA). *Ind Finish (Wheaton Ill)* v 64 n 3 Mar 1988 p 32-34, 55.

## Computer Applications

**075940 TOTALLY INTEGRATED PAINT FACILITY TO DEBUT.** Navistar International (Chicago), formerly International Harvester, is a leader in the manufacture of medium and heavy trucks. In 1985, Navistar began building a 210,000 ft<sup>2</sup> (19 510 m<sup>2</sup>) facility specifically for paint application. Giffels Associates, Inc. (Southfield, MI), designer of the facility, also developed the functional specifications for all its process systems and the Facility Computer Monitoring System (FCMS) to integrate the process systems. The facility will house pretreatment and electrodeposited prime paint lines, sealing robots, ovens, paint skids and transport system, paint booths, and painting robots. Thermal oxidizers to reduce volatile organic compound (VOC) emissions, vision inspection systems, and the FCMS will also be housed there. Author describes the design considerations, system operation, system hierarchy and system integration of the totally integrated paint facility.

Wilson, Donald. *CIM Technol* v 5 n 4 Winter 1986 p 86-88.

**Control Systems** See AUTOMOBILE MANUFACTURE—Painting; AUTOMOBILES—Painting.

## Electrodeposition

**075941 ELECTROCOATING IN THE APPLIANCE INDUSTRY.** Electrocoating has played a major role in the appliance industry. The first application of anodic electrocoating occurred in 1968 at the Clyde Division of the Whirlpool Corp. This process replaced a flow coat operation and featured significant improvements in corrosion resistance due to edge and hole coverage, which could not be effectively achieved with flow coating. Anodic electrocoating tends to dissolve the metal preparation, leading to corrosion as water diffuses into the coating. Cathodic electrocoating became an answer looking for a question and found its feasibility proof in coating air conditioner compressors in 1970. This was followed by the installation of a 42,000 gal tank to coat air conditioner cabinets; replacing a two-coat system with a highly automated process. After proving its potential in appliances, the automotive industry adopted the process with equal success. Today, cationic electrocoating points the way for the successful application of porcelain replacement coatings and high performance single coat top coats. This paper traces the development of cationic electrocoating and its impact on the coatings industry. (Author abstract) 5 refs.

Miranda, Thomas J. (Whirlpool Corp, Benton Harbor, MI, USA). *J Coat Technol* v 60 n 760 May 1988 p 47-49.

**Monitoring** See BRIDGES, STEEL—Painting.

**Research** See AUTOMOBILES—Painting.

**Robot Applications** See Also MOTOR TRUCKS—Cabs.

**075942 ROBOTS APPLY TEXTURE COAT TO COMPUTER HOUSINGS.** Robotic spray is improving the quality of a texture topcoat applied at Fame Plastics (Cummings, GA). The coating is for injection-molded glass-filled polycarbonate computer housings for IBM. The consistency of spray ensures repeatable conformance to finishing specifications set by IBM. This minimizes rejects, increases productivity and cuts paint consumption.

Anon. *Ind Finish (Wheaton Ill)* v 64 n 6 Jun 1988 p 34.



## PALLADIUM ALUMINUM ALLOYS

## Internal Oxidation

**075943 MODULATING THE COMPOSITION OF A METAL/OXIDE INTERFACE AND USING HYDROGEN AS A PROBE.** Strong irreversible traps for hydrogen atoms in internally oxidized Pd-3 at.% Al alloys are related to segregation at the Pd/Al<sub>2</sub>O<sub>3</sub> phase boundaries. From an estimation of the strength of the binding energy, simple thermodynamic considerations, and sample preparation in an oxygen excess environment it is concluded that unsaturated oxygen bond are present at the phase boundary and that the trapping corresponds to the formation of O-H bonds. For the case of Al-excess, oxygen bond should be all saturated and Al-bonds remain unsaturated where no strong trapping of hydrogen is expected in agreement with experiment. The case of free oxygen bonds at the interface and the irreversible trapping of hydrogen could be regained by annealing in air. Thus, hydrogen provides evidence that the composition of a phase boundary can be modulated depending on the chemical potentials of the species forming the compound. 13 Refs.

Huang, X.Y. (Max-Planck-Inst fuer Metallforschung, Stuttgart, West Ger); Mader, W.; Eastman, J.A.; Kirchheim, R. *Scria Metall* v 22 n 7 Jul 1988 p 1109-1114.

## PALLADIUM AND ALLOYS See Also PALLADIUM COMPOUNDS—Stability.

**075944 DIFFUSIVITY OF HYDROGEN IN PALLADIUM-BASED SOLID SOLUTIONS.** An electrolytic method has been used to measure the temperature variation of the diffusivity of hydrogen in Pd-based substitutional solid solutions in the temperature range 270-350 K. The substitutional solutes were Fe, Co, Mn, Cr, and Ni. The kinetic data obtained for these systems, and previous data for systems containing the noble metals, transition metals of the First Long Period, and the Group V metals as substitutional solutes, have been analyzed in terms of equations derived by applying absolute rate theory to the cell model for ternary solid solutions. The analysis shows that the substitutional solute atoms create trapping sites for hydrogen atoms which are relatively shallow (0.4 kJ/mole) in comparison with sites created by the cold deformation of pure palladium (approx. 20–40 kJ/mole). The noble metals create the shallowest trapping sites for hydrogen and the Group V metals the deepest. (Author abstract) 34 refs.

Yoshihara, M. (Rice Univ, Houston, TX, USA); McLellan, R.B. *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 213-219.

## Adsorption See CATALYSTS—Palladium.

## Amorphous

**075945 LOW-ENERGY EXCITATIONS AND THEIR ORIGIN IN AMORPHOUS METALS.** The phonon thermal conductivity  $\kappa^{\text{ph}}(T)$  at low temperatures is measured on a series of amorphous Pd-Cu-Si based alloys. In detail, the changes of the phonon scattering by low-energy excitations (LEE) at temperatures 0.3 K < T < 1 K are systematically investigated, when the glass temperature  $T_g$  and the amount of frozen-in free volume  $v_f$  is altered by different methods. On the basis of calculations of the free volume it will be shown that the density of LEE as inferred from the  $\kappa^{\text{ph}}(T)$  measurements correlates strongly with the amount of free volume. In contrast to the irreversible changes in  $\kappa^{\text{ph}}$  observed upon annealing the samples, also reversible changes occur which are attributed to effects in chemical short range ordering in the Pd-Cu-Si glasses. (Edited author abstract) 35 refs.

Herrlach, D.M. (DFVLR, Cologne, West Ger); Gronert, H.W. *Key Eng Mater* v 13 pt 2 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 401-416.

## Coatings

**075946 EFFECT OF JOULE HEATING IN ELECTROCHEMICAL MEASUREMENT OF HYDROGEN TRANSPORT.** It has been shown that Joule heating during electrochemical charging at high current densities can produce substantial heating of the specimen and results in an increase in measured anodic current. Localized electrolyte heating and specimen temperature rise is a function of cell geometry and electrolyte circulation. The anodic current increase due to heating depends on the anodic current before charging and the palladium coating used. The steady state corrosion current depends on the strain rate and the method of deposition of the palladium coating on the anodic side. Finally, the present work and that of O-I demonstrate clearly that the increase in anodic current observed immediately after electrochemical charging during plastic deformation in nickel is due to Joule heating of the specimen and not dislocation transport of hydrogen. 7 refs.

Lin, Ruey-Way (Cornell Univ, Ithaca, NY, USA); Johnson, Herbert H. *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 263-268.

**075947 AUGER ELECTRON SPECTROSCOPY AND ELECTROCHEMICAL CHARACTERIZATION OF Au-Pd SYSTEM IN 1 M H<sub>2</sub>SO<sub>4</sub>.** The electrochemical characterization of the Au-Pd system has been carried out by measuring the oxygen electroadsorption properties of palladium surfaces coated with gold (vacuum deposited) in 1 M H<sub>2</sub>SO<sub>4</sub> at 25°C. These properties are shown to be different from those of Pd-Au alloy. A prolonged repetitive triangular potential sweep was used to induce changes in surface composition which were followed by Auger electron spectroscopy. The crater edge profiles are consistent with the information obtained in the standard depth profile, showing an interface a few angstroms thick very close to the surface. This layer is enriched in palladium. Between this interface and the bulk of the electrode, gold is predominant, but with a considerable amount of palladium forming a mixture with the gold. (Author abstract) 20 refs.

Genesca, J. (Univ Nacional Autonoma de Mexico, Mexico City, Mex); Gamboa, M.E.; Cota-Araiza, L. *Surf Coat Technol* v 34 n 2 Mar 1988 p 141-148.

## Defects

**075948 INTERACTION OF HYDROGEN WITH DISLOCATIONS IN PALLADIUM - I. ACTIVITY AND DIFFUSIVITY AND THEIR PHENOMENOLOGICAL INTERPRETATION.** Activity and diffusivity of hydrogen in deformed and annealed palladium has been measured by an electrochemical technique for different degrees of deformation (73, 50, 15, and 6%), at 295 and 322 K and over a wide range of hydrogen concentration from about 1 to 10<sup>4</sup> at.ppm. Deviations from the ideal solution behavior are drastic at the low concentration side where the solubility enhancement is as high as 1.2 · 10<sup>6</sup> for 73% deformation and 1 at.ppm. The diffusivity decreases with decreasing hydrogen concentration but at very low concentrations of some at.ppm an enhancement of the diffusion is observed. Evidence for this transport mechanism is also given by an unusual diffusion behavior during current pulse measurements at low concentrations. At 295 K the dislocation pipe diffusivity is about ten times as much as the bulk value in annealed samples. (Edited author abstract) 21 refs.

Kirchheim, R. (Max-Planck-Inst fuer Metallforschung, Stuttgart, West Ger). *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 355-363.

**075949 INTERACTION OF HYDROGEN WITH DISLOCATIONS IN PALLADIUM - II. INTERPRETATION OF ACTIVITY RESULTS BY A FERMIDIRAC DISTRIBUTION.** Measurements of the activity of hydrogen in deformed palladium have revealed

a strong interaction with dislocations. The 'Fermi energy of hydrogen' is equal to the interaction energy and contains a contribution of -18 kJ/mole H which was attributed to the formation of a hydride close to the dislocation core. The elastic contribution was calculated from the stress field of an edge dislocation and its dependence on the reciprocal distance from the dislocation core corresponds to a dependence on the reciprocal square root of concentration in agreement with experimental findings. Deviations from this behavior at small distances were explained by a failure of the continuum mechanical calculations of the stress field yielding a cut-off radius of one Burgers vector. (Edited author abstract) 25 refs.

Kirchheim, R. (Max-Planck-Inst fuer Metallforschung, Stuttgart, West Ger). *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 365-373.

## Electric Conductivity

**075950 HIGH-PURITY PALLADIUM SINGLE-CRYSTAL ELECTRICAL RESISTANCE MEASUREMENTS AT HIGH TEMPERATURE.** Measurements of the electrical resistance of an ultra-high-purity single crystal of palladium have been made to a temperature within 100°C of the melting point. These are reported along with measurements of the molten palladium resistivity. The results are discussed and compared with previously reported values. (Author abstract) 7 refs.

Khellaf, A. (Univ of Arizona, Tucson, AZ, USA); Emrick, R.M.; Vuillemin, J.J. *J Phys F Met Phys* v 17 n 10 Oct 1987 p 2081-2084.

## Electrodeposition

**075951 VERSUCHE ZUR ABSCHIEDUNG VON PALLADIUM AUS POLYAMINHALTIGEN ELEKTROLYTEN. [Experimental Deposition of Palladium from Polyamine-Containing Electrolytes].** With the object of developing an ammonium-free palladium electrolyte, the effect of the addition of low-volatility polyamines on the deposition of palladium from electrolytes which contain the basic substances palladium chloride, palladium bromide, palladium sulphate, or palladium hydroxide was investigated. With the addition of ethylene diamine, diethanolamine, triethanolamine, or tetraethylenepentamine, the effect on the current efficiency and the hydrogen content of the bath composition, the pH value, and the current density was determined. The results of the investigation of a total of twelve electrolytes showed that under specific conditions it was actually possible to obtain bright deposits at high current efficiency. (Edited author abstract) 5 refs. In German.

Luo, R.J. (Forschungsinstitut fuer Edelmetalle und Metallchemie Schwaebisch Gmuend); Friedrich, F.; Raub, Ch.J. *Galvanotechnik* v 78 n 10 Oct 1987 p 2790-2796.

**075952 ELECTRODEPOSITION OF PALLADIUM FROM AMMINE COMPLEXES.** This paper consists of a comparative study of the electrodeposition of palladium from solutions containing palladous ammine nitrite, palladous ammine boroxide or palladous ammine chloride. These complexes were prepared using palladium chloride as the starting material and the baths were examined for their plating characteristics. Besides optimization of plating parameters, the deposits were tested for some of their properties. 6 refs.

Jayakrishnan, Sobha (Central Electrochemical Research Inst, Karaikudi, India); Natarajan, S.R. *Met Finish* v 86 n 2 Feb 1988 p 81-82.

## Electronic Properties See COPPER AND ALLOYS—Electronic Properties.

## Electroplating See GOLD AND ALLOYS—Ion Implantation.



## Extraction

**075953 CATALYTIC EFFECT OF QUATERNARY AMMONIUM SALT ON THE EXTRACTION OF PALLADIUM(II) WITH 2-HYDROXY-5-NONYLBENZOPHENONE OXIME (LIX 65N) IN HEPTANE-CHLOROFORM SOLVENTS.** Extraction of Pd(II) from acidic chloride media using 2-hydroxy-5-nonyl-benzophenone oxime (LIX 65N, HL) in heptane is 60% more rapid than that using chloroform under comparable conditions, as well as more complete, reflecting an eight-fold increase in the extraction constant. A further substantial increase in the extraction rate was achieved using the quaternary ammonium salt, Aliquat 336S, without any change in the extraction constant. The extraction probably occurs through rapid phase transfer of  $\text{PdCl}_4^{2-}$  via ion pair extraction followed by formation of the chelate,  $\text{PdL}_2$ , in the organic phase. (Author abstract) 7 refs.

Rong, Qingxin (Univ of Arizona, Tucson, AZ, USA); Freiser, H. *Solvent Extr Ion Exch* v 5 n 5 1987 p 923-937.

## Gas Alloying

**075954 EFFECT OF TRAPPING ON THE SOLUBILITY AND DIFFUSIVITY OF HYDROGEN IN PALLADIUM ( $\alpha$ -PHASE).** The solubility and diffusivity data of hydrogen in palladium with different concentrations of defects are discussed within the framework of the two-level model with local equilibrium (Oriani's model). Analytical expression of the solubility isotherm and of the variation of the apparent diffusion coefficient depending on the total bulk concentration are derived. A good agreement is found between the experimental results on the solubility and diffusivity of hydrogen and the calculated values using the theoretical expressions. (Author abstract) 19 refs.

Bucur, R.V. (Inst of Isotopic & Molecular Technology, Cluj-Napoca, Rom). *J Mater Sci* v 22 n 9 Sep 1987 p 3402-3406.

## Gases

**075955 STRESS AND SOLUBILITY FOR SOLUTES WITH ASYMMETRICAL DISTORTION FIELDS.** The influence of stress on chemical potential and solubility for solutes with asymmetrical distortion fields is considered. Numerical solutions and series approximations are presented for several examples of different stress states. Both open and closed thermodynamic systems are treated. The calculations are compared with results for hydrogen in crystalline Pd and amorphous Pd alloys. The latter involves an asymmetrical distortion field. (Author abstract) 10 refs.

Kirchheim, R. (Max-Planck-Inst fuer Metallforschung, Stuttgart, West Ger); Hirth, J.P. *Acta Metall* v 35 n 12 Dec 1987 p 2899-2903.

**075956 INFLUENCE OF SURFACE IMPURITIES ON HYDROGEN PERMEATION THROUGH PALLADIUM.** In order to improve the understanding of the hydrogen-metal interaction, we have studied the influence of the surface state of a thin film of palladium on the hydrogen permeation process. Energetic desorption values  $E_d$  have been calculated by thermal programmed desorption experiments for various pretreatments of the sample. Auger spectral analysis shows that carbon, sulphur and oxygen are present at the surface of the metal. Results allow us to conclude that the increase in  $E_d$  is certainly connected with an increase in concentration of sulphur at the surface. (Author abstract) 18 refs.

Lalauze, R. (Ecole Natl Supérieure des Mines de Saint-Etienne, Saint-Etienne, Fr); Gillard, P.; Pijolat, C. *J Less Common Met* v 138 n 2 Mar 15 1988 p 179-187.

## Heat Treatment

**075957 BLOCKING OF HYDROGEN-DISLOCATION INTERACTIONS IN PALLADIUM BY INTERSTITIAL CARBON (BORON) SOLUTES.** It has

been shown that the segregation of hydrogen to dislocations at 323 K decreases in palladium doped with interstitial carbon or boron after a relatively low temperature annealing, at 423 K. After a similar treatment, pure palladium continues to show a large segregation of hydrogen to dislocations. TEM studies have shown that the dislocation densities are large in both the pure palladium and the carbon doped samples after annealing at 423 K. These results are consistent with the explanation that the heavy interstitial atoms, carbon or boron, migrate to dislocations at 423 K and block these dislocations for occupation by hydrogen. (Author abstract). 16 refs.

Flanagan, T.B. (Univ of Vermont, Burlington, VT, USA); Craft, A.P.; Foley, R.; Sakamoto, Y.; Kishimoto, S. *Acta Metall* v 36 n 7 Jul 1988 p 1791-1796.

Leaching See PLATINUM AND ALLOYS—Leaching.

## Low Temperature Properties

**075958 CRYSTAL STRUCTURES OF H-Pd<sub>5</sub>Ce AND Pd<sub>5</sub>La AND THEIR ELECTRICAL RESISTIVITIES AT LOW TEMPERATURES.** The crystal structure of Pd<sub>5</sub>La was analyzed by powder X-ray diffraction and electron microscopy, and it was found that Pd<sub>5</sub>La is almost isomorphous with H-Pd<sub>5</sub>Ce. The electrical resistivity was examined for Pd<sub>5</sub>La, H-Pd<sub>5</sub>Ce and L-Pd<sub>5</sub>Ce in the range between 77 K and 300 K. The temperature dependence of resistivity suggested that H-Pd<sub>5</sub>Ce and L-Pd<sub>5</sub>Ce have a dense Kondo state. (Author abstract) 5 refs.

Itakura, Masaru (Kyushu Univ, Kasuga, Jpn); Hisatsune, Yoshimi; Sato, Hiroshi; Kuwano, Noriyuki; Oki, Kensuke. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 684-685.

## Magnetic Properties

**075959 COMPARISON BETWEEN THE MAGNETIC SUSCEPTIBILITIES OF Pd<sub>1-x</sub>Ag AND SINGLE PHASE PdH<sub>x</sub>.** The rapid decrease of the isothermal magnetic susceptibility  $\chi$  of single phase PdH<sub>x</sub> with n (=atomic ratio H/Pd) above the critical temperature  $T_c = 564$  K differs from that of the magnetically similar single phase system Pd<sub>1-x</sub>Ag<sub>x</sub> ( $x$ : silver mole fraction) at the same temperature and at equal valence electron concentrations ( $n=x$ ), i.e.  $\chi(\text{PdH}_n) - \chi(\text{Pd}_{1-x}\text{Ag}_x) > 0$ . By use of a semiphenomenological susceptibility ansatz related to the nonideal solution behavior of H (AG) in Pd the susceptibility difference is interpreted as an electronic excess effect. The analysis of the steep descent of the magnetic susceptibility also applies to the Pd-rich side of Pd in the subcritical temperature region (so-called  $\alpha$ -phase) and can be supported by  $^1\text{U}$   $^{57}\text{Pd}$  Knight shift data at 348 K. (Author abstract) 19 refs.

Saenger, W. (Univ Muenchen, Munich, West Ger); Voitlander, J. *J Magn Magn Mater* v 71 n 1 Dec 1987 p 111-118.

## Microstructure

**075960 SYSTEMATISCHE METALLOGRAPHISCHE PRAEPARATION ZUR GEFUEGEINTERPRETATION MEHRKOMPONENTIGER PALLADIUM-SYSTEME.** [Systematic Metallographic Preparation for the Structural Interpretation of Multicomponent Palladium Systems.]. Noble metal alloys, especially Pd-based alloys with Sn, In and Ga additions are prominent in dental technology as well as in the chemical industry and jewelry. Knowledge of the relevant phase diagrams and the phases concerned is therefore crucial. Several polishing and etching techniques are involved in the preparation side of this constitutional work for metallographic analysis. Using the revised systems Pd-Ga and Pd-In as examples, the preparation of various alloys is described. The applied metallographic techniques of etch polishing and electro-swab polishing enable a concentration-dependent systematic approach to the preparation to be developed. This is applicable to both higher-component Pd noble metal alloys and Pd nonprecious metal alloys. 12 Refs.

Schmid, Eberhard E. (Max-Planck-Inst fuer Metallforschung, Stuttgart, West Ger); Carle, Veronika. *Prakt Metallogr* v 25 n 7 Jul 1988 p 340-348.

## Phase Diagrams

**075961 EFFECT OF LATTICE DISTORTIONS ON THE X-RAY MEASUREMENT OF LATTICE PARAMETERS FOR PdH<sub>x</sub>. I. EMPIRICAL RELATIONSHIPS.** Measurements have been made of the changes in x-ray lattice parameter which result when a PdH<sub>x</sub> alloy is taken on a path in the PdH<sub>x</sub> phase diagram which traverses the mixed ( $\alpha + \beta$ )-phase region to reach  $\beta$ -phase concentrations ( $0.70 < x < 0.92$ ). The changes were followed by comparing the lattice parameter values for alloys which had been taken along such a path with lattice parameter values of alloys taken along paths avoiding the mixed-phase region in reaching  $\beta$ -phase concentrations of comparable value. From previous experience with the mixed ( $\alpha + \beta$ )-phase region and the observed diffraction line broadening and magnitude and direction of the lattice parameter shifts, it can be inferred that the lattice parameter changes are due to internal stresses resulting from the progression of the  $\alpha \rightarrow \beta$  phase changes as the alloy is moved through the mixed-phase region. A discussion is given of some implications of these observations for the use of lattice parameter measurements in locating coexisting curves for M-H alloys. (Author abstract) 20 refs.

Balaba, I.S. (Univ of Toronto, Toronto, Ont, Can); Hardy, P.A.; San-Martin, A.; Coulter, P.G.; Manchester, F.D. *J Phys F Met Phys* v 17 n 10 Oct 1987 p 2041-2048.

## Physical Properties

**075962 SPIN-RESOLVED PHOTOEMISSION FROM Pd(111).** Circularly polarized synchrotron radiation of BESSY and spin-resolved photoemission have been used for a study of the electronic structure of Pd in  $\Lambda$ -direction. The photon energies were chosen between the photoemission threshold at 5.7 and 23 eV. We used the highly symmetric experimental setup of normal light incidence and normal photoelectron emission and studied transitions from the two  $\Lambda_6^{3/2}/\Lambda_4^{5/2}$ -band-pairs split by spin-orbit interaction. Though the magnitude of the spin-orbit splittings  $\Delta E_{so}$  in this medium-Z material is smaller than lifetime broadening, it is feasible to resolve the spin-orbit splitting of the initial states via photoelectron spin analysis. The data are consistent with a band-structure calculation of Noffke and Eckardt except for an energy dependent shift of 0.4 to 1.1 eV of the final bands towards higher energies. In the occupied part of the bandstructure an avoided crossing could be identified. Surface- (bandgap)- emission was observed for photon energies below 7.8 eV. (Author abstract) 19 refs.

Schmiedeskamp, B. (Univ Bielefeld, Bielefeld, West Ger); Kessler, B.; Mueller, N.; Schoenhense, G.; Heinzmann, U. *Solid State Commun* v 65 n 7 Feb 1988 p 665-670.

## Radiation Effects

**075963 RADIATION CHARACTERISTICS OF PALLADIUM EXTRACTED FROM SPENT FUEL OF THE BOR-60 REACTOR.** Palladium is extensively used in various industrial fields. Its natural abundance is low, but it is produced as a fission product in the burnout of nuclear power-plant fuel; its buildup depends on the type of fuel, operating periods, and cooling time after irradiation. In water-cooled water-moderated reactors the buildup is 1 kg of palladium per ton of fuel, and in fast-neutron reactors it is 5 kg. It is therefore worth considering the possibility of utilizing the raffinates from the reprocessing of spent fuel to extract palladium and put it to further use. The object of this study was to experimentally determine the content of  $^{107}\text{Pd}$  in purified palladium extracted from fast-reactor fuel, and to ascertain its radiation characteristics. 8 refs.

Shcherbakov, B.Ya.; Evgrafova, D.I.; Myshlyavkin, V.I.; Ovechkin, V.V.; Smetanin, E.Ya.; Tsvetayeva, N.E.; Shmidt, V.S.; Shorokhov, N.A. *Sov At Energy* v 63 n 1 Jul 1987 p 509-512.



Reliability See COPPER AND ALLOYS—Thick Films.

## Spectroscopic Analysis

**075964 EXTRACTION-ATOMIC ABSORPTION SPECTROPHOTOMETRIC DETERMINATION OF PALLADIUM AS ITS ANIONIC COMPLEX WITH A SULFONATED AZO DYE.** The use of 3-hydroxy-4-(1H-tetrazol-5-ylazo)-2,7-naphthalenedisulfonic acid (T-azo-R) as a complexing agent for the separation of palladium from rhodium, platinum, or iridium by solvent extraction in the presence of benzalkonium chloride (BACl) has been investigated. After reextraction with perchloric acid from organic to aqueous phase, palladium can be determined by air-acetylene flame atomic absorption spectrometry (FAAS), by means of a calibration curve prepared with commercial standard solutions. The method has been applied to the determination of palladium and rhodium content in two pharmaceutical processing sludges. (Edited author abstract) 14 refs.

Pesavento, Maria (Univ di Pavia, Pavia, Italy); Riolo, Carla; Achilli, Marco. *Anal Chem* v 60 n 4 Feb 1988 p 332-335.

**075965 STUDIES ON HIGHLY SENSITIVE COLOUR REACTION IN THE SYSTEM OF PALLADIUM(II)-TIN(II) CHLORIDE-CRYSTAL VIOLET IN THE PRESENCE OF POLYVINYL ALCOHOL.** A sensitive spectrophotometric method for determination of palladium has been developed. The effect of light for improvement of the reproducibility of the determination and the optimum conditions for formation of the ion associate have been investigated. The molar absorptivity is  $3.7 \times 10^4 \text{ l-mol}^{-1} \text{ cm}^{-1}$  at 550nm. Beer's law is obeyed for 0.1–1.0  $\mu\text{g}/25\text{cm}^3$  of palladium. The method was used for the determination of palladium in some precious metal samples. (Edited author abstract). 8 Refs. In Chinese.

Zhao, Min-Zheng (Kunming Inst of Precious Metals, China); Hu, Sheng-Wen. *Xiyao Jinshu* v 7 n 1 Feb 1988 p 51-54.

**075966 XPS SURFACE AND BULK STUDIES OF HEAT TREATED PALLADIUM IN THE PRESENCE OF HYDROGEN AT 150°C.** Palladium metal powders used for hydrogen isotope pumping were studied for their bulk and surface chemistry changes during cleaning with hydrogen gas at 150°C. Cleaning is necessary to promote rapid hydriding and dehydriding and to prevent contaminant ingrowth in the process gas during use. These studies show that heating the powders in vacuum at moderate temperatures (150°C) in a reducing environment removes surface oxide, leaves a predominately palladium metal surface which presents no significant barrier to hydrogen absorption or desorption, and shows no loss in surface area and pourability. A surface model of PdO is given and XPS results show that the water-forming reaction is the mode of PdO reduction. Thermodynamic data are discussed which support the above results. (Author abstract) 37 refs.

Moddeman, W.E. (Monsanto Research Corp, Miamisburg, OH, USA); Bowling, W.C.; Carter, D.C.; Grove, D.R. *Surf Interface Anal* v 11 n 6 Apr 1988, Proc of the 9th Symp on Appl Surf Anal, Dayton, OH, USA, Jun 3-5 1987 p 317-326.

## Structure

**075967 ELECTRONIC STRUCTURE OF PALLADIUM-NOBLE METAL ALLOYS.** The authors perform a comparative study of the electronic structure of palladium-noble metal alloys  $\text{Cu}_x\text{Pd}_{1-x}$ ,  $\text{Ag}_x\text{Pd}_{1-x}$ , and  $\text{Au}_x\text{Pd}_{1-x}$ . They demonstrate different behaviour of Pd impurities in noble metal alloys and the reliability of their choice of alloy potentials, allowing for a consistent treatment of charge self consistency and lattice relaxations. The method is thus superior to other methods.

Kudrnovsky, J. (Czechoslovak Acad of Sciences, Prague, Czech); Drchal, V. *Phys Status Solidi B* v 148 n 1 Jul 1988 p K23-K27.

Surface Properties See HYDROGEN—Adsorption.

Surfaces See METHANOL—Adsorption.

## Thermodynamic Properties

**075968 THERMODYNAMIC FUNCTIONS IN DILUTE Pd-H SOLID SOLUTIONS.** Authors have demonstrated that virtually all of the variation with temperature of excess entropy and partial molar enthalpy for H in dilute Pd-H solutions arise from the 'oscillator' term and contributions from anharmonicity, the temperature dependence of the local mode frequencies, or the 'electronic' term may be ignored. 20 refs.

McLellan, Rex B. (Rice Univ, Houston, TX, USA). *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 65-68.

## Thermodynamics

**075969 SOLID SOLUTIONS OF Pd CONTAINING HYDROGEN AND A NOBLE METAL SUBSTITUTIONAL COMPONENT - I. THERMODYNAMIC BEHAVIOR.** Elastic data have been measured for Pb-based solid solutions containing Cu, Au, and Ag in the concentration range 0-50 at.% of substitutional solute and in the temperature range 300-1200 K. The elastic data have been used to evaluate a statistical mechanical model for solid solutions of hydrogen in Pb-based solutions containing noble metals. The elastic data are used to calculate that contribution to the partial thermodynamic functions of the dissolved interstitial atoms which arises due to the change in the specific volume of the metal lattice as the substitutional atom concentration is varied. (Author abstract) 8 refs.

Yoshihara, M. (Rice Univ, Houston, TX, USA); McLellan, R.B. *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 3-8.

Thin Films See Also ACETYLENE—Hydrogenation; OLEFINS—Hydrogenation.

**075970 EFFECT OF HEAT TREATMENT OF Pd THIN FILM ALLOY ON HYDROGENATION OF CYCLOPENTADIENE.** The selectivity of the partial hydrogenation of cyclopentadiene was remarkably enhanced by heat treatment over Pd thin films containing boron or phosphorus at high content. This enhancement could be explained in terms of the small ensemble size and the low electron density of Pd. (Edited author abstract) 7 refs.

Tamaki, Jun (Osaka Univ, Toyonaka, Jpn); Yamamura, Masashi; Imanaka, Toshinobu. *Chem Express* v 2 n 10 Oct 1987 p 639-642.

**075971 THIN PALLADIUM FILMS PREPARED BY METAL-ORGANIC PLASMA-ENHANCED CHEMICAL VAPOUR DEPOSITION.** A method for the deposition of palladium films using the allylcyclopentadienyl palladium complex is reported. In a plasma-enhanced chemical vapor deposition process bright metallic films can be produced at low temperatures. The resistivity of these films approaches that of bulk palladium. If oxygen is used as the carrier gas, the films consist of PdO. (Author abstract) 14 refs.

Feurer, E. (Univ of Tuebingen, Tuebingen, West Ger); Suhr, H. *Thin Solid Films* v 157 n 1 Feb 15 1988 p 81-86.

**075972 OBSERVATION OF PERIODIC STRESS PRODUCED BY ION DAMAGE IN THIN FILMS.** The formation of periodic micro-crinkling, which exhibits a 'corduroy' contrast, has been observed in thin films of Pd and Ni after in situ implantation of B, Si, P and Ne at high doses ( $10^{16}$  to  $2 \times 10^{17}$  ions  $\text{cm}^{-2}$ ). This is associated with a macroscopic deformation of the thin film, apparently in the form of periodic bending. This effect increases

with increasing dose, until the thin film tears. (Author abstract). 27 Refs.

Ruault, M.O. (Cent de Spectrometrie Nucleaire et Spectrometrie de Masse, Orsay, Fr); Schack, M.; Bernas, H.; Chevalier, J.P. *Philos Mag A* v 58 n 2 Aug 1988 p 397-408.

**075973 INVESTIGATION OF D.C. PLANAR-MAGNETRON-SPUTTERED PALLADIUM FILMS BY SPECTROSCOPIC ELLIPSPOMETRY.** The pseudodielectric function of palladium films prepared by dc planar magnetron sputtering was measured by spectroscopic ellipsometry as a function of substrate temperature. The film data are in excellent agreement with an optical model using the Sen, Scala and Cohen effective medium theory, which is based on a dielectric coated-particle microstructure. With increasing substrate temperature, the palladium volume fraction was found to decrease slightly, while the r.m.s. microroughness of the film surface increased in magnitude. For temperatures below 115°C the film microstructure was not significantly affected by the substrate temperature but, by 190°C, the r.m.s. microroughness was  $80 \pm 3 \text{ Å}$ , with the palladium volume fraction in the bulk region falling slightly to  $97\% \pm 1\%$  relative to the film deposited at 22°C. These results are compared with those obtained by electron microscopy and x-ray diffraction. (Author abstract) 16 refs.

Sullivan, Brian T. (Univ of British Columbia, Vancouver, BC, Can); Parsons, R.R. *Thin Solid Films* v 154 n 1-2 Nov 12 1987, Pap Presented at the Int Conf on Metall Coat - Part II, San Diego, CA, USA, Mar 23-27 1987 p 281-289.

## Transport Properties

**075974 MACROCYCLE-MEDIATED TRANSPORT IN A BULK 1.5 M  $\text{HNO}_3$ - $\text{CHCl}_3$ -0.01 M  $\text{HNO}_3$  MEMBRANE SYSTEM OF  $\text{Pd}^{2+}$  AND  $\text{M}^{n+}$  FROM  $\text{Pd}^{2+}$ - $\text{M}^{n+}$  MIXTURES.**  $\text{Pd}^{2+}$  has been transported using sulfur substituted macrocycles as carriers and several  $\text{M}^{n+}$  ( $\text{M}^{n+} = \text{Li}^+, \text{Na}^+, \text{K}^+, \text{Rb}^+, \text{Cs}^+, \text{Mg}^{2+}, \text{Ca}^{2+}, \text{Sr}^{2+}, \text{Ba}^{2+}, \text{Ag}^+, \text{Ti}^+, \text{Cd}^{2+}$ , and  $\text{Pb}^{2+}$ ) have been transported using 18-crown-6 (18C6) and sulfur substituted macrocycles as carriers in a 1.5M  $\text{HNO}_3/\text{CHCl}_3/0.01\text{M HNO}_3$  bulk liquid membrane system. Competitive  $\text{Pd}^{2+}$ - $\text{M}^{n+}$  transport studies have also been carried out for the same systems. The cyclic polyether 18C6 transports  $\text{M}^{n+}$  selectively over  $\text{Pd}^{2+}$  for all  $\text{M}^{n+}$  except  $\text{Li}^+$ ,  $\text{Mg}^{2+}$ , and  $\text{Cd}^{2+}$ . In the cases of these three cations, no transport was found for either  $\text{Pd}^{2+}$  or  $\text{M}^{n+}$ . Generally, the sulfur substituted macrocycles transport  $\text{Pd}^{2+}$  selectively over  $\text{M}^{n+}$ . (Author abstract) 31 refs.

Izatt, R.M. (Brigham Young Univ, Provo, UT, USA); Eberhardt, L.; Clark, G.A.; Bruening, R.L.; Bradshaw, J.S.; Cho, M.H.; Christensen, J.J. *Sep Sci Technol* v 22 n 2-3 Feb-Mar 1987, Fourth Symp on Sep Sci and Tec for Energy Appl, Knoxville, TN, USA, Oct 20-24 1985 p 701-710.

## Vapor Deposition

**075975 EFFECT OF MICA SURFACE 'DEHYDROXYLATION' ON PARTICULATE PALLADIUM VAPOR DEPOSITS.** Electron energy loss spectroscopy (ELS) and palladium nucleation were used to study the influence of pre- and post-cleavage annealing on some surface properties of muscovite mica. Two ELS features at 28 eV and 16 eV indicate OH molecules on the mica surface and in the near-surface bulk respectively. On post-cleavage heating of the mica to temperatures above 400°C the two surface losses disappear, causing the simultaneous liberation of water, which is explained by a dehydration of the  $\text{AlO}(\text{OH})$  layer of the mica lattice. The palladium nucleation and growth behavior is strongly influenced by the state of 'dehydration' of the mica surface. On 'dehydroxylated' mica the particle number density of palladium is increased and the mean particle size decreased owing in principle to stronger interaction between the mica substrate and the palladium deposit. (Author abstract)



Koch, R. (Stanford Univ, Stanford, CA, USA); Poppa, H. *Thin Solid Films* v 151 n 3 Aug 17 1987 p 365-371.

**Wear** See ELECTRIC CONTACTS—Contamination.

## PALLADIUM BORON ALLOYS

### Molten

**075976 VAPORIZATION THERMODYNAMICS OF Pd-B(LIQUID) AND Pd-B-C(LIQUID).** The Pd-B and Pd-B-C liquid phases were studied by the Knudsen effusion technique to determine the variation of palladium and boron activity with composition and temperature. Equations are given which describe the thermodynamic properties throughout the liquid phase region. In addition, the phase boundary composition was determined between the liquid and the respective multiphase containing excess boron. The phase forms solid boron at 1600 K when the composition reaches  $Pd_{0.55}B_{0.45}$  and the palladium activity is 0.0186. Dissolved carbon causes the palladium activity to increase and the phase boundary to shift to a higher boron composition. (Author abstract) 7 refs.

Storms, E.K. (Los Alamos Natl Lab, Los Alamos, NM, USA); Szklarz, E.G. *J Less Common Met* v 135 n 2 Nov 1987 p 217-228.

## PALLADIUM CERIUM ALLOYS

### Amorphous

**075977 EVIDENCE OF AN INHOMOGENEOUS VALENCE ADMIXTURE IN THE AMORPHOUS  $Pd_{1-x}Ce_x$ .** Magnetic measurements were carried out on the amorphous  $Pd_{1-x}Ce_x$  alloys. The cerium electronic configuration is found to change from 'tetravalent' to trivalent over the concentration range  $0.125 \leq x \leq 0.25$  with increasing Ce composition. The presence of magnetic Ce ions indicates that the valence admixture is inhomogeneous in this system. This result suggests that fluctuations of short range order stabilize either the trivalent or the 'tetravalent' state. (Edited author abstract) 12 refs.

Siari, A. (Univ de Nancy 1, Vandoeuvre-les-Nancy, Fr); Malterre, D.; Durand, J.; Marchal, G. *Solid State Commun* v 65 n 12 Mar 1988 p 1463-1466.

## PALLADIUM CHROMIUM ALLOYS

### Radiation Damage

**075978 PRECIPITATION AND IRRADIATION DAMAGE IN PROTON-IRRADIATED PALLADIUM-CHROMIUM ALLOYS.** Irradiation damage of Pd-Cr alloys containing 15, 20 and 25 at % Cr was studied over the temperature range 100 to 550°C, primarily in samples irradiated to a dose of 0.7 d.p.a. The solubility limit in this range of temperatures varies from 22 to 38% Cr, and precipitation of a phase having the  $L1_2$  crystal structure was observed in unirradiated samples of the 25% Cr alloy aged at temperatures as low as 100°C. Octahedrally shaped voids, with faces parallel to  $\{111\}$ , were found only in the 25% Cr alloy irradiated from 350 to 550°C but not in the other alloys at any temperature. The undersized chromium atoms migrate to point defect sinks during irradiation, resulting in solute segregation and precipitation under certain conditions. The precipitation of the  $L1_2$  phase, which is the thermodynamically stable phase at higher chromium contents, was irradiation-induced at dislocation loops, voids and grain boundaries in the more concentrated undersaturated alloys. This irradiation-induced precipitation was observed in the same samples containing 20 and 25% Cr but not in those containing 15% Cr. The behavior is compared with Pd-Fe and Ni-Si alloys. (Edited author abstract) 20 refs.

Huang, J.C. (Univ of California, Los Angeles, CA, USA); Ardell, A.J.; Ajaja, O. *J Mater Sci* v 23 n 4 Apr 1988 p 1206-1218.

**PALLADIUM COMPOUNDS** See Also ANODES—Cobalt Compounds; HYDROCARBONS—Hydrogenation; INTERMETALLICS; PALLADIUM AND ALLOYS—Magnetic Properties.

**Applications** See ORGANIC COMPOUNDS—Oxidation.

**Chemical Reactions** See POLYSTYRENES—Chemical Reactions.

### Electric Conductivity

**075979 ANALYSIS OF THE ELECTRICAL CONDUCTIVITY OF THE TWO PHASE Pd H<sub>x</sub> SYSTEM.** The electrical conductivity of the two phase region of the Pd H<sub>x</sub> ( $0 \leq x \leq 0.65$ ) system at 20 K is described by a new semiphenomenological effective medium type equation. This equation has been shown to describe the conductivity of a wide variety of binary mixtures as a function of the conductivities of the two components ( $\rho_\alpha$  and  $\rho_\beta$  in the case of Pd H<sub>x</sub>) and two morphology parameters. One parameter is the critical volume fraction ( $f_c (=1 - f_\beta)$ ) at which the high conductivity phase first forms a continuous percolation path across the system. The other parameter, the exponent  $t$ , is a combination of the effective demagnetization coefficients of the components and the critical volume fraction. This parameter is discussed in terms of the known morphology of the samples. (Author abstract) 12 refs.

McLachlan, D.S. (Univ of the Witwatersrand, Johannesburg, S Afr); Burger, J.P. *Solid State Commun* v 65 n 2 Jan 1988 p 159-161.

### Electronic Properties

**075980 POOR MAN'S SCF-KKR-CPA OR ELECTRONIC STRUCTURE OF  $Pd_3Fe$ : DISORDERED PHASE.** We analyze the influence of disorder on the electronic structure of ferromagnetic  $Pd_3Fe$ . Using self-consistent potentials from the ordered compound we evaluate within the KKK-CPA method the electronic structure of  $Pd_{75}Fe_{25}$  disordered alloy which shows quite different degrees of disorder for the two spin directions. (Edited author abstract) 18 refs.

Kuhnen, C.A. (UNICAMP, Campinas, Brazil); da Silva, E.Z. *Solid State Commun* v 61 n 3 Feb 1987 p 475-478.

**Hydrogenation** See HYDROGEN INORGANIC COMPOUNDS.

**Isotopes** See BIOMEDICAL EQUIPMENT—Radionuclides.

**Optical Properties** See SCANDIUM COMPOUNDS—Physical Properties.

### Order-Disorder

**075981 LOW-TEMPERATURE EVOLUTION OF THE PROTON MAGNETIC RESONANCE LINE SHAPE IN  $\beta$ -PHASE PALLADIUM HYDRIDE.** Measurements of the proton magnetic resonance adsorption line shape in  $\beta$ -phase palladium hydride indicate that there is a short-range ordering associated with the order-disorder phase transition that occurs in the neighborhood of 50 K. However, measurements of the line shape in the range 10-30 K show a change from a Gaussian to a non-Gaussian profile. This effect is not related to the order-disorder phase transition. A possible explanation in terms of thermally assisted tunneling is proposed. (Author abstract) 26 refs.

Avram, Hector E. (Univ of Toronto, Toronto, Can); Armstrong, Robin L. *J Low Temp Phys* v 69 n 5-6 Dec 1987 p 391-400.

### Physical Properties

**075982 CALCULATED PHOTOEMISSION SPECTRA OF ORDERED  $Pd_3Fe$  AND  $Pd_3FeH$ .** Using the band structure calculations of the compounds  $Pd_3Fe$  and  $Pd_3FeH$ , the authors obtained the correspondent photoemission spectra. The initial electronic states are taken as

the muffin-tin orbitals of the LMTO method. This means that only bulk effects are considered in the photoexcitation process; that is, the photocurrent reflects essentially the single particle density of states, as known in the case of XPS spectra. (Edited author abstract) 15 refs.

da Silva, E.Z. (Univ Estadual de Campinas, Campinas, Brazil); Kuhnen, C.A. *Solid State Commun* v 66 n 10 Jun 1988 p 1011-1014.

**Spectroscopic Analysis** See Also NICKEL COMPOUNDS—Spectroscopic Analysis.

**075983 ANALYSIS OF THE SIXTH SPECTRUM OF PALLADIUM (Pd VI).** The spectrum of palladium has been observed in the wavelength region 300-600 Å in which the  $4d^5-4d^45p$  transitions of Pd VI are located. On the basis of these observations the relative values of all 37 levels in the  $4d^5$  ground configuration and of 164 of the 180 levels in the  $4d^45p$  configuration have been established. Parametric calculations of the two configurations were performed and values for the electrostatic Slater and spin-orbit parameters were calculated according to the Hartree-Fock model. (Author abstract) 12 refs.

Raassen, A.J.J. (Univ van Amsterdam, Amsterdam, Neth); van Kleef, Th.A.M. *Physica B & C* v 146 n 3 Oct 1987 p 423-437.

### Stability

**075984 ON THE STABILITY OF THE ORDERED  $Pd_3V$  PHASE IN A PROTON-IRRADIATED Pd-15at. percent V ALLOY.** The maximum temperature at which the ordered  $Pd_3V$  phase forms in a Pd-15at. percent V alloy irradiated by 400 keV protons was determined to lie between 350 and 420 °C. Post-irradiation annealing experiments have established that  $Pd_3V$  is most probably a thermodynamically stable equilibrium phase with a critical ordering temperature slightly below 400 °C.  $Pd_3V$  is not expected to nucleate and grow under conditions of normal isothermal annealing (because of the low temperature range of its stability) unless diffusion is accelerated, in this case by charged particle irradiation. (Edited author abstract) 23 refs.

Chen, J. (Univ of California, Los Angeles, CA, USA); Ardell, A.J. *J Less Common Met* v 141 n 1 Jul 1988 p 45-53.

### Structure

**075985 STRUCTURAL PROPERTIES OF  $Pd_3Si_2$ .** The crystal structure of  $Pd_3Si_2$  has been determined and refined from X-ray single crystal diffractometer data.  $Pd_3Si_2$  crystallizes in space group Pnma (No. 62) with the unit cell dimensions  $a = 9.0528(4)$  Å,  $b = 7.4165(3)$  Å,  $c = 9.4009(4)$  Å, and four formula units per unit cell. The structure has been refined to a conventional R-value of 0.088. (Author abstract)

Andersson, Yvonne (Univ of Uppsala, Uppsala, Sweden). *Chem Scr* v 28 n 1 Mar 1988, Adv in Prep and Prop Charact of Cryst Inorg Mater, St. Leonard des Bois, Fr, Sep 26-28 1987 p 125-127.

### Synthesis

**075986 COMPLEX COMPOUNDS OF Pd(II) WITH HISTIDINE.** The interaction of metallic ions with polypeptides and proteins is a problem of great interest in both coordination chemistry and biochemistry. The imidazole cycle in the molecule of histidine has a great biological importance: it also constitutes a possible way of linking metallic ions and insulin in the albumin serum. A great amount of research has been done on metal-histidine complexes. The study of D. Burk, A.L. Shade and M.L. Hesselbach on complex compounds of Co with histidine, that of P.Y. Morris referring to some chelates of Co(II), Ni(II) and Zn(II) with histidine can be quoted. More recently, Volstein and his coworkers published some papers dealing with the preparation and chemical characterization of a large series of complex combinations on Pt(II) with histidine. Taking into account the similarity of



behavior shown by Pd(II) and Pt(II), in the present paper we attempted the synthesis and chemical characterization of some complex combinations of Pd(II) with histidine. 8 refs.

Vicol, Olga; Hurdac, Natalia; Noroc, Maria. *Bul Inst Politeh Iasi Sect II Chim Ing Chim* v 31 n 1-4 1985 p 29-33.

**Thermodynamics** See INTERMETALLICS—Molten.

**Thin Films** See Also HYDROGEN—Sensors.

**075987 ATOMIC HYDROGEN DESORPTION FROM THIN PALLADIUM HYDRIDE FILMS.** It has been proved that hydrogen atoms desorb from the surface of a decomposing thin palladium hydride film. A thin gold film deposited and sintered in situ was used as a selective adsorbent for atomic hydrogen. The TDMS (thermal desorption mass spectrometry) technique was applied to detect the adsorption of hydrogen on gold and to determine the amount adsorbed. (Author abstract) 11 refs.

Lisowski, W. (Polish Acad of Sciences, Warsaw, Pol); Nowicka, E.; Wolfram, Z.; Dus, R. *Appl Surf Sci* (1985) v 31 n 1 Jan 1988 p 157-162.

**075988 XPS AND IR (ATR) ANALYSIS OF Pd OXIDE FILMS OBTAINED BY ELECTROCHEMICAL METHODS.** Palladium oxide was detected by XPS and IR (Attenuated Total Reflection) analysis of the surface of a Pd electrode which was polarized in the medium 1 M KOH. This oxide set a peak of Pd 3d<sub>5/2</sub> shifted 3.5 eV with respect to the metal which is a much higher value than those reported and obtained for PdO and PdO<sub>2</sub>. An IR absorption band of 535 cm<sup>-1</sup> was found to be different from those reported in the literature of PdO and PdO<sub>2</sub>. The presence of this oxide is in agreement with results obtained using electrochemical methods where the existence of PdO<sub>3</sub> has been assumed. (Author abstract) 14 refs.

Tura, Josep M. (CSIC, Barcelona, Spain); Regull, Pere; Victori, Lluís; de Castellar, M. Dolores. *Surf Interface Anal* v 11 n 8 May 1988 p 447-449.

**Transport Properties** See SILVER COMPOUNDS—Transport Properties.

## PALLADIUM COPPER ALLOYS

### Electronic Properties

**075989 POSITRON ANNIHILATION STUDIES ON THE ELECTRONIC STRUCTURE OF Pd<sub>1-x</sub>MOE<sub>x</sub> C<sub>u</sub>y ALLOYS.** The entire concentration range of α-phase Pd<sub>1-x</sub>Cu<sub>y</sub> alloys have been studied by angular correlation and positron lifetime methods. The conclusions concerning the electronic structure of these alloys are in agreement with SCF-KKR-CPA calculations. The comparison of the present results with the ones for Pd<sub>1-x</sub>Ag<sub>x</sub> alloys obtained previously allows one to confirm the idea that the behavior of the annihilation rate in random alloys can predict whether the split-band regime or VCA is the appropriate description of the electronic structure of a particular alloy. (Author abstract) 25 Refs.

Debowska, E. (Wrocław Univ, Wrocław, Pol); Rudzinska-Girulka, J. *Phys Scr* v 38 n 1 Jul 1988 p 103-108.

### Thermodynamic Properties

**075990 THERMODYNAMICS OF Pd-Cu-H SOLID SOLUTIONS.** Solubility isobars at various temperatures in the range 625-1250 K have been measured for Pd-Cu-H solid solutions containing 0-20 at.% Cu. The H-concentration was always less than approx. 10<sup>-3</sup> at.%. The variation with Cu-concentration of the partial molar thermodynamic functions of the H-atoms, deduced from the measurements, exhibit singularities not observed in other Pd-noble metal-H systems. The observed behavior has been explained using a statistical mechanical model for the solid solution. The contribution of effects related

to changes in the specific volume of the solution with Cu-concentration has been calculated from elastic data measured in the same range of temperature and composition. (Author abstract) 15 refs.

Yoshihara, M. (Rice Univ, Houston, TX, USA); McLellan, R.B. *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 21-28.

## PALLADIUM COPPER SILICON ALLOYS

### Amorphous

**075991 H<sub>v</sub> CHANGE WITH COOLING CONDITION OF LIQUID-QUENCHED Pd<sub>0.775</sub>Cu<sub>0.06</sub>Si<sub>0.165</sub> ALLOY GLASS.** Micro-Vickers' hardness, H<sub>v</sub>, was studied for the liquid-quenched Pd<sub>0.775</sub>Cu<sub>0.06</sub>Si<sub>0.165</sub> alloy glass in relation to cooling conditions. The faster the cooling rate, the smaller the H<sub>v</sub> becomes. Based on the relaxation theory, we show the existence of an approximately linear relationship between H<sub>v</sub> and the sample thickness. 14 refs.

Nishi, Yoshitake (Tokai Univ, Hiratsuka, Jpn); Harano, Hidehiko; Ishizuki, Hisayoshi. *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1445-1446.

**075992 HYDROGEN IN AMORPHOUS METALS - I.** The solubility and diffusivity of hydrogen in amorphous Pd<sub>77.5</sub>Cu<sub>6</sub>Si<sub>16.5</sub> and Ni<sub>49.9</sub>Pd<sub>31.8</sub>P<sub>18.3</sub> have been measured using an electrochemical method. The pressure-concentration isotherms show remarkable deviations from Sievert's Law while the amount of hydrogen dissolved lies in between the solubility of the components of the alloy. The diffusivity of hydrogen is rather high (about 10<sup>-8</sup> cm<sup>2</sup>/s) and it depends on temperature and also on concentration even at very low hydrogen levels contrary to crystalline metals. An equation is derived which relates the width of this function to the width of the radial distribution function which describes the structure of an amorphous alloy. Changes in this structure are believed to take place during annealing and were revealed by changes of hydrogen solubility. (Edited author abstract) 22 refs.

Kirchheim, R. (Max-Planck-Inst Fuer Metallforschung, Stuttgart, West Ger); Sommer, F.; Schluckebier, G. *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 539-548.

### Internal Friction

**075993 HYDROGEN RELATED INTERNAL FRICTION PEAKS IN AMORPHOUS AND CRYSTALLIZED Pd-Cu-Si ALLOYS.** A low frequency internal friction measurement by a torsion pendulum has been made on amorphous and crystallized Pd<sub>77.5</sub>Cu<sub>6</sub>Si<sub>16.5</sub> alloys, electrolytically charged with hydrogen. In the amorphous state, a relaxation peak appears in the temperature range 100-150 K. The peak increases its height and shifts towards lower temperatures with the increase in hydrogen concentration and exhibits the reverse trend on hydrogen desorption. On hydrogenation, crystallized specimens exhibit a large relaxation peak at about 170 K with a subpeak at 130 K. Possible origins of peaks are discussed in reference to the literature on Pd and Pd alloys. (Author abstract) 27 refs.

Yoshinari, O. (Tohoku Univ, Sendai, Jpn); Koiwa, M.; Inoue, A.; Masumoto, T. *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 307-316.

### Microstructure

**075994 HIGH RESOLUTION ELECTRON MICROSCOPIC STUDY OF THE STRUCTURE OF AMORPHOUS Pd<sub>77.5</sub>Cu<sub>6</sub>Si<sub>16.5</sub> ALLOY.** High resolution electron microscopy has been applied to microstructural observations of an amorphous Pd<sub>77.5</sub>Cu<sub>6</sub>Si<sub>16.5</sub> alloy.

In all specimens prepared at different cooling rates, images of microcrystalline domains were observed and the formation of medium range order in this alloy was proved. The average size of these domains varies from 3.0 to 1.5 nm depending on the cooling rate and melt temperature on cooling. From the geometries of the crossed-lattice images and micro-area electron diffraction, the structure of the domains is identified as a face centered cubic structure. (Edited author abstract) 34 refs. In Japanese.

Hiotsu, Yoshihiko (Technological Univ of Nagaoka, Nagaoka, Jpn); Uehara, Masashi. *Nippon Kinzoku Gakkaishi* v 52 n 2 Feb 1988 p 129-138.

## PALLADIUM COPPER SILVER ALLOYS

### Order-Disorder

**075995 FIELD EMISSION MICROSCOPY OF THE EARLY STAGES OF ORDERING AND DECOMPOSITION OF ALLOY PALLADIUM-COPPER-SILVER.** The method of field emission microscopy was used to study the initial stages of decomposition and atomic ordering of type B2 in alloy PdCuAg. The order in which the phases arise and the shape and size of particles at the early stages of decomposition are established. At the atomic level, cell boundaries and particle-matrix phase interfaces are observed. The alloy contained 50.0 wt.% Pd 25.0 wt.% Cu 25.0 wt.% Ag. 5 refs.

Syutkin, N.N. (Acad of Sciences of the USSR, USSR); Ivchenko, V.A.; Telegin, A.B.; Volkov, A.Yu. *Phys Met Metallogr* v 62 n 5 1986 p 123-128.

## PALLADIUM ERBIUM ALLOYS

### Crystallization

**075996 ION- AND ELECTRON-BEAM INDUCED REACTIONS IN MICROCRYSTALLINE Pd<sub>3</sub>Er.** This paper describes the results of an investigation which was originally intended to differentiate between some amorphous phases produced as a result of ion beam thinning and by interdiffusion between the Si substrate and superposed microcrystalline Pd<sub>3</sub>Er. In the former category of processes are included the increased propensity of a material such as Pd<sub>3</sub>Er to form amorphous oxide on exposure to air after ion irradiation. The authors also found that the Pd-Er can undergo both ion and electron beam-induced reactions and discuss these as of interest in their own right. It is demonstrated that a low voltage (5 kv) argon ion beam can promote amorphization with the incorporation of oxygen and that an 100 kv electron beam can accelerate crystallization. 7 refs.

Williams, E.J.; Boothroyd, C.B.; Stobbs, W.M. *Scr Metall* v 21 n 10 Oct 1987 p 1285-1288.

## PALLADIUM EUROPIUM ALLOYS See HYDROGEN—Solubility.

## PALLADIUM GOLD ALLOYS

### Gases

**075997 SOLID SOLUTIONS OF Pd CONTAINING HYDROGEN AND A NOBEL METAL SUBSTITUTIONAL COMPONENT - II. KINETIC BEHAVIOR.** An electrochemical cell method has been used to measure the diffusivity of hydrogen in Pd-Au solid solution in the temperature range 273-360 K and in the concentration range 1-50 at.% Au. Up to 10 at.% Au the mobility of H in the metal lattice is virtually unaffected by the presence of Au in the solid solution. There is then an increase in mobility with increasing Au-concentration. This phenomenon has been interpreted in terms of a statistical model in which interstitial sites adjacent to Au atoms act as antitraps. (Author abstract) 9 refs.

Yoshihara, M. (Rice Univ, Houston, TX, USA); McLellan, R.B. *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 9-13.



## Spectroscopic Analysis

**075998**  $N_{6,7}$  SOFT X-RAY EMISSION SPECTRA OF PLATINUM-GOLD ALLOYS. The  $N_{6,7}$  soft x-ray spectra of platinum and gold from a series of platinum-gold alloys have been measured and their energies adjusted to compensate for the  $N_6$  and  $N_7$  core level shifts which were measured by XPS. The results are compared with the theoretical spectra published by Weinberger et al. The overall agreement in band shapes, peak positions and band widths is good and possible causes of minor discrepancies are discussed. (Author abstract) 13 refs.

Negm, N.Z. (Univ of Strathclyde, Glasgow, Scotl); Watson, L.M.; Norris, P.R.; Szasz, A. *J Phys F Met Phys* v 17 n 11 Nov 1987 p 2295-2301.

## PALLADIUM IRON ALLOYS See Also GLASS, METALLIC—Magnetic Properties.

## Heat Treatment

**075999** DISCONTINUOUS COALESCENCE OF DOMAINS IN ORDERED ALLOY PdFe. Discontinuous coalescence realized by means of grain boundary migration has previously been observed as the result of discontinuous decomposition,  $L1_2$  type ordering and during recovery of the grain in certain steels. Grain boundary displacement has been discovered (with the optical method) in ordered alloy NiPt (after quenching  $L1_0$ ). A more detailed investigation of that effect in alloys of this kind is of interest. Using the method of transmission electron microscopy of foils, the authors have observed and studied grain boundary migration in the ordered alloy PdFe ( $T_c$  680 °C). 9 refs.

Teytel, Ye.I. (Acad of Sciences, USSR); Gushchin, G.M. *Phys Met Metallogr* v 61 n 6 1986 p 187-190.

## Magnetic Properties

**076000** MAGNETIC BEHAVIOR OF HYDROGENATED ORDERED ALLOY Pd<sub>3</sub>Fe IN THE RANGE OF COEXISTENCE OF TWO MAGNETIC SUBSYSTEMS. On the basis of a Mossbauer analysis and magnetization measurements of hydrogenated alloy Pd<sub>3</sub>Fe, the authors consider the magnetic state of the alloys as a set of two interconnected subsystems - a ferromagnetic  $\alpha$  and antiferromagnetic  $\beta$ -phase. The hyperfine field on the nucleus of <sup>57</sup>Fe changes rapidly in the  $\alpha$ -phase of the relative volume of  $\beta$ -phase in the specimen is more than 50%. The magnetization grows when the specimen is cooled in a magnetic field. (Edited author abstract) 5 refs.

Tsurin, V.A. (Acad of Sciences, USSR); Filippova, N.P.; Stepanov, A.P. *Phys Met Metallogr* v 61 n 6 1986 p 69-71.

## Mechanical Properties

**076001** INFLUENCE OF ORDERING ON BEHAVIOUR OF THE ELECTRICAL RESISTIVITY AND MECHANICAL PROPERTIES OF ALLOY PdFe DURING DEFORMATION. The methods of electrical resistivity, X-ray crystallographic analysis and electron microscopy were used to investigate the disturbance of short- and long-range atomic order and the behavior of the mechanical properties during deformation by drawing of alloy PdFe with different initial degrees of ordering and structure states. The highest strength properties are obtained by deforming the partially or totally ordered alloy to a certain degree (0.3-0.7). Higher degrees of deformation are required to achieve the same results during drawing of the unordered alloy. (Author abstract) 12 refs.

Gushchin, G.M.; Kuranov, A.A.; Teytel, Ye.I. *Phys Met Metallogr* v 62 n 3 1986 p 166-173.

## PALLADIUM MANGANESE ALLOYS

## Microstructure

**076002** EVIDENCE FROM HYDROGEN SOLUBILITY STUDIES FOR ORDERING IN HYPOSTOI-

CHIOMETRIC ALLOYS OF Pd<sub>3</sub>Mn. The abrupt increases in hydrogen solubility and electrical resistance as quenched samples of hypostoichiometric Pd<sub>3</sub>Mn are heated is attributed to ordering of the alloy matrix. Low temperature hydrogen solubility comparisons of quenched and slowly cooled alloys show large differences which further support the contention that ordered forms of these alloys exist. In addition, electron diffraction patterns of the slowly cooled alloys show weak superlattice reflections indicative of the Ag<sub>3</sub>Mg structure. 6 refs.

Craft, Andrew (Univ of Vermont, Burlington, VT, USA); Foley, Robert; Flanagan, Ted B.; Baba, K.; Niki, Y.; Sakamoto, Y. *Scr Metall* v 22 n 4 Apr 1988 p 511-515.

## PALLADIUM MOLYBDENUM ALLOYS

## Radiation Effects

**076003** FORMATION OF Pd<sub>3</sub>Mo IN PROTON-IRRADIATED Pd-Mo SOLID SOLUTIONS. The existence of the ordered phase Pd<sub>3</sub>Mo, of the Pt<sub>3</sub>Ti prototype, point group 4/m 2/m 2/m, is reported for the first time. It has been observed in alloys containing 10 at% Mo at 350°C and 18% Mo at 450°C on irradiation by 400 keV protons. The microstructural features of the Pd<sub>3</sub>Mo phase are described and discussed. (Author abstract) 14 refs.

Mostafa, M.S. (Univ of California, Los Angeles, CA, USA); Ardell, A.J. *Mater Lett* v 6 n 3 Dec 1987 p 67-70.

## PALLADIUM NICKEL ALLOYS

## Amorphous

**076004** SURFACE CRYSTALLIZATION OF MELT-SPUN Pd<sub>40</sub>Ni<sub>40</sub>Pd<sub>20</sub> GLASS. The crystallization of Pd<sub>40</sub>Ni<sub>40</sub>Pd<sub>20</sub> glass, produced by melt-spinning in air, has been studied by optical metallography. Crystallization is predominantly from the surface and is more prevalent on the wheel-side. The non-uniformity is attributed to variation in quench rate during production. A three-stage anneal permits crystals which have nucleated at the surface to be identified and their size distribution to be analyzed. The surface nucleation is heterogeneous and appears to be hindered by mild oxidation. The annealing atmosphere markedly affects the surface crystallization behavior, as does removal of the original ribbon surface. When nucleation is sparse, partial crystallization causes the development of noticeable relief on the sample surfaces. (Author abstract) 9 refs.

Garcia Escorial, A. (Centro Nacional de Investigaciones Metalurgicas, Madrid, Spain); Greer, A.L. *J Mater Sci* v 22 n 12 Dec 1987 p 4388-4394.

**076005** ON THE MICROSTRUCTURE OF AMORPHOUS Pd<sub>46</sub>Ni<sub>36</sub>P<sub>18</sub> WITH TWO GLASS TRANSITIONS. The authors performed microscopic observations on thin foils of annealed amorphous Pd<sub>46</sub>Ni<sub>36</sub>P<sub>18</sub>. A phase separation phenomenon leading to the occurrence of two glass transitions intervenes at 605 < T < than 630 K. Immediately after completion of this reaction the scale of the phase separated zones  $r \leq 1.0$  nm and their electron density contrasts are too low to be detected before coarsening on further annealing which allows their detection once  $r > 1.0$  nm. The phase separation seems to produce zones depleted in Pd and richer in P and vice versa but does not seem to be a precursor to the nucleation of the NiPd fcc solid solution that is the first crystallization product at T  $\geq 630$  K. 9 refs.

Yavari, A.R. (CNRS, St. Martin d'Heres, Fr); Hammar-Thibault, S.; Sinning, H.R. *Scr Metall* v 22 n 8 Aug 1988 p 1231-1234.

## Electroplating

**076006** ZUM TRIBOLOGISCHEN VERHALTEN VON GALVANISCH ABGESCHIEDENEN PALLADIUM-NICKEL-LEGIERUNGEN. [Tribological Behaviour of Plated Pd%-Ni% Alloys]. Pd alloy systems and sandwich systems with a thin Au-film have been

investigated using a disk-pin-turbometer. Friction coefficients, wear, roughness, hardness, and surface compositions have been determined. The results exhibit a very distinctive running-in-phase, during which the dominance of the different mechanisms changes permanently. Alloys formed by pulse plating have lower friction coefficients and higher wear resistance. (Edited author abstract) In German. 24 refs.

Feller, Heinz-Gerhard (Technische Univ Berlin, Berlin, West Ger); Akpolat, Hasan. *Z Metallkd* v 78 n 8 Aug 1987 p 590-595.

## Structure

**076007** ELECTRONIC STRUCTURE OF Pd<sub>1-x</sub>Ni<sub>x</sub> ALLOYS INVESTIGATED BY POSITRON ANNIHILATION. The entire concentration range of  $\alpha$ -phase Pd<sub>1-x</sub>Ni<sub>x</sub> alloys is studied by angular correlation and positron lifetime methods. The electron number per one alloy atom is analyzed and the progressive delocalization of d-like electrons with increasing Ni concentration is postulated. Attention is also paid to the problem of annihilation rate in alloys. The changes in the character of annihilation parameter dependences on x are seemed to be connected with para- to ferromagnetic transition. (Author abstract) 16 refs.

Debowska, E. (Univ of Wroclaw, Wroclaw, Pol); Rudzinska-Girulski, J. *Phys Status Solidi B* v 148 n 1 Jul 1988 p 227-231.

## Thermodynamic Properties

**076008** THERMODYNAMICS OF TERNARY PALLADIUM-BASED SOLID SOLUTIONS CONTAINING NICKEL AND HYDROGEN. The solubility of hydrogen in Pd-Ni-H ternary solutions in equilibrium with H gas at atmospheric pressure has been measured in the temperature range 625-1250 K and in Pd-Ni 'binary solvents' containing up to 80 at.% of Ni. Concomitant elastic measurements have provided data which enable the partial thermodynamic functions of the H-atoms, deduced from the solubility measurements, to be converted so as to refer to a hypothetical Pd-Ni lattice of constant specific volume. The resulting 'volume corrected' functions have been discussed in terms of the cell model for ternary solutions and have been shown to vary with temperature and Ni-concentration in a manner in accord with this mode. The usual linear form of cell interaction energy spectrum has been modified by including supplemental contributions to the cell interaction energy which occur when substitutional solute atoms occupy adjacent sites on the fcc Pd-Ni lattice. (Author abstract) 24 refs.

Yoshihara, M. (Rice Univ, Houston, TX, USA). *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 77-83.

## Thin Films

**076009** ENHANCEMENT OF THE MAGNETIC HYSTERESIS IN ULTRATHIN PdNi FILMS BY HYDROGEN ABSORPTION-DESORPTION CYCLING. Measurements of the magnetic hysteresis in ultrathin PdNi films ( $d \leq 100$  Å) show a marked increase of the perpendicular coercive field after hydrogen absorption-desorption cycling; a squaring up of the magnetic hysteresis is observed at the same time. We attribute tentatively this effect to an irreversible change of the stress state of the film in relation with the film-substrate interaction. (Author abstract) 11 refs.

Raffy, H. (Univ Paris-Sud, Orsay, Fr); Dumoulin, L.; Burger, J.B. *J Magn Magn Mater* v 69 n 3 Nov 1987 p 258-262.

## PALLADIUM NICKEL MANGANESE ALLOYS



# Low Temperature Effects

**076010 MAGNETORESISTIVE ANISOTROPY IN DILUTE (PdNi)Mn ALLOYS.** Measurements of the longitudinal and transverse magnetoresistance at 4.2 and 1.6 K of a series of Pd+1.5 at.% Ni-based alloys with between 0.5 and 3.0 at.% Mn are presented. These measurements are qualitatively consistent with the suggestion of an indirect Ni-mediated anisotropy in this system. (Author abstract) 11 refs.

Kunkel, H.P. (Univ of Manitoba, Winnipeg, Manit, Can); Kucukturhan, K.; Wang, Z.; Williams, Gwyn. *J Phys F Met Phys* v 18 n 1 Jan 1988 p 89-97.

# PALLADIUM NICKEL SILICON ALLOYS

## Amorphous

**076011 ANNEAL-INDUCED ENTHALPY RELAXATION BEHAVIOUR OF AMORPHOUS (Pd<sub>0.7</sub>Ni<sub>0.3</sub>)<sub>83</sub>Si<sub>17</sub> ALLOY BY X-RAY DIFFRACTION.** The main purpose of this letter is to present some new systematic X-ray diffraction measurements on structural relaxation which occur in the metallic glass (Pd<sub>0.7</sub>Ni<sub>0.3</sub>)<sub>83</sub>Si<sub>17</sub> caused by annealing. Glass samples of (Pd<sub>0.7</sub>Ni<sub>0.3</sub>)<sub>83</sub>Si<sub>17</sub> were prepared in the shape of ribbons (about 10 mm wide and 0.3 mm thick) by rapid quenching from the melt. These glass samples were annealed in evacuated quartz capsules under the required conditions and the densities were measured by Archimedes method with toluene. The most striking results in this work are the detection of changes corresponding to the anneal-induced enthalpy relaxation and such changes clearly contrast with the previous results of the irreversible relaxation due to low-temperature annealing. 20 Refs.

Waseda, Y. (Tohoku Univ, Sendai, Jpn); Matsubara, E.; Ohzora, M.; Tsai, A.P.; Inoue, A.; Masumoto, T. *J Mater Sci Lett* v 7 n 9 Sep 1988 p 1003-1006.

## Electric Conductivity

**076012 ANNEALING EFFECT ON THE ELECTRICAL RESISTIVITY OF Pd-SiBASED ALLOYS.** The authors investigated the electrical resistivity changes of Pd<sub>77.5</sub>Ni<sub>16.5</sub>Si<sub>6.5</sub> in the temperature region before crystallization. The temperature dependence of relative electrical resistivity of Pd<sub>77.5</sub>Ni<sub>16.5</sub>Si<sub>6.5</sub>, Pd<sub>77.5</sub>Cu<sub>6</sub>Si<sub>16.5</sub> and Pd<sub>80</sub>Si<sub>20</sub> is shown. Du scanning from room temperature to 820 K, the relative electrical resistivity of the glassy matrix increases with temperature and a drop appears near T<sub>x</sub> (the crystallization temperature). However, the resistivity curve has a hump near the glass transition temperature T<sub>g</sub> for an as-received specimen of Pd<sub>77.5</sub>Ni<sub>16.5</sub>Si<sub>6.5</sub>, Pd<sub>77.5</sub>Cu<sub>6</sub>Si<sub>16.5</sub> and such a hump was not observed for Pd<sub>80</sub>Si<sub>20</sub>. During isothermal annealing the electrical resistivity of Pd<sub>77.5</sub>Ni<sub>16.5</sub>Si<sub>6.5</sub> varies depending on the annealing temperatures. The variation of internal friction during isothermal annealing at different temperatures is similar to that of the electrical resistivity measurements. 7 Refs.

He, Yizhen (Acad Sinica, Hefei, China); Li, Xiao-Guang; Sha, Jian; Dong, Yuanda. *J Mater Sci Lett* v 7 n 8 Aug 1988 p 836-838.

# PALLADIUM NICKEL URANIUM ALLOYS

## Phase Diagrams

**076013 POLYTHERMAL SECTION AT 10% U OF THE Pd-Ni-U PHASE DIAGRAM.** Studies of the polythermal section of the Pd-Ni-U system at 10% U showed that alloying with Pd in that part of the system decreases the melting start temperature to 1025°C. Palladium has a moderate effect on formation of the ternary solid solutions region. The homogeneous region formed does not extend above 17% Ni at 10% U. 6 refs.

Terekhov, G.I.; Sinyakova, S.I.; Aleksandrova, L.N.; Lekhtblau, E.A. *Russ Metall Met* n 4 1987 p 213-217.

# PALLADIUM PLATINUM ALLOYS See METALS AND ALLOYS—Impurities.

# PALLADIUM RHENIUM ALLOYS

## Oxidation

**076014 PdRhO<sub>2</sub> FORMATION DURING THE AIR OXIDATION OF A Pd-15Rh ALLOY.** The surfaces of air-oxidized Pd-15Rh alloys have been examined by X-ray photoelectron spectroscopy (XPS) and Raman spectroscopy. The XPS results indicate that the near-surface region of samples oxidized in the temperature range 1075 to 1125 K contains Pd in both the +2 and +1 oxidation states and Rh in the +3 oxidation state. The ratio of Pd (I) to Rh (III) is 1:1. Raman spectra confirm that two Pd-containing phases, PdO and PdRhO<sub>2</sub>, are present in the near-surface region and eliminate the possibility that Rh<sub>2</sub>O<sub>3</sub> is present. A resonant Raman effect is observed in anhydrous PdO for exciting wavelengths in the vicinity of 500 nm. (Author abstract). 13 Refs.

Baird, R.J. (Ford Motor Co, Dearborn, MI, USA); Graham, G.W.; Weber, W.H. *Oxid Met* v 29 n 5-6 Jun 1988 p 435-443.

# PALLADIUM RHODIUM ALLOYS

## Decomposition

**076015 STUDY OF THE Pd-Rh SYSTEM BY ELECTRICAL RESISTIVITY MEASUREMENTS.** The phase diagram results of this experiment differ slightly from those of Raub. Generally, decomposition was found to occur at higher temperatures. Presumably the reason for this is that the resistivity method detects phase separation on a very fine scale as takes place in spinodal decomposition, while earlier results only detected discontinuous precipitation of the two phases. Raub et al. report two lattice parameters for their samples which were aged for long times. Present results show only one lattice parameter as would be expected if separation were taking place on a scale of about 10 nm. 7 refs.

Shield, J.E. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Williams, R.K. *Scr Metall* v 21 n 11 Nov 1987 p 1475-1479.

# PALLADIUM SILICON ALLOYS See Also GLASS, METALLIC—Microscopic Examination.

**076016 ELECTROCHEMICAL STUDIES OF HYDROGEN SORPTION BY Pd<sub>84.5</sub>Si<sub>15.5</sub> AMORPHOUS ALLOY.** It is the aim of this work to study hydrogen sorption and diffusion in Pd<sub>84.5</sub>Si<sub>15.5</sub> alloy (amorphous and crystalline), and to compare the data obtained with similar characteristics for pure Pd. It was found that the concentrations of sorbed hydrogen found in Pd<sub>84.5</sub>Si<sub>15.5</sub> amorphous alloy at the potentials of the α-phase are somewhat higher than those found in palladium. It was found when estimating the ratio between dissolved and adsorbed hydrogen that in the amorphous alloy, the amount of dissolved hydrogen is about an order of magnitude larger than that of adsorbed hydrogen. Electrochemical studies of hydrogen sorption have demonstrated a decrease of hydrogen solubility in the order of: Pd > Pd<sub>84.5</sub>Si<sub>15.5</sub> amorphous alloy > Pd<sub>84.5</sub>Si<sub>15.5</sub> crystalline alloy. 14 refs.

Petrii, O.A. (M.V. Lomonosov State Univ, Moscow, USSR); Kopylova, N.S.; Efimov, Yu.V.; Voronova, L.I.; Glazov, M.V. *Sov Electrochem* v 23 n 3 Mar 1987 p 397-401.

## Amorphous See Also HYDROGEN—Solubility.

**076017 ANISOTROPY IN YOUNG'S MODULUS OF NONFERROMAGNETIC AMORPHOUS WIDE RIBBONS.** Pd-Si and Ni-Si-B amorphous wide ribbons were prepared by the melt-quenching method, and Young's modulus as a function of angle to the ribbon direction has been investigated in the as-prepared, annealed and rolled states. It has been confirmed that these alloys show a large elastic anisotropy in both as-prepared

and annealed states and the anisotropy does not disappear even after full annealing. The elastic anisotropy is enhanced by cold-rolling. By rolling to the width direction of the specimen, the anisotropy becomes large in the direction of the ribbon axis. From the present results it is concluded that the amorphous alloys produced by melt-quenching inherently have the elastic anisotropy. (Author abstract) 19 refs.

Kikuchi, Michio (Tohoku Univ, Sendai, Jpn); Fukamichi, Kazuaki; Kimura, Hisamichi; Masumoto, Tsuyoshi. *Sci Rep Res Inst Tohoku Univ Ser A* v 33 n 1 Mar 1986 p 102-110.

**076018 MOLECULAR DYNAMICS SIMULATION OF AMORPHOUS Pd<sub>80</sub>Si<sub>20</sub> ALLOY.** Molecular dynamics (MD) simulation of an amorphous Pd<sub>80</sub>Si<sub>20</sub> alloy has been carried out to know the microscopic structure in this system. After adjusting parameters of the proposed pair potentials, we have obtained similar structure factor of the simulated system to the experimental one and found some trigonal prismatic structures in the simulated system, which are not always predominant. Most probable coordination number of Pd around Si is 7, which is the same as that obtained Distorted Prismatic Packing model proposed by Gaskell. (Author abstract) 10 refs.

Takagi, Ryuzo (Tokyo Inst of Technology, Tokyo, Jpn); Adya, Ashok K.; Kawamura, Kazutaka. *Trans Jpn Inst Met* v 28 n 10 Oct 1987 p 761-764.

**076019 DISSOLUTION CHARACTERISTICS AND OCCUPANCY SITES OF HYDROGEN IN AMORPHOUS PdSi ALLOYS: PART I.** Hydrogen solubility has been studied in three amorphous PdSi alloys with silicon contents of 14, 18 and 20 at.%. Hydrogen charging was achieved by heating in the temperature range 20-200°C in an atmosphere of hydrogen gas at pressures up to 12 MPa. The dissolved hydrogen concentrations were analyzed by in situ electrical resistivity and thermogravimetry measurements. The heat of solution was determined for hydrogen concentrations ranging from about 0.1 to 6 at.%. The heat of solution was found to depend markedly on the dissolved hydrogen content. (Edited author abstract) 25 refs.

Magnouche, A. (CNRS, Vitry-sur-Seine, Fr); Fromageau, R.; Hillairet, J. *J Less Common Met* v 138 n 2 Mar 15 1988 p 323-336.

**076020 DIFFUSION CHARACTERISTICS OF HYDROGEN IN AMORPHOUS Pd<sub>80</sub>Si<sub>20</sub>: PART II.** Measurement of the kinetics of hydrogen uptake and outgassing in response to the application or release of gas pressure enabled us to make a detailed analysis of the hydrogen mobility in melt-spun Pd<sub>80</sub>Si<sub>20</sub>. The diffusion coefficient of hydrogen was found to be dependent on hydrogen concentration. It increased by a factor of about two when the concentration of dissolved gas increased from 0 to 0.2 at.%. The progressive enhancement of hydrogen mobility reflects the existence of a broad continuous energy spectrum of the available sites. At very low concentrations, a typical value for the migration enthalpy of hydrogen is 0.43 eV (41 kJ mol<sup>-1</sup>). (Author abstract) 18 refs.

Fromageau, R. (CNRS, Vitry-sur-Seine, Fr); Magnouche, A.; Brebec, G.; Hillairet, J. *J Less Common Met* v 138 n 2 Mar 15 1988 p 337-348.

**076021 STUDY OF THE HYDROGEN DISTRIBUTIONS IN AMORPHOUS Pd<sub>80</sub>Si<sub>20</sub> BY THERMAL EVOLUTION OF HYDROGEN.** Hydrogen thermal desorption study in amorphous Pd<sub>80</sub>Si<sub>20</sub> provides phenomenological evidence for a distribution of hydrogen among sites of different energy caused by disorder in an amorphous metal. As a consequence, at low temperatures the sites of low energy are filled first. With increasing concentration, hydrogen occupies sites of higher energy. At higher temperatures or low concentrations, distribution of hydrogen in sites becomes independent of concentration. The dissolution of hydrogen is exothermic. The



pressure-concentration isotherms show deviations from Sievert's law at temperatures between 303 and 473 K for hydrogen pressures between 0.05 and 1 atm. This is attributed to the larger enthalpy of dissolution at higher concentrations, which is related to the distribution of hydrogen atoms in sites of different energies. (Edited author abstract) 21 refs.

Lee, Sung-Man (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Lee, Jai-Young. *Acta Metall* v 36 n 3 Mar 1988 p 605-611.

**076022 RELATION BETWEEN VISCOSITY AND DIFFUSION IN AMORPHOUS METALLIC ALLOYS.** The main characteristics of creep and diffusion data in metallic amorphous alloys (PdSi and FeNiB types) are presented. It is shown that the free volume model cannot satisfactorily explain these data, particularly the different behaviour with respect to the kinetics of relaxation. The creep behaviour of Metglas is qualitatively similar to that of polycrystals at high temperature. From a macroscopic point of view, the Nabarro-Herring (or Coble) models are able to account for creep and diffusion experiments. (Edited author abstract) 49 refs.

Limoge, Y. (CEN de Saclay, Gif sur Yvette, Fr); Brebec, G. *Acta Metall* v 36 n 3 Mar 1988 p 665-673.

**076023 EFFECT OF Cr AND Si COATING ON THE STABILITY AND KINETICS OF CRYSTALLIZATION OF Pd<sub>77</sub>Si<sub>23</sub> AMORPHOUS RIBBONS.** The DSC and metallography are used to study the influence of coating with silicon and chromium on the stability of Pd<sub>77</sub>Si<sub>23</sub> amorphous alloys. General requirements for a good coating material are discussed. (Author abstract) 9 refs.

Calka, A. (Australian Natl Univ, Canberra, Aust); Radlinski, A.P. *Key Eng Mater* v 13 pt 2 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 303-306.

## Deformation

**076024 HYDROGEN IN DEFORMED AND AMORPHOUS Pd<sub>80</sub>Si<sub>20</sub> COMPARED TO HYDROGEN IN DEFORMED AND CRYSTALLINE PALLADIUM.** The purpose of this study is to present experimental results on hydrogen activity, diffusivity and resistivity increment in amorphous Pd<sub>80</sub>Si<sub>20</sub> before and after cold rolling and compare it with the corresponding quantities in crystalline Pd. In amorphous Pd<sub>80</sub>Si<sub>20</sub> the three quantities, emf, diffusivity, resistivity-increment, show a different concentration dependence when compared with the crystalline Pd. This is due to a broad distribution of site energies for hydrogen in amorphous metals. 11 refs.

Kirchheim, R. (Max-Planck-Inst fuer Metallforschung, Stuttgart, West Ger); Szokefalvi-Nagy, A.; Stolz, U.; Speitling, A. *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 99-102.

## Internal Friction

**076025 GORSKY EFFECT MEASUREMENTS ON AMORPHOUS Pd<sub>80</sub>Si<sub>20</sub>H<sub>x</sub> BETWEEN 290 AND 490 K.** Authors have performed Gorsky-effect measurements on amorphous Pd<sub>80</sub>Si<sub>20</sub>H<sub>1.2</sub> in the temperature range 290-490 K. For T > 350 K the relaxation process cannot be described by a single relaxation time. In addition to the hydrogen related relaxation process a recoverable creep process independent of hydrogen content is observed. Surprisingly the activation energy associated with the creep process (E = 0.32 eV) is comparable to the activation energy of the hydrogen diffusion process (E<sub>a</sub> = 0.290 ± 0.005 eV). Within experimental error no temperature dependence of the relaxation strength of the Gorsky-effect has been observed. This is associated with both a large 'repulsive' long range H-H interaction of electronic origin and to a low density-of-sites function in the domain of energy of the sites occupied in Pd<sub>80</sub>Si<sub>20</sub>H<sub>x</sub> at low concentrations. 16 refs.

Verbruggen, A.H. (Vrije Univ, Amsterdam, Neth); van

den Heuvel, R.C.; Griessen, R.; Kuenzi, H.U. *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 323-328.

## Structure

**076026 STRUCTURAL OBSERVATIONS ON Pd<sub>80</sub>Si<sub>20</sub> AMORPHOUS ALLOY PREPARED BY MECHANICAL ALLOYING.** Palladium silicon alloys prepared by mechanical alloying from pure silicon and pure palladium powders were examined by scanning electron microscopy. X-ray diffraction patterns were obtained. A melt-spun ribbon of the same composition as the mechanically alloyed sample was prepared for comparative purposes. Discussed are comparison of diffraction patterns; palladium-silicon bonding; and alloy structure. 9 refs.

Magini, M. (ENEA, Rome, Italy); Martelli, S.; Vittori, M. *J Non Cryst Solids* v 101 n 2-3 May 1988 p 294-296.

## Thin Films

**076027 SIMULATION OF FRACTAL-LIKE STRUCTURES IN BILAYER Pd-Si ALLOY FILMS.** Fractal-like structures have been observed in evaporated Pd-Si bilayer alloy films after the crystallization of a-Si at 400°C or more. A model for the formation of these structures has been proposed. The formation of these structures is the consequence caused by the latent heat released quickly during the crystallization of a-Si and during void formation. The simulation results of our model yields the fractal-like structures which is scale invariant and similar to that of the experimental results. (Edited author abstract) 15 refs.

Duan, Jian-Zhong (Univ of Science & Technology, Hefei, China); Li, Yan; Wu, Zi-qin. *Solid State Commun* v 65 n 1 Jan 1988 p 7-10.

**076028 APPEARANCE OF NEGATIVE FRACTAL-LIKE STRUCTURES IN Pd-Si ALLOY FILMS.** The fractal-like structures, or irregular holes, appear in silicide film after the crystallization of a-Si when the annealing temperature reaches 400-500°C. The fractal dimension of these holes decreases with increasing Si concentration. The structures and compositions of different regions investigated by TEM, HREM, Scanning Auger Microprobe and X-ray EDS show that only Si exists in the fractal-like region, so it is a negative fractal-like structure which is caused by diffusion of Pd atoms away from this region and is contrary to the DLA (diffusion-limited aggregation), a positive fractal-like structure caused by diffusion of atoms towards this region. Crystallized Si is quite perfect but with many twins and stacking faults, especially near the edge of these regions. The mechanism of appearance of fractal-like region and its growth process is discussed. (Edited author abstract) 13 refs.

Jian-zhong, Duan (Univ of Science & Technology of China, Hefei, China); Zi-qin, Wu. *Solid State Commun* v 64 n 1 Oct 1987 p 1-5.

## PALLADIUM SILICON COPPER ALLOYS

### Amorphous

**076029 SOLUBILITY, DIFFUSIVITY AND TRAPPING OF HYDROGEN IN DILUTE ALLOYS, DEFORMED AND AMORPHOUS METALS - II.** The chemical potential and diffusivity of interstitial solute atoms was calculated for disordered materials in a general way. Disorder may be of chemical nature as in alloys or caused by a strain field as around dislocations and a crack tip or disorder may be as total as in an amorphous alloy. For these examples of disordered systems relations were derived from a general expression and compared with corresponding special theoretical results which are mostly related to attractive interaction (trapping) and repulsive interaction (antitrapping) between interstitially and substitutionally dissolved impurity atoms. A comparison with experimental results is namely made for the solubility

and diffusivity of hydrogen in dilute alloys, deformed Fe and Pd and amorphous Pd<sub>77.5</sub>Si<sub>16.5</sub>Cu<sub>6</sub> and Ni<sub>64</sub>Zr<sub>36</sub>. (Author abstract) 29 refs.

Kirchheim, R. (Max-Planck-Inst fuer Metallforschung, Stuttgart, West Ger). *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 549-558.

## PALLADIUM SILVER ALLOYS

### Electronic Properties

**076030 ELECTRONIC STRUCTURE OF Pd<sub>1-x</sub>Ag<sub>x</sub> ALLOYS ON THE BASIS OF POSITRON ANNIHILATION DATA.** The angular correlation and positron lifetime measurements were used to investigate α-phase Pd<sub>1-x</sub>Ag<sub>x</sub> alloys throughout the concentration range. On the basis of the annihilation parameters the numbers of s-like and d-like electrons per one alloy atom were calculated. These numbers are in agreement with the KKR-CPA calculation results. The linearity of positron annihilation rate λ vs. Ag concentration confirms the earlier suggestion concerning the character of λ(x) for random alloys whose densities of states represent split-band regime. (Author abstract) 17 Refs.

Rudzinska-Girulska, J. (Wroclaw Univ, Wroclaw, Pol); Debowska, E. *Phys Scr* v 37 n 6 Jun 1988 p 952-956.

### Thermodynamic Properties

**076031 THERMODYNAMICS OF Pd-Ag-H TERNARY SOLID SOLUTIONS.** The solubility of hydrogen in Pd-Ag-H ternary solutions in equilibrium with H<sub>2</sub> gas at atmospheric pressure has been measured in the temperature range 625-1111 K and in Pd-Ag 'binary solvents' containing up to 93 at.% of Ag. Concomitant elastic measurements have provided data which enable the partial thermodynamic functions of the H-atoms deduced from the solubility measurements to be converted so as to refer to a hypothetical Pd-Ag lattice of constant specific volume. The resulting 'volume corrected' functions have been discussed in terms of the cell model for ternary solutions and have been shown to vary with temperature and Ag-concentration in a manner in accord with this model. (Author abstract) 35 refs.

Yoshihara, M. (Rice Univ, Houston, TX, USA); McLellan, Rex B. *Perspect in Hydrogen in Met, Collect Pap on the Eff of Hydrogen on the Prop of Met and Alloys* Publ by Pergamon Press, Oxford, Engl and New York, NY, USA, 1986 p 69-76.

## PALLADIUM VANADIUM ALLOYS

### Phase Diagrams

**076032 Pd-V (PALLADIUM-VANADIUM) SYSTEM.** The major features of the existing diagram are compatible with currently available information. However, there are some differences with respect to detail. Specifically, the diagram has been modified to incorporate currently accepted melting points for Pd and V and later work concerning the range of homogeneity of PdV<sub>3</sub>. Temperatures and compositions associated with the invariant reactions in the system are summarized. 13 refs.

Smith, J.F. (Iowa State Univ, Ames, IA, USA). *J Alloy Phase Diagrams* v 4 n 1 Jan 1988 p 1-4.

## PALLADIUM YTTRIUM ALLOYS

### Gas Alloying

**076033 THERMODYNAMICS OF HYDROGEN IN PALLADIUM-YTTRIUM SOLID SOLUTIONS.** An equilibrate-quench-analyze technique has been used to measure solubility isobars at 10<sup>5</sup> N/m<sup>2</sup> in the Pd-Y-H system over the temperature span 625-1250 K. These data have been used to derive the dependence upon Y-content and temperature of the partial molar enthalpy and excess entropy of dissolved H-atoms. The partial enthalpy



decreases at all temperatures rapidly as the concentration of Y increases. Virtually all of the large variation is ascribable to the effects of lattice dilation in the Pd-Y matrix as the Y-concentration increases. (Author abstract) 19 refs.

Yoshihara, M. (William Marsh Rice Univ, Houston, TX, USA); McLellan, R.B. *Acta Metall* v 36 n 2 Feb 1988 p 385-391.

## Thermodynamics

**076034 THERMODYNAMIC STUDY OF THE PALLADIUM-YTTRIUM-HYDROGEN SYSTEM.** Equilibrium isobars for the ternary solid solution Pd-Y-H have been measured in the temperature range 625-1250 K and the composition range 0-13 at. % Y. The maximum H content was 1.5 at. %. The isobars were determined at six different pressures ranging from  $1.01 \times 10^3$  to  $1.01 \times 10^5$  N/m<sup>2</sup>. The resulting partial thermodynamic functions for H atoms in the solid solution are in good accord with the predictions of the cell model for such systems. (Author abstract) 15 refs.

Yoshihara, Michiko (William Marsh Rice Univ, Houston, TX, USA); McLellan, Rex B. *J Phys Chem Solids* v 49 n 4 1988 p 401-407.

## PAPER See Also ACIDS—Electric Properties.

**076035 CHEMICAL CARBONLESS COPY PAPER.** Chemical carbonless copy paper (CCP) is one among the fastest growing segments of the paper industry, with a worldwide growth rate of about 10% per year. There are tremendous developments in technology for producing this paper, since the time, the first chemical carbonless copy paper was put into market in 1954. The CCP may be characterized by a combination of an electron donor acceptor solid surface chemical reaction giving distinctive color, with new techniques of micro-encapsulation of chromogenic material in oil drops. The present paper discusses the development and status of CCP technology. (Author abstract). 15 Refs.

Saikia, C.N. (Regional Research Lab, Assam, India); Barua, P.P.; Chaliha, B.P. *J Inst Eng India Part CH* v 68 n 3 Jun 1988 p 105-108.

## Absorption See PAPER PRODUCTS—Physical Properties.

## Applications See PAPERMAKING.

## Calendering

**076036 CONTROL SYSTEMS FOR CALENDERS AND SUPERCALENDERS - POTENTIAL AND LIMITATIONS.** The calendering and supercalendering operations can be controlled to produce either a uniform thickness profile or uniform surface property profiles. To achieve both, the basis weight and moisture content of the paper must also be uniform. Hence, the full potential of calender control cannot be realized in isolation from the other papermaking operations. The development of new control strategies which will make better use of the information from currently available on-line sensors, will provide an interesting and potentially rewarding challenge for process and control engineers for years to come. (Author abstract) 14 refs.

Crotogino, R. (PAPRICAN, Pointe Claire, Que, Can); Gendron, S. *Pulp Pap Can* v 88 n 11 Nov 1987 p 44-49.

**076037 CALENDER STEAM SHOWERS: A NEW, EFFECTIVE MEANS OF HOT CALENDERING.** A new design of steam shower is now being applied at the calender stack to achieve hot calendering. Recent on-machine experience has shown up to 30% improvement in smoothness can be gained on newsprint and specialty groundwood grades. Because the smoothing effect is greater on the side of application, reduced two-sidedness is possible. Fiber softening achieved through steam calendering enhances the calendering effect while reducing calender nip damage. (Edited author abstract) 2 refs.

Hilden, K.K. (Devron-Hercules Inc, North Vancouver, BC, Can); Sawley, D. *Pulp Pap Can* v 88 n 12 Dec 1987 p 195-198.

**076038 HARD-NIP AND SOFT-NIP CALENDERING OF UNCOATED GROUNDWOOD PAPERS.** A review is presented of well-established and newly-emerging calendering techniques for the finishing of uncoated groundwood papers. The basic differences between the hard-nip and soft-nip calendering techniques are also discussed briefly. Machine calendering, gradient techniques, on-line soft calenders and supercalenders are considered. The choice of the most appropriate calendering technology requires a cost/benefit analysis based on incomplete and rapidly changing information. (Author abstract) 28 refs.

Crotogino, R.H. (Paprican, Pointe Claire, Que, Can); Gratton, M.F. *Pulp Pap Can* v 88 n 12 Dec 1987 p 208-216.

**076039 PRACTICAL APPLICATIONS OF NEW CALENDERING TECHNIQUES.** The benefits of recent calendering developments have been documented under production conditions in paper mills in North America and Scandinavia. New installations and upgrades to existing installations show that the latest calendering development offer higher productivity, enhanced calendering, tighter quality control, and the potential for full integration of on-line soft calenders with the papermaking process.

Malkia, Hannu P. (Valmet Paper Machinery Inc, Jarvenpaa, Finl). *Tappi J* v 71 n 5 May 1988 p 83-85.

**076040 EFFECT OF SUPERCALENDERING ON THE STRENGTH PROPERTIES OF PAPER.** Formette handsheets with varying levels of fibre orientation and wet pressing were subjected to supercalendering. Losses in elastic properties were found with increased supercalender loading. Inplane elastic anisotropy decreased with densification by wet pressing, and increased with densification by supercalendering. Tensile and compressive strength losses with supercalendering were not as great as might be expected from losses in elastic properties. Therefore correlations between elastic and failure properties are expected to be modified by calendering and supercalendering. (Author abstract) 24 refs.

Charles, L.A. (Inst of Paper Chemistry, Appleton, WI, USA); Waterhouse, J.F. *J Pulp Pap Sci* v 14 n 3 May 1988 p 59-65.

**076041 EFFECTS OF Z-DIRECTION MOISTURE AND TEMPERATURE GRADIENTS IN THE CALENDERING OF NEWSPRINT.** Temperature-gradient and moisture-gradient calendered papers exhibited much higher gloss, somewhat lower ink transfer and higher set-off than conventionally calendered paper having the same bulk. However, the gradient techniques appear to be able to produce high-gloss paper exhibiting less set-off than high-gloss machine calendered paper. Moisture-gradient calendering produced essentially the same results as temperature-gradient calendering, when both were carried out at the same roll temperature. The application of moisture onto the web prior to calendering did not provide any substantial net benefits. (Edited author abstract). 18 Refs.

Gratton, M.F. (Paprican, Pointe Claire, Que, Can); Crotogino, R.H. *J Pulp Pap Sci* v 14 n 4 Jul 1988 p 82-90.

## Chromatographic Analysis

**076042 RAPID METHOD FOR THE QUALITATIVE ANALYSIS OF PLASTIC AND 'STICKY' CONTAMINANTS BY PYROLYSIS-GAS CHROMATOGRAPHY.** Pyrolysis-gas chromatography (PGC) can be used to quantitatively analyze synthetic polymers that are sometimes found as contaminants (either plastic particles or 'stickies') in pulp, paper, or linerboard products. Analysis of mill samples showed that PGC is particularly suitable for analyzing the variety of materials that can be found as contaminants. An analysis of as little as 1 mg of

sample can be obtained in less than 90 min, usually without any sample preparation. (Author abstract) 49 refs.

Dunlop-Jones, N. (Paprican); Allen, L.H. *Tappi J* v 71 n 2 Feb 1988 p 109-113.

## Coating See Also PAPER AND PULP MILLS—Machinery; PAPERMAKING—Taiwan.

**076043 COATER MEASUREMENT AND CONTROL: STATE-OF-THE-ART.** On-line measurement and control systems are being effectively applied to on-machine and off-machine coaters of all types. An array of sensors is available for these applications. The sensors include those for weight, moisture, ash, opacity, brightness, formation and caliper. Both machine-direction and cross-machine controls have been applied in coater applications. Advanced control techniques have also been used such as co-ordinated speed change, throughput optimization, start-up control and automatic grade change. (Edited author abstract) 7 refs.

Shapiro, S.I. (Aeonic Systems, Billerica, MA, USA). *Pulp Pap Can* v 88 n 8 Aug 1987 p 76-79.

**076044 NEW COATING TECHNOLOGY.** Because the technology of the size press has not kept pace with PM technology it can impose limitations on a high speed operation. Online surface treatment can, for example, cause poor runnability and detract from the efficiency of a first class machine. To overcome this problem a short dwell coater and blade metering size press have been introduced. The latter is being used by most American LWC mills, and they report improved runnability and reduce downtime and coating losses. (Author abstract)

Allan, F. (Beloit Walmsley, Bolton, Engl). *Pap Technol Ind* v 28 n 6 Sep 1987 p 602-603, 606-608.

**076045 SITTINGBOURNE: DOUBLE THE COATING.** A precoat to be installed by end-1988 will give UK Paper's Sittingbourne mill the option to double coat its range of woodfree papers. But the unit is only one part of the mill's investment program. This article reports on developments.

Anon. *PPI Pulp Pap Int* v 30 n 5 May 1988 p 64-66.

**076046 TAPPI PROCEEDINGS - 1987 COATING CONFERENCE.** This conference proceedings contains 17 papers. Topics covered include: predicting solids for blade whisks; coating blade geometry; winder technology for coated papers; use of a supervisory computer system in coating preparation; SB-latex profiles on surface coatings; drying and its effect on binder migration and offset mottling; colloidal chemistry of CMC-Latex coatings; viscoelasticity implications for coating rheology and structure of coatings; layer structure in model coatings; high performance carbonless paper system; water penetration in coating papers; aspects of coating with surfactants upon quality and offset printability; use of auxiliary dispersants to improve coater performance; adsorption of dispersing and thickening polymers and its effect on coating color rheology; soy protein latex interpolymers; the Vari-Dwell - Time Blade Coater; and an evaluation of coating binders for Ultra Light Weight Coated (ULWC) papers. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11251 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (TAPPI, Atlanta, GA, USA). *TAPPI Notes* 1987, TAPPI Proc - 1987 Coat Conf, Houston, TX, USA, May 17-21 1987. Publ by TAPPI Press, Atlanta, GA, USA, 1987 159p.

## Coatings See PAPERMAKING—Finishing.

## Composition Effects See AGRICULTURE—Waste Utilization.



Cutting See Also PAPERBOARDS—Corrugated.

*Electromagn Energy* v 23 n 1 1988 p 29-37.

Laminates See PACKAGING MATERIALS—Composite Materials.

## Marketing

**076052 HOW TO MARKET QUALITY NOT QUANTITY.** Swiss woodfree papermaker Cham-Tenero knows how to stay up in the clouds with the giants of the sector. Strong marketing and a top quality target sell its coated printing and specialty grades. In this article the author reports on this papermaker. Its range includes double-coated art papers and label papers.

Sutton, Peter. *PPI Pulp Pap Int* v 30 n 5 May 1988 p 59, 61-62.

## Measurements

**076053 HERE ARE FOUR STEPS TO SUPERIOR BASIS WEIGHT MEASUREMENT AND CONTROL.** With the development of successful cross-machine control, more uniform basis weight profiles place stringent requirements on basic sensors and their scanning platforms in order to realize the necessary measurement accuracy. Enhanced graphics and data presentation for maximum visibility of the process are needed as well, while new high-performance actuators and control schemes are being developed for even more precise cross-machine control of the process. Recent advantages in these four areas have resulted in higher quality paper at lower costs.

Dukes, John R. (Combustion Engineering Inc, Columbus, OH, USA). *PIMA Mag* v 70 n 8 Aug 1988 p 41-43.

**Mechanical Properties** See Also PAPER-MAKING—Drying; PAPERMAKING—Sizing; PAPER-MAKING MACHINERY—Headbox; STARCH—Physical Properties.

**076054 UNIFIED THEORY OF THE MECHANICAL PROPERTIES OF PAPER AND OTHER H-BOND-DOMINATED SOLIDS - PART II.** This work examines the derivation of modulus vs. apparent density relationships for ideal, isotropic papers through the use of Percolation Theory. The results of Percolation Theory are linked to the hydrogen bond theory of the structural integrity of paper through the maximum value of Young's modulus of an ideal isotropic cellulosic paper at the density of crystalline cellulose. An activity coefficient provides the linkage between the results of Percolation Theory and results for real, isotropic papers. (Edited author abstract) 8 refs.

Nissan, Alfred H. (Batten, George L. Jr.). *Tappi J* v 70 n 10 Oct 1987 p 128-131.

**076055 PREDICTING PAPER PROPERTIES DURING PRODUCTION.** If it were possible to predict the elastic modulus of paper during production it could be possible to quantify product stiffness and other performance criteria on a continuous basis. The author describes how the obstacles to the use of sheet density as a predictor of elastic modulus have been overcome. He presents equations and formulas which could provide a basis for on-machine prediction of elastic modulus of paper during production. The research work, carried out under specific conditions of web consolidation and drying, clarifies the mechanism of modulus improvement through drying restraint. (Edited author abstract) 21 refs.

Byrd, Von L. (Mead Central Research, OH, USA). *Pap Technol Ind* v 28 n 7 Oct 1987 p 654-657.

**076056 EFFECT OF TREATMENT WITH VERY DILUTE ACIDS ON THE WET TENSILE STRENGTH AND CHEMICAL PROPERTIES OF PAPER.** Filter paper was soaked in very dilute solutions of several mineral and aliphatic dicarboxylic acids and heated for various times at temperatures ranging from 100°C to 140°C. The wet strength of the paper, measured with an Instron tester using a jaw span of 15 cm, was greatly increased by these treatments. The largest increase was by nearly 1000%; this was achieved by heating with

oxalic acid at pH 2.7 for 1 h at 140°C. Increases of nearly 750% and 850% were obtained with hydrochloric and sulphuric acids, respectively, under similar conditions. The increases in wet strength have been attributed to the formation of inter-fibre cross-links. (Edited author abstract) 14 refs.

Nevell, T.P. (Univ of Manchester Inst of Science & Technology, Manchester, Engl); Nugawela, D. *Carbohydr Polym* v 7 n 3 1987 p 169-181.

**076057 ROLE OF CONTACTS BETWEEN THE FIBERS IN THE FORMATION OF THE STRENGTH OF PAPER.** The authors have determined independently the area of contact between the fibers. The independent determination of the contact area between the fibers allowed us to assess the strength due to the autohesive interaction between individual fibers ( $b_0$ ) and to identify the factors affecting the autohesion of the fibers. 4 refs.

Malinovskaya, G.K. (Leningrad Technological Inst of the Cellulose & Paper Industry, USSR); Drobosyuk, V.M.; Antonova, N.I. *Colloid J USSR* v 49 n 2 Mar-Apr 1987 p 313-314.

**076058 ON-LINE MEASUREMENT AND CONTROL OF STRENGTH PROPERTIES.** Paper strength is known to be affected by such process variables as furnish, refining, formation, pressing, and drying stresses. The relationships between these variables and product strength for a given machine can only be determined after extended observation and analysis. With the ability to measure strength on-line, an operator can track the effects of subtle changes in process variables, leading to a better understanding of how to control strength. On-line measurement of strength also provides other benefits, such as more uniform quality, reduced costs, and increased production.

Lantz, Keith G. (Measurix Corp, Cupertino, CA, USA); Chase, Lee M. *Tappi J* v 71 n 2 Feb 1988 p 75-78.

**076059 FIBER PROPERTIES AND TEARING RESISTANCE.** The effects of three principal fiber properties - length, strength, and coarseness - on the tearing resistance of paper have been studied. Experiments were carried out by varying one property at a time while keeping the others constant. The dependence of tearing resistance on fiber properties changes with the degree of sheet consolidation. In a poorly-bonded sheet, tearing resistance depends more on fiber length than on fiber strength, but the opposite is the case in a well-bonded sheet. For long, straight, and adequately bonded fibers, the tearing resistance is proportional to the square of fiber strength. This indicates that fiber strength is more important for tearing resistance than previously thought, particularly for softwood market chemical pulps. Among fibers of similar length and strength, coarser fibers make sheets with higher tearing resistance. (Author abstract) 12 refs.

Seth, R.S. (Pulp & Paper Research Inst of Canada, Pointe Claire, Que, Can); Page, D.H. *Tappi J* v 71 n 2 Feb 1988 p 103-107.

**076060 UNIFIED THEORY OF THE MECHANICAL PROPERTIES OF PAPER AND OTHER H-BOND-DOMINATED SOLIDS - PART III.** The modulus of real, isotropic paper is used to derive relationships between modulus and density for anisotropic, machine-made papers. The isotropic modulus is treated as an invariant; i.e., for a constant apparent density and an absence of changes in the furnish, the isotropic modulus is fixed. Structural theory is invoked to account for orientation effects. The resulting equations are simple products:  $E_{MD} = E_{iso} \beta_1$  and  $E_{CD} = E_{iso} \beta_2$ , where  $\beta_1$  and  $\beta_2$  are orientation factors, the forms of which are

**076047 A NEW GENERATION OF PAPER MACHINE TRIM PROGRAMS.** There are two basic approaches to solving trim problems in the paper industry: linear programming and sequential pattern generation. A new and more powerful approach combines the two methods, taking advantage of the most useful capabilities of each while eliminating the weaknesses of both. In most cases, the solution will contain patterns generated by both approaches. In the rare situation in which the problem is best solved exclusively by one method or the other, the procedure is capable of giving that type of solution as well. (Author abstract). 6 Refs.

Haessler, Robert, W. (Univ of Michigan, Ann Arbor, MI, USA). *Tappi J* v 71 n 8 Aug 1988 p 127-130.

Deinking See Also PULP MATERIALS—Waste Paper.

**076048 EVALUATION OF DEINKING PERFORMANCE: A REVIEW OF TEST METHODS.** Test methods for evaluation of deinking performance are not well defined. Standardized test methods are needed to help in assessing the efficiency of alternative deinking systems and the quality of deinked pulp. Techniques that are currently used to evaluate the deinking process include brightness improvement and ink-speck count. This article examines a variety of methods used to prepare brightness pads and discusses some of the factors that can affect pad brightness. Procedures are recommended for consideration as standardized test methods. (Author abstract) 20 refs.

McKinney, R.W.J. (PIRA, Leatherhead, Engl). *Tappi J* v 71 n 1 Jan 1988 p 129-131.

**076049 DEINKING AT PAPELERA PENINSULAR AND THE PHILOSOPHY OF DEINKING SYSTEM DESIGN.** With the adoption of an appropriate system philosophy and the selection of the right equipment and chemicals, it is possible to deink a 100% waste newsprint furnish by flotation alone and produce an excellent product at an attractive cost. The reason these studies have been successful is that we were able to use automatic image analysis techniques. In using image analysis, we were able to compile and transfer technical information not only from within the pulp and paper industry, but also from other technologies, such as mineral flotation and chemical detergent washing technology. Analysis of this knowledge has given us a fundamental technical understanding of the deinking process, which has enabled us to develop more efficient deinking units and systems. (Author abstract). 13 Refs.

Zabala, Jose, Miguel (Papelara Peninsular, Madrid, Spain); McCool, Michael. *Tappi J* v 71 n 8 Aug 1988 p 62-68.

Drying See Also DRYERS—Efficiency.

**076050 POSSIBILITIES OF HIGH-FREQUENCY TECHNIQUES IN PAPER INDUSTRY.** This report treats the possibilities of application of high frequency technology in the (Finnish) paper industry. The author presents a graphical method for evaluation of the sheet surface temperature. 12 refs.

Soininen, Mauri (Teollisuusmittaus Oy, Turku, Finl). *Drying Technol* v 6 n 1 Mar 1988 p 139-156.

**076051 KINETIC MODEL FOR MICROWAVE DRYING OF PAPER.** When paper is dried by microwave energy, the mass balance is governed by a first order linear differential equation, versus time, the constant coefficient of which is linearly related to the square of the instantaneous intensity of the electric field inside the paper web. Up to now, the proposed models have been so complicated that calculations cannot be done in real time. The aim of this paper is to provide and to validate a new, theoretical model for describing the drying process. (Edited author abstract). 8 Refs.

Roussy, G. (CNRS, Vandoeuvre-les-Nancy, Fr); Thiebaut, J.-M.; Bennani, A.; Mouhab, N. *J Microwave Power*



given for an elliptical distribution of fibers. A comparison of theoretical and experimental results show good agreement. (Author abstract) 16 refs.

Batten, George L. Jr. (Westvaco Corp, Covington, VA, USA); Nissan, Alfred H. *Tappi J* v 70 n 11 Nov 1987 p 137-140.

#### 076061 COMPUTER SIMULATION OF THE UNIAXIAL ELASTIC-PLASTIC BEHAVIOR OF PAPER.

The elastic properties of paper materials have been predicted by a micromechanics model of a ribbon-like nonwoven structure. The present model extends the previous linear elastic theory to incorporate nonlinear elastic and deformation theory plastic behavior. The theory incorporates different nonlinear or plastic parameters of fibers that are loaded in tension and compression. The theory is used to develop a computer simulation of the uniaxial straining of a strip of paper. Theoretical results are compared with experiments conducted on two classes of paper materials. (Author abstract)

Ramasubramanian, M.K. (Syracuse Univ, Syracuse, NY, USA); Perkins, R.W. *J Eng Mater Technol Trans ASME* v 110 n 2 Apr 1988 p 117-123.

#### 076062 COMBINED EFFECT OF FIBER FINES AND DISSOLVED ORGANICS ON TISSUE PROPERTIES.

The quality of tissue is influenced by contaminants that may be present in the white water. Fines and dissolved organics are the main cause of trouble in the manufacturing process. In this work, the quantitative effect of these components on tissue properties were studied. Chemithermomechanical pulp (CTMP) fines and a mixture of xylan, lignin, and resin acid were added to bandsheet furnishes. Strength properties, absorbency rate, and formation of bandsheet were measured. Fines and organics have an impact on these properties, especially wet strength and absorbency. Resin acid and lignin are the organic contaminants responsible for the greatest effects. (Author abstract) 7 refs.

Springer, Allan M. (Miami Univ, Oxford, OH, USA); Pires, Eduardo C. *Tappi J* v 71 n 4 Apr 1988 p 141-144.

#### 076063 MECHANISM OF WET-STRENGTH DEVELOPMENT BY ALKALINE-CURING AMINO POLYMER-EPICHLOROHYDRIN RESINS.

Solubility tests of wet-strength paper in cupriethylenediamine ('cuen') have been used as a diagnostic test of the wet-strength mechanism. Tertiary amino polymer-epichlorohydrin ('epi') resins appear to insolubilize cellulose through cuen-resistant ether linkages. Secondary amino polymer resins did not insolubilize cellulose except with artificial curing. The reactivity of the functional groups of model compounds toward cellulose paralleled the insolubilization results. From electrophoretic mobility measurements and analogies with the wet- and dry-strength behavior of combinations of polyamide-epichlorohydrin (PAE) and carboxymethylcellulose, it appears that PAE resin first wet-strengthens paper by forming cuen-labile ester links with pulp carboxyl groups. Additional resin cross-links with itself instead of reacting with cellulose hydroxyls. (Author abstract) 12 refs.

Espey, Herbert H. (Hercules Inc, Wilmington, DE, USA); Rave, Terence W. *Tappi J* v 71 n 5 May 1988 p 133-137.

#### 076064 NOTE ON THE EFFECT OF FIBER STRENGTH ON THE TENSILE STRENGTH OF PAPER.

D.H. Page's equation describes quantitatively the effect of fiber tensile strength on sheet tensile strength. For strongly bonded sheets, sheet strength is approximately proportional to fiber strength. This particular prediction has never before been tested, though. The authors have now conducted an experimental check of the equation by varying the fiber strength in such a way that the other parameters are maintained constant. By weakening fibers in sheets using a vapor-phase treatment with hydrochloric acid, the fiber strength falls. The sheet tensile strength falls accordingly, exactly as the equation predicts. (Edited author abstract) 9 refs.

Page, D.H. (Pulp & Paper Research Inst of Canada, Pointe Claire, Que, Can); Seth, R.S. *Tappi J* v 71 n 10 Oct 1988 p 71-74.

1988 p 182-183.

#### Moisture Control See PAPERMAKING—Coagulation.

**Newsprint** See Also DATA PROCESSING, BUSINESS—Distribution Applications; PAPER AND PULP INDUSTRY—Marketing; PAPER AND PULP MILLS—Construction; PAPER AND PULP MILLS—Modernization; PAPERMAKING MACHINERY; PAPERMAKING MACHINERY—Canada; PAPERMAKING MACHINERY—Dryers; PAPERMAKING MACHINERY—Retrofitting; PULP MATERIALS—Kenaf.

#### 076065 IMPULSE DRYING OF NEWSPRINT.

Impulse drying, a process currently under development for drying paper in a long nip press with one heated surface, has been shown to yield superior newsprint properties with reduced energy requirements. The improvements are the result of the application of new dewatering and densification mechanisms to the drying process. Applied to newsprint, two impulse dryer nips could replace an entire cylinder drying system, while giving increases in sheet density and tensile strength of 30 to 40%. Impulse-dried sheets have excellent surface appearance and properties, including reductions in surface roughness of up to one half, and increases in water absorption time by a factor of six. Energy use is reduced in comparison with cylinder drying, as up to 50% of the water is removed as liquid. (Edited author abstract) 8 refs.

Lavery, H.P. (Inst of Paper Chemistry, Appleton, WI, USA). *J Pulp Pap Sci* v 13 n 6 Nov 1987 p J178-J184.

#### 076066 UPGRADING MECHANICAL PULPS BY CHEMICAL TREATMENT OF REJECTS PRIOR TO REFINING.

Groundwood rejects, TMP rejects and a mixture of groundwood rejects and shredded chips were individually treated with sodium sulfite liquor prior to refining. Newsprint from conventional (untreated rejects) and upgraded (treated rejects) furnishes were produced. Results show that the quality of newsprint from the upgraded groundwood furnish containing 33% less sulfite was comparable to newsprint from the conventional furnish, and the quality of upgraded TMP furnish was comparable to TMP containing 15% sulfite. (Author abstract) 12 refs.

Goel, K. (Reed Inc, Quebec City, Que, Can). *Pulp Pap Can* v 88 n 11 Nov 1987 p 69-73.

#### 076067 NEWSPRINT REQUIREMENTS FOR WATER-BASED FLEXOGRAPHY, PART II: NEWS-PRINT CHEMISTRY AND WATER-BASED INKS.

Water-based inks for newsprint can be destabilized under conditions modeling newsprint chemistry. In the absence of alum, ink dispersions are stable indefinitely at a pH of 4.3 or higher. In the presence of as little as 0.5 ppm of  $Al^{+3}$ , ink dispersions will flocculate with time at any pH, and most rapidly below a pH of 5.3. Newsprint white waters and aqueous extracts from newsprints have a similar effect, except that the harmful effects of alum and low pH are mitigated by as yet unidentified newsprint components. It is suggested that ink destabilization by ions leaching from the paper into the ink at the plate/paper interface may contribute to plate fill-in in water-based flexography. (Author abstract) 14 refs.

Aspler, J.S. (PAPRICAN, Pointe Claire, Que, Can); Perreault, Z.F. *J Pulp Pap Sci* v 14 n 1 Jan 1988 p 12-16.

#### 076068 PRESSABILITY AND STRENGTH OF NEWSPRINT FURNISHES.

Newsprint has been traditionally produced from a mixture of mechanical and chemical pulp. In many mills, the proportion of the more expensive chemical pulp is determined by machine runnability, which depends on adequate web dewatering characteristics and wet-web strength. In these mills, the cost of production could be reduced if satisfactory machine efficiency could be achieved with less chemical pulp. The addition of chemical pulp of ground wood increases the strength of the wet web but does not significantly increase the solids content of pressed sheets. 12 refs.

McDonald, J.D. (Pulp & Paper Research Inst of Canada, Pointe Claire, Que, Can); Pikulik, I.I. *Tappi J* v 71 n 2 Feb 1988 p 71-74.

**076069 MAKING NEWSPRINT FROM A MODERN MIXED FURNISH.** Bridgewater is making a high quality newsprint from a mixed furnish of CTMP and DIP - deinked pulp. The two pulps complement each other, and the end product combines strength with a smooth and even surface - it has none of the problems of springiness and poor stackability that are associated with the bulky mechanical pulps. The author describes the technology that has transformed waste-based pulps so that today they are 'probably better than virgin mechanical fiber' and the properties DIP imparts - properties that have persuaded Bridgewater to move from a 35% to a 55% DIP furnish. (Edited author abstract)

Clewley, John (Bridgewater Paper Co, Engl). *Pap Technol Ind* v 29 n 1 Feb 1988 p 6-10.

#### 076070 MAKING NEWSPRINT FROM A 100% WASTE-PAPER FURNISH.

A discussion is presented of a complete revamping program that transformed the deinking plant, the pulping system, the pressure and wire section; the machine calender, the PM drive and the finishing department at the Aylesford Newsprint firm. Improvements in the press section are presented in tabular form. The final stage of the modernization program is a new drive to take the machine speed up to at least 900 meters/minute, and associated with this will be a new winder and automatic packing and handling system.

Cogger, R.C. (Aylesford Paper Mill). *Pap Technol Ind* v 29 n 2 Mar 1988 p 78-79, 82-84.

#### 076071 NEWSPRINT LOADING OF VACUUM-GEAR-EQUIPPED VESSELS.

Vacuum handling has brought major benefits, both in loading at QNS and unloading at discharge ports. Productivity has increased, costs have been reduced, and damage has dropped to half of what it used to be. 1 ref.

Caron, P.H. (Quebec & Ontario Paper Co, Baie Comeau, Que, Can). *Pulp Pap Can* v 89 n 2 Feb 1988 p 35-37.

#### 076072 GRAININESS AND FORMATION RANKING.

A representative sampling of Canadian newsprint, containing 256 specimens, was sorted into nine levels of subjective preference using the Rangefinder technique. An index of floc intensity and an index of grain size were measured on each specimen using the Paprican Microscanner. Subjective rank was found to depend upon a combination of these two mutually independent variables. (Author abstract) 3 refs.

Jordan, B.D. (Paprican, Pointe Claire, Que, Can); Nguyen, N.G. *J Pulp Pap Sci* v 14 n 2 Mar 1988 p 42-43.

#### 076073 ON-MACHINE STRESS-STRAIN BEHAVIOUR OF NEWSPRINT.

Dynamic tension and draw measurements in the open draw of a pilot paper machine were compared to laboratory measurements on wet, unstrained paper produced under similar machine conditions. It was found that the tensile strength of wet webs in the first open draw was lower and the elongation greater than that measured in a laboratory instrument. Thus, a lower wet-web modulus was measured on the paper machine despite the higher strain rate. It is postulated that this difference is a result of non-uniform tension applied through the thickness of the sheet as it peels from the (Author abstract) 13 refs.

McDonald, J.D. (PAPRICAN, Pointe Claire, Que, Can); Pikulik, I.I.; Daunais, R. *J Pulp Pap Sci* v 14 n 3 May 1988 p 53-58.

#### 076074 NEWSPRINT REQUIREMENTS FOR WATER-BASED FLEXOGRAPHY, PART III: INFLUENCE OF NEWSPRINT PROPERTIES ON FLEXO INK HOLDOUT.

A newsprint was calendered to various roughness levels, and was surface treated to various water absorbency levels. No correlation was found between flexo print density and water absorbency, but a correlation was found with newsprint roughness. However, for a range of commercial newsprints, the correlation between flexo print density and surface roughness was poor. These



findings are in agreement with what is commonly known for conventional oil-based inks. Print through in water-based flexography was found to depend on paper opacity, but not on pH, water absorbency, or other newsprint properties. Although evidence from newsprints that had undergone accelerated aging suggests that second impression setoff is reduced at a low newsprint pH, this cannot be resolved until water absorbency and pH effects have been separated. (Author abstract) 20 refs.

Aspler, J.S. (PAPRICAN, Pointe Claire, Que, Can). *J Pulp Pap Sci* v 14 n 3 May 1988 p 66-72.

**076075 REBUILD AT GNN BOOSTS NEWSPRINT OUTPUT, EVEN WITH SOME SHUTDOWNS.** With the modernization of newsprint machines Nos. 5 and 6 at its East Millinocket, Maine, mill, Great Northern Nekoosa Corp. was able to shut down two of four original machines without any loss in production capacity. The mill's two other original machines had been shut down prior to the recent modernization. Mill newsprint capacity with the two machines rebuilt by Beloit will be approximately 335,000 tpy, which is more than the total output from all four of the original machines. Author describes the new machines and how improvement in production and quality control were achieved by having these replacement machines.

Ferguson, Kelly H. (Pulp & Paper, San Francisco, CA, USA). *Pulp Pap* v 62 n 5 May 1988 p 53-57.

**Nondestructive Examination** See ELECTRIC INSULATING MATERIALS—Paper.

**Opacity** See Also PAPERMAKING—Nonfibrous Materials.

**076076 POWER SERIES FOR THE EFFECT OF FORMATION ON OPACITY.** Opacity is a highly non-linear function of basis weight. Consequently, the increased opacity in the heavy regions fails to balance the loss in the light regions, causing the mean opacity to decrease in proportion to the mass non-uniformity. The net opacity can be calculated from a polynomial function of the formation index. To a good approximation, the opacity loss is proportional to the curvature of the function relating opacity to basis weight. (Author abstract) 2 refs.

Jordan, B.D. (PAPRICAN, Pointe-Claire, Que, Can). *J Pulp Pap Sci* v 13 n 6 Nov 1987 p J185-J186.

**Optical Properties** See Also PAPERMAKING—Coloring.

**076077 EMULATING THE TAPPI DIRT COUNT WITH A MICROCOMPUTER.** Two aspects of the human visual system are emulated by a computerized dirt counter to improve agreement between visual and instrumental dirt assessment. Following Ricco's law, the integrated contrast within the speck's image is calibrated to the assessment of a 'standard observer' to account for the contrast response of the eye. Secondly, the image is sharpened with an appropriate medium-pass spatial filter to identify dirt amidst formation-related reflectance variations in the same manner as the human eye. In this way, the dirt counter can detect at least as much dirt as a person can and scale its visual impact commensurately. (Author abstract) 3 refs.

Jordan, B.D. (PAPRICAN, Pointe Claire, Que, Can); Nguyen, N.G. *J Pulp Pap Sci* v 14 n 1 Jan 1988 p 16-18.

**076078 PROVEN APPROACH TO FLUORESCENT BRIGHTNESS MEASUREMENT AND CONTROL.** The most advanced approach for on-line whiteness/brightness measurement and control is the AccuRay Microscan Color/Brightness Sensor and Fluorescent Brightness Control. The most effective method of fluorescing fluorescent whitening agents (FWAs) is with a xenon lamp, as used in the Accu-Ray Microscan Color/Brightness Sensor. Xenon lamp technology for process applications, such as that found in the AccuRay sensor, makes it possible to measure a full range of color as well as fluorescent brightness by gaging the entire visible spec-

trum at discrete wavelengths, giving a total description of the white papers. The fluorescence is displayed as a delta and obtained by measuring the brightness without ultraviolet light through the use of a software-controlled UV filter and subtracting it from the brightness measured with ultraviolet light present.

Anderson, Kim A. (Combustion Engineering Inc). *PIMA Mag* v 70 n 5 May 1988 p 14-15.

**076079 CALCINED CLAY CAN IMPROVE THE PROPERTIES OF UNCOATED GROUNDWOOD PAPERS.** Manufacturers of uncoated groundwood papers have explored a number of methods to improve paper quality and acceptability with the use of filler pigments. Of the mineral fillers, calcined clays have been found to work in this application at low levels of addition (3 to 5 percent). In North America, Europe and elsewhere, calcined clays have been tested and found to provide benefits in newsprint, improved news, SC, and lightweight directory grades of paper. Some of these results are summarized here and show that calcined clays can offer improved paper quality and printability or maintain these properties while reducing basis weight. These results include: brightness; opacity; smoothness; basis weight; strength; bulk; printability; and retention. 3 Refs.

Turner, R.E. (ECC America, Sandersville, GA, USA). *Pulp Pap Can* v 89 n 6 Jun 1988 p 17-23.

## Packaging

**076080 HIGHLY EFFICIENT CONTINUOUS COIL PACKING LINE.** A highly efficient continuous coil packing line with a new automatic paper packing system developed by SMI and Kawanozoki Inc. went into operation on the cold strip processing line at the Wakayama Steel Works in March 1987. This new system has made it possible to automate several manufacturing processes: paper supply, paper wrapping, paper folding, and taping. It is much more efficient and leads to higher quality than the conventional manual process, and it is highly flexible during operation. This report gives an outline of the continuous coil packing line, focusing primarily on the new automatic paper packing systems. (Author abstract) In Japanese. 1 ref.

Sato, Kenji; Nobuhara, Sueo; Yamamoto, Nobuo; Yamada, Tomisaburo; Ota, Satoshi; Ikawa, Tadasi. *Sumitomo Met* v 40 n 1 Jan 1988 p 99-108.

**Physical Properties** See Also PAPERMAKING; PAPERMAKING—Coating; PAPERMAKING—Synthetic Fibers; PULP MANUFACTURE.

**076081 STATISTICAL ANALYSIS OF CROSS-MACHINE VARIATIONS IN BASIS WEIGHT.** The author's spreadsheet is an aid to T 545, a gravimetric method for measuring basis weight profiles. The cross-direction profile is obtained when these samples are cut into sheets, conditioned, and weighed. A 100-in-wide machine will yield 180 samples for weighing and data analysis, so statistical methods are used to analyze the results. The spreadsheet performs this statistical analysis on up to 800 data points, generating a report in the form described in the test method. The spreadsheet can also be used without any modification for cross-machine profile analysis of other paper properties. (Edited author abstract).

Deodhar, Subhash (Univ of Wisconsin, Stevens Point, WI, USA). *Tappi J* v 71 n 10 Oct 1988 p 223-224.

**Printing Properties** See Also PAPERMAKING MACHINERY—Headbox.

**076082 FUTURE OF SHEET-FED OFFSET PRINTING.** This article analyzes the demands of specific market segments in terms of color usage, coating applications, and paper usage. Major developments in sheet-fed technology - press speed, press accessories, and coating technology, in particular - to meet these demands are assessed. The article closes with a brief analysis of the competitive position of sheet-fed offset printing.

Coulson, Michael G. (Graphic Arts Technical Foundation, Pittsburgh, PA, USA). *Tappi J* v 70 n 10 Oct 1987 p 65-69.

**076083 PRINTING AND PAPER OF THE 21ST CENTURY.** The evolution of printing technology and the growth of offset, flexography and rotogravure for newsprint is traced. The conversion from lead stereo letterpress to cold offset, polymer plates, di-litho, and heatset offset is outlined. The paper quality requirements for each of these printing processes is described. (Author abstract)

Snider, E.H. (CIP Inc, Montreal, Que, Can); Thompson, C.A. *Pulp Pap Can* v 88 n 12 Dec 1987 p 189-193.

**076084 HOW CTMP CAN IMPROVE 'WOOD-FREE' PAPER.** A survey of those who specify woodfree papers reveals that there is a potential market for papers containing CTMP, provided that such papers are dust and shive free. (Author abstract)

Cockram, Richard. *PPI Pulp Pap Int* v 30 n 2 Feb 1988 p 65.

**076085 SPHINX REVEALS ITS MARKET SECRETS.** Metsa-Serla's Lielahi mill makes fluff CTMP for the disposable products market, and a paper grade pulp for printings/writings producers, both under the trade name Sphinx. In this article the author reports on Metsa-Serla's 70,000-ton/yr CTMP line at Lielahi.

Pearson, John. *PPI Pulp Pap Int* v 30 n 6 Jun 1988 p 57, 59.

**076086 BOND PAPER CHARACTERISTICS FOR PRINTING BY RESISTIVE RIBBON THERMAL TRANSFER.** On plain, bond papers, paper surface smoothness and chemistry are the characteristics that most affect image qualities in printing by correctable resistive ribbon thermal transfer. Sheffield smoothness of the papers correlated with 88 percent of the variability in relative print quality, with the best print quality being produced on the smoother papers. The London surface energy, which is dependent upon the surface chemistry of the papers, correlated with 82 percent of the variability in correction performance and 67 percent of the variability in abrasion resistance. Higher surface energies produced poorer correction and better abrasion resistance. The London surface energy can be measured using a gas chromatographic method. (Author abstract). 9 Refs.

Campbell, A.S. (IBM Corp, Lexington, KY, USA); Borch, J. *Tappi J* v 71 n 7 Jul 1988 p 140-144.

**076087 ANALYSIS OF WIRE MARK IN PRINTING PAPER.** Wire mark continues to be a problem in many printing grades of paper. Even though it may not reduce ink transfer, wire mark may be noticed by the reader and thus interfere with his perception of the printed message. The extent, pattern, and linearity of the wire mark affect this perception. The present study has examined the effect of a number of typical modern forming wires on wire mark, qualifying the latter by various methods based on frequency spectrum analysis of analog signals of surface roughness and light transmittance. (Author abstract). 8 Refs.

Helle, T. (Univ of Trondheim, Trondheim, Norw). *J Pulp Pap Sci* v 14 n 4 Jul 1988 p 91-95.

**Recycling** See Also PULP MATERIALS—Waste Paper; WASTE DISPOSAL—Recycling.

**076088 POLYCHLORINATED BIPHENYLS AND HEAVY METAL LEVELS IN RECYCLED PAPER FOR HOUSEHOLD USE.** Besides polychlorinated biphenyls (PCBs), cadmium (Cd), mercury (Hg) lead (Pb) and other heavy metals from the print-inks (colors) may also be introduced to the recycled paper. The aim of the present study was to evaluate, on behalf of Danish Environmental Protection Agency, the levels of PCB's, Cd, Hg and Pb in the recycled paper for the household use. For this purpose a pilot study was undertaken for the determination of the contents of PCB's, Cd, Hg and Pb in recycled papers that were available in the Danish market.



The results of the present study indicate that the Pb content in the recycled papers is much higher than that in the non-recycled paper. Since Pb is toxic, and can be absorbed through the skin, the regulation of Pb content in recycled paper for household use must be considered. 5 refs.

Storr-Hansen, Eva (State Chemical Supervision Service, Soborg, Den); Rastogi, Suresh C. *Bull Environ Contam Toxicol* v 40 n 3 Mar 1988 p 451-456.

**076089 CHEMICALS AND THEIR MODE OF ACTION IN THE FLOTATION DEINKING PROCESS.** The paper discusses flotation studies to gain information on the title subject. Topics covered include process descriptions, surfactants tested, ash flotation and fiber losses, adsorption to interfaces, and others.

Hornfeck, Klaus. *Conserv Recycling* v 10 n 2-3 1987, Recycl of Mater, Sel Pap from the Fifth Int Recycl Congr, Berlin, West Ger, Oct 29-31 1986 p 125-132.

**Sheeting** See Also PAPERMAKING MACHINERY—Drives; PAPERMAKING MACHINERY—Dryers; PAPERMAKING MACHINERY—Headbox.

**076090 DEVELOPMENT OF HIGH CONSISTENCY SHEET FORMING SYSTEM.** Hitachi Zosen Corporation joined the Research Association of Pulp and Paper Technology (RAPPT) and developed a high consistency sheet forming system. Outline of the RAPPT and our achievement in the high consistency headbox development are reported as well as the contents of the pilot plant built in our technical research institute with the aim of consolidated tests to prove the results of elementary researches conducted separately by other members of the association. It was found that only 1/6 volume of water is required to produce sheet having comparable quality with the commercially available printing and writing grade paper. Advantages such as reduction of energy consumption, improvement of fiber retention and smaller size equipment etc., were also proven by the process data. (Author abstract) In Japanese. 6 refs.

Wada, Kiyoshi; Shimizu, Tohru; Suzuki, Satoshi; Baba, Sinji; Takagi, Kohji; Kawasaki, Tadashi; Nomura, Tadayoshi. *Hitachi Zosen Tech Rev* v 48 n 2 Dec 1987 p 1-8.

**076091 BIRTH OF A FULLY AUTOMATED FOLIO SHEETER AND PACKAGING LINES.** Technology development in folio sheeting hit a virtual standstill during the 1970s. Since the early 1980s, however, significant improvements have increased machine speeds up to the 1000-ft/min range. Motorized movement of size-change parts was also introduced, followed by the development of fully automatic size changing. Evolution of backstands during this period also led to major production improvements through flying-splice or quick-splice systems. Technological advancements also brought significant improvements in control of cutoff length and better jogging and stacking. Customer acceptance improved as a result of these quality improvements in precision sheeting, and orders that formerly could only be processed by sheeting and trimming were changed to precision-sheathed tonnage.

Edwards, Robert C. (Union Camp Corp, Franklin, VA, USA). *Tappi J* v 71 n 3 Mar 1988 p 121-124.

**076092 MECHANICAL AND CHEMICAL METHODS ENHANCE TISSUE SHEET PROPERTIES.** This article reviews the mechanical means and furnished variables commonly used to achieve sheet properties. It further explores both wet end chemical additives (as well as Yankee spray boom applications) and the effects that each additive has on sheet properties. Through the use of various chemical additives such as retention/drainage polymers, dye fixatives, absorbency aids, softeners, and coating/release additives, tissue and towel manufacturers not only can make higher-quality paper but can also realize additional production benefits and cost savings such as reduction of wet and dry strength resins, increased crepe blade life, and lower furnish costs.

Novotny, Raymond J. (Nalco Chemical Co, Naperville, IL, USA). *Pulp Pap* v 62 n 8 Aug 1988 p 74-78.

**076093 SHEET RELEASE PROBLEMS INVOLVING MULTILAYER FABRICS EASILY SOLVED.** Papermaking problems are created when the sheet tail cannot be effectively blown off the fabric while threading the sheet. Additionally, the full-width sheet (at breaks) carries back with the fabric on the return run and may land in the wire pit, creating problems with consistency control. This article discusses a number of methods that have produced favorable results. Ensuring successful knockoff, and these involve: flooded nip shower; knockoff shower; wash roll doctor knockoff; inside wire return roll flooded nip.

Jones, Roy (BTR Paper Group, Wake Forest, NC, USA). *Pulp Pap* v 62 n 8 Aug 1988 p 108-110.

**076094 NEW SHEETER BOOSTS OPERATING SPEED AT CLAMPTIP PAPER BY MORE THAN 30%.** A description is presented of an MSL sheeter that has an average running speed of 450 to 550 fpm. This sheeter can produce over 50,000 lb of skidded material during an eight-hour shift. To obtain maximum running efficiency an Airfoil Overlap system was installed which provides fast sheet feeding from the cutting section to the stacker. The patented system forces the tail end of the first sheet down, while pushing the leading edge of the oncoming sheet up to provide jam-free overlapping. This feature is particularly important during operations where four webs are being cut at once due to the quantity of sheet overlapping. After material is sheeted, it is trimmed to size on one of its three guillotine trimmers.

Anon. *Pulp Pap* v 62 n 10 Oct 1988 p 100-101.

## Strain

**076095 MEASUREMENT OF STRAINS IN A PAPER TENSILE SPECIMEN USING COMPUTER VISION AND DIGITAL IMAGE CORRELATION. PART 1: DATA ACQUISITION AND IMAGE ANALYSIS SYSTEM.** An automatic data acquisition and data analysis system for the study of surface deformation in paper specimens through image analysis has been developed. The measurement method is a noncontacting whole-field method that is insensitive to typical laboratory vibrations and which has variable sensitivity that can be modified during post-processing of the data. This range in sensitivity can include the localized variability in paper specimens, or it can be employed to average out such effects and obtain the macroscopic response. (Author abstract) 8 refs.

Sutton, Michael A. (Univ of South Carolina, Columbia, SC, USA); Chao, Yuh J. *Tappi J* v 71 n 3 Mar 1988 p 173-175.

## Surface Properties

**076096 OPTICAL MEASUREMENT THROWS NEW LIGHT ON PAPER SURFACE.** The latest techniques of optical measurement are throwing new light on the surface properties of paper. And, since the printability of paper is influenced by its uniformity, levelness and smoothness, the data obtained could open the way to improved printing papers. Optical measurement is on-line, continuous and very accurate. It reveals that MD and CD samples of paper reflect incident light in different ways, possibly because surface scattering mainly occurs in the plane transverse to the fiber orientation - and the orientation distribution is normally skewed along the MD. (Author abstract) 18 refs.

Hansuebsai, A. (London Coll of Printing, Engl); Morantz, D.J. *Pap Technol Ind* v 28 n 5 Aug 1987 p 563-573.

**076097 RESPONSE OF PAPER SHEET SURFACE AREAS TO CHANGES IN RELATIVE HUMIDITY.** The inverse gas chromatographic method allows measurements of the changes in surface area of paper sheets as a function of relative humidity. Bleached kraft handsheets, formed from pulp beaten to varying degrees and dried

normally, show irreversible loss of surface area on exposure to high humidities; sheets dried free of restraint show an initial increase. The changes are attributed to a combination of fiber swelling and the relaxation of surface fibrillation generated at fiber-fiber bonds during the initial drying of the sheet. (Edited author abstract) 19 refs.

Gurnagul, N. (PAPRICAN, Pointe Claire, Que, Can); Gray, D.G. *J Pulp Pap Sci* v 13 n 5 Sep 1987 p 159-164.

## Swelling

**076098 MEASURING THE SWELLING PRESSURE OF PAPER.** A new technique measures the pressure created when water is added to dry paper sheets restrained in the z direction. Swelling curves obtained with commercial samples and with handsheets are interpreted in terms of fiber wall swelling, fiber shape recovery, and internal flow. Fiber wall swelling is the primary process in chemical pulp fibers, while the fiber shape recovery process predominates in mechanical pulp fibers. Internal flow results from the plasticizing effect of water, which causes the collapse of the paper structure. Swelling pressure develops rapidly and was measurable in less than 1 s. Consequently, water molecules diffuse into the cell wall much faster than is usually assumed. There is an excellent relationship between the irreversible increase in thickness upon redrying and the increase in surface roughness. (Author abstract) 8 refs.

Skowronski, J. (PAPRICAN, Pointe Claire, Que, Can); Lepoutre, P.; Richard, W. *Tappi J* v 71 n 7 Jul 1988 p 125-129.

## Testing

**076099 SHEFFIELD UNIT UPDATE TO TODAY'S TECHNOLOGY.** Recent developments in the measurement of gas flow rate should make it possible to modify a Sheffield tester so that it can be adapted for use within an automated data-collection system. The experimental work and development of instrument is described. The variables in the Sheffield smoothness test are discussed. A comparison is made with other air-leak smoothness testers. The results of the trials are summarized. Sheffield tubes calibrated in the appropriate units indicate a linear response to changes in flow rate as measured in SLPm (standard liters per minute). The linear response of each tube is different. The differences are consistent between mill units manufactured or recalibrated at various times and histories. Discontinuity points exist between flows measured at equal Sheffield units from the top of the lower flow tube to the bottom of the next higher flow tube.

Hagerty, George A. (Hagerty Technologies Inc, Glens Falls, NY, USA); Walkinshaw, John W. *Tappi J* v 71 n 1 Jan 1988 p 101-106.

**076100 CORRELATING THE ON-LINE MEASUREMENT OF ULTRASONIC VELOCITY WITH STRENGTH PROPERTIES.** During the past two years, five generations of ultrasonic-based strength sensors have been tested on a state-of-the-art corrugating medium machine at Nekoosa Packaging, Tomahawk, Wis. Projected velocity accuracies are better than 1%. Excellent correlation between the square of the ultrasound velocity and either STFI compression strength or tensile strength ( $r=0.995$  in both cases) has been demonstrated using samples taken during an extensive rush-drag trial at the mill. Good correlation between CD ring crush and ultrasound velocity is also obtained when both MD and CD velocities are combined. Accurate prediction of results for the flat crush test requires that both MD velocity and sheet caliper be taken into account. The continuous monitoring possible with an on-line sensor has shown some unanticipated stiffness variations during the rush-drag trial that may ultimately lead to new understanding of the process. (Author abstract) 9 refs.

Vahey, David W. (Combustion Engineering Inc, Columbus, OH, USA). *Tappi J* v 71 n 4 Apr 1988 p 149-152.



**076101 MEASUREMENT OF STRAINS IN A PAPER TENSILE SPECIMEN USING COMPUTER VISION AND DIGITAL IMAGE CORRELATION.** An automatic data acquisition and data analysis system for the study of surface deformation in paper specimens through image analysis has been developed. It has been used successfully to study the in-plane deformations in a uniaxial test coupon of paper. The method was also used to determine the displacement field in the gauge region. Both local variations and the microscopic paper response may be obtained from the experimental data. Finally, the technique may also be applied to the determination of a deformation field on the microscale. (Author abstract) 2 refs.

Chao, Yuh J. (Univ of South Carolina, Columbia, SC, USA); Sutton, Michael A. *Tappi J* v 71 n 4 Apr 1988 p 153-156.

**076102 EVALUATING SYNTHETIC FORMING FABRIC TRIALS.** It is imperative to quantify the results whenever a fabric trial is undertaken. In order to do this in an orderly fashion, it is recommended that a 'needs analysis' and test plan be developed to organize the trial and quantify the gains. A detailed approach to fabric trials and a typical test plan format includes: the objective statement; success criteria; abort criteria; potential problem analysis; data collection; data evaluation; quantitative/qualitative evaluation.

Cappell, Daniel D. (Wisconsin Wires Inc, Appleton, WI, USA). *PIMA Mag* v 70 n 6 Jun 1988 p 30, 32-35.

**Ultrasonic Effects** See PAPERBOARDS—Ultrasonic Effects.

## Wetting

**076103 ULTRASONIC TECHNIQUE TO STUDY WETTING AND LIQUID PENETRATION OF PAPER.** A new ultrasonic apparatus was designed to study wetting and liquid penetration of paper. The apparatus can measure both fast and slow transient changes in ultrasonic attenuation by a sheet of paper touched by a rising surface of test liquid pumped into the measuring cell. Test with water showed the time dependence of attenuation, varying with different degrees of sizing of the paper sample. The fast change shows a good correlation with the Bristow absorption test and can be related to the wetting delay of the paper surface. The slow change was interpreted as caused by liquid penetration into the bulk pores of paper sheets. (Author abstract) 17 refs.

Pan, Yun-Long (Univ of Tokyo, Tokyo, Jpn); Kuga, Shigenori; Usuda, Makoto. *Tappi J* v 71 n 5 May 1988 p 119-123.

## X-Ray Analysis

**076104 SOFT X-RAY IMAGING CAN BE USED TO ASSESS SHEET FORMATION AND QUALITY.** Low-energy (< 10 keV) x-ray radiography can be used to assess formation with a spatial resolution on the order of one fiber diameter. Digital image processing can be used to quantify mass and floc size distribution through histogram analysis and two-dimensional Fast Fourier Transforms, respectively. Superior speed and resolution may be achieved via optical image processing techniques. In addition, formation can be assessed independently of sheet color, stickies and other contaminants are easily quantified, and the quality of internal layers in multilayer sheets can be assessed. (Author abstract) 2 refs.

Farrington, Theodore E. Jr. (Inst of Paper Chemistry, Appleton, WI, USA). *Tappi J* v 71 n 5 May 1988 p 140-144.

**PAPER AND PULP INDUSTRY** See Also PULP—Analysis.

**076105 SILVER ANNIVERSARY PROCEEDINGS: INSTRUMENTATION IN THE PULP AND PAPER INDUSTRY, A QUARTER CENTURY OF PROGRESS, 25TH SYMPOSIUM OF THE PULP**

**AND PAPER INDUSTRIES DIVISION (PRESENTED AT: 31ST ANNUAL SOUTHEASTERN CONFERENCE AND EXHIBIT).** Proceedings incorporates 13 papers that are grouped into five sessions dealing with: history of pulp and paper instrumentation, latest developments in sensor application, distributed control system strategies, programmable controller in the pulp and paper industry as well as selecting, installing and utilizing digital systems. Topics considered include: distributed control, process control, loop-controllers, documentation, compensators, multiloop controllers, microprocessor-based instrumentation, pressure control improvement, on-line freeness sensing, optical consistency measurement, instrumentation technicians for the future, field rack enclosures, and a brief historical review of the pulp and paper industry and people associated with it. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10755 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (ISA, Research Triangle Park, NC, USA). *Instrum Pulp Pap Ind* v 21, Silver Anniv Proc: A Quarter Century of Prog, 25th Symp of the Pulp and Pap Ind Div, Birmingham, AL, USA. Publ by ISA, Research Triangle Park, NC, USA, 1985 81p.

**076106 PACIFIC NORTHWEST INSTRUMENTATION '87, PROCEEDINGS OF THE 27TH PULP AND PAPER INDUSTRY DIVISION.** Proceedings incorporates eight papers that deal with the use of modern computer and control technology in the paper and pulp industry. Topics considered include: advanced control strategies, software compatibility, real-time decision making, air dryers, dynamic weighing, moisture measurement for drying processes, the use of the MAP techniques in the forest product industry, microcomputer control, distributed control, and control of continuous digesters. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11588 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (ISA, Seattle Section, District 9, Seattle, WA, USA). *Instrum Pulp Pap Ind* v 23, Pac Northwest Instrum '87, Proc of the 27th Pulp and Pap Ind Div, Seattle, WA, USA, Apr 29-May 1 1987. Publ by ISA, Research Triangle Park, 1987. 59p.

**Australia** See MANAGEMENT SCIENCE.

**Boilers** See COGENERATION PLANTS—Corrosion.

**Canada** See Also PAPER AND PULP MILLS—Maintenance.

**076107 TECHNOECONOMIC TRENDS FAVOURING INCREASED ELECTRICAL DEMAND BY THE PULP AND PAPER INDUSTRY - A STATUS REPORT.** The purpose of this report is to analyze, and project to the mid-1990's, the impact of new pulping and papermaking process technology on incremental electrical energy demand by Canada's pulp and paper industry. Continuing efforts and technological development to enhance this industry's competitive position have favoured increased consumption of electrical energy per tonne of product. The trend towards higher specific electrical energy consumption should continue in the foreseeable future. 21 refs.

Ionides, G.N. (Temanex Consulting Inc, North Vancouver, BC, Can). *Res Rep Can Electr Assoc* 623 U 572 Oct 1987 129p.

## Computer Applications

**076108 WESTRAK PUTS WESTVACO CORP. ON CUSTOMER SERVICE FAST-TRACK.** From the receiving dock to the press room to the shipping platform and everywhere in between, electronic data transmission has swept the graphics industry. The benefits of this kind of record-keeping are steadily giving the competitive edge to those who not only have it, but also know how to put it to work for them. The program is a joint development

of the Graphic Communications Association and the American Paper Institute. It has the support of many paper companies in the United States and Canada. The first implementation of the system was accomplished by Westvaco Corp. through its WesTrak system.

Horton, Virgil (Westvaco Corp). *PIMA Mag* v 69 n 3 Mar 1987 p 19-21.

## Computer Simulation

**076109 DYNAMIC PROCESS SIMULATION IMPROVES PROJECT DESIGN, TRAINING, OPERATION.** Of particular interest to an integrated engineering and construction company and its clients is the use of dynamic process analysis by simulation. This article discusses how dynamic process simulation can be utilized from the ground floor (engineering design) of a project through commissioning (test bed and training applications) to operation (utilization in advanced control).

Dekker, John (BE&K Engineering Co, Birmingham, AL, USA). *Pulp Pap* v 62 n 9 Sep 1988 p 112-115.

**Economics** See PAPER AND PULP MILLS—Modernization.

## Effluent Treatment

**076110 U.A.S.B. - REACTOR TREATING PAPER - AND BOARD MILL EFFLUENT.** Progress has been made on anaerobic wastewater treatment. Now, the Upflow Anaerobic Sludge Blanket (UASB) reactors are developed for the paper industry. In this paper, research and operating results are presented. 4 refs.

Hack, P.J.F.M. *Global Bioconverters* Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 v 1, p 145-154.

## Environmental Impact

**076111 1987 ENVIRONMENTAL CONFERENCE.** This conference proceedings contains 51 papers. The main topics discussed are: effluent treatment case histories; air toxics; sludge handling; in-plant water reuse; scrubber technology; underground tanks; emerging effluent technology; air emission control; anaerobic treatability and pilot plant operation; landfill design; effluent biomonitoring; landfill/lagoon closure; treatment plant improvements; minimizing environmental impacts of chlorine bleaching; air models and visibility; dioxins. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11528 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (TAPPI, Atlanta, GA, USA). *Environ Conf Proc Tech Assoc Pulp Pap Ind* 1987, Portland, OR, USA, Apr 27-29 1987. Publ by TAPPI Press, Atlanta, GA, USA, 1987 379p.

## Europe

**076112 CMEA AIMS TO OPEN FOREST RESERVES.** The developments plans of the CMEA group of eastern European countries are described. Priorities include the expansion of existing mills and the exploitation of vast forests in the USSR. CMEA countries' growing stock and forest areas are summarized. The prognosis for the year 2000, prepared four years ago, predicts present output levels will rise by 50%, which means a total paper production of 21-22 million tons/yr. It is likely, however, that this will not cover demand in 2000. New capacity for most of the countries involves the enlargement of existing mills. In the USSR there are two main directions for development: opening so far unexploited forest areas in the European region; bringing certain transsiberian regions into production. New mills covering the demands of more member countries are to be built with common finance, technology and manpower.

Vamos, Georg. *PPI Pulp Pap Int* v 29 n 7 Jul 1987 p 56-58.



Finland See CHEMICAL INDUSTRY—Energy Utilization.

## Health Hazards

**076113 CANCER INCIDENCE OF WORKERS IN THE FINNISH PULP AND PAPER INDUSTRY.** The cancer incidence of 3 545 workers in the Finnish pulp and paper industry was assessed in a retrospective cohort study. Among the men, 196 cases of primary cancer were detected versus 203.8 expected [standardized incidence ratio (SIR) 96, 95% confidence interval (95% CI) 82 - 114], and there were 47 cancer cases among the women versus 57.9 expected (SIR 91, 95% CI - 108). Lung cancer occurred in 78 men (62.6 expected, SIR 125, 95% CI 98 - 155), and the excess was the most prominent for the male board mill workers (40 observed, 18.1 expected, SIR 222, 95% CI 158 - 302), particularly after 20 years' latency (25 observed, 7.8 expected, SIR 323, 95% CI 209 - 476). Analogous excesses of lung cancer occurred among the men (especially the male board mill workers) who began work after 1 January 1945. The findings were not explained by smoking habits. (Edited author abstract) 23 refs

Jappinen, Paavo (Occupational Health Cent, Imatra, Finl); Hakulinen, Timo; Pukkala, Eero; Tola, Sakari; Kurppa, Kari. *Scand J Work, Environ Health* v 13 n 3 June 1987 p 197-202.

## India

**076114 ENERGY CONSERVATION AT BHADRACHALAM PAPER BOARDS LTD.** M/s. Bhadrachalam Paper Board Limited (BPL) was established in 1979 as an integrated pulp and paper plant. The primary energy need of the plant is in the form of steam and electricity. Coal is used for steam generation and the high pressure steam also generates captive power of 4.5 Mw before it is utilized to meet other needs. As a result of the measures taken specific energy consumption per tonne of paper production was brought down from 9.35 tonnes of steam and 1550 KWH of electricity in 1981, to the level of 8.6 tonnes of steam and 1480 KWH of electricity in 1985. The major areas of improvement have been modifications in the chipper house, stationary side hill screen system optimum utilization of the blow heat recovery system and vacuum pumps in the paper machines. Concerted efforts have also been made for electricity and water savings. Some of the measures undertaken by the company are discussed.

Anon. *Electr Conserv Q* v 8 n 1 Jul 1987 p 6-7.

## Machinery

**076115 PGW UPDATE: SEVENTEEN MILLS NOW USE THE PROCESS TO PRODUCE 5,500 TPD.** The pressurized grinding process has progressed very rapidly from its initial development to widespread acceptance and application. Pressurized groundwood (PGW) is used in all major paper grades that contain mechanical pulp, with the majority going into SC and LWC. The excellent printing properties of groundwood are maintained. Together with reduced share of chemical pulp in the paper furnish, PGW pulp provides a high-quality sheet for printing, especially with lightweight paper grades. The PGW and its advantages are described in this article.

Anon. *Pulp Pap* v 62 n 6 Jun 1988 p 114-117.

## Maintenance

**076116 1987 MAINTENANCE CONFERENCE.** This conference proceedings contains 29 papers discussing several aspects related to maintenance practices in the paper and pulp industry. Topics covered include: selecting a computerized maintenance management program; role of software in predictive maintenance; lubrication practice in Canadian pulp and paper mills; fire research; bearing failures; vibration prevention methods; and analysis of paper machine suction shells. All of the papers are in English except one which is in French. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11283 in the Ei

Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (CPPA, Technical Section, Montreal, Que, Can). 1987 Maint Conf, St. John, NB, Can, Oct 20-22 1987 Publ by CCPA, Technical Section, Montreal, Que, Can, 1987 164p.

## Marketing

**076117 UNCOATED MECHANICAL PULP PRINTING SPECIALTIES: MARKET, MANUFACTURE, QUALITY.** Major reasons for the Canadian newsprint industry's increasing trend towards higher value printing grades are analyzed. These reasons include relatively high manufacturing costs with the exception of energy, out-dated equipment, the need to strengthen the industry's competitive position, plus a rapidly growing and readily accessible U.S. market. (Author abstract) 9 refs.

Ionides, G.N. (Temanex Consulting Inc, North Vancouver, BC, Can). *Pulp Pap Can* v 88 n 9 Sep 1987 p 94-97.

**Personnel Training** See Also ENGINEERING EDUCATION—United States.

**076118 TRAINING PROGRAMS HELP ENGINEERS MAKE THE JUMP INTO MANAGEMENT.** Paper companies keep engineers motivated by offering in-house management training on both the technical and process sides. Several examples of such training programs are presented.

Davis, Bev (Pulp & Paper, San Francisco, CA, USA). *Pulp Pap* v 62 n 9 Sep 1988 p 196-198.

**Planning** See PAPER AND PULP MILLS—Quality Control; RIVER BASIN PROJECTS—Management.

## Quality Control

**076119 QUALITY MOTIVATES AN INCREASING NUMBER OF FORMING FABRIC TRIALS.** It is paramount for the future health of the North American paper industry that it continually improve its competitive position. In order to accomplish this, paper machine clothing trials must be considered. If they are undertaken, a thorough test plan will ensure that an accurate evaluation can be made, thus enabling all participants to reach logical conclusions about the trials. Papermakers as well as clothing suppliers must keep in mind that the paper-making process is intricate and that the value-added aspect of paper machine clothing will continue to be a major factor in the competitive marketplace throughout the 1990s. Customers' demands for quality are motivating an increasing number of machine clothing trials. Author discusses the criteria for conducting the machine clothing trials.

Cappell, Daniel D. (Wisconsin Wires Inc, Appleton, WI, USA). *Pulp Pap* v 62 n 5 May 1988 p 99-102.

## Reliability

**076120 RELIABILITY ANALYSIS OF THE FEEDING SYSTEM IN THE PAPER INDUSTRY.** The paper discusses the performance of a feeding system in a paper mill having five units. Out of these, three are working almost on the same pattern, while the working of the other two is different. Reliability and availability function and mean time to failure (MTTF) of this system are calculated. (Edited author abstract) 3 refs.

Kumar, Dinesh (Regional Engineering Coll, Kurukshetra, India); Singh, I.P.; Singh, Jai. *Microelectron Reliab* v 28 n 2 1988 p 213-215.

**Research** See Also PAPER—Mechanical Properties.

**076121 USING CHEMICALS IN PAPERMAKING.** This conference proceedings contains 7 papers which focus on the use of chemicals in papermaking, and their effects on the mechanical properties and quality of the paper. The sizing agents, fillers, pigments, and starches are

discussed and reviewed. One paper is dedicated to the waste paper deinking process and deinking chemicals. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10499 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Inst of Chemical Engineers, Rugby, Engl). *Symp Pap Inst Chem Eng North West Branch* n 2 1986, Using Chem in Papermaking, Manchester, Engl, Feb 11 1986. Publ by Inst of Chemical Engineers, Rugby, Engl, 1986 var pagings.

**United States** See PAPER AND PULP MILLS—Maintenance.

**PAPER AND PULP MILLS** See Also PAPER-MAKING—Coating; PULP—Bleached.

**076122 BOWATER ADDS CATAWBA LWC PM.** The new 8.5-m wide fourdrinier paper mill (PM) 2 at Bowater Carolina's Catawba mill is described. Although its ultimate purpose was to add 177,000 tons/yr of lightweight coated (LWC) paper capacity, the \$423-million investment at Catawba mill included much more than just the new Beloit PM 2 and its off-machine coater, supercalenders and winders. Three separate projects were completed, the LWC line, three thermomechanical pulp (TMP) lines, a new woodyard, extra kraft pulp capacity and other equipment. This report concentrates on the PM, its coater, and the finishing department.

Smith, Kenneth. *PPI Pulp Pap Int* v 29 n 7 Jul 1987 p 54-55.

**076123 WRAPPING LINE SEALS INVESTMENT.** As part of the same investment program that included the new 220,000-ton/yr PM 1, the Parenco newsprint mill has added a roll handling and wrapping line capable of processing the entire output of the mill. When PM 1 is fully on stream, that will amount to 400,000 tons/yr of standard and improved newsprint grades. The roll handling and wrapping system is complex. And as a prelude to the whole investment, the mill exchanged its Omega computer for a new Vax mill computer system, to allow efficient tracking and controlling of the new production, which will include several soft-calendered, improved news-print grades.

Pearson, John. *PPI Pulp Pap Int* v 29 n 11 Nov 1987 p 51, 53.

**076124 FROM PAPER TO REAM TO BOX TO PALLET.** Bowater's New Thames mill has rebuilt its PM 6 machine extensively in 1984. New lines started up in 1985, and 30,000 tons/year of A4 and A3 papers are being produced. Also, more than 2,500 tons/year of folio papers are converted. Reels coming off the 125,000-ton/yr 6.8-m trim PM 6 enter the converting house, which is adjacent to the end of the machine.

Sutton, Peter. *PPI Pulp Pap Int* v 29 n 11 Nov 1987 p 57, 59, 61.

**076125 SHEETERS HANDLE 350,000 TONS/YR.** Nordland Papier's Dorpen mill in West Germany has one of the largest sheeter installations in Europe. Dorpen mill has three paper machines. All are twin-wire units supplied by Valmet. PM 1 was installed in 1969 and rebuilt in 1984. It is 4.5 m wide and has a maximum operational speed of 750 m/min. It makes the heavier-weight grades, ranging from 80 to 250 g/m<sup>2</sup>. For the production of larger formats, the mill uses six Jagenberg Synchro sheeters ranging from 1.6-2.15 m wide. The latest was installed this year.

Pappens, Rita. *PPI Pulp Pap Int* v 29 n 11 Nov 1987 p 65, 67.

**076126 LAJA MILL INVESTS FOR THE YEAR 2000.** Procel is the name of a \$40-million investment program at CMPC's Laja mill, aimed at increasing



capacity and raising efficiency to keep the mill competitive well into the future. In this article the author reports how CMPC's Laja mill in Chile raised market pulp output.

Vila, Juan (Eurocan Pulp & Paper, Can). *PPI Pulp Pap Int* v 30 n 6 Jun 1988 p 65, 67.

**076127 UPGRADED CTMP MILL PRODUCES EXTRA TONNAGE WITH RELIABILITY, QUALITY.** Powell River, B.C., has installed the first chemi-thermomechanical pulp (CTMP) line on the North American West Coast and now is one of the largest and most productive CTMP lines. The steps that helped it achieve high reliability and quality of product are described. The tight scheduling, woodroom and steam plant improvements, and high quality pulp production are discussed.

Ducey, Michael J. (Pulp & Paper, San Francisco, CA, USA). *Pulp Pap* v 62 n 9 Sep 1988 p 227-229.

**Accident Prevention** See TURBOGENERATORS—Gas Analysis.

**Argentina** See PULP MATERIALS—Bagasse.

## Automation

**076128 NIAGARA PAPER MILL MOVES TO 'AUTOMATED QUALITY MANAGEMENT'.** The Niagara Millwide Quality Management Program is one of the many quality assurance/improvement efforts being initiated by paper mill management throughout North America. Niagara's program involves extensive SPC training, participative management and the employment of the new RoboTest technology to provide timely, accurate and useful quality information throughout the mill.

Anon. *PIMA Mag* v 69 n 10 Oct 1987 p 23-26.

**076129 STRUCTURED APPROACH TO MILLWIDE AUTOMATION.** The mill automation plan approach has been found useful in defining an overall approach to millwide automation. It has been applied both to new mills and also to retrofits into existing mills. In the latter case the existing control systems have been overlaid onto the data flow diagrams before the new alternatives have been explored. The definitions of local and global data bases have also been defined with this method. The structure of data bases is an important element of millwide and should be analyzed carefully. 2 refs.

Fadum, Ole-Kristian (Fadum Enterprises Inc, Westwood, MA, USA). *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul* Publ by TAPPI Press, Atlanta, GA, USA, 1985 p 9-13.

**076130 BEFORE YOU AUTOMATE.** Before you automate, understand your corporate objectives, define and analyze your mill requirements, and then plan your millwide solution. Because of the complexity of the issues involved, as well as the large number of possible solutions and offerings available on the market today, there is no simple answer to millwide automation. This paper addresses some of the issues and poses some questions for discussion. An evolutionary approach to millwide automation based on an evaluation of current and future requirements is proposed. (Author abstract) 14 refs.

Kallos, Steven E. (Foxboro Co, Foxboro, MA, USA); Sawyer, Raymond D. *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul* Publ by TAPPI Press, Atlanta, GA, USA, 1985 p 29-33.

**076131 TALE OF TWO TOWNS.** The article presents a comparison of two companies' methods of installing automation and provides an instruction scenario as to such a system implementation. Both cases are real. Waterton believed in the maxim that 'people would support what they helped to create'. Lufton practiced 'mushroom management' - keep people in the dark and tell them only what they need to know. Both companies faced early choices - they could either manage by fear or manage by trust.

Spiker, Barry K. (Honeywell Industrial Automation Systems Div, Phoenix, AZ, USA). *Manuf Syst* v 6 n 1 Jan 1988 p 25-29.

**076132 FLOW PROBLEMS SOLVED AT NEWS-PRINT MILL USING VENTURI-ELEMENT METER.** Measuring dryer condensate flows at Great Northern Paper required instrumentation capable of withstanding high vibration and noise. As part of this new system, Great Northern installed two venturi-cone primary flow elements to achieve the rangeability and the accuracy required in the updated process. In the system, steam condensate from six separate dryer sections is directed by two 2-in. lines through a vacuum receiver pump. These lines carry the condensate to a vent condenser and back to the boiler, where steam is generated. Precise measurement of flow in this area is critical to papermaking.

Royek, Steve (Ametek Inc, Paoli, PA, USA). *Pulp Pap* v 62 n 9 Sep 1988 p 216-217.

**076133 MASS FLOW METER INSTALLATION AIDS ALKALINE SWITCH AT FINE PAPER MILL.** A case story is described where a six-machine, 550-tpd fine paper mill switched from acid to alkaline papermaking. This required more attention to wet end chemistry. The new complexity of the additive process coupled with a general need to exert tighter control on flow rates led to an evaluation of the Smith S-Mass Coriolis mass meter. The twin S tubes are vibrated at their natural frequency. As fluid flows through the tubes, their displacement relative to each other becomes slightly distorted. The resultant phase shift in the output signals from motion sensors A and B is directly proportional to the mass flow rate. S-mass meter testing program and applications are described. The meter proved to be very accurate. Greater accuracy in flow measurement and more precise control can have a significant impact on machine productivity and profitability.

Butler, Ernest L.; Anderson, Donald P. *Pulp Pap* v 62 n 9 Sep 1988 p 224-226.

**076134 MILL MANAGEMENT'S ROLE IN MILLWIDE AUTOMATION.** It is argued that mill and production managers in the USA have generally been slow to take the appropriate leadership role in defining, justifying and introducing millwide systems planning in their companies. Increasingly, the impediments to efficient investment and implementation of applied technology are seen in cost accounting, management and planning. A simple general model of the use of computers in industry is developed. It consists of three systems: data processing (DP), management information systems (MIS) and applied technology (AP). Their integration is discussed. A true millwide system defined by all of these classes of systems activity can be considered as the horizontal integration of the process control systems, and the vertical integration of these process control systems with conventional management information systems.

Routledge, Thomas C. (H.A. Simons Ltd, Vancouver, BC, Can). *PIMA Mag* v 70 n 10 Oct 1988 p 17-20.

## Auxiliary Equipment

**076135 RECONDITIONING BEATS REPLACEMENT.** Bark presses are subject to severe wear during operations. In this article the author describes how replacement of moving components and a change in frame design can save money and extend press life.

Klang, Hakan. *PPI Pulp Pap Int* v 30 n 6 Jun 1988 p 91.

**Boilers** See Also BOILER CONTROL—Water Level; BOILERS—Efficiency; BOILERS—Waste Heat Utilization; BOILERS—Water Tube; PULP MANUFACTURE—Waste Liquor Utilization.

**076136 PROTECTING YOUR RECOVERY BOILER FROM PMS AND OTHER SORDID CRITTERS.** The author examines the problem of water circuits contamination of the recovery boiler. He points to the pulp mill as the main cause. He suggests the use of the following tools to minimize the problem: sample coolers;

monitoring techniques such as conductivity turbidimetry, membrane filters; warning systems for utilities/personnel; effective condensate corrosion treatment program.

Levine, Gerald (Betz Industrial). *PIMA Mag* v 69 n 7 Jul 1987 p 35-37.

**076137 AIR JETS AND MIXING IN KRAFT RECOVERY BOILERS.** This paper examines several aspects of single and multiple air-jet systems typical of those used in recovery boilers. We first review the extensive work involving the trajectory and penetration for air jets in crossflow in a wide variety of applications, including combustion furnaces. We next discuss the dominant influence of the interaction of multiple jets. This interaction dramatically changes the determination of jet penetration in a boiler furnace. Flow channeling is seen to be a prominent feature of furnace air flows and is shown to influence mixing, combustion, and char entrainment in recovery-boiler furnaces. Finally, some general guidelines for design of recovery-boiler air systems are presented. (Author abstract) 22 refs.

Adams, Terry N. *Tappi J* v 71 n 1 Jan 1988 p 97-100.

**076138 KRAFT RECOVERY BOILER: CONVENTIONAL TO LOW ODOR CONVERSION.** Reduced emissions, reduced energy costs and reduced maintenance costs are the objectives of a recovery boiler low odor conversion. The project affects a number of process streams in several mill areas and presents some options. Exploring the options may uncover additional energy savings that will improve the return on investment (ROI) (Author abstract) 1 ref.

Hein, A.G. (H.A. Simons Ltd, Vancouver, BC, Can). *Pulp Pap Can* v 88 n 12 Dec 1987 p 223-226.

**076139 40-YEAR FIGHT AGAINST CORROSION IN KRAFT RECOVERY BOILERS: A REVIEW.** Recovery boilers of the Tomlinson concept have been used in Sweden since 1936. Increasing dimensions, higher pressures, elevated temperatures and higher capacities have caused increasing corrosion problems. Considerable effort has been made in Scandinavia to reduce the fireside corrosion. Fundamental research was conducted in the 60s. Composite tubes were introduced in the 70s. However, recovery boilers still have corrosion problems. This paper reviews Swedish experience on recovery boiler corrosion, during the last four decades. (Author abstract) 14 refs.

Ingevald, S. (AF-IPK, Stockholm, Swed); Bruno, F.; Ekqvist, F. *Pulp Pap Can* v 88 n 12 Dec 1987 p 250-255.

**076140 RETROFITS: WHERE THE ACTION IS.** Retrofitting, rather than building new recovery boilers, has become the major business of some manufacturers. There are two main factors responsible for this development, one economic, the other technical. The economic impetus is the capital cost of new recovery boilers, which has become so high that it is difficult to justify a new unit to obtain additional capacity or to replace an obsolete, inefficient unit. While not applicable to all boilers, it is clear that there is a substantial reservoir of untapped capacity in existing recovery boilers that could handle much of the anticipated expansion in kraft pumping in the near term.

Grace, Thomas M. (Inst of Paper Chemistry). *PIMA Mag* v 69 n 12 Dec 1987 p 57-58.

**076141 SINTERING OF FIRESIDE DEPOSITS AND ITS IMPACT ON PLUGGING IN KRAFT RECOVERY BOILERS.** The paper first examines the results of laboratory and field studies of the sintering characteristics of deposits and precipitator dusts collected from various recovery boilers. Then the effect of sintering on the boiler plugging is explored. Sintering of deposits



and dust begins at temperatures as low as 300°C. In the range of 500°C to 600°C, deposits sinter rapidly, reaching a maximum strength in less than 1 hour. 5 refs.

Tran, H. N. (Univ of Toronto, Toronto, Can); Barham, D.; Reeve, D. W. *Tappi J* v 71 n 4 Apr 1988 p 109-113.

**Brazil** See Also BARGES—Docking.

**076142 EXTRACTING THE LAST TON OF CAPACITY.** Technical ingenuity has raised Cenibra's market pulp capacity in the last 10 years from 265,000 to 350,000 tons/yr. Now the mill situated near Inatinga in Minas Gerais State of Brazil is implementing a plan to double its capacity to 700,000 t/yr by the early 1990s. The pulp is produced from eucalyptus trees. The equipment's process and economics of production are described. Energy saving and effluent treatment is also discussed.

Pearson, John. *PPI Pulp Pap Int* v 29 n 4 Apr 1987 p 42-45.

**Computer Applications** See Also INDUSTRIAL ENGINEERING—Computer Simulation; PAPERMAKING MACHINERY—Control.

**076143 COMPUTER CAN BE A TECHNOLOGICAL MINEFIELD.** Mills can make costly mistakes when investing in computers. The mill must define exactly what it wants of a computer - what the problems are - before deciding on a system. And, it is vital that the right personnel be allocated to this task. This introduction to computer technology is designed for the non-expert, it points out some of the dangers in the minefield. (Edited author abstract) 5 refs.

Anon (Process Control Working Group, Paper Industry Technical Assoc). *Pap Technol Ind* v 28 n 5 Aug 1987 p 555-556, 558-559, 561-562.

**076144 ULTIMATE SPEED-UP: BEING A TREATISE ON THE SIEVE OF ERATOSTHENES.** A discussion is presented of the PCompatible computers. Their key characteristics are summarized. Current software problems are outlined. Computer performance is also assessed.

McCubbin, Neil. *Pulp Pap Can* v 89 n 9 Sep 1988 p 95-96.

**Computer Simulation**

**076145 ROLES FOR MICROCOMPUTERS IN APPLICATIONS OF MASSBAL TO LARGE AND SMALL PROCESS SYSTEMS.** SACDA's MASSBAL program was originally developed for mainframe use. It has been successfully implemented on minicomputers, and recently it has been installed on a microcomputer. We describe our implementation experience, and our discovery of some eye-opening facts about microcomputer software. Based on our experience, we envisage a number of applications of microcomputers for engineering purposes. Local computing power greatly reduces the requirement for costly timesharing facilities. Software for microcomputer poses a number of difficulties. These problems include security for the software, and a fair return for software developers. Despite the many engineering tasks that micros can accomplish, there are limitations. Some of the current limitations and deficiencies are outlined, which it is hoped will be overcome by future hardware and software releases. (Edited author abstract) 1 ref.

Shewchuk, C.F. (Univ of Western Ontario, London, Ont, Can); Waite, S.J. *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul* Publ by TAPPI Press, Atlanta, GA, USA, 1985 p 161-165.

**076146 CASE STUDIES OF PROCESS SIMULATION IN ENGINEERING.** Computerized Process Simulation is now a standard engineering tool for functions ranging from balancing process flowsheets to detailed computer aided design. This paper outlines typical engineering applications of process simulation in the pulp and paper industry. Specific examples are cited where the use of process simulation has affected the direction of process

design by aiding in the evaluation of process performance and in the calculation of project economics. (Author abstract)

Wilson, P.H. (H.A. Simons (Int) Ltd, Vancouver, BC, Can); Wasik, L.S.; Herschmiller, D.W. *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul* Publ by TAPPI Press, Atlanta, GA, USA, 1985 p 181-185.

**Concrete Construction**

**076147 MASSIVE FOUNDATIONS FOR AYRSHIRE PAPER MILL.** The building is made up of a precast portal frame sitting on in situ pile caps, columns and beams. Cladding consists of precast panels, six metres wide and two-and-a-half metres deep. Main roof beams weigh twenty-eight tonnes, and are twenty-seven metres long. The operating floor of the mill will be seven metres above the ground floor, to suit the installation of machinery which has to be deeply seated in its foundations. Pile caps of various shapes and sizes support the outside of the building and internal columns, and these caps are linked with ground beams.

Barfoot, Jack. *Concrete (London)* v 22 n 2 Feb 1988 p 19-21.

**Construction** See Also CONSTRUCTION INDUSTRY—Management.

**076148 IT'S BOOM TIME FOR ALBERTA'S BURGEOING PULP AND PAPER INDUSTRY.** With one mill soon to be opened, the large expansion of an existing one, and the announcement of the construction of two more, the province is becoming a major player in the Canadian pulp and paper industry. The soon-to-be-opened market pulp mill belongs to Millar Western pulp Ltd. Champion Forest Products in Hinton announced it would be doubling capacity to 385,000 t/y of pulp in a \$361-million project. Daishowa Canada Co. Ltd. announced plans for a \$500-million market pulp mill, in Peace River. The biggest news is the announcement of the construction of Alberta's first paper mill. The Alberta Newsprint Company Ltd. will build a 220,000-t/y mill near Whitecourt.

Rodden, Graeme. *Pulp Pap Can* v 89 n 5 May 1988 p 33-34.

**076149 MILLION-TON MILL MOVES CLOSER.** The author reports from Brazil on the start of work on Aracruz's second eucalyptus pulp line. On completion of the 525,000-ton/yr installation, mill capacity will rise to one million tons/yr. (Edited author abstract)

Knight, Patrick. *PPI Pulp Pap Int* v 30 n 4 Apr 1988 p 55, 57-58.

**Control** See Also CONTROL SYSTEMS—Performance.

**076150 LAYING THE FOUNDATIONS OF MILL-WIDE CONTROL.** The New Thames Mill took a first step towards mill-wide control with the installation of a dual coaxial highway and a distributed control system in 1984. A new module was plugged in to extend control to the wet end in 1985; and future modules will bring finishing and conversion into a mill-wide system. The system is easy to use and mill staff can change and develop control loops. It has proved 100% reliable, and the mill has achieved precise control over the furnish and reduced energy consumption, broke, time loss and off specification paper. (Author abstract)

Morley, R.L. (Bowaters UK Paper Co, Engl). *Pap Technol Ind* v 28 n 9 Dec 1987 p 747-751.

**076151 CONTROLLERS KEEP FLEXIBILITY HIGH, OPERATING COSTS LOW AT PULP MILL.** The Leaf River Forest Products pulp mill in New Augusta, Mississippi can process up to 697,000 cords of wood per year, yielding 367,000 tons of fully bleached hardwood and softened kraft pulp. Leaf River has five operating areas - the woodyard, digester/bleach plant, pulp machine, powerhouse, and wastewater treatment

facility - each of which is supervised by an Allen-Bradley PLC-3 programmable controller with hot back-up. The controllers supervise a number of smaller programmable controllers. An A-B Data Highway lets the controllers 'talk' to each other and to the mill's color graphics operator interface system, linking the five areas into a mill-wide distributed control system.

Palmer, Scott (Leaf River Forest Products, New Augusta, MS, USA). *Chilton's I&CS* v 61 n 3 Mar 1988 p 77-78.

**Control Equipment** See Also PULP MANUFACTURE—Washing.

**076152 ON-LINE SENSORS FOR PULP AND PAPER.** As production control becomes more centralized for paper making, with the growing application of computer integrated mill-wide systems, so does the need for reliable measurements to be available automatically. This means that the traditional skills of certain operators are being replaced with repeatable, rugged and smart sensors that can communicate directly, often in digital format. In this article the author looks at the special needs and developments of sensing in the pulp and paper industry.

Reeve, Alan. *Control Instrum* v 20 n 6 Jun 1988 p 45,48.

**Control Systems** See Also CONTROL SYSTEMS; CONTROL SYSTEMS—Performance; PULP DIGESTERS—Control.

**076153 SPECIFIC ENERGY CONTROL OF SCMP REFINERS AT NBIP.** The SCMP plant is controlled by a Foxboro Videospec/Microspec system and a Fox 300 supervisory computer. A feed forward equation of specific energy versus primary freeness set point is used to determine the primary refiner motor loads and the primary freeness signal is fed back to adjust the equation if freeness drifts from set point. A similar closed loop is used for the secondary refiners except that here there is the benefit of feeding forward the actual primary freeness signal. Refiner throughput is measured by calibrated metering belts and adjusted for press inlet consistency. (Edited author abstract) 2 refs.

Bethune, J.H. (NBIP Forest Products Inc, Dalhousie, NB, Can); Mercier, E. *Pulp Pap Can* v 88 n 10 Oct 1987 p 66-68.

**076154 PROCESS TECHNOLOGY: A COMPILATION OF RECENT ENGINEERING CONFERENCE PAPERS ON PROCESS CONTROL AND SIMULATION.** This book contains 23 papers on process control and process simulation. Specific topics covered are: mill-wide automation; distributed control systems; process engineering; simulation; flowsheet calculations using microcomputers; use of microcomputers in process simulation; and case studies of process simulation in engineering.

Anon. *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul* Publ by TAPPI Press, Atlanta, GA, USA, 1985 186p.

**076155 PAPER-MILL-WIDE SYSTEM DESIGN FROM THE USER'S VIEWPOINT.** The paper-mill-wide needs for process and production control and information are analyzed and synthesized in the context of a typical, rather common type of mill. It was found that the 'Williams' type hierarchy provides a convenient framework for structuring of the present state of the art in paper-mill-wide systems and an extension to 'business-wide' systems is proposed. Some measurement and control problems, unique to paper-making, are reviewed in the mill-wide context. Several options for implementation, including 'customized standard application modules', are briefly reviewed. (Author abstract) 13 refs.

Brewster, Donald B. (Profigrad Inc, Montreal, Que, Can). *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul* Publ by TAPPI Press, Atlanta, GA, USA, 1985 p 1-8.



**076156 MILLWIDE CONTROL - CONFIGURATIONS, NETWORKS AND PROTOCOLS.** This paper is a tutorial discussion of the above topic and will present the pros and cons of the several proposed hierarchical computer control system organizational structures. Communications between the nodes of the hierarchy is the basis of operation of such a system. This paper will therefore also discuss the several proposals for such facilities including the media used and the message codes or protocols involved. (Author abstract) 25 refs.

Williams, Theodore J. (Purdue Univ, West Lafayette, IN, USA). *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul Publ by TAPPI Press, Atlanta, GA, USA* 1985 p 59-71.

**076157 ADVANCED ANALYSIS METHODS FOR USE IN THE DESIGN OF MORE EFFECTIVE CONTROL SYSTEMS IN THE PROCESS INDUSTRY.** Optimization of plant operation in industrial applications is a complex task. In most instances, the optimization is to be performed with respect to cost, usually in the form of increasing the product per-unit cost. Thus, the optimization procedure is concerned with increasing the efficiency of (1) plant management (i.e., scheduling, etc.), and (2) plant operation. This paper discusses a specific set of software analysis tools that can be used very effectively to increase productivity of plant operation. The discussion contains a brief introduction to some of the current control needs in the pulp and paper industry. Also presented is a description of the software tools, current applications of these tools in the aerospace and heating, ventilation, and air conditioning industries and potential use of these tools in the pulp and paper industry. (Author abstract) 14 refs.

MacArthur, J. Ward (Honeywell Inc, Roseville, MN, USA); Konar, A. Ferit. *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul Publ by TAPPI Press, Atlanta, GA, USA*, 1985 p 95-108.

**Corrosion** See Also STEEL CORROSION—Measurements.

**076158 ION CHROMATOGRAPHY: IS IT THE 'NOW' TECHNIQUE FOR MONITORING PROCESS STREAMS IN A PAPER MILL? PART I: PRINCIPLES AND INSTRUMENTATION.** The estimated cost of controlling industry corrosion is over \$8/ton of product. This cost can be defrayed if the source can be identified before equipment failure. The results from an ion chromatography (IC) technique can be used to follow the formation of corrosive ions in a process, to investigate the source and control of certain undesirable species, and to predict the process conditions in a mill. Potential uses of IC techniques are described, with a brief explanation of theoretical principles and modern instrumentation, and practical applications in pulping and papermaking processes of a newsprint mill. (Edited author abstract) 20 refs.

Murarka, S.K. (Abitibi-Price Inc Research Cent, Mississauga, Ont, Can); Fairchild, N.S. *Pulp Pap Can* v 88 n 12 Dec 1987 p 175-177.

**076159 ION CHROMATOGRAPHY: IS IT THE 'NOW' TECHNIQUE FOR MONITORING PROCESS STREAMS IN A PAPER MILL? PART II: SELECTED APPLICATIONS.** The use of ion chromatography (IC) for monitoring process streams (liquors, condensates, white waters, effluents, etc.) from various parts of a sulfite newsprint mill is discussed. The illustrations show how IC data were used in understanding and improving process dynamics and conditions. (Edited author abstract) 10 refs.

Murarka, S.K. (Abitibi-Price Inc Research Cent, Mississauga, Ont, Can); Fairchild, N.S. *Pulp Pap Can* v 88 n 12 Dec 1987 p 181-186.

**076160 CORROSION PROTECTION FOR THE WET END OF PAPER MACHINES.** Corrosion of structural steel members at the wet end of a paper machine continues to be a problem and a real challenge to the

corrosion engineer in the pulp and paper industry. Adverse conditions of operation, minimal downtime for maintenance of the machine, and restrictions on surface preparation put protective coatings and applications to the test. The article gives a brief review of various corrosion protection methods, including surface preparation and protection coatings, as they apply to the wet end of paper machines. 11 refs.

Rodriguez, Al (Simpson Pasadena Paper Co). *J Prot Coat Linings* v 4 n 12 Dec 1987 p 34-37.

**076161 CORROSION MANAGEMENT PROGRAM IN PULP AND PAPER MILLS.** A corrosion management program can extend the life of an industrial facility through effective use of planning and engineering systems. In a pulp and paper mill, a corrosion management program can unify what otherwise is likely to be a fragmented effort at corrosion protection because of the multiple process areas, managements responsibilities, service environments, and types of structure and equipment that require protection.

McAfee, Thomas P. (Valspar Corp). *J Prot Coat Linings* v 4 n 12 Dec 1987 p 38-43.

**076162 PULP MILL EXPERIENCE IN CORROSION OF RECAUSTICIZING EQUIPMENT.** This paper reviews the results of a survey of pulp mills with regard to corrosion of recausticizing equipment, pipelines, pumps and machinery. Operating data, materials of construction, corrosion experience and mechanisms are discussed.

Cornell, Conrad F. (Green Bay Packaging Inc, Birmingham, AL, USA). *Tappi J* v 70 n 11 Nov 1987 p 63-73.

## Corrosion Protection

**076163 BRINGING EXPERTISE TO THE SITE.** One technique employed to control corrosion is electrochemical control. Corrosion Service Co. Ltd., Downsview, Ont., not only offers the service to the pulp and paper industry, it has developed support systems that detect corrosion automatically from its office near Toronto. The firm claims to be one of only two in the world which provide such a service; its competitor is a smaller, Finnish company. Using electrical measurement techniques, Corrosion Service can determine if a vessel is corroding. The company offers two monitoring systems: a computer communications unit (CCU), and a remote monitoring unit (RMU).

Karl, Wayne. *Pulp Pap J* v 40 n 9 Nov 1987 p 19, 36.

**076164 ELECTRONIC CORROSION PROTECTION THROUGH THE USE OF A CONTROLLED ENVIRONMENT MODULE (CEM).** With the pulp and paper industry's growing reliance upon sophisticated process control equipment for production optimization, new techniques of control room design and construction which effectively reduce the potential of corrosion-induced equipment failure are of prime importance. To meet this challenge Circul-Aire Inc. has developed a prefabricated self-contained controlled environment module (CEM) enclosure system. This paper presents examples of potential applications of CEM's and describes the system concept and its development. (Author abstract)

Agopian, N. (Circul-Aire Inc, Montreal, Que, Can); Huza, M. *Pulp Pap Can* v 88 n 12 Dec 1987 p 161-163.

**Design** See CHEMICAL PLANTS—Simulation.

## Drainage

**076165 DRAINAGE TIME FOR STOCK CHESTS AND WATER TANKS.** This article offers equations which have been developed to assist pulp mill designers in predicting the atmospheric drainage time of stock chests and water tanks or in choosing appropriate drain line diameters to reduce drainage time. The equations can be extended to estimate the drainage time of multiple tanks draining simultaneously through a common pipe into another basin at a lower level. 3 refs.

Peters, Norman (Domtar Central Engineering, Montreal, Que, Can). *Pulp Pap Can* v 88 n 9 Sep 1987 p 27, 29-30.

**Economics** See BOILERS—Design; COGENERATION PLANTS—Industrial Applications; PULP MANUFACTURE.

**Effluent Treatment** See Also ENVIRONMENTAL ENGINEERING; FERTILIZERS; HYDROGEN SULFIDE—Toxicity; PULP MANUFACTURE—Bioconversion; WASTEWATER—Color Removal; WASTEWATER—Treatment.

**076166 TREATMENT AND ENERGY RECOVERY - AN INTEGRATED APPROACH FOR SMALL PAPER MILL WASTE SLUDGE.** Waste sludge generated during the manufacture of paper in small scale units producing 5-30 tons per day of paper, poses handling and disposal problems. This sludge along with two other major solid wastes viz., undersize feed and coal fines can be made into briquettes with readily utilizable fuel value. Waste sludge, undersize feed and coal fines registered calorific values of 2500, 3500 and 9000 kcal/kg respectively. Coal fines were found to be less reactive than the other two components. A treatment train consisting of settling, sludge conditioning with cationic polyelectrolyte of d-glucose amine type, and mechanical dewatering by vacuum filtration usually furnished a sludge cake of 20-30% solids consistency at an optimum polyelectrolyte dose of 7 mg/l. Various combinations of these waste solids were used to determine calorific values. Concentrated black liquor can be used as binder for briquettes. (Author abstract) 22 refs.

Wate, S.R. (Nat'l Environmental Engineering Research Inst, Nagpur, India); Ghosh, Arindam. *Indian J Environ Health* v 29 n 2 Apr 1987 p 139-147.

**076167 ORGANIC HALIDE AND ORGANIC CARBON DISTRIBUTION AND REMOVAL IN A PULP AND PAPER WASTEWATER LAGOON.** The primary objective of this study was to determine the total organic halide (TOX) and total organic carbon (TOC) distributions throughout an aerated lagoon. A secondary objective was the definition of spatial molecular weight distributions of organic halide and organic carbon compounds at various sampling locations within the lagoon system. A knowledge of spatial and temporal distributions throughout a lagoon may provide insight into design or operational modifications for improving performance. 28 refs.

Bryant, Curtis W.; Amy, Gary L.; Alleman, Bruce C. *J Water Pollut Control Fed* v 59 n 10 Oct 1987 p 890-896.

**076168 WASTE MANAGEMENT IMPROVES PROFITABILITY.** The article discusses how Rolland Inc, a finished- and coated-paper company in Scarborough, Ontario, used the best available technology for water pollution control in its mill, and employed outside consultants in the task subjects covered include treatment of coating washings, treatment chemicals, pH monitoring, and others.

Simonetti, Marie-Claire (Water & Pollution Control, Don Mills, Ont, Can). *Water Pollut Control (Don Mills Can)* v 125 n 1 Feb 1987 p 7-8.

**076169 UPFLOW ANAEROBIC SLUDGE BLANKET WASTEWATER TREATMENT SYSTEM: A TECHNOLOGICAL REVIEW.** Anaerobic technology offers wastewater treatment with energy production creating potential for economic return. Anaerobic treatment of pulp and paper waste is now applied in pilot and full-scale plants as an alternate to aerobic treatment. Advantages of anaerobic treatment include lower capital/operating costs, less sludge and net energy production. Several anaerobic technologies for the treatment of pulp and paper waste are now available. Performance results of the upflow anaerobic sludge blanket (UASB) system are found to be excellent. (Author abstract) 4 refs.

Maat, D.Z. (Paques Lavalin, Toronto, Ont, Can); Habets, L.H.A. *Pulp Pap Can* v 88 n 11 Nov 1987 p 60-64.



**076170 PULP AND PAPER EFFLUENT MANAGEMENT.** This Annual Literature Review article discusses the title subject within the general topic of industrial wastes. Subjects covered include biological treatment, physicochemical treatment, internal load control, and others. 60 refs.

Gillespie, William J. *J Water Pollut Control Fed* v 58 n 6 Jun 1986 p 564-566.

**076171 BIOLOGICAL TREATMENT OF PULP-AND-PAPER MILL WASTE WATER USING BIOGENIC CATIONS.** Composition of waste water at an integrated pulp mill and wood industry complex is investigated with respect to the most important cations. On the basis of a calculation of the selectivity coefficients, deficient cations for activated sludge are calculated. The efficiency of waste water treatment for concentration of suspended solids and BOD<sub>5</sub> is analyzed depending on the conditions of addition of biogenic additives. (Author abstract) 8 refs.

Stetsenko, L.A.; Trasevich, Yu.I. *Sov J Water Chem Technol* v 9 n 5 1987 p 86-89.

**076172 START-UP OF AN UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR FOR TREATING THERMOMECHANICAL PULPING EFFLUENTS.** The start-up of upflow anaerobic sludge blanket reactors for treating thermomechanical pulping (TMP) wastewater was studied. Three laboratory scale reactors were inoculated with different amounts of sludges originating from a conventional anaerobic digester batch-fed with TMP wastewater and sludge from a municipal digester. The effects of a small amount of pulverized peat coke in the seed sludge was examined. The reactor seeded with the highest amount of sludge was most resistant to sludge washout and retained a greater amount of sludge than the other reactors. The addition of peat coke was not found to facilitate the start-up. There were no remarkable differences in specific sludge activities between the three reactors. It was observed that feed interruptions of several hours disturbed the process and delayed the start-up. (Author abstract) 14 refs.

Rintala, Jukka (Tampere Univ of Technology, Tampere, Finl). *Aqua Fenn* v 17 n 2 1987 p 221-230.

**076173 LOWER COSTS ENCOURAGE MILL INTEREST.** Since the early 1980s, interest has been growing in the paper industry in the use of anaerobic systems for treatment of wastewater from pulp and paper mills. Today, there are at least 20 systems working in the industry and several more are at the pilot stage or about to be implemented. Anaerobic treatment plants basically convert dissolved organic waste present in mill effluent into biogas, which consists of a high proportion of methane and which can be burned in the mill as an energy source. The article reports on some mills investing in such installations and the results obtained.

Pearson, John. *PPI Pulp Pap Int* v 30 n 3 Mar 1988 p 28-30.

**076174 BAIENFURT INVESTS IN THE ENVIRONMENT.** Steady investment in environmental protection procedures has made Feldmuehle's Baienfurt mill a showcase for the West German pulp industry. In the past two and a half years, the mill has invested DM 11 million (\$7 million) in a program aimed at cutting emissions from its 30,000-ton/yr sulfite pulp line. The program has tackled three major areas of concern: pollution by organo-halogens (especially organo-chlorine compounds and other organic compounds (COD) in the mill's wastewater and the emission of sulfur dioxide. In addition, measures have been taken to improve the cleanliness of wastewater before it is returned to the river.

Pearson, John. *PPI Pulp Pap Int* v 30 n 3 Mar 1988 p 31-32.

**076175 ANAEROBIC PILOT PLANT EXPERIENCE AT CONSOLIDATED-BATHURST INC.** Three anaerobic processes to treat combined NSSC-CTMP effluents were being operated on a pilot scale at the

Consolidated-Bathurst Inc. mill at Bathurst, N.B., Canada. These processes included stirred contact, upflow anaerobic sludge blanket (UASB), and two-stage fluidized bed systems. Representative contaminated mill effluent collection and delivery to the pilot units is described, as well as the pilot plant set-up and monitoring program. Operating experience during the first 100 days is discussed. (Edited author abstract). 3 Refs.

Schneider, E. (Klockner Stadler Hurter Ltd, Montreal, Que, Can); Wilson, R.W.; Frenette, E.G. *Pulp Pap Can* v 89 n 9 Sep 1988 p 71-75.

**Effluents** See Also ECOSYSTEMS; MARINE BIOLOGY—Environmental Testing; SULFUR—Chemical Analysis.

**076176 EFFECTS OF PULP AND PAPER MILL EFFLUENTS ON COASTAL FISH COMMUNITIES IN THE GULF OF BOTHNIA, BALTIC SEA.** This article summarizes effects on littoral fish community structure in nine polluted areas in the Gulf of Bothnia. Gill net catches were dominated by perch, roach and ruffe. Catches of roach and ruffe increased in the vicinity of pulp and paper mills, regardless of the production process of the mill. Catches of perch did not change significantly. These changes in abundance are qualitatively similar to those associated with eutrophication and the mechanisms involved are probably the same, since both kinds of pollution increase the organic loading in the receiving area. No diet effect that could explain species distribution was observed. (Edited author abstract) 28 refs.

Hansson, Sture. *Ambio* v 16 n 6 1987 p 344-348.

**076177 EFFLUENT FLOWMETER CALIBRATION USING FLUORESCENT DYE TRACER.** Rhodamine WT fluorescent dye tracer and a fluorometer have proven useful in flow measurements of paper mill effluents. Examples illustrate their use in continuous and discrete sampling modes. Although clays in the effluent have not interfered with tests, notable dye instability has been encountered in bleached kraft mill and wet debarking effluents. (Author abstract) 8 refs.

Steinback, B.J. (Abitibi-Price Inc, Mississauga, Ont, Can). *Pulp Pap Can* v 88 n 12 Dec 1987 p 227-230.

**076178 INDUSTRY MUST ADDRESS EMERGENCY CHEMICAL SPILL RESPONSE PLANNING: MILLS NEED TO ASSESS ACCIDENTAL RELEASE RISKS, SCENARIOS, AND CONSEQUENCES IN ORDER TO DEAL WITH COMMUNITY EMERGENCY PLANS.** Mills need to assess accidental release risks, scenarios, and consequences in order to deal with community emergency plans. Many pulp and paper industry members have gone beyond the specifically mandated aspects of the Superfund Amendments & Reauthorization Act (SARA) Title III regulations to analyze different accidental release scenarios and to review measures for reducing the consequences. This article discusses some of the problem areas for the pulp and paper industry that go beyond the mandated requirements. It also suggests some plans to assist industry in dealing with affected communities.

Egan, Bruce A. (ERT, Boston, MA, USA). *Pulp Pap* v 62 n 4 Apr 1988 p 175-177.

**076179 NATURE AND PROPERTIES OF SOME CHLORINATED, LIPOPHILIC, ORGANIC COMPOUNDS IN SPENT LIQUORS FROM PULP BLEACHING. 1. LIQUORS FROM CONVENTIONAL BLEACHING OF SOFTWOOD KRAFT PULP.** A sample of spent chlorination liquor from the bleaching of softwood kraft pulp was fractionated to isolate the chlorinated lipophilic compounds. These were investigated by gas chromatography and gas chromatography/mass spectrometry, and a number were identified as chlorinated diones and enol lactones. The compounds were found to be weakly mutagenic and to have limited potential for bioaccumulation. Quantities ranged from < 1 to 72 g/ton of pulp. At pH 7 and room temperature, these compounds were found to be relatively unstable and to decompose. (Author abstract) 22 refs.

McKague, A. Bruce (Swedish Pulp & Paper Research Inst, Stockholm, Swed); Kolar, Marie-Claude; Kringstad, Knut P. *Environ Sci Technol* v 22 n 5 May 1988 p 523-526.

**076180 IMPACT OF BLEACHED KRAFT MILL EFFLUENTS ON DRINKING WATER QUALITY.** Bleaching effluents from kraft pulp mills contain large quantities of chlorinated organic compounds, some of which are mutagenic. Mutagenic chloro-organic compounds are also formed as by-products in chlorination of drinking water. The work reported here was a combined field and laboratory study aimed at comparing the evidence of health risks from pulp mill contaminants in drinking water, with corresponding evidence from normal, chlorine disinfection by-products. The study was performed in a Swedish river basin with a large, public water works located downstream from a bleached kraft mill. Chemical analyses (gas chromatography and determination of adsorbable organic halogen) and bioassays for mutagenic activity (bacterial and mammalian cell bioassays) were performed on samples of river water, drinking water and laboratory produced drinking water. (Edited author abstract). 45 Refs.

Wigilius, Bo (Univ of Linköping, Linköping, Swed); Boren, Hans; Grimvall, Anders; Carlberg, Georg E.; Hagen Inger; Brogger, Anton. *Sci Total Environ* v 74 n 1 Aug 1 1988 p 75-96.

**076181 KRAFT MILL BLEACH PLANT EFFLUENTS: RECENT DEVELOPMENTS AIMED AT DECREASING THEIR ENVIRONMENTAL IMPACT, PART 1.** Much work has been conducted to demonstrate new ways to decrease the formation of chlorinated organic compounds during bleaching. The authors review this research, the characteristics of bleach plant effluents, and the current effluent treatment methods. The formation of chlorinated organic compounds may be decreased by three basic methods. Part 1 covers the first two methods. The first is to remove more lignin during pulping by extending the pulping reaction, leaving less lignin to react with chlorine in the first bleaching stage. The second method is oxygen delignification, which is commercially practiced and may be employed to remove as much as 50 percent of the lignin prior to chlorination. (Edited author abstract). 48 Refs.

Heimburger, Stanley A. (FMC Corp, Princeton, NJ, USA); Blevins, Daniel S.; Bostwick, Joseph H.; Donnini, G. Paul. *Tappi J* v 71 n 10 Oct 1988 p 51-60.

**Electric Power** See Also PAPER AND PULP INDUSTRY—Canada.

**076182 UPGRADING HYDRO-ELECTRIC GENERATING FACILITIES.** Approximately 1,720,000 kW of installed hydro-electric generating capacity is either owned directly by pulp and paper companies in Canada or is operated principally in their service. The 216 units involved were commissioned between 1902 and 1982. This paper suggests an approach to upgrading the generating units themselves as well as the related electrical and mechanical equipment and civil structures, giving approximate durations and costs. A complete system study is recommended. (Author abstract) 2 refs.

Coulson, D.M. (Rousseau, Sauve Warren Inc, Montreal, Que, Can); Villalon, M. *Pulp Pap Can* v 88 n 11 Nov 1987 p 78-81.

**Emissions** See Also AIR POLLUTION—Air Quality; GASES—Purification.

**076183 EFFICIENT TRAPPING OF AMBIENT ORGANIC AND SULPHUR GASES FOR GAS CHROMATOGRAPHIC ANALYSIS.** The sensitivity of many available analyzers is inadequate for the quantitative analysis of low concentrations of volatile organic and sulfur compounds encountered in the environment of a pulp mill. An efficient trap (Tenax GC: Carbosieve G:95:5) has been developed to preconcentrate these gaseous components prior to analysis. (Author abstract) 9 refs.



de Souza, T.L.C. (PAPRICAN, Pointe Claire, Que, Can). *Pulp Pap Can* v 89 n 1 Jan 1988 p 139-144.

Pfafflin, G.E. (Hydro Inc, York, PA, USA). *Pulp Pap Can* v 88 n 11 Nov 1987 p 51-58.

**Energy Conservation** See Also ENERGY MANAGEMENT—Computer Applications.

#### Environmental Impact

**076184 STOCK PREPARATION ENERGY-SAVING MEASURES PRODUCE RAPID PAYBACK. PUMPS AND REFINERS ARE THE LARGEST ENERGY CONSUMERS IN A TYPICAL PAPER MILL: OPERATING AT THE HIGHEST EFFICIENCIES IS IMPERATIVE.** The article discusses energy savings potentials in pulping; cleaning and screening; fractionation; refining; storage and mixing; wastepaper washing and pumps. Many of the measures described require considerable investments, while others can be adopted at no significant expense. These improvements are, however, often the result of detailed engineering studies. By integrating the three aspects of technological requirements, energy-saving measures, and operational reliability and flexibility an optimum plant design concept will result. In many cases, simple measures can bring considerable savings without high investments.

Kohrs, M. (Sulzer Escher Wyss GmbH, Ravensburg, West Ger); Strobel, S.; Siewert, W.H. *Pulp Pap* v 62 n 4 Apr 1988 p 49-52.

**076185 METHODOLOGY AND APPROACH FOR UNDERSTANDING AND OPTIMIZING EXISTING PLANT THERMAL CYCLES.** When evaluating an existing plant's thermal cycle, it is important to understand how the plant actually performs under different production conditions. Operating conditions are affected by the type of pulp and paper products being manufactured, the type of fuels being consumed, the cost of purchased power, and the impact of seasonal variations. This paper presents a methodology and approach that has been used successfully to optimize energy usage and to reduce operating costs in existing plants. Each plant has a unique set of operating conditions, equipment configurations, fuel contracts, and power contracts. These factors require individual analysis to determine potential savings on a case-by-case basis.

Lunde, Jeffrey S. (Stone & Webster Engineering Corp, Boston, MA, USA). *Tappi J* v 71 n 7 Jul 1988 p 59-67.

**Energy Management** See Also ENERGY MANAGEMENT—Finland.

**076186 INCREASED PRODUCTION - DECREASED ENERGY CONSUMPTION.** A complete energy audit of the St. Jerome mill was carried out with the program based on: Installation of an energy-management system. Flash steam recuperation at the paper machine condensate tanks. Control of building heating and ventilating systems. Modification of process-air systems. White water recirculation and process water heating. The installation of two boilers lowered energy costs. Closely documented project objectives and close follow-up after the system's start-up permitted to achieve savings. 3 Refs.

Goulet, J.-P. (Rolland Inc, St. Jerome, Que, Can); Lapointe, M. *Pulp Pap Can* v 89 n 6 Jun 1988 p 111-114.

**Energy Utilization** See Also ENERGY CONSERVATION.

**076187 OPTIMIZING THE YIELD FROM EXISTING HYDRO-ELECTRIC GENERATING FACILITIES.** The increasing cost of electrical energy emphasizes the value of examining existing hydro-electric installations for opportunities to increase the energy production from such facilities. With energy representing between 10% and 30% of the total cost in the production of paper optimization, the sourcing of energy is particularly important to the paper industry. This paper examines opportunities for increased power generation at a number of facilities with the conclusion that most hydro-units that have not been upgraded during the past 30 years offer substantial opportunities for increased energy production with attractive pay back periods. (Author abstract)

**076188 SIDESTREAM OXYGENATION OF THE CAPE FEAR RIVER.** Results from operating and evaluating the 5000-lb/day sidestream oxygenation system showed that sidestream oxygenation is a feasible approach for upgrading the quality of the receiving stream. At the design feed rate of 550 lb of O<sub>2</sub>/h, the sidestream oxygen transfer efficiency increased from 83% to 90% after the drilled pipe sparger was replaced with an oxygen diffuser. Sidestream oxygen transfer efficiency decreased from 99% to 83% as the oxygen feed concentration increased from 77mg/L to 228 mg/L. Sidestream oxygen transfer efficiency increased from 42% at 9 s of retention time to 83% at 53 s of retention time at the design feed rate. Efficiency increased from 81% at 75 psig to 88% at 110 psig. Eductors that angled downward at 22° reduced oxygen losses from turbulence at the river surface and improved the mixing of the sidestream with the river. River survey results showed that the present oxygenation system increases the river's dissolved oxygen by approximately 0.5 mg/L but does not have sufficient capacity to raise the dissolved oxygen at the sag point to 5 mg/L. Analysis of the river upstream of the mill showed that the BOD load in the river is almost equal to and sometimes greater than the BOD discharged at the mill site. Empirical calculations showed that the total oxygen utilized in the river correlates better with the total BOD in the river than with the BOD discharged by our mill alone.

Daniels, Douglas L. (Federal Paper Board Co, Riegelwood, NC, USA). *Tappi J* v 70 n 11 Nov 1987 p 107-110.

**076189 TEN TIPS FOR THE INDUSTRY ON HOW TO AVOID ENVIRONMENTAL PROBLEMS.** The recently enacted Clean Water Act and dioxin furor require mills to be more vigilant in monitoring antipollution programs. The truth is that a company can get in trouble over something as seemingly small as improper disposal of a cleaning solvent. Smart mill managers avoid the trap with a systematic preventive approach to complying with environmental laws. Ten basic tips to help mills tackle the job of meeting waste disposal, clean air, and clean water rules are given. These include: environmental manager; training; policies; purchasing review; paper trail; spot checking; landfill review; environmental audit and declaration of responsibility.

Berge, Vanessa Mullins (Wyatt, Tarrant & Combs, Frankfurt, KY, USA). *Pulp Pap* v 62 n 4 Apr 1988 p 53-54.

**Equipment** See Also BOILERS; PAPER—Newsprint; PAPER—Sheeting; PAPERBOARDS—Manufacture; PAPERMAKING MACHINERY—Maintenance; PULP MANUFACTURE—Washing.

**076190 PREDICTION OF SUCTION ROLL PERFORMANCE IN PAPER MAKING.** Suction rolls are used to extract water from paper during paper making by applying a vacuum to the paper web as it passes over the roll surface. Suction rolls have frequently suffered from cracking during service, apparently as a result of corrosion fatigue processes. The search continues for improved suction roll alloys with greater resistance to corrosion fatigue. Previous laboratory tests to measure the corrosion and cracking resistance of candidate alloys have not always displayed good correlations with the performance of these alloys in service. The need for more relevant laboratory tests to predict the service performance of suction rolls is discussed in light of the demands of suction roll applications. Near-threshold fatigue crack growth testing has been conducted on superior and inferior suction roll alloys to determine whether these tests offer better agreement with service performance. A correlation was found between service performance and near-threshold fatigue crack behavior in dilute chloride solutions under conditions of high tensile mean stress. (Author abstract) 15 refs.

Yeske, R.A. (Inst of Paper Chemistry, Appleton, WI, USA). *Mater Perform* v 26 n 10 Oct 1987 p 30-37.

**076191 PULP-STONE DESIGN OPTIMIZATION FOR QUALITY AND PRODUCTION.** Computer-generated models were used to design a pulp stone equal to the demands of today's groundwood process. The study focused on the elimination of core cracking and segment pullout and the minimization of thermally induced segment breakage. Technology for the type of analysis sought was established.

Bernier, W.E. (Norton Co, Worcester, MA, USA); Broderick, L.E.; Loly, M.M. *Tappi J* v 71 n 1 Jan 1988 p 71-76.

**076192 UPGRADING THE COMBUSTION SYSTEM OF A 1956-VINTAGE RECOVERY STEAM GENERATOR.** The upgraded steam generator has demonstrated a 60% increase in steam production over nameplate rating, a 20% increase in liquor processing capability, a 200% increase in operational on-line time between dry cleaning, and a 99% reduction in TRS emissions. (Author abstract)

Fridley, M.W. (Mid America Packaging, Pine Bluff, AR, USA); Barsin, J.A. *Tappi J* v 71 n 3 Mar 1988 p 63-69.

**076193 APM TAKES NEW VIEW OF FINISHING FLOW.** Confronted by a complex web of problems at its Petrie mill, Australia's largest paper manufacturer, APM, has adopted an innovative approach to board finish. As part of a program which will eventually cut order-to-delivery times from 4-6 to two weeks, the mill has effectively separated its papermaking operations from the finishing department. Output from the PM is stored as coreless jumbo rolls in a new 10,000-m<sup>2</sup> warehouse. Collapsible shafts are used to move the rolls to the finishing department machinery. The seven collapsible series 750 leaf-type shafts supplied by Tidland Corp., USA, are central to the scheme. They have a face width of 3.5 m, a diameter of 600 mm and weight three tons each. They are believed to be the largest in operation in the world's paper industry. Without them, the whole philosophy behind a \$20-million plus investment at Petrie over the last 18 months would be unworkable.

Bayliss, Martin. *PPI Pulp Pap Int* v 29 n 11 Nov 1987 p 72-73.

**076194 GEARED MOTORS WITHSTAND TOUGH OPERATING CONDITIONS.** Geared motors provide the required speeds at the point of application without the need to interpose further speed reduction components. They are consequently coming into wider use, especially where a high degree of Ingress Protection (IP code) is specified so that they can be installed in the most exposed positions. Good geared motor units thus offer not only above-average motor efficiencies but also a favorable gearing efficiency which, with present technology, cannot be improved upon in series production. Even with right-angled drives, which, due to space limitations, are often unavoidable, the bevel gear units that are available enable good efficiency to be obtained in comparison with the worm driven which are frequently used for the purpose. Steps in the range of speeds are discussed. Factors relating to noise levels are outlined. Corrosion protection, mechanical braking and real-lubrication intervals are examined from the viewpoint of maximizing equipment operating life.

Greiner, Helmut (Eberhard Bauer GmbH, Esslingen, West Ger). *Pulp Pap Can* v 89 n 9 Sep 1988 p 33-35, 38-40.

**Expansion** See PAPERMAKING—Federal Republic of Germany.

#### Finland

**076195 DID YOU SAY WOODFREE LWCT?** To help cut postal costs of paper for direct mail houses, Tervakoski mill of Finland has rebuilt a large 4.5-m trim PM 12 during 1984-1985. Only the wire section was left from the original unit. The majority of the new equipment was supplied by Ahlstrom, including the press and dryer sections, and a modified size press, which is used for application of coatings. A new machine calendar, from



Hunt & Moscrop, was also installed. Burned lime, which is converted into precipitated calcium carbonate (PCC), is used as a filler material and also as a coating ingredient. The lime is converted at a plant on the mill site, which is Europe's first on-site PCC unit at a mill. The success of Tervakoski with the production of thin printing papers using the new PM owes itself very much to the use of chalk to preserve opacity.

O'Brian, Hugh. *PPI Pulp Pap Int* v 29 n 11 Nov 1987 p 80-81.

## Flexible Manufacturing Systems

**076196 CONSTRUCTION OF WORLD'S MOST ADVANCED BLEACHED CTMP MILL IS ON TRACK.** The mill's major process equipment include: 60-inch, 12,000 hp refiners, pressurized screens, cleaners and disc filters, twin-roll presses, hydraulic drives for dewatering presses, flash dryers, finishing line with slab/bale presses. The extremely flexible facility will operate as a specialty pulp mill, making a wide variety of grades to meet the individual technical requirements of tissue/towel, printing and writing papers and paperboard manufacturers. The new mill's process control system will consist of a Bailey Control Network 90 distributed control system and General Electric Series 6 Genius programmable controllers.

Anon. *PIMA Mag* v 69 n 8 Aug 1987 p 34-35.

## Flow Sheets

**076197 INTERACTIVE MICROCOMPUTER FLOWSHEET CALCULATIONS.** The computer program FlowCalc is a modular simulation software package designed to run on a personal computer. It combines the interactive editing, graphic, and spreadsheet-like input/output capabilities of microcomputers with the modeling and simulation capabilities of modular simulation software. This program, coupled with the low cost and fast response of dedicated microcomputers, allows process simulation to be more readily available throughout the industry to engineering and technical professionals. The context for microcomputer flowsheet calculations and process simulation is discussed, leading to the specification of appropriate hardware and software tools for implementation on microcomputer. (Edited author abstract) 21 refs.

Rouda, Robert H. (Univ of Wisconsin, Stevens Point, WI, USA). *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul Publ by TAPPI Press*, Atlanta, GA, USA, 1985 p 125-135.

## Gas Turbines

**076198 AERO-DERIVATIVE GAS TURBINES GAINING INDUSTRY FAVOR.** Aero-derivative gas turbines have their place in the paper industry. Their high efficiency, reliability, availability and good maintainability, coupled with the added flexibility of Stream Injected Gas Turbines (STIG) cycles, can offer a good fit with the power and steam requirements of many paper mills. Cogeneration systems based on aero-derivatives can help the paper industry maintain its outstanding record of energy management and its lessening dependence on fossil fuels through the efficiency advantages such systems provide.

Brown, R.M. (GE); Gray, R.H. *PIMA Mag* v 69 n 7 Jul 1987 p 17-21.

**076199 GAS TURBINES SUPPLY ENERGY NEEDS IN PAPER INDUSTRY.** Three total energy applications involving Ruston gas turbines have recently been detailed, two of these being cogeneration installations and the third a combined-cycle set. All are in the U.K. paper industry. A Ruston Tornado is the prime mover in a new cogeneration (CHP) plant installed at the Burneside, Kendal, plant of James Cropper plc, the specialist paper maker. The total investment here amounts to £2.75 M, and has been made in response to a changing heat-to-power balance. The new RGT gas-turbine set will

enable Cropper to meet all its electricity needs in-house, and enable the company to sell power to the national grid.

Anon. *Diesel Gas Turbine Worldwide* v 20 n 5 Jun 1988 p 15-16.

## Health Hazards

**076200 LOW HEALTH RISK SEEN FOR DIOXIN IN PAPER PRODUCTS.** The chemical 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and 2,3,7,8-tetrachlorodibenzofuran (TCDF) are formed as trace contaminants in paper mills during bleaching of kraft pulps with chlorine and chlorine derivatives to make white products. The bleaching process varies among mills, producing varying TCDD and TCDF levels. In a study of seven pulps, for example, TCDD levels ranged from nondetectable (below the detection limit of 1.0 ppt) to 51 ppt, with a median of 4.9 ppt. Study finds skin exposure to TCDD in paper goods to be far below hazardous levels; work is under way on paper dust, food packaging.

Krieger, James. *Chem Eng News* v 66 n 2 Jan 11 1988 p 22-23.

Instruments See DRYING—Measurements.

## Korea

**076201 MAKING THE MOST OF BEING THE NEWEST.** Korea's biggest papermaker, Kye Sung, runs the most modern mill. It makes woodfree papers, coated and uncoated. Like others, it has been enjoying higher export sales, specially to the USA. (Author abstract)

Sutton, Peter. *PPI Pulp Pap Int* v 30 n 4 Apr 1988 p 49-51.

## Machinery

**076202 KERWIN PAPER'S NO. 1 PAPER MACHINE REBUILD INCREASES PRODUCTION 45%.** The author describes how the production on a 62-year old specialty paper machine has increased 45% with a new conventional press with blind-drilled rubber-covered roll. The dryer siphoning technique was changed to rotary siphoning which afforded a 10% drying increase.

Anon. *Pulp Pap* v 62 n 6 Jun 1988 p 94-95.

**076203 GILMAN PAPER ADDS Eo BLEACH STAGE AS FIRST PHASE OF PLANT EXPANSION.** Gilman Paper Co., St. Marys, Ga., started up an oxygen extraction stage in September 1987, which has resulted in a CE(OH)DED bleaching sequence. The success of this Eo stage has been shown by a reduction in bleaching costs as well as by lower shive content in the bleached pulp. Gilman is currently installing equipment to split the 600-tpd plant into two 500-tpd bleach plants with a planned startup of both plants by July 1988. Addition of the bleach stage has allowed an existing five-stage sequence to be split into two three-stage lines, thus significantly increasing the production. 4 refs.

Dubose, John (Gilman Paper Co, St. Marys, GA, USA). *Pulp Pap* v 62 n 6 Jun 1988 p 104-107.

**076204 AUTOMATED SYSTEM PREPARES COATING FOR WORLD'S LARGEST LWC MACHINE.** United Paper Mills installed a new lightweight coated paper machine at their facility in Finland. Author describes the machine and the new coating preparation system in detail in his article.

Ducey, Michael J. (Pulp & Paper, San Francisco, CA, USA). *Pulp Pap* v 62 n 5 May 1988 p 43-45.

**076205 CLOTHING COMPANIES JOIN SPC TREND WITH FAST, STREAMLINED PROGRAMS.** Paper machine clothing suppliers have implemented statistical process control programs. Author describes how SPC has improved the quality of the product in the clothing companies.

Ferguson, Kelly H. (Pulp & Paper, San Francisco, CA,

USA). *Pulp Pap* v 62 n 5 May 1988 p 46-50.

**076206 REPAP BEGINS MAJOR COATED FREE-SHEET CAPACITY EXPANSION AT MIDTEC.** Midtec Paper Corp., a Repap Enterprises Corp. Inc. affiliate, is currently building the most advanced coated free-sheet papermaking complex in the world at its Kimberly, Wis., site. The 205,000-tpy facility will cost upwards of \$250 million, and it will create 100,000 tons of incremental coated free-sheet capacity. Author describes the papermaking complex including forming, pressing, drying, coating, supercalendering, process control system, construction schedule and coating preparation as well as how the increase in productivity is attained in the plant.

Patrick, Ken (Pulp & Paper, San Francisco, CA, USA). *Pulp Pap* v 62 n 5 May 1988 p 86-90.

Maintenance See Also MAINTENANCE—Computer Applications; WINDING MACHINES—Vibrations.

**076207 MAINTENANCE PERFORMANCE EVALUATION: A FOLLOW-UP REPORT.** The Maintenance Performance Evaluation (MPE) exposes a cross-section of mill management/staff, production and maintenance personnel to 400 desirable standards of performance. These personnel, who range from managers to hourly employees, compared the standards with their views on the degree to which their mills met each standard. The results are processed to yield composite scores on each standard so that the mill can set aside those aspects which it performs well while focusing on those which need improvement.

Anon (Paul D. Tomlinson Associates Inc). *PIMA Mag* v 69 n 8 Aug 1987 p 38-41.

**076208 SETTING UP AND OPERATING A COST-EFFECTIVE PREDICTIVE MAINTENANCE PROGRAM AT CHAMPION PAPER COMPANY.** The article briefly describes a maintenance program at the Champion Paper Company plant in Quinnesec, Michigan. The predictive maintenance program currently monitors approximately 6,600 points. Some of the units covered are the pulp machine, pulp mills, boilers and woodyard area.

Anon. *Pract Lubr Maint* v 10 n 3 Sep 1987 p 19-20.

**076209 MEETING THE MAINTENANCE CHALLENGE.** As Canadian mills produce record quantities of pulp and paper, maintenance managers face more pressure to keep things running smoothly. This report, prepared from discussions at the CPPA maintenance conference in Saint John, N.B. in October and from other research, looks at some of the problems and possible solutions.

Karl, Wayne. *Pulp Pap J* v 40 n 9 Nov 1987 p 26-27.

**076210 RESULTS ORIENTED MAINTENANCE: THE FUTURE PRODUCTIVITY FACTOR.** In a study of 130 Swedish pulp and paper mills, the author found that the number of mills had decreased more than 31% in the last 15 years. During the same period, the number of hourly operators decreased by more than 18%, while the number of hourly maintenance personnel decreased by only 3.5%. Fifteen years ago, about 26% of all hourly employees were maintenance personnel. Today, that average is about 31%. In many mills, maintenance employees comprise more than half the payroll. In a highly-automated future mill, maintenance people may comprise 70 to 80% of the total mill payroll. Productivity will depend more on reliable and maintainable equipment and efficient maintenance than on efficient operations.

Idhammar, Christer (PBI Maintenance Inc, Raleigh, NC, USA). *PIMA Mag* v 69 n 12 Dec 1987 p 30-33.

**076211 WHERE SCAN AND US MILLS EXCEL.** This article summarizes the author's maintenance philosophy and how this applies to Scandinavian and US pulp



and paper industries, based upon the author's 20 years of experience as a maintenance management consultant in Scandinavia and North America. (Author abstract)

Idhammar, Christer. *PPI Pulp Pap Int* v 30 n 4 Apr 1988 p 41-44, 54.

**076212 PREVENTION IS BETTER THAN CURE.** A PPI survey of 15 EEC paper mills in the newsprint, printings/ writings and packaging sectors, showed that most were either using or planning to implement a preventive maintenance program. (Author abstract)

Pearson, John. *PPI Pulp Pap Int* v 30 n 4 Apr 1988 p 46-48.

**076213 MAINTENANCE SYSTEMS - A CRITICAL CHOICE.** A predictive maintenance programme is developed which is based on the principle that 'the operator is responsible for every aspect of production including the well-being of his equipment'. This concept depends on multi-skilling, or cross-crafting. Over a three year period, the in-house maintenance programme has reduced downtime, increased output, and enabled the paper mill to put in a more consistent performance. At the same time, outside contracting was reduced and labour productivity improved. A mill can achieve this structure through a maintenance management system. The software gives the maintenance crews easy access to the information that is necessary for decision-making and efficiency. The system includes files on all the equipment in the mill.

Anon. *Pap Technol Ind* v 29 n 3 May 1988 p 91, 93.

**076214 MAINTENANCE PROCEDURES FOR COMBATING CORROSION AND BUILDUP OF DEPOSITS.** A wide variety of industrial cleaning services are available for all three major areas of a pulp and paper mill: power and steam generating equipment, pulp processing equipment, and paper making machinery. Although chemical cleaning can be offered using many different types of chemicals and processes, hydrojetting is probably the fastest and most effective method for most pulp and paper mill machinery. The maintenance, cleaning, and corrosion protection of the three types of equipment mentioned above is discussed. In particular, it is stressed that sufficient cool-down time must be allowed to prevent the molten chemical bed from overheating the cleaning solutions, thus causing severe corrosion of metal surfaces. Calcite deposits develop very rapidly in digesters that are pushed to peak production. The hotter the temperatures, the faster deposits form.

Lewis, George (Halliburton Services, Duncan, OK, USA). *Pap Trade J* v 169 n 5 May 1985 p 57-58.

**076215 1987 MAINTENANCE CONFERENCE.** This conference proceedings contains 29 papers, one of which is in French. Some of the subjects covered are maintenance of papermaking machinery, computerized maintenance management, electrochemical metallizing, vibration analysis, helium leak detection, condition monitoring, roll measurements, predictive maintenance, and nondestructive examination. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10870 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (CPPA, Technical Section, Montreal, Que, Can). *1987 Maint Conf, St. John, NB, Can, Oct 20-22 1987* Publ by CPPA, Montreal, Que, Can, 1987 169p.

## Management

**076216 PLATFORM FOR MILLWIDE INFORMATION SYSTEMS.** In one typical installation, the system functions provide, capture, manage, and archive all relevant production information from each parent roll. The building blocks of the structure are: data acquisition; real-time database management; continuous history database management; event history database management; relational database management (optional).

Koppel, Lowell B. (Setpoint Inc, Houston, TX, USA);

Llansa, Jorge I. *Tappi J* v 71 n 6 Jun 1988 p 61-64.

**076217 HOW TO APPLY ANALYTICAL PROBLEM-SOLVING TECHNIQUES IN YOUR PAPER MILL.** Madison Paper Industries experienced a problem with the spindles on two Bruderhaus supercalenders with a screwmatic configuration for three months, and then decided to put together a team to correct the irregular nut movement on the spindles. The key points of this case study are that a multi-disciplined team (different maintenance specialties plus operations) involving interested parties (operators) used a systematic approach to solve a difficult problem. Obviously, most problems in a mill are corrected without taking the time to pull various individuals together as a team. Team problem-solving can foster better cooperation between departments, create excitement for doing the work and improve productivity.

Beary, Rodney P. (PIMA Training Inst); Bearce, Clarence J. *PIMA Mag* v 70 n 7 Jul 1988 p 8-10.

Materials See METALS TESTING—Creep.

Modernization See Also PAPERMAKING—Finishing; PAPERMAKING MACHINERY.

**076218 ROTHESAY RESPONDS TO PRESS-ROOM DEVELOPMENTS BY ADDING QUALITY.** At Rothesay Paper Ltd., Saint John, N.B., paper machine, winder and pulp facility modernizations are a direct response to growing quality requirements. Rothesay saw numerous benefits of the upgrade soon after the rebuilt machines were started up, among them improved sheet formation and reduced steam consumption.

Karl, Wayne. *Pulp Pap J* v 40 n 7 Sep 1987 p 35, 37, 39.

**076219 MODERNIZATIONS AND EXPANSIONS: ANALYZE ALL THE ALTERNATIVES BEFORE YOU PROCEED.** Modernizations and expansions are integral parts of a papermaker's job and they must be approached in a formal and professional manner, the author says. The paper takes a hard look at the considerations and limitations that are part of any major project. (Edited author abstract)

Bellafronto, Malcolm J. (Pope & Talbot Inc). *PIMA Mag* v 69 n 3 Mar 1987 p 35-38.

**076220 REED PAPER MACHINE MODERNIZATION TAKES TWO-SIDEDNESS OUT OF NEWS-PRINT.** The newspaper machines modernization of Reed Inc., Quebec Mill Division, included Bel Bond formers on all machines, Combi presses on P.M. 1 and 2 and Tri-Nip presses on P.M.3 and 4. The object of the program was newsprint quality improvement from a printability point of view. Cost competitiveness and incremental production increases were also contemplated. This program included a modernization related to improvement in working conditions, environment and energy conservation. The paper reviews various paper properties and how they were affected by Bel Bond-Combi press and Bel Bond-Tri-Nip press combinations. The program was completed in May 1986. (Author abstract)

Sarasin, A.C. (Reed Inc, Quebec City, Que, Can); Samson, G.E. *Pulp Pap Can* v 88 n 10 Oct 1987 p 75-77.

**076221 CASCADES AIMS TO MAKE PORT CARTIER THE LARGEST BCTMP MILL IN THE WORLD.** When Cascades bought the ITT mill in 1986 for \$20 million, a \$90-million program was set in to convert the sulfite mill to a bleached chemithermomechanical operation. New equipment includes seven screw presses, eight CTMP refiners, a chip handling system, astock handling system, a medium consistency stock pump, and several motors up to 30,000 hp. The revitalized systems include the bleach plant, the pulp machine, power boiler, water treatment plant, roll handling equipment, and bale finishing equipment.

Williamson, Peter N. (Pulp & Paper Canada, Westmount, Que, Can). *Pulp Pap Can* v 88 n 11 Nov 1987 p 23-25.

**076222 FALK A DRIVING FORCE BEHIND**

**BOWATER PROJECT.** When it comes to a complex process like papermaking, the important role that gear drives play can be easily overlooked. However, speed reducers and couplings are important because, together, they transmit driving forces and produce the necessary torque for turning shafts. If this function fails, the entire PM goes down. This paper reports the modernization of Bowater Carolina Co., which included besides the Falk speed reducers, development of a new woodyard, de-barking equipment, chip conveyor, kraft digesters, demineralizers, evaporators and control systems.

Anon. *PIMA Mag* v 69 n 12 Dec 1987 p 26-27.

**076223 LAKE SUPERIOR PAPER INDUSTRIES BEGINS SUPERCALENDERED PRODUCTION.** Lake Superior Paper Industries (LSPI) began producing uncoated supercalendered (SC) groundwood paper at its Duluth, Minn., greenfield mill early last November. Lake Superior Paper is a joint venture of Pentair Inc. and Minnesota Power. Built at a cost of approximately \$400 million, the mill is designed to initially produce 243,000 tpy on a single machine, and the site is laid out to accommodate two additional machines. Its entire 1988 output is already under contract, and demand for high-quality SC-A paper is so good that management is now anticipating that work on a second machine may begin as early as 1991. The article describes the modernization/expansion project and the machinery, finishing operations, pressure groundwood system, personnel hiring/training.

Smith, Kenneth E. (Pulp & Paper, San Francisco, CA, USA). *Pulp Pap* v 62 n 4 Apr 1988 p 118-123.

**076224 DAISHOWA BEGINS BUILDING C 500 MILLION DOLLARS MARKET PULP MILL IN ALBERTA.** Daishowa is involved in two joint ventures in Canada, both undergoing aggressive expansion programs. Cariboo Pulp & Paper Co is expanding capacity 55,000 metric tpy (softwood chemical market pulp) including a recovery boiler rebuild, a new pressure diffuser, a slaker, and high-density storage. At Quesnel River Pulp Co. chemithermomechanical pulp (CTMP) capacity is being increased by 50 percent with the addition of a 275-metric-tpd TMP line, Flakt dryers, and related engineering. Daishowa also agreed to purchase the assets of Reed International plc's North American Paper Group for C 565 million dollars. The acquisition gives Daishowa a foothold in the North American newsprint market with a 417,000-metric-tpy mill in Quebec City, Que. The mill also produces 35,000 metric tpy of boxboard and 20,000 metric tpy of sulfite pulp. The deal includes a packaging plant, a pigment manufacturing plant, and two lignin sulfate plants.

Ducey, Michael J. (Pulp & Paper, San Francisco, CA, USA). *Pulp Pap* v 62 n 8 Aug 1988 p 96-98.

**076225 PENSACOLA CONVERSION BRINGS MILL INTO CORPORATE MAINSTREAM.** When Champion International Corp. changed its Pensacola, Fla., kraft mill into a manufacturer of white paper, it was the single largest conversion of such a facility ever attempted. The project's centerpiece was a full rebuild of the world-class P-5, including a Beloit Bel Form top wire, new stock prep, headbox and white water installations and the addition of a size press in the rebuilt dryer section. Existing Measurex Corp. profile controls were upgraded and linked to Foxboro Videospecs. Other major additions at Pensacola included a Sunds Defibrator two-line, short-sequence bleach plant with medium-consistency oxygen delignification. Also incorporated into the change-over was a new finishing and converting operation for cut size, sheeting and variable rolls. A new participative style of management has also been introduced.

Anon. *PIMA Mag* v 70 n 9 Sep 1988 p 28-30.

**076226 PULP MILL LIME KILN IMPROVEMENT PROJECTS PRODUCE RAPID PAYBACK.** Several kiln upgrade methods are presented along with costs,



savings, and paybacks. Energy savings as high as 420,000 dollars/year can result, with paybacks as short as three months. Additional benefits include increased production and reduced maintenance costs. Savings and paybacks discussed are based on 300 tpd production, 350 days/year operation, and 2/1 million dollars Btu fuel cost.

Puhr, Francis (Francis Puhr Corp, Clearwater, FL, USA). *Pulp Pap* v 62 n 10 Oct 1988 p 154-157.

## Modification

**076227 CHAMPION UNVEILS P-5, WORLD'S LARGEST PRODUCER OF UNCOATED BLEACHED FREE-SHEET.** This paper reports the conversion of Champion International Corp's brown kraft mill to a producer of fine white paper. The conversion involved a new bleach chemical prep area. Champion installed new facilities for chemical receiving, unloading and storage, as well as a new chlorine dioxide plant.

Anon. *PIMA Mag* v 70 n 1 Jan 1988 p 19-23.

## Optimization

**076228 STUDY OF BROKE HANDLING AND WHITE WATER MANAGEMENT USING A DYNAMIC SIMULATION.** Computer process simulation is becoming widely used in the pulp and paper industry as a tool for process design and optimization. However, most of the programs available are steady-state simulators. For operator assistance and for testing possible control actions, it is important to describe the dynamics of the process. A steady-state flowsheet simulator was adapted at the Pulp and Paper Research Institute of Canada (PAPRICAN) to analyze mill-wide dynamic behavior. The model was used in an integrated TCMP-newsprint mill to evaluate different broke handling and white water management strategies. (Author abstract) 2 refs.

Croteau, A.P. (PAPRICAN, Pointe Claire, Que, Can); Roche, A.A. *Pulp Pap Can* v 88 n 11 Nov 1987 p 74-77.

**076229 OPTIMIZATION OF THE (CD) (EO) BLEACHING SEQUENCE AT CHAMPION'S QUINNESEC MILL.** The Quinnesec mill is ideal for a statistical study because its information systems provide nearly all of the data required to completely describe the bleaching process. Statistical modeling techniques are a convenient way to process the mill data to predict pulp qualities and other parameters from key operating variables. 4 refs.

Powell, David A. (Michigan Technological Univ, Houghton, MI, USA); Barna, Bruce A.; Sullivan, Pat. *Tappi J* v 71 n 6 Jun 1988 p 49-55.

Peoples Republic of China See PAPERMAKING MACHINERY—Retrofitting; PULP MATERIALS—Straw.

## Piping Systems

**076230 QUALITY STARTS WITH PIPING IN THE APPROACH FLOW SYSTEM.** The piping in the approach flow system of a paper-mill can have a big impact on paper quality. It can cause disturbance in the flow of stock - due to the position of bends and valves, for example. And this has a knock-on effect on the accuracy of the flowmeter and the consistency of the stock delivered at the making box. Flowmeters, which work well in ideal conditions, may not be accurate in a paper-mill. Correct installation and upstream piping are of the first importance. The aim of this paper is to give some ideas for the solutions of installation problems. It concentrates on the flow disturbances and on the effects of flow profiles on electromagnetic and vortex flowmeters. Some suggestions for upstream piping are made. 12 refs.

Halttunen, Jouko (Tampere Univ of Technology, Finl). *Pap Technol Ind* v 28 n 8 Nov 1987 p 682-683, 686-687, 689.

**076231 DESIGN OF ABOVEGROUND FIBERGLASS-REINFORCED PIPING SYSTEMS.** Process piping is one of the most complex and demanding systems

in a pulp and paper mill. Piping failures can produce temporary system outages or an entire plant shutdown. The design of FRP pipe is unique in the world of piping design and necessitates that certain precautions be taken in the purchase of the pipe. The author presents an overview of the general nature of problems experienced in piping systems and describes an engineering approach by which the mill engineers can best assure the success of new FRP piping systems. 5 refs.

Renoud, Winston J. (Fiberglass Structural Engineering Inc, Bellingham, WA, USA). *Tappi J* v 71 n 3 Mar 1988 p 55-59.

**076232 OPTIMUM DESIGN OF PULP STOCK PIPELINES.** Because power costs will continue to increase, perhaps even at an accelerated rate in the future, the design engineer must consider power costs as well as capital costs on any project. Optimum pipe design is based on the least sum of fixed costs and power costs. In many installations, pipe friction is responsible for a sizable portion of pumping power costs. The engineer must also consider proper design for nonplugging operation. The method presented here allows the engineer to select a pipe size from friction loss curves on which optimum flows and nonplugging flows are shown. The method applies to stocks of all consistencies and can be extended to any stock for which pipeline friction parameters are known. The curves presented at the end of this paper are for consistencies of 1.5-6.0%. 4 refs.

Laskey, H.L. (Simons-Eastern Consultants Inc, Portland, ME, USA). *Tappi J* v 71 n 6 Jun 1988 p 79-83.

## Port Cartier, Canada

**076233 CASCADES GETS SET TO START CTMP PRODUCTION AT REJUVENATED MILL.** The Port Cartier market pulp mill - a former sulfite operation mothballed in 1979 - is about to begin production again under new owner Cascades Inc. The mill is to produce 180,000 tpy of bleached chemi-thermomechanical pulp (BCTMP). Details of production plans and equipment are given.

Karl, Wayne. *Pulp Pap J* v 40 n 9 Nov 1987 p 20-21, 23, 25.

Port Hudson, LA See PAPERMAKING MACHINERY—Felts.

## Power Supply

**076234 CROPPER UPGRADES ENERGY SYSTEM.** As part of a continuing investment program at its Burnside mill, UK specialty papermaker James Cropper has started up a gas turbine combined heat and power system. (Author abstract)

Jeffs, Eric. *PPI Pulp Pap Int* v 29 n 12 Dec 1987 p 39-41.

**076235 GAS TURBINES LEAD CHP REVIVAL.** Over the last 40 years, significant reductions have been made in the amount of energy required to make a ton of paper. This has been accompanied by a shift in the balance of energy demand from steam towards electricity. Technical developments in energy efficiency and process control have so altered the heat to power balance in the paper industry that combined heat + power systems are again viable. The article describes some current turbines.

Jeffs, Eric. *PPI Pulp Pap Int* v 30 n 3 Mar 1988 p 40-42.

**076236 PM AND POWER ADDED AT ROERMOND.** A Third Paper machine and a fourth gas turbine combined heat and power (CHP) set were the key elements in a DFI 160-million (about \$86 million), five-year investment program completed last year by Dutch producer Roermond Papier. The power plant extension was the final element of the program and started up in October of last year. The new 100,000-ton/yr PM 3 had been started up in August 1986.

Jeffs, Eric. *PPI Pulp Pap Int* v 30 n 3 Mar 1988 p 43-44, 51.

Process Control See Also CONTROL SYSTEMS, DISTRIBUTED PARAMETER; PAPERMAKING—Finishing.

## 076237 TALE OF FOUR MILLWIDE PROJECTS.

From an analysis of four millwide projects in this article, it is concluded that those projects which were based on a long-term plan came out with adaptable and maintainable systems, despite the rapid advance of technology during the lives of these projects. The millwide control encompasses regulatory, supervisory/optimization control. It is the integration of the individual process areas (e.g., digestion, recovery, stock prep, etc.) into a coordinated unit. Millwide incorporates production management and management information systems functions. In addition, millwide can also integrate features such as on-line simulation, on-line maintenance, automatic laboratory management and future items such as robotics.

Kallos, S.E. (Valmet Automation); Nieminen, P. *PIMA Mag* v 69 n 7 Jul 1987 p 29-33.

**076238 CONTROL SYSTEM PERFORMANCE MANAGEMENT: THE HUMAN FACTORS.** Not many companies in the pulp and paper industry successfully manage process control technology and achieve a marked competitive edge as a result. Control system performance directly affects product quality, yet tends naturally to decay with time, often as a result of human factors. Staffing, training, a common language, distributed knowledge, organization and motivation are the issues. Corporate culture and climate will determine how different companies cope. (Author abstract) 4 refs.

Bialkowski, W.L. (Entech Control Engineering Inc, Toronto, Ont, Can). *Pulp Pap Can* v 88 n 12 Dec 1987 p 243-248.

**076239 HOW STATISTICAL PROCESS CONTROL WORKS IN A CORRUGATED BOX PLANT.** Most of the SPC work in the corrugated industry is really a form of statistical quality assurance. This is a prerequisite to true SPC, which involves control of machine settings to reduce variation in product quality. (Author abstract) 4 refs.

Carlson, David A. (Stone Container Corp, Chicago, IL, USA). *Tappi J* v 71 n 3 Mar 1988 p 75-79.

**076240 JAMES RIVER IMPROVED PERFORMANCE, SAVES MONEY WITH ITS CORPORATE PROCESS CONTROL SYSTEM MAINTENANCE PROGRAM.** The Cascade Mill in Gorham, N.H., is the latest James River facility to subscribe to the corporation's process control system (PCS) in-house support program. Mills in Livermore Falls, Me., and Groveton, N.H., transferred maintenance responsibility from vendors to the newly formed James River Digital Field Service (DFS) organization in early 1986, and the Cascade Mill did so this past January. The James River Digital Field Service organization is responsible for hiring, training, and providing technical direction to systems technicians assigned to the three mills. Although administratively personnel report to the DFS organization, pragmatically they are part of mill technical and production teams. This relationship is viewed as essential in establishing a successful in-house program. Each mill also assigns a coordinator from its staff to work closely with DFS technicians on work assignments and communication with various mill departments involved in the maintenance effort.

Young, Jim (Tappi Journal, Norcross, GA, USA). *Tappi J* v 71 n 4 Apr 1988 p 93-96.

**076241 BLEACHING OPERATIONS ARE OPTIMIZED BY DISTRIBUTED CONTROL CAPABILITIES.** The paper mill is dependent on consistent high-quality output from the bleach plant. Using modernized control strategies and techniques, this consistency can be achieved. As a future benefit, the overall upgrade of the mill information base makes mill wide information system



tie-ins practical. Advanced graphics, intelligent alarming capabilities, and new sensors are ideal for multitude of variables that must be handled.

Roberts, Jim (American Technical Services Inc, Tucker, GA, USA); Dartt, Steve. *Pulp Pap* v 62 n 4 Apr 1988 p 165-168.

**076242 STATISTICAL PROCESS CONTROL NEEDS MANAGEMENT COMMITMENT, SUPPORT.** A company began a corporate-wide statistical process control (SPC) program at its press felt manufacturing operations. To implement the program, an in-depth seminar was held for some 30 key Scafa Group employees. The two-day training session focused on SPC mechanics and, in particular, examined specific benefits that can be expected if a company is committed to a program and willing to dedicate necessary time and resources on a daily basis.

Anon. *Pulp Pap* v 62 n 4 Apr 1988 p 178-179.

**076243 STATISTICAL PROCESS CONTROL: AN OVERVIEW OF GOALS AND IMPLEMENTATION.** Traditional approaches to quality control focus on detecting defective product that has already been produced. This approach is costly and wasteful, since defective product must be reprocessed, downgraded, or scrapped. In contrast, the emphasis of statistical process control (SPC) is in preventing the production of defective product. The SPC approach is used to reduce process variability based on the collection and analysis of process data. Unusual process variability is detected using a statistical tool called a control chart. The causes of these variations can then be identified and eliminated. The result is reduced process variability and better process performance.

O'Connell, Richard T. (Miami Univ, Oxford, OH, USA). *Tappi J* v 71 n 6 Jun 1988 p 127-132.

**076244 REPAI BUILD'S WORLD'S LARGEST COATED FREE-SHEET MILL AT MIDTEC.** The project includes one paper machine, two coaters, three supercalenders, two winders and two sheeters. The mill's components include: top wire papermaking machinery; three-nip press with a fourth independent press; two off-machine blade coaters operating in tandem, 2 coaters using applicator roll coaters with a bent blade option; 3 14-roll super calenders with chromium-plated steel rolls; Vari-Top winders; 2 precision sheeters; a Valmet Automation process control system. When the facility goes into production, it will increase Repap's total coated paper capacity to around 700,000 tpy.

Anon. *PIMA Mag* v 70 n 6 Jun 1988 p 63-68.

**076245 TECHNIQUES FOR EXPANDING THE SPHERE OF STATISTICAL PROCESS CONTROL.** As more and more North American paper companies make firm commitments to the continual pursuit of quality improvement, formal, corporate-wide systems for quality control are being instituted. The most successful of these use statistical process control (SPC) to monitor and control processes and to help attain improvements in quality and productivity. If a mill produces only a few grades, SPC may be relatively easy to use. However, when many grades are produced and these grades are changed often, the implementation of SPC can be difficult and confusing. There are workable alternatives to the standard SPC charts for mills in which the production mix makes implementation difficult. When product changes affect process variability, the use of actual minus target values, percent of target value, and Z-scores can allow breakthroughs in quality improvements. 6 Refs.

Armitage, S.J. (Nalco Chemical Co, Naperville, IL, USA); Wilharm, M.T. *Tappi J* v 71 n 7 Jul 1988 p 71-77.

**076246 QUEBEC & ONTARIO PAPER CO. CHOOSES DISTRIBUTED CONTROLS FOR FLEXIBILITY.** The company implemented the strategy in three phases: mill startup and implementation of a Provox instrumentation system from Fisher Controls (1982-1983), integration of the distributed control system (DCS) with a Hewlett Packard A900 host computer

(1985-1986), and ongoing enhancements toward the goal of a totally integrated millwide system in the 1990s. Several possible benefits persuaded the team to try distributed controls: operator effectiveness would be enhanced by the graphic CRT displays; process optimization would be possible because routine control functions would be performed by the microprocessor-based control system; smaller control rooms would be feasible; the mill's long-term competitive position could be better maintained by early adoption of flexible, advanced control technology.

Grubb, Thomas (Quebec & Ontario Paper Co, Thorold, Ont, Can). *Pulp Pap* v 62 n 8 Aug 1988 p 92-95.

**076247 MAKING CHOICES IN THE MULTI-TIERED PROCESS INSTRUMENTATION MARKET.** This article clears up some of the confusion surrounding the market for field-mounted process instrumentation and helps the user make an intelligent purchasing decision. Transmitters available today fall into three categories based on price and performance: conventional, smart, and throwaway, the price accuracy, and features of these tiers of transmitters are compared.

Bowden, Bill (Rosemount Inc, Eden Prairie, MN, USA). *Pulp Pap* v 62 n 8 Aug 1988 p 115-117.

**076248 MODULAR SIMULATOR INTERFACES TO DISTRIBUTED CONTROL FOR TRAINING.** This article demonstrates that the modular pulp and paper simulator, GEMS, can be directly used for training on a particular distributed control system. A trainer has been configured using a modular simulator (GEMS) on a PC, a standard serial interface, and the Bailey Network 90 distributed control system. The trainee uses the identical interface unit configured as it will appear when controlling the real process. The procedure by which this has been accomplished is general, and it can be adapted to other process areas. The models created for engineering analysis using PCGEMS can be altered to include dynamic process elements. The dynamic models can then be incorporated into the trainer. 2 Refs.

Haynes, Jim (Univ of Idaho, Moscow, ID, USA); Scheldorf, Jay; Edwards, Lou. *Pulp Pap* v 62 n 9 Sep 1988 p 192-195.

**Pumps** See PUMPS—Seals; PUMPS—Selection.

**Quality Assurance** See QUALITY ASSURANCE—Standards.

**Quality Control**

**076249 AVOIDING CRISES: STRATEGIC QUALITY PLANNING.** There is a list of familiar products which have something alarming in common. Foreign imports of each of these now constitute from 25% to more than 50% of the U.S. market. A major contributor to this invasion is superior quality. A model of quality trends in the West compared to Japan is preselected. The model shows that several decades ago we had clear quality superiority. By about the mid 1970s, the Japanese had closed that gap, and proceed to become superior in quality causing the 25% market loss of U.S. companies to foreign imports, mostly Japanese. An integrated approach to quality leadership, the author says, is imperative for American industry if it expects to remain competitive with Japan.

Juran, J. M. (Juran Inst Inc). *PIMA Mag* v 69 n 4 Apr 1987 p 27-30.

**076250 PLANNING FOR QUALITY... CATCHING THE 'THIRD WAVE'.** Those companies managing quality more effectively have decided that quality is a key strategic business variable and declared that the old procedures and standards of performance are simply not good enough anymore. They have established an annual quality plan in much the same manner in which they created their annual financial plan. Then a quality improvement process is set in place to meet the new levels of quality performance called for in the plan. Simply

stated, managing for quality improves quality planning, quality improvement, and quality control. This article will address the quality planning function.

Ingman, Lars C. (Robotest Corp). *Pulp Pap* v 62 n 4 Apr 1988 p 185-187.

**076251 KVARNSVEDEN IS BANKING ON QUALITY.** Stora's Kvarnsveden mill started its giant new PM 11 last month. The state-of-the-art PM, combined with high-quality pulp, allow the mill to meet the changing needs of printers. In this article the author describes the new 220,000-ton/yr news print PM at Kvarnsveden mill.

O'Brian, Hugh. *PPI Pulp Pap Int* v 30 n 6 Jun 1988 3 pp.

**Reliability** See PAPER AND PULP INDUSTRY—Reliability.

**Republic of Korea**

**076252 TAKEOVERS BOOST SHINHO'S PROSPECTS.** Shinho is a Korean paper company. Shinho is buying mills and has projects to make more woodfree, testliner and specialties. The article discusses plant facilities and production capacity.

Sutton, Peter. *PPI Pulp Pap Int* v 30 n 3 Mar 1988 p 37-38.

**Retrofitting**

**076253 NO.3 P.M. REVAMP AT GRAND FALLS: INTERFACING DIGITAL DRIVES TO EXISTING DRIVES.** During the rebuilding of PM3 at the Abitibi-Price Grand Falls, Newfoundland, Mill, three new digital drive sections were installed and married to existing Harland analogue drives. A new digital master was interfaced to both the new and old drives providing many of the features of a complete digital drive, at a considerably lower cost. (Author abstract)

Demoe, B.P. (Canadian General Electric, Peterborough, Ont, Can); Gill, D.G. *Pulp Pap Can* v 88 n 12 Dec 1987 p 165-167.

**Simulation**

**076254 SIMULATION ACCURACY - A PSYCHOLOGICAL OR NUMERIC PROBLEM.** This paper considers the accuracy requirements of process simulation. There are two types of accuracy; the first is the accuracy of the data computations such that the simulation gives the correct mathematical answer; the second is the accuracy of the data necessary to satisfy the customer (engineer, operator or manager) that the simulation results are correct and useful. It is suggested in the latter case that the most significant influences are not technical but psychological. (Author abstract)

Gordon-Clark, Matthew R. (Scott Paper Co, Philadelphia, PA, USA). *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul* Publ by TAPPI Press, Atlanta, GA, USA, 1985 p 91-93.

**076255 HYBRID SIMULATION - THE EFFECTIVE ALTERNATIVE.** With the ever increasing demand for improved productivity, reduced energy consumption, tighter environmental controls and upgraded safety standards it is important for the engineers, scientists and managers in the pulp and paper industry to advance their problem solving capabilities through the application of simulation tools. For those practitioners with limited access to mathematical modeling expertise and sophisticated computing facilities, the steady-state flowsheet and pseudo-dynamic simulation packages available on digital computers will provide a vast improvement over manual calculation methods. Problem solvers in the industry capable of supporting a more sophisticated hybrid simulation facility will have the ability to accurately model dynamic systems, to perform real-time analysis, and through direct 'hands-on' operator interaction with the simulation to apply the combined knowledge of experience



operations personnel and skilled technical workers to the solution of complex process and control problems. 3 refs.

Mardon, J. (OMNI Int); Gee, J.W. *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul Publ* by TAPPI Press, Atlanta, GA, USA, 1985 p 109-123.

## Storage

**076256 MODULAR STORAGE SAVES SPACE, HIKES EFFICIENCY AT WESTVACO.** Due to plant improvements and expansion, a mill's management agreed to use modular storage drawer cabinets. The contents from about a dozen rotobins, including hose clamps, fasteners, tools, electrical items and general consumables, were transferred to the four cabinets. Management eventually decided to transfer as many small parts as possible from shelving and rotobins to the new cabinets. Anything that would fit into a cabinet drawer would be stored that way. The conversion plan went into effect in 1984 and cabinets are currently being ordered at the rate of 18 quarterly. Today, there are 213 S-V Model 340 cabinets and 16 Model 245 cabinets in place, a total of 229. Another 18 Model 40s are on order.

Anon. *PIMA Mag* v 70 n 7 Jul 1988 p 22-24.

**Sweden** See PAPERMAKING MACHINERY—Headbox.

## Taiwan

**076257 BAN YU AIMS FOR THE MAJOR LEAGUE.** Taiwan's biggest paper mill is currently carrying out an investment plan to take capacity to 440,000 tons/yr of paper and board by the end of 1988. Two, maybe even three, new PMs, a cogeneration plant, complete replacement of its wastepaper prep. lines and more are all planned for before 1990. A wider product range, more cost-reducing automation and lower energy costs are the reasons behind its biggest-ever expansion.

Sutton, Peter. *PPI Pulp Pap Int* v 29 n 11 Nov 1987 p 76-78.

**076258 NEW MILL MEANS MORE MARKET MUSCLE.** One sign among many of the growing technical sophistication of papermaking in Taiwan is that both of the two new machines will have high-impulse presses—the first in Taiwan. The Cheng Loong mill will also have a power cogeneration plant. Cogeneration is becoming increasingly popular in an industry which uses a lot of energy in a country which has no natural energy resource.

Sutton, Peter. *PPI Pulp Pap Int* v 29 n 12 Dec 1987 p 36-38.

**The Congo** See PULP MATERIALS—Wood.

## Ventilation

**076259 EXPERIENCE PAYS WHEN DESIGNING MACHINE ROOM VENTILATION SYSTEMS.** Several different ventilation systems are required for production in a paper machine building. Each system requires a preventive maintenance program. A description of the 12 required systems is given. They are required in a typical mill producing kraft, fine paper, and newsprint; similar systems apply to tissue machines. In addition to ventilation systems required for production, paper machine buildings have other ventilation systems. These are: air makeup systems, roof heating systems, wet end false ceiling and associated exhaust systems, and general roof exhaust. Techniques for eliminating design problems are given. A list of problems and their solutions that continually occur at pulp and paper mills are outlined.

Murphy, Otis L. (Rust Int Corp, Birmingham, AL, USA). *Pulp Pap* v 62 n 10 Oct 1988 p 132-134.

**Waste Disposal** See Also BOILER FIRING—Low Grade Fuel; WATER POLLUTION—Monitoring.

**076260 HIGH-SOLIDS BLACK LIQUOR COMBUSTION: TAMPELLA'S SUPER COMBUSTION**

**SYSTEM.** A Super Combustion system capable of firing black liquor at 80% dry-solids content was tested at the Rosenlew Aittaluoto kraft pulp mill in Pori, Finland. This mill produces 80,000 tons/year of unbleached sulfate pulp. The pulp mill's boiler is illustrated. Splash-plate-type liquor guns are situated on the boiler's front and rear walls. Boiler steam capacity is 18 kg/s (142,860 lb/h) of 32-bar (435 psig) steam at 410°C (770°F). The Super Combustion system was tested with 100% of the mill's black liquor flow, and the test facility was designed accordingly. Thus, the results received from the boiler correspond to the behavior of the furnace at the higher solids content. (Edited author abstract) 1 ref.

Hytty, P.A. (Tampella Ltd, Tampere, Finl); Ojala, S.T. *Tappi J* v 71 n 1 Jan 1988 p 108-111.

**076261 SIMPSON PAPER SWITCHES TO CO<sub>2</sub> TO ELIMINATE DEPOSITS IN SEWER PIPES.** A paper-mill finds CO<sub>2</sub> addition to be an effective, economical alternative to acid for controlling and stabilizing pH levels in mill effluent. When CO<sub>2</sub> is added to an aqueous stream, such as wastewater, carbonic acid (H<sub>2</sub>CO<sub>3</sub>) is formed. This reduces pH levels and, because of other related chemical reactions, permits them to be maintained within acceptable parameters and with great stability. The method has none of the negative effects associated with the use of acid and often is more economical. It has been used for more than a year by Simpson Paper Co. at its San Gabriel Mill in Pomona, Calif. - virtually eliminating the persistent calcium carbonate buildup, corrosion, and other problems previously experienced with an acid system.

Thomas, Earl (Simpson Paper Co, Pomona, CA, USA); Chua, John. *Pulp Pap* v 62 n 4 Apr 1988 p 100-103.

**076262 REJECT HANDLING IN SECONDARY FIBER SYSTEMS.** The quantity of rejects discharged, and particularly their fiber content, varies widely from mill to mill. Some mills pay several hundred thousand dollars per year in direct hauling and landfill expenses, even ignoring indirect labor expenses by existing employees. Reject conveying and dewatering equipment can often pay for itself in a short period of time in reduced direct labor, hauling, and landfill charges. Mills with on-site burning capabilities have some additional incentive to install equipment capable of discharging dry rejects, since this greatly increases the potential BTU yield of the rejects. It is possible that fairly dry rejects could also be sold for their fuel content by mills that cannot burn them on-site.

Bliss, Terry (Black Clawson Co, Middletown, OH, USA). *Tappi J* v 71 n 6 Jun 1988 p 87-91.

**076263 AGITATION HELPS MILL RAISE STORAGE CAPACITY AND RECOVER CHEMICALS.** Simpson Paper found a unique method for recovering settled solids from a black liquor storage tank at its Pasadena, Texas, mill. Simpson decided to try mechanical agitation. A 125-hp Lightnin VS Series side-entering mixer with a 52-in. A312 impeller was selected. The mixer was angled at 5° off the centerline and 10° off the vertical to create the clockwise swirl needed to effectively free the solids. More than one year later, the mixer was removed and another hole was cut 9 ft lower. The mixer was reinstalled and the process continued. In a period of two and a half years, the level of solids dropped about 12 feet.

Ramos, J. (Simpson Paper Co, Pasadena, TX, USA). *Pulp Pap* v 62 n 8 Aug 1988 p 114.

## Waste Heat Utilization

**076264 NEW GAS TURBINE BOOSTS CHP SYSTEMS.** Berghuizer Papierfabrik in the Netherlands has boosted steam and electricity production mill by installing a new gas turbine at Waapenveld paper mill. The unit is a crucial part of a plan to raise paper output. Since the second oil crisis of 1979-80, the Dutch paper industry has installed nearly 30 small gas turbines in combined heat and power (CHP) systems to reduce energy costs and take advantage of favorable buy-back rates offered by the

public utilities for surplus power, according to nationally-agreed formulas. Most of these sets are either the 3.5-MW Centrax 350 KB5s, or the 5.7-MW Ruston Tornado. The Solar Centauf at Waapenveld, is the first example of this gas turbine in a CHP installation in Europe.

Jeffs, Eric. *PPI Pulp Pap Int* v 29 n 9 Sep 1987 p 73-74.

## Waste Utilization

**076265 CASCADES' DEINKING PLANT PRODUCING HIGH-GRADE MARKET PULP FROM WASTE.** The sixteenth mill of the dynamic Canadian company is now in full operation at Breakeyville, Que., utilizing flotation technology. Nominal capacity is 100 tpd of a 56 to 60 brightness pulp produced from magazine and newspaper waste. A second grade is made from printed kraft waste with a 75 to 83 brightness. The mill is located on the site of a former market groundwood pulp plant. Very little of the equipment from the groundwood mill has been utilized in the new operation. A major exception to this is in the sheet forming, cutting, and baling operation. The article describes the first ink removal; flotation stage; final cleaning; highly automated operation; sheeting and baling; water recycling and effluent treatment.

Evans, John C.W. (Pulp & Paper, San Francisco, CA, USA). *Pulp Pap* v 62 n 4 Apr 1988 p 55-57.

**076266 HIGH-CONSISTENCY PULPING OF BROKE, WASTEPAPER CUTS CYCLE TIME, COSTS.** A batch pulper recently developed by Black Clawson operates at consistencies of 15% or higher. Known as Hicon, the unit uses a triple-flighted turbine rotor to submerge and circulate furnish. The tub has a rounded bottom and baffles to promote a circulating action. Pulped stock is extracted through a perforated bed plate located under the rotor. Zone dilution of the stock as it is discharged lowers the consistency to a pumpable level. High-consistency batch pulpers such as the Hi-Con are mainly used in the following ways: preparing wastepaper for deinking, pulping wet strength broke (both of these use chemicals in the pulper), and pulping plastic-coated broke.

Anon. *Pulp Pap* v 62 n 4 Apr 1988 p 76.

**076267 TRIM-REMOVAL SYSTEMS.** The rate of trim production in a paper-processing plant can surge to more than ten times the average rate. This presents a substantial challenge to a trim-conveying system. In a concentrated trim-handling system where all trim is transported to a single repulper, the design trim-handling rate should not be determined based on the cumulative maximum design output of all winders. Instead, the effect of decreased paper machine speed during production of heavier paper grades should be accompanied by a proportional reduction in winder speed. The development of winders is making the conventional trim-handling system obsolete. Vacuum trim-handling systems are replacing conventional trim-conveying equipment because of their ability to increase winder speed capacity, conserve energy, and reduce noise levels.

Salmela, Jouko (Teollisuusmittaus Oy, Turku, Finl); Perry, Scott. *Tappi J* v 71 n 5 May 1988 p 87-90.

**Wastes** See Also INDUSTRIAL WASTES—Composting.

**076268 QUANTITATIVE ANALYSIS OF LIGNOSULPHONATE USING BENZETHONIUM CHLORIDE - PRELIMINARY INVESTIGATIONS.** Hyamine-1622, or benzethonium chloride, is a high molecular mass quaternary ammonium compound normally used as a germicide. It was found that the chemical could be used to give consistent results for the determination of lignosulphonate in the effluents from a sulphite pulp mill and in the concentrates and permeates resulting from the ultrafiltration of such effluents. Details of an analytical procedure are presented. Although the initial findings appear promising they should be considered to be preliminary. (Edited author abstract) 14 refs.

Lussi, M. (Univ of Natal, Durban, S Afr); Neytzel-de



Wilde, F.G. *Water SA* v 13 n 4 Oct 1987 p 225-228.

**076269 REMOVAL OF ORGANIC CARBON AND CHLORINE FROM A KRAFT MILL WASTEWATER BY PRETREATMENT WITH CATALYZED OZONE AND POWDERED ACTIVATED CARBON.** The objective of this research was to explore the feasibility of applying various physical/chemical processes, including adsorption and oxidation, for removal of discrete molecular weight fractions of the organic chlorine in Kraft mill wastewater. Activated carbon, ozone, and ultraviolet (UV) light catalyzed ozone were studied individually and in combination. It was found that activated carbon treatment removed significant amounts of total organic carbon (TOC) and total organic halide (TOX). However, when adsorption was preceded by plain ozonation or UV-catalyzed ozonation, performance was further enhanced. Physical/chemical treatments produced much higher total TOC and TOX removals than the aerated stabilization basin (ASB) process currently utilized by the pulp and paper industry. Ozone treatment provided the maximum reduction in inhibitory response, as measured by both optical density and adenosine triphosphate responses at low dilutions. At higher dilutions, additional powdered activated carbon treatment enhanced performance. Physical/chemical treatment, if it precedes ASB processing, can produce a less inhibitory influent substrate. 12 refs.

Sierka, R.A. (Univ of Arizona, Tucson, AZ, USA); Bryant, C.W. *Water Pollut Res J Can* v 22 n 3 1987 p 456-467.

**076270 PAPER MILL SLUDGE DISPOSAL: COMPLETING THE ECOLOGICAL CYCLE.** A costly paper mill sludge disposal problem was solved in an environmentally safe manner by using the sludge as a soil conditioner and fertilizer. The test program and methods are described. (Author abstract)

Pridham, N.F. (Quebec & Ontario Paper Co, Thorold, Ont, Can); Cline, R.A. *Pulp Pap Can* v 89 n 2 Feb 1988 p 70-72.

**076271 ANAEROBIC TREATABILITY OF CANADIAN PULP AND PAPER MILL WASTEWATERS.** The anaerobic treatability of wastewaters from several pulp and paper mill was assessed using chemical and batch biological testing procedures. The results allowed the identification of candidate wastewaters with the highest priority for further process development studies. The results also indicated the potential for applying anaerobic treatment technology in the Canadian pulp and paper industry. (Author abstract). 7 Refs.

Hall, E.R. (Environment Canada, Burlington, Ont, Can); Cornacchio, L.-A. *Pulp Pap Can* v 89 n 6 Jun 1988 p 100-104.

**076272 WASTE REDUCTION: WASTE RESULTING FROM ERRORS\*.** An error is a judgment mistake by an individual (salesperson, order entry, supervisor, operator, etc.) who unintentionally deviates from a standard or established procedure, resulting in an economic loss to the employer. The loss may be in the form of wasted product, returned product, extra labor, extra materials, or lower product value. Waste resulting from errors can and often does represent over 30% of a plant's controllable waste. Since all plants vary in degree of training and mechanization, an attempt is made to isolate the major causes of errors in a typical corrugating plant. The article discusses the causes of order entry, supplier, scheduling, corrugator, finishing, shipping, and invoicing errors and recommends remedies for them. A preventive program is suggested.

Schatz, Ervin, R. (Longview Fibre Co, Yakima, WA, USA). *Tappi J* v 71 n 8 Aug 1988 p 184-186.

## Water Recycling

**076273 REUSE OF KRAFT MILL SECONDARY CONDENSATES.** It is practical and possible to reuse all secondary condensates in a kraft mill, including all

digesters and evaporation-plant condensates. The most practical way to remove odors from the foul condensates is by steam stripping the odorous components prior to reuse. The cost of steam stripping can be reduced substantially by splitting the condensate streams according to their odor and their methanol content and by integrating the steam stripper in the evaporation plant. A U.S. mill has a condensate-treatment system that allows reuse of all condensates in pulp washing. The heat cost of the steam stripping is only 0.1 dollars/a.d. ton of pulp.

Sebbas, Eva (EKONO Inc, Bellevue, WA, USA). *Tappi J* v 71 n 7 Jul 1988 p 53-58.

Water Supply See WATER FILTRATION.

## Welding

**076274 NEW METHOD FOR RENOVATION OF PULP DIGESTERS.** Technicians from Uddcomb Engineering AB have increased the resistance to corrosion of a pulp digester at the Billingsfors pulp mill tenfold, and thus saved the cost of a total rebuild. This has been accomplished by overlay-welding with stainless steel on the inner surface, using the 'Uddcomb Method'. The welding operation is performed with Avesta's type P5 alloy welding wire, which produces an acid-resistant surface. In the Swedish market alone there are nearly a hundred digesters which can be expected to require the same treatment. This paper describes Uddcomb's welding method.

Anon. *Weld Rev* v 7 n 1 Feb 1988 p 34.

**PAPER PRODUCTS** See Also PAPER AND PULP MILLS—Finland.

## Applications

**076275 WILL SAP CUT FLUFF USAGE IN DIAPERS?** The article assesses how superabsorbents will affect fluff pulp use in hygiene absorbent products to 1990. A forecast of the change of fluff usage to 1990 is included. Hygiene absorbent products discussed are baby diapers, sanitary towels and panty shields (sanitary protection products), and adult incontinence products. SAPs, superabsorbent polymers are swellable, gel-forming substances, capable of absorbing and retaining under pressure many times their own weight in body fluids, a marginal increase of 3.5% in the total worldwide consumption of fluff pulp from 1987-90, corresponding to an average growth of just below 1%/yr.

Nordgren, Gunnar; Kaivola, Heini. *PPI Pulp Pap Int* v 29 n 8 Aug 1987 p 39-40, 47.

## Health Hazards

**076276 LOW HEALTH RISK SEEN FOR DIOXIN IN PAPER PRODUCTS.** The Environmental Protection Agency and the paper industry announced that small amounts of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) are present in pulp, wastewater, and sludge from paper mills. Of more pressing concern to the public, TCDD also appears in paper products to which consumers are exposed daily. The American Paper Institute (API) has released a study assessing potential health risks from dermal exposure to TCDD in paper products made from bleached pulp. The study finds skin exposure to TCDD in paper goods to be far below hazardous levels; work is under way on paper dust and food packaging.

Krieger, James. *Chem Eng News* v 66 n 2 Jan 11 1988 p 22-23.

Manufacture See PACKAGING MATERIALS—Paper.

**Mechanical Properties** See PAPER—Calendering; PAPER—Sheeting.

## Nondestructive Examination

**076277 COMPUTERIZED TOMOGRAPHY OF A PAPER ROLL.** Paper rolls were analyzed nondestructively

by a computerized tomographic (CT) system. The images of cross sections of paper rolls were shown as faithfully as they were observed by cutting them. The tomographic image density (CT value) of a cut paper sheet bundle was proportional to its sheet paper density. In CD profile of CT values of paper rolls, each roll had a different CD profile. A paper roll wound at higher tension had a poor CD profile of CT values, which indicated internal stress concentrated locally in the roll. The macroscale MD profile of CT values coincided well with the basis weight profile. The long-range MD profile of CT values decreased gradually from a surface to a core of a paper roll, which indicated that internal stress decreased from the core to the surface. (Author abstract). 7 Refs.

Miyaniishi, Takanori (Jujo Paper Co, Tokyo, Jpn); Iida, Kiyoko; Sotobayashi, Hitoshi. *Tappi J* v 71 n 10 Oct 1988 p 167-172.

**Physical Properties** See Also PULP—Thermomechanical.

**076278 EFFECT OF FIBROUS FINES ON TISSUE PROPERTIES.** By means of handsheet and laboratory studies, the potential impact of a fines retention strategy on the papermaking process and on finished product properties was studied. Northern softwood kraft (NSK) and CTMP fines were added to furnishes in conjunction with a retention aid. Strength properties, absorbency rate, sheet formation and drainage time of the slurry were measured. Both types of fines have adverse effects on absorbency, stiffness, and drainage time. NSK fines are more detrimental than CTMP fines on an equivalent weight basis. Use of a fines retention aid partially restores product absorbency rate. However, a negative impact on strength properties was observed. Consequently, a fines retention strategy must balance the beneficial and detrimental effects. (Author abstract) 9 refs.

Springer, Allan M. (Miami Univ, Oxford, OH, USA); Pires, Eduardo C. *Tappi J* v 71 n 2 Feb 1988 p 99-102.

Printing See PAPER—Newsprint.

## Sterilization

**076279 GAMMA-RAY RADIATION PRESERVATION TECHNOLOGY FOR FILMS AND BOOKS.** In this paper, a radiation appliance using Co-60 Gamma-ray to preserve films and books is introduced. The lump and transport radiation techniques for processing films and books with this radiation appliance are described. The cost of preserving films and books with this method has been estimated. Comparison of this method with other processing techniques has been made. (Author abstract) 2 refs.

Fan, Chengfa (Sichuan Province Inst of Nuclear Technology Application, Chengdu, China); Tian, Kaizen; Zhang, Yunlu; Gan, Saohan; Wang, Zhengfu; Xiang, Jiafang. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 757-759.

Storage See PAPER AND PULP MILLS—Equipment.

Testing See PAPERBOARDS—Corrugated.

**Transportation** See Also CARGO HANDLING; LUMBER—Transportation; MOTOR SHIPS—Reviews.

**076280 COASTERS JOIN THE PAPER CHASE.** A number of operators are now successfully transporting damage-sensitive paper reels in small open hatch coasters. The ability of such ships to carry pulp and packaged timber has never been questioned, but the possibility of carrying paper efficiently has led to a recent surge of activity. One particularly successful example is Aros Line, a small Swedish operator based in the inland port of Vasteras on Lake Malaren, which has been able to expand significantly at the expense of ro-ro operators such as T or Line. Using modern West German-built box shaped vessels, Aros, which has operated a service to the UK east coast port of Goole for a number of years, and another



Swedish operator, Pal Line, stepped in to offer shippers a weekly departure at a price level 15-20 percent below the ro-ro alternative over Gothenburg.

Boyce, Jon. *Cargo Syst Int* v 14 n 10 Oct 1987 p 79.

## PAPERBOARDS

### Additives

**076281 PAPERBOARD CHEMICAL ENHANCEMENT FOR STRENGTH AND OTHER BENEFITS.** Today's marketplace for chemical additives is being influenced by a number of factors. Such factors include the need for improved fire resistance, shipping and warehousing costs, insurance costs, the conservation of fiber resources, and costs savings in added capacity in consideration of the growth in production. Processing equipment is available for the first time that obviates the limitations and inefficiencies of past production methods. The potential for this equipment is not limited to corrugated containers but can extend to a whole new arena of products. Solid fiber containers, furniture substrates, paneling, doors, wallboard, and a multitude of other paper fabrications are limited only by the user's imagination.

Walthey, G.J. (Black Clawson Co, Fulton, NY, USA). *Tappi J* v 70 n 10 Oct 1987 p 35-39.

### Coating See PAPERMAKING MACHINERY—Calenders.

**Corrugated** See Also CONTAINERS—Testing; PAPER AND PULP MILLS—Wastes; PAPERMAKING—Drying.

**076282 EINFLUSS DER TEMPERATUR UND DES WASSERGEHALTES AUF DIE FESTIGKEIT VON WELLPAPPE AM BEISPIEL DES KANTENSTAUCHWIDERSTANDES NACH DIN 53 149 (12/77).** [Influence of Temperature and Water Content on the Strength of Corrugated Boards using the Example of the Edge-Crush Resistance According to DIN 53 149 (12/77)]. In most cases, the strength properties of corrugated boards are only tested under one climatic condition, i.e., 23°C/50% relative humidity. For practical use of corrugated boards as packaging materials, especially for overseas transport, it is necessary, however, to know the strength behavior over a broad range of temperature and humidity. The object of this paper is to obtain data on this subject. Tests were made with four types of corrugated boards, the edge-crush resistance being chosen as the strength property. It was found that the edge-crush resistance decreases both with an increase in temperature and with an increase in water content. In the latter case there is an exception, i.e., at temperatures below 0°C the edge-crush resistance rises slightly at first and then decreases. (Edited author abstract). In German. 6 refs.

Eschke, Richard (Fachhochschule Hamburg, Hamburg, West Ger); Koehn, R. *Verpack Rundsch* v 38 n 7 Jul 1987 p 49-53.

**076283 CORRUGATOR CUT-TO-MARK SYSTEMS FOR PREPRINTED LINERBOARD.** It has only become feasible to produce preprinted linerboard in a corrugated box plant since the introduction of the direct drive corrugator cut-off knife. Although the direct drive knife improved corrugated sheet length tolerances, its real potential is its ability to cut to an input signal. The major modification to a direct drive knife to accept an input signal is the cut-to-mark electronics and software. The input signal on the preprinted linerboard is a printed registration line that is read by a cut-to-mark sensor. The mounting of the equipment is important, and there are two modes of operation: the acceptance window and pattern recognition.

Bial, John (Weyerhaeuser Co, Tacoma, WA, USA); Eppli, Randy J. *Tappi J* v 70 n 10 Oct 1987 p 31-34.

**076284 TRENDS IN HIGH-SPEED SINGLE FACER DESIGN.** This generation of single facers represents an advancement in the state of the art. Qualitative and quantitative improvements in single face production have been realized. This article offers an understanding of

these design trends helpful for the corrugated converter when analyzing future equipment requirements. 3 refs.

Sofinowski, John R. (Engineering United Container Machinery Group Inc, Glen Arm, MD, USA). *Tappi J* v 70 n 10 Oct 1987 p 43-47.

**076285 RUNNABILITY AND CORRUGATING MEDIUM PROPERTIES.** Based on analysis of the stresses applied to the corrugating medium during fluting, a physically reasonable model has been developed to show how corrugating medium properties affect critical high-low and fracture speeds during corrugating. The model may also apply to strength retention. Analysis accounts for corrugating medium properties, flute geometry, and the brake tension applied to the corrugating medium. The model indicates that speeds that cause fracturing of the corrugating medium increase as the thickness and coefficient of friction of the corrugating medium decrease and as the MD tensile strength and stretch of the corrugating medium increase. Critical speeds for high-low flute formation are affected similarly. The coefficient of friction between the corrugating medium and a hot steel surface is an important property and one that is not commonly measured. (Edited author abstract) 11 refs.

Whitsitt, William J. (Inst of Paper Chemistry, Appleton, WI, USA). *Tappi J* v 70 n 10 Oct 1987 p 99-103.

**076286 VERSUCHE ZUR OPTIMIERUNG DES RILLENS VON WELLPAPPEN.** [Experiments on Optimizing the Creasing of Corrugated Board]. Owing to automation and high costs, the packaging industries are being forced to create new conditions for efficient production and finishing techniques through well-targeted research. In being the manufacture of corrugated boards this applies to almost the whole treatment subsequent to the machine. In the manufacture of corrugated boards this applies to almost the whole treatment subsequent to the machine. In this connection the creasing of corrugated boards is one of the crucial stages. Tearing inner facings, inaccurate bending edges, an excessively high erection resistance, ill effects of the compression strength of the finished boxes and other impairments of the service qualities of corrugated boards are the characteristic problems in this area. Although these difficulties have been known to the industries for decades, only a few useful investigations have been made to keep the processing problems under control. (Edited author abstract) In German. 7 refs.

Vogelpohl, H. (Technische Univ Muenchen, Freising, West Ger); Hohmann, H.J. *Verpack Rundsch* v 38 n 8 Aug 1987 p 55-66.

**076287 TOWARDS AN INTERNATIONAL STANDARD METHOD FOR THE EDGEWISE COMPRESSION TEST OF CORRUGATED BOARD.** Three factors account for the current interest in reaching international agreement on a single procedure for the edgewise compression test (ECT) of corrugated board: The recognition that the fiberboard industry needs to make better use of its resources and that this can be achieved only if corrugated board standards are based on board properties that relate to box performance. The evidence that, of the currently measured board properties, ECT has the closest relationship with box performance. The realization in the United States that the existing TAPPI method is not well suited to routine use. It is recommended that FEFCO Method No. 8, with mandatory use of a Billerud-type cutter, be adopted as the international standard method. 13 refs.

Stott, Ronald (AMCOR Research & Technology Cent, Fairfield, Aust). *Tappi J* v 71 n 1 Jan 1988 p 57-60.

**076288 TOWARDS AN INTERNATIONAL STANDARD METHOD FOR THE EDGEWISE COMPRESSION TEST OF CORRUGATED BOARD - A SECOND OPINION.** J.W. Koning, Jr. maintains that a combined board test is possible using a necked-down specimen of corrugated fiberboard and TAPPI method T 823. Unfortunately, he asserts, there is an effort to adopt

a less accurate, more expedient test as an international standard. Considering objective criteria, Koning deems unsatisfactory the method proposed by R.A. Stott. Koning details many of the problems in the proposed method and outlines the limitations of the present TAPPI method. Koning also sets forth criteria that an edgewise compression test should meet if it is to be an international standard. (Edited author abstract). 17 Refs.

Koning, John W. Jr. (Univ of Wisconsin, Madison, WI, USA). *Tappi J* v 71 n 10 Oct 1988 p 62-64.

**076289 CLAMPED SPECIMEN TESTING: A FASTER EDGEWISE CRUSH PROCEDURE.** The technology of edgewise crush test (ECT) measurements can be improved by developing a simpler, more efficient method to prepare and test the sample. A newer ECT procedure for cutting and supporting the sample has been developed which uses an unwaxed, 2×2-in. specimen. The specimen is cut with an automatic ECT cutter with two blades. The specimens are tested in a fixture that supports the ends with clamps at a controlled pressure. The fixture fits between the platens of both flexible platen and rigid-platen compression testers. No waxing of the ends is necessary. Results for the clamped-specimen procedure agree well with those of the TAPPI procedure specifying waxed ends. (Edited author abstract). 9 Refs.

Schramper, K.E. (Inst of Paper Chemistry, Appleton, WI, USA); Whitsitt, W.J. *Tappi J* v 71 n 10 Oct 1988 p 65-69.

**Manufacture** See Also COGENERATION PLANTS; PAPER AND PULP MILLS—Taiwan; PULP MANUFACTURE—Sulfite Process.

**076290 EFFECT OF PRESSING PRESSURE OF THE FIRST STAGE ON THE PROPERTIES OF RICE-STRAW HARDBOARD.** In hardboard manufacture, the wet pressing method is most commonly used - in which a three-phase pressing cycle is normally employed. The effect of variation in the pressing pressure during the first phase of this pressing cycle on the properties of rice-straw hardboard is studied. The specific pressure used in this stage is a very important factor that influences the properties of the finished hardboard. An appreciable improvement in the properties of the finished board is noticed when increasing the pressing pressure. A specific pressure of about 60 kg/cm<sup>2</sup> is sufficient to impart desirable properties to the finished board. (Author abstract) 16 refs.

Fadl, Naim A. (Nat'l Research Cent, Cairo, Egypt); El-Kalyoubi, Samira F.; Rakha, Mohamed. *Res Ind* v 32 n 2 Jun 1987 p 107-111.

**076291 HIGH-CONSISTENCY IS FINDING A ROLE.** So far, high-consistency forming has been used to make board grades of 100-300 g/m<sup>2</sup>. In this article the author reviews the way the process is used today and assesses its potential for making other grades.

Waris, Tapio (Valmet-Ahlstrom, Finl). *PPI Pulp Pap Int* v 30 n 6 Jun 1988 p 87, 89.

### Mechanical Properties

**076292 UTILIZATION OF LANTANA CAMARA FIBREBOARDS: PART-1.** Various chemical constituents, viz. extractives, pentosan, lignin, cellulose, ash and nitrogen were estimated. Pulp of Lantana stalks was carried out by semichemical and hydrothermal methods. The pulp yield decreased from 80.2 to 59.8% when digested with increasing amounts of sodium hydroxide from 1 to 5% based on dry weight of the material. The hydrothermal pulp yield ranged from 67.1 to 86.2% when the digestion temperature varied from 150 to 110°C. The slow drainage rate of Lantana pulp was improved by blending with pine wood pulp. Fibreboards produced from Lantana and pine wood blended pulp possessed strength properties ranging between 242 and 556 kg/cm<sup>2</sup> for untempered boards depending upon process conditions. (Edited author abstract) 8 refs.

Negi, J.S. (Regional Research Lab, Jammu Tawi, India);



Prabhakar, D.B.; Wazir, S.S.; Chawla, J.S. *Res Ind* v 32 n 1 Mar 1987 p 25-30.

## Printing Properties

**076293 PRINT QUALITY AND SURFACE SPEEDS.** Better print quality on corrugated packaging is the objective of plants everywhere. The need for accuracy in making, mounting, proofing, and caring for printing plates has been addressed in several recent journal articles and conference papers. The advantages of selecting quality inks and controlling viscosity also have been stressed. Substitution of different mat materials and adhesives can change the total thickness of the printing plate, causing poor printing, registration problems, and excessive plate wear.

Ashwood, Loren F. (SAS Int Inc, New Franken, WI, USA). *Tappi J* v 70 n 10 Oct 1987 p 51-52.

## Production See PAPERMAKING—Quality Control.

## Quality Control

**076294 STATISTICAL PROCESS CONTROL IN A PAPER MILL.** The actual use of SPC (Statistical Process Control) follows this general procedure. A process variable is monitored on a control chart and the average value of that variable is calculated (termed  $\bar{X}$ ). Upper and lower statistical limits for variation are calculated from simple formulas based on three standard deviations from the average (commonly referred to as  $3\sigma$ ). If system variations stay within these limits, that variable is predictable to an accuracy of 99.7% within that range. If not, of course, the object is to get it there by identifying the variation causes and eliminating or reducing them. The system is then evaluated for capability. If the process specifications lie outside the statistical limits, the process is statistically under control and capable of predicting that the product will be within specifications to an accuracy of 99.7%. Factor pertinent to implementing SPC are also analyzed. A discussion is also presented of what points in the process required monitoring. Improvements achieved through the use of SPC are outlined. 2 refs.

Guillory, A.L. (Temple-Eastex Inc, Silsbee, TX, USA). *Chem Eng Prog* v 84 n 4 Apr 1988 p 52-57.

## Sizing See Also PAPERMAKING—Sizing.

**076295 SIZING OF PINE NEEDLE FIBRE-BOARDS.** Experiments were done to improve water resistance of pine needle waste paper-blended fibreboards by the addition of additives during manufacture and by coating of the finished board with wax and wax rosin mixture. Wax-coating was done by three different techniques. In one set of experiments amount of wax uptake per sq m of the board was also varied. Wax treatment, especially by dipping method, is most effective in improving water resistance properties but it has the disadvantage of maximum absorption of wax per sq m of the finished board. There is no appreciable difference in water resistance properties of wax-rosin coated pine needle fibreboard irrespective of the proportion of rosin in wax. (Edited author abstract) 6 refs.

Negi, Jeet Singh (Regional Research Lab, Jammu-Tawi, India); Chawla, J.S. *Res Ind* v 32 n 1 Mar 1987 p 8-13.

## Testing

**076296 COMPRESSIVE LOAD-STRAIN CURVE OF PAPERBOARD: RATE OF LOAD AND HUMIDITY EFFECTS.** This paper reports the effect of load rate and humidity on edgewise compression properties of paperboard. One linerboard and one corrugating medium were tested at three load rates; 263 N/m/s, 2.63 N/m/s, and 0.0263 N/m/s, under constant 50% and 90% relative humidity (rh). Both paperboards exhibited lower compressive strength, smaller initial stiffness, and larger failure strains as load rate was reduced. Compressive strength and initial stiffness were found to vary with the logarithm of load rate. The results also show that the paperboards in this study were more affected by load rate

at 90% rh than at 50% rh. The hyperbolic tangent model is extended to determine load as a function of strain and load rate. In this model, comparison of the machine direction (MD) and the cross-machine direction (CD) response shows that the CD is more sensitive to load rate at 50% rh, but that the MD is more sensitive at 90% rh. 12 refs.

Gunderson, D.E. (USDA, Madison, WI, USA); Considine, J.M.; Scott, C.T. *J Pulp Pap Sci* v 14 n 2 Mar 1988 p 37-41.

**076297 UNIQUE CONVERTIBILITY OF PAPERBOARD.** Although the tensile strength or bending stiffness of paperboard is high, in general the material possesses good fold, creasing or scoring properties. Both crease and fold resistance are surprisingly low, as is the rate of crack propagation along the deformation lines. The background to this characteristic is explained. It is necessary to keep the compression strength as low as possible in the development of paperboard; if compression strength needs to be raised, e.g. for end-usability, tensile strength also needs to be increased, or brittleness reduced, at least in the outer layers of the material. If these adjustments are not made, the properties that make for good convertibility are degraded, according to the results presented. (Edited author abstract) 29 refs.

Cavlin, S.I. (Swedish Packaging Research Inst, Spanga, Sweden). *Pack Technol Sci* v 1 n 2 Apr-Jun 1988 p 77-92.

## Ultrasonic Effects

**076298 AUTOMATIC DETERMINATION OF ULTRASOUND VELOCITIES IN PLANAR MATERIALS.** A computer-controlled, fully-automated instrument which measures ultrasound velocities in planar materials is presented. By finding two longitudinal and two transverse velocities, it can completely characterize the in-plane elastic properties of an orthotropic sheet. Even though it is specifically designed to analyze paper and paperboard samples, other sheet materials can also be tested. (Author abstract) 14 refs.

Van Zummeren, M. (Inst of Paper Chemistry, Appleton, WI, USA); Young, D.; Habeger, C.; Baum, G.; Treleven, R. *Ultrasonics* v 25 n 5 Sep 1987 p 288-294.

## PAPERMAKING See Also PAPER; PAPER—Newsprint; PAPER—Packaging; PAPER AND PULP INDUSTRY; PAPERMAKING MACHINERY—Wet End; PULP MANUFACTURE—Refining.

**076299 TEMPERATURE-GRADIENT CALENDERING OF FOODBORD.** Temperature-gradient (TG) calendering produces smooth, glossy surfaces with less bulk reduction than conventional machine calendering. The unheated paper web is calendered in a single pass through a nip between two hot calender rolls. The web touches the hot rolls only in the nip. Consequently, the surface fibers are permanently deformed to a greater extent than the fibers in the middle of the paper, and a better surface finish can be achieved with less bulk reduction. In this study, sized and unsized food boards were calendered using both the TG and the conventional calendering methods. The objective of the study was to determine whether there are any benefits in applying the TG-calendering technique to food boards and other heavy paper products. 8 refs.

Gratton, M.F. (Paper & Pulp Research Inst of Canada, Pointe Claire, Que, Can); Seth, R.S.; Crotoigno, R.H. *Tappi J* v 71 n 1 Jan 1988 p 81-86.

**076300 FIBER WEB SUPPORT OF THE FORMING WIRE.** Two factors that affect the initial paper web formation are: (a) the optimum geometrical shape of the 'frames' formed between crossing strands in the forming surface of the wire and (b) the strand density, quantified as specific fiber-supporting length per unit area. Based on simplified models of fibers and wire structure, a frame form close to a square is considered to be the optimal one even for highly oriented furnishes. The typical frame dimensions of today's commercial wires lie within a range where rather minor changes may result in significant

changes in the initial fiber retention. Good qualitative agreement was found between calculated fiber support and first-pass fiber retention. (Author abstract) 8 refs.

Helle, Torbjorn (Norwegian Inst of Technology, Trondheim, Norw). *Tappi J* v 71 n 1 Jan 1988 p 112-117.

**076301 MULTILAYER FORMING AND THE SHEET PROPERTIES OF TISSUE.** The Valmet-KMW research centre at Karlstad majors in multilayer forming and tissue production. Trials show that large amounts of CTMP - over 50% - can be successfully used in a multilayer tissue sheet. Multilayering solves the coating problems caused by CTMP on the Yankee dryer, and reduces energy consumption. Research is also revealing the role of pressing in soft and bulky tissue and exploring the drying and creping procedures. The multilayer technique for the production of tissue and towel was first introduced more than 10 years ago. This paper will describe how production and sheet properties can be affected by multilayer forming.

Andersson, Ingmar (Valmet-KMW, Sweden). *Pap Technol Ind* v 29 n 1 Feb 1988 p 28, 30-31.

**076302 EFFECT OF MACHINE SPEED ON FORMATION, DRAINAGE, AND RETENTION.** Machine speed is the most prominent of the many factors affecting paper machine productivity. The pursuit of higher productivity has led to a dramatic increase in machine speeds in recent years. These higher machine speeds have been achieved in large part through development of better techniques for the efficient removal of water from the wet paper web. The evolution of drainage technology, in turn, has affected the interplay of hydrodynamic and chemical forces that govern flocculation, retention and sheet drainage and formation. As paper machine speeds increase, undesirable side effects are often encountered in the wet end. An increase in the number of web breaks can reduce the availability—and the productivity—of a machine whose speed has been increased. Deposition of latex or other suspended impurities can adversely affect product quality and reduce machine productivity. (Edited author abstract) 27 refs.

Marton, Joseph (SUNY-ESF Syracuse, NY, USA). *Tappi J* v 71 n 4 Apr 1988 p 67-71.

**076303 PAPERMAKING PAST AND PRESENT.** The Chinese invention of paper some two thousand years ago, together with the complementary invention of printing from movable type, was one of the seminal developments in the history of civilization. Together, they constitute a unique and enormously powerful means for the storage and dissemination of knowledge. Today, the printing industry in all its forms is the major user of paper, but enormous quantities are also used for packaging, tissues and toweling, sacks, wall coverings, and many other purposes. Although the papermaking process is still in principle virtually the same as that developed by the Chinese, the enormous increase in demand and the much wider range of paper products required has led to considerable developments in the papermaking process. (Author abstract). 5 Refs.

Goedvriend, G.J.M. *Endeavour* v 12 n 1 1988 p 38-43.

**076304 COMBINATION OF HIGHLY CHARGED POLYELECTROLYTES WITH RETENTION AGENTS: RETENTION IN THE PRESENCE OF INTERFERING SUBSTANCES.** During papermaking, anionic 'trash' is often introduced into the papermaking system. Under conditions resembling those in a mill, a laboratory experiment was set up to demonstrate the influence of such interfering substances on a representative parameter, ash retention. Ash retention was measured as a function of the concentrations of retention aid (polyacrylamide) and short-chain cationic polymer. The adsorption of the polymers is the key to the retention process. Because of the differences in adsorption behavior between short-chain polymers with a high charge density and polymers of high molecular weight, two cationic



components are used for retention in the presence of interfering substances. The short-chain polymer is used to neutralize the interfering substances in solution and to control the number of binding sites available for the high-molecular-weight component. (Author abstract). 10 Refs.

Hagedorn, Roland, A. (Sandoz Ltd, Basel, Switz). *Tappi J* v 71 n 8 Aug 1988 p 131-134.

**076305 DTPMPA: POLYAMINO POLYPHOSPHONIC ACID AND ITS USE IN PAPER RELATED PROCESSES.** Paper was produced from silicate-free pulp bleached with DTPMPA as the peroxide stabilizer on the pilot plant of CTP, Grenoble, France. Using such pulp, the efficiency of retention aids on both fines and fillers is greatly enhanced. Evaporation of water from the paper sheet is accelerated and can lead either to substantial energy savings or faster throughput on the machine. The quality of the finished product is unchanged, but some improvement in the final sizing quality can be seen. (Author abstract).

Kuczynski, Krzysztof (Monsanto Europe, Belg); Nijs, Hubert; Henri, Bronislaw, May. *Tappi J* v 71 n 8 Aug 1988 p 142-146.

**076306 1987 PAPER PHYSICS FUNDAMENTALS AND PAPERMAKING PRACTICES SEMINAR.** This conference proceedings contains 19 papers. Some of the physical aspects of papermaking processes covered include properties of individual fibers, fiber-fiber bonds, paper shrinkage, and paper elongation. Other topics discussed include mechanical and optical properties of paper and pulp; paper sheet formation; papermaking machinery and the roles of shear and turbulence generation in papermaking processes. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11021 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (TAPPI, Atlanta, GA, USA). *TAPPI Notes* 1987 Pap Phys Fundam and Papermaking Pract Semin, Appleton, WI, USA, Feb 25-26 1987. Publ by TAPPI Press, Atlanta, GA, USA, 1987 var pagings.

**076307 TAPPI PROCEEDINGS - 1987 PAPERMAKERS CONFERENCE.** This conference proceedings contain 46 papers. Topics covered include: Coloring, colorimetry, color matching, dyes and dyeing; Drying; Analysis of machine vibrations and basis-weight variance; On-line color control, measurement and whitening agents; Effect of pigments and starch properties on paper quality; contaminants and detrimental substances - control, measurement and effects on paper quality; Control and measurement techniques for papermaking and paper machine parameters; Stock preparation, handling, monitoring; and processing; Retention aids and mechanisms of retentions and improvements, innovations and developments in papermaking machines and components. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11227 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (TAPPI, Atlanta, GA, USA). *Papermakers Conf Proc Tech Assoc Pulp Pap Ind* 1987, Atlanta, GA, USA, Apr 6-8 1987. Publ by TAPPI Press, Atlanta, GA, USA, 1987 356p.

**076308 74TH ANNUAL MEETING, TECHNICAL SECTION CANADIAN PULP AND PAPER ASSOCIATION - PREPRINTS.** This conference proceedings contains 102 papers, of which 7 papers appear in abstract form only. One paper is in French and the rest are in English. The papers deal with various aspects of pulp manufacture, papermaking and papermaking machinery. Some of the topics covered include pulp bleaching waste liquor utilization, mechanical and kraft pulps. Other topics covered include quality control, energy management and environmental protection in paper and pulp mills. Technical and professional papers from this conference are indexed and abstracted with the conference code

no. 11062 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (CPPA, Technical Section, Montreal, Que, Can). *Annu Meet Tech Sect Can Pulp Pap Assoc Prepr* 74th, Montreal, Que, Can Jan 26-29 1988. Publ by CPPA, Technical Section, Montreal, Que, Can, 1988 2 vol, 602p.

**076309 1988 PAPERMAKERS CONFERENCE.** This conference proceedings contains 60 papers dealing with papermaking technology. The major topics discussed include on-line measurement, pigments, alkaline papermaking, training and development, deposit control, machine vibration analysis, sizing, additives, stock preparation, electrokinetics, and paper chemistry. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11400 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (TAPPI, Atlanta, GA, USA). *Papermakers Conf Proc Tech Assoc Pulp Pap Ind* Publ by TAPPI Press, Atlanta, GA, USA 399p.

**Bleaching** See PAPER AND PULP MILLS—Machinery; PAPER AND PULP MILLS—Process Control; PULP MANUFACTURE—Bleaching.

**Chile** See PAPER AND PULP MILLS.

**Coagulation**

**076310 NEW CHEMICAL APPROACH TO WATER REMOVAL.** A UK fine paper-mill has increased machine speed by 5.8%, improved formation and retention, and reduced steam pressure by 43%, by means of the new technology of supercoagulation. The system has two components: a synthetic polymer which is added early in the papermaking process - in the thick stock, for example; and an inorganic pigment which is added just before the flowbox, to induce total coagulation. It can be applied to acid and alkaline systems, and over a wide range of paper qualities. (Author abstract)

Peutherer, P. (Allied Colloids Ltd, Bradford, Engl). *Pap Technol Ind* v 29 n 3 May 1988 p 118-120.

**Coating** See Also PAPER—Coating; PAPER AND PULP MILLS—Machinery; PAPER AND PULP MILLS—Process Control; PAPERBOARDS—Sizing; PAPERMAKING MACHINERY; PAPERMAKING MACHINERY—Rolls.

**076311 L'AA QUIETLY LEADS FRENCH REVIVAL.** Papeteries de l'Aa, with assistance from Arjomari, has quietly built its new coating base PM 5, the first of several large investments taking place in France. (Author abstract)

O'Brian, Hugh. *PPI Pulp Pap Int* v 30 n 2 Feb 1988 p 60-61.

**076312 RELATIONSHIP BETWEEN PRINT MOTTLING AND COATING STRUCTURE.** A method of obtaining the surface profile of the binder distribution was developed using ESCA (electron spectroscopy for chemical analysis) with an analyzer slit with an effective area of 2 mm in diameter. Furthermore, a quantitative method for evaluating print mottle by image analysis was developed. Print mottle was caused by nonuniform absorption of dampening solution corresponds directly with the nonuniformity of the surface distribution of binders and pigments. Both print mottle and nonuniformity of binder distribution at the coated surface have a scale of 1-3 mm in diameter. 15 refs.

Arai, Takao (Mitsubishi Paper Mills Ltd, Tokyo, Jpn); Yamasaki, Takeshi; Suzuki, Kunio; Ogura, Toshimasa; Sakai, Yasunosuke. *Tappi J* v 71 n 5 May 1988 p 47-52.

**076313 MILL EXPERIENCE WITH GATE-ROLL-COATED PAPERS.** The gate roll coater is described as a single tool to improve printability. Gate-roll-coated papers have been welcomed by printers and publishers, and the sales of these grades have been growing steadily in Japan. Pigment coating with the gate roll coater improves the printability of paper substan-

tially, though not as extensively as blade coating. A streak-free coat is the most outstanding merit of gate roll coating.

Hirakawa, M. (Jujo Paper Co, Ishinomaki, Jpn); Iwase, H. *Tappi J* v 71 n 5 May 1988 p 53-57.

**076314 APPLYING PILOT COATER RESULTS TO MILL PRACTICE.** Pilot coaters are useful tools in minimizing the risk during the development of new coating formulations or paper grades. Many problems associated with runnability can be studied, and the results correlate well with subsequent mill practice. In all cases where printability is the subject of the experiment, one should be careful in interpreting the results. Generally, all experiments meant to duplicate on-machine coating can only be regarded as showing tendencies. Such tendencies can be established, but a direct correlation with mill practice seldom exists, especially for board. There are other phenomena which cannot be studied on a pilot coater, such as blade wear or other long-term effects. On the other hand, the influence of various coating head configurations (or different blade positions) can be studied easily on the pilot coater. 3 refs.

Rohmann, Michael E. (BASF, Ludwigshafen, West Ger). *Tappi J* v 71 n 5 May 1988 p 61-67.

**076315 CASE STUDIES ON THE USE OF THE OPTICAL MICROSCOPE IN THE ANALYSIS OF COATED PAPERS.** The polarizing microscope is shown to be a powerful analytic tool when applied to coated papers. Among its many uses is the identification of particle contaminants found by the mill quality control laboratory or in the printing plant. Even microscopic quantities of synthetic filaments can be identified by refractive index techniques, dye-staining techniques, or solubility tests. To identify and locate pigments and binders, both chemical and optical staining are used. Microchemical staining is a commonly known technique that can be applied in both surface studies and in cross-sectional studies. Optical staining is less well known and demands a knowledge of the adjustment possibilities of the optics in a polarizing microscope.

Quackenbush, Dale (Island Microscopy, Eastsound, WA, USA). *Tappi J* v 71 n 5 May 1988 p 70-75.

**076316 COMPARISON OF U.S. AND EUROPEAN COATED PAPERS.** The structure of the U.S. market in terms of the apparent consumption for the five main coated paper groups, coated two-sides (C2S) Nos. 1 to 5 and the rate of growth for each group is examined. A comparison is made of the physical characteristics of U.S. and European coated papers considering major differences in brightness and opacity between U.S. and European papers. Some indication of why European papers are different from their U.S. counterparts and in what way European papermaking practice differs from that in the U.S. is given. In summary, it has been shown how superficially similar the U.S. and European markets are. 2 refs.

McAuley, D. (ECC Int Ltd, St. Austell, Engl). *Pulp Pap Can* v 89 n 4 Apr 1988 p 43-48.

**076317 EMERGING TRENDS IN COATING.** U.S. and Canadian papermakers apply coatings to a considerably greater percentage of their production than the industry does in the rest of the world. The reasons for this trend are examined and changes taking place especially in Europe, are pointed out. The trends towards greater efficiency and versatility in paper and paperboard coating in America as well are noted. The Combs-Blade coater by Jagenberg which allows the user to switch metering systems to different blades is described. Hydro-Bar elements replacing blades and the short dwell coater are described.

Greiner, Thomas S. (Jagenberg Inc, Enfield, CT, USA). *Pap Trade J* v 169 n 5 May 1985 p 44-46.



**076318 1987 AIR KNIFE COATING SEMINAR.** This conference proceedings contains 11 papers. The papers cover air-knife coating in papermaking. Some of the topics discussed include papermaking machinery, metering systems; applicator systems; coatings formulation; pigments, coating physical properties; quality control; and coating technique economics. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11275 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (TAPPI, Atlanta, GA, USA). *TAPPI Notes* 1987 Air Knife Coat Semin, Houston, TX, USA, May 21-22 1987. Publ by TAPPI Press, Atlanta, GA, USA, 1987 69p.

## Coatings

**076319 PLC'S MAXIMIZE PRODUCT QUALITY, KEEP COATING PROCESS ON TARGET.** Wavervliet Paper uses programmable controllers in their color kitchen to run the new on-machine coater. Operators have total control over process variables. Tear-out and roll-out tests indicate the coating process is being controlled within narrower limits than ever before. At the same time, reduced handling has cut labor requirements and product losses, improving the company's profitability and productivity. As a result, the company has the ability to enter new markets where cost, quality, and consistency of coated stock are critical to customer acceptance.

Anon. *Pulp Pap* v 62 n 6 Jun 1988 p 124-126.

## Coloring See Also PIGMENTS—Performance.

**076320 IMPROVING COLOUR CONSISTENCY THROUGH CLOSED-LOOP CONTROL.** Great consistency in paper colour can be achieved through the latest closed-loop technology. The computer measures colour continuously through sensors above and below the sheet. It plots colour trends - opacity, pump stroke, moisture and dye usage - and, through control of the dye dispensing pumps, reacts rapidly to change. If the sheet breaks dye flow is reduced, and if broke is added, the computer compensates. The hardware and software of closed-loop control are described in this article. (Edited author abstract)

Lorditch, George M. (Kollmorgen, New York, NY, USA). *Pap Technol Ind* v 28 n 7 Oct 1987 p 634-635.

**076321 IMPROVING QUALITY AND OUTPUT THROUGH COLOUR CONTROL.** Traditionally, color matching has been accomplished through visual comparison by a trained 'colorist', or by laboratory instruments on a once-per-reel basis. On-line measurements supported by a microprocessor-based control system afford an excellent means for the colorist to improve traditional color machine methods, in any situation where shade matching is important. To meet this need, AccuRay has introduced a system which provides reliable measurement and precise control of color. The purpose of this paper is to describe the color package in terms of the measurement technology, control strategy, and results to date.

Marchi, Robert (AccuRay). *Pap Technol Ind* v 29 n 2 Mar 1988 p 72-75.

**076322 INVESTIGATION INTO THE MECHANISM OF TITANIUM-DIOXIDE EXTENSION BY CALCIUM CARBONATE.** Sheets produced from a furnish containing equal weights of  $\text{TiO}_2$  and  $\text{CaCO}_3$  have a light-scattering coefficient that is nearly equal to that of pure  $\text{BO}_2$ . The authors found that the light-scattering behavior of the pigment mixture could be described by an equation that assumes the blended pigments act independently of one another. It is well known that lowering the loading level of a pigment increases its dispersion and thus its light-scattering efficiency. The authors reasoned that independently acting pigments in a 50/50 mixture would each disperse as if it were loaded at 50 percent of the total load. The greater dispersion would then increase the light-scattering efficiency of each pigment. (Edited author abstract). 7 Refs.

Chang, S.-Y. (State Univ of New York, Syracuse, NY, USA); Scott, W.E. *Tappi J* v 71 n 10 Oct 1988 p 128-131.

## Computer Simulation

**076323 SIMULATING THE DEVELOPMENT OF PULP AND PAPER PROPERTIES IN MECHANICAL PULPING SYSTEMS.** Process simulation, property modelling and optimization techniques have been combined to predict optimum performance and quality of pulp and handsheets for high-yield pulping systems. The technique involves a new set of fundamental variables called performance attributes which link the material and energy flows in the process to predictive property models. The effects of refining, screening, cleaning, mixing and bleaching are shown for a typical TMP process. (Author abstract). 14 Refs.

Jones, G.L. (Inst of Paper Chemistry, Appleton, WI, USA). *Pulp Pap Can* v 89 n 6 Jun 1988 p 128-138.

## Contamination

**076324 'ANIONIC TRASH': CONTROLLING DETRIMENTAL SUBSTANCES.** This paper looks at some of the principal facts about detrimental substances, to give some new details about their interaction with other materials and to give a few examples of paper mills where the whole papermaking process was improved by adding process chemicals in spite of a large amount of detrimental substances in the paper stock or in the raw material. Detrimental substances are defined as the total amount of anionic oligomers and polymers and nonionic hydrocolloids. Chemically, these detrimental substances can be of a different organic and inorganic nature and of different origin. 22 refs.

Linhardt, F. (BASF AG, Ludwigshafen, West Ger); Auhorn, W.J.; Degen, H.J.; Lorz, R. *Tappi J* v 70 n 10 Oct 1987 p 79-85.

## Drainage See PAPERMAKING MACHINERY.

**Drying** See Also PAPER—Drying; PAPER—Newsprint; PAPER AND PULP MILLS—Machinery; PAPERMAKING MACHINERY—Design; PAPERMAKING MACHINERY—Dryers; PAPERMAKING MACHINERY—Felts.

**076325 INSTANTANEOUS MEASUREMENT OF DENSITY PROFILE DEVELOPMENT DURING WEB CONSOLIDATION.** A new method for measuring the instantaneous z-direction density profile of fiber mats during consolidation is described. The measurement technique involves the tracking of special open-mesh targets embedded in the sheet at various levels by a noncontact displacement measuring system mounted in the bottom press platen. Factors of critical importance to successful measurements are discussed. Density profile measurements made under wet pressing and impulse drying conditions are presented to demonstrate the applicability of the measurement technique. (Author abstract) 12 refs.

Burton, S.W. (Union Camp Corp, Princeton, NY, USA); Sprague, C.H. *J Pulp Pap Sci* v 13 n 5 Sep 1987 p 145-150.

**076326 IMPULSE DRYING AND HEAT RECOVERY HEAD THE LIST OF THE LATEST DEVELOPMENTS.** Drying has drawn increased attention recently with the development of exciting new techniques. First among these is impulse drying. Still in its early stages, if the potential it holds is realized, it could radically alter the papermaking process. Impulse drying removes water both thermally and mechanically. High-pressure steam is generated rapidly in the web as it is passed through a nip with a hot, top roll. Liquid water is displaced from the sheet onto the felt. Test data show that a 40%-solids web sent through a nip with a heated roll at speeds up to 300 m/min achieves a solids content of 60% after one pass.

Rodden, Graeme (Pulp & Paper Canada, Don Mills, Ont, Can). *Pulp Pap Can* v 88 n 9 Sep 1987 p 56-58.

**076327 SURVEY OF CANADIAN NEWSPRINT DRYER SECTIONS: PART I - TECHNICAL DATA.** A survey of 92 dryer sections of newsprint and groundwood

specialty paper machines at 30 Canadian mills was carried out to determine the energy consumption patterns and the overall drying performance. This paper on the survey results gives basic technical information on items such as: machine type, size and speed; pulp furnish; steam-condensate systems; and pocket ventilation. (Edited author abstract) 3 refs.

Sayegh, N.N. (Paprican, Pointe Claire, Que, Can); Pikulik, I.I.; Simonsen, H.I. *Pulp Pap Can* v 88 n 12 Dec 1987 p 217-221.

**076328 IMPULSE DRYING: A HOT IDEA IN PAPERMAKING TECHNOLOGY.** The large capital and operating expense of removing water from the wet web during the papermaking process is a significant industry problem. Research to develop compact and efficient de-watering processes is therefore important. Impulse drying offers one of the most promising solutions of the new dewatering technologies for the industry.

Thompson, Randall A. (Westinghouse Electric Corp). *PIMA Mag* v 69 n 11 Nov 1987 p 39-40.

**076329 PRESS DRYING CAN LOWER ENERGY COSTS.** After-press drynesses of over 50% have been achieved by 11 mills after installing a new type of press section. In the case of Spanish company, Papelera del Arlanzon, the after-press dryness was 57-58% on its PM making 140-160-g/m<sup>2</sup> packaging grades, while Mexican producer Papelera Atlas has recorded a dryness of 54% on its machine, making 240-g/m<sup>2</sup> board. Central to the new press section is a large-diameter cylinder, coated with a special alloy, and heated internally by steam injection at pressures of 0-3 kg/cm<sup>2</sup>. It forms the press section nips with several press rolls which allow progressively higher pressures to be applied to the paper web. Pressing periods are longer than usual thanks to the diameter of the central cylinder, and there are no open draws.

Garcia, Ernesto. *PPI Pulp Pap Int* v 29 n 10 Oct 1987 p 71, 73.

**076330 PRESS DRYING: A WAY TO USE HARDWOOD CTMP FOR HIGH-STRENGTH PAPERBOARD.** Chemithermomechanical pulp (CTMP) is not presently used in linerboard or corrugating medium. Because of its high lignin content and stiff fibers, CTMP dried conventionally cannot achieve sufficient bonding for products requiring high strength. Results show that press-drying technology offers potential for using high-yield CTMP made from hardwoods for the manufacture of high-strength paperboard products. With the exception of tear strength, strength properties of press-dried CTMP paperboards were equivalent to or better than those of commercial paperboards. In particular, compressive strength of the CTMP paperboards was much higher. Combined board and containers made from press-dried CTMP paperboards met current expectations except in impact resistance. At high humidity, we noted high retention of short-column strength in the combined board and of top-to-bottom compressive strength in the containers. (Author abstract) 13 refs.

Horn, Richard A. (USDA Forest Service, Madison, WI, USA); Bornett, David W.; Setterholm, Vance C. *Tappi J* v 71 n 3 Mar 1988 p 143-146.

**076331 ENERGY SAVING THROUGH HOT PRESSING.** It is shown that heating the sheet in the press section can significantly reduce steam requirements in the dryer section. A model is constructed that compares the relative efficiencies of mechanical vs. evaporative water-removal. The model identifies situations when steam applied at the hot press removes more water than a comparable amount of steam in the dryer section. A mill can use this information to optimize the allocation of steam for use in drying the wet web. The model predicted that two newsprint mills and one linerboard mill would be able to save energy by shifting some of the steam from their dryer sections to a steam shower in the press section.



These mills responded by altering their drying strategies. The net energy savings obtained by the mills matched or exceeded the model's predictions.

Cutshall, Keith (Devron-Hercules Inc, North Vancouver, BC, Can). *Tappi J* v 71 n 4 Apr 1988 p 89-91.

**076332 PENNIMAN PROCESS; A NEW PAPER-MAKING PROCESS.** The process, which involves the addition of synthetic hydrocarbons after the formation and before the press section, was discovered accidentally - pure kerosene, instead of kerosene emulsion, was applied to the press section felts on a modern newsprint machine, and steam pressure in the dryer section fell by half. The typical effect of the Penniman Process on physical properties is to produce a thinner, stronger, smoother and stiffer sheet - not unlike the effects achieved by the impulse drying process. The process also allows the use of chemical additives - at usage reductions as great as 60-80% - to improve wet and dry strength; de-bonding/apparent softness; sizing; brightness and color. This new procedure avoids the destructive effect of anionic trash, and can result in virtually 100% retention. 4 refs.

Penniman, John G.W. (Paper Chemistry Lab, NY, USA); Reichlin, Maria S. *Pap Technol Ind* v 29 n 3 May 1988 p 111-115, 117.

**076333 DRYER SHEET STABILITY FOR OLDER PAPER MACHINES.** There have been many advances in dryer section sheet runnability for older paper machines. It is now possible to reach competitive speeds with an older dryer section design. Sheet stabilizing devices are commonplace on most high-speed dryer sections. Improvements in this area continue to be made. Proper attention to both the air movements and the design of the dryer drainage system are needed to achieve the best results. (Author abstract).

Hill, Kenneth, C. (Engineering & Technical Services, Knoxville, TN, USA). *Tappi J* v 71 n 8 Aug 1988 p 55-59.

**076334 IMPROVED DEWATERING OF SHEETS BY A PETROLEUM HYDROCARBON.** A petroleum hydrocarbon applied in the form of spray on the surface of bandsheets enhanced the dewatering, or increased the consistency, during pressing and drying. Results from differential scanning calorimetry and thermogravimetric analysis indicated that the removal of water from the hydrocarbon-treated sheets took place at a lower temperature and required less energy than the control sheet. The addition of the petroleum hydrocarbon did not have any significant effect on the sheet properties. (Author abstract). 21 Refs.

Rahman, L. (Abitibi-Price Inc, Mississauga, Ont, Can); Tay, C.H. *Tappi J* v 71 n 10 Oct 1988 p 177-181.

**Economics** See PULP MANUFACTURE.

**Energy Conservation** See PAPER—Sheeting.

**Environmental Impact** See PAPER AND PULP MILLS—Modernization.

**Federal Republic of Germany**

**076335 SCHOELLER FOCUSES ON PM 1 DEVELOPMENT.** West German papermaker, Felix Schoeller operates the widest photobase paper machine in the world, and, with its US subsidiary, supplies more than 45% of demand for these grades worldwide. This article reports on this development.

Pearson, John. *PPI Pulp Pap Int* v 30 n 6 Jun 1988 p 75, 77, 79.

**Finishing** See Also PAPERMAKING MACHINERY—Automation.

**076336 FINISHING - NO LONGER THE CINDER-ELLA OF THE MILL.** When Thames Board of Great Britain trebled the capacity of their Workington mill to 150 000tpy, an automated finishing department with the latest bar coding, palletising and shrink wrapping technol-

ogy was set up. The author describes the technology and the computer system that runs it. He describes the teething problems with the Omega computer system which did not have the capacity to handle the expanding mill, and the switch to OSCAR - an order scheduling, control and reporting system that lays the foundations for mill-wide control. (Edited author abstract)

Heyworth, J.L. (Thames Board, Engl). *Pap Technol Ind* v 28 n 7 Oct 1987 p 637-640.

**076337 FUTURE TRENDS IN ROLL FINISHING.** Automation is changing the borders of different tasks in roll finishing. Modern wrapping line lay-out and smooth roll handling systems together with today's computer-based controls provide excellent possibilities to increase productivity and at the same time add safety and increase motivation of the operators who supervise automatic machinery instead of operating it. The justification of new equipment has to come from productivity increases. An improved working environment makes sure that the goals will be met. (Author abstract)

Kotiaho, P. (Valmet-Appleton Inc, Appleton, WI, USA). *Pulp Pap Can* v 89 n 1 Jan 1988 p 133-137.

**076338 NEW CHALLENGES FOR PROCESS COORDINATION IN PAPER FINISHING AND CONVERTING.** At many paper finishing or converting operations today, automation technologies are often applied to isolated machines within the overall process, creating islands of automation. These automation technologies include electronic generation of the shipping manifest through the use of bar codes, automatic storage and retrieval systems, and automated slitter positioning. Their use has made the operator in the finishing room more productive by minimizing the tasks that demand the operator's direct attention. The sequential nature of the finishing and converting process has, however, increased the number of potential bottlenecks. Process coordination can be optimized by adding process diagnostics that link the knowledge of the user and the knowledge contained in the control system.

Au, Burton K. (Allen-Bradley Co, Cleveland, OH, USA). *Tappi J* v 71 n 3 Mar 1988 p 117-120.

**076339 NEUE ENTWICKLUNGEN IN DER PAPIER- UND KUNSTSTOFFVEREDELUNG. [Recent Developments in Finishing of Paper and Plastics].** Considerable research and development work has been undertaken, theses written, on finishing of paper and plastics. Especially on liquid or film coating. Under the present environment and health protection legislation, investigations on the use of solvent-free processing systems are particularly relevant. Besides chemically curing systems, radiation curing formulations have been in existence for some years, in which polymerization is completed either by UV radiation using photoinitiators or with electron radiation acting on the web of material. The following report is restricted to work performed in the Electron Irradiation Department (ESH-Technikum) of the Technical University in Munich. (Edited author abstract) 3 refs.

Nitzi, Knut (Fachhochschule Muenchen, Munich, West Ger). *Adhaesion* v 31 n 6 Jun 1987 p 20, 23-24.

**076340 KAMLOOPS RECAUSTICIZING UP-GRADE.** The recausticizing plant at Kamloops was upgraded by the addition of a white liquor pressure filter. White liquor clarity improved from approximately 100 ppm to less than 5 ppm. The design philosophy, construction and operation of the new system are presented. (Author abstract) 1 ref.

Bruce, P. (Weyerhaeuser Canada Ltd, Kamloops, BC, Can); Dennis, B.; Henzler, B. *Pulp Pap Can* v 89 n 5 May 1988 p 55-58.

**076341 ON- AND OFF-MACHINE SOFT-NIP SURFACE FINISHING OF COATED GROUNDWOOD AND WOOD-FREE PAPER GRADES.** For decades, the supercalender has been the classic soft-nip finishing equipment for production of high-quality coated paper

grades. Even with improvements and speeds up to 1000 m/min, the supercalender is still limited by the fact that it is a purely off-machine operating unit. With further improvements in components, roll covers, and coating formulations, the soft calender may become a viable alternative to the supercalender. On-machine soft-nip calendering reduces space requirements and lowers operating costs through reductions in labor and broke. It also provides a uniform, gentle densification of the sheet without sacrificing opacity, strength, and brightness. The soft calender allows the pressure and temperature in each nip to be controlled individually over a wide range. The flexibility in obtaining finishing effects is far superior to advanced supercalendering technology. This concept also reduces two-sidedness in the paper web. 7 Refs.

Winkels, Heinz (Kleinewefers, Krefeld, West Ger); Svenka, Peter. *Tappi J* v 71 n 8 Aug 1988 p 97-103.

**076342 PRACTICAL ASPECTS OF CALENDER STEAM SHOWERS.** Calender steam showers raise the sheet temperature and increase the sheet moisture content, both of which improve the properties of the sheet surface. Results from calender steam installations on newsprint and specialty groundwood machines show that smoothness improvements of up to 23 percent have been achieved. The extent of smoothness improvement depends on a number of factors, including sheet weight, machine speed, steam shower location, incoming sheet temperature to the calender, and type of furnish. A calender steam shower is an option to consider if sheet smoothness and gloss improvements are required or if sheet two-sidedness is a problem. (Edited author abstract). 3 Refs.

Vyse, R.N. (Devron-Hercules Inc, North Vancouver, BC, Can); Sawley, David J. *Tappi J* v 71 n 10 Oct 1988 p 87-90.

**076343 HAINDL PAPIER TAKES ADVANTAGE OF LIGHTWEIGHT COATED BOOM IN EUROPE.** A description is given of a mill expansion program that sought the acquisition of a paper machine, an offline coater with coating kitchen, elaborate finishing equipment, and expansion of thermomechanical pulp (TMP) production. Mill design capacity is 1,250 metric tpd, with a grade range across the LWC spectrum (single- and double-coated, 42 to 170 g/m<sup>2</sup>) carrying the brand name Valsa. A discussion covers the thin-wire formers and finishing equipment.

Anon. *Pulp Pap* v 62 n 10 Oct 1988 p 74-75.

**076344 GNP UTILIZES DIVERSE TECHNOLOGIES TO MODERNIZE ITS FINISHING ROOM.** A description is given of a modernization plan that included rebuilds of two paper machines, installation of a computerized roll tracking system (RTS), and total automation of its manual wrapping lines. The finishing area requirements included reduced manpower, limited material storage, and minimal car switching, which contrasted with the need for maximum flexibility in assigning rolls to orders and monitoring real-time status of the finishing operations. Potential RTS vendors were required to provide standard DEC hardware and VMS-based (DEC's standard operating system) software throughout the system. This would ensure compatibility with the existing CIS system and make ongoing maintenance costs of hardware and software easier to control. The function of the RTS system is discussed. Ref.

Ducey, Michael J. (Pulp & Paper, San Francisco, CA, USA). *Pulp Pap* v 62 n 10 Oct 1988 p 139-143.

**Finland** See PAPER—Printing Properties; PAPERMAKING MACHINERY—Performance.

**Humidity Control** See PAPERMAKING MACHINERY—Dryers.

**Inspection**

**076345 STROBE SYSTEM PINPOINTS QUALITY PROBLEMS, MACHINERY FAULTS.** Finch Pruyn & Co., Inc., Glens Falls, N.Y., has a new way to detect minute blemishes in quality, save waste paper and speed



the diagnosis of machine problems. The firm uses stroboscopic flood lights to create slow-motion images of paper formation at 600 to 1,400 fpm. Unilux lighting emits pulses of light, as many as 250 per second. Each pulse is an intense burst that lasts only a ten-millionth of a second. A pulsed light source of sufficient intensity and short enough duration provides the eye with a series of frozen images. The eye has time to focus on each image without any blur. The high-intensity overpowers ambient light.

Anon. *PIMA Mag* v 70 n 8 Aug 1988 P48.

## Japan

**076346 FOURTH PRESS OPERATION IN JAPAN.** High-speed paper machines with three presses can be rebuilt with a fourth press. In 1975, a fourth press was installed for the first time in a Japanese mill. There are now 26 fourth presses running on paper machines producing newsprint, coating raw stock, and fine paper. Addition of a fourth press section has provided additional dewatering capacity and has improved sheet properties in many Japanese mills. Off-press solids have been increased by 2-3% for newsprint grades, resulting in higher machine speeds, fewer breaks, and lower stream consumption. Printability has been improved by a reduction in two-sidedness. Lower porosity and higher internal bond were obtained with increased fourth-press nip loads on a coating-rawstock grade. For printing grades, wire-side sheet surface strength was improved to enable multicolor printing. An improvement in felt-side smoothness eliminated two sidedness.

Inoue, Satoshi (Mitsubishi Heavy Industries Ltd, Hiroshima, Jpn); Nagano, Akihito. *Tappi J* v 71 n 4 Apr 1988 p 83-87.

**Materials** See Also AGRICULTURAL WASTES—Applications; PULP MATERIALS—Wood.

**076347 PAPER FROM ACETYLATED BAGASSE KRAFT PULP.** Bleached bagasse kraft paper pulp was subjected to both surface and bulk acetylation under different conditions. The relation between the degree of acetylation and the contact angle as well as the effects of different activating treatments and acetyl content on the optical and physical-strength properties of the paper produced were investigated. (Author abstract) 8 refs.

Abou-State, M. Amine (Cairo Univ, Giza, Egypt); El-Masry, Ahmed M. *Res Ind* v 31 n 4 Dec 1987 p 251-255.

**076348 SUPPLIER REPORT CARDS - A ROUTE TO TOTAL PERFORMANCE.** Obtaining raw materials of high quality encompasses more than statistical process control of measured variables. A good relationship with suppliers allows a common understanding about the mill's requirements. When raw materials parameters are measured, the results must be communicated back to suppliers if problems are to be solved objectively and efficiently. At consolidated papers, suppliers, are graded on quality, delivery, and service performance and trends point to improvements over the past three years. The mill has had fewer production upsets caused by inadequate materials and mill personnel feel that the benefits of this program outweigh its administrative costs. (Edited author abstract).

Dekoch, R.J. (Consolidated Papers Inc, Wisconsin Rapids, WI, USA). *Tappi J* v 71 n 10 Oct 1988 p 109-115.

**Mathematical Models** See PAPERBOARDS—Corrugated.

## Measurements

**076349 ULTRASONIC MEASUREMENT OF GASEOUS AIR IN PULP SUSPENSIONS.** This paper is based on a discovery made in the laboratory during experiments involving ultrasonic interaction in a pulp suspension. Large air bubbles were observed to have only a modest effect on the attenuation of ultrasonic transmissions, while entrained air produced a far more dramatic response. In the case of entrained air, the water-air

interface scatters sound strongly. This occurs because of the considerable difference between the acoustic impedances of water ( $1.5 \times 10^6$  kg/m<sup>2</sup>s) and air ( $4.3 \times 10^2$  kg/m<sup>2</sup>s). The entrained air attaches to the fiber flocs in the suspension and scatters sound effectively. The method has been tested in the laboratory and in several paper mills. Tests prove that a commercial meter can be developed to control the feed of chemical defoamer in paper machines. 9 refs.

Karras, Matti (Univ of Oulu, Oulu, Finl); Pietikainen, Tapio; Kortelainen, Helena; Tornberg, Jouni. *Tappi J* v 71 n 1 Jan 1988 p 65-69.

**Moisture Determination** See PAPER—Calendering.

## Nonfibrous Materials

**076350 USE OF FILLERS IN PAPERMAKING.** Mineral fillers are used to increase the opacity of paper and reduce the use of expensive cellulose fiber. Fillers reduce the strength and, at high levels, the feel of the paper. However, available technology permits the use of 50% or more filler without substantial loss of strength or feel. Many, if not most, fine paper mills in Europe have converted their acid systems to alkaline systems. The advantages of alkaline sizing include the ability to increase the filler content without sacrificing strength, reduced energy usage, improved runnability, and better paper quality, especially in the areas of heat and light stability. North America seems to be following the lead of Europe in converting to alkaline-sized filled sheets. There is a wide choice of fillers available to reduce the material costs for such commodity fine papers as offset, xerographic copy, etc. Many are compatible with an acid or an alkaline system. 18 refs.

Griggs, William H. (Eastman Kodak Co, USA). *Tappi J* v 71 n 4 Apr 1988 p 77-81.

**Optimization** See PULP—Cleaning.

## Pressure Measurement

**076351 MEASUREMENT OF CALENDER NIP PRESSURE.** A reliable and inexpensive method has been developed to measure cross-machine direction nip loads in calender stacks. This technique can be carried out with carbonless nip impression paper, a brightness meter and a microcomputer. The measurements are independent of the characteristics of the nip impression paper and the brightness meter because of a novel, in-situ calibration technique. Several examples are presented to show how this method can be used to identify problems in calender and breaker stacks. (Author abstract) 9 refs.

McDonald, J.D. (PAPRICAN, Pointe Claire, Que, Can); Stevens, R.K. *Pulp Pap Can* v 88 n 9 Sep 1987 p 111-115.

**Production** See PAPER AND PULP INDUSTRY—Machinery.

**Productivity** See PAPERMAKING MACHINERY—Fourdrinier Machines; PAPERMAKING MACHINERY—Rolls.

**Quality Control** See Also PAPER—Newsprint; PAPER—Printing Properties; PAPER AND PULP INDUSTRY—Quality Control; PAPER AND PULP MILLS—Process Control; PAPERBOARDS—Quality Control; PAPERMAKING MACHINERY; PAPERMAKING MACHINERY—Headbox; PAPERMAKING MACHINERY—Rolls; PULP—Mixing.

**076352 AIR CONTENT, RETENTION AND DRAINAGE: IMPORTANT PARAMETERS IN PAPER/BOARD PRODUCTION.** Reduction of air content and improvements in retention and drainage are important in achieving the best quality in paper and board production. With several examples from mill experience, the possible effects that can be reached with the existing chemical additives for these applications are discussed and illustrated. (Author abstract) 6 refs.

Lorz, R.H. (BASF AG, Ludwigshafen, West Ger). *Pulp Pap Can* v 88 n 10 Oct 1987 p 85-89.

**076353 WATER SPRAY SYSTEMS HELP MILL MEET CUSTOMER SPECS.** About a year ago, PWA Industriepapier began using cross-machine control at its fluting mill in Aschaffenburg, West Germany. The two moisture profiling systems - Microset Water Sprays multi-plexed through an AccuRay 1180 Micro - were installed on the mill's PMs No. 3 and No. 4. The moisture actuators correct profile variations by selectively applying an atomized mist of water to the driest portions of the sheet. The system consists of a sprayboom and a series of spray nozzles six inches apart.

Anon. *PIMA Mag* v 69 n 11 Nov 1987 p 37-38.

**076354 CLOTHING PERFORMANCE EVOLUTION HAS LED TO PAPER MACHINE ADVANCES.** The article illustrates just how important the development of machine clothing has been in helping to increase paper production. A southeastern mill, producing fine and brown paper, recently celebrated its fiftieth anniversary. The information given was part of an exhibit showing the growth of that complex. It is obvious that longer clothing life resulted in less down-time and higher production. Designs developed since the early 1970s have also helped to increase machine speeds because of their ability to handle more water while impacting the desired sheet finish. All of these advances in paper machine clothing over the past 50 years have been the result of years of R&D and have all had the same goal: to produce a higher-quality sheet of paper at faster speeds and at a lower cost to the paper industry.

Banks, Roger (Wagner Systems, Greenville, SC, USA). *Pulp Pap* v 62 n 5 May 1988 Op 83-85.

**076355 UNDERSTANDING THE EFFECT OF SAMPLING AND TESTING ERROR.** To interpret quality control test data properly, one must understand the effect of error in sampling and testing. The sampling and testing error for key tests needs to be examined and quantified. If such errors are excessive, it is necessary to design experiments to identify the major sources of variation, which could be in the sampling, the sample preparation, instrument calibration, operator differences, etc. The contribution of sampling and testing variation to total variation can generally be reduced by making additional measurements. Results from designed experiments can provide direction as to the need for more sampling, more testing, or possibly both.

Jaehn, A.H. (Consolidated Papers, Inc, Wisconsin Rapids, WI, USA). *Tappi J* v 71 n 8 Aug 1988 p 187-188.

**076356 HOW TO MEASURE ROLL QUALITY.** The article outlines a comprehensive approach for setting up a statistical quality control program in the finishing room. The author describes methods commonly used to measure roll structure, including hardness impacters (billy club, Rhometer, Schmidt hammer), strain-based tests (Cameron gap, J-line), friction-based tests (core torque, pull tab, Smith needle), rewinders, and density analyzers. The author also presents a method for evaluating these tests based on accuracy, ease of use, cost, destructiveness, and utility of the measured variable. A discussion of statistical methods at the end of the article shows how to correlate defects and measured parameters and how to determine confidence levels in the results of the program. (Edited author abstract). 36 Refs.

Roismun, David R. (Oklahoma State Univ, Stillwater, OK, USA). *Tappi J* v 71 n 10 Oct 1988 p 91-103.

**076357 HAVING CONFIDENCE IN ON-LINE INSTRUMENTS.** Implementing an on-line system successfully involves a two-phase program designed to build user confidence. The first phase is a meticulous evaluation usually conducted at the vendor's factory or immediately after installation. In this phase, the performance of the instruments is verified against specifications, verifying both stability and precision. The second phase involves the operators in a continuing verification program to ascertain that the instruments are conforming to specifica-



tions. Today's measurement systems supply a wealth of diagnostic information, which is analyzed by statistical techniques such as Shewhart control charts. (Edited author abstract). 7 Refs.

Sturm, Steven P. (Combustion Engineering Inc, Columbus, OH, USA). *Tappi J* v 71 n 10 Oct 1988 p 104-108.

## Sizing

**076358 ALKALINE SIZING BENEFITS BOARD MILL.** GP-Inveresk's Carrongrove board mill in Scotland switched to alkaline sizing in 1986 as part of a three-year investment plan. The change brought both expected and unexpected advantages. A production-related benefit attributed to the alkaline system is better retention. This is reflected in a cleaner whitewater return system and so in reduced levels of effluent discharge. But an unforeseen benefit is that broke recycling is now easier too. This means that there is no longer any of the previous overquenching of the rosin/alum conditions and so no problems of cyclical high/low system pH concentrations.

Hurst, Gerry. *PPI Pulp Pap Int* v 29 n 9 Sep 1987 p 79-80.

**076359 ALUM USE IN ALKALINE AND NEUTRAL SIZING SYSTEMS.** Adding 0.25% to 0.75% alum to alkaline systems improves sizing, drainage, retention (particularly of titanium dioxide) and runnability. While paper permanence brought alkaline papermaking to the fore, other benefits added an economic incentive to go alkaline, especially the strength paper gains when made at neutral or alkaline pH. Stronger paper could be produced, or paper could be made with equivalent strength at reduced cost, through the substitution of filler or less costly fiber. In response, rosin-based sizes have been developed that offer good sizing at neutral or near-neutral pH.

Wortley, Barbara (General Chemical Corp). *PIMA Mag* v 70 n 3 Mar 1988 p 62, 64.

**076360 SIZE PRESS TECHNOLOGY CHANGING TO FACILITATE HIGHER MACHINE SPEEDS.** Sizing technology has evolved to facilitate increased machine speeds. Equipment suppliers comments on the changes made to meet new demands are presented in the article.

Ducey, Michael J. (Pulp & Paper, San Francisco, CA, USA). *Pulp Pap* v 62 n 5 May 1988 p 58-62.

**076361 TRENDS IN SECOND GENERATION AKD SIZING.** The development of second generation polymer stabilized alkyl ketene dimer (AKD) sizes provides improvements over starch stabilized products with respect to retention and rate of cure, overcoming previous drawbacks. Improvements in AKD emulsion technology provides the possibility of transporting a high active solid size with improved stability while offering the flexibility of altering the charge density of the sizing agent. Sizing is often taken for granted, but it has a significant effect on the operating performance of the PM in terms of output and product quality. The article describes the AKD sizing module. It also examines the factors that have resulted in European mills' changeover to alkaline papermaking.

Watson, L.F. (Albright & Wilson Americas, Richmond, VA, USA). *PIMA Mag* v 70 n 9 Sep 1988 p 36-38.

**076362 1987 SIZING SHORT COURSE.** This conference proceedings contains 16 papers. Topics covered include: wetting of paper; sizing test methods; surface sizing; paper sizing starches; aluminum salts in papermaking; fundamentals of sizing with rosin; rosin solution sizes; wet end factors and their influence on the choice of size; machine factors influencing sizing; oil resistance using fluorochemicals; surface sizing using polyurethanes and maleic anhydride polymers; cellulose reactive sizes; principles of ASA sizing; optimizing the ASA sizing process; and, alkyl ketene dimer sizing mechanism. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11252 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *TAPPI Notes* 1987, 1987 Sizing Short Course, Atlanta, GA, USA, Apr 8-10 1987. Publ by TAPPI Press, Atlanta, GA, USA, 1987 105p.

**Slime Control** See Also PAPERMAKING MACHINERY—Maintenance.

**076363 IMPORTANCE OF pH IN CONTROLLING METAL-SOAP DEPOSITION.** Considerable evidence is presented suggesting that the formation of metal soaps, which contribute to pitch deposits, is controlled by the availability of dissolved soap anions which, in turn, is controlled by pH. Concentrations of dissolved soap anions measured in newsprint stocks at various pH values suggest that pH values above 7 will be especially detrimental. However, it is quite possible that metal-soap formation occurs in the presence of dissolved-soap concentrations too small to be measured by our technique. Therefore, a more conservative threshold, such as pH 6, probably constitutes a better guideline for pitch control. The film-deposition and surface-tension evidence in the literature suggests that pH 6 might be a better threshold. In unbleached kraft pulp mills, there is ample evidence that pH less than 6.5 appears to be adequate to suppress metal-soap deposition in the brownstock screen rooms. 17 refs.

Allen, L.H. (Pulp & Paper Research Inst of Canada, Pointe Claire, Que, Can). *Tappi J* v 71 n 1 Jan 1988 p 61-64.

**Sweden** See PAPER AND PULP MILLS—Quality Control.

**Switzerland** See PAPER—Marketing.

**Synthetic Fibers** See Also PAPERMAKING MACHINERY—Fourdrinier Machines.

**076364 ROLE OF THE LIQUID PLASTICIZING MEDIUM IN INCREASE OF THE STRENGTH OF DRY-FORMED PAPER CONTAINING POLYVINYL ALCOHOL FIBERS.** Estimation of the minimum quantity of water needed for dispersion of cellulosic and binding fibers (at constant temperature) and formation of a paper sheet of high mechanical strength is important both from the practical and from the scientific standpoint. Changes in the physical state of cellulose and PVA, which are partially crystalline polymers during hot water treatment, are directly linked both with disruption of the close packing of the polymeric chains and with additional crystallization. Both kinds of structural conversions may have a significant influence on bond strength in interphase boundary layers. Another purpose of this investigation was to elucidate the role of structural changes at the cellulose-PVA interface in the development of the strength properties of paper. Experimental data show that paper sheet of high mechanical strength can be obtained from unbeaten cellulose with PVA when the binder fibers (in amounts not exceeding 17.5%) are partially plasticized and form adhesions without transition into the viscofluid state. 7 refs.

Aleshina, E.A. (Leningrad Technological Inst of the Pulp & Paper Industry, USSR); Grivkova, N.A.; Shashilov, A.A. *J Appl Chem USSR* v 60 n 2 pt 2 Feb 1987 p 429-431.

**076365 DEFECTIVE FIBERS IN WET-LAY NONWOVEN FABRICS.** A defect-free wet-lay nonwoven fabric requires near perfection in both the fiber supply and the formation mechanics of the wet-lay process. This article discusses the different types of fiber defects, examines the fiber or equipment characteristics responsible for creating these defects, and suggests methods for minimizing defect formation. There are three major types of wet-lay nonwoven fabric defects: Logs or sticks - bundles of fibers with aligned cut ends that never dispersed; Dumbbells - paired clumps of fibers connected by one or more long fibers; Ropes - assemblages of fiber, with unaligned ends, that are clearly more agglomerated than the general dispersion. Each defect type has different causes, equipment responses, and remedies. 4 refs.

Shiffler, Donald A. (DuPont, Kinston, NC, USA). *Tappi J* v 71 n 6 Jun 1988 p 117-121.

## Taiwan

**076366 ADDING TONS AND VALUE TO STAY ON TOP.** Plans for two new mills and box plants, plus the first twin-wire tissue PM, a new carbonless copy paper line and more coated papers. Yuen Foong Yu Paper clearly aims to remain the biggest in Taiwan. In this article the author outlines these plans by Taiwan's Yuen Foong Yu for new mills and new PMs.

Sutton, Peter. *PPI Pulp Pap Int* v 30 n 6 Jun 1988 p 81, 83, 85.

**United Kingdom** See PAPER—Coating.

**Waste Disposal** See PAPER AND PULP MILLS—Environmental Impact.

**PAPERMAKING MACHINERY** See Also CO-GENERATION PLANTS—Energy Conservation; PAPER AND PULP MILLS; PAPER AND PULP MILLS—Modernization; PAPER AND PULP MILLS—Taiwan; PAPERMAKING; PAPERMAKING—Finishing; PAPERMAKING—Japan.

**076367 PROJECT THUNDER BAY: BRIGHTER NEWSPRINT WITH CLEANER PULP.** The division is gearing up for comprehensive modernizations to its two paper machines (PM) following recent improvements to its pulp operation. The PM upgrades will take full advantage of the better pulp to make higher quality paper which customers demand. PMs 1 and 2 will receive new wet ends designed to run at speeds of about 914 m/min. (3,000 fpm). The machines are currently running at 640 m/min. The mill will install off-machine silos and will modify the chest, couch pit and agitation equipment of both machines. Phases two and three, if approved, will include the installation of new winders.

Karl, Wayne. *Pulp Pap J* v 40 n 4 Apr 1987 p 24-25.

**076368 MACLAREN STARTS UP NEWSPRINT PM.** James MacLaren Industries's new newsprint machine at its Masson mill in Quebec, which started up in 1986, is now running regularly in the 975-m/min range with speed restricted by insufficient pulp capacity. The C\$140-million (\$105-million) 8.4-m trim Beloit machine is the first new PM in North America to be equipped with a Bel Baie III twin-wire former. Equipped with a Converflo headbox, formation is accomplished using slow and gentle water removal using two suction couches, a large-radius forming zone and the absence of foils, eliminating a pumping action. The manufacturing equipment and process is described.

Evans, John. *PPI Pulp Pap Int* v 29 n 4 Apr 1987 p 66-67.

**076369 RETENTION, DRAINAGE, AND FORMATION ON HIGH-SPEED FORMERS.** Outside of the old familiar fourdrinier, modern high-speed formers have basically two classifications. There are gap formers and hybrid formers. Gap formers are true twin-wire formers in which the jet from the headbox is introduced into the drainage zone through a gap formed by two converging wires. In this design, drainage takes place through both wires simultaneously. Hybrid formers combine the fourdrinier with some type of top wire for upward drainage. On high-speed formers, a measure of the drainage capacity is the consistency of the sheet after the couch roll. Most commercial newsprint machines with either a gap former or a true twin-wire have a consistency of 14-17%, depending on the furnish. The mechanism for producing well-formed sheets has an adverse effect on first-pass retention. Shear generated between two wires to reposition fibers also loosens the mat, allowing more fines to be



removed by the drainage flow. Dewatering by vacuum at high speed is an ineffective way to increase dryness after a former. 5 refs.

Hergert, Richard E. (Beloit Corp, Beloit, WI, USA); Harwood, John W. *Tappi J* v 71 n 4 Apr 1988 p 63-66.

**076370 VARIOUS FACTORS AFFECT PRESSURE SCREEN OPERATION AND CAPACITY.** Pressure screens are widely used in pulp mills, secondary fiber processing plants, paper machine approach systems, and broke system applications. Pressure screen design improvements have helped paper machines to be faster and more efficient and to produce higher-quality products. The principle of operation, the flow path through the screen, the operating parameters, the furnish characteristics, and the screen cylinder design parameters are discussed. It is concluded that the challenge for equipment manufacturers today is to design pressure screens that provide the highest capacity while consuming minimal energy and providing the required level of efficiency. The operator can alter variables such as consistency, reject rate, temperature, rotor speed, and pressure drop to improve capacity. Furnish characteristics will also affect screen capacity. 7 Refs.

McCarthy, Christopher (Black Clawson Co, Middletown, OH, USA). *Pulp Pap* v 62 n 9 Sep 1988 p 233-237.

**076371 GULF STATES COMPLETE MAJOR COATER REBUILD ON NO. 1 PAPER MACHINE.** The paper machine rebuild involved the fourdrinier, press section, dryer section, coater section, winder, and peripheral equipment. The original fourdrinier had an all-roll forming table, which was converted to an all-foil table as part of the rebuild. However, some rolls were retained to give the wire 'some action' and thus enhance the formation. The 24-in.-dia dandy roll, from Plank, was replaced with a 48-in.-dia roll. A devronizer steambox from Devron Hercules was installed between the dandy roll and lumbbreaker roll. A modification of the fourdrinier differential drive increased its horsepower. The new press section consists of two presses and the smoothing press. The third press was removed and the smoothing press relocated. The dryer section of the machine consists of seventy-nine 60-in.-dia dryer cylinders divided into five sections. The new coater section, with its two Beloit coaters, is designed to coat both sides of the sheet. A third coater applies additional coating to enhance ink holdout for sharp image printing. The upgrading of peripheral equipment is outlined.

Anon. *Pulp Pap* v 62 n 10 Oct 1988 p 129-131.

**076372 1987 PRACTICAL ASPECTS OF PRESSING AND DRYING SEMINAR.** This conference proceedings contains 26 papers dealing with pressing and drying in papermaking. Covered are topics such as papermaking press design; effect of pressing on sheet two-sidedness; wet pressing-reheated sheet stratification; paper defects due to fluid shear force in pressing; vacuum system for the press section; press felt performance; press vibration analysis; shower system design; press roll covers; press accessories; dryer section operation; hot pressing; moisture control; paper machine dryer testing; modern dryer fabric design; steam heated dryers; and dryer fabric installation. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11105 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (TAPPI, Atlanta, GA, USA). *TAPPI Notes* 1987 Pract Aspects of Pressing and Drying Semin, Geneva, Switz Mar 16-20 1987. Publ by TAPPI Press, Atlanta, GA, USA, 1987 262p.

**076373 1987 TWIN-WIRE SEMINAR.** This conference proceedings contains 19 papers of which one paper appears in abstract form only. Papermaking machinery and applications are covered. Some of the topics discussed include papermaking quality control; printing properties and physical properties of paper; paper sheet formation; drainage systems; twin-wire paper formers; headbox design; and fourdrinier machines. Technical and professional

papers from this conference are indexed and abstracted with the conference code no. 11277 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (TAPPI, Atlanta, GA, USA). *TAPPI Notes* 1987 Twin-Wire Semin, Atlanta, GA, USA, Apr 8-10 1987. Publ by TAPPI, Atlanta, GA, USA, 1987 179p.

**Applications** See PAPERMAKING—Coating.

**Automation** See Also PAPERMAKING—Finishing.

**076374 CONTROL IMPROVEMENTS AND AUTOMATION CAN IMPROVE ROLL QUALITY AND WINDER PRODUCTIVITY.** One Beloit two-drum winder was installed to process all of the production in the new, 600-ton/day, lightweight coated paper mill at Bowater Carolina Co. A winder operator and two helpers run the winder, process orders, number and label finished rolls of paper sent to be wrapped, and throw broke into the repulper. To keep the winder from being a production bottleneck, it was designed to produce top-quality rolls at high speed. It was also designed to allow quick adjustment of winding parameters to accommodate frequent grade changes. Unproductive winder time for set and reel changes had to be minimized, and the time required to change orders had to be cut as much as possible.

Riordan, P.D. (Bowater Carolina Co, Catawba, SC, USA). *Tappi J* v 70 n 10 Oct 1987 p 73-75.

**076375 WHAT YOU SHOULD KNOW ABOUT ROPE SYSTEMS AND AUTOMATIC TRANSFERS.** The authors examined several papermaking machines (PMs) at Mead Paper Corp.'s Chillicothe, Ohio, mill and made several interesting and important discoveries that are commonplace today on most of the industry's PMs. On the slower, smaller machines, for instance, the main contributing factor to lost time associated with ropes was due to improper transfer, sheave sizing and alignment. The PMs examined ranged in speed from 1000 to 2000 fpm and produced various grades of carbonless. As the speeds continued to increase above 1000 fpm, automatic transfers were found to be very desirable, yielding improved operating condition and less downtime.

Diltz, Jack (Westpatt Inc, Springfield, OH, USA); Hamler, John. *PIMA Mag* v 70 n 5 May 1988 p 21, 24-26.

**Bearings**

**076376 INCREASED CAPACITY OF A FINNISH PAPER MAKING MACHINE.** The Finnish paper mill Veitsiluoto Oy in Kemi, Finland, put into operation a papermaking machine which was completely modernized and equipped with FAG rolling bearings. As a result of this modernization, the web speed of the machine was increased from 750 to 1200 metres per minute. This corresponds to a daily output of 280 tons of base paper. All rolling bearings were replaced during the conversion. The majority of bearings are spherical roller bearings varying in size from 45 to 360 mm bore diameter. The setup and properties of some typical bearing arrangements are described.

Lehtonen, Jorma (FAG Helsinki, Finl); Schmieder, Hubert. *Ball Roller Bear Eng* 1985 p 20-23.

**076377 SHOCK PULSE MEASUREMENT SAVES MILLIONS FOR SWEDISH PAPER MILLS.** In order to reduce the risk of bearing breakdowns and other production disturbances, all bearings in the papermaking machinery (PM), as well as those in vital auxiliary equipment such as pumps, gear boxes and electric motors, are checked once a month. The inspections are carried out by staff at the maintenance department, who have several modern technical aids at their disposal. Damage to rolling element bearings can be detected by shock measuring with the shock pulse measurement (SPM) method. In addition, by using electronic stethoscopes, other mechanical faults can also be detected. Thus, every machine in the mill has fixed adapters or permanently installed transducers.

Nystrom, Robert (Industrial News Service). *PIMA Mag*

v 70 n 3 Mar 1988 p 22-23, 26.

**Calenders** See Also PAPER—Calendering; PAPERMAKING—Finishing; PAPERMAKING—Pressure Measurement.

**076378 BRUSH POLISHING OF COATED BOARD AND SUPERCALENDERED COATED PAPERS.** The brush polishing process is an economical technique in improving certain surface properties and is currently used with supercalenders and gloss calenders. A gloss calender is a unit with one or two passages of paper through one or two nips between a normally rubber-coated roller and a heated cylinder with a highly polished surface. Brush polishers are working nowadays in line with linerboard machines and their gloss calenders, or in line with supercalenders.

Pleines, Hanns D. (DOX W. Dossmann Nachf, Dreieich, West Ger). *Tappi J* v 71 n 3 Mar 1988 p 125-128.

**076379 ON-LINE MEASUREMENT/CONTROL FOR SUPERCALENDERS: AN UPDATE.** Because the supercalender traditionally represents the last opportunity to inspect the finished product, a number of on-line sensors are used solely to monitor and document key product characteristics. These sensors have included: basis weight; moisture; color; brightness; opacity; and flaw detection. Other sensors measure and control key product variables including: caliper; smoothness; gloss; moisture; temperature; and roll hardness.

Henry, Bill (Process Automation Business of Combustion Engineering, Columbus, OH, USA). *Pulp Pap Can* v 89 n 5 May 1988 p 23-24, 27-28.

**Canada**

**076380 HIGH-SPEED MACHINE PUTS CIP'S GATINEAU MILL ON LEADING EDGE.** In terms of performance, the Voith Duoformer F equipped with ASEA drives appears first-rate. With a wire width of seven metres (6,550 mm paper trim) and the ability to produce newsprint in basis weights ranging from 36 grams/m<sup>2</sup> to 48.8 grams/m<sup>2</sup>, the machine gives CIP the quality, quantity and flexibility to cater to its customers' changing needs. And it performs to these specifications at speeds which could make it one of the fastest paper machines in the country.

Karl, Wayne. *Pulp Pap J* v 40 n 4 Apr 1987 p 19, 21-22.

**Components** See BEARINGS—Materials.

**Computer Applications**

**076381 MODERN CORE CUTTING TECHNOLOGY REDUCES WASTE, BOOSTS EFFICIENCY.** The introduction of programmable core cutters provided a means of reducing some of the waste generated in a decentralized system. An example of this concept is the Menasha P500 programmable core cutter which allows the operator to easily cut cores of varying lengths from a single parent core, thereby increasing the probability that most of the core can be cut into usable lengths. Recently, Menasha Corp. introduced a programmable core cutter for long parent cores that provides a knife cut. The P600 programmable core cutter can be built in a length that matches the mill's longest parent core requirement. The P600 is a fully integrated system that can provide sets of cores that are cut, identified and loaded for transfer to the core user.

Hammerberg, Barry S. (Menasha Corp). *PIMA Mag* v 70 n 7 Jul 1988 p 38-39.

**Contamination** See NUCLEAR MAGNETIC RESONANCE—Applications.

**Control** See Also CONTROL SYSTEMS; PAPER AND PULP MILLS—Modernization; PAPERMAKING—Coatings.



**076382 PROGRESS TOWARD ONE-BUTTON PAPER MACHINE STARTUP.** A programmable controller sequentially starts and controls a former, five presses, and a stock-approach system. Four buttons control the startup process, and a cold startup can put paper on the reel in less than 40 min. (Author abstract)

Christensen, Leif (Manistique Papers Inc, Manistique, MI, USA). *Tappi J* v 71 n 6 Jun 1988 p 57-60.

**076383 SIMPLIFIED ADAPTIVE MODEL PREDICTIVE CONTROLLER.** We propose an adaptive controller based on predictive control and a simplified identification algorithm. The controller has several advantages for practical operation. It is robust, it obtains initial parameter estimates easily, and it simplifies on-line computation. A simulation study of basis weight control on a paper machine demonstrates its performance. (Author abstract) 12 refs.

Ma, Mark S. (Auburn Univ, Auburn, AL, USA); Williams, D.C. *Tappi J* v 71 n 6 Jun 1988 p 190-194.

**076384 ANATOMY OF A ROLL-TRACKING SYSTEM.** At the heart of the Production Management System (PMS) of a paper mill is a stratus fault-tolerant XA-600 32-bit computer with 12 million bytes (MB) of main memory, two 448-MB hard disks, and a tape drive. The trim clerk has the MAJQTRIM software package at his disposal with which to trim each of the five newsprint PMS. The new system includes a link between the Majiq PMS software and the Mesureux computer control system. A laser scanner at the first station of the main wrapping line identifies the roll to the system. A storage bay allocation algorithm automatically assigns rolls to storage bays in the warehouse. A complete set of production reports is produced by the system daily.

Magnani, Anna (Canadian Pacific Forest Products Ltd, Gatineau, Que, Can). *PIMA Mag* v 70 n 9 Sep 1988 p 23-26.

**Control Systems** See Also PAPER—Calendering; PAPER—Coating; PAPERMAKING—Coloring.

**076385 DYNAMIC SIMULATION FOR EFFICIENT PAPER MACHINE GRADE CHANGE.** It is important to minimize losses resulting from grade changes on a paper machine. The extent of these losses depends on the time required for the new furnish to settle down in the system. The speed of this process is affected by numerous variables. A computer model is presented which can quantitatively simulate the complex dynamic phenomena that occur during grade-change operations. These simulated results can then be displayed visually in powerful computer graphics. Operational parameters such as chest volumes, first-pass retention, and broke ratio are crucial factors that largely determine the extent of grade-change loss. Better management techniques can be induced from the simulated results. It is likely that the System Dynamics approach will prove to be a useful system-analysis tool in other applications. 6 refs.

Miyaniishi, Takanori (Jujo Paper Co, Tokyo, Jpn); Iida, Kiyooki; Iwatsu, Tokue. *Tappi J* v 71 n 1 Jan 1988 p 49-56.

**076386 AUTOMATIC WINDER SLITTER POSITIONING USING A PROGRAMMABLE LOGIC CONTROLLER.** To improve the serviceability, reliability, and simplicity of a new winder, a programmable logic controller (PLC) is used for the total winder control, including automatic slitter positioning. This installation involved interfacing the PLC with 37 position feedback encoders, a color graphics display, an intelligent keypad, and motor control for 37 positioning gearmotors, all of which replaced the vendor's dedicated system. The benefits have proven to be well worth the task of interfacing and the additional programming involved. (Author abstract).

Mortenson, Ronald, J. (Mead, Escanaba, MI, USA). *Tappi J* v 71 n 8 Aug 1988 p 104-107.

**Corrosion** See BRONZE—Evaluation.

**Corrosion Protection** See PAPER AND PULP MILLS—Corrosion; PAPER AND PULP MILLS—Corrosion Protection.

**Design** See Also PAPER—Calendering.

**076387 DISPOSABLE CHIPPER KNIVES INCREASE WOODROOM UPTIME AND GIVE MORE CONSISTENT CHIP QUALITY.** The paper describes process modifications and machine improvements to achieve increased woodroom uptime and more consistent chip quality. Overall pulp quality, chemical savings and improved digester operation were achieved. 1 ref.

Kjerulf, E. (Boise Cascade Canada Ltd, Fort Frances, Ont, Can); Jonsson, J-E. *Pulp Pap Can* v 89 n 2 Feb 1988 p 47-50.

**076388 LOW CONSISTENCY REFINER PLATE DESIGN AND SELECTION.** Basic concepts of low consistency refiner plate design and current plate metallurgies are defined. Plate configurations are discussed relative to their applications in various refining processes. Representative field data collected from operating mills are used. (Author abstract)

Sharpe, P.E. (Sprout-Bauer Inc, Muncy, PA, USA); Rodarmel, J.L. *Pulp Pap Can* v 89 n 2 Feb 1988 p 51-57.

**076389 INITIAL OPERATING TRIALS OF A DANDY ROLL FORMER.** Papermakers have long referred to top-wire formers as oversized dandy rolls. Virtually all of the stock redispersion and sheet formation occurs in the former's entry nip and in the first 20-30' of wrap of the two fabrics around the forming roll. The rest of the top-wire's complex and costly superstructure serves strictly to transport the formed sheet to the couch roll and to control the travel of the top fabric. In a newly patented design it was decided to wrap a conventional large-diameter dandy roll for about 40' of its circumference with the fourdrinier fabric, locate a suction box at the point of separation of the fabric and roll, and employ a roll or two to bring the fabric to the couch roll thus eliminating the top fabric. Running at speeds between 800 and 2800 ft/min, the design functioned well. (Edited author abstract)

Kallmes, Otto J. (M/K Systems Inc, Danvers, MA, USA); Langdok, R. *Tappi J* v 71 n 4 Apr 1988 p 73-76.

**076390 REDUCING RETROFIT RETROGRESSION.** Realizing that twin-wire dewatering makes it possible to get extra dryness to the press section with less sheet destruction, why is this advantage ignored? To encourage the correction of this oversight, the consistencies were examined of the sheet entering and leaving the nip of a single-wire machine. The retrofit has three parts: a flat wire dewatering portion; a twin-wire dewatering portion; and a final flat wire dewatering portion leading to the drilled couch. The drilled couch also received critical examination. (Edited author abstract). 5 refs.

Hansen, V.E. (Johnson Foils Inc, Springfield, MA, USA). *Pulp Pap Can* v 89 n 6 Jun 1988 p 121-126.

**Drainage** See PULP—Mechanical.

**Drives** See Also PAPER AND PULP MILLS—Retrofitting.

**076391 DIRECT DRIVE SYSTEMS FOR SHEETERS: PULSE-WIDTH MODULATED VS. SILICON-CONTROLLED RECTIFIER DRIVES.** Direct-driven sheeters systems have typically consisted of two dc motors and silicon-controlled rectifier (SCR) drives. The two motors that are directly coupled are the draw or pull roll drum and the cutter or knife drum. These two motors are controlled with a processor or a combination of processors with varying capabilities. Ever-improving processor technologies have increased the user's ability to implement sophisticated control schemes, improving the response to system torque disturbances such as out-of-round stock rolls. A pulse-width-modulated (PWM) drive offers even more improvements. With a

PWM drive, transistors are used as gating devices. These transistors can be turned on and off at relatively high frequencies, most often at 1000-3000 times/s. The benefits and features of both a dc PWM and dc SCR drive are discussed as they apply to the operation of a sheeter.

Johnson, Laurie J.S. (Unico Inc, Franksville, WI, USA). *Tappi J* v 70 n 10 Oct 1987 p 59-63.

**076392 LATEST DEVELOPMENTS IN PAPER MACHINE DRIVE TECHNOLOGY.** Every two to three decades a significant advance is made in drive technology. Utility power factor (UPF) drives can be regarded as such an advance. Compared to conventional phase controlled drives they provide improved performance, high efficiency, greatly reduced harmonics, and operate at UPF at all speeds including crawl speed. (Edited author abstract)

Golebiowski, C. (Cortina Electric Co, Watford, Engl); Macisaac, N.D.; Dalton, J. *Pulp Pap Can* v 89 n 1 Jan 1988 p 98-101.

**Dryers** See Also PAPERMAKING—Drying; PULP—Thermomechanical.

**076393 BENNETT FLEET IMPROVES FIBREBOARD QUALITY WITH AN ON-LINE, AIR RADIO-FREQUENCY-ASSISTED DRYER.** Since May 1986, the Bennett Fleet Inc. mill in Chambly, Quebec, has been using an air radio-frequency-assisted dryer (ARFA) in its production of 7000 tonnes per year of specialty fibreboard. The basic principles of the ARFA dryer combine heat generation within material that is placed in a radio frequency (RF) energy field between electrodes, and conventional hot air drying.

Stevenson, Susan (Pulp & Paper Canada, Don Mills, Ont, Can). *Pulp Pap Can* v 88 n 9 Sep 1987 p 49-50, 53.

**076394 NEW DEVELOPMENTS IN HOODS AND POCKET VENTILATION SYSTEMS.** Since the introduction of high-speed paper machines, greater emphasis has to be placed on the design of air systems to ensure good machine runnability. The closed hood conditions should be designed to be energy efficient yet still in a controllable range for reliable operation. Pocket ventilation systems must individually address different characteristics associated with the single-felting section and the conventional felted section to provide optimum evaporation rates and minimum sheet flutter. (Author abstract) 1 ref.

Young, D.A. (Enerquin Air Inc, Montreal, Que, Can). *Pulp Pap Can* v 88 n 9 Sep 1987 p 64-66.

**076395 LINERBOARD DRYING: MODEL DEVELOPMENT AND HEAT TRANSFER COEFFICIENT DETERMINATION.** New computer software has been developed to model a complete paper machine dryer system. Unit operations models and physical property models necessary to simulate the steam, condensate and air flows throughout the entire dryer system have been incorporated into GEMS, the modular computer software system for mass and energy balance calculations. Simulation results for the dryer section of a linerboard machine are reported in this paper. The models are verified against actual mill data both before and after the installation of a Beloit extended nip press (ENP). Changes in operating conditions resulting from the ENP installation are discussed. Heat transfer coefficient determination is also discussed at length. (Author abstract) 24 refs.

Abbott, R.D. (Univ of Idaho, Moscow, ID, USA); Edwards, L.L.; Fischer, F.B.; Dimond, P.M. *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul* Publ by TAPPI Press, Atlanta, GA, USA, 1985 p 73-84.

**076396 OPTIMIZATION OF THE GEOMETRICAL PARAMETERS OF ELEMENTS OF PAPERMAKING MACHINES.** When designing the drying section of a papermaking machine based on the traditional



arrangement of the drying drums it is very important to select not only the geometrical parameters of the individual blocks with account of their strength, rigidity, resistance to vibrations, and reliability, but also the correlation of the parameters at which the metal requirement of the drying section is at a minimum. The authors propose a graphical analytical method for the determination of the geometrical parameters of the equipment, based on the minimization of the metal requirement for the drying section, makes it possible to reduce the mass by 10-12%; this corresponds to a saving of 100-150 tons of metal. The method can also be applied successfully to calendars, presses, and other blocks of papermaking machines. 3 refs.

Podkovyryn, A.I.; Feigin, V.B. *Chem Pet Eng* v 22 n 11-12 Nov-Dec 1986 p 593-596.

**076397 SURVEY OF CANADIAN NEWSPRINT DRYER SECTIONS: PART II - ENERGY CONSUMPTION AND DRYING RATE.** A survey of 92 dryer sections of newsprint and groundwood specialty paper machines at 30 Canadian mills was carried out in 1985. This report examines the energy consumption patterns and the overall drying rates in these units. The average steam consumption was 2.9 kg steam/kg finished product, and 1.5 kg steam/kg water evaporated. Many of the dryer sections were inadequately instrumented, and it appears that the potential for heat recovery from the hood exhaust remains largely underutilized. (Author abstract) 4 refs.

Sayegh, N.N. (PAPRICAN, Pointe Claire, Que, Can); Pikulik, I.I.; Simonsen, H.I. *Pulp Pap Can* v 89 n 1 Jan 1988 p 127-131.

**076398 REGROUT OF P.M. NO. 7 SOLEPLATES, DOMTAR FINE PAPERS, CORNWALL.** The paper describes the problems caused by corrosion of drying machine soleplates. The machine frames were regouted and releveled.

Lalonde, L.A. (Domtar Fine Papers, Cornwall, Ont, Can). *Pulp Pap Can* v 89 n 2 Feb 1988 p 19, 22-24.

**076399 TODAY'S DRYER SECTION: AN OVERVIEW.** Sheet instability in the dryer section is the limiting factor to increasing machine speed on many high-speed, lightweight PMs. Devices have been developed to stabilize the sheet in its travel from the last press to the reel, permitting speeds in excess of 4,000 fpm. Steam and condensate systems have also been re-designed to minimize sheet disturbance, particularly on wet-end dryers. Hoods have been re-designed to make them vapor tight and capable of operation at high exhaust humidities for better sheet stability without sweating or vapor spill to the room. Other developments include: press run blow boxes; single top/bottom felting; higher machine speeds; transfer between drive sections; pocket ventilation.

Chalmers, G.J. (Valmen-Enerdry, Knoxville, TN, USA). *PIMA Mag* v 70 n 6 Jun 1988 p 45-46, 49-51.

**076400 PLASMA-SPRAYED COATING HELPS SAVE YANKEE DRYER FROM THE SCRAP PILE.** In 1984 a yankee dryer at Georgia-Pacific Corp.'s tissue mill in Bellingham, Wash., had worn so thin that mill managers were ready to replace the unit - a procedure that would have meant extensive capital expenditures. After trying other ways of repairing the dryer, the mill turned to Bender Machine Services Inc., which promised the unit would be running in less than two weeks through the use of a new coating process called PS500. Bender's PS500 coating is a plasma-sprayed blend of molybdenum with a nickel alloy applied by Bender technicians at the plant. After 34 months of continuous service, the coating applied to a finished thickness of 0.031 in. has shown wear of 0.002 in.

Anon. *Pulp Pap* v 62 n 6 Jun 1988 p 118-119.

**076401 HUMIDITY AND ITS EFFECT ON THERMAL EFFICIENCY OF YANKEE HOODS.** During the tissue-drying operation, heat is transferred to the sheet by both the Yankee cylinder and the hood air system. Air-side drying rates have improved significantly in recent

years, and the Yankee hood has developed to the point that it can handle over 80 percent of the drying load. The highest production rates and energy efficiencies are achieved through optimum design and operation of the air system.

Schukow, Vic (Flakt Ross Inc, Lasalle, Que, Can); Heberl, Andy. *Tappi J* v 71 n 7 Jul 1988 p 68-70.

**076402 CHAMPION FINDS SHEET BREAK DETECTOR THAT IS EFFECTIVE IN DRYER SECTIONS.** A description is given of a photoelectric infrared sensing detection system which was designed to be able to withstand the high temperatures and dirty environment of the dryer section. The infrared sensors are comprised of strands of glass fiber-optics bundled together into probes that can withstand temperatures up to 260°C (500°F). The probes are connected to a thermally protected amplifier card and a relay control logic card at a remote location up to 100 ft away. This configuration allows the sensor probes to be located inside the dryer hood and the control electronics to be located outside the dryer hood, away from the heat. Two fiber-optic probes achieve the sensing of paper in proximity by using one probe to send a pulse-modulated infrared signal out and the other probe to receive the signal. The two probes are mounted next to each other approximately 2 in. apart and 3 in. above the running sheet of paper. This configuration helps to prevent a false reading from forcing particles such as dust, oil, or paper that can cover or partially block the surface of a probe. A technique to calibrate the sensitivity of the sensors is discussed.

Harrison, Andy (Pulp & Paper, San Francisco, CA, USA). *Pulp Pap* v 62 n 10 Oct 1988 p 110-112.

**076403 1986 PRACTICAL ASPECTS OF PRESSING AND DRYING SEMINAR.** This seminar proceedings contains 27 papers. The topics discussed are: press design; influence of pressing on sheet two-sidedness; roll cover design in press sections; rolls maintenance; press felt/sheet profile management; vacuum systems for presses; sheet stratification; fluid shear force during pressing; press-felt system optimization; press vibration; wet pressing; hot pressing; dryer troubleshooting; infrared heating; non-contamination control techniques for paper machine lubricating/hydraulic systems; air systems in dryers; paper machine hoods, pocket ventilation, heat recovery; spoiler bars; steam condensate; nondestructive dryer testing; dryer fabric installation, guiding and troubleshooting. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10877 in the Ei Engineering Meeting (TM) database produced by Engineering Information, Inc.

Anon (TAPPI, Atlanta, GA, USA). *TAPPI Notes* 1986, Pract Aspects of Pressing and Drying Semin, Atlanta, GA, USA, Mar 17-21 1986. Publ by TAPPI Press, Atlanta, GA, USA, 1986 261p.

#### Electric Drive

**076404 TRENDS IN EUROPEAN PAPER MACHINE DRIVE TECHNOLOGY.** Most of the new paper machine installations and rebuilds in Europe are using sectional-drive systems. Digital/numerical control technology is now the accepted standard, with sectional ac making up almost 50% of all new installations. It appears that the application of drive technology on European paper machines has advanced at a faster rate than in North America. Many of the practices that are considered commonplace in Europe are now beginning to find acceptance elsewhere. These practices include the use of drop-in stations, color graphics, group transformers, and sectional ac drives.

Curtis, J.W. (Allen-Bradley/Stromberg Inc, Cedarburg, WI, USA); Haatainen, Juhani. *Tappi J* v 71 n 1 Jan 1988 p 44-48.

**076405 CALCULATION OF ENERGY REQUIREMENTS FOR A PAPER MACHINE DRIVE REBUILD.** Nekoosa Papers' No. 4 paper machine was installed in 1900. Major rebuilds in 1954 and 1972

brought running speed up to 1200 ft/min. As with many paper machine drives, this machine was powered by a steam-turbine-driven lineshaft. The machine trims 108-114 in. at the reel and runs basis weights of 8-36 lb (1300 ft<sup>2</sup> basis). The steam-driven lineshaft was removed during a rebuild in 1986 and was replaced by a sectional electric drive with felt-roll drive. The machine is geared for 1800 ft/min. The mill's experience in changing the drive system on a 128-in. Fine paper machine from a steam-turbine-driven lineshaft to a sectional electric drive is presented. 3 refs.

Fafnis, A.R. (James River Corp, Green Bay, WI, USA); Drewiske, Donald. *Tappi J* v 71 n 3 Mar 1988 p 83-89.

**076406 CALCULATION OF THE RIGIDITY OF A CARDAN DRIVE SHAFT FOR PAPERMAKING MACHINES.** The rigidity of the Cardan shaft in the assembly ( $C_{\Sigma}$ ) is determined by the rigidity and the sequence of connection of its structural components in transmission of the torque  $M_t$  from the Cardan joint ( $C_c$ ) via the shaft ( $C_s$ ), via a splined joint ( $C_i$ ), and again via a Cardan joint. The angle of torsion of the fork with respect to the embedding cross section is given. The angle of deviation of the fork with respect to the angle of rotation as a result of bending and torsion is also given.

Shugol', I.S. *Chem Pet Eng* v 23 n 5-6 May-Jun 1987 p 273-275.

**076407 ALLEN-BRADLEY SECTIONAL DC DRIVE HELPS MENASHA DOUBLE PM NO. 1'S SPEED.** Digital technology has provided Menasha Corp. drift-free speed regulation and the ability to communicate upward to intelligent operator stations. The result - better control over process variables, greater operator awareness and improved productivity. (Author abstract)

Clark, Chuck F. (Allen-Bradley Co); Gulbranson, Robert V. *PIMA Mag* v 70 n 2 Feb 1988 p 35-38.

Energy Conservation See BOILERS—Energy Utilization.

#### Felts

**076408 REWETTING IN THE EXPANSION SIDE OF PRESS NIPS.** The University of Maine Compression Tester has been modified so that water removal from the sheet can be measured directly. A comparison between this direct measurement and water removed based on thickness measurements indicates that as much as 30% of the total water removed in pressing is returned as rewet in the expansion side of the nip. A systematic study of this difference indicates that 'rewet in the nip' is directly proportional to the total water removed, is strongly influenced by the permeabilities of both the sheet and the pressing media, and has a complex relationship with the expansion time on the exit side of the nip. Model studies suggest that rewet in the nip could be reduced by providing more effective ways for air to reach the interface between the sheet and the pressing media. (Author abstract) 4 refs.

Jaavidaan, Youness (Univ of Maine, Orono, ME, USA); Ceckler, William H.; Thompson, Edward V. *Tappi J* v 71 n 3 Mar 1988 p 151-155.

**076409 PROGRAM APPROACH TO FELT AND WIRE CLEANING.** Deposits on wires and press felts and other ensuing problems can result in press section downtime, off-spec paper and reduced felt life. The end result is lost production and lost profits for the mill. A good felt and wire cleaning program can help minimize these problems. At Nalco, the approach to these filling problems includes identification of the problem; analysis of deposits; selection of the best felt/wire cleaning product; determination of how to best apply it; and evaluation of its performance on the machine.

Novotny, Raymond J. (Nalco Chemical Co). *PIMA Mag* v 70 n 2 Feb 1988 p 25-28.



**076410 SIMPLE MAINTENANCE PROCEDURES CAN HELP EXTEND FORMING FABRIC LIFE. CLOTHING COSTS CAN BE SIGNIFICANTLY REDUCED THROUGH PROPER PREVENTIVE MAINTENANCE; GUIDELINES FOR REGULAR INSPECTIONS ARE OFFERED.** Optimizing forming fabric life, thereby reducing machine clothing costs, is easily achieved by preventive maintenance and a good understanding of the care and handling of fabrics. This article discusses how the proper maintenance of forming fabrics, and of the machine as it relates to fabrics, can increase fabric life and productivity. The article discusses how periodic checks of the machine can maximize fabric life and machine performance. It also discusses how proper care and handling can increase a fabric's useful life.

Houfek, William E. (Wisconsin Wires Inc, Appleton, WI, USA). *Pulp Pap* v 62 n 4 Apr 1988 p 163-164.

**076411 HOW TO MAINTAIN SYNTHETIC FORMING FABRICS.** The author discusses how the proper maintenance of forming fabrics and of the papermaking machinery (PM) as it relates to fabrics, can increase fabric life and productivity. He also discusses how periodic PM checks can maximize PM performance. He also shows how proper care and handling can increase a fabric's useful life.

Houfek, William E. (Wisconsin Wires Inc, Appleton, WI, USA). *PIMA Mag* v 70 n 5 May 1988 p 17-18.

**076412 NEW TOP FELT SYSTEM AT PORT HUDSON HIKES DAILY PRODUCTION 9%.** To obtain more production from its pulp machine at the Port Hudson, La., mill, Georgia-Pacific Corp. installed a top felt on the first press section. By incorporating existing surplus components with new equipment, a design was developed that cut equipment costs by 50 percent. The system was engineered and fabricated within four months at Mill Services' Hattiesburg, Miss., plant. The complete unit was then shipped to the mill in large segments to reduce installation costs. Improved dryer efficiencies have raised hourly production rates from 47 tph to 53 tph - an average daily increase of 140 tons, or 9 percent.

Anon. *PIMA Mag* v 70 n 10 Oct 1988 p 14-15.

**Fourdrinier Machines** See Also PAPER—Newsprint; PAPER—Sheeting; PAPER AND PULP MILLS—Korea; PAPERMAKING—Coating.

**076413 COMPUTATIONAL MODEL FOR WATER DRAINAGE IN FOURDRINIER PAPER MACHINES.** A computational model based on Taylor's equation and the filtration equation was developed to evaluate the location of the wet line (5% consistency) on fourdrinier paper machines. Drainage at table rolls and low-vacuum elements was evaluated by the model. Comparison of the results obtained using the drainage model and by measuring the consistency profile in paper machines presented an agreement within 10%. The value of the specific filtration resistance used in the model was determined by means of experimental runs in a modified laboratory drainage and vacuum retention tester. This device measures dynamic specific filtration resistance, which is different from the constant pressure or constant flow approaches used in the past. (Author abstract) 11 refs.

Pires, Eduardo C. (Univ of Sao Paulo, Brazil); Springer, Allan M.; Kumar, Vinod. *Tappi J* v 71 n 4 Apr 1988 p 133-139.

**076414 MILL USES PORTABLE STROBE LIGHT TO FINE-TUNE SPECIAL DEWATERING BLADE.** Flambeau Paper installed a lightweight, portable strobe light on its No. 3 paper machine in Park Falls, Wis. Formation data collected from this unit was used to help install and align a new dewatering blade. The 20-lb strobe light, made by Unilux Inc., emits continuous pulses for blur-free inspection of a fourdrinier section. Analysis of formation data showed the blade could be aligned to impart even dewatering, helping boost product uniformity and retain raw materials. Since alignment, the blade has been performing in a manner comparable to vacuum foils.

By allowing exact formation analysis, a lightweight, continuous pulsing unit helps Flambeau Paper optimize new fourdrinier foil.

Anon. *Pulp Pap* v 62 n 4 Apr 1988 p 124-125.

**076415 EFFECT OF PIGMENT PROPERTIES ON THE WEAR OF PLASTIC FOURDRINIER WIRE.** The new modified Einlechner abrasion tester has been used to determine the effects of particle size, size distribution, shape, and composition of six different filler pigments on the wear of two different kinds of plastic fourdrinier wire. The new abrasion tester closely resembles the physical condition on a paper machine and has been shown to correlate with plastic wire life on European papermaking equipment. The results suggest that pigment composition may be more important than size, shape, or particle size distribution in determining wire life. In addition, the chemical composition of the wire affects the abrasiveness of different pigments. These results and their practical significance to the papermaker are interpreted in the light of modern theory. (Author abstract) 13 refs.

Hemstock, G.A. (Engelhard Corp, Edison, NJ, USA); Neubold, H.B. *Tappi J* v 71 n 5 May 1988 p 127-132.

**076416 PAPERMAKING - GOOD RESULTS WITH TWINFORMER.** The Escher Wyss Twinformer presented here has been engineered to meet the needs of papermakers and paper processors. It enables equal-sided papers (e.g. writing and printing grades) to be produced with improved formation and lower raw material costs. (Author abstract)

Bubik, A. (Sulzer-Escher Wyss, Ravensburg, West Ger). *Sulzer Tech Rev* v 70 1 1988 p 33-38.

**076417 SYSTEM CONTROLS DRAINAGE, IMPROVES STOCK ACTIVITY ON FOURDRINIER WIRE.** Johnson Foils' Isoflo System for control of drainage and stock activity on the fourdrinier table is finding wider application on a variety of paper machines operating at various speeds and production levels. The system is usually installed early in the table where it can generate beneficial stock activity. It is comprised of low-vacuum Isoflo units, a vacuum indicator panel, an Autovac 2 vacuum controller, and a remote control panel. Located in early stages of fourdrinier, the system enhances water removal and retention and improves formation without sheet sealing problems.

Evans, John C.W. (Pulp & Paper, San Francisco, CA, USA). *Pulp Pap* v 62 n 5 May 1988 p 112-113.

**Headbox** See Also FLOW OF FLUIDS—Suspensions.

**076418 MULTILAYER HEADBOX FOR PRINTING PAPER.** Multiply technology has tremendous potential for the makers of printing grades - in cost savings and improved product quality. A layered, 80gsm paper is, for example, \$26 a ton cheaper to make than a similar mixed paper. It is possible to reduce the basis weight of a layered paper without reducing stiffness. Layering enables a papermaker to engineer his end product - to place fiber in filler in the best possible place and thereby optimize the surface and the interior of the sheet. This article describes the latest multiply technology, which was developed specifically for lighter grades. (Edited author abstract)

Stenberg, Gunmar (VALMET-KMW, Finl). *Pap Technol Ind* v 28 n 6 Sep 1987 p 582-588.

**076419 DEMANDING CUSTOMERS HAVE MEANT DRAMATIC CHANGES IN HEADBOXES.** Headboxes and flow approach systems have been drastically changed to meet the higher demands placed on the PM by the product's end users. This article traces the development of technically sophisticated papermaking machinery.

Newcombe, Doug (Consultants Inc, Appleton, WI, USA). *PIMA Mag* v 69 n 10 Oct 1987 p 27-29, 32-34.

**076420 NEW DEVELOPMENT ON THE STEP**

**DIFFUSOR HEADBOX.** The approach flow in the papermaking process consists of a process-dynamic system of individual operations serving to deliver a suspension of defined consistency, purity and homogeneity to the headbox. In the proven PE System, which precedes every ESCHER WYSS headbox for Fourdrinier machines and thus constitutes part of the headbox system, the absorption and reflection damping principles are combined ingeniously to assure a high degree of pulsation damping. Another essential task performed by the objective design is optimal hydraulic guidance of the total stock flow to the headbox. Segregation of the pulsation damping function from the headbox functions and consequence prevention of interactive influences results in a maximum damping effect, since the entire stock flow is involved and not just an overflow or part flow in the region of the headbox. (Edited author abstract) 1 ref.

Kurtz, R. (Sulzer Bros Ltd, Winterthur, Switz). *Sulzer Tech Rev* v 69 n 4 1987 p 27-30.

**076421 HOW HEADBOX DESIGN AND OPERATING CRITERIA AFFECT MACHINE PERFORMANCE AND SHEET STRUCTURE.** Headboxes require proper set-up for peak and proper performance to produce a good quality, competitive product. The expanded Papyrus headbox slice/flow dynamics computer program is a scientific tool to examine, characterize, and optimize any headbox operation at the mill site with virtually no or minimum capital investment. 6 refs.

Ibrahim, Ahmed A. (Papyrus Inc, Westerville, OH, USA). *Pulp Pap Can* v 88 n 12 Dec 1987 p 33-34, 36-37.

**076422 SLICE LIP AUTOMATION.** Automation of the headbox slice lip for CD weight control is a more complex subject than is commonly realized. Points to consider in a systematic approach are discussed. Mechanization of the slice lip for remote or automatic control is described in detail. (Author abstract) 5 refs.

Cutshall, K.A. (Devron-Hercules Inc, North Vancouver, BC, Can); Hamel, R.G. *Pulp Pap Can* v 89 n 1 Jan 1988 p 85-88, 90-92.

**076423 HOW HEADBOX DESIGN AFFECTS PM PERFORMANCE AND SHEET STRUCTURE.** Headboxes require proper setup for peak performance to produce a quality product. Complex headbox process parameters are interactive and should be calculated according to the laws of physics as opposed to trial and error. This guarantees accurate, measurable and predictable information. Adjustments can then be applied. The Papyrus Headbox Slice/Flow Dynamics computer program in its newly expanded version is indispensable for examining, characterizing and optimizing any headbox operation with little or no capital investment.

Ibrahim, Ahmed A. (Papyrus Inc, Westerville, OH, USA). *PIMA Mag* v 70 n 1 Jan 1988 p 28-31.

**076424 THREE-LAYERS GIVE MANY POSSIBILITIES.** Fine paper producer Munkedal has recently started its new three-layer headbox, the first in the world on printing and writing grades. So far, the results are encouraging. The new Valmet-KMW three-layer headbox is really three individual headboxes on top of each other. Each layer has its own screening system and fan pump, with the layers separated by thin plastic vanes. As the three jets leave the nozzles, they are kept away from each other by means of an air wedge between each layer. The air wedges keep the layers from intermixing, until they are trapped by the two converging wires. This design assures a very good separation.

O'Brian, Hugh. *PPI Pulp Pap Int* v 29 n 4 Apr 1987 p 73-74.

**076425 INFLUENCE OF HEADBOX FLOW CONDITIONS ON PAPER PROPERTIES AND THEIR CONSTANCY.** Certain design parameters and operating conditions of the headbox lead to flow conditions at the slice and on the wire resulting in a displacement of the



main fiber orientation in the xy-plane away from the machine direction. For some paper grades, this means potential problems in subsequent converting operations and in product end use (diagonal curl). The phenomenon is explained by a simple fluid model. Results from tests with commercially installed Step Diffuser headboxes are reported. These tests showed the effect of variations in distributor overflow and local slice bar adjustment on local main fiber orientation across the machine. Results of measures in both headbox design and in facilitating operation show distinct improvements in fiber orientation. (Author abstract) 10 refs.

Dahl, Hans (Sulzer-Escher Wyss GmbH, Ravensburg, West Ger); Holik, Herbert; Weissbuh, Elmer. *Tappi J* v 71 n 2 Feb 1988 p 93-98.

## Lubrication

**076426 PM OILS; THEY'RE CRITICAL TO RELIABLE, EFFICIENT OPERATION.** One of the most critical aspects in maintaining the reliability of today's modern PM is selecting a high-quality oil to lubricate key machine elements. The effect of improper lubricant selection can be significant. In many cases, the loss of critical bearing can cause unscheduled downtime (always when it's most inconvenient), resulting in a loss of production and hiking PM operating costs. This paper reviews the properties of PM oils specially formulated for unique requirement of the mill environment.

Dietz, Thomas G. (Exxon Co, Houston, TX, USA). *PIMA Mag* v 70 n 1 Jan 1988 p 24, 25-27.

**Maintenance** See Also PAPER AND PULP MILLS—Auxiliary Equipment; PAPER AND PULP MILLS—Maintenance.

**076427 RETENTION, DRAINAGE AND PITCH CONTROL WITH ALUM.** Alum is an effective retention agent in moderate-speed papermaking machineries (PM). Alum provides the least costly cationicity. High molecular weight, longchain length polymers provide the most shear resistant retention mechanisms. Controlled trials must be initiated to determine the optimal combination for each PM. Alum enhances drainage by neutralizing the usual anionic surface charge of furnish components. Water release increases as the isoelectric point (zero charge) is approached. Alum has long helped alleviate pitch problems. The alumina floc entraps the resinous material and deposits it on the fiber surface through many of the same mechanisms involved in paper sizing.

Wortley, Barbara (General Chemical Corp, Syracuse, NY, USA). *PIMA Mag* v 70 n 4 Apr 1988 p 42-43.

**076428 COVERED ROLL MAINTENANCE.** The author considers covered roll maintenance in a broad sense. The study includes a short description of cover design, roll-handling and crowing, chemical resistance of cover materials and various paper machine operating factors which influence cover life. Suggestions are included for obtaining the maximum operating life of covered rolls with an efficient maintenance program. (Edited author abstract). 1 Ref.

McNamee, J.P. (Stowe-Woodward Co, Southborough, MA, USA). *Pulp Pap Can* v 89 n 9 Sep 1988 p 90-92, 94.

**Mathematical Models** See PULP MANUFACTURE—Washing.

## Mixers

**076429 MEDIUM CONSISTENCY CHLORINATION IN A LABORATORY MIXER.** A batch laboratory mixer for treating medium consistency pulp in a fluidized state with bleaching gases and solutions has been built. Medium consistency chlorination has been systematically compared to low consistency chlorination. With respect to delignification, 10 PERCENT consistency chlorination at 50°C in the laboratory mixer was only slightly more efficient than 3 PERCENT consistency chlorination under the same conditions. There was little effect of consistency on shive removal or pulp strength.

High-intensity mixing was shown to improve shive removal. (Author abstract). 19 Refs.

Reeve, D.W. (Univ of Toronto, Toronto, Ont, Can); Earl, P.F.; Gullichsen, J.; Pu, C.M.; Magued, A.; Rapson, W.H. *Pulp Pap Can* v 89 n 6 Jun 1988 p 115-120.

## Nondestructive Examination

**076430 SPECIALIZED NDT HELIUM LEAK DETECTION.** Helium mass spectrometer leak detection is a relatively new method of non-destructive testing. The highly corrosive environment in the pulp and paper industry, combined with industrial, and environmental health and safety regulations has prompted industry to develop technology to locate and evaluate the size of leaks on location. This enables mill personnel to repair defective areas during regular maintenance scheduled shutdown periods. The purpose of helium leak testing is to minimize risks to mill personnel and neighbouring residents. It also avoids costly unscheduled downtime due to lost production through untimely leaks. (Edited author abstract). 1 Ref.

Kitchen, G. (A&I Inspection Services Ltd, Cambridge, Ont, Can). *Pulp Pap Can* v 89 n 6 Jun 1988 p 96-99.

## Performance

**076431 ANALYSIS OF PAPER MACHINE PERFORMANCE.** Quality specifications have grown more demanding as paper products customers strive to obtain maximum output from their converting operations. Prior to the introduction of cross-machine control, reject criteria of paper products were based largely on analyses of machine-direction (MD) variation. With the advent of cross-direction (CD) control, the more stringent quality specifications demanded by customers are now achievable. The first step in performance analysis is the robust acquisition of raw data. For paper machines, the raw data consist of variables such as basis weight, moisture content, and caliper. These variables are band-limited by analog filtering and are then sampled temporally and/or spatially at a frequency consistent with Shannon's sampling theorem. Analytical methods to determine the feasibility of CD control, evaluate current machine performance, and locate sources of process variation are described. 8 refs.

Saucier, Michael F. (Combustion Engineering, Columbus, OH, USA); Steinkirchner, Alan D. *Tappi J* v 71 n 4 Apr 1988 p 97-102.

**076432 SMOOTH START FOR WIDEST LWC PM.** With a wire width of 9.1 m, United Paper Mills new PM 6 at Kaipala in Finland is the world's widest LWC line. Its output - about 200,000 tons/yr - is destined mainly for EEC markets. In this article the author reports on the 9.1-m wide PM. The main topics are the mechanical pulp used, coaters, rotogravure printers, and roll wrapping and labelling.

Pearson, John. *PPI Pulp Pap Int* v 30 n 5 May 1988 p 43-45, 47.

## Plastics Parts

**076433 CANADIAN MILLS SOLVE CORROSION PROBLEMS WITH FRP.** A key tool in Fiberglass Canada's customer service program is 'Superlam', a computer software program for the designing and testing of reinforced plastic laminants. The menu-driven program makes it possible to design laminates suitable for the large storage tanks, processing vessels, pollution control equipment and large-diameter pipelines required by pulp and paper mills. After a laminate has been built up layer by layer on the computer, it can then be 'tested' again on the computer under the appropriate loading conditions to determine the stresses and strains in each layer. The laminate analysis program is based on a theory which assumes each lamina in a laminate is in a plane stress state.

Kesterton, Mike (Fiberglass RP Report, Toronto, Ont, Can). *Pulp Pap Can* v 89 n 5 May 1988 p 17-19.

## Protection

**076434 PITCH DEPOSITION IN PAPERMAKING AND THE FUNCTION OF PITCH-CONTROL AGENTS.** Dispersed synthetic pitch was deposited by inducing shearing forces. The deposition tendency of two types of pitch was evaluated with regard to the influence of temperature, water hardness, pH, concentration, and fiber consistency. The effect of pitch-control agents (alum, talc, and three polymers) on the extent of deposit formation was then studied. The conditions required for deposition and the extent of deposit formation were dependent on the composition of the dispersed pitch. Certain pitch-control agents profoundly reduced pitch deposition, with Darasperse cationic polymers being the most effective. A mechanism by which such polymers work is suggested. (Author abstract) 25 refs.

Hassler, Thord (Grace Service Chemicals, Helsingborg, Swed). *Tappi J* v 71 n 6 Jun 1988 p 195-201.

## Retrofitting

**076435 UNION BRUK SPEEDS INTO THE FUTURE.** A new twin-wire former has raised both quality and speed on Union's PM 7 at Skien, Norway, in the first step in a three-year development program. (Author abstract)

O'Brian, Hugh. *PPI Pulp Pap Int* v 30 n 4 Apr 1988 p 52-54.

**076436 NANPING REBUILDS NEWSPRINT PM 1.** Located in Fujian province, Nanping newsprint mill, has completed a rebuild of 3.2-m trim PM 1, raising speed from 320 m/min to 500 m/min. Mill director describes how the rebuild was carried out. (Edited author abstract)

Anon. *PPI Pulp Pap Int* v 30 n 4 Apr 1988 p 59.

**Rolls** See Also MECHANISMS—Stability; PAPERMAKING—Quality Control; PAPERMAKING—Sizing; ROLLS—Failure.

**076437 WINDER TECHNOLOGY FOR PRODUCING LARGE ROLLS OF HIGH-DENSITY COATED PAPER.** While the strength of base papers is being reduced, roll diameters and the width of printing presses are increasing. These trends have made roll structure and roll quality of coated papers increasingly vital issues for the printer. The use of coated paper in the production of finished rolls adds another level of complexity to this process and presents some special problems. This paper formulates strategies for solving these problems by examining them one at a time. 3 refs.

Schikorra, Gert E. (Jagenberg Inc, Enfield, CT, USA). *Tappi J* v 70 n 10 Oct 1987 p 53-57.

**076438 PRACTICAL EXPERIENCES WITH THE KUFFERATH DANDY ROLL FORMER AKUMAT.** Dandy rolls improve formation, retrofit hybrid formers increase drainage capacity. The dandy roll former AKUMAT does both, and it can be installed without any irreversible modifications to the fourdrinier. AKUMAT dandy roll formers in the U.S.A., U.K., Europe and the Far East are witnesses to these claims. (Edited author abstract) 5 refs.

Holle, D. (Andreas Kufferath GmbH & Co, Dueren-Mariaweller, West Ger). *Pulp Pap Can* v 88 n 10 Oct 1987 p 94-98, 100-102.

**076439 EFFICIENT WINDER TECHNOLOGY FOR TWO-DRUM WINDERS.** It is best to increase the capacity of a winder by reducing the shutdown times. The possibilities of this are full or extensive automation of set changing, parent roll changing, trim changing, and new web threading. At an assumed PM speed of 3600 fpm and a reserve time of 30 minutes per shift, the required winder speeds would be 6600 fpm, 5900 fpm, 5750 fpm and 4900



fpm. Considerations in machine design selection and prerequisites for high operating speed and optimum web run for two-drum winders are given.

Kaipf, Walter (J.M. Voith GmbH). *PIMA Mag* v 70 n 3 Mar 1988 p 27-30.

**076440 EFFICIENT WINDER TECHNOLOGY FOR TWO-DRUM WINDERS: PART II.** With the Auto Set microprocessor-controlled slitter positioning device, there is no additional downtime. That's because the positioning operation takes place during the set change. An adjusting time of approximately 40 seconds is attained, irrespective of the number of slitters because they are all positioned simultaneously. The positioning accuracy is  $\pm 0.1$  inches. Automatic reel-spool changing makes a major contribution to further reducing the downtime. Other equipment that contribute to increase in capacity are: quick-change holders for top slitters; small-roll ejector; sorting deck for finished rolls; and web threading devices.

Kaipf, Walter (J.M. Voith GmbH). *PIMA Mag* v 70 n 4 Apr 1988 p 27-30.

**076441 WHAT'S NEW IN BALANCING METHODS FOR CHILLED CAST IRON ROLLS.** Nip control at high calendering temperatures is a consideration in improving paper quality. The author explains several roll designs. He briefly presents an example of how the quality parameters of newsprint have been improved with higher chilled iron roll surface temperatures in a typical six-roll calendar stock.

Rothenbacher, Peter (SHW-Ansonia Inc). *PIMA Mag* v 70 n 4 Apr 1988 p 32-34, 36-37.

**076442 PACKING CRITICAL TO SUCTION ROLL PERFORMANCE, MACHINE RUNABILITY.** Excessive packing wear would occur at the center or at the ends of the packing. This condition would eventually cause a loss of vacuum. As a result, the need for a good, stable packing persisted. This article discusses in general terms the characteristics and physical properties of a useful roll packing material that will function adequately in that application. Early in 1984, Beloit Manhattan R&D, in cooperation with Beloit PMD, developed a nonasbestos suction roll packing line trade named BelSeal. The applications of this material are also discussed. Proper selection of materials, combined with continuous, uniform lubrication and good roll maintenance, assures long packing life.

Boga, Wayne (Beloit Manhattan Inc, Clarks Summit, PA, USA). *Pulp Pap* v 62 n 4 Apr 1988 p 141-145.

**076443 SIZE PRESSES OFFER PROBLEMS, PROMISES.** A brief review of the limitations of the conventional size press is given. As machine speeds have increased, size press roll diameters have also been increased to help compensate for greater hydrodynamic forces. An improvement on the apron size press concept was to combine its use with restricted flow of sizing solution to the pond. The simplest and most reliable device for this use is the weir and spreader pan. The problem with pond turbulence motivated development of modified size press designs to eliminate the pond. These developments include the gate roll size press, metering blade size press; modified size presses featuring short dwell applicators running against the size press rolls.

Klass, Charles P. (Klass Associates Inc, King of Prussia, PA, USA). *PIMA Mag* v 70 n 8 Aug 1988 p 24-27.

**076444 ALTERNATIVES TO THE SIZE PRESS.** The BTG BillBlade coater was invented ago as a size press replacement to apply higher coat weights without film-split-related problems such as sheet marking. The TwoStream is similar in principle to the BillBlade coater, but it runs in an upward direction. Another category is the hybrid combination of a gate roll chain and blade applicator - examples of this are: Beloit Bel Ba Pa coater; Black Clawson Blade Size Press; Gate Roll Jet Fountain. The BTG LAS hydrophilic roll coater has a transfer roll which is chromium plated and treated by a proprietary

etching process. The article discusses the key factors which differentiate the effects of various size application on sheet properties.

Klass, Charles P. (Klass Associates Ltd, King of Prussia, PA, USA). *PIMA Mag* v 70 n 9 Sep 1988 p 19-22.

**076445 IMPROVING APPEARANCES: HOW TO DEAL WITH WRINKLES.** When wrinkles occur, one must determine where the problem occurs - in a certain width of the wrapper, or from a particular backstand. Otherwise, the problem may be with the equipment - which part needs repairs or adjustments. A process of elimination usually works best here. If the equipment checks out, the rubber covering the nip roller must be examined.

Lacroix, Robert (RL&A Inc, Dorion, Que, Can). *PIMA Mag* v 70 n 9 Sep 1988 p 32-33.

**076446 NEWLY DESIGNED TABLE ROLL IMPROVES FORMATION, ALLOWS INCREASE IN SPEED.** Three years ago, a split roll on Gilman Paper Co.'s No. 2 bleached board machine at St. Mary's, Ga., led to a significant new development for improving formation and increasing production speed. The new development, called a Sheraton Roll because of its likeness to a Sheraton column (fluted furniture piece), is a direct result of positive effects the damaged table roll had on wet end performance. Today, several companies use the roll on paper machines making various grades of paper. It is most effective on older machines. The rolls are finding application on machines producing bleached board, lightweight bag, and linerboard, and one is planned for a newsprint machine in Canada. The machine fabric pulls the roll, with its gear-like surface, causing a paddle wheel effect. The roll throws water through the fabric, redispersing the fibers. The roll increased first-pass retention by throwing the fines back up and not letting them come through the wire. It also redistributed the fiber in such a way that the next component could take out more water than it normally would.

Ferguson, Kelly H. (Pulp & Paper, San Francisco, CA, USA). *Pulp Pap* v 62 n 9 Sep 1988 p 214-215.

**076447 ROLL COVER DESIGN CONSIDERATIONS FOR POLYURETHANES.** This article deals with roll cover design considerations for the paper industry. The load-bearing rolls in the press section of a paper machine are typically 20 to 70 inches in diameter. The roll cover thickness varies from 0.5 to 1.25 inches. The surface speed of these machines varies from several hundred to approximately 6,000 feet per minute. The loading may vary from 100 to 2,000 pounds per lineal inch. The elastomers from which the covers are manufactured are viscoelastic. The environment of the press section is one of elevated temperatures in the presence of large quantities of water. The roll cover design is discussed with consideration to these effects. The testing techniques and the methods to determine the hysteresis and dynamic modulus of a material are shown with polyurethane being the example material. (Edited author abstract).

Cheatham, Joseph F. (Stowe Woodward Co). *Rubber World* v 198 n 6 Sep 1988 p 14-19.

## Simulation

**076448 DISCRETE EVENT SIMULATION OF A BROKE SYSTEM.** The use of a discrete event simulation for the analysis of machine breaks on a broke system is demonstrated. The simulation allows us to tie the random nature of machine breaks to the continuous operation of the broke system and its associated control logic. This type of simulation allows the user to understand the effect of break occurrence and the resultant accumulation of broke for use later. The use of this type of simulation in system design, control optimization, and troubleshooting is discussed. (Edited author abstract) 2 refs.

Rounsley, Robert R. (Mead Central Research, Chillicothe, OH, USA). *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul* Publ by TAPPI Press, Atlanta, GA, USA, 1985 p 137-144.

## Testing

**076449 COMPARISON OF METHODS FOR MEASURING WEB TENSION.** The authors tested four web tension meters, covering the principles of using force transducers, sound waves, and pressure. With force transducers, load cells on roll bearings measure the force created by the moving web. The acoustic devices measure the time it takes a sound wave to pass through the web. With pressure, which the web tries to withstand, the web's force of resistance is a function of web tension. While there is no universally suitable technique for measuring web tension, all of the available instruments can be used to solve specific runnability problems. An ideal tension meter has yet to be developed. (Edited author abstract). 6 Refs.

Linna, Hannu (Technical Research Cent of Finland, Espoo, Finl); Moilanen, Pertti. *Tappi J* v 71 n 10 Oct 1988 p 134-137.

## Transportation

**076450 HOW TO RELOCATE A PAPER MACHINE.** Papermaking in Lenzing dates back to the turn of the 19th century. About 10 years ago, the losses of the paper mill began to rise. Several aspects favored continuing paper production at Lenzing. In mid-1982, the company heard of the availability of a 4.8-m wide MG machine from the Hens Papier mill in the Netherlands, which had been shut down. The offer by Escher Wyss included the complete papermaking machinery from the pulper to the winder, with the electrical and process control equipment. A new marketing and feasibility study by Jaakko Poyry favored the project. How the mill moved its papermaking machinery from Holland to Austria, particularly the voyage of the MG cylinder, is described. The original lay-out of Hens Papier was slightly modified. On May 5, 1984, the new plant was ready for start-up, exactly on schedule, one year and one day after the project was begun.

tho Seeth, Heinz. *PPI Pulp Pap Int* v 29 n 12 Dec 1987 p 50-51.

## Ventilation

**076451 ROLE COILS PLAY IN MILL AIR SYSTEMS.** Coils do not always provide the trouble-free service expected of them. The costs of poor coil performance is significant. Proper coil selection and application can reduce these costs. Three factors to consider in eliminating coil problems are discussed: coil design; coil construction and coil installation. Coil corrosion is also given important consideration.

Kennon, Doug (The King Co, Owatonna, MN, USA). *PIMA Mag* v 70 n 6 Jun 1988 p 54-57.

## Vibrations See Also PAPER AND PULP INDUSTRY—Maintenance; PAPERMAKING.

**076452 VIBRATION ANALYSIS IN THE PRESS SECTION.** This article explains how vibration analysis is used to identify the source of vibrations in the press section. In particular, we examine the issues involved in determining whether the vibrations are emanating from a roll assembly or from the felt. We present three case histories where vibration analysis was instrumental in determining the source of vibrations in the press section. But before going on to the case histories, we provide some background information about the physics of vibration, the measurable parameters, and the equipment used to measure vibration. 9 refs.

Vinicki, John (Lockport Felt, Starkville, MS, USA). *Tappi J* v 70 n 11 Nov 1987 p 91-95.

**076453 HOW TO CONDUCT PREDICTIVE MACHINERY VIBRATION PROGRAMS.** There are a number of basic steps involved in putting together a computerized predictive machinery vibration program



(CPMVP). One must determine critical machinery to be included in the CPMVP with a number of guidelines in mind. There is critical production equipment to be considered. This includes the fourdrinier section, press section rolls, dryer rolls, felt rolls, drives, etc. Also, there is critical production support equipment, including air compressors, product pumps, turbine generators, boiler feed pumps and fans and pulp mill equipment. Miscellaneous gear include plant and office air-handling units and computer room air-handling units. Finally, one should consider any piece of equipment that will shut down and/or affect production schedules if a bearing fails.

Miller, James Sr. (Preventive Maintenance Co); Miller, James Jr. *PIMA Mag* v 70 n 7 Jul 1988 p 34-36.

**Wear** See PULP MANUFACTURE—Refining.

**Wet End** See Also PAPER—Newsprint; PAPER AND PULP MILLS—Corrosion; PAPERMAKING.

**076454 CLOSING THE TECHNOLOGY GAP AT THE WET END.** Many mills, including the big ones, have a large gap in their control systems - a gap at the wet end. This paper describes the problems that this gap caused on a rebuilt, 120,000 tpy machine at the New Thames mill - dramatic, short term variations in retention and sheet breaks. To plug the gap Bowaters invested in pioneering wet end technology, which has given the mill a window into the wet end, and the ability to minimize variations. (Edited author abstract)

Street, Graham (New Thames Mill, Sittingbourne, Engl). *Pap Technol Ind* v 28 n 8 Nov 1987 p 678-680.

**076455 MEASUREMENT OF ALUMINUM HYDROLYSIS IN THE WET END.** Measuring and controlling the extent of aluminum hydrolysis taking place on the paper machine should be beneficial in optimizing wet-end performance. By applying some simple colloid analysis to aluminum hydrolysis, an alum control scheme evolves that shows promise when used on the paper machine in the mill environment. The extent of aluminum hydrolysis is a uniquely important index of alum performance in the wet end, whether for optimizing rosin sizing or wet-end retention. The OH:Al ratio in headbox furnishes reliably depicts the extent of aluminum hydrolysis, and the measurement of the OH:Al ratio is easily performed by process laboratory technicians in a paper mill. Theoretical consideration and laboratory and paper machine results place the optimum OH:Al ratio in the range of 1 to 2. 24 refs.

Cordier, David R. (Delta Chemicals Inc, Searsport, ME, USA); Bixler, Harris J. *Tappi J* v 70 n 11 Nov 1987 p 99-102.

**076456 TAKING A REAL-TIME LOOK AT THE WET END.** Real-time predictability from the wet end has become an industry priority. Chemtronics 4000, a wet-end monitoring and control system, responds to this need by providing on-line retention monitoring and automatic control of retention aid dosage. This capability allows the papermaker to control with a high degree of accuracy the quality of the finished product while the sheet is being formed. The primary function of a wet-end monitoring system is to provide information necessary to establish and maintain wet end stability. A second purpose is to provide real-time information during machine trials and other tests. By guaranteeing immediate feedback, trials can be shortened and provide more useful information with minimal risk of losing control along the way.

Stein, Wilfred (Procomp, Marietta, GA, USA); Marascia, Frank. *PIMA Mag* v 70 n 7 Jul 1988 p 19-21.

**076457 1987 WET END OPERATIONS SEMINAR.** This conference proceedings contains 50 papers which consider the theory and operating practice of the wet end of the paper machine. Design and operation of equipment are described. Wet end instrumentation and troubleshooting are discussed from a theoretical, as well as a practical standpoint. Information is presented on the latest type of equipment. Hydraulics is given ample coverage, as well as

water management aspects of the papermaking machinery operation. Synthetic wire applications, fourdrinier drive requirements and wet end control are also discussed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11250 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (TAPPI, Atlanta, GA, USA). *TAPPI Notes* 1987 Wet End Oper Semin, Atlanta, GA, USA, May 4-8 1987. Publ by TAPPI Press, Atlanta, GA, USA, 1987 461p.

## PARACHUTES

### Mathematical Models

**076458 MODELS OF SHAPE DEVELOPMENT IN PARACHUTES ON THE BASIS OF THE THEORY OF LOCAL RADII OF CURVATURE.** This paper is concerned with mathematical models of shape development in parachutes, based on the theory of local radii of curvature. The pertinent equations are derived and the results are compared with experimental data. The agreement is seen to be good. (Author abstract). 8 Refs.

Rysev, O.V. (Univ of Moscow, USSR). *Fluid Mech Sov Res* v 17 n 2 Mar-Apr 1988 p 72-87.

## PARAFFIN WAXES

### Chromatographic Analysis

**076459 DISTRIBUTION OF n-PARAFFINS IN IRAQI PETROLEUM WAXES AND IN A DEVELOPED HIGH MELTING WAX BY GAS CHROMATOGRAPHY.** Iraqi paraffin and microcrystalline waxes and a developed high melting wax were analyzed quantitatively and studied for their distribution of n-paraffins. The method employed an on-column injection technique and capillary gas chromatographic analysis using SCOT SP-2100 fused silica capillary column and certain experimental conditions to ensure quantitative results without discrimination. Hot split injector was also used and results were compared. Physical properties of waxes were studied and discussed as a function of n-paraffin distribution and non n-paraffins content. (Author abstract) 26 refs.

Tameesh, Adnan H.H. (Council of Scientific Research, Baghdad, Iraq); Al-Wahaib, Imad H.; Bender, Ali O.; Hanna, Mazin H. *J Pet Res* v 6 n 2 Dec 1987 p 63-76.

### Dielectric Properties

**076460 DIELECTRIC & ELECTRICAL dc CONDUCTIVITY STUDY OF SOME THERMO-ELECTRETS.** Thermo-electrets of paraffin wax and sealing wax have been prepared by applying various high dc voltages (680, 1320, 2040, 2720, 5400, 4080, 4760 V, etc.) between the electrodes during melting of the waxes. The dc fields were maintained till the completion of solidification of the sample. The dielectric constant ( $\epsilon'$ ) and dc electrical conductivities ( $\sigma$ ) were found out for all the samples. The results are explained satisfactorily on the basis of homocharge and heterocharge. (Author abstract) 13 refs.

Adgaonkar, C.S. (Inst of Science, Bombay, India); Shriramwar, V.S. *Indian J Pure Appl Phys* v 25 n 3 Mar 1987 p 133-134.

### Phase Transitions

**076461 PERIODIC STEADY STATE FOR CYCLIC ENERGY STORAGE IN PARAFFIN WAX.** The thermal performance of a latent heat energy storage unit was studied experimentally at the periodic steady state generated by cyclic energy storage and recovery. The periodic steady state was obtained by alternating identical freezing periods with identical melting periods. The storage unit was a cylindrical container of commercial paraffin wax. Energy was transferred to (and from) the wax by temperature controlled water flowing through a submerged helical coil. Measurements were made of the amount of energy stored and recovered as functions of the

freezing and melting times, the temperature of water and the geometry of the coil. A simple model was proposed to calculate the energy stored or recovered in the periodic steady state. (Author abstract) 13 refs.

Jariwala, V.G. (McGill Univ, Montreal, Que, Can); Mujumdar, A.S.; Weber, M.E. *Can J Chem Eng* v 65 n 6 Dec 1987 p 899-906.

**Physical Properties** See PETROLEUM PRODUCTS—Analysis.

### Precipitation

**076462 METHODS FOR PREDICTING WAX PRECIPITATION AND DEPOSITION.** Removal of wax from wells and flowlines can account for significant additional operating costs. To evaluate these potential costs, the operating conditions that allow waxes to precipitate in the wellbore must be identified, and deposition rates must be estimated to determine the costs associated with removal of wax deposits. Presented in this paper are laboratory and analytic methods that can be used to estimate both the critical operating conditions and the deposition rates. The laboratory tests and analysis presented may be used to characterize any type of oil. (Author abstract) 7 refs.

Weingarten, J.S. (ARCO Oil & Gas Co); Euchner, J.A. *SPE Prod Eng* v 3 n 1 Feb 1988 SPE 15654 p 121-126.

**Recovery** See OIL TANKS—Paraffin Sedimentation.

**Standards** See POLYVINYL CHLORIDE—Lubrication.

### Testing

**076463 ESTABLISHMENT OF STANDARD SLACK WAX SAMPLES: A REPORT OF THE EUROPEAN WAX FEDERATION TECHNICAL TASK FORCE 12.** Six slack waxes of various types and oil contents were selected, and each tested according to eight ASTM procedures in a round-robin programme. Results from the round-robin tests were processed according to ISO 4259 to establish mean values for the characteristics of the slack wax samples. All test results on the samples are listed, and the range of values (around the established mean) within which a result would be regarded as acceptable is indicated. (Edited author abstract)

Lafuente, F.G. (Ibercaser SA, Spain); Davis, B.L.; Lopez Garrido, F.; Petinelli, J.C.; Reimerink, G.H.J.; Schroeter, G.; Sayers, R. *J Q Tech Pap Inst Pet* Jan-Mar 1986 p 1-9.

**PARAFFINS** See Also GASES—Solubility; GEO-CHEMISTRY—Organic Compounds; HYDROCARBONS—Flotation; LIQUIDS—Viscosity; MIXTURES—Phase Equilibria; MIXTURES—Thermal Conductivity; SHALE OIL—Physical Properties.

**076464 PROTON NMR RELAXATION AND MOLECULAR MOTION OF LONG-CHAIN CYCLIC PARAFFINS IN THE SOLID STATE.** Temperature-dependent measurements have been made on the proton NMR relaxations and proton linewidths of the cyclic paraffins (c-C<sub>24</sub>H<sub>48</sub>, c-C<sub>28</sub>H<sub>56</sub>, and c-C<sub>128</sub>H<sub>256</sub>) in the solid state. It is found that in c-C<sub>24</sub>H<sub>48</sub> and c-C<sub>128</sub>H<sub>256</sub> there exist two transitions, one due to the melting process and the other due to a rapid transition between trans and gauche conformers in a compact structure that consists of two parallel trans zigzag straight chains bridged at both ends in the crystalline state. In c-C<sub>28</sub>H<sub>56</sub> there exists only the transition due to melting. Proton NMR relaxations have also been measured for c-C<sub>40</sub>H<sub>80</sub> and c-C<sub>160</sub>H<sub>320</sub> at room temperature, in addition to those for c-C<sub>24</sub>H<sub>48</sub>, c-C<sub>28</sub>H<sub>56</sub>, and c-C<sub>128</sub>H<sub>256</sub>. It is found that the extent of molecular motion decreases as the chain length increases. (Author abstract) 14 refs.

Takenaka, Masami (Tokyo Inst of Technology, Tokyo, Jpn); Yamanobe, Takeshi; Komoto, Tadashi; Ando, Isao; Sato, Hisaya; Sato, Kazuo. *J Polym Sci Part B* v 25 n 10 Oct 1987 p 2165-2178.



**Adsorption** See Also ADSORPTION—Mathematical Models.

**076465 SORPTION KINETICS OF HIGHER n-PARAFFINS ON ZEOLITE MOLECULAR SIEVE 5A.** Sorption kinetic measurements on n-paraffins ranging from n-heptane to n-tridecane have been carried out on zeolite molecular sieve 5A. Apparent diffusivity coefficients have been determined from the kinetic data. The effect of carbon chain length, preadsorbed water, and different nonadsorbing solvents on the kinetics of sorption has been examined. (Author abstract) 13 refs.

Jasra, Raksh V. (Indian Petrochemicals Corp Ltd, Vadodra, India); Bhat, Thirumaleswar S.G. *Ind Eng Chem Res* v 26 n 12 Dec 1987 p 2544-2546.

**076466 GAMMA DISTRIBUTION FUNCTION, BREAKTHROUGH CURVE AND THE ADSORPTION EQUILIBRIA OF NORMAL PARAFFINS.** The adsorption equilibria of normal paraffins in solution with n-pentane on 5A molecular sieves was studied by the dynamic method. The adsorption isotherms of n-decane, n-undecane, and their mixtures were determined at 450K from the breakthrough curves. The isotherms follow Henry's law when the concentration is less than 1.5 mol/l. The gamma distribution function fits the experimental breakthrough curve best. This fact enabled the authors to work out a hypothesis which considers the adsorption in the fixed bed as a typical stochastic process. Thus, the equilibrium loading can be calculated numerically. (Edited author abstract) 6 refs.

Lin, J.Q. (Zhejiang Univ, Hangzhou, China); Hu, S.S.; Huang, C.Y. *Modell Simul Control B* v 13 n 4 1988 p 25-36.

**076467 ADSORPTION OF NEOPENTANE BY NONPOROUS CARBONS AND SILICAS.** The adsorption of neopentane (2,2-dimethylpropane) by a range of nonporous carbons and silicas has been studied. It is shown that the shape of the isotherm in the multilayer region depends only on the chemical nature of the adsorbent (i.e., silica or carbon) and is independent of the degree of hydroxylation or the degree of graphitization. This is shown by, inter alia, the constancy of the FHH index ( $2.19 \pm 0.03$  for carbon and  $1.99 \pm 0.03$  for silica). Standard adsorption data for neopentane adsorbed on nonporous carbon and nonporous silica are presented and used to analyze the adsorption isotherms by the  $\alpha_s$  method. (Author abstract) 21 refs.

Carrott, P.J.M. (Brunel Univ, Uxbridge, Engl); Roberts, R.A.; Sing, K.S.W. *Langmuir* v 4 n 3 May-Jun 1988 p 740-743.

**076468 ADSORPTION OF n-ALKANES ON CARBON FIBERS AT ZERO SURFACE COVERAGE.** The Henry's law region of the adsorption isotherms for a series of n-alkanes ( $C_8$ - $C_{13}$ ) on two types of carbon fibers was studied by inverse gas chromatography. The heat, entropy, and free energy of adsorption, calculated from retention data, vary linearly with the number of carbon atoms. The low heats of adsorption for both high-modulus and high-strength fibers indicate a virtual absence of high-energy sites. Increased values of heats of adsorption obtained after the cleaning of the fibers for 100 h in nitrogen at 160°C suggest that the high-energy sites on 'as received' fibers are occupied by physically adsorbed species ( $CO_2$ ,  $H_2O$ ). It is shown that the entropy loss upon adsorption cannot be attributed solely to the loss of one degree of translational freedom and that contributions from rotational and conformational entropy losses must be taken into account. (Edited author abstract) 35 refs.

Vukov, Aleksandar J. (McGill Univ, Montreal, Que, Can); Gray, Derek G. *Langmuir* v 4 n 3 May-Jun 1988 p 743-748.

**Chemical Reactions** See ACIDS—Production.

## Chemistry

**076469 <sup>13</sup>C N.M.R. CHEMICAL SHIFT AND CRYSTAL STRUCTURES OF CYCLIC PARAFFINS OF LONG CHAIN LENGTHS.** High resolution <sup>13</sup>C N.M.R. spectra of cyclic paraffins of long chain lengths up to the carbon number 200 in the crystalline state have been measured by the cross polarization-magic angle spinning technique. It is found that <sup>13</sup>C chemical shift of the main peak for the trans zigzag methylene carbons of cyclic paraffins having the carbon number from 36 to 80 (triclinic form) appears at about 1 p.p.m. further downfield than those having the carbon number from 128 to 200 (orthorhombic form). Such a difference of about 1 p.p.m. is caused by a local change in intermolecular interactions which result in going from the orthorhombic to the triclinic form. (Author abstract)

Takenaka, M. (Tokyo Inst of Technology, Tokyo, Jpn); Yamanobe, T.; Komoto, T.; Ando, I.; Sato, H. *Solid State Commun* v 61 n 9 Mar 1987 p 563-565.

## Chlorination

**076470 KINETIC ANALYSIS OF ALKANE POLYCHLORINATION WITH MOLECULAR CHLORINE. CHLORINE ATOM/MONOCHLORIDE GEMINATE PAIRS AND THE EFFECT OF REACTIVE 'CAGE WALLS' ON THE COMPETITION BETWEEN MONOCHLORIDE ROTATION AND CHLORINE ATOM ESCAPE.** The free-radical chlorination of alkanes produces polychlorides even at low conversions. These are formed by reaction of chlorine atom/monochloride (or dichloride) geminate pairs. This process has been studied in detail in various solvent systems, and a kinetic scheme has been proposed. Deviations from this scheme have been rationalized as being due to competition between monochloride rotation and reaction of the chlorine atom with reactive molecules in the 'cage walls' surrounding the chlorine atom/chloride geminate pair. Analysis of the dichloride products supports the suggestion that monochloride rotation is not completely 'free' within the lifetime of the geminate pair. (Author abstract) 38 refs.

Raner, K.D. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Luszyk, J.; Ingold, K.U. *J Am Chem Soc* v 110 n 11 May 25 1988 p 3519-3524.

**Chromatographic Analysis** See Also HYDROCARBONS—Chromatographic Analysis.

**076471 CONTRIBUTIONS OF STEREOISOMERISM TO PEAK SHAPES OF BRANCHED PARAFFINS IN THE HIGH-RESOLUTION GAS CHROMATOGRAPHIC ANALYSES OF JET PROPULSION FUELS.** The effects of branched paraffin stereoisomers present in both standards and fuel samples are investigated. Although the standards used in this study are not optically pure, the evidence of the separation of diastereomeric isomers of branched paraffins is shown on a standard nonpolar fused-silica capillary column. Anomalous peak shapes and split peaks are related to stereoisomerism. The typical region of unresolved compounds in the middle of a chromatogram of a kerosene-based fuel is related to the presence of branched paraffin stereoisomers. (Author abstract) 9 refs.

Pitzer, Edward W. (Aero Propulsion Lab, Wright Patterson AFB, OH, USA). *J Chromatogr Sci* v 26 n 5 May 1988 p 223-227.

**076472 AUTOMATED MULTIDIMENSIONAL GAS CHROMATOGRAPHIC PNA ANALYSIS OF HYDROCARBON-TYPE SAMPLES, OPTIMIZATION WITH RESPECT TO SPEED OF ANALYSIS.** The multidimensional gas chromatographic group-type analysis of paraffins, naphthenes, and aromatics (PNA analysis) in hydrocarbon mixtures is optimized with respect to the speed of analysis. The use of nonlinear temperature programming, desorption of aromatics in backflush, and optimization of the operating conditions of the individual columns results in a 50% reduction of the analysis time. (Author abstract) 4 refs.

Curvers, J. (Analytical Controls BV, Delft, Neth); van der Sluys, P. *J Chromatogr Sci* v 26 n 6 Jun 1988 p 267-270.

**076473 FAST SEPARATION OF PARAFFINS, NAPHTHENES, AND AROMATICS IN NAPHTHA AND KEROSENE FRACTIONS BY GAS LIQUID-SOLID CHROMATOGRAPHY.** A gas liquid-solid chromatographic column (GLSC) consisting of molecular sieve 5 angstrom coated with 10 percent (w/w) OV-275 silicone oil is utilized to analyze petroleum distillates, naphtha, and kerosene. This work is based on hydrocarbon group type analysis by carbon number distribution for paraffins and naphthenes; individual separation of aromatics is attained because interference from nonhydrocarbons is eliminated. Despite the short column employed in this technique, high efficiency is obtained as all complex components are eluted in 6 min for naphtha and 10 min for kerosene. (Author abstract) 15 refs.

Al-Thamir, W.K. (Central Petroleum Organization, Baghdad, Iraq). *J Chromatogr Sci* v 26 n 7 Jul 1988 p 345-347.

**Control** See OIL WELL PRODUCTION—Flowlines.

**Cracking** See COAL LIQUEFACTION; HYDROCARBONS—Cracking; ZEOLITES—Coking.

## Crystal Lattices

**076474 ONSET OF CHAIN FOLDING IN ULTRALONG n-ALKANES: AN ELECTRON MICROSCOPIC STUDY OF SOLUTION-GROWN CRYSTALS.** Crystallization of extremely pure n- $C_{398}H_{798}$  from dilute solution is investigated by electron microscopy and differential scanning calorimetry. This long-chain alkane is capable of crystallizing in the extended form or of folding once or twice and thus provides useful insights into the fundamental process of chain-folded crystal growth. Crystallization conditions that give rise to the different crystal types are identified by measuring the variation in dissolution temperature with crystallization temperature and crystallization time. Examples of each type of crystal are examined in the electron microscope using various techniques. Electron diffraction studies show that the chains are substantially perpendicular within the crystals in all cases. In addition, differences in surface regularity between the different crystal types revealed by decoration techniques are discussed. (Edited author abstract) 27 refs.

Organ, S.J. (Univ of Bristol, Bristol, Engl); Keller, A. *J Polym Sci Part B* v 25 n 12 Dec 1987 p 2409-2430.

## Crystalline

**076475 HARTREE-FOCK CALCULATIONS OF CRYSTALLINE PACKING OF SMALL LINEAR n-ALKANES.** Conformation energies for n-propane and n-butane complexes which model the unit cell and the packing of even and odd paraffin hydrocarbons along the crystal c-axis are determined. It is found that Huzinaga's MINI-1 basis is well suited for a first study of the weak interactions which determine the difference between even and odd n-alkanes, whereas the STO-3G basis fails. (Author abstract) 20 refs.

Wyble, D.J. (Michigan Technological Univ, Houghton, MI, USA); Seel, M.; Waber, J.T. *Solid State Commun* v 64 n 5 Nov 1987 p 827-829.

**Crystallization** See Also POLYMERS—Molecular Structure.

**076476 MOLECULAR ORIENTATION MECHANISM OF n-PARAFFINS AND FATTY ACID THIN FILMS BY EVAPORATION METHOD.** The structure of the evaporated thin films of n-paraffins and long chain fatty acids was studied by X-ray symmetrical reflection technique. The activation energy of evaporation of n-paraffins linearly increased with an increase in the carbon number. Sublimation of paraffins was observed at carbon numbers below 28. Paraffin and stearic acid molecules tended to orient perpendicular to a glass



substrate (normal orientation). The normal orientation could be controlled by supercooling defined by the difference between the melting temperature of the sample and the substrate temperature. Mechanism of the orientation is closely related to molecular motion on the substrate. (Edited author abstract) In Japanese. 14 refs.

Tanaka, Katsufumi (Tokyo Inst of Technology, Tokyo, Jpn); Kimura, Shigeo; Nakahashi, Junji; Umemoto, Susumu; Okui, Norimasa; Sakai, Tetsuya. *Kobunshi Ronbunshu* v 44 n 11 1987 p 817-823.

## Diffusion

**076477 DIFFUSION OF C<sub>1</sub> TO C<sub>5</sub> NORMAL PARAFFINS IN SILICALITE.** Diffusion coefficients were measured for the C<sub>1</sub> to C<sub>5</sub> normal paraffins in silicalite using a molecular sieve membrane. The coefficients were measured at 334 K and were found to range from  $1.07 \times 10^{-6}$  cm<sup>2</sup>/s for methane to  $2.42 \times 10^{-8}$  cm<sup>2</sup>/s for n-pentane. For each of the gases tested, the diffusion coefficients were found to be independent of diffusant concentration over the concentration range tested. Values of the diffusion coefficients were found to correlate directly with the carbon number of the diffusant. (Author abstract) 9 refs.

Hayhurst, David T. (Cleveland State Univ, Cleveland, OH, USA); Paravar, Ali R. *Zeolites* v 8 n 1 Jan 1988 p 27-29.

**076478 DIFFUSION OF A CHLOROPARAFFIN IN POLYETHYLENE.** The diffusion of a chloroparaffin from PE into benzene, chloroform, carbon tetrachloride and dioctyl phthalate has been studied at different temperatures and on sorption of benzene and dioctyl phthalate by the polymer. The diffusion coefficient of a chloroparaffin depends on the nature of the solvent and is identical for different chloroparaffin concentrations in the polymer. The depth of desorption of the chloroparaffin from PE into dioctyl phthalate depends on temperature. (Author abstract). 3 refs.

Ruzumovskii, L.P. (USSR Acad of Sciences, USSR); Aseyeva, T.M.; Kulikova, Z.K.; Khokhlova, L.L.; Zai-kov, G. Ye. *Polym Sci USSR* v 29 n 5 1987 p 1009-1014.

**076479 DIFFUSION OF ALKANES IN MOLECULAR SIEVES EVIDENCE FOR CONFINEMENT EFFECTS.** Sorption kinetics, heats of sorption, NMR relaxation time measurements, and molecular graphics simulations support the proposal that confinement effects regulate the diffusional behavior of alkanes in zeolites (ZSM-5, ferrierite, mordenite, type Y) and other molecular sieves (e.g. ALPO-11). The results advocate the existence of a segmental diffusion mode. They also assess the floating and creeping molecule concepts for entities diffusing in pores of atomic size. (Author abstract). 14 refs.

Derouane, Eric G. (Facultes Univ N.D. de la Paix, Namur, Belgium); Nagy, Janos B.; Fernandez, Christian; Gabelica, Zelimir; Laurent, Etienne; Maljean, Passcale. *Appl Catal* v 40 n 1-2 Jun 15 1988 p L1-L10.

**Environmental Impact** See WATER POLLUTION—Marine Pollution.

**Extraction** See DIESEL FUELS—Physical Properties.

## Forming

**076480 THERMODYNAMIC FUNCTIONS OF FORMATION OF n-ALKANE COMPLEXES WITH CRYSTALLINE UREA.** It is important to know the equilibrium constants of formation of complexes of urea with n-alkanes differing in the number of carbon atoms in their molecules, as functions of temperature. In this investigation we obtained experimental data necessary for calculating the thermodynamic functions of formation of n-alkane complexes with crystalline urea up to the decomposition temperature. It is found that the equilibrium constants decrease with rise of temperature and with decrease of the length of the alkane molecule. Therefore

for formation of urea complexes with a mixture of n-alkanes it is necessary to choose the optimal process temperature, which depends on the average molecular weight of the n-alkanes in the feedstock. The equilibrium constants can be used for estimating the process temperature and the ratio of urea to feedstock of known composition required for attaining the required degree of extraction of n-alkanes. 4 refs.

Tolmachev, V.V. (Lensovet Leningrad Technological Inst, USSR); Semenov, L.V.; Gaile, A.A.; Proskuryakov, V.A. *J Appl Chem USSR* v 60 n 1 pt 2 Jan 1987 p 128-132.

**Hydrocracking** See Also ZEOLITES—Activation.

**076481 HYDROISOMERIZATION AND HYDROCRACKING OF n-ALKANES. 2. n-HEPTANE TRANSFORMATION ON A Pt-DEALUMINATED Y ZEOLITE - COMPARISON WITH A Pt-Y ZEOLITE.** The transformation of n-heptane was studied at 250°C, 1 atm., pH<sub>2</sub>/pnC<sub>7</sub> = 9 on a series of PtHY catalysts containing 0.045 to 0.85 wt% Pt and having a Si/Al atomic ratio of 9. The results were compared to those obtained with a similar series having a Si/Al atomic ratio of 3. It is shown that the ratio between the number of accessible Pt atoms and the number of acid sites on which the heat of adsorption of ammonia is greater than 100 KJ mol<sup>-1</sup> (nPt/nA) is a good parameter for characterizing the balance between the hydrogenating and the acid functions. The results indicate that Y zeolite with a Si/Al ratio of about 10 is an excellent support for hydroisomerization catalysts. (Edited author abstract) 17 refs.

Alvarez, F. (CNRS, Poitiers, Fr); Giannetto, G.; Guisnet, M.; Perot, G. *Appl Catal* v 34 n 1-2 Oct 15 1987 p 353-365.

**076482 CATALYTIC ACTIVITY OF SILICA-SUPPORTED VANADIUM PARAFFIN REACTIONS.** The preparation of a silica-supported vanadium catalyst, active for converting paraffins (such as n-hexane and n-octane) to aromatics, is described. The catalyst activity depends strongly upon the oxidation state of vanadium. For example, oxidized vanadium has a substantially higher activity and aromatic selectivity than the pre-reduced form. The reaction of n-hexane over both the oxidized and pre-reduced catalyst can be described using first-order kinetics in which catalyst deactivation is also modeled using a first-order rate constant. The activation energies of both the overall and the dehydrocyclization reactions are determined. Catalytic activity is decreased by steam addition to the feed, catalyst pre-sulfiding, and the addition of either antimony or tin to the vanadium. (Author abstract) 16 refs.

Lee, Fu-Ming (Phillips Petroleum Co, Bartlesville, OK, USA); Schaffer, Arnold M. *Appl Catal* v 39 n 1-2 May 16 1988 p 135-151.

**076483 HYDROCRACKING: SCIENCE AND TECHNOLOGY, PROCEEDINGS OF THE NFWO-FNRS CATALYSIS CONTACT GROUP MEETING.** This issue contains 5 papers from the symposium. Conventional high pressure hydrocracking and catalytic cracking are compared with low pressure hydrocracking. The role that new catalysts and in particular zeolites can play in the development of more efficient hydroprocessing technologies is discussed. Recent progress in the understanding of hydrocracking on bifunctional zeolites is presented. The scope of the reported work goes well beyond the field of hydrocracking. Product distributions obtained with model components allow the elucidation of the texture of new zeolites. The development of rate equations taking into account every single elementary step of the reaction mechanism will certainly be applied to other processes in the future. All papers are abstracted and indexed individually. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10720 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Froment, G.F. (Ed.) (Rijksuniv Gent, Ghent, Belg);

Marin, G.B. (Ed.). *Catal Today* v 1 n 4 Aug 1987, Hydrocracking: Sci and Technol, Proc of the NFWO-FNRS Catal Contact Group Meet, Ghent, Belg, Dec 3 1986 p 367-473.

**076484 HYDROISOMERIZATION AND HYDROCRACKING OF n-HEPTANE ON PtH ZEOLITES. EFFECT OF THE POROSITY AND OF THE DISTRIBUTION OF METALLIC AND ACID SITES.** In the activity, stability and selectivity for n-alkane hydroisomerization and hydrocracking of bifunctional zeolitic catalysts, the ratio of the number of metallic to the number of acid sites is a determining parameter. With PtHY catalysts, the selectivity definitely depends on the number of acid sites which may be encountered by the intermediate olefins between two metallic centres. However, if we were to apply this observation to various PtHY catalysts (in particular with different Si/Al ratios) the active acid sites would have to be identified and their number measured with accuracy. The results obtained with PtHZSM5 catalysts show that the pore structure also plays a significant role through the mode of circulation it imposes on the reactant molecules and through the steric constraints it exerts on the migration and/or on the formation and reactivity of the intermediates. As evidenced with PtHMOR catalysts pore blockage either by platinum crystallites or by carbonaceous compounds can modify the distribution of the products. Moreover their acid sites being stronger, the life time of the adsorbed carbenium ions may be longer and the n-paraffin transformation less selective. 31 refs.

Guisnet, M. (CNRS, Poitiers, Fr); Alvarez, F.; Giannetto, G.; Perot, G. *Catal Today* v 1 n 4 Aug 1987, Hydrocracking: Sci and Technol, Proc of the NFWO-FNRS Catal Contact Group Meet, Ghent, Belg, Dec 3 1986 p 415-433.

**076485 ATTEMPTS TO RATIONALIZE THE DISTRIBUTION OF HYDROCRACKED PRODUCTS. III. MECHANISTIC ASPECTS OF ISOMERIZATION AND HYDROCRACKING OF BRANCHED ALKANES ON IDEAL BIFUNCTIONAL LARGE-PORE ZEOLITE CATALYSTS.** Detailed compositions of the isomerisation and hydrocracking products obtained in the reaction of 2-, 3-, 4- and 5-methylnonane, 2,6- and 3,5-dimethyloctane and 2,4,6- and 3,3,5-trimethylheptane over Pt/USY using a continuous flow reactor and on-line high-resolution gas chromatography are reported. These product distributions can be rationalised and understood by the reaction schemes established for the conversion of long chain normal alkanes over ideal bifunctional large-pore zeolite catalysts. The composition of the hydrocracked products from the mono-, and di-branched feed molecules mentioned is very similar and identical to those from n-decane, previously reported. This indicates that the feedstock molecules are equilibrated in all cases, before substantial cracking occurs. With the tribranched molecules mentioned, the situation is totally different, as the formation of ALPHA-ALPHA-GAMMA-branched isomers, which are cracked very rapidly, requires in the worst case only a few methyl-shifts. (Author abstract) 10 refs.

Martens, Johan A. (Katholieke Univ Leuven, Louvain, Belg); Tielen, Mia; Jacobs, Peter A. *Catal Today* v 1 n 4 Aug 1987, Hydrocracking: Sci and Technol, Proc of the NFWO-FNRS Catal Contact Group Meet, Ghent, Belg, Dec 3 1986 p 435-453.

**076486 KINETICS OF THE HYDROISOMERIZATION AND HYDROCRACKING OF PARAFFINS ON A PLATINUM CONTAINING BIFUNCTIONAL Y-ZEOLITE.** The kinetics of hydroisomerization and hydrocracking of n-octane, n-decane and n-dodecane were studied on a Pt/US-Y zeolite at 130-250°C, 5-100 bar total pressure and molar hydrogen to hydrocarbon ratios from 10 to 150. In first instance modeling was based on the lumping of the components and the reaction network. The obtained Hougen-Watson rate equations are independent of the carbon number of the feed and correspond to a mechanism with a rate-determining step on the acid



function and with a Langmuir sorption isotherm. Next, kinetic equations based upon elementary reaction steps were derived. The corresponding network was generated by an algorithm. The merits of such a fundamental approach are discussed. Estimates of the kinetic parameters obtained by non linear regression are presented. (Author abstract) 12 refs.

Froment, G.F. (Rijksuniv Gent, Ghent, Belg). *Catal Today* v 1 n 4 Aug 1987. Hydrocracking: Sci and Technol, Proc of the NFWO-FNRS Catal Contact Group Meet, Ghent, Belg, Dec 3 1986 p 455-473.

## Hydrogenation

**076487 RELATIONSHIP BETWEEN SELECTIVITY IN THE CATALYTIC HYDROGENATION OF ALKANES AND THE ENERGIES OF INTRAMOLECULAR BONDS.** The results of quantum mechanical calculations of C-C and C-H bond energies and experimental data concerning the hydrogenation of hexane isomers on Pt/Al<sub>2</sub>O<sub>3</sub>, Pt/SiO<sub>2</sub>, and Pt/C catalysts have been compared. Depending on the nature of the catalyst, the alkane degradation reactions can take place via one of two mechanisms, which are selective either with respect to the C-C or to the C-H bond energies. A method has been proposed for the experimental determination of the catalyst reaction pathway by the first or second mechanism. (Author abstract) 13 refs.

Gyul'maliev, A.M. (Inst of Combustible Resources, Moscow, USSR); Gagarin, S.G.; Krichko, A.A. *Kinet Catal* v 28 n 5 pt 1 Sep-Oct 1987 p 935-939.

## Isomerization See Also BUTANE—Pyrolysis.

**076488 ISOMERIZATION OF PARAFFIN HYDROCARBONS AT LOW TEMPERATURE.** The isomerization reaction of n-pentane and n-hexane was studied at low temperature (100-150 °C) and at a total pressure of 20 bar on aluminum-oxide supported platinum catalyst modified by chlorination. It was found that, in contrast to the high temperature process using a IP-62 type catalyst, the amount of isomers can be significantly increased and the results obtained approach BP and UOP data. The process is economic and a considerable increase in capacity can be obtained. The octane number of the product mixture is higher by 5-10 times than that of the traditional process. (Author abstract) 7 refs.

Hancsok, J. (Veszprem Univ of Chemical Engineering, Veszprem, Hung); Gaordos, G.; Perger, J. *Hung J Ind Chem* v 15 n 3 1987 p 309-316.

**076489 HYDROISOMERIZATION OF n-PARAFFINS ON A PLATINUM-RHENIUM/PILLARED CLAY MINERAL CATALYST.** An active hydroisomerization catalyst has been prepared by impregnating an acidic pillared clay mineral with the (de)hydrogenation components platinum and rhenium. This material was used to study the hydroisomerization reactions of n-pentane, n-hexane, and n-heptane in hydrogen flowing through a plug flow reactor operated under differential conversion conditions. Single branched isomers were the major reaction products. The rate data agreed well with a Langmuir-Hinshelwood model based on a conventional bifunctional mechanism. The kinetic parameters varied with temperature in a way that is consistent with this model. Selectivity was also tested by changing the ratio of metallic sites to acid sites through selective poisoning. (Edited author abstract) 19 refs.

Parulekar, Vivekanand N. (Rice Univ, Houston, TX, USA); Hightower, Joe W. *Appl Catal* v 35 n 2 Dec 1987 p 249-262.

**076490 SIMPLE MODEL FOR THE REACTION OF NORMAL OCTANE ON Pt/Al<sub>2</sub>O<sub>3</sub> CATALYST.** Design parameters were obtained from a simple model developed for the catalytic reaction of normal octane on platinum-alumina catalyst. The relevant equations were solved analytically and graphically. The model did not involve intramolecular and intermolecular mass transfer phenomena because of the particle size (0.1-0.4 mm); it

took into account kinetic phenomena and was applied in predicting conversion-temperature and conversion-reactor length profiles. Conversion-temperature profiles obtained from the model compared favorably with those obtained experimentally. (Author abstract) 11 refs.

Ako, Churchill T. (Univ of Lagos, Nigeria); Susu, Alfred A.; Gobina, Edward N. *J Chem Technol Biotechnol* v 41 n 1 1988 p 13-26.

**076491 COMPETITIVE REACTION IN INTRAZEOLITIC MEDIA.** The effects of an aromatics cofeed on paraffin hydroisomerization and hydrocracking over Pt/mordenite are studied as an example of competitive reaction in intrazeolitic medium. Preferential adsorption by the aromatic (benzene) modifies catalytic site distributions available for the paraffin (n-hexane) reaction and also affects diffusional characteristics in the one-dimensional channel structure of the zeolite. A significant inhibition of the hexane reaction is observed. The hexane isomer distribution in the presence of the aromatic is rationalized using concepts of coreactant induced size and shape selectivity modifications. (Author abstract) 30 refs.

Chen, Jan-Ku (Tulane Univ, New Orleans, LA, USA); Martin, Alison M.; Kim, Young Gul; John, Vijay T. *Ind Eng Chem Res* v 27 n 3 Mar 1988 p 401-409.

## Melting See YARN—Processing.

## Molecular Structure See Also COAL—Chromatographic Analysis.

**076492 ENERGETICS OF ROTATION AND TRANSLATION IN HEXAGONAL AGGREGATES OF EXTENDED CHAINS.** Potential energy calculations have been for hexane aggregates in the hexagonal arrangement as models of paraffin-like solids. As a part of the general energy hypersurface the feasibility of translation and rotation of extended chains in aggregates has been examined for various degrees of packing. The pure translation is favored over the pure rotation at all interchain separations. The energy map of coupled rotation-translation motion has been developed for the intermediate degree of packing. The energy minima on the map correspond to the parallel orientation of chain backbones and are presumed to represent the prevailing short-range structure of the rotator phase in n-alkane crystals. (Edited author abstract) 29 refs.

Bleha, T. (Slovak Acad of Sciences, Bratislava, Czech); Gajdos, J. *Colloid Polym Sci* v 265 n 7 Jul 1987 p 574-583.

## Oxidation

**076493 OXIDATION OF ALKANES IN AQUEOUS SOLUTIONS OF MERCURY(II) SALTS WITH UV IRRADIATION.** An oxidation reaction of saturated C<sub>2</sub> to C<sub>7</sub> hydrocarbons and benzene in aqueous solutions of mercury(II) sulfate at 298°K and with irradiation of light at 180-360 nm has been identified. The main product of the oxidation of ethane is CO<sub>2</sub>. The selectivity of the processes and the kinetic isotope effect (cyclo-C<sub>6</sub>H<sub>12</sub>/cyclo-C<sub>6</sub>D<sub>12</sub>=1.46±0.05) have been determined by means of competing reactions. (Edited author abstract) 16 refs.

Rudakov, E.S. (Acad of Sciences of the USSR, Donetsk, USSR); Mitchenko, S.A.; Miroschnichenko, N.A. *Kinet Catal* v 28 n 1 pt 2 Jan-Feb 1987 p 166-170.

**076494 OXIDATION OF n-ALKANES IN PRESENCE OF BINARY NICKEL-CONTAINING CATALYSTS.** Replacement of the manganese component by nickel in the industrial manganese-alkali catalytic system for synthesis of SFA (Synthetic Fatty Acids) improves the fractional composition and raises the content of acids in the oxidation products at the standard degree of oxidation. The binary nickel-alkali catalyst is inferior to the industrial catalyst in activity and selectivity. However, with the use of the nickel-manganese catalyst the oxidation rate can be raised considerably while retaining a

higher yield of acids. The nature of the catalyst components not only influences the activity of the system, but may also alter the selectivity of the process substantially in optimal conditions and concentrations. 5 refs.

Galimov, R.A. (S.M. Kirov Inst of Chemical Technology, Kazan, USSR); Kuznetsova, I.M.; Lebedeva, N.M. *J Appl Chem USSR* v 60 n 3 pt 2 Mar 1987 p 639-641.

**076495 PETROCHEMICALS: THE CHEMISTRY OF CATALYZED AIR OXIDATION OF FOSSIL HYDROCARBONS.** The reaction mechanisms and the selective products formed during the air oxidation of some important industrial paraffins and arenes catalyzed homogeneously by transition metal complexes such as Cu(I), Co(II), and Mn(II) are discussed. In addition, the main uses of the major products generated from these catalytic air oxidation processes are summarized. (Author abstract) 36 refs.

Tsonis, C.P. (Univ of Petroleum & Minerals, Dhahran, Saudi Arabia). *Fuel Process Technol* v 17 n 3 Jan 1988 p 285-300.

**076496 FEATURES OF THE OXIDATION OF n-ALKANES IN THE PRESENCE OF METAL-COMPLEX CATALYSTS.** The inhibiting effect of products of oxidation of n-alkanes on the decomposition of tert-butyl hydroperoxide in the presence of manganese cyclopentadienyl- $\pi$ -tricarbonyl has been revealed. The mechanism of the action of acids and alcohols differs from that of ketones and aldehydes. The force of the effect of acids correlates with their protonic force. During oxidation of n-alkanes in the presence of manganese cyclopentadienyl- $\pi$ -tricarbonyl, oxygen-containing products retard the rate of acid formation in the following order: aldehyde > ketone > alcohol. The rate of formation of carbonyl compounds grows in the presence of aldehydes and acids, ketones having an inhibiting effect, but alcohols hardly affect the rate of the reaction. 5 Refs.

Galimov, R.A. (All-Union Scientific Research Inst for Hydrocarbon Feedstock, USSR); Kuznetsova, I.M. *Pet Chem USSR* v 27 n 1 1987 p 63-66.

## Phase Equilibria See Also MIXTURES—Phase Equilibria.

**076497 GLOBAL PHASE BEHAVIOR OF MIXTURES OF SHORT AND LONG n-ALKANES.** The perturbed-hard-chain model of S. Beret, M.D. Donohue, and J.M. Prausnitz, in the simplified version of C. Kim et al., is compared with recent VLE data on mixtures of ethane and n-alkanes with carbon numbers from 16 to 24. By using and extrapolating the linear relations between the three adjustable model parameters and the carbon number, as given by C. Kim et al., we find that the experimental isothermal bubble curves are well represented up to the critical pressure without the use of any adjustable parameters. Experimental Henry constants for ethane in eicosane are predicted at all temperatures. This global model is more accurate than the Soave-Redlich-Kwong equation. (Edited author abstract) 24 refs.

Peters, C.J. (Delft Univ of Technology, Delft, Neth); de Swaan Arons, J.; Levelt Sengers, J.M.H.; Gallagher, J.S. *AIChE J* v 34 n 5 May 1988 p 834-839.

**076498 VAPOR-LIQUID EQUILIBRIA FOR THE ETHANE-PROPANE SYSTEM AT LOW TEMPERATURE.** Vapor-liquid equilibrium data for the ethane-propane mixture at 270, 255.4, 245, 235, 210, and 195 K are reported. These data have been correlated with good accuracy by the Soave, Redlich-Kwong, and Peng-Robinson equations of state, allowing a variation with temperature of the binary interaction parameter. Variation of equimolar excess Gibbs energy with temperature is also reported. (Author abstract) 10 refs.

Blanc, Claude J. (Elf-Aquitaine, Artix, Fr); Setier, Jean-Claude B. *J Chem Eng Data* v 33 n 2 Apr 1988 p 111-115.



**076499 PHASE EQUILIBRIA IN BINARY MIXTURES OF ETHANE + DOCOSANE AND MOLAR VOLUMES OF LIQUID DOCOSANE.** Experimental results for various types of phase behaviour which can occur in the binary ethane + docosane system are presented. The experimental data cover various two-phase boundaries and the three-phase equilibria solid docosane + liquid + vapour and liquid + liquid + vapour. In addition, p,V,T measurements of liquid docosane are carried out. The experimental work is performed within a temperature range of 290-370 K and at pressure of up to 16 MPa. (Author abstract). 15 Refs.

Peters, C.J. (Delft Univ of Technology, Delft, Neth); Spiegelaar, J.; Arons, J. De Swaan. *Fluid Phase Equilib* v 41 n 3 Jul 1988 p 245-256.

**076500 PARTIAL MISCIBILITY BEHAVIOR OF THE ETHANE + PROPANE + N-DOTRIACONTANE MIXTURE.** The liquid-liquid-vapor partial miscibility of the mixture ethane + propane + n-dotriacontane is experimentally studied by using a visual cell (stoichiometric) technique. The ternary mixture, which has no constituent binary partial miscibility, has a liquid-liquid-vapor region bounded by upper and lower critical end point loci and a quadruple point locus (solid-liquid-liquid-vapor). The three-phase region extends from about 47 to 95°C at pressures from 41 to 52 bar. The boundaries of the three-phase region are located in pressure-temperature space, and phase compositions and molar volumes of the three fluid phases are reported along isotherms at 50, 60, and 70°C. (Author abstract). 25 Refs.

Estrera, Susana S. (Univ of Tulsa, Tulsa, OK, USA); Luks, Kraemer D. *J Chem Eng Data* v 33 n 3 Jul 1988 p 350-354.

## Phase Transitions

**076501 POLYMORPHIC TRANSITIONS OF n-PENTACOSANE SAMPLES PURIFIED BY GEL PERMEATION CHROMATOGRAPHY.** Recently, much attention has been paid to the phase transition behavior of n-alkane crystals. It seems that there is some correlation between these solid-solid transitions and the disordering process of chain molecules in the crystals. For clarification of this, the authors continued the phase study for odd n-alkanes ranging from C23 to C43. This paper is concerned with the interesting finding obtained during the study that the homologous impurity has a profound effect on the polymorphic change in n-pentacosane (C25) crystals. 10 refs.

Takamizawa, Kanichiro (Kyushu Univ, Fukuoka, Jpn); Nagao, Yuji; Urabe, Yoshiko. *Polym J* v 19 n 8 1987 p 981-984.

## Physical Properties

**076502 MOLECULAR MODELING OF THE PHYSICAL PROPERTIES OF THE ALKANES.** Eight physical properties (boiling points, molar volumes, molar refractions, heats of vaporization, surface tensions, melting points, critical temperatures, and critical pressures) of 74 normal and branched alkanes were examined by molecular modeling techniques. Structural parameters employed include Wiener indices, connectivity indices, ad hoc descriptors, information indices, and molecular volumes and surface areas. Most of the properties were well modeled by the Wiener indices, connectivity indices, and ad hoc descriptors. An exception was the melting points, which were not well modeled by any of the available indices. Factor analysis (principal component analysis) was used to examine the intrinsic dimensionalities of the data and parameter sets. (Edited author abstract) 71 refs.

Needham, Diane E. (Wright State Univ, Dayton, OH, USA); Wei, I-Chien; Seybold, Paul G. *J Am Chem Soc* v 110 n 13 Jun 1988 p 4186-4194.

**Pressure Effects** See HYDROCARBONS—Pressure Effects.

**Processing** See Also CATALYSTS—Research; HYDROCARBONS—Hydrocracking.

**076503 CONVERSION OF LIGHT ALKANES INTO AROMATIC HYDROCARBONS: 1-DEHYDROCYCLODIMERIZATION OF PROPANE ON PtHZSM-5 CATALYSTS.** Conversion of propane into aromatic compounds (dehydrocyclodimerization) was studied at 530°C on a series of PtHZSM-5 catalysts with different platinum contents. For this reaction, occurring via propene, the product distribution and its change with the conversion rate were compared with those in the conversion of propene on HZSM-5. Large differences were observed; in particular, the selectivity for C<sub>6</sub>-C<sub>8</sub> aromatic products was greater on PtHZSM-5 than on HZSM-5 whereas the selectivity for C<sub>4</sub> and non-aromatic C<sub>5</sub> was lower. These differences can be explained by the significant increase in the aromatization rate of aliphatic C<sub>6</sub> intermediate, dehydrogenation on the platinum sites being faster than hydrogen transfer on the acid sites. (Edited author abstract) 20 refs.

Gnep, N.S. (CNRS, Poitiers, Fr); Doyemet, J.Y.; Seco, A.M.; Ribeiro, F. Ramao; Guisnet, M. *Appl Catal* v 35 n 1 Nov 16 1987 p 93-108.

**076504 FACTORS AFFECTING THE SELECTIVITY OF THE AROMATIZATION OF LIGHT ALKANES ON MODIFIED ZSM-5 CATALYSTS.** The conversion of light (C<sub>2</sub> to C<sub>4</sub>) alkanes to aromatics, chiefly benzene, toluene and xylenes (BTX), can be accomplished using zeolites of the ZSM-5 type. The conversion to aromatics is not completely selective. Light alkenes, the probable reaction intermediates, together with light alkanes, are formed in addition to the BTX components. On H-ZSM-5, all the hydrogen atoms lost on aromatization of the reactant alkane seem to appear in the products as light alkenes. It has been found that, when propane is used as the reactant at 500°C and 0.1 MPa, the BTX selectivity can be increased from ca. 10 percent (H-ZSM-5) to ca. 40 to 45 percent after treatment of the base zeolite with solutions of zinc or gallium nitrate, such that the final zinc or gallium content is ca. 1.0 mass-percent. (Edited author abstract). 15 Refs.

Surrell, M.S. (CSIR, Pretoria, S. Afr). *Appl Catal* v 41 n 1-2 Jul 15 1988 p 89-98.

**Production** See Also CARBON MONOXIDE—Hydrogenation; HYDROCARBONS—Cracking.

**076505 EXPERIENCE IN OPERATING COMMERCIAL UNITS FOR n-PARAFFIN PRODUCTION.** Analysis of the influence of operation of the principal equipment on the process indices in the recovery of liquid paraffins is of considerable practical interest. The operating efficiency of the units is evaluated on the basis of the coefficient of zeolite utilization. Statistical analysis of equipment operation in commercial units over an extended period showed that unplanned shutdowns were related to burnout of tubes in furnace convection chambers, failure of gears and the guide vanes of compressor impellers, leakage in the tube bundles of coolers and heat exchangers, and leakage in the fittings of valves used to switch the adsorbers. Approximately 60% of the shutdowns were caused by unsatisfactory operation of the compressors. 5 refs.

Kondrat'eva, G.A. (Groznyi Petroleum Scientific Research Inst, USSR); Borisova, L.V.; Pavlyk, I.L.; Shpachenko, V.A. *Chem Technol Fuels Oils* v 23 n 1-2 Jan-Feb 1987 p 12-14.

## Pyrolysis

**076506 MECHANISM OF PYROLYSIS OF n-ALKANES.** The mechanism of pyrolysis of the higher n-alkanes includes the reaction of isomerization of primary n-alkyl radicals to secondary alkyl radicals through a cyclic transition complex (CTC). The most probable path is isomerization through a six-membered CTC; however, isomerization through five- and seven-membered CTCs is also possible. The present work has been aimed at determining the distribution of primary and secondary

n-pentyl radicals formed in the stage of chain propagation and to test the possibility of isomerizing a primary n-pentyl radical R' to a secondary n-pentyl radical R'' through a five-membered CTC. In the pulse-feed experiments, the n-pentane conversion varied from 4 to 27% by weight. The product yields varied linearly with the conversion. 8 refs.

Rumyantsev, A.N. (Acad of Sciences of the USSR, USSR); Oganosova, E.Yu. *Chem Technol Fuels Oils* v 23 n 1-2 Jan-Feb 1987 p 85-88.

**076507 MECHANISM OF PYROLYSIS OF n-ALKANES. 3. n-HEXANE.** In spite of the large number of publications devoted to n-alkane pyrolysis, only in certain studies can there be found any reliable data on the composition of the pyrolysis products at low levels of conversion. In order to obtain comparable data, the authors investigated n-hexane pyrolysis. The purity of the original n-hexane was 99.97% by weight. The n-hexane-/argon ratio was approximately 1 ml/liter. The reactor temperature was held at 660°C. The products from n-hexane pyrolysis were analyzed. The main products from the pyrolysis were hydrogen, methane, ethane, ethylene, propylene, 1-butene, and 1-pentene. 9 refs.

Rumyantsev, A.N. (Acad of Sciences of the USSR, USSR); Oganosova, E.Yu. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 141-144.

**076508 THERMAL DECOMPOSITION OF 3-METHYLPENTANE AND n-HEXANE: REACTION MECHANISM AND CORRELATIONS BETWEEN STRUCTURE AND FORMATION OF LIGHT OLEFINS.** The pyrolysis of two C<sub>6</sub> alkanes, n-hexane and 3-methylpentane, was investigated in a conventional static apparatus at 420°C and 133 mbar, at low extents of reaction. The primary reaction products were identified and measured by gas chromatography and the corresponding stoichiometric equations were determined. Our experimental results are interpreted by a long-chain radical mechanism of the Rice-Herzfeld type, and clearly show the influence of the structure (linear- or branched-chain) on the yields of ethylene. They provide a useful basis for modelling the reaction at higher temperature. (Author abstract) 15 refs.

Malacarne, P. (CNRS, Nancy, Fr); Billaud, F.; Baronnet, F. *J Anal Appl Pyrolysis* v 12 n 3-4 Nov 1987 p 243-256.

**076509 SELECTIVITY OF INTERACTION OF HYDROGEN ATOMS WITH C-H BONDS AT PRIMARY AND SECONDARY CARBON ATOMS.** A study was made of the influence of H atom concentration on the initial distribution of primary and secondary radicals. Many investigators have noted that alkane pyrolysis is accelerated by the presence of hydrogen. For this investigation the authors selected n-pentane and n-hexane. The n-pentane had a purity of 99.98% by weight, the n-hexane 99.97%. As can be seen from the data the presence of a hydrogen medium in the pyrolysis of n-pentane or n-hexane increased the yield of ethane and reduced the yield of ethylene. This effect is explained by the large contribution from conversion of the ·C<sub>2</sub>H<sub>5</sub> radical to ethane in hydrogen medium in comparison with its decomposition to form ethylene. The total yield of ethane and ethylene is practically identical in the two cases. The data show that in the pyrolysis of n-pentane and n-hexane in a hydrogen medium, the H atom concentrations and the H·:·CH<sub>3</sub> ratios in the reaction zone are considerably higher, but the initial distribution of n-alkyl radicals remains the same as in the experiments with argon atmosphere. Consequently, under the conditions that have been studied, no difference can be observed in the interaction of the indicated radicals with C-H bonds. 11 refs.

Oganosova, E.Yu. (Acad of Sciences of the USSR, USSR); Rumyantsev, A.N. *Chem Technol Fuels Oils* v 23 n 7-8 Jul-Aug 1987 p 342-345.



**Radiation Effects** See Also ELECTRONS—Physical Properties; HYDROCARBONS—Radiation Effects.

**076510 MECHANISM OF SINGLET ENERGY TRANSFER FROM ALKANES.** By means of pulse radiolysis energy transfer from the first excited singlet of cyclohexane and C<sub>7</sub>- to C<sub>10</sub>-normal alkanes to benzene as solute was studied. For this solute the reaction probability of singlet energy transfer is expected to be one. If this condition is fulfilled, from the reaction radii measured conclusions can be drawn on the mechanism of singlet transfer. Using known diffusion coefficients reaction radii R was determined which are close to the sum of molecular radii. From a comparison with Foerster radii and the Stokes-Einstein relationship it is concluded that the energy transfer from the singlet states of the alkanes investigated to benzene as solute proceeds by collisional interaction. (Author abstract) 10 refs.

Mehnert, R. (Acad of Sciences of the GDR, Leipzig, East Ger); Brede, O.; Naumann, W.; Hermann, R. *Radiat Phys Chem* v 32 n 3 1988 p 325-328.

## Recovery

**076511 RECOVERY OF OXIDATION QUALITY PARAFFINS FROM GAS OIL: AN EXPERIMENTAL INVESTIGATION.** A two-step process was developed to recover from gas oil purified paraffin wax of suitable carbon chain length for further oxidation to synthetic fatty acids. The process consists of (i) chilling the gas oil to 18°C and separating solidified wax by centrifugal filtration; and (ii) mechanical pressing of the paraffin-enriched fraction to expel the oil and enrich paraffin purity to greater than 90%. The mechanical pressing operation was studied in various pilot scale equipment in order to quantify the effect of operating pressure, cake thickness and retention time, on the quality of wax. The quality was also compared against that of wax obtained by solvent purification. Paraffin wax of the quality suitable as a feed stock for oxidation to fatty acids was obtained. (Author abstract) 5 refs.

Kulkarni, S.M. (Hindustan Lever Research Cent, Bombay, India); Chandrasekaran, K.; Gandhi, A.N. *Indian J Technol* v 25 n 12 Dec 1987 p 607-612.

**076512 PRODUCTION OF HIGH-PURITY PARAFFINS FROM LUBE DISTILLATES.** Laboratory studies have shown that the washing of the adduct in three-stage countercurrent scheme does not always give paraffins with contents of aromatic hydrocarbons no higher than 0.5% by weight. This investigation is aimed at working out conditions for washing the adduct so as to minimize the consumption of washing agent and maximize the purity of the paraffin product. In selecting optimal dewaxing conditions, two goals were set: maximum recovery of paraffins and the production of either a low-pour transformer oil or a component of low-pour oils. It is shown that with countercurrent washing of the adduct in three stages and with a 150% total quantity of solvent, the paraffin contained 0.71% aromatic hydrocarbons. With portion-countercurrent washing in three stages with a 100% total quantity of solvent, the paraffin product contained 0.5% aromatic hydrocarbons; this operation is more economical, and it makes it possible to obtain high-purity paraffins from lube cuts in existing process units without any great amount of reconstruction. The paraffin product obtained can be used in surfactant production. 3 refs.

Abdullaev, E.Sh. (Acad of Sciences of the Azerbaidzhan SSR, USSR); Gadzhiev, A.Sh.; Balayan, R.D.; Novruzov, F.N. *Chem Technol Fuels Oils* v 23 n 7-8 Jul-Aug 1987 p 323-325.

**076513 STABILITY OF ADSORBENT IN RECOVERY OF LIQUID PARAFFINS.** Since engineering calculations of the adsorption process require values of the capacity of the adsorbent for the mixture of n-alkanes contained in the actual feedstocks, the author compared data on the capacity of the MgA adsorbent for n-C<sub>7</sub> with the corresponding values for a mixture of n-alkanes recovered from a 200-320°C cut in a laboratory unit at

400°C with an n-alkane partial pressure of 250 MPa. These studies, which were performed with an accuracy that is adequate for practical purposes, offer a means for determining the adsorbent capacity for the mixture of n-alkanes (α<sub>n</sub>), using x-ray structure analysis data or values of the adsorption capacity for n-heptane. In order to determine the service properties of an adsorbent, it is necessary to know both the adsorption characteristics of the fresh adsorbent and its adsorption isotherms taken during a period of extended operation, modeled by pilot-plant tests. We have tested various modifications of the MgA adsorbent in a pilot unit under steady-state conditions in the stages of adsorption, desorption, and regeneration. As can be seen from these results, satisfactory agreement is obtained between experimental and calculated data on the change in adsorbent capacity. Therefore, the equation derived by the author can be used to predict the level of stable activity of an adsorbent, depending on the operating conditions of the process unit. 6 refs.

Votlokhin, Yu.Z. (Groznyi Petroleum Scientific-Research Inst, USSR). *Chem Technol Fuels Oils* v 23 n 7-8 Jul-Aug 1987 p 326-328.

**076514 RECOVERY OF n-PARAFFINS FROM PETROLEUM FRACTIONS.** The riser adsorption of n-paraffins in a moving stream of adsorbent was investigated. Two diesel fuel cuts were used as feedstocks in these studies: a 180-290°C cut from Stavropol crude and a 200-310°C cut from West Siberian crude, with respective n-paraffin contents of 35% and 15.2% by weight. Experimental data indicate that the riser adsorption process gives n-paraffins with a higher purity. An increase in the partial pressure of n-paraffins also has a greater favorable effect in the riser adsorption. The results of these studies demonstrate the advisability of developing commercial adsorption units for recovery of n-paraffins from petroleum cuts using transfer lines (risers) as reactors. 7 refs.

Votlokhin, Yu.Z. (Groznyi Petroleum Scientific-Research Inst, USSR); Remova, M.M. *Chem Technol Fuels Oils* v 23 n 7-8 Jul-Aug 1987 p 376-378.

## Reforming

**076515 MECHANISM OF DEHYDROCYCLIZATION OF n-ALKANES OVER PLATINUM-ALUMINA CATALYSTS.** In order to examine whether the metal function or the acid function is 'critical' for the reforming reaction, the dehydrocyclization of n-hexane, n-heptane and n-octane was carried out over acidic and non acidic platinum-alumina catalysts. It is concluded that the metal function is the 'critical' parameter with the C<sub>6</sub> and C<sub>7</sub> alkanes whereas both the metal and acid could be important with n-octane. (Author abstract) 6 refs.

Sivasanker, S. (Nat'l Chemical Lab, Pune, India); Padalkar, S.R. *Appl Catal* v 39 n 1-2 May 16 1988 p 123-126.

**Sedimentation** See NATURAL GAS—Purification.

**Solubility** See Also HYDROCARBONS—Phase Equilibria; KETONES—Phase Equilibria; OLEFINS—Solubility.

**076516 SOLUBILITY OF CYCLOPARAFFINS IN DISTILLED WATER AND SALT WATER.** Solubilities of cyclopentane, cyclohexane, methylcyclohexane, and cycloheptane were measured in distilled water and salt water (34.5 parts of NaCl per thousand parts of water). The salt water solubilities were correlated by the polar solubility parameter method. A method for predicting salt water solubility from known distilled water solubility was developed. (Author abstract) 7 refs.

Groves, Frank R. Jr. (Louisiana State Univ, Baton Rouge, LA, USA). *J Chem Eng Data* v 33 n 2 Apr 1988 p 136-138.

**Solutions** See Also HYDROCARBONS—Isomerization; SOLUTIONS—Thermodynamic Properties.

**076517 THERMAL PROPERTIES OF n-HEXADECANE SOLUBILIZED IN AN AQUEOUS LAMELLAR LIQUID CRYSTAL.** The aqueous lamellar phase of the nonionic surfactant n-dodecyl tetraoxyethyl-

lene glycol ether solubilizes n-hexadecane to the extent of ca. 55% w/w. Measurements of the enthalpy of fusion, H<sub>f</sub>, of the solubilized oil indicate it to exist in two identifiably different thermal states. One state is characterized by an H<sub>f</sub> of ca. 18 cal/g and the other by a value of 56.3 cal/g consistent with that of the isotropic liquid oil. Fractions of each component derived from the thermal measurements are shown to be consistent with those derived from the observed order parameters of the solubilized oil. (Author abstract) 14 refs.

O'Neill, Kilian (Univ Coll, Dublin, Ire); Ward, Anthony J.I. *Langmuir* v 4 n 1 Jan-Feb 1988 p 236-238.

**076518 MOLECULAR SELF-DIFFUSION IN N-ALKANE-BRINE MIXTURES WITH SMALL ETHOXYLATED ALCOHOLS.** Pulsed-field gradient NMR was used to examine translational self-diffusion of the components of solutions of monoethylene glycol n-butyl ether, brine (NaCl 0.2 M), and decane and of diethylene glycol n-hexyl ether, brine (NaCl 0.2 M), and dodecane. Recent studies of these mixtures revealed association behavior and the presence of fluid microstructures similar to those in micellar solutions and microemulsions. However, our results distinguish these mixtures from microemulsions. The time-average diffusion coefficients measured in the mixtures indicate that each component diffuses molecularly, implying either a very short lifetime or a small population of any microstructures present. Viscosities are reported for all of the mixtures. (Author abstract) 27 refs.

Bodet, Jean-Francois (Univ of Minnesota, Minneapolis, MN, USA); Davis, H. Ted; Scriven, L.E.; Miller, Wilmer G. *Langmuir* v 4 n 2 Mar-Apr 1988, Mol Process at Solid Surf: Spectrosc of Intermed and Adsorbate Interact, Denver, CO, USA, Apr 6-8, 1987 p 455-458.

**Specific Heat** See SPECIFIC HEAT—Estimation.

**Structure** See Also OLIGOMERS—Synthesis.

**076519 ISOPRENANES OF T-SHAPED STRUCTURE.** This work concentrates mainly on the C<sub>25</sub> isoprenolene-(II) first found in fairly high concentrations (approximately 1%) in crude oils. GC/MS was used to confirm the presence in crude oils of 2,6,10,14-tetramethyl-7-[3-methylpentyl] nonadecane. This hydrocarbon has a 'T-shaped' structure and is present in usually high concentration (1%). 4 refs.

Vorob'yeva, N.S. (Acad of Sciences of the USSR, USSR); Zemskova, Z.K.; Petrov, A.I.A. *Pet Chem USSR* v 26 n 3 1986 p 158-162.

## Thermal Conductivity

**076520 THERMAL CONDUCTIVITY OF n-HEXANE, n-HEPTANE, AND n-DECANE BY THE TRANSIENT HOT-WIRE METHOD.** New absolute measurements of the thermal conductivity of liquid n-hexane, n-heptane, and n-decane are reported. The measurements have been carried out in the temperature range 300-370 K at atmospheric pressure in a transient hotwire instrument. The accuracy of the measurements is estimated to be ±0.5%. The density dependence of the thermal conductivity of n-hexane and n-heptane is found to be well described by a universal equation for the hydrocarbons based on a rough hard-sphere model. The measurements of the three hydrocarbons studied are also employed to generate more accurate effective core volumes, which are the only parameters characteristic of the fluid required for the application of the proposed universal scheme. (Author abstract) 22 refs.

Assael, M.J. (Aristotle Univ of Thessaloniki, Thessaloniki, Greece); Charitidou, E.; Nieto de Castro, C.A.; Wakeham, W.A. *Int J Thermophys* v 8 n 6 Nov 1987 p 663-670.

**Thermodynamic Properties** See Also MIXTURES—Thermodynamic Properties; ORGANIC COMPOUNDS—Thermodynamic Properties.



**076521 VOLUMES OF MIXING OF DECANE ISOMERS WITH NORMAL HEXADECANE AT 298.15 K. AN INTERPRETATION IN TERMS OF THE VAN-PATTERSON THEORY.** Excess molar volumes of 2-methylnonane +, 3-methylnonane +, 4-methylnonane +, and 2,6-dimethyloctane + normal hexadecane at 298.15 K were obtained from precise density measurements. Values of  $V_E^m$  are negative over the whole mole-fraction range and vary slightly with the decane isomers within a series. A reasonable agreement was found between the experimental excess molar volumes and that predicted from the Van-Patterson theory. (Author abstract) 7 refs.

Awad, Akl M. (Petroleum Research Cent, Baghdad, Iraq); Hassan, Fatin A.; Salman, Muna A. *Fluid Phase Equilib* v 38 n 3 Dec 1987 p 291-298.

**076522 CRITICAL CONSTANTS OF NORMAL ALKANES FROM METHANE TO POLYETHYLENE.** If we are to predict the properties of heavy liquids with corresponding-states correlations based on critical constants, we will need to extrapolate available data for lighter liquids to higher carbon numbers. Such extrapolations are possible, at least empirically, because critical constants apparently approach limiting values as the carbon number goes to infinity. These limits are investigated for normal alkanes. Experimental data are given for the critical temperature, pressure, and density. Although it is generally accepted that we know the most about the critical temperature and the least about the critical density, the discussion shows that it is the limiting value of the critical density that we know with the most certainty. 19 refs.

Tsonopoulos, C. (Exxon Research & Engineering Co, Florham Park, NJ, USA). *AIChE J* v 33 n 12 Dec 1987 p 2080-2083.

**076523 EXCESS VOLUMES OF (n-NONANE + n-UNDECANE) BETWEEN 288.15 AND 308.15 K.** Excess molar volumes of (n-nonane + n-undecane) have been determined from density measurements at 288.15, 293.15, 298.15, 303.15, and 308.15 K. Density was obtained with an Anton Paar densimeter. The molar volumes of (n-nonane + n-undecane), (n-octane + n-undecane), and (n-heptane + n-undecane) are given as functions of temperature and the mole fraction of n-undecane. For each of these three binary mixtures, the coefficient of thermal expansion is plotted against the mole fraction of n-undecane at three temperatures. (Author abstract) 7 refs.

Garcia, Manuel (Univ de Santiago, Santiago de Compostela, Spain); Rey, Carlos; Villar, Vicente P.; Rodriguez, Julio R. *J Chem Eng Data* v 33 n 1 Jan 1988 p 46-48.

**076524 COMPARATIVE STUDY OF THERMODYNAMIC PROPERTIES AND MOLECULAR INTERACTIONS IN MONO- AND POLYCHLOROALKANE + n-ALKANE OR + CYCLOHEXANE MIXTURES.** The data available in the literature on the excess Gibbs energies,  $G^E$ , activity coefficients at infinite dilution,  $\gamma_i^\infty$ , excess enthalpies,  $H^E$ , and excess heat capacities,  $C_p^E$ , for 10 classes of mono- or polychloroalkanes + n-alkanes or + cyclohexane are examined on the basis of the DISQUAC group-contribution model. The non-polar  $CCl_4$ -containing mixtures can be treated in the zeroth approximation of the model. The dispersive interaction parameters for  $CCl_4$  + n-alkanes, or + cyclohexane, are used to describe the dispersive term for polar chloroalkanes + alkanes. The quasicheical parameters for polar chloroalkanes of the series  $CH_3(CH_2)_m-2CCl_uH_{3-u}$  are the same for n-alkane and cyclohexane mixtures, and decrease regularly with increasing u. The model describes consistently the excess functions for the investigated mixtures. Literature data are critically evaluated. The parameters provided may serve to accurately predict missing quantities. Systematic discrepancies between theory and experiment are noted in mixtures containing long-chain molecules, particularly for  $H^E$  and  $\gamma_i^\infty$ . The calculated  $C_p^E$  curves differ considerably from experimental data. Possible sources of disagreement and ways of

refining the model are discussed. (Edited author abstract) 158 refs.

Kehiaian, Henry V. (CNRS, Paris, Fr); Marongiu, Bruno. *Fluid Phase Equilib* v 40 n 1-2 Apr 1988 p 23-78.

**076525 PREDICTION OF THERMAL PRESSURE COEFFICIENTS AND INTERNAL PRESSURES FOR NORMAL ALKANES.** Based on the modified van der Waals model, a method for prediction of thermal pressure coefficients and internal pressures for normal alkanes with carbon number 1-36 at various temperatures is established in this paper. It shows that the maximum discrepancy between the calculated and the experimental values is about  $\pm 0.8$  percent for thermal pressure coefficients of normal alkanes at 20°C. Differed from the liquids formed by general small molecules, the value  $B/A^2$  of normal alkanes is not a constant. There is an obvious turning point at carbon number 9. When the carbon number is more than 9, the value  $B/A^2$  decreases remarkably with the increase of carbon chain. (Author abstract). 13 Refs. In Chinese.

Liu, Guojie; He, Wangxing. *Huadong Huagong Xueyuan Xuebao* v 14 n 3 1988 p 321-328.

**Viscosity** See DIFFUSION—Measurements; FLUIDS—Viscosity; HYDROCARBONS—Viscosity.

**PARKS** See HIGHWAY SYSTEMS—Roadside Improvement; HIGHWAY SYSTEMS—Roadside Improvement; RESERVOIRS—Recreational Facilities; REGIONAL PLANNING—Recreational Facilities; RECREATION CENTERS—Welding.

**PARTICLE BEAM TRACKING** See Also CHARGED PARTICLES—Scattering; ELECTRONIC CIRCUITS, TRIGGER; GLASS—Radiation Effects; LIGHT—Spectrum Analysis; MICA—Etching; PARTICLE DETECTORS; PARTICLE DETECTORS—Design; PARTICLE DETECTORS—Performance; PHYSICS—High Energy; PLASTICS—Radiation Effects; RADIATION DETECTORS; SCINTILLATION COUNTERS; SIGNAL FILTERING AND PREDICTION—Kalman Filtering; SIGNAL PROCESSING.

**076526 ELECTROSTATIC IMAGING OF CHARGES LIBERATED IN DIELECTRIC LIQUIDS BY IONIZING RADIATION.** The charge liberated by beta particles in a liquid argon-methane mixture has been collected on a mylar film and the image developed with a technique similar to electrophotography. The image of the beta-emitting lines on a chromatographic gel have also been produced in this way. (Author abstract) 3 refs.

Charpak, G. (CERN-EP, Geneva, Switz); Anderson, D.F.; Kross, B.J. *Nucl Instrum Methods Phys Res Sect A* v A260 n 2-3 Oct 15 1987 p 365-367.

**076527 TRACK FITTING IN THE OPAL VERTEX DETECTOR WITH STEREO WIRES.** The geometry of the vertex chamber for the OPAL detector at LEP is reviewed and expressions for the coordinates of the hits are given in terms of the measured drift distance and z-coordinate. The tracks are fitted by a procedure based on the Lagrange multipliers method. The increase in the accuracy of the fit due to the use of the stereo wires is discussed. (Author abstract) 4 refs.

Shally, R. (Carleton Univ, Ottawa, Ont, Can); McPherson, A.C.; Hemingway, R.J. *Nucl Instrum Methods Phys Res Sect A* v A260 n 1 Oct 1 1987 p 132-141.

**076528 COMBINED SCINTILLATION AND TRACK TECHNIQUE TO SEARCH FOR  $\beta\beta$ -DECAY.** Double beta decay is one of the most powerful ways to test conservation of lepton number. A scintillation spectrometer with wire chambers for the search for  $\beta\beta$ -decay is considered. The time-of-flight technique for the background suppression is proposed. (Edited author abstract) 6 refs.

Akimov, Yu.K. (Joint Inst for Nuclear Research, Dubna, USSR). *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 539-540.

**076529 TRACK RECONSTRUCTION WITH THE TRISTAN-TOPAZ TPC.** A new track finding algorithm

fully utilizing 3-dimensional coordinate measurements like those of TPC-type detectors is described in detail. Based on this algorithm, a track reconstruction program has been developed for the TRISTAN-TOPAZ TPC. The program was applied to Monte Carlo multihadron events, resulting in a quick and efficient tracking for both primary and secondary tracks. (Author abstract) 5 refs.

Fujii, Keisuke (Natl Lab for High Energy Physics, Tsukuba, Jpn); Kawabata, Setsuya; Miyamoto, Akiya; Ochiai, Fumio. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 297-304.

**076530 STUDY OF HEAVY ION TRACKS IN PHOSPHATE GLASS DETECTORS.** Samples of phosphate glass detectors have been exposed vertically to  $^{28}\text{Si}$  (6.4 MeV/N),  $^{40}\text{Ar}$  (5.5, 3.75 and 2.55 MeV/N),  $^{56}\text{Fe}$  (6.4 MeV/N),  $^{59}\text{Ni}$  (6.5 MeV/N),  $^{84}\text{Kr}$  (0.9 MeV/N) and  $^{132}\text{Xe}$  (0.9 MeV/N) ions from heavy ion accelerators at the Joint Institute of Nuclear Research (JINR), Dubna (Moscow), U.S.S.R. The exposed samples have been etched in 40 vol% HF and also in NaOH solution of varying concentrations (1-6 N) at 40°C for different etching times. Track diameter variations against the dissolved detector thickness have been studied. The total etchable track length for these heavy ions in this detector has been determined experimentally. The energy loss rate and the range of the heavy ions in this detector have also been computed theoretically. Comparing the total etchable track length with the theoretical range, the critical threshold for etchable track formation has been determined. (Author abstract) 9 refs.

Garg, A.K. (Kurukshetra Univ, Kurukshetra, India); Shyam Kumar; Sharma, A.P. *Appl Radiat Isot* v 39 n 2 1988 p 109-111.

**076531 EFFICIENCY OF BILLOIR'S TRACK FITTING METHOD FOR THE OPAL CENTRAL DETECTOR.** The OPAL central detector consists of three concentric drift chamber systems designed to measure accurately tracks of charged particles. As a particle moves outwards from the interaction point, it first encounters the Vertex chamber having 19 anodes, then the main Jet chamber with 159 anodes and finally the Zed chamber with 6 anodes. This article discusses how track fitting in the OPAL central detector can be improved at low energies with a recursive method due to Billoir, which accounts for multiple scattering. 4 refs.

Savard, D. (Univ de Montreal, Montreal, Can); Lorazo, B.; Jeremie, H. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 278-280.

**076532 COMPUTER BASED COORDINATE MEASURING STATION FOR NUCLEAR EMULSION CHAMBERS.** We describe a computer based coordinate measuring station designed for measuring high multiplicity events recorded in vertically exposed nuclear emulsion chamber. This setup has a very good angular resolution, especially in the forward region. The hardware is essentially built up with commercially available equipment, but the special software developed makes the system very efficient. We also describe the track fitting technique and the full event reconstruction. (Author abstract) 3 refs.

Garpman, Sten (Univ of Lund, Lund, Swed); Otterlund, Ingvar; Persson, Stefan; Soderstrom, Kaj. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 134-141.

**076533 FROM BUBBLE CHAMBERS TO SCINTILLATING FIBRES: HIGH RESOLUTION PARTICLE TRACKING FOR MICROVERTEX DETECTION.** The problem of high resolution high rate detection of multivertex events associated with heavy flavor production and decay is central to the future physics program both in high energy high statistics fixed target studies, and in the collider detectors. Existing detectors such as silicon microstrip systems, CCDs, etc., are capable of high rate and high precision however they give only one point per track for each plane of the detector with the consequent



large 'overhead' associated with the readout. We therefore consider the alternative of a high resolution high rate triggerable track detector giving 'bubble chamber' quality information with a single plane digital readout. (Edited author abstract) 4 refs.

Fisher, C. (CERN). *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 159-162.

## Electronic Equipment

**076534 FAST HARDWARE TRACK-FINDER FOR THE CDF CENTRAL TRACKING CHAMBER.** We describe the design, construction, and preliminary operation of a hardware track-finder used in the trigger for the Collider Detector at Fermilab (CDF). The track-finder is a 19 stage digital pipeline which uses fast timing information from the central tracking chamber (CTC) to find high momentum tracks. It then transmits information about the track to the CDF trigger system or a final decision. The track finder has 8 programmable thresholds between 2.5 and 15 GeV. A search for all high momentum tracks in the central tracking chamber can be completed in an average of 2.5  $\mu$ s per event. The momentum resolution is  $\delta P_T/P_T^2 = 3.5\%$ , with a high efficiency that is independent of track density. (Author abstract) 5 refs.

Foster, G.W. (Fermi Natl Accelerator Lab, Batavia, IL, USA); Freeman, J.; Newman-Holmes, C.; Patrick, J. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 93-100.

## Equipment See RADIATION COUNTERS.

## Imaging Techniques

**076535 TRACK RECOGNITION IN DIGITIZED STREAMER CHAMBER PICTURES.** A method for recognizing particle tracks in photographic streamer chamber pictures was developed. The pictures were digitized by a high-resolution CCD camera and processed by a computer. After filtering track recognition was carried out in two steps: a 'local' detection of straight track pieces in small sections of the image, followed by a 'global' recognition of the complete track. All tracks were assumed to originate in a single, known interaction point and to be of circular shape. The procedure is demonstrated by means of streamer chamber data for high-energy nucleus-nucleus collisions obtained in the CERN experiment NA35. (Author abstract) 6 refs.

Puhlhofer, F. (Univ Marburg, Marburg, West Ger); Rohrich, D.; Keidel, R. *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 360-367.

## Instruments See PARTICLE DETECTORS.

**Materials** See PARTICLE DETECTORS—Performance; POLYMERS—Radiation Effects.

## Theory

**076536 SUBMICROSCOPIC TRACK KINETIC THEORY AND THE VARIATIONAL PRINCIPLE.** The variational principle was used to obtain the general equations for chemical etching track profiles inside and outside the physical damage region produced by energetic ions in Makrofol E. The track profiles developed at very short etching times were used to obtain the velocity profiles in order to perform computer determinations of track profiles for longer etching times. Track profiles obtained by means of the variational principle and the submicroscopic track kinetic theory are in good agreement, and compare favorably with experimental results. (Author abstract) 9 refs.

Mazzei, R. (CNEA, Buenos Aires, Argent); Grasso, J.C.; Bernaola, O.A.; Bourdin, J.C.; Saint Martin, G. *Nucl Instrum Methods Phys Res Sect B* v B34 n 1 Jul 1988 p 74-80.

**PARTICLE BEAMS** See Also ACCELERATORS—Beam Dynamics; ACCELERATORS—Magnets; ACCELERATORS—Retrofitting; ACCELERATORS—Testing; ACCELERATORS, SYNCHROTRON; CALORIMETERS; CHARGED PARTICLES; ELECTROMAGNETIC FIELDS—Mathematical Models; ION SOURCES; MICROANALYSIS—Instruments; PLASMAS—Density.

**076537 VARIABLE-ENERGY POSITRON BEAM FOR LOW TO MEDIUM ENERGY RESEARCH.** A positron beam facility is described which provides a monoenergetic beam ( $\pm 1$  eV) which is variable in energy from a few eV up to a maximum of approximately 80 keV. The positron moderation process, beam transport, and design of the target chamber are discussed in detail. Some of the research being done with the facility is summarized, including scattering and energy-loss measurements, near-surface defect profiling studies, and low energy positron channeling studies. An ultrahigh-vacuum 2-axis goniometer is described, which is used in the channeling work. (Author abstract) 27 refs.

Schultz, Peter J. (Univ of Western Ontario, London, Ont, Can). *Nucl Instrum Methods Phys Res Sect B* v B30 n 1 Feb 1988 p 94-104.

**076538 PHYSICS DESIGN OF THE DEFLECTION MAGNETS OF THE JET NEUTRAL BEAM INJECTOR.** This paper presents the ion optical calculations for the deflection magnets of the JET neutral injection system. The large amount of ion power to be handled (26 MW) requires more accurate calculations than before. These include 3D magnetic field computations, raytracing and emittance calculations, the latter applied to a multiple aperture ion beam. The resulting power deposition profiles for the full energy ions (80 keV hydrogen, 160 keV deuterium) and for the fractional energy ions are reported. (Author abstract) 15 refs.

Goede, A.P.H. (JET Joint Undertaking, Abingdon, Engl); Nielsen, B.R.; Thompson, E. *Nucl Instrum Methods Phys Res Sect A* v A267 n 1 Apr 15 1988 p 193-202.

**076539 DIFFUSION FROM AN ENTRANCE TO AN EXIT.** Asymptotic and exact solutions are derived from first principles by various methods for the moments of the number of steps or traversal time, etc., of a particle which diffuses, most specifically on a linear chain, to an exit site without previously leaving via an entrance site. The presentation is expository and uses standard methods. (Author abstract)

Fisher, Michael E. *IBM J Res Dev* v 32 n 1 Jan 1988 p 76-81.

**076540 SCATTERING OF A GAUSSIAN BEAM BY A SPHERE USING A BROMWICH FORMULATION: CASE OF AN ARBITRARY LOCATION.** A complete theory of Gaussian beam scattering by a sphere is exposed. It is a generalization of the Lorenz-Mie theory to the case of Gaussian beam illumination. The spherical, isotropic and homogeneous scatterer may be located anywhere with respect to the beam. The Bromwich Scalar Potentials are used to solve the scattering problem and expressions are obtained for the scattered field (both in the near field and far field regions), the scattered intensities and the phase angle. In the limit of special cases the expressions agree with previous works restricted to more particular problems. (Author abstract) 18 refs.

Gouesbet, Gerard (INSA, Rouen, Fr); Maheu, Bruno; Grehan, Gerard. *Part Part Syst Charact* v 5 n 1 Mar 1988 p 1-8.

## Analysis

**076541 SYNTHESIS OF EXTENDED RELATIVISTIC BEAMS USING ANTIPARAXIAL EXPANSIONS.** High-order antiparaxial approximations are constructed for space-charge limited emission and for arbitrary conditions of injection on a curvilinear starting surface in the case of two-dimensional relativistic beams taking into account the intrinsic magnetic field. It is shown that extended high-perveance beams can be synthesized with an accuracy acceptable for practical applica-

tions, by joining the near-cathode asymptotic forms with the regular solution in successive strips. (Author abstract) 11 refs.

Syrovoy, V.A.; Shanturin, L.P. *Sov J Commun Technol Electron* v 32 n 9 Sep 1987 p 145-157.

## Applications

**076542 APPLICATIONS OF NEUTRAL BEAM AND RF TECHNOLOGIES.** This presentation provides an update on the applications of neutral beams and radio-frequency (RF) power in the fusion program: highlights of the ion cyclotron heating (ICH) experiments now in progress as well as the neutral beam experiments; and heating requirements of future devices and some of the available options. Some remarks on current drive are presented because this area of technology is one that is being considered for future devices. Several collaborations that are of critical importance to the program are involved in these technologies. These key areas are identified as the presentation proceeds.

Haselton, Hal H. (Oak Ridge Natl Lab, Oak Ridge, TN, USA). *J Fusion Energy* v 6 n 4 Dec 1987 p 345-350.

## Computer Aided Analysis

**076543 CONTROL AND DATA ACQUISITION SYSTEM FOR USE IN RELATIVISTIC NEUTRAL HYDROGEN BEAM STUDIES.** An experimental facility consisting of both hardware and software is described that has been assembled for use in studies with 10 to 50-MeV  $H^0$  beams. Based on CAMAC/MBD hardware, the system controls an optical monochromator, monitors the  $H^0$  beam, logs data, and performs preliminary analysis of the results. The system has been successfully adapted to use in other experiments that require similar monitor and control functions. 7 refs.

Anderson, James R. (Univ of Manitoba, Winnipeg, Manit, Can); Durocher, J.J.G.; Smith, G.R.; James, D.R. *IEEE Trans Nucl Sci* v NS-34 n 4 Aug 1987, Fifth Conf on Real-Time Comput Appl in Nucl, Part and Plasma Phys, San Francisco, CA, USA, May 12-14 1987 p 810-815.

**076544 NEUTRAL PARTICLE BEAM DISTRIBUTED DATA ACQUISITION SYSTEM.** A distributed data acquisition system designed to support experiments at the Argonne Neutral Particle Beam Accelerator is described. The system uses a host VAXstation II/GPX computer acting as an experimenter's station and linked via Ethernet with multiple MicroVAX IIs and rtVAXs dedicated to acquiring data and controlling hardware at remote sites. The hardware design of the system, the applications-support software on the host and target computers, and the real-time performance are discussed. 4 refs.

Daly, Robert T. (Argonne Natl Lab, IL, USA); Kraimer, M.R.; Novick, A.H. *IEEE Trans Nucl Sci* v NS-34 n 4 Aug 1987, Fifth Conf on Real-Time Comput Appl in Nucl, Part and Plasma Phys, San Francisco, CA, USA, May 12-14 1987 p 816-821.

## Control See ACCELERATORS.

## Energy Dissipation

**076545 IONIZATION LOSS IN BGO.** We report on a precise measurement of the energy loss through ionization by pions in bismuth germanate performed at several values of the incident particles momentum with a prototype of the 1.3 electromagnetic calorimeter. The experimental results are in good agreement with theoretical predictions showing the relativistic rise modified by density effect. (Author abstract) 10 refs.

Bakken, J.A. (RWTH, Aachen, West Ger); Barone, L.; Blaising, J.J.; Boehringer, T.; Borgia, B.; Boutigny, D.; Burq, J.P.; Chemarin, M.; Clare, R.; Coignet, G.; Denes, P.; Diemoz, M.; Dionisi, C.; Elmamouni, H.; Extermann, P.; Falciano, S. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 397-402.



**Focusing** See Also MAGNETIC LENSES—Design; MAGNETS—Applications; PARTICLE OPTICS.

**076546 FOCUSING OF SYNCHROTRON RADIATION.** Focusing of the synchrotron radiation from a storage ring using a convex lens is geometrically analyzed and tested. The source radiation is supposed to have a bivariate normal distribution in its phase space both vertically and horizontally. Its modification caused by a lens is calculated as a function of distances among the source, the lens and the image plane. It is shown that the horizontal image becomes sharpest when the source is focused on the image plane. The vertical image, however, is not sharpest under this condition. The vertical distribution has more information than the horizontal; we can derive the orbit dependence of the vertical profile and the angle distribution of the radiation changing focusing. (Author abstract) 9 refs.

Ogata, Atsushi (Nat'l Lab for Higher Energy Physics, Tsukuba-gun, Jpn). *Nucl Instrum Methods Phys Res Sect A* v A259 n 3 Sep 15 1987 p 566-575.

## Imaging Techniques

**076547 MULTIPLE PENCIL BEAMS FOR PROTON COMPUTED TOMOGRAPHY.** A device for generating and scanning multiple pencil beams has been designed and constructed for proton computed tomography (CT). The device was used to perform proton CT and was found to work well. (Edited author abstract) 13 refs.

Takada, Yoshihisa (Univ of Tsukuba, Sakura-mura, Jpn); Abe, Isao. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 511-521.

**Magnetic Field Effects** See PARTICLE OPTICS; PLASMAS—Switching.

## Mathematical Models

**076548 RELATIVE STABILITY IN NONUNIFORM TEMPERATURE.** Landauer has suggested that the relative stability of a particle diffusing in a bistable potential is affected by an intervening hot layer. We derive this effect both from thermodynamics and from the diffusion equation. For this purpose the proper form of the diffusion equation in a nonuniform medium is established for the case of a Brownian particle. If the diffusion takes place in a ring, the hot layer creates a steady current. (Author abstract) 8 refs.

van Kampen, N.G. *IBM J Res Dev* v 32 n 1 Jan 1988 p 107-111.

**076549 BOUNDARY-LAYER THEORY FOR THE EXTREMELY UNDERDAMPED BROWNIAN MOTION IN A METASTABLE POTENTIAL.** A theory for the boundary layer near the critical trajectory for the extremely underdamped Brownian motion in a metastable potential is presented. The probability distribution function in phase space near this critical trajectory, the average escape energy, and the correction terms for the zero-friction-limit escape rate are calculated. (Author abstract) 26 refs.

Risken, H.; Vogel, K.; Vollmer, H.D. *IBM J Res Dev* v 32 n 1 Jan 1988 p 112-118.

**076550 PARTICLE SIMULATION OF A HIGH-POWER GYROTRON OSCILLATOR.** A self-consistent and time-dependent particle code has been developed to simulate the beam-wave dynamics in a gyrotron oscillator. The code is first applied to investigate the effect of the self-consistent field profile on the scaling of the cavity-filling rate with beam current. The fixed-field theory predicts that the transient-wave growth rate depends linearly on the beam current. The simulation results agree with the theoretical prediction at low beam currents. As the beam current increases, the modified field profile changes the nature of the gain scaling from linear to nonlinear. At higher beam currents, the excited wave is observed to exhibit the behavior of modulated oscillation, due to unequal couplings to the forward- and backward-going waves by the beam. Associated with such

amplitude modulation is a periodic variation of the self-consistent field profile. At still higher beam currents, the system becomes chaotic, showing the effect of period doubling. Simulation results are presented for the efficiency, the self-consistent field profile, and the scaling of the transient growth rate with the beam current. 10 refs.

Lin, A.T. (Univ of California, Los Angeles, CA, USA); Yang, Z.H.; Chu, K.R. *IEEE Trans Plasma Sci* v 16 n 2 Apr 1988 p 129-134.

**Measurements** See Also ACCELERATORS—Beam Dynamics; GASES, INERT—Scintillation; PARTICLE DETECTORS—Electronic Equipment; PARTICLE DETECTORS—Instruments; PARTICLE DETECTORS—Temperature Effects; SCINTILLATION COUNTERS.

**076551 TUNNELING TIMES AND A QUANTUM CLOCK.** The problem of measuring tunneling times by means of a quantum clock is found to lead to difficulties which are thought to arise because the Hamiltonian of the coupled system does not separate into particle and clock parts. (Author abstract) 7 refs.

Foden, C.; Stevens, K.W.H. *IBM J Res Dev* v 32 n 1 Jan 1988 p 99-102.

**076552 MEASUREMENT OF PARTICLES AND VAPOR-DENSITY AFTER HIGH-CURRENT VACUUM-ARCS BY LASER TECHNIQUES.** A laser-shadow technique with high time resolution is applied to study the erosion of high-current Cu vacuum arcs in situ. Cathodic processes lead to emission of high-velocity droplets shortly before and after current zero. Increasing movements of the anodic melt produce large droplets several milliseconds after the arc. The many particles generated are responsible for the slow decay of vapor, as measured by laser-induced fluorescence. Densities greater than  $10^{12} \text{ cm}^{-3}$  are obtained near current zero for the diffuse mode. 14 refs.

Gellert, B. (Brown Boveri & Co, Baden, Switzerland); Schade, E.; Dullini, E. *IEEE Trans Plasma Sci* v PS-15 n 5 Oct 1987, XIIth Int Symp on Discharges and Electr Insul in Vac, Shores, Isr, Sep 22-25 1986 p 545-551.

## Performance

**076553 LOW MOMENTUM TAGGED ANTINEUTRON BEAM.** The operating performance of a low-momentum ( $<270 \text{ MeV/c}$ ) tagged  $n^-$  beam is obtained by means of the charge exchange reaction  $p + p^- \rightarrow n + n^-$  on a liquid hydrogen target. The neutron associated to the  $n^-$  in the two-body reaction is used for the determination of the  $n^-$  energy and direction. The measured total rate of tagged  $n^-$  is  $8.02 \pm 0.03 \times 10^{-5}$  per incident  $p^-$  at  $300 \text{ MeV/c}$ . (Author abstract) 18 refs.

Cugusi, L. (Univ Cagliari, Cagliari, Italy); Macciotta, M.P.; Marcello, S.; Masoni, A.; Puddu, G.; Raimondi, A.; Serici, S.; Sergi, M.T.; Agnello, M.; Iazzi, F.; Minetti, B.; Bressani, T.; Feliciello, A.; Musso, A.; Cherubini, R.; Gramigna, F. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 354-360.

## Production

**076554 TEMPERATURE DEPENDENCE OF SLOW-POSITRON PRODUCTION AND OF POSITRONIUM FORMATION ON UNTREATED SURFACES.** Low-energy positron emission from tungsten moderators placed at an electron accelerator beam stop slows down with increasing moderator temperature. Efficient positronium formation is reported on untreated and unoriented metal surfaces at higher target temperatures. (Author abstract) 5 refs.

Dahm, J. (Univ of Mainz, Mainz, West Ger); Niebling, K.D.; Ley, R.; Werth, G. *Appl Phys A* v A44 n 2 Oct 1987 p 105-106.

## Simulation

**076555 SIMULATION OF INTENSE PARTICLE BEAMS WITH REGULARLY DISTRIBUTED GAUSSIAN SUBBEAMS.** Techniques for the simulation

of intense particle beams are investigated with respect to the required number of simulation particles. It is shown that for nonchaotic systems it is advantageous if the particles initially are not distributed in a statistical manner but rather arranged in a regular pattern in phase space. This reduces the number of required simulation particles drastically. In the case of such an initially regular arrangement of particles the algorithm which assigns the charges of the particles to the computation mesh becomes of prime importance. The performances of different commonly used algorithms are investigated. The Gaussian assignment algorithm proved far superior to other more commonly used techniques, allowing simulations even at the theoretical limit of 1 particle per cell. Examples for very accurate simulations of beam dynamics with very few particles using an initially regular mesh of particles and Gaussian assignment are given. (Author abstract) 9 refs.

Berz, M. (Univ of Giessen, Giessen, West Ger); Wollnik, H. *Nucl Instrum Methods Phys Res Sect A* v A267 n 1 Apr 15 1988 p 25-34.

**Stability** See ACCELERATORS—Storage Rings.

**Transport Properties** See Also ACCELERATORS—Beam Injection; NEUTRONS—Sources; PARTICLE OPTICS.

**076556 CHARACTERISTICS OF MACROPARTICLE EMISSION FROM A HIGH-CURRENT-DENSITY MULTI-CATHODE-SPOT VACUUM ARC.** Macroparticle mass transport, size distribution, and spatial distribution were studied in a  $6.5\text{-MA/m}^2$ ,  $25\text{-ms}$  Cu multi-cathode-spot (MCS) vacuum arc. The macroparticle erosion rate was determined to be  $105 \mu\text{g/C}$ , and together with ionic emission, accounted for most of the cathodic erosion. The number of macroparticles emitted decreased exponentially with macroparticle diameter, with  $20\text{-}80\text{-}\mu\text{m}$  macroparticles carrying the bulk of the mass transport. Macroparticles are emitted preferentially at an angle of  $20^\circ$  with respect to the cathode surface. In comparison to previous investigations, higher macroparticle erosion rates, a larger proportion of large macroparticles, and a higher emission angle are observed, and the differences are attributed to the large current density used in the present experiment. 14 refs.

Disatnik, Gilad (Tel Aviv Univ, Tel Aviv, Isr); Boxman, R.L.; Goldsmith, S. *IEEE Trans Plasma Sci* v PS-15 n 5 Oct 1987, XIIth Int Symp on Discharges and Electr Insul in Vac, Shores, Isr, Sep 22-25 1986 p 520-523.

## PARTICLE BOARD

**076557 BIOLOGICAL RESISTANCE OF SOUTHERN PINE AND ASPEN FLAKEBOARDS MADE FROM ACETYLATED FLAKES.** Standard soil block tests can be used for southern pine and aspen flakeboards made with phenol-formaldehyde adhesive if the boards are first leached to remove toxic residual chemicals which inhibit fungal attack. Standard fungal cellar and termite tests can be applied directly without leaching. Flakeboards made from flakes acetylated by a new simplified dip acetic anhydride procedure are resistant to attack by brown-, white-, and soft-rot fungi and tunneling bacteria at acetyl weight gains above 15%. Acetylated flakeboards at 18 to 21% acetyl weight gains are not completely resistant to attack by subterranean termites. (Author abstract) 20 refs.

Rowell, Roger M. (USDA, Madison, WI, USA); Esenther, Glenn R.; Nicholas, Darrel D.; Nilsson, Thomas. *J Wood Chem Technol* v 7 n 3 Sep 1987 p 427-440.

**076558 CHEMICAL MODIFICATION: ADDING VALUE THROUGH NEW F=PL COMPOSITE PROCESSING TECHNOLOGY.** Chemical modification can greatly improve the biological resistance and dimensional stability of wood products. Application of this technology to wood composites eliminates problems associated with solid wood, such as drying, chemical penetration, and chemical recovery. Aspen flakeboards



made from flakes to about 17-percent acetyl weight gain show no attack after 1 year in fungal cellar tests with brown-, white-, and soft-rot fungi or tunneling bacteria. These same boards swell in water at a much slower rate and to a lesser extent than untreated control boards. The most promising application of chemical modification at this time appears to be in thick fiberboards used in external application. (Author abstract). 20 Refs.

Rowell, Roger M. (USDA, Madison, WI, USA); Youngquist, John A.; Montrey, H.M. *For Prod J* v 38 n 7 pt 8 Jul 8 1988 p 67-70.

## Bonding

**076559 EVALUATION OF FLAKEBOARD BONDED WITH XYLITOL-MODIFIED ALKALINE PHENOLIC RESIN.** Douglas-fir flakeboards bonded with a xylitol-modified alkaline phenolic resin were compared with similar flakeboards bonded with a commercial phenolic flakeboard resin. The properties compared were modulus of rupture (MOR), modulus of elasticity (MOE), internal bond (IB) strength, and thickness swell after 2 and 24 hours of water soaking. The MOR and MOE values obtained were not significantly different for the flakeboards made with the different resins. IB of the flakeboards was compared before and after accelerated-aging exposure. The average IB strength for the flakeboard bonded with xylitol-modified phenolic resin exceeded the minimal requirements for type 2MF as specified by ANSI A208.1. Measurements taken after the 24-hour water-soak exposure indicated that material bonded with xylitol-modified phenolic resin increased in thickness substantially less than material bonded with a commercial phenolic resin. (Edited author abstract) 6 refs.

Jokerst, Ronald W. (USDA, Madison, WI, USA); Conner, Anthony H. *For Prod J* v 38 n 2 Feb 1988 p 43-48.

**076560 ISOCYANATE ADHESIVE AS A BINDER FOR RED MAPLE FLAKEBOARD.** The possibility of using an isocyanate adhesive as a binder in red maple flakeboard was investigated. The modulus of elasticity, modulus of rupture, accelerated exposure modulus of rupture, and linear expansion of experimental isocyanate-bonded flakeboards was equal to that of phenol-formaldehyde-bonded controls. Internal bond and thickness swell properties of isocyanate-bonded flakeboards were superior to those of flakeboards bonded with phenol-formaldehyde. It was concluded that use of isocyanate adhesive as a binder in red maple flakeboard is feasible. (Author abstract) 16 refs.

Jackowski, John A. (Univ of Massachusetts, Amherst, MA, USA); Smulski, Stephen J. *For Prod J* v 38 n 2 Feb 1988 p 49-50.

## Drying

**076561 ASSESSMENT OF THE KINETICS OF THE DESICCATOR TEST FOR FORMALDEHYDE RELEASE FROM PARTICLEBOARDS.** The recently derived kinetics for the 2-hour desiccator test was experimentally assessed. The desiccator value was studied as a function of kinetic parameters. Experimental findings were compared with computer-simulated curves for the kinetics. All investigated parameters affected the desiccator values as predicted by the kinetic equations, with the exception of the surface area of water; instead, the circumference of water was found to play a kinetic role in the desiccator test. It was demonstrated that the desiccator value was governed by the circumference and volume of water, the rates of formaldehyde diffusion in the water, and the duration of the test. (Author abstract). 4 Refs.

Rybicky, Jaroslav (Reichhold Ltd, Weston, Ont, Can); Balatincez, John J.; Rawat, Jagdish K. *For Prod J* v 38 n 7 pt 8 Jul 8 1988 p 46-50.

## Manufacture

**076562 PARTICLE BOARD MANUFACTURER UPS EFFICIENCY WITH PC BASED CONTROL.** An Ontario, Canada based supplier of particle board to the

furniture and prefab housing industries recently built a new factory and automated the manufacturing process with a personal computer (PC) based control system. In starting from the ground up, the company wanted streamlined production methods, increased process efficiency and output, and a lower scrap rate than had been achieved in older plants. To meet these objectives, four factory areas were selected for automation, including: raw material batching and grinding, drying, particle conditioning, gluing, and pressing, sawing and warehouse curing. This article discusses system hardware and software, and application specifics.

Benner, Axel (Action Industrie Computer GmbH, Frankfurt, West Ger); Hall, John. *Chilton's I&CS* v 61 n 4 Apr 1988 p 53-54.

**076563 FUNDAMENTALS OF FLAKEBOARD MANUFACTURE: INTERNAL-MAT CONDITIONS.** Real-time measurements were made of temperature, gas pressure, and compaction pressure in the face and core regions of flakeboard panels during manufacture. Data from the manufacture of 24 yellow-poplar flakeboard panels are presented. The effects of press closing time, initial mat moisture content, and platen temperature on internal-mat conditions are discussed. The trends in mat temperature and gas pressure are explained in terms of fundamental concepts of heat and mass transfer, stress relaxation, and phase equilibria. These phenomena occur simultaneously and are strongly interrelated. Internal temperature and gas pressure data can be used to help explain the formation of density gradients in wood-particle composites. (Author abstract) 18 refs.

Kamke, Frederick A. (Virginia Tech, Blacksburg, VA, USA); Casey, Linda J. *For Prod J* v 38 n 6 Jun 1988 p 38-44.

**076564 PROCEEDINGS OF THE TWENTIETH WASHINGTON STATE UNIVERSITY INTERNATIONAL PARTICLEBOARD/COMPOSITE MATERIALS SYMPOSIUM.** This conference proceedings contains 20 papers. The topics covered include: particle board economics and markets; wood bonding acidity; bonded structural composite boards; composite material adhesive durability tests; computerized process control; composite product manufacture government regulations; panel product continuous pressing; composite gypsum flakeboard; flake; wafer and strand production equipment; industrial particle board applications; composite from hardwood waste; internal bond strength testing and prediction; board production optimum control. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10941 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Maloney, Thomas M. (Ed.) (Washington State Univ, Pullman, WA, USA); Leonhardy, Lucille H. (Ed.); Lentz, Martin T. (Ed.). *Proc Wash State Univ Int Particleboard Compos Mater Ser Symp* 20th, Pullman, WA, USA, Apr 8-10 1986. Publ by Washington State Univ, Pullman, WA, USA, 1986. 450p.

**Materials** See Also FORMALDEHYDE—Environmental Testing.

**076565 PARTICLE BOARDS FROM UNDEBARKED NATURAL RUBBER WOOD AND LIGNOCCELLULOSE BYPRODUCTS.** Particle boards (0.5 in. thick) were prepared from the combination of undebarked rubber wood, wood shavings, mangrove bark, corn cobs, and sugar cane bagasse, by treatment with adhesives based on vegetable tannins. Results from mechanical and various physical tests showed, on an average, that the bending strengths of boards made of 25% undebarked rubber chips were about 30% higher than those of the commercial grade boards of other lignocellulose materials. Additionally, the specific gravity, weight to strength ratio (specific strength), and water resistance of the wood-based board were found to be better. Although no nail fastness test was carried out, all boards showed evidence of nailability. (Author abstract) 10 refs.

Odozi, T.O. (Univ of Port Harcourt, Port Harcourt, Nigeria). *Ind Eng Chem Res* v 26 n 9 Sep 1987 p 1735-1737.

**076566 PROPERTIES OF PARTICLEBOARD FROM REE-TYPHA MIXTURES.** To investigate the suitability of a mixture of reed-typha for particleboard manufacturing, laboratory particleboards were manufactured at a target density of 0.64 g/cm<sup>3</sup> and 16 mm thickness from five levels namely 75 percent Reed (R) with 25 percent Typha (T), 50 percent R/50 percent T, 25 percent R/75 percent T, 100 percent R and 100 percent T, using 8 percent urea-formaldehyde resin as a binder. ASTM standard methods were conducted for evaluation of the mechanical and physical properties. Results show that all properties were highly influenced by the percentage of reed used. Generally, as reed percentage was increased in the mixture, mechanical properties were increased significantly, while physical properties (thickness swelling and water absorption) were significantly decreased. (Edited author abstract). 8 Refs.

Al-Sudani, Osama A. (Council of Scientific Research, Baghdad, Iraq); Daoud, Daoud S.; Michael, Shatha. *J Pet Res* v 7 n 1 Jun 1988 p 197-208.

**Mechanical Properties** See Also WOOD—Drying.

**076567 ADHESIVE BONDING OF ACETYLATED ASPEN FLAKES, PART 2. EFFECTS OF EMULSIFIERS ON PHENOLIC RESIN BONDING.** Acetylation of aspen flakes causes a reduction in the wettability of the flakes to a water-soluble phenolic resin. In this study, addition of emulsifiers to the phenolic resin improved wettability of the acetylated flake surface. In general, water-to-oil emulsifiers were more effective than oil-to-water emulsifiers. Internal bond strength and modulus of rupture were higher in acetylated flakeboards in which a water-to-oil emulsifier was added to the phenolic resin compared to nonacetylated control flakeboards made with phenolic resin alone. Image analysis of the failed surfaces of acetylated flakeboards after an internal bond test showed about 50% board failure in the wood and about 50% in the glue-line, regardless of the emulsifier used in the phenolic resin.

Youngquist, J.A. (Forest Products Lab, USA); Sachs, I.B.; Rowell, R.M. *Int J Adhes Adhes* v 8 n 4 Oct 1988 p 197-200.

## Testing

**076568 TENSILE AND COMPRESSIVE MOE OF FLAKEBOARDS.** Normally pressed gradient-density flakeboards were tested for tensile and compressive modulus of elasticity (MOE). The panels were nonaligned and single-layer aligned. Multiple regression equations were developed for axial MOE versus board specific gravity and ultrasonic wave speed in the direction of mechanical test. These regression equations, along with specific gravity profiles through the panel thickness, were used to calculate predicted effective bending MOE. The regression model found to be most appropriate involved use of logarithmic transformation of the factor and response variables. Tensile MOE of this type of flakeboard apparently exceeds its compressive MOE. Wave propagation speed in the direction of test appears to be a practical measure of alignment, although it is not independent of panel specific gravity. (Edited author abstract) 13 refs.

Carll, Charles G. (USDA, Madison, WI, USA); Link, Carol L. *For Prod J* v 38 n 1 Jan 1988 p 8-14.

**PARTICLE DETECTORS** See Also ACCELERATORS; CYCLOTRON—Targets; AEROSOLS—Atmospheric; AEROSOLS—Testing; AMPLIFIERS; CALORIMETERS; CALORIMETRY; CAPACITORS; CHARGED PARTICLES—Measurements; COLLOIDS; COMPUTER SOFTWARE—Applications; DATA PROCESSING—Data Acquisition; ELECTRON BEAMS—Measurements; ELECTRON TUBES; PHOTOMULTIPLIER; ELECTRONIC CIRCUITS; TRIGGER; ENVIRONMENTAL TESTING—Radioactivity; IMAGING TECHNIQUES; IONS—Measurements; ISOTOPES—Measurements; LIGHT—Emission; MICROANALYSIS—Instruments; NEUTRONS—Production; NEUTRONS—Diffraction; NEUTRONS—Detection; NEUTRONS—Scattering; NUCLEAR ENERGY—Fis-



sion Reactions; OPTICAL INSTRUMENTS—Ionization; PARTICLE BEAM TRACKING; PARTICLE DETECTORS—Electronic Equipment; PHOTOCATHODES; PHOTODETECTORS; PLUTONIUM COMPOUNDS—Chemical Analysis; RADIATION COUNTERS; RADON—Radioactivity; SCINTILLATION COUNTERS; SIGNAL FILTERING AND PREDICTION; SOLAR RADIATION—Research.

**076569 ON THE DETERMINATION OF REACTION PRODUCT PARAMETERS USING MUSCOVITE MICA DETECTORS.** Two independent methods have been described and discussed for the determination of reaction product parameters using Muscovite mica track detectors. The first method is based on the experimentally obtained calibration curves for apparent track etch velocity versus residual range in Muscovite mica. In the second method, an empirical velocity-range relationship is used to convert the parameters of the correlated tracks into particle parameters for heavy charged reaction products. This method has been applied for the analysis of some typical events in the 12.5 MeV/nucleon  $^{84}\text{Kr} + \text{U}$  (natural) reaction. The results indicate that the method based upon the apparent track etch velocity vs residual range calibration curves has some severe limitations. (Edited author abstract) 17 refs.

Khan, Hameed A. (Pakistan Inst of Nuclear Science & Technology, Nilore, Pak); Qureshi, I.E.; Jamil, Khalid; Gottschalk, Peter A.; Vater, Peter; Brandt, Reinhard. *Nucl Instrum Methods Phys Res Sect B v B28 n 1 Aug 1987 p 41-48.*

**076570 CHARACTERISTICS OF CRONAR POLYETHYLENE TEREPHTHALATE TRACK DETECTORS.** Using beams of relativistic heavy ions at the LBL Bevalac, we have found that Cronar, the least sensitive of the commonly used plastic track detectors, has the highest charge resolution for particles with  $Z/\beta \geq 76$  and has other attractive properties that justify its use as a major component of the NASA Heavy Nuclei Collector being considered for the study of ultraheavy cosmic rays. We report measurements of its response curve, its charge resolution, its track-fading behavior, and the dependence of its response on ambient temperature. (Author abstract) 14 refs.

Drach, J. (Univ of California, Berkeley, CA, USA); Price, P.B.; Salamon, M.H. *Nucl Instrum Methods Phys Res Sect B v B28 n 1 Aug 1987 p 49-52.*

**076571 LARGE SOLID ANGLE MAGNETIC DETECTOR FOR PRECISION STUDIES OF e. m. PROCESSES IN LOW-ENERGY  $p^-$  INTERACTIONS.** The detector presented is designed to measure the proton e.m. form factors by measuring  $e^+e^-$  pairs produced in  $p^-p$  annihilations at low energy or at rest. In this paper the apparatus is described in detail, with emphasis on how to achieve a suppression factor of about  $10^{10}$  of the hadronic background. (Author abstract) 13 refs.

Bardin, G. (CEN, Saclay, Fr); Burgun, G.; Calabrese, R.; Capon, G.; Carlin, R.; Dalpiaz, P.; Dalpiaz, P.F.; De Brion, J.P.; De Giorgi, M.; Derre, J.; Dosselli, U.; Ducastring, G.; Duclos, J.; Faure, J.L.; Gasparini, F.; Giantin, R. *Nucl Instrum Methods Phys Res Sect A v A259 n 3 Sep 15 1987 p 376-388.*

**076572 PHOTOELECTRON PRODUCTION IN  $\text{BaF}_2$ -TMAE DETECTORS.** The wavelength dependence of the photoelectron yield in a  $\text{BaF}_2$ -TMAE detector was studied. We found that the signal in such a detector stems mainly from an emission of scintillation light at 195 nm. The decay time constant of this component is the same as that of the 220 nm component:  $(870 \pm 30)$  ps. (Author abstract) 11 refs.

Schotanus, P. (Delft Univ of Technology, Delft, Neth); van Eijk, C.W.E.; Hollander, R.W.; Pijpeling, J. *Nucl Instrum Methods Phys Res Sect A v A259 n 3 Sep 15 1987 p 586-588.*

**076573 DEPENDENCE OF RESPONSE OF PLASTIC TRACK DETECTORS ON POST-IRRADIATION AGING TIME, TEMPERATURE, AND ATMOSPHERE.** We find that, in general, the response track

etch rate of plastic track detector to an energetic charged particle depends not only on ionization rate but also on the aging time between irradiation and chemical etching, on the ambient temperature during aging, and on the atmosphere during aging. Data relevant to the use of plastic track detectors on long-duration space missions will be presented. (Author abstract) 17 refs.

Price, P.B. (Univ of California, Berkeley, CA, USA); Drach, J. *Nucl Instrum Methods Phys Res Sect B v B28 n 2 Sep 1987 p 275-279.*

**076574 COMPUTER-CONTROLLED MAGNETIC POST-LENS SCANNING SYSTEM FOR THE LUND PROTON MICROPROBE.** A post-lens beam scanning system using ferrite-cored magnetic coils is described. The system enables a scanning area, for 2.5 MeV protons, of  $3.6 \times 4.8 \text{ mm}^2$  at a target positioned 17 cm after the focusing elements. The minimum irradiation time per pixel is 1 ms. The scanning system is controlled by a VME microcomputer system. All scanning features are software-controlled with user-selectable beam-scanning parameters such as irradiation time per pixel and scanning pattern. (Author abstract) 12 refs.

Tapner, U.A. Staffan (Lund Inst of Science & Technology, Lund, Swed); Lovestam, N.E. Goran; Karlsson, Erik; Malmqvist, Klas G. *Nucl Instrum Methods Phys Res Sect B v B28 n 2 Sep 1987 p 317-324.*

**076575 NBS LARGE-AREA ALPHA-PARTICLE COUNTING SYSTEMS.** Two alpha-particle counting systems for the measurement of large-area sources have been developed at the National Bureau of Standards. The systems and their characteristics are described. One system uses an internal-source proportional counter and the other measures sources external to the counting volume through a thin aluminized mylar window. The 'internal' system is used to measure sources in the lower activity ranges. These calibrated sources are then used to establish the efficiency of the 'external' counter used to measure the higher-activity sources. (Author abstract)

Hutchinson, J.M.R. (NBS, Gaithersburg, MD, USA); Bright, S.J. *J Res Natl Bur Stand (US) v 92 n 5 Sep-Oct 1987 p 311-324.*

**076576 PARTICLE IDENTIFICATION WITH THE OPAL JET CHAMBER IN THE REGION OF THE RELATIVISTIC RISE.** An important goal of the OPAL jet chamber is particle identification at high momenta by exploiting the relativistic rise of the energy loss. Extensive tests have been performed with the full scale prototype of the OPAL jet chamber to measure the energy loss in an argon-methane-isobutane mixture as function of momentum and particle species. The measurements were done under various operating conditions in order to optimize the operating point, to investigate sources of systematic errors, to monitor the stability of the energy loss measurement and to develop calibration procedures. The particle separation capability in the region of the relativistic rise has been studied at gas pressures of 3 and 4 bar. The adopted operating point represents a reasonable compromise between the requirements for particle identification and tracking accuracy. (Author abstract) 14 refs.

Breuker, H. (Univ Bonn, Bonn, West Ger); Fischer, H.M.; Hauschild, M.; Hartmann, H.; Wuensch, B.; Boerner, H.; Burckhart, H.J.; Dittmar, M.; Hammarstroem, R.; Heuer, R.D.; Michelini, A.; Plane, D.E.; Runolfsson, O.; Schaile, D.; Weisz, S.; Zankel, K. *Nucl Instrum Methods Phys Res Sect A v A260 n 2-3 Oct 15 1987 p 329-342.*

**076577 EVALUATION OF PROTOTYPE SILICON DRIFT DETECTORS.** Silicon drift detectors, of two elementary designs, have been fabricated and tested using  $\beta$  electrons and light pulses. Drift of electrons within the detectors has been observed over distances up to about 8 mm with high efficiency. Results are presented, some of which identify important design parameters of such devices. (Author abstract) 18 refs.

Ellison, J. (Imperial Coll, London, Engl); Hall, G.; Roe, S.; Lucas, A.D. *Nucl Instrum Methods Phys Res Sect A v A260 n 2-3 Oct 15 1987 p 353-360.*

**076578 DETECTOR FOR METASTABLE HELIUM IONS.** We describe a sensitive detector for metastable ( $2S_{1/2}$ ) helium ions. The detector operates in a magnetic field of 4-16 kG and has an overall efficiency of about 1%. Metastable  $\text{He}^+$  ions are quenched in an electric field causing them to decay to the ground state ( $1S_{1/2}$ ) with emission of 304 Å radiation. The radiation is detected in a cylindrical photodiode whose active surfaces are made of copper foils coated with  $\text{MgF}_2$ . Multiple photocathodes are used in an arrangement which maximizes the overall efficiency. (Author abstract) 14 refs.

Powelson, J.C. (Princeton Univ, Princeton, NJ, USA); Dewey, M.S.; Dunford, R.W. *Nucl Instrum Methods Phys Res Sect A v A260 n 2-3 Oct 15 1987 p 403-406.*

**076579 EVALUATION OF A DIGITAL OPTICAL IONIZING RADIATION PARTICLE TRACK DETECTOR.** An outline of an ionizing radiation particle track detector is presented which can, in principle, determine the three-dimensional spatial distribution of all the secondary electrons produced by the passage of the ionizing radiation through a low-pressure (0.1-10 kPa) gas. The electrons in the particle track are excited by the presence of a high-frequency ac electric field, and two digital cameras image the optical radiation produced in electronic excitation collisions of the surrounding gas by the electrons. The specific requirements of the detector for neutron dosimetry and microdosimetry are outlined (i.e., operating conditions of the digital cameras, high voltage fields, gas mixtures, etc.) along with an estimate of the resolution and sensitivity achievable with this technique. (Edited author abstract) 16 refs.

Hunter, S.R. (Oak Ridge Natl Lab, Oak Ridge, TN, USA). *Nucl Instrum Methods Phys Res Sect A v A260 n 2-3 Oct 15 1987 p 469-477.*

**076580 PERFORMANCE OF 'VIRTUAL PHASE' CCDs AS DETECTORS OF MINIMUM-IONIZING PARTICLES.** The Texas Instruments 'Virtual Phase' CCD has been the basis of an ambitious design for a precision vertex detector to be used at the Stanford Linear Collider. The performance of this chip shows promise for future use in electron linear colliders. Experimental results are reported in addition to description of the electronic readout and preliminary mechanical design. (Author abstract) 47 refs.

Akerlof, Carl W. (Univ of Michigan, Ann Arbor, MI, USA); Gialas, Ioannis; Koska, Wayne A.; Nitz, Dave F.; Rodricks, Brian G.; Tschirhart, Robert S.; Karlen, Dean; Chapman, Jay W. *Nucl Instrum Methods Phys Res Sect A v A260 n 1 Oct 1 1987 p 80-100.*

**076581 RESOLUTION OF PLASTIC STREAMER TUBES WITH ANALOG READOUT.** Extruded plastic tubes coated with a resistive material, having a  $1 \text{ cm}^2$  profile and central 100  $\mu\text{m}$  anode wire are operated in limited streamer mode. The charge induced on an external layer of cathode strips aligned perpendicularly to the anode wire is measured and used to compute the streamer coordinate. Test results both with an X-ray source and a particle beam are presented. Spatial resolution of the order of 400  $\mu\text{m}$  is observed over the 40  $\text{cm}^2$  area studied. (Author abstract) 8 refs.

Univ of Wisconsin, WI, USA (Bauer, G.); Bettini, A.; Busetto, G.; Centro, S.; De Giorgi, M.; Fruehwirth, R.; Markiewicz, T.; Meneguzzo, A.; Mohammadi, M.; Pascoli, D.; Placci, A.; Rossi, P.; Sumorok, K.; Zanello, L.; Zotto, P. *Nucl Instrum Methods Phys Res Sect A v A260 n 1 Oct 1 1987 p 101-113.*

**076582 CHARACTERISTICS OF A MINI DRIFT CHAMBER.** The characteristics of a drift chamber with 3 mm drift gap were investigated at a particle beam momentum of 10 GeV/c. The chamber has good linearity of the drift characteristics. It was tested and could reliably work in a particle flux of approximately  $3 \times 10^5 \text{ s}^{-1} \text{ cm}^{-2}$ .



2. A spatial resolution of approximately 45  $\mu\text{m}$  in the center of the drift gap has been achieved. (Author abstract) 10 refs.

Chirkov-Zorin, L.E. (Joint Inst for Nuclear Research, Dubna, USSR); Davydov, Yu.I.; Feshchenko, A.A.; Flyagin, V.B.; Sergeev, S.V.; Spalek, J.; Strmen, P. *Nucl Instrum Methods Phys Res Sect A* v A260 n 1 Oct 1 1987 p 142-145.

**076583** **DIODENE  $4\pi$  DETECTOR AT SATURNE.** Diogene, an electronic  $4\pi$  detector, has been built and installed at the Saturne synchrotron in Saclay. The forward angular range ( $0^\circ$ - $6^\circ$ ) is covered by 48 time-of-flight scintillator telescopes that provide charge identification. The trajectories of fragments emitted at larger angles are recorded in a cylindrical  $0.4\text{-m}^3$  Pictorial Drift Chamber (PDC) surrounding the target. The PDC is inside a 1-T magnetic field; the axis of the PDC cylinder and the magnetic field are parallel to the beam. Good identification has been obtained for both positive and negative  $\pi$  mesons and for hydrogen and helium isotopes. Multiplicities in relativistic nucleus-nucleus reactions up to 40 have been detected, limited mainly by the present electronics. (Author abstract) 15 refs.

Alard, J.P. (LPC Clermont-Ferrand, Aubiere, Fr); Arnold, J.; Augerat, J.; Babinet, R.; Bastid, N.; Brochard, F.; Costilles, J.P.; Crouau, M.; De Marco, N.; Drouet, M.; Dupieux, P.; Fanet, H.; Fodor, Z.; Frayssie, L.; Girard, J.; Gorodetzky, P. *Nucl Instrum Methods Phys Res Sect A* v A261 n 3 Nov 15 1987 p 379-398.

**076584** **NEW TWO-DIMENSIONAL POSITION SENSITIVE DETECTOR WITH A GOOD LINEAR RESPONSE.** A new pin-cushion type two-dimensional position sensitive detector (PSD) with a good linear response, in which the adjacent point-electrodes are connected by a straight resistive strip, has been developed. In the PSD, the ratio of sensitive area to the total detector area is almost unity. The experimental results show that, for achieving a good linear response in a two-dimensional pattern, the resistance of the resistive strip should be 1/10 to 1/15 lower than the surface resistance per unit square in the resistive anode. Under such a condition, the maximum deviation from the linear relation, which occurs at each corner, is less than 2%. (Author abstract) 4 refs.

Doke, Tadayoshi (Waseda Univ, Tokyo, Jpn); Kikuchi, Jun; Yamaguchi, Hiromi; Yamaguchi, Seiji; Yamamura, Kazuhisa. *Nucl Instrum Methods Phys Res Sect A* v A261 n 3 Nov 15 1987 p 605-609.

**076585** **SOLID STATE ELECTRON DETECTOR FOR THE EB60 ELECTRON BEAM LITHOGRAPHY SYSTEM.** This paper discusses the development of a new solid state electron detector (SSD), which is a key component for a high-precision, high-throughput EB direct exposure system, the EB60. The SSD is a low-noise, fast-response detector for a weak input electron beam signal having a nanoampere current and energy of approximately ten kilo electron volts. The SSD has a new metallization structure on the active area for eliminating the effect of incident photons coming from an optical wafer height sensor. For the smallest input signal (15 keV electrons) operation, an SSD with a wide active area of 25  $\text{mm}^2$  has a current gain of 2300, a rise time of less than 350 ns and a leakage current of 80 pA; this is negligible to the output signal of a microampere. A long-term stability of a 3% current gain decrease after electron beam bombardment for 1000 hours, and a leakage current of 100 pA after bombardment for 5000 hours have been obtained. A highly accurate, high-speed registration mark detection of 0.02  $\mu\text{m}$  and 50 ms per mark has been achieved through the SSD. (Author abstract) 9 refs.

Murashita, Toru (NTT Corp, Atsugi, Jpn); Shibayama, Akinori; Fujinami, Minpei. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1513-1518.

**076586** **LARGE SOLID ANGLE DETECTOR FOR MEDIUM ENERGY CHARGED PARTICLES.** A charged particle detector with 0.7 sr solid angular acceptance has been built, principally to detect protons in the

energy range 25-150 MeV in experiments with tagged photon beams. The detector consists of a three element  $\Delta E_1$ - $\Delta E_2$ -E plastic scintillator telescope. Position information is obtained from the time difference between signals from the two ends of each scintillator. The design of the detector and tests of its performance are described. An energy resolution of 2.8 MeV fwhm at 60 MeV proton energy, and a two-dimensional position resolution of 24  $\text{mm} \times 41 \text{ mm}$  fwhm has been obtained. Successful operation in the tagged photon environment is demonstrated. (Author abstract) 9 refs.

MacGregor, Ian J.D. (Glasgow Univ, Glasgow, Scotl); Dancer, Stephen N.; Annand, John R.M.; Wallace, Peter A.; Kellie, James D.; Hall, Samuel J.; McGeorge, John C.; Springham, Stuart V.; Rene, Martin R.; Branford, Derek; Shoter, Alan C.; Vogt, Johannes M.; Schoch, Berthold. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 347-352.

**076587** **INTERSTRIP SURFACE EFFECTS IN OXIDE PASSIVE ION-IMPLANTED SILICON STRIP DETECTORS.** An investigation is reported into charge sharing effects for highly ionising particles penetrating the interstrip gap for ion-implanted silicon strip detectors. It is found that under certain conditions anomalous polarity pulses are induced on adjacent strips. This effect is analyzed with a model that takes account of the surface charge trapped on the Si-SiO<sub>2</sub> interface between the adjacent strips. (Author abstract) 6 refs.

Yorkston, J. (Edinburgh Univ, Edinburgh, Scotl); Shoter, A.C.; Syme, D.B.; Huxtable, G. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 353-358.

**076588** **POSITION-SENSITIVE DETECTOR WITH MICROSTRIP ANODE FOR ELECTRON MULTIPLICATION WITH GASES.** A position-sensitive detector of a new type has been developed. A microstrip anode replaces the wires generally used for electron multiplication with gases. The microstrips which are fixed on a glass substrate are produced by means of photolithography. The applied electric potential alternates between each strip. With a position-sensitive neutron detector equipped with this new type of anode a counting rate of 2.3  $\text{MHz}/\text{cm}^2$  has been measured. The microstrip anode combines the improved qualities of a proportional counter with certain properties of a photomultiplier tube. (Author abstract) 5 refs.

Oed, A. (Inst Laue-Langevin, Grenoble, Fr). *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 351-359.

**076589** **TIME RESOLUTION OF A LARGE AREA PLANAR SPARK COUNTER.** A planar spark counter of size  $1.0 \text{ m} \times 0.1 \text{ m}$  has been developed and tested. The constituent elements are a semiconductive glass anode and a window float-cast glass cathode coated by vacuum-deposited copper. The distance between electrodes is 200  $\mu\text{m}$ . A single counter time resolution of 61 ps was achieved with cosmic rays. (Author abstract) 8 refs.

Fujiwara, Noboru (Nara Women's Univ, Nishi-machi, Jpn); Iida, Naoko; Noguchi, Seishi; Sugahara, Ryuhci; Suwada, Tsuyoshi; Ohama, Taro; Takahashi, Kasuke. *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 381-386.

**076590** **PARTICLE IDENTIFICATION VIA PULSE-SHAPE DISCRIMINATION WITH A CHARGE-INTEGRATING ADC.** A charge-integrating ADC has been used to sample the intensity in two different time regions of a pulse and thus to sense the shape of the pulse. This idea has been applied to produce neutron/ $\gamma$ -discrimination from pulses in a liquid scintillation detector. Optimization of available parameters yields good pulse-shape discrimination for pulses greater than those produced by 100 keV electrons. The method uses only general purpose electronics. (Author abstract) 15 refs.

Heltsley, J.H. (Michigan State Univ, East Lansing, MI, USA); Brandon, L.; Galonsky, A.; Heilbronn, L.; Rem-

ington, B.A.; Langer, S.; Vander Molen, A.; Yurkon, J.; Kasagi, J. *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 441-445.

**076591** **BEHAVIOUR AND RESPONSE VERACITY OF LARGE AREA TRANSMISSION AVALANCHE COUNTERS AS ELEMENTARY DETECTING DEVICES.** Parallel plate avalanche counters (PPAC) with an active area of 80  $\text{cm}^2$  and an electrode spacing of 1-4 mm are investigated. The behavior and the response veracity of the transmission PPAC, when used as an elementary detecting device, i.e. just to count events, with simple spectrometric and timing (without TOF coincidence) mode electronic systems are assessed at n-heptane pressures of 5-30 Torr using low-energy  $\alpha$ -particles. Beside the PPAC intensity transmittance ( $\leq 1.05$  at the plateau centre), the plateau slope ( $\geq 6 \times 10^{-4}/\text{V}$ ) and width ( $\leq 115 \text{ V}$ ) of the counting rate curve are evaluated. In addition, the counter behavior beyond the low-voltage plateau and is investigated. High spurious pulse counting rates, almost solely due to charge carrier regeneration under strong electric fields, are reported. Empirical relations are determined among the PPAC characteristic voltages to provide for a safe estimation of the detector electrical strength. (Author abstract) 17 refs.

Sernicki, Jan (Inst for Nuclear Studies, Swierk, Pol). *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 446-456.

**076592** **THERMAL HISTORY AND LENGTH DISTRIBUTION OF FISSION TRACKS: PART II.** In Part I of this paper a mathematical model was developed to derive the length distribution  $n(l)$  of partially annealed fission tracks within a sample as the result of an earlier time-dependent temperature  $T(t)$ . An empirical annealing law is the basis of this model wherein experimental data in apatite are used as an example. In the present work the length distribution  $\sigma(h)$  of the normal projections  $h$  of stochastically truncated tracks in an intersection plane is considered, and it is shown that the function  $T(t)$  could be pronounced even in the monotonically decreasing length distribution  $\sigma(h)$ . Results of simulating calculations show that - on the basis of a known annealing function - it is in principle possible to compute  $T(t)$  by proceeding from an 'experimentally' given distribution  $\sigma(h)$ . (Author abstract) 4 refs.

Keil, R. (Univ Innsbruck, Innsbruck, Austria); Pahl, M.; Bertagnolli, E. *Nucl Tracks Radiat Meas* v 13 n 1 1987 p 25-33.

**076593** **SOLVENT EFFECT IN NUCLEAR TRACK DEVELOPMENT.** The analysis of the effect of soaking in alcohol and/or water in track development was evaluated in Makrofol E using electron microscopy. Alcohol seems to be the main cause of track development when no other chemical reagent is used. No track development is achieved when water is used as an etching agent. (Author abstract) 13 refs.

Saint Martin, G. (CNEA, Buenos Aires, Argent); Mazzei, R.; Bernaola, O.A.; Bourdin, J.C.; Grasso, C.; Molinari de Rey, B. *Nucl Tracks Radiat Meas* v 13 n 1 1987 p 71-75.

**076594** **ANALYTIC SOLUTION OF THE POTENTIAL AND ELECTRIC FIELD OF A JET TYPE DRIFT CHAMBER.** Starting from the known two-dimensional potential of a multiwire proportional chamber, the analytic expressions of the potential and the electric field are derived for a jet type drift chamber with a central wire plane of alternating sense and potential wires. (Edited author abstract) 3 refs.

Weltin, Armin (Albert Ludwigs Univ, Freiburg, West Ger). *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 213-218.

**076595** **COMPACT MULTIDETECTOR SYSTEM FOR HIGHLY ENERGETIC CHARGED PARTICLES.** A detector system for charged particles consisting of several (20) identical detector elements has been



constructed. Each detector element contains a silicon surface barrier detector and a CsI(Tl) scintillator with photodiode readout. Particle identification is obtained by the  $\Delta E$ -E method. The design and performance of the detector system are discussed. Results on a pulse-shape analysis of the photodiode signal are also presented. (Author abstract) 6 refs.

Meijer, R.J. (Rijksuniversiteit Utrecht, Neth); Van Nieuwenhuizen, G.J.; Van Den Brink, A.; Decowski, P.; Griffioen, K.A.; Kamermans, R. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 285-290.

**076596 MULTIPIN GAS-DISCHARGE DETECTOR WITH BALL-TIPPED ANODES.** A new gas-discharge particle detector is described. The ball-tipped anodes of the detector are 2 mm in diameter. The detector operates in the self-quenching mode with high efficiency, and its counting rate is characterized by a wide plateau. The maximum counting rate at one ball-tipped anode is approx.  $2.5 \times 10^4 \text{ s}^{-1}$ . Utilization of spherical anodes will make possible the construction of reliable detectors of complex shapes. In such detectors two-coordinate registration of multiparticle events may be readily organized in a natural manner. (Author abstract) 9 refs.

Khazins, D.M. (Joint Inst for Nuclear Research, Dubna, USSR); Travkin, V.I. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 305-307.

**076597 ANALYSIS OF A MICROWAVE CAVITY DETECTOR COUPLED TO A NOISY AMPLIFIER.** In a class of detectors for light pseudoscalar particles, a microwave cavity traps photons produced by the interaction of the particles with a strong magnetic field. The cavity strongly influences the signal and noise properties of the amplifier coupled to its output. We present the theory of a noisy amplifier coupled to a microwave cavity, along with experimental data for a cryogenic GaAsFET amplifier. The signal-to-noise ratio of the cavity-amplifier system is determined, and applications to the measurement of amplifier parameters are discussed. (Author abstract) 14 refs.

Moskowitz, Bruce E. (Univ of Rochester, Rochester, NY, USA); Rogers, Joseph. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 445-452.

**076598 DESIGN AND TESTS OF THE Z-COORDINATE DRIFT CHAMBER SYSTEM FOR THE OPAL CENTRAL DETECTOR AT LEP.** A system of drift chambers has been designed to make high resolution measurements of the z-coordinates of charged tracks at the outer radius of the OPAL central detector at LEP. The unit module of this detector is a 25 cm drift length bidirectional cell with six sense wires in a thin 50 cm wide by 29 mm high drift slot. Tests indicate that the chamber has a wide and stable electric field operating range and its performance is unaffected by small misalignments between the drift electric field and an external magnetic field. The drift cell was found to have uniform acceptance up to its geometrical boundaries, and the z-resolution for beam tracks normal to the chamber was measured to be in the range of 40-175  $\mu\text{m}$ . (Author abstract) 12 refs.

Mes, H. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Dixit, M.S.; Godfrey, L.; Hanna, D.; Hargrove, C.K.; Losty, M.J.; Oakham, F.G.; Carnegie, R.K.; Dumont, J.J.; Hemingway, R.J.; McPherson, A.C.; Payne, R.; Bavaria, G.; Jeremie, H.; Lessard, L. *Nucl Instrum Methods Phys Res Sect A* v A265 n 3 Mar 15 1988 p 445-456.

**076599 STUDY OF NONFLAMMABLE GAS MIXTURES FOR LIMITED STREAMER TUBES IN THE VENUS DETECTOR AT TRISTAN.** Performances of limited streamer tubes operated with nonflammable gas mixtures composed of argon (Ar), carbon-dioxide ( $\text{CO}_2$ ) and isobutane ( $i\text{-C}_4\text{H}_{10}$ ) with ratios of 1:1.5:0.15, 1:2:0.2, 1:3:0.3, 1:4:0.4 and 1:6:0.6 were studied. It was found that these mixtures were very suitable for the VENUS detector. The charge spectra exhibited very sharp distributions and indicated the possibility for the limited streamer tubes to be applied to calorimetry use. A mixture of 1:2:0.2 was

chosen for the VENUS streamer tubes because of its moderate gain and long efficiency plateau. (Author abstract) 6 refs.

Uebayashi, T. (Osaka Univ, Toyonaka, Jpn); Haba, J.; Kamitani, T.; Kanematsu, N.; Nagashima, Y.; Osabe, H.; Sakamoto, S.; Sugimoto, S.; Suzuki, Y.; Tsukamoto, A.; Yamashita, Y.; Sumiyoshi, T.; Takasaki, F.; Homma, Y.; Hojo, Y. *Nucl Instrum Methods Phys Res Sect A* v A265 n 3 Mar 15 1988 p 457-460.

**076600 EFFICIENCY OF RADON DETECTOR LR-115.** The efficiency of cellulose nitrate (LR-115, type II) radon detector has been measured at different angles of incidence for alpha particle detection. It is found that the detector efficiency increases with the angle of incidence. The detector is found most efficient for perpendicular incidence. (Author abstract) 5 refs.

Ramola, R.C. (Guru Nanak Dev Univ, Amritsar, India); Singh, Manwinder; Singh, Surinder; Virk, H.S. *Indian J Pure Appl Phys* v 25 n 5-6 May-Jun 1987 p 235-236.

**076601 LEVELING SYSTEM FOR THE CDF CENTRAL MUON CHAMBERS.** The electronic level sensors used in aligning the drift chambers of the CDF central muon tracking system are described. Operation and readout of the level transducers using CAMAC is outlined. Calibration studies and field use show angle measurement to be better than 0.3 mrad. (Author abstract) 3 refs.

Ascoli, G. (Univ of Illinois, Urbana, IL, USA); Holloway, L.E.; Karlner, Inga; Kruse, U.E.; Sard, R.D.; Simaitis, V.J.; Smith, D.A.; Westhusing, T.K. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 41-45.

**076602 CDF VERTEX TIME PROJECTION CHAMBER SYSTEM.** The vertex time projection chamber (VTPC) system is one of the major components of the charged particle tracking system for the Collider Detector at Fermilab (CDF). The chambers cover about seven units of pseudorapidity ( $\eta$ ) and must be capable of handling substantially more than the 30-35 charged particle tracks produced by typical  $\text{pp}$  collisions at center-of-mass energies of 1.8 TeV. The chambers are optimized to provide the good pattern recognition in the  $r$ - $z$  view required to locate the event vertex, measure the overall event topology, and to complement the  $r$ - $\phi$  tracking in the large axial wire drift chamber that surrounds them. (Edited author abstract) 19 refs.

Snider, F. (Univ of Chicago, Chicago, IL, USA); Binkley, M.; Huth, J.; Kephart, R.; Newman-Holmes, C.; Palanque, S.; Patrick, J.; Yarema, R.; Yeh, G.P.; Zimmerman, T.; Schub, M.; Abe, F.; Kondo, K.; Mimashi, T.; Sekiguchi, M. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 75-91.

**076603 BEAM AND DETECTOR FOR A HIGH-PRECISION MEASUREMENT OF CP VIOLATION IN NEUTRAL-KAON DECAYS.** The  $K^0$  beam and detector used for a high-precision measurement of the CP-violation parameter  $\epsilon'$  at the CERN Super Proton Synchrotron (SPS) are described. The beam provides  $K_L$  and  $K_S$  alternately through a common decay region. The detection of the decays is based on wire chambers and calorimeters without employing a magnet. The trigger and readout system achieve a high selectivity for the suppressed, CP-violating, two-pion decays of the  $K_L$  by incorporation of hard-wired processors. The readout is based on Fastbus for maximum data rates. (Author abstract) 15 refs.

Burkhardt, H. (CERN, Geneva, Switz); Clarke, P.; Cundy, D.; Doble, N.; Gagnon, L.; Hagelberg, R.; Kessler, G.; van der Lans, J.; Mannelli, I.; Miczaika, T.; Sander, H.G.; Schaffer, A.C.; Steffen, P.; Steinberger, J.; Taureg, H.; Wahl, H. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 116-143.

**076604 OPERATION OF LIMITED STREAMER TUBES WITH THE GAS MIXTURE  $\text{Ar} + \text{CO}_2 + n\text{-PENTANE}$ .** The active detectors of the ALEPH hadron calorimeter at LEP consist of plastic streamer tubes

developed in Frascati. The standard gas mixture for the operation of such devices is argon-isobutane (30/70). However, in underground experiments, for safety reasons, one has to reduce the hydrocarbon content. Therefore a study of the behaviour of streamer tubes operated with an  $\text{Ar}/\text{CO}_2/n\text{-pentane}$  mixture has been performed. The influence of gas composition on efficiency, charge distribution and stability of operation has been investigated, and the results of these tests are presented. (Author abstract) 5 refs.

Bagliesi, G. (Univ di Pisa, Pisa, Italy); Baldini-Celio, R.; Batignani, G.; Bencivenni, G.; Bologna, G.G.; Bossi, F.; Bottigli, U.; Bradaschia, C.; Campana, P.; Capon, G.; Catanese, M.G.; Chiarella, V.; De Nino, G.; de Palma, M.; D'Ettore Piazzoli, B.; Dreucci, M. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 144-150.

**076605 PARAMETERS OF ASSEMBLY OF MICROCHANNEL PLATES WITH MICROMETER GAPS.** The characteristics of a herringbone assembly of microchannel plates with gaps of 5 and 15  $\mu\text{m}$  between them are studied. Gain  $K \leq 3.10^7$  with amplitude resolution  $R \geq 30\%$  is achieved in registration of ultraviolet photons and energetic neutral particles; a critical load of approximately 0.1/channel/sec is determined. The assembly can be effectively used when microchannel plates with curved channels are required. The assemblies were exposed to beams of neutral He and Ar atoms with energies of 1.5 and 3 keV and also to ultraviolet photons with a wavelength of 147 nm. (Edited author abstract) 7 refs.

Demchenkova, A.A. (Acad of Sciences of the USSR, Moscow, USSR). *Instrum Exp Tech* v 30 n 5 pt 2 Sep-Oct 1987 p 1182-1185.

**076606 INFLUENCE OF GAS MIXTURE AND PRIMARY IONIZATION ON THE PERFORMANCE OF LIMITED STREAMER MODE TUBES.** We report a study of the dependence of limited streamer mode operation on gas composition. Results are given for the plateau onset voltage, plateau length, charge spectra and pulse width for various fractions of (Ar,  $\text{CO}_2$ , pentane) and (Ar, isobutane). In addition, a series of argon-free strong quenching gas mixtures has been studied which have very attractive characteristics. Chamber lifetime tests for these are also reported. As part of a study of the nature of the limited streamer mode mechanism, the response to X-rays and minimum ionizing particles are compared and differences noted. The character of the primary ionization is found to have a clear effect on the chamber response even in the streamer region. (Author abstract) 13 refs.

An, Ji-Gang (Univ of Chicago, Chicago, IL, USA); Anderson, K.J.; Merritt, F.S.; Oreglia, M.; Filcher, J.E.; Possoz, A.; Schappert, W. *Nucl Instrum Methods Phys Res Sect A* v A267 n 2-3 May 1 1988 p 386-395.

**076607 COMPUTER-CONTROLLED WIRE TENSION MEASUREMENT SYSTEM USED IN THE FABRICATION OF THE CDF CENTRAL DRIFT TUBE ARRAY.** We have developed a sensitive computer-controlled method for measuring the anode wire tensions of individual drift tubes which have a wire support located mid-length along the tube. By resonating the anode wire at higher harmonics of the fundamental resonance frequency, simultaneous measurement of the anode wire tension and verification of the location of the wire support was achieved. The anode wire tension for each drift tube was measured to better than 0.5% accuracy and the location of the anode wire support measured to better than 0.01% for drift tubes 3 m in length. This method was used for measuring the wire tensions of 2226 drift tubes during the fabrication of the CDF central drift tube array. (Author abstract) 7 refs.

Bhadra, S. (Univ of Illinois at Urbana, Urbana, IL, USA); Errede, S.; Fishback, L.; Keutelian, H.; Schlabach, P. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 33-39.



**076608 RADIAL WIRE DRIFT CHAMBERS FOR CDF FORWARD TRACKING.** We describe the design, construction, and operating experience of unique drift chambers with radially strung wires for the Collider Detector of Fermilab (CDF) which cover forward and backward cone angles between  $2^\circ$  and  $10^\circ$ , and  $170^\circ$  and  $178^\circ$ . The chambers are capable of operating in our high rate and high tracking multiplicity environment with excellent multitrack resolution of 2-3 mm and high tracking accuracy of 140  $\mu$ m per wire. Results from the recent running experience will be presented. (Author abstract) 12 refs.

Atac, M. (Fermi Natl Accelerator Lab, Batavia, IL, USA); Foster, G.W.; Newman-Holmes, C.; Para, A.; Patrick, J.; Sekiguchi, M.; Yeh, G.P.; Bellinger, J.; Cline, D.; Mondal, N.K.; Markeloff, R.; Rhoades, J.; Feyzi, F. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 40-50.

**076609 DESIGN AND PERFORMANCE OF A TIME-OF-FLIGHT SYSTEM FOR PARTICLE IDENTIFICATION AT THE FERMILAB COLLIDER.** The design and performance of a TOF system used in a Fermilab collider experiment is evaluated in terms of time, mass, and spatial resolution. The system is designed to survive in a high background environment. The overall time resolution of the TOF system is measured to be  $\sigma=110$  ps. (Author abstract) 12 refs.

Banerjee, S. (Univ of Notre Dame, Notre Dame, IN, USA); Beery, P.D.; Biswas, N.N.; Cason, N.M.; Kenney, V.P.; LoSecco, J.M.; McManus, A.P.; Piekars, J.; Stampke, S.R. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 121-133.

**076610 DETECTOR SYSTEM FOR THE STUDY OF INTERMEDIATE ENERGY NEUTRINO INTERACTIONS.** A 15 t fine-grained neutrino detector and high efficiency anticoincidence system are in operation at the LAMPF beam stop an intense source of neutrinos with a maximum energy of 53 MeV. The primary use of this equipment is in an experiment which is directed towards the observation and cross section measurement of the  $\nu_e e^-$  elastic scattering reaction. The design, operation, and performance of the apparatus is reported. (Author abstract) 20 refs.

Allen, R.C. (Univ of California, Irvine, CA, USA); Bharadwaj, V.; Briscoe, N.; Brooks, G.A.; Chen, H.H.; Delay, R.S.; Doe, P.J.; Hausmann, R.; Juds, H.; Lee, W.P.; Liu, X.-Q.; Mahler, H.J.; Potter, M.E.; Rushton, A.M.; Thompson, T.N.; Wang, K.C. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 177-191.

**076611 TYPE II DEAD-TIME LOSSES BETWEEN DETECTIONS OCCURRING AT RANDOM TIMES WITHIN A GATE-OPEN TIME.** The purpose of this paper is to provide an exact estimate of the probabilities of the various possible dead-time losses between  $n$  detections occurring at random times within a gate-open time of duration  $G$ . This arose as a fundamental problem that needed to be solved as part of a separate study concerned with the analysis of results from neutron multiplicity measurements.

Vincent, C.H. (Ministry of Defence, Aldermaston, Engl). *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 335-337.

**076612 TRIGGER SYSTEM FOR THE TOPAZ DETECTOR AT TRISTAN, KEK.** A trigger system for the TOPAZ detector at the TRISTAN  $e^+e^-$  collider has been developed. The system consists of an energy trigger and a track trigger. The track trigger uses track information from the inner drift chamber, the time-of-flight counters and the time projection chamber. A three-dimensional track reconstruction is performed with high-speed logic arrays. The design and the performance are described. (Author abstract) 13 refs.

Enomoto, R. (Natl Lab for Higher Physics, Tsukuba, Jpn); Tsukada, K.; Ujiie, N.; Ikeda, H.; Yamauchi, M.; Kawabata, S.; Imanishi, A.; Ishii, T.; Maruyama, K.;

Masuda, H.; Okuno, H.; Shiino, K.; Ukai, K.; Shirahashi. *Nucl Instrum Methods Phys Res Sect A* v A269 n 3 Jun 20 1988 p 507-512.

**076613 TOPAZ INNER DRIFT CHAMBER.** We have constructed a cylindrical drift chamber with anode and cathode delay-line readouts, which is the innermost tracking device of the TOPAZ detector. This inner drift chamber (IDC) is used for the tracking of charged particles in both  $r\phi$  and  $rz$  planes. Fast track-finding logics have been developed for the event triggering. We describe the design, the construction and the performances of the IDC in the first beam run. (Author abstract) 12 refs.

Imanishi, A. (Univ of Tokyo, Tanashi, Jpn); Ishii, T.; Kato, S.; Kono, K.; Maruyama, K.; Masuda, H.; Morimoto, T.; Norimura, K.; Ohshima, T.; Okuno, H.; Shiino, K.; Ukai, K.; Yoshioka, M.; Tauchi, T. *Nucl Instrum Methods Phys Res Sect A* v A269 n 3 Jun 20 1988 p 513-521.

**076614 FAST TRACK-FINDING PROCESSOR BASED ON RAM LOOK-UP TABLE FOR THE VENUS DETECTOR AT KEK.** We have developed a fast track-finding processor using signals from the central tracking chamber of the VENUS detector in the TRISTAN experiments. Particle tracks are recognized by a look-up table made with a high-speed static RAM. This method enables us to implement the track finder in the first level triggering. The track finder has been working excellently under heavy background due to synchrotron radiation. A processing time of 110 ns is attained. (Author abstract) 3 refs.

Ohsugi, T. (Hiroshima Univ, Hiroshima, Jpn); Chiba, Y.; Hayashibara, I.; Taketani, A.; Yasuishi, S.; Arai, Y.; Sakamoto, H.; Uehara, S. *Nucl Instrum Methods Phys Res Sect A* v A269 n 3 Jun 20 1988 p 522-526.

**076615 AUTOMATED METHOD FOR MEASURING WIRE TENSIONS IN MULTIWIRED CHAMBERS.** A method is presented for measuring the tension of both signal and field wires in multiwire chambers. Without probes, electrodes, magnets, or mechanical parts, this device is well suited to fully assembled chambers where direct access or view of the wires is impossible. (Author abstract) 8 refs.

Jones, Richard T. (Virginia Polytechnic Inst, Blacksburg, VA, USA). *Nucl Instrum Methods Phys Res Sect A* v A269 n 3 Jun 20 1988 p 550-553.

**076616 SELF-QUENCHING STREAMER DISCHARGE IN PURE CO<sub>2</sub>.** The operative characteristics of the self-quenching streamer mode were investigated using graphite coated plastic tubes flushed with pure CO<sub>2</sub> and, for comparison, with Ar/ICuH<sub>10</sub> in the proportion 1/3. We present data on pulse heights, plateau widths and efficiencies for minimum ionizing particles as a function of high voltage, anode wire diameter and gas pressure. In particular, the detailed time structure of the streamer discharge including afterpulsing was studied with flash ADCs. Aging properties were investigated by irradiating the tubes with a radioactive source. The results show that pure CO<sub>2</sub> can be used for this type of detector. (Author abstract) 18 refs.

Bergstein, H. (RWTH, Aachen, West Ger); Braunschweig, W.; Genzel, H.; Kirschfink, F.-J.; Zitzen, S. *Nucl Instrum Methods Phys Res Sect A* v A269 n 3 Jun 20 1988 p 560-567.

**076617 ELECTROSTATIC DEFLECTOR SYSTEM FOR IDENTIFYING EVAPORATION RESIDUES FOLLOWING FUSION BETWEEN HEAVY IONS.** A detection system was built to identify evaporation residues formed in fusion reactions between heavy ions. The evaporation residues are separated from the beam by an electrostatic deflector. Two gas detectors operated in the same gas volume identify the evaporation residues by their energy, energy loss and time of flight. Position information is used to deduce the evaporation residue angular distribution. Fusion cross sections were measured in the  $^{58}$

Ni +  $^{58}$ Ni system with a sensitivity corresponding to cross section level of approx. 100  $\mu$ b. (Author abstract) 15 refs.

Schicker, R. (State Univ of New York, Stony Brook, NY, USA); Alamanos, N.; Braun-Munzinger, P.; Stachel, J.; Waters, L. *Nucl Instrum Methods Phys Res Sect A* v A269 n 3 Jun 20 1988 p 585-594.

**076618 CHARGE COLLECTION IN PARTIALLY DEPLETED SILICON DETECTORS.** The behavior of partially depleted silicon detectors deserves some attention in the design of large systems such as electromagnetic or hadronic calorimeters in which these detectors are used and conservative operating conditions must be imposed. We have experimentally investigated charge collection from the undepleted region in silicon detectors manufactured for high energy calorimetry by Ansaldo Semiconductors SpA. The observed results are compared with a simple model. (Author abstract) 5 refs.

Fontanelli, F. (Univ di Genova, Genoa, Italy); Ramella, P.; Vitale, S. *Nucl Instrum Methods Phys Res Sect A* v A269 n 3 Jun 20 1988 p 603-606.

**076619 SURFACE STUDIES OF PLASTIC STREAMER TUBES.** This study gives new insight into the possible sources of dark currents and continuous discharges in plastic streamer tubes. It was shown that a normal PVC cathode surface is covered by a large number of nonconductive areas which appear to be composed of clusters of grains, 3-5  $\mu$ m in size. An X-ray analysis suggested that these grains are of CaCO<sub>3</sub>, a filler material in the PVC. We suspect that these grains constitute a major cause for the dark currents by provoking electron emission to the gas volume through the Malter effect. We also showed that a treatment with an anti-static liquid, BREOX B-35, helps to cure the lack of conductivity in the observed non-conductive regions. 15 Refs.

Ellila, Markku (CERN, Geneva, Switz). *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 393-396.

**076620 TRACK DIAMETER & LENGTH MEASUREMENT OF HEAVY IONS IN CR-39 (DOP) PLASTIC TRACK DETECTOR.** Samples of CR-39 (Dop) plastic track detector were exposed vertically as well as at different angles of incidence with respect to the detector surface, to  $^{16}\text{O}$ ,  $^{20}\text{Ne}$ ,  $^{28}\text{Si}$ ,  $^{56}\text{Ni}$  ions of energies 8.7, 7.7, 6.4, 6.4 and 6.5 MeV/N respectively at the Joint Institute of Nuclear Research, Dubna, Moscow. These exposed samples have been etched in 6.25 N NaOH at 70°C. The variation of track diameter with etching time has been studied and total etchable range for different heavy ions in this detector has been found. The energy loss rate,  $dE/dx$  and range of these heavy ions in this detector have been computed theoretically. A comparison has been made with the experimental results. (Edited author abstract) 12 Refs.

Kumar, Shyam (Kurukshetra Univ, India); Garg, A.K.; Singh, N.; Sharma, A.P. *Indian J Pure Appl Phys* v 26 n 1 Jan 1988 p 17-20.

**076621 ELECTRONICALLY CONTROLLED DETECTION OF CHARGED PARTICLES IN NUCLEAR EMULSIONS.** The phenomenon of electric-field stimulated increases in the sensitivity of nuclear emulsion is described. In an emulsion with a low content of AgBr, a double field pulse with alternating sign drives the Ag<sup>+</sup> ions to the grain boundaries and creates an internal polarization field. The effect is used to construct a track detector with electronically controlled sensitivity. (Author abstract) 10 Refs.

Gushchin, E.M. (Moscow Physical Engineering Inst, Moscow, USSR); Lebedev, A.N.; Lopyrev, A. Yu.; Somov, S.V.; Tipografshchik, G.I. *Nucl Instrum Methods Phys Res Sect B* v B34 n 2 Aug 1988 p 269-271.

**076622 CDF DETECTOR: AN OVERVIEW.** The Collider Detector at Fermilab (CDF) is a 5000 t magnetic detector built to study 2 TeV  $p\bar{p}$  collisions at the



Fermilab Tevatron. Even analysis is based on charged particle tracking, magnetic momentum analysis and fine-grained calorimetry. The combined electromagnetic and hadron calorimetry has approximately uniform granularity in rapidity-azimuthal angle and extends down to  $2^\circ$  from the beam direction. Various tracking chambers cover the calorimeter acceptance and extend charged particle tracking down to 2 mrad from the beam direction. Charged particle momenta are analyzed in a 1.5 T solenoidal magnetic field, generated by a superconducting coil which is 3 m in diameter and 5 m in length. (Edited author abstract). 27 Refs.

Abe, F. (Univ of Tsukuba, Jpn); Amidei, D.; Apollinari, G.; Ascoli, G.; Atac, M.; Auchincloss, P.; Baden, A.R.; Barbaro-Galtieri, A.; Barnes, V.E.; Barsotti, E.; Bedeschi, F.; Belforte, S.; Bellettini, G.; Bellinger, J.; Besniger, J.; Beretvas, A. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 387-403.

**076623 SILICON COUNTER ARRAY FOR  $^2\text{He}$  DETECTION.** A multicounter array consisting of four Si detector telescopes was developed for the coincidence measurement of two protons with small relative energy ( $^2\text{He}$ ). Silicon detectors were designed and fabricated so that they have large solid angles when they are assembled to form a counter array. A total effective solid angle of 5-7 msr was achieved for the detection of 20-50 MeV  $^2\text{He}$  with relative energy lower than 1 MeV. A compact amplifier system was developed using low-noise hybrid ICs to treat many signals from the counter array. (Author abstract). 13 Refs.

Motobayashi, T. (Rikkyo Univ, Toshima, Jpn); Satoh, S.; Murakami, H.; Sakai, H.; Ishihara, M. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 491-496.

**076624 MODULAR NaI(Tl) DETECTOR FOR INTERMEDIATE ENERGY PHOTONS.** We describe the properties of a detector array made up of 64 NaI(Tl)  $406 \times 63 \times 63 \text{ mm}^3$  modules, used as an intermediate energy photon spectrometer. We obtain an energy resolution of 6% FWHM at 129 MeV, a time resolution of 1 ns FWHM and a resolution of 48 mm FWHM for the location of the impact point on the front face of the detector. The modularity allows to some extent a discrimination between photons and neutrons. We also present the response of the detector to 69 MeV neutrons. (Author abstract). 6 Refs.

Bay, A. (Univ de Lausanne, Lausanne, Switz); Joseph, C.; Loude, J.F.; Perroud, J.P.; Ruegger, D.; Schori, O.; Steiner, D.; Tran, M.T. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 497-506.

**076625 COMPACT AND GRIDLESS CHANNEL PLATE START DETECTOR.** A small gridless time detector consisting of an electron emitting foil and two channel plates with central holes and without any grid or wire, i.e. with 100 percent transmission, is described. For  $\alpha$ -particles a time resolution of 90 ps and an efficiency up to a maximum of about 50 percent have been obtained. The efficiency for heavily ionizing particles like evaporation residues or fission fragments is 100 percent and with an elastically scattered 26 MeV/amu  $^{32}\text{S}$  beam an overall time resolution of 60 ps achieved. (Author abstract). 10 Refs.

Nakagawa, T. (Hahn-Meitner-Inst Berlin GmbH, Berlin, West Ger); Bohné, W. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 523-526.

**076626 LOW NOISE GERMANIUM RADIAL DRIFT DETECTOR.** A germanium radial drift detector with a built-in drift field has been fabricated using conventional processing techniques. It has an active area of  $5 \text{ cm}^2$  and a full depletion capacitance of 1.4 pF. It exhibited low noise and good energy resolution. Detector pulse shapes have been measured and found to agree well with the calculated shape. (Author abstract). 5 Refs.

Luke, Paul N. (Lawrence Berkeley Lab, Berkeley, CA, USA). *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 567-570.

**076627 CRYOGENIC DETECTORS OF PARTICLES: HOPES AND CHALLENGES.** The various methods proposed for cryogenic detection of particles, the current status of their development, and their potential applications are reviewed. The discussion covers quasiparticle detectors and phonon detectors. An extensive bibliography is included as well as a table summarizing cryogenic detector developments identifying institutions and their particular physics interests. 75 refs.

Sadoullet, Bernard (Univ of California, Berkeley, CA, USA). *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 47-54.

**076628 PHONON-MEDIATED PARTICLE DETECTION.** When an incident particle collides with an electron or nucleus in an insulating crystal, the recoil kinetic energy is converted rapidly into a burst of low-energy phonons. If the crystal is very pure and free of defects, and if it is very cold ( $T \approx 0.1 \text{ K}$ ), the phonons will propagate ballistically for distances of several centimeters. The authors report on experiments with two types of superconducting phonon sensors being considered for use on a new kind of particle detector, which is based on this effect. The device, which is called a Silicon Crystal Acoustic Detector (SiCAD), reads out phonons generated by particle scattering events. 7 refs.

Neuhauser, B. (San Francisco State Univ, CA, USA); Cabrera, B.; Martoff, C.J.; Young, B.; Lee, A. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 65-69.

**076629 PHONON MEDIATED POSITION RESOLVED DETECTION OF  $\alpha$ -PARTICLES WITH SUPERCONDUCTING TUNNEL JUNCTIONS.** The authors report that 5-MeV  $\alpha$ -particles bombarding the back of a silicon wafer (3-mm thick) through two collimating holes of 0.75-mm distance were simultaneously detected with three Al tunnel junctions (5-mm separation) at the opposite face of the wafer. Signals from the junctions originated from phonons traveling ballistically from the region of absorption to the crystal surface. The highly anisotropic phonon flux that arises from phonon focusing effects and the relative timing of pulses from different junctions allowed a clear separation of events from  $\alpha$ -particles passing through different holes. 9 refs.

Peterreins, T. (Tech Univ Munich, Garching, West Ger); Probst, F.; Feilitzsch, F.v.; Kraus, H. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 70-72.

**076630 APPLICATIONS OF SUPERHEATED SUPERCONDUCTING DETECTORS.** When an incident particle collides with 8- $\mu\text{m}$  superheated superconducting granules, if the deposition of energy within the granule is sufficient to overcome an energy threshold, the granule will change state. The Meissner effect characteristic of the superconducting state suddenly vanishes and the magnetic field penetrates into the granule, causing a change of flux in a pickup coil containing this granule. This effect provides a practical detector if large numbers of granules are used. X-ray imaging devices, transition-radiation detectors and indium solar neutrino detectors are briefly presented, together with a discussion of the main features of this type of detector. 12 refs.

de Bellefon, A. (Coll de France, Paris, Fr); Broskiewicz, D.; Bruere-Dawson, R.; Espigat, P.; Mettout, B.; Perrin, N.; Limagne, D.; Yuan, L.C.L.; Waysand, G. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 73-77.

**076631 AVERAGE ENERGY NEEDED TO PRODUCE AN ELECTRON-HOLE PAIR IN GASE NUCLEAR PARTICLE DETECTORS.** Gallium selenide (GaSe) detectors, which were fabricated by evaporating small electrodes of various metal films (Au, Al, In, In + Hg, Ag, and Sn) onto 50- to 150- $\mu\text{m}$ -thick plates cleaved from Bridgman-grown crystals, have been tested. One detector exhibited pulse heights that corresponded to 4.5

eV, possibly 4.0 to 4.3 eV, as an average energy necessary to produce an electron-hole pair for 5.5-MeV alpha-particle irradiation. These measured values are smaller than the 6.3 eV predicted by the Klein formula. 4 refs.

Sakai, Eiji (JAERI, Japan Atomic Energy Research Inst, Tokai, Jpn); Nakatani, Hideo; Tatsuyama, Chie; Takeda, Fumio. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 85-88.

**076632 DESIGN AND FABRICATION OF ADVANCED HYBRID CIRCUITS FOR HIGH ENERGY PHYSICS.** Current design and fabrication techniques of hybrid devices as applied to the Stanford Linear Collider Large Detector (SLD) are discussed. Methods of developing layouts ranging from hand-cut templates to advanced designs utilizing CAD tools with special hybrid design software were applied. Physical and electrical design rules for good yield and performance are discussed. Fabrication and assembly of a variety of SLD hybrids using different construction methods are described. 7 refs.

Haller, G.M. (Stanford Univ, CA, USA); Moss, J.; Freytag, D.R.; Nelson, D.; Yim, A.; Lo, C.C. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 217-221.

**076633 DATA ACQUISITION FOR THE HILI DETECTOR.** A large acceptance, multisegmented detector system capable of the simultaneous detection of heavy ions and light ions (HILI) has been constructed. The heavy ions are detected with a segmented gas-ionization chamber and a multiwire proportional counter, while the light ions are detected with a 192-element plastic 'phoswich' hodoscope. Processing the large number of signals is accomplished through a combination of CAMAC and FASTBUS modules and preprocessors and a host mini-computer. Details of the data acquisition system and the reasons for adopting a dual-standard system are discussed. A technique for processing signals from an individual hodoscope detector is presented. 4 refs.

Teh, K.M. (Oak Ridge Natl Lab, TN, USA); Shapira, D.; McConnell, J.W.; Kim, H.; Novotny, R. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 272-276.

**076634 TESTS OF THE SGS D779 BASED READOUT ELECTRONICS FOR THE SLD LIMITED STREAMER TUBE STRIPS.** A study has been made of the properties of the SGS D779-based readout electronics for limited streamer tubes, both with pulses from a pulse generator and with strip pulses from the actual chambers to be used in the SLD detector. To accommodate the special requirements of the SLD detector, a hybrid circuit has been developed and tested that is capable of operating with pulses from the strips of tubes operated below the limited-streamer-node voltages. 6 refs.

Beoncinii, F. (Istituto Nazionale di Fisica Nucleare, Pisa, Italy); Bilei, G.M.; Castaldi, R.; Cazzola, U.; Dell'Orso, R.; Verdini, P.G. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 311-315.

**076635 GERMANIUM PARTICLE SPECTROMETER FOR DETECTING 14 MeV RECOIL PROTONS.** A description is given of a high-purity 7-cm $^2$  germanium detector used as a particle detector for proton energy measurements from an annular polyethylene radiator. The spectrometer system has been developed for neutron measurements to detect the 14-MeV DT reaction. The electrical and radiation performance of the detector is described, as is the method of construction of the experimental single-stage assembly. 8 refs.

Howes, J.H. (Harwell Lab, Oxon, Engl); Allsworth, F.L. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 389-391.



**076636 DESIGN AND PERFORMANCE OF TOPAZ TPC-TRIGGER.** A new track-finding algorithm for use with the TOPAZ time projection chamber (TPC) has been developed. The logic not only finds the number of tracks, but also calculates their vertex positions. It takes care of the sector boundary crossing tracks. Test results for a prototype TPC trigger are reported. Vertex resolution of less than 10 cm (RMS) in the beam direction was achieved. 13 refs.

Enomoto, R. (Natl Lab for High Energy Phys, Tsukuba, Jpn); Tsukada, K.; Ujii, N.; Shirahashi, A. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 419-423.

**076637 STATUS OF THE SILICON STRIP VERTEX DETECTOR FOR THE MARK II EXPERIMENT AT THE SLC.** A silicon-strip vertex detector is being constructed for use in the Mark II detector in the study of  $Z^0$  decays at the SLAC Linear Collider. The status of the project, including the performance of the individual silicon detector modules, is presented. The discussion covers beam tests, vertex resolution, detector modules, module performance, and mechanical support and alignment. 3 refs.

Adolphsen, Chris (Univ of California, CA, USA); Gratta, Giorgio; Litke, Alan; Schwarz, Andreas; Turala, Michal; Breakstone, Alan; Parker, Sherwood; Barnett, Bruce; Dauncey, Paul; Drew, David; Jacobsen, Robert; Luth, Vera. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 424-427.

**076638 RECENT DEVELOPMENT OF DETECTORS WITH INTEGRATED CAPACITORS AND POLYSILICON RESISTORS.** A silicon microstrip detector has been developed with capacitive coupling of the diode strips to the metallization and with polysilicon bias resistors to each diode. It allows the decoupling of the leakage current from the input to the charge-sensitive amplifier. Results are given on the coupling capacity and the breakdown voltage as well as on the polysilicon line resistance. It is found that the coupling capacitance, varying between 25 pF and 80 pF as a function of the oxide thickness, is large enough to avoid capacitance signal losses to the backplane. The 200-nm-thick silicon oxide withstands a potential difference of 100 V or more, thus allowing the operation of the detector with the metal strips and backplane at a ground potential and the bias voltage applied to the diodes. 3 refs.

Evensen, L. (SI, Oslo, Norw); Hansen, T.E.; Horisberger, R.; Hubbeling, L.; Kaukouen, H.-P.; Maehlum, G.; Piesert, A.; Tuuva, T.; Weilhammer, P.; Zalewska, A. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 428-431.

**076639 TEST STANDS FOR THE CENTRAL DRIFT CHAMBER FRONT END HYBRID IN THE STANFORD LINEAR COLLIDER DETECTOR.** The central drift chamber (CDC) of the SLAC Linear Collider Detector (SLD) uses 1280 front-end electronic hybrid modules. Each of these modules contains over 450 components and performs numerous functions. The four test stands for production and detailed circuit characterizations of these hybrids are described, as well as the performance of some of the important functions of the test systems. 3 refs.

Lo, C.C. (Lawrence Berkeley Lab, Berkeley, CA, USA); Yim, Alfred K. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 456-459.

**076640 CYLINDRICAL DRIFT CHAMBER FOR THE MEASUREMENT OF  $K \rightarrow \pi\pi\pi$  DECAY.** A cylindrical drift chamber has been constructed for the study of a rare kaon decay. A description is given of the design and construction of the chamber. Data from two prototype chambers and initial results from the final chamber are presented. 2 refs.

Cresswell, J.V. (TRIUMF, Vancouver, BC, Can); Ahmad,

S.; Blackmore, E.W.; Bryman, D.A.; Khan, N.; Kuno, Y.; Numao, T. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 460-463.

**076641 AGING EFFECTS IN LOW PRESSURE WIRE CHAMBERS CONTAINING TMAE.** The effects of aging in multiwire proportional chambers operated at low pressure with gas mixtures containing TMAE has been studied in connection with their use as a form of readout of  $BaF_2$  crystals in high-rate environments. Aging was induced by ultraviolet light, which simulated high radiation exposure of  $BaF_2$  crystals. Measurements were made on the loss in gain as a function of the total charge removed from the anode wires under various operating conditions. The results indicate a considerable improvement over previous aging effects measured at atmospheric pressure. 10 refs.

Woody, C. (Brookhaven Natl Lab, Upton, NY, USA). *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 493-497.

**076642 HUMIDITY TEMPERATURE TEST ON THE HLNC INSTRUMENT.** This paper presents the findings of a laboratory study made to determine the effects of unusual climatic conditions on high-level neutron coincidence counters (HLCNs). We examine the capability of the instrument when undesirable temperatures and/or humidities are present, the change in count rate as temperature and humidity increase, and the extent of humidity/temperature interaction. (Author abstract) 1 ref.

Goldman, A. (Los Alamos Natl Lab, Los Alamos, NM, USA); Augustson, R.; Karlin, E.W. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 667-669.

**076643 FRONTIER DETECTORS FOR FRONTIER PHYSICS, PROCEEDINGS OF THE THIRD PISA MEETING ON ADVANCED DETECTORS.** This conference proceedings contains 38 papers, all of which are separately indexed and abstracted. The papers address recent developments in particle detectors, and measurement techniques. Particle beam tracking equipment is discussed. Lepton identification and measurement, techniques for measuring energy, and methods for detecting rare decays are presented. Signal processing and data acquisition techniques are given coverage. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10811 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Amendolia, S.R. (Ed.) (Istituto Nazionale di Fisica Nucleare, Pisa, Italy); Bertolucci, E. (Ed.); Giorgi, M. (Ed.). *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 260p.

**076644 TIME EXPANSION CHAMBER AS A VERTEX DETECTOR.** A high-resolution drift chamber based on the time expansion principle has been built as a vertex detector for the Mark J experiment at DESY. The chamber design and the associated control and readout system are described. Results on chamber performance obtained from test beam measurements and first results from running at PETRA are reported. (Author abstract) 19 refs.

Anderhub, H. (ETH, Zurich, Switz); Anders, H.; Ansari, S.; Boehm, A.; Bourquin, M.; Burger, J.; Chen, M.; Commichau, V.; Deutschmann, M.; Dhina, M.; Draheim, K.J.; Fehlmann, J.; Fong, D.; Gessner, U.; Hangarter, K.; Hausammann, R. *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 1-9.

**076645 SILICON DETECTORS IN ELECTRO-**

**MAGNETIC AND HADRONIC CALORIMETRY.** A review of investigations performed by SICAPO collaboration at CERN and Si/W and Si/U sandwich calorimeters employing silicon detectors as active medium is presented. Experimental results, such as the response of sensed energy versus incoming electron energy and depleted layer width, of the longitudinal and lateral development of electromagnetic showers and of the energy resolution, are described. Mosaic modules of silicon detectors, which enable the construction of silicon sampling hadronic calorimeters, are also given. A comparison of results from SICAPO, Hamburg (Si/Pb) and from Tokyo (Si/Pb and Si/W) calorimeters is shown. (Author abstract) 17 refs.

Rancoita, P.G. (INFN Milano, Milan, Italy); Seidman, A. *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 84-93.

**076646 DELPHI SILICON STRIP MICROVERTEX DETECTOR.** The silicon strip microvertex detector for the DELPHI experiment at LEP is presented. It consists of two cylindrical layers with a total of 165,888 strips. The design parameters of the final project are described. The microstrip counters have a pitch of 16.6  $\mu$ m, and are read out every 50  $\mu$ m using the capacitive charge division method. The electronics used is the Microplex chip, an NMOS integrated circuit, which provides 128 channels of low noise charge sensitive amplifiers with multiplexed analog output. Results of signal-to-noise ratio from beam tests on prototype detectors are given and discussed. (Author abstract) 11 refs.

Anzivino, G. (CERN, Geneva, Switz); Horisberger, R.; Hubbeling, L.; Hyams, B.D.; Tuuva, T.; Weilhammer, P.; Zalewska, A.; Caccia, M.; Meroni, C.; Vegni, G.; Tyndel, M.; Bingefors, N. *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 215-220.

**076647 ON THE OPTICAL READOUT OF GAS AVALANCHE CHAMBERS AND ITS APPLICATIONS.** Gaseous avalanche counters with mixtures containing the vapor of triethylamine are coupled to an optical readout system. Different configurations are studied in order to visualize ionization tracks produced by high-energy particles or images caused by vacuum ultraviolet light. This instrument has potential applications in the study of rare or complex events - such as the search for double-beta and proton decay - or Cherenkov ring imaging. (Author abstract) 17 refs.

Suzuki, M. (CERN, Geneva, Switz); Breskin, A.; Charpak, G.; Daubie, E.; Dominik, W.; Fabre, J.-P.; Gaudéan, J.; Sauli, F.; Sauvage, D.; Strock, P.; Zeludziwicz, T. *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 237-242.

**076648 ADVANCES IN EXPERIMENTAL METHODS FOR COLLIDING BEAM PHYSICS.** This conference proceedings contains 41 papers, all of which are separately indexed and abstracted. The papers discuss innovations and advances in experimental methods for colliding beam physics. The following topics are presented: central tracking systems, vertex detection, silicon devices particle identification, beam measurements, calorimetry, and electronic equipment. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11017 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Kirk, W. (Ed.) (SLAC, Stanford, CA, USA). *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 350p.



**076649 CENTRAL AND FORWARD TRACKING CHAMBERS OF CDF.** The Collider Detector at Fermilab is currently study 1.8 TeV  $\bar{p}$ - $p$  interactions at the Fermilab Tevatron. This paper describes the design and construction of the detector's tracking chambers in the light of the measurement requirements dictated by physics goals. The chambers described are the Forward Tracking Chamber, the Central Tracking Chamber, the Central Drift Tubes, and the Vertex Time Projection Chamber. (Author abstract)

Wagner, R.L. (Fermilab, Batavia, IL, USA). *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 1-10.

**076650 OPAL JET CHAMBER.** The characteristic features of the OPAL jet chamber are described, such as the mechanical and electrical structure, the readout electronics, the gas system, and the laser setup for calibration. Results on spatial resolution and on particle identification power, obtained with a full scale prototype chamber, are presented which show that in the final chamber the anticipated performance can be reached. (Author abstract) 14 refs.

Heuer, R.D. (CERN, Geneva, Switz); Wagner, A. *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 11-19.

**076651 MULTICELL DRIFT CHAMBERS.** Vector drift chambers have recently been commissioned for use at high energy storage rings, and new ones are under development. They provide a powerful technique, with good performance features built into the geometry. Further advances can be expected. (Author abstract) 39 refs.

Saxon, D.H. (Rutherford Appleton Lab, Didcot, Engl). *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 20-32.

**076652 PERFORMANCE OF A SCINTILLATING FIBRE DETECTOR FOR THE UA2 UPGRADE.** A large scintillating fibre detector for the UA2 experiment at the CERN  $\bar{p}$ - $p$  Collider is under construction. It will be used for tracking and electron identification. The performance of a full scale test module containing 960 fibres of 2.1 m length and 1 mm diameter is described. (Author abstract) 4 refs.

Ansorge, R.E. (Univ of Cambridge, Engl); Aurouet, C.; Bareyre, P.; Bonamy, P.; Booth, C.N.; Bouchard, M.; Bourdinaud, M.; Cordier, M.; Crittenden, J.; Dupont, J.; Dupraz, J.; Einsweiler, K. *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 33-49.

**076653 OPERATING EXPERIENCE WITH THE MARK J TIME EXPANSION CHAMBER.** A new drift chamber concept with a special charge-sampling geometry, pulse shaping electronics and a 100 MHz flash ADC readout was for the first time operated in a colliding  $e^+e^-$  beam environment. The detector formed part of the MARK J experiment at PETRA (DESY) during the last year before its final shutdown in November 1986. Operated with a  $\text{CO}_2/\text{i-C}_4\text{H}_{10}$  gas mixture at 1.9 bar, an intrinsic resolution of 40  $\mu\text{m}$  for Bhabha events has been achieved. (Author abstract) 18 refs.

Anderhub, H. (ETH, Zurich, Switz); Anders, H.; Ansari, S.; Boehm, A.; Bourquin, M.; Bucher, A.; Burger, J.; Chen, M.; Commichau, V.; Deutschmann, M.; Dhina, M.; Fehlmann, J. *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 50-59.

**076654 DRIFT CHAMBER VERTEX DETECTORS FOR SLC/LEP.** Factors influencing the design of drift chamber vertex detectors for SLC and LEP are discussed including global strategy, chamber gas, cell design, and signal processing. The designs of the vertex chambers for

the L3 and OPAL experiments at LEP and the Mark II experiment at the SLC are described. (Author abstract) 7 refs.

Hayes, Kenneth G. (Stanford Univ, Stanford, CA, USA). *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 60-68.

**076655 STUDY OF THE IDC AS A HIGH RATE VERTEX DETECTOR FOR THE ZEUS EXPERIMENT.** Measurements with the induction drift chamber (IDC), resulting in a position resolution of  $\sigma = 25 \mu\text{m}$ , are reported. The angular effect is determined, and Monte Carlo calculations show that the error is dominated by ionisation fluctuations. The application of this detector principle towards a high rate vertex detector for an  $e$ - $p$  collider is discussed, and a solution for the high density readout presented. (Author abstract) 11 refs.

Walenta, A.H. (Univ of Siegen, Siegen, West Ger); Kapitza, H.; Kraemer, M.; Jonsson, L.; Roderburg, E.; Zech, G. *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 69-77.

**076656 FAST TRACKING DETECTOR USING MULTIDRIFT TUBES.** We describe a tracking detector designed as an assembly of multidrift tube modules because of its fast time-resolution and good position accuracy, coupled with high reliability, the device seems suitable for operation as vertex detector at a collider, and for other high-rate applications. Recent measurements of localization accuracy obtained when operating the modules with a dimethyl ether gas filling are presented. (Author abstract) 10 refs.

Bouclier, R. (CERN, Geneva, Switz); Charpak, G.; Erskine, G.A.; Guerard, B.; Santiard, J.C.; Sauli, F.; Solomey, N. *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 78-84.

**076657 MARK III VERTEX CHAMBER: STUDIES USING DME.** We have performed studies using a prototype of a pressurised wire vertex chamber with 8 mm diameter straw geometry. We obtained 35  $\mu\text{m}$  spatial resolution using dimethyl ether (DME) at 1 bar, and 30  $\mu\text{m}$  using argon/ethane (50/50 mixture) at 4 bar. Preliminary studies show the DME to adversely affect such materials as aluminised Mylar and Delrin. (Author abstract) 1 ref.

Pitman, Dale (Stanford Linear Accelerator Cent, Stanford, CA, USA). *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 85-87.

**076658 PROSPECTS FOR COLLIDER VERTEX DETECTORS.** The technologies available for vertex detection are discussed. The detection techniques now available do not limit the ultimately attainable resolution. The limitations are set first by multiple Coulomb scattering of outgoing tracks and secondly by how close-in detectors can be placed and still function in the radiation backgrounds. (Author abstract) 4 refs.

Ritson, David M. (Stanford Univ, Stanford, CA, USA). *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 88-92.

**076659 SILICON STRIP VERTEX DETECTOR FOR THE MARK II EXPERIMENT AT THE SLAC LINEAR COLLIDER.** In the near future the Mark II experiment will begin the study of the  $Z^0$  at the SLAC Linear Collider (SLC). In order to study the decays of the  $Z^0$  to short-lived particles, the authors are developing a silicon strip vertex detector (SSVD) for use in the Mark II detector. The physics motivation and preliminary design for the SSVD have been given. In this paper, the present design and status of this device are described.

Litke, Alan (Univ of California, Santa Cruz, CA, USA); Adolphsen, Chris; Schwarz, Andreas S.; Turala, Michal; Steiner, Alan; Breakstone, Alan; Parker, Sherwood; Lueth, Vera; Barnett, Bruce; Dauncey, Paul; Drewer, David. *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 93-98.

**076660 CCD VERTEX DETECTORS.** The characteristics and use of charge coupled devices (CCDs) as high precision tracking detectors are reviewed. The current status of the SLD vertex detector is reported upon. (Author abstract) 8 refs.

Watts, S.J. (Brunel Univ, Uxbridge, Engl). *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 99-104.

**076661 STATUS OF SPARK COUNTERS WITH A LOCALIZED DISCHARGE.** A particle identification time-of-flight system based on spark counters has been developed at Novosibirsk. The main parameters of this system are: the counter time resolution  $\sigma_t = 25$  ps, the material thickness is 0.1 radiation lengths, the geometrical thickness is 100 mm. At KEK Japan, spark counters with a time resolution  $\sigma_t = 150$  ps are planned as end cap counters for the TOPAZ detector. The status of these works is described. (Author abstract) 15 refs.

Pestov, Yu.N. (Inst of Nuclear Physics, Novosibirsk, USSR). *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 150-156.

**076662 DELPHI HIGH DENSITY PROJECTION CHAMBER.** The development of the high density projection chamber (HPC) and its realization as barrel electromagnetic calorimeter for the DELPHI experiment at LEP have been described. The project is now in its construction phase. Full-size detector modules are available and have undergone extensive tests. The present paper will not come back to the detector principle and its physics motivations. It will rather present the status of detector construction and some of the developments in mechanics and readout techniques which have taken place around this new device. 7 refs.

Fischer, H.G. (CERN, Geneva, Switz). *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 218-222.

**076663 ANALOG CCD PIPELINE FOR ZEUS.** The ZEUS detector at HERA must have a fundamentally different trigger and data acquisition structure than other existing colliders. A pipelined structure is required because of the short (96 ns) bunch crossing interval, and the presence of a high, proton-related background. A beam-gas event rate  $> 10$  kHz is expected in the vicinity of the detector. The trigger and data acquisition pipelines for the calorimeter are described. A custom integrated circuit is required for the data acquisition pipeline, and both a CCD and a switched capacitor design effort is described. (Author abstract) 5 refs.

Sippach, F.W. (Columbia Univ, New York, NY, USA). *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 321-325.

**Accessories** See Also ELECTRONIC CIRCUITS, PULSE SHAPING—Performance.

**076664 INTELLIGENT, COMPUTER-INDEPENDENT MULTICHANNEL SCALER.** An inexpensive multichannel scaler is described which incorporates a dedicated 6502 microprocessor. The instrument may be interfaced to any computer with an RS232 serial port, and is intended to relieve powerful mini- and microcomputers of the mundane tasks associated with multichannel scaling. The new instrument allows the supporting software to control all the parameters associated with the acquisition



of data. It is also capable of performing functions that have previously been impossible with conventional multi-channel scalars. The instrument has been successfully applied to a number of high resolution electron impact spectrometers. (Edited author abstract) 13 refs.

Howell, S.K. (Manchester Univ, Manchester, Engl). *J Phys E* v 20 n 10 Oct 1987 p 1187-1192.

**Applications** See Also AEROSOLS—Atmospheric.

**076665 LARGE AREA MULTIWIRED CHAMBER  $\Delta E$ -E TELESCOPE FOR (n, Z) STUDIES IN A CONTINUOUS ENERGY NEUTRON BEAM.** Multi-wire chambers have been constructed for detecting reaction products created in a continuous energy neutron beam ranging from 15 to 50 MeV. The results achieved with the large area multiwire chamber  $\Delta E$ -E setup operated in the continuous energy neutron beam support the conclusion that neutron induced reactions on nuclei with small cross sections can be measured. The delay line readout for determining trajectories of charged reaction products represents an easy way for such low count-rate experiments. The quality of the spectroscopic information can be improved in the future by applying sodium iodide crystals for the determination of the residual energy of the charged reaction products. (Edited author abstract). 16 Refs.

Doll, P. (Kernforschungszentrum Karlsruhe Inst fuer Kernphysik I, Karlsruhe, West Ger); Brady, F.P.; Ford, T.D.; Garrett, R.; Krupp, H.; Klages, H.O. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 437-443.

## Calibration

**076666 RESULTS OF THE CALIBRATION OF MULTICELL DRIFT CHAMBER PROTOTYPES FOR THE L3-LEP MUON SPECTROMETER.** Prototypes of large drift chambers designed to measure the coordinate of the muons along the electron-positron beam direction in the L3-LEP muon spectrometer, have been built in the CIEMAT-JEN. We report measurements of the drift velocity and space resolution obtained with these modules. (Author abstract) 6 refs.

Cerrada, M. (CIEMAT-JEN, Madrid, Spain); Duran, I.; Gonzalez, E.; Martinez, L.; Olmos, P.; Salicio, J.; Willmott, C. *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 343-350.

**076667 CALIBRATIONS REQUIREMENTS AND METHODS FOR LIQUID-BORNE PARTICLE COUNTERS.** This paper describes present U.S. practices for calibrating optical liquid-borne particle counters (APCs). Operation of these instruments is described briefly for both light extinction and scattering instruments in order to help the reader understand why empirical calibration is necessary. Calibration requirements are pointed out in terms of the need to verify both particle sizing and particle counting accuracy. Two calibration methods are currently used in the U.S. One is based on size and count response to a suspension of sized isotropic latex spheres. The other is based on APC adjustment to match the stated size distribution of a test dust polydisperse suspension at a specific concentration. Both methods are described and some advantages and problems are presented. (Author abstract) 6 refs.

Lieberman, Alvin F. (Particle Measuring Systems, Fremont, CA, USA). *J Environ Sci* v 31 n 3 May-Jun 1988 p 34-36.

**076668 STRAIGHT LINE CALIBRATION IN DRIFT CHAMBERS OVER EIGHT METERS.** Results are presented from a feasibility study of the use of UV nitrogen lasers for the alignment of a large system of stacked drift chambers. They prove that a straight line calibration is possible over a distance of 8 m with deviations of less than 10  $\mu$ m. The results could be reproduced by a computer simulation. (Author abstract) 8 refs.

Hartjes, Fred (NIKHEF-H, Amsterdam, Neth); Konijn,

Jan; Peng, Yue. *Nucl Instrum Methods Phys Res Sect A* v A269 n 3 Jun 20 1988 p 544-549.

**076669 LASER CALIBRATION SCHEME FOR THE UA1 CENTRAL DETECTOR AT HIGH LUMINOSITY (ACOL).** For the large central drift chambers of the UA1 detector significant geometrical distortions are to be expected, when the new SPS p<sup>+</sup>-p<sup>-</sup> collider program (ACOL) provides a 5 to 10-fold increase in luminosity over present beam intensities. The use of straight tracks from a laser calibration system can help in understanding and mapping these distortions. Such a system is briefly described in this paper. Special emphasis is put upon the selection of suitable doping seeds needed to increase the laser ionization yield in the drift chamber gas. (Author abstract) 9 refs.

Beingessner, Sean P. (Univ of Victoria, Victoria, Can); Meyer, Thomas C.; Vuillemin, Vincent; Yvert, Michel. *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 26-30.

**Components** See Also SPECTROMETERS—Components.

**076670 LARGE DRIFT CHAMBERS FOR FUTURE DETECTORS.** The design and construction of simple and stable drift chambers, suited for production in large quantities and sizes, is presented. These chambers are under construction for the muon detector of the L3 experiment at LEP. (Author abstract) 2 refs.

Willmott, Carlos (Junta de Energia Nuclear, Madrid, Spain). *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 10-13.

## Construction

**076671 CONSTRUCTION AND OPERATION OF A 3m $\times$ 1m DRIFT CHAMBER.** A description of a large area drift chamber used at LAMPF and currently in use at Fermilab is given. Chamber construction is presented, and electronics for both LAMPF and Fermilab are described. Parameters relating to both areas of operation are presented. Since these tests were generally performed with low energy particles, multiple scattering effects in the spectrometer are non-negligible. As a result, the measured spatial resolution of these chambers is generally an upper limit to the true resolution. Typical resolutions obtained with the daily line electronics were  $\pm 210$   $\mu$ m per plane averaged over the whole chamber during the np elastic scattering experiments. These data include a wide range of incident angles (up to approximately 45°). (Edited author abstract) 5 Refs.

Haberichter, W. (Argonne Natl Lab, Argonne, IL, USA); Kasprzyk, T.; Shimizu, H.; Spinka, H.; Stanek, R.; Burleson, G.; Garnett, R.; Tobin, J. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 361-372.

## Control

**076672 MULTI-DATA ACQUISITION CONTROLLER FOR POSITION SENSITIVE DETECTORS.** An on-line multi-data acquisition controller system has been designed to be connected to a DRU-11 interface as a peripheral to a PDP11/44 computer (a host). The system was specifically designed for practical use of multiple detector systems which consist of two  $\Delta E$  detectors and a position sensitive detector. (Author abstract) 2 refs.

Sato, O. (Tohoku Univ, Sendai, Jpn); Yamaya, T.; Kotajima, K.; Hasegawa, K. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 225-228.

**Design** See Also NEUTRONS—Detectors.

**076673 DESIGN, CONSTRUCTION, PROTOTYPE TESTS AND PERFORMANCE OF A VERTEX**

**CHAMBER FOR THE MAC DETECTOR.** The design considerations, construction techniques, prototype tests and performance characteristics of a pressurized drift chamber used in the MAC detector at PEP are described. We also describe resolution studies performed with a prototype chamber in a SLAC test beam. 19 refs.

Ash, W.W. (Univ of Colorado, Boulder, CO, USA); Band, H.R.; Bloom, E.D.; Bosman, M.; Camporesi, T.; Chadwick, G.B.; Delfino, M.C.; De Sangro, R.; Ford, W.T.; Gettner, M.W.; Goderre, G.P.; Godfrey, G.L.; Groom, D.E.; Hurst, R.B.; Johnson, J.R.; Lau, K.H. *Nucl Instrum Methods Phys Res Sect A* v A261 n 3 Nov 15 1987 p 399-419.

**076674 DESIGN AND PERFORMANCE OF MODULARIZED NaI(Tl) DETECTORS WITH RECTANGULAR CRYSTAL ELEMENTS: AN ARRAY OF 49 AND THE CRYSTAL BOX.** An array of 49 NaI(Tl) modules each 20 inch in depth and 2.5 inch  $\times$  2.5 inch in cross section has been constructed and its properties, especially energy resolution, explored for positrons in the range 20 MeV-18 GeV. A subsequent much larger detector, the Crystal Box, has also been constructed from 396 modules of the same cross section, but mostly 12 inch in depth, and operated as a  $\gamma$ -ray and positron detector in a search for rare muon decays. The calibration procedure used for the Crystal Box and its characteristic resolutions in energy, impact point and time are described. (Author abstract) 6 refs.

Wilson, S.L. (Stanford Univ, Stanford, CA, USA); Hofstadter, R.; Hughes, E.B.; Lin, Y.C.; Parks, R.; Ritter, M.W.; Rolfe, J.; Bolton, R.D.; Bowman, J.D.; Cooper, M.D.; Frank, J.S.; Hallin, A.L.; Heusi, P.; Hoffman, C.M.; Hogan, G.E.; Mariam, F.G. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 263-84.

**076675 CDF CENTRAL MUON DETECTOR.** Design, construction and performance characteristics of the streamer chambers for the central muon detector at CDF are described. A single hit TDC is used for measurements in the drift (azimuth) direction while charge division is used for measurements along the sense wire (pseudorapidity). The chambers operate in the limited streamer mode with a 50%/50% ratio of argon/ethane bubbled through ethanol. Measurements in a cosmic ray test stand, pion test beam and as part of the CDF detector indicate that an rms resolution of 250  $\mu$ m in the drift direction and an rms resolution of 1.2 mm along the sense wire are attainable. (Author abstract) 5 refs.

Ascoli, G. (Univ of Illinois, Urbana, IL, USA); Holloway, L.E.; Karliner, I.; Kruse, U.E.; Sard, R.D.; Simaitis, V.J.; Smith, D.A.; Westhusing, T.K. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 33-40.

**076676 DESIGN AND CONSTRUCTION OF THE CDF CENTRAL TRACKING CHAMBER.** The Collider Detector at Fermilab (CDF) is a magnetic spectrometer surrounded by 4  $\pi$  electromagnetic and hadronic calorimeters. This report describes the design and construction of the Central Tracking Chamber (CTC) of the CDF detector which occupies most of the volume of the superconducting, solenoidal 1.5 T magnet. 7 refs.

Bedeschi, F. (Fermi Natl Accelerator Lab, Batavia, IL, USA); Berge, J.P.; Bofill, J.; Dell'Orso, M.; Foster, G.W.; Hrycyk, M.; Kadel, R.W.; Kowalski, J.; Mukherjee, A.; Newman-Holmes, C.; O'Meara, J.; Patrick, J.; Tinsley, D.; Wagner, R.L.; Yarema, R.; Byon, A. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 50-74.

**076677 DESIGN AND CONSTRUCTION OF THE CDF CENTRAL DRIFT TUBE ARRAY.** The central drift tube (CDT) array is one of the charged particle tracking systems for the Collider Detector at Fermilab (CDF). The CDT array, which operates in the limited streamer mode, provides high-accuracy  $r$ - $\phi$ - $z$  information at a radius of 1.4 m for tracking charged particles produced in the central region (pseudorapidity range



$-1 < \eta < 21$ ) of  $\sqrt{s} = 1.8$  TeV  $\text{pp}$  collisions. Tracking of charged particles in the  $r$ - $z$  view of the CDT array is accomplished via charge division along the anode wires; drift-time measurements in three layers of the CDT array provide tracking information in the  $r$ - $\phi$  view. A novel design enabling rigid and precise mechanical support of 2016 3 m long, 12.7 mm diameter ultra-thin walled stainless steel drift tube has been implemented for the CDF central drift tube array. Details of the mechanical design and fabrication of the CDF central drift tube array are described. Some preliminary performance results of the operation of the CDT array obtained from  $\sqrt{s} = 1.8$  TeV  $\text{pp}$  collisions are also discussed. (Author abstract) 31 refs.

Bhadra, S. (Univ of Illinois at Urbana-Champaign, Urbana IL, USA); Errede, S.; Fishback, L.; Keutelian, H.; Schlabach, P. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 92-104.

**076678 MEASUREMENT OF CASCADE SHOWERS IN LEAD WITH THERMOLUMINESCENT SHEETS.** A new type of detector, thermoluminescent (TL) sheets ( $\text{BaSO}_4/\text{Eu}$ ), and a readout system for the TL sheets have been developed to study electromagnetic cascade showers in ultrahigh energy interactions. To perform a measurement of showers recorded in TL sheets, the longitudinal and radial development of an electromagnetic cascade shower in lead produced by accelerator electrons has been studied for comparison. Simulations of the longitudinal and radial development of cascade showers were also performed using the EGS code system. This study is useful for the design of a thermoluminescent calorimeter (TLC) for the measurement of electromagnetic cascade showers originating from ultrahigh energy (above  $10^{15}$  eV) interactions. (Author abstract). 10 Refs.

Takahashi, Nobusuke (Okayama Univ of Science, Okayama, Jpn). *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 347-353.

**076679 NEW IDEA OF AUTOMATIC WALK STABILIZATION FOR CONSTANT FRACTION DISCRIMINATOR.** The idea of automatic walk stabilization for constant fraction discriminator based on compensated base line restoration is presented and tested. Comparison of this idea to gated base line restoration and other principles is discussed. It is simpler than gated base line restoration because the gated feedback loop for time equal to the input pulse width was replaced by the compensation of the input by the inverted from the LLD discriminator. The circuit is dc coupled and its operation is not limited by high frequency. The advantage of this idea in comparison to gated base line restoration is especially pronounced for very short input pulse width and high frequency when errors due to switched on/off times become important. (Edited author abstract). 10 Refs.

Bailkowski, J. (Swiss Inst for Nuclear Research, Villigen, Switzerland); Schoeps, W. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 481-486.

## Efficiency

**076680 GAMMA-RADIATION REGISTRATION EFFICIENCY OF HERRINGBONE ASSEMBLY OF MICROCHANNEL PLATES.** A study is made of the registration efficiency of a herringbone assembly of two microchannel plates (MCP) for gamma radiation from  $^{55}\text{Fe}$  (5.6 keV),  $^{241}\text{Am}$  (59.6 keV), and  $^{137}\text{Cs}$  (662 keV) as a function of plate thickness. The sources are calibrated by a scintillation detector with a  $\text{NaI}(\text{Ti})$  crystal and a proportional counter. The measurements are made in the pulse-count mode, and the registration threshold is approx.  $10^6$  electrons per pulse. It is shown that the optimum voltage, with regard to efficiency, on the first MCP for thin ( $< 1$  mm) MCPs is equal to the voltage of maximum amplification, while for thick (1-3 mm) MCPs, it is somewhat lower. The efficiency is measured as a function of the thickness of the first MCP, which varies within 0.7-3 mm. The maximum registration efficiencies are 2.5% for radiation with an energy of 5.9 keV, 25% for 59.6 keV, and 4% for 662 keV. (Author abstract) 7 refs.

Shilov, A.L.; Ershov, L.S.; Ivanov, V.N.; Il'chenko, A.V.; Morgovskii, L.Ya.; Tyutikov, A.M. *Instrum Exp Tech* v 30 n 3 pt 1 May-Jun 1987 p 538-541.

**076681 QUANTUM EFFICIENCY OF A CHANNELTRON AND A MAGNETIC ELECTRON MULTIPLIER FOR 0.5-5 keV H ATOMS AND IONS.** The quantum efficiencies of a channeltron and a magnetic multiplier have been determined for 0.5-5 keV H atoms and ions. The efficiency of the detectors for ions is obtained by comparing its ion pulse rate with the ion pulse rate of a Daly detector. To determine the efficiency for atoms we partly converted the  $\text{H}^+$  beam into an  $\text{H}^0$  beam using a gas-cell for charge transfer. With this partly neutralized beam we found the efficiency for neutrals in two different ways. Firstly we measured the dependence of the ratio of the atom to ion pulse rate on the pressure in the gas-cell. From its maximum we can determine the absolute detector efficiency. Secondly we can determine the efficiency directly from a measurement of the ratio at a single pressure using the known differential cross sections. The two results are in good agreement. The magnetic electron multiplier has a lower efficiency than the channeltron. The efficiency for atoms is considerably smaller than for ions in the energy region below 1 keV. For both detectors the efficiency decreases when the energy of the particles comes below 1.5 keV. (Author abstract) 11 refs.

Kuipers, E.W. (Rijksuniv, Groningen, Neth); Boers, A.L. *Nucl Instrum Methods Phys Res Sect B* v B29 n 3 Dec 1987 p 567-572.

## Electric Field Effects

**076682 IMPROVEMENT OF THE ELECTRIC FIELD CORRECTION IN RECOIL-PROTON DETECTORS.** An improved correction for distortions of the electric field in recoil-proton detectors, applied in neutron energy spectrum measurements, was developed. It utilizes a simple analytical expression for the representation of the response function for the entire interval of the electric charge, thus avoiding the previous separate treatment of the upper 20 to 30% of the charge range. The simplicity of the functional expression for the response function allowed the integral equation of the unfolding problem to be solved analytically. This refined unfolding technique apparently provides a better solution, as it shows the spectrum deformation due to the large scattering resonances to be more pronounced. This highly accurate analytical unfolding procedure is likely to be applicable in other areas as well. (Author abstract) 6 refs.

Couto, R.T. (Purdue Univ, West Lafayette, IN, USA); Ott, K.O.; Clikeman, F.M. *Nucl Sci Eng* v 98 n 4 Apr 1988 p 317-325.

## Electrodes

**076683 INVESTIGATION OF THE OPERATIONAL STABILITY OF PLASTIC STREAMER TUBES AFTER POLISHING OF THEIR GRAPHITE CATHODES.** In recent times plastic streamer tubes with resistive graphite cathodes have become very popular detectors. However, from experience gained it is established that detectors with a large cathode resistivity are rather unstable in operation. This instability shows up as a short counting plateau restricted by the appearance of self-sustaining discharges leading to large increases of the dark current. It is shown that the polishing of the graphite cathodes of plastic streamer tubes increases their operational stability. 9 refs.

Alekseev, G.D. (Joint Inst for Nuclear Research, Dubna, USSR); Baroncelli, A.; Bosio, C.; Colilli, S.; Cellar, S.; Korytov, A.V.; Micelmacher, G.V.; Sacco, D.; Spiriti, E.; Tortora, L.; Travkin, V.I. *Nucl Instrum Methods Phys Res Sect A* v A269 n 3 Jun 20 1988 p 652-654.

**Electronic Equipment** See Also DATA PROCESSING—Data Acquisition; ELECTRON TUBES, PHOTO-MULTIPLIER—Testing; ELECTRONIC CIRCUITS, TRIGGER.

**076684 ELECTRONICS FOR A XENON TIME PROJECTION CHAMBER.** The design and construction of the electronics for a 336-channel xenon time projection chamber is discussed. Electron trajectories, with charge blobs at the end due to high charge deposition, are reconstructed using a two-level discriminator system. The trajectory information is stored in a memory bank which was designed compatible with the CAMAC standard, for ease of data transfer to a main frame computer. With a sampling rate of 8 MHz, the electronics can process 5 events per second. (Author abstract) 5 refs.

Iqbal, M.Z. (California Inst of Technology, Pasadena, CA, USA); O'Callaghan, B.M.G.; Wong, H.T.-K. *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 387-391.

**076685 ON THE DESIGN OF A JFET-CMOS FRONT-END FOR LOW NOISE DATA ACQUISITION FROM MICROSTRIP DETECTORS.** Design criteria of a monolithic front-end for a microstrip vertex detector are discussed. Two basic items are considered, a preamplifier combining junction field-effect transistors and complementary MOS and a sample-data filter employing the switched capacitor approach. Investigation about the achievable noise performances and the accuracy limitations in the filter is carried out. (Author abstract) 10 refs.

Lutz, G. (Max Planck Inst fuer Physik und Astrophysik, Munich, West Ger); Maloberti, F.; Manfredi, P.F.; Re, V.; Speziali, V.; Buttler, W.; Vogt, H. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 391-398.

**076686 PERSPECTIVES IN THE DESIGN OF TRANSFORMERLESS, LOW-NOISE FRONT-END ELECTRONICS FOR LARGE CAPACITANCE DETECTORS AND CALORIMETERS IN ELEMENTARY PARTICLE PHYSICS.** The achievement of adequate signal-to-noise ratios in the measurement of the energy released by ionizing particles in detectors of large capacitance such as, for instance, calorimeter cells, frequently relies upon transformer coupling between detector and preamplifier. Such a solution, however, may not be feasible if the detector is located in a strong magnetic field. This paper discusses the possibilities opened up by a recently developed field effect transistor for large gate area, whose design has been tailored to the applications in front-end preamplifiers for calorimeters and other large capacitance detectors of frequent use in elementary particle physics. (Author abstract) 9 refs.

Bertolaccini, M. (Politecnico di Milano, Milan, Italy); Padovini, G.; Camin, D.V.; Manfredi, P.F.; Preston, J.A.; Rehn, L.A. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 399-406.

**076687 PILEUP REJECTION IN PULSED BEAM EXPERIMENTS.** A simple method of pileup rejection suitable for pulsed beams is described. Its sensitivity and time resolution are analyzed. (Edited author abstract) 2 refs.

Sen, S. (State Univ of New York at Stony Brook, Stony Brook, NY, USA); Chakraborty, D.R.; Paul, P.; Stachel, J.; Thoennessen, M. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 407-409.

**076688 ELECTRONICS FOR A Si-CsI(Tl)-PHOTODIODE MULTIDETECTOR SYSTEM.** Preamplifiers, computer-controlled main amplifiers and trigger electronics have been designed and built for our charged particle multidetector system (MDS). These electronics process signals from the individual detection elements of the MDS, each consisting of a silicon surface-barrier detector



and a CsI(Tl) scintillator with photodiode readout. Our design is compact, reliable, cheap, and well-suited for the multidetector system. (Author abstract) 3 refs.

Meijer, R.J. (Rijksuniversiteit, Utrecht, Neth); de Haas, A.P.; Langerak, J.J.; Oskamp, C.J.; Smit, W.; Voerman, M.; Decowski, P.; Griffioen, K.A.; van Nieuwenhuizen, G.J.; Kamermans, R. *Nucl Instrum Methods Phys Res Sect A* v A265 n 3 Mar 15 1988 p 511-516.

**076689 CDF FRONT END ELECTRONICS: THE RABBIT SYSTEM.** A new crate-based front end system has been built featuring low cost, compact packaging, fast readout, command capability, 16 bit digitization, and a high degree of redundancy. The crate can contain a variety of instrumentation modules and is designed to be placed near the detector. Remote, special purpose processors direct the data readout. Channel-by-channel pedestal subtraction and threshold comparison in the crate allow the skipping of empty channels. The system is suitable for the readout of a very large number of channels. (Author abstract) 20 refs.

Drake, G. (Fermi Natl Accelerator Lab, Batavia, IL, USA); Droegge, T.F.; Nelson, C.A.; Segler, S.L. Jr.; Stuermer, W.; Turner, K.J.; Kuhlmann, S. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 68-81.

**076690 ON THE FEASIBILITY OF FRONT-END ELECTRONICS FOR MICROSTRIP VERTEX DETECTORS UNDER THE OPERATING CONDITIONS OF LARGE HADRON COLLIDERS.** In the workshops on future colliders the question is frequently raised as to whether the presently employed vertex detectors could cope or not with the very short time intervals between bunch crossings at which the large hadron colliders will operate. Silicon microstrip detectors seems to be suitable for the purpose as they have charge collection times in the ns region. The question of the feasibility of a front-end electronics, able to provide an adequately large signal-to-noise ratio under the operating conditions of future hadron colliders is, however, still open. This paper aims at showing that a front-end employing GaAs MESFETs or silicon microwave bipolar transistors as low noise devices may allow a reliable signal detection with silicon microstrips down to a few tens of nanoseconds interval between bunch crossings. (Author abstract) 6 refs.

Marioli, D. (Univ di Brescia, Brescia, Italy); Manfredi, P.F.; Massetti, P. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 109-114.

**076691 FAST TRACK FINDING TRIGGER PROCESSOR FOR THE BES DETECTOR.** The Beijing Spectrometer (BES) is being designed and constructed for use at the Beijing  $2 \times 2.8$  GeV center-of-mass energy electron-positron collider (BEPC). The BES detector will have approximately 20K channels of electronics, and the beam collision rate will be 1.25 MHz, corresponding to a luminosity of  $10^{30} \cdot 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$ . A fast programmable track finding processor to be used in the second level trigger is described. This processor, mainly consisting of 3 out of 4 logic and track finding logic, is simple and flexible. Only 96 pieces of  $4K \times 1$  bit random access memory (RAM) chips are used for the track finding logic on 4 layers of the main drift chamber. (Author abstract)

Yu Zhongqiang (Acad Sinica, Beijing, China); Sheng Junpeng; Guo Yanan; Ding Huiliang; Yang Xirong; Dong Aiping. *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 336-341.

Etching See PLASTICS—Radiation Effects.

## Imaging Techniques

**076692 SCINTILLATING FIBER-OPTIC ACTIVE TARGET (SFT) FOR STUDIES OF HIGH ENERGY PHOTOPRODUCTION.** A description is given of a high-resolution, gateable scintillating fiber target that has been developed for Fermilab Experiment E687 to study

charm and beauty particle production and decay in high-energy photon interactions. The detector consists of a scintillating target of either GSI cerium glass fibers or polystyrene fibers of 29- $\mu\text{m}$  cross section, a multistage image intensifier, and an intensified CCD or SIT/VIDICON camera system used in conjunction with a custom-built video data acquisition system. 5 refs.

Ruchti, R. (Univ of Notre Dame, IN, USA); Baumbaugh, B.; Bishop, J.; Busenitz, J.; Cason, N.; Cunningham, J.; Gardner, R.; Kennedy, C.; Mannel, E.; Mountain, R.J.; Pusejic, D.; Shephard, W.; Zanabria, M.; Baumbaugh, A.; Knickerbocker, K.; Rogers, A. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 441-445.

## Instruments

**076693 EXPERIMENTAL APPARATUS FOR STUDY OF POLARIZATION EFFECTS IN CHARGE-EXCHANGE REACTIONS OF CHARGED MESONS TO NEUTRAL FINAL STATES.** Apparatus is described for study of polarization effects in exclusive charge-exchange reactions of  $\pi^-$  and  $K^-$  mesons to neutral final states that decay to gamma quanta. The gamma quanta are registered by a total-absorption Cerenkov spectrometer based on lead-glass counters. The apparatus has been used to study asymmetry in the charge-exchange reactions  $\pi^- p \rightarrow (\pi^0, \eta, \eta', \omega, f) + N$ ,  $\pi^- p \rightarrow K^0 \Lambda$ , and  $K^- p \rightarrow K^0 \Lambda$ . (Author abstract) 16 refs.

Avvakumov, I.A. (Inst of High-Energy Physics, Serpukhov, USSR); Apokin, V.D.; Belikov, N.I.; Borisov, N.S.; Bunyatova, E.I.; Vasil'ev, A.N.; Goncharenko, Yu.M.; Grachev, O.A.; Derevshchikov, A.A.; Kazarinov, Yu.M.; Liburg, M.Yu.; Matafonov, V.N.; Matulenko, Yu.A.; Meshchanin, A.P. *Instrum Exp Tech* v 30 n 5 Pt 1 Sep-Oct 1987 p 1062-1067.

## Laser Applications

**076694 STUDY OF THE SELF-QUENCHED STREAMER MODE USING A NITROGEN LASER.** The characteristics and mechanism of the self-quenched streamer mode have been explored using laser induced ionization. Both the size of the streamer signal and the transformation from proportional to streamer mode depend on high voltage and the primary ionization density. Two nearby tracks influence each other mainly by space charge effects. The zone of influence depends on relative drift time of the tracks but is less than 3 mm along the anode. The influence is less with argon-free strong quenching gas mixtures. (Author abstract) 8 refs.

An, Ji-Gang (Univ of Chicago, Chicago, IL, USA); Anderson, K.J.; Merritt, F.S.; Oreglia, M.; Pilcher, J.E.; Possoz, A.; Schappert, W. *Nucl Instrum Methods Phys Res Sect A* v A267 n 2-3 May 1 1988 p 396-407.

## Magnetic Field Effects

**076695 PERFORMANCE OF MICROCHANNEL PLATES IN HIGH MAGNETIC FIELDS.** The behavior of microchannel plate (MCP) detectors in high magnetic fields has been investigated. Satisfactory performance in axial fields of up to 3 T has been observed. (Author abstract) 6 refs.

Morenzoni, E. (Swiss Inst for Nuclear Research, Villigen, Switzerland); Oba, K.; Pedroni, E.; Taqq, D. *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 397-400.

Materials See Also SEMICONDUCTOR MATERIALS—Ionization.

**076696 USE OF THIN PLASTIC FOILS IN LOW-LEVEL ALPHA SPECTROMETRY.** To prevent radioactive surface contamination of solid state detectors for low-level alpha spectrometry, thin plastic foils are used as stopper foils for recoil nuclei. Measurements show that a stopping efficiency of 100% for recoil nuclei may be obtained at the expense of approximately 20% loss of energy resolution (FWHM) for peaks in the resulting

spectrum of the source due to straggling of  $\alpha$  particles. (Author abstract) 5 refs.

van der Wijk, A. (Cent voor Isotopen Onderzoek, Groningen, Neth); Venema, L.; Steendam, S.P. *Appl Radiat Isot* v 38 n 12 1987 p 1061-1065.

**076697 PERMEATION THROUGH LATENT NUCLEAR TRACKS IN POLYMER FOILS.** The stable defects created in most dielectrics by fast heavy ions, called 'latent nuclear tracks', are zones of reduced density. Using the small-angle neutron-scattering technique it is shown that water molecules which permeate a polymer foil are preferentially embedded in these zones. In the track region the diffusion- and the sorption coefficients for various atoms and molecules are larger than in unirradiated material. In the damaged region of tracks produced by uranium ions in polyethylene terephthalate (PETP) the permeability for neon, oxygen, argon, carbon-dioxide, and water is enhanced by factors between 60 and 290. A method for the preferential etching of latent nuclear tracks in PETP using methanol as a solvent is suggested. (Author abstract) 11 refs.

Schaupt, K. (Gesellschaft fuer Schwerionenforschung, Darmstadt, West Ger); Albrecht, D.; Armbruster, P.; Spohr, R. *Appl Phys A* v A44 n 4 Dec 1987 p 347-352.

## Mathematical Models

**076698 COMPUTATION OF EXTENDED DEAD TIME OF PHOTON COUNTERS IN RECORDING UNSTEADY LUMINOUS FLUXES.** This study deals with the determination of the original intensity of an unsteady Poisson flux from the given recorded intensity and dead-time distribution function, and of the dead-time distribution function from the input and recorded intensities. The results are of sufficient generality, and may be applied not only to photon counters, but also to other recording systems of random events. 4 refs.

Apanasovich, V.V.; Gulakov, I.R.; Prolisko, E.E. *J Appl Spectrosc* v 46 n 2 Feb 1987 p 208-211.

## Monitoring

**076699 LUMINOSITY MONITOR FOR THE VENUS DETECTOR AT TRISTAN.** We constructed a luminosity monitor of the lead-scintillator sandwich type for the VENUS detector at the  $e^+e^-$  collider TRISTAN. Photomultiplier tubes with transmissive mesh dynodes could be operated fairly well in a high magnetic field and hence the readout optics system was considerably simplified. We present the performance of the luminosity monitor for  $e^+e^-$  collisions at  $\sqrt{s}=50$  and 52 GeV. (Author abstract). 10 Refs.

Saito, Hitoshi (Tokyo Metropolitan Univ, Tokyo, Jpn); Chiba, Masami; Fukui, Toru; Hirose, Tachishige; Shirakura, Hatsuo; Watanabe, Takashi; Takasaki, Fumihiko. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 319-326.

Performance See Also SPECTROMETERS—Design.

**076700 EFFECT OF OXYGEN ON RESPONSE OF PLASTIC AND GLASS DETECTORS.** Using beams of relativistic Au and U ions, we have found that the sensitivity (reduced track etch rate) of CR-39, Rodyne polycarbonate, and Cronar polyester track detectors depends on the length of time for which the sample is exposed to oxygen before irradiation and to the partial pressure of oxygen before and during irradiation. In contrast, the sensitivity of VG-13 phosphate glass detectors is independent of the presence or absence of oxygen before or during irradiation. (Author abstract) 10 refs.

Drach, J. (Univ of California, Berkeley, CA, USA); Ren, Guoxiao; Price, P.B.; Solarz, M. *Nucl Instrum Methods Phys Res Sect B* v B28 n 3 Oct 1987 p 364-368.



**076701 DETECTOR FOR REGISTRATION OF IONS, ELECTRONS, AND NEUTRAL PARTICLES OF LASER PLASMA.** A detector is described for measurement of ion and electron currents as well as the energy of neutral particles of laser plasma in the same angular aperture. Good agreement is observed between the ion signal of the detector and the ion current of a Faraday cylinder, which permits absolute measurements. A method is proposed for measurement of the average ratio of the mass of an ion to its charge. Data on ion and neutral-particle energy are given and the energy removed by fast electrons is estimated. (Author abstract) 13 refs.

Komarov, V.M. *Instrum Exp Tech* v 30 n 1 pt 2 Jan-Feb 1987 p 175-178.

**076702 SOME OPERATING CHARACTERISTICS OF HERRINGBONE MICROCHANNEL AMPLIFIERS.** The parameters of a herringbone microchannel amplifier are studied as functions of the input signal intensity and the size of the microchannel-plate (MCP) working zones, i.e., the number of actually functioning channels. The sensitivity of the microchannel amplifier to overloads was found to be the higher, the greater the number of functioning channels, and the maximum count rate at the output of a single channel was obtained with the smallest MCP working-zone area (in this case, the channel dead time was approx. 0.3 msec). The dead times of the individual channels can vary according to the irradiation conditions, which allows considerable expansion of the sensitivity dynamic range by changing the dimensions of the MCP input surface with variation of the input signal intensity. (Author abstract) 8 refs.

Shyutte, N.M. (Acad of Sciences of the USSR, Moscow, USSR); Sheronova, S.M.; Vasinina, G.P.; Platov, E.A.; Kaptsov, V.G. *Instrum Exp Tech* v 30 n 1 pt 2 Jan-Feb 1987 p 191-194.

**076703 MULTIPLICITY REGISTRATION IN HODOSCOPE SYSTEMS WITH A LARGE NUMBER OF REGISTRATION CHANNELS.** A method is described in which data are compressed before analysis for multiplicity  $t$  and high-speed PROMs are used. Schematic diagrams are given for the main units of a 64-input device, which permits determination of such multiplicity parameters as  $t=1$ ,  $t=2$ ,  $t=3$ ,  $t=4$ , and  $t \geq 5$  with a delay of  $\leq 35$  nsec. (Author abstract) 9 refs.

Nikityuk, N.M. (Joint Inst for Nuclear Research, Dubna, USSR). *Instrum Exp Tech* v 30 n 3 pt 1 May-Jun 1987 p 559-566.

**076704 DEVICE FOR RECORDING PARTICLE AND PHOTON FLUX DISTRIBUTIONS.** The device described has been designed to record the spatial distribution of particle and photon fluxes in a vacuum. An assembly of a microchannel plate and a luminescence screen on a fiber-optic wafer serves as the detector of the primary flux of particles or photons. The luminescence of the phosphor is recorded by a moving line charge-coupled video-signal sensor controlled by an electronic circuit in the CAMAC standard. The spatial resolution of the instrument is 0.1 mm. (Author abstract) 7 refs.

Shul'zhenko, G.I. (Acad of Sciences of the USSR, Novosibirsk, USSR); Bashkeev, A.A.; Kovalenko, Yu.V.; Fedotov, M.G. *Instrum Exp Tech* v 30 n 3 pt 2 May-Jun 1987 p 685-688.

**076705 DETECTORS OF SHORT-RANGE PARTICLES BASED ON NEUTRON-TRANSMUTATION-DOPED SILICON.** The suitability of neutron-transmutation silicon (NTS) produced without preselection of the starting p-type silicon for precision alpha spectrometry is studied. Use as a starting material of p-type silicon with resistivity  $\rho_p = 2-80$  k $\Omega$ ·cm provides NTS with  $\rho_n \approx 1-25$  k $\Omega$ ·cm; specimens with  $\rho_n \leq 5$  k $\Omega$ ·cm have sufficiently high homogeneity, which ensures an energy resolution of 12-14 keV. The nature of charge transfer in NTS with  $\rho_n \approx 10-25$  k $\Omega$ ·cm indicates the existence of local regions of increased compensation (Approximately 1 M $\Omega$ ·cm). To ensure high energy resolution, the detector must operate in the total-depletion

mode. It is shown that the value of  $\rho_n$ , which is determined by the four-probe method, does not allow prediction of the thickness of the sensitive region of detectors made of high-resistivity NTS, since the presence of deep centers in the material is not taken into account. (Author abstract) 12 refs.

Verbitskaya, E.M. (Acad of Sciences of the USSR, Leningrad, USSR); Grinshtein, P.M.; Guchet, R.I.; Eremin, V.K.; Stokan, N.B.; Shlimak, I.S.; Shokina, E.V. *Instrum Exp Tech* v 30 n 4 pt 1 Jul-Aug 1987 p 827-831.

**076706 RECOIL-PARTICLE DETECTOR FOR BIS-2 SPECTROMETER OF JOINT INSTITUTE FOR NUCLEAR RESEARCH.** A recoil-particle detector designed for determination of the angle of proton escape in the reaction  $np \rightarrow (\Lambda^0 K^0)p$  is developed for study of the process of neutron dissociation to the system  $\Lambda^0 K^0$  with the aid of the BIS-2 spectrometer. The detector consists of two coaxial cylindrical hodoscopes of 18 scintillation counters each. An iron filter of variable thickness is placed between the counters for sampling of events in various ranges of recoil-proton energy. The detector is used in conjunction with a liquid-hydrogen target or a sectional target detector. The design features and characteristics of the detector are given. A method is proposed for separation of interactions of beam neutrons with the hydrogen and with the structural elements of the target. (Edited author abstract) 8 refs.

Arefev, V.A. (Joint Inst for Nuclear Research, Dubna, USSR); Kakurin, I.N.; Skiteva, A.Ya.; Takhtamyshev, G.G. *Instrum Exp Tech* v 30 n 5 Pt 1 Sep-Oct 1987 p 1067-1073.

**076707 FACTORS AFFECTING ETCHING PROPERTIES OF CR-39 DETECTOR FOR ALPHA-PARTICLES.** Several practical factors affecting the track registration performance of CR-39 detectors were studied, adopting as intermediate criterion of detector performance the etch pit diameters left by normally-incident  $\alpha$ -particles. The results are summarized. 9 refs.

Ishigure, Nobuhito (Nat'l Inst of Radiological Sciences, Chiba, Jpn); Matsuoaka, Osamu. *J Nucl Sci Technol* v 25 n 4 Apr 1988 p 404-409.

**076708 PERFORMANCE OF A PROTOTYPE DRIFT CHAMBER WITH 100 MHz FADC READOUT.** Rectangular drift chamber cells have been constructed and tested using an electron test beam facility at DESY. A systematic study of the time, spatial, energy and double track resolutions with a 100 MHz FADC readout is presented. The spatial resolution is 100 to 120  $\mu$ m and the double track resolution is 2.5 mm with an Ar-C<sub>2</sub>H<sub>6</sub> (50:50) gas mixture at atmospheric pressure. The dE/dx resolution obtained corresponds to 6 percent resolution for a 72-layer chamber. (Author abstract). 19 Refs.

Tkaczyk, S.M. (Rutherford Appleton Lab, Chilton, Engl); Blissett, J.A.; Hart, J.C.; Hasell, D.K.; Parham, A.G.; Payne, B.T.; Roberts, J.H.C.; Saxon, D.H.; Foster, B.; Gilmore, R.S.; Malos, J.; Tapper, R.J.; Wilkinson, N. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 373-386.

## Power Supply

**076709 POWER SUPPLY WITH TEMPERATURE AND N<sub>2</sub> LEVEL TEST CONTROLLED BY A PC IBM-XT FOR A HP-Ge DETECTOR.** A high voltage power supply controlled by a PC IBM-XT has been constructed, to work in connection with a HP-Ge detector. Extra controls of temperature and N<sub>2</sub> level have been realized on the same board. (Author abstract). 1 Ref.

Manfredotti, C. (INFN, Turin, Italy); Gervino, G.; Bagnolatti, E.; Nastasi, U.; Marchisio, R.; Brunetti, L.; Monticone, E. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 571-573.

## Pressure Control

**076710 VME PRESSURE CONTROL SYSTEM FOR GAS-FILLED DETECTORS.** A gas pressure regulation system has been constructed for a large number of gas-filled detectors operating with flowing gas. The system uses commercial valves and sensors and is controlled by a CPU operating in a VME environment. The pressure operating values are set through the console. Other useful parameters such as temperature and bias voltage are controlled. Pressure irregularities due to temperature changes are compensated. The performances of the system are satisfactory. (Author abstract) 2 refs.

Bassini, R. (Univ di Milano, Milan, Italy); Boiano, C.; Brambilla, S.; Iori, I.; Moroni, A.; Zhang, Yingji. *Nucl Instrum Methods Phys Res Sect A* v A267 n 2-3 May 1 1988 p 499-501.

## Pressure Effects

**076711 ONE-DIMENSIONAL POSITION-SENSITIVE DETECTOR FOR X-RAY STUDIES AT ULTRAHIGH PRESSURES.** A one-dimensional position-sensitive detector is described for x-ray studies at ultrahigh pressures performed with miniature presses with diamond anvils. The detector has high quantum efficiency and high space resolution: 65% and 170  $\mu$ m for MoK $\alpha$ . (Author abstract) 8 refs.

Zanevskii, Yu.V. (Joint Inst for Nuclear Research, Dubna, USSR); Movchan, S.A.; Peshekhonov, V.P.; Chan Dyk Tkhan; Aleksandrov, I.V.; Zisman, A.N.; Stishov, S.M. *Instrum Exp Tech* v 30 n 3 pt 1 May-Jun 1987 p 551-554.

## Radiation Damage

**076712 INFLUENCE OF FAST NEUTRON IRRADIATION ON THE NOISE PERFORMANCE OF SILICON SURFACE-BARRIER DETECTORS.** The susceptibility to fast neutron irradiation of silicon surface barrier detectors has been investigated. It was shown that the 1/f noise component decreases substantially with increasing fluence in the range from  $10^{10}$  n/cm<sup>2</sup> to  $10^{11}$  n/cm<sup>2</sup>. The deterioration of the detector performance occurs mainly due to the formation of radiation-induced positively charged defects. The critical value of neutron fluence at which the detector performance begins to worsen was also determined. (Author abstract). 5 Refs.

Dabrowski, Wladyslaw (Acad of Mining & Metallurgy, Cracow, Pol); Korbel, Kazimierz. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 585-587.

**076713 RADIATION DAMAGE IN SILICON MICROSTRIP DETECTORS.** A radiation damage effect on silicon strip detectors of pn-junction type is investigated using a high energy proton beam. In order to clarify the cause of leakage current increase, several variations of strip detectors with different surface structures were made and tested. No appreciable differences in leakage current increase are observed among these samples. A strong temperature dependence on leakage current is observed. This can be explained by a formation of radiation induced trap energy levels in the bulk silicon. A moderate room temperature annealing is seen. A pulse height degradation of about 10-20% is observed at a few Mrad of radiation. Some implications of the present results are discussed for possible application of silicon semiconductor detectors in future high energy hadron colliders. (Author abstract) 21 refs.

Ohnogi, T. (Hiroshima Univ, Hiroshima, Jpn); Taketani, A.; Noda, M.; Chiba, Y.; Asai, M.; Kondo, T.; Sato, T.; Takasaki, M.; Tanaka, K.H.; Kondo, K.; Hirayama, H.; Yamamoto, K.; Tanaka, H. *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 105-111.



## Radiation Effects

**076714 RESPONSE OF LR-115 TYPE II AND CR-39 PLASTIC TRACK DETECTORS TO Am-Be AND 14.1-MeV NEUTRONS.** The fast-neutron response of the plastic LR-115 type II and CR-39 track detectors have been compared, using a 14.1-MeV neutron generator and a radionuclide Am-Be neutron source (effective primary neutron energy 4.5-MeV). The distribution of track diameters for a range of etching times has been evaluated, taking into account track registration efficiency and the relevant fast neutron scattering cross-sections. The efficiency of etched-track formation in LR-115 type II due to neutron irradiation is approximately double that in CR-39. The 14.1-MeV neutrons also tend to produce tracks in both materials with somewhat greater efficiency than do the lower energy neutrons from the radionuclide source, for a given etching time. (Author abstract) 25 refs.

Bradley, D.A. (Inst of Cancer Research, London, Engl); Chong, C.S.; Saat, Ahmat; Sidik, Abdul Ghani; Ghose, A.M. *Appl Radiat Isot* v 38 n 11 1987 p 943-947.

## Space Applications

**076715 UoSAT-2 PARTICLE-WAVE EXPERIMENTS.** Models of mechanisms which explain the electron and ion distributions in the aurora and magnetosphere need refining; recent models are based on various wave-particle interactions. The nature of the Earth's radiation environment is described before outlining the sensors and experiments on UoSAT which will aid in resolving the dynamics of space plasma under a variety of conditions. By correlating the measurements from UoSAT-2 and from the Swedish VIKING spacecraft, it is possible to distinguish between the spatial and temporal distribution of particles. (Edited author abstract) 9 refs.

Radbone, J.M. (Univ of Surrey, Guildford, Engl); Underwood, C.I. *J Inst Electron Radio Eng* v 57 n 5 Sep-Oct 1987 Suppl p 174-178.

## Temperature Effects

**076716 DEVICE FOR REGULATION OF SPECIMEN TEMPERATURE.** A device for regulation of specimen temperature in measurements of positron life-time is described. The control range is 100-1000°K, the accuracy of temperature setting is 1 K, and the accuracy of temperature maintenance is 0.15 K. (Author abstract) 1 ref.

Zaitsev, Yu.E. (Leningrad Electrical Engineering Inst, USSR); Li, Mungir; Pashinskii, V.A.; Skokov, S.N. *Instrum Exp Tech* v 30 n 5 Pt 1 Sep-Oct 1987 p 1073-1074.

## Testing

**076717 TEST RESULTS FROM A PRECISION DRIFT CHAMBER VERTEX DETECTOR PROTOTYPE USING DIMETHYL ETHER.** Results of beam tests of a prototype drift chamber vertex detector developed for the D-Zero experiment at the Fermilab collider are reported. The chamber design emphasizes dual goals of high accuracy position measurement and excellent two-track resolution. These requirements are met by using a slow gas, dimethyl ether, in a jet chamber geometry with a double plane of field-shaping wires near the anodes. Resolution of nearby hits is facilitated by 100 MHz flash digitization of the signal pulses. The prototype tested consisted of a full-length (97 cm) model of one azimuthal sector of the innermost layer of the detector, with 8 anode wires. Position measurement accuracy of 30-80  $\mu$ m for drift distances of 2-11 mm and pulse pair resolution of 0.7 mm (for 90% of all pulses) is achieved. (Author abstract) 7 refs.

Clark, A.R. (Lawrence Berkeley Lab, Berkeley, CA, USA); Goozen, F.; Kerth, L.T.; Klopstein, C.; Loken, S.C.; Strovink, M.; Tripp, T.G. *Nucl Instrum Methods Phys Res Sect A* v A261 n 3 Nov 1987 p 420-426.

**076718 INFRARED LIGHT CHARGE INJECTOR**

**AS A TOOL FOR THE STUDY OF SILICON DETECTORS.** In order to study the local response of silicon strip detectors, we have developed a local charge generator using near-infrared light emitting diode. The edge properties of the strip detectors were studied precisely with this tool. In the case of our tested detector, the lateral extension of the depletion area was measured to be about 120  $\mu$ m at a bias voltage of 40 V. (Author abstract) 6 refs.

Tomita, Yasuhiro (Nagoya Univ, Nagoya, Jpn); Nakamura, Mitsuhiro; Niwa, Kimio. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 403-410.

**PARTICLE OPTICS** See Also ACCELERATORS—Beam Dynamics; ACCELERATORS—Beam Injection; ACCELERATORS—Design; ACCELERATORS—Performance; CHARGED PARTICLES—Magnetic Field Effects; ELECTRON LENSES—Applications; ION BEAMS—Focusing; ION BEAMS—Magnetic Field Effects; ION SOURCES; IONS—Magnetic Field Effects; MAGNETIC LENSES; MAGNETS—Design; MASS SPECTROMETERS; MATHEMATICAL TRANSFORMATIONS; PARTICLE BEAM TRACKING; SOLENOIDS—Magnetic Field Effects.

**076719 ION OPTICAL PROPERTIES OF A TRAVELLING-WAVE CHOPPER.** The ion optical properties of a traveling-wave chopper and its influence on energy and time spread of bunched low energy heavy ion beams are investigated. An arrangement where the deflection plates are separated by ground plates is found to be most effective in generating beam pulses with good time structure. Pulse widths of 0.45 ns (fwhm) for protons and deuterons and 1.9 ns for  $^{12}\text{C}$  and  $^{19}\text{F}$  are routinely achieved. (Author abstract) 9 refs.

Domogala, G. (Ruhr-Univ Bochum, Bochum, West Ger); Freiesleben, H. *Nucl Instrum Methods Phys Res Sect A* v A259 n 3 Sep 15 1987 p 365-375.

**076720 IMAGE ABERRATIONS FOR BEAMS FILLING ELLIPTICAL PHASE-SPACE AREAS OR VOLUMES.** The magnitudes of image aberrations of particle-optical systems are different if the corresponding ion beams fill elliptical or parallelogram-like phase-space areas. Corresponding factors are derived for aberrations of all orders and listed numerically for aberrations up to fifth order. (Author abstract) 2 refs.

Wollnik, H. (Univ Giessen, Giessen, West Ger); Berz, M. *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 280-282.

**076721 DYNAMICALLY POLARIZED PROTON FILTER AS A NEUTRON-SPIN POLARIZER USING A  $^3\text{He}$ - $^4\text{He}$  HEAT EXCHANGER.** A dynamically polarized proton filter was constructed as a low-energy neutron polarizer. Protons in filter material were polarized by a similar method as the one for the polarized proton target used in high energy physics experiments. Filter material was immersed in liquid  $^4\text{He}$ , which was cooled by liquid  $^3\text{He}$  through a heat exchanger from outside. Liquid  $^3\text{He}$  was removed from the neutron beam were achieved. (Author abstract) 7 refs.

Masuda, Y. (Natl Lab for High Energy Physics, Oho-machi, Jpn); Ishimoto, S.; Ishida, M.; Ishikawa, Y.; Kohgi, M.; Masaake, A. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 169-172.

**076722 NONLINEAR BEAM OPTICS WITH REAL FIELDS IN COMPACT STORAGE RINGS.** We analyze the proposed Karlsruhe electron storage ring for X-ray in-depth lithography using the 3rd order charged particle beam transport code MARYLIE 3.0. The ring features four 90° superconducting bending magnets. A numerical calculation of their field provides the longitudinal dependence of the multipole expansion coefficients. These are used by the code SCB to compute the Lie algebraic transfer map. Subsequent particle tracking with MARYLIE is employed to find dynamic apertures. Two different magnet designs which both lead to satisfactory dynamic apertures are presented. (Author abstract) 15 refs.

Moser, Herbert O. (Kernforschungszentrum Karlsruhe,

Karlsruhe, West Ger); Krevet, Berthold; Dragt, Alex J. *Nucl Instrum Methods Phys Res Sect B* v B30 n 1 Feb 1988 p 105-109.

**076723 EMPIRICAL TREATMENT OF NONRELATIVISTIC PROTON BEAM SPREADING.** Transverse spreading in proton transmission microscopy limits to some degree the amount of resolution that is possible from the beam. A semi-empirical expression is given which estimates the lateral displacement of a proton beam as it passes through a material. The angular deflections are assumed to be primarily due to small angle Coulomb interactions. The expression includes a proportionality constant which is evaluated with the TRIM ion transport code. The results are compared to experimental data when available. (Author abstract) 7 refs.

Antolak, A.J. (Sandia Natl Lab, Livermore, CA USA). *Nucl Instrum Methods Phys Res Sect B* v B30 n 2 Mar 1988 p 182-184.

**076724 VARIATIONS D'EMITTANCE D'UN FAISCEAU LORS DE SON GUIDAGE DANS UN CHAMP SOLENOÏDAL.** Aberration coefficients of a solenoidal field are given. The emittance variations upon entry and exit from the solenoid are calculated. They are found to be independent of the aberration coefficients. (Author abstract) 11 refs. In French.

Thouroude, D. (Univ de Rennes, Rennes, Fr); Durand, A. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 10-18.

**076725 RADIATION TRAPPING IN AN OPTICALLY PUMPED THICK SODIUM TARGET.** The effect of radiation trapping in an optically pumped sodium target was measured with a Faraday rotation method. The experimental results were compared with calculations based on recent theoretical work, and good agreement was found between the two. (Author abstract) 10 refs.

Mori, Y. (Natl Lab for High Energy Physics, Tsukuba, Jpn); Takagi, A.; Ikegami, K.; Fukumoto, S.; Ueno, A.; Levy, C.D.P.; Schmor, P.W. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 270-272.

**076726 SIMULTANEOUS COMPENSATION OF 2ND-ORDER PARASITIC ABERRATIONS IN BOTH PRINCIPLE SECTIONS OF AN ACHROMATIC QUADRUPOLE LENS DOUBLET.** Experimental measurements are made of the aberrations of a doublet of achromatic quadrupole lenses. Second-order terms are altered and eliminated. Adjustment is guided by a theoretical model containing dipole and hexapole terms. Fixed hexapole terms of unknown magnitude arising from the inherent imperfect symmetry of lens construction cause the parasitic aberrations. Variable hexapole terms, caused by 2-pole electric excitations, are used to achieve compensation. The variable terms are adjusted to null the total hexapole field of each lens, leaving a small dipole field. (Edited author abstract) 23 refs.

Martin, F.W. (Microscope Associates, Dedham, MA, USA); Goloskie, R. *Nucl Instrum Methods Phys Res Sect B* v B30 n 3 Mar II 1988, Nucl Microprobe Technol and Appl, Proc of the First Int Conf, Oxford, Engl, Sep 1-4 1987 p 242-247.

**076727 COOLING AS A MEANS OF OBTAINING A BRIGHT AND ACHROMATIC PROTON MICROBEAM.** An electron cooling ring for a 50 MeV proton beam is proposed for the University of Manitoba Accelerator Centre. With suitable extraction this system would produce 0.25 nA of monochromatic dc beam with a pulse length of 0.1 s deliverable within  $1 \mu\text{m}^2$ . (Author abstract) 33 refs.

Oh, S. (Univ of Manitoba, Winnipeg, Manit, Can); McKee, J.S.C. *Nucl Instrum Methods Phys Res Sect B* v B30 n 3 Mar II 1988, Nucl Microprobe Technol and Appl, Proc of the First Int Conf, Oxford, Engl, Sep 1-4 1987 p 248-251.



**076728 DESIGN OF A VERSATILE SCANNING PROTON MICROPROBE OF HIGH RESOLUTION AND EFFICIENCY.** The designer of a scanning proton (or nuclear) microprobe must make many decisions, some of which may be compromises. There is a wide range of lens types and configurations. Microprobe performance will depend on performance of the accelerator and its ion source, on stability and control of the lens current supply, on the nature of the microprobe supports, on the vacuum system, on magnetic shielding and connection to the accelerator. There are many possible modes of observation and analysis to be considered when the specimen chamber is designed and a versatile chamber should make provision for most of them. They include optical microscopy of front and back surfaces of the specimen, secondary electron imaging, X-Ray imaging, channeling contrast microscopy. Rutherford backscattering and forward scattering, nuclear reaction analysis and scanning transmission ion microscopy in brightfield and darkfield modes. (Edited author abstract) 26 refs.

Legge, G.J.F. (Univ of Melbourne, Parkville, Aust); O'Brien, P.M.; Sealock, R.M.; Allan, G.L.; Bench, G.; Moloney, G.; Jamieson, D.N.; Mazzolini, A.P. *Nucl Instrum Methods Phys Res Sect B* v B30 n 3 Mar II 1988, Nucl Microprobe Technol and Appl, Proc of the First Int Conf, Oxford, Engl, Sep 1-4 1987 p 252-259.

**076729 ACTIVITIES FOR THE CONSTRUCTION OF A NEW HEIDELBERG PROTON MICROPROBE.** A new microprobe system is described which will provide easier operation, especially for outsider, users, a micro- and macro-PIXE facility, improved accuracy for quantitative analysis and an improved scanning system. The probe will have crossed slits as object, a magnetic quadrupole doublet lens and electrostatic deflector plates. Ion optical calculations were done up to third order, using the TRANSPORT and OXRAY computer programs. The image spot size is investigated as function of the geometrical arrangement. A collimation line has so far been built. The scattering of slit edges of the geometrical shape used in the old microprobe is compared with the scattering at the edges of the simpler cylindrical shape. The latter proved to be slightly superior. (Author abstract) 12 refs.

Scherer, J. (Max-Planck-Inst fuer Kernphysik, Heidelberg, West Ger); Braun-Dullaeus, K.-U.; Traxel, K. *Nucl Instrum Methods Phys Res Sect B* v B30 n 3 Mar II 1988, Nucl Microprobe Technol and Appl, Proc of the First Int Conf, Oxford, Engl, Sep 1-4 1987 p 265-270.

**076730 HEAVY-ION MICROPROBE AT GSI - USED FOR SINGLE ION MICROMECHANICS.** Etching of nuclear tracks can yield unique microscopic structures of technical interest in a wide range of different materials. This has already led to many applications using extended beams. Now the heavy ion microprobe has for the first time been used to create micropatterns by shooting every single ion to its desired position. The paper will describe the components of the microprobe essential to the new technique, give an overview over the basic geometries of single ion micromechanics, and show the result of a first experiment. (Author abstract) 6 refs.

Fischer, B.E. *Nucl Instrum Methods Phys Res Sect B* v B30 n 3 Mar II 1988, Nucl Microprobe Technol and Appl, Proc of the First Int Conf, Oxford, Engl, Sep 1-4 1987 p 284-288.

**076731 CHARGED PARTICLE OPTICS, PROCEEDINGS OF THE SECOND INTERNATIONAL CONFERENCE.** This conference proceedings contains 39 papers, all of which are separately indexed and abstracted. The papers concern charged particle optics. Mass spectrometers and separators are reviewed. Hamiltonian optics, aberrations, and codes are considered. Several papers discuss microbeams and lithography. Accelerators, storage rings, light optics, and high intensity beams are also discussed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11404 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Schriber, S.O. (Ed.) (Los Alamos, Natl Lab, Los Alamos, NM, USA); Taylor, L.S. (Ed.). *Nucl Instrum Methods Phys Res Sect A* v A258 n 3 Aug 15 1987, Charged Part Opt, Proc of the Second Int Conf, Albuquerque, NM, USA, May 19-23 1986 p 289-606.

**076732 ION OPTICS OF A NEW TOF MASS SPECTROMETER IN THE THIRD ORDER APPROXIMATION.** The ion optics of a time of flight mass spectrometer with multiple focusing were studied. Triple isochronous focusing and triple space focusing were achieved simultaneously by the symmetrical arrangement of either two or four electric sector fields. A new time of flight mass spectrometer consisting of four 269° electric sector fields was constructed. The flight length of the system is 1.727 m, even though the diameter of the vacuum chamber is 0.41 m. A peak width (fwhm) of 18 ns at  $m/z = 132$  was obtained using a pulsed electron impact ion source (fwhm 15 ns). TOF mass spectra of heavy biomolecules for example, gramicidin S (M.W. 1140) and angiotensin III (M.W. 930) were obtained using a SLMS-type ion source. (Author abstract) 6 refs.

Matsuo, T. (Osaka Univ, Toyonaka, Jpn); Sakurai, T.; Matsuda, H. *Nucl Instrum Methods Phys Res Sect A* v A258 n 3 Aug 15 1987, Charged Part Opt, Proc of the Second Int Conf, Albuquerque, NM, USA, May 19-23 1986 p 327-330.

**076733 STUDY OF THE ABERRATIONS OF PERIODIC ARC USING THE LIE ALGEBRAIC TECHNIQUES.** Since the introduction of second order matrix methods in accelerator physics, algebraic expressions for the matrix have been used in designing systems with little aberration. Our purpose is to show how one can use a Lie algebraic representation to gain additional insight. The aberrations of a periodic achromat are analyzed using the map of a single periodic cell. An action-angle analysis of the Lie operators describing a cell is used to illustrate the differences amongst various phase advances per cell. (Edited author abstract) 6 refs.

Forest, Etienne (Lawrence Berkeley Lab, Berkeley, CA, USA); Douglas, David; Leemann, Beat. *Nucl Instrum Methods Phys Res Sect A* v A258 n 3 Aug 15 1987, Charged Part Opt, Proc of the Second Int Conf, Albuquerque, NM, USA, May 19-23 1986 p 355-363.

**076734 HAMILTONIAN MAGNETIC OPTICS.** This paper outlines a procedure for systematically calculating the paraxial imaging properties and the aberrations of arbitrary static magnetic fields. Since the method is based on general considerations, it can readily be extended to electromagnetic fields. The aberrations are obtained by determining the expansion terms  $E^{(i)}$  of the perturbation cikon. These terms represent polynomials of degree  $i$  in the four geometrical ray parameters  $a$ , and the chromatic parameter  $c$ . 19 refs.

Rose, H. (Technische Hochschule Darmstadt, Darmstadt, West Ger). *Nucl Instrum Methods Phys Res Sect A* v A258 n 3 Aug 15 1987, Charged Part Opt, Proc of the Second Int Conf, Albuquerque, NM, USA, May 19-23 1986 p 374-401.

**076735 TWO DOGMAS OF CHARGED PARTICLE OPTICS.** Designs of charged particle optical systems are invariably based on two assumption: (1) The existence of a reference trajectory and (2) midplane symmetry. The reference trajectory is taken to be the path of a charged particle with certain specified initial conditions. Conditions which break the continuity of the reference trajectory are misalignments of magnets, excess horizontal field in a bending magnet, and vertically bending field in a horizontally bending magnet. Even if midplane symmetry is violated in a magnetic system it is usually respected in each magnetic element. Violations of midplane symmetry in a bending magnet occur if the field is not symmetric about the magnetic midplane. Equations of motion have been worked out for the case where both the above mentioned conditions are violated. Solutions have been produced and incorporated into the first- and second-order formalism of charged particle optics. (Author abstract) 5 refs.

Carey, David C. (Fermilab, Batavia, IL, USA). *Nucl Instrum Methods Phys Res Sect A* v A258 n 3 Aug 15 1987, Charged Part Opt, Proc of the Second Int Conf, Albuquerque, NM, USA, May 19-23 1986 p 417-420.

**076736 ION OPTICS OF MULTIPOLES.** Properties and applications of various kinds of multipoles, in use in mass spectrometry, are discussed; i.e., magnetic as well as electric dipoles and their combinations, quadrupole lenses, hexapole and octupoles. After a short mathematical interlude the dodecapole (12-pole) is introduced: By a proper potential distribution upon the twelve electrodes, it can act as a dipole in an arbitrary direction; as a quadrupole lens, again in an arbitrary direction; as a hexapole; as an octupole; or as a (linear) combination of these devices. An additional feature, however, is the property of the dodecapole with equal potential on all rods, to act as an einzel lens. In combination with the quadrupole lens function the dodecapole become a unique device which can act as a lens focusing in any two mutually perpendicular directions with independent focal strengths. (Author abstract) 12 refs.

Boerboom, A.J.H. (FOM-Inst, Amsterdam, Neth). *Nucl Instrum Methods Phys Res Sect A* v A258 n 3 Aug 15 1987, Charged Part Opt, Proc of the Second Int Conf, Albuquerque, NM, USA, May 19-23 1986 p 426-430.

**076737 METHOD OF POWER SERIES TRACKING FOR THE MATHEMATICAL DESCRIPTION OF BEAM DYNAMICS.** A new method to compute the properties of charged particle optics systems is presented. It is based on the application of operators and functions to a power series algebra instead of real numbers. The method is as versatile as numerical integration methods and comparable to matrix methods in speed and accuracy thus combining the advantages of both strategies. The method has been implemented through fifth order in the code POWERTRACK. Due to the generality of the method, the order can be increased with very little programming effort. (Author abstract) 13 refs.

Berz, M. (Univ Giessen, Giessen, West Ger). *Nucl Instrum Methods Phys Res Sect A* v A258 n 3 Aug 15 1987, Charged Part Opt, Proc of the Second Int Conf, Albuquerque, NM, USA, May 19-23 1986 p 431-436.

**076738 ON THE ION OPTICS OF DIPOLE MAGNETS WITH PARALLEL ENDS INCLUDING STRAY FIELD EFFECTS.** A procedure is developed that allows computing the ion optical transformation matrix of homogeneous dipole magnets with parallel end contours, taking fully into account the effect of the stray fields upon them without approximations. Using the measured field distribution a solution of the equations of motion of the reference particle on the central trajectory is given. Knowing the reference path it is then possible to transform the measured field into the curved coordinate system of ion optics and to derive the differential equations of the matrix elements whose solutions are formulated explicitly in the dispersive plane. In addition, the generally valid differential equations of motion of an arbitrary particle in phase space in the curved coordinate system are derived, explicitly giving the second derivative of the particle's coordinates with respect to the arc length  $s$  of the central trajectory. (Edited author abstract) 6 refs.

Langenbeck, Bernhard (Gesellschaft fuer Schwerionenforschung, Darmstadt, West Ger). *Nucl Instrum Methods Phys Res Sect A* v A258 n 3 Aug 15 1987, Charged Part Opt, Proc of the Second Int Conf, Albuquerque, NM, USA, May 19-23 1986 p 515-524.

**076739 SPACE-CHARGE AND THIRD-ORDER ABERRATIONS IN QUADRUPOLE FOCUSING SYSTEMS.** The purpose of the author is to consider third-order aberrations due to space charge. He derives the single-particle equations of transverse motion for a beam of elliptical cross section that propagates down a focusing channel. These equations include electric and magnetic fields cause by space and magnetic fields caused by quadrupoles and octupoles. The author then calculates



the third-order aberrations of a point-to-parallel system and suggests that beam sizes should be minimized in order to control aberrations. (Author abstract) 8 refs.

Colton, Eugene P. (Los Alamos Natl Lab, Los Alamos, NM, USA). *Nucl Instrum Methods Phys Res Sect A* v A258 n 3 Aug 15 1987, Charged Part Opt, Proc of the Second Int Conf, Albuquerque, NM, USA, May 19-23 1986 p 566-571.

**076740 SOME APPLICATIONS OF PARTICLE-IN-CELL CODES TO PROBLEMS OF HIGH INTENSITY BEAMS.** The purpose of this paper is to demonstrate the application of the 'particle-in-cell' or PIC code method to problems of intense charged particle beams. The PIC code method is most powerful when applied to problems involving rapid transients, as in a pulsed beam, or with rf fields, as in a line buncher or a klystron. 13 refs.

Herrmannsfeldt, W.B. (Stanford Univ, Stanford, CA, USA). *Nucl Instrum Methods Phys Res Sect A* v A258 n 3 Aug 15 1987, Charged Part Opt, Proc of the Second Int Conf, Albuquerque, NM, USA, May 19-23 1986 p 583-588.

## Computer Aided Analysis

**076741 COSY 5.0 - THE FIFTH ORDER CODE FOR CORPUSCULAR OPTICAL SYSTEMS.** COSY 5.0 is a new computer code for the design of corpuscular optical systems based on the principle of transfer matrices. The particle optical calculations include all image aberrations through fifth order. COSY 5.0 uses canonical coordinates and exploits the symplectic condition to increase the speed of computation. COSY 5.0 contains a library for the computation of matrix elements of all commonly used corpuscular optical elements such as electric and magnetic multipoles and sector fields. The corresponding formulas were generated algebraically by the computer code HAMILTON. Care was taken that the optimization of optical elements is achieved with minimal numerical effort. Finally COSY 5.0 has a very general mnemonic input code resembling a higher programming language. (Author abstract) 10 refs.

Berz, M. (Univ Giessen, Giessen, West Ger); Hoffmann, H.C.; Wolnik, H. *Nucl Instrum Methods Phys Res Sect A* v A258 n 3 Aug 15 1987, Charged Part Opt, Proc of the Second Int Conf, Albuquerque, NM, USA, May 19-23 1986 p 402-406.

**076742 ION-OPTICAL PROGRAM RAYTRACE.** This article gives the reader a very brief introduction to the ion-optical program RAYTRACE. Its function and where a copy can be obtained are discussed. 4 refs.

Kowalski, S.B. (MIT, Cambridge, MA, USA); Enge, H.A. *Nucl Instrum Methods Phys Res Sect A* v A258 n 3 Aug 15 1987, Charged Part Opt, Proc of the Second Int Conf, Albuquerque, NM, USA, May 19-23 1986 p 407.

## Mathematical Models See Also EQUATIONS OF MOTION.

**076743 LINEAR ION OPTICS MODEL FOR EXTRACTION FROM A PLASMA ION SOURCE.** A linear ions optics model for ion extraction from a plasma ion source is presented, based on the paraxial equations which account for lens effects, space charge and finite source ion temperature. This model is applied to three- and four-electrode extraction systems with circular apertures. The results are compared with experimental data and numerical calculations in the literature. It is shown that the improved calculations of space charge effects and lens effects allow better agreement to be obtained than in earlier linear optics models. A principal result is that the model presented here describes the dependence of the optimum permeance on the aspect ratio in a manner similar to the nonlinear optics theory. (Author abstract) 23 refs.

Dietrich, J. (Acad of Sciences of the GDR, Rossendorf, East Ger). *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 163-169.

## Performance See Also ELECTROSTATIC LENSES —Performance.

**076744 ANALYSIS OF MECHANICAL ABERRATIONS IN THE ELECTROSTATIC DEFLECTOR.** A third-order aberration formula of mechanical aberrations due to various errors in assembling or machining of the electrostatic deflector is derived from a second-order perturbation theory. Mechanical aberrations in a magnetic focusing and electrostatic deflection system are analyzed by utilizing this new formula. The results show that the electrostatic deflector suffers, in general, more serious effects from errors in machining than in assembling if the error magnitudes are almost the same, and also that the edge of the deflection electrodes where the electric field concentrates exerts a greater influence upon occurrence of mechanical aberrations than other portions with less electric field. It is also ascertained that the octopole deflector is much superior to the quadrupole regarding misalignment through numerical comparison between both deflectors. (Author abstract) 10 refs.

Tsumagari, Takashi (Miyakonojo Natl Coll of Technology, Miyakonojo, Jpn); Murakami, Jun; Ohiwa, Hajime; Noda, Tamotsu. *Jpn J Appl Phys Part 1* v 26 n 10 Oct 1987 p 1772-1776.

## PARTICLE SEPARATORS See BIOLOGICAL MATERIALS—Cells.

**PARTICLE SIZE ANALYSIS** See Also AEROSOLS—Agglomeration; AEROSOLS—Analysis; AEROSOLS—Atmospheric; AEROSOLS—Dielectric Properties; AEROSOLS—Measurements; AEROSOLS—Production; AEROSOLS—Radiation Effects; AEROSOLS—Sampling; AGRICULTURAL PRODUCTS—Processing; AIR POLLUTION—Analysis; AIR POLLUTION—Particulate Emissions; CARBON BLACK—Analysis; CATALYSTS—Supported; CERAMIC MATERIALS—Crack Propagation; CERAMIC PRODUCTS—Fabrication; CLAY—Foundations; CLAY—Moisture Determination; COAL HANDLING; COAL PREPARATION—Crushing and Grinding; COAL SLURRIES—Combustion; COAL SLURRIES—Fluidity; COKE—Graphitization; CONCRETE AGGREGATES—Fly Ash; CONVEYORS—Pneumatic; DUST—Analysis; DUST—Riyadh, Saudi Arabia; DUST COLLECTORS—Electrostatic; FILTERS—Evaluation; FLOW OF WATER—Sediment Transport; FLUIDS—Filtration; FLUIDS—Measurements; FUELS—Pulverization; GRANULAR MATERIALS; INTEGRATED CIRCUIT MANUFACTURE; LAKES—Sedimentation; LATEXES—Polymerization; MICROSCOPIC EXAMINATION—Scanning Electron Microscopy; MILLIMETER WAVES—Propagation; NICKEL COMPOUNDS—Magnetic Properties; ORE SAMPLING; POLYMERS—Blending; POWDER METALLURGY—Bronze; POWDER METALLURGY—Niobium; POWDER METALLURGY—Steel; POWDERS; POWDERS—Granulation; POWDERS—Spectroscopic Analysis; RIVERS—Environmental Testing; RUNOFF—Sedimentation; SEDIMENTATION—Analysis; SEDIMENTATION—Equipment; SEDIMENTATION—Measurements; SIGNAL FILTERING AND PREDICTION; SILICA—Analysis; SILICA—Precipitation; SOILS—Analysis; SOILS—Classification; TUBES—Corrosion; VELOCIMETERS—Laser Doppler; WATER—Spectrum Analysis; WATER TREATMENT—Fluoridation.

**076745 OPTICAL MEASUREMENTS OF PARTICLE SIZE AND CONCENTRATION IN DENSELY LADEN MEDIA USING A VISIBLE/INFRARED DOUBLE EXTINCTION TECHNIQUE.** Measurements of sizes and concentrations of coal particles in densely laden media are carried out by means of a visible/infrared double extinction technique and the underlying theory is explained. It is shown that simultaneous sizing and concentration measurements can be obtained by recording the transmittances of the medium under study at two well chosen wavelengths simultaneously (for instance in the visible and in the far infrared ranges). Experimental results for coal particles sieved between 20 and 80  $\mu\text{m}$  are described and discussed. (Edited author abstract) 46 refs.

Gougeon, P. (CNRS, Mont-St-Aignan, Fr); Le Toulouzan, J.N.; Gouesbet, G.; Thenard, C. *J Phys E* v 20 n 10 Oct 1987 p 1235-1242.

**076746 RAISING THE INTERFERENCE IMMUNITY OF BIOTECHNICAL MEASURING SYSTEMS.** An analysis is given of the possibilities of using integrated microcircuit technology to raise the interfer-

ence immunity of electrophysiological measurements from the surface of a bioobject. The authors also examine the question of raising the interference-immunity of the system and circuit engineering methods that will permit utilization of microelectronic facilities. A measuring system with elevated cophasal interference immunity was developed and fabricated using a voltage-to-frequency converter (VFC) in the input section. A HIS consisting of a differential amplifier and VFC was installed in an electrode and a modulated signal was transmitted along the communications line. Test results of microelectric secondary transducers developed and fabricated by the authors permit raising the cophasal interference-immunity factor by 4-5 times. 10 refs.

Bannikov, S.Yu.; Podlepetskii, B.I. *Meas Tech* v 29 n 1 Jan 1986 p 61-64.

**076747 RAISING THE RESOLVING POWER OF OPTICAL AND ELECTRICAL PARTICLE ANALYSES BY USING DIVERGENT DEFLECTING PLATES.** The authors consider the increase in resolving power on using plates diverging at a certain angle by comparison with parallel ones with fixed dimensions for the unit and with given charging and deflecting voltages. A numerical method has been used to derive the set of points given the minimum in the total energy. As F approaches a value close to 0.0681, the stability condition deteriorates rapidly. Therefore, it is necessary to provide  $F \leq 0.068$  for the sorter to work stably. With this constraint, there is no sharp increase in the coefficient  $k_m = E_{\text{max}}/E_0$  for the field strength at the boundary of the ellipsoid by comparison with a spherical drop. The actual parameters of the sorter built in accordance with the calculations were in good agreement with the theoretical ones. These results can be used in designing sorters for optical and electrical particle flow analyzers. 12 refs.

Ovod, V.I.; Shlyuko, V.Ya. *Meas Tech* v 29 n 1 Jan 1986 p 65-68.

**076748 AUTOMATIC IMAGE ANALYSIS TECHNIQUE FOR THE QUANTITATIVE PARTICLE SIZE CLASSIFICATION OF INHOMOGENEOUS AND SUPERIMPOSED SECOND PHASES.** Quantitative verification of microstructural changes occurring during heat treatments, welding operations, or service at high temperatures requires careful, detailed study if very small size particles are to be investigated and if the variability within the material is to be measured and understood. Studies on microstructural changes observed in 2 1/4 Cr-1 Mo steel components during high-temperature service stimulated the development of an automatic image analysis technique to characterize the morphology of the very small carbides. This technique was based on size classification of precipitates visible on extraction replicas. It was demonstrated that a valid evaluation of significant differences among samples could be computed by utilizing measurements of the area fraction of carbides included in each size class in relation to the total area of extracted carbides. (Edited author abstract) 8 refs.

Rinaldi, F. (Dalmine SpA, Milan, Italy); Rossi, M.A. *Metallography* v 20 n 4 Nov 1987 p 385-400.

**076749 PARTICLE SIZE DISTRIBUTIONS IN CLEAN ROOMS.** Measurements of particle size distributions smaller than 0.1  $\mu\text{m}$  in Class 100 clean rooms are summarized. The size distributions were measured in operational rooms during periods of time with little activity - the so-called 'at rest' conditions. A simple particle number balance model is proposed, illustrating the importance of filter penetration and atmospheric aerosol on the concentration of submicrometer particles. Preliminary calculations are used to explain the absence of <0.1  $\mu\text{m}$  diameter particles in the clean rooms tested. A ratio of condensation nucleus counter concentration to optical particle encounter concentration is suggested as a



parameter to provide an indication of changes in clean room particle size distribution. (Author abstract) 22 refs.

Ensor, David S. (Research Triangle Inst, Research Triangle Park, NC, USA); Donovan, Robert P.; Locke, Bruce R. *J Environ Sci* v 30 n 6 Nov-Dec 1987 p 44-49.

**076750 COMMERCIAL DEVELOPMENT OF AN ON-LINE GRAIN-SIZE MONITOR.** This paper traces the development of the BNF grain-size monitor from the earliest concept to a saleable commercial instrument. The paper explains the importance of grain size in annealed copper alloy strip and highlights the drawbacks associated with the traditional methods of grain-size measurement. The new unit, which recently became commercially available to industry, enables grain size to be determined non-destructively and instantaneously on-line, making possible swift adjustment to process controls. (Edited author abstract)

Johnston, R.D. (BNF Metals Technology Cent, Wantage, Engl); Diamond, R.D. *Int J Technol Manage* v 3 n 1-2 1988 p 21-29.

**076751 STRUCTURAL ANALYSIS OF POROUS MATERIALS BY MEANS OF MERCURY POROSIMETRY.** In this paper, the determination of pore size distribution, specific surface and porosity of porous materials by means of mercury porosimetry are described. The principles and experimental results on the determination of particle size are discussed. The hysteresis and its applications in the structural analysis of porous materials are investigated. (Author abstract) In Chinese. 7 refs.

Chen Yushu (Shanghai 856 Plant, China). *Fenmo Yejin Jishu* v 5 n 4 Nov 1987 p 215-220.

**076752 ON-LINE PARTICLE SAMPLING AND MEASUREMENT SYSTEM.** The technology for measuring particulates has been available to industry for many years. Until now, however, a significant time lapse occurred between sample acquisition, sample analysis, and feedback to production personnel. This delay in obtaining the particulate-diameter data voided any 'real-time' control of the process. With this method, control was adjusted by using wide setpoint guidelines. An on-line particle size measurement system now exists that eliminates the time delay between sample acquisition and feedback. By combining existing particulate measurement equipment with automatic sample extraction equipment, which is located in the process production area, the system allows real-time particulate data to be produced. This paper describes the equipment that composes the system, explains system operation, and discusses benefits and costs. (Author abstract) 3 refs.

Rice, Grant (InterSystems Inc); Kreikebaum, Gerhard. *Powder Bulk Eng* v 1 n 2 Feb 1987 p 30-34.

**076753 REALIZATION OF A CONCEPT OF THE COMPLETE EVALUATION OF DOUBLE PULSE HOLOGRAMS OF PARTICULATE PHASES IN FLOWS.** Double pulse holography is, for experimental investigations, an extremely valuable means of measuring transport processes in disperse phases. This method allows the single or two dimensional frequency distributions of particle size, velocity, momentum and energy to be determined of each recorded sub-collective, with the additional possibility of checking the existence of their correlation. Being an imaging method, the distributions of the particle in space can be displayed along with the instantaneous values of the concentration and particle flux density. A complete and very exact evaluation of the holographic images, coupled with the certainty of image pairing, is one of the prerequisites of a successful application. The best evaluation in this sense is, at present, produced by a semi-automatic, interactive system in which the assessment of certain crucial factors is left to an operator. Although the effort incurred by such a total evaluation is by no means insignificant, it is justified by the profusion of information to be obtained. The present report explains the whole concept including a program system with which the primary data is further processed and with which a variety of results may be called up and

displayed. (Author abstract) 36 refs.

Schaefer, Michael (Univ Karlsruhe, Karlsruhe, West Ger); Umhauer, Heinz. *Part Charact* v 4 n 4 Dec 1987 p 166-174.

**076754 FLUORESCENCE PROBE STUDY OF THE EFFECT OF SIZE ON THE PROPERTIES OF DIOCTADECYLDIMETHYLAMMONIUM CHLORIDE VESICLES.** Fluorescence techniques are used to study the effect of size on the properties of dioctadecyldimethylammonium chloride vesicles. The results obtained are accounted for by considering the structural differences between large and small vesicles. It is shown that the temperature dependence of the interaction rate between the probe and oxygen can be used to monitor the changes in vesicle fluidity accompanying the gel-liquid crystalline phase transition and the sensitivity of the fluidity and phase transition temperature to the incorporation of additives (n-octanol). The effect of vesicle size upon the capacity to incorporate n-alkanols (from hexanol to nonanol) and carbon tetrachloride was also examined. (Edited author abstract) 22 refs.

Abuin, E. (Univ de Santiago de Chile, Santiago, Chile); Lissi, E.; Aravena, D.; Zanocco, A.; Macuer, M. *J Colloid Interface Sci* v 122 n 1 Mar 1988 p 201-208.

**076755 INFLUENCE OF PARTICLE SHAPE ON SIZE MEASURED BY THE LIGHT-BLOCKAGE TECHNIQUE.** Five alumina particles, each of different shape, were independently and repeatedly dropped through the light beam in a Hiac-Royco particle counter which deduces the size of the particle from the amount of light blocked. The sizes of those particles were also measured by use of a Quantimet image analyzer which determines size (diameter) from the area projected by the particle as it lies 'flat'. When the diameter of a flake-like particle is measured, the former instrument shows more variability in results than the latter. Aside from flake-like particles, close correlations are shown between the two different ways of measuring particle size. From one instrument to the other, a correlation is shown between increased variability of size measurements with increased departure of the particle from the shape of a sphere. (Edited author abstract) 8 refs.

AH Chin, A.D. (Univ of Iowa, Iowa City IA, USA); Butler, P.B.; Luerkens, D.W. *Powder Technol* v 54 n 2 Feb 1988 p 99-105.

**076756 DESCRIPTION OF NORMAL, LOG-NORMAL AND ROSIN-RAMMLER PARTICLE POPULATIONS BY A MODIFIED VERSION OF THE BETA DISTRIBUTION FUNCTION.** Data generated by the normal, log-normal and Rosin-Rammler distribution functions were normalized and fitted with a modified version of the beta distribution function. As long as the frequency function had a zero or practically zero value at the two ends of a finite size range, the fitted curves were indistinguishable from the normal and Rosin-Rammler distributions. The fit of the modified beta function to narrow log-normal distributions was also excellent but declined as the distribution spread increased. It appears that for real particle populations having a finite size range and not necessarily a perfectly smooth size distribution, the modified beta function can replace all three functions, thus providing a way to compare different size distribution patterns in terms of a single mathematical expression. (Edited author abstract) 4 refs.

Popplewell, L.M. (Univ of Massachusetts, Amherst, MA, USA); Campanella, O.H.; Normand, M.D.; Peleg, M. *Powder Technol* v 54 n 2 Feb 1988 p 119-125.

**076757 COMPARISON BETWEEN A MODIFIED BETA AND A MODIFIED NORMAL DISTRIBUTION FUNCTION FOR THE DESCRIPTION OF POPULATIONS WITH A FINITE SIZE RANGE.** It has been demonstrated in a recent communication that the particle size distribution of particle populations having finite size range and a mode that is independent of the spread can be described by a given function. A more shortcoming of this distribution function is the presence of

the arbitrary constant B. A way to avoid any arbitrary parameter but to maintain the independence of the mode and spread is to use a modified version of the beta function. The existence of two different mathematical expressions for the description of different kinds of size distributions raises the question of whether they can be used interchangeably. Testing this possibility by generating data with one function and fitting them with the other distribution equation is the objective of this communication. 4 refs.

Popplewell, L.M. (Univ of Massachusetts, Amherst, MA, USA); Campanella, O.H.; Peleg, M. *Powder Technol* v 54 n 2 Feb 1988 p 157-160.

**076758 PARTICLE SIZE ANALYSIS IN TURBID WATER.** A number of experiments were carried out for the analysis of particle size distribution in various types of natural and artificially prepared turbid water samples, treated and untreated with alum, to study the settling characteristics of particles of different sizes with time. The method of electronic counting and sizing of particles, Coulter Counter was used in these experiments. The apertures used in this study were fabricated by a simple laboratory method. The brief details of one of the representative experiments are given in this note. 3 refs.

Lokre, V.L. (Explosives Research & Development Lab, Pune, India). *Indian J Environ Health* v 29 n 3 Jul 1987 p 247-248.

**076759 ON THE MEASUREMENT OF SMALL PARTICLE SIZE BY SEDIMENTATION.** Sedimentation of small particles through liquid has been widely utilized to measure easily the size of the particles. Concerning this, experiments were carried out both for the case of a single particle falling through liquids and for the case where particles constitute a dispersion system and fall through liquids, and the following are clarified: (1) drag coefficients measured on a single particle are approximately expressed with Stokes' law for creeping flow motion; (2) with sedimentation of dispersed particles, the falling velocity is in some cases abnormally low, though the concentration of the dispersion system used is hitherto thought to be too low to induce interaction among the suspended particles; (3) the abnormally low sedimentation speed is possibly due to the interaction among the suspended particles which are surrounded with electric double layers. (Edited author abstract) In Japanese. 5 refs.

Hasegawa, Tomichi; Shiobara, Haruki; Narumi, Takatsune. *Nippon Kikai Gakkai Ronbunshu B Hen* v 54 n 497 Jan 1988 p 119-124.

**076760 PRINCIPLE AND DESIGN OF THE PHOTOELECTRIC INSTRUMENT FOR MONITORING AND MEASURING THE PARTICLE CONTENT IN FLUORESCENT MAGNETIC INK.** Described are the principles of the photoelectric instrument for monitoring and measuring the particle content in fluorescent magnetic ink and the problems in designing. The stability of the instrument is discussed and the methods for solving the problems are given. (Author abstract) In Chinese.

Duan, Zeren (Beijing General Internal Combustion Engine Plant, China); Zhang, Yiwen; Chen, Jiansheng. *Wusun Jiance* v 10 n 1 Jan 1988 p 7-10.

**076761 DIFFRACTION METHOD OF MEASURING SPHERICAL PARTICLE SIZE.** A method of measuring the radius of spherical particles by means of the scattering pattern is proposed. This method permits operational and highly accurate determination of the controllable geometric characteristics because of using a modified method of computation with new rapidly converging functions. 5 refs.

Vorontsov, A.A.; Mirovitskaya, S.D. *Meas Tech* v 30 n 9 Sep 1987 p 867-869.

**076762 INCREASED RESOLUTION OF SIZE DISTRIBUTIONS WITH THE COULTER COUNTER.** The limiting resolution of Coulter size measurements, the



size within which two separate populations can be distinguished, is discussed in relation to the standard aperture. Electronic pulse editing, by comparing pulse height to width, enables small particles to be resolved from baseline instrument noise, but can give incomplete resolution of ultra-narrow distributions from artefactually produced peaks using the standard aperture. Improvements in the minimum measurable size and in sizing resolution of narrow size ranges are also shown to be possible by improving the signal quality from the Coulter aperture. A novel mathematical approach is described for the derivation of true size spectra for narrow particle size distributions by deconvolution of the composite spectra resulting from the effect of the inhomogeneous electric field in the Coulter aperture. Simple empirical equations are used derived from the location and amplitude of the spurious peaks observed in such composites relative to the genuine peaks. (Edited author abstract). 13 Refs.

Harfield, John G. (Coulter Electronics Ltd, Luton, Engl); Wharton, Robert A. *Part Part Syst Charact* v 5 n 1 Mar 1988 p 29-37.

**076763 COMPARISON OF THE SIZE DISTRIBUTION OF BORON POWDERS AS MEASURED BY MALVERN DIFFRACTOMETER AND COULTER COUNTER.** Aspects of measuring the particle size distribution and median diameters of fine boron powders have been investigated. It has been demonstrated that high concentrations, typically 20 w/o, of wetting agent are necessary in a predispersion stage, especially if the material has a wide range of particle size. Measurements were made with both Coulter counting and a light scattering technique from which it has been demonstrated that for particles of median diameter in the range 10-30  $\mu\text{m}$ , the latter overizes with respect to the former by as much as 30%. (Author abstract). 5 refs.

Davies, J. Alwyn (AWE Aldermaston, Reading, Engl); Collins, Dilys L. *Part Part Syst Charact* v 5 n 3 Sep 1988 p 116-121.

**076764 AEROSOL GENERATION METHOD FOR MEASURING PARTICLES SUSPENDED IN WATER - DETECTION OF PARTICULATE IMPURITIES IN ULTRAPURE WATER AND SIZING OF FINE POWDERS.** The method described is based on the fact that the measurement of particles in the gaseous phase is generally easier than that in the liquid phase for fine particles smaller than 1  $\mu\text{m}$  in diameter. The system consists of a liquid nebulizing unit, evaporator, condenser, mixing diluter and two different aerosol sizing instruments. It has been found that this method can continuously detect particulate impurities in ultrapure water in situ and can measure the size distribution of fine powders in the submicron particle size range down to about 0.05  $\mu\text{m}$ . (Author abstract). 4 refs.

Niida, Tohru (Univ of Osaka Prefecture, Sakai, Jpn); Kousaka, Yasuo; Oda, Shinji. *Part Part Syst Charact* v 5 n 3 Sep 1988 p 139-143.

**076765 PARTICLE SIZE ANALYZER ACTS AS A PROCESS CONTROL TOOL IN ALUMINA INDUSTRY.** Over the years, analysts at Kaiser Aluminum in Gramercy, La., have tested and used several methods of particle size analysis in an attempt to find a way to monitor product at all stages of production and to control processes and maintain the product within specifications. Though no method has proved ideal, a recently introduced analyzer, the Lab-Tec 100, has allowed Kaiser's analysts to perform some procedures that other methods are incapable of performing. The instrument employs a laser diode that sends a scanning beam across suspended particles from outside the carrier solution. Because there is no contact, the instrument analyzes the sample without sample preparation.

Anon. *Powder Bulk Eng* v 2 n 10 Oct 1988 p 22-25.

**076766 PARTICLE SIZE ANALYSIS OF MICROMETRE-SIZED PARTICLES USING MAGNETIC LIQUIDS.** A new method of studying non-ferromagnetic particles (1  $\mu\text{m} < d < 60 \mu\text{m}$ ) using magnetic

liquids is discussed. The technique is straightforward and makes particle counting and size analysis simpler and more accurate. (Author abstract) 3 refs.

Davies, P. (Univ Coll of North Wales, Bangor, Wales); Popplewell, J. *J Phys D* v 20 n 11 Nov 1987 p 1540-1541.

**076767 PARTICLE SIZE DISTRIBUTION: ASSESSMENT AND CHARACTERIZATION (DEVELOPED FROM A SYMPOSIUM AT THE 190TH MEETING OF THE AMERICAN CHEMICAL SOCIETY).** This conference proceedings contains 20 papers covering the subjects of photon correlation spectroscopy and light-scattering methods, image analysis, disc centrifuge photosedimentometry and sedimentation field-flow fractionation and also column chromatography methods of particle size analysis. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10984 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Prover, Theodore (Ed.) (Glidden Co, Strongsville, OH, USA). *ACS Symp Ser* 332, Part Size Distrib: Assess and Charact, Chicago, IL, USA, Sep 8-13 1985. Publ by ACS, Washington, DC, USA, 1987 308p.

## Applications

**076768 ANALYSIS OF THE INORGANIC CONSTITUENTS OF PARTICLES ON A PARTICLE-BY-PARTICLE BASIS USING A COMPUTERIZED SEM-EDS SYSTEM.** This paper is based on the development of the Moza-Austin technique for characterizing thousands of coal particles by approximate analysis of the major inorganic constituents Ca, Al, Si, K, Na, Fe and S in each particle. The technique has sufficient sensitivity to work on small volumes, is fast enough to handle large number of particles within a reasonable period of time, and consists of scanning electron microscopy combined with energy dispersive x-ray spectrometry (SEM-EDS). A computerized SEM-EDS system that allows the automated analysis of hundreds of particles per hour is described. (Edited author abstract). 19 Refs.

Gomez, Cesar O. (McGill Univ, Montreal, Que, Can); Austin, Leonard G. *Part Charact* v 5 n 2 Jun 1988 p 77-84.

## Automatic Testing

**076769 AUTOMATION OF PARTICLE ANALYSIS.** The degree of agglomeration can often be determined by comparing the average particle size identified from a surface-area measurement with that found by sedimentation, light scattering, or electrical zone sensing. A wide range of instruments is available for measuring such properties. These instruments, are being upgraded with automatic sample-handling capabilities; most now incorporate computer control for automatic operation and data analysis.

Sheppard, Laurel M. (American Ceramic Soc Bulletin, Westville, OH, USA). *Am Ceram Soc Bull* v 67 n 5 May 1988 p 878-883.

## Calculations

**076770 MODIFIED BACK-CALCULATION METHOD TO PREDICT PARTICLE SIZE DISTRIBUTIONS FOR BATCH GRINDING IN A BALL MILL.** This paper describes a back-calculation procedure based on the quasi-Newton method of optimization. The general solution of the integro-differential equation was undertaken, and with a careful study of the literature, various forms of breakage distribution function and selection function were assumed. An error function was defined as the root mean square error between the calculated and the experimental product size distributions. The values of the parameters at the lowest error were calculated, using the quasi-Newton optimization technique. This method was experimentally verified for different materials and for grinding processes following different forms of selection and breakage functions. The

calculated size distribution compared well with the experimental size distribution. (Edited author abstract) 14 refs.

Devaswithan, A. (Indian Inst of Technology, New Delhi, India); Pitchumani, B.; de Silva, S.R. *Ind Eng Chem Res* v 27 n 4 Apr 1988 p 723-726.

**076771 MODELING OF MULTIPLE SCATTERING EFFECTS IN FRAUNHOFER DIFFRACTION PARTICLE SIZE ANALYSIS.** A model for the direct problem of calculating the forward scattering signature of a multiple scattering medium is presented. The analysis is valid for media where the particle sizes and interparticle spacings are large (relative to the wavelength and the particle size, respectively) such that Fraunhofer diffraction theory adequately describes the properties of the forward scattered light from individual scattering events. The simulated performance of laser diffraction particle sizing instruments was then studied using predictions of the scattered light signatures which would be measured by laser diffraction instrument under multiple scattering conditions. The results were compared with experimental data and theoretical calculations based on other models. (Edited author abstract). 18 Refs.

Hirleman, E. Dan (Arizona State Univ, Tempe, AZ, USA). *Part Charact* v 5 n 2 Jun 1988 p 57-65.

## Calibration

**076772 CALIBRATION OF THE APS 33 AERODYNAMIC PARTICLE SIZER AND ITS USAGE.** This report describes some practical experience in calibrating and using the APS 33 (TSI Inc., St. Paul, MN), which has important consequences for the measurement of aerosol size distributions by the APS. Three aspects of the calibration and usage of the APS are considered. (Edited author abstract) 8 refs.

Griffiths, W.D. (Occupational Medicine & Hygiene Lab, London, Engl); Iles, P.J.; Vaughan, N.P. *TSI J Part Instrum* v 1 n 1 Jan-Jun 1986 p 3-9.

**Computer Applications** See Also DATA PROCESSING—Data Acquisition; POWDERS—Morphology.

**076773 AUTOMATIC ANALYSIS OF FUEL SPRAY IMAGES.** Analysis of fuel spray droplets is being conducted in General Motors Research Laboratories to provide real-time information on in-focus droplet sizes and numerical density. This paper introduces a fast and efficient technique for automatic analysis of fuel spray images. The preprocessing stage consists of a global thresholding of the log-edge of the image. The thresholded image is then used as a reference to detect objects in the gray level image, and the recognition of in-and out-of-focus droplets is achieved through a 3-level tree classifier. (Author abstract) 11 refs.

Badreldin, Amira M. (GM, Warren, MI, USA). *Comput Ind* v 9 n 2 Oct 1987 p 107-113.

**076774 SOFTWARE PACKAGE FOR MEASUREMENT OF PARTICLE SIZE DISTRIBUTIONS.** A computer software package Sizeanal capable of running on IBM compatible personal computers, is described. It resolves the 'apparent' differences in the measurements of different particle size distribution instruments. It can serve as an effective quality control tool in many industries, such as cement, minerals, ceramics, polymers etc. It is especially useful with the 'raw data' of sieving where the measurements upto only 45 or 53 microns sieve sizes can be used to obtain the 'complete' size distribution down to 1 micron. A set of experimental data is used to demonstrate the validity and usefulness of Sizeanal. (Edited author abstract) 8 refs.

Viswanathan, K.; Rattan, A.; Narang, K.C. *ZKG Int Engl Transl* v 41 n 2 Feb 1988 p 82-86.

**Computer Simulation** See Also POWDER METALLURGY—Sintering.

**076775 SIMULATION OF THE SIZE DISTRIBUTION CHANGE OF MULTI-COMPONENT AERO-**



**SOL PARTICLES.** Computer simulations are performed for the size distribution change of multi-component aerosol particles. We reformulated a sectionalization model, using particle radius as an independent variable for spatially homogeneous spherical aerosol system. Included terms are coagulation, condensation, particle sources and removal. Calculated examples are shown for the size distribution change of three-component aerosols by coagulation, gravitational settling and source. Simulations were also made on the dynamics of sulfuric acid aerosol formation by photochemical reaction in a smog chamber for both cases with and without pre-existing particles, and the results show good qualitative agreement with experimental data in the particle size range larger than  $0.01 \mu\text{m}$  in diameter. (Author abstract) 33 refs.

Tohno, Susumu (Kyoto Univ, Uji, Jpn); Takahashi, Kanji; Kasahara, Mikio. *Tech Rep Inst At Energy Kyoto Univ* n 206 Dec 1986 24p.

**Equipment** See Also FILTERS—Monitoring; POWER PLANTS—Emissions.

**076776 OPERATING ENVELOPES OF PARTICLE SIZING INSTRUMENTATION USED FOR ICING RESEARCH.** The Forward Scattering Spectrometer Probe and the Optical Array Probe are analyzed in terms of their ability to make accurate determinations of water droplet size distributions. Sources of counting and sizing errors are explained. The paper describes ways of identifying these errors and how these errors can affect the measurement. (Author abstract) 13 refs.

Hovenac, Edward A. (Sverdrup Technology Inc, Cleveland, OH, USA). *NASA Contract Rep* 180870 Dec 1987 11p.

**076777 ELECTRO-OPTIC SUB-MICRON SIZE DISTRIBUTION MEASUREMENT.** An apparatus is described for rapid particle size analysis. It is based upon the phenomenon of electric birefringence induced under the influence of pulsed electric fields. A major use of the system is the analysis of polydisperse colloidal suspensions where, for monomodal distributions, a complete plot of the size distribution of the particles is generated. The method can produce data in terms of equivalent spherical diameters. A novel feature, however, is that if the particle shape is known, then the distribution can be expressed directly in terms of a true major dimension. The measuring procedure is very fast. (Author abstract) 11 refs.

Jennings, B.R. (Univ of Reading, Engl); Waterman, D.R. *Filtr Sep* v 25 n 3 May-Jun 1988 p 183-185.

**076778 TOTAL PARTICLE MONITORING AND DETECTION.** One of the methods of detecting particles in the ultrafine size range (diameter  $<0.05 \mu\text{m}$ ) is by condensation nuclei counters. Such counters have a broad range of application including clean room monitoring, the characterization of contaminants in fossil energy process streams, and atmospheric monitoring. Based on the condensation of a saturated vapor, the method can amplify the size of the particles being studied by several orders of magnitude so that they can be detected by standard optical methods. However, the lower size limit of detectability is dependent on the proper choice of parameters that create the saturation conditions. This paper presents results of the counting sensitivity tests of two condensation-type counters (the Pollak and the Sinclair continuous flow counters). The results indicate that these instruments should be operated close to the self-nucleation limit in order to ensure total particle counting. (Author abstract) 35 Refs.

Yue, Paul C. (DOE, Morgantown, WV, USA). *Part Sci Technol* v 5 n 4 1987 p 421-433.

**Instruments** See Also AEROSOLS—Testing; AIRCRAFT—Ice Problems; ION EXCHANGE RESINS—Testing.

**076779 USE OF CALIBRATION TECHNIQUES FOR THE DEVELOPMENT AND APPLICATION OF OPTICAL PARTICLE SIZING INSTRUMENTS.** This paper describes seven different methods of calibrat-

ing optical particle sizing instruments based on single particle scattering theory. The results presented were obtained from a Laser Doppler Anemometer (LDA) using two concentric probe volumes of different diameters and colors. Measurements of the Doppler signal frequency, amplitude and visibility can yield the absolute particle size and velocity of individual particles providing that the optics and processor are correctly designed and implemented. The requirements for signal processing without validation bias are discussed together with the use of a Doppler signal generator for testing the processor. Calibration of the system is then described using a scanning pinhole unit, calibration plate and aerosols of bronze spheres. The other techniques described are the use of glass spheres mounted on thin stalks, Berglund-Lui monodisperse particle generator and latex spheres entrained in a recirculating cell. The discussion indicates the sizing range over which the above techniques are applicable. This covers a total size range from 1 micron to 1 millimeter. (Author abstract) 24 refs.

Hemsley, D.J. (Harwell Lab, Engl); Yeoman, M.L.; Bates, C.J.; Hadded, O. *Part Charact* v 4 n 4 Dec 1987 p 157-165.

**Laser Applications** See Also GRANULAR MATERIALS—Size Determination; GYPSUM—Analysis; LASER BEAMS—Scattering.

**076780 PHASE-DOPPLER-DIFFERENCE METHOD, A NEW-LASER-DOPPLER TECHNIQUE FOR SIMULTANEOUS SIZE AND VELOCITY MEASUREMENTS.** Simultaneous size and velocity measurements can be obtained by using photodetector positions of different off-axis-angles. But not for all of these positions one receives unambiguous results for the correlation between the phase difference and the particle diameter. This can be clearly demonstrated by the plots of the numerical calculations of the complete Mie's scattering equations. On the other hand for transparent particles which are less dense compared with the continuous phase and for totally absorbing materials these plots confirm the simplified equations for reckoning the particle diameter by the laws of geometrical optics. (Edited author abstract) 6 Refs.

Baukhage, Klaus (Univ Bremen, Bremen, West Ger); Floegel, Hans-H.; Fritsching, Udo; Hiller, Ruediger. *Part Charact* v 5 n 2 Jun 1988 p 66-71.

**076781 RAPID METHOD FOR DETERMINATION OF CHANGES IN SHAPE OF COMMUNUTED PARTICLES USING A LASER DIFFRACTOMETER.** The size distributions of carefully screened  $\sqrt{2}$  size fractions of ground materials were determined using a Microtrac laser diffractometer. The size distributions were fitted to the empirical function  $P(x) = 1/[1 + (x_{50}/x)^\gamma]$  where  $P(x)$  is cumulative mass fraction less than Microtrac size,  $x$ . The standard deviation of  $\gamma$  for a 50 second test time was approximately 0.5, so that seventeen test times give a mean with an estimated error within  $\pm 0.25$  (95 percent confidence level). Values of  $\gamma$  were 5.44, 4.82, 4.40 for a coal ground under different conditions, indicating statistically different shape distributions; the average value for mica was 2.91 owing to the high aspect ratio of the particles. The ratio of  $X_{50}$  to the geometric mean sieve size was 1.2 for the coal and 0.70 for mica. (Author abstract) 6 Refs.

Austin, Leonard G. (Pennsylvania State Univ, University Park, PA, USA); Trass, Olev; Dumm, Timothy F.; Koka, Venkat R. *Part Part Syst Charact* v 5 n 1 Mar 1988 p 13-15.

**076782 INTERACTION BETWEEN A SPHERE AND A GAUSSIAN BEAM: COMPUTATIONS ON A MICRO-COMPUTER.** This paper presents some characteristics of the light scattered by one spherical particle illuminated by a Gaussian beam. The basic theory is a generalization of the Lorenz-Mie Theory. The fact that the computations can be easily carried out on a micro-computer is pointed out. (Author abstract) 17 refs.

Corbin, Frederic (CNRS, Mont-St.-Aignan, Fr); Grehan, Gerard; Gouesbet, Gerard; Maheu, Bruno. *Part Part Syst*

*Charact* v 5 n 3 Sep 1988 p 103-108.

**Mathematical Models** See Also COKE—Crushing and Grinding; POLYMERIZATION.

**076783 TANDEM DIFFERENTIAL MOBILITY ANALYZER.** An analytic expression for the response of a TDMA system is presented and its validity discussed. A least-squares minimization technique is used with this analytic result to extract inter-DMA size changes from experimental data. A FORTRAN computer code that demonstrates the method is included as an appendix. Using this method and available instrumentation, diameter changes can be measured with a precision of about 0.3%. For aerosols in the 0.01-0.2  $\mu\text{m}$  diameter range where the technique works best, this corresponds to a precision in measuring diameter of 0.03-0.6 nm, or the characteristic thickness of a molecular monolayer. Guidelines for laboratory implementation of the TDMA are suggested and specific examples discussed. A more accurate numerical solution is used to estimate the systematic error introduced by the approximate, analytic expression. (Edited author abstract) 23 refs.

Rader, Daniel J. (Univ of Minnesota, Minneapolis, MN, USA); McMurry, Peter H. *TSI J Part Instrum* v 1 n 2 Jul-Dec 1986 p 3-15.

**076784 COMPARISON OF PARAMETER ESTIMATION PROCEDURES FOR EXPERIMENTAL BIMODAL LOGNORMAL PARTICLE SIZE DISTRIBUTIONS AND GROUPED DATA.** Four estimation methods are compared with regard to the estimated parameters and the resulting estimated moments, when applied to bimodal lognormal particle size distributions. The method of maximum likelihood, of minimum Chi-square and of minimum distance were applied to artificial samples from numerically simulated populations, representative of many aerosol populations found in practice as well as a method derived by the authors, which is based on the binomial distribution of grouped data in diameter intervals. The results of the comparison of estimated and 'true' parameters are evaluated in terms of percentage inaccuracies. The expected percentage inaccuracies of the estimated moments calculated from the estimated parameters are quantified for various physically relevant orders. It is concluded that the maximum likelihood method tends to be preferable to the others. (Author abstract) 18 refs.

de Ruiter, C.J. (TNO, Rijswijk, Neth); Oeseburg, F. *J Aerosol Sci* v 18 n 4 Aug 1987 p 431-444.

**076785 PERSISTENCE OF POLYGONAL HARMONICS AS SHAPE DESCRIPTORS.** Characterization of the overall (large scale) shape of rugged particles poses a problem which is not readily solved by existing shape analysis techniques. Recent research on the divider stepping method used in factual analysis has led to the examination of polygonal harmonics which can be constructed in both smooth and rugged particle silhouettes. The persistence of these harmonics is defined as the ratio of the longest step length to shortest step length which can be used to create that harmonic. It is proposed that the persistences of the first three harmonics provide useful descriptors for particle shape. Variation of these persistences within several geometric figures is explored, protocols for the analysis are adopted and some preliminary work on rugged silhouettes is discussed. (Edited author abstract) 16 refs.

Hurter, Patricia (West Virginia Univ, Morgantown, WV, USA); Clark, Nigel N. *Part Charact* v 4 n 3 Sep 1987 p 101-105.

**076786 FINE PARTICLE REPRESENTATIONS.** A general three dimensional analytical mathematical method of quantitative particle representation is presented. The resulting analytical representations are capable of quantitatively representing the three dimensional morphologies of a broad range of particles. This paper



summarizes some of the more often encountered particle morphologies prevalent in the micro world. (Author abstract) 11 refs.

Luerkens, David W. (Univ of Iowa, Iowa City, IA, USA). *Part Charact* v 4 n 3 Sep 1987 p 118-121.

**076787 EVOLUTION OF THE DIMENSIONAL SPECTRUM AND THE CONDENSATIONAL STABILITY OF PARTICLES IN A FIELD OF TURBULENT-FLOW-TEMPERATURE PULSATIONS.** The evolution of the dimensional spectrum of condensed particles (CP) in a turbulent gas flow is examined with allowance for vapor depletion. We also examine the effect of temperature fluctuations on the condensational stability of the CP's. It is shown that growth of the particle system, including for  $T_0 = \text{const}$ , is accompanied by broadening of the dimensional spectrum at the initial stage of growth (due to turbulent pulsations) and by contraction of the spectrum during the final growth stage (due to vapor depletion). Investigation of the stability of a particle system against condensation-evaporation processes taking place in temperature fluctuation ranges showed that particles will evaporate on the average, even at  $S_0 = 1$  ( $S_0$  is saturation, calculated for the mean temperature). (Edited author abstract) 10 refs.

Shiyan, A.A. (Odessa Structural Engineering Inst, USSR); Chesnokov, M.N. *High Temp* v 25 n 2 Mar-Apr 1987 p 245-249.

**076788 THEORETICAL LINEAL-DISTRIBUTION FOR PARTICLE COARSENING CONTROLLED BY PIPE DIFFUSION ALONG DISLOCATION.** The coarsening of spherical particles of solute, controlled by pipe diffusion through either a planar or three-dimensional stable dislocation network is considered. The purpose of the present note is to derive an exact expression for the theoretical chord-length distribution which corresponds to a model of pipe-diffusion controlled particle coarsening. 4 refs.

Cortes, R.G. (Univ De Chile, Santiago, Chile); Sepulveda, A.O. *J Mater Sci Lett* v 7 n 2 Feb 1988 p 137-138.

## Measurements

**076789 COINCIDENCES EN GRANULOMETRIE PAR SONDE A VARIATION DE RESISTANCE.** [Coincidences in Granulometry Using the Resistance Variation Probe]. The coincidences in granulometry induce two closely related errors: a counting error and a classing one. The counting correction for uniform particles hematology can be extended to any granulometric distribution. Furthermore, it allows the separation of the two kinds of error. The correction of the classing error thus isolated can be made by deconvolution. (Edited author abstract) 10 refs. In French.

Besancon, P. (UFR Medicine-Pharmacie de Rouen, St. Etienne du Rouvray, Fr); Chastang, J.; Frigot, P.; Lafaye, A. *Powder Technol* v 52 n 3 Oct 1987 p 219-226.

**076790 PARTICLE SIZE ANALYSIS VIA MERCURY INTRUSION MEASUREMENTS.** In this work, we use the known shape of the breakthrough curve for a close random packing of monodisperse spheres to correct (in part) for the errors of intrusion particle sizing. To extract the desired size information, the solution of a Fredholm integral equation must be obtained. The solution is obtained using the method of regularization in conjunction with a technique for finding the optimum smoothing value. For monodisperse powders, the calculated mean size and size distribution are in excellent agreement with TEM measurements. For bidisperse mixtures, both peaks can only be identified in the limit of large number fraction and large size ratio between the two sizes. (Edited author abstract) 16 refs.

Smith, D.M. (Univ of New Mexico, Albuquerque, NM, USA); Sterner, D.L. *Powder Technol* v 53 n 1 Nov 1987 p 23-30.

**076791 PARTICLES IN FLOW.** Vast improvements in optics, electronics, stain utilization, and immunofluo-

rescence result in the ability to analyze particles and cells of a natural population by flow cytometers/cell sorters within minutes. Flow cytometers/cell sorters have provided biological and optical oceanographers with an opportunity for new flexibility and experimentation. This is characterized by rapid measurement of two to six parameters made simultaneously on large numbers of individual particles. Knowledge of variability can advance our information base. Information compression as well as information expansion relating size/light scatter and fluorescence parameters are presented. (Edited author abstract) 33 refs.

Yentsch, Clarice M. (Bigelow Lab for Ocean Sciences, West Boothbay Harbor, ME, USA); Spinrad, Richard W. *Mar Technol Soc J* v 21 n 2 Jun 1987 p 58-68.

**076792 VISIBLE INFRA-RED DOUBLE EXTINCTION MEASUREMENTS IN DENSELY LADEN MEDIA, NEW PROGRESS.** This paper describes new progress obtained with an optical technique called V.I.D.E. (Visible Infra-red Double Extinction) which simultaneously measures mean particle size in the range of 10-120  $\mu\text{m}$  and mean number density in densely laden media (up to 0.1 percent volume fraction). The underlying theory, taking account of multiple light scattering, is recalled. Simultaneous size and concentration measurements are obtained by simultaneously recording transmittances of the medium at two well chosen wavelengths. Experimental results for suspensions of glass particles in air, are described and discussed. (Edited author abstract). 19 Refs.

Gouesbet, Gerard (CNRS, Mont-St.-Aignan, Fr); Gougeon, Patrick; Le Toulouzan, Jean-Noel; Thioye, Masamba; Guidt, Jean-Bernard. *Part Charact* v 5 n 2 Jun 1988 p 51-56.

**076793 DETERMINATION OF PARTICLE SIZE DISTRIBUTION IN FLUIDS USING PHOTON CORRELATION SPECTROSCOPY.** Photon correlation spectroscopy (PCS) has been applied to various systems of particles suspended in a fluid. Computer simulations were used to analyse CONTIN, a program for the numerical inversion of the experimental data. Measurements were performed on a spectrometer equipped with a digital correlator. Various suspensions of polystyrene latex spheres differing both in size and size distribution were prepared in double distilled water. Further, some samples provided by an external institution without prior specification were analysed. Diffusivity measurements on submicron DES (di-2-ethylhexyl sebacate) particles in nitrogen were also performed. The results obtained demonstrate the strengths and the limitations of PCS as a method of determining particle size distributions in particle fluid systems. (Author abstract). 11 Refs.

Krahn, Werner (Univ Duisburg, Duisberg, West Ger); Luckas, Michael; Lucas, Klaus. *Part Charact* v 5 n 2 Jun 1988 p 72-76.

**076794 SIZE SEPARATION OF PARTICLES FROM AEROSOL SAMPLES USING IMPACTORS AND CYCLONES.** Investigations are presented on particle separation in impactors, sampling cyclones and other precollectors. These devices are increasingly used for the characterization of particulate matter. Size selective samplers must be characterized by their grade efficiency curves. A new measuring procedure is presented, which permits the determination of the grade efficiency curves of various sampling devices. An optical particle counter and a vibrating orifice generator are used in these measurements. This calibration technique is fast and has a high resolution. Investigations were carried out on the influence of various parameters on the classification efficiency of impactors and sampling cyclones. Using the extensive data measured a better understanding and quantification of impactor and cyclone behaviour is developed which may improve their applications in particle sampling. (Author abstract). 6 Refs.

Buettner, Helmut (Univ Kaiserslautern, Kaiserslautern, West Ger). *Part Charact* v 5 n 2 Jun 1988 p 87-93.

**076795 APPLICATION OF THE STRAINING CAPTURE MECHANISM IN GAPS TO THE MEASUREMENT OF PARTICLE CONCENTRATION AND SIZE DISTRIBUTION.** This paper attempts to answer the question of whether a measurement of the relative flow rate of a suspension of spheres, flowing under constant pressure drop through gaps of precisely determined geometry, may be utilised to measure the concentration and size distribution of the particles. A positive answer is possible only if several restrictions are imposed on the character of the flow, a maximum ratio of sphere diameter to gap height and a maximum number of captured particles. This answer is based on a model of the filtration process taking place in the gap and the consequent relationship between the flow characteristics of the gap and the number and diameter of the captured particles. (Author abstract). 6 Refs.

Cieslicki, Krzysztof (Warsaw Technical Univ, Warsaw, Pol). *Part Charact* v 5 n 2 Jun 1988 p 94-99.

**Microscopic Examination** See Also AEROSOLS—Measurements.

**076796 STUDY OF FRESHLY DEPOSITED METALLIC PARTICLES ON MgO CRYSTAL SURFACES BY SCANNING REFLECTION ELECTRON MICROSCOPY.** In the newly developed specimen chamber of the VG-HB5 STEM microscope, a fresh monolayer of metallic film can be deposited on the MgO surfaces, and the surface phenomena are studied by the SREM technique. The present paper reports some further studies of the formation of small Pd particles on MgO surfaces under electron beam irradiation and some studies of thin Ni and NiO films on MgO and the reactions induced by electron irradiation. 18 refs.

Ou, H.-J. (Arizona State Univ, Tempe, AZ, USA); Cowley, J.M. *Ultramicroscopy* v 23 n 3-4 1987 p 263-269.

**076797 MICROSCOPIC INVESTIGATION OF SMALL PARTICLES.** Different microscopic methods to investigate small particles are described considering lateral resolution and vertical resolution down to atomic dimensions, imaging methods, diffraction techniques and possibilities for chemical analysis. A special consideration is devoted to beam specimen interaction, specimen preparation techniques and contrast phenomena in electron microscopy. (Author abstract) 12 refs.

Tholen, A.R. (Technical Univ of Denmark, Lyngby, Den). *Phys Scr* v 37 n 2 Feb 1988, Proc of the Adriatic Conf: Environ Phys - Atmos Aerosols, Trieste, Italy, Jul 22-25 1986 p 231-236.

## Performance

**076798 IMPROVEMENTS ON THE OPTICAL FIBER PARTICLE SIZER.** The following improvements were made on an optical fiber droplet sizer (previously developed by the author) that is used to measure the particle size and number density: (1) An accurate equation of the light intensity received on an optical fiber was derived while considering the scattering angle range of the light received on the optical fiber and the attenuation of the irradiation beam. (2) The particle size distribution, expressed as the particle number in units of volume, was obtained by solving the above accurate equation. As a result of measurements of polystyrene particles with known size distributions and known number densities, it was confirmed that the accuracy of measurements was improved so that the error of the average diameter  $D$  was less than 0.1  $\mu\text{m}$  ( $0.1 \mu\text{m} \leq D \leq 1.0 \mu\text{m}$ ) and the error of the number density was less than 100% ( $0.3 \mu\text{m} \leq D \leq 1.0 \mu\text{m}$ ). These measurements are used for estimating losses in efficiency and the erosions of turbine blades. (Edited author abstract) 9 refs.

Tatsuno, Kyoichi (Toshiba Corp, Kawasaki, Jpn). *Jpn J Appl Phys Part 1* v 27 n 1 Jan 1988 p 117-123.



**Spectroscopic Analysis** See SNOW AND SNOW-FALL—Measurements.

**Spectrum Analysis** See LATEXES—Spectrum Analysis; LIGHT—Scattering.

**Theory** See COAL—Physical Properties; POWDERS—Size Determination.

**PATENTS AND INVENTIONS** See Also BIO-MEDICAL EQUIPMENT—Marketing; COKE PLANTS—Equipment; DATABASE SYSTEMS; GAS DETECTORS—Sensors; GRAPHITE; HEARING AIDS; LEGISLATION: SENSORS—Japan.

## Bibliographies

**076799 LIST OF PATENTS FEATURING GRAPHITE INTERCALATION COMPOUNDS ISSUED BETWEEN 1977 AND 1986.** This list of patents contains 282 entries. Topics under which entries are listed include: graphite fluoride preparation; graphite bisulfate preparation; preparation of graphite-metal combinations; production of expanded graphite; intercalation compounds in electrodes and batteries; intercalation compounds in storage batteries; intercalation compounds in fuel cells; graphite fluoride in recording materials and photocopying toners; graphite-alkali metal intercalation compounds as getters and sources of metal vapor; graphite fluoride in antifoaming compositions and electrochromic displays.

Setton, R. (Solides a Organisation Cristalline Imparfaites, Orleans, Fr). *Synth Met* v 23 n 1-4 Mar 1988, Graphite Intercalation Compd, Proc of the Fourth Int Symp, Jerusalem, Isr, May 24-29 1987 p 511-517.

## Peoples Republic of China

**076800 ABC OF FILING AN APPLICATION FOR PATENT IN CHINA.** This paper describes the kinds of Chinese patents, requirements for grant of patent right, the documents submitted, principle of application, priority right, the patent agency, filing procedures and compulsory license for exploitation of the patent. In accordance with Article 2 of the Chinese Patent Law there are three types of patent rights, namely, inventions, utility models and designs. Under the Chinese Patent Law, an invention or utility model for which patent rights may be granted must possess novelty, inventiveness and practical applicability. The documents of application include a request, a description and an abstract and claims. Any document submitted must be written in Chinese. (Edited author abstract) In Chinese.

Mu, Zong-Xu (General Research Inst of Non-ferrous Metals, Beijing, China); Sun, Zhen-duo. *Xi You Jin Shu* v 6 n 3 Aug 1987 p 233-236.

**PATTERN RECOGNITION** See Also AUTOMATA THEORY—Computability and Decidability; AUTOMATA THEORY—Grammars; CHARACTER RECOGNITION: CHARACTER RECOGNITION—Automation; CHARACTER RECOGNITION, OPTICAL; CHARACTER RECOGNITION, OPTICAL—Design; COMPUTER AIDED DESIGN; COMPUTER GRAPHICS; COMPUTER GRAPHICS—Three Dimensional Graphics; COMPUTER PROGRAMMING—Algorithms; COMPUTER SOFTWARE; CONTROL SYSTEMS—Simulation; CUTTING TOOLS—Automatic Testing; FLOW OF FLUIDS—Two Phase; HIGHWAY TRAFFIC CONTROL—Operations Research; IMAGE PROCESSING; IMAGE PROCESSING—Enhancement; IMAGE PROCESSING—Image Analysis; MAPS AND MAPPING—Computer Aided Analysis; MAPS AND MAPPING—Computer Applications; MATHEMATICAL TECHNIQUES—Conformal Mapping; MATHEMATICAL TECHNIQUES—Fuzzy Sets; MATHEMATICAL TECHNIQUES—Geometry; METALS AND ALLOYS—Phase Diagrams; PARTICLE BEAM TRACKING—Imaging Techniques; PATTERN RECOGNITION SYSTEMS—Mathematical Models; PROBABILITY; ROBOTS, INDUSTRIAL—Manipulators; ROBOTS, INDUSTRIAL—Proximity Sensors; ROBOTS, INDUSTRIAL—Vision Systems; SIGNAL PROCESSING—Mathematical Models; SPEECH—Recognition; SURFACES—Computer Aided Analysis; SYSTEMS SCIENCE AND CYBERNETICS—Learning Systems; SYSTEMS SCIENCE AND CYBERNETICS—Neural Nets; TEXTILES—Testing; VISION—Artificial; VISION—Sensory Aids.

**076801 EFFICIENT BIT-LEVEL SYSTOLIC ARRAY FOR THE LINEAR DISCRIMINANT FUNCTION CLASSIFIER.** The linear discriminant function

classifier is a widely used but computationally demanding method in statistical pattern recognition. This paper describes a bit-level systolic array for the linear discriminant function classifier to improve its processing speed. The system includes a new scheme for inner product computation, which not only has 100% efficiency but also gains a speed improvement over a previous method, and yields classification results at an average rate of one per B cycles of the array, where B is the wordlength of the input data. The throughput is higher than those of the related bit level arrays described previously. (Author abstract) 16 refs.

Wang, C.-L. (Nat'l Chiao Tung Univ, Hsin-Chu, Taiwan); Wei, C.-H.; Chen, S.-H. *IEE Proc Part G* v 134 n 5 Oct 1987 p 216-224.

**076802 OBJECT DETECTION AND EXPERIMENTAL DESIGNS.** A new object detection classifier is developed by combining the supervised learning model, hypothesis testing techniques, and the robust F-statistic in conjunction with the analysis of variance (ANOVA) process. The visual equivalence of two similarly dimensioned images is interpreted in terms of the F-statistic of two standard patterns resulting from transformations by a set of randomly generated rules. The object registration is related to the target and background portions of the reference template. Using the F-statistic as the test statistic, the object detection procedure is reduced to a simple ANOVA process. The multiple-hits problem is also resolved using either the distance between the test statistic and the threshold values or a set of floating threshold values associated with various confidence levels. (Edited author abstract) 17 refs.

Chang, Edward S.H. (AT&T, Basking Ridge, NJ, USA); Kurz, Ludwik. *Comput Vision Graphics Image Process* v 40 n 2 Nov 1987 p 147-168.

**076803 AVOIDING PEAKING PHENOMENON OF THE QUADRATIC DISCRIMINANT FUNCTION.** The performance of the discriminant function is degraded if the parameters used contain estimation errors. A peaking phenomenon is known in which the classification rate reaches the maximum for a certain feature dimension, but decreases with the further increase of the feature dimension. This paper reports the result of experimental examination of the relations of the classification rates of the Euclid distance, the quadratic discriminant function to the feature dimension. It is shown that the modified quadratic discriminant function corresponds to the discriminant function where the maximum-likelihood estimation for the covariance matrix of the quadratic discriminant function is replaced by a kind of pseudo-Bayes estimation, and suppresses the peaking phenomenon. (Author abstract) 9 refs.

Kimura, Fumitaka (Mie Univ, Tsu, Jpn); Takashina, Kenji; Tsuruoka, Shinji; Miyake, Yasuji. *Syst Comput Jpn* v 18 n 9 Sep 1987 p 44-51.

**076804 OPTICAL INSPECTION/PATTERN RECOGNITION.** Automated optical inspection (AOI), as applied to electronic products, is considered. The optical inspection station is made an integral part of the manufacturing process. This involves taking information downloaded from CAD databases and feeding test results and fault locations to a growing assortment of verification, repair and central processing utilities. The electronics industry's portion of vision technology now is predicted to eclipse that of the automobile manufacturers before the end of the decade, making it the top consumer of optical inspection systems.

Anon. *Eval Eng* v 26 n 9 Sep 1987 6p between p 13 and 22.

**076805 ON THE BIT COMPLEXITY OF DISTRIBUTED COMPUTATIONS IN A RING WITH A LEADER.** We study the bit complexity of pattern recognition in a distributed ring with a leader. Each processor gets as input a letter from some alphabet, and these concatenated letters, starting at the leader, form the pattern of the ring. The leader initiates an algorithm that

accepts or rejects this pattern. Thus each algorithm recognizes a language over a given alphabet. Several results concerning the language are proved. (Edited author abstract) 15 refs.

Mansour, Y. (Technion-Israel Inst of Technology, Haifa, Isr); Zaks, S. *Inf Comput* v 75 n 2 Nov 1987 p 162-177.

**076806 ERROR RATE ESTIMATION BY MIXTURE DECOMPOSITION.** We show how error rate estimation may be viewed as a problem of mixture decomposition. We apply the idea to the average conditional error rate approach to estimation and explore the effectiveness of one particular decomposition method by simulation. (Author abstract) 15 refs.

Hand, D.J. (Inst of Psychiatry, London, Engl); Fitzmaurice, G.M. *Comput Math Appl* v 14 n 7 1987 p 573-578.

**076807 PATTERN MATCHING USING FINITE STATE MACHINES.** The problem of pattern matching is considered. It can be a simple problem solved with a trivial string comparison utility, or it can be so complex as to require the use of a lexical analyzer. This article describes how state machines can be useful in solving this type of problem. To demonstrate the use and effectiveness of state machines, this article provides the source code for a program called findcmd. The program does just what the name implies—it finds commands. When invoked, the program searches each component of the user's path variable for all programs (files) that match the supplied pattern arguments. The pattern string can contain wildcard characters just like those the DOS command shell accepts. The program uses an extension of the Knuth-Morris-Pratt (KMP) algorithm, which implements pattern matching using a finite state machine. 4 refs.

Bowman, Charles F. *Dr Dobb's J Software Tools* v 12 n 10 Oct 1987 14p between p 46 and 108.

**076808 STUDIES IN POSSIBILISTIC RECOGNITION.** This paper introduces an algorithm for pattern recognition. The algorithm will classify a measured object as belonging to one of N known classes or none of the classes, making use of fuzzy techniques and possibility instead of probability. It was conceived with the idea of recognizing fast moving objects, but it is shown to be more general. Fuzzy ISODATA is used as a front end to the algorithm. The algorithm is shown to accomplish the objectives of correct classification or no classification. Values that describe possibility distributions are introduced and some of their properties investigated and illustrated. An expected value for a possibility distribution is also investigated. The algorithm actually proves to be adaptable to a wide variety of imprecise recognition problems. Some test results illustrate the use of the technique embodied in the algorithm and indicate its viability. (Edited author abstract) 40 refs.

Hall, Lawrence O. (Florida State Univ, Tallahassee, FL, USA); Kandel, Abraham. *Fuzzy Sets Syst* v 17 n 2 Nov 1985 p 167-179.

**076809 GENERALIZED k-NEAREST NEIGHBOR RULES.** This paper discusses a suitable framework for generalizing the k-nearest neighbor (k-NNR) algorithms to cases where the design labels are not necessarily crisp, i.e., not binary-valued. The proposed framework imbeds all crisp k-NNR's into a larger structure of fuzzy k-NNR's. The resultant model enables neighborhood voting to be a continuous function of local labels at a point to be classified. We emphasize that the decision itself may be crisp even when a fuzzy k-NNR is utilized. The usefulness of this extension of the conventional technique is illustrated by comparing the observed error rates of four classifiers (the hard k-NNR, two fuzzy k-NNR's, and a fuzzy 1-nearest prototype rule (1-NPR)) on three data sets. (Edited author abstract) 15 refs.

Bezdek, James C. (Univ of South Carolina, Columbia, SC, USA); Chuah, Siew K.; Leap, David. *Fuzzy Sets Syst* v 18 n 3 Apr 1986 p 237-256.



**076810 EFFICIENT TWO-DIMENSIONAL PATTERN MATCHING IN THE PRESENCE OF ERRORS.** We give an algorithm for two-dimensional pattern matching in the presence of errors. We find that the complexity of our algorithm is  $O(kn_1n_2 \log n_2 + n_1^2n_2 + kn_1m_1m_2)$ , where the pattern is an  $n_1 \times n_2$  array, the text is an  $m_1 \times m_2$  array, and  $k$  is the number of mismatches allowed. (Author abstract) 5 refs.

Krithivasan, Kamala (Univ of Maryland, College Park, MD, USA); Sitalakshmi, R. *Inf Sci* v 43 n 3 Dec 1987 p 169-184.

**076811 SYSTEM FOR THE FORMATION OF INVARIANT KEY FEATURES IN PROBLEMS OF RECOGNITION OF FLAT IMAGES.** Algorithms for the formation of flat image features are systematized. They are invariant with respect to the group of similarity transformations, feature ordering and key words formations for organization of an efficient access and selection of the corresponding images. Algorithms are proposed for distinguishing image features which employ a geometric interpretation of autocovariance functions and invariance properties of two-dimensional Fourier transforms. (Author abstract) 11 refs.

Kirichenko, N.F. (Kiev Univ, USSR); Lepekha, P.P. *Sov J Autom Inf Sci* v 20 n 1 Jan-Feb 1987 p 50-57.

**076812 SPONTANEOUS PATTERN CLASSIFICATION BY A DYNAMICAL SYSTEM.** We study features of a recently proposed computer architecture which models a dynamical system. We generalize the model and give some central issues. We apply the basin complexity as a measure and exemplify the use of the system for pattern recognition. (Author abstract) 17 refs.

Banzhaf, W. (Univ Stuttgart, Stuttgart, West Ger). *J Phys (Paris)* v 48 n 12 Dec 1987 p 2027-2035.

**076813 MULTICOMPUTER PARALLEL ARRAYS, PIPELINES, AND PYRAMIDS FOR PATTERN PERCEPTION.** This chapter describes the application of parallel computation to image processing and pattern recognition. Architectures using parallel arrays, pipeline arrays, and pyramids are considered. 38 refs.

Uhr, Leonard (Univ of Wisconsin, Madison, WI, USA). *VLSI and Mod Signal Process*. Publ by Prentice-Hall Inc (Prentice-Hall Inf and Syst Sci Ser), Englewood Cliffs, NJ, USA, 1985 p 406-421.

**076814 ON IMPROVING THE AVERAGE CASE OF THE BOYER-MOORE STRING MATCHING ALGORITHM.** It is shown how to modify the Boyer-Moore string matching algorithm so that the number of characters actually inspected and the running time decrease sharply as the length of pattern gets longer. The basic idea is to utilize two characters for a precomputed table instead of one character as in the original BM algorithm. Whenever a mismatch occurs, we can slide the pattern to the right a longer distance than in the original version. (Edited author abstract) 5 refs.

Zhu Rui Feng (Ibaraki Univ, Hitachi, Jpn); Takaoka, Tadao. *J Inf Process* v 10 n 3 1987 p 173-177.

**076815 HIGHER-ORDERED RULES FOR SYMBOLIC SUBSTITUTION.** Symbolic substitution rules are derived for arbitrary switching functions. The rules presented are based on additional inputs and multiple-valued logic. The result is that fewer applications of the rules are needed to complete an operation. The throughput of a system is effectively increased. In general, as more complex functions are implemented, more rules are needed. (Author abstract) 12 refs.

Kozaitis, S.P. (Wayne State Univ, Detroit, MI, USA). *Opt Commun* v 65 n 5 Mar 1 1988 p 339-342.

**076816 ASTIGMATIC HOLOGRAPHIC PROCESSOR FOR LOCAL PATTERN RECOGNITION.** A coherent processor for local correlation is described. This device can be used to unmask local resemblances between object transparencies and a stored matched filter, which

would be hidden in global correlation, as that of a classical Vander Lugt filter. This is achieved by means of a holographic filter that is an image hologram in one direction and a lensless Fourier transform hologram in the other. The hologram is registered with a line reference beam in the conjugate plane of a cylindrical lens and is reconstructed by means of a spherocylindrical optical system. (Author abstract) 6 refs.

Rabal, H.J. (Centro de Investigaciones Opticas, La Plata, Argent); Furlan, W.D.; Garavaglia, M. *Opt Commun* v 65 n 5 Mar 1 1988 p 343-346.

**076817 ALGORITHM FOR VERTEX DETECTION.** Optical pattern recognition is playing an ever increasing role in the automation of manufacturing processes. A PC-based vision system was used to acquire the 2D image of flat parts (of polygonal geometry). The edges of this image were identified using a boundary encoding technique. Valid intersections of the edges were defined by using a bounding box, to decipher the co-ordinates of the vertices. Thus the identification of the object was done totally in software. (Edited author abstract) 16 refs.

Anand, S. (Pennsylvania State Univ, University Park, PA, USA); Raman, S.; Wysk, R.A. *Comput Ind Eng* v 14 n 2 1988 p 77-83.

**076818 NEURAL NETWORK MODEL BASED ON SHORT-TERM MEMORIES FOR THE HIERARCHICAL RECOGNITION OF TEMPORAL PATTERNS.** A new self-organizing neural network model is proposed and evaluated for the mechanism of temporal pattern recognition of the auditory system. The model is constructed based on the hypothesis that total recognition of temporal patterns approximately of the length of words, is carried out by hierarchical identification and integration of the temporal relations of the constituent features. The model has a hierarchical structure in which short-term memories storing spatial patterns, the circuits extracting temporally transient components of the pattern and the feature detection circuits to identify spatial patterns are iteratively cascaded. After the circuit is self-organized by repetitive presentation of training patterns, the model can correctly identify the training patterns and their temporally compressed and stretched patterns. It is also indicated that the short-term memory function at each layer of the model is essential to the acceptance of temporally deformed patterns. Studies to expand the model to top-down processing are also discussed. (Author abstract) 3 refs.

Futami, Ryoko (Hokkaido Univ, Sapporo, Jpn); Hoshimiya, Nozomu. *Syst Comput Jpn* v 19 n 2 Feb 1988 p 102-109.

**076819 COMPUTER VISION SYSTEM BY MODEL REPRESENTATION INVOLVING AMBIGUOUS CONCEPTS.** The authors consider planar-faced or curved-surface solid bodies having trihedral vertices only. They discuss a model representation and an inference mechanism which can accumulate ambiguous concepts directly and performs recognition of hand drawn figures efficiently with the level of conformity with the input image as a clue. They explain the matching process of models and input figures. Finally, they demonstrate how the whole system works via an actual example of the recognition. 7 refs.

Yoshie, Osamu (Univ of Waseda, Tokyo, Jpn); Miyachi, Hiroki; Andou, Takashi; Akizuki, Kageo. *Electr Eng Jpn* v 107 n 5 Sep-Oct 1987 p 74-84.

**076820 FIGURE RECOGNITION METHOD FOR HAND-WRITTEN DRAWINGS.** A method is proposed to recognize symbols and lines in handwritten plant record drawings of poor quality. This method is composed of symbol candidate detection, symbol discrimination and line segment recognition processes. The symbol candidate detection process extracts symbols of different sizes simultaneously at high speed. The symbol discrimination process classifies the candidates into several plant symbols by interior pattern structure analysis based on distance transformation, thinning and so on. Experiment results

show that the correct recognition rate of symbols and lines is more than 90%. (Author abstract) 10 refs. In Japanese.

Kawada, Etsuo (NTT, Jpn); Ueda, Naonori; Ogawa, Hiroshi; Kosugi, Makoto. *Denki Tsushin Kenkyusho Kenkyu Jitsuyoku Hokoku* v 37 n 3 1988 p 217-223.

**076821 IMAGE-RECOGNITION SYSTEM USING ALGORITHMICALLY DEDICATED INTEGRATED CIRCUITS.** An image-recognition system was implemented with a set of eight algorithmically dedicated integrated circuits to recognize two-dimensional objects that are characterized by their closed outer contours. The complete system operates at rates up to 15 frames/second using a standard workstation as a controller. The recognition system achieved a 97% recognition rate for over 10,000 trials of recognition of eight objects over a wide range of orientation and size variations. A 100% recognition rate was achieved if size variations were eliminated. The set of 4-micron NMOS image processor chips operates on 10-megahertz 8-bit video data (512x512 images) in real time. The relationship between the algorithms that were implemented and the silicon implementation is discussed. (Edited author abstract) 19 refs.

Ruetz, Peter A. (Univ of California at Berkeley, Berkeley, CA, USA); Brodersen, Robert W. *Mach Vision Appl* v 1 n 1 1988 p 3-22.

**076822 PATTERN RECOGNITION BY LABELED GRAPH MATCHING.** A model for position invariant pattern recognition is presented. Although not demonstrated here, the system is insensitive to distortions. Recognition is based on labeled graph matching. The system consists of two layers of neurons, an input layer, and a memory and recognition layer. The latter consists of subnets to represent individual patterns. In both layers, patterns are represented by labeled graphs. Nodes are 'neurons,' labels are local feature types, links are implemented by excitatory connections and represent topology. Recognition is driven by spontaneous dynamic activations of local clusters in the input layer. Network dynamics is able to selectively activate with good reliability corresponding clusters in memory layer. Few cluster activations suffice to identify the subnet and pattern corresponding to the graph in the input layer. The system has been implemented and tested with the help of simulations. (Author abstract) 32 refs.

von der Malsburg, Christoph (Max-Planck-Inst fuer Biophysikalische Chemie). *Neural Networks* v 1 n 2 1988 p 141-148.

**076823 CONTOUR DETECTION ALGORITHM BASED ON THE MINIMUM RADIAL INERTIA (MRI) CRITERION.** A new method for contour detection of objects in images is presented. It works simultaneously on all the pixels of real images, in which the object of interest has a radially connect contour. As a consequence, the contour can be described as a linear combination of period basic (cubic) splines in polar coordinates. To this aim, the 'radial inertia' defined versus generic radially connected curve, is introduced as a functional over the 'significant' pixels the image. The minimization of this functional supplies the required contour. If necessary some iterations of the method allow the distortion effects due to extraneous structures and noise to be reduced. Several examples show the capabilities of the proposed method practical cases. (Author abstract) 26 refs.

Grattoni, Paolo (CNR, Turin, Italy); Pollastri, Fabrizio; Premoli, Amedeo. *Comput Vision Graphics Image Process* v 43 n 1 Jul 1988 p 22-36.

**076824 ESTIMATION OF RIGID BODY MOTION USING STRAIGHT LINE CORRESPONDENCES.** An algorithm for the estimation of rigid body motion using straight line correspondences is presented in this paper. In the case of pure translation, we present a linear algorithm using 5 line correspondences over 3 frames. In the case of general motion, it is found that the rotation and the translation parts are separable. The rotation part can



be computed by the iterative solution of nonlinear equations based on 6 or more line correspondences over 3 frames. After the rotation is found, the translation part is determined just as in the pure translation case. For the special case of constant rotation, the convergence range of the iterative method is wide enough so that global search can be used to estimate the rotation matrix. However, for the case of variable rotation, global search appears computationally infeasible at present. (Author abstract) 12 refs.

Liu, Yuncai (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Huang, Thomas S. *Comput Vision Graphics Image Process* v 43 n 1 Jul 1988 p 37-52.

**076825 FROM AN IMAGE SEQUENCE TO A RECOGNIZED POLYHEDRAL OBJECT.** The paper describes the combination of several novel algorithms into a system that obtains visual motion from a sequence of images and uses it to recover the three-dimensional (3D) geometry and 3D motion of polyhedral objects relative to the sensor. The system goes on to use the recovered geometry to recognize the object from a database, a stage which also resolves the depth/speed scaling ambiguity, resulting in absolute depth and motion recovery. The performance of the system is demonstrated on imagery from a well carpentered constructive solid geometry (CSG) model and on real imagery from a simple wooden model. (Author abstract) 40 refs.

Murray, D.W. (GEC Research Ltd, Wembley, Engl); Castlelow, D.A.; Buxton, B.F. *Image Vision Comput* v 6 n 2 May 1988 p 107-120.

**076826 ZODIAC: PERSONAL IDENTIFICATION BY SIGNATURE.** Research work into signature recognition was carried out at the National Physical Laboratory during the 1970s. Within pattern recognition, signature recognition is probably one of the simpler problems to solve. The objective of a signature recognising machine would be to identify a person from the signature. Signature encoding and application of the technique in ammunition transactions control are outlined. (Edited author abstract)

England, David M. *Comput Bull (London 1986)* v 4 pt 2 Jun 1988 p 33-35.

**076827 PICTURE SYNTHESIS: AN ESSENTIAL TOOL FOR NUMERICAL EXPERIMENTATION.** Science and Technique translate into mathematical language the behaviour and the shape of the objects that they study and produce; these expressions are named models. The corresponding equations must be solved analytically or numerically (according to the possibilities) in order to validate the assumptions and to make predictions. Most of the time, by means of faster and faster computers, these calculations give birth to very large amount of numerical results. The use of supercomputers submerges scientists and engineers with avalanches of numbers. This paper describes the use of the picture synthesis as the best way to output results from numerical simulations.

Colonna, Jean-Francois (Ecole Polytechnique, Palaiseau, Fr). *Comput Phys Commun* v 49 n 1 Apr 1988 p 215-228.

**076828 MODEL-BASED RECOGNITION OF GLOSSY OBJECTS USING THEIR POLARIMETRIC PROPERTIES.** A model-based approach to recognition of glossy objects is presented. Normals of surface patches are obtained by analyzing the polarizational state of the observed rays under illumination of light sources of circular polarization. The object is assumed to lie alone in its stable pose on the floor. Solid models are examined to find the one that matches the observed normals. First, a candidate model based on the relative angles between known surface normals is found. Then the translation so that the observed positions of surface normals coincide with those of models in the image is found. Some examples are also presented. (Author abstract). 4 Refs.

Koshikawa, Kazutada (Electrotechnical Lab, Ibaraki, Jpn); Shirai, Yoshiaki. *Adv Rob* v 2 n 2 1987 p 137-147.

**076829 SEPARATING FORCE OF FEATURES IN PROBLEMS OF RECOGNITION LEARNING BASED ON THE METHOD OF LIMITING SIMPLIFICATIONS.** A notion of the separating force of a feature in pattern recognition learning is introduced and formalized. The procedure of learning by the method of limiting simplifications is organized with due regard for the separating force of a sign. The learning algorithm 'PUMA' is presented and the results of the concrete problem solution are discussed. (Author abstract). 4 Refs.

Vasil'yen, V.I. (Glushkov Inst of Cybernetics, Kiev, USSR); Ovsyannikova, F.P.; Bekmuratov, K.A. *Sov J Autom Inf Sci* v 20 n 4 Jul-Aug 1987 p 1-6.

**076830 GENERALISED THRESHOLD SELECTION FOR EDGE DETECTION.** This paper derives a generalised technique for selecting thresholds of edge strength maps from theoretical considerations of the known noise statistics of the image. A technique is described for estimating the mean and variance of the noise of an image using a pair of images. The threshold selection technique can be applied to any single digital edge operator and has been extended for use with combinations of edge operators. Two examples of thresholded edge maps using the techniques developed here are shown. (Author abstract). 5 Refs.

Haddon, John F. (Royal Aircraft Establishment, Farnborough, Engl). *Pattern Recognit* v 21 n 3 1988 p 195-203.

**076831 ON THE MINIMUM NUMBER OF TEMPLATES REQUIRED FOR SHIFT, ROTATION AND SIZE INVARIANT PATTERN RECOGNITION.** Human observers are generally capable of recognizing patterns invariant to their orientation, position and size within an image. Though techniques are available for similar performance in computer visual systems, most suffer from lack of uniqueness or computational complexity. In this paper we introduce a new adaptive approach to invariant pattern recognition which overcomes both these problems. This technique is based upon the intrinsic invariance properties of the pattern and the recognition criterion. Our simulations demonstrate that the number of templates required to gain efficient pattern recognition is considerably lower than previously thought. (Author abstract). 20 Refs.

Caeli, Terry M. (Univ of Alberta, Edmonton, Alberta, Can); Liu, Zhi-Qiang. *Pattern Recognit* v 21 n 3 1988 p 205-216.

**076832 EXTRACTION OF TREND LINES AND EXTREMA FROM MULTISCALE CURVES.** Multiscale planar curves are curves conveying information at several levels of detail. To extract polygonal approximations of such curves at different resolutions, we propose a parallel method based on connecting locally computed centroids. The implementation makes use of a new pyramidal data structure, the chain pyramid. Coarser and coarser approximations are obtained through a hierarchy of increasingly coarse tessellations. Significant extrema of the curves are localized at the highest resolution by segmenting at a 'natural scale' and employing the structure of the chain pyramid for down-projection. (Author abstract). 12 Refs.

Meer, Peter (Univ of Maryland, College Park, MD, USA); Baugher, Ernest S.; Rosenfeld, Aziel. *Pattern Recognit* v 21 n 3 1988 p 217-226.

**076833 INVARIANT PLANAR SHAPE RECOGNITION USING DYNAMIC ALIGNMENT.** Closed planar shapes are modelled by an ordered sequence that represents the Euclidean distance between the centroid and all contour pixels of the shape. Shapes belonging to the same class have similar sequences, hence a procedure for classifying shapes is based on the degree of similarity between these sequences. In order to determine the similarity between sequences, a dynamic alignment process is developed to find the best correspondence between the sequences. Optimum alignment is obtained by expanding segments of the sequences to minimize a dissimilarity

function between the sequences. Normalization with respect to scaling and rotation is described and an example illustrating the use of dynamic alignment for the classification of noisy shapes is presented. (Author abstract). 5 Refs.

Gupta, L. (Southern Illinois Univ, Carbondale, IL, USA); Srinath, M.D. *Pattern Recognit* v 21 n 3 1988 p 235-239.

**076834 CONSENSUS-BASED PARTITIONS IN THE SPACE OF ORDERED PARTITIONS.** The paper presents a method of determining a representation of ordered partitions, i.e. a partition to which the sum of distance from fixed partitions is minimal. Two metrics are proposed as measures of distance between ordered partitions. The first metric is equal to the minimum number of element moves necessary to transform a partition into another one, and the second one equals the sum of weights of these element moves. Criteria of selecting best representations of chosen ordered partitions are also presented. (Author abstract). 8 Refs.

Danilowicz, Czeslaw (Dep of Information Systems, Wrocław, Pol); Ngoc Thanh Nguyen. *Pattern Recognit* v 21 n 3 1988 p 269-273.

**076835 NEIGHBORHOOD METHOD IN RECOGNITION PROBLEMS.** A new recognition method based on the precedence principle is proposed. In this method, estimation of the nearest neighbors of the recognized object in the training set does not require comparisons with all the elements of the training set and does not presuppose subdivision of classes by means of given hypersurfaces. A new machinery connected with classical mappings of the type of Peano curves is utilized. An example of application of this method for screening diagnostics is given. (Author abstract). 12 Refs.

Gergel, V.P.; Strongin, L.G.; Strongin, P.G. *Sov J Comput Syst Sci* v 26 n 2 Mar-Apr 1988 p 46-54.

**076836 MAXIMUM  $\Sigma$ -COUNT AS A DECISION OPERATOR.** The main approaches in pattern classification can be grouped into two main categories: the statistical and the syntactic pattern classification. This paper presents another method based on fuzzy set theory. At first a brief overview of the statistical method is given and especially the maximum likelihood decision rule. Then the maximum  $\Sigma$ -count operator is introduced which in contrast to the maximum likelihood decision rule is based not on 'a priori' probabilities but on fuzzy labels. An algorithm that operates on a parallel fuzzy labeling file is presented along with a real implementation of the maximum  $\Sigma$ -count operator. The advantages and the versatility of this approach against the statistical one are emphasized and final conclusions are drawn. (Author abstract). 9 Refs.

Mantas, J. (Univ of Athens, Athens, Greece). *Fuzzy Sets Syst* v 27 n 2 Aug 1988 p 149-158.

**076837 CLASSIFICATION OF PATTERNS USING A SELF-ORGANIZING NEURAL NETWORK.** The objective of this study is to evaluate the performance of K. Fukushima's neocognitron model when it is applied to complex imagery. In his original report, Fukushima demonstrated that this system could discriminate between simple alphabetical characters represented in fields of 16 X 16 pixels, and that shift invariance can be achieved through a proper choice of design parameters. The present work describes results for expanded neocognitron architectures operating on complex images of 128 X 128 pixels. These neural network systems were simulated on a VAX-8600 minicomputer. Wire frame models of three different vehicles were used to test the properties which Fukushima had demonstrated. The expanded neocognitron systems were able to classify these objects and to identify their critical features. After training, each object was placed at different positions in the plane, and the neocognitron's shift invariance property was tested. With complex (128 X 128) imagery, it was difficult to achieve proper classification and maintain shift invariance using



only a few levels. In another experiment, the neocognitron trained on polar transforms of objects in the training set. Objects in the training set were rotated, and polar transforms of the rotated images were submitted as input. In this manner, the neocognitron's shift invariance was exploited to recognize rotated imagery. These investigations gave insight into the role of various model parameters and their proper values, as well as demonstrating the model's applicability to complex images. (Author abstract). 4 Refs.

Menon, Murali M. (MIT Lincoln Lab, Lexington, MA, USA); Heinemann, Karl G. *Neural Networks* v 1 n 3 1988 p 201-215.

**076838 INDUCTIVE INFERENCE OF PATTERN RECOGNITION RULES WHICH ARE CAPABLE OF A LINGUISTIC INTERPRETATION.** A new algorithm for the inductive inference of pattern recognition rules from a class of examples and another class of counter-examples is given. An important feature of the algorithm is that a discriminant for the class of examples is generated in a format which allows immediate interpretation into the language of the application domain expert. The approach is an extension to that of R.S. Michalski and incorporates ideas from fuzzy set theory. It is aimed at applications where the observable variables are such that the sample space of each class overlaps. The algorithm has been tested and validated on a complex data set consisting of observations on 1000 head-injured patients. A particular feature of this data set is the large proportion of missing values. This data set was also of special interest, since it has been used by others as a vehicle for comparing several statistical discrimination techniques. The proposed method for transformation to linguistic output is also demonstrated for this data set. (Edited author abstract). 30 refs.

Bigham, J. (Univ of London, London, Engl). *Int J Comput Math* v 15 n 10 1988 p 839-862.

**076839 COMPLEX SYNTHETIC DISCRIMINANT FILTER FOR THE PARALLEL RECOGNITION OF COLOR PATTERNS.** We propose to combine the properties of color image correlation with the flexibility of synthetic discriminant filters to generate filters capable of solving various color pattern recognition problems. We show that in addition to being color sensitive, the resulting complex composite filters yield an improvement in recognition accuracy with respect to conventional intensity filters. (Author abstract). 3 Refs.

Badique, Eric (Imaging Science and Engineering Lab, Yokohama, Japan); Ohyama, Nagaaki; Honda, Toshio; Tsujuchi, Jumpei. *Opt Commun* v 67 n 5 Aug 1 1988 p 335-340.

**076840 MATHEMATICAL FORMULA FOR SUBJECTIVE EXPRESSION ON VISUAL PATTERNS.** In actual image recognition, one does not always view the whole image, but often subjectively selects a certain subregion on the image to obtain some useful information. This paper clarifies theoretically the reason why such an ability possessed by humans is naturally carried out, by using a mathematical analysis regarding the fundamental properties of a visual pattern. A mathematical formula showing multilayer structures of a visual pattern is obtained by the foregoing analysis. The results obtained in this paper may contribute to elucidating the aspect of the basic process of the feature extraction from the pattern. (Author abstract). 8 Refs.

Iijima, Taizo (Tokyo Engineering Univ, Tokyo, Jpn). *Syst Comput Jpn* v 19 n 7 Jul 1988 p 65-71.

**076841 SYNTHESIZING STATISTICAL KNOWLEDGE FROM INCOMPLETE MIXED-MODE DATA.** A method for analyzing and clustering (synthesizing) multivariate data of the mixed type (discrete and continuous) is presented that enables statistical knowledge to be acquired from such data. The method adopts an event-covering approach that covers a subset of statistically relevant outcomes in the outcome space of variable-pairs. Once the covered event patterns are acquired,

subsequent analysis tasks such as probabilistic inference, cluster analysis, and detection of event patterns for each cluster based on the incomplete probability scheme can be performed. The performance is evaluated by experiments using both simulated and real-life data. 22 refs.

Wong, Andrew K.C. (Univ of Waterloo, Ont, Can); Chiu, David K.Y. *IEEE Trans Pattern Anal Mach Intell* v PAMI-9 n 6 Nov 1987 p 796-805.

**076842 CONVERGENCE THEORY FOR FUZZY C-MEANS: COUNTEREXAMPLES AND REPAIRS.** A counterexample to the original incorrect convergence theorem for the fuzzy c-means (FCM) clustering algorithms is provided. This counterexample establishes the existence of saddle points of the FCM objective function at locations other than the geometric centroid of fuzzy c-partition space. Counterexamples previously discussed by W.T. Tucker (1987) are summarized. The correct theorem is stated without proof: every FCM iterate sequence converges, at least along a subsequence, to either a local minimum or saddle point of the FCM objective function. Although Tucker's counterexamples and the corrected theory appear elsewhere, they are restated as a caution not to further propagate the original incorrect convergence statement. 12 refs.

Bezdek, James C. (Boeing Electronics Co, Seattle, WA, USA); Hathaway, Richard J.; Sabin, Michael J.; Tucker, William T. *IEEE Trans Syst Man Cybern* v SMC-17 n 5 1987 p 873-877.

**076843 PARTIAL SHAPE RECOGNITION USING DYNAMIC PROGRAMMING.** A partial-shape-recognition technique utilizing local features described by Fourier descriptors is introduced. A dynamic programming formulation for shape matching is developed, and a method for comparison of match quality is discussed. This technique is shown to recognize unknown contours that may be occluded or that may overlap other objects. Precise scale information is not required, and the unknown objects may appear at any orientation with respect to the camera. The segment-matching dynamic programming method is contrasted with other sequence-comparison techniques that utilize dynamic programming. Experimental results are discussed that indicate that partial contours can be recognized with reasonable accuracy. 19 refs.

Gorman, John W. (Purdue Univ, West Lafayette, IN, USA); Mitchell, O. Robert; Kuhl, Frank P. *IEEE Trans Pattern Anal Mach Intell* v 10 n 2 Mar 1988 p 257-266.

**076844 CAPACITY OF MULTILEVEL THRESHOLD FUNCTIONS.** Lower and upper bounds for the capacity of multilevel threshold elements are estimated, using two essentially different enumeration techniques. It is demonstrated that the exact number of multilevel threshold functions depends strongly on the relative topology of the input set. The results correct a previously published estimate and indicate that adding threshold levels enhances the capacity more than adding variables. 11 refs.

Olafsson, Sverrir (California Inst of Technology, Pasadena, CA, USA); Abu-Mostafa, Yaser S. *IEEE Trans Pattern Anal Mach Intell* v 10 n 2 Mar 1988 p 277-281.

**076845 BOUNDS ON THE BAYES CLASSIFICATION ERROR BASED ON PAIRWISE RISK FUNCTIONS.** Upper and lower bounds on the Bayes risk for multiple, composite-hypothesis classification are obtained. Bounds on the Bayes risk for M simple classes are derived in terms of the risk functions for (M-1) classes, and so on, until the desired result depends only on the pairwise (M = 2) Bayes risks. A method of computing upper and lower bounds on the pairwise Bayes risk for composite classes is developed. Algorithms for computing the upper and lower bounds for the general M-class case and for composite-hypothesis classes are presented. Numerical examples of the application of the bounding techniques to a problem involving the classification of aircraft are discussed. Results for the bounds and other performance measures are compared for the most interesting cases. 17

refs.

Garber, F.D. (Ohio State Univ, Columbus, OH, USA); Djoudi, A. *IEEE Trans Pattern Anal Mach Intell* v 10 n 2 Mar 1988 p 281-288.

**076846 COMPUTERIZED SIGNATURE VERIFICATION SYSTEM.** The fine structure of the human muscle forces that are exerted during the writing of a signature is consistent and well defined for most people. On the basis of this observation, an experimental system that utilizes a person's signature waveform dynamics for identification is proposed. The system is intended to be used for online signature verification. It can successfully verify a person's identity and can also detect forgeries. The acceptance rate for random forgeries, i.e., accidental matching of two different persons' signatures, is very low. 8 refs.

Mital, Dinesh P. (Nanyang Technical Inst, Singapore); Hin, Choo Pee; Leng, Wee Kee. *IEEE Control Syst Mag* v 8 n 3 Jun 1988 p 54-57.

**076847 AUTOMATIC PATTERN RECOGNITION: A STUDY OF THE PROBABILITY OF ERROR.** A test sequence is used to select the best rule from a class of discrimination rules defined in terms of the training sequence. The Vapnik-Chervonenkis and related inequalities are used to obtain distribution-free bounds on the difference between the probability of error of the selected rule and the probability of error of the best rule in the given class. The bounds are used to prove the consistency and asymptotic optimality for several popular classes, including linear discriminators, nearest-neighbor rules, kernel-based rules, histogram rules, binary tree classifiers, and Fourier series classifiers. In particular, the method can be used to choose the smoothing parameter in kernel-based rules, to choose k in the k-nearest neighbor rule, and to choose between parametric and nonparametric rules. 141 refs.

Devroye, Luc (McGill Univ, Montreal, Que, Can). *IEEE Trans Pattern Anal Mach Intell* v 10 n 4 Jul 1988 p 530-543.

**076848 CLASSIFIER FOR FEATURE VECTORS WHOSE PROTOTYPES ARE A FUNCTION OF MULTIPLE CONTINUOUS PARAMETERS.** A fast, compact continuous-parameter (CP) classifier, suitable for a 16-bit microprocessor, is developed for classes which consist of a prototype manifold which is a function of one or more continuous parameters. The classification method consists of approximating the manifold by a number of unit cells and assigning a test vector to the closest cell using a Euclidean distance measure. An experiment is described in which computer-generated magnetic dipole moments are used as feature vectors to classify a set of homogeneous ferrous spheroids. The CP classifier provides accurate estimates of the orientation angles of the test object with error equal to a small fraction of the design set increment (1° out of 15°). The 1-NN (nearest-neighbor) classifier was the only other that could estimate the angles, with an error of one design set increment (15°). The classifier yields a substantially lower probability of misclassification (P(e)) for the same design set than the nearest mean vector, Fisher-pairwise, and K-NN (K > 1) classifiers, about the same P(e) as the 1-NN. A modified Parzen classifier has a substantially higher P(e) than the CP classifier for test vectors with small-to-moderate uncertainties, and substantially lower P(e) for very large uncertainties. 14 refs.

McFee, John E. (Defence Research Establishment Suffield, Ralston, Alberta, Can); Das, Yogadish. *IEEE Trans Pattern Anal Mach Intell* v 10 n 4 Jul 1988 p 599-606.

**076849 INTERNATIONAL SYMPOSIUM ON PATTERN RECOGNITION AND ACOUSTICAL IMAGING.** This conference proceedings contains 50 papers. These papers bring together researchers from the fields of medical ultrasound, nondestructive testing, sonar, and



geophysics to explore the different methods of pattern recognition used in each of these fields. The main subjects are foundations of tomography signal processing models in medical ultrasound, ultrasound pattern recognition, acoustical image reconstruction algorithms, bioacoustic systems, imaging, texture and speckle analysis in medical ultrasound, parameter estimation, material characterization and NDE, and pattern recognition approach to nondestructive evaluation of materials. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11642 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Ferrari, Leonard A. (Ed.) (Univ of California, Irvine, CA, USA). *Proc SPIE Int Soc Opt Eng* v 768, Int Symp on Pattern Recognit and Acoust Imaging, Newport Beach, CA, USA, Feb 4-6 1987. Publ by SPIE, Bellingham, WA, USA, 1987 361p.

**Analysis** See Also IMAGE PROCESSING—Image Analysis.

**076850 APPLICATION OF THE MULTIEDIT-CONDENSING TECHNIQUE TO THE REFERENCE SELECTION PROBLEM IN A PRINT RECOGNITION SYSTEM.** We address the elusive problem of selecting references (templates) for minimum distance classification when the number of pattern classes is very large. We argue that the multiedit/condensing technique offers an automatic solution to this problem which avoids the proliferation of references without impairing the recognition performance. The effectiveness of the approach is demonstrated by experimental results in a print recognition context. Suggestions are made about ways of circumventing problems of computational complexity. (Edited author abstract) 14 refs.

Voisin, Jean (Philips, Brussels, Belg); Devijver, Pierre A. *Pattern Recognit* v 20 n 5 1987 p 465-474.

**076851 NEW FORMS OF SHAPE INVARIANTS FROM ELLIPTIC FOURIER DESCRIPTORS.** New forms of shape invariants are derived, using matrix trace operators, for pattern recognition. These invariants form a non-redundant set, have more straightforward and understandable geometric meanings, and require fewer computations. They are independent of the shape rotation and translation. These invariants are interpreted geometrically and compared to those defined by Granlund. Possible utilizations for pattern recognition are discussed. (Author abstract) 15 refs.

Lin, Chun-Shin (San Diego State Univ, San Diego, CA, USA); Hwang, Chia-Lin. *Pattern Recognit* v 20 n 5 1987 p 535-545.

**076852 BOOTSTRAP TECHNIQUE IN CLUSTER ANALYSIS.** We define a method to estimate the number of clusters in a data set E, using the bootstrap technique. This approach involves the generation of several 'flake' data sets by sampling patterns with replacement in E (bootstrapping). For each number, K, of clusters, a measure of stability of the K-cluster partitions over the bootstrap samples is used to characterize the significance of the K-cluster partition for the original data set. The value of K which provides the most stable partitions is the estimate of the number of clusters in E. The performance of this new technique is demonstrated on both synthetic and real data, and is applied to the segmentation of range images. (Author abstract) 29 refs.

Jain, A.K. (Michigan State Univ, East Lansing, MI, USA); Moreau, J.V. *Pattern Recognit* v 20 n 5 1987 p 547-568.

**076853 FAST CLASSIFICATION OF DISCRETE SHAPE CONTOURS.** A fast and novel nonoverlapping planar shape recognition scheme with efficiency virtually independent of the number of prototypes is developed. It is composed of new contour normalization, control point extraction and discriminant analysis algorithms also presented. The system applies to shapes regardless of their position, size and orientation. A related shape inspection

scheme for detecting locations of shape flaws based on similar principles is demonstrated. (Edited author abstract) 23 refs.

Paglieroni, David W. (Ford Aerospace & Communications Corp, Palo Alto, CA, USA); Jain, Anil K. *Pattern Recognit* v 20 n 6 1987 p 583-598.

**076854 COMPUTING DISTANCE TRANSFORMATIONS IN CONVEX AND NON-CONVEX DOMAINS.** It is shown that the two-pass sequential local transformation algorithm for computing a distance transformation in rectangular domains may fail in some convex integer domains, but that a four-pass algorithm is sufficient in all two-dimensional convex domains. For non-convex domains the number of passes necessary is shown to be generally greater. Two proportional algorithms for computing the distance transformation are described and shown theoretically and experimentally to be computationally more efficient than the sequential local transformation algorithm in non-convex domains of complex shape. The relationship of the distance transformation in non-convex domains to some more general transformations is explored. (Edited author abstract) 14 refs.

Piper, Jim (Western General Hospital, Edinburgh, Scotl); Granum, Erik. *Pattern Recognit* v 20 n 6 1987 p 599-615.

**076855 PATTERN ADAPTIVE THINNING ALGORITHM.** A simple sequential thinning algorithm for peeling off pixels along contours is described. An adaptive algorithm obtained by incorporating shape adaptivity into this sequential process is also given. The distortions in the skeleton at the right-angle and acute-angle corners are minimized in the adaptive algorithm. The asymmetry of the skeleton, which is a characteristic of sequential algorithm, and is due to the presence of T-corners in some of the even-thickness pattern is eliminated. The performance (in terms of time requirements and shape preservation) is compared with that of a modern thinning algorithm. (Author abstract) 24 refs.

Govindan, V.K. (Indian Inst of Science, Bangalore, India); Shivaprasad, A.P. *Pattern Recognit* v 20 n 6 1987 p 623-637.

**076856 FAST ALGORITHM FOR THE COMPUTATION OF MOMENT INVARIANTS.** Moment invariants have been used as feature descriptors in a variety of object recognition applications. When assuming image function, moments calculated using a double-integral formulation, are invariant to variations in translation, rotation, and size of the object. However, due to the recursive nature of the calculations and the limited speed of microprocessors, the moments were not computable in real-time. We present fast invariant moment computations using the 'Delta Method', as a means of scene representation. This method computes moments of contiguous images by using the contribution of each line rather than individual pixel. (Edited author abstract) 11 refs.

Vroomen, L.J. (McGill Univ, Montreal, Que, Can); Zsombor-Murray, P.J.A.; van Kessel, J.M.H.M.; Zakaria, M.F. *Pattern Recognit* v 20 n 6 1987 p 639-643.

**076857 HOW MANY CLUSTERS ARE BEST? - AN EXPERIMENT.** This paper reports the results of a Monte Carlo study on the relative effectiveness of two internal indices in estimating the true number of clusters in multivariate data. The two indices are the Davies and Bouldin index and a new modification of the Hubert  $\Gamma$  statistic. Data in d dimensions are clustered to create sequences of partitions. Estimates are based on plots of the indices as functions of the number of recovered clusters. Neither index uses a-priori information. The effects of sample size, dimensionality, cluster spread, number of true clusters, and sampling window are examined. Clustered data are generated to assure a given number of distinct clusters. The degree of clustering in the data is verified by a separate Monte Carlo study based on the Jaccard and corrected Rand indices that exhibits the importance of correcting external indices for chance. The modified Hubert index is shown to perform better than the

Davies-Bouldin index under all experimental conditions. Recovery of the true number of clusters gets better as the number of true clusters decreases and the number of dimensions increases. No effect occurs due to sampling window. The complete link clustering method and a square error clustering method recognize the true number of clusters consistently better than the single link method. This study demonstrates the difficulty inherent in estimating the number of clusters. (Edited author abstract) 24 refs.

Dubes, Richard C. (Michigan State Univ, East Lansing, MI, USA). *Pattern Recognit* v 20 n 6 1987 p 645-663.

**076858 SHIFT AND SCALE INVARIANT PATTERN RECOGNITION USING MELLIN RADIAL HARMONICS.** Design of matched filters containing a single radial harmonic of an object are shown to provide shift and scale invariant correlations. The theory of the expansion, using Mellin radial harmonics, is analyzed and tested experimentally for some binary optical targets. Crosscorrelation pattern recognition in the presence of scale and shift invariances has been successfully demonstrated. (Author abstract). 6 Refs.

Mendlovic, D. (Tel Aviv Univ, Tel Aviv, Isr); Marom, E.; Konforti, N. *Opt Commun* v 67 n 3 Jul 1 1988 p 172-176.

**076859 POLYHEDRAL OBJECT RECOGNITION USING HOUGH-SPACE FEATURES.** We propose a new technique for three-dimensional (3-D) polyhedral object recognition on the basis of a single two-dimensional (2-D) view of a 3-D scene. The binary gradient image of the captured scene is converted into the Hough-space domain. The cluster patterns originating from straight-line features of the image are explored by reasoning in Hough space. This yields an attributed graph representation of CAD-designed wire frame model objects by means of a new attributed subgraph isomorphism algorithm. Simulation experiments illustrate this promising new approach. (Author abstract). 10 Refs.

Engelbrecht, Jan R. (IBM, Ruschlikon, Switz); Wahl, Friedrich M. *Pattern Recognit* v 21 n 2 1988 p 155-167.

**076860 OPTIMALITY OF REASSIGNMENT RULES IN DYNAMIC CLUSTERING.** The paper is concerned with reassignment rules for the dynamic clustering algorithm family which includes ISODATA. It is shown that these iterative clustering algorithms do not guarantee that each stable partition is locally optimal. The main result derived is a multiple-point reassignment rule which assumes a Gaussian density model for each cluster. The new rule should reduce the changes of the iterative optimization algorithm yielding partitions which do not correspond to local minima of the clustering criterion. (Edited author abstract). 12 Refs.

Kittler, J. (Univ of Surrey, Guildford, Engl); Paiman, D. *Pattern Recognit* v 21 n 2 1988 p 169-174.

**076861 WEIGHTED CHORD FUNCTIONS.** The use of chord functions in shape recognition has been investigated by many authors, with most attention on the angle chord function as the metric chord function has weak discriminatory power. We introduce weighted chord functions which incorporate the metric information into the angle function. They enhance the performance of the angle chord function by emphasizing the chords that carry more information: the longer chords. (Author abstract). 10 Refs.

Gibbon, Greg (Defence Science & Technology Organization, Adelaide, Aust). *Pattern Recognit* v 21 n 4 1988 p 367-379.

**076862 CLASS OF LINEAR MAPS FOR ERROR CORRECTIVE DIMENSIONALITY REDUCTION OF BINARY TEMPLATES.** Binary templates are optimally encoded in a reduced dimension by a proposed class of linear maps that preserves the local neighborhood and a prescribed minimum distance between the prototypes to a workable extent. This in effect generates a nearness



criterion suitable for template matching with a level of error correcting capability in the reduced space while requiring only a fraction of memory storage space and Boolean operations that would have been required otherwise. Characters and symbols may now be designed with reference to separation and shape but with a comparative freedom from the constraint of dimension, while a volume of such data can be transmitted with the speed and bandwidth of the encoded data. Some of the principal problems associated with template matching are thus overcome. All necessary operations are performed in the finite field GF(2) and the methodology developed can be implemented in a microcomputer with improved system performance and economy. (Edited author abstract). 21 Refs.

Kundu, Shovonlal (Indian Statistical Inst, Calcutta, India). *Pattern Recognit* v 21 n 4 1988 p 381-392.

**Applications** See BUTADIENE—Extraction; BUTADIENE—Polymerization; GASES—Sensors; PROTEINS; ROBOTS, INDUSTRIAL—Mobile.

Automation

**076863 TOPOLOGICAL APPROACH TO THE MATCHING OF SINGLE FINGERPRINTS; DEVELOPMENT OF ALGORITHMS FOR USE ON ROLLED IMPRESSIONS.** Fingerprint comparison algorithms based on topological codes are considered. Detailed analysis of the performance of algorithms is given, making extensive use of the results of investigation into the 'match' and 'mismatch' score distributions produced by each one. A final test is described in which the most effective 'topology-based' algorithm was directly tested against one of the best existing 'spatial' algorithms. Topology-based coding, with the inclusion of a crude 'distance measures,' is found to be an extremely accurate and efficient basis for the comparison of rolled impressions. The motivation for seeking topological descriptions of single fingerprints is provided by the elasticity of the human skin; successive rolled impressions from the same finger will invariably have suffered a degree of relative distortion (translation, rotation and stretching). (Edited author abstract) 5 refs.

Sparrow, Malcolm K. (NBS, Gaithersburg, MD, USA); Sparrow, Penelope J. *Natl Bur Stand Spec Publ* 500-124 May 1985 73p.

**076864 AUTOMATIC ROTATIONAL SYMMETRY DETERMINATION FOR SHAPE ANALYSIS.** The determination of the rotational symmetry of a shape is useful for object recognition and shape analysis in computer vision applications. A simple, but effective, algorithm to analyze the rotational symmetry of a given closed-curve shape S is proposed. A circle C with the centroid of S as the circle center and the average radius of S as the circle radius is superimposed on S, resulting in the intersection of C and S at a set of points. By analysis, the relationship between the order  $N_s$  of the rotational symmetry of S and the number of intersection points between C and S is established. All possible values for  $N_s$  are determined.  $N_s$  is determined by evaluating the similarity between S and its rotated versions. In the proposed algorithm, only simple pixel operations and second-order moment function computation are involved. Several problems caused by the use of discrete image coordinates are analyzed and solved for correct decision-making in the algorithm. Experimental results are included. (Edited author abstract) 26 refs.

Jin-Jang Leou (Natl Chiao Tung Univ, Hsinchu, Taiwan); Wen-Hsiang Tsai. *Pattern Recognit* v 20 n 6 1987 p 571-582.

Computer Applications

**076865 EVALUATION OF THE FPS-164 COMPUTER FOR HIGH ENERGY PHYSICS PATTERN RECOGNITION PROBLEMS.** Vectorized pattern recognition algorithms have been compared to traditional scalar algorithms in single-view detectors on the FPS-164 Scientific Computer. The vectorization has been limited to

the track recognition phase of the data analysis. Results show that the traditional scalar algorithm outperforms the vectorized algorithms in chamber multiplicities of immediate physical interest for the model fixed-target detectors considered. (Author abstract) 7 refs.

Roberts, Lee (Fermilab, Batavia, IL, USA). *Comput Phys Commun* v 47 n 2-3 Nov-Dec 1987 p 195-206.

**076866 REAL-TIME HOUGH TRANSFORM PROCESSOR.** One of the disadvantages of the Hough transform, its long computation time, is preventing this transform from being used in real-time applications. This paper presents an architecture that was developed to address this problem and implemented in an experimental hardware model for real-time straight-line detection. This paper provides examples of applying this architecture to the automatic inspection and measurement of objects in factories and laboratories. In these examples, it took less than one second to extract straight-line parameters from captured pictures. The highly parallel architecture proposed for the Hough transform does not require any multiplication or trigonometric calculations at run time. (Edited author abstract) 21 refs.

Hanahara, Keishi (Fujitsu Lab, Kawasaki, Jpn); Maruyama, Tsugito; Uchiyama, Takashi. *Fujitsu Sci Tech J* v 24 n 1 Mar 1988 p 35-46.

Computer Simulation

**076867 VIEWPOINT INDEPENDENT MODELING APPROACH TO OBJECT RECOGNITION.** A robotic vision system is being developed which uses three-dimensional laser range data to sense its environment. The recognition subsystem incorporates topological as well as geometric information to identify viewed objects. Theorem-proving techniques are used to produce symbolic pattern matches. The major contributions of the recognition subsystem are 1) the use of viewpoint-independent descriptors as the basis for representing known object models and 2) the use of theorem-proving techniques to hypothesize object identities and recognize the viewed object as an instance of the appropriate viewpoint independent model descriptor. The representation scheme permits describing objects at a variety of topological and geometric levels. Furthermore, the use of viewpoint-independent descriptors facilitates object recognition from a single arbitrary view despite missing information or the inclusion of viewpoint-dependent artifacts. 13 refs.

Magee, Michael (Univ of Wyoming, Laramie, WY, USA); Nathan, Mitchell. *IEEE J Rob Autom* v RA-3 n 4 Aug 1987 p 351-356.

**076868 MAXIMUM A POSTERIORI APPROACH TO OBJECT RECOGNITION WITH DISTRIBUTED SENSORS.** The maximum a posteriori (MAP) estimation concept is applied to the problem of object recognition with several distributed sensors. It is shown that in binary object recognition the MAP object recognition also minimizes the mean-square error. Simulation results show that the performance of the MAP object recognition is, in general, at least as good as the best performance by the sensors used. 7 refs.

Demirbas, Kerim (Univ of Illinois, Chicago, IL, USA). *IEEE Trans Aerosp Electron Syst* v 24 n 3 May 1988 p 309-313.

Efficiency

**076869 EFFICIENCY OF LEARNING WITH IMPERFECT SUPERVISION.** We consider the problem of supervision errors in training samples in two-group discriminant analysis based on normal distributions. Using a model for training sample misclassifications, we derive Efron's Asymptotic Relative Efficiency (ARE) of the discriminant function estimated under this model, relative to the case when classification is perfect. We tabulate this ARE for certain values of the Mahalanobis distance between the groups and for various levels of supervision errors. We show that training samples are

useful even if prone to a certain amount of misclassification. Our formulae and tables give, for a training sample prone to a certain amount of error, sample size equivalent to that of the one error-free training sample as well as that of an unsupervised sample, the equivalence being in terms of estimation efficiency. (Author abstract). 12 Refs.

Krishnan, T. (Indian Statistical Inst, Calcutta, India). *Pattern Recognit* v 21 n 2 1988 p 183-188.

Estimation

**076870 MAXIMAL MATCHING OF 3-D POINTS FOR MULTIPLE-OBJECT MOTION ESTIMATION.** Determining the relative motion/position between an observer and its environment is important in computer vision. A major task is to find corresponding object features. An efficient algorithm for matching 3-D points of multiple rigid objects is presented. The point-matching algorithm determines the correspondence by initiating a pairing of a triplet of noncollinear sensed points with a triplet of reference points and searching for new pairs of corresponding points, one at a time, using local distance and angular constraints. The pairing of each subsequent sensed point with a reference point is determined if the tetrahedron formed by the sensed point and the initial triplet is congruent to that formed by the corresponding reference points. Only simple computations are required in the algorithm. Global consistency of the pairings found by the algorithms is ensured without using model tests. The algorithm can be extended to incorporate other geometrical or non-geometrical object attributes to further prune the matching. Results of running the algorithm on synthetic and real data are given. (Edited author abstract). 19 Refs.

Chen, Homer H. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Huang, Thomas S. *Pattern Recognit* v 21 n 2 1988 p 75-90.

Imaging Techniques See Also IMAGE PROCESSING—Image Analysis.

**076871 USING DOMAIN KNOWLEDGE IN A LOW-LEVEL VISUAL PROCESSING TO INTERPRET HANDWRITTEN MUSIC: AN EXPERIMENT.** Turning handwritten scores into engraved scores consumes a significant portion of music publishing companies' budget. Pattern recognition is the major bottleneck holding up automation of this process. Human beings who know music can easily read a handwritten score, but without musical knowledge, even people cannot correctly perceive the markings in a handwritten score. This paper reports an experiment in which knowledge of music, a highly structured domain is applied to extract primitive musical features. This experiment shows that if the domain of image processing is well defined, significant improvements in low-level segmentations can be achieved. (Author abstract) 17 refs.

Roach, J.W. (Virginia Tech, Blacksburg, VA, USA); Tatem, J.E. *Pattern Recognit* v 21 n 1 1988 p 33-44.

**076872 MOMENT-PRESERVING LINE DETECTION.** A new method for line detection in two-dimensional image data is presented. Based on the moment-preserving principle, the method is developed to estimate line location and width to the subpixel accuracy within a circular mask. Experimental results are given to show the effectiveness of the proposed line detector. (Author abstract) 14 refs.

Chen, Ling-Hwei (Natl Chiao Tung Univ, Hsinchu, Taiwan); Tsai, Wen-Hsiang. *Pattern Recognit* v 21 n 1 1988 p 45-53.

**076873 NOISE EFFECTS ON CENTROID TRACKER AIM POINT ESTIMATION.** An investigation of errors due to noise in centroid tracker aim-point estimation is presented. The centroid tracker discussed is similar to the tracker described by A.L. Gilbert et al. (1980). Simplifications to this algorithm were made so that



the derived models would be consistent with the actual tracker algorithm. Two statistical models are derived which relate image noise effects to computation of the target centroid. The first model, the simplified aim-point error model, is derived by assuming that the probabilities of incorrectly classifying target and background pixels are equal. The second model, the extended aim-point error model, is derived by assuming that the probability of incorrectly classifying a target pixel can differ from the probability of incorrectly classifying a background pixel. These models are described and their mathematical implication are discussed. Simulation results which verify the models are presented. 5 refs.

Van Rheedeen, Don R. (Texas Instruments Inc, Dallas, TX, USA); Jones, Richard A. *IEEE Trans Aerosp Electron Syst* v 24 n 2 Mar 1988 p 177-185.

**076874 OPTICAL AND DIGITAL PATTERN RECOGNITION.** This proceedings contains 41 papers. Topics include digital image processing and analysis; optical pattern recognition; optical correlators; low-level computer vision; three-dimensional object recognition; spatial light modulator image processing applications; optical matched filters; and various computer and mathematical algorithms used in the above areas of development. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11654 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Liu, Hua-Kuang (Ed.) (JPL, Pasadena, CA, USA); Schenker, Paul S. (Ed.). *Proc SPIE Int Soc Opt Eng* v 754, Opt and Digital Pattern Recognit, Los Angeles, CA, USA, Jan 13-15 1987. Publ by SPIE, Bellingham, WA, USA, 1987 333p.

**Mathematical Models** See Also IMAGE PROCESSING; ROBOTS, INDUSTRIAL—Vision Systems.

**076875 REPRESENTATION AND RECOGNITION OF OBJECTS FROM DENSE RANGE MAPS.** A system for object representation and recognition from dense range maps is presented. The system addresses three problems, namely, (i) object representation from a single-view dense range map, (ii) integrating data or descriptions from multiple views for model construction, and (iii) matching descriptions from a single unknown view to models. Although the main goal of the authors is to develop an algorithm for solving problem (iii), the authors briefly outline solution techniques with the aid of examples, for problems (i) and (ii) as well, to give a complete overview of the system. 42 refs.

Vemuri, Baba C. (Univ of Texas, Austin, TX, USA); Aggarwal, J.K. *IEEE Trans Circuits Syst* v CAS-34 n 11 p 1351-1363.

## Medical Applications

**076876 ZERO-CROSSING INTERVAL CORRECTION IN TRACING EYE-FUNDUS BLOOD VESSELS.** We are developing a health screening system for color eye-fundus photography. The system is designed to detect the first signs of adult diseases, for which purpose it is important to detect and trace eye blood vessels. This paper describes a method of finding the papilla by Hough transform, and from there tracing blood vessels by a second-order derivative Gaussian filter. The width of the blood vessel is obtained as the zero-crossing interval of the filter output. The filter is adjustable to the current width of the blood vessel being traced. In this process, since the obtained zero-crossing interval is larger than the true width of an ideal step-wise blood vessel, it is corrected at each step. (Author abstract). 7 refs.

Tamura, Shinichi (Osaka Univ, Toyonaka, Jpn); Okamoto, Yasukazu; Yanashima, Kenji. *Pattern Recognit* v 21 n 3 1988 p 227-233.

## Performance

**076877 APPROACH TO PERFORMANCE OPTIMIZATION IN FREQUENCY-WEIGHTED MEM-**

**ORY NETWORK PATTERN CLASSIFIERS.** The performance of memory network pattern classifiers based on a feature frequency-weighting scheme can suffer from an inappropriate arbitrary choice of zero-frequency component in the computation of discriminant functions. This letter assesses the effect of optimizing this factor, emphasizing the value of optimization in pairwise class discrimination, which is of particular relevance in the design of efficient hierarchical classifier architectures. (Author abstract) 10 refs.

Fairhurst, M.C. (Univ of Kent, Canterbury, Engl); Abdel Wahab, H.M.S. *Electron Lett* v 23 n 21 Oct 8 1987 p 1116-1118.

**076878 ENSEMBLE AVERAGE CLASSIFIER FOR PATTERN RECOGNITION MACHINES.** The ensemble average classification method introduced is a new nonparametric classification procedure. In this method, ensemble average of training pattern vectors in each class is stored in a computer memory. Classification of an unknown pattern vector depends primarily on the difference between the stored ensemble average vectors and the unknown pattern vector. Performance of the new method in comparison with Bayesian (optimal) and perceptron classifiers has been studied through computer experiments. The results obtained showed that the new method provides classification rates as high as the Bayes classifier. However, it requires less computation complexity and higher storage memory than Bayesian and perceptron classifiers. (Edited author abstract). 6 refs.

Zaki, F.W. (El-Mansoura Univ, Egypt); Abd El-Fattah, A.I.; Enab, Y.M. *Pattern Recognit* v 21 n 4 1988 p 327-332.

**076879 PERFORMANCE MODELLING OF PATTERN RECOGNITION TECHNIQUES FOR CALIBRATION AND REGISTRATION MARK DETECTION.** One of the strengths of focused electron beam lithography systems for direct writing on wafers is the ability to use the electron beam in an imaging mode. By suitable processing of the image the positions of structures fabricated in early layers can be determined for the overlay of subsequent levels. Because the imaging and writing are performed with the same beam, accuracy is limited only by the performance of the pattern recognition algorithm. This paper presents the results of modeling two such algorithms. (Author abstract) 2 refs.

Penberth, M.J. (Cambridge Instruments plc, Cambridge, Engl); Rix, N.F. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Micro lithogr, Jouy-en-Josas, Fr, Sep 22-25 1987 p 135-140.

## Processing

**076880 RULE BASED CONTEXTUAL POST-PROCESSING FOR DEVANAGARI TEXT RECOGNITION.** The spatial relationships among the constituent symbols of Devanagari script play an important role in the interpretation of Devanagari words. There are a number of constraints on these spatial relationships which characterize Devanagari script composition syntax. When the word composition is not found to be syntactically correct, the symbols are substituted with their resembling counterparts. The symbol substitution rules are mostly heuristic in nature. Human interpretation normally involves application of script composition syntax rules and the symbol substitution rules in an interleaved fashion. This paper presents a design of a post-processor which corrects the Devanagari symbol string based on this observation. The composition syntax checker is represented in the form of a finite state machine. The substitution rules are in the form of condition action pairs giving flexibility to the system for easy alteration. Each substitution rule has a penalty associated with it and the accumulated penalty value for a word gives a measure of its confidence level. (Author abstract) 12 refs.

Sinha, R.M.K. (Univ of Quebec, Verdun, Que, Can). *Pattern Recognit* v 20 n 5 1987 p 475-485.

## Research

**076881 ROUGH APPROXIMATION OF SHAPES IN PATTERN RECOGNITION.** The paper approaches the nature of a feature recognition process through the description of image features in terms of the rough sets. Since the basic condition for representing images must be satisfied by any recognition result, elementary features are defined as equivalence classes of possible occurrences of specific fragments existing in images. The names of the equivalence classes (defined through specific numbers of objects and numbers of background parts covered by a window) constitute the best lower approximation of window contents (i.e., names of recognized features). The best upper approximation is formed by the best lower approximation, its attributes, and parameters, all referenced to th object fragments situated in the window. (Edited author abstract) 5 refs.

Wojcik, Zbigniew (Wichita State Univ, Wichita, KS, USA). *Comput Vision Graphics Image Process* v 40 n 2 Nov 1987 p 228-249.

**076882 MODEL-BASED RECOGNITION USING 3D SHAPE ALONE.** The author shows that shape data alone, without absolute size, are highly effective in constraining the size of the search space of matches to stored 3D object models. The shape constraints developed are applied to sparse and error-prone measurements of surface orientations and scaled depths (that is, depths scaled by a constant but unknown factor) synthesized from polyhedral models which themselves have six degrees of positional freedom with respect to the sensor. The matching paradigm used is that of Grimson and Lozano-Perez in which feasible interpretations of the data are obtained by requiring geometric consistency between metrics made on pairs of data and their associated matched pair of model faces and then tested by geometrical transformation. (Edited author abstract) 14 refs.

Murray, D.W. (GEC, Wembley, Engl). *Comput Vision Graphics Image Process* v 40 n 2 Nov 1987 p 250-266.

## Spectrum Analysis

**076883 SIMILARITIES OF FOURIER SPECTRA FROM RANDOM EDGE VARIATIONS.** Fourier spectra of images with zero-one transmission characteristics are analyzed, assuming their boundaries to be described by random functions. The effect on recognition using different correlation functions and correlation coefficients to characterize the boundaries is presented. In one case a closed-form solution is found. (Author abstract) 11 refs.

Poularikas, A.D. (Univ of Alabama in Huntsville, Huntsville, AL, USA); Katsinis, C. *Opt Eng* v 26 n 11 Nov 1987 p 1120-1123.

**Theory** See Also SYSTEMS SCIENCE AND CYBERNETICS—Man Machine Systems.

**076884 PREDICTING AZEOTROPY IN BINARY SYSTEMS FROM PATTERN RECOGNITION THEORY.** The authors present results on forecasting azeotropy (the presence or absence of an azeotrope) on the basis of physicochemical data for pure substances used with pattern-recognition theory. We employ an algorithm and software module as described previously with minor changes concerning mainly the data input and output. The predictive power of this model is largely dependent on how far the features or the transformations performed on them reflect the physical picture in the phenomenon, as well as on the representativeness of the training sample. The model has been tested on about 700 binary zeotropic and azeotropic systems with the optimum set of features, training parameters, and potential function, with these systems including substances representing various classes of organic compounds and water. Some of them were used for training and the rest for checking the forecasting power of the model. Predictions up to 85% were obtained with the control objects. It is thus possible in principle to forecast the presence or absence of binary azeotropes by pattern-recognition theory on the basis of the physicochemical parameters of the individual components. 6 refs.



Inyutin, S.M.; Garber, Yu.N.; Komarova, L.F. *J Appl Chem USSR* v 59 n 7 pt 1 Jul 1986 p 1345-1347.

**PATTERN RECOGNITION SYSTEMS** See Also CHARACTER RECOGNITION; OPTICAL—Automation; FOOD PRODUCTS—Inspection; PATTERN RECOGNITION; PERSONNEL—Security Systems; PRINTED CIRCUITS—Automatic Testing; SPEECH—Recognition; TURBOMACHINERY—Computer Aided Analysis; VISION—Artificial.

**076885 BERUEHRUNGSLOSE DIMENSIONIERUNG VON WERKSTUECKEN - MIT ZWEIDIMENSIONALEN DIODENARRAYS.** [Contactless Dimension Recognition in Workpieces with Two-Dimensional Diode Arrays]. The article is concerned with the concept and application of computer-aided contactless optical sensors which, with their high accuracy, flexibility, and easy adoptability are promising tools for highly accurate and rapid recognition of workpiece dimensions. Emphasis is placed on two-dimensional photodiode arrays as sensors and their potential applications. In German. 11 refs.

Schulze Wilbrenning, B. (Ruhr-Univ Bochum, Bochum, West Ger). *TZ Metallbearb* v 80 n 4 Apr 1986 6p between p 33 and 42.

**076886 DESIGN TECHNIQUE FOR DYNAMICALLY EVOLVING N-TUPLE NETS.** N-tuple nets are conceptually a highly parallel architecture. However, high-speed serial emulations of N-tuple nets offer considerable advantages of flexibility and cost efficiency in applications requiring only moderate bandwidth. In the paper a software technique for designing dynamically evolved N-tuple nets is described and the process whereby the designed structure can be progressively mapped into hardware to a level determined by the application requirements is illustrated. (Author abstract) 7 refs.

Binstead, M.J. (Univ of West London, Uxbridge, Eng); Jones, Antonia J. *IEE Proc Part E* v 134 n 6 Nov 1987 p 265-269.

**076887 MULTIPROCESSOR-BASED RECOGNITION SYSTEM FOR HAND-WRITTEN DRAWINGS.** This paper describes a multiprocessor-based drawing recognition system designed to provide a fast processing environment for various drawing recognition algorithms. The system has a multiprocessor-based architecture to realize a compatibility of high speed processing and software flexibility. For high speed processing, each processing unit (PU) has special functions for image processing, such as a two-dimensional memory access mechanism, bit data access modes, etc., and has a very large memory to execute look-up table processing. Experimental results have shown that the system composed of four PUs realizes 40 to 60 times faster processing than a 1 MIPS mini-computer does. (Author abstract) 10 refs. In Japanese.

Mitsuya, Eiji (NTT, Jpn); Kawada, Etsuo; Hosaka, Ken-ichi; Gotanda, Masayuki. *Denki Tsushin Kenkyusho Kenkyu Jitsuyoku Hokoku* v 37 n 3 1988 p 203-209.

**076888 PATTERN RECOGNITION BASED ON THE TRIPLE CORRELATION.** For recognising a certain pattern it is sometimes preferable not to look at the pattern itself but at a secondary signal. The auto triple correlation is a type of a secondary signal. It is quite resistant against additive noise, against photon noise and against blur caused by the turbulent atmosphere. We propose to recognise a pattern by comparing its auto triple correlation with the auto triple correlation of a reference pattern. The comparison can be performed as inner product, which can be computed by using an efficient algorithm. In an alternate approach the input is at first converted into its auto triple correlation. In that format certain disturbances can be removed efficiently. Next cleaned version of the input is computed. Finally, the cleaned input undergoes standard pattern recognition by means of matched filtering. (Edited author abstract) 17 refs.

Lohmann, Adolf W. (Univ Erlangen-Nuernberg, Er-

langen, West Ger). *Optik (Stuttgart)* v 78 n 3 Feb 1988 p 117-120.

**076889 AUTOMATIC CIRCUIT DIAGRAM READER WITH LOOP-STRUCTURE-BASED SYMBOL RECOGNITION.** A high-performance logic circuit diagram reader was developed for VLSI-CAD (very large-scale integration-computer-aided design) data input. Almost all logic circuit symbols include one or more loop structures. A description is given of an efficient method for recognition of these loop-structured symbols. The proposed method consists of two processes: symbol segmentation and symbol identification. Symbol identification is achieved by a powerful hybrid method which uses heuristics to mediate between template matching and feature extraction. The entire symbol recognition process is carried out under a decision-tree control strategy. The entire recognition system for circuit diagrams is briefly explained, including character string recognition and connecting line analysis. Experimental results show that symbol recognition accuracy is more than 95% and that a Japanese Industrial Standard (JIS) A1-size (594 mm × 841 mm) drawing can be processed within 30 min. To evaluate the symbol recognition method, more than 800 drawings were read automatically. A reduction of about 50% in input time was obtained, compared to conventional interactive entry. 18 refs.

Okazaki, Akio (Toshiba, Kawasaki, Jpn); Kondo, Takashi; Mori, Kazuhiro; Tsunekawa, Shou; Kawamoto, Eiji. *IEEE Trans Pattern Anal Mach Intell* v 10 n 3 May 1988 p 331-341.

**076890 NEW CONCEPT IN BIOMETRIC IDENTIFICATION: 3-DIMENSIONAL HAND GEOMETRY.** A new type of biometric identifier which utilizes hand outline measurements made in three dimensions is described. This device uses solid state imaging with no moving parts. The important characteristics of accuracy, speed, user tolerability, small template size, low power, portability and reliability are discussed. A complete stand-alone biometric access control station with sufficient memory for 10,000 users and weighing less than 10 pounds has been built and tested. A test was conducted involving daily use by 112 users over a seven week period during which over 6300 access attempts were made. The single try equal error rate was found to be 0.4%. There were no false rejects when three tries were allowed before access was denied. Defeat with an artifact is difficult because the hand must be copied in all three dimensions. (Author abstract) 3 refs.

Sidlauskas, David P. (Recognition Systems Inc, San Jose, CA, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 442-447.

## Applications

**076891 DISPLAY-METHODEN BEI DER MUSTERERKENNUNG.** [Display Methods for Pattern Recognition]. In addition to other methods of pattern recognition (for instance cluster analysis) display methods have much importance. They give the possibility of graphical representation of originally multidimensional data sets under different aspects. Some of the most important display methods like principal component analysis, linear discriminant display, nonlinear mapping and others are explained, and compared with each other. Data sets of analytical chemistry results are evaluated by BASIC programs for microcomputers and used for explanation of the possibilities and limits of the above mentioned methods. (Edited author abstract) In German. 11 refs.

Henriren, Rene (Humboldt-Univ zu Berlin, Berlin, East Ger); Henriren, Andre; Henriren, Guenter. *Z Chem* v 27 n 9 Sep 1987 p 324-330.

## Automation

**076892 AUTOMATIC RECOGNITION OF PRIMITIVE CHANGES IN MANUFACTURING PROCESS SIGNALS.** Manufacturing processes are generally monitored by observing sampled process signals. The purpose

of this monitoring is to ensure process and, thereby, product consistency and to help diagnose causes of process instability. We discuss a two-level knowledge-based procedure for automatic recognition of these primitive changes. This procedure involves applying syntactic analysis either directly to the raw process signals or, whenever not possible, to a filtered version of them. The first level, therefore, involves applying special purpose nonlinear filters which are designed to enhance or isolate a particular primitive variation in the signal. The second level consists of a signal interpreter process, written in LISP, which analyzes the filtered signals and produces a data structure to represent the primitive variations. A description of the entire interpretation system is presented, and an example illustrating the application of the method to a process signal of an actual aluminum strip rolling mill is shown. (Edited author abstract). 16 Refs.

Love, P.L. (Alcoa Lab, PA, USA); Simaan, M. *Pattern Recognit* v 21 n 4 1988 p 333-342.

## Components

**076893 PERFORMANCE OF THE TANDEM COMPONENT FILTER FOR PATTERN RECOGNITION.** The performance of the tandem component filter for recognizing one object from a set of objects is studied and compared with the performance of the classical matched spatial filter and the phase-only matched filter. The filter is found to have a performance comparable to the classical matched filter, with the advantage of a much higher light efficiency. An application to character recognition is considered. (Edited author abstract) 19 refs.

Chalasinska-Macukow, K. (Warsaw Univ, Warsaw, Pol); Arsenaull, Henri H. *Opt Commun* v 65 n 5 Mar 1 1988 p 334-338.

## Computers

**076894 PATTERN RECOGNITION BASED ON COINCIDENCE DETECTION.** It has recently been suggested that a possible means by which the human brain recognizes visual patterns is by detecting the occurrences of coincidences in the firing of different visual neurons. In the present paper, this coincidence-detection hypothesis is first outlined, and its pros and cons discussed. Next, the basic proposal is modified and a technique developed which can be used for recognition of stationary and moving patterns by computers; in place of the complex retina a uniform bank of photo-sensitive devices is assumed to provide the signals to be analyzed. The proposed system is adaptive and can cater to linear translation, rotation and size-alteration of patterns. (Author abstract) 5 refs.

Umesh, R.M. (Anna Univ, Madras, India). *AMSE Rev* v 6 n 4 1988 p 23-34.

**Design** See Also SIGNAL PROCESSING—Correlation Detectors.

**076895 PATTERN RECOGNITION MACHINE: ITS CONCEPTION AND CREATION.** This paper presents the conception and the realization of a pattern recognition machine, its hardware and software structure and its operational principles. This machine is capable of acquiring signals, analyzing and identifying their characteristics and then of classifying and recognizing the patterns. (Author abstract) 5 refs.

Bina, M. (Univ de Technologie de Compiègne, Compiègne, Fr); Bae, P.; Gaillard, P. *Microprocess Microprogram* v 19 n 4 Oct 1987 p 327-333.

**076896 AUFBAU UND EINSATZ DES BILDERKENNUNGSSYSTEMS BES 2000.** [Design and Application of the BES 2000 Image Recognition System]. This system produced in the German Democratic Republic serves as a visual inspection system in industrial applications. On the basis of the CCD line camera technique and binary image evaluation, the user has an experimentation



and application system with modular hardware and software at his disposal for problems of length measurement, model comparison and object recognition. (Edited author abstract) In German. 3 refs.

Callsen, J. (VEB Studiotechnik Berlin). *Feingeraetech-nik* v 36 n 12 1987 p 543-546.

**076897 PARALLEL-PROCESSING OPTICAL-DIGITAL RECOGNITION SYSTEM AS A MODEL OF BIOLOGICAL VISUAL PERCEPTION.** An optical-digital pattern recognition system is proposed as a model of biological visual perception. The optical part of this system extracts in parallel the geometrical features of each divided part of a pattern by using multi-matched filters made by an integrated small lens array. The fundamental experiments on the miniaturized matched filter of the reflection type with a small lens of 3.3 mm diameter is reported, which show the feasibility to achieve the optical part of the proposed system. (Author abstract) 6 refs.

Agu, Maksahiro (Ibaraki Univ, Hitachi, Jpn); Akiba, Atsushi; Kamemaru, Shun-ichi. *Opt Commun* v 66 n 2-3 Apr 15 1988 p 69-73.

**076898 LAYERED NEURAL NETS FOR PATTERN RECOGNITION.** A pattern-recognition concept involving first an 'invariance net' and second a 'trainable classifier' is proposed. The invariance net can be trained or designed to produce a set of outputs that are insensitive to translation, rotation, scale change, perspective change, etc., of the retinal input pattern. The outputs of the invariance net are scrambled, however. When these outputs are fed to a trainable classifier, the final outputs are descrambled and the original patterns are reproduced in standard position, orientation, scale, etc. It is expected that the same basic approach will be effective for speech recognition, where insensitivity to certain aspects of speech signals and at the same time sensitivity to other aspects of speech signals will be required. The entire recognition system is a layered network of ADALINE neurons. The ability to adapt a multilayered neural net is fundamental. An adaptation rule is proposed for layered nets which is an extension of the MADALINE rule of the 1960s. The new rule, MRIL, is a useful alternative to the backpropagation algorithm. 15 refs.

Widrow, Bernard (Stanford Univ, Stanford, CA, USA); Winter, Rodney G.; Baxter, Robert A. *IEEE Trans Acoust Speech Signal Process* v 36 n 7 Jul 1988 p 1109-1118.

## Efficiency

**076899 COMPUTERS THAT LEARN.** This paper deals with the development of new computer designs called neural networks. The main advantage of neural networks is their ability to recognize patterns by being trained rather than programmed. Such networks are arrays of processors functioning in parallel. But they are quite different from the parallel processors that have come onto the market in the past few years. For one thing, they are analog, not digital. There are no bits of data as in conventional computers. Second, they are not directly programmed to carry out a given calculation. Rather, their behavior is controlled by a set of weights that determine the strengths of the electrical connections between each pair of processors. The machine is set up to change these weights to minimize errors - the difference between actual and desired performance. For example, one such machine, called NETalk compares its output with a prerecorded pronunciation of a written word.

Lerner, Eric J. (Aerospace America, Washington, DC, USA). *Aerosp Am* v 26 n 6 Jun 1988 p 32-34, 40.

## Imaging Techniques

**076900 AUTOMATIC WAFER INSPECTION SYSTEM USING PIPELINED IMAGE PROCESSING TECHNIQUES.** An automatic wafer pattern inspection system has been developed that can detect defective patterns 6  $\mu$ m or larger in multilayered wafer patterns at

a speed 30 times faster than that of a human inspector. The false-alarm rate is less than 0.5 occurrences/chip. This performance is achieved mainly by the use of a special comparison method between two adjacent patterns obtained through a single optical setup, and also by the use of digital design pattern data (CAD data). The main functions of the design pattern data are to specify the inspection area, to designate optimum parameters for inspection, and to separate defective portions into different layers, thereby facilitating the classification of the defects. All image processing is performed in one pass by a high-speed pipeline-structured image processor that can analyze an input image signal at a 7-MHz video rate. 13 refs.

Yoda, Haruo (Hitachi Ltd, Kokubunji, Jpn); Ohuchi, Yozo; Taniguchi, Yuzo; Ejiri, Masakazu. *IEEE Trans Pattern Anal Mach Intell* v 10 n 1 Jan 1988 p 4-16.

**076901 RULE BASED APPROACH FOR VISUAL PATTERN INSPECTION.** The authors investigate the use of a priori knowledge about a scene to coordinate and control bilevel image segmentation, interpretation, and shape inspection of different objects in the scene. The approach is composed of two main steps. The first step consists of proper segmentation and labeling of individual regions in the image for subsequent ease in interpretation. General as well as scene-specific knowledge is used to improve the segmentation and interpretation processes. Once every region in the image has been identified, the second step proceeds by testing different regions to ensure they meet the design requirements, which are formalized by a set of rules. Morphological techniques are used to extract certain features from the previously processed image for rule verification purposes. As a specific example, results for detecting defects in printed circuit boards are presented. 23 refs.

Darwish, Ahmed M. (Univ of California, Davis, CA, USA); Jain, Anil K. *IEEE Trans Pattern Anal Mach Intell* v 10 n 1 Jan 1988 p 56-68.

**Laser Applications** See INTEGRATED CIRCUIT MANUFACTURE—Instruments.

**Mathematical Models** See Also VISION—Artificial.

**076902 ON THE USE OF THE HOPFIELD MODEL FOR OPTICAL PATTERN RECOGNITION.** The Hopfield neural network model is described along with the modification introduced to render it suitable for optical pattern recognition. Some drawbacks of both the model and the modifications made to it are discussed and a solution to the problem of oscillating states introduced by the use of synchronous updating is described. (Author abstract) 8 refs.

Bayley, J.S. (King's Coll London, London, Engl); Fiddy, M.A. *Opt Commun* v 64 n 2 Oct 15 1987 p 105-110.

## Medical Applications

**076903 FACILITIES FOR DIGITAL PATTERN RECOGNITION: AN ECG DETECTIVE TRICK.** Algorithm for digital pattern recognition optimized for the demands of the physician are urgently needed. They have to provide high levels of recognition, accuracy, reliability, artefact rejection and flexibility in detecting different types of signal time-course. The microcomputer algorithm presented here works on the principle of Walsh-transformation of signal sections and in-image judging. The algorithm efficiently solves simple tasks, and also recognizes, for instance, ECG P-waves using the same algorithm. A test with 1054 randomly selected outpatient's ECG and with an additional 72 ECGs of inpatients with clinically proved myocardial infarcts produced the following results: The recognition ratio for the R-wave amounted to 98.8% with a failure ratio of 2.3%, while an initial common P-T-pattern was correctly recognized in 80.3% of cases, with a failure ratio of 4.9%. (Edited author abstract) 24 refs.

Poll, R. (Medical Acad Dresden, Dresden, East Ger); Hensge, R. *Comput Methods Prog Biomed* v 26 n 1

Jan-Feb 1988 p 75-80.

**Performance** See SPEECH—Recognition.

**Sensors** See PATTERN RECOGNITION—Computer Simulation.

**PAVEMENTS** See Also AUTOMOBILES—Tires; ROADS AND STREETS.

**076904 PEDESTRIAN PAVING IN URBAN AREAS - THE PATH AHEAD.** The paper describes investigations and trials, begun in 1982, aimed at improving urban pedestrian paving in Hong Kong. Laboratory and site trials, of both local and current overseas practice, led to recommendations for a 'standard range' of pavings which includes precast concrete slabs laid in sand, now to be manufactured locally using hydraulic pressing. Although costs using precast units are greater, there are operational and aesthetic advantages worth pursuing. It is opined that, with further development, costs will be reduced, to the benefit of maintenance and appearance of Hong Kong's pedestrian pavements. (Author abstract) 18 refs.

Tang, Kwok-kee; Cooper, Robert P. *Hong Kong Eng* v 14 n 6 Jun 1986 p 9-19.

**076905 OPTIMIZATION MODEL FOR PAVEMENT MARKING SYSTEMS.** An inventory and replacement cost optimization model for pavement marking systems has been developed. The optimum average inventory of performance and the period of replacement for minimum cost are defined. The model provides a basis for the establishment of implementation programs for pavement marking systems. (Author abstract) 10 refs.

Kouskoulas, Vasily (King Saud Univ, Riyadh, Saudi Arabia). *Eur J Oper Res* v 33 n 3 Feb 1988 p 298-303.

**076906 LE RETRAITEMENT DES CHAUSSEES A L'EMULSION DE BITUME: ETAT DE LA TECHNIQUE EN FRANCE.** [Pavement Retreatment with Bitumen Emulsion]. Although a very old technique, the reatment of road pavements with bitumen emulsions has recently been the subject of significant developments, in particular with the high efficiency grinding process. In France, over 300,000 m<sup>2</sup> were treated in 1986, and about 600,000 m<sup>2</sup> will be treated in 1987. After having briefly reviewed the definition of this technique, the authors make a distinction between the reatment of bituminous mixes and that of an untreated pavement material and their fields of application. For each configuration, the outline, the principle of the technique and the implementation methods are presented. The article continues with a description of inspections and some cost evaluations, before concluding on the development of these techniques. (Author abstract) In French. 6 refs.

Lafon, J.-F. (Lab Regionale de Toulouse, Fr); Verhee, F. *Travaux* n 627 Dec 1987 p 38-42.

**076907 DESIGN OF FLEXIBLE PAVEMENT FOR A 650 TONNE CRANE.** In the construction of large structures such as power plants prefabrication of heavy components has been adopted as an efficient and economical method. For handling these prefabricated components, use of heavy-duty cranes is essential. Consequently, for the operation of such a crane, it is necessary to design appropriate pavement systems. Otherwise there is a possibility of undesirably large settlements under the working loads. For the safe working of a crane, the pavement thickness should be adequate for the magnitudes of the imposed load and the subgrade soil support should be adequate to prevent excessive settlement. The authors had worked out relationship curves for flexible pavement thickness vs. C.B.R. of a subgrade soil, for the 650 tonne crane as part of a consultancy assignment for the design of pavement systems for a power plant. The outcome of the design is presented in this paper. 2 refs.

Gokhale, Y.C. (Central Road Research Inst, New Delhi, India); Bose, Sunil. *Indian Highw* v 15 n 10 Oct 1987 p 17-26.



Accident Prevention

**076908 EFFECTS OF SKID-RESISTANCE APPARATUS ON PAVEMENTS.** Skid-resistance apparatus, such as chains and studded tires, are used for safety of drivers in cold and snowy areas. The stress conditions in pavements are affected significantly owing to the apparatus. The stresses may produce fracture in pavements. This study describes the stress and strain conditions in pavements under static and dynamic loading in the case where skid resistance apparatus is used. The effect of the radius of loading contact patterns on stresses in pavements is analyzed. (Edited author abstract) 5 refs. In Japanese.

Takahashi, Hikoto; Murai, Sadanori; Akama, Koji. *Tohoku Kogyo Daigaku Kiyo* 1 n 8 Mar 1988 p 83-88.

**Adhesion** See **TRAFFIC SIGNS, SIGNALS AND MARKINGS—Performance.**

**Aging** See **ASPHALT—Molecular Structure.**

**Asphalt** See Also **AIRPORT RUNWAYS—Design; AIRPORT RUNWAYS—Repair; ASPHALT—Recycling; ASPHALT—Rheology; ASPHALT PLANTS—Computer Applications; BRIDGES, HIGHWAY—Decks; CEMENT—Additives; CONCRETE—Additives; CONCRETE AGGREGATES; GROUTING; ROADS AND STREETS—Maintenance; ROADS AND STREETS—Repair.**

**076909 NOW UNFOLDING: POLYMERS, GEOSYNTHETICS, PRECAST BEAMS.** The next ten years will see new developments in construction materials such as: roller-compacted concrete; polymer concrete; asphalt; concrete additives and geosynthetics. Predictors of pavement performance will be mix stiffness, aggregate gradations and the presence of additives. Rapid growth in the use of precast, prestressed bridge girders for spans between 120 and 160 ft is foreseen. Computers, lasers and electronic devices will be used in controlling field equipment performance.

Brown, Daniel C.; Munn, Walter D. *Highw Heavy Constr* v 130 n 9 Sep 1987 p 46-51.

**076910 MODIFIZIERTER SPLITTMASTIXASPHALT.** [Modified Chips-Filled Mastic Asphalt]. Chips-filled mastic asphalts are based on formulations which were developed in response to the impact of spiked tires on the road net in the sixties. Main characteristics of the ingredients are outlined, further their contribution to the stability of the wearing courses is analyzed. A test series has been carried out with a gyrator to determine the correlation between growing percentages of Trinidad Epure in chips-filled mastic asphalt specimens and their effect in terms of performance improvements. The results are communicated. (Author abstract) 3 refs. In German.

Hartmann, Rainer (Deutsche Asphalt GmbH, Frankfurt, West Ger). *Str Tiefbau* v 41 n 4 Apr 1987 p 20, 23.

**076911 TRAINING CREWS IN ASPHALT RECYCLING.** Putting experienced personnel next to new people is one of the best ways to train recycling crews. Most respondents (70.6%) to a recent Better Roads' survey on asphalt recycling and training agree. The most important training method is use of on-site instruction, including demonstrations. The second-most popular method was use of seminars conducted by third parties, such as equipment manufacturers. One of the problems in using one-on-one training of new personnel is the fact that there are not always experienced foremen and supervisors available. Material preparation is considered the most critical stage in recycling by 57.1% of those responding to the survey. Recycling equipment, used on a site, is the main type of training material used by asphalt contractors.

Anon. *Better Roads* v 58 n 2 Feb 1988 p 35.

**076912 EFFECT OF EVA-MODIFIED BITUMENS ON ROLLED ASPHALTS CONTAINING DIFFERENT FINE AGGREGATES.** The changes in the rheological properties of petroleum bitumens after the addition of ethylene-vinyl acetate co-polymer (EVA) are described and the consequent effect on their use in rolled asphalt wearing course mixtures is reported. In particular, the

changes in the Marshall stability and deformation resistance using four asphalt sands of different stability are quantified. The relationship between these properties and the effect of the EVA component is discussed in detail, and equations are derived relating the Marshall stability of a conventional rolled asphalt wearing course to the Marshall stability of a rolled asphalt containing bitumen modified with 5 percent EVA for the same resistance to permanent deformation. (Author abstract) 8 refs.

Carswell, J. (Transport & Road Research Lab, Crowthorne, Engl). *Res Rep Transp Road Res Lab* 122 1987 15p.

**076913 FLEXIBLE PAVEMENT DESIGN ESTIMATION TECHNIQUES.** Estimation techniques for preliminary flexible pavement design of major thoroughfares have been used very successfully by the City of Longview, Texas. The intent of the techniques is to provide as accurate a preliminary cost estimate as possible. The three basic components of this estimation technique include Soil Conservation Service (SCS) county wide soils maps, soils rating chart, and pavement thickness design curves. The function of each of the three components and their application in the estimation technique are discussed in the article.

Johnston, W.A. *Public Works* v 119 n 4 Apr 1988 p 45-46.

**076914 RISSEMPFINDLICHKEIT HYDRAULISCH GEBUNDENER TRAGSCHICHTEN.** [Cracking Resistance of Hydraulically Compacted Load-Carrying Pavements]. A survey of the performance of binders used in construction of asphalt pavements is given. Recommendations for optimal pavement thickness and composition, based on experimental results, are given. 13 refs. In German.

Sonneward, P. (Gebhard Hinteregger GmbH & Co, Munich, West Ger); Schrage, I. *Tiefbau Ingenieurbau Strassenbau* n 2 Feb 1988 p 79-83.

**076915 ASPHALTBINDERSCHICHTEN FUER HOHE BEANSPRUCHUNGEN.** [Bituminous Binders for Higher Loads]. Asphalt binders can fail under high loads and lead to the destruction of the pavement lying above it. The damage consists either in the loosening up of the bituminously bound debris by pumping water or in a plastic deformation which results in rutting. Measures are shown which can prevent this kind of damage. They are based on the results of a test stretch of 2,640 m with 11 sectors of different binder design. The load amounted to over 80,000 automobiles per day, including about 13% of trucks. The drainage of the binder layer must be ensured. A denser cavity proportion (5-6 vol.%), a higher content of the binder medium, as well as the use of modified binders are recommended. The composition of the asphalt is also important. This involves: mineral composition, binders, aggregate material, placement, and compaction. (Translated author abstract) In German.

Damm, Klaus-Werner (Fachhochschule Hamburg, Hamburg, West Ger). *Str Autobahn* v 38 n 7 Jul 1987 p 255-262.

**076916 PROFILES OF MATERIAL RESISTANCE TO COMPACTION.** The work described in this paper is part of a research program to define the process of layer densification and chip embedment with wearing course hot rolled asphalt. The process is complex and differs from the densification of other pavement layers in that stone chippings are being impregnated into the layer surface. With bituminous materials, their supporting power relates not just to the degree of internal friction but also to the viscosity of the bituminous binder and mix proportions. Although the work recorded has related to two wearing course hot rolled asphalts the procedure to define profiles of supporting power and the interpretation of the results would apply to any bituminous mix. (Edited author abstract) 20 refs.

Fordyce, D. (Heriot-Watt Univ, UK); Al Nageim, H.K. *Highw Transp* v 35 n 3 Mar 1988 p 13-16, 18-20.

**076917 STABILITY OF HRA WEARING COURSES.** Hot rolled asphalt as used in the UK is surfacing material with about one hundred years history. Modern HRA wearing course material has several advantages over continuously graded macadam, for: (1) its gap-graded nature, with a high proportion of fines giving a large surface area, can contain more bitumen than coarser materials, and this higher volume of water proof 'glue' helps durability; (2) the workability of HRA is high, giving good compaction characteristics; (3) its pore structure results in a virtually impermeable layer; (4) its strength in tension, as measured by fatigue resistance, is high. 9 refs.

Ramsey, Steve (Wiltshire City Council, Engl). *Highways (Croydon Engl)* v 56 n 1933 Jan 1988 p 24-26.

**076918 EIN BEITRAG ZUR OPTIMIERUNG STRASSENBAUTECHNISCHER ENTSCHEIDUNGEN Ueber ENERGIEWIRTSCHAFTLICHEN ASPEKTEN.** [Optimization of Highway Engineering Decisions from the Energy Economy Point of View]. Little energy is used for the construction of asphalt revetments, compared to other road construction methods. However, of decisive importance is not the energy spent for the construction of the road but the (additional) energy spent by the road user within the framework of the maintenance measures. Systematic investigation are described, the results of which make possible minimization of the energy requirements through an appropriate choice of traffic control in the construction site area, the allotment length and the time position of the construction period within a year, a week or a day. (Translated author abstract) 8 refs. In German.

Breiter, Bernhard (Univ der Bundeswehr Muenchen, Neubiberg, West Ger). *Bitumen* v 49 n 2 Second Quarter 1987 p 50-57.

**076919 ASPHALTOBERBAU UND ASPHALTFUNDATIONSSCHICHTEN UNTER MITVERWENDUNG VON AUSBAUASPHALT.** [Asphalt Superstructure and Asphalt Foundation Beds Using Asphalt Rubble]. Within the framework of the necessary maintenance of the road network, increasing quantities of rubble asphalt are becoming available for re-use. A reasonable utilization beyond the asphalt carrier beds, to which it is limited at present, is possible and expedient especially for the deep-lying strengthening region. Recommendations are given for rubble asphalt re-use in asphalt superstructure and asphalt foundation layers which have proved themselves in practice. (Translated author abstract) 16 refs. In German.

Duebner, Rolf (Bitumen-Industrie eV, Hamburg, West Ger); Urban, Rolf. *Bitumen* v 49 n 1 First Quarter 1987 p 29-34.

**076920 REJUVENATOR DIFFUSION IN BINDER FILM FOR HOT-MIX RECYCLED ASPHALT PAVEMENT.** An investigation was undertaken to determine the extent to which certain types of rejuvenators diffuse into the hardened asphalt film coating the aggregate and affect its properties during a specified period of time. A partial extraction technique that had the effect of dividing the asphalt film into microlayers was used. The binder recovered from each microlayer was characterized by means of consistency tests. This technique was used to evaluate the consistency distribution of the binder film around the aggregate in (a) the extracted mix containing recycled asphalt pavement (RAP) only; (b) the extracted mix containing RAP and a rejuvenator; and (c) the extracted mix containing RAP, virgin aggregate, and a rejuvenator. (Edited author abstract) 11 refs.

Nourelidin, Ahmed Samy (Purdue Univ, West Lafayette, IN, USA); Wood, Leonard E. *Transp Res Rec* 1115, Asphalt Mater and Mixtures. Publ by Transportation Research Board, Washington, DC, USA, 1987 p 51-61.



**076921 STRUCTURAL RESPONSE OF FOAMED-ASPHALT-SAND MIXTURES IN HOT ENVIRONMENTS.** This research project was conducted to investigate the ability of foamed asphalt to stabilize local marginal sand aggregates for use as base or subbase pavement materials. The variables measured were intended to give indications of the quality of performance of these mixtures as well as aid in the development of design procedures for the use of foamed asphalt as a stabilizing agent under the relatively high temperature conditions in the Arabian Gulf. Quantitative information is given about the effects on mixture response of significant factors such as sand type and gradation, quality and quantity of the fine fraction, asphalt grade and its percentage, moisture content, and curing condition. (Edited author abstract) 20 refs.

Bissada, Amir F. (Kuwait Univ, Kuwait). *Transp Res Rec* 1115, Asphalt Mater and Mixtures. Publ by Transportation Research Board, Washington, DC, USA, 1987 p 134-149.

**076922 SULFUR AS A PARTIAL REPLACEMENT FOR ASPHALT IN PAVEMENT.** A full-scale experiment on introducing sulfur as a partial replacement for asphalt in road-paving mixtures was conducted in Kuwait. Laboratory and field testing programs were designed and carried out to analyze and investigate the results of this experiment. The optimum sulfur percentage in the sulfur-asphalt binder and the optimum binder content were established for the investigated mixtures at various curing ages. The sulfur-asphalt mixture was found to significantly reduce rutting on the road. This was established in both field and laboratory investigations. Laboratory-aged samples showed longer fatigue life (indirect tensile stress control fatigue test). Inclusion of sulfur in the mixture was also shown to improve Marshall stability, indirect tensile strength, and the rate at which strength was gained during curing. (Edited author abstract) 11 refs.

Bayomy, Fouad M. (King Fahd Univ of Petroleum & Minerals, Dhahran, Saudi Arabia); Khedr, Safwan A. *Transp Res Rec* 1115, Asphalt Mater and Mixtures. Publ by Transportation Research Board, Washington, DC, USA, 1987 p 150-160.

**076923 FIELD EVALUATION OF SULFUR-EXTENDED ASPHALT PAVEMENTS.** Twenty-six sulfur-extended asphalt (SEA) paving projects, constructed between 1975 and 1982 in 18 states, were surveyed to measure the incidence and severity of major, visible types of pavement distress. Present condition indices were calculated for each of the SEA pavements and for each pavement in a control group of closely matched, conventional asphalt concrete pavements. Analysis of the evaluation results indicates that the presence of 20 to 40 percent by weight of sulfur in the paving binder had no deleterious effect on the overall performance of SEA pavement but yielded not significant improvement compared with the control group. Within the limits of the analysis, the measured types of distress and their severity were not significantly affected by variation in the sulfur content of the paving binder. (Edited author abstract) 5 refs.

Beatty, Tommy L. (US DOT, Washington, DC, USA); Dunn, Kurt; Harrigan, Edward T.; Stuart, Keven; Weber, Harold. *Transp Res Rec* 1115, Asphalt Mater and Mixtures. Publ by Transportation Research Board, Washington, DC, USA, 1987 p 161-170.

**076924 RECYCLING WASTE ROOFING MATERIAL IN ASPHALT PAVING MIXTURES.** The technical feasibility of using waste roofing products in asphalt concrete paving mixtures is addressed. Approximately 9 million tons of roofing waste are generated annually in the United States. Disposal costs are significant. Recycling represents an economical and, perhaps, environmentally attractive alternative to placing these wastes in landfills. The relatively large quantities of asphalt cement and aggregate-type materials present in roofing waste suggest that these materials have potential as a partial substitute for asphalt cement or aggregate, or both in a paving mixture. A study that arrived at the presented conclusions was conducted. (Edited author abstract) 10

refs.

Paulsen, Greg (Univ of Nevada, Reno, NV, USA); Stroup-Gardiner, Mary; Epps, Jon. *Transp Res Rec* 1115, Asphalt Mater and Mixtures. Publ by Transportation Research Board, Washington, DC, USA, 1987 p 171-182.

**076925 PROCEDURES FOR ESTIMATION OF ASPHALT CONCRETE PAVEMENT MODULI AT IN SITU TEMPERATURES.** The need for methods to evaluate the moduli of pavement layers without excessive extrapolation error is most apparent when NDT data and iteration methods are used to solve for the moduli of three- or four-layer systems. This is particularly true when the asphalt concrete modulus ( $E_1$ ), which is affected by temperature, layer thickness ( $t_1$ ), and the stiffness of underlying pavement layers, is considered. Two methods of providing a more direct approach for the estimation of  $E_1$  have been presented: 1. The first method involves the direct measurement of horizontal strain in the dynamic indirect tension test and computation of  $E_1$ . This method is only limited by specimen size and a sufficiently high binder viscosity. Otherwise, reproducible test results and reliable  $E_1$ -values are obtained for most mixtures. 2. The second method is considered an indirect estimate of  $E_1$  because recovered asphalt viscosity has been related to  $E_1$ -values obtained from direct measurement. 10 refs.

Badu-Tweneboah, Kwasi (Univ of Florida, Gainesville, FL, USA); Tia, Mang; Ruth, Byron E. *Transp Res Rec* 1121 1987 p 1-6.

**076926 BEWAHRUNG VON ASPHALTDECKSCHICHTEN MIT NATURASPHALT IN OESTERREICH.** [Good Performance Record of Bituminous Pavements Containing Natural Trinidad Asphalt in Austria]. There are two major basic concepts of asphalt mix formulations contrasting in contents of binder and voids, the one of them featuring a relatively high binder contents and a low voids percentage, the other one a high voids percentage and less binder. To clear up the uncertainties a systematic investigation has been made in Austria in 1987 at 23 road sections evaluating the state of the road after 10 years of service and the alterations the asphalt mortar had undergone. The results obtained can be interpreted as proving better the concept of high binder contents and low voids percentage in all sections where it was supported by adding 1.3 to 2.5 per cent of natural Trinidad asphalt, which exert a stabilizing effect. (Author abstract) 1 ref. In German.

Potschka, Volker. *Str Tiefbau* v 42 n 5 May 1988 p 12, 14-16, 18.

**076927 RESULTATS DES ESSAIS CROISES BITUMES ET BITUMES RECUPERES.** [Results of Inter-Laboratory Tests on Bitumens and Recycled Bitumens]. The creation of the National Testing Network led the Public Work Laboratories to organize inter-laboratory tests on bitumen. This article describes the organization of these tests and the use made of their results. For each of them, the author gives the values of fidelity (repeatability and reproducibility) which they produce, together with two practical applications, one of them defining the limit of agreement between two test results obtained in two laboratories, the other defining the lower limit permitted of specifications. This latter information is of particular value at a time when bitumen specifications are being revised. (Author abstract) In French.

Vaniscote, Jean-Claude (Lab Central des Ponts et Chaussées, Fr). *Bull Liaison Lab Ponts Chaussees* n 153 Jan-Feb 1988 p 29-36.

**076928 DESIGN OF ASPHALT MIXES FOR HOT CLIMATES.** Performance standards of various asphalt layers play an important role in the many aspects of the paving industry. The performance of asphalt mixes is dependent on: the quality of the mix; the engineering characteristics of the mix; the standard of quality control during the laying of the mix; engineering characteristics of the granular layers of paving, and particularly those of flexibility, rigidity and adhesiveness; traffic load and

types; temperature, humidity and drainage conditions. This paper presents proposals for the quality of the mix components. The maximum water absorption of the aggregate must not exceed 2%. The ratio of filler to bitumen should be between 1.0-1.5. The permitted quantity of natural sand additive must on no account be higher than 5% of the total aggregate weight. (Edited author abstract) In Hebrew.

Livneh, M. (Technion, Haifa, Isr). *Handassa (Tel Aviv-Jaffa)* v 46 n 13 Dec 1987 p 14.

**076929 ASPHALT INNOVATIONS: PREVENTIVE MAINTENANCE CUTS COSTS.** Preventive maintenance (PM) can often extend asphalt pavement life for a number of years - at relatively low costs. This article discusses methods of asphalt PM discussed by E.R. Brown at this year's Transportation Research Board meeting. Rejuvenators, slurry seals, surface treatments, and crack sealing are good PM techniques, according to Brown. The maintenance procedure should be selected for a specific project, and the treatment designed for that project. The article discusses how this is done.

Anon. *Better Roads* v 58 n 7 Jul 1988 p 29-30.

**076930 MECANISMES DE FISSURATION DE SURFACE DES COUCHES DE ROULEMENT.** [Mechanisms of Surface Cracking in Pavement Wearing Courses]. The authors describe a method of analysing permanent deformations in pavement wearing courses. The method consists of superposing two models of calculation: A model predicting the degree of cracking by thermal fatigue, for cracks initiated from the surface, A model of mechanical behaviour, to take account of moving loads on these cracks of thermal origin. The first model estimates the degree of cracking and its rate of propagation, solely from the thermal point of view, in the light of weather conditions on the site and the characteristics of the mix or the bitumen laid or selected. Cracking is simulated by means of a two-dimensional finite elements model which allows a satisfactorily approximate calculation of the factors of stress intensity. The rate of propagation is calculated, for 3 cases of loading, by integrating the law of Paris and determining the number of cycles and corresponding damage for the crack to attain the interface between the wearing course and the underlay. (Edited author abstract). 19 Refs. In French.

Dauzats, Michel (Lab Regional d'Aix-en-Provence, Fr); Rampal, Andre. *Bull Liaison Lab Ponts Chaussees* n 154 Mar-Apr 1988 p 57-72.

**076931 CALCUL DE STRUCTURES A L'ORNIERAGE: PROGRAMME CASTOR.** [Structural Design for Rutting Resistance: CASTOR Program. Method of Predicting Permanent Reformation in Bituminous Structures]. The calculation of permanent deformations is based on a two-dimensional model (transverse profile of the pavement) using a finite elements code. The model takes four types of parameters into account: the geometry of the structure (thickness); the traffic characteristics (number, weight, speed, lane distribution); the laws governing the behaviour of the materials (master curve and law of flow of bituminous materials); and the temperature profile in the structure. Permanent deformations are calculated over elementary periods, while the input parameters remain constant. At each stage, the geometry is updated and memorized so as to record the history of rutting during the period of reference. After describing the method, the author gives an illustration: the simulation of the test using a rutting wheel. This model has been the subject of a software programme, 'Castor', set up on an IBM PC compatible microcomputer. (Edited author abstract). 11 Refs. In French.

Goacolou, Honore (Lab Regional de l'Ouest Parisien, Fr). *Bull Liaison Lab Ponts Chaussees* n 154 Mar-Apr 1988 p 85-94.

## Automatic Testing

**076932 IOWA TESTS AUTOMATED ROAD SURVEY SYSTEM.** The Iowa Department of Transportation



recently evaluated PASCO's automated method of pavement evaluation. The PASCO Road Survey (PRS) system was compared to manual procedures currently used. The PRS system uses 35-mm photography; artificial lighting and hairline projection; tracking wheels; and lasers to measure ride, cracking, and patching, rut depths, and roughness. The Iowa DOT method provides a present Serviceability Index (PSI) value, while the PRS system gives a Maintenance Condition Index (MCI).

Anon. *Better Roads* v 57 n 12 Dec 1987 p 44-48.

## Bituminous

### 076933 LABORATORY TESTING OF MACADAM.

In several parts of Britain problems have been experienced with the premature deterioration of bituminous macadam wearing courses. Some failures have occurred only weeks or months after laying compared with an expected lifetime of perhaps five to 10 years. The deterioration affects road surfaces in several different ways including fretting, loss of stone, pitting, potholing and lateral migration or flowage of the surface layer. This paper investigates the performance of dense bituminous macadam wearing course mixes tested under controlled laboratory conditions. 24 refs.

Cawsey, D.C. (Hatfield Polytechnic, Engl); Raymond-Williams, R.K.; Russell, W.A. *Highw Transp* v 35 n 6 Jun 1988 5p.

## Brick Construction

### 076934 CLAY PAVERS GET FULL TECHNICAL SUPPORT.

Brick paving has been around for centuries. Its visual attributes are well-known, including color fastness, resistance to staining from oil and other spillage, and its sympathy and context with the buildings nearby. As a warm and natural paving material, clay brick pavers have no equal. Structural performance, durability and skid resistance have been the focus of ten years' research by the Brick Development Association. This study reports on the wealth of information now available to specifiers.

Smith, Richard. *Highways (Croydon Engl)* v 56 n 1939 Jul 1988 p 12, 14.

## Coatings

### 076935 EMULCOL: NOUVELLE CONCEPTION DE L'ENDUISAGE. [EMULCOL: New Coating Concept].

EMULCOL, a new concept in pavement surface coating, is an innovative product developed by COLAS to meet specific requirements expressed by today's engineering specialists. It is a product whose innovation lies in the possibility of simultaneously spraying a special emulsion and a breaking agent on the emulsion brushes of a sprayer. It was possible because COLAS made a major commitment and devoted a substantial part of its R&D resources to its development for a number of years. It was tested thoroughly on a series of projects. It is given marketing support by demonstration sites and advertising campaigns. (Edited author abstract) In French.

Chambard, Rene; Langumier, Georges; Montmory, Pierre; Pelion, Robert; Perrono, Gerard. *Travaux Suppl* Mar 1988 p 21-27.

## Computer Aided Analysis

### 076936 SENSITIVITY ANALYSIS OF SELECTED BACKCALCULATION PROCEDURES.

The evaluation of existing pavement systems is necessary to meet today's demands for higher magnitudes of traffic loads and intensity. In particular, there exists a need for a reliable, quick, and nondestructive tool that permits the evaluation of pavements to obtain accurate information about existing structural conditions. Several types of nondestructive testing equipment and analysis procedures have been developed and are currently available. Their use in predicting pavement layer moduli must be carefully evaluated, as this particular application is now an integral part of the new AASHTO overlay design procedure. BISDEF, MODCOMP2, and SEARCH analysis procedures

were evaluated and the sensitivity of the backcalculated moduli to variations in input parameters was investigated. Results obtained for typical asphalt concrete and aggregate-surfaced pavements showed that the backcalculated moduli were sensitive to several of the user-supplied inputs. (Edited author abstract) 12 refs.

Rwebangira, T. (Univ of Dar-es-Salaam, Dar-es-Salaam, Tanzania); Hicks, R.G.; Truebe, Mark. *Transp Res Rec* 1117 1987 p 25-37.

### 076937 FEACONS III COMPUTER PROGRAM FOR ANALYSIS OF JOINTED CONCRETE PAVEMENTS.

A computer program named FEACONS III (Finite Element Analysis of Concrete Slabs) was developed in response to a need for a suitable analytical model to analyze the behavior of concrete pavements effectively and realistically. The program has been used extensively in the analysis of existing concrete pavements and a test road in Florida. The analytical model and computational procedure used by FEACONS III are described in detail. The FEACONS III program was shown to be both versatile and effective in the analysis of concrete pavement response. The modeling of the edge stiffness and the linear joint stiffness and torsional joint stiffness produces fairly realistic analytical results. It is hoped that this paper can enhance proper usage of the program and increase the awareness of highway engineers of the importance of the effects of temperature, joint, edge, and subgrade conditions to concrete pavement response. (Edited author abstract). 8 Refs.

Tia, Mang (Univ of Florida, Gainesville, FL, USA); Armaghani, Jamshid, M.; Wu, Chung-Lung; Lei, Shau; Toye, Kevin. *Transp Res Rec* n 1136 1987 p 12-22.

## Computer Aided Design

### 076938 COMPUTER ORIENTED DESIGN FOR FLEXIBLE PAVEMENTS.

This paper presents a computer program developed for arriving at the thickness of flexible pavement based on the recommendations of the Indian Roads Congress. Cost economy factor in pavement construction has also been considered in this paper by using different types of materials for construction of sub-base and base course layers. This analysis has indicated that the optimum system of pavement construction consists of a sub-base course of stabilized soil-lime-flyash layer and a base course of hot mixed bituminous macadam. 2 refs.

Sastry, M.V.B. Ramana (JNTU Coll of Engineering, Kakinada, India); Gopal, M.S.P. *Indian Highw* v 15 n 6 Jun 1987 p 63-80.

### 076939 MECHANISTIC DESIGN CONCEPTS FOR HEAVYWEIGHT F-15 AIRCRAFT ON FLEXIBLE PAVEMENT.

A new F-15 aircraft is now the heaviest fighter aircraft in the United States Air Force inventory. A mechanistic design procedure is developed for flexible pavements to accommodate the heavyweight F-15 loading. The ILLI-PAVE finite element computer program is used as the structural model to compute pavement structural responses. Design algorithms are developed from an ILLI-PAVE data base and are demonstrated in an example problem. The proposed design procedure is then compared with the present U.S. Department of Defense (DOD) procedure. The DOD procedure does not adequately consider asphalt-concrete fatigue effects. DOD minimum surface thickness requirements may not be sufficient to prevent premature cracking of pavements subjected to long-term use by the heavyweight F-15 aircraft. (Edited author abstract) 24 refs.

Kelly, Henry F. (US Air Force Inst of Technology, Wright-Patterson AFB, OH, USA); Thompson, Marshall R. *J Transp Eng* v 114 n 3 May 1988 p 323-340.

### 076940 DESIGN OF FOOTWAY PAVING FLAGS.

In urban areas, precast concrete paving flags, which provide an aesthetically pleasing and uniformly comfortable walking surface, are the usual form of surfacing for pedestrian footways. With the introduction of pedestrianization into urban areas, it has become necessary for

highway design engineers to give consideration to a number of important problems, viz. the way in which pedestrian areas are surfaced; the provision of adequate access and specially strengthened routes for delivery and emergency vehicles, so that the pedestrian surface is not destroyed by those vehicles; the effects of the public utilities trenching and local authority routine maintenance activities. The computer based analytical modelling of the paving flag pavement, relied heavily upon the mathematical 'finite element method' of analysis. This method of analysis allowed the complex requirements of the laboratory testing, on-site vehicular loading and the paving flag test procedure to be interrelated to produce the required paving flag design package. 8 refs.

Bull, John W. (Univ of Newcastle-upon-Tyne, Engl). *Highways (Croydon Engl)* v 56 n 1936 Apr 1988 p 44-45.

### 076941 ENTWICKLUNG UND ANWENDUNG VON COMPUTER-BEMESSUNGSVERFAHREN FUER BETONSTEINPFLASTER. [Evolution and Application of Mechanistic Design Procedures for Concrete Block Pavements].

This paper describes the evolution of computer-based mechanistic procedures for the design of concrete block pavements for both roads and industrial hardstands. The procedures include sophisticated modelling both of the design traffic and of the properties of the pavement materials. The significance of these models is discussed and their relevance is critically assessed by reference to a series of tests of block pavements conducted by the author from 1978 onwards. These tests included both accelerated trafficking trials of a wide range of prototype pavements and FWD studies of pavements currently in service in Australia. The paper concludes with a description of the application of the design procedures to a range of segmental pavements around the world. (Author abstract). 31 Refs.

Shackel, B. (Univ of New South Wales, Aust). *Betonwerk Fertigteil Tech* v 54 n 5 May 1988 p 60-67.

**Concrete** See Also AIRPORT RUNWAYS; CONCRETE—Admixtures; CONCRETE—Cracking; HIGHWAY ENGINEERING; HIGHWAY SYSTEMS—Skid Resistance; MATHEMATICAL TECHNIQUES—Finite Element Method; ROADS AND STREETS—Maintenance; STREET TRAFFIC CONTROL—Parking.

### 076942 CONCRETE PAVES THE WAY.

Two interesting British developments which point to a healthy future for continuously reinforced methods involve bituminous materials as well as concrete. On a different section of the M18, Humberstone County Council are pioneering the use of CRCP as a remedial overlay to a failing blacktop motorway. The second innovation is best described as the 'Son of CRCP'. The new British DTp Departmental Standard on Paving Design, which is due to be published this autumn, is thought to include the provision of continuously reinforced concrete roadbase (CRCR) alongside CRCP as an approved method of construction. This method, which is sometimes referred to as CRCP (for Base), essentially a lighter CRCP slab acting as the roadbase, upon which is laid a bituminous wearing course. It offers all the advantages of long working life associated with concrete pavements (typically twice that of their flexible counterparts), with the good riding qualities of blacktop.

Swan, Russ. *Int Constr* v 26 n 9 Sep 1987 p 76-78, 81, 85.

### 076943 DER BETONPFLASTERSTEIN - EIN GESTALTUNGSELEMENT DURCH FORM UND FARBE. [Concrete Paving Stone - A Design Tool for Shaping and Coloring].

The outstanding advantages of industrialized production of concrete paving blocks: high quality; high loadbearing capacity; great variety in shape and coloring; easy to place by hand or machine; and recovery of already laid stones and subsequent reutilization, have been opening up ever new areas of application for concrete paving stones. Concrete paving blocks have



long since become a trade-mark article and a major sales item for most concrete block producers. In German and English.

Schmidt, Johannes. *Betonwerk Fertigteil Tech* v 53 n 8 Aug 1987 p 537-540.

**076944 BETON-VERBUNDSTEINPFLASTER. [Interlocking Concrete Block Paving].** The paper reports the results of more than eight years of accelerated trafficking studies on in excess of 100 full-scale concrete block pavements. The evolution of a soundly based technology for the design and construction of concrete block pavements based on the data from these tests is then described. Three aspects of block paving were investigated. These comprised the nature of the block paving surface including studies of the influence of the type, shape, thickness, laying pattern and strength of the paving blocks, studies of a wide range of base and subbase materials and the evolution of comprehensive design procedures for block paving in both road and industrial paving applications. Particular emphasis is placed on the development of computer-based methodology for the design of block pavements. (Edited author abstract) In German and English. 20 refs.

Shackel, B. (Univ of New South Wales, Sydney, Aust). *Betonwerk Fertigteil Tech* v 53 n 8 Aug 1987 p 541-547.

**076945 BRIEF HISTORY OF SMALL ELEMENT PRECAST CONCRETE PAVING FLAGS.** Precast concrete flags have been used for paving footways in British cities for nearly a century and BS 368 was first published in 1929, setting a national standard for this widely used product. Flags have proved popular for several reasons, including performance and user preference, aesthetics and economics. In addition they can be lifted to provide easy access to underground services and re-used when a trench is reinstated, returning a footway to its original condition. The theories were checked by laboratory tests, in which a total of 55 flags were subjected to a static load. 2 refs.

Lilley, Alan (Cement & Concrete Assoc). *Civ Eng (London)* Sep 1987 p 13, 15-16, 18.

**076946 CONTINUOUS CONCRETE ROAD PAVEMENTS.** The article examines continuous concrete road pavements without transversal joints: the concrete slab in fact contains continuous reinforcing, enabling the regulation of cracking by eliminating the transversal joints. The subject is divided into four parts: dimensioning; (the concrete slab performs the task of withstanding the load action while the reinforcing has the task of limiting the opening of the cracks); construction (concrete placing is usually carried out by a slipforming machine with front or lateral in-feed); costs (the greater cost of the reinforcing steel is partly compensated by the lack of transversal joint costs); special uses (continuous concrete pavements can be used for the covering of deteriorated concrete or asphalt pavements, or for the paving of secondary roads). (Author abstract). In Italian. 22 refs.

Bologna, Gaetano. *Ind Ital Cem* v 57 n 1 Jan 1987 p 44-59.

**076947 CONCRETE PAVING HITS THE FAST TRACK.** High-production, heavy-duty pavement will be mostly limited to airports, an occasional new freeway or turnpike, and to the reconstruction of rural Interstates, often featuring monolithic concrete shoulders. The reconstruction of urban freeways with emphasis on coordination and scheduling is foreseen. The new markets in the concrete paving field are: fast track resurfacing with 'type III' high-early strength PC; concrete pavement restoration (CPR), now proven to repair worn concrete pavements with a smooth-riding, skid-resistant surface; recycling concrete as base stone or specification aggregates when replacing pavements; and porous concrete base - a new idea for base construction.

Knutson, M.J. (American Concrete Pavement Assoc, USA); Riley, Randall C. *Highw Heavy Constr* v 130 n 3 Sep 1987 p 80-83.

**076948 DONT LET DEICERS SCALE YOUR**

**CONCRETE.** In the winter, some concrete pavements won't make it through the freezing cold and deicing salt applications without damage. Some concrete will scale. The top 1/16 to 3/16 inch will slowly - sometimes quickly - flake away. But it doesn't have to. How to prevent it? How to keep the concrete from scaling? No matter what else one does, one must use air-entrained concrete. The billions of microscopic air bubbles created by air entrainment relieve the pressures that result when absorbed water freezes and expands. Without these billions of relief valves, the concrete scales. In severe freeze-thaw exposures, fresh concrete should contain 5.5 to 7.5 percent air, depending on the maximum aggregate size. But entrained air alone doesn't guarantee freeze-thaw durability. The author cites other good practices to be followed: slope exterior flatwork for draining off water, using concrete with a water-cement ratio no higher than 0.50, prolonged curing of concrete, and some other recommendations.

Wallace, Mark. *Concr Constr* v 32 n 11 Nov 1987.

**076949 PAVING WITH RCC.** Use of roller compacted concrete (RCC) for pavement is growing rapidly in the U.S. and Canada, both in civilian and military construction. Roller compacted concrete pavement differs from the RCC used for dams as well as from the conventional materials it replaces. Costs aren't the only difference between RCC and other materials and construction procedures. It differs from soil cement in that it has coarse aggregate, from cement treated base in that it has a higher cementitious material content, and from both in its use as a smooth surface course that must withstand traffic and weather.

Keifer, Oswin Jr. *Civ Eng (New York)* v 57 n 10 Oct 1987 p 65-68.

**076950 STRUCTURAL DESIGN OF CONCRETE PAVEMENTS.** In the last 30 years multi-layer elastic theory has been applied with some success to the design of flexible pavements, and particularly those with cemented bases. During 1984-1985 the involvement of the authors in an investigation of the performance of some 2000km of very variable strength concrete roads in the Philippines carrying very heavy wheel-loads made it essential to develop a theoretical design procedure relating axle loading, pavement thickness and concrete strength. The present paper arises from that work. 10 refs.

Croney, David; Currer, Edward W.H.; Croney, Paul. *Highw Transp* v 34 n 11 Nov 1987 p 14-15, 17, 19-23.

**076951 CONCRETE PAVEMENT ON A9 TRUNK ROAD: CONDITION AFTER 50 YEARS.** One of the most interesting features of this road when it was built was the novel adoption of reinforced concrete for the construction of five sections of the road, between Carrbridge and Tomatin, which traversed deep peat deposits. Fifty years later the road was again rebuilt, this time from Perth to Inverness. The construction of the section from Slochd Summit to Dalmagarry required the removal of one of the old concrete sections and this presented an opportunity to inspect its construction and to observe how it had performed during its life. This paper discusses various aspects of the study, including design of the pavement, performance, condition of the materials, and other related subjects. 2 refs.

Livesey, K.H. (W.A. Fairhurst & Partners). *Proc Inst Civ Eng (London)* v 82 pt 1 Oct 1987 p 995-1005.

**076952 BETONFAHRBAHNTECHNIK IN BELGIEN. [Concrete Road Pavements in Belgium].** Planning and execution of concrete road pavement construction in Belgium are outlined, furthering the practice for the kinds of roads concrete layers are generally applied. Another subject of the article are the criteria ruling the systematic inspections and road performance tests in Belgium. The positive evaluation of the concrete pavements leads the authors of this report from the Brussels Road Research Centre, on which this article is based, to the conclusion that it is particularly suitable also for developing countries. (Author abstract) In German.

Binnewies, Wilfried. *Str Tiefbau* v 41 n 10 Oct 1987 p

14-16.

**076953 LANGZEITMESSUNGEN AN BETON-DECKEN. [Long Time Measurements of Concrete Pavements].** The data obtained by long time measurements of concrete pavements of test road sections with different structural designs on the A81 highway near Berolzheimer and on the A6 at Ansbach, with and without the conventional frost protection layer, shows that an increase in rutting, step formation, middle joint opening and loosening-up of the compound structure of concrete and the hydraulically bound carrier layer occur only after several years. The doweling of the heavily trafficked concrete lanes could not be avoided owing to step formation. The doweled concrete superstructure is adequately dimensioned with a concrete top thickness of over 22 cm for an axial load of 10 t. Continuation of long-time measurements is recommended. (Translated author abstract) 6 refs. In German.

Eisenmann, Josef (TU Muenchen, Munich, West Ger); Birmann, Dieter. *Str Autobahn* v 38 n 3 Mar 1987 p 81-86.

**076954 ZUM WIDERSTAND VON BETON-DECKEN GEGEN FROST UND CHEMISCHE ENTEISUNGSMITTEL. [Resistance of Concrete Pavement to Frost and Deicing Media].** Thawing salts, mostly sodium chloride, are used on roads for melting ice and solid snow layers. For environmental protection reasons these salts are used only in exceptional cases. Melting salts are unsuitable for use at airports because of their corrosive effects on materials used in aircraft construction. Liquid deicing media are used there. They consist mostly of glycol and urea. The effects of salts and the thawing media used at airports are compared. Urea, frigidin and LP 1678 thawing media caused damage which could be compared to that caused by sodium chloride. An increase in concrete resistance could be obtained by aftertreatment. Neglect of aftertreatment rapidly accelerated weathering of concrete pavements. 22 refs. In German.

Plaehn, Juergen (Univ Hannover, Hanover, West Ger); Golz, Werner; Schreiber, F.-Rainer. *Str Autobahn* v 38 n 3 Mar 1987 p 87-92.

**076955 FROSTSCHAE DEN AN BETONFAHRBAHNEN UND KAPPEN. [Deterioration of Concrete Pavements and Overlays in Frost Periods].** The deterioration of concrete pavements by descaling of the surface layer and the mechanism of this phenomenon as a consequence of the effects of de-icing salts are analyzed. Some of the methods which are recommended nowadays to prevent the damage are examined with a view to revealing the chances for their effectiveness. Where they fail, the cause can mostly be attributed to concepts neglecting the importance of an impervious surface, their porosity and capillarity. Recommendations are given on how to treat the pavement surface in order to protect it against the penetration of salt anions efficiently. (Author abstract) In German.

Grunau, Edvard B. *Str Tiefbau* v 41 n 12 Dec 1987 p 15-18.

**076956 ROLLER COMPACTED CONCRETE PAVEMENTS.** Roller compacted concrete for pavements is made by mixing crushed aggregate with cement and water in a pugmill. More cement is used than for cement-treated base (CTB) or soil cement. The cement-plus-pozzolan content ranges from 400 to 700 pounds per cubic yard and just enough water is added to produce a moist earth consistency. High density is essential to develop adequate flexural strength. Tamping bars and a vibrating screed on the laydown machine provide initial compaction. Rollers further compact the pavement to its required density. 4 refs.

Malisch, W.R. *Concr Constr* v 33 n 1 Jan 1988 p 13, 15, 17.



**076957 STRESS CAUSED BY TEMPERATURE GRADIENT IN PORTLAND CEMENT CONCRETE PAVEMENTS.** Concern has been expressed in Florida that, because of a nonlinear temperature gradient in a portland cement concrete (PCC) pavement, internal stresses could be developed such that the life of the pavement would be seriously reduced. A research program was undertaken by the Florida Department of Transportation to determine the actual temperature gradient in a PCC pavement. For a period of 9 months, hourly temperatures were recorded from a 9-in.-thick test pavement in Gainesville, Florida. The temperature data were analyzed to determine what curve best fit the data and what were the actual maximum compressive and tensile stresses caused by the nonlinearity of the temperature gradient. These results were compared with those obtained from the AASHTO Test Road and with Bergstrom's prediction method. The results indicated that the nonlinearity of the temperature gradient in a PCC pavement did not have a significant impact on its performance. (Author abstract) 3 refs.

Richardson, Joseph M. (McNeese State Univ, Lake Charles, LA, USA); Armaghani, Jamshid M. *Transp Res Rec* 1121 1987 p 7-13.

**076958 TEMPERATURE RESPONSE OF CONCRETE PAVEMENTS.** It is the objective of this paper to more precisely describe the displacements of a concrete pavement slab associated with temperature variation and weather. Temperature data, accumulated between 1983 and June 1986 from a test road, are analyzed. This is followed by a description of pavement response to temperature, which is based on the analysis of displacement measurements that were obtained from test road slabs. 7 refs.

Armaghani, Jamshid M. (Florida DOT, Gainesville, FL, USA); Larsen, Torbjorn J.; Smith, Lawrence L. *Transp Res Rec* 1121 1987 p 23-33.

**076959 EFFECT OF RAINFALL ON THE PERFORMANCE OF CONTINUOUSLY REINFORCED CONCRETE PAVEMENTS IN TEXAS.** This study indicated that the initial performance of pavements located in different rainfall areas is practically the same. However, when the pavement starts developing failures (punchouts and patches), the average rate of failures per mile (RPPM) is affected by the average rainfall of the area. Pavements located in 10-in. rainfall areas generally showed an almost zero rate of failure development, whereas pavements located in 52-in. rainfall areas developed failures at a rate of about one failure per mile per year. (Edited author abstract) 6 refs.

Saraf, C. (Univ of Texas at Austin, Austin, TX, USA); Chou, Chia-pei; McCullough, B. Frank. *Transp Res Rec* 1121 1987 p 45-49.

**076960 DEVELOPMENT OF A DEMONSTRATION PROTOTYPE EXPERT SYSTEM FOR CONCRETE PAVEMENT EVALUATION.** A computerized system has been developed to assist state highway engineers in evaluating concrete highway pavements. The system uses information collected by the engineer to determine what mechanisms have caused the distresses present in the pavement, so that the rehabilitation techniques that would be most effective in repairing the distresses and preventing their recurrence can be identified. The evaluation procedure has been developed in the form of an expert system that simulates a consultation between the engineer and an expert in concrete pavement evaluation and rehabilitation. The system operates on an IBM-compatible personal computer. The steps in the development of the expert system are described for the benefit of those interested in improved pavement evaluation procedures and in exploring expert systems applications in pavement design, evaluation, and rehabilitation. (Edited author abstract) 5 refs.

Hall, Kathleen T. (Univ of Illinois at Urbana-Champaign, Champaign, IL, USA); Darter, Michael I.; Carpenter, Samuel H.; Connor, James M. *Transp Res Rec* 1117 1987 p 58-65.

**076961 LIMESTONE CRUSHER-RUN AND TAILINGS IN COMPACTION CONCRETE FOR PAVEMENT APPLICATIONS.** Laboratory experiments indicate that both limestone crusher-run and finely grained limestone tailings (by-products of the aggregate mining industry) can be used in concrete made with an emerging technology for flatwork construction known as roller compacted concrete (RCC). This paper reports on tests of laboratory specimens using various combinations of mix components and proportions. The unit cost of concrete progressively decreases as the graded coarse aggregate is substituted with the crusher-run and as the tailings are added. On the other hand, the compressive strength of mixtures including the crusher-run is better than that of graded coarse aggregate and is further improved by the addition of tailings. (Author abstract) 13 refs.

Nanni, Antonio. *ACI Mater J* v 85 n 3 May-Jun 1988 p 158-163.

**076962 DESIGN OF PRESTRESSED CONCRETE PAVEMENTS.** There are no standards or recommended procedures for the design of prestressed concrete pavements; thus design of this type of pavement present unique opportunities and challenges. It also presents a great opportunity to use fundamentally based engineering design methodology rather than the relatively common empirical methods. It is to be anticipated that, as lifecycle costs assume greater importance in the selection of paving solutions, the structural durability of prestressed concrete pavements will make them a competitive alternative, particularly if operational delay caused by maintenance work is a major factor. This paper presents a synthesis of technology appropriate to the design of prestressed concrete pavements. All features of the design calculation are considered, from defining the loading conditions through calculation of both wheel load stresses and those caused by environmental factors, to selection of appropriate limiting stresses for the concrete. Since design is a creative procedure, and designers should be free to use their creative talents to the full, where appropriate, alternative procedures have been described leaving individuals to select the method most appropriate to their needs. (Author abstract) 38 refs.

Stock, A.F. *Struct Eng Part A* v 66 n 11 Jun 7 1988 p 169-175.

**076963 DECORATIVE CONCRETE BLOCK PAVEMENTS.** Engineers today generally utilize Portland cement concrete and bituminous concrete to construct streets. However, an aesthetically pleasing alternative, brick pavers, does exist. Michigan Avenue in Lansing, Michigan, was perceived to need something other than is 'standard' street surface, and concrete stone pavers were selected. It was felt that such a surface was aesthetically pleasing and would establish the needs of pedestrians. Brick surfaces would be a vital part of this emphasized and variations in color, pattern, and texture would play a key role in the design. The final product is an aesthetically pleasing yet a key role in the design. The final product is an aesthetically pleasing yet structurally sound street and is resistant to freeze-thaw actions. Cost of the pavement system was \$6.20/sq ft (\$66.74/m<sup>2</sup>) compared to \$3.14-\$3.54/sq ft (33.80-38.11/m<sup>2</sup>) for more traditional streets built by the city. (Edited author abstract)

Randolph, Dennis A. (City of Lansing, Lansing, MI, USA); Rajendra, Kunwar; Starr, David W. *J Transp Eng* v 114 n 4 Jul 1988 p 409-419.

**076964 REVIEW OF THE DESIGN METHODS FOR CONCRETE PAVEMENTS.** Road pavements are broadly divided into two categories; flexible pavements and rigid pavements. Flexible pavements are constructed with a thin wearing course overlaying the base course. Between the base course and the compacted sub-grade is a sub-base. The load carrying characteristics of a flexible pavement is due to the load-distributing effects of the layered system. As a result of this building up of the thick layers, the applied wheel loads are mainly distributed over the sub-grade with a small amount of the load being supported by the bending action of the bound materials.

In the rigid pavement, the wearing course is a concrete slab overlaying the sub-grade, between which there may or may not be a base course. The load is distributed over a wide area of sub-base, with the concrete slab carrying a major portion of the load in bending. Consequently a major design consideration is the structural strength of the concrete with small variations of the sub-grade not really having significant effects on the structural capacity of the slab. Discussed are rigid pavement analysis, UK standards, and UK design methods. 10 refs.

Bull, John W. (Univ of Newcastle-upon-Tyne, Engl). *Highways (Croydon Engl)* v 56 n 1936 Apr 1988 p 25-26.

**076965 LOCATION OF DOWEL BARS IN CONCRETE PAVEMENTS.** Dowel bars are the most effective means of providing load transfer across movement joints in concrete pavements. In order for the joints to function correctly it is essential that the bars are aligned parallel to each other within suitable tolerances. The problem facing the engineer is the difficulty of establishing that these tolerances have been met. The need for a non-destructive method of inspection and measurement of dowel bar alignment is widely recognised and one which TRRL is endeavouring to meet by the development of a magnetically based device designed specifically for use on road joints. The project is supported by a research contract to the Cranfield School of Industrial Science which has designed and constructed the system in conjunction with the Technical Services Unit of TRRL.

Franklin, R.E. (TRRL, Engl); Winnett, M.A. *Highways (Croydon Engl)* v 56 n 1936 Apr 1988 p 42-43.

**076966 RECOMMENDATIONS FOR DESIGNING PRESTRESSED CONCRETE PAVEMENTS.** Given adequate consideration to the design of joints and the placement of reinforcement, long prestressed slabs with substantially smaller thicknesses than those of conventionally reinforced pavements carrying the same loads can be constructed practically without cracks. Also, by capitalizing on the favorable distribution of the stresses caused by the effect of the difference in the moisture content from top to bottom across the thickness of the slab, the amount of prestressing forces required, and thus the prestressing reinforcement, may be reduced. This report analyzes the factors influencing the design of prestressed concrete pavements and recommends methods for their layout and structural analysis. (Edited author abstract). 42 Refs.

Anon (ACI Committee 325). *ACI Struct J* v 85 n 4 Jul-Aug 1988 p 451-471.

**076967 HOW TO BUILD CONCRETE PARKING LOTS.** To encourage good construction of concrete parking lots, the American Concrete Institute (ACI) formed Committee 330, Parking Lots, in 1982. In December 1987, the committee's first document, ACI 330R-87, "Guide for Design and Construction of Concrete Parking Lots," was published for use and public comment. The guide summarizes accepted practices for designing and constructing many categories of concrete parking lots. This article offers a brief review of the highlight of the guide.

Albright, Richard O. (Indiana Concrete Council, Carmel, IN, USA). *Concr Constr* v 33 n 7 Jul 1988 p 663-666.

**076968 PREDICTING PLASTIC SHRINKAGE CRACKING LMC OVERLAYS.** Plastic shrinkage cracking is a potential problem when latex-modified concrete (LMC) is placed on a dry, windy day. LMC has a lower water content than conventional concrete so it bleeds less. Because plastic cracking is caused by evaporation rate exceeding bleeding rate, LMC's low bleeding rate makes plastic cracking more likely. To avoid the problem, contractors must be able to predict when it's likely to occur so they can take steps to prevent it. Whenever



temperature, relative humidity, and wind conditions are such that evaporation rate exceeds the critical 0.1 value, contractors should be especially careful. 4 Refs.

Sprinkel, Michael M. (Virginia Transportation Research Council, Charlottesville, VA, USA). *Concr Constr* v 33 n 7 Jul 1988 p 672-674.

**076969 VERKEHRSFLACHEN AUS BETONPFLASTERSTEINEN PLANUNG UND GESTALTUNG.** [Concrete Block Pavements Design and Layout]. The concrete paving block has in the past opened up a wide range of application. Pedestrian precincts, traffic-restricted zones, housing estate roads, footways, cycle tracks, cross-country paths, farm tracks, bus stop bays, parking and industrial areas, but also private garden paths, terraces, yards and access ways, are increasingly being paved with concrete blocks. This steady increase in interest in this type of paving is undoubtedly due to its advantageous properties. Carefully designed and expertly constructed pavements consisting of concrete blocks fulfil high demands as to appearance, functional performance, durability and economy. (Edited author abstract). 11 Refs.

Kampen, R. *Betonwerk Fertigteil Tech* v 54 n 5 May 1988 p 32-38.

**076970 VERKEHRSFLACHEN AUS BETONPFLASTERSTEINEN PLANUNG UND AUSFÜHRUNG.** [Concrete Block Pavements Design and Construction]. Pavements constructed of precast concrete blocks or flagstones are one of the most important types of trafficable public area. With these elements it is possible to build paved surfaces that fully satisfy the needs of towns and rural localities. A number of technical problems are associated with the construction of such pavements: earthworks, drainage, joint sealing, etc. Some information on these matters will be given in this article, with particular reference to the relevant regulations, directives and codes of practice. (Author abstract). 4 Refs.

Mortiz, Helmut. *Betonwerk Fertigteil Tech* v 54 n 5 May 1988 p 40-42,44-48.

**076971 BETONPFLASTERSTEINE - RICHTIG EINGESETZT.** [Concrete Paving Blocks - Properly Used]. Between 70 and 80 million square metres of concrete block paving are laid in the Federal Republic of Germany each year. The principal applications are in residential roads, pedestrian precincts and frontage roads; also industrial yards, car parks, and paved areas in parks and gardens. The commercially available range of concrete paving blocks should be scrutinized by the pavings designer with regard to suitability of the products for his particular purpose. Numerous aspects of design and layout have to be considered, but also the interests of the civil engineer, the road user and the road maintenance authorities. Suggestions are made with regard to the assessment of coloured blocks and the occurrence of efflorescence. Finally, some tips relating to correct laying of the blocks, to avoiding mistakes and to the final vibratory compaction of the paving are given and explained. (Author abstract).

Pesch, Lothar. *Betonwerk Fertigteil Tech* v 54 n 5 May 1988 p 50-56,58-59.

**076972 PRECAST CONCRETE PAVING.** Paving blocks lock together to form a membrane or continuous layer, capable of distributing loads applied at the pavement surface to the underlying layers. Before any design can be started it is necessary to have, at least, the following information: 1. Traffic flow at the time of opening; 2. Prediction of any changes in future traffic flows; 3. Design life in terms of either years or traffic flow; 4. Subgrade bearing strength and 5. Location of the water-table. There is no doubt that flags and blocks provide attractive, long lasting, easily maintainable and competitive surfacings for a wide range of applications. Existing block paving design methods are safe, as long as the correct materials are used in the layer immediately beneath the laying course. More sophisticated design methods are possible that may further reduce the overall cost of block paving. The

introduction of the smaller flag sizes and the laying of these on a thin sand bedding has done much to improve the performance of flagged surfaces and simplified construction. 22 Refs.

Lilley, Alan. *Highw Transp* v 35 n 7 Jul 1988 p 18-20,22-25.

**076973 RECYCLING DETROIT'S LODGE FREEWAY.** The scarcity of quality natural aggregates in many locations, and the growing lack of suitable disposal sites for old material, especially in urban areas, make pavement recycling both economically and environmentally desirable. Recycling of the old reinforced concrete pavement provided more than enough coarse aggregate for the new concrete placed during reconstruction of 8.7 miles (14 km) of Detroit's John C. Lodge Freeway in 1987, described in this article. 2.

Pearson, Robert I. (Concrete Int, Detroit, MI, USA). *Concr Int* v 10 n 8 Aug 1988 p 17-19.

**076974 NO-FINES PERVIOUS CONCRETE FOR PAVING.** Results of a laboratory study of no-fines pervious concrete for paving are presented. Conclusions are drawn regarding the percent air voids needed for adequate permeability, the optimum water-cement ratio range, and the amounts of compaction and curing required. Recommendations are made regarding appropriate uses for this type of concrete. (Author abstract).

Meininger, Richard C. *Concr Int* v 10 n 8 Aug 1988 p 20-27.

**076975 FAST-TRACK CONCRETE PAVING.** Fast-track concrete has been successfully used for new paving and both bonded and unbonded overlays. Its ability to carry heavy traffic within 12 hours of placement has been clearly demonstrated, and an 8-hour pavement is a feasible goal. Mixing and placing is possible using conventional mixing plant and pavers, but new equipment is needed to enable full advantage to be taken of the fast-track technique. Fast-track concrete sets up very quickly, so mixing plant must be located close to the site. Mixes that set and gain strength even faster than those currently in use could be utilized if equipment were available that could mix the concrete immediately in front of the paver. Adjustable-width zero-clearance pavers would make it easier to apply fast-track paving within the tight constraints of urban road systems; improved vibration capability would make it easier for pavers to handle this extremely stiff concrete. New admixtures and cements may be helpful in controlling set and workability while still producing the required strengths.

Pearson, Robert I. (Concrete Int, Detroit, MI, USA). *Concr Int* v 10 n 8 Aug 1988 p 33-35.

**076976 TEXTURING CONCRETE PAVEMENTS.** Increased traffic volumes and speeds have increased the need for an improved skid-resistant surface. The emphasis has been to improve skid resistance by creating new surface textures that increase the 'macrotexture' of the concrete pavement. These textures are created by forming the deeper textures in the plastic concrete during the finishing operations or by sawing grooves in the hardened concrete of existing pavements with cutting heads composed of a number of circular diamond saw blades. (Author abstract).

Anon. *Concr Int* v 10 n 8 Aug 1988 p 50-52.

**076977 EXPERT SYSTEM TO EVALUATE CONCRETE PAVEMENTS.** 'Pavement Expert' is an expert system developed to aid in the evaluation of concrete pavements. The system is operational on an IBM microcomputer. 'Pavement Expert' operates in two modes: dialogue and data logging modes. The dialogue mode is controlled by a Savoir shell which controls the dialogue between the user and the system. The system makes decisions 'intelligently' concerning the length of the section to evaluate, extent and severity of the observed distresses, and calculates and store the final indices. The data logging mode acts as an intelligent data logger recording specific observed distresses. The system consists

of five stages ranging from identifying the road to providing a full report on the general condition of the pavement. (Edited author abstract). 4 Refs.

Alshawi, M. (Liverpool Polytechnic, Engl); Cabrera, J.G. *Microcomput Civ Eng* v 3 n 3 Sep 1988 p 191-197.

**076978 SKIDDING RESISTANCE OF CONCRETE: PERFORMANCE OF LIMESTONE AGGREGATE EXPERIMENT AFTER 10 YEARS.** A full-scale experiment was constructed on the Windover to Funtley section of M27 and opened to traffic in 1976. The experiment comprised twelve sections, each 150 m long, containing a variety of concretes chosen to study the effect of using a range of qualities of limestone coarse aggregate and of using different proportions of limestones or shell in the fine aggregate. Measurements of Sideway Force Coefficient have been made annually for 10 years. The factor having the most effect on skid resistance was the acid-soluble content of the fine aggregate. Results of the Polished Mortar Value test correlated with both the acid-soluble content and the Sideway Force Coefficient on two of the three lanes but were relatively insensitive to changes in material quality. The Polished Stone Value of the coarse aggregate was a significant factor but, its effect on skid resistance was limited. (Edited author abstract). 7 Refs.

Franklin, R.E. *Res Rep Transp Road Res Lab* n 144 1988 var paging.

**076979 FUNDAMENTAL EXPERIMENT ON THE ENGINEERING PROPERTIES OF CEMENT MIX MATERIALS FOR BASE COURSE.** This paper presents a comprehensive study to investigate compaction-strength mechanism as well as drying shrinkage characteristics on cement mix materials for base course with water content from low water content region which is suitable for roller-compaction to high water content region which is suitable for vibration-compaction. From the experiment results, dry density changes continuously with respect to water content of both regions and is maximum at the boundary. But at that boundary, compressive strength is different and discontinuous. In other words, compressive strength is not always governed by dry density and is found to be governed by cement-paste/-void ratio. The drying shrinkage of these materials is linearly proportional to water content and cement content during mixing. (Author abstract). 8 Refs.

Ng, Kien Chor (Tohoku Univ, Sendai, Jpn); Fukuda, Tadashi. *Doboku Gakkai Rombun Hokokushu* n 396 V-9 Aug 1988 p 169-175.

## Concrete Construction

**076980 REPORT AND REVIEW OF A MAJOR SLABJACKING CASE HISTORY.** A review is presented of a major case history of lifting and leveling portland cement concrete highway slabs by injection of a fluid cement/pozzolan material between the subgrade and the slab. The paper includes history and background data as well as current practices, advantages, disadvantages, and specific procedures. Grout materials, mixtures, equipment, and lifting controls are discussed. (Author abstract) 2 refs.

Bandimere, Samson W. (Denver Grouting Services, Broomfield, CO, USA). *Transp Res Rec* 1104 1986 p 3-6.

**076981 CONCRETE SLABS AND BLOCKS FOR CAR PARK PAVING.** In addition to its primary function of providing a stable and durable surface for vehicular movement, the parking area pavement must also allow sufficient open spaces for turfing and tree planting. A pavement system consisting of discrete precast perforated-concrete-slab units was found to offer a reasonably satisfactory solution. Later, two new forms of parking area construction, namely, the interlocking-perforated-concrete-block pavement and the cast-in-situ jointed-perforated-concrete-slab pavement. Although both innovations have led to higher construction costs, their



superior structural stability and lower maintenance requirements may justify their use on the basis of life-cycle cost considerations. 5 Refs.

Fwa, T.F. (Nat'l Univ of Singapore, Kent Ridge, Singapore). *Transp Res Rec* n 1127 1987 p 63-70.

**Construction** See Also ROADBUILDING MATERIALS—Standards.

**076982 CONSTRUCTION OF RUBBER-MODIFIED ASPHALT PAVEMENTS.** Public road agencies are currently evaluating hot mix applications of Plus Ride and Arm-R-Shield modified asphalt pavements. The processes use reclaimed rubber from ground automotive and light truck tires to reduce reflective and thermal cracking, suppress traffic noise, increase resistance to studded tire wear, and reduce the environmental impact of tire disposal. The projects constructed to date have primarily been experimental because the capital cost for this surfacing alternative ranges from 1.5 to 2 or more times the cost of conventional asphaltic concrete. A literature review of the construction practices and a questionnaire survey of contractors are used to determine why the construction costs of the modified mixes have been so high. Study results are discussed. 24 refs.

McQuillen, Jay L. Jr. (Granite Constr Co, Sparks, NV, USA); Hicks, R. Gary. *J Constr Eng Manage* v 113 n 4 Dec 1987 p 537-553.

**076983 BETTUNG VON GEHWEPLATTEN-BELAEGEN.** [Bedding of Sidewalk Slab Pavements]. The technique of bedding sidewalk plates had been treated in number 3/1982 of this magazine already. To find out about the best material for bedding, tests were made with three different compositions: trass-lime LP, bituminous mortar, and crushed basalt. All of these materials showed good performance but the third option seems outstanding in some respects. These are: simplicity of application, cost-efficiency, and ease of mending operations. This evaluation is not regarded as final since the test time seems not long enough for a definite assessment, but it is meant as an intermediate report on an on-going test. (Edited author abstract) 2 refs. In German.

Eickmann, Hans-Martin. *Str Tiefbau* v 41 n 1 Jan 1987 p 15-16.

**076984 HOW TO USE AND INSTALL CONCRETE BLOCK PAVERS.** Colored concrete paving stones have become increasingly popular for applications ranging from light-use pedestrian walkways and patios, sidewalks and plazas in downtown renewal projects, to the heaviest industrial uses. The complete concrete masonry pavement has five key elements, each of which is discussed in detail. They are: Subgrade, the natural earth material found on the site; the subbase, which is introduced, leveled, and compacted; the edge restraints, which are used around the perimeter of the pavement; the placing and level screeding of the bedding sand; and the concrete paver surface, which is both the attractive wearing surface and the load-distribution system. The article discusses the details on each step in the procedure.

Croushore, Paul N. (Mobay Chemical Corp, Pittsburgh, PA, USA). *Public Works* v 119 n 7 Jun 1988 p 87-89.

**076985 SPECIFICATIONS FOR QUALITY CONTROL: A CASE STUDY.** Specifications that call for unnecessary perfection through so-called 'hard' or 'tight' requirements are hardly reasonable; furthermore, they do not assure performance. Specifications that attempt to control quality through extremely limited tolerances may in fact be counterproductive. When quality control efforts are directed to compliance with the letter of such specifications, quality may be compromised, contract administration may be difficult, and additional costs may be incurred, all without improving performance of the completed work. A case study of a small paving project is presented to illustrate the problems created by a too-restrictive specification. Alternatives and comments to improve the specification are offered. (Edited author abstract) 1 ref.

Gentry, Claude (Byrd, Tallamy, MacDonald, and Lewis, Falls Church, VA, USA); Yrjanson, William A. *Transp Res Rec* n 1126 1987. Publ by ISA, Washington, DC, USA, 1987 p 37-41.

## Costs

**076986 ECONOMIC ANALYSIS OF RUBBER-MODIFIED ASPHALT MIXES.** The Alaska Department of Transportation and Public Facilities (ADOTPF) is presently evaluating the use of recycled rubber in hot mix pavement applications. The benefits of adding rubber to the mix include increased skid resistance under icy conditions, improved flexibility and crack resistance, elimination of a solid waste, and reduced traffic noise. The major disadvantage of these rubber-modified mixes is their high cost in relation to conventional asphaltic concrete pavements. A comparison of the economics of the rubber-modified system with that of the conventional pavement shows that the rubber-modified surfacing is cost-effective. This conclusion is based on an analysis of life-cycle costs. (Edited author abstract) 9 refs.

McQuillen, Jay L. Jr. (Granite Construction Co, Sparks, NV, USA); Takallou, Hossein B.; Hicks, R. Gary; Esch, Dave. *J Transp Eng* v 114 n 3 May 1988 p 259-277.

## Crack Propagation

**076987 M4 MOTORWAY, A COMPOSITE PAVEMENT. SURFACE CRACKING.** The London-South Wales motorway, M4, was built during 1970/71, in a series of six contracts. In 1981, when the motorway had carried about half its design load, a structural condition survey was set up to assess its condition and plan maintenance. At that time very little maintenance had been carried out to obscure the signs of deterioration, and the strongly characteristic patterns of cracking and rutting on each contract resulting from the use of different aggregates and construction plant by each contractor offered the opportunity to study the processes of decay in a composite pavement. The variety of forces acting simultaneously to influence the rate and frequency of crack formation and subsequent deterioration makes analysis difficult, but identification of the factors described may add to understanding composite pavement decay. The study illustrates the advantage of lean concrete of high strength, with longitudinal joints located generally along the lane lines, and it demonstrates the benefit of wearing course asphalt of high flexibility and resilience. 1 ref.

Burt, A.R. (Berkshire County Council, Engl). *Highway Transp* v 34 n 12 Dec 1987 p 16-19.

## Cracking

**076988 BEHAVIOR AND DESIGN OF VERTICAL MOISTURE BARRIERS.** Seasonal wetting and drying affect pavements on expansive soils with two main damage types: roughness development and longitudinal cracking. The purpose of the moisture barrier is to isolate the subsoil from these climatic changes. The predominate type of damage and the function of the barrier are dominant type of damage and the function of the barrier are found to depend on the initial moisture conditions of the subsoil. For desiccated soils, the barrier must prevent the infiltration of rainfall into the shrinkage cracks to stop the development of roughness. For wet soils, the barrier must prevent excessive drying under the edge of the pavement. The barrier depth is chosen based on the maximum crack depth and the shrinkage of the pavement edge that would occur under the most severe drought intensity expected during the lifetime of the pavement. The drought intensity is chosen based on a statistical analysis of meteorological data for the site. (Edited author abstract) 30 Refs.

Picornell, M. (Univ of Texas at El Paso, El Paso, TX, USA); Lytton, R.L. *Transp Res Rec* n 1137 1987 p 71-81.

## Creep

**076989 CANIK UL - A NEW CREEP TESTING MACHINE.** Highway engineers are very much concerned with the prediction of performance of bituminous surfaced roads. This is done by measuring permanent deformation in a laboratory and applying the data to simple deformation models for the prediction of rutting. A model which has gained much favour is the one proposed by Hills which is based on a creep test carried out applying a static uniaxial load to a specimen maintained at constant temperature and monitoring the deformation-time relation. The good correlation found between creep test and rutting led many research laboratories to use the creep test not only to characterise the mixtures in terms of their deformation properties but also to estimate the rut depth. 11 refs.

Cabrera, Joe G. (Univ of Leeds, Engl); Nikolaides, Athanasios F. *Highway Transp* v 34 n 11 Nov 1987 p 33-36.

## Deformation

**076990 DEFLEXION DES CHAUSSEES ET BI-LAN HYDRIQUE.** [Pavement Deflection and Rainfall Balance]. Systematic monthly measurements of the deflection of sections of pavements, mostly of the traditional type, were begun in 1977 in the six Regional Laboratories which constitute the base of overlay operations. These measurements were accompanied by the calculation of the rainfall balance affecting the ground, on the basis of data gathered by the nearest meteorological station, as is done for agricultural purposes. The object of the study was to observe seasonal variations of deflection and compare them with seasonal variations of the rainfall balance. Examination of the numerous results gathered indeed reveals an analogy in the variation of these two factors, but with a variable shift between the curves representing them. It seems that this shift, and also the more or less 'typical' nature of the curves of evolution of deflection, depends among other things on the geotechnic and hydraulic characteristics of the site under observation. Consideration of meteorological factors alone would therefore seem to be insufficient to predict the way the deflection varies. (Author abstract) 3 refs. In French.

Bellanger, Jacques (Lab Regional d'Angers, Fr). *Bull Liaison Lab Ponts Chaussees* n 149 May-Jun 1987 p 45-50.

**076991 SUBSEALING AND LOAD TRANSFER RESTORATION.** Presented are the evaluation results of slab subsealing and load transfer restoration using dowel bars and double vee shear devices of a jointed concrete pavement at a large truck terminal facility. Nondestructive deflection testing (NDT) procedures using the falling-weight deflectometer (FWD) were used before and after slab subsealing and installation of the load transfer devices to evaluate the efficiency of the slab subsealing and load transfer devices. (Author abstract) 2 refs.

Roman, R.J. (ERES Int Inc, Champaign, IL, USA); Shahin, M.Y.; Crovetto, J.A. *Transp Res Rec* 1117 1987 p 47-57.

**076992 CHARACTERIZATION OF THE METEOROLOGICAL DEMAND FOR THE DESIGN OF VERTICAL MOISTURE BARRIERS.** Pavements founded on expansive soils are damaged because of seasonal wetting and drying of the foundation soils. The magnitude of the damage is controlled by the wettest and driest moisture content profiles that occur at the site. The moisture profiles are altered with the removal or replenishment of soil moisture by the meteorological conditions. Because weather conditions cannot be predicted accurately, the extreme moisture content profiles are stochastic. The purpose of this study is to characterize the wettest and driest moisture content profiles that have the desired probability of occurrence during the lifetime of the



pavement. The wettest and driest profiles are associated with the respective annual maximum and minimum depths of water stored in the soil profile. 31 Refs.

Picornell, M. (Univ of Texas at El Paso, El Paso, TX, USA); Lytton, R.L. *Transp Res Rec* n 1137 1987 p 42-51.

**Degradation** See Also ROADBUILDING MATERIALS—Aggregates.

**076993 BLACK-TOP MAINTENANCE: HORSES FOR COURSES.** Value for money in maintenance of bituminous surfaces and flexible foundations, no less than for any other engineering function requires strict observance of the much publicised 3-Es (Economy, Efficiency and Effectiveness). Cost effective maintenance is achievable in three distinct, but interrelated phases: (1) Identification and assessment of the early stages of deterioration and any apparent contributory factors. (2) Selection of a maintenance treatment appropriate to severity of defect and underlying causes. (3) Specification, execution and quality control of repair and/or maintenance treatment. 6 refs.

Olesen, R.W. *Highw Transp* v 34 n 7 Jul 1987 p 21-23, 26-27, 29-31.

**076994 FACTOR ANALYSIS OF PAVEMENT DISTRESSES FOR SURFACE CONDITION PREDICTIONS.** Pavement distress information is needed to assess maintenance requirements and to plan rehabilitation. For immediate maintenance requirements, it is necessary that the details of individual distress types, severity, and density be known. However, for pavement design and long-range rehabilitation planning, more approximate and aggregated data are sufficient. Furthermore, due to correlation between individual distresses, it is only practical to predict aggregated rather than individual detailed distresses. In this paper, the distress types are aggregated into five fundamental uncorrelated categories (factors) using factor analysis techniques. The five factors are thermal cracking, edge cracking, surface instability, fatigue cracking, and random cracking. (Edited author abstract) 14 refs.

Hajek, J.J. (Ontario Ministry of Transportation & Communications, Downsview, Ont, Can); Haas, R.C.G. *Transp Res Rec* 1117 1987 p 125-133.

**076995 DEVELOPMENT OF SPRING LOAD RESTRICTIONS FOR LOCAL ROADS.** Load restrictions to reduce or preclude pavement damage during spring thaw periods are widely used in the United States and Europe. Load restrictions are primarily applied to low-volume road networks. In recent years extensive examinations of load restriction-related issues have been conducted in states such as Alaska, Minnesota, and Washington. The development of guidelines for use in determining where to apply the load restrictions and their magnitude is reported in this paper. A survey of current practice in the United States and Canada revealed that load restrictions are applied mostly to pavements that have subgrades composed of moisture-susceptible silts and clays. It also revealed that the restrictions are mostly applied to aggregate and asphalt-surfaced pavements. The maximum legal loads are generally reduced about 40 to 50 percent for single axles and 30 to 50 percent for tandem axles during the spring thaw period. (Edited author abstract). 15 Refs.

Rwebangira, T. (Oregon State Univ, Corvallis, OR, USA); Rutherford, M.S.; Mahoney, J.P.; Hicks, R.G. *Transp Res Rec* n 1128 1987 p 42-52.

**076996 NONDESTRUCTIVELY DELINEATING CHANGES IN MODULUS PROFILES OF SECONDARY ROADS.** To load-zone roads properly, mechanisms involved in the deterioration of pavements must be understood and monitored. The state of practice in nondestructively evaluating pavement systems is limited to determining changes in modulus profiles. For secondary roads, deflection basin methods [such as falling-weight deflectometer (FWD) and Dynaflect] are most effective in determining moduli of subgrades and are not as sensitive

to moduli of the surface and base layers. On the other hand, the Spectral-Analysis-of-Surface Waves (SASW) method is quite sensitive to moduli in the upper layers. In addition, the SASW method has the advantage of allowing the pavement system to be divided into numerous layers, say 10 to 15 in the upper 3 ft, so that detailed profiles can be determined. With this resolution, it is possible to delineate changes in the modulus profile from one measurement to the next. (Edited author abstract). 10 Refs.

Nazarian, Soheil (Univ of Texas, Austin, TX, USA); Stokoe, Kenneth, H., II; Briggs, Robert, C. *Transp Res Rec* n 1136 1987 p 96-107.

**Design** See Also HIGHWAY SYSTEMS—Interchanges; HIGHWAY SYSTEMS—Performance; HIGHWAY SYSTEMS—Planning; ROADS AND STREETS—Foundations; ROADS AND STREETS—Skid Resistance; STREET TRAFFIC CONTROL—Parking.

**076997 MINIATURE SUBGRADE IMPACT TESTER: AN ALTERNATIVE TO CBR TEST.** The California Bearing Ratio (CBR) is a commonly used test to determine the load-penetration characteristics of the soil. The design of flexible pavements is mostly guided by the criterion of CBR tests conducted mostly in the laboratory on soil samples. The in-situ field CBR tests conducted on natural subgrade can provide a relatively more reliable picture of the load-penetration characteristics of soil. In this paper, a simple and an economical alternative, viz., the miniature sub-grade impact tester is discussed together with related correlations established for the purpose of flexible pavement design. 7 refs.

Tolia, D.S. (Cent Road Research Inst, New Delhi, India); Jain, R.K. *Indian Highw* v 15 n 8 Aug 1987 p 43-48.

**076998 ALTERNATIVE SOLUTION CHARTS FOR AASHTO PAVEMENT DESIGN GUIDE.** In July 1986 the American Association of State Highway and Transportation Officials (AASHTO) published a revision to its long-standing pavement design method under the title AASHTO Guide for the Design of Pavement Structures (AASHTO 1986). The revised guide retains the basic algorithms for flexible and rigid pavement design that were developed from the data of the AASHTO road test. The purpose of this note is to offer alternative design charts for the solution of the guide equations. It is recognized that with the use of the electronic calculator and the desk-top microcomputer not many engineers will ever use the solution nomographs presented in the guide. For those who must use the nomographs or would like quick graphical solutions for estimation purposes, the following design charts should be easier to use than the nomographs presented in the guide. 2 refs.

Guell, David L. (Univ of Missouri-Columbia, Columbia, MO, USA). *J Transp Eng* v 114 n 2 Mar 1988 p 239-244.

**076999 FLEXIBLE PAVEMENT DESIGN - THE FRENCH PRACTICE.** This paper is an attempt to summarise the flexible pavement design approach as practised in France, based on the material gathered and the discussions conducted by the author while he was on a study tour of France. In order to cater for a very heavy traffic, modern day conditions and redesigning for an axle load of 130 kN (instead of 80 kN according to British design), it became necessary to strengthen the roads in France. Techniques were therefore developed to be economical and yet practical. This is to a greater part achieved by using the industrial byproduct fly ash as a hydraulic binder to stabilise road courses. 13 refs.

Ramaswamy (Natl Univ of Singapore, Singapore). *Highw Transp* v 35 n 1 Jan 1988 p 26-29.

**077000 THICKNESS DESIGN OF ROLLER-COMPACTED CONCRETE PAVEMENTS.** Roller-compacted concrete (RCC) is a relatively stiff or zero-slump concrete mixture that is compacted by vibratory roller. RCC is capable of providing concrete with relatively high in-place strength, and its engineering behavior is similar to that of conventional concrete. RCC is being used as a paving material at off-highway facilities such as container ports, intermodal yards, log-sorting yards, truckparking

areas, and tank aprons (hardstands). A procedure for thickness design of RCC pavements is presented in this paper. The design approach used for RCC pavements is similar to the procedure used by the Portland Cement Association for design of concrete airfield and heavy industrial pavements. The proposed procedure requires computation of allowable pavement stress based on the number of total load applications and computation of expected pavement stress due to the design wheel loading. (Edited author abstract). 4 Refs.

Tayabji, Shiraz, D. (Construction Technology Lab, Skokie, IL, USA); Halpenny, David, J. *Transp Res Rec* n 1136 1987 p 23-32.

**077001 COMBINED EFFECT OF TRAFFIC LOADS AND THERMAL GRADIENTS ON CONCRETE PAVEMENT DESIGN.** The purpose of this work is to study the behavior of concrete pavements under the simultaneous action of traffic and thermal gradients in concrete slabs. A new procedure for the structural design of concrete pavements in Spain is presented. A fatigue equation, taken from an adjustment of Tepfer's fatigue law and based on data on the behavior of several concrete pavements in Spain, is proposed. Analyses of loading stresses, thermal warping stresses, and simultaneous action stresses in slabs resting on a stratified semi-infinite solid were performed using a finite-element computer program. Empirical and theoretical equations for predicting the different values of thermal gradients and the frequency of their occurrence were established; these equations are based on Fourier's law and data obtained from observations in Spain. A computer program was developed to obtain new equivalence factors based on the results of the calculations. (Edited author abstract). 6 Refs.

Faraggi, Victor (Univ of Chile, Santiago, Chile); Jofre, Carlos; Kraemer, Carlos. *Transp Res Rec* n 1136 1987 p 108-118.

**077002 TRENDS IN AXLE LOADING AND THEIR EFFECT ON DESIGN OF ROAD PAVEMENTS.** The results of the continuing program of monitoring using the TRRL weighscale, and the results of static axle weighing surveys, have been used to study trends in axle loading and their effect on the design of road pavements. The results have been analyzed to show how the effect of commercial vehicles has changed with time and how it is related to vehicle type. There is particular emphasis on recent changes in regulations that have allowed higher gross weight vehicles and led to the appearance of considerable numbers of five axle articulated vehicles of 38 ton gvw, and some six axle vehicles. The results of the analysis have been used to provide procedures for the estimation of the effect of commercial vehicles on the design and performance of road pavements for past, present and future years. (Author abstract). 13 Refs.

Robinson, R.G. *TRRL Lab Rep* n 138 1988 var paging.

## Drainage

**077003 ECONOMIC IMPACT OF PAVEMENT SUBSURFACE DRAINAGE.** The relatively recent movement toward subsurface pavement drainage is largely due to the development of improved and economical drainage materials along with greater awareness of the nature and extent of the problem resulting from the research of a number of individuals throughout the world. Among these developments are geotextiles, asphalt-treated permeable materials, concrete pavement edge drains, and others. The article discusses case histories for rigid and flexible pavements, and the economics involved.

Forsyth, Raymond A. (California DOT, Sacramento, CA, USA); Wells, Gordon K.; Woodstorm, James H. *Public Works* v 119 n 1 Jan 1988 p 61-64, 88-89.



**077004 WATER-INDUCED DISTRESS IN FLEXIBLE PAVEMENT IN A WET TROPICAL CLIMATE.** A wet tropical climate characterized by abundance of rainfall and cool nights followed by hot days offers a favorable environment for the development of water-associated distress in flexible pavement. Surface deteriorations such as stripping and raveling have been widely reported and studied in the literature. Other forms of water-induced distress, which are caused by water trapped within the structure system of a flexible pavement, are described in this paper. The occurrence of such distress is difficult to predict, and the subsequent repair is usually quite costly and elaborate. A number of cases of water-induced distress in flexible pavement in Singapore and Malaysia are presented and discussed. The need for drainage analysis in pavement design and the importance of drainage consideration in pavement construction and maintenance are highlighted. On the basis of relevant experience in the region, some preventive measures are recommended for guarding against water-induced problems in flexible pavement. (Author abstract) 5 refs.

Fwa, T.F. (Nat'l Univ of Singapore, Kentridge, Singapore). *Transp Res Rec* 1121 1987 p 57-65.

**077005 ECONOMIC IMPACT OF PAVEMENT SUBSURFACE DRAINAGE.** Much of the water that falls on pavements penetrates the structural section through cracks, joints, and porous surfaces. Conventional slow-draining pavements are deteriorating more rapidly than is necessary because of the impacts of heavy vehicles on flooded structural sections. The most positive pavement drainage systems use an open-graded drainage layer under the full width of a roadbed with adequate collector pipes and outlet pipes. However, the California Department of Transportation has found that retrofit edge drains are greatly reducing the rate of step faulting of existing portland cement concrete pavements. The impact of positive rapid drainage features on the performance of a number of pavements is reviewed, with particular emphasis on the establishment of a cost-benefit relationship. The results of this evaluation indicate that the increased cost of effective pavement drainage is almost incidental to the savings realized through improved performance. (Edited author abstract) 29 refs.

Forsyth, Raymond A. (California DOT, Sacramento, CA, USA); Wells, Gordon K.; Woodstrom, James H. *Transp Res Rec* 1121 1987 p 77-85.

**077006 USE OF OPEN-GRADED, FREE-DRAINING LAYERS IN PAVEMENT SYSTEMS: A NATIONAL SYNTHESIS REPORT.** The effects of excessive and uncontrolled water entrapped in the various components of a paving system are known or suspected to have been responsible for unsatisfactory performance and outright failures of both portland cement concrete and asphaltic concrete pavements. To eliminate or at least reduce the detriment, almost half of the highway and transportation agencies across the nation have been addressing the problem by designing and constructing free-draining pavement systems. In an effort to ascertain just how much and what kind of attention is being given free-draining pavements on a national scale and to gain some insight into the performance characteristics of such systems designed to date, the Transportation Research Board's Committee on Subsurface Drainage prepared a questionnaire for national distribution in the fall of 1985. This paper is an attempt to summarize the responses to that questionnaire. (Author abstract)

Baldwin, John S. (West Virginia Dep of Highways, Charleston, WV, USA). *Transp Res Rec* 1121 1987 p 86-89.

**Dust Abatement** See HIGHWAY SYSTEMS—Maintenance.

**Elasticity** See Also ROADS AND STREETS—Computer Aided Design.

**077007 ANALYSIS OF AXLE LOADS AND AXLE TYPES FOR THE EVALUATION OF LOAD LIMITS ON FLEXIBLE PAVEMENTS.** The Commonwealth of

Pennsylvania is responsible for 44,000 mi of roads, the majority of which have pavements with limited structural capacity. The state has the authority to restrict axle loads on its roads if it is believed that those axle loads would result in excessive damage to the pavement structure. Consequently, a procedure for establishing axle load restrictions is necessary. As part of the development of a framework for load limit analysis, an evaluation was made of the sensitivity of pavement response and predicted performance to variations in loads, layer moduli, and layer thicknesses. To evaluate the effect of axle loads under a variety of conditions, a theoretical elastic layer analysis was conducted that considered various load magnitudes and configurations for different pavement thicknesses and material properties. (Edited author abstract) 9 Refs.

Fernando, Emmanuel, G. (Pennsylvania State Univ, University Park, PA, USA); Luhr, David, R.; Saxena, Hari, N. *Transp Res Rec* 1136 1987 p 69-78.

**077008 RELIABILITY OF THE FLEXIBLE PAVEMENT DESIGN MODEL.** The design of flexible pavements by the U.S. Army Corps of Engineers is currently based on the California bearing ratio (CBR) curve. The CBR curve is empirical, and the current design approach is deterministic. A probabilistic approach, providing more reliable designs at potentially lower costs, can be developed from the current design procedure if the reliability of the CBR curve is known. This study was undertaken to establish the reliability of the current CBR-based flexible pavement design model using existing data from accelerated traffic tests. The reliability of the design model was found to be about 50 percent, excluding the effects of conservative estimates of the design parameters. (Author abstract) 16 Refs.

Potter, John, C. (US Army Engineer Waterways Experiment Station, Vicksburg, MS, USA). *Transp Res Rec* 1136 1987 p 79-85.

**Evaluation** See Also ROADS AND STREETS—Maintenance.

**077009 ERFASSEN UND BEWERTEN DES ZUSTANDES VON STRASSENBEFESTIGUNGEN.** [Recording and Evaluating the Condition of Pavements]. A method of systematic inspection of road pavement surfaces, recording in detail their condition and making evaluations of the general conditions of road stretches is presented. The use of computers and data processing offers possibilities for an advantageous utilization of the acquired information. The state of a road pavement is characterized by its safety value, substance value, and gripping factor. Various representations of the evaluation of pavement conditions are illustrated. This leads to a classification of conditions, degrees of urgency of repair, and priority planning. The effect of rehabilitation measures can be checked with the data available. The costs of maintaining these inspectional records amount to about 0.7 to 1.5% of the total pavement maintenance costs. (Edited author abstract) In German. 14 refs.

Schmuck, Alfred (Univ der Bundeswehr Muenchen, Neubiberg, West Ger). *Str Autobahn* v 38 n 5 May 1987 p 165-175.

**077010 DEVELOPMENT OF A DISTRESS INDEX AND REHABILITATION CRITERIA FOR CONTINUOUSLY REINFORCED CONCRETE PAVEMENTS USING DISCRIMINANT ANALYSIS.** Discriminant analysis is applied to developing the distress index and rehabilitation criteria of the network-level pavement management system for continuously reinforced concrete pavements in Texas. The results are intended to provide the Texas State Department of Highways and Public Transportation with guidelines for evaluating the present pavement conditions and for scheduling rehabilitation. For the discriminant analysis, historical condition survey data were evaluated and separated into two groups, overlaid and nonoverlaid pavements, for which detailed descriptions were given. Each set of data comprised several distress manifestations. (Edited author abstract) 10 refs.

Chou, Chia-Pei (Univ of Texas at Austin, Austin, TX, USA); McCullough, B. Frank. *Transp Res Rec* 1117 1987 p 76-82.

**077011 SUCCESSIVE FUZZIFICATION TECHNIQUE AND ITS APPLICATION TO PAVEMENT EVALUATION.** A successive fuzzification procedure has been developed by extending the 'fuzzifier' concept introduced by Zadeh. This technique provides an efficient fuzzification procedure for cases where an entity is influenced by human and system uncertainty originating from different sources. In such cases, each source of uncertainty is given an individual fuzzifier, and a composite fuzzifier is created for the entity from the individual ones. A specific application is cited in the area of transportation engineering where the technique has been used to improve pavement distress surveys. (Edited author abstract) 5 Refs.

Gunaratne, M. (Tennessee State Univ, Nashville, TN, USA); Chameau, J.L.; Altschaff, A.G. *Civ Eng Syst* v 5 n 2 Jun 1988 p 77-80.

## Failure

**077012 AUTOMATED ACQUISITION OF TRUCK TIRE PRESSURE DATA.** The results of a study into the feasibility of automatically monitoring the contact tire pressures produced by trucks while they are in motion by monitoring tire footprint dimensions and weight are presented. The work undertaken includes a review of principles of tire contact pressure measurement and available sensor technology; an assessment of the feasibility for using each principle/technology for truck contact pressure measurement; and development of the concept for an independent tire contact pressure measurement system. The results of work performed by the Texas Transportation Institute are presented. (Edited author abstract) 1 ref.

Cunagin, Wiley D. (Texas A&M Univ, College Station, TX, USA); Grubbs, Albert B. *Transp Res Rec* 1123 1987 p 112-121.

## Fatigue

**077013 DEVELOPMENT OF DYNAMIC FATIGUE FAILURE CRITERION.** When a truck wheel moves on the road, stress pulses develop within the pavement layers. These pulses are primarily functions of load magnitude, tire pressure, and vehicle speed. In this study, dynamic analysis is used to predict stresses and deflections that develop when a moving wheel load is applied. The method considers the inertial forces and assumes pulsating loads that accurately simulate actual wheel loading. The method is applied on AASHTO road test sections to predict their theoretical response. The change of stresses and deflections at various loading times at different speeds is computed and verified versus actual field data. The evaluated pavement response is used to develop a fatigue failure criterion for a speed of 30 mph, which is the mean speed at the AASHTO road test. (Edited author abstract) 19 refs.

Sebaaly, Peter E. (Pennsylvania State Univ, University Park, PA, USA); Mamlouk, Michael S. *J Transp Eng* v 114 n 4 Jul 1988 p 450-464.

## Foundations

**077014 KENT DESIGNS SLAG-BOUND ROAD-BASE INTO BYPASS SCHEME.** From a technical point of view phosphoric slag cannot be far short of being the ideal roadbase material. Heading the list of merits is an impressive £4/m<sup>2</sup> saving over conventional bituminous roadbase construction. The material is a blend of 85% phosphorous slag and 15% granulated blast furnace slag. The hydraulic or cementitious nature of granulated blast furnace slag slowly imparts a stiffness, strength and, therefore, performance, to the material that is akin to lean concrete roadbase.

Kennedy, John (Econopave Ltd). *Highways (Croydon Engl)* v 55 n 1927 Jul 1987 p 17.



**Inspection** See AIRPORTS; HIGHWAY SYSTEMS—Maintenance.

**Maintenance** See Also ASPHALT—Thermal Effects; HIGHWAY SYSTEMS—Cold Weather Problems; HIGHWAY SYSTEMS—Estimation; HIGHWAY SYSTEMS—Maintenance.

**077015 FACILITE ET QUALITE DE L'ENTRETIEN LOCALISE DES CHAUSSEES - BETON BITUMINEUX COULE AU SOUFRE.** [Facility and Quality of Local Maintenance of Pavements; Sulfur-Extended Bituminous Concrete]. Originally, sulfur-extended bituminous concrete was intended for thin surfacing but was found to be suited to the treatment of potholes. The addition of sulfur makes it possible to lower from 250 to 150°C the manufacturing temperature of the product. Studies conducted by the Laboratoire central des Ponts et Chaussées have led to the use of 5.4% (in weight) of sulfur in the material, achieving good indentation strength, good creep resistance and good skid resistance on all subgrades. After having described the composition of the material, the author looks into the different placement phases. Sulfur-extended bituminous concrete has many applications: potholes, pavement joints, crazing, preparation of bases before surface dressings. The article also discusses the economic aspects of the material. (Edited author abstract) In French.

Lartaut, M. (Lab Central des Ponts et Chaussées, Fr). *Travaux* n 623 Jul-Aug 1987 p 22-24.

**077016 DEVELOPMENT OF MATHEMATICAL MODELS TO ASSESS HIGHWAY MAINTENANCE NEEDS AND ESTABLISH REHABILITATION THRESHOLD LEVELS.** This study examines the mathematical relationship between a variety of pavement attributes, and other quantifiable variables, on the one hand, and maintenance needs and priority evaluations made by district area supervisors on the other. A secondary objective was to establish threshold levels for preventive maintenance, capital maintenance, and rehabilitation. Descriptions, which conform to the Maine Department of Transportation's operations, were included in order to categorize various rehabilitation and maintenance strategies as well as to define various types of maintenance. Measures of pavement distress routinely collected by trained observers and appropriately weighted, using a Delphi technique, proved to correlate the best. (Edited author abstract) 21 refs.

Theberge, Paul E. (Maine DOT, Augusta, ME, USA). *Transp Res Rec* 1109 1987 p 27-35.

**077017 DEVELOPMENT OF A ROUTINE PAVEMENT MAINTENANCE DATA BASE SYSTEM.** To determine what type of data to include in the data base, the relationship between roughness and level of routine maintenance expenditure was analyzed. Condition survey information, based on unit foremen's evaluation of highway deficiencies, may be included in the proposed data base. The condition survey information along with roughness measurements can be used in two ways. Information on rehabilitation activities, such as resurfacing, was included in the data base to increase the level of coordination between the programming of major maintenance and routine maintenance activities. Some other supplementary information, such as average daily traffic, contract number, county, subdistricts, and pavement type, was included in the data base. (Edited author abstract) 8 refs.

Ksaibati, Khaled (Purdue Univ, West Lafayette, IN, USA); Sinha, Kumares C. *Transp Res Rec* 1109 1987 p 36-42.

**077018 PERFORMANCE EVALUATION OF JOINTED CONCRETE PAVEMENT REHABILITATION WITHOUT RESURFACING.** The methods evaluated were pavement grinding, grout undersealing, installing underdrains, retrofitting double-vee load transfer devices, and pavement patching. Five construction sections, located on Interstates in Illinois, were selected for evaluation. Evaluation was done using crack surveys, destructive testing, and nondestructive testing. The performance factors monitored were faulting, pavement

cracking, pavement roughness, skid resistance, deflection, load transfer, void development, and drainage. A great deal of emphasis was placed on grout undersealing and doweled patching in laboratory and field experiments. The findings of this research resulted in improvements in full-depth patch design, improved construction procedures, and proper use of undersealing. (Edited author abstract) 3 refs.

Lippert, David L. (Illinois DOT, Springfield, IL, USA). *Transp Res Rec* 1109 1987 p 42-55.

**077019 MICROCOMPUTER PROGRAM TO EVALUATE COST-EFFECTIVE ALTERNATIVES FOR CONCRETE PAVEMENT RESTORATION.** The life-cycle cost-1 (LCCI) microcomputer program is designed for comprehensive economic evaluation of competing alternatives provided by users. The LCCI program is unique for life-cycle cost analyses because of its flexibility and the options it offers users: it creates and saves multiple input files and provides default data, manipulates input data without going through an entire session, offers seven available optimization options for rank ordering the strategies, and considers multiple maintenance and rehabilitation treatments. The LCCI methodology is capable of computing user operating costs and added user costs due to traffic delays during rehabilitation and reconstruction. (Edited author abstract) 18 refs.

Uddin, Waheed (Univ of Texas at Austin, Austin, TX, USA); Carmichael, R. Frank III; Hudson, W. Ronald. *Transp Res Rec* 1109 1987 p 60-68.

**077020 SYSTEMS APPROACH FOR DESIGN AND EVALUATION OF ALTERNATIVES FOR CONCRETE PAVEMENT REHABILITATION.** The Pavement Rehabilitation Design System (PRDS-1) computer program uses mechanistic analysis to generate numerous rehabilitation design alternatives and perform economic evaluation. The evaluation technique is sensitive to both the performance and the cost of the competing alternatives. Resurfacing alternatives include bituminous concrete, jointed portland cement concrete, and continuously reinforced concrete. The PRDS-1 program was used to evaluate typical concrete pavements for overlay thicknesses and associated life-cycle costs. A comparison of resurfacing alternatives with several restoration alternatives indicates that in certain cases restoration alternatives are more economical. (Edited author abstract) 17 refs.

McCullough, B. Frank (Univ of Texas at Austin, Austin, TX, USA); Uddin, Waheed. *Transp Res Rec* 1109 1987 p 69-78.

**077021 MICRO PMS CUT COMPLAINTS BY 75%.** The City of Lansing, Michigan, is maximizing its investment of road funds by acquiring a micro-computer-based pavement management system from Pavement Management Systems, Inc. (PMS). Implementation was completed in 1986, and it has been used for more than one and one-half years by city staff. Prior to that time, the system ran on PMS's home system and analysis results were provided to the city. The system resides in the city's IBM PC/AT. The pavement management system uses FORTRAN77 programs to analyze and manipulate data, and dBASE III to display results and access and update files. Access to the entire system is via a series of screen display menus.

Anon. *Better Roads* v 58 n 3 Mar 1988 p 46, 49.

**077022 DEVELOPMENT OF A PREVENTIVE MAINTENANCE ALGORITHM FOR USE IN PAVEMENT MANAGEMENT SYSTEMS.** This paper introduces a new concept in determining distress density limits for the recommendation of preventive maintenance treatments. The procedure described relates distress density directly to the Pavement Condition Index used in the PAVER Pavement Management System. It can be applied to both asphalt concrete and portland cement concrete pavements, and is flexible enough to allow for local policies and economic factors. The initial algorithm may be expanded to include environmental or geographic factors and additional preventive maintenance treatments

at a later date. (Edited author abstract) 10 refs.

Cation, Kathryn A. (US Army Construction Engineering Research Lab, Champaign, IL, USA); Shahin, Mohamed Y.; Scullion, Thomas; Lytton, Robert L. *Transp Res Rec* 1123 1987 p 1-11.

**077023 PAVEMENT PERFORMANCE PREDICTION MODEL USING THE MARKOV PROCESS.** A combination of homogeneous and nonhomogeneous Markov chains has been used in the development of the model. The life span of the pavement is divided into zones, with each zone representing a period of 6 years. The transition matrix of each zone is determined using nonlinear programming. If the state of any given pavement section is known, its future condition can be predicted efficiently from the corresponding transition matrices. The model presented will play an integral part in the decision-making procedure for determining optimal maintenance and repair strategies. A comparison between the Markov model and the constrained least-squares model is presented. (Edited author abstract) 10 refs.

Butt, Abbas A. (US Army Construction Engineering Research Lab, Champaign, IL, USA); Shahin, Mohamed Y.; Feighan, Kieran J.; Carpenter, Samuel H. *Transp Res Rec* 1123 1987 p 12-19.

**077024 DEVELOPMENT OF A METHODOLOGY TO ESTIMATE PAVEMENT MAINTENANCE AND REPAIR COSTS FOR DIFFERENT RANGES OF PAVEMENT CONDITION INDEX.** Data from a number of military installations in the United States were used. The analysis was performed separately for each installation. The methodology developed included techniques for determining the fixed initial construction cost of each alternative based on local prices; the cost of pavement preparation before repair as a function of pavement type, condition, local prices, and installation policy for pavement preparation; the annual cost of routine maintenance of each maintenance and repair alternative as a function of pavement condition, local prices, and installation maintenance policy; pavement performance characteristics for various pavement categories; and conducting a life-cycle cost analysis of each alternative for all pavement categories. (Edited author abstract) 4 refs.

Sharaf, Essam A. (Cairo Univ, Giza, Egypt); Reichelt, Eric; Shahin, Mohamed Y.; Sinha, Kumares C. *Transp Res Rec* 1123 1987 p 30-39.

**077025 PAVEMENT MANAGEMENT AT THE LOCAL GOVERNMENT LEVEL.** A discussion is presented of factors to be considered in planning and developing a pavement management system based on the experiences of these organizations. In the planning phase consideration is given to resource requirements (personnel, equipment, and funds) and to information requirements (primarily the type of data to be collected). Specific considerations associated with actual development include: section identification, condition surveys, maintenance and rehabilitation alternatives, data utilization, and report preparation. Practices of the 13 agencies relative to these considerations are summarized in a series of tables for ready reference. (Edited author abstract) 9 refs.

Monismith, C.L. (Univ of California, Berkeley, CA, USA); Finn, F.N.; Epps, J.A.; Kermit, M. *Transp Res Rec* 1123 1987 p 47-66.

**077026 COMPREHENSIVE RANKING SYSTEM FOR LOCAL AGENCY PAVEMENT MANAGEMENT.** An approach has been developed that uses a minimum of information to make reasonable budget analysis concerning maintenance and rehabilitation needs with unconstrained funding. The way in which funding needs are allocated when funding is less than needs is described. It includes consideration of the condition of the pavement, change of condition over time, cost of the maintenance or rehabilitation over time, and stopgap maintenance generated by deferring maintenance. This was accomplished by making it simple for the public



works personnel to visualize and use. It is part of a network-level microcomputer-based pavement management system developed for San Francisco Bay Area agencies. (Edited author abstract) 24 refs.

Smith, Roger E. (Texas A&M Univ, College Station, TX, USA); Shahin, Mohamed Y.; Darter, Michael I.; Carpenter, Samuel H. *Transp Res Rec* 1123 1987 p 67-76.

**077027 NEW ROADS FOR THE MICRO.** This paper analyzes various levels of roadway maintenance and treatment cost miniaturization. Using microcomputers loaded with database software and Fortran programming, engineers are gaining control of pavement maintenance. The computer-based pavement management starts with "condition surveys," rating existing pavement against a predetermined rating scale. The user also establishes a decay curve; the computer then extrapolates the one-time surveys. The product, which is printed in report format, shows which road should be repaired, when they should be repaired and how much it will cost. 3 refs.

Morse, Dan. *Civ Eng (New York)* v 58 n 6 Jun 1988 p 45-47.

**Management** See Also ROADS AND STREETS—Maintenance.

**077028 PHARR DISTRICT USES THE REHABILITATION AND MAINTENANCE SYSTEM OPTIMIZATION MODEL.** Pharr Highway District 21 is serving as a pilot test site in Texas for a pavement management optimization program developed at the Texas Transportation Institute. The Rehabilitation and Maintenance System District Optimization model one, RAMS-DO-1, is one of seven programs that make up the Rehabilitation and Maintenance System (RAMS). Developed by TTI research engineer Robert L. Lytton, this set of programs is a consecutive and interrelated system designed to identify and schedule cost-effective and optimal rehabilitation and maintenance strategies for an entire highway network. By selecting the optimal combination and timing of maintenance and rehabilitation treatments, the lives of highway sections of a network can be extended, thus maximizing the effectiveness of highway maintenance expenditures.

Anon. *Tex Transp Res* v 23 n 1 Mar 1987 p 3-4.

**077029 ANALYTICAL FRAMEWORK FOR OPTIMIZING PAVEMENT MAINTENANCE.** The problem of scheduling maintenance for pavements in an optimum fashion has been approached in a variety of ways by researchers and practitioners. However, the Markov decision process has found very limited use despite the fact that cumulative damage is readily modeled by a Markov chain and that a wealth of immediately applicable theoretical results exist in the literature. The solutions are known for a variety of problems involving inspection, repair, and replacement, making it possible to solve directly for an optimal policy in the form of a control law. This paper reviews some of the relevant theoretical results in order to call them to the attention of civil engineers involved with pavement management systems. (Author abstract) 23 refs.

Carnahan, James V. (Univ of Illinois, Urbana, IL, USA). *J Transp Eng* v 114 n 3 May 1988 p 307-322.

**077030 STATUS OF THE SOUTH DAKOTA PROFILOMETER.** During 1981-1982, the South Dakota Department of Transportation (SDDOT) developed a low-cost profilometer system. The unit has been used to conduct annual statewide profile surveys primarily for pavement management purposes. The University of Michigan Transportation Research Institute (UMTRI) draft report of October 1985 showed that the performance of the SDDOT profilometer was deficient in two respects. First, the beginnings of measured profiles showed extraneous long-wavelength content. Second, the system underestimated the profile magnitudes generally, but most severely on smooth highway sections, at lower test speeds, and at longer wavelengths. Changes have been made to allow rut depth measurement and visual rating of highway condition parameters to occur simultaneously with profile

measurement. (Edited author abstract) 2 refs.

Huft, David L. (South Dakota DOT, Pierre, SD, USA); Corcoran, Debra C.; Lunde, Blair A.; Orth, Paul A. *Transp Res Rec* 1117 1987 p 104-113.

**077031 NEW TECHNIQUES FOR MODELING PAVEMENT DETERIORATION.** The mathematical models investigated are: stepwise regression, B-spline approximation, and constrained least-squares estimation. The best features of each are integrated into an interactive format capable of operating within the PAVER pavement management system. Pavement sections from a given location consisting of the same pavement type, use, and rank are grouped into families. Models that filter obvious errors and statistical outliers from the data are applied to the family data. These procedures constitute a complete method to model and predict pavement family behavior and pavement section behavior accurately. (Edited author abstract) 6 refs.

Shahin, Mohamed Y. (US Army Construction Engineering Research Lab, Champaign, IL, USA); Nunez, Margarita M.; Broten, Margaret R.; Carpenter, Samuel H.; Sameh, Ahmed. *Transp Res Rec* 1123 1987 p 40-46.

**077032 EXPERT SYSTEMS AS A PART OF PAVEMENT MANAGEMENT.** The structures of these systems are defined and compared with current pavement management systems. The present state of expert systems is reviewed. Areas in which pavement management systems can be enhanced are examined, as are the current limitations of these systems. (Edited author abstract) 8 refs.

Flanagan, Patrick R. (Austin Research Engineers Inc, Austin, TX, USA); Halbach, Daniel S. *Transp Res Rec* 1123 1987 p 77-80.

**077033 MAPCON: A PAVEMENT EVALUATION DATA ANALYSIS COMPUTER SYSTEM.** MAPCON guides the user through selection of analysis method, data entry, and analysis. The path taken by MAPCON is determined by the user's answers to questions presented on the screen. The type of data analyzed by MAPCON includes friction and skid, roughness, structural capacity, surface condition, or a combination of the last three. MAPCON is a set of tool useful to pavement management and design engineers. It is available for implementation and use by highway agencies. (Edited author abstract) 15 refs.

Hudson, Stuart W. (ARE Inc, Austin, TX, USA); Hudson, W. Ronald; Zaniewski, John P. *Transp Res Rec* 1123 1987 p 81-87.

**077034 PRIORITY-SETTING PROCEDURES AND SCARCITY DATA: THE SYNTHETIC.** This paper presents a way to synthesize the missing data to permit implementation of priority setting or a pavement management system (PMS), in turn providing valuable guidance to the data collection effort. The magnitude of this effort can be minimized if the agency knows which data are of immediate importance. The use of synthetic data makes that knowledge available. A case study is presented to illustrate actual implementation of the synthetic method and to analyze the results. This method is applicable to road and bridge projects, or any ranking procedure that involves multiple criteria and incomplete data. (Edited author abstract) 3 refs.

Fricker, Jon D. (Purdue Univ, Lafayette, IN, USA). *Transp Res Rec* n 1134 1987 p 10-17.

## Mechanical Properties

**077035 RECYCLED ASPHALT MAKES A BETTER PAVEMENT IN JAPAN.** The recycled asphalt mixtures are made by two methods. One is by the addition of old mixture into the new. It is referred to as the Blending Method. Another is by use of recycling agents referred to as the Rejuvenating Method. In the Blending Method, old asphalt mixture is re-used together with new asphalt mixture. The old mixtures is not heated directly, but by radiation of hot new material. In the Rejuvenating

Method, old asphalt mixture is heated and mixed in a special plant for re-use. Consistency of asphalt is controlled by addition of recycling agents. This paper presents findings of research on mechanical characterization of recycled asphalt mixtures made by the two methods. 4 refs.

Yamada, Masaru (Osaka City Univ, Jpn); Ninomiya, Toshiaki; Mise, Tadashi. *Highways (Croydon Engl)* v 55 n 1932 Dec 1987 p 12, 21, 23.

**077036 ENGINEERING PROPERTIES OF ROLLER-COMPACTED CONCRETE.** An investigation was conducted to develop a procedure for the design of roller-compacted concrete (RCC) pavements. This paper is a report on the laboratory portion of the investigation that was conducted to determine the engineering properties of RCC. Specimens for the laboratory tests were obtained from a full-scale test section constructed using a 10-ton vibratory roller. Specimens were tested for flexural, split-tensile, and compressive strength; modulus of elasticity; and fatigue properties. The engineering behavior of RCC was determined to be similar to that of conventional concrete. Test results for RCC made using 243 to 285 lb/yd<sup>3</sup> of cement show that RCC is capable of providing relatively high in-place strength. As with conventional concrete, RCC strengths produced are even higher when higher cement contents are used. Specimens prepared by using the vibrating table produced significantly lower densities and strengths because the moisture content was lowered. (Edited author abstract). 7 refs.

Tayabji, Shiraz, D. (Construction Technology Lab, Skokie, IL, USA); Okamoto, Paul, A. *Transp Res Rec* n 1136 1987 p 33-45.

**077037 DYNAMIC RESPONSE OF PAVING MATERIALS.** Equipment developed to determine the dynamic properties of paving materials in axial and torsional loading is described. Dynamic properties were determined by the excitation of hollow cylindrical specimens using two independent sinusoidal loads with frequencies up to 30 Hz. An IBM PC/AT equipped with a Metrabyte DASH 16 data acquisition board was used to directly control two MTS hydraulic servos. Menu-driven software was developed, taking advantage of direct memory access channels, so that data acquisition, wave form generation, and closed-loop control could take place simultaneously at rates above 5000 samples/sec/channel. To convert raw data into graphs and parameters representative of dynamic material properties, a postprocessing menu-driven program was also developed. Dynamic properties of an asphalt concrete, a uniform sand, and a silty clay are presented. (Edited author abstract). 6 refs.

Sousa, Jorge, B. (Univ of California, Berkeley, CA, USA); Monismith, Carl, L. *Transp Res Rec* n 1136 1987 p 57-68.

## Moisture

**077038 ANTISTRIPE ADDITIVES: BACKGROUND FOR A FIELD PERFORMANCE STUDY.** This paper presents the results of a study on the effectiveness of antistripe additives for materials used in the reconstruction of Nevada State Highway 207. Preconstruction mixtures containing various antistripping additives (liquids and solids), construction mixtures mixed in the field and compacted in the laboratory, and cores taken after construction were subjected to laboratory conditioning using vacuum saturation plus one cycle of freeze-thaw. Test results show that a slight reduction in water sensitivity was obtained in mixtures that contained the liquid antistripe additives in comparison with control mixtures without additives or mixtures containing portland cement as an antistripping material. Results of evaluation of mixtures during the preconstruction phase of the project indicate that mixtures that contain lime slurry exhibited significant reductions in water sensitivity. Test results of field cores show agreement with preconstruction mixtures in the prediction of water sensitivity. (Edited author abstract) 11 refs.

Copland, John S. (Univ of Nevada, Reno, NV, USA); Epps, Jon A.; Quilici, Ledo. *Transp Res Rec* 1115,



Asphalt Mater and Mixtures. Publ by Transportation Research Board, Washington, DC, USA, 1987 p 1-11.

**077039 EVALUATION OF DESIGN HIGH-WATER CLEARANCES FOR PAVEMENTS.** In this paper is described a study to investigate the effect of capillary water presence on permanent deformation of four common Florida subgrade soils. Physical and engineering properties were first determined, with emphasis on developing soil-water retention characteristics. Repetitive triaxial load tests were then performed on the soils, under several different water conditions. These included at optimum, to represent the as-built condition, and at varied water retention conditions, to represent subgrade conditions in service (i.e., in equilibrium with the designated water table). Deformation characteristics of a subgrade fill, at different water condition, were related to pavement rutting in accordance with the Shell Oil criteria. When a tolerable permanent deformation was obtained at a specified water condition, the specimen's location on the soil-water retention curve was determined. The height of the most economical subgrade fill could then be fixed. (Author abstract) 10 refs.

Elfino, M.K. (Virginia Dep of Highways & Transportation, Richmond, VA, USA); Davidson, J.L. *Transp Res Rec* 1121 1987 p 66-76.

## Moisture Control

**077040 EFFECT OF MOISTURE ON THE STRUCTURAL PERFORMANCE OF A CRUSHED-LIME-STONE ROAD BASE.** A series of repeated load triaxial tests on a crushed-rock aggregate is described, including variations in grading and degree of compaction as well as moisture content. The effects of these variables are discussed and it is found that elastic stiffness tends to decrease slightly with increased moisture content for broadly graded materials. The influence of density is negligible, and that of grading minor, which results in some stiffness reduction as the fines content increases. The accumulation of permanent strain under multicyclic loading is found to be strongly dependent on density; denser material performs better. Grading has a minor effect. Increased moisture content results in substantially increased straining. The value of suction, which could exist in a granular material, is then explored indirectly by means of unconfined compression tests, and its effect on drainage is noted. Permeability measurements are given and their possible effect on drainage considered. (Edited author abstract) 9 refs.

Thom, N.H. (Univ of Nottingham, Nottingham, Engl); Brown, S.F. *Transp Res Rec* 1121 1987 p 50-56.

## Nondestructive Examination

**077041 RECENT IMPROVEMENTS IN HIGH RESOLUTION GROUND-PENETRATING RADAR FOR SUBSURFACE PAVEMENT ASSESSMENT.** The ability of short pulse radar (SPR) to detect, locate and characterize surface and airborne targets is well-established and well-documented. This paper presents a description of SPR technology and discusses its usefulness as a nondestructive pavement assessment tool to detect subsurface pavement anomalies. The major components and the functional operation of an SPR system are summarized first. Next, a brief outline of the theoretical background of SPR is provided. The operation of this device from a phenomenological viewpoint is also described. Finally, a commercially available SPR system designed for pavement is described and the results of recent projects are discussed. 15 refs.

Vogt, Woodward L. (MRA/Materials Engineers, Houston, TX, USA); Brown, Danny R. *Tex Civ Eng* v 57 n 9 Nov 1987 p 14-20.

**077042 USE OF GROUND-PENETRATING RADAR FOR DETECTING VOIDS UNDER A JOINTED CONCRETE PAVEMENT.** A survey of a jointed, reinforced concrete pavement with ground-penetrating radar indicated that radar provides a non-destructive inspection technique that can be used at a minimum

rate of 5 lane-miles of pavement per hour with only minimal interference with traffic. The coring of some slabs and subsequent use of a devised water test revealed that the radar was effective in detecting voids deeper than 1/8 in. but considerably less effective in spotting shallow voids. The overall accuracy was approximately 68 percent, which indicates that the sensitivity of the equipment needs to be improved. The location component used with the radar unit showed insufficient accuracy. (Edited author abstract) 6 refs.

Clemena, Gerardo G. (Virginia Transportation Research Council, Charlottesville, VA, USA); Sprinkel, Michael M.; Long, Robert R. Jr. *Transp Res Rec* 1109 1987 p 1-10.

**077043 VOID DETECTION AND RIGID PAVEMENT UNDERSEALING IN INDIANA: A COMPREHENSIVE APPROACH.** The method uses Dynaflect deflections measured at regular (100-ft) intervals within each contract section. Decision criteria based on midslab deflections are established for each contract; Sensor 5 is the primary indicator variable. Because decision criteria are obtained independently for each contract section, the method is applicable to both jointed and continuously reinforced concrete sections and to previously overlaid sections. When the areas that require undersealing have been identified, all cracks and joints within each area are treated. The procedure involves carefully monitoring slab motion during material injection with a sensitive deflection gauge developed specifically for that purpose. (Edited author abstract) 5 refs.

Mutti, Roger A. (Oregon State Univ, Corvallis, OR, USA); Sudol, Joseph J.; Love, Bradley W. *Transp Res Rec* 1109 1987 p 11-17.

**077044 NEW NONDESTRUCTIVE PAVEMENT EVALUATION METHOD.** Rapid nondestructive evaluation of pavements is needed to help maintain highways and airport runways. A review of current techniques for measuring pavement profile, texture, and deflection under load is conducted. Rapid evaluation of these parameters is needed, due to the high cost of closing highways and runways. The problem of improving the ability of pavement engineers to make these measurements is addressed first by reviewing existing procedures for obtaining these measurements, and then by presenting a new procedure to allow the pavement engineer to measure these three criteria. The proposed procedure allows this absolute measurement to be made. (Edited author abstract) 31 refs.

Elton, David J. (Auburn Univ, Auburn, AL, USA); Harr, Milton E. *J Transp Eng* v 114 n 1 Jan 1988 p 76-92.

**077045 DETERMINATION OF LAYER MODULI USING A FALLING WEIGHT DEFLECTOMETER.** The increasing popularity of nondestructive pavement evaluation methods, based on interpretation of surface deflections, has prompted the development of several different types of nondestructive testing (NDT) devices. One such device is the falling weight deflectometer (FWD), which was used in the evaluation of layer moduli of three pavement sections. Several methods are currently available to interpret the FWD deflection data and backcalculate the layer moduli. Four methods selected for analysis of the deflection data included VESYS, ELMOD, OAF, and MODCOMP2. A comparison of the material properties determined in the laboratory and the backcalculated values indicated that two of the four methods, namely, VESYS and ELMOD, had great potential for pavement evaluation. (Author abstract) 8 refs.

Ali, N.A. (North Carolina State Univ, Raleigh, NC, USA); Khosla, N. Paul. *Transp Res Rec* 1117 1987 p 1-10.

**077046 ANALYTICAL EVALUATION OF VARIABLES AFFECTING SURFACE WAVE TESTING OF PAVEMENTS.** Spectral-Analysis-of-Surface Waves (SASW) is a promising nondestructive technique for evaluating the mechanical properties of pavement systems and soil deposits. In applying the technique, it is assumed that only plane Rayleigh waves are generated by the

source. In reality, when an impulse is applied at the top of a layered system, body waves (shear and compression waves) and other types of surface waves are produced along with Rayleigh waves. In this paper, the dispersion curves (frequency or wavelength versus phase velocity) obtained by assuming only plane Rayleigh waves are compared with dispersion curves obtained when all types of waves are considered. Several cases with different types of layering are studied, and emphasis is placed on typical pavement systems. It is found that the receiver arrangement can significantly influence the dispersion curve and, hence, the resulting modulus profile. (Edited author abstract) 20 Refs.

Sanchez-Salinerio, Ignacio (Univ of Texas, Austin, TX, USA); Roesset, Jose, M.; Shao, Ko-Young; Stokoe, Kenneth, H., II; Rix, Glenn, J. *Transp Res Rec* n 1136 1987 p 86-95.

**Overlays** See Also AIRPORTS—Vehicular Traffic; ASPHALT—Plastics Applications; BRIDGES—Decks; BRIDGES, HIGHWAY—Decks; BRIDGES, SUSPENSION—Decks.

**077047 RUTTING OF ASPHALT CONCRETE OVERLAYS ON CONTINUOUSLY REINFORCED CONCRETE PAVEMENTS IN TEXAS.** Using the limited data available at the present time, it was observed that the rate of rutting was maximum in the first year because of the initial compaction of material in the wheelpath. In the second year, the material between the wheelpaths experienced more compaction than that in the wheelpaths themselves, and therefore rutting was observed to decrease in the second year. However, rutting increased in the years following full compaction of the lanes. A regression equation was developed to characterize the rutting behavior. The analysis of available data indicated that overlay thickness was an important predictor of rutting in overlays. The age of the overlay was not very significant in the regression equation. (Edited author abstract) 1 ref.

Saraf, C.L. (Univ of Texas at Austin, Austin, TX, USA); McCullough, B.F.; Aslam, M.F. *Transp Res Rec* 1109 1987 p 56-59.

**077048 OVERLAYING THE M.18 WITH CONCRETE.** Continuously reinforced concrete pavements (CRCP) have been used extensively for the construction of major roads in the United States of America and Belgium over the past twenty-five years. While other European countries have now started to follow suit, their use in Great Britain has been very limited. In 1985, the Department of Transport selected the northbound carriageway of the M.18 between Junction 6 near Thorne and Junction 35 of the M62 for an important trial in the use of continuously reinforced concrete as an overlay. This was the first time it had been used to overlay a motorway in Great Britain.

Blanshard, S. *Highw Transp* v 35 n 2 Feb 1988 p 29, 31, 33-35.

**077049 MECHANISTIC MODEL FOR THERMALLY INDUCED REFLECTION CRACKING OF PORTLAND CEMENT CONCRETE PAVEMENT WITH REINFORCED ASPHALT CONCRETE OVERLAY.** A new model is presented to analyze the phenomenon of thermally induced reflection cracking of asphalt concrete overlays over portland cement concrete pavements. The model is based on fundamental material properties of creep compliance, fracture toughness, and indirect tensile strength and does not depend on any empirical distress functions. When applied to fabric-reinforced overlays, however, a fabric effectiveness factor is required. This factor is obtained from single laboratory thermal simulation tests on beams and is defined as the ratio of failure times of reinforced and unreinforced



(control) beams. The reflection cracking analysis model has been computer coded as RECK. (Edited author abstract) 11 refs.

Majidzadeh, K. (Resource Int Inc, Westerville, OH, USA); Abdulshafi, A.; Ilves, G.J.; McLaughlin, Aston. *Transp Res Rec* 1117 1987 p 83-93.

**077050 NEW MEXICO STUDY OF INTERLAYERS USED IN REFLECTIVE CRACK CONTROL.** The application of an overlay restores the riding quality and skid properties and prolongs the service life of a roadway that has deteriorated. This type of rehabilitation may result in a new problem, reflective cracking, where subsurface cracks propagate into and through the protective overlay. By placing some form of interlayer between the old deteriorated pavement and the new overlay, reflective cracking may be reduced or even prevented. Thus, the useful life of the overlay is increased, resulting in a savings in maintenance costs. New Mexico established several experimental projects under Category 2 experimental construction in which different forms of interlayers were used. (Edited author abstract) 2 refs.

Lorenz, Virginia M. (New Mexico Highway Dep, Santa Fe, NM, USA). *Transp Res Rec* 1117 1987 p 94-103.

**077051 ESTIMATING THE LIFE OF ASPHALT OVERLAYS USING LONG-TERM PAVEMENT PERFORMANCE DATA.** Asphalt concrete overlays of flexible pavements are the most common pavement rehabilitation treatment in Ontario. In this paper the development of mathematical models for the performance prediction of these overlays is described. The modeling approach was based on a statistical evaluation of observed overlay performance and used readily available data. Its objective was to develop performance prediction models that would fit the existing pavement management system and could be used for life cycle economic analyses. The duration of overlay life cycle, for a predetermined terminal serviceability, was estimated as a function of overlay thickness, traffic (in number of equivalent single axles), maintenance patching, and life cycle duration of the initial pavement. (Edited author abstract) 13 refs.

Hajek, J.J. (Ontario Ministry of Transportation & Communications, Downsview, Ont, Can); Phang, W.A.; Prakash, A. *Transp Res Rec* 1117 1987 p 143-151.

**077052 CONCRETE OVERLAYS POSE CHALLENGE TO ASPHALT.** The trend to concrete overlays lies in their better performance, minimal maintenance and competitive costs. Compared to asphaltic overlays, not only are concrete overlays expected to last long, but their cost, which is now in close vicinity of asphaltic overlays, is also expected to drop, once the technology of concrete overlays is perfected. The concrete industry in the U.S.A. believes that concrete overlays will soon be a viable competitor on even the busiest of highways. Concrete overlays are classified into two categories, namely, bonded and unbonded. Depending upon requirements and site conditions, an overlay can be of plain concrete conventionally-reinforced concrete, or continuously-reinforced concrete. These and other aspects of the subject are discussed.

Anon. *Indian Concr J* v 62 n 2 Feb 1988 p 60-61, 96.

**077053 FIELD ANALYSIS OF RUTTING IN OVERLAYS OF CONCRETE INTERSTATE PAVEMENTS IN ILLINOIS.** Thirty-two overlay projects placed over portland cement concrete pavements were surveyed for the initial development of a comprehensive statewide pavement data base of which these overlay projects would be part. Ninety-two different uniform sections were visually surveyed to obtain performance data on the overlay projects. Design and construction data were collected for inclusion in the data base. The data were analyzed to develop regression relations between rutting and mixture properties of the asphalt concrete overlays. The analysis clearly shows the importance of material properties to the development of rutting, particularly the gradation parameters. The structural tests clearly show that the resilient modulus and indirect tensile

strength bear a strong relationship to the rutting that develops in the overlay during its life. The analysis in this paper clearly shows how a statistically sound examination of pavement performance can furnish data for an analysis that provides information that can be used to alter mix design and construction practices to address a specific problem. It is shown that permanent deformation can be controlled through proper material control. (Edited author abstract) 6 refs.

Carpenter, Samuel, H. (Univ of Illinois, Urbana, IL, USA); Enockson, Linn. *Transp Res Rec* n 1136 1987 p 46-56.

**077054 EFFECT OF CONCRETE OVERLAY DEBONDING ON PAVEMENT PERFORMANCE.** The objectives of this paper were to determine the effect of bond loss on response and performance of bonded concrete overlays and to examine present bonding techniques and bond loss detection methodologies. A finite-element model called ILLI-SLAB was used to evaluate pavement response to load, and Westergaard-Bradbury equations were used to determine curling stresses. It was found that loss of bond adversely affects maximum pavement tensile stress (thus fatigue life) and maximum pavement deflections. It is also believed that curling stresses may cause unbonded thin overlays to separate from the underlying slab, causing extremely high stress in the overlay if a load is applied. The only way bond can be obtained is to follow good construction techniques. A summary of these techniques is presented in the paper. On the basis of deflection analysis it was concluded that it may be possible to detect bond loss using nondestructive testing of corner deflections. (Author abstract) 15 refs.

Van Dam, Thomas (US Army Construction Engineering Research Lab, Champaign, IL, USA); Blackmon, Eleanor; Shahin, M.Y. *Transp Res Rec* n 1136 1987 p 119-129.

**Performance** See Also ASPHALT—Rheology.

**077055 HOW LONG SHOULD PAVEMENT LAST?** The number and type of vehicles have the most significant impact on pavement performance. Climate, including temperature fluctuations, maximum temperature, minimum temperature, rainfall, and duration of freezing conditions can also contribute substantially to pavement deterioration. The roadbed soil which ultimately supports the pavement is also important. This article discusses reasons for failure, evaluating good performance, results of an Asphalt Institute study, and other aspects of the subject.

Anon. *Better Roads* v 57 n 10 Oct 1987 p 32-34.

**077056 SMALL ELEMENT PAVING - THE MODERN ALTERNATIVE FOR TODAY'S TRAFFIC CONDITIONS.** The late 1970s signalled the beginning of a downward trend in the sales of conventional precast concrete flags. An 'unrealised change of use' - most importantly the heavy increase in vehicular overrun - brought about by modern traffic conditions, had sown the seeds of decline. The paper describes how and why the high-performance small-element flag has emerged as the natural choice for engineers in an ever increasing range of applications. (Edited author abstract) 2 refs.

Lilley, Alan (Cement & Concrete Assoc). *Highways (Croydon Engl)* v 55 n 1927 Jul 1987 p 18, 20, 22.

**077057 COST-EFFECTIVE SURFACING FOR TRACKED-VEHICLE TRAFFIC.** There is a need for cost-effective surfacings for areas subjected to tracked-vehicle traffic to reduce maintenance costs and improve safety. Surveys of several locations with tracked-vehicle traffic were made to observe pavement conditions and maintenance requirements. These observations demonstrated that pavement performance depended on how local personnel perceived their problems and local repair methods. A test section to evaluate several mixtures was constructed and tested at Fort Stewart, Georgia. The items tested were these: Fiber-reinforced concrete; Wire-mesh-reinforced concrete; Roller-compacted con-

crete pavement (RCCP) in depths from 4 to 10 in.; Concrete paving blocks over sand-grid base; Latex-modified asphaltic concrete; Steel-slag asphaltic concrete; and State of Georgia standard E-Mix asphaltic concrete. The properties of the various items before and after construction were determined and evaluated. (Edited author abstract) 8 refs.

Shoenberger, James E. (US Army Corps of Engineers, Vicksburg, MS, USA). *Tech Rep US Army Eng Waterw Exp Stn* GL-87-18 Aug 1987 93p.

**077058 ANALYSIS OF PERFORMANCE OF A CRUSHED ROCK PAVEMENT.** The performance of a thin crushed rock pavement is predicted using mechanistic analysis and the results are compared with actual performance after the passage of the equivalent of 250,000 standard axles. (Author abstract) 13 refs.

Smith, R.B.; Yandell, W.O. *Inst Eng Aust Civ Eng v* CE29 n 3 Aug 1987 p 162-168.

**077059 ESTIMATION OF ENVIRONMENTAL AND TRAFFIC LOADING EFFECTS ON HIGHWAY PAVEMENTS.** This paper describes the concept of a methodology for assessing quantitatively the relative effects of environmental and traffic loading on pavement performance. The proposed methodology relies upon pavement performance data which are now available in many highway agencies. It includes a procedure to incorporate the effect of routine maintenance on pavement performance in the analysis. A case study is presented as an example of application of the methodology. By analyzing 75 highway routes in Indiana, the case study serves to demonstrate the feasibility of the proposed procedure as a tool for estimating environmental and traffic loading effects on pavement performance at both project and network levels. (Author abstract) 11 refs.

Fwa, T.F. (Nat'l Univ of Singapore, Singapore); Sinha, K.C. *Aust Road Res* v 17 n 4 Dec 1987 p 256-264.

**077060 PERFORMANCE OF LOAD-TRANSFER DEVICES.** The study reported is part of a large effort to examine various design aspects of rigid pavements in New York. It involves the performance of several types of load-transfer devices (LTDs) for transverse joints. When corrosion and structural deterioration of then-standard LTDs became apparent in the early 1970s, plastic-coated dowels were tried. Soon, epoxy-coated I-beams were put into use and a trial installation of fiberglass dowels was completed. Earliest installations of these devices have since been monitored to determine whether their performance was an improvement. After 10 to 14 years, horizontal and vertical movements along with faulting measurements indicate they are providing better load transfer across transverse joints. 8 refs.

Vyce, John M. (US DOT, Albany, NY, USA). *Res Rep NY State Dep Transp Eng Res Dev Bur* 140 Jul 1987 33p.

**077061 RELIABILITY ANALYSIS OF PREMIUM PAVEMENT DESIGN FEATURES.** This study evaluates the special features of premium design guidelines - features not considered in the AASHTO flexible and rigid pavement design procedures. The significance of these features - fifteen in all for four pavement types - were investigated by evaluating pavement performance and design reliability. The researchers used the VESYS III program to evaluate features of the flexible pavements and an algorithm developed in a companion paper for the other three types (composite, jointed plain concrete, and continuously reinforced concrete). This computer program, Reliability Analysis and Performance of Pavements I (RAPPI), employs Monte Carlo simulation techniques to treat all of the design variables probabilistically. The effectiveness of each feature is evaluated by comparing the



performance or expected life and reliability of typical pavement sections with and without a premium feature. (Edited author abstract) 12 refs.

George, K.P. (Univ of Mississippi, University, MS, USA); Alsheri, A.; Shah, N.S. *J Transp Eng* v 114 n 3 May 1988 p 278-293.

**077062 RELIABILITY MODEL FOR PAVEMENT PERFORMANCE.** A simulation model to calculate the reliability/performance of pavement is developed. The computer program, Reliability Analysis and Performance of Pavements (RAPPI), employs Monte Carlo simulation techniques to solve the design equations (e.g., AASHTO, Premium) in which all of the design variables are assumed to be probabilistic and normally distributed. RAPPI, in conjunction with the respective design model, calculates the present serviceability index (PSI) of pavements in one-year increments. In addition to uncertainties attributable to the design factors, errors due to idealization of the model are included in the PSI calculation. By comparing the computed PSI with the terminal PSI, assuming that both are normally distributed, standard probabilistic techniques are employed for calculating pavement reliability. (Edited author abstract) 13 refs.

Alsheri, A. (Univ of Mississippi, University, MS, USA); George, K.P. *J Transp Eng* v 114 n 3 May 1988 p 294-306.

**077063 EVALUATION OF EFFECT OF UNCRUSHED BASE LAYERS ON PAVEMENT PERFORMANCE.** In 1974, the Alaska Department of Highways decided to save money and fuel by removing the base course and placing the asphalt concrete surface directly on the subbase of the Glenn Highway widening project. In 1969, the original two lanes had been constructed with a crushed base course, thus providing an excellent comparison of the performance of the two bases. Contrary to previous research and experience in crushed and uncrushed gravel, the uncrushed base course performed better than the crushed base course; the resilient modulus was higher, and the permanent deformation was lower. The uncrushed base is apparently superior because of a larger maximum particle size and greater maximum density. An analysis of the future performance of the roadway with equal thicknesses of asphalt indicates that the pavement over the uncrushed base would have a longer life than the pavement over the crushed base by 54 percent. (Edited author abstract) 6 refs.

Johnson, Eric G. (Alaska DOT & Public Facilities, Anchorage, AK, USA); Hicks, R.G. *Transp Res Rec* 1117 1987 p 11-20.

**077064 PERFORMANCE OF A FULL-SCALE PAVEMENT DESIGN EXPERIMENT IN JAMAICA.** The design, construction, and first 4 years' performance of seven experimental sections of road built on the May-Pen bypass in Jamaica are described. The road sections comprise varying pavement thickness of cement-stabilized and unstabilized marly limestones on a relatively weak, imported, clay subgrade having an in situ California bearing ratio (CBR) of 6 percent overlying a granular drainage blanket. After 4 years, about 10 percent of the road pavement (unstabilized bases only) reached a failure condition corresponding to a rut depth of 15 mm. From layer thicknesses, strength distributions, and the deflection performance model, it was possible to predict the performance of the thicker sections of road pavement. At the end of the study, the road was performing well in comparison with expectations from appropriate design charts but the predictions indicated that the relationship between overall thickness and traffic-carrying capacity was somewhat steeper than those of the design charts and therefore the thicker sections of road might not perform as well, relatively, as the thinner sections. (Edited author abstract) 7 refs.

Rolts, J. (Transport & Road Research Lab, Crowthorne, Eng.); Williams, S.G.; Jones, C.R.; Smith, H.R. *Transp Res Rec* 1117 1987 p 38-46.

**077065 VIDEO IMAGE DISTRESS ANALYSIS**

**TECHNIQUE FOR IDAHO TRANSPORTATION DEPARTMENT PAVEMENT MANAGEMENT SYSTEM.** The Idaho Transportation Department (ITD) is developing and implementing an automated highway management system, the Pavement Performance Management Information System (PPMIS). The system consists of structural adequacy data, present serviceability data, an surface distress data. Field data for the first two modules are obtained using automated collection techniques. However, surface distress data are still gathered manually and are incorporated into a visual and subjective methodology. The ITD is pursuing a low-cost, technically sound methodology to automate the collection and analysis of surface distress data. Preliminary findings indicate that automation of the distress data module is feasible. During 1985 and 1986, VideoComp videotaped more than 2,400 lane-mi of Idaho's Interstate highways and 380 lane-mi of principal arterial highways. In addition, computer software capable of determining crack type and size has been successfully demonstrated. (Edited author abstract) 4 refs.

Baker, Jim (VideoComp, Boise, ID, USA); Dahlstrom, Basil; Longenecker, Keith; Buu, Tri. *Transp Res Rec* 1117 1987 p 159-163.

**077066 NINE-YEAR PERFORMANCE EVALUATION OF ARIZONA'S PRESTRESSED CONCRETE PAVEMENT.** The Arizona Department of Transportation constructed an experimental prestressed pavement in 1977 and has monitored its condition for the past 9 years. The traffic volume on the pavement has greatly exceeded the design assumptions. Experiments conducted at the time of construction provide valuable data on curling and warping, shrinkage, elastic shortening, and so forth. Annual measurements of roughness and friction number have been collected, and periodic condition surveys have been made. The condition survey conducted in 1986 found that distress had developed in the pavement since the last survey in 1983. (Author abstract). 6 Refs.

Powers, Richard, L. (Arizona Department of Transportation, Phoenix, AZ, USA); Zaniewski, John, P. *Transp Res Rec* n 1136 1987 p 1-11.

#### Protective Coatings

**077067 SEAL COATING PRACTICE IN SASKATCHEWAN.** Seals are used to prevent moisture penetration, arrest fatigue block deterioration, restore friction resistance, and stop ravel. The primary sealing materials used are graded aggregates and high float emulsified asphalts. Some chip sealing with rapid-setting cationic or rubber-modified asphalts have also been used. Performance and defect levels of seals are mainly related to construction quality and are a function of distributor condition, type of asphalt and aggregate, application rates, surface preparation, and construction of joints and the climatic conditions in which they are applied. Seal coats have served Saskatchewan well by deferring the need for more costly rehabilitation by increasing the life of pavement surfaces maintained and easing demands on cash flow. (Edited author abstract) 4 refs.

Scott, John L.M. (Saskatchewan Highways & Transportation, Regina, Sask, Can). *Transp Res Rec* 1096 1986 p 140-146.

**Quality Control** See CONSTRUCTION INDUSTRY—Economics; ROADS AND STREETS—Testing.

**Recycling** See Also BITUMINOUS MATERIALS—Foams; HIGHWAY SYSTEMS—Maintenance; HIGHWAY SYSTEMS—Modification; ROADBUILDING MATERIALS—Aggregates; ROADS AND STREETS—Rural.

**077068 LES RETRAITEMENTS EN PLACE DES CHAUSSEES AVEC DES LIANTS HYDRAULIQUES.** [In-Situ Retreatment of Pavements with Hydraulic Binders]. Technical progress had led to the development of high-performance in-situ soil treatment equipment offering the possibility of re-using the already old technique of in-place retreatment of existing pavements. This conventional equipment is used only on light and medium traffic roads without treated bases. Modern machines, already experimented or under devel-

opment, and designed specifically for retreatment, make it possible to extend the field of application of these techniques to higher traffic levels and to old pavements with thick treated bases. The follow-up of completed projects shows that it is possible to obtain satisfactory results if the materials and the pavement have appropriate properties (in particular, pavement thickness and aggregate quality) and if the project was completed correctly with suitable equipment and the right binder. These techniques in fact call for even greater care in the initial design phase (decision to use the technique, mix design, structural design) than in the project execution phase. (Author abstract) In French.

Vautrin, J.-C. (SETRA, Fr); Lefort, M. *Travaux* n 627 Dec 1987 p 32-37.

**077069 SIMPLIFIED METHOD FOR RECYCLING OF BITUMINOUS PAVEMENTS.** Recycling is re-utilization of the aggregate and binder in the existing bituminous pavement requiring fresh renewal or rehabilitation courses. Recycling of distressed or deteriorated asphalt pavement has come up as a handy process to save materials and money. Short supply of bitumen in present times has further accentuated the need for measures to affect economy in bitumen consumption. Economy of 50 to 70 percent of the cost of a fresh layer of equivalent thickness can be effected through recycling process. However, lack of 'know-how' at the field level had so far restricted the use of this technology on a large scale. The successful application of the technology entirely depends upon the availability of suitable plant and personnel.

Dharmvir (UP PWD); Agarwal, P.D. *J Indian Roads Congr* v 48 n 2 Oct 1987 p 301-321.

**077070 RECYCLING CONCRETE PAVEMENTS.** The key reasons to recycle concrete pavements are cost savings and reduced environmental impact. High-quality, new aggregates may be scarce or costly to transport. Crushing old pavement produces good quality coarse aggregate at high production rates. Besides saving money, recycling old pavement on site reduces the environmental effects of waste hauling and disposal.

Arnold, C.J. (Michigan DOT, USA). *Concr Constr* v 33 n 3 Mar 1988 4p between p 320 and 326.

**Repair** See Also CONCRETE—Bonding; ROADS AND STREETS—Snow and Ice Control.

**077071 PROPERTIES OF HARDENED MPC MORTAR AND CONCRETE RELEVANT TO THE REQUIREMENTS OF RAPID REPAIR OF CONCRETE PAVEMENTS.** There is an increasing need and demand for new materials and methods for rapid but durable repair of concrete pavements, where the closure time is in hours instead of days. The presence of such materials or techniques will, no doubt, reduce dramatically the high cost related to labour, traffic diversion and control. Magnesia-phosphate cement (MPC) based materials provide the essential requirements for rapid repair of concrete. On mixing with water they provide a workable mix which sets within 15 minutes at normal temperature and hardens to sufficient strength, over 20MPa, within one hour. Almost the same performance can be obtained at sub-zero temperatures and in hot weather conditions using special but simple techniques or by the addition of special admixtures.

El-Jazairi, B. (FEB (Great Britain) Ltd). *Concrete (London)* v 21 n 9 Sep 1987 p 25-31.

**077072 ADAPTABLE, ATTACHABLE AND AVAILABLE.** The problem of road reinstatement, particularly where the road surface is only damaged in places, has a new solution from Econ Groups with a one-man-operated machine. Based on a 50hp industrial tractor, the unit has a backmounted cold planer, the CBP 300, and on the front the equivalent of a dustpan and brush - a sweeper-loader device which will brush up the debris and dump it into a trailer. On the side is a small



hydraulic jack hammer for trimming and finishing. All three units are linked to the tractor's hydraulic and power system.

Anon. *Surveyor (Sutton Engl)* v 168 n 4961 Sep 10 1987 p 23.

**077073 REMISE EN ETAT DES CHAUSSEES.** [Repair of Pavements]. The author sums up existing knowledge in the field of methods of non-destructive inspection of flexible pavements and the use of the results of such inspection. For the investigation of structural properties, the only type of non-destructive inspection dealt with here, the author presents available ways and means of recording visible surface deteriorations, measuring the thickness of courses, and evaluating the structural capacity by measuring the propagation of surface waves and by various methods of measuring deflections (under moving load, stationary vibrating load, and falling load). After a brief discussion of how the results of non-destructive pavement inspection may be used in management and maintenance systems, the author deals with their use for determining remaining service life and for the structural design of overlays. He deals with empirical and theoretical methods involving the determination of maximum deflection alone, and then with methods using an analysis of the degree of curvature of the deflection. He presents in particular a critical study of methods enabling a multi-layer model to be adjusted on the basis of the shape of the deflection basin. The way in which such a model may be used to predict the remaining service life of the pavement and to structurally design an overlay is then discussed. (Edited author abstract) In French. 42 refs.

Bonnot, Jacques (Lab Central des Ponts et Chaussées, Fr). *Bull Liaison Lab Ponts Chaussees* n 153 Jan-Feb 1988 p 13-28.

**077074 SOLVING A WEAK LINK IN PAVEMENT PATCHES.** When a street excavation impact assessment was performed in Burlington in 1985, the data clearly indicated that those streets without utility cut patching had a life expectancy of 18.5 years, while those with utility cut patching had a life expectancy of only 10.9 years. The study consisted of performing a visual condition survey and nondestructive deflection testing using state of the art techniques. With the data from the study available, it was important not only to develop a yearly capital paving program, but it became imperative to find more efficient and effective asphalt pavement maintenance procedures to maintain Burlington's 100-mile street system.

Osborne, Bryan K. *Public Works* v 119 n 8 Jul 1988 p 70-71.

**077075 CAN PROGRAMMED PATCHING WORK?** The paper discusses an experimental expert system to help determine how much and what kind of maintenance work need to be completed on a specific road. Data for the system's development came from the experience and judgment of Indiana Department of Highways' unit foremen. The system also provides cost estimates. The system was developed for estimating highway pavement routine maintenance needs at a subdistrict level. The benefits of the system stem from the fact that it relates to the current condition of the road. The data base, developed using information from unit foremen, allow this kind of feedback.

Anon. *Better Roads* v 58 n 8 Aug 1988 p 42-43.

**077076 EVALUATION OF STAINLESS-STEEL PIPES FOR USE AS DOWEL BARS.** Dowel bars are an important load transfer mechanism that reduce the damage to highway pavements caused by pumping and subsequent faulting at the slab-joint interface. Damage to the pavement when these devices corrode has been a significant problem in the past. In an effort to find a method for improving pavement performance and reducing repair costs, a study was performed to evaluate the effectiveness of using stainless-steel pipes as dowel bars. Based on long-term (40 years) field performance studies, stainless-steel (type 316) was selected because of its proven ability to resist corrosion. Pipe was chosen over a solid

stainless-steel bar for cost considerations. The data from the initial tests produced useful results on load-carrying capacity of concrete-filled and hollow-dowel pipe. 5 refs.

Black, Kevin N.; Larson, Roger M.; Staunton, Loren R. *Public Roads* v 52 n 2 Sep 1988 p 37-43.

## Research

**077077 PAVING PERSPECTIVE - CONCRETE OPTIONS.** This paper discusses the concrete options of paving perspective. Concrete which is used for paving work has evolved and its specification has changed considerably as concrete pavement life, durability and economy has improved. The primary national specification for roadworks needs to be studied in some detail, yet it also needs to be seen in perspective as part of the broader picture of change. The paving options and applications (and the matrix of possible combinations) are extensive but still not complete. It is possible to expand the study to include construction methods, techniques and indeed the features and benefits of old, current and new cement, using CBM and concrete systems. New standard designs were published by the Department of Transport in 1987 and these set the standards for modern main road pavements and include jointed unreinforced concrete pavements; jointed reinforced concrete pavements, continuously reinforced concrete road base design which carries a replaceable thin 'black' surfacing. 10 refs.

Walker, Brian (British Cement Assoc. Engl). *Highways (Croydon Engl)* v 56 n 1936 Apr 1988 p 52-53.

## Seals

**077078 SEAL COATS IN MANITOBA.** Seal coats are applied to seal out moisture, provide a lighter colored surface for nighttime visibility, improve skid resistance, and reduce pavement oxidation. A side benefit is the improvement in appearance by covering sealed and unsealed cracks and any patching that had been required. More than 300 miles of seal coats are placed annually by two permanent summer crews. Application and cost data relative to Manitoba's program are presented. (Edited author abstract) 4 refs.

Young, F.; Robinson, A.; Rowley, B. *Transp Res Rec* 1096 1986 p 135-139.

## Service Life

**077079 PRESENT SERVICEABILITY-ROUGHNESS CORRELATIONS USING RATING PANEL DATA.** The Kansas Department of Transportation (KDOT) has completed an extensive study of pavement serviceability using 24-member rating panels. The AASHTO five-point segmented rating scale and the three-point segmented rating scale designed to develop serviceability estimates directly related to KDOT pavement management system roughness levels were used. The average standard deviation of individual panel ratings over all pavement types was approximately 12 percent of the maximum scale value. This value corresponds to 0.60 for the AASHTO five-point scale and 0.36 for the KDOT three-point scale; these standard deviations appear to be consistent for panel sizes  $\geq 24$ . A statistically significant correlation was established between the AASHTO five-point and KDOT three-point present serviceability rating (PSR) values. It appears that the three-point PSR data are consistent at terminal serviceability values associated with the AASHTO five-point scale. (Edited author abstract) 11 refs.

Moore, Raymond K. (Univ of Kansas, Lawrence, KS, USA); Clark, G. Norman; Plumb, Gary N. *Transp Res Rec* 1117 1987 p 152-158.

**077080 REEVALUATION OF SHELL LIFE BY MECHANO-LATTICE ANALYSIS.** The influence of residual stresses and strain on the fatigue and rutting life of flexible pavements is investigated theoretically using Yandell's mechano-lattice technique. The investigation concentrates on a hypothetical study that has revealed that residual stresses are built up due to the variations of

plastic behavior between the various layers of the pavements. This study indicates that the mechano-lattice method, which assesses the effects of the plasticity of road materials on the pavement structure, can improve the precision of flexible pavement designs. (Author abstract) 11 refs.

Nam Lim, Pyong (Univ of New South Wales, Kensington, Aust); Yandell, William Otto. *J Transp Eng* v 114 n 4 Jul 1988 p 435-449.

## Standards

**077081 NEW DTp DESIGN STANDARDS WILL PUT THE SQUEEZE ON FLEXIBLE-COMPOSITE PAVEMENTS.** A little over a year after the introduction of the 6th edition of the Specification for Highway Works and a year since it first appeared in draft form, the Department of Transport (DTp) has issued its standard on the structural or thickness design of pavements for motorways and trunk roads. From the point of view of convenience it is most welcome, since the profession can at last turn to just one document for trunk road pavement thickness design instead of the four that it replaces. By militating against the use of flexible composite pavements, the recently published standard for the structural design of new road pavements could have the unfortunate effect of polarizing the highways industry even more than it is today, creating less real choice of pavement, less competitiveness and greater construction costs. 10 refs.

Kennedy, John. *Highways (Croydon Engl)* v 55 n 1930 Oct 1987 p 22, 30.

Strain See VEHICLES—Springs and Suspensions.

Stresses See Also HIGHWAY TRAFFIC CONTROL—Computer Applications.

**077082 SCHADEN AN EINEM BEFAHRENNEN BETONWERKSTEIN-BELAG.** [Damages to a Trafficked Precast Concrete Tile Surfacing]. Pavements which have to carry vehicular traffic are subjected to particularly high mechanical stress. This situation places special demands on every aspect of pavement construction and especially on the surfacing. In a shopping center, 2500 m<sup>2</sup> precast concrete paving tiles size 25 x 25 cm were laid as surfacing. Jurassic yellow was employed as aggregate for the tiles and white cement as binder to meet the optical requirements. The surfacing is subjected to the typical rolling loads expected in such areas, i.e. shopping carts and hand pallet trucks used for storing goods in shelves. About 3 months after the shopping center had opened, a few isolated tiles were found to have damaged surfaces. This paper analyzes the causes of damage and repair methods.

Pickel, Ulrich; Permesang, Claus; Hofmann, Olaf. *Betonwerk Fertigteil Tech* v 54 n 5 May 1988 p 69-74.

**077083 JOINT SHEAR TRANSFER EFFECTS ON PAVEMENT BEHAVIOR.** This paper focuses on the relationship between shear transfer capabilities across pavement joints and the effects on the behavior of the pavement. The approach of the present study is to develop a numerical model that could accurately represent the mechanism for shear transfer across reinforced concrete pavement joints and implement it in an existing finite element code. That tool is then used for the analyses of various pavements for which experimental data are available; the model is further refined until the numerical results are in good agreement with the experimental information. This approach is employed for the interpretation of pavement behavior under different combinations of joint shear transfer conditions, asphalt concrete overlay thickness and material properties, and the influence of postpumping damage. (Edited author abstract). 20 Refs.

Krauthammer, T. (Univ of Minnesota, Minneapolis, MN, USA); Western, K.L. *J Transp Eng* v 114 n 5 Sep 1988 p 505-529.



## Structural Analysis

**077084 DEVELOPMENT OF PAVEMENT STRUCTURAL SUBSYSTEMS.** The primary objective of the investigation described in this report was to develop a series of models designed to predict physical distress in asphalt-type pavements. Specifically, methods have been developed that attempt to predict when and how much fatigue cracking and rutting will occur and when low-temperature cracking can be expected. The working hypothesis for the development of the prediction subsystems was the assumption that the forms of distress predicted are related to some combination of stress, strain, or deformation within the pavement and that these responses can be calculated on the basis of estimates of the elastic constants of the pavement and subgrade materials. The computer programs have been developed through the investigation and are referred to as PDMAP (Probabilistic Distress Models for Asphalt Pavements) and COLD (Computation of Low-Temperature Damage). The PDMAP program is designed to predict fatigue cracking and rutting in asphalt-type pavements. (Edited author abstract) 73 refs.

Finn, F. (Woodward-Clyde Consultants, Walnut Creek, CA, USA); Saraf, C.L.; Kulkarni, R.; Nair, K.; Smith, W.; Abdullah, A. *Natl Coop Highw Res Program Rep* 291 Dec 1986 59p.

**077085 RIGID PAVEMENT UPLIFT.** The possibility of uplift of the pavement slab under the influence of traffic loading has not been examined, although it is very important to investigate the influence of uplift on stresses. There is no doubt that a possibility of uplift does exist, because only compression stresses be may sustained at the slab-subgrade interface. That means that a problem of unilateral contact appears. In the case that tension stresses would have been withstandable we would have bilateral contact. The solution of a problem of unilateral contact by analytical methods presents many mathematical difficulties. In this paper the algorithm of Theil and Van de Panne as it was modified by P.D. Panagiotopoulos has been used. It is a trial and error method using special criteria providing the convergence of the procedure and the validity of the solution. 5 refs.

Thomopoulos, K.A. (Thessaloniki Univ, Greece); Tsohos, G. *Highw Transp* v 35 n 1 Jan 1988 p 11-13.

## Structural Design See Also BRIDGES—Approaches.

**077086 STRUCTURAL DESIGN FOR CONCRETE BLOCK ROADS.** During the last few years, concrete block pavement design has advanced on these fronts: a better understanding of the use of civil engineering materials in concrete block paving has been gained. There is now sufficient experience and data available to prevent any inadequate materials from being specified and the concept of Peak Shear Stress Ratio should be applied to all sub-base specifications. The widespread use of concrete block paving on small lightly trafficked areas has led to the development of satisfactory well established design and construction methods. Concrete blocks have become an orthodox solution to heavy duty pavement problems for many designers. 10 refs.

Knapton, John (Nigel Nixon, Knapton & Partners). *Highways (Croydon Engl)* v 56 n 1935 Mar 1988 p 20, 22, 25.

**077087 MICROCOMPUTER PROCEDURE TO ANALYZE AXLE LOAD LIMITS AND PAVEMENT DAMAGE RESPONSIBILITY.** The program generates information concerning predicted years to failure for different load limits. In addition, simple charts were developed to allow engineers to conduct a load-limit analysis in the absence of deflection measurements and to determine pavement damage responsibility for different axle loads. Results of an example application of the procedure indicate more damage responsibility for heavy loads on thin pavements than on thick pavements, as would be expected. However, cost allocation based on marginal pavement damage can be misleading if the initial cost of construction is not considered. (Edited author abstract) 9 refs.

Luhr, David R. (Pennsylvania State Univ, University Park, PA, USA); Fernando, Emmanuel G. *Transp Res Rec* 1123 1987 p 88-98.

**077088 VERIFICATION DES METHODES DE DIMENSIONNEMENT DES CHAUSSEES. SECTIONS D'ESSAIS. SECTIONS DE SUIVI DES DEGRADATIONS. BILAN STATISTIQUE DES STRUCTURES.** [Verification of Methods of Structural Design of Pavements: Test Sections, Sections for the Following Up of Deteriorations, and Statistical Report of Structures]. As soon as the first rational methods of structural design and overlaying were introduced in France in 1965, a test section programme was established to progressively improve the accuracy of the methods. The sections were defined and selected so as to constitute real and representative cases. An experimental procedure was developed involving numerous means of non-destructive testing to be applied at adjustable frequencies. Experimental verification of behavior was carried out on sections mostly between ten and twenty years old. As a complement to this study, a specific sample of two hundred sections of road 1 kilometer long, called sections for the following up of deteriorations, was adopted for the purpose of discerning laws governing the formation and evolution of apparent deteriorations. Lastly, a statistical report of the behavior of maintained pavements was prepared. The three aspects of this study are complementary, and contribute to: the detailed verification of methods of designing and building pavements, and the advancement of these methods; the prediction of surface deteriorations on which maintenance work depends, and strategies of intervention; and an overall verification of design, construction and maintenance taken as a whole. (Edited author abstract) In French. 16 refs.

Siffert, Marcel. *Bull Liaison Lab Ponts Chaussees* n 153 Jan-Feb 1988 p 37-46.

**077089 EVALUATION DU TRAFIC LOURD ET APPLICATION AU DIMENSIONNEMENT STRUCTUREL DES CHAUSSEES.** [Evaluation of Heavy Traffic and Its Application to the Structural Design of Highways]. The evaluation of the moving loads carried by pavements and road structures is seen to be essential to rational construction and maintenance. Existing methods of evaluating traffic loads and their effects are in general cumbersome and inadequate. In France, the piezo-electric ceramic cable has been the subject of much study and development as a detector of traffic, and more precisely, loads. This detector is more economical and easier to maintain than traditional systems; it is susceptible of widespread use in many fields of application. A method of evaluating traffic on the basis of the real effects of loads, based on the use of this type of detector, would doubtless make it possible to improve the precision of methods of structural design of pavements and to establish priorities where maintenance is concerned. (Edited author abstract). 8 Refs. In French.

Siffert, Marcel; Lescure, Bernard. *Bull Liaison Lab Ponts Chaussees* n 154 Mar-Apr 1988 p 73-83.

**077090 COMPARATIVE STUDY OF THE METHODOLOGY OF FLEXIBLE PAVEMENT DESIGN IN USA AND INDIA.** The most commonly used procedures in the U.S.A. for the design of flexible pavements are those contained in the AASHTO Interim Guide for the Design of Flexible Pavement Structures. The design procedures include the determination of total thickness of the pavement structure, as well as the thickness of the individual structural layers. The design methods being used in India include: group index method; California bearing ratio method; California R-Value or stability meter method; tri-axial test method; McLeod method; Burmister method. Flexible pavements in India are being designed within the framework of guidelines set by the Indian Roads Congress. 13 Refs.

Sharma, M.C. (Public Works Dep, Jaipur, India); Saxena, H.N. *Indian Highw* v 16 n 5 May 1988 p 23-47.

**077091 DESIGN-RELATED DISTRESS IN CONCRETE PAVEMENTS.** Concrete pavements that are

properly designed and constructed will perform well and may even outlast their design life. This study discusses the cause of premature cracking in a concrete-concrete pavement system with unbonded interface, tied and doweled joints, and variable-length slabs with skewed joints. Results of tests, analyses, and field inspection of the pavement, on I-75 south of Tampa, Fla., are presented. (Edited author abstract). 5 Refs.

Armaghani, Jamshid M. (Florida Dep of Transportation, Gainesville, FL, USA); Larsen, Torbjorn J.; Smith, Lawrence L. *Concr Int* v 10 n 8 Aug 1988 p 43-49.

## Surface Properties

**077092 TEXTURING CONCRETE PAVEMENTS.** Increased traffic volumes and speeds have increased the need for an improved skid-resistant surface. The emphasis has been to improve skid resistance by creating new surface textures that increase the 'macrotexture' of the concrete pavement. These textures are created by forming the deeper textures in the plastic concrete during the finishing operations. Skid resistance has also been improved in existing concrete pavements by sawing grooves in the hardened concrete with cutting heads composed of a number of circular diamond saw blades. (Edited author abstract) 18 refs.

Duncan, Ralph L.; Albright, Richard O.; Abu-Onk, Walid; Bollin, Glen; Breite, Jerry A.; Colucci, Benjamin; Darter, Michael I.; Fluhr, Robert J.; Greer, Wilbur C. Jr.; Kohn, Starr D.; Larsen, Torbjorn J.; McComb, Richard A. Sr.; McCullough, B. Frank; Meglan, Carl P.; Tayabi, Shiraz D. *ACI Mater J* v 85 n 3 May-Jun 1988 p 202-211.

**Surfaces** See HIGHWAY SYSTEMS—Noise Abatement; HIGHWAY SYSTEMS—Rural.

**Testing** See Also CONCRETE—Moisture Control; ROADS AND STREETS—Foundations.

**077093 TEST RESULTS AND ANALYSIS OF THE ALF TRIAL AT BENALLA, VICTORIA.** This paper describes the second trial conducted with the Accelerated Loading Facility on a section of crushed rock pavement surfaced with a spray seal and subjected to heavy traffic loading. The pavement was subjected to a total of 1,400,000 cycles of a nominal load of 80 kN and pavement response and performance was monitored in terms of residual and resilient deformation, the latter both on the surface and within the pavement. Although the pavement did not deteriorate structurally, the surface seal had to be fully rehabilitated twice and many minor repairs were carried out in order to maintain a waterproof surface. Analysis of the results indicated the stress (load) sensitive nature of the pavement. Ignoring the nonlinear characteristics of the pavement led to significant errors in the estimation of pavement life under different load magnitudes and traffic conditions. Additional study results are discussed. (Edited author abstract) 18 refs.

Kadar, P. (Australian Road Research Board). *Aust Road Res* v 17 n 2 Jun 1987 p 87-101.

**077094 EFFECT OF TEST CONDITION PARAMETERS ON IRR<sub>R</sub>.** The index of retained resilient modulus (IRR<sub>R</sub>) is used to assess moisture-induced distress in asphalt concrete mixtures. The IRR<sub>R</sub> represents the ratio of two moduli and is sensitive to slight deviations in each measured value of modulus. A laboratory and analytical research program was conducted to examine the effect of variations in test condition parameters on the resilient modulus, M<sub>R</sub>, and the IRR<sub>R</sub>. In the laboratory test program, the strain and temperature dependencies of the M<sub>R</sub> were determined for a dense-graded asphalt concrete mixture. The results indicate that constant stress testing may result in a misinterpretation of the IRR<sub>R</sub>, and, further, tests conducted within the currently accepted temperature range may result in a ±20% deviation in the IRR<sub>R</sub>. In the analytical program, the effect of diametral test boundary



conditions on the measured value of  $M_r$  was evaluated using two- and three-dimensional finite element models. (Edited author abstract) 17 refs.

Heinicke, John J. (Oregon State Univ, Corvallis, OR, USA); Vinson, Ted S. *J Transp Eng* v 114 n 2 Mar 1988 p 153-172.

**077095 CHOICE OF DIFFERENT PAVING GRADE BITUMENS FOR DIFFERENT CLIMATIC REGIONS OF INDIA.** The paper deals with the problem of choice of appropriate grade of paving bitumen for different climatic regions of India. The performance evaluation of five test-tracks laid with five grades of paving bitumen namely 30/40, 40/50, 50/60, 60/70, and 80/100 in five distinct climatic regions of India viz. Sikar (low rainfall) Delhi (moderate rainfall) Trivandrum (heavy rainfall coastal region) Cherrapunjee (very heavy rainfall region) and Shimla (snow-bound region) indicated that a minimum of three grades of paving bitumen namely 30/40, 50/60 and 80/100 are technically needed for the country. Specific recommendations are made regarding choice of these three paving grade bitumens based on considerations of climatic conditions and traffic intensity. The findings of the Paper will help in the production and distribution of different paving grade bitumens in the country. (Author abstract) 8 refs.

Shukla, R.S. (Central Road Research Inst, New Delhi, India); Gokhale, Y.C.; Nair, K.P.; Kala, M.P. *J Indian Roads Congr* v 48 n 1 Aug 1987 p 119-174.

**077096 EXAMINATION OF ENVIRONMENTAL VERSUS LOAD EFFECTS ON PAVEMENTS.** This paper is a summary of the results of a study under taken to examine environmental versus load effects on pavements. Pairs of pavement sections were examined at 14 locations in five states. At each location, one section had received normal traffic and the other had never been opened. Visual condition surveys were performed on each section, and pavement condition was compared. It is concluded that traffic loadings are a much more significant cause of pavement distress than are environmental problems. (Author abstract) 8 refs.

Hudson, W.R. (Univ of Texas at Austin, Austin, TX, USA); Flanagan, Patrick R. *Transp Res Rec* 1121 1987 p 34-39.

**077097 NUMERICAL ASSESSMENT OF PAVEMENT TEST SECTIONS.** A numerical study was performed at the University of Minnesota for the Minnesota Department of Transportation for assessing and explaining the observed performance of several highway pavement test sections. The test sections that were considered in this study are located in Minnesota near Rothsay, on I-94, and near Olivia, on Trunk Highway 71. For the Olivia site, the objective was to investigate the effect of a thin layer of bituminous bond breaker on the reflective cracking of the new pavement slab, whereas for the Rothsay site the goal was to understand the differences between bituminous-treated bases (BTBs), cement-treated bases (CTBs), and aggregate bases in affecting the pavement behavior and to determine the causes for relatively poor behavior of pavements on BTBs as compared to pavements on CTBs and aggregate bases. The approach was to use the finite element method and to perform falling-weight deflectometer (FWD) simulations on the test sections. (Edited author abstract) 22 refs.

Krauthammer, T. (Univ of Minnesota, Minneapolis, MN, USA); Khanlari, H. *Transp Res Rec* 1117 1987 p 66-75.

**077098 DEVELOPMENT OF A UTILITY EVALUATION FOR NONDESTRUCTIVE TESTING EQUIPMENT USED ON ASPHALT CONCRETE PAVEMENTS.** Nondestructive testing of pavements has become a cost-effective and invaluable aid in determining the actual condition of pavement sections in a highway network. Because the number of nondestructive testing devices in use grows each year, the choice of the best method involves a complex comparison of alternatives involving the test equipment itself, the resulting data, and

the available methods of analyzing the data provided. All of these factors are considered in a systematic way by the application of utility theory. A hierarchical weighting system is developed using nonlinear utility curves. Five generic nondestructive testing devices are evaluated for use on asphalt concrete pavements for both project-level design and network-level planning. (Edited author abstract) 15 refs.

Stoffels, Shelley M. (ERES Consultants Inc, Champaign, IL, USA); Lytton, Robert L. *Transp Res Rec* 1117 1987 p 134-142.

**077099 EFFECT OF LOAD, TIRE PRESSURE, AND TIRE TYPE ON FLEXIBLE PAVEMENT RESPONSE.** The effect of increased truck tire pressures on flexible pavement performance recently has become a subject of great concern. Various researchers have used analytical methods to attribute decreased fatigue life, increased rutting, and accelerated serviceability loss to the effects of increased tire pressure. The study summarized in this article investigated these concerns by measuring the effects of load, tire pressure, and tire type on the response of an asphalt concrete pavement. This experiment was conducted at the Federal Highway Administration's (FHWA's) Pavement Testing Facility (PTF). The relative effects of load and tire pressure on pavement fatigue may be investigated using fatigue equivalency factors which account for both load and tire pressure. Such factors were developed in this study using an exponential relationship between the number of cycles to failure and the magnitude of the tensile strain at the bottom of the asphalt layer. 4 refs.

Bonaquist, Ramon; Churilla, Charles; Freund, Deborah. *Public Roads* v 52 n 1 Jun 1988 p 1-7.

**077100 DEVELOPMENTS IN THE BRITISH APPROACH TO PREVENTION OF FROST HEAVE IN PAVEMENTS.** In Britain, frost heave is prevented by ensuring that all materials within 450 mm of the road surface are non-frost susceptible as defined by the Transport and Road Research Laboratory test. The evolution of the test is summarized and the implications of the revisions and of other factors in design, such as depth of frost penetration and the availability of water, are examined critically. Results of a series of tests are presented that show that the British frost-susceptible materials correlate with the 'highly frost-susceptible' classification in the United States and French systems. Particle size distribution and saturation moisture content are shown to be poor indicators of the frost susceptibility of aggregates, because neither can reflect the contribution of between-particle and within-particle pore size distributions. (Edited author abstract) 24 Refs.

Jones, R.H. (Univ of Nottingham, Nottingham, Engl). *Transp Res Rec* n 1146 1987 p 33-40.

## Thermal Effects

**077101 CHARACTERIZING TEMPERATURE EFFECTS FOR PAVEMENT ANALYSIS AND DESIGN.** Pavement temperatures can be accurately quantified utilizing the Climatic-Materials-Structural (CMS) computer model developed at the University of Illinois. Required CMS inputs (for temperature modeling) are (a) thermal properties of materials and soils, (b) air temperature data, (c) solar radiation data, and (d) wind velocity data. In this paper the development and use of a comprehensive Illinois Climatic Data Base for Pavements are presented. Air temperature data are summarized on a weekly basis and solar radiation and wind velocity data are presented in the form of a monthly state map. Illustrative, applications-oriented examples are presented for (a) strength-degree-day curing relations for pozzolanic stabilized base materials, (b) asphalt concrete modular-pavement temperature effects, and (c) temperature gradients in portland cement concrete slabs. The emphasis here is on the concepts and techniques used to establish the Illinois Climatic Data Base for Pavements. (Edited author abstract) 14 refs.

Thompson, M.R. (Univ of Illinois at Urbana-Champaign,

Urbana, IL, USA); Dempsey, B.J.; Hill, H.; Vogel, J. *Transp Res Rec* 1121 1987 p 14-22.

**Waste Utilization** See HEAVY METAL COMPOUNDS—Environmental Impact.

## Wear

**077102 LE PROCEDE REGECHAPE. [REGECHAPE Process].** The innovation consists in rejuvenating in situ and in reshaping old wearing courses of bituminous coated materials in the cold state. For this purpose, Beugnet designed: a rejuvenating binder giving to the mixture ageing bitumen plus rejuvenating binder, the properties of a new bitumen; a multifunction machine rejuvenating old coated materials in the cold state and implementing the recycled coated materials. The advantages of this process are: the utilization of materials in situ; the rejuvenation in the cold state and therefore an energy saving; the reshaping of the pavement; preserving the level of pavement; the very competitive costs of the process compared to traditional solutions. (Edited author abstract) In French.

Elie, Denis; Faure, Bernard; Guillon, Roger; Sainton, Alain. *Travaux Suppl* Mar 1988 p 29.

**077103 EFFECTS OF PERMIT AND ILLEGAL OVERLOADS ON PAVEMENTS.** In recent years the nation's highways are wearing out - many of them far earlier than anticipated. One of the causes of premature deterioration is increased traffic, often much more than expected. The volume of truck traffic has increased rapidly as the Interstate Highway System has become available and popular. A serious contributor to early pavement wear-out is the overloaded truck, whether legal or illegal. AASHTO (American Association of State Highway and Transportation Officials) equivalency factors can be used to estimate the effects of overloaded vehicles on pavement damage. Uniform policies among states regarding vehicle size and weight regulations would be beneficial as would uniform policies within a state regarding limits on Interstate highways and other federal-aid highways. Pavement design and evaluation practices should be capable of considering overloaded vehicles. This would require comprehensive traffic data and design procedures that can be used to analyze the effect of identified overloads. Use of weight-in-motion (WIM) equipment and adoption of sampling plans should ensure adequate data collection. (Edited author abstract) 88 refs.

Terrill, Ronald L. (Terrill Associates Inc); Bell, Chris A. *Natl Coop Highw Res Program Synth Highw Pract* 131 Sep 1987 99p.

## Wear Resisting

**077104 WEAR RESISTANT CONCRETE FOR PAVEMENTS.** A special test rig that simulates 10 years traffic with 10,000 ADT within one week was used to determine factors that strongly influence rutting resistance in concrete pavement, an important consideration in Norway where studded tires are used throughout the long winter season. These factors include concrete strength, aggregate type, sand type, air entrainment, and condensed silica fume. Tests are continuing to optimize all variables to achieve the highest possible resistance of the lowest cost. (Author abstract). 8 Refs.

Pedersen, Nils. *Concr Int* v 10 n 8 Aug 1988 p 53-58.

**PEAT** See Also COAL LIQUEFACTION; GEOLOGY—Coal; WATER POLLUTION—Water Quality; WATER, UNDERGROUND; WAXES—Magnetic Properties.

**077105 SENSITIVITY OF THE GROUNDWATER MOUND MODEL FOR PREDICTING MIRE TOPOGRAPHY.** The Dupuit-Forchheimer model for groundwater mounds has been proposed to explain the morphology of raised peat mires. This paper discusses the sensitivity of the model as a predictor for mire profiles using data from a raised Irish mire where an attempt was



made to reconstruct the equilibrium profile. The most sensitive parameters are shown to be hydraulic conductivity and net recharge. Detailed measurements of saturated hydraulic conductivity show significant spatial variability, which is correlated with mire stratigraphy. Objective determination of an average value for modeling would have an error band of an order of magnitude which is unsatisfactory for prediction. Net recharge is calculated from the water balance but parameters like overlandflow must be estimated, usually from limited data, making the proposed value suspect. (Edited author abstract) 11 refs.

Kneale, Pauline E. (Univ of Leeds, Leeds, Engl). *Nord Hydrol* v 18 n 4-5 1987 p 193-202.

**077106 STUDIES OF PEAT AS THE INPUT TO COALIFICATION, I. RATIONALE AND PRELIMINARY EXAMINATION OF POLYSACCHARIDES IN PEATS.** It is widely believed that macerals of the huminite and vitrinite groups in coals consist to an important extent of a cross-linked macromolecular network, but the nature of the starting materials for this network, and the manner in which it is formed, are still not satisfactorily settled. In a preliminary study peats in two cores from the Florida Everglades were fractionated by procedures adapted from those used in soil science. Measurements of optical rotation and viscometric molecular weights show that the plant polysaccharides are already altered in surface litter. Acid hydrolysates of whole peat and the humic acid and humin fractions gave distributions of sugars different from what is expected from plant polysaccharides; that is, hemicelluloses and  $\alpha$ -cellulose seem to have been at least partly destroyed and various bacterial and/or fungal polysaccharides added. (Edited author abstract) 51 refs.

Lucas, A.J. (Pennsylvania State Univ, University Park, PA, USA); Given, P.H.; Spackman, W. *Int J Coal Geol* v 9 n 3 Mar 1988 p 235-251.

**077107 EFFECT OF SURFACTANTS ON PEAT DEWATERING.** The effect of cationic, anionic and neutral surfactants on the mechanical dewatering of a highly decomposed fuel-grade peat has been examined. Surfactant adsorption and zeta potential of the peat particles correlated with dewatering of peat samples. The cationic surfactants had large positive effects on dewatering, the anionic surfactants had a negative effect while the neutral surfactant had no effect. The effects of the surfactants could be explained by charge neutralization and double layer suppression. The cationic surfactants were superior to analogous organic salts because of enhanced interaction by the hydrophobic effect. (Author abstract) 9 refs.

Cooper, D.G. (McGill Univ, Montreal, Que, Can); Eccles, E.R.A.; Sheppard, J.D. *Can J Chem Eng* v 66 n 3 Jun 1988 p 393-397.

**077108 EVALUATING PEAT-MINING HYDROLOGY USING DRAINMOD.** A process that uses the field-scale model DRAINMOD to simulate the hydrologic response of a watershed to peat mining is presented. An eastern North Carolina watershed has been proposed as the site of a peat mining project. Within the watershed are several distinct soils, land uses, and drainage characteristics. Land use, drainage, and even soil characteristics change as peat soil is mined and reclaimed. The hydrologic response of this watershed is determined for each year of the proposed mining project by combining the field hydrology model with a simple reservoir model, a spreadsheet program, and a statistical program. Study results are discussed. (Edited author abstract). 6 Refs.

Konyha, Kenneth D. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Robbins, Kevin D.; Skaggs, R.W. *J Irrig Drain Eng* v 114 n 3 Aug 1988 p 490-504.

**077109 HISTORICAL PERSPECTIVE OF ATMOSPHERIC CHEMICALS DEPOSITED ON A MOUNTAIN TOP PEAT BOG IN PENNSYLVANIA.** A chronology of a mountain top peat bog in Pennsylvania has been developed using  $^{210}\text{Pb}$  techniques, checked with fallout  $^{137}\text{Cs}$  from nuclear weapons tests, and applied to

measurements of the deposition of sulfur, nitrogen, bromine, and trace metals. The local wind, precipitation patterns and vegetation of the bog increased the deposition of materials two to five times more than expected. The trace metals, nutrients and magnetic materials found in the core profiles originate regionally as well as from across the Great Plains of North America and illustrate the history of industrial and domestic activities since 1800. (Edited author abstract) 45 refs.

Schell, W.R. (Univ of Pittsburgh, Pittsburgh, PA, USA). *Int J Coal Geol* v 8 n 1-2 Jun 1987, Sel Pap from the Symp 'Peat: Geochem Res and Util', Miami Beach, FL, USA p 147-173.

## Analysis

**077110 CORRECTION FOR ENVIRONMENTAL  $^{230}\text{Th}$  IN U/Th DISEQUILIBRIUM DATING OF PEAT.** The use of strong acids to dissolve U and Th of organic origin from the sample ashes after combustion causes fractionation and introduction of environmental Th. Resulting unreliable ages most likely relate to the composition of the inorganic fraction and the locality of the sample. U/Th measurements of the .12% NaOH soluble fraction confirm that Th (and possibly U as well) in the mineral fraction is subjected to an in-situ ion-exchange with the organic fraction (humic and fulvic acids), resulting in high concentrations of  $^{232}\text{Th}$  in the organic fraction. Depletion of  $^{230}\text{Th}$  relative to  $^{232}\text{Th}$  in the organic phase for a steady-state is shown mathematically to be determined by the ratio of the half-lives of the isotopes. The consequence is that the correction for environmental  $^{230}\text{Th}$  is not necessary. (Edited author abstract) 10 refs.

Van Der Wijk, A. (Univ of Groningen, Groningen, Neth); Mook, G.; Ivanovich, M. *Sci Total Environ* v 70 Mar 1988, Environ Radiochem Anal, Proc of the Fifth Symp, Harwell, Engl, Oct 1-3 1986 p 19-40.

## Biodegradation

**077111 GENERATION OF GASES IN THE BIOCHEMICAL TRANSFORMATION OF THE ORGANIC MATTER OF PEAT.** In the laboratory modeling of the biochemical transformation of the organic matter of peat, the scales and dynamics of the generation of gases have been determined and their composition has been studied. The nonuniform evolution of gases with time has been shown. The gas-generating potential of the top 10-cm layer of sediment in the initial stage of transformation has been estimated theoretically. (Author abstract) 12 refs.

Rogozina, E.A.; Norenkova, I.K.; Vil'tovskaya, S.V.; Kostyunicheva, E.V. *Solid Fuel Chem* v 21 n 2 1987 p 27-31.

## Briquetting See COKE—Briquetting.

## Calorific Value

**077112 SUON ENERGIASISALLON LASKEMINEN TURPEEN VESIPITOISUUDEN JA MAATUMISASTEEN PERUSTEELA.** [Calculation of the Energy Content of Peat Deposits on the Basis of the Water Content and Humification Degree of Peat]. The study presents formulae derived from extensive data for calculating the energy content of peat deposits in areas of raised bogs and aapa mires. Various properties of peat (water content, degree of humification and ash content) are studied for their influence on energy content in Sphagnum and Carex predominant peats. The effect of contributory peat factors is discussed, and attention is also paid to changes in water content, structure of peat, ash content and heating value as humification advances. 13 refs. In Finnish.

Makila, Markku. *Tutkimusrap Geol Tutkimuskeskus* n 77 1987 p 1-35.

## Chemical Analysis

**077113 STUDIES OF THE STRUCTURE OF PEAT HUMIC ACID (III) - STRUCTURAL ANALYSES OF THE PRODUCTS OF REDUCTION OF PEAT HUMIC ACID WITH SODIUM AMALGAM BY  $^{13}\text{C}$ ,  $^1\text{H}$ -NMR SPECTROSCOPY.** Ethanol-soluble reduction products of peat humic acid have been characterized by means of  $^{13}\text{C}$ - and  $^1\text{H}$ -NMR spectroscopic technique. The reduction of peat humic acid with sodium amalgam was carried out in 0.5 N sodium hydroxide aqueous solution at  $100^\circ\text{C}$  for 4hr in a stream of nitrogen. Thus two parts of the ethanol-soluble humic acid and the ethanol-insoluble humic acid were obtained; the total yield of the ethanol-soluble humic acid, namely fulvic acid, in four reductive reactions was 43%. By using the results of  $^{13}\text{C}$ -NMR spectra on a combination with  $^1\text{H}$ -NMR results, the structural parameters such as  $f_{\text{ar}}$ ,  $\text{H}_{\text{ar}}/\text{C}_{\text{ar}}$  and  $\delta$  were calculated. It was concluded that the fulvic acid was obtained by reduction of peat humic acid, the ratio of aromatic carbon atoms to all carbon is about 50%, and the acids have mainly mono-ring systems with a few naphthalene units in the aromatic constitution. (Edited author abstract) In Japanese. 27 refs.

Oka, Hiroshi (Kitami Inst of Technology, Jpn); Funaki, Minoru; Yokoyama, Susumu; Sanada, Yuzo. *Nenryo Kyokai Shi* v 67 n 4 Apr 1988 p 231-240.

## Classification

**077114 NOTE ON THE CLASSIFICATION OF PEAT.** The difficulties involved in a generally acceptable classification of peat are described. A compromise morphological definition of peat is proposed. 4 refs.

Hobbs, N.B. (Soil Mechanics Ltd). *Geotechnique* v 37 n 3 Sep 1987 p 405-407.

## Compaction

**077115 DEWATERING AND COMPACTION OF WET PEAT BY MECHANICAL METHODS.** The production of fuel peat involves both mechanical and thermal dewatering, and to minimise the operating cost, a high solids content of the pressed cake is important. Since peat is a highly compressible material, the application of pressure and pressure level during the wet pressing operation has a fundamental impact on the dewatering result. It was found that a low initial dry solids content obtained by diluting the peat to form a slurry resulted in a lower final dry solids content. It was also found that the use of polyelectrolytes rendered a final dry solids content comparable to that obtained with no polyelectrolyte added, in spite of the positive effects found regarding the compressibility, filtration resistance and particle size distribution. (Author abstract) 5 refs.

Muenter, M. (Chalmers Univ of Technology, Goteborg, Swed); Gren, U. *Filtr Sep* v 25 n 3 May-Jun 1988 p 180-182.

## Compressibility

**077116 COMPRESSIBILITY PROPERTIES OF A HORTICULTURAL PEAT.** The compressibility of a typical horticultural peat has been studied in the laboratory. Compressibility is an important factor in the processing of this material single volume governs the cost of shipping. The final reconstituted volume and the appearance of the peat after shipping must also be taken into account for marketing. Compression tests have been carried out on a horticultural peat from Newfoundland. Simple equations relating initial water content, relative volume change, and vertical applied pressure are proposed. A fluff factor has been defined, and it was found to decrease with the maximum applied pressure. Finally the results obtained in the laboratory are applied to storage and processing examples that are encountered in the horticultural peat industry. (Author abstract) 4 refs.

Morin, Pierre (Memorial Univ of Newfoundland, St. John's, Newfoundl, Can). *Geotech Test J* v 11 n 1 Mar 1988 p 44-48.



## Dispersions

**077117 INFLUENCE OF DISPERSION ON THE PROPERTIES OF PEAT AND ACTIVE CARBONS.** The influence of mechanical action on peats of different botanical compositions on their dispersion in ball mills and vibromills has been studied. It has been shown that the type of dispersing apparatus and the degree of grinding have an influence on the X-ray structural characteristics, on the content of phenolic hydroxy groups, and on the behavior of the materials on thermal treatment. The mechanochemical degradation of peats undergoing dispersion has considerable effect on the properties of the adsorbents obtained from them. (Author abstract) 15 refs.

Khonyak, V.P.; Mazina, O.I. *Solid Fuel Chem* v 21 n 3 1987 p 78-83.

## Drying

**077118 ARTIFICIAL DEWATERING OF PEAT: PART 2. THE STRUCTURE OF FINNISH PEAT AND ITS INFLUENCE ON WATER RETENTION.** The water-binding properties of peat were studied with six peat samples from two peat production areas in Finland. The samples represented the two main types of Finnish peat, Sphagnum and Carex. The water-retention capacities measured for the samples varied strongly with the dewatering procedure. A direct connection between water-retention capacity and the physical and chemical properties was thus difficult to establish. Pressing without the addition of a flocculant was the most effective dewatering method for low-humidified peats with large mean particle size and low carbon content. The effect of pressing on Sphagnum peat samples could be predicted from the infrared spectra. Medium and highly humidified peats were more effectively dried by water suction, suggesting that the methods may complement each other. If a flocculant is not used, water suction drying would seem to give slightly higher dry peat contents than pressing. (Edited author abstract) 32 refs.

Aho, Martti (Technical Research Cent of Finland, Espoo, Finl); Laiho, Raija; Tummavuori, Jouni. *Valt Tek Tutkimuskeskus Tutkimuksia* 494 Aug 1987 58p.

**077119 KEINOTEKOINEN VEDENPOISTO TURPEESTA: OSA 3. MEKAANINEN VEDENEROTUS.** [Artificial Dewatering of Peat: III. Mechanical Dewatering]. The capability of a screen belt press to remove water especially from well decomposed Finnish peat was investigated in this study. The most important result was obtained when well decomposed peat fed as slurry was dewatered by a production-scale mechanical screen belt press with a capacity of 400 kg DS/hm to a moisture content of 30%. This result was obtained by combining several treatments promoting water release, the most important of which were the use of a thick slurry (dry solid content > 10%), the use of an anionic flocculation chemical (dosage < 1 kg/t dry solids) and the preheating of the slurry. It is possible to obtain an even higher capacity without decreasing the dry solid content of the pressing cake, because the velocity of the belt was only 5 m/min. It already approached a commercially profitable pressing process. A dry solid content of 35% was obtained by a high pressure production-scale screen belt press, but the capacity remained at 300 kg DS/hm due to damage to the device. In Finnish. 53 refs.

Pirkonen, Pentti (Technical Research Cent of Finland, Finl); Luukkainen, Veli-Matti. *Valt Tek Tutkimuskeskus Tutkimuksia* 501 Oct 1987 139p.

**077120 CHARACTERIZATION AND QUANTIFICATION OF CHANGES OCCURRING IN THE LOW-SEVERITY DEWATERING OF PEAT.** The rapid passage of peat slurries through nozzles disrupts the ultrastructure of the peat substrate and facilitates solution of key components resulting in changes of hydrophilicity. Improved dewaterability can thus be achieved. Characterization of the chemical changes occurring in peat and the development of a simple yet quantitative procedure to account for dewaterability are discussed in this presentation. The carbohydrate content is used as marker for the

chemical changes. (Author abstract) 8 refs.

Leger, S. (Univ de Sherbrooke, Sherbrooke, Que, Can); Chornet, E.; Overend, R.P. *Int J Coal Geol* v 8 n 1-2 Jun 1987, Sel Pap from the Symp 'Peat: Geochem, Res and Util', Miami Beach, FL, USA p 135-146.

## Energy Utilization

**077121 ENERGIAN TUOTANTO TURPEESTA KETJUJEN VERTAILUMENETELMA.** [Energy Production from Peat. Method of Comparing Production Chains]. A method has been developed for comparing energy production chains for research allocation. The method has been applied to comparison of district heating chains (capacity of 3-10 MW) which use peat as fuel. The energy production chains to be compared are on different technical levels: some of them are commercially available and the rest may be in commercial use within 5-20 years. The chains have been planned as operating entities, which has presupposed a choice of activity ranking and compatibility of subprocesses. A comparison is made of the technical characteristics and the price of heat of the various chains. On the basis of this comparison, conclusions are drawn about the problem areas of the energy chains and about the possibilities of further research. In addition, the usability of the method has been evaluated and has been found to be very good. (Edited author abstract) In Finnish. 31 refs.

Pesonen, Pekka (Technical Research Cent of Finland, Espoo, Finl); Hallikas, Jarmo; Asplund, Dan. *Valt Tek Tutkimuskeskus Tutkimuksia* 499 Sep 1987 89p.

## Extraction

**077122 PRESENCE OF CAROTENOIDS IN PEAT WAX.** Fractions enriched with carotenoids have been isolated from an ethanolic extract of the resinous part of peat wax and investigated. The presence of oxygen-containing carotenoid compounds of the type of fucoxanthins has been shown. (Author abstract) 6 refs.

Yurkevich, E.A.; Dolidovich, E.F.; Bel'kevich, P.I.; Shemet, L.S.; Drozdovskaya, S.V. *Solid Fuel Chem* v 21 n 3 1987 p 15-17.

## Fractionation

**077123 STUDIES OF PEAT AS THE INPUT TO COALIFICATION, II. SAMPLING SITES AND PRELIMINARY FRACTIONATION.** Five investigation sites in the Florida Everglades and Okefenokee Swamp have been selected in which the present vegetational cover includes a gymnosperm and various monocotyledonous and dicotyledonous angiosperms, and cores have been obtained that represent complete profiles from surface to underlying inorganic sediment. Since previous methods of fractionating peat were regarded as unsatisfactory for various reasons, a purely mechanical technique has been used in which organized plant tissue is separated from fine-grained humic matter by slurrying the peat samples in an excess of water and passing the slurry through standard 20 and 80 mesh sieves. (Edited author abstract) 16 refs.

Spackman, W. (Pennsylvania State Univ, University Park, PA, USA); Ryan, N.J.; Rhoads, C.A.; Given, P.H. *Int J Coal Geol* v 9 n 3 Mar 1988 p 253-265.

## Geochemistry

**077124 SELECTED PAPERS FROM THE SYMPOSIUM 'PEAT: GEOCHEMISTRY, RESEARCH AND UTILIZATION' (PART OF THE 189TH ACS NATIONAL MEETING).** This conference proceedings contains 12 papers. Individual papers are abstracted and indexed separately. Topics covered include: an overview of peat research, utilization and environmental considerations; early diagenesis of organic matter; microscopic investigation of woody tissues in peats; contributions of plant polymers to coal formation; analysis of wax and resin components from Minnesota peat bog; peat beneficiation; bitumen and wax yields from untreated peats; peat dewatering; atmospheric chemicals deposited on a moun-

tain top peat bog; relationship between peat geochemistry and depositional environments; and comparison of data from a New York mining operation. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10582 in the Ei Engineering Meetings (TM) database produced by Information Engineering, Inc.

Boron, David J. (Ed.) (Virginia Polytechnic Inst & State Univ, Dep of Mining & Minerals Engineering, Blacksburg, VA, USA). *Int J Coal Geol* v 8 n 1-2 Jun 1987, Sel Pap from the Symp 'Peat: Geochem, Res and Util', Miami Beach, FL, USA 202p.

**077125 RELATIONSHIP BETWEEN PEAT GEOCHEMISTRY AND DEPOSITIONAL ENVIRONMENTS, CRANBERRY ISLAND, MAINE.** The Heath, Great Cranberry Island, Maine, offers a unique locality for studying lateral and vertical relationships between radically different peat types within 1 km<sup>2</sup>. The majority of The Heath is a Sphagnum moss-dominated raised bog. Surrounding the raised bog is a swamp/marsh complex containing grass, sedge, Sphagnum moss, alder, tamarack, and skunk cabbage. Swamp/marsh-deposited peat occurs both around the margins of The Heath and under Sphagnum-dominated peat, which was deposited within the raised bog. A third peat type, dominated by herbaceous aquatics, is presented underlying the swamp/marsh-dominated peat but is not present as a dominant botanical community of The Heath. (Edited author abstract) 11 refs.

Raymond, Robert Jr. (Los Alamos Natl Lab, Los Alamos, NM, USA); Cameron, Cornelia C.; Cohen, Arthur D. *Int J Coal Geol* v 8 n 1-2 Jun 1987, Sel Pap from the Symp 'Peat: Geochem Res and Util', Miami Beach, FL, USA p 175-187.

**077126 PRELIMINARY STUDY OF THE REFLECTANCE OF HUMINITIC MACERALS IN RECENT SURFACE PEATS.** Mean random reflectances of huminitic macerals were measured from 12 polished microtome sections of surface peats. These peats were collected from a wide variety of depositional and ecological settings, including grass/sedge environments in Florida, Nymphaea (deeper water aquatic) environments in Florida and Georgia, Sphagnum bogs in Minnesota and Maine, and various swamp-forest environments in Florida, Georgia, North Carolina, Minnesota, and New York. At least two (and occasionally as many as 4) distinct subtypes of huminitic macerals were evident in each peat sample. However, for this report all huminitic macerals were grouped into two categories (1) cell walls and cell wall fragments (humotelinites) and (2) cell fillings, secretions, or amorphous masses (humocollinites).

Cohen, A.D. (Los Alamos Natl Lab, Los Alamos, NM, USA); Raymond, R. Jr.; Archuleta, L.M.; Mann, D.A. *Org Geochem* v 11 n 5 1987, Sel of Pap from the 2nd Annu Meet of the Soc for Org Petrol, Houston, TX, USA, Nov 7-9 1985 p 429-430.

## Microscopic Examination

**077127 MICROSCOPIC INVESTIGATION OF WOODY TISSUES IN PEATS: SOME PROCESSES ACTIVE IN THE PEATIFICATION OF LIGNO-CELLULOSIC CELL WALLS.** The objective of this study is to physically define the processes active on xylem cell walls during peatification. Peatified woody fragments from various depths and environments in southwestern Florida and Okefenokee Swamp were examined microscopically in normal white light, crossed-polarized light, and incident blue light. The examination revealed that three processes were commonly active on woody cell walls during peatification: (1) alteration, (2) degradation, and (3) gelification. Each of these processes is anatomically defined and the optical characteristics of each are used to infer the chemical fate of the major cell wall polymers, cellulose and lignin, during each process. (Edited author abstract) 17 refs.

Stout, S.A. (Pennsylvania State Univ, University Park, PA, USA); Spackman, W. *Int J Coal Geol* v 8 n 1-2 Jun



1987, Sel Pap from the Symp 'Peat: Geochem, Res and Util', Miami Beach, FL, USA p 55-68.

**Moisture** See COAL—Moisture.

## Moisture Determination

**077128 MEASUREMENTS OF THE EXPLOSIBILITY OF PEAT DUST.** Results from dust explosion tests carried out with peat dust samples are reported. The maximum explosion pressure and the  $K_{St}$  value have been measured, and especially their dependences on the moisture content and mean particle size have been investigated. It is concluded that the maximum explosion pressure and the  $K_{St}$  value of homogeneous dry (moisture content < 35% W/W) and fine (mean particle size < 200  $\mu$ m) peat dust can be estimated with a reasonable accuracy from the moisture content and the mean particle size. For moist (moisture content > 35% W/W) and/or coarse (mean particle size > 200  $\mu$ m) peat dust, it is often possible only to predict whether the dust is explosible or not. (Edited author abstract) 5 refs.

Weckman, Henry (Technical Research Cent of Finland, Espoo, Finl). *Fire Saf J* v 12 n 2 Oct 1 1987 p 97-102.

## Pelletizing

**077129 KENTAPELLETTIEN KAYTTO JA KUSTANNUKSET.** [Use and Costs of Field Pellets]. A study was made of the storage, drying and use of peat pellets produced by the field pelletization method. In addition, a technical-economic analysis including a cost evaluation was made of the various stages of the field pelletization method. When storing peat pellets in stockpiles, losses occur due to deterioration of the topmost layer and due to crushing of the pellets. The pile must be covered so that the water vapor which rises to the topmost layer evaporates. Field pellets can be stored in standing silos; this is even cheaper than stockpiling, because no losses will occur. Field pellets can be dried in pellet form, so that they are almost equal to industrial peat pellets. In summer, cool air drying can be used, and the costs will be small. Drying around the year requires a warm-air drier. In small buildings pellets can be successfully burned only by so-called stoker burners. With these burners, however, it is possible to obtain only half the power attainable from burning dry pellets, because field pellets must stay longer at the grate than drier pellets, due to the drying process. An under feed coal-stoker is suitable, as is, for the combustion of field pellets in larger buildings. Ash removal from the boiler must be mechanical. A mechanical grate suitable for combustion of sod peat does not work well with field pellets. The ash melts into a thick layer on the grate and must be removed manually from time to time. 3 refs. In Finnish.

Oravainen, Heikki (Technical Research Cent of Finland, Espoo, Finl); Kautto, Jarmo; Linna, Veli; Orjala, Markku. *Valt Tek Tutkimuskeskus Tutkimuksia* 478 1987 126p.

## Processing

**077130 TECHNO-ECONOMIC ASSESSMENT OF HIGH-PRESSURE PEAT LIQUEFACTION.** This study is part of a research program, the aim of which is to identify the most promising process concept for the conversion of peat into transport fuels by high-pressure liquefaction. The study consists of technico-economic assessments of a base-case concept and of four sensitivity-case concepts. The products are heavy primary oils which require further upgrading into transport fuels. The designs of the processes were based on data generated in bench-scale experiments. The main results of the economic evaluation of the base-case concept are presented in terms of costs in US dollars as of mid-1985. On the basis of the results of the sensitivity studies it was concluded that thermal drying of milled peat, prior to liquefaction, is advantageous; that the concentration of peat in the feed slurry should be limited to about 30 wt% solids; that operating pressures lower than 20 MPa should be sought; and that the economics of the process are not sensitive to

the chosen method of separating solids from the product stream. A preliminary estimate of the costs of upgrading the primary product into gasoline was also made. Gasoline production costs in the range 10 - 12 USD/GJ were obtained for the base case. This is a promising result, particularly when the Finnish refinery price (exclusive of taxes) is used as a reference. (Edited author abstract) 20 refs.

McKeough, Paterson (Lab of Fuel Processing & Lubricant Technology, Finl); Tulenheimo, Virve. *Valt Tek Tutkimuskeskus Tutkimuksia* 492 Aug 1987 59p.

**077131 PEAT BENEFICIATION BY WET CARBONIZATION.** A comprehensive study of the effects of operating conditions on the wet-carbonization characteristics of Minnesota peat was conducted. Tests were conducted in a 360-kg/h continuous process research unit. The effluent process water was treated by IGT's two-phase anaerobic digestion process for energy recovery. This process maximizes the production of methane and minimizes hydraulic retention times in the digesters. An integrated wet-carbonization process to produce a solid peat fuel with energy and by-product recoveries from the liquid effluent streams has been developed. This paper discusses the work accomplished in this study. (Edited author abstract) 3 refs.

Lau, Francis S. (Inst of Gas Technology, Chicago, IL, USA); Roberts, Michael J.; Rue, David M.; Punwani, Dharam V.; Wen, Wu-Wey; Johnson, Paul B. *Int J Coal Geol* v 8 n 1-2 Jun 1987, Sel Pap from the Symp 'Peat: Geochem, Res and Util', Miami Beach, FL, USA p 111-121.

**077132 BITUMEN AND WAX YIELDS FROM WET-CARBONIZED, HYDROLYZED AND UNTREATED PEATS.** A reed-sedge peat from Northern Minnesota was used to determine the effects of hydrolysis and wet carbonization on the yield and quality of peat waxes extracted with various solvents. The purpose of the study was to evaluate the potential for producing commercial waxes from Minnesota peat and the possibility of combining peat waxes and fuel processes. Air-dried peats extracted with five different solvent systems yielded total bitumens of 1.4 to 7.1 wt.% of the dried peat and waxes ranging from 1.1 to 4.7%. Hydrolysis and wet carbonization of peats prior to bitumen extraction resulted in yields which increased by factors of 2-3 $\times$ . In general, polar solvents gave higher yields than nonpolar solvents, but the wax melting points and acid values were higher with polar solvents. Bitumen extraction reduced the energy values of residual peat solids by 10-15%. (Author abstract) 10 refs.

Spigarelli, S.A. (Bemidji State Univ, Bemidji, MN, USA); Chang, F.H.; Kumari, D. *Int J Coal Geol* v 8 n 1-2 Jun 1987, Sel Pap from the Symp 'Peat: Geochem, Res and Util', Miami Beach, FL, USA p 123-133.

## Production

**077133 RAKEISEN TURVETUOTTEEN OMINAISUUDET JA TUOTANNON PERUSTEET.** [Properties and Principles of Production of a Granulated Peat Product]. The aim of this research project was to make milled and sod peat production methods more similar. In this way weather dependence could be reduced and better shrinkage properties achieved. The basic techniques of production and the properties of the granular peat product were studied. The methods employed are derived from modern milled and sod peat production, field granulation and pelletizing methods. Some new laboratory and field research equipment had to be developed and manufactured. These tools were used in experiments when searching for the best methods and technologies for harvesting peat. In all of the tests of various methods and techniques those technical parameters by means of which it was possible to make granules from different types of peat were determined. The properties of granules made by all of these methods were quite similar to each other and to the properties of sod peat. Therefore, in principle, any of the tested methods could be the basis for the future planning of actual field equipment. (Edited author abstract) In Finnish. Refs.

Lindh, Tuulikki; Perttala, Tarja-Liisa; Erkkila, Ari. *Valt Tek Tutkimuskeskus Tutkimuksia* 475 Apr 1987 96p.

**Pyrolysis** See Also LIQUID FUELS—Production.

**077134 FLASH-PYROLYSIS OF PEAT, WOOD, BARK AND LIGNIN: PART 2. PYROLYSIS TEST WITH FINNISH PEAT AT THE UNIVERSITY OF WATERLOO.** This publication deals with flash pyrolysis tests carried out with Finnish Peat in fluidized bed reactors at the University of Waterloo, Canada. A bench-scale unit (10-100 g/h) was the main tool in this test program. In one experiment a larger (pilot) unit (1-3 kg/h) was employed. The main objective of the work was to investigate the effects of temperature (range 450-750°C), reactive atmosphere (nitrogen, methane), and gas-phase residence time (0.30-1.00 s) on the organic liquid yields. The pilot run was done at near optimal conditions to produce a larger quantity of organic liquid. The highest yield of recovered organic liquids, about 50 wt-% of moisture- and ash-free raw material, was found at 450-475°C. The organic liquid yield decreased quickly in favor of gaseous components, such as carbon monoxide and hydrocarbons. The maximum yield of light olefins was found to be about 10 wt-% at the highest temperature employed (750°C). Methane was an inert reaction gas in the conditions of these tests. The total recovery of pyrolysis products was excellent, typically 98-100%. (Edited author abstract) 9 refs

Piskorz, Jan (Technical Research Cent of Finland, Finl); Scott, Donald S.; Westerberg, Ian B.; Arpiainen, Vesa. *Valt Tek Tutkimuskeskus Tutkimuksia* 507 Oct 1987 36p.

**077135 FLASH PYROLYSIS OF PEAT IN A FLUIDIZED BED.** It is shown that high yields of oil can be obtained from a good quality peat by fast pyrolysis in an atmospheric pressure fluidized bed reactor. Maximum oil yields were obtained at about 500°C with an apparent vapor residence time of 0.5 seconds or less. At these conditions, on a m.a.f. basis, yields of tar were about 47-50%, gas about 13%, char 28-32% and product water about 12%. The atomic H/C ratios of both char and tar tended to decrease as temperature increased. Oxygen content of the oil decreased also with temperature and was about 24% at optimum conditions. The pyrolysis oil from peat can probably be used successfully as a substitute fuel oil, or possibly converted to higher quality fuels. (Author abstract) 6 refs.

Scott, Donald S. (Univ of Waterloo, Waterloo, Ont, Can); Piskorz, Jan; Westerberg, Ian B.; McKeough, P. *Fuel Process Technol* v 18 n 1 Mar 1988 p 81-95.

**077136 STUDY OF THE FATE OF PLANT POLYMERS IN PEATS BY CURIE-POINT PYROLYSIS.** Four cores of peat from the Florida Everglades and one from the Okefenokee Swamp, Georgia, have been studied to clarify the roles of plant polymers as input to coalification. Curie-point pyrolysis/mass spectrometry with multivariate statistical analyses, supplemented by Py/GC and Py/GC/MS, revealed differences in chemistry between peats derived from different types of plants. Some  $\alpha$ -cellulose is presented in the upper levels of the peats, but the polysaccharide content decreases markedly with depth. Pyrolysis products contain many phenolic structures related to lignin monomers, the distribution of which changes with depth and in peat fractions of different particle size. The results demonstrate that the pyrolysis techniques are indeed valuable means of studying structural features of peats. (Edited author abstract) 26 refs.

Ryan, Nancy J. (Pennsylvania State Univ, University Park, PA, USA); Given, Peter H.; Boon, Jaap J.; De Leeuw, Jan W. *Int J Coal Geol* v 8 n 1-2 Jun 1987, Sel Pap from the Symp 'Peat: Geochem, Res and Util', Miami Beach, FL, USA p 85-98.



**077137 PYROLYSIS AND COMBUSTION OF PEAT AND WOOD AS SINGLE PARTICLES AND AS A LAYER.** This work was carried out in order to characterize the burning and emission properties of peat and wood in grate combustion simulators to assist the development of grate-based burners by improving air feeding. Scandinavian peat and wood give higher yields of volatile products and generally contain less inorganic matter and sulfur than coals of various grades. The nitrogen content can be high in peat (up to 3% by weight). Moreover, the moisture content of wood and extruded peat varies over a wide when burned. Pyrolysis experiments with three peat types indicated that the concentration of nitrogen in the solid residue increased between 573 and 773 K. The burning rate was sensitive to changes in oxygen content at low temperatures and the evolution profiles of NO and CO<sub>2</sub> were very similar during flame combustion in the reactor for single particle combustion, which simulated a single fuel particle moving on a grate. 13 refs.

Aho, Martti (Technical Research Cent of Finland, Jyväskylä, Finl). *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 149-162.

## Research

**077138 OVERVIEW OF PEAT RESEARCH, UTILIZATION, AND ENVIRONMENTAL CONSIDERATIONS.** The peat reserves in this country represent a vast resource for fuel and for chemical feedstock. As a fuel for combustion, peat generally has a low to moderate sulfur content (0.5-3.0% on a dry basis), a low to high ash content (5.0-20% on a dry basis), and an intermediate Btu content (6,000-10,000 per pound on a dry basis). As a chemical feedstock, peat can be extracted to provide various aliphatic, cyclic, and aromatic compounds, particularly oxygenated derivatives of these. Because of its chemical structure, peat provides a suitable feedstock for gasification not only for energy production but also for the synthesis of more complex compounds. The objective of this study is to provide some background information on peat and to overview select research, utilization, and environmental considerations involving peat. (Edited author abstract) 71 refs.

Boron, David J. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Evans, Earl W.; Peterson, Jeffrey M. *Int J Coal Geol* v 8 n 1-2 Jun 1987, Sel Pap from the Symp 'Peat: Geochem, Res and Util', Miami Beach, FL, USA p 1-31.

**077139 EARLY DIAGENESIS OF ORGANIC MATTER IN A SAWGRASS PEAT FROM THE EVERGLADES, FLORIDA.** The transformation of plant biopolymers to humic substances in peats during early diagenesis is a critical but poorly understood step in the formation of coal. This paper presents results concerning the structural interrelationships among various fractions of the organic matter in peat and the dissolved organic matter in the pore water from a site in The Everglades, relying primarily on elemental analysis and <sup>13</sup>C nuclear magnetic resonance for structural elucidation. Our goal was to obtain some insight into the sequence of steps involved in the formation of humic substances. Results show that the major change occurring in the whole peat during diagenesis is loss of carbohydrates. The components of the peat which are more resistant to microbial degradation become concentrated in the humic fraction. (Edited author abstract) 45 refs.

Orem, W.H. (US Geological Survey, Reston, VA, USA); Hatcher, P.G. *Int J Coal Geol* v 8 n 1-2 Jun 1987, Sel Pap from the Symp 'Peat: Geochem, Res and Util', Miami Beach, FL, USA p 33-54.

**077140 ANALYSIS OF WAX AND RESIN COMPONENTS FROM MINNESOTA PEAT BOG.** A peat sample from a Minnesota (St. Louis County) bog was examined for waxy and resin components by extraction with petroleum ether (35-60°), chloroform and ethyl acetate. The waxy solids were separated from the resins by crystallization from methanol at 0°C. A sample of wax was

saponified with 0.5 N NaOH for 4 h. Wax, resin, unsaponified and saponified fractions were analyzed with a Hewlett-Packard Model No. 5995 MS/GC/DA system equipped with a fused-silica capillary column, internally coated with SE-30. All fractions contained C<sub>21</sub> through C<sub>27</sub> alkanes, n-alcohols, straight-chain fatty acids, phenolic acids, polynuclear aromatic hydrocarbons and triterpenoids. Many of the compounds isolated and identified have not been previously reported in peat analyses. (Author abstract) 10 refs.

Kumari, Durga (Bemidji State Univ, Bemidji, MN, USA). *Int J Coal Geol* v 8 n 1-2 Jun 1987, Sel Pap from the Symp 'Peat: Geochem, Res and Util', Miami Beach, FL, USA p 99-109.

## Sampling

**077141 DISTRIBUTION OF BASE METALS IN PEAT NEAR A SMELTER AT FLIN FLON, MANITOBA.** Peatlands were sampled within 250 km radius of Flin Flon, Manitoba where a smelter was a source of base metals in particulate emissions. Increased Zn, Pb, Cu, and As concentrations were found in the surface peat up to 100 km from the source, decreasing exponentially away from the source. The upper part of the peat deposits is enriched with base metals. The vertical distribution pattern in the peat suggests in situ accumulation of base metals with little or no downward translocation. (Author abstract) 18 refs.

Zoltai, S.C. *Water Air Soil Pollut* v 37 n 1-2 Jan 1988 p 217-228.

Scotland See RUNOFF.

## Specific Heat

**077142 EXPERIMENTAL STUDY OF THE TEMPERATURE DEPENDENCE OF THE EFFECTIVE HEAT CAPACITY OF PEAT.** A study has been made of the temperature dependence of the effective specific heat capacity of organic sorbents (peats of different composition and properties). The characteristic features of the phase transitions of free and bound moisture in the material have been established over the temperature range of 223 to 313°K. Examination of the results shows that the behavior of all the curves of the experimental dependence of the effective specific heat capacity of peat on the temperature is similar for all moisture contents. For the water-saturated samples of the lowland sedge-hypnum, pine-cotton-grass highland, and lowland sedge peats over the temperature range 268-273°K sharp maxima are observed on the heat capacity curves that reach values of 68, 24.5, and 40 kJ (kg·K), respectively. (Edited author abstract) 11 refs.

Gamayunov, N.I. (Kalinin Polytechnic Inst, USSR); Krykanova, O.N.; Stotland, D.M. *Colloid J USSR* v 49 n 1 Jan-Feb 1987 p 111-115.

## Spectroscopic Analysis

**077143 CHARACTERIZATION OF PEAT SAMPLES BY DIFFUSE REFLECTANCE FT-IR SPECTROSCOPY.** A Fourier transform infrared spectroscopic study of Sphagnum peat, Carex peat, and mixtures of these peat types is reported. Intensity values from selected wavenumber regions of the infrared spectra were correlated with calorific value, degree of decomposition, carbon, and nitrogen content, and content of amino acids and amino sugars, with the use of the method of partial least-squares modelling with latent variables (PLS). The application of this method is shown to give valuable information about properties of peat which have no easily measured quantitative relationship to the infrared spectrum. (Author abstract) 35 refs.

Holmgren, Allan (Univ of Umea, Umea, Sweden); Norden, Bo. *Appl Spectrosc* v 42 n 2 Feb 1988 p 255-262.

## Surface Properties

**077144 SURFACE AND COLLOID CHEMISTRY OF PEAT AND PEAT DEWATERING. ELECTROSTATIC EFFECTS.** A study of the potentiometric titration and metal ion binding properties of peat is reported. Peat is found to behave as a typical polyelectrolyte system which, especially at higher pH, can be very highly charged. For the analysis of potentiometric titrations, a theoretical model is developed. The electrostatic potential on the surface is calculated using the Poisson-Boltzmann equation. (Edited author abstract) 18 refs.

Andreasson, A. (Univ of Lund, Lund, Sweden); Jonsson, B.; Lindman, B. *Colloid Polym Sci* v 266 n 2 Feb 1988 p 164-172.

## Testing

**077145 PHYSICAL PRINCIPLES OF AN IR PEAT WATER-CONTENT METER.** The author examined cut peat of upland and lowland types with degrees of decomposition R from 5 to 45%, absolute water contents W from 0.2 to 5 kg/kg, and weighted-mean particle diameters d from 0.25 to 17.5 mm. They ranged in wavelength λ from 0.4 to 2.5 μm. The spectral reflectivity Rλ was measured with a SF-4A spectrophotometer. A difference from existing IR water-content meters is that in this study multiwave IR methods are used. Water contents are measured with these instruments as follows: The specimen is exposed to an integral IR flux. The long-wave limit corresponds to the maximum wavelength that can be recorded by the FSA photoresistors used in these instruments, while the short-wave limit is the upper end of the visible region. The reflected IR radiation provides information on two phases. Then the same specimen is exposed to IR radiation previously passed through a filter, which is a cylindrical cell transparent to the IR filled with a thin layer of water (1-2 mm). The reflected signal then provides information only on the solid phase, since the IR radiation that interacts with the water is cut off. The ratio of the two IR fluxes gives the water content. The main advantages of this method are that no contact is required, the throughput is high, recalibration is rapid, and the readings are independent of the poured density and temperature. 11 refs.

Afanas'ev, A.E.; Arkhipov, G.A.; Tsvetkov, I.I. *Meas Tech* v 29 n 2 Feb 1986 p 152-156.

**077146 COMPARISON OF BULK AND ELUTRIATE TEST DATA FROM A NEW YORK PEAT MINING OPERATION: LEACHABILITY OF SELECTED TRACE ELEMENTS.** Bulk and elutriate test data from 43 depth-composited cores in 3 New York, USA, peat deposits are compared in order to evaluate the leachability of 11 metals under simulated stormwater runoff conditions. Synthetic rain water was used to simulate the type and quality of water which interacts with the peat during stockpiling and mining operations. Bulk analysis data revealed elevated concentrations of chromium, iron, lead, and manganese in the peat deposits. Elutriate test data indicates that iron and manganese are easily leached and may be mobile under the proposed site drainage plan. (Edited author abstract) 13 refs.

McNeill, D.F. (Environmental Science & Engineering Inc, Gainesville, FL, USA); Kinsley-Momberger, R.J. *Int J Coal Geol* v 8 n 1-2 Jun 1987, Sel Pap from the Symp 'Peat: Geochem Res and Util', Miami Beach, FL, USA p 189-202.

## Thermal Effects

**077147 THERMAL DEWATERING OF CHATHAM ISLANDS PEAT.** The utilisation of the waxy peat deposits on the Chatham Islands as a synchrone resource through char pyrolysis would require the removal of large quantities of water. Conventional methods of dewatering by pressing followed by thermal drying are likely to be uneconomical. The most attractive alternative method investigated so far is the Evans-Siemon process, which involves liquid-phase removal of moisture under pressure at a temperature of order 250°C. The required moisture



level of 0.1 kg/kg or lower was achieved by heating a sample of moorland peat for 13.5 min at a temperature of 250°C and allowing the peat to cool with the minimum of reabsorption of moisture liquid. (Author abstract) 11 refs.

Keey, R.B. (Univ of Canterbury, Christchurch, NZ); Lu, J. Vernon. *NZ J Technol* v 3 n 3 1987 p 165-168.

## Thermodynamics

**077148 WET PEAT POWER PROCESSES: A THERMODYNAMIC STUDY.** The efficiencies of four power processes for wet peat have been studied. These include gas turbine cycles, steam power cycles, and combinations thereof. It is concluded that wet peat can be used in power processes with reasonable efficiency. The paper suggests that wet peat power processes could be cost competitive relative to conventional power production. (Author abstract) 6 refs.

Lyngfelt, A. (Chalmers Univ of Technology, Goteborg, Sweden); Stenberg, P. *J Eng Gas Turbines Power Trans ASME* v 110 n 2 Apr 1988 p 155-161.

**PELLETIZING** See CATALYSTS—Selection; IRON ORE PELLETS—Manufacture.

**PENDULUMS** See Also MAGNETIC MEASUREMENTS—High Temperature Effects; MECHANISMS—Control; VIBRATIONS—Damping.

**077149 ON CHELOMEY'S PENDULUM.** In 1983, a study was published of the effect of high-frequency actions on various mechanical and elastic systems. In particular, a mechanical vibrational system with two degrees of freedom was investigated which consisted of a straight rod and a ring pulled over the rod with a small clearance. The ring could move freely along the rod. The author demonstrated experimentally and by direct computer calculations that the effect of high-frequency vibrations at the hinge base of the rod could generate its overturned position in which the ring on the axis of the rod would be in a state of dynamic equilibrium. The rod would perform small, practically imperceptible vibrations relative to the system's vertical axis. This effect was discovered and described by V.N. Chelomey, a member of the USSR Academy of Sciences. This mechanical system is thus referred to as Chelomey's pendulum. (Author abstract) 6 refs.

Kurbatov, A.M.; Chelomey, S.V.; Khromushkin, A.V. *Mech Solids* v 21 n 6 1986 p 58-60.

**077150 MOTIONS OF A PLANE PHYSICAL PENDULUM WITH AN ELASTIC SUSPENSION.** The paper studies the motions of a shaft (or a plane physical pendulum) in elastic bearings in the neighborhood of the stable equilibrium position, making use of the results of studies by V.M. Starzhinskii and correcting for the gravity force. (Edited author abstract) 5 refs.

Blinov, A.P. *Mech Solids* v 22 n 1 1987 p 45-49.

**077151 MECHANICAL SYSTEM - THE PENDULUM.** The purpose of this paper is to analyze graphically the motion of pendulums. In order to do this, we have used an interactive digital computer program developed at Florida Institute of Technology which simulates an analog computer. 2 refs.

Abdo, George E. (Florida Inst of Technology, Melbourne, FL, USA). *CoED J* v 7 n 4 Oct-Dec 1987 p 32-41.

**077152 RESONANCE INTERACTION WITH RETARDATION BETWEEN A PENDULUM AND AN EXCITATION MECHANISM.** Oscillation (fundamental parametric resonance) of a pendulum with vertical vibration of its suspender induced by an electric motor with limited power. In addition to resonance interaction, we will account for variable retardations of the pendulum and the medium. Two classes of steady-state conditions are obtained and their stability is investigated. An analysis of the effect of retardations on the dynamics of the system is carried out.

Krasnopol'skaya, T.S. (Acad of Sciences of the Ukrainian

SSR, Kiev, USSR); Shvets, A.Yu. *Sov Appl Mech* v 23 n 2 Feb 1987 p 179-185.

**077153 PENDULUM WITH SUPPORT IN CIRCULAR ORBIT.** The equation of motion of a pendulum whose support is in steady circular motion is a nonlinear variation of the Mathieu form which, when linearized, becomes a nonhomogeneous Mathieu equation. For high support speeds, when the pendulum oscillates about rotating radial lines, a model of a mechanical shredder may be constructed. At low speeds, the pendulum oscillates about the vertical position, and the familiar ferris wheel may be simulated. With the aid of the symbolic program Macsyma, exact and perturbation solutions to the linearized equation are obtained over the entire stable region. A perturbation solution by the method of multiple scales is obtained for the nonlinear equation, from the high-speed range of practical shredder design to the transition range when oscillations about radial lines become unstable. (Edited author abstract) 10 refs.

Panayotidi, Tom (Perkin-Elmer, Danbury, CT, USA); DiMaggio, Frank. *J Eng Mech* v 114 n 3 Mar 1988 p 478-488.

**Applications** See Also NUCLEAR REACTORS—Measurements.

**077154 RING-SHAPED DAMPER OF NUTATION MOTION OF A ROTATING BODY.** It is known that many objects have at least one body axis stabilized in space. The most natural method of stabilization of an axis is steady rotation of the body around the selected symmetry axis. Due to the gyroscopic effect, the body becomes more resistant to the action of external moments. From the point of view of minimum power consumption, such a method of stabilization is the most preferable one especially at prolonged rotations. The author presents details of damping mechanisms which can be useful for designing such devices. 4 refs.

Gavrikov, V. *Vib Eng* v 1 n 1-4 1987 p 245-250.

## Control

**077155 ANWENDUNG VON KONTROLL-STOER-GROESSENBEOBACHTERN ZUR REGELUNG UND ZUR KOMPENSATION TROCKENER REIBUNG.** [Application of Control Disturbance Observers for the Control and Compensation of Dry Friction]. In this paper an application of disturbance observers for the control and disturbance compensation of the laboratory model 'inverted pendulum' is described. The dry friction of the pendulum sliding carriage is viewed as disturbance variable, which causes an undesirable large limit cycle and must therefore be compensated. The disturbance observer is realized as a control observer. The experimental results are presented and discussed. (Author abstract) 8 refs. In German with English abstract.

Bakri, N.; Becker, N.; Ostertag, E. *Automatisierungstechnik* v 36 n 2 Feb 1988 p 50-54.

## Control Systems

**077156 DESIGN AND SIMULATION OF CONTROL SYSTEMS OF AN INVERTED PENDULUM.** This is a preliminary study to provide useful information for the design of the control of a monocyclus which is one of the intelligent movable robots. In this paper, the two-degree-of-freedom monocyclus is modeled by an inverted pendulum with a controlling arm pivoted at its upper end. The controlling arm is rotated to give the pendulum restoring moment. The feedback control systems for the model have been designed using two methods - the pole assignment and the optimal control, respectively. Simulations of the control systems designed with the above methods are carried out on a personal computer. Although the pendulum can be stabilized with either of these methods, it is found that the optimal control method is superior to the pole assignment one, because in the former the control system can be designed to be suitably corresponding to the design demands based on definite

criterion. (Author abstract). 7 refs.

Feng, Qing (Univ of Electro-Communications, Tokyo, Jpn); Yamafuji, Kazuo. *Robotica* v 6 n 3 Jul-Sep 1988 p 235-241.

## Mathematical Models

**077157 DAMPING AND NOISE TEMPERATURE OF TORSIONAL MICROPENDULUMS.** For torsional micropendulums with a quartz suspension thread of diameter 1-10  $\mu\text{m}$ , the laws of Q-factor variation as a function of the fiber diameter, frequency, temperature, and other parameters are deduced; the noise temperature of the pendulum is measured from the amplitude fluctuations of the oscillations. (Author abstract) 6 refs.

Mitrofanov, V.P.; Ponomareva, O.I. *Moscow Univ Phys Bull* v 42 n 5 1987 p 26-30.

**Oscillations** See Also OSCILLATORS—Variable Frequency.

**077158 SELF-EXCITED OSCILLATORY INSTABILITIES AND SKEW-SYMMETRIC COUPLING.** Non-conservative, position-dependent forces - called 'follower forces' by some - are common in mechanical systems but not easily identified or distinguished from potential forces by the novice, whether physically or analytically. Their physical effect in inducing self-excited vibration is especially difficult to visualize. A very simple, articulated pendulum is described, upon which is impressed a follower force, providing an intuitive illustration of how such a force modulates the vibratory response of the pendulum. A linear analysis is provided, too, which highlights the symmetry properties of the equations of motion of such systems, the special couplings which allow self-excitation, the unpredictable influence of damping, and the essential energy modal relationships which govern the existence of self-excitation. (Edited author abstract) 8 refs.

Crisp, John D.C. (Cambridge Univ, Engl). *Int J Mech Eng Educ* v 15 n 2 Apr 1987 p 71-90.

**077159 KAOITICNO NIHANJE FROUDOVEGA NIHALA.** [Chaotic Movement of Froud's Pendulum]. The paper describes an example of the development of chaotic movement in a system consisting of an electrically driven rotor and a pendulum which is coupled to it by a friction clutch. The solutions of the corresponding nonlinear system of motion equations are unstable. They are determined numerically and characterized by spectral distributions and by the dimensionality of the corresponding attractor. (Edited author abstract) 9 refs. In Slovenian.

Zgonc, Kornelija (Univ Edvard Kardelj, Ljubljana, Yugoslavia); Grabec, Igor. *Stroj Vest* v 34 n 1-3 Jan-Mar 1988 p 7-9.

## Stability

**077160 ON THE STABILITY OF QUASI-EQUILIBRIUM POSITIONS OF CHELOMEY'S PENDULUM.** A study published in 1983 described a paradoxical effect observed in experiments with systems containing vibrating elements. One of these effects is the hanging of a ring on a pendulum, built as a rod hinged to a vibrating base when the pendulum assumes a vertical position. In other papers the existence and stability conditions of such quasi-equilibrium positions were formulated; the pattern of these points was additionally analyzed. The present study makes an analysis of these conditions derived in a different way it also considers the case of several rings placed on the rod. (Author abstract) 3 refs.

Kirgetov, A.V. *Mech Solids* v 21 n 6 1986 p 52-57.

**077161 STOCHASTIC STABILITY OF A GYRO-PENDULUM UNDER RANDOM VERTICAL SUPPORT EXCITATION.** The mean square stability of a gyropendulum under random vertical support excitation is considered. The intensity and the correlation time of the stochastic excitations are assumed to be small in order to



obtain approximate analytical results. The stochastic averaging procedure of Stratonovich and Khasminskii is used to establish the drift and diffusion coefficients in the corresponding Ito equation. Explicit results are obtained for stochastic stability boundaries. (Author abstract) 18 refs.

Sri Namachchivaya, N. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA). *J Sound Vib* v 119 n 2 Dec 8 1987 p 363-373.

**PENSION PLANS** See WAGE PAYMENT PLANS—Legislation.

## PENSTOCKS

### Design

**077162 ZUR FRAGE DER BEMESSUNG VON DRUCKROHRLEITUNGEN AUFGRUND VON TRANSIENTEN VORGAENGEN UND NICHT-TRANSIENTEN BETRIEBSZUSTAENDEN.** [Contribution to the Problem of Penstock Design Based on Transient Processes and Non-Transient Operating Conditions]. After discussing the basic principles, the author first explains the conventional method of penstock design based on a design piezometric line, which is then determined for the penstock of a hypothetical power station. After explaining the hydraulic impedance method, the author examines the potential resonance risks from unstable control, applying the explained numerical method as well as a simulation study. It is seen that the penstock is subjected to a continuous stress of some 90 percent of the design pressure, with the number of load cycles that may be reached within a period of 5 years being as much as 2 million. In the light of this penstock designers should to the conventional water hammer analysis and the purely static design based on it. In German. 10 refs.

Fasol, K.H. *OZE Oesterr Z Elektrizitaetswirtsch* v 40 n 3 Mar 1987 p 113-114, 115-119.

### Vibrations

**077163 VIBRATIONS IN PENSTOCKS.** In spite of the fact that no international standards exist for the limits of penstock vibration, potentially dangerous vibrations can always be recognized. However, finding the source is not always possible, and in any case, it cannot always be eliminated. Detailed analysis is required to find the fundamental exciting frequency, to help identify the exciting source. Often the only solution is to modify the natural frequency of the system, as illustrated in the case study, describing experience at an Indian hydro plant. It was found that the severe penstock vibration was being caused by self-excited pressure waves, the elimination of which required either a change in length and/or diameter of the penstock, or interconnection of the penstocks, which was not considered to be feasible. The problem required structural modification of the system, as well as reinforcement of the penstocks with ring stiffeners. (Edited author abstract) 5 refs.

Bhave, S.K. (Bharat Heavy Electricals Ltd, Hyderabad, India); Acharekar, C.L.; Murthy, Ch.B.N.; Goyal, S.K. *Int Water Power Dam Constr* v 39 n 11 Nov 1987 p 41-43.

**PERCOLATION** See Also CLAY—Hydrology; IRRIGATION—Analysis; MATERIALS SCIENCE—Failure; PHYSICS—Solid State; POLYESTERS—Electric Properties; POLYMERS—Conductive; QUARRIES AND QUARRYING—Drainage; RAIN AND RAINFALL—Simulation; SEWAGE TREATMENT—Biological Treatment; WASTE WATER—Treatment.

**077164 INFILTRATION JOINING PROBLEM.** Since the 1950s there has been continuing interest in the problem of joining the intermediate-time series solution for one-dimensional infiltration and the large time traveling wave solution. In practical field terms, however, observational errors, and errors produced by minor heterogeneities and nonuniformities of initial moisture content, will be far larger than the errors of even the crudest joining technique. The practical problem thus

warrants only the minimum number of parameters and maximum simplicity. For soils which are initially relatively dry, two parameters suffice, and these are ideally taken as the physically meaningful and measurable sorptivity  $S$  and hydraulic conductivity  $K_f$ . Polynomial fractions are unsuitable; piecewise representation is simple and adequate for most purposes, but a technique using the Knight infiltration solution of J.M. Burgers' equation gives greater accuracy. It is well suited when a continuous representation and/or accuracy is desired (Author abstract) 23 refs.

Philip, J.R. (CSIRO, Canberra, Aust). *Water Resour Res* v 23 n 12 Dec 1987 p 2239-2245.

**077165 INFILTRATION CAPACITY OF DISTURBED SOILS: TEMPORAL CHANGE AND LITHOLOGIC CONTROL.** Reconstructed soils on surface mines (minesoils) of different age (1 to 4 years old) are used to investigate infiltration rates on disturbed landscapes. The data consist of soil/surface properties and runoff volumes fit to the Horton infiltration equation. Infiltration rates on newly reclaimed minesoils are an order of magnitude lower than adjacent, undisturbed soil. Multiple regressions are used to explore relationships between infiltration parameters and soil/surface properties for each soil age. Regression models of 30-min infiltration volume and the steady-state rate consistently include the percent silt and clay, slope, and bulk density, and vegetation. Mean infiltration volumes at different mines are equal in the first year following reclamation, but become significantly different with surface age. The magnitude of the increase is controlled by the soil texture, vegetation, slope, and bulk density. (Edited author abstract) 30 refs.

Jorgensen, David W. (Colorado State Univ, Fort Collins, CO, USA); Gardner, Thomas W. *Water Resour Bull* v 23 n 6 Dec 1987 p 1161-1172.

**077166 EVALUATING THE EFFECT OF PUDDLING ON INFILTRATION USING THE GREEN AND AMPT EQUATION.** After exposure to several different initial rainfall durations and rainfall sequences, the constant-head cumulative infiltration of water into disturbed Hagerstown slit loam Ap horizon soil samples of two aggregate sizes was measured. The Green-Ampt equation was fit to the cumulative infiltration data to yield hydraulic conductivity and capillary suction parameters. The conductivities and suction values obtained were unique and characteristic of the flow process for all treatments containing a surface puddle or partial surface puddle caused by rainfall energy. The infiltration responses to rainfall of 0 to 20 min duration showed that the hydraulic conductivities decreased from 576 mm/h for the no rain treatment to 5.4 mm/h for the coarse aggregates receiving 20 min of rain. For all treatments the capillary suction was very small. Flow through the surface puddle was controlled by the very thin surface layer of partially broken aggregates and primary particles. Additional study results are discussed. (Edited author abstract) 22 Refs.

Jennings, G.D. (Univ of Nebraska, NE, USA); Jarrett, A.R.; Hoover, J.R. *Trans ASAE* v 31 n 3 May 6 1988 p 761-768.

**Control** See IRRIGATION; WATER POLLUTION—Control.

**Mathematical Models** See GELS—Chemical Reactions; IRRIGATION—Analysis.

### Measurements

**077167 COMPARISON OF INFILTRATION MEASURING METHODS FOR SURFACE IRRIGATION.** Several methods for measuring the rate of infiltration in a volcanic ash soil are compared on the basis of field measurements. Methods that use stagnant water give lower values of soil infiltration rate than those that use flowing water. The performances of the Kostikov and the modified Kostikov infiltration equations are analyzed for seven methods. These equations closely match field data

collected with each technique used. Functional relationships among the infiltration rate equations are also obtained for each method of infiltration. (Author abstract) Refs.

Holzappel, Eduardo, A. (Univ of Concepcion, Chillan, Chile); Marino, Miguel A.; Valenzuela, Alejandro; Diaz, Francisco. *J Irrig Drain Eng* v 114 n 1 Feb 1988 p 130-142.

**077168 INFLOW-OUTFLOW INFILTRATION MEASUREMENT ACCURACY.** Furrow infiltration and channel seepage are often measured with inflow-outflow measurements. Inaccuracy in the flow measurement will cause a larger uncertainty in the calculated infiltration. The infiltration rate determination uncertainty increases rapidly as the percent of the inflow that is infiltrated decreases. The effect of measurement uncertainty on infiltration measurements can be estimated so that the confidence interval of a mean or the actual infiltration variability level can be determined. (Author abstract) 7 refs.

Trout, Thomas J. (USDA, Kimberly, ID, USA); Mackey, Bruce E. *J Irrig Drain Eng* v 114 n 2 May 1988 p 256-265.

**Models** See FLOW OF FLUIDS—Porous Materials.

### Prediction

**077169 PREDICTING INFILTRATION PARAMETERS FOR A ROAD SEDIMENT MODEL.** Methods for predicting Green-Ampt infiltration parameters for very coarse-textured soils are not well established. Before accurate runoff and erosion predictions can be made for these soils, a large data base and correlations to other soil properties are required. Runoff data were collected and infiltration parameters were determined for simulated rainfall events on forest roads. These results were combined with data from similar studies, and predictive equations were established for the Green-Ampt infiltration parameters using soil texture and porosity. The equations account for 70% of the variation in hydraulic conductivity and 88% of the variation in capillary suction head. (Author abstract) 17 refs.

Flerchinger, G.N. (USDA-ARS, Pullman, WA, USA); Watts, F.J. *Trans ASAE* v 30 n 6 Nov-Dec 1987 p 1700-1705.

**Simulation** See BLAST FURNACE PRACTICE—Physical Chemistry.

**PERMEAMETERS, MECHANICAL PERMEABILITY** See Also SOILS—Permeability.

**077170 WIDE RANGE PERMEAMETER FOR USE IN ROCK PHYSICS.** An apparatus was designed which was capable of measuring about 8 orders of magnitude in permeability under high confining pressure. A first version of this permeameter was built in 1981 and used for synthetic rocks (hot-pressed quartz and calcite) prepared in the laboratory to different porosities; permeability ranged from  $10^{-15}$  to  $10^{-20}$  m<sup>2</sup>. To extend this work to even less permeable samples, a second, more elaborate version capable of permeabilities as low as  $10^{-22}$  under pressures up to 200 MPa was built. The upper limit is around  $10^{-14}$  m<sup>2</sup>. This new system also enabled the pore volume changes to be measured. 8 refs.

Bernabe, Y. (MIT, Cambridge, MA, USA). *Int J Rock Mech Min Sci Geomech Abstr* v 24 n 5 Oct 1987 p 309-315.

**PEROXIDES** See Also POLYMERS—Oxidation.

**Applications** See ELASTOMERS—Curing; POLYMERS—Crosslinking.

### Chemical Analysis

**077171 ZUR COULOMETRISCHEN BESTIMMUNG ANORGANISCHER PEROXIDE.** [Contributions to the Coulometric Determination of Inorganic



Peroxides]. A coulometric titration cell, integrating the functional parts generator electrode, auxiliary electrode chamber, photometric and biamperometric flow through detector, injection valve and magnetic centrifugal pump, has been used to perform rapid titrations. The  $H_2O_2$  content of percarbonate, perborate and urea peroxohydrate was determined. A rapid peroxodisulphate titration procedure was developed. The concept of continuous set point titrations combined with a precise sample and excess reagent injection provided high precision and accuracy in the  $\mu g$  and the sub- $\mu g$  range. (Author abstract) In German. 14 refs.

Spohn, Uwe (Martin-Luther Univ Halle-Wittenberg, Halle, East Ger); Ruettinger, Hans-Hermann; Matschiner, Hermann; Thiele, Wolfgang; Wildner, Knut. *Chem Tech (Leipzig)* v 39 n 7 Jul 1987 p 284-287.

## Flammability

**077172 EVALUATION OF THE DEFLAGRATION HAZARDS OF ORGANIC PEROXIDES BY THE REVISED TIME-PRESSURE TEST.** The revised Time-Pressure test has been applied to organic peroxides to evaluate their deflagration hazards. Liquid organic peroxides were also tested successfully using a firing method with a fusehead. The results show that the ignition sensitivity and the violence of deflagration can be obtained from the amount of igniting material giving the apparent maximum rate of pressure rise, and its maximum rate, respectively. From an evaluation of the deflagration hazards of many types of organic peroxides, it is also shown that the ignition sensitivity and the violence of deflagration for each organic peroxide may have a tendency to increase with increasing active oxygen content among the same type of organic peroxide, with a few exceptions and that the ignition sensitivity and the violence of deflagration for each type of organic peroxide may decrease in the following order, given the same active oxygen content: diacyl peroxides > peroxyesters > dialkyl peroxides > hydroperoxides. (Author abstract) 11 refs.

Tamura, M. (Univ of Tokyo, Tokyo, Jpn); Ishida, H.; Itoh, M.; Yoshida, T.; Watanabe, M.; Muranaga, K.; Abe, T.; Morisaki, S. *J Hazard Mater* v 17 n 1 Dec 1987 p 89-98.

## Research

**077173 ROLE OF SEGMENTAL MOBILITY AND LOW-MOLECULAR MASS RADICALS IN THE ANNIHILATION OF POLYPROPYLENE PEROXIDE MACRO-RADICALS.** Electron paramagnetic resonance has been used to study the kinetics of annihilation of peroxide macro-radicals, formed from isotactic polypropylene, and the effect on the annihilation process of additions to the polymer matrix of low-molecular mass solvents and tert-butyl hydroperoxide. The molecular mobility of a nitroxyl radical has been studied under the same conditions and the bimolecular constant for the rate of contacts has been compared with the constant for the annihilation of peroxide macro-radicals. It is shown that the process of annihilation of macro-radicals is determined by segmental mobility together with the 'relay-race' transfer of the valency. (Edited author abstract) 24 refs.

Griva, A.P. (USSR Acad of Sciences, USSR); Denisova, L.N. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2828-2834.

## Synthesis

**077174 SYNTHESIS AND STUDY OF THE STRUCTURE OF PEROXIDE OLIGOMERS BASED ON EPOXIDE COMPOUNDS.** Stepwise telomerization of diglycidyl esters of ethylene glycol and diphenylolpropane with ethylene glycol, diethylene glycol, and diphenylolpropane at 40°C for 1 hr using tert-butyl hydroperoxide as the reaction telogen yielded oligomers with terminal peroxide groups. The synthesis of oligomers was carried out in an anhydrous chloroform medium in the presence of 7.2 mole% boron trifluoride etherate based on telogen. The structure was studied by IR and PMR spectroscopic methods, and the average degree of telomerization and functionality of the obtained oligomers were

also found. (Author abstract) 7 refs.

Bratychak, M.N.; Vostres, V.B.; Puchin, V.A.; Yablonskii, O.P. *Sov Prog Chem* v 53 n 2 1987 p 114-117.

## Thermal Properties

**077175 THERMAL STABILITY OF TERT-BUTYL HYDROPEROXIDE-ACID MIXTURES.** The behaviour of the tert-butyl hydroperoxide in presence of p-toluenesulphonic acid is studied under adiabatic conditions. The tert-butyl hydroperoxide molecule decomposes via C-O or O-O bond cleavage, depending on  $H^+$  attack. In the first case di-tert-butyl peroxide and hydrogen peroxide are produced, methyl alcohol and acetone in the second. Calorimetric measurements show an effect of the produced acetone on the stability of tert-butyl hydroperoxide. A simplified mathematical model is used to fit the experimental results. (Author abstract) 13 refs.

Andreozzi, R. (CNR, Naples, Italy); Caprio, V.; Crestielli, S.; Russo, G. *J Hazard Mater* v 17 n 3 Mar 1988 p 305-313.

**PERSONNEL** See Also AIR TRANSPORTATION—Traffic Control; DATA PROCESSING—Security of Data; EAR PROTECTORS—Classification; ENGINEERING EDUCATION—Teaching; INDUSTRIAL MANAGEMENT—Quality Assurance; SECURITY SYSTEMS; SYSTEMS SCIENCE AND CYBERNETICS—Man Machine Systems.

**077176 ERHOEHUNG DER BEREITSCHAFT DER LEITER IN FORSCHUNG UND ENTWICKLUNG ZUR ANWENDUNG VON LEISTUNGSEINSCHAEZTUNGEN.** [How to Increase the Readiness of Research and Development Department Heads to Evaluate Performance Results]. According to the investigations carried out by the authors, certain means of work have to be provided for the heads, which are in agreement with the specific demands of Research & Development. Further, it is required to include self-appreciations of the researchers increasingly and to evaluate the activity of the heads themselves both periodically and convincingly, as well as to connect the performance estimation with material incentives in a more efficient manner. (Edited author abstract) In German. 4 refs.

Fischer, Heinz (Technische Hochschule 'Carl Schorlemmer', Leuna-Merseburg, East Ger); Henning, Neithard. *Chem Tech (Leipzig)* v 38 n 10 Oct 1986 p 411-412.

**077177 MULTI-PERIOD, MULTIPLE CRITERIA OPTIMIZATION SYSTEM FOR MANPOWER PLANNING.** This paper discusses a multi-period, multiple criteria optimization system for manpower supply forecasting. The system is used to identify recruitment and promotion strategies for managing the enlisted force of the U.S. Navy. With the criteria modeled as trajectories of goal values over the multiple time periods, the system uses the interactive augmented weighted Tchebycheff method as its solution procedure. Illustrative computer results are presented. (Author abstract) 25 refs.

Silverman, Joe (US Navy Personnel Research & Development Cent, San Diego, CA, USA). *Eur J Oper Res* v 34 n 2 Mar 1988 p 160-170.

**Ability Testing** See Also AVIATORS—Accidents; DATA PROCESSING, BUSINESS—Personnel; SYSTEMS ENGINEERING—Professional Aspects; VISION—Physiology; WELDING—Quality Assurance.

**077178 TIME-SHARING REVISITED: TEST OF A COMPONENTIAL MODEL FOR THE ASSESSMENT OF INDIVIDUAL DIFFERENCES.** Five proposed components were assessed: (1) serial processing ability; (2) an internal model of the system dynamics; (3) performing heterogeneous operations; (4) adaptation to rapidly changing dynamic conditions; (5) parallel processing ability. The approach combined methodologies from experimental psychology and from individual differences research. The results of a factor analysis and a series of stepwise multiple-regression analyses revealed two important dimensions of individual differences in dual task performance: (1) individual differences in cognitive style linked to the concept of field dependence/independence;

(2) individual differences in time-sharing ability. (Edited author abstract) 27 refs.

Braune, Rolf (Univ of Illinois, Savoy, IL, USA); Wickens, Christopher D. *Ergonomics* v 29 n 11 Nov 1986 p 1399-1414.

**Accident Prevention** See FIRE PROTECTION—Australia; FORESTRY—Equipment; INDUSTRIAL PLANTS—Presses.

**Education** See Also PRODUCTION ENGINEERING—Education.

**077179 ON THE EXPERIENCE AND GOALS OF THE WORK CARRIED OUT AMONG YOUNG SCIENTISTS AND SPECIALISTS.** The primary goal of all scientists and the Soviet youth is promotion of scientific research work and provision of a decisive shift to the solution of vital practical problems significant for the country. Unification of young scientists within the task-force committee for scientific principles of occupational hygiene and pathology facilitates successful solution of topical problems. Councils of young scientists and specialists make an essential contribution to enhancing research and political activity of young scientific workers. The necessity of improving the councils' activity aimed at professional training of the youth and accomplishing close links between theory and practice is set forth. (Author abstract) In Russian.

Pankova, V.B.; Komleva, L.M. *Gig Tr Prof Zabol* n 9 1987 p 1-4.

**Equipment** See ELECTRIC LINES—Equipment.

## Evaluation

**077180 PITFALLS IN MEASURING MIS PERFORMANCE.** The techniques for evaluation of performance which are currently in use are described. Three types of pitfalls are discussed: pitfalls in the measurement itself, psychological pitfalls, and pitfalls in the evaluation interview.

Bologna, G.J. (Siena Heights Coll, Adrian, MI, USA). *Comput Secur* v 7 n 2 Apr 1988 p 137-138.

**Eye Protection** See GOGGLES—Optical Properties; LASERS, SOLID STATE—Military Applications.

## Handicapped Persons

**077181 SUBSIDIZED TECHNOLOGY AND ITS UTILIZATION: AIDS FOR THE DISABLED.** Subsidized research into advance technology is one means employed to attain social and ideological goals recognized as vital to a society. Increasing sensitivity to the social uses of technology has recently led to funding of R&D in aids for the disabled. An analysis of 89 such projects between 1979 and 1983 confirm the impact of subsidized public funding on such research, leading to a narrow focus on applied research in specific disability areas with the objective of creating a viable commercial prototype for a highly visible but extremely small number of severely disabled. Subsidized funding also reinforces specialization through selective support of projects by institutional setting. The impact of subsidized R&D for the disabled can therefore be said to be effective as an example of societal intervention in directing technological advances. (Edited author abstract) 21 refs.

Kirschenbaum, Alan (Technion-Israel Inst of Technology, Haifa, Isr). *Technol Forecast Soc Change* v 31 n 4 Jul 1987 p 335-345.

**Health** See Also ASBESTOS—Manufacture; BIOMECHANICS—Mathematical Models; BIOMECHANICS—Musculoskeletal Systems; CHEMICAL PLANTS—Accident Prevention; EARTHMOVING MACHINERY—Vibrations; FUNGICIDES—Toxicity; MATERIALS HANDLING—Pallets; MICA—Processing; MINES AND MINING—Accident Prevention; OCCUPATIONAL DISEASES; OIL WELLS—Repair; PESTICIDES—Manufacture; PETROLEUM REFINERIES—Modernization; SYNTHETIC FIBERS—Manufacture.



**077182 SIMPLE TECHNIQUE OF ASSESSING CREDIBILITY OF DIFFERENCES IN TEMPORARY DISABILITY RATES.** Recommended techniques of assessing differences in disability day rates by diseases can be used only while studying temporary disability in large population groups or under significant in large population groups or under significant rate differences. Determination of regular distribution rates of disability days by diseases offers a possibility of developing a simpler and more convenient formula for calculating a mean error and evaluating the significance of indices while analyzing temporary disease-associated disability rates in various working groups. (Author abstract) In Russian. 4 refs.

Klebanov, R.D.; Chuiko, M.P. *Gig Tr Prof Zabol* n 7 Jul 1987 p 39-42.

**077183 BENEFITS AND COST SAVINGS FROM A SMOKING POLICY.** The first section of this article describes various smoking policies and discusses their implementation. The next section on the potential cost savings from a smoking policy covers such areas as health care, disability, premature withdrawal from the workforce, absenteeism, productivity, maintenance, property damage, depreciation, insurance, and involuntary smoking. The legal implications of not having a smoking policy are discussed. 14 refs.

Longenecker, Kevin E. (Shippensburg Univ, PA, USA); Ulrich, Thomas A.; Hollon, Charles J. *SAM Adv Manage J* v 53 n 1 Winter 1988 p 23-27.

**077184 CLEAN ROOM GARMENTS - A DAY IN THE LIFE.** An experiment is described in which garments worn in a Class 100 room were tested for particulate contamination at four intervals during one day. Clean room clothing made of lightweight, cold-calendered polyester (Terylene), of pore size 20-27 micron diameter<sup>4</sup>, was processed to a mean batch particle count of 840 particles (5 microns and larger) per square foot of fabric. On the basis of the least squares correlation, the slope of the line gives a value of 592 particles per square foot per hour as the mean rate at which the outer surface of clean room garments became contaminated with 5 micron particles during active work in a Class 100 room.

Miller, William F. (MIQA, Lutterworth, Engl). *J Soc Environ Eng* v 26-4 n 115 Dec 1987 p 12-13.

**Health Care** See Also PACKING—Accident Prevention; POLYCHLORINATED BIPHENYLS—Toxicity; WELDING—Personnel.

**077185 RENDERING MEDICAL AID TO THE POPULATION AND PROBLEMS OF MEDICAL EXAMINATION OF OCCUPATIONAL DISEASES IN THE GDR.** Population health control and health care methods in the German Democratic Republic are described. Occupational disease examination, monitoring, and curing in industry are independent from industrial plants. Industrial hygiene inspection and occupational disease prevention methods are analyzed. Industrial medical personnel two-year special training courses are organized and the program highlights are included. In Russian.

Bachmann, V. *Gig Tr Prof Zabol* 10 Oct 1987 p 12-15.

**Health Hazards** See METAL FORMING—Pressing.

**Human Factors** See ENGINEERING—Project Management.

**Job Satisfaction** See Also COKE PLANTS—Personnel; MANAGEMENT—Information Systems.

**077186 PRODUCTIVITY AND JOB SATISFACTION AFTER THE INTRODUCTION OF NEW TECHNOLOGY: SOME EMPIRICAL FINDINGS FROM THE SWEDISH TRANSPORT AND ENGINEERING SECTOR.** In the transport sector the results from the empirical studies show both a gain in productivity and an improvement of job satisfaction. In the engineering industry, however, the implementation of new

technology has been prolonged to such an extent, that it is too early to make any definite judgement about the development of productivity and job satisfaction. As a conclusion based on observations during the studies reported, some fundamental job demand conditions for a positive outcome are given. (Edited author abstract)

Rubenowitz, Sigvard (Univ of Gothenburg, Goteborg, Swed); Runblad, Bengt. *Int J Prod Res* v 25 n 11 Nov 1987 p 1693-1702.

**Management** See Also DAMS—Construction; DECISION THEORY AND ANALYSIS; JOB ANALYSIS—Japan; MANAGEMENT—Education; QUALITY CONTROL—Management; TRANSPORTATION—Personnel.

**077187 HUMAN RESOURCES MANAGEMENT: THE G.N.F.C. EXPERIENCE.** GNFC, a joint sector Company manufacturing fertilizers, is now in the fourth year of commercial production. The organization has had many 'firsts' to its credit during this brief period. Effective human resources management is a major factor in this achievement. An outline is presented of the strategies used in the recruitment and training of new personnel, their training in the process licensors' plant abroad and training by process simulation. Special features of human resources management during the project stage are presented.

Bhatt, M.M. (Gujarat Narmada Valley Fertilizers Co, Narmadanagar, India). *Chem Age India* v 37 n 8 Aug 1986 p 583-586.

**077188 MAKING GROUP COLLABORATION WORK.** Collaborative group building improves the way a work unit can accomplish tasks, solve problems, and deal with related matters. In general, group members (subordinates and group leader) should always encourage and support an open dialog of ideas and thought. When an individual can demonstrate the superiority and validity of his or her ideas, the others should be sufficiently flexible to throw their support in the direction of the best decision. Members of the work unit should always be willing to consult with others in the group who have the required knowledge so that the best collaborative solution may be reached. 5 refs.

Levine, Marc (Queens Coll, CUNY, Flushing, NY, USA). *Prod Invent Manage* v 28 n 3 3rd Quarter 1987 p 31-33.

**077189 EARLY RETIREMENT OR FORCED RESIGNATION: POLICY ISSUES FOR DOWNSIZING HUMAN RESOURCES.** The impact of downsizing goes well beyond mere economic considerations. Trimming the labor force more particularly—the specific method chosen to cut staff—will affect not only the firm's economic status, but also the overall competency of the human resource group, the success of current and future business strategies, and the organization's culture and image.

Kuzmits, Frank E. (Univ of Louisville, KY, USA); Sussman, Lyle. *SAM Adv Manage J* v 53 n 1 Winter 1988 p 28-32.

**077190 SOME PRINCIPLES CONCERNING RELIGIOUS DISCRIMINATION IN THE WORK-PLACE.** This article discusses some of the principles concerning religious discrimination that have emerged from the courts, largely within the last decade. After explaining how Congress has defined 'religion' and what principles are used to determine religious discrimination, the author summarizes how these principles have been interpreted in various courts. Lastly, he offers human resource managers some recommendations on avoiding religious discrimination in the workplace.

Pullum, Stephen J. (Indiana Univ, Bloomington, IN, USA). *SAM Adv Manage J* v 53 n 1 Winter 1988 p 33-38.

**077191 MANPOWER PLANNING IN THE UNITED KINGDOM: AN HISTORICAL REVIEW.** This paper traces the growth of manpower planning in the United Kingdom from its origins in the Second World War to the present day. It identifies a series of stages, starting with the beginnings and growing awareness of the 1950s and early 1960s, which led on to an explosive

growth between 1965 and 1970, and the lengthy period of consolidation thereafter. It places on record the interest and contribution of many individuals and organizations who laid the foundations of manpower planning in this country, and review trends in methodology and the growing role of computers. The paper concludes with some notes on possible future developments. (Edited author abstract) 51 refs.

Smith, A.R. (London School of Economics & Political Science, Engl); Bartholomew, D.J. *J Oper Res Soc* v 39 n 3 Mar 1988 p 235-248.

**077192 ARMY MANPOWER LONG-RANGE PLANNING SYSTEM.** The Army Manpower Long-Range Planning System (MLRPS) provides the analytical capability to project the strength of the active U.S. Army for 20 years, thus allowing for the development of long-range manpower plans. The system's models simulate the interaction of gains, losses, promotions and reclassifications to enable the analyst to determine the impact of existing policies over the long term, and to determine changes that might be required to reach a desired force. The MLRPS currently supports the personnel planning requirements of the Army Office of the Deputy Chief of Staff for Personnel in long-range planning, policy planning and force structure analysis, and cost analysis. This article describes the system's main elements and component subsystems. (Author abstract) 9 refs.

Gass, Saul I. (Univ of Maryland, College Park, MD, USA); Collins, Roger W.; Meinhardt, Craig W.; Lemon, Douglas M.; Gillette, Marcia D. *Oper Res* v 36 n 1 Jan-Feb 1988 p 5-17.

## Mathematical Models

**077193 DYNAMICS MODEL OF THE AGE AND QUALIFICATION STRUCTURE OF A PERSONNEL SYSTEM.** Methods of the queueing theory can be used in modeling the movement of personnel, in problems of demography, etc. An organizational system based on rank was considered and moment functions were obtained for the number of personnel of various qualifications given by their ranks. In this paper we consider a more general problem concerned with the study of dynamics of an organizational system of the rank type, with the age (or the length of service) of the personnel taken into account. 1 ref.

Mudrov, V.P. *Sov J Comput Syst Sci* v 25 n 3 May-Jun 1987 p 158-162.

**Monitoring** See IRON AND STEEL PLANTS—Health Hazards.

**Motivation** See Also INDUSTRIAL HYGIENE—Personnel Training.

**077194 MANAGING CHANGE WITH PEOPLE.** Changes connected with factory automation and their effects on personnel are discussed. The success or failure, adoption or rejection of a transition, transformation or change process - regardless of form - depends on the people involved. Employees are considered as intelligent professionals who do make a contribute to overall success of the manufacturing process. Without the personal involvement of the individual, any probability for real success is impossible and the best technical or hardware-oriented plan will fail. While the new processes are planned and adopted in stages or cells, care must be taken to make sure that ultimately all of the pieces can be integrated.

Raymond, George G. Jr. (Raymond Corp, Greene, NY, USA). *Manuf Syst* v 5 n 9 Sep 1987 p 56, 58.

**Optimization** See TRANSPORTATION—Scheduling.

**Performance** See HUMAN ENGINEERING.



**Planning** See JOB ANALYSIS—Mathematical Models.

**Productivity** See HUMAN ENGINEERING—Sleep Studies; JOB ANALYSIS—Computer Aided Analysis; PRODUCTION CONTROL—Scheduling; WAGE PAYMENT PLANS.

**Protection** See DIE CASTING—Accident Prevention; RAILROADS—Personnel; WELDING—Human Factors.

**Protective Clothing** See Also BUILDINGS—Fires; ECONOMICS—Mathematical Models; PLASMA ARC CUTTING—Personnel.

**077195 MAKING SURE PROTECTIVE CLOTHING PROTECTS.** The recommendations in this article reflect the subcommittee's current direction, unless otherwise attributed to ASTM or some other source. Developing realistic standards of either the documentation or performance type entails making choices about what characteristics to test, how to test, and how extensively to test. These considerations are apparent in the chemical protective suit standards ASTM and the National Fire Protection Association (NFPA) are coming up with, which fall into four general areas: chemical resistance, physical properties, component functioning, and overall suit quality.

Stull, Jeffrey O. (NFPA). *Fire Eng* v 140 n 9 Sep 1987 10p between p 22 and 37.

**077196 HOTTER THAN HOT.** Generations of fire-fighters have tested themselves against smoke and heat, protected, for many years, by the simple barrier of a leather helmet and a canvas or rubber turnout coat. These were reliable allies against the punishing conditions of the vast majority of fires, good for temperatures reaching as high as 500°F in structural fires. Even with wraparound insulation, no one would associate the word comfort with high-temperature protective suits. Even though a shiny outer layer on some of the suits reflects a lot of heat, the heat that gets through stays inside. One thing remains the same as in the more familiar structural fire - size-up is important. Part of the size-up the identification of the sources of heat.

Grenader, Robert (Halprin Supply Co, Los Angeles, CA, USA). *Fire Eng* v 140 n 9 Sep 1987 p 39-41.

**077197 EFFECT OF MOISTURE ON THE BURN POTENTIAL IN FIRE FIGHTERS' GLOVES.** The effect of moisture on thermal protection in fire fighters' glove materials was determined during radiant and conductive heat/pressure exposure. Typical glove materials were studied with and without a Gore-Tex moisture barrier. During exposures to a radiant load of 2.3 cal/cm<sup>2</sup> sec, wetted samples provided more thermal protection than dry samples. Different results were obtained using conductive heat/pressure tests (500°C at 0.25 kg/cm<sup>2</sup> pressure): dry Gore-Tex mitts provided more thermal protection than totally wetted samples, while the reverse was true of glove materials without Gore-Tex. (Author abstract) 11 refs.

Veghte, James H. (Biotherm Inc, Beavercreek, OH, USA). *Fire Technol* v 23 n 4 Nov 1987 p 313-322.

**077198 SIMPLIFYING SELECTION OF PROTECTIVE CLOTHING.** Changes that may improve the process of selecting protective equipment are now taking place. Among recent developments in the United States are (a) the consideration of industry-wide standards for testing total-ensemble suits and documenting the results; (b) the introduction of new suit materials with unsurpassed ability to resist chemical permeation; and (c) a growing awareness of the importance of integrated equipment. Together, these developments are leading to changes that should eliminate much of the guesswork in the suit selection process.

Kairys, Christopher F. (MSA, Pittsburg, PA, USA). *Fire Int* v 11 n 107 Oct-Nov 1987 p 111-113, 116-117.

**077199 PROTECTIVE SUITS FOR CHEMICAL SPILL RESPONSE.** In their role of responding to potential or actual hazardous chemical discharges, U.S.

Coast Guard response personnel and marine inspectors need adequate protection equipment and procedures to ensure their safety. The hazards associated with chemicals require a wide range of personnel protection gear from gloves and overalls to totally-encapsulating suits with self-contained breathing systems. A Chemical Response Suit developed by the Coast Guard has been successful in meeting field protection needs. The development has been extensively supported by materials testing and evaluations of overall garment performance. Promotion of suit selection guidelines provides a consolidated information source for hazardous chemical response teams in selecting and procuring protective clothing. The development of comprehensive standards will permit all response organizations to have greater confidence in the materials and clothing they do procure. 10 refs.

Stull, Jeffrey O. (US Coast Guard Office of Research & Development, Washington, DC, USA). *Chem Eng Prog* v 83 n 11 Nov 1987 p 34-39.

**077200 CONSTRUCTION SITE WORKERS HELMETS.** Instrumented impact tests were carried out on various types of industrial safety helmets manufactured to BS5240, and force versus deflection graphs produced. A simple mathematical model was used to explain the results obtained when helmets are hit on the top. The model can then be used to protect the effect of modifying the shell stiffness or suspension stiffness. It also predicts the large force oscillations at 300 Hz caused by the striker exciting the resonant frequency of the shell mass/suspension spring system. It was concluded that while the helmets perform adequately during top impacts, the protection given at the sides, front and back of the helmet is so poor that a redesign is necessary. (Author abstract) 8 refs.

Gilchrist, A. (Univ of Birmingham, Birmingham, Engl); Mills, N.J. *J Occup Accid* v 9 n 3 Nov 1987 p 199-211.

**077201 DURABILITY OF FIREFIGHTER'S PROTECTIVE CLOTHING TO HEAT AND LIGHT.** Fabrics used in firefighter's protective clothing were exposed to simulated sunlight from a xenon arc Weather-Ometer and heat in a forced air circulating oven, and the resulting changes in properties were measured. Outer shell fabrics Of Nomex III, Zirpro flame resistant wool and PBI/Kevlar were all susceptible to light and underwent marked reductions in tensile tearing strength. Heat exposure resulted in a significant reduction in the tearing strength of all outer shell fabrics while increasing the tearing strength of moisture barrier fabrics. A polyamid/flame resistant viscose blend was extremely sensitive to heat exposure, undergoing a substantial loss in tearing strength and appreciable thermal shrinkage. Zirpro flame resistant wool was particularly sensitive to temperatures greater than 230°C. Although both light and heat caused losses in physical strength, there was no noticeable reduction in the flame resistance or thermal protective performance of the individual fabrics and garment assemblies studied. (Edited author abstract) 12 refs.

Day, M. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Cooney, J.D.; Suprunchuk, T. *Text Res J* v 58 n 3 Mar 1988 p 141-147.

**077202 PROTECTION WITH SUITS AND BREATHING APPARATUS.** This article discusses the problems associated with the combined use of breathing apparatus sets and chemical protection clothing, and means of reducing stress in fire-fighting underground. The user requirements correspond to the well-known principles for chemical protection suits. One currently available fabric combination, which was developed for firemen on the basis of these principles, consists of a chemical protection suit having an outer coat of fluorocarbon elastomer (Viton) and an inner coat consisting of chloroprene rubber. This suit represents the technically feasible compromise for a wide range of many different application criteria.

Bellamy, John (Draeger, UK). *Fire Int* v 12 n 110 Apr-May 1988 p 38-40.

**077203 SOME INDUSTRIAL AND CLIMBING**

**HELMETS SUBJECTED TO A RANGE OF IMPACT ENERGIES.** Ten types of injection molded industrial safety helmets, three types of injection molded climbing helmets, and seven types of glass fibre reinforced polyester climbing helmets have been subjected to various impact energies and the transmitted forces compared. The variation in British and foreign standards requirements for different types of helmet are discussed. Harmonisation of standards for helmets is suggested. (Author abstract). 5 Refs.

Rowland, F.J. (Safety Engineering Lab, Sheffield, Engl); Patel, B.; Keighley, J.H. *J Occup Accid* v 10 n 1 Jun 1988 p 29-37.

## Radiation Effects

**077204 BIOLOGISCHE WIRKUNG ELEKTROMAGNETISCHER 50-HZ-FELDER AUF DEN MENSCHEN.** [Biological Effects of Electromagnetic 50 Hz Fields on Humans]. For several years apprehensions have been voiced on the health dangers from the electrical and magnetic fields of plants of electricity utilities. Thermic effects, such as those from the expressly restricted high frequency fields of communications technology, are excluded from the low frequency 50 Hz fields. Dangerous irritant effects from induced body currents could not be established, despite worldwide research. Consequently, reliable evidence on the harmless limits of directly effective 50 Hz fields is today available. (Author abstract) In German. 41 refs.

Haubrich, Hans-Juergen (Vereinigte Elektrizitaetswerke Westfalen AG, Dortmund, West Ger). *Elektrozitaetswirtschaft* v 86 n 16-17 Aug 17 1987 p 697-705.

**Radiation Protection** See INDUSTRIAL HYGIENE; NUCLEAR POWER PLANTS—Accident Prevention; NUCLEAR POWER PLANTS—Maintenance; SPACECRAFT—Radiation Hazards.

**Radioactivity** See Also DOSIMETRY—Video Recording.

**077205 CONTROLLING OCCUPATIONAL EXPOSURE AT FINLAND'S LOVIISA PWRS.** The two VVER-440 PWRS at Loviisa, in commercial operation since 1977 and 1980 respectively, have distinguished themselves by recording annual collective doses, including both plant staff and outside contractors, of less than 0.9man-Sv per unit. Reasons for this low exposure include plant design features, waste handling arrangements, administrative procedures, and, perhaps most important, short annual outages. (Author abstract). 5 Refs.

Wahlstrom, Bjorn (Imatran Voima Oy, Loviisa, Finl). *Nucl Eng Int* v 33 n 409 Aug 1988 4p.

**077206 BETTER MONITORING OF PERSONNEL FOR SURFACE CONTAMINATION.** In recent years there has been a marked increase in the use of high performance installed personnel monitors employing large arrays of detectors to examine people for surface contamination automatically and rapidly. The IPM 8 from NE Technology promises improved quality of monitoring in radiation controlled zones, in temporary work areas and older buildings, as well as at main exits. (Edited author abstract).

Peel, Tom (NE Technology Ltd, Reading, Engl). *Nucl Eng Int* v 33 n 409 Aug 1988 p 50, 52.

## Rating

**077207 ENGINEERING AN APPROACH TO PERFORMANCE EVALUATIONS.** Based on performance management in engineering, it is possible to extract a new definition of performance management, which includes a pre-determined definition of performance standards, pre-defined performance levels, performance evaluated by the pre-defined standards, planning and reworking the system based upon the evaluation results. Together, these steps form this definition: performance management is the process of planning for the future, not criticizing the past. The article discusses each of these points, along with



conducting an evaluation, performance monitoring, and other aspects of the subject.

Michaels, Mark. *World Wastes* v 30 n 11 Nov 1987 p 40-41, 58.

**Safety Codes** See BUILDINGS—Fires.

**Scheduling** See Also MOTOR BUS TRANSPORTATION—Personnel.

**077208 COST OF CONSECUTIVITY IN THE (5, 7) CYCLIC STAFFING PROBLEM.** The (5, 7) cyclic staffing problem is the problem of finding the least number of workers assigned to a 7 day cyclic schedule, so that sufficient workers are present during day *i* to meet requirement *b<sub>i</sub>*, and each person works a shift of 5 consecutive days and is idle for the other 2. We derive an expression for the minimal workforce size in the problem in terms of the *b<sub>i</sub>*'s. This result is interesting because it shows the extra number of workers needed by insisting that each person's idle days are consecutive. (Author abstract) 8 refs.

Vohra, Rakesh V. (Ohio State Univ, Columbus, OH, USA). *IIE Trans* v 19 n 3 Sep 1987 p 296-299.

**077209 DYNAMIC JOB-ASSIGNMENT POLICY.** This report considers a dynamic job-assignment policy making use of online information for assignment. This policy attempts to achieve a good skill match between jobs and operators, and to eliminate unnecessary assignments. To fulfill this policy, a two-part assignment program is proposed: an algorithm for job matching and a set of ad hoc rules. The matching algorithm is well established in literature, but the ad hoc rules are application-dependent. Discussion here concentrates on the ad hoc rules and online data collection. (Edited author abstract) 5 refs.

Chow, We-Min (IBM, San Jose, CA, USA). *Int J Prod Res* v 26 n 6 Jun 1988 p 1073-1087.

**077210 GENERATING ACCEPTABLE SHIFT-WORKING SCHEDULES.** When a factory operates a shift system of working, the work patterns are usually laid down at the start and adhered to for long periods. In this case study, small out-stations with frequent changes in manning require the frequent generation of new schedules. Producing and co-ordinating such schedules with the workforce can be a time-consuming task. Hence a computer routine was devised which takes over the generation. An interesting feature is that several feasible routines are generated, allowing the final decision to be taken by the workforce itself. (Author abstract). 5 Refs.

Baxter, John (Coventry Polytechnic, Engl); Mosby, Mark. *J Oper Res Soc* v 39 n 6 Jun 1988 p 537-542.

**Security Systems**

**077211 PERFORMANCE EVALUATION OF PERSONNEL IDENTITY VERIFIERS.** Personnel identity verification devices, which are based on the examination and assessment of a body feature or a unique repeatable personal action, are steadily improving. These biometric devices are becoming more practical with respect to accuracy, speed, user compatibility, reliability and cost, but more development is necessary to satisfy the varied and sometimes ill-defined future requirements of the security industry. In an attempt to maintain an awareness of the availability and the capabilities of identity verifiers for the DOE security community, Sandia Laboratories continues to comparatively evaluate the capabilities and improvements of developing devices. An evaluation of several recently available verifiers is discussed in this paper. Operating environments and procedures more typical of physical access control use can reveal performance substantially different from the basic laboratory tests. (Author abstract)

Maxwell, Russell L. (Sandia Natl Lab, Albuquerque, NM, USA); Wright, Larry J. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 417-423.

**Selection** See AEROSPACE ENGINEERING—Professional Aspects; AIR TRANSPORTATION—Traffic Control; PETROLEUM INDUSTRY—Personnel; SPACE FLIGHT—Personnel.

**Standards** See SHIPYARDS—Production.

**Supervisory** See INDUSTRIAL PLANTS—Accident Prevention; PERSONNEL TRAINING.

**Wages** See WAGE PAYMENT PLANS—Mathematical Models.

**PERSONNEL TRAINING** See Also CHEMICAL PLANTS—Personnel Training; CIVIL ENGINEERING—Professional Aspects; COMPUTER INTEGRATED MANUFACTURING; ENGINEERING EDUCATION; ENGINEERING EDUCATION—Evaluation; MANAGEMENT—Education; MANAGEMENT—Information Systems; MILITARY ENGINEERING—Operations Research; QUALITY CONTROL—Management; RADIATION PROTECTION; SECURITY SYSTEMS—Personnel Training; SYSTEMS SCIENCE AND CYBERNETICS—Man Machine Systems; WELDING—Education.

**077212 PREPARING THE SECTION FOREMAN FOR HIS FULL RESPONSIBILITIES.** The health and safety of employees, efficiency of the operating systems, and production are paramount goals in underground coal mining. The section foreman assumes responsibility for making his part of the total system function to meet these goals. However, section foremen often have not been prepared to assume the full range of their responsibilities upon becoming a supervisor. This paper addresses the full range of section foreman responsibilities and concomitant authority. Management principles that must be mastered by him are presented, and performance expectations as well as criteria for their evaluation are examined. The benefits realized from effective foreman training are discussed. (Author abstract) 7 refs.

Grayson, R.L. (West Virginia Univ, Morgantown, WV, USA); Althouse, R.C.; Klisshis, M.J. *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt A 1986 p 2089-2094.

**Computer Applications** See Also COMPUTER SIMULATION; COMPUTER SIMULATION—Applications; NATURAL GAS PIPELINES—Control; NUCLEAR POWER PLANTS—Personnel; NUCLEAR REACTORS—Simulators; PETROLEUM PIPELINES—Personnel Training; SECURITY SYSTEMS—Personnel Training; SHIPS—Simulators.

**077213 HOW TO MAKE COMPUTERS REALLY WORK FOR YOU.** The authors examine the link between learning and job performance with reference to the CAD/CAM field. Productivity is discussed from the viewpoint of training personnel. The three groups of people the authors feel need some level of training include: day-to-day end users; managers in departments where CAD/CAM is used; and, systems managers. Sources of training and training methods are outlined.

Hardinger, Sarah Sue (Control Data Corp, Minneapolis, MN, USA); Washam, Ware. *Des News (Boston)* v 43 n 3 Feb 9 1987 p 78-80, 83.

**077214 HOW INTERACTIVE VIDEO AIDS SAFETY AT BNFL.** At Sellafield, BNFL's purpose-built Training Centre Trains over 15,000 people annually, while at any one time there are about 500 apprentices and junior process workers on site. Training does not stop once staff leave the Centre, however, because a new initiative is taking the latest computer-based training technology to the actual place of work. (Author abstract)

Anon (Marcom Systems Ltd, Twickenham, Engl). *Nucl Eng Int* v 33 n 406 May 1988 p 50.

**077215 OPTICAL MEDIA IN TRAINING.** This article discusses the market opportunities for videodisks, CD-ROM, CD-I, DVI, and other technologies in training environments. It examines the major training markets for the different technologies and covers the main factors affecting the success of each technology, including cost, the availability of sufficient generic courseware, strong standards, and imaginative software design. Each technology needs to be matched with appropriate applications

that the best take advantage of the technology's capabilities. The willingness of an organization to utilize optical media in training seems largely contingent on the organization's broader view of training. (Edited author abstract).

Mascioni, Michael. *Opt Inf Syst* v 8 n 4 Jul-Aug 1988 p 184-189.

**Demonstrations**

**077216 INTERACTIVE VIDEODISC SYSTEM FOR TRAINING.** Under the sponsorship of the US Department of Energy's Office of Classification (DOE/OC), Brookhaven National Laboratory/Technical Support Organization (BNL/TSO) has prepared a level-three interactive-laserdisc program for the training of authorized classifiers in the Department of Energy. This training program consists of six modules presented in several formats. The material is presented in a highly interactive manner with various tests to reinforce and evaluate the trainee's progress in learning the material. A lengthy qualification test is presented at the end of the educational material. (Edited author abstract)

Cadwell, Jerry J. (Brookhaven Natl Lab, Upton, NY, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 286-289.

**Medical Applications** See INDUSTRIAL HYGIENE—Research.

**USSR** See MACHINERY—Computer Aided Manufacturing.

**Zimbabwe** See MINERS—Zimbabwe.

**PESTICIDES** See Also FOOD PRODUCTS—Analysis; GENETIC ENGINEERING.

**077217 PESTICIDE FORMULATIONS AND APPLICATION SYSTEMS: FIFTH VOLUME.** This conference proceedings contains 15 papers divided into 2 sections. The first section discusses General Topics; the second session is concerned with the use of Spray Drop Size Analyzers. Some of the topics in the first section are the formulation of pesticides; metering of pesticide concentrations; electrostatic spraying; and the use of water-soluble polymer suspending agents. In section two: drop size measurement; instruments and procedures in drop-sizing; laser droplet interferometry analysis; and two-dimensional imaging spectrometry, as well as laser imaging systems, are discussed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11002 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Spicer, L.D. (Ed.) (Rhône-Poulenc Chemical Co); Kaneko, T.M. (Ed.). *ASTM Spec Tech Publ* 915, Pestic Form and Appl Syst: Fifth Vol, Kansas City, MO, USA, Nov 7-8 1984. Publ by ASTM, Philadelphia, PA, USA, 1986 155p.

**Adsorption**

**077218 ADSORPTION OF THIRAM FROM AQUEOUS SOLUTION ON ACTIVATED CARBON AND SEPIOLITE.** Recently, the extent of pesticide contamination of the water environment has raised much concern because of the potential health hazards associated with the entry of these compounds into the food chain of humans and animals. One of the main reasons that decontamination and disposal of these hazardous waste chemical is such a complex problem involves the wide range of chemical compounds which are used as pesticides. It is difficult, if not impossible, to produce a single method for pesticide disposal that applies universally. Therefore, several methods for decontamination and disposal of these unwanted chemicals may be required to solve this problem. Sorption on solid substrates, such as clay or activated carbon, is one of the methods which has been used for removing pesticides from waters. This study evaluates the effectiveness of the activated carbon and an



acid-heat treated sepiolite in removing the pesticide thiram ( $C_6H_{12}N_2S_4$ ) from aqueous solution over a range of experimental conditions. 10 refs.

Gonzalez-Pradas, E. (Colegio Univ de Almeria, Spain); Villafraña-Sanchez, M.; Socias-Viciana, M.; del Rey-Bueno, F.; Garcia-Rodriguez, A. *J Chem Technol Biotechnol* v 39 n 1 1987 p 19-27.

## Analysis

**077219 'TIME OF THE SHORTEST RESISTANCE' OF THE BODY EXPOSED TO TRICHLOR-METAFOS-3.** Trichlormetafos-3 is a pesticide and insecticide of contact action. This study describes contact tests of trichlormetafos-3 on experimental animals. Shortest time of animal body resistance to this pesticide effects is calculated. Different resistance time in seasonal and climatic conditions are assessed and animal body thermal reaction is analyzed. In Russian. 9 refs.

Dobryan, B.B.; Shpirt, M.B.; Abdashimov, K.A. *Gig Tr Prof Zabol* n 4 Apr 1988 p 52-54.

**Applications** See Also INSECTICIDES—Environmental Testing.

**077220 DEPOSITION EFFICIENCY OF DIFFERENT DROPLET SIZES FOR CITRUS SPRAYING.** The purpose of this study was to develop a methodology for fast and accurate assessment of deposition efficiency for foliar spray applications. Two criteria were used to evaluate deposition efficiency: percent of material deposited on leaf surfaces and percent coverage of water sensitive targets. Using this methodology, the highest deposition efficiency on washed citrus leaves was obtained when spray droplets were approximately 400  $\mu$ m in diameter. (Author abstract) 11 refs.

Salyani, M. (Univ of Florida, Lake Alfred, FL, USA); Hedden, S.L.; Edwards, G.J. *Trans ASAE* v 30 n 6 Nov-Dec 1987 p 1595-1599.

**077221 EFFECTS OF ELECTROSTATIC CHARGING AND VERTICAL AIR CURRENT ON DEPOSITION OF PESTICIDE ON COTTON PLANT CANOPY.** The objectives of this study were to investigate the influence of electrostatic force and vertical air current to carry pesticide deposits, obtained by cone, fan and disc type nozzles, on the cotton plant canopy. The pesticide deposit quantities and the relative deposition rates were determined and compared between different application treatments using three different nozzle types. As tracer substance BSF was used, the deposit was detected by fluorometric method. The results obtained by BSF were controlled by using real pesticide. Because of the high relative humidity during the application period, electrostatic charging effectiveness was not as high as expected. (Author abstract) 17 refs.

Zeren, Y. (Univ of Cukurova, Adana, Turk); Moser, E. *AMA Agric Mech Asia Afr Lat Am* v 19 n 1 Winter 1988 p 55-60.

## Automation

**077222 AUTOMATED SYSTEM FOR PESTICIDE DETECTION.** A system consisting of an automated analyser is designed for pesticide (organophosphorus and carbamates) determinations at very low levels of concentration. A discontinuous technique is designed in view of routine control of river water pollution. It is based on the use of a butyrylcholinesterase probe as the element sensitive to the pesticide activity. (Author abstract). 13 Refs.

El Yamani, H. (Ecole des Mines de St-Etienne, St-Etienne, Fr); Tran-Minh, C.; Abdul, M.A.; Chavanne, D. *Sens Actuators* v 15 n 2 Oct 1988 p 193-198.

## Chemical Reactions

**077223 INTERACTION OF PHENAMIPHOS WITH MONTMORILLONITE.** Phenamiphos interacted with homoionic montmorillonites of  $Ca^{2+}$ ,  $Mn^{2+}$

,  $Co^{2+}$ , and  $Ni^{2+}$  to form interlayer complexes having basal spacings of about 16.5 Å. In the infrared spectra, the  $\nu$ -PO bands were displaced towards lower frequencies suggesting that this group interacted with the exchange cations. Moreover, a small shoulder at 1600  $cm^{-1}$  indicated the partial protonation of the phenamiphos. After heating the complexes to 110°, 160°, and 200°C, however, the bands corresponding to  $\delta$ -NH $_2^+$  and  $\nu$ -NH intensified because of increased protonation, whereas the  $\nu$ -PO bands had the same intensity as in pure phenamiphos. The fundamental implication of these observations is that phenamiphos interacts with exchange cations through molecules of coordinated water, possibly by means of the P=O group. (Author abstract) 13 refs.

Maza Rodriguez, J. (Univ de Malaga, Malaga, Spain); Jimenez Lopez, A.; Bruque, Sebastian. *Clays Clay Miner* v 36 n 3 Jun 1988 p 284-288.

**Chlorination** See POLYCHLORINATED BIPHENYLS—Chemical Analysis.

**Chromatographic Analysis** See Also INSECTICIDES—Chromatographic Analysis; PROBES—Design.

**077224 RAPID DETERMINATION OF ORGANO-CHLORINE PESTICIDE RESIDUES IN FEEDS BY CAPILLARY GAS CHROMATOGRAPHY.** A simple micro-method is described for determination of 15 organochlorine pesticide residues in mixed feeds. Clean-up of the petroleum ether extract is by basic alumina minicolumn chromatography and quantitative identification is by capillary gas chromatography with electron capture detection. Cyano-propyl-polysiloxane chemically bonded fused silica capillary columns have been used to perform high resolution analyses in short time as well as to overcome possible interferences by PCBs. Recovery, repeatability, and detection limits of the proposed procedure are checked and results are also reported for non random samples of 180 feeds collected in Italy. (Author abstract) 9 refs.

Torreti, L. (Inst Zooprofilattico Sperimentale dell'Abruzzo e del Molise 'G. Caporale', Teramo, Italy); Simonella, A.; Falgiani, A.; Filippini, C.; Gramenzi, F. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 10 n 9 Sep 1987 p 510-515.

**077225 POSTCOLUMN PHOTOLYSIS OF PESTICIDES FOR FLUOROMETRIC DETERMINATION BY HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY.** A high-performance liquid chromatography postcolumn reaction detector that employs UV photolysis with an optional reaction by using o-phthalaldehyde-2-mercaptoethanol (OPA-MERC) followed by fluorescence detection was found to be useful for several classes of pesticides. In the presence of the OPA-MERC reagent, most carbamates, carbamoyl oximes, carbamothioic acids, and substituted ureas gave a sensitive response while the response of dithiocarbamates, phenylamides, and phenylcarbamates varied. The response of most of the pesticides tested was significantly affected by the solvent used. (Edited author abstract) 19 refs.

Miles, Carl J. (Univ of Hawaii at Manoa, Honolulu, HI, USA); Moye, H. Anson. *Anal Chem* v 60 n 3 Feb 1 1988 p 220-226.

**077226 SEPARATION AND IDENTIFICATION OF CERTAIN ORGANOPHOSPHOROUS PESTICIDES RESIDUES IN VEGETABLE.** A rapid and sensitive method using impregnated thin layer chromatography (TLC) for detection and estimation of organophosphorous pesticides residues from vegetable has been developed. Compared to ordinary thin layer chromatography this method is faster more sensitive and accurate. The correlation with the impregnated (p-cresol) and the pesticides have been determined by infrared spectroscopy. (Author abstract) 7 refs.

Kumar, Reena (Univ of Roorkee, Roorkee, India); Sharma, C.B. *J Liq Chromatogr* v 10 n 16 1987 p 3637-3645.

**077227 ANALYTICAL METHODS FOR DETECTION OF NONOCCUPATIONAL EXPOSURE TO PESTICIDES.** An analytical protocol is developed to analyze for 33 compounds in ambient air around the household, drinking water, and from dermal contact while applying pesticides. Soxhlet extraction is used on both the polyurethane foam plugs, which were used as air sample trapping media, and the gloves reflecting dermal contact. The extraction procedure of U.S. Environmental Protection Agency (EPA) Method 608 is used for water samples. A stringent gas chromatography/mass spectroscopy/multiple ion detection (GC/MS/MD) analytical approach parallel to the procedures of the current EPA contract laboratory program is used for analysis. (Author abstract) 2 refs.

Hsu, J.P. (Southwest Research Inst, San Antonio, TX, USA); Wheeler, Herbert G. Jr.; Camann, David E.; Schattenberg, Herbert J. III; Lewis, Robert G.; Bond, Andrew E. *J Chromatogr Sci* v 26 n 4 Apr 1988 p 181-194.

**077228 EVALUATION OF AUTOMATED AND MANUAL HOT-SPLITLESS, COLD-SPLITLESS (PTV), AND ON-COLUMN INJECTION TECHNIQUE USING CAPILLARY GAS CHROMATOGRAPHY FOR THE ANALYSIS OF ORGANOPHOSPHORUS PESTICIDES.** Three different injection modes were compared for the analysis of organophosphorus pesticides. Differing results were found for several compounds depending on their chemical structure and thermostability. The programmed temperature vaporizing injector used in this study seemed to be the most promising sampling device for pesticide residue analysis in biological samples. (Author abstract) 15 refs.

Stan, H.-J. (Technische Univ Berlin, Berlin, West Ger); Mueller, H.-M. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 11 n 1 Jan 1988, Eighth Int Symp on Capillary Chromatogr, Riva del Garda, Italy, May 19-21 1987 p 140-143.

## Decomposition

**077229 PHOTODECOMPOSITION OF PICLO- RAM IN THE PRESENCE OF HYDROGEN PEROXIDE.** The present investigation is a continuation of studies of the process of decomposition of picloram (4-amino-3,5,6-trichloropicolinic acid) in aqueous media under the effect of UV light. The investigations were carried out at a concentration of picloram in the irradiated solutions of  $5 \cdot 10^{-4}$  mole/liter. The picloram may be decomposed either as a result of photolysis or due to its reaction with  $H_2O_2$  photodecomposition products. The relative role of these two basic directions of this photoreaction depends principally on the distribution of the actinic light energy absorbed by the system between the photoactive components - picloram and hydrogen peroxide. Thus, the concentration of the components was varied so that in the corresponding series of experiments the light was absorbed predominantly by only one of the reaction components. At an  $H_2O_2$  concentration of less than  $5 \cdot 10^{-3}$  M, picloram is the principal light-absorbing and, consequently, photoactive component of the investigated solutions. At higher  $H_2O_2$  concentrations its molecules also take part in the primary photochemical process. 10 refs.

Soboleva, N.M. (Dumanskii Inst of Colloidal Chemistry & Water Chemistry, Kiev, USSR); Nosonovich, A.A.; Goncharuk, V.V.; Rudyak, S.S. *Sov J Water Chem Technol* v 9 n 2 1987 p 20-23.

**Environmental Impact** See Also COTTON—Environmental Testing; MARINE BIOLOGY; SOIL POLLUTION; SOIL POLLUTION—Chemical Reactions; WATER POLLUTION—Analysis; WATER POLLUTION—Morocco; WATER POLLUTION—Pesticide Effects; WATER POLLUTION—Underground.

**077230 LIVER WEIGHT RESPONSE TO EXTENDED CHLORDEKONE EXPOSURE.** Chlordane (Kepone) is a chlorinated hydrocarbon pesticide that



has been shown to be both a neurotoxin and a reproductive toxin. Of primary concern is whether a female, who is exposed to a chemical agent such as chlordecone in the workplace, not continuously, but for five consecutive days at a time for an extended period of time, would suffer ill effects. The purpose of this study is to determine the response of the liver to specific doses of chlordecone for five consecutive days/week for periods of up to ten weeks. An understanding of the liver response to this regimen of exposure is necessary because this timetable best reflects the occupational exposure that might occur. Study materials, methods and results are discussed. 17 refs.

Swartz, William J. (Louisiana State Univ, New Orleans, LA, USA); Schutzmann, Roy L. *Bull Environ Contam Toxicol* v 38 n 4 Oct 1987 p 615-621.

**077231 LAUNDERING VARIABLES IN REMOVING CARBARYL AND ATRAZINE RESIDUES FROM CONTAMINATED FABRICS.** During mixing and application of pesticides, the clothing worn by agricultural or urban pesticide applicators is subject to contamination. Completeness of pesticide removal in laundering is essential if the garment is to be used again. This study examines the efficacy of laundering variables such as detergent type, wash water temperature and number of launderings in removal of carbaryl (1-Naphthyl-N-methyl carbamate) and atrazine (2-Chloro-4-ethylamino-6-isopropylamino-S-triazine) residues from fabrics of various fiber contents. In addition, the effect of durable-press functional finish on residue removal from polyester/cotton fabrics is examined. 17 refs.

Raheel, Mastura (Univ of Illinois, Urbana, IL, USA). *Bull Environ Contam Toxicol* v 38 n 4 Oct 1987 p 671-679.

**077232 EXPORT OF MIREX FROM LAKE ONTARIO TO THE ST. LAWRENCE ESTUARY.** The relative importance of migrating eels and suspended particulate material (biotic and abiotic) as transporters of mirex from Lake Ontario to the St. Lawrence River Estuary is evaluated in the context of a possible adverse impact on the St. Lawrence beluga population. Estimates suggest that transport of mirex out of Lake Ontario by eels (2270 g annually) is almost twice that due to suspended particulate flux (1370 g annually). Mass balance calculations for mirex in Lake Ontario indicate that transport by migrating eels and particulate matter, combined with coverage of surficial sediments by continuing deposition of new material, could effectively 'cleanse' Lake Ontario of mirex inputs in 100 years or less. Using mirex as a prototype to simulate the fate of hydrophobic organic chemicals in Lake Ontario led to a revised sediment budget for this final lake in the Great Lakes-St. Lawrence system, which the paper also discusses. (Edited author abstract) 36 refs.

Lum, Ken R. (Natl Water Research Inst, Burlington, Ont, Can); Kaiser, Klaus L.E.; Comba, Mike E. *Sci Total Environ* v 67 n 1 Nov 1987 p 41-51.

**077233 EVALUATION OF PESTICIDE GROUNDWATER POLLUTION POTENTIAL FROM STANDARD INDICES OF SOIL-CHEMICAL ADSORPTION AND BIODEGRADATION.** A mathematical screening model of the pesticide leaching process is used to estimate the potential for a pesticide to reach groundwater at significant concentrations. The model assumes steady water flow, equilibrium linear adsorption, and depth-dependent first-order biodegradation and predicts groundwater travel times and residual concentrations that depend on soil and environmental conditions as well as pesticide adsorption and decay constants. When groundwater protection is expressed as a condition that the residual undegraded pesticide mass remaining below the surface layer of soil must be less than a specified fraction of the initial mass added in a pulse application at the surface, the model prediction is shown to reduce to a linear inequality between the organic C partition coefficient  $K_{oc}$  and the biochemical half-life,  $\tau$ . The screening model is illustrated on 50 pesticides and two scenarios representing low and high potential for groundwater contamination. (Edited author abstract) 24 refs.

Jury, William A. (Univ of California, Riverside, CA, USA); Focht, Dennis D.; Farmer, Walter J. *J Environ Qual* v 16 n 4 Oct-Dec 1987 p 422-428.

**077234 COEFFICIENTS OF PESTICIDE ENTRAINMENT FROM DRAINAGE BASINS.** Summarized and analyzed are Soviet and foreign publications on the conditions and factors which influence the formation and character of surface runoff and pesticide entrainment from soils of agricultural lands and the modeling of entrainment of xenobiotics into surface reservoirs. Estimated are the coefficients of entrainment and the role of surface runoff from a drainage basin as factors in the pesticide pollution of water sources. (Author abstract) 25 refs.

Medovar, A.M. (All-Union Scientific Research Inst of Hygiene & Toxicology of Pesticides, Polymers, & Plastic Masses). *Sov Meteorol Hydrol* n 9 1987 p 100-103.

**077235 CHLORINATED PESTICIDES IN INDOOR AIR.** Indoor concentrations of chlorinated pesticides were measured in the air of 12 homes and found to be elevated with respect to typical outdoor concentrations. For example, indoor to outdoor concentration ratios for  $\gamma$ -chlordane were as high as 60 in the living area of one home and as high as 1000 in the basement of this home. Indoor sources for these chemicals are implied. (Author abstract) 20 refs.

Anderson, David J. (Indiana Univ, Bloomington, IN, USA); Hites, Ronald A. *Environ Sci Technol* v 22 n 6 Jun 1988 p 717-720.

**077236 BEHAVIOR OF PESTICIDES IN LAKE KASUMIGAUZA, JAPAN.** Pesticides such as oxadiazon, isoprothiolane, diazinon, IBP, simetryne and benthicarb, from surface runoff from rice paddy fields to Lake Kasumigaura, Japan were examined in order to determine seasonal changes in their concentrations in the lake water. The highest concentrations were observed near the river mouths during May to August, soon after pesticide application; hence they are transported mainly by surface runoff. Although these pesticides have been reported to be labile, concentrations of some of them, dispersed with the movement of the water, did not decrease rapidly in the natural aquatic environment. The highest concentrations, in 1985, of oxadiazon, isoprothiolane, diazinon, IBP, simetryne, benthicarb and CSB were 0.66, 0.84, 0.16, 3.24, 3.23, 2.15 and 1.13 ppb, respectively. The relative order of persistence and mobility of pesticides in the lake water was estimated as: isoprothiolane, CSB, simetryne > IBP > diazinon > oxadiazon > benthicarb. (Author abstract) 23 refs.

Shiraishi, Hiroaki (Natl Inst for Environmental Studies, Yatabe, Jpn); Pula, Flutra; Otsuki, Akira; Iwakuma, Toshio. *Sci Total Environ* v 72 Jun 15 1988 p 29-42.

**077237 PESTICIDE TRANSPORT IN SHALLOW GROUNDWATER.** Residues of selected pesticides, EDB, atrazine, butylate, aldicarb, and fenamiphos were monitored in shallow groundwater beneath a Bonifay sand in the southeast Coastal Plain near Tifton, GA. Pesticides in the tile outflow from the treated area were also monitored along with pesticide residue in soil. Low concentrations of atrazine and butylate were present in wells at depths of 1.0 m, 1.5 m, and 2.4 m beginning with the second year (1984) of the study. Fenamiphos was detected in only one well throughout the study. However, EDB and aldicarb moved readily to groundwater and in the tile outflow. Masses of pesticide transported from the treated area were computed using concentrations and estimated water budgets. Comparing leaching losses from the root zone estimated using GLEAMS simulation with groundwater transport shows that < 10% of the leaching losses were actually transported from the treated area in shallow groundwater during the observation period. (Edited author abstract). 21 Refs.

Leonard, R.A. (Southeast Watershed Research Lab, Tifton, GA, USA); Shirmohammadi, A.; Johnson, A.W.; Marti, L.R. *Trans ASAE* v 31 n 3 May 6 1988 p 776-788.

**077238 PESTICIDES IN AGRICULTURAL WATERS: THE ROLE OF WATER QUALITY GUIDELINES.** This paper focuses on the relationship between the use of pesticides in Canadian agriculture and the hazards associated with the quality of agricultural waters used in irrigation and livestock watering. The extent and complexity of this problem is assessed initially by examining the overlap between pesticide use and agricultural water use in Canada. The inherent properties of selected pesticides used in Canadian agriculture are highlighted and related to their potential for release to agricultural water supplies. Field and laboratory investigations as related to agricultural water uses are reviewed and a discussion of pesticide water quality guidelines to ensure protection of agricultural water supplies is provided. (Edited author abstract). 57 Refs.

Pierce, Ronald C. (Environment Canada, Ottawa, Ont, Can); Wong, Michael P. *Can Water Resour J* v 13 n 3 Jul 1988 p 33-49.

**077239 EFFECTS OF PARAQUAT ON MICROSOMAL OXYGEN REDUCTION AND ANTIOXIDANT DEFENSES IN RIBBED MUSSELS (GEUKENSIA DEMISSA) AND WEDGE CLAMS (RANGIA CUNEATA).** In vitro studies indicated a dose-dependent increase in the rate of superoxide anion ( $O_2^-$ ) generation in microsomal fractions supplemented with NADPH; the highest concentration of paraquat employed (4mM) elicited an 81% increase in cytochrome c reduction in *G. demissa* and a 135% increase in *R. cuneata*. In both species, cytochrome c reduction was inhibited by the addition of exogenous superoxide dismutase (SOD). For in vivo studies, a single application of paraquat (0.5, 1.0 or 2.0 mM) was added to aerated salt-water aquaria containing *G. demissa*. Biochemical analyses of antioxidant enzymes, reduced glutathione (GSH) and lipid peroxidation were performed in hepatopancreatic tissue after exposures of 6, 12, 24 and 36 h. (Edited author abstract) 11 refs.

Wenning, Richard J. (Duke Univ, Durham, NC, USA); Di Giulio, Richard T. *Mar Environ Res* v 24 n 1-4 1988, Fourth Int Symp on Responses of Mar Org to Pollut, Woods Hole, MA, USA, Apr 22-24 1987 p 301-305.

## Fires

**077240 PREINCIDENT PLANNING FOR PESTICIDE FIRES.** A recognized procedure (evolved through preincident planning and fire scene size-up) for a pesticide storage fire is to let it burn. If the structural fire temperature can be raised to more than 1,800°F, thermal decomposition of the pesticides into less toxic products can be effected. The structure should be vented as much as possible so the fire can proceed in the free-burn stage. In deciding on a let-it-burn strategy, three factors of chemical destruction by combustion are considered: temperature, time and turbulence.

Bowen, John E. (Prince George's County Fire Dep, MD, USA). *Fire Eng* v 141 n 2 Feb 1988 p 36-39.

## Leaching

**077241 CHARACTERIZING THE UNCERTAINTY OF PESTICIDE LEACHING IN AGRICULTURAL SOILS.** A Monte-Carlo numerical simulation procedure for making regional assessments of pesticide leaching has been developed. This procedure uses probability density functions for organic matter, field capacity, and wilting point developed from information on approximately 3000 soils. Variations in climatic conditions were incorporated by random selection of yearly rainfall data. The procedure was demonstrated for aldicarb applied to corn grown in Ohio. A total of 2000 parameter sets were evaluated using the unsaturated zone model PRZM. The simulation results indicated that convergence of the 90th, 95th, and 99th percentiles for movement past 0.3, 0.6, 0.9, and 1.5 m was obtained after 500 simulations. The relative uncertainty associated with these percentiles was approximately 50% after 1500 simulations. The downward movement of aldicarb residues was most sensitive to changes in field capacity. These simulations, coupled with additional



soil-specific simulations, indicated no significant movement of aldicarb residues beyond 1.8 m for applications to Ohio corn. (Author abstract) 31 refs.

Carsel, Robert F. (US EPA, Athens, GA, USA); Parrish, Rudolph S.; Jones, Russell L.; Hansen, James L.; Lamb, Richard L. *J Contam Hydrol* v 2 n 2 Mar 1988 p 111-124.

**077242 SIMULATION PROCEDURE FOR GROUNDWATER QUALITY ASSESSMENTS OF PESTICIDES.** A procedure is described for making regional assessments of pesticide residue loadings and movement in groundwater underneath and downgradient from treated fields. A Monte-Carlo numerical simulation technique is used to generate model parameters for both the unsaturated and saturated zones. Simulations are performed using the Pesticide Root Zone Model linked to a simple groundwater solute transport model. The procedure is useful for evaluating the potential for producing pesticide residues in drinking water wells before actual field applications are made. Appropriate land management options, including restrictions on pesticide application, also can be developed using this procedure. The procedure was used to assess aldicarb levels in northeastern North Carolina groundwater resulting from application of the pesticide to peanuts. Probability density functions for selected soil characteristics were developed using a direct-access soils information data base. Probability density functions for selected groundwater characteristics were developed from available data for the study area. Simulation results indicated that mass fluxes to groundwater exceeded 0.01 and 0.1 kg ha<sup>-1</sup> approximately 6.9 and 1.0 percent of the time, respectively. No fluxes exceeded 0.1 kg ha<sup>-1</sup> at a distance of 60 m downgradient in any of the cases evaluated. (Author abstract) 24 refs.

Carsel, Robert F. (EPA, Athens, GA, USA); Jones, Russell L.; Hansen, James L.; Lamb, Richard L.; Anderson, Mary P. *J Contam Hydrol* v 2 n 2 Mar 1988 p 125-138.

## Manufacture

**077243 STATE OF IMMUNITY IN THOSE OCCUPATIONALLY EXPOSED TO PESTICIDES.** The state of immunity in those having a long-term contact with pesticides, i.e., mechanics and storehouse workers, is examined. Unbalance of immunologic indicators detected in T-cell subpopulations is specified by an increase in the number of inducers and decrease in the level of immunogenesis regulators. The studied immunity disfunction directly depends on the length of service. Weakening of the inhibition mechanism of T-suppressors due to their quantitative decrease results in hyperproduction of general immunoglobulin E. A high level of spontaneous proliferation of lymph cells indicates endogenous T-cell stimulation. Immunity disfunction is accomplished by an increase in the incidence of pathologic changes of the cardiovascular, nervous, and digestive systems. (Author abstract) 17 refs. In Russian.

Anisimova, L.A.; Kozlyuk, A.S.; Shroyt, I.G.; Pivnik, E.S.; Bakumenko, A.L. *Gig Tr Prof Zabol* n 6 Jun 1987 p 15-18.

## Modification

**077244 POLYMER-MODIFIED MICROELECTRODES FOR METAL ION DETERMINATION AND THE DEVELOPMENT OF A CALCIUM AMPEROMETRIC PROBE BASED ON SURFACE-IMMOBILIZED ANTIPYRYLAZO III.** The feasibility of employing chemically modified microelectrodes in analytical determination is demonstrated. For Fe(II), determinations down to  $5 \times 10^{-8}$  M could be performed, and this limit was dictated by background levels of Fe(II) rather than by the sensitivity of the method. In addition, the utility of electrodes modified with antipyrilazo III (AP-III) for the determination of Ca<sup>2+</sup> is shown. These electrodes exhibit submicromolar sensitivity and a dynamic range that extends over 3 orders of magnitude. The presence of magnesium at a thousand-fold excess has only minor effects. (Edited author abstract) 45 refs.

Hurrell, Helen C. (Cornell Univ, Ithaca, NY, USA); Abruna, Hector D. *Anal Chem* v 60 n 3 Feb 1 1988 p 254-258.

## Oxidation

**077245 OXIDATIVE DESTRUCTION OF UREA DERIVATIVE PESTICIDES.** Pesticides of the phenyl-substituted-urea type have been used extensively in agriculture and pose a problem for water pollution. Chlorine and ozone were employed in an experiment to oxidize the above pesticides found in water. The investigation permitted a comparison of the prospects for ozone with those for a reagent (chlorine) widely used in water treatment practice, with an indication of the limits of applicability of these oxidizers. It was shown that for treatment of phenyl-substituted ureas active chlorine or preparations containing it should be used only on waste waters. In distinction from chlorine, ozonation is applicable both in processes of preparation of potable water and in the treatment of waste waters. The choice of the oxidizer - chlorine or ozone - in the treatment of waste water is dictated by the particular water composition. 15 refs.

Konyk, L.V. (Dumanskii Inst of Colloidal Chemistry & Water Chemistry, Kiev, USSR); Taran, P.N.; Shevchenko, M.A. *Sov J Water Chem Technol* v 9 n 2 1987 p 67-70.

## Removal

**077246 REMOVAL OF TETRAMETHYL THIURAM DISULPHIDE FROM AQUEOUS SOLUTION BY CHEMICALLY MODIFIED BENTONITE.** The adsorption of tetramethyl thiuram disulphide (thiram) on bentonite, acid-treated with H<sub>2</sub>SO<sub>4</sub> (over a concentration range between 0.25 mol dm<sup>-3</sup> and 2.00 mol dm<sup>-3</sup>), and heat-treated at 110°C or at 200°C, from aqueous solution at 20°C has been studied. In general, the adsorption isotherms may be classified as L type of the Giles classification which suggests that there is no strong competition from the solvent for adsorption sites. The experimental data points have been fitted to the Freundlich equation in order to calculate the adsorption capacities (K) of the samples; K values range from 230 µg g<sup>-1</sup> for the sample acid-treated with 0.25 mol dm<sup>-3</sup> H<sub>2</sub>SO<sub>4</sub> and heat-treated at 110°C up to 2010 µg g<sup>-1</sup> for the sample acid-treated with 1.00 mol dm<sup>-3</sup> H<sub>2</sub>SO<sub>4</sub> and heat-treated at 200°C. In all cases the K values for samples heat-treated at 200°C were higher than those heat-treated at 110°C. The removal efficiency (R) has also been calculated for all the samples; R values range from 42.8 percent up to 89.9 percent. (Author abstract) 17 refs.

Gonzalez Pradas, E. (Colegio Univ de Almeria, Almeria, Spain); Villafraña Sanches, M.; Valverde Garcia, A.; del Rey Bueno, F.; Garcia Rodriguez, A. *J Chem Technol Biotechnol* v 42 n 2 1988 p 105-112.

**077247 FILTERING UNIT FOR THE REMOVAL OF PESTICIDE RESIDUES FROM AQUEOUS SOLUTIONS.** Pesticide loss during filling and washing spray tanks can be considerable especially where cooperative pesticide distribution centers exist (up to 200 1000-liter tanks daily). A filtering unit using readily available organic media (peat, moss and manure) was designed to filter out a variety of commonly-used pesticides in apple orchards. Each filtering unit received residues from 20 pesticide applications consisting of a typical pesticide treatment schedule for apples. Initial concentration of the pesticides in the wastewater was between 26 and 1820 mg l<sup>-1</sup>. Average removal efficiencies were > 99 percent for dodine, copper oxychloride, azinphos methyl, triadimefon, bifenox, dithianon, fenarimol, chlorpyrifos ethyl, cyhexatin, benzoate, dinocap and benomyl. Removal efficiency for vamidothion averaged 61 percent; removal for sulphur was 73 percent. Bioassays with *Daphnia magna* and *Gloeosporium* sp. were performed to evaluate effluent toxicity. (Author abstract) 6 refs.

Toller, Giambattista (Experimental Station for Agriculture & Forestry, Trento, Italy); Flaim, Giovanna M. *Water Res* v 22 n 5 May 1988 p 657-661.

**Spectroscopic Analysis** See Also ORGANIC COMPOUNDS—Spectroscopic Analysis.

**077248 DIRECT OBSERVATION OF PESTICIDES ON PLANTS USING LAMMS: IMAZAQUIN ON SOYBEAN LEAVES.** LAMMS (Laser Microprobe Mass Spectrometry) has been used to observe the presence and location of a herbicide on plant leaves. Leaves from soybean plants, sprayed with imazaquin, a member of the imidazolinone class of herbicides, at varying application rates, were examined by LAMMS without any special preparation. A rapid analysis for imazaquin was obtained confirming the suitability of LAMMS as an organic microprobe analyzer. A comparison with standard chemical ionization and electron impact mass spectra of imazaquin showed evidence for laser-induced fragmentation. (Author abstract) 4 Refs.

Brinen, J.S. (American Cyanamid Co, Stamford, CT, USA); Los, M.; Kelland, D.; Wallach, E.R. *Surf Interface Anal* v 11 n 11 Aug 1988 p 559-562.

## Storage

**077249 METHODOLOGY FOR CONSTRUCTING A PESTICIDE STORAGE BUILDING.** Agriculture mechanization education programs would be incomplete without hands-on experience in planning and constructing agricultural structures. Instructional procedures, standards for design, and plans used to construct a pesticide storage building are included. The building is being used on the Agricultural Experiment Station in Hutchinson, KS. (Author abstract) 6 refs.

Slocombe, John W. (Kansas State Univ, Manhattan, KS, USA); Swallow, Clarence W.; Kuhlman, Dennis K. *Appl Eng Agric* v 3 n 2 Nov 1987 p 131-134.

## Toxicity

**077250 DINITROPHENOL COMPOUNDS: TOXICOLOGY, TREATMENT, AND PREVENTION OF INTOXICATIONS (REVIEW OF LITERATURE).** Dinitrophenol compounds are universal agricultural pesticides. These compounds are highly toxic. This paper contains literature review on the subject of toxicity, poisoning prevention and intoxicated personnel treatment methods. In Russian. 44 refs.

Lukyanichuk, V.D. *Gig Tr Prof Zabol* n 7 Jul 1987 p 42-45.

**077251 TOXICOLOGIC CHARACTERISTIC OF POLYCARBACENE-BASED COMBINED PESTICIDES.** Polycarbacyne-based pesticide toxicity was evaluated in animal experiments. Resulting hygienic evaluation of combined pesticides proved their low toxicity. Animal inhalation experiments results in failure of neurophysiological system. Pesticide safe concentration must be assessed. In Russian. 7 refs.

Gzhegotsky, M.I.; Kuzminov, B.P.; Kokot, V.R.; Zhuk, S.Sh. *Gig Tr Prof Zabol* n 8 Aug 1987 p 51-52.

**PETROCHEMICAL PLANTS** See Also PETROCHEMICALS.

**077252 INCENTIVES IN PRODUCTION: A CASE STUDY.** The motivation, rationale, and experiences of implementing an incentive scheme in a large petrochemical plant in the People's Republic of China for the purpose of conserving the consumption of cooling water is described. Experimental implementation in a section of a plant is described in detail. A few incentive-induced features uncovered after analyzing the experimental data are reported. A mathematical model with several variations is presented. A better predictive property of the incentive scheme in comparison to a more conventional method is proved analytically. The effectiveness of the scheme is shown by the amount of water conserved, and by the management's decision for plantwide adoption of the scheme. Practical issues encountered in experimental implementation, extensions of the scheme to more general situations, and theoretical problems inspired by the



experiment are discussed. 8 refs.

Ho, Yu-Chi (Harvard Univ, Cambridge, MA, USA); Luh, Peter B.; Zheng, Ying-Ping; Wu, Jong-Ming; Wang, Qing-Yu; Chen, Liang. *IEEE Trans Autom Control* v 33 n 3 Mar 1988 p 227-237.

**Computer Applications** See Also PETROLEUM REFINERIES—Computer Applications.

**077253 COMPUTER CONTROL IMPROVES ETHYLENE PLANT OPERATION.** ICIA Australia ordered a turnkey 250,000-tpy ethylene plant to be built at the Botany site, Sydney, Australia. Following a feasibility study, an additional order was placed for a process computer system for advanced process control and optimization. This article gives a broad outline of the process computer tasks, how the tasks were implemented, what problems were met, what lessons were learned and what results were achieved.

Whitehead, B.D. (Linde AG, West Ger); Parnis, M. *Hydrocarbon Process* v 66 n 11 Nov 1987 p 105-108.

## Construction

**077254 COLD WEATHER CONCRETING FOR OIL PRODUCTION PLANT.** Heated special enclosures at site 500 km (310 miles) northwest of Edmonton, Alberta permit building of plant for oil production from bituminously impregnated sand during harsh winter temperatures. Special efforts by contracting joint venture keeps job on tight schedule, costs down. (Author abstract).

Moore, Ken (Dillingham Construction Ltd, North Vancouver, BC, Can); Wothead, Roger; Tuttle, Hugh. *Concr Int* v 10 n 10 Oct 1988 p 31-33.

## Corrosion

**077255 KORROSION UND ZERSTÖRUNGSFREIE PRUEFUNG IN DER PETROCHEMISCHEN INDUSTRIE.** [Corrosion and Non-Destructive Testing in the Petrochemical Industry]. Corrosion due to hydrogen-initiated cracks plays a dominant role in the petrochemical industry. In this paper causes of cracks in ferritic steels used in hydrogenation plants are discussed. The related methods and results of ultrasonic inspection are described in detail. Finally, protection methods are presented. (Author abstract) In German. 4 refs.

Gayk, W. (Union Rheinische Braunkohlen Kraftstoff AG, Wesseling, West Ger). *Tech Mess TM* v 55 n 4 1988 p 132-138.

## Effluent Treatment

**077256 NITROGEN AND PHOSPHATE REQUIREMENTS FOR THE ANAEROBIC DIGESTION OF A PETROCHEMICAL EFFLUENT.** This study was undertaken to determine the minimum nitrogen and phosphate concentrations at which the downflow fixed-bed anaerobic reactor could still operate efficiently. Results obtained from the first phase of the study showed that urea could be successfully substituted by ammonia, when the reactor population became acclimatized to the newly added nitrogen source. In the second phase it was found that the substrate phosphate concentration necessary for efficient reactor performance, could be lowered from 115 to 8 mg l<sup>-1</sup> as PO<sub>4</sub>-P. At this level no phosphate could be detected in the reactor effluent. In the final phase the substrate ammonia concentration necessary was lowered from 1060 to 45 mg l<sup>-1</sup> TKN. At these low phosphate and nitrogen concentrations, the reactor was still able to operate at COD (Chemical Oxygen Demand) removal efficiency > 95%. (Author abstract) 30 refs.

Britz, T.J. (Univ of the Orange Free State, Bloemfontein, S Afr); Noeth, C.; Lategan, P.M. *Water Res* v 22 n 2 Feb 1988 p 163-169.

**077257 SIDESTREAM SOFTENING SYSTEM CUTS PETROCHEM PLANT'S EFFLUENT.** USS

Chemical's Houston plant produces ethylene from an ethane rich refinery gas by steam cracking. Prior to 1979, the plant discharged roughly 300 to 500 gpm of effluent to the Houston Ship Channel. The construction of a maximum recycle sidestream softening system began in 1977 for the treatment of wastewater from the plant. The system is composed of two lime softening units that treat the blowdown from the cooling water system. The softeners remove the calcium, magnesium, silica, and carbonate ions. Softened water is processed through a recarbonator and filter for return to the cooling water system. Carbon dioxide is used to control pH in the cooling water system instead of sulfuric acid. Polymaleic anhydride polymers mechanistically prevented scale formation by fluidizing small crystals rather than inhibiting crystals rather than inhibiting crystal formation.

Matson, Jack V. (Univ of Houston, Houston, TX, USA); Mouche, Wendy G.; Rosenblum, Eric. *Oil Gas J* v 83 n 20 May 20 1985 p 76-78.

## Electric Equipment

**077258 PRINCIPALES CARACTERIQUES, CONCEPTION ET EVOLUTION DES ENTRAÎNEMENTS ELECTRIQUES DESTINES AU REMPLACEMENT DE TURBINES DANS L'INDUSTRIE CHIMIQUE.** [Main Features, Design Requirements and Development of Electric Motors Drives Fitted to the Replacement of Steam Turbines in Chemical Plants]. During the last few years French petrochemical and refining plants have replaced a comparatively important amount of steam turbines by electric motor drives. This paper gathers data regarding the solutions which seem to be the more suitable in this matter, thereby directed to powers being above 1MW. Limits of feasibility and characteristics of constant speed drives are given. The subject of variable speed drives is then tackled with a special stress on the principle, the performances and the selection and design criteria of the most used solutions which are currently: the design criteria of motor with hydrodynamic coupling and mainly the synchronous motor fed by frequency converter. The constraints that have to be taken into consideration before connecting the various types of drives are explained. The interest in high power electric motor developments to increase the available speeds is emphasized. (Edited author abstract) In French. 11 refs.

Charrat, O. (Service Material Electrique, Fr). *Electr Fr Bull Dir Etud Rech Ser B* v 3 Oct 1987 p 23-44.

## Energy Conservation

**077259 ENERGY CONSERVATION AT I.P.C.L.** The energy consumption pattern at a large petrochemical complex in India is described. An approach to achieving optimum energy utilization efficiency at this plant is summarized, and proposed energy conservation measures for the short term, medium term and long term are highlighted. (Edited author abstract)

Venkatraman, V. (Indian Petrochemicals Corp, Vadodara, India); Mehta, M.J. *Energy Manage (New Delhi)* v 10 n 4 Oct-Dec 1986 p 251-260.

## Environmental Impact

**077260 COMMUNITY ODOURS IN THE VICINITY OF A PETROCHEMICAL INDUSTRIAL COMPLEX.** Community odors in the vicinity of an oil refinery and petrochemical industrial area were studied by an observer network throughout an entire year. Odor episodes occurred during 0.86 percent of the time of the study. Odor reports increased closer to the refinery. Within a range of 12.5 km, more than 50 percent of the odors were estimated to originate from the refinery. The most typical odor was that of reduced sulfur compounds (35.2 percent of all observations). Odor episodes occurred during low wind velocities and high humidity. Odors were most frequent during January-April, and were usually reported early in the morning. The odors were evidently due to the general operation of the plants, as no single activity or in-plant factor could be identified as the source

of the odors. (Author abstract) 15 refs.

Persson, Per-Edvin (Finnish Science Cent Foundation, Vantaa, Finl); Skog, Stefan; Hasenson, Benny. *JAPCA* v 37 n 12 Dec 1987 p 1418-1420.

**077261 ENVIRONMENTAL CONSIDERATIONS IN PLANNING PETROCHEMICAL COMPLEXES - A CASE STUDY FOR THE PROPOSED COMPLEX AT SALEEMPUR, U.P.** An in-depth study was conducted on extent and quality of a green belt and the manner in which the same could be achieved most effectively. Keeping in mind the constraints imposed by locality factors, such as alkaline soil, waterlogging etc., as also the impact of the proposed petrochemical complex, a strategy for establishment of a green belt is being evolved. This paper describes the considerations of the choice of species, planting techniques and manner in which the green belt needs to be maintained. Such an approach will ensure development with the least ecological disturbance i.e., development without destruction. (Edited author abstract) 23 refs.

Mathur, R.S. (Forest Research Inst, Dehra Dun, India); Gogate, M.G. *Chem Age India* v 38 n 5 1987 p 205-212.

**Materials** See REFRACTORY METALS—Corrosion Resisting.

## Modernization

**077262 WAYS TO REVAMP UREA UNITS.** A number of factors should be examined when considering a revamp of a urea plant. Experience teaches which parts of the unit are likely to be involved. Some of the topics covered are increased production capacity; vacuum systems capacity; reduction of feed and utilities consumption; reduced maintenance costs; pollution control; and improved product quality. (Edited author abstract).

Granelli, F. (Snamprogetti SpA, San Donato Milanese, Italy). *Hydrocarbon Process* v 67 n 6 Jun 1988 p 59-63.

**Personnel Training** See PETROLEUM REFINERIES—Personnel Training.

**Retrofitting** See PETROLEUM REFINERIES—Retrofitting.

## Saudi Arabia

**077263 GENERAL ENVIRONMENTAL PLANNING AND MANAGEMENT OF A PETROCHEMICAL COMPLEX IN SAUDI ARABIA - A CASE STUDY.** This paper examines the general environmental planning and management considerations that were involved in the design of a petroleum refinery to be located in the Qasim area of the Kingdom of Saudi Arabia. We present details of the considerations that were involved in the environmental planning of the Qasim refinery and provide specific information on the control of the refinery's air, water, noise, solid and hazardous waste streams. Even though this particular project did not proceed to completion, it does provide an excellent case study of the environmental planning and management activities that are currently being practiced to protect the environment in Saudi Arabia. In conclusion, had the project proceeded to completion, it would have resulted in a modern refinery operating without any significant adverse environmental impacts and with the maintenance of a clean and safe environment for adjacent communities. 7 refs.

Al-Gain, Abdulbar (Meteorology & Environmental Protection Administration, Saudi Arabia). *Ind Environ* v 10 n 1 Jan-Mar 1987 p 7-10.

## Welding

**077264 QUALITY WELDING FOR SPECIFIC APPLICATIONS.** The production of petrochemicals involves a wide range of processes and operating conditions. High temperatures and pressures, difficult materials and complex fabrications make great demands on the welding process. This article describes how these problems are met from the viewpoint of BP Chemicals International. (Au-



thor abstract).

Anon. *Weld Rev* v 7 n 3 Aug 1988 3p.

## PETROCHEMICALS See Also PARAFFINS—Oxidation.

**077265 RECENT PROGRESS IN PETROCHEMICAL TECHNOLOGY.** The recent technical developments in some bulk organic chemicals (ethylene, ethylene oxide, propylene oxide, styrene, acrylonitrile, phthalic and maleic anhydrides), polymers, fine chemicals, and on advanced technologies and chemical engineering science have been briefly reviewed. Although the import of foreign technologies for building petrochemical complexes in China has so far been a routine practice, it is suggested that efforts should be concentrated in the development of selected technologies for the production of bulk petrochemicals and the improvement of existing imported technologies. The target of technical development has also been discussed. (Edited author abstract) In Chinese.

Ou Canqi (China Petrochemical Corp, China); Yuan Qingtang. *Shiyou Xuebao Shiyou Huangong* v 3 n 1 Mar 1987 p 1-7.

**077266 LEARNING FROM PETROCHEMICAL HISTORY: STRATEGIES TO THE YEAR 2000.** A review is presented of the historical patterns of the petrochemical industry. The petrochemical industry today is examined in detail. The role of costs, profit potential and prices relative to market growth is considered. The domestic markets of industrialized nations are assessed. Two strategies for generating growth are discussed.

Stobaugh, Robert (Harvard Business Sch, Boston, MA, USA); Gagne, James. *Chem Eng Prog* v 84 n 7 Jul 1988 p 25-29.

## Chromatographic Analysis

**077267 APPLICAZIONI DELLA GASCROMATOGRAFA CAPILLARE IN PETROLCHIMICA.** [Applications of Capillary Gas Chromatography in Petrochemistry]. Some comments are made on the evolution undergone by capillary gas chromatography and recent developments in related column technology. In particular, applications of the technique to products of petrochemical origin are discussed, and some examples of analysis of naphthas and gasolines, polynuclear aromatic hydrocarbons, and spilled crude oils are presented. (Translated author abstract) In Italian. 19 refs.

Mascherpa, A. (Stazione Sperimentale per i Combustibili, San Donato Milanese, Italy). *Riv Combust* v 41 n 4-5 Apr-May 1987 p 87-95.

## Economics See Also PETROLEUM GAS, LIQUEFIED.

**077268 RISING COSTS PREDICTED FOR WORLD PETROCHEMICAL RAW MATERIALS.** Since the subject of world petrochemical raw materials is so vast, a great deal of selectivity is exercised to present a brief outlook. The first selection made is to limit this paper to hydrocarbons. The hydrocarbons reviewed fall into three basic categories. The lightest is methane, or natural gas, which is used to make methanol and ammonia. Next come the natural gas liquids and LPGs. The natural gas liquids are comprised specifically of ethane, propane, isobutane and normal butane. The next category is the dominant source of petrochemical manufacture: naphtha.

Acosta, T. (DeWitt & Co, Houston, TX, USA). *Hydrocarbon Process* v 67 n 2 Feb 1988 p 90A-90B, 90E, 90G-90H.

**077269 WORLD-SCALE MODEL PREDICTS PETROCHEMICAL TRENDS.** The petrochemicals industry is in the midst of a global structural change caused by the ability of energy-rich industrially developing nations to undercut the prices of bulk chemicals traditionally produced by the United States, Western Europe and Japan. The maturing of the industry and saturation of the markets is causing a shift in the advantages in production

away from innovations in process technology towards the availability of cheap feedstocks. Countries with a great abundance of cheap petroleum and natural gas are beginning to export not only these basic resources but also the more valuable petrochemical derivatives. Often the new petrochemical producers are far from the traditional markets and are subject to restraints imposed to protect those markets. Also, it is usually more expensive to build the manufacturing facilities in an industrially undeveloped nation to compete with facilities that already exist elsewhere.

Sigurdsson, M. (Univ of Wisconsin, Madison, WI, USA); Rudd, D.F. *Hydrocarbon Process* v 67 n 6 Jun 1988 p 98.b-98.n.

**077270 WORLD-SCALE MODEL PREDICTS PETROCHEMICAL TRENDS.** A model is used to examine the advantage of the petroleum-rich regions in the established markets of the United States, Western Europe and Japan. The regions considered are Canada, Mexico, Middle East, Africa and Australasia. There are three questions that a model of international trade should be able to answer: What chemicals do countries trade? With whom do countries trade? How much do countries trade? To evaluate the competitiveness of the products from those five regions in the developed world, the model is run under restricted trade environment; that is, a small upper bound is placed on all trade activity and the magnitudes of the penalty terms observed. 2 Refs.

Sigurdsson, M. (Univ of Wisconsin, Madison, WI, USA); Rudd, D.F. *Hydrocarbon Process* v 67 n 7 Jul 1988 p 34.E-34.L.

## Environmental Impact See WATER POLLUTION—Oil Spills.

## Physical Properties

**077271 DEGREE OF DRYING AND CORROSIVITY OF PETROLEUM SULFOXIDES.** The authors establish the sources of formation of sludge during prolonged storage of sulfoxides in St3 mild steel drums, and evaluate the quality of the sulfoxides after extended storage. Experimental data indicate that extended storage of the sulfoxides over a period of 1.5 years in a St3 steel drum does not affect the sulfoxide quality. But in the presence of water, the sulfoxides become contaminated with corrosion products. This means that if the sulfoxides are to be stored for extended periods or transported, either they must be dried (part of the dissolved water must be removed) or alloy steel drums must be used. In order to determine the required degree of drying of the sulfoxides corrosion tests were run on metals in a laboratory unit under static conditions at room temperature. In rating the test results, the basic index of the rate of uniform corrosion was the ratio of specimen weight change per unit of surface area per unit of time. In order to characterize the scatter of the data, average values of the corrosion rate were taken from tests on three specimens of the same steel.

Sharipov, A.Kh. (Scientific-Research Inst of Petrochemical Production, USSR); Isupova, N.F.; Suleimanova, Z.A.; Gorshkova, R.N. *Chem Technol Fuels Oils* v 23 n 7-8 Jul-Aug 1987 p 371-373.

## Processing See SURFACE ACTIVE AGENTS—Production.

## Production

**077272 CATALYSEURS ET PROCEDES CATALYTIQUES UTILISES DANS LA PRODUCTION DES GRANDS INTERMEDIAIRES PETROCHIMIQUES: SITUATION ACTUELLE ET FUTUR.** [Catalysis and Catalytic Processes Used for the Production of the Major Petrochemical Building Blocks: Present Situation and the Future]. Petrochemicals account for a modest share of the market for catalysts, but there have been substantial improvements in the catalysts and processes used in the last ten years. These improvements have brought about a better response to the demand for major petrochemical building blocks. This trend is clearly

illustrated by hydrogenations in the field of steam cracking to produce olefins, by catalytic reforming and satellite processes to produce aromatics, and by new processes such as dehydrogenation, metathesis and oligomerization which provide better balance to the market for olefins. (Author abstract) In French. 31 refs.

Boitiaux, J.-P. (Inst Français du Pétrole, Rueil-Malmaison, Fr); Le Page, J.-F. *Rev Inst Fr Pet* v 43 n 3 May-Jun 1988 p 405-422.

## Reviews See PETROLEUM INDUSTRY—Reviews.

## PETROLEUM ANALYSIS See Also DIESEL FUELS—Analysis; GAS OIL—Chemical Analysis; PETROLEUM, CRUDE—Additives; WATER POLLUTION—Oil Spills.

**077273 POSSIBLE LATE MIDDLE ORDOVICIAN ORGANIC CARBON ISOTOPE EXCURSION: EVIDENCE FROM ORDOVICIAN OILS AND HYDROCARBON SOURCE ROCKS, MID-CONTINENT AND EAST-CENTRAL UNITED STATES.** Oils generated by Middle Ordovician rocks are found throughout the Mid-Continent and east-central regions of the United States. Gas chromatographic characteristics of these oils include a relatively high abundance of n-alkanes with carbon numbers less than 20, a strong predominance of odd-numbered n-alkanes between C<sub>10</sub> and C<sub>20</sub>, and relatively small amounts of branched and cyclic alkanes. The wide ranges in  $\delta^{13}\text{C}$  for oils and rock extracts reflect a major, positive excursion(s) in organic matter  $\delta^{13}\text{C}$  in late Middle Ordovician rocks. This excursion has at least regional significance in that it can be documented in sections 480 mi apart in south-central Kansas and eastern Iowa. The distance may be as much as 930 mi. The parallel shifts in organic and carbonate  $\delta^{13}\text{C}$  in core samples from 1 E.M. Greene well, Washington County, Iowa, imply changes in the isotope composition of the ocean-atmosphere carbon reservoir. These and other aspects of the subject are discussed. (Edited author abstract) 60 refs.

Hatch, Joseph R. (US Geological Survey, Denver, CO, USA); Jacobson, Stephen R.; Witzke, Brian J.; Risatti, J. Bruno; Anders, Donald E.; Watney, W. Lynn; Newell, K. David; Vuletic, April K. *AAPG Bull* v 71 n 11 Nov 1987 p 1342-1354.

**077274 MACROSTRUCTURE OF ASPHALTENE DISPERSIONS BY SMALL-ANGLE X-RAY SCATTERING.** Three asphaltene dispersions have been studied by small angle X-ray scattering. Pematang and Grenada are two benzene dispersions of asphaltenes from atmospheric residues (350°C). Safaniya is asphaltene dispersed in maltene from a vacuum residue. The scattering data present characteristic profiles which can be explained by comparing the experimental with simulated curves. The macrostructure model used for the curve simulations is based upon a distribution of thin discs which all have the same thickness (3.4 Å) and a radius which follows a power law. The validity of such a model, discussed in the light of known properties of the asphaltenic particles, suggests that these membranes could result from the aggregation of small Yen's elementary units. (Edited author abstract) 30 refs.

Herzog, P. (Univ d'Orleans, Fr); Tchoubar, D.; Espinat, D. *Fuel* v 67 n 2 Feb 1988 p 245-250.

**077275 PRESENCE OF TRACE ELEMENTS IN CRUDE OILS AND ALLIED SUBSTANCES.** Individual crude oils have distinct trace element patterns, apart from what may be termed the common bulk earth elements. Analytical methods can now detect elements down to parts per billion. The distinction in the content of trace elements can be employed, as finger prints, to identify the source of an unknown crude specimen - as in an oil spill accident. While some of the elements found in crudes appear to be extrinsic in nature, some appear to be



intrinsic; that is to say, they may be part of the fossil organic matter not derived from the geologic surroundings. 7 refs.

Jones, Peter (Inst of Petroleum, London, Engl). *Pet Rev* v 42 n 497 Jun 1988 p 39-42.

**077276 IDENTIFICATION OF WEATHERED OILS.** Crude oils from the Cook and Brent formations in the same well at the Gullfaks field in the North Sea were weathered for one year under natural conditions. Samples of the oils were collected at intervals and analysed by GC-MS for the common so-called biomarkers: steranes at m/z 217, and pentacyclic triterpanes at m/z 191 and m/z 177. The resulting fragmentograms were treated by multivariate analysis. The patterns of steranes differed between the unweathered oils, but weathering affected them in such a way that identification was impossible after 4 months. The pattern of pentacyclic triterpanes were different for the two oils during the year, rendering these a good tool for identification of weathered oils, the demethylated triterpanes in particular. (Author abstract). 18 Refs.

Brakstad, Frode (Univ of Bergen, Bergen, Norw); Grahl-Nielsen, Otto. *Mar Pollut Bull* v 19 n 7 Jul 1988 p 319-324.

## Chromatographic Analysis

**077277 LA GASCROMATOGRAFIA NELLA GEOCHIMICA DEL PETROLIO.** [Gas Chromatography in Petroleum Geochemistry]. The aim of this paper is to describe the application of high-resolution gas chromatography (HRGC) to the geochemical study of oils and rock-extracts for oil-oil and oil-source rock correlation purposes. Certain gas-chromatographically derived parameters relevant to the type of organic matter and the depositional environment from which the oils have been generated are defined. Finally, some examples of maturity parameters and oil-oil and oil-source rock correlations are given. (Edited author abstract) In Italian.

Riva, Angelo (Agip Spa, San Donato Milanese, Italy). *Riv Combust* v 41 n 8-9 Aug-Sep 1987 p 199-221.

**077278 SEPARATION AND IDENTIFICATION OF A NEW BIOLOGICAL MARKER, 18 $\beta$ (H)OLEANANE, IN CRUDE OIL AND ANCIENT SEDIMENTS, BY HIGH RESOLUTION GAS CHROMATOGRAPHY-MASS SPECTROMETRY.** One method for the analysis of complex mixtures from geological sources is the use of high resolution gas chromatography data together with mass spectra obtained by combined gas chromatography-mass spectrometry (GC-MS). The aim of this study is to separate and identify a compound that was already shown by several authors and called 'peak J', which under the usual conditions of routine gas chromatography co-elutes with the 18 $\alpha$ (H)oleanane peak. It is possible to separate the 18 $\alpha$ (H)oleanane peak and that of the 'J compound' by using commercial standard columns and the temperature program. This separation is obtained with an analysis time typical of routine analysis. The 'peak J' was identified as 18 $\beta$ (H)oleanane by mass spectrometry, using the spectra obtained as indicated above, and by retention time, co-injecting the pure compound. (Edited author abstract) 11 refs.

Caccialanza, P.G. (Agip Spa, San Donato Milanese, Italy); Riva, A. *Riv Combust* v 42 n 1 Jan 1988 p 3-8.

**077279 18 $\beta$ (H)OLEANANE IN CRUDES AND IN TERTIARY-UPPER CRETACEOUS SEDIMENTS. DEFINITION OF A NEW MATURITY PARAMETER.** Ekweozor (1979) first discovered a new unknown compound with a retention time very close to the 18 $\alpha$ (H)oleanane peak in oils and Tertiary sediments of the Nigerian Delta. This compound was called the 'J compound'. Several Authors (e.g. BENSCHAW et al. 1981, SCHOELL et al. 1981, etc.) found the 18 $\alpha$ (H)oleanane without underlining the presence of the 'J compound', because of their perfect co-elution. In this study the presence of 'J compound' has been confirmed in more than 150 rock-extracts and 20 oils from different countries, and

is identified as the 18 $\beta$ (H)oleanane by means of retention time, mass spectra and standard co-injection. Apart from Tertiary sediments, the 18 $\alpha$ (H) and 18 $\beta$ (H)oleananes have also been found in Upper Cretaceous sediments, extending the occurrence of these compounds back in age. (Edited author abstract) 11 refs.

Riva, A. (Agip Spa, San Donato Milanese, Italy); Caccialanza, P.G.; Quagliaroli, F. *Oil Gas J* v 86 n 23 Jun 6 1988 p 9-16.

**077280 IDENTIFICATION OF SOME NOVEL TETRACYCLIC DITERPENE HYDROCARBONS IN PETROLEUM.** A new group of tetracyclic diterpene hydrocarbons of molecular formula C<sub>19</sub>H<sub>32</sub> has been found in the Jurassic oils and condensates of the Central Kara-Kum (Turkmenia, USSR). The structure of the hydrocarbons has been determined by gas chromatography-mass spectrometry and <sup>1</sup>H and <sup>13</sup>C NMR. Of the compounds identified 4,8-dimethyl-13-isopropyltetracyclo[6.6.0.0<sup>1,11</sup>.0<sup>0,7</sup>]- and 5,14-dimethyl-10-isopropyltetracyclo[6.4.1.1<sup>1,9</sup>.0<sup>4,13</sup>]tetradeccanes are present in the highest concentrations. Some ideas are put forward about the source and the reactions involved in the formation of the hydrocarbons under natural conditions by the enzymic C<sub>5</sub> cyclization of aliphatic isoprenoids. (Author abstract). 20 Refs.

Petrov, Alexander A. (Inst of Geology & Exploitation of Combustible Minerals, Moscow, USSR); Pehk, Tonis Y.; Vorobieva, Nadezhda; Zemskova, Zinaida K. *Org Geochem* v 12 n 2 1988 p 151-156.

Hydrocarbon Determination See PETROLEUM, CRUDE—Chromatographic Analysis.

## Sampling

**077281 ROBOTISATION OF SAMPLE PREPARATION IN A PETROLEUM LABORATORY.** The Esso Research Centre near Abingdon in Oxfordshire is the main focus of research effort in Europe for the Exxon Corporation. A study of the testing carried out by the instrumental elemental analysis group showed that although many different types of analyses were carried out, 5 principal tests accounted for some 50 per cent of the workload. It was clear that big benefits would accrue from the automation of these 5 tests. The overall impression at Esso Research of the laboratory automation system employed is favorable. It has demonstrated that it is capable of carrying out the work for which it was purchased and can be left to run unattended both during the day and, when required, overnight.

Wright, E.R. (Esso Research Cent, Abingdon, Engl). *Q J Tech Pap Inst Pet* Oct-Dec 1986 p 87-89.

## Spectroscopic Analysis

**077282 SPECTROSCOPIC STUDIES OF PETROLEUM RESINS.** Resin fractions containing heteroatoms obtained from deasphalted oils of petroleum residues (500°C+) of Bombay High (BH) and Gujrat Crude Mix (GCM) have been separated into acidic, basic and neutral Lewis (NLB) types employing chromatographic methods. Ultimate compositions of these fractions have been determined for deducing the average molecular formulae. Infrared spectroscopy has been employed for assigning various heteroatomic functional groups and estimating compound types. (Edited author abstract) 15 refs.

Sarowha, S.L.S. (Indian Inst of Petroleum, Dehra Dun, India); Singh, I.D. *Fuel Sci Technol Int* v 6 n 1 Feb 1988 p 1-25.

Trace Analysis See PETROLEUM CHEMISTRY—Geochemistry.

PETROLEUM CHEMISTRY See Also PETROLEUM GEOLOGY; PETROLEUM RESERVOIR ENGINEERING—Core Analysis.

**077283 PRESENCE OF TRACE ELEMENTS IN CRUDE OILS AND ALLIED SUBSTANCES.** From time to time there is an expressed interest in the trace elements' and in particular metallic elements that, measured in parts per million, are present in all crude oils. Because the pattern of many of these trace elements is quite distinctive for various crude oils, their measurement can be used, in the forensic sense, for finger printing the source of otherwise unknown oil spill found on the sea, or stranded on a coastline. Another factor of interest is that in the process of refining the crude oil, the trace metals are accumulated in the distillation residues from the crude oil. The paper reviews: what effect do they have on the fouling and possible poisoning of the catalyst and its useful life what is the effect of these trace elements when the residues are blended up to produce the heavy industrial burner fuels. 7 Refs.

Jones, Peter (Inst of Petroleum, London, Engl). *Q J Tech Pap Inst Pet* Apr-Jun 1988 p 73-76.

**077284 METAL COMPLEXES IN FOSSIL FUELS: GEOCHEMISTRY, CHARACTERIZATION, AND PROCESSING (DEVELOPED FROM A SYMPOSIUM AT THE 191ST MEETING OF ACS).** This conference proceedings contains 26 papers. The papers are divided into the following groups: Geochemistry; processing; and Characterization. The emphasis is mostly on metalloporphyrins because these compounds possess spectral characteristics that permit detection in small concentrations and have chemical properties that allow purification from background materials. The investigations concern the compounds derived as a consequence of geochemical processes. The metal complexes formed may cause problems in processing, therefore a number of papers represent research to remove them or otherwise deal with their deleterious effects. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11463 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Filby, Royston H. (Ed.) (Washington State Univ, Pullman, WA, USA); Branthaver, Jan F. (Ed.). *ACS Symp Ser* 344, Met Complexes in Fossil Fuels: Geochem, Charact, and Process, New York, NY, USA, Apr 13-18 1986. Publ by ACS, Washington, DC, USA, 1987 436p.

Bibliographies See CHEMICAL REACTIONS—Pyrolysis.

## Chromatographic Analysis

**077285 DETERMINATION AUTOMATIQUE DE L'INDICE D'OCTANE ET DE LA COMPOSITION DES REFORMATS PAR CHROMATOGRAPHIE EN PHASE GAZEUSE.** [Automatic Determination of Reformate Octane Number and Composition by Gas Chromatography]. This article describes the operating conditions of an optimized chromatographic method for reformates with a view to obtaining calculated values of the research octane number (RON) different by at least one point from the values measured with a CFR engine according to the ASTM/D2699 standard. Chromatographic analysis was formed in a capillary column operating with programmed temperature. Data processing was done with a software ensuring the identification of the constituents and computing of the octane number from standard chromatographic data (retention time and peak area). The results concern some 60 different reformates. (Edited author abstract) 10 refs. In French.

Petroff, N. (Inst Francais du Petrole, Rueil-Malmaison, Fr); Boscher, Y.; Durand, J.P. *Rev Inst Fr Pet* v 43 n 2 Mar-Apr 1988 p 259-271.

## Geochemistry

**077286 COMPOSITIONAL AND GEOCHEMICAL CHARACTERISTICS OF CONTINENTAL HEAVY**



**OILS OF CHINA.** Using the solvent extraction, TLC, HPLC, GC-MS, FT-IR, UV-Visible spectrophotometry, this article analyzes the group composition, the steranes and terpanes, porphyrins, and the functional groups of asphaltene and resin components in the heavy crude oil fields of Kalamai, Uho, Dagang, Liaohe, and Jiangnan in China, and the trace metal elements in the ashes of crude of Jiangnan gypsum-salt basin. From the analyzed results, the following can be concluded: The asphaltene contents in heavy crude are 1 to 4 times higher than those in normal crude. The steranes and terpanes in the saturated hydrocarbons have two typical characteristics. Heavy oils generally contain porphyrin compounds. Their contents and types vary with the stage of the crude's maturation. The ashes of Jiangnan heavy oils contained more than 13 trace metallic elements. (Edited author abstract) 8 refs.

Yang, Zhiqiong (Research Inst of Petroleum, Beijing, China); Gu, Xinzhang; Zhang, Ling. *Energy Sources* v 9 n 4 1987 p 211-227.

**077287 OIL PROSPECTS OF THE GULF OF SUEZ, EGYPT - A CASE STUDY.** Four groups of rocks, having more than 0.5 PERCENT of organic carbon are defined within the subsurface section of Rahmi area, Gulf of Suez. The deduced types of indigenous kerogen are: algal-amorphous, inertinite-woody, and herbaceous. The algal-amorphous kerogen of Rudeis/Nukhul Formations (Lower Miocene), Eocene and pre-Eocene rocks is recognized as being oil prone, that is having high capacity for generating oil. The application of hydrocarbon liquid window concept shows that the LOM values fall within the range from 8.6 to 10.8, and the thermal alteration index for the different units is not extended into oil generation window, where it ranges from immature (Kareem Formation-Lower Miocene), to moderately mature (Paleocene), to the beginning of the thermal phase of oil generation (Senonian). The vitrinite reflectance values indicate a low level of thermal maturity. The study of organic richness, quality and maturity revealed that, where the Nukhul, Eocene and Senonian rocks are buried deeper would have been excellent source rocks for oil. (Edited author abstract). 26 Refs.

Elzarka, M.H. (Alexandria Univ, Alexandria, Egypt); Mostafa, A.R. *Org Geochem* v 12 n 2 1988 p 109-121.

**077288 GEOCHEMICAL APPLICATION OF STERANE AND TRITERPANE BIOMARKERS TO A DESCRIPTION OF OILS FROM THE TARANAKI BASIN IN NEW ZEALAND.** The distributions of sterane and terpane biomarkers in a suite of 25 oils from onshore and offshore regions of the Taranaki Basin of New Zealand have been determined by gc-ms. Features of these distributions include the presence of relatively high concentrations of a number of  $C_{24}$  tetracyclic terpanes, the virtual absence of tricyclic terpanes, a predominance of  $C_{29}$  normal-, iso- and diasteranes and the presence of a number of non-hopanoid triterpanes. Based upon the distributions of  $18\alpha$ (H)oleanane, the McKee and Moturoa families of oils can be delineated. These terpane distributions are qualitatively similar to those encountered in crude oils from a number of Far-Eastern basins and from the Handil field of the Mahakam delta (Indonesia). The Taranaki oils are of approximately the same thermal maturity. An attempt has been made to correlate the McKee-1 and Maui-4 crude oils with potential source rocks from depths of 3708 m and 3825 m respectively. The rocks studied have attained insufficient maturity to have been the sources of these oils. (Edited author abstract). 43 Refs.

Czochanska, Z. (DSIR, Petone, NZ); Gilbert, T.D.; Philp, R.P.; Sheppard, C.M.; Weston, R.J.; Wood, T.A.; Woolhouse, A.D. *Org Geochem* v 12 n 2 1988 p 123-135.

**077289 INVESTIGATION ON THE EFFECTS OF ORGANIC SOLVENT EXTRACTION ON WHOLE-ROCK PYROLYSIS: MULTIPLE-LOBED AND SYMMETRICAL  $P_2$  PEAKS.** Pyrolysis techniques provide an estimate of oil-generating potential of a sediment based on the amount of  $P_2$  (or  $S_2$ ) hydrocarbons. Multiple-lobed and symmetrical  $P_2$  peaks were studied to determine if extractable bitumen affected the  $P_2$  results.

Samples from the Tiglukpak and Ledbetter wells were analyzed as whole, unextracted, ground sediment and after organic solvent extraction using pyrolysis techniques. Results indicate that  $P_2$  for the Tiglukpak well appears unaffected by solvent extraction.  $P_2$  peaks for the Ledbetter well samples appear to include extractable bitumen or asphaltene. Pyrolysis-gas chromatography (pyrolysis-GC) and pyrolysis-gas chromatography-mass spectrometry (pyrolysis-GC/MS) determined the composition of the portion of the  $P_2$  peak for the Ledbetter well that was removed by organic solvent extraction. Pyrolysis-GC analysis also demonstrated that for the Ledbetter well gas-generating organic material was not removed by organic solvents. (Author abstract). 20 Refs.

Tarafa, Martha E. (Woods Hole Oceanographic Inst, Woods Hole, MA, USA); Whelan, Jean K.; Farrington, John W. *Org Geochem* v 12 n 2 1988 p 137-149.

**077290 ORGANIC GEOCHEMICAL CORRELATION OF OKLAHOMA CRUDE OILS USING R- AND Q-MODE FACTOR ANALYSIS.** For the past several decades, there has been a significant amount of crude oil exploration and production throughout the state of Oklahoma. Publications with respect to biological marker compound distributions and stable isotopic compositions of Oklahoma crude oils, their potential genetic relationships and possible sources have, however, been very limited. In this study, a detailed organic geochemical investigation of 46 crude oils from throughout the state of Oklahoma is presented. In addition to assessing similarities and differences of the oils with respect to reservoir ages and geologic provinces, an attempt was made to establish possible genetic relationships on the basis of combined R- and Q-mode factor analysis of source-related geochemical parameters. While the oils from throughout the state were found to be remarkably similar in chemical and stable isotopic composition, four genetic families of oils have been delineated based on this statistical approach. (Edited author abstract). 52 Refs.

Engel, Michael H. (Univ of Oklahoma, Norman, OK, USA); Imbus, Scott W.; Zumberge, John E. *Org Geochem* v 12 n 2 1988 p 157-170.

**PETROLEUM COKE** See Also CHEMICAL REACTIONS—Desulfurization.

**077291 FORMATION OF PETROLEUM CARBO- NACEOUS SUBSTANCES AND THEIR INTERAC- TION WITH A METAL SURFACE.** The results are given of an investigation of the laws of interaction of carbonaceous substances with a metal surface. A mechanism of the interaction is suggested which is illustrated by experimental results. (Author abstract) 5 refs.

Kuzev, I.R.; Khairudinov, I.R.; Abyzgil'din, Yu.M. *Solid Fuel Chem* v 21 n 2 1987 p 136-138.

**077292 COKE FORMATION ON METAL FOILS FROM HEAVY OILS.** The coke deposition on nickel and steel foils during pyrolysis of heavy oils has been studied. The amount of coke deposited on the foils was found to be dependent on foil type, reactor history, feed type and reaction conditions. On nickel, an asphaltene-containing feed gave more coke than an asphaltene-free feed. The coking on the metal foils increased in the order SS-302 < Inconel 718, Inconel X < Nickel. Introducing a rougher surface by rubbing the foils increased the coking. Scanning electron micrographs of the coked foils are presented and reveal details of two types of deposit. (Edited author abstract) 23 refs.

Blekkan, Edd Anders (Norwegian Inst of Technology, Trondheim, Norw); Holmen, Anders. *Carbon* v 25 n 6 1987 p 827-835.

**077293 EFECTOS DE LA ADICION DE COQUE DE PETROLEO A MEZCLAS CON PROPIEDADES PLASTICAS DIFERENTES.** [Effect of Petroleum Coke Addition on Blends with Different Plastic Properties]. The search of possible ways for increasing the use of national raw materials and lowering coking costs led to a research program based on the domestic petroleum coke

utilization in coking blends. This report is the second of that program. Variable amounts of petroleum coke were added to blends with different plastic properties. The effect of petroleum coke addition turned out to depend upon the rheological characteristics of the base blend. The addition of petroleum coke to the blend improves abrasion strength, expressed in terms of M40 index, when the base blend has good plastic properties while it deteriorates if the base blend has poor plastic properties. The M40 index evolution shows that it improves due to less fissuring or becomes worse because of poorer bonding with reference to the base blend properties. (Author abstract) 3 refs. In Spanish.

Madias, J. (Inst Argentino de Siderurgia, Argent); Colombo, L.; Ruiz, O. *Rev Metal (Madrid)* v 24 n 1 Jan-Feb 1988 p 8-15.

**Applications** See BOILER FIRING—Oil Fuel.

**Chemical Reactions** See ELECTRODES—Manufacture.

**Graphitization**

**077294 PUFFING BEHAVIOR OF NEEDLE COKE PREPARED FROM HETEROCYCLIC COMPOUNDS.** The influence of sulfur and nitrogen on puffing was investigated separately and jointly by using needle coke specimens prepared from acenaphthylene, thianthrene (sulfur source), and phenazine (nitrogen source). Puffing is closely related to the presence of sulfur and/or nitrogen in the coke. The influence of sulfur in the coke on puffing is stronger than that of nitrogen. There is no mutual interaction of the two elements in their effect on puffing. The extent of puffing is inversely proportional to the bulk density of graphitized coke. (Author abstract) 14 refs.

Fujimoto, Ken-ichi (Nippon Steel Corp, Kawasaki, Jpn); Nagino, Hisayuki. *High Temp High Pressures* v 19 n 5 1987 p 559-565.

**Magnetic Field Effects**

**077295 EFFECTS OF A MAGNETIC FIELD ON HEAVY OIL RESIDUES AT HIGH TEMPERATURES.** The authors have measured the effects of magnetic fields on heavy oil residues at high temperatures. This was necessary because deposits (coking) may be formed in heat-transfer equipment in oil refineries. Deposition occurs in heat exchangers, reboilers, ovens, tubes, and compressors in systems for distilling petroleum, alkylation, and cracking over wide parameter ranges for liquids with boiling points up to 311°K at flow temperatures of 408-755°K with metal surfaces at 477-803°K, with the deposition most pronounced in tubular ovens in slow-coking systems. There are several ways of reducing the coking in these tube coils, which include chemical ones (the introduction of solvents) and hydrodynamic ones (increased turbulence in the flow). The authors examine the use of magnetic fields for these purposes. 11 refs.

Kozlova, R.G. (All-Union Research Inst for Collecting, Preparing, & Transporting Oil & Oil Products, Ufa, USSR); Gostev, N.M.; Kandaurov, A.A. *J Eng Phys* v 51 n 6 Dec 1986 p 1452-1454.

**Manufacture**

**077296 OPTIMIZATION OF CARBONIZATION CONDITIONS FOR NEEDLE COKE PRODUCTION FROM A LOW-SULPHUR PETROLEUM VACUUM RESIDUE.** The optimum carbonization conditions for converting a low-sulphur petroleum vacuum residue in a tube bomb in terms of pressure and temperature into better needle coke of low coefficient of thermal expansion (CTE) with less production of poor bottom coke, were studied by observation of the resultant cokes and sequential analyses of carbonization intermediates by means of solvent fractionation and gas evolution. Carbonization at 460°C under 15 kg cm<sup>-2</sup> G produced the best needle coke. The quality of the resultant needle coke was strongly influenced by viscosity changes of the system, the solidifi-



cation range and gas evolution. The formation of a bottom coke of fine mosaic texture is discussed from the viewpoint of the co-carbonization concept. (Edited author abstract) 13 refs.

Mochida, Isao (Kyushu Univ, Fukuoka, Jpn); Oyama, Takashi; Fei, You Qing; Furuno, Tetsuya; Korai, Yozo. *J Mater Sci* v 23 n 1 Jan 1988 p 298-304.

## Oxidation

**077297 OXIDATION STUDIES OF VARIOUS PETROLEUM COKES.** In situ scanning transmission electron microscopy has been used to evaluate various coke samples ranging from very isotropic to ultrapremium needle-like in terms of their oxidation characteristics. Three major modes of attack were identified: a) low temperature (375°C) shallow pitting, which predominated in isotropic materials, b) high temperature (525°C) deep pitting, which appeared to be associated with highly anisotropic structures and c) edge recession, which occurred with all cokes but was most apparent with anisotropic structures. A rationale is presented which accounts for the behavior of isotropic and anisotropic cokes in oxygen. (Author abstract) 24 refs.

Rodriguez, N.M. (Auburn Univ, Auburn, AL, USA); Marsh, H.; Heintz, E.A.; Sherwood, R.D.; Baker, R.T.K. *Carbon* v 25 n 5 1987 p 629-635.

**077298 METHOD OF INVESTIGATING THE INTERACTION OF COKES WITH OXYGEN.** In the present work the authors have shown the possibility of using a differential flow-through reactor for studying the non-steady-state reaction of petroleum coke with atmospheric oxygen (volume concentration of oxygen 21%). The reactor consists of a tube with an internal diameter of 8 mm the bottom of which is filled with crushed quartz. The temperature in the reaction zone is measured by a thermocouple of the TPP type and a portable potentiometer of the PP-63 type. 7 refs.

Zhirnov, B.S.; Murtazin, F.R.; Akhmetov, S.A. *Solid Fuel Chem* v 21 n 4 1987 p 126-130.

## Production

**077299 MECHANISTIC MODEL FOR FORMATION OF COKE IN PYROLYSIS UNITS PRODUCING ETHYLENE.** Coke is formed by three mechanisms during pyrolysis processes used to produce ethylene. The mechanisms result in metal-catalyzed coke, noncatalytic coke formed from tars, and pyrocarbon coke that is produced when small precursors react with free radicals on the coke surface. The relative importance of each of the above mechanisms depends on the operating conditions, hydrocarbon feedstock, and type of reactor used. (Author abstract) 19 refs.

Albright, Lyle F. (Purdue Univ, West Lafayette, IN, USA); Marek, James C. *Ind Eng Chem Res* v 27 n 5 May 1988 p 755-759.

## Spectroscopic Analysis

**077300 SPECTROGRAPHIC DETERMINATION OF NITROGEN CONTENT IN PETROLEUM COKE.** A procedure is described for the determination of nitrogen in raw and calcined petroleum coke according to the band of cyanogen that is formed by reaction of carbon with nitrogen in the zone of an arc. The spectra were recorded on an ISP-51 spectrograph with a three-lens system of slit illumination. Experiments showed that with an argon flow rate of 5 liters/min, the difference in densities of the cyanogen band and the background is minimal, and remains unchanged when the purge rate is further increased. The residual content of nitrogen in the chamber is monitored by means of a blank experiment. The results obtained by the proposed method on raw cokes are compared with results obtained by the Kjeldahl method; for the calcined coke, they are compared with results obtained by the method of additions. The content of nitrogen in needle cokes is at the 0.2% level. The lower level for determination of nitrogen content in coke is

0.05%, and the relative standard deviation is 0.1. 6 refs.

Ryzhenko, I.I. (Bashkirian Scientific-Research Inst for Petroleum Processing, USSR); Biktimirova, T.G.; Zamilova, L.M.; Sokolova, V.I. *Chem Technol Fuels Oils* v 23 n 7-8 Aug 1987 p 352-354.

## Testing

**077301 ABRADABILITY OF PETROLEUM PYROLYSIS COKES.** Grade KNPS pyrolysis coke as a filler in carbonaceous materials of construction (CMCs) determines their properties to a considerable degree. The coke accounts for 70-90% of the total material weight. The authors have carried out a statistical analysis of experimental data collected over an extended period (approx. 20 years); this analysis has shown that abrasability coefficient  $K_a$  essentially does not correlate with any of the basic standard quality indexes. The coefficient of correlation for the comparison pairs  $K_a/d_a$  (where  $d_a$  is the actual density) and  $K_a/V$  were found to be 0.31 and 0.07, respectively, with a significance of this value greater than 0.5. The limits of variation of abrasability for different grades of pyrolysis coke were determined. 4 refs.

Ostrovskii, V.S.; Sinel'nikov, L.Z. *Chem Technol Fuels Oils* v 23 n 1-2 Jan-Feb 1987 p 89-92.

**PETROLEUM, CRUDE** See Also ASPHALT—Physical Properties; EMULSIONS—Microscopic Examination; EMULSIONS—Rheology; ENERGY RESOURCES; OIL FUEL—Residual; PETROLEUM PIPELINES—Mathematical Models; PETROLEUM REFINING—Demulsification.

**077302 CRUDE OILS AND THEIR DISTILLATES: CHARACTERIZATION BY DIFFERENTIAL SCANNING CALORIMETRY.** Differential scanning calorimetry has been used to characterize crude petroleum. A thermal fingerprint can be obtained in a short time with a single experiment. Several parameters such as the glass transition temperature  $T_g$  of the hydrocarbon matrix, temperature of crystallization, and paraffin content can be measured with good reproducibility. For the same crude, a correlation has been found between  $T_g$  and  $T_c$  for distillates prepared under the ASTM method D2892. (Edited author abstract) 12 refs.

Claudy, Pierre (CNRS, Villeurbanne, Fr); Letoffe, Jean-Marie; Chague, Benoit; Orrit, Jean. *Fuel* v 67 n 1 Jan 1988 p 58-61.

**077303 CORRELATING THE PVT PROPERTIES OF NIGERIAN CRUDES.** Existing correlations for predicting solution gas oil ratio,  $R_s$ , and oil formation volume factor,  $B_o$ , gave standard deviations as high as 50 and 12 percent, respectively, for Nigerian crudes. New correlations developed using 503 pressure-volume-temperature (PVT) data points from 100 Nigerian crude oil reservoirs of the Niger Delta Basin are presented. The correlations for  $R_s$  and  $B_o$  predict values from different reservoirs within 6 and 2 percent standard deviations, respectively, and apply to crudes of specific gravity range 0.811 to 0.966. These correlations are applicable to other crudes with characteristics similar to those of Nigerian crudes. (Author abstract) 7 refs.

Obomanu, D.A. (Nigerian Natl Petroleum Corp, Port Harcourt, Nigeria); Okpobiri, G.A. *J Energy Resour Technol Trans ASME* v 109 n 4 Dec 1987 p 214-217.

**077304 VACUUM RESIDS FROM SYRIAN AND CUBAN CRUDES AS COKER FEEDS.** Vacuum resid from Syrian crude and commercial mixed Cuban crudes were subjected to delayed coking in a laboratory batch unit under conditions simulating the commercial unit operation. It can be seen from the data that the vacuum resid from Syrian and Cuban crudes offer promise for use as coker feedstocks. The coke obtained from the Syrian and Cuban vacuum resid is distinguished by a high sulfur content, 1.5-2 times than in the coke from the high-sulfur Oxino vacuum resid. Studies have demonstrated the economic advisability of using vacuum resid from Cuban and Syrian crudes in the delayed coking process. 5 refs.

Stekhun, A.I.; Warfolomeev, D.F. *Chem Technol Fuels*

*Oils* v 23 n 5-6 May-Jun 1987 p 260-261.

**077305 METHOD FOR EVALUATING KINETIC STABILITY OF PETROLEUM DISPERSE SYSTEMS.** The authors study the phase equilibrium of PDS (Petroleum Disperse Systems) and their stability against aggregation of the asphaltene. We are proposing that the ratio of paraffinic/naphthenic and aromatic hydrocarbons in the system should be varied by introducing a model dispersion medium, and the dynamics of change of PDS composition should be noted on a triangular diagram. Data for the construction of the PDS phase equilibrium curve are given. Phase equilibrium curves, which are represented for convenience on Cartesian coordinates, offer a means for a quantitative evaluation of the kinetic stability of a PDS according to the threshold concentration of the disperse phase with a constant fraction of precipitant in the system. This procedure can be used in determining the quantity of precipitant required to achieve the necessary depth of deasphalting, or to determine the depth of deasphalting with a given consumption of precipitant.

Marushkin, A.B.; Kurochkin, A.K.; Gimaev, R.N. *Chem Technol Fuels Oils* v 23 n 5-6 May-Jun 1987 p 262-264.

**077306 NEW TECHNOLOGY SEEKS TO END PIPELINES' HEAVY CRUDE DILUENT.** Sponsors are nearing commercialization of a new technology for infield partial upgrading of heavy crude and bitumen which they say could eliminate the need for diluent blending of Canadian heavy oil. Production growth of Canadian heavy oil and bitumen may be slowed in the 1990's for lack of condensate to dilute the low gravity, viscous hydrocarbons for pipeline shipment. Resource Technology Associates (RTA), Boulder, Colo., reported successful results from a 30 day run of its Geotreater process 50 b/d pilot plant at Hazen Research Inc., Golden, Colo. Further, an engineering study Santa Fe Braun Inc. conducted for RTA on 10,000-50,000 b/d Geotreater units showed commercial potential, especially in Canada.

Anon. *Oil Gas J* v 86 n 22 May 30 1988 p 40.

**077307 GROUP COMPOSITION OF THE LOW MOLECULAR WEIGHT NITROGEN BASES OF SAMOTLOR CRUDE OIL.** Low molecular weight nitrogen bases of Samotlor oil, extracted by aqueous and 50 percent acetic acid solutions of 25 percent sulfuric acid, are mainly quinoline derivatives containing benzene and naphthalene rings, respectively, and also thiazole derivatives. Of the non-extracted part of the ultimate concentrate of the nitrogen bases, mixed heteroatomic structures predominate, most probably in the form of thio-phenoxinolines, amides, and carboxylic derivatives of pyridine containing benzene and naphthalene rings. Fractionation of the concentrate of the nitrogen bases by the given sulfuric acid solutions occurs in accordance with increase in the molecular weight and reduction in the aromatic nature of the molecules on account of an increase in cycloalkane and aliphatic framing of the latter. 5 refs.

Turov, Yu.P. (USSR Acad of Sciences, Tomsk, USSR); Gerasimova, N.N.; Sagachenko, T.A.; Beiko, O.A. *Pet Chem USSR* v 27 n 1 1987 p 20-25.

## Additives

**077308 INFLUENCE OF ADDITIVES OF DISPERSE COMPOSITION OF PETROLEUM.** The present work has been aimed at determining the effects on the disperse composition of crude oils from various fields (Kalamkas, Karazhanbas, Uzen', Zhetysai, Oimasha) by the addition of technical carbon (PM-100, PM-75, PM-50), light pyrolysis tar, and crude oils from other fields. The crudes from the Kalamkas and Karazhanbas fields are classed as high-resin and low-wax; the Uzen' and Zhetysai crudes are classed as high-wax; and the Oimasha crude is classed as medium-wax without any resins or asphaltene. Characteristics of the crudes are given. Disperse systems are studied by means of such physical methods as small-angle X-ray scattering, conductivity measurement, laser correlation spectroscopy, etc. 8 refs.



Nadirov, N.K. (Acad of Sciences of the Kazakh SSR, USSR); Zhumasheva, K.S.; Burkitbaev, S.M.; Kenzhebaev, A.B. *Chem Technol Fuels Oils* v 23 n 1-2 Jan-Feb 1987 p 92-96.

**Analysis** See Also ACIDS—Composition Effects; PETROLEUM GEOLOGY.

**077309 RELATIONSHIPS IN COMPONENT-FRACTIONAL AND CHEMICAL COMPOSITION OF CRUDE OILS.** The proposed series of articles, of which this is the first, reflects the results obtained by applying systems analysis methods to a large volume of analytical data for crude oils from various regions of the world. So far as, crude oils have not been previously examined in this particular aspect; therefore, the developments set forth in these articles may prove to be useful not only because of the methods and techniques that are set forth, but also in terms of the use of the very principles of mathematical systems research. Some of the relationships that a described have been found to give an adequate representation of results obtained in investigation of the composition of not only crude oils, but also products of many chemical conversions in hydrocarbon systems, particularly in natural gases and gas condensates. 8 refs.

Eigenson, A.S. (Bashkirian Scientific-Research & Design Inst of the Petroleum Industry, USSR); Sheikh-Ali, D.M. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 197-204.

**077310 ASPHALTENES IN SAUDI ARABIAN HEAVY CRUDE OIL SOLUBILITY AND MOLECULAR WEIGHTS IN HYDROCARBON SOLVENTS.** The asphaltenes from Saudi Arabian Heavy crude oil residue (370°C+) were precipitated by adding n-alkane solvents (n-C<sub>5</sub> to n-C<sub>10</sub>) to the crude oil/residue. The asphaltenes thus prepared were examined for their percent yields, VPO molecular weights and ultimate composition. VPO molecular weights were measured in five different solvents of varying dielectric constant (2.2 to 12.3). The yield and atomic H/C ratio of Arabian Heavy asphaltenes were found to decrease with an increase in the carbon number of precipitating solvent. (Edited author abstract)

Ali, Mohammad Farhat (King Fahd Univ of Petroleum & Minerals, Dhahran, Saudi Arabia); Saleem, Mohammad. *Fuel Sci Technol Int* v 6 n 5 Oct 1988 p 541-556.

**077311 CRUDE OIL FROM THE ZABURUN'E FIELD.** The oil from the Zaburun'e field is heavy (density 894.5 kg/m<sup>3</sup> at 20°C), viscous (46.3 mm<sup>2</sup>/sec at 50°C) medium-resin (content of silica gel resins 8.8% by weight), and low-pour (solid point -37°C), with small contents of asphaltenes (0.3% by weight), wax (0.02% by weight), and sulfur (0.4% by weight). Investigation of the hydrocarbon group composition of 50°C fractions of the oil showed that the fractions distilling below 350°C consist mainly of high-energy isoparaffinic and naphthenic hydrocarbons, the total content of which amounts to 82-94% by weight. The contents of naphtha fractions in the crude are very low: 1.6% by weight below 180°C, 2.5% by weight below 200°C. Lube stocks obtained from the Zaburun'e crude have high viscosity indexes, low solid points, and low sulfur contents.

Dorogochinskaya, V.A. (Groznyi Petroleum Scientific-Research Inst, USSR); Shul'zhenko, E.D.; Varshaver, V.P.; Khabibulina, R.K. *Chem Technol Fuels Oils* v 23 n 7-8 Jul-Aug 1987 p 337-339.

**077312 SPILLS FROM LARGE CRUDE-OIL-CARRYING TRANSMISSION PIPELINES - AN ANALYSIS BY CAUSE, FREQUENCY, AND CONSEQUENCE.** The author presents for one particular type of pipeline a probabilistic assessment of the likelihood of unwanted failures, and the likely spill volumes associated with each of the main failure causes. The failure frequencies shown in this analysis are low when compared with other forms of transportation, with the mean volume of oil spilt in these failure incidents being some 100m<sup>3</sup>. Clearly, the environmental, humanitarian, and economic risks presented by any pipeline system will depend on particular circumstances, for example the pipeline routing, and

must of course be compared against those risks associated with any alternative. The analysis presented provides the type of information which can assist this comparison. Further, the author believes that the analysis also highlights those areas where maximum benefit could be achieved if it was thought necessary to expend resources on any further risk-reduction measures. 7 Refs.

Hall, Dr. S.M. (BP International Ltd). *Pipes Pipelines Int* v 33 n 4 Jul-Aug 1988 p 15-20.

**Biodegradation** See Also PETROLEUM ANALYSIS.

**077313 EFFECT OF BIODEGRADATION ON CRUDE OIL BULK AND MOLECULAR COMPOSITION.** A laboratory simulation of an oil spill was used to monitor the effect of microbial alteration on crude oil molecular, bulk and carbon isotopic compositions. The rate of microbial alteration of alkanes decreased with increasing carbon number. Straight-chain alkanes were more rapidly removed than branched (isoprenoids) hydrocarbons though ultimately even the isoprenoids were degraded. Aromatic compounds were also altered. Isomer specific degradation was observed within a given aromatic alkylation (i.e., methylphenanthrenes). The most stable properties, under the given conditions, were carbon isotopic composition, Ni/V ratios, total scanning fluorescence spectra, and various molecular distributions. (Edited author abstract) 31 refs.

Kennicutt, Mahlon C. II (Texas A&M Univ, College Station, TX, USA). *Oil Chem Pollut* v 4 n 2 1988 p 89-112.

**077314 BAKTERIELLER ABBAU ALS MOEGLICHE URSACHE FUR DIE ENTSTEHUNG VON SCHWEROELEN.** [Biodegradation as Possible Cause for Heavy Oil Generation: Microbiological, Organic-Geochemical and Isotope-Geochemical Investigations of Crude Oils]. The investigations performed contribute to the theory of heavy oil generation by biodegradation of conventional crude oils in reservoir rocks. The geological setting in a field of the Giffhorn Trough allows the occurrence of biodegraded and non-degraded oils of the same origin in close vicinity. From the degraded samples microorganisms (bacteria and yeasts) were cultivated under aerobic and anaerobic conditions and then in vitro degradations were performed by inoculating nondegraded oils with cultures obtained. All experiments to degrade oils under anaerobic conditions failed. (Edited author abstract) 11 refs. In German.

Wehner, H. (Bundesanstalt fuer Geowissenschaften und Rohstoffe, Hanover, West Ger); Teschner, M.; Bosecker, K. *Erdoel Kohle Erdgas Petrochem* v 41 n 3 Mar 1988 p 107-112.

**Catalysis** See Also CATALYSTS—Activity.

**077315 PROCESO EN LECHO FIJO PARA LA DESMETALIZACION Y LA HIDROCONVERSION DE CRUDOS PESADOS Y RESIDUALES MEDIANTE CATALIZADOR DE ARCILLA NATURAL.** [Process for the Demetalization and Hydroconversion of Heavy Crudes and Residues Using a Natural Clay Catalyst]. Venezuelan heavy crudes are characterized by their high metal content. Great research effort is being devoted to upgrade this kind of feedstock in order to obtain more valuable products such as gasoline and distillates. Catalytic hydroprocessing has been considered by several oil companies as the first step to reduce the impurities to a certain level, so that the products can be efficiently processed in any downstream unit. This paper deals with the results obtained at bench scale, in the hydroprocessing of a typical Venezuelan heavy crude and its residue, using a natural clay catalyst (INT-AR3). Data on the catalytic activity for hydrocracking, hydrometalization and asphaltenes conversion is presented. (Edited author abstract) In Spanish. 4 refs.

Morales, Alfredo (Univ Central de Venezuela, Venez); Salazary, Jose Armando; Mata, Amiklar; Rosa-Brussini, Marcos; Sepulveda, Gonzalo. *Rev Tec INTEVEP* v 7 n 2 Jul 1987 p 103-116.

## Catalytic Cracking

**077316 CATALYTIC AND THERMAL CRACKING STUDIES ON DEASPHALTED QAIYARAH LONG RESIDUE.** Attempts are made to upgrade Qaiyarah residue (350°C+) by a combination of extraction (deasphalting) and thermal or catalytic cracking routes in order to obtain more valuable products. The catalytic cracking is performed in stages using a local natural clay as a catalyst. Data on yield of products obtained by each process are reported. Comparison of the physico-chemical properties of the products of the two processes are made. (Edited author abstract). 7 Refs.

Al-Soufi, Hussain H. (Council of Scientific Research, Baghdad, Iraq); Luzan, Nina. *J Pet Res* v 7 n 1 Jun 1988 p 83-92.

**Chemical Analysis** See Also ASPHALT—Physical Properties.

**077317 CRUDE OIL IDENTIFICATION WITH ELECTROTHERMAL VAPORIZATION - MULTIPLE WAVELENGTH ABSORPTION SPECTROMETRY.** A spectrometric technique utilizing electrothermal vaporization (graphite furnace) and gas phase-multiple wavelength absorption with photodiode array detection is used to characterize crude oil. Study materials, instruments, methods and results are discussed. 8 refs.

Shekiri, J.M. Jr. (Colorado State Univ, Fort Collins, CO, USA); Skogerboe, R.K.; Taylor, H.E. *Chemosphere* v 16 n 5 1987 p 983-988.

**077318 EFFECT OF WATER WASHING ON CRUDE OIL COMPOSITIONS.** Crude oils from Venezuela, Oklahoma, and New Mexico were water washed in the laboratory at temperatures from room temperature to 80°C, and with water salinities from 0 to 300,000 mg/L in experiments lasting from 7 to 338 hours. The effects of water washing were determined by gas chromatographic and gas chromatography-mass spectrometric analysis of the residual oil. (Edited author abstract) 25 refs.

Lafargue, Eric (Univ of Tulsa, Tulsa, OK, USA); Barker, Colin. *AAPG Bull* v 73 n 3 Mar 1988 p 263-276.

**Chromatographic Analysis** See Also GAS OIL—Chromatographic Analysis.

**077319 GAS CHROMATOGRAPHIC METHOD FOR THE DETERMINATION OF LIGHT HYDROCARBONS IN CRUDE OIL BY SINGLE PHASE SAMPLE INJECTION USING A VALVE.** The practice of introducing light hydrocarbon gases into crude oil (spiking) has created a need for the accurate determination of the gas contents of these crudes, particularly for allocation purposes where shared pipelines are used as in the North Sea. A rapid gas-chromatographic method has been developed, for the analysis of single-phase crude oil at high pressure, that gives excellent precision in the determination of light hydrocarbons (C1-C6) and can be easily modified to include heavier components. (Edited author abstract) 1 ref.

Rushby, B. (Shell Research Ltd, Chester, Engl). *Q J Tech Pap Inst Pet* Jan-Mar 1986 p 45-47.

**077320 NITROGEN COMPOUNDS IN HIGH-BOILING AND RESIDUAL PRODUCTS OF WEST-SIBERIAN CRUDE OIL.** Distribution of basic, acidic and neutral nitrogen compounds was examined in concentrates from a 350°-540°C distillate, a residue higher than 540°C and group components of the residue (asphaltenes, resins and oils). 39 basic nitrogen compounds, 22 acidic and neutral compounds, 19 compounds containing nitrogen and sulfur and 12 compounds containing nitrogen and oxygen were identified in a nitrogen compound concentrate from a 350°-540°C fraction. 1 ref.

Kiselev, V. (Polish Acad of Sciences, Gliwice, Pol); Bodzek, D.; Kernbakh, V.; Vazhekha, L. *Pet Chem USSR* v 26 n 3 1986 p 123-136.



**077321 APPLICATION OF ROBOTICS TO SIMULATED DISTILLATION ANALYSIS OF CRUDE OIL AND LUBE OIL SAMPLES.** Timely simulated distillation (SIMDIS) analysis of refinery process streams is allowing better process variable control in the petroleum industry. To satisfy the constantly increasing demand for SIMDIS analyses of crude oil (CRUDE) and lube-range (LUBE) samples, a robotics system is employed. The method used for SIMDIS analyses of such heavy samples containing residual material boiling above 1000°F requires that an internal standard material be weighed into each sample. This is a very time-intensive activity. Further, the accuracy of the manual analyses is not acceptable for process control. The use of the robotics system improves the accuracy to an acceptable level and significantly decreases sample preparation time. (Author abstract) 4 refs.

Maynard, J.B. (Shell Oil Co, Wood River, IL, USA); Michalik, W.A. *J Chromatogr Sci* v 26 n 6 Jun 1988 p 290-293.

**077322 ANALYSIS OF RESIDUM DESULFURIZATION BY SIZE EXCLUSION CHROMATOGRAPHY WITH ELEMENT SPECIFIC DETECTION, PART II.** Heavy crude residua are analyzed by size exclusion chromatography with element specific detection (SEC-ICP), to elucidate structural information about the S-containing compounds. These compounds appear to fall into two categories: those which are (1) moderately small components (probably thiophenic), and (2) larger components associated with apparent precursors of asphaltene. The effects of thermal hydroprocessing on the S-containing compounds were also examined. The results indicate the S-containing compounds behave similarly to the metal-containing compounds under the same processing conditions. Possible binding site relationships between some of the S- and metal-containing compounds in heavy crudes and residua are discussed. (Edited author abstract) 65 refs.

Reynolds, John G. (Univ of California, Livermore, CA, USA); Biggs, Wilton R. *Fuel Sci Technol Int* v 6 n 3 Jun 1988 p 329-354.

**Combustion** See OIL WELL PRODUCTION—In Situ Combustion.

**Components** See Also HYDROCARBONS—Cracking; SULFUR COMPOUNDS—Alkylation.

**077323 PORPHYRINS OF SAKHALIN CRUDE OILS.** The quantitative distribution and the composition of porphyrins in North Sakhalin crude oil were examined. The concentration of vanadylporphyrins was shown to decrease and the content of nickel complexes in crude oils was shown to increase in southerly and westerly directions. All the crude oils examined had similar vanadylporphyrin structural-group composition. Sakhalin crude oils differ from those in Western Ekhab in the relative content of porphyrin isomers most likely to be retained in inverted-phase chromatography (molar mass values 487, 501 and 515). 7 refs.

Mozzhelina, T.K. (USSR Acad of Sciences, Tomsk, USSR); Serebrennikova, O.V.; Shilonosova, N.I. *Pet Chem USSR* v 26 n 2 1986 p 76-81.

**077324 STUDY OF PMR SPECTRA OF C<sub>30</sub>, C<sub>31</sub> AND C<sub>32</sub> HOMOLOGUES OF PETROLEUM PORPHYRINS.** This work highlights a PMR spectrometric study of four porphyrin compounds isolated from West-Surgut crude oil by liquid-extraction, column and thin-layer (TLC) chromatography on polar sorbents and by highly effective liquid chromatography (HELC) from an inverted phase. The study confirms the presence of porphyrins in West Surgut crude oil, the structure of the compounds suggest that they result from the breakdown of chlorophyll during transformation of precursors in the sedimentary rocks that gave rise to them. 8 refs.

Shul'ga, A.M. (USSR Acad of Sciences, USSR); Serebrennikova, O.V.; Mozhelina, T.K. *Pet Chem USSR* v 26 n 2 1986 p 82-88.

**077325 DETERMINATION OF NAPHTHENIC ACIDS IN CALIFORNIA CRUDES AND REFINERY WASTEWATERS BY FLUORIDE ION CHEMICAL IONIZATION MASS SPECTROMETRY.** A method based on negative ion chemical ionization mass spectrometry using fluoride (F<sup>-</sup>) ions produced from NF<sub>3</sub> reagent gas has been applied to the analysis of naphthenic acids in California crude oils and refinery wastewaters. Since complex mixtures of naphthenic acids cannot be separated into individual components, only the determination of relative distribution of acids classified by the hydrogen deficiency was possible. The identities and relative distribution of paraffinic and mono-, di-, tri-, and higher polycyclic acids were obtained from the intensities of the carboxylate (RCOO<sup>-</sup>) ions. (Author abstract) 16 refs.

Dzidic, Ismet (Shell Development Co, Houston, TX, USA); Somerville, A.C.; Raia, J.C.; Hart, H.V. *Anal Chem* v 60 n 13 Jul 1 1988 p 1318-1223.

**077326 SYNTHESIS OF 2-SUBSTITUTED THIOLANES AND THANES.** A method has been developed for preparing thiolanes with an R substituent in position 2 on the basis of allylhalides and aliphatic aldehydes RCHO. Methods have been developed for preparing pure 2-substituted thiolanes and thianes on the basis of 1-methoxyalkanol-4(5) by means of their transformation into chlorides by an S<sub>N</sub>2 mechanism with subsequent replacement of the methoxy group by bromine and two-stage cyclization with KSH and KOH. 13 refs.

Volynskii, N.P. (USSR Acad of Sciences, USSR); Perelitchenko, L.I. *Pet Chem USSR* v 27 n 1 1987 p 71-80.

## Composition Effects

**077327 WETTABILITY AND ADSORPTION CHARACTERISTICS OF CRUDE-OIL ASPHALTENE AND POLAR FRACTIONS.** This study relates the chemical composition of the polar compounds of crude oil to the wettability of rock/oil/brine systems. Adsorption properties of polar and asphaltene fractions were evaluated to determine their effects on wettability. Polar compound fractions were found to cause an oil-wet state on Berea sandstone, but the effects were not a function of the polar-fraction concentration. The concentration of nitrogen/sulfur compounds in six crude-oil polar fractions correlated with the wettability of the polar fractions on Berea sandstone. Langmuir-type adsorption on Berea sandstone was observed in adsorption studies of the asphaltene and polar fractions. Additional analysis with brine-saturated Berea sandstone resulted in adsorption values up to three times less than that for dry Berea. The amount of polar fraction adsorbed on brine-saturated Berea sandstone correlated with crude-oil wettability. (Author abstract) 18 refs.

Crocker, M.E. (Nat'l Inst for Petroleum & Energy Research); Marchin, L.M. *JPT J Pet Technol* v 40 n 4 Apr 1988 SPE 14885, p 470-474.

**077328 RELATIONSHIPS IN COMPONENT-FRACTIONAL AND CHEMICAL COMPOSITION OF CRUDE OILS.** On the basis of the available data, the authors propose that (beginning with the heaviest residue and down to C<sub>4</sub>, i.e., to approximately 0°C) the yield up to each particular temperature should be calculated using the equation derived by the authors. In order to eliminate these difficulties in the analysis of new crude oils, it is necessary to require that the scheme of analysis include a determination of the average MW of the crude oil by methods that eliminate the possibility of significant errors; also, in order to monitor the accuracy of analyses, this scheme must include a determination of the MW of the distillates and the residue. In the case of crude oils that have been investigated previously, but without including the indicated determinations certain calculations must be made. These calculations are presented. 12 refs.

Eigenson, A.S. *Chem Technol Fuels Oils* v 23 n 5-6 May-Jun 1987 P 282-289.

**Costs** See Also ECONOMICS—Mathematical Models; PETROLEUM INDUSTRY.

**077329 CRUDE OIL WINDFALL PROFIT TAX ACT OF 1980: AN ECONOMIC ANALYSIS OF ITS EFFECT ON DOMESTIC CRUDE OIL PRODUCTION.** A framework is developed to examine the effects of the Crude Oil Windfall Profit Tax Act of 1980 on domestic production of crude oil that specifically takes into account both the pre-existing systems of price controls the Act replaced and the temporary nature of the tax. The Act established three categories of oil, called tiers, which are taxed at different rates on the difference between the removal price and an adjusted base price. Assuming that the market for oil is competitive, and given reasonable assumptions about extraction costs, the Act will increase the production of crude oil from tier one above the level that would have been produced had the price controls remained in effect for the same length of time, although less than the socially optimal amount of oil will be extracted from tier one while the tax is in effect. (Edited author abstract) 23 refs.

Knoll, Michael S. (Debevoise & Plimpton, New York, NY, USA). *Resour Energy* v 9 n 2 Aug 1987 p 163-185.

## Dehydration

**077330 POSSIBILITY OF USING ELECTRON-ION TECHNOLOGY FOR DEWATERING AND SALT-OUT CRUDE OILS.** Electron-ion (EI) technology offers promise as a means of thoroughly ridding crude oils of water and salts. EI dehydrators operate by charging the water globules by ionization in a steeply nonuniform electrostatic field and precipitation on the grounded surface of a precipitation electrode under the action of mirror-image forces. These dehydrators have been found effective in the dewatering and salt-out of very viscous heavy crudes. (Edited author abstract) 8 refs.

Kagan, Ya.M.; Latypov, V.Kh.; Neupokoev, M.S. *Sov Surf Eng Appl Electrochem* n 5 1986 p 62-65.

**077331 WATER DROPLET COAGULATION DURING ELECTRICAL DEHYDRATION OF PETROLEUM.** A simple analytical model is constructed for coagulation of emulsion droplets, describing the process of petroleum dehydration by an external electric field. The coagulation model achieves full correspondence to the physical formulation of the process being described yet provides sufficient simplicity in the mathematical solution. (Edited author abstract) 11 refs.

Burkitbaev, S.M. (Kotoyants, K.V.); Nadirov, N.K.; Poluektov, P.P. *J Eng Phys* v 53 n 4 Oct 1987 p 1137-1139.

## Density

**077332 DETERMINATION OF DENSITY AND ITS ERRORS.** At first sight, the determination of the density of crude oil or products appears to be a simple matter. When one carries out a close scrutiny of the procedures involved one comes to the realization that, at least for crude oils, and especially for North Sea crudes which are normally shipped with a high RVP (8 psi), there is much more to the process, and in this paper the authors give a few of their ideas on the probable errors involved at the moment, and how these might be reduced in future. 1 ref.

Fitzgerald, H. (Moore, Barrett & Redwood Ltd); Fitzgerald, D. *Q J Tech Pap Inst Pet* Oct-Dec 1987 p 55-58.

## Density Measurement

**077333 DETERMINATION OF DENSITY AND ITS ERRORS.** When one carries out a scrutiny of the procedures involved one comes to the realization that, at least for crude oils, and especially for North Sea crudes which are normally shipped with a high RVP (8 psi), there is more to the process than initially meets the eye. As an indication of some of the confusion that surrounds the determination and subsequent use of a crude oil density,



there are at least eight different terms for defining the particular figure under discussion. This paper provides some thoughts on clarifying the issues. 1 ref.

Fitzgerald, H. (Moore, Barrett & Redwood Ltd); Fitzgerald, D. *Pet Rev* v 41 n 490 Nov 1987 p 25-26, 28-29.

**Distillation** See Also HYDROCARBONS—Combustion.

**077334 UNIQUE FEATURES IMPROVED CRUDE UNIT ADVANCED CONTROL.** Rafinor A/S and Co. initiated a project to investigate and implement advanced control on their crude distillation unit. Project implementation, control system architecture, crude unit control strategies and project results are presented.

Veland, L.H. (Rafinor A/S & Co, Mongstad, Norw); Hoyland, J.; Aronson, C.R.; White, D.C. *Hydrocarbon Process* v 66 n 9 Sep 1987 p 73-78.

**077335 DESTILACION SIMULADA DE CRUDOS: ESTUDIO DE PRECISION Y COMPARACION CON CURVAS DE DESTILACION TBP.** [Simulated Distillation of Crudes: a Precision Study and a Comparison with TBP Distillation Curves]. The proposed method of simulated distillation for crudes (ASTM D-2 Proposal P167) does not have yet the support of a precision study. This method has been used at INTEVEP for routine analyses of medium and heavy crude oils, and hydroconversion products. Data with a precision of  $\pm 3\%$ , similar to simulated distillation method for petroleum fractions (ASTM D 2887), have been obtained from repetitive analysis of some selected samples. From the comparison of distillation curves obtained by the simulated distillation method for crudes and by the ASTM D 2892 distillation method (TBP 15/5), it is observed that in crudes ranging 29 - 12°API, these curves are closer to TBP 15/5 curves in weight T than in volume %, but this difference is never larger than 3%. (Author abstract) In Spanish. 8 refs.

Ceballo, Carmen (INTEVEP SA); Bellet, Allain; Aranguren, Sergio; Herrera, Miriam. *Rev Tec INTEVEP* v 7 n 1 Jan 1987 p 81-83.

**077336 SURFACE PROPERTIES OF DISTILLATION RESIDUES FROM HEAVY OILS - INFLUENCE OF VISCOREDUCTION.** Liquid contact angle measurements were performed on films of heavy oil distillation residues deposited on mica plates. The results are used to calculate the dispersive component of the surface energy and also the polar interaction energy with various liquids. The residues have different surface properties, which should be taken into account during their use and processing. It is also shown that viscoreduction changes the surface energy characteristics according to the composition of the residue before such treatment. (Author abstract) 4 refs.

Papier, Eugene (Cent de Recherches sur la Physico-Chemie des Surfaces Solides, Mulhouse, Fr); Kuczinski, Jersey; Siffert, Bernard. *Fuel* v 66 n 12 Dec 1987 p 1691-1693.

**077337 DIE FAELLUNG VON ASPHALTENEN AUS ERDOEL-DESTILLATIONSRUUCKSTAENDEN MIT KOHLENDIOXID.** [Deasphalting of Crude Oil Distillation Residues With Carbon Dioxide]. The use of carbon dioxide as deasphalting agent is investigated. From the experimental results the following conclusions can be drawn: The precipitation of asphaltenes with CO<sub>2</sub> is possible both at its liquid state and above its critical conditions. It is pertinent to point out that the successful precipitation of asphaltenes from crude oil distillation residues depends on favorable reaction conditions. CO<sub>2</sub>-deasphalting procedure could be grouped under the technical methods for the precipitation of asphaltenes. This work is recommended for a reaction temperature of about 40°C. (Edited author abstract) In German.

Obah, B.; Neumann, H.J. *Erdoel Kohle Erdgas Petrochem* v 40 n 11 Nov 1987 p 486-488.

**077338 COMPOSITION OF CARBOXYLIC ACIDS FROM DISTILLATES FROM TURKMENIAN CRUDES.** The authors present results obtained in a mass spectrometric study of carboxylic acids recovered from

kerosene distillates at the Krasnovodsk refinery, and the hydrocarbons obtained by decarboxylation of individual fractions of the acids. The acids were prepurified and separated by ion exchange chromatography; the aliphatic acids were segregated by urea adduct formation and were partially identified. From the results of the mass spectrometric study, it follows that the preparation of saturated hydrocarbons for investigation of the composition and structure of carboxylic acids, following scheme, is unacceptable because of losses of certain groups of acids mainly polycyclic acids, leading to an incorrect evaluation of the quantitative composition of the original acids. The data we obtained on the composition of the acids are consistent with data reported by other investigators on the composition of natural carboxylic acids. 8 refs.

Niyazov, A.N.; Niyazberdyeva, E.F.; Zhil'tsov, N.I. *Chem Technol Fuels Oils* v 23 n 5-6 May-Jun 1987 p 250-254.

**077339 DISTILLATION PROCESS OF CRUDE OIL BY THE METHANE STRIPPING METHOD.** In the ordinary-pressure distillation of crude oil by using the light ends gas with the compressing cycle instead of the water-blowing vapour process, the condensing load can be reduced at the top of the tower. At the same time it can improve dew point corrosion prevention. (Edited author abstract) In Chinese.

Toshiaki, Ikuta. *Huagong Jixie* v 14 n 4 1987, Tech Rep on 3rd Sino-Jpn Chem Equip Symp, 1986 p 343-345.

**Economics** See Also SOLAR ENERGY—Economics.

**077340 FORECASTING OIL PRICES TO 1995.** Two oil price scenarios are presented - \$12/bbl and \$20/bbl - which represent attainable price trends in today's world. The data are presented in such a way that alternate prices can be analyzed as well. (Author abstract)

Jones, S.T. (Wharton Econometrics Inc, Bala Cynwyd, PA, USA). *Hydrocarbon Process* v 66 n 8 Aug 1987 p 78.A-78.B.

**077341 NEXT OIL CRISIS.** The causes and types of oil crises are identified and explained. Technical and political crises are differentiated. Changes in the world oil market since 1973 are analyzed. The ways to deal with crises are considered and the benefits of a moderate oil import tariff are pointed out. Other useful measures that can be taken to prevent or mitigate an oil crises are discussed.

Lynch, Michael. *Technol Rev* v 90 n 8 Nov-Dec 1987 p 39-45, 66.

**077342 TOMORROW'S OIL PRICES AND DEMAND.** GRI prepares an annual baseline projection of U.S. energy supply and demand as the basis for the strategic planning of its research and development program. One input to the baseline projection is an assumption of the future price track for U.S. refiners' acquisition cost of crude oil. From this price track, regional prices for petroleum products are estimated for each product and demand sector. For the analysis of future oil and gas supplies, a consistent projection of the wellhead crude oil prices that would be expected by producers is also developed. A major portion of U.S. petroleum supply is imported and as crude oil is internationally traded, the price is set in the global market. Any projection of the oil price outlook, therefore, must be based upon an evaluation of the global petroleum market outlook.

Ashby, A.B. (Gas Research Inst, Washington, DC, USA). *Hydrocarbon Process* v 67 n 4 Apr 1988 p 43-44, 46, 49-50.

**077343 A COMPARATIVE ANALYSIS OF CRUDE OIL LIFE-CYCLE MODELS.** An alternative to a logistic function form life-cycle model for crude oil is presented. Development of the polynomial model is discussed and empirically estimated parameters are examined for consistency. The logistic and polynomial functions are compared on the basis of their descriptive and predictive characteristics. (Author abstract). 5 Refs.

Hotard, Daniel G. (Southeastern Louisiana Univ, Hammond, LA, USA). *Energy (Oxford)* v 13 n 4 Apr 1988 p 313-318.

**Environmental Impact** See WATER BACTERIOLOGY.

**Geochemistry** See Also PETROLEUM GEOLOGY—Sulfate of Oman.

**077344 CRUDE OIL GEOCHEMISTRY OF THE SOUTHERN SONGLIAO BASIN.** Twenty-three crude oils from the southern Songliao Basin, Heilongjiang Province (People's Republic of China), were characterized by various organic geochemical techniques to have a very uniform bulk and molecular composition in terms of source characteristics (type I kerogen) but to vary significantly in thermal maturity. Two middle Cretaceous source rocks, i.e. the Members 1 of the Qingshankou (Q<sub>1</sub>) and Nenjiang (Nen<sub>1</sub>) Formations, were considered to be the most likely origin of the oils investigated, but a Jurassic source cannot be fully excluded for the Nang'an oils. (Edited author abstract) 30 refs.

Taiming, Li (KFA, Juelich, West Ger); Rullkoetter, Juergen; Radke, Matthias; Schaefer, Rainer G.; Welte, Dietrich H. *Erdoel Kohle Erdgas Petrochem* v 40 n 8 Aug 1987 p 337-346.

**077345 GEOCHEMICAL INVESTIGATION OF OILS AND SOURCE ROCKS FROM THE SURAT BASIN.** A series of twelve oils and five source rocks and potential source rocks from the Surat Basin have been subjected to detailed geochemical analyses. Particular attention has been given to determining the distribution of various classes of biomarkers such as the steranes and triterpanes. A number of the oils in this basin are extensively biodegraded. In particular biodegradation has been very heavy in the Riverslea/Yapunyah area. The biomarker data from oils and source rocks of the Surat Basin have been used to provide a new insight into the origin of the Surat Basin oils and their post-formation history. (Edited author abstract) 24 refs.

Philp, R.P. (Univ of Oklahoma, Norman, OK, USA); Gilbert, T.D. *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 172-186.

**Heavy Oil** See PETROLEUM PROSPECTING—Seismic Survey.

**Impurities** See Also ELECTRODES—Applications.

**077346 EFECTOS DE MATRIX EN LA DETERMINACION DIRECTA DE VANADIO Y NIQUEL EN CRUDOS Y DERIVADOS POR ABSORCION ATOMICA CON ATOMIZACION ELECTROTROMICA.** [Matrix Effects in the Direct Determination of Vanadium and Nickel in Crudes and Derivatives by Flameless Atomic Absorption Spectroscopy]. The dependence of vanadium and nickel absorbance signals with the nature of the matrix of different crude oils, gas oils, and some commonly used standards, as well as the dependence of the signal on ashing and atomization temperatures as obtained by flameless atomic absorption spectroscopy is studied. Different calibration curves are obtained from standard reference solutions of different organometallic compounds under identical conditions of concentration and optimum graphite tube operating parameters. The results indicate that every crude sample and standard behaves in a very particular manner, depending on its organic matrix and on the selected conditions of ashing and atomization temperatures. (Author abstract) In Spanish. 15 refs.

de Abreu, Marhilda S. (INTEVEP SA). *Rev Tec INTEVEP* v 7 n 1 Jan 1987 p 51-58.

**Iodine Determination** See Also IODINE—Extraction.

**077347 DETERMINATION OF <sup>129</sup>I IN HEAVY RESIDUES OF TWO CRUDE OILS.** <sup>129</sup>I/<sup>127</sup>I ratios were determined in heavy residues of two crude oils which were produced from 10 Ma and 300 Ma old formations.



The measured  $^{129}\text{I}/^{127}\text{I}$  ratios were between 5 and  $10 \times 10^{-12}$ . These values are significantly above the ratios determined for marine sediments and, for the older oil, also above those supported by in situ production of  $^{129}\text{I}$  from uranium. We attribute the high level of  $^{129}\text{I}$  in the residues to addition of anthropogenic iodine during the production of the oils. The ratios indicate also that more than 90% of the iodine measured came originally from the oils. (Author abstract) 20 refs.

Fehn, Udo (Univ of Rochester, Rochester, NY, USA); Tullai, Sharon; Teng, Ray T.D.; Elmore, David; Kubik, Peter W. *Nucl Instrum Methods Phys Res Sect B* v B29 n 1-2 Nov 11 1987, Accel Mass Spectrum, Proc of the Fourth Int Symp, Niagara-on-the-Lake, Ont, Can, Apr 27-30 1987 p 380-382.

## Measurements

**077348 PREVIEW OF CARGO MEASUREMENT AND INSPECTION GUIDELINES.** A preview of the Institute of Petroleum Cargo Measurement by Cargo Surveyors, Part I Crude Oil, is given by explaining the background and derivation of the work. A description of the committee (PM-L-3), its methods of working and the format of the document is given along with a brief discussion on related items from the procedures. Mention is made of further procedures applicable to products currently under production by the committee, which are to be published in mid-1988. (Edited author abstract)

Cowin, R.D. (Esso Petroleum Co). *Pet Rev* v 41 n 490 Nov 1987 p 34-36.

## Moisture

**077349 BASES FUNDAMENTALES DEL PAPEL DE LA QUIMICA DESHIDRATANTE: INFLUENCIA DE LA FORMULACION FISICOQUIMICA SOBRE LA ESTABILIDAD DE UNA EMULSION.** [Fundamentals of Emulsion-Breaking Agents Action: Influence of Physicochemical Formulation on Emulsion Stability]. The stability of a crude oil emulsion is mainly due to the presence of adsorbed natural surfactants, at crude-water interphase. The mixture of emulsion-breaking agents with natural surfactants results in very unstable emulsions. Using model systems, the influence of the physico-chemical variables on emulsion stability is determined, and conditions are found which result in unstable emulsions. The causes for the instability are discussed, and the dehydration process, is interpreted by means of a formulation-water/oil ratio map. (Author abstract) In Spanish. 80 refs.

Salager, Jean-Louis (Univ de Los Andes, Merida, Venez). *Rev Tec INTEVEP* v 7 n 1 Jan 1987 p 3-15.

## Moisture Determination

**077350 COMPUTATIONAL METHOD TO ASSESS CONCENTRATION OF WATER IN CRUDE OIL DOWNSTREAM OF A MIXING SECTION.** This paper describes a method for predicting the concentration distribution of water in crude oil in a pipe section downstream of a region of mixing and droplet break-up. The complexity of the problem and the necessary simplifications are described. The method with its approximations is justified on grounds of possible savings in financial outlay. Details of governing equations, computational method and boundary conditions lead on to the link between forces on the droplet and the velocity of the droplet relative to the bulk liquid. The model incorporates turbulence enhancement and decay, and secondary velocities likely to approximate to those following a T-piece or bend or swirl-creating element. The computer program was tested against data provided by BP and the results suggest that if the predictions indicate adequate mixing then they are likely to underestimate the uniformity of the mixture. (Edited author abstract) 16 refs.

Baker, Roger C. (Cranfield Inst of Technology, Bedford, Engl). *Proc Inst Mech Eng Part A* v 202 n A2 1988 p 117-127.

## Molecular Weight

**077351 COMPOSICION Y CARACTERISTICAS FISICOQUIMICAS DE SURFACTANTES NATURALES EXTRAIDOS DE CRUDOS EXTRAPESADOS.** [Composition and Physicochemical Characteristics of Natural Surfactants From Extra Heavy Crude Oils]. Natural surfactants from Cerro Negro and Zuata crude oils were isolated; it was found that intermolecular associations that could affect the molecular weight value were absent. On the other hand, the variation in interfacial tension (oil-water) as a function of pH for crude oils, was not similar to that showed by their fractions; this indicates that such behavior results from the joint activity of asphaltenes and resins. (Edited author abstract) 9 refs. In Spanish.

Marquez, Humberto M. (Univ Central de Venezuela, Venez); Rivas, Hercilio; Layrisse, Ignacio; Acevedo, Socarates; Escobar, Gaston; Gutierrez, Luis B.; Leon, Olga V.; Silva, Miriam; Marchionna, Rosa. *Rev Tec INTEVEP* v 7 n 2 Jul 1987 p 117-122.

Oxidation See HYDROCARBONS—Oxidation.

## Photochemical Reactions

**077352 DESTRUCTIVE-CONDENSATION TRANSFORMATIONS OF RESINOUS CRUDE OIL BY THE ACTION OF LIGHT.** The effect of radiation from a mercury-quartz lamp PRK-2 upon native resin-asphaltene substances of Norian, Samgore and Supsin crude oils was examined. Irradiated resin substances from crude oil undergo marked changes-photochemical breakdown to form gaseous hydrocarbons (methane, ethane and propane) and photochemical condensation. During the condensation step molar mass increases and three-dimensional structures are formed, these have a high softening point (above 400°C) and do not dissolve in organic solvents. 2 refs.

Melikadze, L.D. (GSSR Acad of Sciences, Tbilisi, USSR); Kuprashvili, B.G.; Barabadze, Sh.Sh.; Bakhturidze, G.Sh.; Shatakishvili, T.N. *Pet Chem USSR* v 26 n 2 1986 p 88-93.

## Physical Properties

**077353 CORRELATIONS OF VISCOSITY, GAS SOLUBILITY, AND DENSITY FOR SASKATCHEWAN HEAVY OILS.** The complex chemical nature of crude oil has made it extremely difficult to develop reliable models capable of predicting physical properties. Yet the importance of crude oil as a source of energy or as a precursor in chemical synthesis makes it necessary that simple equations be available that engineers can use to accurately predict these properties. Three noncomponent equations are presented which were found to accurately model the viscosity, density, and gas solubility of a wide range of Saskatchewan heavy oils. These equations were developed from previous work with extended terms to allow for additional independent parameters. The extended equations allow for variations in temperature, pressure, dissolved methane concentration, and dissolved carbon dioxide concentration. (Author abstract) 8 refs.

Quail, Beverly (Univ of Saskatchewan, Saskatoon, Sask, Can); Hill, G.A.; Jha, Kamal N. *Ind Eng Chem Res* v 27 n 3 Mar 1988 p 519-523.

**077354 HIGH-WAX CRUDE FROM ARKHANGEL OBLAST.** The Kharyaginsk crude is low-sulfur and low-resin; it is distinguished by an extremely high content of wax (21%) and a high yield of fraction below 350°C (50.1% by weight). The naphtha distillates are characterized by low octane number (40 ON for IPB-180°C cut), as paraffinic hydrocarbons predominate in these distillates. The diesel fuel cuts are characterized by high cetane numbers, very low sulfur contents, and large quantities of straight-chain paraffinic hydrocarbons. The dewaxed 200-320° and 200-350° cuts (respective yield 9.1% and 14% one crude) have respectively solid points below -61° and below 50°C; they can be used as components of winter-grade diesel fuel. The lube cuts contain about 40% solid

waxes. 3 refs.

Zhmykhova, N.M.; Demidenko, K.A.; Kolevatova, V.P. *Chem Technol Fuels Oils* v 23 n 5-6 May-Jun 1987 p 279-281.

Processing See Also HEAT EXCHANGERS—Costs; HYDROCARBONS—Coking.

**077355 PHARMACEUTICAL WHITE OIL FROM WEST SIBERIAN CRUDES.** A pharmaceutical white oil meeting the requirements of GOST 3164-78 has been obtained from West Siberian crudes. This oil is very similar in physicochemical properties and also in content of aromatic hydrocarbons to the commercially manufactured pharmaceutical white oil. A comparison of the structural-group composition of these oils indicates that they differ in elemental composition, content of carbon in naphthenic rings ( $C_n$ ) and paraffinic chains ( $C_p$ ), and number of rings in the average molecule. This means that these oils have been obtained from raw materials that differ in chemical nature. 6 refs.

Potatina, V.A. (All-Union Scientific Research Inst for Petroleum Processing, USSR); Drenova, T.I.; Ponomareva, T.P. *Chem Technol Fuels Oils* v 23 n 1-2 Jan-Feb 1987 p 65-67.

**077356 LA EMULSION DE BITUMEN ORINOCO EN AGUA (ORIMULSION) COMO COMBUSTIBLE EXCEPCIONAL EN PLANTAS TERMOELECTRICAS.** [Orinoco Bitumen-in-Water (Orimulsion): Un-tapping an Unlimited Premium Fuel]. Venezuela has extensive recoverable reserves of extra heavy crudes and natural bitumens located in the Orinoco Oil Belt. INTEVEP, S.A. and LAGOVEN, S.A. have developed the Orinoco bitumen-in-water emulsion (ORIMULSION) for the production, handling and transportation of those hydrocarbons. This emulsion is considered a premium fuel due to its performance in conventional liquid firing systems. Pilot scale combustion tests have demonstrated the technical feasibility of burning this natural fuel with high combustion efficiency values (99.90%). This allows to forecast a promising future for ORIMULSION as a new fuel for thermal power stations. (Edited author abstract) In Spanish. 1 ref.

Rodriguez Polanco, Domingo (INTEVEP SA); Jimenez G., Euler; Izaguirre M., Javier; Salazar P., Jose; Carrizo, Ruben; Alcantara, Julio. *Rev Tec INTEVEP* v 7 n 1 Jan 1987 p 17-32.

**077357 DESALTERS CAN REMOVE MORE THAN SALTS AND SEDIMENT.** A properly designed and operated crude oil desalter is capable of removing much more than chloride salts and sediment from crude oil. Crude and residual fuel desalting can be used to remove water-soluble contaminants such as salts, acids, and bases; water-insoluble contaminants such as salts, basic sediment, filterable solids, and some heavy metals; and it can remove brine water from the crude. 5 refs.

Barnett, Jack W. (Petrolium Corp, Houston, TX, USA). *Oil Gas J* v 86 n 15 Apr 11 1988 p 43-44, 48-49.

**077358 PRODUCTION OF LOW-FREEZING FUEL FRACTIONS FROM MIXED PARAFFINIC CRUDES.** The authors have investigated the possibility of producing fuel fractions from paraffinic crudes. The initial crystallization temperature of fuel fractions from mixed paraffinic crudes, as a function of the yield relative to original crude is presented. With a required initial crystallization temperature of -60°C, a fuel fraction is obtained with an end point of 235°C and a yield of only 13.97% by weight on crude. The authors show the depression of the initial crystallization temperature and the content of aromatic hydrocarbons in the fuel fractions distilled from the hydrogenated products obtained on the different catalysts under different process conditions, and also the yield of these fractions as a function of the process temperature. Under the experimental conditions, the yield of the desired fraction is 81% by weight, and the process



increases the content of aromatic hydrocarbons from 15.5% to 19% by weight. Based on the test results, the process of selective hydrocracking can be recommended for the production of low-freezing middle-distillate fuels from paraffinic crudes. 2 refs.

Sultanov, S.A. (Acad. of Sciences of the Azerbaijan SSR, USSR); Rustamov, M.I.; Nefedov, B.K.; Gasanova, Zh.I.; Musaeva, S.G.; Konoval'chikov, L.D.; Konoval'chikov, O.D. *Chem Technol Fuels Oils* v 23 n 7-8 Jul-Aug 1987 p 310-313.

**077359 PRODUCTION OF PITCHES IN EXHAUSTIVE CRUDE OIL PROCESSING SCHEMES.** The author examines possible variants in obtaining petroleum pitches and pitch distillates in exhaustive crude oil processing schemes. It is shown that petroleum pitches for various applications can be obtained in special process sections added to commercial units receiving or processing pyrolysis tar. The processing of pyrolysis tar includes recovery of the light part (drying oil fraction). If the feed to the pitch production section consists of the total pyrolysis tar, the pitch section includes a vaporizer to remove the light part of the tar, distilling below 200°C. Pyrolysis pitch, in comparison with cracking pitch, is obtained under milder temperature conditions, but at a higher pressure in the pitch-forming reactor. 13 refs.

Dolmatov, L.V. (Ufa Petroleum Inst, USSR). *Chem Technol Fuels Oils* v 23 n 7-8 Jul-Aug 1987 p 313-315.

**077360 FOOD FROM CRUDE OIL VAPOR.** The synthesis of protein from petroleum involves the growing of microorganisms on various petroleum substrates and harvesting dried microbial cells as a product. Many species of yeast and bacteria are applicable so that the product is sometimes referred to as single-cell protein (SCP). Depending on the organism, the protein content can range from 40 percent to 80 percent; the remainder of the material consists primarily of nucleic acids, carbohydrates, lipids, and minerals. A number of petroleum hydrocarbons can serve as a source of carbon and energy for the microbial growth; however, methane and the normal C<sub>10</sub> to C<sub>20</sub> alkanes are most likely to produce worthwhile results. The author grew 2.5 g of yeast in a flask filled with 100 mL of water and 50 mL of crude oil. She observed that yeast grew in the mixture within 24 h. She removed the yeast from oil using centrifugation and flocculation. The yeast weighed 20 g. It was found that it was possible to grow protein on hydrocarbons above the mixture, instead of in it as was previously done. This process avoids the costly and difficult step of separating the product from the petroleum substrate. In the future this method could probably be adapted for mass production purposes by having rolls of nets or cloths on reels running across a vat used to store crude oil in factories. A beneficial factor of this process is that the synthesis of yeast uses up some nitrogen from the crude oil. 4 refs.

Burrows, Christine (Duke Univ, Durham, NC, USA). *CHEMTECH* v 18 n 7 Jul 1988 p 422-423.

**077361 ISOLATION AND FRACTIONATION OF THE NITROGEN BASES FROM PETROLEUM.** A method of differentiated isolation of basic nitrogen compounds from petroleum was developed, consisting in obtaining an ultimate concentrate of bases by means of 25 percent sulfuric acid in an 80 percent acetic acid solution with its subsequent fractionation by aqueous and water-acetic acid (1:1) solutions by 25 percent sulfuric acid. It was established that the ultimate concentrate contains nitrogen bases recovered from the hydrocarbon part of the petroleum, and a negligible amount of nitrogen bases recovered from the resin part (approx. 5 percent). The possibility of extraction separation of ultimate concentrate with the obtained products containing only strongly basic nitrogen and the residue with weakly basic nitrogen concentrated in it was shown. 10 Refs.

Gerasimova, N.N. (USSR Acad. of Sciences, Tomsk, USSR); Sagachenko, T.A.; Beiko, O.A.; Ogorodnikov, V.D. *Pet Chem USSR* v 27 n 1 1987 p 12-19.

**077362 USE OF DRAG REDUCER CHEMICAL IN**

**THE BASS STRAIT CRUDE OIL PRODUCING SYSTEM.** Esso Australia Ltd (on behalf of the Esso/BHP joint venture) operates a crude oil and natural gas processing system based on the offshore fields in Bass Strait. Crude oil is discharged from the offshore fields via a 132-km pipeline to the crude stabilization plant at Longford. A 187-km pipeline is then used to transfer stabilized crude to Long Island Point, where the oil is held in storage prior to discharge to Australian refineries and to export. Without the use of drag reducer chemical, Bass Strait crude production is limited by pipeline hydraulic capacity. Since the last quarter of 1983, drag reducer has been injected at both Halibut platform and Longford as required to meet the demand for crude oil. As a result, daily production rates have been increased by more than ten per cent. (Edited author abstract) 1 ref.

Wilmshurst, Jan (Esso Australia Ltd, Sale, Aust). *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 119-122.

## Pyrolysis

**077363 EFECTO DE LA ATMOSFERA AUTOGENA PRODUCIDA DURANTE LA ACUATERMOLISIS DE UN CRUDO EXTRAPESADO DE LA FPO.** [Effect of Autogenous Atmosphere During the Aquathermolysis of an Extra-heavy Oil from the Orinoco Oil Belt]. The effect of hydrogen sulfide (H<sub>2</sub>S) and carbon dioxide (CO<sub>2</sub>) on the properties of an extra heavy crude oil from the Orinoco Oil Belt is evaluated. The H<sub>2</sub>S and CO<sub>2</sub> are produced by steam stimulation of Cerro Negro, Piritul and Jobo whole cores. By using additives with the steam, we are able to quantify the effect of the atmosphere generated during aquathermolysis of the Cerro Negro whole cores (autogenous atmosphere), on the viscosity of the crude oil, and on the re-distribution of the organosulfur compounds. (Author abstract) In Spanish. 7 refs.

Vilorio, Alfredo (INTEVEP SA); Hernandez, Jose; Borges, Luis. *Rev Tec INTEVEP* v 7 n 1 Jan 1987 p 75-80.

**Recovery** See Also OIL WELL PRODUCTION—Thermal; PETROLEUM RESERVOIR ENGINEERING.

**077364 CONSIDERATI PRIVIND FORAJUL DE INDESIRE SI CRESTEREA RECUPERARII TITELULUI.** [Considerations Regarding High Density Drilling and the Increase of Crude Recovery]. The article discusses some aspects concerning the influence of the deposit model on the distance between wells; some problems pertinent to the relationship between distance and the efficiency of recovery, as well as some of the most typical examples of Romanian deposits, and the means for the improvement of recovery. (Edited author abstract) 44 refs. In Romanian.

Mocuta, St. Tr. (Inst de Cercetari si proiectari Pentru Petrol si gaze Cimpina). *Mine Pet Gaze* v 39 n 1 Jan 1988 p 26-37.

**Rheology** See Also HYDROCARBONS—Phase Transitions.

**077365 RHEOLOGICAL PROPERTIES OF DAQING CRUDE OIL AND THEIR APPLICATION IN PIPELINE TRANSPORTATION.** The variation of the rheological properties of Daqing waxy crudes with their thermal history and their time effect are discussed. Rheological properties of Daqing crude were determined in the laboratory with rotational viscometers and U-tube devices. The feasibility of using the proper heat treatment to improve the low-temperature flow property of Daqing crude was studied. Field tests on three long-distance heated-crude pipelines showed good agreement with laboratory measurement. A mathematical model for determination of the optimum operation parameters of pipeline transportation is also given. (Author abstract) 13 refs.

Yan, Dafan (East China Petroleum Inst, China); Luo, Zheming. *SPE Prod Eng* v 2 n 4 Nov 1987 SPE 14854, p 267-276.

**077366 STUDY OF POUR POINT DEPRESSION OF PUCHENG CRUDE OIL BY MEANS OF HEAT TREATMENT AND ADDITIVES.** In order to transport the Pucheng waxy crude oil under normal conditions, a combination method of heat treatment and additive application was investigated. The additive, pour point depressant EVA was used in combination with an oil soluble surfactant. Satisfactory results were obtained. Under the most favorable conditions, the pour point of the crude oil could be lowered as much as 23-27°C and the apparent viscosity was reduced to a value below 0.2 Pa·s with a combination additive dosage of 100 to about 300 ppm. In addition, the low temperature flow property of the crude oil was remarkably improved and a great change in rheological properties of the crude oil was observed. The effects of operating conditions, such as the temperature of heat treatment, the mode of cooling, the final temperature, the concentration of additive solution, etc. were examined. In the course of investigation, a crusting phenomenon over the surface of crude oil was observed. (Edited author abstract) In Chinese. 13 refs.

Xu, Shuhua (East China Petroleum Inst, China); Bao, Chong; Wu, Fangyun. *Shiyou Xuebao Shiyou Huagong* v 2 n 3 Sep 1986 p 59-67.

## Sampling

**077367 CRUDE OIL FROM TENGIZ FIELD.** The oil is light, low-pour, and high-wax, with low percentages of resins, asphaltenes, and sulfur. With regard to metal content, the oil contains practically no vanadium or nickel. The light part of the crude contains considerable quantities of C<sub>4</sub>-C<sub>6</sub> n-alkanes, about 50% by weight on the cut, or 2.44% on crude. The naphtha cuts distilling below 200°C consist mainly (60-73% by weight) of alkanes, including 15-23% n-alkanes, and 17-27% cyclanes. The 120-230° and 120-240°C jet fuel cuts have good combustion quality and viscosity properties, low initial crystallization temperatures, and very high contents of mercaptan sulfur, several times the maximum allowed in Ts-1 and RT jet fuels. The kerosene cuts are high in acidity and sulfur content.

Dorogochinskaya, V.A. (Groznyi Petroleum Scientific-Research Inst, USSR); Shul'zhenko, E.D.; Varshaver, V.P.; Khabibulina, R.K.; Kochuleva, L.R. *Chem Technol Fuels Oils* v 23 n 7-8 Jul-Aug 1987 p 387-389.

## Solubility

**077368 CRUDE OIL DISSOLUTION IN SALINE WATER.** The solubilities and diffusion coefficients of crude oils having API° ranging from 11 to 28 have been measured in distilled and saline water of 44 g L<sup>-1</sup> NaCl at temperatures 25, 35, and 45°C. A linear relationship was observed between the maximum oil solubilities in distilled water and those in saline water for all the crudes over the range of temperature studied. The Setschenow salting-out parameter was found to be 0.125 independent of temperature and API°. Such a parameter is valuable in estimating the crude oil solubilities in waters of different salinity. An analytical solution for unsteady-state diffusion was done using Fourier series. A linear relationship was found between the diffusion coefficient of oils in distilled water and those in saline water. Observed data for diffusion coefficients of the oils have been correlated in terms of API°, temperature and ionic strength with an average absolute deviation of 2%. (Author abstract) 10 refs.

Hamam, Salah E.M. (Kuwait Univ, Safat, Kuwait); Hamoda, Mohamed F.; Shaban, Habib I.; Kilani, Amal S. *Water Air Soil Pollut* v 37 n 1-2 Jan 1988 p 55-64.

**Spectroscopic Analysis** See Also HYDROCARBONS—Chromatographic Analysis; HYDROCARBONS—Spectroscopic Analysis.

**077369 NMR USED FOR SAUDI CRUDE ASPHALTENES.** Nuclear magnetic resonance (NMR) spectroscopy with proton (1H) and carbon 13 (13C) has been used to determine the structural characteristics of



asphaltenes from four commercial Saudi Arabian crude oils. These characteristics are important to refiners that have deep conversion processes to determine yields from the residual fractions of the Saudi crudes, and to determine the operating parameters of the process units. The spectra obtained give some structural similarities among the crude oils, as well as some differences. Values of various structural parameters have been tabulated from the spectra. 3 refs.

Hasan, Misbah Ul (Fuel Research Cent, Karachi, Pak); Siddiqui, M. Naheed; Arab, M. *Oil Gas J* v 86 n 6 Feb 8 1988 p 38-40.

**077370 DECONVOLUTION TECHNIQUE FOR DETERMINING THE INTRINSIC FLUORESCENCE DECAY LIFETIMES OF CRUDE OILS.** A simple deconvolution procedure using FT was developed for determining the average lifetime of samples excited by a nitrogen laser pumped dye laser operating at 428 nm. To overcome the noise limitations imposed by including higher frequency harmonics in the analysis, we used an alternative approach. This approach relied on taking the Fourier transform at 21 subharmonic frequencies and using an appropriate weighting procedure in the calculation of amplitude and lifetime of the sample impulse response. A single exponential decay was assumed. (Author abstract) 9 refs.

Quinn, M.F. (Kuwait Inst for Scientific Research, Safat, Kuwait); Joubian, S.; Al-Bahrani, F.; Al-Aruri, S.; Alameddine, Oussama. *Appl Spectrosc* v 42 n 3 Mar-Apr 1988 p 406-410.

**077371 CARATTERIZZAZIONE DEL GREZZO ITALIANO VEGA.** [Characterization of the Italian Vega Crude Oil]. The Vega crude oil (Ragusa, Italy), extracted from the largest Italian offshore oil field about 25 km off the coast of southern Sicily, could represent a significant resource for the national economy. A multidisciplinary approach is presented for elucidating the physicochemical properties of the Vega crude oil at a molecular level. The physicochemical parameters indicate that the Vega oil is a heavy product with a low content of light-boiling fractions. Spectroscopic data (IR, UV, NMR) indicate an average molecule with an aromatic-naphthenic structure and a high 'compactness index'. The spectroscopic results for the Vega oil have been compared with those of other crude oils. Some relationships between the spectroscopic data and the asphaltene content of various crudes have been found. (Edited author abstract) 22 refs. In Italian.

Zerlia, T. (Stazione Sperimentale per i Combustibili, San Donato Milanese, Italy); Vecchi, C.; Pinelli, G. *Riv Combust* v 41 n 10 Oct 1987 p 243-251.

**077372 AVERAGE STRUCTURAL COMPOSITION OF ASTM DISTILLATE FRACTIONS OF BOMBAY HIGH AND RATNAGIRI CRUDE OILS BY <sup>1</sup>H AND <sup>13</sup>C NMR SPECTROSCOPY.** The offshore Bombay High Crude and Ratnagiri Crude Oil are high waxy and high pourpoint crudes. Their transportation through pipeline without one of the established pre-treatment methods is not feasible. Chemical additive treatment is found to be the most suitable and economical method. Several flow improver additives were tested on these crude oils. Structural data of respective fractions of the two crudes are compared. (Edited author abstract) 23 refs.

Husain, S. (Regional Research Lab, Hyderabad, India); Bhaskarrao, V.S.; Nageswarao, R. *Soc Pet Eng AIME Pap SPE* n 17550 1987 11p.

**Stability** See Also HYDROCARBONS—Recovery.

**077373 INTENSIFICATION OF CRUDE OIL STABILIZATION PROCESS.** Light crudes, after dehydrating and desalting, must be stabilized by taking off the propane-butane cut and sometimes the pentane cut. Stabilization is aimed at reducing the losses of valuable hydrocarbons in transportation and storage, and also at the delivery of crude to the refinery with a constant vapor pressure. In order to evaluate the applicability and select

a reliable analytical relationship for calculating phase equilibrium constants of individual components, the authors performed a calculational analysis in the examples of 20 samples of oil-in-place from fields in West Siberia. 6 refs.

Mukhmedzyanov, A.Zh. (Ufa Petroleum Inst, USSR). *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 109-112.

**Storage** See Also OIL WELL PRODUCTION—Offshore.

**077374 PETROLEUM PRODUCT STORAGE BY COMPETITIVE CRUDE OIL PROCESSORS.** This paper presents and tests a model of the storage behavior of competitive crude oil processors. A formalization of the decision problem of such a firm is first presented that permits the derivation of behavioral relations for stocks of crude and refined oil products. Given explicit functional forms, it is possible to test for the existence of such relations empirically. The relations are tested using data from the United States market for distillate fuel oils. The data provides strong support for the model in its linear form. However, there is evidence that the true relationship is non-linear. (Author abstract). 17 Refs.

Lowry, Mark Newton (Pennsylvania State Univ, University Park, PA, USA). *Resour Energy* v 10 n 2 Jun 1988 p 95-110.

**Structure**

**077375 MODEL OF COMPLEX STRUCTURAL UNIT IN CONDENSED MEDIA.** In support of the proposed CSU (Complex Structural Units) model, we have analyzed experimental data relative to the heats of mixing of compounds of different classes present in crude oil (paraffins, naphthenes, aromatic hydrocarbons). The strongest interaction is observed between aromatic compounds; therefore, in the systems under consideration, aromatic compounds are the core-forming components of the CSU. With increasing length of the alkyl radical in the molecule of the aromatic compound, the heat of mixing in these systems increases. Compounds of the naphthenic series in these systems interact better with paraffins than with aromatic hydrocarbons. 5 refs.

Krasnogorskaya, N.N.; Uner, F.G.; Andreeva, L.N.; Gabbidkeeva, A.R.; Sokov, Yu.F.; Khlestkin, R.N. *Chem Technol Fuels Oils* v 23 n 5-6 May-Jun 1987 p 248-250.

**Synthesis** See OIL SANDS—Processing.

**Thermal Effects**

**077376 THERMAL REACTIONS OF WHOLE CRUDE OILS AND RELATED MODEL COMPOUNDS.** The quantities of olefins, polyaromatic hydrocarbons and char formed during thermal decomposition in closed systems of alkylbenzenes are substantially reduced if the decomposition takes place in the presence of a good acceptor molecule such as pyrene or adamantane. The chemistry seems to be applicable to the upgrading of whole crude oils by a thermal treatment at 425-450°C in a closed system for 20-25 minutes. (Author abstract) 10 refs.

Farcasiu, M. (Mobil Research & Development Corp, Princeton, NJ, USA); LaPierre, R.B. *Fuel Sci Technol Int* v 5 n 6 Dec 1987 p 697-711.

**Thermodynamic Properties**

**077377 BIRBA FIELD PVT VARIATIONS ALONG THE HYDROCARBON COLUMN AND CONFIRMATORY FIELD TESTS.** This paper describes a practical application of thermodynamic modeling that indicated that the PVT properties of the reservoir fluid in the Birba field were strongly depth-dependent, explaining the presence of significantly undersaturated oil only 200 m [655 ft] below a gas cap. Field tests confirmed the thermodynamic model to be correct. Furthermore, this paper discusses the options for field development, including the consideration of possible benefits of (developed) miscibility when gas is

injected. (Author abstract) 4 refs.

Riemens, W.G. (Petroleum Development Oman); Schulte, A.M.; de Jong, L.N.J. *JPT J Pet Technol* v 40 n 1 Jan 1988 SPE 13719, p 83-88.

**077378 PVT CORRELATIONS FOR MIDDLE EAST CRUDE OILS.** Empirical equations for estimating bubblepoint pressure, oil FVF at bubblepoint pressure, and total FVF for Middle East crude oils were derived as a function of reservoir temperature, total surface gas relative density, solution GOR, and stock-tank oil relative density. These empirical equations should be valid for all types of oil and gas mixtures with properties falling within the range of the data used in this study. (Author abstract) 10 refs.

Al-Marhoun, Muhammad Ali (King Fahd Univ of Petroleum & Minerals, Saudi Arabia). *JPT J Pet Technol* v 40 n 5 May 1988 SPE 13718, p 650-666.

**Trace Analysis**

**077379 TRACE-METAL DISTRIBUTION IN MOSLAVINA BASIN CRUDE OIL AND OIL PRODUCTS.** Crude oil from the Moslavina basin was found to have very low abundances of the trace metals vanadium, nickel, iron, sodium, potassium and calcium, ranging from a minimum of 0.02 to a maximum of 16 µg g<sup>-1</sup>. Of the metals originally presented in the crude oil, nickel had the highest means mass yield of 6.0 µg g<sup>-1</sup>, vanadium the lowest (0.5 µg g<sup>-1</sup>). The metal abundances determined in oil distillation products (light gas oil, heavy gas oil and atmospheric residue) were low. Vanadium and nickel were primarily identified in the resin fraction of Moslavina oil, proving them to be mainly associated with the less polar constituents of intermediate molecular mass. Investigation of trace metal distribution in products of atmospheric distillation of Moslavina oil showed that up to a temperature limit of 350°C metals evaporated only slightly; they could not be detected in the petrol fraction. In the course of the processing procedures ~90% of all the trace metals present in crude oil was concentrated in the atmospheric residue. (Edited author abstract) 25 refs.

Ugarkovic, Dubravka (Univ of Zagreb, Sisak, Yugosl); Premerl, Dinko. *Fuel* v 66 n 10 Oct 1987 p 1431-1435.

**Transportation** See Also OIL WELL PRODUCTION—Sub-sea Production System.

**077380 LOSSES IN THE SHIPMENT OF CRUDE OIL: RECENT DEVELOPMENTS IN ANALYSIS AND QUANTIFICATION.** The underlying problem in the reconciliation of oil measurements for the purpose of loss control is the identification and quantification of real losses as opposed to apparent losses due to measurement error. An overall material balance provides a useful framework for analysis. The results of a recent pilot study of oil loss statistics, derived from conventional voyage files for liftings of Middle East crude parcels during 1984/86, are presented. The factors which govern evaporative loss are identified and discussed. The magnitude of crude evaporative losses during loaded passage is considered from fundamental principles. Predicted transit losses are relatively small and lie within the 95% confidence limits derived from the pilot study. (Edited author abstract) 14 refs.

Tomi, David (CWA Consultants Ltd); Vince, Ivan. *Pet Rev* v 41 n 487 Aug 1987 p 55-61.

**USSR** See ASPHALT—Materials.

**Vaporization**

**077381 INVESTIGATION OF THE EFFECTS OF PRESSURE AND TEMPERATURE ON THE VAPOURIZATION CHARACTERISTICS OF CRUDE OIL USING FIRST APPROXIMATION THERMAL ANALYSIS.** This study investigates the effect of pressure and temperature on crude oil vaporization using first approximation thermal analysis. Developed here is a technique for quantifying the vaporization



of fractions of a crude oil using an experimentally obtained thermogravimetric curve of the crude. The initial data utilized is the weight loss versus temperature values at atmospheric pressure, together with physical property data and equilibrium constant,  $k$  values. The results of this study allow the estimation of the volume of oil distilled underground when steam is injected into oil reservoirs at varying pressures and temperatures to recover crude oil. (Author abstract) 7 refs.

Bartlett, G.W. (Univ of the West Indies, St. Augustine, Trinidad); Subero, D. *J Therm Anal* v 32 n 6 Nov-Dec 1987 p 1843-1854.

**Viscosity** See Also OIL WELL PRODUCTION—Enhanced Recovery; OIL WELL PRODUCTION—In Situ Combustion; OIL WELL PRODUCTION—Thermal.

**077382 SIMULACION FLUIDODINAMICA DE UN REACTOR DE HIDROCONVERSION A ESCALA LABORATORIO.** [Fluidodynamic Simulation of a Hydroconversion Reactor at Bench Scale]. The fluid dynamics of a laboratory reactor employed for the hydrovisbreaking of Cerro Negro crude oil was simulated. A cold model reactor in plexiglas using kerosene-air and water-butanol-air fluid streams were employed to determine the effect of a number of trays and the open area on them, with or without thermowells. It was demonstrated that gas hold-up is affected by the presence of the thermowell and the trays. Liquid dispersion depends on gas flow and on the number and type of trays. Under stable flow conditions the experimental dispersion coefficients could be predicted from the Ohki-Inoue equation. (Author abstract) In Spanish. 24 refs.

Gallasso, Roberto (INTEVEP SA); Huskey, Donald; Nunez, Alejandro; Barbarossa, Leopoldo. *Rev Tec INTEVEP* v 7 n 1 Jan 1987 p 33-41.

**077383 VISCOSITY OF CRUDE OIL BLENDS.** The viscosities of light, medium, and heavy crude oils and the viscosities of their blends were experimentally measured over a temperature range of 10-60°C. These viscosity data were used to develop a new method for predicting the viscosity of crude oil blends based on known component viscosity. In addition, ASTM D341 and Refutas index methods were evaluated for predicting viscosities of crude oil blends. It was found that the new method gave the best representation of experimental results. The deviation in most cases was less than 6%. (Author abstract) 14 refs.

Al-Besharah, Jasem M. (Kuwait Inst for Scientific Research, Safat, Kuwait); Salman, Omar A.; Akashah, Saed A. *Ind Eng Chem Res* v 26 n 12 Dec 1987 p 2445-2449.

**077384 VISCOSITY CORRELATION FOR DEAD, LIVE AND UNDERSATURATED CRUDE OILS.** The predictive accuracy of the existing correlations used to estimate dead, live and undersaturated oil viscosities, was tested against 1270 data points. The relative performance of each correlation was determined using statistical methods. It was found that Beal's correlation gave accurate results for dead oil viscosity. For live oil viscosity, Chew and Connolly correlation proved to be more accurate than the others. This correlation was extended to cover a wide range of solution gas-oil ratio and new equations were developed to estimate the slope (B) and the intercept (A). For undersaturated oil viscosities, none of the available correlations yielded satisfactory results. Therefore, a new correlation was developed from plotting values of (P-Pb) versus ( $\mu$ - $\mu_p$ ) on log-log paper. The plots revealed a series of straight lines of a constant slope. Each line represented oils of a particular API gravity. The new correlation showed excellent results when tested against the measured data. (Author abstract) 3 refs.

Al-Khafaji, Ali H. (Council of Scientific Research, Baghdad, Iraq); Abdul-Majeed, Ghassan H.; Hassoon, Saadia F. *J Pet Res* v 6 n 2 Dec 1987 p 1-16.

**077385 GENERALIZED KINEMATIC VISCOSITY-TEMPERATURE CORRELATION FOR UNDEFINED PETROLEUM FRACTIONS.** A generalized kinematic viscosity-temperature correlation for undefined

liquid petroleum fractions has been developed to represent the data for a wide range of temperature from 100 to 400°F. The correlation is based on experimental kinematic viscosity data from twelve TBP fractions of Arab heavy, Arab medium and Arab Berri (extra-light) crude oils with boiling ranges between 200 and 850°F. The only characterization properties required for estimation are the API gravity and 50% boiling point. Detailed analysis shows that the proposed correlation fits the data from 102 experimental measurements of kinematic viscosity, made on 34 world crude oil fractions, with an overall absolute error of 7.4%. (Author abstract) 18 refs.

Beg, S.A. (King Fahd Univ of Petroleum & Minerals, Dhahran, Saudi Arabia); Amin, M.B.; Hussain, I. *Chem Eng J Biochem Eng J* v 38 n 2 Jun 1988 p 123-136.

**077386 REGULATION OF DISPERSITY AND RHEOLOGICAL PROPERTIES OF HIGH-VISCOSITY CRUDES.** A study is made of the degree of dispersity and the rheological properties of crude oils from the Mangyshlak Peninsula when they are compounded. The crudes used in this study were high-wax crudes from the Uzen' and Zhetybai fields and high-aromatics crudes from the Kalamkas and Karazhanbas fields. It was found that the dependence of the viscosity of the ratio of blend components can be explained by the sharp change in size of the asphaltene associates, which in the actual system are nuclei of the disperse particles. Thus, the ratio of components in crude oil blends influences the degree of dispersity of colloidal formations in these blends. This is turn governs the viscosity of the blends. We also found that the shearing stress in the system influences the variation of viscosity of the crudes and blends. Data show conclusively that the degree of dispersity and rheological properties of high-viscosity crudes are influenced by two basic factors: the specific ratio of components in the blend ('from within') and the intensity of energy supply. 6 refs.

Nadirov, N.K. (Acad of Sciences of the Kazakh SSR, USSR); Zhumasheva, K.S.; Burkitbaev, S.M.; Antoshkin, A.S. *Chem Technol Fuels Oils* v 23 n 7-8 Jul-Aug 1987 p 339-342.

## PETROLEUM ENGINEERING See Also PETROLEUM INDUSTRY.

**077387 ROLE OF THE ENGINEER IN THE PETROLEUM E&P INDUSTRY IN THE YEAR 2000.** This paper examines the role of engineers in major oil companies during the period from 1986 to 2000. It looks at both the majors' involvement in petroleum E&P and the significant technical challenges facing the industry for the remainder of the 20th century. The paper forecasts the functions of the engineer during this period, the computer support available to the engineer in the year 2000, and the qualifications required of the entry-level engineer in 2000. (Author abstract) 5 refs.

Jorden, James R. (Shell Development Co). *JPT J Pet Technol* v 39 n 10 Oct 1987 SPE 15346, p 1237-1242.

**077388 PETROLEUM SERVICE COMPANY ENGINEER IN THE YEAR 2000.** This paper details the technical problems that the engineer will have to face and the qualifications that will be required of an entry-level service-company engineer in the year 2000. The environment in the year 2000 in which the E&P service-company engineer will have to function is addressed as background to these forecasts. Projections are provided for the likely economic, political, and business climates. By the year 2000, there will be far fewer international service companies, but they will be larger and more capable. The service-company engineers will have to understand better the needs and problems of the international oil companies because they will have to work in partnership with the international companies personnel in mostly hostile environments. (Edited author abstract) 13 refs.

Fontenot, J.E. (NL Industries Inc). *JPT J Pet Technol* v 39 n 10 Oct 1987 SPE 15349, p 1247-1252.

**077389 PROFESSIONAL AND TECHNICAL ROLES CONFUSED.** There are two classes of profes-

sionals: (1) those who produce ideas, data, correlations, and procedures, and (2) those who apply the output of (1). Both are equally important, although the former tend to be accorded more prestige. The deterrents that exist in the effective technical communication between the two groups is discussed. Also examined is a growing recognition of the technician factor. More professionals, even the younger ones, are awaking to the reality that too much of their time is spent doing work that a technician can do, more cheaply and profitably. Examples demonstrate this situation. Measures for corrective action are outlined.

Campbell, John M. Sr.; Campbell, John M. Jr. *Pet Eng Int* v 60 n 8 Aug 1988 p 46-48.

**077390 PROCEEDINGS - 1987 SPE ANNUAL TECHNICAL CONFERENCE AND EXHIBITION.** This conference proceedings is contained in six volumes. Some of the topics discussed are here cited as illustrative examples: production forecasting for gas wells under variable conditions; a robust prediction method for rapid phase behavior calculations; modeling the performance of fractured wells in pattern floods using orthogonal, curvilinear grids; self-powered pumps for watered-out trapped gas; the effects of underbalance on perforation flow; hydraulically fractured gas well productivity modeling; calcium carbonate scale in oilfield operations; an investigation of analytical and numerical sucker rod pumping mathematical models; a study of horizontal wellbore failure; fracturing of a deviated well; field evaluation of D.E. and cartridge filters for completion/workover fluid filtration; and cementing of liners in horizontal and high-angle wells at Prudhoe Bay, Alaska. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10317 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Soc of Petroleum Engineers of AIME, Richardson, TX, USA). *Soc Pet Eng AIME Pap SPE Proc - 1987 SPE Annu Tech Conf and Exhib*, Dallas, TX, USA, Sep 27-30 1987. Publ by the Soc of Petroleum Engineers of AIME, Richardson, TX, USA, 1987. 2 vol 1238p.

**077391 38TH ANNUAL TECHNICAL MEETING OF THE PETROLEUM SOCIETY OF CIM.** This issue of the journal contains seven of the papers presented at a conference. Some of the subjects covered one recovery mechanisms in enriched gas drives, pressure buildsups analysis, plunger lift techniques for sour gas wells, coiled tube logging, synergistic evolution of the Norman Wells reservoir, and X-ray imaging techniques for oil sands. All papers are abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11525 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (CIM, Petroleum Soc, Can). *J Can Pet Technol* v 27 n 2 Mar-Apr 1988, 38th Annu Tech Meet Pet Soc CIM, Jun 1987 p 54-110.

**077392 NEW INTERPRETATION OF RECOVERY MECHANISMS IN ENRICHED GAS DRIVES.** This paper provides a new interpretation of multiple-contact miscible oil recovery processes by enriched gas drives. Using an example of solvent design for an Alberta reservoir it is shown that the low-pressure enriched gas drive is not always a condensing process as traditionally assumed by the industry. Often the process is a vaporizing drive qualitatively different from a high-pressure lean gas drive. This interpretation of process mechanism is supported by equation of state calculations which offer further insight into factors determining the process type for a given combination of reservoir fluid, solvent, reservoir temperature and operating pressures. The relationship between the solvent pressure-temperature phase and reservoir conditions is the most important factor. The vaporizing mechanism is favoured when the reservoir temperature is high and the solvent is lean in components heavier than propane. A limited review of the literature dealing with condensing gas drives was conducted and the



recovery mechanisms of several ongoing or planned miscible projects in Alberta were examined. The analysis indicates that many of these are vaporizing gas drives. (Edited author abstract) 18 refs.

Novosad, Zdenka (Shell Canada Ltd, Can); Costain, Terry. *J Can Pet Technol* v 27 n 2 Mar-Apr 1988, 38th Annu Tech Meet Pet Soc CIM, Jun 1987 p 54-60.

**077393 NEW INTERPRETATION OF RECOVERY MECHANISMS IN ENRICHED GAS DRIVES.** This paper provides a new interpretation of multiple-contact miscible oil recovery processes by enriched gas drives. Using an example of solvent design for an Alberta reservoir it is shown that the low-pressure enriched gas drive is not always a condensing process as traditionally assumed by the industry. Often the process is a vaporizing drive qualitatively different from a high-pressure lean gas drive. This interpretation of process mechanism is supported by equation of state calculations which offer further insight into factors determining the process type for a given combination of reservoir fluid, solvent, reservoir temperature and operating pressures. The relationship between the solvent pressure-temperature phase and reservoir conditions is the most important factor. The vaporizing mechanism is favoured when the reservoir temperature is high and the solvent is lean in components heavier than propane. A limited review of the literature dealing with condensing gas drives was conducted and the recovery mechanisms of several ongoing or planned miscible projects in Alberta were examined. The analysis indicates that many of these are vaporizing gas drives. (Author abstract) 26 refs.

Novosad, Zdenka (Esso Resources Canada Ltd, Can); Costain, Terry. *J Can Pet Technol* v 27 n 2 Mar-Apr 1988, 38th Annu Tech Meet Pet Soc CIM, Jun 1987 p 61-71.

**Calculations See PETROLEUM RESERVOIR ENGINEERING—Calculations.**

## Economics

**077394 COMPARING COST ESTIMATES OF PROCESSES AT DIFFERENT STAGES OF DEVELOPMENT.** The technical and economic feasibility of eleven oil shale beneficiation and recovery process alternatives has been investigated. Because of the wide variation of engineering and cost information available, the most accurate conventional evaluation method warranted by the data has been applied to each process. To compare on a uniform basis, all alternatives have also been evaluated using the rapid modular estimation method. The results are in good agreement and thus increase confidence in the investigation and provide a good test of the rapid modular estimation (RME) method. 16 refs.

KJumpar, Ivan V. (MIT, Cambridge, MA, USA); Weiss, Malcolm A. *Eng Costs Prod Econ* v 13 n 3 Mar 1988 p 183-188.

**077395 NET VALUES OF OUR INFORMATION.** Petroleum engineers are producers primarily of information, and they flourish according to the value of the information they produce. In a very real sense, the most important decisions petroleum engineers make are choices of which information to produce. A method to guide these decisions on the basis of net value of information produced or purchased is presented in this paper. A simple decision tree is used to quantify net information values with four petroleum engineering examples. For each example, the method guides the decision to obtain (or not to obtain) information. The maximum that can be paid for information is shown. Finally, the effect of oil price on net values of information is treated. A lower oil price can actually increase the value of information. 25 refs.

Lohrenz, John. *JPT J Pet Technol* v 40 n 4 Apr 1988 SPE 16842, p 499-503.

## Education

**077396 PETROLEUM ENGINEERING EDUCATION IN THE YEAR 2000.** The curricula for most undergraduate petroleum engineering programs are similar because of the accreditation criteria specified by the Accreditation Board for Engineering and Technology (ABET) and SPE. Changes in curricula occur gradually. There will probably be no major changes in petroleum engineering curricula by the year 2000. New technology is incorporated into the curricula yearly. More emphasis will probably be placed on economics, communication skills, and a better overall understanding of the petroleum industry. Also, petroleum engineering departments need to develop ways to stabilize their faculties during the large swings of the boom-and-bust cycles of the petroleum industry. (Edited author abstract)

Von Gonten, W.D. (Texas A&M Univ, TX, USA). *JPT J Pet Technol* v 39 n 10 Oct 1987 SPE 15347, p 1253-1255.

**077397 MORE DIVERSIFIED PETROLEUM ENGINEERING EDUCATION FOR NEW ENERGY CHALLENGES.** Although the most diversified petroleum engineering program possible should be provided for our undergraduates, such a program cannot be at the expense of our current core programs. An undergraduate curriculum emphasizing basic science and engineering is our best assurance that our graduates can contribute to society in spite of cyclic demand for petroleum engineers. Petroleum engineering departments and the profession should anticipate the need for engineers to develop alternative energy sources, but this is not expected to affect petroleum engineering programs significantly before the turn of the century. These changes, when they do come, most likely will and should occur first in graduate programs. (Author abstract) 1 ref.

Handy, Lyman L. (Univ of Southern California, USA). *JPT J Pet Technol* v 39 n 12 Dec 1987 SPE 15351, p 1591-1592.

**077398 61ST ANNUAL TECHNICAL CONFERENCE AND EXHIBITION OF THE SOCIETY OF PETROLEUM ENGINEERS.** This conference proceedings contains 5 papers. Topics covered include: petroleum engineering education in the year 2000; analysis of dispersion in a layered porous medium with micro-heterogeneity of arbitrary shapes and size distribution; corporate restructuring; oil and gas relative permeabilities determined from rate-time performance data; and, interpretation of pressure building responses in gas condensate wells. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 08622 in the Ei Engineering Meeting (TM) database produced by Engineering Information, Inc.

Anon (Soc of Petroleum Engineers of AIME, Richardson, TX, USA). *Soc Pet Eng AIME Pap SPE* 61st Annu Tech Conf and Exhib of the Soc of Pet Eng, New Orleans, LA, USA, Oct 5-8 1986. Publ by Soc of Petroleum Engineers of AIME, Richardson, TX, USA, 1986 var pagings.

**Project Management See SYNTHETIC FUELS—Production.**

**PETROLEUM GAS, LIQUEFIED See Also NATURAL GAS—Energy Utilization.**

**077399 FUTURE OF LPG AS A PETROCHEMICAL FEEDSTOCK - AN ANALYSIS FOR 1980-1990.** The LPG industry needs to recognize the special needs of the chemical industry and offer LPG prices indexed to alternative chemical feedstocks. In return the chemical industry offers the opportunity of absorbing surplus LPG supplies and thus stabilizing prices in the traditional LPG markets. This paper was originally presented at the Asian Council on Petroleum (ASOPE) Conference in Malaysia in 1985 and a modified version was also given at the 1986 LPG-ITA AGM in Scotland. Despite the chaos which has prevailed in oil product markets since the beginning of 1986, the paper still stands up to scrutiny, since it mainly discusses LPG price ratios and relationships with other products, rather than specific prices. (Edited author

abstract)

Williamson, E.I. (Coll of Petroleum Studies, Engl). *Q J Tech Pap Inst Pet* Jul-Sep 1986 p 73-79.

**077400 PERIODIC REVIEW ENHANCES LPG METERING PERFORMANCE.** Because of the loss of experienced personnel throughout our industry, we must start over teaching the basics of liquid measurement. Warren Petroleum Co., a division of Chevron U.S.A. Inc., has developed a checklist review method for its metering systems, complete with enough explanation to allow the reviewer to understand why each item is important. Simultaneously, it continues with more in-depth and theoretical training in our training courses.

Van Orsdel, F.G. (Warren Petroleum Co, Tulsa, OK, USA). *Oil Gas J* v 86 n 4 Jan 25 1988 p 75-80.

## Combustion

**077401 CHARACTERISTICS OF OPEN LPG JET FLAMES IN HELICAL AND TANGENTIAL-SLOT SWIRL BURNERS.** This paper reports the characteristics of LPG diffusion flames in a swirl burner in which the swirling air flow is generated by three spiralling air jets issuing from the helical grooves. The performance of the helical swirl burner (HSB) is compared with a conventional tangential-slot swirl burner (TSB) of the same diameter and under identical amounts of fuel and air flow rates. The data obtained for the two burners on flow velocity components, static pressure and central recirculation zone in isothermal flow and flame stability and flame temperature mapping have been presented. It is observed that the HSB produces higher swirl intensity compared with the TSB at the burner exit. The geometry of the central recirculation zone analyzed in the two burners indicates that the average residence time is higher in the HSB than in the TSB. Additional study results are discussed. (Edited author abstract) 10 refs.

Joseph, Vince (Indian Inst of Technology, Madras, India); Ganesan, V.; Shet, U.S.P. *J Inst Energy* v 60 n 445 Dec 1987 p 193-198.

## Manufacture

**077402 NEW LPG PLANT WILL EARN EXPORT DOLLARS.** When the LPG plant now being commissioned at Kwinana near Perth comes on full stream, it will have the capacity to process 320TJ/d of gas originating from the Northwest Shelf project and arriving via the Dampier-Bunbury pipeline. Utilising the latest cryogenic technology, the plant will produce about 113,000t/a of propane and about 54,000t/a of butane, as well as smaller quantities of heavier gases. The plant is divided more or less equally between its liquid extraction part (LEX) and its offsite facilities. The liquid extraction portion of the plant encompasses dehydration, extraction, fractionation and treating facilities. The offsite facilities include gas storage tanks, loading equipment, and the power and control systems.

Grad, Paul. *J Inst Eng Aust* v 60 n 16 Aug 5 1988 p 44-45.

## Measurements

**077403 HOW TO CHECK METERING SYSTEMS ON AN LPG LINE.** A check list is presented that can be used to check metering and custody transfer systems. Check metering systems should be reviewed along with custody transfer systems. This is to ensure not only that they are adequate, but also that both systems are metering exactly the same stream. A discussion is presented of: pulsation variation, fouling, control system effects, inlet strainers, meters and proving considerations. Factors relating to a sampling system review are also presented. 5 Refs.

Van Orsdel, F.G. (Warren Petroleum Co, Tulsa, OK, USA). *Pipe Line Ind* v 69 n 1 Jul 1988 p 23-28.



**Recovery** See HYDROGEN—Recovery.

**Storage** See Also PIPING SYSTEMS—Safety Valves.

**077404 AI-KILLED STEEL PLATES FOR LPG STORAGE TANKS.** Investigation has been made on the properties of continuously cast 38 mm thick SLA37 steel plates for LPG storage tanks. The crack arrest toughness  $K_{Ic}$  of the steel plates manufactured by Kawasaki Thermomechanical Rolling (KTR) and Multipurpose Accelerated Cooling System (MACS) processes was higher than 600 kgf/mm<sup>3/2</sup> at -50°C. In vertical MIG, TIG, SAW, and horizontal SAW of steel plates manufactured by the quenching and tempering (QT) process, and in EGW with a high weld heat input of 65 to approximately 115 kJ/cm of QT, KTR, and MACS steel plates, bond properties measured at the fusion line of welded joints are 7 kgf-m and over in JE-50°C, 0.3 mm and over in -50°C COD value, and 470 kgf/mm<sup>3/2</sup> in  $K_{Ic}$ . The foregoing results proved the technical feasibility of the production of SLA37 steel plate for LPG storage tanks by using the combination of continuous casting and QT, KTR and MACS processes. (Author abstract) 5 refs.

Kinaka, Ryoji (Kawasaki Steel Corp, Jpn); Okumura, Taketo; Terashima, Hisae; Minagawa, Sho; Nakano, Yoshifumi; Matsumoto, Shigeto. *Kawasaki Steel Tech Rep* n 17 Oct 1987 p 56-63.

## Venezuela

**077405 LP-GAS IN VENEZUELA.** All LPG for Venezuelan consumption and export is obtained from the processing of natural gas. Until December, 1985 only 5,000 barrels per day were available for export. During that month, a large cryogenic gas processing plant facility came on-stream. At capacity, an additional 50,000 barrels per day of LPG supplies will become available. (Edited author abstract)

Romero, Oscar (Lagoven SA, Caracas, Venez). *Energy Prog* v 7 n 3 Sep 1987 p 134-136.

**PETROLEUM GEOLOGY** See Also GEOCHEMISTRY; GEOCHEMISTRY—Organic Compounds; GEOPHYSICS—Geothermal; HYDROCARBONS—Geochemistry; OIL FIELDS; OIL FIELDS—Egypt; OIL FIELDS—Gulf of Mexico; OIL FIELDS—Reservoir Evaluation; OIL SHALE—Microscopic Examination; OIL WELLS—Testing; PETROLEUM, CRUDE—Geochemistry; PETROLEUM PROSPECTING—Australia; PETROLEUM PROSPECTING—Finland; PETROLEUM RESERVOIR ENGINEERING; PETROLEUM RESERVOIR ENGINEERING—Australia.

**077406 OCCURRENCE AND GEOCHEMICAL SIGNIFICANCE OF LONG-CHAIN DIALKYLTHIACYCLOPENTANES.** The authors report the conclusive identification and geochemical significance of long-chain 2,5-dialkylthiacyclopentanes of type 1, occurring as major components in some heavy sulfur-rich crude oils. In addition to providing new information about the 'aromatic' fractions of these crude oils (which are in fact largely non-aromatic), these results give useful indications of some of the mechanisms of incorporation of sulfur into organic matter in the sub-surface environment. Furthermore, as confirmed by thermal simulation experiments, these dialkylthiacyclopentanes are thermally labile, which seems to restrict their occurrence to immature crude oils. They could therefore serve as useful maturation parameters for the early stages of petroleum formation in carbonate basins. (Edited author abstract) 20 refs.

Schmid, J.C. (Univ Louis Pasteur, Strasbourg, Fr); Connan, J.; Albrecht, P. *Nature* v 329 n 6134 Sep 3-9 1987 p 54-56.

**077407 STEROIDAL HYDROCARBONS OF THE KISHENEHN FORMATION, NORTHWEST MONTANA.** The Oligocene Kishenehn Formation of northwest Montana and southeast British Columbia consists of fluvial and lacustrine sediments (marlstones, lignites and oil shales) deposited in an elongate, intermontane half-graben. The petroleum source rock potential and steroidal hydrocarbon distribution of selected shales of the Kishenehn Formation were examined. Several steroidal hydrocarbon series were documented, including 4-desme-

thylsteranes, 4-methylsteranes, sterenes, diasterenes, spirosterenes, C-ring monoaromatic steroids and B-ring monoaromatic anthrasteroids. Non-steroid hydrocarbons present include hopenes,  $\beta\beta$ -hopanes, moretanes, perylene, botryocane, a series of alkylcyclohexanes, and a fused-ring aromatic tentatively identified as a tetrahydrochrysene. Source rock analysis indicates that the Kishenehn Formation possesses excellent petroleum source potential. Conventional thermal maturity parameters (vitrinite reflectance and Rock-Eval  $T_{max}$  values), as well as maturity parameters derived from molecular parameters (n-alkane, steroid and hopanoid distributions) suggest that much of the Kishenehn Formation is currently undergoing organic diagenesis. (Edited author abstract) 45 refs.

Curiale, Joseph A. (Unocal Inc, Brea, CA, USA). *Org Geochem* v 11 n 4 1987 p 233-244.

**077408 APPLICATION OF METALLOPORPHYRIN BIOMARKERS AS PETROLEUM MATURITY INDICATORS: THE IMPORTANCE OF QUANTIFICATION.** The parameters derived from analyses of vanadyl tetraporphyrins in a suite of con-familial (single-source) oils from the Big Horn Basin were found to reflect thermal stress and to correlate well with the bulk maturity parameters, except in one case (i.e. Manderson). Interestingly, the low vanadyl porphyrin concentration in Manderson (10  $\mu\text{g/g}$ ) was consistent with that expected of a quite mature petroleum rather than one of low maturity as indicated by the biomarker profile. Hence, it is argued that the Manderson porphyrins are not representative of the major portion of this petroleum, but rather of a minor amount (ca 5-10%) of less mature petroleum or bitumen picked up during migration to or in the current reservoir. It is concluded that, in general, reliability of biomarker based ratio parameters must be considered contingent on occurrence in expected concentrations and concurrence with bulk petroleum parameters. (Author abstract) 44 refs.

Baker, Earl W. (Florida Atlantic Univ, Boca Raton, FL, USA); Louda, J. William; Orr, Wilson L. *Org Geochem* v 11 n 4 1987 p 303-309.

**077409 SURVEY OF HYDROTHERMALLY-GENERATED PETROLEUMS FROM THE GUAYMAS BASIN SPREADING CENTER.** The Guaymas Basin spreading center and hydrothermal system are generating an assortment of petroleum-like bitumens by pyrolysis of organic matter in the overlying unconsolidated sediments. Samples collected by D.S.V. Alvin from hydrothermal fields in the Southern Trough exhibit large variations in the quantities and character of the solvent-soluble organic materials. Various pyrolytic regimes combined with fluctuating thermal gradients and migration velocities may impart a compositional fractionation, possibly by differential gaseous solubilization and hydrodynamic alteration of the multicomponent fluids. The data suggest that differential condensation/solidification, biodegradation, and water-washing cause selective removal of components at the seabed. Many hydrothermal oils are unlike normal reservoir petroleum, because they contain significant concentrations of polar material, due to their rapid genesis and transport and probable solubilization or advection of polar, immature components. The biomarker distributions confirm high-temperature pyrolysis at depth with variable entrainment of less thermally-mature bitumens during transport. (Edited author abstract) 63 refs.

Kawka, Orest E. (Oregon State Univ, Corvallis, OR, USA); Simoneit, Bernd R.T. *Org Geochem* v 11 n 4 1987 p 311-328.

**077410 NON-HYDROCARBONS OF SIGNIFICANCE IN PETROLEUM EXPLORATION: VOLATILE FATTY ACIDS AND NONHYDROCARBON GASES.** Nonhydrocarbon gas species ( $\text{CO}_2$ ,  $\text{N}_2$ ,  $\text{H}_2$ ) are locally important in exploration for gas, and there is a growing body of evidence that acid water originating in shales materially affects the diagenesis of nearby sandstones. These gases have been studied by analyzing the products of closed-vessel hydrous pyrolysis of known petroleum source rocks, and comparing the results with

field observations. Alteration of petroleum source rocks at temperatures  $>250^\circ\text{C}$  yields a significant amount of nonhydrocarbon components. Ethanoate and higher acid anions are liberated in substantial quantities; the yield appears to be related to the oxygen content of the sedimentary organic matter present. The nonhydrocarbon gases  $\text{CO}_2$ ,  $\text{H}_2$  and  $\text{N}_2$  are frequently the dominant gaseous products from hydrous pyrolysis: in the natural environment the same rock sequences at a higher maturity preferentially generate hydrocarbon gases - mainly methane. This discrepancy may be attributed to reaction and phase thermodynamic effects between laboratory and natural systems, behavior that has important implications in the prediction of gas generation and composition in nature by source rock pyrolysis in the laboratory. (Author abstract) 21 refs.

Cooles, G.P. (BP, Sunbury-on-Thames, Engl); Mackenzie, A.S.; Parkes, R.J. *Mineral Mag* v 51 pt 4 Oct 1987 p 483-493.

**077411 MODEL FOR THE DETERMINATION OF WATER SATURATION FROM DIELECTRIC PERMITTIVITY MEASUREMENTS.** The dielectric permittivity of a saturated formation is controlled mainly by the amount of water present in the pores; thus, the porosity calculated from the dielectric permittivity is related to the water-filled porosity. The percentage of water present in the pore space is the ratio of water-filled porosity to total porosity. Because the geometrical distribution of the water in the pores changes with water saturation, a direct comparison of the calculated water-filled porosity from dielectric mixing laws to the total porosity is not always a good estimate of water saturation. A more reliable prediction method is to relate the water saturation to the porosity ratio using a saturation exponent analogous to the saturation exponent in Archie's water saturation equation. An equation using an exponent to relate water saturation to the water-filled porosity has been developed using the Hanai-Bruggeman equation to determine the water-filled porosity. The water saturation equation is analogous to, and reduces to, Archie's saturation equation when the conductivity of the rock dominates the electrical response. The magnitude of the exponent varies between formations and can be determined from laboratory measurements. Laboratory measurements on core samples show a high correlation between the water saturation and the ratio of calculated water-filled porosity to total porosity. An approximate relationship between the dielectric saturation exponent and Archie's saturation exponent has been derived and verified. (Author abstract) 12 refs.

Sherman, Michael M. (Amoco Production Co, Tulsa, OK, USA). *Log Anal* v 28 n 3 May-Jun 1987 p 282-288.

**077412 EFFECT OF THE THERMODYNAMIC PORE WATER PRESSURE GRADIENT ON GEOTHERMAL GRADIENTS AND WATER MINERALIZATION IN PETROLIFEROUS BASINS.** The considerable changes of geothermal gradients and mineralization of formation waters often observed in lithologically homogeneous series of sedimentary basins with ellipsoidal or stagnating water pressure conditions are explained by the effect of the convective heat transfer by the downcoming water filtration with a lowering of the average annual paleotemperature on the surface. The downcoming filtration arises in densely packed water-saturated rocks under the effect of the thermodynamic pore water pressure gradient. (Translated author abstract) 6 refs. In Russian.

Dobrynin, V.M.; Serebryakov, V.A.; Parfenenko, N.V. *Izv Vyssh Uchebn Zaved Neft Gaz* n 9 Sep 1986 p 3-10.

**077413 METHODOLOGICAL PRINCIPLES OF THE STUDY OF STRATUM AND STRATAL FLUID HETEROGENEITY.** In order to study macro- and microheterogeneity of layers and layer fluids, a method has been developed and implemented to detect and evaluate the geological heterogeneity of deposits. It is based on a complex combination of different mathematical methods. An appropriate technological scheme envisaging generalization of data by means of the proposed mathematical



tool has been implemented by a computer program in the form of the 'Heterogeneity' software. In Russian 5 refs.

Bagirov, B.A.; Bagirova, R.S. *Izv Vyssh Uchebn Zaved Neft Gaz* n 1 1987 p 15-22.

**077414 GAS- AND ORGANOHYDROCHEMICAL CRITERIA FOR DIFFERENTIAL PETROLEUM POTENTIAL PREDICTION.** An attempt is made to determine the most informative and reasonable (regarding the number of indices and the possibility of their practical utilization) set of gas and organohydrochemical criteria for separate prediction of oil and gas potential - regional and local methods of regional forecasting by using data on the content of water-soluble gases (WSG) and organic substances (WSOS) and local forecasting by using data on gashydrochemical indices and on organohydrochemical indices are presented and evaluated. In Russian.

Samsonov, F.P.; Yakobson, G.P.; Novosel'tseva, D.Sh. *Geol Nefti Gaza* n 2 1987 p 37-41.

**077415 DETERMINATION OF LITHOLOGY FROM WELL LOGS BY STATISTICAL ANALYSIS.** This paper presents a method of predicting lithology by statistical analysis of wireline log measurements with calibration to a core lithology standard. Although an example of the technique applied to the Shublik formation of the Prudhoe Bay area, North Slope, AK, is developed and presented, the method can be applied to any field where some core has been taken. A lithology standard must be available to calibrate against during development of a log model of lithology. For the Shublik, the core available provided an excellent sample of the total formation. Using the statistical technique of discriminant analysis, we were able to evaluate a number of log models and to choose the most appropriate one. (Edited author abstract) 8 refs.

Busch, J.M. (Arco Alaska Inc); Fortney, W.G.; Berry, L.N. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 14301, p 412-418.

**077416 REGIONAL CAPROCK-DESTROYING DOLomite ON THE MIDDLE JURASSIC TO EARLY CRETACEOUS ARABIAN SHELF.** Massive, stratigraphically discordant dolomite occurs on the late Mesozoic Arabian Shelf in the northern portion of Aramco's main producing area. The dolomite is associated with solution-collapse of anhydrite seals and with enhancement of porosity and permeability in tight limestone seals within the region. By destroying regional caprocks, dolomitization has had an adverse effect on oil accumulation. The spatial distribution of this regional dolomite was mapped with wireline log and core data. Geochemical and fluid-inclusion analyses indicate that the dolomite formed from hot saline brines that were first expelled from halite-bearing evaporites, and then migrated into Arabian Shelf carbonates during burial. (Author abstract) 18 refs.

Broomhall, R.W. (Arabian American Oil Co); Allan, J.R. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 13697, p 435-441.

**077417 EVOLUTION DIAGRAM OF KEROGEN STRUCTURE IN THE PROCESS OF HYDROCARBON FORMATION.** It has been established that kerogen, the insoluble organic material in source rocks, is the principal source matrix for hydrocarbon generation. The authors have studied some kerogens which are of different types and maturities. Their IR data are marked on a ternary diagram which takes the relative percentages of 1460  $\text{cm}^{-1}$ , 1600  $\text{cm}^{-1}$ , and 1710  $\text{cm}^{-1}$  as its three vertices. Thus the diagram, which is discussed in this paper, shows the evolution of kerogen structure and composition.

Huang, Difan (Research Inst of Petroleum Exploration & Development, Beijing, China); Li, Jinchao; Wang, Huixiang. *Energy Sources* v 9 n 3 1987 p 203-208.

**077418 MODEL OF THE STRUCTURE OF AND THE EFFECTIVE THERMAL CONDUCTIVITY OF A BAZHENOV SUITE.** One of the promising oil fields in the Soviet Union is the deposits of the Berias-Volga stage of Western Siberia. They consist of nontraditional

rock reservoirs, called a Bazhenov suite. A Bazhenov suite consists of mudstone formations, which were for a long time believed to be fluid supports. A model is proposed for the structure of a Bazhenov suite. The relationship between the structure (porosity of emptiness, oil content) and the thermophysical properties of the rock is found. The characteristics obtained are checked under laboratory conditions and then extrapolated to reservoir conditions. 7 refs.

Dul'nev, G.N. (Leningrad Inst of Precision Mechanics & Optics, USSR); Dorofeeva, T.V.; Volkov, D.P.; Muratova, B.L. *J Eng Phys* v 52 n 1 Jan 1987 p 87-94.

**077419 THERMAL HISTORY OF SEDIMENTARY BASINS, MATURATION INDICES, AND KINETICS OF OIL AND GAS GENERATION.** No measurable parameter can be directly converted to paleotemperature. Maturation indices such as vitrinite reflectance,  $T_{\text{max}}$  from Rock-Eval pyrolysis, spore coloration, Thermal Alteration Index (TAI), or concentration of biological markers offer an indirect approach. All these indices are a function of the thermal history through rather complex kinetics, frequently influenced by the type of organic matter. Their significance and validity are reviewed. Kinetics of kerogen decomposition controls the amount and composition of hydrocarbons generated. Kinetic models, based on a specific calibration made on actual source rock samples, can simulate the evolution of all types of organic matter and can provide a quantitative evaluation of oil and gas generated. Examples from the Jurassic source rocks of the Paris basin, Monterey Formation of California, Green River shales of Utah, Paleozoic source beds of the Algerian Sahara, and Miocene rocks of the Manhattan Delta, Indonesia, illustrate various aspects of the discussion. (Edited author abstract) 80 refs.

Tissot, B.P. (Inst Francais du Petrole, Rueil-Malmaison, Fr); Pelet, R.; Ungerer, Ph. *AAPG Bull* v 71 n 12 Dec 1987 p 1445-1466.

**077420 THERMODYNAMIC SEALS OF OIL AND GAS DEPOSITS.** It is argued that, following a modification of certain thermodynamic conditions of rocks, the role of regional seals may be played by light microfissured rocks, e.g. limestones. In this case, the floating up of oil or gas is prevented by the negative thermodynamic pressure gradient of pore water (TPG). This gradient arises in poorly interconnected pores as a result of nonuniform thermal compression of the formation water following a drop in rock temperature. Some examples of such seals are presented. In Russian. 6 refs.

Dobrynin, V.M. *Geol Nefti Gaza* n 4 Apr 1987 p 9-16.

**077421 REVIEW OF THE CRETACEOUS FORMATIONS IN THE ARABIAN PENINSULA AND GULF: PART II. MID-CRETACEOUS (WASIA GROUP) STRATIGRAPHY AND PALEOGEOGRAPHY.** The stratigraphic sequence of the 'Middle' Cretaceous Wasia Group in the Arabian Gulf, and the terminology used, is reviewed. Type sections and synonymy are established for the succession in the United Arab Emirates. An historical introduction provides a key to the understanding of the varied formational and member names in current use. Facies distribution maps show that shallow-water, predominantly carbonate, belts extend across the whole region. Two plastic-carbonate cycles are apparent in the northeastern part of the Gulf, the lower Nahr Umr-Maaddud cycle and an upper Wara-Mishrif cycle. The upper cycle is poorly defined in the southeastern Gulf, and in the Abu Dhabi region a zone of carbonate build-up surrounds a slightly deeper intracratonic basin which developed in Late Albian-Early Cenomanian time. (Author abstract) Refs.

Alsharhan, A.S. (United Arab Emirates Univ, Al-Ain, United Arab Emirates); Nairn, A.E.M. *J Pet Geol* v 11 n 1 Jan 1988 p 89-112.

**077422 THEORETICAL ASPECTS OF CAP-ROCK AND FAULT SEALS FOR SINGLE- AND TWO-PHASE HYDROCARBON COLUMNS.**

Cap-rock seals can be divided genetically into those that fail by leakage (membrane seals) and those whose capillary entry pressures are so high that seal failure preferentially occurs by fracturing and/or wedging open of faults (hydraulic seals). A given membrane seal can trap a larger oil column than gas column at shallow depths, but below a critical depth (interval), gas is more easily sealed than oil. Fault-related seals are effectively analogous to membrane cap-rocks which have tilted to the angle of the fault plane. The membrane sealing theory developed assumes that all reservoirs and seals are water-wet and no hydrodynamic flow exists. The conclusions on membrane seal capacity place constraints on the migration efficiency of gas along low-permeability paths at depth where fracturing, wedging open of faults and/or diffusion process may be more important. The developed seal theory and pressure/depth profile concepts are applied to a series of development geological problems. Additional aspects of the subject are discussed. 38 refs.

Watts, N.L. (Shell Int Petroleum Maatschappij BV, The Hague, Neth). *Mar Pet Geol* v 4 n 4 Nov 1987 p 274-307.

**077423 OPTICAL PROPERTIES OF SCOECODONTS AND THEIR USE AS INDICATORS OF THERMAL MATURITY.** Dispersion of reflectances in air and oil between 400 and 700 nm of a suite of scoecodonts concentrate with known Conodont Alteration Index was determined using a reflected light microscope. Refractive and absorptive indices of these scoecodonts were calculated using their determined reflectances. Morphologically, scoecodonts in carbonate show similar granular morphology to that of graptolites. Fine structural details of scoecodonts can be observed under reflected light. Reflectances, refractive and absorptive indices of scoecodonts at 546 nm increase with increase of the Conodont Alteration Index, indicating that these properties of scoecodonts can be used to determine the maturity of sediments. (Edited author abstract) 21 refs.

Goodarzi, F. (Inst of Sedimentary & Petroleum Geology, Calgary, Alberta, Can); Higgins, A.C. *Mar Pet Geol* v 4 n 4 Nov 1987 p 353-359.

**077424 PRECAMBRIAN AS A HYDROCARBON EXPLORATION TARGET.** As recently as 1950 it was generally accepted that sedimentary rock of Precambrian age located within basins, geosynclines, and platforms could not contain hydrocarbon deposits. The absence of pre-Paleozoic Era life and the lack of reservoir rock characteristics in these Precambrian rock columns were the most often presented reasons why Precambrian terranes should be ignored by the petroleum geologist. Within the past three decades evidence for varied forms of life has been discovered in sedimentary rock as old as 3.6 Ga. Simultaneously many Precambrian rock columns have been recognized as possessing excellent reservoir characteristics. With the discovery of commercial deposits of indigenous Precambrian-age hydrocarbons, sedimentary rock deposited throughout the world during this early chapter in earth history is being analyzed by the oil and gas industry. (Author abstract)

Dickes, Albert B. *Geosci Wis* v 11 Sept 1986 p 5-7.

**077425 WORLDWIDE DISTRIBUTION OF PRECAMBRIAN HYDROCARBON DEPOSITS.** Prior to the 1960s a minor amount of 'Precambrian' production was known. These fields normally were created by hydrocarbons derived from Phanerozoic sources migrating into fractured Precambrian igneous rock because of favorable structural associations. Since the 1960s, however, at least a dozen oil and gas fields, several of considerable size, have been discovered in Precambrian reservoir rock, the oil of which was supplied from Precambrian source strata. Such relationships have been made or reported in the East Siberian Platform and the Ural-Volga regions of the USSR, the Amadeus Basin of



Australia, the Sichean and Bohai Bay Basins of China, and the Montana and Lake Superior areas of the United States. (Edited author abstract)

Dickas, Albert B. *Geosci Wis* v 11 Sept 1986 p 8-13.

**077426 PROBLEM OF OIL AND GAS POTENTIAL IN REGIONAL OVERTHRUST ZONES.** A number of regional overthrust zones in the USSR and other regions of the world are considered for their oil and gas-bearing potential. It is argued that the most promising are overthrust rocks situated between the main overthrust planes as well as the natural reservoirs formed in the post-thrust phase. New tasks for regional geophysical explorations are pointed out. Overthrusts whose structures contain deposits of barium of ancient passive forges transformed in the course of orogenesis should be explored in the first place. It is recommended that a computer program be worked out by the year 2000 to assist in modeling the structure of areas with petroleum potential. In Russian. 15 refs.

Maksimov, S.P.; Kapustin, I.N.; Kiryukhin, L.G.; Solov'ev, B.A.; Shein, V.S.; Kucheruk, E.V. *Geol Nefti Gaza* 7 Jul 1987 p 1-8.

**077427 LA MIGRATION DES HYDROCARBURES DANS LES BASSINS SEDIMENTAIRES: ASPECTS GEOLOGIQUES ET GEOCHIMIQUES.** [Migration of Hydrocarbons in Sedimentary Basins: Geological and Geochemical Aspects]. Oil migration toward reservoirs and traps, and especially its expulsion from the source rock where it was formed (primary migration), has remained one of the least understood problems in petroleum geology. The displacement of oil and gas occurs in a separate hydrocarbon phase. Water, which is often considered as the vehicle for oil during migration, effectively plays a negative role. Water saturation must have been sufficiently diminished (by expulsion) and hydrocarbon saturation must be sufficiently increased (by generation from kerogen) for the flow of a hydrocarbon phase to become possible. The driving force for this expulsion is the pressure gradient. A rise in pressure in the pore volume of source rocks results from three causes (the sedimentary load, the formation of hydrocarbons, and the thermal expansion of water). Microfracturing, which occurs when the internal pressure of fluids exceeds the mechanical strength of the rock, may play an important role. Among the consequences of migration, mention can be made of the possibility of oil/source-rock correlation, the lower content of heavy products in reservoirs than in source rocks, and the role often played by a displacement in which liquid and gaseous hydrocarbons form a single phase that migrates while progressively leaving the heavier fractions behind it. (Edited author abstract) 41 refs. In French.

Tissot, B.P. (Inst Francais du Pétrole, Rueil-Malmaison, Fr). *Rev Inst Fr Pet* v 43 n 2 Mar-Apr 1988 p 143-153.

**077428 MODEL OF SECONDARY HYDROCARBON MIGRATION AS A BUOYANCY-DRIVEN SEPARATE PHASE FLOW.** A mathematical model of secondary migration is described which permits the prediction of hydrocarbon migration and accumulation patterns in a sedimentary basin if source rock expulsion rates and geometrical and hydraulic properties of major carrier systems are known through geological time. In this model, secondary migration is treated as buoyancy-driven segregated flow of hydrocarbons in hydrostatic aquifers. Lateral updip migration is conceived as a Boussinesq-type free-surface flow with source and sink terms representing supply from source rocks and leakage through cap rocks and faults. This permits a two-dimensional map-view mathematical description of a three-dimensional time-dependent secondary migration (Edited author abstract) 17 refs.

Lehner, F.K. (Koninklijke/Shell Exploratie en Productie Lab, Rijswijk, Neth); Marsal, D.; Hermans, L.; van Kuik, A. *Rev Inst Fr Pet* v 43 n 2 Mar-Apr 1988 p 155-164.

**077429 FLUID FLOW IN LOW PERMEABLE,**

**POROUS MEDIA.** The author presents a methodology for pre-drill pressure prediction system using seismic velocity analysis. This is followed by a simple model of shale compaction as a source of geopressing. The model includes a time and temperature dependent shale compaction law to account for shale dehydration and the smectite to illite transformation. A major conclusion is that geohistory based models, with reasonable control or notions about ranges of geologically accepted parameters such as burial rates and temperature gradients, can predict reliable pre-drill estimates of pressure, stresses and seismic parameters (for example, porosity and velocity). Such information, when calibrated with available well control and integrated with sequence stratigraphic results, can provide a guide to high grade prospects for hydrocarbon detection prior to drill and assist in safety of operation in a geopressed environment. 23 refs.

Dutta, N.C. (ARCO Oil & Gas Co, Plano, TX, USA). *Rev Inst Fr Pet* v 43 n 2 Mar-Apr 1988 p 165-180.

**077430 RELATIONS ENTRE LES TYPES DE DEPOTS EVAPORITQUES ET LA PRESENCE DE COUCHES RICHES EN MATIERE ORGANIQUE (ROCHES-MERES POTENTIELLES).** [Relationship Between Different Types of Evaporitic Deposits and the Occurrence of Organic-Rich Layers (Potential Source Rocks)]. The fertility of saline waters has been confirmed by studies of salterns in the western Mediterranean. The effectiveness of stratified water bodies for the preservation of organic matter originally produced in photic and oxygenated water is brought out. In shelf (or epicritic) evaporites, where the segregation of salinities and deposits has been synchronous and lateral, the water depth must have been shallow hence unsuitable for the formation of stratified water bodies and their geological duration. In basin-center evaporites, the deposits are attributed to a succession of phases of increasing salinity in time. The third type of evaporitic deposits is represented by basin-margin evaporites. In such a system, the basin center remains starved for long periods of time. The filling of the central part by basin-center evaporites may be a brief episode and may result in the disappearance of the basin. The shelf evaporites spreading on both the former basin area and the former marginal shelves may be the start of new sedimentary cycle without any connection to the past. 56 refs. In French.

Busson, G. (Museum Natl d'Histoire Naturelle, Paris, Fr). *Rev Inst Fr Pet* v 43 n 2 Mar-Apr 1988 p 181-215.

**077431 SIMPLE ANALYSIS OF PRIMARY OIL MIGRATION THROUGH OIL-PROPAGATED FRACTURES.** The following conditions are necessary for oil-induced fracture propagation: (a) Organic matter is concentrated into discrete, isolated flakes. If kerogen is finely disseminated, oil-induced fracture propagation is not possible. (b) Kerogen flakes are thin and elongate with a large length to thickness ratio. The length of a kerogen flake must be 6 mm, if it is 0.1 mm thick. (c) Kerogen does not acquire permeability until a small amount of oil is generated. (d) The oil-source rock permeability is not more than that of a compact shale or argillaceous limestone. Oil-generation may cause existent flaws in oil-source rocks to propagate and form a fracture network which acts as a pathway for primary oil-migration. However, before a definite conclusion can be reached, further study is necessary of the relationship between the kerogen size distribution and oil expulsion efficiency of source rocks, and the permeability behaviour of kerogen flakes during source rock maturation. (Edited author abstract) 11 refs.

Ozkaya, Ismail (Kuwait Univ, Kuwait). *Mar Pet Geol* v 5 n 2 May 1988 p 170-174.

**077432 TRIANGULATION: MATHEMATICALLY WELL-DEFINED TECHNIQUE FOR CONSTRUCTING GEOLOGIC MAPS.** Special circumstances arise which require the construction of geologic maps without subjective bias and according to a prescribed set of mathematical rules. This article describes triangulation, a mathematically well-defined collection of rules for the manual construction of geologic maps. Given only control

points and a region defined by a closed polygonal boundary, triangulation defines uniquely a continuous surface throughout the bounded region, has no discontinuities, and honors each control point. The map construction requires only a pen, ruler, and hand calculator. Map contours are drawn as straight line segments joining interpolated contour control points and control points of the same value. These contours follow a surface of linked triangular facets (planes) whose intersections and attitudes are defined by the control point locations, their values, and the polygonal boundary.

Henson, M.R. (Conoco (UK) Ltd, London, Engl); Moyer, R.W. *Oil Gas J* v 86 n 19 May 9 1988 p 56-58.

**077433 MAJOR STAGES OF TRANSFORMATION OF DISPERSED ORGANIC MATTER AS VIEWED IN THE SOVIET UNION - AN HISTORICAL REVIEW.** Major stages of transformation of dispersed organic matter in sediments and sedimentary rocks during catagenesis are discussed. The paper mainly represents an historical review of views held by Soviet petroleum geologists and geochemists through 1981. The views and theories of N.B. Vasoevich (whom the authors consider to be a giant of geology) on organic origin of petroleum are presented in detail. (Author abstract) 37 refs.

Korchagina, Yu.I. (Moscow Government Univ, Moscow, USSR); Ivanov, M.K.; Chilingarian, George V.; Yen, Teh Fu. *Energy Sources* v 10 n 1 1988 p 21-42.

**077434 PATTERNS OF PERMEABILITY IN EOLIAN DEPOSITS: PAGE SANDSTONE (JURASSIC), NORTHEASTERN ARIZONA.** One of the most important aspects of this study is the correlation of qualitative geologic descriptions with quantitative variables such as permeability. About 2,000 measurements were made with a field minipermeameter on an outcrop of the Page sandstone. These data show that three distinct permeability modes directly relate to the different stratification types. Permeability exhibits two components of variation: a structural or systematic component and a random or noise component. In this context, the structural component may be correlated to identifiable geologic processes, whereas the random component covers all unexplained variations. These definitions, however, are entirely scale dependent. By decreasing the scale of measurement, structure is revealed in the random variation. This scale dependence is evident in the subject outcrop and, using several statistical tools, we are able to illustrate the "nested" nature of the spatial variation in permeability. The work is pertinent to enhanced recovery. (Edited author abstract) 20 Refs.

Goggin, D.J. (Univ of Texas, Houston, TX, USA); Chandler, M.A.; Kocurek, G.; Lake, L.W. *SPE Form Eval* v 3 n 2 Jun 1988 p 297-306.

**077435 BURIED RIFTS LIKELY PLACES TO FIND OIL, GAS.** Petroleum geology of a number of regions in western North America is covered. These regions include Wyoming, Montana, and Southern Alberta. Some of the topics discussed are buried rift zones as locations for petroleum reserves, and hydrocarbon trapping mechanisms. Other regions covered are eastern China, Saudi Arabia, and North Sea basins.

Hagen, Donald W. (Texaco Canada Resources Ltd, Calgary, Alberta, Can). *Oil Gas J* v 86 n 30 Jul 25 1988 p 103-109.

**077436 APPLICATION OF AROMATIC COMPOUNDS AS MATURITY INDICATORS IN SOURCE ROCKS AND CRUDE OILS.** Generally, these indicators rely either on an increase with maturity in the degree of alkylation of a given parent compound or a shift in the isomer distribution of alkyl-aromatic homologues towards thermally more stable isomers. A combination of both concepts in the Methylphenanthrene Index (MPI) resulted in an excellent maturity parameter, as demonstrated for rock extracts by an improved correla-



tion with mean vitrinite reflectance ( $R_m$ ) between 0.65 and 1.4%, i.e., in the zone of oil formation. Organic facies effects should be taken into account in the interpretation of aromatic distributions of such source rocks and related crude oils. Aromatic maturity parameters are particularly useful in the maturity evaluation of post-mature crude oils and condensates. In contrast to biological markers, substantially higher concentrations of the key alkyl-aromatics persist at elevated maturation levels. Additional aspects of the subject are discussed. (Edited author abstract). 31 Refs.

Radke, Matthias (KFA, Juelich, West Ger). *Mar Pet Geol* v 5 n 3 Aug 1988 p 224-236.

**077437 GAS-CONDENSATE MIGRATION AND OIL FRACTIONATION IN DELTAIC SYSTEMS.** The term evaporative fractionation is proposed to describe several phenomena involved in the secondary alteration of reservoir oil. Firstly, it is suggested that oil is frequently partially vaporized in the reservoir; secondly, that gas, bearing substantial portions of the oil in solution, is conducted along faults to form independent gas-condensate accumulations; thirdly, that residual oils formed in this fashion bear internal evidence of fractionation. In addition to the conspicuous loss of light ends, there is an increase in the content of light aromatic and naphthenic hydrocarbons relative to paraffins in the residual oil. Evaporative fractionation effects are recognized for the first time in the distillation and physical property data of US Bureau of Mines Routine Method Oil Analyses. Experimental evidence shows that partial vaporization results in enhanced levels of light aromatic hydrocarbons in residual oils. Additional aspects of the subject are discussed. (Edited author abstract). 17 Refs.

Thompson, K.F.M. (Texas A&M Univ, College Station, TX, USA). *Mar Pet Geol* v 5 n 3 Aug 1988 p 237-246.

**077438 SIMPLE ANALYSIS OF OIL-INDUCED FRACTURING IN SEDIMENTARY ROCKS.** Geometric form of kerosen patches control oil-induced fracturing in impermeable source rocks. Thin elongate kerosen flakes cause lateral fracturing. Kerosen has to occur in spherical or cylindrical forms to induce vertical fractures. If length to width ratio of kerosen flakes is sufficiently large, then lateral fractures are definitely initiated during oil generation in impermeable source rock. Oil and rock compressibilities and lateral to vertical stress ratio are decisive factors in vertical fracturing in impermeable rocks. When the source rock is permeable, then the rate of oil seepage from kerosen into the surrounding rock is crucial in fracture initiation. Oil-induced fractures cannot form unless permeability, and hence rate of oil seepage from kerosen into the surrounding rock, is non-existent or negligible. Most source rocks have some permeability. Therefore, oil-induced fracture initiation should be a rare phenomenon. (Edited author abstract). 12 Refs.

Ozkaya, Ismail (Kuwait Univ, Kuwait). *Mar Pet Geol* v 5 n 3 Aug 1988 p 293-297.

**077439 ORIGIN OF PETROLEUM.** The theory of the direct origin of petroleum from living organisms and of proto petroleum origin in the theory of organic origin has declined recently because it is difficult to explain their primary migrations. As a result, the theory of kerosen origin has been put forward. Kerosen is insoluble organic matter, and contains over 90 percent of sedimentary organic matter. Moreover, kerosen generates hydrocarbons by thermal distillation. Petroleum source rocks and reservoir rocks are bound to muddy rocks having abundant organic matter, and to sandstones or carbonates having high porosity and permeability, respectively. Commercial oils were generated by thermal transformation of the kerosen in source rocks, and then migrated and accumulated in reservoir rocks. The mechanism of the primary migration of oils from kerosen is explained by the oil phase or gas phase transport. Recently, immature oils have been found in many fields. In this paper, the possibility of the origin of immature oils is discussed, but a detailed study of this problem should be made in the future. (Edited author abstract). 29 Refs. In Japanese.

Sato, Shunji (Japan Natl Oil Corp, Jpn). *Neuryo Kyokai Shi* v 67 n 6 Jun 1988 p 364-373.

**077440 OCCURRENCE OF PETROLEUM.** The world's oil is found in marine sediments of sedimentary basins. Oil accumulations are usually found in the areas of the most intimate association of source and reservoir facies. Petroleum is found in rocks from most geologic ages and all over the world, but it is most abundant in sediments younger than the Jurassic and in the Middle East and Gulf of Mexico areas. Since an increase in continental shelves and restricted basins occurred when the continents split during the Jurassic, older oil fields became increasingly destroyed and the rate of sediment formation has changed over geologic time. As a result, giant oil fields are distributed in the Middle East and Gulf of Mexico where they were located in shallow sea areas during the Jurassic-Cretaceous. (Edited author abstract). 8 Refs. In Japanese.

Sato, Shunji (Japan Natl Oil Corp, Jpn). *Neuryo Kyokai Shi* v 67 n 6 Jun 1988 p 382-387.

**077441 STABILIREA ECHILIBRULUI STRAT-SONDA PRIN LAMINARIZAREA CURGERII. [Determination of the Seam-Well Balance by Laminar Flow].** An original method for the determination of the seam-well balance for the geologic formations with low pressures is presented. The basic premise is that the balance state is determined during the various operations in the well, not in a static state. (Edited author abstract). In Romanian.

Iordache, G. (Inst de Petrol si Gaze Ploiesti, Rom). *Mine Pet Gaze* v 39 n 5 May 1988 p 252-257.

**077442 RESERVOIR HETEROGENEITIES IN FLUVIAL SANDSTONES: LESSON FROM OUTCROP STUDIES.** Outcrop studies provide information on typical geometries and size ranges for input into reservoir model studies. Macroforms are complex, compound bars (e.g., point bars) bounded by fourth-order surfaces. Accretionary phases may be separated by internal, low-angle third-order surfaces. Fifth-order surfaces define major channel bodies, ranging from ribbon to sheetlike in geometry. Sheet sandstones may be mappable using closely spaced well data, but ribbon sandstones are difficult to correlate except in the most well-developed field. Three-dimensional seismic is a powerful new tool for mapping fifth-order surfaces. The largest scale represents units at the member or submember level, bounded by sixth-order surfaces. These units are mappable using conventional wireline log correlation. The area of a shale bed depends on the scale of the lithosome with which it is associated. (Edited author abstract). 69 Refs.

Miall, Andrew D. (Univ of Toronto, Toronto, Ont, Can). *AAPG Bull* v 72 n 6 Jun 1988 p 682-697.

**077443 CHLORINE ISOTOPE DISTRIBUTION IN FORMATION WATERS, TEXAS AND LOUISIANA.** Theoretically, the chlorine isotope ratio,  $^{37}\text{Cl}/^{35}\text{Cl}$ , can aid in identifying chloride sources and in distinguishing chloride-transport mechanisms among formation waters if ratio differences exist among samples. We measured the chlorine ratios of 18 formation-water samples from oil fields along the Texas-Louisiana Gulf Coast representing depths between 2,016 and 4,267 m. Chloride concentrations of samples ranged from 4 to 94.874 g/L, the chlorine ratios ranged from -1.24 to 0.58 percent (with respect to standard mean ocean chloride or SMOC, precision 0.12 percent). We conclude that significant chlorine isotope ratio differences exist among formation waters and between the waters and potential sources in the Gulf Coast region, and that the chlorine ratio will be a valuable tool in interpreting chloride geochemistry in this region. (Edited author abstract). 22 Refs.

Kaufmann, Ronald S. (Northern Illinois Univ, Dekalb, IL, USA); Long, Austin; Campbell, Darcy J. *AAPG Bull* v 72 n 7 Jul 1988 p 839-844.

**077444 DETERMINATION OF SUBSURFACE DISTANCE BETWEEN VERTICAL PARALLEL NATURAL FRACTURES BASED ON CORE DATA.**

A simplified method is presented to estimate subsurface distance between vertical parallel fractures based on core analysis and the binomial theorem. The geologic model used in this paper is identical to the one presented by Narr and Lerche in 1984. Required input data includes core diameter (D), thickness of each bed intercepted by the core (T), angle between core axis and fractures ( $\beta$ ), and angle between core axis and bedding ( $\theta$ ). The method is corroborated with the use of outcrop data previously published by Narr and Lerche in 1984. The approach is illustrated with a step-by-step example, which easily can be reproduced with a hand-held calculator by the practicing geologist. (Author abstract). 5 Refs.

Aguilera, Roberto (Servipetrol Ltd, Calgary, Alberta, Can). *AAPG Bull* v 72 n 7 Jul 1988 p 845-851.

**077445 TO TACKLE THE DECONVOLUTION PROBLEM - A POWERFUL METHOD BASED ON MORE GEOLOGICAL HYPOTHESES.** The approach described in this paper abandons the usual hypothesis (white reflectivity spectra) made by deconvolution methods and employs as alternative information the lateral redundancies which are always present on a seismic section. Our method first estimates the location of high amplitude reflectors with good lateral continuity, by means of an elegant automatic picking program. Based on these locations, a generalized inversion can be used to yield the wavelet emitted by the source, and the amplitude of the main reflection coefficients simultaneously for each trace. All the reflection coefficients are then estimated using the amplitudes and the wavelets computed previously. The various stages of this method which is called Deconvolution-Inversion are illustrated in the paper by means of both synthetic and real examples. (Edited author abstract)

Denelle, E. (Total Compagnie Francaise des Petroles, Paris-La Defense, Fr). *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 192-201.

**077446 DEPOSITIONAL MODEL FOR THE DUPUY MEMBER AND THE BARROW GROUP IN THE BARROW SUB-BASIN, NORTHWESTERN AUSTRALIA.** A detailed sedimentological study of the Dupuy Member and the Barrow Group has resulted in a regional model for the deposition of these Upper Jurassic to Lower Cretaceous reservoir sequences in the Barrow Sub-basin. The Dupuy Member is interpreted as a prograding offshore slope sequence of turbidite sandstones and debris flows, which built laterally into the Barrow Sub-basin from along its eastern margin. Structural growth of the Barrow Island anticline took place during deltaic deposition and caused anomalous relationships between foresets and bottomsets under the north of Barrow Island. Known hydrocarbon accumulations and common shows in the Dupuy Member and the Barrow Group make these sequences attractive exploration targets. (Edited author abstract) 12 refs.

Tait, A.M. (West Australian Petroleum Pty Ltd, Perth, Aust). *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 282-290.

Alabama

**077447 ENVIRONMENTS OF DEPOSITION AND PETROLEUM GEOLOGY OF TUSCALOOSA GROUP (UPPER CRETACEOUS), SOUTH CARLTON AND POLLARD FIELDS, SOUTHWESTERN ALABAMA.** In southwestern Alabama, the lower Tuscaloosa Group (Upper Cretaceous) consists of two informally defined units, the Massive and Pilot sand intervals. The Massive sand interval accumulated principally as sands in a wave-dominated, high-destructive delta system. The Pilot sand interval, which overlies the Massive sand interval, accumulated as shelf sands and clays during a marine transgression. The Pilot sand interval is overlain by a marine claystone (Marine shale) containing a diverse faunal assemblage of macroinvertebrates, including ammonites, inoceramids and other bivalves, and a rich microfossil assemblage of planktonic foraminifera and calcareous microfossils. Petroleum traps in the Tuscaloosa are structural traps involving salt anticlines (South



Carlton field) and extensional fault traps associated with salt movement (Pollard field). Although Tuscaloosa marine claystones contain significant amounts of organic carbon, these rocks are thermally too immature to be the petroleum source rocks for the Tuscaloosa crude oils in South Carlton and Pollard fields. (Edited author abstract) 40 refs.

Mancini, Ernest A. (Univ of Alabama, Tuscaloosa, AL, USA); Mink, Robert M.; Payton, J. Wayne; Bearden, Bennett L. *AAPG Bull* v 71 n 10 Oct 1987 p 1128-1142.

## Alaska

**077448 EVOLUTION AND PETROLEUM GEOLOGY OF AMLIA AND AMUKTA INTRA-ARC SUMMIT BASINS, ALEUTIAN RIDGE.** Amlia and Amukta Basins are the largest of many intra-arc basins formed in late Cenozoic time along the crest of the Aleutian Arc. Both basins are grabens filled with 2-5 km of arc-derived sediment. Two groups of normal faults occur: major boundary faults common to both basins and 'intra-basin' faults that arise primarily from arc-parallel extension of the arc. Although, the hydrocarbon potential of Amlia and Amukta Basins is difficult to assess based on existing data, regional considerations imply that an adequate thermal history conducive to hydrocarbon generation has prevailed during the past 6-5 my. Additional aspects of the subject are discussed. 42 refs.

Geist, Eric L. (US Geological Survey, Menlo Park, CA, USA); Childs, Jonathan R.; Scholl, David W. *Mar Pet Geol* v 4 n 4 Nov 1987 p 332-352.

## Alberta

**077449 GEOLOGICAL AND SEISMIC EVALUATION OF A LOWER MANNVILLE VALLEY SYSTEM; ALDERSON PROSPECT, ROLLING HILLS, SOUTHEASTERN ALBERTA.** A Lower Mannville valley complex cut into Jurassic and Mississippian strata in southeastern Alberta was identified on a conventional seismic section. Sediments adjacent to the valley are interpreted as contemporaneous levee and splay deposits of a channel that occupied the valley, whereas the muddy sandstones within the channel represent either a fine grained point bar, or an abandoned channel-fill deposit. In the latter case, coarse grained, sandy, point bar deposits can be expected to occur elsewhere in the channel system. Oil is trapped in crevasse splay deposits draped over a local Mississippian high, but not in the valley because of poor reservoir quality of the channel sandstones. It is proposed here that reflection above Lower Manhattan valleys can provide a means of determining the type of valley fill. (Edited author abstract) Refs.

Hopkins, John C. (Univ of Calgary, Calgary, Alberta, Can); Lawton, Don C.; Gunn, Jack D. *Bull Can Pet Geol* v 35 n 3 Sep 1987 p 296-315.

**077450 COMPUTERIZED DATABASE APPLICATIONS TO THE LOWER CRETACEOUS MANNVILLE GROUP OF THE LLOYDMINSTER AREA, CANADA: PRINCIPLES, CONCEPTS AND APPROACHES.** A computerized system for the acquisition, storage and retrieval of subsurface data applicable to clastic sequences of the Lloydminster area of western Canada is described. The system incorporates stratigraphic, lithologic and fluid data obtained from well logs. The data base is comprehensive enough to permit that examination of lithologic sequences with respect to both external geometry and internal heterogeneities. Data are gathered over large stratigraphic intervals, but at a detail near the vertical lithologic resolution of the well logs employed. Information for stratigraphic markers contains a factor related to their ease of correlation, and all correlatable markers are assumed to represent chronostratigraphic surfaces. A complete suite of lithologic types is systematically obtained from spontaneous potential well log traces. Additional aspects of the subject are discussed. (Edited author abstract) 4 refs.

Putnam, Peter E. (Petrel Consultants Ltd, Calgary, Alberta, Can); Klován, J. Edward. *Bull Can Pet Geol* v

35 n 4 Dec 1987 p 430-442.

## Alberta, Canada

**077451 CHEMICAL AND ISOTOPIC EVIDENCE OF THERMOCHEMICAL SULPHATE REDUCTION BY LIGHT HYDROCARBON GASES IN DEEP CARBONATE RESERVOIRS.** Large H<sub>2</sub>S accumulations in deep carbonate reservoirs have been attributed to thermochemical sulphate reduction. Although organic matter has been invoked as the reducing agent, individual reactants in specific environments have hitherto not been identified. Carbon isotope data reveal that light hydrocarbon gases have been effective reducing agents in some Palaeozoic foothill reservoirs of western Canada. 34 refs.

Krouse, H. Roy (Univ of Calgary, Calgary, Alberta, Can); Viau, Christian A.; Eliuk, Leslie S.; Ueda, Akira; Halas, Stan. *Nature* v 333 n 6172 Jun 2 1988 p 415-419.

## Analysis

**077452 PREDICTIVE ISOPACH MAPPING OF GAS SANDS FROM SEISMIC IMPEDANCE: MODELED AND EMPIRICAL CASES FROM SHIP SHOAL BLOCK 134 FIELD.** Gulf of Mexico Miocene through Holocene stratigraphy exhibits general physical properties conducive to detailed geophysical investigation. Reflected seismic energy displayed as acoustic impedance sections are used to produce pseudo 'net pay' isopach maps, which are used to predict gas sand thickness, gas distribution, and gas reserves. The techniques and concepts used in this form of geologic analysis are demonstrated in the rediscovery and development of the Ship Shoal Block 134 gas field of offshore Louisiana. Using the properties of amplitude, acoustic impedance, and reflected energy to produce net pay isopach maps has led to 95% successful prediction of gas reserves within this study area and other areas. Additional study results are discussed. (Edited author abstract) 12 refs.

Woock, Robert D. (Odeco Oil & Gas Co, New Orleans, LA, USA); Kin, Alan R. *AAPG Bull* v 71 n 10 Oct 1987 p 1143-1151.

## Antarctica

**077453 PRELIMINARY ASSESSMENT OF THE HYDROCARBON POTENTIAL OF THE LARSEN BASIN, ANTARCTICA.** Upper Jurassic anoxic marine strata, deposited prior to the main phase of arc development, form a rich potential source (T.O.C. up to 3.5%) with both marine and terrestrial kerogens. Arc-derived volcanoclastic sediments of Barremian-Oligocene age form a regressive megasequence. Basal strata represent slope apron and rudaceous submarine fan deposits proximal to the margin; fan conglomerates form lenticular bodies hundreds of meters thick and tens of kilometers across, enveloped in slope-apron mudstones. Late Cretaceous fault reactivation and uplift led to dramatic shallowing of the basin, with deposition of shelf facies. In the Larsen Basin, there is moderate potential for oil generated from Upper Jurassic source rocks and reservoired in Cretaceous and Tertiary sandstones and conglomerates in large stratigraphic or structural traps caused by partial basin inversion during deposition. (Edited author abstract) 82 refs.

Macdonald, D.I.M. (British Antarctic Survey, Cambridge, Engl); Barker, P.F.; Garrett, S.W.; Ineson, J.R.; Pirrie, D.; Storey, B.C.; Whitham, A.G.; Kinghorn, R.R.F.; Marshall, J.E.A. *Mar Pet Geol* v 5 n 1 Feb 1988 p 34-53.

## Arkansas

**077454 THRUST CONTROL ON THERMAL MATURITY OF THE FRONTAL OUACHITA MOUNTAINS, CENTRAL ARKANSAS, USA.** Three types of anomalies in thermal maturity exist within the frontal thrust belt of the Ouachita Mountains, Arkansas, USA. The anomalies were documented by combining structural mapping with measurements of vitrinite reflectance; all

samples were obtained from surface exposures. Maturity-inversion occurs along the Y-City Fault, where Jackfork and Johns Valley strata (Lower Pennsylvanian) have been thrust over less-mature sequences of the lower Atoka Formation (Middle Pennsylvanian). An apparent shear-heating aureole is also associated with this important thrust, although the spatial extent of the aureole is limited. When allowances are made for both structural and stratigraphic position, it is found that internal gradients in vitrinite reflectance within individual thrust sheets are abnormally low. These gradients are attributed to tectonic burial. Weak remnants of the primary stratigraphic gradients are retained in most instances, so organic metamorphic reactions evidently failed to equilibrate during thrust loading; rapid unroofing of the thrust belt may have begun even as some faults remained active. Similar patterns of maturation should be expected within other thrust belts where peak burial and heating events were synchronous with deformation. (Edited author abstract) 50 Refs.

Underwood, M.B. (Univ of Missouri, Columbia, MO, USA); Fulton, D.A.; McDonald, K.W. *J Pet Geol* v 11 n 3 Jul 1988 p 325-339.

**Australia** See Also OIL FIELDS—Australia; OIL FIELDS—Reservoir Evaluation; OIL WELL PRODUCTION—Enhanced Recovery; PETROLEUM PROSPECTING—Seismic Survey; SANDSTONE—Analysis.

**077455 HYDROCARBON POTENTIAL OF THE UPPER JURASSIC/LOWER CRETACEOUS OF THE AUSTRALIAN NW SHELF.** Source-rock richness, timing of hydrocarbon generation, and thicknesses of potential source shales of the Upper Jurassic/Lower Cretaceous section of the Australian NW Shelf have been examined in order to make predictions as to the hydrocarbon potential of the several basins in that region. The result is a rating of four areas potentially productive of liquid hydrocarbons: the Browse Basin, the Malita Graben/NW Bonaparte Gulf Basin, the Rowley Sub-basin, and the Vulcan Sub-basin/Sahul Syncline, respectively. Recent liquid hydrocarbon discoveries in the Vulcan Sub-basin, probably sourced by the Upper Jurassic shales, upgrade all four of these areas, and lead to the conclusion that, overall, drilling results on the NW Shelf have to date not been indicative of its true potential. Therefore, it is recommended that future hydrocarbon 'plays' incorporate the timing of generation as delineated in this study with the timing of structural development in order to improve chances of success, rather than relying on the size of structures alone. (Edited author abstract)

Baird, R.A. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Philp, R.P. *J Pet Geol* v 11 n 2 Apr 1988 p 125-140.

**077456 DEPOSITIONAL ENVIRONMENTS AND HYDROCARBON POTENTIAL OF THE EVERGREEN FORMATION, ATP 145P, SURAT BASIN, QUEENSLAND.** Hydrocarbon discoveries in the Jurassic Evergreen Formation along the western shelf of the Surat Basin lie in a northwest-trending structurally controlled belt adjacent to Bridge-operated ATP 145P. Shows and commercial accumulations are generally associated with specific sand/shale ratios, which influence source, reservoir, and seal effectiveness. Proximity to basement and early faults are other favourable factors. Four distinct log facies were calibrated against cuttings and core and interpreted genetically. On the basis of a petrographic study the highest source potential for the Evergreen Formation in ATP 145P is around Spring Grove 1 well. A band of high source potential lies parallel to the deltaic shoreline, in a generally north-south direction. (Edited author abstract) 23 refs.

Golin, V. (Bridge Oil Ltd, Sydney, Aust); Smyth, M. *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 156-158, 160-171.



**077457 COMPARISON OF SELECTED NON-MARINE PETROLEUM-BEARING BASINS IN AUSTRALIA AND CHINA.** This paper summarises the geology and hydrocarbon potential of two Chinese and two Australian basins (Ordos, Northern Jiangsu, Eromanga, and Surat basins) in order to compare factors affecting the generation, migration, and entrapment of hydrocarbons. In all four basins, hydrocarbons are generated from nonmarine source rocks of lacustrine and fluvial-overbank origin. While the Chinese and Australian basins contain a similar range of sedimentary facies, from alluvial fan to lacustrine, the arrangement and relative thicknesses of these facies vary considerably as a result of different tectonic and palaeoclimatic settings. (Edited author abstract) 52 refs.

Moore, P.S. (CSR Oil & Gas Div, Adelaide, Aust); Hobday, D.K.; Mai, H.; Sun, Z.C. *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 285-309.

**077458 SUBSURFACE GEOLOGY OF THE WESTERN OFFICER BASIN - RESULTS OF SHELL'S 1980-1984 PETROLEUM EXPLORATION CAMPAIGN.** The Officer Basin described in this paper includes four Proterozoic to Lower Palaeozoic sub-basins (Gibson, Yowalga, Lennis, Waigen) which extend in a northwest to southeast belt across 200,000 sq. km of central Western Australia. These sub-basins are bounded by Archaean to Proterozoic basement blocks and are almost entirely concealed by a veneer of Permian and Cretaceous sediments. Depth to magnetic basement locally exceeds eight kilometres. The results of 4700 km of seismic data and three deep wildcat wells, combined with gravity, aeromagnetic, Landsat, outcrop and corehole information, has led to a better understanding of the regional subsurface geology. (Edited author abstract) 21 refs.

Townson, W.G. (Shell Development (Australia) Pty Ltd, Melbourne, Aust). *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 34-51.

**077459 HYDROCARBON GENERATION, MIGRATION AND ENTRAPMENT IN THE JACKSON-NACCOWLAH AREA, ATP 259P, SOUTH-WESTERN QUEENSLAND.** The northern part of the Naccowlah Block, situated in the southeastern part of the Authority to Prospect 259P in southwestern Queensland, is a major Eromanga Basin hydrocarbon province. The Hutton Sandstone is the main reservoir but hydrocarbons have been encountered at several levels within the Jurassic-Cretaceous sequence. In contrast, the underlying Cooper Basin sequence is generally unproductive in the Naccowlah Block although gas was discovered in the Permian at Naccowlah South 1. Oil and gas discoveries within the Eromanga Basin sequence are confined to the Naccowlah-Jackson Trend. (Edited author abstract) Refs.

Vincent, P.W. (Vamgas Ltd, Melbourne, Aust); Mortimore, I.R.; McKirdy, D.M. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 62-84.

**077460 TECTONICS OF THE JACKSON-NACCOWLAH AREA, COOPER-EROMANGA BASINS, SOUTHWEST QUEENSLAND, AND THEIR IMPLICATIONS FOR HYDROCARBON ACCUMULATION.** The Naccowlah-Jackson Trend in the Cooper-Eromanga Basins, southwest Queensland, has been the scene of a high hydrocarbon exploration drilling success ratio during the 1980s. The structural trend is mainly the result of sinistral convergent wrenching, which has given rise to a series of major reverse faults and two distinct series of relatively minor parallel and orthogonal basement faults. Structural growth due to wrenching has been responsible for a favourable integration of the components necessary for hydrocarbon generation and accumulation, but also appears to be responsible for crestal faulting which in several cases is interpreted to have led to the escape of hydrocarbons. Two basic oil types (Hutton type and Murta type) are known. (Edited author abstract) 13 refs.

Nelson, A.W. (CSR, Adelaide, Aust). *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 85-94.

**077461 REVIEW OF THE HYDROCARBON HABITAT OF THE EASTERN AND CENTRAL BARROW - DAMPIER SUB-BASIN, WESTERN AUSTRALIA.** This paper describes a number of aspects of the petroleum geology and geophysics of the northern Carnarvon Basin resulting from exploration undertaken by second round joint ventures since 1981, mainly in the area surrounding Barrow Island. New techniques applied by the industry over the last few years have enabled a more detailed analysis of exploration areas and basin models. Greatly improved seismic quality (Ramsden, 1984), plus more tightly spaced seismic grids has enabled definition of depositional patterns and facies distributions (Kirk, 1985), while the introduction of new, detailed geochemical techniques has led to a better understanding of likely oil source beds and timing of hydrocarbon expulsion. These factors, in combination with a near doubling of exploration drilling density over the past few years and an increase in the discovery success rates, has led to a more complete understanding of the Carnarvon Basin and its hydrocarbon habitat. 20 refs.

Kopsen, E. (Minora Resources NL); McGann, G. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 154-176.

**077462 RIFT AND DRIFT IN THE DAMPIER SUB-BASIN, A SEISMIC AND STRUCTURAL INTERPRETATION.** Quality improvements in marine reflection seismic data over recent years have led to a better understanding of the relationships between seismic-stratigraphical sequences present in the Dampier Sub-basin and those in adjacent areas. The 'drift-onset' unconformity, which separates the syntectonic rift sequence from the post-tectonic drift sequence, can now be seismically recognised as a single unfaulted surface. The presence of Callovian and Upper Jurassic marine sands on the Rankin Platform shows that the Rankin Platform was in places submerged during Callovian and Upper Jurassic times. (Edited author abstract) 16 refs.

Veenstra, E. (Woodside Offshore Petroleum Pty Ltd, Perth, Aust). *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 177-189.

**077463 PETROLEUM GEOLOGY OF THE MERLINLEIGH SUB-BASIN, WESTERN AUSTRALIA.** Esso's recent drilling program in the Merlinleigh Sub-basin, onshore Carnarvon Basin, represents the culmination of the first phase of concerted exploration activity in the area since the WAPET era of the 1960s. The region is unusual among Australian petroleum provinces in having excellent exposures of reservoir, source and seal rocks of Palaeozoic age. While both Esso wells (Burna 1 and Gascoyne 1) failed to encounter hydrocarbons in the primary Wooramel Group play, encouraging potential still exists. The reservoir in the Wooramel Group play is the Early Permian Moogooloo Sandstone, a fluvio-deltaic to nearshore sheet-sand facies with porosities to 23 per cent and permeabilities in excess of 100 millidarcys. Likely hydrocarbon sources are siltstones in the overlying Byro Group. (Edited author abstract) 14 refs.

Percival, I.G. (Esso Australia Ltd, Sydney, Aust); Cooney, P.M. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 190-203.

**077464 SOURCE POTENTIAL OF UPPER TRIASSIC FLUVIO-DELTAIC SYSTEMS OF THE EXMOUTH PLATEAU.** The fluvio-deltaic rocks of the Upper Triassic Mungaroo Formation of the Exmouth Plateau contain abundant organic material in the form of both coal seams and dispersed fragments. Several thousand metres of these sediments lie within the oil generation window but they have commonly not been considered as source rocks for oil because the organic matter is of terrestrial origin. Increasing acceptance of plant material as a source for oil warrants an assessment of the oil generating potential of the Mungaroo Formation. A quantitative assessment of the oil-generating potential of

the organic matter based on maceral composition, vitrinite reflectance and volume of coal and dispersed organic matter was made for a range of time-rock units. On this basis, the Carnian-Ladinian and Carnian sequences have the best source potentials. (Edited author abstract) 22 refs.

Cook, A.C. (Univ of Wollongong, Wollongong, Aust); Smyth, Michelle; Vos, R.G. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 204-215.

**077465 GEOLOGY AND EVOLUTION OF THE SOUTH PEPPER HYDROCARBON ACCUMULATION.** The South Pepper field, discovered in 1982, is located 30 km southwest of Barrow Island in the offshore portion of the Barrow Sub-basin, Western Australia. The oil and gas accumulation occurs in the uppermost sands of the Lower Cretaceous Barrow Group and the overlying low permeability Mardie Greensand Member of the Muderong Shale. The hydrocarbons are trapped in one of several fault closed anticlines which lie on a high trend that includes the North Herald, Pepper and Barrow Island structures. The proposed structural and hydrocarbon migration history fits regional as well as local geological observations for the Barrow Sub-basin. (Edited author abstract) 18 refs.

Williams, A.F. (Western Mining Corp Ltd, Perth, Aust); Poynton, D.J. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 235-247.

**077466 EXTENSIONAL BASIN - FORMING STRUCTURES IN BASS STRAIT AND THEIR IMPORTANCE FOR HYDROCARBON EXPLORATION.** The Bass, Gippsland and Otway Basins of south-eastern Australia were initiated by north-northeast to south-southwest lithospheric extension, largely during the Early Cretaceous. The extensional stage was followed by a Late Cretaceous to Pliocene thermal subsidence stage and a late stage of compressional tectonic overprinting. The major extensional structures have had an important influence on all stages of the evolution of these basins. It is contended that a thorough understanding of their extensional framework is an important factor in hydrocarbon exploration of these and other basins. (Edited author abstract) Refs.

Etheridge, M.A. (Bur of Mineral Resources, Canberra, Aust); Branson, J.C.; Stuart-Smith, P.G. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 344-361.

## Austria

**077467 ORGANIC GEOCHEMISTRY OF VIENNA BASIN: MODEL FOR HYDROCARBON GENERATION IN OVERTHRUST BELTS.** The Vienna basin is a Tertiary pull-apart basin in the Alpine-Carpathian overthrust belt. Thickness of the sedimentary sequence, including Neogene basin fill, Mesozoic overthrust complex, and Mesozoic autochthonous strata, can exceed 10,000 m (33,000 ft). Source rocks for oil and gas are in the autochthonous Jurassic sequence beneath the overthrust. We can assume that much of the source potential of these rocks was preserved during thrusting and most of the hydrocarbon generation took place after thrusting during Neogene burial. The vertical stacking of hydrocarbon pools indicates predominantly vertical migration through major faults. Results of geochemical studies have influenced exploration strategy in the Vienna basin as well as in the northern Alps and the foreland basin. The Vienna basin could thus be considered a model for hydrocarbon generation in other overthrust belts. (Author abstract). 18 Refs.

Ladwein, H.W. (OMV-AG Lab for Exploration & Production, Vienna, Austria). *AAPG Bull* v 72 n 5 May 1988 p 586-599.

## Azerbaijan See Also PETROLEUM PROSPECTING.

**077468 OIL AND GAS GEOLOGICAL ZONING AND REASONABLE COMPLEX OF EXPLORATION AND PROSPECTING IN AZERBAIDZHAN.**



Altogether eight oil and gas bearing regions have been established. They are characterized by different degrees of geological exploration and extraction of the initial oil and gas resources. They are the following ones: Apsheron, Shemakha-Kobystan, Lower Kura, Baku Archipelago, Kirovabad, Evlakh-Agdzhabedy, Kura-Iori interfluvium, and Precaspian-Kuba regions. The most promising area is the Apsheron periclinal trough. Promising areas of the first category are: Baku Archipelago, Lower Kura depression, Evlakh-Agdzhabedy trough, and the Kura-Iori interfluvium. Details on the various promising areas are given. In Russian. 4 refs.

Mekhtiev, Sh.F.; Salaev, S.G.; Dadashev, F.G.; Buniat-Zade, Z.A.; Bagir-Zade, F.M.; Yusufzade, Kh.B.; Aliev, A.I.; Guseinov, A.N. *Geol Nefti Gaza* n 3 Mar 1987 p 6-12.

## Bashkiria, USSR

**077469 LOWER PERMIAN CARBONATES - PROMISING OIL EXPLORATION TARGET IN BASHKIRIA.** The main productive levels in the platform part of Bashkiria are the terrigenous-carbonate deposits of the middle and lower part of the Paleozoic sedimentary cover which have been fairly well explored by a great number of deep wells. However, the oil and gas potential of the Lower Permian carbonate strata up to 1000 m thick has not been adequately studied. A purposeful investigation of the petroleum potential of these strata has shown the presence of hydrocarbon deposits at shallow depths. Some recommendations are more intensive explorations in certain specific areas are given. In Russian. 2 refs.

Afanas'ev, V.S.; Masagutov, R.Kh.; Nadezhkin, A.D. *Geol Nefti Gaza* n 6 Jun 1987 p 1-6.

## Canada See OIL SHALE—Canada.

## Caspian Sea

**077470 MECHANISM OF FORMATION OF SOUTH CASPIAN MEGADEPRESSION AND THE MAIN REGULARITIES OF ITS TECTONIC DEVELOPMENT.** Based on an integrated analysis and generalization of the geological and geophysical data on the South Caspian megadepression (SCMD), the mechanism and time of its formation have been clarified. It is shown that the geodynamic situation existing in the SCMD as well as the geophysical fields that characterize it are very similar to those existing in a number of deep water basins of the Alpine-Himalayan folded belt, the formation of which took place as a result of the mantle diapirism which resulted in the tension and destruction of the earth's crust. An attempt is made to single out three stages of rift genesis in the history of the SCMD. The dependence of the geological events taking place in the Cenozoic period within the SCMD on the movements of the lithospheric plates also resulted in the reformation of its structural plan formed earlier. (Translated author abstract) In Russian. 17 refs.

Akhmedov, A.G. *Izv Vyssh Uchebn Zaved Neft Gaz* n 3 Mar 1987 p 9-16.

## Chile

**077471 GEOLOGY, GEOMORPHOLOGY, AND PETROLEUM POSSIBILITIES OF THE EL GODO AREA, IQUIQUE, CHILE.** The presence of solid bitumen in the El Godo area of Tarapaca province, northern Chile, has been known for centuries but, from a petroleum viewpoint, the region has been little studied. A major deterrent to exploration has been the presence of volcanic accumulations in the objective section, a marine Jurassic sequence more than 3,000 m thick, which has been intruded by some younger silicic plutons. Objectives older than the Jurassic are unknown but may be present, especially in the deep part of the Jurassic basins and in the offshore. Two basins are present with a total prospective area of about 20,000 sq. kms. They contain shale and carbonate source rocks, shale and evaporite seals, and probable reservoir rocks (carbonates, terrigenous clastics, breccias). Anticlines, formed during the Nevadan orog-

eny, are present. The widespread presence of bitumen in outcrops indicates that oil has been generated. The western basin has thick syndepositional volcanics, and is the less attractive of the two basins. The eastern basin is nearly free of volcanic rocks and is a prime prospect. (Edited author abstract).

Cecioni, G. (Univ de Chile, Santiago, Chile); Meyerhoff, A.A.; Teitz, H.H. *J Pet Geol* v 11 n 3 Jul 1988 p 245-276.

## Crimea, Ukraine See PETROLEUM PROSPECTING.

## Dating See Also OIL FIELDS—North Sea.

**077472 DETERMINATION OF PALEO HEAT-FLUX FROM FISSION SCAR TRACKS IN APATITE.** Three methods are presented for determining paleo heat flux from fission scar tracks in detrital apatite collected from wells. The three methods invert the present-day fission-track well data along the burial paths of the sedimentary units. The first two methods involve inverting the depth-dependent (a) areal track-number density per gm of uranium and (b) mean track length to obtain an estimate of the temporal dependence of the paleo heat flux. Since these methods tend to overlook short tracks (method (a)), and be biased towards longer tracks (method (b)), they tend to provide paleo heat-flux variations which are too high and too low, respectively. The uncertainty in the determination of paleo heat-flux variation is also quite high, as is shown by using data from two wells: Kambara-1 and Curunga-1 in the NW Canning Basin, Australia. The third method inverts all of the individual distributions of track lengths at each sampled depth in a well. The sensitivity of this method is much higher than methods (a) or (b). In fact, with this method it is possible to determine not only the rate of change of heat flux with time but, for the first time, variations in the direction of change of heat flux, thus making it possible to quantify heating and cooling events, as opposed to just detecting heating or cooling events. (Edited author abstract) Refs.

Huntsberger, T.L. (Univ of South Carolina, Columbia, SC, USA); Lerche, I. *J Pet Geol* v 10 n 4 Oct 1987 p 365-394.

## East Siberia, USSR

**077473 UPPER LENA VAULT UPLIFT - A NEW PROMISING OBJECT OF GAS POOL EXPLORATION IN ANGARA-LENA OIL AND GAS REGION.** Several parametric and exploratory drillings in the central part of the Angara-Lena oil and gas region and its south-eastern flank (Upper Lena region) have yielded geological data testifying to considerable potentialities of these formations. Gas condensate deposits are likely to be found within the Upper Lena vault which is the main positive structural element of the Angara-Lena bench. The zone of its conjugation with the Pre-Baykal trough is also evaluated positively. In Russian. 4 refs.

Shutov, G.Ya. *Geol Nefti Gaza* n 1 Jan 1987 p 5-8.

## Florida

**077474 SUCCESS AND SENSIBILITY IN SOUTH FLORIDA.** To date, the central and southern portions of the Florida peninsula have supported the discovery and development of a single hydrocarbon trend - that in the Sunniland formation of Early Cretaceous age, which currently produces along a northwest-southeast zone near the updip margins of the South Florida basin. The South Florida basin covers some 50,000 square miles, encompassing the entire southern portion of the peninsula and its shallow westward extension to the Florida Escarpment. Total sedimentary thicknesses within the basin are greater than 15,000 ft and may be as high as 25,000-30,000 ft. A total of 14 fields has been discovered to date in the Sunniland Trend. Estimated oil in place is 260 million bbls, of which approximately 100-120 million bbls are presumed recoverable. A historical and policy overview of the drilling activity in South Florida is followed by a summary of the geologic history of South Florida, structural geology, productive and prospective forma-

tions, and the source rock potential evaluation of the South Florida basin. 99 refs.

Montgomery, S.L. (Petroleum Frontiers). *Pet Front* v 4 n 3 1987 52p.

## Gulf of Mexico

**077475 EXPLORING THE EASTERN GULF: THE CASE FOR EXPANSION.** A survey of the present-day geologic setting of the Eastern Gulf of Mexico is followed by an overview of the drilling in southwestern Alabama and northwestern Florida. Further chapters present a geotectonic history of the eastern Gulf, structural overview of the eastern Gulf, reservoir intervals of the northeastern Gulf, productivity trends and possibilities in the northeastern Gulf, and the costs and regulations connected with the exploration. 207 refs.

Anon. *Pet Front* v 4 n 2 1987 101p.

**077476 GEOLOGY OF A CONTINENTAL SLOPE OIL SEEP, NORTHERN GULF OF MEXICO.** An oil and gas seep was documented by replicate sampling with piston corer, abundant high-resolution and sparse multi-channel seismic reflection profiling, and chemical and isotopic analyses. The seep occurs on the upper continental slope over a salt ridge interpreted to split and plunge eastward, northeastward, and northward. The relatively shallow diapir over which the seepage occurs is manifested at the surface by a graben in strike section and by a half-graben in dip section. Faulting over the crest is commonly associated with loss of reflected energy or acoustic wipeouts. Most cores taken in wipeouts with prolonged bottom echoes contain oil and gas. The seepage demonstrates the existence of source rocks and maturation at this site. Additional aspects of the subject are discussed. (Edited author abstract) 17 refs.

Behrens, E. William (Univ of Texas at Austin, Austin, TX, USA). *AAPG Bull* v 72 n 2 Feb 1988 p 105-114.

## Gulf of Suez

**077477 GULF OF SUEZ-NORTHERN RED SEA NEOGENE RIFT: A QUANTITATIVE BASIN ANALYSIS.** Subsidence analysis (backstripping) was carried out on a series of wells from the Gulf of Suez and northern Red Sea region of Egypt in order to examine the interplay between tectonic events, basin subsidence, sedimentation and sea level changes in a young, developing ocean basin and continental margin. Using constraints on chronostratigraphy and paleodepth from various sources combined with stratigraphic and structural information from industry wells and other geophysical sources it has been possible to compile the data necessary to perform geohistory analyses throughout the region. Major subsidence due to crustal thinning began 25 Ma with sedimentation initially occurring in isolated sub-basins. Open marine sedimentation occurred across all structural regimes. The mid-Clysmic tectonic event (16.5 Ma) resulted in structural rearrangement of the rift basin and uplift of the rift shoulders. Rapid subsidence continued as global sea level fell. The quiescence in subsidence combined with a lowered global sea level resulted in the deposition of a thick (up to 4 km) series of evaporites within the central trough of the rift from the middle to latest Miocene. Additional aspects of the subject are discussed. (Edited author abstract). 100 Refs.

Richardson, Mark (Univ of Rhode Island, Narragansett, RI, USA); Arthur, Michael A. *Mar Pet Geol* v 5 n 3 Aug 1988 p 247-270.

## High Temperature Effects

**077478 TEMPERATURES OF OIL AND GAS FORMATION IN THE SUB-SURFACE.** The authors have calibrated a kinetic scheme that describes oil and gas formation using geological samples that have been heated under both natural and laboratory conditions. These equations predict that in the subsurface the influence of time is not great, and that most oil is formed between 100 and 150°C; and most gas between 50 and 220°C. 24 refs.



Quigley, T.M. (BP Exploration Co, London, Engl); Mackenzie, A.S. *Nature* v 333 n 6173 Jun 9 1988 p 549-552.

Illinois See PETROLEUM PROSPECTING—Illinois.

## Iowa

**077479 FOREST CITY BASIN: IS THERE OIL IN THE PALEOZOIC SEDIMENTS?** Between shallow oil production to the south and a deep dry hole to the north there exists a vast area that has only been sparsely tested by drilling to any depth, shallow or deep. The distance between the oil discovery and Amoco's well is 200 miles. The oil discovery to the south and the deep well to the north have created an interest in the area. The area of interest is Southwest Iowa. This article discusses whether the deeper part of the sedimentary Forest City basin contains large accumulations of hydrocarbons, and whether the undrilled shelf area of the Forest City basin contains hydrocarbons in abundance. Data from one reflection seismograph profile suggest there is 20,000 ft of sediments, a thick section of potential oil source rocks, and a large shallow anticline as a possible oil trap. 13 refs.

Miller, George H. *Oil Gas J* v 86 n 16 Apr 18 1988 p 103-104, 106-107, 109.

## Israel

**077480 LATE CENOZOIC THERMAL GRADIENTS IN DEAD SEA TRANSFORM SYSTEM BASINS.** Coal-rank measurements and heat-flow data from three rhomb-shaped grabens along the continental portion of the Dead Sea Transform - the Hula Depression, the Sea of Galilee and the Dead Sea Graben - reveal contrasting thermal regimes. The coalification profile from the Hula Depression indicates a relatively high thermal gradient, averaging 40°C/km, throughout the Late Cenozoic. Similarly, a relatively high heat flow, approx. 1.77 HFU, was reported in the Sea of Galilee, 35 km to the south. Coalification profile, heat flow data and BHT measurements on the Dead Sea Graben (200 km to the south) reveal a considerably lower thermal regime (approx. 0.7 HFU, 20°C/km) that has prevailed since the mid-Miocene. However, the differences in the thermal regime do not represent different mechanisms of basin formation. With the corroboration of hydrological and geophysical data, it is suggested that the high thermal regime in the two northern basins reflects a regional phenomenon associated with the nearby extensive Golan-Jebel Druze young volcanic terrain. Therefore, it has no relationship to the mechanism of rhomb-shaped graben formation, and should not be cited in support of kinematic models requiring a high thermal regime. (Author abstract)

Bein, Amos (Geological Survey of Israel, Jerusalem, Isr); Feinstein, Shimon. *J Pet Geol* v 11 n 2 Apr 1988 p 185-192.

**077481 JURASSIC FACIES IN THE LEVANT.** An attempt to display the thickness-relationship of the Jurassic facies in Israel and the immediate neighborhood, based on drilling data and outcropping Jurassic sections, is illustrated in a number of columnar sections. The Jurassic column in Northern Israel seems to counteract the Helez-Ramallah Low, and overall is thinner; the column probably belongs to a High that extends into adjacent Lebanon. The regional main depocentres indicate the wearing-down of the Arabian Massif, producing clastic, littoral and paralic sediments (e.g. the Inmar-Sherif facies) in the eastern parts of the Negev and Judea; while the influence of the Tethys Sea resulted in predominantly shallow platform carbonates (i.e. the Haifa - Lebanon facies) over most of the rest of Israel (including northern Sinai, Hermon and Lebanon). Bioherms and biostromes are most notably developed in the Brur-Nir Am facies that was initiated in the Callovian, and which as abundant stromatoporoids, but has its greatest extension in the Oxfordian. Prograding from the narrow belt of the coastal area, the Callovian is found in the NE Negev in Hamakhtesh Hagadol's Cladocoropsis-Shugraia beds. This is supposedly connected with global epeirogenic move-

ments, which in Israel are related to the 'sudden' and 'short-time' clastic Kidod deposits. The extent of the latter suggests the existence of a land-mass to the west of the present land area, concealed at great depths beneath the Mediterranean Sea. 80 Refs.

Hirsch, F. (Geological Survey of Israel, Isr); Picard, L. *J Pet Geol* v 11 n 3 Jul 1988 p 277-307.

## Krasnodar Territory, USSR

**077482 BLOCK TECTONICS AND PETROLEUM POTENTIAL OF WESTERN PRE-CAUCASUS.** Deep faults identified from geological and geophysical data had a decisive influence on the history of the geological development of the territory of Western Pre-Caucasus. The basement block tectonics has been the main factor conditioning the regularities of the formation and distribution of hydrocarbon pools. An analysis of the thicknesses and litho-facies characteristics of the Paleozoic, Mesozoic and Cenozoic complexes has made it possible to evaluate the petroleum potential prospects and to recommend the arrangement of integrated geophysical explorations, and of the parametric and prospecting drilling in the indicated areas. (Translated author abstract) In Russian. 7 refs.

Lotiev, B.K.; Sazonov, I.G.; Istratov, I.V.; Kerimov, I.A. *Izv Vyssh Uchebn Zaved Neft Gaz* n 1 1987 p 9-15.

**077483 PETROLEUM AND GAS PROSPECTS OF WESTERN PRECAUCASUS IN THE LIGHT OF GEOLOGICAL AND GRAVIMETRIC DATA.** The territory of western Precaucasus is a region highly promising as regards the oil and gas potential of its deep sedimentary strata. Geological interpretation of gravitational anomalies by comparing the data of gravitational exploration, seismic exploration and deep drilling, and by establishing a relation between local gravitational anomalies and structural and tectonic peculiarities of deposits, has shown that local gravitational maxima correspond to local uplifts. Some promising local uplifts are recommended for further exploration. In Russian. 14 refs.

Kerimov, I.A. *Izv Vyssh Uchebn Zaved Neft Gaz* n 12 Dec 1987 p 9-15.

## Libya

**077484 THERMAL MATURATION HISTORY OF THE SIRTE BASIN, LIBYA.** The high degree of thermal maturity observed in shallow sediments in the western part of the Sirte Basin, Libya, requires higher geothermal gradients and/or thicker overburden in the past than exist today. The degree of thermal maturity of the Upper Cretaceous shales, the regional structure, and the subsidence history of the basin all indicate that over 3000 m of section was removed from the western flank of the basin by uplift and erosion in the mid-Tertiary. Vitrinite reflectance values in wells suggest that gradients of 1.6°F/100 ft to 1.8°F/100 ft existed in the western region at the time of peak thermal activity, in contrast with a general basin average of 1.2°F/100 ft. (Author abstract)

Gumati, Y.D. (Univ of South Carolina, Columbia, SC, USA); Schamel, S. *J Pet Geol* v 11 n 2 Apr 1988 p 205-218.

Louisiana See OIL FIELDS—Reservoir Evaluation.

## Models

**077485 APPLICATION OF BOREHOLE IMAGES TO THREE-DIMENSIONAL GEOMETRIC MODELING OF EOLIAN SANDSTONE RESERVOIRS, PERMIAN ROTLIEGENDE, NORTH SEA.** High-resolution electrical borehole images of the Permian Rotliegende Sandstone (North Sea) clearly reveal a vertical succession of eolian and fluvial bedding facies. Porosities, which are found to be primarily a function of these facies, show a hierarchy of reservoir heterogeneities azimuths were measured in interdune layers, bounding surfaces, and cross-strata using, in addition to electrical images, full-circumference acoustic borehole images and dipmeter results. The vertical sequence and geometry of the bedding

elements indicate composite cross-bedding formed by downwind migration of superimposed bed forms alternating with interdune sections containing only few single bed forms. Statistical modeling of the thickness and foreset direction of cross-bedded sets is shown to constrain the three-dimensional geometry of the sand bodies. The results statistically predict distances at which wells are not connected by highly porous layers. Additional study results are discussed. (Edited author abstract). 42 Refs.

Luthi, Stefan (Schlumberger-Doll Research, Ridgefield, CT, USA); Banavar, Jayanth R. *AAPG Bull* v 72 n 9 Sep 1988 p 1074-1089.

## Nebraska

**077486 WESTERN NEBRASKA: THE LATE PALEOZOIC COMES OF AGE.** Within the past several years, a new and highly successful Paleozoic oil play has emerged in the western panhandle of Nebraska. It has evoked widespread new interest in the whole of the northern Denver-Julesburg basin. The paper presents a historical perspective of the drilling activity in the area, a survey of the geotectonic history of the northern Denver basin, structural geology, descriptions of the Permo-Pennsylvanian carbonate cycles of the northern Denver-Julesburg basin and of its late Paleozoic productive intervals, as well as a brief summary of the Amazon field. The practices and problems of drilling and completion and basic exploration economics are also discussed. 79 refs.

Anon. *Pet Front* v 4 n 1 1987 74p.

## Nevada

**077487 NEVADA: THE NEXT GREAT AWAKENING? PART 1: COMPREHENDING THE COMPLEXITIES.** This is the first of a two-volume study on the petroleum geology and exploration potential of Nevada, one of the least explored of the proven frontier regions in the continental United States. The geology of Nevada is highly unique and often very complex. This issue summarizes the current state of knowledge and thinking with respect to the region. It includes an introductory overview; discussions of geotectonic history, reservoir/source rocks and structural features; a history of drilling activity; exploratory strategies; and drilling problems/solutions. A series of stratigraphic sections derived from a representative spectrum of localities (ranges) is provided in an appendix.

Anon. *Pet Front* v 5 n 1 1988 var paging.

New Zealand See GEOCHEMISTRY—Organic Compounds.

## North Dakota

**077488 CORE WORKSHOP VOLUME: FIFTH INTERNATIONAL WILLISTON BASIN SYMPOSIUM.** The volume contains four papers presented at the meeting. The papers are: Winnipegosis Platform margin and Pinnacle Reef Reservoirs, Northwestern North Dakota; the Lower Ratcliffe Interval (Mississippian) in Williams and McKenzie Counties, North Dakota; silurian Interlake Group - a sequence of cyclic marine and freshwater carbonate deposits in the central Williston Basin; and Coteau and Dale Intervals of the Mississippian Mission Canyon Formation, Flaxton Field, Burke County, North Dakota. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11144 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Fischer, D.W. (Ed.). *Misc Ser ND Geol Surv* 69, Core Workshop Vol: Fifth Int Williston Basin Symp, Grand Forks, ND, USA, Jun 1987. Publ by North Dakota Geological Survey, USA, 1987 109p.

North Sea See Also SANDSTONE—Analysis.

**077489 HIGH-TEMPERATURE DIAGENESIS IN SHALLOW CHALK RESERVOIR, SKJOLD OIL**



**FIELD, DANISH NORTH SEA: EVIDENCE FROM FLUID INCLUSIONS AND OXYGEN ISOTOPES.** Samples of calcite-filled fractures from the chalk reservoir of the Skjold oil field were studied by fluorescence microscopy, cathodoluminescence microscopy, fluid inclusion microthermometry, and oxygen and carbon stable isotope and trace element analyses. Two generations of calcite infilling are tentatively related to two major phases of faulting caused by salt movements. Results of the fluid inclusion studies suggest a precipitation temperature of the infilling calcite significantly above what it should be, applying today's geothermal gradient to the past. This higher temperature indicates that hot water ascending from deeper strata may have flushed the reservoir, apparently during a late Miocene to Pliocene faulting phase when ring faults guided the water to the reservoir. (Edited author abstract) 31 refs.

Jensenius, Jorgen (Univ of Copenhagen, Copenhagen, Den). *AAPG Bull* v 71 n 11 Nov 1987 p 1378-1386.

**077490 MOVEMENT OF HYDROCARBONS IN SHALES.** The authors have analyzed Kimmeridge Clay (Upper Jurassic) shales from the North Sea which are currently expelling hydrocarbons into adjacent sandstones. The results could be explained if most expulsion occurs by the pressure-driven flow of a discrete hydrocarbon phase through the pores of shales and into the pores of the sandstones, as suggested previously. In addition, capillary forces seem to increase the efficiency of expulsion close to the interfaces between the shales and interbedded sandstones. It appears that molecular diffusion of hydrocarbons with less than about ten carbon atoms alters the composition of the hydrocarbon fluids remaining in, and expelled from, the shales. (Edited author abstract) 10 refs.

Mackenzie, A.S. (BP Petroleum Development Ltd, London, Engl); Leythaeuser, D.; Muller, P.; Quigley, T.M.; Radke, M. *Nature* v 331 n 6151 Jan 7 1988 p 63-65.

**077491 APPLICATION OF HEAVY-MINERAL ANALYSIS TO LITHOSTRATIGRAPHY AND RESERVOIR MODELLING IN THE OSEBERG FIELD, NORTHERN NORTH SEA.** Three distinctive detrital garnet associations have been recognized in Brent Group sandstones of the Oseberg area (northern North Sea) by means of electron microprobe analysis. These have lithostratigraphical significance, with one association occurring in the Eivie and Oseberg Formations, one in the Ness Formation and one in the Tarbert Formation. Differentiation of Ness and Eivie/Oseberg Formations by means of detrital garnet geochemistry has enabled the recognition of fluvial channel sandstones belonging to the Ness Formation which have cut down into the Eivie Formation shoreline complex. This provides direct evidence of communication between Ness and Eivie/Oseberg, adding an extra degree of sophistication to the geological input for reservoir simulation. A strong permeability anisotropy can be modelled around the fluvial channels, and a net sand volume can be modelled in agreement with channel orientation. (Edited author abstract) 9 refs.

Hurst, Andrew (Statoil, Forus, Stavanger, Norw); Morton, Andrew C. *Mar Pet Geol* v 5 n 2 May 1988 p 157-169.

**077492 SEDIMENTOLOGY AND RESERVOIR POTENTIAL OF A 'MARGINAL FACIES' LIMESTONE FROM THE CRETACEOUS OF THE NORTH SEA.** The lower Cretaceous section of UK North Sea well 3/16-1, on the eastern flank of the Shetland Platform, drilled by Sovereign Oil & Gas plc, is dominated by marine 'shelf-type' limestones with a very low argillaceous content. In this respect it differs both from the typical open-sea coccolith-rich Chalk and from the argillaceous Cretaceous of the Viking Graben. Diagenesis has resulted in crystal overgrowths, corrosion, and development of very fine to coarsely crystalline void filling calcite. Hydrocarbon staining is confined to patches of void-filling calcite and partially cemented fractures. No oil staining was observed in the carbonate matrix. The lithological and petrophysical characteristics of the interval are similar to the Chalk Group of Norwegian well 1/3-1. The thickness is considerably less in 3/16-1,

probably as a result of deposition on a topographic high such as existed along the margins of the Viking Graben and the East Shetland Platform during the Cretaceous. (Edited author abstract) 31 refs.

Amiri-Garroussi, K. (V.C. Illing & Partners, Cheam, Engl). *Mar Pet Geol* v 5 n 2 May 1988 p 182-192.

## North Slope, Alaska

**077493 POROSITY ENHANCEMENT FROM CHERT DISSOLUTION BENEATH NEOCOMIAN UNCONFORMITY: IVISHAK FORMATION, NORTH SLOPE, ALASKA.** Secondary porosity caused by chert dissolution is common in the hydrocarbon-producing fluvial facies of the Ivishak Formation (Triassic), North Slope, Alaska. Petrographic observations suggest that macroporosity caused by chert dissolution tends to increase toward the Neocomian unconformity. In the Prudhoe Bay field, a lateral increase in core porosity (from 15 percent at about 30 km from the unconformity to 30 percent near the unconformity) and in permeability (from 50 md at about 30 km from the unconformity to 800 md near the unconformity) is evident toward the unconformity. This increase occurs within the fluvial facies (zone 4) of nearly uniform grain size and framework composition (chert litharenite). Major chert dissolution probably took place during the Neocomian uplift when the Ivishak Formation was exposed to acidic meteoric waters in the near-surface environment. (Author abstract) 39 Refs.

Shanmugam, G. (Mobil Research & Development Corp, Dallas, TX, USA); Higgins, J.B. *AAPG Bull* v 72 n 5 May 1988 p 523-535.

## Norway

**077494 ENVIRONMENTAL SETTING AND DIAGENESIS OF LOWER PERMIAN PALAEOPLYSINID BUILD-UPS AND ASSOCIATED SEDIMENTS FROM BJORNOYA: IMPLICATIONS FOR THE EXPLORATION OF THE BARENTS SEA.** Lower Permian palaeoptysinid build-ups, interbedded with inter-build-up lagoonal sediments, occur both on Bjornoya and in the subsurface of the Barents Sea. They formed on a low-energy, broad and shallow shelf, and show a cyclic development which was probably related to minor eustatic sea-level changes. During periodic lowering of sea level, build-ups were subaerially exposed, meteoric diagenesis with karstification took place within the build-ups, and hypersaline conditions prevailed in the lagoons. In the Barents Sea, the palaeoptysinid build-ups have composite thicknesses on the order of several hundred metres and are restricted to positive structural elements. They are regarded as potential reservoir rocks in this area, partly because of the high porosity of similar build-ups in Central Spitsbergen. The reservoir quality of the build-ups on Bjornoya and from the single cored build-up complex in the Barents Sea is, however, relatively poor. Early Tertiary fracturing increased the permeability of the bulk rock, but also caused leakage of accumulated hydrocarbons. (Edited author abstract)

Lonoy, A. (Norsk Hydro Research Cent, Bergen, Norw). *J Pet Geol* v 11 n 2 Apr 1988 p 141-156.

## Reviews

**077495 HYDROCARBON POTENTIAL AND TECTONICS OF INDOCHINA.** The region under discussion is that part of Indochina which includes Vietnam, Laos, Kampuchea and eastern Thailand. The Kontum Massif, composed of a metamorphosed basement complex, is the core of the Indochina region, and crops out from eastern Vietnam to Laos and Kampuchea. The concept of concentric growth of orogenic belts along the periphery of this massif seems to have been accepted as being within the scope of the classic theory of orogeny. The application of a modern plate-tectonic hypothesis with the aid of Landsat image analysis, has, however, enabled a new interpretation of the tectonic development of the area to be made. The hydrocarbon potential of Indochina is here investigated, based on this interpretation of the region's tectonic development, and taking account of the morpho-

logical and textural characteristics detected from Landsat imagery. Three areas: (1) the Mekong Delta, (2) the Khorat Plateau, and (3) the Hanoi Basin-Gulf of Tonkin, are selected for detailed discussion of their hydrocarbon potential. (Author abstract)

Hayashi, M. (Idemitsu Oil Development Co, Tokyo, Jpn). *J Pet Geol* v 11 n 2 Apr 1988 p 219-232.

**Saskatchewan** See Also OIL WELL PRODUCTION—Tertiary.

**077496 MIDDLE BEDS LOG-CORE CORRELATIONS IN TATAGWA OIL FIELD, SOUTHERN SASKATCHEWAN, CANADA.** The present study provides a review of the lithology, corresponding core data and down-hole log parameters from the Tatagwa oil field. It includes a brief description of the lithologic types which can be recognized as the 'Marly' and 'Vuggy' units, a petrological study based on thin section. X-ray diffraction and scanning electron microscopy, and a summary of standard core and down-hole log data. The benefits derived from a correlation between the core data and the log parameter are threefold: more realistic down-hole log charts, better volumetric estimates of reserves, and an accurate data base for enhanced recovery. It is shown that the use of down-hole logs in combination with coring through the prospective zones is essential for the proper evaluation of this type of reservoir. (Author abstract) 8 refs.

Matiisen, A. (GEOTECHNICAL Resources Ltd, Calgary, Alberta, Can); Shehata, M. *Bull Can Pet Geol* v 35 n 4 Dec 1987 p 443-453.

## Sedimentology

**077497 THE muPETROL EXPERT SYSTEM FOR CLASSIFYING WORLD SEDIMENTARY BASINS.** muPETROL, an operational prototype expert system, patterned after muPROSPECTOR, provides the means for classifying sedimentary basins of the world as a first step in developing an integrated expert systems approach to estimating undiscovered worldwide petroleum resources. The basin classification is based on nine sedimentary basin models using H.D. Klemme's recognition criteria for a world sedimentary basin classification system. Each model is defined by a rule-based system and embodies the geologic concepts of plate tectonics modified by regional tectonics and lithologic and depositional sequences. The system of rule-based models is used to evaluate the likelihood of one hydrocarbon occurrence or more in a basin on the basis of the geologic characteristics that categorize that basin. These characteristics are also matched against those of known basins in a data base containing nearly 800 world basins. (Edited author abstract) 59 refs.

Miller, Betty M. (US Geological Survey, USA). *Geol Surv Bull (US)* 1810 1987 87p.

**077498 RELATIONSHIPS BETWEEN THERMAL MATURITY INDICES CALCULATED USING ARRHENIUS EQUATION AND LOPATIN METHOD: IMPLICATIONS FOR PETROLEUM EXPLORATION.** Thermal maturity can be calculated with time-temperature indices (TTI) based on the Arrhenius equation using kinetics applicable to a range of Types II and III kerogens. These TTIs are compared with TTI calculations based on the N.V. Lopatin method and are related theoretically (and empirically via vitrinite reflectance) to the petroleum-generation window. Heating rates control the thermal-maturation trends of buried sediments. Relative to Arrhenius TTIs, Lopatin TTIs tend to underestimate thermal maturity at high heating rates and overestimate it as low heating rates. Complex burial histories applicable to a range of tectonic environments illustrate the different exploration decisions that might be



made on the basis of independent results of these two thermal-maturation models. (Edited author abstract) 46 refs.

Wood, David A. (Eurocan Ventures Ltd, Bogota DE, Colomb). *AAPG Bull* v 72 n 2 Feb 1988 p 115-134.

**077499 SEDIMENTOLOGY AND CHARACTERISTICS OF DISPERSED ORGANIC MATTER IN TERTIARY NIGER DELTA: ORIGIN OF SOURCE ROCKS IN A DELTAIC ENVIRONMENT.** The distribution and abundance of the organic matter are related to both the age of the strata and depositional environment. The most significant variation is the decline in mean total organic carbon (TOC) content from late Eocene (2.2% TOC) to Pliocene strata (0.9% TOC) and an associated general decline in pyrolysis-defined hydrogen index (HI) and pristane/phytane ratio. The decrease in TOC and HI in younger strata reflects increased dilution of a nearly constant supply of terrestrial organic matter with the generally higher sedimentation rates of younger strata. The variation in organic matter with depositional environments and environmental depth zones (defined by foraminiferal assemblages) is significant, although less important than variation due to age. Paradoxically, no rich source rocks occur in the Tertiary succession in the Niger delta and, as conventionally measured, the strata have little or no oil-generating potential. Additional aspects of the subject are discussed. (Edited author abstract) 55 refs.

Bustin, R.M. (Univ of British Columbia, Vancouver, BC, Can). *AAPG Bull* v 73 n 3 Mar 1988 p 277-298.

**077500 DEEP-WATER DENSITY CURRENT DEPOSITS OF DELAWARE MOUNTAIN GROUP (PERMIAN), DELAWARE BASIN, TEXAS AND NEW MEXICO.** The Guadalupian Delaware Mountain Group is a 1,000-1,600-m thick section of siltstone and sandstone deposited in a deep-water density-stratified basin surrounded by carbonate banks or reefs and broad shallow evaporite-clastic shelves. The most prevalent style of basinal deposition was suspension settling of silt. Channels can be observed in outcrop at the basin margin and can be inferred from closely spaced wells in the basin. Hydrocarbon sealing beds are provided by laminated organic siltstone, which laterally can form the erosional margin where channels are cut into siltstone beds. Thick beds of very fine-grained sandstones fill the channels. These sandstones contain abundant large and small-scale traction-current-produced stratification. Outcrop and subsurface evidence indicates Delaware Mountain Group sediments were deposited by saline density currents. Exploration predictions based on submarine fan models formed by turbidity currents would anticipate very different proximal-distal changes in sandstone geometry and facies. Additional aspects of the subject are discussed. (Edited author abstract) 55 refs.

Harms, John C. (Harms & Brady Inc, Littleton, CO, USA); Williamson, Charles R. *AAPG Bull* v 73 n 3 Mar 1988 p 299-317.

**077501 ZOOPLANKTON FECAL PELLETS AS A SOURCE OF HYDROCARBONS IN CHALK.** Evidence from biochemistry, marine geology and sedimentology shows that chalk could be a source of hydrocarbons, and that some hydrocarbons in some chalk reservoirs could have originated within the chalk. Coccolith ooze, the precursor of chalk is deposited as the fecal pellets of zooplankton, most probably copepods. These fecal pellets contain dihydrophytol, which is a precursor of pristane; the latter is a precursor of some crude oil deposits. Zooplankton fecal pellets probably provided the organic source for some of the hydrocarbons in chalk. Some hydrocarbons in marine- and lacustrine-shale source rocks could have originated in much the same way. (Edited author abstract) 32 Refs.

Moussa, M.T. (Gulf Oil Exploration & Production Co, Houston, TX, USA). *J Pet Geol* v 11 n 3 Jul 1988 p 347-353.

## Somalia

**077502 FOLDING OF THE MESOZOIC COVER IN SW SOMALIA: A COMPRESSIONAL EPISODE RELATED TO THE EARLY STAGES OF INDIAN OCEAN EVOLUTION.** The tectonic-sedimentary evolution of SW and central Somalia is characterized by two main depositional cycles. The first cycle (Triassic to Early Cretaceous) is characterized by subsiding basins related to a process of crustal thinning, and is associated with the separation of Madagascar from Africa, between 165 and 121 million years ago. The second cycle, starting in the Late Cretaceous with a regional unconformity, is related to the separation and northeastward drift of India, at approximately 80 million years ago. The folds that affect the Jurassic and Early Cretaceous formations of the Lugh-Mandera basin in SW Somalia are the result of a compressive phase connected with dextral transcurrent movements along NE-SW trending fracture zones. These zones are developed parallel to the oceanic system of transform faults, in connection with the change in the stress regime intervening at the shift of the direction of spreading between the first and the second stages of evolution of the Indian Ocean. (Edited author abstract)

Boccaletti, M. (Univ of Florence, Florence, Italy); Dainelli, P.; Angelucci, A.; Arush, M.A.; Cabdulqadir, M.M.; Nafissi, P.; Piccoli, G.; Robba, E. *J Pet Geol* v 11 n 2 Apr 1988 p 157-168.

**Stratigraphy** See Also OIL FIELDS—Offshore; OIL FIELDS—Reservoir Evaluation; PETROLEUM PROSPECTING—Australia; PETROLEUM PROSPECTING—Offshore; PETROLEUM PROSPECTING—Seismic Survey; SANDSTONE—Analysis.

**077503 'ALBIAN TRANSGRESSION' IN THE SOUTHERN NORTH SEA BASIN.** The 'Albian transgression' may be recognized lithostratigraphically in a number of boreholes in the UK sector of the southern North Sea Basin. This event is also recognized onshore the United Kingdom. The importance of this event for hydrocarbon exploration is discussed, and comparisons are made with sections in West Germany. The 'Albian transgression' is a regional event in NW Europe which is important for understanding the pattern of basin evolution during Early and 'Mid' Cretaceous times. It is also important because the diachronous coarse clastics associated with the transgression may prove to be of important reservoir potential in the southern North Sea area (UK sector). (Author abstract) Refs.

Crittenden, Stephen (Gearhart Geo Consultants Ltd, Aberdeen, Scotl). *J Pet Geol* v 10 n 4 Oct 1987 p 395-414.

**077504 STRATIFICATION OF THE SEDIMENTARY COVER AND DETERMINATION OF THE NATURE OF DISCREPANCIES WITHIN THE PRE-CASPIAN LOWLAND ON THE BASIS OF A SEISMOSTRATIGRAPHIC ANALYSIS.** Results of the first-time application of the principles of seismostratigraphy to a number of petroliferous fields of the Precaspian lowland are presented. This method was used to describe the wave picture on temporal logs with the purpose of identifying the Cenozoic complex strata as sedimentary series and establishing more precisely the nature of the breaks and discrepancies in the sedimentary cover. (Translated author abstract) In Russian. 4 refs.

Mamedov, P.Z.; Zarka, Riad. *Izv Vyssh Uchebn Zaved Nefi Gaz* n 2 Feb 1987 p 9-12.

**077505 STRATIGRAPHY, RESERVOIR CHARACTERISTICS OF BEREASANDSTONE IN MICHIGAN FIELDS.** This report concerns the stratigraphy and reservoir characteristics of the Berea sandstone in the Larkin and Williams fields of Midland and Bay counties of Michigan. A cross section was constructed across the Larkin through Williams area using computerized gamma ray logs.

Gunn, George R. (Sun Exploration & Production Co, Dallas, TX, USA). *Oil Gas J* v 86 n 10 Mar 7 1988 p 57-60.

**077506 RESERVOIR CHARACTERISTICS OF THE KEWEENAWAN SUPERGROUP, LAKE SUPERIOR REGION.** This is a brief review of the stratigraphic, sedimentologic, and petrographic characteristics of the several thousand meter thick, post-volcanic siliciclastic Keweenaw Supergroup in the Lake Superior region with an emphasis on petroleum reservoir potential. During late Precambrian time, many sedimentary and volcanic rock units were deposited in the Lake Superior region. The upper Precambrian rock column can be thought of as consisting of three sequences: pre-volcanic quartz sandstone, Keweenaw volcanic rock, and the post-volcanic sedimentary rock units that are the subject of this paper. Keweenaw Supergroup rock, a red bed sequence that includes the Oronto Group and the overlying Bayfield Group, and their correlative rock units, are dominated by coarse clastic units that have potential as reservoir rock for petroleum that may have been generated within the Nonesuch Shale during deep burial.

Ojakangas, Richard W. *Geosci Wis* v 11 Sept 1986 p 25-31.

**077507 SOURCE ROCK EVALUATION OF HEATH FORMATION (MISSISSIPPIAN) IN MONTANA THRUST BELT.** The Heath formation of the Big Snowy group (Mississippian) consists of dark-gray to black, petroliferous shale and limestone that were deposited in an east-trending marine trough that extends from West Central Montana to western North Dakota. The authors' work in the overthrust belt of West Central Montana indicates that maturation of rocks of the Heath formation there proceeded beyond the preservation limits of oil and wet gas, and probably dry gas. Therefore, the Heath passed through peak hydrocarbon generation zones and the hydrocarbons may have been thermally destroyed. Modeling of the depositional and thermal history of this part of the Montana overthrust belt using the Lopatin method indicates the prior-to-thrusting maturation was slightly below the oil generation window. They interpret hydrocarbon generation to have occurred after thrusting, probably in response to tectonic burial beneath thrust sheets with dry gas the only hydrocarbon possible present.

Longden, Mark R. (Univ of New Mexico, Albuquerque, NM, USA); Banowsky, Bill R.; Woodward, Lee A. *Oil Gas J* v 86 n 19 May 9 1988 p 60, 62-63.

**077508 CEMENT STRATIGRAPHY OF PENNSYLVANIA HOLDER FORMATION, SACRAMENTO MOUNTAINS, NEW MEXICO.** Cyclic strata of the Holder Formation (Virgilian, New Mexico) were deposited across a Pennsylvanian shelf-to-basin transition during a time when sea level fluctuated over tens of meters. Cement-stratigraphy studies indicate abundant calcite precipitation from low-temperature fresh water within shelf, shelf-crest, and shelf-edge marine limestones. Fresh-water cementation occurred during 15 periods of intraformational subaerial exposure. Distribution of early calcite cements provides new data for interpretation of cycles, diagenetic systems, and porosity evolution in petroleum reservoirs. Trace-element analyses support a low-temperature, freshwater origin for the early cements. Cement-stratigraphy studies, fluid-inclusion analyses, and trace-element analyses indicate a later cement that occluded remaining limestone porosity precipitated from a sodium- and calcium-rich brine at a temperature of about 100°C. Additional study results are discussed. (Edited author abstract) 56 Refs.

Goldstein, Robert H. (Univ of Wisconsin, Madison, WI, USA). *AAPG Bull* v 72 n 4 Apr 1988 p 425-438.

**Subaqueous** See GEOLOGY—Canada; OIL FIELDS—Egypt.

## Sultanate of Oman

**077509 STRATIGRAPHY AND ROCK UNIT NOMENCLATURE IN THE OIL-PRODUCING AREA OF INTERIOR OMAN.** The sedimentary rock sequence in the oilfield areas of Interior Oman ranges from the Late Proterozoic through Paleozoic, Mesozoic and Tertiary. A number of major gaps or changes in sedimentation are



recognized, and these punctuate a subdivision into major rock units ranked as groups. Eleven named groups are recognized. Most of these groups are further subdivided and 35 named formations are described giving lithologic characteristics, boundaries, inferred age span and variability. These descriptions, together with reference well sections indicating wire-line log characteristics, provide a sufficient basis for consistent future use of the rock units. Hydrocarbon occurrence within this sedimentary sequence is primarily controlled by the presence of good impermeable sealing units, particularly those of sufficient thickness to be least breached by faulting. Seven important sealing units are recognized. Commercial hydrocarbon accumulations are retained by all these seals. Reservoirs are in both carbonate and clastic units, and in South Oman are commonly in much older units than the seal, which overlies unconformably. (Edited author abstract) Refs.

Hughes Clarke, Michael W. (Petroleum Development Oman LLC, Muscat, Oman). *J Pet Geol* v 11 n 1 Jan 1988 p 5-60.

**077510 ORIGIN OF CRUDE OILS IN OMAN.** The crude oils of Oman can be geochemically classified into five groups. Three groups can be related to good oil source rocks found in the pre-Cambrian Huqf Group, the Silurian Safiq and the Cretaceous Natih Formations. Another group of oils probably originates from the Upper Jurassic Diyab Formation, while the fifth group of crudes (named 'Q') cannot be correlated to a known source rock, but is inferred to have originated from an unsampled Huqf level. The 'Huqf oils' are those that have been correlated to known Infra-Cambrian Huqf source rocks, and are characterized by a strong  $C_{29}$  sterane predominance and very light carbon isotope values of around  $-36.0/0.00$ . In contrast, the 'Q' crudes, derived from the unknown source, are characterized by a  $C_{27}$  sterane predominance and carbon isotope ratios of around  $-30.5/0.00$ . Oils reasoned to originate from Silurian Safiq source rocks have a weak  $C_{29}$  sterane predominance, a significant content of rearranged steranes and carbon isotope ratios of  $-30.5/0.00$ . The oils thought to originate from the Jurassic Diyab Formation have a similar sterane distribution but heavier carbon isotope values of around  $-26.5/0.00$ . Finally, the crude oils from the mid-Cretaceous Natih Formation source rocks are characterized by steranes with an equivalent distribution of  $C_{27}$ ,  $C_{28}$  and  $C_{29}$  isomers, and carbon isotope values of around  $-26.9/0.00$ . (Edited author abstract) Refs.

Graham, P.J. (Koninklijke/Shell Exploratie en Productie Lab, Rijswijk, Neth); Lijmbach, G.W.M.; Posthuma, J.; Hughes Clarke, M.W.; Willink, R.J. *J Pet Geol* v 11 n 1 Jan 1988 p 61-80.

**077511 EVIDENCE OF PERMO-CARBONIFEROUS GLACIATION IN THE BASAL MURBAT SANDSTONE FORMATION, SOUTHERN REGION, SULTANATE OF OMAN.** The most massive basal diamictite of the Murbat Sandstone Formation exhibits many sedimentary features which indicate its subglacial deposition. Some of the most important features are: (1) striated and grooved sandstone slivers within the diamictite; (2) striated and faceted clasts; (3) small stratified sandstone lenses within the diamictite; (4) 'dropstones' or 'out-of-size clasts' in the shale; and (5) the large lateral and vertical extent of the diamictite. The overlying sequence of the Murbat Sandstone Formation consists of an alternating succession of conglomerate and sandstone followed by siltstone and shale, whose sedimentary structures, however, suggest their deposition in deeper-water basins. The Murbat Sandstone Formation has been assigned to various ages ranging from Infra-Cambrian to Ordovician by different workers, in view of its isolated occurrence and the absence of flora and fauna. The Metal Mining Agency of Japan, however, has dated the Murbat Sandstone Formation as Permo-Carboniferous, as it unconformably overlies Lower Carboniferous dikes of the crystalline basement. The dikes have been dated by the K-Ar method. 13 refs.

Qidwai, H.A. (Ministry of Petroleum & Minerals, Salalah, Oman); Khalifa, M.I.; Ba-mkhalif, Khalid A. *J Pet Geol*

v 11 n 1 Jan 1988 p 81-88.

## Tanzania

**077512 GAS-PRONE SOURCE ROCKS FROM CRATOGENE KAROO BASINS IN TANZANIA.** Source-rock quality and organic matter maturity of coals and sediments from several Tanzanian Karoo basins (Permian-Triassic) have been evaluated by microscopic, pyrolytic and geochemical methods. The intracratonic Ruhuhu Basin (SW Tanzania) differs from two peripheral cratogene basins (Mikumi and Rufiji) with respect to the composition of organic matter, thermal evolution and probable hydrocarbon generation in a tensional tectonic stress field of the East African craton at the Palaeozoic/Mesozoic boundary. The Lower Permian sediments and coals and the Upper Permian sediments of the Ruhuhu Basin exhibit moderate source-rock properties. They were not subjected to significant subsidence and are moderately mature source rocks. They possibly experienced temperatures in the range  $60-110^{\circ}\text{C}$  and vitrinite reflectance values of  $0.5-0.8$  were attained, thus placing them within the 'oil window'. Kerogen Type III is typical for all the basins, and productivity indices indicate moderate to advanced stages of evolution. The coastal basins differ in most parameters. The sediments do not have source-rock properties. High vitrinite reflectance values ( $1.0-2.0\%$ ) imply a higher degree of thermal maturation, and geochemical results confirm that organic matter in these sediments is postmature, and that hydrocarbon generation, if it occurred at all, ceased some time ago. (Edited author abstract)

Kreuser, T. (Universitaet zu Koeln, Cologne, West Ger); Schramedei, R.; Rullkoetter, J. *J Pet Geol* v 11 n 2 Apr 1988 p 169-184.

**Tectonics** See Also GEOLOGY—Alberta; GEOLOGY—Nigeria; GEOLOGY—Wisconsin; OIL FIELDS—Reservoir Evaluation; OIL WELL LOGGING—Acoustic; PETROLEUM PROSPECTING—Australia; PETROLEUM PROSPECTING—Geochemistry; PETROLEUM PROSPECTING—United States; SANDSTONE—Analysis.

**077513 FAULT SLICING - A NEW APPROACH TO THE INTERPRETATION OF FAULT DETAIL.** The manner in which a fault intersects a hydrocarbon reservoir affects production characteristics and thus must be understood in great detail. A 3-D seismic data volume can be sliced interactively to yield seismic sections parallel to a fault plane. These fault slices can then be used in several ways for the study of faults. Tracking of correlative horizons on fault slices provides a map of fault throw and permits study of the throw as a function of vertical traveltime and horizontal position. Because a fault slice remains within one major fault block, the study of growth relationships in that block is facilitated. Splinter faults, which are also significant in development and production, can be studied effectively on fault slices because of the uniform proximity of these sections to the parent fault. (Edited author abstract)

Brown, Alistair R. (Geophysical Service Inc, Dallas, TX, USA); Edwards, G. Serpell; Howard, Robert E. *Geophysics* v 52 n 10 Oct 1987 p 1319-1327.

**077514 TECTONIC BASIS FOR SEPARATE FORECASTING OF OIL AND GAS POTENTIAL OF SEDIMENTARY ROCK BASINS OF PLATFORMS AND FOREDEEPS.** Based on the data on the Azov-Kuban, Middle Caspian West Siberian and other oil and gas-bearing basins ( $>50$  deposits), a new historical-dynamic method of predicting oil and gas potential has been developed. It consists in the utilization of a set of structural and paleotectonic indices - static (morphology, size, time of formation of folds) and dynamic (rate and gradients of sedimentation, rate of growth of local uplifts, contrasts). The basis of the method is identification of terrigenous, terrigeno-carbonate and carbonate formations of a normally marine type of compensated sedimentation. In Russian.

D'yakov, A.I.; Geiro, S.S.; Rodygin, V.R. *Geol Nefti Gaza* n 2 1987 p 32-34.

**077515 CONTINENTAL CRUST UNDER THE NW PACIFIC OCEAN.** Reinterpretation of seismic profiles and DSDP drilling results, together with dredging data from the Japan Trench and Nankai Trough areas, NW Pacific, shows that the so-called oceanic crust is composed of Precambrian continental crust, consisting partly of Proterozoic orthoquartzite. This is supported by paleogeographic evidence, which requires the presence of large continental masses on the present Pacific side of the Japanese islands during Paleozoic-Mesozoic-Paleogene times, as source areas for the large volume of sediments carried into the Japanese part of the Tethys. Most of the present NW Pacific was either subaerially exposed or was partly very shallow sea during Paleozoic to Early Mesozoic times, and first became deep sea about the end of the Jurassic. These conclusions require the fundamental revision of plate-tectonic models for the geological development of the island arcs and trenches in the NW Pacific region. (Author abstract) Refs.

Choi, D.R. *J Pet Geol* v 10 n 4 Oct 1987 p 425-440.

**077516 MAIN PROBLEMS OF TECTONODYNAMICS AND OIL AND GAS ONTOGENESIS.** An attempt is made to show the potentialities and the main problems of tectonodynamic evaluation of the conditions of formation of oil and gas pools. This approach is termed tectonodynamics of the ontogenesis of oil and gas, meaning the area of studies of a complex of natural processes that are a function of the nonlinear-variable dynamic effects of a tectonic nature that exerts an influence on the direction and style of oil and gas formation and accumulation. In Russian. 12 refs.

Amurskii, G.I.; Solov'ev, N.N. *Geol Nefti Gaza* n 4 Apr 1987 p 34-39.

**077517 MIDCONTINENT RIFT AS A FRONTIER HYDROCARBON TARGET.** Graben development by crustal extension approximately 1.1 Ga, followed by infilling by numerous basaltic flows, and isostatic sinking of volcanic rock created erosion and deposition of older (Oronto Group) sedimentary rock with reactivation and uplift of the central (St. Croix) horst. The Oronto Group was eroded and the sediment deposited as Bayfield Group sedimentary rock in the flanking basins; erosion of St. Croix Horst continued into Paleozoic time until terminated by transgression of Lower Paleozoic units. The basic structure of the Midcontinent Rift System southwest of Lake Superior is a central horst block flanked by basins. The trend of the central St. Croix Horst is not continuous. In Wisconsin the Oronto Group is associated with the Ashland-Lake Superior Syncline. To the southwest a 580 m column of Oronto-like sedimentary rock was drilled south of Minneapolis-St. Paul in search of suitable natural gas storage reservoir.

Dickas, Albert B. *Geosci Wis* v 11 Sept 1986 p 15-19.

**077518 LITHOSPHERIC FLEXURE AND EVOLUTION OF THE MIDCONTINENT RIFT.** Seismic reflection and refraction data give two snapshots of basin evolution. The following scenario is suggested for the evolution of the Midcontinent Rift System in this region: extension and high heat flow thins the lithosphere, and the mantle material intrudes the lower crust; volcanic activity ceases and the cooling intrusion contracts, increasing in density and loading the crust; sedimentation keeps pace with the deepening basin; and subsidence stops when the intrusive body has cooled. The St. Croix Horst is thrust up along the Douglas and Lake Owen Faults. The intracrustal body is preserved by the stable cratonic environment, but as the lithosphere thickens compensation occurs at a greater depth and with a longer wavelength reflected in the present day deformation of the Moho.

Nyquist, Jonathan E.; Wang, Herbert F. *Geosci Wis* v 11 Sept 1986 p 19-21.



**077519 SOME DEFORMATION EFFECTS IN A CLASTIC OVERBURDEN RESULTING FROM SALT MOBILITY.** In a basin containing an evaporite sequence that includes salt rock, should the salt become mobile and deform plastically, it will produce important structural effects in overlying sediments. These effects may include folding, faulting, slumping, and in some cases where dissolution of the salt also occurs, collapse structures. The movement of the salt/overburden system during plastic deformation of the salt may be syndepositional, in which case rim syncline sedimentation will take place at the surface. The form taken by the rim syncline deposits will be related to the stage of development of the salt structures with which they are associated. An understanding of the mechanisms involved is important, particularly in a basin containing hydrocarbons. Also, study of the behavior at depth of sediments which are subject to deformational stress may assist in solving structural problems on the larger, regional scale. Selected examples of various effects seen in the North Sea Zechstein salt basin are discussed and illustrated with recently acquired seismic data. (Author abstract). 17 Refs.

Jenyon, M.K. (Seismograph Service (England) Ltd, Kent, Engl). *J Pet Geol* v 11 n 3 Jul 1988 p 309-324.

Texas

**077520 COMPOSITE CLASSIFICATION OF FRACTURED AND BRECCIATED CARBONATE ROCKS - EXAMPLES FROM THE ORDOVICIAN ELLENBURGER GROUP, WEST TEXAS.** The attention paid to rock fracturing in recent years is a result of the discovery of large volumes of hydrocarbons in fractured rock reservoirs. This regional study was conducted in order to facilitate a better understanding of the performance of fractured reservoirs, and to select the proper procedures and well intervals for artificial fracturing. Five classification schemes are proposed for fracture, breccia, porosity and permeability developments, as revealed by mega- and microscopic examination of cores, thin-sections and outcrop samples. A composite classification combines the attributes of the other schemes in an attempt to predict residual porosity and permeability on a reservoir scale. Various genetic types of breccia were encountered in this study, but those of tectonic origin predominate and control hydrocarbon production. (Edited author abstract)

Ijirigbo, B.T. (Univ of Ibadan, Ibadan, Nigeria); Schreiber, J.F. Jr. *J Pet Geol* v 11 n 2 Apr 1988 p 193-204.

Thailand

**077521 STRUCTURAL CONTROL OF NEOGENE SEDIMENTATION IN THE MAE SOT BASIN (THAI-BURMESE BORDER): IMPLICATIONS FOR OIL-SHALE RESERVES.** The Mae Sot Basin is here interpreted as a tilted fault-block bounded on the east by a normal fault which, acting as a growth fault, controlled sedimentation during the Neogene. It is suggested that oil-shale reserves are greater than those currently estimated, and that they may be greatest near the eastern margin of the basin due to the development of a thicker sequence here, and repetition of the facies at depth in sedimentary cyclothem. (Author abstract). 17 Refs.

Stokes, R.B. (Kingston Polytechnic, Kingston upon Thames, Engl). *J Pet Geol* v 11 n 3 Jul 1988 p 341-346.

Theory

**077522 GEOLOGICAL REASONING FOR THE PETROLEUM SOURCE ROCKS OF KNOWN FIELDS.** Geological reasoning for the petroleum source-migration-accumulation relationships centres around petroleum composition and its variability, water composition and its variability, and stratigraphy. The author argues hypothesis of petroleum origin and migration mechanism will be satisfactory unless all observations, geological, hydrogeological, and geochemical, can be reconciled; and no hypothesis can be satisfactory that does not take geological argument into account. The purpose of this paper is to examine geological arguments

for the location of petroleum source rocks, and to discuss some fields where the published geochemical conclusions appear to be contradicted by the geological evidence. 40 refs.

Chapman, R.E. (Univ of Queensland, St. Lucia, Aust). *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 132-141.

Thermal Effects

**077523 INVERSION OF BOTTOM-HOLE TEMPERATURE DATA: THE PINEVIEW FIELD, UTAH-WYOMING THRUST BELT.** The present-day temperature field in a sedimentary basin is a constraint on the maturation of hydrocarbons; this temperature field may be estimated by inverting corrected bottom-hole temperature (BHT) data. Thirty-two BHTs from the Pineview oil field are corrected for drilling disturbances by a Horner plot and inverted for the geothermal gradient in nine formations. Both least-squares ( $l_2$ ) norm and uniform ( $l_1$ ) norm inversions are used; the  $l_1$  norm is found to be more robust for the Pineview data. The inversion removes random error from the corrected BHT data by partitioning scatter between noise associated with the BHT measurement and correction processes and local variations in the geothermal gradient. (Edited author abstract) 33 refs.

Deming, Dave (Univ of Utah, Salt Lake City, UT, USA); Chapman, David S. *Geophysics* v 53 n 5 May 1988 p 707-720.

Turkmen SSR

**077524 KUMBET-KARADZHAULAK UPLIFT ZONE - A NEW PROMISING REGION FOR HYDROCARBON RESOURCE EXPLORATION IN TURKMENIA.** The Kumbet-Karadzhaulak uplift zone and the gas-condensate deposits associated with it have been discovered in the above-salt Titon-Valanzhian level of the outer fringe of the Pre-Kopetdag border trough. Further prospects of the gas and oil potential of the zone are connected with the subsalt Carbonate level of the Oxfordian Aier, as well as with the continuation of the exploration of the above-salt level. Lithological-type pools may be discovered there. A program of drilling work is suggested. (Edited author abstract) In Russian.

Ashirmamedov, M.A.; Melikhov, V.N.; Kravchenko, Yu.K.; Sibirev, V.S.; Rozhkov, E.L. *Izv Vyssh Uchebn Zaved Neft Gaz* n 9 Sep 1986 p 15-19.

Ukraine See PETROLEUM PROSPECTING—Ukraine.

Ulyanov Region, USSR

**077525 NEW DATA ON THE OIL BEARING CAPACITY OF THE PALEOZOIC OF THE TRANS-VOLGA PART OF THE ULYANOV REGION.** The oil-bearing capacity of the Devonian strata has been established as a result of drilling at the Labitovskoe uplift (at the south-eastern fringe of the Ulyanov region). This encourages the search for similar deposits in the same formations in neighboring areas, in particular within the confines of the Melekess trough which has not been adequately explored yet. In Russian. 4 refs.

Kokurnikov, V.P.; Badamshin, E.Z.; Goryachev, A.S.; Lebedev, N.P.; Smelkov, V.M. *Geol Nefti Gaza* n 6 Jun 1987 p 13-16.

United Kingdom

**077526 ORIGIN AND RECOGNITION OF LATERALLY CONTINUOUS CARBONATE-CEMENTED HORIZONS IN THE UPPER LIAS SANDS OF SOUTHERN ENGLAND.** The Upper Lias Sands of southern England contain numerous, laterally extensive, carbonate-cemented horizons. Petrographical analyses of samples from outcrop sections and the Marchwood No. 1 borehole indicate that these horizons result from preferential cementation of bioclast-rich, clay-poor sediments by

comparison with interbedded clay-rich, bioclast-poor sediments. The alternation of the two sediment types is attributed to the effects of, respectively, fairweather and storm processes on a submerged marine shoal. Petrographical and ichnological data indicate an early distinction of the strongly and weakly cemented horizons. The widespread extent of the cemented horizons, as indicated by outcrop studies on the Dorset coast, is considered to be a direct consequence of episodic storm activity on the low relief shoal. Sedimentological, palynological and petrophysical criteria are presented to assist in recognition of similar extensive cements in subsurface reservoir horizons that do not outcrop. (Author abstract) 65 refs.

Bryant, Ian D. (Koninklijke/Shell Exploratie en Productie Laboratorium, Rijswijk, Neth); Kantorowicz, John D.; Love, Charles F. *Mar Pet Geol* v 5 n 2 May 1988 p 108-133.

**077527 EARLY CARBONIFEROUS OF THE SOLWAY BASIN: A TECTONOSTRATIGRAPHIC MODEL AND ITS BEARING ON HYDROCARBON POTENTIAL.** The Solway Basin forms the western portion of the Northumberland Trough, a Carboniferous basin system trending WSW-ENE across northern England. A study of the tectono-stratigraphic variations along the margins allows certain predictions to be made regarding the hydrocarbon prospectivity of the Dinantian. It is proposed that earliest Carboniferous extension initiated a series of half-grabens separated by transfer zones that have subsequently formed fold culminations and fault belts within the basin. A model for the proposed graben polarity-switching in the basin system is outlined. Differential subsidence across active faults led to pronounced facies variations in the Courcayan-Chadian which subsequently declined in importance until, in Brigantian-Pendleian times, deposition was governed by regional subsidence. The model anticipates that the best development of reservoir facies is in the distal nearshore equivalent of the Early Dinantian alluvial coarse clastics. Additional aspects of the subject are discussed. (Edited author abstract). 35 Refs.

Barrett, Paul A. (Barrett Exploration Services Clampwood, Engl). *Mar Pet Geol* v 5 n 3 Aug 1988 p 271-281.

United States

**077528 EFFECTS OF DEFORMATION MECHANISMS ON RESERVOIR POTENTIAL IN CENTRAL APPALACHIAN OVERTHRUST BELT.** Finite strain associated with various deformation mechanisms can significantly alter the porosity and permeability of reservoir rocks in overthrust belts. Mechanisms such as pressure solution and cataclasis reduce porosity and permeability, whereas extension fracturing and brecciation increase them. It is concluded that the potential for oil production is primarily restricted to the Appalachian Plateau province. The potential for gas production decreases from west to east in the Valley and Ridge and Plateau provinces, with its approximate eastern limit defined by the North Mountain thrust. (Edited author abstract). 31 Refs.

Mitra, Shankar (ARCO Oil & Gas Co, Plano, TX, USA). *AAPG Bull* v 72 n 5 May 1988 p 536-554.

**077529 FRAMEWORK OF HYDROCARBON GENERATION AND DESTRUCTION IN EASTERN SMACKOVER TREND.** Laminated lime mudstones of the lower member of the Jurassic Smackover Formation are significant source rocks for crude oil across Mississippi, Alabama, and Florida. The source facies was deposited in an anoxic and perhaps hypersaline environment that preserved algal-derived kerogen. The distribution of kerogen along laminations of depositional origin and long stylolites of diagenetic origin resulted in efficient expulsion of crude oil. With increasing thermal maturity, crude oil initially emplaced in reservoirs was cracked to yield gas condensate and then methane rich in nonhydrocarbon gases such as hydrogen sulfide, carbon dioxide, and nitrogen. Early destruction of methane was driven by



thermochemical sulfate reduction. The thermal maturity framework of the Smackover trend explains the distribution of hydrocarbon discoveries and suggests areas previously overlooked by exploration. (Author abstract). 52 Refs.

Sassen, Roger (Louisiana State Univ, Baton Rouge, LA, USA); Moore, Clyde H. *AAPG Bull* v 72 n 6 Jun 1988 p 649-663.

#### USSR See Also NATURAL GAS DEPOSITS—USSR.

**077530 STARYI OSKOL-PASHIAN NONCOMPENSATED TROUGHS - NEW RESERVE FOR OIL AND GAS PROSPECTING.** Noncompensated troughs (NCT) of the Upper Devonian-Lower Carboniferous age are the most promising regional targets of prospecting for oil and gas at the present time. Over 300 oil and gas deposits have been explored in these formations within the Volga-Urals oil and gas province. Promising areas are found in the Timan-Pechora province. An analysis of the Staryi Oskol-Pashian complex in the southern part of the Orenburg and Kuibyshev regions has allowed identification of the Lebyazhinskoe system of NCTs. Recommendations are given on prospecting targets in this area. In Russian. 4 refs.

Zhukov, I.M.; Yakhimovich, N.N.; Kovrizhkin, V.S.; Postoenko, P.I. *Geol Nefti Gaza* n 6 Jun 1987 p 6-10.

**077531 CONDITIONS OF TECTONIC EVOLUTION AND PETROLEUM POTENTIAL.** Using the example of the extensive Pripyat-North-Caspian lineament, the tectonic conditions and their effects on the sedimentation and hydrocarbon pool generation are investigated. It is shown what tectonic conditions are the most favorable for the development and preservation of hydrocarbon deposits subjected to high pressures and temperatures. The Pripyat-North-Caspian lineament represents a complex structure which started, to be formed in the Riphean period. Following the accumulation of thick sedimentation strata in the Paleozoic Era, great inversions and formation of folded Herzinide structures led to the localization of hydrocarbon deposits in a zone under the overthrust. West of the Donbas, the petroliferous strata belong to the Paleozoic and east of the Donbas to the Mesozoic. In Russian. 1 ref.

Maksimov, S.P. (Goncharenko, B.D.); Dikenshtein, G.Kh. *Geol Nefti Gaza* 12 Dec 1987 p 29-35.

#### Utah

**077532 STRUCTURAL ANALYSIS USING THRUST-FAULT HANGING-W SEQUENCE DIAGRAMS: OGDEN DUPLEX, WASATCH RANGE, UTAH.** Detailed mapping and cross-section traverses provide the control of structural analysis and geometric modeling of the Ogden duplex, a complex thrust system exposed in the Wasatch Mountains, east of Ogden, Utah. The structures consist of east-dipping folded thrust faults, basement-cored horses, lateral ramps and folds, and tear faults. The sequence of thrusting is determined by means of lateral overlap of horses, thrust-splay relationships, and a top-to-bottom piggyback development. This exposed duplex serves as a good model to illustrate the method of constructing a hanging-wall sequence diagram - a series of longitudinal cross sections that move forward in time and space, and show how a thrust system formed as it moved updip over various footwall ramps. A hanging-wall sequence diagram also shows the complex lateral variations in a thrust system and helps to locate lateral ramps, lateral folds, tear faults, and other features not shown on dip-oriented cross sections. (Edited author abstract). 31 Refs.

Schirmer, T.W. (Chevron USA Inc, Denver, CO, USA). *AAPG Bull* v 72 n 5 May 1988 p 573-585.

#### West Siberia, USSR

**077533 APPLICATION OF A COMBINATION OF SPACE PHOTOGRAPHY AND GEOPHYSICAL DATA IN STUDYING THE GEOLOGICAL STRUC-**

**TURE OF WESTERN SIBERIA.** Some results of the application of space photography data to geotectonic investigations are considered. Low effectiveness of the method of direct combined analysis of the data of aerial photography decoding and primary geophysical information for the purpose of their geological diagnostics is shown on the example of Western Siberia. An alternative method of combined interpretation of space photography, geophysical and geological data is outlined. In Russian. 6 refs.

Peskovskii, I.D.; Borovskii, V.V. *Geol Nefti Gaza* n 5 May 1987 p 7-13.

**077534 FORMATION CONDITIONS AND PETROLEUM POTENTIAL OF LOWER JURASSIC IN WEST SIBERIA.** Reground oil and gas potential of Lower Jurassic in West Siberia has been proven. Commercial hydrocarbon deposits have been detected in the western part of the Krasnoleninskii oil and gas region and to the north of it at the Bolshoye deposit in the Nyuroi depression (Nizhnetabaganskoe, Kalinovo and Urinskoe deposits), on the Nizhnevartovskii arch (Khvoinoe and Kvartovoe deposits). Noncommercial oil flows have been obtained at a number of other places. Some regularities in the location of deposits are considered and promising areas are pointed out. 3 refs. In Russian.

Yasovich, G.S.; Mukher, A.G.; Myasnikova, G.P. *Geol Nefti Gaza* 9 Sep 1987 p 23-28.

#### West Virginia

**077535 GEOLOGY OF DEVONIAN SHALE OIL AND GAS IN PLEASANTS, WOOD, AND RITCHIE COUNTIES, WEST VIRGINIA.** The Upper Devonian shale play of western West Virginia is an area of active development of unconventional oil and gas reserves. It is unconventional in that production is from fine-grained fractured reservoirs. Examination of recent drilling results has led to a more detailed understanding of the structure and stratigraphy of the area, which in turn can explain some of the production trends observed. Areas of greater fracture density and therefore higher productivity are related to areas of shearing motion in the Burning Springs thrust sheet. Open flows after stimulation in these wells can be very high, but first-year decline is rapid. It is uncertain at this time how long a production life these wells will have. (Author abstract) 33 refs.

Filer, J.K. (West Virginia Geological & Economic Survey, USA). *SPE Form Eval* v 2 n 4 Dec 1987 SPE 12834, p 419-427.

#### Wisconsin See Also PETROLEUM PROSPECTING—Wisconsin.

**077536 PRECAMBRIAN PETROLEUM POTENTIAL, WISCONSIN AND MICHIGAN. I. OVERVIEW.** Nearly 700,000 acres of land have been leased for petroleum exploration in Wisconsin, and several million more acres have been leased along the Midcontinent trend in Minnesota, Iowa, and Kansas. The papers in this volume represent a summary of much of the historic information that has led to petroleum evaluation of the Midcontinent trend, and new evaluation of tectonics based on known geology and preliminary analysis of seismic data. Subjects covered include Proterozoic petroleum, and Middle Proterozoic geology of the Lake Superior area.

Mudrey, M.G. Jr. *Geosci Wis* v 11 Sept 1986 p 1-3.

**077537 EXTENT OF ORONTO GROUP.** The Nonesuch Formation of the Proterozoic Oronto Group of northern Wisconsin and Upper Michigan contains known hydrocarbon source strata. Other Oronto Group sedimentary rocks contain potential reservoir beds. Deposition of the Oronto Group was controlled by development of the Midcontinent Rift System. Within the central horst of the rift, formations are confined to the limits of the Ashland Syncline. Several areas of Precambrian sedimentation equivalent in age to the Oronto Group are known in adjacent rift-horst sections of Minnesota. (Author ab-

stract)

Dickas, Albert B. *Geosci Wis* v 11 Sept 1986 p 32-38.

#### PETROLEUM INDUSTRY See Also METALS AND ALLOYS—Corrosion Resisting; OIL WELL DRILLING; PETROLEUM ENGINEERING; PETROLEUM ENGINEERING—Education; PETROLEUM REFINING; PROCESS CONTROL.

**077538 PETROLEUM ENGINEERS AND INDEPENDENT EXPLORATION AND PRODUCTION COMPANIES IN THE YEAR 2000.** This paper contains certain opinions and observations made on behalf of independent exploration and production companies regarding the future of the oil industry and of petroleum engineers. It was prepared at the request of SPE's Committee on Education and Professionalism for presentation at the 1986 SPE Annual Technical Conference and Exhibition during the depths of a serious downturn in the industry. Because our national security dictates that there must be a future for the domestic petroleum industry, the domestically oriented independent sector will be required to play a key role in that future. Petroleum and the ability to find and extract it efficiently and economically are valuable resources that will not soon nor easily be replaced. (Edited author abstract) 5 refs.

Hawkins, Warren S. (Quintana Petroleum Corp). *JPT J Pet Technol* v 39 n 10 Oct 1987 SPE 15348, p 1243-1246.

**077539 EPIDEMIOLOGICAL SURVEYS IN THE OIL INDUSTRY.** Recent epidemiological surveys in the oil industry are discussed, with particular reference to three UK petroleum related studies. These are compared with studies carried out in the USA and Canada. The UK studies comprise the retrospective mortality follow up by standardized mortality comparison with age and sex equivalent national population data over the 25 year period 1950-1975 for 34,781 employees in eight UK refineries. 23 358 employees in 700 UK bulk distribution plants and 8500 workers engaged on diesel bus maintenance. Reviewing the hypothesis testing studies shows lack of concurrence in identifying any specific excess in site specific cancer, thus arguing against the presence of any serious and consistent occupational cancer problem in refineries. (Edited author abstract) 23 refs.

Leese, W.L.B. (Britoil plc, Glasgow, Scott); Jones, P. *Q J Tech Pap Inst Pet* Apr-Jun 1987 p 18-28.

**077540 EVOLUTION RECENTE DU MARCHÉ PARAPETROLIER MONDIAL.** [Recent Evolution of the World Petroleum Equipment and Service Market]. The decrease in world investments by the petroleum industry in the last four years suddenly speeded up at the beginning of 1986 with the drop in crude-oil prices. Consequently, the world petroleum equipment and service market showed a pronounced downward trend, particularly in the field of exploration and production of hydrocarbons. Geographically, this decline began in the United States before spreading to the North Sea and the rest of the world. The entire world petroleum equipment and service industry is deeply affected by this extensive degradation of the market. With such an outlook, the French petroleum equipment and service industry could have a business turnover of some 40 billion French francs and between 50,000 and 55,000 employees in 1986. (Edited author abstract) In French.

Boisserpe, P. (Inst Français du Pétrole, Rueil-Malmaison, Fr). *Rev Inst Fr Pet* v 41 n 6 Nov-Dec 1986 p 707-716.

**077541 HPI MARKETS AND STRATEGIES.** How the HPI and government react to new directions will not only set the course for the future of refining and marketing, it will have profound implications for the entire energy industry. Strategies developed by individual refiners and marketers in response to the changing environment will determine their future in the industry. Three forces have been identified and are discussed that will determine the downstream playing field in the nineties: 1. Imbalances between market demands and



refinery capacity will continue to promote intense competition and to depress margins, 2. Product and crude price volatility will be at least as great in the future as it has been in the last three years, and 3. Renewed environmental concerns will add new capital investment burdens to the industry. Why these forces have evolved and how they have led to new strategies and developments are examined.

Eklof, W.D. (Cambridge Energy Research Assoc, Cambridge, MA, USA). *Hydrocarbon Process* v 67 n 3 Mar 1988 p 125-126, 130.

**077542 VIABLE STRATEGIES FOR OIL AND GAS COMPANIES IN THE 1990S.** Key factors relating to corporate strategy formulation are discussed. The evolution of strategy at Petroleos de Venezuela is examined. The strategy of Petroleos de Venezuela is geared towards one overriding objective: to integrate our activities into the end-user market. In addition to strengthening its position in the downstream sector, the firm prefers joint ventures and to diversify its revenue base. The author indicates that the 1990s likely will be characterized by a high degree of competition in the oil industry. It is altogether probable that the buyer's market of the late 1980s will continue well into the coming decade. Regionalization will be a key word in the formulation of strategies, as sellers find it prudent to concentrate their attention on their natural markets and to service the needs of their traditional clients.

Chacin, J. (Petroleos de Venezuela, Caracas, Venez). *Hydrocarbon Process* v 67 n 5 May 1988 3p.

**077543 PROFITABILITIES ON FEDERAL OFFSHORE OIL AND GAS LEASES: A REVIEW.** This review has covered the past performance and projected future of profits from oil and gas leasing in the OCS (Outer Continental Shelf). The past performance has been dismal: a projected performance is even worse. Bonuses paid for leases are a major contributor to these unsatisfactory profits. Bonuses are also one cost that is wholly controllable by prudent management. Thus, this review arrives at its conclusion, which is that too high bonuses have been paid in the past and prudent management will pay lower bonuses in the future. 45 Refs.

Lohrenz, John. *JPT J Pet Technol* v 40 n 6 Jun 1988 p 760-764.

**077544 ASSESSING RISK IN ESTIMATING HYDRO-CARBON RESERVES AND IN EVALUATING HYDROCARBON-PRODUCING PROPERTIES.** The risks associated with estimating the reserves and value of a hydrocarbon-producing property are divided into three classifications: (1) the technical risk that the hydrocarbon values estimated by the geologists and engineers do exist in the ground and that the recoverable amounts can be recovered within the time frame projected by the engineers; (2) the economic risk that product prices, operating costs, equipment costs, inflation, and market conditions will be in reasonable agreement with the assumptions used in the economic analysis; and (3) the political risk that world economics, international political stability, taxation, and regulations will not be significantly different than projected in the evaluation. This paper focuses on these risk categories and presents methods for implementing risk estimates in the evaluation of a producing property, taking into account the maturity of the technical data, the location, and the life of the property. (Edited author abstract). 29 Refs.

Garb, Forrest A. (Forrest A. Garb & Assocs Inc). *JPT J Pet Technol* v 40 n 6 Jun 1988 p 765-778.

**077545 INNOVATION FOR COMPETITIVITY - PERSPECTIVES ON AN ENGINEER'S CONTRIBUTION.** The author discusses some of the technical challenges which the exploration and production side of his company is addressing for the future development of the North Sea. BP's market strategy against a background of oil prices and overcapacity of the 1980's is reviewed. Comments are made on information technology and the changing working culture of engineers.

Darley, J.R. (BP Int). *Min Technol* v 70 n 813 Jul 1988

9p.

**Accident Prevention** See **CHEMICAL INDUSTRY—Electric Equipment.**

## Alaska

**077546 ENVIRONMENTAL AND PETROLEUM RESOURCE CONFLICTS: A SIMULATION MODEL TO DETERMINE THE BENEFITS OF PETROLEUM PRODUCTION IN THE ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA.** The Arctic National Wildlife Refuge (ANWR), located on the Alaska North Slope, is believed to contain high petroleum production potential. This region also has outstanding wildlife and wilderness values. Congress is considering an Interior Department recommendation to open a portion of ANWR to oil and gas production. A draft study by the Interior Department reports values that are used to generate an expected present value of the net economic benefits of petroleum development in ANWR of \$2.98 billion. Alternatively, using updated oil price projections and revised tax and financial assumptions, the Arctic National Wildlife Refuge Financial Analysis Simulation Model (AFAM) projects the expected present value of net economic benefits of oil production at between \$0.32 and \$1.39 billion. Decision makers considering whether or not to open ANWR to petroleum development can use these values to judge if the economic benefits outweigh the projected negative wilderness and wildlife impacts. (Edited author abstract) 10 refs.

Goerold, W. Thomas (Wilderness Soc, Washington, DC, USA). *Mater Soc* v 11 n 3 1987 p 279-307.

**Australia** See Also **PETROLEUM PROSPECTING—Legislation.**

**077547 LEGAL AND TAXATION IMPLICATIONS FOR THE ACQUISITION AND DISPOSAL OF OFFSHORE PETROLEUM PRODUCTION AND EXPLORATION TENEMENTS - A PRACTICAL VIEW AND UPDATE.** The administrative aspects of petroleum mining and exploration companies have become more complex of recent years. One area where this is particularly so is in relation to the livelihood of the industry, i.e. access to tenements. Recent amendments to the Petroleum (Submerged Lands) Act, and associated Acts, and proposed new tax imposts (e.g. cash bonus bids, retention licence fees, resource rent tax, and capital gains tax) in relation to the offshore segment of the industry have added significantly to the complexities in planning the acquisition and disposal and ongoing control of tenements. Each of these is examined individually and in conjunction for the benefit of planners and executives administering tenements within their organisations. (Edited author abstract)

Allen, J. (Allen Allen & Hemsley, Sydney, Aust); Williamson, M. *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 7-21.

**077548 DEREGULATION OF THE AUSTRALIAN OIL MARKET.** In late 1984 the Government decided, after an extensive review, to partially deregulate immediately and to move to a substantially deregulated domestic oil market by 1988. After only four months of the new arrangements the Government announced a further review claiming that changes in international and domestic market conditions had led to calls from the industry to accelerate the move to deregulation. Deregulation would directly affect the prices and consumption patterns for domestic crude oils. The diverse positions taken during the mid 1985 review reflected differing assessments of the consequences of deregulation and differing impacts on interested parties. The Government decided to halt the move toward deregulation but to review the position again in 1987. (Edited author abstract)

Hart, G.E. (CSR Ltd, Sydney, Aust). *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 54-65.

**077549 ALIENATION OF LAND FROM EXPLO-**

**RATION - A SOUTH AUSTRALIAN EXAMPLE.** Access to the land surface for exploration is vital if the state's subsurface resources are to be discovered and developed. Over the past ten years, however, there has been a major increase in limitations on access to land for exploration in South Australia. Less than 0.1 per cent of the area of the state has been directly involved in resource exploration and development. Despite this, and despite successful introduction of codes of practice to limit the effect of exploration activities and to speed rehabilitation of access tracks and drillsites, the industry is generally and erroneously perceived to be a major land user. This is evidenced in community attitudes and reflected in recent legislation. (Edited author abstract) 6 refs.

Laws, R.A. (South Australian Dep of Mines & Energy, Parkside, Aust). *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 73-87.

**077550 FOREIGN FUNDING OF THE AUSTRALIAN PETROLEUM INDUSTRY - IMPORTANT ASPECTS OF THE DIRECT INVESTMENT DECISION PROCESS.** The paper provides an outline of the financial aspects of the foreign direct investment decision process and an understanding of how this can help attract funds for Australian petroleum exploration and development. The techniques in assessing country risk are reviewed, and the methodology of international banks assessed. The Go/No-Go, Premium for Risk, Range of Estimates, and Risk Analysis techniques are described. In considering the forecasting of exchange rate movements it is recognized that, while there is no adequate forecasting measure, the major variables of comparative prices, interest rates, and comparative money supply require attention. (Edited author abstract) 10 refs.

McKee, J. (Petroleum Management Associates Pty Ltd, Unley, Aust). *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 88-95.

**077551 RECENT CHANGES TO AUSTRALIA'S OFFSHORE PETROLEUM REGIME.** A practical consequence of the Offshore Constitutional Settlement for the industry is that many offshore titles are now being split into two separate titles - one under State legislation within the three-mile territorial sea and the other under Commonwealth legislation for the Adjacent Area beyond the territorial sea. The Commonwealth proposal to introduce cash bonus bidding for highly prospective offshore exploration permits after being defeated in the Senate in the first half of 1985 was subsequently passed in November 1985. An APEA proposal for the introduction of a new form of title under the Petroleum (Submerged Lands) Act (PSLA) to protect currently non-commercial reserves has been adopted by legislation. Some recommendations are given for establishing a more secure and certain system of title under the PSLA and to minimize the current administrative delays being experienced by industry. (Edited author abstract)

Reid, P.C. (Esso Australia Ltd, Sydney, Aust). *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 102-104.

**077552 AUSTRALIAN OIL INDUSTRY - TWO YEARS OF FLOOD BEFORE THE PERMANENT DROUGHT.** Australia has achieved 100 per cent self-sufficiency in crude oil, but a substantial increase in exploration activity is required if a major fall in self-sufficiency is to be averted after Bass Strait peaks in 1987. Browse Basin (Timor Sea) disappointments indicate that while there will be good production from Jabiru and perhaps Challis, these will not replace the declining Mackerel, Halibut, and Kingfish fields in Bass Strait. If oil is not found the balance of payments will suffer badly. Each percentage point drop in self sufficiency will cost Australia \$85 million or nearly 0.5 per cent of exports. If domestic production falls to 470



000 barrels per day by 1990, imports of crude oil will cost \$2 billion in 1985 dollars (assuming flat oil prices). (Edited author abstract)

Story, I. (Meares & Philips Ltd, Sydney, Aust). *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 106-122.

**J77553 TAXATION ASPECTS OF SOLE RISK, OR, HOW TO MAKE THE TAX SYSTEM WORK FOR YOU.** This paper describes the taxation implications of a sole-risk program and the taxation results that one expects to flow to a sole-risk party and a non-sole-risk party if a structure different from that now used is adopted for that program. The taxation implications will be considered under the headings of income tax, resource rent tax, and resource rent royalty. The paper will discuss how the tax system can be used to diminish the incentive for a company to allow a party to undertake a sole-risk operation.

Wilson, P.A. (Arthur Young Chartered Accountants, Sydney, Aust). *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 123-130.

**Canada** See **ENERGY RESOURCES—Economics; OIL WELL PRODUCTION—Heavy Oil.**

**Computer Applications** See Also **DATABASE SYSTEMS; PETROLEUM ENGINEERING.**

**077554 MAINFRAME-TO-MICROCOMPUTER SOFTWARE TRANSPORTABILITY.** Most development and maintenance work on our suite of technical drilling applications is done in the mainframe environment. With microcomputers and mainframes being used to distribute the final product, special attention must be paid to the production of a 'transportable' code. This paper describes some of the problems encountered when petroleum industry FORTRAN applications are moved from a mainframe to microcomputers and outlines a development environment that facilitates mainframe-to-microcomputer software migration. (Author abstract) 4 refs.

Seehafer, John A. (Amoco Production Co). *JPT J Pet Technol* v 39 n 12 Dec 1987 SPE 15289, p 1571-1575.

**077555 OIL & COMPUTERS: EXPLORATION.** The rapid expansion of geophysical and geological applications and the great need to reduce oil and natural gas finding costs have combined to encourage exploration companies to exploit computer technology to its fullest potential. One method to exploit computers that has gained wide acceptance is known as functional analysis, which generally is creation of a multi-department, multi-discipline task force to develop goals and evaluation criteria, evaluate available systems, and guide implementation of systems once they are purchased. Texaco U.S.A.'s geoscience technology department, for instance, used its own version of this approach to define the function to be provided. The result was a switch of its mainframe architecture late last year. The same method is being used by Mobil Exploration & Producing Services Inc. to select a new seismic processing package. And at Standard Oil Production Co., functional analysis was used in combining the computer support services for the company's exploration and production strategic business units.

Hagar, Rick (Oil & Gas Journal, Tulsa, OK, USA). *Oil Gas J* v 86 n 2 Jan 11 1988 p 42, 44-46.

**077556 COMPUTER USE ROCKETS AS ENGINEERS TRADE TOOLS FOR SOFTWARE.** Innovative new software programs range from numerical procedures for accurate downhole mechanics to expert system technology, providing rules or logic for fundamental problem solving. The expert system, a phase of artificial intelligence, is a set of computer programs coupled with a database to act as a human expert. Graphics programs now are also widely used in the industry. Computer work stations are finding a place in the engineering community, as well. The work station is a combination of software and hardware. There are several types of work stations from

stand-alone systems to mainframe dependents. Work stations dovetail with another growth area - integrated hardware and software systems. These integrated systems allow a group of programs to exchange data. Another means by which to exchange and gather data is the public-access dial-up network. The role of computers in the field is discussed along with the application of computers to reservoir analysis. 2 refs.

Moore, Steven D. (Petroleum Engineer Int, Dallas, TX, USA); Lindsey, Jennifer. *Pet Eng Int* v 59 n 12 Dec 1987 p 14-16.

**Contracts** See **OIL WELL DRILLING—Contracts.**

**Costs** See Also **ENERGY POLICY; OIL WELL PRODUCTION—Costs; PETROLEUM PROSPECTING—Economics.**

**077557 INCORPORATING CURRENT PRICES INTO LONG-TERM ENERGY FORECASTS: A MAXIMUM LIKELIHOOD, ADAPTIVE EXPECTATIONS APPROACH.** A maximum likelihood estimation procedure is applied to a simple adaptive expectations model of historically based long-term energy price forecasting to evaluate the appropriate weighting of current prices. Maximum likelihood estimates for five- and ten-year forecasts are produced, along with corresponding one-standard-deviation dispersions, and compared with both the ordinary least squares estimates prepared by Manne and Schrattenholzer (1986b) and the 1985 IEW Poll responses. Disagreement across poll respondents seems to understate the uncertainty reflected in efficient forecasts derived from historical price data. The averages of the poll responses are, in addition, higher than the corresponding likelihood estimates. (Author abstract) 7 refs.

Yohe, Gary W. (Wesleyan Univ, Middletown, CT, USA). *Resour Energy* v 9 n 2 Aug 1987 p 141-152.

**077558 OPEC'S RETURN TO FIXED OIL PRICING.** The system of international oil pricing has moved from one extreme to the other. It has either been very rigid, based on a market crude with a fixed relative price for all other crudes (i.e., fixed price differentials) or floating prices with each country free to set its price and output level. It is possible, however, to conceive of a pricing system that is responsive to the market forces, while providing control and avoiding chaos. Such a system would have a better chance of success than the highly inflexible system of fixed prices. In the paper this possibility is discussed and a conclusion presented. (Author abstract) 8 refs.

Samii, Massoud V. (OPEC). *Energy Policy* v 15 n 5 Oct 1987 p 421-431.

**Database Systems** See **INFORMATION RETRIEVAL SYSTEMS.**

**Economics** See Also **OIL FIELDS—Offshore; PETROLEUM PROSPECTING—Wisconsin.**

**077559 PROGRAM CALCULATES VOLATILITIES OF OIL FUTURES PRICES.** A program for an HP-41CX calculator has been developed that calculates the implied volatilities of commodity futures prices, including those for oil. Such data are useful to the oil industry for improving inventory strategies, the hedging of risk, and the evaluation of investment alternatives. The iterative program to solve for the expected volatility ( $v$ ) presumes that the exercise price, the expiration date of the option, the price of the option, and the price of the underlying futures are entered in that order. The assumptions on which the program is based are discussed, and the program and an application example are given. 3 refs.

Johnston, James L. (Amoco Corp, Chicago, IL, USA). *Oil Gas J* v 86 n 28 Jul 11 1988 p 82-84.

**077560 ENERGY AND ECONOMIC PROBLEMS IN THE OIL PATCH.** Among the most prominent effects of the energy industry's problems including record decline of oil prices and downturn of the energy industry,

are those revealed in business and bank failures. The 10 oil producing states surveyed are Alaska, California, Colorado, Kansas, Louisiana, New Mexico, North Dakota, Oklahoma, Texas and Wyoming. Economic indicators in the study included business failures, bankruptcy filings, unemployment rates, rotary drilling rig counts, reported drilling well completions, crude oil production rates and bank failures. Business failures continue to be heavy in the West South Central Region - which includes Texas, Louisiana, Oklahoma and Arkansas.

Anon. *Energy (Stamford Conn)* v 13 n 4 Sep 1988 p 25-26.

**Employee Training**

**077561 PROCESS SIMULATORS FOR OIL- AND GAS-PLANT OPERATORS.** Process simulators have been used for some years in the oil and gas industries. As a training device, the simulators allow the trainee to perform plant or platform operations under normal and abnormal conditions without risk to personnel, equipment, or production. Startup and commissioning phases of new plants and processes are shortened and proceed more smoothly because tasks have been rehearsed through simulation. This paper describes how simulator systems have been successfully integrated into an operator training program. (Author abstract) 2 refs.

Dempsey, J. (Arabian American Oil Co); Richardson, J.L. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 13739, p 276-280.

**Environmental Impact** See Also **ENVIRONMENTAL PROTECTION—Europe.**

**077562 BESTIMMUNG DES GEFAEHRDUNGSPOTENTIALS OELVERUNREINIGTER STANDORTE.** [Evaluating the Risk Potential of Oil Contaminated Sites: Current Assessment Methods]. Due to increasing environmental concern it is no longer accepted in Germany, to terminate industrial operations without investigating and cleaning up the site. Identification, valuation and clean-up of oil contaminated sites, however, has proved to be rather difficult, since most of the pollution problems were caused decades ago. This paper describes a decontamination management, consisting of a proven routine investigation strategy and a scheme for the relative rating of the risk potential from contaminated sites. (Author abstract) In German. 6 refs.

Zeschmann, Ernst-G. *Erdoel Kohle Erdgas Petrochem* v 40 n 6 Jun 1987 p 255-262.

**Ireland** See **OIL FIELDS—Ireland.**

**Land Reclamation**

**077563 MULTIPLE LAND USE - AN ESSENTIAL PART OF ENVIRONMENTAL PLANNING.** The Australian petroleum industry has been involved in environmental planning and has developed an awareness of multiple land use over the past twenty-five years, more particularly over the past decade. This is in accord with the World Conservation Strategy and the National Conservation Strategy for Australia upon which the Australian State and Territory conservation strategies are based. As the term implies, multiple land use means a sharing of the land. The range of uses includes reserves, heritage areas, agriculture, urban and suburban development and mining. This paper deals primarily with the restoration of the existing environment. Restoration is achieved by preserving, to the greatest extent possible, the vegetation and topsoil which are stripped from the development area. (Edited author abstract) 2 refs.

Butler, W.H. (Dinara Pty Ltd, Perth, Aust). *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 311-315.

**Legislation** See Also **PETROLEUM PROSPECTING—Australia.**

**077564 CAPITAL GAINS TAX IN THE PETROLEUM INDUSTRY.** Federal Labor Government has announced its intention to incorporate into the Australian



fiscal scene a capital gain tax. The tax is to be levied at marginal and corporate income tax rates on 100 per cent of inflation adjusted gains realised on assets acquired on and after 20 September 1985. There are substantial areas of uncertainty in the capital gains tax proposals generally, and in particular as they relate to the petroleum industry. The capital gains tax proposals outlined to date deal, superficially, with basic and very tangible property. (Edited author abstract)

Breckenridge, S. (KMG Hungerfords, Sydney, Aust). *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 23-30.

Losses

**077565 OIL LOSS, MEASUREMENT AND CONTROL.** Absolute accuracy in measurement is not achievable - it would be impossibly costly to even try. Oil loss is however important and a choice of appropriate measurement methods is essential, and the points at which they should be applied if the results are to have best effect for the expenditure involved. It is the purpose of this paper from the experience of others to highlight those areas of loss which are most significant compared with others where investment for reduction is less likely to pay out. 4 refs.

Anon (Inst of Petroleum, London, Engl). *Q J Tech Pap Inst Pet* Apr-June 1986 p 3-51.

**077566 COMPUTER AIDED LOSS INVESTIGATION AND MONITORING.** Computer aided loss control is particularly applicable for complex product distribution systems, where there are mixtures of static and dynamic measurements, continuous and batch transfers, long interterminal pipelines. Computer statistical analyses of historic data distinguishes between the relatively small systematic errors and the larger errors. Individual and overall measurement uncertainties can be readily estimated. Computer graphic display of control charts assist in the monitoring of individual plant and overall system reconciliation and in the interpretation of the results. (Edited author abstract).

Miles, J. (Moore, Barrett & Redwood Ltd); Jelffs, P.A.M. *Q J Tech Pap Inst Pet* Jan-Mar 1988 p 41-43.

**Marketing** See Also ENERGY RESOURCES—Economics.

**077567 PRICE OF OIL: LOWER AND UPPER BOUNDS.** The magnitude of the recent dramatic fall in oil prices has once again (like the rises of 1973 and 1979) taken most energy analysts and oil industry participants by surprise, creating even greater uncertainty about future developments in the oil market. We suggest that a return to first principles is appropriate at this time in order to help clarify the outlook. Two simple Hotelling-type models of the oil market are described - one of the perfectly competitive market, the other of a purely monopolistic market. These two models are used to derive lower and upper bounds on oil prices. A reinterpretation of the history of the oil market over the last 25 years is suggested, with some implications for the future course of oil prices. (Edited author abstract) Refs.

Morrison, Michael B. (Shell Int Petroleum Co, London, Engl). *Energy Policy* v 15 n 5 Oct 1987 p 399-407.

**077568 EXTERNAL DEBT AND OIL PRICES: SOME PROSPECTS FOR OIL-EXPORTING DEVELOPING COUNTRIES.** This article examines the extent to which selected oil-exporting developing countries can continue to depend on their major source of hard currency earnings to service their external debt in particular and to promote the process of future economic growth in general. The four countries under consideration are: Ecuador, Egypt, Indonesia and Nigeria. Incorporated into the study are alternative sets of assumptions regarding future oil output, export potential, future oil prices, external debt levels and future interest rates. Both the effects of the recently formulated Baker Plan and the collapse of oil prices are examined within this context.

(Author abstract) Refs. 25 refs.

Sohn, Ira (Montclair State Coll, Upper Montclair, NJ, USA). *Energy Policy* v 15 n 5 Oct 1987 p 408-420.

**Nigeria** See OIL SANDS—Solvent Extraction.

**Peoples Republic of China** See OIL FIELDS—Peoples Republic of China.

Personnel

**077569 OVERSEAS RECRUITING IN THE OIL AND GAS INDUSTRY - A CASE STUDY.** Early in 1982 CSR Limited established an Oil and Gas Division. By 1983 this Division had recruited twenty-six overseas technical personnel mainly from Canada and the United Kingdom. The Company needed to recruit overseas because the skills required were not available in Australia. During 1983 a review of the recruitment and settlement of these personnel and their families was undertaken. The objectives of this review were to: (i) improve the Company performance in the recruitment, induction and settlement of overseas recruits and their families; (ii) increase the likely 'length of stay' in Australia of overseas recruits and their families; (iii) address specific problems faced by recruits and their families in settlement in Australia. In depth interviews were conducted with twenty-one of the twenty-six recruits and their families using a structured interview format. (Edited author abstract)

Bogan, R. (CSR Ltd, Sydney, Aust). *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 134-142.

**Process Control** See DATA TRANSMISSION—Mathematical Models.

**Production** See SUPERCONDUCTING DEVICES—Applications.

**Research** See TECHNOLOGY—Economic and Sociological Effects.

Reviews

**077570 DEVELOPMENTS IN THE OIL REFINING AND PETROCHEMICAL INDUSTRIES.** The purpose of this paper is to review some of the major developments in the oil and petrochemical sectors and to speculate as to how the industries will develop over the next decade. Much of the substantial capacity surplus which was a problem to the oil refining and petrochemical industries during the 1970s and 1980s has been eradicated. However, it is unlikely that the processes of plant closures, companies restructuring and takeovers has finished. Within the oil sector, only Exxon and Shell look secure to maintain their business structure and strengthen their positions in the next decade. The oil companies of Kuwait and Saudi Arabia are likely to continue their progress and could be Exxon's and Shell's main rivals by the year 2000. (Author abstract). Refs.

Jenkins, Gilbert (Chem Systems Int Ltd). *Pet Rev* v 42 n 498 Jul 1988 p 36-39.

**United Kingdom** See OIL FIELDS—North Sea.

**United States** See Also ECONOMICS—Computer Simulation.

**077571 LOOK AT THE STATUS OF U.S. PETROLEUM.** Use of historical occurrences of petroleum in decision-making for future exploration must be made with care. Lithology, trap style, and reservoir age of the past are not good indicators of the future in nonfrontier areas; rather, they may suggest exactly opposite conclusions. Nonetheless, detrital reservoirs continue to be significant to exploration. Subdivision of the contiguous 48 states into petroleum provinces permits the generalization of regional characteristics and evaluation of future potential. This compilation illustrates the status of U.S. oil production and its vulnerability to fluctuations in both price and availability of risk capital.

Gerhard, Lee C. (Kansas Geological Survey, Lawrence, KS, USA); Graber, Lee A.; Brostuen, Erling A. *Oil Gas J* v 86 n 25 Jun 20 1988 p 73-76, 78.

**077572 GULF COAST REFINERS GAIN ACCESS TO MORE CALIFORNIA CRUDES.** Refiners east of the Rockies, particularly Gulf Coast refiners, have gained access to eastern and central California crudes with the opening of Celeron Corp.'s All American Pipeline (AAPL). Currently, AAPL is carrying a blend of California crudes with properties similar to Alaskan North Slope (ANS). Although the blend is of moderate gravity and sulfur content, it is comprised of crudes from several fields in California that display wide variations in quality. Future deliveries east from California will be from regions with even more extremes of quality. To familiarize refiners with the crudes that will become available, some of the properties of these California crudes are discussed, along with some of the problems refiners may encounter in processing these materials.

Vautrain, John H. (Purvin & Gertz Inc, Long Beach, CA, USA); Sanderson, William J. *Oil Gas J* v 86 n 28 Jul 11 1988 p 78-82.

**077573 US PETROLEUM INDUSTRY INCREASES ITS SPENDING ON FOREIGN EXPLORATION.** The US petroleum industry is spending money on foreign exploration and drilling at a faster rate than on any other area of spending. Part of the attraction is that the dollar per acre cost for finding commercial reserves is about 50-60 percent less in the underdeveloped countries than it is in the United States. Among the resources for foreign prospects commanding a growing share of US companies' capital spending are: current oil prices; economics of many foreign exploration and development prospects are more attractive; high production costs and the lack of accessible world class structures tending to outweigh the smaller political risk in the US vs. foreign countries; with the oil price collapse, many developing nations outside OPEC are improving contract terms with foreign companies.

Miskell, Jack T. *Energy (Stamford Conn)* v 13 n 3 Spring 1988 p 20-21.

**USSR** See NATURAL GAS—USSR.

Waste Disposal

**077574 WASTE MINIMIZATION IN THE PETROLEUM INDUSTRY.** This paper describes the petroleum industry and the products it makes along with their associated waste streams. The industry's commitment to waste minimization is described with examples of specific minimization projects provided. Although the opportunities for minimization are limited, the economic incentives for reducing waste disposal costs, not to mention long term liability from improper disposal practice, has put the petroleum industry on the road to waste minimization. (Edited author abstract) 16 refs.

Leemann, James E. (Conoco Inc, Houston, TX, USA). *JAPCA* v 38 n 6 Jun 1988 p 814-823.

**Wastes** See WASTEWATER—Treatment.

**PETROLEUM PIPELINES** See Also OIL WELL PRODUCTION—Heavy Oil; PETROLEUM, CRUDE—Rheology; PLATES—Steel.

**077575 TESTS EVALUATE EQUIPMENT TO LOCATE SUBSEA LINES.** Field tests of four pipe-locating sensors in the Gulf of Mexico indicate that a magnetic gradiometer array positioned by a remotely operated vehicle can locate either buried or exposed pipelines in water as deep as 900 m (2,952 ft). The tests led to recommendations for improvements in deployment equipment and operational procedures, especially for use in seas



up to 2 m. Four pipeline systems in the Gulf of Mexico were chosen as targets for evaluating the four sensors. 6 refs.

Bickham, K.L. (Shell Development Co, Houston, TX, USA). *Oil Gas J* v 86 n 23 Jun 6 1988 p 60-64.

**Accessories** See OIL WELL PRODUCTION—Sub-sea Production System.

## Accident Prevention

**077576 METHODS TO DETECT AND CONTROL SPILLAGES IN EUROPEAN OIL LINES - PART 1.** The following report outlines and compares the preventive measures taken and the current methods used to detect spillage from cross-country oil pipe lines, together with the emergency procedures to be implemented in the event of an incident. The factors such as product, pipe line size, length and type of operation are considered to determine the most appropriate application of spill prevention methods. The requirements for a pipe line are determined during the design phase by the owner(s) or operator and must meet any regulator authority requirements. A well-designed line, fit for the purpose of its specified duty and compatible with the environment it passes through, provides the basis for an efficient and safe system.

Brown, J.R. (CONCAWE Oil Pipelines Management Group, The Hague, Neth); Bianchini, M.; Lighthart, M.; Du Payrat, C. Noel; Whitmore, J.B. *Pipe Line Ind* v 67 n 5 Nov 1987 p 56, 58, 127.

## Canada

**077577 ALBERTA PIPELINE EXPANSION, CONVERSION MOVES HEAVY OIL TO CANADIAN AND U.S. MARKETS.** Expansion of Alberta Energy Co. Ltd.'s (AEC) Cold Lake pipeline system has allowed the economic and efficient transportation of increasing volumes of heavy oil from the Cold Lake and Wolf Lake areas in Alberta to markets in Edmonton, Eastern and Western Canada, and the U.S. A comprehensive construction program was planned and implemented. The program involved construction of a 610-mm (24-in.) OD pipeline to carry bitumen blend and the conversion of the existing 323.9-mm (12.76-in.) bitumen-blend pipeline to transport diluent. Some topics discussed are the following: the expansion program; displacement and linefill; Stage 1 (Ardmore to Bellis); Stage 2 (Bellis to Edmonton); Stage 3 (MLV-17 to the terminal); fabrication and installation; mainline-valve installation; and completion and linefill.

Zboya, T.M. (Canuck GIE Engineering Ltd, Calgary, Alberta, Can); Zakowski, J.R. *Oil Gas J* v 85 n 44 Nov 2 1987 p 44-48.

## Cathodic Protection

**077578 AUTOMATED DATA KEEPING FOR CATHODIC PROTECTION SYSTEMS.** The application used Framework, a multifunction software package, and Tricorder Companion, a communications program. The hardware consists of a personal host computer housed in All American Pipeline (AAPL's) operations headquarters and tricorders used by technicians in the field. Each test site is set up as a database which is printed out in the form of a data sheet. This data sheet includes pertinent test site information such as location, test station type and a complete history of readings. The program has a feature that can plot a graph of the latest cathodic protection readings for any given section of the pipe line on any scale specified. Data entry is fairly simple and can be performed manually or automatically.

Webb, Tom (All American Pipeline Co, Bakersfield, CA, USA); Sandoval, Sandy. *Pipe Line Ind* v 68 n 6 Jun 1988 p 15-16.

**077579 METHODOICAL APPROACH KEY TO CATHODIC-PROTECTION EVALUATION.** Effective pipeline-maintenance procedures depend on a methodical approach to evaluating the cathodic-protection (CP) system and coating integrity. These procedures are critical

in reducing corrosion failures and resulting costly repairs. An evaluation should include a CP-system audit, a coating-defect survey, a CP-potential survey, an interpretation of results, and necessary remedial action. Various coating and potential survey methods currently utilized are compared and their effectiveness under differing conditions noted in this final part of a four-part series on pipeline protection. 5 Refs.

Davies, P. *Oil Gas J* v 86 n 31 Aug 1 1988 p 40-43.

## Compressor Stations

**077580 VIBRATION ANALYSIS KEY TO COMPRESSOR FOUNDATION MAINTENANCE.** Vibration results from unbalanced forces generated by the machines resting on these foundations. The stress which results from this vibration in turn leads to fatigue which causes cracking. An excellent way to investigate fatigue is through close scrutiny of maintenance and daily operating records. Any change in the operating conditions from those for which a foundation was designed can nullify the predicted performance of the foundation, nullify the initial design computations and lead to excessive vibration, the shortening of fatigue life, and the eventual failure of the foundation. This article discusses foundation cracking, oil seepage, multiple compressors, sand cushion and rock foundations, and other aspects of the subject. 11 Refs.

Watson, W.D. (Watson & Associates, Midland, TX, USA). *Oil Gas J* v 86 n 32 Aug 8 1988 4p.

## Computer Applications

**077581 BATCH TRACKING REFINED PRODUCTS BY COMPUTER.** Explorer Pipeline's computers are configured with SCADA, batch tracking and stock accounting on the primary computer with other applications programs on the secondary. A 'watch dog' routine monitors the operation of the SCADA computer to determine its status and will automatically switch SCADA operations to the secondary computer in the event of failure. Data are continuously transmitted from the primary to the secondary via a high speed computer-to-computer data link, including dynamic batch tracking and ticket information. Once each day all data files are backed up to magnetic tape for security, recovery and historical purposes.

Mauer, Wallace J. (Explorer Pipeline Co, Tulsa, OK, USA). *Pipe Line Ind* v 68 n 6 Jun 1988 p 17-18.

## Construction

**077582 ENTREPOSE INSTALLS EGYPTIAN CRUDE TRUNKLINE SYSTEM.** The latest crude trunkline construction project to be completed is Agiba Petroleum Co.'s 166-km (103-mi) line between wells in the Meleha concession to a shipping terminal at El Hamra. Construction problems on the project resulted from the short time available to supply materials, mobilize equipment and personnel and move in and set up construction camps in the rocky western desert. Location, terrain and soil conditions also were major sources of construction problems. Corrosion protection was furnished, according to DIN 30670, by an application of fusion bonded epoxy coating, which was covered by Mannesmann polyethylene coating. Field welding was done manually using stick electrodes to join the .375-in. WT line pipe.

Lafarge, G. (Entrepose Int, Levallois-Perret, Fr). *Pipe Line Ind* v 67 n 5 Nov 1987 p 60.

**077583 UNDERSEA UNDERGROUND.** Exploitation of the Oseberg oil field in the Norwegian sector of the North Sea has produced new problems and new answers. To ensure that the line will carry safely the 600,000 barrels a day of its estimated capacity, Norsk Hydro has had to develop new welding and maintenance techniques. A remote controlled system has been evolved which represents a significant step towards introducing robot technology into deep water welding. Another first for Oseberg is the use of the newly built Petrojarl 1 production ship. Petrojarl's initial job will be to monitor the behavior of the

oil reservoir, through long-term testing of two wells, enabling better positioning of production wells for future development. A description of Phase I development of Oseberg is presented.

Anon. *Int Constr* v 26 n 12 Dec 1987 p 18-19.

## Control

**077584 TELECONTROL SYSTEM FOR A MULTI-PRODUCTS PIPELINE.** The operation of a multi-products pipeline is complex. This article describes a telecontrol system that was implemented to automate such a pipeline. (Edited author abstract) 2 refs.

Hallas, J.M. (South African Transport Services). *Elektron (Johannesburg)* v 4 n 9 Sep 1987 p 5-7.

**077585 ARCO ENSURES SYSTEM RELIABILITY.** Arco Pipe Line Co., a subsidiary of Atlantic Richfield Co., operates crude oil gathering lines, trunk lines and refined products pipelines. Movement of crude oil and products through the South and Southwest requires regulation of pipeline pump sequencing, line pressures, tank volumes and product metering. The Arco control center at Independence, Kans., is headquarters for the entire pipeline control network. The control network has three principal elements: the telecommunications system, the supervisory control and data acquisition system and the control center itself. Each is protected from a loss of power.

Anon. (Pipeline & Gas Journal, Cleveland, OH, USA). *Pipeline Gas J* v 214 n 11 Nov 1987 p 35-36.

**077586 HOW SUN PIPE LINE HANDLES MEASUREMENT MANAGEMENT.** The Eastern area supervisory control and data acquisition (SCADA) system of Sun Pipe Line Co. allows the dispatchers in Wayne, Pa. to control 1,500 mi of common carrier products pipe line having 36 delivery facilities with 187 tanks, 19 pump stations, two transfer systems and a total of 42 meters. Every hour the SCADA computer transfers data via an inter-computer link to the operations control computer. The manned locations use a remote terminal device to send their data directly to the operational control computer. The trend within SPL has been toward a higher integration in operational systems which includes scheduling, meter factor management and ticketing.

Jarvis, Larry D. (Sun Pipe Line Co, Wayne, PA, USA); Sells, Christian; Western, Philip D. *Pipe Line Ind* v 68 n 6 Jun 1988 p 22-24.

**077587 TEXAS EASTERN'S NEW SCADA SYSTEM USES DECENTRALIZED STRUCTURE FOR EFFICIENCY.** Texas Eastern Products Pipeline Co.'s new supervisory control and data-acquisition (scada) system, currently in the final stages of installation, speeds data flow and improves interaction between the operator and the pipeline system. Texas Eastern installed its first computerized scada hardware and software in 1975. The new system provides faster processing, graphics capabilities, alarm, and back-up systems necessary to enhance the pipeline's efficiency and its response to customer needs. With the SCADA system, which the article describes, Texas Eastern controls and monitors shipment of an average 414,000 b/d of refined petroleum products and LPG.

Moore, G.E. (Texas Eastern Products Pipeline Co, Houston, TX, USA). *Oil Gas J* v 86 n 32 Aug 8 1988 p 33-36, 38.

## Control Systems

**077588 DEPARTMENT OF ENERGY AUTOMATES STRATEGIC PETROLEUM RESERVES.** The U.S. Department of Energy (DOE), is automating the process control system for the major Strategic Petroleum Reserves (SPR), located along the Gulf Coast of Texas and Louisiana. Each of these crude oil storage facilities is being equipped with a Coggins Systems Series 8100 Distributed Control System. This system is programmed for automatic operation, while affording ease-of-user interface through color graphics process display terminals



(operator's terminals). Under normal operations, a single operator is able to manage an entire facility. Complex control operations require only function selection and initiation through simple keystrokes with the aid of process display menus.

Stiles, Robert E. *Pipe Line Ind* v 67 n 6 Dec 1987 p 23-24, 29.

## Corrosion

**077589 MECHANISMS AND CONTROL OF MICROBIOLOGICAL CORROSION IN PETROLEUM INDUSTRY.** Microbiological corrosion is a severe problem in the petroleum industry. Cathodic protection is usually applied for minimizing the loss of microbiologically induced corrosion. But bacteria can thrive where the potential of the system is less than  $-0.85V$  vs  $Cu/CuSO_4$  electrode. In this review article, the mechanisms of microbiological corrosion of mild steel, stainless steel, aluminum alloys, copper alloys and cathodically protected pipelines have been described in detail. Procedures have been outlined for the location of microbiological growth along the buried pipeline route. Various methods have been described for the control of microbiological corrosion for the onshore and offshore installations. (Edited author abstract) 18 refs.

Chatterjee, S.S. (Project & Development India Ltd, Dhanbad, India); Banerjee, K.C. *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 1, p 717-726.

## Corrosion Protection

**077590 PIPELINE PROTECTION - 1. COMBINATION OF CORROSION-SURVEY METHODS IMPROVES PROTECTION.** Combining the three most widely used above-ground-survey procedures for evaluating coating integrity and cathodic protection adequacy can overcome the technical and economic penalties of choosing a single survey method. A review of each method and of several case histories shows how the procedures complement each other. 4 refs.

Allen, M.D. (Spencer & Partners, London, Engl); Barnes, N.R. *Oil Gas J* v 86 n 9 Feb 1988 p 59-60, 62-64.

**077591 COATINGS TO RETROFIT IN-SERVICE PIPE LINES.** Repairing coating failures on in-service lines, which are caused for several reasons, can be accomplished with time-consuming and expensive procedures. The authors describe how a new two-part coating system has been used successfully on several locations. They also describe how retrofitting coatings on loaded lines can be easily accomplished. 2 refs.

Wallace, B. (Raychem Corp, Menlo Park, CA, USA); Van Hooff, W. *Pipe Line Ind* v 68 n 3 Mar 1988 p 50-51, 53.

## Design See PIPELINES—Offshore.

## Earthquake Resistance

**077592 DESIGNS FOR BURIED PIPELINE CAN REDUCE SEISMIC HAZARDS.** Pipelines usually cross a variety of soil conditions, some of which could pose a danger when subjected to seismic movement. The more common ground-failure hazards associated with seismic events, including faults, liquefaction, densification, and landslides are discussed in this article. Current design practices to limit seismic damage include locating the pipeline away from active faults, steep hillsides, and soft soils; increasing the flexibility of the system by use of more ductile materials and providing "fail-safe" systems at sites where damage may be anticipated. 15 refs.

Whitelaw, Joseph A. (Southern Pacific Pipe Lines Inc, Los Angeles, CA, USA); Reppond, Dennis W. *Oil Gas J* v 86 n 42 Oct 17 1988 7p.

## Economics

**077593 SCIENCE, ENGINEERING AND ECONOMICS: OR AT THE INTERFACE.** Engineers designing submarine oil-pipeline systems for the Beaufort Sea need to know how deep to bury them. Scientists studying ice scour have a major input into this decision; so do the economics of burying and pipeline failures. An operational researcher was asked to examine the way these aspects can be treated and the way they can be fitted together. This paper describes the resulting study, to illustrate how operational research might help in other interfacing contexts. (Author abstract) 11 refs.

Chapman, C.B. (Univ of Southampton, Engl). *J Oper Res Soc* v 39 n 1 Jan 1988 p 1-6.

## Environmental Impact

**077594 SOCIOENVIRONMENTAL IMPACTS OF PANAMA'S TRANS-ISTHMIAN OIL PIPELINE.** The Trans-Panama Oil Pipeline is an illustrative case study of environmental mismanagement. The project was approved and completed in 1981-1982 before submission of an environmental impact assessment. The environmental studies are seriously flawed by a number of omissions. Baseline studies of petroleum hydrocarbons in the marine ecosystems were not performed. Serious attention was not given to the possibility of a land spill or degradation of terrestrial ecosystems. The socioeconomic considerations of locating the pipeline and adjacent road through the watershed of a major hydroelectric project, as well as through the homelands of the Guaymí Indians, were ignored. As national planners guide the development of Panama's infrastructure, they can ill-afford to continue to ignore social, economic, and environmental considerations. (Author abstract) 58 refs.

Suman, Daniel O. (World Coll West, Petaluma, CA, USA). *Environ Impact Assess Rev* v 7 n 3 Sep 1987 p 227-246.

## Expansion Joints

**077595 RUBBER EXPANSION JOINTS.** Pipeline dynamics can create stresses and strains that may cause damage ranging from aggravating minor leaks at the flanges to major ruptures that require lengthy service interruptions and repairs. Rubber expansion joints and pipe connectors provide flexibility that protects pressurized systems from damage caused by the almost constant movement in piping systems. A flexible expansion joint also acts as an efficient isolator that absorbs vibration and deadens noise as well as compensating for minor misalignment of pipeline sections.

Magner, Ray (Vibration Mountings & Controls Inc, Bloomington, NJ, USA). *Pipeline Gas J* v 215 n 3 Mar 1988 p 30, 32-33.

## Failure

**077596 PETROLUL PIERDUT PRIN DEFECTELE CONDUCTELOR. [Oil Losses Due to Pipeline Failure].** During the oil pipeline transport certain failures may occur through which oil or oil products are leaking to the surface. The presence of porous media over a pipeline failure reduces the leakage rate through an orifice, as compared to the situation when the same orifice would be open. (Author abstract) In Romanian. 3 refs.

Stan, Al. D. (Inst de Petrol si Gaze Ploiesti, Rom). *Mine Pet Gaze* v 38 n 3 Mar 1987 p 147-149.

**077597 NORTHEAST U.S. PRODUCTS LINE UPGRADED AFTER MAJOR LINE BREAK.** Failure at the toe of the fillet weld of a full encirclement repair sleeve resulted in a major petroleum-product spill in a heavily populated and traveled part of the Eastern U.S. The first indication of this was at 9:55 a.m., Oct. 7, 1986, when the recording charts at Sun Pipe Line Co.'s Twin Oaks, Pa., pump station indicated a pressure drop and a flowrate increase on the 14-in., east line high-pressure petroleum-products pipeline. At 10:04 a.m., the line was

shut down. An investigation of the failure and cause led Sun Pipe Line Co. to remove all sleeves which had been installed on its 14-in., 110-mile East Line. A project-management team was assembled and a shutdown of the entire line to complete the repairs was organized. During the 36-day shutdown, 97 sleeves were located and removed, 19 mainline valves were reconditioned, and other line improvements made at a cost of nearly \$6 million.

Cross, T.F. (Sun Pipe Line Co, Wayne, PA, USA); Robertson, C.A. *Oil Gas J* v 86 n 7 Feb 15 1988 p 35-38, 40.

## Flow

**077598 NEW PRESSURE-DROP, HOLDUP EQUATIONS AGREE WITH FIELD DATA.** New equations for pressure drop and holdup in a two-phase pipeline not only show good agreement with a broad range of large-diameter data but also can be easily applied. These equations are based upon a fundamental model for both pressure drop and liquid holdup. And they are compared to large-diameter field data encompassing a wide range in operating parameters. 11 refs.

Barnette, John A. *Oil Gas J* v 85 n 52 Dec 28 1987 p 103-104, 106-108.

**077599 SLURRIES AND EMULSIONS OF WAXY AND HEAVY CRUDE OILS FOR PIPELINE TRANSPORTATION OF CRUDE OIL.** The high viscosity of many asphaltic crude oils and the high pour points of many waxy crude oils present significant problems in their transportation over long distances by pipeline and tanker. A possible solution which we have studied in the laboratory is the emulsification or dispersion of the oil in water or brine so that shear takes place in the continuous aqueous phase rather than the oil droplets or particles. Synthetic waxy crude oils were prepared by dissolving paraffin wax in white mineral oil at slightly elevated temperatures and then measuring the pour point. One containing 30% wax had a pour point of 43°C and was selected for preparations of the dispersions. This was emulsified in water at a temperature higher than the pour point by using a suitable surfactant as an emulsifying agent. (Edited author abstract) 5 refs.

Marsden, S.S. (Stanford Univ, Stanford, CA, USA); Ishimoto, Kiyoshi; Chen, Lidian. *Colloids Surf* v 29 n 1 Jan 15 1988, Emulsification and Demulsification, Apr 1986 p 133-146.

## Heating

**077600 SOME CONSIDERATIONS ON A NEW OIL TRANSPORTING SYSTEM USING THE MAGNETIC COAXIAL PIPE.** A discussion is made on a new oil transporting system using magnetic coaxial pipe concerning its electrical characteristics and the experimental results on a 150m length test pipeline. When magnetic coaxial pipe is used as a heater, the heat generation occurs uniformly and the voltage of the outside of the coaxial pipe is sufficiently low to be electrically safe even when the frequency is low. This system is applicable to long distance submarine pipelines. 2 refs.

Hojo, H. (Nippon Kokan KK, Kawasaki, Jpn); Nagamune, A.; Murakami, K. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3281-3283.

## Inspection

**077601 INTELLIGENT PIGS PROVE VALUABLE.** Pipeline operators in various parts of the world are beginning to evaluate a service for locating corrosion and mechanical damage in high-pressure oil and gas pipelines. Originally developed by British Gas to inspect its domestic U.K. gas pipeline network, the technique of using intelligent pigs with onboard processing computers to pinpoint flaws is commercially available to pipeline operators both onshore and offshore. The full range of pigs covers pipelines between 8- and 48-in.

Shannon, R.W.E. (British Gas plc, Cramlington, Engl).



Pipeline Gas J v 214 n 10 Oct 1987 p 14-16.

**077602 FLUX-LEAKAGE VEHICLES PASS TESTS FOR PIPELINE INSPECTION.** Tests of pipeline-inspection equipment based on principles of magnetic flux leakage have shown it to be capable of routine maintenance and to provide technical and economic advantages over hydrostatic testing. The equipment accurately locates and describes metal-loss defects and enables a pipeline's condition to be determined before a feature becomes critical. Further, equipment capable of detecting and sizing a range of different stress-corrosion cracking (SCC) geometries and types has also been developed and prototypes successfully evaluated during live gas tests in operating pipelines. The article discusses two additional vehicle systems developed by British Gas plc at its On Line Inspection Centre. The vehicles can detect and size external stress-corrosion cracking and survey offshore pipelines for weight-coating damage or loss of seabed cover. They have reached the prototype development stage and are currently undergoing performance evaluation in operating pipelines. 8 Refs.

Shannon, R.W.E. (British Gas plc, Cramlington, Engl); Braithwaite, J.C.; Morgan, L.L. *Oil Gas J* v 86 n 32 Aug 8 1988 7p.

#### Instrumentation

**077603 ELECTRICAL AND INSTRUMENTATION FEATURES OF THE CORTEZ AND CHOCTAW CO<sub>2</sub> PIPELINES.** Pipelines transporting CO<sub>2</sub> to crude-oil-producing fields for tertiary recovery injection are a relatively novel segment of the pipeline industry. An affiliate of the Shell Oil Company has participated in two major pipelines for this service. The electrical and instrumentation features of these pipelines are discussed. 1 ref.

Wilson, J.E. (Shell Oil Co, Houston, TX, USA); Bried, Frederick. *IEEE Trans Ind Appl* v 1A-23 n 6 1987 p 1077-1083.

#### Insulation

**077604 INSULATING GATHERING LINES.** A California pipeline contractor relied on its 40 years of experience to meet an unusually tight deadline on job. Isotherm Co. Inc., Bakersfield, installed more than 1 million linear ft of fiberglass pipe insulation on 2- and 3-in. crude oil gathering lines at the Belridge oil field in Kern County, Calif. The project, which involved insulating 200 miles of pipeline, was completed in 7 months. ?

Anon (Pipeline & Gas Journal, Cleveland, OH, USA). *Pipeline Gas J* v 215 n 3 Mar 1988 p 22-23.

**Interface Separation** See ELECTROSTATICS—Electric Charge.

**Laying** See Also PIPELINES, SUBMARINE—Earthquake Resistance; PIPELINES, SUBMARINE—Laying.

**077605 SEA-BOTTOM FORCES CRUCIAL IN PIPELINE CROSSINGS DESIGN.** Designing for sub-sea pipeline installation in certain regions of the world often implies crossing several existing pipelines or cables in operation. Careful attention to such contingencies can ensure a safe and a cost-effective installation. Economical and safe design of submarine pipeline crossings varies with the environmental conditions, pipeline characteristics, and construction means. The purpose of the article is to focus on the fundamental points of design. 11 refs.

Friedmann, Yves (Omnium Technique des Transports par Pipelines, Montreuil, Fr). *Oil Gas J* v 86 n 26 Jun 27 1988 p 47-50, 52-53.

#### Leak Detection

**077606 MAJOR PIPELINE INSTALLS SYSTEM TO PINPOINT LEAK SIZE, LOCATION.** Williams Pipe Line Co.'s recently installed leak-detection system can provide full time early warning protection. It is based on a modeling system whose software package lies at the heart of the leak-detection scheme. This paper describes

the equipment developments, operating constraints and modeling techniques used for this project.

Mears, M.N. (Williams Pipe Line Co, Tulsa, OK, USA). *Oil Gas J* v 86 n 15 Apr 11 1988 p 37-43.

**Legislation** See PIPELINES—Environmental Impact.

#### Maintenance

**077607 METHODS TO DETECT AND CONTROL SPILLAGES IN EUROPEAN OIL LINES - PART 2.** This concluding installment discusses more design and construction features for liquid lines that will reduce spillages. Design features, leak detection and other preventive measures minimize environmental damages. Emergency measures to minimize such damages are presented.

Brown, J.R. (Concawe Oil Pipelines, The Hague, Neth); Bianchini, M.; Ligthart, M.; du Payrat, C. Noel; Whitmore, J.B. *Pipe Line Ind* v 67 n 6 Dec 1987 p 30-32.

**077608 PIPELINE REPAIR SYSTEM TESTED IN ENGLAND.** To enable divers to gain longer work periods with improved protection during emergency pipeline repairs, engineers at the Engineering Research Station of British Gas plc (ERS) have conducted trials on the use of protective cofferdams that would be sunk into the seabed around the pipeline. The work was carried out to support the offshore activities of the exploration companies of British Gas. Once each cofferdam is in place, seabed materials, including pipeline cover, are removed from the inside to leave the diving teams with an accessible pipeline inside an enclosure protected from tides, currents, and shifting seabed materials. RS consulted dredging specialists, Alluvial Mining Ltd., who offered the use of a jet pump based on their AMROD remotely operated dredge to remove the seabed materials.

Anon. *World Dredging Mar Constr* v 23 n 11 Nov 1987 p 26-27.

#### Materials

**077609 FIBERGLASS LINE PIPE REQUIRES SPECIAL CARE.** Following a brief discussion of the methods for manufacturing fiberglass line pipe, the author examines joining methods, pipe design, cyclic pressure service and in-service failures. Factors that warrant consideration when installing fiberglass pipe are outlined. Operation of fiberglass systems is also briefly discussed.

Oney, Charles L. (Cities Service Oil & Gas Corp, Tulsa, OK, USA). *Pet Eng Int* v 59 n 11 Nov 1987 p 34-36.

**Mathematical Models** See Also PETROLEUM, CRUDE—Rheology.

**077610 IMPROVED MODEL FOR START-UP OF PIPELINES CONTAINING GELLED CRUDE OIL.** A sophisticated model has been developed to predict the time necessary to start-up and clean-out a pipeline full of gelled crude oil after an operational or emergency shut-down. Velocities and pressures were obtained, using the momentum and continuity equations, as a function of time, radial and axial positions. It was found that the model predicts clearing times significantly shorter than the simple model of Sestak. Further, the model can determine if compressible gels with high yield stress can, in fact, be cleared from the pipeline. Thus, the algorithm provides much more insight into the problem than the earlier work. (Edited author abstract) 11 refs.

Cawkwell, M.G. (Univ of Toronto, Toronto, Ont, Can); Charles, M.E. *J Pipelines* v 7 n 1 Nov 1987 p 41-52.

#### Measurements

**077611 HOLDUP, PRESSURE-LOSS CALCULATIONS CONFIRMED.** This final Part of three articles concludes comparisons of performances of several pressure loss and holdup correlations, including those proposed in Part 1 (OGJ, Mar. 14, p. 55), against field data taken from two large-diameter gas and gas-condensate

pipelines. This comparison began in Part 2 (OGJ, Mar. 21, p. 78). The comparison refers to the Marlin Pipeline, a 107-km (65-mile), 20 in. line with a liquid/gas ratio of 360 cu m/MMcu m (65 bbl/MMscf). 10 refs.

Baker, A. (Baker Jardine & Associates, London, Engl); Nielsen, K.; Gabb, A. *Oil Gas J* v 86 n 13 Mar 28 1988 p 44-46, 48, 50.

#### New York

**077612 PROPANE PIPELINE RESTORATION.** When Texas Eastern Products Pipeline determined it needed to rehabilitate a 165-mile segment of an 8-in. liquid propane pipeline between Watkins Glen and Selkirk, N.Y., the company was faced with a dilemma. The problem was how could propane deliveries to two of the system's common-carrier terminals be continued during the repair period. The article describes the solution.

Mumper, James A. Jr. (Texas Eastern Products Pipeline Co, Watkins Glen, NY, USA). *Pipeline Gas J* v 215 n 3 Mar 1988 p 12-13, 15-16.

**Nondestructive Examination** See OFFSHORE STRUCTURES—Nondestructive Examination.

**Offshore** See Also PIPELINES, SUBMARINE—Insulation; TUNNELS AND TUNNELING.

**077613 FIRST OIL PIPELINE TO NORWAY CROSSES NORWEGIAN TRENCH.** Norsk Hydro has laid the first oil pipeline from North Sea fields to Norway last summer as part of the Oseberg transportation system. The line was hydrostatically tested last fall in preparation for start-up next year. This article discusses the trench crossing approach tunnel, storage caverns, repair system, and other aspects of the subject.

Johnsrud, Paul (Norsk Hydro AS, Oslo, Norw). *Oil Gas J* v 86 n 18 May 2 1988 4p between p 35-42.

**077614 PIPELINES FOLLOWING EXPLORATION IN DEEPER GULF OF MEXICO.** Gulf of Mexico pipeline construction has been falling off sharply for shallow-water areas, while construction for middle-depth and deepwater areas has been holding steady. These trends are evident from analyses of 5-year data compiled by the U.S. Department of Interior (DOI) Minerals Management Service (MMS). This article continues a series of updates based on MMS gulf-pipeline data. These installments track construction patterns in water depths, diameter classifications, and mileage. The figures are also evaluated in terms of pipeline-construction cost data published in *Oil & Gas Journal's* annual Pipeline Economics Reports.

True, Warren R. *Oil Gas J* v 86 n 27 Jul 4 1988 p 27-32.

**077615 PIPELINES FOR SUBSEA OIL AND GAS TRANSMISSION.** Pipelines in some form or other are the essential link between offshore oil and gas production facilities and the onshore users. Be they seabed, seabed trenched, interfield, onshore transport, or transport to offshore loading facilities, all operations are dependent on the effectiveness and integrity of the transmission pipeline. Fifteen years experience in the North Sea has seen in excess of 150 subsea oil and gas pipelines installed in the UK sector extending for a total length exceeding 4000 km. At the time of writing, no hazard or incident has arisen from these installations. An overview of the important technical issues that need to be considered to ensure safe design, installation, and operation of pipelines for North Sea service is presented. (Author abstract). 33 Refs.

Parlane, A.J.A. (Bristoil plc, Glasgow, Scotl); Still, J.R. *Mater Sci Technol* v 4 n 4 Apr 1988 p 314-323.

#### Personnel Training

**077616 COMPUTER-BASED TRAINER.** Interprovincial Pipe Line Ltd., together with its wholly owned subsidiary Lakhead Pipe Line Co., operates 6,200 miles of trunk pipelines for the transportation of crude oil, refined products, natural gas liquids and other liquid



petroleum hydrocarbons. Control centers at Edmonton, Superior, Wisc., and Samia, Ont., operate 10 separate pipelines using a SCADA system communicating with remote terminal units at various pump stations. The article discusses a computerized trainer for pipeline dispatchers.

Lin, James H. (Interprovincial Pipe Line Ltd, Edmonton, Alberta, Can); Rachford, Henry H. Jr.; Weber, Mark V. *Pipeline Gas J* v 215 n 3 Mar 1988 p 18,20.

## Protection

**077617 METHODS OF PREVENTION, DETECTION AND CONTROL OF SPILLAGES IN WEST EUROPEAN OIL PIPELINES.** This report reviews the causes of spillage from operating cross-country oil pipelines and discusses the current practice in spillage prevention, detection and control. Performance data for the past fifteen years shows that the rate of spillage has continued to be extremely low. Data on spillages is recorded by CONCAWE and this knowledge assists in the continuous efforts to improve on the performance and minimise the effects on the environment. Spillages are prevented by competent design, careful construction, rigorous inspection and efficient operation. (Edited author abstract) 1 ref.

Bown, J.R. (CONCAWE); Bianchini, M.; Lighthart, M.; Noel du Payrat, C.; Whitmore, J.B. *Q J Tech Pap Inst Pet* Oct-Dec 1987 p ia-23.

## Protective Coatings

**077618 PIPELINE COATING PERFORMANCE - FIELD EXPERIENCE OF AN OPERATING PETROLEUM COMPANY.** The performances of various kinds of coatings used to protect buried and offshore pipelines and risers are presented through case histories experienced by the authors' company. Bituminous enamels, tapes and heat-shrinkable sleeves, polyethylene, fusion bonded epoxy polyamide, polymer cement compounds, glass fiber reinforced epoxy, and rubbers are the coating families considered. The general behavior and failures or problems encountered are reviewed for each. Current choices and future trends for pipeline coating selection are given in relation to laying and operating conditions. (Edited author abstract) 31 refs.

Roche, M. (Soc Natl Elf Aquitaine, Paris La Defense, Fr.); Samaran, J.P. *Mater Perform* v 26 n 11 Nov 1987 p 28-34.

**077619 METHOD TESTS EFFECTS OF HEAT ON FBE PIPELINE COATINGS.** A new procedure for testing elevated-temperature cathodic disbondment (C.D.) in fusion-bonded epoxy (FBE) pipeline coatings appears consistent and reliable. Further, its results question C.D. theories that fail to account for effects at above-ambient temperatures. The work to develop this procedure also included experiments that demonstrated how the relative performance of coating systems - especially FBE line-pipe coatings operated at elevated temperature - could not be predicted from ambient-temperature assessment. 9 refs.

Higgins, G.L. (Ardrox Pyrene Ltd, Iver, Engl); Bates, C.R. *Oil Gas J* v 86 n 25 Jun 20 1988 p 62-65.

## Pumping Stations

**077620 SEMIOPTIMAL CONTROL OF UNSTEADY LOAD-NODE REGIMES FOR OIL-PUMPING STATIONS.** A solution is proposed for the multicriterion problem of optimizing transient-regime control for load nodes of an electric-drive oil-pumping station, allowance being made for the hierarchy and variation of objective conditions. A method is indicated for coordination of inconsistent optimality criteria; a realization is shown for coordinate-parametric control with the aid of a regulator having variable structure. (Author abstract) 9 refs.

Borisov, R.I.; Kostyshin, V.S. *Power Eng (New York)* v 25 n 4 1987 p 112-115.

## Repair

**077621 MODELS AID PIPELINE-REPAIR WELDING PROCEDURE.** Improved welding procedures to repair a pressurized pipeline can now be designed with the use of computer models of the welding process. These procedures can reduce the chances of burnthrough or heat-affected zone cracking. The models were developed by Battelle Columbus Division from research sponsored by several major petroleum liquids and natural-gas pipeline operating companies. The key to correct design of procedures for welding on live pipelines as embodied in the Battelle project was the computer modeling of the heat input and heat dissipation associated with the welding process. Two models were developed, one for the fillet weld joining the end of a full-encirclement sleeve to the carrier pipe and one for the groove weld around a branch pipe to carrier pipe juncture. 8 refs.

Keifner, John F. (Battelle Columbus Div, Columbus, OH, USA); Fischer, Robert D. *Oil Gas J* v 86 n 10 Mar 7 1988 p 41-47.

## Research

**077622 PETROLEUM PIPELINE RELATED RESEARCH REVIEWED.** Multiphase production systems, pipeline erosion and corrosion, and valve testing and evaluation, are subjects of wide industry interest. This paper reviews these areas of petroleum pipeline related research. Among the topics examined are: multiphase flow; multiphase flow in risers; multiphase meters; multiphase pumping; the development of corrosion inhibitor packages and techniques for assessing them; valve development and evaluation; and factors to consider in valve selection. 5 refs.

Harrison, D. (BP Int, Sunbury-on-Thames, Engl). *Pet Rev* v 42 n 495 Apr 1988 5p.

**077623 PETROLEUM PIPELINE RELATED RESEARCH REVIEWED.** Multiphase production systems, pipeline erosion and corrosion, and valve testing and evaluation, are subjects of wide industry interest. This paper reviews these areas of petroleum pipeline related research. (Author abstract) 5 Refs.

Harrison, D. (BP Int, Sunbury-on-Thames, Engl). *Q J Tech Pap Inst Pet* Apr-Jun 1988 p 63-67.

## Scotland

**077624 PIPELINE ROUTING - EXPERIENCES FROM NORTHERN SCOTLAND.** The author, from Aberdeen University's Centre for Environmental Management and Planning, discusses the manner in which the nine major hydrocarbons pipelines in Scotland have been planned and how they affect the environment. He concludes that although there has not been a clear pipeline routing policy, one of Scotland's largest civil engineering programmes has progressed with minor impact thanks to continued negotiation and discussion between all the parties involved. (Author abstract) 17 refs.

Ryder, Alan (Univ of Aberdeen, Scotl). *Pipes Pipelines Int* v 32 n 3 May-Jun 1987 p 5-12, 13-14.

## Stresses

**077625 PREVENTIVE MEASURES TO AVERT CRUDE LINE SUBSIDENCE.** Longwall coal mining has affected Capline's 40-in. crude pipe line that operates from Louisiana to Patoka, Ill. The affects and corrective measures taken to properly support Capline during a four panel, longwall mining operation are outlined. Preventive action is focused on two distinct pipe line concerns caused by the subsidence. The first is soil friction forces acting on the surface of the line which could cause tensile failure. The second concern is ground subsidence curvature exceeding the critical bending radius of the pipe which could cause a buckling failure.

Wallace, M.R. (Shell Pipe Line Corp, Houston, TX, USA). *Pipe Line Ind* v 68 n 6 Jun 1988 p 19-21.

## Structural Analysis

**077626 PIPELINE INTEGRITY ANALYSIS AND MONITORING SYSTEM SHOWS DEFORMATION BEHAVIOR.** A pipeline analysis and monitoring system developed and field tested by Nova Corp. of Alberta has achieved close agreement between field measurements and structural simulations in its initial field tests. The system integrates measurements for displacements, rotations, pressures, and strains with finite-element structural models (FEM). It is designed for detecting, preventing, and predicting failures by identifying critical areas approaching limit states. The system is also a design tool for determining data-optimization strategies and is capable of utilizing displacement and strain measurements from various sources in the analysis. Measurements of displacements provide the best reliability for a dependable monitoring system. Measurements of strain are used in the system as verification and supplementary information. 12 Refs.

Wong, F. (NOVA Corp of Alberta, Calgary, Alberta, Can); Mohitpour, M.; St. J. Price, P.; Porter, T.R.; Teskey, W.F. *Oil Gas J* v 86 n 30 Jul 25 1988 p 86-91.

## Testing See Also NATURAL GAS PIPELINES—Testing.

**077627 PRESSURE TESTING WITH AIR WORKS FOR OIL PIPELINES.** During April 1985, Interprovincial Pipe Line Ltd. began delivery of oil through the Norman Wells pipeline. Evaluations of air for pressure testing found it to be a safe, efficient, economic, and environmentally sound medium for pressure testing oil pipelines during winter. Since this use, CSA-Z183 now accepts air as a test medium subject to a maximum pressure limitation equivalent to 90% specified minimum yield strength (SMYS) at the high point of a test section, 95% SMYS at the low point, and a minimum leak-test hold period of 24 hr. 5 refs.

Pick, A.R. (Interprovincial Pipe Line Ltd, Edmonton, Alberta, Can); Smith, J.D. *Oil Gas J* v 86 n 24 Jun 13 1988 p 44-47.

## Tibet

**077628 PIPELINE ON THE ROOF OF THE WORLD.** In a rare glimpse at pipeline technology in China, the author provides a fascinating account of the construction and operational problems of the 1,000-km pipeline which is Tibet's sole supply of various grades of fuel.

Lu, Xiaoming. *Pipes Pipelines Int* v 32 n 6 Nov-Dec 1987 p 14-15.

## Welding See WELDS—Defects.

**PETROLEUM PRODUCTS** See Also CARBON—Carbonization; CARBON—Textures; CARBON BLACK—Manufacture; LIQUID FUELS; PETROLEUM, CRUDE—Distillation; PETROLEUM REFINING.

**077629 AVERAGE STRUCTURE DETERMINATION AND PROPERTY CORRELATIONS OF LUBRICATING OIL BASE STOCKS.** Recent trends for characterizing the heavy ends of the petroleum fractions have been through the determination of the average molecular structure utilizing the results of elemental analysis, <sup>1</sup>H- and <sup>13</sup>C- NMR spectroscopy and the molecular weight data. The aim of this investigation is to extend an earlier work further to present the structural parameters of lubricating oil basestocks in the form of average molecular structure. Attempt has been made to correlate the physico-chemical properties with the structures of the average molecules of basestocks so derived. 11 refs.

Singh, Himmat (Indian Inst of Petroleum, Dehradun, India); Srivastava, S.P. *Q J Tech Pap Inst Pet* Jul-Sep 1986 p 65-72.



**077630 PAPERS PRESENTED AT THE 1986 NATIONAL PETROLEUM REFINERS ASSOCIATION ANNUAL MEETING.** This conference proceedings in two volumes contains 50 papers. Some of the topics discussed are cited here as illustrative examples: a view of lubricant demand and quality into the '90's; increase lead susceptibility of a sour coker naphtha stream via caustic treating; how solvent selection affects extraction performance; refinery savings with Amine Guard ST system; hydrogen plant expansion using oxygen secondary reforming; residuum upgrading for petrochemicals; FCC heat balance control effect on resid processing efficiency and flexibility; and the relative merits of cylindrical and non-cylindrical extrudates in vacuum distillate hydrodesulfurization. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10712 EI Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Nat'l Petroleum Refiners Association, Washington, DC, USA). *Natl Pet Refiners Assoc Tech Pap* 1986, Los Angeles, CA, USA, Mar 23-25 1986. Publ by Nat'l Petroleum Refiners Assoc, Washington, DC, USA, 1986 var pagings.

### Additive Compounds

**077631 SET OF QUALIFICATION TEST METHODS FOR PROTECTIVE PROPERTIES OF PRESERVATIVES.** In recent decades, major attention has been given to shortening the time required to test new samples of protective materials without any loss of reliability of results. To this end, much work has been performed on the development of methods for qualification testing of individual properties of protective materials, and sets of such methods for each type of protective material. The sets of methods generally include laboratory methods for qualification testing of physicochemical properties. The authors have presented the methods for qualification testing of preservative materials that are included in the different sets of methods. Most of these methods have been metrologically certified. 7 refs.

Shirokova, G.B.; Lazarenko, V.P.; Englin, A.B. *Chem Technol Fuels Oils* v 23 n 1-2 Jan-Feb 1987 p 44-47.

**077632 NEW QUALIFICATION TEST METHODS FOR GASOLINES WITH SYNTHETIC COMPONENTS.** The test methods used to evaluate gasoline corrosivity in accordance with GOST [All-Union State Standard] 18597-73 (under conditions of moisture condensation) and in contact with saline water cannot be used for testing gasolines with alcohol components, since such gasolines separate into layers when they come into contact with water. When no water is present, corrosion damage to specimens made of various metals is so insignificant that it is impossible to differentiate gasolines with respect to their content of alcohols. Because of this situation, a new method has been developed. In this paper the authors present results obtained by this method in evaluating the corrosivity of gasolines with SCs, on specimens of the metals and alloys used in manufacturing parts for the fuel feed system in automotive vehicles. 6 refs.

Lebedev, S.R.; Burnistrov, O.A.; Kuznetsova, L.N.; Shtan'ko, G.I. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 152-155.

**077633 DETERMINATION OF CONTENT OF ACTIVE SUBSTANCE IN COPOLYMERIC POUR-DEPRESSANT ADDITIVES.** Copolymers of ethylene with vinyl acetate are effective pour-point depressants for petroleum products; these additives are usually supplied in the form of solutions in various hydrocarbon solvents. An important index of the additive quality is the content of active substance. It was proposed to determine the content of active substance by means of IR Fourier transform spectroscopy. The use of this method is subject to one limitation: There must not be any overlapping bands in the spectra of the polymer and the solvent. In view of this limitation, the authors turned their attention to the possibility of determining the content of active substance by means of high-performance exclusion chromatography. The studies were performed in a Dupont Model 8841

chromatograph with an IR detector, with  $\text{CHCl}_3$  as the eluent at a fed rate of 1 ml/min, at a temperature of  $40 \pm 0.2^\circ\text{C}$ . 3 refs.

Filippov, A.A. (All-Union Scientific-Research Inst for Petroleum Processing, USSR); Pavlovskaya, N.G.; Itsikson, L.B. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 158-159.

**077634 DETERMINATION OF METAL-CONTAINING ADDITIVES IN PETROLEUM PRODUCTS.** Results obtained in measurements of  $\rho_v$  of the model and real systems in the presence of the additive MASK [overbased calcium alkylsalicylate], which at the optimal concentration of 0.01% by weight gives the best process indexes in filter pressing. With increasing concentration of the additives,  $\rho_v$  of the model and real systems of slack wax and filtrate decreases, owing to the ionic character of the additives in solutions of the products from filter-pressing. For the determination of concentration of modifying additives in products from filter-pressing, the authors propose a graphical method. On the basis of volume resistivity, it is not only possible to determine the character of distribution of the modifier between the solid and liquid phases, but also to estimate this distribution quantitatively. 4 refs.

Gundiyev, A.A.; Kazakova, L.P.; Fokina, T.V.; Sochevko, T.I. *Chem Technol Fuels Oils* v 23 n 5-6 May-Jun 1987 p 294-295.

Additives See POLYMERS—Applications.

### Analysis

**077635 COMPONENT COMPOSITION OF OXIDIZED PETROLEUM CERESINS ACCORDING TO THE RESULTS OF ESR SPECTROSCOPY.** It has been shown by the methods of physicochemical analysis and the use of a spin probe that the oxidation of petroleum ceresins leads to the same structural transformations as in the case of the oxidation of polyethylene waxes. The resinous and waxy fractions of the ceresins differ substantially in molecular rigidity and physicochemical properties. (Author abstract) 6 refs.

Bel'kevich, P.I.; Prokhorov, S.G.; Chistyakova, E.I.; Ivanova, L.A.; Strigutskii, V.P.; Podlesnyi, N.K.; Shablina, L.G.; Ratkevich, L.I. *Solid Fuel Chem* v 21 n 4 1987 p 78-82.

Antioxidants See COPPER COMPOUNDS—Research.

Applications See HYDRAULIC FLUIDS—Evaluation; LUBRICATION—Standardization.

### Blending

**077636 BLENDING OF HEAVY PETROLEUM FRACTIONS WITH ALCOHOLS.** The addition of methanol or ethanol in a low concentration to middle distillates and heavy petroleum fractions lead to a reduction of their apparent viscosity. The maximum decrease in viscosity was obtained by the addition of 3-6 percent by volume methanol. Achieved reduction in viscosity of blends was a function of initial viscosity of original petroleum fractions. The highest reduction in viscosity was achieved for fuel oil and petroleum residues, which were more viscous. Lowering the viscosity of fuel oil, reduced crude and the blends of vacuum residue with fuel oil and methanol would lead to an improvement in their flow properties. (Edited author abstract). 11 Refs.

Shanshool, Jabir (Univ of Technology, Baghdad, Iraq); Mohammed, Amira I. *J Pet Res* v 7 n 1 Jun 1988 p 103-112.

Carbonization See PETROLEUM COKE—Manufacture.

### Chemical Analysis

**077637 ANALYTISCHE CHARAKTERISIERUNG VON IM PAREX-VERFAHREN VERWENDETEN ERDOELMITTELDESTILLATEN.** [Analytical Char-

acterization of Petroleum Middle Distillates Used in the Parex Process]. Two different straight-run and hydrocatalytically pretreated petroleum middle distillates have been characterized by means of mass spectrometrical family analysis, mass fragmentography and mineral oil analysis. The dominating reaction in the hydrocatalytical treatment of the straight-run products is the hydrogenation of olefinic and hetero compounds as well as of condensed aromatics. The demonstrated ring cleavage of condensed aromatics and naphtheno-aromatics is of minor importance. (Edited author abstract) In German. 9 refs.

Spindler, Heinz (VEB Leuna-Werke 'Walter Ulbricht', Leuna, East Ger); Estel, Dietrich; Doering, Claus-Eberhard; Mueller, Ernst. *Chem Tech (Leipzig)* v 39 n 8 Aug 1987 p 350-353.

**077638 INVESTIGATION OF NITROGEN COMPOUND TYPES IN HIGH-BOILING PETROLEUM DISTILLATES FROM SAUDI ARABIAN CRUDE OILS.** Acid, bases and neutral nitrogen compounds from high-boiling petroleum distillates were separated and further fractionated into fractions containing nitrogen compound types by HPLC on neutral alumina. Acids and bases were separated with anion and cation exchange resins respectively while the neutral nitrogen compounds were removed by complexation with ferric chloride supported on Attapulgus clay. The HPLC fractions were characterized by potentiometric titration for their basic and nonbasic nitrogen contents while infrared spectroscopy was used for the quantitative determination of major compound types present which are pyridines, pyrroles, amides, phenols and carboxylic acids. Characterization of individual nitrogen compounds was accomplished using gas chromatography and gas chromatography-mass spectrometry. The nitrogen compounds identified belong to three compound types which are pyridine, pyrrole and amide. (Author abstract) 16 refs.

Ali, Mohammed Fahat (King Fahd Univ of Petroleum & Minerals, Dhahran, Saudi Arabia); Ali, Mohammed Ashraf. *Fuel Sci Technol Int* v 6 n 3 Jun 1988 p 259-290.

**077639 CHARACTERIZATION OF ARAB BERRI (EXTRA LIGHT) CRUDE FRACTIONS WITH EMPHASIS ON KINEMATIC VISCOSITY-TEMPERATURE BEHAVIOR.** The characterization data has been obtained for Arab Berri extra light crude oil (API 46.9), which is one of the four crude oils being commercially produced by Saudi Arabia. Further, six true boiling point fractions (IBP-95°C, 95-205°C, 205-260°C, 260-345°C, 345-455°C and 455°C+) of this crude were characterized in terms of API gravity, total sulfur,  $\text{H}_2\text{S}$ , mercaptans, molecular weight, elemental analysis for total carbon, hydrogen and nitrogen, analysis of various metals and paraffin, aromatic and naphthalene contents of lighter fractions. The kinematic viscosity-temperature data have been obtained for 95°C+ TBP fractions for wide range of temperatures. 8 refs.

Beg, S.A. (King Fahd Univ Petroleum & Minerals, Dhahran, Saudi Arabia); Amin, M.B.; Hussain, I. *Fuel Sci Technol Int* v 6 n 3 Jun 1988 p 291-308.

### Chromatographic Analysis

**077640 HYDROCARBON GROUPS TYPE ANALYSIS OF PETROLEUM PRODUCTS BY HPLC ON SPECIFIC STATIONARY PHASES.** The hydrocarbon group-type analysis of a large number of petroleum products by HPLC equipped with columns of suitable selectivity is described. An effective approach to the factors influencing the specificity of the columns was developed and stationary phases were synthesized by the products to be separated. All new phases were characterized by elemental,  $^{29}\text{Si}$  and  $^{13}\text{C}$  NMR analyses. The potential of these phases were illustrated by analysis of selected samples either of fundamental or of industrial interest. (Author abstract) 18 refs.

Felix, Guy (CNRS, Talence, Fr); Thoumazau, Elisabeth; Colin, Jean-Michel; Vion, Gisele. *J Liq Chromatogr* v 10 n 10 Aug 1987 p 2115-2132.



**077641 CHROMATOGRAPHIC PROCEDURE FOR THE COMPREHENSIVE SEPARATION AND ESTIMATION OF POLYCYCLIC AROMATIC HYDROCARBONS IN PETROLEUM PRODUCTS.** A chromatographic procedure using liquid and gas chromatography for the determination of both total and certain individual 4-6-ring polycyclic aromatic hydrocarbons from a single sample aliquot is described. The total PCA content of the sample is determined gravimetrically. This fraction is subsequently further fractionated on Sephadex LH20 to give one rich in PCA parent hydrocarbons which are determined using high-resolution capillary gas chromatography (g.c.). The compounds of interest are quantified by comparison of their g.c. peak areas with those from secondary internal standards. The results are corrected for losses occurring during the analysis by determining the recovery of an internal standard using ultraviolet (u.v.) spectroscopy. (Edited author abstract) 17 refs.

Pullen, David L. (BP, Sunbury-on-Thames, Engl); Scammells, Daniel V. *Fuel* v 67 n 2 Feb 1988 p 251-256.

**077642 CHARACTERIZATION OF VACUUM RESIDUES BY ADSORPTION CHROMATOGRAPHY AND <sup>1</sup>H-NMR SPECTROSCOPY.** The chemical compositions of, and structural types in, vacuum residues from Daqing, Shengli, Renqiu and Linpan crude oil vacuum residues were investigated. The residues were separated into six fractions by use of normal pentane precipitation and liquid adsorption chromatography using alumina containing 5% water as adsorbent. The nitrogen and nickel distributions in every fraction were then observed. The removal of nickel, nitrogen and residual carbon with the liquid chromatography separation techniques are comparable with the solvent deasphalting pilot plant data. The structural parameters were calculated with modified Brown-Ladner's method on the basis of the elementary analysis, molecular weight determination and <sup>1</sup>H-NMR spectroscopy, the results obtained show that the six fractions are obviously different in their chemical compositions and structures. (Author abstract) 7 refs.

Chenguang Liu (East China Petroleum Inst, Shandong, China); Guohe Que; Yuezu Chen; Wenjie Liang. *Fuel Sci Technol Int* v 6 n 4 1988 p 449-469.

## Coloring

**077643 COLOUR AND COLOUR STABILITY ASPECTS OF PETROLEUM PRODUCTS.** Petroleum products quite often on storage show deterioration in color due to oxidation of the active hydrocarbons such as olefins, diolefins and those containing sulphur, nitrogen and oxygen. The test procedures used to measure color on various scales, color specifications of different products followed internationally and causes of color deterioration are reviewed. Refining practices followed to deal with the problems of color and color stability are discussed with the support of some experimental results. (Author abstract). 47 Refs.

Bahl, J.S. (Indian Inst of Petroleum, Dehra Dun, India); Krishna, R.; Singh, Himmat. *Indian J Technol* v 26 n 3 Mar 1988 p 120-128.

## Degradation

**077644 STRUCTURE OF HIGH-MOLECULAR-WEIGHT COMPOUNDS IN THE THERMAL DEGRADATION OF PETROLEUM RESIDUES.** The results of an investigation of the thermal-degradative transformations of the asphaltenes of petroleum residues by <sup>1</sup>H NMR spectroscopy are given. An increase in the time of thermal degradation leads to decrease in the number, in the degree of substitution, and in the length of the alkyl substituents and to an increase in the proportion of aromatic carbon atoms in the structure of the asphaltenes. The latter is determined mainly by the increase in the number of aromatic fragments. (Edited author abstract) 5 refs.

Daniil'yan, T.D.; Rogacheva, O.V.; Yangurozova, A.R.; Mindiyarov, Kh.G.; Gimae, R.N. *Solid Fuel Chem* v 21 n 4 1987 p 83-86.

## Desulfurization

**077645 HYDRODESULPHURIZATION AND DIFUSION OF THIOPHENE ON NICKEL SULPHIDE CONTAINING CATALYSTS.** The NiS catalyst was prepared by precipitating Ni(OH)<sub>2</sub> from a Ni(NO<sub>3</sub>)<sub>2</sub> solution using ammonia solution. Adsorption-desorption isotherms were determined at -195.8°C using a static apparatus. An Arrhenius plot showing wide difference between the activities of the three catalysts, under study, for thiophene hydrodesulfurization is presented. The results show that the coprecipitated NiS/Al<sub>2</sub>O<sub>3</sub> catalyst is the most active whereas the unsupported one is the least active. Refs.

Aboul-Gheit, Ahmed K.; El-Fadly, A.A.M.; Faramawy, S.; Abdel-Hamid, S.M.; Abd-el-Khalik, M. *Erdol Kohle Erdgas Petrochem* v 40 n 7 Jul 1987 p 315-316.

**077646 APPLICATION OF SIZE EXCLUSION CHROMATOGRAPHY WITH INDUCTIVELY COUPLED PLASMA EMISSION SPECTROMETRIC DETECTION TO RESIDUAL OIL HYDRODESULFURIZATION (HDS) AND HYDROMETALLIZATION (HDM) STUDIES.** Size exclusion chromatography with inductively coupled plasma optical emission detection (SEC-ICP) has been applied to the study of the hydroprocessing of residual oils for vanadium (HDV) and sulfur (HDS) removal. SEC-ICP and kinetic studies show that in many residual oil feeds HDV appears to follow parallel, first-order kinetics with fast and slow-reacting vanadium molecules. Application of parallel, first-order kinetics suggests that kinetics and not reactor hydrodynamics may explain deviations from ideal plug flow, first-order kinetic models observed for many hydrotreating reactions. Adequate comparison of residual oils for relative HDS activities is not accomplished by SEC alone. Desulfurization of large sulfur molecules is a combination of size reduction and removal of thiophenic sulfur. (Author abstract) 19 refs.

Sughrue, Edward L. (Phillips Petroleum Co, Bartlesville, OK, USA); Hausler, Douglas W.; Liao, Ping C.; Strope, Daniel J. *Ind Eng Chem Res* v 27 n 3 Mar 1988 p 397-401.

**077647 DIE STOFFWANDLUNG BEI DER HYDRORAFFINATION VON MITTELDESTILLATEN.** [Material Conversion During the Hydrotreating of Medium Distillates]. A new method for the characterization of hydrocatalytic processes is applied to the hydrotreating of petroleum middle distillates. The method is based on a hydrocarbon type of analysis and provides quantitative information about the hydrogenation and cleavage of rings and the destruction of sulfur compounds. By using results from pilot plants, the dependence of these reactions on pressure, temperature, and catalysts is discussed. (Edited author abstract). 2 Refs. In German.

Mueller, Ernst H. (VEB, Leuna, East Ger); Henze, Antje. *Chem Tech (Heidelberg)* v 40 n 5 May 1988 p 205-208.

Distillation See PETROLEUM, CRUDE—Distillation.

## Economics

**077648 PROBLEMS AND LESSONS IN ESTIMATING SUPPLY CURVES FOR REFINED PETROLEUM PRODUCTS.** This paper describes a hybrid approach to the econometrics and process modeling of supply curves for refined petroleum products. The output from successive runs of a large-scale linear programming (LP) model of the petroleum-refining process (previously constructed for refinery analysis tasks by the U.S. Department of Energy) was used to generate a base of pseudo data from which individual short-run supply curves for each of five major refined products were then econometrically estimated.

Farmer, Richard C. (US DOE, Washington, DC, USA). *J Energy Dev* v 12 n 1 Autumn 1986 p 27-42.

## Electric Field Effects

**077649 STRUCTURE FORMATION OF MOTOR OILS IN A NONUNIFORM ELECTRIC FIELD.** The results of investigating the mechanism of structure formation of spent motor oil AS-8 in a nonuniform alternating electric field formed by electrodes having the shape of dihedral angles directed with vertices toward one another are presented. With the use of the experimental design method the optimal conditions of the most effective structure formation of the particles of the dispersed phase in an electric field were determined, which can be used when developing electrical apparatus for removing mechanical impurities, moisture, and aging products from spent motor oils. (Author abstract) 3 refs.

Nadirov, N.K.; Borodkin, L.P.; Kozachkov, A.G.; Filipova, V.A.; Kotoyants, K.V. *Sov Surf Eng Appl Electrochem* n 2 1987 p 63-64.

## Evaluation

**077650 DETERMINATION OF ACTIVE STATE OF PETROLEUM DISPERSE SYSTEMS.** The authors are reporting on an investigation of the feasibility of direct determination of the active state of an atmospheric resid on the basis of the disperse-phase particle size, for comparison with results obtained by the indirect methods that had been used previously for this purpose. As objects of investigation the authors selected atmospheric resids from Tyumen' and Tuimzy crudes, as proposed at the Novo-Ufa Petroleum Refinery. As the modifier a solvent extract obtained in treating the No. III lube cut from a mixture of these two crudes was used. The characteristics of the stocks used in this investigation are also listed. 8 refs.

Antoshkin, A.S. (I.M. Gubkin Moscow Inst of the Petrochemical & Gas Industry, USSR); Fishchuk, G.F.; Nesterov, A.N.; Glagoleva, O.F. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 144-146.

## Extraction

**077651 OBTAINING VANADYL PORPHYRINS FROM ASPHALTITE OF SADKINSK DEPOSIT.** In this paper the authors are proposing a method for obtaining vanadyl porphyrins by acetone treatment of asphaltite from the Sadkinsk deposit. This particular asphaltite was selected as a starting material because of its relatively high content of vanadyl porphyrins, 766 mg/100 g, as determined by alcohol-acetone extraction. The maximum yield of vanadyl porphyrins (890 mg/100 g) was obtained by three-stage extraction: 714 mg/100 g in the first stage, 120 mg/100 g in the second, and 56 mg/100 g in the third. When ethanol was used instead of the acetone, the vanadyl porphyrin yield was 742 mg/100 g. In order to prevent loss of asphaltite and evaporation of acetone during the filtration, it is proposed that the extraction should be performed in a Soxhlet apparatus. 6 refs.

Nadirov, N.K. (Acad of Sciences of the Kazakh SSR, USSR); Kotova, A.V.; Ergalieva, A.K.; Yag'yeva, S.M.; Gol'dberg, I.S. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 116-117.

## Gravimetric Analysis

**077652 APLICACION DEL ANALISIS TERMOGRAVIMETRICO A LA DETERMINACION DE CURVAS DE FRACCIONES PESADAS DE PETROLEO.** [Application of Thermogravimetric Analysis to Determine Distillation Curves of Heavy Petroleum Fractions]. Vacuum thermogravimetric analysis (TGA) is used to determine weight loss curves of heavy petroleum fractions up to an atmospheric temperature equivalent to 800°C. These curves are compared with those obtained from gas chromatography (simulated distillation) and from those calculated by mathematical models of simulation and extrapolation of distillation curves. The results of this study show that it is possible to obtain distillation curves at temperatures higher than those attainable by conventional distillation techniques. This would allow the



determination of cut point temperatures of heavy petroleum fractions from molecular distillation. Limitations of the techniques employed are indicated and modifications and improvements are proposed. (Edited author abstract) In Spanish. 18 refs.

Ceballo, Carmen D. (Intevep, Venez); Reyes, Harold; Herrera, Miriam; Mujica, Emilia; Khayan, Michael. *Rev Tec INTEVEP* v 7 n 2 Jul 1987 p 149-153.

## Heating

**077653 EVALUATION OF BOILING PROCESS ON THE BASIS OF ELECTRICAL RESISTANCE OF PETROLEUM FRACTIONS.** A study was made of the process of petroleum product boiling and the effects of surfactant additives. The intensity of the boiling process for one particular petroleum product was rated on the basis of the change in its electrical resistance. Data indicate that a decrease in surface tension or an increase in the degree of dispersity (decrease in radius  $r$ ) will lead to increases in the number of vapor-phase nuclei and hence to increases in the electrical resistance. Thus, the character of the change in electrical resistance close to the liquid-vapor transition point when an additive is introduced can be used to judge the change in character of the phase transition due to the presence of the modifying additive. Measurements of electrical resistance can also be used to investigate the boiling process for crude oils and products. This approach offers a means for characterizing intermolecular interactions of one fraction or another in the course of the liquid-vapor phase transition, an important factor in selecting additives with the aim of increasing the yields of the desired fractions. 8 refs.

Zimin, B.A. (I.M. Gubkin Moscow Inst of Oil & Gas, USSR); Stolonogov, I.I.; Gusev, M.A.; Nesterov, A.N. *Chem Technol Fuels Oils* v 23 n 7-8 Jul-Aug 1987 p 393-395.

## Marketing See Also PETROCHEMICALS—Economics.

**077654 SUPERMARKETS BOOM AHEAD IN UK MOGAS RETAILING.** Petrol retailing by supermarkets is taking an increasing share of the UK mogas market. The authors examine in some detail the policies of the supermarket companies and the trends in the market, including pricing, electronic point of sale installations, volume and the major suppliers of equipment and product.

Anon. *Pet Times* v 90 n 2204 Nov 1986 p 13, 15, 29.

## Measurements See LIQUIDS—Measurements.

## Molecular Structure

**077655 EVALUATION OF INTERMOLECULAR INTERACTIONS IN PETROLEUM HYDROCARBONS.** Intermolecular interactions in petroleum products are responsible for structural transitions, structurization, separation of solid hydrocarbons, and loss of mobility, all of which have considerable influence on the industrial applications of the products. One method used widely to detect structural transitions is based on the temperature dependence of the electrical conductivity of the product; another method, used much less frequently, is based on the temperature dependence of viscosity. An equation for the detection of structural transitions in hydrocarbon liquids is recommended. 18 refs.

Belousov, A.I. (All-Union Scientific Research Inst for Petroleum Processing, USSR); Bushueva, E.M. *Chem Technol Fuels Oils* v 23 n 1-2 Jan-Feb 1987 p 31-34.

## Oxidation

**077656 PRODUCTION OF BINDER FOR PAVING MIX BY OXIDATION OF ACID-POND TAR AND ASPHALTS FROM DEASPHALTING OPERATIONS.** The rheological and service properties of binders depend on the ratio and chemical structure of the binder components, in particular the oils, resins, and asphaltenes, which create the colloidal macrostructure that is charac-

teristic for binders. In order to clarify the role and activity of individual components of the binder in chemical conversions, the authors have carried out a kinetic study of the oxidation of APT and AD, both separately and as a blend. The basic physicochemical characteristics and the group chemical composition of the APT and the AD (light grade ADL and heavy grade ADH) are given. 8 refs.

Frolov, A.F. (Yaroslavl Polytechnic Inst, USSR); Titova, T.S.; Aminov, A.N.; Bilobrov, P.P. *Chem Technol Fuels Oils* v 23 n 1-2 Jan-Feb 1987 p 3-5.

## Phase Transitions

**077657 INFLUENCE OF THE COMPOSITION OF THE RAW MATERIAL ON THE DYNAMICS OF THE MESOPHASE TRANSFORMATIONS IN HEAVY PETROLEUM RESIDUES.** The dynamics of mesophase transitions in the carbonization of a distillate cracking residue from Koturpet petroleum and the asphaltenes isolated from it on a heated microscope stage have been studied. (Author abstract) 13 refs.

Zaporin, V.P.; Sadykov, R.Kh.; Sukhov, S.V.; Chuvyrov, A.N.; Ledebev, Yu.A. *Solid Fuel Chem* v 21 n 4 1987 p 87-90.

## Physical Properties See Also COMPUTER SOFTWARE; PETROLEUM REFINING—Precipitation.

**077658 PREDICTING FLASH AND POUR POINTS.** Flash point is correlated with ASTM 10% temperature. Pour point is correlated with: molecular weight, specific gravity and kinematic viscosity at 100°F. The flash point method was tested over an ASTM 10% temperature range of about 400 to 900°F. The correlation for pour points is applicable to fractions with molecular weights of 140 to 800 and viscosities of 1 to 3,500 cSt. 5 refs.

Riazi, M.R. (Pennsylvania State Univ, University Park, PA, USA); Daubert, T.E. *Hydrocarbon Process* v 66 n 9 Sep 1987 p 81-83.

## Pipelines

**077659 COMPUTERS IN PIPELINE MANAGEMENT.** Esso Petroleum Company Ltd. operates and maintains several major pipeline networks throughout the United Kingdom. Over the past five years we have been modernising and consolidating, with the result that we have invested in computer hardware to achieve an efficient, low cost, safe operation. To this end, the main areas addressed have been the supervisory and control systems, and the automation of scheduling the 26 different products to their destinations. (Author abstract).

Tindell, B.P. (Esso Petroleum Co). *Q J Tech Pap Inst Pet* Jan-Mar 1988 p 27-29.

## Processing

**077660 NEW PETROLEUM WASH OIL TO RECOVER CRUDE BENZOL.** Information obtained permitted limitation of the number of products which should be investigated as solar oil substitutes. The following petroleum products were chosen for investigation as possible substitutes: (1) The deparaffinized fraction, used as a base for production of all-weather hydraulic oil; (2) Hydrogenated paraffin-naphthene fraction of the Angarsknefteorgsintez PO [Industrial Association]; (3) Distillate of the diesel fuel of the Permnefteorgsintez PO. The characteristics of the petroleum products are given. Of the oils, the deparaffinized target fraction fully meets the specifications of the crude benzol recovery process. The analysis of wash oil data are presented. A discussion is also presented of conclusions based on experimental data for the following: fractional composition, hardening temperature, separation, and, sludge formation. 6 refs.

Kuz'mina, E.Ya. (Eastern Scientific Research Inst of Coal Chemistry, USSR); Frolovnin, Yu.V.; Dement'eva, N.V. *Coke Chem (USSR)* n 12 1987 p 45-49.

## Quality Control

**077661 CHROMATOGRAPHIC DISTILLATION IN PETROLEUM PRODUCT QUALITY CONTROL.** The authors demonstrate the feasibility of determining the distillation curves of various petroleum products by chromatographic distillation (CD). The mixtures are separated in a capillary column or in a column packed with an inert support. Repetitive processes of vaporization and condensation take place in the flow of carrier gas. The mixtures are separated into components not according to boiling point  $t_b$  of the components, but rather according to their vapor pressure at the column exit temperature  $t_{co}$ . The results obtained confirm the possibility of universal application of the CD method; it is suitable for the analysis of various petroleum products, from gasolines to motor oils. The results also point out the possibility of combining the existing methods for the determination of distillation curve.

Kholostova, G.G.; Shimonae, G.S.; Burova, M.O. *Chem Technol Fuels Oils* v 23 n 7-8 Aug 1987 p 361-363.

## Sampling See PARAFFIN WAXES—Testing.

## Spectroscopic Analysis

**077662 COMPOSITIONAL AND STRUCTURAL STUDIES OF PETROLEUM ASPHALTENES EMPLOYING SPECTROSCOPIC TECHNIQUES.** Petroleum asphaltenes of Bombay High (BH) and Gujarat Crude Mix (GCM) have been precipitated by extracting the respective residues (> 500°C) with normal heptane at room temperature. Ultimate compositions have been determined for deducing the average molecular formulas. Field ionization mass spectrometry  $^{13}C$  and  $^1H$  NMR and IR techniques have been employed to generate the structural and compositional data.  $^{13}C$  NMR provided the percentage distribution of different types of carbons and some other structural parameters. IR allowed the identification and estimation of various polar functional groups. (Edited author abstract) 24 refs.

Sarowha, S.L.S. (Indian Inst of Petroleum, Dehra-Dun, India); Singh, I.D. *Fuel* v 67 n 1 Jan 1988 p 145-146.

**077663 ROOM-TEMPERATURE PHOSPHORIMETRY TO STUDY PETROLEUM PRODUCT PERMEATION THROUGH PROTECTIVE CLOTHING MATERIALS.** A simple analytical tool based on room-temperature phosphorimetry (RTP) is developed and used for evaluating the effectiveness of protective clothing materials against permeation of organic substances containing compounds such as the polycyclic aromatic compounds. A special permeation cell is designed, which allows direct RTP measurements of the permeated products after exposure, without requiring any sample extraction procedure. Results for a variety of petroleum product-protective material combinations illustrate the usefulness of the technique. (Edited author abstract) 14 refs.

White, D.A. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Vo-Dinh, T. *Appl Spectrosc* v 42 n 2 Feb 1988 p 285-288.

## Spectrum Analysis

**077664 INTERFACIAL TENSION BEHAVIOUR AND ESR PROPERTIES OF ASPHALTENES DERIVED FROM HEAVY OIL.** Asphaltenes extracted from Lloydminster heavy oil (from Saskatchewan, Canada) were separated by sequential elution solvent chromatography (SESC) using ten different organic solvents. The fractions so obtained were dissolved in toluene and then examined for their interfacial tension (IFT) behavior against 0.1 wt.% sodium hydroxide solution. It was found that only about 40% (by weight) of the original asphaltenes contained species which were capable of lowering IFT against the alkaline solution. Multi-functional phenolic and other polar compounds were considered to be the components most likely responsible for the observed interfacial activity. Electron spin resonance measurements showed that the individual fractions contained varying



concentrations of free radicals and  $VO^{2+}$  ions. However, no direct correlation between the content of either of these two species and the interfacial tension could be detected. (Author abstract). 25 Refs.

Khulbe, Khalish C. (Univ of Ottawa, Ottawa, Ont, Can); Neale, Graham H.; Hornof, Vladimir. *Fuel Process Technol* v 19 n 1 Jul 1988 p 61-72.

**Stability** See Also PETROLEUM, CRUDE.

**077665 EFFECT OF VISBREAKING CONDITIONS ON THE STABILITY OF SOME IRAQI LONG RESIDUES.** A study has been done to investigate the change in the stability of residue during thermal process (visbreaking) at different cracking severity using flocculation ratio method. For this purpose, three long residues ( $350^{\circ}\text{C}^{+}$ ) of different crude oils were used. The obtained results were discussed as a function of reaction temperature and residence time. Moreover, the stability was correlated with the nature and chemical composition of the feedstock. We observed that the intermediate paraffinic base feedstock (type A) was more stable than the other two asphaltic base (Types B & C) when visbreaking temperature was  $460^{\circ}\text{C}$ . At higher temperatures, a sudden and large decrease in the stability of type A visbroken products was observed while only a gradual decrease in the stability of the other two products was noticed when visbreaking process was carried out at the same operating conditions. (Author abstract) 11 refs.

Savaya, Z.F. (Petroleum Research Cent, Jadriyah, Baghdad); Al-Soufi, H.H.; Al-Azawi, I.; Mohammed, H.K. *Fuel Sci Technol Int* v 6 n 3 Jun 1988 p 355-366.

**Storage** See Also DIESEL FUELS—Storage; OIL TANKS—Plastics Applications.

**077666 UNDERGROUND STORAGE TANKS: TANK OWNER'S SURVIVAL GUIDE.** Minimum requirements for new petroleum tank and pipe systems are expected to include: single-wall construction; sacrificial anode or impressed-current (electrically-charged anode) system for steel tanks and pipes, including steel pipe attached to a fiberglass tank; an overfill-containment device with a 20-gal capacity or a device to prevent overfilling; and some form of continuous leak detection for the tank and its piping. As an alternative, periodic tank and pipe tests may be conducted at intervals not exceeding 30 days. Existing steel tanks not protected against corrosion by an FRP coating, sacrificial anode or impressed-current system initially must be leak tested or frequently/continuously monitored for leaks.

Cross, Rich. *Prof Saf* v 32 n 9 Sep 1987 p 13-17.

**Structure**

**077667 EVALUATION OF COMPONENT COMPOSITION OF COMPLEX STRUCTURAL UNITS OF PETROLEUM DISPERSE SYSTEMS.** Research on the composition and properties of CSUs is greatly hindered by the lack of any methods for isolation of their components (core and solvate shell) for detailed study. The authors propose a variant of a fractionation procedure for high-molecular-weight petroleum stocks, based on stepwise extraction with a set of solvents. The objects of investigation were a vacuum resid from West Siberian crude, asphalts, and a product obtained by coking this stock. Because of the presence of a spectrum of these interactions, it is impossible to separate the CSU cores in absolutely pure form from the solvate shells enclosing the cores, hence, the fractionated products obtained by our procedure can be regarded only as concentrates of the corresponding components of the CSU. Thus, as a result of fractionation of petroleum products by the proposed methods, it is possible to recover concentrates of the solvate shell and CSU cores from petroleum disperse systems such as a petroleum resid, asphalts, coker residues, and pitches. 4 refs.

Khairudinov, I.R.; Unger, F.G.; Syunyaev, Z.I. *Chem Technol Fuels Oils* v 23 n 5-6 May-Jun 1987 p 297-300.

**Surface Properties**

**077668 METHOD PREDICTS SURFACE TENSION OF PETROLEUM FRACTIONS.** There is a convenient correlation for predicting the dynamic surface tension of crude oils and petroleum fractions at a specific temperature. The convenient prediction of surface tension becomes quite important wherever foaming, emulsification, droplet formation, or wetting are involved. Surface-tension data are needed, for example, when designing distillation towers, extraction units, and tower internals such as bubble caps and trays. Values computed from this equation are in good agreement with published graphs that give the values for surface tension. 2 refs.

Gomez, Jose Vicente (Maravan SA, Punto Fijo, Venez). *Oil Gas J* v 85 n 49 Dec 7 1987 p 68.

**Tar** See COAL—Coking Properties; OIL SANDS—Thermal Recovery; PETROLEUM, CRUDE—Processing.

**Testing** See PETROLEUM, CRUDE—Processing; PETROLEUM REFINING—Cracking.

**Trace Analysis** See PETROLEUM, CRUDE—Trace Analysis.

**Viscosity**

**077669 MOLECULAR WEIGHT OF HEAVY-OIL FRACTIONS FROM VISCOSITY.** A simple equation is presented for estimating the molecular weights of heavy petroleum fractions using input parameters of kinematic viscosity  $100^{\circ}\text{F}$  and  $210^{\circ}\text{F}$ , and specific gravity at  $60^{\circ}\text{F}$ . The proposed correlation is applicable to fractions with molecular weights ranging from 200 to 800, with average errors of about 3% - less than half the error associated with previous methods. The correlation will be recommended by the American Petroleum Institute (API) in the revised Chapter 2 of its Technical Data Book - Petroleum Refining. The revision will be released in late 1987. 9 refs.

Riazi, Mohammad R. (Pennsylvania State Univ, University Park, PA, USA); Daubert, Thomas E. *Oil Gas J* v 85 n 52 Dec 28 1987 p 110-112.

**PETROLEUM PROSPECTING** See Also GEO-CHEMISTRY; GEOPHYSICS—Seismic; NATURAL GAS WELLS—Australia; OIL FIELDS—Reservoir Evaluation; OIL WELL DRILLING—Exploratory; PETROLEUM GEOLOGY; PETROLEUM GEOLOGY—Australia; PETROLEUM GEOLOGY—Bashkiria, USSR; PETROLEUM GEOLOGY—Gulf of Mexico; PETROLEUM GEOLOGY—Iowa; PETROLEUM GEOLOGY—Tectonics; PETROLEUM GEOLOGY—Ulyanov Region, USSR; PETROLEUM GEOLOGY—USSR; PETROLEUM GEOLOGY—West Siberia, USSR; PETROLEUM GEOLOGY—Wisconsin; PETROLEUM RESERVOIR ENGINEERING—Computer Simulation; WATER POLLUTION—Underground.

**077670 PETROLEUM HYDROGEOLOGY: A NEW BASIC IN EXPLORATION.** Petroleum hydrogeology is the science and practice of applying hydrogeological principles and techniques to petroleum exploration and basin analysis. It is based on the effects of groundwater flow on the subsurface distribution of petroleum hydrocarbons. The three basic technical arguments in favor of a hydrogeological approach to petroleum exploration are discussed. There are four general types of exploration problems to which hydrogeology may contribute, namely: (1) regional reconnaissance, (2) estimates of migrated hydrocarbon volumes, (3) location of hydrodynamic traps and stepping out from known deposits, and (4) evaluation and interpretation of surface signatures of accumulations. 46 refs.

Toth, J. (Univ of Alberta, Edmonton, Alberta, Can). *World Oil* v 205 n 3 Sep 1987 p 48-50.

**077671 POSSIBILITY OF PREDICTING ANOMALOUSLY LOW FORMATION PRESSURES FROM BUREHOLE ELECTROMETRY DATA.** Results of investigations on carbonate deposits of Upper Cretaceous at the Scythian plate of the Crimean peninsula are presented. They testify that it is possible to predict anomalously low formation pressures by the electrometry

method when drilling exploratory wells. (Translated author abstract) 2 refs. In Russian.

Orlov, A.A.; Zhuchenko, G.A. *Izv Vyssh Uchebn Zaved Neft Gaz* n 10 1986 p 3-6.

**077672 CAPILLARY PRESSURE TECHNIQUES: APPLICATION TO EXPLORATION AND DEVELOPMENT GEOLOGY.** Capillary pressure can be viewed as the pressure required to drive a fluid through a pore throat and displace the pore wetting fluid, with greater pressure being required as the pore throat becomes smaller. The size and distribution of pore throats within a host rock control its capillary pressure characteristics, which in turn control fluid behavior in the pore system. Regional capillary pressure maps of calculated values identify a north-south trend of favorable reservoir rock along the state line between Montana and North Dakota in the third porosity ('C') zone of the Ordovician Red River Formation. Oil migration and trapping can be significantly controlled by capillary pressure. Oil columns can be estimated from capillary pressure data by determining the buoyancy force of the oil floating on water and then converting from a mercury-air capillary system to an oil-water capillary system. Relative permeability data may also be calculated from capillary pressure data and can be used to estimate fractional water production at given water saturations. These and other aspects of the subject are discussed. (Edited author abstract) 25 refs.

Jennings, Jeffrey B. *AAPG Bull* v 71 n 10 Oct 1987 p 1196-1209.

**077673 INTEGRATED EXPLORATION IMPROVES WILDCAT SUCCESS, PART 2.** Integrated petroleum exploration experience to date has shown that exploration costs can total less than \$1/bbl of discovered oil reserves, and less than \$0.50/acre evaluated, when employed over large areas (several hundred sq mi). The authors present specifics on each of the exploration methods that might be included in an integrated approach. 24 refs.

Saunders, Donald F. (RECON Exploration Co, Dallas, TX, USA); Thompson, C. Keith. *World Oil* v 205 n 5 Nov 1987 p 512-405.

**077674 PROCEDURES, POSSIBILITIES AND TRENDS IN USING AEROSPACE METHODS AT THE REGIONAL AND EXPLORATION STAGES OF GEOLOGICAL PROSPECTING FOR OIL AND GAS.** Improvement of structural decoding of aerial and space photographs should be directed towards the recognition of images of regional and local structures of the productive levels of the sedimentary cover on the background of the overall landscape information. For this purpose it is necessary to carry out selection and classification of standard samples of different types of structures. Integration of multispectral, infrared and radar photographs will make it possible to expand considerably the possibilities of the remote sensing methods. One of the most important problems is improvement of the method of integrated interpretation of remote sensing photographic, geological, geophysical, hydrogeological, and geochemical data. In Russian.

Trofimov, D.M.; Polkanova, L.P. *Geol Nefti Gaza* n 5 May 1987 p 1-7.

**077675 PROSPECTING FOR STRUCTURES ON THE BASIS OF STRUCTURAL MORPHOMETRIC METHOD.** The shortcomings in the construction of morphometric and structural maps used in searching for structures are considered and the degree of their subjectivism is analyzed. With the existing methods the matching of the drilling and morphometry data is carried out by comparing available maps (secondary data) each of which contains elements of subjectivism. The proposed method eliminates it because it synthesizes drilling and morphometry data, operates with primary data, namely the absolute



depth points of the marking horizons of the geological section and morphometric surfaces. (Translated author abstract) In Russian. 2 refs.

Alekseev, V.I. *Izv Vyssh Uchebn Zaved Neft Gaz* n 5 May 1987 p 13-17.

**077676 POSSIBILITY OF UTILIZING SPECIFIC ELECTRIC RESISTANCE OF ARGILLACEOUS STRATA IN EVALUATING THE PETROLEUM POTENTIAL OF A BOREHOLE LOG.** A study of a number of oil pools of the south of the USSR represented by deposits in arenaceous-argillaceous lithological facies divided into two groups of strata - petroleum bearing and water-bearing - has shown that the specific electric resistance of the same argillaceous strata depends to a considerable extent on the productivity variations of the reservoirs that are in contact with them. Thus, electric resistance of argillaceous strata lying directly above hydrocarbon pools noticeably exceeds the specific electric resistance of the same clays lying beyond the contour of petroleum pools. This fact can be used in locating petroleum pool boundaries and capacities. 8 refs. In Russian.

Kerimov, K.M.; Abdullaev, A.P.; Kerimov, Z.N. *Izv Vyssh Uchebn Zaved Neft Gaz* n 2 Feb 1988 p 6-12.

**077677 EXPLORATION-STRATEGY PLANNING HELPS REDUCE RISKS AND FOCUS EXPENDITURES.** Various strategies for forecasting reserves, future discoveries, and resources have been developed over the years in an effort to quantify the probabilities of petroleum being discovered and produced for national planning purposes. While most of these calculations are not valid for individual basins or reservoirs, they can be useful in context when viewed as provincial probabilities and considered to be order of magnitude figures. Several of these extrapolations are used in this study. 15 refs.

Gerhard, Lee C. (Kansas Geological Survey, Lawrence, KS, USA); Graber, Lee A.; Brostuen, Erling A. *Oil Gas J* v 86 n 26 Jun 27 1988 4p.

**077678 PRINCIPLES OF GEOCHEMICAL PROSPECT APPRAISAL.** In most sedimentary basins, oil is expelled from source rocks between 120° and 150°C, whereas most gas and gas condensate are released between 150° and 230°C. When the initial potential of source rocks exceeds 10kg/MT, oil expulsion efficiencies are between 60 and 90 percent. Expelled oil and gas migrate as petroleum-rich phases driven by fluid potential gradients. Most flow is laterally up dip in beds with effective horizontal permeabilities greater than 1 md. In lower permeability rocks, the petroleum fluids move vertically, up or down, along the path of least resistance. Geochemical analysis of source rocks helps determine the yields and compositions of petroleum fluids expelled in the catchment area of a prospect. Evaluation of the total volume of rock through which the petroleum potentially can migrate and the mean porosity of the rocks that constitute the migration pathway allow migration losses to be assessed. (Edited author abstract). 51 Refs.

Mackenzie, Andrew S. (BP Exploration Co, London, Engl); Quigley, Tom M. *AAPG Bull* v 72 n 4 Apr 1988 p 399-415.

**077679 OIL AND GAS PLAY MAPS IN EXPLORATION AND ASSESSMENT.** Play summary maps show the superimposed boundaries of favorable areas for all key geologic controls of oil and gas occurrence - sources, migration, reservoir, trap, timing, seal, preservation, and recovery - for a genetic group of prospects or fields. These maps are invaluable for high-grading the best areas, thereby reducing exploration risks, and for quantitatively estimating hydrocarbon volume and success factors in both prospect and play assessment. Play summary maps are based on standard exploration map suites but demand a systematic integration of all the essential geologic controls, none of which can safely be ignored. (Author abstract). 21 Refs.

White, David A. *AAPG Bull* v 72 n 8 Aug 1988 p 944-949.

Alberta See PETROLEUM GEOLOGY—Alberta.

**Australia** See Also GEOPHYSICS—Exploratory; NATURAL GAS DEPOSITS—Australia; OIL FIELDS—Australia; OIL WELL LOGGING—Acoustic; PETROLEUM GEOLOGY; PETROLEUM GEOLOGY—Australia; PETROLEUM INDUSTRY—Australia; PETROLEUM RESERVOIR ENGINEERING—Core Analysis.

**077680 COOPER/EROMANGA BASINS HYDRO-CARBON POTENTIAL.** The Cooper/Eromanga basins, which occupy an area of some 1 million sq km in East Central Australia, are by far Australia's most important onshore basins. The Eromanga basin contains sediments of Jurassic age and younger, and these are underlain by Triassic and Permian sediments that were deposited in a number of smaller infrabasins of which the Cooper basin is the most important. Oil production from these basins currently comprises about 11% of Australia's total, and sales gas has been supplied to the Sydney and Adelaide markets since 1969. Condensate and liquid petroleum gas (LPG) are important by-products of this gas production. During 1985-86, Petroleum Management Associates (Australia) Pty. Ltd. (PMA) undertook a detailed technical investigation of these basins, integrating all geological, geophysical, and geochemical aspects in order to provide a complete perspective of the hydrocarbon potential for investors and explorers. Some topics discussed are these: exploration history, structure, stratigraphy, Cooper basin succession, and hydrocarbon model and exploration potential. 1 ref.

Mackie, S.I. (Petroleum Management Associates (Australia) Pty, Adelaide, Aust). *Oil Gas J* v 85 n 45 Nov 9 1987 p 90-92.

**077681 1986 APEA CONFERENCE.** This conference proceedings contains 49 papers. Individual papers are abstracted and indexed separately. Topics covered include: legal and tax implications for the acquisition of offshore properties; capital gains tax in the petroleum industry; national pipeline grid for natural gas; economics of marginal offshore oil fields; the origin and migration of oil; geochemical investigation of oils and source rocks; evaluation of properties from logs; porosity and permeability of reservoirs and caprocks; the use of Vertical Seismic Profiling; geophysical exploration; reservoir geological modelling; reservoir simulation; use of computer graphics; performance of an LPG plant; and, drilling mud evaluation. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10313 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *APEA J* v 26 pt 1 and pt 2 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 2 vol, 608p.

**077682 DISCOVERY AND EXPLOITATION OF NEW OILFIELDS IN THE COOPER-EROMANGA BASINS.** Since 1975 the level of petroleum exploration in the Cooper-Eromanga basins has undergone an unprecedented expansion due to the discovery and development of an increasing number of oil reservoirs, largely in the Eromanga Basin sequence. Three types of oil discovery in the Eromanga Basin sequence are evident; firstly, shallow pools above Cooper Basin gas fields; secondly, separate single-field discoveries in areas of limited exploration; and thirdly, as multifield discoveries along major structural trends. Exploitation of the Eromanga Basin oil discoveries has been made possible by a combination of rapid appraisal and development drilling and early commencement of production. (Edited author abstract) 11 refs.

Lavering, I.H. (Bur of Mineral Resources, Canberra, Aust); Passmore, V.L.; Paton, I.M. *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 250-259.

**077683 PETROLEUM EXPLORATION AND DEVELOPMENTS IN QUEENSLAND DURING 1985.** Petroleum exploration in Queensland during 1985 remained at the high levels that existed during 1984. Of the 115 wells spudded, 88 were wildcat exploration wells, 24 were appraisal wells, and three were development wells. New field discoveries numbered 23, being 16 oil and 7 of

gas, the highest number ever recorded. All but two of the appraisal wells and all three development wells were successful. Queensland's petroleum reserves now stand at 66 million barrels remaining recoverable oil, 17 billion cu m gas, and 500 000 tonnes of LPG. Daily production is about 29 000 barrels of oil and condensate, about 1.2 million cu m of gas, and 97 tonnes of LPG. (Edited author abstract) 6 refs.

Randal, M.A. (Geological Survey of Queensland, Brisbane, Aust). *APEA J* v 26 pt 2 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 46-62.

**077684 NEW SOUTH WALES PETROLEUM EXPLORATION AND DEVELOPMENTS 1985.** A discussion is presented of petroleum exploration and developments in New South Wales. Development activity, reserves and production, legislation and exploration policy are examined. Environmental/Aboriginal issues are also discussed. Data relative to exploration wells, development wells and seismic activity are presented in tabular form. Exploration expenditures and licenses granted are also given. 7 refs.

Etheridge, L. (NSW Government Dep of Mineral Resources, Sydney, Aust). *APEA J* v 26 pt 2 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 63-69.

**077685 VICTORIA'S ROLE IN HYDROCARBON PRODUCTION AND EXPLORATION IN 1985.** In 1985, a total of sixteen exploration wells were drilled in the Gippsland Basin. Eleven of these were offshore wells, of which eight were drilled in Licence areas and three in Permit areas. Five wells were drilled in the onshore Gippsland Basin during the year. In the onshore Otway Basin, Barton Corner 1 and Fahley 1 were drilled in PEP 105 with Beach Petroleum NL as operator, and Green-slopes 1 in PEP 101 with Phoenix Oil and Gas NL as operator. In addition, with seismic surveys undertaken involving 1117 km of traverses were completed in 1985. Total production from the Gippsland fields increased during the year, and there has been a significant increase in exports.

Thompson, B.R. (Victorian Dep of Industry, Technology Resources, East Melbourne, Aust). *APEA J* v 26 pt 2 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 70-73.

**077686 PETROLEUM EXPLORATION IN TASMANIA IN 1985.** 1985 saw an increase in exploration intensity in the Bass Basin, and has witnessed the Yolla oil and gas discovery well and encouraging hydrocarbon indications at the Tilana well; both wells were drilled by a consortium headed by Amoco Australia Petroleum Company. This year, 1986, has also seen a decline in offshore acreage held under permit: all current acreage is in the Bass Basin and is held by two consortia. Exploration expenditure increased sharply in 1985. To the end of 1985, 31 exploration wells had been drilled in Tasmanian waters. Of these, four have been drilled in the Otway/West Tasmanian basins, three on the Gippsland Shelf, and 24 in the Bass Basin. Geophysical surveys carried out in 1985 consisted mostly of seismic, with some marine gravity and marine magnetic. 6 refs.

Baillie, P.W. (Dep of Mines, Aust). *APEA J* v 26 pt 2 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 74-76.

**077687 PETROLEUM EXPLORATION AND DEVELOPMENT IN SOUTH AUSTRALIA.** In 1985, \$103 million was spent on exploration in South Australia (51 exploration and appraisal wells plus 13 582 km of seismic). In 1986 expenditure is predicted to exceed \$100 million (52 wells, 10 000 km of seismic). These levels of exploration have been maintained since 1983 and reflect the success of the Cooper Basin Development which currently provides a gross income from the sale of petroleum products approaching \$1 billion per year, with royalties of \$50 million per year. In the period from 1976 to 1985, exploration and appraisal drilling onshore ranged



from 3 wells to 49 wells per year, with the most active year being 1984 with 62 wells. Important development projects under way in 1985 concern secondary recovery of oil in the Tirrawarra, Moorari, and Dullangari oilfields. Three significant discoveries of hydrocarbons in South Australia during 1985 were all drilled under the Accelerated Gas Program and these are described.

Frears, R. (SA Dep of Mines & Energy, Parkside, Aust). *APEA J* v 26 pt 2 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 77-88.

**077688 PETROLEUM EXPLORATION, DEVELOPMENT, AND PRODUCTION IN WESTERN AUSTRALIA DURING 1985.** Phanerozoic sedimentary basins in Western Australia cover some 2.1 million sq km, divided almost equally between onshore and offshore. Of the nine principal basins, 1985 exploration activity focused on five: the Carnarvon, Canning, Perth, Bonaparte, and Browse. Western Australian production for 1985 consisted of 1.223 million kL crude oil, 2.55 billion cu m natural gas, 229 000 kL condensate, and 3057 kL LPG. Oil was produced from six fields, Barrow Island, Blina, West Terrace, Sundown, Dongara, and Mount Horner, while gas and condensate were produced from North Rankin, Dongara, Mondarra, Yardarino, and Woodada fields. Three highlights of the 1985 exploration drilling are the Saladin 1 and Harriet C1 oil discoveries offshore Carnarvon and the West Terrace 1 oil discovery onshore in the Canning Basin. Onshore the most significant oil discovery in 1985 was West Terrace 1.

Fraser, I. (Dep of Mines Western Australia, Perth, Aust). *APEA J* v 26 pt 2 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 89-102.

**077689 NORTHERN TERRITORY PETROLEUM EXPLORATION AND DEVELOPMENT.** In 1985, statistics reflect accelerated development drilling in the Palm Valley and Mereenie fields, and a pause in offshore activity as key permits in the Joseph Bonaparte Gulf and Timor Sea were renewed. 1985 saw only one onshore exploration well, Waterhouse 2 in the Amadeus Basin which was unsuccessful. Re-entry and testing of the 1982 well Weaver 1 (Bonaparte Basin) yielded significant gas flows. Construction of the 1500 km gas pipeline from the Palm Valley and Mereenie fields to Darwin via Tennant Creek and Katherine commenced in August 1985. Construction of the floating production facility to be moored over the Jabiru Field has commenced, and oil production of some 2000 kL/day is scheduled to flow in mid 1986.

Le Messurier, P. (Northern Territory Dep of Mines & Energy, Darwin, Aust). *APEA J* v 26 pt 2 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 103-107.

**077690 1985 APEA CONFERENCE: TECHNICAL PAPERS.** This conference proceedings contains 32 papers. Various aspects of petroleum prospecting in Australia are covered. Some of the topics discussed are: petroleum geology; petroleum reservoir engineering; geophysical applications; natural gas well logging; petrology; oil well drilling; oil well production; and automotive fuel manufacture. Other topics covered include seismic surveys; computer applications in petroleum prospecting; tectonics; exploration history; prospecting economics; and overseas recruitment of personnel. All papers are indexed and abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10312 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Australian Petroleum Exploration Assoc Ltd, Sydney, Aust). *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 386p.

**077691 PETROLEUM PROSPECTIVITY OF THE CLARENCE-MORETON BASIN IN NEW SOUTH WALES.** The Clarence-Moreton Basin covers an area of some 28,000 km<sup>2</sup> in north-eastern New South Wales and south-eastern Queensland. The basin is relatively unexplored, with a well density in New South Wales of one per 1600 km<sup>2</sup>. Since 1980, Endeavour Resources and its

co-venturers have pursued an active exploration programme which has resulted in the recognition of significant petroleum potential in the New South Wales portion of the basin. The primary exploration targets in the Clarence-Moreton Basin sequence are Lower Jurassic sediments comprising a thick, porous and permeable sandstone unit in the Bundamba Group, and channel and point-bar sands in the Marburg Formation. (Edited author abstract) 24 refs.

Ties, P. (Webb, Jessop & Co, Melbourne, Aust); Shaw, R.D.; Geary, G.C. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 15-33.

**077692 GEOLOGY AND HYDROCARBON POTENTIAL OF THE NORTH-WESTERN OFFICER BASIN.** Recent petroleum exploration in EP 186 and EP 187 in the north-western Officer Basin has greatly increased knowledge of the regional stratigraphy, structure and petroleum prospectivity of the region. This exploration programme has involved the drilling of two deep stratigraphic wells (Dragoon 1 and Hussar 1) and the acquisition of 1438 km of seismic data. Integration of regional gravity and aeromagnetic data with regional seismic and well data reveals that the Gibson Sub-basin primarily contains a Proterozoic evaporitic sequence. In contrast, the Herbert Sub-basin contains a Late Proterozoic to Cambrian clastic and carbonate sequence above the evaporites. This sequence, which was intersected in Hussar 1, is identified as the primary exploration target in the Western Officer Basin. The sequence contains excellent reservoir and seal rocks in association with mature source rocks. (Edited author abstract) 14 refs.

Phillips, Bruce J. (News Corp Ltd); James, Alan W.; Philip, Graeme M. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 52-61.

**077693 SOME COMMERCIAL ASPECTS OF PETROLEUM EXPLORATION AND MINING.** The petroleum industry in Australia is at the centre of a web of complex laws. In addition to the legislation under which petroleum exploration and production tenements are granted there is a multiplicity of statutes and regulations, Commonwealth and State, which have a direct bearing on the conduct of those involved in exploring for or exploiting Australia's petroleum reserves. For example, the level of participation by foreigners is governed by the Commonwealth Foreign Investment Guidelines and the Foreign Takeovers Act 1975; the Commonwealth has control over the export of petroleum under the Customs (Prohibited Exports) Regulations and domestic markets are subject to the operation of the Crude Oil Allocation Scheme. The Commonwealth continues to have the right to regulate the transfer of funds to and from Australia under the Banking (Foreign Exchange) Regulations. (Edited author abstract) 22 refs.

Moore, R.K. (Touche Ross & Co, Sydney, Aust); Willcocks, R.M. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 143-153.

**Azerbaijan** See PETROLEUM GEOLOGY—Azerbaijan.

**Computer Applications** See Also OIL WELL PRODUCTION—Computer Applications.

**077694 PERSONAL EVALUATION KEY TO TECHNICAL COMPUTING SELECTION.** The acquisition of technical computing hardware and software is an extremely personal process and a long-term commitment. Although most commercial system configurations have one of several general organizations, the individual requirements of the purchaser can have a large impact on successful implementation, even though differences between the products may seem small. In short, because each company has individual business needs, the evaluation of computing systems is not a matter of task performance, but rather one of task suitability. The end user is responsible, therefore, for choosing the most suitable system. The author presents a review of one purchaser's in-depth method for choosing the most appropriate computing environment for his company.

Shaw, Brian R. (BHP Petroleum (Americas) Inc, Houston, TX, USA). *World Oil* v 205 n 3 Sep 1987 p 39-41.

**077695 SYSTEM APPROACH TO THE PREDICTION, EXPLORATION AND PROSPECTING FOR OIL AND GAS POOLS.** A system is proposed characterizing the relationships between the conditions of formation and the regularities of distribution of oil and gas pools and the sequence of operations for predicting, exploring and prospecting them. The system shows the double role of the dynamic geosociological systems as a form of organization of the cognitive process and simultaneously as models reflecting actual reality represented in the form of geological systems. The possibility of implementing an algorithmic approach to resolve these problems is considered. The necessity of introducing informal heuristic elements into such an algorithm is demonstrated. In Russian. 6 refs.

Kerimov, V.Yu. *Izv Vyssh Uchebn Zaved Neft Gaz* n 1 1987 p 22-30.

**077696 TRENDS IN DATA ANALYSIS FOR PETROLEUM EXPLORATION AND DEVELOPMENT.** The computer world is presently locked in a race to produce the futuristic fifth generation computer, one which will simulate some parts of human intelligence. At the back of this is the current interest in expert systems and their adaptation to petroleum exploration and development. Converging hardware and software technologies, combined with industry requirements, show a definite trend to move from the emphasis on hardware and operations systems toward software and informational systems. It is not possible to predict the precise form in which this will impact petroleum industry operations but it is certain that much greater analytical power and control will rest in the hands of the interpreters enabling much higher rates of productivity and effectiveness in the location of hydrocarbon reservoirs. (Author abstract) 6 refs.

Lindseth, R.O. (Teknica Resource Development Ltd, Calgary, Alberta, Can). *APEA J* v 25 pt 1 1985, APEA Conf, Tech Pap, Perth, Aust, Mar 24-27 1985 p 382-386.

## Computer Simulation

**077697 THREE-DIMENSIONAL GRAVITY MODELING OF GULF COAST SALT DOMES.** In this article we demonstrate how gravity modeling can accurately determine the size and shape of salt domes. This is important to exploration and development of oil and gas reservoirs beneath the overhanging salt. We have shown that gravity modeling is a viable tool in the location of overhang. By the employment of this technique combined with a properly designed seismic program, using modeling, ray tracing, and correction for travel paths through the salt prior to stacking, and accurate delineation of the size and shape of the overhang can be made with a high degree of accuracy. We recommend an exploration program which uses a combination of subsurface, seismic, and gravity modeling on any prospect associated with a salt or shale dome or structure related to salt tectonics.

Greene, E.F.; Breshnahan, C.M. *Oil Gas J* v 85 n 41 Oct 12 1987 p 64-66, 68-69.

## Core Analysis See Also PETROLEUM GEOLOGY.

**077698 CORE ORIENTATION AND PRESENTATION OF DATA.** Orientation data such as measured from core offer many opportunities for geologic evaluation that often go overlooked or are not fully utilized. Two of the biggest difficulties appear to be that the procedures for evaluating such data are poorly described and the methods used to show such data are not adequate. The description provided of core orientation and data presentation should help in understanding what can be done and how to go about it. An example is included to show how data manipulation and the type of data presentation can alter the final interpretation. The types of data presentation discussed are equally applicable to other forms of orientation data such as from dipmeter logs.



Kirkland, James T. *Oil Gas J* v 85 n 43 Oct 26 1987 p 81-83.

**077699 NEW METHOD OF DETERMINATION OF WATER CONTENT IN SAMPLES OF OIL-SATURATED ROCKS.** In order to improve the accuracy of determination of the content of water in oil-saturated water rock samples of smaller than standard sizes, a method has been developed that is based on the property of selective permeability of polymer films by vapors of polar and nonpolar liquids. Taking into account that oil vapors are a mixture of mostly nonpolar fluids, the filtration properties of a cellophane film have been tested. The test apparatus and test procedures are described. This method is somewhat more accurate than the generally accepted extraction/distillation method. In Russian. 7 refs.

Potapov, V.P. *Geol Nefti Gaza* n 2 1987 p 20-23.

**Costs** See OIL WELL DRILLING—Economics.

**Economics** See Also OIL WELL PRODUCTION—Economics; PETROLEUM INDUSTRY—United States.

**077700 TRACKING CHANGES IN OIL EXPLORATION AND DEVELOPMENT TECHNOLOGY AND THEIR ECONOMIC IMPLICATIONS.** The objectives of this paper are to identify improvements made during the past 15 years in the technology and methods used for the exploration, development, and production of oil reserves in the U.S. Wherever possible, observations have been made with respect to the effect of these improvements on the exploitation of these reserves. Areas of research that will be of interest in the future have also been referenced. In this regard, it may be recognized that after an era in which it was important to find oil at any price to ensure supplies, the petroleum industry is now entering a period of systematic research to reduce costs in response to the new market conditions. (Author abstract) 29 refs.

van Rensburg, W.C.J. (Univ of Texas, TX, USA); Malik, Krishan A. *JPT J Pet Technol* v 40 n 1 Jan 1988 SPE 17021, p 71-74.

**077701 INTERNATIONAL PETROLEUM INVESTMENT - WHY AUSTRALIA?** This paper presents the methodology that Conoco, a major international energy company, uses to make exploration investment decisions. This methodology includes a detailed and well coordinated analysis of the technical merits, cost environment, political/economic environment, and contract terms for every area of interest. This paper considers how each of these elements in the analysis might be a plus or a minus with regard to directing exploration funds toward Australia and shows that Australia affords an ideal mix of technical/geological merit with a workable acquisition environment and attractive economic reward. Comparisons will be made with other areas around the world. (Edited author abstract)

Patterson, J.C. (Conoco Inc, Houston, TX, USA). *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 7-14.

**Electromagnetic** See GEOPHYSICS—Electromagnetic.

## Equipment

**077702 ADVANCES IN VIBRATOR SYSTEMS TECHNOLOGY.** Technical progress has been substantial over recent years in vibroseis mechanical and control configurations, field recording, and computing, data processing, and sweep methods. Together these improvements are available to provide new systems-level solutions to the difficult problems which face the exploration and field development decision makers. 2 refs.

Harmon, Jerry (Geophysical Service Inc, Dallas, TX, USA); Brook, Bob. *Oil Gas J* v 85 n 41 Oct 12 1987 p 89-93.

## Finland

**077703 HYDROCARBONS IN THE SAVIA VOLCANIC SCHIST ZONE, CENTRAL FINLAND.** Light hydrocarbon gases have been analysed from 21 samples of hydrothermally unaltered and 11 samples of hydrothermally altered metavolcanic rocks from the Savia volcanic schist zone in the southwestern part of the Proterozoic Vihanti - Pyhasalmi - Pielavesi Cu-Zn ore province, central Finland. The altered rocks are enriched in the lightest hydrocarbons (propanes and lighter) and depleted in the heavier hydrocarbons (butanes and heavier) compared with the metavolcanic rocks. The difference is clearest for methane (297.3 ppb in the altered rocks vs. 150.3 ppb in the metavolcanic rocks, becoming less marked for the heavier hydrocarbons. A pre-metamorphic hydrothermal origin related to the alteration of the volcanic rocks is the most probable reason for the difference. It is suggested, in the light of the limited data available, that a negative methane anomaly (diameter about 8 km) and positive cyclopropane and pentane anomalies (diameters about 2 km) generated by ore forming processes exist around the Savia Cu-Zn deposit. (Author abstract) 19 refs.

Rasilainen, K. (Geological Survey of Finland, Espoo, Finl). *Bull Geol Soc Finl* n 59 pt 2 1987 p 109-115.

Florida See PETROLEUM GEOLOGY—Florida.

France See OIL FIELDS—France.

## Geochemistry

**077704 RELATIONSHIP BETWEEN SEDIMENT THERMAL MATURITY AND RESERVOIRED OILS WITHIN OHIO.** The objectives of this study were to evaluate the maturity of potential source units and to demonstrate the relationship between the maturity trends of the potential source units and the reservoir oils. Approximately 40 oils were analyzed for their general composition, and approximately 75 rock samples of potential Devonian source rocks for thermal maturity using standardized whole-rock vitrinite reflectance techniques. The shales from Ordovician Point Pleasant Formation were also measured for their maturity using qualitative techniques (fluorescence, thermal alteration index, and transformation ratios from Rock-Eval pyrolysis). A total of about 700 rock samples were analyzed for source quality (% TOC, Rock-Eval pyrolysis, pyrolysis-gas chromatography). 1 ref.

Cole, Gary A. (Standard Oil Production Co, Irving, TX, USA); Halpern, Henry I.; Sedivy, Robert A.; Drozd, Richard J. *Org Geochem* v 11 n 5 1987, Sel of Pap from the 2nd Annu Meet of the Soc for Org Petrol, Houston, TX, USA, Nov 7-9 1985 p 419-421.

Gulf of Mexico See PETROLEUM GEOLOGY—Gulf of Mexico.

## Illinois

**077705 PETROLEUM FRONTIERS.** Some of the topics discussed in this paper are these: an overview of Western Illinois - the boom and after; a historical overview of drilling activity; a brief geologic history and description of units in Western Illinois; productive intervals in Western Illinois; and drilling and completion: practices and problems.

Anon. *Pet Front* v 4 n 4 1988 65p.

## Instruments

**077706 OVERVIEW OF GAS-SENSING RADAR SURVEYS THEORY, INSTRUMENTATION, SURVEYING, AND INTERPRETATION.** To investigate a possible geologic deposit of hydrocarbons, an x-band radar transmitter and its antenna direct pulses of microwave energy toward the area under investigation. The presumed petroleum gas molecules leaking out of the deposit, initially excited by the microwave, reradiate back almost instantly the absorbed energy generally at micro-

wave frequencies in a way characteristic for each kind of molecule. Neither methane nor ethane can be forced to absorb and reradiate in this fashion. However, propane has a fortuitous combination of characteristics that makes it a prime choice for seepage detection. The radar system can be mounted on a helicopter or on a truck. With helicopters, thirty to fifty square miles of flat terrain can be covered in a survey day.

Sandy, John (Geochemical Exploration Services Inc, Dallas, TX, USA); Gournay, Luke S. *Oil Gas J* v 86 n 5 Feb 1 1988 p 69-71.

## Legislation

**077707 QUEENSLAND PETROLEUM ACT - RUSTING ANACHRONISM OR WELL-OILED DISCRETION?** The current legislative framework for the exploration for petroleum in Queensland has its genesis in legislation enacted some 70 years ago. In more recent times exploration activity in Queensland has increased markedly, and there is every prospect of it being sustained at high levels for the remainder of this century. This paper reviews the history of petroleum legislation in Queensland, and outline the current provisions with respect to exploration; those provisions are then compared with industry's aims and practices, and, where any shortcomings in the legislation are identified, necessary, or appropriate, reforms are recommended. 14 refs.

Gately, D.J. *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 42-53.

## Management

**077708 EXPERT SYSTEM FOR STRATEGIC PLANNING.** An expert system program is proposed, named the Exploration Planning Assistant. The use of the expert system allows the user to manipulate and analyze huge amounts of input data. If the user organization is sophisticated, the expert system will allow modification through the addition of more refined rules and logic. If the user company is less experienced in its planning expertise, then the expert system can be built using outside experts to give the uninitiated the sophistication needed to successfully create a viable exploration plan with its associated strategies. The article discusses basic concepts of strategic planning and artificial intelligence, program decision modules, and other aspects of the subject. 2 Refs.

Quick, Allen N. (Allen Quick & Associates, Wheat Ridge, CO, USA); Schuyler, John R. *Oil Gas J* v 86 n 32 Aug 8 1988 p 75-79.

## Michigan

**077709 EVALUATION OF SILURIAN-NIAGARAN REEF BELT IN NORTHEASTERN MICHIGAN.** Silurian pinnacle reefs have remained the main exploration targets in the Michigan basin over the last decade. The results of exploration activities in northeastern Michigan in Cheboygan, Montmorency, and Presque Isle counties is different from the rest of the northern portion of the belt. A detailed study used the data available from the exploration activities in this area to determine the reef belt characteristics and reserves potential in northeastern Michigan and its extension into Lake Huron. The results indicated some interesting features, including the narrowing of the belt as it approaches Lake Huron. It was concluded that the different depositional environment during the Silurian Age had affected the development of the belt and the hydrocarbon accumulation in the pinnacle reefs in this part of the basin. (Edited author abstract) 13 refs.

Aminian, K. (West Virginia Univ, WV, USA); Ameri, S.; Bomar, R.M. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 13370, p 428-434.

Montana See PETROLEUM GEOLOGY—Stratigraphy.



Nebraska See PETROLEUM GEOLOGY—Nebraska.

New Zealand See PETROLEUM CHEMISTRY—Geochemistry.

Offshore See Also PETROLEUM GEOLOGY—Stratigraphy; WATER POLLUTION—Marine Pollution.

**077710 FINDING RESERVOIR SANDS IN DEEP GULF OF MEXICO WATERS.** The distribution of sand reservoirs in the Gulf of Mexico is controlled by sea-level change, provenance (origin), rate and style of sedimentation, and structural development. An understanding of these controls is especially important in the deepwater Gulf, where sand is scarce and exploration and production costs are high. Everest Geotech uses a combination of well-log interpretation, biostratigraphy and seismic stratigraphy to recognize depositional sequences and map the distribution of potential reservoir sand. Depositional sequences related to sea level are identified by special geometric relationships of the reflectors and seismic records which have been generated by changes in sea level and the associated sediment style. 1 ref.

Bowen, Bruce E. (Everest Geotech, Houston, TX, USA); Cucci, Maurice A. *Ocean Ind* v 22 n 1 Jan 1987 p 11-13.

**077711 ATTITUDES CHANGE ABOUT N. CALIFORNIA BASINS.** Exploratory drilling in the northern California offshore basins in the mid-1960s penetrated a substantial section of oil-stained Monterey formation rocks. All the wells were abandoned because the Monterey was not considered to be a viable reservoir rock at the time. Today, oil companies are expending considerable resources preparing for upcoming lease sales in the same areas. Many companies consider the northern California basins to be one of the most prospective pioneer areas in North America.

Bachman, Steven B. (Crouch, Bachman & Associates Inc, Santa Barbara, CA, USA); Crouch, James K. *Oil Gas J* v 85 n 50 Dec 14 1987 p 55-58.

**077712 BRITISH EXPERTISE FOR DIVERLESS DEVELOPMENT OF SUBSEA OIL.** One highly promising route to low cost deep water production, as is needed, for example, in Brazil's Campos Basin project, is subsea completion - the placing of production equipment on the sea bed rather than on a conventional platform. Here the ability to go diverless has been pioneered by a number of British oil companies, notably Shell and Esso, with the Central Cormorant underwater manifold centre (UMC) in the North Sea, which was itself based on earlier work by Esso offshore Mexico. The UMC concept allows drilling and production from a centralized manifold facility normally controlled either remotely from a platform on an associated field, or from the shore. Esso is now looking at a variation of the UMC theme known as the Esso deepwater integrated production system (EDIPS) in which a sea bed manifold accepts production from template drilled wells, and also from satellite single wells nearby. Similarly Shell International has shown how to work with other countries in its own deepwater project, known as the diverless installable and maintainable oil production system (DIMOS). This article presents a review of the diverless systems.

Grange, Peter. *Mar Technol* v 18 n 4 Dec 1987 p 130-131.

**077713 C<sub>1</sub>-C<sub>8</sub> HYDROCARBONS IN SEDIMENTS FROM GUAYMAS BASIN, GULF OF CALIFORNIA TO PERU MARGIN, JAPAN TRENCH AND CALIFORNIA BORDERLANDS.** Surface seafloor sediments, hydrothermal vent samples, and Deep Sea Drilling Project sediments (Hole 481A) from the Guaymas Basin were examined for C<sub>1</sub>-C<sub>8</sub> hydrocarbons. The proportions of various classes of compounds were examined and compared to those from other geographic areas (Peru upwelling region and Japan Trench) to gain insight into the relative importance of thermal generation, migration and biodegradation. Alkene/alkane ratios of 0.1 or greater were typical of both geothermally cold sediments and also of very hydrocarbon-rich Alvin samples recovered from the seafloor. Because little or no alkene was generally

detected in buried sediments exposed to geothermal temperatures greater than 30°C, it is suggested that the alkenes are produced by biogenic processes. Similarities in compositions of branched and cyclic compounds were observed in some pairs of bitumen-rich Guaymas seafloor samples recovered from different areas, suggesting common mechanisms of light hydrocarbon generation and/or migration. (Edited author abstract). 77 Refs.

Whelan, Jean K. (Woods Hole Oceanographic Inst, Woods Hole, MA, USA); Simoneit, Bernd R.T.; Tarafa, Martha E. *Org Geochem* v 12 n 2 1988 p 171-194.

**077714 GEOCHEMICAL AND BIOLOGICAL MARKER ASSESSMENT OF DEPOSITIONAL ENVIRONMENTS USING BRAZILIAN OFFSHORE OILS.** A combined geochemical and molecular characterization of a wide selection of oils from the major Brazilian offshore basins has been undertaken. The elemental (sulfur, nickel and vanadium) and bulk (<sup>41</sup>API and <sup>813</sup>C) properties of each sample have been considered, together with its molecular composition determined using liquid and gas chromatography, and quantitative biological marker investigations using gas chromatography-mass spectrometry for alkanes. The results reveal significant differences in the chemical features of the various oils which enable them to be divided into five groups. The distinction of the groups appears to reflect differences in the depositional environment of the source rocks of the oils. Each group is correlated tentatively with source rocks laid down in a specific depositional regime, namely lacustrine freshwater, lacustrine saline water, marine evaporitic, marine carbonate or marine deltaic. Additional aspects of the subject are discussed. (Edited author abstract). 81 Refs.

Mello, M.R. (Petrobras/Cenpes/Dives, Rio de Janeiro, Brazil); Gaglianone, P.C.; Brassell, S.C.; Maxwell, J.R. *Mar Pet Geol* v 5 n 3 Aug 1988 p 205-223.

## Oklahoma

**077715 WILDCAT REOPENS DEEP ANADARKO BASIN.** Wildcat Reopens Deep Anadarko Basin. This paper reports on new exploration in the deep Anadarko basin of western Oklahoma and the Texas Panhandle. Of great significance to future exploratory work in the Anadarko basin's deep trench is the June report that Unocal Corp. spudded a geological wildcat that could set a new producing depth record for Oklahoma. Petroleum Information says that the 2-33 Bruner, SE SW NE 33-1N-25W, Beckham County, began drilling on June 14. Projected depth is 28,000 ft. Objectives will be horizons including the Hunton at 23,850 ft and the Artuckle (Cambro-Ordovician) at 28,000 ft.

McCaslin, John C. *Oil Gas J* v 86 n 30 Jul 25 1988 p 101.

## Optimization See PETROLEUM, CRUDE—Costs.

## Radioactive Methods

**077716 CARBON ISOTOPIC VARIATIONS OF KEROGEN PYROLYZATES.** A method has been developed for isotopic analysis of pyrolyzates from temperature-programmed pyrolysis of small quantities of immature to early mature kerogen concentrates. A C<sub>5</sub> pyrolyzate is collected and oxidized on-line to carbon dioxide for stable carbon isotopic measurement. Results indicate that the carbon isotopic composition of the pyrolyzate varies with final pyrolysis temperature by up to 0.7 ppt. Based on the limited pyrolyzate isotopic variation with temperature, this method is considered to have potential application to source-oil assignment problems. Correlation can be achieved via composite carbon isotopic profiling; the elegance of the method deriving from the comparison of a petroleum with the oil labile component of a candidate source kerogen assemblage. (Author abstract). 23 Refs.

Burwood, R. (Standard Oil Production Co, Irving, TX, USA); Drozd, R.J.; Halpern, H.I.; Sedivy, R.A. *Org Geochem* v 12 n 2 1988 p 195-205.

## Seismic See PETROLEUM RESERVOIR ENGINEERING.

Seismic Survey See Also OIL FIELDS—Reservoir Evaluation; PETROLEUM GEOLOGY; PETROLEUM GEOLOGY—Australia; PETROLEUM GEOLOGY—Stratigraphy.

**077717 CARBONATE POROSITY FROM S/P TRAVELTIME RATIOS.** A twenty-mile S-wave seismic line was acquired on the northeastern shelf of the Anadarko basin by the 1977-1978 Conoco P-Wave/S-Wave Group Shoot. The resolution of the S-wave section is at least as good as the resolution of a coincident P-wave section acquired in 1975. The top and bottom of a collection of Paleozoic carbonates called the Hunton group can be identified on both sets of data. P and S traveltimes and traveltime ratios delineate lateral variations in the thickness and average porosity of the Hunton. Where the pore space is saturated with liquid, a systematic increase in average porosity from less than 2 percent to about 11 percent correlates with an increase in the S/P traveltime ratio from 1.84 to 1.96. The ratio decreases to values between 1.65 and 1.80 at two places along the line, probably indicating that the pore space is partially gas-saturated at these locations. (Edited author abstract)

Robertson, James D. (ARCO Oil & Gas Co, Dallas, TX, USA). *Geophysics* v 52 n 10 Oct 1987 p 1346-1354.

**077718 INTEGRATED EXPLORATION IMPROVES WILDCAT SUCCESS.** The need to find and produce petroleum at costs that allow a reasonable profit at today's oil prices will require some drastic changes in conventional exploration philosophy. An integrated system of low-cost, direct and semidirect geochemical methods coupled with geomorphic analyses based on Landsat and/or topographic maps and NHAP (National High Altitude Photography) aerial photos is suggested as a workable solution to this problem. The savings can come from three principal sources: (1) fewer dry holes, (2) fewer unproductive leases and (3) better focusing of more expensive methods on smaller, more prospective areas. It is recommended that the Regional Reconnaissance stage include maximum practical use of available low-cost data sets, such as the NURE aerial gamma-ray spectrometer and magnetometer data, Landsat images, topographic maps, and USGS NHAP (National High Altitude Photography) coverage. 15 refs.

Saunders, Donald F. (RECON Exploration Inc, Dallas, TX, USA); Thompson, C. Keith. *World Oil* v 205 n 3 Sep 1987 p 42-46.

**077719 SACRAMENTO DELTA: NEW APPROACH TO SEISMIC EXPLORATION IN AREA OF NEAR-SURFACE PROBLEMS.** Seismic exploration of prospective areas of hydrocarbon deposits is commonly hindered by poor data quality related to near-surface problems. This article is a case history from the Sacramento delta of California, an area which locally exhibits severe near-surface problems. We review the geology of the area, discuss the nature of the near-surface problems, present the field approach developed to try to solve these problems, and show improvements gained from implementing the approach. 8 refs.

Vuillermoz, Claude (CGG American Services, Denver, CO, USA); Bertagne, Allen L.; Delzer, Rollin. *Oil Gas J* v 85 n 46 Nov 16 1987 p 63-66.

**077720 IN SEARCH OF SUBTLE FAULT TRAPS USING SEISMIC MODELING TECHNIQUES.** This article, which was designed for practical applications, deals with prospect generation around fault systems that already have established production. This is very prevalent in today's economic climate where many companies are primarily involved in close-in exploration and/or development work. The main thesis of this article is that many small faults, or obscure structures, have been passed over because they are not recognizable on older vintage seismic data. Example of synthetic seismic sections which



were generated from a geological model show that better data processing, combined with current modeling techniques, can help delineate these subtle reservoirs.

Cline, W. Michael (Amerada Hess Corp, Houston, TX, USA). *Oil Gas J* v 85 n 48 Nov 30 1987 p 56-58.

**077721 GEOTOMOGRAPHY FOR EXPLORATION OF HEAVY OIL DEPOSITS.** Seismic and electromagnetic geotomography are useful exploration techniques in heavy oil deposits. They will serve to delineate reserves and measure the progress of in-situ recovery schemes. The propagation characteristics for various Athabasca sands can be deduced from laboratory and limited field results. Such results are essential to the proper design and interpretation of exploration projects. The choice of transmission frequency in EM tomography and the choice of source design in seismic tomography are controlled by the kind of propagation expected in the project. Once these properties are converted to propagation characteristics it remains to invert the geotomographic data set to obtain structure. We suggest the use of an inversion method well-known in seismology but not widely used in industrial geotomography. The Lanczos inverse of the observation equations allows investigation of missing data, resolution of conflicting data, and a clear statement of the significance of the results. (Edited author abstract) 21 refs.

Singh, R.P. (Indian Inst of Technology, Kanpur, India); Nyland, E. *Energy Sources* v 9 n 4 1987 p 229-238.

**077722 SEISMIC EXPRESSION OF THE UPPER MORROW SANDS, WESTERN ANADARKO BASIN.** One-dimensional merged log modeling, two-dimensional log interpolation modeling, color seismic inversion processing, and seismic facies mapping techniques have been applied to the Lear and Darden fields, two Upper Morrow sand fields of the western Anadarko Basin in the Texas Panhandle. Here the Morrow sands reach an isopach thickness of 10 to 15 m at a depth of 2500 to 3000 m. These Morrow sands are within the thin-bed regime (below the tuning point) so that there is a correlation between the amplitude of the reflection and the thickness of the sand. The velocity and density contrasts of the shales and sands are sufficient to produce a good acoustic impedance contrast, making the sands detectable on seismic data with good signal-to-noise ratios. The comparison of geologic isopach mapping and geophysical seismic facies mapping shows an excellent correlation in the delineation of the Upper Morrow sands. (Edited author abstract) 2 refs.

Halverson, Jens R. (Seismic Interpretations Inc, Amarillo, TX, USA). *Geophysics* v 53 n 3 Mar 1988 p 290-303.

**077723 COMPUTER-AIDED SEISMIC INTERPRETATION SYSTEMS.** Interpretation of seismic data is very much dependent on personal experience and background knowledge of the geoscientist. However, for a few years now a new generation of computer systems has provided support in this specific area as well. Currently about half a dozen different seismic interpretation systems are marketed worldwide. Although hard- and software architecture and basic philosophy might differ somewhat, all these systems are based on one common idea: To provide support for the interpreter in his task to gain a picture, as complete and as accurate as possible, of the subsurface area he is exploring for hydrocarbons. (Author abstract)

Albert, G. (Mobil Oil AG, Celle, West Ger). *Erdoel Kohle Erdgas Petrochem* v 41 n 5 May 1988 p 190-192.

**077724 EXPERIENCE WITH THUMPER, DYNAMITE, AND VIBROSEIS SOURCES IN EP 308, THE EASTERN CANNING BASIN.** The aim of Shell's seismic survey was to acquire high resolution data in the shallow part of the section (0.3-1.0 seconds) as an aid to prospect definition. Extensive testing was carried out with Thumper, dynamite, and Vibroseis sources to determine which source would best meet this data requirement. Field processing results indicated that the Vibroseis was the best source, although special attention was needed to ensure

adequate low frequency energy was input in poor data areas. In-house processing of production and downhole Vibroseis data suggests that low frequency attenuation may still be an area for future concern. (Edited author abstract) 2 refs.

Stienstra, J.J. (Shell Co of Australia Ltd, Melbourne, Aust); Prudence, T.J.C.; Haneveld, C.J. *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 353-362.

**077725 RECENT EXPLORATION AND HYDROCARBON POTENTIAL OF THE ROMA SHELF, QUEENSLAND.** The probability of finding additional gas reserves on the Roma Shelf within Authority to Prospect 336P and Petroleum Leases 3-13 is assessed as being very high. There is a 50 percent probability that 80 billion cubic feet (2250 million cubic metres) will be found and a 20 percent probability that 290 billion cubic feet (8170 million cubic metres) will be discovered. Recent seismic information together with geologic models developed for the Roma Shelf, Queensland have refined the settings of various plays of this important hydrocarbon province. Recent exploration has been highly successful with 67 percent of the exploration drilling resulting in new field discoveries. This success rate has stemmed from finer spaced grids of high resolution seismic which has provided accurate prospect mapping. Refinements to exploration concepts have also resulted from an integrated geological and geophysical approach. (Edited author abstract) 16 refs.

Cosgrove, J.L. (CSR, Brisbane, Aust); Mogg, W.G. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 216-234.

**077726 POINT TORMENT SEISMIC SURVEY: A SEMI-PORTABLE SEISMIC OPERATION.** Point Torment, an area of low-lying tidal mudflats and adjacent coastal peninsula, was the site of a seismic survey unique to Australian geophysical exploration. This survey was conducted by Esso Australia Ltd and the area, part of EP 104, is located north of the township of Derby in Western Australia. Surface conditions in the area varied from thickly wooded grassland on the peninsula to open mudflats. Vehicle access to the mudflats was severely restricted and helicopter support was necessary to maintain the seismic operation throughout. The operation was extremely labour intensive; for example, line-cutting through mangrove areas was carried out by hand. Seismic recording was achieved using an OPSEIS® 5500 digital radio telemetry system. With this system, data is collected by portable field units. (Edited author abstract)

Angove, Ron (Esso Australia Ltd, Sydney, Aust). *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 248-253.

**077727 VSP CASE HISTORY, KANPA 1A, THE WESTERN OFFICER BASIN.** The Kanpa 1A Vertical Seismic Profile (VSP) was conducted for Shell by Schlumberger and incorporated variable time and depth sampling, different source offsets and recording in cased and uncased hole. Stacked VSP traces for Kanpa 1A were compared with a zero-phase seismic section and synthetic seismogram at the well. The VSP/seismic match is good and, due to poor synthetic/seismic correlation, was the basis for the final seismic/well tie. Interpretation of deep VSP data enabled the estimation of formation boundaries below the total depth of the well. (Edited author abstract) 4 refs.

Prudence, T.J.C. (Shell Development (Australia) Pty Ltd, Melbourne, Aust); Flentri, J. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 254-264.

**077728 PRE-Eocene STRATIGRAPHY, STRUCTURE, AND PETROLEUM POTENTIAL OF THE BASS BASIN.** Exploration in the Bass Basin has mainly concentrated on the Eocene part of the Eastern View Coal Measures with the pre-Eocene stratigraphy hardly being tested. Structural mapping using a good quality Bureau of Mineral Resources regional seismic survey and infill

industry seismic data, in conjunction with seismic stratigraphy and well data, has generated an understanding of the structure and stratigraphy of the pre-Eocene basin, which suggests that exploration potential exists in structural and stratigraphic leads of both Paleocene and Cretaceous age. Pre-Eocene structural and stratigraphic studies of the Bass Basin thus point to reservoir and hydrocarbon source potential for possible multiple hydrocarbon exploration targets. (Edited author abstract) 22 refs.

Williamson, P.E. (Bur of Mineral Resources, Canberra, Aust); Pigram, C.J.; Colwell, J.B.; Scherl, A.S.; Lockwood, K.L.; Branson, J.C. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 362-381.

## Siberia, USSR

**077729 COMBINED COSMOAEROGEOLOGIC AND GEOCHEMICAL INVESTIGATIONS IN NORTHERN SIBERIA.** In the course of the last 10 years, the Soviet 'Aerogeologiya' production and geological association has carried out space and aerial geological explorations in the northern regions of Siberia. As a result, some new elements of the geological structure have been detected. They are useful for solving problems of predicting potential oil and gas deposits. In the first place this concerns the rupture tectonics as well as identification of large and particularly local auticlinal structures that have become active in more recent times. Geochemical methods are based on the ideas about the filtration and diffusion mass transfer of hydrocarbon gases from a deposit to the overburden, including the ground surface and their concentration in surface waters, soils and plants. In Russian.

Bidzhiev, R.A.; Lyapina, G.G.; Rozhnova, T.A.; Vanin, A.L. *Geol Nefti Gaza* n 5 May 1987 p 13-19.

## Texas

**077730 TEST OF NATIONAL URANIUM RESOURCE EVALUATION GAMMA-RAY SPECTRAL DATA IN PETROLEUM RECONNAISSANCE.** Advances in interpretation techniques have made possible effective use of aerial high-sensitivity gamma-ray spectral data to explore for petroleum in selected environments. These data were collected by the U.S. Department of Energy during the National Uranium Resource Evaluation (NURE) program throughout the conterminous U.S. and most of Alaska between 1974 and 1981. The tests reported in this paper were carried out in three different areas of the state of Texas. It is shown that the application of high-sensitivity gamma-ray spectrometry has regional advantages and limitations, which depend on the nature, origin, moisture content, and possible shielding cover of the surface soils. If these factors are carefully considered, the NURE radiometric data offer promise as an inexpensive reconnaissance guide to help locate new onshore oil and gas prospects or possible field extensions in the East Texas Basin, the west Texas area, and similar environments. Refs.

Saunders, Donald F. (RECON Exploration, Dallas, TX, USA); Terry, Stephen A.; Thompson, C. Keith. *Geophysics* v 52 n 11 Nov 1987 p 1547-1556.

## Ukraine

**077731 EFFICACY OF GEOLOGICAL EXPLORATION FOR OIL AND GAS AT GREAT DEPTHS IN THE DNEIPER-DONETS DEPRESSION.** The maximum depth of the sedimentary cover in the Dnieper-Donets depression is 18-20 km. Sedimentary Devonian, Carboniferous, Permian and Mesozoic-Cenozoic, and possibly Paleozoic and Riphean formations are developed here. The largest quantity of explored oil and gas deposits is related to the Lower Permian and Upper Carboniferous stage. As the reserves of the top formations are being exhausted, prospecting at depths of 3500-4000 m is carried on. Commercial hydrocarbon pools have been discovered at depths below 4500 m at 33 fields; 14 deposits have productive levels at depths of more than 5000 m. The most promising areas are the Glinsko-Solokhovskii and



Talalaevsko-Rybalskii petroliferous regions, i.e. central axial and northeastern flank parts of the depression. Natural gas deposits increase with the depth. In Russian.

Zav'yalov, V.M.; Aleshko, I.F.; Kuchma, L.M.; Mel'nikchuk, T.V. *Geol Nefti Gaza* n 11 Nov 1987 p 6-9.

## United Kingdom

**077732 UNITED KINGDOM: OIL POLICY IN A CHANGING WORLD MARKET.** The United Kingdom has gone, in the space of 10 years, from producing an insignificant amount of onshore oil to being the fifth largest producer of oil worldwide, mostly from offshore fields. This turn of events has occurred for a variety of reasons, such as the fourfold oil price increases of 1973-74 and the economic recession of the 1970s, have largely fallen outside the influence and control of UK government policy. This paper shows that despite the success of the past decade the underlying failure of the UK Government to formulate an energy policy which sought to enhance the benefits of North Sea oil will, against the background of a changing world oil market, put at risk the continued exploration for and development of North Sea oil.

Humphries, M.E. (Midland Bank plc). *Q J Tech Pap Inst Pet* Oct-Dec 1986 p 57-68.

**077733 RESEARCH NECESSARY TO INCREASE THE OPPORTUNITIES FOR ECONOMIC USE OF THE UK'S RESOURCES OF ITS OCEANS AND THE EARTH BENEATH THEM.** Despite the recent collapse in oil prices, hydrocarbon deposits in the North Sea remain the United Kingdom's most commercially attractive marine resource. For this reason I have restricted the scope of this essay to research which increases the opportunities for economic use of the UK hydrocarbon resources. With oil job losses looking set to rise to as high as 32,700 by early 1988, there are more practical reasons for concentrating on this area. This essay is split into two parts. The first part addresses the title directly and lists research projects which will increase the opportunities for economic use of the UK's hydrocarbon resources. These projects have been selected by the various organizations involved in formulating offshore research strategy. The second part goes on to examine the more important factors responsible for shaping this strategy. (Edited author abstract) 28 refs.

Nowell, Graham. *Underwater Technol* v 13 n 4 Winter 1987 p 27-35.

## United States

**077734 EARLY MESOZOIC RIFT SYSTEM: HYDROCARBON FRONTIER ON THE EAST COAST.** Numerous buried Mesozoic basins are known onshore beneath the Atlantic Coastal Plain sediments from Long Island to Florida, while similar basins have been suggested offshore by aeromagnetic, gravimetric, and seismic data interpretations. However, the understanding of the economic importance of these basins has been hindered by the paucity of local and regional stratigraphic control, the lack of good, unambiguous geophysical data and, historically, a general domestic industry prejudice against nonmarine basins. Noting the changed industry attitude, a data acquisition program was commenced by Teledyne Exploration Co. to provide stratigraphically placed seismic reflection profiles across some of these basins. The article describes the program and discusses some of its recent results.

Bowman, Harold E. (Elcoex Inc, Great Falls, VA, USA); Sheppard, Richard C.; Ziegler, Daniel G. *Oil Gas J* v 85 n 41 Oct 12 1987 p 57-58, 63.

**077735 PETROLEUM EXPLORATION POTENTIAL OF THE MIDCONTINENT RIFT, U.S.A.** Assessment of the potential for petroleum of Proterozoic age in rift-related marginal and overlying axial basins indicates a possible 5 billion barrel TOC (total organic carbon content) resource. However, source volume constraints curtail that estimate to 70 million barrels of oil and 420 billion cubic feet of gas. Adequate volumes of reservoir

rock have been identified in all rift segments. The most promising horsts are fault-related clastics of Proterozoic age or more extensive basal Paleozoic sandstone that locally occurs in marginal basins along and in sheets adjacent to the rift. It is postulated that both structural and stratigraphic traps are likely to occur.

Davidson, Donald M. Jr.; Mudrey, M.G. Jr. *Geosci Wis* v 11 Sept 1986 p 63.

## Wisconsin

**077736 EXPLORATION AND LEASING.** The general public became aware of the recent interest in petroleum exploration along the Midcontinent trend in northern Wisconsin in the fall of 1983. Leasing and seismic evaluation programs have occurred along the Midcontinent trend in Kansas, Iowa, and Minnesota, as well as in Wisconsin, but the focus of this discussion is on the northwestern counties of Wisconsin from Lake Superior southwestward. Subject covered include seismic evaluation, Wisconsin leasing activity, and regulatory response to petroleum interest.

Evans, Thomas J. *Geosci Wis* v 11 Sept 1986 p 59-62.

**077737 OIL AND GAS POTENTIAL OF KEWEENAWAN MIDCONTINENT RIFT SYSTEM IN NORTHWESTERN WISCONSIN.** Extensive leasing and seismic exploration along the Keweenawan Midcontinent Rift System from Upper Michigan into Kansas centered in northwestern Wisconsin during 1983-1985. Detailed geochemical and geophysical justification for this petroleum play remains confidential, but regional geological knowledge encourages speculation. This regional geology is discussed in the paper. Keweenawan petroleum potential is heightened by inexpensive leases for large tracts of public land, relatively cheap drilling in a politically stable area, and the potential for discovering gas storage. Wisconsin, however, has high taxes and strong environmental laws, and drilling in Lake Superior would be prohibited even if a lakeside field were discovered. Exploration activity has waned due to current economics in the petroleum industry, and Amoco cancelled a 1985 wildcard in Bayfield County that would have evaluated the St. Croix Horst. (Edited author abstract)

Paull, Richard A. *Geosci Wis* v 11 Sept 1986 p 64-73.

**PETROLEUM REFINERIES** See Also DISTILLATION EQUIPMENT; ENERGY POLICY—India; FUELS—Additive Compounds; PETROLEUM INDUSTRY—United States.

**077738 HYDROCARBON PROCESSING SYMPOSIUM - 1988 (PRESENTED AT THE ELEVENTH ANNUAL ENERGY-SOURCES TECHNOLOGY CONFERENCE AND EXHIBITION).** This conference contains 10 papers. These papers cover a range of technology and problems of concern to the industry - liquid ring vacuum pumps, reciprocating pumps for slurry services, air pollution concerns and controls, liquid waste treatment, conversion of natural gas into liquid fuels, and identification of hazards and planning of safety countermeasures. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11164 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Lewis, J.P. (Ed.) (Project Technical Liaison Inc, Houston, TX, USA). *ASME Pet Div Publ PD* v 13, Hydrocarbon Process Symp - 1988, New Orleans, LA, USA, Jan 10-13 1988. Publ by ASME, New York, NY, USA, 1988 67p.

## Accident Prevention

**077739 A COMPUTER AIDED SHUTDOWN SYSTEM ANALYSIS AND DESIGN PROCEDURE.** A procedure is developed for designing safety shutdown systems. Shutdown system configurations using different types of hardware are evaluated. The probability of the failure modes of each configuration is evaluated using failure mode analysis techniques. Unless predefined failure probability levels are met, the method evaluates iteratively various forms of part redundancy for each configuration

until the specified failure probabilities are satisfied. Then the achieved risk reduction from the use of each configuration is quantified and the corresponding total life cost is estimated. The configuration which presents the highest risk reduction and the least total life cost is selected. The proposed method is applied to the design of a shutdown system for a turbine driven compressor of an oil refinery. (Author abstract) 12 refs.

Hassapis, G. (Univ of Thessaloniki, Thessaloniki, Greece); Petrou, L.; Klefouri, D. *Comput Ind* v 9 n 2 Oct 1987 p 115-125.

California See COGENERATION PLANTS—California.

## Catalytic Cracking

**077740 PRELIMINARY HAZARDS ANALYSIS CONDUCTED ON FCCU COMPLEX.** A preliminary hazards analysis (PHA) was conducted on an actual fluid catalytic cracking unit (FCCU) complex at a refinery. The PHA was conducted to improve the FCCU's availability and profitability. The preliminary hazards analysis conducted on the FCCU had two specific objectives: to identify potential component failures that represent relatively high economic risks at the refinery, and to obtain the information necessary for performing a detailed analysis of each of the high risk areas identified. In addition, numerous recommendations for improving FCCU complex availability based on qualitative insights gained during the analysis were made. The article discusses economic risk concepts, failure modes and effects consequence of assessment, and other aspects of the subject. 7 Refs.

Rooney, James J. (JBF Associates Inc, Knoxville, TN, USA); Turner, Joe H.; Arendt, John S. *Oil Gas J* v 86 n 32 Aug 8 1988 p 60-66.

## Computer Applications

**077741 OPERATORS CAN USE EXPERT SYSTEMS.** Just on the horizon are expert systems that plant operators can tap to resolve problems. And such systems will be welcome indeed. This situation raises the question of 'artificial intelligence' (AI) as applied to an expert system that could answer an operator's question quickly, without needless guesswork. AI has long been the domain of science fiction writers. More recently, with the growth and availability of computers, AI has become a buzz word in the process and manufacturing industries. However, with the increasing power of computers and the availability of specialized programming methods, the paper discusses how something close to AI can be achieved.

Kerridge, A.E. (M.W. Kellogg Co, Houston, TX, USA). *Hydrocarbon Process* v 66 n 9 Sep 1987 4p between p 97 and 105.

**077742 OIL & COMPUTERS: REFINING/DESIGN.** Refiners, petrochemical processors, and engineering companies involved in process design and operation have geared their management philosophies to closely link management and operating strategies to computer technology. The result is that modern computer technology is critically linked to the way these companies do business. The important point is that companies are not using computers to simply automate existing business practices. Most indicate that in order to take full advantage of available computer technology and modern management methods, a combined integration of computer hardware and software and forward thinking management techniques is necessary. As a result, computer system departments or groups in the process companies generally serve as advisors and coordinators, very much like consultants to all of the other company departments. This places the primary responsibility for the selection and implementation of computer systems on the operating departments - essentially, the potential users of the system.

Corbett, Richard A. (Oil & Gas Journal, Tulsa, OK, USA). *Oil Gas J* v 86 n 2 Jan 11 1988 p 56-60, 62.



**077743 FCCU PROCESS CONTROL IMPROVED BY DECISION-SUPPORT COMPUTER SYSTEM PROGRAM.** Operator effectiveness, ease of troubleshooting, and control of refining processes have been improved with the installation of a decision support system (DSS) at Texas City Refining Inc. (TRC), Texas City, Tex. The DSS is used at the discretion of the operator as opposed to placing total reliance on automation to operate the refinery. Use of the DSS has enabled TCR to eliminate production of high-end-point gasoline. The system is also useful as a training device for operators. 8 refs.

Lofton, F. Wesley (Texas City Refining Inc, Texas City, TX, USA); Staigerwald, John W. *Oil Gas J* v 86 n 22 May 30 1988 p 74-77.

**Computer Simulation** See Also MATHEMATICAL PROGRAMMING, LINEAR.

**077744 SIMULATION ANALYSIS CONSERVES ENERGY AND RESOURCES IN OLEFIN PLANT DESIGN AND OPERATION.** OSA (Operations Simulation Analysis) achieved energy and resource conservation in commercial naphtha, gas oil LPG crackers, and in process design and operations, achieving maximum profit operation at maximum operating flexibility. This report summarizes our successful story on how OSA achieved this goal in an 8 month process-improvement program. 19 refs.

Huang, Warren (Int Operations Analysis Corp, Taipei, Taiwan). *Modell Simul Control B* v 11 n 4 1987 p 55-64.

## Corrosion

**077745 GETTING THE MOST OUT OF CORROSION CONTROL.** Refineries have long recognized the cost penalties on operations of an onstream failure caused by corrosion. In 1980 Esso started to recommend the setting up of organized corrosion control programs at each of its ten European refineries. The aim of the programs was to achieve the optimum combination of reliability, safety and operating flexibility while still maintaining reasonable materials economics. The philosophy can equally be applied to chemical and other process plants.

Royse, Susan. *Process Eng (London)* v 69 n 1 Jan 1988 p 37-39.

**077746 FIRST APPLICATION OF ARTIFICIAL INTELLIGENCE FOR CORROSION CONTROL IN THE PETROLEUM INDUSTRY.** The first artificial intelligence (AI) programmed Expert Adviser for the corrosion control of a refinery process unit has been installed at the Sun Refining & Marketing Co. Yabucoa Refinery. The MOR-or-LES crude unit expert adviser is a part of the operating computer system. The Adviser provides real time analysis of process conditions and is configured to become an automatic process control system. Details regarding the problem definition, system logic, and informational responses are presented. An overview of the AI programming development and conversion to the operational computer system is discussed. (Edited author abstract)

Loushin, L. Louis (Sun Refining & Marketing Co, Newton Square, PA, USA). *Mater Perform* v 27 n 6 Jun 1988 p 77-83.

**Design** See CHEMICAL PLANTS—Design; PETROLEUM REFINING—Fluid Catalytic Cracking.

**Economics** See Also PETROLEUM REFINING—Efficiency.

**077747 OUTLOOK FOR ASIAN REFINERY INVESTMENTS IN THE 1990'S.** This paper focuses on a diverse group of nations in a region of Asia stretching from Pakistan in the west to Japan in the east. The region's present refining capacity of 11.5 million barrels per day (BPD) has recently operated at 74% of capacity. During the next 10 years, the economies in this region will continue to outperform the world economy. Strong economic growth combined with the energy-intensive,

developing nature of many Asian nations' economies will increase oil demand, resulting in the need for additional investments in the region's refining facilities during the 1990's. (Author abstract)

Boepple, John T. (Caltex Petroleum Corp, Dallas, TX, USA). *Energy Prog* v 7 n 3 Sep 1987 p 127-129.

**077748 REFINERY INVESTMENT AND NAVAL FUEL PRODUCTION.** Survey data and linear programming techniques have been combined to forecast probable domestic refinery configurations and the production of Navy and other fuels for the years 1990 and 1995. The forecasts suggest that Gulf and West Coast refinery investments could be used largely for support of major gasoline production. Future refinery configurations affect the availability of Navy mobility fuels. To maintain current fuel-supply levels, it appears that the military will have to pay more for Navy jet fuel relative to the prices of civilian jet fuel. The quality of Navy jet fuel is projected to be stable during the forecast period. The Navy's marine diesel fuel is forecast to be in good supply. However, the low-temperature fluidity of the fuel is expected to deteriorate. (Author abstract) 11 refs.

Hadder, G.R. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Das, S.; Davis, R.M. *Energy (Oxford)* v 13 n 1 Jan 1988 p 45-56.

## Efficiency

**077749 IMPROVING REFINERY EFFICIENCIES.** With the decline of crude prices starting two years ago and constraints in capital availability, some refiners have significantly reduced their efficiency improvement programs under the illusion that these are less critical to their operations. However, it has been the authors' experience through three recent efficiency improvement surveys that plant profitability can still be improved by 20 to 50¢/bbl (\$1.26-3.14/m<sup>3</sup>) of crude processed, even at crude prices of \$14-18/bbl (\$88-113/m<sup>3</sup>). Considering the recent competitive market for petroleum products and current indications that crude prices are rising once again, this seems a logical time to reinstate efficiency improvement programs and at least proceed with those that have little or no investment associated with them.

Lockett, W. Jr. (ENCON Associates Inc, Bernardsville, NJ, USA); Plumstead, J.A. *Chem Eng Prog* v 83 n 4 Apr 1987 p 33-36.

## Effluent Treatment

**077750 STORMWATER MANAGEMENT FOR PETROLEUM REFINERIES.** Stormwater management analysis for a petroleum refinery drainage system requires the careful consideration of all components to ensure that wastewater effluent guidelines are met during rainfall events. Refinery runoff areas can be divided into three types for stormwater management analysis: contaminated areas such as the process unit areas; potentially contaminated areas such as roadways and tank fields; and uncontaminated areas in undeveloped parts of the refinery. The management of the runoff from each area can be markedly different depending on the quality and quantity of the runoff to be dealt with. Short duration storm events are often as important as long duration events in sizing the various drainage facilities. Runoff from each area must, therefore, be analyzed carefully, with consideration given to its interaction with other drainage system components and the process wastewater flow. (Edited author abstract) 10 refs.

Hodgson, J.E. (Stanley Associates Engineering Ltd, Edmonton, Alberta, Can); Bendiak, L.C. *Can Water Resour J* v 12 n 3 1987 p 38-47.

**077751 PETROLEUM PROCESSING AND SYNTHETIC FUELS.** This Annual Literature Review article discusses the title subject within the general topic of industrial wastes. Brief reviews of research and application literature on petroleum processing and synfuels are presented. 61 refs.

Cowan, Brent W.; Stover, Enos L. *J Water Pollut Control*

*Fed* v 58 n 6 Jun 1986 p 571-574.

**077752 INVESTIGATION OF PETROLEUM REFINERY EFFLUENT TREATMENT IN AN AEROBIC FIXED-FILM BIOLOGICAL SYSTEM.** The feasibility of treating a synthetic toxic waste and a petroleum refinery effluent was evaluated using a four-stage, fixed-film aerated bioreactor with a 50 l capacity and a surface area-to-volume ratio of 72. The process performance at various waste strengths and influent flow rates was found satisfactory. Organic loading proved to be a better operational or design parameter. Treatment efficiency decreased as the loading was increased. An organic loading of 42 g COD/m<sup>2</sup>d or less is recommended to ensure good quality effluent. The reactor coped with organic and hydraulic overloads because of the good oxygen transfer capacity and the considerable quantity of attached biomass attained. Staging of the reactor was effective in damping excessive loadings. Treatment of the refinery waste in the bioreactor removed up to 80 percent of the COD and reduced the oil, sulfide and amm.N concentrations substantially, but polishing of reactor effluent using alum treatment improved effluent quality for potential reuse. (Author abstract) 12 refs.

Hamoda, M.F. (Kuwait Univ); Al-Haddad, A.A. *J Inst Water Environ Manage* v 1 n 2 Oct 1987 p 239-246.

**077753 ROLE OF GAC ACTIVITY AND PARTICLE SIZE DURING THE FLUIDIZED-BED ANAEROBIC TREATMENT OF REFINERY SOUR WATER STRIPPER BOTTOMS.** Three expanded-bed anaerobic reactors were operated in parallel on sour water stripper bottoms. Two sizes of granular activated carbon (GAC) and non-activated carbon were used in the reactors. Performance was evaluated. Results indicated that the adsorptive capacity of GAC was essential for reducing the toxicity of the wastewater, thus permitting uninhibited biological treatment. Reactor performance improved with decreasing GAC particle size and when higher loading rates of the wastewater were used. This was attributed to the increased surface available for microbial attachment and the decreased diffusional resistance to adsorption that accompany a decrease in GAC particle size. (Author abstract) 12 refs.

Gardner, David A.; Suidan, Makram T.; Kobayashi, Hester A. *J Water Pollut Control Fed* v 60 n 4 Apr 1988 p 505-513.

## Effluents

**077754 HOW TO MEET THE NEW EMISSION STANDARDS FOR REFINERIES.** This paper summarizes the options open to respond to the new and necessary emission standards. It gives an overview of the options studied. The refinery emission problem should be viewed in the context of the total European air pollution situation. Subjects covered include flue gas treatment, emission reduction combined with cogeneration, gasification of heavy oil, and desulfurization of fuel. 4 refs.

Steenwinkel, F.E. (Comprim BV, Amsterdam, Neth); Mink, B.H. *Oil Gas Eur Mag* v 13 n 1 1987 p 33-36.

**Emissions** See HYDROFLUORIC ACID.

## Energy Conservation

**077755 SAVE BY ABSORPTION HEAT PUMPING.** Absorption heat pumping (AHP) is an absorption refrigeration system redesigned for use at temperatures entirely above ambient. Applied to fractional distillations, absorption heat pumping eliminates approximately half the reboiler steam demand by temperature elevating low-level latent heat from the tower overhead (normally rejected to the environment) and rejecting it instead to the reboiler. The mechanical vapor compressor (MVC) can also achieve this; however, the two system, AHP and MVC, differ fundamentally with respect to the practical concerns of real plant applications.

Davidson, W.F. (Energy Concepts Co, Annapolis, MD, USA); Campagne, W.v.L. *Hydrocarbon Process* v 66 n 12



Dec 1987 p 30-31.

## Environmental Impact

**077756 DETERMINATION OF NITRATE ION CONTENT IN RECIRCULATING WATER IN PETROLEUM REFINERIES AND PETROCHEMICAL PLANTS.** Various photometric methods are used in determining small quantities of nitrates. In investigating the component composition of water in recirculating water supply systems, a rapid method is needed for nitrate determination. The authors have checked the widely used salicylate method and have found that it gives unduly low results. In this connection, a method which has been developed for determining nitrate ions using a solution of 2,6-diacetaminopyridine in concentrated  $H_2SO_4$  was found; the authors have adopted this method as the basis for the work. The relative standard deviation in determining 5-25 ml/liter of nitrate ion by this method is 0.2. The range of determinable concentrations is 0.04-2  $\mu g/ml$ . 4 refs.

Sukhova, N.S. (Scientific-Industrial Assoc 'Lennftekhim', USSR); Bokova, Z.I. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 210-211.

**Equipment** See MINERAL OIL—Production; PETROLEUM REFINING—Coking; VALVES AND VALVE GEAR.

**Flare Stacks** See OIL FIELD EQUIPMENT—Design.

**Flow Sheets** See PETROLEUM REFINING—Fluid Catalytic Cracking.

**Fractionating Units** See Also PETROLEUM REFINING—Hydrocracking.

**077757 PC-BASED CONTROL SYSTEM COMPLEMENTS NGL HEAT-RECOVERY PROJECT.** Valero Hydrocarbons has employed a PC-based control system to realize the energy-saving potential of a heat-recovery project at its Corpus Christi, Tex., NGL fractionator (CCF). The operation of CCF as an isobutane-butane-natural gasoline fractionation complex started in 1982. As a part of a continuing effort to optimize and improve the operations of its gas and gas-liquid processing facilities, Valero Hydrocarbons recently revamped CCF. Valero's studies revealed that the modified process, although energy efficient, could promote disturbances to the plant's heat balance with a resultant deterioration of product quality. An advanced control system would be required to compensate for disturbances. Valero selected a low-cost system which would utilize one of its surplus personal computers.

Young, Roy M. (R&M Associates Inc, Stafford, TX, USA). *Oil Gas J* v 86 n 18 May 2 1988 p 84-86.

**Heat Exchangers** See Also HEAT EXCHANGERS—Scale Formation.

**077758 SPECIALTY STAINLESS STEELS INCREASE REFINERY EXCHANGER LIFE.** Practical experience using duplex (ferritic-austenitic) and high-alloyed austenitic stainless steels in various refinery heat exchangers is outlined. Although called 'specialty steels' to distinguish them from the 300 series, they are standard as to availability and fabrication properties; two most important factors for the maintenance personnel to consider. A recognition of this is the fact that today there are hundreds of heat exchangers equipped with these tubes in service in refineries around the world. 7 refs.

Berglund, G. (AB Sandvik Steel, Sandviken, Sweden); Wilhelmsson, P.H.; Martenson, C. *Hydrocarbon Process* v 67 n 1 Jan 1988 p 46-49.

## Heaters

**077759 BETTER PROCESS HEATER CONTROL.** This paper discusses some of the fundamentals of refinery and chemical plant process heater controls and gives practical data for evaluating control effectiveness. The objectives of heater control systems are to keep the operation safe and satisfy the process requirements while

maintaining maximum profit. Process heaters have a technical optimum, which is minimum cost (i.e., minimum fuel rate for the desired load). Furnaces that operate as reactors have economic optimums, which have a yield that is a trade-off between selectivity, conversion and runtime, and a cost which is proportional to the fuel flowrate. The same basic combustion control circuits are used for both types of furnaces, but the optimal control systems are different.

Stanton, B.D. (Continental Controls, Houston, TX, USA). *Hydrocarbon Process* v 66 n 7 Jul 1987 p 35-39.

**077760 SIMULACION DE CALENTADORES A FUEGO DIRECTO CILINDRICOS VERTICALES.** [Simulation of Vertical-Cylindrical Fired Heaters]. Frequently, the process equipment designer has to decide if equipment designed for specified operation conditions can be employed satisfactorily for other operating conditions, sensibly different to those originally designed for. The simulation described is for both, the radiant and convective sections. A zone method is employed to calculate the radiant heat transfer in the combustion chamber, for the heat transferred in the convective section a method proposed by C.Q. Torrijos is used. Included in this article is an algorithm to evaluate the heat transfer inside tubes. An analysis of a vertical-cylindrical fired heater is presented to illustrate the use of the methods described. (Edited author abstract) In Spanish. 8 refs.

Rangel Davalos, Humberto (Inst Mexicano del Petroleo, Mex); Parra Fernandez, Anaberti; Briones Vallejo, Victor M. *Rev Inst Mex Pet* v 19 n 2 Apr 1987 p 38-51.

**077761 ANALISIS DE FLEXIBILIDAD DE SERPENTINES DE CALENTADORES A FUEGO DIRECTO.** [Coil Flexibility Analysis of Fired Heaters]. Utilization of vertical-cylindrical fired heaters in the Campeche Bay refinery is very important due to the little plot area needed. These heaters raise the temperature of the thermal fluid that circulates inside the coil tubes. The temperature gradient, the pressure gradient and the weight causes the coil to deform. The flexibility analysis is made by a tridimensional computer program (SADAPS). (Edited author abstract) In Spanish. 2 refs.

Beltran Garcia, Jorge Luis (Inst Mexicano del Petroleo, Mex); Garcia Silva, Gustavo. *Rev Inst Mex Pet* v 19 n 2 Apr 1987 p 52-61.

**077762 COMBUSTION AIR PREHEATING FOR REFINERY HEATERS USING PLATE-TYPE HEAT EXCHANGERS.** To be justified economically, air preheating systems have to be characterized by reduced mass and volume and flexible design to allow economical integration into the heater design. Plate-type heat exchangers made of smooth plates respond well to all these requirements and gained the acceptance of the petrochemical industry worldwide. The use of air preheating is determined by economical criteria, function of energy cost and capital investment. The flow characteristics of these exchangers are presented and it is shown that the improved flow pattern results in their main advantages, i.e. reduced mass and volume while being of a heavy duty construction and with an excellent corrosion resistance.

Dinulescu, Mircea (North Atlantic Technologies (Canada) Inc, Calgary, Alberta, Can). *Energy Prog* v 8 n 2 Jun 1988 p 103-108.

## Instruments

**077763 RE-INSTRUMENTING ON A TIGHT BUDGET.** The need to upgrade control systems and instrumentation within tight budgetary constraints is a familiar theme throughout the process industries. This article outlines the steps taken by one refinery to reinstrument four plants in a four-year program. Central to the success of the approach was a planning process in which a number of important decisions were made - including decisions to standardize on one distributed control system vendor and to use a hot cutter approach to install the new control systems. (Edited author abstract) ?

Lytle, Thomas R. (Sun Refining & Marketing Co, Toledo,

OH, USA). *InTech* v 35 n 5 May 1988 p 49-51.

## Integrated Control

**077764 IMPROVING REFINERY OPERATIONS: A GOAL OF TODAY'S INSTRUMENTATION.** New microprocessor-based instruments can provide refiners with control tools capable of improving process operations. This paper discusses features and control enhancement capabilities of new instrumentation as well as its ability to provide truly centralized control. Examples illustrate integration of microprocessor-based control systems that result in highly cost-effective solutions for increasing refinery production and energy conservation. (Author abstract) 13 refs.

Dean, Donna M. (Foxboro Co, Foxboro, MA, USA); Hall, G. Frederic. *Energy Prog* v 7 n 3 Sep 1987 p 142-147.

## Loss Prevention

**077765 SAFETY CASE MODELLING AT SHELL UK.** The author outlines the general approach to safety case modelling. The safety case is divided into three parts which are examined under the following headings: general description and site location; management control policies and systems; and, identification, selection and consequence analysis for potential incidents. The estimation of consequences is also examined.

Eberlein, John (Shell UK Ltd, London, Engl). *Chem Eng (London)* Suppl n 439 Aug 1987 p11-14.

**Maintenance** See Also CHEMICAL PLANTS—Maintenance.

**077766 EFFECTIVE DOCUMENTATION CAN IMPROVE REVAMPS.** Revamp complexity is increased when a combination of activities must be done under a tight, fixed schedule and be integrated with a major expansion. Application of five principles leads to efficient revamp execution: 1) logical, orderly planning; 2) adequate documentation; 3) definition of exact scope before demolition or construction; 4) clear communication using standard formats; and 5) design to minimize shutdown time.

Austin, J.F. (Badger Engineers Inc, Cambridge, MA, USA); Sultan, M.S. *Hydrocarbon Process* v 66 n 11 Nov 1987 5p between p 111 and 121.

## Models

**077767 LINEAR PROGRAM OPTIMIZATION OF REFINERY SPREADSHEETS.** The advantages of representing a complex petroleum refining operation in flow diagram form showing the volume of each stream flow is evident to most engineers. With the evolution of spreadsheet refinery programming models, it became possible not only to provide such a representation but also to have it in mathematical form such that any change introduced anywhere in the refinery would reflect in all relevant stream flows, plus changes in utility use, hydrogen balance and sulfur balance. The time required for rebalancing the refinery model to show all changes on its flow diagram is about three seconds with present day microcomputers. In its simplest context, the spreadsheet model can be thought of as a complete, very fast, refinery simulator. 2 refs.

White, J.R. (Mobil Research & Development Corp, Princeton, NJ, USA). *Hydrocarbon Process* v 66 n 11 Nov 1987 p 92.

## Modernization

**077768 PROGRESS OF OCCUPATIONAL HYGIENE IN PETROLEUM REFINING INDUSTRY.** Hygienic characteristics of scientific and technical reconstruction in the petroleum refining industry is presented from 1961. Sanitary, hygienic, and socioeconomic effect of the technical reconstruction and hygienic activities have been analyzed along with the dynamic indices of workers' health status. (Author abstract) In Russian. 10 refs.



Karamova, L.M. *Gig Tr Prof Zabol* n 1 Jan 1988 p 40-44.

## Modification

**077769 GAINING AN ECONOMIC ADVANTAGE BY MODERNIZING A CRUDE UNIT.** A large Vacuum Distillation Crude Unit at Texaco's Port Arthur Plant began continuous service in the early 1970's. It was designed to refine 130k BPD of raw crude and produce simultaneous lube-oil cuts off the vacuum tower. In 1980, the unit was upgraded to 170k BPD. Texaco desired to develop an energy conservation investment program encompassing the entire unit. Near the end of 1984, a program was developed to include the following: air preheat for the four large heaters; vacuum pump installation to replace steam jet ejectors for the vacuum system; vacuum tower internal modifications; and automation and instrumentation. Using the projected fuel prices, these projects were expected to have superior economic returns.

McConnell, Marc (Texaco Refining & Marketing Inc, Port Arthur, TX, USA); Royer, Leroy Jr. *Energy Prog* v 8 n 1 Mar 1988 p 54-58.

## Nondestructive Examination

**077770 NDT EQUIPMENT AND METHODS IN PETROLEUM.** The objective of NDT (Non Destructive Testing) is to establish testing procedures, methods and routines which do not affect the process or component under test and NDT is therefore particularly suitable for the petroleum industry where many processes are continuous and where interruption of manufacturing and processing can be particularly costly. The major NDT techniques include ultrasonic testing, eddy current testing, magnetic particle inspection, x-ray inspection and visual techniques. Of these, ultrasonics is the most widely used in the petroleum industry and this is the major concern of this article. It is shown that in particular, NDT makes a significant contribution to both safety and cost control and assists in the planning of maintenance and component replacement. The application of microprocessors to conventional NDT techniques is overcoming the problems of the large amounts of data produced from petroleum and chemical plants.

Brook, Chris (Wells Krautkramer). *Pet Rev* v 41 n 487 Aug 1987 p 15, 17-18.

## Personnel Training

**077771 ORGANIZZAZIONE DELL'ADDESTRAMENTO IN RAFFINERIE E COMPLESSI PETROLCHIMICI.** [Organization of Personnel Training at Refineries and Petrochemical Plants]. Interest in personnel training organized and conducted with professional and modern criteria is growing in Italian industries. Based on experience abroad and in Italy, the authors summarize some principles and problems concerning the training of new and experienced personnel in refineries and chemical industries. Then an example is given of training organization in a typical refinery, both for new and old workers at the operator and supervisor level. (Edited author abstract) In Italian.

Giavarini, C. (Univ di Roma 'La Sapienza', Italy); Campailla, B. *Riv Combust* v 41 n 6 Jun 1987 p 154-160.

## Piping Systems See PIPING SYSTEMS—Maintenance.

## Port Harcourt, Nigeria

**077772 ZWEI RIESEN FUER DIE RAFFINERIE PORT HARCOURT, NIGERIA.** [Two Giants for Port Harcourt Refinery, Nigeria]. This article describes the largest pieces of equipment ever to be manufactured in one piece by Voest Alpine AG, a crude oil column and a vacuum column. The dimensions: inside diameter max. 7,800 mm, length 52,000 mm wall thickness 21-30 mm, weight 240 t. New advances in production technology made it possible to minimize manufacturing costs. For example, completely new welding techniques were used. (Author abstract) In German.

Anon. *Stahlbau Rundsch* n 69 Oct 1987 p 28-29.

## Pressure Vessels

**077773 SCHLUESSELKOMONENTEN FUER DEN DERZEIT GROESSTEN RAFFINERIEKOMPLEX EUROPAS.** [Key Components for Europe's Largest Refinery Complex]. The author describes the major pressure tanks in some detail. Fluid cat cracker is the main component. Reactor with max. diam. of 6.6 m, length 34 m, weight 160 t; cylinder jacket diam. 5.8 m. Regenerator: max. diam. 9 m, length 31 m, weight 220 t; cylinder jacket diam. 8.2 m. Primary fractionating column: length 49.5 m, weight 245 t, wall thicknesses 11 + 3 and 52 + 3 mm. Waste heat boiler: 195 t. diam. 3.3 m, length 20.9 m. (Author abstract) In German.

Anon (Voest-Alpine Hebag, Linz, Austria). *Stahlbau Rundsch* n 68 Apr 1987 p 14-15.

## Refractory Materials

**077774 PORTABLE BURNER DRYOUTS OF REFRACTORY MUST BE PROPERLY ENGINEERED.** The drying of castable refractory linings on major refining

process units, such as fluid catalytic crackers and fluid coking units, before the mechanical completion of the units has provided practical advantages. The dryout of the lining must be carefully controlled to gradually release the water, and thereby to avoid the buildup of detrimental steam pressure within the lining material. Recently, contractors typically utilize portable, gas-fired burners for dryout service. A personal computer (PC) program was used to more effectively design the set-up of dryout equipment and address unit design parameters. The theoretical bases for these calculations are defined. Recent data from actual unit dryouts are shown and compared to predicted temperatures based on the PC calculations. These data confirm the validity of the engineering calculations, and the value of computer evaluations in the planning of portable burner dryouts. 1 ref.

Linck, F.E. (Turnaround Maintenance Inc); Linck, Mark. *Oil Gas J* v 86 n 4 Jan 25 1988 p 70, 72-75.

## Retrofitting

**077775 RETROFITTING REFINERY AND PETROCHEMICAL PLANTS.** The author focuses on process improvements as the best way to reduce plant energy use. Despite the progress to date, there is growing evidence that these heat losses can be further reduced economically by about 20-30% in most refineries and petrochemical plants. One way to reduce the losses is to increase recovery of low-level heat by improved heat exchange, which has been the subject of most publications on plant energy conservation. A better way is to develop new process schemes that require less air/water cooling. One useful concept in developing new schemes is to concentrate on heat losses, rather than heat input, as an easier measure of proposed improvements. By an overall heat balance, eliminating a unit of energy loss is equivalent to saving a unit of heat input somewhere in the plant. 7 refs.

Kesler, M.G. (Kesler Engineering Inc, Highland Park, NJ, USA). *Chem Eng Prog* v 84 n 6 Jun 1988 p 59-64.

## Salt Removal See PETROLEUM, CRUDE—Processing.

## Schwechat an der Oder German Democratic Republic See WASTEWATER—Treatment.

## Separators

**077776 DEVELOPMENT AND INTRODUCTION OF AUTOMATED SEPARATOR BLOCKS.** The common use in the USSR of single-pipeline sealed systems for simultaneous collection and transport of oil and gas instead of two-pipeline systems for separate collection and transport as also the centralization and enlargement of the oil refining points changed the conditions of separating the oil and gas mixtures. Based on the new requirements arising from a basic redesign of the oil collection,

transport, and preparation systems, the Tatar Institute of Petroleum Engineering Research developed and the 'Salavatneftemash' Production Combine organized the commercial production of standardized normal series of automated separator blocks of type UBS with preliminary gas collection.

Gainutdinov, R.S.; Nikolaev, N.A.; Diarov, R.K.; Fattakhov, M.Sh. *Chem Pet Eng* v 23 n 3-4 Mar-Apr 1987 p 182-183.

## Shutdown See PARAFFINS—Production.

## Texas

**077777 REVAMP INCREASES SULFUR-RECOVERY CAPACITY AT CORPUS CHRISTI'S CHAMPLIN REFINING CO.** Champlin Refining Co. recently completed a revamp of the 140 long ton/day sulfur recovery plant at its 160,000-b/d Corpus Christi, Tex., refinery. The refinery needed to quickly and economically gain an incremental 15-20% in sulfur recovery capacity to boost its capability to process higher-sulfur crude oils and/or to accommodate higher conversion operation. Management decided that enrichment of the air supply to

the sulfur-recovery units with oxygen would provide the necessary capacity increase. This required replacement of two thermal reactors, replacing the existing burners, repacking the quench tower, adding a quench-water cooler, adding a quench-water circulating pump, installing an oxygen-supply system, and adding additional analysis and control equipment. The revamp resulted in an increase in sulfur recovery capacity of 30 long tons/day, in a timely and cost-effective manner, when the air supply was enriched to 30 vol % total oxygen. The modifications not only enabled the plant to increase to current capacity, but also will permit further plant debottlenecking by additional oxygen enrichment. 3 refs.

Rice, Fred J. (Champlin Refining Co, Corpus Christi, TX, USA); Siegmund, Scott C.; Hull, Randall L. *Oil Gas J* v 86 n 3 Jan 18 1988 p 39-43.

## Thermal Insulation See THERMAL INSULATION—Calculations.

## Waste Disposal See Also INDUSTRIAL WASTES—Treatment.

**077778 HAZARDOUS-WASTE REGULATIONS SUMMARIZED FOR REFINERS.** Refiners face more stringent regulation of the treatment, storage, and disposal of hazardous wastes. Under recent regulations, a larger number of compounds have been, and are being, studied. Long-time methods of disposal, such as land farming of refinery waste, are being phased out. As a result, many refineries are changing their waste management practices. New regulations are becoming even more stringent, and they encompass a broader range of chemical constituents and processes. Continued pressure from the U.S. Congress has led to more explicit laws allowing little leeway for industry, the U.S. Environmental Protection Agency (EPA), or state agencies. A summary of the current regulations and what they mean to refiners is given. It is hoped that the summary will clarify the sometimes confusing rules, and help refiners deal with a situation that could entail major costs for the industry in the years to come.

Olschewsky, David (ERT Inc, Dallas, TX, USA); Megna, Alice. *Oil Gas J* v 86 n 1 Jan 4 1988 p 39-44.

## Waste Heat Utilization See Also TURBOMACHINERY—Waste Heat Utilization.

**077779 WASTE HEAT RECOVERY OF DURA (IRAQ) OIL REFINERY AND ALTERNATIVE CO-GENERATION ENERGY PLANT.** The first part of this paper presents a waste recovery scheme for an oil refinery energy plant. Both the wasted heat of the process return condensate and the flue gases are utilized for low temperature feedwater and fuel heating. The steam saved, both from the main steam line and turbine extraction system, was found to increase the steam and plant overall



efficiency by 18%. An alternative cogeneration energy plant is presented in the second part of this study. The proposed plant utilizes the gas turbine exhaust, in conjunction with a heat recovery boiler, to produce the process steam requirement. (Edited author abstract) 5 refs.

Fath, Hassan E.S. (Alexandria Univ, Alexandria, Egypt); Hashem, Hameed H. *Heat Recovery Syst CHP* v 8 n 3 1988 p 265-270.

**Waste Utilization** See SULFUR—Recovery.

**PETROLEUM REFINING** See Also AUTOMOTIVE FUELS—Optimization; CATALYSTS—Performance; CATALYSTS—Regeneration; CATALYSTS—Selectivity; LUBRICATING OILS—Physical Properties; LUBRICATING OILS—Structure; PETROLEUM PRODUCTS; PETROLEUM PRODUCTS—Chromatographic Analysis; PETROLEUM PRODUCTS—Economics; PETROLEUM PRODUCTS—Stability.

**077780 SHELL MIDDLE DISTILLATE SYNTHETIC PROCESS.** A description of the Shell Middle Distillate Synthesis (SMDS) process is given. In this two-stage process, which has been specifically developed for the production of middle distillates, a liquid product is obtained which typically consists of naphtha, kerosene and gas oil in the ratios 15:25:60 to 25:50:25. Starting from natural gas, a thermal efficiency for a stand-alone plant of 60% can be achieved by using shell technology for both syngas manufacture and middle distillates synthesis. Apart from the synthesis per se, special attention is paid to the production of the synthesis gas with its consequences for the overall process efficiency and the impact on the environment. (Edited author abstract)

van der Burgt, M.J. (Shell Int Petroleum Maatschappij BV, Hague, Neth); van Klinken, J.; Sie, S.T. *Q J Tech Pap Inst Pet* Jan-Mar 1986 p 11-17.

**077781 SEVERAL APPROACHES CAN UPGRADE CALIFORNIA HEAVY CRUDES.** Because refinery processing capability on the West and Gulf Coasts may be limited for directly processing California Outer Continental Shelf (OCS) crude oil, several processing methods were studied to upgrade the OCS crude oil to a syncrude similar in properties to Alaska North Slope (ANS) crude. Processes studied include: delayed coking, Flexicoking, resid hydrotreating, and resid hydrotreating. Based on typical properties of OCS crude oils, yields from the various process configurations were compared, including alternative schemes of manufacturing hydrogen from resid vs. steam reforming of refinery off gases. Process schemes producing streams with better than target properties included bypassing untreated stocks to achieve overall syncrude specifications. The syncrude produced via these processes would be suitable for charging to West and Gulf Coast refineries with minimal refinery modification. 11 refs.

Chapel, D.G. (Fluor Daniel, Irvine, CA, USA); Brown, Robert E.; Cobb, David D.; Heaven, D.L. *Oil Gas J* v 85 n 46 Nov 16 1987 p 41-44, 46, 48.

**077782 REACTION KINETIC CORRELATION EQUATION PREDICTS FLUID CATALYTIC CRACKING COKE YIELDS.** Coke yields in fluid catalytic cracking units (FCCU's) can be accurately predicted by a recently developed reaction kinetic equation. The equation has been checked against actual coke yields in both pilot and commercial FCCU's. It is well known that coke yield is important in the heat balance of fluid catalytic crackers. The amount of coke produced in the FCCU can limit the extent of the cracking reaction and, in turn, affect the primary product yields. 12 refs.

Yen, Lewis C. (M.W. Kellogg Co, Houston, TX, USA); Wrench, Richard E.; Ong, Andres S. *Oil Gas J* v 86 n 2 Jan 11 1988 p 67-70.

**077783 COMPARISON OF PERFORMANCE OF AN INDUSTRIAL VGO-TREATER WITH REACTOR MODEL PREDICTIONS.** A simplified reactor model can be used for predicting the performance of an industrial VGO-treater. Laboratory-scale experiments

performed on the same feed and catalyst as those in the industrial unit lead to a reactor simulation which agrees well with the data from this unit. In the laboratory experiments, it is possible to overcome the specific hydrodynamic problems of trickle-bed reactors by applying the catalyst dilution technique. Results obtained by this technique allowed the development of a reactor model which enables the user to simulate the adiabatic behavior of the industrial reactor. In this way, the significant gap between the reactor temperature in the isothermal laboratory reactor and the WABT of the industrial adiabatic reactor can be bridged. (Author abstract) 7 refs.

Doehler, Werner (VEBA Oel Entwicklungsgesellschaft mbH, Gelsenkirchen, West Ger); Rupp, Martin. *Chem Eng Technol* v 10 n 5 Oct 1987 p 349-352.

**077784 CONTINUOUS DEASPHALTING OF HEAVY PETROLEUM RESIDUES WITH ETHYL ACETATE.** When crude oil is vacuum distilled, about 30% of the feed remain as low value residue. Hydrocracking can upgrade this residue into valuable light hydrocarbons. The hydrocarbons could be optimized catalytically, if the residue were not to contain the metals vanadium and nickel that poison the catalyst. This contribution shows that continuous extractions of the residue with ethyl acetate yields a fraction with low metal content, while an asphaltene fraction with the remaining metal content is filtered off. (Author abstract) 15 refs.

Hoeker, Juergen (Technical Univ of Clausthal, Clausthal-Zellerfeld, West Ger); Vogel, Alfons. *Chem Eng Technol* v 10 n 2 Apr 1987 p 125-131.

**077785 HYDROGENATION OF SRC-II HEAVY DISTILLATE OVER Co-Mo/ALUMINA: EFFECT OF HYDROGEN SULPHIDE.** The effect of gas phase addition of H<sub>2</sub>S on the hydrogenation of SRC-II heavy distillate over reduced and/or sulphided Co/Mo/alumina was studied using a trickle bed reactor under the following conditions: temperature 400°C, pressure 9.81 MPa, LHSV 1.8 h<sup>-1</sup>, and H<sub>2</sub>/distillate feed ratio 1000 vol/vol. Hydrogenation activity, as expressed by [octahydrophenanthrene]/[phenanthrene] ratio in the product, attained its highest with the presulphided catalyst. The activity of the presulphided catalyst was not influenced by the addition of H<sub>2</sub>S. (Author abstract) 8 refs.

Yamada, Muneyoshi (Tohoku Univ, Sendai, Jpn); Obara, Toshiyuki; Shindo, Takayoshi; Yan, Jian-Wei; Amano, Akira. *Fuel* v 67 n 2 Feb 1988 p 298-299.

**077786 IMPROVING CLASP PLANT SULPHUR CAPACITY.** The COPE process (Claus Oxygen based Process Expansion), jointly developed and commercialized by Air Products and Chemicals together with Goar, Allison and Associates, has the potential of doubling the sulfur capacity of existing Claus plant which is used in over 80 percent of the world's refineries and sour gas processing plants. By oxygen enrichment, COPE adapts Claus units to process an acid gas feed with a high H<sub>2</sub>S content while reducing SO<sub>x</sub> emission to meet stricter environmental regulations. Retrofitting can offer attractive savings compared with installing new air based capacity.

Ruston, Mike (Air Products). *Pet Times* v 91 n 2216 Nov 1987 p 14.

**077787 CATALYST SELECTION FOR HYDROTREATMENT TURNAROUND.** Catalyst selection very seldom gets the attention it deserves during a hydrotreater turnaround, but proper selection of the replacement catalyst can have significant effects on hydroprocessing performance and on product values and downstream operations. Experience shows that the optimum catalyst loading for a given plant can be defined by a close working relationship between refinery operations, the refinery technical group, and the catalyst vendor. The vendor provides a performance prediction or pilot plant test indicating the expected catalyst performance at a given set of operating conditions. When looking to improve catalyst performance or activity, the following parameters should be considered: catalyst type, catalyst particle size, catalyst

shape, catalytic properties, and catalytic loading. 2 refs.

Moyse, Brian M. (Haldor Topsoe, Houston, TX, USA); Ward, John W. *Oil Gas J* v 86 n 9 Feb 1988 p 64-66.

**077788 PROMOTED COMBUSTION IMPROVES FCCU FLEXIBILITY.** Well-controlled CO combustion in the regenerator of a fluid catalytic cracking unit (FCCU) can be a valuable tool for the refiner to optimize unit energy balance and conversion, and to improve the flexibility of the FCC operation. Various aspects of the combustion of coke and CO in the regenerator are influenced by variables when the unit is operated with a promoted or unpromoted catalyst system. Some topics discussed are these: coke and heat balance, nonpromoted combustion, promoted combustion, regenerator effects, temperature effects on the amount of coke burned from the regenerated catalysts (CRC), promoter content effects, after burn  $\Delta T$ , promoter type, coke selectivity and feed quality, and process variables. 7 refs.

Upson, Lawrence L. (Katalistiks BV, Leiderdorp, Neth); van der Zwan, Hans. *Oil Gas J* v 85 n 47 Nov 23 1987 p 65-70.

**077789 NON-CATALYTIC HYDROCRACKING OF ASPHALTENES: 1. PRODUCT DISTRIBUTIONS.** Athabasca asphaltenes were hydrocracked (non-catalytic) at temperatures ranging from 350 to 425°C for reaction times up to 26 h in a batch autoclave reactor. Product fractions of gas, resins, oils (saturates and aromatics), coke and asphaltenes were recovered using a solvent extraction sequence. Gas products were analysed by gas chromatography. The variation of product yields with time and temperature provided insight into asphaltene structure and thermal hydrocracking reaction pathways. Primary hydrocracking products include light hydrocarbon gases, alkanes and sulphur compounds (H<sub>2</sub>S), from which the presence of corresponding moieties in the asphaltene was inferred. Primary asphaltene reactions also produce coke. (Edited author abstract) 38 refs.

Soodhoo, Ken (Univ of Toronto, Toronto, Ont, Can); Phillips, Colin R. *Fuel* v 67 n 3 Mar 1988 p 361-374.

**077790 VISBREAKING STUDIES ON AGHAJARI LONG RESIDUE.** Visbreaking studies on Aghajari long residue (370°C+) have been conducted in a continuous bench-scale unit at different severity conditions. The effects of temperature and residence time on the yields and properties of the visbroken distillates and residues have been studied. The kinetics of cracking has been determined to be first order. (Author abstract) 10 refs.

Krishna, R. (Indian Inst of Petroleum, Dehra Dun, India); Kuchhal, Y.K.; Sarna, G.S.; Singh, I.D. *Fuel* v 67 n 3 Mar 1988 p 379-383.

**077791 REFINERY ECONOMICS AFFECTED BY FCC IMPACT ON ALKYLATION.** The fluid catalytic cracking (FCC) 'complex', including alkylation and other downstream processes, must be operated as an integrated system in order to maximize profits. Many factors have changed refining economics, including the increased demand for higher-quality unleaded gasoline. Therefore, an evaluation of the cumulative impact of the FCC operation on downstream processes must be considered to maximize the operating margin of the total complex. IONA's FCC simulation model evaluates the significant items that contribute to the impact of FCC operating condition changes. Economics and alkylation, the vapor recovery unit (VRU), polymerization, MTBE, and other processes are included in the evaluation.

McDonald, G.W.G. (IONA Ltd, Sarasota, FL, USA). *Oil Gas J* v 83 n 13 Apr 1 1985 p 111-115.

**077792 FACTORS IMPACTING REFINING INVESTMENTS FOR THE 1990S.** The author assesses the worldwide refining industry in terms of internal and external factors impacting refining in the future. The effect of crude prices on investment spending is discussed and



the demand for resid and distillates examined. Environmental concerns are outlined. Governmental impact is also measured. 18 refs.

Trowbridge, Theodore D. *Chem Eng Prog* v 84 n 3 Mar 1988 p 26-33.

**077793 ETUDE DES PROPRIETES RHEOLOGIQUES DES COUPES LOURDES A HAUTE TEMPERATURE ET PRESSION.** [Study of the Rheological Properties of Heavy Cuts at High Temperature and Pressure]. Processes used for the upgrading of residues and heavy oils makes use of equipment for which the optimal sizing requires understanding of the rheological properties of the hydrocarbon phase involved over a wide temperature and pressure range. The thermodynamics laboratory of the ENSM Center for Reactors and Processes has carried out the development of a viscosimeter suited for such measurements. It is based on determining the resistant torque caused by the fluid to be analyzed sheared between two coaxial cylinders with relative rotation. The viscosity range from 10 to 40,000 cP, with maximum temperatures and pressures of use being 500°C and 30 MPa. The results obtained were tested at varying temperatures and dilutions with heavy cuts from Safaniya and Boscan crudes after deasphalting or hydrovisbreaking. Reliable values were obtained for viscosity over a wide temperature range. Above 430-440°C the operating pressure of the cell increases abruptly, revealing thermal cracking of the samples, thus providing a way of studying and simulating industrial visbreaking processes. (Edited author abstract) 11 refs. In French.

Cohen, A. (Ecole Natl Supérieure des Mines de Paris, Fontainebleau, Fr); Di Bernardo, G.; Decroocq, D. *Rev Inst Fr Pet* v 43 n 2 Mar-Apr 1988 p 281-292.

**077794 DECONTAMINATION OF PETROLEUM SLUDGES BY HOT WATER EXTRACTION.** The process of hot water extraction of tar sand was modified and adapted for removal of heavy oil from bottom tank petroleum sludges, and was submitted to a laboratory feasibility study. This process can also be utilized to clean beach sands contaminated by accidental heavy oil spills. In the case of oil contaminated sands, a single stage extraction has yielded a 99% recovery of hydrocarbons and clean sands (containing less than 0.1% of hydrocarbons) which are thus safe to be returned to the environment. In the case of petroleum bottom tank sludge, it was necessary to proceed with a double stage extraction with the addition of a wetting agent. A dosage of a  $\text{Na}_2\text{SiO}_3$  aqueous solution of 1% by weight has proven efficient, allowing an 82% recovery of hydrocarbons, with only 0.5% of hydrocarbons content in the solid residues. (Author abstract) 17 refs.

Tran, Francis T. (Inst Natl de la Recherche Scientifique, Ste. Foy, Que, Can); Couillard, Denis; Rouleau, Denis. *Can J Chem Eng* v 66 n 3 Jun 1988 p 386-392.

**077795 HYDROGEN-TRANSFER REACTIONS IN THE THERMAL CRACKING OF ASPHALTENES.** Experimental investigations of hydrogen-transfer reactions have been carried out with asphaltenes simulating kerogen, tetralin, and/or water as hydrogen-donor/hydrogen-transfer compounds and benzene as an inert solvent. Experiments lasted 3 h in the temperature range from 350 to 430°C in sealed gold tubes under an argon atmosphere. Our results show that tetralin is effective as a hydrogen-transfer agent and as a hydrogen-donor compound, being in kinetic competition with asphaltene hydrogen-donor moieties in this latter role. Water does not act as a hydrogen donor under the experimental conditions used but may act as a hydrogen-transfer compound in the presence of other donor molecules. (Edited author abstract) 9 refs.

Behar, F. (Inst Français du Pétrole, Rueil Malmaison, Fr); Pelet, R. *Energy Fuels* v 2 n 3 May-Jun 1988 p 259-264.

**077796 ISOLATION OF ASPHALTENES USING A CONTINUOUS PRECIPITATION METHOD.** A new continuous method allows the isolation of heptane asphaltenes which are nearly identical to asphaltenes isolated by

a well-studied batch method. Samples of one-half liter of atmospheric resid can be treated using one to two liters of n-heptane, while keeping heptane/resid ratios at 40:1. Asphaltenes precipitated by a well established batch method were identical within the errors of elemental and NMR characterization methods. Small amounts of colored, heptane-soluble materials can be extracted from samples prepared by the continuous technique, but this extraction does not change the analyses of the extracted solids. (Author abstract) 3 refs.

Dolbear, Geoffrey E. (Unocal Science & Technology Div, Brea, CA, USA); Phan, Huyen N. *Fuel Sci Technol Int* v 6 n 4 1988 p 471-481.

**077797 CONTINUOUS REFORMER CATALYST REGENERATION TECHNOLOGY IMPROVED.** Since its introduction in 1971, the continuous catalyst regeneration (CCR) reforming process has been continuously pushed toward lower-pressure operation at equivalent or higher octane severity. Engineering refinement, design innovation, and desirable features discovered through start-up and operating experience have improved both the operability and profitability of the CCR reforming process. These improvements have been incorporated into revamps of existing semiregenerative reformers and into the design of a second-generation CCR process. An economic summary compares revamping and the second-generation design to semiregenerative technology.

Peer, Roger L. (UOP Inc, Des Plaines, IL, USA); Bennett, Richard W.; Bakas, Steve T. *Oil Gas J* v 86 n 22 May 30 1988 5p.

**077798 HF ALKY UNIT OPERATIONS IMPROVED BY ON-SITE TROUBLESHOOTING TO BOOST CAPACITY, PROFIT.** When problems are encountered in the operation of hydrofluoric acid (HF) alkylation units, they can often be solved by involving the technical personnel in the process analyses and troubleshooting at the unit site. For refiners that have reduced both operating and technical staffs to cope with present economics, the troubleshooting and analyses can be done by outside consultants or technical personnel from the supplier or designer of the alkylation unit. Several cases are presented that shows how these direct field evaluations can improve a unit's capacity and profitability.

Lieberman, Norman P. (Process Improvement Engineering, Woodland Hills, CA, USA); Liolios, Glenn. *Oil Gas J* v 86 n 25 Jun 20 1988 p 66-68.

**077799 DEAROMATISING OF NAPHTHA - TECHNO - ECONOMIC ASPECTS.** The Bombay High Crude Oil of India on refining, while yielding much high octane gasoline, produces little of other needed petroleum products. One strategy is to dearomatize the crude prior to cracking. This article considers the technoeconomics of extraction of high aromatic naphtha without prior reforming operations. Experimental evidence obtained at the Indian Institute of Petroleum, Dehradun indicates such a possibility. Investigations indicate that such plants are not only commercially viable, but also financially feasible. The article summarizes investigations on the quality and quantity of naphtha available and presents process schemes along with technoeconomic considerations for solutions to predicaments.

Kothary, N.C.; Mulchandani, H.K.; Sharma, C.S.; Prakash, Jai. *CEW Chem Eng World* v 23 n 3 Mar 1988 p 56-60.

**077800 NATIONAL PETROLEUM REFINERS ASSOCIATION TECHNICAL PAPERS (PRESENTED AT THE 1985 FUELS & LUBRICANTS MEETING AND THE 1985 COMPUTER CONFERENCE).** This conference proceedings contains 27 papers on petroleum refining processes and products. Eleven papers deal with fuels and lubricants. The main topics of those papers include: health hazards of petroleum products; health risk studies and accident prevention in the petroleum refining industry; combustion of diesel fuels, gasoline, and distillate fuels; packaging, health hazards, and testing of lubricating oils; and exhaust gases of automobile engines.

Sixteen papers are devoted to various computer applications in the petroleum refining industry. Computer aided management of petroleum refineries is discussed in some detail. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10711 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Nat'l Petroleum Refiners Assoc, Washington, DC, USA). *Natl Pet Refiners Assoc Tech Pap* n 85-78 to 85-108, New Orleans, LA and Houston, TX, USA, Oct 27-30 and Nov 7-8 1985. Publ by Nat'l Petroleum Refiners Assoc, Washington, DC, USA, 1985 var pagings.

**Adsorption** See Also OLEFINS—Recovery.

**077801 ACTIVITY OF ADSORBENTS IN TREATING LIGHT DISTILLATE STOCKS TO REMOVE HETEROORGANIC COMPOUNDS.** The authors are reporting on an investigation of the adsorption capabilities of certain commercial adsorbents and newly synthesized adsorbents with respect to heteroorganic compounds present in naphtha and kerosene cuts. For this work, a fraction of the adsorbent in the form of beads with a diameter of 1-3 mm, after drying for 5 h at 170-200°C, was cooled to room temperature in a desiccator and charged to an adsorbent. The feedstock for the investigation of adsorption capabilities of the adsorbents with respect to oxygen-containing compounds was a 140-280°C cut obtained from low-sulfur Baku crudes, containing 0.21% petroleum acids by weight. 3 refs.

Sultanov, N.T. (Acad of Sciences of the Azerbaizhdzhan SSR, USSR); Allakhverdiev, D.I.; Maitlova, Kh.M.; Ashurova, L.S. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 118-120.

**Alkylation** See BUTENES—Separation.

**Australia** See PETROLEUM INDUSTRY—Australia.

**Catalysis** See Also GASOLINE—Analysis; ZEOLITES—Applications.

**077802 DETERMINACION SIMULTANEA DE AZUFRE, FOSFORO Y MOLIBDENO EN CATALIZADORES FRESCOS HIDRODESULFURACION POR CROMATOGRAFIA IONICA.** [Simultaneous Determination of Sulfur, Phosphorus and Molybdenum in Hydrodesulfurization and Hydrodesulfurization Catalysts by Ion Chromatography]. A method for the simultaneous determination of sulfur, phosphorus and molybdenum in hydrometallization and hydrodesulfurization fresh catalysts is described. These elements are determined as sulfate, phosphate and molybdate by ion chromatography after sample digestion in a mixture of HF and  $\text{H}_2\text{O}_2$ . The solution obtained is adjusted to basic pH prior to injection in the chromatograph. The method was found to be free of interferences. Results obtained using real samples were compared to those of other instrumental methods showing very good agreement for concentrations ranging from 0.1 to 1.5% of  $\text{SO}_3$ , 1 to 8% of  $\text{P}_2\text{O}_5$  and 10 to 26% of  $\text{MoO}_3$ . Relative standard deviations of results were less than 4%, 1.6% and 1.5% for the sulfur, phosphorus and molybdenum determination, respectively. (Author abstract) In Spanish. 13 refs.

Oquendo, Javier (INTEVEP SA); Prieto, Hernan; Henriquez, Hector; Rengel, Aristides. *Rev Tec INTEVEP* v 7 n 1 Jan 1987 p 69-74.

**077803 REFINERY EXPERIENCE WITH FRAMEWORK SILICON ENRICHED MAXIMUM OCTANE TYPE ZEOLITES.** In early 1986 Katalistiks commercialized a new generation of FCC catalyst, based on framework silicon enriched LZ-210 type Y zeolites. The catalytic merit of this technology, which allows for the substitution of framework aluminum by silicon with full retention of the crystalline structure, was recently discussed extensively. Of particular interest is the maximum octane option. In the present paper, the commercial



experience with this catalyst is discussed in the light of some laboratory observations which led to the development of the catalyst. 8 refs.

Magnusson, Jeppe E.; Valeri, Francis; Upson, Lawrence L. *Erdöl Kohle Erdgas Petrochem* v 40 n 9 Sep 1987 p 404-407.

**077804 HYDROTREATMENT DE GAZOLES CRAQUES.** [Hydrotreatment of Cracked Gas Oils]. The hydrotreatment of various cracked gas oils was the subject of a study using NiMo/Al<sub>2</sub>O<sub>3</sub>, CoMo/Al<sub>2</sub>O<sub>3</sub> and WNi/Al<sub>2</sub>O<sub>3</sub> type catalysts for different experimental conditions. Research was done to determine the effect of pressure, temperature and type of feedstock. With an operating pressure higher than 50.6 bar, NiMo catalysts were more active for eliminating nitrogen, for aromatics saturation and for improving the cetane number. At low pressures, all the catalysts had the same activity. Strong hydrogenation conditions and NiMo type catalysts are required to improve the color, stability and cetane number of feedstocks with a high aromatics content. To obtain a stable color and a change in the cetane number (more than 2 units) for high-aromatics feedstocks, strong hydrogenation conditions and NiMo type catalysts are indispensable. (Edited author abstract) 11 refs. In French.

Galiasso, R. (Intevep SA, Caracas, Venez); Badras, C.; Garcia, W.; Ramirez de Agudelo, R.; Rodriguez, E. *Rev Inst Pet* v 42 n 5 Sep-Oct 1987 p 567-585.

**077805 WHITE OILS: OPTIMIZATION OF PARAMETERS HYDROREFINING.** A vacuum distillate was used to obtain white oil. The research resulted in a catalyst containing 40% WO<sub>3</sub> and 7% Ni. Methods of statistical analysis were applied for the optimization. The catalyst developed for the catalytic refining decreases the content of monoaromatic hydrocarbons from 21 to 1.5% and of diaromatic hydrocarbons from 1.6 to 0.1%. (Author abstract) 12 refs.

Grzechowiak, Jerzy (Politechniki Wroclawskiej, Wroclaw, Pol); Grzechowiak, R. Jolanta; Radomyski, Bohdan; Szczygiel, Jerzy; Sztuba, Zbigniew. *Erdöl Kohle Erdgas Petrochem* v 41 n 3 Mar 1988 p 115-119.

## Catalytic Cracking

**077806 EFFECT OF ADDED ATMOSPHERIC RESID ON PROCESS INDEXES IN CAT CRACKING OF VACUUM DISTILLATE.** No data are available on the cracking of vacuum distillate with atmospheric resids from USSR crudes. Therefore such data are obtained in order to determine the optimal ratio of components in the blend and to define the influence of the quantity of added resid on the yield and quality of the products. As feedstocks the authors selected a low-sulfur (hydrotreated) vacuum distillate and a medium-sulfur atmospheric resid, in application to a G-43-107 unit. The experiments were performed in a pilot unit at GrozNII. The experiments were performed with an equilibrium super-D microbead zeolitic catalyst. 9 refs.

Kruglova, L.E. (Groznyi Petroleum Scientific Research Inst, USSR); Khadzhiyev, S.N.; Syunayev, Z.I.; Smidovich, E.V.; Fedoseeva, V.I.; Kapustin, V.M. *Chem Technol Fuels Oils* v 23 n 1-2 Jan-Feb 1987 p 57-60.

**077807 INCREASE PROFITS FROM THE FCCU.** The refinery unit from which the most revenue can be generated most easily is the fluid catalytic cracking unit (FCCU). A quick review of some ideas for increasing FCCU profitability is presented. These ideas are by no means all of the methods available for increasing FCCU profitability, but they are possibilities that should be considered: increasing feed rates; improving product quality, distribution, and recovery; and reducing energy consumption.

Tolen, D.F. (Akzo Chemie America, Pasadena, TX, USA); Desai, P.H. *Hydrocarbon Process* v 66 n 7 Jul 1987 p 49-51.

**077808 ZSM-5 IN FCC: POTENTIAL IMPACT ON REFINERY OPERATIONS.** The use of the shape

selective zeolite ZSM-5 for octane enhancement of both FCC and TCC gasolines is described. Mobil's proprietary ZSM-5 has been evaluated in over 30 commercial cracking units. This paper discusses the twofold mechanism which explains how ZSM-5 works and presents the results from the use of ZSM-5 in EniChem Anic's FCC unit in Gela, Italy. The value of ZSM-5 in catalytic cracking is assessed. In particular, various processing schemes are discussed which show how to take maximum advantage of the changes in product distribution which occur when ZSM-5 is introduced into a cracking unit. (Edited author abstract) 12 refs.

Dwyer, F.G. (Mobil Research & Development Corp, USA); Economides, N.L.; Herbst, J.A.; Gorra, F. *Q J Tech Pap Inst Pet* Jul-Sep 1987 p 47-50.

**077809 INTENSIFICATION OF CATALYTIC CRACKING PROCESS BY ADDITION OF HEAVY CATALYTIC GASOIL.** Operation of cat cracking units yields rather large amounts of a highly aromatic product, heavy catalytic gasoil. Therefore, it has been of interest to investigate the addition of this product to cat cracker feed as a means of reducing the formation of coke. In these studies, the authors used as the feedstock a vacuum gasoil from the Moscow Petroleum Refinery, and as the activating additives a lube oil solvent extract from the Novo-Ufa Petroleum Refinery (most typical additive) and a heavy catalytic gasoil from the Moscow refinery. The authors carried out the catalytic cracking of vacuum gasoil with and without additives in a large flow-type laboratory unit with a fluidized bed of catalyst. 6 refs.

Serikov, P.Yu. (I.M. Gubkin Moscow Inst of the Petrochemical & Gas Industry, USSR); Zaitseva, N.P.; Smidovich, E.V. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 112-115.

**077810 EFFECTIVENESS OF DIFFERENT PROCESS CONDITIONS IN HYDROTREATING CAT CRACKER FEED.** Cat cracker feed hydrotreating is widely practiced in industry. One of the basic indexes of the process conditions and degree of treatment is the hydrogen consumption. In this paper the authors are presenting comparative data on the effectiveness of various process conditions in hydrotreating cat cracker feed, with due regard for the hydrogen consumption. 3 refs.

Pivovarova, N.A. (Groznyi Petroleum Scientific-Research Inst, USSR); Khadzhiyev, S.N.; Zhorov, Yu.M. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 183-186.

**077811 STUDY OF THE LUMPING KINETIC MODEL FOR CATALYTIC CRACKING REACTION.** A description is given of the process established for a kinetic model with eleven lumps used for fluid catalytic cracking. The lumping and reaction scheme are presented for the following: heavy fuel oil (paraffin P<sub>h</sub>, naphthene N<sub>h</sub>, aromatic substituent groups A<sub>h</sub>, mono- or di-aromatic rings C<sub>Ah</sub>, polyaromatic rings PC<sub>Ah</sub>), light fuel oil (Paraffin P<sub>l</sub>, naphthene N<sub>l</sub>, aromatic substituent groups A<sub>l</sub>, aromatic rings C<sub>Al</sub>), G lump (gasoline) and C lump (C<sub>1</sub>-C<sub>4</sub>+coke). The method by which the rate constants are determined experimentally is outlined. Yields of light fuel oil, gasoline and C lump can be calculated with this model. The comparison between the results obtained in laboratory and the data of initial verification obtained from a commercial FCC unit is given. The agreement is good. (Edited author abstract) In Chinese. 18 refs.

Weng Huixin (East China Inst of Chemical Technology, China); Wang Shunsheng; Zou Ying; Mao Xinjun. *Huaxue Fanying Gongcheng Yu Gongyi* v 3 n 4 Dec 1987 p 9-17.

**077812 HYDROCRACKER PERFORMANCE CORRELATED FROM ACTUAL RUNS.** Good yield correlation was developed from tests conducted on Amoco Oil Co.'s LC-Fining resid hydrocracker started nearly 2½ years ago at Amoco's Texas City, Tex., refinery. The yields were developed over a wide range of feed quality, feed rate, and operating conditions. The yields correlate well with 1,000°F+ vol% conversion over the range of 50-95% conversion. In general, yields appear

to be independent of feed rate and quality. Sulfur, Ramsbottom carbon content, and metals removal from the commercial unit tests also correlate well with 1,000°F+ conversion. 3 refs.

McDaniel, Norman K. (Amoco Oil Co, Texas City, TX, USA); Lerman, David B.; Peck, Lawrence B. *Oil Gas J* v 86 n 22 May 30 1988 3p.

**Coking** See Also PETROLEUM COKE—Magnetic Field Effects.

**077813 DYNAMICS OF FORMATION OF PETROLEUM CARBON DEPOSITS ON METAL SURFACES.** In thermal contacting of petroleum pitch with a metal, carbon deposits are formed on the metal surface in the form of spiral structures that are revealed when crystallized pitch is detached from the metal. For a more detailed investigation of the dynamics of carbon deposit formation, the authors prepared model samples of petroleum pitch with different contents of carboids. The experiments were performed in a thermostated drying oven at 270°, 300°, and 330°C, with contact times of 8, 15, 30, and 45 min. Specimens of 12Kh18N10T stainless steel [similar to Type 321] were made in the form of 23-mm diameter disks with a thickness of 3 mm. 5 refs.

Khairudinov, I.R. (Ufa Petroleum Inst, USSR); Kuzeev, I.R.; Galeev, R.G. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 194-196.

**077814 ADHESION IN COKING PETROLEUM RESIDS.** In the process of coking heavy petroleum resids, the reactor shell interacts with the coke, forming adhesive bonds. The adhesion is accompanied by structural, physical, and chemical conversions, and also by the evolution of volatile substances as a consequence of the high temperature of the process (up to 500°C). Because of these circumstances, the phenomena of adhesion cannot be studied by conventional methods. In this connection, we have designed and constructed a laboratory unit with a reactor, in the cylindrical body of which there are rods loosely positioned in sockets. After coking is completed and the reactor is opened, the rods are pulled out of the coke mass by means of a tensile tester. Experiments have confirmed the possibility of predicting the intensity of interaction of the coke/metal system. The shearing stress is directly related to the density of the resid and the content of asphaltene, and inversely related to the content of paraffinic hydrocarbons. 3 refs.

Kuzeev, I.R.; Sharafiev, R.G.; Abyzgil'din, Yu.M. *Chem Technol Fuels Oils* v 23 n 5-6 May-Jun 1987 p 224-227.

## Control Systems

**077815 CUT-POINT CALCULATIONS IN MODERN DCS.** Techniques utilizing distillation cut-point calculation correlations for fractionation tower optimization are presented. Their implementation and use in modern Distributed Control Systems, without the assistance of traditional peripheral devices (process computer or PC), are examined. Depending on the economic value of crude distillation products, the refiner can maximize profitably by adhering to well defined (and in some cases, seasonal) product specifications. In real-time tower control, the use of product cut-point specifications is a primary method of product quality control. 5 refs.

Coser, R.J. (Rosemount Inc, Eden Prairie, MN, USA). *Hydrocarbon Process* v 67 n 4 Apr 1988 p 35-37.

**Cracking** See Also CATALYSTS—Clay.

**077816 VISBREAKING WITH A REACTION CHAMBER.** Visbreaking can be defined as single-pass, light thermal cracking of petroleum resids (vacuum tars) in order to obtain boiler fuel with the required viscosity and solid point. The studies have been carried out in a pilot unit with feed to the top or bottom of the reaction chamber. The feedstocks used in this work were two samples of vacuum resid (tar) from a mixture of West Siberian and Ukhta crudes, these two tars differing in content of fractions distilling below 500°C. Both of the tars



were too high in viscosity to permit their use as commercial boiler fuel. The liquid products from the visbreaking operation were distilled into IBP-160°C, 160-350°C, and 350-500°C cuts and 500°C+residue. These cuts were back-blended to make up products with various distillation ranges. The 160°C+product (residue after distilling off the naphtha) was tested to determine its quality as Grade 100 boiler fuel. 5 refs.

Gerasicheva, Z.V. (All-Union Scientific Research Inst for Petroleum Processing, USSR); Soskind, D.M.; Melik-Akhazarov, T.Kh.; Voronova, O.K.; Tomarkova, M.A. *Chem Technol Fuels Oils* v 23 n 1-2 Jan-Feb 1987 p 60-64.

**077817 SOAKER VISBREAKING OF SOME IRAQI RESIDUES.** An attempt has been made to increase the fuel oil yield of two Iraqi residues using a soaker visbreaking process. This was carried out in a continuous laboratory scale unit at a range of mild conditions, namely, 420-480°C and 43-109 sec. in the coil and 151-379 sec. in the soaker. Physical properties of the products have been characterized and reported. The fuel oils obtained under the studied conditions remained stable compared with the original feedstocks. Furthermore, data on yield and characteristics of the different distillates from the visbroken products have been obtained. There was an increase in the distillates up to 350°C (11%) for type A residue and (15%) for type B residue. (Author abstract) 5 refs.

Al-Soufi, H.H. (Petroleum Research Cent, Jaiyah Baghdad, Iraq); Shanshool, J.; Savaya, Z.F. *Fuel Sci Technol Int* v 5 n 5 Oct 1987 p 543-559.

**077818 COMBINATION OF THERMAL CRACKING WITH VACUUM DISTILLATION OF CRACKED TAR.** The traditional raw material sources (extracts from lube oil production, heavy catalytic gasoils) do not satisfy the growing demands for thermal gasoil and electrode coke. A prospective source for obtaining greater amounts of distillate feedstocks may be found in the heavy gasoil recovered by vacuum distillation of the products of thermal cracking of petroleum resids. The combination of thermal cracking with vacuum distillation of the cracked tar has made it possible to curtail the production of boiler fuel, expand the resources of feed for the production of thermal gasoil, and improve the quality of petroleum coke. The results obtained by introducing the technology of vacuum distillation of cracked tar have confirmed the correctness of the approach the authors have selected and the promise that it offers.

Telyashev, G.G. (Novo-Ufa Petroleum Refinery, USSR); Gimaev, R.N.; Makhov, A.F.; Usmanov, R.M.; Baimbetov, A.M.; Vafin, I.A. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 165-168.

**Demulsification** See Also MEMBRANES.

**077819 CHEMICAL DEMULSIFICATION OF CRUDE OIL EMULSION.** There is an increasing number of crude oil fields that are now producing both crude oil and brine. The high fluid temperatures, indigenous crude oil surfactants and turbulence experienced at the wellhead chokes and valves all contribute to produce a finely dispersed emulsion of brine in crude oil. Hence most crude oils are produced in the form of emulsions. The main objective of this investigation is to improve the efficiency of the chemical resolution of the crude oil emulsion produced in the Niger Delta. (Edited author abstract) 6 refs.

Obah, Boniface (Federal Univ of Technology, Owerri, Nigeria). *Erdöl Kohle Erdgas Petrochem* v 41 n 2 Feb 1988 p 71-74.

**Desulfurization** See CATALYSTS—Cobalt.

**Dewaxing** See Also CATALYSTS—Hydrogen Mordenite.

**077820 VISCOSITY-TEMPERATURE PROPERTIES OF OILS IN DEWAXING RAFFINATES**

**FROM SOLVENT TREATING.** Viscosity and the variation of viscosity with temperature are important service characteristics of lube base stocks. It was shown previously that the kinematic viscosity  $\nu_{40}$  of the dewaxed oil (low-melting component) increases linearly with increasing difference between the filtration temperature and the initial crystallization of the feedstock/solvent system. Prediction of these properties on the basis of the raffinate quality and the dewaxing conditions is presented. 4 refs.

Tyumin, S.V. (All-Union Scientific Research Inst for Petroleum Processing, USSR); Shabalina, T.N.; Akimov, V.T. *Chem Technol Fuels Oils* v 23 n 1-2 Jan-Feb 1987 p 17-19.

**077821 INFLUENCE OF BIURET AND CYANURIC ACID ON DEWAXING PETROLEUM STOCKS WITH ALCOHOLIC UREA SOLUTION.** In the process of urea dewaxing of petroleum distillates, in the stage in which the adduct is decomposed, the urea is partly converted to biuret and cyanuric acid. The effect of biuret on the degree of dewaxing with an aqueous urea solution was investigated previously. The present work has been aimed at investigating the influence of the contents of biuret and cyanuric acid on the formation and separation of the adduct in commercial dewaxing of petroleum stocks by a solution of urea in a mixture of water and isopropyl alcohol. 2 refs.

Abdullaev, E.Sh. (Acad of Sciences of the Azerbaidzhan SSR, USSR); Ismailov, A.G.; Gadzhiev, A.Sh.; Balayan, R.D. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 188-189.

**Distillation** See Also LUBRICATING OILS—Solvent Extraction.

**077822 ESTIMATION OF EXERGY DIFFERENCE IN THE SEPARATING PROCESS OF PETROLEUM AND ITS DISTILLATES.** Based on the fact that the separating exergy of a complex mixture is only a function of the number of components and the distribution of their concentrations and is independent of their properties, an equation for estimating the successive separating exergy is derived through deduction and analysis. Two parameters, the distribution factor and degree of overlap of pure components are discussed and defined and are related to the separating exergy. A practical simplified equation for estimating the separating exergy of petroleum and its distillates is proposed with the purpose of efficient utilization of energy. The calculation error can be limited within the allowable range. (Author abstract) In Chinese. 3 refs.

Hua, Ben (LuoYang Petrochemical Engineering Corp, China). *Shiyou Xuebao Shiyou Huagong* v 2 n 3 Sep 1986 p 101-107.

**Economics** See PETROLEUM REFINERIES—Efficiency.

**Efficiency**

**077823 EFFICIENCY IN PETROLEUM REFINING.** In recent years substantial action has been taken within the oil refining industry to reduce their own in-house energy consumption and hence, cost. However, much of this has been achieved by technical change, including the introduction of new processes, new equipment, smaller plant with lower processing inventory, process changes and sophisticated capital intensive techniques such as process integration, involving the formal matching of heating and cooling loads and engineering the plant to suit. The bulk of this paper is concerned with the more cost-effective area of managing energy. The paper is backed up with pertinent examples and suggests that the remaining potential for achievement of operational energy usage reduction in the oil refining industry is significant. (Edited author abstract)

Roberts, Michael (PA Management Consultants). *Energy World* n 150 Aug-Sep 1987 p 13, 17.

**Energy Conservation**

**077824 RECOVER THAT LOW-LEVEL HEAT.** Direct heat integration is the best way to use heat that would otherwise be rejected. However, all heat going to cooling water, air coolers, or atmosphere that cannot be used for direct heat integration at the unit where it occurs or at a nearby unit is available for other uses remains to be recovered. This is typically process heat below 225 to 250°F. It is usually found in process streams going to condensers and coolers. Condensers offer larger quantities of heat at more constant temperature, but some large coolers with high flow rates can provide significant amounts of heat. Heat to the atmosphere via flue gas from boilers and furnaces is typically recovered by preheating combustion air, generating steam, or preheating process feed streams.

O'Brien, W.J. (Exxon Chemical Co, Florham Park, NJ, USA). *Hydrocarbon Process* v 66 n 12 Dec 1987 p 34-35.

**England**

**077825 WORLD'S FIRST TAME UNIT ON-STREAM.** Two firsts were recently achieved at Lindsey Oil Refinery (LOR), Humberside, UK. The tertiary amyl methyl ether (TAME) unit is the first of its kind in the world and the methyl tertiary butyl ether (MTBE) unit, the first in the UK. The two plants, designed to produce high octane blending components, will expand the refinery's gasoline potential by 200,000 tpy to 2.7 million tonnes. The licence has been bought out by BP as the Etherol process. Catalyst for the unit uses Bayer technology.

Anon. *Pet Times* v 91 n 2216 Nov 1987 p 16-17.

**Environmental Impact** See WELDING—Carbon Steel.

**Extraction**

**077826 CONTACT DEVICES FOR EXTRACTION TOWERS IN UNITS FOR SELECTIVE SOLVENT TREATMENT OF LUBE STOCKS.** An analysis of the operation of packed-type towers with sieve trays has shown that these towers do not provide proper conditions for coalescence of the emulsion drops after the first and successive contact stages. High values of the mass transfer coefficient can be achieved only through repeated coalescence and redispersion. On the basis of an analysis of the contact device designs that have been described here, the Ufa Branch of VNIIneftemash, in cooperation with the Novo-Ufa Petroleum Refinery, has developed an improved sieve tray design for use with the oil/phenol system. An investigation of the hydrodynamics and mass transfer in the operation of this tray has confirmed the correctness of the principles on which the design was based and has demonstrated the high efficiency of the tray. 13 refs.

Yaushev, R.G. (Novo-Ufa Petroleum Refinery, USSR); Vyazovkin, E.S. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 192-194.

**Filtration** See FLOW OF FLUIDS—Capillaries.

**Fluid Catalytic Cracking** See Also GASOLINE REFINING—Fluid Catalytic Cracking.

**077827 FCC'S EFFECT ON REFINERY YIELDS.** For planning and optimizing an integrated refinery operation, a flowsheet system based on simulation technology has many advantages. Case studies using such a simulation system are presented to show the effect of changing FCC unit operations on the refinery scheme depicted. The studies look first at the effect of switching to an octane catalyst and then at the effect of using a deep vacuum cut point for the feed. The article concludes that the refinery-wide simulation program is easy to use because it generates its own process performance information.

Krikorian, K.V. (KBC Process Technology Ltd, Weybridge, Engl); Brice, J.C. *Hydrocarbon Process* v 66 n 9 Sep 1987 p 63-66.



**077828 NEW FCC DESIGN NOW COMMERCIAL.** In April of this year, Idemitsu Kosan Co., Ltd. brought onstream a catalytic cracking unit that incorporates new technology developed jointly by Total France and Institut Français du Pétrole. The 5,000-metric-tpd (35,000-bpd) unit is located at Idemitsu's Aichi refinery, near Tokyo. The feed is heavy resid coming from the atmospheric and vacuum crude distillation units. The investment for the unit is about 600 million French francs (\$95 million). The new process is called R2R Resid Cracking, where R2R denotes the use of one stage of reaction and two stages of catalyst regeneration. The process can convert feeds that are difficult to process, having high metals content (up to nearly 50 ppm) or high Conradson carbon (8 to 10 wt%). Features and benefits of the process are discussed.

Anon. *Hydrocarbon Process* v 66 n 9 Sep 1987 p 67.

**077829 CATALYST AGING PROCEDURE SIMULATES FCC CONDITIONS.** A hydrothermal deactivation procedure, using varied catalyst sample steaming times, has been developed to better simulate the distribution of near-fresh and moderately and severely deactivated catalyst particles in equilibrium fluid catalytic cracking (FCC) catalysts. Better simulation of the actual equilibrium catalyst results in better pilot plant simulation of actual operations, and better indications of commercial product distribution and quality. Comparison of hydrothermal deactivation procedures has shown that conventional aging of catalyst samples, that generally hydrothermally age fresh catalyst for a defined period of time, does not simulate commercial operations as well. 2 refs.

Keyworth, Donald A. (Akzo Chemie America, Houston, TX, USA); Turner, W. Jay; Reid, Terry A. *Oil Gas J* v 86 n 11 Mar 14 1988 p 65-68.

**077830 OPTIMUM FCC CONDITIONS GIVE MAXIMUM GASOLINE AND OCTANE.** The strong demand for higher octane gasoline dictates that most refineries operate their fluid catalytic crackers (FCCUs) at as high a reactor temperature as possible to produce maximum octane. Catalyst activity should also be targeted at a high level, but activity should not be high enough to overcrack the FCC gasoline to lighter  $C_3$  and  $C_4$ s. Results of laboratory studies indicate that maximum gasoline yield is achieved by maintaining an appropriate target catalyst activity at all catalyst-circulation rates.

Leuenberger, Ernest L. (Engelhard Corp, Iselin, NJ, USA). *Oil Gas J* v 86 n 12 Mar 21 1988 p 45-46.

**077831 FCC CATALYSTS CAN BE DESIGNED AND SELECTED FOR OPTIMUM PERFORMANCE.** A review of the fundamentals of FCC catalyst design, and how they relate to selection of grades that will achieve optimum performance, can simplify the selection of the optimum FCC catalyst for a particular operation and unit. Specifically, performance parameters such as zeolite type, anticipated equilibrium unit cell size, and the balance between zeolite and matrix cracking selectivity are considered. With a means to rank the selectivities of the various commercial FCC catalysts available, refiners can select catalysts that move the FCC operation nearer to process objectives, while accommodating the mechanical limitations imposed by FCC hardware. The North American refining situation is also reviewed to put the selection process into perspective with current operating practices. These practices include the increased use of octane catalysts, no appreciable increase in resid cracking, and the formulation of more catalysts for specific operations. 11 refs.

Wear, Charles C. (W.R. Grace & Co, Baltimore, MD, USA); Mott, Raymond W. *Oil Gas J* v 86 n 30 Jul 25 1988 p 71-79.

## Fractionation

**077832 FROM SIMPLE REGULATORY CONTROL TO COMPUTER OPTIMIZATION.** One cost-effective way to improve plant profitability is to convert from analog control equipment to distributed control and computer optimization. A stepwise approach

to such conversions will greatly enhance the success of these projects. The steps involved in retrofitting a hydrocracker main fractionator to computer optimization at the Kerr-McGee refinery are presented. 12 refs.

Sofer, S.S. (New Jersey Inst of Technology, NJ, USA); Mulholland, R.J.; Bare, W.H. *Hydrocarbon Process* v 67 n 1 Jan 1988 p 38-42.

**Heat Exchangers** See HEAT EXCHANGERS—Maintenance.

**Hydrocracking** See Also PETROLEUM, CRUDE—Viscosity.

**077833 RECENT DATA ON RESID HYDROCRACKER.** The performance of the LC-Fining resid hydrocracker in the first year of operation (1985) was outstanding. Following a turnaround of the fractionation section, observed performance increased significantly. Increases in resid conversion as well as sulfur, metals, and Rams carbon removal are demonstrated. High conversion along with the operating factor improvement, increases the profitability of this LC-Finer. 2 refs.

Boening, R.E. (Amoco Oil Co, Texas City, TX, USA); McDaniel, N.K.; Petersen, R.D.; Van Driesen, R.P. *Hydrocarbon Process* v 66 n 9 Sep 1987 p 59-62.

**077834 SUITABILITY OF SPENT HYDRODESULPHURISATION (HDS) CATALYST IN LOW PRESSURE DISTILLATE HYDROCRACKING - A CASE STUDY.** Due to increased demands for middle distillates, the importance of hydrocracking the heavier crude oil feedstocks is growing. Vacuum distillates from Ankleshwar and Bombay High Crudes were used as feed. The spent regenerated catalyst used, it was removed from the top bed of the gas oil HDS reactor plant after a useful life of greater than 4 years. The spent HDS catalyst, which is of negligible cost, is found to give good yields of middle distillate on processing vacuum distillates from High crudes at pressures around 80 atm. 425°C temperature and 0.5 liquid hourly space velocity. Yields of middle distillate can be increased by recycling the residue along with the fresh feed. Due to low pressure operation and the marginal cost of catalyst, the process of mild hydrocracking appears to be economically attractive. 2 refs.

Mittal, Krishan G. (Indian Inst of Petroleum, Uttar Pradesh, India); Gupta, Sri C.; Agarwal, Ravindra K.; Rai, Jai R. *J Chem Technol Biotechnol* v 39 n 1 1987 p 59-64.

**077835 NEW DEVELOPMENTS IN HYDROCRACKING: LOW PRESSURE HIGH-CONVERSION HYDROCRACKING.** Hydrogen partial pressure is a key parameter for distillate hydrocracking processes. There are two types of distillate hydrocracking processes. Mild hydrocracking is an improved vacuum gas oil hydrotreatment process with a relatively low conversion, which operates at hydrogen pressures usually less than 50 bars. Total conversion hydrocracking operates at hydrogen pressures of more than 100 bars. It is thus obvious that hydrogen pressure is a key parameter for hydrocracking performances. By looking at the different reactions taking place in the hydrocracking process, we try to explain this effect from thermodynamic and kinetic standpoints. For instance the hydroconversion of n-heptane has a negative order with respect to hydrogen pressure, when this order is positive for the conversion of a vacuum gas oil. We present pilot data showing the great influence of a first step hydrotreatment of a VGO on the second hydrocracking step. We demonstrate also the possibility of achieving very high conversion when operating at 'medium pressure' (i.e. around 70 bars) with a recently developed zeolite hydrocracking catalyst. (Author abstract) 15 refs.

Dufresne, P. (Inst Français du Pétrole, Rucl Malmaison, Fr); Bigeard, P.H.; Billon, A. *Catal Today* v 1 n 4 Aug 1987, Hydrocracking: Sci and Technol, Proc of the NFWO-FNRS Catal Contact Group Meet, Ghent, Belg, Dec 3 1986 p 367-384.

**077836 ZEOLITE CATALYSIS IN HYDROPROCESSING TECHNOLOGY.** Hydroprocessing technology

plays a major role in the modern complex oil refinery and zeolite catalysts are creating exciting new opportunities for this type of processing. This review covers a range of processes, including hydroisomerization, gasoline upgrading, catalytic dewaxing, and hydrocracking, where zeolite catalysts have been adopted. The advantages and limitations of zeolite catalysis in hydroprocessing are highlighted. Finally, some challenges for catalytic research in this field are discussed: it is envisaged that zeolite catalyst design will figure significantly in the development of new, advanced process technology in the future. (Author abstract) 27 refs.

Maxwell, I.E. (Amsterdam (Shell Research BV), Amsterdam, Neth). *Catal Today* v 1 n 4 Aug 1987, Hydrocracking: Sci and Technol, Proc of the NFWO-FNRS Catal Contact Group Meet, Ghent, Belg, Dec 3 1986 p 385-413.

**Hydrogenation** See CATALYSTS—Marketing; CATALYSTS—Research.

**Isomerization** See PARAFFINS—Pyrolysis.

## Mass Transfer

**077837 EFFECT OF ACTIVATING ADDITIVE ON PROCESS OF BOILING OF PETROLEUM FRACTIONS.** It has been established that a surface-active substance, which concentrates itself on an interface, will change the conditions of nucleation of a vapor phase in boiling and hence will change the kinetics of exchange processes between the liquid and vapor. In the work reported here, the authors investigated the influence of an activating additive - a dodecylbenzene fraction from propylene tetramers - on the boiling process in a 140-240°C straight-run cut from Kotur-Tepe crude. This particular activating additive was selected on the basis of practical considerations, as it is used in the manufacture of synthetic detergents, and the technology for its manufacture has been worked out on a commercial scale. 5 refs.

Zimin, B.A. (I.M. Gubkin Moscow Inst of the Petrochemical & Gas Industry, USSR); Syunyaev, Z.I.; Saidak-medov, I.M.; Gur'yanov, A.M.; Grushevenko, A.E. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 169-171.

## Modification

**077838 MTBE FROM BUTADIENE-RICH  $C_4$ S.** Methyl tert-butyl ether (MTBE), is made by reacting methanol with isobutylene. The preferred source of isobutylene is a steam cracker  $C_4$  cut from which butadiene has been removed. However, moving the MTBE synthesis upstream of the butadiene extraction will improve the extraction step. The following is a review of conditions imposed on the MTBE unit's design and operation when placed in this new location. 15 refs.

Ancillotti, F. (Snamprogetti SpA, Milan, Italy); Pescarollo, E.; Szatmari, E.; Lazar, L. *Hydrocarbon Process* v 66 n 12 Dec 1987 p 50-53.

**Moisture Control** See OFFSHORE STRUCTURES—Design.

## Nitrogen Removal

**077839 HYDRODENITROGENATION CATALYSIS.** Catalytic hydrodenitrogenation (HDN) is a process in which organonitrogen compounds are removed from hydrocarbon feedstocks to produce processible, stable, and environmentally acceptable liquid fuels and lube base stocks. The purpose of this review is to give some idea of the extent to which HDN catalysis is understood. The emphasis is placed on what is known about conventional metal sulfide hydrotreating catalysts. The review begins with a brief summary of the properties of nitrogen compounds possibly pertaining to HDN catalysis. Following this is a discussion of HDN thermodynamics. The current understanding of the structure of conventional catalysts is then summarized. There follows the main body of the review, which deals with HDN kinetics and catalytic chemistry. A major portion of this part discusses the interaction between HDN and other hydroreactions



such as hydrodesulfurization and aromatics hydrogenation. The final section addresses some practical aspects of HDN, viz., catalyst development and process kinetics. 112 refs.

Ho, T.H. (Exxon Research & Engineering Co, Annandale, NJ, USA). *Catal Rev Sci Eng* v 30 n 1 Feb 1988 p 117-160.

## Precipitation

**077840 CHARACTERIZATION OF HEAVY RESIDUA BY APPLICATION OF A MODIFIED D 2007 AND ASPHALTENE SEPARATION; EFFECT OF SOLVENTS ON PHYSICAL AND CHEMICAL PROPERTIES OF FRACTIONS DERIVED FROM HONDO 850°F RESIDUUM.** Hondo 850°F residuum was separated into saturate, aromatic, resin, and asphaltene fractions by a modified D 2007 and asphaltene separation. Two different asphaltene precipitation solvents were used - isooctane and heptane - and differences in selected physical and chemical properties of the derived fractions were compared. A small solvent dependency was seen in the concentration of S and N and the H/C. The amount of material precipitating appears to have the most dramatic effect on the elemental concentration and distribution. Included is a discussion about the significance of the differences seen in the use of the two precipitating solvents. (Edited author abstract) 24 refs.

Reynolds, John G. (Lawrence Livermore Natl Lab, Livermore, CA, USA). *Fuel Sci Technol Int* v 5 n 5 Oct 1987 p 593-620.

**Refining See CATALYSTS—Performance; SYNTHESIS GAS—Production.**

**Research See HYDROCARBONS—Processing.**

**Salt Removal See PETROLEUM, CRUDE—Dehydration.**

**Simulation See PETROLEUM, CRUDE—Chromatographic Analysis.**

**Solvent Extraction See PETROLEUM PRODUCTS—Evaluation.**

**Sulfur Determination See OIL FUEL—Viscosity.**

## Waste Utilization

**077841 SEDIMENTATION OF SULFURIC ACID IN ACID TARS FROM CURRENT PRODUCTION.** One of the methods for utilization of acid tars is to burn them, producing concentrated sulfuric acid, which can then be used in treating petroleum oils. The authors investigated acid tars obtained in treating T-750 KhF-12, and I-8A oils. These tars differ from each other in their content of sulfuric acid and in the composition of the organic part. The experiments on storage of the tars were performed in separatory funnels with an electric heater; the tars were allowed to settle without stirring at temperatures of 20, 60, and 90°C. After each day of storage, the acid number was determined potentiometrically, and the amount of acid settled out was measured and expressed as a percentage. 12 refs.

Denisova, T.L. (Yaroslavl Polytechnic Inst, USSR); Frolow, A.F.; Aminov, A.N.; Novosel'tsev, S.P. *Chem Technol Fuels Oils* v 23 n 1-2 Jan-Feb 1987 p 6-9.

## PETROLEUM RESERVOIR ENGINEERING

See Also FLOW OF FLUIDS—Underground; HYDROCARBONS—Composition Effects; NATURAL GAS WELLS—Hydraulic Fracturing; OIL FIELDS—Field Development; OIL FIELDS—North Sea; OIL FIELDS—Offshore; OIL FIELDS—Reservoir Evaluation; OIL WELL COMPLETION; OIL WELL COMPLETION—Offshore Operations; OIL WELL DRILLING; OIL WELL DRILLING—Computer Simulation; OIL WELL DRILLING—Directional; OIL WELL DRILLING—Equipment; OIL WELL DRILLING—Rotary Mud; OIL WELL LOGGING; OIL WELL LOGGING—Neutron; OIL WELL LOGGING—Nuclear; OIL WELL PRODUCTION—Calculations; OIL WELL PRODUCTION—Enhanced Recovery; OIL WELL PRODUCTION—Estimation; OIL WELL PRODUCTION—Flooding; OIL WELL PRODUCTION—Flow; OIL WELL PRODUC-

TION—Gas Lift; OIL WELL PRODUCTION—In Situ Combustion; OIL WELL PRODUCTION—Offshore; OIL WELL PRODUCTION—Optimization; OIL WELL PRODUCTION—Performance; OIL WELL PRODUCTION—Tertiary; OIL WELL PRODUCTION—Thermal; OIL WELLS—Fracturing; OIL WELLS—Hydraulic Fracturing; OIL WELLS—Testing; PETROLEUM, CRUDE—Thermodynamic Properties; PETROLEUM ENGINEERING; PETROLEUM GEOLOGY; RESERVOIRS—Ion Exchange.

**077842 MICROSCOPIC DISTRIBUTION OF WETTING AND NONWETTING PHASES IN SANDSTONES DURING IMMISCIBLE DISPLACEMENTS.** A novel technique has been developed and used to study the microscopic distribution of wetting and nonwetting phases in reservoir rocks during immiscible displacements. The underlying principle is the use of appropriate fluids, serving as the wetting and the nonwetting phases, that can be solidified in situ, one at a time, without altering to any significant extent the position and orientation of the phases acquired at capillary equilibrium conditions. After both phases are solidified, the rock matrix is etched and replaced by a resin to enhance the quality of polishing. Wettabilities of the fluid pairs were also visualized directly by this new technique. (Edited author abstract)

Yadav, G.D. (Univ of Waterloo, Waterloo, Ont, Can); Dullien, F.A.L.; Chatzis, I.; Macdonald, I.F. *SPE Reservoir Eng* v 2 n 2 May 1987 p 137-147.

**077843 DEVELOPMENT OF A NEW ALUMINUM/POLYMER GEL SYSTEM FOR PERMEABILITY ADJUSTMENT.** A new method for gelling polyacrylamide with aluminum has been developed to reduce the effect of reservoir heterogeneity, resulting in improved waterflood efficiency and higher oil recovery. The method uses a soluble aluminum compound in a high-pH, nonreactive form that is mixed directly with the polymer at optimum concentrations. Polymer gelling occurs in the reservoir when reactive aluminum is generated by consumption of hydroxyl ions. Variations in gel strength and gel time are obtained by adjusting polymer and aluminate concentrations in the slug to the desired levels. This process has several advantages over the current aluminum citrate technology as well as the chromium redox bulk gel system. (Edited author abstract) 10 refs.

Dovan, H.T. (Unocal Corp); Hutchins, R.D. *SPE Reservoir Eng* v 2 n 2 May 1987 p 177-183.

**077844 DETERMINATION OF BOUNDARY VALUES OF PERMEABILITY AND POROSITY OF TERRIGENOUS RESERVOIRS BY PETROPHYSICAL AND AND GEOPHYSICAL METHODS.** From the results of standard and special studies of core samples and from data of geophysical well tests, by means of statistical methods, boundary values of permeability and porosity characterizing a different degree of mobility of fluids in rocks is determined. Fluid flow takes place when rock permeability and porosity exceed some boundary values. These values may be used to identify reservoirs with a certain probability. In Russian. 7 refs.

Kozyar, V.F.; Duzin, V.I.; Dratsov, V.G.; Petersil'e, V.I.; Rabits, E.G. *Geol Nefti Gaza* n 2 1987 p 11-17.

**077845 BRAIDED STREAM RESERVOIRS.** Two types of river deposits commonly are excellent reservoirs - braided and meandering streams. Braided streams are complex networks of low-sinuosity channels that flow on alluvial plains with slopes greater than  $1/2$  to  $2'$  [0.026 to 0.034 rad]. Discharge through the channels is normally low, but during a year sporadic floods carry enormous volumes of water and sediments into the system. Lateral continuity of the pay is usually good to excellent in braided stream reservoirs and vertical continuity is fair to good. Development of production from braided stream reservoirs requires careful attention to placement of completion intervals in wells. Because the isolated shales have limited areal extent, they may not be effective in preventing coning. Thus, perforations should be placed low if a gasdrive is expected or high if waterdrive is expected. 3 refs.

Richardson, J.G. (Richardson, Sangree & Sneider); Sangree, J.B.; Sneider, R.M. *JPT J Pet Technol* v 39 n 12 Dec 1987 SPE 15782, p 1499-1500.

**077846 MEANDERING STREAM RESERVOIRS.** Braided stream deposits and meandering stream deposits commonly are excellent reservoirs. Meandering high-sinuosity channels are found on flat alluvial plains with slopes less than  $1/2$  [0.026 rad]. These rivers have wide ranges of discharges from low-water flow to flood stage. Two main processes are responsible for development of sand bodies. These are point-bar deposits left by channel migration, and oxbow-lake deposits left in loops of the river course abandoned when the stream cuts a new course during flooding. Extremely high floods spill over the banks and deposit sheets of very fine sand, silt, and clay onto the flood plain. 3 refs.

Richardson, J.G. (Richard, Sangree & Sneider); Sangree, J.B.; Sneider, R.M. *JPT J Pet Technol* v 39 n 12 Dec 1987 SPE 15781, p 1501-1502.

**077847 SIMULATION DES PROCESSUS DANS LES SYSTEMES A PLUSIEURS COUCHES COMPTE TENU DE L'ECHANGE LOCAL.** [Simulation of Processes in Systems with Several Layers Keeping in Mind Local Exchange]. The aim of this article is to study problems of simulating complex, nonstationary processes in systems with several layers characterized by a connection between these layers by way of local permeable zones. The influence of zones in the differential equation of the process is taken into consideration by introducing the unitary Heviside function. Results of simulation of concrete problems of liquid flow in a petroleum layer with a permeable roof are presented, as well as a comparison of these results with those of numerical calculations flowing approximate formulas obtained with Galerkin's method. In French. 7 refs.

Gouliev, Mamedkerim A. (Inst de Cybernetique de AS RSS d'Azerb, Baku, USSR); Gousseinzade, Medjid A. *Modell Simul Control B* v 11 n 4 1987 p 33-43.

**077848 ROCK PROPERTY CORRELATIONS FOR HYDROCARBON PRODUCING RESERVOIR SANDS OF THE NIGER DELTA.** Correlations made with petrophysical/reservoir properties from a given formation in a particular region may not yield reliable results when applied to a formation from another region even when the rock type is the same. This fact demonstrates the need for the development of empirical correlations which are unique to the hydrocarbon-producing reservoir sands of the Niger Delta. Correlation functions were sought for the petrophysical properties of the hydrocarbon-producing sands, of the Niger Delta. The relationships studied are porosity/permeability, formation resistivity factor/porosity/permeability, and porosity/water saturation. Data used for these correlations were derived from laboratory measurements on rock core samples and well logs from producing formations in the Niger Delta. Results on the above correlations appear very satisfactory. Permeability and porosity were correlated together with formation resistivity factor to produce improved results.

Udegbuma, E.Q. (Univ of Port Harcourt, Nigeria); Ndukwe, L.C. *Oil Gas J* v 86 n 6 Feb 8 1988 p 55-58.

**077849 RESERVOIR DEVELOPMENT USING OFFSET VSP TECHNIQUES IN THE DENVER-JULESBURG BASIN.** Multioffset vertical seismic profiles (VSPs) have been used successfully to delineate and develop a Sand D field in the Denver-Julesburg basin. Sand D production in Wattenberg field was established by the Sierra Energy and Berge Exploration Well 34-3. Subsequently, three successive wells failed to find the Sand D channel. A stratigraphic model study suggested that offset VSP techniques could be used to determine the extent of the Sand D reservoir accurately and to identify potential offset drilling locations. On the basis of this study, a five-offset VSP was conducted in the discovery



well. Interpretation of the data produced an accurate map of the reservoir limits and identified two additional drilling locations. (Edited author abstract) 2 refs.

Cramer, P.W. (Geosource Inc). *JPT J Pet Technol* v 40 n 2 Feb 1988 p 197-205.

**077850 HELE-SHAW CELL STUDY OF A NEW APPROACH TO INSTABILITY THEORY IN POROUS MEDIA.** Whether a displacement is stable or unstable has a profound effect on how efficiently one fluid immiscibly displaces another within a porous medium. As a consequence it is of interest to be able to predict the boundary which separates stable displacements from those which are unstable. Recently, a new approach to stability theory has been developed which is based on the assumption that the immiscible displacement of one fluid by another can be treated as a moving boundary problem. This paper describes a number of experiments undertaken to validate the newly developed theory. Because the assumption of a sharp front between the two fluids is satisfied exactly in a Hele-Shaw cell, these preliminary experiments were undertaken in such a model. (Edited author abstract) 25 refs.

Coskuner, G. (Univ of Alberta, Can); Bentsen, R.G. *J Can Pet Technol* v 27 n 1 Jan-Feb 1988 p 87-95.

**077851 IN THE DIRECTION OF NEW RESERVOIR GEOPHYSICS.** In recent years geophysics has been brought into closer contact with reservoir interests through the implementation of high resolution seismics in the zones of interest, the development of more specialized processing, the advent of increasingly finer stratigraphic interpretations and development of three-dimensional seismics. However, the effects on the seismic signal of interface scatter as it travels through the terrain as well as alterations caused by its path in and out of the weathered layer, are some of the factors that hamper the recovery of the high resolution information that is sought. Therefore, a new direction has been taken with the development of vertical seismic profiles and more recently the appearance of new cross-hole geophysics, adapted for the reservoir. This has allowed a close up study of the reservoir. The methods of study of reservoirs by 'transparency' by the processing of trace gathers and by the study of guided wave propagation phenomena are briefly explained.

Delvaux, Jacques (Elf Aquitaine). *Rev Energ* v 38 n 391 Apr 1987 p 197-203.

**077852 WATER IMBIBITION AND CHARACTERIZATION OF NORTH SEA CHALK RESERVOIR SURFACES.** Water imbibition of a reservoir core was dramatically affected by the removal of small amounts of tightly bound material. Both water-wet and oil-wet chalk cores contained sufficient extractable material to form multimolecular coatings over their entire surfaces. Analysis of the material removed from these reservoir cores provided some clues regarding the fluid dynamics. (Author abstract) 34 refs.

Baldwin, Bernard A. (Phillips Petroleum Co). *SPE Form Eval* v 3 n 1 Mar 1988 SPE 14108, p 125-130.

**077853 FACTORS AFFECTING THE EQUIVALENCY OF DIFFERENT CAPILLARY PRESSURE MEASUREMENT TECHNIQUES.** The results of a laboratory investigation of the effects of some factors that affect the equivalency of different drainage capillary pressure measurement techniques are presented. These factors are Bond number, clay alteration by sample drying, wettability, equilibration, sample orientation, and overburden pressure. The results, among other things, suggest an extension of the range of validity of liquid/liquid centrifuge tests. A method of estimating contact angles of weakly wetting systems with capillary pressure data is presented. (Author abstract) 28 refs.

Omorgie, Zuwa S. (Chevron Oilfield Research Co). *SPE Form Eval* v 3 n 1 Mar 1988 SPE 15384, p 147-155.

**077854 NEW APPROACH FOR CONSTRUCTING DERIVATIVE TYPE CURVES FOR WELL TEST ANALYSIS.** This work presents a new general procedure

for constructing type curves based on a new combination of dimensionless pressure and the derivative of dimensionless pressure. The procedure can be used to construct type curves for all standard problems encountered in well testing. The new type curves always have good character so that nonuniqueness problems sometimes encountered in type-curve matching are eliminated; thus, the type curves constructed by our method should improve our sometimes encountered in type-curve matching are eliminated; thus, the type curves constructed by our method should improve our ability to obtain accurate estimates of reservoir parameters by type-curve matching. The basic procedure is used to construct new type curves for wellbore storage and skin problems and for fractured wells (uniform-flux and infinite-conductivity). (Edited author abstract) 23 refs.

Onur, Mustafa (Univ of Tulsa); Reynolds, Albert C. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 16473, p 197-206.

**077855 NOTE ON THE DURATION OF THE TRANSITIONAL PERIOD OF RESPONSES INFLUENCED BY WELLBORE STORAGE AND SKIN.** Several correlations are available for computing times at which storage effects can be considered to be negligible. The times given by these correlations are not in agreement principally because the criteria used to determine times for storage effects to become negligible are different. This paper clarifies the reasons for the differences and provides a unified treatment of the rules proposed in the literature. We show that correlations that specify the duration of the various flow periods depend on the manner in which the estimates are computed and on the tolerance used to obtain the estimate. A new correlation to determine the time for the start of the semilog straight line is presented. (Edited author abstract) 18 refs.

Vongvuthipornchai, S. (Univ of Tulsa); Raghavan, R. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 15273, p 207-214.

**077856 MODEL SELECTION FOR WELL TEST AND PRODUCTION DATA ANALYSIS.** We develop a procedure for selecting the most appropriate model from a pool of candidates. A parameter estimation algorithm is used to evaluate parameters within candidate models. Statistical measures are then used to select the most appropriate model. We demonstrate our procedure for model selection with actual well test data and production data from the Devonian shale. We show how our methodology can be used to evaluate whether certain reservoir features can be identified from measured production or pressure data. We also present a test for evaluating whether independent estimates of reservoir properties are consistent with measured pressure and production data. (Edited author abstract) 20 refs.

Watson, A.T. (Texas A&M Univ); Gatens, J.M. III; Lane, H.S. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 15926, p 215-221.

**077857 TWO-POINT DETERMINATIONS OF PERMEABILITY AND PV VS. NET CONFINING STRESS.** Empirical equations are presented that accurately fit permeability, PV, or porosity data vs. net confining stress. Each of these equations has four adjustable parameters. With little loss of accuracy, however, two of the coefficients can be preset. Consequently, permeability, PV, or porosity measurements need to be made at only two confining stresses - e.g., at 1,500 and 5,000 psi [10.3 and 34.5 MPa] to define the stress dependence within close tolerances completely. With the techniques described, economical measurements of these dependent properties can be made on a routine basis. The results can be used to calculate PV compressibility and to estimate productivity declines resulting from permeability reduction as deep, high-pressure reservoirs are drawn down. (Author abstract) 36 refs.

Jones, Stanley C. (Marathon Oil Co). *SPE Form Eval* v 3 n 1 Mar 1988 SPE 15380, p 235-241.

**077858 PHYSICS OF BLOB DISPLACEMENT IN A TWO-DIMENSIONAL POROUS MEDIUM.** This paper presents theoretical and experimental results con-

cerning the physical mechanisms of trapping and displacement of a nonwetting phase in a porous medium. The evolution of the geometry of blobs is observed during displacements in a two-dimensional (2D) transparent micromodel, and such macroscopic parameters as pressure drop and recovery are monitored simultaneously. The results are in good agreement with experiments performed in real media and with theoretical calculations of the conditions required for blob mobilization when the presence of loops in the structure is taken into account. (Edited author abstract) 18 refs.

Lenormand, Roland (Dowell Schlumberger); Zarcone, Cesar. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 14882, p 271-275.

**077859 AIR STRIPPING FOR TREATMENT OF PRODUCED WATER.** In a laboratory study, air stripping shows a promising potential for treatment of produced water to meet new government regulations on total organic carbon (TOC). Reservoir hydrocarbons dissolved in water, such as volatile paraffins and aromatics, can be removed by air stripping through interphase mass transfer. However, air stripping cannot remove many chemicals added to crude oil by the operator. (Author abstract) 13 refs.

Fang, C.S. (Univ of Southwestern Louisiana, LA, USA); Lin, J.H. *JPT J Pet Technol* v 40 n 5 May 1988 SPE 16328, p 619-624.

**077860 BOTTOMWATER DRIVE IN TARMAT RESERVOIRS.** Tarmat reservoirs subject to bottomwater drive are studied. Different shapes of tar layers are simulated physically and numerically to study the behavior of WOR and oil recovery. Four different cases were studied: a square barrier beneath the well, a disk beneath the well, a hollow square or disk beneath the well, and a half plane. The breakthrough time occurs earlier in the case of hollow tarmat barriers, while it is delayed considerably in the case of tarmat barriers shaped in the form of a disk beneath the well. (Edited author abstract) 9 refs.

Al-Kaabi, Abdul Aziz (King Fahd Univ of Petroleum & Minerals); Menouar, Habib; Al-Marhoun, Muhammad Ali; Al-Hashim, Hasan S. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 15687, p 395-400.

**077861 INFLUENCE OF SAMPLE SIZE AND PERMEABILITY DISTRIBUTION IN HETEROGENEITY MEASURES.** This study evaluates the influence of sample size on the Dykstra-Parsons and Lorenz measures of heterogeneity. Because either coefficient is determined for a reservoir from a finite number of data, only an estimate is made of the true coefficient. We show that, on average, the estimate is less than the true value. We give the relationship between estimate error and number of samples and show how significant errors may arise when too few data are used. The influence of the permeability distribution on heterogeneity measures is also studied. We show that a variety of distributions exhibiting different reservoir performance can have the same Dykstra-Parsons coefficient. (Edited author abstract) 18 refs.

Jensen, Jerry L. (Heriot Watt Univ); Lake, Larry W. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 15434, p 629-637.

**077862 EOS PREDICTIONS OF COMPRESSIBILITY AND PHASE BEHAVIOR IN SYSTEMS CONTAINING WATER, HYDROCARBONS, AND CO<sub>2</sub>.** Two cubic equations of state (EOS) have been adopted to compute multicomponent two-phase compressibility, CO<sub>2</sub>/water and hydrocarbon/water phase behavior, and gas- and liquid-phase densities. The equations used are the Schmidt-Wenzel (SW) EOS and the Peng-Robinson (PR) EOS. While these cubic equations have the same form, the SW is reported to be more accurate for predicting hydrocarbon gas- and liquid-phase densities. Density predictions are compared with experimental data to confirm the superiority of the SW EOS. The use of EOS



to predict equilibrium phase compositions of water/hydrocarbon and water/CO<sub>2</sub> systems is discussed. For the water/hydrocarbon systems, the aqueous-phase interaction coefficient between water and the dissolved component shows a strong temperature dependency, while in the gas phases, a constant value of interaction coefficient is adequate. (Edited author abstract) 40 refs.

Firoozabadi, A. (Stanford Univ); Nutakki, R.; Wong, T.W.; Aziz, K. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 15674, p 673-684.

**077863 SOME INVARIANT SOLUTIONS TO TWO-PHASE FLUID DISPLACEMENT PROBLEMS INCLUDING CAPILLARY EFFECT.** Analytical investigation of the two-phase displacement problem that considers capillary force is one of the most important and difficult problems in the theory of fluid flow through porous media. This paper presents some invariant solutions on the subject, including a self-similar solution for the axisymmetric case, a self-similar solution in a linear, isoclinic reservoir that considers the effects of gravity and capillary forces simultaneously, and a progressive wave solution corresponding to a stabilized zone of saturation distribution. The relations and differences among (1) a model that completely includes capillary effect, (2) a model that considers capillary action partially and implicitly (the Buckley-Leverett model), and (3) a model that completely ignores capillary effect are indicated and discussed. (Author abstract) 14 refs.

Chen, Z.-X. (Research Inst of Petroleum Exploration & Development). *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 14874, p 691-700.

**077864 IMPORTANCIA DE LA DIFUSION EN EL DESPLAZAMIENTO DE FLUIDOS EN YACIMIENTOS PETROLIFEROS.** [Importance of Diffusion in Fluid Displacement Within Oil Reservoirs]. Molecules of all fluids have random movements of the Brownian type. Due to these movements, a fluid can be diffused into another, when there is miscibility between them. During the exploitation stage of reservoirs, the diffusion phenomenon generally is not taken into account. In this paper, a study is made of this subject, and it is concluded that diffusion is an important phenomenon for fluid displacement within reservoirs. Consequently, a sound knowledge of diffusion properties is necessary for improving oil recovery. (Edited author abstract) In Spanish. 7 refs.

Perez Rosales, Candelario (Inst Mexicano del Petroleo, Mex). *Rev Inst Mex Pet* v 19 n 2 Apr 1987 p 12-17.

**077865 SLUG-TEST ANALYSIS IN DOUBLE-POROSITY RESERVOIRS.** The pressure response of a double-porosity reservoir to a slug test in a fully penetrating well with wellbore storage and skin is presented. Pseudosteady-state matrix flow and transient matrix flow with and without matrix skin are considered. Three kinds of type curves are discussed: early-time log-log, intermediate-time semilog, and late-time log-log. Pressure distribution around the active well and the prospects of interference slug testing are considered. The early-time response of the slug test depends on the presence of wellbore skin; hence, two kinds of early-time type curves are presented. When the active well has wellbore skin, the early-time correlating parameter is the product of the skin and the dimensionless storage, resulting in a new log-log type curve. When wellbore skin is not present, the early-time response is proportional to the square root of time with dimensionless storage as the correlating parameter. (Edited author abstract). 31 refs.

Grader, Abraham S. (Stanford Univ, Stanford, CA, USA); Ramey, Henry J. Jr. *SPE Form Eval* v 3 n 2 Jun 1988 p 329-339.

**077866 PREDICTION OF ABRUPT RESERVOIR COMPACTION AND SURFACE SUBSIDENCE CAUSED BY PORE COLLAPSE IN CARBONATES.** A new procedure has been developed to predict the abrupt in-situ compaction and the associated surface subsidence above high-porosity carbonate fields that show pore collapse. The approach is based on an extensive laboratory

compaction study in which the effects of carbonate type, porosity, core preparation, pore saturant, horizontal/vertical stress ratio, and loading rate on pore-collapse behavior were investigated. For a number of carbonate types, a trendline was established that describes the relationship between the porosity after collapse and the vertical effective stress. This trendline concept, in combination with existing subsidence models, enables reservoir compaction and surface subsidence to be predicted on the basis of wireline porosity logs. Static and dynamic elastic constants were found to be uncorrelated during pore collapse. (Edited author abstract). 13 refs.

Smits, R.M.M. (Koninklijke/Shell E&P Lab, Rijswijk, Neth); De Waal, J.A.; Van Kooten, J.F.C. *SPE Form Eval* v 3 n 2 Jun 1988 p 340-346.

**077867 PREDICTION OF RESERVOIR COMPACTION AND SURFACE SUBSIDENCE: FIELD APPLICATION OF A NEW MODEL.** A new loading-rate-dependent compaction model for unconsolidated clastic reservoirs is presented that considerably improves the accuracy of predicting reservoir rock compaction and surface subsidence resulting from pressure depletion in oil and gas fields. The model has been developed on the basis of extensive laboratory studies and can be derived from a theory relating compaction to time-dependent intergranular friction. The procedure for calculating reservoir compaction from laboratory measurements with the new model is outlined. Both field and laboratory compaction behaviors appear to be described by one single normalized, nonlinear compaction curve. With the new model, the large discrepancies usually observed between predictions based on linear compaction models and actual (nonlinear) field behavior can be explained. (Author abstract). 26 refs.

De Waal, J.A. (Koninklijke/Shell E&P Lab, Rijswijk, Neth); Smits, R.M.M. *SPE Form Eval* v 3 n 2 Jun 1988 p 347-356.

**077868 COMPARISON BETWEEN THE PRESSURE-LAG MODEL AND THE RATE-TYPE MODEL FOR THE PREDICTION OF RESERVOIR COMPACTION AND SURFACE SUBSIDENCE.** A theoretical study has been carried out to investigate whether the nonlinear compaction behavior of sandstone reservoirs, which has been reported for most well-documented field cases, can be explained by pressure lags in interbedding and/or neighboring low-permeability (shale) layers. On the basis of the results obtained, it is concluded that pressure-lag effects in normally encountered production scenarios cannot account for these nonlinearities, even under worst-case conditions. Therefore, the nonlinear field-compaction behavior must be caused by rate effects in the sandstone reservoir rock itself. This is supported by the fact that a rate-type compaction model recently introduced does indeed give a good description of the observed field behavior. (Author abstract).

Smits, R.M.M. (Koninklijke/Shell E&P Lab, Rijswijk, Neth); De Waal, J.A. *SPE Form Eval* v 3 n 2 Jun 1988 p 357-363.

**077869 ANALYSIS OF PRESTIMULATION TEST DATA IN DEVONIAN SHALE RESERVOIRS.** Prestimulation testing in Devonian shales has proved to be complicated because of the long duration of wellbore storage distortion that must be exceeded during flow and shut-in periods to obtain an analyzable test. This paper presents field examples of four prestimulation well tests that illustrate the practical difficulties in obtaining analyzable data. We were not able to analyze these tests with conventional semilog and type-curve methods. To understand the cause of the difficulties, we simulated a prestimulation well test to verify that the actual wells had not been produced long enough to exceed wellbore storage distortion. Guidelines are presented to aid in the design and implementation of a prestimulation test in Devonian shales. (Edited author abstract). 10 refs.

Holgate, K.E. (Texas A&M Univ, TX, USA); Lancaster, D.E.; Lee, W.J. *SPE Form Eval* v 3 n 2 Jun 1988 p 364-370.

**077870 INTERFERENCE TESTING: DETECTING A CIRCULAR IMPERMEABLE OR COMPRESSIBLE SUBREGION.** A practical consideration of the effects of a single, circular, heterogeneous reservoir subregion on interference transient pressure testing is presented. The production well and the observation wells are external to the circular subregion. The internal circular boundary is considered as a constant-pressure source or as an impermeable subregion. The constant-pressure subregion has significant effects on interference pressure responses regardless of the size of the subregion. Ignoring the presence of a neighboring compressible portion of the reservoir, such as a gas or a steam cap, may yield erroneously high storativities and transmissivities. Multiple interference tests may suggest the probable location of the gas cap. The effects of an impermeable subregion are subtle, and in some cases, large, impermeable portions of the reservoir may not be detected by neighboring interference wells. (Edited author abstract). 20 refs.

Grader, Abraham S. (Stanford Univ, Stanford, CA, USA); Horne, Roland N. *SPE Form Eval* v 3 n 2 Jun 1988 p 420-428.

**077871 PRESSURE TRANSIENTS AND CROSSLAYER FLOW CAUSED BY DIFFUSIVITIES IN MULTILAYER RESERVOIRS.** This paper considers single-phase unsteady flow in a system of homogeneous layers separated by thin, low-permeability shales, and having interlayer crossflow caused by different diffusivities for different layers. The model considers all layers open to a single well that flows at a constant total rate. Numerical simulations of the problem for the semipermeable-wall model are used to find the structure of the crossflows in typical cases. Analytic solutions for pressure and the n-1 diffusivity crossflows are developed and compared with the numerical results. These solutions show how the diffusivity crossflows depend on layer properties and ordering. Their behavior and properties are discussed and their effects on pressure distributions are shown. (Author abstract). 13 refs.

Gao, Cheng-Tai (Research Inst of Chan-Qing Oil Field, Chan-Qing, China); Deans, H.A. *SPE Form Eval* v 3 n 2 Jun 1988 p 438-448.

**077872 MECHANISM OF TRANSIT TIME INCREASE AND ITS INTERPRETATION AFTER WATER INJECTION INTO RESERVOIR M IN THE LAO JUN MIAO OIL FIELD.** Reservoir M in the Lao Jun Miao oil field is a very massive sandstone oil reservoir about 60 m [200 ft] thick. Within the reservoir, there are no evident shale barriers and no interlayer standard water zones. This reservoir is classified as a fractured porous reservoir. The reservoir rocks have a high shale content; montmorillonite is the main clay mineral with a maximum percentage content of up to 60 percent. This paper gives an idea of the mechanism for the increase in sonic transit time in flooded intervals of the reservoir on the basis of the measurement and analysis of the noninvaded cores. Study results show that the increase in sonic transit time after flooding is linked to the rock texture in relation to the high montmorillonite content. This paper also gives an in-house measurement technique for samples with high montmorillonite content. (Edited author abstract). 3 refs.

Hao, Zhi-Xing (Research Inst of Petroleum E&D, Beijing, China); Shen, Lian-di. *SPE Form Eval* v 3 n 2 Jun 1988 p 471-479.

**077873 GAS BRINE CONTACT DETECTION BY SONIC WAVE VELOCITIES.** Shear wave velocities of dry and liquid saturated sandstone samples were measured at elevated reservoir conditions of pressure and temperature. Research as well as Biot's theory confirmed that the shear wave velocity decreased with the increase in liquid saturation and the dilatational wave velocity increased with the increased liquid saturation of the porous media. The ratio of shear to dilatational wave velocities for dry (gas saturated) sandstone samples was found to be higher than that of liquid saturated ones. Accordingly, this phenomena should be utilized in log interpretation as



a diagnostic feature to distinguish the gas-oil or gas-water contact in a subsurface formation. (Edited author abstract). 8 Refs.

Al-Khafaji, Ali H. (Council of Scientific Research, Baghdad, Iraq); Jabur, Merriam A.; Al-Mashat, Ali M. *J Pet Res* v 7 n 1 Jun 1988 p 1-12.

**077874 NEW PRESSURE ANALYSIS TECHNIQUE USING REPEAT FORMATION TESTER DATA.** Current practice is to derive permeability from the pretest of wireline formation testers by the conventional Horner plot method. The major drawback of this type of analysis is the reliability of the flow time and flow rate estimates. A new technique to derive permeability from pressure response during the sampling period has been developed. The new method is based on the principle that at the end of the sampling period the volume of the fluid in the chamber is equal to the nominal volume of the sample chamber. The suggested method applies the approximation of the continuous pressure decline by a series of pressure steps as applied for water influx calculations. In its present form the technique has limitations due to flow regime shapes, number of phases present and the degree of formation damage. Research is underway to find acceptable solutions for the stated limitations. (Author abstract) 4 refs.

Samson, Paul N.; Figelman, Haim; Braester, Carol. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 275-281.

**077875 SYNERGISTIC EVOLUTION OF THE NORMAN WELLS RESERVOIR DESCRIPTION.** A major development drilling program at Norman Wells has seen 237 wells drilled since 1981. With this expansion, enhanced understanding of the reservoir has evolved from a synergistic treatment of the data base by geologists and engineers. Volumetric and flow capacity characteristics have been determined to provide a basis for managing the depletion of this crude oil reservoir. The development strategy implemented was a waterflood with pattern spacing and orientation designed to take advantage of the directional permeabilities associated with the fracture system. Geologic control has been integrated with performance data to describe the spatial variation in fracture-enhanced permeability. Comparisons of injection performance and core-derived permeability thickness data permitted quantifying the influence of the fractures on reservoir flow capacity. An areal map representing the effective flow capacity of the Norman Wells reservoir is assisting in the selection of workover candidates. (Edited author abstract) 5 refs.

West, L.W. (Esso Resources Canada Ltd, Can); Doyle-Read, F.M. *J Can Pet Technol* v 27 n 2 Mar-Apr 1988, 38th Annu Tech Meet, Pet Soc CIM, Jun 1987 p 96-103.

**077876 PROCEEDINGS - SPE EASTERN REGIONAL MEETING.** This conference proceedings contains 40 papers covering an array of topics of interest to petroleum reservoir engineering. Papers on petroleum reservoir engineering, well test analysis, performance and production of oil and gas wells, and evaluations of Devonian shales are presented. Other topics discussed include oil field valuation, petroleum industry economics and legislation, enhanced oil recovery, pressure transients, production decline type curves, mathematical modeling, and production forecasting. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10492 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Soc of Petroleum Engineers of AIME, Pittsburgh Petroleum Section, Pittsburgh, PA, USA). *Soc Pet Eng AIME Pap SPE* 1987, Proc - SPE East Reg Meet, Champion, PA, USA, Oct 21-23 1987. Publ by Soc of Petroleum Engineers of AIME, Richardson, TX, USA 461p.

Applications See FLOW OF FLUIDS—Two Phase.

# Australia

**077877 FORTESCUE RESERVOIR DEVELOPMENT AND RESERVOIR STUDIES.** The Fortescue field in the Gippsland Basin, offshore southeastern Australia is being developed from two platforms (Fortescue A and Cobia A) by Esso Australia Ltd. (operator) and BHP Petroleum. The Fortescue reservoir is a stratigraphic trap at the top of the Latrobe Group of sediments. It overlies the western flank of the Halibut and Cobia fields and is separated from them by a non-net sequence of shales and coals which form a hydraulic barrier between the two systems. Development drilling into the Fortescue reservoir commenced in April 1983 with production coming onstream in May 1983. Fortescue, with booked reserves of 44 stock tank giga litres (280 million stock tank barrels) of 43° API oil, is the seventh major oil reservoir to be developed in the offshore Gippsland Basin by Esso/BHP. (Edited author abstract) 2 refs.

Henzell, S.T. (Esso Australia Ltd); Irrgang, H.R.; Janssen, E.J.; Mitchell, R.A.H.; Morrell, G.O.; Palmer, I.D.; Seage, N.W.; Hicks, G.J.; Hordern, M.J.; Kable, C.W. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 95-106.

**Calculations** See Also HYDROCARBONS—Physical Properties; OIL WELL PRODUCTION—Flooding; OIL WELLS—Fracturing; OIL WELLS—Hydraulic Fracturing; PETROLEUM PROSPECTING—Economics.

**077878 METHOD TO DETERMINE SEMIPERMEABILITIES BY STEADY RATES.** This paper gives an analytical method to calculate the semipermeabilities for individual layers in an n-layer reservoir by using the steady layer rates when all layers produce together with a common wellbore pressure and a constant total rate. (Author abstract) 1 ref.

Gao, Cheng-tai (Chan-ting Oil Field Res Inst, China). *Soc Pet Eng AIME Pap SPE Unsolicited Manuscr Sep 1987 SPE* 017024, 3p.

**077879 EXACT SOLUTIONS FOR INFINITE-CONDUCTIVITY WELLS.** In pressure transient testing, the infinite-conductivity condition translates mathematically into a uniform-pressure (or uniform-potential) condition at the well. This means the flux at different points of the well should be determined in such a way that potential remains uniform at the well. The integral equation for accomplishing this is solved analytically to yield the Laplace-transformed potential. For fractured-well problems, this leads to a relatively fast algorithm for drawing type curves directly on a computer screen. For limited-flow-entry problems, the analytical pressure expression can be used with the method of images to treat problems in reservoirs of finite thickness and/or areal extent. (Author abstract) 13 refs.

Papatzacos, Paul (Rogaland Research Inst). *SPE Reservoir Eng* v 2 n 2 May 1987 p 217-226.

**077880 APPROXIMATE PARTIAL-PENETRATION PSEUDOSKIN FOR INFINITE-CONDUCTIVITY WELLS.** This paper presents a simple formula for the pseudoskin factor of a well with restricted flow entry where infinite conductivity is taken into account analytically. The author derives an equation which is based on the assumption of a line-source well. The introduction of a nonzero well radius causes an error that is small only if the well radius is small compared to the interval open to flow. Comparisons with previously published results are shown graphically and in tabulated form. 15 refs.

Papatzacos, Paul (Rogaland Research Inst). *SPE Reservoir Eng* v 2 n 2 May 1987 p 227-234.

**077881 DEVELOPMENT OF AN EFFICIENT ALGORITHM FOR THE CALCULATION OF TWO-PHASE FLASH EQUILIBRIA.** This paper details the development of an efficient algorithm for the calculation of two-phase equilibrium in multicomponent hydrocarbon systems with an equation of state (EOS). A

number of numerical solution algorithms are evaluated for speed and robustness. To ensure generality, the composition used in the study range from a synthetic 3-component fluid to a real 20-component reservoir fluid, and the calculations are performed at different positions on the fluid-phase diagram. The results of the study are used in the construction of a stable and efficient algorithm. Although the method was developed with reservoir engineering applications in mind, it should also be applicable in chemical, process, and petroleum engineering. (Author abstract) 31 refs.

Abhvan, A.S. (British Gas plc); Beaumont, D.N. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 13951, p 695-702.

**077882 WELL SINGULARITIES IN RESERVOIR SIMULATION.** In this study, we examine the problem of relating the computed solution at a well in reservoir simulation to the actual bottomhole pressure (BHP) and the related questions concerning determination of an effective radius for the computed pressure. We provide a mathematical analysis of this problem from a slightly different standpoint than that used elsewhere. Our approach provides further insight into the nature of the singularity, the extension to multisingularities, nonuniform grids, and the development of related approximation techniques for radially symmetric nonhomogeneous problems. We present some fundamental new results based on the analysis. (Author abstract) 7 refs.

Carey, G.F. (Univ of Texas, TX, USA); Chow, S.S. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14812, p 713-719.

**077883 IMPROVED CALCULATIONS FOR VISCOUS AND GRAVITY DISPLACEMENT IN MATRIX BLOCKS IN DUAL-POROSITY SIMULATORS.** This paper presents two innovations to improve the mathematical representation of viscous and gravity displacement from matrix blocks in dual-porosity simulators. The first improvement accounts for viscous displacement and convective mass transport in matrix blocks caused by potential gradients in the fracture network. Computation time is not significantly increased compared with current dual-porosity simulators. The second improvement provides two computationally efficient methods to refine simulation of gravity displacement in the matrix. Examples show that the improvements are highly desirable in many situations. (Author abstract) 11 refs.

Gilman, J.R. (Marathon Oil Co); Kazemi, H. *JPT J Pet Technol* v 40 n 1 Jan 1988 SPE 16010, p 60-70.

**077884 MODIFIED SLUG TEST FOR UNDERPRESSURED RESERVOIRS.** A simple technique is presented to determine injectivity in underpressured reservoirs. This technique, called the falling head test (FHT), allows calculations of kh and skin by use of type curves developed for drillstem tests (DST's). Results from the FHT compare favorably with values obtained from conventional buildup tests. The tests cited in this paper were conducted in heavy-oil reservoirs. (Author abstract) 8 refs.

Sufi, Arshad H. (Amoco Production Co); Thompson, Richard J. *JPT J Pet Technol* v 40 n 1 Jan 1988 SPE 15112, p 105-110.

**077885 RELATIONSHIP BETWEEN RADIUS OF DRAINAGE AND CUMULATIVE PRODUCTION.** At least six radius-of-drainage formulas have been published. These formulas are reviewed and correlated on the basis of the fraction of net production for which each accounts. Numerical results are summarized in an equation for calculating the radius of drainage that corresponds to a given fraction of the net production. (Author abstract) 9 refs.

Johnson, P.W. (New Mexico Inst of Mining & Technology). *SPE Form Eval* v 3 n 1 Mar 1988 SPE 16035, p 267-270.



**077886 CALCULATION OF WATER INFLUX FOR BOTTOMWATER DRIVE RESERVOIRS.** A new water influx model is presented that differs from traditional approaches in that it includes the effect of vertical flow at the reservoir/aquifer interface. The results are presented in the form of dimensionless groups, which makes the model readily applicable to a wide range of systems. A sample calculation is given showing how the predictions of this new model can be significantly different from those of conventional radial flow models. (Edited author abstract) 7 refs.

Allard, D.R. (Gulf Canada Resources Ltd); Chen, S.M. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 13170, p 369-379.

**077887 ESTIMATING RESERVOIR PARAMETERS FROM THE GAS BACKPRESSURE EQUATION.** Two equation forms are commonly used to evaluate gas flow. The empirical U.S. Bureau of Mines (USBM) backpressure equation and a more exact method of analysis which is based on the Forchheimer equation. The discussion shows how the constants of the U.S. Bureau of Mines can be related to the other equation. Examples demonstrate the methods. 3 refs.

Brigham, William E. (Stanford Univ). *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 13302, p 649-650.

**077888 PRESSURE-HISTORY-MATCHING METHOD FOR DETERMINATION OF RELATIVE PERMEABILITIES.** A pressure-history-matching method for determining relative permeabilities was developed and verified in a one-dimensional (1D), analytical/experimental study. The matching method is based on a pressure history induced by injecting a gas (nitrogen in this study) into an incompressible-fluid-saturated porous medium. The analytical model uses relative permeabilities expressed as two-parameter functions of saturation. A parametric study with a finite-difference implicit pressure, explicit saturation (IMPES) solution of the analytical model showed that the relative permeabilities can be determined by matching pressure histories in three steps: (1) match calculated pressure history with measured pressure history during the initial period of 1% of the total injection time, (2) match calculated pressure history with measured pressure history during the final period of 1% of the total injection time, and (3) minimize differences between calculated and measured pressure histories at no fewer than three selected intermediate times. (Edited author abstract) 31 refs.

Lai, W. (Lawrence Livermore Natl Lab); Brandt, H. *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 13928, p 651-661.

**077889 INTEGRAL APPROACH FOR DISCRETIZING THE RESERVOIR FLOW EQUATIONS.** An approach for discretizing the integral form of the flow equations in porous media is proposed. The method has the advantage of providing the correct block volume calculations and steady-state flow in curvilinear coordinates. The harmonic mean for permeability is also obtained from the discretization. The equations are developed for a general orthogonal curvilinear grid system in terms of the components of the metric tensor. (Author abstract) 16 refs.

Nghiem, Long (Computer Modelling Group). *SPE Reservoir Eng* v 3 n 2 May 1988 SPE 12727, p 685-690.

**077890 PC PROGRAM CALCULATES OIL AND GAS PROPERTIES.** A basic program was developed for the IBM PC to calculate physical properties and formation volume factors for oil and gas reservoirs at various pressures. The program utilizes mathematical functions that represent the best fit for pressure-volume-temperature (PVT) correlations derived by empirical data. The program makes calculations for gas reservoirs (with and without condensate yields) and oil reservoirs. Results can be used for reserve calculations and as 'reasonable' input data for material balance or reservoir simulation. Results will be useful if the oil reservoir is under-saturated and the input GOR is the solution GOR at or above the bubble point. Calculations for pressures between initial reservoir

pressure and bubble point pressure are useful for simulation only. 8 refs.

Santos, Rene (Mobil Oil Co, Houston, TX); Allred, Paul. *Pet Eng Int* v 60 n 3 Mar 1988 p 47-48.

**077891 A SIMPLE APPROACH FOR ESTIMATING AVERAGE RESERVOIR PRESSURE IN DEPLETION-TYPE RESERVOIR.** A simple approach is presented for estimating average reservoir pressure in solution-gas-drive reservoirs using data of two flow tests. The two general IPR equations developed by L.E. Couto are the basis of this work. With this approach, provided that certain data is available, one can estimate flow efficiency, skin factor and relative permeability to oil. Excellent agreement is shown between the estimated and actual results. A field example is solved to illustrate the use of the procedure presented. (Edited author abstract). 8 Refs.

Al-Attar, Hazim (Univ of Baghdad, Baghdad, Iraq); Abdul-Majeed, Ghassan H. *J Pet Res* v 7 n 1 Jun 1988 p 37-50.

Canada See OIL WELL PRODUCTION—Heavy Oil.

**Computer Applications** See Also OIL WELL DRILLING—Control; OIL WELL DRILLING—Core; OIL WELL PRODUCTION—Computer Applications; OIL WELL PRODUCTION—Thermal; OIL WELLS—Fracturing; OIL WELLS—Hydraulic Fracturing.

**077892 DIGITAL FILTER FOR DATA SMOOTHING WITH APPLICATION TO RELATIVE PERMEABILITY ESTIMATION.** Automatic data acquisition systems that allow data to be sampled very rapidly can provide much more information from experiments than manual data sampling. Computer storage and work requirements for interpretive procedures for calculating rock properties from measured data, however, generally increase significantly with the number of data. Rather than choosing a sampling rate on the basis of work requirements of the interpretive procedure, we recommend sampling as frequently as possible. Improved estimates for data values to be used in the interpretive procedure can then be obtained by a smoothing process. We present a simple digital filter for data smoothing. We evaluate improvements in relative permeability estimates that may be obtained when the digital filter is used with data collected from displacement experiments. (Edited author abstract) 13 refs.

Tao, T.M. (Texas A&M Univ, USA); Kerig, P.D.; Watson, A.T. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 13843, p 475-477.

**077893 EFFECTS OF MULTIPHASE FLOW ON THE INTERPRETATION OF PRESSURE-BUILDUP TESTS.** A two-dimensional (2D), three-phase, variable-bubblepoint reservoir simulator was developed to simulate pressure-buildup tests involving multiple phases. The simulation indicated that nonuniform saturation distributions throughout the drainage area can cause erroneous interpretations when single liquid-phase techniques, as modified by the Perrine-Martin theory, are used for the analysis. (Author abstract). 26 Refs.

Ayan, Cosan (Texas A&M Univ, TX, USA); Lee, W.J. *SPE Form Eval* v 3 n 2 Jun 1988 p 459-466.

**Computer Simulation** See Also MATHEMATICAL TECHNIQUES—Finite Element Method.

**077894 ADAPTIVE IMPLICIT METHODS APPLIED TO THERMAL SIMULATION.** The application of adaptive implicit methods to a dead-oil steam simulator is discussed. Various test results are presented. The adaptive implicit method works well on thermal problems, demonstrating a 30 to 50% computing time reduction compared with a fully implicit solution technique, while giving essentially the same results. (Author abstract) 11 refs.

Behie, G.A. (Computer Modelling Group); Forsyth, P.A. Jr.; Sammon, P.H. *SPE Reservoir Eng* v 2 n 4 Nov 1987

SPE 14043, p 596-598.

**077895 NEW APPROACH TO LIMITED COMPOSITIONAL SIMULATION: DIRECT SOLUTION OF THE PHASE EQUILIBRIUM EQUATIONS.** A new method for solving the phase equilibrium in limited compositional models is presented. It is a direct solution algorithm based on simplified thermodynamics and can be easily implemented in existing simulators to model such mechanisms as retrograde condensation, oil stripping by gas cycling, and miscible and immiscible gas drive. In field-scale studies, the simplification in phase behavior is more than compensated for by the increase in simulator efficiency. Examples are given to illustrate the method's use in large-scale gas cycling. (Author abstract) 9 refs.

Lo, Tak Sing (Arco Alaska Inc); Youngren, Gary K. *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 13518, p 703-712.

**077896 CUSTOMIZED MINIMIZATION TECHNIQUES FOR PHASE EQUILIBRIUM COMPUTATIONS IN RESERVOIR SIMULATION.** This paper discusses a minimization algorithm for the solution of the Gibbs free energy minimization problem involving at most two phases. There are three major aspects to this paper. The first is the selection of descent directions and step lengths in order to handle the poorly scaled phase equilibrium problems associated with mixtures near bubble points and critical points. The second is the prevention of convergence to trivial solutions in both the Gibbs free energy minimization problem for two-phase mixtures and the associated phase stability test for single-phase mixtures. The third is the use of effective convergence criteria to obtain either the desired level of accuracy in the solution or the maximum accuracy allowed by the problem and the computer. (Author abstract) 43 refs.

Trangenstein, John A. (Exxon Production Research Co, Houston, TX, USA). *Chem Eng Sci* v 42 n 12 1987 p 2847-2863.

**077897 ENTOELUNGSPROZESS IN GESCHITTETEN TRAEGERN.** [Effect of Flow Barriers on Waterflooding of Heterogeneous Reservoirs]. In this report the effect of flow barriers on waterflooding of heterogeneous reservoirs was studied. Three types of flow barriers were investigated: a horizontal discontinuous flow barrier, a vertical leaking fault, a high permeable flow channel. The results were obtained with a numerical simulation program, BETA II. The model considers gravitational, capillary and viscous forces. A systematic variation of the permeability distribution, crossflow, injection scheme and dip of the reservoir was used to study the sensitivity of the oil recovery versus the key parameters. The results underline the importance of crossflow and gravity forces for oil recovery in faulted reservoirs even when the mobility ratio is one. (Edited author abstract) In German. 23 refs.

Weber, R.; Pusch, G.; Mueller, Th. *Erdoel Kohle Erdgas Petrochem* v 40 n 11 Nov 1987 p 467-474.

**077898 COMPARISON OF IMPLICIT AND EXPLICIT METHODS FOR INTERPRETING DISPLACEMENT DATA.** Accurate estimates of reservoir rock properties, such as relative permeability curves, are desired for obtaining reliable predictions of reservoir behavior. There are two distinct approaches for interpreting unsteady-state coreflood data to obtain relative permeability estimates. The JBN and related methods are explicit methods, in that relative permeability values are computed explicitly from coreflood data. With implicit methods, relative permeability curves are adjusted until values computed with a mathematical simulation of the laboratory experiment match. 12 refs.

Richmond, P.C. (Texas A&M Univ, College Station, TX, USA); Watson, A.T. *Soc Pet Eng AIME Pap SPE* n 17649 1988 22p.



**077899 RESERVOIR SIMULATION IN OIL AND GAS FIELD DEVELOPMENT.** Oil and gas field development, particularly in offshore or remote locations, is expensive financially and in terms of scarce engineering skills. Computer modelling, especially reservoir simulation, is of great value in evaluating technical risks and in optimizing economic return. With the ever increasing power and accessibility of computing, reservoir simulation will be used even more extensively in the future. Developments in computer hardware and in numerical analysis over the past two decades, coupled with greatly improved measurement programs in the field, have now made simulation an accessible and valuable operational tool. (Author abstract)

Fox, W. (Winfrith Atomic Energy Establishment, Dorchester, Engl). *Eng Dig (Toronto)* v 34 n 3 Jun 1988 p 45-46, 48.

**077900 EFFICIENT RESERVOIR SIMULATION BY THE SUCCESSIVE EXPLICITIZATION PROCESS (SEP).** This paper presents a mathematical method named 'Successive Explicitization Process' (SEP) that realizes considerable reduction of computing time required for the numerical petroleum reservoir simulation. The SEP attains aimed reduction by successive/complete explicitization of the unknown on a grid block base during multi-unknown Newton-Raphson iterative process. It is applicable to most of the existing petroleum reservoir simulator. (Edited author abstract). 6 Refs. In Japanese.

Tosaka, Hiroyuki. *J Fac Eng Univ Tokyo Ser A* n 25 1987 p 50-51.

**077901 USE OF COMPUTER GRAPHICS: THE WEST KINGFISH POST DEVELOPMENT RESERVOIR SIMULATION STUDY.** A total of 19 development wells were drilled from the West Kingfish platform between October 1982 and May 1984. Information provided by these wells was used in a West Kingfish post-development geologic study and a reservoir simulation study. As a result of these studies the estimated recoverable oil volume has been increased 55 per cent to 27.0 stock tank gigalitres (170 million stock tank barrels). The studies also formed the technical basis for obtaining new oil classification of the P-1.1 reservoir which is the only sand body that has been found in the Gurnard Formation in the Kingfish area. (Edited author abstract) 1 ref.

Younes, A.M. (Esso Australia Ltd, Sydney, Aust); Morrell, G.O.; Thompson, A.B. *APEA J* v 26 pt 1 1986, 1986 APEA Conf, Adelaide, Aust, Apr 7-9 1986 p 447-457.

**Core Analysis** See ALSO OIL FIELDS—Reservoir Evaluation; OIL WELL PRODUCTION—Enhanced Recovery.

**077902 VISUALIZATION OF LABORATORY COREFLOODS WITH THE AID OF COMPUTERIZED TOMOGRAPHY OF X-RAYS.** This paper presents the use of X-ray tomography to inspect a series of laboratory core-displacement tests. Saturation profiles in thin longitudinal planes of view (slices) in the core are followed as a function of time. Immiscible and miscible displacements in single core plugs and butted composite plugs are presented. Effects of heterogeneity of the core, dispersion of flood fronts, and end effects are observed and discussed. The technique has a large potential to improve the understanding of fluid displacement processes in laboratory core experiments. (Author abstract) 13 refs.

Hove, A.O. (Statoil A/S); Ringen, J.K.; Read, P.A. *SPE Reservoir Eng* v 2 n 2 May 1987 p 148-154.

**077903 PROPERTIES OF CAPILLARY FLUIDS AT THE MICROSCOPIC LEVEL.** Results are presented of experimental measurements of the properties of model reservoir fluids (water and hydrocarbons) at the microscopic and submicroscopic level—i.e., when they are confined in narrow spaces comparable to the pore sizes of reservoir rocks. Measurements of capillary forces (or pressures) were carried out for curved oil/water interfaces (menisci) of radii as small as 20 Angstrom [2 nm]. The results show that the capillary pressure is accurately given

by the Laplace equation for even the smallest pore radii of interest in waterflooding. The Kelvin equation describing the equilibrium radius of an oil/water interface has also been verified down to very small radii. (Edited author abstract) 23 refs.

Christenson, Hugo K. (Australian Natl Univ, Aust); Israelachvili, Jacob N.; Pashley, Richard M. *SPE Reservoir Eng* v 2 n 2 May 1987 p 155-165.

**077904 STATISTICAL STUDY OF RESERVOIR PERMEABILITY: DISTRIBUTIONS, CORRELATIONS, AND AVERAGES.** We propose that reservoir permeability may be statistically distributed in a variety of ways. Two hypothetical cases of reservoir layering are statistically analyzed. This analysis suggests that a restricted family of functions - all related to the normal distribution - can be used to represent permeability distributions. The log-normal distribution is one member of the family. Several sets of field data are analyzed. The analyses show that (1) permeability data are not necessarily log-normally distributed, (2) all the permeability distributions considered are closely approximated by members of the proposed family of functions, and (3) improved porosity/permeability relationships result when the permeability distribution is known. (Author abstract) 23 refs.

Jensen, Jerry L. (Univ of Texas, USA); Hinkley, David V.; Lake, Larry W. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 14270, p 461-468.

**077905 RESTORED-STATE CORE ANALYSIS FOR THE HUTTON RESERVOIR.** Wettability is a major control parameter in multiphase flow analyses such as relative permeability. When such analyses are required, the native wettability of the reservoir must be maintained in the test plug. Special cleaning and restoration procedures are described for cores from the Hutton field, located in the U.K. sector of the North Sea. Plugs taken from Hutton cores were contaminated with invert-oil-emulsion drilling mud, which made them strongly oil-wet. By use of special cleaning methods, the surfactants from the drilling mud were removed, and the Hutton reservoir was subsequently shown to be only slightly oil-wet by use of relative permeabilities on plugs that had been restored to native wettability. It was also found that some sections of the Hutton cores were neutral-wet to slightly oil-wet even when clean, possibly because of the presence of coal. (Edited author abstract) 36 refs.

Wendel, D.J. (Conoco Inc); Anderson, W.G.; Meyers, J.D. *SPE Form Eval* v 2 n 4 Dec 1987 SPE 14298, p 509-517.

**077906 NEW METHOD OF COATING OILFIELD CORE FOR LABORATORY STUDIES.** A new method has been developed for coating oilfield core for laboratory studies. It consists of applying a steel coating and aluminum wraps around the outer surface of a core. The strength of the coating, the short time needed to apply it, and its low cost are the major advantages of this new method. (Author abstract) 1 ref.

Menzle, D.E. (Univ of Oklahoma, OK, USA); Dutta, S.; Shadizadeh, R.S. *JPT J Pet Technol* v 40 n 5 May 1988 SPE 16176, p 643-644.

**077907 PARAGLACIAL AEOLIANITES: POTENTIAL NEW HYDROCARBON RESERVOIRS, GIDGALPA GROUP, SOUTHERN COOPER BASIN.** Facies analysis of core from the Gidgealpa Group has led to the first recognition of sandstones of aeolian origin in the Cooper Basin. The aeolian suite was recognised in core from the Merrimelia Formation penetrated by wells within the Merrimelia field. Potential hydrocarbon traps may occur at the top of the aeolianites, or within them beneath intraformational seals formed by muddy interdune facies. The recognition of an aeolian suite at Merrimelia indicates the potential for similar facies development elsewhere in the southern Cooper Basin. Locally these could form important reservoirs beneath the level of existing production. (Edited author abstract) Refs.

Williams, B.P.J. (Univ of Bristol, Bristol, Engl); Wild,

E.K.; Suttill, R.J. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 291-310.

**077908 PALM VALLEY - A CASE FOR INTERPRETATION, 1965-1984.** During the past 18 years, estimations of reserves of the Palm Valley gas field were the subject of many unpublished studies and one that was published in the Journal of Petroleum Technology by Strobel, Gulati and Ramey in 1976. In this study, a reservoir simulator was used to formulate a model that matched the observed pressures in both wells. Except for the reservoir area, all of the reservoir parameters derived by Strobel from the interference test data were used. The results show that the Palm Valley reservoir contains between 262 and 356 billion standard cubic feet of gas-in-place in the fracture system and the higher permeability matrix rock. Based on our model and including gas in the tight matrix, it is quite possible that the total gas-in-place ranges between 726 billion standard cubic feet and 1.106 trillion standard cubic feet. (Edited author abstract) 3 refs.

Sabet, M. (Magellan Petroleum Australia Ltd); Franks, L. *APEA J* v 25 pt 1 1985, APEA Conf: Tech Pap, Perth, Aust, Mar 24-27 1985 p 329-343.

## Costs

**077909 DEVELOPMENT OF AN OFFSHORE GAS-CONDENSATE RESERVOIR BY NITROGEN INJECTION VS. PRESSURE DEPLETION.** A conceptual study is presented of the development of an offshore gas-condensate reservoir by nitrogen injection vs. pressure depletion. Nitrogen injection could enhance condensate recovery, but requires additional capital investments and is more costly to operate. The results of the study indicate that nitrogen injection is a realistic alternative for pressure depletion, provided that the reservoir is not too heterogeneous and the reservoir fluid is sufficiently rich in condensate. Under these conditions, nitrogen injection could be as profitable as conventional pressure depletion and in addition may double the condensate yield. The business risk for nitrogen injection is greater, however, and for this reason governments should consider granting special tax and/or royalty reliefs for enhanced condensate recovery schemes. (Author abstract) 11 refs.

Hagoort, Jacques (Hagoort & Associates); Brinkhorst, Jan W.; van der Kleyn, Piet H. *JPT J Pet Technol* v 40 n 4 Apr 1988 SPE 15873, p 463-469.

**Fluid Dynamics** See FLOW OF FLUIDS—Pipes.

**Mathematical Models** See ALSO FLOW OF FLUIDS—Porous Materials; OIL WELL LOGGING—Electric; OIL WELL LOGGING—Instruments; OIL WELL PRODUCTION—Gas Lift; OIL WELL PRODUCTION—In Situ Combustion; OIL WELLS—Fracturing; OIL WELLS—Mathematical Models.

**077910 PERMEABILITY DISTRIBUTIONS IN RESERVOIRS.** Determining permeability distributions in reservoirs from data measured at wells requires conceptual models of how the rock properties vary between wells. It is usually observed that arithmetic averages of foot-by-foot horizontal permeabilities measured parallel to the bedding planes in the cores agree with permeabilities calculated from well tests. This is logical because arithmetic averaging assumes that flow occurs through the various strata parallel to the bedding planes. In this conceptual model, a consistent assumption is that vertical permeabilities measured perpendicular to the bedding planes should be averaged harmonically (in series) to reflect flow in the vertical direction in a zone between two continuous shales. 2 refs.

Richardson, J.G. (Richardson, Sangree & Sneider); Sangree, J.B.; Sneider, R.M. *JPT J Pet Technol* v 39 n 10 Oct 1987 SPE 15785, p 1197-1199.



**077911 UNE APPROCHE ANALYTIQUE D'UN MODELE BLACK OIL DES ECOULEMENTS TRI-PHASES COMPRESSIBLES EN INGENIERIE PETROLIERE.** [Analytical Approach to a Black-Oil Model for Three-Phase Compressible Flows in Petroleum Engineering]. An analytical study is made of three-phase compressible isothermal flows in porous media, within the general framework of the secondary recovery processes of petroleum engineering, taking into account realistic boundary conditions. The pseudo-compositional black-oil model, which is studied, leads to a variational formulation of the problem: a strongly coupled system is obtained that includes an equation and an inequality which are degenerate quasi-linear parabolic expressions containing a nonlinear forced-convection term and a pressure equation which is locally elliptic or parabolic, depending on the evolution of the gas phase. The introduction of a unilateral problem arises from the nature of the governing equations describing the black-oil model, which depends locally on whether the gas-phase exists (saturated oil) or does not exist (sub-saturated oil), which leads to a free boundary value problem. To this problem, a time-discretized regularized problem is associated; it is proven that, within a functional precise framework, the latter is mathematically well-posed and has a physically admissible solution. (Edited author abstract) In French. 12 refs.

Gagneux, Gerard (CNRS, Pau, Fr); Lefevre, Anne-Marie; Madaune-Tort, Monique. *J Mec Theor Appl* v 6 n 4 1987 p 547-569.

**077912 CONCEPT OF RELATIVE GANGLION VELOCITY AND GENERALIZATION TO OIL-BANK MOVEMENTS IN POROUS MEDIA.** This paper discusses a simple computational technique for determining relative ganglion velocity in a pore and its implication to the formation and propagation of an oil bank. The approach is based on a simple theory of the movement of a discontinuous oil droplet (ganglion) through a model pore. The analysis, based on a simplified conical geometric model, permits the development of expressions for relative ganglion velocity (velocity of the oil ganglion relative to the bulk liquid velocity) under various flow conditions. This parameter is essential for modeling waterflooding and/or EOR processes and facilitates the prediction of oil-bank movements. Results of the calculations indicate that faster oil-bank movements are attained when interfacial tensions (IFT's) are low and pressure gradients are high. (Edited author abstract) 4 refs.

Egbogah, Emmanuel O. (Amerigo Int). *SPE Reservoir Eng* v 2 n 4 Nov 1987 SPE 14876, p 671-676.

**077913 TWO-POINT METHOD FOR DETERMINATION OF UNDISTURBED RESERVOIR TEMPERATURE.** The modeling of primary oil production and the design of EOR operations require knowledge of the undisturbed reservoir temperature. The drilling process, however, greatly alters the temperature of the reservoir immediately surrounding the well. In this paper, we present a method to determine the undisturbed reservoir temperature based on temperature measurements taken a short time after cessation of drilling. (Author abstract) 12 refs.

Kritikos, W.P. (Louisiana Tech Univ); Kutasov, I.M. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 15204, p 222-226.

**077914 NEW ANALYTIC MODEL FOR FRACTURE-DOMINATED RESERVOIRS.** A new analytic model for analyzing well test data from fracture-dominated reservoirs is presented. It is a concentric composite model with a finite-radius well located in the center. In the inner region the flow is assumed to be linear, and in the outer region the flow is assumed to be radial. Solutions are obtained analytically and type curves for ranges of dimensionless parameters are presented. The model can be used to find the extent and the flow parameters of the fractures near the well and the average values for the entire system provided that wellbore-storage effects do not mask the early-time data. (Author abstract) 18 refs.

Karasaki, Kenzi (Lawrence Berkeley Lab); Long, Jane

C.S.; Witherspoon, Paul A. *SPE Form Eval* v 3 n 1 Mar 1988 SPE 14171, p 242-250.

**077915 PREDICTION OF DIMENSIONLESS PRESSURE DURING PRODUCTION FROM A CIRCULAR RESERVOIR WITH GENERALIZED BOUNDARY CONDITIONS.** To the authors knowledge, no one has published the situation in petroleum reservoirs with mixed boundary conditions, although such situations may arise in reservoirs adjoining aquifers. In this study, a similar problem is solved with a generalized form of the boundary conditions. The problem is solved in Laplace transform space and inverted numerically using the Stehfest (1970) inversion technique. A computer program is given to implement the algorithm. With the program, solutions to situations already solved as well as the more general boundary value problem can be produced. The computer program will be useful to petroleum engineers, hydrologists, and engineers working in the area of heat transfer. 4 refs.

Onyekonwu, M.O. (Univ of Port Harcourt, Nigeria); Abiye, M. *Comput Geosci* v 14 n 2 1988 p 271-277.

## Models

**077916 RESERVOIR DESCRIPTION FROM SEISMIC LITHOLOGIC PARAMETER ESTIMATION.** Modern three-dimensional seismic data assist not only in delineating reservoir geometry, but also in predicting porosity and lithology variations away from well control. This case study of an oil-producing channel sand in the Taber/Turin area, Alberta, Canada, illustrates the improvement in reservoir characterization achieved with an integrated approach incorporating both well and seismic information. (Edited author abstract) 11 refs.

de Buyl, M. (Western Atlas Int); Guidish, T.; Bell, F. *JPT J Pet Technol* v 40 n 4 Apr 1988 SPE 15505, p 475-482.

Operations Research See PETROLEUM PIPELINES—Economics.

## Research

**077917 RADIAL FINGERING IN A WATER-WET POROUS MEDIUM.** Radial displacement of a non-wetting fluid (paraffin oil) by a wetting fluid (water) was studied in a consolidated porous medium for a wide range of flowrates. The effects of injection flowrate on the displacement pattern were observed photographically, and the volumetric oil recovery at the breakthrough condition was measured. The experimental results indicate that the recovery versus flowrate curve can be divided into three main regions: (1) a 'capillary region' at low flowrates where capillary forces are dominant; (2) a 'viscous region' at high flowrates where viscous forces are dominant; and (3) an intermediate 'stabilized region' where capillary and viscous forces are of comparable magnitude. The experimental data for the number of fingers are compared with theoretical predictions and the so-called wettability number is calculated. The results are finally compared with previous data for systems of reversed wettability and the differences, which are very significant, are discussed. (Author abstract) 26 refs.

Nasr-el-din, H. (Univ of Ottawa, Ottawa, Ont, Can); Hornof, V.; Neale, G. *Rev Inst Fr Pet* v 42 n 6 Nov-Dec 1987 p 783-796.

Simulation See OIL WELL PRODUCTION—Thermal.

## Thermodynamics

**077918 RESERVOIR-FLUID PHASE BEHAVIOR AND VOLUMETRIC PREDICTION WITH EQUATIONS OF STATE.** The use of several cubic equations of state in predicting vapor/liquid equilibria and volumetric behavior of reservoir-like and real reservoir fluids is discussed, and the difference between these equations is examined. It is shown that these equations can reliably predict phase behavior of complex reservoir crude and gas-condensate systems away from the critical and retrograde regions. The cubic equations examined predict

nearly the same K values. The volumetric prediction, however, is different from one equation to another. (Edited author abstract) 35 refs.

Firoozabadi, Abbas (Norsk/Hydro A/S). *JPT J Pet Technol* v 40 n 4 Apr 1988 SPE 17653, p 397-406.

## PETROLEUM TRANSPORTATION

**077919 SOME CAUSES OF ERROR IN MEASUREMENT AND ACCOUNTING.** Apart from physical losses resulting from leakage, evaporation or fraud, 'losses' (and 'gains') can arise from mismeasurement. Bulk oil measurements cannot be precise and in all custody transfers one party will gain and the other will lose. When a bulk oil quantity is measured twice, differences will be disclosed which represent the net effect of many variations from the absolute. Differences of a minor nature are acceptable but abnormal discrepancies should be investigated.

Browne, Desmond (Inst of Petroleum Panels PM-C-3 and PM-L-1). *Pet Rev* v 41 n 488 Sep 1987 p 44-47.

**077920 LOSSES IN THE SHIPMENT OF CRUDE OIL: RECENT DEVELOPMENTS IN ANALYSIS AND QUANTIFICATION.** The underlying problem in the reconciliation of oil measurements for the purpose of loss control is the identification and quantification of real losses as opposed to apparent losses due to measurement error. An overall material balance provides a useful framework for analysis. The results of a pilot study of oil loss statistics derived from conventional voyage files for liftings of Middle East crude parcels during 1984/86 are presented. The factors which govern evaporative loss are discussed. The magnitude of crude evaporative losses during loaded passage is considered. There are grounds to suggest that evaporative losses of light ends during COW can produce a net penalty in NSV outturn. (Edited author abstract) 14 refs.

Tom, David (CWA Consultants Ltd); Vince, Ivan. *Q J Tech Pap Inst Pet* Jul-Sep 1987 p 51-57.

**077921 SOME CAUSES OF ERROR IN MEASUREMENT AND ACCOUNTING.** Apart from physical losses resulting from leakage, evaporation or fraud, 'losses' (and 'gains') can arise from mismeasurement. Bulk oil measurements cannot be precise and in all custody transfers one party will gain and the other will lose. When a bulk oil quantity is measured twice, differences will be disclosed which represent the net effect of many variations from the absolute. Differences of a minor nature are acceptable but abnormal discrepancies should be investigated.

Browne, Desmond (Inst of Petroleum, Engl). *Q J Tech Pap Inst Pet* Jul-Sep 1987 p 59-62.

**077922 PREVIEW OF CARGO MEASUREMENT AND INSPECTION GUIDELINES.** A preview of the Institute of Petroleum Cargo Measurement by Cargo Surveyors, Part I Crude Oil is given by explaining the background and derivation of the work. A description of the committee (PM-L-3), its methods of working, and the format of the document is given along with a brief discussion on related items from the procedures. A brief mention is made of further procedures applicable to Products currently under production by the same committee. (Edited author abstract)

Cowin, R.D. (Esso Petroleum Co). *Q J Tech Pap Inst Pet* Oct-Dec 1987 p 63-65.

## Operations Research

**077923 EFFECTIVE METHODS FOR PETROLEUM TANK TRUCK DISPATCHING.** Two methods are described for dispatching and sequencing petroleum tank trucks used in the pickup and delivery of crude oil. The problem is similar to the multi-terminal vehicle dispatch problem except that each pickup at a well site must be followed by a delivery to an acceptable collection terminal. A greedy-type algorithm is developed which is



efficient for real-time dispatching. A subproblem optimization approach is also presented and computational results on test problems are reported. Lower bound calculations indicate that solution quality is often within 10 percent of optimality. (Author abstract). 14 refs.

Russell, Robert A. (Univ of Tulsa, Tulsa, OK, USA); Challinor, Paul E. *Comput Oper Res* v 15 n 4 1988 p 323-331.

## Reliability

**077924 ASSESSMENT OF TRANSPORT REGULARITY.** ASTRA (Assessment of Transport Regularity) provides an effective tool for evaluating the regularity of systems for transporting offshore oil and gas. This interactive computer program has been specially designed to support the early development phases of a project. It is well suited for comparing alternative transport solutions and finding the optimal answer in terms of system regularity. Among other features, it offers an easy method for performing sensitivity studies. (Author abstract) 3 refs.

Haugen, S. (SikteC A/S, Trondheim, Norw); Vinnem, J.E. *Reliab Eng* v 19 n 4 1987 p 277-286.

**PETROLOGY** See Also COAL—Petrography; COPPER DEPOSITS—British Columbia; COPPER DEPOSITS—Nevada; GEOCHEMISTRY—Analytical; GEOLOGY—Coal; ROCK—Crystallization; ROCK—Sampling.

**077925 SAPPHIRE-BEARING ULTRAMAFIC LAMPROPHYRE FROM YOGO, MONTANA: A OUCHITITE.** The Yogo lamprophyre dyke, central Montana, is the only known igneous rock from which sapphire is mined. The rock consists of subhedral grains of phlogopite and clinopyroxene set in a finer groundmass of mica, clinopyroxene, titaniferous magnetite and apatite within a mesostasis of chlorite, calcite, serpentine and rare K-feldspar. Pyroxene also occurs as polycrystalline aggregates. Phlogopite occurs as euhedral crystals that have been distorted during emplacement and subsequently deformed and altered. Sapphirite occurs as an accessory phase and is thought to be xenocrystic. Based on chemical and mineralogical evidence the Yogo lamprophyre is classified as a ouachitite. (Edited author abstract) 33 refs.

Meyer, Henry O.A. (Purdue Univ, West Lafayette, IN, USA); Mitchell, Roger H. *Can Mineral* v 26 pt 1 Mar 1988 p 81-88.

**Computer Applications** See ROCK—Phase Diagrams.

## Measurements

**077926 IN SITU MEASUREMENT OF ELECTROMAGNETIC PROPERTIES OF WELDED TUFF UNDER COMPRESSION.** The high-frequency electromagnetic permittivity and attenuation rate were measured in situ a block of densely welded ash-flow tuff compressed uniaxially. For stress changes up to 800 psi, the electromagnetic properties were found to be independent of stress, except where the water content of fractures may have been controlled by aperture changes induced by the compressional loading. 8 refs.

Daily, William D. (Lawrence Livermore Natl Lab, Livermore, CA, USA); Ramirez, Abelardo L. *IEEE Trans Geosci Remote Sens* v GE-25 n 6 Nov 1987, 1986 Int Geosci and Remote Sens Symp (IGARSS'86) - Remote Sens - Today's Solutions for Tomorrow's Inf Needs, Zurich, Switz, Sep 8-11 1986 p 859-861.

## Mixing

**077927 HYPERFUNC BASIC PROGRAM TO CALCULATE HYPERBOLIC MAGMA-MIXING CURVES FOR GEOCHEMICAL DATA.** Magma-modifying process is super-imposed on a mixed system and one element is plotted against another on a Cartesian diagram. A straightline joining the two end-member compositions results. Mixed rocks, representing different amounts of the two end-member compositions, plot in the same order on a petrochemical diagram, regardless of the element se-

lected. However, in ratio-element or ratio-ratio plots, mixing lines of a 'two rock system' related by a mixing process are represented by hyperbolic curves. A computer program has been designed to fit hyperbolic mixing curves to geochemical data using the equations developed by Langmuir and others. A hardcopy of the graphs that appear on the video display unit (VDU) can be printed. An example of input and output is presented. 7 refs.

Woussen, Gerard (Univ du Quebec a Chicoutimi, Chicoutimi, Que, Can); Cote, Denis. *Comput Geosci* v 13 n 4 1987 p 421-431.

## Peoples Republic of China

**077928 K-AR AGE AND STRONTIUM ISOTOPIC COMPOSITION OF THE TENGCHONG VOLCANIC ROCKS, WEST YUNNAN PROVINCE, CHINA.** Dating of 47 samples of the Tengchong volcanic rocks gave K-Ar ages ranging between 0.09 and 17.84 My. The  $^{40}\text{Ar}/^{36}\text{Ar}$  vs  $^{40}\text{K}/^{36}\text{Ar}$  plot was made on the basis of those data in which radiogenic  $^{40}\text{Ar}$  is more than 2%. Four isochrones at 2.93, 0.81, 0.31 and 0.13 My were then obtained. The eruption time was from the Miocene to Pleistocene, with the climax occurring in the Late Pleistocene. The K-Ar ages were determined by statistical analysis and the probability of eruptions indicates that the Tengchong volcanoes are not to be considered extinguished but dormant volcanoes. Rb and Sr contents and the strontium isotopic compositions were determined on 20 samples of Tengchong volcanic rocks. The initial  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios range from 0.70578 to 0.71437. It would appear that the 'parent magma' is of deep origin ( $^{87}\text{Sr}/^{86}\text{Sr}$  near 0.706) and that it underwent a progressive contamination by crustal material rich in radiogenic  $^{87}\text{Sr}$ . (Author abstract) 36 refs.

Mu, Zhiguo (Peking Univ, Beijing, China); Curtis, G.H.; Liao, Zhijie; Tong, Wei. *Geothermics* v 16 n 3 1987 p 283-297.

**Petrography** See COAL—Structure; COAL DEPOSITS—India; COKE—Microstructure; GEOCHEMISTRY—Organic Compounds; OIL FIELDS—Reservoir Evaluation; OIL SHALE—Classification; PETROLEUM GEOLOGY—North Slope, Alaska; PETROLEUM GEOLOGY—Stratigraphy; PETROLEUM GEOLOGY—Texas; QUARTZ—Analysis; RAILROAD PLANT AND STRUCTURES—Track; ROCK—Strain; SAND, FOUNDRY—Binders.

**Sedimentology** See Also GEOLOGY—Coal; GEOLOGY—Stratigraphy; PETROLEUM GEOLOGY; PHOSPHATE DEPOSITS—Peru; ROCK—Deformation.

**077929 IRON-PHOSPHATE LAYERS IN SEDIMENTS OF LAKE ONTARIO.** Moessbauer spectral and chemical fractionation studies of four sediment cores retrieved from the Niagara Basin of Lake Ontario reveal layers enriched in  $\text{Fe}^{3+}$  ion and in non-apatite inorganic phosphorus (NAIP). At least two layers are not as visually or compositionally prominent as the (primary) red layer present in cores from an adjacent 200 km<sup>2</sup> area. The red layer and the secondary layers are of similar origin. Most of the precipitated phosphorus is retained within the layers over more than 150 years. A core from the Central Basin of Lake Erie shows no evidence of layering. (Edited author abstract) 26 refs.

Manning, Philip G. (Natl Water Research Inst, Burlington, Ont, Can); Mayer, Tatiana. *Can Mineral* v 25 pt 4 Dec 1987 p 603-610.

**PHASE LOCKED LOOPS** See Also ELECTRIC MEASUREMENTS—Frequency; ELECTRIC MOTORS—Speed Control; FREQUENCY SYNTHESIZERS; FREQUENCY SYNTHESIZERS—Noise, Spurious Signal; LASERS, SEMICONDUCTOR—Modes; SIGNAL DISTORTION.

**077930 LAGRANGE-LIKE STABILITY OF LOCAL CYCLES TO A CERTAIN FORCED PHASE-LOCKED LOOP DESCRIBED BY THE THIRD-ORDER DIFFERENTIAL EQUATION.** A periodically perturbed PLL system described by the third-order differential equation is considered. Sufficient conditions for the existence of local cycles and their Lagrange-like

stability are satisfied. (Author abstract) 5 refs.

Andres, J.; Strung, M. *Rev Roum Sci Tech Ser Electrotech Energ* v 32 n 2 Apr-Jun 1987 p 219-223.

**077931 PLL PERFORMANCE IN THE PRESENCE OF PHASE-SUM TERM.** Unlike classical PLL models, the effects of the phase-sum term due to the phase-detector are investigated. Since no universal analytical solution to this non-linear problem is known, a numerical evaluation was made assuming a perfect proportional-plus-integral loop filter. It was determined that pull-in time and pull-in range are altered by the phase-sum term. The pull-in range becomes unsymmetrical and one-sided finite. In the synchronized state the phase-sum term introduces a periodic phase and frequency jitter. With changes in system parameters, this jitter amplitude may grow until chaotic oscillations and no synchronization occur. For all stable conditions the pull-out range remains near its classical value. (Author abstract) 10 refs.

Durcansky, George (KFA, Juelich, West Ger); Janssen, Franz. *Frequenz* v 41 n 10 Oct 1987 p 261-266.

**077932 EXACT DESCRIPTION OF PLLs WITH EDGE-TRIGGERED PHASE DETECTORS.** The behavior of analog PLLs with edge-triggered phase detector, active proportional-plus-integral loop filter and frequency divider is unsatisfactorily described by the known theory, especially if the period of the input signal tends towards the time constant of the filter. The new model derived via a digital analysis describes exactly the time- and frequency response of the system under consideration. A proposed adjustment of loop gain which is easily performed in practice yields a linear demodulation behavior of the loop. The theoretical results are experimentally verified. (Author abstract) 7 refs.

Hauke, Winfrid (Univ Erlangen-Nuernberg, Erlangen, West Ger); Saalfrank, Werner. *AEU Arch Elektron Uebertrag Electron Commun* v 41 n 5 Sep-Oct 1987 p 273-280.

**077933 DIE STATISCHEN UND DYNAMISCHEN PHASENFÄHLEN EINES PHASE-LOCKED LOOP.** [Static and Dynamic Phase Errors of a Phase-Locked Loop]. The system behavior of the linear model of a PLL with proportional-integral regulator is described in relation to the asymptotic bandwidth, with the damping factor as parameter; therefore the eigenfrequency has to be eliminated. There are resulting diagrams, in which the bandwidth and the control time constant become visible. (Author abstract). 6 Refs. In German.

Birth, Winfrid. *Frequenz* v 42 n 6-7 Jun-Jul 1988 p 200-203.

## Analysis

**077934 DIGITAL PLL LOCK-DETECTION CIRCUIT.** A digital lock detection circuit is described which can be used in combination with all known sequential phase detectors. The principle of operation is based on the detection of cycle slips, which is one of the possible unlock definitions of a PLL. Therefore definitions of phaselock are reviewed. The proposed circuit acts also in combination with the built-in phase detectors of a widely used PLL integrated circuit as a reliable lock detector. (Edited author abstract). 10 Refs.

Den Dulk, R.C. (Delft Univ of Technology, Delft, Neth). *Electron Lett* v 24 n 14 Jul 7 1988 p 880-882.

## Computer Interfaces

**077935 EFFICIENT SOFTWARE-CONTROLLED PLL FOR LOW-FREQUENCY APPLICATIONS.** The concept of a software-controlled phase-locked loop (SCPLL) is presented. It is shown that SCPLLs can offer several advantages over pure hardware implementations. An example design of a SCPLL for a power converter controller is presented, and the experimental results are reported. This SCPLL can efficiently substitute for the conventional hardware PLL used for timing and clock frequency multiplication in the control circuit of a power



converter. 10 refs.

El-Amawy, Ahmed A. (Louisiana State Univ, Baton Rouge, LA, USA); Mirbod, Ali. *IEEE Trans Ind Electron* v 35 n 2 May 1988 p 341-344.

**Computer Simulation** See Also ELECTRONICS ENGINEERING—Computer Aided Engineering.

**077936 MODELING AND SIMULATION OF AN ANALOG CHARGE-PUMP PHASE LOCKED LOOP.** We describe a nonlinear computer simulation model of an Analog Charge-Pump Phase Locked Loop (ACP-PLL). Offsets of the Phase Detector and Analog Charge-Pump are modeled as disturbances to simulate their effects on the steady-state phase error of the loop. An extensive computer simulation study is carried out for the design of an example Analog CP-PLL using the proposed nonlinear model and comparing it to the conventional linear model. Results demonstrate the linear model is not sufficient to fully analyze and predict the behaviour of the Analog CP-PLL. (Author abstract) 5 refs.

Can, Sumer (Signetics Corp, Sunnyvale, CA, USA); Sahinkaya, Yilmaz E. *Simulation* v 50 n 4 Apr 1988 p 155-160.

**Fabrication** See SEMICONDUCTOR DEVICES, BIPO-LAR—Applications.

**Mathematical Models** See Also ELECTRONIC CIRCUITS—Computer Simulation.

**077937 OPERATING MODES AND PULL-IN RANGE OF A PHASE-LOCK SYSTEM WITH AN AUTOMATIC GAIN CONTROL (AGC) CIRCUIT.** The locking properties of a model of a phase-lock system provided with an automatic gain control circuit and an additional coupling in the control circuits are investigated. Operating modes of the system are established, the pull-in and unique locking ranges are estimated, and the effect of inertia and additional control on the operating modes and stability of the system is analyzed. (Author abstract) 11 refs.

Ponomarenko, V.P. *Sov J Commun Technol Electron* v 32 n 2 Feb 1987 p 87-94.

## Noise, Spurious Signal

**077938 INTEGRAL MEASURE OF THE PHASE NOISE POWER IN PHASE LOCKED LOOPS.** An integral measure of the difference between the actual value and the minimum value of the phase noise power spectral density of the PLL (phase locked loop) output signal has been defined. The measure is linked with the power of the output signal phase noise. The effect of second-order PLL parameters on the value of this measure at fixed noise power spectral densities of reference signal and VCO generators is determined. (Author abstract) In German. 3 refs.

Artuch, Roman (Technical Univ of Wroclaw, Wroclaw, Pol). *AEU Arch Elektron Uebertrag Electron Commun* v 41 n 5 Sep-Oct 1987 p 289-293.

## Performance

**077939 SINGLE-CHIP INTERFACE EASES DATA SEPARATOR DESIGN IN HARD-DISK CONTROL CIRCUITS.** A jitter-rejection algorithm, added to a digital phase-locked loop, helps a CMOS chip supply the required ST506 functions in the data separator while saving design effort and board space. Since the device is fabricated in CMOS, it consumes a mere 50 mw from a single 5-V supply.

Collins, Karen N. (NEC Electronics Inc, Natick, MA, USA). *Electron Des* v 34 n 5 Mar 6 1986 p 145-148.

**077940 PHASE-LOCKED LOOPS.** This volume contains 30 selected reprints dealing with various aspects of Phase Locked Loops (PLL). Various applications, performance measures and analyses, general principles, network synchronization, automatic frequency control, digital

PLL's and other aspects are considered. A few new tutorial papers and some analytical results are also presented. Refs.

Lindsey, William C. (Ed.) (Univ of Southern California, CA, USA); Chie, Chak M. (Ed.). *Phase-Locked Loops* Publ by IEEE Press, New York, NY USA, 1986 343p.

## Sampling

**077941 PERFORMANCE IMPROVEMENT OF DPPLL'S IN NON-GAUSSIAN NOISE USING ROBUST ESTIMATORS.** Digital phase-locked loops (DPPLLs) operating in the presence of non-Gaussian noise are analyzed. The loop model developed here allows for multiple input samples during each loop sampling period, complex processing of the input sample set, and various noise distributions. In particular, six different robust estimators are used as processors of the input: there are the trimmed mean estimator, a one-step Huber M-type estimator, a novel M-type estimator, and three versions of a zero-memory nonlinear (ZNL) estimator. The tracking performance of a second-order DPPLL is simulated and analyzed for five different types of noise. Comparisons are made for signal-to-noise ratios ranging from 0 to -10 dB. It is found that the ZNL estimators provide performance superior to that of the other robust estimators, especially for noise densities that are heavy tailed. 25 refs.

McCain, W. Bruce (Harris Corp, Melbourne, FL, USA); McGillem, Clare D. *IEEE Trans Commun* v COM-35 n 11 Nov 1987 p 1207-1216.

## Stability

**077942 THIRD-ORDER DIGITAL PHASE-LOCKED LOOP WITH IMPROVED STABILITY.** When a signal from a moving source is received by a phase-locked loop (PLL), the input-signal frequency of the PLL often changes in a ramp-function state with a constant-frequency offset. The conventional perfect-integration third-order PLL has a serious problem of being unstable for small-amplitude inputs, and thus it cannot be used in practice in a low SNR environment. This paper proposes three types of stable perfect third-order digital PLL's (M-DPLL) which are independent of the input-signal amplitude. This M-DPLL realizes the perfect third-order behavior by combining three first-order DPLLs using a digital signal processing technique. The excellent characteristics of this M-DPLL are confirmed by theoretical analysis and computer simulation. (Edited author abstract) 17 refs.

Yamasaki, Shoichiro (Keio Univ, Yokohama, Jpn); Nakagawa, Masao. *Electron Commun Jpn Part 2* v 70 n 8 Aug 1987 p 1-11.

## Theory

**077943 FALSE LOCK AND BIFURCATION IN THE PHASE LOCKED LOOP.** New results are given on the phenomenon of false lock in phase locked loops (PLL). First, it is proved that for small values of closed loop gain  $\delta$ , there is only one function  $\omega_f(\delta)$  which represents the frequency error in a false locked Type I PLL. That is, there is only one false lock equilibrium point for  $\delta$  in a neighborhood of the origin. Furthermore, this equilibrium point is stable. The proof establishes that bifurcation of periodic solutions does not occur at  $\delta = 0$  in the nonlinear differential equation which describes the classical Type I PLL. Next, a perturbation-based method for analyzing false lock in Type I PLLs is given. The technique expresses  $\omega_f(\delta)$  and the periodic solution of the equation describing the false locked loop as power series in  $\delta$ . The algorithm is applied to the classical second order loop containing an imperfect integrator. (Edited author abstract) 10 refs.

Stensby, John (Univ of Alabama, Huntsville, AL, USA). *SIAM J Appl Math* v 47 n 6 Dec 1987 p 1177-1184.

**PHASE METERS** See Also ELECTRIC MEASUREMENTS—Phase; INTERFEROMETERS—Digital Devices.

**077944 LOW-FREQUENCY ERROR OF MULTI-CHANNEL DIGITAL PHASEMETER DUTY FACTOR.** The authors analyze the low-frequency errors (LFEs) of both single channel and multichannel multiphase digital duty-factor meters (DDFM's) in order to check the efficacy of using multichannel converters; to determine the lag between channel triggering; and also to prove the advantage of DDFM synchronization. Discussed are the optimal design of multichannel meters, the periodicity of the meters, and the standard deviations of the error in measurements. 7 refs.

Goroshkova, T.V.; Malitskii, V.V.; Pokhilyuk, A.P.; Trotsishin, I.V.; Shevaldin, B.M. *Meas Tech* v 30 n 1 Jan 1987 p 75-79.

## Analysis

**077945 DYNAMIC MULTICYCLE PHASE SHIFT MEASUREMENTS.** One problem of modern phasometry is the measurement of fast varying phase shifts in the presence of known and random impediments. At present the following methods are used for the measurement of the phase shift: method of separation of time intervals, based on fixing the moments of transition through zero; method of overlap, executing the logical function exclusive OR; compensation method realized with analog as well as numerical balancing; correlation method; and method of orthogonal processing of signals. It is argued that the method of separation of time intervals is the most suitable for dynamical multicycle measurements of the phase shift. This latter method is analyzed. 9 refs.

Gupalov, V.I. *Meas Tech* v 30 n 4 Apr 1987 p 375-379.

**Applications** See Also MAGNETIC MEASUREMENTS.

**077946 DYNAMIC PHASE METER FOR PROGRAM MATERIAL.** A method is described for a metering device that is capable of measuring the phase angle relationship of two audio program channels. A treatment of alternate techniques is given. Mathematical analysis shows how dynamic measurement can be performed. In addition, a circuit is realized and described that incorporates these techniques and allows for an indication of phase differences over an 80-dB range. Error sources of the meter are identified. (Author abstract).

Monforte, John (Univ of Miami, Coral Gables, FL, USA). *J Audio Eng Soc* v 36 n 6 Jun 1988 p 481-486.

## Calibration

**077947 PHASE METER CALIBRATION AT NBS.** To provide a phase meter calibration service, a phase angle calibration standard has been developed at NBS. This standard is a signal generator with two sinusoidal outputs and uses direct digital synthesis to generate the signals. The phase angle between the two sinusoids is determined by the input parameters in the calculation of the sets of digital values from which the analog output is synthesized. An auto-zero compensation mode corrects for residual phase differences in the two output channels. The phase resolution is better than 0.002° over a frequency range from 2 Hz to 5 kHz and 0.005° from 5 to 50 kHz. 10 refs.

Turgel, Raymond S. (NBS, Gaithersburg, MD, USA). *J Res Natl Bur Stand (US)* v 93 n 1 Jan-Feb 1988 p 53-60.

**077948 PRECISION CALIBRATION OF PHASE METERS.** Using the calibration of a phase meter with a nominally linear response as an example, a statistical approach is discussed for predicting worse-case offsets of the meter response characteristic from the value of the reference standard. A linear calibration curve is used to model the meter response, and statistical tests are described which test the appropriateness of the model and whether the calculated calibration curve differs significantly from the ideal. Various levels of corrections to be



applied can then be determined on the basis of these tests, and limits to offsets are calculated for each of the levels. By extending this approach, it is possible to predict limits of uncertainty when using the calibrated meter to make measurements. 6 refs.

Turgel, Raymond S. (NBS, Gaithersburg, MD, USA); Vecchia, Dominic F. *IEEE Trans Instrum Meas* v IM-36 n 4 Dec 1987, IMTC/1987: The Fourth IEEE Instrum and Meas Technol Conf, Boston, MA, USA, Apr 27-29 1987 p 918-922.

## Circuits

**077949 MICROWAVE PULSE PHASE METER.** A method is discussed for measurement of phase difference by means of phase detectors whose amplitude-phase characteristics are shifted by  $60^\circ$  relative to one another and form a measurement range of  $0-360^\circ$  with linear regions. Possible circuits that employ the method are analyzed. A digital microwave phase meter is described that was developed using one of the circuits to measure the phase difference of pulse signals. The nonlinearity of the digital readings of the phase meter at a frequency of 2795 MHz in the range of  $0-360^\circ$  is not over  $\pm 4^\circ$ . The analysis time is 2  $\mu$ sec. The minimum input-signal power is approximately 0.5 mw. (Author abstract) 8 refs.

Prosin, B.V. (Inst of High Energy Physics, Serpukhov, USSR); Chernyi, S.A. *Instrum Exp Tech* v 30 n 4 pt 2 Jul-Aug 1987 p 895-898.

## Digital Readout

**077950 HIGH-FREQUENCY SAMPLING ERROR OF AVERAGING DIGITAL PHASE METERS.** The high-frequency sampling error (HSE) of averaging digital phase meters (ADPM) based on phase shift-to-time interval-to-digital signal conversion for more than one input frequency period is due to the sampling error of a single phase time interval which builds up in the course of measurement. The HSE has a random nature since it depends on the random position of a single phase interval in relation to sampling pulses filling it and also on the input signal frequency  $F$ , sampling frequency  $F_0$ , and measurement time  $T_m$ . Difficulties with existing methods are pointed out and improvements are suggested. 3 refs.

Dolganov, M.V. *Meas Tech* v 30 n 4 Apr 1987 p 379-382.

**077951 UTILIZATION OF AN APPROXIMATION ALGORITHM IN A DIGITAL PHASEMETER.** The measurement of phase differences for narrowband processes that have amplitude and frequency modulation of complex form in a noise background cannot, as a rule, be executed by ordinary phase-measuring instruments. Obtaining estimates of the phase differences for the processes under consideration requires the creation of digital phase measuring systems and the development of appropriate algorithms. Elsewhere it was proposed to use an algorithm of discretely orthogonal processing of input processes to obtain estimates of the phase difference. This approach, undoubtedly effective, is proposed in this paper, to supplement the introduction of a subsearch in the frequency in order to expand the functional possibilities of the device. One of the variants of algorithms to estimate the phase difference using orthogonal processing can be based on solving problems of approximating the measured narrowband oscillatory process in a definite time interval by a model sinusoidal function. 4 refs.

Genkin, M.D.; Getmanov, V.G. *Meas Tech* v 30 n 9 Sep 1987 p 900-902.

**077952 NOVEL DIGITAL PHASE METER.** A simple digital phase meter using the dual-slope principle is described. It gives a digital output number independent of the input frequency or the clock frequency used for the measurement process. The meter performs its measurement within two cycles of the input wave. 3 refs.

Ibrahim, Khalid M. (Univ of Baghdad, Iraq); Abdul-Karim, Majid A.H. *IEEE Trans Instrum Meas* v IM-36 n 3 Sep 1987 p 711-716.

**077953 HIGH-PERFORMANCE DIGITAL PHASE COMPARATOR.** A digital phase comparator has been developed that is especially well suited to making precision phase measurements at high frequency. The circuit consists of two standard phase comparators that are interconnected so that their outputs are averaged to give the desired phase measurement. A clipping circuit consisting of back-to-back Schottky diodes is used to square up the output pulses, which improves the linearity. A variable-modulus digital prescaler is used to change the range from  $\pm 1$  fringe to  $\pm 32$  fringes. Instruments using this circuitry are being used to measure transient phase signals from a microwave interferometer that measures the plasma line density on the magnetic-fusion tandem mirror experiment. The resolution is less than 0.1 degree at a carrier frequency of 40 MHz with a maximum nonlinearity of 0.5%. 3 refs.

Coffield, Frederick E. (Lawrence Livermore Natl Lab, Livermore, CA, USA). *IEEE Trans Instrum Meas* v IM-36 n 3 Sep 1987 p 717-720.

**077954 NOISE-RESISTANT DIGITAL PHASE METER DESIGN.** A noise-resistant wide-bandwidth digital phase meter is described. The device is based on the phase compensation principle. A digitally controlled phase shifter, described in detail, is the main part of the circuit. The instrument readings are correct even for -6-dB signal-to-noise ratios. 10 refs.

Siuzdak, Jerzy (Warsaw Polytechnic, Pol). *IEEE Trans Instrum Meas* v IM-36 n 3 Sep 1987 p 841-842.

Errors See MEASUREMENTS—Standards.

## Performance

**077955 ANALOG SELF-EXCITED PHASE-FREQUENCY CONVERTER.** In the course of development for information-measuring systems considerable attention is given to methods of forming measuring signals in which phase shift is an information parameter. Information concerning the physical quantities being measured in this case is obtained with phase meters. The accuracy of this kind of digital phase meters is affected substantially by the higher harmonic components of input signals and by the unavoidable attending additive noise. The degree of this influence has, in general, a complicated character and cannot be essentially reduced without changing the nature of the phase-shift conversion to a digital signal. The experimental results show that analog phase frequency converters increase the resolution of phase meters. 5 refs.

Kolesnik, E.S.; Skul'skii, K.V. *Meas Tech* v 30 n 2 Feb 1987 p 186-190.

**PHASE MODULATION** See Also ANTENNAS—Mathematical Models; DEMODULATION—Optimization; DIGITAL COMMUNICATION SYSTEMS; DIGITAL DEVICES; LIGHT—Modulators; OPTICAL FIBERS—Measurements; SEMICONDUCTING GALLIUM COMPOUNDS—Electric Properties; SIGNAL DETECTION—Performance; SIGNAL PROCESSING—Signal Encoding; SPEECH—Coding; TELEVISION SYSTEMS, CABLE—Security Systems; WAVEGUIDES, OPTICAL—Modulation; WAVEGUIDES, OPTICAL—Performance.

**077956 LOW COMPLEXITY ALGORITHM FOR THE DEMODULATION OF CONTINUOUS PHASE MODULATIONS.** Continuous phase digital modulations often present good spectral properties and low error probabilities. However, these modulation techniques require complex detection algorithms. In this paper, a detector algorithm with reduced complexity with respect to an optimum maximum likelihood detector is described. The complexity reduction is achieved by associating an additional information, called the reliability information, with each received symbol. A net reduction in the demodulation complexity can be obtained by using this algorithm. The performance of this algorithm is evaluated in the case of a correlative encoded FM scheme. (Author abstract) 16 refs.

Benelli, Giuliano (Univ degli Studi di Firenze, Florence, Italy); Fantacci, Romano; Procopio, Dorico. *Alta Freq* v 56 n 6 Aug 1987 p 265-271.

## Analysis

**077957 CONVOLUTIONAL CODED CONTINUOUS PHASE MODULATION WITH PLURAL MODULATION INDICES.** The convolutional coding combined with continuous phase modulation (CPM) is known for its good tradeoff between coding gain and bandwidth. The multi-h modulation, i.e., the scheme in which plural modulation indices are in cyclical use, is introduced to obtain higher power efficiency. However the study of the combination of convolutional coding multi-h scheme has not been reported yet. In this study, we consider the combination of convolutional coded CPM with multi-h modulation to achieve larger Euclidean distance. We found that, in some cases, our proposed convolutional coded multi-h CPM can give considerable gains compared with those of conventional single-h scheme. (Edited author abstract) 6 refs.

Honda, Teruhiko (Keio Univ, Yokohama, Jpn); Sasase, Iwao; Mori, Shinsaku. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 12 Dec 1987 p 1214-1219.

Applications See RADIO SYSTEMS, MOBILE; RADIO SYSTEMS, MOBILE—Cellular Technology.

## Equipment

**077958 MODULATOR PACKS MULTIPLE FUNCTIONS IN COMPACT CASING.** Packaging density drives most EW designs, especially those earmarked for airborne applications. Component and subsystem suppliers continually strive to achieve the greatest number of electrical functions in the smallest size. Many could take lessons from General Electric Co.'s Aerospace Electronic Systems Dept., whose A12/A13 LO synthesizer (LOS) phase modulator represents a textbook on how to integrate components. The A12/A13 LOS phase modulator contains a 5-b phase modulator, several stages of GaAs FET amplification, and numerous bandpass filters, powered by onboard voltage regulators.

Browne, Jack (Microwaves & RF, Hasbrouck, NJ, USA). *Microwaves RF* v 26 n 10 Oct 1987 p 151-152, 154-155, 157.

Mathematical Models See Also AUDIO ACOUSTICS—Synthesis.

**077959 CONVERSION OF PHASE MODULATION TO AMPLITUDE MODULATION USING A PHASE CONJUGATE MIRROR.** We predict that conversion of phase modulated light to amplitude modulated light takes place when two continuous monochromatic pumps and a phase modulated probe are mixed in a Kerr medium used as a phase conjugate mirror. The phase conjugate beam can be reshaped as a train of pulses when the probe phase is periodically modulated. Discontinuous phase jumps of the probe field are converted into dips in the temporal profile of the reflected beam. (Author abstract) 13 refs.

Piche, Michel (Univ Laval, Quebec, Que, Can); Pare, Claude; Belanger, Pierre-Andre. *Opt Commun* v 65 n 2 Jan 15 1988 p 146-150.

Optimization See AMPLITUDE MODULATION—Performance.

## Performance

**077960 PHASE MODULATOR WITH IMPROVED MODULATION-CHARACTERISTIC LINEARITY.** Rigorous requirements apply to phase modulators from the viewpoint of sensitivity, modulation-characteristic linearity, and level of stray amplitude modulation. These circuits are varicaps as control elements, so that they have a modulation characteristic that has but negligible slope and linearity of the modulation characteristic, and the stray amplitude modulation is also fairly high. We give a theoretical analysis of a phase modulator with unipolar transistor used as a control element that meets given requirements. 9 refs.

Nekrasov, I.S. *Radioelectron Commun Syst* v 30 n 9 1987



p 50-53.

**077961 METHOD FOR LINEARIZATION OF THE MODULATION CHARACTERISTIC OF AN ACOUSTO-OPTIC PHASE MODULATOR.** The AOPM described makes it possible to form radio signals with angle modulation over a wide range of variation in carrier frequency (tens-hundreds of megahertz) with a relatively broad spectrum of the order of 40-50%, determined basically by the frequency characteristics of the AOM used. The comparative simplicity of linearizing the modulation characteristic in a range of phase variation capable of substantially exceeding the most common interval of  $\pm 180^\circ$  used in conventional phase modulators makes the acousto-optic method of phase modulation considered promising for indirect production of frequency modulation. 2 refs.

Egorov, Yu.V.; Ushakov, V.N. *Radioelectron Commun Syst* v 30 n 9 1987 p 57-59.

**077962 OPTICAL WAVEGUIDE PHASE MODULATOR IN GaInAsP USING DEPLETION EDGE TRANSLATION.** Under reverse bias a phase shift per unit length of up to 500°/mm is observed in a GaInAsP-InP inverted rib waveguide embedded in a double-heterostructure pin diode. The waveguides were fabricated by wet chemical etching and subsequent liquid phase epitaxy. Diodes were formed by selective Zn diffusion in the InP cladding layer. The planar structure is favourable for integration with other electronic or optoelectronic devices. (Author abstract) 8 refs.

Maehns, J. (Technische Univ Braunschweig, Braunschweig, West Ger); Kowalsky, W.; Ebeling, K.J. *Electron Lett* v 24 n 9 Apr 28 1988 p 518-519.

**077963 ERROR PROBABILITY FOR A DISCRIMINATOR DETECTOR WITH DECISION FEEDBACK FOR CONTINUOUS PHASE MODULATION.** A discriminator detector using decision feedback for continuous phase modulation (CPM) is proposed. Different thresholds are employed in the hard decision device owing to the memory in the CPM signal. This leads to an improved performance, especially for high signal/noise ratios. Parameters such as bandwidth of the IF filter, sampling time and integration time are optimised. (Author abstract) 7 refs.

Anderson, T. (Univ of Lund, Lund, Swed); Svensson, A. *Electron Lett* v 24 n 12 Jun 9 1988 p 753-754.

**Phase Shift Keying** See Also DATA TRANSMISSION—Laser Applications; DEMODULATORS; DIGITAL COMMUNICATION SYSTEMS; MICROWAVES—Propagation; MODULATORS—Performance; OPTICAL COMMUNICATION; OPTICAL COMMUNICATION—Analysis; OPTICAL COMMUNICATION—Design; OPTICAL COMMUNICATION—Performance; OPTICAL FIBERS—Spectrum Analysis; PHASE METERS—Performance; RADIO SYSTEMS, DIVERSITY; RADIO TRANSMISSION—Fading; RADIO TRANSMISSION—Spread Spectrum; SATELLITES—Communication Systems; SIGNAL DETECTION—Performance; SIGNAL FILTERING AND PREDICTION—Optimization; SIGNAL GENERATORS—Modulation; SIGNAL PROCESSING—Mathematical Models; TELECOMMUNICATION LINKS; SATELLITE.

**077964 ZUM RECHNERGESTUETZTEN ENTWURF VON PSK-DIREKTMODULATOREN.** [PSK-Modulators Designed by CAD Methods]. Computer-aided design tools are increasingly used in the product-oriented development of microwave circuits to eliminate cut and try methods and thus to achieve a reduction of costs and of time requirements. This trend is especially favoured, if microstrip circuits are considered, since meanwhile microstrip techniques have reached a certain degree of maturity, i.e., for many elementary microstrip structures, analytical mathematical models have become available. In this contribution the efficient application of the CAD to the design of reflection type microstrip PSK-modulators using PIN-diodes as switching elements is described. (Author abstract) 9 refs. In German.

Mueller, Fred-Egon (Standard Elektrik Lorenz AG, Pforzheim, West Ger). *Frequenz* v 41 n 10 Oct 1987 p 267-274.

**077965 ENCAP-4: AN OQPSK-TYPE MODULATION TECHNIQUE FOR DIGITAL RADIO.** A class of OQPSK-type signals (offset quadrature phase shift keyed) is defined which generalises several modulation formats. These signals are generated by means of a set of encoding rules which introduce a controlled amount of correlation between the in-phase (I) and quadrature (Q) components and between signal elements in each component. These encoding rules imply the specification of four generating functions directly related to the eye diagram of the I and Q baseband signals. It is shown that the proposed signal representation provides an efficient means of design and performance evaluation. Advantageous trade-offs between spectral efficiency and power efficiency can be achieved with some of the proposed signals, making them suitable for digital radio applications. (Edited author abstract) 11 refs.

Gusmao, A.M. (Univ Tecnica de Lisboa, Lisbon, Port); Esteves, N.L. *IEE Proc Part F* v 135 n 1 Feb 1988 p 105-110.

**077966 TRELLIS-CODIERTE MODULATION.** [Trellis-Coded Modulation]. Coding gains up to 6db over the uncoded modulation are obtained through the use of Trellis-Coded Modulation (TCM). The redundant coding is possible because of the wider, multivalent signal constellations. Applications are possible in all band-limited communication channels for multivalent modulation signals with relatively high signal-to-noise ratios. (Translated author abstract) In German. 14 refs.

Ungerboeck, G. (IBM-Forschungslaboratorium Zurich, Rueschlikon, Switz). *Bull Assoc Suisse Electr* v 78 n 15 Aug 8 1987 p 904-910.

**077967 ERROR PROBABILITY OF OFFSET DIFFERENTIAL PHASE SHIFT KEYING WITH INTERSYMBOL AND ADJACENT CHANNEL INTERFERENCE.** We compute the error probability for conventional and for symmetric differential phase shift keying (CDPSK and SDPSK) with differential detection in systems with binary, ternary and quaternary symbols and with two kinds of filters. In the first system the system response is a Butterworth filter with two, three and four poles, which causes both intersymbol interference (ISI) and noise correlation which depend on the normalized 3 db filter bandwidth B. In the second system the system response is a Nyquist filter with excess bandwidth. In this system we consider both ISI caused by errors in sampling time and adjacent channel interference (ACI) caused by a signal in a neighboring channel with frequency separation. (Edited author abstract) 24 refs.

Korn, I. (Univ of New South Wales, Kensington, Aust). *IEE Proc Part F* v 135 n 2 Apr 1988 p 175-182.

**077968 SYNCHRONIZATION ACCURACY OF PHASE-SHIFT-KEYED SIGNALS.** A circuit for filtering the random delay of phase-shift-keyed signals, synthesized by the methods of Markovian theory of optimum nonlinear filtering, is analyzed. The possibility of increasing the synchronization accuracy of phase-shift-keyed (PSK) signals is investigated. (Author abstract) 11 refs.

Ivanov, A.V. *Sov J Commun Technol Electron* v 32 n 6 Jun 1987 p 66-70.

**077969 DATA TRANSMISSION WITH VESTIGIAL-SIDEBAND-4-PHASE-SHIFT-KEYING (VSB-4-PSK).** Vestigial sideband transmission in 4-PSK systems will in general cause crosstalk between the two channels with orthogonal carriers. The absolute value of this crosstalk is the same as in double sideband partial response transmission and therefore the same decoding methods can be used with the same results. By using a pre- and postequalization technique, however, some additional data transmission capacity depending on the width of the vestigial sideband can be achieved. This method is described and experimental results are given. (Author abstract) 7 refs.

Zschunke, Willmut (Technical Univ of Darmstadt, West Ger). *Frequenz* v 42 n 2-3 Feb-Mar 1988 p 38-43.

**077970 SYMBOL TIMING RECOVERY IN MULTI-H PHASE CODED SYSTEMS.** This paper deals with synchronization techniques for multi-h Phase Coded Signals. A theoretical analysis, checked by computer simulations, is presented for a generalized deBuda synchronizer to be employed for both carrier and clock recovery. Performance comparisons are made between such a synchronizer and other schemes which can be used for clock recovery of Multi-h signals. (Author abstract) 15 refs.

D'Andrea, Aldo Nunzio (Univ di Pisa, Pisa, Italy); Luise, Marco. *Alta Freq* v 57 n 1 Jan 1988 p 33-38.

**077971 POLARISATION PHASE-SHIFT KEYING: A COHERENT TRANSMISSION TECHNIQUE WITH DIFFERENTIAL HETERODYNE DETECTION.** An original coherent transmission technique with polarization modulation and (two-channel) differential heterodyne detection is demonstrated. In a preliminary experiment, sensitivities within 4 db of the shot noise limit have been achieved. High immunity to laser phase noise is obtained. (Author abstract) 4 refs.

Calvani, R. (CSELT, Turin, Italy); Caponi, R.; Cisternino, F. *Electron Lett* v 24 n 10 May 12 1988 p 642-643.

**077972 PROBABILITY OF ERROR FOR M-ARY PSK AND DPSK ON A RAYLEIGH FADING CHANNEL.** M-ary phase-shift keying and differential phase-shift keying (DPSK) on a slow fading Rayleigh channel without diversity is investigated. Expressions for the distribution of the phase angle between a vector with Rayleigh amplitude distribution and a noiseless reference, and between two vectors both with Rayleigh amplitude distribution perturbed by Gaussian noise are obtained. 4 refs.

Pauw, Christoff K. (Univ of Pretoria, S Afr); Schilling, Donald L. *IEEE Trans Commun* v 36 n 6 Jun 1988 p 755-756.

**PHENOLIC RESINS** See Also COMPOSITE MATERIALS; PARTICLE BOARD—Bonding.

**077973 PHENOL FORMALDEHYDE RESIN FOR BONDING OF MAG CARBON REFRACTORIES.** The authors describe the nature of phenolic resins and their practical application in the field of mag carbon refractories. The advantages of using phenolic resin has been highlighted. The general manufacturing procedures for making mag carbon bricks are also outlined. (Edited author abstract) 10 refs.

Sridharan, P. (Bakelite Hylam Ltd, Hyderabad, India); Rajan, S. *Refract J* v 62 n 6 Nov-Dec 1987 p 10-11.

**077974 SAFER FLYING WITH PHENOLICS.** Phenolics have among the best fire/smoke/toxicity (F/S/T) performance balances of all commercial resins, and provide this exceptional performance at a surprisingly low price. Phenolics are also among the most rigid of resins, and retain their rigidity under loads to high temperatures. They can be fabricated by all of the common composite molding methods, and are continually being upgraded in performance and expanded in application. Of the 248 polymer-based aerospace structural composites listed on the Department of Defense high-temperature materials properties numerical data base (HTMP), 75 are phenolic-based. The article discusses the material, its processing, properties and applications.

English, Lawrence K. (Materials Engineering, Cleveland, OH, USA). *Mater Eng (Cleveland)* v 105 n 4 Apr 1988 p 42-46.

**Aging**

**077975 ACCELERATED HEAT AGE TESTING OF PHENOLICS: MORPHOLOGICAL CHANGES.** The morphological changes that occur in molded phenolic specimens during long-term heat aging tests have been observed in optical and scanning electron microscopy. The changes in morphology include shrinking and the formation of both cracks and charred zones in the



phenolic matrix. The relationship of these morphological changes to weight losses and flexural strength losses was demonstrated. (Author abstract) 10 refs.

Stransky, Paul D. (Univ of Connecticut, Storrs, CT, USA); Johnson, Julian F.; Yates, W. Ross. *J Appl Polym Sci* v 34 n 6 Nov 5 1987 p 2259-2271.

**077976 EXTERIOR AND ACCELERATED AGING OF AN ACID-PHENOLIC MOLDING RESIN IN H-CURED DOUGLAS-FIR JOINTS.** The durability of adhesive bonds of an acid-catalyzed phenol-formaldehyde molding resin to Douglas-fir was evaluated by two outdoor and two accelerated aging procedures. The resin's performance was judged by comparisons with three standards: bonds of the highly durable phenol-resorcinol-formaldehyde, a less durable melamine-urea-formaldehyde, and the solid wood of Douglas-fir itself. Durabilities were determined by periodically measuring loss in wet shear strength of bonded and solid wood specimens as they were exposed to the same four aging environments: 1) 40 days of moist-heat aging; 2) 800 cycles of boiling and drying in an automatic boil test; 3) 3 years of sheltered outdoor exposure; and 4) 3 years of direct outdoor weathering; both outdoor exposures were in Athens, Ga. (Edited author abstract) 6 refs.

Vick, Charles B. (USDA Forest Service, Athens, GA, USA). *For Prod J* v 37 n 10 Oct 1987 p 43-48.

**Applications** See Also ION EXCHANGERS—Plastics Applications; THERMOSETS—Mechanical Properties.

**077977 PHENOLIC RESINS.** Phenolic resins, according to DIN 16916 part 1 are oligomeric condensation products of phenols and aldehydes (especially formaldehyde) and have been used for more than 75 years as solid or liquid binders and impregnating agents for the production of materials in a large number of fields of applications. They are distinguished by a favourable combination of physical and chemical properties, which they impart to the finished products in the cured stage. Because of their relatively low energy requirement, good blending properties and less dependence on oil, phenolic materials are also in future expected to exhibit good growth rates. Utilization of the typical thermoset properties - thermal, electrical and chemical property range - will additionally result in a further expansion of the fields of application of this group of plastics. 28 refs.

Gardziella, A.; Mueller, R. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 71-75.

## Chromatographic Analysis

**077978 STUDY OF THE MOLECULAR MASS CHARACTERISTICS OF PHENOL FORMALDEHYDE RESINS BY GEL-PERMEATION CHROMATOGRAPHY.** The possibility of fractionation based on M of phenol formaldehyde resins by GPC has been studied on the Sephadex of different grades and Styrogel. On fractionation in ethyl alcohol for the Sephadex separation occurs by the adsorption mechanism and in DMFA on both types of packings by the GPC principle. It is shown that the GPC method on Sephadex and Styrogel may be used to analyze MD of phenol formaldehyde resins and study the change in their molecular characteristics with time. (Edited author abstract) 4 refs.

Vakhtina, I.A. (All-Union Synthetic Resin Research Inst, USSR); Shirokova, G.V.; Yemelina, Ch.M.; Tarakanov, O.G. *Polym Sci USSR* v 28 n 10 1986 p 2322-2326.

**Curing** See Also GRINDING WHEELS—Bonds; MELAMINE FORMALDEHYDE RESINS—Curing.

**077979 KINETIC INVESTIGATION ON THE CURING OF PHENOL-FURFURAL RESIN BY DIFFERENTIAL SCANNING CALORIMETRY.** Curing reactions of phenol-furfural resin with hexamethylene tetramine (Hexa) have been studied by differential scanning calorimetry technique both dynamically as well as isothermally. The curing exotherms obtained have been analyzed to derive the kinetic parameters associated with the curing process. The effect of the concentration of hexa

and the temperature on the curing characteristics have been investigated. The optimum concentration of hexa and the optimum temperature for curing are observed to be 12% and 160°C, respectively. (Author abstract) 15 refs.

Patel, Ravji D. (Sardar Patel Univ, Vallabh Vidyanagar, India); Patel, Ranjan G.; Patel, Vithal S.; Pearce, E.M. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2583-2589.

**Electrochemistry** See ELECTROPHORESIS.

**Fillers** See ELECTRON DEVICE MANUFACTURE—Encapsulation; EPOXY RESINS—Fillers.

**Foams** See POLYMERS—Thermal Conductivity.

## Manufacture

**077980 ZYWICE FENOLOWE. [Phenolic Resins].** This paper presents stages in the preparation and start-up of the production of phenol-formaldehyde resins at 'Gamrat-Erg' Plastics Works in Jaslo. It also discusses cooperation of the works with scientific and research institutes in the developments and implementation of technologies for the various types of resins production. Products applications in various industries is also presented. (Author abstract) In Polish.

Zborowski, Robert; Mazur, Jerzy; Majchrzak, Jerzy. *Przem Chem* v 66 n 3 Mar 1987 p 126-128.

## Mechanical Properties

**077981 HOCHWERTIGES PHENOLHARZ-BASIS MATERIAL. [High-Grade Phenolic Resin Base Material].** A cold-punchable, difficult to inflame base material for printed circuit boards of the FR2-VO-quality is represented, which was produced by a novel method. Compared with known materials the advantage consists of heavily reducing the bromine content, apart from improving different mechanical properties. (Author abstract) In German. 7 refs.

Doehring, D. (AdW der DDR, Berlin, East Ger); Raubach, H.; Singer, K.; Jaekel, E.; Latka, G. *Elektrik* v 41 n 6 1987 p 216.

**Molecular Structure** See ASBESTOS—Friction; VINYL RESINS—Glass Transition.

## Synthesis

**077982 SYNTHESIS, CHARACTERIZATION AND CURING OF m-DIETHYLAMINOPHENOL-FORMALDEHYDE RESIN.** Polycondensation of m-diethylaminophenol with formaldehyde has been studied under various reaction conditions. The resins formed are fusible and soluble in common organic solvents. All the resin samples have been characterized by spectral studies, measurement of solution viscosity, estimation of  $M_n$  and by t.g.a. The curing of selected resin samples by hexamine has been studied both by measuring percentage of cured material as a function of time at different temperatures and by differential scanning calorimetry. The d.s.c. data have been analyzed by various methods to evaluate the gross kinetic parameters of the curing reactions. (Author abstract) 20 refs.

Patel, Pradip S. (Sardar Patel Univ, Vallabh Vidyanagar, India); Patel, Shanti R. *Br Polym J* v 20 n 1 1988 p 13-17.

## Wastes

**077983 BENCH SCALE TREATABILITY OF LEACHATE FROM AN ABANDONED PHENOLIC WASTE SITE.** The treatability of a phenolic waste that was leaching from the site of a former pine-tar manufacturing facility was determined. Bench-scale activated sludge pilot plants were used to model the proposed wastewater treatment plant and to determine the effect of the leachate on nitrifying and denitrifying sludge. Chemical compound removals in the bench-scale activated sludge units and denitrifying units revealed that the leachate was treatable at a 1.25% leachate and wastewater concentration which was the expected concentration at

the wastewater treatment plant. (Author abstract) 10 refs.

Drinkwater, Lisa A.; Zoltek, John Jr.; Delfino, Joseph J. *J Water Pollut Control Fed* v 58 n 11 Nov 1986 p 1057-1065.

**PHENOLS** See Also CARBON—Chemical Reactions; CARBON—Chromatographic Analysis; EPOXY RESINS—Curing; EPOXY RESINS—Spectrum Analysis; HALOGEN COMPOUNDS—Decomposition; NAPHTHALENE—Production; OLIGOMERS—Spectroscopic Analysis; POLYMERIZATION—Condensation Reactions; RUBBER—Antioxidants; SAND, FOUNDRY; WASTEWATER—Purification.

**077984 ON THE INTERACTION OF PHENOL STABILIZERS WITH OXYGEN DURING THE INHIBITED OXIDATION OF POLYMERS.** A kinetic study was made of the consumption of sterically hindered phenols, namely, tritert-butylphenol, Ionol and Bisphenol-2246 in an inert solvent (chlorobenzene) and in oxidised PP at 130°. It is shown that direct oxidation by oxygen is the main process determining the consumption of phenols under these conditions. The contribution made by direct oxidation of phenols to the total rate of phenol consumption may be expressed in terms of parameter presented; the need to take oxidation of phenols into account arises in cases where this parameter differs significantly from zero. (Edited author abstract) 19 refs.

Shanina, Ye.L. (USSR Acad of Sciences, USSR); Roginskii, V.A.; Zaikov, G.Ye. *Polym Sci USSR* v 28 n 9 1986 p 2192-2199.

**077985 CATALYSIS OF THE BROMINATION OF PHENOLS AND PHENOXIDE IONS IN AQUEOUS SOLUTION BY  $\alpha$ -CYCLODEXTRIN.**  $\alpha$ -Cyclodextrin (CD) causes slight accelerations or retardations in the bromination of nine phenols and six phenoxide ions. Since CD forms fairly strong complexes with  $Br_2$ ,  $Br_3^-$ , and phenols, large rate reductions should be observed if the only reaction occurring involved free bromine reacting with free substrate. Thus, the results are consistent with a bromination pathway that is catalyzed by CD, and analysis of the kinetics shows that the reaction involves bromine, substrate, and one molecule of the cyclodextrin. Two pathways are plausible: A, reaction between free substrate and the bromine-CD complex; B, attack of free bromine on the substrate-CD complex. (Edited author abstract) 57 refs.

Tee, Oswald S. (Concordia Univ, Montreal, Que, Can); Bennett, Janice M. *J Am Chem Soc* v 110 n 1 Jan 6 1988 p 269-274.

## Absorption

**077986 UPTAKE RATE OF PHENOL BY PSEUDOMONAS PUTIDA GROWN IN UNSTEADY STATE.** The uptake rate of phenol by washed cells of *Pseudomonas putida* grown on phenol in fermenter in an unsteady state, caused by the step increase of dilution rate and/or phenol concentration in the feed, was studied. The Monod-Haldane type equation was applied to fit the data and the best kinetic parameters were calculated by nonlinear least-square techniques. It was found that the minimum period of unsteady required for induction of the phenol metabolic pathway was approximately 30 min. The values of kinetic parameters in an unsteady state varied according to each parameter. (Edited author abstract). 13 Refs.

Sokol, W. (Technical and Agricultural Acad, Bydgoszcz, Pol). *Biotechnol Bioeng* v 32 n 9 Oct 20 1988 p 1097-1103.

**Adsorption** See Also ADSORPTION; CLAY—Surfaces; SEWAGE TREATMENT—Activated Sludge; WATER TREATMENT—Chemicals Removal.



**077987 pH-WERT-ABHÄNGIGKEIT DER ADSORPTION VON PHENOL AN WINKLER-STAU.** [Dependence of the Phenol Adsorption at Winkler-Dust on the pH Value]. The parameters of the Freundlich-equation for the adsorption of phenol from an aqueous solution at Winkler-dust depend on the pH value. The effect is conditioned by the phenolate anion formed in accordance with the dissociation equilibrium and by its adsorbability being less compared with the undissociated phenol. The connections between the phenol load on the pH value can be described both by means of an empirical model and a mixture-adsorption model being physically and chemically founded by the IAS-theory. The developed mathematical relations permit the precalculation of the adsorption result in the case of a pH modification in phenolic effluents. (Author abstract) 8 refs. In German.

Tille, Anton (VEB Leuna-Werke 'Walter Ulbricht', Leuna, East Ger); Seidel, Andreas; Jobst, Wilfried; Schroeder, Lothar. *Chem Tech (Leipzig)* v 39 n 10 Oct 1987 p 445-447.

**077988 SURFACE DIFFUSION COEFFICIENT IN AQUEOUS PHASES ADSORPTION ON MACRORETICULAR ADSORBENTS.** The objectives of this study were to investigate the dependence of  $D_s$  on  $q$  for the adsorption of phenols on XAD-4 and XAD-7 from aqueous solutions, and to find the relationship between  $D_s$  (Surface Diffusivity) and  $E$  (Heat of Adsorption) by the use of one of the authors' equations. It is shown that the activation energy of the hole-making step ( $\beta$ ) was much larger than that of the jumping step ( $\alpha E$ ). Moreover, the surface of XAD-7 is more hydrophilic than that of XAD-4. Hence, in the case of XAD-7, a water molecule is more strongly adsorbed on the surface and more energy is required to produce a vacant site. However, the value of  $\beta$  is smaller for XAD-7 than for XAD-4. 10 refs.

Itaya, Akira (Yamaguchi Univ, Ube, Jpn); Fujita, Yuji; Kato, Nobuyuki; Okamoto, Ken-Ichi. *J Chem Eng Jpn* v 20 n 6 Dec 1987 p 638-640.

**077989 PENTACHLOROPHENOL SORPTION BY ORGANO-CLAYS.** Several clay organic complexes were prepared by placing organic cations on the exchange sites of smectite clays and studied as sorbents for pentachlorophenol (PCP). The organic cations used ranged from very hydrophobic in nature (e.g., dioctadecyldimethyl+ (DODMA)+ and hexadecyltrimethyl+ (HDTMA)+)-ammonium to those having minimal hydrophobic properties, such as tetramethylammonium+ (TMA+). In general, the more hydrophobic the cation on the smectite the greater the uptake of PCP from water. For those organo-clays containing small organic cations (e.g., TMA+), the organic phase consisted of separate small organic moieties, such as the methyl group. This phase did not act as an effective partitioning medium despite a significant carbon content, and very little PCP was taken up. Additional study results are discussed. (Edited author abstract) 16 refs.

Boyd, Stephen A. (Michigan State Univ, East Lansing, MI, USA); Sun, Shaobai; Lee, Jiunn-Fwu; Mortland, Max M. *Clays Clay Miner* v 36 n 2 Apr 1988 p 125-130.

**077990 BINDING OF PHENOLS TO ALUMINUM OXIDE SURFACES. 1. PHENOLS WITH A SINGLE HYDROXY GROUP.** The relative binding ability of each of a series of substituted phenols with an aluminum/aluminum oxide surface was determined through competitive adsorption experiments. The ability of each phenol to compete with acetic acid for surface sites, when coadsorbed from toluene onto a thermally evaporated aluminum surface, was determined. The resulting surface concentrations were determined primarily through changes in the water contact angle. The relative binding of the phenols was directly related to the acidity ( $pK_a$ ) of the phenol group in each molecule, with more acidic species having greater binding. All of the phenols, regardless of acidity, were less effective at binding than acetic acid. Meta and para substitution appears to influence binding only through the  $pK_a$  of the phenol group, while ortho substitution appears to lead to steric hindrance, with larger groups causing more hindrance.

Implications for design of phenol-containing adhesives are discussed. (Author abstract) 22 refs.

Holmes-Farley, Stephen Randall (Lord Corp, Cary, NC, USA). *Langmuir* v 4 n 3 May-Jun 1988 p 766-774.

**077991 ADSORPTION OF SUBSTITUTED PHENOLS ON ACTIVATED CARBON.** The adsorption of phenol and the substituted phenols, 4-nitrophenol, 2,4-dinitrophenol, 4-chlorophenol, and 2,4-dichlorophenol in aqueous solution, has been determined at 298 K on a series of activated carbons, prepared from olive stones having a wide range of burn-off (8-52%) and micropore size distributions. The adsorption process is controlled predominantly by the porosity of carbon when the microporosity is narrow in range. If the range of microporosity is wide then the adsorption process is affected by the chemical nature of the carbon and by the nature of the substituent group in the phenol. The adsorption isotherm of 2,4-dinitrophenol is a step function, which is interpreted as being due to the coexistence of neutral and anionic adsorbate species, and not due to a change in the orientation of the neutral adsorbate species. (Author abstract). 19 Refs.

Caturla, F. (Univ de Alicante, Alicante, Spain); Martin-Martinez, J.M.; Molina-Sabio, M.; Rodriguez-Reinoso, F.; Torregrosa, R. *J Colloid Interface Sci* v 124 n 2 Aug 1988 p 528-534.

**Alkylation** See Also SILICA GEL—Modification.

**077992 STUDY OF THE POSSIBILITY OF INCREASING THE YIELD OF THE MONOALKYL-PHENOL END PRODUCT IN THE ALKYLATION OF PHENOL WITH  $C_8$ - $C_{10}$  OLEFINS.** It was found that the introduction of 2.5-3.0 wt.% dialkylphenols into the initial mixture leads to more complete utilization of the reagents used to obtain the end product - monoalkylphenol. When 3.0 wt.% dioctylphenol was introduced into an initial mixture consisting of 58 wt.% phenol and 34 wt.% olefin, the average concentration of dialkylphenol in four selected samples of alkylate amounted to 3.1 wt.%. It is concluded that alkylation of phenol is more economical when carried out in the presence of dialkyl derivatives. 6 refs. In Russian.

Sukhovkhor, L.V.; Zhurba, A.S.; Sukhovkhor, V.D.; Mrinskaya, I.V. *Khim Tekhnol (Kiev)* n 4 Jul-Aug 1987 p 35-38.

**077993 INFLUENCE OF STRUCTURE OF SULFONATED CATION EXCHANGE RESINS ON THEIR CATALYTIC ACTIVITY IN ALKYLATION OF PHENOL BY OLEFINS.** To determine the interrelation between catalytic activity and porosity characteristics of the sulfonated resins we tested various Soviet and foreign cation exchange resins prepared from styrene copolymers with 4-30% divinylbenzene. The catalytic activity of the resins was evaluated from the results obtained in alkylation of phenol by *n*-nonene and *n*-decene in two series of experiments. The macroporous resins with small quantities of divinylbenzene, with an overall catalytic activity that is quite high, give considerable quantities of alkyl phenyl ethers and little dialkylphenols (particularly with excess phenol), whereas the resins with 15% or more divinylbenzene in the polymer matrix give only small amounts of ethers and relatively large amounts of dialkylphenols. Both the alkyl phenyl ethers and the dialkylphenols have adverse effects on the quality of the monoalkylphenols and on products prepared from these materials, such as lube oil additives and water-soluble surfactants. The dialkylphenols can be removed cleanly by fractionation. Optimal activity and selectivity of catalytic action in the alkylation of phenol by higher olefins are exhibited by macroporous cation exchange resins of the KU-23 (10/60) type with  $W_0 = (2.4) \cdot 10^{-3} \text{ m}^3/\text{kg}$ ,  $r_m = (2.8-4.0) \cdot 10^{-8} \text{ m}$ , and  $W_0/r_m = (7-15) \cdot 10^3$ . 9 refs.

Korenev, K.D. (I.M. Gubkin Moscow Inst of Oil & Gas, USSR); Belov, P.S.; Zavadovskaya, A.S.; Kapustin, P.P.; Kozyreva, G.I.; Uvarova, E.A.; Zavorotnyi, V.A. *Chem Technol Fuels Oils* v 23 n 7-8 Jul-Aug 1987 p 379-381.

## Applications

**077994 CHELATING POLYMER-BEARING 4-(3-TRIAZOLYLAXO)PHENOL MOIETY AS THE FUNCTIONAL GROUP.** The polymer-bearing 4-(3-triazolylazo)phenol moiety was synthesized, and the metal adsorption properties of it for 6 divalent heavy metal ions ( $M^{2+}$ ):  $Co^{2+}$ ,  $Ni^{2+}$ ,  $Cu^{2+}$ ,  $Zn^{2+}$ ,  $Cd^{2+}$ , and  $Pb^{2+}$  were investigated. The object of this paper is to examine the effect of the donor oxygen atom of the hydroxyl group on the metal adsorption ability of the chelating polymer-bearing triazolyloxyphenol moiety, and to investigate the application of the polymer for removal of heavy metals from plating process solutions. 5 refs.

Onari, Yasuo (Mie Industrial Research Inst, Tsu, Jpn). *J Appl Polym Sci* v 35 n 6 May 5 1988 p 1695-1699.

**Biodegradation** See AROMATIC COMPOUNDS—Biodegradation; SEWAGE TREATMENT—Activated Sludge.

## Chemical Analysis

**077995 IDENTIFICATION OF METHOXYLATED PHENOLS AS CANDIDATE TRACERS FOR ATMOSPHERIC WOOD SMOKE POLLUTION.** More than 70 organic compounds have been identified in unfractionated methylene chloride extracts of soot from residential wood stoves by a combination of capillary gas chromatography coupled with low-resolution mass spectrometry (GC/MS), GC coupled with high-resolution mass spectrometry, and chemical ionization mass spectrometry with deuterated methanol as the reagent gas. Thirty of the species are derivatives of guaiacol (2-methoxyphenol) and syringol (2,6-dimethoxyphenol), which result from the pyrolysis of wood lignin. Soots from hardwood and pine show similar proportions of the syringol derivatives, but pine soot has much higher proportions of the guaiacol derivatives. These species are expected to be unique to wood smoke in urban atmospheres and are therefore suggested as tracers for atmospheric wood smoke pollution. (Edited author abstract). 29 Refs.

Hawthorne, Steven B. (Univ of North Dakota, Grand Forks, ND, USA); Miller, David J.; Barkley, Robert M.; Krieger, Mark S. *Environ Sci Technol* v 22 n 10 Oct 1988 p 1191-1196.

## Chemical Reactions

**077996 COMPOUND PROPERTIES RELEVANT FOR ASSESSING THE ENVIRONMENTAL PARTITIONING OF NITROPHENOLS.** Acidity constants, UV/vis absorption maxima, aqueous solubilities, octanol/water partition constants and ratios, vapor pressures, and estimated Henry's law constants are reported and discussed for 17 mono- and dinitrophenols. For substituted 2-nitrophenols in which intramolecular hydrogen bonding between hydroxyl and nitro group is not affected by proximity effects, the acidity constant  $K_a$  can be estimated from the Hammett relationship. For these nitrophenols, the aqueous activity coefficient of the nondissociated species is approximately independent of solute concentration, and a good correlation between octanol/water partition constant and aqueous solubility of the liquid compound is found. The electric effect of substituents on the octanol/water partitioning behavior of the dissociated 2-nitrophenols can be reasonably quantified by using Hammett substituent constants. Additional study results are discussed. (Edited author abstract) 37 refs.

Schwarzenbach, Rene P. (Swiss Federal Inst for Water Resources & Water Pollution Control, Kastanienbaum, Switzerland); Stierli, Ruth; Folsom, Brian R.; Zeyer, Josef. *Environ Sci Technol* v 22 n 1 Jan 1988 p 83-92.

**077997 KINETICS OF REACTIONS OF METHYL  $\alpha$ -ELEOSTEARATE WITH CRESOLS.** The kinetics of addition reactions between methyl  $\alpha$ -eleostearate which forms the main chain of tung oil and cresols when



catalyzed by an acid, p-toluene sulfonic acid, have been studied. The addition reactions, carried out with any one of the o-, m-, and p-cresols were shown to be first order with regard to both methyl  $\alpha$ -eleostearate and cresol concentrations. The reactions were additions of two cresol molecules to one methyl  $\alpha$ -eleostearate molecule, and it was presumed that they proceed in two steps in which the first step is rate-determining. (Edited author abstract) 24 refs.

Yoshimura, Yukio (Hitachi Chemical Co, Shimodate, Jpn). *J Polym Sci Part A* v 26 n 5 May 1988 p 1343-1359.

**077998 EFFECTS OF METHANOL ON THE REACTIONS OF THE PHENOL-FORMALDEHYDE SYSTEM.** Phenol was reacted with formaldehyde at 60°C and 80°C with various amounts of methanol present in the reaction mixture. The apparent rate constants and activation energies were calculated with a modified second order equation, which was the best fitted by data obtained from the entire reaction period of the experiment. Methanol decreased the rate of reaction. However, the activation energies were not significantly affected by the methanol concentration. (Author abstract) 10 refs.

Chen, Chia M. (Univ of Georgia, Athens, GA, USA); Chen, S.L. *For Prod J* v 38 n 5 May 1988 p 49-52.

**Chromatographic Analysis** See Also ORGANIC COMPOUNDS—Chromatographic Analysis.

**077999 OPTIMIZED GAS CHROMATOGRAPHIC DETERMINATION OF PRIORITY POLLUTANT PHENOLS.** Priority pollutant phenols are determined by gas chromatography on an SE-30 WCOT column using hydrogen carrier and flame ionization detection with dual internal standards. Linear responses over ranges ca. 12-125 ng per component are achieved and detection limits at or below 1 ng are obtained. Carrier flow and temperature program are optimized to maintain baseline resolution while affording an analysis time of less than 15 minutes. (Author abstract) 9 refs.

Masi, O.H. (Michigan Technological Univ, Houghton, MI, USA); Gulick, W.M. Jr. *HRC & CCJ High Resolut Chromatogr Chromatogr Commun* v 10 n 12 Dec 1987 p 647-649.

**078000 UEBER DIE PHENOLISCHEN INHALTSSTOFFE HOCHSIEDENDER ANTEILE DES PHENOSOLVANEXTRAKTES AUS PROZESSWASSER DER THERMISCHEN VEREDLUNG XYLITISCHER BRAUNKOHLN.** [On the Phenolic Constituents of High-Boiling Fractions of the 'Phenosolvan' Extract Obtained from Effluent Liquors in Thermal Upgrading of Xylitol Brown Coals]. Separation and identification of high-boiling phenols of a 'phenosolvan' extract using temperature-programmed capillary gas chromatography combined with structure-specific reactions are described. More than 100 individual compounds are present, but only a few of them in greater quantities. The predominating phenol type is the pyrocatechols with 4-methyl-, 4-ethyl- and 3-methylpyrocatechols and the parent substance being the main components. Moreover, resorcinols, hydroquinones, alkylated monohydric phenols, phenolic ethers and phenolic aldehydes were detected and, in part, identified. The origin of the material under investigation is explained and potential uses as a source of phenols are discussed. (Edited author abstract) In German. 13 refs.

Schmiers, Helmut (Bergakad Freiberg, Freiberg, East Ger); Stein, Johann; Buttker, Bernd; Socher, Karl. *Chem Tech (Leipzig)* v 39 n 12 Dec 1987 p 522-525.

**078001 COMPARATIVE EVALUATION OF SOME METHODS OF INVESTIGATIONS OF THE COMPOSITION OF HYDROXYETHYLATED ALKYLPHENOLS.** An attempt is made in this study to use column fractionation, turbidimetric titration (TT), and gel permeation chromatography (GPC) for determining the molecular inhomogeneity of HEAP<sub>n</sub> (n=10) characterized by the molecular-weight distribution (MWD). It is shown that for operational control of the molecular and

structural inhomogeneities in the preparation of HEAP, it is desirable to use such methods as GPC and TT. The preference which should be given to GPC due to its rapidity and the volume of the information obtained is neutralized by the difficulty in procuring the instruments. For this reason, the availability and simplicity of the apparatus used is a favorable circumstance for the use of TT. 13 refs.

Fabrichnaya, A.L.; Rubanov, V.E.; Tavrin, A.E. *J Appl Chem USSR* v 60 n 5 pt 2 May 1987 p 1074-1076.

**Concentration** See COAL TAR—Components; COKE—Adsorption; COKE PLANTS—Monitoring; WATER ANALYSIS—Trace Analysis.

**Decomposition** See COAL—Pyrolysis; WATER TREATMENT—Chemicals Removal.

**Degradation** See Also BIOREACTORS; BIOREACTORS—Evaluation; FOOD PRODUCTS—Fruit Juices.

**078002 EFFECT OF ANODIC AND CATHODIC REACTIONS ON OXIDATIVE DEGRADATION OF PHENOL IN AN UNDIVIDED BIPOLAR ELECTROLYZER.** Both anodic oxidation and generation of hydrogen peroxide through electroreduction of oxygen may be useful for oxidative degradation of organic compounds present in the wastewater to be treated. To clarify the effect of electrode reactions of both sides of a bipolar plate on the current efficiency for oxidative degradation of phenol, experiments were conducted by using an undivided bipolar electrolyzer having a vertical stack of perforated graphite electrodes. The Faradaic current  $I_f$  was arranged as a function of the electrode potential difference  $E_B$  between opposite sides of a bipolar plate. By analyzing the  $I_f$ - $E_B$  curves for the electrolyses in solutions containing different reactants, separate currents corresponding to anodic and cathodic reactions were determined. (Edited author abstract) 10 refs.

Sudoh, Masao (Shizuoka Univ, Hamamatsu, Jpn); Kodera, Takamasa; Hino, Haruyoshi; Shimamura, Hiroshi. *J Chem Eng Jpn* v 21 n 2 Apr 1988 p 198-203.

**Dehalogenation** See Also CHLORINE COMPOUNDS—Biodegradation.

**078003 REDUCTIVE DECHLORINATION OF CHLORINATED PHENOLS IN ANAEROBIC UPFLOW BIOREACTORS.** The reductive dechlorination of chlorinated aromatic compounds was studied in anaerobic upflow bioreactors with chlorinated phenols as the sole carbon and energy source. Dechlorinating activity was maintained in three separate anaerobic bioreactors for 350, 400 and 190 days. Mineralization of approx. 40% of added chlorophenols to  $CH_4$  and  $CO_2$  was demonstrated. Substrate loading rates of up to 20 mg  $l^{-1}$  day $^{-1}$  at a hydraulic retention time of 2 or 4 days were achieved at a substrate conversion efficiency of >90% as determined by measurement of chlorophenol concentration in the effluent. The ability to degrade a mixture of all three monochlorophenols and 3,4,5-trichlorophenol was demonstrated. The majority of the active biomass was located at the bottom of the bioreactor in the form of a sludge blanket. Three microorganisms which dominated the biomass were identified by morphology as a putative anaerobic phenol-oxidizing bacterium, a *Methanosarcina* sp. and a *Methanotrix* sp. (Author abstract) 28 refs.

Krumme, Mary Luise (Michigan State Univ, East Lansing, MI, USA); Boyd, Stephen A. *Water Res* v 22 n 2 Feb 1988 p 171-177.

**Derivatives**

**078004 INTENSIFICATION OF THE PROCESS OF OZONATION OF NITRO DERIVATIVES OF PHENOL IN AQUEOUS SOLUTIONS.** Processes of ozonation of nitro derivatives of phenol - 4-nitrophenol, 2,4-dinitrophenol, 2,5-dinitrophenol, 2-methyl-4,6-dinitrophenol, and 2,4,6-trinitrophenol - are studied in the 2-11 pH range. It is shown that the relative reaction capacity of these compounds is determined both by the degree of their dissolution in solution and by the nature

of the aromatic ring substituents. The specific quantities of oxidizer required for decomposition of these compounds in aqueous media are found to be 4-8 moles of  $O_3$  per mole of the compound. It is shown that alkalization of the solution or combined presence of ozone with hydrogen peroxide of UV irradiation are ineffective as a means of intensifying the ozone oxidation process. (Author abstract) 11 refs.

Vakulenko, V.F.; Taran, P.N.; Goncharuk, V.V.; Shevchenko, M.A. *Sov J Water Chem Technol* v 9 n 5 1987 p 38-41.

**Desorption**

**078005 TEMPERATURE-PROGRAMMED DESORPTION OF PHENOL FROM OXIDE SURFACES.** Interactions between phenol molecules and surfaces of  $SiO_2-Al_2O_3$  (SA), MgO and  $ZrO_2$  were studied by using the temperature-programmed-desorption (TPD) method and infrared spectroscopy. Desorption of phenol gave a single peak in the TPD profiles of SA and  $ZrO_2$  at 363 and 783 K, respectively, but complicated profiles were found on MgO. A part of the adsorbed phenol was found to decompose to benzene and water at 803 K on  $ZrO_2$ , 853 K on MgO and above 873 K on SA. Desorption of water was also found below the decomposition temperatures; SA and  $ZrO_2$  gave a similar profile in which the water desorption peak appeared at around 473 K. No desorption of water was found on MgO at lower temperatures for MgO evacuated at 1073 K but a new peak appeared at around 538 K for MgO evacuated at 873 K. The difference in the desorption temperatures on the three samples was explained by considering the individual surface acid-base properties and OH concentration at the surface. The relative difficulty for phenol desorption and easiness for its decomposition on  $ZrO_2$  were interpreted in terms of its weak acid and weak base properties. (Author abstract) 6 refs.

Xu, B.-Q. (Hokkaido Univ, Sapporo, Jpn); Yamaguchi, T.; Tanabe, K. *Mater Chem Phys* v 19 n 3 Apr 1988 p 291-297.

**Esterification**

**078006 PHASE TRANSFER CATALYSED ESTERIFICATION OF PHENOLS WITH ALIPHATIC ACID CHLORIDES. PART II: PHENYL ACRYLATES FROM 3-CHLOROPROPIONYL CHLORIDE.** The phase transfer catalyzed reaction of phenols with 3-chloropropionyl chloride was carried out in a basic bi-phase aqueous-organic medium. Phenyl acrylates were isolated in good yields with high (>99%) purity. (Author abstract) 4 refs.

Direktor, David (IMI-Inst for Research & Development, Haifa, Isr); Effenberger, Reinhard. *J Chem Technol Biotechnol* v 41 n 1 1988 p 45-49.

**Extraction** See Also COKE PLANTS—Effluent Treatment.

**078007 EXTRACTION OF PHENOLS FROM SHALE AQUEOUS LIQUORS BY A MIXED EXTRACTANT.** To describe the isotherms of the extraction of individual components of water-soluble shale phenols (alkylresorcinols) an equation is proposed which takes into account the concentration of the compound being separated, the temperature, and the composition of a mixed extractant. The residual concentrations of the eight main alkylresorcinols in water under various conditions of counter-current extraction with a mixture of butyl acetate and diisopropyl ether have been calculated. A regression equation has been obtained for the dependence of the residual concentrations of the phenols on the composition and amount of extractant, the number of theoretical stages, and the temperature of extraction. (Author abstract) 6 refs.

Mel'der, L.I.; Tamvelius, Kh.Ya.; Tiikma, L.V. *Solid Fuel Chem* v 21 n 2 1987 p 77-81.



**078008 SYNERGISTIC AND SALTING OUT EFFECTS IN EXTRACTION OF PHENOLS.** As a result of studying some features of extraction of phenol, cresols, and pyrocatechol with mixtures of solvents using directed actions which increase the distribution coefficients  $K_d$  (synergism, salting out, solvotropic effect), the constants of entry of the components of binary mixtures of extracting agents in mixed solvents were calculated and their composition was established. Regardless of the mixture of extracting agents used, synergism is manifested to a much greater degree in the extraction of *o*-cresol (ortho effect). The simultaneous effect of salting out and synergism with certain combinations of the parameters of the extraction system ensures almost total (96%) transfer of phenols to the extract. Addition of dialkyl phthalates in the phase of the extracting agent increases the efficiency of extraction of pyrocatechol from aqueous solutions by 1.5-2 times. 10 refs.

Korenman, Ya.I. (Inst of Technology, Voronezh, USSR); Minasyants, V.A.; Ermolaeva, T.N.; Sel'manshchuk, N.N.; Aleksyuk, M.P. *J Appl Chem USSR* v 60 n 7 pt 2 Jul 1987 p 1476-1481.

**Industrial Applications** See DYES AND DYEING—Color Fastness.

**Optical Properties** See Also AMINO ACIDS—Optical Properties.

**078009 THIRD-ORDER OPTICAL NONLINEARITY OF CHLOROPHENOLS.** Degenerate four-wave mixing of infrared (1.064  $\mu$ m) pulses with 130 ps duration was studied in *o*-, *p*- and *m*-chlorophenols. Nonlinear susceptibilities  $\chi^{(3)}$  of  $(5.5-6.0) \times 10^{-20}$  m<sup>2</sup>/V<sup>2</sup> were measured. By temporally delaying the incidence of the second pump pulse contributions from an optical Kerr effect and an electrostrictive effect are observed. (Author abstract) 13 refs.

Maloney, C. (Trinity Coll, Dublin, Irel); Blau, W. *Physica B & C* v 147 n 2-3 Jan-Feb 1988 p 332-335.

**Oxidation** See Also BIOREACTORS—Chemostats; CATALYSTS—Activity; WASTEWATER—Treatment.

**078010 OXIDATION OF PHENOLIC COMPOUNDS BY OZONE AND OZONE+U.V. RADIATION: A COMPARATIVE STUDY.** This study was designed to investigate the reaction mechanisms of oxidation of various phenolic compounds by ozone and ozone+u.v. radiation at pH 2.5, 7.0 and 9.0. Experimental results indicated that the molecular ozone is the predominant oxidant only at acidic pH; at neutral and basic pH, in the absence or presence of u.v. radiation, free radical reaction is the major pathway in the oxidation of phenolic compounds. The overall removal of phenols and the removal of TOC increase with increasing pH during ozonation with or without u.v. light. For a specific pH, the removal rates of phenol and TOC are highest for ozone+u.v. light followed by ozone and then u.v. light alone. (Author abstract) 17 refs.

Gurol, Mirat (Drexel Univ, Philadelphia, PA, USA); Vatistas, Robert. *Water Res* v 21 n 8 Aug 1987 p 895-900.

**078011 SENSITIZED PHOTOOXIDATION OF PHENOLS BY FULVIC ACID AND IN NATURAL WATERS.** In addition to singlet oxygen, irradiation of fulvic acid solutions and lake water with UV and visible light ( $\lambda > 315$  nm) produces another transient oxidant species. This transient oxidant (probably an organic peroxy radical) is derived from natural dissolved organic material (DOM) and controls DOM-sensitized photooxidations of various alkylphenols. On the basis of kinetic data for the transient oxidant, DOM-sensitized photooxidation half-lives of alkylphenols are estimated to range from 1 day to several months in middle-latitude shallow surface waters. (Author abstract) 45 refs.

Faust, Bruce C. (ETH for Water Resources & Water Pollution Control, Dübendorf, Switz); Holgne, Juerg. *Environ Sci Technol* v 21 n 10 Oct 1987 p 957-964.

**078012 COBALT(II) ION CATALYZED OXIDA-**

**TION OF *o*-SUBSTITUTED ANILINES WITH MOLECULAR OXYGEN.** In this communication we report the catalytic oxidation of two related compounds, 2-aminothiophenol (HAT) and 2-aminophenol (AP) under ambient conditions. It was found that the yield increases with increasing basicity of the solvent. It has been identified as 2-aminophenoxazine-3-one (APX) by comparing its IR, <sup>1</sup>H NMR and <sup>13</sup>C NMR spectra, as well as its HPLC behavior with those of the authentic compound. One of the major byproducts in EtOH as solvent has been identified as 2,2'-dihydroxyazobenzene (DHAB). 10 refs.

Simandi, Laszlo I. (Hungarian Acad of Sciences, Budapest, Hung); Nemeth, Sandor; Rumelis, Nikos. *J Mol Catal* v 42 n 3 Nov 2 1987 p 357-360.

**078013 ANODIC OXIDATION OF 2,6-DIMETHYLPHENOL IN VARIOUS ELECTROLYTIC SOLUTIONS.** The electrolytic synthesis of poly(2,6-dimethyl-1,4-phenyleneoxide) (PPO), 3,3',5,5'-tetramethyl-4,4'-diphenylquinone (TMDDQ), and 2,2',6,6'-tetramethyl-1,1'-biphenol (TMBP) from 2,6-dimethylphenol in various electrolytic solutions was carried out. They were characterized by chemical (using IR absorption spectroscopy, <sup>1</sup>H- and <sup>13</sup>C-NMR technique, etc.) and electrochemical means. The results were compared with those obtained for the oxidative coupling of 2,6-dimethylphenol in the presence of oxygen using a copper-amine complex as the catalyst. On the basis of the results obtained, the possible mechanism of the anodic oxidation of 2,6-dimethylphenol is discussed. (Edited author abstract) 37 refs.

Oyama, N. (Tokyo Univ of Agriculture & Technology, Koganei, Jpn); Ohsaka, T.; Ohnuki, Y.; Suzuki, T. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3068-3073.

**078014 ADSORPTION AND OXIDATION OF PHENOLIC COMPOUNDS BY IRON AND MANGANESE OXIDES.** The adsorption and oxidation of catechol and hydroquinone by Fe and Mn oxides has been investigated by Fourier transform infrared spectroscopic (FTIR) analysis of the adsorbed molecules and by the measurement of O<sub>2</sub> consumption by aqueous suspensions of these oxides. A model of surface oxidation by Mn and Fe is presented in which coordination of the organic at the surface is a prerequisite to electron transfer. Oxidation of organics can proceed with or without the uptake of O<sub>2</sub>, depending largely on pH, which determines the rate of reoxidation of the reduced metal ions by O<sub>2</sub>. The results emphasize the difficulty in interpreting the effects that chemical buffers have on oxidation reactions at oxide surfaces. (Edited author abstract) 33 refs.

McBride, M.B. (Cornell Univ, Ithaca, NY, USA). *Soil Sci Soc Am J* v 51 n 6 Nov-Dec 1987 p 1466-1472.

**078015 OXIDATION OF AN INHIBITORY SUBSTRATE BY WASHED CELLS (OXIDATION OF PHENOL BY PSEUDOMONAS PUTIDA).** The specific uptake rate of phenol by washed cells of *Pseudomonas putida* grown on phenol in steady-state continuous culture at various dilution rates was studied. The Monod-Haldane-type equation was applied to fit the data and the best kinetic parameters were determined by nonlinear least-squares techniques. The values of the kinetic parameters were found to increase monotonically with the phenol concentration in the original chemostat. The relations between the values of kinetic parameters and phenol concentration in the chemostat were described by empirical equations. Then the equation governing the instant uptake of phenol by microorganisms in chemostat in the high conversion range of phenol was proposed. This equation together with the mass balance of continuous stirred tank biochemical reactors (CSTBR) utilizing phenol. (Author abstract) 10 refs.

Sokol, W. (Technical & Agricultural Acad, Bydgoszcz, Pol). *Biotechnol Bioeng* v 30 n 8 Dec 5 1987 p 921-927.

**078016 LIQUID PHASE HETEROCATALYTIC OXIDATION OF PHENOL BY HYDROGEN PEROXIDE ON MAGNETITE.** We present the results of a study of the heterogeneous oxidation of phenol on iron

compounds containing the metal in the 2+ oxidation state. The selection of phenol as the model substrate was made because it is one of the most widespread, toxic, and difficult to remove environmental contaminants. Homogeneous catalytic oxidation of phenols by means of hydrogen peroxide leads to quite a high degree of purification of industrial sewage. The study has shown that magnetite, a natural material containing Fe<sup>2+</sup>, catalyzes the destructive, liquid-phase oxidation of phenol by hydrogen peroxide. The oxidation process takes place in two stages with a conversion of phenol to carbon dioxide up to 82%. 27 refs.

Vasilenko, I.I.; Fedosova, A.N.; Shevel', N.M. *J Appl Chem USSR* v 60 n 4 pt 2 Apr 1987 p 824-828.

**078017 MECHANISTIC STUDY ON THE OXIDATION OF 2,6-DIMETHYLPHENOL BY DMAP\*-AND POLYSTYRENE-BOUND DMAP\*-BASED COPPER CATALYSTS.** A possible mechanism for the oxidation of 2,6-dimethylphenol by soluble and polystyrene-bound Cu(II)-DMAP catalysts is described. The work further shows that the phenol oxidation obeys Michaelis-Menten kinetics. For the Cu(I) reoxidation, an equilibrium is suggested in which molecular O<sub>2</sub> is reversibly bound to mononuclear Cu(I)-DMAP complexes, prior to Cu(I) dimerization and electron transfers. Combination of the results with generally accepted steps in the oxidation of phenols allowed the construction of a possible reaction mechanism for our particular system. (Edited author abstract) 42 refs.

Koning, C.E. (State Univ of Groningen, Groningen, Neth); Viersen, F.J.; Challa, G.; Reedijk, J. *J Mol Catal* v 44 n 2 Feb 29 1988 p 245-257.

**078018 LIQUID PHASE OXIDATION OF THIOPHENOL AND INDENE BY *t*-BUTYL HYDROPEROXIDE AND OXYGEN.** The *tert*-butyl hydroperoxide (tBHP) or oxygen initiated oxidation of thiophenol in the presence of the active olefin indene was examined in benzene at 120°C. The reaction is kinetically complex, but it was possible to relate the product distribution to a few competing reactions. The product mix was determined for several reaction time periods. The product slate was similar for all time periods, but yields of the individual components varied significantly with increasing reaction time. Gaseous products included isobutylene and a trace of methane. The major product from tBHP was *t*-butanol. (Edited author abstract) 29 refs.

Mushrush, George W. (US Naval Research Lab, Washington, DC, USA); Watkins, John M.; Hazlett, Robert N.; Hardy, Dennis R.; Eaton, Harold G. *Fuel Sci Technol Int* v 6 n 2 Apr 1988 p 165-183.

**Physical Properties** See ALCOHOLS—Physical Properties.

**Polymerization**

**078019 PREPARATION AND OXIDATIVE POLYMERIZATION OF 2-METHYL-6-GERANYLPHENOL.** 2-Methyl-6-Geranylphenol (MGP) was efficiently prepared by the reaction of *o*-cresol and 1-chloro-3,7-dimethyl-2,6-octadiene in the presence of alkali metal. MGP was oxidatively polymerized to poly(2-methyl-6-geranyl-1,4-phenyleneoxide). The oxidative polymerization of MGP is described. (Edited author abstract) 8 refs.

Hyun, S.H. (Waseda Univ, Tokyo, Jpn); Nishide, H.; Tsuchida, E.; Yamada, S. *Polym Bull (Berlin)* v 18 n 4 Oct 1987 p 283-286.

**078020 OVERVIEW OF PHENOL ELECTROPOLYMERIZATION FOR METAL PROTECTION.** After briefly summarizing the most common reactions used in the chemical synthesis of polyoxyphenyls, this paper reviews the electrochemical polymerization of phenols for metal protection. It also describes how the reaction media, sometimes in unexpected ways, influ-



ence the chemical composition of the coatings and the status of the metal surface. The role of the adsorption of monomers and other components of electrolysis baths is discussed on the basis of in situ spectroelectrochemical data. (Edited author abstract) 49 refs.

Mengoli, Giuliano (CNR, Padua, Italy); Musiani, Marco M. *J Electrochem Soc* v 134 n 12 Dec 1987 p 643C-652C.

## Processing

**078021 MICROBIOLOGICAL TREATMENT OF PHENOLIC EFFLUENTS (DEVELOPMENT OF TRENDS, SCIENTIFIC BASIS, AND PRACTICAL ADOPTION).** The author describes results of the development of a scientific and practical basis of microbiological treatment of phenolic effluents from coking plants and gas generator stations. The items covered include: dihydric phenols, polycyclic aromatic hydrocarbons, volatile fatty acids, thiocyanates, cyanides and aluminum salts. 43 refs.

Yurovskaya, E.M. *Coke Chem (USSR)* n 12 1986 p 75-84.

**078022 STUDY ON CATALYTIC ACTIVITY OF  $\gamma\text{-Al}_2\text{O}_3$  IN AMMONIATION OF PHENOL.** The surface properties and catalytic activity of  $\gamma\text{-Al}_2\text{O}_3$  prepared from different raw materials as well as those modified by treating with HCl of different concentrations have been investigated. The surface properties were studied by TPD technique. Experimental results show that the existence of sodium ion on the surface restrains the surface acidity, and the catalytic activity is decreased. Sites of stronger adsorption appear on the surface, so the surface of this kind of  $\gamma\text{-Al}_2\text{O}_3$  becomes more heterogeneous than that of those without sodium ion. (Edited author abstract) In Chinese. 9 refs.

Zhang Jianzhong; Zhou Minfeng; Yan Zhiguang; Wu Zhinan. *Huadong Huagong Xueyuan Xuebao* v 14 n 1 1988 p 16-21.

**078023 POLOPROVOZNI ZKOUSKY BIOLOGICKEHO CISTENI SUROVYCH A OD-FENOLOVANYCH FENOLCPAVKOVYCH VOD.** [Pilot-Plant Trials with Biologic Purification of Crude and Dephenolized Phenol-Ammonia Liquors]. The paper gives process costs for biological purification of crude phenol ammonia liquors that amount to one half of dephenolizing in a phenol plant. Biological purification may be a substitute in phenol plant operation. 5 Refs. In Czech.

Opalkova, Vendulka (NHKG, Ostrava, Czech); Knybel, Frantisek. *Hutn Listy* v 43 n 5 May 1988 p 232-236.

**Production** See ORGANIC COMPOUNDS—Oxidation.

## Pyrolysis

**078024 PYROLYSIS OF 4-METHYLPHENOL IN THE PRESENCE OF CARBON DISULFIDE.** The goal of this investigation was to study the effect of carbon disulfide (as representative of sulfur compounds) on the process of thermal decomposition of 4-methylphenol - one of the components of coal phenols. It is shown that the process of pyrolysis of 4-methylphenol includes primary and secondary reactions. The presence of carbon disulfide results in a decrease in the partial pressure of the reacting materials, resulting in a decrease in the quantity of high-molecular compounds formed in the secondary reactions of polymerization and polycondensation. It was shown that the presence of carbon disulfide significantly accelerates the reactions of formation of benzene, toluene, and naphthalene. The presence of carbon disulfide has less effect on processes of formation of phenol, methyl-naphthalene, and diphenyl. 7 refs.

Nabivach, V.M.; Berlizov, Yu.S.; Bur'yan, P.; Macak, I. *Coke Chem (USSR)* n 7 1987 p 45-49.

**078025 PYROLYSIS-MASS SPECTROMETRIC INVESTIGATIONS OF THE MECHANISTIC AND KINETIC ASPECTS OF THERMAL DEGRADA-**

**TION OF PHENOL-FORMALDEHYDE POLYCONDENSATES.** High-molecular-weight phenol-formaldehyde polycondensates, deuterium-labelled at the aromatic or methylene linkages, were subjected to pyrolysis in the direct insertion probe of a mass spectrometer or in separate pulse-mode pyrolysers interfaced to the mass spectrometer or to the gas chromatograph-mass spectrometer. The principal route of the thermal degradation in vacuum and in an inert atmosphere, involving the cleavage of phenol-methylene bonds and subsequent hydrogen abstraction and resulting in the ultimate formation of phenol and methyl-substituted phenols as volatile products, exhibited hydrogen-deuterium scrambling owing to the isomerization of the macroradicals. (Edited author abstract) 10 refs.

Prokai, Laszlo (Hungarian Oil & Gas Research Inst, Veszprem, Hung). *J Anal Appl Pyrolysis* v 12 n 3-4 Nov 1987 p 265-273.

## Recovery

**078026 PHENOLANREICHERUNG DURCH PERVAPORATION.** [Phenol Enrichment by Pervaporation]. Following a brief introduction to pervaporation principles and membranes, results of a study to separate aqueous phenols by pervaporation are presented. Phenols, when volatile with steam, are enriched from dilute solutions using highly selective elastomeric membranes, and from concentrated solutions using moderately selective anion exchange membranes. Process variables, in addition to the nature of the membranes, are downstream pressure (selectivity) and temperature (flux). A two-stage process scheme for phenol recovery is proposed, combining pervaporation with phase separation of the enriched permeates. (Author abstract) In German. 4 refs.

Boeddeker, Karl W.; Bengtson, Gisela. *Erdoel Kohle Erdgas Petrochem* v 40 n 10 Oct 1987 p 439-441.

## Reduction

**078027 DETERMINATION OF THE RATE CONSTANTS FOR A CECE REDUCTION MECHANISM.** We have made a generalized treatment of first-order kinetic processes in dc polarography, obtaining approximate analytic expressions, applicable to any conditions. This treatment is applied to the electrochemical reduction of O-nitrophenol, which undergoes a CECE mechanism in which both chemical stages influence the process simultaneously. All the rate constants involved in the process have been calculated. (Author abstract) 23 refs.

Heras, A.M. (Univ of Cordoba, Cordoba, Spain); Munoz, E.; Avila, J.L.; Camacho, L. *Electrochim Acta* v 32 n 10 Oct 1987 p 1495-1497.

**Removal** See Also SEWAGE TREATMENT—Activated Sludge; WASTEWATER—Biological Treatment; WASTEWATER—Treatment; WATER TREATMENT—Activated Carbon.

**078028 EFFICIENCY OF A COCURRENT CONTACT DEVICE IN A PHENOL-REMOVAL SCRUBBER.** The results of analysis of samples of tar supernatant in the circulating solution of sodium phenolates during testing of a cocurrent contact device, conducted without irrigation of the packing or a supply of fresh base for 3 days, are presented. According to the calculations, a depth of the gas-liquid layer of 0.25 m on a foam-swirl plate at a gas velocity in the device of 3.5 m/sec provides the same phenol distillation efficiency as a packing 5-6 m in depth. Thus, in order to minimize the size and weight of the device it appears most promising to design a device with three cocurrent contact devices in the absorption part of the device and three foam-swirl plates with total hydraulic resistance of 1.5 kPa in the description part. 5 refs.

Brodskii, E.V.; Gudimenko, S.V.; Sidogin, V.P.; Kovalenko, V.P.; Khomin, V.T.; Smirnov, E.A.; Babitsin, S.M. *Coke Chem (USSR)* n 5 1987 p 59-62.

**Separation** See Also SOLUTIONS—Separation.

**078029 ISOLATION OF TERT-ALKYLPHENOLS FROM THE PRODUCTS OF ALKYLATION OF PHENOLS.** A preliminary stage, flash evaporation of the reaction mass at 4-13 Pa for 5-15 min, is needed to prevent decomposition of tert-alkylphenols during their isolation from acid reaction mixtures by fraction. Flash distillation of high-boiling tert-alkylphenols should be conducted in presence of a component lowering the boiling point of the mixture, added in 1:(0.5-1.0) weight ratio of original mixture to the component. In the case of high-boiling compounds of low thermal stability, such as tert-dodecyl-phenols and tert-butylhydroquinones, flash evaporation was performed in the presence of a component boiling at a lower temperature than the main substance. The most suitable component for this purpose is phenol, but good results were also obtained with the use of alkylphenols. Results are also given of distillation, flash evaporation, and flash evaporation with a low-boiling component, of a reaction mixture containing hydroquinone, 2-tert-butylhydroquinone, and 2,5-di-tert-butylhydroquinone. 2 refs.

Nesterova, T.N. (V.V. Kuibyshev Polytechnic Inst, Kuibyshev, USSR); Verevkin, S.P.; Rempel, R.D.; Shashkin, N.P. *J Appl Chem USSR* v 60 n 2 pt 2 Feb 1987 p 347-349.

**Solutions** See LIQUIDS—Drop Breakup; OXYGEN—Adsorption; SOLUTIONS—Phase Equilibria.

## Solvent Extraction

**078030 SYNERGISM DURING EXTRACTION OF PHENOL WITH BINARY SOLVENT MIXTURES.** Extraction of phenol with mixtures of n-butyl acetate with solvents of various classes, leading to a synergistic effect, was studied; synergism coefficients (S) were calculated. It was established that the synergism effect weakens with a decrease in the extracting effectiveness of the less active components of the solvent mixture. The dependence of S on the phenol distribution coefficients ( $K_d$ ) in the solvent mixture-water system and also on the number of carbon atoms (n) in the molecules of extractant homologs ( $C_5\text{-}C_{10}$  alcohols) is described by straight lines; equations of the lines  $S = b(K_d)$  and  $S = b(n)$  are presented. (Author abstract) 3 refs.

Korenman, Ya.I. (Vorenezh Technological Inst, USSR); Minasyants, V.A.; Goncharova, M.V.; Podgurskaya, E.D. *Sov Prog Chem* v 53 n 10 1987 p 81-83.

**078031 LIQUID PHOSPHINE OXIDE: SOLVENT EXTRACTION OF PHENOL, ACETIC ACID AND ETHANOL.** A liquid phosphine oxide has been developed with a phosphoryl concentration of 2.3M, twice the maximum that can be reached in TOPO solvents at 50°C. Distribution coefficients are increased by  $2^{2m}$  where m relates to mols phosphoryl in the extracting complex. The value of m is 1.6 for phenol, 1.0 for acetic acid and 0.9 for ethanol. Kinetics are unchanged. Costs of extracting phenol with the new extractant and with isopropyl ether are compared. Extraction coefficient and separation factor for ethanol are compared with other potential extractants. (Author abstract) 15 refs.

Watson, E.K. (Cyanamid Canada Inc, Niagara Falls, Ont, Can); Rickelton, W.A.; Robertson, A.J.; Brown, T.J. *Solvent Extr Ion Exch* v 6 n 2 Apr 1988 p 207-220.

**Sorption** See Also ACRYLICS—Surface Properties.

**078032 CHEMISORPTION OF CATECHOL ON GIBBSITE, BOEHMITE, AND NONCRYSTALLINE ALUMINA SURFACES.** The mechanism of bonding of catechol and related phenolic compounds on aluminum oxides was elucidated from sorption behavior in the presence of competing adsorbates and the nature of the infrared spectra of the surface-bound molecules. The surfaces demonstrated a high degree of selectivity toward catechol, adsorbing the molecule in the presence of a large excess of chloride. Phosphate competed effectively with catechol for sorption sites while acetate did not. Catechol bound on the aluminum oxide surfaces was chemically



perturbed in much the same manner as catechol chelated by  $Al^{3+}$ , suggesting that the dominant sorption process involved the formation of a 1:1 bidentate complex with surface Al. The mechanism of bonding was similar for all the aluminum oxides, but the dominant crystal surfaces of the crystalline oxides were unreactive toward catechol, and adsorption was attributed to  $-AlOH$  groups situated on 'edge' faces. (Edited author abstract) 20 refs.

McBride, Murray B. (Cornell Univ, Ithaca, NY, USA); Wessellink, Lambert G. *Environ Sci Technol* v 22 n 6 Jun 1988 p 703-708.

## Spectrum Analysis

**078033 BINDING OF PHENOLS AND PHENOXY-IDE IONS TO CATIONIC MICELLES.** The proton NMR spectra of phenol, p-cresol, and p-ethylphenol bound to micelles of cetyltrimethylammonium bromide (CTABr) support binding adjacent to the cationic head groups. Anions of these phenols and of p-n-propylphenol and p-t-amyphenol also bind adjacent to the head groups. Changes in the chemical shifts of the hydrogen atoms of the surfactant due to interactions with the ring current of the solute are consistent with its inserting into the micelle rather than binding tangentially. (Author abstract) 33 refs.

Bunton, Clifford A. (Univ of California, Santa Barbara, CA, USA); Cowell, Charles P. *J Colloid Interface Sci* v 122 n 1 Mar 1988 p 154-162.

## Synthesis

**078034 HYDROGENOLYSIS OF LIGNIN IN HYDROGEN-DONOR VEHICLE.** Kraft lignin, slurried with tetralin, was hydrogenolyzed at 400-420°C with the  $FeCl_3$  or  $ZnCl_2$  catalyst to give phenol and cresols. The effects of reaction conditions were studied. With the  $FeCl_3$  catalyst, the acidic fraction of the products amounted to 24 percent, and it consisted of phenols having no methoxyl groups.  $ZnCl_2$  was less effective as the catalyst. (Edited author abstract) 5 refs.

Sugita, Toshio (Kyoto Univ, Kyoto, Jpn); Tsuji, Yasuo; Mori, Hiroyuki. *Chem Express* v 3 n 8 Aug 1988 p 507-510.

## Toxicity

**078035 TOXICITY OF PHENOL TO ASELLUS AQUATICUS (L.) - EFFECTS OF TEMPERATURE AND EPISODE EXPOSURE.** The toxicity of phenol to the freshwater crustacean *Asellus aquaticus* was assessed by use of three response criteria (immobilization, paralysis and mortality). Median response times were longer (i.e. phenol appeared less toxic) at higher temperatures and reasons for this are discussed. Immobilized animals were able to recover from brief periods of exposure if placed in clean water, the rate of recovery being dependant upon exposure time, exposure concentration and temperature during exposure and recovery periods. The implications of this study for an understanding of pollution incidents are discussed. (Author abstract) 29 refs.

Green, David W.J. (Univ of Wales, Cardiff, Wales); Williams, Kendall A.; Hughes, David R.L.; Shaik, Gulnazbi A.R.; Pascoe, David. *Water Res* v 22 n 2 Feb 1988 p 225-231.

**078036 REDUCTION IN ORGANIC EFFLUENT STATIC ACUTE TOXICITY TO FATHEAD MINNOWS BY VARIOUS AERATION TECHNIQUES.** This study compared results of no aeration, intermittent aeration, and constant aeration strategies in determining the static acute (48-h) toxicity of phenolic-based effluents to adult fathead minnows (*Pimephales promelas*). Toxicity was greatest in no aeration tests followed by intermittent aeration and constant aeration. Aeration strategies in these studies demonstrated potential air-stripping of volatile compounds, although stress to test organisms from low dissolved oxygen was relieved. (Edited author abstract) 28 refs.

Belanger, Scott E. (Virginia Polytechnic Inst & State

Univ, Blacksburg, VA, USA); Farris, Jerry L.; Cherry, Donald S. *Environ Pollut* (1987) v 50 n 3 1988 p 189-210.

**078037 MATERIALS TO BE USED IN VALIDATION OF MAXIMUM ALLOWABLE CONCENTRATION OF PHENOL TETRAFLUORETHYL ETHER IN THE WORK ZONE AIR.** Tetrafluorethyl ether is a polymer used in radio and electric wire industry as an insulating material. This study investigates its toxicity and threshold quantity of its vapors in the working zone air. Experimental tests in mice and rats are described. Medium toxicity of tetrafluorethyl ether is assessed. In Russian.

Ibatullina, R.B.; Korneeva, R.V.; Lapina, L.M.; Melnikova, N.N.; Gracheva, K.M.; Yaglov, V.V.; Katosova, L.D. *Gig Tr Prof Zabol* n 2 Feb 1988 p 47-48.

Trace Analysis See WATER ANALYSIS—Trace Analysis.

## PHENOXY RESINS

### Blending

**078038 SOLID STATE BEHAVIOUR AND PROPERTIES OF PLASTICIZED CELLULOSE ACETOBUTYRATE/PHENOXY BLENDS.** Blends of commercial plasticized cellulose acetobutylate (CAB) and the polyhydroxypropylether of bisphenol A (Phenoxy) were obtained in order to study the possibility of the plasticizer of the CAB to be distributed in the blend and to change the miscibility behaviour and the mechanical properties of the blends. During melt mixing the plasticizer of the CAB migrated to the phenoxy and changed the positions of the transitions of the blends. This change in the  $T_g$  values did not show any influence on the miscibility level. An antiplasticization process was evident, giving rise to higher modulus but poor ductilities in the blends. (Author abstract) 14 refs.

Jurado, M.J. (Univ del Pais Vasco, San Sebastian, Spain); Gaztelumendi, M.; Nazabal, J.; Mondragon, I. *Mater Chem Phys* v 18 n 4 Dec 1987 p 343-350.

### Degradation

**078039 SURFACE PHOTO-OXIDATION OF PHENOXY RESIN AND POLYETHERETHERKETONE.** The changes in surface chemistry of phenoxy resin and polyetheretherketone during photo-oxidation were monitored by ESCA. Extensive oxygen uptake was observed for both materials and the data showed that oxidation of the phenyl rings had occurred. Comparison of phenoxy resin with its acetylated derivative indicated that the changes in surface chemistry of the former during the initial stages of exposure were not due to the hydroxyl group. (Author abstract) 6 refs.

Munro, Hugh S. (Univ of Durham, Durham, Engl); Clark, D.T.; Recca, A. *Polym Degradation Stab* v 19 n 4 1987 p 353-363.

## Synthesis

**078040 CATALYSIS BY CYCLODEXTRIN FOR para-ORIENTED ATTACK OF FORMALDEHYDE TO PHENOL.** Previously, the authors showed that 4-hydroxybenzaldehyde and 4-hydroxybenzoic acid are prepared at virtually 100 percent selectivity by use of cyclodextrins as catalysts. The present paper reports the catalytic effects of cyclodextrins in the formation of (hydroxymethyl)phenols from formaldehyde and phenol. Cyclodextrins exhibit significant increase in selectivity and yield for the formation of (4-hydroxymethyl)phenol. 4 Refs.

Komiyama, Makoto (Univ of Tsukuba, Tsukuba, Jpn). *Polym J* v 20 n 5 1988 p 439-440.

## PHONOGRAPH RECORDS

**078041 NO GUTS, NO GLORY: ENTREPRENEUR PLACES BIG BET ON CDS.** Revolutionary new digital audio compact discs (CDs), developed only five years ago, reportedly will completely replace traditional vinyl records as the dominant musical home entertainment media in the U.S. by 1995. This report describes the inside of Technetronics, and examines the philosophies driving the company's management style and manufacturing plan. Also included is a detailed report on Technetronics' exciting new third-generation CD manufacturing technology of the monoline. Rather than relying on complex methods to recreate a plant's environment to suit the disc during its critical stage of manufacture, Technetronics opted on shielding the disc itself from the normal environment of a plant. Hands-off automation is said to virtually eliminate damaging sensitive disc surfaces after metalization.

Kirkland, Carl (Plastics World, Newton, MA, USA). *Plast World* v 45 n 9 Aug 1987 p 40-42,44-46.

Processing See SIGNAL PROCESSING—Digital Techniques.

## PHONOGRAPHS

### Digital Devices

**078042 CD PLAYER TECHNOLOGIES.** CD players have rapidly been accepted since they were marketed because of their high sound quality. In order to enhance their features, some improvements have been made in CD technology by introducing new systems and developing new LSIs. In pursuing higher sound quality, high-fidelity reproduction of low-level signals and economy has been achieved by developing a 4-DAC 18-bit high resolution system and a CMOS DF/DAC LSI. As a result, a dynamic range of more than 100 dB, an S/N ratio of more than 113 dB, and a total harmonic distortion of less than 0.0025% have been attained. In pursuing operational convenience, signal processing of LSIs having a 'digital out' function and a peak level detecting function have been developed for compatibility with future digital audio systems and automation of tape dubbing. Also, a CD player system using these LSIs has been developed. The new technologies are mainly applied to the SL-P990/P770 Technics CD player. (Edited author abstract) In Japanese. 2 refs.

Yamada, Jiro; Nishida, Koji; Tanaka, Yoshiichi; Nagata, Atsushi. *Natl Tech Rep Matsushita Electr Ind Co* v 32 n 2 Apr 1988 p 12-18.

**078043 RX-FD75 CD RADIO-CASSETTE PLAYER WITH MULTIPLE FUNCTIONS.** As the CD radio-cassette player market has remarkably expanded in recent years, demand for better sound quality and more recording functions is increasing. In order to meet these demands, CD units, full logic auto-reverse mechanisms, cabinet structure for better sound quality, etc. have been developed. By the employment of these new element techniques, the RX-FD75 high-class CD radio-cassette player with superior sound quality and multiple functions has been developed. (Author abstract) In Japanese. 2 refs.

Kawai, Michio; Sakamoto, Noriyuki. *Natl Tech Rep Matsushita Electr Ind Co* v 32 n 2 Apr 1988 p 86-92.

**PHONONS** See Also ALKALI METAL COMPOUNDS—Spectroscopic Analysis; BAND STRUCTURE; CESIUM COMPOUNDS—Electronic Properties; CRYSTALS—Defects; CRYSTALS—Electric Field Effects; CRYSTALS—Electronic Properties; CRYSTALS—Structure; DIELECTRIC MATERIALS—Radiation Effects; ELECTRONS—Resonance; ELECTRONS—Tunneling; GLASS—Optical Quality; GLASS—Specific Heat; GLASS—Spectroscopic Analysis; GRAPHITE; GRAPHITE—Structure; INDIUM THALLIUM ALLOYS—Microstructure; IRON AND ALLOYS—Thermal Effects; IRON AND STEEL METALLOGRAPHY—Martensite; LITHIUM AND ALLOYS—Pressure Effects; LITHIUM COMPOUNDS; MAGNETIC MATERIALS—Ferromagnetism; MERCURY AND AMALGAMS—Physical Properties; METALLOGRAPHY—Transformations; MOLECULAR CRYSTALS; MOLECULAR CRYSTALS—Spectroscopic Analysis; MOLECULES—Adsorption; NIOBIUM COM-



POINTS—Electric Conductivity; POLYMERS—Electric Conductivity; POTASSIUM COMPOUNDS—Structure; SEMICONDUCTING ALUMINUM COMPOUNDS—Optical Properties; SEMICONDUCTING ALUMINUM COMPOUNDS—Physical Properties; SEMICONDUCTING ALUMINUM COMPOUNDS—Pressure Effects; SEMICONDUCTING CADMIUM COMPOUNDS—Spectroscopic Analysis; SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers; SEMICONDUCTING GALLIUM ARSENIDE—Electronic Properties; SEMICONDUCTING GALLIUM ARSENIDE—Physical Properties; SEMICONDUCTING GALLIUM ARSENIDE—Radiation Effects; SEMICONDUCTING GALLIUM COMPOUNDS—Charge Carriers; SEMICONDUCTING GALLIUM COMPOUNDS—Doping; SEMICONDUCTING GALLIUM COMPOUNDS—Spectroscopic Analysis; SEMICONDUCTING LEAD COMPOUNDS—Charge Carriers; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Physical Properties; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES—MOSFET—Magnetic Field Effects; SEMICONDUCTOR MATERIALS—Amorphous; SEMICONDUCTOR MATERIALS—Calculations; SEMICONDUCTOR MATERIALS—Charge Carriers; SEMICONDUCTOR MATERIALS—Crystal Lattices; SEMICONDUCTOR MATERIALS—Defects; SEMICONDUCTOR MATERIALS—Impurities; SEMICONDUCTOR MATERIALS—Optical Properties; SEMICONDUCTOR MATERIALS—Photoconductivity; SEMICONDUCTOR MATERIALS—Physical Properties; SEMICONDUCTOR MATERIALS—Surfaces; SILICON AND ALLOYS—Thermal Conductivity; SOLIDS—Electronic Properties; SOLIDS—Order-Disorder; SPECTROSCOPY, ABSORPTION—Theory; SUPERCONDUCTING MATERIALS; SUPERCONDUCTING MATERIALS—Calculations; SUPERCONDUCTING MATERIALS—Composition Effects; SUPERCONDUCTING MATERIALS—Electronic Properties; SUPERCONDUCTING MATERIALS—High Temperature Effects; SUPERCONDUCTING MATERIALS—Optical Properties; SUPERCONDUCTING MATERIALS—Physical Properties; SUPERCONDUCTIVITY—Theory; TITANIUM AND ALLOYS—Diffusion; TRANSISTORS, FIELD EFFECT; TRANSITION METALS—Crystal Lattices.

**078044 FLUXES OF NONEQUILIBRIUM PHOTO-EXCITED PHONONS ALONG SURFACES OF CRYSTALS WITHOUT AN INVERSION CENTER.** The flux of nonequilibrium phonons excited by light in the near-surface domain of a crystal or a thin plate is investigated. An exact expression is obtained for the phonon energy flux for a crystal with a polar direction and its polarization dependence is analyzed. The magnitude of the energy flux can reach the incident light intensity. The temperature difference produced by the flux of nonequilibrium photo-excited phonons is found. (Author abstract) 6 refs.

Blokh, M.D. (Novosibirsk Inst of Geodesy, Aerial Photography & Cartography Engineers, USSR). *Sov Phys J* v 30 n 7 Jul 1987 p 581-584.

**078045 STUDY OF THE ISOCHORIC FREQUENCY SHIFT OF THE PHONONS IN Al AND Cu.** The temperature dependences of phonon frequencies for Al and Cu have been measured under constant volume as a function of the wave vector  $k$  by means of inelastic neutron scattering. The isochoric condition was achieved by using high pressure. The common feature of the present results for Al and Cu as well as the previous results for solid Ne by Skalyo et al., is that the frequency shift for  $k$  less than  $0.5 (2\pi/a)$  can be expressed as  $-\alpha k/(1 + 3k^2)$ , where  $\alpha$  is inversely proportional to the melting temperature. This result can be understood by means of a nonlinear wave theory which is based on the modified Korteweg-de Vries equation. (Author abstract) 16 refs.

Nakai, Y. (Osaka Univ, Toyonaka, Jpn); Kunitomi, N.; Hagen, M.; Nicklow, R.M.; Onodera, A. *Solid State Commun* v 64 n 5 Nov 1987 p 783-788.

**Impurities** See SUPERCONDUCTIVITY—High Temperature Effects.

## Magnetic Field Effects

**078046 MAGNETIC-FIELD EFFECT ON THE PHONON ECHOES IN A RARE-EARTH-DOPED GLASS.** We have observed phonon echoes in a holmium-doped aluminosilica glass, down to 10 mK, up to 60 kOe, in the acoustic frequency range 450-800 MHz. The echo amplitude increases by a factor 3 as the magnetic field increases from 0 to 60 kOe. The magnetic field acts also on the phonon-echo decays. A saturation recovery experiment is reported. The tunneling-state-lattice relax-

ation time increases by a factor 6 as the magnetic field increases from 0 to 60 kOe. Relaxation of the tunneling states by the rare-earth ions is considered. (Author abstract) 23 refs.

Lerbet, F. (Univ Paris-Sud, Orsay, Fr); Bellessa, G. *J Phys (Paris)* v 48 n 8 Aug 1987 p 1251-1254.

## Mathematical Models

**078047 OPTICAL SOLITONS THROUGH AN HARMONIC VIBRATIONAL MODE.** An optic field interacting with an infrared active vibrational mode with a cubic nonlinearity is considered. The slowly varying envelope of the electric field is shown to satisfy the nonlinear Schrodinger equation. Various aspects of the model are discussed. (Author abstract) 15 refs.

Gursev, Yusuf (Yale Univ, New Haven, CT, USA). *Int J Eng Sci* v 25 n 11-12 1987 p 1491-1496.

**Measurements** See SEMICONDUCTOR DEVICES—Heterojunctions.

**Physical Properties** See Also COPPER AND ALLOYS—Surface; CRYSTALS—Lattice Vibrations.

**078048 PHONONS.** This chapter deals with phonons, namely vibration modes of a periodic array of atoms in a crystal. We summarize the basic concepts. 37 refs.

Pick, R. (Univ Pierre et Marie Curie, Paris, Fr); Takemori, T. *Cryst Semicond Mater Devices, Trieste, Italy, 1984* Publ by Plenum Press, New York, NY, USA, 1988 p 103-130.

## Spectroscopic Analysis

**078049 SPECTROSCOPY OF BALLISTIC PHONONS REFLECTED FROM A LEAD FILM IN INTERMEDIATE STATE.** The phonon reflection from solid-solid interfaces has been investigated by means of the heat pulse technique, but the contribution of the electrons is not yet understood. In order to clarify this role, we have studied the phonon reflection from a silicon-Pb film held in the intermediate state by a perpendicular magnetic field. We observed an increase in the intensity of the reflected phonons below the critical field. We interpreted this effect as a phonon reemission from the Pb film back into the crystal. (Edited author abstract) 14 refs.

Boragno, C. (Univ di Genova, Genoa, Italy); Valbusa, U. *Solid State Commun* v 65 n 4 Jan 1988 p 267-270.

## Spectrum Analysis

**078050 PHONONS RADIATED BY MOVING DISLOCATIONS IN DISORDERED ALLOYS.** Lattice dynamics calculations together with the Green's function techniques for disordered systems are used to describe the phonon spectrum radiated by a moving dislocation in a random alloy. The attenuation of these waves by scattering at the impurities and by excitation of local modes is evaluated. Large amplitude vibrations of the impurities are predicted and modification of the diffusion behavior in the neighborhood of the dislocation is suggested. (Author abstract) 16 refs.

Ramos de Debiaggi, S. (Centro Atomico Bariloche, San Carlos de Bariloche, Argent); Caro, A. *J Phys (Paris)* v 48 n 9 Sep 1987 p 1499-1504.

**078051 SCATTERING OF PHONONS BY VACANCIES.** The scattering of phonons by vacancies is estimated by a perturbation technique in terms of the missing mass and the missing linkages. An argument is given why distortion effects can be disregarded. The resonance frequency of the defect is sufficiently high so that resonance effects can be disregarded for phonons in the important frequency range for thermal conduction. The theory is applied to the thermal resistance by vacancies in cases where the vacancy concentration is known: potassium chloride with divalent cations, nonstoichiometric zirconium carbide, and tin telluride. (Author abstract) 18 refs.

Ratsifaritana, C. A. (Univ of Madagascar, Antananarivo, Madagascar); Klemens, P. G. *Int J Thermophys* v 8 n 6 Nov 1987 p 737-750.

**Surfaces** See GRAPHITE—Physical Properties.

## Theory

**078052 PHONONS AND QUANTUM FLUCTUATIONS IN A DIMERIZED ELECTRON-PHONON CHAIN.** Quantum fluctuations in a dimerized electron-phonon chain are studied within the Su-Schrieffer-Heeger model using a  $1/n$  expansion. The calculated phonon spectrum differs appreciably from recent results of Rice et al., and quantum corrections to the phonon order parameter are found to be smaller than those predicted by Monte Carlo simulations. (Edited author abstract) 10 refs.

Psaltakis, G.C. (Research Cent of Crete, Iraklion, Crete, Greece); Papanicolaou, N. *Solid State Commun* v 66 n 1 Apr 1988 p 87-92.

**Thermal Effects** See SUPERCONDUCTING MATERIALS—Thermal Effects.

## PHOSPHATE DEPOSITS

### Africa

**078053 CARACTERISATION GRANULOMETRIQUE DU GISEMENT DE PHOSPHATE DU DJEBEL ONK IMPLICATIONS MINERALURGIQUES.** [Size Range Definition of the Phosphate Deposit of Djebel Onk Mineralogical Implications]. The size range definition of the phosphate ore of Djebel Onk reveals characteristic size range systems at 125  $\mu$ m and 450-630  $\mu$ m for the phosphate particles, as well as at 80  $\mu$ m for the dolomite and quartz elements. A study of the sequential evolution of these size range systems shows that their position is constant in the deposit and that merely the size range stock which they represent will vary. A knowledge of these characteristics of the size range permits the setting up of a flow sheet for the treatment which does not reach the standard temperatures of carbonate removal, thus preserving the reactivity of the ore. The result obtained in the laboratory on crude ore samples, assaying 22-23%  $P_2O_5$ , show a gain of 7-8%  $P_2O_5$  in the fraction of 100  $\mu$ m-1 mm which is of possible value. In French. 10 refs.

Hamdadou, M. (Ecole Natl Supérieure de Geologie Appliquée, Nancy, Fr); Champetier, Y. *Ind Miner Mines Carrieres Tech* v 69 Suppl to Jun 1987 p 199-205.

**Alberta, Canada** See ROCK—Sedimentary.

### Exploration

**078054 PHOSPHORITE MANIFESTATIONS IN THE NORTHERN PART OF THE POLAR URALS.** In the course of geological surveys and thematic studies on the western slope of the Polar Urals and in adjacent regions a whole series of phosphorite ore manifestations and deposits of various geological-industrial and genetic types was revealed. With respect to phosphorus content and reserves the manifestations of greatest interest are microgranular and nodular phosphorites of geosynclinal type and infiltration-Karst ores of weathering crusts. The outlook for the discovery of phosphorite ore deposits of these types on the eastern slope of the northern part of the Polar Urals (The Sob' River basin) is discussed. In Russian. 4 refs.

Shadrin, L.F.; Zudina, S.P.; Ostrovskii, L.Ya.; Kostyuk, M.A. *Razved Okhr Nedr* n 10 Oct 1987 p 20-22.

### Florida

**078055 RECOVERY OF PHOSPHATE FROM FLORIDA PHOSPHATE SLIMES.** The Bureau of Mines conducted tests on samples of two Florida phosphate slimes to devise a technique to recover phosphate currently discarded because of its fine size. A flotation technique was devised to recover the phosphate contained in two fractions of each slime: the plus 37- $\mu$ m fraction and



the plus 20- $\mu$ m fraction. The technique involved conditioning the flotation feed with sodium silicate and a fatty acid-fuel oil emulsion, floating a rougher phosphate concentrate, and cleaning the concentrate in two cleaner stages with sodium silicate added to each for gangue depression. Concentrates containing 21.0 to 32.3 pct  $P_2O_5$  were produced with recoveries of 68.1 to 84.2 pct of the  $P_2O_5$  contained in the flotation feed. (Author abstract) 7 refs.

Davis, B.E. (Bur of Mines, Tuscaloosa, AL, USA); Davis, E.G.; Llewellyn, T.O. *Rep Invest US Bur Mines* 9110 1987 17p.

Jordan See CLAY MINERALS.

Peru See Also GEOLOGY—Sedimentology.

**078056 DISTRIBUTION, TEXTURE AND COMPOSITION OF MODERN PHOSPHATE PELLETS IN PERU SHELF MUDDS.** Textural analysis, including estimates of concentrations of authigenic phosphate pellets, were made for right sediment cores from the Peru continental margin. Phosphatic pellets separated from these modern organic-rich sediments are black, spherical-ovoidal in shape, and in thin section often display a concentric structure around a nucleus consisting of inorganic mineral grains. Some pellets have a gray-white exterior coating which appears to be secondary diagenetic calcite. Phosphatic pellets account for upwards of 80 percent of the sediment mass in some cores. Pellets concentrate in specific size classes, generally between 125 and 500  $\mu$ m in diameter, and occur within a poorly sorted sediment. (Author abstract). 50 Refs.

Baker, K. Bryan (Florida State Univ, Tallahassee, FL, USA); Burnett, William C. *Mar Geol* v 80 n 3 pt 4 May 1988 p 195-213.

**078057 URANIUM-SERIES AND AMS  $^{14}C$  STUDIES OF MODERN PHOSPHATIC PELLETS FROM PERU SHELF MUDDS.** Recent sediments and separated phosphate pellets from the Peru shelf have been analyzed for uranium decay-series isotopes and  $^{14}C$  in order to determine age relationships and mineralization rates. Uranium-series ages of pellets separated from one box core are significantly higher than AMS radiocarbon ages determined for the same pellets. These differences appear to be a consequence of mixing of an older generation of pellets with ones which are more recently formed. High concentrations of phosphate pellets have accumulated in some Peru shelf sediments without extensive reworking. Individual pellets apparently form very quickly, on time scales of a few years. Estimated authigenic uptake rates of phosphorus into pellets ranges from 0.5 to 9.40  $\mu$ mol-P  $cm^{-2} yr^{-1}$ , somewhat higher than rates measured for nodules from the same area. (Edited author abstract). 30 Refs.

Burnett, William C. (Florida State Univ, Tallahassee, FL, USA); Baker, K. Bryan; Chin, Philip A.; McCabe, William; Ditchburn, Robert. *Mar Geol* v 80 n 3 pt 4 May 1988 p 215-230.

**078058 PETROLOGY AND MAJOR ELEMENT GEOCHEMISTRY OF PERU MARGIN PHOSPHORITES AND ASSOCIATED DIAGENETIC MINERALS: AUTHIGENESIS IN MODERN ORGANIC-RICH SEDIMENTS.** New petrographic and major element geochemical data from modern Peru margin upper slope-outer shelf phosphorites are presented, which provide insight into their origin and paragenetic relationship with other authigenic minerals (glauconite, pyrite and dolomite) occurring in organic-rich sediments. Glauconites are precipitated relatively early following the partial reduction of ferric iron and, following this process, phosphate, pyrite, and then dolomite precipitation take place at progressively deeper levels in the sediment in association with microbial reduction of sulfate. The phosphatic facies here consist of nodules, crusts, coatings and strata composed of phosphatic pelletal grains in association with organic-rich biosiliceous sediments. All are considered to have formed within a few centimeters or within a few tens of centimeters below the

sediment-water interface. Bacterial mediation may play an important, but as yet unspecified role in the precipitation process. Depth-stratified threshold carbonate ion concentrations may control the lower limit at which phosphatic minerals may precipitate. Additional aspects of the subject are discussed. (Edited author abstract). 130 Refs.

Glenn, Craig R. (Univ of Rhode Island, Narragansett, RI, USA); Arthur, Michael A. *Mar Geol* v 80 n 3 pt 4 May 1988 p 231-267.

**078059 RARE EARTH ELEMENTS IN THE PHOSPHATIC-ENRICHED SEDIMENT OF THE PERU SHELF.** Apatite-enriched materials from the Peru shelf have been analyzed for their major oxide and rare earth element (REE) concentrations. The samples consist of (1) the fine fraction of sediment, mostly clay material, (2) phosphatic pellets and fish debris, which are dispersed throughout the fine-grained sediment, (3) tabular-shaped phosphatic crusts, which occur within the uppermost few centimeters of sediment, and (4) phosphatic nodules, which occur on the seafloor. The bulk REE concentrations of the concretions suggest that these elements are partitioned between the enclosed detrital material and the apatite fraction. Analysis of the fine-grained sediment with which the samples are associated suggested that this detrital fraction in the concretions should have shale REE values; the analysis of the fish debris suggested that the apatite fraction might have seawater values. The REE pattern of the pelletal apatite suggests a seawater source and the absolute REE concentrations are relatively high. Subtle variations in the depositional environment might cause a significant variation in the REE content of this authigenic fraction of the sediment. Additional aspects of the subject are discussed. (Edited author abstract). 30 Refs.

Piper, David Z. (US Geological Survey, Menlo Park, CA, USA); Baedeker, Philip A.; Crock, James G.; Burnett, William C.; Loebner, Benny J. *Mar Geol* v 80 n 3 pt 4 May 1988 p 269-285.

## PHOSPHATE MINES AND MINING

**078060 POTENTIAL FOR MARINE MINING OF PHOSPHATE WITHIN THE U.S. EXCLUSIVE ECONOMIC ZONE (EEZ).** The U.S. phosphate industry has, historically, been the dominant world producer. However, the industry has recently been facing growing pressures by the exhaustion of low-cost land-based resources, foreign competition, unfavorable public policies resulting from environmental concerns, and attractiveness of alternative land uses. Even though phosphorus is not recognized as a strategic mineral, its important role in the production of inorganic fertilizer demands that special attention be given to the future of the industry. Survival of the industry in the future, in part, depends upon its successful application of a suitable mining technology, such as hydraulic slurry mining, to either the deep, high-grade, land-based resources, or the offshore deposits within the Exclusive Economic Zone (EEZ). Potentials of the offshore phosphate deposits of southern California, Georgia and North Carolina are compared. Based on the available geological knowledge, this paper identifies the deposits on the North Carolina continental shelf, especially the Frying Pan Area, as the most promising for exploitation in the near future. (Author abstract) 30 refs.

Marvasti, A. (East Carolina Univ, Greenville, NC, USA); Riggs, S. *Mar Min* v 6 n 3 1987 p 291-300.

## Economics

**078061 ECONOMIC AND ENVIRONMENTAL COMPARISON: BOREHOLE MINING VERSUS CONVENTIONAL MINING OF PHOSPHATE.** An economic comparison of the borehole mining system with conventional dragline and bucket wheel excavator mining systems was completed at various mining depths and production rates. Hypothetical phosphate deposits, with various overburden thicknesses and reserve tonnage, are defined. Geologic conditions necessary for the application of the borehole system are identified. Discounted cash

flow analyses based on derived capital and operating costs are used to generate rates of return and product prices. (Edited author abstract) 14 refs.

Hrabik, J.A. (US Bur of Mines, Pittsburgh, PA, USA). *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt A 1986 p 33-39.

## Florida

**078062 IMC'S PHOSPHATE MINES IN FLORIDA.** IMC Fertilizer Inc. is a wholly-owned subsidiary of International Minerals & Chemical Corporation, headquartered in Northbrook, Illinois. It is the world's largest private enterprise producer of phosphate rock and a major world producer of phosphate chemical fertilizers. The company's phosphate mining operations in Florida are reviewed with respect to geology, mining and milling operations including the phosphate fertilizer plant.

Anon. *Min Mag* v 157 n 5 Nov 1987 5p between p 444 and 451.

## Georgia

**078063 EVALUATION OF POTENTIAL RADON EXPOSURE FROM DEVELOPMENT OF GEORGIA PHOSPHATE DEPOSITS.** This paper estimates the magnitude of any radon-based health effects that might arise from future mining operations in selected areas of the Georgia coastal region. To do this, a calculational model was developed that took into account the mining operations themselves, the atmospheric dispersion of the radon released, and the radon daughter concentrations in nearby towns. The model was applied to both extremes. The first application was a hypothetical mining operation in Echols County. The second application was at a site near Savannah, Georgia. Both sites contain economically feasible phosphorite deposits. According to both calculations, there is very little health risk from such mining operations to the general public. 10 refs.

Eichholz, G.G. (Georgia Inst of Technology, Atlanta, GA, USA); Ambrose, J.P.; Skowroski, M.G. *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt A 1986 p 195-196.

## Mathematical Models

**078064 ANALYSIS AND MODELING OF A PROPOSED MINING AND BENEFICIATION PROCESS.** The purpose of this research was to develop an analytic model of a proposed phosphate mine which could be used to predict the quality of the water within the system throughout the useful life of the mine. The water quality is determined by tracking the concentrations of various chemical ions at key locations in the mining and beneficiation process. In this paper we will describe the features of the proposed process, analyze the process and develop a nonstationary differential flow network model, discuss model assumptions and exogenous driving functions, compare steady-state model results with a laboratory simulation, and, finally, present dynamic modeling results. (Author abstract) 6 refs.

Hodgson, Thom J. (North Carolina State Univ, Raleigh, NC, USA); King, Russell E.; McClave, James T.; Sullivan, James H.; Zegel, William C. *Ind Eng Chem Res* v 26 n 11 Nov 1987 p 2223-2228.

Morocco See INDUSTRIAL TRUCKS—Scheduling.

Recovery See PHOSPHATE DEPOSITS—Florida.

## PHOSPHATE ORE TREATMENT

Beneficiation See Also PHOSPHATE MINES AND MINING—Mathematical Models.

**078065 BENEFICIATION OF A DOLOMITIC PHOSPHATE PEBBLE FROM FLORIDA.** A different version of the modified Crago-TVA process was developed for beneficiation of a weathered dolomitic phosphate pebble from Florida. In this process, the phosphate



mineral first is concentrated with fatty acid and fuel oil in the overflow and then refloated to remove additional coarse dolomite in the underflow. The concentrate from the cleaner flotation stage then is subjected to conventional deoiling, but not silica flotation with amine. The remaining dolomite contaminant in the phosphate concentrate is finally floated as waste by using TVA's diphosphonic acid depressant process. (Edited author abstract) 7 refs.

Hsieh, Shuang-shii. *Ind Eng Chem Res* v 27 n 4 Apr 1988 p 594-596.

**078066 INTERACTION OF THE COMPONENTS OF PHOSPHATE ORES WITH DILUTE SULFURIC ACID SOLUTIONS.** This investigation was carried out in connection with development of methods for flotation and chemical beneficiation of phosphate ores. The experiments were conducted at 20, 40, 60, and 80° in the pH range of 1.5-4, with reaction times from 5 to 60 min. It is shown that an increase of pH is accompanied by decrease of  $K_v$ , which approaches zero at pH above 2.5. This is the region of practical significance for selective leaching of magnesium compounds from phosphate ores during flotation and chemical beneficiation. Intensive decomposition of shell rock begins at pH below 2.5, whereas dolomite is decomposed by sulfuric acid over the entire acidity range studied (pH=1.5-4). In order to achieve 60-80% decomposition of carbonates 10-20 min (pH=2-3) is sufficient, whereas at least 2 h is required in order to attain similar degrees of decomposition of shell rock at pH=1.5-2.5 refs.

Trushchenko, N.N.; Belyakov, V.A.; Pozin, M.E. *J Appl Chem USSR* v 60 n 8 pt 1 Aug 1987 p 1573-1576.

**078067 INNOVATIVE PROCESS FOR BENEFICIATION OF DOLOMITIC PHOSPHATE ORES.** In current phosphate beneficiation practice, double-float froth flotation is widely used for upgrading siliceous phosphatic ores. However, this process has generally been ineffective for beneficiating high dolomite/limestone phosphate ore because the fatty acid collectors used to float phosphate minerals also collect carbonate minerals. This work describes a new approach for selective fatty acid carbonate/phosphate flotation. The technique employed allows selective removal of carbonate gangue in the forth without the specific use of a phosphate depressant and without conditioning the pulp with the fatty acid collector. The samples tested were two dolomitic ores (Jhamarkotra, India and Guizhou, China), one dolomitic calcareous siliceous ore (Mussoorie, India) and a dolomitic siliceous ore (South Florida). 4 refs.

Anazia, Ibezim (Univ of Alabama, Tuscaloosa, AL, USA); Hanna, John. *Int J Miner Process* v 23 n 3-4 Jul 1988 p 311-314.

## Crushing and Grinding

**078068 WEAR OF 12 ALLOYS DURING LABORATORY MILLING OF PHOSPHATE ROCK IN PHOSPHORIC ACID WASTE WATER.** As part of its research on wear of mining and mineral processing equipment, the US Bureau of Mines evaluated the erosion-corrosion characteristics of 12 alloys in phosphoric acid waste water. Tests were conducted in ball mills by grinding phosphate rock in gypsum pond water with an initial pH of 1.6. For comparison, grinding tests were conducted in tap water. Static corrosion tests in gypsum pond water were also carried out. For all alloys tested, the wear by erosion-corrosion was greater than the sum of erosion plus static corrosion. A low-alloy high-carbon steel and a high-manganese nitrided stainless steel were the most cost-effective materials. (Edited author abstract) 4 refs.

Tylczak, J.H. (US Bur of Mines, Albany, OR, USA); Singleton, D.J.; Blickensderfer, R. *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt B 1986 p 187-190.

**078069 MILL SIZING FOR PHOSPHATE GRINDING IN MILLS OF 0.2 TO 5 METERS IN DIAMETER.** The breakage parameters of phosphate ore were determined by batch first-ordering grinding studies in a laboratory ball mill according to the Austin, Klimpel, and Luckie procedures. The results were scaled to five larger mills of 0.56, 0.82, 3.36, 4.41, and 5 m in diameter assuming equilibrium ball charges for the full-scale mills. The results are used to predict product size distributions and capacities for batch grinding in the smaller mills and open circuit grinding in the larger mills. The Bond method gave capacity predictions that were 45% to 150% too high. (Edited author abstract) 16 refs.

Rogers, R.S.C. (SOHIO, Bridgeport, NJ, USA); Austin, L.G.; Brame, K.A. *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt B 1986 p 240-246.

Decomposition See FERTILIZERS—Manufacture.

## Flocculation

**078070 FLOCCULATION OF FINE PARTICLES WITH POLYETHYLENE OXIDE: A PROPOSED MECHANISM.** Treatment of ores to recover metal and mineral values results in waste materials usually in the form of dilute slurries. The US Bureau of Mines investigated a technique for dewatering phosphatic clay waste by flocculating with polyethylene oxide (PEO) and dewatering the resulting flocs on a static screen and/or trommel screen. In the investigation, it was determined that PEO was superior to polyacrylamide polymers for this type of dewatering. This paper discusses reasons for this superior performance. 4 refs.

Scheiner, B.J. (US Bur of Mines, Tuscaloosa, AL, USA); Stanley, D.A. *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt A 1986 p 2115-2117.

Florida See PHOSPHATE MINES AND MINING—Florida.

## Flotation

**078071 NEW FLOTATION APPROACH FOR CARBONATE PHOSPHATE SEPARATION.** Selective fatty acid flotation of carbonate gangue from sedimentary apatite was achieved under acidic pH conditions without specific apatite depressant and without conditioning the pulp with the collector. Concentrates (35% to 38%  $P_2O_5$ , 0.8% to 1% MgO) with high recoveries (80% to 85%) were produced from Indian and Chinese dolomitic ores. The calcareous and/or dolomitic-siliceous phosphate ores from Florida and Utah required two flotation stages for carbonate removal and the other for recovery from siliceous gangue. Preliminary tests with Florida ore gave concentrates analyzing 21%  $P_2O_5$  and 0.8% MgO, with a  $P_2O_5$  recovery of 76%. A Utah ore gave concentrates analyzing 35%  $P_2O_5$  and about 1% MgO, with a  $P_2O_5$  recovery of 76%. (Edited author abstract) 11 refs.

Anazia, Ibezim (Univ of Alabama, Tuscaloosa, AL, USA); Hanna, John. *Int J Miner Process* v 23 n 4 Nov 1987 p 196-202.

**078072 CONDITIONING OF FLORIDA PHOSPHATE ROCK USING A GRAVITY-FLOW MIXER.** A conventional paddle-type mixer and a gravity flow mixing device were evaluated for conditioning of fine phosphate feed (-35 + 150 mesh) with fatty acid and fuel oil and for acid scrubbing prior to cationic flotation. Gravity flow mixing required less residence time but slightly higher reagent concentrations to achieve recovery levels similar to conventional conditioning. Grade was less sensitive to reagent concentration using the gravity flow mixer. For acid scrubbing, the gravity flow mixer proved equally effective. In this paper, the effect of time, pulp density, reagent concentration, and emulsification on conditioning and acid scrubbing efficiency of the two devices is discussed. (Author abstract) 9 refs.

Moudgil, B.M. (Univ of Florida, Gainesville, FL, USA); Ransdell, J.C. *Miner Metall Process* v 5 n 1 Feb 1988 p 17-21.

**078073 FLOTATION OF DOLOMITIC IMPURITIES FROM JHAMARKOTRA (INDIA) PHOSPHORITES.** Flotation separation of dolomite from Jhamarkotra phosphorite ore deposit in India, has been achieved using the two-stage conditioning process. An alternate process using a proprietary reagent scheme has also shown considerable promise in removal of dolomitic impurities. Hallimond cell flotation of the 65 × 100 mesh size fraction using sodium oleate as the collector yielded concentrates containing 35%  $P_2O_5$  and 0.9% MgO with phosphate recoveries in the range of 80-90%. The above-mentioned processes have also been determined to be equally effective in separating dolomitic impurities from sedimentary Florida phosphate rocks. The mechanism of selectivity for the two-stage conditioning process has been attributed to the higher collector adsorption on calcareous ore during the first stage of conditioning and changes in the chemical nature of the adsorbed species upon reconditioning at a lower pH. (Edited author abstract) 13 refs.

Moudgil, Brij M. (Univ of Florida, Gainesville, FL, USA); Ince, Dursun. *Int J Miner Process* v 24 n 1-2 Sep 1988 p 47-54.

Health Hazards See FERTILIZERS—Manufacture.

## Processing

**078074 DIGESTION OF PHOSPHATE ORE IN PHOSPHORIC ACID.** Phosphoric acid is used for fertilizer applications. To minimize environmental pollution by heavy metals, a new process is being designed. One of the important steps in this process is the complete digestion of phosphate ore in phosphoric acid. The rates of digestion of fluoroapatite particles in phosphoric acid were determined. The particle size was varied from 150 to 2000  $\mu$ m, the phosphoric acid concentration from 30 to 50 wt%  $P_2O_5$ , and the temperature between 60 and 90°C. The rate of digestion was found to be controlled by transport of calcium ions to the solution. A model for the digestion process was developed, based on the diffusion of calcium ions as the rate-limiting step. (Edited author abstract) 15 refs.

van der Sluis, Sietse (Technical Univ of Delft, Delft, Netherlands); Meszaros, Yulia; Marchee, Wim G.J.; Wesselingh, Hans A.; van Rosmalen, Gerda M. *Ind Eng Chem Res* v 26 n 12 Dec 1987 p 2501-2505.

## Roasting

**078075 STUDY OF THE GAS-PHASE COMPOSITION DURING THE ROASTING OF PHOSPHORITE PELLETS.** Studies have confirmed the possibility of reducing the concentration of harmful components in the gases coming from the roasting zone by reducing the residual moisture content of the pellets arriving in the high-temperature zone. A sharp decrease in the moisture content of the pellets reduces the action of the most active defluorinating agent - water vapor - and leads to a reduction of the concentration of fluorine compounds in the flue gases. In Russian. 3 refs.

Talkhaev, M.P.; Gal'perina, S.Ya.; Borisova, L.I.; Botryakova, V.A.; Ustelmova, L.I. *Khim Prom* n 4 1987 p 216-219.

## Waste Utilization

**078076 NOVEL TECHNIQUE FOR THE RECOVERY OF COARSE NORTH CAROLINA PHOSPHATE.** A technique was devised by the US Bureau of Mines to recover coarse +1.2-mm (14-mesh) North Carolina phosphate now discarded as waste. Concentration utilizes the difference in particle sphericity between the relatively flat calcite and the rounded phosphate pebbles. Sizing, treatment in a continuous hydraulic classification system, and grinding upgraded a 17%  $P_2O_5$  reject to 24.5%  $P_2O_5$  with a phosphate recovery of 63%. The  $CaO:P_2O_5$  ratio was reduced from 2.49 to 1.66. (Author abstract) 4 refs.

Davis, B.E. (US Bur of Mines, Tuscaloosa, AL, USA); Llewellyn, T.O.; Sullivan, G.V. *Trans Am Inst Min Metall*



Pet Eng Soc Min Eng AIME v 280 pt B 1986 p 198-200.

**PHOSPHATES** See Also CALCITE—Crystallization; CARBON—Activated; FERTILIZERS—Packaging; GLASS—Optical Properties; LIPIDS; LIPIDS—Structure; URANIUM COMPOUNDS—Precipitation.

**078077 CHARACTERIZATION OF TRICALCIUM PHOSPHATE POWDERS PREPARED BY SPRAY-PYROLYSIS TECHNIQUE.** Crystalline tricalcium phosphate (TCP) was directly prepared by the spray-pyrolysis technique from ethanol-nitric acid solution of calcium nitrate and phosphoric acid. The concentration of the solution  $[(Ca^{2+}) + (PO_4^{3-})]$  was 0.05-1.0 mol/l. The spray-pyrolysis temperature ranged from 1100° to 1400°C. TCP powders of the  $\alpha$  form were obtained under all experimental conditions studied. When the temperature of the powders being produced in the reaction zone was lower than the  $\beta \rightarrow \alpha$  phase transformation temperature, metastable  $\alpha$ -TCP was obtained though the  $\beta$  phase is thermodynamically stable. On the other hand, stable  $\alpha$ -TCP was obtained when the temperature of the powders was higher than the transformation temperature. (Edited author abstract) In Japanese. 13 refs.

Inoue, Senya (Kanto Chemical Co, Soka, Jpn); Kobayashi, Mikio; Ono, Akira. *Yogyo Kyokai Shi* v 96 n 2 1988 p 182-185.

**078078 HYDRAULICITY OF THE DICALCIUM PHOSPHATE-CALCIUM CARBONATE MIXTURE AND PROPERTIES OF THE RESULTING POROUS APATITE.** Dihydrate ( $CaHPO_4 \cdot 2 H_2O$ ; DCPD) and anhydride ( $CaHPO_4$ ; DCPA) of dicalcium phosphate are studied on their hydraulicity (hydration and hardening) induced by the addition of  $CaCO_3$  and properties of the resulting porous apatite. The hardening was caused by the entanglement of microcrystals of reaction products, i.e., carbonate-containing apatite and/or octacalcium phosphate. DCPD is hydrated and hardens more easily than DCPA. The addition of  $F^-$  accelerates the hydration reaction remarkably, however no hardening occurs. The resulting hardened apatite bodies have 70-80% porosity and a diametral tensile strength of 0.3-1.5 MPa. Sintered apatite bodies prepared by heating the hardened bodies are densified to 45-60% and strengthened to 0.7-4.8 MPa. (Edited author abstract) In Japanese. 10 refs.

Monma, Hideki (Nat Inst for Research in Inorganic Materials, Tsukuba, Jpn); Kawasaki, Tsutomu; Takahashi, Shoichi. *Yogyo Kyokai Shi* v 96 n 2 1988 p 217-220.

**078079 PHOSPHATE IN REINIGERN.** [Phosphates in Cleaning Products]. The lecture is concerned with builder systems of alkaline cleaning agents that are mainly based on phosphates and silicates. The cleaning agents dealt with are cleaning agents to be used in the industry or household and dishwashing agents. In addition to the cleaning effect corrosion and erosion effects and other interactions with the surface are considered. The prevention of incrustations, synergisms with other components and possibilities of preparing cleaning agents having special physical properties are also discussed. (Author abstract) In German.

Kandler, J.; Ulrich, H. *Tenside Surfactants Deterg* v 24 n 6 Nov-Dec 1987 p 328-333.

**078080 STUDY ON SYNTHETIC METHODS OF TRIALKYL PHOSPHATE OXIDE AND ITS EXTRACTION BEHAVIOR OF SOME ACIDS.** Trioctyl phosphine oxide (TOPO) is useful for the extraction of many inorganic and organic compounds. A mixed trialkyl phosphine oxide (TRPO) is similar in property to TOPO. The total number of carbon atoms per molecule of TRPO ranges from 15 to 27. Three methods for synthesizing TRPO are described in this paper. Examinations of IR and NMR show that the complex interaction of  $P=O$  bond of TRPO with extracted substances is the same as that of TOPO. The distribution coefficients of phosphoric acid, citric acid, malic acid, oxalic acid, and tartaric acid with TRPO are reported. (Edited author abstract) 11 refs.

Yu, Jiang Ming (East China Inst of Chemical Technology, Shanghai, China); Yuan, Fu Su. *Sep Sci Technol* v 22 n

2-3 Feb-Mar 1987, Fourth Symp on Sep Sci and Tec for Energy Appl, Knoxville, TN, USA, Oct 20-24 1985 p 315-323.

**Adhesion** See PROTECTIVE COATINGS—Phosphate.

**Adsorption** See SOILS; SOILS—pH Effects.

**Amorphous** See ION EXCHANGERS—Composition Effects.

**Applications** See SAND, FOUNDRY—Additives.

**Biosynthesis** See ENZYMES—Immobilization.

**Chemical Analysis** See DETERGENTS—Chemical Analysis.

**Chemical Reactions**

**078081 LITHIUM INSERTION REACTIONS OF  $KM_3P_6Si_2O_{25}$  POTASSIUM TRANSITION METAL SILICOPHOSPHATES.** Lithium insertion reactions were carried out on the potassium silicophosphates  $KTi_3P_6Si_2O_{25}$ ,  $KMo_3P_6Si_2O_{25}$ ,  $KMo_2TiP_6Si_2O_{25}$  and  $KSn_2TiP_6Si_2O_{25}$ . These reactions result in the formation of  $Li_xM_3P_6Si_2O_{25}$  phases with optimal stoichiometries of  $x = 2, 2, 2$  and 1, respectively. These compounds exhibit 3D intersecting tunnel structures. Lithiation does not result in any observable changes in the electronic conductivity of the hosts, which remain electronic insulators. Complex impedance measurements confirm that these compounds have relatively low activation energies for ionic conduction, in agreement with the observed ion-exchange properties. (Edited author abstract) 23 refs.

Wang, E. (Rutgers State Univ of New Jersey, New Brunswick, NJ, USA); Rinaldi, F.; Greenblatt, M. *Mater Res Bull* v 23 n 1 Jan 1988 p 113-118.

**Chromatographic Analysis** See ION EXCHANGERS—Performance.

**Concentration** See CHLORINE COMPOUNDS—Decomposition.

**Control**

**078082 MARYLAND'S PHOSPHATE BAN - HISTORY AND EARLY RESULTS.** On May 28, 1985, Governor Harry R. Hughes formally signed into law a bill that prohibits the sale of phosphate detergents in the state of Maryland. This recent initiative, designed to help curb phosphorus over-enrichment, was one of several aimed at reversing the decline of Maryland's single greatest resource - the Chesapeake Bay. Analyses of early ban results reveal that influent phosphorus concentrations have dropped by nearly one-third at advanced wastewater treatment facilities operated by the Washington Suburban Sanitary Commission. The purpose of this article is to present the early results of the ban, cite the memorable events and turning points that paved the way for the ban, and briefly discuss what phosphorus over-enrichment is and why it is a problem in the bay. 5 refs.

Jones, Edgar R.; Hubbard, Susan D. *J Water Pollut Control Fed* v 58 n 8 Aug 1986 p 816-822.

**Corrosive Effects** See STEEL CORROSION—Stress Corrosion Cracking.

**Crystalline** See AMINES—Adsorption.

**Dielectric Properties** See CRYSTALS—Phase Transitions.

**Dissociation**

**078083 THERMAL DISSOCIATION OF FLUORAPATITE IN PRESENCE OF SILICON AND TITANIUM DIOXIDES.** The purpose of this investigation was to study the influence of silicon and titanium dioxides on thermal dissociation of synthetic fluorapatite and of Oshurkovsk apatite concentrate. According to our experimental data, the degree of transfer of fluorine into the gas

phase during heat treatment of synthetic fluorapatite for 15 min in the temperature range 1773-1973 K increases from 8.5 to 61.3%. It has been shown by calculation and experimentally that joint presence of silicon and titanium dioxides in the mixture has a favorable effect on thermal dissociation of fluorapatite and native phosphate, lowering the temperature and raising the rate of transfer both of fluorine and of phosphorus into the gas phase. 11 refs.

Pechkovskii, V.V. (S.M. Kirov Byelorussian Technological Inst, USSR); Shepeleva, V.V.; Dzyuba, E.D.; Sokolov, M.T.; Belov, S.A.; Ivkovich, N.A. *J Appl Chem USSR* v 60 n 8 pt 1 Aug 1987 p 1576-1581.

**Dissolution** See CERAMIC MATERIALS—Biocompatibility.

**Efficiency** See FERTILIZERS—Composition Effects.

**Electrolysis**

**078084 REACTIVITY DIFFERENCES BETWEEN  $PO_4^{3-}$  AND  $HPO_4^{2-}$  IONS IN OXYGEN AND POTASSIUM PEROXYDIPHOSPHATE FORMATION AT THE PLATINUM ELECTRODE.** The paper generalizes results obtained in comprehensive kinetic studies of oxygen and peroxydiphosphate formation at platinum in the electrolysis of  $K_3PO_4$  and  $K_2HPO_4$  solutions with KCl, KSCN,  $Na_2SO_3$ ,  $(NH_2)_2CS$ , and  $(NH_2)_2CO$  as additives. The reactivity differences between the  $PO_4^{3-}$  and  $HPO_4^{2-}$  ions in the two anodic reactions were made apparent. The results were compared with those obtained previously with added KF. (Author abstract) 15 refs.

Tyurikova, O.G. (L.Ya. Karpov Physicochemical Scientific-Research Inst, Moscow, USSR); Kasatkin, E.V.; Miller, N.B.; Tishakina, A.E.; Kantor, Zh.N. *Sov Electrochem* v 23 n 2 Feb 1987 p 176-184.

**Electronic Properties** See MINERALS—Structure.

**Environmental Testing** See WATER POLLUTION—Analysis.

**Estimation** See WATER RESOURCES—Groundwater.

**Extraction** See SOILS—Components.

**Fabrication**

**078085 PREPARATION OF FIBROUS HYDROXYAPATITE BY USE OF SODIUM ALGINATE.** Fibrous hydroxyapatite (HAP), which is expected to be used as an implant material to periodontal bone defects, was prepared by using sodium alginate (Na-Alg). The starting materials were prepared by dissolving  $Na_4P_2O_7$  into 5% Na-Alg. solution; Na-Alg./ $Na_4P_2O_7$  (weight ratio) = 2.4, 2.6, 2.8, 3.0, 3.2, while the mixed solution of 0.15 mol  $Ca(CH_3COO)_2$  and 0.1 mol  $CaCl_2$  was used as the spinning solution; pH = 6.0, 6.5, 7.0, 7.5. The starting materials were spun through a nozzle of 0.14 mm into the spinning solution in a vessel of 16 ml capacity. Gelatinous fibers obtained were aged, dried and calcined at 900°C for 1 hour. The thermal transformation of the calcined fibers and their compositions were examined by using X-ray diffraction, DTA, and chemical analysis. From these results, the optimum condition for preparing fibrous HAP was found to be as follows; Na-Alg./ $Na_4P_2O_7$  = 3.0, pH = 6.5. In order to remove pores appearing during the heating process, the dried fibers formed under the optimum condition were heat-treated under reduced pressure (at 133 Pa and 900°C for 3 hours). The resulting HAP fibers were about 30-40  $\mu m$  in diameter. It was also confirmed that the HAP phase in the fibers were maintained ever after heat-treated at 1300°C for 1 hour in air. (Edited author abstract) 15 refs. In Japanese.

Iwasaki, Hiromichi (Ritsumeikan Univ, Kyoto, Jpn); Kaneko, Yasunari. *Zairyo* v 37 n 412 Jan 1988 p 60-64.



**Hydrolysis** See CALCIUM COMPOUNDS—Electric Conductivity.

## Ionic Conduction

**078086 IMPEDANCE MEASUREMENTS FOR SOME NASICON ANALOGUES.** New phosphates  $\text{Na}_2(\text{R}, \text{M}^{3+})\text{M}^{4+}\text{P}_2\text{O}_{12}$  and  $\text{NaM}_2^{2+}\text{ZrP}_3\text{O}_{12}$ , where  $\text{R} \equiv \text{La}, \text{Ce}$  or  $\text{Nd}$ ;  $\text{M}^{2+} \equiv \text{Ni}, \text{Cu}$ ;  $\text{M}^{3+} \equiv \text{Co}, \text{Al}, \text{Cr}$ ;  $\text{M}^{4+} \equiv \text{Ti}, \text{Zr}$ , were synthesized by the hydrothermal method. The crystals were subjected to impedance measurements and calculated activation energy, hopping rate, jump frequency etc. The ionic conductivity values in these compounds range from  $10^{-4}$  to  $10^{-1} (\Delta \text{cm})^{-1}$  at  $300^\circ\text{C}$  and the activation energy values for ionic motion range from 0.18 to 0.7 eV. In general the ionic conductivity in compounds containing zirconium is higher than in compounds containing titanium. (Author abstract) 7 refs.

Byrappa, K. (Univ of Mysore, Mysore, India); Gopalakrishna, G.S.; Kulkarni, A.B.; Desai, N.B. *J Less Common Met* v 138 n 1 Mar 1 1988 p 1-6.

## Leaching

**078087 LEACHING CHRISTMAS ISLAND C PHOSPHATE WITH SODIUM HYDROXIDE - A REVIEW.** Christmas Island C phosphate is an ore-overburden rich in phosphates of aluminum, iron, and calcium (c. 30%  $\text{P}_2\text{O}_5$ ; 25%  $\text{Al}_2\text{O}_3$ ; 12%  $\text{Fe}_2\text{O}_3$ ; 15%  $\text{CaO}$ ) and low in silica. A simple procedure was developed for leaching this material with sodium hydroxide solution at  $70^\circ\text{C}$ , filtering, and sequentially crystallizing pure trisodium phosphate and alumina trihydrate. Laboratory and pilot-plant work has developed a range of uses for the trisodium phosphate. Recently the alumina trihydrate crystallizing technique has been improved to allow direct production of smelter-grade alumina, with an adequately low phosphate concentration. The author briefly reviews each of these developments. (Edited author abstract) 29 refs.

Rothbaum, H.P. (DSIR, Petone, NZ). *NZ J Technol* v 3 n 2 1987 p 105-111.

## Manufacture

**078088 FLUOROVE EMISIE Z VYROBY TROJITEHO SUPERFOSFATU.** [Fluorine Emission from the Production of Triple Superphosphate]. The amount of fluorine released and emitted to the atmosphere from the production of triple superphosphate was measured. The decomposition of Jordan-type phosphorite by 70 per cent phosphoric acid proceeded at  $55^\circ\text{C}$ . Only 106.4 g F per one ton of  $\text{P}_2\text{O}_5$  is released, i.e., 0.3 per cent of fluorine present; 2.03 g F/ton of produced  $\text{P}_2\text{O}_5$  is emitted. (Author abstract) In Czech. 18 refs.

Violova, Anna (Chemicke Zavody J. Dimitrova, Bratislava, Czech); Hruzik, Dominik; Stefanka, Ladislav. *Chem Prum* v 37 n 10 1987 p 521-524.

**078089 PREPARATION OF HYDROXYAPATITE BY THE HYDROLYSIS OF BRUSHITE.** The conversion of brushite ( $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$ ; DCPD) into hydroxyapatite (HAP) by hydrolysis has been studied by separating the conversion process into two stages, i.e. the structural change of DCPD into HAP (I) and the subsequent compositional increase in Ca/P ratio of the HAP (II). Two-stage processing was reasonable and convenient for the preparation of stoichiometric HAP, because it was possible to manage the controlling factors in both Reactions I and II independently. The resulting HAP powders showed a comparatively low crystallinity similar to precipitated HAP and large weight losses (above 6%) on heating, and were composed of dense aggregates of irregular thin microcrystals. (Edited author abstract) 10 refs.

Monma, H. (Nat Inst for Research in Inorganic Materials, Sakura-mura, Jpn); Kamiya, T. *J Mater Sci* v 22 n 12 Dec 1987 p 4247-4250.

## Microstructure

**078090 MICROSTRUCTURE OF SEDIMENTARY PHOSPHATE FROM ISRAEL.** Phosphorites from the Zin and Arad fields near the Dead Sea in southern Israel are composed mainly of francolite (93-95 percent after beneficiation). Using mercury porosimetry and the BET method, it was found that the pores in the rocks are composed of three sizes; large (approximately 60  $\mu\text{m}$ ), medium (approximately 1  $\mu\text{m}$ ), and small (approximately 0.01  $\mu\text{m}$ ). The large and small pores have narrow size distributions, but that of the medium pores is very broad. Increase in the  $\text{CO}_2$  content of francolite is accompanied by an increase in the surface area and by a decrease in the mean size of the small pores. The small pores are also sensitive to calcination; they disappear above  $900^\circ\text{C}$ . (Author abstract) 10 refs.

Zevin, L. (Ben-Gurion Univ of the Negev, Beer-Sheva, Isr); Lach, S.; Aszodi, A.; Fang, J.H. *Powder Technol* v 56 n 1 Sep 1988 p 63-66.

**Morphology** See ALUMINUM COMPOUNDS—Crystallization.

## Optical Properties

**078091 LUMINESCENCE OF THE  $\text{Sb}^{3+}$  ION IN CALCIUM FLUORAPATITE AND OTHER PHOSPHATES.** Luminescence spectra and decay times of  $\text{Sb}^{3+}$  in  $\text{AlPO}_4$ ,  $\text{LaPO}_4$ ,  $\text{LiLaP}_4\text{O}_{12}$  and calcium fluorapatite ( $\text{Ca}_{10}(\text{PO}_4)_6\text{F}_2$ ) are reported. The luminescence properties of  $\text{Sb}^{3+}$  in  $\text{AlPO}_4$ ,  $\text{LaPO}_4$  and  $\text{LiLaP}_4\text{O}_{12}$  are explained by using existing models. The luminescence properties of  $\text{Sb}^{3+}$  in calcium halophosphate have been reported before, but were not completely understood. We find that a strong Jahn-Teller interaction is working on the relaxed excited state of the  $\text{Sb}^{3+}$  ion from which the luminescence properties can be explained. Evidence is given that  $\text{Sb}^{3+}$  in calcium fluorapatite occupies a  $\text{Ca}^{2+}$  site. (Author abstract) 24 refs.

Oomen, E.W.J.L. (State Univ of Utrecht, Utrecht, Neth); Smit, W.M.A.; Blasse, G. *Mater Chem Phys* v 19 n 4 May 1988 p 357-368.

**Phase Diagrams** See JOINTS, ADHESIVE—Degradation.

## Phase Transitions

**078092 SEQUENTIAL PHASE DEVELOPMENT OF  $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$  ON HEATING.** Recently, calcium phosphates have raised much interest mainly because they have potential for use as bio-materials.  $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$  is one of the most common compounds in the system  $\text{CaO}-\text{P}_2\text{O}_5-\text{H}_2\text{O}$  and is known as a precursor of hydroxyapatite which is useful for implants as teeth and bones. In this letter, the phase development of  $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$  on heating was investigated based on X-ray, infrared (IR) and electron spin resonance (ESR) analyses. The sequential phase development is summarized. As it is likely that the local structure around  $\text{Ca}^{2+}$  of the X phase is similar to that of  $\text{CaHPO}_4$ , the X phase would tend to form before the  $\gamma$  phase appears. 8 refs.

Nagai, Masayuki (Musashi Inst of Technology, Tokyo, Jpn); Nishino, Tadashi; Kanazawa, Takafumi. *J Mater Sci Lett* v 7 n 9 Sep 1988 p 991-992.

## Physical Properties

**078093 PHYSICAL PROPERTIES OF SOME MIXED PHOSPHATES FROM THE NATROPHYLLITE FAMILY.** Measurements of the temperature dependence of relative dielectric permittivity, electric sensitivity, and magnetic susceptibility of  $\text{NaMgPO}_4$ ,  $\text{NaCaPO}_4$ ,  $\text{NaNiPO}_4$ , and  $\text{NaCuPO}_4$  are reported. All follow a similar pattern, indicating the presence of two phase transitions, the nature of which has not been established. (Author abstract) 5 refs.

Dojicilovic, Jilaban (Univ of Belgrade, Belgrade, Yugosl); Napijalo, Milena; Napijalo, Milan; Novakovic, Lazar. *High Temp High Pressures* v 19 n 4 1987 p 431-435.

**Precipitation** See SOILS—Chemistry.

**Processing** See Also FERTILIZERS—Phosphates.

**078094 ENRICHMENT OF LOW-GRADE MAZIDAGI PHOSPHATES BY CALCINATION AND EXTRACTION METHODS.** Experimental results show that depending on particle size before calcination, time of calcination, temperature, and the methods of differentiation process after calcination, product concentrations were changed from 20 to 27 and 30 to 35%  $\text{P}_2\text{O}_5$ , respectively. By increasing the calcination time from 1 to 1.5 h at  $870^\circ\text{C}$  and using a sugar solution, and again removing the small particles, we were able to obtain products which were concentrated to about 34.5%  $\text{P}_2\text{O}_5$  with a yield of 78%. We regenerated the solution obtained at the end of these processes by passing  $\text{CO}_2$  gas through them and obtained powder  $\text{CaCO}_3$  with a purity of 99.6%. 6 refs.

Gunduz, T. (Univ of Ankara, Ankara, Turk); Gumgum, B. *Sep Sci Technol* v 22 n 6 Jun 1987 p 1645-1648.

**078095 VERMINDERUNG DES CADMIUM-GEHALTES VON ROHPHOSPHATEN UND MINERALDUENGERN.** [Reducing the Cadmium Content in Raw Phosphates and Mineral Fertilizers]. Processes have been developed to separate the Cd from the phosphate rock or from the crude phosphoric acids arising therefrom as intermediates. In this way, the Cd content of the phosphate rock can be reduced to less than 10% of its original value, and to 50% thereof by extractive treatment with acidic calcium nitrate solution. Older calcination processes for crude phosphate have been improved to give residual Cd contents of 10 to 50% at temperatures of 800 to  $1000^\circ\text{C}$ . Cadmium can be removed almost quantitatively from crude phosphate by means of dialkyl dithiophosphoric acid esters by extraction, binding to adsorbents, or ion flotation. Cadmium can be extracted from crude acids in high yield by long-chained amines. After partial neutralization of the crude acids, precipitation as cadmium sulphide is also possible. (Edited author abstract) 43 refs. In German.

von Plessen, Helmold (Hoechst AG, Frankfurt am Main, West Ger); Schimmel, Guenther. *Chem Ing Tech* v 59 n 10 Oct 1987 p 772-778.

**Production** See SILICON COMPOUNDS—Research.

## Separation

**078096 FLOTATION SEPARATION OF COLLOPHANE FROM DOLOMITE USING A 'METAL ION-HYDROPHILIC LIGAND' ADSORPTION METHOD.** Relying on thermodynamic calculations and the difference of bonding to some metal ions, the authors designed a metal ion-hydrophilic ligand method to separate collophane from dolomite. It employs some metal ions,  $\text{Fe}^{3+}$ , for example, to activate the adsorption of hydrophilic ligand onto collophane surface, and thus the collophane particles are made hydrophilic and depressed without evident effect on dolomite because of adsorbing little amount of  $\text{Fe}^{3+}$ . Separation results of batch flotation on artificial mixture of pure minerals (25.87 percent  $\text{P}_2\text{O}_5$  and 6.25 percent  $\text{MgO}$ ) have indicated that it is possible to recover a concentrate containing 37.1 percent  $\text{P}_2\text{O}_5$  and 0.6 percent  $\text{MgO}$  with 95.6 percent  $\text{P}_2\text{O}_5$  recovery, using  $\text{Fe}^{3+}$  - hydrophilic ligand as depressant. With the help of modern analysis methods, such as UV and X-ray photoelectron spectroscopy, the mechanism of the method has been studied and an adsorption model of  $\text{Fe}^{3+}$  - hydrophilic ligand on the mineral surface has been established. (Edited author abstract) 29 refs. In Chinese.

Yongqiang, Lu (Beijing General Research Inst of Mining & Metallurgy, China); Weizhong, Xing. *Yu Se Chin Shu* v 40 n 2 May 1988 p 30-42.



**078097 REMOVING APATITE FROM ULTRAFINE RHODOCHROSITE BY CONTROLLED DISPERSION - SHEAR FLOCCULATION FLOTATION TECHNOLOGY.** Based on controlled dispersion flotation and shear flocculation, a new approach for ultrafine particle is put forward. It is called controlled dispersion-shear flocculation flotation technology (CDSFF). Satisfactory results were obtained in experiments on pure apatite (-7.8µm 81.5 percent) and pure rhodochrosite (-6.9µm 83.67 percent). A product which contained 0.13 percent was obtained from the mixture containing the impurity 0.28 percent P in ultrafine apatite and rhodochrosite, and the recovery was 66.2 percent. Other technologies could not remove apatite as effectively as CDSFF. The mechanism of CDSFF was explored in detail by means of SME, AES, etc. (Edited author abstract). 6 Refs. In Chinese.

Mulong, Yu (Beijing Graduate School, China); Yongping, Hu. *Yu Se Chin Shu* v 40 n 2 May 1988 p 43-53.

**Solubility** See SOILS—Ion Exchange.

**Solutions** See ALUMINUM AND ALLOYS—Anodic Oxidation; IRON COBALT ALLOYS—Dissolution; NICKEL AND ALLOYS—Corrosion.

**Spectroscopic Analysis**

**078098 ANALYSIS OF JORDANIAN PHOSPHATE USING NUCLEAR TECHNIQUES.** The concentrations of major, minor and trace element content of Jordanian phosphate ores were determined using different complementary nuclear techniques. These techniques were: Gammay-Ray Spectrometry (GRS), X-Ray Fluorescence (XRF) and Proton Induced X-ray Emission (PIXE). Special emphasis was given to the determination of Uranium and rare earth element concentrations. (Author abstract) 10 refs.

Saleh, N.S. (Univ of Jordan, Amman, Jordan); Al-Saleh, K.A. *Appl Phys Commun* v 7 n 4 Dec 1987 p 313-327.

**Stability** See NONFERROUS METALS—Extraction.

**Structure**

**078099 SYNTHESIS AND CRYSTAL STRUCTURE REFINEMENT OF  $\text{Cu}(\text{Ti}_2(\text{PO}_4)_3)$ .** Single crystals of the Nasicon-type compound,  $\text{Cu}(\text{I})\text{Ti}_2(\text{PO}_4)_3$  were grown hydrothermally at 500°C under 3 kbar pressure. The crystal structure was solved by means of single crystal x-ray diffraction and refined to  $R = 0.027$ . Although the  $[\text{Ti}_2\text{P}_3\text{O}_{12}]^{-1}$  framework in  $\text{CuTi}_2(\text{PO}_4)_3$  is identical to  $\text{ZrP}$  framework in  $\text{NaZr}_2(\text{PO}_4)_3$ , the Cu atoms are shifted away from the M1 sites occupied by Na in latter structure. The Cu atoms in  $\text{CuTi}_2(\text{PO}_4)_3$  are three-fold coordinated and are located near the bottle-neck in the path between M1 and M2 sites of the Nasicon structure. (Edited author abstract) 13 refs.

McCarron, E.M. III (DuPont, Wilmington, DE, USA); Calabrese, J.C.; Subramanian, M.A. *Mater Res Bull* v 22 n 10 Oct 1987 p 1421-1426.

**078100 HIGH RESOLUTION SOLID STATE  $^{31}\text{P}$  NMR IN SOME ANTIMONY-PHOSPHATES.** antimony-phosphates have been studied by MAS high resolution solid state  $^{31}\text{P}$  NMR. Correlations have been drawn between NMR chemical shifts and structural data. They show that the  $^{31}\text{P}$  resonance line moves towards high field when the number of bridging oxygens in the  $\text{PO}_4$  group increases. The chemical shift anisotropy is related to the dimensionality of the solid network. It is smaller for 3D lattices. Water intercalation in layered phosphates leads to a shift of the  $^{31}\text{P}$  resonance towards higher or low field suggesting that protonation of some  $(\text{PO}_4)^{3-}$  group occurs. A correlation between the P-O  $\pi$  bonding and the chemical shift is also proposed. (Author abstract) 18 refs.

Taulelle, F. (Univ Pierre et Marie Curie, Paris, Fr); Sanchez, C.; Livage, J.; Lachgar, A.; Piffard, Y. *J Phys Chem Solids* v 49 n 3 1988 p 299-305.

**078101 RELATIONSHIPS BETWEEN STRUCTURE AND MAGNETIC PROPERTIES OF TITANIUM (III) NASICON-TYPE PHOSPHATES.** The properties of titanium (III) are investigated in  $\text{Li}_3\text{Ti}_2(\text{PO}_4)_3$ ,  $\text{Li}_2\text{Ca}_{0.5}(\text{PO}_4)_3$  and  $\text{Na}_3\text{Ti}_2(\text{PO}_4)_3$ . The magnetic data are consistent with the model of Figgis, for a  $d^1$  ion. They imply a strong distortion of the  $\text{TiO}_6$  octahedra in the sodium phosphate skeleton. (Edited author abstract). 22 Refs.

El Jazouli, A. (CNRS, Talence, Fr); Nadiri, A.; Dance, J.M.; Delmas, C.; Le Flem, G. *J Phys Chem Solids* v 49 n 7 1988 p 779-783.

**Synthesis** See CATALYSTS—Vanadium Compounds; FERTILIZERS—Manufacture.

**X-Ray Analysis** See GLASS—Structure.

**PHOSPHORESCENCE** See Also ELECTRIC LAMPS, FLUORESCENT; ELECTRON TUBES, CATHODE RAY—Imaging Techniques; HYDROCARBONS—Spectroscopic Analysis; MAGNETIC MEASUREMENTS—Resonance; ORGANIC COMPOUNDS—Processing; ORGANIC COMPOUNDS—Spectroscopic Analysis; POLYMERS—Solutions.

**078102 SITE-SELECTION PHOSPHORIMETRY VIA SINGLE-STATE EXCITATION.** This paper describes the technique of excitation energy site-selection (SS) phosphorimetry for chemical analysis of polycyclic aromatic compounds in Shpolskii matrices at 4.2 K. The principle of the SS phosphorescence technique, which uses excitation via the singlet state and produces narrow-band phosphorescence, is discussed. The analysis of a three-component mixture is used to illustrate the spectral selectivity of the SS phosphorimetric technique. (Author abstract) 28 refs.

Tuan, Vo-Dinh (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Lamotte, Michael. *Appl Spectrosc* v 42 n 1 Jan 1988 p 65-68.

**Low Temperature Properties** See QUARTZ—Optical Properties.

**Measurements** See LUMINESCENCE—Measurements; PETROLEUM PRODUCTS—Spectroscopic Analysis.

**Spectrum Analysis** See Also ORGANIC COMPOUNDS—Spectrum Analysis.

**078103 TEMPERATURE DEPENDENCE OF THE PHOSPHORESCENCE OF NAPHTHALENE-TETRACHLOROPHTHALIC ANHYDRIDE CHARGE-TRANSFER CRYSTAL COMPLEX.** We studied the phosphorescence of the N-TCPA crystal CTC for temperatures in the interval 1.4-77 K. We discuss the possible role of strong distortions of the crystal in the formation of cells for excitation. 15 refs.

Avedeenko, A.A.; Karachevtsev, V.A.; Naboikin, Yu.V. *J Appl Spectrosc* v 46 n 4 Apr 1987 p 377-380.

**PHOSPHORIC ACID** See Also ALUMINUM AND ALLOYS—Anodic Oxidation; CALCIUM COMPOUNDS—Solubility; CARBON BLACK—Corrosion; CARBON STEEL—Etching; CATALYSTS—Mechanical Properties; CHROMIUM AND ALLOYS—Extraction; FUEL CELLS—Materials; FUEL CELLS—Performance; FUEL CELLS—Research; ION EXCHANGERS—Materials; LIPIDS—Chromatographic Analysis; MONOMERS—Polymerization; ORE TREATMENT—Solvent Extraction; POLYETHYLENES—Oxidation; POLYMERS—Reaction Kinetics; RARE EARTH ELEMENTS—Solvent Extraction; STAINLESS STEEL—Corrosion; STEEL—Etching; STEEL CORROSION—Atmospheric; TIN ORE TREATMENT—Solvent Extraction; URANIUM AND ALLOYS.

**078104 SOLUBILITY OF POTASSIUM HEXAFLUOROSILICATE IN AMMONIATED PHOSPHORIC ACID.** There are no reported data on the solubility of  $\text{K}_2\text{SiF}_6$  in the products of ammoniation of phosphoric acid. The experimental results show that when fluorine is precipitated in the form of  $\text{K}_2\text{SiF}_6$  from the products of WPA ammoniation the equilibrium concentration of soluble fluorine compounds in solutions containing 10-15%  $\text{P}_2\text{O}_5$  at  $\text{NH}_3:\text{H}_3\text{PO}_4$  ratios over 1.4 exceeds 0.45-0.64%. At  $\text{P}_2\text{O}_5$  concentrations above 20% in

ammoniated solutions their equilibrium fluorine concentrations can be maintained at a level below 0.1%; with the use of potassium compounds for defluorination of WPA in a combined process of purification and ammoniation of the acid (with 20-35%  $\text{P}_2\text{O}_5$  concentration) it then becomes possible to obtain fodder ammonium phosphates of certified quality. 10 refs.

Gladushko, V.I. (Kiev Polytechnic Inst, USSR); Olefrenko, V.I.; Astrelin, I.M. *J Appl Chem USSR* v 59 n 11 pt 2 Nov 1986 p 2333-2335.

**Concentration** See FERTILIZERS—Manufacture; HYDROGEN INORGANIC COMPOUNDS—Dissociation; PHOSPHATE ORE TREATMENT—Processing.

**Corrosive Effects** See NICKEL AND ALLOYS—Corrosion; STAINLESS STEEL—Corrosion.

**Extraction** See Also MIXTURES—Phase Equilibria.

**078105 PROPERTIES OF THE EXTRACTION SYSTEM  $\text{H}_3\text{PO}_4\text{-H}_2\text{SO}_4\text{-H}_2\text{O-TBP}$  AT 293-353 K.** Tri-n-butyl ester of phosphoric acid (tributyl phosphate, TBP) with its high temperatures of boiling and fulmination and low solubility in water and acids, is a promising extracting agent for use in processes for purifying extraction phosphoric acid of impurities. Earlier data on the system  $\text{H}_3\text{PO}_4\text{-H}_2\text{SO}_4\text{-H}_2\text{O-TBP}$  were obtained at a temperature of 293 K. With the possible temperature conditions of the process in mind, the equilibrium in this system at 293-353 K and the physicochemical properties of the organic phase have been studied. 10 refs.

Bogdanova, S.S. (S.M. Kirov Leningrad Inst of the Textile & Light Industries, USSR); Panov, V.P.; Chulkova, E.N.; Tereshchenko, L.Ya. *J Appl Chem USSR* v 60 n 1 pt 1 Jan 1987 p 40-44.

**078106 QUATERNARY LIQUID-LIQUID EQUILIBRIUM: WATER-PHOSPHORIC ACID-1-PENTANOL-3-PENTANONE AT 25°C.** Liquid-liquid equilibrium, solubility and tie-line data, for the quaternary system Water-Phosphoric Acid-1-Pentanol-3-Pentanone, were obtained at 25°C and atmospheric pressure, using an analytical method. 1-Pentanol appears to be more effective than 3-Pentanol as extractant solvent of phosphoric acid. Advantages are not observed with the use of mixed solvents in the purification of wet process phosphoric acid by means of solvent extraction. (Author abstract) 5 refs.

Marco, Jose M. (Univ de Barcelona, Barcelona, Spain); Galan, Maria I.; Costa, Jose. *Solvent Extr Ion Exch* v 6 n 1 Feb 1988 p 125-140.

**Manufacture** See MELAMINE—Solubility; MIXTURES—Phase Equilibria.

**Phase Equilibria**

**078107 LIQUID-LIQUID EQUILIBRIA FOR THE SYSTEM WATER-PHOSPHORIC ACID-1-PENTANOL-3-PENTANONE AT 25°C IN THE PRESENCE OF SODIUM CHLORIDE.** A quantitative study of the effect of sodium chloride has been made on the liquid-liquid equilibria Water-Phosphoric Acid-1-Pentanol-3-Pentanone at 25°C and atmospheric pressure. Mutual solubility and tie-line data are obtained at saturation of sodium chloride in both conjugated phases. The addition of sodium chloride increases the distribution coefficient of phosphoric acid and the selectivity of extractant solvents for 1-Pentanol and mixtures of 1-Pentanol and 3-Pentanol, whereas it has no significant influence when the extractant solvent is 3-Pentanol. (Author abstract) 9 refs.

Marco, Jose M. (Univ de Barcelona, Barcelona, Spain); Galan, Maria I.; Costa, Jose. *Solvent Extr Ion Exch* v 6 n 1 Feb 1988 p 141-156.

**Physical Chemistry**

**078108 STUDY OF AGGREGATION BEHAVIOUR IN HDEHP-N-HEPTANE SYSTEM BY POSITRON ANNIHILATION TECHNIQUE.** The aggregation be-



havior of di(2-ethyl hexyl) phosphoric acid (HDEHP) in n-heptane was studied by the positron annihilation technique. The discontinuity in the positronium formation intensity,  $I_2$ , as a function of HDEHP concentration suggested formation of close aggregates of HDEHP molecules. (Author abstract) 17 refs.

Ganguly, B. (Saha Inst of Nuclear Physics, Calcutta, India); Sen, P. *Appl Radiat Isot* v 38 n 9 1987 p 681-684.

**Production** See Also SHAFTS AND SHAFTING.

**078109 FLUORIDE DISTRIBUTION COEFFICIENTS IN WET PHOSPHORIC ACID PROCESSES.** Phosphoric acid for use in fertilizer applications is mainly produced by digestion of phosphate ore, containing 2-4 wt% F, with sulfuric acid. During the digestion of the ore, the fluoride is released as hydrogen fluoride, which reacts with silica to produce fluoroaluminic acid. Part of this acid decomposes in  $\text{SiF}_4$  and HF, which on their turn partly evade into the air. These fluoride distribution coefficients were measured by saturation of a nitrogen gas stream passing through fluoroaluminic acid dissolved in mixtures of distilled water, chemically pure phosphoric acid, and sulfuric acid at various temperatures. A theoretical expression is derived, which allows calculation of the fluoride distribution coefficients between the acid and the ambient air between 70 and 95°C, for solutions containing 30-50 wt%  $\text{P}_2\text{O}_5$ , up to 6 wt%  $\text{H}_2\text{SO}_4$ , maximal 4 wt%  $\text{H}_2\text{SiF}_6$ , and a molar F/Si ratio of six. (Author abstract) 36 refs.

van der Sluis, Sietse (Technical Univ of Delft, Delft, Neth); Schrijver, Annie H.M.; Baak, Frits P.C.; van Rosmalen, Gerda M. *Ind Eng Chem Res* v 27 n 3 Mar 1988 p 527-536.

**078110 CONTINUOUS RECRYSTALLIZATION OF CALCIUM SULFATE DIHYDRATE TO THE HEMIHYDRATE IN THE PHOSPHORIC ACID WET PROCESS.** The authors examine the aggregation of hemihydrate crystals in acid phosphate solutions. In particular, they examined such factors as the concentration and temperature of the EPA, the  $\text{SO}_4^{2-}$  content of the solutions, the addition of a surfactant, the residence time of the slurry in the continuous recrystallizer, and the intensity of stirring, on the following indexes which characterize the recrystallization process: average dimensions of the hemihydrate crystal aggregates, porosity of the hemihydrate precipitate, filtration time, and the  $\text{P}_2\text{O}_5$  content of the precipitate. The effect of different surfactants on the properties of the hemihydrate aggregates obtained on recrystallization of dihydrate is presented in tabular form. It can be seen from these results that the presence of a surfactant led, in all cases, to a reduction in the amount of  $\text{P}_2\text{O}_5$  in the precipitate but at the same time only three of the eleven surfactants tested increased the average diameter of the aggregate particles. This indicates that surfactants do have a definite effect in reducing the capture of phosphate ion from solution by the crystallizing hemihydrate. 12 refs.

Torocheshnikov, N.S.; Petropavlovskii, I.A.; Ba Cau, Thai; Lanh, Le. *J Appl Chem USSR* v 59 n 6 1 Jun 1986 p 1109-1113.

**Purification**

**078111 SEPARATION OF TRACE METAL IMPURITIES FROM PHOSPHORIC ACID ON CHELEX-100.** Impurities like Fe, Cu, Ni, Mn, Co, Cd and Pb at ppm levels are successfully separated from phosphoric acid on chelex-100 ion exchanger and determined subsequently employing flame atomic absorption spectrophotometry. Attempts were made to improve the overall sensitivity by using GFAAS. These cations are sorbed on the exchanger through interaction with IDA group and not through precipitation ion exchange. (Author abstract). 13 refs.

Murugaiyan, P. (Bhabha Atomic Research Centre, Bombay, India); Parasurama Iyer, H.; Venkateswarlu, C. *Indian J Technol* v 26 n 4 Apr 1988 p 194-196.

**Reaction Kinetics** See OXYGEN—Reduction.

**Solutions** See CADMIUM AND ALLOYS—Extraction; CALCIUM COMPOUNDS—Phase Transitions; CALCIUM COMPOUNDS—Solutions.

**PHOSPHORS** See Also CALCIUM COMPOUNDS—Optical Properties; CALCIUM COMPOUNDS—Thermal Effects; LANTHANUM COMPOUNDS—Crystallization; THERMOLUMINESCENCE; YTTRIUM COMPOUNDS—Spectroscopic Analysis.

**078112 EFFICIENT GREEN-EMITTING LUMINESCENT MATERIAL:  $\text{Tb}^{3+}$ -ACTIVATED MONOCLINIC  $\text{Gd}_2\text{O}_3$ .** Monoclinic gadolinium oxide activated with  $\text{Tb}^{3+}$  is efficient green-emitting phosphor, even at low  $\text{Tb}^{3+}$  concentrations. Under X-ray excitation its efficiency is about 50% of that of  $\text{Gd}_2\text{O}_3\text{:Sb}$ . The low amount of blue  $^5\text{D}_3$  emission from  $\text{Gd}_2\text{O}_3\text{:Tb}$  is ascribed to the low-energy position of the 4f-5d band. The intensity ratio of the  $\text{Gd}^{3+}$  excitation lines in the photoluminescence excitation spectrum provides information on the location of the quenching sites. (Author abstract) 14 refs.

Blasse, G. (Univ of Utrecht, Utrecht, Neth); Dirksen, G.J.; Meyerink, A.; Terrell, D.R.; Neyens, L. *Mater Chem Phys* v 19 n 6 Jul 1988 p 547-556.

**078113 EFFECT OF  $\text{N}_2\text{-O}_2$  ANNEALING ON THE BLUE ELECTROLUMINESCENCE OF  $\text{Zn}_{1-x}\text{Mg}_x\text{S:Cu,Br}$  POWDER PHOSPHORS.** Stability of blue emitting AC electroluminescent (EL) powder phosphors of the type  $\text{Zn}_{1-x}\text{Mg}_x\text{S:Cu,Br}$  has been examined during annealing in static air, with a view to improving their lifetimes. The EL emission maximum is shifted from 436 (blue) to 520 nm (green) when annealed in  $\text{N}_2\text{-O}_2$  atmospheres of  $p_{\text{O}_2} \geq 0.01$  atm at 700°C. Under the same conditions, the solubility limit of  $\text{Zn}_{1-x}\text{Mg}_x\text{S}$  system decreases from  $x=0.24$  to 0.11. In  $\text{Zn}_{1-x}\text{Mg}_x\text{S:Cu,Br}$  phosphors, the phase content and the solubility limit are additionally dependent on the concentration of copper. The exsolution of MgS is probably due to the stabilization of the 3C phase by Cu and O. Annealing in  $\text{N}_2\text{-O}_2$  of  $p_{\text{O}_2} = 1 \times 10^{-3}$  atm increases the half-life of  $\text{Zn}_{1-x}\text{Mg}_x\text{S:Cu,Br}$  from approximately 150 h to approximately  $1.7 \times 10^3$  h. (Author abstract). 17 Refs.

Revathi, R. (Indian Inst of Science, Bangalore, India); Kutty, T.R.N. *Indian J Technol* v 26 n 4 Apr 1988 p 168-174.

**Additives**

**078114 EFFECT OF GADOLINIUM CONCENTRATION ON THERMOLUMINESCENCE OF DEFORMED  $\text{NaYF}_4$  PHOSPHORS.** The purpose of the present investigation was to study the 130°C peak in deformed  $\text{NaYF}_4$  phosphor as a function of gadolinium concentration. In view of the large size of the  $\text{Gd}^{2+}$  ion occupying the sodium or yttrium position in the lattice, there will be strong elastic interactions between  $\text{Gd}^{2+}$  ions and moving dislocations during the deformation process. Therefore, it is to be expected that in a specimen with sufficiently high concentration of gadolinium, the dislocation motion and multiplication will become nearly impossible. This, in turn, will suppress the production of vacancy clusters and dislocation dipoles. Such a situation will not favor the formation of 130°C centers. On the other hand, decrease in gadolinium concentration permits motion of the dislocations and the multiplication which is conducive to the generation of centers responsible for the 130°C glow peak. This explains the rapid fall in intensity of the 130°C peak as the gadolinium concentration is decreased. 12 refs.

Narasimha Reddy, K. (Osmania Univ, Hyderabad, India); Pandaraiah, N.; Subba Rao, U.V. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1115-1116.

**Analysis**

**078115 SURFACE ANALYSIS OF  $\text{Zn}_{1-x}\text{Cd}_x\text{S}$  PHOSPHORS EXPOSED TO UV LIGHT IRRADIATION.** Surface darkening of  $\text{Zn}_x\text{Cd}_{1-x}\text{S}$  phosphors induced by UV light irradiation has been studied using

Auger electron spectroscopy, x-ray photoelectron spectroscopy, and x-ray diffraction. It has been found that the light irradiation in a humid atmosphere forms sulfates and precipitates colloidal metals of Zn and Cd on the phosphor surface. The darkened surface due to the metal precipitate can be bleached to some extent when the phosphors are dried. (Author abstract) 3 refs.

Itoh, Shigeo (Futaba Corp, Mobara, Jpn); Tonegawa, Takeshi; Morimoto, Kiyoshi; Kukimoto, Hiroshi. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2628-2631.

**Applications** See Also ELECTRIC LAMPS, FLUORESCENT; PRINTING; THERMOGRAPHY—Laser Applications.

**078116 THERMOGRAPHIC PHOSPHORS: PART II - AN ALTERNATIVE FOR SURFACE TEMPERATURE MEASUREMENT IN COMBUSTION ENVIRONMENTS.** The second part of the article discusses how the thermal phosphor method can be used to advantage over pyrometric techniques for surface temperature determinations in the presence of combustion flame. Advances in light sources, detectors, and associated electronics have made the method less expensive and more useful. Typically, a short-pulse-width (5 ns or less) laser is used to stimulate luminescence from a rare-earth-doped phosphor. The emission consists of sharp lines in the visible region of the spectrum. The duration (or lifetime) of the luminescence, as well as the amplitude, is temperature dependent. The rate of decay of this emission is exponential. By measuring the laser-induced fluorescence time constant of a sample of phosphor bonded to the surface of interest, it is possible to determine its temperature. An example of aerospace application of this method to measure the temperature of surfaces immersed in jet engine flames is presented.

Allison, S.W. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Gillies, G.T. *Ind Heat* v 55 n 10 Oct 1988 p 38-40.

**Bibliographies**

**078117 RESEARCH BIBLIOGRAPHY ON THE TEMPERATURE DEPENDENCIES OF THERMOGRAPHIC PHOSPHORS.** We have prepared a comprehensive research bibliography on the fundamental physics and engineering applications of thermographic phosphors. This bibliography is based on a survey of the literature cited in the Physics Abstracts over the past fifteen years. There are five major subject areas covered in this document. They are (1) phosphor spectroscopy, (2) the physical and chemical properties of ceramic phosphors, (3) methods of binding phosphors to various surfaces, (4) phosphor-based thermometry and (5) other applications of these materials to remote sensing and diagnostics. (Edited author abstract) 1 ref.

Dowell, L.J. (Univ of Virginia, Charlottesville, VA, USA); Gillies, G.T.; Allison, S.W.; Cates, M.R. *J Lumin* v 36 n 6 Mar 1987 p 375-376.

**Crystal Lattices** See LUMINESCENCE—Inorganic Solids.

**Degradation**

**078118 DEGRADATION OF PHOSPHORS UNDER CATHODE-RAY EXCITATION.** A systematic analysis of phosphor degradation is presented. An increase of the self-absorption of the luminescence, destruction of luminescence centres, a decreased energy flow to these centres, and increased energy losses in the phosphor host lattice - both in the bulk and at the surface - can be distinguished as causes of the deterioration of the external radiant efficiency of phosphors. Simple measurements are suggested to disentangle the contribution of each of these parameters to the observed degradation effects. As an illustration degradation effects of  $\text{Zn}_2\text{SiO}_4\text{:Mn}$ ,  $\text{Y}_2\text{SiO}_5\text{:Ce}$ ,  $\text{Sr}_2\text{Al}_6\text{O}_{11}\text{:Eu}$  and a  $\text{Tb}^{3+}$  activated borate glass are analyzed. (Author abstract) 22 refs.

Klaassen, D.B.M. (Philips Research Lab, Eindhoven, Neth); de Leeuw, D.M.; Welker, T. *J Lumin* v 37 n 1 Apr 1987 p 21-28.



**Efficiency** See ELECTRON TUBES, CATHODE RAY—Materials.

## Electronic Properties

**078119 EFFECT OF Mn CONCENTRATION ON ELECTRON EXCITATION IN ZnS:Mn ELECTROLUMINESCENT DEVICES.** In activated phosphors such as ZnS:Mn the brightness varies with the concentration of the activator, in electroluminescence in another way than in photoluminescence. A model is presented that explains this on the basis of a quenching term and an excitation term involving electron interaction cross sections in Mn. The model is consistent with observed brightness data and supports the findings of other work in ZnS:Mn. An estimate of the low-energy electron interaction cross section of Mn ions suggests a strong interaction to take place. (Author abstract) 10 refs.

Kitai, Adrian H. (McMaster Univ, Hamilton, Ont, Can). *J Lumin* v 39 n 4 Mar 1988 p 227-230.

## Garnets

**078120 SINGLE-CRYSTAL GARNET PHOSPHORS.** Single crystal garnet phosphors are considered for cathodoluminescent screens in cathode ray tubes (CRT) yttrium aluminum garnet activated with cerium (Ce:YAG). It was observed that this material overcame all the shortcomings for the powder phosphors. The single-crystal phosphor can be excited with a high-power electron beam to provide a display of uniform output and exceptional brightness with very little coulombic degradation. The material is capable of resolution equal to that of the exciting electron beam, and because of its nonscattering nature, it produces a very high contrast image. 4 refs.

Wittenberg, Albert M. (AT&T Bell Lab, Murray Hill, NJ, USA). *Inf Disp* v 3 n 5 May 1987 p 14-17.

## Hydrolysis

**078121 HYDROLYSIS REACTIONS OF CaAs PHOSPHORS.** Elementary processes of hydrolysis were studied on CaS:Ce and (Ca, Mg):S:Mn phosphors by ion chromatography. Analysis of a phosphor suspension solution has shown that oxidation of SH producing  $\text{SO}_3^{2-}$ , as well as formation of  $\text{CaCO}_3$  accelerates the overall hydrolysis. On the basis of these results, methods of suppressing hydrolysis were examined and used to develop a screening process for monochromatic tubes. (Author abstract) 6 refs.

Suzuki, Teruki (Hitachi Ltd, Kokubunji, Jpn); Yamamoto, Hajime; Megumi, Kohichi; Kanehisa, Osamu; Morita, Yasukazu; Watanabe, Naomitsu; Uehara, Yasuhiko. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2620-2623.

## Medical Applications See X-RAY APPARATUS.

**Optical Properties** See Also CATHODOLUMINESCENCE—Thermal Effects; TELEVISION EQUIPMENT—Optimization; ZINC COMPOUNDS—Radiation Effects.

**078122 GREEN PHOSPHOR BASED ON  $\text{CeAl}_{12}\text{O}_{19.5}$  ACTIVATED WITH  $\text{Mn}^{2+}$ -INCORPORATION.** The photoluminescence of  $\text{Mn}^{2+}$  in  $\text{Ce}(\text{Mn}, \text{Al})_{11.5-12}\text{O}_{18-19.5}$  has been measured under UV 254nm excitation. The spectral energy distribution of the  $\text{Mn}^{2+}$  emission is shown. The presence of divalent manganese suppressed the 454nm peak which exists in  $\text{CeAl}_{11}\text{O}_{18}$  without  $\text{Mn}^{2+}$  incorporation and gives a second peak at 520nm. With increasing divalent manganese content the phosphor emission goes from blue green to green. (Edited author abstract) 3 refs. In Chinese.

Anon (Baotou Rare Earth Research Inst, China). *Xi You Jin Shu* v 5 n 2 May 1986 p 86-90.

**078123 INFLUENCE OF GRINDING AND BAKING PROCESSES ON THE LUMINESCENT PROPERTIES OF ZINC CADMIUM SULFIDE PHOSPHORS FOR VACUUM FLUORESCENT DISPLAYS.** The surfaces of  $\text{Zn}_{0.25}\text{Cd}_{0.75}\text{S}:\text{Ag}, \text{Cl}$  phosphors

added with  $\text{In}_2\text{O}_3$  for vacuum fluorescent displays (VFD's) have been studied by x-ray diffraction, SEM, and Auger electron spectroscopy with emphasis on the effect of the grinding and baking processes upon nonuniform strain, decomposition, and oxidation. It is found that these phenomena affect the properties of low voltage cathodoluminescence used for VFD's. (Author abstract) 4 refs.

Itoh, Shigeo (Futaba Corp, Mobara, Jpn); Tonegawa, Takeshi; Pykosz, Thomas L.; Morimoto, Kiyoshi; Kukimoto, Hiroshi. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3178-3181.

**078124 REGENERATED THERMOLUMINESCENCE AS A FUNCTION OF IRRADIATION TEMPERATURE.** The regenerated thermoluminescence (R-TL) is thermoluminescence when the phosphor is reheated after a regeneration time from and in the absence of irradiation. The phenomenon is more easily observed when the phosphors are heated before the first heating. The R-TL spectra, to  $T_m$ , consists of a continuum and well separated peaks.  $T_m$  is the maximum temperature of the first heating which quenches all peaks existing up to  $T_m$ . The authors investigated the R-TL in  $\text{LiF}$  (TLD-100),  $\text{F}_2\text{:Dy}$  (TLD-200) as a function of irradiation dose. 15 refs.

Kitis, G. (Univ of Thessaloniki, Thessaloniki, Greece); Charalambous, St. *Phys Status Solidi A* v 106 n 2 Feb 1988 p K175-K179.

**078125 SOME PECULIARITIES OF PHOTO-TRANSFER THERMOLUMINESCENCE IN  $\text{LiF}$ -TLD 100.**  $\text{LiF}$ -TLD 100 subjected to high exposure, annealed at 350 °C for 15 min, and then exposed to UV light exhibits thermoluminescence. This is known as photo-transfer thermoluminescence (PTTL) and is attributed to the transfer of charges from peak X1 traps, the only known survivors following a post-irradiation thermal anneal, to the shallower traps. Several results which cannot be explained by this simple model are presented. It is shown that peak XII traps play only a catalytic role in PTTL and actual transfer proceeds from some centers which have not been directly studied so far. (Author abstract) 21 refs.

Bhasin, B.D. (BARC, Bombay, India); Kathuria, S.P.; Moharil, S.V. *Phys Status Solidi A* v 106 n 1 Mar 1988 p 271-276.

**078126 ELECTROLUMINESCENCE OF  $\text{ZnS:Pb}$ ,  $\text{Cu}$ ,  $\text{Br}$  PHOSPHORS.** Some new data on  $\text{ZnS:Pb}$ ,  $\text{Cu}$ ,  $\text{Br}$  electroluminescent phosphors are presented. They show that the brightness could be increased and the initial instability could disappear almost completely by changes in the synthesis conditions and by making an appropriate solid state electroluminescent cell. The function of the lead impurity in the composition is to participate in the formation of a second phase of  $\text{PbS}$  which is more conducting than the  $\text{ZnS}$  phase. The  $\text{PbS}$  is more stable under ordinary atmospheric conditions compared to  $\text{Cu}_2\text{S}$ . That is probably the reason for the low aging rate of the blue emitting  $\text{ZnS:Pb}$ ,  $\text{Cu}$ ,  $\text{Br}$  electroluminescent phosphors. 4 refs.

Pakeva, S. (Univ of Sofia, Sofia, Bulg); Dafinova, R. *Phys Status Solidi A* v 106 n 1 Mar 1988 p K97-K100.

**078127 THERMOLUMINESCENCE IN SYNTHETIC LANGBEINITE.** The synthetic langbeinite  $\text{K}_2\text{Mg}_2(\text{SO}_4)_3$  doped with Sm is an efficient phosphor. In contrast to several other sulphate phosphors such as  $\text{CaSO}_4:\text{Dy}$ , the sulphate developed a visible colour upon irradiation. This note reports reflectance spectra, monochromatic glow curves, and TL emission spectra which provide an insight into the basic mechanism of thermoluminescence in this material. 4 refs.

Deshmukh, B.T. (Nagpur Univ, Nagpur, India); Bodade, S.V.; Moharil, S.V. *Phys Status Solidi A* v 106 n 1 Mar 1988 p K107-K111.

**078128 DOSIMETRIC PROPERTIES OF  $\text{KCl:Eu}$ .**  $\text{Eu}^{2+}$  ions change their valence state during the irradiation process as a consequence of the capture of either

electrons or holes. A strong emission in the blue region of the electromagnetic spectrum is produced when the irradiated specimens are heated from about room temperature up to 600 K. These results suggest that the europium-doped alkali halides may be good candidates for use in dosimetric applications because some of the characteristics which one tries to find in a solid state dosimeter are: (a) high thermoluminescence efficiency; (b) TL-spectrum of wavelengths in the wavelength region (400 to 500nm) in which commercial photodetectors respond well; and (c) low cost and easy availability. In order to achieve a better insight into this possibility, the dosimetric characteristics of the  $\text{KCl:Eu}$  phosphor material have been investigated. 13 refs.

Camacho, A.Q. (Univ Autonoma Metropolitana-Iztapalapa, Mex); Munoz, G.H.; Rubio J.O.; Garcia, J.M.; Murrieta, H.S.; Hernandez, J.A. *J Mater Sci Lett* v 7 n 5 May 1988 p 437-440.

**078129 TEMPERATURE DEPENDENT STUDIES OF CATHODOLUMINESCENCE OF GREEN BAND OF  $\text{ZnO}$  CRYSTALS.** Most of the work on cathode ray excitations of  $\text{ZnO}$  phosphors has been concentrated on low voltage excitations. The present paper reports cathodoluminescence studies of green band of  $\text{ZnO}$  crystals under high energy (40 keV) of excitation for the temperature range 4.2 to 300 K. These results enhance the utility of the model proposed by S. Bhushan et al. for the green band of  $\text{ZnO}$ . The crystals used in the present investigation have been prepared by the hydrothermal method. The excitation energy and the beam current of the cathode rays were 40 keV and 0.005  $\mu\text{A}$ , respectively. 22 refs.

Bhushan, S. (Moscow State Univ, Moscow, USSR); Chukichev, M.V. *J Mater Sci Lett* v 7 n 4 Apr 1988 p 319-321.

**078130 OXYGEN RELATED LUMINESCENCE CENTER IN  $\text{CaS:Bi}^{3+}$  PHOSPHOR.** For photoluminescence measurements, 100 w Hg-lamp and 25 cm monochromator combination luminescence spectra were obtained using 75 cm Spex monochromator equipped with RCA31034 photomultiplier tube. A new luminescence center in  $\text{CaS:Bi}^{3+}$  phosphor has been observed. The origin of this center was studied and found that it related to oxygen incorporated in  $\text{CaS}$  host structure. (Edited author abstract) 15 refs.

Park, H.L. (Yonsei Univ, Seoul, South Korea); Kim, H.K.; Chung, C.H. *Solid State Commun* v 66 n 8 May 1988 p 867-868.

## Performance

**078131 IMPROVED TERBIUM-ACTIVATED SINGLE-CRYSTAL PHOSPHOR FOR HEAD UP DISPLAY CATHODE RAY TUBE.** We report a new efficient  $\text{Ga}^{3+}$  substituted single-crystal phosphor  $\text{Y}_{3-x-y}\text{ Tb}_x\text{Lu}_y\text{Al}_5-w\text{Ga}_w\text{O}_{12}$  grown epitaxially on a  $\text{Y}_3\text{Al}_5\text{O}_{12}$  substrate. Gallium substitutions up to  $w \approx 2$  were made with y approximately 1.4w. The total light output was measured under electron beam excitation, and we observed a 35% increase in the light output at high power density excitation over that achievable with the best  $\text{Y}_{3-x}\text{ Tb}_x\text{Al}_5\text{O}_{12}$  films. The phosphor composition optimization with respect to  $\text{Tb}^{3+}$  and  $\text{Ga}^{3+}$  concentrations is reported. Our results are compared with literature data on similar garnet compounds prepared in powder form, or as bulk grown crystals, and films grown by liquid phase epitaxy. (Author abstract) 11 refs.

Berkstresser, G.W. (AT&T Bell Lab, Murray Hill, NJ, USA); Shmulovich, J.; Huo, D.T.C.; Matulis, G.; Brande, C.D.; Valentino, A.J. *J Electrochem Soc* v 135 n 5 May 1988 p 1302-1305.

**078132 IMPROVED PERFORMANCE OF CERTAIN II-VI PHOSPHORS.** Sunstone-IR and Sunstone-FL, proprietary II-VI phosphors, demonstrate superior fluorescent, phosphorescent and IR up-conversion



properties. These characteristics are important for IR sensors, optical data storage, digital radiography and other applications. (Author abstract) 4 refs.

Buhks, Ephraim (Sunstone Inc, Dayton, NJ, USA); Goldstein, Amnon; Yen, William. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 145-146.

## Physical Properties

**078133 PHOTOLUMINESCENCE SPECTRA AND VIBRATIONAL STRUCTURES OF THE  $\text{SrS}:\text{Ce}^{3+}$  AND  $\text{SrSe}:\text{Ce}^{3+}$  PHOSPHORS.** The details of photoluminescence and excitation spectra of powder phosphors were obtained at various temperatures between 6 and 300 K. At 300 K, two emission bands originating from the  $^2T_{2g}(5d) \rightarrow ^2F_{7/2}$ ,  $^2F_{5/2}(4f)$  transitions are observed at 480 and 535 nm for  $\text{SrS}:\text{Ce}^{3+}$  and at 470 and 527 nm for  $\text{SrSe}:\text{Ce}^{3+}$ , respectively. In the excitation spectra, bands corresponding to the  $^2F_{5/2}(4f) \rightarrow ^2T_{2g}(5d)$  transition are observed at 433 ( $\text{SrS}:\text{Ce}^{3+}$ ) and 430 nm ( $\text{SrSe}:\text{Ce}^{3+}$ ), and plateaus due to the fundamental absorption of the host crystals in higher energy region. The vibrational structures on the emission and excitation bands are analyzed by the use of energy matrices in order to determine the coupling constant of spin-orbit interaction  $\zeta$  and the crystal field parameters  $V_4^{(0)}$ ,  $V_6^{(0)}$  for the 4f orbit. (Author abstract) 9 refs.

Yamashita, N. (Okayama Univ, Okayama, Jpn); Michitani, Y.; Asano, S. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2932-2934.

## Processing

**078134 EFFECT OF PREPARATION METHOD ON THERMOLUMINESCENCE IN  $\text{CaS}:\text{Ce}$ .** The work reported here is part of a systematic study of host lattice defects in  $\text{CaS}$ .  $\text{CaS}$  phosphors doped with cerium have been prepared by the reduction of sulphates in  $\text{H}_2/\text{H}_2\text{S}$  at 1020°C for 2 h. These samples were refired at 1020°C with  $\text{Na}_2\text{CO}_3/\text{S}$ ,  $\text{CaF}_2$  or  $\text{NH}_4\text{Cl}$  added as fluxing agents. Phase purity was monitored by X-ray diffractometry. Thermoluminescence spectra have been measured on both fluxed and unfluxed samples in the range 80 to 450 K. Five glow peaks were observed. One may be related to sulphur vacancies, another to calcium vacancies and a third to the presence of transition metal impurities in the lattice. With increasing cerium concentration the TL emissions increase and also broaden. (Author abstract) 9 refs.

Green, A.G.J. (Coventry Polytechnic, Coventry, Engl); Brightwell, J.W.; Viney, I.V.F.; Ray, B. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 639-643.

## Production

**078135 GROWTH PARAMETER OPTIMIZATION AND  $\text{Tb}^{3+}$  SENSITIZATION OF  $\text{Ce}^{3+}$  ACTIVATED  $\text{Y}_3\text{Al}_5\text{O}_{12}$  PHOSPHOR.** Cerium activated  $\text{Y}_3\text{Al}_5\text{O}_{12}$  has been grown by liquid phase epitaxy (LPE) from a  $\text{PbO}-\text{B}_2\text{O}_3$  flux. Cathodoluminescence measurements of  $(\text{Y}_{3-x}\text{Ce}_x)\text{Al}_5\text{O}_{12}$  show an internal efficiency of 6.5% at the film composition and optimal growth conditions. Numerous lanthanide ions were studied in a series of LPE film growths to evaluate each as a sensitizer of  $\text{Ce}^{3+}$  emission in  $\text{Y}_3\text{Al}_5\text{O}_{12}$  hosts.  $\text{Tb}^{3+}$  additions increased the cathodoluminescence by 70% to yield an internal efficiency of 11%. The conditions of LPE growth which provide maximum performance in  $(\text{Y}_{3-x}\text{Ce}_x)\text{Al}_5\text{O}_{12}$  and in  $(\text{Y}_{3-x-y}\text{Ce}_x\text{Tb}_y)\text{Al}_5\text{O}_{12}$  are discussed. Consideration is given to reagent purity of the solute and flux components. The luminescence of  $(\text{Y}_{3-x-y}\text{Ce}_x\text{Tb}_y)\text{Al}_5\text{O}_{12}$  was analyzed by photoluminescence and time-resolved cathodoluminescence. (Edited author abstract) 18 refs.

Berkstresser, G.W. (AT&T, Murray Hill, NJ, USA); Shmulovich, J.; Huo, T.C.D.; Matulis, G. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2624-2628.

## Research

**078136 EFFECT OF ELECTRON-HOLE CORRELATIONS ON THE LUMINESCENCE OF CRYSTALLINE PHOSPHOR WITH TRAPS.** A model of a crystalline phosphor with traps with two channels of electron-hole recombination (direct and through the luminescence center) is examined. The dependence of the quantum output of luminescence of one of the channels on the dispersion length of the electron and hole during the hot relaxation stage is established. The dependence of the quantum output of luminescence on the energy of the incident photons, the intensity of the incident light, and its temperature is constructed. (Author abstract) 6 refs.

Vasil'ev, A.N.; Mikhailin, V.V.; Ovchinnikova, I.V. *Moscow Univ Phys Bull* v 42 n 3 1987 p 57-61.

**078137 TERBIUM-EUROPIUM ACTIVATED SILICATES.** Efficient, 254 nm excited emission has been realized for both trivalent terbium and europium in a series of calcium magnesium silicates. The existence of significant emission intensities of both species is associated with excitation of Eu by Tb emission in the ultraviolet and at 485 nm. This indicates that cross-relaxation between terbium and europium energy levels is the responsible energy transfer mechanism. (Edited author abstract) 8 refs.

McAllister, W.A. (North American Philips Lighting Corp, Bath, NY, USA); Smets, B. *J Electrochem Soc* v 135 n 3 Mar 1988 p 771-773.

## Service Life

**078138 FLUORESCENCE LIFETIME OF 5-(4-CARBOXYPHENYL)-10,15, 20-TRITOLYLPORPHYRIN IN A MIXED LANGMUIR-BLODGETT FILM WITH DIOLEOYLPHOSPHATIDYLCHOLINE. A PROPOSED STANDARD.** Time-resolved fluorescence lifetime measurements of 5-(4-carboxyphenyl)-10,15,20-tritolylporphyrin (TTPa) with dioleoylphosphatidylcholine (DOPC) in mixed Langmuir-Blodgett (LB) films on quartz slides were performed at two different laboratories. TTPa in the mixed LB film exhibited a simpler and longer decay profile than did a pure TTPa monolayer. At a DOPC/TTPa molar ratio of 50:1, the decay consisted primarily of one lifetime of  $10.7 \pm 0.2$  ns. This mixed LB film is being offered as a standard for time-resolved fluorescence lifetime measurements of LB films. Simplification and lengthening of the lifetime were attributed to reduction of TTPa aggregate formation in the film. This effect is also seen in fluorescence and absorption spectra. The fluorescence lifetime of the standard system at the air-water interface was also measured and found to be essentially the same as that of the LB film. (Author abstract) 14 refs.

Dick, Harold A. (Univ of Western Ontario, London, Ont, Can); Bolton, James R.; Picard, Gilles; Munger, Gaetan; Leblanc, Roger M. *Langmuir* v 4 n 1 Jan-Feb 1988 p 133-136.

## Spectroscopic Analysis

**078139 ENERGY TRANSFER BETWEEN  $\text{Ce}^{3+}$  AND  $\text{Tb}^{3+}$  IONS IN  $\text{LaOBr}:\text{Ce}^{3+}$ ,  $\text{Tb}^{3+}$ .** The energy transfer between  $\text{Ce}^{3+}$  and  $\text{Tb}^{3+}$  ions in  $\text{LaOBr}:\text{Ce}^{3+}$ ,  $\text{Tb}^{3+}$  was systematically studied. The emission spectra of  $\text{Ce}^{3+}$  and  $\text{Tb}^{3+}$  in  $\text{LaOBr}:\text{Ce}^{3+}$ ,  $\text{Tb}^{3+}$  have been measured with excitation at 355 and 250 nm. At the same time, the fluorescence lifetime and time-resolved spectra in nanosecond scale, for a series of samples doped with different concentrations, were measured. The temperature dependence of energy transfer efficiency  $\eta_{\text{SA}}$  and probability of energy transfer  $P_{\text{SA}}$  from  $\text{Ce}^{3+}$  to  $\text{Tb}^{3+}$  was studied. It was found that energy is transferred, not only from  $\text{Ce}^{3+}$  to  $\text{Tb}^{3+}$ , but also from  $\text{T}^{3+}$  to  $\text{Ce}^{3+}$ . A model of energy transfer is proposed. (Author abstract) 7 refs.

Zhao, Fu-Tan (Chinese Acad of Science, Chang Chun, China); Chao, Li-Yun; Xu, Xu-Rong. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3186-3190.

**078140 SPECTRAL CHARACTERISTICS OF SIX PHOSPHORS USED IN THERMOLUMINESCENCE DOSIMETRY.** Thermoluminescence emission spectra of six phosphors commonly used for TL dosimetry are presented at doses between 15 mGy and 1 Gy. The use of a Fourier transform spectrometer has made it possible to obtain spectra at doses considerably lower than those for spectra previously reported. The spectra are in the form of isometric plots of intensity versus temperature and wavelength. They are compared with previous observations at higher doses with comments on the mechanisms involved. (Author abstract) 23 refs.

Fox, P.J. (Univ of Adelaide, Adelaide, Aust); Akber, R.A.; Prescott, John R. *J Phys D* v 21 n 1 Jan 14 1988 p 189-193.

**078141  $\text{Ce}^{3+}$  SENSITIZED,  $\text{Tb}^{3+}$ ,  $\text{Mn}^{2+}$  CODOPED POLYALUMINATE PHOSPHOR.** The idea of using one sensitizer with two 'cooperative' activator has been carried out in a  $\text{Ce}^{3+}$  sensitized,  $\text{Tb}^{3+}$ ,  $\text{Mn}^{2+}$  codoped polyaluminate. The phosphor emits strong green light and may be used as a competitive component of tricolor phosphor for fluorescent lamp. (Author abstract) 4 refs.

Hong, Guangyan (Acad Sinica, Changchun, China); Jia, Qinxin; Li, Youmo. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 661-662.

**078142 DISCRETE MODEL FOR ENERGY TRANSFER AND ITS APPLICATION TO ALUMINATE AND OCTABORATE.** Recently, a discrete model for energy transfer from sensitizers (S) to activators (A) in phosphors without S-S transfer was presented by Stevens et al. In this study, the discrete model is expanded to include S-S transfer and then the developed model is applied to hexaaluminate and octaborate where S-A and S-S transfers occur. 4 refs.

Huang, Jinggen (Fudan Univ, Shanghai, China). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 669-670.

**078143 COLOR HIGH LUMINANCE LOW VOLTAGE CATHODOLUMINESCENCE.** The luminous efficiency and luminance of the low voltage cathodoluminescence have been improved, for example, the value of them are respectively up to 8 lm/W and 50,000 cd/m<sup>2</sup> at 300 V for green phosphor, they can be used for making a new kind of fluorescent display, including high luminance display, high contrast display, full-color large-screen and ultra-large-screen displays. (Author abstract) 3 refs.

Ge, Shichao (Hangzhou Univ, Hangzhou, China); Huang, Xi. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 879-880.

## Spectrum Analysis

**078144 MECHANISM AND INTENSITY OF RADICAL-RECOMBINATION LUMINESCENCE OF CRYSTAL PHOSPHORS.** The interaction of gases dissociated into atoms (hydrogen, nitrogen, oxygen) with the surface of crystal phosphors is accompanied by luminescence - radical-recombination luminescence (RRL). The purpose of this work is to examine the model of RRL corresponding to the experimental data for the excitation of luminescence of luminophors based on ZnS and CaO atomic hydrogen. 16 refs.

Kharlamov, V.F. *J Appl Spectrosc* v 46 n 3 Mar 1987 p 273-277.

## Synthesis See ZINC COMPOUNDS—Precipitation.

## Thermal Effects

**078145 PREPARATION AND THE CHARACTERISTIC OF TEMPERATURE-SENSITIVE PHOSPHORS.** Two types of temperature-sensitive phosphors, (Zn,Cd) (S,Se):Ag(or Cu) and compounds activated with



rare-earth ions, which can be used in non-contact temperature measurement were prepared. The dependence between the compositions of phosphors, kinds and concentrations of activator and killer and temperature-sensitive characteristics were studied. (Author abstract) 2 refs.

Zhang, Weiping (Univ of Science & Technology of China, Hefei, China); Lu, Xiaopu; Wang, Hong; Shi, Chaoshu; Zhang, Jifa. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 850-851.

**PHOSPHORUS** See Also COAL DUST; SEMICONDUCTING INDIUM COMPOUNDS—Chemical Vapor Deposition; SEMICONDUCTING INDIUM COMPOUNDS—Ion Implantation; SEMICONDUCTING INDIUM COMPOUNDS—Surfaces; SEMICONDUCTING SILICON—Ion Implantation; SEMICONDUCTOR MATERIALS—Amorphous; SILICA—Impurities; WASTEWATER—Biological Treatment.

**Adsorption** See Also SOILS—Processing.

**078146 ADSORPTION MECHANISM OF PHOSPHORUS ON ALUMINA.** The effect of phosphorus on the acidity and physical properties of a support of  $\gamma$ -alumina was studied, as a preliminary stage to understanding its role as an additive in hydrotreatment catalysts. The results showed that phosphorus was adsorbed on alumina following a Langmuir-type mechanism, in which a phosphate ion monolayer was formed at the surface. Equilibrium was strongly displaced towards adsorption. These results were verified using X-ray photoelectron spectroscopy. Phosphorus modified not only the acidity but also the physical properties of the alumina. From the experimental results obtained, an adsorption mechanism of phosphorus on alumina could be established. (Author abstract). 13 Refs.

Morales, A. (INTEVEP, Caracas, Venez); Ramirez de Agudelo, M.M.; Hernandez, F. *Appl Catal* v 41 n 1-2 Jul 15 1988 p 261-271.

**Amorphous** See PHOTOLUMINESCENCE—Theory.

**Applications** See ELECTROLESS PLATING—Nickel; FERTILIZERS—Spreaders.

**Association** See SOILS—Composition Effects.

**Concentration** See LAKES; NICKEL AND ALLOYS—Impurities; SOILS—Components.

**Diffusion** See SEMICONDUCTING SILICON—Processing.

**Environmental Impact** See RUNOFF—Mathematical Models.

**Manufacture** See Also FERTILIZERS—Phosphates; PAVEMENTS—Foundations.

**078147 PREPARATION OF HIGH PURITY PHOSPHORUS.** Purification of indigenous technical grade white phosphorus (99.5-99.8% purity) to achieve ultrapurity (99.999+%) was attempted on 100 g scale. The scheme for purification consists of filtration, leaching with nitric acid and multiple vacuum distillation in quartz apparatus. Subsequent conversion of the purified white phosphorus to the red and stable allotropic form is also included. (Edited author abstract) 7 refs.

Mathur, B.S. (BARC, Bombay, India); Mungekar, D.S. *Indian J Technol* v 25 n 8 Aug 1987 p 359-362.

**Phase Transitions**

**078148 STABILITY OF THE SIMPLE CUBIC PHASE OF PHOSPHORUS.** The transition from the rhombohedral phase to the simple cubic phase of phosphorus under pressure is studied within the local density-functional formalism with use of the norm-conserving pseudopotential. The calculated transition pressure is 15.8 GPa, which is in good agreement with the measured value, 10 GPa. The bonding in the simple cubic phase is shown to be structure under low pressures is understood

by a Peierls' instability, which is just the same as the case of arsenic. It is also shown that the mixing of atomic 3d-orbitals in the occupied states is important for stabilizing the simple cubic structure under high pressure. (Author abstract) 14 refs.

Sasaki, T. (Tohoku Univ, Sendai, Jpn); Shindo, K.; Niizeki, K.; Morita, A. *Solid State Commun* v 62 n 12 Jun 1987 p 795-799.

**Physical Properties**

**078149 INTERPLANAR FORCES OF BLACK PHOSPHORUS CAUSED BY ELECTRON-LATTICE INTERACTION.** The generalized electronic susceptibility of a narrow gap semiconductor, black phosphorus, is calculated by using electron-lattice coupling constants derived microscopically on the basis of tight-binding calculations of the electronic band structure. Interplanar forces along the [100] direction caused by the electron-lattice interaction are evaluated from the obtained generalized electronic susceptibility. Reflecting the narrow gap the interplanar forces take significant values even for far neighboring planes. Considerable decrease of the energy gap induced by pressure gives rise to characteristic pressure dependences of the interplanar forces, which lead to qualitative explanation of the observed pressure dependences of the phonon dispersion curves. (Edited author abstract) 29 refs.

Suzuki, Naoshi (Osaka Univ, Toyonaka, Jpn); Aoki, Masato. *Solid State Commun* v 61 n 10 Mar 1987 p 595-600.

**Processing** See SEWAGE TREATMENT—Biological Treatment.

**Production** See Also POWDERS—Compaction.

**078150 ELEKTROKINETIC POTENTIAL OF PHOSPHORUS DISPERSION IN SLIMES OF PHOSPHORUS PRODUCTION.** In order to develop and improve the method of yellow phosphorus isolation from the slime by applying an external electric field, it is necessary to know the sign of the charge of the dispersed phosphorus in the slime as well as the factors affecting it. Determination of the conditions in which the phosphorus dispersion loses its charge is essential. To solve these problems, in this work we measured the electrokinetic potentials of the phosphorus dispersion right in the salt-containing water taken from the slime collector in the neutralization section. The results obtained give enough information for evaluation of the electrochemical behavior of phosphorus dispersion, which is a constituent of the phosphorus slime, in practicable conditions and for ascertaining the technological parameters of the process of isolation of the phosphorus dispersion from the mineral part of the slime in an external electric field. Comparing the data obtained, it can be concluded that orthophosphates are adsorbed in concentrated solutions, i.e., in salt-containing slime water, mainly at low pH values (2-3). In more diluted solutions, i.e., at a reduced ionic strength, orthophosphates are adsorbed at higher pH values (4-5). Thus phosphorus dispersion in slimes of phosphorus production is negatively charged due to adsorption of ortho- and polyphosphates. At 60°C and pH 2-3 the potential-determining ions are desorbed and the phosphorus dispersion loses its charge. 9 refs.

Saparov, O.T. (Kazakh Chemical Technology Inst, USSR); Chechina, O.N.; Estrela-Lopes, V.R.; Zhurinov, M.Zh. *J Appl Chem USSR* v 59 n 8 pt 1 Aug 1986 p 1611-1614.

**Recovery** See LAKES—Sedimentation; SEWAGE TREATMENT—Research.

**Removal** See SEWAGE TREATMENT—Activated Sludge; SEWAGE TREATMENT—Biological Treatment; SOILS—Erosion; WASTEWATER—Treatment.

**Solutions** See SOILS—Physical Chemistry.

**Spectroscopic Analysis**

**078151 DETERMINATION OF PHOSPHORUS DISTRIBUTION IN THE SILICON DIOXIDE/SILICON LAYER SYSTEM BY SECONDARY ION MASS SPECTROMETRY.** A measurement technique for quantitative distribution analysis of phosphorus in the layer system  $\text{SiO}_2/\text{Si}$  was developed. Oxygen primary ions and an increased oxygen pressure ( $5 \times 10^{-5}$  mbar) in the sample chamber were used for elimination of the matrix effect. Precise adjustment of the mass spectrometer during depth profiling with high mass resolution was controlled by a computer routine. Charging effects were compensated by flooding of the sample with electrons, optimized biasing of the accelerating potential of the secondary ions, and normalization to a reference signal. A detection limit of  $1 \times 10^{16}$  atoms  $\cdot \text{cm}^{-3}$  and an accuracy of  $\pm 30$  percent were obtained. (Edited author abstract). 22 refs.

Stingeder, Gerhard (Technical Univ Vienna, Vienna, Austria). *Anal Chem* v 60 n 15 Aug 1 1988 p 1524-1529.

**PHOSPHORUS COMPOUNDS** See Also GLASS—Additives; PHOTOVOLTAIC CELLS—Manufacture.

**Adsorption** See ALUMINA—Surface Properties.

**Agglomeration** See FUELS—Materials.

**Chemical Analysis** See SOILS—Sediments.

**Chemical Reactions**

**078152 RADIOCHEMICAL ANALYSIS OF PHOSPHORUS EXCHANGE KINETICS BETWEEN SEDIMENTS AND WATER UNDER AEROBIC CONDITIONS.** Adsorption-desorption reactions of P by lake sediments, Lake Kasumigaura, Japan, were studied using radioisotope  $^{32}\text{P}$  inorganic phosphate. Exchange rates and amounts of exchangeable P in sediments were measured in aerobic sediments-water batch systems under different pH and P concentration conditions. Exchangeable P ranged from 6 to 43% of the total P in the indigenous sediments. Increasing pH induced P desorption from sediment. The relationship between the concentration in water and the amount of exchangeable P could be explained by the Langmuir equilibrium model. However, the Langmuir rate equation cannot describe the kinetics of whole exchange reactions. The adsorption-desorption reaction was composed of an exchange reaction and a slow adsorbed-reaction. The exchange reaction has two phases - very rapid reaction and a Langmuir-type reaction. (Author abstract) 16 refs.

Furumai, H. (Kyushu Univ, Fukuoka, Jpn); Ohgaki, S. *J Environ Qual* v 17 n 2 Apr-Jun 1988 p 205-212.

**Chromatographic Analysis**

**078153 GAS-CHROMATOGRAPHIC DETERMINATION OF PHOSPHINE IN HIGHLY PURE MONOGERMANE.** The gas-chromatographic determination of phosphine in monogermene depends in many respects on the efficiency of separation of these substances. The goal of the present research was to further decrease the limit of detection of phosphine in monogermene. The investigation was carried out with a Tsvet-100 chromatograph remodeled for work with reactive substances. The detector was a flame-photometric detector with a light filter. The optimum ratio of the hydrogen and air flow rates was selected experimentally. The maximum signal for phosphine was obtained at a hydrogen and air flow ratio of 3:17. 5 refs.

Ezheleva, A.E. (Acad of Sciences of the USSR, Gorkii, USSR); Baturina, N.M.; Kazakov, V.P.; Krylov, V.A. *Ind Lab (USSR)* v 53 n 3 Mar 1987 p 217-219.



**078154 GAS PHASE PYROLYSIS GAS CHROMATOGRAPHY-FOURIER TRANSFORM INFRARED SYSTEM FOR USE IN THERMAL DECOMPOSITION STUDIES OF VOLATILE COMPOUNDS.** A gas phase pyrolysis gas chromatography-Fourier transform infrared system has been developed for studying the thermal decomposition of high purity, low molecular-weight compounds. The system used a rotary valve/cold trap injection technique coupled to a closed vacuum system for the sampling and introduction of compounds which are both air sensitive and highly toxic. The system is shown to give reasonable, reproducible results and has proven to be reliable over a large number of experimental runs. A detailed description of the system is presented along with an evaluation of its performance. (Author abstract) 34 refs.

Smith, David F. (Univ of South Carolina, Columbia, SC, USA); Durig, J.R. *J Anal Appl Pyrolysis* v 13 n 1-2 Jan 1988 p 63-76.

**Decomposition** See LUBRICATING OILS—Additives.

## Dehydration

**078155 THERMOLYSIS OF DIVALENT METAL DIHYDROPHOSPHATES.** It was shown that thermal dehydration of divalent metal dihydrophosphates is accompanied by intramolecular hydrolysis of the salt, which can lead to separation of free phosphoric acid and also to formation of acidic condensed phosphates. The nature of the cation, degree of hydration of the monophosphate, and thermal treatment conditions have an effect on thermolysis. (Author abstract) 21 refs.

Shchegrov, L.N. *Sov Prog Chem* v 53 n 2 1987 p 31-35.

**Environmental Impact** See Also INDUSTRIAL WASTES—Environmental Impact; WATER POLLUTION—Underground.

**078156 PHOSPHORUS TRANSPORT MODEL FOR SMALL AGRICULTURAL WATERSHEDS.** GAMESP, the Guelph model for evaluating the effects of Agricultural Management systems on Erosion, Sedimentation and Phosphorus yields, is proposed to delineate source areas of sediment and phosphorus delivery to surface waters of small agricultural watersheds. The purpose of this study is to introduce the concepts and components of the model, describe the computational approach, and present an application of the model on a small agricultural watershed in southern Ontario. (Author abstract) 26 Refs.

Rousseau, A. (Cornell Univ, Ithaca, NY, USA); Dickinson, W.T.; Rudra, R.P.; Wall, G.J. *Can Agric Eng* v 30 n 2 Jul 1988 p 213-220.

**Evaluation** See RESERVOIRS—Sampling.

## Magnetic Properties

**078157 (Fe,Co)-P THIN FILMS PREPARED WITH A REACTIVE EVAPORATION METHOD.** Magnetic properties of (Fe,Co)<sub>2</sub>P thin films prepared with the thermal-activated reactive evaporation method were investigated for recording media application. Above 300°C, metals (Fe,Co) and phosphorus react to form M<sub>2</sub>P. The coercive forces of these films had a maximum value of 1.3 kOe at 10% Co concentration, and the saturation magnetization increased with the increase in Co concentration. Annealing at 500°C for 30 min increased the coercive force of the films up to two times. The reproduced output from the isolated magnetization transitions of a (Fe,Co)-P-film rigid disk with a ring head showed waveforms of typical longitudinal recording. A recording density of 62 kfrpi at D<sub>50</sub> was attained with a disk medium of about an 800-angstrom-thick layer. 16 refs.

Haeiwa, Tetsuzi (Shinshu Univ, Nagano, Jpn); Matsumoto, Mitsunori. *IEEE Trans Magn* v 24 n 3 May 1988 p 2055-2059.

## Molecular Structure

**078158 IR AND/OR NMR SPECTRA-STRUCTURE CORRELATIONS FOR ORGANOPHOSPHORUS COMPOUNDS.** This study is an attempt to develop correlations between IR and/or NMR phosphorus-31 data with molecular structure. It is found that increased branching on the  $\alpha$ -C-P carbon atom causes  $\delta(^{31}\text{P})$  to occur at increasing higher frequency in a systematic manner. The  $\delta(^{31}\text{P})$  frequency increases with increased electron release of the alkyl groups. Correlations exist between  $\delta(^{31}\text{P})$  and  $\delta(\text{N})$  for corresponding alkyl analogs of RPH<sub>2</sub> vs. RNH<sub>2</sub>, (R)<sub>2</sub>PH vs. (R)<sub>2</sub>NH, and (R)<sub>3</sub>P vs. (R)<sub>3</sub>N. The  $\nu(\text{P}=\text{O})$  frequency and  $\delta(^{31}\text{P})$  decrease in frequency with increased branching on the  $\alpha$ -C-O-P carbon atoms for P(=O)(OR) analogs, and a correlation exists between  $\nu(\text{P}=\text{O})$  and  $\delta(^{31}\text{P})$ . 9 Refs.

Nyquist, R.A. (Dow Chemical Co, Midland, MI, USA). *Appl Spectrosc* v 42 n 5 Jul 1988 p 854-864.

## Polymerization

**078159 CYCLIC COMPOUNDS CONTAINING PHOSPHORUS ATOMS IN THE RING.** This paper describes the ring-opening polymerization of cyclic phosphorus-containing monomers. Polymers discussed in this paper are derived from cyclic monomers with the phosphorus atom at two different levels of oxidation, namely penta- and trivalent. Structurally these compounds can be penta-, tetra- or tri-coordinated with direct bonding of phosphorus with oxygen or carbon atoms. Some inorganic monomers and polymers are also presented, mostly based on the 6-membered cyclic phosphazenes. Monomers are discussed first, including general methods of preparation and some properties (e.g. stereochemistry), and then the conditions of polymerization, thermodynamics, kinetics and mechanism of polymerization. 265 refs.

Lapienis, G. (Polish Acad of Sciences, Lodz, Pol); Penczek, S. *Ring-Opening Polym* v 2. Publ by Elsevier Applied Science Publ, London, Engl and New York, NY, USA, 1984 p 919-1053.

**Pyrolysis** See SEMICONDUCTING INDIUM COMPOUNDS—Growth.

## Spectroscopic Analysis

**078160 NMR STUDIES OF THE P<sub>2</sub>O<sub>5</sub>-SiO<sub>2</sub> SOL AND GEL CHEMISTRY.** Two phosphosilicate sols were studied by <sup>1</sup>H, <sup>13</sup>C and <sup>31</sup>P NMR, and their gels were studied by <sup>31</sup>P NMR. The <sup>1</sup>H and <sup>13</sup>C NMR spectra show that the hydrolysis of Si(OCH<sub>2</sub>CH<sub>3</sub>)<sub>4</sub> is much faster than that of PO(OCH<sub>2</sub>CH<sub>3</sub>)<sub>3</sub> in alcoholic solvent. The hydrolysis of PO(OCH<sub>2</sub>CH<sub>3</sub>)<sub>3</sub> is slow as its content increases in the sol while the other conditions are unchanged. The <sup>31</sup>P NMR spectra show that there are no P-O-P and P-O-Si bonds in the sols 9 h after the beginning of the reaction, but these bonds were found in the gels. (Author abstract) 9 Refs.

Tian, Feng (East China Normal Univ, Shanghai, China); Pan, Linzhang; Wu, Xuewen; Wu, Fengqing. *J Non Cryst Solids* v 104 n 1 Aug 1988 p 129-134.

## Structure

**078161 THERMAL NEUTRON DIFFRACTION STUDY OF LIQUID PHOSPHOR TRIBROMIDE UNDER ISOBARIC CONDITION AT 295 K.** The intermolecular scattering function of liquid phosphorus tribromide is studied under isobaric condition at 295 K in a range of the scattering parameter,  $5.0 < k[\text{nm}^{-1}] < 60$ . A striking resemblance is found with results reported on liquid SbCl<sub>3</sub>. The intermolecular scattering function is tabulated. The liquid structure of PBr<sub>3</sub> can not be described very well by the RISM, similar to SbCl<sub>3</sub>. (Edited author abstract) 10 Refs.

Van Tricht, J.B. (Interfacultair Reactor Inst, Delft, Neth); Van Zeyl, H.W.; Van der Ende, P. *J Mol Catal* v 38 n 2 Jul 1988 p 97-105.

## Synthesis

**078162 STRUCTURAL STUDIES OF SOME NEW LAMELLAR MAGNESIUM, MANGANESE AND CALCIUM PHOSPHONATES.** Layered phosphonate salts of divalent metal ions (Mg, Ca and Mn) are prepared by combining solutions of soluble metal salts and alkyl- or arylphosphonic acids. The M(O<sub>3</sub>PC<sub>6</sub>H<sub>5</sub>)-H<sub>2</sub>O compounds show good thermal stability losing lattice water at 250-300°C without further decomposition below 550°C. Compounds derived from alkylphosphonic acids decompose at lower temperatures. The structure consists of roughly coplanar layers of metal atoms coordinated by phenylphosphonate groups above and below. Each metal atom is coordinated by five phosphonate oxygens and one lattice water molecule. These compounds are interesting as potential microporous catalysts, sorbents and ion exchangers. 17 refs.

Cao, Guang (Univ of Texas at Austin, Austin, TX, USA); Lee, Haiwon; Lynch, Vincent M.; Mallouk, Thomas E. *Solid State Ionics* v 26 n 2 Feb-Mar 1988 p 63-69.

**PHOTOCATHODES** See Also ELECTRON TUBES, IMAGE INTENSIFIER; PHOTODETECTORS; PHOTOEMISSIVE DEVICES.

**078163 LIQUID AND SOLID ORGANIC PHOTOCATHODES.** We have investigated the possibility of creating photocathodes for gaseous detectors with a high sensitivity in the photon spectral region between 105 and 300 nm. Metal cathodes covered with liquid or solid organic layers, such as tetrakis(dimethylamine)ethylene (TMAE) and tetramethyl-p-phenylenediamine (TMPD) and solutions of these substances, were studied using two different experimental setups: a proportional wire chamber and a single-wire counter. Three effects were observed. (Edited author abstract) 34 refs.

Peskov, V. (CERN, Geneva, Switz); Charpak, G.; Mine, P.; Sauli, F.; Scigocki, D.; Seguinot, J.; Schmidt, W.F.; Ypsilantis, T. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1988 p 149-160.

## Applications

**078164 APPLICATION OF FEU WITH SEMITRANSSPARENT NEGATIVE-ELECTRON-AFFINITY PHOTOCATHODES FOR SCINTILLATION DETECTORS AND LIGHTGUIDES.** The development of scintillation blocks for detecting  $\gamma$  radiation with an energy resolution of 4-7% is very important for the analysis of the elemental composition of rocks and ores. In this connection, together with improving the quality of the scintillation detectors, it is also necessary to improve the characteristic amplitude resolution of FEU. This is especially important for the group of scintillation detectors whose emission spectra lie in the range 500-900 nm. The use of semitransparent photocathodes of a new class with structures with negative electron affinity (NEA-photocathodes) are discussed. This opens up the possibility of raising substantially (by a factor of 5-10) the sensitivity of the photocathode and therefore reducing significantly the characteristic amplitude resolution of FEU. Such FEU are called quantocons. 4 refs.

Aksenov, V.N.; Aksenova, T.T.; Arm, E.M.; Pyatakhin, V.I.; Smolitskii, V.A.; Suvorov, E.V.; Khaustov, A.I. *Sov At Energy* v 63 n 1 Jul 1987 p 555-557.

## Efficiency

**078165 PHOTOACOUSTIC IN SITU MEASUREMENT OF QUANTUM EFFICIENCY FOR PHOTOELECTROCHEMICAL EVOLUTION OF HYDROGEN ON p-INDIUM PHOSPHIDE.** It is known that InP functions as an efficient semiconductor photoelectrode in a photoelectrochemical cell. The direct band gap of 1.35 eV makes it a very suitable material for photovoltaic solar energy conversion. In this paper, the authors report the results of measurements of optical behavior with respect to p-InP and the 'in situ' quantum efficiency for the photoelectrochemical evolution of hydrogen on p-InP and Pt-plated p-InP photocathodes by photoacous-



tic spectroscopy, using a piezoelectric transducer as the detector. 11 refs.

Yoshihara, Sachio (Univ of Tokyo, Tokyo, Jpn); Fujishima, Akira. *Mater Res Bull* v 23 n 5 May 1988 p 759-763.

**Electric Properties** See ELECTRON TUBES, PHOTO-MULTIPLIER—Thermal Effects.

**Materials** See Also CALCIUM COMPOUNDS—Doping; ELECTRIC CONTACTS—Applications.

**078166 SURFACE CHARACTERISTICS AND QUANTUM EFFICIENCY MEASUREMENTS OF CsI-COATED MICROCHANNEL PLATES.** We have investigated several properties that affect the physical growth and reproducibility of PVD CsI photocathode material particularly used as a coating for microchannel plates (MCPs) to improve soft X-ray sensitivity. We have measured the quantum efficiency of the CsI-coated microchannel plates in response to X-rays from 0.7 to 4.5 keV. (Author abstract) 6 refs.

Chappell, J.H. (Harvard-Smithsonian Cent for Astrophysics, Cambridge, MA, USA); Everman, E.; Murray, S.S. *Nucl Instrum Methods Phys Res Sect A* v A260 n 2-3 Oct 15 1987 p 483-490.

**078167 PULSED PHOTOCURRENTS FROM LANTHANUM HEXABORIDE CATHODES IN THE ns REGIME.** Photocathode emission investigation represents an essential part in developing new rf sources and new bunched electron guns. In order to determine the photoemissivity of different materials with work functions which can be easily lowered, we studied lanthanum hexaboride ( $\text{LaB}_6$ ) as a first step. The results of measurements with a nanosecond Nd-YAG laser, using wavelengths from 1064 to 355 nm, show that pulsed photocurrent densities can reach  $7 \text{ kA/cm}^2$ . Quantum yields evolved from  $10^{-7}$  to  $10^{-3}$  with the lowering of the work function when cleaning the surface under laser exposition. The results also show that with the use of high density photon beams of approx.  $45 \text{ J/cm}^2$ , lanthanum desorption occurs at the surface. Suggestions are given for a cure of this desorption problem. (Author abstract) 5 refs.

Boussoukaya, M. (Cent d'Orsay, Orsay, Fr); Bergeret, H.; Chehab, R.; Leblond, B. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 131-134.

## Service Life

**078168 TUNGSTEN HAIRPIN CATHODES WITH LONGER LIFETIMES.** The lifetime of tungsten hairpin cathodes is shorter than would be theoretically possible, if their maximum temperature were always in the emission centre. The publications dealing with this problem only explain why the maximum temperature is not at the vertex, but offer no solution on how to overcome the resulting asymmetry and the instability of the temperature distribution. An analysis of the possible reasons for this phenomenon indicated possibilities of how this could be corrected. This paper will discuss how raising the temperature gradient near the vertex can increase the lifetime of the cathode. This places the maximum temperature very close to or directly in the emission centre. The thickness of the wire and the temperature at this point will then determine the lifetime, which becomes therefore many times longer. (Author abstract) 5 refs.

Winkler, O. *Optik (Stuttgart)* v 78 n 3 Feb 1988 p 111-116.

## Spectrum Analysis

**078169 SPECTRAL SENSITIVITY OF CsI PHOTOCATHODES APPLIED TO MICROCHANNEL PLATES.** The spectral sensitivity of a CsI photocathode applied to a microchannel plate in a prototype of an image converter with an  $\text{MgF}_2$  entrance window is measured in the range of 116-550 nm. (Author abstract)

Bragin, B.N. (All-Union Scientific-Research Inst of Opticophysical Measurements, Moscow, USSR); Vesel'nit-

skii, I.M.; Voskoboinikova, E.S.; Melamid, A.E.; Akopyan, A.A. *Instrum Exp Tech* v 30 n 2 pt 2 Mar-Apr 1987 p 429-430.

**PHOTOCHROMISM** See Also CADMIUM COMPOUNDS—Optical Properties; FLOW OF FLUIDS—Pipes; GLASS—Optical Properties; MEMBRANES—Fluidity; POLYMERS—Optical Properties.

**078170 LAWS OF COLORING OF PHOTOCHROMIC SOLUTIONS USED IN EXPERIMENTAL HYDRODYNAMICS.** It is known that the introduction of small quantities of photochromic compounds into a liquid flow makes it possible to obtain colored tracks in the solution by directional irradiation at a certain wavelength. The authors study the photochromic characteristics of an aqueous solution of spiropyran 11. We determined the length of the colored track in relation to the energy of the activating laser radiation and the concentration of photochromic substance in the solvent. They established the range of concentration of the photochromic substance and of other parameters necessary to reliably record a colored track. 11 refs.

Alvarez-Suarez, V.A.; Polyani, A.D.; Ryazantsev, Yu.S. *J Appl Mech Tech Phys* v 28 n 1 Jan-Feb 1987 p 10-13.

## Mathematical Models

**078171 MATHEMATICAL MODELING OF THE FORMATION OF COLOR CENTERS IN HETEROGENEOUS PHOTOCHROMIC GLASS.** A mathematical model in the form of a system of differential equations for the change in the concentration of color centers and pre-centers has been proposed. An analysis of the solution of this system makes it possible to explain important features of the darkening kinetics of heterogeneous photochromic glasses: the presence of an induction period, the dependence on the intensity of activation, and the deviations from the law of mutual substitution. 24 refs.

Dotsenko, A.V.; Morozov, A.V.; Tsekhomskii, V.A. *Sov J Glass Phys Chem* v 13 n 2 Mar-Apr 1987 p 88-93.

**Reaction Kinetics** See GLASS—Optical Properties.

**PHOTOCONDUCTING DEVICES** See Also ELECTRETs—Photoconductivity; MICROWAVE DEVICES.

**078172 QUANTUM EFFICIENCY OF PHOTOCONDUCTIVE DETECTORS - INFLUENCE OF REFLECTION AND SURFACE RECOMBINATION VELOCITY.** In this work, analytical expressions determining the quantum efficiency at low electric fields, taking into account reflections at front and back detector surfaces and corresponding surface recombination velocities, are obtained. Using these expressions, the dependence of the quantum efficiency of  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  photoconductive detectors on the wavelength of the incident radiation for  $x=0.215$ , at liquid nitrogen temperature, is calculated. (Author abstract) 10 refs.

Djuric, Z. (Inst for Chemistry, Technology & Metallurgy, Belgrade, Yugoslavia). *Infrared Phys* v 27 n 6 Nov 1987 p 407-410.

**Amorphous** See ELECTRON TUBES, TELEVISION CAMERA.

**Manufacture** See SEMICONDUCTING SILICON—Doping.

## Mathematical Models

**078173 MATHEMATICAL MODELING OF PHOTOCONDUCTOR TRANSIENT RESPONSE.** A photoconductor device model that is based on time-dependent convective/diffusive continuity and transport equations is presented. Electron and hole trapping on deep-level impurities is accounted for by trapping-kinetics rate equations. The coupling between carrier drift and electric field is expressed by Poisson's equation. The system of model equations is solved numerically with boundary conditions that represent ideal ohmic contacts. Computed

results are presented for different photoconductor lengths and bias voltages with spatially uniform, rectangular light-pulse excitation. Material parameters appropriate for iron-doped indium phosphide are used. 10 refs.

Iverson, A. Evan (Los Alamos Natl Lab, NM, USA); Smith, Darryl L. *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2098-2107.

**Optical Properties** See SEMICONDUCTING ZINC COMPOUNDS—Spectrum Analysis.

## Switching

**078174 TRANSPORT CORRELATION COEFFICIENTS AND PHOTOCONDUCTIVE SWITCHING.** The use of a retarded Langevin equation for the development of a simple model of a photoconductive switch is described. This model allows the accurate determination of carrier transport transients in the switch provided that certain commonly made assumptions concerning spatial homogeneity remain valid and an appropriate optical pulse energy and wavelength are chosen. The model utilizes velocity autocorrelation functions which could be estimated by Monte Carlo techniques or potentially measured by applying the model to experimental data. The validity of the model is demonstrated for wavelengths in which carriers are generated somewhat below the threshold for intervalley scattering. A mechanism by which an applied field can actually delay the initial rise in a photocurrent in a subpicosecond photoconductive experiment is described. (Edited author abstract) 9 refs.

Grondin, Robert O. (Arizona State Univ, Tempe, AZ, USA); Kann, Meng J. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 567-570.

**PHOTOCONDUCTING MATERIALS** See Also GLASS, METALLIC—Synthesis; IMAGE SENSORS—Contacts; POLYMERS—Electric Properties.

**078175 NEW APPARATUS FOR MEASURING PHOTOCONDUCTIVE CHARACTERISTICS LINKED TO VACUUM EVAPORATION EQUIPMENT.** The high sensitivity of photoconductive film (called target) in the pick-up tube of the high definition TV (HDTV) camera is sought. A mechanism to move a target in vacuum has been designed, and an apparatus for measuring target characteristics, linked to a vacuum evaporation equipment, has been developed. This apparatus can be used to measure the characteristics of evaporated target immediately, without exposure to the atmosphere. Since all the processes from evaporation to measurement are accomplished continuously in a vacuum, measurement efficiency can be improved. Another advantage is that materials which oxidize easily in the atmosphere can be tested, and changes in the characteristics of a target in the process of evaporation can also be measured. This paper describes the configuration of the new apparatus, and gives examples of the measurement of target characteristics as an application. 1 ref.

Yamazaki, Junichi (NHK, Tokyo, Jpn); Kosugi, Mitsuo; Shidara, Keichi; Kawamura, Tatsuro. *NHK Lab Note* n 337 Oct 1986 11p.

**078176 MEASUREMENT OF PHOTOCARRIER INJECTION EFFICIENCIES AT THE INTERFACE IN DOUBLE LAYERED ORGANIC PHOTOCONDUCTORS.** Photocarrier injection efficiencies from the carrier generation layer into the transport layer in double-layered photoconductors were measured by using a photoacoustic technique. Photoinjection efficiencies were derived by measuring the decrease in photoacoustic signal when an electric field was applied to the samples. A linear relationship was observed between the logarithm of the photoinjection efficiencies and the square root of the applied electric field. Photocarrier injection efficiencies are



limited by a barrier between the carrier generation layer and the carrier transport layer. (Author abstract) 9 refs.

Kanemitsu, Yoshihiko (Chiba Univ, Chiba, Jpn); Imamura, Shunji. *Solid State Commun* v 63 n 12 Sep 1987 p 1161-1164.

**078177 TIME-DEPENDENT PHOTOCONDUCTIVITY IN  $\text{CdIn}_2\text{S}_4$ .** To investigate the photoresponse due to defect levels in  $\text{CdIn}_2\text{S}_4$ , the measurement of photocurrent was carried out as a function of light intensity and time. It was found that the photocurrent showed a strong dependence both on time and light intensity, indicating the existence of photoactive levels at the top of the valence bands. The  $\text{CdIn}_2\text{S}_4$  single crystals were grown from a melt of the stoichiometric composition of six-nine purity elements with 0.25% excess sulfur. The resistivity of the crystal exceeded more than  $5 \text{ M}\Omega \cdot \text{cm}$  at room temperature. Chopped light (80 Hz) was incident and focused on the  $1 \times 1 \text{ mm}^2$  area in the center of the  $3 \times 7 \text{ mm}^2$  sample surface, and the a.c. amplitude of photocurrent was measured using usual synchronous detection techniques at room temperature. 7 refs.

Takizawa, Takeo (Nihon Univ, Tokyo, Jpn); Takeuchi, Hidemi; Kanbara, Kohji. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 234-236.

**078178 HIGH TEMPERATURE PHOTOCONDUCTIVITY OF CHEMICALLY DEPOSITED CADMIUM SULPHIDE THIN FILM.** The group II-IV compounds are an important class of materials for photoconductivity; they include the most sensitive photoconductors CdS and CdSe. The photoconducting property of chemically deposited CdS films in the temperature range 303 to 380 K are reported. 6 refs.

Das, B.N. (Indian Inst of Technology, Kharagpur, India); Sahu, S. *J Mater Sci Lett* v 7 n 2 Feb 1988 p 151-152.

**078179 PHOTOELECTROCHEMICAL CHARACTERIZATION OF NOVEL RHODIUM IODIDE PHOTOCONDUCTORS.** The physical and photoelectrochemical (PEC) properties of three rhodium iodide semiconducting materials have been investigated; crystalline  $\text{RhI}_3$ , amorphous  $\text{RhI}_3$ , and a new material that may be formulated as  $\text{RhI}_{4.1-4.3}$ . Although the former two materials have been previously prepared, their semiconducting material ( $\text{RhI}_{4.1-4.3}$ ) results from reacting  $\text{RhBr}_3 \cdot 2\text{H}_2\text{O}$  with triiodide ion in aqueous solutions. Its chemical and physical properties are substantially different from the known rhodium iodides (either crystalline or amorphous). (Edited author abstract) 19 refs.

Peterson, Mark W. (Solar Energy Research Inst, Golden, CO, USA); Parkinson, Bruce A. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1424-1431.

## Electrochemistry

**078180 PHOTOELECTROCHEMICAL SPECTRAL RESPONSE OF AIR-SINTERED PHOTOCONDUCTING  $\text{CdS}$  IN RELATION TO SURFACE IMPURITY PHASE(S).** We explored the possibility of employing photoelectrical (PEC) measurement techniques in order to study the relevant photoeffects in air-sintered pellets of CdS, principally, because such measurement techniques necessarily deal with a solid (electrode)-liquid (electrolyte) junction in contrast to only solid state as in the case of photoconductivity measurement techniques. During the course of this investigation, we dealt with PEC spectral response studies on such air-sintered pellets of  $\text{CdS}:\text{Cu}:\text{Cl}$ . Although PEC spectral response studies on air-sintered pellets of  $\text{CdS}:\text{Cu}:\text{Cl}$  are interesting, the purpose of characterizing impurity phase(s) photoelectrochemically in order to understand the relevant photoeffects at  $\text{CdS}:\text{Cu}:\text{Cl}$  has not been fully served, because of chemical reaction between the impurity phase(s) and an electrolyte [i.e.  $\text{Na}_2\text{S}$ ]. 9 refs.

Amalnerkar, D.P. (Gifu Univ, Jpn); Suzuki, E.; Sugiura, T.; Ueno, Y.; Minoura, H. *J Mater Sci Lett* v 6 n 11 Nov 1987 p 1307-1309.

**Low Temperature Effects** See LEAD TIN TELLURIUM INDIUM ALLOYS—Electronic Properties.

**Radiation Effects** See GLASS—Photoconductivity.

**Simulation** See SEMICONDUCTOR MATERIALS—Photoconductivity.

## Spectrum Analysis

**078181 INTRINSIC CARRIER CONCENTRATIONS AND EFFECTIVE MASSES IN THE POTENTIAL INFRARED DETECTOR MATERIAL,  $\text{Hg}_{1-x}\text{Zn}_x\text{Te}$ .** The intrinsic carrier concentration, electron effective mass ratio and the reduced Fermi energy are calculated for  $\text{Hg}_{1-x}\text{Zn}_x\text{Te}$  with  $0.10 \leq x \leq 0.40$  and  $50 \leq T \leq 350 \text{ K}$ . The calculations have been performed in terms of the k-p method (Kane and model). By fitting the calculated nonparabolic  $n_1$  values to the expression for parabolic bands, approximation for the intrinsic carrier concentration has been obtained. (Edited author abstract) 31 refs.

Jozwikowski, K. (WAT, Warsaw, Pol); Rogalski, A. *Infrared Phys* v 28 n 2 Mar 1988 p 101-107.

**Surfaces** See SEMICONDUCTING CADMIUM COMPOUNDS—Surfaces.

## Synthesis

**078182 PHOTOCONDUCTION OF RAPIDLY QUENCHED FILMS IN THE  $\text{PbO-TiO}_2$  SYSTEM.**  $\text{PbO-TiO}_2$  films were prepared by a rapid quenching technique, using twin-roller type equipment. The quenched films, containing from 10 to 30 mol%  $\text{TiO}_2$ , precipitated tetragonal  $\text{PbO}$  solid solution as a single phase.  $\text{PbTiO}_3$  crystals precipitated from a melt with an equimolar composition of  $\text{PbO}$  and  $\text{TiO}_2$  had a denser structure and a lower tetragonality compared to those obtained by solid-phase reaction. In films containing 60 mol%  $\text{TiO}_2$  or more, the formation of an amorphous phase was predominant. Both crystalline films and amorphous  $\text{PbTiO}_3$  films showed photoconductivity. (Edited author abstract) 16 refs.

Sekiya, T. (Government Industrial Research Inst, Nagoya, Jpn); Futakuchi, T.; Tsuzuki, A.; Kawakami, S.; Torii, Y. *Mater Res Bull* v 22 n 11 Nov 1987 p 1555-1561.

## Temperature Effects

**078183 TEMPERATURE DEPENDENCE OF AMBIPOLAR MOBILITY FOR A 0.1 eV n-TYPE  $\text{HgCdTe}$  PHOTOCONDUCTOR.** Temperature dependence of ambipolar mobility for a 0.1 eV n-type  $\text{HgCdTe}$  photoconductor was derived in the 10-100 K temperature range, from experimental results on excess minority carrier lifetime and ratio of responsivity at low electric field to that at high field. It was found that the ambipolar mobility decreases exponentially above 60 K, while it has a constant value between 30 and 60 K. The mobility behavior above 60 K indicates that a dominant scattering mechanism is a polar optical phonon scattering with approximately 16 meV phonon energy. The results will be useful for design of SPRITE detectors. (Author abstract) 14 refs.

Oda, Naoki (NEC Corp, Kawasaki, Jpn). *Infrared Phys* v 28 n 2 Mar 1988 p 91-95.

## Testing

**078184 FIELD DEPENDENCE OF OPTICAL BAND GAP IN MANGANESE PHOSPHATE GLASSES.** Photoconduction measurements are made in the spectral energy range 1.5-6.2 eV on a manganese phosphate glass with composition 40 mol%  $\text{MnO}$  and 60 mol%  $\text{P}_2\text{O}_5$ . The values of energy band gap are deduced by extrapolation of the linear region of the spectral dependence curves, obtained at various applied fields. These values decrease slowly with increasing field, and a band gap value of 5.07 eV is derived for zero field. The results can be explained in terms of energy bands for

amorphous materials, and are similar to those obtained for other metal phosphate glasses. (Author abstract) 13 refs.

Siddiqi, S.A. (Univ of the Punjab, Lahore, Pak); Ahmed, I.; Naseem, S. *Int J Electron* v 63 n 5 Nov 1987 p 733-738.

**Thermal Properties** See SEMICONDUCTOR MATERIALS—Photoconductivity.

**Thin Films** See Also SEMICONDUCTING FILMS—Thin Films.

**078185 SPACE-CHARGE LIMITED CONDUCTION IN VACUUM-DEPOSITED  $\text{Sb}_2\text{S}_3$  FILMS.** In the course of study of photoconductive films for use as target materials in the vidicon, current-voltage characteristics were observed in the dark in antimony trisulfide that were strongly suggestive of space-charge limited (SCL) currents. In the present letter SCL current conduction in  $\text{Sb}_2\text{S}_3$  films of thickness 100 to 700 nm using gold electrodes is reported. This is compared with the temperature dependence of the dark conductivity of the corresponding films. Metal-semiconductor-metal (MSM) sandwich structures for the I-V studies were prepared on microglass slides using thick vacuum-deposited gold films as base and counter electrodes. 8 refs.

Mady, Kh.A. (Nat'l Research Cent, Cairo, Egypt); El-Nahas, M.M.; Gabr, A.A. *J Mater Sci Lett* v 6 n 8 Aug 1987 p 912-914.

## Transport Properties

**078186 PULSED LASER INDUCED PHOTOCONDUCTIVITY IN  $\text{ZnS}$  - PART I.** The photoconductivity spectrum of  $\text{ZnS}$  has been recorded using dye lasers, and the nonlinearity of the lux-ampere characteristics has been studied at the band edge frequency. The presence of space charge effect in the crystal has been confirmed by studying the current-voltage characteristics. The charge vs. intensity characteristics using high power pulsed lasers (XeCl excimer laser, frequency doubled and fundamental Nd:YAG laser) indicate one, two and four photon photoconductivity processes in the crystal. The long-lasting controversy between the superlinear behavior of lux-ampere characteristics and the two photon photoconductivity of the V-C'-C type (V stands for valence band, C' for intermediate band and C for conduction band) has been resolved. (Edited author abstract) 22 refs.

Singh, R.D. (Maharshi Dayanand Univ, Rohtak, India); Unnikrishnan, N.V.; Maters, M. *J Phys Chem Solids* v 49 n 1 1988 p 79-83.

**PHOTOCONDUCTIVITY** See Also ACETYLENE—Thermal Effects; BISMUTH COMPOUNDS—Optical Properties; CRYSTALS—Optical Properties; GERMANIUM AND ALLOYS—Thin Films; GERMANIUM SELENIUM TELLURIUM ALLOYS—Amorphous; IRON COMPOUNDS—Electric Properties; MERCURY AND AMALGAMS—Measurements; OPTICS—Nonlinear; PLASMA FILMS—Electric Properties; POLYMERS—Optical Properties; SEMICONDUCTING ALUMINUM COMPOUNDS—Optical Properties; SEMICONDUCTING CADMIUM COMPOUNDS—Charge Carriers; SEMICONDUCTING CADMIUM COMPOUNDS—Electronic Properties; SEMICONDUCTING CADMIUM COMPOUNDS—Optical Properties; SEMICONDUCTING CADMIUM COMPOUNDS—Thin Films; SEMICONDUCTING GALLIUM ARSENIDE—Doping; SEMICONDUCTING GALLIUM ARSENIDE—Transport Properties; SEMICONDUCTING GALLIUM COMPOUNDS; SEMICONDUCTING INDIUM COMPOUNDS—Defects; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Charge Carriers; SEMICONDUCTING SILVER COMPOUNDS—Optical Properties; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR MATERIALS; SEMICONDUCTOR MATERIALS—Amorphous; SILVER AND ALLOYS—Diffusion; SOLAR CELLS—Cadmium Sulfide.

**Applications** See SEMICONDUCTOR DEVICES, MOS—Radiation Effects.

**Laser Applications** See Also PHOTOCONDUCTING MATERIALS—Transport Properties.

**078187 LASER PHOTOEXCITATION OF IMBALANCED CARRIERS IN ALKALINE-HALOID CRYSTALS.** A theoretical analysis is performed of a kinetic model of two-photon laser excitation of imbalanced



carriers in broad band dielectrics with consideration of the processes of admixture ionization and different types of recombination. A comparison is performed with the experimental results about the laser photoconductivity of alkaline-haloid crystals. (Author abstract) 5 refs.

Garnov, S.V.; Epifanov, A.S.; Klimentov, S.M.; Panov, A.A.; Shakhverdiev, E.M. *Sov Phys Lebedev Inst Rep* n 4 1987 p 1-6.

**Mathematical Models** See MICROWAVE DEVICES—Switching; SEMICONDUCTOR DEVICES, BIPO-LAR—Mathematical Models.

**Measurements** See PHOTOCONDUCTING MATERIALS; POLYACETYLENES—Electric Properties; SEMICONDUCTING ALUMINUM COMPOUNDS—Ionization; SEMICONDUCTING GALLIUM COMPOUNDS—Charge Carriers; SEMICONDUCTING INDIUM COMPOUNDS—Magnetic Properties; SEMICONDUCTING SELENIUM COMPOUNDS—Amorphous; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Radiation Effects; SILICON AND ALLOYS—Amorphous.

**Research** See SEMICONDUCTING SILICON—Amorphous.

**Spectrum Analysis** See SEMICONDUCTOR MATERIALS—Doping.

ALS—Doping.

**Theory** See SEMICONDUCTING SILICON—Amorphous.

**Transients** See GERMANIUM COMPOUNDS—Thin Films; PHOTOCONDUCTING DEVICES—Mathematical Models; POLYMERS—Photoconductivity; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Charge Carriers; SEMICONDUCTOR MATERIALS—Charge Carriers; SEMICONDUCTOR MATERIALS—Grain Boundaries.

**PHOTODETECTORS** See Also ASTRONOMY—Imaging Techniques; DISPLAY DEVICES; GAGES—Computer Applications; IMAGE PROCESSING; LIGHT—Measurements; LIGHT—Propagation in Guides; OPTICAL COMMUNICATION EQUIPMENT; OPTICAL DATA PROCESSING; OPTOELECTRONIC DEVICES; PHOTOCONDUCTING DEVICES; PHOTOGRAPHIC REPRODUCTION—Xerography; SCINTILLATION COUNTERS; SEMICONDUCTING INDIUM COMPOUNDS—Growth; SEMICONDUCTOR DIODES, PHOTODIODE—Thermal Effects; SPECTROMETERS, GAMMA RAY; SPECTROSCOPY—Scintillation; SUPERCONDUCTING DEVICES—Electric Properties.

**078188 PROCESSING A DIFFRACTION PATTERN WITH A CHARGE-COUPLED DEVICE PHOTODETECTOR.** The widespread use of charge-coupled device (CCD) photodetectors as contactless devices for measuring dimensions can be credited to several advantages of these detectors: a low supply voltage, a fast response, small dimensions, low weight, etc. In particular, CCD photodetectors hold promise in diffraction systems for measuring the parameters of microscopic objects from their Fraunhofer diffraction patterns. Despite the advantages of this new type of photodetector, its use in such systems can result in errors which are unjustifiably large. The purpose of the present study was to determine the reason for modulation of diffraction intensity distribution and to develop an algorithm for correcting the optical signal on the basis of a distortion-inversion method. 5 refs.

Gos'kov, P.I.; Grozov, V.I.; Pronin, S.P. *Optoelectron Instrum Data Process* n 3 1987 p 112-114.

**078189 Pb<sub>2</sub>CrO<sub>5</sub> PHOTOVOLTAIC DEVICE FOR THE DETECTING LIGHT-BEAM POSITION.** A light position detector operating through a photovoltaic effect of a Pb<sub>2</sub>CrO<sub>5</sub> ceramic disk with a pair of Au planar electrodes is investigated. A fabrication technique and the basic characteristics of the photovoltaic device for position detection are described. A peak photovoltage is obtained around the edge of the electrode for an incident light beam. The incident light beam shape and the electrode pattern are important factors for obtaining a linear relation between the light-beam position and the output signal from the device. A device fabricated for detecting one-dimensional light position has a high position resolution of 0.5 μm and a good linearity of ±2 μm or less. A two-dimensional device can be fabricated in the same way as the one-dimensional device, except for the electrode

pattern. A method for two-dimensional light position detection using a Pb<sub>2</sub>CrO<sub>5</sub> photovoltaic cell is demonstrated for a green LED as a light source. (Author abstract) 5 refs.

Toda, K. (Natl Defence Acad, Yokosuka, Jpn); Yoshida, S. *Appl Phys B* v B45 n 2 Feb 1988 p 65-69.

**078190 LOW-PRESSURE ULTRAVIOLET PHOTON DETECTOR WITH TMAE GAS PHOTOCATHODE.** Results of the study of the properties of a low pressure multistep avalanche counter with TMAE (tetraakis(dimethylamine)ethylene) as the photosensitive gas are presented. The optimization of parameters is discussed. Absolute gas amplification, drift velocity and diffusion of drifting photoelectrons in a low pressure gas and the efficiency of single photoelectron detection are measured. The practical multihit capability and spatial resolution are explored in view of possible application in a Cherenkov ring imaging with multipad wedge-and-strip cathode readout with flash ADCs. The present limit in spatial resolution is due to diffusion of drifting electrons in a low-pressure gas. For applications where photons are detected in a high-rate background of charged particles, the low-pressure operation has many advantages over the

atmospheric pressure detectors. (Author abstract) 38 refs.

Majewski, Stan (Fermilab, Batavia, IL, USA); Anderson, David F.; Constanta-Fanourakis, Penelope; Kross, Brian; Fanourakis, George. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 235-250.

**078191 GATED WIRE PHOTODETECTOR FOR HIGH FLUX OPERATION.** A method of gating the wire gas discharge photodetector with electrical and fibre-optical readout is investigated. No restrictions due to positive space-charge effects have been revealed in the flux range up to  $5 \times 10^5$  p.h.e./mms per anode wire. Hodoscope photomultipliers are used for light detection at the fibre exits. (Author abstract) 11 refs.

Buzulutskov, A.F. (Inst for High Energy Physics, Serpukhov, USSR); Turchanovich, L.K.; Vasilchenko, V.G. *Nucl Instrum Methods Phys Res Sect A* v A265 n Mar 15 1988 p 517-520.

**078192 POWER SPECTRAL DENSITY ESTIMATION OF LIGHT INTENSITY FLUCTUATIONS IN PHOTON COUNTING.** A light beam which has a constant amplitude and is incident on a photomultiplier cathode generates completely random current impulses. When the incident light intensity is fluctuating, the probability of generating current impulses is also fluctuating in time, and hence one will find current impulses obeying a compound Poisson process. The ratio of the variance to the average number of counts in successive time slots becomes larger than unity and dependent on the time slot width of the photon counting. The present paper gives a formula which reduces the shot noise level and derives the psd of the intensity fluctuations from the dependence of the variance-to-mean ratio on the time slot width. The limitation of this technique is discussed and the validity of the technique is demonstrated by computer simulation. (Author abstract) 5 refs.

Musha, Toshimitsu (Tokyo Inst of Technology, Yokohama, Jpn); Shimizu, Keichi. *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 2022-2025.

**078193 OPTICAL PHOTODETECTION BY TRANSFORMATION OF PHOTOELECTRONS INTO SECONDARY WAVES.** A method has been developed whereby near-photon-counting performance can be achieved at high signal levels in gated optical systems of long coherence time. The method involves converting the received photoelectrons into single-frequency secondary waves. Linear performance has been demonstrated even when the photon-counting pulses greatly overlap. Furthermore, the effect of a non-stationary background may be taken into account simply as the square root of its intensity, without recourse to chopping at the signal overlap and in the background spectra. (Author abstract) 7 refs.

Stoyanov, D.V. (Bulgarian Acad of Sciences, Sofia, Bulg.)

*J Mod Opt* v 35 n 5 May 1988 p 827-832.

**078194 RAPPORT DES COEFFICIENTS D'IONISATION ET DE BRUIT DANS LES PHOTODETECTEURS A AVALANCHE Hg<sub>0.44</sub>Cd<sub>0.56</sub>Te λ = 1,6 μm.** [Relation Between Ionization and Noise Coefficients in Hg<sub>0.44</sub>Cd<sub>0.56</sub>Te Avalanche Photodetectors at λ = μm]. The purpose of this paper is the characterization of Hg<sub>1-x</sub>Cd<sub>x</sub>Te avalanche photodiode with  $x \approx 0.56$ ,  $E_g = 0.73$  eV and  $\Delta = 0.8$  eV. The difference with full equality  $\Delta = E_g$  is 0.07 eV, which is higher than 2kT. This characterization will give the experimental proof in the case where  $\Delta > E_g + 2kT$  that the ionization by impact process relative to spin-orbit resonance and Auger recombination are not involved. Also the electrons become the most ionizing carriers with an ionization energy of 1.1 E<sub>g</sub>. The value of the ratio  $k = \alpha/\beta$  is deduced from noise measurements,  $\alpha$  and  $\beta$  being respectively the electron and hole ionization coefficients. The value  $k$  is equal or higher than 4. This result shows that Hg<sub>0.44</sub>Cd<sub>0.56</sub>Te APD technology must be modified in order to initiate the multiplication by electrons and not by holes which is the case in this study. (Author abstract). 9 Refs. In French.

Alabedra, R. (CNRS); Orsal, B.; Maatougui, A.H.;

Raniriharinosy, K.D.; Gori, P.; Boisrobert, C. *Ann Telecommun* v 43 n 3-4 Apr-May 1988 p 117-122.

**078195 PHOTODETECTEURS POUR TRANSMISSIONS PAR FIBRE OPTIQUE A 1,3 μm - 1,55 μm : ETAT DE L'ART.** [Photodetectors for 1.3μm-1.55μm Fiber Optical Transmissions: State of the Art.]. In the optical fiber telecommunication systems, the emission and reception modules contain optoelectronic components such as laser diodes and photodiodes. Beside the laser whole task and complexity are obvious, the photodiode, the mechanism of which is quite straight-forward, becomes a sophisticated device when optimized for 1.3-1.55 μm fiber window. For photodetection, the photodiode is always associated to a preamplifier obtained from a transistor. For a given link, the performances of the receiver straightly depend on those of the photodiode and of the transistor. Different types of photodetectors are suitable for 1.3 μm and 1.5 μm transmissions. This paper surveys the different semiconductor materials and device structures encountered nowadays, pointing out the respective merits of each solution. Comparisons between photoreceivers outline the importance of matching the photodiode to the transistor, whether dealing with hybrid or monolithic circuits. (Author abstract). 7 Refs. In French.

Mottet, Serge (CNET, Lannion, Fr); Viallet, Jean Emmanuel; Boisrobert, Christian; Scavennec, Andre. *Ann Telecommun* v 43 n 7-8 Jul-Aug 1988 p 365-377.

**078196 PHOTOELECTROCHEMICAL DETECTOR FOR HIGH-PRESSURE LIQUID CHROMATOGRAPHY.** A flow-through photoelectrochemical detector (TiO<sub>2</sub>/Pt) suitable for attachment to a high-pressure liquid chromatograph is described. The detector is sensitive to many oxidizable functional groups and is capable of detecting as little as 1.6 μg of aniline. The relative peak heights of signals engendered by pairs of eluting compounds correlate roughly with the relative rates of photoinduced oxidation of isomeric butanols on analogous semiconductor suspensions. (Author abstract). 17 refs.

Fox, Marye Anne (Univ of Texas, Austin, TX, USA); Tien, Tze-pei. *Anal Chem* v 60 n 20 Oct 15 1988 p 2278-2282.

**078197 BANDWIDTH MEASUREMENTS OF ULTRAHIGH-FREQUENCY OPTICAL DETECTORS USING THE INTERFEROMETRIC FM SIDEBAND TECHNIQUE.** A frequency-modulated semiconductor laser and an interferometer are used as a source of very-high-frequency amplitude modulation to measure the response of optical detectors. This technique does not require a laser with a flat, or even known, frequency response, and measures the detector response at frequencies well above the modulation frequency applied to the



laser. The response of several InGaAs p-i-n detectors was measured to 22 GHz using 1.3- $\mu$ m and 1.55- $\mu$ m semiconductor lasers modulated at 500 MHz. These measurements were not limited by the measurement method, which may be capable of measuring bandwidths substantially in excess of 20 GHz. 19 refs.

Eichen, Elliott (GTE, Waltham, MA, USA); Silletti, Andrew. *J Lightwave Technol* v LT-5 n 10 p 1377-1381.

**078198 INTERFACE ROUGHNESS/ISLAND EFFECTS ON INTERSUBBAND TRANSITIONS IN QUANTUM WELLS.** We introduce a perturbation approach to study interface roughness/island electron diffraction effects in quantum wells and apply this approach to photoexcitation and infrared detection. Interfacial imperfections spoil the usual selection rules associated with intersubband optical transitions, thereby making transitions due to photons polarized in the plane of the quantum well non-forbidden. This can have a beneficial effect since normal incidence photoexcitation would provide the simplest approach to detector, modulator, and focal plane array applications. A general result for quantum well interfaces with arbitrary (random or regular) island patterns is obtained. Some estimates of the effect are included. In addition, the effect of interface roughness on intrasubband transitions is briefly discussed. (Author abstract) 16 refs.

Liu, H.C. (Univ of Pittsburgh, Pittsburgh, PA, USA); Coon, D.D. *Superlattices Microstruct* v 3 n 4 1987 p 357-363.

**078199 GENERATION-RECOMBINATION PROCESSES AND AUGER SUPPRESSION IN SMALL-BANDGAP DETECTORS.** While some noise mechanisms in low band-gap photodetectors are in principle avoidable through the use of optimized growth and device technology procedures, the dominant process in devices working at near ambient temperatures is an Auger mechanism which is a property of the band structure itself. This paper reviews some of the ways in which noise from this source can be largely eliminated. To capitalize on these innovations it seems likely that heterostructure technology will be required in order to avoid extraneous contact related noise problems. (Author abstract) 21 refs.

White, A.M. (Royal Signals & Radar Establishment, Great Malvern, Engl.) *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 840-848.

## Accessories

**078200 HIGH-CURRENT MODE IN WIRE PHOTODETECTOR WITH ANODE WIRE 28  $\mu$ m IN DIAMETER.** The charge, count, and load characteristics are studied for a wire chamber with a thin (28  $\mu$ m) anode wire operating in the high-current mode in various photosensitive gas mixtures with triethylamine (TEA). A mixture of CH<sub>4</sub> + TEA provides a working region with a load capacity of 10<sup>3</sup> photoelectrons/mm<sup>2</sup>·sec on the wire for a gas amplification of 10<sup>8</sup>. Paired anode wires are used to resolve left-right uncertainty in the case of single-photoelectron registration. (Author abstract) 9 refs.

Buzulutskov, A.F. (Inst of High-Energy Physics, Serpukhov, USSR); Vasil'chenko, V.G.; Turchanovich, L.K. *Instrum Exp Tech* v 30 n 4 pt 1 Jul-Aug 1987 p 823-827.

**Applications** See Also ELECTRONIC CIRCUITS, DELAY TYPE, MATERIALS TESTING—Nondestructive Examination; POLYMERS—Testing.

**078201 DYNAMIC RANGE ENHANCEMENT OF PHOTODIODE ARRAY SPECTRA.** The dynamic range of the photodiode array is typically 30 db. In situations requiring a dynamic range greater than 30 db, the photomultiplier tube is a popular alternative, but the advantage of multiwavelength simultaneous data acquisition - possible with a photodiode array - is lost. A method has been developed to enhance the dynamic range of spectra taken with the use of a photodiode array. A set of spectra is collected under computer control at varied

integration times, and the optimum integration time is chosen individually for each detecting element. (Edited author abstract) 3 refs.

Wirsz, Douglas F. (Univ of British Columbia, Vancouver, BC, Can); Browne, R.J.; Blades, M.W. *Appl Spectrosc* v 41 n 8 Nov-Dec 1987 p 1383-1387.

## Control

**078202 CONTROL OF DATA CHARACTERISTICS OF PHOTODETECTOR BASED ON CHARGE-COUPLED DEVICE FOR IMAGE INPUT TO COMPUTER.** Organization of control of photodetectors based on charge-coupled devices is examined that allows the following data parameters to be programmed: sensitivity, space resolution, and volume of data input to computer. A control that interfaces the photodetector with a computer and an experimental procedure and results of a study of the method are described. (Author abstract) 9 refs.

Molodyakov, S.A. (Leningrad Polytechnic Inst, USSR). *Instrum Exp Tech* v 30 n 3 pt 1 May-Jun 1987 p 572-576.

**Design** See Also CHROMATOGRAPHIC ANALYSIS—Liquid; SPACECRAFT—Control Systems.

**078203 OPEN-CELL PHOTOACOUSTIC RADIATION DETECTOR.** A simple and inexpensive photoacoustic radiation detector requiring no cell machining and minimal preparation is proposed. It consists of the front air chamber of a commercial electret microphone used as the transducer medium itself. The measured noise-equivalent power (NEP) at a modulation frequency of 40 Hz was found to be of the order of  $5 \times 10^{-7}$  W Hz<sup>-1/2</sup> for both black-body and visible illumination. (Author abstract) 9 refs.

da Silva, M.D. (Inst de Pesquisas Espaciais, San Jose dos Campos, Braz); Bandeira, I.N.; Miranda, L.C.M. *J Phys E* v 20 n 12 Dec 1987 p 1476-1478.

**078204 BIFACIAL, LARGE-AREA SILICON SENSORS FOR RADIATIVE ENERGY SIGNALS.** A comprehensive design/technological study was conducted with the aim of obtaining high-quality, bifacial optical sensors with reproducible parameters on large-area n- and p-silicon wafers. Practical ways of attenuating the severe limitations imposed by different kinds of material (areal) inhomogeneities on the electro-optical performance of large-area single-crystal silicon sensors for radiative energy signals are described theoretically and tested experimentally. Various procedures leading to a substantial increase of both the emitter and the base contributions to the generated photocurrent are implemented and discussed in detail. The test devices were processed on 2 and 3 inch commercially-available silicon and it was sought to minimize the cost of the cells. The combination of simple design/technological approaches described in this work has ultimately led to the development of low-cost, high quality large-area silicon sensors with good overall electro-optical performance as bifacial devices. (Edited author abstract) 18 Refs.

Silard, Andrei P. (Polytechnic Inst, Bucharest, Rom); Nani, Gabriel. *Sens Actuators* v 15 n 3 Nov 1988 p 243-256.

**078205 ULTRAFast INTERDIGITAL PHOTODETECTORS AND INTEGRATION WITH OPTICAL WAVEGUIDES ON SILICON.** The development of new types of high-speed photodetectors and techniques to incorporate these detectors into integrated optical structures are reported in this paper. Schottky-barrier detectors with an interdigital electrode configuration have been fabricated on commercially available silicon-on-sapphire substrates. Response times of < 30 ps have been measured for wavelengths from infrared to the ultraviolet. These experimental results agree well with a supporting numerical model of these detectors. Using the same electrode configuration, we have fabricated photoconductive detectors on bulk silicon and germanium-on-gallium arsenide substrates. These have slower response times, on the order

of a nanosecond, but demonstrate a good responsivity of approximately 1.5 A·W<sup>-1</sup>. Using a modified electrode configuration, we have fabricated an integrated detector array on silicon, combining a glass waveguide channel with each detector element for the efficient delivery of an optical input signal. (Author abstract) 8 refs.

Bruce, D.M. (McMaster Univ, Hamilton, Ont, Can); Seymour, R.J.; Cheong, D.; Jessop, P.E.; Garside, B.K. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 924-928.

## Electronics Packaging

**078206 NEW STRIDES FOR PHOTODETECTORS.** A growing variety of product lines including local area networks, document and bar-code readers, robots, missiles, medical instruments, and long-haul telephone systems need photodiodes to change light input signals to their analog electrical equivalents. Some of these applications need the detector to be flooded with light; others require the light to be swept across the face of the detector in a beam. Both of these application types now benefit by the trend toward the use of shadow masks etched in opaque material on the diode's surface. The authors discuss opaque coatings, self-encoding masks, packaging trends and performance enhancement.

Mattock, Dennis L. (Silicon Detector Corp, Newbury Park, CA, USA); Forrest, Roger W. *Photonics Spectra* v 22 n 5 May 1988 p 141-142, 144.

**Fabrication** See Also SEMICONDUCTOR DIODES, PHOTODIODE—Fabrication.

**078207 RADIATION TOLERANT PHOTODETECTOR.** The development and test of a radiation-tolerant photodetector are described. This was accomplished by building a single-stage photomultiplier tube with a physically small, dielectrically isolated, silicon photodiode array at the anode. In this device the optically generated photocurrent is multiplied by a much larger factor than is the photo-Compton current. Using matched 'signed' and 'optically blind' diodes to differentiate the optical signal from the 'common-mode' ionizing radiation photocurrent also contributes to radiation tolerance. 10 refs.

Passenheim, Burr C. (Jaycor, San Diego, CA, USA); Ginaven, Robert O. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1588-1591.

**Materials** See PHOTOGRAPHIC REPRODUCTION—Xerography.

**Mathematical Models** See SEMICONDUCTOR DIODES, PHOTODIODE.

**Measurements** See Also ELECTRIC MEASUREMENTS—Current.

**078208 MEASUREMENT OF THE PHASE CHARACTERISTICS OF PHOTODETECTORS.** Measurements of the PFC as well as the phase shifts of photodetectors are reported as a function of their spatial shift. The measurements are based on using bimodal lasers with tunable intermodal splitting. The signal from the photodetector that records the radiation intensity of such lasers is, as is known, amplitude-modulated with a 100% degree of modulation (for equality of the intensities and agreement of the mode polarization directions), and frequency modulation is determined by the magnitude of the intermodal splitting. The investigations were performed with photodetectors at the wavelengths  $\lambda$  of visible and infrared spectrum bands lasers. It is shown that the recording part of the installation can be simplified by replacement of the complex phase difference meter by a phase null indicator. In this version the radiation of a bimodal laser proceeding to one of the photodetectors should pass through the calibrated phase shifter. 9 refs.

Vas'kov, V.A.; Gonchukov, S.A.; Naumov, N.V.; Petrovskii, V.N.; Shaninin, R.A. *Meas Tech* v 30 n 8 Aug 1987 p 764-766.



## Multiplexing

**078209 MONOLITHIC GaInAs/InP PHOTODETECTOR ARRAYS FOR HIGH-DENSITY WAVELENGTH DIVISION MULTIPLEXING (HDWDM) APPLICATIONS.** Monolithic arrays of interdigitated GaInAs/InP photodetectors have been fabricated for high density wavelength division multiplexing (HDWDM) applications. The detectors typically exhibit a reverse leakage current of 400 nA, capacitance of less than 70 fF and a responsivity of 0.5 A/W at  $-5$  V bias. An optical crosstalk of  $-33.4$  dB has been measured between adjacent detectors in an experimental grating demultiplexer system. Preliminary electrical crosstalk measurements in the frequency range of 1-500 MHz indicate signal isolation of the order of 46 dB. (Author abstract). 6 Refs.

Lee, W.S. (STC Technology Ltd, Essex, Engl); Bland, S.W.; Robertson, A.J. *Electron Lett* v 24 n 18 Sep 1 1988 p 1143-1145.

## Noise, Spurious Signal See Also ASTRONOMY—Imaging Techniques.

**078210 NOISE IN THE OPTICAL DETECTION OF ATOMS IN A BEAM.** The noise processes which affect the optical detection of atoms in a beam are identified. A noise factor of the atom to fluorescence photon conversion is defined in the case where the counting statistics of the fluorescence photons can be assumed Poissonian. The signal to noise ratio of the atom detection is given in the case where a photomultiplier or a silicon photocell is used. It is shown that the noise added to the actual atomic beam shot noise can be represented in terms of the shot noise of an equivalent fictitious flux of incident atoms. Results given are applied to the optical detection of cesium atoms. (Author abstract). 16 Refs.

Giordano, V. (CNRS, Orsay, Fr); Candelier, V.; Hamel, A.; Audoin, C.; Theobald, G.; Cerez, P. *Opt Commun* v 67 n 4 Jul 15 1988 p 287-292.

**078211 SHOT NOISE IN PHOTODETECTORS AND VACUUM FLUCTUATIONS.** The photodetection process can be described using the well known approach worked out by Glauber. Recently, Yurke has proposed a different formalism which is especially well suited to the description of the balanced homodyne detection scheme used for the actual observation of the squeezing effect. These two approaches present formulae for the shot noise that are significantly different. In the present paper, it is shown that, nevertheless, these formulae yield results that practically agree, as long as the field commutator involved in Yurke's formula is properly evaluated. (Author abstract). 12 Refs.

Paul, H. (Akad der Wissenschaften der DDR, Berlin, East Ger). *Opt Acta* v 35 n 7 Jul 1988 p 1225-1235.

## Performance See Also OPTOELECTRONIC DEVICES.

**078212 IMPROVED WIDE DYNAMIC RANGE SILICON PHOTODETECTOR FOR INTEGRATION IN IMAGE SENSOR ARRAYS.** A novel silicon photodetector offering several important performance advantages over current industry-standard devices is described. Currently available imaging devices offered by various manufacturers are typically sensitive to varying light intensity over three orders of magnitude in optical power, while this new design offers a logarithmic response of greater than six orders of magnitude in light intensity. Designed to use to advantage the subthreshold effect of short-channel metal oxide semiconductor field effect transistors, the new device is readily integrated into large arrays featuring charge-coupled-device readout shift registers and metal oxide semiconductor support circuitry. Several devices incorporating the new detector have been fabricated and tested, including discrete detectors, linear arrays, and area arrays. (Edited author abstract) 27 Refs.

Doody, Brian C. (DALSA Inc, Waterloo, Ont, Can); Chamberlain, Savvas G. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 919-923.

## Radiation Effects See LIGHT—Emission.

**PHOTOELASTICITY** See Also BOLTS AND NUTS—Stresses; CELLULOSE—Stresses; CRYSTALS—Stresses; DISKS—Stresses; DOMES AND SHELLS—Stresses; FORGING; GEARS—Stresses; LIGHT—Birefringence; OPTICAL FIBERS—Optical Properties; PLASTICS—Viscoelasticity; PLATES—Stresses; POLYBUTADIENES; POLYCARBONATES—Deformation; POLYMERS—Physical Properties; SEMICONDUCTOR DEVICES—Stresses; STRESSES—Measurements; WELDING—Spot.

**078213 CHARACTERISTIC ANGLE AND LIGHT INTENSITY IN DESCRIBING THE POLARIZED STATE.** In a photoelastic-plate-model where membrane  $\sigma^N$  as well as bending stresses  $\sigma^M$  are present, the following quantities are related: the light intensity measured in crossed arrangement of the polarizing filters, the characteristic angle  $\Psi$ , the characteristic phase retardation  $\Delta$ , the angle between the axes of the bending and membrane stresses  $\theta$ , and the ratio between these stresses  $P$ . Based on experimental work, a nomograph that links all these parameters was developed. Entering this diagram with any two parameters shall yield the others. Furthermore, the so-obtained light intensity is introduced as a parameter that contributes to the description of the state of polarization of three-dimensional photoelastic media. In this paper important observations on the experimentally obtained data are presented. (Edited author abstract) 16 Refs.

Issa, S.S. (Univ of Kuwait, Safat, Kuwait); Laermann, K.-H. *Exp Mech* v 27 n 3 Sep 1987 p 298-303.

**078214 SUMMATION STRAIN-GAGE ALTERNATIVE TO OBLIQUE INCIDENCE IN PHOTOELASTIC COATINGS.** A special strain gage (PhotoStress) designed to measure the sum ( $\epsilon_1 + \epsilon_2$ ) of the principal strains, is used in conjunction with photoelastic-coating measurements ( $\epsilon_1 - \epsilon_2$ ) to establish the value of each principal strain ( $\epsilon_1$  and  $\epsilon_2$ ). The summation strain gage is effectively independent of angular orientation (measurement direction), and by design, the gage negates soldering risks, self-heating, and localized-reinforcement considerations normally associated with strain-gage measurements on plastic parts. (Author abstract) 7 Refs.

Nickola, Wayne E. (Measurements Group Inc, Raleigh, NC, USA). *Exp Mech* v 27 n 3 Sep 1987 p 304-313.

**078215 BASIC THEORY AND EXPERIMENTAL TECHNIQUES OF THE STRAIN-GRADIENT METHOD.** The theories of presently used experimental methods of stress and deformation analysis which employ radiant energy as a detector are based on the assumption that light propagates rectilinearly within both undeformed and deformed bodies which are initially homogeneous and isotropic when diffraction phenomena are negligible. This assumption is not correct. On the basis of empirical data produced by the authors in the period 1948-1983, this paper presents theories and foundations of the techniques of a new experimental method which is based on the relations between stress/strain gradients and curvatures of light beams. This method is called the strain-gradient method or, less rigorously, gradient photoelasticity. (Edited author abstract) 39 Refs.

Pindera, J.T. (Univ of Waterloo, Waterloo, Ont, Can); Hecker, F.W. *Exp Mech* v 27 n 3 Sep 1987 p 314-327.

**078216 DOUBLE-LIGHT-BEAM METHOD IN THREE-DIMENSIONAL SCATTERED-LIGHT PHOTOELASTICITY.** This paper presents a new scattered-light photo-elasticity technique which may be called the double-light-beam measurement method. Principal-stress directions and relative retardants related to the principal-stress differences can be measured at any point within an ordinary three-dimensional photoelastic model by this method. This method does not need double loading and the quantities to be measured depend only on the relative light intensity. Moreover, the output signals alternate, providing improved accuracy and stability. It supported by an appropriate program-control and digital processing system, the double-beam method can be used to quickly determine the internal stress distribution in

ordinary three-dimensional photoelastic models. (Author abstract) 9 Refs.

Liu, X.-L. (Tsinghua Univ, Beijing, China); Pan, S.-C.; Ha, L.-Z. *Exp Mech* v 28 n 1 Mar 1988 p 60-64.

## Analysis See COMPRESSORS—Testing.

Applications See ELECTRIC MOTORS—Components; STRESSES—Computer Aided Analysis.

Measurements See ALSO COMPOSITE MATERIALS—Synthesis; OPTICAL FIBERS—Strain.

**078217 ILLUMINATION OF LIGHT VECTORS MODULATED IN A 3-D PHOTOELASTIC MEDIA.** The dependence of the illumination of a light vector that is subjected to modulation along its path in a three-dimensional photoelastic medium, on the rotation of the principal directions (RPD) of stresses is investigated. The consistency and characteristics of the interaction of the light intensity and the RPD for three different photoelastic materials are explored. The deviation of the rotation of the optical axes from those of the principal ones, in 3-D birefringent material, is illustrated. (Edited author abstract) 9 Refs.

Issa, S.S. *Acta Mech* v 71 n 1-4 Feb 1988 p 157-166.

## Radiation Effects

**078218 EINIGE ASPEKTE DER ANWENDUNG VON GAMMABESTRAHLUNG IN DER SPANNUNGSMESSTECHNIK.** [Certain Aspects of the use of Gamma Irradiation in Photoelasticity]. The results of experimental studies concerning a relatively new method of fixation of photoelastic fringe patterns with the aid of gamma irradiation in the analysis of three-dimensional stress states are presented. The efficiency of this method in comparison with the conventional freezing method is demonstrated in a contact-stress problem. In German. 19 Refs.

Jecic, Stjepan; Goja, Zeljko. *OIAZ Oesterr Ing Archit Z* v 132 n 7-8 Jul-Aug 1987 p 243-248.

## Research

**078219 SOME REFLECTIONS ON CHARACTERISTIC ANGLE, LIGHT INTENSITY AND THEIR CORRELATION TO WAVELENGTH IN THREE DIMENSIONAL PHOTOELASTIC MEDIA.** Some optical phenomena in three dimensional photoelastic media are analyzed. Suggestions made in a paper by S.S. Issa and I. Marie (1986) relative to the experimental technique of integrated photoelasticity are analyzed and some misleading statements of the latter paper are indicated. (Edited author abstract) 3 Refs.

Aben, H. (Estonian Acad of Sciences, Estonia, USSR). *Strain* v 24 n 2 May 1988 p 71.

## Theory

**078220 EFFECT OF STRESS GRADIENT ON THE MINIMUM LIGHT INTENSITY OF 3-D PHOTOELASTIC MEDIA.** The problems associated with the inverse photoelasticity of three-dimensional thin plates and shells are discussed. A novel algorithm for the determination of three-dimensional photoelastic parameters is presented. The detailed processes of data acquisition, storage, interpolation and implementation are explored, with special emphasis on the normalized minimum light intensity as a new characteristic parameter. (Edited author abstract) 11 Refs.

Issa, Sameh S. *OIAZ Oesterr Ing Archit Z* v 132 n 7-8 Jul-Aug 1987 p 230-233.

**078221 HYBRID TECHNIQUES IN PHOTOVISCOELASTICITY.** Photoviscoelastic methods based on various approaches are frequently used in experimental analysis. However, evaluation of the experimental data



taken from material testing measurements to determine the mechanical and optical properties of the viscoelastic model materials, as well as the large quantity of data from the experiment itself, demands extensive efforts in calculation. Therefore algorithms are derived for computer-orientated on-line evaluation according to the principle of 'hybrid techniques'. They are based on the assumption of linear, viscoelastic response and the supposition of isothermal and quasi-static processes. (Edited author abstract) 12 refs.

Laermann, K.-H. *OIAZ Oesterr Ing Archit Z* v 132 n 7-8 Jul-Aug 1987 p 233-235.

**PHOTOELECTRIC CELLS** See Also ELECTRIC MEASURING INSTRUMENTS—Accessories; SEMICONDUCTING GALLIUM COMPOUNDS—Thin Films; SOLAR CELLS; SOLAR CELLS—Silicon; SOLAR RADIATION—Concentrators; TEXTILES—Spinning.

**078222 OPTIMIZING THE OPERATING CONDITIONS OF A PHOTOELECTRIC HYDROGEN UNIT IN VARYING INTENSITY OF SOLAR RADIATION.** Various programs of agreement are suggested, with appropriate choices of switching times, thanks to which further automation of the process is facilitated; photovoltaic systems (PVS) have been developed with adjustable parameters, and an automation unit for switching. Possibilities of automating the process for PVS of various powers are cited. (Author abstract) 5 refs.

Salamov, O.M.; Bakirov, M.Ya.; Rzaev, P.F. *Appl Sol Energy* v 23 n 3 1987 p 16-20.

**078223 SEMICONDUCTOR SEPTUM PHOTOELECTROCHEMICAL CELL.** CdSe semiconductor septum photoelectrochemical cells have been constructed and their photoelectrochemical characteristics studied using cyclic voltammetry. Photovoltages and photocurrent densities as high as 1.8 V and 7 mA cm<sup>-2</sup> respectively were obtained. The changes in polarity of open-circuit voltage and short-circuit current of the cell upon illumination suggest that a rechargeable photoelectrochemical cell may be developed using dual electrolyte semiconductor contacts. (Author abstract) 27 refs.

Xiao, Ke (Michigan State Univ, East Lansing, MI, USA); Tien, H.Ti. *Sol Cells* v 23 n 3-4 Apr 1988 p 233-244.

**Applications** See SENSORS—Design.

**Design** See SEMICONDUCTOR DEVICES—Junctions.

**Electrochemistry**

**078224 SURVEY OF PHOTOELECTROCHEMICAL CELLS WITH POWER CONVERSION EFFICIENCIES GREATER THAN OR EQUAL TO 5%.** The efficiency and stability of photoelectrochemical (PEC) cells are strongly dependent on the preparation conditions of the photoelectrode and electrolyte and on experimental conditions during tests. Therefore, the mention of such conditions is essential when reporting PEC cell performance. Data on PEC cells are presented and the stability and efficiency of the cells are discussed. (Edited author abstract) 112 refs.

Lokhande, C.D. (Central Electrochemical Research Inst, Karaikudi, India). *Sol Cells* v 22 n 2 Oct 1987 p 133-158.

**Measurements**

**078225 PHOTOELECTROCHEMICAL CELL WITH SEMICONDUCTOR SEPTUM ELECTRODE.** Photoelectrochemical cells consisting of CdSe or CdS pellets separating two redox couples have been studied. The current-voltage relation, output power efficiency, open-circuit voltage and short-circuit current were measured in a two-electrode system. Photovoltages as high as 1.0-1.3 V were obtained. In all cases studied, the power characteristics were linear with low fill factor and output power efficiency. It was possible to improve the performance of such cells by applying external voltage. (Author abstract) 19 refs.

Jackowska, K. (Michigan State Univ, East Lansing, MI, USA); Tien, H.T. *Sol Cells* v 23 n 3-4 Apr 1988 p 147-157.

**Selection** See SENSORS—Selection.

**Transients**

**078226 PHOTOPILES EN REGIME TRANSITOIRE: MESURE DE LA DUREE DE VIE DES PORTEURS.** [Photocells Operating Under Transient Conditions. Measurement of Lifetime of Charge Carriers]. A practical measuring technique is presented for measuring the lifetime of minority carriers in the base of a photocell. A theoretical model makes it possible to define the precise experimental conditions and simulate the parasitic effects. A method is proposed for fast control of the quality of photocells. In French. 7 refs.

Sissoko, G. (Faculte des Science, Dakar-Fann, Senegal); Kane, M.; Mialhe, P. *Modell Simul Control A* v 14 n 4 1987 p 57-63.

**PHOTOELECTRICITY** See Also CLOCKS, MECHANICAL—Testing; CRYSTALS, LIQUID—Electric Properties; ELECTROOPTICAL DEVICES—Performance; PARTICLE SIZE ANALYSIS; SEMICONDUCTING CADMIUM COMPOUNDS—Thin Films; SOLAR CELLS—Efficiency.

**078227 EFFECT OF MECHANICAL TREATMENT OF ELECTRODE SURFACES ON THEIR PHOTOELECTROCHEMICAL PROPERTIES.** The authors investigated the photoelectric properties of electrodes based on single-crystal and ceramic strontium titanate depending on mechanical treatment of their surfaces. The electrodes' surfaces were treated with powders of abrasive materials. For all the electrodes investigated, the following effects are observed with mechanical treatment of their surface: appearance of photosensitivity in the visible part of the spectrum, an increase in photosensitivity in the ultraviolet part of the spectrum and displacement of the maximum toward longer wavelengths, and a shift in the potential of the plane zones toward positive values. The indicated effects are connected with states in the forbidden zone of SrTiO<sub>3</sub> arising due to weakening or breaking of (Ti-O) bonds, as well as with changes in the electrodes' effective (working) surface with mechanical treatment of their surfaces. 10 refs.

Sarkisyan, A.G.; Arutyunyan, V.M.; Melikyan, V.V. *Appl Sol Energy* v 23 n 4 1987 p 9-13.

**Measurements** See EPOXY RESINS—Electric Properties; ORGANIC COMPOUNDS—Thin Films; SEMICONDUCTING ZINC COMPOUNDS—Electric Properties.

**Transients** See POLYTETRAFLUOROETHYLENE—Radiation Effects; SEMICONDUCTOR DIODES, PHOTODIODE—Performance.

**PHOTOELECTROMAGNETIC EFFECTS** See AROMATIC COMPOUNDS—Ionization.

**PHOTOEMISSION** See Also ACCELERATORS, SYNCHROTRON—Accessories; ACCELERATORS, SYNCHROTRON—Storage Rings; AEROSOLS—Electric Properties; CERIUM COMPOUNDS—Physical Properties; CERIUM COMPOUNDS—Spectroscopic Analysis; DIELECTRIC MATERIALS—Radiation Effects; INTEGRATED CIRCUIT TESTING—Laser Applications; INTERMETALLICS—Electronic Properties; IONS—Analysis; Iridium AND ALLOYS—Spectroscopic Analysis; IRON AND ALLOYS—Physical Properties; IRON PLATINUM ALLOYS—Electronic Properties; MOLECULES—Adsorption; NICKEL AND ALLOYS—Amorphous; PALLADIUM AND ALLOYS—Physical Properties; RARE EARTH COMPOUNDS—Physical Properties; SEMICONDUCTING SILICON; SEMICONDUCTOR MATERIALS; SEMICONDUCTOR MATERIALS—Magnetic Field Effects; SILVER AND ALLOYS—Electronic Properties; SPECTROSCOPY, X-RAY; STRONTIUM COMPOUNDS—Electronic Properties; URANIUM COMPOUNDS—Spectroscopic Analysis.

**Calculations**

**078228 INTERPRETATION OF PHOTOEMISSION FROM Na (110).** A self-consistent calculation of the electronic structure of the Na (110) surface, using an embedding method to treat the semi-infinite system, gives

a prominent surface resonance peak at 0.75 eV above the Fermi energy. The tail of this resonance extends below E<sub>F</sub> at the surface, and it is suggested that surface photoemission from this tail is responsible for the peak in the photocurrent at E<sub>F</sub> observed experimentally. A photoemission calculation, with non-self-consistent surface potential, reproduces the enhancement of the peak as a direct transition moves through it. (Author abstract) 15 refs.

Kaiser, J.H. (SERC Daresbury Lab, Warrington, Engl); Inglesfield, J.E.; Aers, G.C. *Solid State Commun* v 63 n 7 Aug 1987 p 689-691.

**Laser Applications** See ELECTRON BEAMS—Production.

**Measurements** See GADOLINIUM AND ALLOYS—Thin Films; SILICON CARBIDE.

**Spectroscopic Analysis** See SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Analysis.

**Surfaces**

**078229 RELATIONSHIP BETWEEN PHOTOEMISSION AND PROPAGATION VELOCITY OF LOCAL DISCHARGE ON ELECTROLYTIC SURFACES.** The authors present experimental study results on local discharge propagation along an electrolytic surface under the application of impulse voltage. Experiments were performed using a water channel with point-plane electrodes. The resistivity of the electrolyte (aqueous solution of potassium chloride) was varied from 350 to 3500 Ω-cm. Local discharges propagate on the electrolytic surface and emit light that is more intense at the tip of the local discharge. The discharge velocity and the intensity of the photoemission from the tip of the local discharge were measured simultaneously. It was found that the velocity of the local discharge is determined by the intensity of the photoemission and is independent of the length of the water channel and the applied voltage when the resistance-per-unit-length of water channel is the same. The local discharge propagation mechanism is also discussed. 15 refs.

Yamashita, T. (Nagasaki Univ, Jpn); Matsuo, H.; Fujiyama, H.; Oshige, T. *IEEE Trans Electr Insul* v EI-22 n 6 p 811-817.

**Theory** See Also PHOTONS—Theory.

**078230 ON THE THEORY OF PHOTOEMISSION FROM ADSORBATE-INDUCED SURFACE STATES.** On the basis of a tight-binding model, the photoemission from adsorbate-covered transition metal surfaces is investigated. The photoemission current from the bulk states and the adsorbate-induced surface states is deduced from both poles of the excitation function. The conditions for the existence of surface states for a given overlayer structure are given and compared with the case of a 1×1 structure. The connection between the peak widths and the various lifetimes is elucidated. (Author abstract) 19 refs.

Beckmann, A. (Akad der Wissenschaften der DDR, Halle, East Ger). *Phys Status Solidi B* v 144 n 1 Nov 1987 p 213-224.

**PHOTOEMISSION DEVICES**

**078231 COMPOSITION ET PROPRIETES DE TRANSPORT ELECTRONIQUE DES COUCHES DE Na<sub>2</sub>KSb, Cs.** [Chemical Composition and Electronic Transport Properties of Na<sub>2</sub>KSb, Cs Thin Films]. This article is focused on photoelectric alkali-antimonide thin films exhibiting photoelectric sensitivity higher than 500 μA·lm<sup>-1</sup>. The bulk composition is studied with optical tools such as spectral reflectance and transmittance. The effects of mixing or superposition of Na<sub>2</sub>Sb and Na<sub>2</sub>KSb phases upon photoemission properties are considered. The surfaces of Na<sub>2</sub>KSb and Na<sub>2</sub>KSb, Cs films are analyzed by Auger electron spectroscopy. The effect of chemical binding nature taking place between alkali and antimony atoms upon photoemissivity is outlined. The photoelec-



tron escape depths are determined over the visible spectrum. Finally some concluding remarks are drawn out for night vision applications. (Author abstract) In French. 24 refs.

Doliz, Pierre (Organisation de Recherche Int de Philips, Limeil-Brevannes, Fr). *Acta Electron* v 27 n 3-4 1987 p 181-190.

**PHOTOGRAMMETRY** See Also BIOMEDICAL ENGINEERING; IMAGE PROCESSING; IMAGE SENSORS; MAPS AND MAPPING; MAPS AND MAPPING—Taiwan; MICROSCOPIC EXAMINATION—Scanning Electron Microscopy; MINE SURVEYING—Equipment; REMOTE SENSING; SURVEYING INSTRUMENTS—Computer Applications; SURVEYING INSTRUMENTS—Electronics.

**078232 NOTE ON PHOTOGRAMMETRIC BLOCK ADJUSTMENT WITH ADDITIONAL PARAMETERS.** Photogrammetric block adjustment with additional parameters has found wide application in practice. The additional parameters are used to compensate for possible systematic image errors. In order to come to a clear understanding of the requirements for a unique determination of the additional parameters, we consider a block with minor control points situated at the ideal grid locations on the images. It is shown that one needs as a minimum one additional piece of control information for every additional parameter. In order to ensure a well determined solution, this control should be positioned in one model (image). In summary, block adjustment with additional parameters does not save any work. It equals in work a proper camera calibration done independently before (and after) the photo mission. 1 ref.

Kubik, Kurt (Ohio State Univ, Columbus, OH, USA). *Photogramm Eng Remote Sens* v 53 n 11 Nov 1987 p 1531-1532.

**078233 TERRAIN SIMULATION FOR TRANSPORTATION PLANNING.** Surface simulation models based on U.S. Geological Survey (USGS) digital elevation models were accomplished on a VAX 11/780 with a Vectrix VX384 display. A Hermite curve technique was used to simulate the surface configuration of the terrain. The terrain surface simulation was overlaid with USGS digital line graph data to show transportation routes. In addition to vertical views, oblique views from any direction may be shown and the direction and vertical angle of the source of lighting may be chosen. (Edited author abstract) 8 refs.

Hansen, Jack H. (Univ of Tennessee Space Inst, Tullahoma, TN, USA); Hurst, Mitchell J. *Transp Res Rec* 1119 1987 p 134-138.

**078234 GEOMETRICALLY CONSTRAINED MULTIPHOTO MATCHING.** The Adaptive Least-Squares Correlation, combining gray level matching with geometrical constraints, is applied for X, Y, Z object coordinate determination. The constraints used are the collinearity conditions. A new aspect is the simultaneous use of multiple (more than two) scenes. This paper outlines the mathematical model and highlights some essential features of the algorithm with practical data. Tests using CCD camera data in a close-range environment were performed on the aspects of pull-in range, occlusions, and reliability (multiple solutions, mismatch). In all cases remarkable advantages result from the use of geometrical constraints (conditional one-dimensional search) and multiple scenes. Depth errors of 5% average depth ( $d_0$ ) (6 pixels pull-in range) and 10%  $d_0$  (12 pixels pull-in range) were examined, with 100 percent and 70 percent success rate, respectively. (Edited author abstract) 5 refs.

Gruen, Armin W. (ETH, Zurich, Switz); Baltsavias, Emmanuel P. *Photogramm Eng Remote Sens* v 54 n 5 May 1988 p 633-641.

**078235 TOWARDS REAL-TIME PHOTOGRAMMETRY.** This overview paper is mainly concerned with a system's approach to real-time photogrammetry and a few hardware issues. Particular emphasis is put on the image acquisition problem, because this is the key to

high-accuracy results. Some problems of current systems are highlighted and prospects for future directions indicated. A brief survey of present-day truly photogrammetric systems (systems with a substantial amount of photogrammetric expertise incorporated) is presented and their point-positioning accuracies, as obtained up to now, are reported. (Edited author abstract) 50 refs.

Gruen, Armin (ETH, Zurich, Switz). *Photogrammetria* v 42 n 5-6 May 1988 p 209-244.

**078236 ARTIFICIAL INTELLIGENCE IN PHOTOGRAMMETRY.** The scope of the discipline of artificial intelligence is reviewed and its relevance for the discipline of photogrammetry is analyzed. The most appropriate artificial intelligence techniques are dealt with more in detail, especially the usage of heuristics in algorithms, rule-based knowledge representation and programming, and also object-oriented programming. Urgent need for using expert-system technology is seen when replacing semiautomatic man-machine systems with fully automatic systems. In building expert systems, especially in gathering of knowledge as rules, a system-analytical approach is considered to be a necessity. It is concluded that the key issue will be the structuring task in the building of complex systems for photogrammetric analysis - also when gathering the knowledge-base for rule-based programming. (Edited author abstract) 47 refs.

Sarjakoski, Tapani (Technical Research Cent of Finland, Espoo, Finl). *Photogrammetria* v 42 n 5-6 May 1988 p 245-270.

**078237 INFORMATION RETRIEVAL IN THE PHOTOGRAMMETRY AND REMOTE SENSING LITERATURE.** This paper analyzes the present state of affairs and summarizes details for establishing ISPRS-IRS, the Information Retrieval System of the International Society for Photogrammetry and Remote Sensing, which is tailored to cover surveying and mapping, including remote sensing. ISPRS-IRS should be available online and should be free-of-charge, using the postcard approach. In order to decide whether there is at present really a need to implement ISPRS-IRS, the next phase should be to collect data to judge the capabilities, efficiency, reliability and costs of the bibliographic and factual information which is available at present. (Edited author abstract) 11 refs.

Hothmer, Juergen. *Photogrammetria* v 42 n 5-6 May 1988 p 271-282.

**078238 ETABLISSEMENT D'UNE BANQUE DE DONNEES URBAINES A L'AIDE DU LOGICIEL DEMETER-PH.** [Establishment of an Urban Databank with the Aid of DEMETER-PH Software]. A discussion is presented of the various stages in the constitution of the Urban Databank and describes the photogrammetric phases in detail: preparing operations for plotting, formation and use of the stereo-photogrammetric model, collection and storage of the topographic data (plotted-point coordinates) with their codes and their geographic or administrative identifiers. Information on the results of applying the DEMETER-PH software is also given. (Edited author abstract) In French.

Masala, Bernard. *Bull Soc Fr Photogramm Teledetect* n 108 1987 p 25-32.

**078239 OPTIMAL ESTIMATION OF DISPLACEMENTS BY COMBINING PHOTOGRAMMETRIC AND DYNAMIC MODELS.** The dynamic characteristics of displaced object points are integrated with the photogrammetric observation model. The developed formulae, recursively updated for the current state information, are based on the principles of the sequential weighted least-squares adjustment with time consideration. They constitute a formulation of the iterated extended Bayes filter. Test results showed that this approach can improve the final position and accuracy information. (Author abstract) 16 refs.

Armenakis, C. (Univ of New Brunswick, Fredericton, NB, Can); Faig, W. *Photogramm Eng Remote Sens* v 54 n 8 Aug 1988 p 1169-1173.

**Applications** See Also AIRCRAFT MANUFACTURE—Inspection.

**078240 FROM MAPPING TO MEASURING WITH THE ANALYTICAL STEREOPLOTTER.** The analytical stereoplotter is a modern mapping tool, usually acquired by photogrammetric organizations with a history of providing clients with topographic maps. However, the analytical stereoplotter is much more than a mapping device. It is an extremely versatile and powerful system for extracting measurements from images. The exploitation of system measuring capabilities by a traditional mapping organization is hampered by biases and mind-sets of personnel with only a mapping background. This presents barriers that must first be recognized and appreciated if they are to be overcome. Several of these barriers that have been identified while integrating a modern analytical plotter into a mapping group are discussed. The changing needs of the clients and the obstacles to meeting those needs are also described. (Author abstract) 2 refs.

Valentine, W.H. (US Forest Service, Missoula, MT, USA). *J Surv Eng* v 113 n 3 Oct 1987 p 133-138.

**078241 APPLICATIONS ARCHITECTURALES DES METHODES NUMERIQUES ET DES EQUIPEMENTS PHOTOGRAMMETRIQUES MODERNES.** [Architectural Applications of Numerical Methods and Modern Photogrammetric Equipment]. In this investigation, by examining successively the six main operations which must or can be undertaken in architectural photogrammetric surveys (operational planning and photography, photographic triangulation, graphic plotting, digital plotting, photographic plotting, file-building and up-dating of surveyed data) and by considering the four main types of photogrammetric systems (analogue, semi-analogue, hybrid, analytic), system-performances with respect to cost, accuracy and quality are compared and practical examples are given. This analysis shows that digital photogrammetry and computer-assisted plotting systems increase the possibilities of using photogrammetry for architectural surveys. (Edited author abstract) In French. 36 refs.

Vozikis, Evangelos. *Bull Soc Fr Photogramm Teledetect* n 102 1986 p 5-24.

**078242 BRUK AV FOTOGRAMMETRI FOR KULTURMINNE-REGISTRERING.** [Close-Range Photogrammetry in Conservation of Cultural Monuments]. The article gives an overview of the history of photogrammetric methods in registration of shape in architecture and conservation. Current methods, equipment and forms of representation are presented. (Edited author abstract) In Norwegian. 5 refs.

Maalen-Johansen, Ivar (Norwegian Inst of Technology, Trondheim, Norw). *Kart Plan* v 47 n 5 Nov 1987 p 479-482.

**078243 INDUSTRIAL PHOTOGRAMMETRY-ITS APPLICATION TO SHIPBUILDING.** Photogrammetry is the science of acquiring and interpreting three-dimensional data of physical objects by measuring and analyzing their images on photographic plates. The development of this technology since the mid-seventies has increased its credibility for application to industrial and shipbuilding use. Analytical photogrammetry is now routinely employed in shipbuilding for tasks as diverse as predicting the fit-up of structural steel assemblies prior to their joining, verifying the circularity of submarine hulls, and checking the alignment of catapult trough components on aircraft carriers. The authors address the practical applications of photogrammetric technology, and identify the reliability, versatility, and productivity of photogrammetric surveying when applied to shipbuilding. (Author abstract) 1 ref.

Gunn, Michael J. (Newport News Shipbuilding, Newport News, VA, USA); Hicks, Ronald S. *Mar Technol* v 25 n 3 Jul 1988 p 229-236.



Automation

**078244 AUTOMATION IN PHOTOGRAMMETRIC BLOCK ADJUSTMENT SYSTEMS—ON THE ROLE OF HEURISTIC INFORMATION AND METHODS.** Automation in photogrammetric block adjustment systems is studied, especially the role of heuristic information and methods in automatic systems. The purpose of a block adjustment is considered in the context of the whole mapping process and of the other systems involved in that process. It is shown that heuristic information related to a block adjustment appears in connection with incomplete integration of system components. Heuristic methods are related to the models and strategies used in the block adjustment. State-space representation is used in the detection of gross errors, to emphasize the distinction between goal definition (problem formulation) and the solution techniques. Heuristic techniques are necessary to overcome the computational complexity of the problem. The close relation between heuristic search techniques and weight reduction methods is clarified. The studies on the distribution of test values used in the detection of gross errors reveal that in practice heuristic approximations must be used. (Edited author abstract). 107 Refs.

Sarjakoski, Tapani (Technical Research Cent of Finland, Espoo, Finl). *Acta Polytech Scand Civ Eng Build Constr Ser n 88* 1988 125p.

**Calibration** See BIOMECHANICS—Analysis.

**Cameras** See Also AERIAL PHOTOGRAPHY—Canada; AERIAL PHOTOGRAPHY—Equipment; LANDSLIDES—Monitoring.

**078245 ANALYSE COMPARATIVE DE CLICHES PRIS AVEC DIFFERENTES CHAMBRES DE PRISE DE VUES AERIENNES.** [Comparative Analysis of Negatives Taken with Aerial Cameras with Different Chambers]. In this study three aerial cameras are compared for image quality and metric precision. The cameras involved are the LMK from Zeiss Jena, the RC10A from Wild Heerbrugg and the RMK from Zeiss Oberkochen. The image quality was analyzed by determination of the modulation transfer function under flight conditions. Furthermore the reproduction of signal points was included in the evaluation. The analysis of the metric precision is based on a precision aerial triangulation. (Edited author abstract) In French. 4 refs.

Kolbl, Otto (Ecole Polytechnique Federale de Lausanne, Lausanne, Switz). *Bull Soc Fr Photogramm Teledetect n 102* 1986 p 37-51.

**078246 USE OF CAMERA ORIENTATION DATA IN PHOTOGRAMMETRY - A REVIEW.** Classical photogrammetric working methods had to solve the problem of camera orientation indirectly by means of ground control points. The performance of new navigation systems will allow in-flight measurement of carrier position and attitude to an accuracy which will change the photogrammetric methods fundamentally. The precision requirements for orientation data on various levels of application (pinpoint photography, combined block-adjustment, direct orientation of photographs and sensors) and the economic advantages are reviewed. (Author abstract) 10 refs.

Ackermann, Friedrich (Inst for Photogrammetry, Stuttgart, West Ger). *Photogrammetria v 42 n 1-2* Nov 1987 p 19-33.

**078247 MULTIPLE EXPOSURES IN NON-METRIC CAMERA APPLICATIONS.** Systematic errors introduced through film deformation constitute a major factor limiting the photogrammetric accuracy of non-metric images. This paper examines the effectiveness of multiple exposure photography in reducing that component of the object-point positioning bias which is due to film unflatness. Aspects of network precision and accuracy are discussed, as are details concerning the additional parameter model selection and the use of orientation constraints. A non-metric camera experiment, in which

multiple exposures were employed, is outlined and the results of this practical application are presented. (Author abstract) 6 refs.

Fraser, C.S. (Geodetic Services, Melbourne, FL, USA). *Photogrammetria v 42 n 1-2* Nov 1987 p 62-72.

**078248 TWISTED CUBIC AND CAMERA CALIBRATION.** This note points out a tie-in between the geometry of the twisted cubic and camera calibration. We state a uniqueness theorem for camera calibration in terms of the twisted cubic. The theorem assumes the general linear model and is essentially a reformulation of Seydewitz's star generation theorem. (Edited author abstract) 7 refs.

Buchanan, Thomas (Robert Bosch GmbH, Darmstadt, West Ger). *Comput Vision Graphics Image Process v 42 n 1* Apr 1988 p 130-132.

**078249 COASTLINE MONITORING BY REMOTE SENSING.** In order that the structures can serve their protective function over a long (calculable) time and for an extended (calculable) section of the coast, the hydro- and sediment-dynamic processes in coastal waters (on the shore platform) must be exactly known, same as their interaction with structures. All traditional, watercraft-bound methods and explorations are restricted to 'pointwise' working with considerable time gaps in between. A balance sheet obtained in that way shows the various regions in different phases of the process, and soil analyses never cover the entire area. 9 Refs.

Voigt, Thomas (Cent for Environmental Engineering, Berlin, East Ger); Weiss, Dietrich. *Jena Rev v 32 n 4* 1987 p 164-167.

**Computer Applications** See Also SURVEYING INSTRUMENTS—Electronics; URBAN PLANNING—Remote Sensing.

**078250 TRANSFERENCE OF METHODS FROM ANALYTICAL TO DIGITAL PHOTOGRAMMETRY.** Photogrammetry has passed through the phases of plane-table, analogue and analytical photogrammetry and we are now facing the next step, digital photogrammetry. In a transition period between phases, old concepts are transferred more or less unchanged to new technology. Examples of transition are given for concepts like DEM measurements in model space, epipolar geometry, adjustment by elements to estimate unknowns, error propagation, and datumsnoping. These concepts are used in multi-point-matching and multi-image-matching in order to increase performance and reliability. Photogrammetrists and computer experts have to co-operate so as to develop and improve digital photogrammetry. (Author abstract) 25 refs.

Torlegard, Kennert (Royal Inst of Technology, Stockholm, Swed). *Photogrammetria v 42 n 3-6* May 1988 p 197-208.

**078251 MICROCOMPUTERS AND PHOTOGRAMMETRY A NEW TOOL: THE VIDEO PLOTTER.** This paper describes the prototype of a plotter. It shows how stereo-images are stored in a digital form and displayed on a screen on which three-dimensional measurements and plotting can be achieved, using a stereoscope, digital mapping techniques, and a measuring mark that has the advantage of being part of the image matrix. An example of interior orientation and plotting is given, using the simple case of a model taken by stereometric cameras. On-going developments, directed at universal plotting, are also presented, along with the main advantages of the new and inexpensive technique. (Edited author abstract).

Agnard, J.P. (Laval Univ, Que, Can); Gagnon, P.A.; Nolette, C. *Photogramm Eng Remote Sens v 54 n 8* Aug 1988 p 1165-1167.

Data Reduction

**078252 PROJECTIVE ANALYSIS IN PHOTOGRAMMETRY.** As photograph can be considered as central projection, photogrammetry is naturally a topic of

projective geometry. Basing on projective geometry, the author of this paper offers a general analysis of photogrammetric geometry theory and puts forward the photogrammetric equations expressed by homogeneous projective coordinates. In stereophotogrammetry, without knowing the exterior and interior orientation parameters, we can obtain the necessary information (the shape, size and position of an object) by merely measuring and calculating the information of the photograph. (Author abstract) 6 refs. In Chinese.

Fuhua, Liu (Tianjin Univ, China). *Tianjin Daxue Xuebao n 1* 1988 p 117-124.

**Equipment** See Also MAPS AND MAPPING—Computer Aided Design.

**078253 NEW APPROACH TO MONITORING DATA COLLECTION IN PHOTOGRAMMETRIC MODELS.** Collecting data for topographic digital mapping is discussed. A suggestion is made to form a DTM from data collected along two families of profiles, orthogonal to one another, supplemented by data describing planimetric locations and approximate elevations of break lines. Results of tests show that collecting data in the proposed mode is advantageous both with respect to rates of collecting and to accuracy of derived DTMs. (Author abstract) 4 refs.

Doytsher, Y. (Technion-Israel Inst of Technology, Haifa, Isr); Shmutter, B. *Photogramm Eng Remote Sens v 54 n 6 pt 1* Jun 1988 p 715-722.

**078254 ON THE GEOMETRIC ACCURACY ACHIEVED IN PHOTOSCANNING AND PHOTO-WRITING WITH THE FEAG.** The FEAG Photoscan & Photowrite Instrument, a peripheral unit to digital image processing systems, serves two purposes, viz. digital scanning of transparent photographs or graphs, and writing (plotting) of raster images on black-and-white film from digital information. In scanning, the photograph (or other transparent image), mounted on a continuously rotating drum, passes below a stationary laser beam and is converted into digital data line by line. Every image line is resolved into discrete spots by a high-resolution pulse transmitter system. 3 Refs.

Gehler, Steffen; Riedesel, Paul; Klukowski, Kerstin. *Jena Rev v 32 n 4* 1987 p 185-186.

**Forestry Applications** See Also AERIAL PHOTOGRAPHY; SATELLITES—Remote Sensing.

**078255 MONITORING THE LONG-TERM EFFECTS OF SILVICULTURAL ACTIVITIES WITH AERIAL PHOTOGRAPHY.** Because aerial photographs provide a reasonably permanent and accurate record of forest conditions, the opportunity exists to develop a historical perspective on current management decisions. Historical photography can be extremely useful in documenting the timing and areal extent of many silvicultural activities. In addition, historical aerial photography may show ground conditions that cannot be detected with more recent photography because of the presence of a tree canopy.

Hudson, William D. (Michigan State Univ, East Lansing, MI, USA). *J For v 86 n 3* Mar 1988 p 21-26.

**Instruments** See Also MAPS AND MAPPING—Instruments.

**078256 ANAGRAF: AN ANALYTIC INSTRUMENT FOR REMOTE STUDIES.** The first Soviet analytic instrument for serial production is described. This instrument is intended for processing single and stereo photographs in a semi-automatic mode. The structural and functional features of the instrument are described. The technical specifications from experimental testing of the instrument are reported. 2 refs.

Zotov, G.A.; Olokhtonov, V.P.; Tsvetkov, V.Ya. *Optoelectron Instrum Data Process n 2* 1987 p 121-122.



**078257 EXPERIENCE MADE WITH WILD OR-1 AVIOPLAN ORTHOPHOTO SYSTEM.** Between 1982 and 1984 the Technical University, Budapest, in cooperation with EROTERV (Power Plant and Mains Planning Bureau) set up a closed-circuit stereophotogrammetric system. One of its elements is the Wild OR-1 Avioplan system, able to generate dimensionally accurate, correct in key pictorial output. This is a concise description of the operational principles of WILD OR-1. The Technical University, Budapest purchased the instrument two years ago. The experiences of application in various fields are reported. Special attention is paid to the preparation of data input using various types of photogrammetric instruments. Some computer programs have been written at this Institute. These program sets facilitate the interactive use of the SORA software packages. (Edited author abstract)

Sarkozy, F. (Technical Univ, Budapest, Hung). *Period Polytech Civ Eng* v 30 n 1-2 1986 p 3-11.

**Interpretation** See GEOLOGICAL SURVEYS—Remote Sensing; MAPS AND MAPPING—Computer Aided Analysis.

## Materials

**078258 VERY HIGH RESOLUTION AERIAL FILMS.** The use of very high resolution aerial films in the aerial photography practice is evaluated. Comparisons are made between commonly used panchromatic, color and CIR films and their high resolution equivalents. Based on practical experience and systematic investigations, this paper demonstrates the very high image quality and improved height accuracy that can be achieved using these films. It evaluates the advantages to be gained from this improvement and discusses the present operational restrictions encountered when using high resolution film materials. (Author abstract) 12 refs.

Becker, Rolf. *Photogrammetria* v 42 n 5-6 May 1988 p 283-302.

**Medical Applications** See BIOMECHANICS—Musculoskeletal Systems.

## Monitoring

**078259 ON-LINE MEASUREMENTS FOR MULTI-TEMPORAL PHOTOGRAPHS USING AN ANALYTICAL STEREO-PLOTTER.** Photogrammetric monitoring of displacements requires repetitive photography. The conventional mensuration scheme of targeted and natural points, and inherent problems are briefly discussed. An integrated measuring system using the computer-controlled capabilities of the analytical stereo-plotter OMI AP-2C is described and applied. This on-line mode of operations increases the speed of execution, enhances the quality of data, offers editing capabilities and increases flexibility. (Author abstract) 13 refs.

Armenakis, C. (Univ of New Brunswick, Fredericton, NB, Can); Faig, W. *Photogrammetria* v 42 n 1-2 Nov 1987 p 51-61.

Quebec, Canada See AERIAL PHOTOGRAPHY.

## Theory

**078260 BASES OF NULL-SPACE IN ANALYTICAL PHOTOGRAMMETRY.** In analytical photogrammetry the concept of null-space is associated normally with 3-D coordinates of object points or of bundle projection-centers. Bases of null-space for all the parameters in a rank-deficient photogrammetric problem become indispensable whenever small variations in datum (S-transformations) have to be implemented. This paper discusses bases of null-space which relate to the orientation angles of a photogrammetric bundle. A simple geometric approach is used for deriving bases of null-space for various sets of orientation angles. The mathematical expressions for evaluating bases of null-space by the proposed method are tested analytically as well as by numerical differentiation. Singular cases are studied and interpreted. (Edited author abstract) 14 refs.

Papo, Haim B. (Technion, Israel Inst of Technology, Haifa, Isr). *Photogrammetria* v 41 n 4 Sep 1987 p 233-244.

**Underwater** See Also NUCLEAR REACTORS, PRESSURIZED WATER—Fuel Elements.

**078261 COMPARISON OF SUBMARINE RELIEF FEATURES ON A RADAR SATELLITE IMAGE AND ON A SKYLAB SATELLITE PHOTOGRAPH.** A Skylab photograph and a Seasat radar image of the North American east coast (Nantucket Shoals) taken at different dates, but at the same tidal phase and under comparable weather conditions, are analyzed. It is shown that the radar imaging as well as the optical imaging is caused by roughness variations of the water surface due to tidal flow over submarine relief. It is investigated whether optical imaging is affected by backscattering by suspended sediment in the water column, by reflection from the sea floor or by variations of the surface roughness associated with wind and tidal flow over underwater bottom topography. We conclude from the analysis of the densities in the blue, green and red layers of the Skylab color film that specularly reflected sunlight at the rough ocean surface is the dominant imaging mechanism. (Edited author abstract) 36 refs.

Hennings, Ingo (GKSS Forschungszentrum Geesthacht GmbH, Geesthacht, West Ger); Doerffer, Roland; Alpers, Werner. *Int J Remote Sens* v 9 n 1 Jan 1988 p 45-67.

**PHOTOGRAPHIC EMULSIONS** See Also CRYSTALS—Growing; HOLOGRAPHY; PHOTOGRAPHIC FILMS AND PLATES; PHOTOGRAPHIC FILMS AND PLATES—Processing; PHOTOGRAPHY.

**078262 CHARGE MEASUREMENTS OF STOPPING HIGH-Z NUCLEI ( $6 \leq Z \leq 92$ ) IN NUCLEAR EMULSION.** The technique of charge determination by measurements of track-width of stopping tracks in nuclear emulsion has been extended to uranium nuclei. The method utilizes the last 1 mm of residual range to estimate mean-track-widths, and has been applied to nuclear beams of  $Z=6, 26, 57$  and  $92$ . A resolution in charge of  $\sigma(Z) = \pm 2$  units was obtained over the entire interval of charges  $6 \leq Z \leq 92$ . (Author abstract) 7 refs.

Ghoniem, M.T. (Lawrence Berkeley Lab, Berkeley, CA, USA); Heckman, H.H.; Karant, Y.J. *Nucl Tracks Radiat Meas* v 13 n 2-3 1987 p 99-103.

**078263 PROGRESS IN PHOTOGRAPHIC IMAGING.** The performance of silver halide as a detector is reviewed with respect to theoretical limits, and sources of inefficiency are identified. A brief comparison is made with electronic sensors, focusing on the requirements of astronomical imaging. (Author abstract) 9 refs.

Jeanmaire, D.L. (Eastman Kodak Co, Rochester, NY, USA). *J Opt* v 18 n 4 Jul-Aug 1987 p 199-201.

**078264 ELEMENTARY PROCESSES IN LATENT IMAGE FORMATION INVOLVING POLYVALENT CATIONS.** The lower valency states of polyvalent provide donor centers at which electrons may be transferred to the conduction band or holes trapped from the full band of silver halide crystals. The higher valency states provide acceptor centers at which electrons may be trapped from the conduction band or holes transferred to the full band. The transfer processes result from the decay of excitons or the direct absorption of photons at the centers. In the presence of both donor and acceptor centers, electron-hole pairs may be created by a two-step process in which one exciton or adsorbed photon releases an electron to the conduction band from a donor center and a second exciton or photon, a hole to the full band from an acceptor center. (Edited author abstract) 31 refs.

Mitchell, J.W. (Univ of Virginia, Charlottesville, VA, USA). *J Imaging Sci* v 31 n 6 Nov-Dec 1987 p 239-243.

**078265 NEW ROLES FOR SILVER BASED SENSITIZED MATERIALS IN MODERN IMAGING.** The current technologies incorporated into general photography, motion picture production, and photomechanical

reproduction, are continuing to be merged to an ever increasing degree with the more recent imaging technologies, such as electronic imaging, to bring about a wider variety of uses. Through several examples this article indicates that in the production of the color pictorial image, otherwise known as high quality imaging, silver halide based sensitized materials will continue to very ably meet the many requirements essential to these new imaging orientations. Further, within the imaging technology network related to the color pictorial image, the question of the future developmental roles that can be expected of silver halide materials within these new imaging contexts, are delineated and investigated. (Author abstract) 13 refs. In Japanese.

Oishi, Yasushi. *Fuji Shashin Fuirumu Kenkyu Hokoku* n 33 1988 p 38-43.

**078266 DEMBER PHOTOVOLTAGE DUE TO DIFFUSION OF POSITIVE HOLES IN SILVER BROMIDE MICROCRYSTALS.** A Dember photovoltage whose sign was opposite to that of the photovoltage due to the diffusion of photoelectrons was observed on AgBr emulsion grains only in the presence of strong electron traps (i.e., photolytically formed silver clusters and electron-trapping dyes), and was called the negative Dember signal. Hole-trapping dyes prevented the appearance of the negative signal. It is therefore concluded that the negative signal originates from the diffusion of photoholes in the grains. (Author abstract) 13 refs.

Kaneda, T. (Fuji Photo Film Co, Minami-Ashigara, Jpn); Ohshima, N.; Tani, T. *Fuji Shashin Fuirumu Kenkyu Hokoku* n 33 1988 p 44-48.

**078267 STUDY OF ADSORPTION OF SOME  $Ag^+$ -COMPLEXING AGENTS TO SILVER BROMIDE GRAINS.** A study has been made on the adsorption to silver bromide grains of typical  $Ag^+$ -complexing agents, tetramethyl thiourea (Compound 1), 3,4-dimethyl-4-thiazoline-2-thione (2), potassium thiocyanate (3), and 3,6-dithia-1,8-octanediol (4), by considering their heat of adsorption, orientation on the grain surface, influence upon electric charge of the grains, and desorption of sensitizing dyes from the grain surface. The results have indicated that Compounds 1 and 2 have stronger adsorptivity to the grains than Compounds 3 and 4. It was found from XPS of these agents that sulfur atoms in Compounds 1 and 2 had larger electron density and were more available for complex formation with  $Ag^+$  than those in Compounds 3 and 4. (Author abstract) 4 refs. In Japanese.

Tani, Tadaaki (Fuji Photo Film Co, Minami-Ashigara, Jpn); Mifune, Hiroyuki. *Fuji Shashin Fuirumu Kenkyu Hokoku* n 33 1988 p 55-59.

**Agging** See PHOTOGRAPHIC FILMS AND PLATES—Processing.

**Materials** See SILVER COMPOUNDS—Photography; SILVER COMPOUNDS—Thin Films.

## Research

**078268 MICROWAVE DEPOLARIZATION AND DIELECTRIC ANISOTROPY IN KODAK T-GRAIN EMULSION COATINGS.** The orientation of grains in a Kodak T-Grain emulsion coating results in a material with anisotropic dielectric properties. This anisotropy has been observed experimentally via its effect on the microwave photoconductivity of such coatings; the sensitivity of this technique could be altered by a factor of 10-20 by changing the orientation of a T-Grain coating relative to the applied microwave electric field. The experimental results are readily explainable semiquantitatively in terms of electromagnetic depolarization phenomena. Our results show that depolarization effects can be important in influencing the results of microwave photoeffect measurements on T-Grain coatings. (Edited author abstract) 14 refs.

Spoonhower, J.P. (Eastman Kodak Co, Rochester, NY, USA); Deri, R.J. *J Imaging Sci* v 31 n 4 Jul-Aug 1987 p 141-145.



**Sensitivity** See Also PHOTOGRAPHIC FILMS AND PLATES; PHOTOGRAPHIC FILMS AND PLATES—Processing.

**078269 PRODUCTION OF FOG CENTERS AFTER REDUCTION SENSITIZATION BY THE ADDITION OF BROMIDE OR THIOCYANATE.** An increase in fog has been observed from the addition of the silver halide solvents, NaSCN or NaBr, to a reduction-sensitized 5- $\mu$ m polydispersed tabular AgBr emulsion. No fog was observed from the solvent treatment of the nonsensitized emulsion. The addition of a carbocyanine sensitizing dye before the NaSCN or NaBr addition significantly reduced the fog formation. The addition of 4-hydroxy-6-methyl-1,3,3a,7-tetraazaindene (TAI) to the sensitized emulsion before addition of the solvents decreased the fog from the NaSCN, but increased the fog from the NaBr addition. These observations suggest that the nondevelopable silver centers formed by reduction sensitization become developable fog centers when the silver halide solvents are added. (Author abstract) 17 refs.

Collier, Susan S. (Eastman Kodak Co, Rochester, NY, USA). *J Imaging Sci* v 31 n 3 May-Jun 1987 p 135-137.

**078270 ENERGY LEVELS OF SULFUR SENSITIZER CENTERS.** The sensitivity of sulfur- and sulfur-plus-gold-sensitized octahedral emulsions to light of wavelengths  $> 620$  nm has been studied photographically. These measurements have shown that the addition of dyes with low oxidation potentials enhanced the long-wavelength sensitivity of the sulfur- and sulfur-plus-gold-sensitized emulsions. The long-wavelength sensitivity also increased with increasing exposure temperatures. The activation energy,  $E_a$ , calculated from the temperature dependence was  $E_a = 0.33$  eV for the sulfur-sensitized sample and  $E_a = 0.19$  eV for the sulfur-plus-gold-sensitized sample. These results are consistent with a model where the energy levels of the sulfur and sulfur-plus-gold-sensitizer centers are within the bandgap of the silver halide. (Author abstract) 7 refs.

Hamilton, J.F. (Eastman Kodak Co, Rochester, NY, USA); Harbison, J.M.; Jeanmaire, D.L. *J Imaging Sci* v 32 n 1 Jan-Feb 1988 p 17-19.

**078271 EFFECTS OF TETRAAZAINDENE ON REACTION AND AGGREGATION PROCESSES IN SULFUR SENSITIZATION WITH THIOSULFATE.** The effects of 4-hydroxy-6-methyl-1,3,3a,7-tetraazaindene as a controller for the processes involved in sulfur sensitization with thiosulfate of octahedral AgBr and AgBrI grain emulsions were studied. Compared with reaction kinetics in the absence of TAI, the reaction kinetics of silver sulfide formation with thiosulfate in the presence of TAI becomes more dependent on interstitial silver ion concentration, or active surface physical defect concentration, and shows resemblances to the reaction kinetics of cubic grains in the absence of TAI. The amount of sulfide required to attain a given photographic speed increases with the presence of TAI, presumably owing to inhibition of sulfide aggregation. As a result, however, TAI has an effect on the size distribution and topography of silver sulfide sensitivity specks, and, under certain conditions, improves sensitometric properties such as high-intensity reciprocity characteristics. (Author abstract) 30 refs.

Takiguchi, Hideki (Konica Corp, Hino, Jpn). *J Imaging Sci* v 32 n 1 Jan-Feb 1988 p 20-27.

**078272 SULFUR-PLUS-GOLD SENSITIZATION: LATENSIFICATION DURING EXPOSURE.** The function of gold in a sulfur-plus-gold-sensitized octahedral emulsion has been studied in bathing experiments, in which the coated film was bathed either before or after exposure. A bath containing a dilute solution of potassium cyanide removes gold, in either ionic or metallic form, from sensitizer centers before exposure or from latent-image centers after exposure. In contrast, gold can be added by the use of a gold-latensifying bath. For high-intensity exposure, gold in the sensitizer centers induces varying amounts of speed through its influence upon the electronic-ionic steps in latent-image formation.

This amount varies both with sensitization and the developer used. For an optimally sensitized emulsion developed in the James surface developer MAA-1, the gold latensification during exposure at  $10^{-4}$  sec contributes about 1 log exposure unit to the photographic speed. (Edited author abstract) 18 refs.

Spencer, Harry E. (Oberlin Coll, Oberlin, OH, USA). *J Imaging Sci* v 32 n 1 Jan-Feb 1988 p 28-34.

**078273 SOME FACTORS AFFECTING QUANTUM SENSITIVITIES OF A SILVER HALIDE EMULSION.** On the basis of data recently published by Hailstone, Liebert, Levy, and Hamilton, it is argued that in a sulfur-plus-gold-sensitized AgBr emulsion exposure generates  $Ag_2$  and larger centers on nearly all grains which have absorbed at least two photons. As contrasted to this efficient creation of centers, the detection of the centers by customary development is not as efficient. The  $Ag_2$  centers are too small to trigger development, unless the grains are light-latensified, which can also increase unwanted fog. Vigorous development needed to detect somewhat larger centers, perhaps three-atom ones, also induces fog, and less vigorous development leads to less fog but only responds to even larger latent-image centers. It is suggested that increased quantum sensitivities can be attained either by more efficient growth of small centers into larger ones or more efficient detection of small centers. Renewed attention to processing details, including suppression of fog, is one way to attack the problem. (Author abstract) 12 refs.

Spencer, Harry E. (Oberlin Coll, Oberlin, OH, USA). *J Imaging Sci* v 32 n 1 Jan-Feb 1988 p 40-42.

**078274 XPS STUDY OF CYANINE DYE ADSORPTION ON AgBr EMULSIONS.** Adsorption of 3,3'-dimethyl-9-ethylthiacarbocyanine iodide on AgBr emulsions was studied comparing previous results on AgCl fused crystal plates. Optical absorption spectra suggested that dye molecules adsorbed on AgBr microcrystals as J-aggregate. Since XPS signal intensities varied depending on gelatin contents of specimen emulsions, intensity normalization based on the substrate bromide signal was utilized. XPS intensity analysis showed that the adsorption of the dye was limited to be monolayer, and iodide, the counter ion in the aggregate, was always detected in the spectra of adsorbed dye layers. The existence of competitive adsorbate, gelatin or fragments, on the AgBr microcrystal surface might lead the dye to J-aggregate formation on adsorption. The surface element of octahedral AgBr was bromide rather than Ag. (Author abstract) 9 refs.

Ohtani, Hirofumi (Konica Corp, Hino, Jpn); Kitamura, Takeshi; Saijo, Hiroshi. *J Imaging Sci* v 32 n 1 Jan-Feb 1988 p 43-45.

**078275 ENHANCEMENT OF DISPERSION OF LATENT IMAGES BY A CYANINE DYE AS A NEW MECHANISM FOR ITS DESENSITIZATION IN SULFUR-SENSITIZED AgBr EMULSION.** The enhancement of dispersion of latent images by a cyanine dye is proposed as a new mechanism for the desensitization by the dye in a sulfur-sensitized cubic AgBr emulsion. It was confirmed that the dye caused neither densensitization due to its retardation of the development process nor that due to its capture of positive holes by the dye, which was observed in a chemically unsensitized emulsion, was not predominant in a sulfur-sensitized emulsion. The degree of the desensitization observed increased with the increase in the amount of thiosulfate used for sulfur sensitization. (Edited author abstract) 24 refs.

Ihama, Mikio (Fuji Photo Film Co, Kanagawa, Jpn); Tani, Tadaaki. *J Imaging Sci* v 31 n 4 Jul-Aug 1987 p 157-161.

**078276 MINIMIZING PHOTOGRAPHIC SENSITIVITY TO ENVIRONMENTAL RADIATION BY CONTROLLING SILVER HALIDE EMULSION MORPHOLOGY.** AS photographic film speeds are increased by advances in technology, natural background radiation contributes significantly to the degradation of

film performance with age. The goals of this study were twofold: (1) to establish and validate a laboratory model to investigate environmental radiation sensitivity, and (2) to determine a practical way to minimize this sensitivity without photographic performance loss. A natural-aging study of simple model emulsion coatings confirmed that the integrated exposure of film to background sources, which are heterogeneous and polychromatic, can be simulated by 60-cobalt  $\gamma$  radiation, which has a two-line photon spectrum. (Edited author abstract) 35 refs.

Sowinski, A.F. (Eastman Kodak Co, Rochester, NY, USA); Wightman, P.J. *J Imaging Sci* v 31 n 4 Jul-Aug 1987 p 162-168.

**078277 PHYSICAL-CHEMICAL PROPERTIES OF ORGANIZED SENSITIZER MOLECULES.** Molecular organization has been studied by using the Langmuir-Blodgett technique, self-organization by adsorption at two-dimensional fatty acid matrices at the air-water interface and micellar systems. Cyanine molecules were organized into J-aggregates, and the parameters which influence dye aggregation are discussed by comparing model systems with emulsion crystals of silver halides. Applications of organized sensitizer systems for the study of electron- and energy transfer and related mechanisms are shown. (Author abstract) 34 refs.

Steiger, R. (Ilford AG, Fribourg, Switz); Zbinden, F. *J Imaging Sci* v 32 n 2 Mar-Apr 1988 p 64-81.

**078278 STUDIES OF SUPERSENSITIZATION OF SOME BRIDGED DICARBOCYANINES BY TRIAZINO STILBENEDISULFONIC ACIDS.** IR studies have been made on dicarbocyanines and/or triazino stilbenedisulfonic acids adsorbed on the surface of AgBr grains, and the results indicate that the dye and supersensitizer are adsorbed in a way different from that described by O. Riester due to molecular interaction through opposite charges. Light-induced ESR signals of the dyes and/or supersensitizer added to AgBr emulsion (0.7  $\mu$ cubic) have been observed. It is found that the speed of sensitization increases with increasing intensity of ESR signal in the presence of supersensitizer. (Edited author abstract) 6 refs.

Luo, Weimei (East China Univ of Chemical Technology, Shanghai, China); Zhu, Zhenghua; Yao, Zuguang; Wang, Suiyong; Chen, Tao. *J Imaging Sci* v 32 n 2 Mar-Apr 1988 p 81-84.

**078279 STUDY OF REACTION AND AGGREGATION STEPS IN SULFUR SENSITIZATION AND THE ROLE OF TETRAAZAINDENE.** A model has been developed for the combined reaction and aggregation processes involved in sulfur sensitization. Limiting forms for the population of aggregates of various sizes have been obtained. The results are compared with experimental data on an AgClBr emulsion. It is concluded that centers containing two sulfides make a substantial contribution to photographic speed. An aggregation rate constant at 80°C is determined for the AgClBr emulsion studied, and this has been used to estimate that about 1000 sulfide pairs/ $\mu$ m<sup>2</sup> confer maximum speed gain under the particular exposure and processing conditions used. (Edited author abstract) 26 refs.

Keever, J.E. (Eastman Kodak Co, Rochester, NY, USA); Gokhale, V.V. *J Imaging Sci* v 31 n 6 Nov-Dec 1987 p 243-249.

**078280 EFFECT OF S-DONOR LIGANDS ON THE SENSITIZATION OF SILVER BROMIDE CRYSTALS WITH IRIIDIUM(III).** Different levels of potassium thiocyanate were used in combination with potassium hexachloroiridate to surface sensitize an octahedral silver bromide emulsion. Surface sensitivity increased by 0.90 log H over the unsensitized emulsion when IR and SCN were added during sensitization compared to 0.45 log H when the iridium salt is used alone. A decrease of down to 2.40 log H was observed when the Ir-SCN complex was formed and then added to the emulsion. An



increase of 1.05 log H was obtained if gold, thiocyanate and iridium were used. Similar results were obtained using tetramethylthiourea and thiodiglycol instead of SCN. The mechanism of iridium sensitization is discussed based on the experimental results. (Author abstract) 31 refs.

Zuleta, Juan A. (Rochester Inst of Technology, Rochester, NY, USA). *J Imaging Sci* v 31 n 6 Nov-Dec 1987 p 250-254.

**078281 LATENT SUBIMAGE IN A AgBr MODEL EMULSION. 2. SULFUR-SENSITIZED VERSIONS.** Post-exposure light latensification of an optimally sulfur-sensitized AgBr emulsion containing 0.475- $\mu$ m octahedra caused a sensitivity increase of  $-1.0$  log E when the emulsion was developed 12 min in Kodak rapid x-ray developer. The degrees of light latensification decreased with increasing development time and decreasing sulfur level. These experimental results are compared with the predictions of the nucleation-and-growth model of latent-image formation. Quantum sensitivity and degree of HIRF data were used to select the key parameters in the model. Although a unique parameter set could not be found, two parameter sets gave light-latensification values in reasonable agreement with the experimental values. (Edited author abstract) 8 refs.

Hallstone, R.K. (Eastman Kodak Co, Rochester, NY, USA); Liebert, N.B.; Levy, M.; Hamilton, J.F. *J Imaging Sci* v 31 n 6 Nov-Dec 1987 p 255-262.

**078282 STUDY OF THE CHARGE SEPARATION PROCESS IN SPECTRA SENSITIZATION THROUGH AN ANALYSIS OF ITS RELATIVE QUANTUM YIELDS.** The knowledge on the efficiencies of the electron and hole injections by an excited dye is of great importance for the understanding of the mechanism of spectral sensitization. However, it seems that there is no systematic knowledge on  $\phi_4^1$  and  $\phi_4^2$ . This work was undertaken to obtain measuring  $\phi_4^1$  and  $\phi_4^2$  for a series of sensitizing dyes on two typical emulsion grains, i.e., cubic and octahedral AgBr grains whose surfaces consists of (100) and (111) faces, respectively. 14 refs.

Tani, Tadaaki (Ashigara Research Lab, Minami-ashigara, Jpn). *J Imaging Sci* v 31 n 6 Nov-Dec 1987 p 263-267.

**078283 MULTIFLASH RESPONSES OF SULFUR SENSITIZED OCTAHEDRAL EMULSION ORIGINATED FROM COMPETITIVE NUCLEATION EFFECT.** The competitive nucleation or latent image dispersion effect in sulfur sensitized octahedral AgBr emulsion was examined by the multiflash exposure method. As the result of the effect a unique positive multiflash response emerged, where the optical density increased remarkably with the increase of the interruption period  $\Delta t$ , within a definite range of log  $\Delta t$ . A sufficient reduction of the minimum developable size of latent image by gold latensification converted the positive response to a negative type of response commonly observed for chemically unsensitized emulsions. Both the positive and the negative responses, however, were shown to be governed by substantially the same process in silver halides. (Edited author abstract) 12 refs.

Kawasaki, Mitsuo (Kyoto Univ, Kyoto, Jpn); Hada, Hiroshi. *J Imaging Sci* v 31 n 6 Nov-Dec 1987 p 267-271.

**078284 LATENT SUBIMAGE IN A AgBr MODEL EMULSION. 1. SULFUR-PLUS-GOLD-SENSITIZED VERSIONS.** The predictions of the nucleation-and-growth model of latent-image formation regarding the fraction of subimage grains in an exposed emulsion are reviewed. These subimage grains were detected experimentally by using low-intensity light latensification. A AgBr emulsion containing 0.475  $\mu$ m octahedra and sensitized with various levels of sulfur and gold served as a model system. Reciprocity data and the dependence of the D-log E curve shape on exposure intensity indicated that the minimum cluster size which could catalyze development was three atoms for 12 min in Kodak rapid x-ray developer. (Edited author abstract) 12 refs.

Hallstone, R.K. (Eastman Kodak Co, Rochester, NY, USA); Liebert, N.B.; Levy, M.; Hamilton, J.F. *J Imaging*

*Sci* v 31 n 5 Sep-Oct 1987 p 185-193.

**078285 MODIFIED PPP-CI TREATMENT OF THIACARBOCYANINE AND ITS AZA DERIVATIVES.** Thiocarbocyanine (TCC) and its aza derivatives were computed using a modified PPP-CI method with standard parameters. Some calculated results are compared to experimental data. The relation between observed desensitization and calculated electron affinity is discussed. Some properties of the dyes in the first excited state are compared with those in the ground state. It can be expected that the photochemical behavior of dyes in the excited state are, generally speaking, different from the reactions of the ground state. (Author abstract) 9 refs.

Tao, Shen (Acad Sinica, Beijing, China); Chen, Kong-chang; Zhu, Zheng-hua. *J Imaging Sci* v 31 n 5 Sep-Oct 1987 p 225-227.

**Spectrum Analysis See X-RAY FILMS—Measurements.**

**PHOTOGRAPHIC FILMS AND PLATES, COLOR** See Also DYES AND DYEING—Ionization; DYES AND DYEING—Synthesis; ELECTROSTATICS—Electric Charge; MAGNETIC DEVICES, THIN FILM; PHOTOGRAPHIC REPRODUCTION—Computer Simulation; PRINTED CIRCUITS—Manufacture.

**078286 ROLE OF SILVER CENTERS IN THE PROCESS OF CATALYTIC DYE FORMATION.** The goal of this paper was to establish the mechanism of the process of catalytic dye formation. Complex compounds of cobalt(III) were synthesized using familiar techniques. The compounds were identified by elemental analysis for cobalt and carbon, hydrogen, and nitrogen content. The color developer (CD) used was 4-amino-N-ethyl-N- $\beta$ -hydroxyethyl anilinesulfate, purified by activated carbon and recrystallized from an aqueous alcohol solution. Formation of the dye on silver centers was observed for sequential treatment of the photographic paper in a solution of cobalt(III) compounds and then after washing with water in a CD solution. The fact that the dye was not formed when a sequence of treatments was used was evidence for reaction of Co(III) with Ag as the first stage of the process of dye formation. Possible pathway for this reaction are proposed. 24 refs.

Gerleman, N.G. (A.I. Gertsens Leningrad State Pedagogic Inst, USSR); Shagisultanova, G.A.; Yakovlev, Yu.B. *J Appl Chem USSR* v 60 n 1 pt 1 Jan 1987 p 12-17.

**078287 IMAGE IN TERMS OF COVERING POWER.** The design of a system which will result in the formation of a negative transparency in an integral form that is presented in this paper. The stabilization of the internal image depends from the classical means of forming stable, transparent complexes of silver when fixation and wash steps are omitted. In its place a system has been devised which takes advantage of solution physical development to fully develop silver in all areas of exposure including  $D_{min}$ . Image discrimination is effected by differences in the covering power of silver formed at various exposure levels. (Edited author abstract) 4 refs.

Spiegel, Arnold (Polaroid Corp, Cambridge, MA, USA). *J Imaging Technol* v 13 n 6 Dec 1987 p 185-188.

**078288 STABILITY OF KODAK PROFESSIONAL MOTION PICTURE FILM BASES.** The authors report on the development of film bases suitable for professional motion picture film, and summarize recommendations for film with long life.

Lee, W.E.; Bard, C.C. *Image Technol (London)* v 69 n 12 Dec 1987 p 518-521.

**078289 PHOTOGRAPHIC SPEED OF COLOR NEGATIVE FILM BASED ON SIGNAL-TO-NOISE PERFORMANCE.** A new photographic speed criterion for recent ultra-high-speed color negative film 'Graininess-Aimed-Speed' (GAS) is introduced and quantified with a mathematical correlation of signal-to-noise ratio and subjective image evaluation. Since the color negative film exhibits reduced granularity in the direction of

overexposure, the GAS can be specified for the granularity expected on the print. The rationality of the GAS is confirmed in the case of HR 1600 color negative images and their prints produced in various print sizes. We conclude that to add the new speed criterion based on the signal-to-noise performance to the conventional speed criterion is useful for recent ultra-high-speed color negative film. (Author abstract) 7 refs.

Kubo, Souichi (Chiba Univ, Chiba, Jpn); Miyake, Yoichi; Arai Hiroko. *J Imaging Sci* v 31 n 6 Nov-Dec 1987 p 271-274.

**078290 COLOR MOTION PICTURE FILM FOR LASER RECORDING.** Application of high-definition television (HDTV) technology to theatrical motion picture production is being explored in various countries. An electrocinematographic system based on HDTV camera shooting requires a certain kind of kinescope recording. In Japan, two recording systems have been proposed and practised; electron beam recording development by Sony Corp., and laser recording by NHK. The present paper firstly deals with the problems encountered when conventional color motion picture films are used for laser kinescope recording, and then describes the characteristics of our new type of film specifically designed for that purpose and free from such problems. (Author abstract) 4 refs. In Japanese.

Urata, Yukihide (Fuji Photo Film Co, Minami-Ashigara, Jpn); Honjo, Satoru. *Fuji Shashin Fuirumu Kenkyu Hokoku* n 33 1988 p 9-14.

**078291 DIRECT PLATE-MAKING SYSTEM WITH THE IMPROVED ULTRA HIGH SPEED PLATES.** HP-system, direct plate-making system which consists of the ultra high speed plate of composite type FNH and the automatic processing system FHP, has been developed in 1980. Recently, in parallel with making great progress in the original making system, users' needs to use the direct plate-making system are notably increasing. Based on above mentioned needs, we have improved the HP system in the following points: 1) Improvement of the image sharpness, resolution and tone-reproduction, 2) Improvement of the spectral sensitivity suitable to Ar ion laser light, 3) Simplification and stabilization of the processing, 4) Development of more compact type processor. Thus, we succeeded in putting in the market: (1) LASER direct plate-making system and (2) Projection direct plate-making system. (Edited author abstract) 11 refs. In Japanese.

Shiba, Keisuke (Fuji Photo Film Co, Shizuoka, Jpn); Koizumi, Shigeo. *Fuji Shashin Fuirumu Kenkyu Hokoku* n 33 1988 p 105-113.

**078292 TOWARDS A QUANTITATIVE USE OF AERIAL CIR FILMS ON A QUANTITATIVE BASIS FOR VARIOUS APPLICATIONS** such as recognition and monitoring of trees at various degrees of stress, a method is proposed to correct the main errors introduced by the photographic acquisition system. After an analysis of the origin of these errors, including atmospheric effects and various distortions introduced by the film, the camera, and the drum scanner producing three digital color channels recorded on magnetic tape, an algorithm has been derived which gives the relative values of reflectance of any target area of a CIR photograph. This algorithm has been validated using data acquired, in situ and from several aircraft flights, of reference targets whose properties have been measured in the laboratory. Results are satisfactory. (Author abstract) 17 refs.

Becker, F. (LSIT/GSTS, Strasbourg, Fr); Nerry, F.; Ramanantsozihena, P.; Fischer, J. *Photogramm Eng Remote Sens* v 54 n 6 pt 1 Jun 1988 p 743-750.

**Applications See HOLOGRAPHY.**

**Computer Aided Design See COLOR—Evaluation.**



**Deformation** See PHOTOGRAMMETRY—Cameras.

**Electric Field Effects** See PHOTOGRAPHIC REPRODUCTION—Xerography.

**Evaluation** See IMAGE PROCESSING—Image Analysis; PHOTOGRAMMETRY—Materials.

**Mathematical Models** See PHOTOGRAPHY—Infrared Radiation.

**Performance** See Also ACCELERATORS, SYNCHROTRON—Beam Extraction.

**078293 PHOTOGRAPHIC FILM AND PLOTTER.** At present, there are approximately 20-25 OEM manufacturers of photoplotter CAD/CAE/CAM systems, all of whom offer close to 50 different models from which to choose, employing different technologies and imaging devices. Features, performance and economic aspects associated with photoplotters used in the electronics industry are dealt with. Typically, there are two developing systems on the market today: rapid access and lith. Both are viable means for making artwork masters from photoplotters. A comparison is made of the uses and advantages of each.

Cathcart, Richard F. *Printed Circuit Des* v 5 n 3 Mar 1988 p 21-22.

**Plastics Applications** See POLYMERS—Chemical Reactions.

**Processing** See Also EMULSIONS—Measurements; SILVER AND ALLOYS—Recovery.

**078294 PRODUCING TINTS AND TONES IN MONOCHROME FILMS USING MODERN COLOR TECHNIQUES.** Many early black-and-white films were given artificial coloring by the chemical processing of tinting and toning. Most remaining prints have lost these colors, and the original methods of tinting and toning are rarely practical or economical today. A system of recreating the effect of both tinting and toning has been devised, using modern color-film materials. The technique was applied to the restored copy of the 1927 Australian film classic *For the Term of His Natural Life*. (Author abstract)

Case, Dominic (Colorfilm Pty Ltd, Sydney, Aust). *SMPTE J* v 96 n 2 Feb 1987 p 186-190.

**078295 EXPERIMENTAL QUALITY CONTROL PROGRAM FOR PRINTING ARCHIVAL FILMS.** The Preservation Commission of the International Federation of Film Archives (FIAF) has a program for establishing standards for the duplication of archival film. Evaluation of quality in such film is difficult because the preprint is often marred by previous heavy use, shrinkage, and deterioration of the film base. Furthermore, subjective factors influence the overall assessment. The aim of this program is to develop a test film which makes it possible to quantify the various quality factors so that quality assessment may be more objective. (Author abstract)

Schou, Henning (Natl Film & Sound Archive, Canberra, Aust); Case, Dominic. *SMPTE J* v 96 n 12 Dec 1987 p 1180-1185.

**078296 FURTHER STUDY OF THE SABATIER EFFECT.** Photographic enlarging papers that show good Sabatier effects with Metol developers are shown to have grains with mainly surface sensitivity centers. We propose a mechanism for the Sabatier effect that is consistent with this observation and with various other phenomena associated with the effect. In this mechanism, grains which received initial exposures corresponding to the minimum in the Sabatier H and D curve have many surface subimage specks and a few internal subimage specks. Metol anions are adsorbed on the surface specks and cause an effective migration of silver to the internal specks, forming internal latent image specks and thus desensitizing the grains toward further exposure to light. (Author abstract) 11 refs.

Hyde, Mary L. (Univ of California, Berkeley, CA, USA);

Sismore, Marlene; Attaran, Amir; Draganescu, Alexandra; Ezaz-Nikpay, Khosro; Heine, Andreas; Liegeois, Angele; Stueben, Warren C.; Jolly, William L. *J Imaging Sci* v 32 n 2 Mar-Apr 1988 p 85-89.

**078297 EFFECT OF A DISTRIBUTION OF DEVELOPABLE SIZES IN DETERMINATIONS OF THE MINIMUM SIZE OF THE LATENT IMAGE.** Earlier determinations of the minimum developable size were in terms of an abrupt developability criterion and therefore an integral minimum size. We now report an extension of this work to include the concept of a less abrupt transition between developable and undevelopable cluster sizes. When our emulsion is sulfur-plus-gold sensitized, we find that development for 12 min in Kodak rapid x-ray developer at 20°C causes development of all grains whose minimum cluster is three metal atoms and 10% of the grains whose largest cluster is two metal atoms. (Edited author abstract) 18 refs.

Hailstone, R.K. (Eastman Kodak Co, Rochester, NY, USA); Hamilton, J.F. *J Imaging Sci* v 31 n 6 Nov-Dec 1987 p 229-238.

**078298 THIOUREA AND AMMONIUM THIOSULFATE TREATMENTS FOR THE REMOVAL OF 'SILVERING' FROM AGED NEGATIVE MATERIALS.** Most black and white photographic materials take on a 'silvery' appearance as a consequence of aging. This paper addresses the occurrence of 'silvering' with reference to negative photographic materials and describes the experimental characterization of this phenomenon. It then discusses thiourea and ammonium thiosulfate treatments often recommended for the removal of silvering and demonstrates why these treatments are ill advised. (Author abstract) 15 refs.

Barger, M. Susan (Johns Hopkins Univ, Baltimore, MD, USA); Hill, Thomas T. *J Imaging Technol* v 14 n 2 Apr 1988 p 43-46.

**078299 SENSORS INFORM COMPUTER TO AUTOMATE FILM MACHINE.** A pneumatically operated video disc machine uses timed cycles to provide exacting exposure of film. All motions of the LazerFilm Videodisc Automatic Printer are powered by compressed air or vacuum and are controlled by computer. The machine automatically produces an emulsion-to-emulsion-side photographic contact print of the master video disc using an ultra-violet strobe flash for the exposure.

Brown, R. (Idea Engineering Co, Plattsmouth, NE, USA). *Hydraul Pneum* v 41 n 5 May 1988 p 49-50.

## Production

**078300 STABILITY OF LIQUID LAYERS IN COATING PROCESSES: THE STABILITY OF A TWO-LAYER STRATIFIED FLOW ON AN INCLINED PLANE.** The multi-layer slide coating and multi-layer curtain coating methods used in the production of photographic light sensitive materials retain special characteristics in relation to which improvements in coating processes for the slide surface will require the introduction of greater multi-layer flow stability. In this paper, the problem of the fluid flow stability on a flat surface is dealt with in terms of the two-layer stratified fluid flow linear stability theory based on the Orr-Sommerfeld method. (Author abstract) 24 refs. In Japanese.

Kobayashi, Chuzo. *Fuji Shashin Fuirumu Kenkyu Hokoku* n 33 1988 p 132-144.

**Radiation Effects** See Also PHOTOGRAPHIC EMULSIONS—Sensitivity.

**078301 EFFECTS OF NATURAL BACKGROUND RADIATION ON ULTRA-HIGH SPEED FILM.** With the development of ultra-high speed color negative films, the natural background radiation that has been ignored with lower sensitivity films has come into purview as a source of fogging, loss of grain quality, and other quality compromising problems. With the use of low level radiation induction equipment, the effects of natural

background radiation on ultra-high speed film has been defined and determined. Further with the application of alpha-and X-rays, effect simulations are hereby delineated. (Author abstract) 9 refs. In Japanese.

Nozawa, Yasushi (Fuji Photo Film Co, Minami-Ashigara, Jpn); Ikoma, Hideo. *Fuji Shashin Fuirumu Kenkyu Hokoku* n 33 1988 p 60-65.

## Stability

**078302 IMAGE STABILITY: NEW MEDIA POSE NEW RISKS.** The steadily increasing dependence on medical diagnostic imaging and the proliferation of imaging systems have focused attention on information quality and permanence. Hardcopy images must be capable of displaying all levels of data initially captured by the diagnostic device and retaining that level of information for as long a period as appropriate for research, medical-legal or government-mandated archival requirements. Image stability has always been a cornerstone of Polaroid instant film design. The company recognizes the silver halide photographic image as one of the densest forms of information storage available; and the retention of key information as an expectation users place on photographic products, instant or otherwise. This article discusses stability tests, competitive imaging media, and thermal systems.

Aberbach, Leonard (Polaroid Film & Research Div). *Ind Photogr* v 36 n 11 Nov 1987 p B26-B28.

## Storage

**078303 PRIME PROVE SULLA CONSERVAZIONE DELL'IMMAGINE REGISTRATA SU PELICOLE RADIOGRAFICHE ARCHIVATE.** [First Tests on the Conservation of the Image Recorded on Archival Radiographic Films]. The aim of this paper is to inform the users about the problem of the stability in time of the radiographic images on films as a function of the film processing and of the environmental storage conditions. The authors stress the importance of optimizing the process and of choosing the most suitable environmental conditions according to different durations of film storage. In fact, no national standards exist so far, which could give exact indications about the tests to be performed for verifying the stability in time of radiographic films. (Author abstract) In Italian. 3 refs.

Calcagno, G. (Istituto Italiano della Saldatura, Genoa, Italy); Costa, G.; Marmigi, R. *Riv Ital Saldatura* v 39 n 4 Jul-Aug 1987 p 329-331, 333-335.

## Structure

**078304 FNX ULTRA LONG RUN NEGATIVE WORKING PS-PLATE.** Ultra-long run negative working PS plate FNX oriented for a new water based development system has been developed. This plate is made on a multi-grained base on which a newly developed highly light sensitive binder and photo-polymerizable material have been coated. The light sensitive allyl group and alkali soluble group are used in the new binder through which the incorporated light sensitive material is provided with an extra degree of printing durability within the context of a water based development system. This plate is also highly suited to the use of UV ink and in contrast to former plates is also amenable to baking procedures and post-exposure processing for increased impression life. (Author abstract) In Japanese.

Imai, Masanori (Fuji Photo Film Co, Shizuoka, Jpn); Kita, Nobuyuki. *Fuji Shashin Fuirumu Kenkyu Hokoku* n 33 1988 p 27-31.

**Testing** See MOTION PICTURES—Performance.

**PHOTOGRAPHIC REPRODUCTION** See Also IMAGE PROCESSING—Image Analysis.

**078305 FACTS ABOUT FAX.** In a world where fast communication is often equated with computers, facsimile (FAX) offers speed and simplicity in sending or receiving



communications. FAX can send or receive a page of text or graphics in as little as 11 seconds on a desktop system weighing less than 20 pounds. The article provides brief guidelines for equipment selection.

Anon. *Weld Distrib* v 32 n 1 Jan-Feb 1988 p 65-66.

**078306 USING PIXEL OVERLAP TO OBTAIN MORE GRAY LEVELS IN HALFTONE REPRODUCTIONS.** A new halftoning technique is described that makes use of pixel overlap to attain more gray levels for a given halftone cell size than conventional methods. Although the method has been developed for an ink-jet printing process, it is easily extendible to other processes where the printed spots are larger than the pixel spacing (i.e., thermal transfer, Versatec process, dot-matrix printers, etc.). In such processes, two pixels, for example, may be printed as neighbors so that they overlap, or far apart, so that they do not overlap. A simple model is described for analyzing this method. Selection procedures for determining a base pattern set for an N-level scheme are also discussed, along with some practical considerations. The new method is finally compared with some conventional halftoning techniques. (Edited author abstract)

Torpey, Peter A. (Xerox Corp, Webster, NY, USA). *J Imaging Technol* v 14 n 2 Apr 1988 p 25-28.

## Analysis

**078307 ANALYSIS OF TONE REPRODUCTION CHARACTERISTICS FOR INKJET IMAGES BY A MODIFIED YULE-NIELSEN EQUATION.** In this paper, a modified Yule-Nielsen equation is introduced for analyzing theoretically the tone reproduction characteristics of inkjet images. This equation includes the characteristics of the paper and the dither matrix as parameters. The significance of the proposed equation for three kind of recording papers and dither matrices. (Edited author abstract) 2 refs.

Naing, Win (Chiba Univ, Chiba, Jpn); Miyake, Y.; Abe, N.; Kubo, S. *J Imaging Technol* v 14 n 1 Feb 1988 p 6-11.

**Color** See Also IMAGING TECHNIQUES; PHOTOGRAPHIC FILMS AND PLATES, COLOR.

**078308 CREATIVE COLOR COPYING.** Advanced office copier technology has created a new graphics tool. Medical illustrators at Indiana University tested six top machines, and evaluated them on 10 important characteristics indispensable in the biocommunications studio. The machines evaluated were Canon, Minolta, Mita, Sharp, Toshiba and Xerox. Study results are discussed.

Gosling, Craig; Nixon, John. *Ind Photogr* v 36 n 11 Nov 1987 p B37-B39.

**078309 COMPARISON OF HARD COPY TECHNOLOGIES WITH A STRESS ON HIGHLIGHT REPRODUCTION.** To make a hard copy is to realize an image-wise distribution of image forming material on a support. For any hard copy system there must be an elementary quantity of image forming material below which its control is substantially impossible. We measured such elementary quantities in terms of the minimum controllable area covered by image forming material for three systems, i.e., color reversal film, offset printing and inkjet printing. Since the first one is based on intensity modulation, the density fluctuation at highlight was converted into the equivalent fluctuation of area. The result showed that there is almost two orders of magnitude difference between color film and offset print as well as between offset and inkjet prints. It should be noted that the inkjet system treated is 'Jetgraphy' for large format images. Further, a simple model describing noise in offset printing was proposed. (Author abstract) 10 refs. In Japanese.

Honjo, Satoru (Fuji Photo Film Co, Minami-Ashigara, Jpn); Taguchi, Sei-ichi. *Fuji Shashin Fuirumu Kenkyu Hokoku* n 33 1988 p 77-82.

**078310 ILFORD CIBACOPY SYSTEM 120 PHOTOGRAPHIC COLOR COPIER.** Ilford Photo Corpora-

tion's new Cibacopy System 120 represents an evolutionary advance in automated photographic color copying. The CC-120 is an easy-to-use system designed to produce high quality, low cost color prints and overhead projection transparencies in minimal time directly from positive originals (opaque or transparent) using Cibachrome film or paper in a P-222 process. Options include a device for making copies directly from 35mm slides and an illuminator or light box for making color prints or overhead projection slides from larger format transparencies. The copy system can output up to 120 8½ × 11" prints per hour at an average cost per print of \$.92. Multiple microprocessors and sensors continuously monitor 76 different functions. These and other aspects of the copier are discussed.

Denstman, Hal. *Ind Photogr* v 37 n 5 May 1988 p 47-49.

**078311 PRODUCTION OF COLOUR COMPOSITE IMAGES WITH THE RECTIMAT-C RECTIFIER.** The RECTIMAT-C Precision Rectifier has been available to users for several years. Although it had from the beginning been the design concept of the manufacturer to use the equipment system also for the processing of colour materials, it had not been intended to process multispectral black-and-white film materials for producing color composite images. Practical work with the machine, the high performance of the lenses and the high precision of the moving elements have however shown that under specific boundary conditions the RECTIMAT-C can also be employed for producing colour composite images.

Rulf, Joachim (Menoptik Jena GmbH, Jena, East Ger); Kuhne, Christa; Rank, Helmut. *Jena Rev* v 32 n 4 1987 p 167-169.

## Computer Simulation

**078312 STUDY ON TONE REPRODUCTION OF POSITIVE WORKING PRESENSITIZED PLATE.** The tone reproduction of positive presensitized plates influenced by exposure and developing processes has been examined by computer simulation. With regard to the dot loss of the plate due to exposure, a very good agreement is obtained between experimental and calculated data by considering both the intensity distribution of incident light and the intensity attenuation of reflected light. The tone reproduction is varied by both the concentration of developers and exposure time. But the effect of the former is less than the latter. Good correlation is found also between dot area and narrow lines. Thus by checking the narrow lines, the tone reproduction on the plates can be administered. (Author abstract) 2 refs. In Japanese.

Nishioka, Akira (Fuji Photo Film Co, Shizuoka, Jpn); Yamasue, Kotaro. *Fuji Shashin Fuirumu Kenkyu Hokoku* n 33 1988 p 121-131.

**Electrostatic** See Also IMAGE PROCESSING—Image Analysis.

**078313 HIGH-QUALITY COLOR PRINTING TECHNOLOGY BY ELECTROPHOTOGRAPHY.** This paper attempts to obtain a high-quality color printing with high speed and high stability. First, the effects of the tone levels and resolution on the image quality were examined. To find their best combination, evaluation experiments were carried out by using various values of the tone levels and resolutions. Second, it was confirmed that electrophotography with an elliptical laser beam scanning is superior to that with a conventional circular laser beam scanning in the tone level and stability. Experiments were done on the former with the conditions which satisfy the forementioned values, by employing the submatrix-type dither. (Edited author abstract) 11 refs.

Tanaka, Tomoaki (NTT, Electrical Communications Lab, Yokosuka, Jpn); Hoshino, Yasushi. *Electron Commun Jpn Part 2* v 70 n 9 Sep 1987 p 12-19.

**078314 CONSTRUCTION AND CHARACTERIZATION OF 12-in. LONG TFEL EDGE EMITTER ERASER BAR FOR ELECTROPHOTOGRAPHIC**

**APPLICATIONS.** A 12-in. long, 20 dpi thin film electroluminescent (TFEL) edge emitter bar was constructed. The purpose was to evaluate if it could be used as an eraser bar in electrophotographic printers. The 12-in. long eraser bar was butted together from four 3-in. long modules. The drive electronics were mounted on a PC board. The electrical interconnects were made using elastomeric connectors. Measurements showed that the output and output uniformity meet the potential user's specifications. Printing tests were made to confirm the high output. Type 7773 dry silver paper was exposed at 1 cm/sec. This paper requires 100 ergs/cm² at 580 nm. (Edited author abstract) 5 refs.

Leksell, David (Westhouse Research & Development Cent, Pittsburgh, PA, USA); Kun, Zoltan K.; Phillips, Norman J.; Koch, Karl C. *J Imaging Technol* v 14 n 1 Feb 1988 p 12-15.

## Equipment

**078315 STEREO PLOT, AN ANALOGUE STEREO PLOTTER.** The current trend in photogrammetry towards universal analytical restitution systems has not impaired the great importance of analogue stereoplotting machines for map production. In the next decade analytical and analogue stereoplotters will continue to be the dominating systems in photogrammetric map production, with analytical machines being preferred for special tasks, while analogue plotters will primarily be used for map production. For such tasks analogue plotting machines will be the most economical solution. Distinguishing features are their simple operation, rugged construction, relatively little maintenance work, high adjustment stability, long life and high accuracy.

Starosczyk, Herbert. *Jena Rev* v 32 n 4 1987 p 180-182.

## Laser Applications

**078316 SILVER TOOLS SENT TO WORK.** The advent of raster plotting has opened up a new era. Shops can now store circuitry in digital form instead of as master plots and then plot artwork in about 4 to 6 min. First-generation phototooling offers a big advantage since a shop can avoid a lot of intermediate steps. Every time a fabricator makes a contact print, there is the potential to introduce scratches, dirt or perhaps most important, a size change. The fewer reproductions to be made, the better. Many shops are already using film off a laser plotter as the final tool. Unfortunately, registration problems have not completely disappeared. Larger panel sizes, tighter boards and more layers are putting increasingly stringent demands on the phototool, both for size holding and for durability. The author examines slotted hole systems, humidity problems and the use of silver-gelatin films.

Smith, Kenneth (DuPont, Wilmington, DE, USA); Steinberg, Neil. *Circuits Manuf* v 28 n 7 Jul 1988 p 22-23, 25.

## Magnetic Field Effects

**078317 MODEL FOR A MONO-COMPONENT DEVELOPMENT PROCESS USING EDGE ENHANCEMENT EFFECTS OF FLOATING ELECTRODES.** The contributions of the electrostatic and magnetic fields to the development characteristics of a monocomponent development system are analyzed. This development system uses a special development roller which comprises a development sleeve and a magnet roller rotating at high speed within the development sleeve. The analysis indicates that the magnetic field has a significant effect only on the toner particles, which are charged below a certain level, but the effect of the magnetic field on the toner particles, which are normally charged above a predetermined level, is negligible. The analysis of the magnetic field indicates that the presently used magnet roller, which rotates at high speed, can be replaced by a micropitch magnet roller, which rotates at low speed. The analysis also indicates that if the quality of the electric charge on the toner particles can be controlled, a nonmagnetic toner can also be used in the present development system. 6 refs.



Takeda, Fuchio (Ricoh Co, Tokyo, Jpn); Sakamoto, Koji; Kobayashi, Kazuo. *IEEE Trans Ind Appl* v 24 n 2 1988 p 256-261.

**Materials** See COBALT COMPOUNDS—Processing.

### Quality Control

**078318 WORKING WITH SUPPLIERS TO IMPROVE PRODUCT QUALITY.** A discussion is presented of four key factors in having suppliers aid in achieving corporate product quality goals. These factors are: the supplier improvement process (SIP); the early production supplier improvement process; certification for parts process; and, supplier performance measure process. The tasks that must be completed prior to involving a supplier are also examined. Two classes of part certification were defined: Class A and Class B. Class A Certification was developed in concert with the B Certification process. Class B is a process based on historical data. Suppliers that manage their processes statistically provide the materials having low parts per million nonconformance, the best delivery performance, the lowest lead times, and the most competitive prices. They will provide the highest value. Class A Certification is our preferred method - the process we are asking our suppliers to use today and into the future.

Davis, William W. (Eastman Kodak Co, Rochester, NY, USA). *Chem Eng Prog* v 84 n 4 Apr 1988 p 32-35.

**Xerography** See Also OPTICAL DEVICES—Electric Properties; ORGANIC COMPOUNDS—Synthesis; PIGMENTS—Physical Properties; SEMICONDUCTING SELENIUM COMPOUNDS—Optical Properties.

**078319 ROLE OF PARTICLES AND DISPERSIONS IN ELECTROPHOTOGRAPHY.** The genesis of the electrophotographic industry can be traced to Chester Carlson who demonstrated in 1938 that dry images could be produced by a process involving the attraction of charged pigmented particles to an electrostatic image formed on a photoconducting film. Carlson's invention, a form of electrophotography, is known as xerography. Most electrophotographic processes are based on the deposition of charged particles in either an air or liquid medium. The marking particles are usually pigments dispersed in a polymer matrix. The various electrophotographic processes are dependent on the electrical and mechanical properties of particles and dispersions. (Edited author abstract) 28 refs.

Hays, Dan A. (Xerox Corp, Rochester, NY, USA); Morrison, Ian D.; Smith, Lewis S. *Part Sci Technol* v 5 n 1 1987 p 39-51.

**078320 ELECTRON INJECTION FROM BIS(4-DIMETHYLAMINOPHENYL)SQUARINE INTO (4-BUTOXYCARBONYL-9-FLUORENYLIDENE)MALONONITRILE.** The injection of photo-excited electrons from bis(4-dimethylaminophenyl)squaraine into (4-butoxycarbonyl-9-fluorenylidene)malononitrile was studied by using the xerographic discharge technique. The present study has demonstrated for the first time that electrons can be injected from a squaraine into an electron transport layer. The photo-injected current data, analyzed in terms of Schottky emission model, indicate that the injection barrier height at the squaraine/BCMF interface is 0.24 eV. (Author abstract) 10 refs.

Murti, D.K. (Xerox Research Cent of Canada, Mississauga, Ont, Can); Kazmaier, P.M.; DiPaola-Baranyi, G.; Hsiao, C.K.; Ong, B.S. *J Phys D* v 20 n 12 Dec 1987 p 1606-1608.

**078321 ISSUES IN THE PRAGMATICS OF QUALITATIVE MODELING: LESSONS LEARNED FROM A XEROGRAPHICS PROJECT.** The authors discuss ARIA, a qualitative simulation of xerography that is intended to teach a conceptual understanding of the workings of xerographic copiers that will enable service personnel to understand, remember, and, when necessary, modify and create repair procedures for servicing copiers

effectively. This effort to model xerography exposed shortcomings in the techniques of qualitative modeling as applied to complex systems and helped to better understand the impact of certain basic modeling decisions. (Edited author abstract) 14 refs.

Shrager, Jeff; Jordan, Daniel S.; Moran, Thomas P.; Kiczales, Gregor; Russell, Daniel M. *Commun ACM* v 30 n 12 Dec 1987 p 1036-1047.

**078322 PHOTOGENERATING PROPERTIES OF UNSYMMETRICAL SQUARAINES AND SQUARINE COMPOSITES.** Novel unsymmetrical and composite squaraines have been synthesized and characterized as IR photogenerators. These pigments on dispersal in a binder and coating on a conductive substrate followed by overcoating with a hole transport layer give moderate to excellent near IR photosensitivity. (Author abstract) 7 refs.

Kazmaier, Peter M. (Xerox Research Cent of Canada, Mississauga, Ont, Can); Burt, Richard; DiPaola-Baranyi, Giuseppe; Hsiao, Cheng-Kuo; Loutfy, Rafik O.; Martin, Trevor I.; Hamer, Gordon K.; Bluhm, Terry L.; Taylor, Michael G. *J Imaging Sci* v 32 n 1 Jan-Feb 1988 p 1-4.

**078323 TIME-OF-FLIGHT TRANSIENT SIGNALS OF TWO-LAYER ELECTROPHOTOGRAPHIC PHOTORECEPTORS.** The xerographic time-of-flight technique (XTOF) is applied to SeTe two-layer photoreceptors. The shape of the signal as a function of time is explained in terms of a dispersive charge transport in the generator layer and charge injection and transport in the base layer without dispersion. The charge injection into the base layer is calculated from the XTOF signal. A model based on trapping and release events in the generator layer is developed to describe the charge transport. The model is applied to calculate the charge injection into the transport layer as a function of time. The experimental data obtained from the shape of the XTOF signal is fitted to the model and the energy levels and the trap concentration are determined. The trap concentration as a function of energy follows an exponential law. (Author abstract) 17 refs.

Pinsler, Heinz (AEG AG Warstein, West Ger). *J Imaging Sci* v 32 n 1 Jan-Feb 1988 p 5-11.

**078324 MTF ANALYSIS OF XEROGRAPHIC DEVELOPMENT AND TRANSFER.** Xerographic marking engines are widely used in copiers and printers. To succeed in the marketplace, they must be capable of producing high quality images of black lines on a white background, white lines on a black background, halftones, solid areas, text, kanji, graphics, etc. Therefore, it would be very useful to be able to describe the response of the marking engine to an arbitrary image. This can be done for the optics with an MTF (Modulation Transfer Function) model, which describes the blurring produced by the lens. Photoreceptor response is described by the PIDC (Photo-Induced Discharge Curve) which models the nonlinear relationship between exposure and photoreceptor potential. In these models, spatial frequency response is used to model 'blur', and solid area response is used to model nonlinear effects. In this presentation, these techniques will be applied to the development and transfer subsystems of two xerographic marking engines. (Edited author abstract) 4 refs.

Maltz, M. (Xerox Webster Research Cent, Webster, NY, USA); Szczepanik, J. *J Imaging Sci* v 32 n 1 Jan-Feb 1988 p 11-15.

**078325 CHARGING EFFECTS OF ORGANIC PIGMENTS IN ELECTROPHOTOGRAPHIC TONERS.** The 'electronic printing ink' for electrophotography is called toner and until recently only black copies and prints were available. However, color hard copy is now becoming increasingly attractive and organic pigments can be used to give color to the toner. They do, however, also influence the toner chargeability. The authors have investigated the influence of organic pigments on the electrostatic chargeability of xerographic toners. These charging effects were studied by measuring Q/M-values of test

toners consisting only of toner resin and 5% pigment. By use of this method, a correlation between toner chargeability and the incorporated pigment is apparent. (Edited author abstract) 13 refs.

Macholdt, Hans-Tobias (Hoechst AG, Frankfurt, West Ger); Sieber, Alexander. *Dyes Pigment* v 9 n 2 1988 p 119-127.

**078326 XEROGRAPHIC APPLICATION OF PLASMA-DEPOSITED AMORPHOUS TETRAHEDRAL MATERIALS.** The progress made in establishing the usefulness of a-Si:H as a xerographic photoreceptor will be discussed. The basic xerographic parameters are defined and the results for a-Si:H will be discussed. These basic figures of merit can be established using relatively small planar samples. However, the ultimate test of photoreceptor performance is the demonstration of its ability to make prints within a xerographic machine. To this end, the fabrication of photoreceptor drums is essential, and Section III will deal with the topic of reactor concepts for their production; a discussion of key process variables and results will be given. Section IV deals with the details of print evaluation, which reveals some problems peculiar to a-Si:H. These are a consequence of the unique feature of this material, viz., the ability to move the Fermi level either by doping or electric field. Finally, a discussion of generic applications for which a-Si:H photoreceptors are or could be used will be given. 40 refs.

Mort, Joseph (Xerox Corp, Webster, NY, USA); Janssen, Frank. *Plasma Deposited Thin Films* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 p 187-204.

**078327 ELECTROPHOTOGRAPHIC PROPERTIES OF Se-Te-Sb-HALOGEN ALLOY.** In order to reduce the residual potential of Se-Te alloy, we clarified the effect of antimony and halogens on the electrophotographic properties of Se-Te alloy. It was found that Se-(13 wt%)Te alloy doped with antimony (1 wt%) and chlorine (20 ppm) had sufficiently low residual potential and they had enough surface potential. It was also found that the addition of antimony improved the thermal stability of Se-Te alloy. (Author abstract). 8 Refs.

Onozuka, Arata (Nippon Mining Co, Toda, Jpn); Oda, Osamu. *J Non Cryst Solids* v 103 n 2-3 Jul 1988 p 289-294.

**078328 STUDY OF TONER FUSING FOR ELECTROPHOTOGRAPHY (1ST REPORT, THE ANALYSIS OF UNSTEADY TEMPERATURE DISTRIBUTION DURING FUSING).** In toner fusing techniques for electrophotographic machinery, the basic analysis of fusing phenomenon has been required. In the first place, it is necessary to understand the unsteady temperature field in the toner during fusing. Actually, the temperature variation is nonlinear with property changes according to melting. However, even the linear analysis of the temperature field has not been carried out because of the difficulty of the phenomenon. As the first approach to the analysis, the one-dimensional unsteady temperature distribution assumed to be the linear temperature field is analyzed using finite element method. Heat flux which is supplied to the toner layer, thermal properties of the toner and paper, toner layer thickness, paper thickness and toner coverage are measured. The results of these measurements are used in the boundary condition and properties of FEM calculation. In this way, the temperature distribution during fusing is obtained. (Author abstract). 6 Refs. In Japanese.

Mistsuya, Teruaki; Kumasaka, Takao; Fujiwara, Shigetaka; Nishino, Shinichi. *Nippon Kikai Gakkai Ronbunshu B Hen* v 54 n 502 Jun 1988 p 1476-1481.

**078329 ELECTRICAL PROPERTIES OF CONDUCTIVE TWO-COMPONENT XEROGRAPHIC DEVELOPER.** Xerographic development with a conductive two-component magnetic brush depends on the electrical properties of a developer mixture consisting of insulative toner particles and conductive carrier beads.



The electric field driving toner deposition onto an image receiver is affected by the carrier bead conductivity, toner concentration, magnetic field strength, developer thickness, and developer agitation due to the relative motion between the developer and image receiver. To elucidate the dependence of the electrical properties on these parameters, the measurements on an electroded cell of developer under conditions simulating magnetic brush development systems are described. The measurements provide insight into the solid area and line development process with conductive xerographic developer. 7 refs.

Hays, Dan A. (Xerox Corp, Webster, NY, USA). *IEEE Trans Ind Appl* v IA-23 n 6 1987 p 970-974.

**078330 SIMULATION OF TONER DEPOSITING PROCESS IN XEROGRAPHIC IMAGE STUDIES.** A novel concept of insulative magnetic brush (IMB) development which exhibits excellent reproduction of solid-area images while maintaining IMB line image reproduction capability is discussed. The process is based on a simulation of the profile of the electric field in the development zone, the behavior of toner in the development gap, and the balance of charges in the developer in a two-component magnetic brush development system. 10 refs.

Teshigawara, Toru (Fuji Xerox Co, Kanagawa, Jpn); Tachibana, Hidekiyo; Terao, Kazuo. *IEEE Trans Ind Appl* v 24 n 2 1988 p 232-237.

**078331 XEROGRAPHIC DEVELOPMENT USING SINGLE-COMPONENT NONMAGNETIC TONER.** No magnetic material is necessary for this system. A thin layer of nonmagnetic toner is formed on the surface of a metal roller by means of an elastic plate which is pressed against the roller. The toner particles are charged triboelectrically by friction with the metal plate. The toner layer is attached to the roller by electrostatic force, and is carried around to the photosensitive drum. The latent image is developed with the noncontact development technique. The insulative toner developed for this system has a superior triboelectric characteristic. A model for toner charging is shown. The numerical calculations based on the model agree well with the experimental results. The model suggests that the metal plate controls the toner charge. 6 refs.

Hosoya, Masahiro (Toshiba Corp, Kawasaki, Jpn); Tomura, Shinya; Uehara, Tsutomu. *IEEE Trans Ind Appl* v 24 n 2 1988 p 238-244.

**PHOTOGRAPHY** See Also ACCIDENTS—Photography; ASTRONOMY; BIOMEDICAL ENGINEERING—Diagnosis; FLOW OF FLUIDS—Turbulent; HOLOGRAPHY; IMAGE PROCESSING—Reconstruction; PATTERN RECOGNITION—Medical Applications; PRINTING—Color.

**078332 PARTICLES AND PHOTOGRAPHY.** The technical and commercial developments of photography are outlined. The roles of particles in the black and white and color photographic processes are described in terms of the basic technology of photography. The desired properties of particles in photographic systems are also described. Several illustrations of photographic particles and of particles in photographic systems are presented. An example of the properties of photographic systems that depend on particle properties is also presented. (Author abstract) 3 refs.

Dahneke, Barton (Eastman Kodak Co, Rochester, NY, USA). *Part Sci Technol* v 5 n 1 1987 p 1-12.

**078333 ROTATING APERTURE METHOD OF SPECKLE PHOTOGRAPHY FOR DYNAMIC PROBLEMS I: TWO-APERTURE AND FOUR-APERTURE.** In this paper, a new experimental technique - rotating aperture method of speckle photography for dynamic problem is proposed. The displacement field of any moment of a specimen can be obtained, while simple equipment is needed. Using a rotation device, the whole dynamic process can be recorded on a single specklegram, and then information of every moment can be separated from each other easily by whole-field filtering. This method is applicable not only to vibration

problems, but also to non-periodic dynamic problems. Three experiments have been carried out for demonstration. Speckle fringes are clear and reliable. Quantitative analysis of experiments agree well with the results obtained from other methods. (Author abstract) 6 refs. In Chinese.

Gu, Jie (Suzhou Univ, China); Shen, Yongzhao; Cai, Mingzhi. *Guangxue Xuebao* v 7 n 12 Dec 1987 p 1069-1075.

**078334 POINT-WISE ANALYSIS OF ROTATING APERTURE METHOD FOR SPECKLE PHOTOGRAPHY.** In this paper, we make a point-wise analysis of a specklegram made by the rotating aperture method for speckle photography. The Young's pattern is generally not equally spaced straight fringes, but curved fringes according to the dynamic process of displacements. In this paper, the meaning of the pattern is explained, and theoretical analysis and experimental demonstration are presented. (Author abstract) 4 refs. In Chinese.

Gu, Jie (Suzhou Univ, China); Shen, Yongzhao. *Guangxue Xuebao* v 8 n 2 Feb 1988 p 188-192.

**Applications** See FLOW OF FLUIDS—Visualization; HEAT TRANSFER—Liquids; INTERNAL COMBUSTION ENGINES—Fuel Injection; LIGHT—Speckle; NUCLEAR REACTORS, LIQUID METAL COOLED—Loss of Coolant Accident; SHOCK WAVES—Reflection.

### Computer Applications

**078335 COMPUTERIZED PHOTO FILING.** An overview is given of hardware and software available for putting your image information 'on line'. This first part of a two-part article should help you choose the most qualified equipment, hardware and software, best suited to your needs. Discussion of hardware cannot be inclusive because the topic is so broad. But a succinct mention of the available equipment should familiarize you with industry buzzwords, while providing benchmarks so you can make intelligent choices when you computerize.

McDonnell, Robert J. *Ind Photogr* v 37 n 9 Sep 1988 p 26-27.

**High Speed** See DIESEL ENGINES—Fuel Injection.

### Infrared Radiation

**078336 PRELIMINARY MODEL FOR INFRARED PRESENSITIZATION PHOTOGRAPHY.** Unconventional use is made of a statistical model for the photographic process to explain the mechanism of infrared presensitization photography (IRPP). The model is used to explore the influence of thermal expansion of silver halide grains and their quantum sensitivity. The latter is shown to be the critical parameter. (Author abstract) 7 refs.

Geary, Joseph M. (US Air Force Weapons Lab, Kirtland AFB, NM, USA). *Opt Eng* v 26 n 4 Apr 1987 p 337-341.

**078337 INFRARED SPECKLE PHOTOGRAPHY ON A METAL THERMOPLASTIC CARRIER.** Direct implementation of the speckle photography in the IR region of the spectrum on a metal thermoplastic carrier is performed. Consideration is made of the main advantages of speckle photography in the IR region. The method of recording is described, the basic characteristics of the used devices, elements and media as well as the experimental results on IR radiation at 1.06 and 10.6  $\mu$ m are presented. (Author abstract) 7 refs.

Achasov, O.V. (BSSR Acad of Sciences, Minsk, USSR); Belkin, V.G.; Blinkov, G.N.; Kukharchik, P.L.; Skripko, A.S.; Fomin, N.A. *Opt Commun* v 68 n 3 Oct 1 1988 p 171-174.

**Laser Applications** See Also MATERIALS—Crack Propagation.

**078338 HIGH RESOLUTION 9.5-IN. DRY SILVER/WET FILM LBR FOR TACTICAL APPLICATION.** RCA has developed a High Resolution Laser

Beam Recorder (HRLBR) image generator for tactical operation. This ruggedized film recorder uses 9.5-in. film and is designed for tactical shelters. It contains an in-line processor for dry silver film operation providing non-chemical, almost immediate output usable imagery. It also has a take-up cassette for wet film off-line processing operation. The first application was for 8000 picture elements/scan, but this can be conveniently increased to handle 20,000 picture elements/scan. The image data input is computer compatible with many extra control and computer interface setup characteristics. (Edited author abstract)

Compton, B.L. (RCA, Camden, NJ, USA); Basile, R.J.; Herzog, D.G.; Schweitzer, C.C. *J Imaging Technol* v 13 n 5 Oct 1987 p 179-184.

**078339 MEASUREMENT AND VISUALIZATION OF TWO-DIMENSIONAL VELOCITY DISTRIBUTION BY THE LASER SPECKLE PHOTOGRAPHY USING A He-Ne GAS LASER (1ST REPORT, APPLICATION TO THE FREE CONVECTION FIELD AROUND A VERTICAL PLATE IN AIR AND MEASURING ACCURACY).** The speckle photography technique is one of the most novel velocity measurement methods. This study examines the possibility that this technique will become practically applicable. In this study, this technique is applied to the laminar-free convection field around a uniformly heated vertical plate in air. Moreover, a He-Ne gas laser is employed as the light source in order to enhance the validity of this technique. The measuring results agree with a similar solution within  $\pm 10\%$  at the local velocity  $u(y) = 0.057$  approximately 0.185 m/s. It becomes clear that this technique using a He-Ne gas laser can obtain a whole instantaneous two-dimensional velocity distribution with fair accuracy. (Author abstract) 8 refs. In Japanese.

Narumi, Akira; Hayashi, Takao; Kashiwagi, Takao. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 495 Nov 1987 p 3262-3266.

**078340 INVESTIGATION ON THE ROTATING APERTURE METHODS OF WHITE-LIGHT SPECKLE PHOTOGRAPHY.** Rotating aperture methods of white-light speckle photography used for measuring the dynamic problems are proposed in this paper. In addition to the advantages of rotating aperture methods of laser speckle photography, in particular it can be used for dynamic measurement in the field. (Author abstract) In Chinese. 1 ref.

Chen Bingquan (Suzhou Univ, China); Cheng Chuanfu. *Guangxue Xuebao* v 8 n 3 Mar 1988 p 281-283.

**Materials** See PHOTOGRAPHIC FILMS AND PLATES—Structure.

**Projection Screens** See LOUSPEAKERS—Design.

**Projectors** See Also TELECONFERENCING—Equipment.

**078341 NEW OVERHEAD PROJECTION SYSTEM USING A 400X640 PIXEL ACTIVE-MATRIX LCD.** An overhead projection system consisting of a 400x640 pixel active-matrix LCD with a transparent digitizer has been developed. This system is capable of projecting vivid moving pictures because of the LCD's high contrast ratio and fast response time. The combination of an LCD and digitizer makes manipulation of on-screen images easy and speeds up image searching. (Author abstract) 4 refs.

Takahashi, Yukio (NTT, Jpn); Nomura, Tomoyoshi; Kohda, Shigeto; Kawada, Tadamiichi. *Rev Electr Commun Lab (Tokyo)* v 36 n 4 1988 p 411-418.

**Schlieren System** See Also COMBUSTION—Fluid Dynamics; DIESEL FUELS—Measurements; FLOW OF FLUIDS—Cylinders; FLOW OF FLUIDS—Visualization; FLOW OF FLUIDS—Vortex Flow.



**078342 SCHLIEN TECHNIQUE APPLIED TO INVESTIGATE THE COMBUSTION PROCESSES IN A DI DIESEL ENGINE.** The paper reports the schlieren technique applied in investigating combustion processes in a DI diesel engine. The design of the schlieren system and the high speed photo-graph control system are described. The paper analyses effects of the air swirl intensity on the injection fuel and the flame propagation in the cylinder with the aid of photographs. The conclusion is that the schlieren technique is an important method for investigating the combustion processes in I-C engines. (Author abstract) 4 refs. In Chinese.

Ye, Feng (Tianjin Univ, China). *Guangxue Xuebao* v 7 n 12 Dec 1987 p 1094-1098.

**Special Effects** See Also LANDSLIDES—Monitoring; LENSES—Design.

**078343 MOVING IMAGE.** Although still photography cannot achieve the sense of movement created by cine and video formats, a variety of tools and techniques enables the photographer to suggest motion in a still photograph. This article shows how simple movements of subject and camera, combined with multiple flash and tungsten lighting, can produce images possessing the illusion of motion. Included are three examples to illustrate a different approach to the subject.

Schwartz, Sing-Si. *Ind Photogr* v 37 n 5 May 1988 p 33-35.

**PHOTOGRAPHY, COLOR** See Also PHOTOGRAPHIC FILMS AND PLATES, COLOR.

**078344 SILVER SALTS AND STANDING WAVES: THE HISTORY OF INTERFERENCE COLOR PHOTOGRAPHY.** Gabriel Lippmann's interference color photography is totally disused today, but his ideas and technique were to prove essential for holography. Here we describe first the aborted Newtonian attempts at explaining substantial colors through interference effects analogous to those actually at work in Lippmann's plates. Second, we show how the standing-waves concept passed from acoustics to optics. Third, we follow across the 19th century what now appears to be now a sideline in the development of color photography; the discoveries of Seebeck, Herschel and Becquerel. While these are no longer of any practical importance, their little known story is more complex and perhaps more instructive than that of three-color photography. (Edited author abstract) 83 refs.

Connes, P. (CNRS, Verrieres-le-Buisson, Fr). *J Opt* v 18 n 4 Jul-Aug 1987 p 147-165.

**078345 COLOR GAMUT OBTAINABLE BY THE COMBINATION OF SUBTRACTIVE COLOR DYES.** The optimum absorption bands  $D_{opt}(\lambda)$  of subtractive color dyes (cyan, magenta, and yellow) have been determined in color transparencies, by use of a nonlinear optimization technique, at four luminous transmittance levels of  $Y_g = 10, 20, 40$ , and  $80$ . The constraint to the maximum density  $D_{max}$  is imposed in the optimization. The results show that the  $D_{opt}(\lambda)$  cannot be uniquely determined but can be determined as a function of two factors  $Y_g$  and  $D_{max}$ . (Author abstract) 9 refs.

Ohta, Noboru (Fuji Photo Film Co, Minami-Ashigara, Jpn). *Fuji Shashin Fuirumu Kenkyu Hokoku* n 33 1988 p 73-76.

**Laser Applications** See PHOTOGRAPHIC REPRODUCTION—Electrostatic.

**Processing** See PHOTOGRAMMETRY—Cameras; PHOTOGRAPHIC REPRODUCTION—Color.

**PHOTOGRAPHY, HIGH SPEED** See Also ELECTRON TUBES, IMAGE INTENSIFIER—Applications.

**078346 REDUCTION OF TEMPERATURE RISE IN HIGH-SPEED PHOTOGRAPHY.** This report provides information to professional industrial, scientific, and

technical photographers on filtration with glass and infrared-absorbing and reflecting filters. Glass and infrared filtration is a simple and effective method to reduce the radiation heat transfer associated with continuous high-intensity tungsten lamps. The results of a filtration experiment conducted at the NASA Lewis Research Center are explained. The figures provide starting points for quantifying the effectiveness of various filters and associated light intensities. The combination of a spectrally selective reflector (hot or cold mirror) based on multilayer thin-film principles and heat-absorbing or infrared opaque glass results in the maximum reduction in temperature rise with a minimum of incident light loss. (Edited author abstract) 2 refs.

Slater, Howard A. (NASA, Cleveland, OH, USA). *NASA Tech Memo* 100222 1987 15p.

**078347 AMOUNT OF INFORMATION OF HIGH-SPEED PHOTOGRAPHY SYSTEM.** Based on the theory of optical information, the expression of the amount of information for high-speed photography system is obtained. It shows that the amount of information depends on the object, parameters of the system and its working condition. (Author abstract) In Chinese. 12 refs.

Tao Chuncan (East China Inst of Technology, Nanjing, China). *Guangxue Xuebao* v 8 n 3 Mar 1988 p 242-248.

**Applications** See ELECTRIC ARCS, CIRCUIT BREAKING—Photography; FLOW OF SOLIDS—Granular Materials; LASER BEAMS—Measurements.

**Components** See ELECTROOPTICAL DEVICES—Mathematical Models.

**Computer Applications**

**078348 APPLICATION OF LI-7024 SUPERKRENNIKON FOR HIGH-SPEED COMPUTER PHOTOGRAPHY.** The results of an investigation of the operation of an LI-207-4 superkrennikon in the single recording mode, storage of the optical image, and subsequent reading of information are described. 2 refs.

Alekseev, M.B. (All-Union Electrical Engineering Inst, Moscow, USSR); Artemov, V.P.; Zheleznova, M.A. *Instrum Exp Tech* v 30 n 3 pt 2 May-Jun 1987 p 734-735.

**Industrial Applications**

**078349 HIGH-SPEED CHASE.** Whether the investigation as being conducted to improve a process or to determine why it went wrong, high-speed cinematography provides a dynamic look at the action. Process and product design, materials research, and even litigation can often be aided by using this medium, which has capabilities not shared by videotaping of high-speed still photography. Sometimes the best way to catch problems in a machine or process is to film it at its normal running speed and then slow down the moving image for analysis.

Anon. *Mech Eng* v 110 n 3 Mar 1988 p 60-62.

**Synchronization** See RADIOGRAPHY—X-Ray.

**PHOTOLUMINESCENCE** See Also ALUMINA—Thin Films; BARIUM COMPOUNDS—Optical Properties; CADMIUM AND ALLOYS—Impurities; CALCIUM COMPOUNDS—Defects; CALCIUM COMPOUNDS—Radiation Effects; CALCIUM COMPOUNDS—Spectroscopic Analysis; CARBON—Spectroscopic Analysis; CATALYSTS—Spectroscopic Analysis; CHROMIUM AND ALLOYS—Spectroscopic Analysis; CRYSTALS—Impurities; EUROPIUM—Spectroscopic Analysis; GALLIUM AND ALLOYS—Spectroscopic Analysis; GLASS—Optical Properties; GLASS—Spectroscopic Analysis; IRON AND ALLOYS—Spectroscopic Analysis; LEAD TELLURIUM ALLOYS—Thin Films; MAGNESIUM COMPOUNDS—Optical Properties; MAGNESIUM COMPOUNDS—Spectroscopic Analysis; MAGNETIC SEMICONDUCTORS; MAGNETIC SEMICONDUCTORS—Optical Properties; MANGANESE AND ALLOYS—Spectroscopic Analysis; MOLECULAR CRYSTALS—Spectroscopic Analysis; NEON—Spectroscopic Analysis; ORGANIC COMPOUNDS—Spectroscopic Analysis; PHOSPHORS—Optical Properties; POLYMERS—Spectroscopic Analysis; POTASSIUM COMPOUNDS—Electric Field Effects; RARE EARTH COMPOUNDS—Structure; SEMICONDUCTING ALUMINUM COMPOUNDS—Spectroscopic Analysis; SEMICONDUCTING ALUMI-

NUM COMPOUNDS—Vapor Deposition; SEMICONDUCTING BISMUTH COMPOUNDS—Spectroscopic Analysis; SEMICONDUCTING CADMIUM COMPOUNDS—Analysis; SEMICONDUCTING CADMIUM COMPOUNDS—Growth; SEMICONDUCTING CADMIUM COMPOUNDS—Impurities; SEMICONDUCTING CADMIUM COMPOUNDS—Ion Implantation; SEMICONDUCTING CADMIUM COMPOUNDS—Optical Properties; SEMICONDUCTING CADMIUM COMPOUNDS—Pressure Effects; SEMICONDUCTING CADMIUM COMPOUNDS—Spectroscopic Analysis; SEMICONDUCTING CADMIUM COMPOUNDS—Thin Films; SEMICONDUCTING FILMS—Doping; SEMICONDUCTING GALLIUM ARSENIDE; SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers; SEMICONDUCTING GALLIUM ARSENIDE—Chemical Vapor Deposition; SEMICONDUCTING GALLIUM ARSENIDE—Defects; SEMICONDUCTING GALLIUM ARSENIDE—Doping; SEMICONDUCTING GALLIUM ARSENIDE—Growth; SEMICONDUCTING GALLIUM ARSENIDE—Optical Properties; SEMICONDUCTING GALLIUM ARSENIDE—Physical Properties; SEMICONDUCTING GALLIUM ARSENIDE—Plasmas; SEMICONDUCTING GALLIUM ARSENIDE—Purification; SEMICONDUCTING GALLIUM ARSENIDE—Radiation Effects; SEMICONDUCTING GALLIUM ARSENIDE—Spectroscopic Analysis; SEMICONDUCTING GALLIUM ARSENIDE—Thin Films; SEMICONDUCTING GALLIUM COMPOUNDS—Chemical Vapor Deposition; SEMICONDUCTING GALLIUM COMPOUNDS—Growth; SEMICONDUCTING GALLIUM COMPOUNDS—Impurities; SEMICONDUCTING GALLIUM COMPOUNDS—Ion Implantation; SEMICONDUCTING GALLIUM COMPOUNDS—Optical Properties; SEMICONDUCTING GALLIUM COMPOUNDS—Order-Disorder; SEMICONDUCTING GALLIUM COMPOUNDS—Physical Properties; SEMICONDUCTING GALLIUM COMPOUNDS—Spectroscopic Analysis; SEMICONDUCTING GERMANIUM—Impurities; SEMICONDUCTING GLASS—Optical Properties; SEMICONDUCTING GLASS—Structure; SEMICONDUCTING INDIUM COMPOUNDS—Electronic Properties; SEMICONDUCTING INDIUM COMPOUNDS—Growth; SEMICONDUCTING INDIUM COMPOUNDS—Optical Properties; SEMICONDUCTING INDIUM COMPOUNDS—Spectroscopic Analysis; SEMICONDUCTING INDIUM COMPOUNDS—Substrates; SEMICONDUCTING POLYMERS—Optical Properties; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Defects; SEMICONDUCTING SILICON—Doping; SEMICONDUCTING SILICON—Electric Field Effects; SEMICONDUCTING SILICON—Optical Properties; SEMICONDUCTING SILICON—Spectroscopic Analysis; SEMICONDUCTING SILICON—Thin Films; SEMICONDUCTING SILICON COMPOUNDS—Amorphous; SEMICONDUCTING SILICON COMPOUNDS—Defects; SEMICONDUCTING ZINC COMPOUNDS—Chemical Vapor Deposition; SEMICONDUCTING ZINC COMPOUNDS—Electronic Properties; SEMICONDUCTING ZINC COMPOUNDS—Growth; SEMICONDUCTING ZINC COMPOUNDS—Optical Properties; SEMICONDUCTING ZINC COMPOUNDS—Spectroscopic Analysis; SEMICONDUCTING ZINC COMPOUNDS—Vapor Deposition; SEMICONDUCTOR DEVICE MANUFACTURE; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES—Semiconductor Insulator Boundaries; SEMICONDUCTOR MATERIALS—Charge Carriers; SEMICONDUCTOR MATERIALS—Defects; SEMICONDUCTOR MATERIALS—Optical Properties; SEMICONDUCTOR MATERIALS—Physical Properties; SILICON CARBIDE; SILICON CARBIDE—Chemical Vapor Deposition; SILICON CARBIDE—Spectroscopic Analysis; SILVER COMPOUNDS—Doping; TERBIUM—Spectroscopic Analysis; ZEOLITES; ZINC COMPOUNDS—Optical Properties; ZINC SULFIDE—Chemical Vapor Deposition; ZINC SULFIDE—Crystallization; ZINC SULFIDE—Spectroscopic Analysis.

**078350 EFFECT OF PRESSURE ON TRIVALENT CHROMIUM PHOTOLUMINESCENCE IN FLUORIDE GARNET  $\text{Na}_3\text{In}_2\text{Li}_3\text{F}_{12}$ .** This compound shows at one atmosphere only fluorescence from the  $^4\text{T}_2$  band, the pressure leading to a blue shift of  $14.8 \text{ cm}^{-1}/\text{kbar}$ . A new emission attributed to  $^2\text{E}$  level and its phonon satellites appears at 40 kbar and gains intensity with compression up to 125 kbar. The increase in the exponential lifetime of the  $^4\text{T}_2$  emission from  $310 \mu\text{s}$  at 1 atm. to  $580 \mu\text{s}$  at 125 kbar reflects the low crystal field-high crystal field transition. (Author abstract) 12 refs.

de Vry, D. (CNRS, Fr); Denis, J.P.; Tercier, N.; Blanzat, B. *Solid State Commun* v 63 n 12 Sep 1987 p 1183-1188.

**078351 NEAR BAND EDGE PHOTOLUMINESCENCE IN  $\text{Sb}_2\text{S}_3$ .** Photoluminescence spectra in  $\text{Sb}_2\text{S}_3$  have been investigated for the first time. The photoluminescence composed of many peaks is observed near the indirect fundamental gap at 2 K. From the study of sample, excitation intensity and temperature dependences of photoluminescence and the time decay spectra, it is shown that the photoluminescence is caused by three



different origins. Models of the origins are proposed. It is also shown that the photoluminescence spectra are very sensitive to the deviation from stoichiometry. (Author abstract) 15 refs.

Fujita, T. (Hiroshima Univ, Higashi-Hiroshima, Jpn); Kurita, K.; Takiyama, K.; Oda, T. *J Lumin* v 39 n 4 Mar 1988 p 175-180.

**078352 FOTOLUMINESCENCIA WARSTW EPI-TAKSJALNYCH GaAs OTRZYMYWANYCH METODQ VPE (WODORKOWQ).** [Photoluminescence of Epitaxial Layer GaAs Obtained by Hydride Method VPE]. The Vapor-Phase Epitaxy (hydride type) method of GaAs epitaxial layers preparation method is introduced that is used in the production of microwave devices. The photoluminescent properties of the layers are examined and the results are presented. 12 refs. In Polish.

Bugajski, Maciej (Inst Technologii Elektronowej, Warsaw, Pol); Lewandowski, Wojciech; Panek, Marek; Ratuszek, Marek; Tlaczala, Marek. *Elektronika* v 28 n 9 1987 p 13-15.

**078353 NEW ASPECTS OF THE SOLVENT MODE IN THE PHOTOINDUCED ELECTRON TRANSFER IN POLAR SOLUTION.** Assuming that the vibrational frequency of possibly coordinated solvent molecules around the charged reactant becomes considerably larger than that around the neutral reactant, we have derived formulas for the electron transfer rate as a function of the energy gap which differ greatly among the three kinds of electron transfer reactions; photoinduced charge separation, charge recombination and charge shift reactions. Those theoretical predictions are in good agreement with the experimental data so far available. By performing the Monte Carlo simulation study, it is confirmed that a considerable dielectric saturation of the coordinated solvent exists around the molecular ion and a substantial difference of the potential curvature is realized for the coordinated solvent mode around the charged molecule from that around the neutral molecule. (Author abstract) 4 refs.

Kakitani, Toshiaki (Nagoya Univ, Nagoya, Jpn). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 43-46.

**078354 NEW TYPE OF CONFIGURATION DEFECT IN PLASTICALLY STRAINED CdS CRYSTALS.** Measurements have been made on the polarization and time characteristics of spatially resolved photoluminescence in plastically strained CdS crystals. Cooperative defect behavior and other luminescence features can be explained from a model for configuration defects produced by dislocation motion. (Author abstract) 10 refs.

Osip'yan, Yu. A.; Negrii, V. D.; Bul'enkov, N. A. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 1-5.

## Analysis

**078355 EXTRINSIC PHOTOLUMINESCENCE IN COUPLED-WELL SUPERLATTICES.** Extrinsic luminescence involving residual donor and acceptor impurities in a nominally undoped, coupled-well 80 Angstroms GaAs/20 Angstroms  $Al_{0.3}Ga_{0.7}As$  superlattice grown by organometallic chemical vapor deposition has been investigated. Separate peaks are observed in the luminescence lineshape corresponding to acceptors in the barriers and in the wells, with ionization energies of about 13.5 and 31.9 meV, respectively. The relative amplitudes of the peaks indicate that most of the acceptors are located in the AlGaAs barriers. Varying the temperature from 1.7 to 31 K and the excitation intensity from 0.28 to 1400 mW cm<sup>-2</sup> reveals both donor-to-acceptor and miniband-to-acceptor recombination involving each type of acceptor. (Author abstract) 21 refs.

Skromme, B.J. (Bell Communications Research, Red Bank, NJ, USA); Bhat, R.; Koza, M.A. *Solid State Commun* v 66 n 5 May 1988 p 543-547.

**Applications** See SEMICONDUCTING SILICON COMPOUNDS—Crystalline.

## Degradation

**078356 STUDIES ON THE DEGRADATION OF PHOTOLUMINESCENCE OF SOME PHOSPHORS.** The degradation of photoluminescent phosphors has been studied by using XPS, EPR, IR and optical reflectance spectra analytical methods. The structure changes on the surface of phosphors are discussed. (Author abstract) 2 refs.

Lu, Ling (Fudan Univ, Shanghai, China); Xu, Yan. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 173-174.

**Inorganic Solids** See SEMICONDUCTING INDIUM COMPOUNDS—Ion Implantation.

**Low Temperature Properties** See SEMICONDUCTING SILICON—Electronic Properties.

**Measurements** See Also CADMIUM COMPOUND—S—Optical Properties; LUMINESCENCE—Measurements; MANGANESE COMPOUNDS—Phase Transitions; PHOSPHORS—Optical Properties; SEMICONDUCTING CADMIUM COMPOUNDS—Impurities; SEMICONDUCTING CADMIUM COMPOUNDS—Surfaces; SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers; SEMICONDUCTING GALLIUM ARSENIDE—Defects; SEMICONDUCTING GALLIUM ARSENIDE—Doping; SEMICONDUCTING GALLIUM ARSENIDE—Measurements; SEMICONDUCTING GALLIUM COMPOUNDS—Optical Properties; SEMICONDUCTING INDIUM COMPOUNDS; SEMICONDUCTING SILICON—Amorphous.

**078357 INFLUENCE OF LOCAL ENVIRONMENT ON LUMINESCENCE OF EXCITON BOUND TO BI-TRAP IN GaP: <Bi, N>.** An observation of increase in the value of Huang-Rhys factor and energy shift and broadening of emission lines due to excitons bound to Bi traps is reported for the first time. The experimental results have been interpreted in terms of the influence of the local environment around Bi center on binding energy and lattice relaxation during radiative transitions. (Author abstract) 4 refs.

Jiang Bing-xi (Xiamen Univ, Xiamen, China); Zhang Dong; Lin Xiu-hua. *Solid State Commun* v 66 n 5 May 1988 p 513-515.

**Solids** See SILICON NITRIDE—Amorphous; SOLIDS—Amorphous.

**Spectrum Analysis** See SEMICONDUCTING SILICON—Spectrum Analysis; SEMICONDUCTOR MATERIALS—Spectrum Analysis.

## Theory

**078358 INITIAL PHOTOLUMINESCENCE DECAY RATES IN AMORPHOUS PHOSPHORUS.** Previous measurements of the photoluminescence of amorphous phosphorus have not been able to distinguish between two models of the time-dependent shift of the emission energy of the early radiative recombination. This may arise from recombination of carriers trapped at charged defects or from thermalization of a carrier in a tail of localized states. The present work extends the time resolution of the luminescence measurement to approximately 50 ps which enables a distinction to be made between the two models. The initial decay rates for luminescence in the photon energy ranges 1.45 - 1.6 and 1.45 - 1.85 eV are the same to within approximately 1% at 4 K, which supports the assignment of the recombination to carriers trapped at oppositely charged intrinsic defects. The temperature dependence of the initial decay follows the empirical law  $v(T) = v_1 + v_0 \exp(T/T_0)$  with  $v_1 = 8.6 \times 10^8 \text{ s}^{-1}$ ,  $v_0 = 3.7 \times 10^8 \text{ s}^{-1}$  and  $T_0 = 104 \text{ K}$ . A temperature-dependent branching between two radiative channels is proposed in order to reconcile these observations with earlier work. (Author abstract) 10 refs.

Phillips, R.T. (Univ of Exeter, Exeter, Engl); Sobiesierski, Z.; Toner, W.T.; Barr, J.R.M.; Langley, A.J. *Solid State*

*Commun* v 63 n 6 Aug 1987 p 481-484.

**Thermal Effects** See SEMICONDUCTING CADMIUM COMPOUNDS—Photoconductivity; SEMICONDUCTING ZINC COMPOUNDS—Spectroscopic Analysis.

**Transients** See SEMICONDUCTING ALUMINUM COMPOUNDS—Optical Properties; SEMICONDUCTING GALLIUM ARSENIDE—Optical Properties.

**PHOTOMETERS** See Also COAL—Petrography; ULTRAVIOLET RADIATION—Spectrum Analysis.

**078359 DIGITAL VIDEO LIGHTMETER TESTS DISPLAYS.** Evaluating the luminance and radiance values of illuminated avionic displays typically involves the use of spot photometers. To test luminance uniformity, three 'spots' are read on each character of the displays. A new technology offers an alternative to spot photometer testing. The Korr digital video lightmeter (DVL) utilizes digital video techniques to produce a color-coded representation of any portion of an illuminated surface - from individual characters to an entire legend. The system consists of four main components: a solid-state CCD camera and lens, a photopic correction filter, a dedicated microcomputer with special image processing circuitry and hardware, and a color monitor.

Nelson, E. (Korry Electronics); Green, J.R. *New Electron* v 20 n 12 Jun 9 1987 p 52.

**078360 REDUKCJA BLEDU METODY POMIARU STRUMIENIA SWIETLNEGO W LUMENOMIERZU, PRZEZ ZMIANE WARUNKOW OBIEGU STRUMIENIA SWIETLNEGO WEWNATrz KULI FOTOMETRYCZNEJ.** [Error Reduction of Measurement Method of Luminous Flux in an Integrating Sphere by Changing Circulation Conditions of Luminous Flux Inside Photometric Sphere]. The technique of covering surface of a photometric sphere with a coating of varying reflectivity coefficient is proposed. This coating diminishes a systematic error of luminous flux measurement caused by the lack of geometric similarity of the light distribution in sources of the measuring set. The reduction of the effective reflectivity due to this coating will also reduce systematic errors connected with dissimilarity of spectral distributions of radiation as well as with share of the arrangement sources in reflection and absorption of the luminous flux. (Edited author abstract) In Polish. 16 refs.

Gorczevska, Malgorzata (Politechnika Poznanska, Pol); Golik, Wladyslaw. *Arch Elektrotech (Warsaw)* v 35 n 1 1986 p 265-275.

**078361 FILTER PENETRATION MEASUREMENTS USING A CONDENSATION NUCLEI COUNTER AND AN AEROSOL PHOTOMETER.** We conducted both theoretical and experimental comparisons of two instruments, a condensation nuclei counter and an aerosol light-scattering photometer, to determine how they measured the penetration of high-efficiency particulate air (HEPA) filters. In some experiments we simulated leaks around the test filter to ascertain how such leaks affect the two instruments' penetration measurements. Results of all of the experiments indicate that differences in the measurements vary widely from no difference to a factor of 10. These variations are related to certain functions that depend on particle size: the response function of the photometer, the filter penetration, and the distribution of the test aerosol. (Edited author abstract). 18 refs.

Biermann, A.H. (Lawrence Livermore Natl Lab, Livermore, CA, USA); Bergman, W. *J Aerosol Sci* v 19 n 4 Aug 1988 p 471-483.

## Calibration

**078362 METHOD OF DETERMINING PHOTOMETER CALIBRATION CHARACTERISTICS.** A computational experiment was performed with  $u = \log(1 + 100\tau)$  as the test function, which showed that with  $\tau_0 = 0.5$ , five multiplicative tests provided an approximation with an accuracy better than 0.2% for a dynamic range of two orders. The author shows the approximation for  $u =$



log  $(1 + 100\tau)$ , as a polynomial of degree  $n$  obtained in multiplicative tests:  $n = 3$  (a),  $n = 4$  (b), and  $n = 5$  (c). Here 1 and 2 are different sets of filters with unknown transmissions. The experiment shows that one can provide an error in the calibration curve within 1.0% by calibrating the  $\tau_0$  filter with an accuracy better than 0.05% if the instrumental error is  $\delta\tau_0 \leq 0.01\%$ . This method does not involve any essential difficulties, so it can be widely used in calibrating commercial photometers. 5 refs.

Kudryavtsev, V.V.; Smirnov, A.V.; Chadeeva, M.V. *Meas Tech* v 29 n 9 Sep 1986 p 835-837.

**078363 DEVICES FOR CHECKING PHOTOMETRIC ANALYZERS.** Spectrophotometric analytical instruments are evaluated by a collection of characteristics following GOST 8.009-84, expressed in units of the concentration of the material being determined. Instruments of this type are calibrated and checked using standard samples of the materials or certified solutions whose composition is known. In order to calibrate and check photometric scales, attenuators made of neutral glass of the NS type for the visible region of the spectrum and quartz attenuators with vacuum deposition of metallic coatings for UV, visible, and near-IR regions of the spectrum (190-2500 nm) are most widely used. The main factors determining the use of glass and quartz attenuators are their good spectral and photometric characteristics. 2 refs.

Karabegov, M.A.; Kostanyan, G.A.; Tsitsushvili, M.Sh. *Meas Tech* v 30 n 5 May 1987 p 431-433.

**078364 NBS MEASUREMENT SERVICES: PHOTOMETRIC CALIBRATIONS.** The National Bureau of Standards supplies calibrated standards of luminous intensity, luminous flux, and color temperature on a routine basis. The procedures, equipment, and techniques used to perform these calibrations as of July 1986 are described. Detailed estimates and procedures for determining uncertainties of the reported values are also presented. (Author abstract) 28 refs.

Booker, Robert L. (NBS, Gaithersburg, MD, USA); McSparron, Donald A. *Natl Bur Stand Spec Publ* n 250-15 Oct 1987 83p.

**Design** See Also SPECTROSCOPY—Equipment.

**078365 DEVELOPMENT AND PERFORMANCE OF AN AUTOMATED MOVING ARM GONIOPHOTOMETER FOR MEASURING THE SPATIAL DISTRIBUTION OF LIGHT OF LUMINAIRES.** An automatic photometer for measuring the spatial distribution of light of luminaires has been designed and built in INTI in Buenos Aires, Argentina. An arm 7.5 m long, on the end of which the photoelectric detector is fixed, moves in a vertical plane. A maximum angle of elevation of  $130^\circ$  can be obtained. The luminaire rotates almost a full circle in the horizontal plane. The system is controlled by a desk computer. A brief description of its performance and some construction details are given. (Author abstract) 8 refs.

Cazabat, C.R. (INTI, San Martin, Argent); Lozano, R.D.; Yasan, E.D. *CIE J* v 5 n 2 Dec 1986 p 31-39.

**Efficiency** See ATMOSPHERIC OPTICS—Measurements.

**Errors**

**078366 UNDERCOMPENSATION ERROR OF TWO-CHANNEL ABSORPTION PHOTOMETERS.** Absorption photometers (AP) are an important part of a large group of analytic instruments for studying the composition and properties of liquid media. Among the AP there is a subgroup of instruments which are used for measuring the optical density of the medium under study and whose output signal is a linear function of the measured parameter. The article presents a theoretical evaluation of the errors of AP schemes with sequential conversion owing to the characteristic noise of the circuits and the instability of their parameters. The operation of the AP is based on the dependence of the magnitude of the

radiation flux passing through the medium under study on the absorption of the medium. 5 refs.

Galustov, I.G.; Sultanov, E.G. *Meas Tech* v 30 n 5 May 1987 p 428-430.

**PHOTOMETRY** See Also ATMOSPHERIC OPTICS—Visibility; ELECTRON TUBES, PHOTOMULTIPLIER—Distortion; LIGHT SOURCES—Measurements; UNITS OF MEASUREMENT; VISION, COLOR.

**078367 IMPORTANCE OF SPECTRAL MATCH IN PHOTOMETRY.** Light sources which we meet in daily life have different power spectral distribution. To achieve accuracy in photometric measurements with these sources, the spectral match should follow the curve for photopic vision, the  $V(\lambda)$  function. The consequence of spectral deviation is shown and the new CIE method of error definition compared to the US and Japanese definitions is discussed. (Author abstract) 10 refs.

Nielsen, Ole. *Light Des Appl* v 17 n 1 Jan 1987 p 38-42.

**078368 INTERNATIONAL INTERCOMPARISONS OF PHOTOMETRIC BASE UNITS.** In order to evaluate the worldwide consistency of practical implementations of the 1979 redefinition of the candela, the Consultative Committee for Photometry and Radiometry (CCPR) has conducted an international intercomparison of photometric base units. The intercomparison showed 0.8% agreement (one standard deviation) of independent luminous-intensity scale realizations by 15 national laboratories, and 0.6% agreement of luminous-flux scale realizations by 11 laboratories. The NBS candela and lumen agreed with the world mean within quoted uncertainty limits, and were shown to be consistent with one another within 0.5%. (Author abstract)

Mielenz, Klaus D. (NBS, Gaithersburg, MD, USA). *J Res Natl Bur Stand (US)* v 92 n 5 Sep-Oct 1987 p 335-337.

**Applications** See COAL—Petrography; COPPER COMPOUNDS—Analysis; NUCLEAR FUELS—Mixed Oxides.

**Reliability** See PHOTOMETERS—Calibration.

**Research**

**078369 ALTERNATIVE SUBDIVISION FOR THE SKY VAULT.** An alternative to Tregenza's recent scanning pattern for sky photometry is presented and discussed. Tregenza has described an ingenious method of packing the surface of a hemisphere with a large number of identical circular caps in such a way as to cover, in parallel bands, without overlap, the largest possible proportion of the hemisphere surface. The resulting array of circular caps defines a pattern of aiming points, and the (constant) acceptance angle, for a photometer programmed to sample the directional luminance of the sky vault. This note reports a packing study for the same application, but the requirement for identical caps is relaxed; caps at different altitudes may have different diameters. 3 refs.

Lynes, J.A. (Humbly Grove Coll of Higher Education, Hull, Engl). *Light Res Technol* v 20 n 1 1988 p 33-37.

**Sensors** See BOLOMETERS—Calibration; PHOTOMETERS—Errors.

**Standards** See PHOTOMETERS—Calibration.

**PHOTONS** See Also ACCELERATORS, SYNCHROTRON—Beam Dynamics; ACCELERATORS, SYNCHROTRON—Magnets; ACCELERATORS, SYNCHROTRON—Storage Rings; BERYLLIUM AND ALLOYS—Ion Implantation; CESIUM COMPOUNDS—Spectroscopic Analysis; CODES, SYMBOLIC—Error Correction; COPPER COMPOUNDS—Spectroscopic Analysis; DATA STORAGE, OPTICAL—Performance; ELECTRIC SPARK GAPS—Performance; ELECTRON TUBES, PHOTOMULTIPLIER—Performance; FLUORESCENCE; FLUORESCENCE—Spectrum Analysis; INORGANIC COMPOUNDS—Spectroscopic Analysis; LASER BEAMS—Effects; LASERS; LEAD COMPOUNDS—Radioactivity; LIGHT—Coherent; PARTICLE DETECTORS—Mathematical Models; PARTICLE DETECTORS—Performance; PHOTODETECTORS—Noise, Spurious Signal; PHYSICS—High Energy; PHYSICS—Nuclear; PLASMAS—

Etching; RADIATION DETECTORS; SCINTILLATION COUNTERS; SEMICONDUCTING GALLIUM ARSENIDE—Optical Properties; SEMICONDUCTOR DEVICES—Junctions; ZINC SULFIDE—Spectroscopic Analysis.

**078370 DETERMINATION OF THE DOSE EQUIVALENT DISTRIBUTION IN THE ICRU SPHERE FOR PHOTON RADIATION.** For practical radiation protection purposes with regard to photon irradiation, different types of dose equivalent quantities within the ICRU sphere phantom are summarized and the corresponding fluence-to-dose equivalent conversion factors stated for photon radiation. The quantities considered are the dose equivalent index, the dose equivalent at specified depth, special mean values, and a geometry factor which might be of interest in multidirectional irradiation fields. Details are given for the calculation determination of dose equivalent distributions within the ICRU sphere using the Monte Carlo method and for the experimental determination of dose equivalent quantities by means of TL-dosimeters and ionization chambers in the photon energy range between 10 keV and 10 MeV. (Edited author abstract) 31 refs.

Grosswendt, B.; Hohlfield, K.; Selbach, H.-J. *PTB Mitt* v 97 n 4 Aug 1987 p 270-282.

**Absorption** See Also DYES AND DYEING—Spectrum Analysis; ELECTRONS—Absorption; HYDROGEN—Radiation Effects; SEMICONDUCTOR MATERIALS—Research; SEMICONDUCTOR MATERIALS—Spectrum Analysis; SOLIDS—Spectrum Analysis.

**078371 SATURATION OF TWO-PHOTON ABSORPTION IN STRAIGHT-BAND SEMICONDUCTORS.** Within the framework of the Klein model, two-photon absorption in straight-band semiconductors of type GaAs is theoretically investigated. The limiting cases of fast ( $\tau_p \gg T_v$ ) and slow ( $\tau_p \ll T_v$ ) intraband relaxation are considered; here  $\tau_p$  is the duration of the light pulse;  $T_v$  is the time of intraband relaxation. It is shown that dynamic variation in the saturation difference is the basic mechanism of saturation of two-photon absorption of a straight-band semiconductor by picosecond pulses, up to the intensities of the order of 600 MW/cm<sup>2</sup>. (Author abstract) 5 refs.

Dubenskaya, M.G.; Il'ina, T.M.; Pavel'ev, A.B. *Moscow Univ Phys Bull* v 42 n 5 1987 p 75-80.

**Analysis**

**078372 SELECTION OF REFERENCE PULSE IN ANALYSIS OF RANDOMLY OVERLAPPING PHOTON FLUXES.** Methods are examined for reference-pulse selection in analysis of two genetically related random pulse flows that are typical of radioluminescence. The methods are compared according to the results of computer modeling. (Author abstract) 3 refs.

Denisenko, V.N. (Scientific Research Inst of Applied Physics Problems, Minsk, USSR); Ivanov, M.A.; Prokopovich, I.P. *Instrum Exp Tech* v 30 n 2 pt 1 Mar-Apr 1987 p 325-327.

**Dissociation** See IONS—Structure.

**Emission** See Also BIOCHEMISTRY; TANTALUM AND ALLOYS—Radiation Effects.

**078373 COOPERATIVE EMISSION OF PHOTONS BY WEAKLY COUPLED CHROMIUM IONS IN YAG AND LaAlO<sub>3</sub>.** In YAG: Cr<sup>3+</sup> and LaAlO<sub>3</sub>: Cr<sup>3+</sup> we have found cooperative emissions of one photon by two excited Cr<sup>3+</sup> ions analogous to those recently observed by us in Al<sub>2</sub>O<sub>3</sub>: Cr<sup>3+</sup>. The vibronic sideband of this fluorescence confirms our earlier identification of the phonons involved with the polar longitudinal optical modes of the host lattice. Fluorescence decay measurements again indicate radiationless decay processes of the doubly excited pair states leading to non-equilibrium R<sub>2</sub> emission. A fluorescence <sup>2</sup>A<sub>1</sub> → <sup>4</sup>A<sub>2</sub> of chromium ions in YAG has been detected for the first time. (Author abstract) 30 refs.

Wannemacher, R. (Technische Hochschule Darmstadt,



West Ger); Heber, J. *J Lumin* v 39 n 1 Nov 1987 p 49-56.

**078374 NEUTRON-INDUCED PHOTON PRODUCTION CROSS SECTIONS.** A procedure for the determination of neutron-induced production cross sections is described, including corrections for the neutron-induced photon background and the unfolding of the gamma-ray spectra. As an example, data have been obtained for tantalum and beryllium with five bismuth germanate detectors and the high-energy white neutron source at the Los Alamos Meson Physics Facility. Calculations and measurements indicate that a beryllium sample may be used to simulate a neutron-induced photon background. Results for the  $Ta(n,\gamma)$  reaction for neutron energies below  $E_n=20$  Mev are compared with previous measurements at the Oak Ridge Electron Linear Accelerator. (Author abstract) 17 refs.

Ramakrishnan, P. (North Carolina State Univ, Raleigh, NC, USA); Mitchell, G.E.; Gould, C.R.; Wender, S.A.; Auchampaugh, G.F.; Little, R.C. *Nucl Sci Eng* v 98 n 4 Apr 1988 p 357-364.

**078375 RADIATIVE PROCESSES IN HIGH-ENERGY ION-ATOM COLLISIONS.** Instantaneous photon emission in ion-atom collisions is considered from the standpoint of theoretical consistency. The processes discussed include electron bremsstrahlung, radiative electron capture, and atomic bremsstrahlung. Particularly detailed discussion is made on radiative electron capture. Formulas based on nonrelativistic quantum mechanics and on semiclassical theory are found to conflict with each other. This inconsistency is removed by taking the gauge-invariance requirement into consideration on the matrix elements of the interaction of the particle system with the radiation field. Finally, we present an approximation method that satisfies the gauge-invariance requirement. In addition, we show the results of calculations for radiative electron capture by  $Xe^{34+30}$  and by  $U^{92+30}$  from Be as examples and compare them with experiments as well as calculations based on existing theories. (Author abstract) 17 refs.

Watanabe, Tsutomu (Inst of Physical & Chemical Research, Wako, Jpn); Hino, Ken-ichi. *Nucl Instrum Methods Phys Res Sect A* v A262 n 1 Dec 1 1987, Phys of High Charged Ions Prod in Heavy Ion Collisions, Proc of the Second US/Jpn Semin, Kobe, Jpn, Mar 16-20 1987 p 29-32.

**Mathematical Models** See Also ATOMS—Electromagnetic Field Effects.

**078376 THEORY OF TWO-PHOTON TRANSITIONS IN IONIZED ATOMS.** The probabilities for radiative two-photon transitions between discrete states of hydrogen-like atoms with arbitrary nuclear charge  $Z$  are investigated within the framework of the relativistic theory. As an example the two-photon transition  $2s_{1/2}-1s_{5/2}$  is calculated. The theoretical results are compared with the experimental measurements for the ions  $He^+$ ,  $O^{7+}$ ,  $F^{8+}$ ,  $Si^{13+}$ ,  $Ar^{17+}$ . 13 refs.

Lavrinenko, S.I.; Pal'chikov, V.G. *J Appl Spectrosc* v 46 n 2 Feb 1987 p 120-124.

**078377 LIGHT ABSORPTION BY A COLLISIONAL SYSTEM.** Perturbation theory is applied to the interaction between a binary collisional system and a weak radiation field to obtain the rate of induced absorption or the line profile of an optically allowed transition at low density. The collisional system wave functions are not affected by the radiation field and appropriate different expansions of these functions must be used for the two electron-atom or atom-atom systems under study. Unified expressions of the profile are given which converges to the impact limit at small detunings. The semi-classical approach of the collisional problem is given to underlie the correspondence with the usual autocorrelation formalism. Both approaches break down for large detunings where a quantum collisional theory must be used. (Author abstract) 47 refs.

Van Regemorter, H. (Observatoire de Paris, Meudon, Fr).

*J Phys (Paris)* v 48 n 8 Aug 1987 p 1299-1309.

**078378 EXPERIMENTAL DETERMINATION OF THE 2s-4d TWO-PHOTON TRANSITION PROBABILITY IN LITHIUM.** We report another possibility which makes use of the saturation characteristic of a two-photon excitation. The species used as lithium, the transition selected 2s-4d. 10 refs.

Schunke, B. (Ruhr Univ, Bochum, West Ger); Kunze, H.-J. *Opt Commun* v 64 n 5 Dec 1 1987 p 481-484.

**078379 COLLECTIVE SPONTANEOUS EMISSION FROM A SYSTEM OF TWO ATOMS WITH MULTIPHOTON TRANSITIONS IN A CAVITY.** Characteristics of the collective spontaneous emission of a system consisting of two two-level multiphoton-transition atoms excited in a lossless resonant cavity are calculated. The photon-multiplicity collective behavior is found to affect the photon dynamics and statistics considerably. (Author abstract) 31 refs.

Shumovsky, A.S. (Joint Inst for Nuclear Research, Moscow, USSR); Le Kien, Fam; Aliskenderov, E.I. *J Phys (Paris)* v 48 n 11 Nov 1987 p 1933-1937.

**Measurements** See Also CALORIMETERS—Design; LIGHT—Scattering; PARTICLE DETECTORS; PHOTODETECTORS; PHOTODETECTORS—Noise, Spurious Signal; RADIATION DETECTORS; SCINTILLATION COUNTERS; SOLAR RADIATION—Analysis.

**078380 DETECTION OF HARD PHOTONS WITH  $BaF_2$  SCINTILLATORS.** Large  $BaF_2$  crystals have been used for hard photon detection. The response to  $\gamma$ -rays with energies up to 130 MeV has been measured by means of tagged photons. Experimental line shapes and resolution are compared to simulations with the Monte Carlo shower code GEANT3. (Author abstract) 19 refs.

Novotny, R. (Univ Giessen Giessen, West Ger); Riess, R.; Hingmann, R.; Strocher, H.; Fischer, R.D.; Koch, G.; Kuehn, W.; Metag, V.; Muehlhans, R.; Kneissl, U.; Wilke, W.; Haas, B.; Vivien, J.P.; Beck, R.; Schoch, B.; Schutz, Y. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 340-346.

**078381 PHOTON COUNTING METHOD FOR MEASURING THE CURRENT FRACTION IN  $D_2^+$ - $He^+$  MIXED ION SPUTTERING.** A photon counting method has been developed for measuring the current fraction in a  $D_2^+$ - $He^+$  mixed ion beam. Photons produced by feeding Ar-gas into the beam course are counted through 486 nm- and 389 nm-filters, and the current fraction is instantaneously derived from processing the photon yields with a microcomputer. The sputtering yields of Ta and W obtained by the incidence of pure and mixed ion beams at an energy of 25 keV are demonstrated. (Author abstract) 8 refs.

Akatsuka, Hiroshi (Kyoto Univ, Kyoto, Jpn); Takami, Makito; Hirabayashi, Naoto; Sakisaka, Masakatsu; Tomita, Michio. *Nucl Instrum Methods Phys Res Sect B* v B30 n 2 Mar 1988 p 207-210.

**078382 PHOTON COUNTING BY AVALANCHE PHOTODIODES.** The characteristics of FD-115L (B) avalanche photodiodes in the photon-count mode are studied. A photon counter employing an avalanche photodiode is developed that can record luminous fluxes of  $10^{-16}$ - $10^{-11}$  W in the wavelength range of 0.4-1.1  $\mu$ m. (Author abstract) 8 refs.

Gulakov, I.R. (Belorussian State Univ, Minsk, USSR); Shuneyev, S.A. *Instrum Exp Tech* v 30 n 4 pt 2 Jul-Aug 1987 p 959-961.

**Research** See SPACE RESEARCH—Australia.

**Scattering** See Also NONDESTRUCTIVE EXAMINATION—Density Measurement; SOLIDS—Order-Disorder.

**078383 STRUCTURAL FUNCTION OF A COUPLED SYSTEM OF PARTICLES.** It is shown that the structural function  $F_2$  is determined by the single-particle

characteristics of a system and the photon scattering amplitude in the coupled particle. It was shown earlier that both the Fermi movement and the coherence of nucleons play a role in the EMC effect. Certain basic issues of such an approach are presented. (Edited author abstract) 3 refs.

Vagrado, G.M. *Sov Phys Lebedev Inst Rep* n 4 1987 p 12-16.

**078384 MEASUREMENT OF DOUBLE-PHOTON COMPTON SCATTERING CROSS-SECTIONS OF 662 keV GAMMA RAYS.** The cross-section for double-photon Compton scattering for incident photons of energy 662 keV and two emitted photons having energies  $\geq 100$  keV has been measured at different scattering angles  $\theta_1=30^\circ$  to  $150^\circ$  and  $\theta_2=\phi_2=\pi/2$ . The experimental results are compared with the theory of Mandl and Skyrme. Some calculations are also carried out to understand the important features of the phenomenon. (Author abstract) 13 refs.

Sekhon, G.S. (Punjabi Univ, Patiala, India); Sandhu, B.S.; Ghuman, B.S. *Physica B & C* v 150 n 3 Jun 1988 p 473-476.

## Sensors

**078385 ULTIMATE PARAMETERS OF MIDDLE AND LONG WAVELENGTH INFRARED DETECTORS (Cd, Hg)Te BASED ON THE DEMBER EFFECT.** Intense research being conducted in many research centres with a view to making use of various physical phenomena to construct (Cd,Hg)Te detectors of medium and far infrared. However, the theoretical and experimental research is concentrated chiefly on the construction of photoresistors, photodiodes and PEM detectors. As regards the theoretical analysis of such detectors, the influence of Dember effects is usually disregarded. The present authors make an attempt, for both cognitive and practical reasons, to appraise the properties of (Cd,Hg)Te Dember detectors, by comparing the Dember effect with photoelectromagnetic effect. 9 refs.

Niedziela, T.; Piotrowski, J. *J Tech Phys* v 28 n 2 1987 p 173-183.

## Sources

**078386 CALIBRATION OF LARGE AREA SOURCES USING A GAMMA-RAY SPECTROMETER.** A method has been developed for calibrating large-area, photon-emitting sources in terms of activity. The method has been used to assay sources of  $^{51}Cr$  in connection with a recent survey of surface-contamination monitoring in the UK. The results obtained for the detection efficiency were compared to values predicted by a semi-empirical model of the detector. 5 refs.

Judge, S.M. (NPL, Teddington, Engl); Mercer, R.A.; Smith, D.; Sparrow, S.J. *Appl Radiat Isot* v 38 n 10 1987, Tech in Radionuclide Metrol, Proc of an ICRM Semin, Rome, Italy, Jun 15-16 1987 p 865-868.

**078387 ON DEVISING A PULSED SYNCHROTRON RADIATION SOURCE FOR LABORATORY APPLICATIONS.** Along with large-sized synchrotron radiation (SR) sources, which are rather expensive and require special rooms, small-sized table-top devices are of considerable interest. The devising of a laboratory pulsed synchrotron radiation source with an electron orbit radius of 6 cm is reported. The unit can be applied in spectroscopy investigations from the IR to UV regions of the spectrum. 6 refs.

Kuznetsov, A.S.; Bahmann, H.-R.; Haamer, A.; Piilma, M.; Pill, K.; Sidorin, K.K.; Tammik, A.-A.; Tiit, V.; Vilt, E. *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 58-59.



**Spectrum Analysis** See Also **ELECTRONS—Spectrum Analysis**; **GAMMA RAYS—Propagation**; **PHOTONS—Spectrum Analysis**.

**078388 METHOD OF QUANTITATIVE MEASUREMENTS OF ONE- AND TWO-PHOTON ABSORPTION SPECTRA OBTAINED BY INTRACAVITY LASER SPECTROSCOPY.** The use of the complete absorption method, modified for intracavity spectra is proposed. The proposed method of determination of the absorption coefficient and the integrated sections by measuring the complete absorption in spectra obtained by the method of intracavity laser spectroscopy makes it possible to perform quantitative measurements with high accuracy, even if the width of the absorption lines is smaller than the width of the apparatus function of the spectral instrument. 9 refs.

Baev, V.M.; Gamalii, V.F.; Sviridenkov, E.A.; Toptygin, D.D.; Yushchuk, O.I. *J Appl Spectrosc* v 46 n 4 Apr 1987 p 360-364.

**078389 POLARISATION-DEPENDENT INTERFERENCE OF TWO-PHOTON ABSORPTION IN A BROAD-BAND LASER.** The technique of broad-band laser intra-cavity absorption spectroscopy was amended by the injection of light pulses into the absorber, for recording of Na 3S-5S two-photon absorption spectra. The contributions of the P fine structure levels to the two-photon amplitude interfere constructively or destructively depending on tuning and polarization of the pulsed light: The transition probability vanishes completely at a particular tuning between the D lines only for parallel polarisation of the lasers. 11 refs.

Baev, Valery M. (Univ Hamburg, Hamburg, West Ger); Boller, Klaus-J.; Toschek, Peter E. *Opt Commun* v 66 n 4 May 1 1988 p 225-230.

## Theory

**078390 EXTENSION OF EINSTEIN'S TREATMENT OF SPONTANEOUS EMISSION.** Einstein's balance argument in which the concept of spontaneous emission was first introduced is used to demonstrate that spontaneous emission is a classical phenomenon and is not a consequence of zero point quanta as is widely believed. The average rates of photoinduced excitation and emission are also computed classically. (Edited author abstract) 5 refs.

Rose, Albert (Exxon Lab, Clinton, NJ, USA). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 389-400.

**Transport Properties** See **GAMMA RAYS—Scattering**.

**PHOTORESISTS** See Also **DYES AND DYEING—Thin Films**; **INTEGRATED CIRCUIT MANUFACTURE—Materials**; **LITHOGRAPHY—LITHOGRAPHY—Performance**; **LITHOGRAPHY—Photolithography**; **LITHOGRAPHY—Simulation**; **ORGANIC COMPOUNDS—Thin Films**; **POLYMERS—Photosensitivity**.

**078391 POLYMER MATERIALS FOR MICROLITHOGRAPHY - ELECTRON BEAM RESISTS.** Polymers play a critical role in both the fabrication of masks and the patterns required for micro circuit construction. In an earlier article, the chemistry of photo resists was extensively reviewed. Currently, photo resists are capable of being used in the fabrication of circuits with dimensions down to one micron and it is possible that through modification of conventional materials and the use of shorter wavelength sources that this technology will be extended down to sub-micron dimensions. The next generation of very large scale integrated circuits (VLSI) will require the production of patterns with structures having dimensions as small as 0.4 microns. To generate these patterns it is necessary to produce highly perfect masks and this is best achieved by use of electron beam lithography. (Author abstract) 47 refs.

Pethrick, Richard A. (Univ of Strathclyde, Glasgow, Scotl). *Progr Rubber Plast Technol* v 3 n 2 1987 p 11-22.

**078392 ELECTRON BEAM RESISTS-NEGATIVE RESISTS BASED ON POLY(ALKYL METHACRYLATE).** This communication described the influence of changes in the pendant group structure on the electron beam sensitivity of a series of poly(alkyl methacrylate). It was found that the sensitivity changes markedly with the length of the pendant alkyl chain and is also a function of its stereochemistry. (Author abstract) 7 refs.

Hayward, David (Univ of Strathclyde, Glasgow, Scotl); Bakhshae, Massoud; Affrossman, Stanley; Pethrick, Richard A. *Polym Commun (Guildford Engl)* v 28 n 11 Nov 1987 p 315-317.

**078393 ORGANOSILICON DEEP UV POSITIVE RESIST CONSISTING OF POLY(P-DISILANYLENEPHENYLENE).** A new class of positive deep ultraviolet (UV) resists consisting of poly(p-disilanylene)phenylene)s was developed, in which a disilanylene unit and a phenylene unit are connected alternatively in the polymer main chain. These resists had very high etching resistance against oxygen plasma. The lithographic applications of a double-layer resist system in which the poly(p-disilanylene)phenylene film was used as the top imaging layer were examined. As a result, very high resolution and high contrast were attained. The double-layer resist technique using organosilicon deep UV positive resist appears very promising for lithographic applications. (Author abstract) 8 refs.

Nate, Kazuo (Hitachi Ltd, Yokohama, Jpn); Inoue, Takashi; Sugiyama, Hisashi; Ishikawa, Mitsuo. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2445-2455.

**078394 TAPERED RESIST WALL PROFILES BY FLOOD EXPOSURE.** A resist wall profile tapering procedure is proposed for positive resist systems that are normally designed to produce near vertical profiles. A flood exposure step has been added, but no change in the softbake, develop, or postbake procedure is required. At the same contact hole dimension, different ratios of flood to pattern exposure dose produce different slopes for the resist profiles. The unexposed resist film thickness loss can be used to monitor the resist tapering results. SAMPLE resist exposure and development simulations are done to analyze the effects of substrate reflectivity, thickness variations, and postexposure bakes on the resist wall profile at various flood exposure dose fractions. (Author abstract) 15 refs.

White, L.K. (David Sarnoff Research Cent, Princeton, NJ, USA); Meyerhofer, D. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3125-3129.

**078395 SILOXANE POLYMERS AS SENSITIVE ELECTRON RESISTS.** Future generations of integrated circuits will require a higher density of devices on a single chip in order to be commercially viable and consequently individual devices will need to be smaller. The limits of conventional (optical) lithography are such that increasing use of other forms of pattern generation, e.g., electron or X-ray lithography, will be required. The newer forms of lithography require improved resists in order to obtain reliable pattern dimension below 1  $\mu$ m. 2 refs.

Whipps, P.W.; Stearn, G.M. *Annu Rev Philips Res Lab* 1986 p 41-43.

**078396 NEGATIVE, DEEP-UV RESIST FOR 248 NM LITHOGRAPHY.** The negative tone deep ultraviolet resist described in this paper is based on a novolak resin. The chemistry of this negative resist is based on an acid-hardening resin system. A novolak resin combined with an acid activatable cross-linker and a photoacid generator (PAG) comprise the resist. Exposure to high energy photons (below 320 nm) converts some PAG to acidic species. These acids catalyze the formation of several covalent bonds between the novolak and the substituted melamine cross-linker. A postexposure bake accelerates the cross-linking reaction. High contrast is obtained because the appropriate exposure dose and postbake process render the resist nearly insoluble in the developer. Thus, the high ratio of the unexposed to exposed dissolution rates of the resist provides high

contrast, high resolution resist images.

O'Toole, Michael M. (Hewlett-Packard Co, Palo Alto, CA, USA); deGrandpre, Mark P.; Feely, Wayne E. *J Electrochem Soc* v 135 n 4 Apr 1988 p 1026-1027.

**078397 OPTIMIERUNG DER CHEMISCHEN ZUSAMMENSETZUNG FUER GaAs-PROZESSE: POSITIV-FOTORESIST FUER DEN EINSATZ IM MITTLEREN UV-BEREICH.** [Optimization of the Chemical Combination for GaAs Processes: Positive Photoresists for the Application in the Middle UV Region]. Use of the middle UV spectral region (from 365 to 312 nm) brought about improvements and optimization in the photolithography of chip production, which are possible only with photoresists, the spectral sensitivity of which lies within this region. New positive photoresist combinations have been developed in order to meet these demands. As a result, the photoresists Dynalith X 1608 and X 1605 were developed which are described. 20 refs. In German.

Lazarus, R.M.; Dixit, S.S. *Elektron Prod Prueftech* n 11 Nov 1987 p 17-18, 21-23.

**078398 CALORIMETRIC CHARACTERIZATION OF PHOTSENSITIVE MATERIALS.** A negative-acting dry-film photoresist was examined via both photocalorimetry and conventional calorimetry. The photo reaction of the resist was investigated as a function of temperature, and two distinct regimes with different activation energies have been identified. Possible reaction mechanisms were discussed in terms of termination reactions of the polymerization as well as effects of vitrification. The thermal reactivity of this particular resist was studied as well. It was possible to use Kissinger's equations to predict thermal aging effects. Finally, the utility of photocalorimetry as a tool to examine quickly the reactivity of monomers and initiation systems was demonstrated. (Author abstract) 16 refs.

Appelt, B.K. (IBM, Endicott, NY, USA); Abadie, M.J.M. *Polym Eng Sci* v 28 n 6 Mar 1988 p 367-371.

**078399 FTIR AND UV/VIS STUDY OF THE INTERFACE BETWEEN PMMA AND DYED POLYIMIDE THIN FILMS.** A modified bilayer resist scheme was studied that used a poly(methyl methacrylate) (PMMA) as the bottom, deep ultraviolet (DUV) resist, a novolak-based system as the top near ultraviolet (NUV) resist, and an intervening antireflective coating (ARC). The ARC consisted of a polyimide film formed by the thermal curing of a solution of polyamide acid, dyes, and solvents that was applied to the PMMA layer by spin-coating. An interfacial layer was found to form at the PMMA/ARC interface that remained after the NUV resist and ARC were striped prior to the UV exposure step. Fourier transform infrared (FTIR) and ultraviolet/visible (UV/VIS) spectrophotometries were used to characterize the extent of formation of the interfacial layers as a function of the ARC curing process. (Edited author abstract) 14 Refs.

Cox, J.N. (Intel Corp, Santa Clara, CA, USA); /bozarth, J.L.; Ting, C.H.; Carruthers, J.R. *J Electrochem Soc* v 135 n 8 Aug 1988 p 2070-2076.

**078400 RESIST OVERVIEW.** This paper gives a general overview of the important parameters and trends in the evolution of positive optical resists as they still form the workhorse in advanced lithographic applications. We discuss the basic lithographic requirements for the application of resist systems in semiconductor fabrication. From that starting point we show how process control and sophistication on the one hand and materials improvements on the other have made the important increase



in performance of these resist systems possible. Finally the future of positive resists is related to the new challenges of sub-0.7  $\mu\text{m}$  lithography. (Author abstract) 9 refs.

Coopmans, Fedor (IMEC vzw, Leuven, Belg). *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microlithogr, Jouay-en-Josas, Fr, Sep 22-25 1987 p 369-380.

**078401 RESIST IMAGE ENHANCEMENT BY UV-, SOFT VACUUM PULSED ELECTRON BEAMS AND ORGANOMETALLIC COMPOUNDS.** UV-hardening/photostabilization process is used for preventing thermal flow of resist images at high temperatures. Because of high temperature stability and highly cross-linked nature of resist surfaces, UV-hardening is used for resist enhancement for reactive ion etchings of metals, high temperature sputtering, lift-off and others. We present here multilayer resist applications using highly crosslinked resist surfaces. Because of large deep UV absorption coefficients, application of UV-hardening to thick films is limited. For thick resist films, resist stabilization by pulsed electron beams operating in soft vacuum is far more efficient because of deeper penetration of electron beams of 25 KeV energy. The present technique has an advantage over a conventional CW electron source with a larger diameter, cold cathode of an ordinary metal operating in a soft vacuum with high efficiency. Exposures of resist images to organometallic compounds either in vapor phase or in solutions provide them specific RIE resistances and thermal flow resistance. (Author abstract) 13 refs.

Hiraoka, Hiroyuki (IBM, San Jose, CA, USA). *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microlithogr, Jouay-en-Josas, Fr, Sep 22-25 1987 p 407-412.

**078402 WET AND DRY DEVELOPABLE PHOTOSENSITIVE DEEP UV RESIST.** The PMMA-bisazide resist, containing a deep UV sensitizer (3,3'-diazodiphenyl sulfone) was found to reverse PMMA from positive tone to negative tone, and the sensitivity of this resist was enhanced by a factor of 40 compared to normally used positive tone PMMA. The optimum bisazide concentration was determined to be 25 wt% (based on PMMA weight) to give the highest sensitization and best lithographic results (capable of submicron resolution). This resist was also found to be dry developable by oxygen plasma and the resolution can go down to 1-2  $\mu\text{m}$  lines/spaces although the remaining thickness after development is around 20-30%. 7 refs.

Han, C.C. (Rensselaer Polytechnic Inst, Troy, NY, USA); Corbelli, J.C. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microlithogr, Jouay-en-Josas, Fr, Sep 22-25 1987 p 413-419.

**078403 A- AND B-PARAMETER DEPENDENT SUBMICRON STEPPER PERFORMANCE OF POSITIVE TYPE PHOTORESIST.** A systematical investigation of the g-line stepper performance of positive type photoresists with varying absorption properties has been carried out on highly reflective substrates. Numerous parameters such as photospeed, pattern profile, focus and exposure energy latitude are evaluated by SEM inspection of submicron resist lines after exposure with a stepper of NA=0.42. It is shown that the amount of non-bleachable absorption (B-value) alters only slowly the imaging properties of the resists on aluminum surfaces, whereas changes in the bleachable absorption (expressed by the A-value) lead to large differences in the resist profiles and the tolerance of the lithographic process. Profile simulations with PROSIM and PROLITH indicate that the development characteristics rather than the optical properties determine the performance of the resists. (Author abstract) 12 refs.

Muenzel, H. (Merck, Darmstadt, West Ger); Schulz, R.; Lux, T. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microlithogr, Jouay-en-Josas, Fr, Sep 22-25 1987 p 421-426.

**078404 PHOTORESIST SPIN COATING MECHA-**

**NISM RELATED TO POLYMER SOLUTION RHEOLOGY.** This study examines the influence of the macromolecular characteristics on the PMMA spin coating both experimentally and from a phenomenological point of view. It is concluded that the weight average molecular weight of the spun on solution is a pertinent parameter, and that chain entanglements in polymer solutions may be considered as the basic phenomenon responsible for the formation of the solid polymer layer. (Author abstract) 17 refs.

Weill, Andre (CNET, Meylan, Fr); Dechenaux, Elisabeth; Francou, Jean Marc. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microlithogr, Jouay-en-Josas, Fr, Sep 22-25 1987 p 427-431.

## Absorption

**078405 DISPELLING THE MYTHS ABOUT DYED PHOTORESIST.** When light passes through a thin photoresist film coated on a reflecting substrate, a standing wave is produced within the film which can significantly degrade fine line photoresist patterns. Absorption parameters are measured for dyed resists. The effects of absorption on standing waves are determined rigorously and linewidth control is investigated. Finally, the drawbacks of dyed resists are discussed. (Edited author abstract) 28 refs.

Mack, Chris A. (US Dep of Defense, Fort Meade, MD, USA). *Solid State Technol* v 31 n 1 Jan 1988 p 125-130.

## Additives

**078406 CONTRAST ENHANCING ADDITIVES FOR POSITIVE PHOTORESIST.** Adding catalytic amounts of acidic organic compounds, such as phenols and carboxylic acids, to positive photoresists induced the formation of surface skin, leading to increased photoresist wall angles and higher resolution. When the additives were dyes and added at levels which absorbed significantly, at the actinic wavelengths, linewidth variability over topology was reduced without a reduction in the wall angles of the patterned features. For example, dyed resist matched to the g-line stepper gave less than 0.1  $\mu\text{m}$  linewidth variability over reflective tantalum disilicide islands compared to 0.24  $\mu\text{m}$  (1) for undyed resist. The wall angles for both resists were 85°, and the dyed resist required an exposure dose only two times greater. A partial mechanism was suggested for the formation of the surface skin during softbake. (Author abstract) 19 refs.

Pampalona, T.R. (RCA/GE Microelectronics Cent, Somerville, NJ, USA); Kuyan, F.A. *J Electrochem Soc* v 135 n 2 Feb 1988 p 471-476.

**Applications** See Also LITHOGRAPHY—Photolithography; SUPERCONDUCTING DEVICES—Josephson Junctions.

**078407 APPLICATION OF HEAVILY DYED PHOTORESIST TO WAFER PRODUCTION.** This article describes the use of heavily dyed photoresist in patterning wafers in production. The dyed resist is made by adding the commercially available 1-(2-pyridylazo)-2-naphthol dye to AZ 1350J-SF photoresist, which is then exposed using g-line steppers and spray-developed with metal-ion-free developer. The resultant images have greater than 80° wall angles and excellent linewidth control over reflective topography. The resist is characterized with respect to linewidth control over large islands, and wafer-to-wafer and across-the-wafer uniformity. (author abstract) 13 refs.

Pampalona, T.R. (RCA/GE Microelectronics Cent, Somerville, NJ, USA); Massa, R.R. *J Electrochem Soc* v 135 n 2 Feb 1988 p 477-481.

**078408 PHOTOPOLYMERS IN NEWSPAPER PRINTING: A NOVEL APPLICATION OF PHOTORESIST TECHNOLOGY.** By making it feasible to put a large number of identical copies on the market at any given time, Gutenberg set into motion technological advances that make possible the production of an ever

increasing number of copies while reducing the time needed for their issue. Printing is a technical process; as such, it responds to the same technological changes that fuel other industrial advances. The use of radiation curing technology has made possible developments in printing plates that rival the mechanical developments of the printing presses themselves. Photopolymer technology has made newspaper production faster, safer and of the highest quality ever achieved. 3 refs.

Wagner, William R. (Napp Systems (USA) Inc). *Radiat Curing* v 14 n 4 Nov 1987 p 2-7.

**078409 ORGANOSILICON PHOTORESIST FOR USE IN EXCIMER LASER LITHOGRAPHY.** An investigation of an organosilicon resist for use in deep UV excimer laser lithography was performed. The resist is based on the poly(vinylphenol) resin, and was found to exhibit transparency at 248 nm comparable to the transparency of g-line light in conventional novolak resists, making single-layer resist processing possible. The results of single-layer patterning on an excimer laser contact printer are presented. Results are also presented for a bilayer resist process using oxygen RIE etch for transfer of the top layer pattern into a thick underlying novolak layer. (Author abstract) 5 refs.

Orvek, Kevin J. (Texas Instruments Inc, Dallas, TX, USA); Cunningham, Wells C. Jr.; McFarland, Janet CP. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microlithogr, Jouay-en-Josas, Fr, Sep 22-25 1987 p 393-398.

## Computer Simulation

**078410 SIMULATION OF POST-EXPOSURE BAKE EFFECTS ON PHOTOLITHOGRAPHIC PERFORMANCE OF A RESIST FILM.** Developed relief images in positive photoresist subjected to various levels of post-exposure bake are modelled and simulated using the computer simulation program SPESA. The bake process is represented by simple diffusion of the photoactive compound distribution that forms the latent image before development by a solvent. Quantitative performance criteria such as thickness contrast, sidewall angle, exposure dose requirement, develop time latitude, nodality sensitivity, and exposure latitude are extracted from the simulated resist profiles. When these criteria are examined as functions of the phenomenological diffusion length that parametrizes the post-exposure bake model, we observe a well-defined optimal diffusion length that precedes the threshold for standing wave removal in the relief image, and for which an order tenfold enhancement in develop and exposure latitudes is predicted. The dose requirement also tends to be reduced. Thus post-exposure bake appears to improve the photolithographic process within the context of the simple diffusion model. Refinements relating to the model are discussed. (Edited author abstract) 20 refs.

Bernard, D.A. (Signetics Corp, Sunnyvale, CA, USA). *Philips J Res* v 42 n 5-6 1987 p 566-582.

## Diffusion

**078411 DIFFUSION IN AZ-5214 IMAGE REVERSAL PROCESS AND ITS APPLICATION TO E-BEAM PROXIMITY EFFECT CORRECTION.** Here we report our discovery of the diffusion phenomenon of AZ5214 resist during a post-exposure bake process step and its application to improve the electron beam lithographic performance of the resist. The diffusion phenomena are that the exposed features gain an extra amount of material from their immediate neighborhoods and become thick at the pattern edge and wider in feature size. In general, variations in pattern dimensions are unfavorable for process control. However, in this case, the changes in the exposed geometry are just opposite to those caused by the electron beam proximity effect. Therefore, by carefully controlling the parameters of the post-exposure bake, excellent proximity effect corrections have been obtained. (Edited author abstract) 10 refs.

Liu, Hua-yu (Hewlett Packard Co, Palo Alto, CA, USA);



Liu, E.D. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microli-thogr, Jouy-en-Josas, Fr, Sep 22-25 1987 p 439-446.

## Dissolution

**078412 SOLVENT PENETRATION AND PHOTO-RESIST DISSOLUTION: A FLUORESCENCE QUENCHING AND INTERFEROMETRY STUDY.** A novel method, based upon fluorescence quenching measurements, is described for the study of the mechanistic details of solvent penetration into thin polymer films. Here poly(methyl methacrylate) (PMMA) labelled with phenanthrene (Phe) groups was coated as a film onto quartz disks. Diffusion of solvent (1:1 2-butanone/2-propanol) into the film was followed by a decrease in the fluorescence, while film dissolution was monitored simultaneously by laser interferometry. In the case of PMMA both processes occur at approximately the same rate and exhibit non-Fickian (relaxation-controlled) diffusion behavior. Correlating the results of these two experiments shows that, once the steady state is reached, the dissolution rate is controlled by the advance of the solvent front into the PMMA film. The 'transition layer,' an important dissolution parameter, increases its thickness from 50 to 90 nm during the plasticization stage of solvent penetration and maintains its thickness until the solvent front reaches the quartz substrate. (Edited author abstract) 21 refs.

Limm, William (Univ of Toronto, Toronto, Ont, Can); Stanton, Deirdre; Dimnik, Gerald P.; Winnik, Mitchell A.; Smith, Barton A. *J Appl Polym Sci* v 35 n 8 Jun 1988 p 2099-2116.

**Dyeing** See INTEGRATED CIRCUIT MANUFACTURE.

**Etching** See Also PRINTED CIRCUITS—Manufacture.

**078413 SYNERGISTIC ENHANCEMENT OF DIRECT SYNCHROTRON RADIATION ETCHING OF A RESIST BY A LOW-ENERGY OXYGEN BEAM.** The effect of the simultaneous irradiation of a low-energy ion beam with synchrotron radiation (SR) was investigated. The purpose was the enhancement of the direct resist etching by SR. Although the removal by sputtering of the resist was observed due to the wide energy width of the ion beam used, it was confirmed that the net SR etching, which was estimated after subtraction of the sputtering contribution, increased about two times. Possibilities for the enhancement of this 'synergistic effect' induced by low-energy ion beam bombardment to improve the direct SR etching and make it more practical are also discussed. (Author abstract) 8 refs.

Murakami, Hiroshi (Electrotechnical Lab, Sakura, Jpn); Ichimura, Shingo; Shimizu, Hazime; Kudo, Isao; Atoda, Nobufumi. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1774-1776.

## Evaluation

**078414 COMPARISON OF STANDARD PHOTO-RESIST AND CONTRAST-ENHANCED PHOTO-RESIST PROCESS SENSITIVITIES.** Statistical experimental design techniques were used to make a systematic comparison between a standard photoresist process and a contrast-enhanced photoresist process. This approach allowed determination and comparison of process sensitivities and their dependence on process changes. The resist used in this study was HPR204, and the contrast-enhancement material was Altilith CEM 420. All substrates were exposed on a GCA 10X stepper with a 0.28NA, G-line lens. The results indicate that the contrast-enhanced process is less sensitive to focus and exposure dose variation, extends the effective working resolution of the exposure tool, and gives an increased sidewall angle in the final resist pattern, when compared to the standard resist process. (Edited author abstract) 17 refs.

Blanco, M. (Signetics Corp, Sunnyvale, CA, USA); Hightower, J.; Cagan, M.; Monahan, K. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2882-2888.

## Fabrication

**078415 IDENTIFYING SURFACE CONTAMINATION ON PELICULIZED PHOTOMASKS.** Several users of pelliclized chrome masks have reported the appearance of particulate deposits on the masks under the pellicle. Efforts to identify the particulate material were undertaken as a first step toward understanding and eliminating the problem. A combination of various spectroscopic analyses with gas chromatography/mass spectrometry allowed specific identification of the material as 2,5-di-tert-pentylhydroquinone. Comparison of the IR and MS spectra of the contaminating material with the spectra obtained from known samples of the pure compound confirmed its identity. The source of this impurity was traced to an adhesive tape used for attaching the frame to the photomask.

Frey, Donald (Hoya Electronic Corp, San Jose, CA, USA); Kagaya, Ken. *Microcontamination* v 6 n 10 Oct 1988 p 60, 62-64.

## Focusing

**078416 CHARACTERIZATION OF LINEWIDTH VARIATION FOR SINGLE- AND MULTIPLE-LAYER RESIST SYSTEMS.** The advantages gained by the use of a multilayer resist system were examined by electrical linewidth measurements of polysilicon lines ranging in width from 0.7 to 1.0  $\mu\text{m}$ . Multilayer resist was compared to single-layer resist and quantitative data was obtained regarding the theoretical advantages of reduced reflectivity, improved planarity, and thinner imaging resist inherent to a multilayer resist system. Two different thicknesses of single-layer resist revealed that a thinner imaging layer resulted in improvements of up to 15% for linewidth variation and 35% for depth of focus. Reducing reflections from the substrate from 33% to 3.5% led to improvements of up to 30% in linewidth variation and depth of focus. Introduction of a particular type of topography under the polysilicon led to a worsened linewidth variation and depth of focus, by up to 30%. 11 refs.

Bruce, James A. (IBM, Essex Junction, VT, USA); Lin, Burn J.; Sundling, Dianne L.; Lee, Tanya N. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2428-2435.

**Manufacture** See Also INTEGRATED CIRCUITS, VLSI—Imaging Techniques.

**078417 LIQUID PARTICLE COUNTING: DEVELOPING SPECIFICATIONS THROUGH PROCESS CAPABILITY ANALYSIS.** Liquid particle counting specifications have been set for nonmetallic developer and 30 cps positive photoresist, expanding a comprehensive quality program already in place. The reason for using this technology is to increase the ability to measure smaller particles in response to the needs of submicron lithography. As control of analytical and manufacturing methods improve, specification limits are expected to become narrower. 4 refs.

Hecht, Jeffrey K. (Morton Thiokol Inc, Tustin, CA, USA); Reardon, Edward J.; Thompson, Douglas A. *Microcontamination* v 6 n 7 Jul 1988 p 34-40.

**Materials** See Also POLYIMIDES—Applications; SEMI-CONDUCTING SILICON—Amorphous.

**078418 IMPROVED POSITIVE PHOTO-RESIST.** An improved positive photoresist has been formulated using a styrene-maleimide binder in place of the previously used methacrylates. Film toughness is markedly improved, and the resists can be developed in aqueous solvents with little or no organic assist. Second images can be created with essentially the same exposure-development cycle as the first images. (Author abstract) 3 refs.

Weigert, F.J. (DuPont, Wilmington, DE, USA); Proskow, S.; Mitchell, R.S. *J Imaging Sci* v 31 n 5 Sep-Oct 1987 p 223-225.

**078419 PLASMA-PROCESSED OBLIQUELY DE-POSITED Bi-Ge-Se AND Ag/Bi-Ge-Se FILMS AS RESIST MATERIALS.** Lithographic properties of photoexposed  $\text{Bi}_{10}\text{Ge}_{20}\text{Se}_{70}$  and  $\text{Ag/Bi}_{10}\text{Ge}_{20}\text{Se}_{70}$  films and hydrogen plasma exposed  $\text{Ag/Bi}_{10}\text{Ge}_{20}\text{Se}_{70}$  films have been investigated. The as-deposited films show a positive resist behavior on exposure to photons and the silver overlayers show a negative resist behavior on exposure to both photons and hydrogen plasma. The contrast values are 1.25 and 2.3 for photoexposed positive and negative resists, respectively, and 5.0 for plasma-exposed negative resist. The sensitivity is approximately  $10^{20}$  photons/cm<sup>2</sup> for the photoexposed positive and negative resists and  $10^{18}$  ions/cm<sup>2</sup> (0.11 C/cm<sup>2</sup>) for the plasma-exposed negative resist. (Author abstract) 26 refs.

Gupta, P.K. (Indian Inst of Technology, New Delhi, India); Chopra, K.L. *Appl Phys A* v A46 n 2 Jun 1988 p 103-106.

**078420 WATER SOLUBLE POSITIVE-TYPE PHOTO-RESIST USING A PHOTOLYSIS OF IMINO SULFONATES.** Positive-type photoresists which can be developed with water are synthesized from the copolymerization of 9-fluorenylideneimino p-styrenesulfonate and 2-(dialkylamino)ethyl methacrylate. The photochemical properties of the polymers are studied. Poly(dialkylaminoethyl methacrylate) bearing imino sulfonate units were found to be a useful positive-type photoresist which can be developed with water. (Edited author abstract). 4 refs.

Shirai, Masamitsu (Univ of Osaka Prefecture, Sakai, Jpn); Katsuta, Nobuyuki; Tsunooka, Masahiro; Tanaka, Makoto; Nishijima, Kanji; Ishikawa, Katsukiyo. *Chem Express* v 3 n 7 Jul 1988 p 439-442.

**078421 NEW APPROACH TO HIGH TEMPERATURE PHOTO-RESISTS BASED ON STYRYL-PYRIDINIUM UNITS.** Four linear polyesters containing styrylpyridinium units were prepared from 2,6-bis(p-hydroxystyryl)pyridine and terephthalic acid, isophthalic acid, adipic acid, and sebacic acid, respectively. The polyesters are thermally stable in the 365 to 450°C range. The decomposition temperature is higher for aromatic polyesters, lower for their aliphatic analogs. The polyesters are photoreactive and crosslink on irradiation with UV. The crosslinking mechanism is 2 + 2 cycloaddition. The polyesters form protonated complexes with  $\text{CF}_3\text{COOH}$  which absorb at longer wavelengths and are also photoreactive. The quantum yield of the photoreaction and the relative photosensitivities of the polyesters and their complexes were determined. (Author abstract). 9 refs.

Li, Min Yu (Polytechnic Univ, Brooklyn, NY, USA); Pearce, Eli M.; Reiser, A. *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2517-2527.

**078422 POLYMER COMPLEX AS A NEW TYPE OF ELECTRON BEAM RESIST FOR DRY DEVELOPMENT.** Polymer complex of poly(4-vinylpyridine) and malonic acid was investigated as a new type of electron beam (EB) resist for dry development, as malonic acid was decomposed by EB irradiation. It was found that the polymer complex could be developed with  $\text{O}_2$  plasma etching and that the positive resist patterns with high resolution could be obtained. The mechanism for this lithography process was studied by means of IR and ESCA spectra. (Author abstract). 7 refs.

Yoneyama, Sachiko (Sophia Univ, Tokyo, Jpn); Oguchi, Kiyoshi; Watanabe, Masayoshi; Sanui, Kohei; Ogata, Naoya; Takahashi, Yoichi; Nakada, Tomihiko. *Polym Eng Sci* v 28 n 14 Jul 1988 p 912-915.

## Microscopic Examination

**078423 PHOTOCLEAVE - A METHOD FOR NON-DESTRUCTIVE SECTIONING BY PHOTO-RESIST FEATURES FOR SCANNING ELECTRON MICROSCOPE INSPECTION.** A simple nondestructive method of photolithographically sectioning resist features is pres-



ented. The method utilizes the superposition of the normally exposed device features followed by a second exposure of a long wide linear feature, all before the development step. The superposition results in a precise and clean cross-sectioning of the feature, allowing inspection of line-edge profiles and contact windows in addition to measurements at the crucial substrate-resist interface. (Author abstract) 2 refs.

Schrope, D.E. (AT&T Bell Lab, Allentown, PA, USA). *Scanning Microsc* v 1 n 3 Sep 1987 p 1055-1058.

**Optical Properties** See COPOLYMERS—Synthesis.

## Optimization

**078424 THREE-DIMENSIONAL REISTS SHAPE SIMULATOR AND ITS APPLICATION TO SUBMICRON VLSI PROCESS.** A three-dimensional photoresist shape simulator has been developed for the submicron process. Using this simulator, it is possible to analyze and optimize the photoresist process using an arbitrary projector, photoresist, and developer. In this technique, considering the man-machine interface, the three-dimensional shape of the photoresist can be shown in a colorgraphic VDT and plotter. Comparing the result of the three-dimensional simulation using the contact hole pattern with that of the two-dimensional simulation, a discrepancy occurs in the dimension less than 1  $\mu$ m between the two techniques, and it has been found that three-dimensional simulation is necessary when the width and depth of the pattern are in the same order. Using the three-dimensional simulation, a resolution of 0.5  $\mu$ m cannot be achieved when the wavelength of the light source is 435.8 nm, the numerical aperture of the projection lens N.A. is 0.28, and the coherency  $\sigma$  is 0.7. However, such a resolution can be achieved by using the wavelength of the light source of 435.8 nm, N.A. of 0.42, and  $\sigma$  of 0.5. (Author abstract) 7 refs.

Itoh, Tetsuo (Hitachi Ltd, Hitachi, Jpn); Matsuzawa, Toshiharu; Kadota Kazuya; Hanashima, Shuichi. *Electron Commun Jpn Part 2* v 71 n 1 Jan 1988 p 41-49.

## Performance

**078425 IMPROVED PHOTORESIST TECHNOLOGY AVAILABLE IN EUROPE.** Major trends in the PWB industry and the requirements from the manufacturers to reduce reject rates at the imaging and chemical process stages have demanded a new generation of dry film photoresists. Details are given of the requirements laid down by the industry, how the dry film resist manufacturers have responded, and how the improved resist technology meets these demands. These latest products are available in Europe and resist improvements have been welcomed by the board manufacturers.

Newport, B.L. (OMI Int (GB) Ltd, Woking, Engl). *Circuit World* v 14 n 4 Jul 1988 p 21-22.

## Photochemical Reactions

**078426 RECIPROCITY FAILURE IN NOVOLAK/DIAZOQUINONE PHOTORESIST WITH 364-NM EXPOSURE.** Intensity-independent photobleaching (reciprocity failure) was observed when a film of novolak/diazoquinone photoresist was exposed at 364 and 351 nm in the intensity range 1 to 400 mW/cm<sup>2</sup>. It was found that a dark reaction can be observed for short times after turning off the light during a bleach. It is postulated that these effects are a result of the absorbance of the intermediate ketene, which may decay on the same time scale as the exposure time and hence introduce a non-photochemical time-dependent bleaching that couples with the photochemical bleaching to give reciprocity failure. The magnitude of the reciprocity failure is sufficient to have a significant detrimental effect on resolution and process control. Thus it is important not only to reduce the absorbance of the final product but also that of the intermediates. 14 refs.

Sheats, James R. (Hewlett-Packard Co, Palo Alto, CA, USA). *IEEE Trans Electron Devices* v 35 n 1 Jan 1988

p 129-131.

**Plastics Applications** See ACRYLICS—Photochemical Reactions.

**Research** See Also POLYMERS—Photochemical Reactions; SEMICONDUCTING INDIUM COMPOUNDS—Etching.

**078427 SPIN-COATABLE INORGANIC RESISTS BASED ON NOVEL: PEROXOPOLYNOBOTUNGSTIC ACIDS FOR BILAYER LITHOGRAPHY.** New peroxopolyacids based on tungsten and niobium (Nb-HPA) were synthesized and investigated as negative inorganic resist materials for microlithography. Amorphous and microstructure-free thin films, obtained from their water-based solution using a conventional spin-coating technique, exhibited sensitivity to deep UV ( $D_{0.5} = 150$  mJ/cm<sup>2</sup>, Xe-Hg lamp), E-beam (10  $\mu$ C/cm<sup>2</sup>, 30 kV) and x-ray (120 mJ/cm<sup>2</sup>, Mo L). The O<sub>2</sub>-RIE resistivity of Nb-NPA film was found to be 50 times greater than that of polyimide resin (PIQ resin). Patterns as fine as 0.2  $\mu$ m with an aspect ratio of 7.5 were successfully fabricated through the E-beam bilayer process in which the bottom layer was PIQ (1.5  $\mu$ m thickness) and the top, Nb-HPA (0.1  $\mu$ m). (Author abstract) 10 refs.

Kudo, Tetsuchi (Hitachi Ltd, Kokubunji, Jpn); Ishikawa, Akira; Okamoto, Hiroshi; Miyauchi, Katsuki; Murai, Fumio; Mochiji, Kozo; Umezaki, Hiroshi. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2607-2613.

**078428 EMISSION SPECTRA OF AN AZIDE PHOTORESIST INITIATOR AND EXPOSURE RECIPROCITY.** From the excitation and emission spectra presented, it can be concluded that the assumption of the broad absorption band for negative photoresists being due to a single transition is not valid. This absorption band is composed of transitions between discrete states one of which, <sup>3</sup>nπ\*, is attributed to be narrow. De-excitation from the excited states of the broad band does not occur by a cascading mechanism that includes the <sup>3</sup>nπ\* state, if these discrete states are narrow, similar to the observed state, it may also be concluded that the lifetimes in these states are consisted of a broad single state only. 13 refs.

Novotny, Donald B. (NBS, Gaithersburg, MD, USA). *J Electrochem Soc* v 135 n 3 Mar 1988 p 774-775.

## Spectroscopic Analysis

**078429 CHARACTERIZATION OF ION-IMPLANTED PHOTORESIST FILMS BY FOURIER TRANSFORM INFRARED SPECTROSCOPY.** Positive photoresist was characterized by Fourier Transform infrared (FTIR) spectroscopy after high dose, high power ion implantation. The concentration of individual components in the resist such as the photosensitizer and organic C-H bonds were determined independently by examining the integrated absorbances at the corresponding infrared absorption peaks: 2040-2200 cm<sup>-1</sup> for the sensitizer, and 2820-2995 cm<sup>-1</sup> for the stretch of C-H bonds. Degradation of the sensitizer was found to be largely due to the elevated wafer temperature which is dependent on the heat generated by the ion implant and the cooling mechanism of the implanter. The thickness of the carbonized layer can be estimated by the loss of C-H bonds, which is in agreement with SEM results. (Edited author abstract) 8 refs.

Lee, Jen-Jiang (Motorola Inc, Austin, TX, USA); Lee, Chang-Ou; Alvis, John; Sun, S.W. *J Electrochem Soc* v 135 n 3 Mar 1988 p 711-714.

**078430 CHARACTERIZATION OF THIN-FILM NEGATIVE RESIST VIA PHOTO-FT-IR.** Negative thin-film photoresists are used extensively in the circuitization of metalized substrates. Frequently questions regarding resist performance and reproducibility arise which require extensive functional evaluation. The analysis of the exposure (intensity, dose, and wavelength) and temperature effects typically requires the incremental analysis of a large matrix of samples. Photoreactions occurring in

these resists can be conveniently monitored by FT-IR and correlated with functional performance. We have developed hardware and software accessories for an FT-IR spectrometer which allows spectroscopic analysis of photoresists during exposure to UV light. The utility of the Photo-FT-IR is demonstrated by a report of the photoreaction of two typical negative photoresists as a function of intensity and wavelength. We also report on the thermal stability of these two resist systems. (Author abstract) 7 refs.

Sommer, A.J. (IBM Corp, Endicott, NY, USA); Fuerniss, S.J.; Appelt, B.K. *Appl Spectrosc* v 42 n 3 Mar-Apr 1988 p 460-468.

## Synthesis

**078431 PREPARATION OF PHOTORESIST POLYMER BY A PHOTOREACTIVE MONOMER CONTAINING N,N-DIETHYLDITHIOCARBAMATE GROUP.** A novel photosensitive monomer with a pendant photoreactive diethyldithiocarbamoyl group, VEDC, was synthesized and copolymerized with some vinyl monomers by AIBN. The copolymers obtained have efficient photocrosslinking abilities, and are thermally stable. Therefore, there was no loss of dithiocarbamoyl group during radical polymerization, and the polymerization proceeded through vinyl group, but photosensitivity of the polymer was not. Water-soluble photoreactive copolymers, VBDC with AAm or MA, were also prepared. The mechanism of photocrosslinking was studied by photodecomposition of benzyl N,N-diethyldithiocarbamate, and the result that the decreases of sulfur content clearly related to photocrosslinking points was also obtained. (Edited author abstract) 12 refs.

Yamashita, Keiji (Nagoya Inst of Technology, Showa, Jpn); Nakano, Akio; Tsuda, Kazuichi. *J Appl Polym Sci* v 35 n 2 Feb 5 1988 p 465-473.

**078432 SYNTHESIS AND STUDIES OF RESISTS BEARING TETRATHIAFULVALENE GROUPS AND SENSITIVE TO U.V. AND ELECTRON BEAM IRRADIATIONS.** Polymers bearing tetrathiafulvalene groups have been tested under e-beam and UV irradiation. The dependence of resist sensitivity on molecular weight is reported. Resolution between 0.1 and 0.4  $\mu$ m were obtained. These polymers are shown to have desirable combinations of properties, including high sensitivity and high resolution. (Author abstract) 6 refs.

Schue, F. (USTL, Montpellier, Fr); Monginoul, C.; Fabre, J.M.; Giral, L.; Mungroo, A.; Sagnes, R. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microthorh, Jouy-en-Josas, Fr, Sep 22-25 1987 p 433-438.

**PHOTOVOLTAIC CELLS** See Also ELECTRIC POWER PLANTS, MOBILE—Performance; NUCLEAR REACTORS—Fission Products; OPTICAL COMMUNICATION EQUIPMENT; PHOTOELECTRIC CELLS—Electrochemistry; SOLAR CELLS; SOLAR CELLS—Performance; SOLAR ENERGY—Mathematical Models; SOLAR POWER PLANTS; SOLAR RADIATION—Analysis; SOLAR RADIATION—Collectors; SOLAR RADIATION—Concentrators; SOLAR RADIATION—Mathematical Models.

**078433 ON ELECTROCHEMICAL PHOTOVOLTAIC CELLS FORMED WITH CuInS<sub>2</sub> FILMS.** Results on the performance and stability of polycrystalline CuInS<sub>2</sub> in polysulfide and polyiodide electrolytes are reported. The CuInS<sub>2</sub> films were prepared by chalcogenization of Cu-In alloy films in an H<sub>2</sub>S atmosphere. The Cu-In alloy films were prepared by electrodeposition from 100 mM In<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>-75 mM CuSO<sub>4</sub> solutions. The formation of Cu-In alloy and of CuInS<sub>2</sub> was confirmed by X-ray diffraction (XRD) patterns. 7 refs.

Lokhande, C.D. (Weizmann Inst of Science, Rehovot, Isr). *J Power Sources* v 21 n 1 Aug 1987 p 59-62.



**078434 INVESTIGATION OF THE EFFECT OF A SPACE-CHARGE FIELD ON CHARACTERISTICS OF SILICON PHOTOVOLTAIC CELLS.** The article examines the effects of direct and indirect action of the charge accumulated in glass when photovoltaic (PV) cells are irradiated with electrons of average energies on the PV cells' volt-ampere characteristics. (Author abstract) 6 refs.

Bordina, N.M.; Knyazev, B.N.; Kozlov, A.G.; Letin, V.A.; Milovanova, N.A.; Starodubtsev, V.A.; Yagushkin, N.I. *Appl Sol Energy* v 23 n 2 1987 p 5-9.

**078435 EXPERIMENTAL VERIFICATION OF SUPERLINEAR DEPENDENCE OF THE PHOTOCURRENT OF A SILICON PHOTOVOLTAIC CELL ON THE LEVEL OF ILLUMINATION.** The authors investigated silicon photovoltaic cells with an isotype back junction in conditions of concentrated radiation. We used a concentrating device based on a one-meter concentrator with an automatic system for tracking the sun in two planes. To determine the photocurrents ( $I_{ph}$ ) of two PV cells, we measured their volt-ampere characteristics (VAC) in a photodiode regime over a wide range of illumination: from 1 to 200 solar constants (SC). The degree of concentration of the luminous flux (K) was determined according to the ratio of photocurrents from the PV cells made of GaAs. The results are presented in the form of the dependence of C on K. Beginning with K=20, a superlinear dependence of  $I_{ph}$  on the level of illumination is manifested. With an increase in K, C rises, and at K=40 saturation of C sets in, which is equal to 1.4. 3 refs.

Bordina, N.M.; Kagan, M.B.; Komilov, A.; Mirzabaev, M.M.; Rasulov, K. *Appl Sol Energy* v 23 n 4 1987 p 5-8.

**078436 ELECTROPLATED  $Cu_2S$ -CdS PHOTOVOLTAIC CELLS.** The results of a reliable electroplating method for the formation of the chalcocite ( $Cu_2S$ ) phase of copper sulphide on thin film CdS substrates are reported. The problem of the stability of the CdS- $Cu_2S$  photovoltaic devices so formed is addressed by studying the combined effect of the substrate on which the CdS is deposited and the ambient used when annealing. Steady state photocapacitance measurements show that the most stable cells, which are fabricated on Ag/Cr substrates, exhibit a deep electron trap in the CdS some 0.95 eV below the conduction band. It is concluded that this trap inhibits the in-diffusion of copper into the CdS during annealing of the CdS- $Cu_2S$  cell and can be attributed to a complex associate formed between silver and oxygen. (Author abstract) 24 refs.

Al-Dhafiri, A.M. (Univ of Durham, Durham, Engl); Pande, P.C.; Russell, G.J.; Woods, J. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 900-905.

**Applications** See Also WELL PUMPS—Electric Power Supplies.

**078437 DYNAMIC OPTIMAL COUPLING OF A PHOTOVOLTAIC POWER SYSTEM AND INDUCTION MOTOR.** In this paper a new method for optimum matching the induction motor with varying mechanical load to a solar photovoltaic power system (PV) is presented. This method utilizes a maximum mechanical energy supply to the load by means of switching procedures and other devices. Dc/ac inverter has been used to change the SCA output to ac power. Harmonic analysis is applied on the inverter output wave. Then the suitable ac-filter is designed to improve the waveform output from the used inverter. New hourly series-parallel solar cell modules connections (SMMC) are proposed and applied. The impact of induction motor starting on the optimum SCA size and on the energy cost figure is discussed in detail. (Author abstract) 8 refs.

El-Tamaly, H.H. (Elminia Univ, Elminia, Egypt). *Modell Simul Control A* v 13 n 3 1987 p 47-63.

**078438 LIGHT-POWERED ARCHITECTURE.** Photovoltaics (PVs) are semiconductors that generate

electricity when exposed to light. In the family of semiconductor technology, photovoltaics are kin to simple semiconductor switches, the key part of all microprocessors. In the US, including Alaska and Hawaii, PVs now electrify a few thousand remotely located homes and thousands of remote facilities such as microwave stations, railroad signals, and harbor navigation lights. Compared to all other forms of energy technology, PVs are uniquely modular. One 4-ft-sq PV module, about an inch thick, can provide basic power to a remote homesite, boat, or telephone system. The same module, mass-produced in the thousands and installed on racks to track the sun, becomes a utility-scale generating station. With PVs, it is technically feasible to design a building with no utility connections except water, sewage, and possibly gas.

Swan, Christopher C. (Suntrain Inc, CA, USA). *Archit Rec* v 176 n 3 Mar 1988 p 126, 128.

**Computer Aided Analysis** See SOLAR RADIATION—Concentrators.

### Computer Simulation

**078439 SIMULATION PHOTOVOLTAISCHER ANLAGEN - RANDBEDINGUNGEN, SYSTEMVERGLEICHE UND ERGEBNISSE.** [Simulation of Photovoltaic Plants - Boundary Conditions Comparison of Systems, and Results]. The basic arrangement of computer aided simulation of photovoltaic installations is described. Principal data on the efficiency of such installations depending on boundary conditions are presented. These boundary conditions discussed include the following: location, guidance system for the solar cells, magnitude of the area of the solar cells in relation to their use, magnitude of the capacity of the battery in relation to the area of the solar cells and to the use; matching of the battery rated voltage to the solar cell voltage, switching-off criteria for the solar cells by the user. In German. 5 refs.

Rouvel, Lothar. *ETA Elektrowerke Tech Ausbau* v 45 n 3 May 1987 p 86-93.

**Contacts** See SOLAR CELLS—Design.

### Design

**078440 OPERATIONAL EXPERIENCE WITH PHOTOVOLTAIC SYSTEMS AT THE FLORIDA SOLAR ENERGY CENTER.** This paper describes the design and operational experience with photovoltaic systems at Florida Solar Energy Center. An attempt has been made to focus on the subject matter relevant to Indian research and application need. The photovoltaic systems covered include stand-alone, grid-connected residential and grid-connected tracking systems. Based on the experience, some recommendations are made for the implementation of photovoltaic systems research and applications in India. (Author abstract) 9 refs.

Atmaram, Gobind H. (Florida Solar Research Cent, Cape Canaveral, FL, USA). *Prog in Sol Eng* Publ by Hemisphere Publ Co, Washington, DC, USA and Springer-Verlag, Berlin, West Ger and New York, NY, USA p 263-285.

**078441 CONSEQUENCES OF MISFIT AND THREADING DISLOCATIONS ON PV DEVICE DESIGN.** The relative weights of surface recombination, misfit dislocation density and threading dislocation density in the performance of a photovoltaic device are ascertained in the generation-recombination operating limit of a planar HgCdTe double layer heterostructure. In this limit, surface recombination is found to be much less important than the dislocations, while the balance between misfit and threading dislocations is determined by the relative size of the average misfit segment length and the device lateral dimension. (Author abstract) 14 refs.

Szilagyi, A. (Honeywell, Lexington, MA, USA); Grimbergen, M.N. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 912-916.

**Economics** See ELECTRIC POWER GENERATION—Photovoltaic Effects.

**Efficiency** See Also SOLAR CELLS—Silicon; SOLAR RADIATION—Concentrators.

**078442 HYDROGEN PASSIVATION OF GRAIN BOUNDARIES' CHARGE STATES IN FILM POLYCRYSTALLINE PHOTOVOLTAIC CELLS.** It is shown that hydrogen passivation leads to a sharp rise in the output and efficiency of film polycrystalline photovoltaic cells in concentrated luminous fluxes. 3 refs.

Saidov, M.S.; Bilyalov, R.R.; Mukhamadiev, R.E.; Chirva, V.P. *Appl Sol Energy* v 23 n 6 1987 p 17-20.

**078443 SOME WAYS OF RAISING THE ENERGY OUTPUT OF PHOTOVOLTAIC BATTERIES IN AGRICULTURAL-PURPOSE UNITS.** The article considers possibilities of raising the efficiency of utilization of existing photovoltaic batteries employed in agriculture as sources of electricity for autonomous facilities remote from power lines. (Author abstract) 3 refs.

Belonov, A.T.; Aliev, R.K. *Appl Sol Energy* v 23 n 6 1987 p 57-61.

**Electrochemistry** See SEMICONDUCTING FILMS—Optical Properties.

### Energy Resources

**078444 AKUMULACIA ENERGIE ZISKANEJ Z FOTOVOLTICKYCH PANELOV.** [Accumulation of Energy Gained from Photovoltaic Panels]. The article presents principal parts of a photovoltaic system consisting of panels, control unit and energy storing medium. The design of an intermediate element-control unit is treated in detail. A short-circuit protection unit of accumulators protecting these before short-circuits in electrical appliances is considered here. The control unit for solar panels with the voltage of 12 V and system output current of 4 A is designed using Czechoslovak components base. (Author abstract) In Slovak. 10 refs.

Baratka, Stanislav (SVST, Bratislava, Czech); Lukac, Lubomir; Kuzinsky, Michal. *Elektrotech Obz* v 76 n 8 Aug 1987 p 429-434.

### Energy Utilization

**078445 FEASIBILITY STUDY OF PHOTOVOLTAIC-FUEL CELL HYBRID ENERGY SYSTEM.** The concept and feasibility study results of applying fuel cells to provide operational support to photovoltaic (PV) arrays are presented. Through simulation using actual data, it is shown that it is feasible to use fuel cells in coordination with PV to meet variable loads to either utility or stand-alone applications. The dynamic response required of the fuel cell to support the hybrid operation is found to be well within the capabilities of the prototype designs that have been tested in the United States and Japan. The hybrid operation overcomes the intermittency problem inherent with PV and makes possible novel applications for the fuel cell technology. 17 refs.

Rahman, Saifur (Virginia Tech, Blacksburg, VA, USA); Tam, Kwa-sur. *IEEE Trans Energy Convers* v 3 n 1 Mar 1988 p 50-55.

### Manufacture

**078446 CHARACTERIZATION AND CONTROL OF PHOSPHINE HAZARDS IN PHOTOVOLTAIC CELL MANUFACTURE.** Phosphine ( $PH_3$ ) is a highly toxic and flammable gas used in photovoltaic cell manufacturing. Its use can present serious occupational and public health hazards if appropriate prevention and control options are not implemented. This report reviews technologies for controlling  $PH_3$  emissions during routine operation and accidents, hazard prevention options, and emergency preparedness and response strategies. Routine  $PH_3$  emissions can be controlled by using carbon adsorption for very low concentrations and thermal incineration or multistage chemical scrubbing for higher concentra-



tions. Massive accidental releases are difficult to control and could jeopardize the life and health of persons living near a plant. Options for preventing or minimizing accidental releases (e.g. flow-restricting valves) need to be implemented to reduce such risks. Industry and community emergency response planning can further reduce the magnitude of these hazards. (Edited author abstract) 14 refs.

Fthenakis, V.M. (Associated Univ Inc, Upton, NY, USA); Moskowitz, P.D. *Sol Cells* v 22 n 4 Dec 1987 p 303-317.

**078447 LARGE-AREA CdS/CdTe PHOTOVOLTAIC CELLS.** An inexpensive process for the production of relatively large-area CdS/CdTe cells is described. The resulting cell characteristics are reported. (Edited author abstract) 9 refs.

Jordan, John F. (Photon Energy Inc, El Paso, TX, USA); Albright, Scot P. *Sol Cells* v 23 n 1-2 Jan-Feb 1988 p 107-113.

**Materials** See Also COPPER COMPOUNDS—Surfaces; SEMICONDUCTING CADMIUM COMPOUNDS—Thin Films; SEMICONDUCTING ZINC COMPOUNDS—Electric Properties; SILICON COMPOUNDS.

**078448 LOW TEMPERATURE CHEMICAL PRECIPITATION AND VAPOR DEPOSITION OF  $\text{Sn}_2\text{S}$  THIN FILMS.** Films of gray-black  $\text{Sn}_{1-x}\text{S}$  ( $E_g \approx 1.0$ -1.3 eV), brown  $\text{Sn}_{2-x}\text{S}_3$  ( $E_g \approx 1.6$ -1.9 eV), and/or  $\text{SnS}_{2-x}$  ( $E_g \approx 2.1$ -2.3 eV) were deposited onto nonconductive substrates by (i) an 'electroless' chemical precipitation mechanism in organic acid/ $\text{H}_2\text{O}$  baths of  $\text{SnCl}_2$ , S, and  $\text{Sn(II)}$ -complexing agents and/or (ii) a novel, above-solution CVD mechanism involving condensation and reaction of Sn and S species such as  $\text{SnCl}_4$  and  $\text{H}_2\text{S}$ .  $\text{H}_2\text{O}$  and complexing agent (potassium gluconate or tartaric acid) concentrations critically affect film stoichiometry due to their 'freeing' (with acid ionization) or chelating of the  $\text{Sn(II)}$ . A surface area-minimizing  $\text{Sn(II,IV)}\text{-S(II)}$  exchange reaction is postulated to explain slow transfer of  $\text{Sn}_2\text{S}$  deposit/precipitate to smooth surfaces. (Edited author abstract) 17 refs.

Engelken, R.D. (Arkansas State Univ, Jonesboro, AR, USA); McCloud, H.E.; Lee, Chuan; Slayton, Mike; Ghoreishi, Hossein. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2696-2707.

**078449 EFFECT OF PLASMA TREATMENT ON PHOTOVOLTAIC PROPERTIES IN COPPER PHTHALOCYANINE.** The power-conversion efficiency of ITO (indium tin oxide)/CuPc (copper phthalocyanine)/Al cells increased to as high as 0.8 percent when a CuPc evaporated film was treated by Ar-plasma. The results of the ESCA spectrum and the absorption spectrum suggested that the film surface changed to a structure containing oxygen which is introduced after contact with air. (Author abstract) 6 refs.

Miyata, Seizo (Tokyo Univ of Agriculture & Technology, Koganei, Jpn); Park, Yun Heum; Soeda, Yoshihiro; Itoh, Rie; Tasaka, Shigeru. *Jpn J Appl Phys Part 2* a2 p 1632-1634.

**078450 SPECTRAL COSENSITIZATION IN PHTHALOCYANINE-PORPHYRIN PHOTOELECTROCHEMICAL CELLS.** An organic multilayer photoelectrochemical cell was fabricated by sequential vacuum deposition of hydroxylaluminum phthalocyanine (PcA-I-OH) and hydroxylaluminum tetraphenylporphyrin (TPPAIOH). Absorption and action spectra of the NESA/PCAI-OH/TPPAIOH/ $\text{I}_3^-/\text{I}^-$ /Pt cell cover the entire visible spectrum up to 900 nm. In the reverse deposition sequence, only NESA/TPPAIOH/PCAI-OH/ $\text{I}_3^-/\text{I}^-$ /Pt photoelectrochemical cell with very thin organic layers showed a sensitization effect. The sensitization effects are probably due to the porosity of the organic thin films, allowing the contact of the electrolyte with each semiconductor. (Author abstract) 17 refs.

Perrier, Gerard (INRS-Energie, Varennes, Que, Can); Gauthier, Rosanne; Dao, Le H. *J Electrochem Soc* v 135

n 3 Mar 1988 p 598-602.

**078451 PHOTOVOLTAIC EFFECT BASED ON WET POLY(VINYL ALCOHOL)/MERCYANINE DYE JUNCTION.** The sandwich cell, Au/wet poly(vinyl alcohol) (PVA)/merocyanine (MD)/Au, based on the PVA/MD junction exhibited photovoltaic and rectifying effects. Forward dark current from the MD/Au electrode to the counter PVA/Au electrode through the cell was observed. The Au/MD electrode showed a positive photovoltage with respect to the PVA/Au electrode regardless of the direction of the incident light. It was suggested that a heterojunction barrier similar to the Schottky type formed at polymer/dye interface was responsible for the photo charge separation. (Author abstract) 8 refs.

Uehara, Kaku (Univ of Osaka Prefecture, Sakai, Jpn); Takagishi, Kenji; Tanaka, Makoto. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1759-1767.

**078452 SOLAR POWER COMES DOWN TO EARTH.** An American company, Chronar Corporation, was set up in 1975 with the aim of developing a commercial, low-cost photovoltaic technology. The results of these efforts have recently come to fruition with the introduction of a series of commercial products and a major generating installation set up in the US. The basic structure of the photovoltaic panel comprises a thin layer of silicon semiconductor sandwiched between two electrodes, the whole being supported on a glass substrate. The back electrode that faces the light source is a transparent layer of tin(IV) oxide. While there are numerous ways of obtaining tin oxide coatings, the method chosen is atmospheric pressure chemical vapor deposition (APCVD) using equipment specially developed for this technique. 3 refs.

Karpel, S. *Tin Its Uses* n 154 1987 p 11-13.

## Mathematical Models

**078453 GENERALIZED CAPACITY FACTORS FOR GRID-INTERTIE SOLAR PHOTOVOLTAIC SYSTEMS.** We present a simple calculation and graphical procedure for direct determination of the annual capacity factor of no-storage grid-intertie photovoltaic systems. This is applicable to the principal solar collector types and to a wide range of climates. This method provides 'translation equations' for predicting both instantaneous power output (under any specified test conditions) and long-term average power output of photovoltaic modules from instantaneous measurements. Such a procedure, which we validate for one site only, should enable a designer to make accurate preliminary assessments concerning the suitability of potential sites and solar collector types by simple analytic calculations or, equivalently, by reading points off the graphs presented herein. (Author abstract) 13 refs.

Gordon, J.M. (Ben-Gurion Univ of the Negev, Sede Boqer, Isr); Reddy, T.A. *Sol Cells* v 23 n 3-4 Apr 1988 p 127-137.

**078454 THREE-DIMENSIONAL ANALYTICAL SIMULATION OF SELF- AND CROSS-RESPONSIVITIES OF PHOTOVOLTAIC DETECTOR ARRAYS.** The degradation of spatial resolution and sensitivity due to lateral transport is modeled using a novel 3-D analytical solution of the continuity equation. Three detector structures are investigated: the semi-infinite substrate, the perfectly collecting, and the perfectly reflecting backside. The front and rear illuminations are treated. The calculated results for the 3-D case deviate fundamentally from those predicted by the 1-D model. The 3-D model explains the reduced quantum efficiency of small-area detectors and predicts the limited effect that diffusion length has on self-responsivity and cutoff wavelength. The calculated spectral responses fit data measured on InSb and HgCdTe test arrays extremely well. 28 refs.

Levy, David (Technion, Haifa, Isr); Schacham, Samuel E.; Kidron, I. *IEEE Trans Electron Devices* v ED-34 n 10

Oct 1987 p 2059-2070.

## Measurements

**078455 CHARACTERIZATION OF PHOTOVOLTAIC CELLS USING THE PHOTOTHERMAL DEFLECTION SPECTROSCOPY.** The use of photothermal deflection spectroscopy for a noncontact characterization of photovoltaic cells is presented. It is shown that this technique is capable of providing not only the optimum load resistance and conversion efficiency, but also the value of the internal series resistance of the cell. A comparison with other photothermal detection technique is also presented. (Author abstract) 14 refs.

Riette, H.L. (Avancados Centro Tecnico Aeroespacial, Sao Jose dos Campos, Brazil); Miranda, L.C.M.; Vargas, H. *Appl Phys A* v 44 n 3 Nov 1987 p 219-222.

**Optical Properties** See SEMICONDUCTING SILICON—Amorphous.

**Optimization** See SOLAR CELLS.

**Performance** See Also SOLAR CELLS—Design; SOLAR CELLS—Efficiency.

**078456 POWER CONTROLLER FOR AUTONOMOUS PHOTOVOLTAIC SYSTEMS.** The performance of an optimized power controller is studied. It shows a maximum power point tracking efficiency of the order of 99% independent of the insolation value. The proposed system may substitute the conventional battery charge regulators used in low and medium power ( $P < 10$  kWp) autonomous photovoltaic systems with a simultaneous annual increase in power yield. (Edited author abstract) 12 refs.

Avaritsiotis, J.N. (Natl Technical Univ of Athens, Athens, Greece); Tsilis, M. *Sol Cells* v 22 n 3 Nov 1987 p 175-186.

**078457 Al/INDIGO/Au PHOTOVOLTAIC CELL.** The Al/Indigo/Au sandwich cell exhibits photovoltaic and rectifying effects. It is suggested that a Schottky barrier, formed at the interface between the aluminum electrode and the indigo dye layer, is responsible for the charge-carrier separation. (Author abstract) 8 refs.

Uehara, K. (Univ of Osaka Prefecture, Sakai, Jpn); Takagishi, K.; Tanaka, M. *Sol Cells* v 22 n 4 Dec 1987 p 295-301.

**Plastics Applications** See AROMATIC POLYMERS—Physical Properties.

## Research

**078458 OPENING THE DOOR FOR UTILITY PHOTOVOLTAICS.** EPRI's point-contact photovoltaic cell has achieved the world's highest conversion efficiencies in a laboratory environment. But can such devices be economically mass-produced for utility-scale applications? Researchers, microcircuit manufacturers, and utility investors are betting that they can. This paper discusses the physics of a point-contact cell, the materials used for its development, packaging the solar concentrator and the performance of central station photovoltaic plant. 9 refs.

Anon. *EPRI J* v 12 n 1 Jan-Feb 1987 p 5-15.

**078459 SINTERED p-CuInSe<sub>2</sub>/n-CdS PHOTOVOLTAIC HETEROJUNCTION.** The photovoltaic effect in p-CuInSe<sub>2</sub>/n-CdS heterojunctions has been obtained by the evaporation of In-doped CdS thin film on a sintered CuInSe<sub>2</sub> substrate. By suitable selection of sintering conditions it was possible to obtain large grain CuInSe<sub>2</sub>



polycrystals with controlled electrical properties for solar cells. An efficiency of about 6.9% was obtained. (Author abstract) 13 refs.

Vigil, O. (La Habana Univ, La Habana, Cuba); Seuret, D.; Leccabue, F.; Hernandez, L. *Mater Lett* v 6 n 3 Dec 1987 p 85-88.

**078460 REVIEW OF PHOTOVOLTAIC RESEARCH IN THE UNITED STATES.** Current U.S. research in photovoltaics is developing new generations of technologies having the potential for lower costs and better performance than the older generations of crystalline silicon technologies. The newer generations consist primarily of single- and multi-junction thin-film devices destined for either flat-plate or concentrator, photovoltaic systems. The principal sponsors of the research are the U.S. Department of Energy, U.S. photovoltaic companies, the Electric Power Research Institute, and those U.S. government agencies interested in the use of photovoltaics in space. This paper also describes future research activities in the areas of amorphous silicon polycrystalline thin films high efficiency concepts and fundamental research. 1 ref.

McConnell, R.D. (Solar Energy Research Inst, Golden, CO, USA). *Prog in Sol Eng* Publ by Hemisphere Publ Co, Washington, DC, USA and Springer-Verlag, Berlin, West Ger and New York, NY, USA p 255-262.

**Sensors** See INDIUM AND ALLOYS—Thin Films.

**Space Applications** See Also SATELLITES—Power Supply.

**078461 ISSUES IN SPACE PHOTOVOLTAIC RESEARCH AND TECHNOLOGY.** This paper addresses key issues and opportunities in space photovoltaic research and technology relative to future NASA mission requirements and drivers. Examples are given of future space missions and/or operational capabilities that are on NASA's planning horizon that present major technology challenges to the use of photovoltaic power generation in space. A brief description of the capabilities ascribed to the competing technologies of nuclear and solar thermal power systems is given. The performance goals that space photovoltaic power systems must meet to remain competitive are described. (Edited author abstract) 14 refs.

Flood, Dennis J. (NASA, Lewis Research Cent, Cleveland, OH, USA). *NASA Tech Memo* 89922 1987 14p.

**078462 RECENT PROGRESS IN SPACE PHOTOVOLTAIC SYSTEMS.** This paper addresses key issues and opportunities in space photovoltaic research and technology relative to future NASA mission requirements and drivers. Examples are given of future space missions and/or operational capabilities that present major technology challenges to the use of photovoltaic power generation in space. The status of cell R&D and the performance goals that space photovoltaic power systems must meet to remain competitive is described. (Edited author abstract) 17 refs.

Brandhorst, Henry W. Jr. (NASA, Cleveland, OH, USA); Flood, Dennis J.; Weinberg, Irving. *NASA Tech Memo* 100208 Nov 1987 11p.

**078463 SPACE PHOTOVOLTAIC RESEARCH AND TECHNOLOGY 1986: HIGH EFFICIENCY, SPACE ENVIRONMENT, AND ARRAY TECHNOLOGY.** This conference proceedings contains 41 papers, one of which is in abstract form only. The conference includes five workshops on space applications of photovoltaic and solar cell technology. The workshop topics are high power/large area systems, opportunities for PV applications, gallium arsenide high efficiency limits, device modeling, and indium phosphide materials/cell fabrication. Also discussed are radiation effects and radiation damage, semiconductor material growth techniques, and methods to improve conversion efficiencies. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10485 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

neering Information, Inc.

Anon (NASA, Washington, DC, USA). *NASA Conf Publ* 2475, Space Photovoltaic Res and Technol 1986: High Effic, Space Environ, and Array Technol, Cleveland, OH, USA, Oct 7-9 1986. Publ by NASA, Washington, DC, USA, 1986 390p.

**Stability** See SOLAR CELLS—Cadmium Sulfide.

**Testing**

**078464 NEW MEASURED Z-VALUES AND THEIR EFFECTS ON THE VOLTAGE EFFICIENCY OF VCl<sub>3</sub>-THIONINE PHOTO GALVANIC SYSTEM.** In this paper, new Z-values for twenty pure solvents and their aqueous mixtures at 25%, 50% and 75% water by volume have been determined by using 1-methyl-4-carbomethoxy-pyridinium iodide at room temperature. The effect of pure solvents and their water mixtures on the VCl<sub>3</sub>-Thionine photogalvanic system has been investigated. The voltage efficiency of the photogalvanic cell was determined for each solution and was related with the Z-values. The results show that the highest voltage efficiency was obtained with acetonitrile and acetone and aqueous mixtures of these two solvents. (Edited author abstract) 27 refs.

Aliwi, S.M. (Solar Energy Research Cent, Baghdad, Iraq); Hanna, E.M. *J Sol Energy Res* v 5 n 2 Sep 1987 p 39-52.

**078465 PHOTOVOLTAIC COMPONENTS AND SYSTEMS TESTING: A PROPOSED PROGRAM.** Since the application of PV power systems has rapidly increased in Indonesia, and hence the need for information on PV components, subsystems and systems, a facility and capability for testing their performance need to be established. This facility is being developed to ensure that the PV components, subsystems and systems used in Indonesia meet the established standards and specifications. 6 refs.

Moehtar, Meirios (BPP Teknologi, Jakarta, Indones); Juwono, Melanie. *Sunworld* v 11 n 1 1987 p 17-19, 28.

**Thermal Effects**

**078466 MIRAGE EFFECT IN PHOTOELECTROCHEMISTRY.** The mirage effect can be used to characterize the power dissipation mechanisms of solid-state photovoltaic cells. The present work discusses the mirage effect in a photoelectrochemical cell, with the specific purpose of demonstrating that both thermal and concentration waves contribute to the beam deflection experiments and that the two effects can be separated only with a careful choice of the experimental conditions. 4 refs.

Decker, Franco (UNICAMP, Campinas, Braz); Fracastoro-Decker, Marietella. *J Electroanal Chem Interfacial Electrochem* v 243 n 1 Mar 10 1988 p 187-191.

**Thin Films** See Also SOLAR CELLS—Thin Films.

**078467 VOLTAIC CELLS OF (Zn<sub>1-x</sub>Cu<sub>x</sub>)<sub>2</sub>O<sub>3</sub> THIN FILMS DEPOSITED BY R.F. SPUTTERING.** The growth of (Zn<sub>28-42</sub>Cu<sub>39-25</sub>)O<sub>33</sub> thin films deposited by r.f. sputtering was studied. Voltaic elements with an ITO/(Zn, Cu)O/Al structure (where ITO is indium tin oxide) were fabricated. The open-circuit voltage and short-circuit current at temperatures of 0-45°C were 0.5-1.25 V and 0.3-1.5  $\mu$ A cm<sup>-2</sup> respectively. The composition of the films was studied by Auger analysis. (Author abstract) 5 refs.

Fujinaka, Masaharu (Tokyo Denki Univ, Tokyo, Jpn); Tanaka, Toru; Satoh, Toshimi. *Thin Solid Films* v 152 n 3 Sep 28 1987 p 443-448.

**078468 CELLE FOTOVOLTAICHE A FILM SOTTILE DI SILICIO AMORFO. [Thin Film Amorphous Silicon Photovoltaic Cells].** Thin film amorphous silicon photovoltaic cells promise efficient conversion of solar energy and production costs capable of generating, in medium-long term, economically competitive electric power. Characteristics of the material require structures of

the device that are different from those used in the crystalline material. The principles of operation of these structures, the configurations most frequently used, the factors limiting the performance, and some solutions to improve efficiency and stability are analyzed. The structure and the process of fabrication of amorphous integrated models are finally briefly described. (Translated author abstract). 6 Refs. In Italian.

Galluzzi, F. (Eniricerche SpA, Rome, Italy). *Alta Freq* v 57 n 3 Apr 1988 p 33-42.

**Transients**

**078469 TRANSIENTS IN CIRCUITS WITH PHOTOVOLTAIC CELLS.** The authors investigated electric processes in circuits with photovoltaic cells arising with sudden switching of the load. The article gives basic equations and results of computer calculations. The procedure for the experiment is covered, and a comparison is made of the calculated and experimental investigations. (Author abstract) 7 refs.

Vasil'ev, V.V.; Zayavlin, V.R.; Letin, V.A.; Khotuntsev, Yu.P. *Appl Sol Energy* v 23 n 4 1987 p 1-4.

**Transport Properties**

**078470 ELECTRICAL TRANSPORT PROPERTIES OF POLYCRYSTALLINE CuInSe<sub>2</sub> FILMS.** Electrical conductivity and Hall effect measurements were made on CuInSe<sub>2</sub> films prepared by coevaporation. The films were characterized as grown and after annealing in a 90 percent N<sub>2</sub> + 10 percent H<sub>2</sub> atmosphere. The hole density was in the interval 10<sup>13</sup>-10<sup>19</sup> cm<sup>-3</sup>. The conductivity activation energy ranged from 0.03 to 0.5 eV in the range 300-400 K. The hole density decreased and the mobility increased with the annealing process. Grain boundary trapping models were considered in the analysis of the results. Compensation effects, partial or total depletion of the grains, and variations in the compensation ratio and the trap density with annealing were observed. (Author abstract). 28 Refs.

Garcia-Cuenca, M.V. (Univ de Barcelona, Barcelona, Spain); Manchon, M.; Varela, M.; Lousa, A.; Morenza, J.L. *Sol Energy Mater* v 17 n 5 Aug 1988 p 347-355.

**PHOTOVOLTAIC EFFECTS** See Also PHOTOVOLTAIC CELLS—Thermal Effects; SEMICONDUCTING GALLIUM COMPOUNDS—Spectroscopic Analysis; SEMICONDUCTING SILICON—Charge Carriers; SOLAR CELLS—Fabrication; SOLAR ENERGY; TUNGSTEN COMPOUNDS—Thin Films.

**078471 PHOTOVOLTAIC EFFECT OF AN INSULATING POLYMER-HYBRIDIZED p-Si SOLAR CELL.** The authors report on a photovoltaic cell in which a p-Si electrode is hybridized with an insulating polymer. The well-known photovoltaic effect of a MIS (Metal-Insulator-Semiconductor) cell is based on the Schottky barrier and therefore the cell represents rectification. The photovoltaic cell has a structure similar to that of a MIS cell but shows peculiar current-voltage (I-V) characteristics. 6 refs.

Yamamura, Soichiro (Government Industrial Research Inst, Ikeda, Jpn); Kojima, Hiroyuki. *J Electroanal Chem Interfacial Electrochem* v 241 n 1-2 Feb 10 1988 p 379-383.

**Applications** See PHOTODETECTORS; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Junctions.

**Mathematical Models** See SEMICONDUCTOR MATERIALS—Photovoltaic Effects.

**Measurements** See ELECTROOPTICAL MATERIALS—Physical Properties; SEMICONDUCTING SILICON—Electric Properties.

**Research** See SEMICONDUCTING ORGANIC COMPOUNDS—Charge Carriers.



**PHYSICAL CHEMISTRY** See Also ALUMINUM MAGNESIUM SAMARIUM ALLOYS—Phase Equilibria; CALCIUM COMPOUNDS—Composition Effects; CHLORINE COMPOUNDS—Chemical Reactions; CLAY MINERALS; CLAY MINERALS—Classification; COAL—Plasticity; ELECTRONIC PROPERTIES—Computer Aided Analysis; GALLIUM COMPOUNDS—Solvent Extraction; GERMANIUM COMPOUNDS; IRON COMPOUNDS—Thermal Effects; MATHEMATICAL TECHNIQUES—Graph Theory; MINERALS—X-Ray Analysis; ORGANIC COMPOUNDS—Thermal Effects; POLYMERS—Mathematical Models; SILICATES—Phase Transitions; SILVER COMPOUNDS—Solubility; SOLUTIONS—Thermodynamic Properties; STEELMAKING—Ladle Process; SURFACE ACTIVE AGENTS; VAPORS.

**078472 ASSOZIATIONSVERHALTEN UND DIPOLMOMENTE VON TETRA(N-BUTYL)-AMMONIUMPERTECHNETAT UND TETRA(N-BUTYL)AMMONIUMPERCHLORAT IN BENZOL.** [Association Behavior and Dipole Moments of Tetra-n-butylammonium Pertechnetate and Tetra-n-butylammonium perchlorate in Benzene]. At very low concentrations tetra-n-butylammonium pertechnetate and tetra-n-butylammonium perchlorate from ion pairs in benzene solutions. At room temperature, formation of dimers and larger aggregates begins to occur at concentrations of  $10^{-5}$  mol/l. This behavior has been investigated quantitatively by the determination of the molecular weight in the case of the perchlorate salt, and by the concentration-dependence of the pertechnetate phase equilibrium between water and benzene. It is demonstrated that  $\text{Bu}_4\text{NTO}_4$ -dimers and larger aggregates have no apparent dipole moment. (Edited author abstract) In German. 17 refs.

Maier, Ralph (Kernforschungszentrum Karlsruhe, Karlsruhe, West Ger); Kanellakopoulos, Basil. *Ber Bunsenges Phys Chem* v 92 n 2 Feb 1988 p 123-127.

## Adsorption

**078473 ELECTRONIC STRUCTURE OF CHEMISORBED FORMATE LAYERS ON COPPER SURFACES.** Much can be learned about the bonding of adsorbates on transition- and noble-metal surfaces from calculations of the electronic structure of chemisorbed overlayers on thin slabs. We demonstrate the technique here applied to formate on copper (100) and (110) surfaces. After consideration of the molecular orbitals of the free formic acid and formate radicals, we show the changes in electronic structure accompanying chemisorption in the various potential surface sites suggested by LEED, X-ray absorption, and vibrational spectra. For both atop and bridge sites occupied adsorbate bands fall into three main groups, 12 ( $4a_1$ ), 9 ( $5a_1$ ,  $3b_1$ ,  $1b_2$ ) and 5 ( $1a_2$ ,  $6a_1$  and  $4b_1$ ) eV below  $E_F$ , close to the peaks seen in photoemission studies; the closest agreement is probably for the formate in bridge sites, oriented along with its oxygen atoms almost directly above surface copper atoms. (Author abstract) 25 refs.

Bullett, D.W. (Univ of Bath, Bath, Engl); Dawson, W.G. *Prog Surf Sci* v 25 n 1-4 1987 p 275-284.

## Coagulation

**078474 NUMERICAL EVALUATION OF SELF-PRESERVING SPECTRA IN SMOLUCHOWSKI'S COAGULATION THEORY.** The cluster size distribution  $c_k(t)$  in aggregation and coagulation phenomena for large cluster sizes  $k$  and large times  $t$  approaches a scaling form of self-preserving spectrum  $c_k(t) \approx s^{-2}(\phi(k/s))$ , where  $s(t)$  is the mean cluster size. In a mean field approach the scaling form  $\phi(x)$  is described by a nonlinear integrodifferential equation, obtained from Smoluchowski's coagulation equation. To verify some theoretical predictions and to provide quantitative information on the scaling form we develop a fixed point method to determine numerical solutions of this equation for aggregation rate constants  $K(s,y) = \alpha y^\beta + \gamma x^\beta$  with  $\alpha > \beta$  and  $\beta < 0$  (class III models), where  $\phi(x)$  is bell-shaped, and we study the crossover to class II models ( $\beta = 0$ ), where  $\phi(x) \approx x^{-\tau}$  as  $x \rightarrow 0$ , and calculate the exponent  $\tau$ . (Author abstract) 14 refs.

Meesters, A. (State Univ of Utrecht, Utrecht, Neth);

Ernst, M.H. *J Colloid Interface Sci* v 119 n 2 Oct 1987 p 576-587.

## Computer Aided Analysis

**078475 COMPUTER-AIDED FORMULATION.** Currently available on the market are new, low-cost personal computer (PC) software packages that can considerably reduce the theoretical work of physical properties analysis and of formulating for specific target properties. A software system previously developed for smaller paint manufacturers can computerize batch ticketing, cost analysis, physical properties analyses, inventory, and MSDs (material safety data sheets).

Peck, Randy D. (Pacific Micro Software Engineering). *J Radiat Curing* v 14 n 4 Oct 1987 p 5-6, 8, 10.

**Computer Simulation** See ADSORPTION—Mathematical Models.

**Crystallization** See CRYSTALLIZATION—Mathematical Models.

**Desorption** See ORGANIC COMPOUNDS—Desorption.

**Diffusion** See DIFFUSION—Mathematical Models.

## Flocculation

**078476 HYDROPHOBIC FLOCCULATION.** Aggregation and flocculation of dispersed clays and silica by cationic polyelectrolytes depends upon the nature of the solids and the solution properties of the polyelectrolytes. The energy required for the formation of aggregates or flocs is provided by hydrophobic interactions between polymer molecules adsorbed onto adjacent particles. Polymer performance is directly related to the mass of polymer which can be added to the system before the overtreatment regime is reached. (Author abstract) 31 refs.

Parazak, Dennis P. (Petrolium Corp, St. Louis, MO, USA); Burkhardt, Charles W.; McCarthy, Kevin J.; Stehlin, Mark P. *J Colloid Interface Sci* v 123 n 1 May 1988 p 59-72.

**Mathematical Models** See Also CALCIUM COMPOUNDS; LIQUIDS—Bubble Formation; MATERIALS SCIENCE—Sublimation; MINERALS—Flocculation; POLYMERS—Grafting; SPHERES—Electric Field Effects; SURFACE ACTIVE AGENTS—Analysis; SURFACES—Mathematical Models.

**078477 EQUILIBRIUM SHAPES OF LIQUID BRIDGES UNDER GRAVITY: SYMMETRY BREAKING AND IMPERFECT BIFURCATIONS OF TWO-DIMENSIONAL BRIDGES.** The equilibrium shapes of a two-dimensional liquid bridge are constructed via a shooting and continuation numerical solution of the Laplace-Young equation which focuses on the bifurcation point of the solution branches. With the introduction of gravitational effects, this codimension 5 singularity is retained although the critical contact angle decreases slightly below  $90^\circ$  as one increases the difference between the interior and the exterior densities. However, when a slight tilt angle is introduced to the bridge, the maximum pressure singularity degenerates into two turning points (folds) and the solution branches are isolated from each other. This indicates that hysteretic jumps in the surface curvature and excess pressure exist with respect to changes in diameter/length ratio or liquid volume. Our numerical solution also reveals the existence of a maximum bridge volume that can be sustained by a nonneutrally buoyant bridge. No equilibrium shapes, symmetric or asymmetric, exist for bridge volumes beyond this critical value. (Edited author abstract) 19 refs.

Chen, Liang-Heng (Univ of Houston, Houston, TX, USA); Chang, Hsueh-Chia. *J Colloid Interface Sci* v 120 n 2 Dec 1987 p 377-388.

**078478 INFLUENCE OF VOLUME-RESTRICTION EFFECT ON PHASE SEPARATION PHENOMENA IN STERIC DISPERSIONS.** Steric systems

such as paints, inks, milk and other dairy products, and biocolloids such as tissue and blood cells and protein solutions form a significant class of practically and theoretically important dispersions. The volume-restriction effect in steric systems is examined. (Edited author abstract) 42 refs.

Cates, D.L. (Syracuse Univ, Syracuse, NY, USA); Hirtzel, C.S. *J Colloid Interface Sci* v 120 n 2 Dec 1987 p 404-418.

**078479 SIMPLE MODEL FOR SUSTAINED OSCILLATIONS IN ISOTHERMAL BRANCHED-CHAIN OR AUTOCATALYTIC REACTIONS IN A WELL-STIRRED OPEN SYSTEM. III MULTIPLE STATIONARY STATES AND HOPF BIFURCATIONS.** A model is proposed for autocatalytic or branched-chain chemical systems, including some aspects of the oxidations of hydrogen or of carbon monoxide. Similar rate laws may arise in biochemical situations. The important parameters for this system are: the relative concentration of A and B in the inflow; the relative rates of reactions (1) and (2); the mean residence time and the saturation term. The system shows multiple stationary states. Sustained oscillatory reaction is also possible. This begins at Hopf bifurcation points. Degenerate bifurcations, of different types, have also been located, and tracked through the parameter space by numerical path-following techniques developed during this investigation. (Edited author abstract). 27 Refs.

Brindley, J. (Univ of Leeds, Leeds, Engl); Kaas-Petersen, C.; Merkin, J.H.; Scott, S.K. *Proc R Soc London Ser A* v 417 n 1853 Jun 8 1988 p 463-496.

**Measurements** See GELS—Electric Field Effects; LIQUIDS—Surface Tension.

**Phase Diagrams** See AMMONIUM COMPOUNDS—Phase Diagrams.

**Solubility** See EMULSIONS—Theory.

## Spectroscopic Analysis

**078480 EXPERIENCE IN USE OF SYNCHROTRON RADIATION IN SOLID STATE CHEMISTRY STUDIES.** The characteristics of chemical reactions in solids - (1), local process, (2) high velocity, (3) nuclei formation in the crystal volume - makes special methods of investigation necessary. In this work it is shown that investigations of structural transformation which accompany chemical reactions proceeding at a high rate in local regions either in the volume, or on the crystal surface, are possible due to the unique peculiarities of synchrotron radiation. (Author abstract) 6 refs.

Boldyrev, Vladimir V. (Inst of Solid State Chemistry, Novosibirsk, USSR); Gaponov, Yuri A.; Lyakhov, Nikolai Z.; Politov, Anatolii A.; Tolochko, Boris P.; Shakhshneider, Tatjana P.; Sheromov, Mikhail A. *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 192-199.

**Theory** See CHEMICAL REACTIONS—Thermodynamics; FLUIDS—Physical Properties.

**Thermodynamics** See ETHERS—Physical Chemistry; THERMODYNAMICS—Computer Aided Analysis.

**Van der Waals Force** See CARBON FIBER—Adsorption; CHEMICAL OPERATIONS—Agglomeration; CRYSTALS—Anisotropy; FLUORSPAR—Flotation; MIXING.

**X-Ray Analysis** See EMULSIONS—Phase Diagrams.

**PHYSICS** See Also CHARGED PARTICLES—Transport Properties; COMPUTERS, MICROCOMPUTER; ELECTROMAGNETIC WAVES—Scattering; ICE; MATHEMATICAL TECHNIQUES—Boundary Value Problems; SPRINGS—Design; TRITIUM.



**078481 ORIGIN OF LIFE AND PHYSICS: DIVERSIFIED MICROSTRUCTURE - INDUCEMENT TO FORM INFORMATION-CARRYING AND KNOWLEDGE-ACCUMULATING SYSTEMS.** The process leading to the origin and evolution of life is caused by the presence of distinct physical and chemical conditions at a distinct location in the universe. A specified system originates and evolves under the continuous influence of a complex operational environment. The system develops toward increasing independence of the original environment by becoming increasingly complex. Modeling a detailed scenario consisting of a sequence of reasonable physico-chemical steps is essential in rationalizing the phenomenon. The basic process, accumulation of knowledge by continuously testing environmental properties, is intimately related to the measuring process in physics. Evolution is a physical process, and this process leads to man developing physics. Thus physics appears to be self-consistent - the basis and consequence of evolution. The physics-producing system is considered to be a measuring and information-processing device based upon the mechanism which operates in the origin and evolution of life. (Author abstract) 27 refs.

Kuhn, Hans. *IBM J Res Dev* v 32 n 1 Jan 1988 p 37-46.

**078482 SPECIFICATION OF PHYSICAL ATTRIBUTE INFORMATION FOR ENGINEERING ANALYSIS.** This paper addresses the issue of specifying the functional information beyond that of the geometric domain of the object needed to qualify a problem in mathematical physics for which an engineering analysis is to be performed. A generalized geometry-based approach for the specification of this information is presented. This information, plus the domain definition to which it is tied, represents the complete specification of the problem to be analyzed. (Author abstract). 18 Refs.

Shehard, Mark S. (Rensselaer Polytechnic Inst, Troy, NY, USA). *Eng Comput (New York)* v 4 n 3 1988 p 145-155.

**Atomic** See Also ATOMIC BEAMS; BAND STRUCTURE; CHARGED PARTICLES—Scattering; CRYSTALS—Microanalysis; ELECTRODYNAMICS; ELECTRONS—Absorption; ELECTRONS—Emission; ELECTRONS—Transport Properties; EUROPIUM—Isotopes; GASES—Radiation Effects; HYDROGEN—Structure; HYDROGEN—Transport Properties; ION SOURCES; IONIZATION; IONIZATION—Theory; IONS—Transport Properties; LITHIUM AND ALLOYS—Radiation Effects; MATERIALS—Ion Implantation; METALS AND ALLOYS—Diffusion; METALS AND ALLOYS—Gases; MICROSCOPIC EXAMINATION; NEON—Ionization; ORGANOMETALLICS; OSCILLATORS; PARTICLE DETECTORS—Efficiency; PROTONS—Transport Properties; SILICON AND ALLOYS—Ion Implantation; SPECTROSCOPY, AUGER ELECTRON; SPECTROSCOPY, X-RAY; SPUTTERING—Computer Simulation; SPUTTERING—Mathematical Models; TITANIUM METALLOGRAPHY—Diffusion.

**078483 ION BEAM INDUCED ATOMIC MIXING IN Ti/SiC.** The effects of 100 keV  $N_2^+$  and  $Ar^+$  ion implantation on atomic mixing and the hardness in 400 Å Ti deposited SiC were investigated by means of Monte Carlo simulation, He backscattering, Auger electron spectroscopy, and Vickers indentation method. It was shown that the carbon concentration near the surface was increased remarkably by  $N_2^+$  ion implantation at 1000°C, and those C atoms formed TiC. The experimental results far exceed the results obtained by the Monte Carlo simulation based on binary collision model. It was concluded that the C atoms, which originated from lattice sites in SiC by collision cascades, would migrate to the upper Ti layer by radiation enhanced thermal diffusion and react with Ti atoms. (Author abstract) 35 refs.

Miyagawa, Y. (Government Industrial Research Inst, Nagoya, Jpn); Miyagawa, S. *Nucl Instrum Methods Phys Res Sect B* v B28 n 1 Aug 1987 p 27-33.

**078484 PHYSICAL MEANING OF NONELECTROMAGNETIC FIELDS IN A SPECIAL QUASICLASSICAL MODEL OF ATOMIC SYSTEMS.** It is assumed that to describe the quantum properties of an atomic system it is possible to introduce two nonelectromagnetic fields, one of which is described by the Schrödinger equation (the S-field), the other by the  $v$ -equation proposed by B.N. Rodimov (the K-field). Beginning with

the basic goal of the article, i.e., the construction of a quasiclassical model of an atomic system which details its inner structure, equations are obtained which determine the physical meaning of the K-field, and it is shown that it is not possible to construct analogous equations for the S-field. (Author abstract) 4 refs.

Korotchenko, F.B. (S.M. Kirov Polytechnical Inst, Tomsk, USSR). *Sov Phys J* v 30 n 3 Mar 1987 p 207-209.

**078485 RESTRUCTURING OF THE ATOMIC CONDENSED STATE UNDER CONDITIONS OF AN INTENSE EXTERNAL FIELD.** The ensemble of restructurable potential contours, the analysis of which permits modeling of the atomic state restructuring, is introduced. The corresponding changes in the behavior of the collective mode spectrum is analyzed. The mutually dependent restructuring of single-atom and collective states is examined. The spatial dependence of the hydrodynamic variables is considered in the framework of a field approach. The interpretation of specific physical phenomena on the basis of the developed formalism concludes the study. 56 refs.

Olemskoi, A.I. (Acad of Sciences of the USSR, USSR); Petrunin, V.A. *Sov Phys J* v 30 n 1 Jan 1987 p 61-92.

**078486 SHAPE OF THE DELAUNAY SIMPLICES IN DENSE RANDOM PACKINGS OF HARD AND SOFT SPHERES.** Two novel shape parameters for Delaunay simplices are proposed which allow one to recognize slightly distorted tetrahedral and octahedral simplices. These simplex types are found to be the basic building units in dense packings of hard and soft spheres. (Author abstract) 14 refs.

Medvedev, N.N. (USSR Acad of Sciences, Novosibirsk, USSR); Naberukhin, Yu.I. *J Non Cryst Solids* v 94 n 3 Dec III 1987 p 402-406.

**078487 EXCITATION OF ATOMIC NUCLEI AND ATOMS BY RELATIVISTIC CHARGE PARTICLES BOUND IN A ONE-DIMENSIONAL POTENTIAL.** The process of exciting atoms and atomic nuclei by relativistic electrons and positrons bound in a one-dimensional potential is investigated theoretically. It is shown that a pole corresponding to the emergence of a virtual photon on a bulk surface occurs in the matrix interaction element under definite kinematic relationships. It is obtained that the probability of the excitation process depends on the lifetime of the level being excited, the virtual photon, and the charged particle in a definite energetic state. An estimate of the magnitude of the excitation section of low-lying nuclear states yields a value exceeding by several orders the section obtained for charge particles in the absence of a binding potential. (Author abstract) 8 refs.

Almaliev, A.N. (Lenin Komsomol Pedagogical Inst, Tomsk, USSR); Batkin, I.S.; Kopytin, I.V. *Sov Phys J* v 30 n 5 May 1987 p 362-366.

**078488 ON THE USE OF E-r AND A-p IN PERTURBATION CALCULATIONS OF TRANSITION INTENSITIES FOR PARAMAGNETIC IONS IN SOLIDS.** Perturbation calculations of the probability amplitudes for electric dipole transitions, particularly the 'parity forbidden' transitions within the  $1N$  configuration of paramagnetic ions in solids, are discussed. In general, the same results are obtained for the A-p and E-r forms of the atom-radiation interaction only if gauge invariance is properly accounted for. (Author abstract) 20 refs.

Reid, Michael F. (Univ of Hong Kong, Hong Kong). *J Phys Chem Solids* v 49 n 2 1988 p 185-189.

**078489 INFLUENCE OF INITIAL CONDITIONS ON SQUEEZING AND ANTI-BUNCHING IN THE JAYNES-CUMMINGS MODEL.** We have carried out a detailed investigation of squeezing and anti-bunching in the Jaynes-Cummings model, thereby extending the earlier work of Meystre and Zubairy. Analytic criteria are formulated relating the initial states of atom and field to the tendency of the field to undergo squeezing or anti-bunching when the atom enters the cavity. Some

interesting connections are established between atomic squeezing and field squeezing/anti-bunching. Using the initial conditions suggested by our criteria, we explore the generation of non-classical states of the cavity field. The relationship of our work to other recent work on squeezing and anti-bunching in the Jaynes-Cummings model is discussed. (Author abstract) 27 refs.

Aravind, P.K. (Worcester Polytechnic Inst, Worcester, MA, USA); Hu, Guanghui. *Physica B & C* v 150 n 3 Jun 1988 p 427-439.

**078490 LIGHT SQUEEZING IN THE TWO-ATOM ONE-MODE MODEL WITH MULTI-PHOTON TRANSITIONS.** The generation of squeezed states of the cavity radiation field in the two-atom one-mode model with multi-photon transitions is investigated. The time-dependent squeezing factors are calculated. The conditions for optimum squeezing are derived. (Author abstract) 20 refs.

Kien, Fam Le (Joint Inst for Nuclear Research, Moscow, USSR); Kadantseva, E.P.; Shumovsky, A.S. *Physica B & C* v 150 n 3 Jun 1988 p 445-456.

**078491 HEXADECAPOLE REORIENTATION IN COULOMB EXCITATION.** The possibility of measuring static hexadecapole moments of nuclei is canvassed. Attention is restricted to hexadecapole moments of first excited states of even-even nuclei. Two schemes of measurement are explored. Both suffer from problems which make their implementation difficult. (Author abstract) 37 refs.

Fewell, M.P. (Australian Natl Univ, Canberra, Aust). *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 202-208.

**078492 PARAMETERIZED CROSS SECTIONS FOR COULOMB DISSOCIATION IN HEAVY-ION COLLISIONS.** Simple parameterizations of Coulomb dissociation cross sections for use in heavy-ion transport calculations are presented and compared to available experimental dissociation data. The agreement between calculation and experiment is satisfactory considering the simplicity of the calculations. (Author abstract) 16 refs.

Norbury, John W. (Univ of Idaho, Moscow, ID, USA); Cucinotta, F.A.; Townsend, L.W.; Badavi, F.F. *Nucl Instrum Methods Phys Res Sect B* v B31 n 4 Jun 1 1988 p 535-537.

**078493 STARK-BROADENING OF Ar I LINES.** The half-width and shift of some Stark-broadened Ar I lines are measured using a highly-stabilized argon arc at different electron densities. The relation of the ratio of the half-width over the plasma electron density as a function of the electron density itself, for the isolated argon line, 4300 Å, shows an excellent agreement with the theory. This argon line may therefore be used for the accurate determination of the electron density in argon plasma sources. The line profile is analysed and discussed. (Author abstract). 14 Refs.

Abbas, A. (Assiut Univ, Egypt); Basha, T.S.; Abdel-Aal, Z.A. *Jpn J Appl Phys Part 1* v 27 n 5 May 1988 p 801-803.

**078494 THEORY OF COUPLING OF ELECTRONIC SYSTEMS: EXPERIMENTAL STRUCTURES USING ADVANCED LITHOGRAPHIC TECHNIQUES.** This paper focuses on the physics of disorder-induced localization and the important role of advanced material microfabrication technology for realizing novel microstructures as physical models. Present and future microfabrication capabilities for tailoring materials in the submicron and ultramicroscale range offer the opportunity to fabricate controllable physical models, approaching atomic scale, for the fundamental study of coupling of electronic systems and the effect of dimensionality on transport properties. These physical models will require the ingenious exploitation of advanced lithographic/patterning techniques for controlling lateral dimensions, particularly if this is combined with advanced



vapor or molecular beam deposition technique for controlling vertical dimensions. The type of studies discussed here has great significance in understanding and designing highly-dense very large-scale/ultra large-scale integrated (VLSI/ULSI) circuits and interconnecting-lines-dominated neural network IC systems, as well as in the studies of the scaling theories of localization. It is expected that these studies will lead to the design of novel device concepts. (Author abstract) 39 refs.

Buot, F.A. (US Naval Research Lab, Washington, DC, USA). *Superlattices Microstruct* v 3 n 4 1987 p 399-408.

**078495 STATISTICAL ASPECTS OF ION-ATOM COLLISIONS.** The maximum-entropy description of ion-atom collisions is reviewed. The method is illustrated by recent analyses of recoil charge distributions in electron-capture collisions and of final-state charge distributions in charge transfer from Rydberg atoms. (Author abstract) 39 refs.

Aberg, T. (Helsinki Univ of Technology, Espoo, Finl). *Nucl Instrum Methods Phys Res Sect A* v A262 n 1 Dec 1 1987, Phys of High Charged Ions Prod in Heavy Ion Collisions, Proc of the Second US/Jpn Semin, Kobe, Jpn, Mar 16-20 1987 p 1-5.

**078496 IRREGULARITIES IN THE DIFFERENTIAL AND INTEGRAL CROSS SECTIONS FIGURES FOR ION-ATOM COLLISIONS IN THE PLANE-WAVE BORN APPROXIMATION.** We discuss the generalized oscillator strength (GOS), a fundamental physical quantity that represents the response of an atom to the interaction with a charge. The GOS is related to the differential cross section for excitation in ion-atom collisions in the plane-wave Born approximation (PWBA). The GOS for a particular transition is a function of the momentum transferred from the relative motion to the atom. Approximate scaling of the GOS is sometimes found along an isoelectronic sequence, but is not found for those cases we have studied for which the GOS has a minimum. Two different mechanisms produce minima of the GOS; one is due essentially to nodes of one-electron radial wave functions, and the other is an effect of the configuration interaction that introduces an avoided crossing of energy levels plotted against the nuclear charge. A minimum of the GOS sometimes leads to a double-maximum structure of the integral cross section for ion-atom collisions in the PWBA, though one usually expects the PWBA to produce only one maximum. (Author abstract) 15 refs.

Iwai, Masahiro (Inst of Physical & Chemical Research, Wako, Jpn); Shimamura, Isao; Watanabe, Tsutomu. *Nucl Instrum Methods Phys Res Sect A* v A262 n 1 Dec 1 1987, Phys of High Charged Ions Prod in Heavy Ion Collisions, Proc of the Second US/Jpn Semin, Kobe, Jpn, Mar 16-20 1987 p 37-41.

**078497 ATOMIC LIFETIME MEASUREMENTS USING RECOIL IONS.** Recoil ions are the secondary ions produced in energetic collisions of highly-charged heavy ions with atoms. The advantages and problems of using recoil ions for atomic lifetime measurements are outlined. Three types of experiments are discussed: a) pulsed primary ion beam and electronic lifetime measurement (in the ns range) of ions inside the target gas; b) time-of-flight measurements with position-sensitive detection on beams of recoil ions extracted from the production target (sub- $\mu$ s range); and c) external trapping of charge-state analysed recoil ions (up to ms). (Edited author abstract) 36 refs.

Traebert, E. (Ruhr-Univ Bochum, West Ger); Hubricht, G.; Hellman, H.M. *Nucl Instrum Methods Phys Res Sect B* v B31 n 1-2 Apr II 1988, Proc of the Symp on At Spectrosc and Highly Ionized At, Lisle, IL, USA, Aug 16-21 1987 p 290-293.

**Computer Aided Analysis** See Also MATHEMATICAL TECHNIQUES—Finite Element Method.

**078498 FINITE ELEMENTS IN PHYSICS, PROCEEDINGS OF THE 1ST EUROPEAN GRADUATE**

**SUMMER COURSE ON COMPUTATIONAL PHYSICS.** This publication contains 11 papers by various authors dealing with finite elements in physics. Major topics covered are: basic course in finite element methods (FEM), FEM to solve the Navier-Stokes equations, hyperbolic equations, Schrodinger equations; MHD analysis, plasma physics; material science; turbulence; solution of matrix problems and treatment of nonlinear partial differential equations by a continuation method. All papers are abstracted and indexed separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10544 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Gruber, R. (Ed.) (Ecole Polytechnique Federale de Lausanne, Switz). *Comput Phys Rep* v 6 n 1-6 Aug 1987, Finite Elem in Phys, Proc of the 1st Eur Grad Summer Course on Comput Phys, Lausanne, Switz, Sep 1-10 1986 414p.

**Computer Applications** See COMPUTER PROGRAMMING—Subroutines; COMPUTER SOFTWARE—Software Engineering.

**Education** See Also ENGINEERING EDUCATION—Computer Applications.

**078499 DEVELOPMENT OF SEVERAL OHP EQUIPMENT OF PHYSICS USING MOIRE PATTERNS.** This paper reports on several simple OHP equipments for education using Moire patterns. The first equipment is concerned with centrifugal waves. The Moire pattern is produced by superposing two specified patterns composed of straight lines and curves. The two patterns are determined as functions of the wave propagation velocity. The second is the fluid model used in demonstrating such notions in vector analysis as divergence. The spiral traveling wave is simulated using the reverse Moire, which is a counterpart of the Moire technique. The third is the equipment to simulate the electric lines of force produced by a pair of point charges and is used in teaching electromagnetics. The patterns are designed also for easy understanding of Moire phenomena. (Edited author abstract) 9 refs.

Kitagaki, Ikuo (Employment Promotion Corp, Sagami, Jpn). *Electron Commun Jpn Part 1* v 70 n 8 Aug 1987 p 1-10.

**078500 COMPUTERIZED PENDULUM EXPERIMENT FOR THE INTRODUCTORY PHYSICS LABORATORY.** A Commodore 64 micro computer is used to control a simple pendulum experiment. The computer is interfaced to an interruptable light beam. It measures the pendulum parameters with good accuracy. The experiment is organized in three parts: (i) Tutorial: The student works through a tutorial based on an animated pendulum in preparation for the real experiment. (ii) Experiment (a): The student measures the pendulum parameters using conventional techniques. The computer constantly supervises the experiment and points out mistakes to the student. (iii) Experiment (b): The student uses the computer as an electronic measuring device to examine the relationship between period and amplitude. (Author abstract) 4 refs.

Van Staden, Johan C. (Univ of Pretoria, Pretoria, S Afr); Braun, Max W.H.; Van Tonder, B.J.E. *Comput Educ* v 11 n 4 1987 p 281-292.

**High Energy** See Also ACCELERATORS—Design; ACCELERATORS—Storage Rings; CALORIMETERS—Components; CALORIMETERS—Calibration; CALORIMETERS—Computer Simulation; CALORIMETERS—Performance; CALORIMETERS—Testing; CALORIMETRY; CHARGED PARTICLES—Measurements; CHARGED PARTICLES—Spectrum Analysis; COMPUTER AIDED ANALYSIS; COMPUTER INTERFACES; COMPUTER SIMULATION—Applications; COMPUTER SYSTEMS, DIGITAL—Parallel Processing; COSMIC RAYS; COSMIC RAYS—Measurements; DATA PROCESSING—Data Acquisition; DATA STORAGE, DIGITAL—Cellular Arrays; DATA STORAGE, OPTICAL; DOSIMETRY—Mathematical Models; ELECTROMAGNETIC FIELD THEORY; ELECTRON TUBES; PHOTOMULTIPLIER—Applications; ELECTRON TUBES, PHOTOMULTIPLIER—Performance; ELECTRONS—Transport Properties; GEIGER COUNTERS—Electrodes; INTEGRATED

CIRCUITS—Design; IONIZATION CHAMBERS; LASERS, SOLID STATE—Q Switching; NUCLEAR INSTRUMENTATION; PARTICLE BEAM TRACKING; PARTICLE BEAM TRACKING—Electronic Equipment; PARTICLE DETECTORS; PARTICLE DETECTORS—Calibration; PARTICLE DETECTORS—Design; PARTICLE DETECTORS—Imaging Techniques; PARTICLE DETECTORS—Testing; PATTERN RECOGNITION—Computer Applications; PLASMA—Production; PROPORTIONAL COUNTERS; QUANTUM THEORY; RADIATION DETECTORS; RADIATION DETECTORS—Reviews; RADIATION EFFECTS; SCINTILLATION COUNTERS—Materials; SIGNAL PROCESSING—Digital Techniques; SUPERCONDUCTING MAGNETS—Cooling; TIME MEASUREMENT.

**078501 A-RELATION OF THE DIFFERENTIAL CROSS SECTION OF PHOTOPRODUCTION OF  $\pi^+$ -MESONS IN NUCLEI AT LOW ANGLES IN A RANGE OF  $P_{33}$ -RESONANCE.** Data are cited about the A-relation of the differential cross section of photoproduction of  $\pi^+$ -mesons in nuclei of  $^6\text{Li}$ ,  $^{12}\text{C}$ ,  $^{27}\text{Al}$ , Cu, and Cd (Cu, Cd - a natural mixture of isotopes) for a medium angle of meson escape of approximately  $10^\circ$  in c.m.s. (center of mass system) in an energy range of approximately 300-500 MeV. It is shown that the index of the A-relation is greatly changed with consideration of the difference in the measured points of the form factors of the nuclei and the meson escape angles. (Author abstract) 4 refs.

Belousov, A.S.; Vazdik, Ya. A.; Malinovskii, E.I.; Ruskov, S.V.; Smirnov, P.A.; Solov'ev, Yu. V.; Usik, A.P.; Terkulov, A.R.; Fomenko, A.M. *Sov Phys Lebedev Inst Rep* n 2 1987 p 13-15.

**078502 VECTOR POLARIZATION OF DEUTERONS IN THE  $pp \rightarrow d\pi^+$  REACTION.** The vector polarization of deuterons near the threshold of generation of pions is calculated in the  $pp \rightarrow d\pi^+$  reaction with unpolarized and polarized protons. The results are compared with a unique experiment in this energy range. (Author abstract) 4 refs.

Efrosinin, V.P.; Zaikin, D.A.; Osipchuk, I.I. *Sov Phys Lebedev Inst Rep* n 2 1987 p 20-23.

**078503 NONRELATIVISTIC POTENTIAL MODEL AND THE PROPERTIES OF LIGHT AND HEAVY MESONS.** The possibility of simultaneous description of light and heavy mesons in a potential model is discussed. The levels and lepton widths are calculated for bottomonium with the use of an exponential potential, and predictions for toponium are given. (Author abstract) 14 refs.

Efrosinin, V.P.; Zaikin, D.A. *Sov Phys Lebedev Inst Rep* n 2 1987 p 24-27.

**078504 ENERGY RELATION OF THE TOTAL CROSS SECTIONS OF STRONG INELASTIC INTERACTION IN NUCLEAR-NUCLEAR COLLISIONS BASED ON A MODEL OF QUARK-GLUON JETS.** The total cross sections of strong inelastic interaction are calculated and their parametrization is acquired for a number of nuclei which interact with uranium and a nuclear photoemulsion up to values of the Lorentz factor of  $\gamma \approx 10^6-10^7$ . (Author abstract) 5 refs.

Goryachev, B.I.; Lin'kova, N.V. *Sov Phys Lebedev Inst Rep* n 2 1987 p 28-31.

**078505 INFLUENCE OF ELECTROSPALLATION OF RELATIVISTIC NUCLEI ON THEIR MEAN FREE PATH WITH RESPECT TO STRONG INELASTIC INTERACTION.** The cross sections of electrospallation of relativistic nuclei of varying atomic weight, which interact with uranium and a photoemulsion up to values of the Lorentz-factor of  $\gamma = 10^6-10^7$ , are calculated with consideration of screening. It is shown that the electrospallation reduces the mean free path with respect to strong inelastic interaction for the relativistic nuclei. (Author abstract) 4 refs.

Goryachev, B.I.; Lin'kova, N.V. *Sov Phys Lebedev Inst Rep* n 2 1987 p 32-36.



**078506 DYNAMIC MASS OF QUARKS IN A BAG MODEL.** The effect of the dynamic mass of quarks on the energy levels and wave functions of quarks is examined in a bag model. It is shown that corrections to these values caused by the dynamic mass do not exceed 1%, and cannot be experimentally detected with the current rate of precision. (Author abstract) 3 refs.

Solov'ev, A.A. *Sov Phys Lebedev Inst Rep* n 2 1987 p 54-56.

**078507 REINFORCING THE GRIBOV-SINGER THEOREM ABOUT GLOBAL CALIBRATION.** It is shown that in the non-Abelian field theory not only is there no global calibration, but even an incomplete global calibration, with which the residual group of symmetry is a finite Lie group, is impossible. (Author abstract) 10 refs.

Solov'ev, M.A. *Sov Phys Lebedev Inst Rep* n 2 1987 p 57-60.

**078508 GENERAL PROPERTIES OF THE POLARIZATION EFFECTS IN THE DECAYS.** The general structure is obtained of the polarization effects for the single-photon mechanism in the decays  $A \rightarrow B + l^+ + l^-$ . This structure takes into account possible violations of the P- and T-invariances in the electromagnetic interaction of hadrons. Use is made only of the principal properties of the electrodynamics of hadrons, such as the conservation of the hadronic electromagnetic current and the symmetry properties of the current under spatial and temporal reflections. (Author abstract) 13 refs.

Rekalo, M.P. (Physicotechnical Inst, Khar'kov, USSR). *Sov Phys J* v 30 n 4 Apr 1987 p 341-344.

**078509 PHOTON BREEDING OF SELF-QUENCHING STREAMERS (SQS).** A quantitative formalism for the photon breeding of the SQS is proposed and the number of breeding photons per electron is determined for argon-isobutane mixtures for concentrations of the quencher from 32% up to 60%. This number (probably in the region  $h\nu < 14$  eV) is about  $5 \times 10^{-2}$ . (Author abstract) 20 refs.

De Lima, E.P. (Univ de Coimbra, Coimbra, Port); Policarpo, A.J.P.L.; Salet, M.; Leite, S.C.P.; Ferreira, Marques, R. *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 368-374.

**078510 EXPERIMENTAL INVESTIGATIONS OF EXPLOSIVE, CYLINDRICAL MULTILAYER SYSTEM OF METAL LINERS ACCELERATED TO HIGH VELOCITIES.** This paper presents the results of theoretical and experimental investigations concerning the determination of possibility of utilizing the method for increasing the liner velocities in cylindrical explosive systems. A simple method of evaluating the parameters of multilayer systems and the results showing its possible applications are presented. The final part of the paper is devoted to the description of experimental system and presents the results of initial experiments. 17 refs.

Bagrowski, J.; Derentowicz, H.; Luckner, H. *J Tech Phys* v 28 n 1 1987 p 7-17.

**078511 ELECTROWEAK LEPTON DECAY IN THE EXTERNAL FIELD OF A PLANAR ELECTROMAGNETIC WAVE WITH CIRCULAR POLARIZATION.** The process of lepton decay into a W-boson and a neutrino and decay of a W-boson into a lepton and antineutrino in the field of a plane electromagnetic wave are considered within the framework of the Weinberg-Salam model. Exact expressions in terms of the external field are obtained for the probabilities of these processes and special cases are considered. (Author abstract) 10 refs.

Obukhov, I.A. (M.V. Lomonosov State Univ, Moscow, USSR); Perez-Fernandez, V.K.; Khalikov, V.R. *Sov Phys J* v 30 n 5 May 1987 p 383-387.

**078512  $Z \rightarrow e^+e^-$  DECAY IN A CONSTANT MAGNETIC FIELD.** In the one-loop approximation we calculate the electronic contribution to the elastic scatter-

ing amplitude of a Z-boson in a constant homogeneous magnetic field. Using this amplitude we obtain the probability of the decay of a Z-boson into an  $e^+e^-$  pair, and we investigate its dependence on the boson energy and the external field strength. (Author abstract) 11 refs.

Borisov, A.V. (M.V. Lomonosov State Univ, Moscow, USSR); Zhukovskii, V.Ch.; Knizhnikov, M.Yu.; Prokopenya, A.N. *Sov Phys J* v 30 n 5 May 1987 p 396-399.

**078513 SYSTEMS FOR PRESELECTION OF DESIRED EVENTS IN ACCELERATOR EXPERIMENTS (SURVEY).** Design principles of systems of data preselection in high-energy physics experiments are examined. Structures of selection systems used in actual experiments are given. (Author abstract) 33 refs.

Kantserov, V.A. (Moscow Engineering Physics Inst, USSR); Pershin, A.S. *Instrum Exp Tech* v 30 n 4 pt 1 Jul-Aug 1987 p 755-769.

**078514 CONFINEMENT EFFECTS AND THE  $e^+e^- \rightarrow \pi^+\pi^-\gamma$  REACTION.** The  $e^+e^- \rightarrow \pi^+\pi^-\gamma$  reaction is examined in a model where confinement is considered by the limitation of the spatial region of quark and gluon existence as free particles. It is shown that the influence of confinement on photon radiation leads to the observed effect. (Author abstract) 6 refs.

Dremin, I.M.; Nazirov, M.T. *Sov Phys Lebedev Inst Rep* n 7 1987 p 41-44.

**078515 CDF FORWARD MUON SYSTEM.** The general properties of the toroids, drift chambers and trigger counters in the CDF forward muon (FMU) system are discussed. The operation of the PSL time-to-digital converter and the UW HOPU (Half Octant Pattern Unit) module is also described. The forward muon level 1 trigger is presented. (Author abstract) 8 refs.

Byrum, K. (Univ of Wisconsin, Madison, WI, USA); Carlsmith, D.; Cline, D.; Handler, R.; Jaske, A.; Markosky, L.; Ott, G.; Pondrom, L.; Rhoades, J.; Sheaff, M.; Skarha, J.; Thompson, M.A.; Werner, M.; Winch, T. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 46-49.

**078516 PRECISE LIMIT OF THE NONPERTURBATIVE THREE-GLUON APICAL FUNCTION IN QCD<sub>3</sub>.** The precise limit of the nonperturbative three-gluon apical function for QCD<sub>3</sub> is found in an axial gauge when all of the pulses are collinear in the calibrating vector. The acquired expression is tested by direct calculation of the single-loop diagrams. (Author abstract) 7 refs.

Kalashnikov, O.K.; Casado, E. *Sov Phys Lebedev Inst Rep* n 8 1987 p 15-19.

**078517 SINGLE-LOOP CONTINUAL INTEGRAL IN THE O(2) STRING THEORY.** The single-loop continual integral in the O(2) string theory is calculated in a critical dimensionality of D = 2. Its precise correspondence to the two-dimensional quantum field theory is shown. (Author abstract) 13 refs.

Marshakov, A.V. *Sov Phys Lebedev Inst Rep* n 8 1987 p 24-28.

**078518 GREEN'S FUNCTIONS IN AN EXTERIOR GAUGE FIELD.** We consider the problem of evaluating the fermion Green's functions in an exterior Abelian-like gauge field. It is shown that in the field considered, the fermion Green's functions are expressed in terms of spinor particle Green's functions in some exterior electromagnetic field. The Green's functions are found in a combination of a constant homogeneous field and a plane wave field. (Author abstract) 12 refs.

Barashev, V.P. (Lenin Komsomol Tomsk Pedagogical Inst, USSR); Likhtshter, I.M.; Shvartsman, Sh. M. *Sov Phys J* v 30 n 9 Sep 1987 p 780-783.

**078519 COMPUTERS IN HIGH-ENERGY PHYSICS.** High-energy physics is a branch of science whose roots might be considered to go back to the pioneering experiment of Cockcroft and Walton in 1932 which, using

a beam of accelerated protons to split the lithium nucleus into two helium nuclei, demonstrated that the atomic nucleus was divisible. This field of research shares a common feature with computers - its dependence on progress in electronics to provide it with the capability to increase both the scale and the complexity of its performance. In this article we shall examine the use and impact of computers throughout the realm of high-energy physics research. It is the aim of this article not only to set out the way in which high energy physics has come to rely totally on computing, but also to point to those areas in which this field of research has itself been able to stimulate developments in computing. 60 refs.

Metcalfe, Michael (CERN, Geneva, Switz). *Adv Comput* v 25. Publ by Academic Press Inc, Orlando, FL, USA, 1986 p 277-334.

**078520 THREE-DIMENSIONAL PARAMETRIZATION OF PHOTON-INITIATED HIGH ENERGY SHOWERS.** A three-dimensional parameterization of photon-initiated shower in a homogeneous absorber is presented. The form, suggested by a model assimilating the transverse shower development to a random walk process, displays a simple scaling with the primary energy, and is very suitable for numerical integration. The parameters are explicitly calculated for the case of showers in SF3 lead glass, and the results are compared with explicit simulation by GEANT3.11. Fields of application are investigated. (Author abstract). 5 refs.

De Angelis, A. (Univ di Udine, Udine, Italy). *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 455-463.

**078521 DETECTOR MAGNETS IN HIGH ENERGY PHYSICS.** The research developments concerning detector magnets for high-energy physics during 1985 to 1987 are briefly described. It is noted that after the 9th International Conference on Magnet Technology at Zurich in 1985, the major developments in this field have been made in colliding beam detectors in Europe, Japan and the US. The authors compare and discuss the CDF, TOPAZ, VENUS, AMY, ALEPH, DELPHI, and CLEO-II detectors. 14 refs.

Hirabayashi, H. (KEK Natl Lab for High Energy Physics, Tsukuba). *IEEE Trans Magn* v 24 n 2 Mar 1988, Tenth Int Conf Magnet Technol, Boston, MA, USA, Sep 21-25 1987 p 1256-1259.

**078522 ENQUIRY ON THE INTERACTION BETWEEN INDUSTRY AND PHYSICISTS.** Each participant of the Third Pisa Meeting on Advanced Detectors had received a questionnaire prepared by S.R. Amendolia under the supervision of L. Stringa, convener of the round-table. The questionnaires addressed the most important points in the technical and economical aspects of high energy physics experiments, with the scope of focusing on the interaction of the industrial world with the pure research branch which the participants represented. The questionnaires were elaborated and shown as an introductory talk to the round-table. (Author abstract)

Amendolia, S.R. (Univ di Pisa, Italy). *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys. Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 155-158.

**078523 NEUTRINO OSCILLATION EXPERIMENTS.** We review the status and results of neutrino oscillation experiments with emphasis on non-accelerator experiments. To date there is no confirmed evidence for neutrino oscillations, with limits for the mass parameter  $\Delta m^2$  of  $2 \times 10^{-2}$  eV<sup>2</sup> for full mixing, and limits for mixing angles  $\sin^2 2\theta$  of about  $10^{-3}$  for large  $\Delta m^2$ . (Author abstract) 11 refs.

Boehm, F. (California Inst of Technology, Pasadena, CA, USA). *Nucl Instrum Methods Phys Res Sect A* v A264 n 1 Feb 1988, Non-Accel Part Phys, Proc of the Workshop, Rochester, NY, USA, Jun 1-3 1987 p 114-119.



## Instruments

**078524 FAST ANALOG INTEGRATED CIRCUITS FOR PARTICLE PHYSICS.** A review is presented of the International Conference on Fast Analog Integrated Circuits for Particle Physics which was held in Philadelphia, March 2-4, 1987. Papers on CMOS charge preamplifiers, bipolar circuits, time measurement systems, flash analog-to-digital converters, waveform sampling, gallium arsenide, system reliability, and radiation damage are discussed. 17 refs.

Williams, H. (Univ of Pennsylvania, Philadelphia, PA, USA). *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 146-150.

**078525 DEVELOPMENT OF A SWITCHED CAPACITOR BASED MULTI-CHANNEL TRANSIENT WAVEFORM RECORDING INTEGRATED CIRCUIT.** A full-custom integrated circuit addressing the problem of transient analog signal recording is presented. The chip includes 2048 sample-and-hold cells, fast-clock-generation logic, and readout amplifiers. The sample-and-hold circuits are divided into 16 channels of 128 samples per channel. One read amplifier is used per channel. Clock signals are generated by on-chip redundant interleaved shift registers. The circuit is designed in an inexpensive and widely available 3- $\mu$ m, single-metal, double-polysilicon CMOS process that allows easy integration of high-density digital and analog circuitry with the possibility of very-low-power operation. Prototypes have been fabricated and proved to be operational. 7 refs.

Kleinfelder, Stuart A. (Lawrence Berkeley Lab, Berkeley, CA, USA). *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 151-154.

**Mathematical Models** See Also MATHEMATICAL TECHNIQUES—Number Theory; PLASMAS—Wave-Plasma Interactions; POLYMERS—Rheology.

**078526 ON THE IRREDUCIBILITY OF PROFESSOR G.F. SMITH'S REPRESENTATIONS FOR ISOTROPIC FUNCTIONS.** Irreducibility is proved of the basis for scalar-valued isotropic functions due to G.F. Smith, once the redundant elements found by J.P. Boehler are eliminated. Similarly Smith's basis for vector-valued, second order skew-symmetric tensor-valued and second order symmetric tensor-valued isotropic functions are proved irreducible. An argument by J.J. Telega leading to reducibility of the last of them is proved incorrect. (Author abstract) 26 refs.

Pennisi, S.; Trovato, M. *Int J Eng Sci* v 25 n 8 1987 p 1059-1065.

**078527 DIAGNOSIS OF DYNAMICAL SYSTEMS WITH FLUCTUATING PARAMETERS.** Many time evolutions occurring in nature may be considered as non-autonomous, but dependent on parameters that vary slowly with time. It is argued that some, but not all, of the tools used to understand chaotic dynamics remain useful in this situation. The asymptotic evolution takes place on a (usually) complicated set in phase space called a strange attractor. A fundamental finding is that hydrodynamic turbulence is chaotic, and described by strange attractors. (Edited author abstract) 7 refs.

Ruelle, D. (Inst des Hautes Etudes Scientifiques, Bures-sur-Yvette, Fr). *Proc R Soc London Ser A* v 413 n 1844 Sep 8 1987 p 5-8.

**Molecular** See Also FRACTURE MECHANICS—Theory; GASES—Aerodynamics; GLASS—Structure; NEUTRONS—Scattering; POLYACETYLENES—Calculations; POLYACETYLENES—Structure; POLYMERS—Crystallization; POLYMERS—Research; RADIATION EFFECTS; SOLIDS—Amorphous; SPUTTERING.

**078528 UNIFIED APPROACH TO DENSITY FUNCTIONAL AND MOLECULAR DYNAMICS IN REAL SPACE.** The Lagrangian introduced previously by the authors is modified with the introduction of an auxiliary field that represents the Hartree potential. While

leading to the same results, the present version of the theory offers considerable practical and theoretical advantages. In particular, it provides the possibility of working entirely in real space, reducing the number of operations required. An interesting and potentially useful isomorphism of local density theory to a continuous spin lattice model is pointed out. (Edited author abstract) 6 refs.

Car, R. (Int Sch for Advanced Studies, Trieste, Italy); Parrinello, M. *Solid State Commun* v 62 n 6 May 1987 p 403-405.

**078529 DENSITY OF STATES OF ONE-DIMENSIONAL RANDOM POTENTIALS.** Following an introduction to the early history of the theories of the density of electronic states in one-dimensional structures, pioneered, among others, by R. Landauer and J.C. Helland, a particular model, that of a multistep random potential, is discussed. It is shown that Kolmogorov-type equations can be obtained for the probability distribution of the phase of the wave function, and, by solving these equations, the density of states may be calculated. An analogy with the classical rotator in a random force field is worked out, and helps in visualizing the results. (Author abstract) 9 refs.

Erdos, Paul. *IBM J Res Dev* v 32 n 1 Jan 1988 p 47-51.

**078530 CALCULATION OF THE POTENTIAL ENERGY OF THE INTERACTION OF AN ELECTRON WITH A MOLECULE.** We set forth a mathematically correct algorithm, simple in computer realization, for calculation of the potential energy of the interaction of an electron with a molecule and for the calculation of electric 2<sup>nd</sup>-pole molecular moments in the framework of the Hartree-Fock-Roothaan method. The proposed method permits consideration of the dynamics of the problem of the dependence of the energy on oscillatory motion in the molecule. (Author abstract) 11 refs.

El'kin, M.D. *Sov Phys J* v 30 n 8 Aug 1987 p 668-671.

**078531 INTRAMOLECULAR VOIDS AND INTERMOLECULAR CHANNELS.** Two algorithms are described for estimating the volume and surface area of intramolecular voids and intermolecular channels. One is a variant, the other a special case, of corresponding algorithms for filled spaces. In calculating hollows, the investigator has often to decree some of the bounds, that is, define a box that delimits the hollow. The choice of box and the positioning of species within the box are commented upon. (Author abstract) 19 refs.

Wigderson, E. (Hebrew Univ, Jerusalem, Isr); Meyer, A.Y. *Comput Chem* v 12 n 3 1988 p 237-244.

**078532 COMPUTER SIMULATION OF THE ATOMIC BEHAVIOUR IN CONDENSED PHASES.** A molecular dynamics simulation method for the study of condensed phases of matter is described. Computer programs for the simulation of atomic motion have been developed. Time-saving techniques, like the 'cellular method', have been incorporated in order to optimize the available computer resources. We have applied this method to the simulation of argon near its melting point. Differences in the structure, thermodynamic properties and time correlation functions of solid and liquid phases are discussed. (Author abstract) 26 refs.

Giro, A. (Univ Politecnica de Catalunya, Barcelona, Spain); Padro, J.A. *Questio* v 11 n 2 1987 p 65-79.

**078533 EXPERIMENTAL LIFETIME FOR THE B <sup>3</sup>Π<sub>g</sub> (v=0) LEVEL OF N<sub>2</sub>.** Electron impact excitation followed by fluorescence induced by N<sub>2</sub>-laser absorption was used to study the lifetime of the lowest vibrational level of the B <sup>3</sup>Π<sub>g</sub> electronic state of N<sub>2</sub>. The experimental result of this work is 13±1 μs and comparison is made with recent experimental and theoretical results. (Author abstract) 14 refs.

Ortiz, M. (Univ of Madrid, Madrid, Spain); Perez, A.; Campos, J. *Physica B & C* v 150 n 3 Jun 1988 p 440-444.

**078534 LIFETIME MEASUREMENTS OF EX-**

**CITED QUANTUM STATES USING A DIODE LASER: RADIATIVE LIFETIME OF THE B<sup>2</sup>Σ<sup>+</sup> STATE IN BaCl.** A new method has been developed for measuring radiative lifetimes of excited molecular and atomic quantum levels. It is based on the unique time characteristics and the high spectral resolution of single mode diode lasers. The diode laser is tuned through the spectral region of interest at a high repetition frequency. With the delayed coincidence method fluorescence decay is recorded from each spectrally resolved line, allowing for lifetime determinations of several sequentially excited levels in each time-resolved spectrum. This method is applied on several rotational and vibrational levels of the B<sup>2</sup>Σ<sup>+</sup> state of gaseous BaCl. From the measured lifetime, 104±3 ns, band oscillator strengths and electronic transition moment were derived for the BaCl B-X transition. (Author abstract) 17 refs.

Gustafsson, G. (Univ of Stockholm, Stockholm, Swed); Martin, H.; Wejnitz, P. *Opt Commun* v 67 n 2 Jun 15 1988 p 112-118.

**Nuclear** See Also ACCELERATORS—Beam Dynamics; ACCELERATORS—Construction; BERYLLIUM AND ALLOYS—Radiation Effects; COMPUTER SYSTEMS, DIGITAL—Parallel Processing; DATA PROCESSING—Data Acquisition; DATA PROCESSING—Natural Sciences Applications; DATABASE SYSTEMS; FILMS—Preparation; GAMMA RAYS—Measurements; GAMMA RAYS—Propagation; LASERS, EXCIMER—Design; MASS SPECTROMETERS—Applications; MATHEMATICAL TECHNIQUES; MATHEMATICAL TECHNIQUES—Algorithms; NEPTUNIUM—Isotopes; NEUTRONS; NEUTRONS—Absorption; NEUTRONS—Activation Analysis; NEUTRONS—Diffusion; NEUTRONS—Emission; NEUTRONS—Measurements; NEUTRONS—Sources; NEUTRONS—Spectrum Analysis; NEUTRONS—Transport Properties; NUCLEAR ENERGY—Fusion Reactions; NUCLEAR FUELS—Computer Simulation; NUCLEAR MAGNETIC RESONANCE; NUCLEAR REACTORS—Calculations; NUCLEAR REACTORS—Theory; NUCLEAR REACTORS, BOILING WATER—Cores; NUCLEAR REACTORS, BOILING WATER—Design; NUCLEAR REACTORS, FAST—Cores; NUCLEAR REACTORS, HIGH TEMPERATURE—Control Rods; NUCLEAR REACTORS, HIGH TEMPERATURE—Cores; NUCLEAR REACTORS, LIGHT WATER—Fission Products; NUCLEAR REACTORS, LIGHT WATER—Monitoring; NUCLEAR REACTORS, PRESSURIZED WATER—Cores; NUCLEAR REACTORS, PRESSURIZED WATER—Theory; PARTICLE BEAMS—Performance; PHOTOGRAPHIC EMULSIONS; PHOTONS—Mathematical Models; POLARIMETERS—Design; PROTONS—Scattering; PULSE GENERATORS; QUANTUM THEORY—Mathematical Models; RADIATION DETECTORS; RUBIDIUM; SEMICONDUCTOR DEVICES, CHARGE COUPLED—Design; SILICON AND ALLOYS—Ion Implantation; SPECTROSCOPY, MOSSBAUER; SPECTROSCOPY, NUCLEAR RADIATION; SPECTRUM ANALYSIS; TANTALUM COMPOUNDS—Thickness Measurement; URANIUM AND ALLOYS—Fission.

**078535 LIFETIME MEASUREMENT OF THE <sup>28</sup>Si COMPOUND STATE AT 13.095 MeV BY THE BLOCKING EFFECT.** The <110> axial and <111> planar blocking dips in an Al crystal are used to measure the lifetime of the state at 13.095 Mev in the compound nucleus <sup>28</sup>Si excited by the <sup>27</sup>Al(p, α)<sup>24</sup>Mg reaction at E<sub>p</sub> = 1565 kev. The blocking dips for 2.12 Mev α particles from this reaction at E<sub>p</sub> = 1183.4 kev are also measured and the radiation damage in the crystal is investigated. Monte Carlo simulations and analytical methods in the axial blocking measurement and analytical methods in the planar blocking case are used. The measured lifetime at the E<sub>p</sub> = 1565 kev resonance, τ = 15 ± 2 as, is in good agreement with the value derived from the reaction-yield measurement. (Author abstract) 18 refs.

Jin, W.G. (Fudan Univ, Shanghai, China); Zhao, G.Q.; Shao, Q.Y.; Ren, Y.H.; Wu, X.J.; Zhou, Z.Y. *Nucl Instrum Methods Phys Res Sect B* v B28 n 1 Aug 1987 p 82-87.

**078536 OPTIMUM SEGMENTATION OF A TARGET FOR NUCLEAR INTERACTION LENGTH MEASUREMENTS.** The statistical accuracy of nuclear interaction length estimation from the distribution of interaction points inside a segmented target, composed of alternating layers of absorbers and detectors, is studied. It is shown that for a given number of target segments the



thickness of the absorber layers can be optimized allowing to achieve an almost limiting statistical accuracy of measurements. (Author abstract) 4 refs.

Amatuni, Ts.A. (Yerevan Physics Inst, Yerevan, USSR); Sanossyan, Kh.N. *Nucl Instrum Methods Phys Res Sect A* v A260 n 2-3 Oct 15 1987 p 463-468.

**078537 (n,p), (n, $\alpha$ ) AND (n,2n) REACTION CROSS-SECTIONS FOR SOME ISOTOPES OF Zr, Pd, AND Cd AT 14.8 MeV.** The cross-sections for the  $^{90}\text{Zr}(n,p)$ ,  $^{91}\text{Zr}(n,p)$ ,  $^{94}\text{Zr}(n,p)$ ,  $^{102}\text{Pd}(n,2n)$ ,  $^{106}\text{Pd}(n,p)$ ,  $^{108}\text{Pd}(n,2n)$ ,  $^{110}\text{Pd}(n,2n)$ ,  $^{108}\text{Cd}(n,2n)$ ,  $^{112}\text{Cd}(n,2n)$  and  $^{116}\text{Cd}(n,2n)$  reactions at 14.8 MeV were measured by the activation technique. Full experimental details are included. The results are compared with other published values. (Author abstract) 8 refs.

Goncalves, Isabel F. (LNETI, Sacavem, Port); Schram, Zs.; Papp, Z.; Daroczy, S. *Appl Radiat Isot* v 38 n 11 1987 p 989-991.

**078538 MEASUREMENT OF FAST NEUTRON INDUCED FISSION CROSS SECTIONS OF AMERICIUM-243 RELATIVE TO URANIUM-235.** The fission cross section ratio of  $^{243}\text{Am}$  to  $^{235}\text{U}$  has been measured in the energy range of 1.1-6.8 MeV with monoenergetic neutrons. An ionization fission chamber was used to detect fission events. The quantitative analyses of the fission samples were made with a low geometry counter and a  $2\pi$  counter. Uncertainties of the measured data were analyzed considering correlations between error elements. The present result is very close to that of Fursov et al. and lower by about 20% than the values reported by Behrens & Browne. (Author abstract) 12 refs.

Kanda, Kazutaka (Tohoku Univ, Sendai, Jpn); Imaruoka, Hiromitsu; Terayama, Hiromichi; Karino, Yoshiji; Hirakawa, Naohiro. *J Nucl Sci Technol* v 24 n 6 Jun 1987 p 423-430.

**078539 ISOMERIC RATIOS OF THE YIELDS (CROSS SECTIONS) OF PHOTONUCLEAR REACTIONS.** The relative probability of population of isomeric (metastable m and ground g) states of the final nucleus (isomeric ratio of yields  $d = Y^m/Y^g$  or cross sections  $r = \sigma^m/\sigma^g$ ) of photonuclear reactions (PNR)  $A(\gamma, x)^m \rightarrow B$  has been investigated intensively in numerous experimental works since the early 1960s. As yet, there has been no sufficiently complete review of experimental data on the IR of PNR yields. In the present work, values of the IR of PNR yields (cross sections) are given, together with a brief indication of the conditions in which they were calculated, either in the present work or elsewhere. 77 refs.

Davydov, M.G.; Magera, V.G.; Trukhov, A.V. *Sov At Energy* v 62 n 4 Apr 1987 p 277-285.

**078540 EMPIRICAL FORMULAS FOR 14-MeV (n,p) AND (n, $\alpha$ ) CROSS SECTIONS.** Empirical formulas for the 14 MeV (n,p) and (n, $\alpha$ ) cross sections given by Levkovskii were modified separately in three ranges of mass number, in each of which, coefficients modifying Levkovskii's formulas were determined by least-squares fitting to experimental cross sections. The resulting modified formulas yielded cross sections representing markedly smaller chi-square deviations from experimental values, and moreover gathered closer to unity, compared with calculation using Levkovskii's original formulas. (Author abstract) 8 refs.

Kumabe, Isao (Kyushu Univ, Fukuoka, Jpn); Fukuda, Katsuya. *J Nucl Sci Technol* v 24 n 10 Oct 1987 p 839-843.

**078541 ENERGY DEPENDENCE OF NUCLEON-NUCLEON INELASTIC TOTAL CROSS-SECTIONS.** The purpose of this article is to provide a phenomenological treatment of all existing nucleon-nucleon inelastic total cross-section data. More specifically, we have collected the data on exclusive and inclusive total cross-sections for reactions occurring in the NN system. We have then fitted the energy dependences of these

cross-sections by smooth curves with a reasonable number of free parameters, obtaining thereby a parametrization of the inelastic cross-sections for energies at which data are available. Whenever possible, we made comparisons between experimental total cross-sections and predictions following from isospin invariance. Finally the isospin decomposition (i.e. the  $I=0, 1$  cross-sections) for  $NN \rightarrow NN\pi$ ,  $NN \rightarrow d\pi$ ,  $NN \rightarrow NN\pi\pi$  and  $NN \rightarrow d\pi\pi$  processes is performed. 49 refs.

Bystricky, J. (CEN, Gif sur Yvette, Fr); La France, P.; Lehar, F.; Perrot, F.; Siemarczuk, T.; Winternitz, P. *J Phys (Paris)* v 48 n 11 Nov 1987 p 1901-1924.

**078542 CROSS SECTION OF ELASTIC SCATTERING IN HIGHLY ABSORBING OPTICAL POTENTIALS.** Quasi-classical expressions are found for the cross section of elastic scattering in realistic hadron-nuclear, highly absorbing optical potentials. The effect of damping of the cross section oscillations with a rise in the scattering angles is noted. (Author abstract) 4 refs.

Belyak, V.I. *Sov Phys Lebedev Inst Rep* n 5 1987 p 1-5.

**078543 INFLUENCE OF THE DECAYING PARTICLE GENERATION SPECTRUM ON THE RANGE FOR ABSORPTION OF A NUCLEAR-ELECTROMAGNETIC CASCADE.** The ranges for absorption L of nuclear-electromagnetic cascades are calculated at different energies in an assumption of large cross sections of generation in hadron-nuclear interaction of particles, whose decay length is comparable to the range for interaction. It is shown that only generation of such particles with spectra maximal in rigidity in terms of x may have a substantive effect on L. (Author abstract) 4 refs.

Dremin, I.M.; Madogozhin, D.T. *Sov Phys Lebedev Inst Rep* n 5 1987 p 13-16.

**078544 STRUCTURAL FUNCTIONS OF NUCLEI AND GENERATION OF  $\pi$ -MESONS IN A CUMULATIVE REGION.** It is shown that agreement between theoretical calculations for the relations of structural functions of nuclei, acquired from an analysis of the processes of deeply inelastic scattering of leptons in nuclei within a fluctuon model with rescaling, and experimental data for generation of  $\pi$ -mesons in nuclei in the cumulative region confirms the hypothesis of maximal fragmentation. (Author abstract) 8 refs.

Zotov, N.P.; Saleev, V.A.; Tsarev, V.A. *Sov Phys Lebedev Inst Rep* n 5 1987 p 51-54.

**078545 MEASURING THE FULL CROSS SECTIONS OF INTERACTIONS BETWEEN NEUTRONS AND TELLURIUM ISOTOPES USING AN AUTOMATED SYSTEM BASED ON AN IVK-1.** An automated system is created for measuring full cross sections. The full cross sections of interaction between neutrons and even tellurium isotopes in an energy range of 0.2-1.1 MeV are measured. (Author abstract) 4 refs.

Burmistrov, Yu.M.; Grigor'eva, T.E.; Molodtsov, E.D.; Musaelyan, R.M.; Potashev, S.I.; Skorkin, V.M. *Sov Phys Lebedev Inst Rep* n 4 1987 p 68-72.

**078546 NONLINEAR ISOTHERMAL NUCLEAR REACTION DYNAMICS.** The dynamical equations frequently encountered in the reaction analysis of nuclear systems always involve cross products and frequently also contain squared terms. We investigate here such complex systems by casting the reaction dynamics into a matrix Riccati form. Isothermal point kinetic formulations are used throughout. Numerical tests are performed and compared to direct simulations. (Author abstract) 8 refs.

Gaboury, G. (McMaster Univ, Hamilton, Ont, Can); Harms, A.A. *Ann Nucl Energy* v 14 n 10 1987 p 555-561.

**078547 RELATIVISTIC MESON NUCLEUS MODEL.** A model of a nucleus with a phenomenological Lagrangian, which includes the scalar and vector meson fields, is examined. It is shown that in this model the classical approximation is not stable due to rearrangement

of the vacuum and the high contribution of quantum corrections. (Author abstract) 3 refs.

Vagrado, G.M.; Pafomov, V.E. *Sov Phys Lebedev Inst Rep* n 6 1987 p 75-79.

**078548 GENERAL MONTE CARLO CALCULATION FOR THE GEOMETRICAL EFFICIENCY OF A DETECTION SYSTEM.** A general Monte Carlo procedure is described for calculating the geometrical efficiency of a detection system with regard to a beam of particles impinging on a gaseous target or on a plane parallel target plate with finite thickness, while the detected particles are emitted with an isotropic angular distribution or one of the form  $[1-0.5P_2(\cos \theta)]$ , with  $P_2(\cos \theta)$  the second Legendre polynomial. This method was successfully applied to the analysis of the  $^{16}\text{O}(\gamma, p_0)^{15}\text{N}$  data. (Author abstract) 13 refs.

Van Otten, P. (Rijksuniversiteit Gent, Ghent, Belg); Van de Vyver, R.; Van Camp, E.; Kerkhove, E.; Berkvens, P.; Ferdinande, H.; Ryckbosch, D.; De Graeve, A.; Van Hoorebeke, L. *Nucl Instrum Methods Phys Res Sect A* v A267 n 1 Apr 15 1988 p 183-192.

**078549 INCLUSIVE DIFFERENTIAL CROSS SECTIONS OF PHOTOPRODUCTION OF  $\pi^0$  MESONS IN  $^6\text{Li}$ ,  $^{12}\text{C}$ ,  $^{27}\text{Al}$ , Cu, AND Cd AT LOW ANGLES IN A GAMMA-QUANTA ENERGY RANGE OF 300-450 MeV.** The work cites refined data about inclusive differential cross sections of photoproduction of  $\pi^0$  mesons in  $^6\text{Li}$ ,  $^{12}\text{C}$ ,  $^{27}\text{Al}$ , Cu, and Cd (Cu and Cd are a natural mixture of isotopes) nuclei in a gamma-quanta energy range of 300-450 MeV and for a mean escape angle of the  $\pi^0$  mesons of approximately  $8.4^\circ$  in a center of mass system (c.m.s.). (Author abstract) 12 refs.

Belousov, A.S.; Vazdik, Ya. A.; Malinovskii, E.I.; Rusaakov, S.V.; Smirnov, P.A.; Solovov, Yu.V.; Usik, A.P.; Terkulov, A.R.; Fomenko, A.M. *Sov Phys Lebedev Inst Rep* n 9 1987 p 35-40.

**078550 ELECTRON FORM FACTORS OF DEFORMABLE NUCLEI.** Using the smallness of the deformation parameter of the nucleus, we obtain simple explicit expressions for the form factors of electroexcitation of the low-lying rotation-vibration states of light, deformable, even-even nuclei. The expressions satisfactorily describe the experimental data on the excitation of collective nuclear states by the inelastic scattering of fast electrons. (Author abstract) 10 refs.

Tartakovskii, V.K. (T.G. Shevchenko Kiev State Univ, USSR); Isupov, V. Yu. *Sov Phys J* v 30 n 9 Sep 1987 p 776-779.

**078551 ACCURACY OF PROCESSED NUCLEAR DATA.** The results of the International Atomic Energy Agency cross-section processing code verification project are described. This project has been conducted over the last 7 yr in an attempt to improve the reliability of the results produced by cross-section processing computer codes. Initial comparisons of results received from 42 participants using 13 different cross-section processing codes demonstrated that, even though all of the codes started from exactly the same evaluated data, in no case did the multigroup cross sections calculated by any two codes agree for all materials and groups used in the comparison. This code verification project has led to positive results by improving cross-section processing codes as well as the conventions used to interpret ENDF/B evaluations. In several cases it has led to changes in ENDF/B evaluations. (Edited author abstract) 8 refs.

Cullen, Dermott E. (IAEA, Vienna, Austria). *Nucl Sci Eng* v 99 n 2 Jun 1988 p 172-181.

**078552 RECOIL DISTRIBUTIONS IN ISOTOPE SEPARATOR TARGETS.** The depth distribution of recoil daughter nuclei following the radioactive decay of implanted parent nuclei has been calculated. Moments of the depth distribution of the daughter nuclei are obtained



from tabulated moments of the usual range distributions of the parent and daughter atoms. The daughter nuclei are nearly symmetrically distributed about the mean implantation depth with a variance slightly greater than a third of the square of the mean range of the daughter. The distribution may be represented by a Pearson Type II distribution or by the form  $\exp(-a|x|)^p$ , with parameter  $p > 2$ . An example is given. (Author abstract) 4 refs.

Winterbon, K.B. (AECL, Chalk River, Ont, Can). *Nucl Instrum Methods Phys Res Sect B* v B31 n 4 Jun 1 1988 p 538-540.

**078553 VERIFICATION OF THE ACCURACY OF DOPPLER BROADENED, SELF-SHIELDED MULTIGROUP CROSS SECTIONS FOR FAST POWER REACTOR APPLICATIONS.** Over the last 5 yr the IAEA nuclear data processing code verification project has attempted to improve the accuracy of the results produced by processing codes. The first found of verification only considered unshielded, cold, group-averaged cross sections. In the second round of verification the effects of Doppler broadening and self-shielding are considered. In this paper we present verification results for Doppler broadening and self-shielding. One of the important results presented in this paper is that the original SIGMA1 method of numerical Doppler broadening as proposed by Cullen and Weisbin (1976) has now been demonstrated to be inaccurate and not capable of producing results to within required accuracies. Fortunately, due to this study, the SIGMA1 method has been significantly improved and the new SIGMA1 is now capable of producing results to within required accuracies. (Edited author abstract) 60 Refs.

Ganesan, S. (Indira Gandhi Centre for Atomic Research, Tamil Nadu, India); Gopalakrishnan, V.; Ramanadham, M.M.; Cullen, D.E. *Ann Nucl Energy* v 15 n 3 1988 p 113-140.

**078554 INTEGRAL CATCHER ANALYSIS OF NUCLEAR RECOIL EXPERIMENTS.** The integral thick target thick catcher equations for extracting excitation and relaxation recoil velocities of nuclear reaction products have been reformulated. The new data analysis scheme corrects certain limitations and deficiencies inherent in the conventional procedure. Like the latter, our integral catcher analysis uses forward and backward recoil fractions F and B, but has no constraints on target thickness. The utility of the method may be extended with advantage to thinner targets. Additionally, there are no restrictions on the form of the range-velocity relationship that can be employed. Finally, the procedure inherently provides an excellent evaluation of the statistical uncertainties in the derived velocities based on the experimental uncertainties in F and B. (Author abstract) 20 Refs.

Tobin, Michael J. (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Karol, Paul J. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 511-519.

**078555 NUCLEON-NUCLEUS INTERACTION DATA BASE: TOTAL NUCLEAR AND ABSORPTION CROSS SECTIONS.** Neutron total cross sections are represented for Li to Pu targets at energies above 0.1 MeV and less than 100 MeV using a modified nuclear Ramsauer formalism. The formalism is derived for energies above 100 MeV by fitting theoretical cross sections. Neutron absorption cross sections are represented by analytic expressions of similar form, but shape resonance phenomena of the Ramsauer effect are not present. Elastic differential cross sections are given as a renormalized impulse approximation. These cross section data bases will be useful for nucleon transport applications. (Author abstract) 15 Refs.

Wilson, J.W. (Langley Research Cent, Hampton, VA, USA); Townsend, L.W.; Buck, W.W.; Chun, S.Y.; Hong, B.S.; Lamkin, S.L. *NASA Tech Memo* n 4053 Aug 1988 25p.

**078556 APPLICATIONS OF THE SUBMICROSCOPIC NUCLEAR TRACK KINETIC THEORY.** The submicroscopic track kinetic theory (STKT) is able to

deal with a broad range of cases. We derive here its behavior for very short etching times (new born tracks) and also for long etching times, where the classical track kinetic theory is a particular case of the STKT. Experimental data obtained by previous researchers using the electroconductivity method are then analyzed by the STKT method. We show that good agreement is obtained between them and STKT theoretical results for the track diameter evolution. (Edited author abstract) 12 Refs.

Mazzei, R. (CNEA, Buenos Aires, Argent); Saint Martin, G.; Bernaola, O.A.; Bourdin, J.C.; Grasso, J.C. *Nucl Instrum Methods Phys Res Sect B* v B34 n 2 Aug 1988 p 237-242.

## Research

**078557 REVIEW OF S. KALISKI'S SCIENTIFIC ACHIEVEMENTS IN THE DOMAIN OF COUPLED FIELDS.** Kaliski's scientific achievement in the realm of coupled fields has been presented in a synthetic way. Our main concern was to save them from oblivion and make them a source of encouragement for further research in the modern and rapidly progressing domain of coupled fields. Kaliski's ideas are very much alive and prompt his former students and co-researchers to continue numerous studies in the domain in question. 144 refs.

Kapelewski, J.; Nowacki, W.; Rymarz, CZ.; Włodarczyk, E. *Int J Eng Sci* v 25 n 8 1987 p 987-1001.

**078558 PARTICLE PHYSICS WITH SLOW NEUTRONS AT THE INSTITUTE LAUE-LANGEVIN.** We give an overview over the particle and fundamental physics program at the European High Flux Reactor of the Institut Max von Laue-Paul Langevin at Grenoble, France. The experiments on neutron-antineutron oscillations, the neutron electric dipole moment, and on free neutron beta decay are reviewed in more detail. (Author abstract) 29 refs.

Dubbers, D. (Inst Max von Laue-Paul Langevin, Grenoble, Fr). *Nucl Instrum Methods Phys Res Sect A* v A264 n 1 Feb 1988, Non-Accel Part Phys, Proc of the Workshop, Rochester, NY, USA, Jun 1-3 1987 p 120-124.

**Solid State** See Also ALUMINUM SILICON ALLOYS—Aging; BAND STRUCTURE; BAND STRUCTURE—Spectrum Analysis; BERYLLIUM AND ALLOYS—Thin Films; CRYSTALS—Defects; CRYSTALS—Elasticity; CRYSTALS—Magnetic Properties; CRYSTALS—Structure; CRYSTALS—Theory; ELECTRONS—Density Measurement; FERROELECTRIC MATERIALS—Phase Transitions; FRACTURE MECHANICS; GERMANIUM SELENIUM ALLOYS—Thin Films; GLASS—Electronic Properties; GLASS, METALLIC—Low Temperature Effects; METALLIC COMPOUNDS—Physical Properties; MICROSCOPIC EXAMINATION; ORGANOMETALLICS—Phase Transitions; PHOTOLUMINESCENCE—Measurements; POLYACETYLENES; POLYACETYLENES—Electric Properties; POTASSIUM COMPOUNDS—Thin Films; SEMI-CONDUCTING CADMIUM COMPOUNDS—Phase Transitions; SEMI-CONDUCTING SILICON—Doping; SEMI-CONDUCTOR DEVICES—Heterojunctions; SEMI-CONDUCTOR DEVICES, MOSFET—Mathematical Models; SEMI-CONDUCTOR MATERIALS—Charge Carriers; SEMI-CONDUCTOR MATERIALS—Electronic Properties; SILICON NITRIDE—Electric Conductivity; SOLID STATE DEVICES—Research; SOLIDS—Order-Disorder; SUPERCONDUCTING DEVICES—Josephson Junctions; TRANSISTORS, BIPOLAR—Mathematical Models.

**078559 CONTEMPORARY PROBLEMS OF THE PHYSICS OF THE STRENGTH OF SOLIDS.** A survey of the research carried out at the Institute of the Physics of Strength and Materials Science of the Siberian branch of the Academy of Sciences of the USSR into strongly excited states in crystals in application to the problem of the physics of plasticity and strength of solids is presented. Consideration of the theory of the behavior of solids in the fields of strong external effects leads to the concept of strongly excited states in crystals which is based on the appearance of permitted structural states in the interstitial space and the possibility of regular disposition of atoms not only in the crystal lattice modes but also in the interstices. A combination of this approach with the concept of structural levels of the deformation of solids and the principle of local calibration invariance makes it possible to substantiate the generation of a vortical mechanical field in a solid undergoing deforma-

tion. This theory is experimentally confirmed. Recommendations are given on the formation of vortical damping structures to create high-strength and wear-resistant materials. (Translated author abstract) In Russian. 33 refs.

Panin, V.E. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 11 1987 p 87-97.

**078560 SOLID STATE PHYSICS: ADVANCES IN RESEARCH AND APPLICATIONS.** The volume comprises four articles dealing with physics of fracture, the internal structure of Guinier-Preston zones in alloys, fractals and their applications in condensed matter physics, and electronic structure of 3d transition-atom impurities in semiconductors. All the papers are abstracted and indexed separately.

Ehrenreich, Henry (Ed.) (Harvard Univ, Cambridge, MA, USA); Turnbull, David (Ed.). *Solid State Phys* v 39. Publ by Academic Press, Orlando, FL, USA, 1986 477p.

**078561 FRACTALS AND THEIR APPLICATIONS IN CONDENSED MATTER PHYSICS.** The article deals with a major theoretical concept and mathematical technique that has found its way into condensed matter physics during the past few years. Fractals have become important in a wide variety of areas including percolation theory, polymer science, and the understanding of porous materials, rough surfaces, colloidal aggregates, dendritic growth, anomalous diffusion, and dilute magnetism. 119 refs.

Liu, S.H. (Oak Ridge Natl Lab, Oak Ridge, TN, USA). *Solid State Phys* v 39. Publ by Academic Press, Orlando, FL, USA, 1986 p 207-273.

**078562 QUANTUM DYNAMICS OF A DAMPED FREE PARTICLE.** We investigate the exact quantum dynamics of a free particle damped through its interaction with an harmonic bath, when the effective coupling strength behaves as  $\omega^6$  at low frequency. We find that various regimes can occur depending on the value of  $\delta$  and of the temperature. At large times, the mean square displacement is shown either to diverge as  $t^4$ , the exponent  $\nu$  being never greater than 2 or to tend towards a finite value, indicating a confinement in the broad sense. In addition, for  $\delta < 1$ , an oscillation (absent in the uncoupled system) is found: due to the friction on the dominant low-frequency modes and to the existence of retardation effects, the particle is forced to relax in the mean towards its initial location, the net dynamical effect of the bath being similar to that of an applied potential. In the limit  $\delta \rightarrow 0$ , the particle is frozen. (Author abstract) 13 refs.

Aslangul, C. (Univ Paris VII, Paris, Fr); Pottier, N.; Saint-James, D. *J Phys (Paris)* v 48 n 11 Nov 1987 p 1871-1880.

**078563 MULTIPHONON RENORMALIZATION OF THE SPECTRUM OF TWO-DIMENSIONAL EXCITONS IN A MAGNETIC FIELD.** The renormalization of the dispersion law for two-dimensional excitons in a magnetic field is studied by the Green's-function method taking into account multiphonon processes. (Author abstract) 11 refs.

Val', A.D. (Chernovitskii State Univ, USSR); Tkach, N.V. *Sov Phys J* v 30 n 4 Apr 1987 p 267-270.

**078564 MODIFIED OPTICAL POSITRON MODEL. POSITRON ANNIHILATION IN IONIC MEDIA.** Positron annihilation from a positron-anion bound state is considered. A critical analysis of the optical positron model is given, and a modification is suggested with the purpose of removing drawbacks of this model. A calculation of angular correlation curves and positron life time is carried out. In the calculation we explicitly account for repulsion forces between the positron and the nucleus, dominating at short distances. It is shown that the inner electron of the anion plays no significant role in the formation of the angular correlation curve, and does not affect the value of the positron lifetime. The model makes



it possible to determine the effective anion charges and the value of the repulsion force between the positron and the nucleus from experimental angular correlation curve and positron lifetimes in ionic media. Specific analysis is carried out for the  $O_2^-$  ion. (Author abstract) 7 refs.

Moskvitin, M.L. (V.I. Lenin Moscow Pedagogic Inst, USSR); Sabirov, R.Kh. *Sov Phys J* v 30 n 4 Apr 1987 p 315-319.

**078565 SOLID STATE PHYSICS - 1947.** The author, codiscoverer of the transistor, reports about early research activities in solid-state physics and about a trip that he and some coworkers made to Europe in 1947 to attend a scientific conference and exchange ideas with leading European scientists. The trip led them to England, Holland, France and Switzerland.

Bardeen, John (Univ of Illinois, Urbana, IL, USA). *Solid State Technol* v 30 n 12 Dec 1987 p 68-71.

**078566 ON THE DYNAMIC LOCAL FIELD FACTOR OF A UNIFORM ELECTRON LIQUID.** We consider the dynamic local field factor  $G(q, \omega)$  of a uniform interacting electron liquid, and describe approximation which yield a  $G$  having a static part analogous to that of the Vashista-Singwi theory, and a dynamic part having a structure similar to that obtainable from the mode-coupling theory of the memory-function approach. We present the  $q \rightarrow 0$  limit of the imaginary part of  $G(q, \omega)$  and obtain the  $\omega^{-3/2}$  dependence at large  $\omega$ , in agreement with the diagrammatic calculations. (Edited author abstract) 22 refs.

Mukhopadhyay, G. (Int Cent for Theoretical Physics, Trieste, Italy). *Solid State Commun* v 64 n 12 Dec 1987 p 1483-1487.

**078567 REFLECTION OF SURFACE POLARITONS AT A DIELECTRIC BARRIER.** The theory is worked out which considers reflection of surface polaritons normally incident on a vertical dielectric barrier. The theory is based upon treatments of interactions of localized and non-localized eigen modes of the system. For the cases of plasmon and photon polaritons calculated are the reflection and transmission coefficients of polaritons and the energy diagrams of volume waves excited during reflection. (Author abstract) 6 refs.

Voronko, A.I. (USSR Acad of Sciences, Moscow, USSR); Klimova, L.G.; Shkardin, G.N. *Solid State Commun* v 61 n 6 Feb 1987 p 361-364.

**078568 RANDOM CHAINS AND COMPLEX TRANSFER MATRIX ATTRACTORS.** The physical properties of one-dimensional disordered systems are reobtained with a method which is a generalization of work by H. Schmidt. This generalization is carried out reformulating Schmidt's procedure in the language of non-linear process and extending it to the complex plane. The average Green's functions are evaluated in this way and from them the density of eigenstates for each atomic species. The coherence length of these eigenstates is also obtained and related to the Lyapunov exponent of the non-linear process mentioned above. Illustrative numerical results are provided. (Author abstract) 16 refs.

Rossler, J. (Univ de Chile, Santiago, Chile); Martinez, G.; Kiwi, M. *Solid State Commun* v 61 n 6 Feb 1987 p 395-400.

**078569 OUTLINE OF FUNDAMENTAL SCIENCE DIVISION.** The research activities in the Fundamental Science Division in the last six years are reviewed. The covered fields are classified as follows; fundamental studies on electron systems in condensed matter, superconductivity, crystal synthesis and new method for material fabrication, molecular assembly and its physical properties, development of measuring method and structural analysis, and contribution to applied fields. (Author abstract) In Japanese. 103 refs.

Ishiguro, T. *Denshi Gijutsu Sogo Kenkyusho Iho* v 52 n 1 1988 p 104-130.

**078570 SOME OF THE PROGRESS IN THE TECHNIQUE FOR PHYSICAL STUDY UNDER HIGH PRESSURE IN THE LABORATORY FOR INFRARED PHYSICS.** Some new results obtained in recent years about the techniques and the methods of high pressure experiments in this laboratory are described, including a two-stage nonmagnetic high pressure equipment, a new method for producing the modulated magnetic field in high pressure chamber, the diamond anvil cell and photo-modulated spectroscopy under high pressure. (Author abstract) 10 refs.

Zhu Haorong (Acad Sinica, Shanghai, China); Shan Wei; Li Qiguang; Ju Guanglin; Shen Xuechu. *Chin J Infrared Res Ser B (Engl Ed)* v 6 1987 p 67-72.

**078571 HUBBARD MODELS AND THEIR APPLICABILITY IN SOLID STATE AND MOLECULAR PHYSICS.** The reliability of the widely used Hubbard models is investigated. It is shown that, despite the apparent neglect of bond-charge repulsion terms, the Hubbard models can be adopted to analyze the properties of one dimensional systems of any bandwidth, provided that the range of the interelectronic potential is large enough. (Author abstract) 10 refs.

Painelli, Anna (Univ of Padova, Padua, Italy); Girlando, Alberto. *Solid State Commun* v 66 n 3 Apr 1988 p 273-275.

**078572 CONTRIBUTIONS TO THE SECOND ORDER DIELECTRIC RESPONSE OF AN ELECTRON LIQUID.** The dielectric response function  $\chi$  of a uniform electron gas is investigated up to the second order of the Coulomb interaction with different methods. When examining all polarization diagrams with two interaction lines, it is confirmed that previous work in the Green's function formalism does not contain all second order processes and the importance of the corrections is pointed out. It is further shown how the evaluation of  $\chi$  with Green's function can be greatly simplified when taking into account the symmetry of the expressions. (Author abstract) 19 refs.

Bachlechner, Martina E. (Johannes Kepler Univ, Linz, Austria); Miesenboeck, Helga M.; Macke, Wilhelm. *Physica B & C* v 150 n 3 Jun 1988 p 337-345.

**078573 SPIN DYNAMICS OF FIELD-INDUCED SPIN DENSITY WAVES IN BECHGAARD SALTS.** Theoretical results for spin response functions of field-induced spin density waves (FISDWs) in Bechgaard salts are summarized. The transverse spin susceptibility in a FISDW develops a pole near  $q=Q$ , describing a spin wave with dispersion. (Edited author abstract) 9 refs.

Maki, Kazumi (Max-Planck-Institut fuer Festkoerperforschung, Stuttgart, West Ger); Virosztek, Attila. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 279-283.

**078574 IRREDUCIBLE REPRESENTATION MATRICES OF THE ICOSAHEDRAL POINT GROUPS  $I$  AND  $I_h$ .** The irreducible representation matrices of the icosahedral point groups  $I$  and  $I_h$  are presented. These matrices are useful in calculating the electronic structures of the icosahedral quasicrystals. (Author abstract) 4 refs.

Wei Min Hu (Univ of Science & Technology of China, Hefei, China); Jin Long Yong; Jing Zhou; Fang Shu. *Superlattices Microstruct* v 3 n 4 1987 p 391-398.

## Theory

**078575 LARGE-SCALE LIMIT OF DYNAMIC-TORSION THEORY.** A definition of the large-scale limit of theories in which the metric and torsion of space-time are independent dynamic variables is given. It is shown that in this limit the equations of motion for a tetradic field coincide with the free Hilber-Einstein equations. (Author abstract) 15 refs.

Katanaev, M.A. (Inst of Physicotechnical Problems, USSR). *Sov Phys J* v 30 n 5 May 1987 p 392-396.

**PICKLING** See Also FASTENERS—Protective Coatings; ROLLING MILLS—France.

## Electrodes

**078576 GETTING THE LEAD OUT.** Lead is very effective as an anode but it dissolves into the bath. Carbon would be effective, too, but it also dissolves and has a short life. State Plating had been considering platinized titanium, but that was expensive. In electrolyte pickling prior to plating, specially coated titanium is the replacement. The new anodes help to lessen water pollution and lower cost at the same time.

Stempel, Shelly. *Prod Finish (Cincinnati)* v 52 n 1 Oct 1987 p 92-94.

**Energy Conservation** See STEEL—Pickling.

## Waste Disposal

**078577 RECOVERY OF FERROUS SULFATE AND SULFURIC ACID FROM SPENT PICKLE LIQUOR OF THE STEEL INDUSTRY.** This paper demonstrates that spent sulfuric acid pickle liquor can be recycled by recovering sulfuric acid and ferrous sulfate. This is achieved by removing part of the water from the liquor followed by ferrous sulfate crystallization and separation of the ferrous sulfate from the resulting slurry. Depending on energy consumption, three cases of carrying out the process can be distinguished. The percentage of sulfuric acid recovered for these three cases was 92.4, 90.4 and 89.7, respectively, and the percentages of ferrous sulfate recovered were 69.7, 85.3 and 92.7, respectively. The sulfuric acid concentration in the respective filtrates increased from 7.62% in the spent pickle liquor to 17.7%, 19.5% and 35.5%. The ferrous sulfate concentration decreased from 15.1% to 11.5%, 6.31% and 5.75%, respectively. The crystals of recovered ferrous sulfate contained small amounts of occluded sulfuric acid. (Author abstract) 6 refs.

Niecko, Jerzy (Maria Curie-Skłodowska Univ, Lublin, Pol). *Conserv Recycling* v 10 n 4 1987 p 309-314.

## Waste Utilization

**078578 AQUATECH SYSTEM - A COMMERCIAL PROCESS TO RECYCLE SPENT PICKLE LIQUOR.** AQUATECH Systems has developed an electrochemical membrane process that economically separates salt solutions into their constituent acids and bases. The technology transforms the once-through pickling process into an essentially closed-loop operation with minimal chemical makeup requirements and potentially no disposal costs. It has been piloted at the Washington Steel facility in Washington, Pa., for over two years, resulting in the design and construction of the first commercial plant. The plant will regenerate over 1.5 million gal of spent pickle acid per year into reusable  $HF/HNO_3$  acid as well as eliminating disposal costs now estimated at \$0.55/gal (\$860,000 annually). 1 ref.

Hutter-Byzowski, Carolyn (Allied-Signal Inc, Warren, NJ, USA); Bogeatzes, Andrew S. *Iron Steel Eng* v 65 n 3 Mar 1988 p 40-44.

## PICKUPS

**078579 OPTICAL TECHNOLOGY FOR COMPACT DISK PICKUPS.** Instead of a stylus, the compact audio disk player employs an optical pickup head to reproduce high-quality sound over a wide dynamic range from prerecorded disks. The laser beam from the optical pickup illuminates a very small area of the recording surface, so that information recorded on the disk can be sensed by a detector. The detectors also provide signals to a servo system to control the movement of the objective lens so that the laser beam is kept focused correctly on the track. Therefore, the optical pickup is the most important device in the compact disk player; it links the recording medium with the electronic and mechanical systems. In this article we shall review only the optical pickup technologies for the compact disk player. A new technol-



ogy for using holographic optical elements will improve the cost/performance ratio of the optical pickup head. 1 ref.

Lee, Wai-Hon (Pentcom Int Corp, Santa Clara, CA, USA). *Lasers Optonics* v 6 n 9 Sep 1987 p 85-87.

**Applications** See SURFACES—Roughness Measurement.

## Performance

**078580 DEVELOPMENT OF THE FOCUSING AND THE TRACKING ACTUATOR IN AN OPTICAL DISC SYSTEM.** Optical pickups are used to pick up information from optical discs and are important for optical disc systems such as compact-disc (CD) players. To pick up information from discs without physical contact, an optical pickup is provided with an actuator which drives a laser spot on the disc surface according to the disc deflection and the track deviation. The driving efficiency is an important factor regarding actuators. Through development of forming and magnetization technics and elaborate analysis of the magnetic field, it was possible to significantly improve the driving efficiency. 7 Refs.

Kime, Kenjiro (Mitsubishi Electric Corp, Nagakakyō, Jpn); Hashimoto, Akira; Egusa, Naoyuki; Sakabe, Shigekazu. *Bull Jpn Soc Precis Eng* v 22 n 2 Jun 1988 p 133-138.

## PIERS

### Concrete Construction

**078581 COMMERCIAL BOAT PIER C-1.** The article discusses how precast prestressed deck channel sections, finger pier slabs, piles and pile caps provide strength, durability and economy for a 416 ft (127 m) long commercial boat pier situated in a hurricane prone harbor. This precast prestressed concrete commercial boat pier, with 51 boat slips, was built for docking 40 to 55 ft (12.2 to 16.8 m) long fishing boats. It is located in a picturesque part of Pass Christian Harbor, Pass Christian, Mississippi. (Edited author abstract)

Anon. *PCI J* v 33 n 1 Jan-Feb 1988 p 142-147.

### Failure

**078582 EFFECT OF CREEP ON THE UPLIFT BEHAVIOUR OF DRILLED PIERS.** A pier in tension under the action of a design load may collapse not because the static collapse load had been wrongly estimated but because the creep on the shaft-soil interface due to the sustained load had influenced the pullout behavior of the foundation. Laboratory model tests were carried out on short concrete piers in a compacted soil. Some piers were subjected to uplift forces to determine the ultimate failure load while others were subjected to various design loads. They were subsequently pulled out to failure. Results showed that the pullout behavior of piers is influenced by the occurrence of creep on the pier-soil interface and that the post-creep pullout capacities are dependent on the design (creep) loads sustained on the pier. (Author abstract) 13 refs.

Akinmusuru, Joe O. (Univ of Ife, Ife-Ife, Nigeria). *Int J Struct* v 7 n 2 Jul-Dec 1987 p 199-208.

### Foundations

**078583 REINFORCEMENT EFFECTS OF PIER FOUNDATION BY QUICK-LIME CONSOLIDATED BRIQUETTE PILE.** The bearing storage of foundation pile has turned out in earthquake by the examinations of several kinds of pile of pier constructed in the decade from 1955. Quick-lime consolidated briquette pile method used as a protection method against the weak point of pier foundation is described from the following viewpoints: investigation results of piled foundation, discussion of the protection methods, planning and construction of the protection methods, and confirmation of improvement

effects. (Edited author abstract) 5 refs. In Japanese.

Ito, Takao; Asada, Akie; Konno, Tatsuo. *Tohoku Kogyo Daigaku Kiyo* 1 n 8 Mar 1988 p 59-72.

### Repair

**078584 REHABILITATION OF SOUTH PIER, GODERICH HARBOUR.** This article deals with the deepening of an existing pier to allow berthing of fully loaded vessels operating in the North American Great Lakes and inland waterway system. The existing pier is a complex structure. The article discusses a method used to investigate the strength of the structure, the difficulties encountered and the limits to which improvements could be achieved. The article presents the solution finally devised and describes the method used in its analysis. The article also deals with the construction of the rehabilitation work, problems during the construction and solutions. (Author abstract).

Shah, V.K. (Public Works Canada, Can). *Bull Perm Int Assoc Navig Congr* v 61 1988 p 34-45.

### Structural Analysis

**078585 DYNAMIC CHARACTERISTICS OF PIERS SUBJECT TO BERTHING FORCES.** The effects on the berthing force due to: the masses of pier and ship; the stiffness of pier and fendering system; and the velocity of the ship berthing have all been investigated. A simplified mathematical model has also been developed to predict the berthing force. Three different mathematical models have been used to represent the pier deck and are employed in the dynamic analysis to obtain the dynamic behavior of piers subjected to ship berthing. The parametric study shows the influence of the rigidities of the pier deck on the dynamic behavior of the pier. A suggestion for the practical dynamic design of pier has been given. Field observation of piers subjected to ship berthing and ambient vibrations has been carried out, and results are discussed. (Edited author abstract) 10 refs.

Wong, C.W. (Hong Kong Polytechnic); Ko, J.M.; Lai, K.H. *Hong Kong Eng* v 14 n 5 May 1986 p 23-31.

### Vibrations

**078586 PRELIMINARY ANALYSIS OF THE DAMPING COMPOUND VIBRATION OF DEEP-WATER PILE PIER DUE TO IMPACT OF AN APPROACHING SHIP.** A method is proposed for the analysis of the compound vibration of a deep water pile pier equipped with a rubber fender system. The analysis is based on an hypothesis. During the plastic impact between the ship and the pier through the rubber fender, the motion behavior of the system is assumed to be free vibrations with damping and five degrees of freedom in a horizontal plane. The general solutions of the damped compound vibration are derived. With an illustrative example, the influence of the main parameters on the impact force, compression of the rubber fender, dynamic resistance and displacement of the piles is analyzed. (Edited author abstract) In Chinese. 6 refs.

Chen, Guozhu (Hohai Univ, China). *Shuili Xuebao* n 6 1987 p 26-35.

**PIEZOELECTRIC DEVICES** See Also ACOUSTIC SURFACE WAVE DEVICES—Analysis; INTERFEROMETERS—Laser Applications; VIBRATIONS—Damping.

**078587 COIL-LESS MINIATURE PIEZOELECTRIC CERAMIC TRANSFORMER.** A coil-less miniature piezoelectric transformer has been designed and fabricated using NPLZT-5 ceramic material. Such transformers are superior to other transformers in that these are light weight, small in size and coil-less thus eliminating electromagnetic interference. A voltage gain up to 10 can be obtained with the transformer developed. Linearity in gain has been observed from the input-output voltage characteristics curve at the input voltage studied. The effect of acoustic damping due to the medium in which the transformer vibrates has also been studied. Results ob-

tained in vacuum, air and oil have been discussed. The effect of temperature and position of mounting on voltage gain has also been studied. (Author abstract) 13 refs.

Bindal, V.N. (NPL, New Delhi, India); Kumar, Ashok; Jain, S.K. *Indian J Technol* v 25 n 4 Apr 1987 p 171-175.

**078588 MICROPOSITIONING USING PIEZOELECTRIC TRANSLATORS.** The phenomenon of piezoelectricity was discovered by the brothers Pierre and Jacques Curie in 1880. It was merely a scientific curiosity until Langevin began to use it in ultrasonic transducers at the start of World War I, which marked the beginning of a series of rapid developments. The piezoelectric effect is now used in an enormous variety of applications relating to the conversion of electrical energy to mechanical energy. This article introduces piezoelectricity and discusses some of its recent applications. The article shows how piezoelectric translators offer fine movement with speed and force for new levels of precision. 10 refs.

Atherton, Paul. *Photonics Spectra* v 21 n 12 Dec 1987 p 51-54.

**Acoustoelectric Effects** See ACOUSTIC VARIABLES MEASUREMENT—Ultrasonic Applications.

**Analysis** See ELECTRIC LAMPS, FLUORESCENT—Balloasts; ULTRASONIC TRANSDUCERS—Design.

**Applications** See Also TELEPHONE APPARATUS—Coin Operation.

**078589 USE OF PIEZOELECTRIC VIBRATION GENERATOR FOR VIBRATORY ASSEMBLY OF A RING ON A SHAFT WITH AN INTERFERENCE FIT.** Modern manufacturing engineering, especially precision instrument manufacturing, calls for tightened specifications for assembly of shaft-bush subunits with interference (for example, press-fitting of a precision ball bearing on the shaft). The most rational solution of the problem can be achieved by means of a vibration stimulation of the part being pressed on. Resulting elastic vibrations in the part are decreasing the effective pressing force (P). A model is shown of the assembly device, employing a ring-shaped piezoceramic vibration generator (PVG). The authors consider the mathematical model of a device permitting one to calculate the optimum parameters of the PVG. 1 ref.

Konenkov, Yu.K.; Striuzas, A.S. *Vib Eng* v 1 n 1-4 1987 p 209-213.

**Manufacture** See CERAMIC MATERIALS—Marketing.

**Measurements** See ULTRASONIC TRANSDUCERS—Measurements.

**Medical Applications** See DENTAL EQUIPMENT AND SUPPLIES—Ultrasonic Devices.

**Performance** See Also ACTUATORS—Performance.

**078590 DEVICES USING HIGH-COUPLING PIEZOELECTRIC CRYSTALS.** This paper reviews the development and application piezoelectric devices using high-coupling piezoelectric crystals, such as LiTaO<sub>3</sub> and LiNbO<sub>3</sub>, and describes some products that incorporate these devices. This paper describes the technological development of a substrate in the form of a large wafer, the process development of device manufacturing, device design technology, mass-production technology, and device applications in relation to market trends. (Edited author abstract). 29 Refs.

Tominaga, Hideki (Fujitsu Ltd, Kawasaki, Jpn); Ono, Masaaki; Fujiwara, Yoshiro. *Fujitsu Sci Tech J* v 24 n 2 Summer 1988 p 71-99.

### Pumps

**078591 PIEZOELECTRIC MICROPUMP BASED ON MICROMACHINING OF SILICON.** The design and realization of two pumps based on micromachining of silicon are described. The pumps, which are of the



reciprocating displacement type, comprise one or two pump chambers, a thin glass pump membrane actuated by a piezoelectric disk and passive silicon check valves to direct the flow. Chambers, channels and valves are realized in a silicon wafer by wet chemical etching. The results of mechanical calculations and simulations show agreement with the actual behavior. It is possible to design pumps having a specific yield and pressure dependence, and which are fail-safe (the flow is blocked while the pump is switched off). (Edited author abstract). 9 Refs.

Van Lintel, H.T.G. (CME Twente, Enschede, Neth); Van De Pol, F.C.M.; Bouwstra, S. *Sens Actuators* v 15 n 2 Oct 1988 p 153-167.

**Quartz Applications** See SURFACES—Roughness Measurement.

**Space Applications** See ARTIFICIAL INTELLIGENCE.

**Thermal Effects** See ACCELEROMETERS—Calibration.

**Thin Films** See ALUMINUM COMPOUNDS—Acoustoelectric Effects.

**Vibrations**

**078592 NONSTATIONARY VIBRATIONS OF A SECTIONED PIEZOELECTRIC CYLINDER IN ELECTRIC FIELD.** Until now there have been published relatively many papers devoted to studying periodical in time processes in piezoelectric bodies. Under the influence of electric impulses of short duration or shock loads the conditions of work of construction elements made of piezoelectric materials can be substantially nonstationary. The rules of behavior of electroelastic transducers under nonstationary electrical or mechanical perturbation are practically not studied at all. This article presents a method of solution of nonstationary wave problems of electroelasticity which is illustrated on the example of perturbation of a circular thick-walled piezoelectric cylinder by a nonstationary electric signal. It is assumed that the cylinder is of infinite extent and is polarized along the angular coordinate (circular polarization). 11 refs.

Babaev, A.E.; Savin, V.G. *Sov Appl Mech* v 22 n 12 Dec 1986 p 1130-1135.

**078593 VIBRATION FIELD CALCULATION FOR PIEZOELECTRIC VIBRATION GENERATORS OF WAVE-TYPE VIBROMOTORS.** In wave-type vibromotors (VM), various types of piezoelectric generators are used as input (driving) members for two and three dimensional wave vibrations generation. Interaction of the input and output members in VM can be investigated by solving the set of not less than four partial differential equations of the fourth-sixth order. It is quite complicated, even with computers. A computational method for steady vibration field parameters when the input member interacts with the output member, is presented in this paper. 5 refs.

Kurilo, R.; Ragulskis, K. *Vib Eng* v 1 n 1-4 1987 p 183-191.

**078594 TORSIONAL VIBRATION OF A PIEZOELECTRIC SOLID CYLINDER OF ARBITRARY CROSS SECTION OF (622) CLASS.** The torsional vibration of a piezoelectric solid cylinder of arbitrary cross section of class (622) crystals is investigated. The boundary conditions are satisfied using the Fourier expansion collocation method, and the frequency equation which is applicable for the general cross section is derived. Numerical calculations have been carried out for the circular cylinder and elliptic cylinders of  $\beta$ -quartz. The frequencies obtained in the present method for the circular cylinder are compared with those of an exact method. (Author abstract) 28 refs.

Paul, H.S. (Indian Inst of Technology, Madras, India); Venkatesan, M. *Int J Eng Sci* v 26 n 5 1988 p 437-443.

**PIEZOELECTRIC MATERIALS** See Also ACOUSTIC HOLOGRAPHY; ACOUSTIC WAVES; ACOUSTIC WAVES—Propagation; ACOUSTOELECTRIC EFFECTS; CERAMIC MATERIALS—Piezoelectric; CERAMIC MATERIALS—Synthesis; FLUORSPAR; LIGHT—Modulators; PIEZOELECTRIC TRANSDUCERS—Efficiency; PIEZOELECTRIC TRANSDUCERS—Performance; SEMICONDUCTING POLYMERS—Research; SURFACE WAVES—Propagation; SURFACE WAVES—Transmission; ULTRASONIC TRANSDUCERS—Mathematical Models.

**078595 NEW PIEZOELECTRIC POLYMERS.** Piezoelectricity and pyroelectricity, traditionally encountered in single crystals and ceramics, have now been documented in a number of polymers. The most successful and widely used polymer is polyvinylidene fluoride (PVF<sub>2</sub>) which has been shown to be ferroelectric. The copolymers of PVF<sub>2</sub> with related fluorinated vinyl monomers also exhibit piezoelectric activity and those with trifluoroethylene (VF<sub>2</sub>) show enhanced activity over the homopolymer. These particular copolymers crystallize into an intrinsically piezoelectric crystal phase from the melt and thus offer advantages in processing and potential application. This paper compares piezoelectric consumers obtained for commercially available PVF<sub>2</sub> with those for a series of PVF<sub>2</sub>/VF<sub>2</sub> copolymers. One copolymer shows a 50 percent increase in activity over PVF<sub>2</sub> when evaluated as a hydrophone material. The chemistry of alternative piezoelectric polymers is described. Areas of application are presented. (Edited author abstract) 27 refs.

Suttle, N.A. *GEC J Res* v 5 n 3 1987 p 141-147.

**078596 AXISYMMETRIC CONTACT PROBLEM OF ELECTROELASTICITY FOR A HALF-SPACE.** In a series of devices for electromechanical energy transformation one makes use of combined metal-ceramics (metal-piezoelectric ceramics) structures and one applies elements with separated electrodes of various configurations. The investigation of the contact rigidity of such elements under various supply and removal of electric energy regimes is of both scientific and practical interest. In this paper one obtains the exact solution of two contact problems regarding the pressing of a circular rigid punch against a piezoelectric ceramics half-space ( $z \geq 0$ ) with axial polarization. In the first case the boundary of the half-space is without electrodes, while in the second case one has a circular electrode whose radius is equal to the radius of the punch. On the basis of the obtained results it is concluded, that in calculating contact interactions in metal-ceramics structures, it is necessary to take into account the electric operating regimes of the piezoelectric ceramics elements. 6 refs.

Melkumyan, S.A. (Kiev Univ, USSR); Ulitko, A.F. *Sov Appl Mech* v 23 n 9 Sep 1987 p 836-843.

**078597 POTENTIALITIES OF THE AVERAGING METHOD IN THE PROBLEM OF WAVE PROPAGATION IN AN ELECTROELASTIC LAYER WITH PERIODIC NONUNIFORMITY OVER THE THICKNESS.** An earlier paper developed analytic and numerical methods for investigating wave processes in a layer made up of a number of piezoceramic layers. For structures with large numbers of layers, however, the numerical methods involved entail large amounts of machine time. This stems from the fact that the coefficients in the differential equations of motion are highly variable over the thickness, and thus an excessively small integration step must be chosen. In this paper, for the case of a periodic thickness nonuniformity, we employ the averaging method to set up equations whose coefficients are not rapidly variable, and whose solutions are close to the solutions of the original problem. We offer a detailed investigation of the changes in the dispersion set that arise as a result of averaging, and we estimate the error of the proposed method. (Edited author abstract) 4 refs.

Getman, I.P.; Ryabov, A.P.; Ustinov, Yu.A. *Mech Solids* v 22 n 3 1987 p 113-119.

**078598 COLLISION OF PIEZOCERAMIC RODS.** We consider identical piezoceramic rods that are initially polarized along their axes. There are electrically grounded electrodes on the end faces of the rods. An electrode is

inserted at the center of the first rod and is joined rigidly to it. It is assumed that a second rod moves with velocity  $v_0$  in the positive direction of the x axis toward the first rod, which lies on the same x axis on the interval  $0 < x < Z$ . These two rods collide at time  $t=0$ . We determine the electroelastic stressed state of the rods for  $t > 0$ , and the duration of the impact. Our results enable us to propose a technique for experimentally measuring the moduli of electroelasticity of piezoceramics (for small  $k_2$ ). 4 refs.

Chau, Le Hanh. *Mech Solids* v 22 n 3 1987 p 178-181.

**078599 MINI MOTION-DETECTOR SENSES IR WITH PIEZO FILM 'RETINA'.** This method of operation is based on the 'pyroelectric' energy conversion properties of a plastic piezoelectric film. Selectively sensitized, a semicylindrical strip of this infrared-sensitive material provides a retina-like function. Incident infrared (IR) radiation is focused on the 'retina' by a wide-angle plastic lens. Whenever IR energy from a moving heat source passes across its surface, the retina's pyroelectric properties generate a transient voltage. The voltage signal is amplified and analyzed by logic circuitry. This circuitry can be designed to recognize the entry or departure of a warm object of a specific size. It only reacts to objects passing through the area visible to the lens.

Stefanides, E.J. (Design News, Russellton, PA, USA). *Des News (Boston)* v 44 n 8 Apr 18 1988 p 88-89, 91.

**Acoustic Properties**

**078600 OPTICAL GENERATION OF SOUND IN A PHOTOCONDUCTING PIEZOELECTRIC MATERIAL.** We have studied the generation of surface acoustic waves (SAW) in a CdS crystal under the action of nanosecond laser pulses with a periodic intensity distribution. With an external electric bias field we observed high frequency ( $f=16$  MHz) acoustic signals with record low levels of absorbed light energy  $W \approx 10^{-8}$  J/cm<sup>2</sup>. The aim of the present work was to show experimentally, with CdS as an example, that it is possible to increase the effectiveness of photoacoustic conversion in high resistance photoconducting piezoelectric materials and to study the special features of the occurrence of the photoacoustic effect in this substance. 4 refs.

Deev, V.N.; Pyatkov, P.A. *Russ Ultrason* v 17 n 2 1987 p 71-74.

**Anisotropy** See Also SEMICONDUCTOR MATERIALS—Thermal Effects.

**078601 FIELDS OF DISPLACEMENT AND ELECTRIC POTENTIAL PRODUCED BY MOVING DISLOCATIONS IN ANISOTROPIC PIEZOELECTRIC CRYSTALS.** The displacement and electric potential fields produced by moving dislocations in anisotropic piezoelectric crystals are treated by using the method of Green's potential functions. The line integral expressions are derived for the fields around a uniformly moving dislocation-loop. The analytical solutions for the displacement and electric potential around a straight screw-dislocation moving in a cubic crystal or in a hexagonal crystal are obtained, and the stress and electric potential fields are numerically computed for several values of the velocity of the dislocation. (Author abstract). 15 Refs.

Shintani, Kazuhito (Univ of Electro-Communications, Chofu, Jpn); Minagawa, Sitiro. *Int J Eng Sci* v 26 n 8 1988 p 893-901.

**Applications** See INFRARED DETECTORS—Fabrication; PRESSURE MEASUREMENT—Automation.

**Crystal Lattices**

**078602 CRYSTALLOGRAPHIC ASPECTS OF UNIT CELL DISTORTION IN Pb(Zr, Ti)O<sub>3</sub>-Pb(Co, Nb)O<sub>3</sub> SOLID SOLUTIONS.** Pb(Co, Nb)O<sub>3</sub> (PCN) has a perovskite structure and a very low Curie temperature of  $-70^\circ\text{C}$ . Since the lattice parameters of PCN are very near those of Pb(Zr, Ti)O<sub>3</sub> (PZT), PCN and PZT readily form a solid solution. In the present work, the crystallographic phases and dielectric properties of PCN-PZT



solid-solution ceramics were investigated with respect to the degree of solid solution. For each sintering temperature, the lattice parameters as a function of the substituted PCN concentration are given. For all temperatures the lattice parameter along the axis is markedly decreased with an increase in PCN concentration; however, the lattice parameter along the a axis is slightly increased. Therefore the symmetry of the unit cell should be decreased as the degree of substitution of PCN is increased. Plots of the relative dielectric constant and planar electromechanical quality factor of the ceramics prepared at 1120°C against the concentration of PCN are also given. 11 Refs.

Lee, Jeon-Kook (Korea Advanced Inst of Science & Technology, Seoul, South Korea). *J Mater Sci Lett* v 7 n 9 Sep 1988 p 909-911.

## Defects

**078603 DISLOCATION DYNAMICS IN ANISOTROPIC PIEZOELECTRIC CRYSTALS. II. ADDITIONAL EXAMPLES.** The authors' theory for the stress and electric fields produced by moving dislocations in an anisotropic piezoelectric crystal is applied to the calculation of the electric fields produced by a uniformly moving infinite straight dislocation in lithium tantalate, bismuth germanium oxide, and zinc oxide. (Author abstract) 12 refs.

Minagawa, Saito (Univ of Electro-Communications, Chofu, Jpn); Shintani, Kazuhito. *Philos Mag A* v 56 n 3 Sep 1987 p 343-352.

**Electric Field Effects** See Also PIEZOELECTRIC DEVICES—Vibrations; QUARTZ—Vibrations.

**078604 AXISYMMETRICAL PROBLEM OF ELECTROELASTICITY FOR PIEZOELECTRIC LAYER WITH RING ELECTRODES.** Electroelastic fields are analyzed which appear in a piezoceramic layer polarized across the thickness  $2h$ , on the surface of which infinitely thin ring electrodes are located. It is shown that both radial and circular voltage as well as charge density possess root peculiarities at the edges of electrodes. Numerical calculations of electrical and mechanical fields on the electrode surface of the layer are presented for some parameters of a ceramic strip. (Edited author abstract) 5 Refs. In Russian.

Kokunov, V.A.; Parton, V.Z.; Fenin, N.A. *Probl Prochn* n 5 May 1988 p 84-88.

## Electromagnetic Field Effects

**078605 CHARACTERISTIC MODES OF OSCILLATION IN A PIEZOELECTRIC SEMICONDUCTOR IN AN ALTERNATING ELECTRIC FIELD.** The characteristic excitations in a piezoelectric semiconductor in an alternating electric field are studied theoretically. The coupled equation for the strain, charge density, electric fields, and the current in the piezoelectric semiconductor are solved using the continuous-fraction formalism. Analytic expressions are presented for the characteristic modes of the system and its Green's function. (Author abstract) 12 refs.

Gulyayev, Yu.V.; Kozorezov, A.G.; Mansfel'd, G.D. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 142-151.

**Energy Dissipation** See CERAMIC MATERIALS—Piezoelectric.

## Evaluation

**078606 CHARACTERIZATION OF PIEZOPLASTICS.** An evaluation method for piezoelectric plastics is presented. The method allows the intrinsic characteristics in the thickness mode to be obtained. It is based on the fitting of simulated and measured electrical impedance-frequency curves. The simulated curves are derived from a Mason model that takes into account the mechanical and dielectric losses of the material and their possible frequency dependences. Finally, an extension of the

method is described for the characterization of non-piezoelectric materials. (Author abstract) 11 refs.

Mequio, C. (Lab d-Electronique et de Physique Appliquee, Limeil-Brevannes, Fr); Coursant, R.H.; Tellier, J.M. *Sens Actuators* v 14 n 1 May 1988 p 1-8.

## Fiber Reinforcement

**078607 EFFECTIVE CONSTANTS OF PIEZOACTIVE COMPOSITES OF STOCHASTIC STRUCTURE.** Interest has recently increased in developing new piezoelectric materials, possessing enhanced stability properties. One of the promising directions in solving this problem is the creation of composite materials on the basis of piezoelectric (piezoelectric and piezomagnetic) ceramics, reinforced along the polarization axes by high-modulus anisotropic monocrystalline or polycrystalline fibers. A method is suggested in the present study for calculating the effective constants of piezoactive composites of a stochastic structure, based on applying the apparatus of conditional moment functions. The method can be used for prognosis of electroelastic and magnetoelastic characteristics of strongly inhomogeneous composites with arbitrary component concentrations. (Author abstract) 10 refs.

Leshchenko, P.V. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Maslov, B.P. *Sov Appl Mech* v 23 n 3 Mar 1987 p 268-275.

**Films** See SENSORS—Reviews.

**Low Temperature Properties** See SEMICONDUCTING INDIUM COMPOUNDS—Low Temperature Properties.

**Mathematical Models** See SEMICONDUCTOR MATERIALS—Mathematical Models.

**Mechanical Properties** See BIOLOGICAL MATERIALS—Bone.

**Medical Applications** See Also BIOMEDICAL ENGINEERING—Neurology.

**078608 EXTERNAL ULTRASOUND CAN GENERATE MICROAMPERE DIRECT CURRENTS IN VIVO FROM IMPLANTED PIEZOELECTRIC MATERIALS.** Under development is an internal fixation plate that incorporates a piezoelectric element to generate current when excited mechanically by either weight bearing or external application of ultrasound. The intent is to deliver this current to electrodes at a fracture or osteotomy site to aid in prevention or treatment of nonunion. The present study examines quantitatively the ability of external ultrasound to generate current from small piezoelectric ceramic elements implanted in tissue. An ultrasonic transducer was employed to excite small test coupons of a piezoelectric ceramic in vitro and in vivo with various materials, including water, PVC gel, cortical bone, and living soft tissues, interposed. (Edited author abstract) 7 refs.

Cochran, George V.B. (Helen Hayes Hospital, West Haverstraw, NY, USA); Kadaba, Murali P.; Palmieri, Vincent R. *J Orthop Res* v 6 n 1 Jan 1988 p 145-147.

## Morphology

**078609 MORPHOLOGY OF LEAD ZIRCONATE-TITANATE SINTERING PRECURSORS.** Studies on sintering are performed in order to find out the relationship between powder morphology, green density, chemical composition, inhomogeneities, heating program, atmosphere on the one hand and shrinkage, microstructure and physical properties on the other hand. In this situation the properties of the initial raw materials are very important. Thus, the powder morphology determined by the kind of precursor and its decomposition type is a decisive factor for the sintering result. In this paper, additional evidence is presented relative to the complexity of the lead zirconate-titanate ceramic problem, when the powder characteristics are highly dependent on the kind of precursors, the solid state reaction during sintering

being complex. 5 refs.

Zborea, I. (Inst for Physics & Technology of Materials, Bucharest, Rom); Constantinescu, F.; Robu, M. *Rev Roum Phys* v 33 n 1 1988 p 81-83.

**Phase Transitions** See Also CRYSTALS—Phase Transitions.

**078610 TEMPERATURE VARIATION OF THE DEBYE-WALLER FACTOR OF  $\text{NaNO}_2$ .** Sodium nitrite shows piezoelectric property at room temperature and has a phase transition in the range 160 to 166°C. In the present work measurements were carried out with the object of extracting the overall X-ray Debye-Waller factor (B) for  $\text{NaNO}_2$ . The motivation was to study the variation of overall Debye-Waller factor (B) of  $\text{NaNO}_2$  with temperature below and above the phase transition. The Debye-Waller factor decreases with increases with temperature below the phase transition, and increases with temperature above the phase transition. 10 Refs.

Somashekar, R. (Univ of Mysore, Manasagangotri, India); Prahlad, U.D.; Madhava, M.S. *J Mater Sci Lett* v 7 n 9 Sep 1988 p 989-990.

**Physical Properties** See CERAMIC MATERIALS—Electric Properties.

## Plastics Applications

**078611 WIDE-BAND PIEZOELECTRIC POLYMER ACOUSTIC SOURCES.** The design of a wideband acoustic source made of the piezoelectric polymer polyvinylidene fluoride (PVDF) is described. The source was developed for the characterization and absolute calibration of ultrasonic hydrophone probes. Construction details are described and performance characteristics of the wideband PVDF transmitter, including its transmitting voltage response and directivity patterns, are compared with theoretical predictions in the frequency range up to 40 MHz. The Krimholtz-Leedom-Mattaei (KLM) model was used to examine the influence of the PVDF polymer film thickness, the backing acoustic impedance, the cable length, and the electrical source resistance on overall transmit transfer characteristics. A comparison is made with traditional piezoelectric ceramic acoustic sources, and it is shown that piezopolymer transmitters exhibit some improved properties and are well suited for certain ultrasound dosimetry applications. In particular, the polymer sources have been found useful in measurements based on swept-frequency excitation. Those measurements allow characterization of transmitters and receivers to be performed as a virtually continuous function of frequency. 35 refs.

Lewin, Peter A. (Drexel Univ, Philadelphia, PA, USA); Schafer, Mark E. *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 2 Mar 1988 p 175-184.

**Processing** See CERAMIC MATERIALS—Piezoelectric; REFRACTORY MATERIALS—Zirconia.

**Stability** See BARIUM TITANATE.

**Synthesis** See Also LEAD COMPOUNDS—Hydrolysis.

**078612 TRANSPARENT  $(\text{Pb}, \text{Ca})(\text{Zr}, \text{Ti})\text{O}_3$  CERAMIC OBTAINED WITH THE AID OF THE ALKOXY TECHNOLOGY.** An ecologically clean method of synthesizing the complex oxides  $(\text{Pb}, \text{La})(\text{Zr}, \text{Ti})\text{O}_3$  (lead lanthanum zirconate titanate) is the so-called alkoxy technology—namely, the hydrolysis of metal alcoholate solutions in an organic solvent medium with subsequent heat treatment of the complex-oxide hydrate formed. A study was made of the process of formation of a lead lanthanum zirconate titanate solid solution of composition  $\text{Pb}_{0.90}\text{La}_{0.10}(\text{Zr}_{0.65}\text{Ti}_{0.35})_{0.975}\text{O}_3$  from an amorphous precipitate forming during the hydrolysis of an alcohol solution of titanium and zirconium alcoholates by an aqueous solution of Pb and La acetates or only  $\text{La}(\text{CH}_3\text{COO})_3$  in the presence of solid  $\text{PbO}$ . After annealing at 600°C for 30 minutes a single-phase crystalline product with an average crystallite size of about 150 Å is formed.



In Russian. 12 refs.

Yanovskaya, M.I.; Turevskaya, E.P.; Turova, N.Ya.; Dambekalne, M.Ya.; Kolganova, N.V.; Ivanov, S.A.; Degalla, A.G.; Belov, V.V.; Novoselova, A.V.; Venevsev, Yu.N. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 4 Apr 1987 p 658-661.

**078613 EFFECT OF THE PRECIPITATION TEMPERATURE ON THE STRUCTURE AND PROPERTIES OF A BISMUTH AND TITANIUM COPRECIPITATE.** A study was made of the effect of the precipitation temperature on the dispersion characteristics, phase composition and chemical activity of a bismuth and titanium coprecipitate. With an increase in the precipitation temperature an increase in primary precipitation particles and secondary agglomerates is observed. These processes are accompanied by loss of the phase homogeneity and a decrease in the chemical activity of the precipitate, which causes an increase in the bismuth titanate synthesis temperature. From these samples a ceramic was sintered. Studies showed that at a given sintering temperature the density of the ceramic is lower in powders obtained at high temperatures. For the preparation of a ceramic with a maximum density from these powders high sintering temperatures are required. (Translated author abstract) In Russian. 6 refs.

Parkhomenko, V.D.; Vereshchak, V.G.; Troyan, M.M. *Khim Tekhnol (Kiev)* n 3 (153) May-Jun 1987 p 7-9.

**078614 SYNTHESIS OF MULTICOMPONENT NIOBATE PIEZOCERAMIC.** A study was made of the process of formation at solid solutions of complex niobates, using X-ray phase and differential-thermal analyses and radiography. It was established that this process is characterized by overlapping and simultaneously occurring reactions of formation of intermediate compounds. On the basis of samples of the  $\text{Li}_2\text{O}-\text{Na}_2\text{O}-\text{Nb}_2\text{O}_5$  system with additions of the oxides  $\text{MgO}$ ,  $\text{CaO}$ ,  $\text{SrO}$ ,  $\text{BaO}$  and  $\text{TiO}_2$ , piezoceramic materials with low permittivities and comparatively high piezoelectric properties have been obtained. In Russian. 8 refs.

Aboltinya, I.V.; Vinogradova, I.S.; Freidenfel'd, E.Zh. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 10 Oct 1987 p 1726-1729.

## Thermal Expansion

**078615 THERMAL DEFORMATIONS AND PHASE TRANSFORMATIONS IN TOURMALINES.** In air, Tourmalines are stable up to 825-995°C, depending on their composition. The decomposition products are mullite and an X-ray amorphous phase, and also hypersthene in the case of magnesium-containing varieties and spodumene in the case of lithium-containing varieties. Up to 400°C, only a thermal expansion which is more intense along the c-axis occurs. In iron-containing tourmalines above 400°C oxidation of iron begins. The result is compression of the structure along the a-axis with compensation of the thermal expansion and a sharp increase in the c-parameter at high temperatures. The directions of the maximum thermal expansion, the maximum amplitudes of the thermal vibrations of atoms, and the minimum refractive index in the Tourmaline structure coincide with each other and are perpendicular to packets of the (001) structure. In Russian. 12 refs.

Filatov, S.K.; Gorskaya, M.G.; Bolotnikova, N.I. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 4 Apr 1987 p 594-599.

**Thermoelasticity** See THERMOELASTICITY—Theory.

**Thin Films** See Also PIEZOELECTRIC TRANSDUCERS—Materials; SPEECH—Measurements.

**078616 STRUCTURAL CHARACTERISTICS OF ZINC OXIDE FILMS.** A study was made of the structural characteristics of ZnO films deposited by three-electrode sputtering, using the methods of X-ray diffractometry and vibrational spectroscopy. It is shown that the investigated ZnO films possess residual elastic

stresses. By enriching the sputtering atmosphere with oxygen, ZnO films without residual elastic stresses (equilibrium films) can be obtained. In spite of the fact that, by combining sputtering with heat treatment, it is possible to obtain fine-crystalline ZnO films without mechanical stresses, in the surface layer of the substrates irreversible changes resulting from the action of the initially deformed film in the substrates may remain. In Russian. 10 refs.

Galina, G.A.; Kal'naya, G.I.; Ogurtsov, S.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 10 Oct 1987 p 1669-1673.

**Ultrasonic Applications** See ULTRASONIC TRANSDUCERS—Design.

## Vibrations

**078617 DETERMINATION PAR LA METHODE DES ELEMENTS FINIS DES MODES DE VIBRATION DES CERAMIQUES PIEZOELECTRIQUES.** [Determination of the Modes of Vibration of Piezoelectric Ceramics by the Method of Finite Elements]. The solution of the general expressions for the propagation of vibrations in piezoelectric materials is only possible using certain simplifying assumptions. In contrast the numerical methods of solving partial differential equations are perfectly adapted to this type of problem. They are an effective and indispensable tool for determining the stress fields and deformations of vibrating elements to be used for the manufacture of transducers for imaging or echography. Since existing finite element codes do not take account of the piezoelectric effect, we have written our own finite element program, but limiting it to the case of materials with simple geometries. We describe the general structure of our algorithm and then present the results obtained from the simulation. (Author abstract) In French. 37 refs.

Brissaud, M. (INSA, Villeurbanne, Fr); Eyraud, L.; Kleimann, H. *Acustica* v 64 n 1 Jul 1987 p 14-25.

**PIEZOELECTRIC TRANSDUCERS** See Also ACOUSTIC VARIABLES MEASUREMENT—Wave Velocity; ACOUSTOOPTICAL DEVICES—Spectrum Analysis; ELECTRIC MOTORS—Starting; ULTRASONIC TRANSDUCERS—Performance.

**078618 RESONANT CHARACTERISTICS OF PZT-4 TRANSDUCERS FOR PHOTOACOUSTIC SIGNAL DETECTION.** Rectangular and circular types of PZT-4 transducers have been studied. Their resonant frequencies were determined in different media and related to the photoacoustic signal generation. Recommendations were made for maximum signal detection with these transducers. (Author abstract) 11 refs.

Koyuncu, B. (Kuwait Univ, Kuwait). *Opt Laser Technol* v 19 n 5 Oct 1987 p 265-268.

**078619 PVDF TRANSDUCERS GENERATING SCHOLTE WAVES.** We show that Scholte waves, propagated at a water/silica interface, may be generated by an interdigital transducer using a thin film of polyvinylidene fluoride as piezoelectric material. (Author abstract) 6 refs.

Nasr, S. (LEAH Ultrasons, Le Havre, Fr); Duclos, J.; Leduc, M. *Electron Lett* v 24 n 6 Mar 17 1988 p 309-311.

## Analysis

**078620 EQUIVALENT CIRCUIT ANALYSIS FOR TONPILZ PIEZOELECTRIC TRANSDUCER.** Tonpilz piezoelectric transducers are one style of transducers for high-power sound generation. However, the transducers have mainly been designed by the trial-and-error method. This paper precisely estimates the transducer performances beforehand by an equivalent circuit analysis. The precise electro-mechano-acoustical equivalent circuit is derived for the transducer, including housing, an acoustic rubber layer and a bolt, and its transmission matrix is presented. To improve the calculation accuracy, the effects of adhesive layers in a piezoelectric ceramic stack part and compressive stress by bolting them

together are included into the electrical and mechanical equivalent constants for the ceramic stack. To accurately evaluate any errors between theoretical and measured values, transducer performances are expressed as absolute values in MKS units. Based on this analysis, a Tonpilz transducer has been built. Transmitting and receiving voltage sensitivities for the transducer, as well as the respective resonant frequencies, mechanical quality factors and free admittance loci in air and in water, have been measured. (Edited author abstract) 17 refs.

Inoue, Takeshi (NEC Corp, Kawasaki, Jpn); Sasaki, Takashi; Miyama, Tetsuo; Sugiuchi, Katsumi; Takahashi, Sadayuki. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 10 Oct 1987 p 909-917.

**Applications** See LASER BEAMS—Measurements; MATERIALS TESTING—Nondestructive Examination; ULTRASONIC EQUIPMENT—Modular Construction.

## Design

**078621 FREQUENCY CHARACTERISTICS OF THE SENSITIVITY OF A TWO-LAYER PIEZORECEIVER WITH OPPOSITE POLARIZATION OF LAYERS.** On the basis of calculations it is shown that if sections are connected in series with opposite polarization, the piezoreceiver has wide-range properties. The working range was expanded to a certain extent using a two-layer transducer with opposite polarization of the layers. A planar sound wave travels to the transducer from one side, e.g., from a liquid. On the other side, the transducer borders with air or is covered with an acoustically soft screen. The sections of the transducers are connected in series. The resultant electrical voltage at the output of the transducer is equal to the difference of the voltages which would form in each of the layers if the polarization direct were the same. (Edited author abstract) 1 ref.

Bystrov, Yu.M. (Electrotechnical Inst, Leningrad, USSR); Kuz'menko, A.G. *Sov J Nondestr Test* v 23 n 5 May 1987 p 340-342.

**078622 SYSTEMATISCHE VERSUCHE BEI DER KONSTRUKTION EINES PIEZOELEKTRISCHEN WANDLERS.** [Systematic Experiments When Designing a Piezoelectric Transducer]. When the physical principle of a transducer has been determined, its mechanical realization requires extensive work in the laboratory. Many interdependent parameters have to be optimized at the same time by means of calculations and experiments, which are essential for the functioning and the production costs of the transducer. Using a piezoelectric current transducer with PVDF membranes it is shown how systematization of the experimental parameters can improve the general view and make laboratory work more efficient. (Edited author abstract) In German. 7 refs.

Burr, Jacob. *F&M Feinwerktech Messtech* v 95 n 8 Dec 1987 p 499-501.

**078623 MONOLITHIC BIMORPH WITH INTERNAL ELECTRODES.** Monolithic bimorphs with internal electrodes which are composed of two, three and four layers were made from the high  $d_{31}$  material of a modified  $\text{Pb}(\text{Ti}, \text{Zr})\text{O}_3$ . The new bimorphs utilized unstiffened mode and were used as large-displacement transducers under low DC bias. Those bimorphs with four layers generate displacement of up to 0.6 mm at a voltage of 30 V with 4 msec response. The force induced by the DC bias was in proportion to the bias. Hysteresis of the displacement became smaller by introducing an intermediate layer or internal Pd electrodes. (Author abstract) 6 refs.

Ogawa, Toshio (Murata Manufacturing Co, Nagaokakyo, Jpn); Ando, Akira; Wakino, Kikuo. *Jpn J Appl Phys Suppl* v 25 suppl 25-1 1986, Proc 6th Symp on Ultrason Electron, Tokyo, Jpn, Dec 10-12 1985 p 25-27.

## Efficiency

**078624 VIBRATIONAL MODES AND EFFICIENCY OF ENERGY CONVERSION IN COMPOSITE PIEZOELECTRIC RODS.** Longitudinal, flexural and asymmetrical vibrations of the initial region of the



spectrum of a compound rod-type piezoelectric transducer and its state of stress under uniform and nonuniform electric loading are considered. It is shown that by means of a controlled supply of electric power to the transducer components it is possible to increase the square of the dynamic coefficient of the electromechanical coupling of the most intensive longitudinal mode by 7-20%, and of its harmonics by a factor of 7-8. 4 refs.

Karlash, V.L. (Acad of Sciences of the Ukrainian SSR, USSR). *Sov Appl Mech* v 23 n 2 Feb 1987 p 170-174.

**Materials** See Also PRESSURE TRANSDUCERS—Materials.

**078625 SOLEF PVDF BIAXIALY ORIENTED PIEZO- AND PYROELECTRIC FILMS FOR TRANSDUCERS.** Previous work has shown that biaxially oriented PVDF, which is subsequently poled by means of corona discharge, gives piezo- and pyroelectric films with improved physical and piezoelectric properties. These films exhibit superior aging characteristics. More recent work by Solvay has confirmed that the choices of base material,  $\beta$ -transformation and polarization conditions are important factors for the optimization of film quality. Cost of the continuously poled film for the first time is in a range suggesting new end uses. Improved methods of adhesion of the metal electrode layer to the surface of the film give adhesion strength test results surpassing those of the standard Scotch tape test. (Edited author abstract) 22 refs.

Gerliczy, G. (Solvay Technologies Inc, New York, NY, USA); Betz, R. *Sens Actuators* v 12 n 3 Oct 1987 p 207-223.

**078626 CHARACTERIZATION OF MODIFIED LEAD TITANATE PIEZOCERAMICS. APPLICATION TO THE DESIGN OF ARRAY TRANSDUCERS.** Due to their high electromechanical anisotropy, lead titanate piezoelectric ceramics of modified composition are very interesting for designing either linear or annular ultrasonic transducer arrays used in medical diagnosis and in non-destructive testing. In this paper results of the characterization of three varieties of this type of material are presented. The characterization includes the measurement of the resonance frequency dispersion diagram of thin parallelepipedic elements and the measurement of the characteristics in the longitudinal thickness mode and the planar mode. In view of the application to the design of transducers, several types of structures are presented. (Author abstract) 17 refs.

Coursant, R.H. (Lab d'Electronique et de Physique Appliquee, Limeil-Brevannes, Fr); Tellier, J.M.; Eyraud, L.; Eyraud, P.; Fink, M. *Sens Actuators* v 13 n 4 Apr 1988 p 351-363.

**Mathematical Models** See Also NONDESTRUCTIVE EXAMINATION—Ultrasonic Applications.

**078627 ETUDE THEORIQUE DE LA DETERMINATION DE LA POLARISATION INDUITE DANS LES CAPTEURS SPHERIQUES PIEZOELECTRIQUES.** [Theoretical Determination of the Induced Polarization in Spherical Piezoelectric Transducers]. The influences of anisotropy on the static characteristics of spherical transducers is considered. Simplified equations corresponding to elastic anisotropy are used for determining those characteristics of a great majority of piezoelectric ceramics. In French. 7 refs.

Brissaud, M. (INSA, Fr); Eyraud, C.H.; Eyraud, L.; Kleimann, H. *Acustica* v 63 n 4 Jun 1987 p 293-296.

**078628 DESIGN AND DEVELOPMENT OF BROADBAND AXISYMMETRICAL PIEZOELECTRIC TRANSDUCERS OF VARIABLE THICKNESS.** Axisymmetrical transducers of variable thickness are analyzed. Their interrelationship with various surface profiles and amplitude-frequency responses is demonstrated. The design features of broadband transducers are indicated. Methods of correcting the amplitude-frequency response are discussed. (Author abstract) 5 refs.

Vopilkin, A.Kh. (Central Scientific Research Inst of Technology & Machine Construction, Moscow, USSR). *Sov J Nondestr Test* v 23 n 4 Apr 1987 p 265-273.

**078629 PIEZOELECTRIC TRANSDUCERS WITH A NONUNIFORM ELECTRIC FIELD IN A TWO-DIMENSIONAL APPROXIMATION.** Results are presented from theoretical and experimental investigations of the transient operating mode for piezoelectric transducers that have a nonuniform electric field. Rules are developed for the transient processes in longitudinally and transversely polarized piezoelectric ceramic transducers. (Author abstract) 7 refs.

Kazhisi, R.-I.Yu. (Antanas Snehkus Kaunas Polytechnic Inst, USSR); Mazheika, L.Yu. *Sov J Nondestr Test* v 23 n 6 Jun 1987 p 400-405.

**078630 CONTROL OF APERIODIC MOTIONS OF PIEZOCERAMIC TRANSDUCER.** The subject of this paper is the problem of calculating control voltages in order to obtain a specified time history of motion of the points of a piezotransducer or the time history which is the closest to the specified one. For the description of dynamics of the piezotransducer we shall use the finite elements method and will limit ourselves to models based on the linear theory of piezoelectricity. The problem of optimal control is solved by using the correlations presented in another paper. The results of the solution of the numerical example are also presented. 2 refs.

Barauskas, R.A.; Ragulskis, K.M.; Reinikis, V.K. *Vib Eng* v 2 n 2 1988 p 193-202.

## Medical Applications

**078631 APPLICATION OF PIEZO/PYROELECTRIC FILMS IN MEDICAL TRANSDUCERS.** Piezo-/pyroelectric films are capable of generating electrical signals in response to mechanical stress or heat flow, making them the equivalent of a capacitor connected in parallel with a leakage resistor and current source. The piezo- and pyroelectric coefficients, and electrical and thermal time constants of such films can be useful in the design of medical sensors. The author describes three electronic interface circuits: a voltage follower, current-to-voltage converter, and charge-to-voltage converter. Applications for such transducers include a contact microphone, strain-gauge plethysmograph, respiration monitor, thermal imaging sensor, 'instant' thermometer, and a thermal scanner. (Author abstract) 7 refs.

Fraden, Jacob (FreMed Inc, New Haven, CT, USA). *J Clin Eng* v 13 n 2 Mar-Apr 1988 p 133-138.

## Oscillations

**078632 COUPLED FLEXURAL-SHEAR OSCILLATIONS OF STEPWISE-LAYERED PIEZOCERAMIC DISK TRANSDUCERS.** The stepwise-layered piezoceramic disk transducers are widely used in various domains of technology as emitters and receivers. We consider the oscillations of stepwise-layered piezoceramic disk transducers taking into account the connection between flexural and shear oscillations. 7 refs.

Allaverdiev, A.M. (Moscow Electronic Technology Inst, USSR); Akhmedov, N.B.; Shermegor, T.D. *Sov Appl Mech* v 23 n 5 May 1987 p 465-471.

**Performance** See Also LASER BEAMS—Measurements; PRESSURE TRANSDUCERS—Performance.

**078633 CHARACTERIZATION OF NONCONTACT PIEZOELECTRIC TRANSDUCER WITH CONICALLY SHAPED PIEZOELEMENT.** The characterization of a dynamic surface displacement transducer (IQI Model 501) by a non-contact method is presented. The transducer is designed for ultrasonic as well as acoustic emission measurements and, according to the manufacturer, its characteristic features include: a flat frequency response range which is from 50kHz to 1000kHz and a quality factor Q of less than unity. The characterization is based on the behavior of the transducer

as a receiver and involves exciting the transducer directly by transient pulse input stress signals of quasi-electrostatic origin and observing its response in a digital storage oscilloscope. Theoretical models for studying the response of the transducer to pulse input stress signals and for generating pulse stress signals are presented. The characteristic features of the transducer which include the central frequency  $f_0$ , quality factor Q, and flat frequency response range are obtained. They compare favorably with those obtained by a tone burst method which are also presented. (Edited author abstract). 30 Refs.

Williams, James H. (MIT, Cambridge, MA, USA); Ochi, Simeon C.U. *NASA Contract Rep* n 4151 Jun 1988 87p.

**078634 PERFORMANCE ANALYSIS OF PIEZOELECTRIC COMPOSITE PLATES WITH CONSIDERATION OF THE INTERNAL LOSSES.** The performance of a 2.3-MHz composite transducer with 1-3 connectivity is analyzed using the transmission line model. The basic transducer parameters, including the attenuation coefficient, are determined from the electrical impedance in the vicinity of the resonance. Using these parameters, the effects of internal losses on round trip insertion loss (RTIL) are investigated. Also, electrical impedance, pulse-echo, and RTIL response are calculated and found to be in good agreement with the experimental data. 17 refs.

Ih, Jong Hyun (Electronics & Telecommunications Research Inst, Chungnam.); Lee, Byung Ho. *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 1 Jan 1988 p 73-77.

## Pressure Measurement

**078635 KOLBENPIEZOMETER FUER DRUECKE BIS 100 MPa UND TEMPERATUREN BIS 180 °C.** [Piston-Piezometer for Pressures to 100 MPa and Temperatures to 180 °C]. The experimental set-up of a piston piezometer constructed at PTB is described. The calibration, the filling, and the measurement procedures are reported. The evaluation is discussed, the measurement uncertainty is estimated. The results of a measurement series on the mineral oil BP Transcal N are communicated. (Author abstract) 13 refs. In German.

Klingenberg, Guenther. *PTB Mitt* v 98 n 2 Apr 1988 p 121-127.

## Reliability

**078636 METHOD TO INCREASE RELIABILITY OF PIEZOELECTRIC ANGULAR RATE SENSORS.** TQC (Total Quality Control) and elimination of the early failure can make the average lifetime of PARS (Piezoelectric Angular Rate Sensors) increase by 8.95 and 9.20 times, respectively. With the two methods, the lived distributions of uniaxial and triaxial PARS are also Weibull distributions. The MTBF are 20,250 and 6,750 hours, respectively, i.e., increase by 20.92 and 20.96 times. (Author abstract) 6 refs.

Zhang, Fu Xue (Beijing Information Technology Inst, Beijing, China). *Reliab Eng* v 19 n 1 1987 p 15-21.

**078637 ALLOWING FOR THE INDIVIDUAL FEATURES OF TRANSDUCERS WHEN PLOTTING ARD-DIAGRAMS.** Various piezoelectric transducers (PET) are produced, some of which can be used only for UT of an actual finished item. The differences in PET characteristics are due to the properties of the materials, the designs, the manufacturing techniques and so forth. The use of dimensionless ARD-diagrams with these PET give rise to additional errors in determining  $S_0$  because of the differences in transducer operating conditions, which becomes particularly apparent in the short-range zone of PET. This article outlines the results of an investigation into the possibility of describing the short-range and long-range zones of a transducer by a single approximating function.

Blyumen, A.L.; Samedov, Ya. Yu.; Shcherbinskii, V.G.; Zabortsev, S.A. *Sov Energy Technol* n 7 1987 p 43-45.



**PIEZOELECTRICITY** See Also BIOLOGICAL MATERIALS—Bone; CERAMIC MATERIALS—Acoustic Emission Testing; ELECTRETS; POLYMERS—Electric Properties; TRANSISTORS, FIELD EFFECT—Stresses.

**078638 CONTRIBUTION OF MACROSCOPIC DIMENSION EFFECT TO PIEZOELECTRICITY IN POLYVINYLIDENE FLUORIDE.** In this paper, we have studied the piezoelectricity in the poled uniaxially drawn polyvinylidene fluoride. The piezoelectric constants  $d_{31}$ ,  $d_{32}$ ,  $d_{33}^*$  and Young's moduli  $1/s_{11}$  and  $1/s_{22}$  have been determined as a function of the remanent polarization  $P_r$ . The piezoelectric constants of the samples show a strong in-plane anisotropy. Such an anisotropy is mostly attributable to different Poisson's ratio. It is found that the piezoelectric activity mainly arises from macroscopic dimensional change. (Author abstract) 22 refs.

Wen, Jianxun (Acad Sinica, Shanghai, China); Furukawa, Takeo. *Chin J Polym Sci (Engl Ed)* v 5 n 4 1987 p 292-297.

**Mathematical Models** See Also CRYSTALS—Electric Properties; SEMICONDUCTOR MATERIALS—Mathematical Models.

**078639 PLANE STRAIN PROBLEMS IN PIEZOELECTRICITY.** The paper is concerned with some boundary-value problems in the static theory of linear piezoelectricity. First, fundamental solutions are established. Then, the boundary-value problems are reduced to integral equations for which Fredholm's basic theorems are valid. Existence theorems are derived. (Author abstract) 11 refs.

Iesan, D. (Univ of Iasi, Iasi, Rom). *Int J Eng Sci* v 25 n 11-12 1987 p 1511-1523.

**Theory** See PIEZOELECTRIC DEVICES.

**PIG IRON** See Also BLAST FURNACE PRACTICE.

**Chemical Reactions**

**078640 DESILICONIZATION OF PIG IRON BY USING OF  $Cl_2$  AND  $H_2$  SIMULTANEOUSLY.** A desiliconization method for pig iron using  $FeCl_2$  has been reported by one of the authors. The work shows that the utilization efficiency of  $FeCl_2$  was low. An object of this study is to examine whether silicon in pig iron can be evaporated by  $Cl_2$  gas as  $SiCl_2$ .  $FeCl_2$  produced by a simultaneous reaction is reduced by  $H_2$  blown onto the surface of molten pig iron. 2 refs.

Kaneko, Masao (Chiba Inst of Technology, Narashino, Jpn); Sasabe, Minoru. *Trans Iron Steel Inst Jpn* v 28 n 1 1988, Prepr for the 114th ISIJ Meet, Part I, Kumamoto, Jpn, Oct 9-11 1987 p B.34.

**Impurities** See IRON ORE TREATMENT—Smelting.

**Manufacture** See Also BLAST FURNACE PRACTICE—USSR.

**078641 VYROBA CHROMOVEHO SUROVEHO ZELEZA Z LOUZENCVOHEO AGLOMERATU.** [Chrome Pig Iron Process]. The process has been tested in order to utilize the waste leached product from nickel production. The feasibility of the process has been proved. From the data obtained a material and thermal balance has been set up. The experiment is characterized by low blast furnace productivity and high energy demands. 3 refs. In Czech.

Kabelac, Oldrich (VITKOVICE, Ostrava, Czech); Sousek, Vladimir; Had, Alois. *Hutn Listy* v 42 n 10 Oct 1987 p 705-711.

**Mechanical Properties** See CAST IRON—Castings.

**Physical Chemistry**

**078642 POSSIBILITIES OF REDUCING THE MANGANESE AND SILICON CONTENT OF PIG IRON IN RELATION TO SULPHUR CONTENT**

**AND CARBON OXIDATION KINETICS.** In Czechoslovak steelplants, pig iron is produced from iron ore containing mostly 0.05-0.56% Mn. Therefore, Mn ore with 36-45% Mn is added to the blast furnace charge. In addition to Mn ore, recirculating steelmaking slag with 4.44-5.6% Mn and also 0.49-1.5% P is added. In the conditions existing in Czechoslovak steelworks, a reduction of 0.1% in the manganese content of pig iron is expected to save 5.5 kg of manganese ore, 1.5 kg/t of coke, and improve output by 0.3%. The Mn, Si and S content has a negative effect on the kinetics of carbon oxidation. 7 refs.

Parma, Vaclav (Technical Univ, Ostrava-Poruba, Czech); Bazan, Jiri. *Met Mater (Cambridge Engl)* v 25 n 6 Nov-Dec 1987 p 370-375.

**Production**

**078643 ENTWICKLUNG DER ROHEISEN-PRODUKTION IN VANDERBYLPARK (SUEDA-FRIKA).** [Development of Pig Iron Production at Vanderbylpark (South Africa)]. The ISCOR blast furnace plant at Vanderbylpak is Africa's largest pig iron producer with an annual production of 3.4 million tons (1986). This is the result of a productivity increase of more than 40% with the same furnace capacity over a ten-year period. The fuel consumption was reduced by about 20% in the same time period. Other cost-reducing measures have contributed to making South Africa one of the most economical sites for the production of pig iron and steel. In this paper the author describes the metallurgical developments and blast furnace modification which made these achievements possible. In German. 3 refs.

Noska, T.G. (South African Iron & Steel Corp, Vanderbylpark, S Afr). *Berg Huettenmaenn Monatsh* v 133 n 1 1988 p 61-76.

**Refining** See FERROALLOYS—Manufacture.

**Standards**

**078644 PRIPREMA VLASTITIH STANDARDA GVOZDA U ANALIZI SPEKTROMETRIJOM EMISIJE X-ZRAKA.** [Preparation of Standard Samples of Pig-Iron for X-ray Emission Spectrometry Analysis]. The samples were obtained by admixing of pure elements and by melting this mixture in an induction furnace. The melts were charged into a copper mold for hot pressing. The samples can be applied for calibration curves for determination of Cu, Mn, Si, P, Cr and Ni by x-ray emission spectrometry. (Edited author abstract) In Serbo-Croatian. 8 refs.

Kesic-Racan, Milica (Metalurski Fakultet, Sisak, Yugosl); Matkovic, Prosper. *Metalurgija (Sisak Yugosl)* v 26 n 2-3 Apr-Sep 1987 p 59-65.

**Temperature Measurement**

**078645 USE OF A SYSTEM TO CONTINUOUSLY MEASURE PIG-IRON TEMPERATURE DURING TAPPING.** A system to continuously measure pig-iron temperature during tapping has been in use on blast furnace No. 9 at the Krivorožstal' combine since 1982. Analysis of its performance has made it possible to implement several measures to increase the accuracy and reliability of the temperature measurement. The authors made changes in the circuit of the measurement system, corrected the program for initiation of temperature measurement, and moved the pyrometric sensors and computer links into the casthouse control room. This made it possible to provide pig measurements from 1350 to 1600°C with an error no greater than 1% relative to a control thermocouple.

Leonov, O.I. ('Krivorožstal' Combine, USSR); Shidlovskii, A.A.; Grinshtein, N.S.; Tarakanov, A.K.; Bairaka, M.N. *Metalurgist (USSR)* v 31 n 5-6 May-Jun 1987 p 158-159.

**PIGMENTS** See Also COATINGS—Materials; COLOR—Evaluation; COPOLYMERS—Adsorption; DYES AND DYING; FLUORESCENCE—Laser Applications; INDUSTRIAL PLANTS—Costs; THERMOPLASTICS—Coloring.

**078646 PIGMENT DEVELOPMENT.** Pigments for the decoration of ceramics have been used since prehistoric times and although over the centuries significant additions have been made to the potters' palette, it was not until about 200 years ago in Europe that the systematic development of ceramic pigments began. It is only in relatively recent times that a scientific approach to pigment development has been introduced into what at one time was considered to be an art. This paper describes some of the pigment research and development which is in progress with the ultimate objective of extending the color palette of the potter.

Airey, A.C. (British Ceramic Research Ltd). *Br Ceram Trans J* v 86 n 5 1987 p 138-142.

**078647 DEFINING ORGANIC AND INORGANIC PIGMENTS.** Pigments are categorized according to their generic name and chemical makeup. They are available in a number of forms. Pigment selection is dependent on the intended end-use of the coating. In many applications, organic and inorganic pigments are used together as their individual properties complement each other.

Anon. *Ind Finish (Wheaton Ill)* v 63 n 12 Dec 1987 p 22, 24.

**078648 ANORGANISCHE WEISSPIGMENTE.** [Inorganic White Pigments]. The manufacture and applications of the most important white pigments are described. By the example of  $TiO_2$ , the basic principles of pigment chemistry and physics are explained for a better understanding of their optical properties, stability, and dispersibility. In ZnS-based pigments, properties other than brightening and covering are currently valued. (Edited author abstract) In German.

Griebler, W.-D. ('Sachtleben' Chemie GmbH, Duisburg-Homberg, West Ger). *Sprechsaal* v 120 n 12 Dec 1987 p 1103-1111.

**078649 DEVELOPMENT OF NEW TYPE COLORED NACREOUS PIGMENT.** The authors have developed a colored nacreous pigment having bright color tone and a pearly gloss having excellent stability and safety. In order to obtain the pigment, a titanium dioxide layer on mica was reduced to black titanium oxide and the reduced  $TiO_2$ -coated mica was coated with titanium dioxide. Various colors are available by adjusting the thickness of the titanium dioxide layer. (Edited author abstract) In Japanese. 3 refs.

Kimura, Asa; Suzuki, Fukuji. *J Jpn Soc Powder Powder Metall* v 34 n 9 Nov 1987 p 497-501.

**078650 SPECTROSCOPIC INVESTIGATION OF THE ANISOTROPY OF A LIQUID CRYSTAL MATRIX DOPED WITH PHOTOSYNTHETIC PIGMENTS: EFFECT OF PIGMENT CONCENTRATION ON THE DEGREE OF MACROSCOPIC ORDER.** The macroscopic order parameters of the homogeneously aligned liquid crystal (MBBA) with dissolved photosynthetic pigments (chlorophyll a, chlorophyll b and  $\beta$ -carotene) were determined using polarized absorption, emission and Raman scattering methods. Assuming the cylindrical symmetry of the pigment orientation around the liquid crystal director, the experimental and calculated values of the order parameter were correlated by using the distribution function of the nematics. It was shown that the order parameter of the matrix is dramatically destroyed by a high chlorophyll concentration ( $3 \times 10^{-3}M$ ), whereas over a wide range of concentration the carotene did not change the matrix order. (Author abstract). 9 refs.

Martynski, T. (Poznan Technical Univ, Piotrowo, Poland); Drodowski, M.; Kozielski, M.; Salamon, Z. *Dyes Pigm* v 9 n 5 1988 p 371-383.



## Agglomeration

**078651 EXAMPLE OF SPHERICAL AGGLOMERATION OF PIGMENT IN LATEX PAINT.** Spherical agglomeration, as defined by the mineral refining industry, can result from adsorption of a surfactant and a hydrocarbon solvent onto solid particles dispersed in an aqueous medium. Bridging of the particles by the hydrocarbon leads to separation as unique, large spherical agglomerates. Such behavior was observed in a water-based latex paint where preferential agglomeration of a particular pigment, yellow iron oxide, caused an undesirable loss of tinting strength with increased shaking time. The pigment agglomerates were studied after separation by dilution and decanting. The problem was avoided by making the pigment less hydrophobic. (Author abstract) 10 refs.

Smith, Ronald E. (PPG Industries Inc, Allison Park, PA, USA). *J Coat Technol* v 60 n 761 Jun 1988 p 61-63.

## Analysis

**078652 METHODS OF DETERMINING THE STATE OF PIGMENT DISPERSION.** Three direct and three indirect methods are reported for analyzing the degree of pigment dispersion. Microscopy and sedimentation, which are well-known direct methods, and fiber optic quasi-elastic light scattering, which is a recent addition. Among indirect methods, rheological, viscoelastic and optical methods are well-known, and they have now been supplemented by methods involving the measurement of flocculation gradient and energy distribution broadening during proton or  $\alpha$ -particle scattering. All these various methods illustrate a common feature of colloid and interface science: only the combined application of several, different methods can explain how and why a dispersion behaves in a particular way. 28 refs.

Schroeder, Joerg (BASF AG, Ludwigshafen am Rhein, West Ger). *Prog Org Coatings* v 15 n 4 Feb 29 1988 p 337-353.

**Applications** See CATALYSTS—Cobalt Compounds; PHOTOGRAPHIC REPRODUCTION—Xerography; SOLAR CELLS—Materials.

**Chemical Reactions** See CADMIUM COMPOUNDS—Chemical Reactions; RUBBER—Latex.

## Chemistry

**078653 UTILIZATION OF THE COMPARATIVE QUANTITATIVE ASSESSMENT OF SENSITIZING EFFECT OF PHENYLENE DIAMINE ISOMERS FOR SUBSTANTIATION OF THEIR MACs IN THE WORK ZONE AIR.** Organic chemical phenylene diamine is used in pigment manufacture. One of the hygienic problems in the paint production industry is the assessment method of sensitizing effect of phenylene diamine isomers and evaluation of their toxicity limits. Sensitizing effect experiments in guinea pigs are described and analyzed. In Russian. 9 refs.

Kurlyandsky, B.A.; Alekseeva, O.G.; Livke, T.N.; Bandurova, G.P.; Pavlova, T.A. *Gig Tr Prof Zabol* n 8 Aug 1987 p 46-48.

**Composition Effects** See PLASTICS—Coloring.

**Concentration** See WOOD PRODUCTS—Finishing.

**Dissolution** See PAINT—Production.

## Fabrication

**078654 ZINC IRON CHROMITE PIGMENTS.** The system  $\text{ZnO-Fe}_2\text{O}_3\text{-Cr}_2\text{O}_3$  is the basis of most of the brown pigments used in the whitewares industry. The ability of iron to occur on both the tetrahedral and octahedral sites of the spinel structure leads to a versatile system yielding a variety of related shades. (Author abstract) 15 refs.

Murdock, Stephen H. (O. Hommel Co, Pittsburgh, PA,

USA); Eppler, Richard A. *J Am Ceram Soc* v 71 n 4 Apr 1988 p C212-C214.

## Grinding

**078655 EVOLUTION OF THE PAINT MILL.** The grinding and dispersing of pigments is the most important processing step in paint manufacturing. This article discusses how paint mills have evolved. Effective pigment grinding and uniform dispersion can be achieved using a small media mill that breaks up large pigment clusters into colloidal-size entities and distributes them evenly in the solution. A media mill consists essentially of a chamber containing a set of equally spaced disks fixed on a shaft and a motor drive. The disks can be rotated at tip speeds of 1700 to 2200 fpm. After grinding media is added to the chamber, pigment and vehicle slurry are pumped in, passing through a whirling bed of media that grinds and disperses the pigment particles. The dispersed product is then removed from the chamber through a screen that retains the media.

Janatpour, Mojee (Morehouse Industries Inc, Fullerton, CA, USA). *Ind Finish (Wheaton III)* v 64 n 1 Jan 1988 p 24-25.

**Luminescence** See Also AGRICULTURAL PRODUCTS—Spectroscopic Analysis.

**078656 SENSITIZED FLUORESCENCE OF CHLOROPHYLL A BY CAROTENOID.** The sensitized fluorescence of chlorophyll a (Chla) by carotenoid (Car) was studied. The transmission efficiency was estimated and the effect of acceptor concentration on the transmission efficiency was analyzed. The optical measurements were performed with the RF-520 Dual Beam difference Spectrofluorophotometer and the UV-200 Spectrophotometer. The samples were separated from spinach by chromatography. 5 refs.

Meng, Jiwu (Acad Sinica, Changchun, China); Hou, Shangong. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 686-687.

**Magnetic Properties** See COATINGS—Synthesis.

**Manufacture** See Also SCRUBBERS.

**078657 NEW TECHNIQUE OF PRODUCTION OF BRUNSWICK GREENS.** A new technique developed by the Regional Research Laboratory, Bhubaneswar, for the production of Brunswick Greens directly from the basic raw materials has been described. The properties of the product obtained by the new method have also been studied and compared with those of a product produced by other methods. The commercial production of these pigments still continues even though on a reduced scale due to their low cost and the shades which can not be imitated by any other formulation. The reduced production is also attributed to the availability of phthalocyanine Greens which replaced them in some applications. (Edited author abstract)

Prasad, T.P. (Regional Research Lab, Bhubaneswar, India); Suryanarayana, A.; Nayak, R. *Res Ind* v 32 n 1 Mar 1987 p 61-63.

**078658 PREPARATION AND PROPERTIES OF UNIFORMLY COATED INORGANIC COLLOIDAL PARTICLES. 2. CHROMIUM HYDROUS OXIDE ON HEMATITE.** Mixed or complex colloidal matter has been of interest in various applications, such as in fabrication of composite materials. For certain uses it may be advantageous to deposit uniform layers of a given substance on the particles of another kind to achieve a modification of the surface charge characteristics and/or other properties (magnetic, optical, adsorptive, density, etc.) For instance, several processes have been developed for coating pigments. Spindle-type hematite particles of narrow size distribution were coated with uniform layers of chromium hydrous oxide by using a 'forced hydrolysis-precipitation' procedure. The coating process can be enhanced either by aging the chrom alum solution or by

pretreating it with an addition of base. The subsequent heating of such solutions in the presence of hematite 'cores' yielded uniformly coated particles if the available surface areas of the dispersed solids and the concentration of the chromium complex solutions were in appropriate ratios. Various properties of the coated solids are described. (Edited author abstract) 44 refs.

Garg, Ajay (Clarkson Univ, Potsdam, NY, USA); Matijevic, Egon. *Langmuir* v 4 n 1 Jan-Feb 1988 p 38-44.

**078659 CERAMIC PIGMENTS IN THE NIO-MgO-SiO<sub>2</sub> SYSTEM.** Attempts were made to obtain new nickel-bearing greenish pigments using a completed isomorphism of magnesium and nickel in the orthosilicates of olivine group; their green coloration is due to the presence of the chromophore ion of nickel in the hexagonal (six-fold) coordination. X-ray phase analysis carried out showed that the fired materials contain only a small amount of nickel-olivine. In order to delineate the reasons for the deviation, a study was made using a heating assembly (attachment) in conjunction with the diffractometer. The results are discussed.

Sobolev, E.V. (State Inst of Glass, USSR); Bystrikov, A.S.; Kozakova, N.N. *Glass Ceram* v 44 n 9-10 Sep-Oct 1987 p 390-393.

**078660 BIOLOGICAL MONITORING OF OCCUPATIONAL EXPOSURE IN THE CHROMATE PIGMENT PRODUCTION INDUSTRY.** A survey of occupational exposure to hexavalent chromium in chromate pigment production was undertaken in factories producing lead chromate ( $\text{PbCrO}_4$ ) and strontium chromate ( $\text{SrCrO}_4$ ). Exceptionally high levels of chromium in blood ( $387\text{-}4160 \text{ nmol l}^{-1}$ ) and urine ( $41\text{-}1250 \text{ nmol nmol}^{-1}$  creatinine) as well as skin and nasal lesions, were discovered amongst the workforce at the strontium chromate plant. These contrasted with occupationally unexposed levels of  $< 20 \text{ nmol l}^{-1}$  and  $< 1 \text{ nmol nmol}^{-1}$  creatinine, respectively, and led to the continuation of the biological monitoring programme. At the same time, improved working practices and respiratory protection equipment were introduced. A steady elimination of chromium from whole blood with a half-life of approximately 24 days was found. This elimination rate was confirmed over a 14-day period when the workforce were completely removed from exposure. (Edited author abstract). 7 refs.

McAughey, J.J. (Occupational Medicine & Hygiene Lab, London, Engl); Samuel, A.M.; Baxter, P.J.; Smith, N.J. *Sci Total Environ* v 71 n 3 Jun 1 1988 p 317-322.

**Materials** See Also TITANIUM OXIDES—Flotation.

**078661 INFLUENCE OF AGGREGATE STRUCTURE AND WETTING ON THE DISPERSIBILITY OF  $\beta$ -COPPER PHTHALOCYANINE PIGMENTS IN VISCOUS PRINTING INKS.** In the specific context of dispersibility of  $\beta$ -copper phthalocyanine pigments for viscous printing inks, attention is concentrated on two aspects. One is the influence of crystal growth on aggregate structure; the other is the influence of abiethyl resin additives on aggregate structure and wettability. It is shown that the aggregate structure is, however, extensively penetrated and opened up by organic liquids at room temperature and higher. These liquids gain access to surfaces inaccessible to nitrogen. Crystal growth then occurs to produce rod-shaped  $\beta$ -form crystals. The extent of crystal growth is dependent upon the strength of interaction of the liquid with the copper phthalocyanine surface. Above a critical region for the heat of interaction of  $104$  to  $106 \text{ mJ m}^{-2}$  extensive growth occurs. At higher levels of growth, a second growth mechanism becomes evident: this involves side-by-side fusion of  $\beta$ -form crystals and results in lower crystal axial ratios. 12 refs.

McKay, Robert B. (Ciba-Geigy Pigments, Paisley, Engl); Mather, Robert R. *Colloids Surf* v 27 n 1-3 Oct 1987 p 175-186.



Measurements See MAGNETIC MATERIALS—Measurements.

## Mechanical Properties

**078662 EINFLUSS ORGANISCHER OBERFLÄCHENBEHANDLUNGEN AUF DIE FESTIGKEIT VON  $\text{TiO}_2$ -AGGLOMERATEN.** [Influence of Surface Treatment on the Strength of  $\text{TiO}_2$  Agglomerates]. The extent to which the reduction in agglomerate strength caused by surface treatment of titanium dioxide pigments can be explained by Van der Waals' interaction forces of individual pigment particles was investigated. The Hamaker constants of 27 organic surface treatment substances were determined and the attraction energies were calculated using an equation derived by M.J. Vold. It is assumed that in the region of lowest coverage, a liquid bridge model described in the literature can be used in place of the Vold model. (Edited author abstract) 7 refs. In German.

Winkler, J. *Farbe Lack* v 94 n 4 Apr 1988 p 263-269.

Mixing See COATINGS—Production.

Modification See Also TITANIUM OXIDES—Modification.

**078663 SURFACE TREATMENT OF PIGMENTS.** Coated pigments which possess a high affinity for binder molecules and preserve such affinity into the dry film will exhibit a high degree of dispersion in the film and favorable properties such as gloss, color strength, chroma and better light- and weather-resistant properties than the corresponding untreated pigments. This arises from the improved wettability achieved since better wetted pigment particles are also shielded to a greater extent by the binder molecules against the adverse action of light and weather. In addition, the film as a whole will exhibit a lower permeability towards water and oxygen and a higher durability and mechanical properties in contrast to the situation where 'pigment wetting' is lower. The surface treatment of pigments provides a powerful method for achieving this goal. 30 refs.

Schroeder, Joerg (BASF AG, Ludwigshafen am Rhein, West Ger). *Prog Org Coatings* v 16 n 1 May 17 1988 p 3-17.

Morphology See DYES AND DYEING—Morphology.

## Optical Properties

**078664 OZONE FADING OF NATURAL ORGANIC COLORANTS: MECHANISMS AND PRODUCTS OF THE REACTION OF OZONE WITH INDIGOS.** Indigo, dibromoindigo, and colorants containing thioindigo and tetrachlorothioindigo were exposed in the dark to dry, purified air containing ozone (10 ppm) for 4 days, and the exposed samples were analyzed by mass spectrometry. Under the conditions employed, indigo and dibromoindigo were entirely consumed, and the major reaction products were isatin and isatoic anhydride from indigo and bromoisatin and bromoisatoic anhydride from dibromoindigo. Thioindigo and its chloro derivative also reacted with ozone, though at a slower rate; the corresponding substituted isatins and anhydrides were tentatively identified as reaction products. These results can be rationalized in terms of a mechanism involving electrophilic addition of ozone onto the unsaturated carbon-carbon bond. (Author abstract) 15 refs.

Grosjean, Daniel (California Inst of Technology, Pasadena, CA, USA); Whitmore, Paul M.; Cass, Glen R.; Druzak, James R. *Environ Sci Technol* v 22 n 3 Mar 1988 p 292-298.

**078665 GLOBAL OPTIMIZATION IN AN INVERSE PAINT-OPTICS PROBLEM.** Pigment-system optics (PSO) has applications of direct and inverse types. The direct class involves determining the optical and color characteristics for systems from those of the components. By inverse problems, one means the determination of component characteristics to provide overall characteris-

tics for the system as a whole. The latter are optimizations, since one needs to determine the optimum values for the components to minimize the target function. The objective of this work is to choose an effective global-optimization method for that purpose. Four algorithms were selected. One of the simplest global-optimization ones is complete search and involves search on an LP grid, which is an approximation to a grid with uniformly distributed nodes, while Torn's algorithm is based on random search with cluster analysis to identify local minima, whose main advantage is its speed, since the auxiliary calculations consume only a little time. The other two algorithms are based on statistical models: the simplified Bayes one and an axiomatically constructed statistical simulation method. The authors conclude that the axiomatic algorithm is the most effective, and it was selected for calculating mixtures with given spectral and color features. The modified variable-metric algorithm was used as the local-optimization one to refine the global search results. 14 refs.

Pilyavskii, V.P.; Vol'fovskii, I.G. *J Appl Chem USSR* v 60 n 9 pt 1 Sep 1987 p 1845-1848.

**078666 OPTISCHE EIGENSCHAFTEN GERICH-TET ANGEORDNETER EISENOXIDGELBPIG-MENTE.** [Optical Properties of Oriented Iron Oxide Yellow Pigments]. When needle-shaped iron oxide yellow pigments are mixed with a roll mill into PVC films, the impression of color is highly dependent on the angle of view (silking). As the iron oxide needles have a high degree of orientation, it was possible for the first time to obtain information on the optical constants of an anisotropic pigment. The extent of the silking effect is dependent only on the difference in scattering power along and across the needles. (Author abstract) In German 5 refs.

Keifer, Siegfried. *Farbe Lack* v 94 n 5 May 1988 p 345-350.

**078667 FARBSTARKE VON PIGMENTEN IN OFFSETDRUCKFARBEN.** [Colour Strength of Pigments in Offset Printing Inks]. Colour strength is an important quality criterion for organic pigments. Determination of colour strength is, however, frequently a problem in practice especially when comparing coloristically similar pigments with the same colour index. These difficulties are examined, causes shown and solutions discussed using examples. (Author abstract). 3 Refs. In German.

Braun, F. (BASF Aktiengesellschaft, West Ger). *Farbe Lack* v 94 n 6 Jun 1988 p 447-450.

## Performance

**078668 EFFECT OF FIBER BEATING ON  $\text{TiO}_2$  PIGMENT PERFORMANCE.** The retention of  $\text{TiO}_2$  pigment and its light-scattering efficiency were evaluated on handsheets formed from fibers beaten to different degrees of freeness. Cationic  $\text{TiO}_2$ , which deposits on anionic fibers, was used to eliminate the effect of pigment flocculation caused by retention aids. The degree of beating had only a small effect on the amount of pigment that was deposited on fiber and retained during sheet preparation when less pigment was added than required for full fiber coverage. On the other hand, beating considerably affected the apparent light-scattering efficiency of the pigment, which increased progressively with beating level. It is assumed that the fibrils and fines generated by beating are prevented from collapsing onto the fiber surface by the pigment particles and that this provides an additional source of light scattering. (Author abstract) 15 refs.

Alinec, B. (Pulp & Paper Research Inst of Canada, Pointe Claire, Que, Can). *Tappi J* v 70 n 10 Oct 1987 p 114-117.

## Photochemical Reactions

**078669 IMPROVEMENT IN THE LIGHTFAST-NESS OF DYED AND PIGMENTED MATERIALS-PART 2: EFFECT OF SINGLE OXYGEN QUENCHERS ON THE PHOTOSTABILISATION**

**OF ORGANIC PIGMENTS IN SOME COATING FILMS.** The effect of some singlet oxygen quenchers on the photostabilisation of C.I. Pigment Red 3 and C.I. Pigment Red 49 in coating films prepared from cellulosic lacquer, alkyd resin and polyurethane-type paints was examined. The rates of photodegradation of the pigments were retarded by adding effective singlet oxygen quenchers, such as nickel diethyldithiocarbamate, nickel bis(dithiobenzil) and nickel bis(N-n-dodecylsalicylaldimine). The coexistence of an equal amount of the singlet oxygen quencher and a hindered phenol (good radical scavenger) was effective in improving the light resistance of the pigments, but the addition of a hindered phenol alone was not effective. (Author abstract). 31 refs.

Kuramoto, Nobuhiro (Osaka Prefectural Industrial Research Inst, Osaka, Japan); Natsukawa, Kazuki; Hirota, Minoru. *Dyes Pigm* v 9 n 5 1988 p 319-327.

Photoconductivity See DYES AND DYEING.

## Physical Properties

**078670 SQUARAINE CHEMISTRY: EFFECT OF SYNTHESIS ON THE MORPHOLOGICAL AND XEROGRAPHIC PROPERTIES OF PHOTOCONDUCTIVE SQUARAINES.** A new general synthesis of photoconductive squaraines, namely bis(4-dimethylaminophenyl)squaraine HSq and its derivatives FSq, MeSq, and HOSq, using dialkyl squarates as precursors (ester-route) has been developed. The morphological properties of the squaraine pigments synthesized were studied by scanning electron microscopy and x-ray powder diffraction. Results show that pigment particles synthesized by our new procedure are smaller in size and exhibit different crystallographic orientation as compared to their counter-parts synthesized by the squaric acid procedure (acid-route). (Edited author abstract) 39 refs.

Law, Kock-Yee (Xerox Corp, Webster, NY, USA); Bailey, F. Court. *J Imaging Sci* v 31 n 4 Jul-Aug 1987 p 172-177.

## Production

**078671 EPAORGAANISSET PIGMENTIT.** [Inorganic Pigments]. The history, classification and production of inorganic pigments are reviewed. Various types of pigments and their applications are discussed with special emphasis on colored pigments. (Author abstract) In Finnish. 37 refs.

Leskela, Tuula (Teknillinen Korkeakoulu, Espoo, Finl); Niinisto, Lauri. *Kem Kem* v 14 n 10 1987 p 806-811.

Remote Sensing See REMOTE SENSING.

Research See CERAMIC MATERIALS—Research.

Selection See CERAMIC MATERIALS—Coloring; LUBRICANTS—Solid Films.

## Synthesis

**078672 PECULIARITIES OF THE SYNTHESIS OF CERAMIC PINK PIGMENT.** The authors studied the possibility of synthesizing rose colored pigments on the basis of corundum with additions of  $\text{Mn}_2\text{O}_3$ ,  $\text{Fe}_2\text{O}_3$  and  $\text{Cr}_2\text{O}_3$  in amounts of from 1 to 10%. To reduce the synthesis temperature of the pigments we added boric, alkali, and phosphate compounds to the original mixtures. The results of the determination of the color characteristics of the pigments with the various mineralizing agents are presented. The investigations showed that adding 10-20% calcium borate ensures a high tone purity (25%). The modifying action of borate is caused by the capacity of the ions of the alkaline earth metals to reinforce the deformation of the electron shells of the chromophores. However, during the production of colored glazes we noted a reduction in the tone purity. It is known that zinc oxides stabilizes the color of pigments. An addition of 5-15%  $\text{ZnO}$  led to the formation of graphite,  $\text{ZnAl}_2\text{O}_4$ , and contributed to color stability of the pigment in the glaze melts. The investigation showed that the optimum



firing temperature is 1200°C at which color stability is provided with the maximum tone purity of pigment. 5 refs.

Pishch, I.V. (Byelorussian S.M. Kirov Inst of Technology, USSR); Rotman, T.I.; Romanenko, Z.A. *Glass Ceram* v 43 n 9-10 Sep-Oct 1986 p 465-467.

**078673 BASIC STAGES IN SYNTHESIZING IRON OXIDE PIGMENTS FROM Fe(II) SOLUTIONS.** The authors consider the chemistry of the main stages and the effects of synthesis parameters on the phase composition, morphology, and size. Experiments indicate that the kinetic and thermodynamic parameters have substantial effects on pigment synthesis rates and on the physical and other parameters. The mean size tends to decrease as the formation rate increases, which indicates that there are optimum conditions for making these pigments, which can be defined by experiment. 10 refs.

Raspopov, Yu.G. (Inorganic Pigments & Marine Coatings Research & Development Inst, USSR); Kleshchev, D.G.; Sheinkman, A.I.; Krasnobai, N.G.; Bubnov, A.A. *J Appl Chem USSR* v 60 n 5 pt 2 May 1987 p 1039-1042.

**078674 COLOUR AND CONSTITUTION RELATIONSHIPS IN ORGANIC PIGMENTS. PART I. MONOAZOACETOACETANILIDES.** Monoazoacetanilides provide some of the most important classical organic pigments in the yellow to orange shade area for a range of applications. As a first step in attempting to establish the color and constitution relationships in this series of products, a range of monoazoacetanilides was synthesized and their uv/visible spectral behavior in solution investigated. PPP molecular orbital calculations, using the generalized set of parameters approach, were refined by parameter optimization to provide an excellent correlation between calculated and experimental  $\lambda_{max}$  values for the principal absorption band, and in addition there was generally good qualitative agreement between molar extinction coefficients and the calculated oscillator strengths. The nature of the electronic excitation process is discussed in terms of the calculated changes in  $\pi$ -electron charge densities. (Author abstract) 28 refs.

Christie, Robert M. (Scottish Coll of Textiles, Galashiels, Scotl); Standing, Paul N.; Griffiths, John. *Dyes Pigm* v 9 n 1 1988 p 37-56.

**078675 NEW HETEROCYCLIC PIGMENTS.** The discovery of a novel family of heterocyclic compound pigments, 1,4-diketopyrrolo(3,4-c)pyrrole, called the DPP is discussed. An attempt is made to rationalize their properties in terms of their solid state structures. Various mechanisms of formation of DPP are described and the chemistry, especially bearing on the synthesis and development of pigmentary forms of DPP, also is briefly outlined. (Edited author abstract) 7 refs.

Iqbal, A. (CIBA-GEIGY Ltd, Fribourg, Switz); Cassar, L.; Rochat, A.C.; Pfenniger, J.; Wallquist, O. *J Coat Technol* v 60 n 758 Mar 1988 p 37-45.

**078676 SQUARINE CHEMISTRY. SYNTHESIS, STRUCTURAL CHARACTERIZATION AND XEROGRAPHIC PROPERTIES OF MIXTURES OF HALOSQUARINES.** A number of mixtures of halosquarines have been synthesized by co-reacting mixtures of N,N-dimethylaniline and N, N-dimethylhaloaniline with dibutyl squarate in water-saturated 1-butanol. Yield decreases as the concentration of N, N-dimethylhaloaniline increases and this decrease is attributable to the low reactivity of N,N-dimethylhaloaniline. This low reactivity is also revealed in the lower than expected halogen incorporation in all the mixtures studied. The chemical composition of each mixture was studied by high-resolution proton NMR spectroscopy and mass spectrometry. The merit of these two techniques in the identification and quantification of individual squarines in the mixtures is presented and discussed. The xerographic properties of each mixture were studied by xerographic photodischarge technique in bilayer photoreceptor devices. (Edited author abstract) 21 refs.

Law, Koch-Yee (Xerox Webster Research Cent, Webster, NY, USA); Kaplan, Samuel; Crandall, Raymond K. *Dyes*

*Pigm* v 9 n 3 1988 p 187-200.

**078677 SYNTHESIS OF A BLUE ZIRCON PIGMENT.** Thermal analysis (DTA, DTG, TG), calcination of the starting mixture in an electric furnace at various temperatures and for different periods of time, and tabletting (marking) experiments have been used to evaluate the reactions involved in the synthesis of the blue zircon pigment  $Zr_{1-x}V_xSiO_4$ . Three industrial samples of  $ZrO_2$  were evaluated as the starting zircon components. The temperature of the pigment synthesis was determined for each of three samples, their different reactivity explained, and the mechanism and kinetics of the pigment formation investigated. (Author abstract) 31 refs.

Trojan, M. (Inst of Chemical Technology, Pardubice, Czech). *Dyes Pigm* v 9 n 3 1988 p 221-232.

**078678 PIGMENTS HAVING A CORDIERITE TYPE STRUCTURE.** Based on the method suggested by S.G. Tumanov, pigments were obtained of different colors having the willemite, mullite, spene, and zircon-like structures etc. The possibility of synthesizing such pigments for the structures of different types was confirmed by the thermodynamic analysis of the energy state of the process of evolution (formation) of crystalline phases. Differently colored ceramic pigments based on cordierite  $2 MgO \cdot 2 Al_2O_3 \cdot 5 SiO_2$  have been synthesized by equimolecular substitution of magnesium oxide with the oxides of other metals. It can be concluded that the synthesis reaction of the nickel-bearing cordierite is characterized by large negative values of the Gibbs energy as compared to the reaction of formation of nickel spinel. 5 refs.

Maslennikova, G.N. (S. Ordzhonikidze MIU, USSR); Fomina, N.P. *Glass Ceram* v 44 n 9-10 Sep-Oct 1987 p 387-389.

**078679 SYNTHESIS OF A PINK ZIRCON PIGMENT.** A pink zircon pigment of the inclusion type,  $(ZrSiO_4)_{1-x}XFe_2O_3$ , has been synthesized by a thermal process from the starting oxides  $ZrO_2$  and  $SiO_2$ . Green vitriol (ferrous sulphate) or ferric oxide-hydroxide has been used as the chromophore (source of the inclusions). The reactions in the synthesis have been followed by thermal analysis, by analysis of the products prepared under isothermal conditions at various temperatures and during various reaction times in an electric furnace, and by tabletting (marking) experiments. Two types of commercial  $ZrO_2$  have been used, both of them being raw materials for the industrial production of zircon pigments. The reactivity of these oxides has been evaluated, the conditions of the pigments synthesis have been determined and the reaction mechanism and kinetics have been investigated. (Edited author abstract) 29 refs.

Trojan, M. (Inst of Chemical Technology, Pardubice, Czech). *Dyes Pigm* v 9 n 5 1988 p 329-342.

**078680 NOVEL SYNTHESIS OF FLUORESCENT WHITENERS OF THE PALANIL WHITE R SERIES.** A novel route for the synthesis of the commercially important 1,4-bis(styryl)benzene fluorophore is described. The synthesis involves the reaction of 1,4-benzenediacetic acid with phthalic anhydride to yield a 1,4-bis(phthalyl)benzene, reduction and subsequent dehydration of which gives the 1,4-bis(o-carboxystyryl)benzene derivative, which can be readily converted into the desired dinitrile. (Author abstract) 6 refs.

Naik, H.A. (Univ of Bombay, Bombay, India); Seshadri, S. *Dyes Pigm* v 9 n 5 1988 p 351-356.

**Temperature Measurement** See POLYVINYL CHLORIDE—Thermal Effects.

**Testing** See Also PAINT—Degradation; PROTECTIVE COATINGS—Plastics.

**078681 PRINCIPLE OF SPECTRAL EVALUATION IN PIGMENT TESTING. A REVIEW OF 20 YEARS' APPLICATION OF A SUCCESSFUL METHOD.** The development and applications of the Principle of Spectral Evaluation in pigment testing is

described in this paper. The 'principle of spectral evaluation' permits mathematical simulation of the visual evaluation of the adjustment of two sample coatings by combining elements of Kubelka-Munk theory and colorimetry. When determining the hiding power, that film thickness of the paint film is found at which the contrast background just disappears to the eye of the observer. The reciprocal of the thickness of this hiding layer gives the hiding power as a yield property, since it specifies the area which can be hidden by coating with one liter of this paint. Some of the new improvements are discussed. 23 refs.

Voelz, Hans G. (Bayer AG, Krefeld-Uerdingen, West Ger). *Prog Org Coatings* v 15 n 2 Jun 26 1987 p 99-124.

**078682 KAOLIN-BASED CERAMIC PIGMENTS.** The purpose of this investigation is to determine the maximum amount of kaolin based on which one can produce pigments and to examine the role of chromophores and modifying additives. For subsequent experiments we selected  $ZrO_2$ ,  $SnO_2$  and  $TiO_2$  as the modifying oxide additives since they are known to impart thermal stability and chemical resistance to the pigments. The optimum synthesis temperature was 1200°C. Introducing 10-60%  $Fe_2O_3$  makes it possible to obtain brown colored pigments. The presence of chromium oxides (5-30%) in the kaolin-bearing systems led to an increase in the firing temperature up to 1250°C because of the refractoriness of  $Cr_2O_3$  and imparted greenish coloration to the pigments. It is shown that kaolin-based pigments possess improved color characteristics and their application is economical. 6 refs.

Pishch, I.V. (S.M. Kirov Byelorussian Technological Inst, USSR); Rotman, T.I.; Romanenko, Z.A. *Glass Ceram* v 43 n 7-8 Jul-Aug 1986 p 319-322.

**078683 CROWDING AND SPACING OF TITANIUM DIOXIDE PIGMENTS.** For geometric reasons, the maximum size of extender particles intended to improve hiding is limited by rutile size and volume concentration. Maximum size of hiding effective extender is small, less than commercial products and dispersion processes can deliver. Hiding improvements can, however, be obtained through uniform spacing of rutile by coatings no rutile particles. The hiding power advantage of such product over conventional rutile could be as much as 10%. 15 refs.

Braun, Juergen H. (DuPont, Wilmington, DE, USA). *J Coat Technol* v 60 n 758 Mar 1988 p 67-71.

**078684 EFFECT OF PIGMENTS ON THE FLAMMABILITY OF REINFORCED THERMOPLASTICS.** A study was undertaken to determine the effect of selected colorants on the flammability characteristics of unreinforced flame-retarded nylon 6/6, 20 percent glass-reinforced flame-retarded nylon 6/6, and 20 percent glass-reinforced flame-retarded polycarbonate. This article reviews the effects of colorant addition on flammability properties measured according to UL 94 and on key mechanical properties such as tensile strength and notched Izod impact strength. Colorants can adversely affect tensile, impact, and flammability properties, possibly even UL ratings - as shown by studies on unreinforced nylon, reinforced nylon, and reinforced polycarbonate. 2 refs.

Nangrani, K.J. (Wilson Fiberfil Int, Evansville, IN, USA); Wenger, R.; Daugherty, P.G. *Plast Compd* v 11 n 2 Mar-Apr 1988 4p.

**Thermal Effects** See COATINGS—Thermal Effects.

**Thin Films**

**078685 PHOTOVOLTAIC AND CATALYTIC ACTIVITY OF PLASMA-POLYMERIZED PHTHALOCYANINE FILMS.** Poly metal and metal-free phthalocyanine thin films were prepared from the gas phase by low-temperature plasma polymerization. Electronic and FT-IR spectra indicated that no extensive alteration or destruction of the original ring structure had occurred. The obtained film showed good rectification, photovol-



taic, and electrochromic effects. The film also reduced methyl viologen under visible light, and its catalytic activity was as high as that of monomeric phthalocyanine particles. The formation mechanism and properties of the polymeric phthalocyanine films are discussed briefly. (Author abstract) 28 refs.

Osada, Yoshihito (Ibaraki Univ, Mito, Jpn); Mizumoto, Akira; Tsuruta, Hiroaki. *J Macromol Sci Chem* v 24 n 3-4 1987, Macromol-Met Complexes: Sel Pap from the US-China-Jpn Jt Semin, Beijing, China, Oct 20-24 1985 p 403-418.

## Toxicity

**078686 MIXED METAL OXIDE COLORS ARE STABLE, LOW IN TOXICITY.** Mixed metal oxide colorants are a class of synthetic mineral pigments to be watched owing to their low toxicity combined with chemical stability and excellent lightfastness. These inert colorants are becoming available in a greater range of colors with improved working properties. The recent, heightened research activity on the development of new ceramic products has simultaneously resulted in new ceramic processing technology that includes improved high temperature kilns for calcining and improved methods for controlling particle size and uniformity. Both are very important properties in the manufacture of quality pigments.

Dickenson, John (Harshaw/Filtrol Partnership, Cleveland, OH, USA). *Plast Eng* v 43 n 12 Dec 1987 p 33-35.

**Zinc Oxide** See INK—Curing.

## PILE DRIVERS See Also BRIDGES, SUSPENSION—Foundations.

**078687 REVIEW OF METHODS FOR ESTIMATING PILE CAPACITY.** The first phase of an investigation of methods for construction control of pile driving and determination of pile capacity has been completed for the Washington State Department of Transportation. A literature review covering the use of dynamic pile driving equations, wave equation methods, and pile analyzers has been conducted. In addition, a survey of current practices by state transportation departments has been completed. The literature review has shown that dynamic formulas provide the least reliable pile capacity predictions. Of the numerous formulas studied, no single dynamic pile driving formula was found to be superior to all others. (Edited author abstract) 26 refs.

Lawton, Evert C. (Univ of Miami, Coral Gables, FL, USA); Fragaszy, Richard J.; Higgins, Jerry D.; Kilian, Alan P.; Peters, Arthur J. *Transp Res Rec* 1105 1986 p 32-40.

**078688 IHC HYDROHAMMER: PILE HAMMER - CUM - ROCKBREAKER.** The hydrohammer which may be described as the third generation of hydraulic pile hammers was developed for piling in air or under water. The special ram which forms part of the piston rod, is mounted in the totally-enclosed housing and runs in sealed, oil-lubricated bushes and this bearing arrangement affords low friction and wear. Hydraulic fluid flows via the hose connection and the valves in ring to the underside of the piston in the cylinder. The pressure of the fluid lifts the ram. On the downward stroke, additional energy is delivered to the ram, producing an acceleration of 2 g. The maximum stroke of 1 m thus corresponds to a fall height of 2 m. The electronic control system, which is easy to operate, contributes in large measure to the reliability and versatility of the Hydrohammer. Its advantages for underwater rockbreaking include: controllability; optimum energy transfer; safety.

Anon. *Ports Dredging* n E129 1988 p 6-9.

## Computer Applications See FOUNDATIONS—Piles.

**Design** See PILES—Driving.

## Hydraulic Drive

**078689 PILING EQUIPMENT.** Recent developments in equipment for driven and bored piles have been the introduction of hydraulically driven machines with, in some areas, the use of sophisticated control systems. This has resulted in more efficient pile installation and often the reduction of men needed on site. Hydraulic pile hammers are now being increasingly used to drive steel sheet piles and bearing piles. Hydraulic piling vibrators are now widely used for driving steel sheet piles, open tube piles, H beams, and casings for bored piles. Hydraulic pile driving rigs are now used for driving both bearing and steel sheet piles.

Rawlings, Peter (Rawlings Collerton, Engl). *Civ Eng (London)* Aug 1987 p 19.

**078690 HYDRAULIC HAMMERS SET THE TREND IN PILING.** There is no doubt that pile driving is moving in a general direction towards more environmentally acceptable hammers. If this can be coupled with a more economic pile installation rate then we should have the answer to most of the problems today facing the contractor in an urban environment. Because of the trend in recent years toward hydraulically operated site equipment including cranes, the obvious development was also in this direction. The hydraulic pile hammer is now with us and to understand the reasons for its development we should examine its advantages.

Redhead, David (BSP Int Foundations Ltd). *Highways (Croydon Engl)* v 55 n 1930 Oct 1987 p 14, 26.

## PILES

**078691 ITERATIVE ANALYSIS OF PILE-SOIL-PILE INTERACTION.** Consistent formulations of direct and iterative methods of pile group analysis are presented. The iterative methods are derived from the same equilibrium and compatibility equations as the direct methods but are cast in different forms. These new iterative methods highlight the shortcomings of some existing iterative methods of analysis, although conceptually they are similar. Unlike the direct methods of analysis in which the stiffness matrix of the pile group system is generally fully coupled, the individual pile stiffness matrix can be uncoupled in the iterative methods and requires only a minimal amount of computer core storage. The accuracy of the iterative methods is compared with that of the direct method, and generally good agreement can be obtained. (Edited author abstract) 24 refs.

Chow, Y.K. (Natl Univ of Singapore, Singapore). *Geotechnique* v 37 n 3 Sep 1987 p 321-333.

**078692 UPLIFT CAPACITY OF DRIVEN PILES IN SAND.** Driven piles widely used in civil engineering construction are sometimes subjected to uplift forces. Available methods of estimating the uplift capacity of piles show wide variations. A theoretical method for predicting the uplift capacity of driven piles, considering the effect of driving on the properties of surrounding soil, has been proposed. Predictions from the proposed method show agreement with the experimental results on model and field piles. (Author abstract) 12 refs.

Pise, P.J. (IIT, Kharagpur, India); Chattopadhyay, B.C. *J Inst Eng India Part CI* v 68 n 2 Sep 1987 p 89-91.

**078693 PILE DISPLACEMENT DUE TO TENSILE LOADS.** Displacement of a pile subjected to tensile load is analyzed. The pile is treated as rigid and soil as a semi-infinite elastic half-space. The displacement influence coefficient,  $I$ , for the pile is evaluated as a function of the length to diameter ratio of the pile, and the Poisson's ratio of the soil. The values of  $I$  are about 25-30 percent more than those for compressive loads. It is now possible to interpret tension tests on piles for the modulus of deformation of the soil. Two case studies analyzed show comparable values of the modulus of deformation of the soil evaluated from different in situ tests. (Author ab-

stract). 5 Refs.

Madhav, M.R. (Indian Inst of Technology, Kanpur, India); Pooroshasb, Hormoz, B. *Indian Geotech J* v 18 n 1 Jan 1988 p 48-53.

## Bearing Capacity See Also PILE DRIVERS.

**078694 CASE HISTORY ON PIPE PILE INSTALLATION.** In current practice, pile foundation design is based on a general understanding of pile-soil interaction during installation and superstructure-pile-soil interaction after construction. The pile design is a reflection of experience, precedent and judgment for normal piling practices of working load capacities up to approximately 100 tons with corresponding ultimate capacities up to 200 tons. For higher capacity piles, pile design is even less predictable. In particular, the feasibility of pile installation is an important design consideration that must be given the proper attention. (Edited author abstract)

Parola, Jerry F. (Case Int Corp, Roselle, IL, USA). *Deep Found J* Spring 1986 p 53-64.

**078695 MODELING OF BEARING CAPACITY OF PILES IN CLAYS.** To determine the bearing capacity of piles, in the modern construction practice wide use is made of soil testing methods by means of standard piles and probes 36-150 mm in diameter, that is, pile models of a different scale. At the Dal'NIIS Institute, investigations have been carried out to establish the relation between the limit strengths of pile models having different scales. The investigation of such models in clays, which is connected with certain difficulties, has been carried out in the USSR for the first time. The results obtained make it possible to substantiate the general laws of modeling of the bearing capacity of piles having any shapes. 2 refs.

Fedorov, V.I. (Dal'NIIS Inst). *Soil Mech Found Eng* v 24 n 3 May-Jun 1987 p 101-104.

**078696 SICHERHEIT AUF STATISTISCHER GRUNDLAGE BEI FRANKI-ORTRAMPFPAHLEN UNTER VERWENDUNG VON VORINFORMATION.** [Statistically Based Safety of Franki-piles Using Prior Informations]. On the basis of numerous test results with Franki-piles prior informations about the point resistance are established. These are: density function of point resistance, mean values and coefficient of variation, determination of the soil class with sounding and the distribution of the soil classes. Combining prior information, additional pile tests and sounding with Bayes-statistics, admissible pile loads are calculated. The procedure is illustrated by two examples. (Author abstract) 9 refs. In German.

Hettler, A. (Univ Karlsruhe, Karlsruhe, West Ger). *Bauingenieur* v 62 n 12 Dec 1987 p 539-545.

**078697 ULTIMATE LATERAL PILE CAPACITY IN TWO-LAYER SOIL.** Expressions are derived for the ultimate lateral load capacity of a pile in a two-layer cohesive soil profile. Both free head and fixed head piles are considered and in each case, dimensionless solutions are given for failure of the supporting soil ('short pile' failure) and failure of the pile itself ('long pile' failure). Some parametric solutions are plotted and an illustrative example is given to demonstrate the application of the analysis. (Author abstract) 3 refs.

Poulos, H.G. (Univ of Sydney, Aust). *Res Rep Univ Sydney Sch Civ Min Eng* n R503 Aug 1985 25p.

**078698 SOIL IMPROVEMENT WITH GRANULAR PILES.** An effective method of construction of granular piles as an economical alternative to 'stone columns' using vibroflot has been developed. The technique uses labour oriented technology based on indigenous know-how, avoiding import of costly equipment suiting to the developing countries. In the present investigation a new concept of skirted granular piles has been advanced. Full scale in situ tests have been carried out at four different sites on both virgin and soils improved by



granular piles, by cating plain, individually and collectively skirted granular piles in single and in group. The effectiveness of installing granular piles for soil improvement and benefit of using skirt individually or collectively have been fully demonstrated, by noting a significant improvement in bearing capacity. A simple method of predicting the ultimate capacity and settlement of granular piles installed in weak sub-soil deposit has been proposed. (Edited author abstract) 19 refs.

Ranjan, Gopal (Univ of Roorkee, Roorkee, India); Govind Rao, B. *Indian Geotech J* v 17 n 2 Apr 1987 p 103-120.

**078699 EVALUATION OF PILE BEARING CAPACITY FROM RESULTS OF STATIC PENETRATION TESTS USING A PROBABILISTIC APPROACH.** One of the most important objectives of the use of static penetration tests of soils is to obtain initial data for analysis of the bearing capacity of piles. When use is made of data from static penetration tests it is advisable to increase the calculated bearing capacity of piles by about 25%. It is recommended to carry out static penetration tests in all the design stages to determine the bearing capacity of piles up to 15 m long. This paper considers the possibility of a probabilistic approach to the evaluation of the bearing capacity of a driven friction pile from static penetration test results. 4 refs.

Divinskii, M.L. *Soil Mech Found Eng* v 24 n 4 Jul-Aug 1987 p 133-137.

**078700 CHANGE IN BEARING CAPACITY OF BORED-CAST-IN-PLACE PILES UNDER SALT LIxivATION FROM SOIL BASE.** For construction on saline and gypsum soils, in many cases it is advisable to use reliable, economical pile foundations. In this article, the writers present results of static tests of bored-cast-in-place piles of gypsum clays, which were carried out for the first time in order to determine the changes in the bearing capacity of a pile for soil desalination, to study the factors which govern these changes, and to work out methods of evaluation of the bearing capacity of piles under such soil conditions. The tests were performed at a test site located in the arid zone of the Uzbek SSR, the soil base of which consisted of proluvial-deluvial gypsum loams and gypsum sandy loams. 2 refs.

Petrukhin, V.P. (Scientific-Research Inst of Bases & Underground Structures, USSR); Gemmerling, V.O. *Soil Mech Found Eng* v 24 n 4 Jul-Aug 1987 p 144-148.

**078701 REASONABLE APPROACH TO DETERMINATION OF BEARING CAPACITY OF PILE.** Bearing capacity of pile is usually determined by field test. The results of few test piles are conventionally regarded as a design basis for all other piles in the same site. However, the practical experience of pile test shows that quite a large deviation of the actual bearing capacity of piles exists. Based on the test data of 71 cast-in-place piles the following conclusions have been drawn: 1. It is evident that the test data of pile load tests scatter over a wide range and the maximum bearing capacity can be twice as large as the minimum one. 2. The reasons that cause dispersion of bearing capacity values are: non-homogeneity of soil; the differences in real pile length and diameter; the quality of casting concrete; the thickness of sludge directly beneath the pile bottom as well as the verticality of pile shaft. Thus, the dispersion of bearing capacity is closely related to the construction technology. 3. The real value of pile bearing capacity is a random variable, therefore it should be handled by means of mathematical statistics. (Edited author abstract) 2 refs. In Chinese.

Xu, Youzai (Central Research Inst of Building & Construction, China); Liu, Xingman. *Tumu Gongcheng Xuebao* v 20 n 2 May 1987 p 69-77.

**078702 STATIC-PENETRATION DETERMINATION OF THE BEARING CAPACITY OF PILES IN PLASTIC-FROZEN SOILS.** Field methods, which make it possible to determine the frozen-soil conditions of construction sites quickly and rather reliably, have recently come into increasingly broader practical use in

geocryologic-engineering surveys. One of the most promising of these methods is static penetration by series-produced domestic apparatus, S-832M, SP-59B, and SP-72. Stabilization of penetrometer settlement will signal that the penetrometer-soil system has come to equilibrium. We can then assume that the strength  $q_p$  corresponding to the stabilized deformation of the penetrometer will be close to the soil's long-term ultimate strength. Use of the method of static penetration during geologic-engineering surveys will make it possible to investigate the strength properties of soils in greater detail, and, in turn, to improve the reliability and economy of the design solutions employed for pile foundations. Moreover, a partial reduction in the number of static pile tests with their replacement by static penetration makes it possible to reduce significantly the labor outlays, duration, and cost of these operations. 10 refs.

Isaev, O.N. (Moscow Inst of Railroad Engineers, Moscow, USSR); Volkov, F.E.; Minkin, M.A. *Soil Mech Found Eng* v 24 n 5 Sep-Oct 1987 p 194-198.

**Boring** See Also FOUNDATIONS—Costs.

**078703 ZUR BEMESSUNG VON GROSSBOHRPFAEHLN AUFGRUND VON PROBELASTUNGEN.** [Dimensioning Large Bored Piles with the Aid of Trial Loads]. When installing flue gas desulfurization plants for the RWE lignite power stations, large bored piles were required for the foundations of the flue gas duct supports. Proof of a sufficient pile loadbearing capacity under vertical and horizontal stress was provided by test-loading eight piles with different diameters and in different soil types. The principal results, in particular those achieved under the influence of dynamic load, are outlined and assessed. The decisive dimensioning approaches for satisfying the demands for observance of particular differential settlements and horizontal displacements are presented and explained. (Author abstract). 4 Refs. In German.

Graef, Hansjürgen (RWE-Hauptverwaltung, Essen, West Ger); Placzek, Dietmar. *Bautechnik* v 65 n 9 Sep 1988 p 313-320.

**Calculations**

**078704 HORIZONTAL BELASTETE STARRE BOHRPFAEHLN IN BOESCHUNGEN.** [Horizontally Loaded Rigid Bored Piles in Slopes]. A method of calculation for rigid bored piles in sloping ground is presented. The method is based on Coulomb's classical thrust theory and has been extended to cover restricted compression areas. The method produces economical pile lengths which, although considerably lower than those determined to date, are still stable. The reaction forces of the soil actually present are taken into consideration, and the soil resistance is calculated as the minimum value together with the corresponding sliding joints. The soil resistance is made up of plane, spatial and lateral elements. The progressive fracture is defined as the angle  $\omega$ . The method can be extended to include different soil types and slope inclinations with the aid of further model tests and trial loads. (Edited author abstract). 10 Refs. In German.

Lammen, Hermann (Baustofflaboratorium Oevermann, Muenster, West Ger). *Bautechnik* v 65 n 7 Jul 1988 p 243-249.

**Computer Aided Analysis** See FOUNDATIONS—Settlement.

**Concrete** See Also CONCRETE TESTING.

**078705 CONTINUOUS FLIGHT AUGER PILING AT ST ENOCH SQUARE, GLASGOW.** At the St. Enoch Square Development in Glasgow, continuous flight auger piles were selected for those foundations close to existing structures of tunnels. Two trial piles were constructed and test loaded in advance of constructing the works piles. Under test load, the concrete shaft of each trial pile failed at less than 1.75 times the pile working load. This article describes the construction and investigation of the failed trial piles, and the revised construction

method implemented in which monitoring the volume of concrete pumped into the pile became the principal factor in controlling pile construction.

Couldery, P.A.J. (Ove Arup & Partners Scotland); Fleming, W.G.K. *Ground Eng* v 20 n 6 Sep 1987 8p between p 17 and 28.

**078706 PERFORMANCE OF DRIVEN PRE-STRESSED CONCRETE PILES.** The performance of pre-stressed concrete piles in various ground conditions has been examined and the results described so that the suitability of this type of pile can be judged for the different ground conditions encountered in Hong Kong. It has been found that pre-stressed high-strength concrete piles can penetrate crushed-rock reclamation filling and alluvial cobble layers, but special shoes should improve driving in these hard conditions. In medium-soft ground, such as completely decomposed granite, piles have sometimes stopped shorter than expected in strata with relatively low blow-counts in the Standard Penetration Test (SPT 'N' values.) Loading and integrity tests have demonstrated completely satisfactory load bearing capacity. Investigations after driving the piles have shown that significant 'densification' of the ground had occurred for several metres around and below the piles. (Edited author abstract) 12 refs.

Evans, G.L. *Hong Kong Eng* v 15 n 3 Mar 1987 p 9-14, 16.

**078707 PRACTICAL GUIDANCE ON THE USE OF INTEGRITY TESTS FOR THE QUALITY CONTROL OF CAST-IN-SITU PILES.** The most common integrity test measures, in various ways, the dynamic response of the pile shaft and require access only to the pile head. These tests can provide a valuable measure of quality control, but in common with all non-destructive test methods, they have serious limitations which must be recognized before they are specified. This paper describes the physical principles of the most common pile integrity tests and quantitatively defines their acoustical capabilities and limitations. The relationship between the acoustical and structural significance of faults in the integrity of cast-in-situ piles is discussed, and guidance is given on the assessment of pile integrity test results. 8 refs.

Ellway, K. (N.D. Technology, Southampton, Engl). *Ground Eng* v 20 n 7 Oct 1987 p 8-10, 12-13.

**078708 PALI RADICE: THEIR USES IN STABILISING EXISTING RETAINING WALLS AND CREATING CAST-IN-SITU RETAINING STRUCTURES.** When used for stabilization, the piles are installed through the existing structure thereby achieving a direct connection between the foundation and a competent underlying subsoil stratum providing the structure with 'roots' and hence giving the piles the proprietary name. The principal of constructing alternately raking piles through conventional footings and column based has been developed and extended to treat complex foundation engineering problems where structures are subjected to more complex externally applied forces. Their application to the stabilization of existing retaining walls offers a versatile solution which minimizes the necessity for any conventional civil engineering works. A recent example of the successful use of this system was at Weston Point Docks, Runcorn. The Fondedile process known as a Reticulated Pali Radice Structure is designed to transform a naturally heterogeneous soil into a composite material with a controllable structural behavior. This technique was employed at the Dartford Tunnel Southern Approach Road. Both applications are discussed in the article.

Attwood, S. (Fondedile Foundations Ltd). *Ground Eng* v 40 n 3 Mar 1987 p 23-24, 26-27.

**078709 INSTALLING PILES WITHOUT IMPACT - A CASE HISTORY.** The conventional method of installing piles is by driving. The impact of driving imparts vibration to the adjoining soil. As a result, loose and medium compact sands and silts tend to become consoli-



dated. The consolidation causes structures to settle. The settlement in turn leads to cracks in buildings. The subject of this paper is a case history of avoiding the pile driving vibrations and thus sidestepping the vibration induced damage by changing the piles in the potentially sensitive areas during construction from H-piling to auger-cast piling. This was the first application of auger cast piles in the City of New York. The project was the Hamilton Avenue Marine Transfer Station in Brooklyn, New York.

Kald, Lembit (Hayden-Wegman Inc, USA). *Munic Eng J* v 73 Summer 1987 p 1-11.

**078710 LE PROCEDE STARSOL. [STARSOL Process].** The French pile market can be divided in three parts: the small piles (with a diameter up to 0.20 m); the medium-size piles (with a diameter between 0.40 m and 1.20 m); the strip piles (with a cross section area more than 1 m<sup>2</sup>). The medium segment, the most important, is dominated both by the classic auger and the continuous flight auger. A new equipment, 'STARSOL', has been set up, which combines a continuous flight auger, a tremie pipe and a cleaning system. Usual diameters vary between 0.50 and 1.00 m. The maximum depth is 30 m. This tool presents numerous advantages: penetration capacity in hard layers (30 to 50 MPa); drilling speed; no temporary casing, no slurry; concreting with a tremie pipe and under pressure; concreting and spoils extraction speeds; possibility to set reinforcement frames 18 m deep, as well as tubes for later sonic control. (Edited author abstract) In French.

Bollinger, Karl; Chagnot, Philippe; Sage, Daniel. *Travaux Suppl* Mar 1988 p 7-13.

**078711 CONCRETE IN PILING.** Displacement piles are formed by driving materials into the ground, thus displacing the soil. These materials can be timber, steel, but more commonly reinforced concrete. Concrete displacement piles can either be totally precast or a displacement method is used either by driving steel tubes or concrete shells to form a void which is then infilled with reinforced concrete. Non-displacement piles can also be called replacement piles, as soil is extracted from the ground and replaced by concrete which is subsequently steel reinforced. In general they fall into two main categories: where a void is formed by either percussive boring, rotary boring or drilling and the void infilled as in the case of displacement piles; or continuous flight augered (CFA) piling where a bore is formed with a hollow stemmed flight auger.

Wain, D. (Westpile Ltd). *Concrete (London)* v 22 n 2 Feb 1988 p 15-16.

**Concrete Construction** See FOUNDATIONS—Construction.

**Construction** See ELECTRIC LINES—Construction; LANDSLIDES—Control.

**Corrosion** See Also STEEL CORROSION—Seawater; STEEL CORROSION—Underground.

**078712 GALVANIC CORROSION OF COPPER-NICKEL SHEATHED STEEL PILING.** A study was conducted to determine the extent of galvanic corrosion that would be caused by copper-nickel sheathing of offshore steel platforms. The study investigated the effects of selected steel-to-CuNi area ratios on the magnitude and distribution of the galvanic current. One-year seawater exposure tests were conducted near Ocean City, NJ. The results the maximum galvanic corrosion rate of the steel will be between 0.2 and 0.3 mm/y immediately next to the sheathing. The galvanic attack will be confined primarily to the first few meters of piling near to the sheathing. Beyond this, the intensity of galvanic attack will decline. (Edited author abstract)

Ellor, J.A. (Ocean City Research Corp, Ocean City, NJ, USA); Gehring, G.A. Jr. *Mater Perform* v 27 n 5 May 1988 p 45-48.

**078713 TWO-YEAR RESULTS OF LONG-TERM, COPPER-NICKEL SHEATHED PILING STUDIES.** A series of cylindrical steel piling sheathed with copper

alloy UNS C70600 were exposed in Banks Channel at Wrightsville Beach, North Carolina in 1983 to provide long-term base line data on the corrosion and biofouling behavior of insulated and directly welded sheathing techniques. After a two-year exposure, one series of piling were removed and evaluated. Insulated sheathed piling exhibited a minimal amount of biofouling attachment and unprotected piling with directly welded sheathing showing no accelerated corrosion of the adjacent steel. This paper presents the techniques used and the results after the first two years of exposure. (Author abstract).

Melton, D.G. (LaQue Cent for Corrosion Technology Inc, Wrightsville Beach, NC, USA). *Corrosion (Houston)* v 44 n 7 Jul 1988 p 478-482.

**Deformation** See Also BRIDGES, HIGHWAY—Abutments.

**078714 ON THE BUCKLING OF SLENDER PILES.** The published analyses of axially loaded piles are based on the notion that the buckling load is  $P_{cr}$ , the so-called critical load that is obtained from a linear eigenvalue problem. The purpose of this paper is to show that generally this assumption is not justified for slender piles. Since the main aim of the presentation is to clarify the basic features of the pile buckling phenomenon, and to show how they are related to the various buckling analyses, this study is conducted on a simple model that exhibits the essential buckling mechanism of the pile but is amenable to an exact nonlinear analysis. One presented analysis is based on the common assumption that the lateral soil resistance increase linearly with the lateral displacement. Another analysis assumes that the lateral resistance stiffens nonlinearly with increasing pile displacements. Thus, for the stability analysis of slender piles, the actual soil response to lateral pile displacements is needed. (Edited author abstract). 10 Refs.

Kerr, Arnold D. (Univ of Delaware, Newark, DE, USA). *Soils Found* v 28 n 2 Jun 1988 p 144-148.

## Design

**078715 STATE OF THE ART FOR DESIGN AND CONSTRUCTION OF SAND COMPACTION PILES.** Sand compaction piles can be used to improve marginal sites for stability, liquefaction, and settlement applications. They have been employed extensively in Japan for many years to improve land reclaimed from the sea. The advantages and disadvantages of using sand compaction piles are compared with other vibro-compaction techniques such as stone columns. Methods are described for construction of sand compaction piles on land and over water. Design theories are given for the utilization of sand compaction piles at sites underlain by both cohesionless and cohesive soils. For sites underlain by cohesionless sands, procedures are presented for estimating the increase in standard penetration resistance in both the sand compaction pile and the surrounding sand. Finally, typical applications of sand compaction piles are described, and practical design criteria and practices are given. (Edited author abstract) 20 refs.

Barksdale, Richard D. (Georgia Inst of Technology, Atlanta, GA, USA). *Tech Rep US Army Eng Waterway Exp Stn REMR-GT-4* Nov 1987 55p.

**078716 UPLIFT CAPACITY OF CAST IN SITU BORED PILE IN COHESIONLESS SOIL.** Capacity to withstand uplift forces by cast in situ bored piles is normally neglected by the designers. The theoretical basis has long been developed by the soil scientists in working out the safe capacity of such piles. Till recently actual use of such piles being designed against tension forces are not common. This paper discusses in detail the load displacement behavior of piles under upward load with particular reference to piling work done in a steel plant construction in Libya. It has been observed during the course of investigation on working piles of various diameter that even the straight piles on predominantly cohesionless soil resting on bed rock can sustain a considerable upward pullout force. (Author abstract)

Majumdar, S.K. (Triveni Engineering Works Ltd, New Delhi, India). *J Inst Eng India Part CI* v 68 Mar 1988 p 252-256.

**078717 IMPACT OF RECENT CHANGES IN THE API RECOMMENDED PRACTICE FOR OFFSHORE PILES IN SAND AND CLAYS.** The publication of the 15th Edition of the American Petroleum Institute (API) Recommendations in 1984 changed the guidelines for the design of piles in cohesionless (sand) soils and, in particular, the design of piles under tensile loading. Subsequently, the 17th Edition also provided revised recommendations for the design of piles in cohesive (clay) soils. This paper quantifies the changes that may occur as a result of the application of these revised procedures and relates them to the factors of safety generally applied to the design of the foundations for offshore structures. Computed capacities are compared with the results of relevant pile tests. 18 refs.

Toolan, F.E. (Fugro-McClelland Ltd); Ims, B.W. *Underwater Technol* v 14 n 1 Spring 1988 p 9-13, 29.

**078718 FROM THEORY TO PRACTICE IN PILE DESIGN.** The procedures used for pile design are classified into three categories: empirical, simplified but theory-based, and site-specific advanced theory-based methods. The various aspects of pile behavior which may need to be considered are reviewed and design procedures in each category are reviewed for each aspect. In many cases involving conventional loadings, the second category of design procedure is often quite adequate, but for problems involving special loading conditions, such as cyclic loading or loading arising from soil movements, the use of more sophisticated methods of analysis may be necessary to obtain an economical and safe design. Examples are presented to illustrate the use of each category of design in actual field cases. (Author abstract). 138 Refs.

Poulos, H.G. (Univ of Sydney, Aust). *Res Rep Univ Sydney Sch Civ Min Eng* n R559 Dec 1987 122p.

## Driving

**078719 CRANE BOOM LOADINGS FROM PILE DRIVING.** Piles are being driven in longer sections and ever increasing weights. The reasons for these increases are purely economic. Loads and stresses from pile driving are increasing from heavier piles and more powerful hammers. Stresses can be dangerous to equipment stability. Equipment developer MacKinnon tells how to compute stresses for all positions of the crane boom and angles of pile batter. (Edited author abstract)

MacKinnon, Alan G. (Foundation Equipment Corp, Dover, OH, USA). *Deep Found J* Spring 1986 p 29-51.

**078720 ANALIZA RUCHU PALA ZAGLEBIANEGO W GRUNT PRZEZ URZADZENIE WIBRACYJNO-UDERZENIOWE O ZLOZONYM WYMUSZENIU. [Analysis of the Motion of a Pile Driven into the Ground by a Vibration-Impact Machine Causing Complex Excitation].** The motion of a pile driven into the soil is analyzed under the assumption that it performs vibrations in the axial direction and rotates in the plane perpendicular to this direction. The soil is assumed to act on the point of the pile as an elastic-viscoplastic medium and exerts dry and viscous friction forces on its lateral surfaces. Theoretical results obtained with a computer agree fairly well with experimental data. (Edited author abstract) In Polish. 11 refs.

Mituta, Aleksander; Raniszewski, Jozef. *Rozpr Inz* v 35 n 1 1987 p 95-112.

**078721 PILE DRIVING BY JACKING UNDER RECONSTRUCTION CONDITIONS.** The increase in the work volumes under reconstruction of buildings and structures, connected with the construction of pile foundations under constrained conditions near existing buildings, calls for improvement of the pile driving methods. The



authors have proposed a new method based on jacking of piles by means of hydraulic cylinders through openings in cap-slabs or wide strips constructed as a prefabricated-cast-in-place alternative before the start of pile driving. In this process, the forces are transmitted through the lateral surface of the pile, or its end, and the jacking reactions are resisted by the weight of the slab or strip. 2 refs.

Novikov, M.F.; Pushkarevich, V.S. *Soil Mech Found Eng* v 24 n 2 Mar-Apr 1987 p 55-58.

**078722 DEVICE FOR CONTROL OF PILE DRIVING VERTICALITY.** Piles occupy an important place in the construction industry, and their overall volume increases continually. At the same time, the loads transmitted to piles also increase, which places higher requirements on the work quality. One of the main requirements is the prohibition of deviation of the pile from the vertical beyond the limits established by the SNiP Norms. At the present time, control of the observance of this requirement is performed visually or with the help of the simplest plumbs. The device proposed in this article makes it possible to perform local and remote control of the verticality of the pile during the process of its installation and driving, by using a magnetic system and LED's (light-emitting diodes) to determine the position of a pendulum, which is the sensitive element of a primary detector.

Krichke, V.O. (Kuibyshev Civil Engineering Inst, USSR). *Soil Mech Found Eng* v 24 n 2 Mar-Apr 1987 p 61-62.

**078723 EXPERIENCE IN CHEMICAL STABILIZATION OF LOESS SOILS AT THE BASE OF BORED INJECTION PILES.** Injection piles of the type 'Mega,' 'Highway,' etc., are used widely in the construction of buildings and structures in Hungary, a characteristic of which is the placement in the pile body of a device for injecting a stabilizing reagent under its foot for creating a supporting mass of increasing bearing capacity. Such injection piles make it possible to increase its bearing capacity by simple methods and with small additional expenditures. The Scientific-Research Institute of Mechanics and Applied Mathematics of Rostov State University together with the Volgodonsk Administration of the State All-Union Trust for Stabilization of Foundations and Structures (Gidrospeitsstroj) has developed an original method of constructing a bored injection pile, the essence of which consists in chemical stabilization of the base under the pile foot with subsequent pressure testing of the stabilized mass with cement grout. 4 refs.

Badeev, S.Yu. (Rostov State Univ, USSR); Soshin, M.V.; Kuzin, B.N.; Isaev, B.N. *Soil Mech Found Eng* v 24 n 2 Mar-Apr 1987 p 72-75.

**078724 DRIVEABILITY OF PILES AND THE EFFECTS OF FOLLOWERS.** This paper presents a wave equation study on the effects of using pile followers on drivability and driving stresses, as well as drivability analyses of large-diameter offshore piles at three sites. The analyses were carried out using a new wave equation model. These show that the use of followers which are impedance-matched can result in minimal loss of drivability. The analysis also included followers for land piles driven below ground as may be required for piles supporting basements. For the drivability analyses, the drivability of large-diameter piles at three offshore sites was investigated. These cases were for piles driven in chalk, clay and sand. (Edited author abstract) 13 refs.

Wong, K.Y. (Natl Univ of Singapore, Singapore); Chow, Y.K.; Karunaratne, G.P.; Lee, S.L. *Geotech Eng* v 18 n 2 Dec 1987 p 167-184.

**078725 EFFECT OF VERTICAL LOAD ON FLEXURAL BEHAVIOUR OF PILES.** Analytical investigations suggest an increase in lateral deflection when a vertical pile is axially loaded, some published experimental investigations, both field tests and laboratory model tests, suggest a reduction in lateral deflection due to the presence of vertical load. The possible reasons for this contradiction are hypothesized. One reason is the reduc-

tion in tensile stress for axially loaded concrete sections. The restraint to the pile head imposed by the loading device used for the application of a vertical load is suspected to be another cause, and this is investigated in detail. For this purpose, a loading device was designed and fabricated which facilitated application of a vertical load without causing restraint to the pile head. Using the device, tests on fully and partially embedded model piles subjected to vertical and lateral loads were carried out. The results show that the presence of a vertical load causes an increase in lateral deflection, which is in agreement with the trend predicted by analytical methods. (Edited author abstract) 17 refs.

Kumar Jain, Nirmal (Madhav Inst of Technology, Qwalior, India); Ranjan, Gopal; Ramasamy, Govindachettiar. *Geotech Eng* v 18 n 2 Dec 1987 p 185-204.

**078726 DRIVING AND TENSION LOADING OF PILES IN SAND ON A CENTRIFUGE.** A facility has been developed on the Cambridge 10 m Geotechnical Centrifuge to drive single piles into sand and then perform monotonic and cyclic tension load tests. The driving and loading are performed by two independent systems which have been optimised to meet the modelling requirement of each phase. Model open ended piles, instrumented externally along the length of the shaft, have been successfully installed and load tested using the facility. The paper describes the design of the model piles and details of the driving and loading equipment, and presents results from some of the pile tests. The resulting pile capacities and response under cyclic loading are discussed in the light of current design criteria for piles in sand. (Author abstract) 9 refs.

Nunez, I.L. (Cambridge Univ, Engl); Hoadley, P.J.; Randolph, M.F.; Hulett, J.M. *Cambridge Univ Eng Dep Tech Rep CUED/D-Soils* TR 207 1987 11p.

**078727 RATIONAL WAVE EQUATION MODEL FOR PILE-DRIVING ANALYSIS.** A one-dimensional wave equation model for pile-driving analysis is presented. In this model, the pile is represented by discrete elements, while the soil is represented by a series of springs and dashpots, the coefficients of which are derived using elasto-dynamic theory. The capability of the proposed model is demonstrated by comparison with field data of two instrumented piles. The analyses include predictions of set, and driving stresses at various levels of the piles. Comparisons are made with the sets and driving stresses predicted by the E.A.L. Smith model. From the analyses by the proposed model and load test results, estimations of soil setup for the two piles are also presented. (Edited author abstract) 30 refs.

Lee, S.L. (Natl Univ of Singapore, Singapore); Chow, Y.K.; Karunaratne, G.P.; Wong, K.Y. *J Geotech Eng* v 114 n 3 Mar 1988 p 306-325.

**078728 PILE JETTING.** The state-of-the-art of pile jetting is reviewed. In general, jetting is a very effective time-saving method of pile driving. It can be effectively utilized for the driving of both vertical and batter piles. It is almost indispensable for the driving of wide flange piles, T-shaped sheet piles, or similar types of piling. The method requires very simple equipment, which typically includes a centrifugal pump, jet pipes, flexible pressure hoses, and a jet pipe handling winch. The flow rate and head required for the successful pile jetting primarily depend on foundation soil conditions and the type of pile. (Author abstract) 7 refs.

Tsinker, Gregory P. (Acres Int Ltd, Niagara Falls, Can). *J Geotech Eng* v 114 n 3 Mar 1988 p 326-334.

**078729 NOTE ON FINITE ELEMENT SIMULATIONS OF PILE DRIVING.** The analyses of pile driving using solid, axisymmetric finite elements previously reported are extended to different soil conditions and hammer characteristics. Correlation with 'pile analyser' procedures is made. (Edited author abstract) 5 refs.

To, P. (Scott Wilson Kirkpatrick & Partners, Hong Kong); Smith, I.M. *Int J Numer Anal Methods Geomech* v 12 n 2 Mar-Apr 1988 p 213-219.

**078730 DYNAMICS OF PILE DRIVING BY THE FINITE ELEMENT METHOD.** It is proposed that the dynamics of pile driving based on the one-dimensional theory of wave propagation be analyzed by the finite element method. This approach enables one to continuously interpolate the displacement, velocity and acceleration profiles throughout the pile length. In contrast to the finite difference technique presented by E.A.L. Smith and the finite element procedure presented by I.M. Smith in which initial conditions are defined on the basis of a prescribed hammer velocity, the method presented herein defines initial conditions on the basis of a prescribed impact force versus time curve at the pile/hammer point of contact. Applications of the proposed technique to typical pile driving problems on an elastoplastic soil and using an implicit time-integration scheme are discussed using a numerical example. (Author abstract) 11 refs.

Borja, Ronaldo I. (Stanford Univ, Stanford, CA, USA). *Comput Geotech* v 5 n 1 1988 p 39-49.

**078731 EXPERIMENTAL STUDY ON STRENGTH OF STEEL SHEET PILE MODELS UNDER REPETITIVE COMPRESSION.** This paper presents an experimental investigation on the buckling strength of stub channel columns under repetitive compression to determine cross sections of steel sheet piles against the repeated driving force by diesel hammer. The tests were performed under the pseudo-static condition using microcomputer-based servo-controlled testing system to find the deteriorating properties of steel sheet pile models undergoing the large elasto-plastic deformations under repetitive compression. Through the study, the deteriorating properties of the sheet pile model were clarified and found to be influenced by the width-thickness ratio, aspect ratio of the flange plates, and the relative dimensioning of the web and flanges. (Author abstract) 10 refs.

Watanabe, Eiichi (Kyoto Univ, Kyoto, Jpn); Fukuwaka, Masakazu; Isami, Hidenori; Fukumori, Yoshio. *Doboku Gakkai Rombun-hokokushu* v 9 n 4 Apr 1988 p 33-42.

**078732 MEASURED AND PREDICTED AXIAL RESPONSE OF 98 PILES.** This article summarizes the results of a research project performed for the Mississippi State Highway Department (MSHD) as a follow-up of the work done by Clisby et al. (1978). The project consisted of the analysis of 98 load tests where full-scale piles had been subjected to monotonic axial loading by the MSHD over the period 1970 to 1975. 20 refs.

Briaud, Jean-Louis (Texas A&M Univ, College Station, TX, USA); Tucker, Larry M. *Tex Civ Eng* v 58 n 6 Jun-Jul 1988 p 13-19.

## Earthquake Resistance

**078733 ANALYSIS OF LATERALLY LOADED PILES IN SOFT CLAYS.** The results of an alternative procedure to the p-y method for the elastoplastic analysis of laterally loaded piles are presented. This analysis is based on the boundary-element method and assumes knowledge of the shear-strength profile of the soil. In this paper, the shear strength is assumed to increase linearly with depth, a reasonable assumption for soft clays. The influence of soil yielding on the loading response of laterally loaded single piles is explicated by the results of a comprehensive parametric study. These results are cast in a form that is particularly suitable for design purposes. The validity of the analysis is demonstrated through comparisons with data obtained from a published case history. The ease with which the method can be applied to practice is illustrated by an example. (Author abstract) 15 refs.

Budhu, Muniram (State Univ of New York at Buffalo, Buffalo, NY, USA); Davies, Trevor G. *J Geotech Eng* v 114 n 1 Jan 1988 p 21-39.

## Elasticity

**078734 EFFECT OF NONLINEAR FLEXURAL RIGIDITY ON THE BEHAVIOR OF CONCRETE PILES UNDER LATERAL LOADING.** The flexural



behavior of a structural element such as a beam, column, or a pile subjected to bending is dependent on its flexural rigidity EI. The value of EI is found from the product of the modulus of elasticity of the material of which it is made and the moment of inertia of the cross section about the axis of bending. The value of EI is essentially constant for the level of loading to which a structural-steel member is subjected, but both E and I vary as the stress conditions change for a reinforced-concrete member. The EI value of a reinforced-concrete pile is assumed to be constant for simplicity in the analysis. This paper is concerned with the influence of variation of EI on pile behavior. The analysis of a field-loading test and some recommendations for design are presented. 5 refs.

Wang, Shin-Tower (ENSOFT Inc, Austin, TX, USA); Reese, Lydon C. *Tex Civ Eng* v 58 n 5 May 1988 p 17-22.

## Friction

**078735 PILE SKIN FRICTION RELATED TO PARTICLE CHARACTERISTICS OF OFFSHORE CARBONATE SANDS.** This paper reports the results of tests on model pile shafts jacked into two types of carbonate sand. It is found that both particle size and particle grading characteristics influence the skin friction and soil modulus under static loading, and the degradation of skin friction under cyclic loading. (Author abstract) 7 refs.

Poulos, H.G. (Univ of Sydney, Aust); Lee, C.Y. *Res Rep Univ Sydney Sch Civ Min Eng* n R549 Aug 1987 31p.

**078736 EVALUATION OF GROUTED PILE FRICTION FROM GROUTED SECTION TESTS.** Data from grouted section tests at the North Rankin A site were analysed in order to determine parameters for static and cyclic axial response analyses of proposed insert piles in the underlying calcarenite layers. This paper describes briefly the method of interpretation of the data and the use of laboratory test data to try and reproduce theoretically the observed response. The development of cyclic degradation model is outlined. This model is then used in a boundary element analysis to investigate the behaviour of single inserts and groups of inserts under both static and cyclic loading. It is concluded that cyclic degradation of skin friction may cause a severe reduction of insert pile capacity and that insert piles of reasonable length may not have sufficient capacity to adequately support the maximum storm loads. However, many of the assumptions made in the analysis are conservative. (Edited author abstract) 11 refs.

Poulos, H.G. *Res Rep Univ Sydney Sch Civ Min Eng* n R573 Jul 1988. Publ by Univ of Sydney, Department of Architectural Science, Sydney, Aust, 1988 var paging.

## In Situ

**078737 VERBUNDWIRKUNG ZWISCHEN ORTBETON-VERPRESSPFAEHLN UND DEM BODEN BEI MEHRREIHIGEN, AUFGELOESTEN PFAHLWAENDEN.** [Interface Strength Between In Situ Injection Piles and the Soil for Multi-Row, Broken Diaphragm Walls]. A computational method is presented which enables the interface strength in 'diaphragm walls' to be examined. This is based on investigations into this problem conducted by Brandl, application of the compound theory on a pile/soil composite material and Mohr's fracture conditions for soil. The results of calculation have been confirmed by measurements carried out on Lot D 76 A of the new underground railway extension in Berlin. The experience gained from comparative calculations and from the field is described in 'Recommendations for calculating and executing diaphragm walls'. If the necessary boundary conditions are observed, the method may also be used for dimensioning high-pressure injection underpinning elements. (Author abstract) In German. 10 refs.

Wiesiolek, Bernd (Bpi-Buero fuer Planung und Ingenieurtechnik GmbH, Grenzach-Wyhlen, West Ger); Neumann, Werner. *Bautechnik* v 65 n 1 Jan 1988 p 16-22.

**Measurements** See OFFSHORE STRUCTURES—Foundations.

## Performance

**078738 MONITORING THE BELOW GROUND PERFORMANCE OF LATERALLY LOADED PILES.** Lateral loading tests were carried out on an 'H'-section steel pile at a site near Plancoet, Brittany, to compare the information obtained from two instrumentation systems that were used to monitor the below ground performance of the pile. One of the systems used electrical resistance strain gages that were bonded to the pile and the other system used electro-levels (precise tilt indicators) that were installed in a tube that had been securely attached to the pile. Very good agreement was found in the bending moments, soil reactions and p-y curves determined from the two systems. Some of the factors that have to be considered when using each of the systems are briefly discussed together with their respective advantages and disadvantages. The approximate cost of the instrumentation used in the pile is given. (Author abstract) 7 refs.

Price, G. (Building Research Station, Watford, Engl); Wardle, I.F.; Frank, R.; Jezequel, J.F. *Ground Eng* v 20 n 5 Jul 1987 p 11-12, 14-15.

**078739 PERFORMANCE OF DRIVEN PILES IN A CRUSHED-ROCK-FILLED RECLAMATION.** With the increasing use in Hong Kong of crushed rock as a filling material in reclamations there was concern that this would create constraints to the selection of foundation methods for high rise housing estate developments. After the formation of a trial area of crushed rock reclamation, pile installations and tests were undertaken with pre-stressed concrete, steel H, steel tube and steel sheet piles. Machine-bored piles and a barrette were also installed, but this paper is limited to a description of the driven piles and the test results. All piles except the sheet piles were successfully installed although in some cases with difficulty. (Author abstract) 8 refs.

Evans, G.L. (Housing Dep, Hong Kong); Wong, P.P.; Sanders, H. *Hong Kong Eng* v 15 n 4 Apr 1987 p 29-40, 42.

**078740 FINITE ELEMENT ANALYSIS OF MECHANISMS OF PILE GROUP BEHAVIOUR.** Solutions are presented for the non-linear load-settlement behavior of square-configuration pile groups. The groups are represented by an equivalent axially-symmetric model, and a nonlinear finite element is used to examine the mechanisms of group behavior and their variation with pile spacing. It is shown that, at close spacings, the block failure mechanism occurs, with significant plastic zones being developed below the group and full pile-soil slip only being developed along the outer piles. As the pile spacing increases, the failure mechanism gradually changes to the 'single-pile' mode, whereby full pile-soil slip occurs along all piles. (Edited author abstract) 9 refs.

Pressley, J.S.; Poulos, H.G. *Res Rep Univ Sydney Sch Civ Min Eng* n R518 Mar 1986 20p.

**078741 BUILDING PILE CAPS ON WEAK SOILS.** Design and construction considerations for pile caps on weak soils are discussed. Field observations of the behavior during construction of several large pile caps at a solid waste management facility are presented. Based on these observations, recommendations are made for pile cap construction on weak soils. (Author abstract)

Tiner, W. (W.M. Kellogg Co, Houston, TX, USA); Ulrich, E.J.; Moore, P.D. *Concr Int* v 10 n 7 Jul 1988 p 13-17.

## Service Life

**078742 LONG TERM BEHAVIOR OF PILES.** Longevity of structural units, as compared to the planned useful life of a facility, always is a design consideration. Typical concerns include slow-decay due to environmental factors, and changes in constitutive relationships

governing the performance of the material involved. With respect to foundations, the usual items of interest are corrosion of steel and concrete, and time dependent behavior of the soil/structure system. For piles, as with other foundations, deterioration is precluded, mitigated or otherwise accounted for by assessing properly the ambient situation (sulfates, pH, stray currents, resistivity) and providing safeguards, such as resistant construction products, oversizing, coatings, and/or cathodic protection. Long term performance of the pile foundations, as affected by time dependent characteristics of the pile foundations, as affected by time dependent characteristics of the supporting soil or rock, can be predicted and controlled only with a synergistic coupling of analyses and field tests. (Edited author abstract)

Murphy, Donald J. (Langan Engineering Associates, Elmwood Park, NJ, USA); Dette, James T. *Deep Found J Spring* 1986 p 71-84.

## Stability

**078743 CYCLIC STABILITY DIAGRAM FOR AXIALLY LOADED PILES.** This paper develops the idea of a cyclic stability diagram in which the mean and cyclic axial loads on a pile are plotted and three regions are identified: (1) a stable zone in which cyclic loading has no effect on pile capacity; (2) a metastable zone in which cyclic loading causes some limited reduction of load capacity; and (3) an unstable zone in which cyclic loading will result in failure of the pile within a specified number of cycles. An analysis that can be used to generate the stability diagram is described, and two examples are presented to demonstrate the characteristics of the three zones. One example also examines the relative importance of cyclic degradation and degradation due to a strain-softening shaft response. Finally, a comparison is made between theoretical predictions of the lower boundary of the unstable zone and the results of some field and laboratory tests. (Author abstract) 13 refs.

Poulos, H.G. (Univ of Sydney, Sydney, Aust). *J Geotech Eng* v 114 n 8 Aug 1988 p 877-895.

**078744 CYCLIC STABILITY DIAGRAM FOR AXIALLY LOADED PILES.** This paper develops the idea of a cyclic stability diagram in which the mean and cyclic axial loads on a pile are plotted and three regions are identified: a stable zone in which cyclic loading has no effect on pile capacity; a metastable zone in which cyclic loading causes some limited reduction of load capacity; an unstable zone in which cyclic loading will result in failure of the pile within a specified number of cycles. An analysis which can be used to generate the stability diagram is described and two examples are presented to demonstrate the characteristics of the three zones. One example also examines the relative importance of cyclic degradation and degradation due to a strain-softening shaft response. Finally, a comparison is made between theoretical predictions of the lower boundary of the unstable zone and the results of some field and laboratory tests. (Author abstract) 12 refs.

Poulos, H.G. *Res Rep Univ Sydney Sch Civ Min Eng* n R574 Jul 1988. Publ by Univ of Sydney, Department of Architectural Science, Sydney, Aust, 1988 var paging.

**Steel** See RETAINING WALLS.

**Steel Construction** See Also FOUNDATIONS—Piles; PORT STRUCTURES—Construction.

**078745 STUDY ON A STATIC BEHAVIOR OF A SC PILE MADE OF STK50 STEEL PIPE.** An SC pile is a composite pile in which a pipe is lined with concrete. Concrete is placed uniformly on the inner surface of a pile by applying a centrifugal force. This study investigates static behavior of an SC pile made of STK50 subject to bending moment with constant axial force. (Edited author abstract) In Japanese.

Murakami, Hirotomo (Waseda Univ, Jpn); Koizumi, Atsushi; Kawamura, Shoji. *Waseda Daigaku Rikogaku Kenkyusho Hokoku* n 117 1987 p 27-34.



## Stresses

**078746 STRESS WAVES IN Laterally LOADED PILES.** The behavior of single vertical piles subjected to lateral loading at the pile head was analyzed. Based on the assumption of beam on elastic foundation, the analysis was made by using the method of direct analysis which is a numerical approach making direct use of governing physical laws without explicitly utilizing the differential equation of vibration. The analysis provides short-time pile response to pulse loadings. These results indicate, among others, that an interaction between the dilatation and shear waves results in a stress discontinuity of considerable magnitude which may deserve special attention in pile design. (Author abstract) 7 refs.

Wang, M.C. (Pennsylvania State Univ, University Park, PA, USA); Liao, W.P. *Int J Numer Anal Methods Geomech* v 11 n 6 Nov-Dec 1987 p 639-644.

**078747 ANALYSIS OF RESIDUAL STRESS EFFECTS IN PILES.** A simple method is outlined for analyzing the residual stresses in a single pile following driving or jacking, and for determining the subsequent axial load-deformation behavior. It is found that the stiffness of the pile head response is generally less for tensile loading than for compression loading. The most significant effects occur for piles in sand; piles in soft clay are not significantly influenced by the presence of residual stresses. The cyclic response of piles in sand may also be affected adversely by residual stresses. Comparisons with field and laboratory test data suggest that the theory incorporating residual stress effects can give reasonable estimates of axial pile behavior. (Author abstract) 12 refs.

Poulos, H.G. *Res Rep Univ Sydney Sch Civ Min Eng n R543 May 1987* 33p.

## Structural Analysis

**078748 LOAD-DEFORMATION RESPONSE OF AXIALLY LOADED PILES.** A new empirical scheme for simulating the nonlinear point resistance response of single piles in cohesionless soils is proposed. The pile-soil system is idealized by using a one-dimensional finite element technique. The shear resistance response along the pile shaft is found by using the concept of  $t$ - $z$  curve proposed by L.M. Kraft et al., whereas the new method is used to define the tip resistance response or the so-called  $p$ - $z$  curve. A generalized Ramberg-Osgood model is utilized to simulate the nonlinear  $t$ - $z$  and  $p$ - $z$  curves. To check the validity of the method, four examples involving field and laboratory tests on piles in sands are considered. (Edited author abstract) 29 refs.

Armaleh, Sonia (Univ of Arizona, Tucson, AZ, USA); Desai, C.S. *J Geotech Eng* v 113 n 12 Dec 1987 p 1483-1500.

**078749 AXIAL AND LATERAL RESPONSE OF PILE GROUPS EMBEDDED IN NONHOMOGENEOUS SOILS.** A numerical method of analysis based on elasticity theory is presented for the analysis of axially and laterally loaded pile groups embedded in nonhomogeneous soils. The problem is decomposed into two systems, namely the group piles acted upon by external applied loads and pile-soil interaction forces, and a layered soil continuum acted upon by a system of pile-soil interaction forces at the imaginary positions of the piles. The group piles are discretized into discrete elements while the nonhomogeneous soil behavior is determined from an economically viable finite element procedure. The load-deformation relationship of the pile group system is then determined by considering the equilibrium of the pile-soil interaction forces, and the compatibility of the pile and soil displacements. The influence of soil nonlinearity can be studied by limiting the soil forces at the pile-soil interface, and redistributing the 'excess forces' by an 'initial stress' process popular in elasto-plastic finite element analysis. Additional study results are discussed. (Edited author abstract) 32 refs.

Chow, Y.K. (Natl Univ of Singapore, Singapore). *Int J Numer Anal Methods Geomech* v 11 n 6 Nov-Dec 1987

p 621-638.

**078750 INTERACTION BETWEEN TORSIONAL AND AXIAL PILE RESPONSES.** The effect of axial load on the torsional pile response and the effect of torque on the axial pile response are investigated. To perform this investigation, a computer program was developed which uses the transfer matrix method to analyze a pile supported by a series of coupled axial and torsional elasto-plastic springs. The study indicated that the ultimate torsional and axial pile capacities, as well as the axial displacements and rotations, are significantly affected by the combined load action. (Author abstract) 11 refs.

Georgiadis, Michael (Univ of Thessaloniki, Greece). *Int J Numer Anal Methods Geomech* v 11 n 6 Nov-Dec 1987 p 645-650.

**078751 AXIAL INTERACTION BETWEEN DISSIMILAR PILES IN A GROUP.** This paper describes the results of an investigation into axial interaction among a group of dissimilar piles. Consideration is given to the settlement and load distribution in a group containing piles of different section or length, arranged in any general configuration, and subjected to static or cyclic axial loading. Solutions are presented for a circular eight pile group, for the following cases: (a) some piles in the group have belled bases (b) some piles have different lengths or diameters (c) some piles have reduced stiffness (to simulate construction defects). Under cyclic loading, it is found that degradation of skin friction begins at lower load levels in a group with dissimilar piles than in a group of identical piles. (Edited author abstract) 8 refs.

Poulos, H.G. (Univ of Sydney, Aust); Hewitt, C.M. *Res Rep Univ Sydney Sch Civ Min Eng n R512 Dec 1985* 30p.

**078752 LATERALLY LOADED PILES IN LAYERED SOIL.** Laterally loaded circular elastic piles in layered soil are analyzed by means of a rigorous elastic load transfer theory. In terms of effective stresses, the problem is decomposed into extended soil layers with elastic properties of the layered soil and a fictitious pile characterized by Young's modulus of the real pile and the respective Young's moduli of the soil layers. The unknown fictitious-pile shear force is determined from the condition that the horizontal displacement in the extended soil layers along the centroidal axis of the original pile location caused by a system of interactive forces is equal to the horizontal displacement in the fictitious pile. The real-pile shear force is obtained by combining the fictitious-pile shear force with the areal integral of the effective horizontal shear stress in the extended soil layers at the original pile position. Extensive parametric studies with regard to the maximum bending moment and pile top deflection are presented in graphical form for the design and analysis of laterally loaded piles in layered soil. (Edited author abstract) 15 refs.

Lee, S.L. (Natl Univ of Singapore, Singapore); Kog, Y.C.; Karunaratne, G.P. *Soils Found* v 27 n 4 Dec 1987 p 1-10.

**078753 TORSIONAL RESISTANCE OF SINGLE PILE IN LAYERED SOIL.** Lateral loads on an offshore structure may result in torsional moments acting on the individual piles. In the present work, simple mathematical solutions are developed for a torsionally loaded pile in a layered soil and nondimensional charts are presented for design purposes. 4 refs.

Hache, R.A.G. (Jacques, Whitford & Assoc Ltd, Halifax, NS, Can); Valsangkar, A.J. *J Geotech Eng* v 114 n 2 Feb 1988 p 216-220.

**078754 PREDICTION OF LOAD-CARRYING CAPACITY OF DRIVEN PILES.** Two methods are presented to estimate the load-carrying capacity of driven piles. These methods use a new wave equation model that incorporates the loss of energy to the soil mass through radiation damping of the soil. Conventional soil parameters are used in this new model. Both methods use the load-test result of a test pile to estimate the soil parameters at the site by set matching. These soil parameters are then used to predict the load-carrying capacity of similar piles

at the site in subsequent analyses from set measurements. The two methods are demonstrated by the prediction of the load-carrying capacity of 21 piles at four sites. (Author abstract) 28 refs.

Chow, Y.K. (Natl Univ of Singapore, Singapore); Karunaratne, G.P.; Wong, K.Y.; Lee, S.L. *Can Geotech J* v 25 n 1 Feb 1988 p 13-23.

**078755 TIME DOMAIN FLEXURAL RESPONSE OF DYNAMICALLY LOADED SINGLE PILES.** Adopting a Winkler assumption, a simple mechanical soil model is developed for the flexural response analysis of dynamically loaded piles. The model is defined by examining a frequency-domain analytical expression obtained for the dynamic response of a plane strain massless cylinder and an infinite medium system. Using this soil model, the time-domain transfer matrix is developed for the flexural response of a single pile. The steady-state harmonic response of a single pile is computed by both the present approach and a previously developed frequency-domain solution. Good agreement between the two computed results validates the present approach. The dynamic responses of single piles subjected to the lateral impulse load are computed for piles in both capability of the present approach. It is confirmed that the developed soil model and pile response formulation are very efficient in numerical computation. (Author abstract) 16 refs.

Nogami, Toyooki (Univ of California, San Diego, CA, USA); Konaigai, Kazuo. *J Eng Mech* v 114 n 9 Sep 1988 p 1512-1525.

**078756 LATERAL LOAD ANALYSIS OF NON-LINEAR PILES.** The response of pile foundations to lateral loads depends on the interaction between the piles and the surrounding soil. Analysis of this response requires accurate characterization of the behavior of both the pile and the soil surrounding the pile. Commonly used existing methods for analysis of the lateral load response of single piles consider the nonlinearity of the soil resistance, but they treat the pile as a linear, elastic beam. The assumption of pile linearity may not be valid in many cases. This note introduces a method for representing nonlinear pile behavior in the analysis of laterally loaded piles. 7 refs.

Kramer, Steven L. (Univ of Washington, Seattle, WA, USA); Heavey, Edward J. *J Geotech Eng* v 114 n 9 Sep 1988 p 1045-1049.

**Structural Design** See Also FOUNDATIONS—Soil Structure Interaction; RETAINING WALLS—Concrete Construction.

**078757 DIMENSIONNEMENT DE PIEUX QUELQUES EXPERIENCES ET RECHERCHES EN GRECE.** [Design of Piles: Experiments and Research in Greece]. The author describes some experiments and research concerning the structural design of piles, the main purpose being to inform readers of current practice in Greece. He deals with the problem of factors affecting the behaviour of the pile and gives correlations between the modulus of elasticity of the soil on the one hand and the number of blows  $N$  (SPT) and the cone resistance (CPT) on the other hand, so as to be able to estimate the settlement of piles on the basis of the theory of H. Poulos and E. Davis. A brief description is also given of loading tests of tubes for predicting the bearing capacity and settlement of real piles. (Author abstract) 8 refs. In French.

Christoulas, Stavros G. (Univ Technique Natl d'Athènes, Athens, Greece). *Bull Liaison Lab Ponts Chaussees* n 154 Mar-Apr 1988 p 5-10.

**Testing** See Also PORT STRUCTURES; SOILS—Permafrost.

**078758 ALLOWABLE COMPRESSIVE DESIGN STRESSES FOR PRESSURE-TREATED ROUND TIMBER FOUNDATION PILING.** Research at the University of Colorado on southern pine and Douglas-fir piling has determined that the existing building code design stress values of 1200 psi and 1250 psi, as deter-



mined by ASTM D-2899, are substantiated; but testing procedures should be revised. All full size piling tests should be standardized at 1/d ratios of 2:1, or confined tests performed. Also, it has been determined that theoretical design values for timber piling should not be based on the lumber criteria of D-245 and D-2555, but instead should follow the pattern set by engineers in the utility industry for timber poles, in accordance with ANSI O5.1. (Author abstract) 28 refs.

Graham, James S. (Nat'l Timber Piling Council, Rye, NY, USA). *Deep Found J* Spring 1986 p 13-28.

**078759 STEEL PILE LOAD TEST DATA.** The results of numerous pile load tests on high-capacity steel piles are presented. The test data were contributed by design firms and by members of the steelmaking industry or their consultants and represent actual field testing programs. Test results show that the safety factor which exists in many pile foundations is much larger than necessary. Therefore, more consideration should be given to designing pile foundations using load test results as a guide to provide economical yet safe structures. The ultimate capacities of the piles have been evaluated on the basis of interpretation of the load-settlement criteria stipulated by the representative codes. It is suggested that direct application of these data to sites with similar geological conditions be limited to preliminary design only. Final design parameters for any large project employing high-capacity piles must be substantiated by pile load tests and analytical interpretation. (Edited author abstract) 7 refs.

Anon (American Iron & Steel Inst, Washington, DC, USA). *Steel Pile Load Test Data* Publ by American Iron & Steel Inst, Washington, DC, USA, 1985 82p.

**078760 TEST ON MODEL PILE GROUPS IN CLAY.** This paper describes an investigation of the 2x2 model pile groups embedded in clay bed with floating pile cap subjected to vertical working loads. The experimental results were compared with elastic continuum analysis using homogeneous and non-homogeneous soil models. The comparisons suggest that the non-homogeneous soil model (the shear modulus varying linearly with depth) is more appropriate than the homogeneous model (modulus remains constant) for the clay bed. The elastic response of pile groups could be predicted on the basis of shear modulus evaluated from single pile load tests. (Author abstract) 5 refs.

Khan, Abdul Samad (NED. Univ of Engineering & Technology, Karachi, Pak). *Mehran Univ Res J Eng Technol* v 6 n 3 Jul 1987 p 17-20.

**078761 ADFREEZING STRENGTH OF ICE TO MODEL PILES.** Results of tests to determine the adfreezing strength of freshwater ice to piles having different surface characteristics show that adfreezing strength increases with increase in the rate of displacement and loading of the pile. Surface coatings such as creosote on wood piles and paint and silicone sealer on metallic piles drastically decrease the adfreezing strength of ice. (Author abstract) 3 refs.

Parameswaran, V.R. (Nat'l Research Council of Canada, Ottawa, Ont, Can). *Can Geotech J* v 24 n 3 Aug 1987 p 446-452.

**078762 TEST PILING IN CRUSHED ROCK FILLING.** The article presents a report of an address to the Geotechnical Group of the Hong Kong Institution of Engineers on the title subject. It presents the results of pull-out tests of the piles carried out to estimate skin friction. The tests were carried out on steel H-piles and tubular piles. It was concluded that only a small value of skin friction was actually mobilized within the rock fill layer and the major portion of pull-out resistance was derived from the more cohesive alluvium and completely-weathered-rock layers.

Evans, G.L. *Hong Kong Eng* v 14 n 5 May 1986 p 21.

**078763 CYCLIC AXIAL DISPLACEMENT TESTS ON MODEL PILES IN CLAY.** Offshore structures

experience severe storm loading which is the most critical situation for foundation stability. Under these conditions considerable variations in axial pile forces occur and small cyclic axial displacements can develop, possibly resulting in a weakening of the adhesion bond between the pile and the clay soil. This article reports on investigations of these phenomena using small-scale physical modeling. Briefly the technique involves the study of a model pile element installed in a remolded clay bed. The pile models are elements in the sense that they are intended to represent a small part of a prototype pile at a particular depth, rather than the whole pile over its entire length. The surface of the bed can be surcharged so that any selected depth can be represented.

Procter, D.C. (Univ of Manchester, Engl); Khaffaf, J.H. *Geotechnique* v 37 n 4 Dec 1987 p 505-509.

**078764 CYCLIC LATERAL LOADING OF A LARGE-SCALE PILE GROUP.** A large-scale group of nine steel-pipe piles in a closely-spaced arrangement was subjected to two-way, cyclic, lateral loading with water above the ground surface. The test was conducted in stiff, overconsolidated clay at a site in Houston, Texas. All of the piles in the group were extensively instrumented to allow the results to be compared with those from other piles in the group and from the testing of an isolated, single pile. The results emphasize the highly nonlinear nature of the pile-soil-pile interaction. A substantial reduction in ultimate soil resistance was measured in the group piles relative to that of a similarly loaded single pile for both the first cycle and for 100 cycles of load. (Author abstract) 10 refs.

Brown, Dan A. (Auburn Univ, AL, USA); Reese, Lyndon C.; O'Neill, Michael W. *J Geotech Eng* v 113 n 11 Nov 1987 p 1326-1343.

**078765 EFFECT OF LOADING RATE ON PILE SKIN FRICTION IN SANDS.** This paper describes simple model pile tests to investigate the effect of loading rate on pile skin friction in reconstituted silicon and carbonate sands. The tests show that the ultimate skin friction of the pile increases as the loading rate increases in carbonate sands, but that there is no effect in silica sands. (Author abstract) 7 refs.

Mao, Yuan B.E.; Poulos, H.G. *Res Rep Univ Sydney Sch Civ Min Eng* n R519 Mar 1986 19p.

**078766 FIELD MEASUREMENTS ON MODEL PILE IN TWO CLAY DEPOSITS.** The piezo-lateral stress (PLS) cell is an in situ testing device that is capable of providing simultaneous measurements of the total horizontal stress, the pore pressure, and the shear stress acting on cylindrical pile shafts during the various stages in the life of a pile. PLS cell measurements obtained during penetration and subsequent soil consolidation in two clay deposits are presented herein and clearly show that clay sensitivity has an important effect on pile shaft behavior. Moreover, measurements are in reasonable agreement with predictions based on the strain path method that are significantly different from predictions obtained by means of the more popular cavity expansion method. (Author abstract) 17 refs.

Azzouz, S. (Kuwait Univ, Kuwait); Morrison, Michael J. *J Geotech Eng* v 114 n 1 Jan 1988 p 104-121.

**078767 MODELLING LATERALLY LOADED PILES IN CALCAREOUS SAND.** A program of 17 model pile tests was performed on the Cambridge 10 m Geotechnical Centrifuge in order to investigate the lateral load performance of offshore piles in calcareous soil. The tests comprised monotonic and cyclic lateral loading of single piles and groups of two and three piles in reconstituted, uncemented calcareous soils from Bass Strait, Australia. The piles modeled prototype piles with diameters in the range 0.3 to 2.1 m. Each test had one instrumented pile with which bending moment distributions were measured. The paper describes the modeling techniques, the class of results obtained, the validation of model scaling factors and the application of the work. (Author abstract) 8 refs.

Nunez, I.L. (Cambridge Univ, Engl); Phillips, R.; Randolph, M.F.; Wessellink, B.D. *Cambridge Univ Eng Dep Tech Rep CUED/D-Soils* 208 1987 12p.

**078768 PILES IN CLAY UNDER CYCLIC AXIAL LOADING - FIELD TESTS AND COMPUTATIONAL MODELLING.** An extensive series of static and cyclic axial pile load tests have been carried out by the Norwegian Geotechnical Institute in an overconsolidated clay deposit. The test piles used were 5.15 m long with diameter of 15.3 cm. The cyclic capacity was determined in a load-controlled mode, and varied from 42% of the ultimate static capacity in symmetrical two-way loading to 76 to 100% in one-way cyclic loading. Large-displacement cyclic loading degraded the capacity further to about 30% of the static capacity. The static and cyclic interface skin friction are modeled well by direct simple shear tests on remolded reconsolidated clay when effective stresses at onset of loading are properly considered. General computational models for predicting the cyclic performance of piles must take into account both load and displacement controlled loading, and must satisfy compatibility in terms of both cyclic and average stresses and displacements. (Edited author abstract) 21 refs.

Karlsrud, Kjell; Nadim, Farokh; Haugen, Torgeir. *Publ Nor Geotek Inst* n 169 1987 13p.

**078769 POSSIBILITY OF USING MULTISECTION COMPOSITE PILES OF SQUARE CROSS SECTION AND LONG LENGTH.** Composite piles have come into widespread use in connection with the expansion of construction into areas containing deep strata of weak soils, for example, in regions near the Baltic Sea. Composite reinforced-concrete piles of square cross section are normally used in industrial and civil construction. The trust 'Stroimekhanizatsii', Ministry of Construction of the Latvian SSR first experimented with their use in 1964, and at the present time, the volume of these piles has exceeded 180,000 m<sup>3</sup> in the Latvian SSR alone. Bolted, welded, and socket joints are used to connect the elements of the composite piles. With the trend toward an increase in the number of floors in buildings and the loads on the columns of industrial projects, the need has arisen to use composite piles of even greater length and with an even greater number of joints. To determine the feasibility of the use of these piles, the trust 'Stroimekhanizatsii' performed an experimental investigation under complex geological-engineering conditions. 3 refs.

Bakholdin, B.V. (Scientific-Research Inst of Bases & Underground Structures, USSR); Svetinskii, E.V.; Lekakh, M.R. *Soil Mech Found Eng* v 24 n 4 Jul-Aug 1987 p 154-156.

**078770 PILE LOAD TESTS IN SALINE PERMAFROST AT CLYDE RIVER, NORTHWEST TERRITORIES.** At Clyde River on the northwest coast of Baffin Island, pile load tests were carried out in 1982. Three piles were subjected to loads of five different magnitudes for different durations. Creep settlement was initiated and persisted in all cases. Continuous curve fitting was carried out by computer, and the resulting smoothed strain rate plotted with time. The minimum settlement rates were compared with earlier predictions. They were generally somewhat faster than results from previous laboratory saline creep testing combined with theoretical pile design based on creep settlement. The tests highlight the dramatic reductions in foundation bearing capacity and acceleration in pile creep rates that can be expected in permafrost exhibiting significant pore water salinity. A simplified testing procedure suitable for laboratory or field testing is described. (Edited author abstract) 14 refs.

Nixon, J.F. (Hardy BBT Ltd, Calgary, Alberta, Can). *Can Geotech J* v 25 n 1 Feb 1988 p 24-32.

**078771 MEASURED AND PREDICTED AXIAL RESPONSE OF 98 PILES.** This article deals with the prediction of the response to monotonic axial loading of single piles in various soil conditions. A 98-pile load test data base was obtained from the Mississippi State High-



way Department and was used to evaluate 13 methods designed to predict the ultimate load of a pile and five methods designed to predict the settlement of a pile. The methods include SPT/ $S_u$  methods, cone penetrometer methods, a pressuremeter method, and a dynamic formula method. The accuracy and precision of each method is quantified statistically, and a risk analysis is performed in order to properly assess the factor of safety. A cost analysis is also performed in order to find the factor of safety that will minimize the cost of construction plus the cost of a potential failure. (Author abstract). 20 Refs.

Braud, Jean-Louis (Texas A&M Univ, College Station, TX, USA); Tucker, Larry M. *J Geotech Eng* v 114 n 9 Sep 1988 p 984-1001.

**078772 DATA REPORT OF THREE DYNAMIC CENTRIFUGE MODEL TEST ON PILES AND PILE GROUPS.** This data report describes the centrifuge model test carried out (in April 1987) to study the earthquake response of piles and pile groups. Three tests were conducted; one with a single pile with a cap, one with a single pile without a pile cap and one with a group of four piles with a pile cap. The model construction and the experimental methods are described briefly. The data obtained in these tests are presented. In the geotechnical centrifuge modelling the prototype gravitational forces are simulated by centrifuge acceleration (N times the gravity). The earthquake accelerations are simulated by shaking the model flight with the acceleration N times higher than that of the prototype in order to satisfy the dynamic similarity. 4 Refs.

Maheetharan, A. (Univ of Cambridge, Cambridge, Engl); Steedman, R.S. *Cambridge Univ Eng Dep Tech Rep CUED/D-Soils* n 206 1987 60p.

**078773 MOVEMENTS OF RIGID PILES UNDER ECCENTRIC AND INCLINED LOADS IN SAND AND CLAY.** The movement of single rigid soil vertical model piles and pile groups under eccentric, inclined as well as axial and horizontal loads are experimentally investigated. From displacements of single piles in sand and clay the vertical and horizontal secant moduli of soil are evaluated by relationships based on elastic theory. It is found that changes in the loading eccentricity cause induced anisotropy in sand. The values of secant moduli of sand and clay from pile tests are compared with the values obtained from laboratory plate bearing tests. Effects of grouping of piles on movements are analyzed by displacement and rotational ratios determined from tests. These ratios are compared with their experimental values given by Oda (1972). The method of pile installation and soil density are found to have significant influence on the displacement and rotation ratios from pile tests conducted in sand. (Edited author abstract). 12 Refs.

Yalcin, A.S. (Technical Univ of Nova Scotia, Halifax, NS, Can); Meyerhof, G.G. *Soils Found* v 28 n 2 Jun 1988 p 25-34.

**078774 LATERAL RESISTANCE AND DEFLECTION OF FLEXIBLE PILES.** The ultimate lateral resistance and the groundline lateral deflections under working loads of freestanding single model piles and small pile groups, of various materials and different embedded lengths, subjected to horizontal load have been investigated. The test results of piles of various stiffnesses in sand and clay are compared with theoretical analyses based on the concept of an effective embedment depth in terms of the behavior of equivalent rigid piles. (Author abstract). 14 Refs.

Meyerhof, G.G. (Technical Univ of Nova Scotia, Halifax, NS, Can); Sastry, V.V.R.N.; Yalcin, A.S. *Can Geotech J* v 25 n 3 Aug 1988 p 511-522.

**078775 DYNAMIC BEHAVIOUR OF SINGLE PILES UNDER STRONG HARMONIC EXCITATION.** Dynamic experiments were conducted on large-scale model piles in sand subjected to strong horizontal and vertical excitation. The theoretical response curves are calculated using DYNA2 and PILAY2 computer codes, and using also for the vertical direction,

the theory of nonlinear vibration. The theoretical curves are compared with the experimental results. The dynamic behavior of the pile is presented as frequency response curves for displacement, stiffness, dashpot constants, and damping ratios. The influence of excitation intensity, repeated loading, and cap contact with soil on the dynamic behavior of single piles is investigated. (Author abstract). 23 Refs.

Han, Yingcai (Inst of Engineering Mechanics, Harbin, China); Novak, Milos. *Can Geotech J* v 25 n 3 Aug 1988 p 523-534.

**078776 EVALUATION OF PILE FRICTION FROM CONDUCTOR TESTS.** The paper considers the results of load tests performed on conductor pipes installed at North Rankin, with a view to evaluating the likely shaft capacity of the main driven piles. The average skin friction values measured from the conductor tests range from close to 20 kPa, down to as little as 4 kPa for a conductor that had been tested re-driven and then tested again. The low skin friction values are exacerbated by the slender nature of the conductor pipes and by the tensile direction of loading. Allowing for these factors, the average skin friction available to the main piles under monotonic loading is estimated as about 20 kPa. However, that value is liable to significant reduction under the action of cyclic loading. (Author abstract). 8 Refs.

Poulos, H.G.; Randolph, M.F.; Semple, R.M. *Res Rep Univ Sydney Sch Civ Min Eng* n 572 Jul 1988 var paging.

Vibrations See FOUNDATIONS—Vibrations.

**PIPE** See Also FLOW OF FLUIDS—Films; FLOW OF FLUIDS—Laminar; FLOW OF FLUIDS—Pulsatile Flow; FLOW OF FLUIDS—Stability; FLOW OF FLUIDS—Two Phase.

**078777 LOETEN VON RINGSTUECK/ROHR-VERBINDUNGEN MIT ELEKTRISCHER WIDERSTANDSERWARMUNG.** [Electric Resistance Brazing of Ring-Segment/Pipe Joints]. A method and equipment for gas-shielded brazing of ring-segment/pipe joints have been developed. The use of special contact means between the electrodes and components has made it possible to use direct electrical resistance heating. By using this method, it is possible to produce tight joints that are resistant to internal pressure. (Edited author abstract) In German. 5 refs.

Salzberg, Bernd-Peter (VEB, Teltow, East Ger); Bogdahn, Heiner. *Schweisstechnik (Berlin)* v 37 n 11 1987 p 500-501.

**078778 NEW SNAKEPIPE.** The snakepipe is a flexible pipe that can protect a pipeline from deformation and breakage. It simultaneously absorbs bending deformation and elongation due of subsidence of ground. At present, snakepipes are used mainly for protecting pipes surrounding a building. In addition, they can be used in valve pits, abutments, weak ground areas, buried double pipes and pipe bridges.

Nasu, Masaru; Fujikawa, Masami. *Nippon Kokan Tech Rep Overseas* n 52 Apr 1988 p 65-66.

Bends See PIPELINES—Bends; SLAGS—Melting.

Cleaning See BRUSHES—Mechanical Drive.

Computer Aided Design

**078779 CIRCULAR PIPE-CONNECTIONS.** Designers sometimes need specially formed pipe bends to connect given openings. Choosing a curve of constant curvature for the central curve of such a pipe-connection improves its aerodynamical properties. Further pipe bends with circular central curve are much easier to produce than that based on arbitrary spatial curves. Hence the following geometric problem arises: Let (A, a), (B, b) be given line elements with skew oriented tangent lines a, b. How to connect these two elements by a smooth curve? How to fulfill additional requirements? Within the continuum of possible connections we pay attention only to the follow-

ing four cases: The connecting curve is a helix or it consists of two circles, of  $n \geq 2$  congruent circular arcs with congruent twist angles or of  $n \geq 3$  congruent circular arcs with almost congruent twist angles. Solutions of the first and third kind turn out to exist only if the given line elements are symmetric in a certain sense. We present an algorithm for generating curves of the fourth type with the aid of computers. (Author abstract) 3 refs.

Fuhs, Wilhelm (Technische Univ Wien, Vienna, Austria); Stachel, Hellmuth. *Comput Graphics (Pergamon)* v 12 n 1 1988 p 53-57.

Cooling

**078780 STUDY ON HIGH ACCURATE PREDICTION OF PIPE COOLING EFFECT.** The pipe cooling method is of use for control of thermal cracks in various massive concrete structures. This paper presents a new theoretical technique for solving the pipe cooling problems. The numerical computation is made by means of the modified Fluid in Cell (MFLIC) method which was developed for simulating energy equation with a large Peclet number. The experiment is done by using a large-sized rectangular concrete prism. Comparing theoretical results with experimental ones, the application technique of MFLIC method is confirmed. In addition, some characteristics of heat transfer at cooling pipe surface are theoretically clarified by the aid of computed results. (Author abstract). 10 Refs. In Japanese.

Ito, Yo; Sakaguchi, Takehiko; Nishiyama, Katsue; Mori, Kiyonari. *Doboku Gakkai Rombun Hokokushu* n 396 V-9 Aug 1988 p 29-37.

Corrosion See NATURAL GAS WELLS—Corrosion.

Corrosion Protection

**078781 DES CANALISATIONS CONTRE LA CORROSION.** [Protection of Pipes Against Corrosion]. The rate of corrosion of iron and copper pipes was studied by investigating the gradient of the weight loss curve after 120 and 60 days for the iron corrosion studies. In the copper corrosion studies, the copper uptake after 10 weeks was taken as the magnitude of the copper corrosion. The paper shows that different pipe materials require different water qualities to minimize corrosions. On the basis of laboratory tests, field tests and observations from waterworks applying corrosion control methods, the following water composition seems to decrease corrosion in a distribution system of iron and copper pipes: pH 8-8.5; hydrogen carbonate 40-100 mg/ $\text{HCO}_3^-$ /l; calcium content 15-30 mg  $\text{Ca}^{2+}$ /l; sulphate and chloride as low as possible. 16 refs. In English, French.

Hedberg, T. (Chalmers Univ of Technology, Goteborg, Sweden); Johansson, E. *Water Supply* v 5 n 3/4 1987, Uniting the World of Water, Rome, Italy, Nov 3-7 1986 p SS20.1-SS20.6.

Crack Propagation See Also PIPING SYSTEMS—Components.

**078782 THERMAL SHOCK OF A PIPE WITH A PARTLY CIRCUMFERENTIAL SURFACE CRACK.** Stress intensity factors are calculated at the deepest point of partly circumferential surface cracks in a pipe loaded thermally and by internal pressure. The method of calculation is based on weight functions using the program package 'EASY' developed by Mattheck and Munz. Numerical values of the stress intensity factors are given for various crack depths and crack lengths in a pipe with an inner radius to wall thickness ratio of 10. (Author abstract) 6 refs.

Grebner, Hans (Brown, Boveri & Cie AG, Mannheim, West Ger). *Eng Fract Mech* v 28 n 3 1987 p 309-317.



**078783 EFFECT OF AN AXIAL COMPRESSIVE LOAD ON THE STABILITY OF A CIRCUMFERENTIAL CRACK IN A STAINLESS STEEL PIPE THAT IS BUILT-IN AT BOTH ENDS.** Against the background of the integrity of boiling water reactor piping systems, this paper investigates the effect of an axial compressive load on the stability of a circumferential crack in a stainless steel pipe that is built-in at both ends. One end is fixed, while the other, though allowed to move in an axial direction, is subject to a transverse displacement, and crack instability is examined when this displacement is fixed. The circumferential instability of through-wall crack and the radial instability of a part-through and part-circumference crack are both examined. For both types of instability, it is shown that a compressive load has an adverse influence on crack stability only when the compressive load is a large fraction of the Euler critical load. (Edited author abstract)

Smith, E. (Manchester Univ/UMIST, Manchester, Engl). *Int J Pressure Vessels Piping* v 30 n 5 1987 p 335-349.

**078784 TEARING OF CIRCUMFERENTIAL CRACKS IN PIPES LOADED BY BENDING.** The paper develops a theory of tearing for circumferential through-cracks in pipes. Resistance to tearing is postulated to be a consequence of invariance in shape at the tip of a growing crack. The present paper is concerned with the use of a crack growth hypothesis in place for a resistance curve to serve as an alternative theoretical foundation for stability analyses. (Edited author abstract) 9 refs.

Sanders, J. Lyell Jr. (Harvard Univ, Cambridge, MA, USA). *Int J Fract* v 35 n 4 Dec 1987 p 283-294.

**078785 INSTABILITY OF CIRCUMFERENTIAL CRACK GROWTH IN PIPES - III. A PIPE WITH BUILT-IN ENDS: THE EFFECTS OF (a) THE TYPE OF IMPOSED DEFORMATION, AND (b) THE FLEXIBILITY AT THE BUILT-IN ENDS.** This paper focuses on the instability of growth of a through-wall circumferential crack in a pipe that is built-in at both ends. Two issues are addressed: (a) the effect of the type of deformation (i.e. rotation and/or transverse displacement) imposed at some part of the system, and (b) the effect of the flexibility at the built-in ends. (Author abstract) 4 refs.

Smith, E. (UMIST, Manchester, Engl). *Int J Eng Sci* v 26 n 1 1988 p 95-102.

**078786 INSTABILITY OF CIRCUMFERENTIAL CRACK GROWTH IN PIPES - IV. THE EFFECT OF RESTRAINTS ON THE INSTABILITY CRITERION.** This paper examines the effect of a restraint imposed at some part of the system on the instability of growth of a through-wall circumferential crack in a straight-pipe that is built-in at one end, the pipe being subject to bending deformation due to a fixed displacement applied at the free-end. The results clearly demonstrate the beneficial effects of restraints on the stability of circumferential crack growth. (Author abstract) 6 refs.

Smith, E. (Joint Manchester Univ/UMIST, Manchester, Engl). *Int J Eng Sci* v 26 n 1 1988 p 103-109.

## Cracking

**078787 FINITE ELEMENT ELASTIC-PLASTIC ANALYSIS OF GROWTH AND PENETRATION OF A SURFACE CRACK.** The authors have carried out a series of elastic-plastic analyses for circumferentially cracked pipes loaded in four-point bending. They have obtained load-displacement and the J-displacement curves and the crack opening area for cracks with various configurations. Based upon these curves, an engineering approach has been applied to estimate the stable growth and instability of a surface crack. The Battelle round robin on the crack growth has been estimated well by this analysis. (Edited author abstract). 5 Refs.

Miyoshi, T. (Univ of Tokyo, Tokyo, Jpn); Shiratori, M.; Yoshida, Y. *Int J Pressure Vessels Piping* v 33 n 1 1988 p 15-25.

Cutting See Also STEAM GENERATORS—Repair.

**078788 CUTTING MACHINE WITH PC CONTROL.** Digital control for machines typically means CNC as applied to machine tools. This type of control can also apply to other kinds of machine motions such as those for an automated pipe and beam cutting machine built by Vernon Tool Co (Oceanside, Calif.) The company is delivering CNC cutting machines with a complete PC enclosed in a hardened, industrial control cabinet to be installed next to the cutting machine.

Emerson, Charles (American Machinist & Automated Manufacturing, New York, NY, USA). *Am Mach Autom Manuf* v 131 n 10 Oct 1987 p 72-73.

**078789 DEVELOPMENT OF COMPUTER CONTROLLED PIPE-CUTTING MACHINE.** IHI has developed a computer controlled automatic pipe cutting machine and put it to practical use successfully. The development of software made it possible to control the machine using the design data from the design department. This machine provides higher productivity and better quality. (Edited author abstract) 2 refs.

Miyashita, Hiroshi (IHI, Tokyo, Jpn); Katsuki, Masayuki; Yoneyama, Toshio; Ito, Kenji; Ohta, Mitsunori. *IHI Eng Rev (Engl Ed)* v 20 n 1 Jan 1987 p 9-13.

**078790 ROHRSEGMENTE BRENNNSCHNEIDEN MIT HILFE DES COMPUTERS. [Computer-Aided Flame Cutting of Pipe Segments].** The first mechanically controlled machines for the flame cutting of pipe were developed over 35 years ago. In recent years their use has been simplified by NC controls for three or four axes. With the new tube flame cutters of the third generation the torch is controlled - as in robots - in six axes. These machines are suitable for cutting all the contours usually encountered in off-shore engineering and in the construction of power stations and of pipelines. In addition, software modifications also permit special cuts to be performed. In German.

Diethert, Hans-Helmut (Industriegase- und Schweissgerätesteller, Frankfurt am Main, West Ger). *Baender Bleche Rohre* v 29 n 1 Jan 1988 p 34-37.

Defects See Also METAL CUTTING—Electrochemical.

**078791 J-INTEGRAL ESTIMATION ANALYSIS FOR CIRCUMFERENTIAL THROUGHWALL CRACKED PIPES.** J-integral estimation solution is derived for pipes containing a circumferential throughwall crack. Bending moment and axial tension loadings are considered. These solutions are useful for calculating J from single load-displacement record obtained as part of pipe fracture testing, and are applicable for a wide range of flaw length to pipe circumference ratios. Results for J at initiation of crack growth generated using the solution developed in this paper agree well with J results from finite elements analyses. (Author abstract). 16 Refs.

Zahoor, Akram (Novetech Corp, Rockville, MD, USA). *Nucl Eng Des* v 108 n 3 Jul-Aug 1988 p 515-522.

## Deformation

**078792 PLASTIC DEFORMATION INDUCED BY PRESSURE TRANSIENTS IN FLUID-FILLED PIPES.** Severe pressure transients, caused for example by pump breakdown, may induce plastic deformation of a pipe wall. The speed of propagation of waves inducing plastic deformation is of importance in the analysis and design of piping systems. A general expression for the speed of propagation is derived. This also accounts for the type of pipe support. The analysis presented in this paper suggests that there is no propagation at the point of plastic instability. (Author abstract). 2 Refs.

Chohan, R.K. (Queen Mary Coll, London, Engl). *Int J Pressure Vessels Piping* v 33 n 5 1988 p 333-343.

## Equipment

**078793 SIZING THE ENDS OF PIPES AND PIPELINE PARTS.** The authors have developed a modified design of the sizing head. In this design the conical jaws have been turned by 180°. Therefore, the engagement between the jaws and the body is at the big end. This has resulted in a significant increase in the strength and reliability of the jaws and eliminated breakage when sizing thickwalled pipes. This device can be used for sizing pipes of diameter less than 108 mm (89, 76, 57 mm). The machine for sizing of pipes and pipeline parts of 57-325-mm diameter includes the sizing head, a hydraulic cylinder, a hydraulic power pack, an electric cabinet, and a control panel. Technical characteristics of the machine are presented. 1 ref.

Medvedev, V.A.; Akumhametov, A.Kh.; Boiko, V.A.; Matkava, I.I.; Pevnev, N.I. *Chem Pet Eng* v 22 n 9-10 Sep-Oct 1986 p 473-475.

## Failure

**078794 CAUSES FOR THE FAILURE OF WATER-HEATER PIPES IN AMMONIA PRODUCTION.** The causes for the failure of subassemblies and components of apparatus used for chemical production should be diagnosed using modern methods of investigation for the complex study of the properties of the damaged metal and the character of the fracture. The authors investigated the pipes of two water heaters that had operated for 11,163 and 1200 h, respectively. The pipes under investigation were compared with pipes formed from type 12Kh18N10T steel in the as-delivered state and after heating for expansion. 7 refs.

Shapiro, M.B.; Surkov, Yu.P.; Chizhnikov, M.B.; Belinkii, A.L.; Sokolova, O.M.; Rybalko, V.G. *Chem Pet Eng* v 23 n 3-4 Mar-Apr 1987 p 190-193.

**078795 ANALYTICAL MODEL FOR FAILURE BENDING MOMENT OF STRAIGHT PIPES INCLUDING RESIDUAL STRESS AND OVALITY.** When a pipe breaks the fracture starts in the vicinity of an initial or nucleating defect, such a defect being usually located near to the weldment. In this paper, a four-parameter model is given which describes four fundamental aspects of the pipe section at the moment of breakage. These parameters are: (a) the effective stress in the uncracked area as defined by M.F. Kanninen, (b) the effective stress in the cracked area as defined by K. Hasegawa, and two new parameters to describe (c) residual stresses and (d) ovality. Additionally, a simplified approach to describe crack growth is included in the model. This approach requires two new parameters, namely the minimum defect length and the effective defect area at the failure instant. (Edited author abstract) 7 refs.

Gonzalez, Antonio Moreno (Empresarios Agrupados SA, Madrid, Spain). *Int J Pressure Vessels Piping* v 30 n 4 1987 p 311-319.

**078796 ESTIMATION OF THE DUCTILE UNSTABLE FRACTURE OF PIPE WITH A CIRCUMFERENTIAL SURFACE CRACK SUBJECTED TO BENDING.** Several simple limit-load criteria have been proposed to predict in a light water reactor (LWR) pressure boundary piping the failure bending moment of a tough pipe which has a circumferential crack and is subjected to an external bending moment. However, some of those limit-load criteria give an unconservative prediction when the pipe has a short and deep circumferential surface crack. The present paper proposes a semi-empirical limit-load criterion on the basis of test results. This limit-load criterion gives a conservative prediction by choosing the optimum parameter, even if the pipe has an arbitrary circumferential surface crack. The present paper also proposes a method to calculate the tearing modulus  $T_{appL}$  of the pipe containing the circumferential surface crack just after the ligament failure. Moreover, the



compliance of a four-point bending machine is converted to an equivalent pipe length, which is used to calculate the value of  $T_{appL}$ . (Author abstract) 13 refs.

Kurihara, Ryoichi (JAERI, Tokai-mura, Jpn); Ueda, Shuzo; Sturm, Dietmar. *Nucl Eng Des* v 106 n 2 Feb (II) 1988 p 265-273.

**Flow** See HEAT TRANSFER—Boundary Layer; WATER PIPING SYSTEMS—Design.

**Fluid Dynamics** See Also FLOW OF FLUIDS—Theory; FLOW OF FLUIDS—Turbulent.

**078797 PREDICTION OF THE DECAY PROCESS IN TURBULENT SWIRL FLOW.** Swirl flow in a pipe is studied experimentally and the data so obtained have been compared with theoretical predictions computed from a proposed calculation procedure which determines the swirl intensity, tangential and axial velocity distributions by defining only the flow parameters at the inlet of the test pipe. (Author abstract) 14 refs.

Algifri, A.H. (Motilal Nehru Regional Engineering Coll, Allahabad, India); Bhardwaj, R.K.; Rao, Y.V.N. *Proc Inst Mech Eng Part C* v 201 n 4 1987 p 279-283.

**Fracture** See NUCLEAR REACTORS, BOILING WATER—Piping Systems.

**Freezing** See HEAT TRANSFER—Ice Problems.

**Friction**

**078798 RESEARCH ON THE COEFFICIENT OF RESISTANCE FOR PIPES WITH OBLATE CROSS-SECTIONS.** Based on theoretical analysis and experiments the friction factor and resistance coefficient for a tube and a tube bend of oblate cross-sections are determined. The main resistances are measured for a series of bends of oblate cross-sections with various angles. The regression equations and regression curves for resistance coefficients are presented. In general, the resistance coefficient for a series of bends is not equal to the sum of those of the bends. The experiments show that the ratio of the resistance coefficients ranges from 0.60 to 1.80. (Author abstract) 4 refs. In Chinese.

Xu, Tongmo (Xian Jiaotong Univ, Shanxi, China); Hui, Shien. *Huagong Jixie* v 14 n 6 1987 p 466-472.

**Heat Transfer** See HEAT TRANSFER—Convection.

**Heat Treatment**

**078799 QUANTITATIVE DESCRIPTION OF THE THERMAL STATE OF THE SURFACE LAYERS OF A PIPE HEATED BY HIGH-FREQUENCY CURRENTS.** An attempt is made to establish the nature of the change in the temperature field accompanying heating of the external surface of a pipe with HFC. We examine two temperature states: continuous, as a result of which the temperature increases monotonically up to a maximum admissible value  $T_2$ , and impulsive, when the maximum temperature of the outer surface is reached very rapidly and is then maintained in the interval  $T_1 < T < T_2$ . To determine the temperature distribution, the heat-conduction problem is solved neglecting the composition and structure of the coating. It is concluded that impulsive heating with HFC is preferable for localizing a high temperature in the diffusion zone. The instantaneous value of the temperature at any point of the diffusion zone is the same and is practically equal to the temperature on the outer surface of the pipe at this time. 5 refs.

Nesterenko, A.I. (Dnepropetrovsk Chemical Engineering Inst, USSR); Sakho, V.N.; Shatinskii, V.F. *Sov Mater Sci* v 22 n 6 Nov-Dec 1986 p 576-580.

**High Pressure Effects**

**078800 CALCULATION OF CREEP STRESSES IN HIGH-PRESSURE PIPES.** The authors developed a program for calculation of residual creep stresses for pipes made of steel 30CrNiMo8 at any given moment of time of

their operation. To carry out the calculation, we analyzed the relaxation characteristics of this steel. A decrease of the stresses in the logarithmic time coordinate at different initial stresses of the specimens and test temperatures occurred the first 10 h according to a curve (unsteady regime) which later became an inclined straight line (Steady regime). The authors obtain the distribution of the creep-induced stresses with respect to the entire pipe wall, which, being summed with the operating stresses, leads to a redistribution of the stresses in the pipe during its operation. We have developed an algorithm and written a program for calculation (on an ES-1033 computer) of the stresses at any given moment of time from the beginning of operation of pipes made of steel 30CrNiMo8. We carried out calculations of the stressed state of specific pipes at different moments of operation under different operating conditions. 1 ref.

Bryanskaya, E.A.; Yakup, A.V. *Chem Pet Eng* v 23 n 5-6 May-Jun 1987 p 210-212.

**Inspection** See Also OIL FIELD EQUIPMENT—Tubular Goods.

**078801 ADVANCED AUTOMATIC INSPECTION SYSTEM FOR HIGH QUALITY SEAMLESS PIPE AND TUBES.** An advanced automatic inspection system has been developed for quality assurance of high quality seamless tubes and pipe. It consists of an ultrasonic testing machine, an ultrasonic measuring system and an electromagnetic inspection machine with a compound magnetic field. The electromagnetic inspection machine in particular has been newly developed for detection of three dimensional surface defects on both magnetic and non-magnetic materials. In the No. 4 tube-making plant of the Steel Tube Works of Sumitomo Metal Industries, Ltd., material grades, small lots and short delivery periods are the rule. The present system has contributed to flexible on-line manufacturing. (Author abstract)

Hiroshima, Tatsuo (Sumitomo Metal Industries Ltd, Jpn); Hirota, Tetsuya; Ishihara, Michiaki; Hyodo, Shigetoshi; Nakao, Yoshiyuki. *Sumitomo Search* n 35 Nov 1987 p 53-56.

**Insulation**

**078802 FROST PROTECTION REGULATIONS: THE REAL IMPLICATIONS.** In the UK the Model Water Byelaws are a set of regulations produced by the Department of the Environment and presented to the enforcing Authorities as a model upon which to base local water byelaws. This article discusses certain aspects of the regulations. The discussion concerns frost protection of pipe for hot and cold water service.

Johnson, Les (Armstrong World Industries Ltd). *Insul J (Rickmansworth Engl)* v 32 n 3 Mar 1988 p 12-14, 21.

**Lining** See PIPELINES—Repair.

**Maintenance**

**078803 PIPE BURSTING FOR TRENCHLESS SEWER REPLACEMENT.** A system of pipe bursting has been developed which will remove the problems associated with impact moling and allow the replacement of sewer pipes with a pipe of similar or larger diameter. The machine is robustly constructed in the form of a series of interleaved segments which have the outer edges chamfered to avoid jamming. These leaves are hinged centrally to enable them to flex through the action of an axially mounted hydraulic piston operating at a pressure of up to 280 bar.

Anon. *Eur Water Sewage* v 91 n 1097 Jul 1987 p 290-291.

**Manufacture** See Also METAL DRAWING—Dies; ROLLING MILL PRACTICE—Pipe.

**078804 AUSBAUCHEN VON ROHREN, [Bulging of Pipes].** If pipes or tubes have to be provided with bulged flanges for lateral connections such an operation may present a problem to workshops which are not equipped for making them. This is particularly true if these

connections have to be made at a considerable distance from the pipe ends. (Author abstract) In German.

Strasser, Federico. *Werkstatt Betr* v 120 n 9 Sep 1987 p 744.

**Materials** See Also GLASS MANUFACTURE; WATER PIPELINES—Developing countries; WATER PIPING SYSTEMS—Safety Codes.

**078805 CERAMIC LAYER COMPOSITION OF METAL-CERAMIC COMPOSITE PIPES PRODUCED BY A CENTRIFUGAL-THERMIT PROCESS.** The ceramic layer produced by a centrifugal-thermit process consists of corundum ( $\alpha$ - $Al_2O_3$ ) and hercynite ( $FeO-Al_2O_3$  spinel) when inducing the thermit reaction with aluminum and iron oxide powders. Although the hercynite in the ceramic layer plays some role in improving mechanical properties of the ceramic layer such as toughness and thermal shock resistance, it is not desirable for improving the corrosion resistance because the  $FeO$  component included in hercynite would be attacked in highly acidic conditions. In the present work, in order to make clear the mechanism of  $FeO$  remaining in the ceramic products and to reduce its content, the centrifugal-thermit process was performed with  $Al$  and  $Fe_2O_3$  powder mixtures of the mole ratios ( $Fe_2O_3/2Al$ ) of 1.1, 1.0, and 0.9 under environments of nitrogen gas and air flow. It was also performed by adding  $Mg$  and  $Si$  powders to the stoichiometric mixture of  $Al$  and  $Fe_2O_3$  powders. (Edited author abstract) In Japanese. 7 refs.

Odawara, Osamu (Tokyo Inst of Technology, Yokohama, Jpn); Nagata, Kazuhiro; Goto, Kazuhiro S.; Ishii, Yasumasa; Yamasaki, Hiroshi; Sato, Mikio. *Nippon Kinzoku Gakkaishi* v 52 n 1 Jan 1988 p 116-120.

**078806 APPLICATIONS OF MAGNETIC COAXIAL PIPE TO CURRENT DETECTION.** Basic characteristics and applications of magnetic coaxial pipe to current detection are described in this paper. Skin and proximity effect in the pipe with tape-wound structure are discussed. Amorphous tape-wound pipe exhibits very good performance for current detection at over several tens of kHz. A new ground fault detector is also developed by using a coaxial pipe in power line. A relay system using the detector operated within 42 ms, which is practically enough to protect the power line. (Author abstract) 4 refs.

Yamaguchi, M. (Tohoku Univ, Sendai, Jpn); Hayasaka, A.; Horizaki, K.; Murakami, K.; Hojo, H. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2206-2208.

**Mechanical Properties** See Also PIPE, STEEL—Manufacture; STEEL—Mechanical Properties.

**078807 ACCURACY OF DETERMINING THE STRENGTH PROPERTIES OF PIPE MATERIAL.** The result obtained by the methods of mathematical processing show that the value of the error in determining the strength properties depends strongly on the accuracy of determining the cross-sectional area of the specimens and on the accuracy of recording the load. When the requirements on the accuracy of measuring the specimens (up to 0.01 or 0.05 mm) specified by GOST 1497-84 and GOST 10006-80 are fulfilled, the error of determination of the strength characteristics in testing the cylindrical and segment specimens (longitudinal strips taken from pipes) varies up to 2% and that in the case of the specimens/nozzles up to 5%. In determining proof stress  $\sigma_{0.2}$  from the tensile diagram, the error increases and may vary additionally up to 3%. In determining the strength characteristics of the pipes on the basis of the nominal dimensions of the diameter and wall thickness, the error may reach 20%. The magnitude of the error rapidly increases with reduction of wall thickness. Therefore, the method of determining the strength properties of the pipes on the basis of the nominal dimensions may be recommended in cases in which the pipes are manufactured with high accuracy and if the ratio of wall thickness to diameter is, for example, not lower than 1.10. 3 refs.

Malys, A.D. (All-Union Scientific-Research Inst of Pipe Industry, Dnepropetrovsk, USSR); Ostrin, G.Ya.; Bur-



nos, V.A.; Tertyshnik, I.M.; Kolpakova, G.V. *Ind Lab (USSR)* v 53 n 4 Apr 1987 p 359-362.

**Nondestructive Examination** See NUCLEAR REACTORS—Inspection; PIPE, CAST IRON—Quality Control.

## Oscillations

**078808 SELF-EXCITED OSCILLATION IN AN AXI-SYMMETRIC JET WITH A COAXIAL FINITE-LENGTH CIRCULAR PIPE.** An experimental investigation has been carried out on the sound resonance associated with the circular pipe of finite length, which is positioned coaxially downstream of a round free jet. Self-sustained oscillation arises due to the impingement of the free shear layer on the pipe's leading edge, and this results in the periodic production of discrete ring vortices in the jet. The predominant frequency of oscillation is found to vary intrinsically with the position of the pipe's leading edge as in the case of the circular ring, in which several modal stages of oscillation have been observed previously. However, when this intrinsic predominant frequency approaches the first or higher eigen-frequencies of the pipe, sound resonance between these two frequency components occurs. (Edited author abstract) In Japanese. 6 refs.

Kurasawa, Hideo; Obata, Teruo; Hirata, Masaru; Kasagi, Nobuhide; Yamane, Kanji. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 494 Oct 1987 p 3018-3026.

## Pressure Effects

**078809 PHENOMENON OF REROUNDING.** When the cross section of a circular pipe is loaded with external forces, e.g. ground forces and increased gas pressure, then a new shape will arise which of itself is in total equilibrium. This shape will only be correct if any part of it is also in equilibrium, i.e. the total of the moments of the external forces, e.g. at the end of the part, should be zero. With the computer program BPC3 this end state is obtained in three to four iterations. The end state created with the generally used formulas of Spangler is not obtained; nor is it obtained, even after ten iterations, with the computer program NASTRAN. (Edited author abstract) 5 refs.

Bish, J.F. (Raadgevend Ingenieur, Delft, Neth.). *J Pipe-lines* v 7 n 1 Nov 1987 p 65-71.

**078810 ELASTO-PLASTIC RESPONSE OF PIPES UNDER EXTERNAL PRESSURE AND BENDING.** The collapse of thin cylindrical pipes subject to combined bending moment and external pressure has been studied. Nonlinear finite deflection thin shell theory is employed in the elastic solution. The analysis is extended to include the plastic behavior with the assumption of linear work-hardening material. Results are presented for various geometric material and load configurations. (Author abstract) 14 refs.

Tay, C.J. (Natl Univ of Singapore, Kent Ridge, Singapore); Toh, S.L. *J Offshore Mech Arct Eng* v 110 n 2 May 1988 p 148-153.

## Production

**078811 PRODUCTION OF PIPES FROM BOROSILICATE GLASS.** Experimental evidence indicates that the most effective temperatures of the glass in the working chamber for the preparation of the vertical drawing machine and during the period of producing the pipes, and also such molding parameters as the drawing rate, the position of the cooler with the plate barrier screen, the diameter of the molding nozzle, the depth to which it should be immersed, and the value of the air pressure supplied to the pipe to be molded. During the launching and drawing of the pipe, the presence and distribution of the siliceous crust along the surface of the glass are important; this in turn affects the isothermia of the glass around the cooler. The drain provides for a constant renewal of the glass in the mechanized working chamber. These studies and the measures taken have made it possible to increase the molding rate of the 50-mm

borosilicate pipes by 35% (from 140 to 185-195 m/h) and of the 40-mm pipes by 60% (from 200 to 310-320 m/h). 1 ref.

Akulich, S.S. (State Scientific Research Inst of Glass, USSR); Orlov, D.L.; Moiseev, V.G.; Golozubov, O.A.; Cherednichenko, V.I.; Ignatov, S.V.; Pronin, A.V.; Yurchenko, A.V.; Shipuk, P.V. *Glass Ceram* v 44 n 5-6 May-Jun 1987 p 233-236.

**Protective Coatings** See Also PIPING SYSTEMS—Insulation.

**078812 PRIESKUM MOZNOSTI OPTIMALIZACIE ZLOZENIA LIACEHO PRASKU, 'NETOLIT CCI'.** [Optimization Feasibility of Antipe Compound Analysis - NETOLIT CCI]. Basic characteristics of antipe compound were ascertained. An optimum recipe is suggested. Chemical analysis was established with a melting interval of more than 50°C. Model test of antipe-compound is described. (Edited author abstract) 2 refs. In Czech.

Kijac, Jozef (VST, Kosice, Czech). *Hutn Listy* v 43 n 2 Feb 1988 p 105-107.

## Quality Control

**078813 RELIABILITY OF DIMENSIONAL NON-DESTRUCTIVE CONTROL OF SEAMLESS PIPES.** The article examines problems of the reliability of dimensional nondestructive control with a view to the expected requirements that the quality of seamless pipes will have to meet. It describes the sources of systematic errors when modern means of nondestructive control are used for evaluating wall thickness, eccentricity, ovality. It explains the requirements which dimensional nondestructive control has to meet to ensure the operational properties of pipes for important purposes and the possibility of controlling the technological process. (Author abstract)

Kuznetsov, E.D. (All-Union Scientific, Engineering, & Technical Inst, Dnepropetrovsk, USSR). *Sov J Nondestruct Test* v 23 n 5 May 1987 p 346-349.

**Sedimentation** See SOILS—Drainage.

## Stability

**078814 STABILITY ANALYSIS WITH LUMPED MASS AND FRICTION EFFECTS IN ELASTICALLY SUPPORTED PIPES CONVEYING FLUID.** This paper presents an accurate finite element procedure for the stability analysis of elastically supported pipes conveying fluid. With consideration of effects of lumped masses, fluid pressure and friction, the equations of motion are derived based on Hamilton's principle for the mass transport system. The kinematics of the pipe is based on Timoshenko beam theory for which the transverse shear deformation and rotary inertia of the pipe are included. The material behavior of the pipe is described by the Kelvin viscoelastic model. The dynamic stability behavior obtained by the present work are more conservative as compared with those evaluated by conventional Euler-Bernoulli beam theory. (Edited author abstract) 30 refs.

Chen, W.H. (Natl Tsing Hua Univ, Hsinchu, Taiwan); Fan, C.-N. *J Sound Vib* v 119 n 3 Dec 22 1987 p 429-442.

**078815 STUDIES ON THE STABILITY OF PIPES CONVEYING FLUID (THE EFFECT OF A DAMPER).** The intended aim of the paper is to provide the scope of the effect of an attached damper upon the stability of a cantilevered viscoelastic tubular pipe conveying fluid. The effect of the damage coefficient of a damper is investigated in detail in connection with the position of the damper as well. It is found that a damper attached to a thin pipe may have a little stabilizing effect on the pipe. Any damper attached to the pipe at the discharge end may be most destabilizing. A lumped mass accompanied by a damper may be destabilizing. The theoretical predictions were checked by some experiments. (Author abstract) In Japanese. 11 refs.

Sugiyama, Yoshihiko; Chiba, Masakatsu; Katayama, Tadakazu; Shiraki, Kazuhiro; Fujita, Katsuhisa. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 498 Feb 1988 p 353-356.

**078816 DYNAMIC STABILITY AND ACTIVE CONTROL OF CANTILEVERED PIPES CONVEYING FLUID (AN ATTEMPT OF STABILIZATION BY TENDON CONTROL METHOD).** Theoretical studies on the dynamic stability and active control of cantilevered pipes conveying fluid are conducted. In order to control the response of the cantilevered pipe, an active control force is derived by the torque produced by a pair of tendons attached to the pipe. The problem is solved by means of the Galerkin method, in conjunction with the optimal regulator theory. The effect of a tendon on the stability of a cantilevered pipe conveying fluid in the uncontrolled system is clarified. Furthermore, the effect of the internal damping is taken into consideration in the present study. The numerical simulation of the response of a cantilevered pipe conveying fluid is also carried out for various conditions. It is found that active tendon control method is effective to stabilize the cantilevered pipe conveying fluid, even if the control input is limited. (Author abstract) In Japanese. 14 refs.

Doki, Hitoshi; Tani, Junji. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 498 Feb 1988 p 357-362.

**078817 STUDIES ON THE STABILITY OF PIPES CONVEYING FLUID (THE COMBINED EFFECT OF A SPRING SUPPORT AND A LUMPED MASS).** The present paper deals with the combined effect of a spring support and a lumped mass on the stability of a tubular cantilever conveying fluid. The support and the mass are assumed to be attached to the cantilever at the same location. The validity of Galerkin's 8 term approximation is discussed from the view point of predominant eigenmodes in critical flutter configurations. It is shown that for particular combinations of spring stiffness and lumped mass there exists an instability region which juts out from the main flutter domain. Both theory and experiment confirm that the instability in the region is of the mild flutter type, not the violent type. (Author abstract) 11 refs.

Sugiyama, Yoshihiko (Univ of Osaka Prefecture, Sakai, Jpn); Kawagoe, Haruo; Kishi, Takeyasu; Nishiyama, Shoichi. *JSME Int J Ser I* v 31 n 1 Jan 1988 p 20-26.

## Strain

**078818 OPTIMIZATION OF STRESS-STRAINED STATE OF THICK-WALLED TUBE ACCORDING TO MATERIAL ELASTICITY MODULUS.** The problem of finding the optimal distribution of the elastic modulus along the radius of a thick-walled tube subjected to an internal pressure is considered. Formulas are obtained for two cases: minimization of circumferential stresses and minimization of circumferential strains. Numerical results of the problem are presented. (Edited author abstract) 6 refs. In Russian.

Kalinnikov, A.E.; Korlyakov, S.V. *Probl Prochn* n 2 Feb 1988 p 88-91.

**Stresses** See Also PIPE, CLAY—Physical Properties; PIPE, CONCRETE—Structural Analysis; PIPE, PLASTIC—Aging; PIPE, PLASTIC—Structural Design; PIPING SYSTEMS—Computer Aided Design; PRESSURE VESSELS—Stresses; TUBES—Calculations; TUBES—Strain.

**078819 FRICTION HEAD LOSSES IN PIPE.** Experiments have shown that the Darcy coefficient of friction  $f$  is not a constant but depends on the diameter of the pipe, quantity of flow, roughness of the pipe and the temperature. In the range of  $Re < 2000$ , the flow is laminar. The one with  $Re > 2500$  is turbulent flow. Based on the computations, laminar flow occurs when the Reynolds number is less than 2000 and turbulent flow occurs for larger than 2500. In between these values is called the transition period, or a mixture of both the



laminar and turbulent flow. Unfortunately, there is no equation or empirical formula governing it at the present time.

Tsang, Lingman (Lee Yu Kee Ltd, Hong Kong). *Plumbing Eng* v 15 n 3 Apr 1987 p 42, 45.

**078820 STRESS INTENSITY FACTORS FOR LONG AXIAL SURFACE CRACKS AT THE OUTER WALL OF A PIPE LOADED BY STRESS GRADIENTS.** By means of the finite element method, crack opening displacements were calculated for long axial surface cracks at the outer wall of a pipe. The wall thickness to inner radius ratio of the pipe was 1 to 10. Weight functions were evaluated by means of the finite element results. Using these weight functions it is possible to calculate stress intensity factors for arbitrary radially varying stress distributions. In this paper stress intensity factors were evaluated for a constant hoop stress loading as well as for stress distributions with a linear and a quadratic dependence on the radius. (Edited author abstract) 16 refs.

Grebner, H. *Materialwiss Werkstofftech* v 19 n 2 Feb 1988 p 51-54.

**078821 CALCULATION OF STRESS INTENSITY FACTORS FOR AXIAL SEMI-ELLIPTICAL SURFACE CRACKS IN A PIPE WITH CLADDING LOADED THERMALLY.** By means of the weight functions method the stress intensity factors were calculated for axial semi-elliptical surface cracks in a pipe with cladding. The component was loaded by a thermoshock. Starting from a stress-free state the inner surface of the cladding is suddenly cooled down. The time-dependent temperature and hoop stress distributions of the uncracked component were calculated. Numerical values of the stress intensity factors at the deepest point and at the surface points of the crack were evaluated at different time steps for a range of crack depths and crack lengths. (Author abstract) 8 refs.

Grebner, H. *Materialwiss Werkstofftech* v 19 n 1 Jan 1988 p 28-33.

## Supports

**078822 ROHRAUFLAGER NACH DIN 4033: 'JEDES ROHR BRAUCHT SEIN AUFLAGER.'** [Pipe Bedding According to DIN 4033: 'Every Pipe Needs Its Bedding']. The formation of the bedding for pipes is crucial to the uniform loading of the subsoil, it influences the amount of stresses and strains of the pipe, the settlements of the pipeline and is decisive for the watertightness of the pipe joints. The pipe bedding for sewers and sewage pipelines must be carried out according to the German standard DIN 4033 'Sewers and sewage pipelines, code of practice for construction'. The bedding should ensure uniform pressure distribution in the bedding zone. Pipes should therefore be laid in such a manner that there is neither line support nor point support. It is possible to lay pipes on a flat trench bottom if the bedding is produced by placing in layers and careful compaction of the bedding material. In German and English.

Hornung, Karl. *Betonwerk Fertigteil Tech* v 54 n 7 Jun 1988 p 32-35.

**Testing** See Also CONVEYORS—Pneumatic; PIPE, PLASTIC—Performance.

**078823 PIPE WHIP: A SUMMARY OF THE DAMAGE OBSERVED IN BNL PIPE-ON-PIPE IMPACT TESTS.** This paper describes examples of the damage resulting from the impact of a whipping pipe on a nearby pressurized pipe. The work is a by-product of a study of the motion of a whipping pipe. The tests were conducted with small-diameter pipes mounted in rigid supports and hence the results are not directly applicable to large-scale plant applications where flexible support mountings are employed. The results illustrate the influence of whipping pipe energy, impact position and support type on the damage sustained by the target pipe. (Edited author abstract) 3 refs.

Baum, M.R. (CEGB, Berkeley, Engl). *Int J Pressure Vessels Piping* v 30 n 3 1987 p 217-232.

**Thermal Effects** See TILE—Thermal Effects.

## Transportation

**078824 HOW TO PREVENT TRANSIT FATIGUE TO TUBULAR GOODS.** Transit fatigue results from cyclic stresses induced by gravitational and inertial forces. The manner in which pipe is subjected to fatigue-inducing stresses during transportation is discussed. Transit fatigue is usually, but not always, accompanied by surface damage such as abrasion, denting and fretting. Surface damage can lower the fatigue resistance and, in the absence of denting, more cracks are found at the outside surface than at the inside. Based on a survey of failures, the data indicate that there appears to be no particular pattern of failures related to either the type of pipe, the grade or the mode of transport between rail and ship. Similarly, there appears to be no relationship between the number of failures and the size of pipe, although more have been expected in large diameter pipe or in pipe with larger diameter-to-thickness ratios. The characteristics of transit fatigue failures are outlined as are preventive practices. 5 Refs.

Bruno, T.V. (Metallurgical Consultant Inc, Houston, TX, USA). *Pipe Line Ind* v 69 n 1 Jul 1988 p 31-34.

**Vibrations** See Also VIBRATIONS—Absorption.

**078825 TORSIONAL VIBRATION TRANSMISSIBILITY CHARACTERISTICS OF REINFORCED VISCOELASTIC FLEXIBLE PIPES.** The dynamic complex shear moduli of fiber and steel reinforced viscoelastic flexible pipes are determined by using a torsional non-resonance method. Material property master curves as a function of frequency and temperature are obtained by using reduced modulus methods. In situations where the loss factor data is difficult to measure directly it is shown that these data can be obtained from the modulus data by using a stepwise Hilbert transform technique. Predictions of the torsional vibration transmissibility of reinforced pipes, by using a simple theory in conjunction with the material properties, results in a close comparison with experimental measurements of the torsional vibration transmissibility characteristics of the pipes over a wide frequency range. (Author abstract) 19 refs.

Kennedy, I. (Univ of Manchester, Manchester, Engl); Tomlinson, G.R. *J Sound Vib* v 122 n 1 Apr 8 1988 p 149-169.

## Wear

**078826 PIPE BEND WEAR - IS TUNGSTEN CARBIDE THE ANSWER?** The article compares relative wear resistance of various grades of sintered tungsten carbide liners against a mild steel standard in a full pneumatic conveying test rig. Specimens ranging in cobalt content from 6 to 30 per cent and in grain size from 0.56 to 2.98 microns, including a mild steel standard, were placed on a specially designed holder which fitted into a tee type 100 mm diameter bend. The specimens were tested under various operating conditions, i.e. air velocity ranging from 28 m/s to 52 m/s, impact angles of 30° to 70°, mass flow rates of 35 kg/min to 83 kg/min and phase densities of 1.2 to 2.9, using a 4 mm nominal size crushed granite rock. The experimental results show that the ultrafine-grained, low cobalt (6 per cent) tungsten carbide displays little sensitivity to varying velocities, impact angles, mass flow rates or phase densities, and consistently gave the best wear resistance under all testing conditions. An empirical model for the prediction of wear for each type of material tested has been proposed, given the particular operating conditions. (Edited author abstract) 12 refs.

Freinkel, David (Univ of the Witwatersrand, S Afr); Wright, Graham; Marcus, Roy. *S Afr Mech Eng* v 38 n 3 Mar 1988 p 142-148.

**Welding** See Also WELDING—Magnetic Field Effects.

**078827 ESTIMATION OF THE PARAMETERS OF ULTRASONIC PIPE-WELD INSPECTION BY MULTIFACTORIAL MATHEMATICAL ANALYSIS.** A solution of the problem of optimizing the design characteristics of the elements of a multiparameter ultrasonic inspection system is described. Mathematical experimental design and regression analysis was used. An experiment in implementation of the calculated parameters of a four-element acoustical system for automated ultrasonic inspection indicates 95% inspection reliability with a tenfold increase in the information yield over the manual inspection procedure. (Author abstract) 7 refs.

Volchenko, V.N. (N.E. Bauman Higher Technical Sch, Moscow, USSR); Yarovoi, A.A. *Sov J Nondestruct Test* v 23 n 2 Feb 1987 p 96-102.

**078828 ADAPTIVE AUTOMATIC SYSTEM OF CONTROLLING THE PROCESS OF ARGON-ARC WELDING PIPES.** An algorithm of controlling the welding process constructed on the basis of examining the thermal model is proposed which makes it possible to compensate technology disruptions of different physical nature. Graphs of dependences of the effect of disruptions of the welding process on the parameters of the temperature field on the surface of the component are presented. 3 refs.

Shirkovskii, N.A. (N.E. Bauman Higher Technical Sch, Moscow, USSR). *Weld Prod* v 33 n 11 Nov 1986 p 3-6.

**078829 ACCURACY OF STRESS INTENSIFICATION FACTORS FOR BRANCH CONNECTIONS.** This report presents a detailed examination of the stress intensification factor (SIF) formulations for perpendicular branch connections that are specified in American standard codes for use in the design of industrial and nuclear Class 2 and 3 piping systems. The historical evolution of these formulations, beginning with the initial fatigue test data, is discussed first to provide a consistent basis for later discussions of identified problem areas. Solutions to these problems are developed throughout the report and finally summarized as a series of recommendations for specific changes in the ANSI and ASME piping design codes. An Appendix gives recommended code language proposals for revisions to Subsections NC and ND of Section III, ASME Boiler and Pressure Vessel Code. (Author abstract) 28 refs.

Rodabaugh, E.C. (E.C. Rodabaugh Associates Inc, Hilliard, OH, USA). *Weld Res Counc Bull* 329 Dec 1987 p 1-44.

**078830 DEVELOPMENT OF FULLY AUTOMATIC PIPE WELDING SYSTEM.** The article reports on the development of the so-called Computer-Controlled All-Position Pipe TIG-welding system (CAPTIG) which enables unmanned welding operations from the initial layer to the final finishing layer continuously. This system is designed for continuous, multilayered welding of thick and large diameter fixed pipes of nuclear power plants and large-size boiler plants where high-quality welding is required. In the tests conducted with this welding system, several hours of continuous unmanned welding corroborated that excellent beads are formed, good results are obtained in radiographic inspection, and that quality welding is possible most reliably. (Edited author abstract)

Tanioka, Shin-ichi (IHI, Tokyo, Jpn); Teijima, Akio; Saito, Tatsuo; Nakano, Mitsuhiro; Yamada, Minoru; Saito, Yoshiyuki; Abe, Rikio. *IHI Eng Rev (Engl Ed)* v 19 n 2 Apr 1986 p 86-90.

**078831 AUTOMATIC GTA GIRTH WELDING OF HIGH ALLOY PIPE.** Automatic GTA girth welding of austenitic high alloy materials and application of automatic GTA welding of high alloy pipe in ASME 5G position were investigated. The results obtained are as follows: (1) The effects of welding variables, welding current, arc voltage, welding speed and groove configura-



tion on the weld bead shape in root pass welding were obtained, and the proper range of welding conditions was clarified. (2) The mechanical properties of the girth welded joints to which the automatic GTA welding was applied showed good results. (Author abstract)

Miura, Minoru (Sumitomo Metal Industries Ltd, Jpn); Ogawa, Kazuhiro; Kobayashi, Toshimi. *Sumitomo Search* n 35 Nov 1987 p 57-66.

**078832 HIGH SPEED TACK WELDING TECHNOLOGY.** To minimize construction and operation costs, development of a high speed tack welding technique was needed. Nippon Kokan has developed a technology to achieve one man-one machine operation. In March 1986, operations started at a welding speed of 8 m/min. In October 1986, the welding speed reached 12 m/min. A tandem gas-shielded metal arc welding (GMAW) process was found suitable.

Anon. *Trans Iron Steel Inst Jpn* v 27 n 12 1987 p 995.

**078833 HEAT INPUT CONTROL AND MONITORING SYSTEM FOR ERW PIPE WELDING (ER-TEMPERATURE DISTRIBUTION AND BEAD SHAPE CONTROL SYSTEM).** In response to the increasingly severe demands for high reliability of ERW pipes, Nippon Kokan (NKK) has developed a temperature distribution & bead shape control (NK ER-TBC) system. The system is in operation in all the ERW pipe mills at NKK, contributing to the stable manufacture of high grade ERW pipes. The system has been applied to optimize the heat input and upset quantity and to minimize the misalignment between both coil edges for welding.

Anon (Nippon Kokan KK, Kawasaki, Jpn). *Trans Iron Steel Inst Jpn* v 28 n 1 1988 p 78.

**PIPE, ASBESTOS CEMENT** See WATER PIPELINES; ASBESTOS CEMENT; PIPE, PLASTIC—Permeability, Mechanical.

## PIPE, CAST IRON

### Corrosion Protection

**078834 PROTECTION OF DUCTILE IRON PIPE AGAINST CORROSION.** Cast iron pipe has a long history in Japan of approximately one century since it was used for the first time in Yokohama city in 1885. It has been widely used as an excellent pipe with high durability. In this description, the results of a survey and investigation on corrosion of the external and internal surfaces of cast iron pipe, and also about the corrosion protection methods, are summed up. A statistical analysis of the data resulted in a clear correlation between corrosion rate and soil characteristics (existence of underground water, Redox potential, soil color, soil resistivity, etc.). As an external protection procedure, tar-epoxy or bituminous coating is generally used. Also, zinc rich paint coating or zinc spray specified in ISO standards can be applied as a prior coating. However, when laid in the much higher corrosive areas, very high corrosion resistance is required. In such cases polyethylene sleeving method, polyurethane coating or polyethylene coating is adopted.

Miyamoto, H. (Kubota Ltd, Amagasaki, Jpn). *Water Supply* v 5 n 3/4 1987, Uniting the World of Water, Rome, Italy, Nov 3-7 1986 p SS20.12 - SS20.13.

**Manufacture** See IRON FOUNDRY PRACTICE—Continuous Casting.

### Mechanical Properties

**078835 INFLUENCE OF CARBON AND SILICON CONTENTS ON MECHANICAL PROPERTIES OF CENTRIFUGAL DUCTILE IRON PIPES AND SELECTION OF OPTIMAL C AND SI CONTENT.** The influence of carbon and silicon content in centrifugal ductile iron pipes produced in metallic molds on tensile strength and elongation was studied. The relationship between carbon or silicon content and tensile strength or elongation are given. Limits for selecting carbon and

silicon content are provided. (Edited author abstract) In Chinese. 4 refs.

Lin, Bainian (Harbin Inst of Technology, China); Zhang, Cheng Jun. *Zhuzao* n 6 Jun 1987 p 17-20.

### Quality Control

**078836 QUALITY CONTROL TEST FOR CAST IRON PIPES USING ACOUSTIC EMISSION.** Cast iron water pipes are currently produced in conformity with GOST [All-Union State Standard] 9583-75 and TU14-3-259-77. The existing specifications are based on a maximum working pressure of 1.6 MPa. The producers test the pipes at 2.5 times the maximum working pressure, i.e., at 2.5-4 MPa depending on the class and diameter of the pipes. When pipes are tested in a hydraulic press, they are not merely subjected to an internal pressure which must be withstood with a wide safety margin [1]; they are also subjected to longitudinal bending, since the pressure force on the pipe ends amounts to 900 kN. These testing conditions often result in pipe failure under what is intended only as a soundness control check. 3 refs.

Smolyakov, A.N.; Korenyako, V.A. *Sov Cast Technol* n 2 1986 p 70-71.

### PIPE, CLAY

#### Contamination

**078837 PROBLEM OF NaCl-CONTAMINATION IN VITRIFIED-CLAY PIPE (VCP) BODIES.** Depending on how the vitrified-clay body is pretreated and dried (in room air, in a tunnel dryer, or in a chamber dryer), wet-glazed VCP shows various surface defects. The main cause of defect is the nature of the NaCl-concentration profile, with the highest concentration occurring at the body/glaze interface. The concentration profiles are plotted, and the reaction mechanisms are interpreted. (In German and English)

Hartmann, J. (Cremer & Breuer Kermische Betriebe GmbH, Frechen, West Ger). *CFI Ceram Forum Int Ber DKG* v 65 n 1-2 Jan-Feb 1988 p 11-14.

**Manufacture** See Also CERAMIC PRODUCTS—Manufacture; CLAY PRODUCTS—Manufacture.

**078838 SINGLE-COURSE JET DRYING AND FIRING OF CERAMIC PIPES IN FURNACES WITH A GAS CUSHION.** Attempts were made to create new heating equipment for which the operations of placing the greenware on tunnel drier and kiln cars is not needed. One such unit could be that using single-course, jet drying-firing of ceramic drain pipes in special, perforated, semicylindrical trays, and transfer on a gas cushion. The advantages of the continuous, single-high method of drying and firing are as follows: elimination of cars, the possibility of creating mechanized and automated drying and firing processes, improvements in the uniformity of the temperature field in the goods, and a marked reduction in the heat-process time (drying and firing), a reduction in the number of personnel servicing the plant, and improvements in working conditions. 2 refs.

Ionin, A.A. (V.V. Kuibyshev MISI, USSR); Starov, V. Yu.; Sobolev, V.I.; Ashmarin, G.D.; Buz, M.A. *Glass Ceram* v 44 n 9-10 Sep-Oct 1987 p 393-396.

### Physical Properties

**078839 NEW BEDDING FACTORS FOR VITRIFIED CLAY SEWER PIPES.** New bedding factors were predicted by the finite element analyses of buried vitrified clay pipes with four types of backfill and bedding materials. These bedding factors were calculated as the ratio of the maximum tensile strain in the computer-simulated three-edge bearing test of vitrified clay pipes to that in the finite element analyses of buried pipes. The new bedding factors are generally higher than those given in the current ASTM specifications. It is shown that the bedding factors are affected by the backfill material type and compaction density, backfill height, trench width, and

pipe diameter. Design practice around the world is also summarized. (Edited author abstract). 21 Refs.

Jeyapalan, Jey K. (Univ of Wisconsin, Madison, WI, USA); Jiang, Naiyi. *Transp Res Rec* n 1129 1987 p 31-38.

**Pressure Effects** See PIPELINES—Design.

## PIPE, CONCRETE

**Degradation** See CULVERTS—Service Life; SEWERS—Concrete Construction.

**Manufacture** See Also WATER PIPELINES.

**078840 IT'S THE HANDLING THAT COUNTS - SIMPLE IN-PLANT HANDLING SYSTEMS FOR FRESH AND HARDENED CONCRETE PIPES AND MANHOLE SEGMENTS.** Fully automated as well as simple systems are available for handling fresh and hardened concrete pipes and manhole segments. In this report, simple systems for a variety of handling tasks are described. Simple systems, for the purpose of this report, are ancillary devices that can be attached to fork lifts or cranes. The handling tasks have been divided into pipes and manhole segments; essentially, they consist of a sensible means of transport from the production site to the curing station; and from there to storage and truck. (Edited author abstract) In German and English.

Kroemer, Rupert. *Betonwerk Fertigteil Tech* v 53 n 9 Sep 1987 p 643-652.

**078841 PIPEMAKER'S CONFIDENT STAKE IN THE FUTURE.** The purchase of one of the latest models of Prinzing pipemaking machinery underlines a faith in the future by Jphohnston Pipes Ltd. Now, while retaining the traditional expertise garnered over 50 years, as one of the UK's surviving half-dozen major pipe manufacturers, Johnston Pipes are fully committed to the use of vertical casting with high frequency vibration. This is by no means a new method of manufacture.

Barfoot, Jack (Johnston Pipes Ltd). *Concrete (London)* v 22 n 1 Jan 1988 p 29-31.

**078842 PRECAST CONCRETE PIPES COPE WITH THRUST-BORE SITE PROBLEMS.** Good progress is reported from the £4.4 million Ashcroft Road to Parr Treatment Works sewer replacement scheme in St Helens, Lancs. In their choice of tunneling methods the designers selected thrust boring in preference to using bolted segments, to minimise the number of joints and so avoid the possibility of ground water inflows carrying chemical elements into the sewer and through to the treatment works. Thrust-bore quality precast concrete pipes with high-grade joints were adopted.

Anon. *Concr Plant Prod* v 6 n 2 Feb 1988 p 55-56.

**078843 CHANCEN UND HERAUSFORDERUNGEN DER BETONROHRHERSTELLER.** [Chances and Challenges of the Reinforced Concrete Pipe Producers for the Future.]. The sociopolitical significance of wastewater removal increases with rising awareness of the environment. Concrete can continue to be the market leader. Prerequisites are: Furtherance of the quality consciousness of employers; compilation of quality standards; conductance of quality controls; and marketing of pipes with a quality seal. (Author abstract) In German, English.

Kroemer, Rupert. *Betonwerk Fertigteil Tech* v 54 n 7 Jun 1988 p 26-27.

**078844 AUTOMATION IM QUALITÄTSORIENTIERTEN PRODUKTIONSABLAUF VON ROHREN AM BEISPIEL DES ROHRWERKES RISSE, WARSTEIN.** [Automation in Quality-Oriented Pipe Production on the Example of the Risse Pipe Factory, Warstein.]. The quality thought in production flows is related to the production stages concrete preparation, the actual manufacturing process including - in the



case of reinforced concrete pipes - reinforcing cages, in-plant handling of the fresh and finished products, bottom pallet circulation, and quality control. Only the optimization of these individual stations and their finely tuned interplay enables quality-oriented production flow. The Steinwerke F.J. Risse, D-4788 Warstein, have found their solution to this problem based on their particular requirements. Their product line includes concrete and reinforced concrete pipes of DN 300-2000 mm and individual manholes and accessories. This paper describes the automated pipe production manufacturing process. In German and English.

Kromer, Rupert. *Betonwerk Fertigteil Tech* v 54 n 7 Jun 1988 p 46-51.

**078845 VOLLAUTOMATISCHE FLEXIBLE ROHRFERTIGUNG MIT INTEGRIERTER ZWEIFACHER QUALITÄTSPRÜFUNG.** [European Market Firmly in Sight. Fully Automatic Flexible Pipe Production with Integrated Double Quality Assurance]. Nijmeegse Betonindustrie De Hamer bv - a company of the R.W.K.-Group - produces in its four concrete and assembly unit works a complete range of products for public works, road and bridge construction and hydraulic engineering. Recently, the company's management have been working on the design for a new production plant for manufacturing concrete and reinforced concrete pipes, which became fully operational at the beginning of this year in Nijmegen. The remarkable features of this plant are its almost completely automated mode of operation, a high degree of versatility and assured pipe quality as a result of integrated inspection equipment, as this report confirms. (Edited author abstract) In German, English.

Schwarz, Siegfried. *Betonwerk Fertigteil Tech* v 54 n 7 Jun 1988 p 52-58, 60.

**Pressure Effects** See CONCRETE CONSTRUCTION—Prestressing; WATER PIPELINES—Lining.

## Quality Control

**078846 COMPARISON OF THE QUALITY CONTROL OF REINFORCED CONCRETE PIPES ACCORDING TO DIN 4035, ASTM C 76 AND BS 5911 TAKING THE BEARING CAPACITY AS AN EXAMPLE.** There is a close connection between the standardized construction and design regulations for reinforced concrete pipes and the applicable stipulations regarding quality control. The wider the scope of pipe construction, the more precisely adherence to the stipulated qualities must be supervised and controlled. The basic differences can be clearly illustrated based on the three standards, the American ASTM C 76, the British BS 5911 and the German DIN 4035. Each of these three alternatives has its own particular advantages. In German and English. 6 refs.

Hornung, Karl. *Betonwerk Fertigteil Tech* v 53 n 9 Sep 1987 p 616-620.

## Reliability

**078847 DAUERHAFTES ROHRLEITUNGEN AUS BETON.** [Durable Piping Made of Concrete]. Water and sewage pipes were made of Roman concrete as long as 2000 years ago. In our day and age concrete is also an excellent material for applications involving water and sewage - thanks to its pressure and abrasion resistance, its long service life and its practically unlimited moldability. The article treats the durability of concrete, with special emphasis on chemical corrosion. (Author abstract) In German. 17 refs.

Lamprecht, Heinz-Otto. *Beton* v 37 n 11 Nov 1987 P 437-442.

## Structural Analysis

**078848 PERFORMANCE OF THIN-WALL CONCRETE PIPE.** An analytical and experimental study was conducted of thin-wall unreinforced-concrete pipes of dimension ratios 16 through 70 under surcharge loads equivalent to 30 ft of fill. Special attention was directed

towards bedding and trench properties and geometries. The advantages and efficiencies of matching the stiffnesses of the bedding with that of the soil envelope are discussed. Narrow trench widths are shown to be more efficient when trench fill is of lesser stiffness than trench walls. Recommendations for practice are made. (Author abstract). 8 Refs.

Gabriel, L.H. (California State Univ, Sacramento, CA, USA); Blower, H.E. *Transp Res Rec* n 1129 1987 p 21-30.

## PIPE, COPPER

### Corrosion

**078849 CORROSION EXTERIOR DE TUBERIAS EN LA VIVIENDA. III PARTE. TUBERIAS DE COBRE.** [External Corrosion of Pipes in Housing. III. Copper Pipes]. An attempt was made to evaluate the corrosion process of copper tubing in contact with both low cement/sand ratio Portland mortars and plaster. Tests were carried out for one year in conditions of partial immersion in distilled water and also in environments with 50 and 100 percent relative humidity. An attempt was made to distinguish the effects due to the carbonation of the mortar as well as those of the  $\text{CaCl}_2$  addition to the mixing water in corrosion phenomena. Electrochemical techniques using both direct and alternating current, were used for the corrosion process evaluation. Results obtained showed that the corrosion of copper is normally lower than that suffered by the other metallic materials tested: steel and galvanized steel, considered in Parts I and 2. Nevertheless, an apparent anomaly was observed in the case of plaster in 50 percent relative humidity, in which case  $\text{Cu}_2\text{O}$  was formed. (Edited author abstract). 22 Refs. In Spanish.

Huete, F.A. (Centro Nacional de Investigaciones Metalúrgicas, Madrid, Spain); Royuela, J.J. *Rev Metal (Madrid)* v 24 n 2 Mar-Apr 1988 p 67-76.

**078850 CORROSION AND ITS PROTECTION OF EVAPORATOR'S RED COPPER HEATING PIPE IN CHEMICAL PRODUCTION OF SALT.** This paper makes comparisons between red copper and carbon steel heating pipes. These heating pipes are used in the salt industry, where they come in contact with ocean bittern, well brine, or lake and mineral brine. These brines consist of  $\text{Cl}^-$ ,  $\text{Na}^+$ ,  $\text{Mg}^{++}$ ,  $\text{Ca}^{++}$ , and  $\text{SO}_4^{--}$  along with harmful gases. These gases cause corrosion of the equipment and seriously damage heating pipes. It has been shown that red copper pipes are better than carbon steel.

Ma, Xinhua (Inst of Light Industry, Tianjin, China). *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 1, p 753-755.

**078851 FAILURE OF COPPER PIPES IN KUWAIT'S DOMESTIC TAP WATER.** Annealed phosphorus deoxidized copper water pipes which failed after 16 and 20 months of service in hot and cold water piping, respectively, were investigated. When the pipes were sectioned, some areas were covered by bluish-green crusts and the rest by a dark-greyish layer. Pits were found along a longitudinal axis. The pits were hemispherical in shape, and intergranular corrosion was observed inside and around the pits. Residual carbon found on the internal surfaces of the pipes varied from 1.2 to 4.7 mg/dm<sup>2</sup>. The water contains high levels of chloride, sulfate, and a lower level of bicarbonate. The pH ranges from 7 to 9, and the water was treated with a silicate-phosphate inhibitor. (Edited author abstract) 18 refs.

Al-Kharafi, F. (Kuwait Univ); Shalaby, H.M.; Gouda, V.K. *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 1, p 767-781.

**PIPE FITTINGS** See Also FLOW OF FLUIDS—Pipes; FLOW OF FLUIDS—Turbulent; FLOW OF FLUIDS—Two Phase; LOCKS; VALVES AND VALVE GEAR—Seals.

## Analysis

**078852 COLLAPSE CHARACTERISTICS OF A THIN-WALLED ELBOW: VALIDATION OF AN ANALYTICAL PROCEDURE.** A nonlinear analysis procedure is validated in this paper to predict deformation response, up to collapse, of thin-walled Liquid Metal Reactor (LMR) piping elbows. Nonlinear shell analysis predictions are compared with experimental measurements of two full-scale large diameter (406 mm), thin-walled ( $D/t = 38$ ), piping elbows tested at room temperature and at an elevated temperature in the Multi-Load Test Facility (MLTF) at Westinghouse. The overall and local deformation predictions agree very well with the measured deformation responses up to 60 percent of the measured plastic collapse moment,  $M_{pc}$ . The analytical-experimental correlation is reasonable up to 0.8  $M_{pc}$ . At higher load levels the correlation is not as good; at collapse the analysis overpredicts measured deformations by as much as 30 percent. (Author abstract) 16 refs.

Dhalla, A.K. (Westinghouse Advanced Energy Systems Division, Madison, PA, USA). *J Pressure Vessel Technol Trans ASME* v 109 n 4 Nov 1987 p 394-401.

**Automation** See LATHES, TURRET—Control Systems.

## Cutting

**078853 DEVICE FOR GAS CUTTING OF FITTINGS ALONG THE LINE OF CONTACT WITH EQUIPMENT CASINGS.** The authors have developed a special device for mechanized gas cutting, without preliminary marking, of tubular fittings which are to be mounted along the central axes of different equipment, or along the line of contact with the casings of equipment. The device can be mounted on standard welding positioners or rotary rigs which can ensure rotation of the fitting at the speeds necessary for gas cutting and which have a smooth regulation of faceplate speed. The device consists of welding positioner and a gas-cutting device. The device comprises of a cross-type faceplate used for centering the fitting; a special column for mounting the gas torch; and a shaft with interchangeable cam. Actual use of the device under production conditions showed that reliability was high, resetting was fast, and servicing was simple. 1 ref.

Gubanov, A.S.; Tumashchik, A.G.; Berezhnov, Yu.M. *Chem Pet Eng* v 22 n 9-10 Sep-Oct 1986 p 471-472.

**Design** See PIPE JOINTS—Friction; PIPE JOINTS—Stresses.

## Hydrodynamics

**078854 INVESTIGATION OF HYDRODYNAMICS OF TWO-PHASE FLOW IN A TEE.** Two-phase flows in pipelines of power-generating plants are often split into different branches. The physical pattern of the process is sometimes complicated by the fact that, after splitting, one part of the flow is underpressure and in the other steam bubbles through a layer of water. The authors present the results of an experimental investigation of hydrodynamics of steam-water flow in a tee of equal passage areas, formed by a vertical tube with a horizontal branch. In the bottom vertical branch and the horizontal branch the flow is under pressure and in the top vertical branch steam bubbles through a layer of water with a free level. The investigation was conducted on an experimental apparatus, the main element of which is a high-pressure vessel with vertical tee fitted in it. 3 refs.

Ageev, A.G. (G.M. Krzhizhanovskii Power Engineering Inst, USSR); Babin, V.D.; Dubovskii, V.B.; Gritsyna, V.P.; Kol'chugin, B.A.; Osokin, G.V.; Tikhonenko, L.K. *Therm Eng* v 34 n 9 Sep 1987 p 502-504.



Materials See CAST IRON; STEEL—Modification.

Stresses

**078855 STRESS AND STRENGTH ANALYSIS OF CONCENTRIC REDUCERS CONSISTING OF PLATES.** This paper presents a new kind of piping component - a concentric reducer consisting of plates. The authors performed experimental and elastic, elastic-plastic analyses on five test models having different structural parameters. The elastic stress distribution under hydraulic test pressure, the extension of the plastic region under higher than operating loads and the results of bursting tests are also reported on. Results indicate that under test pressure the maximum stress occurs at the inside of the junction area between the small end of the reducer and the small end of the tube. Yield and final burst also occur at this area under higher than operating pressure. Based on the results of the analysis, it can be concluded that the reducer is safe and reliable. (Author abstract) 6 refs.

Sang, Z.F. (Nanjing Inst of Chemical Technology, Nanjing, China); Widera, G.E.O. *J Pressure Vessel Technol Trans ASME* v 110 n 2 May 1988 p 217-224.

**078856 DISPLACEMENT-BASED PIPE ELBOW ELEMENT.** A new element for stress analysis of piping is presented. The element can handle interaction effects and can be seen as an enhancement of the element from K.J. Bathe and C.A. Almeida. The necessary inter-element continuity for the elbow skin is assured through Hermitian interpolation of the ovalization pattern in the axial direction. The inclusion of warping for the elbow cross-section increases the element's capability. The main characteristics of the C<sup>0</sup> elbow element, the easy handling of boundary conditions and the satisfaction of the rigid-body mode criterion, are retained. (Author abstract) 7 refs.

Militello, C. (Fundacion ARCIEN, Avellaneda, Argent); Huespe, A.E. *Comput Struct* v 29 n 2 1988 p 339-343.

Structural Design

**078857 STRESS INDEX METHOD OF DESIGN: APPLICATION TO IN-PLAND CLOSING COLLAPSE OF ELBOWS.** This paper presents an appraisal of the design rules for bends under primary moments. For the study, we have examined over 70 experimental results, half of which concern closure bend tests. We find that the current design rules for level D loadings offered by the codes are unsafe for large angle ( $\geq 60^\circ$ ) or low pressurized pipe bends, so we propose a new formulation for a more suitable B<sub>2</sub> index, founded on the limit analysis carried out by Spence and Findlay, and on empirical corrections based on our experimental results. The paper provides advice on the use of ASME limits applicable to all components. (Author abstract). 11 Refs.

Touboul, F. (CEA-CEN Saclay, Gif-sur-Yvette, Fr); Djedidia, M. Ben; Acker, D. *Int J Pressure Vessels Piping* v 33 n 2 1988 p 153-164.

Surfaces See JOINTS—Stresses.

Testing

**078858 EXPERIMENTAL STUDY OF BEHAVIOUR AND FUNCTIONAL CAPABILITY OF FERRITIC STEEL ELBOWS AND AUSTENITIC STAINLESS STEEL THIN-WALLED ELBOWS.** This paper presents the results of two series of tests performed on 90°C large-radius elbows. A first series of 10 tests was conducted on TU 42 C (equivalent to ASME SA 106 grade B) ferritic steel elbows with an outside diameter-to-wall thickness ratio of 6.7. A second series of 15 tests was conducted on Z2 CN 18-10 (equivalent to ASME TP 304 L) austenitic stainless steel elbows with an outside diameter-to-wall thickness ratio of 90. The test supplied extensive data on the behavior of thin-walled austenitic stainless steel elbows when subjected to large displacements, including ability of the elbow to carry the flow under high loadings. Analysis in accordance with the requirements of the RCC-M was also performed to

quantify flow area reduction at stress limits allowed by these rules, in addition to the displacement amplitude margin allowed by the level D service limit criteria with respect to the experimental limit moment. (Edited author abstract). 4 Refs.

Hilsenkopf, P. (Framatome, Paris, Fr); Boneh, B.; Sollogoub, P. *Int J Pressure Vessels Piping* v 33 n 2 1988 p 111-128.

Thermal Effects

**078859 SELECTION OF BOUNDARY CONDITIONS IN PERFORMING THERMAL CALCULATION OF PIPE FITTINGS.** For thermal calculations of fittings by numerical methods on a computer, boundary conditions of the third kind are specified, whose basic parameters are the temperature of the process medium  $t_m$ , the rate  $b$  of change of the process medium temperature, and the heat exchange coefficient  $\alpha$ . In this paper, the authors attempted to determine the degree to which the rate in change of the medium temperature affected the temperature field of the flange connection of the fitting. For this purpose the authors used the numerical method of finite differences and experimental investigation of a mode of a shut-off valve. 3 refs.

Kosykh, N.S.; Nikitin, V.V.; Godyaeva, E.E. *Chem Pet Eng* v 23 n 3-4 Mar-Apr 1987 p 119-121.

**PIPE JOINTS** See Also PIPE, STEEL; PIPELINES, SUBMARINE—Construction; PIPELINES, SUBMARINE—Joints.

**078860 RELIABILITY OF MECHANICAL WRENCHES FOR SCREWING TOGETHER AND UNSCREWING PUMP AND COMPRESSOR PIPES.** In the investigation of the actual values of the parameters of the automatic machine APR-2VB we studied the processes of screwing together and unscrewing PCP (pump and compressor pipes) with nominal diameter 60, 73, and 89 mm. It was established that the maximal torques provided by the automatic machine APR-2VB (with two fly-wheels) in screwing together and unscrewing pipes are the following: from the place without withdrawal of the driving pinion from the handle of the wrench 550 N·m; with withdrawal of the driving pinion from the handle of the wrench through an angle of up to  $360^\circ$  with one impact of the driving pinion 870 and 890 N·m, respectively; with withdrawal of the driving pinion from the handle of the wrench by an angle of up to  $360^\circ$  and several (5-6) impacts of the driving pinion 1410 and 2250 N·m, respectively. Processing the results of the experimental data on the screwing together and the unscrewing of PCP with the use of the least squares method yielded the regression equations presented. The mathematical model of the dependence of the probability density of breakdowns on the number of worked cycles of screwing-unscrewing for insert pieces of wrenches KTDU is presented. 2 refs.

Shakhtbazov, E.K.; Babaev, S.G.; Gadzhiev, S.K. *Chem Pet Eng* v 23 n 7-8 Jul-Aug 1987 p 332-335.

**078861 PHILADELPHIA PUTS PYPLOK TO SLEP TEST.** The Philadelphia Naval Shipyard is getting better and better at extending the life of elderly aircraft carriers under the Navy's SLEP (Service Life Extension Program). The USS Kitty Hawk is the fourth one in the yard, following the Saratoga, Forrestal, and Independence. New technology being used on the Kitty Hawk should prove more successful. In the pipe shop a change in the way that pressure piping is being permanently connected in some areas of the ship is showing very satisfactory results. This article reviews a new recently approved technology: Pyplok swage marine fittings, manufactured by Deutsch Metal Components, Gardena, Calif. Pyplok high-pressure, 6,000 lb/in<sup>2</sup> fittings have been authorized by NavSea as a method of joining piping systems on specific classes of non-nuclear surface ship since 1980, and 3,750 lb/in<sup>2</sup> stainless steel fittings received approval for a limited number of systems in 1983.

Anon. *Mar Log* v 93 n 8 Sep 1988 p 67-69.

Analysis

**078862 FINITE ELEMENT SIMULATION OF JUMP-OUT BEHAVIOR OF THREADED PIPE JOINTS USED IN OIL-PRODUCING WELLS.** High tensile strength is one of the most important requirements for threaded pipe joints used in oil or gas-producing wells. If an excessively large tensile load is applied to the joints, a jump-out phenomenon of the pipe from the coupling occurs. The jump-out phenomenon depends largely on the thread profile, the nonlinear material properties and the contact condition at threads. In this paper, as a fundamental study, the jump-out behavior of a one-ring thread model was experimentally investigated and the FEM simulation was conducted considering the material nonlinearity and the contact condition at threads. Here, the penalty function method was applied as a technique of introducing contact condition into a large deformation elasto-plastic FEM code CAPS, which has been developed by the authors. (Edited author abstract) 5 refs.

Morita, Y. (Sumitomo Metal Industries Ltd, Amagasaki, Jpn); Kawashima, H.; Ishihara, K. *J Energy Resour Technol Trans ASME* v 110 n 1 Mar 1988 p 27-33.

Flanges See Also GASKETS—Materials; PIPE—Manufacture; WATER PIPING SYSTEMS—Insulation.

**078863 ACCURATE SIMPLE MODEL TO EVALUATE INTEGRAL FLANGE ROTATION.** Bolted flanged joints must satisfy the requirements of structural integrity and be leakproof. To attain the latter goal we need accurate information from the gasket and the flange ring rotation. In this work an approximate formula to evaluate the flange rotation is presented. To obtain it, a model which behaves in an equivalent manner to the Murray and Stuart model is proposed. Several flanges distributed over the proposed domain are computed. Satisfactory ring rotation results are obtained. (Author abstract) 5 refs.

Cascales, Daniel H. (INGAR, Santa Fe, Argent); Militello, Carmelo. *Int J Pressure Vessels Piping* v 30 n 2 1987 p 151-159.

**078864 CALCULATING A VACUUM SELF-SEALING FLANGE JOINT WITH A FLAT GASKET.** A method is given for calculating a vacuum self-sealing flange joint with a flat nonmetallic gasket. The experimental rig and methods of measurement are described briefly, and some calculation and test results are also included. (Author abstract) 3 refs.

Sinichenko, G.A. *Sov Mach Sci* n 2 1987 p 90-94.

**078865 SIMULATED FIELD TESTS OF CARBON STEEL FLANGES AT MINUS 46°C.** In order to ascertain low temperature capabilities of carbon steel flanges that failed to meet A350 LF2 impact requirements, simulated full scale field testing was carried out on flanges containing artificial saw-cut defects. Bolt-up, pressure and bending tests were conducted at  $-46^\circ\text{C}$ . (Author abstract) 3 refs.

Mirovics, I. (ICI Australia Engineering Pty Ltd, Aust). *Mech Eng Trans Inst Eng Aust* V ME 11 n 2 Jul 1986 p 112-116.

**078866 DETERMINATION OF THE INITIAL GAPS BETWEEN FLAT FLANGES WITHOUT GASKETS.** This paper describes a method of finding the size and shape of the gaps which exist between the faces of an assembled but unloaded flat-faced, metal-to-metal flange joint. The low-pressure leakage of 26 such assemblies has been measured experimentally, and pressure tappings have been used to record the pressure distribution under the contact faces of some of the flanges. Formulae are derived for the conversion from experimental data to gap size and shape. The method gives a very sensitive measure of gap height because of the cubic nature of the conversion formulae. It is shown by finite element calculations that



deflections due to bolt loading of a perfectly flat flange are much smaller than the observed initial gaps. (Edited author abstract) 6 refs.

Lewis, L.V. (Univ of Nottingham, Engl); Fessler, H.; Hyde, T.H. *Proc Inst Mech Eng Part A* v 201 n A4 1987 p 267-277.

**078867 BOLTED FLANGED JOINT LEAKAGE ANALYSIS WITH NON-LINEAR GASKET BEHAVIOR.** A model for the bolted flanged joint was developed; one which allows the evaluation of the gasket and bolt load by analyzing the equilibrium configuration. The sealing capability of the joint is checked when the load-leakage gasket correlation is known. A three-dimensional graphic analysis is discussed. An approximate formula is introduced to ascertain the flange ring rotation. Sample problems with non-linear gasket behavior are considered. (Author abstract) 4 refs.

Cascales, Daniel H. (Inst de Desarrollo y Diseño, Santa Fe, Argent); Militello, Carmelo; Mulhall, Walter J. *Int J Pressure Vessels Piping* v 30 n 3 1987 p 205-215.

**078868 EFFECT ON CONTACT HEAT TRANSFER ON THERMALLY STRESSED STATE OF THE FLANGED JOINTS OF A POWER PLANT PIPELINE VALVE.** An analysis of experimental and theoretical data has led to the conclusion that the most thermally stressed element in the design of a pipeline valve is the flanged joint. In a valve, three types of joint between the body and the cover are used: with integral (rigid) flanges, with detached (couple) flanges, and a combination of the first two, in which the bottom flange is an integral one and the top is a detached one. As an example, for designs of a wedge disc-type gate valve and of a control valve, the authors investigated the thermal state of the flanges of the two most widely used types in pipeline valves, i.e. with integral and detached flanges. 5 Refs.

Krylov, V.I. (Leningrad Inst of Rail Transport Engineers, USSR); Kiselev, I.G. *Therm Eng* v 34 n 11 Nov 1987 p 630-632.

## Friction

**078869 CONTACT PROBLEMS OF NIPPLE JOINTS.** In the presence of unidirectional couplings, when the region of contact and separation is unknown in advance, contact problems can be solved numerically using mathematical programming methods. The solution reduces to a system of inequalities in which various iterative algorithms are used to find contact zones and various expedients speed convergence of the iterations. In this paper the authors examine application of a trial method to solution of axisymmetric contact problems in the design of pipeline nipple joints. The computing scheme is constructed on the assumption that the union nut and nipple are absolutely rigid. The compliances of these elements of the joint are insignificant compared to those of the pipe and packing element, which are thin-walled. (Edited author abstract) 13 refs.

Rubin, A.M. *Sov Mach Sci* n 3 1987 p 98-101.

## Monitoring

**078870 ULTRASONIC MONITORING OF WELDED ANGLE-BUTT AND TEE JOINTS IN HIGH-ALLOY STEELS.** The feasibility of ultrasonic monitoring (USM) to evaluate the quality of angle-butt and tee joints in high-alloy steels is considered. Instructions have been developed for ultrasonic monitoring of welded angle-butt joints in chromium-nickel steels of the austenitic class. Experience with its use has indicated positive results in detecting defects of the crack and cold-spot type. For broader use of these instructions, however, it was necessary to investigate the effect of the structure and phase composition of the metal in the angle-butt joints on its acoustic characteristics, and to define the ultrasonic-monitoring regime more precisely as applies to welded joints in chemical apparatus. To confirm the effectiveness of ultrasonic monitoring of the quality of the welded angle-butt joints, the seams were radiographed

additionally by the method of gamma-radiography to expose most critical cold-spot-type defects in the root and along the edge of the seam, as well as cracks; this is confirmed by the results of a comparison made between the three methods of monitoring. Fine pores and individual slag inclusions cannot be detected with the same reliability. 5 refs.

Khimchenko, N.V.; Volokitin, V.V.; Bobrov, V.A.; Mulyukin, V.I. *Chem Pet Eng* v 23 n 7-8 Jul-Aug 1987 p 356-360.

## Plastics Applications

**078871 EXPERIMENTS ON PEELING-OFF OF REINFORCEMENT LAYERS FROM INNER SURFACE OF FRP PIPE DUE TO WATER FLOW. PART 1: PEELING-OFF CHARACTERISTICS NEGLECTING AGING DETERIORATION.** This report is to make clear the basis of the peeling-off limit. In this report of part 1, the experiment of the peeling-off by the water jet is shown. This experiment is concerned with the forming factor and selection of material, disregarding the secular deterioration of resin. In the next report (Part 2), the same experiment on the secular deterioration of resin will be shown. The mechanism of peeling-off by water flow will also be considered. Further a new method of the second adhesion joint which will prevent the occurrence of the peeling-off will be proposed. (Edited author abstract) 3 refs.

Nishino, Yoshinori (Hitachi Zosen Corp, Osaka, Jpn); Yamamoto, Masahiko; Uda, Tadayoshi. *J Text Mach Soc Jpn* v 33 n 3 1987 p 86-93.

## Seals See GAS PIPELINES—Seals.

## Strain

**078872 NUMERICAL INVESTIGATION OF THE STATE OF STRESS AND STRAIN IN THREADED PIPE JOINTS.** Problems on determination of a stress-strained state in threaded connections of pipes are considered. A linear-elastic problem for two tension-conjugate cylindrical bodies is solved by the method of finite differences. Calculation results are presented for particular threaded connection. (Author abstract) In Russian. 5 refs.

Kokhanenko, N.V.; Kokhanenko, Yu.V.; Ordynskaya, Z.P. *Probl Prochn* v 11 Nov 1987 p 94-96.

## Stresses See Also CULVERTS—Structural Design; PRODUCTION PLATFORMS—Testing.

**078873 STRESS ANALYSIS AND EXPERIMENTAL RESEARCH OF TUBULAR K-JOINTS WITH OVERLAP.** The geometry of overlapping tubular joints, the equations of intersection curves and the coordinate of the intersection point are introduced. The variational method for simple tubular joints is extended to the stress analysis of tubular K-joints with overlap. The computer program, stress concentration factor and the position of the hot spot of an overlapping joint are reviewed. For the sake of proving the feasibility of the analysis and program, the computed results are compared with experimental data of photoelastic and other experiments. (Edited author abstract) 7 refs.

Chen Tie-yun (Shanghai Jiao Tong Univ, Shanghai, China); Chen Wei-min. *J Offshore Mech Arct Eng* v 109 n 4 Nov 1987 p 375-380.

**078874 STUDY OF STRESS CONCENTRATION IN TEE-JOINTS FOR OPTIMUM DESIGN.** An experiment-design technique is used to investigate stress concentrations in tee joints under the action of external pressure, axial force, and bending moments applied to the stem of the T. The studies were made in the ranges of the geometric parameters that are characteristic for reactor-equipment plumbing. Empirical formulas and nomograms are given to describe the stress concentration factors in tee-joints as functions of their geometric parameters. Specific cases of application of the empirical formulas to strength analysis of structure under operating

loads are considered. (Author abstract) 5 refs.

Ageev, V.L.; Dranchenko, B.N.; Portnov, B.B.; Seleznev, A.V. *Sov Mach Sci* n 3 1987 p 50-55.

## Testing See Also OFFSHORE STRUCTURES—Fatigue.

**078875 INVESTIGATION OF THE STRENGTH AND ENDURANCE OF WELDED T-JOINTS.** The authors have examined the results of theoretical and experimental investigations of the stress-strain state and carrying capacity of equal conduit T-joints of three different types made from steel and aluminum alloys during static and low-cycle stress due to internal pressure. The theoretical investigation was carried out using the finite element method which is applicable to the linear theory of thin elastic shells. As can be seen from the results obtained shifting in the weld joint changes the stress distribution along the coupling line. The experiments show that for T-joints tested at  $\sigma_n = 0.4-0.7\sigma_{1.0}$  the maximum value of  $e_{90}$  is observed in the section where  $\phi = 90^\circ$  and was 10-25%. On the basis of this investigation we propose a method for evaluating T-joints made of steel 12Kh18N10T. 7 refs.

Likhman, V.V.; Kopysitskaya, L.N.; Muratov, V.M.; Samarin, A.V. *Chem Pet Eng* v 23 n 5-6 May-Jun 1987 p 278-282.

## PIPE, PLASTIC See Also AQUACULTURE—Equipment; COMPRESSED AIR; GAS PIPELINES—Plastics Applications; GAS PIPELINES—Pressure Regulation; IRRIGATION—Piping Systems; SEWERS—Repair.

## Acoustic Emission Testing See CHEMICAL EQUIPMENT—Nondestructive Examination.

## Aging

**078876 EFFECTS OF AGING ON POLYETHYLENE GAS PIPE.** The authors describe tests for the Gas Research Institute to determine the extent and effects of aging on buried plastic pipe. The results show that polyethylene pipe which has been in natural gas distribution service for as much as 20 years is not showing any evidence of physical or chemical aging. Compressed ring ESCR results appear unchanged over this time and residual stresses in pipe wall appear to be the same in aged pipe as in new pipe. Some pipe samples were found where a thin layer of the inner surface of the pipe has been oxidized, but this is not due to aging in the service environment since these samples were never used in a gas distribution system. However, hydrostatic pressure testing of these pipes shows how the presence of an embrittled inner surface layer in a polyethylene (PE) pipe may lead to a reduced service life. 8 refs.

Broutman, L.J. (L.J. Broutman & Associates Ltd, Chicago, IL, USA); Duvall, D.E.; Nylander, L.R. *Pipe Line Ind* v 68 n 2 Feb 1988 p 37-40.

**078877 RESEARCHERS PLOT THE LONG LIFE OF PE PIPE.** Already, tests have been completed that can be used to study the effects age has on plastic pipe. Results of the program indicate that polyethylene pipe - which has been in distribution service for up to 20 years - is not showing any evidence of physical or chemical aging. The Environmental Crack Resistance method was one test used. The effect of residual stresses on plastic gas pipe was also studied. The ring slitting technique was used to determine whether or not a decrease in residual stresses occurs in a service environment.

Anon. *Gas Ind (Park Ridge IL)* v 32 n 3 Jan 1988 p 22-23.

## Applications See Also GAS PIPELINES—Changeover.

**078878 ANY WAY YOU BEND IT.** New developments in plastic distribution piping are making an already versatile product even more useful to the natural gas industry. A review of developments related to the use of plastic pipe is presented. Joint inspection with ultra-sound is discussed.

Stoddard, Brooke. *AGA Mon* v 70 n 7 Jul 1988 p 26-29.



## Corrosion

**078879 CARBON DIOXIDE RESISTANCE OF AROMATIC AMINE CURED EPOXY FIBERGLASS OIL FIELD PIPE.** Aromatic amine cured epoxy fiberglass piping systems have been used successfully to handle oil field services requiring resistance to carbon dioxide. Laboratory and field test data verify the suitability of this type of pipe for these services. The laboratory study covers the effects of wet and dry carbon dioxide on aromatic amine cured epoxy fiberglass pipe under pressures from 300 to 850 psig (2.07 to 5.86 MPa). The oil field test data show the effects of 10 years of flowline service handling produced water saturated with gases containing carbon dioxide and hydrogen sulfide. (Author abstract) 12 refs.

Oswald, Kenneth J. (Smith Fiberglass Products Inc, Little Rock, AR, USA). *Mater Perform* v 27 n 3 Mar 1988 p 9-11.

**Corrosion Resistance** See COMPOSITE MATERIALS—Mechanical Properties.

**Crack Propagation** See POLYETHYLENES—Medium Density.

## Cracking

**078880 INITIATION OF FRACTURES IN RIGID PVC PIPES BY SOFT PARTICLES.** Rigid PVC pipes prepared from a particle-free, tin-stabilized formulation were subjected to constant internal pressure tests (16 MPa, 60°C), originally in order to study the scattering in time-to-failure of pipes free from crack-initiating particles. Although many efforts were made to produce pipes free from all possible foreign particles, most failures were initiated by particles. The particles in this case were soft and rubbery. Particles of this kind have previously never been found in any of the several hundred fracture surfaces in lead-stabilized PVC pipes containing calcium carbonate studied in this laboratory. The possible origin of the soft particles is discussed. The results suggest that soft particles represent serious flaws. Besides a full-grown (penetrating) crack, some of the pipes also contained growing, particle-induced cracks. (Edited author abstract) 16 refs.

Johansson, Lennart (Lund Univ, Lund, Swed); Tornell, Bertil. *J Vinyl Technol* v 9 n 3 Sep 1987 p 103-107.

## Degradation

**078881 DEGRADATION AND STABILISATION OF BLUE WATER PIPE.** Degradation caused by natural and artificial exposure of blue polyethylene water pipe compounds has been studied using thermal, spectroscopic and mechanical testing techniques. The results indicate that whilst thermal properties can be used as an effective quality control tool, deterioration of mechanical properties corresponds rather more with carbonyl index measurements. Samples in thin and thick sections have been studied and differences in behaviour are noted, with thick section samples retaining mechanical (impact) properties even after substantial degradation has occurred. Limitations in the use of artificial exposure to monitor changes that occur during natural weathering are discussed. It is concluded that, in thick section, the surface nature of ultraviolet degradation in the extreme conditions of artificial exposure effects mechanical properties in a different manner than longer-term periods of natural exposure. (Author abstract) 3 refs.

Moore, L.M. (Manchester Polytechnic, Manchester, Engl); Marshall, G.P.; Allen, N.S. *Polym Degradation Stab* v 20 n 3-4 1988, Polym Addit in Stab: Perform and Mech, Birmingham, Engl, Sep 2-4 1987 p 337-354.

## Drainage

**078882 uPVC GRAVITY DRAINAGE SYSTEMS - A NEW ERA.** The uponor Ltd. UPVC gravity drainage system Ultra-Rib, heralds a new era for flexible pipes in the construction industry. Ultra-Rib combines the latest in plastics industry production engineering processes with

scientifically revised material behaviour algorithms and simple theories of structural mechanics. This combination results in a structurally optimised design for a second generation pipe with enhanced mechanical properties. Ultra-Rib is a concentrically rib-reinforced solid wall uPVC gravity drainage system. It is intended for use in the adoptable sewer, highway drainage and industrial sectors of the construction industry. The article discusses pipe characteristics, testing, and applications.

Anon. *Water Serv* v 92 n 1107 May 1988 p 203-204.

## Extrusion

**078883 AUTOMATIC ULTRASONIC WALL THICKNESS MEASUREMENT IN PIPE EXTRUSION.** The combination of ultrasonic wall thickness measurement with meter-weight control provides an automatically operating measuring system for the wall thickness of extruded pipes. The system operates fully automatically, from calibration of the thickness data values through to documentation. (Edited author abstract) 1 ref. In German and English.

Orzechowski, J. *Kunstst Ger Plast* v 77 n 9 Sep 1987 p 3-4.

**Fiber Reinforcement** See PIPELINES—Corrosion Resistance.

## Fire Protection

**078884 FIRE STOPS FOR PLASTIC PIPE.** Undue fire hazards may arise when plastic pipe penetrates fire-rated walls or floors. Fire stops for protecting these penetration openings are available commercially. This paper discusses the physical characteristics and operating modes of these devices. A selected number of fire stops were tested in accordance with CAN 4-S115-M85 in either horizontal (wall) or vertical (floor) configurations, using two small-scale furnaces. (Author abstract) 9 refs.

Choi, K.K. (Fabricated Plastics Ltd, Maple, Ont, Can). *Fire Technol* v 23 n 4 Nov 1987 p 267-279.

**Industrial Applications** See FLUE GASES—Piping Systems.

## Joints

**078885 QUALITAETSSICHERUNG BEI DER MUFFENMONTAGE AN KUNSTSTOFF-MANTELROHREN.** [Quality Assurance for the Socket Assembly on Plastic Jacket Tubes]. The author points out the various stresses to which socket connections of plastic jacket tubes are exposed in district heating pipes. Therefore, the sockets require besides a satisfactory design, a careful assembly. In two extensive tables, recommendations are presented for the production and assembly of sockets. (Author abstract). In German.

Brachetti, H.E. *Brennst Waerme Kraft* v 40 n 6 Jun 1988 p 229-230.

**Lining** See PIPE JOINTS—Plastics Applications.

## Manufacture

**078886 HIGH-TECH MEANS SURVIVAL IN PVC PIPE TODAY.** Processors and equipment suppliers agree that pipe plants without advanced technologies, such as computer automation, won't be around in the next decade. Here's a report on two plants that have automated successfully, and a survey of some of the latest advances in PVC pipe hardware. (Author abstract)

Kreisher, Keith. *Plast Technol* v 33 n 10 Sep 1987 p 101-104.

**078887 DOSKONALENIE TECHNOLOGII PRODUKCIJI RUR Z PCW.** [Improvements in PVC Pipes Production Technology]. This paper outlines the development of pressure PVC pipes production at 'Gamrat-Erg' Plastics Works in Jaslo. Achievements of the Research Department in the technology improvements are reviewed

for various pipe types. Difficulties in the implementations of technology improvements also discussed. (Author abstract) In Polish.

Brach, Bronislaw. *Przem Chem* v 66 n 3 Mar 1987 p 122-124.

**078888 MANUFACTURE AND SIZE ASSORTMENT OF HEAT SHRINKABLE PIPES MADE OF POLYETHYLENE, CROSSLINKED BY RADIATION.** Heat shrinkable plastics pipes are important means to update mounting technology in the heavy-current industry, electronics and numerous other areas of economy (postal cables, air technique, cooling industry, gas conduits, etc.). In order to reduce and compensate imports resp. the Electrical Insulating Materials and Plastics Factory (VSZM) started in 1979 the experimental production of heat shrinkable plastics pipes and produces them at large scale level since 1980 in wide assortment, beside steady development of quality, manufacturing technology and manufacturing tools. The present article presents briefly problems of manufacturing, formation of finished product properties, through procedures of manufacturing technology. Its summarizes the quality characteristics, types, size assortment, discusses the application possibilities, the practical execution of shrinking. Finally new members of shrunk products under development are discussed. (Author abstract)

Garas, Sandor (Villamosszigetelo-es Muanyaggyar, Budapest, Hung). *Muanyag Gumi* v 24 Special Issue 1987 p 22-29.

**078889 SPECIAL HELICALLY WOUND PIPES FOR CAIRO WASTEWATER SCHEME.** Phase 1 of the Greater Cairo Wastewater Scheme has been instrumental in bringing forward many innovative ideas. Among them has been the use of the Helix process for the production of special pipe sections of up to six feet diameter for the discharge openings into the main sewer. The Helix process involves the extrusion of material at a melt temperature of 220°C and winding it with an overlap onto a preheated revolving and traversing mandrel. Complete fusion of the windings is achieved by a combination of infra-red preheat and the material's inherent self-welding properties. The result is a homogeneous mass with a weld-free smooth interior finish.

Anon (Sommer Allibert (UK) Ltd, Gloucester, Engl). *Anti Corros Methods Mater* v 35 n 4 Apr 1988 p 8.

**078890 COEXTRUSION PROCESS FOR THE MANUFACTURE OF SHORT-FIBER-REINFORCED THERMOPLASTIC PIPE.** The advantageous use of short-fiber-reinforced thermoplastic (SFRTP) resins in the manufacture of pipe requires that the fiber orientation be controlled and that the surface finish not be adversely affected by the presence of the fibers. It is proposed here that a coextrusion process be combined with the use of a specially designed, expanding channel die to achieve these objectives. The use of a three-layer, coextrusion process in which unreinforced resin is used for both the inner and outer layers makes it possible to minimize the shear effects on the fiber orientation in the middle SFRTP layer. At the same time, it provides a smooth, fiber-free pipe surface. A theoretical analysis of this process is presented. The analysis shows that the presence of unreinforced surface layers increases the level and uniformity of fiber orientation. The results of an experimental study of fiber orientation in the middle SFRTP layer are found to be in qualitative agreement with the predictions of the theory. (Edited author abstract). 24 Refs.

Doshi, S.R. (McGill Univ, Montreal, Can); Charrier, J.M.; Dealy, J.M. *Polym Eng Sci* v 28 n 15 mid-august 1988 p 964-973.

**Mechanical Properties** See Also AIR CONDITIONING—Piping Systems.

**078891 TENSILE AND PRESSURE YIELD BEHAVIOR OF FLOWFORMED POLYPROPYLENE PIPE.** Flowforming is a cold-forming, rotary point



extrusion process. Polypropylene pipes were flowformed using a single roller on a conventional lathe machine to various degrees of percentage radial reduction ranging from 17 percent to 78 percent. In order to study the forces involved in the reduction process, radial, axial and tangential forces were measured. The flowformed pipes were tested under uniaxial tension and uniaxial pressure burst tests. Both the tensile strength and maximum hoop stresses of the pipes increased with percentage radial reduction. At high percentage radial reduction, the tensile strength increases more than 4-fold over the original tensile strength value. The extension at yield increases to a maximum at about 60 percent radial reduction after which the extension at yield decreases. Results from the pressure tests show that flowforming increases the ductility of the pipes. At large percentage reductions the pipes yield in a balloon-like manner. Various fracture phenomena are also presented. (Author abstract). 7 Refs.

Lee, K.S. (Natl Univ of Singapore, Kent Ridge, Singapore); Teoh, S.H. *Mater Forum* v 10 n 4 1987 p 237-240.

**078892 EFFECT OF SHEAR ON FUSION AND MECHANICAL PROPERTIES OF RIGID PVC PIPES.** The shear level was increased during twin screw extrusion of PVC at different melt temperatures by inserting a hole plate in front of the screw tips. The variation of shear level did not significantly affect the capillary pressure in capillary viscometry at 135°C. However, the falling weight impact strength was markedly influenced. In internal water pressure tests at 60°C premature failure was obtained for pipes extruded at 198°C at the highest shear level. (Author abstract). 10 Refs.

Bystedt, Jan (Norsk Hydro Plast AB, Stenungsund, Sweden); Flensjö, Martin; Svensson, Gunnar; Terselius, Björn. *J Vinyl Technol* v 10 n 2 Jun 1988 p 100-102.

**Oxidation** See POLYOLEFINS—Oxidation.

## Performance

**078893 PERFORMANCE OF BURIED SMALL PIPES.** An analytical and experimental program was conducted to study the deflection and load-carrying capacity of small-diameter corrugated plastic drain pipes. The pipe samples were buried in different soils with various compaction conditions around the pipe. Measurements were taken of the vertical deflection and the pressure around the pipe under a wide range of surface loads. The most important parameters governing the pipe deformation are the pipe stiffness and the type and degree of compaction of the soil around the pipe. The variation of the modulus of elasticity of the pipe with deformation should be taken into account in pipe deflection prediction. The pipe stiffness was found to deteriorate under cyclic loading and unloading. (Edited author abstract). 11 Refs.

Ghobarah, Ahmed (McMaster Univ, Hamilton, Ont, Can). *J Irrig Drain Eng* v 114 n 3 Aug 1988 p 476-489.

## Permeability, Mechanical

**078894 EVALUATION OF PERMEATION OF ORGANIC SOLVENTS THROUGH PVC, ASBESTOS/CEMENT, AND DUCTILE IRON PIPES.** Buried potable waterpipes are susceptible to permeation by organic solvents. In studying piping made of PVC, asbestos/cement, and ductile iron, full-pipe assemblies and laboratory bench techniques were employed. Elastomeric gaskets for all three systems become permeated, at least under exaggerated conditions. Results show that thermodynamic activity, as opposed to concentration, is the driving force. At solvent activities well above those encountered in typical soil, PVC is seen to be an effective barrier against permeation. (Author abstract) 14 refs.

Olson, Alan J. (BF Goodrich, Independence, OH, USA); Goodman, Donald; Pfau, James P. *J Vinyl Technol* v 9 n 3 Sep 1987 p 114-118.

**Production** See PLASTICS MACHINERY—Dies and Presses.

## Stresses

**078895 STRAIN GAGE ANALYSIS OF RESIDUAL STRESS IN PLASTIC PIPES.** Residual stress distribution in medium density polyethylene (MDPE) 102 mm (4 in.) pipe with 11.1 mm wall thickness is evaluated using three different procedures. A modified layer removal procedure is employed to evaluate the residual stress component in the longitudinal direction as a function of the pipe wall thickness. On the other hand, the residual stress distribution in the circumferential direction is estimated using the conventional ring slitting method. A strain gage technique for direct residual strain measurements is described. The results obtained from the three procedures in a given direction are in qualitative agreements. A tensile residual stress dominates about 24% of the inner section of the pipe wall. The residual stress then becomes compressive reaching its maximum value at the outermost layer. (Edited author abstract) 18 refs.

Chaoui, Kamel (Case Western Reserve Univ, Cleveland, OH, USA); Moet, Abdelsamir; Chudnovsky, Alexander. *J Test Eval* v 16 n 3 May 1988 p 286-290.

**078896 INFLUENCE OF SURROUNDING SOIL ON FLEXIBLE PIPE PERFORMANCE.** The type of soil used to surround the pipes was found to have a considerable influence on pipe behavior. Various uncompacted granular materials provided good support, whereas uncompacted silty clay and silty sand did not. Compaction of the surrounding soil had a variable influence wholly dependent on soil type. Silty clay performed well only when thoroughly compacted in thin layers. Light compaction of a broadly graded granular soil improved performance slightly, whereas uniform gravel is generally considered to be unresponsive to compaction. The use of a thin bedding layer was shown to be beneficial in reducing pipe deformation, whereas a thicker bedding layer was shown to be less beneficial. The problems of measuring pertinent soil properties on site for fill selection are discussed and assessment of two empirical methods is made. (Edited author abstract). 10 Refs.

Rogers, C.D.F. (Loughborough Univ of Technology, Loughborough, Engl). *Transp Res Rec* n 1129 1987 p 1-11.

## Structural Design

**078897 STRUCTURAL DESIGN OF BURIED CORRUGATED POLYETHYLENE PIPES.** Minimum soil cover was investigated under multiple passes of live loads. Conditions for structural stability of the pipe were identified. An analytical procedure was developed for predicting the minimum height of soil cover to assure ring stability under multiple passes of live loads. Maximum soil cover tests confirmed the ring compression analysis as the primary basis for design but also revealed a need to include the effects of ring deflection. An observable performance limit was identified, and a method of design was developed that combined the effect of ring deflection and ring compression on the performance limits of CPEP buried under maximum height of soil cover. (Edited author abstract).

Watkins, R.K. (Utah State Univ, Logan, UT, USA); Dwiggins, J.M.; Altermatt, W.E. *Transp Res Rec* n 1129 1987 p 12-20.

**Testing** See Also DRAINAGE—Pipelines.

**078898 FRP PIPING DESIGN WITH THE AID OF THE SIMILARITY LAW.** By using this method, the strength of FRP pipes of the same laminate materials and laminate structure with different diameters can be predicted by a less experiment. In addition, the strength of the three-point bending, internal pressing and compressing destruction were calculated by the experiment, and these results were examined. Further, the designing method of FRP piping with the help of the similarity law is described after briefly reviewing the conventional method of the

strength analysis of fiber reinforced plastic (FRP) piping. (Edited author abstract) 4 refs.

Nishino, Yoshinori (Hitachi Zosen Corp, Osaka, Jpn); Yamamoto, Masahiko; Kawachi, Josuke; Uda, Tadayoshi. *J Text Mach Soc Jpn* v 33 n 1 1987 p 16-21.

**078899 FIELD PERFORMANCE OF CORRUGATED POLYETHYLENE PIPE.** Several Ohio Department of Transportation (ODOT) districts and Ohio county engineers have been using corrugated polyethylene pipe for small culvert replacements on a provisional basis since 1981. Use of this material by ODOT and the county engineers contacted has been limited to 12- through 24-in. sizes. Most culvert installations have been on secondary highways with no more than 6 ft of shallow cover. The structural and durability performance of all existing known corrugated polyethylene pipe culverts installed in Ohio was evaluated. This study was undertaken in February 1985 and completed in August 1985. A total of 172 culverts were inspected in 21 counties in Ohio. This article presents information pertinent to the structural performance and durability of corrugated polyethylene pipe culverts, which was obtained during the field data collection phase.

Hurd, John O. (Ohio Dep of Transportation, Columbus, OH, USA). *Public Works* v 118 n 10 Oct 1987 p 67-69, 107.

**078900 NOTCH GENERATION AND GEOMETRY IN QUALITY CONTROL TEST SPECIMENS.** This paper discusses the problems of notching test samples and provides evidence of the extreme variation that can result from the alternative methods of manufacture quite apart from the imperfections that are possible within the methods. Finally it lists a number of design considerations and indicates a method of manufacture that avoids some of the problems associated with conventional machining. (Edited author abstract) 7 refs.

Lawrence, C. (North East London Polytechnic, Dagenham, Engl); Sumner, C. *Polym Test* v 7 n 4 1987 p 225-237.

**078901 NOVEL TECHNIQUE TO INDUCE RAPID CRACK PROPAGATION IN TOUGH POLYMERS.** Pressurized plastic pipes, such as PE used for gas distribution, can be prone to catastrophic failure due to Rapid Crack Propagation (RCP). Once initiated, a brittle crack may propagate rapidly along the pressurized pipe for a considerable distance. Since initiation of cracks cannot be eliminated, PE pipes should be designed to ensure crack arrest as close as possible to the initiation site. In order to apply fracture mechanics concepts to this problem, the dynamic crack resistance of the material should be characterized. A new method for conducting reproducible and meaningful RCP experiments in simple, small-scale samples of tough PE grades was developed. The sample consists of a SEN plate of the tough polymer, with a glass slide adhered to the crack mouth. As the sample is being quasistatically loaded in tension, the glass stops the crack mouth from opening, carrying most of the load applied on the crack. Thus, it prevents the crack tip from blunting while the sample accumulates a sufficient amount of elastic strain energy. This note describes the novel method of propagating crack measurement. 5 Refs.

Genussow, R.M.S. (Imperial Coll of Science & Technology, London, Engl); Williams, J.G. *Int J Fract* v 38 n 1 Sep 1988 p R9-R12.

**Welding** See Also WELDING MACHINES.

**078902 ELECTROFUSION JOINTING - THEORY AND PRACTICE.** Since 1969, when the British gas industry first introduced polyethylene (PE) systems for the distribution of gas, the vast majority of joints have been constructed using heated tool fusion techniques. The jointing processes (socket, saddle and butt fusion) employed have necessitated a high level of operator involvement in a difficult working environment and the continued availability on site of tools and equipment in good operating condition. Electrofusion fittings have good



potential for the simplification of socket and saddle fusion techniques using the minimum of equipment. British Gas have adopted the method for both new construction and repair operations.

Ewing, L. (British Gas plc). *Gas Eng Manage* v 27 n 3 Mar 1987 p 7p between p 67 and 76.

**078903 USER-FRIENDLY JOINING SYSTEMS AVOID POOR PLASTIC PIPE JOINTS.** User-friendly mounting systems avoid poor joints in PE plastic pipe, although the electrofusion fittings still are relatively expensive. The authors explain that the heated tool fusion techniques were abandoned because of their user-unfriendliness and they also describe how manufacturers of electrofusion fittings and equipment could improve standardization.

Roebbers, H.J. (Veg-Gasinst NV, Apeldoorn, Neth); Mutter, F. *Pipe Line Ind* v 68 n 2 Feb 1988 p 40-42.

**078904 DEVELOPMENT OF SEMI-AUTOMATIC FUSION EQUIPMENT AND A STUDY OF FUSION PARAMETERS.** Simplified semi-automatic equipment has been developed to carry out heated tool welding of MDPE tubes. In liaison with this automation, an investigation was carried out to quantify the heating time as well as the applied force. In addition, a study was made of the fusion parameters of PE pipe systems of 100 mm in diameter as well as of the temperature distribution in the axial direction, the shortening of the fusion zone due to pressure and the relationship between the strength of the fusion joint and the mean flow velocity of the fusion zone. (Author abstract) 3 refs. In English, French.

Nakakura, M. (Osaka Gas Co); Mori, K.; Takahashi, K. *Weld World Soudage Monde* v 26 n 1-2 1988 p 8-17.

**078905 SCALE UP LAWS IN HEATED TOOL BUTT WELDING OF SEMICRYSTALLINE THERMOPLASTICS.** Study of model laws which enable optimum welding parameters that have been established for small pipes to be transposed to pipes with a greater wall thickness and a greater diameter during heated tool butt welding. The first part deals with the analysis of various welding processes. The second part concerns the equation setting of these various process phases and the determination of dimensionless coefficients leading to the determination of the model laws. (Author abstract) 5 refs. In English and French.

Potente, H. (Univ of Paderborn, West Ger); Tappe, P. *Weld World Soudage Monde* v 26 n 1-2 1988 p 18-25.

**PIPE, STEEL** See Also MARINE PLATFORMS—Construction; STEEL.

**078906 ROHRE AUS NICHTROSTENDEM STAHL.** [Stainless Steel Pipe]. Welded pipes of stainless steels for the chemical industry were produced shortly after the invention of these materials, and were followed in the 20's also by seamless pipes. Today they are used also in other engineering fields, e.g., in the production of oil and gas, in pollution control, in power station construction and in automobile manufacture. The new technologies not only call for special material properties but also influence the manufacturing methods for producing stainless steel pipes. Thus, for example, pipes with reduced residual stresses and pipes with high degree of purity of their inner surfaces are currently produced. (Author abstract) In German.

Kalwa, Gerhard (Mannesmann Forschungsinst, Duisburg, West Ger); Westerfeld, Karl-Josef. *Stahl Eisen* v 107 n 25-26 Dec 14 1987 p 1229-1232.

**078907 NKK SUPPLIES WORLD'S FIRST HIGH-NICKEL-CLAD UOE PIPE.** NKK, together with the Mitsubishi Corporation, has begun production on a pipe order won from Snamprogetti, the Italian construction and engineering company currently developing the second phase of the oil and gas pipeline across India. The order is the world's first for high nickel clad pipe produced by the UOE process. NKK is supplying 2,900 tons of double layered pipe - carbon steel (APL 5L

× 65) on the outside, and NKK-developed NK-NIC 42 on the inside (42% nickel, 22% chromium, 3% molybdenum). The pipe will be used as submarine pipeline in the development of India's South Bessemer gas field, off the West Coast near Bombay.

Anon. *Anti Corros Methods Mater* v 35 n 2 Feb 1988 p 8, 13.

**078908 ABZWEIGROHRE (SYSTEM ESCHER WYSS).** [Branch Pipes (Escher Wyss System)]. The author describes the design and construction of the branch pipes of the Strassen-Amlach power station. The calculation and design were performed using the software of the firm's main data installation. (Author abstract) In German.

Anon (Wagner-Biro AG, Graz, Austria). *Stahlbau Rundsch* n 68 Apr 1987 p 10-11.

**Applications** See PILES—Steel Construction; RETAINING WALLS—Materials.

## Bends

**078909 INVESTIGATIONS ON BENDING CONDITION FOR WELDED CARBON STEEL PIPE BY HIGH FREQUENCY INDUCTION HEATING.** The induction heating bent pipes of carbon steel welded pipes are used for the piping in nuclear power plants, in place of elbows. This application is useful to suppress the radiation exposure at in-service inspection. The quality of the bent pipes is controlled by the technical standards of welding for electrical equipment. However, the influence of the bending condition has not been yet sufficiently understood on the mechanical properties of the bent pipes. The purpose of this investigation is to establish the appropriate bending condition for the carbon steel weld pipe which corresponds to the carbon steel pipe STPT 42 in JIS G 3456, in relation to the transformation of the structures of the base metal and the weld metal during bending. (Edited author abstract) In Japanese. 3 refs.

Matsumoto, Toshimi (Hitachi Ltd, Jpn); Matsumoto, Teruo; Tamai, Yasumasa. *Yosetsu Gakkai Ronbunshu* v 5 n 3 Aug 1987 p 389-396.

## Cathodic Protection

**078910 INTERNAL CATHODIC PROTECTION OF CEMENT-LINED STEEL PIPES.** Internally coated, cement-lined, carbon steel pipes have been used extensively for ballast- and service-water systems offshore. Mechanical cracking of the lining, undercutting, and erosion have resulted in corrosion and system leaks. The cathodic protection experiments have yielded interesting and promising results. The current distribution has been much better than expected. Both an impressed current polymer anode and a new design of sacrificial anode have been tested. This paper presents the test results as well as a solution to the problem. (Edited author abstract). 2 Refs.

Jensen, F.O. (Skarpenord Corrosion, Langesund, Norw); Toms, R.D. *Mater Perform* v 27 n 7 Jul 1988 p 16-21.

## Corrosion

 See Also HEAT PIPES—Calculations.

**078911 COMPENSATING FOR THE IR DROP COMPONENT IN PIPE-TO-SOIL POTENTIAL MEASUREMENTS.** NACE Standard RP0169-76 specifies that the corrosion engineer must consider voltage (IR) drops other than those across the structure-electrolyte boundary when interpreting any pipe-to-soil potential. Those items that cause an IR drop and the effect of the IR drop component on the validity of measured pipe-to-soil potentials will be investigated. The methods generally used to compensate for the IR drop component will be reviewed, and recommended procedures will be outlined to ensure adherence to the NACE recommended practice to yield meaningful structure potentials. (Author abstract) 19 refs.

Webster, R.D. (Commonwealth Seager Group, Calgary, Alberta, Can). *Mater Perform* v 26 n 10 Oct 1987 p 38-41.

**078912 HIGH NICKEL ALLOY CLAD PIPE MANUFACTURED BY UOE PROCESS.** Two manufacturing processes of welded pipes, application of TMCP to clad plate rolling and as-quenched type heat treatment of welded clad pipe have been developed in NKK. For both processes, use of low carbon steels as a backing steel and longitudinal seam overlay welding by tandem GTA welding with type 625 filler metal led to high toughness and good corrosion resistance. It is confirmed that the high nickel clad pipes can be used for linepipes transporting corrosive fluids containing  $H_2S-CO_2-Cl^-$ . (Edited author abstract) 10 refs.

Kitada, Toyofumi (Nippon Kokan KK, Jpn); Kobayashi, Yasuo; Tsuji, Masao; Taira, Tadaaki; Ume, Kazuyoshi; Ito, Motokyo. *Nippon Kokan Tech Rep Overseas* n 51 Dec 1987 p 37-45.

**078913 CORROSION EXTERIOR DE TUBERIAS EN LA VIVIENDA: I PARTE. TUBERIAS DE ACERO.** [External Corrosion of Pipes in Housing - 1: Steel Pipes]. External corrosion of steel pipes in contact with Portland cement mortars and plaster is studied. Only low cement/sand ratios are considered. Specimens were tested in conditions of partial immersion in distillate water and also in environments with 50 and 100% of relative humidity. The effects due to the carbonation process as well as those due to the  $CaCl_2$  additions to the mortar were also determined. The corrosion monitoring was carried out by means of electrochemical techniques of measurement of instantaneous corrosion rate. Results clearly show the harmful influence of chloride additions. Plaster shows a harmful influence, except in very low humidity conditions. (Edited author abstract) In Spanish. 16 refs.

Huete, F.A. (Cent Natl de Investigaciones Metalurgicas, Madrid, Spain); Royuela, J.J. *Rev Metal (Madrid)* v 23 n 6 Nov-Dec 1987 p 402-412.

**078914 CORROSION EXTERIOR DE TUBERIAS EN LA VIVIENDA. II PARTE. TUBERIAS DE ACERO GALVANIZADO.** [Outside Corrosion of Pipes in Housing. Part 2. Galvanized Steel Pipes]. An attempt was made to follow during one year the corrosion process of galvanized steel pipes in contact with Portland cement mortars and with plaster, both in conditions of partial immersion in distillate water and also in environments with 50 and 100% of relative humidity. Results obtained showed an acceptable concordance between corrosion evaluations carried out by means of electrochemical methods and gravimetric determinations. Calcium chloride addition to the mortar signifies an increase of corrosion in one order of magnitude except in partial immersion conditions, in which a case no differences are observed. Plaster gives place to an intense attack, except when very low environmental humidity is maintained. (Edited author abstract) 10 refs. In Spanish.

Royuela, J.J. (Cent Nacional de Investigaciones Metalurgicas, Madrid, Spain); Huete, F.A. *Rev Metal (Madrid)* v 24 n 1 Jan-Feb 1988 p 37-47.

**078915 CORROSION OF STEEL PIPES BY POTABLE WATER.** Corrosive potable waters can severely attack the steel pipes of the distribution system. The corrosion reaction is briefly outlined and the theoretical relations for the proper conditioning of the water are derived. The importance of the oxygen reduction reaction securing the formation of an inhibiting film is revealed. The conditions are defined as those where the fluxes of  $HCO_3^-$  and  $Ca^{2+}$  are equal to or exceed that of  $OH^-$  ion resulting from the cathodic reduction of oxygen. (Edited author abstract) 17 refs.

Shams El Din, A.M. (Material Testing Lab, Abu Dhabi, United Arab Emirates); El Sum, E.A.; El Roubi, E.Y. *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 3, p 2449-2460.

**Corrosion Protection** See FOUNDATIONS—Piles.



## Crack Propagation

**078916 EFFECT OF PIPE BENDS ON THE STABILITY OF A CIRCUMFERENTIAL THROUGH-WALL CRACK IN A TYPE 304 STAINLESS STEEL PIPING SYSTEM.** The paper analyses simple models that simulate the effect of pipe bends on the stability of a circumferential through-wall crack in a Type 304 stainless steel piping system that is subject to fixed displacement loadings, which are appropriate for an accident condition. The instability criterion is expressed in terms of the applied and material tearing moduli, i.e.  $T_{APP}$  and  $T_{MAT}$ , or equivalently in terms of an effective pipe length  $L_{EFF}$ . By expressing  $T_{APP}$  (or  $L_{EFF}$ ) as a function of the position of the cracked section in the piping system, it is possible to specify the positions where  $T_{APP}$  is a maximum, and identify them in relation to the pipe bends. (Author abstract) 7 refs.

Smith, E. (UMIST, Manchester, Engl.). *Eng Fract Mech* v 29 n 6 1988 p 705-712.

## Cracking See WELDS—Heat Treatment.

## Creep See BOILERS—Maintenance.

## Cutting

**078917 OPTIMIEREN DER ARBEITSBEDINGUNGEN BEIM ABSTECHE VON PREZISIONS-STAHLOHREN.** [Optimization of the Working Conditions in Cutting of Precision Steel Pipes]. Cutting to length belongs to the most difficult metal cutting processes, with only limited prediction of the machining results. The cutting to length of pipes, in particular precision steel pipes where the wall thickness is sometimes very small, is especially difficult due to requirements imposed on dimensional and shape accuracy and a good surface finish. Special tools have been developed for this purpose. The criteria for the process are tool life, cutting speed, feed rate, burr formation, and surface quality, as well as exact positioning and a good chip flow. (Edited author abstract) In German.

Wertheim, Rafi. *Werkstatt Betr* v 118 n 9 Sep 1985 p 639-644.

## Elastoplasticity

**078918 TWO-PARAMETER APPROACH TO ELASTIC-PLASTIC FRACTURE AND FAILURE ASSESSMENT DIAGRAM (APPLICATION TO CARBON STEEL FOR PIPING).** In a previous study, the elastic-plastic fracture toughness,  $J_{IC}$ , and the elastic-plastic fracture resistance curve (J-R curve) were evaluated by using compact specimens for a carbon steel, STS 42, used for piping in nuclear reactors. Based on those results, the applicability of the two-parameter approach to carbon steel piping was examined in this study. The construction of the failure assessment diagram (FAD) was also attempted. The results obtained are summarized as follows; (1) In the application of the two-parameter approach, it is essential to adapt the J-integral as a fracture criterion accounting for the strain-hardening effect. (2) Based on the FAD constructed, it is shown that the whole fracture process, from the fracture initiation to the unstable fracture (or the plastic collapse) including the stable crack growth, is predicted precisely for various sizes of specimen. (Edited author abstract) In Japanese. 11 refs.

Kobayashi, Hideo; Nakamura, Haruo; Kashiwagi, Kohmei. *Nippon Kikai Gakkai Ronbunshu A Hen* v 53 n 496 Dec 1987 p 2363-2369.

## Electric Properties See TUBES—Electromagnetic Field Effects.

## Failure See NUCLEAR POWER PLANTS—Earthquake Resistance; NUCLEAR REACTORS—Piping Systems; STAINLESS STEEL—Crack Propagation.

## Fatigue See OIL WELL DRILLING—Drill Pipe.

## Heat Treatment See Also STEEL HEAT TREATMENT.

**078919 DEVELOPEMENT DE NOUVEAUX ACIERS A HAUTES CARACTERISTIQUES POUR TRANSPORT DE GAZ ET DE PETROLE ACIDES.** [Development of New High Strength Linepipe Steels for Sour Service]. The use of pipelines under a more stringent environment has led to a change in demand for steel with improved strength toughness, weldability and HIC resistance. The paper describes the effect of the most important metallurgical parameters influencing the resistance of steel to  $H_2S$ . The HIC resistance is mainly controlled by cleanliness, segregation and rolling conditions. These three parameters were studied using 8 different steels covering a wide range of chemical compositions. Controlled rolling performed in austenite plus ferrite for the improvement of strength is detrimental for HIC resistance. Segregation of Mn, C and P leads to the formation of hard structures (bainite/martensite) at mid-thickness of the plates. These hard bands are sensitive to hydrogen cracking and must be avoided. Strict control of cleanliness, a low sulphur content ( $S < 0.002$ ) and shape control of inclusion (Ca treatment are important in improving HIC behaviour. The carbon-manganese balance has to be kept below a critical level in order to reduce the content and avoid the formation of hard segregated zones. 13 Refs. In French.

Bridoux, D.; Perdrix, C.; Lafrance, M.; Provov, Y. *Cah Inf Tech Rev Metall* v 85 n 5 May 1988 p 425-436.

## Inspection See STEEL—Heat Resisting.

## Lining See Also PIPING SYSTEMS—Corrosion Protection.

**078920 CORROSION-RESISTANT LININGS: THE CASE FOR PLASTICS GROWS STRONGER.** Plastic-lined pipes and vessels have been used in the chemical processing and related industries for about 30 years. They combine the corrosion resistance properties of plastics, particularly fluoropolymers, with the strength of steel housings. Courtauld's Advanced Materials has used a high-performance thermoplastic elastomer sheet to line a mild steel storage vessel in what is believed to be the first application of its kind. Recently, a fabric-backed version of the company's high-density polyethylene sheet has been introduced to complement Celmar in areas where polypropylene is not normally recommended, such as hypochlorite storage. Electrostatic build-up can be avoided using a technique in which a semi-conductive inner layer of PTFE carries induced charges to earth - preventing pin-holing and arcing - by surface conduction to the fittings.

Anon. *Process Eng (London)* v 69 n 8 Aug 1988 p 37-38.

## Magnetic Properties

**078921 MAGNETIZATION CHANGES INDUCED BY STRESS UNDER CONSTANT APPLIED FIELD IN 2% Mn PIPELINE STEEL.** Reversible and irreversible magnetization components have been derived from cyclic stress applied to initial magnetization curves at different magnetization levels and for different stress cycle amplitudes. The irreversible and reversible magnetization components derived were found to vary symmetrically and antisymmetrically with the applied stress, respectively. The variation of the irreversible magnetization component with applied compressive and tensile stresses was found to be in qualitative agreement with the extended Brown's theory of L. Brugel and A. Rimet. 14 refs.

Atherton, David L. (Queen's Univ, Kingston, Ont, Can); Rao, T. Sudersena; Schobachler, Markus. *IEEE Trans Magn* v 24 n 3 May 1988 p 2029-2032.

**078922 EFFECT OF APPLIED STRESS ON THE REVERSIBLE AND IRREVERSIBLE DIFFERENTIAL PERMEABILITIES IN 2% Mn PIPELINE STEEL.** The contributions of reversible differential permeability (RDP) and irreversible differential permeability

(IDP) to the total measured permeability have been derived from initial magnetization curves for a 2% Mn pipeline steel. In general, the effects of uniaxial stress on the IDP were significantly greater than on the RDP, and all the observed changes tended to be smaller at high magnetizations. At lower magnetization RDP tended to increase initially with tensile stress, while IDP was almost unaffected. On the other hand, compressive stress gave generally larger decreases both in RDP and IDP. The observed variations of RDP and IDP were, however, found to be complex functions of the magnetization. 16 refs.

Atherton, David L. (Queen's Univ, Kingston, Ont, Can); Rao, T. Sudersena; Schobachler, Markus. *IEEE Trans Magn* v 24 n 3 May 1988 p 2033-2037.

## Manufacture See Also CARBON STEEL—Fracture; POWDER METALLURGY—Stainless Steel; ROLLING MILL PRACTICE—Pipe.

**078923 [NEUENTWICKLUNGEN IN DER TECHNOLOGIE UND BEI ANLAGEN FÜR DIE HERSTELLUNG KALTGEWALZTER STAHLROHRE IN DER UDSSR].** [New Developments in the Technology and Facilities for the Manufacture of Cold-Rolled Steel Pipe in the USSR]. The developments in the cold rolling technology in pipe manufacture proceeded in the USSR in recent years in two directions, namely, improvement of the existing rolling mills, as well as development of new high-performance semi-continuous ones. Further developments were towards the rise of the output of thin-walled pipes with both small diameters and higher precision and surface finish on ChPTV 15-30 type rolling mills combining the advantages of roll forming and grooved rolling as well as the use of flying mandrels during cold rolling. In cold drawing multiple mandrel drawing has been widely used. The use of special mandrels with flexible ends provides a stable mandrel position in the deformation zone and its easy removal after finishing the drawing operation. In linear drawing semi-continuous, three-strand draw-benches are employed. The use of specially designed die plates for drawing in plasto-hydrodynamic conditions results in a rise of productivity by 30% without the need for an essential equipment reconstruction. (Edited author abstract) In German. 9 refs.

Araptanov, Gennadi V.; Serebrjakov, Andrej V.; Mamaev, Aleksandr B. *Neue Huette* v 32 n 5 May 1987 p 169-173.

**078924 THICKNESS VARIATION OF HOT ROLLED SKELP FOR PRODUCTION OF ELECTRICALLY WELDED PIPES.** The thickness variation of pilot plant batches of hot rolled skelp for electrically welded pipes was investigated to establish the possibility of reducing metal consumption. Investigations were carried out with the use of an X-ray thickness gage whose transducer was moved back and forth across skelp travelling at speeds of 0.8-1.0m s<sup>-1</sup>. Thickness was recorded by a recording potentiometer. Similar investigations were made of the thickness variation of hot rolled coil steel, but in this case with the thickness gage transducer in a stationary position at entry into the forming mill. Results enabled the optimum thickness of skelp to be established for the production of water and gas linepipe. (Author abstract) 2 refs.

Totskii, I.T. (Seversk Tube Works); Zav'yalova, G.K.; Men'shchikova, O.V. *Steel USSR* v 17 n 4 Apr 1987 p 186-187.

**078925 CENTRIFUGAL SUSPENSION CASTING OF STEEL TUBES WITH A GUARANTEED LEVEL OF MECHANICAL AND OPERATING PROPERTIES.** A new pipe casting method which combines powder metallurgy with centrifugal casting is proposed. The mechanism of formation of the structure and proper-



ties of the tubes is analyzed. This is a promising process for manufacturing tubes with excellent guaranteed properties. (Translated author abstract) In Russian. 10 refs.

Sterling, E.Yu. *Izv Vyssh Uchebn Zaved Mashinost* n 10 1987 p 116-122.

**078926 FORMING OF BILLETS FOR ELECTRICALLY WELDED, LARGE DIAMETER, STRAIGHT SEAM PIPES.** Forming of billets for electrically welded, large diameter pipes on three roll and four roll plate bending mills is examined. Processes of forming cylindrical and semicylindrical billets in presses are analyzed. Problems encountered in developing a technology for continuous roll-roller forming of semicylindrical billets are discussed. The developments in various methods of billet forming have enabled the dimensional accuracy of billets to be improved and the design of forming equipment to be optimized. (Author abstract) 10 refs.

Kalinushkin, P.N. (All-Union Scientific Research & Design Inst for the Tube Industry, USSR). *Steel USSR* v 17 n 7 Jul 1987 p 318-321.

**078927 CALCULATION OF CHARACTERISTIC CURVES OF SAMPLING OPTIONS FOR STEEL PIPE BLANK EXAMINATION.** This paper presents for methods direct calculation of operating characteristic curves for steel products on the basis of the sampling options for steel pipe blank examination in the Baoshan Iron and Steel Complex. Through comparison of several options a practical conclusion is obtained. (Author abstract) In Chinese.

Yunliang, Fei (Shanghai Baoshan Iron & Steel Complex). *Kang Tieh* v 23 n 2 Feb 1988 p 47-50.

**078928 COLD DRAWN ERW PIPES WITH SUPERIOR FORMABILITY.** Cold drawn ERW pipes sometimes show the difficulty in formability during cold working, expanding, and swaging because of the difference in recrystallization behaviors between the welded zone and base metal in cold drawing. In this report, recrystallization behavior was on the results, a uniform recrystallized microstructure is established by post heat treatment of the welded zone or control of the chemical composition and rolling conditions in manufacturing of hot-rolled coils. Cold drawn ERW pipes with superior formability are thus produced. (Edited author abstract) 2 refs.

Adaniya, Takeshi; Takamura, Toshihiro; Maeda, Tatsuo; Nishimura, Fumihiko; Morimoto, Mitoshi; Yazawa, Tsuneharu. *Nippon Kokan Tech Rep Overseas* n 52 Apr 1988 p 25-33.

**078929 MANUFACTURE AND PROPERTIES OF 9 CR STEEL LARGE DIAMETER PIPE.** 9 Cr ferritic steels have been studied as an alternative material for high-pressure parts in fossil-fuel fired power plants. These parts include main steam pipe and header applications, for which 2.25 Cr-1 Mo steel is currently being used. The increased chromium content of 9 Cr steels produces higher oxidation resistance than 2.25 Cr-1 Mo steel, and the elevated temperature strengths of these steels are also high. Furthermore, these steels, compared with austenitic stainless steels, provide advantages in terms of cost reduction and reduction of the thermal stresses generated during field operation. This work confirmed that 9 Cr steels are applicable to large diameter heavy walled pipe. Effective procedures for manufacturing this pipe have also been established. (Edited author abstract). 19 Refs. In Japanese.

Kubota, Minoru; Yamamoto, Satomi; Iseda, Atsuro; Yoshikawa, Kunihiko. *Sumitomo Met* v 40 n 2 Apr 1988 p 163-178.

**078930 MANUFACTURING TECHNIQUES AND CHARACTERISTICS OF HIGH GRADE ERW LINE PIPE API 5L X80.** Kawasaki Steel has been exploring technology for API 5L X80 by 26 in.  $\phi$  ERW pipe mill at Chita Works. It is the most important to develop the high-strength, large-thickness hot rolled coil with excellent toughness and to improve the toughness of welded seam. By adoption of the new controlled-rolling method,

edge miller machine and gas-shielded welding technology, Kawasaki Steel has made the development of API 5L X80 ERW line pipe 26 in.  $\phi \times 0.574$  in. t with excellent toughness, whose  $\sigma_{TS}$  of the Charpy impact test is under  $-32^\circ\text{C}$ . This paper describes the details of the pipe manufacturing process and the properties obtained. (Author abstract). 6 Refs.

Fukai, Makoto (High-Technology Research Lab, Jpn); Karasawa, Junichi; Shiotani, Osamu; Ogawa, Yozo; Morita, Masahiko; Sugie, Yoshinori. *Kawasaki Steel Tech Rep* n 18 May 1988 p 25-31.

**Measurements** See ULTRASONIC TRANSDUCERS—Applications.

**Mechanical Properties** See Also STEELMAKING—Physical Chemistry.

**078931 FINITE ELEMENT ANALYSIS OF COLLAPSE STRENGTH OF CASING.** Collapse is a phenomenon that pipe buckles under external pressure. The authors have run many collapse tests and established an empirical formula for estimating the collapse strength of casing under combined external pressure and axial load. This paper describes the effects of ovality, stress-strain characteristics and circumferential residual stress on collapse strength. 12 refs.

Mimura, Hiroyuki (Nippon Steel Corp, Jpn); Tamano, Toshitaka; Mimaki, Toshitaro. *Nippon Steel Tech Rep* n 34 Jul 1987 p 62-69.

#### Nondestructive Examination

**078932 ELECTROMAGNETIC FLAW DETECTOR EDI-03 FOR CHECKING WATER-AND GAS-LINE PIPE IN THE HOT STATE.** One of the ways of improving the reliability of pipes is providing for their nondestructive inspection for flaws early in the production process. This makes it possible to correct the defects in time and avoid rejection of the product. As regards the production of pipes for water and gas lines by furnace welding, providing such inspection has been hindered by the high process temperatures of the pipes (up to  $1200^\circ\text{C}$  on the delivery side of the forming-welding mill). To solve this problem, the Scientific-Research Institute of Electronic Flaw Detection and the Chelyabinsk Pipe Plant collaborated to develop an electromagnetic flaw detector to check pipes with an outside diameter of 80-90 mm and temperatures up to  $1300^\circ\text{C}$  moving at speeds up to 5 m/sec. The sensitive elements of the eddy current transducer of the detector are protected from overheating by a water cooling system.

Zhukov, V.K. (Chelyabinsk Pipe Plant, USSR); Panasyuchenko, A.M.; Tolmachev, I.I.; Bronnikov, V.K.; Petrov, A.F. *Metallurgist (USSR)* v 31 n 5-6 May-Jun 1987 p 183-184.

**078933 DEVELOPMENTS IN THE DUAL-PROBE TECHNIQUE FOR IMMERSION ANGLE-BEAM ULTRASONIC TESTING OF STEEL TUBE AND PIPE.** Use of the dual-probe technique is proposed for immersion angle-beam ultrasonic pipe testing. This technique can give a steadier and more stable surface echo than the one obtained by the conventional single-probe technique. The acoustic coupling can be monitored and the start point of the gate and distance-amplitude correction can be controlled. The validity and usefulness of this proposal has been proven by both analytical calculation and experimental data. The development of a model of the proposed probe is described. The developed probe has contributed significantly to updating of rotating-probe ultrasonic testing equipment for steel tube and pipe. (Author abstract) 2 refs.

Iiyama, K. (Tokyo Keiki Co, Tokyo, Jpn); Yagi, T. *Mater Eval* v 46 n 7 Jun 1988 p 993-999.

**078934 NONDESTRUCTIVE EVALUATION OF FERRITIC PIPING FOR EROSION-CORROSION.** Erosion-corrosion of ferritic piping in both nuclear and fossil plants is an industrywide concern. This survey of 32 utilities presents guidance on selecting site-specific exami-

nation techniques, assessing capabilities of various NDE techniques, and conducting detailed examinations if erosion-corrosion is present. This report highlights the assessment of various examination techniques and provides utilities with a road map for examining pipe wall reduction due to erosion-corrosion. (Edited author abstract)

Anon. *Electr Power Res Inst Rep EPRI NP 5410 Sep 1987* 204p.

**078935 ELECTROMAGNETIC TESTING METHOD USING COMPOUND MAGNETIC FIELD.** Testing equipment using a compound magnetic field has been developed to detect three-dimensional surface defects such as seams, scabs, and pits. The equipment is installed in the Wakayama Steel Works of Sumitomo Metal Industries, Ltd. It is useful to assess the inner surface quality of seamless pipes and tubes.

Anon. *Trans Iron Steel Inst Jpn* v 27 n 10 1987 p 835.

#### Protective Coatings

**078936 CHARACTERISTICS OF NEWLY DEVELOPED POLYPROPYLENE COATED STEEL PIPE FOR HIGH TEMPERATURE SERVICE.** Polypropylene extrusion coating has been developed for external corrosion protection of steel pipes for high temperature service. The coating can be used for corrosion protection between  $-30^\circ\text{C}$  and  $120^\circ\text{C}$ . Main disadvantages are brittleness at low temperature and long term durability at high temperature. The former has been solved by block copolymerization with ethylene and the latter has been solved by the addition of specific antioxidants. The estimation technique called oven aging method is more accurate than the measurement of oxidative induction time. (Edited author abstract) In Japanese. 6 refs.

Arai, Tetsuzo; Ohkita, Masakazu; Ohtsuka, Takezumi; Okayama, Masayuki. *Sumitomo Met* v 39 n 4 Oct 1987 p 375-384.

**078937 EXTRUDED POLYOLEFIN SYSTEMS FOR PIPELINE PROTECTION.** Extruded polyolefin pipe coating systems have been used for over 32 years. They were developed to offer improved properties such as resistance to impact, abrasion, and cathodic disbondment for mill-applied coating systems. This article examines the history, development, and future potential of extruded polyolefin systems together with their advantages and disadvantages. 4 refs.

Sloan, Richard N. *J Prot Coat Linings* v 5 n 1 Jan 1988 p 45-49.

**078938 ANTICORROSION PROTECTION OF PIPES.** A description is given of recent Soviet developments in the field of protective pipe coatings, particularly those developments achieved by the protective coatings laboratory of the All-Union Research Institute for the Tube Industry (VNITI). These developments include hot galvanizing in zinc melts alloyed with magnesium, titanium, nickel, and aluminum; electrogalvanizing; powderless dispersion galvanizing; hot aluminum coating in aluminum melts alloyed with other metals; simultaneous inner and outer surface enamelling; fluoride-free enamels; crystal glass enamels exhibiting high wear resistance; and the replacement of refractory clays for the preparation of enamel drosses. The pipes concerned include those produced for the agricultural, gas, oil, shipbuilding, housing, and land reclamation industries. (Author abstract).

Gladush, V.M.; Proskurkin, E.V. *Steel USSR* v 17 n 12 Dec 1987 p 563-565.

#### Spectroscopic Analysis

**078939 SURFACE AND THERMAL DESORPTION INVESTIGATIONS OF CHEMICALLY CLEANED 316-L STAINLESS STEEL TUBINGS.** When dealing with high purity gas handling, the nature of metallic surfaces in contact with the gas is a major concern because these surfaces are a possible source of gaseous pollution. Several surface treatments may be applied to



stainless steel tubes used in gas handling systems, and these lead to different desorption properties. A comparison of the topographical effects accomplished by roughness and SEM measurements, and chemical effects by XPS determinations was made. Results were correlated to the outgassing behaviour of 316-L SS surfaces, as determined by thermal desorption mass spectroscopy. It appears that similar treatments of 316-L SS may not result in similar outgassing properties. Electropolished surfaces are smoother and present the least outgassing, although carefully cold drawn and chempolished stainless steel surfaces also show a comparable outgassing behaviour. (Author abstract) 5 refs.

Simondet, F. (Cent de Recherche Claude Delorme, Jouy en Josas, Fr); di Giulio, C.; Noel, A.; Olivier, E.; de Rugy, H. *Surf Interface Anal* v 11 n 6 Apr 1988, Proc of the 9th Symp on Appl Surf Anal, Dayton, OH, USA, Jun 3-5 1987 p 366-370.

**Stresses** See FLOW OF FLUIDS—Two Phase.

## Testing

**078940 MULTI-STEP APPROACH FOR EVALUATION OF PIPE IMPACT EFFECTS.** A methodology has been developed and applied to the requalification of the high-energy piping at the Santa Maria de Garona Nuclear Power Plant in Spain. It provides techniques for evaluation of pipe-whip and jet effects. The methodology developed breaks down the evaluation effort into various levels of decreasing conservatism and increasing complexity and cost. Higher evaluation levels are applied only to interactions where lower levels fail and where there is a reasonable expectation that more realistic analysis might demonstrate acceptability. The lower levels of evaluation are described in this paper for the pipe-on-pipe impact interactions, targets other than pipes are relatively straightforward. (Edited author abstract) 6 refs.

Vazquez-Sierra, J.M. (Nucleon, Santander, Spain); Marti, J.; Molina, R. *Int J Pressure Vessels Piping* v 31 n 1 1988 p 15-28.

## Wear

**078941 BREAKTHROUGH IN ABRASION RESISTANT PIPING.** NASPipe, the abrasion-resistant carbon steel pipe from Canada, is unlike many of the conventional abrasion-resistant products presently in use in that it is not cast and it does not rely on synthetic or ceramic liners. In the manufacturing process, the pipe chemistry is changed, resulting in a pipe with an internal bore of at least 600 Brinell hardness, but with physical toughness and ductility similar to normal steel. Hardening is achieved by induction heating and quenching and it is during this phase that the pipe can be bent to almost any centerline radius or bend angle required.

Anon (Pipeline Supplies of Australia, Glen Waverley, Aust). *Aust Min* v 80 n 7 Jul 1988 p 60.

**Welding** See Also NUCLEAR FUELS—Pipelines; PIPELINES—Fabrication; WELDING, ELECTRIC ARC—Inert Gas; WELDING, ELECTRIC RESISTANCE—Control; WELDS—Defects.

**078942 KORROSIONSVERHALTEN BEI RUHRSCHEISSVERBINDUNGEN AN ROHREN AUS NICHTTOSTENDEM DUPLEXSTAHL.** [Corrosion Behavior of Circumferential Welded Joints in Duplex Stainless Steel Pipes]. The article reports on an improvement of the pitting corrosion resistance in the HAZ of circumferential welded joints of pipes made from stainless duplex steel using a welding technique characterized by high thermal input (in excess of 10 kJ/cm). The improved pitting corrosion resistance is explained by a slow cooling which leaves chromium sufficient time to heal up chromium-deficient areas in the neighborhood of chromium nitride precipitations in the ferrite phase. (Translated author abstract) In German.

Yasuda, Koichi (Kawasaki Steel Corp, Jpn); Tamaki, Katsuomi; Nakano, Shozaburo; Kobayashi, Kunihiko; Nishiyama, Noboru. *ZIS Mitt* v 29 n 3 Mar 1987 p

229-237.

**078943 PROCESS CONTROL SYSTEM OF SUMITOMO'S HOT WELDED PIPE MAKING MILL. (SW METHOD).** The most characteristic points of new pipemaking system are to carry out welding under high temperature conditions by using a high frequency induction welder and removing the weld bead just after welding. After that, the pipe is reheated continuously in the furnace to get a uniform temperature for the stretch reduction process. The article describes the electric and computer control system. (Edited author abstract) In Japanese. 8 refs.

Nagashima, Matajiro; Yamashita, Akiya; Arai, Osamu; Hamada, Masami; Matada, Tatsuaki. *Sumitomo Met* v 39 n 4 Oct 1987 p 385-396.

**078944 HIGH TEMPERATURE WELDING FOR PIPE MAKING (SW METHOD).** A new pipe making process, the SW method, has been developed by Sumitomo Metals as an innovation of the continuous butt welding pipe mill at the Kashima Steel Works. The principal characteristics of the system are to weld at high temperatures by using a high frequency induction welder and to remove the weld bead by a cut-off device just after welding. Subsequently the pipe is reheated continuously in a furnace to homogenize the temperature along the circumference for the stretch reducing process.

Anon. *Trans Iron Steel Inst Jpn* v 28 n 5 1988 P415.

**078945 STUDY ON INTEGRITY IMPROVEMENT OF STAINLESS STEEL PIPE WELDS IN NUCLEAR POWER PLANT BY LOCAL INDUCTION HEATING METHOD.** In order to eliminate tensile residual stresses near the weld heat affected zone on the inner surface of Type 304 stainless steel pipe welds in nuclear plants, the induction heating stress improvement (IHSI) method, in which the outside wall of a pipe is heated by an induction current while the inside surface of the pipe is cooled with water, has been investigated analytically and experimentally. This method has been found to be effective in reducing the fatigue crack propagation rate of cracks in pipes under the repeated loading associated with plant operation and in preventing the intergranular stress corrosion cracking. Test results showed that compressive residual stresses relax under certain circumstances, but that the compressive residual stresses on the inner surface of a pipe do not relax during operation enough to cause them to change into tensile stresses large enough to cause intergranular stress corrosion cracking. (Edited author abstract) In Japanese. 10 refs.

Shimizu, Tasuku (Hitachi Ltd, Jpn); Enomoto, Kunio. *Yosetsu Gakkai Ronbunshu* v 5 n 3 Aug 1987, Natl Meet (Jpn Weld Soc), Autumn 1987 p 335-341.

**PIPELINES** See Also COPPER ORE TREATMENT—Beneficiation; FLOW OF FLUIDS—Two Phase; GAS TURBINES—Energy Resources; HEATING—District; METALS AND ALLOYS—Fracture.

**078946 FEASIBILITY AND EFFICIENCY OF DENSE PHASE PNEUMATIC TRANSPORTATION.** This paper demonstrates a technique for determining a material's suitability to be conveyed in the dense phase mode by using pneumatic conveying characteristics and theoretical slugging criteria. A more practical definition of dense phase is proposed in the light of experimental results. Various types of conveying mode and blow tank configuration are also investigated for the purpose of obtaining more efficient transportation, in relation to air usage, flow stability and general plant erosion. (Author abstract) 8 refs.

Wypych, P.W. (Univ of Wollongong, Aust); Arnold, P.C. *Mech Eng Trans Inst Eng Aust* v ME 11 n 1 Mar 1986 p 1-5.

**078947 EIGENHEITEN RECHTECKFOERMIGER KAMMERN IN ROHRLEITUNGEN.** [Properties of Rectangular Chambers in Pipelines]. Heat exchangers and other pipe systems often use rectangular containers as collecting or connecting stations. In dimensioning these,

higher loads must be taken into account than for round or oval vessels. Consequently such rectangular pressure vessels must be given stiffer dimensions, either by using behavior wall thicknesses, stronger steel sheet material, or special stiffening elements. (Edited author abstract) In German.

Salko, Djozic. *Werkstatt Betr* v 121 n 1 Jan 1988 p 73-74.

**078948 MAGNETIC FIELD ANALYSIS IN BURIED PIPE DETECTION.** Magnetic detection of a buried pipe gives correct results only in the case of a single pipeline. The case of two parallel pipelines is considered in order to gain a theoretical understanding of the cause of the error, and the analytical results show good agreement with the measured results. It is found that the error is due to an earth current leaking from one line to the other. 1 ref.

Wasa, Y. (NEC Corp, Jpn); Kondo, Y.; Yamauchi, F.; Miyamoto, Y. *IEEE Transl J Magn Jpn* v TJMJ-2 n 12 Dec 1987, Contrib from the Ninth Annu Conf on Magn in Jpn, Jpn, Nov 26-29 1985 p 1120-1121.

**078949 PIPELINE ENGINEERING SYMPOSIUM - 1988 (PRESENTED AT THE ELEVENTH ANNUAL ENERGY-SOURCES TECHNOLOGY CONFERENCE AND EXHIBITION).** This symposium proceedings contains 13 papers focusing on an area of growing public awareness with the pipeline industry; that is, safety and reliability. Several papers deal with how to prevent system deterioration and failure. Also examined are upcoming developments which are foreseen for pipeline SCADA over the next several years. One paper presents a composite mechanistic flow pattern predictor and applies it to multiphase pipelines. Two papers discuss instrumentation, and design aspects of equipment for the detection of leaks in pipelines. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11108 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Seiders, E.J. (Ed.) (Willbros Butler Engineers Inc, Tulsa, OK, USA). *ASME Pet Div Publ PD* v 14, Pipeline Eng Symp - 1988, New Orleans, LA, USA, Jan 10-13 1988. Publ by ASME, New York, NY, USA, 1988 92p.

**078950 PREPRINTS - PIPELINES, SYMPOSIUM ORGANISED IN COLLABORATION WITH THE EXHIBITION PIPE, PIPELINE, PIPELINE SYSTEMS.** This conference proceedings contains 20 papers arranged in three volumes. Topics presented include computer control; Quality Assurance of pipeline materials; repair methods; inspection; coatings; designing for multi-phase flow; slug flow in flowline riser systems; slug catchers; pipeline drying; pressure wave leak detection; and predicting of pressure surges and dynamic forces in pipeline systems. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11065 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Inst of Chemical Engineers, European Branch, Rugby, Engl). *Prepr - Pipelines, Symp Organ in Collab with the Exhib Pipe, Pipeline, Pipeline Syst, Utrecht, Neth, Nov 6-8 1985* Publ by Inst of Chemical Engineers, Rugby, Engl, 1985 3 v, 335p.

## Acoustic Wave Effects

**078951 SCHALLENTSTEHUNG UND -AUSBREITUNG IN ROHRLEITUNGEN.** [Sound Generation and Propagation in Pipelines]. Results are given of flow-acoustic examinations at pipelines with built-in fittings. These results show that mechanism of sound generation mainly depends on geometry of fittings. Sound propagation and emission are determined by the pipeline at the efflux side. (Edited author abstract) In German. 8 refs.

Dittmar, R. (Technische Univ Dresden, East Ger). *Maschinenbautechnik* v 36 n 5 1987 p 210-215.



**078952 ON THE GENERATION OF ACOUSTIC RESONANCE IN PIPELINES - PART 1.** An experimental and theoretical study has been conducted to investigate acoustic resonance in a pipeline caused by a pipeline singularity. A pure tone noise source in the form of a double orifice was used and the nature of the fluid excitation mechanism was studied using flow visualization. It was found that free shear layer oscillations across the cavity formed by the double orifice excite those pipeline plane-wave modes which have an acoustic velocity antinode at or near the cavity. Experimental results are presented for resonant frequencies as a function of flow velocity, and Strouhal number as a function of the cavity dimensions. The theoretical predictions for acoustic resonant frequencies are compared with the experimental data. This paper described the experimental facility for the research. (Edited author abstract)

Harris, R.E. (McMaster Univ, Hamilton, Ont, Can); Weaver, D.S.; Dokainish, M.A. *Pipes Pipelines Int* v 33 n 1 Jan-Feb 1988 p 30-32.

**078953 ON THE GENERATION OF ACOUSTIC RESONANCE IN PIPELINES - PART 2.** The first part of this paper, published in our January-February issue, considered the experimental facilities used in the authors' research. Part 2 goes on to describe the experimental techniques employed, and provides a discussion of the authors' results and conclusions. The main characteristics of a resonator exciting the plane-wave modes of a pipeline have been illustrated. The acoustic source has been shown to exhibit the main features of local cavity oscillators. The results of the flow visualization study indicate the presence of a rolled-up shear layer, and not the convection of separated vortices. 21 refs.

Harris, R.E. (McMaster Univ, Hamilton, Ont, Can); Weaver, D.S.; Dokainish, M.A. *Pipes Pipelines Int* v 33 n 2 Mar-Apr 1988 p 22-25.

## Analysis

**078954 PIPELINE SIMULATION INTEREST GROUP EIGHTEENTH ANNUAL MEETING.** This conference proceedings contains 9 papers discussing pipeline simulation techniques. One paper uses Dynamic Programming for the optimal design of Gas Pipelines. Leak detection procedures are described, and an optimization algorithm is used for looped water networks. A discussion is given of transient flow analysis for natural gas networks. The performance of real-time pipeline leak monitors is also evaluated. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10910 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Pipeline Simulation Interest Group). *Pipeline Simul Interest Group Eighteenth Annu Meet, New Orleans, LA, USA, Oct 30-31 1986* Publ by Pipeline Simulation Interest Group var pagings.

**Applications** See RIVERS—Dredging.

## Automatic Testing

**078955 METHOD OF PIPELINE DIAGNOSIS BY A MOBILE ROBOT.** A newly designed articulated mobile robot of variable-attitude type, the Mark II, which consists of three modules with a joint between modules, has the capabilities of straight and spiral movement along the outside of pipelines, and of free passage of obstacles, such as flanges, T-joints and other plant equipment. The robot uses its front-installed infrared proximity sensors to sense and recognize T-joints. A method of controlling maneuverability in the passage of T-joints is achieved by calculating the positions and attitudes of each module of the robot. To inspect any arbitrary position in a pipeline, a method of compensating independently for the torque generated by gravitational forces for each module is proposed. Based on the inspection results of a modeled pipeline having a T-joint and flange, it has been clarified that the Mark II installed with non-contact gap sensors as diagnostic sensors can detect not only the position of

flaws, but also their depth. 6 refs.

Hosokai, Hidemi (Science Univ of Tokyo, Jpn); Fukuda, Toshio. *Electr Eng Jpn* v 107 n 6 Nov-Dec 1987 p 68-75.

**Bends** See Also FLOW OF FLUIDS—Laminar; FLOW OF FLUIDS—Two Phase; STRESSES—Analysis.

**078956 ANALYSIS OF PIPE BENDS WITH SYMMETRICAL NONCIRCULAR CROSS SECTIONS.** A thin shell analysis is presented for pipe bends with symmetric noncircular cross sections under in-plane bending or internal pressure, using the static-geometric analogy and neglecting end effects. Any symmetric shape is possible but the analysis mainly concerns cross sections with double symmetry; an investigation of the two-lobe (oval) and four-lobe cross sections demonstrates that pipe bend flexibility is almost inversely proportional to flank radius if the pipe wall is thin. Pressurizing a pipe bend of oval cross section produces a similar hoop stress distribution to that of a bending moment straightening the pipe. (Author abstract) 6 refs.

Whatham, J.F. (Australian Atomic Energy Commission, Sutherland, Aust). *J Appl Mech Trans ASME* v 54 n 3 Sep 1987 p 604-610.

**078957 STIFFNESS OF A CURVED SECTION OF PIPE IN BENDING.** The problem of determination of the stiffness and state of stress of a curvilinear pipe section joined to straight pipe sections and subjected to the effect of bending and internal pressure is considered. Apart from the main state of stress, account is taken of the boundary effect state in accordance with the moment engineering theory of shells. The method developed for the determination of the stiffness in bending of curvilinear pipe sections may be recommended for use in calculating and designing piping systems. 5 refs.

Chernii, V.P. (All-Union Scientific-Research Inst for the Construction of Main Pipelines, Moscow, USSR). *Sov Appl Mech* v 23 n 2 Feb 1987 p 144-151.

**078958 CAST-STONE SECTORS FOR LINING BENDS IN PIPEWORK.** An effective method of prolonging the useful life of the process pipework between maintenance shutdowns is to protect it with cast-stone which has a high abrasive-resistance and is stable against chemical attack by acid media. Large-scale ring sectors of diameter 680 to 1165 mm were cast in a horizontal centrifugal machine. Before the melt is cast into the mold, steel ring partitions are mounted at a specified angle to the axis and these are secured by ring inserts made of reinforcing mesh. The end covers are closed and the substrate is rotated at 280-300 min<sup>-1</sup> and, by means of the spout, the silicate melt is cast at 1320-1360°C. The use of this method makes it possible to produce cast-stone sectors with a tongue-and-groove end which provides a dense and reliable protection for the butt seams when the lining is installed. To avoid crazing in the cast, it is necessary to ensure that the central rod is pliable after casting and this is done by forming a shell with a wall thickness of 8-10 mm.

Chechulin, V.A. (S.M. Kirov Urals Polytechnic Inst, USSR); Novikov, A.I.; Karpov, V.M.; Sotnik, A.A.; Sedyshev, B.L. *Glass Ceram* v 43 n 7-8 Jul-Aug 1986 p 283-284.

**078959 ELIMINATION OF BENDS DATA IN COMPUTER-AIDED DESIGN OF PIPELINES.** In computer-aided design of pipelines, end points as well as the mid-point of each bend are always specified as a part of the input data to introduce the geometry of the network. In addition to these, five specific bend data, i.e. its radius, angle and coordinates of its center must also be furnished as requirements of further computations. This paper describes how the specific bend data could be eliminated, thus considerably reducing the input data. (Edited author abstract) 3 refs.

Abhary, Kazem (Univ of Tehran, Tehran, Iran). *Int J Pressure Vessels Piping* v 30 n 3 1987 p 233-236.

**Cathodic Protection** See Also ANODES—Materials.

**078960 CATHODIC PROTECTION MONITORING ON BURIED PIPELINE SYSTEMS BY CLOSE INTERVAL POTENTIAL SURVEYS.** Continued development of site data collection equipment and the introduction of computer assisted data processing systems has allowed the cathodic protection engineer to obtain more comprehensive site measurements which can be used to improve the overall performance and effectiveness of the installed systems. A procedure which ideally lends itself to this technology for buried pipelines is a close interval pipe to soil potential survey. The success of this method for the determination of unpolarized coating fault and cathodic protection deficiencies has been effective to the point where dedicated systems for this work are readily available.

Anon. *Anti Corros Methods Mater* v 34 n 8 Aug 1987 p 17-18.

**078961 PROTECTION OF PIPELINES FROM CORROSION BY CATHODIC PROTECTION.** Pipelines are one of the most convenient means of transporting low-viscosity material, such as gases and liquids, from supplier to consumer. Buried pipelines can deliver the product over great distances with minimal, if any, inconvenience to the public. However, long, buried pipelines represent a high capital investment which must be protected if the pipeline is to operate cost-effectively with minimal maintenance over long periods. Public safety must also be considered, and pipelines must be free from the risk of degradation which could cause environmental hazards and a potential threat to life. They must be protected from corrosion. Soil stresses and damage during backfill can cause superficial damage which exposes the base metal, leaving it vulnerable to corrosion. The paper discusses the method of cathodic protection as a means to prevent corrosion damages on pipelines.

Shepherd, W. (Wilson Walton Int (UK) Ltd). *Pipes Pipelines Int* v 32 n 4 Jul-Aug 1987 p 18-21.

**078962 MONITORING PIPELINE CATHODIC PROTECTION.** Electrically speaking, a pipeline represents a complex conductor installed in a complex environment - the earth. To ensure adequate corrosion protection, every measure is taken in the design stage to minimize corrosion effects. The overall umbrella is provided by the cathodic protection system, which essentially stops corrosion from occurring at defects and anomalies in the pipeline coating system. As pipelines are put into service, various anomalies begin to show up and it is a rare circumstance when a pipeline is totally free of all defects.

Rog, Joseph W. (CORRPRO Co, Medina, OH, USA). *Pipeline Gas J* v 215 n 2 Feb 1988 p 14-17.

**078963 EVALUATING DESIGN AND COST OF PIPE LINE COATINGS - PART 1.** TransCanada PipeLines uses several methods to assess the performance of its coatings system on more than 10,000 km of large diameter gas lines. In this first installment, the author describes the correlation between field performance and laboratory testing of the various coatings. He also provides guidelines for selecting an effective repair or recoating system.

Banach, J.L. (TransCanada Pipelines, Toronto, Ont, Can). *Pipe Line Ind* v 68 n 3 Mar 1988 p 62-67.

**078964 PROBLEME DER IR-FREIEN POTENTIALMESSUNG IN GEGENWART VON AUSGLEICHSTROMEN.** [Problems Related to the Measurement of IR-Drop Free Potentials in the Presence of Compensating Currents]. For supervision of the cathodic protection of pipelines the potentials must be measured free from ohmic drops. In general, off-potentials are measured in this context. By this technique only the ohmic drops caused by the protection current can be eliminated, but not the ohmic drops caused by compensating or cell currents. With the help of simulated tests it can be shown



that it is possible to calculate true potentials using pipe-to-soil potentials and potential gradients at the soil surface for 'on' and 'off' conditions. Errors associated with reference electrodes have a strong influence on the calculated values. Practical examples show that completely unreasonable values can be obtained. Possibilities leading to errors of reference electrodes are discussed. Electrodes with KCl or  $N_4NO_3$  electrolytes are to be preferred. Further possibilities of errors related to soil parameters require additional detailed investigations. (Author abstract) 6 refs. In German.

Fischer, W. (Fachhochschule Hagen, Iserlohn, West Ger); Hildebrand, H.; Prinz, W.; Schwenk, W. *Werkst Korros* v 39 n 1 Jan 1988 p 18-22.

## Cleaning

**078965 KINETICS OF PIPELINE CLEANING BY FOAMS.** The authors studied the factors influencing the efficiency of pipeline cleaning by foam. Experimental data show convincingly that 1% AS solutions used in the form of foams of 200-500 ratio are the most effective agents for removing gas condensate. The cleaning efficiency is improved by addition of HAA in amounts of 10% on the mass of surfactant. Foams based on SEO solutions (1% surfactant) do not differ significantly in efficiency from AS-based foams. Of the three types of surfactants studied the least effective is the nonionic Prevoell, since it has the lowest surface activity (this is the cause of the low foaming power of its solutions and poor stability of its foam in contact with the gas condensate). For effective cleaning the average foam velocity in the pipe must be at least 9-10 m/sec. The open cross section of the pipe must be completely filled with moving foam. 4 refs.

Tikhomirov, V.K.; Goncharov, V.N. *J Appl Chem USSR* v 60 n 1 pt 2 Jan 1987 p 197-200.

**078966 PIPELINE CLEANING SYSTEM FOR MECHANICAL DEPOSIT REMOVAL.** Pipelines in which deposits occur frequently must be cleaned in course of time to avoid loss of flow capacity. The Idromec system for mechanical deposit removal has proved itself to be particularly suitable. Main features are: effective cleaning of all viscous and hard deposits; restoring original flow capacity for pipes with diameter of 100mm to 200mm; cleaning speed 0.5m/s to 1.5m/s; no damage to inside walls or protective lining; no corrosion or abrasion cleaning vertically rising pipelines clearing elbows of 90° with radius  $\times$  1.5 pipe diameter. Generally, Idromec is applied in all those cases where pipeline cleaning is not possible by either chemical methods, high pressure water jets, motorised flexible rods or by using pigs. The cleaning is effected by a hydromechanical method, using specially designed tools. 4 refs.

Anon. *Eur Water Sewage* v 91 n 1097 Jul 1987 p 283-284.

**078967 INTERACTION OF A MOVING FOAM WITH GAS CONDENSATE IN PIPELINE CLEANING.** The purpose of this paper is to discuss a possible mechanism for foam interacting with contaminants during pipeline cleaning. The authors consider the flow of a foam as that of a single-phase system while the properties  $\rho$  and  $\nu$  of the foam are constant, as the measurements for different foams are averaged. It is found that the higher the foam speed in the cell (the less the diameter), the greater the drop in cleaning rate. At low foam speeds ( $d = 55$  mm), the rate of removal for a gas condensate is practically constant throughout, because the main part is played in the initial stage by the dynamic action of the foam on the layer of gas condensate at rest, which causes mechanical expulsion of some of the material from the cell. For cells of diameter 28 and 36 mm, this effect accounts for up to 50 or 25% of the material. 6 refs.

Tikhomirov, V.K.; Goncharov, V.N. *J Appl Chem USSR* v 60 n 4 pt 1 Apr 1987 p 777-782.

**Communication Systems** See NATURAL GAS PIPELINES—Computer Applications; NATURAL GAS PIPELINES—Leak Detection; TELECOMMUNICATION SYSTEMS.

**Components** See RINGS—Pressure Effects.

**Compressor Stations** See NATURAL GAS PIPELINES; NATURAL GAS PIPELINES—Automation; NATURAL GAS PIPELINES—Construction; PUMPS—Control.

## Computer Aided Analysis

**078968 DISTRIBUTED PARAMETER IDENTIFICATION OF A PIPELINE USING A SENSITIVITY MODEL.** The purpose of identifying diameter and/or friction distribution of a pipeline is threefold: (1) to diagnose pipeline faults; (2) to calibrate a mathematical pipeline model and (3) to monitor the state of the pipeline during operation. In this paper, a technique is proposed to estimate an arbitrary diameter distribution  $D(x)$  of a pipeline. Output least-square criterion is used which results in a gradient-based estimation algorithm. The gradients are evaluated from a parameter-sensitivity model alongside of the real-time pipeline model. (Edited author abstract) 12 refs.

Fang, Chong-Zhi (Tsinghua Univ, Beijing, China); Tao, Luo-Wen. *J Pipelines* v 7 n 1 Nov 1987 p 53-63.

## Computer Aided Design

**078969 SEADRIFT CUTS DRAFTING TIME WITH DESKTOP COMPUTERS.** Seadrift's engineering department maintains more than 25,000 drawings of Seadrift's pipe line control systems, which include electrical, microwave, structural and telecommunications systems. Virtually all new drawings for the company, as well as existing drawings requiring major revisions, are created and stored on the desktop computers. Seadrift's three designers use AutoCAD software running on the MS-DOS operating system on the IBM computer. AutoCAD acts as an electronic drafting board and users input drawings, then move, copy, erase, rotate, stretch, trim or extend the drawings onscreen. Seadrift designers also employ a special software interface written for the AutoCAD system by personnel at the MicroAge Computer Store in San Antonio. The interface allows the designers to create and store symbols for electrical and control systems design.

Wood, Henry (Seadrift Pipeline Corp, Port Lavaca, TX, USA); Muller, Gert. *Pipe Line Ind* v 67 n 4 Oct 1987 p 49.

**Computer Applications** See NATURAL GAS PIPELINES—Control; PETROLEUM PIPELINES—Cathodic Protection; PETROLEUM PRODUCTS—Pipelines.

## Computer Simulation

**078970 CALCULATION OF PRESSURE PULSATION IN PIPING SYSTEM ATTACHED TO RECIPROCATING COMPRESSOR.** The theory of analysis of pressure pulsation in reciprocating compressor piping and the numerical program 'PULSAS' developed by Kobe Steel are described. The program, which employs the finite element method, has a long history of successful application to piping design. Results of calculations agree well with theoretical experimental, and field data. (Author abstract) 9 refs.

Fujikawa, Takeshi (Kobe Steel, Jpn); Kurohashi, Michiya; Kato, Minoru; Aoshima, Masakatsu; Yamamura, Hidemasa. *Kobelco Technol Rev* n 2 Aug 1987 p 53-57.

**078971 NUMERICAL STUDY OF THE EFFECT OF SUPPLY AND DELIVERY PIPELINE RESISTANCE ON THE OPERATION OF A SAFETY VALVE.** The authors have developed a package of programs in PL/I language for the calculation of on steady-state processes taking place as a result of high pressure in a supply pipeline (tank) and of safety valve wear in a system consisting of a tank (or compressible fluids) supplying a pipeline, a safety valve (SV), and a delivery pipeline. The authors illustrate the use of this package by the example of a calculation of the wear process in a direct-action full-rise SV in a pneumatic system consisting of a tank and a supply pipeline. The program package can be used to study the effect of supply

and delivery pipeline parameters on the nature of the SV's operation; to develop engineering methods for the calculation of pipeline parameters other than a valve's slide vibrations (however, such calculation methods can apparently be developed only for concrete valves, since the stability of a valve's operation depends to a great extent on the shape of the force characteristics); and to model emergency situations that lead to abrasion of the SV. It can also be used to study the operation of any type of accessory, such as regulators, check valves, etc. 6 refs.

Taras'ev, Yu.L.; Eremeev, Yu.V.; Krivosheev, A.G. *Chem Pet Eng* v 23 n 7-8 Jul-Aug 1987 p 341-342.

**Construction** See Also GAS PIPELINES—Norway; NATURAL GAS PIPELINES—Europe; SEWERS—Outfall; SOILS—Frozen; TUNNELS AND TUNNELING—Construction.

**078972 MAKING AN IMPACT IN SWITZERLAND.** This report details the successful pushing of a steel pipe ND600 over 84 m under the river Rhone at Collonges, Canton Wallis in Switzerland. This was achieved with a Grundoram Goliath - pipe-jacking machine from Tracto-Technik. The pipe is intended for use as a cable ducting sleeve. The contract for installation was awarded to Stalder & Co from Langnau/Switzerland, a contractor which specializes exclusively in pipe-jacking.

Anon (Tracto-Technik, West Ger). *Tunnels Tunneling* v 19 n 9 Sep 1987 p 64.

**078973 PROJEKTIERUNG UND BAUDURCHFUEHRUNG ZWEIER GROSSDUEKER DURCH DIE UNTERWARNOW IN ROSTOCK.** [Design and Construction of Two Large Culverts Under the Unterwarnow River in Rostock]. Housing construction in Rostock is presently concentrated east of the Warnow River in the Dierkow district of the city. The Warnow presents a natural obstacle to utilities. Problems of preparation, design and construction of a 710 m long three-pipeline district heating culvert and a 780 m long four-pipeline sewage culvert under the Warnow are described. The pipe fitting and hydraulic construction works are detailed. Extreme weather conditions present additional difficulties. In German. 6 refs.

Dietrich, Peter (VEB, Berlin, East Ger); Klemann, Erwin; Gehrke, Klaus. *Bauplanung Bautech* v 41 n 2 Feb 1987 p 67-71.

**078974 COMPUTERISED PIPELINE SYSTEM FOR OPERATIONAL SURVEY COLLATION AND ARCHIVE RETRIEVAL (OSCAR).** The rapid retrieval of paper documentation from the construction phases of a pipeline project presents a major task which becomes increasingly more difficult with time. The production of more paperwork from each inspection survey carried out means that archive management and storage requirements increase annually. Furthermore, experience from many projects has shown that important data is often lost or very difficult to find when needed quickly to support the decision-making process. OSCAR (Operational Survey Collation and Archive Retrieval) is designed to provide a low-cost computerised solution to data management for project and operations groups throughout the life of a pipeline.

Marshall, Greg (Marshall Marlow Associates). *Pipes Pipelines Int* v 32 n 6 Nov-Dec 1987 p 23-24.

**078975 TRENCHLESS REVOLUTION.** The principal technical advances in recent years for the construction of new underground services have been the trenchless methods: improvements in unsteerable percussive moles; the development of steerable small-bore models; the development of steerable auger-type microtunneling machines for installing pipes down to 250 mm diameter; the development of steerable bentonite slurry-type microtunneling machines for installing pipes down to 250 mm diameter. Over much the same period there have been equally striking advances in techniques for renovating and replacing (on-line) existing buried services, including: slip



lining; spray-on linings; rolldown; hose inversion; percussive on-line replacement; hydraulic on-line bursting and replacement. 5 refs.

Flaxman, E.W. (Binnie & Partners); Watson, T.J. *J Int Water Environ Manage* v 2 n 2 Apr 1988 p 135-140.

**078976 PIPELINE PIGGING - AN INDUSTRY OVERVIEW.** Rapid technological change, combined with strong social and economic pressures, have resulted in a rate of change within the pipeline pigging industry which was unimaginable just a few years ago. This paper highlights many of these changes, covering both their causes and effects, and attempts to draw some conclusions as to what may lie ahead. Mention is made of subsea pigging systems, briefly commenting on the overall layouts, pig traps, signalers, etc., with mention of the companies currently involved. This is followed by a look at the situation with respect to intelligent and conventional pigs. The paper also considers the present trends in the exploration and production of hydrocarbons, particularly in deeper waters and marginal conditions, and attempts to predict how this is likely to affect development within the pipeline pigging industry in the foreseeable future. 2 Refs.

Cordell, J.L. *Pipes Pipelines Int* v 33 n 3 May-Jun 1988 p 14-19.

**Control** See Also GAS PIPELINES—Computer Applications; NATURAL GAS PIPELINES—Communication Systems.

**078977 ROBUST OBSERVER DESIGN FOR A FLUID PIPELINE.** Observer design for nonlinear systems is difficult, especially for systems of high order. We present a state-space representation of a fluid pipeline. Then we turn the nonlinear observer design task into optimization problems in order to bridge the gap between nonlinear observer theory and its applications. In applying this method to the discrete high-order model of a pipeline, analytic solutions can be obtained. A structural condition for observers to be robust to pipeline friction and diameter variation is proved through steady-state analysis. Simulation studies and experiments on a water pipeline show that: (a) the observers designed converge rapidly and reliably; (b) the computational expenditure is small in comparison with the Kalman filter; and (c) friction and diameter variations may have little influence on the estimation accuracy. (Edited author abstract) 16 refs.

Tao, Luo-Wen (Tsinghua Univ, Beijing, China); Fang, Chong-Zhi. *Int J Control* v 47 n 2 1988 p 601-613.

**Control Systems** See Also PETROLEUM PIPELINES—Computer Applications.

**Corrosion** See Also ELECTRIC CABLES—Underground; METALS AND ALLOYS—Corrosion; PETROLEUM PIPELINES—Tibet.

**078978 EFFECT OF POWERLINE FAULTS ON PIPELINES IN A COMMON CORRIDOR.** The report summarizes the study of power line fault effects on pipelines in a common corridor. Phase 1 has concentrated on establishing a laboratory set-up that will permit the simulation of field conditions for pipeline damageability studies. A facility has been set up at Ontario Hydro Research that will permit the effect of varying fault conditions and pipeline parameters to be studied. Initial experiments have been performed primarily at 10 and 20 kA for 6 and 12 cycle durations. The damage on the pipeline has been quantified in terms of its fault condition, damage diameter and depth. The experimental results have been compared to actual field failures and other related research work. (Edited author abstract) 8 refs.

Cherney, E.A. (ONTARIO HYDRO, Toronto, Ont, Can); Glover, A.G. *Res Rep Can Electr Assoc* 239 T 532 Dec 1987 23p.

**078979 NACHWEIS VON ANKRUSTUNGEN UND VERSTOPFUNGEN IN ROHRLEITUNGEN.** [Detection of Encrustations and Obstructions in Pipelines].

Some of the physical methods used in the non-destructive testing of materials are highly suitable for detecting and localizing encrustations or blockages that obstruct the flow of liquids in pipelines. They are the absorption of ionizing radiation, the reflection of ultrasonic waves at interfaces between materials with different densities and velocities of sound propagation, the interpretation of the formation of eddy currents in conductive materials, the detection of magnetic direct-current fields, and a flow effect produced by vacuum pumps. (Edited author abstract) In German. 8 refs.

Steiger, K. *Tech Mess TM* v 55 n 3 1988 p 101-104.

**078980 ECOLOGICAL AND BIOCHEMICAL ASPECTS OF CORROSION OF UNDERGROUND CONSTRUCTIONS.** Many-years study of distribution of sulphate-reducing and thionic bacteria in trench soils of gas pipe-lines permitted to discover regularity of distribution of these groups of bacteria as regard to massive of tube of pipe-line. The interaction between intensity of accumulation of elementary sulphur and sulphuric acid by thionic bacteria, the release of hydrogen sulfide and increase hydrogenase activity by sulphate-reducing bacteria depending on distance from metal have been established. Special zone or sphere, facilitating the development of microorganism cenosis, called 'ferrosphere', was formed around the tube. 9 refs.

Andreyuk, E.I. (Acad of Sciences of the Ukrainian SSR, USSR); Kozlova, I.A.; Antonovskaya, N.S.; Pilyashenko-Novohatny, A.I. *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 1, p 705-712.

**Corrosion Protection** See PETROLEUM PIPELINES—Construction.

**Corrosion Resistance**

**078981 GRP IN PRESSURE PIPELINES.** Before the introduction of glass reinforced plastic, the main competition for iron was asbestos cement. A major advantage of GRP over ductile iron is its resistance to corrosion and where this is of paramount importance GRP is often considered for pressure water mains. This paper seeks to re-examine the specific applications and advantages of one pipeline material over another.

Barrie, C. (Stanton plc). *Civ Eng (London)* Sep 1987 p 50-52, 55-56.

**Costs** See GAS PIPELINES—Design; NATURAL GAS PIPELINES—Marketing.

**Design** See Also CONVEYORS—Pneumatic; PETROLEUM PIPELINES—Earthquake Resistance; SEWERS—Storm Drainage; WATER PIPELINES—Plastics Applications.

**078982 COMPARISON OF GERMAN TO MARSTON DESIGN METHODS.** In the United States and several other countries around the world, the Marston load theory is commonly used in computing the trench backfill loads on rigid pipes. Germany is using an alternative method developed by Abwassertechnischen Vereinigung e.V. (ATV) as the working design method for rigid and flexible pipe. This paper presents the German design method and a comparison of the two theories as they are applied to buried vitrified clay pipe design. The load ratio is defined as the ratio of the German load to Marston load. This ratio that the Marston theory is conservative for small pipes backfilled with well-compacted granular material because it neglects the load relieving effect of the side fill and underestimates the friction between backfill soil and trench walls. The effects of the trench geometry, soil characteristics, the pipe diameter, and the stiffness ratio of bedding and backfill soils on the trench loads are studied in detail for both German and Marston methods of design. (Edited author abstract) 9 refs.

Jeyapalan, J.K. (Univ of Wisconsin, Madison, WI, USA); Hamida, H. Ben. *J Transp Eng* v 114 n 4 Jul 1988 p 420-434.

**Earthquake Resistance**

**078983 DISTRIBUTION OF SEISMIC HAZARD AND RISK ANALYSIS OF BURIED PIPELINES IN TAIWAN.** Based on the seismicity and tectonics of Taiwan area, a set of potential earthquake sources is identified. Using available attenuation laws and fault-rupture model, the individual influences of potential sources are integrated into the probability distribution of maximum annual intensity and peak acceleration. The results are presented in the form of seismic risk maps for a 475-year return period. Based on the result of this study, it concludes that the seismic hazard potential for the central region is moderate, but it is high for east-coast region. This paper also presents a reliability analysis method for safety evaluation of buried pipelines in Taiwan region. The result of the reliability analysis of the buried pipelines subjected to earthquake ground accelerations are presented and a fragility result for peak ground acceleration (PGA) studies is also constructed. (Author abstract) 15 refs.

Chang, Shuenn-Yih (Nat'l Taiwan Univ, Taipei, Taiwan); Loh, Chin-Hsiung; Chen, Shyi-Shing. *Chung kuo Kung Ch'eng Hsueh K'an* v 11 n 1 Jan 1988 p 11-23.

**078984 SAFEGUARDING THE LIFELINES.** The Technical Council on Lifeline Earthquake Engineering has identified four major types of lifelines: electric power and telecommunications; gas and liquid fuel; transportation; and water and sewage. Provision for the maintenance of essential services such as fire protection, utilities, and transportation in the event of an earthquake is the subject of this article.

O'Rourke, Thomas D.; Grigoriu, Mircea D. *Eng Cornell Q* v 21 n 3 1987 p 7-14.

**078985 FEM STUDY OF GROUND STRAINS FROM STRONG MOTION ARRAY DATA FOR LIFELINE APPLICATION.** The seismic behavior of lifeline systems is predominately controlled by the ground displacement/strain characteristics. This study investigates the wave propagation effect. Ground displacements and ground strains from the latest strong-motion array data recorded at the Public Works Research Institute (PWRI) of Japan by using the finite element method. Usually, the movement of the buried pipeline is almost the same as that of the surrounding soil during seismic shaking. In this respect, the investigation of ground displacement characteristics can be used for further applications to the seismic design of buried pipelines. (Edited author abstract). 21 Refs.

Yeh, Yaw-Huei (Nat'l Taiwan Inst of Technology, Taipei, Taiwan); Wang, Leon Ru-Liang. *Chung kuo Kung Ch'eng Hsueh K'an* v 11 n 3 May 1988 p 207-218.

**078986 ANALYSIS OF CONTINUOUS BURIED PIPELINES FOR SEISMIC WAVE EFFECTS.** An analysis procedure for seismic wave propagation effects on straight continuous buried pipelines is proposed. It is shown that ground strain due to surface waves can be substantially larger than that due to body waves. An elastic model of a buried pipeline surrounded by equivalent soil springs indicates that frictional slip between the pipeline and the surrounding soil springs is likely for high ground strains. A method for estimating ground strain due to surface waves, based on data from the 1971 San Fernando earthquake, is reviewed. An analysis procedure, which utilizes frictional forces near the soil-pipeline interface, is proposed for surface wave effects on straight buried continuous pipelines. (Edited author abstract). 33 Refs.

O'Rourke, Michael J. (Rensselaer Polytechnic Inst, Troy, NY, USA); El Hmadi, Kamel. *Earthquake Eng Struct Dyn* v 16 n 6 Aug 1988 p 917-929.

**Environmental Impact**

**078987 PIPELINES AND THE ENVIRONMENT: THE LOCAL AUTHORITY VIEWPOINT.** This paper focuses on the process by which the Purbeck-Southamp-



ton pipeline was selected as the means of transporting oil away from the Wytch Farm oilfield, and the main factors that were taken into account. The exercise provided an interesting and possibly unique example of cooperation between a local authority and the oil industry to identify the most acceptable solution to a key problem which arose in planning the development of a major onshore oilfield. The varying influences of economic, environmental and political considerations on the decision to proceed with the selected option are discussed from the local authority's perspective.

Price, Andrew (Dorset County Council). *Pipes Pipelines Int* v 33 n 4 Jul-Aug 1988 p 26-32.

**Equipment** See PIPE—Equipment.

**Evaluation** See SEWERS—Bibliographies.

**Expansion Joints** See Also JOINTS—Expansion.

**078988 EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LOADING ASYMMETRY ON COMPENSATOR LIFE.** Results of experimental studies on full-scale specimens of lens compensators are given to reveal low-cycle fatigue under various loads. On the basis of statistical analysis of the experimental data it is shown possible to use integral criteria of the compensator loading in evaluating their cyclic strength under antisymmetrical recurrent-static elastoplastic strain. The earlier obtained mathematical model of probable life estimation for axial compensators proves to be adequate to the new experimental data and may be applied for predicting life of hinged compensators taking up angular movements. (Author abstract) In Russian. 8 refs.

Kartsev, A.I.; Dedusenko, V.Yu.; Kudrenko, V.V. *Probl Prochn* a2 p 86-90.

**078989 DEHNUNGS-AUFNAHME UND MANTEL-ROHRVERBINDUNG BEIM KUNSTSTOFF-MANTELROHRSYSTEM.** [Expansion Compensation and Jacket Tube Connection for Plastic Jacket Tube Systems]. The plastic jacket tube for district heating systems, which has been used for two decades, contains two problems - expansion compensation and jacket tube connection, which still require further development. The author describes the problem situation and the latest developments. (Author abstract). 3 Refs. In German.

Gerke-Reineke, L. *Brennst Waerme Kraft* v 40 n 6 Jun 1988 p 225-228.

**Extension** See NATURAL GAS PIPELINES—Construction.

**Fabrication**

**078990 PIPEWORK PREFABRICATION - THE ECONOMICS.** Prefabrication shops should not be limited to prefabrication of pipe for one contract at a time as, dependent on size of shop, two or three contracts could be taken 'in house' for other contractors. Therefore, in a very short space of time, one can see a return on capital invested, and within one or two years, a handsome profit on investment. Author details the main costs of on-site prefabrication in comparison to workshop prefabrication. Expenses for labour to get to site need to be paid, as well as weekly, or monthly costs of materials delivered to site. Production time is lost on site due to bad weather if prefabrication is not done in a covered area, as well as if accidents happen. The costs for a prefabrication shop would only be for materials, which could be bought in bulk thus saving on purchasing costs for each contract.

Forster, T. (Pipeanduct Services Ltd). *Pipes Pipelines Int* v 32 n 6 Nov-Dec 1987 p 27-28.

**Failure** See Also WATER PIPELINES—Winnipeg, Manitoba.

**078991 PLASTIC COLLAPSE ANALYSIS OF GIRTH WELD REPAIR GROOVES IN PIPE SUBJECTED TO OFFSHORE LAYING STRESSES.** The overload failure of pipes containing girth weld repair

grooves subjected to offshore laying stresses was investigated. Repair welding trials were conducted on full scale pipe sections, and tensile tests on weld metal and parent metal were performed at elevated temperatures in order to determine whether or not heat from the welding process would result in a loss of strength locally. A new plastic collapse solution for circumferentially notched pipes in bending was derived. This analysis can be used to predict failure in pipes containing part-wall or through-wall repair grooves at various circumferential positions. Four-point bend tests on small scale pipe sections were performed. (Edited author abstract) 7 refs.

Anderson, T.L. (Texas A&M Univ, College Station, TX, USA); Belloni, A.; Willoughby, A.A. *Int J Pressure Vessels Piping* v 31 n 2 1988 p 105-130.

**078992 ESTIMATION OF THE UNSTABLE FRACTURE OF PIPE WITH A CIRCUMFERENTIAL SURFACE CRACK.** Several criteria are proposed to predict the failure bending moment of a pipe which has a circumferential crack and is subjected to external bending moment in LWR (Light Water Reactor) pressure boundary piping. However, those criteria give an unconservative prediction when the pipe has a short and deep circumferential surface crack. This paper presents a half-empirical criterion on the basis of the test results. This criterion gives a conservative prediction by choosing the optimum parameter, even if the pipe has an arbitrary circumferential surface crack. This paper also presents a method to calculate a tearing modulus,  $T_{app}$ , of the pipe containing the circumferential surface crack just after the ligament failure. (Author abstract) 13 refs. In Japanese.

Kurihara, Ryoichi; Ueda, Shuzo. *Nippon Kikai Gakkai Ronbunshu A Hen* v 53 n 495 Nov 1987 p 2090-2096.

**Filters**

**078993 PIPELINE STRAINERS: A TOOL FOR POLLUTION CONTROL.** A strainer is a basic device which is widely used in industry and municipal treatment systems for pollution control. It is simple to operate and lasts for many years. Yet design engineers and plant managers often overlook pipeline strainers when planning or laying out their systems. This article discusses types of strainers, strainer applications, and selection.

Lewis, Sidney A. (Hayward Industrial Products Inc, Elizabeth, NJ, USA). *Pollut Eng* v 20 n 4 Apr 1988 p 90-91.

**Flow** See Also FLOW OF FLUIDS—Pipes; FLOW OF FLUIDS—Turbulent; FLOW OF WATER—Conduits; FLUID MECHANICS—Mathematical Models; NATURAL GAS PIPELINES—Monitoring; NATURAL GAS PIPELINES—Nozzles; SEWERS—Computer Aided Design.

**078994 EFFECT OF GAS EXPANSION ON SLUG LENGTH IN LONG PIPELINES.** One of the important parameters in slug flow is the length of the liquid slug. Slug length is important in determining the average pressure drop as well as fluctuations in the pressure. Moreover, knowledge of the length of the slugs leaving long pipelines is crucial for the design of slug catchers. For short pipelines, the slug length is determined by the entrance phenomenon and by the stability of the slugs. For long pipelines the situation is not entirely clear. Long slugs may be formed due to terrain slugging. In this work, it is shown that long slugs can also be formed due to the decrease in pressure in the downstream direction. (Author abstract) 17 refs.

Taitel, Y. (Tel-Aviv Univ, Ramat-Aviv, Isr). *Int J Multiphase Flow* v 13 n 5 Sep-Oct 1987 p 629-637.

**078995 CALCUL DIRECT, SANS ITERATION, DE LA PERTE DE CHARGE EN CONDUITE PAR LA FORMULE DE COLEBROOK.** [Direct Calculation, Without Iteration, of Conduit Head Loss by Means of Colebrook's Formula]. The head coefficient of the smooth pipe relation calculated according to Reynold's number, via an explicit formula provided by the author, and introduced in the second member of the Colebrook's formula. The first iteration gives an adequate approxima-

tion of the head loss coefficient. (Author abstract) In French.

Nackab, J. *Houille Blanche* v 43 n 1 1988 p 61.

**078996 FLUID TRANSIENTS IN PIPELINE - LIQUID COLUMN SEPARATION AND DEVELOPMENT OF COMPREHENSIVE PROGRAM.** NKK has developed a computer program, SURGE 2, to simulate transient phenomena in a liquid pipeline. SURGE 2 can analyze any piping system, however complicated it may be. This program can simulate liquid column separation. For numerical analysis, the air release method is adopted. Liquid column separation experiments were conducted using a 15.2 mm diameter and 200 m long test pipeline. Experimental data are compared with calculated results to find agreement with respect to change of flow rate and pressure. (Edited author abstract) 12 refs.

Kamemura, Toshihiko; Jyowo, Kazuo; Hata, Teruhiko; Hayashi, Hideo; Yoshikai, Tatsuki; Kondo, Munetaka. *Nippon Kokan Tech Rep Overseas* n 52 Apr 1988 p 42-49.

**Fluid Dynamics** See Also FLOW OF FLUIDS—Laminar; FLOW OF FLUIDS—Pulsatile Flow; FLOW OF FLUIDS—Turbulent; FLOW OF FLUIDS—Two Phase; WATER HAMMER.

**078997 FLUID MECHANICS OF CAPSULE PIPELINES (5TH REPORT, ANALYSIS OF THE CAPSULE VELOCITY, DRAG COEFFICIENT AND DESIGN OPTIMIZATION).** The most important problem in the study on a flow of capsule transport is to clarify the characteristics of pressure loss and capsule velocity in the turbulent flow regime. In this capsule pipelining series, the authors have mainly reported fundamental work on the pressure loss of cylindrical capsule flow. The present paper describes the theoretical prediction of capsule velocity and discusses the optimum situation of transport. The capsule velocity is determined after consideration of the agreement between the pressure loss formed by geometric capsule conditions and the pressure drop required to move capsules steadily. The predicted velocities are in good agreement with reliable experimental data. In this report through a numerical calculation simulating various capsule-flow conditions, the optimum velocities for minimizing power consumption and pressure loss, respectively, become evident. (Edited author abstract) 10 refs. In Japanese.

Ohashi, Akira; Yanai, Katsuya. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 495 Nov 1987 p 3291-3299.

**Fracture** See FLUIDS—Phase Equilibria.

**Freezing** See Also FLOW OF FLUIDS—Pipes; FLOW OF WATER—Pipes.

**078998 DYNAMICS OF THE FREEZING OVER OF UNDERGROUND PIPES.** Pipeline transport of water, aqueous solutions and suspensions under conditions of low ambient temperatures may be accompanied by their freezing. The formation of an ice layer on the inner pipe surface causes increased hydraulic resistance. In view of that the prediction of freezing over of pipes under extreme climatic and technological conditions has to be included in the pipeline project. This article suggests a method of calculating the unsteady process of freezing over of an underground pipe transporting a freezing liquid. 11 refs.

Krasovitskii, B.A. (All-Union Research, Project & Survey Inst of Hydraulic Pipeline Transport, Moscow, USSR). *J Eng Phys* v 51 n 5 Nov 1986 p 1331-1337.

**078999 MOBIL'S PIPE FREEZE BREAKS NEW GROUND.** The authors report an interesting and complex pipefreezing operator carried out in 1986 at the base of the North Sea's Statfjord A platform, 150 m below sealevel. Using nitrogen liquid at  $-196^{\circ}\text{C}$ , MCL froze a succession of pipes in the base of the condeep structure to form plugs of sufficient strength to allow removal of



corroded pipe sections and their replacement. The work involved 16 separate freezes on pipes of 18in diameter at the base of the structure approximately 150m below water line and 175m below deck base level. The work was carried out from June to August last year, after extensive trials in 1984 and 1985 held in Norway and approved by all parties involved, including DNV.

Anon. *Pipes Pipelines Int* v 32 n 4 Jul-Aug 1987 p 22-23.

**079000 OPERATION 'DEEP FREEZE'.** Corroded pipe sections in the Strøtfjord A Ballast Water System have, through a successful and complicated operation carried out in 1986, been changed and replaced by titanium, a new material in an offshore context, having better anti-corrosion properties and a much longer working life than other materials used in such pipes on the platform today. The paper describes the project which was finalized ahead of schedule and below budget. Physically, the operation took place in the Utility Shaft on the platform, and it had no impact on the production on board. Several departments of the Strøtfjord Division platform operator Mobil Exploration Norway Inc have been involved, as have contractor companies.

Anon. *Pipes Pipelines Int* v 32 n 4 Jul-Aug 1987 p 23-25.

German Democratic Republic See HEATING—District.

Hamburg, Federal Republic of Germany See HEATING—District.

Heat Transfer See HEAT TRANSFER—Convection; HEATING—District; PIPE JOINTS—Flanges.

Heating See GAS PIPELINES—Flow; PIPELINES, SUBMARINE—Analysis.

## Ice Problems

**079001 STUDY OF ICE-FORMATION PHENOMENA ON FREEZING OF FLOWING WATER IN A PIPE.** Ice-formation phenomena in a water pipe whose wall is kept at a uniform temperature lower than the freezing temperature of water are examined under the conditions of an unstable ice-water interface. The onset conditions for a step or smooth change in ice thickness occurring with flow transition from laminar to turbulent are found to be correlated with ice thickness at the contraction region of the ice band and are expressed as a function of a pipe Reynolds number  $Re_D$  and a cooling temperature ratio  $\theta$ . It is shown that the transient freezing process depends strongly on flow as well as temperature conditions and that the typical ice shapes at steady-state conditions can be classified on a  $\theta-Re_D$  coordinate system. (Author abstract) 11 refs.

Hirata, T. (Shinshu Univ, Nagano, Jpn); Matsuzawa, H. *J Heat Transfer Trans ASME* v 109 n 4 Nov 1987 p 965-970.

Inspection See Also GAS PIPELINES—Inspection; NUCLEAR REACTORS, HEAVY WATER—Reliability; PETROLEUM PIPELINES—Corrosion Protection; SIGNAL PROCESSING—Applications; ULTRASONIC TRANSDUCERS—Design.

**079002 INTELLIGENT PIGS NOW INSPECT PIPELINES DOWN TO 200 MM DIAMETER.** A monitoring and inspection service that locates flaws in high-pressure oil and gas transmission pipelines to within 1.5 metres is available for diameters down to 200 mm (8 inches). The pipeline inspection system developed by British Gas plc at its On Line Inspection Centre in Cramlington, England provides pipeline operators with a high precision lower cost alternative to hydrostatic pressure re-testing. Inspection vehicles known as intelligent pigs are carried along pipelines by product flow. A magnetic detection system identifies any metal loss indicating pitting, general corrosion or mechanical damage such as gouging or spalling.

Anon. *Anti Corros Methods Mater* v 34 n 10 Oct 1987 p 7-8.

Insulation See HEATING—District; HEATING—Pipelines.

Joints See FLOW OF FLUIDS—Two Phase; WATER PIPELINES—Design.

Laying See Also EARTHMOVING MACHINERY—Excavators; NATURAL GAS PIPELINES—Construction.

**079003 TRENCHLESS SYSTEMS GAIN WIDER ACCEPTANCE.** The term 'trenchless construction' refers to any construction (or reconstruction) method which involves minimum disruption of the surface. But, in general the term is reserved for smaller diameter passages (say up to 1.8m diameter) and includes such applications as the installation of pipes and ducts for sewerage, water supply, gas supply, telecommunications and oil pipelines.

Jones, Maurice B. *Civ Eng (London)* Oct 1987 p 54, 56-57.

Leak Detection See Also HEATING—District; PETROLEUM PIPELINES—Maintenance.

**079004 MATHEMATICAL MODEL FOR LEAK LOCATION IN PIPELINES.** In the present paper, a novel method for leak detection in pipelines is described. The method is based on a unidimensional flow analysis. The theoretical findings have been verified experimentally for two different hole geometries (circular and rectangular). The comparison set between theory and experiment confirms the physical realism of the mathematical model. The accuracy in calculating the leak position is estimated to be less than a few percent for the different hole geometries in question. (Author abstract) 6 refs.

Baghdadi, A.H.A. (Cairo Univ, Egypt); Mansy, H.A. *Appl Math Modelling* v 12 n 1 Feb 1988 p 25-30.

**079005 SOME CONSIDERATION ON LEAKAGE DETECTION IN PIPELINES BY ACOUSTIC EMISSION.** It is emphasized in this paper that the flow density of a jet is an important factor which affects the AE signal levels. In the case of subsonic jet, AE signal level goes up as pressure in pipeline  $P_0$  increases regardless of shape and size of leakage hole. When a blocked jet occurs, the condition is very complex. Sometimes, but by no means always, a supersonic jet may be formed and AE signal level drops as  $P_0$  increases. AE signal excited by leaking jet is of continuous type and its frequency range is very wide. If the circumstance noise level is low, an accelerometer may be used to seek leakage. (Author abstract) 10 refs. In Chinese.

Wang, Zuyin (Sichuan Coll of Light Chemical Technology, China). *Wusun Jiance* v 10 n 2 Feb 1988 p 36-38.

Lining See SEWERS—Repair.

Maintenance See Also WATER PIPING SYSTEMS—Standards.

**079006 STUDY ON AUTONOMOUS PIPELINE MAINTENANCE ROBOT (3RD REPORT, STRUCTURE AND CONTROL OF MARK III AND OBSTACLE SENSING).** A new type of mobile robots with a looping movement mechanism in the lateral and circular direction of a pipeline is presented in this paper for pipeline maintenance operations. This robot has four degrees of freedom and more flexibility than the first and the second prototype robots, which have the wheel type of mobile mechanism for horizontally located pipelines. This robot can pass over obstacles such as flanges and also T-joint pipelines, which the previously reported robots can do, and furthermore has more pipeline maintenance adaptabilities such that the new robot can move along vertically located pipelines and that it can move to an adjacently located pipeline. Therefore, the control must be so complicated that the dual mode control is introduced by employing the coordinate transformation matrix. (Edited author abstract) In Japanese. 8 refs.

Fukuda, Toshio; Hosokai, Hidemi; Otsuka, Masashi. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 492 Aug 1987 p 1788-1794.

**079007 STUDY ON AUTONOMOUS PIPELINE MAINTENANCE ROBOT (4TH REPORT, JOINT CONTROL AND ITS TRAJECTORY GENERATION FOR MARK III).** The pipeline maintenance robot Mark III with the inch worm mechanism, presented in the 3rd report, can pass over obstacles on pipelines, such as flanges and T-joints and others. For this motion control, the joint control methods for Mark III, especially the optimal trajectory generation, are shown in this report. First, this robot system has the modified dual control mode, A and B, with the transfer matrices different from the previous method. The control mode is changed mutually when the basic arm grasping the pipe is changed. Second, the static joint torques are calculated to determine the desired transfer matrix, and a configuration which has the minimum joint torques is selected. Third, an optimal trajectory is generated by dynamic programming in order to control joints from the present angles to the desired angles. It has two criteria: joint torques and position errors. (Author abstract) In Japanese. 6 refs.

Fukuda, Toshio; Hosokai, Hidemi; Otsuka, Masashi. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 495 Nov 1987 p 2325-2330.

Mathematical Models See Also HYDRAULICS—Theory.

**079008 ON THE DYNAMIC RESPONSE OF FLUID-FILLED BURIED PIPELINES.** This paper presents a theoretical analysis of the axisymmetric steady state dynamic response of buried fluid-filled pipelines excited by seismic waves traveling in the surrounding infinite medium (soil). An infinite cylindrical shell model including the rotary inertia and shear deformation effects, has been used for the pipeline. Comparisons of the numerical results for a fluid-filled shell with those for an empty shell show that the presence of the fluid suppresses the response at some wavelengths but augments it at others. The overall response of the fluid-filled shell is observed to be quite different from that of the empty shells, and this difference is found to be more pronounced in softer soil conditions. (Author abstract) 12 refs.

Mishra, B.K. (Banaras Hindu Univ, Varanasi, India); Upadhyay, P.C. *J Sound Vib* v 117 n 1 Aug 22 1987 p 59-67.

**079009 POWERFUL IMPROVEMENT ON THE METHODOLOGY FOR SOLVING LARGE-SCALE PIPELINE NETWORKS.** Solving large-scale pipeline networks that give rise to huge sets of nonlinear algebraic equations is very time consuming and cannot be treated by conventional partitioning and tearing techniques, which tend to be very expensive in computer time. A new arrangement of the Hardy-Cross linearized system for the simulation of large-scale fluid network problems is presented, which dramatically improves the calculating procedure. Comparisons with other known procedures show a large reduction of the memory storage and computation time. The strategy makes a trade-off between the number of iterations and time required for each calculation resulting in an overall optimization of any physical system. Furthermore the method has been satisfactorily applied to the optimization of gas networks. (Edited author abstract) 16 refs.

Martinez-Benet, J.M. (Univ Politecnica de Catalunya, Barcelona, Spain); Puigjaner, L. *Comput Chem Eng* v 12 n 2-3 Feb-Mar 1988, MATCHEM, Sel Pap from the Conf on Math Methods in Chem Eng, Balatonfured, Hung, May 5-8 1986 p 261-265.

## Measurements

**079010 STUDY ON POSITION MEASUREMENT METHOD OF A CONDUIT PIPELINE USING CUMULATING ATTITUDE.** A new position measurement method for conduit pipelines buried under public roads is proposed. In the new method, a piece of equipment consisting of two modules, a vehicle and a probe, move inside a pipeline. The probe measures the pipeline inclination and curvature radius. The pipelines position is calculated by cumulating the inclination and the attitude



obtained from the curvature radius measurement. Furthermore, position measurement accuracy is analyzed and evaluated with standard deviations of the inclination or curvature radius. The usefulness of this measurement method is confirmed through an experiment using a pipeline 80 mm in internal diameter and 40 m in length. The horizontal and vertical position measurement error is found to be smaller than 20 cm in the experiment. (Author abstract) 3 refs. In Japanese.

Morimitsu, Takenori; Shiraishi, Kenji; Sakata, Hideaki. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 496 Dec 1987 p 2602-2607.

## Mechanical Properties

**079011 INCLUSION OF INTERMEDIATE PARTIAL CONSTRAINTS IN PIPING FLEXIBILITY ANALYSIS - A GENERAL APPROACH.** No method has yet been developed to unite intermediate partial constraints into the body of the equilibrium equation of the piping system. This paper describes a very general approach to piping flexibility analysis incorporating intermediate partial constraints. The method admits all types of intermediate partial constraints to be imposed simultaneously upon any node of the structure, such that some degrees of freedom of a node may be restrained by springs, some by external forces and some could be suppressed rigidly. The method, unlike all others, obtains the proper matrix equilibrium equation of the whole piping system. It is particularly suited for automatic computation. (Edited author abstract) 22 refs.

Abhary, Kazem (Univ of Tehran, Tehran, Iran). *Int J Pressure Vessels Piping* v 31 n 1 1988 p 43-54.

## Monitoring See Also PETROLEUM PIPELINES—Structural Analysis.

**079012 TROUBLE-SHOOTING TOOL.** Buried pipelines are constructed and operate in dynamic environments that make them vulnerable to a number of influences that are hazardous to their safe operation. The main operating principle of the C-Scan System is the remote measurement of the strength of a signal applied to the pipeline. The attenuation of signal strength is determined by measuring the strength of the C-Scan signal carried by the pipeline at any given survey point and comparing it with the current measured in the pipeline at some other survey point.

Sturgess, Robert W. (Pipeline Information Technologies Ltd, Calgary, Alberta, Can). *Pipeline Gas J* v 215 n 2 Feb 1988 p 18, 20-22.

**079013 INTEGRITY MONITORING FOR FLEXIBLE PIPES.** Flexible reinforced hoses to carry hydrocarbons and chemicals have been in operation for over 50 years. During the last war, the first steel reinforced subsea flexible hose was laid across the channel to transport fuel to support Allied landing operations in France. However, not until the 1970s because of progressions in oilfield developments and due to the need to reduce pipeline installation time and costs, were the first steel-reinforced flexible pipes actually placed in service. Flexible pipes should not be confused with and differ from flexible hoses, largely due to their method of construction, material, composition and reinforcement. Pipe construction is made up from alternating layers of polymeric (thermoplastic or elastomeric) materials, steels (both carbon and stainless), textiles (polyamide, Kevlar, polyethylene) and fabrics (for ozone, abrasion and fire resistance). The paper describes the two major types of construction of flexible pipe, bonded construction and unbonded construction. Discussed are designs and construction guidelines, modes and causes of pipe failure, and tools for pipe monitoring. 11 Refs.

Neftgen, J.M. (Neptun Pag-o-Flex Offshore Flexibles GmbH). *Pipes Pipelines Int* v 33 n 3 May-Jun 1988 p 7-14.

## Nondestructive Examination See Also NONDESTRUCTIVE EXAMINATION—Eddy Current Testing.

**079014 FINITE ELEMENT CALCULATIONS AND COMPUTER MEASUREMENTS OF MAGNETIC FLUX LEAKAGE PATTERNS FOR PITS.** Two dimensional finite element calculations for anomalous leakage fluxes generated by far side grooves in pipes inspected using magnetic leakage flux anomaly detectors are compared with precision computer controlled experimental measurements of three dimensional synthetic corrosion pits. The experimental measurements are presented as contour maps and surface plots. There is a strong linear correlation between peak anomalous radial flux densities calculated using two dimensional finite element techniques and those measured experimentally for the corresponding three dimensional anomalies. (Author abstract) 5 refs.

Atherton, D.L. (Queen's Univ, Can). *Br J Non Destr Test* v 30 n 3 May 1988 p 159-162.

## Offshore See Also GAS PIPELINES—Corrosion; MARINE RISERS—Wave Effects; PETROLEUM PIPELINES—Laying; PIPELINES, SUBMARINE—Removal.

**079015 FORCES ON A SMOOTH SUBMARINE PIPELINE IN RANDOM WAVES - A COMPARATIVE STUDY.** The submarine pipeline was subjected to Pierson-Moskowitz spectrum (P-M spectrum) at various energy levels. The water particle kinematics were computed based on the linear random wave model and the Morison equation was chosen as the wave force predictor model. The inline hydrodynamic coefficients of drag and inertia were evaluated using two different methods, one in the frequency domain and the other in the time domain. Five mathematical formulations were considered for the analysis of transverse wave forces and these were compared in terms of the correlation coefficient. Study results are discussed. (Edited author abstract) 20 refs.

Shankar, N. Jothi (Nat'l Univ of Singapore, Kent Ridge, Singapore); Cheong, Hin-Fatt; Subbiah, K. *Coastal Eng* v 11 n 3 Sep 1987 p 189-218.

**079016 NEW TRENDS IN CORROSION-RESISTANT OFF-SHORE PIPELINES.** The methods used for the production of clad steel pipe are roughly classified into assembling methods and casting methods. Of these, the following four methods are becoming popular. Seamless pipe of clad steel made by inserting alloy pipe into the carbon-steel pipe. The resulting pipe is hot-rolled or cold-worked. Welded pipe made from clad steel plate produced by explosion bonding or welding. Welded pipe made from plate produced by the hot-rolling of clad steel ingot. To make the ingot, molten carbon steel is poured into the mould in which the alloy plate has been placed. Carbon-steel pipe made by centrifugal casting or the like, after which alloy steel is cast inside it.

Anon. *Chromium Rev* n 7 Aug 1987 p 10-11.

**079017 OFFSHORE PIPELINES IN EUROPEAN MARITIME AREAS - THE YEARS AHEAD.** For effective pipelaying in these depths, where driver assistance is difficult, totally integrated installation systems will be required. The specific areas for deep water pipelaying in the European maritime areas are in the Norwegian Sea, Northern Atlantic Ocean between Rockall, the Faeroes and Scotland, in the Norwegian Trench and crossings of the Mediterranean. Effective pipelaying in deep water will require an integrated system. An integrated system consists of the totality of surface and subsea equipment needed to lay and connect a pipeline in deep water. The pipelay method is an important part of the overall pipeline design. Elements of the system required for deep water work are given. The author discusses pipelaying systems and their extension to deep water and factors relevant to the repair of deepwater pipelines.

Smith, C.J. *Mar Technol* v 17 n 2 May 1986 p 62-63.

**079018 AUTOMATED CHARTING FOR OFF-SHORE PIPELINES.** The latest TRAC IVB/CHART-IV automated processing and charting systems

allows the surveyor to choose a layout to suit his specific application from simple base sheets to customized multiple layouts with convenient defaults for rapid set-up. Complete intermixing of chart types is possible, including trackplots, bathymetric data, long sections, cross sections, profiles, key charts, information and logo panels. The system can produce any size of pipeline chart from A3 to AO with standard default sizes; non-standard sizes can be entered manually. Progressive recording of component sections of the chart to file eases editing and speeds duplication of the final sheet. Sheets may be replotted from file at a reduced overall size for inclusion in reports.

Brougham, P. (Qubit Ltd); Cookson, E.W. *Pipes Pipelines Int* v 32 n 5 Sep-Oct 1987 p 18-21.

**079019 NORTH SEA PIPELAY PROJECTS WILL STRETCH SUPPLY BOAT MARKET.** On current trends, once plans being developed for major pipeline projects in the North Sea are put into effect in the early 1990s, there are unlikely to be sufficient specialized supply vessels to support the construction activity. The likely result will be a major increase in demand for conventional supply vessels during the pipelay operations, which could lead to shortages and day rate increases in the North Sea supply vessel market. This article reviews the project plans and discusses boat shortages and effects the construction activities.

Anon. *Mar Eng Rev* Jan 1988 p 24-25.

**079020 DESIGN AND OPERATIONAL CONSIDERATIONS FOR UNSUPPORTED OFFSHORE PIPELINE SPANS.** Design and operational considerations have been examined in determining the significance of unsupported offshore pipeline spans that may develop during pipeline installation or field operation. Allowable unsupported span lengths determined during design are generally based on strict code compliance and a design foundation encompassing the worst possible environmental and operational loads. During operation, however, unsupported spans develop beyond the allowable limits, perhaps as a result of various unforeseen local conditions. Applying original design criteria is likely to result in cost-prohibitive repair predictions, while lack of action may result in loss of production. Without the design code requirements of an existing or a proposed pipeline system being violated, realistically safe design can be approached through evaluation of the sensitivity of the key design parameters. (Edited author abstract) 8 refs.

Shah, B.C. (Lummus Crest Inc); White, C.N.; Rippon, I.J. *SPE Prod Eng* v 3 n 2 May 1988 SPE 15810, p 227-237.

## Packing

**079021 EXTRUDED PACKING.** A new material, called KEN, intended for gland packing in pipeline fittings has been developed at VNIATI. This material is suitable for operation in media like inorganic and organic acids, steam, and feed water. The KEN packing is made by extruding a plastic asbestos-rubber mixture (asbestos, graphite, rubber) in the form of a cylindrical spiral of square section. This article describes the results of studies on the qualities of KEN packings conducted on the test rig. The working medium was air at a pressure from 1 to 20 MPa. 2 refs.

Malyshev, V.M.; Kuznetsova, G.R.; Zav'yaloova, M.I. *Chem Pet Eng* v 23 n 3-4 Mar-Apr 1987 p 121-122.

## Performance See PETROLEUM PIPELINES—Protection.

## Planning See PETROLEUM PIPELINES—Environmental Impact.

## Plastics Applications See Also OIL FIELD EQUIPMENT—Tubular Goods; WATER PIPELINES—Pressure Effects.



**079022 APPRAISAL OF GLASS REINFORCED PLASTIC AS A PRESURE PIPELINE MATERIAL.** GRP pipe is a specialist pipe which can offer advantages in a small number of applications. However, when GRP is considered for pressure water mains, its limitations, risks and special characteristics must be evaluated. 'Stiff' GRP pipes are not equivalent to ductile iron and should not be considered as direct replacements. They are fragile, many times less stiff than ductile and require special embedments and close site control in order to ensure a reliable long term performance. The British Standard allows GRP pipes to be designed to very low, long term safety factors giving little reserve for the incidental loadings which inevitably occur in practice.

Greatorex, C. Barrie (Stanton Plc). *Water Serv* v 91 n 1099 Sep 1987 p 365-369.

**Porosity** See PETROLEUM PIPELINES—Failure.

**Pressure Effects** See Also NATURAL GAS PIPELINES—Lining; SOLIDS—Transport Properties.

**079023 TWO-DIMENSIONAL ANALYSIS OF PRESSURE TRANSIENTS IN PIPELINES.** The paper presents a two-dimensional model for the investigation of pressure transients in pipelines. The governing equations have been established and a method of solving the equations using the center implicit method is presented. The theoretically predicted values are compared with the experimentally determined pressure transients for horizontal pipelines with a valve at the end. The two-dimensional model gives results which are more accurate than those of the one-dimensional model and are in good agreement with the experimental results. (Author abstract) 8 refs.

Nathan, G.K. (Nat'l Univ of Singapore, Singapore); Tan, J.K.; Ng, K.C. *Int J Numer Methods Fluids* v 8 n 3 Mar 1988 p 339-349.

**Pressure Measurement** See NATURAL GAS PIPELINES—Leak Detection.

**Pressure Regulation** See Also NATURAL GAS PIPELINES—Valves; VALVES AND VALVE GEAR—Pressure Effects.

**079024 CONTROLLING PRESSURE PULSE SPREAD PROCESSES IN PIPELINE SYSTEMS.** In pipeline systems, the greatest danger is from low-frequency pulsing generated by pumps and valves. Pressure pulse spread processes in pipeline systems can be controlled by using a device with an acoustic resistance which can be varied smoothly within wide limits by altering its stiffness characteristic. The proposed device with variable acoustic resistance can be used both for setting the pipeline system away from resonance conditions, and for reducing pressure pulse levels in pipelines containing conventional and corrosive fluids. 7 refs.

Gorin, S.V.; Lesnyak, A.N. *Sov Eng Res* v 7 n 1 Jan 1987 p 21-23.

**Protection** See Also PIPE.

**079025 INCREASING THE PROTECTIVE CHARACTERISTICS OF BITUMINOUS COATINGS BY MODIFICATION WITH CORROSION INHIBITORS.** The influence of specific modifiers (standard products and waste products of large tonnage chemical and petrochemical production) on the anticorrosion properties of petroleum bituminous coatings is considered. The inhibiting modifiers were selected so that, in the composition of the bituminous coatings they did not have a significant detrimental effect on the strength and insulation properties. Quantitative data were obtained confirming the increased anticorrosion characteristics of coal tar and KKhO inhibitor modified bituminous coatings. The order of other inhibitors combining well with the bituminous base and strengthening its protective effect was also determined. The practical use of inhibiting modifiers makes it possible to substantially improve the technical and service parameters of the coatings and to prolong the service life of steel main oil and gas lines, water lines, and

pipe for irrigation and public systems. 9 refs.

Serednitskii, Ya.A. (Acad of Sciences of the Ukrainian SSR, Lvov, USSR); Mindyuk, A.K.; Tselyukh, O.I.; Suprun, V.V.; Dzikovskii, O.M.; Dombrovskii, B.O. *Sov Mater Sci* v 22 n 6 Nov-Dec 1986 p 625-628.

**079026 SICHERHEITSVERBESSERUNG VON ROHRLEITUNGEN IN BERGSENKUNGS- GEBIETEN.** [Better Protection of Pipelines against Mining Ground Subsidence]. Although the instability of the ground in mining areas is well-known, there remains the need for public utility pipelines in these regions too, which must be protected against breakage. What happens in such a ground is outlined through literature sources and the author's own findings. In conclusion, it was found that the resistance to sliding of the pipe surface is the decisive parameter. A solution is presented to reduce this friction for better protection of the pipelines. (Author abstract) In German. 14 refs.

Kolonko, A. (TU Wroclaw, Pol). *Str Tiefbau* v 41 n 9 Sep 1987 p 14-16, 18-19.

## Protective Coatings

**079027 TAPE SYSTEMS FOR PIPELINE PROTECTION.** Pipeline tapes have been used for over 35 years and continue to be important and useful materials for protection against corrosion in a variety of environments. Pipelines, particularly those used underground, have special protection requirements, because of the susceptibility to mechanical damage during handling, lowering, and backfilling, and the corrosive nature of the soils. Pipeline tapes are one of the major options for achieving that protection, along with various other types of coatings. A disadvantage of the tapes is the vulnerability of the seam to ingress by water or other pollutants. Application of tapes is crucial, and improperly wound or poorly bonded tapes are susceptible to water penetration and corrosion. 8 refs.

Appleman, Bernard R. (Journal of Protective Coatings & Linings, Pittsburgh, PA, USA). *J Prot Coat Linings* v 4 n 7 Jul 1987 p 52-60.

**079028 DEVELOPMENT OF AN ULTRAVIOLET CURABLE PRIMER (UVC) SYSTEM FOR POLYETHYLENE COATED STEEL LINE PIPE.** Polyethylene extrusion coating pretreated with thermosetting epoxy primer has recently been applied for external pipeline protection. However, thermosetting primer takes more than a few minutes for curing, so it has been difficult to apply it in a high speed polyethylene coating line. To cope with this problem, we have studied and developed a new primer system, an 'Ultraviolet Curable (UVC) Primer System'. This newly developed UVC primer system has the following properties: 1) Quick curing, with a curing time of less than 5 sec. 2) High adhesion strength for both the steel surface and adhesive. 3) Excellent corrosion resistance. 4) Safe in the coating plant. Our new system has already been installed in the polyethylene coating line at the Wakayama Steel Works. (Author abstract) 5 refs.

Arai, Tetsuzo (Sumitomo Metal Industries Ltd, Jpn); Ohkita, Masakazu; Ohtsuka, Takezumi; Yamauchi, Shigemichi. *Sumitomo Search* n 35 Nov 1987 p 77-82.

**079029 INTERNAL COATING JUSTIFIED BY OPERATING COSTS.** Internal coating of gas and liquid pipelines can be economically justified by resulting reductions in operating costs. A typical payback period is 3-5 years. These are the primary conclusions of an economic study which used improvements in pipeline hydraulics to estimate savings in operating costs over a wide range of fluid and pipeline parameters. This is the second article (Part 1, OGI, Feb. 29, p. 59) in a series aimed at giving pipeline operators information on protecting their pipelines. (Author abstract) 10 refs.

Singh, Gurdial (PLT Engineering Ltd, London, Engl); Samdal, Ove R. *Oil Gas J* v 86 n 14 Apr 4 1988 p 50-55.

**Pumping Stations** See WATER PIPELINES—Construction.

## Reliability

**079030 CALCULATING THE RELIABILITY INDICATORS OF MAIN PIPE LINES BY A STATISTICAL MODELLING METHOD.** The finite element method is used to solve the problem of interaction when a large-diameter pipeline comes into contact with mounds of frost-swollen earth. The reliability indicators and empirical distributions of the functions of state of the pipelines are obtained using the theory of the elimination of random factors, the theory of the distribution of extreme random values, and methods of statistical modeling. It is shown that the widely used hypothesis on the normality of functions of state can lead to crude errors when the reliability levels of main pipelines are evaluated. (Author abstract) 7 refs.

Lobanov, E.V. *Sov Mach Sci* n 2 1987 p 78-83.

**079031 EVALUATING THE RELIABILITY OF PIPELINES AT HYPERCRITICAL DEFORMATION IN STATISTICALLY INHOMOGENEOUS WEAK SOILS.** A problem of hypercritical strain in trunk pipelines is solved with allowance for nonlinear bending and essentially nonlinear soil resistance. Reliability indicators are estimated by using a statistical-linearization technique and the theory of random-function spikes. It is shown that allowance for the nonlinear property of the soil reduces the failure rate to a fraction of that encountered with the classical Winkler base. (Author abstract) 3 refs.

Lobanov, E.V. *Sov Mach Sci* n 3 1987 p 44-49.

## Relocation

**079032 BORING REVOLUTION.** With many kilometres of old services to replace and new ones to lay, non-disruptive methods of installation offer attractive solutions, especially in urban environments. The preferred alternative which is rapidly penetrating the market is trenchless pipelaying. This is a term given to a wide variety of techniques and equipment which have the common characteristic of installing or renovating pipe without the need to trench. These trenchless pipelaying techniques include impact muling, pipe pushing, steerable moles, directional drilling, auger boring, microtunnelling and pipe jacking. The techniques of on-line replacement and in-situ renovation are now also included in this general term.

Thomson, James (Jason Consultants). *Int Constr* v 26 n 11 Nov 1987 p 80-82, 85, 87.

## Remote Control

**079033 SCADA FOR PIPELINE MONITORING AND CONTROL.** Supervisory control and data acquisition (SCADA) is a term used to describe the whole philosophy of electronic control and monitoring of plant processes, unlimited by distances, where a large amount of monitoring and few control points are used. Control center functions concentrate on all the information needed to monitor and control the pipeline - interactive graphic displays and reports, alarming and trending packages and event loggers with priorities given to pipeline safety sequencing.

Reeve, Alan. *Control Instrum* v 19 n 11 Nov 1987 p 55, 57, 59.

**Removal** See WATER PIPELINES—Wear.

**Repair** See Also GAS PIPELINES—Leakage; INVENTORY CONTROL—Reliability; NATURAL GAS PIPELINES—Offshore; SEWERS—FAILURE; WATER PIPELINES—Leak Detection.

**079034 PIPELINE LINER ENABLES REPAIR WITHOUT DISRUPTION.** First used commercially in the United Kingdom in 1973, the Insituform process has



been developed to overcome the problems of failing pipes, be they sewers or industrial pipework, underground or just inaccessible. Insituform provides a new structural lining within the original pipe, greatly extending its life. A liner is manufactured of polyester felt to fit exactly the internal dimensions of the pipe to be lined, the outer layer of felt is coated with polyurethane to seal the felt tube. Resin is then mixed with a catalyst and fed into the end of the soft felt liner, the resin totally impregnates the felt. The liner is then taken to site and turned inside out into the defective pipe. This is known as the inversion.

Anon. *Eur Water Sewage* v 91 n 1100 Oct 1987 p 417.

## Reviews

**079035 PIPELINE INFRASTRUCTURE, PROCEEDINGS.** This conference proceedings contains 49 papers, which concern pipeline infrastructure topics. The papers cover innovative pipeline design, condition monitoring, soil-pipe interaction, inspection, maintenance, and rehabilitation. The entire spectrum of pipeline fluid systems is discussed. This includes oil, gas, water, sewer, and steam piping systems. Seismic design is also addressed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11596 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Bennett, Bruce A. (Ed.) (Heat Exchanger Systems Inc, Boston, MA, USA). *Pipeline Infrastructure, Proc, Boston, MA, USA, Jun 6-7 1988* Publ by ASCE, New York, NY, USA, 1988 521p.

**River Crossings** See NATURAL GAS PIPELINES—Construction.

**Saarland, Federal Republic of Germany** See HEATING—District.

**Shock Waves** See Also HYDRAULICS—Shock Waves.

**079036 EFFECT OF A GROUND SHOCK WAVE ON AN UNDERGROUND PIPELINE.** Underground pipelines may be affected by seismic or explosive waves spreading in the ground. In a previous paper stationary problem was investigated where a seismic wave acted on an infinite pipeline modeled by an elastic rod and interacting through the surface with the surrounding ground. The present paper analyzes nonstationary motion of a semiinfinite pipeline - a rod affected by a stepped shock wave spreading in the ground. (Edited author abstract) 2 refs.

Nikitin, L.V.; Tyurekhodzhaev, A.N. *Mech Solids* v 22 n 1 1987 p 95-102.

## Simulation

**079037 PIPELINE SIMULATION INTEREST GROUP AGENDA, PSIG EIGHTEENTH ANNUAL MEETING.** This conference contains 9 papers. The subject matter is primarily concerned with monitoring, simulation and evaluation of transients associated with flow in pipelines. Some specific topics are optimal gas pipeline design, leak detection in pipeline networks, optimization of a city water distribution system, application of transient analysis to a pipeline system, transient flow simulation in natural gas pipelines, real time simulation on a gas transmission system, real time simulation of a batched pipeline network, real-time pipeline leak monitors, and composition tracking for pipeline networks. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11285 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Pipeline Simulation Interest Group). *Pipeline Simul Interest Group Agenda, PSIG Eighteenth Annu Meet, New Orleans, LA, USA, Oct 30-31 1986* Publ by Pipeline Simulation Interest Group, 1986 var pagings.

## Stability

**079038 STUDIES ON THE STABILITY OF PIPES CONVEYING FLUID: (THE COMBINED EFFECT OF A SPRING SUPPORT AND A LUMPED MASS).** The present paper deals with the combined effect of a spring support and a lumped mass on the stability of a tubular cantilever conveying fluid. The support and the mass are assumed to be attached to the cantilever at the same location. The validity of Galerkin's 8 term approximation is discussed from the viewpoint of predominant eigenmodes in critical flutter configurations. It is shown that for particular combinations of spring stiffness and lumped mass there exists an instability region which juts out from the main flutter domain. Both theory and experiment confirm that the instability in the region is of mild flutter type, not violent. (Author abstract) In Japanese. 11 refs.

Sugiyama, Yoshihiko; Kawagoe, Haruo; Kishi, Takeyasu; Nishiyama, Shoichi. *Nippon Kikai Gakkai Ronbunshu A Hen* v 53 n 492 Aug 1987 p 1728-1734.

**079039 INSTABILITY OF BURIED FLEXIBLE PIPE - PART 1.** This paper reviews various instability or buckling theories, models and tests, and proposes a method for predicting and preventing pipe buckling that is based on proven theory and consistent with experience. Many of its aspects depart substantially from the usual approaches. The paper also includes supporting data. (Author abstract).

Prevost, Robert C.; Kiewnow, Kenneth K. *Pipes Pipelines Int* v 33 n 3 May-Jun 1988 p 26-33.

**079040 INSTABILITY OF BURIED FLEXIBLE PIPE - PART 2.** This is the second part of a major investigation into the design of buried flexible pipe. In Part I the authors examined the theory of two basic instabilities, and discussed the experimental evidence that exists to date. Part 2 starts with the continuing review of the metal corrugated culvert. (Author abstract). 15 Refs.

Prevost, Robert C.; Kienow, Kenneth K. *Pipes Pipelines Int* v 33 n 4 Jul-Aug 1988 p 20-25.

**Stresses** See Also BELLOWS—Stresses; PETROLEUM PIPELINES—Accident Prevention; PIPELINES, SUBMARINE—Laying.

**079041 NOTCH DUCTILITY REQUIREMENTS OF LINE PIPES FOR ARRESTING PROPAGATING SHEAR FRACTURE.** Full-scale burst tests were carried out on X70 line pipes, 48 in. o.d.  $\times$  0.720 in. w. t., with air and rich and natural gas as the pressurizing gases. The experimental results indicated that very high notch ductilities of pipes are required for arresting propagating shear fracture especially in the case of the rich natural gas. From theoretical investigations a method was developed which enabled the prediction of the required notch ductilities of line pipes with regard to the type of gas, design stress and acceptable fracture length. (Author abstract) 6 refs.

Sugie, E. (Kawasaki Steel Corp, Jpn); Matsuoka, M.; Akiyama, T.; Tanaka, K.; Kawaguchi, Y. *J Pressure Vessel Technol Trans ASME* v 109 n 4 Nov 1987 p 428-434.

**079042 DETERMINATION OF STRESS FIELD IN BURIED THIN PIPELINES RESULTING FROM GROUND SUBSIDENCE DUE TO LONGWALL MINING.** When a pipeline is laid across a subsidence-prone area as a result of underground longwall mining, it is not always necessary to take measures to protect the full length of the pipe. In this paper, some guidelines are proposed for partial or full protection in order to prevent possible damage to the pipeline. The techniques of determining the magnitudes and locations of the maximum tensile and compressive stresses on the pipeline are developed. Based on the assumptions that the pipelines are thin and that the ground subsidence can be predicted by the probability function integration method. Two computer programs were developed to assist in the determination of the optimal control parameters of a

subsidence profile and evaluate the stresses on the pipeline. (Author abstract) 4 refs.

Peng, S.S. (West Virginia Univ, Morgantown, WV, USA); Luo, Y. *Min Sci Technol* v 6 n 2 Jan 1988 p 205-216.

**079043 ENGINEERING DESIGN METHOD CAN PREDICT TAPE WRINKLES.** Buried line pipe wrapped with tape, is subjected to shearing forces induced by the surrounding soil which can result in tape wrinkling. The authors propose an engineering design method to predict the time of wrinkling and describe the actions to be taken to avoid this problem. The proposed design method allows the following properties as variables: soil density, soil internal friction, burial depth, pipe radius, soil/coating friction coefficient, coating/soil adhesion coefficient, tape thickness, film elastic modulus, number and size of wrinkles. 3 refs.

Sancaktar, Erol (Clarkson Univ, Potsdam, NY, USA); Jozavi, Hooshang. *Pipe Line Ind* v 68 n 3 Mar 1988 p 45-49.

**Structural Analysis** See Also RINGS—Structural Analysis.

**079044 HIGH LEVEL DYNAMIC TESTING AND ANALYTICAL CORRELATIONS FOR A SMALL BORE PIPING SYSTEM.** High-level dynamic testing of a prototype insulated small bore diameter pipe system is described. The pipe system was supported by a minimum number of supports, with several combinations of supports and support locations tested. Load input consisted of a dynamic multifrequency time history and sinusoidal loading at increasing acceleration levels until gross deformation of the system occurred. Very high level pipe damping was exhibited when plastic response occurred. Post-test analyses were performed to assess the structural loading and response of the pipe system under the dynamic load input. Several elastic and elasto-plastic analysis failure prediction methods were used, along with simplified inelastic analysis. (Author abstract). 8 Refs.

Lindquist, M.R. (Westinghouse Hanford Co, Richland, WA, USA); Anderson, M.J.; Severud, L.K.; Weiner, E.O. *J Pressure Vessel Technol Trans ASME* v 110 n 3 Aug 1988 p 270-275.

## Substrates

**079045 EFFECTS OF LEE-WAKE ON SCOUR BELOW PIPELINES IN CURRENT.** The results of an investigation of the effect of lee-wake on scour below pipelines in currents are reviewed. The subject is investigated both experimentally and numerically. The experiments show that the scour downstream of the pipe is apparently governed by the action of an organized wake flow, which is an agglomeration of large-scale vortices which are shed from the pipe and steadily convected downstream. The experimental results lead to a clear understanding of the effect of lee-wake on the scour phenomenon. In the numerical part of the study the so-called cloud-in-cell method is employed to predict the flow. The results appear to reveal almost all the features of the organized wake flow shown by the experiments. The theoretical calculations demonstrate that the time average bed shear stress is not a suitable parameter to work with in mathematical-model studies of lee-wake scour. (Author abstract). 10 Refs.

Sumer, Mutlu, B. (Tech Univ of Denmark, Den); Jensen, Rene, H.; Mao, Ye; Fredsoe, Jorgen. *J Waterw Port Coastal Ocean Eng* v 114 n 5 Sep 1988 p 599-614.

## Thawing

**079046 THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE DYNAMICS OF FORMATION OF THE THAWING AUREOLE IN FROZEN SOIL AROUND A COMMUNICATION CORRIDOR.** A number of experiments and analysis of the thermal interaction between a communication corridor, consisting of different number of pipes, with frozen soils has been carried out. The repeatability of the experiments



has been checked and experimental data have been compared with the calculation results. (Translated author abstract) In Russian. 7 refs.

Danielyan, Yu.S.; Kudryavtsev, E.A.; Yanitskii, P.A. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 18 1987 p 113-119.

**Thermal Effects** See NATURAL GAS PIPELINES—Testing.

## Transients

**079047 INVESTIGATION OF NON-STATIONARY REGIMES OF THE MAIN PIPELINE.** A mathematical model describing thermohydraulic processes in main pipelines is presented in a form sufficiently complete for real tubing study. Originating from the difference in the thermal and hydraulic phenomena in the pipeline, the method of non-stationary thermohydraulic process division into two types of problems is suggested allowing a considerable simplification of the non-stationary oil flow regime study. The temperature dependence consideration of the friction factor is shown. Individual member effects in the model equations, taking into consideration different oil flow conditions, was estimated. The paper describes solution methods of thermal and hydraulic problems. (Edited author abstract) 2 refs.

Yevseyev, O.N.; Neronov, V.S. *Modell Simul Control B* v 15 n 2 1988 p 37-44.

**Trenching** See Also NATURAL GAS PIPELINES—Laying; PIPE—Supports.

**079048 INDUCED TRENCH METHOD - A CRITICAL REVIEW AND CASE HISTORY.** The "induced trench" method for buried pipe protection is reviewed. By installing a zone of relatively compressible material within the backfill above a pipe, soil arching is induced. This has the effect of reducing the vertical earth load on the pipe, permitting the pipe to be buried at a greater depth than would otherwise be tolerable. In many circumstances, the method can offer significant economic benefits over alternatives. The theory on which currently available design methods are based is somewhat outdated and fails to address many factors that affect performance. For a recent project in Calgary, Alberta, a nonlinear finite element simulation was carried out to optimize the design. Performance during and after installation was monitored. Vertical pressures on the pipe were significantly less than those predicted by conventional theory. There is a need for the development of a more rational approach that is suitable for routine design. (Edited author abstract). 18 Refs.

Sladen, J.A. (EBA Engineering Consultants Ltd, Calgary, Alberta, Can); Oswell, J.M. *Can Geotech J* v 25 n 3 Aug 1988 p 541-549.

**Vibrations** See Also FLOW OF FLUIDS—Pipes; SOILS—Underwater.

**079049 DYNAMICS OF BURIED PIPES IN BACK-FILLED TRENCH.** Dynamic response of pipelines lying in a back-filled trench in a semi-infinite medium is investigated. The pipelines are modeled as circular cylindrical shells of small thickness. The problems considered are the ones of plane strain, in which it is assumed that the waves are propagating perpendicular to the pipe-axes. Since no exact solution is obtainable for the problems considered here, a numerical technique that combines the finite element method with multipolar representation of the scattered field is used. Numerical results are presented for the normal displacements, as well as the hoop stress in the pipewall either in the presence or absence of another pipe lying nearby. (Author abstract) 11 refs.

Chin, Y.F. (Univ of Manitoba, Winnipeg, Manit, Can); Rajapakse, R.K.N.D.; Shah, A.H.; Datta, S.K. *Soil Dyn Earthquake Eng* v 6 n 3 Jul 1987 p 158-163.

**079050 LATERAL VIBRATION OF A CANTILEVERED FLEXIBLE PIPE CONVEYING FLUID (A**

**HORIZONTAL EXCITATION AT THE UPPER END OF THE VERTICAL PIPE).** The lateral vibration of a flexible pipe, which is hung vertically and conveys fluid is examined theoretically and experimentally for the case where the upper end of the pipe is periodically excited. Using nonlinear coupled equations with respect to axial fluid velocity and lateral deflection of the pipe, the complex equation governing the amplitude and the frequency of the lateral vibration is derived, near the critical fluid velocity above which the lateral vibration is self-excited. Furthermore, the experiment was conducted with the flexible pipe model conveying water. The heat phenomena in the lateral vibration of the pipe, as predicted by the theory, was observed slightly above the critical fluid velocity. (Author abstract) In Japanese. 7 refs.

Yoshizawa, Masatsugu; Ueno, Kazuo; Hasegawa, Eiji; Tsuchioka, Yasushi. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 497 Jan 1988 p 100-107.

## Wear

**079051 APRECLEREA GRADULUL DE UZURA LA O CONDUCTA.** [Estimation of the Wear-Out Degree in a Pipeline]. The possibilities of detecting, by calculation, a failure occurring in a pipeline, by continuously supervising the pumping technology are presented. A technique is also presented for the calculation of the rate of a liquid flowing through an orifice, on the basis of which any element of the relation can be deduced. (Edited author abstract) 2 refs. In Romanian.

Stan, Al. D. (Inst de Petrol si Gaze Ploiesti, Rom); Stolanovel, D. *Mine Pet Gaze* v 38 n 8 Aug 1987 p 373-378.

**Welding** See Also PIPELINES, STEEL—Corrosion Resistance.

**079052 EFFECT OF MODIFYING ADDITIONS ON THE SERVICE RELIABILITY OF WELDED JOINTS IN PIPELINES.** Results are presented of examining the separate and combined effects of microadditions of cerium and zirconium, as well as together with cobalt on the structure and toughness of deposited metal based on the manganese-nickel-molybdenum electrode alloying system. The experiments were carried out on VSt3sp steel. The results show that cold strength of deposited metal in the given alloying system can be increased by complex introduction into the composition of the electrode coating of cobalt, CO<sub>2</sub> and an Si-Zr master alloy. The beneficial effect resulting from the introduction of these components is obtained if the deposited metal contains 0.10-0.15%Co, <0.010%Ce, <0.006%Zr. 8 refs.

Rakhmanov, A.S. *Weld Prod* v 33 n 11 Nov 1986 p 22-24.

**079053 HEAT HARDENING OF ELECTRIC-RESISTANCE WELDED LARGE DIAMETER LINE PIPE.** The commercial production of heat hardened 820, 1020 and 1220 mm electric-welded thin-walled K-60 pipes from steel grades 17G2SF and 17GIS for 5.5 MPa gas and oil lines has been outlined. The mechanical properties of pilot batches of heat hardened 1420 x 14 mm 16GFR pipes and 1420 x 15.1 mm 17GIS-U pipes in strength categories K-70 and K-65 for 7.5 MPa Arctic lines have been analyzed. It has been shown that use of optimal heat hardening conditions results in property levels which meet the specification requirements. (Author abstract) 3 refs.

Pozdnyakov, L.G.; Atamanenko, V.A.; Pichurin, I.I. *Sov Mater Sci Rev* v 1 n 1 1987 p 109-113.

**079054 PERFORMANCE OF HEAT HARDENED SPIRAL-WELDED LINE PIPE.** The production of heat hardened spiral-welded pipes at the Volzhskiy pipe plant has been described. The heat hardening process has been found to be highly effective in terms of improved life, better resistance to brittle fracture and to ductile crack propagation, as well as higher design strength of pipes. Trends in the use of heat hardened pipes have been considered. (Author abstract)

Bolotov, A.S.; Anuchkin, M.P.; Al'tzitsler, A.Ya. *Sov*

*Mater Sci Rev* v 1 n 1 1987 p 115-117.

**079055 LONGITUDINAL WELDING OF PIPES WITH HIGH-FREQUENCY GENERATORS.** Electronics is indispensable for the longitudinal welding of pipes with high-frequency generators. Rising quality requirements and larger dimensions are leading of necessity to greater high-frequency outputs. Using a precise and quickly adjustable high-frequency output combined with a temperature control facility, it was possible to automate the welding operation of a second high-frequency generator with a high terminal output of 1100 kW. Pipes to API standard can also be welded with this generator. (Author abstract)

Wiehn, Peter. *Strips Sheets Tubes* v 4 n 2 Dec 1987 p 25-27.

**079056 MAG-ORBITALSCHWEISSEN IM ANLAGENBAU UND BAU ERDVERLEGETER ROHRLEITUNGEN.** [MAG Orbital Welding in Plant Construction and in the Installation of Earth-laid Pipelines]. The author compares the MAG orbital welding and drop joint welding techniques. He describes the method, the equipment and the power sources and explains the personnel requirements, additional materials, the course of the work and the welding parameters. Finally, he reports on his experiences in the construction of district heat pipelines in Copenhagen and Berlin. The new MAG orbital welding technology is currently only a supplement to drop joint welding, because its economy is dependent on the pipe dimensions and the thickness of the pipe walls. The MAG orbital method has been used in pipeline construction for some time in countries where climatic conditions are different from those prevailing in Europe. 3 refs. In German.

Vietz, Eginhard (E. Vietz Schweisstechnik, GmbH, Hanover, West Ger). *Fernwaerme Int* v 17 n 2 Mar-Apr 1988 p 72-77.

**079057 SHORTAGE OF SKILLS, LABOUR PUTS EMPHASIS ON MACHINERY.** The manual metal arc (MMA) welding process originated in the 1920s and continues to be the most widely used joining technique for pipeline construction on land. The fabrication procedure has hardly changed. The paper discusses the developments of welding processes in on-shore pipeline construction. These processes have not changed much in 60 years, but off-shore developments are pointing the way to higher welding speeds and improved quality, according to The Welding Institute based in Cambridge.

Anon. *Gas World* Jun 1988 p 14,16.

**079058 EFFECTS OF FLOWING PRODUCT ON LINE WELDABILITY.** Experiments on a flowing liquid-propane pipeline have established welding parameters for repair and hot-tap welding on pressurized pipelines. The welding experiments on a liquid-propane pipeline in service confirmed the influence of pipe-wall thickness (W.T.), heat input, fluid-flow velocity, and material carbon equivalent on safety and pipeline integrity. Data reported follow an earlier article which describes the computer models of the heat-transfer process during welding. In this article results of a series of hot-tap welding experiments are analyzed. 7 Refs.

Kieffer, J.F. (Battelle Columbus Div, Columbus, OH, USA). *Oil Gas J* v 86 n 29 Jul 18 1988 p 49-54.

## PIPELINES, CAST IRON

### Corrosion

**079059 DETERIORATION DIAGNOSIS IN IRON CONDUIT.** This paper describes a technique for diagnosing deterioration in iron conduits. The outer surface of an underground iron conduit corrodes to contact the soil. A non-contact measurement technique is developed for determining corrosion in iron conduits thinner than 4 mm by frequency-domain signal processing to an electromagnetic ultrasonic technique. Speedy diagnostic equipment using these techniques has been developed, while features



a new compact sensor which can be extended into conduits. (Author abstract) 11 refs.

Sudoh, Yoshikazu (NTT, Jpn); Honjoh, Katsuhiko; Masuda, Jun-ichi. *Rev Electr Commun Lab (Tokyo)* v 35 n 6 Nov 1987 p 701-706.

## PIPELINES, CONCRETE

### Concrete Construction

**079060 TECHNOLOGY OF CASTING PRECAST PIPELINE ELEMENTS OF THE KAISIADORYS PUMPED-STORAGE STATION.** The Soviet construction industry widely used superplasticizers—technological additives to the concrete mix having properties of brief effective dilution of the concrete mix for a period of its placement of 1.5-2.0 h from the time of mixing and not affecting the structural and deformation properties of the concrete, since it does not enter into chemical reactions occurring in the concrete during its hardening. Among such effective diluents of a concrete mix are the superplasticizer S-3 (technical specifications TU 6-15-623-80) and —Dofen— (TU 6-188-81) developed for the manufacture of precast reinforced concrete at casting yards or factories. The use of the cast concrete mix with a superplasticizer for concreting structures is technically expedient and economically effective. Such structures are: bored piles, heavily reinforced structures, plain cast, those cast in reinforcement panels, precast pipelines, etc.

Ospov, A. D.; Yudina, N. V.; Yakubonis, R. A.; Velanishkis, I. M.; Lyapin, O. B.; Slozhenikin, V. V. *Hydrotech Constr* v 21 n 7 Jul 1987 p 436-441.

Inspection See HEATING—Pipelines.

### Laying

**079061 REINFORCED CONCRETE PIPES FOR PIPEJACKING.** The impact of loading on the still young construction method of pipe-jacking is evident. As can be seen, different load induction areas can occur and act upon the pipe which greatly affect the stress and strain it is subjected to. Proceeding from the Kolosov principle on stress functions a generally applicable relation on effecton earth loads can be derived for calculating the earth load development. Suggestions on the background and further possible applications of the theory complete the observation. The bibliography contains a selection of the applied theoretical principles and information on existing literature on pipe-jacking. (Edited author abstract) In German and English. 23 refs.

Vogler, Georg. *Betonwerk Fertigteil Tech* v 53 n 12 Dec 1987 p 851-856.

### Performance

**079062 ANALYSIS OF REINFORCED CONCRETE-PIPE PERFORMANCE DATA.** Concrete pipes may be subject to deterioration from various conditions, including freeze-thaw weathering, acid corrosion, sulfate disruption, velocity abrasion of the concrete, and chloride corrosion of the reinforcing steel. The service life of reinforced concrete pipe thus varies significantly. Also, there are few detailed studies on concrete-pipe durability. Furthermore, analyses of the same data by different researchers have produced equations predicting dramatically different service lives. The results of two researchers' analyses in the form of service-life equations, based on the most complete data set available, are presented and analyzed. While neither of their service-life equations can be judged a good model of concrete-pipe deterioration, one is shown to better model actual field performance. This analysis also suggests the direction for future data-collection efforts. (Edited author abstract). 6 Refs.

Potter, John C. (US Army Engineers, Vicksburg, MS, USA). *J Transp Eng* v 114 n 5 Sep 1988 p 530-538.

### Standards

**079063 MANHOLE SYSTEMS: A DESCRIPTION OF PREFABRICATED MANHOLES FOR GRAVITY-FLOW PIPELINES ESPECIALLY PRODUCED IN SCANDINAVIA.** Demands on the design of manhole bases are being introduced in norms and standards. The latest Danish Standard of concrete pipes thus contain detailed demands on geometrical design. In order that a manhole system can form a natural part of a drainage and sewerage system it is necessary to have a well-developed range of fittings such as short-length pipes, double-spigot pipes, reducing pipes, bends and junctions. The manhole base itself must not be heavier than absolutely necessary to avoid using extra heavy lifting gear for the work. The lower weight limit is, however, decided by production considerations. There are both advantages and disadvantages connected with the use of prefabricated manholes. In conclusion, some of these are mentioned in this article. In German and English.

Ingwersen, John B. *Betonwerk Fertigteil Tech* v 53 n 9 Sep 1987 p 627-631.

### Trenching

**079064 NEW DUTCH METHOD FOR THE CALCULATION OF LOADS ON BURIED PIPES AND THEIR ANALYSIS.** The report on which this article is based has been published by the Netherlands Centre for Research and Development in the Field of Concrete (CUR), Gouda, in collaboration with the Delft University of Technology's Institute for Soil Mechanics and the consulting engineers' firm of DHV, Amersfoort. We believe that with CUR 122 we have split up an overall problem into manageable parts. Many of the assumptions made are controversial, but with the overview that we now have we can study each detail and, if necessary, improve it. We are convinced that this will lead to further improvement in the analysis of buried pipes. It emerges that, in comparison with the other pipe materials considered here, concrete—the construction material par excellence of this century—offers the most reliable solution. (Edited author abstract) In German and English.

Geene, W.F. *Betonwerk Fertigteil Tech* v 53 n 9 Sep 1987 p 621-626.

## PIPELINES, STEEL

Cathodic Protection See Also NATURAL GAS PIPELINES—Leak Detection.

**079065 MAGNESIUM ANODE UTILIZATION.** Magnesium is one of the most effective and economical metals for underground sacrificial anodes because of its strong anodic potential and high electrochemical equivalent. The most practical and economical method of providing cathodic protection for coated pipelines is a system of anodes distributed along the length of the pipeline. Installations vary from one anode per mile to groups of three or four anodes with a spacing between groups of 2 to 5 miles.

Anon (Pipeline & Gas Journal, Dallas, TX, USA). *Pipeline Gas J* v 215 n 2 Feb 1988 p 23-24, 26.

**079066 HYDROGEN GAS EVOLUTION FROM CATHODICALLY PROTECTED PIPELINE STEEL SURFACES EXPOSED TO CHLORINE-SULFATE SOLUTIONS.** An experimental study of the conditions for hydrogen discharge and the associated pH changes in chloride-sulfate solutions was conducted for different pipeline steel surface conditions. The highest potential for gas discharge is shown to be in reasonable agreement with the value quoted in the literature ( $-1.15 \text{ V Cu-CuSO}_4$ ) for pipeline surfaces exposed to other solutions, although somewhat higher potentials can prevail if the surface has previously been exposed to lower potentials. The extent of gas evolution is essentially determined by the magnitude of the current flowing at the surface, which varies with the polarization characteristics of different surfaces and solution compositions. The associated pH value increases in the solution, a matter of considerable importance in

relation to coating disbondment or the generation of a potent stress corrosion cracking (SCC) environment, are dependent upon solution composition as well as the amount of gas evolved. (Edited author abstract). 5 Refs.

Parkins, R.N. (University of Newcastle upon Tyne, Newcastle upon Tyne, Engl); Markworth, A.J.; Holbrook, J.H. *Corrosion (Houston)* v 44 n 8 Aug 1988 p 572-580.

### Cavitation Corrosion

**079067 CORROSION-EROSION CONDITION OF THE STEEL TUBES OF NO. 4 LOW-PRESSURE FEEDHEATER DURING A LONG PERIOD OF OPERATION WITH OXYGEN WATER TREATMENT.** A mandatory condition for changing over supercritical power-generating units to oxygen water treatment is that there must be no elements of plant fabricated from copper-containing alloys after the condensate polishing plant, so as to prevent entrainment of copper compounds into the turbine with subsequent build up in the flow section of the high-pressure cylinder. The experience which has been gained over 13 years with stainless steel tubes in 1.p feedheaters with oxygen treatment of water has shown their high operational reliability. Industrial testing under oxygen water treatment conditions of tubes of 20K steel of diameter 16 mm and with wall thickness of 1.5 mm was started in February 1979 on No. 4 1.p. feedheater of the No. 4 300 MW generating unit at Konakovo CP Station. During a six-year period of testing, i.e. from 1979 to March 1985, No. 4 unit worked for 45 500 h, 85% of the calendar time. The mean annual operational characteristics with oxygen water treatment during these years were below the Standard levels, iron concentration in the feedwater and live steam varying within bounds of 5-7  $\mu\text{g/kg}$ . 5 refs.

Shitsman, M.E. (G.M. Krzhizhanovskii Power Engineering Inst, Konakovo, USSR); Midler, L.S.; Breiterman, S.A.; Ryzhkov, F.E. *Therm Eng* v 34 n 12 Dec 1987 p 656-659.

### Construction

**079068 EXPERIENCE IN THE CONSTRUCTION AND OPERATION OF STEEL PRESSURE PIPELINES OF HYDROPOWER DEVELOPMENTS.** The experience of designing, constructing, and operating high-head hydro developments, primarily of a power purpose, indicates considerable success of Soviet pipeline construction. With respect to the achieved indices of HD and HD<sup>2</sup> (H, head; D, pipe diameter) Soviet pipelines are not inferior to the largest foreign representatives. The construction of pipelines at the Nurek, Charvak, Krasnoyarsk, Shamba, Sayano-Shushenskoe, and other hydroelectric stations and the Zagorsk and Kaisiadorys pumped-storage stations was accompanied by the creation of new designs and technologies concerning the construction of branches, the use of effective high-strength steels, mechanization of assembly and welding operations on slopes and in tunnels in combination with drilling and grouting operations, high-productivity technology of manufacturing reinforcement cages and links, and improvement of inspection methods. 4 refs.

Freishtat, A.R. *Hydrotech Constr* v 21 n 3 Mar 1987 p 123-134.

Corrosion See Also PIPELINES—Offshore; SLURRY PIPELINES—Erosion; STEEL CORROSION—Underground.

**079069 USE OF LATERAL OR SIDE-DRAIN POTENTIALS TO INDICATE EARTH CURRENT DIRECTION ON BARE PIPELINES.** Lateral or side-drain potentials measured over and/or transverse to a buried pipe have been used to assess hot spots (current discharge areas) on unprotected pipe. In some cases, side-drain potentials have been used to indicate the direction of cathodic protection current criterion recommended in NACE Standard RP0169-83. Research has



shown by computer simulation and field measurements that the current (direction and magnitude) at the pipe is linearly related to the ground level transverse potential gradient. The lateral distance of the reference electrode(s) is important for correct interpretation of current direction, particularly with distributed-anode protection systems. There are minimum values for the transverse potential gradient that must be exceeded to have confidence that the net current on the pipe is all cathodic. (Author abstract) 2 refs.

Barlo, Thomas J. (Science Applications Int Corp, Hoffman Estates, IL, USA). *Mater Perform* v 27 n 5 May 1988 p 49-57.

**079070 APPLICATION OF THE SLOW STRAIN RATE TEST METHOD FOR THE DEVELOPMENT OF LINEPIPE STEELS RESISTANT TO SULPHIDE STRESS CRACKING.** High grade linepipe steels may be sensitive to hydrogen embrittlement in sour environments. This sensitivity may appear under conditions of sulphide stress cracking (SSC) and even in the absence of applied stress. Several metallurgical parameters play a role in this susceptibility. In this study, only SSC is considered. The slow strain rate technique (SSRT) is shown to complement the constant load test method (NACE TM01-77) in pointing to the influence of some metallurgical parameters and to differentiate more accurately the behaviour of some high grade linepipe steels. The influence of specimen orientation with respect to rolling direction, of rolling conditions and segregation leading to the formation of hard bands on cooling is particularly considered. The influence of experimental conditions on the SSRT results is discussed. The results obtained by these two test methods are in agreement, although SSRT seems more accurate and selective. The choice of sensitivity criteria is discussed and the criterion best describing the material behaviour in the corrosive environment is the normalized uniform elongation. This criterion represents the loss of ductility of the steel due to hydrogen embrittlement. (Author abstract) 35 refs.

Margot-Marette, H. (IRSID, St. Germain-en-Laye, Fr); Bardou, G.; Charbonnier, J.C. *Corros Sci* v 27 n 10-11 1987 p 1009-1026.

**079071 CORROSION AND HYDROGEN-INDUCED CRACKING OF PIPELINE STEEL IN MOIST TRIETHYLENE GLYCOL DILUTED WITH LIQUID HYDROGEN SULFIDE.** The corrosion of flowline steel in mixtures of liquid  $H_2S$  and triethylene glycol (TEG) at 3°C increases with increasing water content. With 1% of water in the total liquid no corrosion occurs even in the presence of elemental sulfur and chlorides. With 2% of water in the total liquid corrosion occurs at and above 5°C. At 3°C contact of steel with elemental sulfur considerably enhances the corrosion rate, but not the susceptibility to hydrogen-induced cracking (HIC) which is in contrast to sour systems without liquid  $H_2S$  at or above 10°C. The presence of NaCl stimulates HIC. Increasing the temperature from 3 to 7°C significantly enhances the corrosion rate. Additional  $CO_2$  yields no extra effects. (Author abstract) 2 refs.

Schmitt, Guenter (Ruhr-Univ Bochum, West Ger); Sobbe, Ludger; Bruckhoff, Wolfgang. *Corros Sci* v 27 n 10-11 1987, Hydrogen Sulphide Induced Environ Sensitive Fract of Steels, Sel Proc from the Int Conf, Amsterdam, Neth, Sep 10-12 1986 p 1071-1076.

**079072 HYDROGEN PERMEATION AND HYDROGEN-INDUCED CRACKING BEHAVIOUR OF LINEPIPE IN DYNAMIC FULL SCALE TESTS.** Full scale simulation tests have been conducted on large diameter linepipes of API grade from X42 to X65 with various hydrogen-induced cracking (HIC) susceptibilities. The pipes are tested under pressure of 72% SMYS with circulating dynamic natural gas including 0.2 or 1.5 MPa of  $H_2S$  partial pressure and 3.0 MPa of  $CO_2$  partial pressure brine present at the bottom of the pipes. The influence of  $H_2S$  partial pressure, gas velocity and chemical composition of the pipes on the hydrogen permeation behavior and HIC occurrence are studied by electrochemical measurement, ultrasonic test and metallographic

observation. The relationship between the full scale tests and laboratory tests are also discussed. (Author abstract) 19 refs.

Hyodo, T. (Iron & Steel Inst of Japan, Tokyo, Jpn); Iino, M.; Ikeda, A.; Kimura, M.; Shimizu, M. *Corros Sci* v 27 n 10-11 1987 p 1077-1098.

**079073 USE OF FRACTURE MECHANICS IN SULPHIDE STRESS CRACKING TESTING.** The traditional test method for sulphide stress cracking, i.e. the NACE TM 0177, provides a frame of conformity and gives an index of susceptibility of the tested steels. It gives, however, very little information of direct engineering use. By the use of fracture mechanics testing it is possible to obtain more quantitative data for use in predictive life analysis, etc. The step-loading test method has been shown to produce reliable test results of  $K_{ISCC}$  for sulphide-induced hydrogen crack initiation in a relatively short test time and with a minimum number of test specimens. (Author abstract) 5 refs.

Christensen, C. (Korrosioncentralen ATV, Copenhagen, Den); Hill, R.T. *Corros Sci* v 27 n 10-11 1987 p 1137-1144.

## Corrosion Resistance

**079074 STAINLESS STEEL GAINS GROUND ON CORROSION.** In the continued effort to enhance corrosion resistance, such elements as nickel, molybdenum, and titanium have been added to today's stainless steels. The results have been alloys that exhibit tremendous strength, along with greatly increased corrosion resistance. Of these complex stainless steel superalloys, the 300 series appears to demonstrate these qualities best. And it is from two specific products within the 300 series, Type 301 and Type 304, that most stainless steel pipe, couplings and other fittings are made. In the results of tests conducted by the National Bureau of Standards there is evidence to show that, in its current formulation containing 18 percent chromium and 8 percent nickel, Type 304 is superior to Type 301 in corrosion resistance. This is especially true where underground, in-soil applications are concerned.

Tarara, James (Clamp-All Corp, Haverhill, MA, USA). *Water Eng Manage* v 135 n 1 Jan 1988 p 33-34.

**079075 RESISTANCE OF WELDED LINEPIPES TO SULFIDE STRESS CRACKING.** The SSC behavior of welded linepipes has been studied using tensile SSC tests (NACE TM-01-77), full thickness SSC tests, and full scale SSC tests. The results have indicated that homogenization of microstructures, which can be attained by reducing a carbon content to <0.05% or by quenching and tempering, improves the resistance to SSC. Most specimens from SAW welds fail at the heat affected zone (HAZ), regardless of differences in the microstructures of the parent materials, and they show nearly the same level of  $\sigma_{th}/\sigma_y$  ratio. Detailed metallographic examinations have been performed in order to understand the influences of steel chemistries and heat inputs in welding on the SSC resistance of the HAZ. Relations between the results of the laboratory tests and full scale tests are also discussed. (Author abstract) 11 refs.

Kobayashi, Y. (Nippon Kokan KK, Fukuyama, Jpn); Ume, K.; Hyodo, T.; Taira, T. *Corros Sci* v 27 n 10-11 1987 p 1117-1135.

## Failure

**079076 UNSTABLE FRACTURE TEST OF CIRCUMFERENTIALLY CRACKED TYPE 304 STAINLESS STEEL PIPES.** The authors are performing an unstable fracture test of circumferentially cracked pipes in order to investigate the possibility of mitigating the conservative assumption of guillotine break in lightwater reactor pressure boundary piping. The tests were performed at 285°C and at 6.86 MPa using type 304 stainless steel pipes of 165.2 mm in diameter and 11.0 mm in thickness. It is concluded that the predicted fracture load by the net-section-stress approach is conservative in a limited range of crack dimensions. (Author abstract) 9

refs. In Japanese.

Ueda, Shuzo; Kurihara, Ryoichi; Kato, Kiyoshi; Onizawa, Kunio; Sekiya, Hideo; Miyazono, Shohachiro. *Nippon Kikai Gakkai Ronbunshu A Hen* v 53 n 495 Nov 1987 p 2097-2100.

## Lining

**079077 ABRASION RESISTANT PRODUCTS AND LUBRICATION.** The china clay has always been extracted by washing it out of the kaolinized granite with water. It is difficult to imagine a more abrasive mixture than mica, quartz sand and granite stone and this problem is exacerbated by the large volumes involved. The engineering and equipment arm of ECC International Ltd, now known as Charlestown Engineering, commenced a detailed search for a suitable pipe lining material which would give the necessary life. As a direct result of the successful test program it was decided that the pipeline would be lined with a polyurethane lining. The first pipes for this micaceous residue system were laid and commissioned in 1972. To date, the promised performance of the early test work on polyurethanes has more than lived up to expectations. In addition to its anti-abrasion properties, polyurethane has excellent tolerance to a wide range of corrosive materials, making it an ideal solution to wear problems in most industries.

Anon. *Mine Quarry* v 17 n 6 Jun 1988 p 20-22.

## Manufacture

**079078 MODERN BRITISH STEEL SELLS QUALITY PIPELINE TO THE WORLD.** British Steel's Tubes Division operates modern tube-making mills at Corby in Northamptonshire, in the north-east, in Scotland and in the East Midlands to supply world markets with high-quality linepipe for gas transmission. The processes used to produce to American Petroleum Institute (API) standard are by electric welded and submerged arc welded pipe methods, and by seamless pipe manufacture. Electric welded linepipe, manufactured by the division's Welded Business - the Tubemasters - is increasingly being accepted for high-integrity applications such as linepipe. The paper gives a review of the revitalised corporation which, after spending millions on modernising and restructuring its plants, is finding a ready home and export market for its gas transmission products.

Anon. *Gas World* Jun 1988 p 12-13.

Pressure Effects See PRESSURE VESSELS—Stresses.

## Protective Coatings

**079079 SHORTER FBE-COATING TESTS PASS TRIALS.** Evaluations by NOVA Corp. of Alberta have shown that 24-hr cathodic-disbondment tests of fusion-bonded epoxy pipeline coatings will indicate coating adhesion as reliably as the industry-standard 48-hr tests. These results imply significant cost savings during pipe-laying operations when these routine tests indicate the need for recoating a section of pipe. 3 Refs.

Coulson, K. (NOVA Corp of Alberta, Calgary, Alberta, Can); Temple, D. *Oil Gas J* v 86 n 33 Aug 15 1988 p 57-59.

Quality Control See STEEL TESTING—Fracture.

## Testing

**079080 ROTATING-DRUM RIG FOR TESTING PIPELINE ANOMALY DETECTORS UNDER SIMULATED LINE PRESSURE.** A rig for testing magnetic flux leakage detectors for pipeline monitoring applications is described. It uses short sections of line pipe supported and driven by two pairs of truck wheels. Test detectors are pressed against the outside of the pipe. Detector design, including the use of neodymium-iron-boron magnets and finite-element flux leakage calculations, is described. Experimental results are presented and signal processing and noise are discussed. A hydraulically pressurized



sealed pipe has been used to investigate the effects of line-pressure stress on detector performance. (Author abstract) 5 refs.

Atherton, D.L. (Queen's Univ, Kingston, Ont, Can); Welbourn, C. *Mater Eval* v 46 n 1 Jan 1988 p 101-107.

**Welding** See Also GAS PIPELINES—Welding; NATURAL GAS PIPELINES—Welding.

**079081 STILL WELDING IN THE WASTES?** No, there isn't a misprint in the headline. It really refers to desert waste conditions and not to waste, although there is naturally some of this as well. The one recalls the old 'Karl May', the other a desolate region where one is always thirsty. Those of a romantic nature may perhaps recall an old dream, lounging at an oasis surrounded by a whole bevy of ladies from the harem, letting the sun shine on their bellies. Only very few of the local latitudes can be safely recommended for working in the desert, for example, for welding. Yet that too is more or less on the agenda, for example, when it involves the laying of pipelines in unalloyed steels. (Author abstract) In German and English.

Salko, Djozic. *Schweissen Schneiden* v 39 n 1 Jan 1987 p E13-E15.

**079082 FIELD GIRTH WELDING OF HIGH ALLOY LINE PIPE.** The mechanical and corrosion properties needed for the welding of duplex stainless steel and high alloy internally clad line pipe were investigated. Typical problems experienced in the welding of duplex stainless steel and high alloy internally clad line pipe are low deposition rate in the GTAW process and high weld repair in the SMAW process. Ferrite-austenite balance corrosion resistance and higher productivity were also studied in the field girth welding of duplex stainless steel pipe. The optimum welding material for the welding of high alloy internally clad line pipe was investigated, and the best groove configuration and welding conditions for low dilution were also studied. (Author abstract). 10 Refs. In Japanese.

Nakanishi, Mutuo; Komizo, Yu-ichi; Akasaka, Mitsuo. *Sumitomo Met* v 40 n 2 Apr 1988 p 193-206.

**PIPELINES, SUBMARINE** See Also PETROLEUM PIPELINES.

**079083 WAVE-INDUCED FORCES ON BURIED PIPELINES.** An analytical model is developed for estimating the pore pressure in the soil and the resulting pressure force on buried pipelines. A solution is developed for a circular, rigid pipeline using conformal mapping techniques. The solution is compared with the results of both small- and large-scale tests; reasonable agreement is obtained for the small-scale tests. Wave-induced seepage forces are evaluated by integrating the pressure distribution over the pipe surface. The magnitude of the force remains constant but the direction rotates around the cylinder once with the passage of each wave. This force may be of sufficient magnitude to be an important consideration in the design of buried marine pipelines. (Edited author abstract) 32 refs.

McDougal, William G. (Oregon State Univ, Corvallis, OR, USA); Davidson, Susan H.; Monkmeyer, Peter L.; Sollitt, Charles K. *J Waterw Port Coastal Ocean Eng* v 114 n 2 Mar 1988 p 220-236.

**079084 WAVE FORCE COEFFICIENTS FOR SUBMARINE PIPELINES.** Wave-induced forces on a submarine pipeline in regular waves placed near a plane boundary were studied in the inertia-drag regime. Rms hydrodynamic coefficients were correlated with Keulegan-Carpenter number or period parameter, gap ratio, and depth parameter. The rms hydrodynamic coefficients were found to depend not only on period parameter and gap ratio but also on depth parameter. The dependence of the hydrodynamic coefficients on depth parameter is such that they decrease with a decrease in depth parameter. The presentation of the results as a single force coefficient, such as rms coefficients, is found to reduce the scatter in the

results considerably and avoids any phase problems. Additional results are discussed. (Edited author abstract) 21 refs.

Jothi Shankar, N. (Natl Univ of Singapore, Singapore); Cheong, Hin-Fatt; Subbiah, K. *J Waterw Port Coastal Ocean Eng* v 114 n 4 Jul 1988 p 472-486.

**079085 NEW PIPELINES ON LAND AND ACROSS VICTORIA HARBOUR, HONG KONG.** This paper describes the design and construction of twin submarine pipelines laid across Victoria Harbour, Hong Kong, and pipelines laid on land in the extensively urbanized and populated areas of Kowloon peninsula and Hong Kong island. The pipelines form a new link in the treated-water trunk mains system, and with a designated capacity of 180 Ml/d are required to carry about half the demand of Hong Kong island. (Author abstract)

Little, M.J. (Binnie & Partners, Hong Kong). *Pipes Pipelines Int* v 33 n 2 Mar-Apr 1988 p 8-17.

**079086 SURVEYING THE ROUTE FOR THE GREEN CANYON 29 PIPELINE TOW.** The world's longest and deepest bottom-tow pipeline installation required innovative survey and positioning support at every phase of the operation. This article discusses how it was accomplished.

Scott, Roger J. (Wimpol Inc, Houston, TX, USA). *Ocean Ind* v 23 n 5 May 1988 p 27-30.

## Accident Prevention

**079087 OVERHEAD HAZARDS TO SUBSEA INSTALLATIONS.** The growing use of subsea systems has required that traditional onshore and topsides functions be adapted for an underwater environment. While the problems of hydrostatic pressure, buoyancy, hydrodynamic effects and corrosion (for example) leave solutions to be found, the methodology exists to approach these aspects of design which are understandable and well defined. It has not however been historically necessary to develop a process or philosophy onshore or offshore for dealing with a complex regime of 'accidental' loads from overhead. This paper discusses an appraisal methodology, to evaluate overhead regards in subsea installations.

Head, J.W. (KE Int Ltd). *Pipes Pipelines Int* v 32 n 4 Jul-Aug 1987 p 25-26.

## Analysis

**079088 UPHEAVAL CREEP OF BURIED HEATED PIPELINES WITH INITIAL IMPERFECTIONS.** Based on a study of the soil-pipeline interaction, a new design procedure is presented for heated marine pipelines buried in the seabed. It has been observed that geometric imperfections in buried heated pipelines can increase in size with time such that the compressive stresses induced due to thermal expansion and internal pressure can lead to vertical buckling of the pipeline. In the present paper a consistent theory is developed for analysis of imperfect, heated pipelines. It is shown that the observed gradual upheaval can be caused by temperature fluctuations in combination with initial imperfections of the pipeline. For a given pipeline temperature and burial depth the mathematical model can be used to impose restrictions on the allowable imperfections of the unloaded pipe centre line (plastic deformations) combined with restrictions on the allowable imperfections of the trench. (Author abstract). 9 Refs.

Pedersen, P. Terndrup (Technical Univ of Denmark, Lyngby, Den); Jensen, J. *Mar Struct* v 1 n 1 1988 p 11-22.

## Computer Aided Design

**079089 PROGRESS TOWARDS AN INTELLIGENT COMPUTER AIDED RISK EVALUATION OF PIPELINE DESIGNS.** The design of an offshore pipeline is a complex activity involving teams of engineers and scientists. It is the task of the design team to produce a blue-print for the pipeline which, in addition to satisfying

the primary function of transporting the specified fluid product across the marine environment, must clearly recognize and make appropriate allowances for the many risks to which an offshore pipeline will be exposed, while incurring minimum life cycle costs. The paper discusses results of pipeline reliability studies, and detailed analysis of failures. Refs.

Strutt, J.E. (Cranfield Inst of Technology, Engl); Stead, J.P.; Billingham, J. *Pipes Pipelines Int* v 32 n 4 Jul-Aug 1987 p 7-13.

**Construction** See Also PETROLEUM PIPELINES—Offshore; PIPELINES—Construction.

**079090 HOT TAPPING OF SUBSEA PIPELINES.** Over 100 subsea hot taps have been performed worldwide to connect lateral lines to existing submarine pipelines, the majority in the Gulf of Mexico. They include both welded and mechanical type tee fittings. This article reviews the state of the art in subsea hot tapping with particular emphasis on the welding aspects. (Author abstract)

Boran, John (PLT Offshore Ltd). *Weld Rev* v 6 n 4 Nov 1987 p 283-284, 286, 288.

**079091 SUBSEA STRUCTURES AND METHODS INSTALLATION.** Subsea flowlines, vital to the development of future hydrocarbon comprise two main types - steel flowlines and flexible lines. Both have places in fluid transportation, each having advantages and disadvantages in relation to the other. However, once the flowline has been selected the method of installation becomes crucial, particularly with regard to ease of operation and cost. (Author abstract)

Anon. *Mar Eng Rev* Apr 1988 p 36-37.

## Design

**079092 SUBSEA HOT TAPPING: A REVIEW OF APPLICABLE CODES AND STANDARDS.** Hottapping on pipelines has primarily been carried out for the tie-in of lateral lines while maintaining the pipeline under operating conditions. When hot tapping has been combined with stopping techniques it has been used for repair of damaged pipelines without the need to decommission the line. This article reviews the codes and standards applicable to hot tapping on subsea pipelines. Codes are compared for the various aspects of design, construction, installation and testing. Most of the codes have been developed for onshore environments and little reference is made to subsea aspects. The codes mainly address the requirements for welded-type hot-tap fittings, giving little or no consideration to the use of mechanical-type tees. Areas where guidance and future developments are required are outlined. (Author abstract).

Williams, R.J. (John Brown Engineers & Constructors Ltd). *Pipes Pipelines Int* v 33 n 3 May-Jun 1988 p 20-25.

**Earthquake Resistance** See Also OFFSHORE STRUCTURES—Structural Design.

**079093 CHOICE OF THE DEPTH OF LAYING SUBMARINE PIPELINES UNDER THE CONDITIONS OF SEISMIC ACTIVITY.** Based on an analysis of the failure rate of pipelines after intensive earthquakes, recommendations are given on the selection of the depth of laying into the soil of underwater pipelines as applied to the pipelines between the North Sakhalin oil and gas wells and the Soviet Far East mainland. It is recommended that 79% of the length of the pipeline should be laid in shallow trenches (up to 1.5 m in depth) and 21% in deep-trenches (from 1.5 to 4.5 m deep). (Translated author abstract) In Russian. 7 refs.

Asta'ev, V.I.; Kandaurov, A.A. *Izv Vyssh Uchebn Zaved Neft Gaz* n 12 Dec 1987 p 75-78.

## Failure

**079094 COLLAPSE OF DEEPWATER PIPELINES.** The paper describes a series of full-scale collapse experiments using X-42 and X-65 grade steel tubes. The



initial geometric imperfections of the tubes were measured using a specially designed scanning facility prior to collapsing them under external pressure. Geometric deviations from a circular shape were recorded at 90 points around the circumference. The wall thickness was also recorded at the same points. At least 31 circumferential scans were made over lengths of 9 diameters. The stress-strain characteristics in the axial and circumferential directions were measured for each tube. The measured parameters were used to calculate numerically the collapse pressures of the tubes. (Edited author abstract) 13 refs.

Yeh, M.K. (Univ of Texas at Austin, Austin, TX, USA); Kyriakides, S. *J Energy Resour Technol Trans ASME* v 110 n 1 Mar 1988 p 1-11.

## Insulation

**079095 DOUBLE PIPE ENSURES RELIABLE INSULATION OF OFFSHORE PIPELINES.** At the beginning of the eighties, the offshore technology relevant to thermally insulated pipelines did not offer a cost-effective and technically challenging solution. Nowadays, the oil industry requires an ever-increasing use of thermally insulated pipelines with improved reliability in the offshore and, more particularly, for the exploitation of arctic fields. The present solution has been developed on the basis of easy handling, conventional laying procedures and long-term integrity criteria adopting a special field joint connector. This type of connector allows the two coaxial pipes to be assembled in a workshop and the individual double pipe sections to be connected in the field by means of a standard butt weld. This paper includes: the presentation of the DPIS (Double Pipe Insulated System) concept, which deals with the structural and thermal insulation aspects relevant to this new system; and a brief description of the first application of the DPIS for a pipeline connecting an unloading terminal for heavy oils to onshore plants. (Author abstract). 10 Refs.

Bruschi, R. (Snamprogetti S.p.A., Italy); Gambelli, L.; Pierangeli, P.; Raffaelli, E. *J Energy Resour Technol Trans ASME* v 110 n 2 Jun 1988 p 59-67.

**Joints** See Also OIL WELL PRODUCTION—Sub-Sea Production System.

**079096 CONCEPTS FOR MAINLINE PIPELINE TIE-INS.** There are now a large number of pipelines in the North Sea for the transportation of oil and gas. This paper considers the current development of pipelines in the North Sea and then discusses methods by which subsea junctions may be installed in both new and operating pipelines. Operating considerations are identified and conclusions drawn. 1 Ref.

Barber, W.A. (Brown & Root Vickers Ltd). *Underwater Technol* v 14 n 2 Summer 1988 p 3-9.

## Laying

**079097 FLEXIBLE PIPELINES.** A crucial part of an offshore transport system is the pipeline. Underwater pipelines must carry a specified fluid at a given internal pressure, be adequately protected against internal and external corrosion, be able to resist external hydrostatic pressure, and to withstand any loads that might arise in the course of installation. These layered, or flexible, pipelines have been used successfully in offshore oil and gas installations. They are constructed of steel, for mechanical strength, and of thermoplastics, for protection against corrosion and leaks.

Shekher, Vinod. *Mech Eng* v 109 n 2 Feb 1987 p 82-83.

**079098 SUBSEA PIPE BURIAL.** The laybarge Delta I broke its own record for laying and burying pipelines in a 24-hr period on April 16, 1987. The contractor laid and buried, to a depth of 3 ft in 60 ft of water, a total of 9,158.3 ft of 6-in. pipe in the period. The line is part of a gas gathering system being built by Corpus Christi Oil & Gas in West Cameron Block 238, offshore Louisiana. The Mudbug was used in the project.

Anon. *Pipeline Gas J* v 214 n 10 Oct 1987 p 33-35.

**079099 PIPELAYING FROM A BARGE.** New problems in the laying of steel pipelines on to the sea-bed have appeared with the advent of relatively deep water, offshore oil and gas developments. The laying of these pipelines from a barge is controlled by the geometry of the stinger and the applied tension. Correct settings of these two parameters are essential to ensure that the pipe does not suffer any damage during its installation. A three-dimensional, large rotation model, for which the state of deformation of the pipe is described by three angles, is presented. A model in which the deformation is described by two-angles is also considered, so enabling a comparison to be made with previously published models. It is shown that the profile of the pipe is restricted by the neglect of the third angle. A critical assessment of two-angle modeling of these systems is made. (Author abstract) 23 refs.

Brown, M.J. (Univ of Leeds, Leeds, Engl); Elliott, L. *Math Eng Industry* v 1 n 1 1987 p 33-46.

**079100 HYDROSTATIC PRESSURE IS SECRET OF 'HYDROPULL' PIPELAYING METHOD.** The hypopull technique for laying submarine pipe was invented about 12 years ago. The employment of hydrostatic pressure is the basic operating principle behind the hypopull technique. Pipe sections are still lowered into place in the traditional manner. The difference, however, manifests itself most readily in the two watertight bulkheads that are fundamental to the hypopull concept. One bulkhead is left stationary, normally capping the upstream end of the first pipe section to be installed. The other bulkhead, the actual hypopulling unit, is normally chained to the bell end of the pipe section being lowered into place. An integral part of this bulkhead is a motorized impeller driven by pressurized hydraulic fluid. The fluid is fed through hose that connects the bulkhead to a hydraulic pump positioned on the work barge. When the pump is activated, water is driven from the inside of the pipe section. The beauty of this technique lies in the suction effect that is created when the joint starts to come together. By driving water from the pipe, a pressure differential is created whereby tons of hydrostatic force are effectively harnessed. This force acts to push the pipe sections together to form a tight joint.

Ganas, Michael J. (Boswell Underwater Engineering). *Sea Technol* v 29 n 4 Apr 1988 p 21-24.

**079101 PARAMETRIC INFORMATION FOR LAY-BARGE INSTALLATION OF SUBMARINE PIPELINE.** A method is described for obtaining the onboard information for the safe laying of pipeline by lay-barge technique. With the help of the method, the effect of the quasi-static barge motion on the installation stresses in the pipeline is also investigated. The procedure for selecting the values of the control parameters for the safe laying of the pipeline including the effects of current and barge motions is then discussed. The method consists of an analytical procedure for the solution of the suspended pipeline under its own weight and current by using a finite difference formulation. The results of the analysis are composed into a set of graphical plots from which the necessary information is extracted to prepare the onboard data for the safe laying of pipeline and also to investigate the effect of barge motions. The method is illustrated with the help of a numerical example on a 75 cm O-D pipeline to be laid in 170 meter depth of water. (Author abstract). 16 Refs.

Datta, T.K. (Indian Inst of Technology, Delhi, India). *Int Shipbuild Prog* v 35 n 402 Jul 1988 p 101-121.

**Magnetic Field Effects** See PETROLEUM PIPELINES—Heating.

## Removal

**079102 UNDERWATER OPERATIONS FOR DECOMMISSIONING OF SUBSEA PIPELINES AND RELATED FACILITIES.** This paper considers the underwater operations required for decommissioning pipelines installed in the North Sea Continental Shelf areas. The type of work is described under the areas of

survey/inspection/measurement, valve/mechanical manipulation, cutting/welding and lateral/vertical movement. The subject of excavation is also discussed in the paper. Work requirements, methods and techniques available are defined within three groups: divers (saturation), remotely operated vehicles (ROVs) and manned submersibles. Consideration is given to the difficulties that may occur on the seabed for decommissioning and removal of pipelines. To illustrate this, a number of typical problems are described. They are complete pipeline burial, fixed seabed pipeline structures, connecting pipelines, seized pipeline end connectors, damaged/buckled pipelines, severe internal corrosion and crossing pipelines. It is then proposed that specialized equipment may need to be designed and developed for particular recovery operations. Such equipment could be a pipe-lift seabed crawler, a de-burial plough, a de-burial jetting sled and special reeling equipment. (Edited author abstract)

Smith, C.J. (John Brown Engineers & Constructors Ltd). *Pipes Pipelines Int* v 32 n 6 Nov-Dec 1987 p 7-13.

**Selection** See OIL WELL PRODUCTION—Sub-Sea Production System.

## Structural Analysis

**079103 ANALYSIS OF BUCKLE INITIATION IN DAMAGED SUBSEA PIPELINES.** A rigid, perfectly plastic mechanism analysis, embodying interactive uniaxial membrane and bending plasticity, is used to predict the form of localized impact damage for tubulars. An extension of the model allows the pressure response of a pipe containing damage, and in particular the pressure at which buckling is initiated in a damaged pipeline. Test results are shown to confirm the validity of the mechanistic approach employed in predicting the damage process, while initiation tests based on a different initial imperfection configuration are shown to reproduce the trend of predicted initiation pressures. An attempt to improve the buckle performance through the use of spirally rib-reinforced pipelines is also described. (Edited author abstract) 13 refs.

Tam, C.K.W. (Univ Coll London, London, Engl); Croll, J.G.A. *J Offshore Mech Arct Eng* v 109 n 4 Nov 1987 p 366-374.

**079104 NONLINEAR ANALYSIS OF FLEXIBLE RISERS USING HYBRID FINITE ELEMENTS.** A method is developed for the static and dynamic analysis of flexible risers and pipelines in the offshore environment under conditions of arbitrarily large motions due to wave loading and vessel movements. A mixed finite element formulation is adopted where the axial force is independently interpolated and only combined with the corresponding axial displacements via a Lagrangian constraint. An advantage of the resulting hybrid beam element is that it may be applied to offshore components varying from mooring lines or cables to pipelines with finite bending stiffnesses. Results are presented for the motions and forces on a flexible riser connecting a tanker to a subsea tower and also on a combined flexible riser and subsea support buoy structure which is part of a floating offshore production system. (Author abstract). 13 Refs.

McNamara, J.F. (Univ Coll, Galway, Irel); O'Brien, P.J.; Gilroy, S.G. *J Offshore Mech Arct Eng* v 110 n 3 Aug 1988 p 197-204.

## Testing

**079105 ON THE COLLAPSE STRENGTH OF SUBMARINE PIPELINES.** A simplified method of analyzing the collapse strength of submarine pipelines subjected to combined bending, external pressure and axial force is presented. In this analysis, the collapse load is determined by investigating both the limit load types of failure and bifurcation of the compressed region. A computer program 'PCOLAS' is devised based on the theory. Because of the simplicity of the method, the collapse behavior can easily be investigated. The theoretical results agree well with available test results for combined bending and external pressure. (Edited author abstract) In Japanese. 3



refs.

Nomoto, Toshiharu (Univ of Tokyo, Jpn); Enosawa, Makoto. *J Fac Eng Univ Tokyo Ser A* n 24 1986 p 22-23.

## Wave Effects

**079106 ROOT MEAN SQUARE FORCE COEFFICIENTS FOR SUBMARINE PIPELINES.** An experimental investigation has been carried out on forces induced by regular and random waves on submarine pipelines placed near a plane boundary. The inline and transverse forces are analyzed in terms of combined root mean square (rms) hydrodynamic coefficient. The total rms coefficient is correlated with Keulegan-Carpenter number or period parameter and relative clearance of the pipeline from the plane boundary. The pipeline was subjected to Pierson-Moskowitz spectrum (P-M spectrum) in the random wave force tests. The time histories of water particle kinematics are generated using the linear numerical transforms. This paper also reports the effect of depth parameter on the total rms coefficient. The results of the random wave force tests are finally compared with those of regular waves. (Author abstract) 17 refs.

Jothi Shankar, N. (Nat'l Univ of Singapore, Singapore); Cheong, Hin-Fatt; Subbiah, K. *Ocean Eng (Pergamon)* v 15 n 1 1988 p 55-69.

**PIPE, STEEL** See NATURAL GAS PIPELINES—Welding.

**PIPING SYSTEMS** See Also PRESSURE VESSELS.

**079107 ROHRE, BAUTEILE UND ROHRLEITUNGSSYSTEME AUS BOROSILIKATGLAS RASOTHERM - GRENZEN UND MOEGLICHKEITEN DER ANWENDUNG.** [Tubing, Piping and Components of RASOTHERM Borosilicate Glass: Principles and Design of Piping Systems from RASOTHERM Glass]. This paper deals with the basic principles of designing piping systems from RASOTHERM borosilicate glass. Presented are general considerations for piping system design work. In German. 35 refs.

Fiedler, Hans-Joachim (VEB, Ilmenau, East Ger); Neuback, Eberhard. *Schweisstechnik (Berlin)* v 37 n 11 1987 p 484-487.

**079108 STEAM OR ELECTRIC TRACE HEATING: WHICH SHOULD YOU CHOOSE?** Steam tracing has been the standard method for maintaining process temperatures and preventing freeze-ups. While steam systems are noted for being safe and reliable, they are both energy and labour intensive. With escalating costs, many plant engineers have begun to seek a more cost-effective alternative, such as electric trace heating systems. The most significant development of the 1970s was that of self-regulating trace heating. The concept was introduced by California-based Raychem in its AutoTrace system, and other companies have followed with similar products. The principle behind self-regulating tape is that its power output automatically decreases as its temperature rises. The Raychem tape comprises a carbon polymer matrix extruded between two copper busbars. The factors to be evaluated in selecting the trace heating system are considered and a software program designed to give a direct comparison of costs is described.

Royse, Susan. *Process Eng (London)* v 69 n 6 Jun 1988 p 57,59.

**079109 PRESSURE PULSATION IN A CENTRIFUGAL PUMP-PIPING SYSTEM (1ST REPORT, EXPERIMENTAL EXAMINATION OF CHARACTERISTICS FOR PRESSURE PULSATION).** In piping systems, including centrifugal pumps, a pressure pulsation is generated. In this report, a centrifugal pump is assumed to have two characteristics: one is the generation of pulsation and the other is the propagation of waves. The combination of these two characteristics is linear, and the latter is described by a transfer matrix. The values of these characteristics are obtained by experiments and the above assumption is confirmed. The mechanism for pressure

pulsation generation and the roll of the pump in pressure pulsation are grasped more exactly. The pulsation source of a centrifugal pump is the pulsating pump head. These experiments make it clear that the strength of the pulsation source is independent of piping systems, and its amplitude and phase are both almost constant at constant revolutions of the impeller. (Author abstract). 14 Refs. In Japanese.

Goto, Masanori. *Nippon Kikai Gakkai Ronbunshu B Hen* v 54 n 502 Jun 1988 p 1364-1370.

**079110 PRESSURE PULSATION IN A CENTRIFUGAL PUMP-PIPING SYSTEM (2ND REPORT, PRESSURE DISTRIBUTION IN A PIPE AND EFFECTS OF PUMP CONFIGURATION ON PRESSURE PULSATION).** A centrifugal pump is assumed to have two characteristics for pressure pulsation: one is the generation of pulsation and the other is the propagation of waves. In this report, pressure distributions in a pump-piping system with the same pump as the first report are obtained by experiments, and are compared with calculated values based on the result of the first report. The pressure pulsation may be explained clearly based on the propagation and generation phenomena of pressure waves in a simple pipe system of reasonable length, instead of a pump. Effects of pump configuration on the pressure pulsation become clear by experiments using two dimensional centrifugal pumps which have a different divergent angle of the volute, clearance gap between an impeller and a tongue, and blade number. (Author abstract). 9 Refs. In Japanese.

Goto, Masanori. *Nippon Kikai Gakkai Ronbunshu B Hen* v 54 n 502 Jun 1988 p 1371-1377.

## Accident Prevention

**079111 SAFETY IN GAS SYSTEMS.** The article discusses the potential hazards in gas systems using the destruction of a building in New York City by natural gas explosion as an illustration. This example serves as an excellent guide to three principles for safe gas system installations: design the system to satisfy the system demands while minimizing the opportunity for failure; integrate the gas system design and location with those of the other building systems; ensure that construction and installation of all parts of the gas system conform precisely to the design specifications. The author suggests some general rules for designing/installing gas piping systems.

Anon (American Gas Assoc, Arlington, VA, USA). *Plumbing Eng* v 15 n 3 Apr 1987 p 32-34, 36.

**Bends** See MASS TRANSFER; PIPE, STEEL—Crack Propagation.

**Cleaning** See CHEMICAL PLANTS—Piping Systems.

## Cold Weather Problems

**079112 COLD WEATHER DESIGN OF PLUMBING SYSTEMS.** A recent, in-depth study of various utilities in freezing climates provides information enabling an engineer to predict if freezing will occur, and discusses various methods that can prevent freezing. These studies show that the freezing process of water in pipes is more complicated than originally thought, and is different for both static and flowing water. A formula is discussed which is developed to determine ice formation on an open vessel's surface and considers the insulating effect that the forming layer of ice has on the transfer of heat from the surface of the water to the air. The derivation of the basic formula for frost depth is discussed.

Frankel, Michael (Syska & Hennessy Inc, New York, NY, USA). *Plumbing Eng* v 15 n 9 Nov-Dec 1987 12p.

## Components

**079113 STRESS INTENSITY FACTORS FOR TWO DIFFERENTLY SHAPED CIRCUMFERENTIAL SURFACE CRACKS AT THE OUTER WALL OF A PIPE.** The exclusion of failure of components of the

piping systems of a reactor by crack growth is often proved by experimental studies of pipes having artificially produced surface flaws. In many cases - especially for circumferentially oriented flaws - the shape of these flaws doesn't coincide with the semi-elliptical surface crack model commonly used in fracture mechanics. Therefore the stress intensity factors of such flaws are not exactly known, which may cause some problems in the interpretation of the experiments. In this paper the results of finite element calculations of two differently shaped circumferential surface cracks at the outer wall of a pipe are presented. 4 refs.

Grebner, H. (Brown, Boveri & Cie, Mannheim, Wes Ger); Strathmeier, U. *Int J Fract* v 35 n 1 Sep 1987 p R9-R14.

**Computer Aided Analysis** See NUCLEAR POWER PLANTS—Testing.

## Computer Aided Design

**079114 DESIGNING SUPPORT PLACEMENT FOR HUBLESS PIPE SYSTEMS.** The article discusses the use of computers in the design of support placement for cast iron hubless pipe systems. The program requires that no load be transferred from one pipe section to another. The program allows for the analysis of the piping in five sections beginning with the soil stack, vent stack, and three horizontal drain diameters and lengths.

Konen, Thomas P. (Stevens Inst of Technology, Hoboken, NJ, USA); Falcon, Juan R. *Plumbing Eng* v 15 n 6 Jul-Aug 1987 4 p between p 30-35.

## Computer Simulation

**079115 SIMULATION OF FLUID PIPES IN HYDROSTATIC CIRCUITS USING MODAL AND SEGMENTED METHODS.** Distributed parameter systems can be simulated by cutting the system, like a fluid pipe, into slices or segments. Or one can use a method based on solving a partial differential equation with suitable boundary conditions, and assign a bondgraph R, I, C combination to each mode or eigenfunction. This contribution compares both approaches for a fluid power hose and determines the superior accuracy of the model approach. Variation of the terminating resistor influences the resonant frequencies, and depends not on the resistance alone, but on a suitable non-dimensional combination with the global capacitance and inductance of the hose as suggested by dimensional analysis. Simulations were carried out by the CAMP and ACSL programs on one side, and by TUTSIM and FANSY programs on the other side; the results confirm each other. (Author abstract) 10 refs.

Thoma, Jean U. (Univ of Waterloo, Waterloo, Ont, Can); Richter, Doris B. *Trans Soc Comput Simul* v 3 n 4 Oct 1986 p 337-349.

**Construction** See FLUE GASES—Desulfurization.

**Corrosion** See NUCLEAR REACTORS, BOILING WATER—Piping Systems; NUCLEAR REACTORS, LIGHT WATER—Piping Systems.

## Corrosion Protection

**079116 INSITUFORM'S VERTICAL TAKE OFF AT HEATHROW.** The 'Insituform' system which has been for many years well established in the field of pipe lining in sewers and pipes in the water, chemical and petroleum industries has recently moved into a new area lining vertical drain pipes in the oldest British Airways hangar at London's Heathrow Airport. Travers Morgan & Partners, the East Grinstead-based consulting engineer, was called in by British Airways to find a solution to the problems caused by the corrosion of mild steel drain pipes encased in the reinforced concrete columns inside the hangar. A review of the solution is presented in this article.

Anon. *Pipes Pipelines Int* v 33 n 2 Mar-Apr 1988 p 30.



## Cracking

**079117 ATTAINMENT OF HIGH VALUES OF THE APPLIED TEARING MODULUS FOR CIRCUMFERENTIAL CRACKS IN STAINLESS STEEL PIPING SYSTEMS.** When assessing the stability of a crack in a Type 304 stainless steel Boiling Water Reactor piping system, for the displacement-controlled loading conditions that are appropriate to an accident situation, the accepted procedure is to determine the applied tearing modulus  $T_{APP}$  and compare this with the material tearing modulus  $T_{MAT}$ ; high  $T_{APP}$  values therefore favor crack instability. This paper presents a general analysis which gives  $T_{APP}$  for a circumferential through-wall crack in a straight pipe segment of length  $L$ , where one end is subject to fixed deformations, while the boundary conditions at the other end are flexible, thereby reflecting the interaction with the remainder of the piping system. (Edited author abstract) 5 refs.

Smith, E. (Joint Manchester Univ/UMIST, Manchester, Engl). *Int J Pressure Vessels Piping* v 30 n 4 1987 p 299-309.

**Design** See Also FARM BUILDINGS—Heating; FIRE PROTECTION—Sprinkler Systems; FLOW OF FLUIDS—Two Phase; IRRIGATION—Piping Systems; PAPER AND PULP MILLS—Piping Systems.

**079118 FUNDAMENTAL CONCEPTS OF TWO-PHASE FLOW IN UPWARDS SLOPING PIPELINES.** Experimental data obtained by the author shows that the results can be predicted which theoretically lead to a semi-empirical approach for pressure drop and transition to slug flow. The geometry of a suggested piping system is defined through five lengths, A-B, B-C, C-D, D-E and E-F. In addition the slope angles for the five segments are needed to complete the description of the system. It is the purpose of this paper to discuss the rather large effects that the geometry of such a system may have on the flow in it. In addition, some observations from a series of experiments with inclined pipes will be discussed. (Edited author abstract) 3 refs.

Persen, Leif N. (Univ Trondheim, Trondheim, Norw). *Energy Prog* v 7 n 3 Sep 1987 p 170-179.

**079119 PIPING METHOD FOR ACCOMMODATING PIPE OFFSETS.** A procedure is described for calculating a number of couplings, grooved pipe spool lengths, and displacements to accommodate pipe run offsets due to misalignments or building settlement. The offset transition can be achieved only with flexible couplings since they allow for angular deletion at each joint. Offsets are determined by the amount of lateral misalignment on the particular pipe run and the length along the pipe run that is required for the parallel shift of the run. (Edited author abstract)

Trinker, Gary B. (Victaulic Co of America, Easton, PA, USA). *Heat Piping Air Cond* v 59 n 10 Oct 1987 p 65-68.

**079120 HOW TO PREDICT PRESSURE DROP BEFORE DESIGNING THE PIPING.** In the design of process and power plants, it often is necessary to estimate the pressure drop of a piping system before all the required information is available. A correlation developed by W.B. Hooper accurately predicts the number and type of valves and fittings per unit length for piping of various sizes. These predictions, combined with the known line lengths and published equivalent-length factors, provide an accurate estimate of the true equivalent length and, therefore, the pressure drop. This article converts the data presented by Hooper into equations for estimating pressure drop. This method has been found to be very useful for preliminary estimates of pipe use size and pressure drop, for checking final design calculations to see whether they are reasonable, and even for ordering pumps and compressors in cases where the frictional pressure drop is relatively small compared with the total pressure drop. The method is applied by means of an example. 3 refs.

Brown, Grant S. (Rust Int Corp, Pittsburgh, PA, USA). *Chem Eng (New York)* v 94 n 4 Mar 16 1987 p 85-86.

**079121 PREDICTION OF OPTIMUM ECONOMIC PIPE DIAMETER BY NOMOGRAPH.** An attempt has been made in this communication to predict the optimum economic pipe diameter for the viscous and the turbulent flow regimes with the help of nomograph prepared on the basis of modified equations, incorporating the cost factor. Values of economic pipe diameter obtained from the nomograph have been found to compare fairly well with the respective values calculated by the developed equations. (Edited author abstract). 2 Refs.

Roy, G.K. (Regional Engineering Coll, Rourkela, India). *J Inst Eng India Part CH* v 68 n 3 Jun 1988 p 83-85.

**079122 PIPING DESIGN CRITERIA AND RESEARCH: CURRENT NRC ACTIVITIES IN DYNAMIC DESIGN.** The current design process for nuclear power plant piping relies heavily on detailed dynamic response analyses. The criteria and design practices used in this process were themselves justified largely by analytical studies using judgment about high level response and failure mechanisms. Now, 'physical' data from recent dynamic failure tests and earthquake experience surveys indicate that the overall design margins for piping dynamic loads are much greater than previously believed. Conservatism is introduced in three general areas of the piping design process: (1) piping input loads (2) piping response calculation, and (3) ASME Code piping design criteria. 42 refs.

Guzy, Dan (USNRC Office of Nuclear Regulatory Research, Washington, DC, USA). *Nucl Eng Des* v 107 n 1-2 Apr 1988, Curr Issues Relat to Nucl Power Plant Struct, Equip and Piping-Sel Pap, Raleigh, NC, USA, Dec 10-12 1986 p 161-167.

**Earthquake Resistance** See Also HYDRODYNAMICS—Fluid Structure Interaction.

**079123 POSITIVE USE OF DAMPING DEVICES FOR PIPING SYSTEMS - SOME EXPERIENCES AND NEW PROPOSALS.** An increase of the damping ratio is known to be very effective for the seismic design of a piping system. It is reported that the energy dissipation in piping supports contributes to increase the damping ratio of the piping system. In this paper, with regard to increasing the damping and reducing the seismic response of the piping system, three application methods of damping devices used in other engineering fields are reviewed: (1) direct damper, (2) dynamic vibration absorber, and (3) connecting damper. Based on the results of this review, the following three types of damping devices for piping systems are introduced: (1) visco-elastic damper (direct damper), (2) elasto-plastic damper (direct damper), and (3) compact dynamic absorber (dynamic vibration absorber). (Edited author abstract) 14 refs.

Kunieda, Masaharu (IHI, Tokyo, Jpn); Chiba, Toshio; Kobayashi, Hiroe. *Nucl Eng Des* v 104 n 2 Oct 2 1987 p 107-120.

**079124 ACCUMULATED DAMAGE EVALUATION FOR A PIPING SYSTEM BY THE RESPONSE FACTOR ON NON-STATIONARY RANDOM PROCESS (1ST REPORT, A SINGLE-DEGREE-OF-FREEDOM SYSTEM).** This paper shows that the average and variance of the accumulated damage caused by earthquakes in a piping system are related to the seismic response factor. The earthquakes in this paper are of a non-stationary random process. The average is proportional to  $\lambda^2$  and the variance is to  $\lambda^4$ . The analytical values of the average and variance for a single-degree-of-freedom system are compared with those obtained from computer simulations. Both averages of accumulated damage are approximately equal. The variance obtained from analysis does not coincide with that from simulations. The reason is considered to be the fluctuation in power spectra of input accelerations and a small number of sample data. But increasing the number, the average and variance become approximately equal for both analysis and simulation. (Author abstract) In Japanese. 12 refs.

Shintani, Masanori. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 497 Jan 1988 p 135-142.

**079125 COUPLED SEISMIC RESPONSE OF PIPING AND LIQUID COLUMN (3RD REPORT, SEISMIC RESPONSE OF BENDING PIPELINE).** To estimate the coupled seismic response of a 3D piping system and an internal pressurized fluid, and to make clear the difference between the coupled model and the conventional dead mass model of fluid, a calculation method was applied. This method is based on the model analysis for piping structural response and the characteristics method for fluid response, and the coupling was considered by fluid force to pipe and variable boundary conditions to fluid. The response in each condition was compared with that of the dead mass model, and the following results were obtained: (1) The dead mass model, in some cases, has given unconservative estimation in acceleration response, but no significant difference in displacement response comparing with the coupled model. (2) The induced pressure is about the same level in the soft and hard support system and is possible to reach the negative pressure in a resonance response of a low pressure and low friction system. (3) The system including a constant pressurized tank has generally shown the higher response in acceleration and pressure than the system without tank. (Edited author abstract) In Japanese. 4 refs.

Ogawa, Nobuyuki. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 497 Jan 1988 p 143-150.

**079126 ACCUMULATED DAMAGE EVALUATION FOR A PIPING SYSTEM BY THE RESPONSE FACTOR ON NON-STATIONARY RANDOM PROCESS (2ND REPORT, A TWO-DEGREE-OF-FREEDOM SYSTEM).** This paper shows that the average and variance of the accumulated damage caused by earthquakes on the piping system attached to a building are related to the seismic response factor  $\lambda$ . The earthquakes referred to in this paper are of a non-stationary random process kind. The average is proportional to  $\lambda^2$  and the variance to  $\lambda^4$ . The analytical values of the average and variance for a single-degree-of-freedom system are compared with those obtained from computer simulations. Here the model of the building is a single-degree-of-freedom system. Both averages of accumulated damage are approximately equal. The variance obtained from the analysis does not coincide with that from simulations. The reason is considered to be the forced vibration by sinusoidal waves, and the sinusoidal waves included random waves. Taking account of amplitude magnification factor, the values of the variance approach those obtained from simulations. (Author abstract) In Japanese. 13 refs.

Shintani, Masanori. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 498 Feb 1988 p 376-384.

**079127 PIPING SEISMIC ADEQUACY CRITERIA RECOMMENDATIONS BASED ON PERFORMANCE DURING EARTHQUAKES.** Design and analysis of piping in a typical nuclear power plant has been estimated to cost as much as \$80 million, at least 60% of which is associated with the implementation of current seismic design criteria. These current design criteria require seismic qualification of nuclear plant piping based on rigorous and expensive mathematical analysis and testing. Past earthquake experience has shown that piping within power facilities which have undergone little or no seismic qualification have performed very well with only a limited number of resulting cases in which the pressure boundary has been breached. The purpose of this paper is to document the performance of piping in past earthquakes and to explore the possibilities of using the results of this earthquake experience data to guide the development of a more reasonable criteria for assessing the seismic adequacy of power piping. (Edited author abstract) 6 refs.

Hardy, G.S. (EQE Inc, Costa Mesa, CA, USA); Smith, P.D.; Tang, Y.K. *Nucl Eng Des* v 107 n 1-2 Apr 1988, Curr Issues Relat to Nucl Power Plant Struct, Equip and Piping-Sel Pap, Raleigh, NC, USA, Dec 10-12 1986 p 155-160.



**079128 SIMPLIFIED METHOD FOR INELASTIC PIPING SYSTEM SEISMIC RESPONSE PREDICTION.** This paper presents a seismic response prediction method based on a simplified plastic system analysis. The analysis uses a dynamically equivalent static-g loading that has been adjusted for inelastic energy dissipation. The simplified plastic system analysis utilizes an incremental series of equivalent static-g loadings and replaces yielded components with hinge elements when a predefined hinge moment is reached. This hinge moment value is selected to result in inelastic energy absorption of the same magnitude as observed in piping component dynamic tests and analyses. Two definitions of dynamically equivalent static-g loadings are employed: one conservatively based on the peak of the design acceleration response spectrum, the other based on modal analysis results of the simplified plastic system model. A comparison of predicted results versus experimental results is provided for a high-level seismic test of a representative LWR piping system. (Edited author abstract) 41 refs.

Jaquay, K.R. (Rockwell Int, Canoga Park, CA, USA); Larson, J.E.; Tang, H.T. *Nucl Eng Des* v 107 n 1-2 Apr 1988, Curr Issues Relat to Nucl Power Plant Struct, Equip and Piping-Sel Pap, Raleigh, NC, USA, Dec 10-12 1986 p 169-181.

**Expansion Joints** See PIPELINES—Expansion Joints.

**Failure** See Also PRESSURE VESSELS—Failure.

**079129 EXPERIMENTAL AND ANALYTICAL STUDIES OF PIPE WHIP TESTS UNDER PWR LOCA CONDITIONS.** A series of pipe rupture tests has been performed at the Japan Atomic Energy Research Institute (JAERI) to demonstrate the safety of primary coolant circuits in the event of pipe rupture in nuclear power plants. Pipe whip tests and jet discharge tests have been conducted under boiling water reactor (BWR) and pressurized water reactor (PWR) loss-of-coolant accident (LOCA) conditions. The present paper describes the experimental and analytical results of the pipe whip tests performed under PWR LOCA conditions using 4, 6 and 8-inch test pipes. The tests were carried out at an initial pressure and temperature of 15.7 MPa and 325°C, respectively. Moreover, a dynamic analysis of pipe whip tests was carried out using the general purpose finite element program ADINA. (Author abstract) 10 refs.

Kurihara, Ryoichi (JAERI, Tokai-mura, Jpn); Ueda, Shuzo; Miyazono, Shohachiro. *Nucl Eng Des* v 103 n 3 Sep 1987 p 253-265.

**079130 DUCTILE FRACTURE MECHANICS METHODOLOGY FOR COMPLEX CRACKS IN NUCLEAR PIPING.** Limit load and J-integral estimation solutions are developed for circumferentially complex-cracked pipes in bending. The limit load solution is developed using thick-walled cylinder analysis which included the effects of flaw depth accurately. J-integral estimation solutions are developed that are suitable for a wide range of loading from linear elastic, elastic-plastic to net-section yielding of the flawed section. Mode I stress intensity factor solution is developed from experimental compliance data. Two types of J solutions are developed. (Edited author abstract) 16 refs.

Zahoor, Akram (Novetech Corp, Rockville, MD, USA). *Nucl Eng Des* v 106 n 2 Feb (II) 1988 p 243-256.

**Flow** See Also FLOW OF FLUIDS—Mathematical Models; FLOW OF FLUIDS—Unsteady Flow.

**079131 BERECHNUNG VON VOLUMENSTROMEN IN VERZWEIGTEN HYDRAULISCHEN KREISLAUFEN MIT HILFE VON KLEINRECHNERN.** [Calculation of Volumetric Flows in Branched Hydraulic Circuits by Means of Calculators]. A program for calculation of partial volumetric flows through the elements installed in the branches is presented. An iterative calculation method is taken as a basis for the program. Fundamentals and application of program for calculators are explained and demonstrated with an example of application. (Edited author abstract) In

German. 6 refs.

Artjuschin, J. (Werkhochschule 'beim SIL-Automobilwerk, Moscow, USSR); Eggerth, S. *Maschinenbautechnik* v 36 n 11 Nov 1987 p 489-493.

**Freezing** See HEAT EXCHANGERS—Regenerators.

**High Temperature Effects** See NUCLEAR REACTORS, PRESSURIZED WATER—Cooling Systems.

**Inspection** See Also STAINLESS STEEL—Defects.

**079132 ROBOTS MOBILES POUR L'INSPECTION ET LA MAINTENANCE DES TUYAUTERIES DANS LES CENTRALES.** [Mobile Robots for Inspection and Maintenance of Piping in Electrical Power Plants]. Service life of piping in electrical power plants can be prolonged by employing mobile robots designed specifically for piping inspection and maintenance. This article discusses some experience acquired in this field. 7 refs. In French.

Jezequel, P. (Electricite de France, Chatou, Fr). *RFM Rev Fr Mec* n 4 1987, Cycle de Conf d'Etude et d'Inf de la Soc Fr des Mec sur les Rob Ind, Mar 25-26 1987 p 295-299.

**Insulation**

**079133 THERMAL INSULATION OF PLUMBING SYSTEMS.** This is the second part of a two-part series about thermal insulation of plumbing systems. In part I, July/August, Plumbing Engineer, the author discussed fundamentals of heat transfer, water vapor migration, types of insulation, and jackets. In this part the writer will cover coatings, adhesives, sealants, installation of insulation for straight lengths of pipe, valves and fittings insulating tanks, reasons for selecting and using insulation and code requirements.

Frankel, Michael (Syska & Hennessy Inc, New York, NY, USA). *Plumbing Eng* v 16 n 7 Sep 1988 8p.

**Leak Detection** See PAPERMAKING MACHINERY—Nondestructive Examination.

**Leakage**

**079134 COOLANT FLOW RATE LIMITERS FOR USE IN PIPELINE FAILURE.** The Dzerzhinskii All-Union Heat-Engineering Institute has developed restrictive inserts that can be placed within a pipeline at points of junction with components of larger cross section to reduce the critical flow rates considerably in the emergency escape of coolant from a nuclear power station. An Inventors' Certificate has been issued for the method of constraining the specific flow rate by intensifying the boiling. The design of the inserts is based on the following assumptions: an insert should have a resistance less than the limiting permissible value in the nominal working state and should provide a considerable reduction in the leak flow rate in the emergency state when the pipe breaks. 3 refs.

Khlestkin, D.A.; Mal'tsev, B.K.; Kanishchev, V.P. *Sov At Energy* v 61 n 5 Nov 1986 p 954-956.

**Maintenance** See Also ELECTRIC POWER PLANTS—Piping Systems.

**079135 EXTRUDED CONNECTIONS SOLVE PIPING PROBLEMS.** Stress cracking on FCCU pipe air grids has long been a problem for refiners. This cracking is one of the primary problems that continually needs to be remedied during planned or unplanned shutdowns. A successful solution to this maintenance problem is the use of extruded connections instead of traditional reinforcing saddles or stub-in welding designs. The extruded outlet header design is not a new concept, having been widely used in pipeline applications for decades. Its acceptance in refinery applications, has surfaced within the past few years. Examples show how extruded header connections give better service life than fabricated branch connections in several refinery applications.

Miles, C.E. (Texas City Refining Co, Texas City, TX, USA). *Hydrocarbon Process* v 66 n 11 Nov 1987 p 97-98.

**Materials** See Also INTEGRATED CIRCUIT MANUFACTURE—Contamination; PETROLEUM PIPELINES—Materials.

**079136 MATERIALS SELECTION FOR INDUSTRIAL PIPING SYSTEMS.** Industrial piping is an essential part of most production and distribution systems, not only in chemical and petrochemical facilities but in almost every industrial installation from abattoirs to bleach plants, food processors, mines, mills, plating and plant shops, to waterworks and zinc diecasters. The designer and specifier can choose from an array of pipe materials: glass, earthenware, ceramics, metals, alloys, plastics and composites as well as combinations of these. Therefore a thorough knowledge of these materials is essential. (Author abstract)

Tuthill, A.H. *Eng Dig (Toronto)* v 34 n 2 Apr 1988 p 30, 32.

**Nondestructive Examination**

**079137 RESISTIVITY TESTING FOR FINDING SEAM WELDS IN CARBON-STEEL PIPING.** This article presents a method for finding seam welds in apparently seamless pipe. Resistivity testing provides an economical and effective tool to increase the confidence of programs to verify seamless welds in hot reheat piping. Results to date indicate a distinct measurable difference in resistivity between base metal and weld metal. 1 Ref.

Strauss, Bernard M. (Teledyne Engineering Services, Waltham, MA, USA); Blaschak, James J. *Mater Eval* v 46 n 8 Jul 1988 p 1043-1044.

**Plastics Applications** See Also PAPER AND PULP MILLS—Piping Systems.

**079138 EXPERIMENTAL EVALUATION OF THE LONG-TERM STRENGTH OF REINFORCED PLASTIC (GRP) PIPES.** The long-term mechanical strength of glass-fiber-reinforced polyester resin pipes is studied in internal pressure tests. The initial pressure resistance of the pipe structure and the strain in the pipe wall were measured. The longest running times of the pressure tests reached nearly 40,000 h. The results of all pressure tests are extrapolated according to the procedure in the ASTM standard to give an estimate of the strength of the pipe after an expected period under certain stressed conditions. A certain correlation is found between evaluations based on short- and long-term measurements. Behavioral differences during the pressure tests were also found to be related to differences in the pipe structure. (Edited author abstract) 10 refs.

Koski, Laila (Technical Research Cent of Finland, Espoo, Finl). *Valt Tek Tutkimuskeskus Tutkimuksia* 518 Jan 1988 26p.

**Pressure Effects** See COMPRESSORS—Pressure Measurement.

**Safety Valves**

**079139 SIZING EXCESS FLOW VALVES.** The use of Liquefied Petroleum Gases (LPG) as a fuel is widespread in both industry and in private homes. LPG consists of mixtures of propane, butane, and other alkanes which are normally stored and used at temperatures above the normal boiling point. An excess flow valve is a device that is designed to stop the flow of a material when the flow rate exceeds a preset limit. It is the author's belief that a safety device, such as an excess flow valve, should have a reasonable chance of working in the event of an accident. If the safety device can not be designed with a reasonable chance of working, it should not be installed. The critical parameter needed to select an excess flow valve is the expected flow rate through the valve during an incident. This paper will present a calculation method (based on recent developments in two-phase flow modeling) to estimate the actual limiting flow that can be expected in LPG piping systems. 14 Refs.



Freeman, R.A. (Monsanto Co, St. Louis, MO, USA); Shaw, D.A. *Plant Oper Prog* v 7 n 3 Jul 1988 p 176-182.

## Standards

**079140 PRESSURE VESSEL AND PIPING CODES.** Much of the piping in a nuclear plant is designed to the ASME Boiler and Pressure Vessel Code, Section III, Class 2 or 3 requirements. The Code rules are given in NC/ND-3600 of Section III. These rules were developed from the B31.1 rules, and incorporated into Section III 1971 for nuclear components. However, the Class 2/3 piping Code requirements have changing significantly since that time. There is not a criteria document available from ASME that describes the Class 2/3 piping rules. The purpose of this paper is to provide background information and a discussion of the Code stress limits so that the piping analyst can properly interpret the meaning of the Code requirements. (Author abstract.) 11 refs.

Slagis, G.C. (G.C. Slagis Associates, Walnut Creek, CA, USA). *J Pressure Vessel Technol Trans ASME* v 110 n 3 Aug 1988 p 329-334.

## Structural Analysis

**079141 NUMERICAL ALGORITHM FOR ANALYZING PIPING RESPONSE TO THERMAL TRANSIENTS AND SEISMIC EXCITATIONS.** This paper describes a three-dimensional finite-element method for the structural response analyses of reactor piping systems subjected to thermal transients and seismic excitations. In the thermal-transient analysis, the algorithm appropriately accounts for stresses arising from the temperature dependence of the elastic material properties, the thermal expansion of the materials, and the change in the temperature-dependent yield surface. It includes a thermoviscoplastic constitutive equation that incorporates capabilities of treating thermal softening, failure, strain rate, creep, and stress ratcheting. In the piping seismic analysis, a time-history method is utilized to account for possible nonlinear phenomena as well as to reduce the solution conservatism obtained from response-spectrum analyses. Variation in dominant stress frequencies and translational frequencies are easily handled. (Edited Author abstract) 17 refs.

Wang, Chung-Yi (Argonne Natl Lab, Argonne, IL, USA). *Nucl Eng Des* v 106 n 1 Feb 1 1988 p 147-160.

**079142 DYNAMIC RESPONSE ANALYSIS OF THE PIPING SYSTEM CONSIDERING NONLINEAR CHARACTERISTICS OF SUPPORT (2ND REPORT, INFLUENCE OF FRICTION ON SUPPORT).** This investigation deals with the seismic response analysis of a pipe-support system with friction characteristics. The friction characteristics are assumed to be as the Coulomb friction model. This paper highlights, particularly, the effect of friction forces upon the maximum response of the piping system subjected to random excitations including seismic motions as follows: (1) The maximum response of the piping is generally suppressed by the growth of friction force. (2) The response reduction factor based on the maximum response of the linear piping is proposed. This factor can be obtained only through the ratio of the natural period of piping to that of the supporting structure. (3) The other response reduction factor is proposed. (Edited author abstract) In Japanese. 11 refs.

Aoki, Shigeru; Suzuki, Kohei. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 495 Nov 1987 p 2243-2248.

**079143 MODAL DECOUPLING METHODS FOR FLUID-STRUCTURE INTERACTION IN PIPING SYSTEMS.** A simple model for fluid-structure interaction in piping systems is considered, using beam elements for the structure and assuming the propagation of planar pressure waves in the fluid. The forces, exerted, on the structure at the 'singular' points of the piping system due to the change of the fluid momentum, are treated in a natural and straightforward way. The model is shown to behave quite well in the low frequency range, provided that certain corrections are made to the structure inertia, to the structure flexibility at the 'singular' points (elbows,

tees, etc) and to the fluid sound speed. Recent advances concerning the general 'acoustoelastic' fluid structure model - symmetrisation procedures, modal decoupling methods - are applied to the model. The modal methods start with the solution of the 'in vacuum' and of the 'acoustic' eigenproblems and lead to the solution, not only of the 'full' eigenproblem, but also of several 'limit case' eigenproblems, such as the 'incompressible' fluid. (Edited author abstract.) 18 refs.

Antoniadis, I. (Natl Technical Univ of Athens, Greece); Kanarachos, A. *Comput Struct* v 29 n 4 1988 p 577-585.

**079144 EFFECTS OF PLASTICITY ON DYNAMIC RESPONSE OF PIPING STRUCTURES.** The analysis of elastoplastic structures under a combination of static and dynamic loads is examined. It is shown that under the hypothesis of a ductile behavior, progressive distortion is the leading failure mechanism. Procedures are described to compute: (a) the equivalent damping due to hysteretic losses; (b) frequency shifting due to structural softening in the plastic fields; (c) ductility effects on dynamic loads; and (d) ratcheting due to a combination of static and dynamic loads. (Author abstract.) 32 refs.

Lazzeri, L. (Ansaldo SpA, Genoa, Italy). *J Pressure Vessel Technol Trans ASME* v 110 n 3 Aug 1988 p 263-269.

## Structural Design

**079145 DESIGN OF PIPING IN PLASTIC CONDITIONS UNDER DYNAMIC LOADS.** The problem of the design of piping in plastic conditions under dynamic loads is discussed making reference to an analog, by which frequency shifting, damping and ratcheting are found. A comparison between the criteria based on damping increase and the ductility ones is made showing that the usual values are compatible with ductilities between 5 and 10, depending on the static value. It is shown that very large increases over yielding can be sustained by the structure (even in the elastically perfectly plastic scheme) with moderate ductility values; in this way dynamic loads should be regarded basically as secondary ones. (Edited author abstract) 19 refs.

Lazzeri, L. (Ansaldo SpA, Genoa, Italy). *Int J Pressure Vessels Piping* v 30 n 5 1987 p 351-365.

**079146 WATER HAMMER PRODUCTION AND DESIGN MEASURES IN PIPING SYSTEMS.** Water hammer in piping systems produces large dynamic forces, which can damage the pipes and supports. Therefore, it is important to minimize the water hammer and its effects on the piping system. In this work, reduction of the water hammer by active measures is described - that means the reduction of water hammer effects by influencing the fluid dynamic conditions of the system. Where these measures give no satisfactory results, design measures to control the dynamic forces are described. The article does not claim to be complete, but it does give the engineer some aspects of the design of the piping system and the supports. (Author abstract.)

Gillissen, R. (Deutsche Babcock Werke AG, Oberhausen, West Ger); Lange, H. *Int J Pressure Vessels Piping* v 33 n 3 1988 p 219-234.

## Supports

**079147 STANDARDIZATION OF PIPING SUPPORTS IN NUCLEAR POWER PLANTS USING PRETESTED COMPONENTS.** The article reports on the 'standard piping-support catalog', which was used in connection with the Convoy-nuclear-power-plants in the Federal Republic of Germany, under special consideration of: (i) cost reduction for planning and installation, (ii) suitability tests (type testing for standardized supports), and (iii) application of CAD. The advantages using the piping support catalog are summarized. (Author abstract.)

Lauer, J. (Siemens AG, Offenbach, West Ger); Labes, M.; Huelsen, H. *Nucl Eng Des* v 108 n 3 Jul-Aug 1988 p 477-483.

**079148 DECREASING SNUBBER INSERVICE INSPECTION COSTS THROUGH SNUBBER REDUCTION AND IMPROVED TEST LIMITS.** Snubber inservice inspection (ISI) requirements, along with a history of snubber malfunctions, has made inspection and maintenance of snubbers a significant part of a nuclear power plant's ISI budget. These expenses can be minimized through snubber reduction and the use of improved test limits for snubber functional testing. This paper presents a snubber overview and reviews snubber ISI requirements. Examples are given of the high cost that maintaining a snubber in an operating nuclear plant represents. (Edited author abstract) 14 refs.

Olson, D.E. (Sargent & Lundy, Chicago, IL, USA); Tang, Y.K. *Nucl Eng Des* v 107 n 1-2 Apr 1988, Curr Issues Relat to Nucl Power Plant Struct, Equip and Piping-Sel Pap, Raleigh, NC, USA, Dec 10-12 1986 p 183-199.

**079149 WIRE ROPE SEISMIC SUPPORT.** Current piping system snubber reduction programs have shown that the number of snubbers can be reduced by the use of optimization computer codes and solid engineering design experience. Many engineering firms claim snubber reduction as high as 50%. Unfortunately, these claims are often based on ideal situations without any design constraints. A new energy absorbing seismic support is presented which can eliminate all snubbers in a nuclear power plant. In addition, the support has application for supporting sensitive plant equipment which must withstand earthquake loadings at reduced G-levels. The device is simple and inexpensive. The proposed device has been utilized in military, satellite, warship, space shuttle, aircraft and off-road vehicle applications for the past 20 years. The use of the device in such applications has resulted in conformance to government and military specifications along with quality control requirements similar to those of the nuclear industry. (Author abstract)

Loziuk, Larry A. (GDS Assoc Inc, Chicago, IL, USA). *Nucl Eng Des* v 107 n 1-2 Apr 1988, Curr Issues Relat to Nucl Power Plant Struct, Equip and Piping-Sel Pap, Raleigh, NC, USA, Dec 10-12 1986 p 201-204.

**079150 SEISMIC STOPS VS. SNUBBERS, A RELIABLE ALTERNATIVE.** The Seismic Stops methodology has been developed to provide a reliable alternative for providing seismic support to nuclear power plant piping. The concept is based on using rigid passive supports with large clearances. These gaps permit unrestrained thermal expansion while limiting excessive seismic displacements. This type of restraint has performed successfully in fossil fueled power plants. A simplified production analysis tool has been developed which evaluates the nonlinear piping response including the effect of the gapped supports. The methodology utilizes the response spectrum approach and has been incorporated into a piping analysis computer program RLCA-GAP. Full scale shake table tests of piping specimens were performed to provide test correlation with the developed methodology. Analyses using RLCA-GAP were in good agreement with test results. (Edited author abstract) 3 refs.

Cloud, Robert L. (Robert L. Cloud Assoc Inc, Berkeley, CA, USA); Anderson, Paul H.; Leung, James S.M. *Nucl Eng Des* v 107 n 1-2 Apr 1988, Curr Issues Relat to Nucl Power Plant, Struct, Equip and Piping-Sel Pap, Raleigh, NC, USA, Dec 10-12 1986 p 205-213.

**079151 DIFFERENCES IN DYNAMIC RESPONSE OF TYPICAL CLASS II PIPING DUE TO RESTRAINT METHOD AND INPUT AMPLITUDE.** A 50-ft (15.2 m) section of pressurized 8-in. and 6-in. (200 mm and 150 mm) piping with multiple bends and a simulated motor-operated valve was tested using shake table techniques to note differences in piping response and in stress levels due to the incorporation of four different pipe restraint devices. These devices included a rigid element, a mechanical shock arrestor, a hydraulic snub-



ber, and a new, unique triaxial visco-elastic piping damper. The latter device was configured in two ways. (Author abstract) 2 refs.

Keowen, Robert S. (ANCO Engineers Inc, Culver City, CA, USA); Johnson, Blake A.; Merz, K.L. *Nucl Eng Des* v 107 n 1-2 Apr 1988, Curr Issues Relat to Nucl Power Plant Struct, Equip and Piping-Sel Pap, Raleigh, NC, USA, Dec 10-12 1986 p 215-226.

**Testing** See NUCLEAR POWER PLANTS—Earthquake Resistance.

**Vacuum Applications** See HOSPITALS—Piping Systems.

## Valves

**079152 APPLYING AIR RELEASE VALVES IN PIPING SYSTEMS.** Potentially damaging pressure surges and vacuum conditions which may occur in piping systems can be avoided with the judicious use of air release valves described here. Air release valves are hydro-mechanical devices which automatically vent small pockets of air as these accumulate at high points in a piping system while the system is operating and under pressure. An air/vacuum valve is float operated and has a large discharge orifice equal to the size of the valve's inlet. This type automatically allows large volumes of air to be exhausted or admitted into a system, as required. Combination air valves have the operating features of both air/vacuum valves and air release valves. Combination air valves can be installed at all high points of a piping system where it has been determined both air/vacuum valves and air release valves are needed to properly vent and protect the system. (Edited author abstract).

Anon. *Water Eng Manage* v 135 n 8 Aug 1988 p 66-67, 71.

**Vibrations** See Also COMPRESSORS—Piping Systems; NUCLEAR POWER PLANTS—Earthquake Resistance.

**079153 OVERCOMING STEAM HAMMER IN HIGH PRESSURE PIPEWORK.** The event known as 'steam hammer' is set up by the turbine stop valves slamming shut after a turbine trip. Compression waves generated at the stop valves travel up the Main Steam and Hot Reheat lines towards the boiler. As the turbine cylinder is starved of steam the pressure in it drops, and a rarefaction wave is generated. This travels up the Cold Reheat towards the boiler. In the fluid flow analysis of steam hammer, the pressure transients and resulting unbalanced forces acting on the pipework are calculated. A number of commercially available computer codes, such as Relap or Wavenet can be used for this. The numerical solution scheme of Relap is based on a finite-difference integration method. Wavenet has a smaller range of applicability, and uses the method of characteristics to solve the wave equations explicitly. The models built for the static design of the system can be used providing the software has facilities for time-history analysis. Software available for this purpose include: Superpipe and Babcock's Pipestress 2000. The authors argue that steam hammer analysis should be carried out at the design stage, using the recommendations made for fully modeling the boundary conditions in the fluid transient analysis, as they will produce more realistic results.

Crawford, Malcolm (Babcock Power, London, Engl); Santos, Lewis. *Process Eng (London)* v 67 n 11 Nov 1986 p 57, 59.

**079154 VIBRATIONS DES TUYAUTERIES SOUS ECOULEMENT: PREMIERES ANALYSES.** [Flow Induced Vibrations in Piping Systems: First Analysis]. Industrial piping systems conveying fluids are very often submitted to undesired vibrations. Those phenomena are generally related to flow singularities (pumps, valves) and can be of different nature: a) The vibrations are very strong, and lead to a fast failure of the structures. Those instabilities are linked to a strong interaction between the source and the response; b) The vibrations are at a lower level, and generate damages by fatigue. In that case, the

fluid excitation can be characterized by random sources which are not connected to the system response. The aim of this report is to summarize the main theoretical models for prediction of random excitation due to the fluid unsteadiness, and to give some industrial examples. (Edited author abstract) In French. 13 refs.

Tephany, F.; Thomas, P. *Electr Fr Bull Dir Etud Rech Ser A* n 4 1987 p 33-49.

**Welding** See STEAM GENERATORS—Piping Systems.

**PISTON RINGS** See Also COMPRESSORS—Lubrication.

**079155 BESTIMMUNG DER RADIALDRUCK-VERTEILUNG AN KOLBENRINGEN.** [Distribution of Radial Pressure on Piston Rings]. Pressure distribution is a decisive factor for the sealing function, the operating characteristics, and the wear of piston rings. On the basis of the theory of bending test beams and by measuring the form of the untensioned geometry, the procedure described in this article deduces the radial pressure distribution in the installed piston ring. On a shape analyzing device, the contact surface of the piston ring is scanned over its circumference in an untensioned state. The relationship between radial pressure distribution and the untensioned piston ring shape is represented in a simulation model. (Edited author abstract) 6 refs. In German.

Neumann, Peter; Rau, Norbert; Heubner, Gerd. *MTZ Motortech* v 48 n 11 Nov 1987 p 467-469.

## Deformation

**079156 UNERWUNSCHT E PLASTISCHE VERFORMUNG DES KOLBENRINGES.** [Undesirable Plastic Deformation of the Piston Ring]. This article deals with the traditional piston ring made of either pearlitic grey iron or - increasingly - nodular iron. The problem is plastic deformation of the ring in the area opposite the gap due to excessive stress. This high stress is the result of gaps and/or radial widths that are too large. The plastic deformation changes the pressure pattern which the manufacturer has taken great pains to give the ring. This, though, usually remains undetected, since the deformation occurs during the process of installation. Unless one is willing to undertake a radical departure from the conventional concept of the piston ring, the answer can only be: reduced free gap widths and radial widths to improve conformability, use of back-up springs to increase wall pressure and stiffer engine blocks to reduce thermal distortion of the cylinder. The resulting additional cost would have to be accepted in the interest of quality. (Edited author abstract) In German.

Mey, Helmut. *MTZ Motortech* v 49 n 3 Mar 1988 p 101-104.

**Friction** See Also INTERNAL COMBUSTION ENGINES—Piston Rings.

**079157 STUDY ON THE MATHEMATICAL MODEL OF A REAL FRICTION SURFACE FOR PISTON RING BY USING THE CONJUGATE CURVED SURFACE PRINCIPLE.** The moving state of a working piston ring was analysed by using the principle of conjugate curved surface and a mathematical model of the real friction surface for the piston ring was established. It was proven by an example calculation that the theoretical values of oil film thickness obtained by the model are in good agreement with that of experimental data. (Edited author abstract). 5 Refs. In Chinese.

Haishan, Wang (Tianjin Transportation Engineering Inst, China). *Neiranji Xuebao* v 6 n 2 1988 p 171-176.

## High Temperature Properties

**079158 HOT PISTON RING TESTS.** As part of the DOE/NASA Automotive Stirling Engine Project, tests were made at NASA Lewis Research Center to determine whether appendix gap losses could be reduced and Stirling engine performance increased by installing an additional

piston ring near the top of each piston dome. Unlike the conventional rings at the bottom of the piston, these rings operated in a high temperature environment (700°C). Because of this, we called them 'hot-rings'. It was necessary that they be made of a high-temperature alloy (Stellite 6B) and that a high-temperature solid lubricant coating (NASA Lewis-developed PS-200) be applied to the cylinder walls. Results indicated a slight increase in power and efficiency with the hot-rings over the baseline configuration. This increase was over and above the friction loss introduced by the hot-rings. Seal leakage measurements showed a significant reduction in leakage with the hot-rings in place. (Edited author abstract) 2 refs.

Allen, David J. (Sverdrup Technology Inc, Middleburg Heights, OH, USA); Tomazic, William A. *NASA Tech Memo* 100256 Oct 26 1987 14p.

## Iron

**079159 ENHANCING THE QUALITY OF PISTON RING IRON.** A study has been made of the influence of various complex modifiers on the structure and properties of piston rings 210, 230 and 260 mm in diameter, made from a nodular iron (ChShG). The iron was melted in a type ICHT-1 induction furnace from a metallic charge comprising 30% steel-making pig iron (grade PVK-1), 10% steel scrap and 60% internal scrap, and superheated to 1480-1520°C. The green clay-bonded sand molds were poured at 1350-1380°C. The pots (piston ring blanks) of wall thickness 20-35 mm were knocked out after 30 min and cooled in air. Modification with the master alloy ZhKMK-4R, with up to 6% Ca and 4% REM, followed by late modification with FS75, produces irons with superior machinability and a stable surface finish after machining with ceramic-tipped tools. During running in, the piston rings provide a uniform pressure distribution over the cylinder walls; they are extremely reliable and durable.

Cherepov, A.A.; Khenkin, V.I.; Buslov, B.N. *Sov Cast Technol* n 1 1986 p 73-74.

## Lubrication

**079160 CALCULATING METHOD OF OIL FILM THICKNESS IN PISTON RING PACK WITH CONSIDERATION OF STARVED LUBRICATION.** S. Furuhashi's piston ring lubrication theory is analysed in this paper. The main deficiency in the prediction of piston ring pack working under fully flooded condition has been indicated. In light of the mentioned deficiency, the authors develop an approach to oil film thickness prediction considering starved lubrication. Finally, the calculated film thickness values obtained by both methods are compared with the measured results. (Edited author abstract) 3 refs.

Wang, Ducai (Xi'an Inst of Technology, China); Chen, Zhaoxiang; Zhu, Wenjun. *Neiranji Gongcheng* v 9 n 1 1988 p 60-67.

**079161 FULL AND STARVED LUBRICATION MODEL OF PISTON RING PACK.** D. Dowson et al. published an article dealing with the lubrication of a piston ring pack in which the starved lubrication of a piston ring was considered. It marked a giant leap in this field. But there are still some defects in it. In order to eliminate them, a new model of full and starved lubrication of a piston ring pack is put forward and the numerical procedure is presented. There are calculation examples at the end of the paper. The values of the film thickness of the piston ring in an engine calculated under the new model are closer to the measured ones and agree well with what occurred in practice. (Edited author abstract). 5 Refs. In Chinese.

Ducai, Wang (Xi'an Inst of Technology, China); Zhaoxiang, Chen; Wenjun, Zhu. *Neiranji Xuebao* v 6 n 2 1988 p 163-170.



**Protective Coatings** See CAST IRON—Protective Coatings.

**Wear** See Also DIESEL ENGINES—Wear.

**079162 THERMAL STABILIZATION OF IRON PISTON RINGS.** It is recommended that thermal stabilization of iron piston rings be done in the 600-620°C range, which provides a polygonization structure and the maximum strength and elasticity. Alloying of irons with cerium makes it possible to broaden the thermal stabilization temperature range, to provide stabilization of the polygonized structure, and to strengthen the resistant to recrystallization. Irons with spheroidal and vermicular graphite possess higher elasticity and heat resistance than special gray irons.

Pogrebnyak, G.D. (Lvov Polytechnic Inst, Pol); Kuzina, M.G. *Met Sci Heat Treat* v 29 n 5-6 May-Jun 1987 p 407-409.

**PISTONS** See Also INTERNAL COMBUSTION ENGINES—Pistons; PISTON RINGS; PNEUMATIC DRIVE—Mathematical Models.

**Acoustic Wave Effects** See ACOUSTIC WAVES—Propagation.

**Bearings** See HYDRAULIC MACHINERY—Pistons.

**Computer Aided Design** See INTERNAL COMBUSTION ENGINES—Pistons.

## Design

**079163 ANALYSIS TECHNIQUE USED IN THE DESIGN OF THE SPHEROIDAL CAST IRON PISTON OF CONCAVING COMBUSTION CHAMBER.** This paper uses an analysis technique to analyze the spheroidal iron piston of concaving combustion chamber in detail. The analysis consists of a calculation of the piston thermal stress and mechanical stress by using the finite element method and an evaluation of the life of the piston. An analysis of the failure probability due to the nature of the material used and the degree of dispersion of the load of the piston is also considered. The analysis shows that the radial crack of the spheroidal iron piston throat of the concaving combustion chamber displays a -433MPa thermal circular stress and creep because of fatigue interaction. (Edited author abstract) 4 refs. In Chinese.

Zang Quantong (Dalian Diesel Locomotive Research Inst, China). *Neiranji Xuebao* v 6 n 1 1988 p 41-48.

## Diesel Engines

**079164 VERSUCHE MIT EINEM SERIEN-DIESELMOTOR NACH UMRUESTUNG AUF EIN KNICKPLEUEL.** [Investigations of a Diesel Engine with Divided Piston Rod]. The work in hand analyses a motor concept that was presented by the inventor to the public at the beginning of the 80s. This motor concept deals with a diesel motor with divided piston rod, which should cause a much better behaviour with regard to the specific consumption and the exhaust gas. Initiated and sponsored by the Bayerisches Oberbergamt, Munich, the authors analysed this motor concept theoretically as well as experimentally and compared the forenamed characteristic values of the base motor with the values of the modified motor. The results of the investigations did not establish high expectations. (Author abstract) 10 refs. In German.

Blumenberg, Juergen; Gerster, Josef. *MTZ Motortech Z* v 49 n 3 Mar 1988 p 105-108, 113-114.

## Fluid Dynamics

**079165 DEFLECTION OF A PISTON.** This paper concerns itself with the determination of the detection of an annular plate exerting a pressure on a fluid-filled cylinder, a problem which can occur in machine design when describing the action of a piston. For the purpose of this analysis, the cylinder is considered to be 'rigid' while the fluid can be compressible or incompressible. The load

P is applied by means of a shaft rigidly attached to the inner edge of the plate. The outer edge is considered to be either guided in the cylinder or free to rotate. It is furthermore assumed that the effect of buoyancy is negligible. It can be eliminated by letting a thin layer of fluid cover the top of the plate. 4 refs.

Amon, R. (Univ of Illinois at Chicago, Chicago, IL, USA); Bhattacharya, R.K. *J Pressure Vessel Technol Trans ASME* v 110 n 2 May 1988 p 210-212.

**Friction** See Also AUTOMOBILE ENGINES—Pistons.

**079166 PISTON FRICTION FORCE OF A SMALL HIGH SPEED GASOLINE ENGINE.** This paper clarified piston friction forces and conditions of lubrication in the high engine speed range through the improvement of piston friction measuring instruments. Measurements of piston friction forces of the two-ring package have also been done. It is found that the effect of the two-ring package on the reduction of friction forces is greater than predicted by means of the oil starvation phenomenon. (Author abstract) 7 refs.

Takiguchi, M.; Machida, K.; Furuhashi, S. *J Tribol Trans ASME* v 110 n 1 Jan 1988 p 112-118.

## Heat Treatment

**079167 HEAT TREATMENT OF CAST ALLOY AK18 PISTONS.** The aim of this work is looking for possibilities of improving the hardness of pistons. The life of alloy AK18 pistons, governed in particular by hardness, may be increased as a result of reducing the casting temperature, increasing the cooling rate after alloy solidification, correcting alloy composition within the grade limits, and using homogenizing before artificial aging. 3 refs.

Shikolaev, V.P. (Kostroma Agricultural Inst, USSR). *Met Sci Heat Treat* v 29 n 5-6 May-Jun 1987 p 435-438.

## High Pressure Effects

**079168 SEALING UNIT FOR PISTONS OF HIGH-PRESSURE DEVICES.** A sealing unit for pistons of high-pressure (up to 2 GPa) devices is described that consists of a thin-walled elastic sleeve with conical inner and outer surfaces, which is implemented as one piece with a guide bushing, which, in turn, is sealed relative to the vessel wall by a ring. (Author abstract) 4 refs.

Cherepov, S.V. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Chernenko, V.A. *Instrum Exp Tech* v 30 n 1 pt 2 Jan-Feb 1987 p 233-235.

**079169 USE OF CONTROLLED-CLEARANCE HIGH-PRESSURE BALANCES WITH HIGHLY VISCOUS PRESSURE TRANSMITTING MEDIA.** It is shown that in the case of a nonlinear dependence of the zero-clearance pressure  $p_z$  on the measured pressure  $p$ , controlled-clearance high-pressure piston-cylinder systems can be operated over large portions of their measurement range at constant jacket pressure  $p_j$ . This suggests characterizing the effective area by the equation  $A_e = A_0 (1 + \lambda p - d \cdot p_j)$  with the deformation coefficient  $\lambda$  defined as for 'simple' piston-cylinder systems. It is confirmed experimentally that  $\lambda$  and  $d$  do not depend on the measured pressure or on the jacket pressure. The standard pressure balance used to measure the parameters  $A_0$ ,  $\lambda$  and  $d$  of two controlled-clearance piston-cylinder systems has been checked against the mercury melting line. The measuring method is described and results are reported. If use is made of the mercury fixed point of the pressure scale, controlled-clearance high-pressure balances operated with viscous media can be characterized independent of a primary standard by measurement uncertainties of a few parts in 10,000. (Edited author abstract) 4 refs.

Bandyopadhyay, A.K.; Hilsch, P.; Jaeger, J. *PTB Mitt* v 97 n 4 Aug 1987 p 264-269.

## Lubrication

**079170 ALTERNATIVE WAYS FOR COMPRESSOR LUBRICATING OIL.** The lubricating condition of piston-ring-liner is presented by analog computation of computer, and alternative ways for compressor lubrication is proposed. The theoretical calculation corresponds very closely to the practical results. (Edited author abstract) 2 refs. In Chinese.

Qu, Zongchang (Xian Jiatong Univ, Shanxi, China). *Huagong Jixie* v 15 n 1 1988 p 11-15.

**Machining** See Also CONNECTING RODS—Manufacture.

**079171 ONE CLASS PISTONS FROM COMPUTER CONTROLLED MACHINING LINE.** Variations in the past sizes - particularly shaft and hole limits and fits - means that car manufacturers have to cope with matching variously sourced components on a massive scale. However, Ingersoll Milling Machine of Rockford, Illinois, has completed a piston machining line which virtually eliminates dimensional variation of one critically important part. The line is part of the company's response to the automotive industry's goals for light weight high performance engines, improved quality and reliability of engine parts.

Anon. *Metalwork Prod* v 131 n 12 Dec 1987 p 32-33.

**Manufacture** See AUTOMOBILE ENGINE MANUFACTURE—Chrysler.

**Materials** See ALUMINUM CASTINGS—Mechanical Properties.

## Noise Abatement

**079172 QUANTIFICATION AND REDUCTION OF PISTON SLAP NOISE.** Recent advances by engine and vehicle manufacturers in the reduction of overall noise levels have resulted in piston slap noise becoming more intrusive and its reduction increasingly important. This paper describes an essential part of a large program aimed at achieving this objective which was to develop a technique to assess piston noise in gasoline engines. The paper describes the technique and its application to investigate the effect of piston clearance and bore ovality. The technique may be applied to engines in development without recourse to internal instrumentation and correlates well with the result of listening panels. (Edited author abstract) 5 refs.

Richmond, J.W. (AE Developments Ltd, Rugby, Engl); Parker, D.A. *Proc Inst Mech Eng Part D* v 201 n 4 1987 p 235-244.

**Noise, Acoustic** See INTERNAL COMBUSTION ENGINES—Pistons.

## Packing

**079173 OPTIMIERUNG VON DATEN DER KOLBENDICHTUNG DES KAELTVERDICHTERS.** [Optimization of Data of the Refrigerating Compressor Piston Packing]. A procedure is proposed for the mathematical modelling of the function of the refrigerating compressor piston packing. Using the mathematical model it is appropriate to optimise the parameters of the working profile of the piston rings and the design of the whole piston packing. The experimental investigations into the function of piston rings carried out on compressor 2FUBS9 have supported the results of mathematical modelling. Recommendations were prepared for the design of the piston packing of a compressor employing no stuffing boxes. (Author abstract) 5 refs. In German.

Milowanow, W.I. (Technologische Hochschule fuer Kaelte-technik Odessa); Budanow, W.A. *Luft Kaeltetech* v 24 n 1 1988 p 29-34.



## Reliability

**079174 PARTIALLY STABILIZED ZIRCONIA PISTON BOWL RELIABILITY.** The Weibull based 'Simplified Structural Ceramic Design Technique' was used to calculate the reliability of a partially stabilized zirconia (PSZ) piston bowl design. The details of the method and a set of sample calculations are presented. Test results of the piston bowl showed cracks in regions which had a high calculated probability of failure. In addition cracks developed in a region of high compressive/shear stress. Since Weibull reliability analysis only uses tensile stresses this area did not have a high calculated probability of failure. Several hypotheses are presented for the mode of failure in this region. The simplified technique was used to predict what the necessary material properties would have to be for successful PSZ insert of the design shown. (Author abstract) 10 refs.

Hartsock, D.L. (Ford Motor Co, Dearborn, MI, USA). *J Eng Gas Turbines Power Trans ASME* v 109 n 4 Oct 1987 p 367-373.

## Seals

**079175 DEVELOPMENT OF A NEW COMPACT PISTON SEAL.** From a seal supplier's viewpoint it is vital that existing product ranges are manufactured efficiently and that new ranges are designed, developed and manufactured using the latest CAD-CAM techniques. New ranges must also be capable of operating with wider parameters and show real savings to the user. Hallite Seals International has introduced a new range of compact piston seals for use in light, medium and heavy duty hydraulic cylinders.

Anon. *Power Int* v 33 n 389 1987 p 162-163.

## Testing

**079176 CHOICE OF METHOD FOR CHECKING PISTON TEST SYSTEMS AND VOLUME DETERMINATION RELIABILITY ESTIMATION.** A basic condition for providing reliability in determining PTS (Piston Test Systems) volumes is that there is no liquid leak during the check. To test for the absence of leaks, the standardization documentation envisages determining the volumes at two flow rates:  $V_1$  the larger and  $V_2$  the smaller. In practice,  $\Delta_1$  may be positive or negative; if  $\Delta_1$  is more than 0.2Δ and is positive, this usually indicates a leak. It is then necessary to check for leaks in the piston device or in the four-way stopcock and to adjust the piston to increase the thrust and repeat the measurements. If  $\Delta_1$  is negative and larger in value than 0.2Δ, this indicates errors in the measurements. One can judge the measurement performance and the quality of the PTS from the standard deviation in the results, as the quality of the measurements and the PTS increases as the standard deviation decreases. 5 refs.

Fatkhutdinov, A.Sh. *Meas Tech* v 30 n 7 Jul 1987 p 668-670.

## Thermoanalysis See DIESEL ENGINES—Pistons.

## Wear See DIESEL ENGINES—Wear; INTERNAL COMBUSTION ENGINES—Wear.

## PLANETARIUMS

## Bangalore, India

**079177 MODERN PLANETARIUM COMPLEX IN BANGALORE.** A modern planetarium is recently constructed in the garden city of Bangalore. Situated near the Raj Bhavan, the planetarium complex, costing Rs. 2.28 crores, is one of the best in the country. The complex has a total area of about 2,650 m<sup>2</sup> and comprises a 300-seat sky theater, exhibition area, lecture halls, revolving dome with claude telescope, children's art gallery, and services. The elegant-looking buildings are attractively clad with sandstone from Rajasthan. The whole complex is enveloped by delightful greenery and extensive landscaping. (Author abstract).

Nath, Prem. *Indian Concr J* v 62 n 5 May 1988 p 235-237.

## Equipment See OPTICAL PROJECTORS—Automation.

## Instruments See Also OPTICAL PROJECTORS—Performance.

**079178 COSMORAMA - JENA'S LATEST PLANETARIUM DESIGN.** In July 1984 the Space Sciences Centre was opened in Edmonton (Canada). Visitors experienced the first planetarium shows with the new COSMORAMA projection machine supplied by JENOPTIK JENA GmbH. Designed for large domes 17.5 to 25 m in diameter, the COSMORAMA can impressively demonstrate the starry sky to several hundred spectators at a time. A brief survey of the development that led to this planetarium designed in Jena is given. The instrument is the world's first large planetarium to be controlled exclusively through microcomputers. 3 refs.

Meier, Ludwig; Reiche, Jurgen. *Jena Rev* n 3 1986 Suppl p 3-14.

## PLANETS See Also SPACECRAFT—Mathematical Models.

## Exploration

**079179 TOWARDS BECOMING A MULTI-PLANET SPECIES.** The future exploration of the solar system will be a mix of humans and machines working together. In some cases the human-machine link may be over thousands to tens of million kilometers. In other cases it may be just a few meters, as humans themselves visit and work on other planets. In addition to the scientific investigation and the possible development of utilitarian applications on other planets, one of the principal aims of solar system exploration is to understand and develop the role of humans off of the planet Earth. One can conceive of very limited roles with occasional forays of exploration or of much more involved roles, leading to possible colonization on other planets. More limited models may be valid with machines doing most of the investigation - such as in our underwater activities in the ocean. It is to be emphasized here, and specifically cited later, that saying this is not to set up Mars missions as having priority over other space (or terrestrial) activities. 13 refs.

Friedman, Louis (Planetary Soc, Pasadena, CA, USA). *Space Technol (Oxford)* v 7 n 3 1987 p 217-225.

**079180 REACHING FOR THE PLANET MARS: HUMANKIND'S EVOLVING PERSPECTIVES.** The historical background provides a broad range of perspectives of Mars commencing with the realization that a point of light called Mars was a wanderer or planet. The viewpoint of many people early in this century, based upon a paucity of data, was that the Martian environment was earthlike. Mars was thought to be inhabited. The realization now is that the Martian environment is radically different than the terrestrial. Fundamental questions in comparative planetology arise regarding the environments of Earth, the Moon, Venus and Mars, which have important implications for the terrestrial environment and man's approach to that environment. Mars is the keystone of comparative planetology. To learn the nature of Martian atmospheric and solid body dynamics is also to learn of competing processes at work on all of the terrestrial planets. (Author abstract) 26 refs.

Johnson, Stewart W. (BDM Corp, Albuquerque, NM, USA). *Space Technol (Oxford)* v 7 n 3 1987 p 243-247.

## Remote Sensing See EXTRATERRESTRIAL ATMOSPHERES—Remote Sensing.

## PLASMA ARC CUTTING See Also CONCRETE CONSTRUCTION—Radiation Effects; METAL CUTTING—Laser Beam; METALS AND ALLOYS—Fatigue; WELDING—Sensors.

**079181 AIR PLASMA CUTTING DEVELOPMENT AND PRESENT TRENDS IN EQUIPMENT AND APPLICATIONS.** Principles of the process, equipment

and techniques used, and applications and current developments are described. Topics include a history of air plasma cutting, formation and effects of the plasma, electrodes (water cooled copper electrodes with hafnium or zirconium inserts), the drag cutting technique, safety, fume, applications removal, new equipment, and the scope of the process case histories are given.

Harris, Ian (Welding Inst, Abington, Engl). *Met Constr* v 19 n 10 Oct 1987 p 586-590.

**079182 NEW CATHODE MATERIALS FOR AIR-PLASMA CUTTING.** The air-plasma cutting technique is very simple, and comparatively low current up to 50 A is mainly applied. The cathode is a small-tip electrode made of zirconium or hafnium, tightly mounted in copper sheath. At these tip electrode are exposed to oxidizing atmosphere at high temperatures, the durability of the electrode material is a serious problem. In this paper, it is shown that a new material which is obtained by sintering of rhenium (Re) and yttrium-oxide (Y<sub>2</sub>O<sub>3</sub>) mixture, a superior durability can be achieved.

Matsuda, Fukuhisa; Ushio, Masao; Umez, Sadao. *Trans JWRI* v 16 n 1 Jun 1987 p 215-216.

## Automation

**079183 PLASMA ARC CUTTING SYSTEM PROVES A CUT ABOVE THE ORDINARY.** From its plant in Martinsville, Va., Koger/Air designs, builds and installs dust collection and air handling systems. Metal cutting is a major part of the fabricating process, and until 1986, all cutting was done manually or supplied by outside vendors. The recent installation of an MG Mini-bridge 3500 with a Hypertherm HT400 automated plasma cutting system has had a major and very positive effect on the business. Koger's cutting applications cover a wide selection of metals and thicknesses - galvanized, stainless steel, carbon steel and aluminum, from 24 gauge to 1 in. thick. The paper describes the benefits obtained by Koger with the installation of its new automated plasma arc cutting system. A description is given of the software features of the new system which has included some accounting functions. Productivity improvements and the adaptation of the employees to the new cutting operations are also reviewed.

Anon (American Welding Soc). *Weld J (Miami Fla)* v 67 n 2 Feb 1988 p 45-46.

## Computer Applications See MACHINE SHOPS—Computer Applications.

## Control Systems

**079184 MICROPROCESSOR-BASED SHAPE AND VELOCITY CONTROL SYSTEM FOR PLASMA ARC CUTTING.** Plasma arc cutting is a fusion cutting process in which a gas-constricted arc is employed to produce a high-temperature, high-velocity plasma jet on the workpiece. This process provides some advantages, such as increased cutting velocity, excellent working accuracy and the ability to cut special materials (widely used stainless steels and Al-alloys, for example), when compared to conventional oxyfuel gas cutting. From the viewpoint of price and reliability of the power source, plasma arc cutting also has some distinct advantages over laser beam cutting. The paper discusses a software program which allows any shape composed of line and circle to be cut with great accuracy using the plasma arc cutting process.

Na, S.-J. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Park, S.-W.; Cho, S.-H.; Lho, T.-J. *Weld J (Miami Fla)* v 67 n 2 Feb 1988 p 27-33.

## Efficiency See SHEET AND STRIP METAL—Cutting.

## Equipment

**079185 PLASMA ARC CUTTING POWER SUPPLIES EXPLAINED.** Since 1980, there have been two major trends in the plasma cutting industry. The first



has been the rise of small systems (under 100 A) to market dominance, and the second is the use of more electronics in the power supply design. The market shift to small power supplies has resulted primarily from the development of new markets for small systems in such areas as HVAC, sheetmetal fabrication and auto body fabrication, as well as a relatively flat demand for large systems from heavy industry. This article will focus on the three most common types of small power supplies and will compare their relative merits. The three types of plasma cutting power supplies in common use today are the drooper, the inverter, and the chopper. The drooper is a 'conventional' power supply, while the other two are referred to as switchmode supplies.

Frappier, M.B. (Thermal Dynamics Corp, West Lebanon, NH, USA). *Weld J (Miami Fla)* v 67 n 2 Feb 1988 p 48-50.

## Measurements

**079186 RADIAL CURRENT-DENSITY DISTRIBUTION IN THE MAIN SPOTS IN A PLASMA CUTTING ARC.** Air-plasma metal cutting is increasingly used, where the plasmatron may have a thermochemical cathode or a cylindrical copper electrode. A major distinctive feature is that the arc burns between the inner electrode and the metal to be cut and passes through a narrow nozzle along with the air. Intense heating and rapid melting occur in the arc spot on the metal, while the plasma flux through the nozzle blows the molten metal away, and the spot moves along the generator in the cutting cavity. The efficiency and economy in plasma cutting are dependent to a considerable extent on the heat transfer between the arc spot and the metal, and the rate of this is dependent on the spot parameters, particularly the radial current-density distribution. Measurements have been made on the current density in a cutting arc as affected by polarity and by the design and working parameters. (Edited author abstract) 7 refs.

Kiselev, Yu.Ya. (Kishinev Polytechnical Inst, USSR); Pogora, V.K. *J Eng Phys* v 53 n 2 Aug 1987 p 950-953.

## Personnel

**079187 WHAT DISTRIBUTORS SHOULD KNOW ABOUT PLASMA ARC CUTTING.** When it comes to thermal cutting, the oxyfuel process faces competition from plasma arc cutting. One reason is that oxyfuel cutting is slower in many cutting operations than the plasma arc process, which first came into use some 30 years ago. Another reason is improvements in the portable handheld air plasma torches which reduce the cost of plasma arc cutting considerably.

Jefferson, Ted B. (Welding Distributor, Cleveland, OH, USA). *Weld Distrib* 32 n 3 May-Jun 1988 p 76-78.

## Quality Control

**079188 QUALITY OF PLASMA-ARC CUTTING AND AEROSOL-GENERATION.** Underwater plasma cutting is a method of thermal cutting, whereby a high performance (thickness of metal to be cut 10 mm), the small tool required, and no restoring forces are all advantages. A high temperature plasma arc (about 25,000 K) cuts electrically conducting materials by melting and partially evaporating them. The melted or evaporated particles produced either remain in the water in solution or in assistance of coarse-grained or hollow spheres or become partially aerosol depending on the parameters of cutting. The possible methods of recognition and analysis of the cutting products are discussed. Interpretation of the results shows that the quality of plasma cutting depends on the degree of aerosol-generation. 2 refs.

Windelberg, D. (Univ of Hannover, Hanover, West Ger); Bach, Fr.W.; Georgi, B.; Steiner, H. *J Aerosol Sci* v 18 n 6 Dec 1987, Aerosols in Sci, Med and Technol with Spec Emphasis on Urban and Environ air Pollut, Hanover, West Ger, Sep 9-11 1987 p 919-922.

**Robot Applications** See NUCLEAR REACTORS—Decommissioning.

**PLASMA DEVICES** See Also CATHODES; CHARGED PARTICLES—Transport Properties; DISPLAY DEVICES—Performance; ELECTRIC ARCS—Computer Simulation; GYROTRONS—Performance; MAGNETIC FIELDS; MAGNETIC FIELDS—Optimization; MAGNETIC MEASUREMENTS; PLASMAS—Density; PLASMAS—Fluid Dynamics; PLASMAS—Heating; PLASMAS—Magnetic Field Effects; PLASMAS—Stability; PLASMAS—Transport Properties; PLASMAS—Wave-Plasma Interactions; POWDERS—Manufacture.

**079189 INITIAL RESULTS FROM THE COAXIAL SLOW SOURCE FRC DEVICE.** The Coaxial Slow Source (CSS) is a device in which 'annular' FRCs, i.e., small aspect ratio, highly elongated plasmas with poloidal fields only, are formed in the annular space between concentric coils carrying toroidal currents. The device is constructed so that the plasma can be translated into a simple cylindrical chamber and re-formed as a true FRC. The goal of the investigation is to form FRCs on slow (diffusive) time-scales and at low voltage. Initial operation shows that the desired configurations are formed over a wide range of coil voltages and fill pressures. The radial plasma position can be controlled. Configuration life-times are 30-60  $\mu$ s, with flux lifetimes of 15-20  $\mu$ s. Flux is built up over 25  $\mu$ s, at loop voltages of 1-2 kV, in comparison with 2.5  $\mu$ s and 100 kV for comparably sized field reversed theta pinches conventionally employed for FRC generation. (Author abstract) 16 refs.

Pietrzyk, Z.A. (Univ of Washington, Seattle, WA, USA); Vlasses, G.C.; Brooks, R.D.; Hahn, K.D.; Raman, R. *Nucl Fusion* v 27 n 9 Sep 1987 p 1478-1488.

**079190 GROUND-BASED PLASMA CONTACTOR CHARACTERIZATION.** This paper presents recent NASA Lewis Research Center (LeRC) plasma contactor experimental results, as well as a description of the plasma contactor test facility. The operation of a 24 cm diameter plasma source with hollow cathode was investigated in the 'ignited-mode' regime of electron current collection from 0.1 to 7.0 A. These results are compared to those obtained with a 12 cm plasma source. Full two-dimensional plasma potential profiles were constructed from emissive probe traces of the contactor plume. The experimentally measured dimensions of the plume sheaths were then compared to those theoretically predicted using a model of a spherical double sheath. (Edited author abstract) 11 refs.

Patterson, Michael J. (NASA, Cleveland, OH, USA); Aadland, Randall S. *NASA Tech Memo* 100194 1987 15p.

**079191 ENERGY THEORY ON DISCHARGES OF  $E \times B$  TYPE DEVICES.** A systematic theory to interpret discharge phenomena generated in  $E \times B$  structural discharge devices (magnetron type, PIG type, concentric quasi-spherical type, and so forth) is developed by applying the classical magnetron theory to  $E \times B$  structural systems. The theory presented in this paper is useful for designing such devices as ion sources for ion beam technology, and fundamental researches on cosmic plasmas and nuclear fusion plasmas and for interpreting discharge phenomena generated in these types of devices. (Edited author abstract) 14 refs.

Tanizuka, Noboru (Univ of Osaka Prefecture, Sakai, Jpn). *Electron Commun Jpn Part 2* v 71 n 2 Feb 1988 p 30-39.

**079192 PG-45 PLASMA GENERATOR.** Processes have been developed in the USSR and abroad that use low-temperature plasma; to introduce these into industry the All-Union Scientific Research Institute for Electrothermal Equipment has developed the PG-45 plasmas generator. Series production began in 1986. The device is provided with the following: a basic power supply consisting of a series KTE thyristor converter and a power transformer; a supply unit for the keep-alive arc; an arc plasma gun; a high-frequency oscillator; a water-cooling system that includes gages for flow rate and temperature of the cooling water; a gas-supply system that includes systems for regulating and measuring gas flow rate; control panels and console. A figure shows a plasma gun

of linear arrangement with a fixed arc length.

Bortnichuk, N.I. *Sov Electr Eng* v 58 n 11 1987 p 114-115.

**079193 FINITE PRESSURE EQUILIBRIUM EFFECTS ON HELICAL RIPPLE TRANSPORT IN TORSATONS.** A three-dimensional equilibrium code (NEAR) is used to study plasma equilibrium in torsatron configurations having various winding laws. The harmonic spectra describing the variation of  $|B|$  along magnetic field lines are calculated at finite plasma pressure and then used to calculate the geometric factors that determine the magnitudes of the neoclassical transport coefficients in the helical ripple regime, where the particle and heat fluxes are inversely proportional to the collision frequency. The results show that an appropriate choice of winding law can reduce helical ripple transport by a factor of about 2 in the vacuum field and at high plasma pressure. (Author abstract) 14 refs.

Bykov, V.E. (Acad of Sciences of the Ukrainian USSR, Kharkov, USSR); Grekov, D.L.; Shishkin, A.A.; Garcia, L.; Harris, J.H.; Rome, J.A. *Nucl Fusion* v 28 n 5 May 1988 p 871-879.

## Accelerators

**079194 EFFICIENCY ASPECTS OF SHORT, LOW VELOCITY RAILGUNS.** The factors controlling the performance of short, low velocity railguns are studied and mathematical expressions defining the bounds of realizable efficiencies are obtained. The restrictions governing the validity of the expressions are discussed. The expressions are based on the proposition that during acceleration of the projectile in the railgun, the current falls almost linearly with time. Under the conditions discussed in this report it is shown that the maximum achievable efficiency is about 1.6%. 13 refs.

Sach, C.I. *Rep Mater Res Lab Aust MRL-R-1029 Jun 1987 30p.*

**079195 ANALYSIS OF A SERIES OF ELECTRO-MAGNETIC LAUNCHER FIRINGS.** In this report theoretical aspects of electromagnetic launchers are presented in conjunction with an analysis of diagnostic measurements taken during the RAPID Plasma Intensity Profiles (RPIP) series of firings. These theoretical aspects deal with the current-time behavior, the plasma temperature and the evaluation of railgun parameters such as the efficiency and effective inductance per unit length. The principal aims of the RPIP series were: (1) to see if different types and masses of plasma-generating foils affected railgun performance and the diagnostic measurements taken during each firing and (2) to compare some of the theoretical predictions of the Plasma Armature Rail Accelerator (PARA) simulation code with experimental results. Projectile displacement-time results for the series were obtained by digitizing photographs from a streak camera and in order to verify the PARA predictions for plasma-length behavior, light intensity profiles were produced from microdensitometer readings of the streak films. The experimental results were affected by plasma disruption, arcing ahead of the projectile and plasma leakage. These effects are also discussed in this report. (Author abstract) 38 refs.

Kowalenko, V. *Rep Mater Res Lab Aust MRL-R-1053 Jun 1987 85p.*

**079196 EVALUATION OF ACCELERATION AND HEATING OF PARTICLES BY PULSED PLASMA FLOW.** Using a simplified approach, based on the shortness of the discharge time compared with the time of plasma flow out of a pulsed accelerator, it is possible to evaluate the parameter of the plasma flowing out of the accelerator barrel. A relation proposed taking into account of the effect of the shape of the solid particles on their aerodynamic resistance, as well as a method of calculating the nonsphericity coefficient, are proposed. The calculation of the velocity of the particles in a pulsed



flow corresponds well with the experiments. It is shown that acceleration of the particles of the hard cobalt-tungsten carbide alloys VK-25 is accompanied by their melting and partial evaporation, which makes it possible to explain the lack of correspondence between the sizes of the carbide grains in a coating with the sizes of the powder being sprayed. (Translated author abstract) 10 refs. In Russian.

Gasim, D.A.; Uryukov, B.A. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 4 Feb 1988 p 68-76.

**079197 DATA ACQUISITION SYSTEM FOR THE SANDIA PARTICLE BEAM FUSION ACCELERATOR II.** The authors describe the data acquisition system (DAS) for the Particle Beam Fusion Accelerator II (PBFA II) at Sandia National Laboratories. This DAS incorporates several advanced features over those developed for previous pulsed power facilities at Sandia. Some major improvements are the use of LeCroy 6880 waveform recorders; multiplexing of up to four signals on each 6880; dual 32-bit, virtual-memory computers; a pulsed reference source automatic waveform recorder calibration system; and LeCroy 4208 time-interval digitizers. 5 refs.

Boyer, William B. (Sandia Natl Lab, Albuquerque, NM, USA); Bouchier, Frank A.; Chaba, Steven J.; Mattson, C.R. *IEEE Trans Nucl Sci* v NS-34 n 4 Aug 1987, Fifth Conf on Real-Time Comput Appl in Nucl, Part and Plasma Phys, San Francisco, CA, USA, May 12-14 1987 p 733-738.

**Applications** See ELECTRON DEVICE MANUFACTURE—Etching.

#### Computer Applications

**079198 UPGRADE OF MHD DATA ACQUISITION SYSTEM FROM ISX-B TO ATF.** The data acquisition system assembled to study magnetohydrodynamic (MHD) activity on the Impurity Study Experiment (ISX-B) tokamak at Oak Ridge National Laboratory (ORNL) is being revised for use on the Advanced Toroidal Facility (ATF) at the same lab. The hardware organization and software components are described in detail. The system will store a flexible mix of data and will allow the operator to acquire and examine data simultaneously. Different modes of operation for the data acquisition system will address the various plasma control and turbulence studies to be undertaken on ATF. 2 refs.

Bell, John D. (Oak Ridge Natl Lab, TN, USA); Pare, V.K. *IEEE Trans Nucl Sci* v NS-34 n 4 Aug 1987, Fifth Conf on Real-Time Comput Appl in Nucl, Part and Plasma Phys, San Francisco, CA, USA, May 12-14 1987 p 768-771.

**Computer Simulation** See PLASMAS—Diagnostics.

#### Control Systems

**079199 DATA ACQUISITION AND CONTROL SYSTEM FOR ATF: AN OVERVIEW.** A data acquisition and control system is being developed to support the Advanced Toroidal Facility (ATF) at the Oak Ridge National Laboratory. This system has two separate elements: a VAX-based data acquisition and management system and a status and control system that uses programmable logic controllers. Although these systems can operate independently, they are intended to cooperate fully and complement one another. An overview of the hardware components, software architecture, and operations of these systems is presented. 3 refs.

Stewart, K.A. (Oak Ridge Natl Lab, TN, USA); Baylor, L.R.; Greenwood, David E.; Kannan, Kay L.; Overbey, D.R.; Wing, W.R.; Sumner, J.N.; DeVan, W.R. *IEEE Trans Nucl Sci* v NS-34 n 4 Aug 1987, Fifth Conf on Real-Time Comput Appl in Nucl, Part and Plasma Phys, San Francisco, CA, USA, May 12-14 1987 p 739-741.

**079200 ATF STATUS AND CONTROL SYSTEM.** The Advanced Toroidal Facility (ATF) status and control system (SCS) is a programmable controlled-based state

monitoring and supervisory control system. The authors describe the SCS implementation and its use of a host computer to run a commercially available software package that provides color graphic interactive displays, alarm logging, and archiving of state data. 5 refs.

Baylor, L.R. (Oak Ridge Natl Lab, TN, USA); Devan, W.R.; Sumner, J.N.; Alban, A.M. *IEEE Trans Nucl Sci* v NS-34 n 4 Aug 1987, Fifth Conf on Real-Time Comput Appl in Nucl, Part and Plasma Phys, San Francisco, CA, USA, May 12-14 1987 p 984-986.

**Design** See TOKAMAK DEVICES—Components.

**Diodes** See Also ION SOURCES—Low Temperature Effects; PLASMAS—Photography.

**079201 CHARGED-PARTICLE BEAM GENERATION IN A VACUUM MICROWAVE DISCHARGE INITIATED BY EXPLOSIVE EMISSION.** It is shown that the plasma formed by explosive emission (EE) in a high-power microwave field is a source of charged particles (electrons and ions). Stable ion-beam generation is observed only when the cathode has an extended emitting surface. It is found that the expansion velocity of the plasma for small gaps in the diode is lower than with EE in pulsed fields. (Edited author abstract). 5 refs.

Andriyanov, Yu. V.; Bazdyrev, V.N.; Borisov, D.A.; Zhukov, V.M. *Sov J Commun Technol Electron* v 32 n 9 Sep 1987 p 139-145.

**079202 CHARGE FLOW AND PLASMA BEHAVIOR IN INTENSE ION BEAM DIODES.** Spatial nonuniformities of the diode plasmas, plasma expansion, ion transverse velocities in the diode gap, electron flow to the anode, and the charge distribution in the gap have been investigated for magnetically insulated diodes. Rapid closure of the diode gap, resulting from fast expansion of the electric field, was observed, excluding anode plasma early in the pulse. This contributes significantly to the measured ion-current-density enhancement. The electron cloud in the gap spread toward the anode beyond the region of the theoretical electron sheath, which is consistent with observed ion current densities being larger than the values calculated using the actual diode gap. The ion angular spread increased locally due to nonuniform expansion of the cathode plasma for one class of phenomena of the anode plasma for two other classes. The ion divergence angle in the gap was independent of the ion mass and significantly smaller than angles previously observed outside the diode. 35 refs.

Maron, Y. (Weizmann Inst of Science, Rehovot, Isr). *IEEE Trans Plasma Sci* v PS-15 n 5 Oct 1987, XIIth Int Symp on Discharges and Electr Insul in Vac, Shores, Isr, Sep 22-25 1986 p 571-577.

**Electric Power Supplies** See PLASMA ARC CUTTING—Equipment.

**Erosion** See GRAPHITE—Radiation Damage.

**Guns** See Also ELECTRIC RECTIFIERS—Protection; ELECTRIC SWITCHES—Vacuum Applications.

**079203 EXPERIMENTAL INVESTIGATIONS OF ELECTRIC ARCS IN TURBULENT FLOW OF GAS.** Some results of experimental investigations of integral and local characteristics of electric arcs in turbulent flows of gas are presented. A survey of experimental investigations of averaged and pulsational characteristics of turbulent plasma is given. The most promising contact and contactless diagnostics methods are considered. Attention is drawn to the need for measuring local pulsational values of temperature and velocity. Possible aspects of such measurements are analyzed and examples are offered. (Translated author abstract) In Russian. 130 refs.

Zhukov, M.F.; Zasyupkin, I.M.; Levitan, Yu.S. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 11 1987 p 25-51.

**079204 POWER SOURCES FOR UNITS WITH CONCENTRATED ENERGY FLUXES.** Progress in machine and instrument fabrication, metallurgy, and

other industries is closely associated with the extensive utilization of modern technologies; here an important position is occupied by units employing heating sources with concentrated energy fluxes (plasma, electron-plasma, electron-beam, and laser devices) in which following several conversions electrical energy acts on the product being processed, with the liberation of heat. Plasma units are employed successfully in welding, cutting, and remelting of metals, deposition and buildup of coatings, enrichment of ores, and in other applications. It is shown that it is desirable to employ converter sets operating in current-source mode to supply units with concentrated energy fluxes. The basic requirements for power sources are given. (Edited author abstract) 8 refs.

Kruchinin, A.M.; Dolbilin, E.V.; Chursin, A.Yu. *Sov Electr Eng* v 58 n 8 1987 p 58-62.

**079205 NOZZLES TO PROVIDE LOCAL PROTECTION IN PLASMA SPRAYING.** A survey of the designs of nozzles to provide quasienclosures during plasma deposition of coatings is presented. Some criteria of economic and technological characteristics of the local protection systems are proposed. The need for a complex investigation of the process of plasma spraying under the conditions of the deposition zone shielding is pointed out. (Translated author abstract) In Russian. 26 refs.

Kudinov, V.V.; Kosolapov, A.N.; Pekshev, P.Yu. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* v 21 1987 p 69-75.

**079206 OPTIMIZATION OF THE PROCESS AND APPARATUS FOR PLASMA SPRAYING.** The variational problem of optimization of thermophysical and gas dynamic processes in a high temperature flux during plasma spraying is formulated with the purpose of minimizing the losses of the powder sprayed. The solution is based on a steady-state quasi one-dimensional model of high temperature flux of a non-ideal gas with particles. Calculation results show a good match with experimental data. (Translated author abstract) 12 refs. In Russian.

Gonopol'skii, A.M. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 4 Feb 1988 p 81-88.

**079207 GEOMAGNETIC FIELD - AN EXPLANATION FOR THE MICROTURBULENCE IN COAXIAL GUN PLASMAS.** The complexity introduced by the geomagnetic field in several regions of a coaxial gun plasma device is described. It is shown that the annihilation of the swept-up geomagnetic flux, trapped within the highly compressed turbulent plasma, provides an explanation for varied performance and experimental results. The results indicate that the device should be aligned along the direction of the local geomagnetic field or enclosed in a mu-metal shield. 2 refs.

Mather, J.W. (Univ of New Mexico, Albuquerque, NM, USA); Ahluwalia, H.S. *IEEE Trans Plasma Sci* v 16 n 1 Feb 1988 p 56-57.

#### Heat Transfer

**079208 FLUID FLOW AND HEAT TRANSFER IN PLASMA REACTORS - I. CALCULATION OF VELOCITIES, TEMPERATURE PROFILES AND MIXING.** A mathematical representation has been developed to describe the velocity field and the associated temperature and concentration fields in a plasma jet system, which involves the injection of additional gas streams. In the statement of the problem, allowance was made for the swirl of the plasma jet, and one important objective of the work was to explore the effect of this swirl on the principal process variables. It was found that swirl plays an important role in providing mixing between the plasma jet and a reactant or diluent gas stream. (Edited author abstract) 25 refs.

Dilawari, A.H. (MIT, Cambridge, MA, USA); Szekely, J. *Int J Heat Mass Transfer* v 30 n 11 Nov 1987 p 2357-2372.



## Ion Implantation

**079209 PERFORMANCE OF A PLANAR MAGNETRON SPUTTERING APPARATUS WITH COMPLEX TARGET.** A planar magnetron sputtering apparatus with complex targets has been made for depositing high quality metal films onto various substrates. The apparatus can be used in several configurations such as that for multilayer, interdigitated wedge deposition and co-sputtering. The vacuum chamber contains four pairs of two-element targets and a rotatable substrate holder, which permits eight elements to be deposited onto one substrate without removal of the substrate from the vacuum chamber. A liquid nitrogen trap is used for cooling the substrate. (Edited author abstract) 12 Refs.

Chen, Qing-Ming (Tsinghua Univ, Beijing, China); Fan, Yu-Dian; Li, Heng-De. *Vacuum* v 38 n 6 1988 p 491-495.

**Jets** See Also HEAT TRANSFER; PLASMAS—Measurements; SILICON NITRIDE—Chemical Vapor Deposition.

**079210 PARTICLE DYNAMICS AND PARTICLE HEAT AND MASS TRANSFER IN THERMAL PLASMAS. PART III. THERMAL PLASMA JET REACTORS AND MULTIPARTICLE INJECTION.** Thermal plasma processing involves complex interactions of particulates with plasma. A mathematical model is proposed for the simulation of thermal plasma jet reactors, including the mixing phenomena between the jet and the surrounding gases by generalizing the governing equations for simple mixing flows. Also included is the density fluctuation effect by extending the K- $\epsilon$  model to a four-equation turbulence model combined with a probability density function. For multiparticle injection, the simulation repeats calculations for single-particle injection, but with different initial conditions correcting the solutions by considering the coupling effects between particles and the plasma. (Edited author abstract) 35 refs.

Lee, Y.C. (Univ of Minnesota, Minneapolis, MN, USA); Pfender, E. *Plasma Chem Plasma Process* v 7 n 1 Mar 1987 p 1-27.

**079211 DYNAMIC CHARACTERISTICS OF A DENSE PLASMA JET IN THE ATMOSPHERE.** The electrical characteristics of a plasma-dynamic accelerator with a gas fill are studied. The dynamics of a dense plasma jet in air at atmospheric pressure was studied with the help of ultrafast photography and the Schlieren technique. It is shown that for impulsive injection of a dense plasma jet into the atmosphere a spherical shock wave and a cloud of intensely radiating plasma, from which under certain conditions a stable long-lived toroidal or spherical plasma configuration forms, are produced. (Author abstract) 8 refs.

Anders, A. (M.V. Lomonosov Moscow State Univ, USSR); Anders, S.; Timofeev, I.B.; Yusupaliev, U. *High Temp* v 25 n 3 May-Jun 1987 p 338-343.

**079212 INFLUENCE OF THE BLOWOFF OF BOUNDARY GAS FROM THE DISCHARGE CHAMBER OF A PLASMATRON ON THE PARAMETERS OF THE JET.** The results of an experimental investigation of the parameters of an argon jet heated in a plasmatron with an anode permitting the removal of part of the cool gas from the discharge chamber are presented. An analysis of the results of the measurements show that removal of the cool part of the working gas from the discharge chamber of a plasmatron has slight influence on the maximum temperature near the nozzle. This indicates that under the given conditions, the electric arc in the anode behaves like an unventilated body to a certain extent, while the hot gas mixes insignificantly with the cool boundary stream. An increase in the fraction of removed gas makes the radial temperature distribution level off much more. (Edited author abstract) 20 refs.

Dundr, J. (Acad of Sciences of Czechoslovakia, Prague, Czech); Plojhar, F.; Slechta, J. *J Eng Phys* v 52 n 1 Jan 1987 p 115-121.

**079213 INFLUENCE OF A WEAK MAGNETIC**

**FIELD ON THE INTENSITY OF THE PLASMA JET OF AN ARC PROTON SOURCE.** An arc source of a plasma jet, used as an element of a system of plasma diagnostics or as the injection system for a proton accelerator, experiences the influence of the stray magnetic fields of these systems. The influence of a longitudinal magnetic field with an induction  $10 < B < 70$  G on the arc source leads to an increase in the density of the plasma jet generated by it and of the current extracted from the fixed plasma boundary in proportion to B. A similar result was obtained in the range of strong magnetic fields  $300 < B < 800$  G. The influence of longitudinal magnetic fields with  $B < 13$  G on these parameters is analyzed in the present paper in connection with problems of stabilization and control of the current of a source. 7 refs.

Getmanov, V.N.; Savchenko, O.Ya. *J Appl Mech Tech Phys* v 28 n 3 May-Jun 1987 p 326-331.

**079214 PROBE DIAGNOSTICS OF THE LATE STAGES OF OUTFLOW OF A DENSE PLASMA JET INTO THE ATMOSPHERE.** Data are given on the evolution in time and space of the electron concentration in a plasma jet, ejected into the air from the nozzle of a powerful pulse plasmatron. These data are obtained using the probe method and the uhf method. It is shown that during the late stage of outflow (up to times of 1.5-2 msec) typical values of the electron density range from  $10^{14}$  to  $10^{13}$  cm $^{-3}$  and change little during the indicated time interval. (Author abstract) 12 refs.

Andres, A. (Moscow State Univ, USSR); Ershov, A.P.; Isaev, K.Sh.; Timofeev, I.B. *High Temp* v 25 n 4 Jul-Aug 1987 p 566-570.

**079215 PROBE MEASUREMENTS IN THERMAL PLASMA JETS.** Measurements of composition, temperature, and velocity in atmospheric argon plasma jets are reported, using enthalpy probes. The plasma jets are generated by a commercial type plasma gun and the measurements are expected to be of particular interest for individual applications such as plasma spraying. Emphasis has been on the central and downstream regions of the plasma flame. The environment of air into the jet was found to be very high, even close to the axis of the jet. Gas samples analyzed with a gas chromatograph showed demixing of the air, i.e., nitrogen is more abundant in the jet than at room temperature. (Edited author abstract) 40 refs.

Brossa, M. (Univ of Minnesota, Minneapolis, MN, USA); Pfender, E. *Plasma Chem Plasma Process* v 8 n 1 Mar 1988 p 75-90.

**079216 TEMPERATURE STUDIES OF A SUBSONIC JET IN MOLECULAR GASES AT LOW PRESSURES.** The results of measurements of the temperature in an air and nitrogen plasma jet at low pressures on the VGU-2 setup are presented. The flame of the air and nitrogen plasma jet has a characteristic structure: a high-temperature core and a peripheral part - a mixing layer with a lower temperature. The core of the nitrogen plasma jet is wider than that of the air plasma jet for the same values of the pressures and powers. (Edited author abstract) 7 refs.

Georg, E.B. (Acad of Sciences of the USSR, Moscow, USSR); Yakushin, M.I. *J Eng Phys* v 53 n 3 Sep 1987 p 1045-1050.

**079217 TEMPERATURE MEASUREMENTS OF ATMOSPHERIC AIR PLASMA FREEJETS BY MEANS OF THE MOIRE-SCHLIEREN AND SPECTROSCOPIC METHODS.** The atmospheric Ar plasma freejets, generated by an electric arc discharge, are visualized and measured by the Moire-Schlieren method to obtain the details of their higher temperature fields. Electron temperatures and electron number densities are also deduced from a combined method of the absolute measurement of Ar spectral lines and the collisional-radiative process theory. From the experiments performed under the conditions of arc currents of 100-200 A and nozzle diameters of 3-4 mm, the following are found: (i) The gas temperatures are 1000-5000 K and the electron

temperatures are about 8500 K. (ii) The distributions of gas temperature for the conditions show a similar form. (iii) The freejets are thermally in nonequilibrium, though the plasmas are fairly dense. (Author abstract) In Japanese. 19 refs.

Tabei, Katsune; Shirai, Hiroyuki; Oikawa, Shinro; Takakusagi, Fumio. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 494 Oct 1987 p 3052-3058.

**079218 SIX-ELECTRODE, DIRECT-CURRENT, VARIABLE-LENGTH PLASMA SOURCE FOR ATOMIC EMISSION SPECTROSCOPY.** A variable-length plasma source has been developed for analytical atomic emission spectroscopy. The length of the plasma, adjustable during plasma operation, provides a means of adjusting the sample residence time in the plasma. The plasma operates from three compact, simple, and inexpensive direct-current power supplies. Three concentric quartz tubes supply argon and sample aerosol to the plasma. The modular design allows the quartz tubing to be easily replaced and a variety of electrode distances to be established. The argon consumption, typically 7.4 L/min, is comparable to, or less than, that for commercial DCP and ICP systems. Many of the vertical spatial characteristics of the plasma described are similar to those documented for the ICP. Changes in the nebulizer gas flow rate produced spatial shifts in the maximum of the vertical, spatial analyte emission profiles of Mg. Increases in the signal-to-background ratios at common analytical wavelengths were observed with increasing plasma length. (Edited author abstract) 62 refs.

Shields, James P. (Oregon State Univ, Corvallis, OR, USA); Lee, Gae Ho; Piepmeyer, Edward H. *Appl Spectrosc* v 42 n 4 May-June 1988 p 684-692.

**079219 SPATIAL STUDY OF THE INFLUENCE OF PLASMA LENGTH ON INTERFERENCE EFFECTS IN A SIX-ELECTRODE, DIRECT-CURRENT, VARIABLE-LENGTH PLASMA.** Vertical spatial profiles of a six-electrode, direct-current plasma emission source were used to study the influence of plasma length on the interference of Na on Ca and Zn and P on Ca. For the shortest plasma (11.5 mm) depression of the Ca atom line is observed in the region up to 10 mm above the tip of the sample bullet when Na is present. A cross-over to enhancement occurs for higher regions. This is directly opposite to the observations in the ICP for the Na interference on Ca. Increasing the plasma length causes downward shifts in the crossover point which are not a simple effect of the lowering of the sample bullet. When P is present, the Ca atom emission is initially depressed in the region directly above the sample bullet. At higher observation heights, little effect is observed. Similar behavior is observed for the Ca ion line in the presence of P, suggesting the possibility of a classical vaporization-type interference mechanism. The interference effects studied can be eliminated by careful selection of plasma length and observation height. (Edited author abstract) 21 refs.

Shields, James P. (Oregon State Univ, Corvallis, OR, USA); Piepmeyer, Edward H. *Appl Spectrosc* v 42 n 4 May-Jun 1988 p 693-698.

**Magnetic Field Effects** See MAGNETOHYDRODYNAMICS—Diffusion.

**Mass Transfer** See PLASMAS—Contamination.

## Microwaves

**079220 MAKROSKOPOWY MODEL BILANSU ENERGII DLA WYLADOWAN MIKROFALOWYCH W GAZACH O CISNIENIU ATMOSFERYCZNYM. [Macroscopic Model of Microwave Discharges at Atmospheric Pressure].** A macroscopic model of energy exchange in microwave plasma is proposed. This model facilitates calculations of the radial temperature distribution in plasma, dependence of the temperature on microwave power level and other operating parameters of the microwave plasmatrons of coaxial and waveguide-types. Some numerical results are pres-



ented and discussed in the light of experimental works. (Edited author abstract) In Polish. 11 refs.

Parosa, Ryszard (Politechnika Wroclawska, Pol); Reszke, Edward. *Arch Elektrotech (Warsaw)* v 35 n 1 1986 p 71-82.

## Research

**079221 CURRENT-VOLTAGE CHARACTERISTICS AND POTENTIAL OSCILLATIONS OF A DOUBLE LAYER IN A TRIPLE-PLASMA DEVICE.** The properties of a strong double layer in a current circuit with a capacitance and an inductance are investigated in a triple-plasma device. The double layer gives rise to region of negative differential resistance in the current-voltage characteristic of the device, and this gives nonlinear oscillations in the current and the potential drop over the double layer ( $\Phi_{DL}$ ). A variable potential minimum exists in the plasma on the low-potential side of the double layer, and the depth of the minimum increases with  $\Phi_{DL}$  increases. An increasing fraction of the electrons incident at the double layer are then reflected, and this is found to be the main process giving rise to the negative differential resistance. A qualitative model for the variation of the minimum potential with  $\Phi_{DL}$  is proposed. 23 refs.

Carpenter, R.T. (Univ of Iowa, Iowa City, IA, USA); Torven, S. *IEEE Trans Plasma Sci* v PS-15 n 4 Aug 1987 p 434-444.

**Torches** See Also ELECTROMAGNETIC FIELDS—Mathematical Models; FERRITES—Thin Films; FURNACES, MELTING—Research; PLASMAS—Measurements.

**079222 TUBULAR ELECTRODE TORCH FOR CAPACITATIVELY COUPLED HELIUM MICROWAVE PLASMA AS A SPECTROCHEMICAL EXCITATION SOURCE.** A new tubular electrode torch is developed for the capacitatively coupled single electrode helium microwave plasma. The tubular configuration of the central electrode permitted direct introduction of the sample into the center of the plasma. The plasma generated with this tubular torch design is very stable, reproducible, and spectrally clean. The performance of the Ta tubular plasma torch is evaluated in terms of plasma characteristics, including the spectroscopic temperature, electron number density, plasma background, signal-to-noise and signal-to-background ratios, and analytical figures of merit for excitation of organotin samples preceded by hydride conversion. (Edited author abstract) 38 refs.

Patel, B.M. (Univ of Florida, Gainesville, FL, USA); Heithamer, Edward; Winefordner, J.D. *Anal Chem* v 59 n 19 Oct 1987 p 2374-2377.

**079223 PLASMA HOT MACHINING FOR HIGH HARDNESS METALS.** This report describes the plasma heating equipment designed and its performance. A high manganese steel and a chilled cast iron are tested by continuously turning their outer surfaces with carbide tools. Investigations of cutting forces, cutting temperature, tool wear and surface roughness are carried out in various cutting and heating conditions, showing the appropriateness of PHM. 8 Refs.

Kitagawa, Takeaki (Kitami Inst of Technology, Kitami, Jpn); Maekawa, Katsuhiko; Kubo, Akihiko. *Bull Jpn Soc Precis Eng* v 22 n 2 Jun 1988 p 145-151.

## Vacuum Applications

**079224 VACUUM ARC PLASMA CENTRIFUGE FOR ELEMENT AND ISOTOPE SEPARATION.** An arc was produced in a 30-cm-diameter, 4-m-long cylindrical chamber with coaxially mounted electromagnets providing a 2.6-m-long constant axial magnetic field of up to 6 kG. A pulse-forming network of 70-m $\Omega$  impedance provided nearly constant-current discharge pulses of several kA and 6-12-ms duration. The magnetized plasma column, flowing axially from the anode with a typical velocity of 10<sup>6</sup> cm/s, rotated nearly as a solid body. A typical rotation frequency was 10<sup>5</sup> rad/s. The centrifugal

effect due to the rotation caused a radial redistribution of ions within the plasma column, thereby producing elemental and isotope enrichment. The separation increased exponentially with the square of the radius. Enrichments of up to 300% were measured in a Cu-Zn plasma. The radial plasma density profile was roughly Gaussian, with central electron densities of about 10<sup>13</sup> cm<sup>-3</sup>. The radial potential profile across the column was parabolic with radius. These observations can be accounted for by a steady-state multispecies fluid model of the rotating plasma. 6 refs.

Geva, M. (Isomed Ltd, Jerusalem, Isr); Cohen, C.; Danziger, O.; Dothan, F.; Friedland, L.; Levin, L.A.; Maharshak, S.; Hirschfeld, J.L. *IEEE Trans Plasma Sci* v PS-15 n 5 Oct 1987, XIIth Int Symp on Discharges and Electr Insul in Vac, Shores, Isr, Sep 22-25 1986 p 583-588.

**PLASMAS** See Also ANTENNAS—Theory; CERAMIC MATERIALS—Sintering; CHARGED PARTICLES; CHROMATOGRAPHIC ANALYSIS—Equipment; COPPER AND ALLOYS—Vaporization; ELECTRIC CORONA—Mathematical Models; ELECTRIC DISCHARGES—Calculations; ELECTRIC DISCHARGES—High Pressure Effects; ELECTRIC WINDINGS—Analysis; ELECTRON BEAMS—Stability; ELECTRONS—Scattering; ELECTRONS—Surface; FILMS—Ion Implantation; FLUORINE CONTAINING POLYMERS—Surfaces; GLOW DISCHARGES—Electric Properties; INTEGRATED CIRCUIT MANUFACTURE—Etching; ION ACOUSTIC WAVES; ION SOURCES; IONIZATION CHAMBERS; IONS—Scattering; LASER BEAMS—Applications; LASER BEAMS—Brillouin Scattering; LASER BEAMS—Effects; LASERS, GAS—Oscillations; MATHEMATICAL TECHNIQUES—Algorithms; NUCLEAR ENERGY—Fusion Reactions; NUCLEAR REACTORS, FUSION; NUCLEAR REACTORS, FUSION—Materials; PLASMA DEVICES; POWER GENERATION—Magnetohydrodynamic; RESONATORS, CAVITY—Analysis; SEMICONDUCTING FILMS—Electronic Properties; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Defects; SEMICONDUCTING SILICON—Etching; SILICA; SILICON AND ALLOYS—Etching; SILICON COMPOUNDS; SPECTROSCOPY, ELECTRON; STEEL HEAT TREATMENT—Control; THYRISTORS—Performance; TOKAMAK DEVICES; TOKAMAK DEVICES—Components; TOKAMAK DEVICES—Design; TOKAMAK DEVICES—Heat Transfer; TOKAMAK DEVICES—Testing.

**079225 HIGH-INTENSITY POINT PERTURBATION IN A TWO-TEMPERATURE MHD PLASMA.** The development of self-generated nonuniformities has been the focus of many studies in MHD power generators, but relatively few studies have dealt with externally induced nonuniformities. This paper deals with the development of a nonuniformity initiated by a very localized production of a highly ionized spark in an otherwise uniform MHD plasma. The MHD device is an infinitely segmented linear generator operating in the two-temperature mode at a high value of the Hall coefficient. 4 refs.

Lin, Bor-Chyuan (MIT, Cambridge, MA, USA); Louis, Jean F. *J Propul Power* v 3 n 5 Sep-Oct 1987 p 478-480.

**079226 FISSION-FRAGMENT EXCITATION OF METAL ELECTRONS.** Impurities occur in fusion plasmas as highly charged ions; for example, in the T=10 installation, the charges on the iron ions are  $z \geq 20$ . When such an ion is neutralized at a metal, the electrons in it receive energy of some tens of kiloelectron-volts, which can lead to sputtering in the first wall. In this article the formation and relaxation of excited-electron regions along the paths of fission fragments are examined. 10 refs.

Martynenko, Yu.V.; Yavlinskii, Yu.N. *Sov At Energy* v 62 n 2 Feb 1987 p 93-97.

**079227 EFFECT OF AN OXYGEN PLASMA ON UNCOATED THIN ALUMINUM REFLECTING FILMS.** Thin aluminum films have been considered for use as a reflective surface for solar collectors on orbiting solar dynamic power systems. A matter of concern is the durability of such reflective coatings against oxidative attack by highly reactive neutral atomic oxygen, which is the predominant chemical species in low earth orbit. Research to date has been aimed at evaluating the protective merit of thin dielectric coatings over aluminum or other reflective metals. However, an uncoated aluminum reflector may self-protect by virtue of the oxide formed from its exposed surface, which constitutes a

physical barrier to further oxidation. This possibility was investigated, and an attempt was made to characterize the effects of atomic oxygen on thin Al films. It was found that long-term specular reflectance for uncoated aluminum exceeded that of Al and Ag reflectors with dielectric coatings. (Edited author abstract) 5 refs.

Parsons, Roger L. (Cleveland State Univ, Cleveland, OH, USA); Gulino, Daniel A. *NASA Tech Memo* 89882 May 1987 16p.

**079228 FINITE BETA EFFECTS ON TEARING MODES IN THE TOKAMAK.** Details are given of a numerical study of finite-beta tearing modes in the tokamak. The linear compressible resistive MHD equations are solved in full toroidal geometry with no ordering assumptions. The results show a strong stabilizing effect as beta is increased, arising from the average curvature within the resistive layer. This stabilizing effect is particularly pronounced for high conductivity temperatures and small aspect ratios. (Author abstract) 24 refs.

Hender, T.C. (Euratom-UKAEA Fusion Assoc, Abingdon, Engl); Hastie, R.J.; Robinson, D.C. *Nucl Fusion* v 27 n 9 Sep 1987 p 1389-1400.

**079229 ECR PLASMA IN A HIGH POWER MILLIMETER-WAVE BEAM (REPORT IV) - CONTRIBUTION OF HIGHER HARMONIC RESONANCE HEATING.** Remarkable contribution of the 2nd and the 3rd harmonic resonances to the heating of electrons has been clarified experimentally by the radial launch of the millimeter-wave beam to the plasma. While existence of the fundamental (1st harmonic) resonance within the vacuum chamber is verified to be necessary for the efficient ignition of the plasma, irrespective of the wave launching position and/or direction. The heating is observed to be most effective in the resonance zone through which the wave propagates in the first passage, whether it is the 2nd or the 3rd harmonic one. (Author abstract) 2 refs.

Arata, Yoshiaki (Kyushu Univ, Jpn); Miyake, Shoji; Kishimoto, Hiroaki; Abe, Nobuyuki; Kawai, Yoshinobu. *Trans JWRI* v 16 n 1 Jun 1987 p 1-6.

**079230 ENERGY ACCOMMODATION OF IONS FROM A FLUX OF RAREFIED PLASMA ON A METAL SURFACE PARTIALLY COVERED BY A LAYER OF DIELECTRIC.** A method is proposed for determining the energy accommodation coefficient of gas ions on surfaces of electrically conducting materials partially covered by a dielectric layer. Results of measurements of the accommodation coefficients of ions from a flux of rarefied plasma incident on a metal surface covered by a dielectric mesh pattern are presented. The dependences of the ion energy accommodation coefficients on the angle of attack of an element of the surface around which the plasma flows, on the molecular weight of the ions, and on the partial composition of the gas mixture are determined. (Edited author abstract) 20 refs.

Shuvalov, V.A. (Acad of Sciences of the Ukrainian SSR, USSR); Reznichenko, N.P.; Gubin, V.V.; Gavrilov, A.V. *High Temp* v 24 n 6 Nov-Dec 1986 p 777-781.

**079231 TIME DEPENDENCE OF NONEQUILIBRIUM IN THE Hg RESONANCE LEVEL IN AN AC ARC PLASMA.** The time-dependent behavior of the degree of excitation non-equilibrium in the low lying 6<sup>3</sup>P<sub>1</sub> resonance level of mercury at the arc core during half a period of a 50-Hz ac mercury arc plasma has been experimentally determined. The population density of this level is less than the calculated one assuming equilibrium conditions and it exhibits a modulation out of phase with that of the high lying 6<sup>3</sup>D<sub>2</sub> level and in phase with the electron temperature. (Author abstract) 9 refs.

Karabourniotis, D. (Univ of Crete, Iraklion, Greece); Couris, S. *Opt Commun* v 65 n 1 Jan 1988 p 22-25.

**079232 KINETIC COEFFICIENTS FOR ELECTRONS IN AIR IN AN HF ELECTRIC FIELD.** The characteristics of a low-temperature air plasma created by



an hf electric field are determined. Some of the topics covered are electron energy distribution; kinetic coefficients; nitrogen-electron interaction; oxygen-electron interaction; air ionization, and electric field effects. (Edited author abstract) 14 refs.

Dyatko, N.A.; Kochevov, I.V.; Napartovich, A.P. *J Eng Phys* v 52 n 1 Jan 1987 p 75-80.

**079233 CONVECTIVE INFLUX OF PLASMA AND BEAMS IN TOKAMAKS WITH AN ASYMMETRIC RIPLE.** It has been pointed out by several authors that there is an inwardly directed anomalous particle flux in tokamaks which is much greater than the Ware flux. The anomalous influx counteracts the diffusion and anomalous outflow and can give a proper explanation of the relatively peaked density profiles of tokamak devices. This paper discusses a method of inducing the influx by using a specially structured asymmetric ripple. The induced influx will also counteract the diffusion outflow like anomalous influx in a controlled fashion. 33 refs.

Yang, T.F. (MIT, Cambridge, MA, USA); Wang, P.W. *Nucl Fusion* v 27 n 11 Nov 1987 p 1904-1914.

**079234 CRITICAL RESUME OF PRESENT KNOWLEDGE ABOUT RECOMBINATION OF IONS AND ELECTRONS ON GLASS EXPOSED TO POSITIVE COLUMN PLASMAS.** This paper contains a critical summary of what is known about the recombination of positive ions and electrons on glass surfaces exposed to plasmas, with special reference to positive columns. There are still outstanding problems of a fundamental character. In particular, although the rate at which recombination has to occur is calculable from the plasma and wall-sheath parameters, the recombination coefficient is proving hard to determine except as a function of another unknown quantity, the gross positive surface charge density. Again, although the kinetics of the processes by which the ions reach their surface sites and the electrons approach them are reasonably clear, details of how they ultimately recombine are not. (Edited author abstract) 5 refs.

Coulter, J.R.M. (Queen's Univ of Belfast, Belfast, North Irel); Emeleus, K.G. *Rev Roum Phys* v 32 n 4 1987 p 399-403.

**079235 ION-ELECTRON RECOMBINATION IN A NEON, MEDIUM PRESSURE STATIONARY PLASMA.** The paper reports quantitative results on the losses of the charge carriers in a medium pressure, neon plasma. The results show that for pressures of about 15 Torr the recombination losses are as important as the diffusion losses while for pressures of about 30 Torr the recombination losses overtake the diffusion losses. (Author abstract) 6 refs.

Toader, Emil I. (Univ of Bucharest, Rom). *Rev Roum Phys* v 32 n 4 1987 p 405-410.

**079236 ON THE DOUBLE LAYER DYNAMICS IN COLLISIONLESS PLASMAS.** As it is known, double layers (DLs) formed in collisional and collisionless plasma are involved in the appearance of different kinds of plasma instabilities. One of these, the so-called relaxation instability observed in certain conditions in a Q-machine plasma, was explained considering a DL formed near the plasma source which moves towards a cold plate positively biased with respect to the plasma source. It was further found that the so-called anode instability involves also the presence of DLs whose moving direction is away from the positively biased electrode (anode). The aim of this paper is to explain this apparent contradiction concerning the DLs moving direction and to show that in both cases the DLs dynamics involves the same phenomena. 11 refs.

Sanduloviciu, M. ('Al.I. Cuza' Univ, Iasi, Rom). *Rev Roum Phys* v 32 n 4 1987 p 411-414.

**079237 HELIAC EQUILIBRIA.** Three-dimensional numerical calculations of Heliac equilibria are presented. The results indicate that finite- $\beta$  distortions in the flux surfaces can arise because of the presence of low order rational surfaces within or near the plasma. These distortions

arise as a result of nonlinear beatings between the toroidal shift and the helical components of the magnetic field. Reducing the toroidal shift by increasing the number of field periods and/or the aspect ratio improves the equilibrium  $\beta$ -limit. (Author abstract) 13 refs.

Hender, T.C. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Carreras, B.A.; Lynch, V.E. *Nucl Fusion* v 27 n 12 Dec 1987 p 2161-2170.

**079238 CHEMICAL TRANSPORT IN NON-ISOTHERMAL LOW PRESSURE PLASMAS.** Application of non-isothermal plasmas broadens the range of heterogeneous systems in which chemical transport reactions can occur. Kinetically irreversible systems can be utilized if a weak glow discharge is applied in the gas phase. Intense glow discharges, which can completely change the chemistry of a given heterogeneous system, are suitable for opening up new reaction routes via radicals in systems which are strongly endothermic without plasma. Examples are discussed to illustrate these possibilities. (Edited author abstract) 19 refs.

Veprek, S. (Univ of Zurich, Zurich, Switz). *J Less Common Met* v 137 Feb 1 1988 p 367-373.

**079239 SIMULATION STUDY OF ULTRA-LOW-q DISCHARGE PROCESS.** MHD phenomena in ultra-low-q (ULQ;  $q < 1$ ) discharges are extensively studied by means of three-dimensional magnetohydrodynamic (MHD) simulations. ULQ discharges are operated in the intermediate current range between the tokamak and the reversed field pinch. It is shown that ULQ dynamics is a competitive process between resistive diffusion and MHD activities: the former leads to current profile peaking ( $dq/dr > 0$ ) and the latter to current profile broadening ( $dq/dr < 0$ ). The MHD activity of ULQ discharges is studied, and it is found that the key process is non-linear growth of an  $m = 1$  ideal kink instability. It is observed that after the MHD activity has organized a global model stable state, resistive diffusion dominates the ULQ dynamics on the diffusion time-scale, leading to a global mode unstable state; then, MHD activity appears again. (Author abstract) 23 refs.

Kusano, K. (Hiroshima Univ, Hiroshima, Jpn); Sato, T.; Yamada, H.; Murakami, Y.; Yoshida, Z.; Inoue, N. *Nucl Fusion* v 28 n 1 Jan 1988 p 89-98.

**079240 THEORY OF CLUSTER SYSTEMS IN PLASMA-LIKE MEDIA.** The conditions of existence of stable formations of charged particles (clusters) moving in a plasma-like medium are discussed in this paper. The interaction of clusters is considered in the framework of a one-dimensional model. It is shown that the stability of a cluster depends strongly on the number of particles that form part of it. When two clusters moving with respect to each other interact, they break up if the relative velocity is fairly low. Fast-moving clusters hardly interact with each other. (Author abstract) 10 refs.

Kondratenko, A.N. (A.M. Gor'kii State Univ, Khar'kov, USSR); Kuklin, V.M.; Panchenko, I.P.; Sevidov, S.M. *Sov Phys J* v 30 n 5 May 1987 p 433-437.

**079241 EXCHANGE OF ENERGY AND MOMENTUM BETWEEN IONS IN A RAREFIELD-PLASMA FLOW AND AN ELECTRICALLY CONDUCTING SURFACE COATED WITH A THIN LAYER OF DIELECTRIC.** A method is proposed for determining the parameters characterizing the dynamic interaction of ions in a rarefield-plasma flow with an electrically conducting surface coated with a thin layer of dielectric. The results of experimental studies are presented. Two-parameter models are constructed for the coefficients of accommodation of momentum and energy of gas ions approximating their dependence on the angle of attack of the element flowing over the surface and the ratios of the atomic masses of the gas-surface system. (Edited author abstract) 23 refs.

Shuvalov, V.A. (Acad of Sciences of the Ukrainian SSR, USSR). *High Temp* v 25 n 4 Jul-Aug 1987 p 477-481.

**079242 MEASUREMENT OF THE PLASMA FRE-**

**QUENCY OF ELECTRON BEAMS DRIFTING IN A MAGNETIC FIELD.** In the analysis of physical processes occurring in electronic microwave devices, an important characteristic parameter is the plasma frequency of the oscillations, which depends on the form and geometry of the beam and also on the type of structure in which the beam propagates. The authors present the results of an experimental determination of the plasma frequency of circular cylindrical electron beams, propagating in a longitudinal magnetic field. To achieve efficiency and simplicity without loss of accuracy, the experiments were performed based on physical modeling of the phenomena occurring in O-type microwave devices by the electronic probe method. 7 refs.

Dmitriyev, B.S.; Dmitriyeva, M.A.; Zharkov, Yu.D. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 175-176.

**079243 VERSATILE MICROWAVE PLASMA APPLICATOR.** This paper describes a device used for the introduction of microwave energy into a plasma chamber over a wide area with high transfer efficiency and good energy uniformity. The applicator design was based on a slotted waveguide combined with a quartz window. The impedance properties were calculated for slots in the broad wall of a WR430 waveguide. Low-power simulating tests were conducted to determine the optimum geometry. A simple test system was used to measure and plot the three-dimensional spatial energy distribution. (Author abstract) 4 refs.

Ji, Tian-Ren (Guoguang Electron Tube Works, Chengdu, China); Gerling, John E. *J Microwave Power Electromagn Energy* v 23 n 1 1988 p 3-10.

**079244 THEORETICAL MODEL OF THE HALO PLASMA OBSERVED IN A SMALL ASPECT RATIO FRC PLASMA.** A halo plasma, which is a low density plasma surrounding field reversed configurations (FRC), was observed in the Staged Theta Pinch-Linear experiment. As long as the plasma is kept free from the end walls with the help of a guide field structure, azimuthal ion flow builds up in the halo. The direction of the ion flow at the edge of the halo is opposite to that in the vicinity of the separatrix. This double structure of the ion flow can be explained by a model which assumes that the halo plasma is formed by energetic ions shuttling between the FRC and the open field region. The numerical results are in good agreement with the experiment. The model also suggests that the FRC has a good confinement ability for energetic particles if the plasma is not in contact with the discharge tube. (Author abstract) 15 refs.

Aso, Y. (Inst de Pesquisas Espaciais, Sao Jose dos Campos, Braz). *Nucl Fusion* v 28 n 5 May 1988 p 809-815.

**079245 MHD ANALYSIS OF HIGH  $\langle \beta_T \rangle$  DISRUPTIONS IN PBX.** Princeton Beta Experiment (PBX) discharges run at the lowest  $q$  and highest  $\langle \beta_T \rangle$  always terminated in a hard disruption. The discharges, with  $\langle \beta_T \rangle$  value of up to 5.5% and  $q$ -values down to 2.2, were obtained by employing large current ramps and large gas feed rates during neutral beam injection. Previous work has indicated that the achieved  $\langle \beta_T \rangle$  values were consistent with the limit imposed by the  $n=1$  ideal external kink with a conducting wall at  $b/a=2$ . The authors of the paper investigate further the validity of ideal MHD theory in explaining the low  $q$  disruptions. (Edited author abstract) 13 refs.

Jahns, G.L. (Princeton Univ, Princeton, NJ, USA); Chance, M.S.; Kaye, S.M.; Manickam, J.; Takahashi, H.; LeBlanc, B.; Morris, A.W.; Reusch, M.; Sesnic, S. *Nucl Fusion* v 28 n 5 May 1988 p 881-889.

**079246 CONFERENCE RECORD - ABSTRACTS: 1987 IEEE INTERNATIONAL CONFERENCE ON PLASMA SCIENCE.** The following topics are dealt with: magnetohydrodynamics; thermionics and plasma diodes; basic plasma phenomena; gaseous electronics; arc



technology; electron, ion, and plasma sources; space plasmas; intense electron and ion beams; laser-plasma interactions; plasma diagnostics; plasma chemistry and processing; plasma heating; mirrors; tokamaks and stellarators; reversed field pinches; spheromaks and alternate concepts; plasma waves and instabilities; microwave and millimeter-wave generation; fast-opening switches; plasma focus; ultrafast Z-pinches; electromagnetic launchers; solid-state plasmas; X-ray lasers; and free-electron lasers. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10704 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEEE, Nuclear & Plasma Sciences Soc, New York, NY, USA). *Conf Rec - Abstr: 1987 IEEE Int Conf on Plasma Sci, Arlington, VA, USA, Jun 1-3 1987* Publ by IEEE, New York, NY, USA, 1987. Available from IEEE Service Cent (CAT n 87CH2451-3), Piscataway, NJ, USA 130p.

**079247 SIZE OF THE VIRTUAL SOURCE BEHIND A CONVEX SPHERICAL SURFACE EMITTING A SPACE CHARGE LIMITED ION CURRENT.** A plasma source fitted with a circular orifice and emitting a space charge limited ion current can be made to operate with a convex spherical plasma boundary (meniscus) by approximately adjusting its extraction parameters. In this case, the diameter of the virtual source behind the meniscus is much smaller than the orifice diameter. The effective value of this virtual source diameter depends significantly on various practical factors that are more or less controllable. Its lower ideal limit, however, depends only on the ratio  $\delta$  of the interelectrode distance to the meniscus curvature radius and on the ratio  $\omega$  of the initial to final ion energy. This ideal limit is given for the ranges  $0.1 \leq \delta \leq 10$  and  $10^{-7} \leq \omega \leq 10^{-3}$ . Preliminary experimental results are reported. (Author abstract) 8 refs.

Chavet, I (Soreq Nuclear Research Cent, Yavne, Isr). *Nucl Instrum Methods Phys Res Sect A* v A258 n 3 Aug 15 1987, Charged Part Opt, Proc of the Second Int Conf, Albuquerque, NM, USA, May 19-23 1986 p 589-592.

## Acceleration

**079248 ACCELERATION OF COMETARY PLASMA IN THE VICINITY OF COMET HALLEY ASSOCIATED WITH AN INTERPLANETARY MAGNETIC FIELD POLARITY CHANGE.** Based on the ion plasma and magnetic field observations of Vega-1 near its consistent scenario is developed according to which the observed magnetic field topology, the observed burst of ions at energies 200-600 eV, and the observed directional dependence of the flow of these ions leads to the conclusion that these burst-particles are cometary ions which have been accelerated by the process of merging of magnetic field lines of opposite polarity. (Author abstract) 12 refs.

Verigin, M.I. (USSR Acad of Sciences, Moscow, USSR); Axford, W.I.; Gringauz, K.I.; Richter, A.K. *Geophys Res Lett* v 14 n 10 Oct 1987 p 987-990.

**079249 NUMERICAL ANALYSIS OF MPD ARCS FOR PLASMA ACCELERATION.** The characteristics of the arc region of a plasma thruster are investigated by the numerical solution of coupled MHD equations. The flow is assumed to be two-dimensional, but all other realistic effects are included, i.e., the Hall effect, ion slip, and other dissipations such as viscosity, thermal conductivity, and electrical resistivity. The results show the current concentration at the trailing edge of the anode and the raised temperature of the area. The Hall current causes harmful effects by lowering the thrust efficiency and eroding the electrodes. The thermal diffusion is beneficial in that it raises the thrust efficiency and prevents the erosion of the electrodes. 5 refs.

Park, Won-Taek (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Choi, Duk-In. *IEEE Trans Plasma Sci* v PS-15 n 5 Oct 1987, XIIth Int Symp on Discharges and Electr Insul in Vac, Shores, Isr, Sep

22-25 1986 p 618-624.

## Analysis

**079250 NOVEL SIMULATION TECHNIQUE OF ISOTROPIC LOSSY PLASMA USING TWO-DIMENSIONAL STRIP MEDIUM.** The simulation of an isotropic lossy plasma medium using an artificial dielectric is studied. A two-dimensional strip medium is used as the artificial dielectric. (Edited author abstract) 8 refs.

Prasad, R. (Univ of Dar es Salaam, Dar es Salaam, Tanzania); Mgombelo, H.R. *Modell Simul Control A* v 15 n 1 1988 p 29-35.

**079251 DEVIATIONS FROM EQUILIBRIUM IN THE 6<sup>3</sup>P LEVELS OF MERCURY IN AN AC ARC PLASMA.** Deviations from excitation equilibrium in the Hg 6<sup>3</sup>P levels averaged along a radius and in the core of an ac (50 Hz) high-pressure (approx. 3 atm) mercury arc at 0.5 and 5 ms after the voltage-zero crossing are determined spectroscopically. The results are interpreted in terms of ionization nonequilibrium, overpopulation of the Hg ground state and emission of the resonance radiation. (Author abstract). 10 Refs.

Karabourniotis, D. (Univ of Crete, Crete, Greece); Couris, S. *Opt Commun* v 67 n 3 Jul 1 1988 p 214-217.

**079252 POPULATION DISTRIBUTION BETWEEN LOW LYING ATOMIC LEVELS IN A NON-LTE ARC PLASMA.** The population-density and the temperature distribution between the lower atomic levels of self-reversed lines emitted by a non-LTE arc plasma can be determined experimentally from the characteristics of the line contours. The proposed diagnostic scheme is applied to the Hg 6<sup>3</sup>P<sub>2,1,0</sub> levels in a high-pressure ac mercury arc. Results concerning the population distribution between these levels are reported. (Edited author abstract). 4 Refs.

Karabourniotis, D. (Univ of Crete, Crete, Greece). *Opt Commun* v 67 n 3 Jul 1 1988 p 218-220.

**079253 GREEN'S FUNCTION FOR MAXWELL'S EQUATIONS IN AN ANISOTROPIC PLASMA.** The singular part of Green's function for Maxwell's equations for an anisotropic plasma is isolated, and its analytic representation is obtained. An exact representation is found for Green's function for a uniaxial plasma. (Author abstract). 10 Refs.

Yeremin, S.M. *Sov J Commun Technol Electron* v 32 n 9 Sep 1987 p 69-76.

**Applications** See Also ALUMINUM AND ALLOYS—Etching; AMMONIA—Synthesis; ARSENIC COMPOUNDS—Vapor Deposition; BORON CARBIDE; CARBON—Heat Treatment; CARBON—Thin Films; CERAMIC MATERIALS—Physical Properties; CHROMIUM COMPOUNDS—Decomposition; DIAMONDS—Synthetic; ETCHING—Computer Simulation; ETCHING—Equipment; FILMS—Electric Properties; FLUORESCENCE; GASES—Manufacture; GOLD AND ALLOYS—Chemical Vapor Deposition; HEAT TREATMENT; IRON AND STEEL METALLURGY—Research; METALS AND ALLOYS—Processing; MICROSCOPES, ELECTRON—Contamination; NITROGEN OXIDES—Decomposition; PLASTICS—Cleaning; PLASTICS—Processing; PLASTICS FILMS—Vapor Deposition; POLYETHYLENES—Structure; POLYMERIZATION; POLYMERS—Thin Films; POWDERS—Heating; POWDERS—Synthesis; PRINTED CIRCUITS—Cleaning; PROPULSION—Electric Energy; PROTECTIVE COATINGS—Plasma Spraying; SEMICONDUCTING FILMS—Chemical Vapor Deposition; SEMICONDUCTING GALLIUM ARSENIDE; SEMICONDUCTING SILICON—Etching; SEMICONDUCTING SILICON—Oxidation; SEMICONDUCTING SILICON COMPOUNDS; SEMICONDUCTOR MATERIALS—Etching; SEMICONDUCTOR MATERIALS—Processing; SILICON COMPOUNDS—Chemical Vapor Deposition; SILICON NITRIDE—Thin Films; SOLAR CELLS—Silicon; SPECTROSCOPY; SPECTROSCOPY, EMISSION; STEEL—Hardening; STEEL HEAT TREATMENT; STEEL HEAT TREATMENT—Carburizing; STEEL HEAT TREATMENT—Nitriding; STEELMAKING—Plasma Arc Remelting; TEXTILE FIBERS—Processing; TITANIUM AND ALLOYS—Processing.

**079254 GROSSTECHNISCHE ANWENDUNGEN VON LICHTBOGENPLASMAVERFAHREN IN DER CHEMIE.** [Large-Scale Engineering Applications

of the Arc Plasma Process in the Chemical Industry]. Although employed in chemistry for almost 200 years, the principle of electric discharge is still being used on an empirical basis. Reliable mathematical relationships similar to those permitting the scaling-up commonly used in chemical process engineering are absent here. Part 1 of this paper, apart from outlining the apparatus required, deals with the difficulties encountered in the development and operation of industrial plasma generation of industrial plasma generators. A number of applications are described. The economic significance of plasma processes is briefly dealt with. (Author abstract) In German.

Mueller, R. (Huels AG, Marl, West Ger). *Elektrowaerme Int Ed B* v 45 n 3-4 Jun-Aug 1987 p 146-154.

**079255 NEGATIVE IONS IN INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY.** Basic characteristics of negative ions observed in ICP-MS have been evaluated and compared with those reported for positive ions. The types of ion species, ion sensitivities, background ions, and ion energies suggest that the negative ions observed in this study do not originate directly from the plasma but rather from electron capture or reaction downstream of the free jet expansion. It is shown that. 5 refs.

Fulford, J.E. (SCIEX, Thornhill, Ont, Can); Quan, E.S.K. *Appl Spectrosc* v 42 n 3 Mar-Apr 1988 p 425-428.

**079256 DECARBONIZATION BY USING ECR PLASMA.** Decarbonization rates were measured by the use of ECR plasmas of H<sub>2</sub> or O<sub>2</sub>. The rates are  $2.0 \times 10^{16}$  m<sup>-2</sup>s<sup>-1</sup> for H<sub>2</sub> and  $2.4 \times 10^{18}$  m<sup>-2</sup>s<sup>-1</sup> for O<sub>2</sub> at the same pressure of  $1.6 \times 10^{-2}$  Pa. The rate for O<sub>2</sub> is two orders of magnitude higher than that for H<sub>2</sub>. These results are analyzed depending on the equilibrium theory and the processing of decarbonization can be explained. (Author abstract) 11 refs.

Ishibe, Yukio (Inst of Physical & Chemical Research, Wako, Jpn); Kokai, Hideki; Oyama, Hitoshi; Sakamoto, Yuichi. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 663-665.

**079257 PLASMA DEPOSITION PROCESSES.** The objective of this chapter is to provide the reader with a perspective on the unique features and the inherent limitations of the plasma deposition process for macroelectronic applications. The emphasis here will focus on the practical aspects of plasma deposition. First, the unique characteristics of the plasma process as a deposition technique will be reviewed and compared to other physical vapor deposition processes. In a subsequent section, attention will be given to the practical requirements of the plasma reactor itself, as well as its most important peripheral hardware, such as pumps and gas-handling equipment. We briefly review the use of the diagnostic tools as they are commonly used to enhance the reproducibility and reliability of the process. Finally, because the process has considerable commercial potential for a variety of practical applications, some of the scale-up issues and the economics of the process will be considered. 69 refs.

Jansen, Frank (Xerox Corp, Webster, NY, USA). *Plasma Deposited Thin Films* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 p 1-19.

**079258 PLASMA EROSION OPENING SWITCH OPERATION AT LONG CONDUCTION TIMES.** The conduction time of the plasma erosion opening switch (PEOS) has been extended to carry mega-ampere currents for several hundred nanoseconds. The dependence of the peak conduction current on PEOS parameters and the results of magnetic probe and load voltage measurements are all consistent with PEOS theory. They indicate that the PEOS operating mechanisms at these long conduction times are the same as those operating in previous experiments at shorter conduction times. Translation of



the switch plasma into the load region, due to  $j \times B$  forces during the conduction phase, was not observed in this experiment. 19 refs.

Hinshelwood, D.D. (Jaycor, Vienna, VA, USA); Boller, J.R.; Comisso, R.J.; Cooperstein, G.; Meger, R.A.; Neri, J.M.; Ottinger, P.F.; Weber, B.V. *IEEE Trans Plasma Sci* v PS-15 n 5 Oct 1987, XIIIth Int Symp on Discharges and Electr Insul in Vac, Shores, Isr, Sep 22-25 1986 p 564-570.

**Beam-Plasma Interactions** See Also ACCELERATORS—Ion Sources; ELECTROMAGNETIC WAVES—Propagation in Plasma; MASERS; PROTECTIVE COATINGS—Plasma Spraying; SATELLITES—Radiation Effects; TOKAMAK DEVICES.

**079259 BEAM INSTABILITY IN A RELATIVISTIC PLASMA.** The question about wave excitation in a one-dimensional relativistic plasma by a low density electron beam with low thermal scattering of the particles is investigated. The increment of excitation of plasma waves is found for frequencies similar to a low-frequency intrinsic mode. The influence of thermal scatter of the beam electrons on the frequency of oscillations and the increment in instability of the excited wave is analyzed. (Author abstract) 10 refs.

Matveev, A.N. (Polyakov, P.A.); Tasev, M.A. *Moscow Univ Phys Bull* v 42 n 3 1987 p 52-56.

**079260 BEAM-PLASMA INTERACTION IN CONDITIONS OF THE CHERENKOV COLLECTIVE EFFECT.** An analytical solution is given for the problem of the interaction of 'thin' completely magnetized plasma and an electron beam in conditions of the collective Cherenkov effect. The saturation mechanism of the beam-plasma instability in the given conditions is elucidated. (Author abstract) 6 refs.

Aleksandrov, A.F.; Kuzelev, M.V.; Khalilo, A.N. *Moscow Univ Phys Bull* v 42 n 4 1987 p 113-116.

**079261 NUMERICAL MODELING OF THE DYNAMICS OF ELECTRON BEAM IN PLASMA.** The method of large particles is employed to study the two-dimensional dynamics of an electron beam injected in a plasma. Evolutions of current and of the transverse profile of beam current density and the effects due to betatron oscillation of the beam particles, under conditions of charge and current neutralization are discussed in detail. A beam instability corresponding to the 'intersection' of the nonresonance electron-electron instability and filamentation instability has been revealed and studied. The quasistationary state of the nonlinear stage of instability has been analytically studied. (Author abstract) 13 refs.

Al'terker, B.A.; Zheksemin, S.R.; Rukhlin, V.G.; Tarakanov, V.P. *IVTAN Rev* v 1 n 2-4 1987 p 291-327.

**079262 NONLINEAR FREQUENCY SHIFT AND SPECTRAL WIDENING OF OSCILLATIONS EXCITED BY AN ELECTRON BEAM WITH AN ANOMALOUS DOPPLER EFFECT.** The nonlinear dynamics of a multimode relativistic beam-plasma system are investigated in conditions of an anomalous Doppler effect. It is shown that there is a substantial widening of the oscillation spectrum during development of instability. In this case the electron beam is slowed to a unit of the phase velocity of the excited wave. Asymptotic formulas are cited for the spectra of electromagnetic and beam waves. (Author abstract) 3 refs.

Kuzelev, M.V.; Panin, V.A.; Plotnikov, A.P.; Rukhadze, A.A. *Sov Phys Lebedev Inst Rep* n 6 1987 p 36-39.

**079263 GENERAL STRUCTURE OF CUBIC NONLINEARITY AND THE NONLINEAR POTENTIAL IN THE THEORY OF PARAMETRIC INSTABILITIES OF A BEAM PLASMA.** Nonlinear stabilization of three wave parametric instabilities of a beam plasma is investigated in an approximation of cubic nonlinearities. A number of new cubic nonlinearities are identified in the examined beam-plasma system. Analytical solutions are found for the explosive process and for the process of

decay with an increase in frequency. (Author abstract) 4 refs.

Kuzelev, M.V.; Rukhadze, A.A.; Bobylev, Yu.V.; Panin, V.A. *Sov Phys Lebedev Inst Rep* n 6 1987 p 40-43.

**079264 NUMERICAL MODELING OF THE PROPAGATION OF A QUASI-STATIONARY RELATIVISTIC ELECTRON BEAM IN A RAREFIED PLASMA.** Propagation of a quasi-stationary, charge-neutralized relativistic electron beam in a nondissipative medium is examined on the basis of a simple numerical model. The acquired results are compared with solution of the envelope equation and the results of other authors. (Author abstract) 5 refs.

Nauryzbaev, A.E. *Sov Phys Lebedev Inst Rep* n 6 1987 p 80-83.

**079265 EXCITATION OF IONS IN DENSE PLASMA BY ELECTRON IMPACT.** The (1s-2s), (1s-3s), (1s-2p), and (1s-3p) scaled excitation collision strengths in the presence of a dense plasma have been calculated including the effect of exchange in the framework of first-order theory. The effect of exchange is found to reduce the collision strengths further over the Born approximation results, only at high energies. The effect of exchange is found to persist in the energy range considered (up to the scaled incident energy  $E/Z^2 = 6.0$ ). The variations of collision strengths with change of screening parameters have also been reported. (Author abstract) 7 refs.

Sarkar, K.P. (Gurudas Coll, Calcutta, India); Basu, Madhumita; Ghosh, A.S. *Indian J Pure Appl Phys* v 25 n 9 Sep 1987 p 358-362.

**079266 PROBABILITY-MAXIMIZATION THEORY FOR A HIGHLY TURBULENT BEAM-PLASMA SYSTEM.** A new approach to the theoretical study of turbulent behavior of a collisionless plasma is developed. This approach is based upon the concept or probability maximization originally applied to collisional gases by Boltzmann. The probability-maximization theory deals with stochastic processes in a steady turbulent plasma by solving for the most-probable distribution. Our theory as applied to counter-streaming electron beams can quantitatively predict beam retardation, i.e. a decrease in the mean velocity of electrons injected from the system boundary. This is also in agreement with the results of a one-dimensional numerical experiment performed for such a beam-plasma system. (Author abstract) 20 refs.

Nakamura, Tadas (Univ of Tokyo, Tokyo, Jpn); Yamamoto, Takashi. *J Plasma Phys* v 38 pt 3 Dec 1987 p 483-493.

**079267 ELECTROSTATIC POTENTIAL INDUCED BY A FAST CHARGED PARTICLE PASSING PARALLEL TO A PLANAR SHEET OF TWO-DIMENSIONAL PLASMA.** This paper presents a calculation for the screened electrostatic Coulomb potential of a fast particle interacting with a sheet of two-dimensional (2D) plasma. The particle motion is taken to be parallel to the 2D plasma sheet and the plasma is in its ground state. The density perturbation response properties of the plasma are described in the random phase approximation. The screened effective potential is calculated as a function of the distance of the particle from the plane of the 2D plasma and its velocity. (Author Abstract) 17 refs.

Gumbs, G. (Univ of Lethbridge, Alberta, Can). *Solid State Commun* v 62 n 5 May 1987 p 365-368.

**079268 REFLECTION OF ION WAVES FROM A BIPOLAR ELECTRODE IN AN ION BEAM-PLASMA SYSTEM.** Wave reflection in an ion beam-plasma system was studied using a bipolar electrode as a reflector. For an incident beam mode, both the beam and the ion acoustic modes were observed. It was found that these reflected waves depend on the energy distribution of the reflected ions. Wave excitation by a grid is also discussed. (Author abstract) 16 refs.

Noda, Shunichi (Kyushu Univ, Kasuga, Jpn); Nakamura, Yoshiharu; Kawai, Yoshinobu; Akazaki, Masanori. *Jpn J Appl Phys Part 1* v 27 n 3 Mar 1988 p 403-407.

**079269 TIME EVOLUTION OF THE VELOCITY DISTRIBUTION OF NEUTRAL-BEAM-INJECTED IONS HEATED BY ICRH IN A TWO-COMPONENT PLASMA.** The time evolution of the distribution function of the beam-injected particles in the presence of ICRH in a two-component plasma is determined. Consideration is restricted to the time development during two complementary time periods: (i) the early time period, i.e.  $0 \leq t \ll \tau_g$ , and (ii) the quasi-steady state, i.e.  $t > \tau_g$ , where  $\tau_g$  is the slowing-down time for beam-ion-electron collisions. Explicit analytical solutions are obtained for anisotropic as well as isotropic beam injection. (Author abstract) 16 refs.

Anderson, D. (EURATOM, Goteborg, Swed); Eriksson, L.-G.; Lisak, M. *J Plasma Phys* v 39 pt 2 Apr 1988 p 285-296.

**079270 NONLINEAR INTERACTION BETWEEN AN ELECTRON-ION BEAM AND A DISSIPATIVE PLASMA.** The interaction between an electron-ion beam and a collisional plasma is investigated. It is shown that taking into account dissipation in the plasma stabilizes instabilities in the beam. The instability saturation amplitude as a function of the dissipation level in the plasma and the beam is investigated numerically and analytically. It is shown that the saturation level in a dissipative medium can exceed the saturation level in ordinary beam-plasma instability. (Author abstract) 9 refs.

Bondarenko, M.B.; Tkachenko, V.I.; Tkachenko, V.I. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 25-29.

**079271 EMISSION OF ELECTROMAGNETIC WAVES FROM AN AXIALLY SYMMETRIC MODULATED ELECTRON BEAM IN A NONUNIFORM PLASMA.** The emission of electromagnetic waves, produced when an axially symmetric modulated electron beam with a finite cross section is incident normally on the boundary of a semiinfinite nonuniform isotropic plasma, is studied. An expression is derived for the radiation pattern of such emission, and the radiation power is evaluated numerically. (Author abstract) 11 refs.

Anisimov, I.A.; Kotlyarov, I.Yu. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 29-32.

**079272 FAST ION CONFINEMENT DURING HIGH POWER TANGENTIAL NEUTRAL BEAM INJECTION INTO LOW PLASMA CURRENT DISCHARGES ON THE ISX-B TOKAMAK.** The beam ion thermalization process during tangential neutral beam injection in the ISX-B tokamak is investigated. The classical model is tested in co- and counter-injected discharges at low plasma current, a regime where large orbit width excursions enhance the importance of the loss regions. To test the model, experimental charge exchange spectra are compared with the predictions of an orbit following Monte Carlo code. Measurements of beam-plasma neutron emission and measured decay rates of the emission following beam turnoff provide additional information. (Edited author abstract). 35 Refs.

Carnevali, A. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Scott, S.D.; Neilson, H.; Galloway, M.; Stevens, P.; Thomas, C.E. *Nucl Fusion* v 28 n 6 Jun 1988 p 951-966.

**079273 HEAVY ION BEAM TARGET CORONAL PHYSICS.** Numerical calculations of the heavy ion beam interaction with the low density plasma (corona) surrounding a small fusion pellet are discussed. As heavy ions enter the coronal plasma, they lose some of their electrons, and these stripped electrons, called 'drop-offs', constitute an electron beam with approximately the velocity of the ions. The interaction among the heavy ions, the drop-off electrons and the background electrons is investigated. The coronal density and temperature profiles are deter-



mined from one-dimensional hydrodynamic calculations, assuming classical ion deposition. The electron-electron and ion-electron cold two-stream instabilities are examined with one-dimensional particle-in-cell calculations. The results suggest that a strong coupling among the heavy ions, the drop-off electrons and the background electrons can exist; this leads to the creation of a non-Maxwellian electron plasma and significant electron heating. (Edited author abstract) 25 Refs.

Magelsen, G.R. (Los Alamos Natl Lab, Los Alamos, NM, USA). *Nucl Fusion* v 28 n 6 Jun 1988 p 967-979.

**079274 SPECTROSCOPIC STUDY OF ANODE PLASMAS IN A MICROSECOND ELECTRON BEAM DIODE.** Experiments have been performed to investigate the visible emissions (370-600 nm) from long-pulse electron-beam-driven carbon anode plasmas, and to correlate the spectroscopic evidence for ions with deviations of the diode current and voltage from Child-Langmuir behavior. The electron beams had peak voltages of -0.8 MV, current densities approaching  $10^3$  A/cm<sup>2</sup>, and pulselengths of about 1  $\mu$ s. A three-phase beam/plasma evolution process is described. 29 refs.

Cuneo, M.E. (Univ of Michigan, Ann Arbor, MI, USA); Gilgenbach, R.M.; Brake, M.L. *IEEE Trans Plasma Sci* v PS-15 n 4 Aug 1987 p 375-383.

## Calculations

**079275 TIME-DEPENDENT SOLUTION OF BOLTZMANN EQUATION IN RF PLASMAS: A COMPARISON WITH THE EFFECTIVE FIELD APPROXIMATION.** Electron isotropic distribution function (idf) and related quantities in rf plasmas (CO, H<sub>2</sub>, Ne), calculated by solving the time-dependent Boltzmann equation, are compared with the corresponding values obtained by using the effective field approximation (efa). We show that the agreement between the two methods depends on the ratio between the applied field frequency and the lumped frequencies for impulse and energy dissipation. In fact, only at moderately high field frequencies are results obtained according to efa comparable with the corresponding ones obtained by the time-dependent solution and subsequent time averaging, while in the other cases differences up to two orders of magnitude are observed. (Author abstract) 11 refs.

Winkler, R. (AdW, Greifswald, East Ger); Dilonardo, M.; Capitelli, M.; Wilhelm, J. *Plasma Chem Plasma Process* v 7 n 1 Mar 1987 p 125-137.

## Cleaning See TOKAMAK DEVICES—Research.

## Collision Processes See Also ELECTRON BEAMS.—Analysis; GASES, INERT.

**079276 NEW COLLISIONAL RELAXATION MODEL FOR SMALL DEVIATIONS FROM EQUILIBRIUM.** A new collisional relaxation model, applicable to small deviations from equilibrium, is established. In distinction from previous models, the new model involves three different collision frequencies for momentum transfer, energy transfer and randomization, extends the relaxation function to include the full pressure tensor rather than only its trace, and describes relaxation to individual rather than composite Maxwellian distributions. The model is applied to the kinetic theory of waves in a magnetized two-component plasma. As a particular example, magnetosonic waves are discussed for the sake of demonstrating a wave damping mechanism due to incomplete collisional activation of translational degrees of freedom. (Edited author abstract) 16 refs.

Stubbe, Peter (Max-Planck Inst fuer Aeronomie, Katlenburg-Lindau, West Ger). *J Plasma Phys* v 38 pt 1 Aug 1987 p 95-116.

**079277 KINETIC THEORY OF THE HIGH-FREQUENCY PART OF THE SLOW ELECTROMAGNETIC MODE IN WEAKLY IONIZED GAS-DISCHARGE ARGON PLASMA WITH INELASTIC COLLISIONS.** The spectral characteristics of the

high-frequency part of the slow electromagnetic mode, specific for plasmas placed in an external dc electric field, as well as the features of the corresponding instability, are analyzed for weakly ionized argon gas-discharge plasmas with E/n ranging from 25 to 150 Td, and with electron temperatures between 60,000 and 70,000 K. The analysis is based on the linear theory of perturbation, and the dynamics of the electrons is described by appropriately modified kinetic equations for the one-particle distribution function. Attention is focused on the collisional processes between electrons and neutrals, and both elastic and excitational collisions are taken into account. (Edited author abstract) 21 refs.

Zigman, V.J. (Inst of Physics, Belgrade, Yugosl); Milic, B.S. *J Plasma Phys* v 38 pt 2 Oct 1987 p 223-233.

**079278 GENERALIZED BALESCU-LENARD COLLISION OPERATOR.** The generalization of the Balescu-Lenard collision operator to its fully electromagnetic counterpart in A.W. Kaufman's action-angle formalism is derived and its properties investigated. The general form may be specialized to any particular geometry where the unperturbed particle motion is integrable, and thus includes cylindrical plasmas, inhomogeneous slabs with non-uniform magnetic fields, tokamaks and the particularly simple geometry of the standard operator as special cases. The general form points to the commonality between axisymmetric, turbulent and ripple transport, and implies properties (e.g. intrinsic ambipolarity) that should be shared by them, under appropriate conditions. Along with a turbulent 'anomalous diffusion coefficient' calculated for tokamaks in previous work, an 'anomalous pinch' term of closely related structure and scaling is also implied by the generalized operator. (Author abstract) 20 refs.

Mynick, Harry E. (Princeton Univ, Princeton, NJ, USA). *J Plasma Phys* v 39 pt 2 Apr 1988 p 303-317.

**079279 ELECTRON KINETICS OF COLLISION DOMINATED R.F. BULK PLASMA IN CO: THE ROLE OF SECOND-KIND COLLISIONS.** Electron energy distribution functions (EEDF) and related properties in the bulk region of the rf CO plasma at the reduced rf field frequency  $\omega/p_0 = \pi \times 10^7$  sec<sup>-1</sup> torr<sup>-1</sup> have been calculated by solving the time-dependent spatially homogeneous Boltzmann equation in the presence of second-kind collisions and have been interpreted on a microphysical basis. The results show that second-kind collisions (vibrational and electronic) strongly affect the temporal evolution of EEDF, of the mean energy, and of the mean collision frequencies for vibrational and electronic excitation processes, as well as for ionization. Furthermore, the effect of second-kind collisions on an approximate determination of the time-averaged EEDF in the rf bulk plasma using the so-called effective-field approximation has been estimated. (Edited author abstract) 11 refs.

Capitelli, M. (Univ of Bari, Bari, Italy); Celiberto, R.; Gorse, C.; Winkler, R.; Wilhelm, J. *Plasma Chem Plasma Process* v 8 n 2 Jun 1988 p 175-188.

**079280 REFLECTION OF METASTABLE ATOMS BY A GLASS WALL IN A POSITIVE COLUMN DISCHARGE PLASMA.** The laser-induced fluorescence-spectroscopy (LIFS) method has been applied to a dc discharge plasma, and the radial density distribution of metastable (<sup>2</sup> <sup>1</sup>S) helium atoms has been measured. It was found that the density did not tend to zero at the discharge tube wall. Rather, the density was about 20-30 percent of the value on the tube axis. Using the collisional-radiative model, the authors interpret this result. Two possibilities are suggested as the origin of this finite population at the wall, namely, 1) the helium ions which recombine at the wall converted partly into metastable atoms and 2) the metastable atoms were not quenched completely at the wall, but were reflected by a certain amount. It was found that the first process could not reproduce the experimental population distribution, while the second process with a reflection coefficient of the metastable atoms of 80-90 percent accounted for the experiment. (Edited author abstract) 6 Refs.

Fujimoto, Takashi (Kyoto Univ, Kyoto, Jpn); Okuda, Seiji; Shimizu, Naofumi. *Mem Fac Eng Kyoto Univ* v 50 n 2 Apr 1988 p 82-93.

## Composition Effects See Also ELECTRIC SPARKS.

**079281 EFFECT OF PROPANE ON ATOMIC SPECTROMETRIC SIGNALS IN THE DIRECT-CURRENT PLASMA.** The addition of small amounts of propane to the direct-current plasma (DCP) affects the emission signal of analyte species in the plasma. In the normal analytical region of the plasma, a reduction in emission is seen; this reduction can be accounted for by a decrease in excitation temperature caused by the propane in this region of the plasma. Above the analytical region, an enhancement in atomic emission is seen. The excitation temperature in this region of the plasma was found to remain unchanged when propane was added. The mechanism for the enhancement is thought to be the reduction of metal oxides to the corresponding free metal by carbon. (Edited author abstract) 12 refs.

McCreary, Terry W. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Long, Gary L. *Appl Spectrosc* v 42 n 3 Mar-Apr 1988 p 390-394.

## Computer Aided Analysis See Also NUCLEAR ENGINEERING—Computer Applications; TOKAMAK DEVICES—Computer Applications.

**079282 HIGH-SPEED NUMERICAL CALCULATION METHOD FOR RATE EQUATIONS OF ABRUPTLY RECOMBINING PLASMAS.** A high-speed numerical calculation method for the rate equation of abruptly recombining plasmas is proposed. It is demonstrated that, compared with the conventional trial and error method, the presented method can shorten the computing time by a small factor for a hydrogen-like plasma. When there are more than two ion species, such as in a helium plasma, the computing time can be shortened by one or two orders by using the present method. We conclude that this numerical method is especially useful in studying the gain and the duration of the laser oscillation using a plasma composed of multiply charged ions or a mixed gas. 10 Refs.

Tsuji, Yasumasa (Ehime Univ, Matsuyama, Jpn); Oda, Toshitsugu; Furukane, Utao. *Electr Eng Jpn* v 108 n 1 Jan-Feb 1988 p 36-41.

**079283 PROGRESS ON THE FLEXIBLE DATA ACQUISITION SYSTEM AT TWO PLASMA PHYSICS LABORATORIES.** A description is given of RSX-DAS, a flexible CAMAC-based data acquisition software system that runs on a variety of PDP-11 architectures and under RSX-11 operating systems. The system has modular, multitasking, and concurrent processing features. The communication among 17 tasks is accomplished through parent/offspring tasking, event flags, and shared regions. The user interface to RSX-DAS consists of a set of user-friendly commands, indirect command files, and menus. The database consists of four static shared regions for the control of data acquisition and display, one dynamic shared region for the data of current shot, and data files for previous shots. The modularity of the CAMAC interface software allows operation on several CAMAC organizations, e.g., a parallel branch or some dedicated crates, and allows easy addition and subtraction of CAMAC hardware. 3 refs.

Shu, Yan-Tai (Acad Sinica, Hefei, China); Liu, Gen-Chen; Chen, Yun-Hui; Jiang, Hai-Yan. *IEEE Trans Nucl Sci* v NS-34 n 4 Aug 1987, Fifth Conf on Real-Time Comput Appl in Nucl, Part and Plasma Phys, San Francisco, CA, USA, May 12-14 1987 p 941-944.

## Computer Simulation

**079284 MAGNETIC RECONNECTION IN A COLLISIONLESS PLASMA: EVIDENCE FOR THE CURRENT SHEET ACCELERATION.** The magnetic reconnection process in a collisionless plasma is studied based on a particle simulation. It is found that the magnetic field reversal and particle energization take place



mainly in the midplane of the outflow region and the particle acceleration by slow shocks is not important. This result is consistent with the collisionless reconnection model proposed by Hill. (Author abstract) 20 refs.

Lee, L.C. (Univ of Alaska, USA); Ding, D.Q. *Geophys Res Lett* v 14 n 10 Oct 1987 p 1003-1006.

**079285 GRIDLESS PARTICLE SIMULATION USING THE MASSIVELY PARALLEL PROCESSOR.** A two-dimensional gridless electrostatic simulation code is developed for the Massively Parallel Processor (MPP), which consists of 16384 processors configured in a  $128 \times 128$  array with nearest-neighbor communication. The gridless model instead of the particle-in-cell (PIC) model is adopted on the MPP, since the gridless model can be efficiently parallelized on a via Discrete Fourier Transform which minimizes interprocessor communication. The advantage of the gridless model is that it can be easily developed for three dimensional simulation. Our results suggest that parallel processors have the potential for performing large scale plasma simulations. (Edited author abstract) 8 refs.

Lin, C.S. (Southwest Research Inst, San Antonio, TX, USA); Thring, A.L.; Koga, J. *Comput Phys Commun* v 48 n 1 Jan 1988, Part Methods in Fluid Dyn and Plasma Phys, Proc of the Workshop, Los Alamos, NM, USA, Apr 13-15 1987 p 149-154.

**Confinement** See Also ION BEAMS—Production; LASERS—Fusion Applications; MAGNETOHYDRODYNAMICS—Mathematical Models; MAGNETOHYDRODYNAMICS—Stability; NUCLEAR ENERGY—Fusion Reactions; NUCLEAR FUELS—Fusion; NUCLEAR REACTORS—Fusion; NUCLEAR REACTORS; FUSION; TOKAMAK DEVICES; TOKAMAK DEVICES—Analysis; TOKAMAK DEVICES—Control; TOKAMAK DEVICES—Magnetic Field Effects.

**079286 INTERMEDIATE-FREQUENCY FLUTE MODES IN A MAGNETIC QUADRUPOLE.** A dispersion equation is derived for flute modes with frequencies between the electron and ion bounce frequencies in a plasma confined to a magnetic quadrupole. Two intermediate-frequency flute modes which propagate in opposite directions along the quadrupole axis are predicted for the UMIST quadrupole. The possible excitation of a flute mode by self-interaction of a drift mode is considered. (Author abstract) 5 refs.

Willett, Joseph E. (Univ of Missouri-Columbia, Columbia, MO, USA); Wu, Hsi-Shu. *J Phys D* v 20 n 9 Sep 14 1987 p 1215-1217.

**079287 TWISTED COIL GEOMETRY IN PLASMA CONFINEMENT DEVICES.** In the present work, the techniques of differential geometry are used to determine the actual location of turns as they are wound on arbitrary surfaces. In the process, a set of natural winding coordinates is derived; the Biot Savart law for calculation of magnetic fields is expressed in terms of these natural coordinates. Next, the advantages of using a class of surfaces, called developables, for winding surfaces are discussed. A particular developable, called the rectifying developable, offers the additional advantages that the turns on it are geodesics and that wide flat conductors can be wound on it to minimize bending strains. Finally, the problem of windings with conductors of finite thickness is briefly discussed. (Edited author abstract) 5 refs.

Walstrom, P.L. (Univ of Wisconsin, Madison, WI, USA). *J Fusion Energy* v 6 n 3 Sep 1987 p 265-273.

**079288 PARTICLE CONFINEMENT AND ADIABATIC INVARIANCE.** The general problem of adiabatic invariance is discussed by using, as an example, the particle motion in a mirror magnetic trap. A new, resonant, adiabaticity parameter is introduced, which allows the reduction of the axisymmetric problem to the standard map, and which provides a sharp estimate for the chaos (instability) border in magnetic traps. Peculiarities of the particle diffusion out of the trap, due to the presence of the chaos border, are considered. The mechanism of slow Arnold diffusion in a non-axisymmetric field is explained, and some rough estimates are given, including

the impact of weak noise (gas scattering). (Author abstract) Refs.

Chirikov, B.V. (Inst of Nuclear Physics, Novosibirsk, USSR). *Proc R Soc London Ser A* v 413 n 1844 Sep 8 1987 p 145-156.

**079289 TOROIDAL PLASMA CONFIGURATION WITH ANISOTROPIC PRESSURE.** The relation between various surface quantities required in hydrodynamic calculations, and the relation between the parallel and perpendicular currents in an arbitrary magnetic toroidal plasma configuration with scalar pressure, are generalized to the case of anisotropic pressure. Magnetic co-ordinates for hydrodynamic equilibria in this configuration are defined. A general expression for the mean velocity of diffusion through a magnetic surface, on the basis of the one-fluid magnetohydrodynamic equation with anisotropic pressure, is derived. (Author abstract) 15 refs.

Rizk, Hussain M. (Arabian Gulf Univ, Manama, Bahrain). *J Plasma Phys* v 38 pt 2 Oct 1987 p 209-222.

**079290 CONTAINMENT FORCES IN LOW ENERGY STATES OF PLASMOIDS.** The application of Hamilton's principle to the problem of the determination of the structure of low free energy state plasmoids is discussed. It is shown that Clebsch representations of the vector fields and representations involving side conditions on the functional result in the same sets of Euler-Lagrange equations. The relationship of these representations to the problem of containment forces in vortex structures (plasmoids) is considered. It is demonstrated that the lowest free energy state of an incompressible plasma is always Lorentz force and Magnus force free. For a compressible plasma obeying the adiabatic gas laws, the Magnus force is finite. Introduction of conservation of angular momentum as an additional side condition also results in finite containment forces. (Author abstract) 19 refs.

Wells, Daniel R. (Univ of Miami, Coral Gables, FL, USA); Hawkins, Lawrence Carl. *J Plasma Phys* v 38 pt 2 Oct 1987 p 263-274.

**079291 EFFICIENCY OF RF CURRENT DRIVE IN THE PRESENCE OF FAST PARTICLE LOSSES.** The effects of losses of fast electron current carriers are included in a calculation of the efficiency of RF current drive. The analytical expressions obtained for the current drive efficiency  $J/P_A$  and bulk heating rate  $P_D/P_A$  are explicitly dependent on the fast electron confinement time,  $\tau_F$ . In most present tokamak experiments, fast particle losses are predicted to reduce the current drive efficiency from 50% to more than an order of magnitude. However, in future fusion plasmas fast electron confinement appears to be sufficient to allow nearly ideal efficiencies to be achieved. (Author abstract) 4 refs.

Luckhardt, S.C. (MIT, Cambridge, MA, USA). *Nucl Fusion* v 27 n 11 Nov 1987 p 1914-1917.

**079292 IMPURITY INJECTION EXPERIMENT ON THE TEXTOR TOKAMAK: EFFECT OF DETACHED PLASMA ON CONFINEMENT TIME.** A marked increase in the confinement time of injected impurities was measured during detachment of the plasmas in the TEXTOR tokamak. Non-recycling, metallic elements were introduced via laser blow-off, and scaling studies were performed. As the electron density increased, a threshold was reached beyond which the decay time of the brightness of the injected impurity transition was seen to increase from 75 ms to greater than 500 ms. The detachment of the plasma appeared coincident with the onset of this long confinement regime. (Author abstract) 15 refs.

Castracane, J. (KFA, Juelich, West Ger); Demers, Y.; Koenen, L.; Pospieszczyk, A. *Nucl Fusion* v 27 n 11 Nov 1987 p 1921-1925.

**079293 NUMERIC CALCULATIONS OF THE STABILITY OF COMPACT TORI.** A numeric study is made of the stability of uniaxial and biaxial compact tori, placed inside a jacket that is ideally conducting relative to

the fast oscillations of the plasma pinch. The position of the jacket at which the plasma attains the stability boundary is defined. For the biaxial compact torus, a characteristic motion has been discovered that corresponds to the tendency of the plasma configuration to merge into a uniaxial system. (Author abstract) 9 refs.

Shabarov, A.Yu. *Moscow Univ Comput Math Cybern* n 4 1987 p 27-32.

**079294 CONDITIONS FOR CONFINEMENT AND POSITIONAL STABILITY OF A Z-PINCH IN HIGH ORDER MULTIPOLE AND CUSP FIELDS.** Conditions for the existence of equilibria and their positional stability (axisymmetric  $m = 1$  model) are investigated for a generalized N-conductor Extrap configuration in the approximation  $N \gg 1$ . This kind of approach elucidates and exploits the boundary layer character of the external field influence on the plasma. It is shown that a 'confinement condition' (plasma inside the separatrix) in general can be expressed in terms of a restriction on the 'non-circularity' of the plasma. By an expansion in the non-circularity, an analytic expression for the growth rate of ideal MHD  $m = 1$  displacements, with an arbitrary current profile in the plasma, is derived, and non-expandable equilibria, including equilibria where the separatrix coincides with the plasma surface, are treated numerically. (Edited author abstract) 20 refs.

Wahlberg, C. (Uppsala Univ, Uppsala, Swed). *Phys Scr* v 37 n 1 Jan 1988 p 105-116.

**079295 CONFINEMENT OF ANGULAR MOMENTUM IN DIVERTOR AND LIMITER DISCHARGES IN THE DOUBLET III TOKAMAK.** Angular momentum confinement has been studied in neutral beam heated limiter and divertor discharges in Doublet III. Scaling of the angular momentum time with plasma current and neutral beam power has been determined. For divertor discharges, the angular momentum confinement time and the energy confinement time are equal and scale in the same way. This suggests that a single mechanism governs the transport of both energy and angular momentum in divertor discharges. For limiter discharges, the angular momentum confinement time is less than energy confinement time and the scalings are dissimilar. In both limiter and divertor discharges the measured angular rotation speed profiles are consistent with the theoretical prediction that angular rotation speed is a function of the flux surface co-ordinate only and is independent of poloidal angle. (Author abstract) 48 refs.

Burrell, K.H. (GA Technologies Inc, San Diego, CA, USA); Groebner, R.J.; St. John, H.; Seraydarian, R.P. *Nucl Fusion* v 28 n 1 Jan 1988 p 3-15.

**079296 ENERGY CONFINEMENT IN JET OHMICALLY HEATED PLASMAS.** The energy confinement properties of ohmically heated JET discharges are discussed in detail, from both a local and a global point of view. Also, the plasma resistivity and poloidal field diffusion are discussed in some detail. (Author abstract) 23 refs.

Bartlett, D.V. (JET Joint Undertaking, Abingdon, Engl); Bickerton, R.J.; Brusati, M.; Campbell, D.J.; Christiansen, J.P.; Cordey, J.G.; Corti, S.; Costley, A.E.; Edwards, A.; Fessey, J.; Gadeberg, M.; Gibson, A.; Gill, R.D.; Gottardi, N.; Gondhalekar, A.; Gowers, C.W. *Nucl Fusion* v 28 n 1 Jan 1988 p 73-88.

**079297 CALCULATION OF DIAMAGNETIC CURRENT IN A QUADRUPOLE MINIMUM B MIRROR FIELD.** An analytical expression of the diamagnetic current in a quadrupole minimum B mirror field is derived in the flux coordinates using a paraxial approximation. For various plasma pressure profiles, a diamagnetic flux is calculated which goes through racetrack- and base-



ball-shaped diamagnetic coils installed in the anchor cell of the GAMMA 10 tandem mirror. (Author abstract) 6 refs.

Katanuma, Isao (Univ of Tsukuba, Tsukuba, Jpn); Kiyamoto, Yasuhito; Saito, Tetsuo; Yamaguchi, Naohiro; Miyoshi, Syoichi. *Jpn J Appl Phys Part 1* v 27 n 1 Jan 1988 p 159-160.

**079298 PHENOMENOLOGICAL CONSIDERATION ON  $E \times B$  DISCHARGES.** In the decade between 1960 and 1970 many experiments were performed on confining ions in the  $E \times B$  field systems to obtain a thermonuclear reaction. This paper proposes to develop a theory of a small fluctuating electric field by which the electric field of the crossed field system is superposed. The resonance between the fluctuation and the motion of ions confined in the field system induces a convergence to a component of the ionic motion. As a result, under a certain condition, the chaotic ions in the field system form spokes. These phenomena (spoke formation process and spoke rotation) observed in  $E \times B$  devices are interpreted by comparing the theoretical results. (Edited author abstract) 9 refs.

Tanizuka, Noboru (Univ of Osaka Prefecture, Sakai, Jpn). *Electron Commun Jpn Part 2* v 71 n 2 Feb 1988 p 1-8.

**079299 MAGNETO-INERTIA CONFINEMENT APPROACH (MICA) TO FUSION IN DYNAMIC Z-PINCH FORMED FROM A FROZEN DEUTERIUM-TRITIUM TUBE.** This paper reconsiders the magneto-inertia confinement approach to fusion in dynamic z-pinch with a new method of generating a hot plasma using a frozen deuterium-tritium (D-T) tube as an initial condition. If modern pulsed power technology can induce the high current of the order of 10 MA along the tube, the dense z-pinch plasma formed from the electro-magnetical implosion of thin tubular D-T ice with a radius of about 1 mm can satisfy the Lawson criterion for its 1 cm length. (Author abstract) 11 refs.

Ikuta, Kazunari (Nagoya Univ, Nagoya, Jpn). *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 266-268.

**079300 STUDIES OF A FLEXIBLE HELIAC CONFIGURATION.** A detailed study of the flexible Helic configuration is presented. The remarkable flexibility of this device, which allows variation of the rotational transform, shear, and magnetic well depth over a relatively wide range, is described. Engineering considerations of error fields, finite cross-section conductors, and plasma-coil clearances are also discussed. (Author abstract) 13 refs.

Hender, T.C. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Cantrell, J.L.; Harris, J.H.; Carreras, B.A.; Lynch, V.E.; Lyon, J.F.; Fabregas, J.A.; Guasp, J.; Lopez-Fraguas, A.; Navarro, A.P. *Fusion Technol* v 13 n 4 May 1988 p 521-535.

**079301 INVESTIGATION OF MAGNETIC FIELD PROPERTIES IN THE HELICAL AXIS STELLARATOR: ASPERATOR NP-4.** Experimental measurements of the magnetic field properties of a helical axis stellarator were carried out. The results, together with the numerical calculation, are described herein. The toroidal device, Asperator NP-4, has a helical magnetic axis with a pitch angle of 45° and a multi-field period of  $n=8$ . The magnetic field of NP-4 is produced by the currents of helical solenoids and  $L=+1, -1$  helical windings. By an electron beam mapping of field lines, the existence of a high rotational transform angle and magnetic surfaces are confirmed and the position of the helical magnetic axis is obtained. The other fundamental magnetic properties such as the shear and the specific volume of the configuration are also deduced from the measurements. Numerical calculations lead to a good agreement with the results of the experiment. (Author abstract). 14 refs.

Funato, Yasuyuki (Tohoku Univ, Sendai, Jpn); Kitajima, Sumio; Watanabe, Hiroshige. *Jpn J Appl Phys Part 1* v 27 n 5 May 1988 p 821-826.

**079302 SIGNATURES OF RESISTIVE BALLOONING**

**ING MODES FOR ASDEX HIGH BETA DISCHARGES.** The signature of resistive ballooning modes in ASDEX high beta discharges are investigated. It is shown that the growth rates of these modes increase significantly when  $\beta_p$  reaches its maximum value during the discharge and therefore they can be used to explain the 'hard  $\beta_p$  saturation' behavior. A simple estimate of the corresponding electron heat conductivity gives values of  $\chi_e > 1 \text{ m}^2 \text{ s}^{-1}$ , in agreement with expectations from the observed confinement deterioration at maximum beta. (Author abstract). 5 Refs.

Grassie, K. (Max-Planck-Institut fuer Plasmaphysik, West Ger); Zehrfeld, H.-P. *Nucl Fusion* v 28 n 5 May 1988 p 899-901.

**079303 TRANSPORT THROUGH DISSIPATIVE TRAPPED ELECTRON MODE AND TOROIDAL ION TEMPERATURE GRADIENT MODE IN TEXTOR.** A self-consistent transport code is used to evaluate how plasma confinement in tokamaks is influenced by the microturbulent fields excited by the dissipative trapped electron (DTE) instability. As shown previously, the saturation theory on which the code is based has been developed from first principles. The numerical results reproduce well the Neo-Alcator scaling law observed experimentally (for example in TEXTOR) in non-detached Ohmic discharges, the confinement degradation resulting when auxiliary heating is applied. (Edited author abstract). 60 Refs.

Register, A. (KFA, Juelich, West Ger); Hasselberg, G.; Waelbroeck, F.G.; Weiland, J. *Nucl Fusion* v 28 n 6 Jun 1988 p 1053-1073.

**079304 DEVELOPMENT OF A TWO-DIMENSIONAL PARTICLE TRAJECTORY CODE AND APPLICATION TO A DESIGN OF A PLASMA DIRECT ENERGY CONVERTER IN THE FUSION ENGINEERING FACILITY BASED ON MIRROR PLASMA CONFINEMENT.** A two-dimensional code for an axisymmetrical plasma direct energy converter (PDC), the Kyoto University Numerical Analysis for Ion Trajectories in Axisymmetrical System (KUNAITAS), has been developed with the aid of the two-dimensional code Kyoto University Advanced DART (KUAD), including evaluation of atomic processes. The two-dimensional code was applied successfully to a PDC design for the Fusion Engineering Facility based on mirror confinement, with space-charge effects taken into account, yielding approx. 60 percent recovery efficiency at pressures of  $10^{-4}$  Pa. Calculations are made for particle trajectories of incident ions, slow ions and electrons and secondary electrons in the presence of expanding magnetic fields and self-consistent electric fields with particle trajectories. (Author abstract). 13 Refs.

Yoshikawa, Kiyoshi (Kyoto Univ, Uji, Jpn); Kouda, Shinji; Yamamoto, Yasushi; Maeda, Kouichi. *Fusion Technol* v 14 n 2 Sep 1988 p 264-283.

**079305 NUMERICAL STUDY OF GYROPHASE AND TIME-DEPENDENT LOSSES IN AXIALLY SYMMETRIC MAGNETIC MIRROR FIELDS.** Charged-particle motion in vacuum magnetic fields with 2 degrees of freedom has been investigated by numerically integrating the relativistic Lorentz force equation. The numerical simulation demonstrated that collisionless particle losses due to the nonexistence of a globally conserved quantity other than the energy and canonical angular momentum are gyrophase dependent, thus resulting in the existence of multiple particle confinement times. This is consistent with the cited experimental results and, in addition, demonstrates the indistinct nature of the mirror loss cone for  $p/L_M < 2 \times 10^{-2}$ . (Author abstract). 11 Refs.

Wallace, Christopher B. (Univ of Missouri, Columbia, MO, USA); Prelas, Mark A. *Fusion Technol* v 14 n 2 Sep 1988 p 284-287.

**079306 STATUS AND DEVELOPMENT OF MAGNETIC MIRROR SYSTEMS FOR NUCLEAR TESTING APPLICATIONS.** Several system studies have

concluded that the small size and steady-state nature of magnetic mirror systems provide attractive features for nuclear testing applications such as blanket testing, fission fuel production, tritium production, or decontamination of high-level radioactive nuclear reactor wastes. A summary of the data base is presented, and next-generation experiments that could be carried out to explore plasma physics issues associated with the production of high neutron fluxes in magnetic mirror configurations are described. (Author abstract). 38 Refs.

Simonen, Thomas C. (Lawrence Livermore Natl Lab, Livermore, CA, USA); Futch, Archer H.; Kaiser, Thomas B. *Fusion Technol* v 14 n 2 Sep 1988 p 329-338.

**079307 LOW-FREQUENCY FLUTE MODES IN A MAGNETIC QUADRUPOLE.** An eigenvalue equation is derived for electrostatic waves with frequencies below the ion bounce frequency in a plasma confined by a magnetic quadrupole. This integral equation for the electrostatic potential is developed to second order in the curvature and contains the effects of electron and ion temperature gradients. A dispersion equation for flute modes is derived from it. The present theory applied to the private flux region of the UMIST quadrupole predicts that low-frequency flute modes will propagate in the electron and ion diamagnetic drift directions. (Author abstract). 4 Refs.

Willett, Joseph E. (Univ of Missouri-Columbia, Columbia, MO, USA); Wu, Hsi-Shu. *J Plasma Phys* v 39 n 3 Jun 1988 p 503-510.

**079308 THREE-DIMENSIONAL EQUILIBRIA IN DRAKONS.** An analytic formula of the second-order equilibrium  $\beta$  limit for DRAKONS with triangular connectors of rectilinear elements (CRELs) with arbitrary pressure profile is derived. Its predictions for a parabolic pressure profile are compared with the full third-order numerical results, leading to a semi-analytic formula. The  $\beta$  limits obtained here are much lower than those obtained previously. Pressure profiles with sharper boundaries have lower  $\beta$  limits. The equilibrium is governed by the predominant quadrupole Pfirsch-Schluter current. Small deviations from the CREL condition have almost no effects on the equilibrium and thus the  $\beta$  limit. Optimal triangular CRELs are found. They give  $\beta$  limits slightly higher than those for the standard triangular CREL. Other possible ways of raising the  $\beta$  limit are also discussed. (Edited author abstract). 7 Refs.

Lau, Y.T. (MIT, Cambridge, MA, USA). *Nucl Fusion* v 28 n 7 Jul 1988 p 1223-1240.

**079309 EXPERIMENTAL STUDIES ON THE SUSTAINMENT OF SPHEROMAK PLASMAS BY AN INDUCTIVE DRIVE OF THE TOROIDAL CURRENT.** Sustainment of spheromak plasmas produced in an external equilibrium field has been demonstrated with a center current transformer (ohmic heating (OH) coil), which is used to inductively drive the toroidal current of the plasma. The OH coil is covered by a cylindrical metal liner that is electrically disconnected from the main vacuum vessel (spheromak mode). A dynamo effect, i.e., automatic generation of toroidal flux similar to that of a reversed field pinch (RFP), is observed. The measured MHD activity consists of multihelicity helical modes with toroidal mode numbers  $N = 1-3$ . In order to investigate the difference between spheromaks and RFPs in the MHD activity during sustainment, experiments have also been made with the metal line of the OH coil connected to the vessel (RFP mode). The dynamics of the MHD activities observed are compared simulation results and their implication for the dynamo effect is discussed. 19 refs.

Ono, Yasushi (Univ of Tokyo, Tokyo, Jpn); Yumoto, Akira; Katsurai, Makoto. *IEEE Trans Plasma Sci* v PS-15 n 4 Aug 1987 p 418-427.



**079310 ELECTROSTATIC CONFINEMENT EFFECTS ON A HOT CATHODE dc GLOW DISCHARGE IN SILANE.** A low pressure (2  $\mu$ bar) silane plasma has been obtained with a hot cathode dc glow discharge and electrostatic confinement. The plasma parameters have been measured with a Langmuir probe and their dependence on confining potential for three different anode sizes have been obtained. The dependence of plasma parameters on discharge current has also been studied. It has been shown that the plasma density increases significantly with the confinement and this increase is attributed to the reflection of primary electrons at the confining electrode. (Author abstract) 12 refs.

Andreu, J. (Univ de Barcelona, Barcelona, Spain); Sardin, G.; Esteve, J.; Morenza, J.L. *J Phys D* v 20 n 11 Nov 1987 p 1479-1483.

## Contamination

**079311 SPECIAL FEATURES OF MASS TRANSFER OF THE WALL MATERIAL OF URAGAN-2 STELLARATOR.** Deposits formed on glass and graphite specimens after exposure in the discharge chamber of Uragan-2 stellarator (race tracks) were examined. The thickness and composition of the deposit were determined by chemical analysis, Rutherford backscattering, characteristic x-radiation, and mass spectrometry of secondary ions. The results show that: 1) the main contribution to transfer of metallic solutes and formation of the deposit comes from the working discharges; 2) distribution of the deposited material is determined by magnetic configuration; 3) toroidal sections of the vacuum chamber provide the main contribution to deposit formation. (Author abstract) 18 refs.

Burchenko, P.Ya.; Voitsenya, V.S.; Volkov, E.D.; Gribov, Yu.A.; Dikii, A.G.; Kolot, V.Ya.; Rybalko, V.F.; Samoilov, V.P.; Solodovchenko, S.I. *Phys Chem Mater Treat* v 21 n 5 Sep-Oct 1987 p 439-442.

## Cooling

**079312 LOCAL RADIATIVE COOLING OF EDGE PLASMAS BY INTENSE NEUTRAL GAS PUFFING.** It is proposed that the overheating of tokamak limiters can be controlled by introducing a strong local source of neutral  $H_2$  directly at that limiter to convert the incident particle energy into isotropic radiation. The neutral influx rate required to substantially reduce the heat flux to the limiter is calculated as a function of the incident plasma parameters using a simplified one-dimensional fluid model. Application of this scheme to large tokamaks is discussed. (Author abstract) 12 refs.

Prinja, A.K. (Univ of California, Los Angeles, Los Angeles, CA, USA); Zweben, Stewart J. *Fusion Technol* v 12 n 3 Nov 1987 p 428-436.

## Cylinders

**079313 EXCITATION OF WHISTLERS AND QUASI-STATIC MODES BY AN ANNULAR ELECTRON BEAM IN A PLASMA CYLINDER.** A non-local theory of whistler and quasi-static mode excitation by an annular electron beam in a plasma cylinder is presented. Cerenkov and slow-cyclotron interaction are considered in the weak-beam approximation. The growth rate is found to be quite sensitive to the beam radius except in the case of slow-cyclotron interaction of quasi-static modes. The growth rate varies significantly with beam velocity in the case of Cerenkov interaction of quasi-static modes, but in other cases it is rather insensitive to the beam velocity. (Author abstract) 9 refs.

Talukdar, I. (Indian Inst of Technology, New Delhi, India); Jain, V.K. *J Plasma Phys* v 39 n 3 Jun 1988 p 407-411.

**Density** See Also CATHODES—Electric Conductivity; CATHODES—Research; TOKAMAK DEVICES.

**079314 EFFECTS OF NBI POWER MODULATION ON PELLETT INJECTION INTO A CURRENT**

**FREE PLASMA IN HELIOTRON E.** Hydrogen pellets are injected into the current free neutral beam injection (NBI) heated plasma in Heliotron E to effectively increase the plasma density and the internal energy. The chord averaged density of the target plasma is about  $2 \times 10^{19} m^{-3}$ , and the density increase by pellet injection is  $(4-6) \times 10^{19} m^{-3}$ . During this process the plasma remains stable. Under the present operational conditions, the pellet reaches the central axis; the penetration depth ranges from 27 cm to 35 cm (the magnetic axis corresponds to 30 cm). To optimize the plasma parameters obtainable by pellet injection, the NBI heating power is modulated. It is found that the mode of operation in which pellets are injected at relatively low NBI power followed by a higher-NBI-power phase is preferable to that in which pellets are injected during a constant high power phase. The main reason for this difference is the penetration depth of the pellet in the plasma which determines the deposition profile of particles in the plasma. (Author abstract) 19 refs.

Sudo, S. (Kyoto Univ, Uji, Jpn); Motojima, O.; Sano, F.; Zushi, H.; Kondo, K.; Muto, T.; Sato, M.; Kaneko, H.; Mizuchi, T.; Besshou, S.; Takeiri, Y.; Okada, H.; Baba, T.; Obiki, T.; Iiyoshi, A.; Uo, K. *Nucl Fusion* v 27 n 9 Sep 1987 p 1401-1410.

**079315 DETERMINATION OF THE DEUTERIUM PLASMA DENSITY RATIO  $n_d/n_e$  THROUGH NEUTRON MEASUREMENTS.** JET has been operating with deuterium plasma for the past two years, during which time neutron spectrometry has been applied as a diagnostic technique for determining the ion temperature for suitable discharges. Combining the 'neutron temperature' with the neutron yield determination made with a fission counter diagnostic permits the central deuteron to electron density ratio ( $n_d/n_e$ ) to be determined. It is found that this ratio, for ohmically heated discharges, appears to fall with ion temperature from about 70% at 2 keV to 40% at 3 keV. The addition of ICRF heating does not alter the density ratio. These findings are consistent with the observation that high temperatures achieved with Ohmic heating in tokamaks are correlated with high impurity levels. (Author abstract) 14 refs.

Jarvis, O.N. (JET Joint Undertaking, Abingdon, Engl); Gorini, G.; Kallne, J.; Merlo, V.; Sadler, G.; Van Belle, P. *Nucl Fusion* v 27 n 11 Nov 1987 p 1755-1763.

**079316 DENSITY FLUCTUATIONS IN PLASMA BY LASER INDUCED FLUORESCENCE METHOD.** A method based on laser induced fluorescence has been developed to measure the density fluctuation in plasma. An expression giving the intensity spectrum of light scattered by a turbulent plasma has been derived using hydrodynamical equations with nonlinear terms. An estimate of the relaxation time of the turbulence in the plasma can be made by correlating the expression with observed intensity spectrum. (Author abstract) 9 refs.

Khan, T.P. (Dinabandhu Andrews Coll, Calcutta, India). *Indian J Pure Appl Phys* v 25 n 9 Sep 1987 p 355-357.

**079317 TEMPORAL FEATURE OF DENSITY PROFILE DETERMINED BY PONDEROMOTIVE FORCE IN A LASER PLASMA.** The quasi-steady density profile determined by the ponderomotive force in a laser plasma is studied. The dependences of the local density scale length, the lengths of upper and lower density shelves and the average density scale length at lower shelf on the incident light intensity and time are derived. It is shown that after the quasi-steady state is reached, with the lapse of time the lengths of upper and lower density shelves and the average density scale length at lower shelf rise, and the density scale length in the critical density region increases slightly. (Author abstract) In Chinese. 6 refs.

Shen Wenda (Shanghai Univ of Science & Technology, China); Zhu Shitong. *Guangxue Xuebao* v 7 n 11 Nov 1987 p 1002-1006.

**079318 USE OF BALMER RADIATION FROM INJECTED NEUTRAL BEAMS FOR MEASUR-**

**MENT OF BEAM DEPOSITION AND PLASMA DENSITY PROFILES.** An analysis of the attenuation behavior of neutral beams injected for plasma heating is discussed, which yields a beam deposition profile for a known plasma density profile or which may provide a plasma density profile. The population of surviving beam trails at a penetration depth into a plasma is inferred from the excitation process of the fast neutrals. The excitation light is roughly independent of the electron temperature, and the line spectra can easily be distinguished by means of Doppler-shift spectroscopy. Hydrogenic neutral beams typically consist of three energy species (E, E/2, E/3) with different survival probabilities. By comparing the excitation light from each species at several points along the beam path, it is possible to decode information on the plasma density through which the beam has passed. On the other hand, if the plasma density profile is known from other diagnostics, the fast ion deposition profile can be obtained. A preliminary result of single-chord measurements in Doublet III is presented. (Author abstract) 13 refs.

Sleaford, B.W. (GA Technologies, Inc, San Diego, CA, USA); Cottrell, G.A.; Kim, Jinchoon. *Nucl Fusion* v 28 n 3 Mar 1988 p 523-527.

**079319 NEW DENSITY DIAGNOSTIC METHOD BASED ON EMISSION LINE INTENSITY RATIO OF NEUTRAL HYDROGEN IN AN IONIZING PHASE PLASMA.** For high temperature hydrogen plasmas in the ionizing phase, the population density of the excited levels has been calculated for a wide range of electron densities and temperatures. In the calculation we employed the most recent and reliable cross-section data for excitation between discrete levels and the ionization cross-section data from these levels. The line intensity ratios calculated under conditions of optical thinness are presented graphically for the Lyman and Balmer series lines. The intensity ratios are found to be rather insensitive to the electron temperature for temperatures higher than 10 eV. These values may be used for determining the electron density in the region of  $10^{17} < n_e < 10^{21} m^{-3}$ , which is relevant to fusion research plasmas. Radiation loss from the plasma and energy loss from the plasma electrons are also presented for a wide range of electron densities and temperatures. (Author abstract) 22 refs.

Fujimoto, T. (Kyoto Univ, Kyoto, Jpn); Miyachi, S.; Sawada, K. *Nucl Fusion* v 28 n 7 Jul 1988 p 1255-1263.

**Diagnostics** See Also ARGON—Measurements; ELECTROMAGNETIC WAVES; IONOSPHERE—Electromagnetic Field Effects; LASERS, GAS—Applications; MAGNETOHYDRODYNAMIC CONVERTERS—Measurements; MAGNETOHYDRODYNAMICS—Mathematical Models; METAL CUTTING—Laser Beam; NEUTRONS—Measurements; NUCLEAR ENGINEERING; NUCLEAR FUELS—Pelletizing; PROTECTIVE COATINGS—Plasma Spraying; ROCKET ENGINES—Ion Propulsion; SPECTROSCOPY—In Situ; TOKAMAK DEVICES—Control Systems; WATER—Electric Breakdown.

**079320 ION ENERGETICS IN THE INNER COMA OF COMET HALLEY.** The cometary plasma in the magnetic barrier just outside the diamagnetic cavity which surrounds the nucleus of comet Halley is virtually stagnant. The outflowing neutral gas exerts an outward ion-neutral drag force on this plasma, which balances the inward magnetic pressure gradient force in the vicinity of the contact surface. The cometary ions are frictionally heated due to the relative motion of the ion and neutral gases. The ion flow velocity must have a few km/s non-radial component in order to explain the ion temperatures measured by the ion mass spectrometer on Giotto. (Author abstract) 18 refs.

Cravens, T.E. (Univ of Michigan, Ann Arbor, MI, USA). *Geophys Res Lett* v 14 n 10 Oct 1987 p 983-986.

**079321 TOMOGRAPHIC DIAGNOSTICS OF LOW TEMPERATURE PLASMA.** A brief survey of the results of a cycle of investigations by the authors on designing apparatus and software for emission tomography of low temperature plasma is presented. A description



is given of the method of determination of the spread function (SF) of the emission plasma tomography (EPT) - computer complex, and results of SF measurements in different regions of the computer operating field are presented. In the course of the reconstruction of the SF, modified algorithms of computerized tomography have been employed. They take into account substantially the positive character of the tomograms and include the techniques for reducing the high frequency components of the unknown image. Results of experimental investigations of physical processes in low temperature plasma are illustrated by some examples obtained for arc discharge in a laminar flow of gas. (Translated author abstract) In Russian. 21 refs.

Mel'nikova, T.S.; Pikalov, V.V. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 11 1987 p 60-68.

**079322 EXCITATION OF A SPACE-TIME ECHO BY ELONGATED EXTERNAL SOURCES.** Excitation in a plasma of a space-time echo elongated in space or time by external sources is investigated. It is shown that the place and time of formation of the echo response is determined by the relation of the frequencies (the wave numbers) of the occupation of the envelope of the outside signals. (Author abstract) 5 refs.

Aliev, Yu.M.; Revenchuk, S.M. *Sov Phys Lebedev Inst Rep* n 2 1987 p 46-49.

**079323 INVESTIGATION OF SYMMETRY OF DISPERSION OF A PLASMA CORONA OF A MICROCROSPHERE IRRADIATED BY A LASER.** An interferometric method is proposed for investigating the symmetry of distribution of mass and ablation pressure in a plasma corona of shell targets irradiated by a laser. At a current density of  $10^{13}$ - $10^{14}$  W/cm<sup>2</sup> the degree of uniformity of the plasma corona in terms of mass was 0.5 and in ablation pressure, 0.9. (Author abstract) 5 refs.

Denus, S. (S. Kaliskii Inst of Plasma Physics & Laser Microsynthesis, Warsaw, Pol); Vilchinsky, A.; Volovski, E.; Zakharenkov, Yu.A.; Kosterin, A.V.; Mruz, V.; Nagraba, S.; Pavlovich, V.; Sklizkov, G.V.; Farny, Yu.; Shikanov, A.S. *Sov Phys Lebedev Inst Rep* n 2 1987 p 50-53.

**079324 ELECTRON DENSITY MEASUREMENTS FROM STARK BROADENED EMISSION IN A SODIUM PLASMA PRODUCED BY LASER RESONANCE SATURATION.** Electron Stark broadening of the  $4d_{3/2}$ - $3^2p$  multiplet transition in a sodium plasma produced by laser resonance saturation is used for undertaking spatial measurements of the free electron density across and along the plasma channel created in sodium vapor of density  $10^{15}$ - $5 \times 10^{16}$  cm<sup>-3</sup>. From these measurements and measurements of the neutral sodium density within a heat sandwich oven, we are able to deduce the corresponding electron temperature. These temperatures compare favorably with the electron temperature estimated from a Boltzmann analysis of line intensities. These experimental results demonstrate that this LIBORS code is capable of predicting the 3-dimensional nature of this new mode of laser ionization with reasonable accuracy, and may also explain the low electron temperatures and free electron densities observed by other research teams. (Edited author abstract) 88 refs.

Cappelli, Mark Antony. *UTIAS-Rep* n 306 Sep 1987 190p.

**079325 RUBY-LASER SCATTERING DIAGNOSTICS OF A SUPERSONIC PLASMA FLOW FOR LOW-PRESSURE PLASMA SPRAYING.** Truly reliable measurements of electron temperature and density in a plasma flow for low-pressure plasma spraying (LPPS) were performed for the first time, using incoherent Thomson scattering of ruby-laser light. The results indicate the characteristic feature of a supersonic nozzle flow, namely, successive appearance of oblique shock-wave heating (approximately 1 eV) and compression ( $4 \times 10^{21}$  m<sup>-3</sup>), and subsequent cooling (approximately 0.2 eV) and rarefaction ( $1 \times 10^{21}$  m<sup>-3</sup>). (Author abstract) 4 refs.

Hidaka, Ryouta (Nippon Steel Corp, Tobata, Jpn); Ooki,

Tsutomu; Takeda, Kouichi; Kondo, Katsuyuki; Kanda, Hiroshi; Uchino, Kiichiro; Matsuda, Yoshinobu; Muraoka, Katsunori; Akazaki, Masanori. *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1724-1726.

**079326 PLASMA DIAGNOSTIC APPLICATIONS ON THE TEXT TOKAMAK USING A HIGH POWER, TWIN FREQUENCY OPTICALLY PUMPED FAR-INFRARED LASER.** A high-power, twin-frequency, optically-pumped, far-infrared (FIR) laser has been developed at University of California, Los Angeles, California, for diagnostic application on the TEXT tokamak. The source is operated at 245 GHz ( $\lambda = 1.22$  mm) for heterodyne scattering measurements and 694 GHz ( $\lambda = 432$   $\mu$ m) for high resolution interferometry. Future plans include a 30 channel interferometer/polarimeter operating at 694 GHz to accurately determine current profiles. (Edited author abstract) 3 refs.

Peebles, W.A. (Univ of California, Los Angeles, CA, USA); Savage, R.L. Jr.; Brower, D.L.; Kim, S.K.; Lehecka, T.; Howard, J.; Doyle, E.J.; Luhmann, N.C. Jr. *Int J Infrared Millim Waves* v 8 n 11 Nov 1987 p 1355-1363.

**079327 EVOLUTION OF RADIATION POWER PROFILES IN ASDEX H-MODE DISCHARGES.** The paper investigates bolometrically determined radiation power profiles, energy exhaust and impurity accumulation in the two types of H-mode in ASDEX. During the burst dominated H-mode, the repetitive burst-like energy and particle expulsion into the divertor prevents an increase of radiation within the outer half of the plasma minor radius. This type of H-mode arrives at an equilibrium state. During the burst free H-mode, the radiation power losses, unimpeded by bursts, grow over the entire plasma cross-section until this H-mode ends in radiation collapse. Impurity accumulation, resulting in central peaking of the radiation power profiles, takes place in both types of H-mode. The time evolutions of the central radiation power density and the predominantly responsible iron concentration are not significantly affected by the presence or absence of bursts. (Edited author abstract) 16 refs.

Mueller, E.R. (Euratom-IPP Assoc, Garching, West Ger); Janeschitz, G.; Smeulders, P.; Fussmann, G. *Nucl Fusion* v 27 n 11 Nov 1987 p 1817-1826.

**079328 CASCADE FLUORESCENCES FROM LASER-EXCITED LITHIUM ATOMS IMMERSSED IN A STATIC ELECTRIC FIELD FOR PLASMA DIAGNOSTICS.** The Stark effect on a laser-pumped Li atom to the  $4^2D$  or  $4^2F$  level was studied by the observation of two cascade fluorescence of 610.4 nm ( $3^2D \rightarrow 2^2P$ ) and 323.3 nm ( $3^2P \rightarrow 2^2S$ ) under a static electric field in order to develop a spectroscopic measurement of the static or quasi-static electric fields in plasmas with a combined technique of Li-beam probing and laser-induced fluorescence (LIF). The excitation spectra and field dependencies of both lines were obtained and found to agree with the theoretical values obtained by solving the rate equations. It was also shown that a method for exciting the forbidden transition from  $2^2P$  to  $4^2F$  is so sensitive as to make it possible to measure an electric field as weak as approx. 100 V/cm. A practical method that is applicable to plasma devices is described, and the effect of the electron density on LIF is also discussed. (Author abstract) 14 refs.

Takiyama, Ken (Hiroshima Univ, Higashihiroshima, Jpn); Kamiura, Yoshitomo; Fujita, Toshiaki; Oda, Toshiatsu; Sakai, Hisashi; Kawasaki, Ken. *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 1945-1951.

**079329 PROPERTIES OF ECR PLASMA IN A SIMPLE MIRROR FIELD I - CORRELATION IN COLD AND HOT ELECTRON PRODUCTION.** The properties of an ECR plasma in various gas species have been clarified through soft X-ray and probe measurements. Soft X-ray measurements were performed on hot electron plasmas in the energy range of 1-15 keV and hot electron parameters were determined. Using data concerning cold plasma parameters determined from probe measurements, a close correlation was found in the production and/or heating of cold and hot electron components by changing the external parameters over a

wide range. (Author abstract) 10 refs.

Arata, Yoshiaki (Osaka Univ, Ibaraki, Jpn); Miyake, Shoji; Kishimoto, Hiroaki. *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 2072-2078.

**079330 PROPERTIES OF ECR PLASMA IN A SIMPLE MIRROR FIELD II - SPATIAL STRUCTURE OF THE PLASMA.** The spatial structure of an ECR plasma in a simple mirror field was experimentally studied. From axial measurements of the cold plasma parameters it was found that a plasma can be efficiently confined between the two resonance zones in the axial direction, rather than between the mirror throats, when the gas pressure is low enough to produce sufficiently hot and/or warm electrons. While measuring the radial distribution of low-energy soft X-ray emissions, it was verified that the 2nd-harmonic, as well as the fundamental, resonance zones contribute remarkably to the production of hot and/or warm electrons. (Author abstract) 1 ref.

Arata, Yoshiaki (Osaka Univ, Ibaraki, Jpn); Miyake, Shoji; Kishimoto, Hiroaki. *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 2079-2085.

**079331 BROADENING OF SPECTRAL LINES OF POSITIVE IONS OF NITROGEN AND OXYGEN.** A study was conducted into the theory of broadening of spectral lines of positive ions of nitrogen and oxygen in a plasma. The current status of the problem is reviewed. The approximate method of calculating the parameters of ion line broadening, previously proposed by the author, is further developed. The contribution by inelastic electron collisions is included in a Bethe-Born-Seaton approximation. The Gaunt factor for electron impact excitation is normalized anew on the basis of numerous quantum-mechanical calculations. 131 refs.

Kobzev, G.A. *IVTAN Rev* v 2 n 1 1988 p 57-95.

**079332 RADIAL DISTRIBUTION MEASUREMENT OF SiH<sup>+</sup> IN A LOW-PRESSURE SILANE PLASMA.** The radial emission intensity distribution of SiH<sup>+</sup> over the substrate of a low-pressure silane plasma was investigated for various substrate temperatures. Measured lateral intensities were converted to radial emission coefficients using an Abel inversion. The intensity near the center of the substrate was found to increase with  $T_s$  and yielded an activation energy  $E_a$  of 1.1 kcal/mole. This result is consistent with the value of  $E_a$  determined by laser-induced fluorescence measurements obtained previously. Radially resolved emission data obtained by varying the operating parameters of rf power, gas flow rate, silane/argon mixing rate, and total gas pressure provide a useful means of determining the conditions necessary to generate a uniform plasma. (Edited author abstract) 15 refs.

Asano, Yuichiro (Kawasaki Steel Corp, Chiba, Jpn); Baer, Douglas S.; Hernberg, Rolf; Hanson, Ronald K. *Plasma Chem Plasma Process* v 8 n 1 Mar 1988 p 1-8.

**079333 MEASUREMENT OF ABSORPTION LINE PROFILE BY LASER OPTOGALVANIC SPECTROSCOPY.** In plasma diagnostics, the gas temperature is usually computed on the basis of a measurement of the Doppler width of the emission line profile. This Doppler width is measured by a spectroscopic method, for example by means of a Fabry-Perot interferometer. For some time past the optogalvanic effect (OG) has found broad application as a new spectroscopic method. The high sensitivity of the laser OG method permits one to study the structure of high-lying and, therefore, low-density, energy levels; the transition frequencies between these levels fall in the IR region of the spectrum. This paper describes an experiment where the absorption line profile of neon at wavelength  $\lambda = 1.15$   $\mu$ m in a plasma in a hollow-cathode lamp of type LSP-1 was measured. The choice of the object under investigation was dictated by the presence of specific knowledge about the form of the profile and the width of selected line of neon; this is



important for analyzing the measurement method. A He-Ne laser is used as a probe source of radiation with power near 9 mW. The results presented here indicate the outlook of the laser OG method for measurement of absorption profiles by scanning absorption lines with a magnetic field. 8 refs.

Kalinov, V.S.; Ovseichuk, S.I. *J Appl Spectrosc* v 47 n 2 Aug 1987 p 771-774.

**079334 DIRECT OBSERVATION OF A STRONG ELECTRON HOLE IN A LINEAR TURBULENT HEATING DEVICE.** Appearance of a high potential region whose potential is larger than the externally applied potential difference, has been observed for the first time in a linear turbulent heating device. The positive potential pulse is identified as a strong electron hole. After the decay phase of the hole, a strong double layer is formed. A one-dimensional numerical simulation has been also carried out, showing qualitative agreement with the experimental results. (Author abstract) 12 refs.

Inuzuka, Hiroshi (Nagoya Univ, Nagoya, Jpn); Suzuki, Akihiro; Nagatsu, Masaaki; Tsukishima, Takashige. *Phys Scr* v 37 n 4 Apr 1988 p 542-545.

**079335 FAST ALPHA DIAGNOSTICS USING PELLET INJECTION.** Alpha particles will interact with the ablation cloud surrounding an injected pellet via charge-exchange (CX) and nuclear reactions. The possibility of using helium neutrals resulting from CX interactions between the incident alphas and a carbon pellet ablation cloud to determine the fast alpha energy spectrum is discussed. The upper limit on the ablation cloud density necessary to avoid significant energy loss by the incident alphas due to scattering is considered. The results of a pellet penetration and ablation model and its implications for alpha diagnostics are examined. The conceptual design of a diagnostic system for the Compact Ignition Tokamak (CIT) is reviewed. Proposed alternative approaches, which include nuclear reactions and observation of singly ionized helium from CX reactions are presented. (Edited author abstract) 19 refs.

Fisher, Raymond K. (GA Technologies, San Diego, CA, USA); Leffler, J. Stephen; Howald, Arthur M.; Parks, Paul B. *Fusion Technol* v 13 n 4 May 1988 p 536-542.

**079336 DIAGNOSTIC TECHNIQUE FOR MEASUREMENT OF PLASMA PARAMETER IN rf DISCHARGE.** A discharge model for rf plasma has been proposed. The microwave interferometer technique has been used to measure the steady state electron density by measuring the phase shift suffered by microwave signals in the plasma tube with and without plasma. The recombination coefficient for argon measured by delayed microwave scanning technique reported earlier has been used to measure the generation rate of this discharge. The rf electric field strength of this discharge is studied theoretically. With the knowledge of recombination coefficient and the field strength values of parameters like power absorbed, ionization frequency, electron-neutral collision frequency have been calculated. Using the amount of power absorbed in this typical rf discharge, the electron energy has been estimated from an empirical relationship. (Author abstract) 13 refs.

Majumdar, D. (Univ of Kalyani, India); Kundu, S.P.; Sarkar, D.C. *Indian J Pure Appl Phys* v 25 n 11 Nov 1987 p 435-441.

**079337 ANALYSIS OF LOW  $Z_a$  IMPURITY PELLET ABLATION FOR FUSION DIAGNOSTIC STUDIES.** The possibility of using low atomic number ( $Z_a$ ) impurity pellets such as carbon, lithium and beryllium as diagnostic probes for fusion grade plasma is investigated using an ablation model based on the vapor shielding phenomenon. It is shown that pellet injection velocities of approximately six kilometers per second would be required for penetration of a 1 mm sized carbon (diamond) pellet half-way into a CIT-like plasma. Properties of the high density ablation cloud surrounding a low  $Z_a$  pellet are discussed in relation to a diagnostic scheme that uses charge-exchange interactions of fusion-born

alpha particles with the ablation cloud to determine the local alpha energy distribution function. Pellet lifetime results are given and compared with experimental ones. (Author abstract) 20 refs.

Parks, P.B. (GA Technologies Inc, San Diego, CA, USA); Fisher, R.K.; Leffler, J.S. *Nucl Fusion* v 28 n 3 Mar 1988 p 477-490.

**079338 ANALYSIS OF ELECTRON CYCLOTRON EMISSION FROM NONTHERMAL GAS DISCHARGES.** Nonthermal ASDEX plasmas created by the injection of lower hybrid waves have been analyzed by simulating the observed electron cyclotron emission (ECE) spectra with the help of a two-component (low- and high-energy) plasma in the perpendicular slab approximation. Numerical simulations confirm the two-component description of the nonthermal discharges and provide estimates of the population and energy of the suprathermal electrons. (Edited author abstract). 5 Refs.

Wong, Kin-Lu (Nat'l Sun Yat-Sen Univ, Kaohsiung, Taiwan). *Chung kuo Kung Ch'eng Hsueh K'an* v 11 n 3 May 1988 p 301-303.

**079339 MEASUREMENTS OF PLASMA X-RADIATION BY THE PHOTOELECTRON METHOD.** The authors used the photoelectron method to study plasma X-ray spectra and to determine the electron temperature of the plasma,  $T_e$ . The measurements were made on the T-13 tokamak and the OGRA-4 mirror trap using a five-channel photoelectron spectrometer in the 50 eV to 40 keV energy range with a time resolution of 1 to 20 ms. The results are in good agreement with data obtained by Thomson scattering and by the filter method, and also with calculations of  $T_e$  based on plasma conductivity. It is shown that at large modern facilities a photoelectron spectrometer with no load limit can record  $10^4$  to  $10^5$  times more photons in a given time interval than an X-ray pulse height analysis system. Moreover, the photoelectron spectrometer has low sensitivity to hard X-rays and neutron radiation and can therefore be used at facilities with reactor parameters in experiments with D-D and D-T plasma. (Author abstract). 25 Refs.

Gott, Yu. V. (I.V. Kurchatov Inst of Atomic Energy, Moscow, USSR); Shurygin, V.A. *Nucl Fusion* v 28 n 4 Apr 1988 p 543-548.

**079340 REVIEW PAPER PLASMA DIAGNOSTICS ON LARGE TOKAMAKS.** The main tasks of the large tokamaks which are under construction (T-15 and Tore Supra) and of those which have already been built (TFTR, JET, JT-60 and DIII-D) together with their design features which are relevant to plasma diagnostics are briefly discussed. The structural features and principal characteristics of the diagnostic systems being developed or already being used on these devices are also examined. The different diagnostic methods are described according to the physical quantities to be measured: electric and magnetic diagnostics, measurements of electron density, electron temperature, the ion components of the plasma, radiation loss measurements, spectroscopy of impurities, edge diagnostics and study of plasma stability. The main parameters of the various diagnostic systems used on the six large tokamaks are summarized in tables. (Author abstract). 351 Refs.

Orlinskij, D.V. (I.V. Kurchatov Inst of Atomic Energy, Moscow, USSR); Magyar, G. *Nucl Fusion* v 28 n 4 Apr 1988 p 611-697.

**079341 SPACE-TIME DIAGNOSTICS OF REACTIVE IMPULSE PLASMA.** Spectral investigations of the space-time distribution of reactive impulse plasma ejected from a coaxial accelerator were carried out. A two-zone structure of the plasmoid, related to interactions between the gas plasma and the accelerator electrode, was found. The isotropization kinetics of the chemical composition of the plasmoid was determined. 18 refs.

Walkowicz, Jan (Science Cent of Maintenance, Radom, Pol); Sekula, Jerzy. *IEEE Trans Plasma Sci* v PS-15 n 5 Oct 1987, XIIth Int Symp on Discharges and Electr Insul in Vac, Shresh, Isr, Sep 22-25 1986 p 603-608.

**079342 CARACTERISATION ELECTRIQUE DES PLASMAS DE DEPOTS.** [Electric Characterization of Deposition Plasmas]. The diagnostics of deposition plasmas by Langmuir or electric probes is briefly reviewed. The analysis of the probe current-voltage characteristic provides the plasma parameters: electron temperature, electron density and plasma potential. The use of these probes in different discharges of interest in thin film deposition is considered. (Author abstract) 28 refs. In French.

Lemperiere, G. (CNRS, Nantes, Fr). *Vide Couches Minces* v 41 n 230 Jan-Feb 1986, C R des Journ d'Etude sur les Depots Ioniques, Limoges, Fr, Sep 25-26 1985 p 27-32.

Diffusion See Also TOKAMAK DEVICES.

**079343 CLASSICAL PLASMA DIFFUSION WITH RATIONAL MAGNETIC SURFACES.** The Pfirsch-Schluter classical diffusion of a general stationary toroidal plasma with rational magnetic surfaces and anisotropic pressure is calculated. The effect of pressure anisotropy on the classical diffusion is studied. It is found that the classical diffusion depends on the direction of the neutral beam injection. (Author abstract) 12 refs.

Rizk, Hussain M. (Arabian Gulf Univ, Manama, Bahrain). *Phys Scr* v 37 n 1 Jan 1988 p 102-104.

**079344 RESISTIVELY INDUCED PLASMA DIFFUSION DUE TO THE TRIVIAL MARGINAL MODES OF IDEAL MHD.** The influence of nonlinearities and plasma resistivity on the so-called trivial marginal modes of ideal MHD is investigated. It turns out that to lowest significant order of a reductive perturbation analysis nonlinearities have no influence, while in toroidal confinement configurations resistivity induces a local plasma diffusion across the magnetic surfaces. This is demonstrated for tokamaks with zero poloidal current density. In addition, the appearance of singularities in the plasma motion parallel to the magnetic field lines suggests a profile condition at the edge of the plasma. Heat conduction would directly tend to keep these effects at lower level, while indirectly it creates a reinforcement mechanism through the coupling to usual cross diffusion. (Author abstract) 5 refs.

Liebert, W. (Univ Duesseldorf, Duesseldorf, West Ger); Rebhan, E. *J Plasma Phys* v 39 n 1 Feb 1988 p 157-168.

Dissociation

**079345 DETERMINATION OF THE DEGREE OF DISSOCIATION OF HYDROGEN PLASMAS.** The degree of dissociation of hydrogen plasma bounded by cylindrical metal discharge vessel walls is calculated. The problem is solved in the diffusion approximation neglecting loss of atoms in the volume. It is shown that under certain conditions the degree of dissociation is independent of the association coefficient for atoms at the walls. (Author abstract) 13 refs.

Lavrov, B.P. (G.V. Plekhanov Mining Inst, Leningrad, USSR); Simonov, V.Ya. *High Temp* v 25 n 4 Jul-Aug 1987 p 482-485.

Electric Conductivity See Also ELECTRIC POWER GENERATION—Magnetohydrodynamic; ELECTRIC SWITCHES—Computer Simulation; ELECTRIC SWITCHES—Research.

**079346 ELECTRICAL CONDUCTIVITY OF COMPLETELY IONIZED NONIDEAL PLASMA.** Using the Kubo formula, the electrical conductivity of completely ionized plasma in the region  $\Gamma = e^2 / r_D T > 1$  ( $r_D$  is the Debye radius;  $T$  is the temperature) is calculated. First, the influence of flow effects is taken into account. The electron mobility for energies above the flow level is determined by methods of the theory of an effective medium, and depends on the characteristic scale of inhomogeneity of the potential and the velocity of electron motion in potential relief. The theoretical electrical-con-



ductivity values are compared with the experimental data and the results of other calculations. (Edited author abstract) 13 refs.

Vorob'ev, V.S. (Acad of Sciences of the USSR, USSR). *High Temp* v 25 n 3 May-Jun 1987 p 311-315.

**079347 GROWTH OF BULK CONDUCTIVITY PERTURBATIONS IN A CONTRACTED GLOW DISCHARGE.** Measurements have been made on artificial conductivity perturbations in a plasma column arising from a contracted stationary transverse discharge in nitrogen or air produced by sectioned electrodes. The initial state of the diffuse glow discharge is stable against contraction in the linear approximation. Theoretical estimates are made of the conditions for perturbation in the column. (Edited author abstract) 8 refs.

Akishev, Yu.S.; Volchek, A.M.; Napartovich, A.P.; Sokolov, N.A.; Trushkin, N.I. *High Temp* v 25 n 4 Jul-Aug 1987 p 465-470.

**079348 PLASMA RESISTIVITY AND FIELD PENETRATION IN JET.** The evolution of current and temperature profiles in JET has been analyzed using an advanced equilibrium analysis code and absolutely calibrated ECE measurements. It is found that during the discharge 'flat-top' the evolution of the current is well described by neoclassical resistivity. However, during the discharge rise phase, the current penetration can be more rapid. The MHD processes influencing the rapid penetration are discussed qualitatively by analyzing the trajectories of several discharges in the  $(q_0, q_a)$  plane. (Author abstract) 20 Refs.

Campbell, D.J. (JET Joint Undertaking, Abingdon, Engl); Lazzaro, E.; Nave, M.F.F.; Christiansen, J.P.; Cordey, J.G.; Schuller, F.C.; Thomas, P.R. *Nucl Fusion* v 28 n 6 Jun 1988 p 981-990.

## Electric Field Effects

**079349 OCCURRENCE OF ELECTROKINETIC INSTABILITY DURING DISCHARGE OF AN IONIZED JET.** A physical model of the occurrence in an electric field of ion-plasma oscillations in an ionized gas jet due to electrokinetic interaction is examined. The presence of such oscillations is confirmed experimentally by measuring the charge of the circuit, the capacitance of which is the conductive part of the jet of the gas plasma generator. The mechanism of occurrence of electrokinetic instability is examined for the case of a freely discharging jet in an approximation when the charged component does not have a substantial effect on the flow. 3 refs.

Tambovtsev, V.I.; Usachev, V.K.; Pisarev, N.M. *Sov Surf Eng Appl Electrochem* n 1 1987 p 68-70.

**079350 PARAMETRIC SURFACE-WAVE EXCITATION AT THE SECOND HARMONICS OF ION AND ELECTRON CYCLOTRON FREQUENCIES.** A study has been made on the effects of an external alternating electric field on surface cyclotron waves in a semiinfinite plasma in a steady magnetic field parallel to the boundary. Calculations are performed on the increments for the parametric instabilities in the extraordinary ion and electron surface cyclotron waves under conditions of weak spatial dispersion. (Author abstract) 9 refs.

Girka, V.A. (Kharkov Univ, USSR); Lapshin, V.I. *Radio-physics Quantum Electron* v 30 n 6 Jun 1987 p 544-547.

**079351 PARTICLE PATHS AND PHASE PLANE FOR TIME-DEPENDENT SIMILARITY SOLUTIONS OF THE ONE-DIMENSIONAL VLASOV-MAXWELL EQUATIONS.** Lie group point transformations applied to the one-dimensional Vlasov-Maxwell equations yield general similarity forms for the dependent and independent variables. One class of such solutions is seemingly like Bernstein-Greene-Kruskal solutions in allowing a relatively free choice of electric field, but with a more complex time dependence. The phase trajectories of the particles are found here for both temporally damped and (possibly unphysical) growing electric fields in this class by numerical integration in the

original and in transformed co-ordinates. The analysis, which includes an analytic consideration of phase-plane fixed (critical) points, shows the advantages of the new co-ordinates, and reveals qualitative features of the distribution function. (Author abstract) 21 refs.

Roberts, Dana Aaron (Washington Univ, St. Louis, MO, USA); Abraham-Shrauner, Barbara. *J Plasma Phys* v 38 pt 3 Dec 1987 p 335-350.

## Electric Field Measurement

**079352 CONTACTLESS METHOD FOR STUDY OF RADIO-FREQUENCY PLASMA FIELDS.** A method is developed for study of localized microwave fields in plasma by means of a diagnostic electron beam. The fields are measured by analysis of the radio-frequency modulation of the electron beam by means of phase analyzer. The method permits measurement of rf electric fields with a characteristic field-localization dimension of  $\leq 1$  cm and a field strength of  $\geq 10$  v/cm in a band of  $\pm 20$  MHz relative to the reference signal. Measurements are performed in the 10-cm band. (Author abstract) 5 refs.

Busheva, E.M. (Acad of Sciences of the USSR, Moscow, USSR); Gol'tsman, V.L.; Zadiraka, Yu.V.; Silin, V.A.; Faizullin, R.Z.; Khavaev, V.B. *Instrum Exp Tech* v 30 n 1 pt 2 Jan-Feb 1987 p 185-187.

## Electronic Properties

**079353 COLLISIONLESS ABSORPTION AND POSSIBLE FIR AMPLIFICATION IN MICROSTRUCTURED 2D ELECTRON SYSTEMS.** The absorption of FIR in a 2D electron plasma due to Landau damping is calculated. The frequency and drift velocity criteria of amplification (negative Landau damping) are formulated. Doppler splitting plasmon resonance is predicted. (Author abstract) 5 refs.

Chaplik, A.V. (Acad of Sciences of USSR, Novosibirsk, USSR). *Solid State Commun* v 65 n 12 Mar 1988 p 1589-1591.

**Etching** See Also CRYSTALS—Etching; INTEGRATED CIRCUIT MANUFACTURE—Etching; SEMICONDUCTOR DEVICE MANUFACTURE—Etching.

**079354 PHOTON ASSISTED PLASMA ETCHING.** Combining light-driven etching with plasma processing is a natural extension of the techniques that have been developed in each of the separate areas. The light may be used to modify both the gas-phase and the surface-phase chemistry occurring in a plasma reactor. The combination can result in processing capabilities not attainable using either light-driven or plasma techniques alone. (Author abstract) 27 refs.

Holber, W.M. (Columbia Univ, New York, NY, USA); Osgood, R.M. Jr. *Solid State Technol* v 30 n 4 Apr 1987 p 139-143.

**079355 DOWNSTREAM PLASMA ETCHING AND STRIPPING.** Fine-featured, high-density semiconductor devices' susceptibility to damage by electrostatic discharge, coupled with the need for extremely fine etch control, taxes current technologies and motivates the search for new approaches. Downstream plasma methods, where the plasma generation and reaction regions are physically separated, have a number of properties that may alleviate some of these problems and concerns. These general characteristics are presented along with several examples of semiconductor and organic polymer etching. Kinetics of transport are also covered as are factors that influence the processing. A review of the literature is included and future directions are discussed. (Edited author abstract) 49 refs.

Cook, J.M. (AT&T Bell Lab, Murray Hill, NJ, USA). *Solid State Technol* v 30 n 4 Apr 1987 p 147-151.

**Flow** See Also ELECTRIC SWITCHES—Computer Simulation; ELECTRIC SWITCHES—Research; ELECTRIC SWITCHES—Vacuum Applications; FLOW OF FLUIDS—Channel Flow; FLOW OF FLUIDS—Two Phase; MAGNETOHYDRODYNAMIC CONVERTERS—Testing;

PLASMA DEVICES—Heat Transfer; PROTECTIVE COATINGS—Plasma Spraying.

**079356 PROBLEMS OF PLASMA DYNAMICS OF JET DISPERSE SYSTEMS, JOINT PHYSICAL AND COMPUTATIONAL EXPERIMENT.** A survey of the status of research into high-temperature dust-laden jets of a complex gaseous composition and of the processes of interaction between molten particles and a base under the conditions characteristic of plasma coating deposition is presented. Results obtained at the Institute of Thermophysics of the Siberian branch of the Academy of Sciences of the USSR within the framework of development of a methodical approach are outlined. This approach makes it possible to tackle the research into the processes of impulse, heat and mass transfer in plasma jets of a complex chemical composition, both single-phase ones and those carrying inert impurity particles. The most important problems of research are formulated. (Translated author abstract) In Russian. 66 refs.

Zhukov, M.F.; Solonenko, O.P. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 11 1987 p 69-86.

**079357 STRUCTURE OF THE PLASMA FLOW FORMED IN MULTISTREAM MIXING CHAMBERS OF DIFFERENT TYPE.** The results of spectral measurements of the temperatures of an air plasma flow are presented and analyzed. The distribution of the temperature of the plasma flow over the cross section of the conical and tangential mixing chambers at their outlet was measured by the method of relative intensities of copper lines with wavelengths of 5105, 5153, and 5220 Angstrom. The spectra were recorded with an ISP-51 spectrograph with a chamber  $F = 270$  mm. 9 refs.

Mosse, A.L. (Acad of Sciences of the Byelorussian SSR, Minsk, USSR); Knak, A.N.; Ermolaeva, E.M. *J Eng Phys* v 52 n 3 Mar 1987 p 321-325.

**079358 ON THE FLOW PLASMA AROUND A DIPOLE MAGNETIC FIELD.** Experiments intended to examine the flow characteristics of a plasma incident on a localized magnetic dipole field in a low  $\beta$  plasma are described. Both the electron and ion densities are measured upstream and downstream from the magnetic structure, and the results are compared with a nonflowing plasma of the same density. Differences are detected which can be attributed to the flowing plasma. (Edited author abstract) 25 refs.

Hill, Jacqueline L. (Univ of Iowa, Iowa City, IA, USA); Seyhonzadeh, Amir; Chang, Hong-Young; Lonngren, Karl E. *Radio Sci* v 22 n 7 Dec 1987 p 1211-1218.

**079359 TWO-MODE MODEL OF FLOW IN A PLASMATRON CHANNEL.** The characteristics of an electric arc in a turbulent gas flow are calculated on the basis of the concept of laminar flow in the arc zone. The given two-mode model of flow in a plasmatron channel may be used at sufficiently large arc currents and moderate Reynolds numbers of the turbulent argon flow. The analytical expressions obtained may be used in calculations of the basic characteristics of the stabilized section of the arc in a plasmatron with corresponding operating conditions. 14 refs.

Aleshin, N.F. (Acad of Sciences of the Belorussian SSR, Minsk, USSR); Bublikovskii, A.F. *J Eng Phys* v 51 n 5 Nov 1986 p 1354-1358.

**079360 GAS DYNAMICS OF THE BOUNDARY LAYER OF A CAPILLARY DISCHARGE WITH A VOLATILE WALL.** Investigations of a capillary discharge with a volatile wall (CDVW) have established that as the length of the capillary increases, the pressure of the plasma in it increases linearly, if the other parameters remain constant. The purpose of the present investigation was to clarify the space-time characteristics of the plasma flow in a CDVW. This work was stimulated by the observation of an entire series of small deviations from constant values of the characteristics of the CDVW within the flat part of the current pulse. The geometric structure



of the boundary layer of a quasistationary capillary discharge with a volatile wall is studied as a function of its length. (Edited author abstract) 8 refs.

Ogurtsova, N.N.; Podmoshenskii, I.V.; Smirnov, V.L.; Shelemina, V.M. *High Temp* v 24 n 6 Nov-Dec 1986 p 767-771.

**079361 HEAT TRANSFER OF PARTICLES IN PLASMA FLOW.** Small spherical particles injected into a flowing high-temperature plasma stream attain an increase in heat energy by conduction and convective heat transfer. Because of the non-linear temperature dependence of the material functions and the transport properties of the plasma gas, the solution is usually obtained by an extensive numerical method. This paper describes a simple and fast polynomial series method to calculate the transient radial temperature distributions and the required melting time of single-phase particles as functions of the plasma temperature and velocity fields. (Author abstract) 14 refs.

Lee, H.E. (CSIRO Div of Applied Physics, Lindfield, Aust.). *J Phys D* v 21 n 1 Jan 14 1988 p 73-78.

**079362 FROZEN STATE OF IONISATION IN A CATHODIC PLASMA JET OF A VACUUM ARC.** The regions and conditions in which the Saha equation can be applied to the cathodic plasma of a vacuum arc are examined. Considering the relaxation times of ionization and recombination, it is found that the plasma is in a frozen state of ionization due to the rapid expansion for  $r \geq (10-100) \mu\text{m}$ , where  $r$  is the distance from the cathode spot. As a consequence, the electron density and all ion densities should be proportional to  $r^{-2}$ . The parameters of the frozen state accessible to experimental investigations ( $r > 100 \mu\text{m}$ ) result from the parameters of the strongly non-ideal plasma of the cathode spot. This opens a new approach to investigate strongly non-ideal plasmas by comparatively simple methods. (Author abstract) 11 refs.

Anders, S. (Acad of Sciences of the German Democratic Republic, Berlin, East Ger); Anders, A. *J Phys D* v 21 n 1 Jan 14 1988 p 213-215.

**079363 HYDRODYNAMIC ANALOGY OF NON-LINEAR PLASMA FLOWS.** Some new aspects of an analogy between plasma in a magnetic field and a rotating shallow liquid are considered. Effects of gyroscopic screening and resonant wave excitation are studied. The results of numerical simulations of the nonlinear evolution of sheared flows in rotating shallow water are presented. (Author abstract) 21 refs.

Bazdenkov, S.V. (I.V. Kurchatov Inst of Atomic Energy, Moscow, USSR); Pogutse, O.P. *J Plasma Phys* v 39 n 1 Feb 1988 p 27-39.

**079364 PLASMA JET OPERATED BY SUBLIMATION GASES.** Evaluation of performance has been made empirically for an original type of plasma jet which is operated by using sublimation gases of solids. Both the production and the heating of the sublimation gases are conducted at the same time by arc discharges; hence the working gases can be generated on demand. The extinctions and ignitions are possible, repeatedly and instantaneously, with the application or interruption of arc discharges when appropriate solids are employed as its charge, and the sublimation rate of the charge can be controlled by the arc intensity. Measurements show that the efficiency of this plasma jet is in no way inferior to the ordinary gas plasma jet, and can be further improved by employing a composite type of charge solid or a consumption type of electrode in order that the evaporation gases may react and release high combustion energy. (Author abstract) 3 refs. In Japanese.

Tachibana, Takeshi; Kimura, Itsuro. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 495 Nov 1987 p 3432-3436.

**079365 MULTIGROUP ANALYSIS OF NUCLEAR ELASTIC SCATTERING EFFECTS IN CAT-D AND DD<sup>3</sup>He FUSION PLASMAS.** Effects of nuclear elastic scattering (NES) on the slowing down of charged fusion

products in a typical deuterium plasma and the burn dynamics of ignited Cat-D and DD<sup>3</sup>He plasmas are investigated. A time-dependent multigroup method is used to take into account the effect of finite (non-zero) slowing-down time as well as the discrete nature of NES. It is shown that adequate treatment of the slowing-down process, especially consideration of NES and slowing-down time delay, is essential for an accurate prediction of the dynamic behavior and thermal instability of the plasmas. (Edited author abstract) 30 refs.

Nakao, Yasuyuki (Kyushu Univ, Fukuoka, Jpn); Hanada, Takahiro; Hori, Hidetoshi; Kudo, Kazuhiko; Ohta, Masao. *Mem Fac Eng Kyushu Univ* v 47 n 4 Dec 1987 p 339-350.

**079366 OPERATING CHARACTERISTICS OF DC ARC PLASMA FLOW.** The object of this study is to develop engineering application methods of plasma flow. A stabilized circulation type plasma jet generator has been designed and produced to research the generation and operation regions of a constant plasma flow, and basic data on the operating characteristics of DC arc plasma and its fluidic characteristics have been obtained. The results are summarized as follows: (1) the figure which shows the operating region of the plasma torch was obtained and it also shows the interrelationship between the voltage, the current and the distance of electrodes (2) by qualitative observation of the plasma jet, it has been revealed that the greater the argon flowrate, the voltage between electrodes, the current and the distance between the electrodes, the longer the length of the plasma jet. In addition, when the argon flowrate increases, the jet tends to be narrower. (Author abstract) 8 refs.

Morimune, Takaaki. *Mem Fac Technol Tokyo Metropol Univ* n 37 1987 p 3785-3794.

**079367 NEW STATIONARY VORTEX SOLUTIONS OF THE HASEGAWA-MIMA EQUATION.** Two different families of explicit stationary solutions of the Hasegawa-Mima equation are obtained. In the first case the well-known modon (dipole vortex) is used as the zeroth-order solution, and new solutions that are close to but distinctly different from it are found by perturbation analysis. In the second case the dispersive term of the equation is treated as a small parameter, and a radially symmetric solution (a monopole vortex) is used as the zeroth-order approximation. Both families of solutions are found to be infinite and to contain an arbitrary function. A recent general proof of the existence of infinitely many stationary solutions containing an arbitrary function is examined and found to be invalid. (Author abstract). 25 Refs.

Nycander, J. (Uppsala Univ, Uppsala, Swed). *J Plasma Phys* v 39 n 3 Jun 1988 p 413-430.

**Fluid Dynamics** See Also FLOW OF FLUIDS—Supersonic.

**079368 OPERATING CHARACTERISTICS OF DC ARC PLASMA FLOW.** The object of this study is to develop engineering application methods of plasma flow. A stabilized circulation type plasma jet generator has been designed and produced to research the generation and operation regions of a constant plasma flow, and basic data on the operating characteristics of dc arc plasma and its fluidic characteristics have been obtained. The results are summarized as follows: (1) the figure which shows the operating region of the plasma torch was obtained and it also shows the interrelationship between the voltage, the current and the distance of electrodes; and (2) by qualitative observations of the plasma jet, it has been revealed that the greater the argon flowrate, the voltage between electrodes, the current and the distance between the electrodes, the longer the length of the plasma jet. In addition, when the argon flowrate increases, the jet tends to be narrower. (Author abstract). 8 Refs.

Morimune, Takaaki (Tokyo Metropolitan Univ, Tokyo, Jpn). *Mem Fac Technol Tokyo Metropol Univ* n 37 1987 p 3785-3794.

**Focusing** See X-RAYS—Analysis.

## Heat Transfer

**079369 FOKKER-PLANCK CALCULATIONS ON HEAT FLOW IN PLASMAS.** This paper deals with the application of a Fokker-Planck code to the problem of heat conduction down steep thermal gradients. The results are compared with those obtained with other codes based on the Fokker-Planck equation in which various simplifying assumptions are made in the calculation of the Rosenbluth potentials. The particular problem considered is that of heat flow between spherical shells at different temperatures. The difference between the heat flows resulting from isotropic and anisotropic distributions is specially emphasized. The results show that, for calculating temperature, the usual Legendre polynomial expansion for the angular dependence of the distribution functions gives reasonable results even when it is limited to two terms. (Edited author abstract) 9 refs.

Jorna, S. (Univ of St. Andrews, Scotl); Wood, L. *J Plasma Phys* v 38 pt 2 Oct 1987 p 317-333.

**079370 RADIATIVE HEAT TRANSFER FROM POTASSIUM SEEDED WATER GAS COMBUSTION PLASMA.** The radiative heat transfer calculation from a potassium seeded water gas combustion plasma has been made to estimate the heat losses through the walls of a MHD channel. The contributions of CO<sub>2</sub> and H<sub>2</sub>O to the heat flux are important, and more than half of it comes from bands lying up to 2.7  $\mu\text{m}$ . The heat flux from the potassium seed using various absorption cross-section data has been evaluated and compared. Potassium contributes about 25-30% of the total radiative heat flux. The radiative heat flux, both from combustion products and from seed increases about five times as the channel width increases from 8.4 mm to 2.0 m. 9 refs.

Joshi, N.K. (BARC, Bombay, India); Thiagarajan, T.K.; Rohatgi, V.K. *Energy Convers Manage* v 28 n 1 1988 p 59-62.

**079371 TRANSFER OF HEAT FROM A NITROGEN ELECTRIC ARC TO A FLAT ANODE.** An experimental study of heat transfer from a nitrogen electric arc to a flat anode at  $I$  between 40 and 80 A,  $G$  from 0.2 to 0.6 gram/sec and  $l=114$  mm at atmospheric pressure is described. The relative fraction of heat flux transmitted by electrons to the anode is determined as a function of  $I$ . The distribution of convective heat flux density across the anode heating spot was measured and correlated. The experimental data on convective heat transfer to the anode (average and in critical point) are correlated by dimensionless equations. (Author abstract) 16 refs.

Juskevicius, R.A. (Lithuanian Acad of Sciences, USSR); Ambrazevicius, A.B. *Heat Transfer Sov Res* v 19 n 6 Nov-Dec 1987 p 103-113.

**Heating** See Also CERAMIC MATERIALS—Sintering; EDDY CURRENTS; ELECTROMAGNETIC WAVES—Propagation in Plasma; ELECTRON BEAMS; ELECTRONS—Transport Properties; EXTRACTIVE METALLURGY; ION ACOUSTIC WAVES; IONOSPHERE; LASER BEAMS—Effects; LASERS—Fusion Applications; LIQUID METALS—Gases; MAGNETOHYDRODYNAMIC CONVERTERS—Performance; MAGNETS—Applications; NUCLEAR REACTORS, FUSION—Radioactivity; PARTICLE BEAMS—Applications; PLASMA DEVICES—Accelerators; TOKAMAK DEVICES; TOKAMAK DEVICES—Components; TOKAMAK DEVICES—Heat Transfer; TOKAMAK DEVICES—Performance; WAVEGUIDE COMPONENTS—Junctions; WAVEGUIDES—Mathematical Models; WAVEGUIDES, RECTANGULAR—Plasma Filled.

**079372 NUMERICAL MODELLING OF THE COLD ION-ION HYBRID RESONANCE.** A new way is discussed to handle numerically the ion-ion hybrid resonance appearing in the cold plasma model for plasma heating in the ion-cyclotron range of frequency (ICRF). It is shown that this singularity can be correctly treated without introducing artificial and unphysical damping



outside the resonance domain. This feature is particularly important for computations in two dimensions. This note supplements and corrects a recently published conference contribution. (Author abstract) 8 refs.

Sauter, O. (EURATOM, Lausanne, Switz); Appert, K.; Villard, L.; Vaclavik, J. *Comput Phys Commun* v 46 n 2 Aug 11 1987 p 205-208.

**079373 REQUIREMENTS FOR OHMIC IGNITION.** An analysis of ohmic ignition criteria is presented, giving the requirements on  $T$ ,  $n_r$ , and  $n/j$  in a form easily applicable to various confinement assumptions. For circular cross-section 'NeoAlcator' tokamaks with Spitzer resistivity, a value of  $B^2a$  approximately equal to  $250 \text{ T}^2 \text{ m}$  is required. The outstanding uncertainties in schemes to lower this value are how much increase in current density is achievable by plasma shaping and what the exact NeoAlcator coefficient is. (Author abstract) 9 refs.

Hutchinson, I.H. (MIT, Cambridge, MA, USA). *J Fusion Energy* v 6 n 3 Sep 1987 p 257-264.

**079374 INTERPRETATION OF ELECTRON CYCLOTRON HEATING RESULTS IN OVERDENSE PLASMA IN DOUBLET III.** The electron cyclotron heating (ECH) experiment on the Doublet III tokamak with inside oblique launch of the extraordinary mode has shown good heating even at very high densities, up to the operational density limit. According to ray tracing calculations for the high density discharges, the ECH waves are reflected at the periphery of the plasma around  $r/a$  approximately 0.9, and bulk plasma heating is not expected theoretically. But effective good heating has been observed in the increases of both the central electron temperature measured by Thompson scattering and the total energy measured magnetically. Furthermore, in the high density discharges, an extremely high density layer (marfe) exists in front of the antenna before the application of RF, and this layer persists for several milliseconds into the RF pulse. This paper describes a theoretical interpretation of this unexpected result of the good heating of an overdense plasma. The experimental results of the overdense plasma heating are reviewed, including information on the power deposition profiles, although the data are limited. Details of wave interaction with the high density plasma, starting with an intuitive expectation that deposition might take place in the plasma interior, are described. 18 refs.

Ejima, S. (GA Technologies Inc, San Diego, CA, USA); Prater, R. *Nucl Fusion* v 27 n 7 Jul 1987 p 1135-1146.

**079375 H-MODE PHENOMENA DURING ICRF HEATING ON JFT-2M.** Significant improvement of energy confinement has been observed on JFT-2M during ICRF heating. This improvement is preceded by a sudden drop in the  $H_{92}/D_{92}$  emission and a successive increase in stored plasma energy, electron density and radiation loss. This is believed to be the same phenomenon as the H-mode transition observed in ASDEX, and in PDX divertor experiments with neutral beam injection. However, in JFT-2M, this transition is observed both in limiter discharges and in open divertor configurations. (Author abstract) 11 refs.

Matsumoto, H. (JAERI, Naka-machi, Jpn); Ogawa, T.; Tamai, H.; Odajima, K.; Hasegawa, M.; Hoshino, K.; Kasai, S.; Kawakami, T.; Kawashima, H.; Matoba, T.; Matsuda, T.; Miura, Y.; Mori, M.; Ogawa, H.; Ohtsuka, H.; Sengoku, S. *Nucl Fusion* v 27 n 7 Jul 1987 p 1181-1187.

**079376 DIRECT RECOVERY OF ION BEAM ENERGY USING MAGNETIC ELECTRON SUPPRESSION - I. ANALYSIS OF ORNL ENERGY RECOVERY EXPERIMENTS.** The charge-exchange neutralization efficiency of positive ion-based neutral beams used in plasma heating applications decreases as the beam energy increases. Direct energy recovery from the remaining charged particles can be accomplished by electrostatically decelerating the positive ions; the space-charge neutralizing electrons are constrained from being accelerated by the application of a transverse magnetic field. A finite differ-

ence nonlinear sheath analysis is used to analyze the transverse magnetic field electron suppression experiments carried out at Oak Ridge National Laboratory in the early 1980s. A double plasma model, which assumes an equilibrium Boltzmann distribution of electrons at both the neutralizer potential and the ion collector potential, is used to study the experimental data obtained from operating 40 keV, 10 A ion beam energy recovery experiments. The effects of the magnetic field strength, ion 'boost' energy, and ion beam current density are examined in detail. (Author abstract) 43 refs.

Ryan, P.M. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Stirling, W.L.; Wheaton, J.H.; Alexeff, I. *Nucl Instrum Methods Phys Res Sect A* v A261 n 3 Nov 15 1987 p 556-572.

**079377 CHARACTERISTICS OF ION BERNSTEIN WAVE HEATING ON THE JIPP T-IIU TOKAMAK.** Ion Bernstein Wave (IBW) heating has been examined on the JIPP T-IIU tokamak under two different conditions referred to as Mode-I and Mode-II. In the Mode-I regime, a wave is launched on an IBW branch between the third and fourth cyclotron harmonics of deuterium ions. In the Mode-II regime, a wave is launched on a branch between the second and third cyclotron harmonics. These two modes show quite different heating characteristics. The causes of this difference are analysed by using a simple model to determine the  $k_{\perp}$  spectrum of the excited wave and by applying a ray tracing code. In connection with the Mode-I experiment as discussed in a previous report (1985), two important new experimental results are obtained. It is shown that an IBW heats the core of the plasma rather than causing plasma-edge interaction, as anticipated. It is also shown that the energy tail of the hydrogen ions is higher than that of the deuterium ions, which indicates that the responsible heating mechanisms are different. (Author abstract) 18 refs.

Ogawa, Y. (Nagoya Univ, Nagoya, Jpn); Kawahata, K.; Ando, R.; Kako, E.; Watari, T.; Hirokura, S.; Kawasumi, Y.; Morita, S.; Sakai, K.; Sato, K.; Tanahashi, S.; Taniguchi, Y.; Toi, K. *Nucl Fusion* v 27 n 9 Sep 1987 p 1379-1388.

**079378 OBSERVATION OF HOT ELECTRONS PRODUCED BY SECOND HARMONIC ELECTRON CYCLOTRON HEATING IN THE AXISYMMETRIC TANDEM MIRROR GAMMA 10.** Microwave power,  $P_{ECH} \leq 140 \text{ kW}$ , has been injected at 28 GHz into the axisymmetric plug/barrier cell in the axisymmetrized tandem mirror GAMMA 10. As observed by soft X-ray measurements, the microwaves generate a hot (50-60 KeV) electron population, radially peaked on the magnetic axis, which results in the formation of a thermal barrier. The production mechanism of these hot electrons is found to be second harmonic electron cyclotron heating (ECH), corrected for the effects of the relativistic mass variation and the Doppler shift. This mechanism also explains the first experimental observation of a saturation of the single-component hot electron temperature  $T_{eh}$  as being caused by the finite width of the incident microwave lobe. (Edited author abstract) 37 refs.

Cho, T. (Univ of Tsukuba, Sakura-mura, Jpn); Kondoh, T.; Hirata, M.; Sakasai, A.; Yamaguchi, N.; Mase, A.; Kiwamoto, Y.; Hirose, A.; Ogura, K.; Tanaka, S.; Miyoshi, S. *Nucl Fusion* v 27 n 9 Sep 1987 p 1421-1438.

**079379 ASYMPTOTIC APPROXIMATION FOR THE DISPERSION RELATION OF A HOT MAGNETIZED PLASMA.** An asymptotic expression for the dielectric tensor  $\epsilon$  of a hot magnetized plasma is obtained employing the steepest descents method, via the transformation of the components of  $\epsilon$  into their integral representation. The electrostatic Bernstein dispersion relation for oblique and perpendicular propagation is discussed under this treatment. It is shown that with this procedure the computation of the dispersion relation is up to 20 times faster when it is compared with the original expression, and the relative accuracy is usually as good as 0.1% for a typical case. (Author abstract) 22 refs.

Bravo-Ortega, A. (Auburn Univ, Auburn, AL, USA); Swanson, D.G.; Glasser, A.H. *J Plasma Phys* v 38 pt 2 Oct 1987 p 275-286.

**079380 MULTIPARABOLIC APPROXIMATION FOR RAY TRACING IN LINEAR PLASMA COLUMNS.** The equations for ray tracing in linear plasma columns with piecewise continuous quadratic electron density profiles are presented. Examples of calculations using these equations are given and compared with ray tracing in constant density shell plasmas. It is shown that significant savings in computing time can be achieved for long columns in which the rays undergo many radial oscillations. (Author abstract) 17 refs.

McMullin, J.N. (Univ of Alberta, Edmonton, Alberta, Can); Capjack, C.E.; Au, S. *Comput Phys Commun* v 47 n 2-3 Nov-Dec 1987 p 187-193.

**079381 EFFECTIVE ION TAIL FORMATION BY BEAM AND ION CYCLOTRON HEATING.** Ion tail formation by neutral beam ( $D^0$ ) injection and second harmonic ion ( $D^+$ ) cyclotron heating in a 50:50 D-T plasma is investigated on the basis of a local Fokker-Planck calculation. The deformation of the deuteron velocity distribution function is examined analytically and numerically. The effectiveness of the tail formation is estimated from the enhancement of the D-T fusion reactivity,  $\langle \sigma v \rangle = \int d\mathbf{v} \rightarrow f(\mathbf{v} \rightarrow) G(\mathbf{v})$  ( $f$  is the deuteron distribution and  $G$  is the ' $\sigma v$ -function', averaged over the isotropic triton distribution). The profile of the integrand typically exhibits two humps in velocity space. This results in a large reactivity enhancement for high energy beam injection. For a radiofrequency (RF) induced tail, a 'wing' or smeared tail rather than a hump is formed. ICRF waves couple well with the beam induced tail ions and enhance the reactivity, especially when the beam is injected perpendicularly to the magnetic field. The efficient use of the power supplied by beam and RF waves to enhance the reactivity is also discussed. (Author abstract) 16 refs.

Yamagiwa, M. (JAERI, Naka-gun, Jpn); Takizuka, T.; Kishimoto, Y. *Nucl Fusion* v 27 n 11 Nov 1987 p 1773-1784.

**079382 REQUIREMENTS ON HEATING OR CURRENT DRIVE FOR TEARING MODE STABILIZATION BY CURRENT PROFILE TAILORING.** A simple model is constructed which allows a systematic study of the effect of local heating or non-inductive current drive on tearing modes. The current profile changes due to the heating and current drive are calculated in steady state. An extensive study is made of the properties of the  $m=2$ ,  $n=1$  tearing mode within this model. It is shown that the effect of local heating on the  $m=2$ ,  $n=1$  mode stability is extremely sensitive to its localization. This sensitivity will, in practice, be prohibitive for mode stabilization by local heating. Non-inductive current drive is shown to be far more efficient in stabilizing than  $m=2$ ,  $n=1$  mode. The optimum effect of the non-inductively driven currents is obtained when it is positioned such that the current density gradient immediately inside the mode resonant surface is reduced. (Author abstract) 18 refs.

Westerhof, E. (FOM, Nieuwegein, Neth). *Nucl Fusion* v 27 n 11 Nov 1987 p 1929-1934.

**079383 CORRELATION OF PELLET PENETRATION DEPTHS ON ASDEX FOR OHMIC AND AUXILIARY HEATED DISCHARGES.** Penetration depths for frozen  $D_2$  pellets into ASDEX ohmically and auxiliary heated discharges are reported for a wide range of plasma and pellet parameters. It is found that the data are well correlated by a single parameter  $Z = d_p^{5/3} v_p / n_{e0}^{1/3} T_{e0}^{5/3}$  (pellet diameter, pellet velocity, central electron density and temperature), which emerges from the neutral shielding model. The pellet depths, however, are systemat-



ically smaller than is expected from the model, implying a higher ablation rate in the outer plasma layers. (Author abstract) 9 refs.

Buechl, K. (Max-Planck-Inst fuer Plasmaphysik, Garching, West Ger); Vlasses, G.C.; Sandmann, W.; Lang, R. *Nucl Fusion* v 27 n 11 Nov 1987 p 1939-1945.

**079384 ION CYCLOTRON HEATING IN TMX-U.** Ion cyclotron heating (ICH) is applied to TMX-U to improve the thermal barrier performance by reducing the passing ion collisionality. During its development, measurements of the antenna loading resistance,  $R_p$ , and the absorption efficiency,  $\eta$ , were compared with calculations with the antenna design code ANTENA over a wide range of densities and frequencies. Good agreement in  $R_p$  was obtained in the short wavelength slow wave regime but not for long wavelength fast waves because the experimental magnetic field gradients are not modelled in ANTENA. Similarly,  $\eta$  is much larger experimentally (40%) than in ANTENA (10%) due to the magnetic beach in TMX-U. In its application, ICH successfully decreased the passing ion collisionality tenfold but did not extend thermal barrier plugging to higher density, indicating that collisional barrier filling is not currently limiting TMX-U performance. (Author abstract) 23 refs.

Dimonte, G. (Lawrence Livermore Natl Lab, Livermore, CA, USA); Molvik, A.W.; Barter, J.; Cummins, W.F.; Falabella, S.; Poulsen, P.; Romesser, T. *Nucl Fusion* v 27 n 12 Dec 1987 p 1959-1974.

**079385 IONIZATION, HEATING AND STABILIZATION BY CURRENTS ALONG A POLOIDAL MAGNETIC FIELD.** The ionization and heating effects of induced low frequency poloidal currents in the internal ring device FIV A have been studied. The start-up process is more efficient and works at lower filling pressures than without poloidal currents. The plasma temperature is increased due to ohmic heating. Rotating plasmas with a density of  $1.5 \times 10^{21} \text{ m}^{-3}$  were obtained for a filling pressure of 6 mTorr. Fluctuations are stabilized already at low power poloidal currents. The stabilizing effect seems to be related to the applied toroidal magnetic field rather than the induced poloidal current. At the lowest filling pressures (0.2 mTorr) a nonrotating plasma, sustained only by the poloidal current, with a density of  $1.5 \times 10^{20} \text{ m}^{-3}$  and a temperature of 7 eV was produced. At this low density, the plasma is permeable to neutral gas, as opposed to the impermeable plasmas in the earlier experiments with this device. (Author abstract) 10 refs.

Brunsell, Per (Royal Inst of Technology, Stockholm, Sweden); Tennfors, Einar. *Nucl Instrum Methods Phys Res Sect A* v A265 n 3 Mar 15 1988 p 548-557.

**079386 TEST OF THE POWER-CARRYING CAPABILITY OF WATER-DIELECTRIC-LOADED ION CYCLOTRON HEATING WAVEGUIDE LAUNCHERS.** An external waveguide launcher is an alternative to an internal loop for launching high-power ion cyclotron radiation into the magnetically confined plasma of a fusion reactor. Water, filling the waveguide, can perform the dual function of dielectric medium and coolant, while remaining highly insensitive to the 14-MeV neutron flux from a fusion reactor. The results of tests on the power-handling capacity of a water-loaded-dielectric waveguide (WR1150) at frequencies of approximately 80 MHz are presented. A tunable radio-frequency cavity, which when filled with water resonates at 80 MHz, was used to achieve electromagnetic stress levels that approach that which ion cyclotron heating launchers would have to withstand in a fusion reactor. The tests show that the waterfilled WR1150 waveguide is capable of transmitting  $\geq 500 \text{ kW}$  at 80 MHz. (Edited author abstract) 8 refs.

Moses, K.G. (Jaycor, Torrance, CA, USA). *Fusion Technol* v 13 n 3 Mar 1988 p 495-502.

**079387 SEMIANALYTICAL ANALYSIS OF ION VELOCITY DISTRIBUTIONS IN THE PRESENCE OF COMBINED NEUTRAL-BEAM AND ICRF-HEATING.** The energy clamping scheme with combined neutral-beam and ICRF-heating is considered. Assuming

the neutral-beam particles to be injected almost isotropically, an approximate equation is derived for the pitch angle averaged distribution function. Comparison between results obtained from this equation and those of a full 2D numerical calculation, shows good agreement for physically significant quantities, like total absorbed power, power transfer to background plasma particles and fusion reactivities. This indicates that the equation for the averaged distribution function should be useful in situations where time consuming 2D numerical calculations of the distribution function are impractical, e.g., in plasma transport codes. (Author abstract) 16 refs.

Anderson, D. (Chalmers Univ of Technology, Goteborg, Sweden); Core, W.; Eriksson, L.-G.; Hamnen, H.; Hellsten, T.; Lisak, M. *Phys Scr* v 37 n 1 Jan 1988 p 83-88.

**079388 DIVERTOR EXPERIMENT ON PARTICLE AND ENERGY CONTROL IN NEUTRAL BEAM HEATED JT-60 DISCHARGES.** The divertor characteristics in particle and energy control in the neutral beam (NB) heated discharges on JT-60 have been studied with injection powers of up to 20 MW. The essential divertor functions are achieved successfully. The effectiveness of the divertor pumping system in particle control is demonstrated for NB pulses of, at least, 1 s. Reduction of evaporation by separatrix swing is also shown. (Edited author abstract) 29 refs.

Nakamura, H. (JAERI, Naka-gun, Jpn); Ando, T.; Yoshida, H.; Niikura, S.; Nishitani, T.; Nagashima, K. *Nucl Fusion* v 28 n 1 Jan 1988 p 43-52.

**079389 NEUTRAL PARTICLE EMISSION IN JET DURING RADIOFREQUENCY HEATING EXPERIMENTS.** The paper deals with the simulation of neutral particle spectra obtained in JET with an array of four passive neutral particle analysers during discharges with applied stationary or modulated radiofrequency power in the ion cyclotron range of frequencies for a deuterium plasma with hydrogen minority. The distribution function of the hydrogen ions has been computed using a one-dimensional Fokker-Planck equation describing wave-particle interaction by a quasi-linear diffusion term in velocity space. Both stationary and oscillating solutions of the Fokker-Planck equation have been worked out and the computed by hydrogen fluxes have been found to be in very good agreement with the measured ones. (Edited author abstract) 27 refs.

Giannella, R. (JET Joint Undertaking, Abingdon, Engl); Zanza, V.; Barbato, E.; Bracco, G.; Corti, S.; Gambier, D.J. *Nucl Fusion* v 28 n 2 Feb 1988 p 193-206.

**079390 PARAMETRIC INSTABILITIES ASSOCIATED WITH INTENSE ELECTRON CYCLOTRON HEATING IN THE MTX TOKAMAK.** The paper presents a survey of possible parametric instabilities in the upcoming Microwave Tokamak Experiment (MTX) at the Lawrence Livermore National Laboratory in which an intense pulsed free-electron laser will be used to carry out electron cyclotron heating in the Alcator C tokamak. Potentially the most dangerous instability is stimulated Brillouin backscatter by electrostatic ion cyclotron modes or quasi-modes for ordinary-mode heating at the fundamental harmonic or extraordinary-mode heating at the second electron cyclotron harmonic. Large reflectances may occur for coherent microwave sources. In addition, extraordinary waves at the amplitudes considered here can be non-linearly absorbed by parametric decay processes at the resonance layers where the pump frequency equals the second electron cyclotron harmonic and where it equals twice the local upper hybrid frequency. (Edited author abstract) 31 refs.

Porkolab, M. (MIT, Cambridge, MA, USA); Cohen, B. I. *Nucl Fusion* v 28 n 2 Feb 1988 p 239-254.

**079391 POWER DEPOSITION FOR ION CYCLOTRON HEATING IN LARGE TOKAMAKS.** The power deposition profiles during minority ion cyclotron heating are analysed in large tokamaks by using the global, toroidal wave code LION. A simplified model for calculating the power deposition is given for the case

where the power is absorbed along one cyclotron resonance. In Section 2 a formula for the power deposition is given for the case where the cyclotron resonance passes through the magnetic axis. In Section 3 a formula for off-axis heating is given for a particular shape of the plasma cross-section. 7 refs.

Hellsten, T. (JET Joint Undertaking, Abingdon, Engl); Villard, L. *Nucl Fusion* v 28 n 2 Feb 1988 p 285-295.

**079392 TRANSITION FROM THE L-MODE TO THE H-MODE BY ELECTRON CYCLOTRON HEATING OF A TOKAMAK EDGE PLASMA.** Transitions of L-mode plasmas to the H-mode have been induced by an electron cyclotron heating (ECH) pulse. The transitions occur when ECH is applied to plasmas preheated either by a neutral beam or by waves in the ion cyclotron range of frequency with power levels well below their own threshold power for the H-mode transition. The position of the electron cyclotron resonance layer has been scanned and it has been shown that edge heating rather than central heating is effective in inducing the transition to the H-mode. (Author abstract) 20 refs.

Hoshino, K. (JAERI, Tokai-mura, Jpn); Yamamoto, T.; Suzuki, N.; Kawashima, H.; Kasai, S.; Kawakami, T.; Maeda, H.; Matoba, T.; Matsuda, T.; Matsumoto, H.; Miura, Y.; Mori, M. *Nucl Fusion* v 28 n 2 Feb 1988 p 301-306.

**079393 ANALYSIS OF DIVERTOR PLASMA IN OHMICALLY AND NEUTRAL BEAM HEATED HYDROGEN DISCHARGES IN JT-60.** The characteristics of ohmically and high power neutral beam heated (PNBI approx. 20 MW) hydrogen divertor plasmas in JT-60 are analysed on the basis of a plasma fluid model. The calculated radiation loss of the divertor plasma and the density dependence of the neutral pressure in the divertor chamber  $P_{H_2}^{div} \propto n_e^{-2}$  are qualitatively in good agreement with the experimental results, the divertor radiation loss in ohmically heated discharges can be explained by hydrogen line radiation and impurity radiation. The higher neutral pressure in neutral beam heated discharges can be explained by the decrease of the global particle confinement time in comparison with that in ohmically heated discharges. (Author abstract) 26 refs.

Yoshida, H. (JAERI, Tokai-mura, Jpn); Niikura, S.; Shimizu, K.; Ando, T.; Nakamura, H.; Nishitani, T.; Nagashima, K. *Nucl Fusion* v 28 n 2 Feb 1988 p 318-323.

**079394 ANALYSIS OF A MICROWAVE-HEATED PLANAR PROPAGATING HYDROGEN PLASMA.** The heating of a gas to high temperature by absorption of microwave radiation has been proposed as a potential electrothermal rocket propulsion system. One possible mode of microwave energy absorption is by means of a planar plasma region propagating toward the source of the microwave radiation. Such a planar propagating plasma can be spatially stabilized by a gas stream flowing in the same direction as the microwave with a velocity equal to the plasma propagation velocity. A one-dimensional analysis of the microwave-heated planar propagating plasma for hydrogen gas was developed to predict maximum gas temperatures and propagation velocities. The governing electromagnetic and energy equations were numerically integrated with temperature-dependent thermodynamic properties of equilibrium hydrogen. The propagation velocity eigenvalue was solved by means of an iterative technique. (Edited author abstract) 19 refs.

Knecht, J.P. (Pennsylvania State Univ, University Park, PA, USA); Micci, M.M. *AIAA J* v 26 n 2 Feb 1988 p 188-194.

**079395 ANALYSIS OF THE TWO-DIMENSIONAL T-TYPE PLASMA WAVEGUIDE STRUCTURE.** The accurate solutions for the secular equation of the parallel plate anisotropic plasma waveguide and the reflection characteristics of the two dimensional plasma heating system are found. The electromagnetic fields are represented as a mode expansion in one waveguide and as



a Fourier inverse transform in the other. The eigenvalues of the plasma guide and the reflection characteristics of the exciting guide are numerically examined for several cases. (Edited author abstract) 4 refs.

Liu, Hong (Kyushu Univ, Fukuoka, Jpn); Aoki, Kazuo. *Mem Fac Eng Kyushu Univ* v 47 n 4 Dec 1987 p 317-323.

**079396 FORMATION OF STABLE, HIGH-BETA, RELATIVISTIC-ELECTRON PLASMAS USING ELECTRON CYCLOTRON HEATING.** A one-dimensional, steady-state, relativistic Fokker-Planck model of electron cyclotron heating (ECH) is used to analyze the heating kinetics underlying the formation of the two-component hot-electron plasmas characteristic of ECH in magnetic mirror configurations. The model is first applied to the well diagnosed plasmas obtained in SM-1 and is then used to simulate the effective generation of relativistic electrons by upper off-resonant heating (UORH), as demonstrated empirically in ELMO. The characteristics of unstable whistler modes and cyclotron maser modes are then determined for two-component hot-electron plasmas sustained by UORH. Cyclotron maser modes are shown to be strongly suppressed by the colder background electron species, while the growth rates of whistler modes are reduced by relativistic effects to levels that may render them unobservable, provided the hot-electron pressure anisotropy is below an energy dependent threshold. (Author abstract) 29 refs.

Guest, G.E. (Applied Microwave Plasma Concepts Inc, Carlsbad, CA, USA); Miller, R.L. *Nucl Fusion* v 28 n 3 Mar 1988 p 419-432.

**079397 NEUTRAL IRON GENERATION WITH SAWTOOTH OSCILLATION IN TEXTOR ICRF HEATED PLASMAS.** The emission of neutral iron atoms from a metal target in the shadow of the limiter was investigated during ICRF heating of the TEXTOR plasma, using laser induced fluorescence. By collecting the data over many similar sawtooth periods, the sawtooth oscillation of the neutral iron density was found for the first time. The sawtooth oscillation of the neutral iron density occurring during additional heating was in reverse phase to the neutral oxygen flux from the main limiter, but in phase with the central electron temperature. On the other hand, another case which was in contrast to the above case was found. The incident ion on the metal surface was studied. (Author abstract) 23 refs.

Yamauchi, Toshihiko (KFA Juelich, Juelich, West Ger); Schweer, Bernd; Bay, Helge L.; Hoeftker, Klaus; Hintz, Edward; Van Nieuwenhove, Rudi. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 658-662.

**079398 EXPERIMENTAL STUDY OF EFFECTIVE PARTICLE HEATING BY A THERMAL PLASMA FLOW CONFINED IN A POROUS CERAMIC TUBE.** The heating of a single alumina particle (1 mm diameter) was experimentally investigated using a thermal argon plasma flow confined in a tube. Two kinds of tube were used; a porous ceramic tube (PCT) with a transpiration gas and a water-cooled copper tube (WCT). The temperature and velocity of the particle heated in a thermal plasma flow were measured at the exit of the tube by the calorimetric and optical method, respectively. The plasma temperature and velocity at the exit of the tube were also measured. The heating rate of a particle was estimated from these experimental results. According to the results, the heating rate of a particle is higher for PCT with a small flow rate of transpiration gas than for WCT. Therefore, PCT is effective for the particle heating. (Author abstract) 10 refs.

Park, Dong-Wha (Tokyo Inst of Technology, Tokyo, Jpn); Honda, Takuya; Kanzawa, Atsushi. *Plasma Chem Plasma Process* v 8 n 2 Jun 1988 p 159-173.

**079399 KRUPP 3-PHASE A.C. PLASMA TECHNOLOGY FOR MELTING SCRAP AND HEATING MOLTEN STEEL.** Aiming towards a high-power 3-phase a.c. plasma heating system, Krupp developed suitable plasma torches, power supply and furnace mechanisms and initially tested them in a 1.5-MW pilot

furnace. In 1986 a 20-MVA 3-phase a.c. plasma furnace was installed in the Siegen works of Krupp Stahl AG. At present it is operating as a 10-t melting furnace and in due course will also be used as a 45-t ladle furnace. This article describes the characteristic features of the plasma heating system and discusses the results of initial metallurgical investigations into recovery and oxidation of alloying elements. 7 refs.

Rossner, H.-O. (Krupp Forschungsinstitut, Essen, West Ger); Beber, H.J.; Heinen, K.H.; Neuschütz, D. *Tech Mitt Krupp (Engl Ed)* n 2 Sep 1987 p 89-94.

**079400 EFFECT OF ION LOSS ON ICRF HEATING.** The effect of spatial loss on ICRF ion cyclotron range of frequency wave heating is studied. A simple model for the energy-dependent loss term is adopted in the Fokker-Planck equation. The case of the minority ion heating by fundamental cyclotron resonance is analysed. It is found that the high energy particle loss imposes a limit on the heating power density, above which an increase in the heating power does not raise the energy transfer to the bulk particles, i.e. the heating efficiency deteriorates. This power limit is serious for losses with strong energy dependence such as ripple diffusion. Small spatial loss can annihilate the increment of the fusion reaction by tail generation. (Author abstract) 27 refs.

Itoh, K. (Kyoto Univ, Kyoto, Jpn); Itho, S.-I.; Fukuyama, A. *Nucl Fusion* v 28 n 5 May 1988 p 779-787.

**079401 D III-D DIVERTOR TARGET HEAT FLUX MEASUREMENTS DURING OHMIC AND NEUTRAL BEAM HEATING.** Time resolved power deposition profiles on the D III-D divertor target plates have been measured for Ohmic and neutral beam injection heated plasma using fast response infrared thermography ( $\pi \leq 150 \mu\text{s}$ ). Giant Edge Localized Modes have been observed which punctuate quiescent periods of good H-mode confinement and deposit more than 5% of the stored energy of the core plasma on the divertor armour tiles on millisecond timescales. The heat pulse associated with these events arrives approximately 0.5 ms earlier on the outer leg of the divertor relative to the inner leg. The measured power deposition profiles are displaced relative to the separatrix intercepts on the target plates and the peak fluxes are a function of core plasma density. (Author abstract) 11 refs.

Hill, D.N. (Lawrence Livermore Natl Lab, Livermore, CA, USA); Petrie, T.; Mahdavi, M. Ali; Lao, L. *Nucl Fusion* v 28 n 5 May 1988 p 902-907.

**079402 SAWTEETH, TRANSPORT AND ELECTRON CYCLOTRON HEATING IN T-10.** The paper presents transport code simulations of sawteeth discharges in T-10. Two models were employed to describe the sawtooth oscillations. In the first (reconnection) model the sawtooth collapse is caused by complete reconnection. In the second (turbulent) model the collapse is ascribed to increased radial transport caused by the generation of turbulence at some critical size of the  $m = 1$ ,  $n = 1$  magnetic island. For one particular discharge the predictions of the two models for the temperature, density and current profiles as well as the evolution of the heat pulse generated by the sawtooth collapse were analysed in detail and compared with the experiment. Also the influence of both central and off-axis heating by electron cyclotron waves on the sawtooth dynamics as given by the two models was investigated and compared with the experiment. In all respects good agreement with the experiment was obtained with the turbulent model. In contrast, it was not possible to obtain satisfactory simulations with the reconnection model. (Edited author abstract) 24 refs.

Goedheer, W.J. (Association Euratom-FOM, Nieuwegein, Neth); Westerhof, E. *Nucl Fusion* v 28 n 4 Apr 1988 p 565-576.

**079403 ICRF HEATING EXPERIMENT USING A PHASED ANTENNA ARRAY.** The paper discusses the results of a heating experiment in the ion cyclotron range of frequencies (ICRF) conducted on the JIPP T-IIU device with a five-element antenna array. This antenna

system provides precisely shaped  $k_{\parallel}$  spectra which vary according to the relative phasing angle of the neighbouring antennas,  $\Delta\pi$ . In the experiment,  $\Delta$  is scanned in a close pitch and it is found that the electron heating efficiency is drastically improved with  $\Delta = \pi$  and the lowest efficiency is obtained with  $\Delta = 0$ . This observation is analysed by calculating the  $k_{\parallel}$  spectra and then the power deposition profiles using a ray tracing code. It is also found that the effect of the phasing on the impurity problem is unexpectedly small. The reasons for the discrepancies between these data and theoretical expectations are also discussed. (Author abstract) 15 refs.

Ando, R. (Nagoya Univ, Nagoya, Jpn); Sato, K.K.; Watari, T.; Ogawa, Y.; Kawahata, K.; Akiyama, R.; Hamada, Y.; Hirokura, S.; Ida, K.; Kako, E.; Kawasumi, Y.; Kitagawa, S.; Masai, K.; Matsuoka, K.; Mohri, A.; Morita, S. *Nucl Fusion* v 28 n 4 Apr 1988 p 577-584.

**079404 NUMERICAL MODELLING OF LOWER HYBRID RF HEATING AND CURRENT DRIVE EXPERIMENTS IN THE ALCATOR C TOKAMAK.** A simulation model is described for lower hybrid (LH) current drive, rampup, heating, and sawtooth stabilization. The model incorporates a one-dimensional radial transport code, parallel velocity Fokker-Planck calculation, and a toroidal ray tracing code. For steady LH current drive it is found that the RF current generation is accurately predicted by a fast electron confinement time of the form  $\tau_1 = \tau_0 (\pm) \gamma^3$ , with  $\tau_0 (\pm) = 3$  ms in the density range  $3 \times 10^{19} \text{ m}^{-3} \leq n_e \leq 7 \times 10^{19} \text{ m}^{-3}$  (where  $\pm$  distinguishes electrons moving parallel (antiparallel) to the current drive direction). Also in this range, the theoretically predicted wave absorption and experimentally measured electron temperatures and stored energy were found to be consistent with an electron thermal diffusivity whose magnitude is independent of  $n_e$ . (Edited author abstract) 41 refs.

Bonoli, P.T. (MIT, Cambridge, MA, USA); Porkolab, M.; Takase, Y.; Knowlton, S.F. *Nucl Fusion* v 28 n 6 Jun 1988 p 991-1012.

**079405 ANOMALOUS TRANSPORT AND ANOMALOUS HEATING DUE TO LOWER-HYBRID WAVE FIELDS.** The microscopic and macroscopic behaviours of a linear reflex discharge in the presence of low-frequency turbulence are investigated under the action of moderate lower-hybrid wave power. The frequency and wavenumber spectra of both the low-frequency fluctuations and the high-frequency waves are measured using a correlation-analysis technique with two probes. The wavenumbers observed in the lower-hybrid resonance region outside the antenna are - in contrast with expectation - not larger than in the plasma edge region. From the electric-field energy-density spectra and from measurements of the density and the temperatures, a detailed energy balance can be performed. The calculated heating rates are anomalously large for both the electrons and the ions. The absorption processes, relevant for the present experiment, are discussed. (Edited author abstract) 37 refs.

Karamer, M. (Ruhr-Univ Bochum, Bochum, West Ger); Sollich, N.; Dietrich, J. *J Plasma Phys* v 39 n 3 Jun 1988 p 447-474.

**079406 HEAT PULSE PROPAGATION: DIFFUSIVE MODELS CHECKED AGAINST FULL TRANSPORT CALCULATIONS.** The problem of deducing  $\chi_e$  from heat pulse propagation measurements is addressed. An extended diffusive model is described, which takes into account perturbed sources and sinks.  $\chi_e$  is expressed as a function of two observables, the heat pulse velocity  $v_{HP}$  and the radial damping rate  $\alpha$ . A simple expression is derived in the typical heat pulse measuring region, i.e. 0.1 to 0.2 a outside of the sawtooth mixing radius:  $\chi_e = 4.3 \cdot v_{HP} / \alpha$ . Here,  $v_{HP}$  and  $\alpha$  are defined for cylindrical geometry, hence corrected for Shafranov shift and possible elongation of the plasma. This expression is checked against full transport simulations and found to be accurate. It is also shown that the



thus inferred  $\chi_e$  is a local value, not affected by the  $\chi_e$  profile outside the measuring region. (Author abstract) 12 Refs.

Lopes Cardozo, N.J. (JET Joint Undertaking, Abingdon, Engl); Tubbing, B.J.D.; Tibone, F.; Taroni, A. *Nucl Fusion* v 28 n 7 Jul 1988 p 1173-1181.

**079407 TMX-U THERMAL-BARRIER EXPERIMENTS.** Thermal-barrier experiments in the Tandem Mirror Experiment Upgrade (TMX-U) are reported, along with progress made at the Lawrence Livermore National Laboratory in plasma confinement and central-cell heating. Thermal barriers in TMX-U improved axial confinement by two orders of magnitude over a limited range of densities, compared with confinement in single-cell mirrors at the same ion temperature. It is shown that central-cell radial nonambipolar confinement scales as neoclassical theory and can be eliminated by floating the end walls. Radial ambipolar losses can also be measured and reduced. The electron energy balance is improved in tandem mirrors to near classical, resulting in  $T_e$  up to 0.28 keV. Electron cyclotron heating (ECH) efficiencies up to 42%, with low levels of electron microinstability, were achieved when hot electrons in the thermal barrier were heated to average betas as large as 15%. The hot-electron distribution was measured from X-rays and is modeled by a Fokker-Planck code that includes heating from cavity radio-frequency (RF) fields. Neutral-beam injection in the central cell created average ion betas up to 5% with radial profiles of hot ions that are modeled accurately by a radial Fokker-Planck code. Gas fueling between two fundamental ion cyclotron heating (ICH) resonances resulted in symmetrical heating of passing ions toward both ends. 30 refs.

Simonen, T.C. (Lawrence Livermore Natl Lab, Livermore, CA, USA); Allen, S.L.; Barter, J.D.; Casper, T.A.; Correll, D.L.; Carter, M.R.; Clauser, J.F.; Dimonte, G.; Foote, J.H.; Futch, A.H.; Goodman, R.K.; Grubb, D.P.; Hill, D.N.; Hooper, E.B.; Hornady, R.S.; James, R.A. *IEEE Trans Plasma Sci* v 16 n 1 Feb 1988 p 1-10.

**079408 ONE-DIMENSIONAL MODELING OF TRANSPORT IN SMALL STELLARATORS.** An existing stellarator reactor transport code was modified to model small stellarator experiments. Changes were made in the treatment of neutrals, the atomic physics process, and the transport models. The authors investigated the extent to which the hollow density profiles experimentally detected during electron cyclotron resonance heating (ECRH) experiments in the interchangeable module stellarator (IMS), a small modular stellarator, can be modeled. In this they were guided by the experimental observation of large variations in potential around the magnetic surfaces, which can give rise to radially directed  $E \times B$  convective flow. A diffusion model based on small-scale convective cell structures cannot simulate the experimental profiles. Including a purely convective term in the particle balance equation allows for a much more accurate modeling of the profiles. A comparison between numerical and experimental results is presented. 28 refs.

Mertens, K.J.S. (Univ of Wisconsin, Madison, WI, USA); Hitchon, W.N.G.; Anderson, D.T.; Shohet, J.L. *IEEE Trans Plasma Sci* v 16 n 2 Apr 1988 p 296-304.

## Imaging Techniques

**079409 X-RAY TOMOGRAPHY ON JET.** Measurements of soft X-ray emission from the JET plasma have been analyzed with tomographic reconstruction methods. Because there are two detector arrays, two-dimensional images of X-ray emissivity are obtained without having to resort to rotation models. Several algorithms are employed in order to get as much detail as possible in the images while keeping any guiding assumptions to a minimum. The data analyzed so far have been used principally to study MHD instabilities, and illustrative examples of the sawtooth crash and of disruptions are described. (Author abstract) 28 refs.

Granetz, R.S. (JET Joint Undertaking, Abingdon, Engl);

Smeulders, P. *Nucl Fusion* v 28 n 3 Mar 1988 p 457-476.

**079410 IMAGING OF LASER-PRODUCED PLASMAS AT 44 Å USING A MULTILAYER MIRROR.** Images of imploding laser-fusion targets have been obtained using a spherical multilayer mirror. The mirror was coated to reflect Si XII 44.1 Ångström radiation and produced images of the coronal plasma regions of the glass microballoon and stalk. Clearly visible in the images are emission features as small as 40  $\mu$ m. (Author abstract) 21 refs.

Brown, C.M. (US Naval Research Lab, Washington, DC, USA); Feldman, U.; Seely, J.F.; Richardson, M.C.; Chen, H.; Underwood, J.H.; Zigler, A. *Opt Commun* v 68 n 3 Oct 1 1988 p 190-195.

**079411 APPROACH WITH THE AKAIKE INFORMATION CRITERION TO THE RADIATION DISTRIBUTION RECONSTRUCTION OF TOROIDAL PLASMA.** The Akaike information criterion (AIC) is used to optimize a spline function model for reconstructing the image of a toroidal plasma. The criterion is used to find the optimum number of B splines and to evaluate the effect of adjusting their positions. The behavior of the estimator is examined by numerical simulation and by analyzing an X-ray pinhole image of tokamak plasma. The results suggest the utility of the AIC in least-squares model-fitting approaches. 14 refs.

Iwama, N. (Nagoya Univ, Nagoya, Jpn); Takami, H.; Takamura, S.; Tsukishima, T. *IEEE Trans Plasma Sci* v PS-15 n 5 Oct 1987, XIIth Int Symp on Discharges and Electr Insul in Vac, Shores, Isr, Sep 22-25 1986 p 609-617.

**Impurities** See Also NUCLEAR ENERGY—Fusion Reactions; TOKAMAK DEVICES.

**079412 RUNAWAY ELECTRONS DURING TOKAMAK STARTUP.** Runaway electrons significantly affect the plasma and impurity evolution during tokamak startup. During its rise, a runaway pulse stores magnetic flux inductively; this is then released during the decay phase of the runaway pulse. This process affects formation plasma, current initiation and current buildup. Because of their relativistic velocities the runaway electrons have higher ionization and excitation rates than the plasma electrons. This leads to a significant modification of the impurity behavior and consequently the plasma evolution. (Edited author abstract) 20 refs.

Sharma, A.S. (Inst for Plasma Research, Gandhinagar, India); Jayakumar, R. *Nucl Fusion* v 28 n 3 Mar 1988 p 491-498.

## Ion Sources

**079413 SURFACE-PLASMA SOURCE OF NEGATIVE HYDROGEN IONS.** The characteristics of a surface-plasma source with a gas-discharge cell with half-planotron geometry are studied. The beam of  $H^-$  ions has an intensity of up to 0.2 A, the normalized brightness is up to  $10^8$  A/cm<sup>2</sup>·rad<sup>2</sup>, the pulse duration is 200  $\mu$ sec, and the repetition frequency is up to 50 Hz. The source is a highly efficient generator of  $H^-$  ions and has a simple design. (Author abstract) 12 refs.

Derevyankin, G.E. (USSR Acad of Sciences, Novosibirsk, USSR); Dudnikov, V.G. *Instrum Exp Tech* v 30 n 3 pt 1 May-Jun 1987 p 523-528.

**Ionization** See Also AERODYNAMICS—Hypersonic; ELECTRIC DISCHARGES—Calculations.

**079414 CALCULATION OF VALUES OF INTERACTION TERMS OF ELECTRON WITH ELECTRONS AND HEAVY PARTICLES FOR PARTIALLY IONIZED PLASMA.** To calculate the electron transport coefficients of partially ionized plasma the values of interaction terms of electron with electrons and heavy particles are necessary. In this paper these values  $H_{r,s}$  for r and s from the set (1, 2, ..., 16) are evaluated. (Author abstract) 2 refs.

Sado, Jerzy. *Bull Pol Acad Sci Tech Sci* v 35 n 9-10 1987 p 577-589.

**079415 IONIZATION EFFICIENCY IN A NEON, MEDIUM PRESSURE STATIONARY PLASMA.** The paper presents the quantitative results obtained for the ionization efficiency in the case of a neon, medium pressure stationary plasma within a pressure range of 2 Torr to 32 Torr and for discharge current levels from 80 mA to 400 mA. The ionization efficiency for this type of plasma is quite high, from about fifty percent to about seventy five percent. It is concluded that a neon, medium pressure stationary plasma is not worth being used as an optical radiation source. (Author abstract) 2 refs.

Toader, Emil I. (Univ of Bucharest, Rom). *Rev Roum Phys* v 32 n 7 1987 p 765-768.

**079416 THERMODYNAMIC DERIVATION OF SAHA'S EQUATION FOR A MULTI-TEMPERATURE PLASMA.** The ionization equilibrium between the constituents of a multi-temperature plasma is investigated within the thermodynamics of fluid mixtures. As a result, a law of mass action is derived that, in the approximation of ideal gases for the constituents, leads to a direct generalization of Saha's equation. The main properties of this generalization are discussed, and contrasted with those of other equations which have appeared in the literature. (Author abstract) 15 refs.

Morro, Angelo (Univ of Genoa, Genoa, Italy); Romeo, Maurizio. *J Plasma Phys* v 39 n 1 Feb 1988 p 41-51.

## Laser Applications

**079417 THERMOELECTRIC DETECTOR FOR MEASUREMENT OF ION AND X-RAY ENERGIES OF LASER PLASMA.** The errors of measurement of the ion and x-ray energies of laser plasma with calorimetric sensors are analyzed. A thermoelectric detector is described whose absorber is a glass disk with a multilayer dielectric coating that reflects the laser radiation. The results of measurement of the sensitivity and error of the detector are given. (Author abstract) 7 refs.

Komarov, V.M. (Leningrad Electrical Engineering Inst, USSR); Mezenov, A.V.; Migel', V.M.; Ponomareva, N.V. *Instrum Exp Tech* v 30 n 2 pt 2 Mar-Apr 1987 p 487-489.

**Laser-Produced** See Also GASES—Ionization; GRANITE—Radiation Effects; INTERFEROMETERS; LASERS—Optical Pumping; LASERS, EXCIMER; LASERS, GAS DYNAMIC—Efficiency; LIGHT—Brillouin Scattering; METAL CUTTING—Laser Beam; METALLIZING—Plasma Spraying; PARTICLE DETECTORS—Performance; X-RAYS—Instruments.

**079418 FAST-ION SPECTRUM EMITTED FROM LASER PLASMAS.** Broad- and narrow-band Nd glass lasers have been used to irradiate CD<sub>2</sub>, Al and Ta plasma targets at 0.3 - 2 × 10<sup>14</sup> W/cm<sup>2</sup>. Temporally-resolved fast-ion signals have been diagnosed by the Faraday charge collector oriented at 39° to the laser axis. There are two peaks demonstrating the motion of C and D ions in fast-ion spectra for the CD<sub>2</sub> target. For the Al target only one peak was observed, and for the Ta target the signal was very weak. High-translation energy of electrons and ions was obtained with the aid of laser field accelerations. Then the translation energy was converted into thermal energy by electron-electron or electron-ion collisions, and finally electrons and ions were heated to a high temperature. The translational energy and the temperature were calculated are consistent with those of the experiment. The dependence of the electron and ion temperature on the laser frequency bandwidth is quantitatively described. (Edited author abstract) 8 refs.

Tan, Weihai (Shanghai Inst of Optics & Fine Mechanics, China); Lin, Zunqi; Zhang, Yanzhen; Lu, Weiping; Yu, Wenyan; Deng, Ximing. *Sci Sin Ser A* v 30 n 10 Oct 1987 p 1113-1130.



**079419 POLARIZATION DEPENDENT ENERGY TRANSFER IN LASER PRODUCED PLASMA EXPERIMENTS.** Polarization dependent light absorption in laser produced plasmas of small focal diameter (28  $\mu\text{m}$  full  $1/e^2$  width) has been investigated simultaneously in five different channels of observation: specular reflection of the laser light, second harmonic ( $2\omega$ ) generation, charge and velocity distribution of the emitted ions and ablation pressure to the target. The experiments have been performed using a Nd-YAG mode locking pulse ( $\lambda=1.06 \mu\text{m}$ ,  $\lambda=45 \text{ ps}$ ) which has been focused onto plane, thick plexiglass ( $\text{C}_6\text{H}_8\text{O}_2$ )<sub>n</sub> disks to intensities up to  $10^{14} \text{ W/cm}^2$ . As a result of the small focal spot size, a very small density scale length of  $0.6 \mu\text{m}$  is derived from the resonance curves, consistently, for all channels of diagnostics. (Author abstract) Refs.

Dinger, R. (Univ Kaiserslautern, Kaiserslautern, West Ger); Rohr, K.; Weber, H. *Laser Part Beams* v 5 pt 4 Nov 1987 p 691-698.

**079420 PHYSICAL PROPERTIES AND REGULARITIES OF DEVELOPMENT OF CONTINUOUS EXTENDED LASER-INDUCED SPARKS.** The relationship between the length of continuous extended laser-induced spark and the parameters of laser pulse and focusing axicon is determined in this paper. The paper further describes the results of experimental study of spark channel, dynamics of the channel formation and its electrophysical properties. (Author abstract) 37 refs.

Korobkin, V.V.; Marin, M.Yu.; Pil'skii, V.I.; Polonskii, L.Ya.; Pyatnitskii, L.N.; Reingold, A.V. *IVTAN Rev* v 1 n 2-4 1987 p 223-255.

**079421 ELECTRON THERMAL TRANSPORT IN LASER-TARGET PLASMAS ON THE BASIS OF GRAD'S 13-MOMENT TRANSPORT EQUATIONS.** Grad's 13-moment theory is used to model thermal transport in laser-produced plasmas where conditions are such that one may not assume that the plasma is collision-dominated. The equations are presented for a multi-fluid model in slab geometry and are solved numerically for various cases. Comparisons are made with classical theory and with simulations of collisionless plasmas. Results show that, although there are differences between 13-moment and classical predictions, the two theories agree on the general behaviour of the plasma. In particular, 13-moment theory fails to explain the heat-flux inhibition implied by some experimental observations. The theory has also been applied to model thermal transport in plasmas with a population of suprathermal electrons. (Author abstract) 18 refs.

Boyd, T.J.M. (Univ of Wales, Bangor, Wales); Lonsdale, R.D.; Sanderson, J.J. *J Plasma Phys* v 39 n 1 Feb 1988 p 115-138.

**079422 EVIDENCE, FROM SPACE RESOLVED SPECTRA, OF  $2\omega_0$  HARMONIC GENERATION IN LASER IRRADIATED PLASMA FILAMENTS.** Space resolved spectra with both high spectral resolution ( $\approx 0.2 \text{ \AA}$ ) and spatial resolution ( $\approx 2 \mu\text{m}$ ) of the second harmonic emission scattered at  $90^\circ$  to the laser axis were observed when both narrow band and broad band laser beams were used in an Al planar target experiment. Analyzing many experimental phenomena, we have proved that the second harmonic emission observed at  $90^\circ$  to the laser axis is initiated by laser-plasma-filament interaction and not by planar-wave-plasma interaction. The experiments are, on the whole, in agreement with our theory. (Author abstract) 20 refs.

Gu, Min (Acad Sinica, Shanghai, China); Tan, Weihai; Lin, Zunqi; Chen, Wenhua; Zheng, Yuxia; Yu, Wenyan; Deng, Ximing. *Opt Commun* v 66 n 1 Apr 1 1988 p 35-40.

**079423 MODELS OF LASER-PLASMA ABLATION. PART 3. STEADY-STATE THEORY: DEFLAGRATION FLOW.** The theory of plasma ablation by laser irradiation from cylindrical and spherical solid targets is considered when thermal conduction is dominant and absorption is local at the critical density. Analytic solutions for both inhibited and uninhibited heat

fluxes are developed, but only investigated in detail when flux limiting does not introduce a step discontinuity. In most cases it is found that only a restricted region of flow is steady, and must be terminated by a rarefaction wave. The transition from quasi-planar to strongly divergent flow is shown to depend on a characteristic parameter, which represents the ratio of the thermal conduction length to the target radius. (Author abstract) 22 refs.

Pert, G.J. (Univ of Hull, Hull, Engl). *J Plasma Phys* v 39 pt 2 Apr 1988 p 241-276.

**079424 GENERATION OF  $\text{H}^-$  IONS IN A DIODE WITH MAGNETIC INSULATION WITH LASER PULSE INITIATION OF DIELECTRIC ARCING.** This work proposes a new system for generating pulsed kiloampere currents of negative ions in a diode with magnetic insulation with laser radiation initiation of surface arcing of a dielectric. The acquired results showed the effectiveness of the proposed method and its suitability for creating ion cannons. (Author abstract) 6 refs.

Papadichev, V.A.; Pikus, S.A.; Shelkovenko, T.A. *Sov Phys Lebedev Inst Rep* n 11 1987 p 76-79.

**079425 ENHANCEMENT OF ULTRAVIOLET LASER PLASMA EMISSION PRODUCED IN A STRONG STATIC ELECTRIC FIELD.** Enhancement of the ultraviolet (UV) radiation (200-350 nm) emitted from a laser produced plasma created on a gold target surface in the pressure of high negative static field by an order of magnitude was observed. The enhancement ratios for various spectral lines of gold atoms and gold ions, under a variety of voltage and laser pulse energy combinations were examined. A KrF excimer laser emitting at 248 nm was employed for generating the plasma. Electric field induced recombination processes are posited as a mechanism for the UV radiation enhancement. 20 refs.

Hontzopoulos, E. (Research Cent of Crete, Crete, Greece); Charalambidis, D.; Fotakis, C.; Farkas, Gy.; Horvath, Z.Gy.; Toth, Cs. *Opt Commun* v 67 n 2 Jun 15 1988 p 124-128.

**079426 A NEW TECHNIQUE FOR ESTIMATING THE DENSITY SCALE-LENGTH OF LASER PRODUCED PLASMAS.** The variation of frequency shift or stimulated Raman sidescattered radiation has been calculated theoretically as a function of the laser intensity, the density scale-length and the plasma electron temperature for a  $1.06 \mu\text{m}$  laser-produced plasma. Although this variation depends on all three parameters, the dependence is very strong on the density scale-length in the domain of  $1$  to  $100 \mu\text{m}$ . On the basis of this strong dependence, a new technique for estimating the density scale-length is proposed. (Author abstract). 18 Refs.

Sinha, B.K. (BATRC, Bombay, India); Kutty, A.P.G. *Nucl Fusion* v 28 n 5 May 1988 p 922-926.

**079427 INFLUENCE OF THE BACKGROUND GAS PRESSURE ON THE ION MEASUREMENTS IN EXPANDING LASER-PRODUCED PLASMA.** Measurement of properties of ion emission from plasma generated by high power laser pulses is an important source of information about parameters of such plasma. The measurement of the number of emitted ions, their energy and ionization charge numbers to conclude about the plasma electron temperature, ionization-recombination processes and also anomalous processes occurring in laser plasma. An investigation was made of the influence of background gas pressure on ion emission properties in the case of comparable masses of the target and background gas atoms and the preliminary analysis of interaction processes. The obtained results show that the accuracy of the estimated plasma parameters is strongly affected by the background gas pressure higher than  $10^{-5} \text{ Torr}$ . 14 Refs.

Farny, J.; Nagraba, S.; Woryna, E. *J Tech Phys* v 28 n 2 1987 p 185-198.

**079428 RELATIVE STRENGTH OF SECOND HARMONIC AND  $3/2$  OMEGA EMISSIONS FROM LONG-SCALE-LENGTH LASER PRODUCED**

**PLASMAS.** Experiments were conducted on the planar slab targets of carbon, aluminum, and copper using a  $1.0641\text{-}\mu\text{m}$  laser at laser intensities varying from  $2 \times 10^{12}$  to  $1 \times 10^{14} \text{ W/cm}^2$ . The laser had a fluorescent linewidth of  $4.5 \text{ \AA}$ . Spectral profiles of parametrically modulated second-harmonic as well as  $3/2\omega_0$  emissions have been measured for the long-scale-length plasmas so generated. Relative strengths of these emissions with respect to peak signal intensity and spectral energy content as a function of laser intensity are graphically reported. Results are discussed on the basis of two plasmon and parametric decay instabilities. 33 refs.

Sinha, Binoy Kumar (Bhabha Atomic Research Cent, Bombay, India); Kumbhare, Sudhakar Ramaji. *IEEE J Quantum Electron* v 24 n 6 Jun 1988 p 864-871.

**Low Temperature Effects** See SURFACES—Ionization.

**Magnetic Field Effects** See Also MAGNETIC FIELDS; PLASMA DEVICES—Jets; THERMIONIC POWER GENERATION—Mathematical Models; TOKAMAK DEVICES—Control; TOKAMAK DEVICES—Magnetic Field Effects.

**079429 MAGNETICALLY ENHANCED PLASMA DEPOSITION AND ETCHING.** Magnetically enhanced deposition and etching are useful techniques for the fabrication of thin films. Some of the characteristics of these methods are presented which illustrate the advantages and disadvantages of magnetic enhancement. The discussion is limited to plasma deposition and etching in magnetic fields. This survey provides 41 literature references as an aid in reviewing the field. (Edited author abstract) 41 refs.

Leahy, Michael F. (RCA, Princeton, NJ, USA); Kaganowicz, Grzegorz. *Solid State Technol* v 30 n 4 Apr 1987 p 99-104.

**079430 STUDIES OF LARGE, NON-CIRCULAR, REVERSED FIELD PINCH DISCHARGES.** Reversed field pinch (RFP) discharges have been produced in a large aluminum vacuum vessel with indented sides. The discharges are self-reversed and ramped up to a current of  $300 \text{ kA}$  over a time of  $10 \text{ ms}$ . Reversal is sustained for  $> 10$  resistive diffusion times, despite the presence of large magnetic fluctuations. The influence of the bad poloidal magnetic curvature on RFP stability is examined by measurement of magnetic fluctuations near the plasma edge in the separate bad and good curvature regions of the non-circular plasma for RFP and non-reversed discharges with an edge safety factor,  $q_a$ , of  $0.4$  and  $1.4$ . For  $q_a$  approximately  $1.4$  discharges, the poloidal field curvature is small. The large device size permits RFP startup at a low toroidal loop voltage ( $< 200 \text{ V}$ ), which is applied to a gap exposed to plasma, but successfully protected against arcing (up to  $300 \text{ V}$ ). RFP plasmas have also been obtained with a toroidal limiter. (Edited author abstract) 14 refs.

Almagri, A. (Univ of Wisconsin, Madison, WI, USA); Assadi, S.; Dexter, R.N.; Prager, S.C.; Sarff, J.S.; Sprott, J.C. *Nucl Fusion* v 27 n 11 Nov 1987 p 1795-1803.

**079431 CURRENT LIMITATION AND FORMATION OF PLASMA DOUBLE LAYERS IN A NON-UNIFORM MAGNETIC FIELD.** Formation of strong double layers has been observed experimentally in a magnetized plasma column maintained by a plasma source. The magnetic field is approximately axially homogeneous except in a region at the anode where the electric current flows into a converging magnetic field. For field strengths larger than about  $200 \text{ G}$  the double layer has a stationary position only in the region of non-uniform magnetic field or at the aperture separating the source and the plasma column. It is characterized by a negative differential resistance in the current-voltage characteristic of the device. Electron reflection by the resulting potential barrier is found to explain the essential features of the current-voltage characteristics observed, but further in-



vestigations of waves and fluctuations are required to clarify the current transport. (Edited author abstract) 20 refs.

Plamondon, R. (Univ de Montreal, Montreal, Que, Can); Teichmann, J.; Torven, S. *J Phys D* v 21 n 2 Feb 14 1988 p 286-292.

**079432 SLOW FORMATION OF FIELD REVERSED CONFIGURATIONS BY COLLIDING HIGH BETA COUNTER FLOWS.** To produce a field reversed configuration (FRC) without using the very high voltage techniques required in a conventional theta pinch, the author has studied the steady head-on collision of counter plasma streams, flowing along the magnetic field, as ejected from two identical co-axial plasma sources mounted at each end of the apparatus. The study was motivated by the fact that such a flow can be regarded as a steady state theta pinch. Ideal Poisson and shock adiabatic flow models were used to analyse the steady colliding process. It was demonstrated that an FRC involving a large number of particles can only be produced by the weak shock mode, which is achieved when energetic plasma flow is decelerated and heated up exclusively through the Poisson adiabatic process before the streams collide. (Author abstract) 19 refs.

Hirano, K. (Nagoya Univ, Nagoya, Jpn). *Nucl Fusion* v 28 n 2 Feb 1988 p 207-216.

**079433 EXPERIMENTAL INVESTIGATION OF DIFFERENT CONFIGURATIONS IN A FLEXIBLE HELIAC.** The effect of varying the magnetic field configuration by adding an  $n=1$  helical winding to the standard heliac has been studied experimentally. Equilibrium plasma configuration in the range  $0.7 \leq \beta \leq 1.86$  have been obtained. Analyses of the plasma pressure profiles measured by Langmuir probes in this range show good agreement between the plasma isobars and the computed vacuum magnetic surfaces; for configurations with a rotational transform  $\langle 0 \rangle$  close to unity it is necessary to take known error fields into account. When low-order rational surfaces are present, a deterioration of the plasma confinement is clearly observed. Magnetic islands, resulting from the resonance between the low-order rational surface,  $1/3$  and the  $m=2$ ,  $n=3$  vacuum field harmonics inherent in the geometry, are identified with features observed in both the plasma pressure and the floating potential files. (Author abstract) 8 refs.

Shi, X.H. (Australian Natl Univ, Canberra, Aust); Hamberger, S.M.; Balackwell, B.D. *Nucl Fusion* v 28 n 5 May 1988 p 859-869.

**079434 DETERMINATION OF EQUILIBRIUM GLOBAL PARAMETERS FROM EXTERNAL MAGNETIC MEASUREMENTS IN JET DISCHARGE WITH AUXILIARY HEATING.** A simple procedure has been devised to extend the analysis of external magnetic measurements, using a free-boundary equilibrium solver with the additional constraint of diamagnetic measurement. The paper discusses the application of the method to ohmically and auxilially heated JET plasmas where pressure anisotropy could occur. It is shown that approximate relations commonly in use for a fast calculation of poloidal beta and internal inductance are not accurate in the case of JET. A better approximation for isotropic pressure is given. (Author abstract). 13 Refs.

Lazzaro, E. (Jet Joint Undertaking, Oxfordshire, Engl); Mantica, P. *Nucl Fusion* v 28 n 5 May 1988 p 913-918.

**079435 SELF-CONSISTENT, THREE-DIMENSIONAL EQUILIBRIUM EFFECTS ON TOKAMAK MAGNETIC FIELD RIPLE.** Self-consistent equilibrium effects on tokamak magnetic field ripple have been calculated using a three-dimensional equilibrium code. The poloidal component of the plasma current is found to amplify the magnitude of the ripple. This effect is large enough that it should be included in tokamak ignition experiment design studies. An analysis of the results separates the contribution of the Shafranov shift to the ripple modification from the contributions of other finite pressure effects. (Author abstract). 6 Refs.

Johnson, J.L. (Princeton Univ, Princeton, NJ, USA); Reiman, A.H. *Nucl Fusion* v 28 n 6 Jun 1988 p 1116-1120.

**079436 PROPERTIES OF REVERSED FIELD PINCH DISCHARGES IN OHTE WITH A POLOIDAL RING LIMITER.** A poloidal ring limiter was installed at one toroidal location in the OHTE device operated as a reversed field pinch. The ring acts as the solitary limiter beyond the smooth carbon tile vacuum vessel wall. The mere presence of the poloidal ring limiter broadens the current profile, rather than narrowing it by the reduced aperture, and raises the necessary one-turn voltage needed to sustain the current. The magnetic fluctuation frequency spectrum for both  $m=0$  and  $m=1$  poloidal modes is shifted to higher frequency in discharges with the ring limiter. The observed voltage increase is compared with that predicted by two recent edge helicity loss models. (Author abstract). 8 Refs.

La Haye, R.J. (General Atomics, San Diego, CA, USA); Schaffer, M.J.; Tamano, T.; Taylor, P.L. *Nucl Fusion* v 28 n 6 Jun 1988 p 1125-1129.

**079437 CURRENT DISTRIBUTION AND PLASMA ACCELERATION IN MPD ARCJETS WITH APPLIED MAGNETIC FIELDS.** Current distribution and plasma acceleration mechanisms in MPD arcjets with applied magnetic fields are analyzed theoretically based on induction and quasi-one-dimensional gas-dynamic equations. The finite-element method is used to obtain current distribution and magnetic field patterns. The applied magnetic fields are of diverging type ( $B_0=0$ , 0.1, 0.2 T at cathode base), and calculations are conducted in the cases of discharge currents of 1000 and 2000 A and mass flow rate of 100 mg/s for a conventional electrode geometry. From a comparison of the results calculated, if we assume the magnetic Reynolds number  $R_m$  is negligibly small or not, it is shown that current distribution on the cathode is not influenced by plasma flow and the influence of it on current distribution is bounded in the downstream region. (Edited author abstract). 9 Refs.

Tanaka, Masafumi (Univ of Tokyo, Tokyo, Jpn); Kimura, Itsuro. *J Propul Power* v 4 n 5 Sep-Oct 1988 p 428-436.

## Magnetoplasma

**079438 DYNAMICS OF KINK INSTABILITY IN A NON-UNIFORM MAGNETOPLASMA.** Accounting for an external electron current gradient, a set of nonlinear fluid equations governing the dynamics of kink instability in an inhomogeneous magnetized plasma has been derived. In the linear regime, the dispersion relation is analyzed and the variation of the growth rate is graphically shown. In the nonlinear regime, it is shown that a quasi-stationary solution of the mode coupling equations can be represented as a dipolar vortex. Conditions under which the latter arises are given. (Author abstract) 6 refs.

Bharuthram, R. (Ruhr-Univ Bochum, Bochum, West Ger); Shukla, P.K. *J Plasma Phys* v 38 pt 2 Oct 1987 p 309-316.

**079439 ON SCALAR SUPERPOTENTIALS FOR INHOMOGENEOUS GYROTROPIC MEDIA.** The electromagnetic field in an inhomogeneous gyrotropic medium can be represented in terms of one scalar function, the so-called superpotential. The partial differential equation of fourth order for the superpotential is derived and the connection to a simple ionospheric model is outlined. (Author abstract) 6 refs.

Weighofer, Werner (Univ of Adelaide, Adelaide, Aust). *AEU Arch Elektron Uebertrag Electron Commun* v 41 n 6 Nov-Dec 1987 p 371-372.

**079440 DYNAMICS OF A RADIATING PLASMA FLOW IN A MAGNETIC PLASMA COMPRESSOR.** A numerical simulation has been performed for the discharge in a magnetoplasma compressor of gas type with allowance for the plasma emission. The model enables one to determine the discharge dynamics and structure as well as the major radiative characteristics.

The radiation has a marked effect on the plasma parameters in the compression region, as it tends to increase the degree of compression considerably and to reduce the temperature. When one determines the emissivity of such a plasma, one needs to consider the emission spectrum. A study is made of the effects of the boundary conditions at the inlet to the acceleration channel. (Author abstract) 13 refs.

Ananin, S.I. (Acad of Sciences of the Byelorussian SSR, USSR). *High Temp* v 24 n 6 Nov-Dec 1986 p 890-895.

**079441 SPLITTING OF SURFACE POLARITON DISPERSION CURVES DUE TO RESONANCE WITH MAGNETOPLASMA TRANSITION LAYER.** We study magnetoplasma polaritons of a thin semiconductor film on a polar-semiconductor substrate. In the vicinity of the hybrid cyclotron-plasmon frequency the surface-phonon polariton dispersion curve exhibits a splitting. The repulsion between the upper and lower branches depends on the intensity of the applied magnetic field. The authors have considered propagation in directions that are parallel or perpendicular to the magnetic field (itself parallel to the thin film) and find a strong directional effect. (Author abstract) 11 refs.

Kushwaha, M.S. (Univ Autonoma de Puebla, Puebla, Mexico); Halevi, P. *Solid State Commun* v 64 n 11 Dec 1987 p 1405-1408.

**Mathematical Models** See Also ELECTRIC SWITCHES—Magnetic Field Effects; ELECTRONS—Mathematical Models; LASERS, GAS; RADIO ASTRONOMY.

**079442 COUPLED ION-ACOUSTIC-DRIFT SOLITONS IN NONUNIFORM PLASMAS.** The effects of parallel ion motion are included in the study of drift wave solitons in a magnetized plasma with electron temperature and density gradients. A new nonlinear differential equation governing the evolution of coupled ion-acoustic-drift modes is derived. A quasi-stationary solution of the nonlinear equation is presented. It is found that the sound term can put a constraint on the speed and the profile of drift wave solitons. (Author abstract) 12 refs.

Shukla, P.K. (Ruhr-Univ Bochum, Bochum, West Ger). *Phys Scr* v 36 n 4 Oct 1987 p 644-645.

**079443 PLASMA-OPTICAL SYSTEM MODELLED USING PARTICLES.** A 'particle' model of plasma behaviour, suitable for application to the study of plasma-optical systems, has been developed. A plasma-optical system which removes macroscopic droplets from a neutralized beam of ions and electrons, produced by an arc, has been modelled and its performance has been analysed. This method will be equally effective for time-dependent fields such as occur in RF discharges used in 'plasma processing'. The variation in ion current to a substrate, where the ions deposit as a thin film, has been studied. The objective is to maximize the deposition rate whilst preventing macroscopic particles which arise at the arc from striking the film. An alternative system whose calculated transmittal rate from source to target is higher, for long mean-free-paths, is also examined. (Edited author abstract) 7 refs.

Hitchon, W.N.G. (Univ of Wisconsin, Madison, WI, USA). *J Plasma Phys* v 38 pt 1 Aug 1987 p 87-94.

**079444 POWER BALANCE MODELS FOR ROTAMAK PLASMAS.** Energy transfer processes are calculated for a range of rotamak plasmas which are modelled by equilibria with plasma pressure proportional to either the poloidal flux function or the square of this function. The latter case is more realistic, so it is used to study the conditions for which global power balance can be obtained for both the electrons and the ions. The absence of a toroidal magnetic field means that there is no neo-classical transport. Provided that the particle and energy diffusion remains classical when the plasma temperature increases, the energy confinement time is predicted to scale as  $n^{3/2} R^8$ , where  $n$  is the density and  $R$  is the radius of



the separatrix. As the plasma temperature increases, the dominant energy loss process changes from plasma recycling to electron thermal conductivity and then to ion thermal conductivity. (Author abstract) 18 refs.

Donnelly, I.J. (Australian Atomic Energy Commission Research Establishment, Menai, Aust); Rose, E.K.; Cook, J.L. *Aust J Phys* v 40 n 3 1987 p 393-412.

**079445 ANALYTIC MODEL FOR FLOW REVERSAL IN DIVERTOR PLASMAS.** An analytic model is developed and used to study the phenomenon of flow reversal which is observed in two-dimensional simulations of divertor plasmas. The effect is shown to be caused by the radial spread of neutral particles emitted from the divertor target which can lead to a strong peaking of the ionization source at certain radial locations. The results indicate that flow reversal over a portion of the width of the scrape-off layer is inevitable in high recycling conditions. Implications for impurity transport and particle removal in reactors are discussed. (Author abstract) 8 refs.

Cooke, P.I.H. (Univ of California, Los Angeles, CA, USA); Prinja, A.K. *Nucl Fusion* v 27 n 7 Jul 1987 p 1165-1169.

**079446 EQUATIONS OF STATE AND IONIZATION EQUILIBRIUM OF NON-DEBYE PLASMA.** A semiphenomenological theory of the thermodynamic properties of non-Debye plasma is constructed, on the basis of dividing the states of the electron spectrum into three parts: bound states (atoms), free states, and intermediate (localized) states. This allows the thermodynamic potential of the plasma to be expressed as the sum of contributions. (Edited author abstract) 29 refs.

Kaklyugin, A.S. (Acad of Sciences of the USSR, USSR); Norman, G.E. *High Temp* v 25 n 2 Mar-Apr 1987 p 137-144.

**079447 THERMOPHYSICAL AND TRANSPORT PROPERTIES OF MULTICOMPONENT GAS PLASMAS AT MULTIPLE TEMPERATURES.** For a gas plasma, with the electrons at an elevated temperature with respect to the heavy particles temperature, a general method is presented using the rigorous kinetic theory to calculate the equilibrium composition and transport properties such as the viscosity, the thermal conductivity, the electrical conductivity, the electron diffusion coefficient and the mobility coefficient. The values for the noble gas plasma and air plasma are determined for various pressures, electron temperature up to 50,000 K and electron to heavy particles temperature ratio up to two. However, the two-temperature calculations are made only for the cases where there are no molecular species present in the gas mixture. (Author abstract) 62 refs.

Bose, Tarit K. (Indian Inst of Technology, Madras, India). *Prog Aerosp Sci* v 25 n 1 1988 p 1-42.

**079448 TAKING ACCOUNT OF SHORT-RANGE REPULSIVE POTENTIAL IN DESCRIBING CHARGED-PARTICLE SYSTEMS.** It is shown that the term independent of the ionic charge present in the expressions for the pressure and free energy corresponding to the approximation of the second virial coefficient for the model of solid charged spheres of the same diameter  $r_0$ , like the other terms of these expressions, is a function of the plasma parameter. Conditions are found such that the expressions for the thermodynamic functions of a completely ionized system described by the model of solid uncharged spheres corresponding to the approximation of the second virial coefficient transform to the equivalent expression of the second approximation of Debye-Hückel theory, except for terms equivalent to the product of the plasma and the ratio of  $r_0$  to the Debye radius. (Author abstract) 25 refs.

Denisov, D.A. (D.I. Mendeleev Moscow Chemicotechnological Inst, USSR). *High Temp* v 25 n 3 May-Jun 1987 p 315-324.

**079449 MATHEMATICAL MODEL OF THE INTERACTION OF HIGH-ENERGY PASSING IONS WITH TOROIDAL PLASMA.** The Focke-Planck ki-

netic equation for high-energy ions derived in an earlier study is simplified for the motion of ions along passing trajectories. As a result, the stationary problem is reduced to a Cauchy problem for a two-dimensional parabolic equation; a numeric solution of this equation allows calculating the energy characteristics of the process of deceleration of fast ions in a background plasma. The results are relevant to tokamak plasmas. (Edited author abstract) 3 refs.

Kostomarov, D.P.; Mitrofanov, V.A. *Moscow Univ Comput Math Cybern* n 3 1987 p 1-9.

**079450 TIME-AVERAGE MODEL OF THE rf PLASMA SHEATH.** A time-averaged model of the rf plasma sheath was developed. The ion 'fluid' equations were used with a frictional force to account for ion-neutral collisions. Consideration of the collision dynamics showed that the frictional force may be taken as proportional to the square of the ion drift velocity. The sheath model was used to investigate the ion energy and flux on the electrodes of plasma reactor. The dimensionless quantity CO (collision number) was found to be important in describing the ion motion in the sheath. An analytical expression for the ion bombardment energy was derived, in terms of CO and the sheath voltage, for the range of parameter values typical of high pressure (approx. 1 torr) diode plasma etchers. An application of the model to an oxygen discharge in a parallel plate reactor was considered. (Edited author abstract) 27 refs.

Economou, Demetre J. (Univ of Illinois, Urbana, IL, USA); Evans, David R.; Alkire, Richard C. *J Electrochem Soc* v 135 n 3 Mar 1988 p 756-763.

**079451 NOVEL SIMULATION TECHNIQUE OF ISOTROPIC LOSSY PLASMA USING TWO-DIMENSIONAL STRIP MEDIUM.** The simulation of an isotropic lossy plasma medium using an artificial dielectric is studied in this paper. Two-dimensional strip medium is used as artificial dielectric. (Author abstract) 8 refs.

Prasad, R. (Univ of Dar es Salaam, Dar es Salaam, Tanzania); Mgombeo, H.R. *Modell Simul Control A* v 14 n 3 1987 p 41-46.

**079452 ELECTRON-ION TWO-STREAM INSTABILITY IN ANISOTROPIC ISOTHERMAL PLASMA.** The linear excitation of electron-ion two-stream instability excited in inhomogeneous, magnetized isothermal plasma ( $T_e = T_i$ ) is investigated analytically. Expressions for the frequency, growth rate and conditions of instability are obtained when the current velocity slightly exceeds the instability threshold velocity. Inhomogeneity in density and existence of external static magnetic field may stabilize the instability. (Author abstract) 18 refs.

Khalil, Sh.M. (Int Cent for Theoretical Physics, Trieste, Italy); Mohamed, B.F. *J Phys (Paris)* v 49 n 3 Mar 1988 p 451-455.

**079453 MODELLING PARTICLE FORMATION AND GROWTH IN A PLASMA SYNTHESIS REACTOR.** A model for particle nucleation and growth in a thermal plasma reactor is discussed. A nondimensional form of the aerosol general dynamic equation is derived under a set of simplifying assumptions which are appropriate to plasma powder synthesis and the resulting set of equations is solved numerically. The results are converted to dimensional form for the case of iron powder, for which experimental data are available, and for silicon carbide. Calculated particle sizes increase significantly with increasing reactant concentrations and with decreasing cooling rate, although the influence of cooling rate is mainly a residence time effect. (Author abstract) 13 refs.

Girshick, Steven L. (Univ of Minnesota, Minneapolis, MN, USA); Chiu, Chia-Pin; McMurray, Peter H. *Plasma Chem Plasma Process* v 8 n 2 Jun 1988 p 145-157.

**079454 SIMPLE MODEL FOR FLASHBOARD PLASMA EXPANSION.** A simple model for flashboard plasma expansion is presented. It is based on the  $j \times B$  force and the fact that only a fraction  $\alpha$  of the total current

flows through the expanding plasma. For the parameters under consideration, maximum velocities are roughly proportional to  $\alpha$  and reach 70 cm/ $\mu$ s for  $\alpha = 1$ . B-field profiles from the model are compared to experiment. 5 refs.

Colombant, D.G. (US Naval Research Lab, Washington, DC, USA); Weber, B.V. *IEEE Trans Plasma Sci* v PS-15 n 6 Dec 1987 p 741-746.

**079455 SIMPLE MODEL FOR FAST CORRECTION OF THE HORIZONTAL POSITION OF A TOKAMAK PLASMA.** A virtual movement of the plasma in the radial direction was studied in order to obtain the magnitude of the vertical field applied to the Tokamak de Varennes plasma for fast horizontal motion using coils inside the vacuum vessel. The developed model includes the radial dependence of several parameters. 14 refs.

Geoffrion, J. (IREQ, Varennes, Que, Can); Gregory, B.C.; Couture, P. *IEEE Trans Plasma Sci* v 16 n 3 Jun 1988 p 393-395.

**079456 NUMERICAL SIMULATION OF THE PLASMA EQUILIBRIUM IN A TOKAMAK.** This paper deals with the numerical simulation of the axisymmetric equilibrium of the plasma in a Tokamak. The modelization takes into account both the Maxwell equations and the Grad-Shafranov equilibrium equation. The plasma boundary is a free boundary, defined as being the flux line which is in contact with a limiter. A weak formulation of the equations for the flux  $\psi$  of the poloidal magnetic field is given and a finite element method is then presented. Both a direct resolution for  $\psi$  in an Eulerian grid of the cross-section of the torus and an inverse formulation in terms of coordinates linked to the flux lines are given, as well as a quasi-inverse finite element technique. Several algorithms are presented for the treatment of the nonlinearities. Finally typical equilibrium configurations are calculated for the European JET Tokamak. (Edited author abstract) 25 refs.

Blum, J. (Lab d'Analyse Numerique de Paris VI, Paris, Fr). *Comput Phys Rep* v 6 n 1-6 Aug 1987, Finite Elem in Phys, Proc of the 1st Eur Grad Summer Course on Comput Phys, Lausanne, Switz, Sep 1-10 1986 p 275-298.

**079457 FINITE ELEMENTS APPLIED TO PLASMA WAVES.** An introduction is given into two subjects of the theory of plasma waves and their numerical treatment with the finite element method: Linear propagation in an inhomogeneous medium and quasilinear theory. It is attempted to present the two subjects in such a way that the knowledge of plasma physics is not a prerequisite. With the information contained here a non-specialist should be able to appreciate at least the numerical part of the specialized research papers devoted to the subjects. (Author abstract) 15 refs.

Appert, K. (Ecole Polytechnique Federale de Lausanne, Lausanne, Switz); Succi, S.; Vacklavik, J.; Villard, L. *Comput Phys Rep* v 6 n 1-6 Aug 1987, Finite Elem in Phys, Proc of the 1st Eur Grad Summer Course on Comput Phys, Lausanne, Switz, Sep 1-10 1986 p 335-349.

**Measurements** See Also ELECTRIC DISCHARGES—Microwaves; IONS—Energy Analyzers; LITHIUM COMPOUNDS—Spectroscopic Analysis; SPECTROGRAPHS—Design; TOKAMAK DEVICES—Measurements.

**079458 DIGITAL SIGNAL PROCESSING TECHNIQUES FOR PLASMA DISPERSION CURVE MEASUREMENTS.** Five different digital signal processing techniques for estimating the dispersion properties of plasma or fluid instabilities are discussed. The implementation of each method on a minicomputer is described, and a comparison of their relative merits is made by employing data obtained from a steady-state linear quadrupole plasma containment device. (Author abstract) 20 refs.

Conway, G.D. (UMIST, Manchester, Engl); Elliott, J.A. *J Phys E* v 20 n 11 Nov 1987 p 1341-1350.



**079459 EFFECT OF EROSION ON CONDUCTIVITY MEASUREMENTS OF A SEEDED COMBUSTION PLASMA.** The electrical conductivity of the seeded (with  $K_2CO_3$ ) combustion products of an oxy-LPG ( $C_3H_8$ ) system is measured with the help of double probes. An analytical model is developed to take into account the effect of erosion on the dimensions of the probes. The conductivity of the seeded oxy-LPG system is then evaluated by considering the effect of erosion. The values of electrical conductivity so obtained are found to be in better agreement with theoretically predicted conductivity results than those obtained without considering erosion of the probes. The effect of erosion on the conductivity values at high temperatures and high seeding is found to be as much as about 50-70%. (Author abstract) 10 refs.

Verma, S.S. (Indian Inst of Technology, New Delhi, India); Sawhney, B.K. *Energy Convers Manage* v 28 n 1 1988 p 11-14.

**079460 NEW METHOD FOR MEASURING PLASMA POTENTIALS WITH A HIGH TIME RESOLUTION.** A new method is proposed for measuring plasma potentials in a low temperature and density plasma (electron temperature of a few ten thousands Kelvin, a density below  $10^{12} \text{cm}^{-3}$ ) with a high time resolution ( $\sim 10 \mu\text{s}$ ). An emissive problem which is heated to emit electrons into a plasma is used, and is biased automatically at the floating potential with a zero current of the probe. The validity of this method is clarified by comparing it with the conventional one. In addition, the double layer is formed by injecting an ion beam into an electron sheath, and a formation process is studied by measuring the time variation of the potential profile. (Author abstract) 13 refs.

Fujita, Hiroharu (Saga Univ, Saga, Jpn); Yagura, Shinya. *Electron Commun Jpn Part 2* v 71 n 1 Jan 1988 p 102-110.

**079461 FAST IDENTIFICATION OF PLASMA BOUNDARY AND X-POINTS IN ELONGATED TOKAMAKS.** A new method of identifying the plasma boundary and X-points in elongated tokamaks is presented. The method uses a finite element representation of the plasma current. It is applied to a number of computed equilibria with various shapes and elongations up to  $b/a=3$ . Errors in the flux, magnetic field and coil current measurements are simulated by adding random perturbations to the values obtained from the equilibrium code. The method appears to be sufficiently accurate and fast for real-time shape control. (Author abstract) 12 refs.

Hofmann, F. (EURATOM, Lausanne, Switz); Tonetti, G. *Nucl Fusion* v 28 n 3 Mar 1988 p 519-522.

**079462 LASER DOPPLER ANEMOMETRY UNDER PLASMA CONDITIONS. PART I. MEASUREMENTS IN A D.C. PLASMA JET.** A study is presented on the use of laser Doppler anemometry (LDA) techniques for the measurement of the gas and particle velocities under plasma conditions. Experimental data is presented for a d.c. plasma jet in which alumina particles are injected under different operating conditions. The results reveal that the plasma velocity at the exit of the jet is of the order of 200-300 m/s. The intensity of turbulence is as high as 30 to 40% in the free shear layer and the particle velocity distribution is shown to be asymmetric, with particle dispersion in the plane of injection considerably more important than that in the perpendicular direction. The average particle velocity depends on the composition of the plasma gas, the torch current, and power. (Author abstract) 27 refs.

Lesinski, J. (Univ de Sherbrooke, Sherbrooke, Que, Can); Boulos, M.I. *Plasma Chem Plasma Process* v 8 n 2 Jun 1988 p 113-132.

**079463 LASER DOPPLER ANEMOMETRY UNDER PLASMA CONDITIONS. PART II. MEASUREMENTS IN AN INDUCTIVELY COUPLED R.F. PLASMA.** Laser Doppler anemometry is used for the measurements of the plasma and particle velocity profiles

in the coil region of an inductively coupled r.f. plasma. Results are reported for a 50 mm i.d. induction plasma torch operated at atmospheric pressure with argon as the plasma gas. The oscillator frequency is 3 MHz and the plate power is varied between 4.6 and 10.5 kW. Plasma velocity measurements are obtained using a fine carbon powder as a tracer. Measurements are also given for larger silicon particles ( $d_p=33 \mu\text{m}$  and  $\sigma=13 \mu\text{m}$ ) centrally injected into the discharge under different operating conditions. (Author abstract) 10 refs.

Lesinski, J. (Univ de Sherbrooke, Sherbrooke, Que, Can); Boulos, M.I. *Plasma Chem Plasma Process* v 8 n 2 Jun 1988 p 133-144.

**079464 STEEP GRADIENT AND PEDESTAL OF ELECTRON PROFILES IN H-MODE JFT-2M PLASMA.** The steepening of the density gradient and the pedestal of the edge temperature inside the separatrix (the most outward magnetic surface limiting a plasma) were observed in tokamak H-mode phase. The plateau region on the pedestal corresponds to the region of greatest increase of the density at the beginning of the H-mode transition, and a hollow profile is formed. This is due to a transport barrier, which reduces the effect of enhanced transport by internal disruption. (Author abstract). 15 Refs.

Yamauchi, Toshihiko (JAERI, Tokai, Jpn). *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 924-926.

**079465 MEASUREMENTS OF ENERGY DISTRIBUTIONS IN ECR PLASMA.** The electron energy distribution is measured in an ECR device for  $H_2$  and  $N_2$  plasmas as a function of pressure. The maximum measurable energy and the high-energy tail increase with decreasing pressure. However, the energy distribution at the high-energy part progressively departs from a Maxwellian shape as the pressure is increased. The electron temperature obtained from the low-energy part increases with decreasing pressure. The positive ion temperature is of the order of a few eV and increases with the electron temperature. A mechanism of ion acceleration should exist. (Author abstract). 16 Refs.

Amemiya, Hiroshi (Inst of Physical and Chemical Research, Hiroshima, Jpn); Shimizu, Kazuo; Kato, Shigeki; Sakamoto, Yuichi. *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 927-930.

**079466 MEASUREMENTS OF NEGATIVE POTENTIALS IN A TANDEM MIRROR EXPERIMENT.** Negative plasma potentials as large as  $-400 \text{ V}$  were measured in the magnetic fusion experiment Tandem Mirror Experiment-Upgrade (TMX-U). Normally, a plasma confined by an open ended magnetic field produces a positive potential. To measure the negative potentials, neutral beams were injected into the plasma region at angles within the loss cone. The greatest negative potentials were observed after the electron cyclotron heating power was turned off but while energetic ions were still being introduced into the plasma with large-angle neutral beams. These negative potentials are explained in terms of thermal ions electrostatically trapped by long lived, hot, mirror confined electrons. (Author abstract). 9 Refs.

Foote, J.H. (Lawrence Livermore Natl Lab, Livermore, CA, USA); Hall, L.S. *Nucl Fusion* v 28 n 6 Jun 1988 p 1129-1133.

**079467 DESIGN, CONSTRUCTION, AND LABORATORY CALIBRATION OF THE ANGLE RESOLVING ENERGY ANALYZER (AREA): A 'TOP-HAT' INSTRUMENT FOR AURORAL RESEARCH.** The design philosophy, construction, and laboratory evaluation of the AREA instrument for space plasma measurement, that is generically a top-hat electrostatic analyzer, are reported. The instrument accepts particles from eleven  $16^\circ$  azimuth sectors equally spaced around  $360^\circ$  in the acceptance plane. Laboratory measurements of energy resolution and angular responses demonstrate sharp focusing in azimuth, satisfactory energy resolution, and a large geometric factor. These measure-

ments compare favorably with computer simulations of the same instrument reported previously. 11 refs.

Sharber, James R. (Southwest Research Inst, San Antonio, TX, USA); Winningham, J. David; Scherrer, John R.; Sablik, Martin J.; Bargainer, Carl A.; Jensen, Poul A.; Mask, Bobby J.; Eaker, Nick; Biard, James C. *IEEE Trans Geosci Remote Sens* v 26 n 4 Jul 1988 p 474-486.

**Medical Applications** See ENZYMES—Immobilization.

**Microwaves** See Also SEMICONDUCTING SILICON—Etching.

**079468 SMALL-SCALE FRAGMENTATION OF THE PLASMA OF A MICROWAVE DISCHARGE IN CROSSED WAVE BEAMS AT MODERATE PRESSURES.** The phenomenon of small-scale fragmentation of a microwave discharge produced in a gas at moderate pressure by a field of crossed wave beams is investigated experimentally. The character of the observed fragmentation (stratification in the direction of the electric field vector), its spatial-temporal scales, and the conditions of development are in satisfactory agreement with the concepts of the theory of ionization-field (plasma-resonance) instability of a discharge in a wave field. Significant differences are established between discharge structures formed in beams with polarizations of the TE and TM types. (Author abstract) 21 refs.

Vikharev, A.L. (USSR Acad of Sciences, USSR); Gil'denburg, V.B.; Ivanov, O.A.; Semenov, V.E.; Stepanov, A.N. *Radiophys Quantum Electron* v 30 n 2 Feb 1987 p 248-254.

**079469 VERSATILE MICROWAVE PLASMA APPLICATOR.** The design and performance of a microwave applicator designed to introduce high levels of microwave power into a plasma chamber over a large area with good electric field uniformity are considered. 2 refs.

Ren, Ji Tian; Gerling, J.E. *J Microwave Power Electromagn* v 22 n 3 1987, Radio Freq Ind Appl, 1987 p 170-172.

**079470 PLASMA PROCESSING FOR MICROELECTRONIC APPLICATIONS USING MICROWAVE EXCITATION.** Considerable interest has recently been aroused in the use of microwave excited plasma for microelectronic processing. This paper discusses the advantages of this technique and reports on recent results obtained. (Edited author abstract)

Paraszezak, J. (IBM, Yorktown Heights, NY, USA); Heidenreich, J.; Hatzakis, M.; Moisan, M. *J Microwave Power Electromagn* v 22 n 3 1987, Radio Freq Ind Appl, 1987 p 178.

## Military Applications

**079471 TEMPERATURE ESTIMATES FOR A FREE FLOWING RAILGUN PLASMA.** In-bore spectroscopic observations of a free-flowing plasma for wavelengths between 3000 and  $6250 \text{ \AA}$  were made for a series of railgun firings. In this report the experimental arrangement for the series is described and the results are presented. Atomic species present in the plasma are identified from absorption and emission spectra. Calculations of the degree of ionization of these species are then used to produce a temperature estimate between  $11 \times 10^3 \text{ K}$  to  $25 \times 10^3 \text{ K}$  for the railgun plasma. A comparison of theoretical values of the plasma electrical conductivity with values obtained from muzzle voltage records indicates that the peak plasma temperature is approximately  $11 \times 10^3 \text{ K}$ , which is consistent with estimates obtained from the spectra. (Author abstract) 41 refs.

Clark, G.A.; Kowalenko, V. *Rep Mater Res Lab Aust* 1054 Jun 1987 44p.



**079472 EXPERIMENTAL INVESTIGATION OF A THREE-STAGE RAILGUN INCORPORATING PUFF-SWITCHING.** A sequence of four firings of a 2.4 m long, 10 mm square bore railgun is described and analyzed. The railgun comprised an injection stage, a breech power source and a second power source which was connected by a 'puff-switch'. The report deals with the puff-switching results, distribution of current in the plasma, the proportion of projectile kinetic energy due to plasma expansion forces as compared to electromagnetic forces, the correlation of rail damage with current and plasma length, and velocity limitation according to the ablation model. (Author abstract) 15 refs.

Sadedin, D.R.; Stainsby, D.F. *Rep Mater Res Lab Aust* 1056 May 1987 70p.

**079473 RAILGUN AND ITS POWER SOURCE.** Investigations into the propulsion mechanisms of railguns and into the power source requirements of railguns are reported. Power sources based upon rotating machines, capacitors and explosives are reviewed and a new method based upon batteries and pulse transformers is identified. The battery and pulse transformer method is studied in detail. (Author abstract) 160 refs.

Sadedin, D.R. (Materials Research Laboratories, Ascot Vale, Aust); Bonwick, W.J. *Rep Mater Res Lab Aust MRL-R-1058* Jun 1987 34p.

**Modulation** See PROTECTIVE COATINGS—Plasma Spraying.

## Optical Properties

**079474 OPTICAL PROPERTIES OF AIR PLASMA AT HIGH TEMPERATURES. CONTINUOUS SPECTRUM: BASIC PROCESSES, CALCULATION TECHNIQUES.** This paper describes an extension of the temperature range to  $3 \times 10^4$  K, as well as a check of the accuracy of previously employed methods of calculating the cross-sections of elementary radiation processes by comparison with a restricted set of recently performed standard calculations, and demonstrates the acceptability and advantages of the techniques employed. The present publication consists of two parts. In the first part, the current status of studies into the cross-sections of radiation processes in high-temperature plasma is analyzed, and the methods of calculating the contribution made by individual processes are refined. The second part describes the results of calculation of the total photoabsorption cross-sections for different ions of nitrogen and oxygen 142 refs.

Kobzev, G.A. *IVTAN Rev* v 1 n 1 1987 p 1-74.

**Oscillations** See Also ALKALI METALS—Physical Properties; ELECTRIC DISCHARGES; GASES—Electric Conductivity.

**079475 PLASMA OSCILLATION MODES IN A LOW-PRESSURE PLANE POSITIVE COLUMN.** The effect of the transverse non-uniformity of plane low-pressure gas discharges on LF ion-acoustic waves is investigated. The dispersion laws of the oscillation eigen-modes are found. The estimated frequency of 300 kHz for the case of an argon-laser plasma is in rough agreement with the value of 250 kHz measured by Luthi and Seelig and Donin and co-workers. (Author abstract) 11 refs.

Shapiro, D.A. (Acad of Sciences of the USSR, Novosibirsk, USSR). *J Phys D* v 20 n 10 Oct 14 1987 p 1230-1231.

**079476 COLLECTIVE EFFECTS AND ANOMALOUS CONDUCTIVITY IN A NONIDEAL CURRENT-CARRYING PLASMA. PHYSICAL MODEL. STRATIFICATION OF A CURRENT-CARRYING CONDUCTOR.** The possibility of a buildup of superthermal plasma oscillations in a nonideal plasma is discussed for the example of experiments on the generation of a dense plasma by the method of isobaric heating of conductors. A physical model, which explains from a unified viewpoint the appearance and evolution of strata accompanying an 'electrical explosion' and the appearance

of anomalous electrical conductivity in a nonideal current-carrying plasma, is proposed. Numerical solutions for the initial preplasma stage of the discharge are presented and discussed. (Author abstract) 26 refs.

Batenin, V.M. (Acad of Sciences of the USSR, USSR); Berkovskii, M.A.; Valuev, A.A.; Kurilenkov, Yu.K. *High Temp* v 25 n 2 Mar-Apr 1987 p 145-151.

**079477 COLLECTIVE EFFECTS IN AND ANOMALOUS CONDUCTIVITY OF A NONIDEAL CURRENT-CARRYING PLASMA. EVOLUTION OF STRATA AT THE PLASMA STAGE OF THE DISCHARGE. BUILDUP OF SUPERHERMAL LANGMUIR NOISE.** The possibility of the buildup of nonequilibrium (superthermal) plasma oscillations in a nonideal plasma is discussed for the example of experiments on isobaric Joule heating of wires. A model describing the plasma stage of a discharge is proposed and realized numerically. A possible mechanism for the appearance and character of the turbulent state of a nonideal plasma is studied. It is concluded that turbulent heating of nonideal strongly-collisional plasma is possible. (Author abstract) 22 refs.

Batenin, V.M. (Acad of Sciences of the USSR, USSR); Berkovskii, M.A.; Valuev, A.A.; Kurilenkov, Yu.K. *High Temp* v 25 n 3 May-Jun 1987 p 299-305.

**079478 SELF-SUSTAINED OSCILLATIONS IN THE DIVERTOR PLASMA.** A simple analytical model for a high recycling edge plasma, which relies on the presence of a small parameter - the ratio of the particle flows crossing the magnetic field to those impinging on the target - is proposed. The concept of a one-dimensional steady state (OSS) is introduced as a zero approximation in the small parameter. The mean number density  $N^-$  of the particles - ions plus neutrals - in the magnetic flux tube is chosen as the most representative and convenient parameter of the problem. The OSS is shown to be ambiguous in a certain  $N^-$  range for sufficiently high values of the energy flow entering the scrape-off layer from the bulk plasma. This ambiguity is confirmed by 1-D calculations. (Edited author abstract) 24 refs.

Krashennnikov, S.I. (USSR State Committee on the Utilization of Atomic Energy, Moscow, USSR); Kukushkin, A.S.; Pistunovich, V.I.; Pozharov, V.A. *Nucl Fusion* v 27 n 11 Nov 1987 p 1805-1816.

**079479 ON THE INFLUENCE OF DISSIPATIVE PROCESSES ON THE SPACE-TIME DYNAMICS OF INSTABILITY IN A PLASMA.** When electromagnetic waves and beams of charged particles propagate in a plasma, instabilities appear with the excitation of intercoupled oscillations and, correspondingly, a pumping wave or beam of particles by the space-time synchronism conditions. The level of energy dissipation of the excited oscillations and the boundedness of the system influence the development of instabilities. This paper discusses the unique features of the variation of the space-time dynamics of instabilities of this type because of the presence of dissipative processes in the system. We restrict our consideration to the simplest instabilities in the linear approximation in terms of the amplitudes of the excited oscillations. 6 refs.

Kuklin, V.M. *Sov J Commun Technol Electron* v 32 n 6 Jun 1987 p 185-188.

**079480 PLASMON DISPERSION RELATION FOR A DISORDERED INTERACTING QUASI-TWO-DIMENSIONAL ELECTRON GAS.** The dispersion relation for plasma oscillations is considered for a quasi-two-dimensional interacting electron gas at zero temperature in the presence of randomly distributed impurities. Electron-impurity scattering is described in a relaxation time approximation which conserves local particle number density and electron-electron interactions beyond RPA are included by a static local field correction. (Author abstract) 33 refs.

Geldart, D.J.W. (Dalhousie Univ, Halifax, NS, Can); Das, A.K.; Gumbs, G. *Solid State Commun* v 60 n 12 Dec 1986 p 987-990.

**Photography** See Also PHOTOGRAPHY, HIGH SPEED—Computer Applications.

**079481 SPACE-TIME-DEPENDENT DEVELOPMENT OF THE PLASMA IN A PULSED HOLLOW-CATHODE DISCHARGE.** The fast (nanosecond) breakdown of hollow-cathode discharges is studied. Streak camera investigations are presented on the space-time-dependent development of pulsed discharges, starting from low-current preionization discharges. The discharges start near the entrance to the cathode, then move further back into the cathode, and then spread over a wider range along the axis of the cathode. The depth range of the intense pulsed hollow-cathode plasma was found to be two to eight times the cathode diameter. 5 refs.

Schaefer, G. (Polytechnical Univ, Farmingdale, NY, USA); Wages, M. *IEEE Trans Plasma Sci* v 16 n 1 Feb 1988 p 54-56.

**Physical Properties** See Also FLOW OF FLUIDS.

**079482 OPTICAL AND THERMODYNAMIC PROPERTIES OF A PLASTIC PLASMA.** The results of calculating the properties of an equilibrium plasma of polymethyl methacrylate at a temperature of from 1 to 100 eV are given, according to which it is possible to model the radiation - gas-dynamic processes in the multigroup approximation. The techniques for determining the radiative absorption coefficient provided for calculating the photoionized spectra in the vacuum ultraviolet while taking into account the observed similarity in cross section, individual consideration of the contributions of numerous calculations (up to 100 per ion) of the excited states, bremsstrahlung photo-processes, negative ions, etc. The results of the calculations are discussed. (Author abstract) 14 refs.

Kamrukov, A.S. (N.E. Bauman Higher Technical Coll, USSR); Kozlov, N.P.; Protasov, Yu.S.; Chuvashov, S.N. *Sov Phys J* v 30 n 4 Apr 1987 p 325-328.

**Pinch Effect** See Also ELECTRON BEAMS—Research; NUCLEAR REACTORS; NUCLEAR REACTORS, FUSION—Pressure Vessels; X-RAYS—Spectrum Analysis.

**079483 ON SHIFTING OF PLOWED PLASMA TO BACK OF CURRENT SHEATH IN IMPLOSION PHASE OF THETA-PINCH.** In order to study a phenomenon that the plowed plasma had shifted to the back of the current sheath region in the implosion phase of a theta pinch, computer simulations were performed by using MHD equations consisting of electrons, ions and atoms. The simulations clarified the mechanism by which the plasma plowed in front of the current sheath had shifted to the back of the sheath. The phenomenon is caused by a decrease in the electron temperature or a resistivity enhancement due to inelastic collisions, especially excitation collisions, of electrons with atoms. The shifted plasma still implodes with the  $E \cdot 4 \times B$  drift velocity. The charge exchange has little effect on the phenomenon. (Author abstract) 12 refs.

Ogi, Sukeomi (Kyushu Univ, Fukuoka, Jpn); Shiratani, Masaharu; Takamatsu, Masahiro; Watanabe, Yukio. *Jpn J Appl Phys Part 1* v 26 n 8 Aug 1987 p 1334-1341.

**079484 SPHERICAL PINCH.** This is essentially a review article covering several years of work on the spherical pinch (SP) concept of plasma formation and containment. Central to this concept is the creation of a hot plasma in the center of a sphere, plasma which is then compressed by strong imploding shock waves launched from the periphery of the vessel. In a pilot experimental program of modest initial condenser bank energy (approx. 1 kJ), we find that the instantaneous energy deposition in the central plasma can lead to temperatures of the order of 2 Kev, in agreement with the prediction of the Braginskii resistivity for such a plasma, and with the



relation to the velocity of the diverging shock wave generated by the sudden deposition of energy into this plasma. (Edited author abstract) 18 refs.

Panarella, E. (Nat'l Research Council, Ottawa, Can.). *J Fusion Energy* v 6 n 3 Sep 1987 p 285-305.

**079485 GAS-PUFF Z PINCHES WITH STRONG AXIAL MAGNETIC FIELDS.** Ultrahigh axial magnetic fields have been compressed and measured in a gas-puff Z pinch. A 0.5-MA, 2-cm-radius annular gas-puff Z pinch with a 3-minute repetition rate was imploded radially onto an axial seed field, causing the field to compress. Axial magnetic field compressions up to 180 and peak magnetic fields up to 1.6 MG were measured. Faraday rotation of an argon laser (515.4 nm) in a quartz fiber on axis was the principal magnetic field diagnostic. Other diagnostics included a nitrogen laser interferometer, x-ray diodes, and magnetic field probes. The method of compressing axial fields in a gas-puff Z pinch is extrapolable to the order of 100 MG. Scaling laws are presented. Potential applications of ultrahigh axial fields in Z pinches are discussed for x-ray lasers, inertial confinement fusion, and collimated sources of gamma radiation. (Edited author abstract) 9 refs.

Felber, F.S. (Jaycor, San Diego, CA, USA); Wessel, F.J.; Wild, N.C.; Rahman, H.U.; Fisher, A.; Fowler, C.M.; Liberman, M.A.; Velikovich, A.L. *Laser Part Beams* v 5 pt 4 Nov 1987 p 699-706.

**079486 GENERATION OF A LARGE SWELLING IN THE SPATIAL MAGNETIC FIELD PROFILE NEAR THE COIL AXIS OF A THETA PINCH.** A large magnetic field swelling near the coil axis in a theta pinch with low discharge energy was investigated in detail by changing the gas-fill pressure, the kind of gas and intensity of the applied magnetic field. Under the experimental conditions, the maximum magnetic field around the axis amounted to more than three times the applied field. It was experimentally clarified that the shifting of the plowed plasma to the back of the current sheath in the implosion phase is essential for the phenomenon and that the amplitude of the field around the axis can be explained by the flux trapped by the shifted plasma. (Author abstract) 13 refs.

Ogi, Sukeomi (Kyushu Univ, Fukuoka, Jpn); Shiratani, Masaharu; Watanabe, Yukio. *Jpn J Appl Phys Part 1* v 26 n 10 Oct 1987 p 1727-1732.

**079487 STUDIES OF A VERTICALLY ELONGATED SCREW PINCH AND A TOROIDAL Z-PINCH.** Two types of toroidal pinch, a vertically elongated screw pinch and a toroidal Z-pinch based on spontaneous generation of toroidal field flux, are described. The equilibrium of a non-circular screw pinch plasma is numerically examined. A limiting beta is obtained from optimization of the plasma cross section and is 18% for a plasma of elongation of 2. The equilibrium of a toroidal Z-pinch plasma, with toroidal field and plasma current profiles vanishing at the boundary, is also examined. (Edited author abstract) 75 refs.

Sugisaki, Kiwamu (Electrotechnical Lab, Tsukuba, Jpn). *Denshi Gijyutsu Sogo Kenkyusho Kenkyu Hokoku* n 884 Sep 1987 66p.

**079488 OBSERVATIONS OF HIGH ION TEMPERATURES IN A REVERSED FIELD PINCH PLASMA.** The ion temperature,  $T_i$ , of reversed field pinch plasmas was measured by means of a neutral particle energy analyzer (NPA) and by measuring the Doppler broadening of a CV line (227.091 nm) in TPE-IRM. The results obtained by these two methods agree within the experimental error. The measured  $T_i$  is about 600-800 eV and is higher than  $T_{e0}$ , the central electron temperature measured by Thomson scattering. This fact cannot be explained by the classical ion heating mechanism and suggests that an anomalous ion heating mechanism exists in the RFP plasma. This high  $T_i$  seems to correspond to the bulk of the ions.  $T_i$  increases with the plasma current over the range of 55-100 kA. (Author abstract) 19 refs.

Hirano, Yoichi (Nihon Univ, Tokyo, Jpn); Nogi,

Yasuyuki; Shimada, Toshio; Maejima, Yoshiki; Yagi, Yasuyuki; Ogawa, Kiyosi. *Jpn J Appl Phys Part 1* v 27 n 3 Mar 1988 p 397-402.

**079489 EFFECT OF INSULATOR GAP ON THE PERFORMANCE OF A REVERSED-FIELD PINCH PRODUCED IN A THICK METAL CHAMBER.** A reversed-field pinch (RFP) plasma which has characteristics typical of that produced in a conventional thin metal liner has been obtained in the STE-1(M) device. It uses a 3.4 mm-thick stainless-steel chamber with four insulators for the application of the toroidal voltage, along with the aided self-reversal mode for setting up the RFP configuration. Displacement of the center-of-current channel at the insulator gap was twice as large as that far from the gap. This local displacement could be reduced by the vertical field. Optimization of the vertical field resulted in a 20% decrease of the sustaining voltage. (Author abstract) 8 refs.

Masamune, Sadao (Kyoto Inst of Technology, Kyoto, Jpn); Oshiyama, Hiroshi. *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 710-712.

**079490 STABILITY PROPERTIES OF A TOROIDAL z-PINCH IN AN EXTERNAL MAGNETIC MULTIPOLE FIELD.** MHD stability of  $m=1$ , axisymmetric, external modes of a toroidal z-pinch immersed in an external multipole field (Extrap configuration) is studied. The description includes the effects of a weak toroidicity, a non-circular plasma cross-section and the influence of induced currents in the external conductors. It is found that the non-circularity of the plasma cross-section always has a destabilizing effect but that the  $m=1$  mode can be stabilized by the external feedback if the non-circularity is small. (Author abstract). 10 Refs.

Eriksson, H.G. (Uppsala Univ, Uppsala, Swed). *Phys Scr* v 37 n 6 Jun 1988 p 876-884.

**079491 FINITE ELEMENT STUDY OF A CURRENT-CARRYING PINCH IN A STRONG LONGITUDINAL MAGNETIC FIELD.** A linear finite element method has been applied to the analysis of the stability of a current carrying pinch in a strong magnetic field. The two cases of fixed and free boundaries are studied extensively for a wide range of values for the two parameters  $m$  and  $k$ . The growth rate of instabilities has been calculated numerically. It has been shown that the numerical results, for which corresponding analytical results are available, are in good agreement with them. There are, however, some new numerical results which are not confirmed analytically but represent the physics of the problem property. (Author abstract). 6 Refs.

Zaki, Sherif I. (Suez Canal Univ, Ismailia, Egypt). *Phys Scr* v 37 n 6 Jun 1988 p 885-890.

**079492 ON THE APPLICATION OF THE IDEAL MAGNETOHYDRODYNAMIC LINEAR EIGENVALUE EQUATION TO THE Z-PINCH.** A study of the ideal magnetohydrodynamic linear eigenvalue spectrum for free-boundary modes in the Z-pinch is presented. The application of a variational method to estimate eigenvalues is described and limitations imposed by the nature of the spectrum are discussed. An analytic expression for the long-wavelength  $m=0$  growth rate is derived. (Author abstract). 16 Refs.

Kanellopoulos, S. (Imperial Coll, London, Engl); Coppins, M.; Haines, M.G. *J Plasma Phys* v 39 n 3 Jun 1988 p 521-538.

**079493 STARTUP OF REVERSED FIELD PINCHES AND CURRENT RAMPING USING DYNAMO ACTION.** This paper discusses the startup of a reversed-field pinch (RFP) and some of the different modes by which a final RFP state can be reached. RFP startup differs from startup of other toroidal devices such as the tokamak because of the spatial variations of toroidal flux and the reversal of the toroidal magnetic field in the outer region of the plasma required in the final state. The purpose of this paper is to address the techniques used to reduce the voltage and volt-second (V·s) requirements

during an RFP startup - a subject of high importance in the design of the next-generation RFP experiments. 40 Refs.

Phillips, J.A. (Los Alamos Nat'l Lab, Los Alamos, NM, USA); Baker, D.A.; Gribble, R.F.; Munson, C. *Nucl Fusion* v 28 n 7 Jul 1988 p 1241-1254.

**Probes** See Also GLOW DISCHARGES—Measurements; PLASMA DEVICES—Jets.

**079494 SATURATION CURRENTS ON ELECTRIC PROBES IN FLOWS OF A CHEMICALLY REACTING PLASMA WITH DIFFERENT TYPES OF IONS.** The theory of saturation currents in a weakly ionized plasma with different types of ions is studied. The results of measurements of the ionic sections of the current-voltage characteristics of probes in the flow of combustion-product plasma with an alkali additive are presented. It is shown that a calculation based on a model taking into account the presence of negative ions, in particular,  $\text{HCO}_3^-$  ions, under the given conditions gives results that agree with experiment, and if only the ions of the additive atoms are taken into account the results disagree significantly. (Author abstract) 21 refs.

Benilov, M.S. (Acad of Sciences of the USSR, USSR); Kosov, V.F.; Rogov, B.V.; Sinel'shchikov, V.A. *High Temp* v 25 n 3 May-Jun 1987 p 436-444.

**079495 MEASURING METHODS OF PLASMA PARAMETERS BY A DIFFERENTIATING AND MODULATING DOUBLE PROBE.** Methods for the (1) determination of the electron temperature by differentiation of the probe curve, (2) detection of a non-Maxwellian energy distribution and plasma inhomogeneity, (3) rapid measurement of the electron temperature by voltage modulation, and (4) measurement of the space potential are developed. (Author abstract) 7 refs.

Amemiya, Hiroshi (Inst of Physical & Chemical Research, Wako, Jpn). *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 694-695.

**079496 INTERPRETATION OF LANGMUIR, HEAT-FLUX, DEPOSITION, TRAPPING AND GRIDDED ENERGY ANALYSER PROBE DATA FOR IMPURE PLASMAS.** The impurity level in the central plasma of fusion devices can be almost entirely controlled by the properties of the edge plasma. Progress on better understanding and control of the impurity problem requires improved diagnosis of the edge, including probes. The impurity fraction in the edge plasma is likely to be substantially greater than in the central plasma. The influence of high impurity levels on the interpretation of probe data is examined. (Edited author abstract) 25 refs.

Stangeby, P.C. (Univ of Toronto, Ont, Can.). *J Phys D* v 20 n 11 Nov 1987 p 1472-1478.

**Production** See Also GRAPHITE—Surfaces; MASERS—Mathematical Models; OZONE—Synthesis; PLASMA DEVICES—Torches; PROTECTIVE COATINGS—Plasma Spraying; SEMICONDUCTOR DIODES—Measurements; TITANIUM AND ALLOYS—Surfaces.

**079497 PLASMA ELECTRON SOURCE WITH SECTIONAL COLD HOLLOW CATHODE.** A glow-discharge plasma electron source is described that has a cold hollow cathode formed by 36 individual cathode elements. Connection of the elements to the power supply through separate resistors prevents arching of the glow discharge and considerably increases the duration of the pulsed electron beam. Beams with durations of up to 2.5 msec with currents of up to 50 A and electron energies of up to 150 keV are obtained. (Author abstract) 7 refs.

Metel', A.S. (All-Union Electrical Engineering Inst, USSR). *Instrum Exp Tech* v 30 n 1 pt 2 Jan-Feb 1987 p 178-181.



**079498 STUDY OF SURFACE-WAVE-PRODUCED PLASMA COLUMN LENGTHS.** An experimental description of the length of cylindrical plasma columns produced and sustained by a weakly damped surface wave is presented. A general experimental law for the column length is obtained that depends on the operating parameters in a wide range of discharge conditions. This general empirical law can be deduced theoretically from similarity laws already known to apply to such plasmas. (Author abstract) 16 refs.

Sola, A. (Univ de Cordoba, Cordoba, Spain); Cotrino, J.; Gamero, A.; Colomer, V. *J Phys D* v 20 n 10 Oct 14 1987 p 1250-1258.

**079499 WAVEGUIDE SURFATRON: A HIGH POWER SURFACE-WAVE LAUNCHER TO SUSTAIN LARGE-DIAMETER DENSE PLASMA COLUMNS.** A novel microwave structure which allows a plasma column to be sustained through the propagation of an electromagnetic surface wave is investigated. This plasma source is analysed in terms of a simple equivalent circuit which correctly predicts the transfer of power from the microwave generator to the plasma as a function of the tuning system of the launcher; it further shows that such a microwave structure is the waveguide equivalent of the surfatron. This device seems a particularly well adapted substitute for the surfatron at 2.45 GHz (or higher frequencies) when there is a need to operate at high (> 500 W) microwave power levels or with large ( $\leq 15$  mm) tube diameters. (Author abstract) 12 refs.

Moisan, M. (Univ of Montreal, Montreal, Que, Can); Chaker, M.; Zakrzewski, Z.; Paraszczak, J. *J Phys E* v 20 n 11 Nov 1987 p 1356-1361.

**079500 FUNDAMENTAL PLASMA EMISSION INVOLVING ION SOUND WAVES.** The theory for fundamental plasma emission by the three-wave processes  $L \pm S \rightarrow T$  (where L, S and T denote Langmuir, ion sound and transverse waves, respectively) is developed. Kinematic constraints on the characteristics and growth lengths of waves participating in the wave processes are identified. In addition the rates, path-integrated wave temperatures, and limits on the brightness temperature of the radiation are derived. (Author abstract) 14 refs.

Cairns, Iver H. (Univ of Sydney, Aust). *J Plasma Phys* v 38 pt 2 Oct 1987 p 169-178.

**079501 SECOND HARMONIC PLASMA EMISSION INVOLVING ION SOUND WAVES.** The theory for second harmonic plasma emission by the weak turbulence (or random phase) processes  $L + L \pm S \rightarrow T$ , proceeding in two three-wave steps,  $L \pm S \rightarrow L'$  and  $L + L' \rightarrow T$ , where L, S and T denote Langmuir, ion sound and electromagnetic waves, respectively, is developed. Kinematic constraints on the characteristics and growth lengths of waves participating in the wave processes, and constraints on the characteristics of the source plasma, are derived. Limits on the brightness temperature of the radiation and the levels of the  $L'$  and S waves are determined. Expressions for the growth rates and path-integrated wave temperatures are derived for simple models of the wave spectra and source plasma. (Author abstract) 15 refs.

Cairns, Iver H. (Univ of Iowa, Iowa City, IA, USA). *J Plasma Phys* v 38 pt 2 Oct 1987 p 179-198.

**079502 THIRD AND HIGHER HARMONIC PLASMA EMISSION DUE TO RAMAN SCATTERING.** The theory for third and higher harmonic plasma emission by the weak turbulence (or random phase) process  $L + T' \rightarrow T$  (where L denotes a Langmuir wave, and T and T' denote transverse waves) is developed. Kinematic constraints on the characteristics and growth lengths of waves participating in the wave processes are identified. The cases of L waves produced either directly by a streaming instability, or by the decay  $L \rightarrow L' + S$  (S is an ion sound wave) of L waves generated by a streaming instability, are considered. Limits on the brightness temperature of the radiation are determined, and expressions for the growth rate and path-integrated wave

temperatures are derived. (Author abstract) 16 refs.

Cairns, Iver H. (Univ of Sydney, Aust). *J Plasma Phys* v 38 pt 2 Oct 1987 p 199-208.

**079503 METAL-PLASMA SOURCE.** A metal-plasma source is described in which plasma fluxes are generated by semi-self-maintained vacuum discharge in vapors of the working material, which is evaporated from a water-cooled crucible-anode. A cell with crossed magnetic and electric fields is used for additional ionization of the plasma fluxes, which increases the degree of their ionization to 40-65%. The source is especially effective for metallization of dielectric substrates. The use of an additional-ionization cell increased by a factor of 5-8 the adhesion strength of Ni films to polykor substrates. The rate of Ni-film deposition was 0.1-1.0 nm/sec. The plasma source has been used to produce films of Cu, Cr, Ni, Ti, Mo, C, and W with thicknesses of 0.1-2.0  $\mu$ m. (Author abstract) 6 refs.

Vladimirov, A.I. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Goryuk, S.V.; Saenko, V.A. *Instrum Exp Tech* v 30 n 2 pt 2 Mar-Apr 1987 p 395-398.

**079504 ERZEUGUNG VON MIKROWELLEN-PLASMA IN GROSSEN ENTLADUNGSRAEUMEN.** [Generation of Microwave Plasma in Large Discharge Cavities]. In the application of plasmas to thin film technology, large discharge spaces are necessary. Methods of plasma excitation by microwaves are presented and fundamental principles for the design of discharge cavities are explained. The reflection of the microwaves on plasmas is then considered. (Translated author abstract) 14 refs. In German.

Hammer, Klaus. *Wiss Z Tech Univ Karl Marx Stadt* v 29 n 2 1987 p 256-262.

**079505 CHARACTERIZATION OF AN ANALYTICAL THETA-PINCH PLASMA GENERATED WITH A UNIDIRECTIONAL CAPACITIVE DISCHARGE.** The plasma produced by a high-current capacitive discharge through a graphite fiber bundle is compressed by a magnetic field coaxial with the plasma. The magnetic field is generated by the plasma current in a large coil surrounding the plasma. The field induces an azimuthal ( $\theta$ ) current in the plasma. This current couples with the external magnetic field and produces a radial Lorentz force which reduces the rate of plasma expansion. A diode shunt in the capacitive discharge circuit is used for the generation of a unidirectional discharge current. This arrangement eliminates zero-crossings of the discharge current and thus increases the effectiveness of the magnetic field in controlling the radiative properties of the plasma. Design features of the discharge circuit are presented. (Edited author abstract) 21 refs.

Johnson, E.T. (Univ of Michigan, Ann Arbor, MI, USA); Sacks, R.D. *Appl Spectrosc* v 42 n 1 Jan 1988 p 77-83.

**079506 FORMATION OF A CATHODE PLASMA IN A MAGNETICALLY INSULATED HIGH CURRENT DIODE FOR PRODUCING NEGATIVE HYDROGEN IONS AT A CURRENT DENSITY OF UP TO 200 A/cm<sup>2</sup>.** Experiments are described to form a dense plasma on the cathode of a high current diode with magnetic insulation in order to produce kiloampere currents of negative hydrogen ions. Currents of up to 7 kA are produced at a current density of up to 200 A/cm<sup>2</sup>. (Author abstract) 9 refs.

Papadichev, V.A.; Shelkovenko, T.A. *Sov Phys Lebedev Inst Rep* n 7 1987 p 80-84.

**079507 PROPERTIES AND SOME CHARACTERISTIC FEATURES OF THE RING DISCHARGES.** Electrodeless discharges, particularly ring discharges, play an important part in the study of electric gas discharges, owing to the special phenomena and properties they involve, and to their wide application range. The paper begins by a short review of the high frequency electric discharges, followed by a presentation of ring discharge characteristic features and attempts made to describe them theoretically. Finally, the main practical

applications are reviewed with special emphasis on the inductive plasmatrons. (Author abstract) 12 refs.

Popescu, I.I. (Univ of Bucharest, Rom); Gherbanovschi, N.; Stoican, O. *Rev Roum Phys* v 33 n 1 1988 p 47-56.

## Radiation Effects

**079508 OBSERVATION OF THREE-HALF HARMONIC RADIATION FROM PLASMAS IRRADIATED BY A 0.26  $\mu$ m WAVELENGTH LASER.** Time-integrated measurements have been made of three-half harmonic light energy emitted from 0.26  $\mu$ m laser-produced plasmas. The main results are the experimental dependence of  $3/2\omega_0$  conversion efficiency and threshold on electron density-profile shape. Various density profiles are achieved by irradiating different kinds of target; their shapes are estimated with the help of two-dimensional hydrodynamic simulations. (Author abstract) 24 refs.

Labaune, C. (Ecole Polytechnique, Palaiseau, Fr); Fabre, E.; Bonnaud, G. *J Plasma Phys* v 38 pt 3 Dec 1987 p 445-451.

**079509 INDUCED RECOMBINATION AND THE POSSIBILITY OF AMPLIFYING RADIATION IN A PLASMA.** A study is made of induced photorecombination caused by collisions of electrons with ions (atoms) of a plasma in the presence of a strong electromagnetic field. A negative coefficient of absorption of the radiation is obtained for the recombination of an electron in the discrete state, with subsequent spontaneous radiation decay of the electron. If the autoionized state is present in the continuous spectrum of an atom, then taking photoabsorption into account means that for narrow electron distribution functions the absorption coefficient can be either positive or negative. (Author abstract) 10 refs.

Voitkov, A.B. (V.I. Lenin Tashkent State Univ, USSR); Pazdzerskii, V.A.; Usachenko, V.I. *Sov Phys J* v 30 n 8 Aug 1987 p 672-676.

**079510 ELECTRON FLUID EQUATIONS AND MAGNETIC FIELD GENERATION IN LASER-IRRADIATED COLLISIONAL PLASMAS.** The results of a previous paper are used for deriving the electron fluid equation of laser-irradiated collisional plasmas as well as the equations which govern the magnetic field generation in these media. It is shown that these equations involve various collisional contributions which can be exactly calculated at each order for any electron-ion interaction law, and that they enable us to recover, as special cases, the results given in other works. These methods provide a self-consistent theory of transport phenomena in high Z plasmas, in which the background state is generally non-Maxwellian and evolves on a slow time scale determined by the electron heating process. The full calculations are given for the Coulomb law in a particular case, and the results so obtained are compared to those derived from the Krook model. (Author abstract) 12 refs.

Jancel, R. (CNRS, Paris, Fr). *Phys Scr* v 36 n 6 Dec 1987 p 927-939.

## Research See Also ION SOURCES; MAGNETOHYDRODYNAMICS—Equipment.

**079511 PHYSICAL DOMAINS IN PLASMA PHYSICS.** The article describes the division of plasma domains according to the quantum degeneracy parameter. The equations of motion applicable to these different domains are presented. The division of plasmas into collective and fluid dynamic domains, plasmas immersed in electric and magnetic fields are discussed. The guidelines are given proper choosing of a plasma mathematical description for a particular engineering task.

Liboff, Richard L. (Cornell Univ, Ithaca, NY, USA). *Eng Cornell Q* v 22 n 1 Autumn 1987 p 19-24.



**079512 PLASMA PHYSICS: A PURE AND APPLIED FIELD.** The author gives a review of theoretical studies underway in the Cornell's Laboratory of Plasma studies. He emphasizes the importance of large-scale computing, touches upon the most important applications of plasma physics in controlled thermonuclear fusion, astrophysics, geophysics, and intense relativistic electron beams.

Seyler, Charles E. Jr. (Cornell Univ, Ithaca, NY, USA). *Eng Cornell Q* v 22 n 1 Autumn 1987 p 25-29.

**Sheaths** See Also ANTENNAS, CYLINDRICAL—Measurements.

**079513 GENERAL SOLUTION CONDITION FOR COLLISIONLESS SHEATHS.** A general solution condition for collisionless sheaths is developed. Previous work has assumed that the Bohm criterion or the generalized Bohm criterion ensures a self-consistent sheath solution. This paper shows that for non-monotonic collisionless sheath structures, such as double sheaths containing trapped ions, the generalized Bohm criterion is a necessary but not a sufficient condition. The general solution condition developed is always sufficient and the generalized Bohm criterion is shown to be special case of it. The general solution condition is applied to a double emitter sheath containing trapped ions. Both the sheath structure and the generalized Bohm speed depend on the amount of trapped ions. Thus collisional effects may dominate the structure of a presumably collisionless sheath through the trapping mechanism and the collisional pre-sheath which determines the low-energy ion component entering the collisionless sheath. (Edited author abstract) 10 refs.

Main, Geoffrey L. (Georgia Inst of Technology, Atlanta, GA, USA); Lam, S.H. *J Plasma Phys* v 38 pt 2 Oct 1987 p 287-300.

**079514 FIELD-DRIVEN ION MIGRATION AGAINST DEAD-STOP COLLISIONAL BRAKING.** The steady-state migration of ions, driven by a uniform electric field against full-stop collisions, is investigated in some detail. The required phase-space distribution is obtained very easily from Boltzmann's equation together with explicit recognition of energy conservation and population balance for the stagnant ion pool. Numerical consequences of the solution obtained here reveal that both ion density and average kinetic energy relax to their terminal values within just a few mean free-path lengths. Such modest scaling of plasma-sheath extent evidently carries a beneficial implication for the technological ease with which surface properties (such as metal corrosion resistance and hardness) remain open to improvement via ion bombardment. (Edited author abstract)

Grzesik, J.A. (TRW, Redondo Beach, CA, USA). *J Plasma Phys* v 39 n 1 Feb 1988 p 53-60.

## Shock Waves

**079515 TIME-ASYMPTOTIC STABILITY OF SHOCKS IN COSMIC-RAY HYDRODYNAMICS.** The nonlinear behaviour of short-wavelength perturbations in the two-fluid cosmic-ray hydrodynamical model is examined. We show that such a perturbation leads to shock formation and derive the appropriate wave equation. We show that a discontinuous perturbation incident on a weak cosmic-ray shock destabilizes, in a time-asymptotic sense, the shock. (Author abstract). 13 refs.

Zank, G.P. (Max-Planck-Institut fuer Kernphysik, Heidelberg, West Ger). *J Plasma Phys* v 39 n 3 Jun 1988 p 539-548.

## Simulation

**079516 FAST MULTIPOLE METHOD FOR GRIDLESS PARTICLE SIMULATION.** The numerical solution to N-body problems in gravitation or electrostatics has traditionally been obtained via particle-in-cell methods (PIC) since direct evaluation of all pairwise interparticle forces, requiring  $\mathcal{O}(N^2)$  operations, is too expensive. Recently, hierarchical solvers, which use tree data struc-

tures and lumped-force approximations, have made gridless simulations feasible in  $\mathcal{O}(N \log N)$  operations. In this paper, we explore the use of the fast multipole method (FMM) - a highly accurate order  $\mathcal{O}(N)$  algorithm - in particle simulations. We briefly describe the FMM and its relation to other methods. Technical considerations of gridless simulations such as discrete particle fluctuations, sampling errors and boundary conditions are discussed and compared with PIC methodology. Examples of electrostatic simulations in plasma physics are presented. (Author abstract) 13 refs.

Ambrosiano, John (Berkeley Research Associates, Springfield, VA, USA); Greengard, Leslie; Rokhlin, Vladimir. *Comput Phys Commun* v 48 n 1 Jan 1988, Part Methods in Fluid Dyn and Plasma Phys, Proc of the Workshop, Los Alamos, NM, USA, Apr 13-15 1987 p 117-125.

**079517 RECENT PROGRESS WITH AVANTI: A 2.5D EM DIRECT IMPLICIT PIC CODE.** An overview of the electromagnetic Direct Implicit PIC plasma simulation algorithm is presented in the form it is now implemented in the 2.5D code AVANTI. A test case that has ideal properties for testing the algorithm is presented. Recently the relativistic extension of the algorithm has been investigated and preliminary consideration is given to the changes required in the algorithm for this capability. (Author abstract) 8 refs.

Hewett, Dennis W. (Lawrence Livermore Natl Lab, Livermore, CA, USA); Langdon, A. Bruce. *Comput Phys Commun* v 48 n 1 Jan 1988, Part Methods in Fluid Dyn and Plasma Phys, Proc of the Workshop, Los Alamos, NM, USA, Apr 13-15 1987 p 127-133.

**079518 MULTIDIMENSIONAL SIMULATIONS USING HYBRID PARTICLE CODES.** In this paper the advantages and disadvantages of using a hybrid particle code approach to simulate highly nonlinear plasma phenomena on scale lengths beyond the Debye length are discussed. The formalism for building hybrid codes is discussed. It is shown that many features not attainable with traditional MHD formalisms can be simulated on scale sizes that can approach planetary scales. Results of 2½ and 3-D simulations will be discussed to demonstrate the strengths and weakness of this approach. (Author abstract) 21 refs.

Brecht, Stephen H. (Berkeley Research Associates, Berkeley, CA, USA); Thomas, Vincent A. *Comput Phys Commun* v 48 n 1 Jan 1988, Part Methods in Fluid Dyn and Plasma Phys, Proc of the Workshop, Los Alamos, NM, USA, Apr 13-15 1987 p 135-143.

## Space Charge

**079519 REMOVAL OF SINGULARITIES IN THE HYDRODYNAMIC DESCRIPTION OF PLASMAS INCLUDING SPACE-CHARGE EFFECTS, SEVERAL SPECIES OF IONS AND NON-VANISHING ION TEMPERATURE.** The hydrodynamic or gas-dynamic theory of plasma including space-charge effects and several species of ions involves singular points within the plasma if the pressure and inertia of the charged particles are taken into account simultaneously. These singularities, which occur if the mean velocity of one of the species of particles reaches the sound velocity, can be removed. The required smoothing conditions lead to a well determined, non-linear eigenvalue problem for the concentrations of the various species of ions. Three methods are elaborated to calculate the eigenvalues and to obtain smooth solutions. It is shown that even under quasi-neutral conditions similar mathematical problems occur if the plasma contains several species of positive ions. The methods described can be applied to plasmas in low-pressure discharges, in hollow cathodes and near electrodes and to fusion plasma. (Author abstract) 31 refs.

Valentini, H.-B. (Akad der Wissenschaften der DDR, Jena, East Ger). *J Phys D* v 21 n 2 Feb 14 1988 p 311-321.

## Spectroscopic Analysis

**079520 EFFECT OF PLASMA OPACITY ON THE DOPPLER-FREE POLARIZATION SPECTRUM IN A HYDROGEN PLASMA.** In a low-density hydrogen plasma, the saturation behavior of the  $H_{\alpha}$  line emission has been studied by Doppler-free polarization spectroscopy with a pulsed high-power tunable laser. Spectral profiles of the Doppler-free fine structure components of the  $H_{\alpha}$  line were found to be largely distorted by the effect of reabsorption in the plasma. A simple calculation of the spectral profiles, while taking into account of the effect of the plasma opacity in the saturation conditions, is in good agreement with the experimental results. (Author abstract) 7 refs.

Arata, Yoshiaki (Osaka Univ, Ibaraki, Jpn); Miyake, Shoji; Matsuoka, Hidesato. *Jpn J Appl Phys Part 1* v 26 n 8 Aug 1987 p 1285-1289.

**079521 SPECTROSCOPIC STUDY OF IMPURITY BEHAVIOUR IN NEUTRAL BEAM HEATED AND OHMICALLY HEATED TFTR DISCHARGES.** This paper presents a detailed analysis of extreme UV and visible impurity emissions from TFTR plasmas on a movable graphite limiter with up to 5.6 MW of beam power. It provides reference documentation of both ohmically heated and standard beam heated (L-mode confinement) discharges. The techniques used to analyse extreme UV and visible impurity emissions from TFTR plasmas are discussed in detail. As a further focus, variations in impurity behaviour with density and beam power in discharges with 2.2 MA plasma current ( $I_p$ ) and 4.7 T toroidal field ( $B_T$ ) are considered. 28 refs.

Stratton, B.C. (Princeton Univ, Princeton, NJ, USA); Ramsey, A.T.; Boody, F.P.; Bush, C.E.; Fonck, R.J.; Groebner, R.J.; Hulse, R.A.; Richards, R.K.; Schivell, J. *Nucl Fusion* v 27 n 7 Jul 1987 p 1147-1164.

**079522 PRINCIPLES OF SPECTROSCOPIC DIAGNOSTICS OF PLASMA WITH OSCILLATING ELECTRIC FIELDS.** The author developed a method for performing quasiloocal measurements of the parameters of the QEF Quasimonochromatic Electric Fields in the region of a strong field (for observations integrated over the line of sight), based on the adiabatic theory of satellites (ATS) of dipole-forbidden lines of helium-like or lithium-like atoms. The standard three-level scheme was studied: a quantum system consisting of two close-lying levels 1 and 2, only one of which is linked by a dipole transition with a distant third level. Under the action of a QEF two satellites of the dipole-forbidden line appear in the spontaneous emission spectrum of such a system in addition to the dipole-allowed line (with intensity  $I_A$ ). The main part of the theory consists of solving a fundamental nonlinear-optics problem: the problem of the quasienergy states of a three-level system of a very general form in a strong or high-frequency field. The author points out that the analytic solution of the fundamental problem of the QS of a three-level system in a strong QEF, and developed in this work is not only a new division of the nonlinear theory of satellites, but it also extends the possibility of active (for example, laser fluorescence) diagnostic methods. 26 refs.

Oks, E.A. *Meas Tech* v 29 n 9 Sep 1986 p 805-811.

**079523 DETERMINATION OF ION TEMPERATURE AND TOROIDAL ROTATION VELOCITY VIA CHARGE-EXCHANGE RECOMBINATION SPECTROSCOPY.** In JFT-2M plasmas spatially and temporally resolved ion temperature and toroidal rotation velocity were determined by measuring the Doppler-broadened profiles of spectral lines excited by charge-exchange recombination reaction between the neutral hydrogen beam ( $H^0$ ) and fully stripped ions ( $H^+$ ,  $C^{6+}$ ). The obtained ion temperature was in agreement with that measured by the neutral particle analyzer (NPA). These experimental results indicate that the



charge-exchange recombination spectroscopy (CXRS) method is a powerful technique to measure hot and dense plasmas. (Author abstract). 20 Refs.

Ogawa, Hiroaki (JAERI, Ibaraki, Jpn); Miura, Yukitoshi; Kasai, Satoshi. *Jpn J Appl Phys Part 1* v 27 n 5 May 1988 p 808-815.

**079524 DETERMINATION OF THE ELECTRIC FIELD STRENGTHS IN DEUTERIUM FROM SATELLITE STRUCTURE OF BALMER LINES.** In a linear magnetoplasma with  $n_e \leq 5 \times 10^{18} \text{ m}^{-3}$  microwaves with frequency  $f = 34.8 \text{ GHz}$  and power  $P \leq 100 \text{ kW}$  were focussed with a quasi-optical horn-lens system. The profiles of the deuterium lines  $D_\beta$ ,  $D_\gamma$ , and  $D_\delta$  were recorded from the focus. The profiles show a satellite structure which is generated by the rf electric field. Beside the first order satellites which can be resolved from the main line, even second order satellites were detectable. Comparing the satellites' intensities with theory it is possible to determine the electric field strength in the focus. Due to a sensitive dependence of the satellites' intensities upon the polarization direction one can also determine an unknown polarization direction. (Author abstract). 14 Refs.

Kamp, A. (Ruhr-Univ, Bochum, West Ger); Himmel, G. *Appl Phys B* v 47 n 2 Oct 1988 p 177-185.

**Spectrum Analysis** See Also GASES—Spectrum Analysis.

**079525 STABILIZATION OF A HIGH-PRESSURE ARC IN HYDROGEN.** We describe hydrogen plasma sources with densities of approx.  $10^{18} \text{ cm}^{-3}$  for investigating spectral optical characteristics. The plasma is created using a gas vortex-stabilized arc at high atmospheric pressures. A system is described that includes an electrical discharge high-pressure chamber and an arc feed source, and the arc characteristics for a large current  $i = 2-8 \text{ A}$  at a pressure of  $p = (1-30) \cdot 10^5 \text{ Pa}$  and the hydrogen plasma parameters are given. 15 refs.

Ershov-Pavlov, E.A.; Krat'ko, L.E.; Chubruk, N.I.; Shimanovich, V.D. *J Appl Spectrosc* v 46 n 3 Mar 1987 p 317-321.

**079526 METHOD FOR RELAXATION CONSTANT SEPARATION OF OPTICALLY EXCITED STATES.** A method for the separation of population and alignment decay constants is proposed. A comparison is carried out of different experimental geometries and the choice of the spectral lines to be observed is discussed, aiming at optimizing the magnitude of the useful signal. It is shown that the use of the suggested method allows separation of the relaxation constants with higher accuracy. (Author abstract) 3 refs.

Alipieva, E. (Bulgarian Acad of Sciences, Sofia, Bulg); Grigorieva, V.; Todorov, G. *Opt Commun* v 66 n 4 May 1988 p 198-202.

**079527 OPTICAL EMISSION SPECTROSCOPY OF  $\text{CF}_4 + \text{O}_2$  PLASMAS USING A NEW TECHNIQUE.** In this study a Cu rod is inserted into the plasma, and the rod potential is altered from the ground potential to a negative potential with a frequency of 20 Hz. The emission spectra from a  $\text{CF}_4 + \text{O}_2$  plasma are measured. A small amount of Ar gas and/or  $\text{N}_2$  gas is added and the output signal of the lock-in amplifier is adjusted to zero for either the Ar emission line or the  $\text{N}_2$  emission line. In a fluorine-contained plasma the F emission intensity normalized by the Ar one has been widely used in order to obtain the F density. This validity is confirmed by the present experiment. It is also confirmed that the CO emission intensity normalized by that of  $\text{N}_2$  is proportional to the CO density. The metastable states play an important role in the optical emission intensities of CO and  $\text{N}_2$  molecules. (Edited author abstract) 13 refs.

Kawata, H. (Univ of Osaka, Sakai, Jpn); Takao, Y.; Murata, K.; Nagami, K. *Plasma Chem Plasma Process* v 8 n 2 Jun 1988 p 189-206.

**Stability** See Also ELECTRIC CONDUCTORS—Magnetic Field Effects; ELECTROMAGNETIC WAVES—Propagation in Plasma; ELECTRON BEAMS—Transport Properties; MAGNETOHYDRODYNAMICS; MAGNETOHYDRODYNAMICS—Mathematical Models; NEUTRONS—Scattering; NUCLEAR ENERGY—Fusion Reactions; PLASMAS; TOKAMAK DEVICES.

**079528 STRUCTURALLY INVARIANT PLASMAS.** It is shown that it may be possible to operate devices in which plasmas are magnetically confined in such a way that the structure of the configuration remains constant during the discharge, i.e. the space and time variables are separable. Since MHD stability depends on structure only, it may be possible to realize circumstances under which the plasma is MHD stable throughout the discharge. Separation of the variables is possible only for certain functional forms of the appropriate transport coefficients, among which are the classical transport coefficients. A simple case where separation is possible has been calculated numerically and it appears that MHD stable configurations are among the solutions. (Author abstract) 2 refs.

Jensen, T.H. (GA Technologies Inc, San Diego, CA, USA); Politzer, P.A. *Nucl Fusion* v 27 n 7 Jul 1987 p 1119-1124.

**079529 OBSERVATION OF ULTRA LOW  $q$  EQUILIBRIUM.** The characteristics of a toroidal discharge with  $q_a \approx 1/2$  is studied on TORIUT-6. Ultra low  $q$  equilibria that are stable against the global kink mode are realized through MHD relaxation and are shown to be characterized by  $dq/dr < 0$  and a hollow current profile. The stable state lasts for 600  $\mu\text{s}$ , which is of the order of the classical diffusion time. These experimental observations are consistent with non-linear MHD simulation results. (Author abstract) 8 refs.

Yamada, H. (Univ of Tokyo, Tokyo, Jpn); Kusano, K.; Kamada, Y.; Utsumi, M.; Yoshida, Z.; Inoue, N. *Nucl Fusion* v 27 n 7 Jul 1987 p 1169-1173.

**079530 SEARCH FOR ION TEMPERATURE GRADIENT DRIVEN ELECTROSTATIC HYDRODYNAMIC INSTABILITY IN TOKAMAKS.** The ion temperature gradient drive electrostatic instability in tokamak magnetic geometry has been investigated numerically in terms of a generalized ion density moment. For typical tokamak parameters (ratio between the density gradient scale length and the major radius,  $\epsilon_0 = L_n/R$ , about 0 (0.1) and  $T_i \approx T_e$ ) the search for rapidly growing instabilities of a hydrodynamic nature has been unsuccessful, even with the ion temperature gradient relative to the density gradient,  $\eta_i = d(\ln T_i)/d(\ln n_i)$ , as large as six. (Author abstract) 19 refs.

Hirose, A. (Univ of Saskatchewan, Saskatoon, Sask, Can); Ishihara, O. *Nucl Fusion* v 27 n 9 Sep 1987 p 1439-1451.

**079531 IDEAL MHD STABILITY PROPERTIES OF PRESSURE DRIVEN MODES IN LOW SHEAR TOKAMAKS.** The role of shear in determining the ideal MHD stability properties of tokamaks is discussed. In particular, the effects of low shear within the plasma upon pressure driven modes are assessed. The standard ballooning theory is shown to break down as the shear is reduced, and the growth rate is shown to be an oscillatory function of  $n$ , the toroidal mode number, treated as a continuous parameter. The oscillations are shown to depend on both the pressure profile and the safety factor profile. When the shear is sufficiently weak, the oscillations can result in bands of unstable  $n$ -values, which are present even when the standard ballooning theory predicts complete stability. These instabilities are named 'infernal modes'. The occurrence of these instabilities at integer  $n$  is shown to be a sensitive function of the  $q$ -axis, raising the possibility of a sharp onset as the plasma parameters evolve. (Author abstract) 22 refs.

Manickam, J. (Princeton Plasma Physics Lab, Princeton, NJ, USA); Pomphrey, N.; Todd, A.M.M. *Nucl Fusion* v 27 n 9 Sep 1987 p 1461-1472.

**079532 STABILITY CONDITIONS FOR PERTURBATIONS WITH A SINGULARITY DERIVED**

**FROM THE ENERGY PRINCIPLE.** The stability conditions of an equilibrium plasma for perturbations with a singularity are derived from the energy principle for a non-ideal MHD plasma. The stability conditions are shown to include a stability criterion for the helical resistive tearing mode that is equivalent to the stability condition derived from conventional tearing mode theory. The effects of the resistive wall on stability are also discussed briefly. (Author abstract) 24 refs.

Kondoh, Y. (GA Technologies Inc, San Diego, CA, USA); Yamagishi, T.; Chu, M.S. *Nucl Fusion* v 27 n 9 Sep 1987 p 1473-1477.

**079533 ACCELERATION OF PARTICLES IN DEVELOPING PERTURBATIONS IN FINITE AMPLITUDE IN AN UNSTABLE PLASMA.** The nonlinear stage of large-scale instabilities in a plasma, caused by relative movement of electrons and ions, is investigated using numerical modeling by means of a macroparticle method. Formation of groups of high-speed ions with energies which greatly exceed the energy of the regular movement of the electrons is demonstrated. (Author abstract) 13 refs.

Bulanov, S.V.; Sasorov, P.V.; Sakharov, A.S. *Sov Phys Lebedev Inst Rep* n 5 1987 p 69-72.

**079534 NUMERIC STUDY OF STEADY STATES IN PLASMA.** A model of description of quasi-steady states of plasma with a finite conductivity is constructed. A method of calculation of the characteristics of these states is suggested which does not make use of variable inversion. The results of numeric simulations of high- $\beta$  steady states in INTOR are described. (Author abstract) 6 refs.

Zotov, I.V. *Moscow Univ Comput Math Cybern* n 2 1987 p 44-50.

**079535 CYCLOTRON INSTABILITY OF THE SLOW EXTRAORDINARY WAVE IN A MAGNETOACTIVE PLASMA.** The dipole approximation is applied to the kinetic instability in longitudinally propagating whistlers and the Z mode at frequencies below the nonrelativistic electron gyrofrequency, which is due to a group of fast electrons in a magnetic trap. Numerical calculations are used to analyze the effects from the parameters of the hot and cold components on the increment for the waves propagating parallel to the magnetic field and at a small angle to it; it is shown that relativistic effects allow marked instability for the oblique Z mode only in a restricted energy range for the hot component. The relation between the extraordinary-wave increments is considered for longitudinal and transverse propagation. Analytic estimates are obtained for the increment and amplification coefficient for the Z mode in the case of perpendicular propagation. (Author abstract) 19 refs.

Demekhov, A.G. (Acad of Sciences of the USSR, USSR). *Radiophys Quantum Electron* v 30 n 6 Jun 1987 p 547-557.

**079536 BIFURCATED TEMPERATURE PROFILES AND THE H-MODE.** One of the most striking features of the H-mode, in contrast to the L-mode, is the existence of very steep pressure gradients in a narrow layer just inside the plasma boundary. In this paper, it is shown how the existence of H- and L-regimes, together with their characteristic profiles, is a natural consequence of the modified ballooning stability properties near a magnetic separatrix. (Author abstract) 8 refs.

Bishop, C.M. (Euratom-UKAEA Fusion Assoc, Abingdon, Engl). *Nucl Fusion* v 27 n 11 Nov 1987 p 1765-1771.

**079537 CONFINEMENT AND BALLOONING STABILITY AT THE BETA LIMIT.** Cross-field transport and ballooning stability in neutral heated ASDEX divertor tokamak plasma below and at the  $\beta$  limit are analysed by computer simulations. It is found that the discharge below the limit are ballooning stable and exhibit



H transport. No gradual reduction of confinement happens when beta approaches the limit ('hard'  $\beta$  limit). The degradation of energy confinement at the  $\beta$  limit is shown to be due to enhanced electron heat conduction. Resistive ballooning modes with high wavenumbers are found to be marginally stable or unstable in a radial zone where the electron heat diffusivity is enhanced by a factor of four. Broader zones correspond to stronger degradation of global energy confinement. The diffusion coefficient is raised much less than the electron heat diffusivity. Fast flattening of the current profile which keeps resistive ballooning modes close to marginal stability seems to occur. Such modes with high wavenumber generate small scale, fluctuating  $B_z$  fields which can cause magnetic braiding. It is shown that the confinement properties at the  $\beta$  limit are consistent with transport in stochastic magnetic fields. (Author abstract) 25 refs.

Becker, G. (EURATOM-IPP Assoc, Garching, West Ger). *Nucl Fusion* v 27 n 11 Nov 1987 p 1785-1793.

**079538 ASYMPTOTIC STABILITY BOUNDARIES OF BALLOONING MODES IN CIRCULAR TOKAMAKS.** The model ballooning mode equation of Connor, Hastie and Taylor for large-aspect-ratio circular tokamaks is analysed in the limit of large pressure gradient, and corresponding expressions for stability boundaries are derived. In particular, it is found that for fixed radial wavenumbers infinite sequences of unstable bands exist and that minimizing over the radial wavenumbers leads to asymptotic merging between the neighboring bands, which significantly modifies the second stability boundary compared with that for zero radial wavenumber. (Author abstract) 10 refs.

Chen, Liu (Princeton Univ, Princeton, NJ, USA); Bonedson, A.; Chance, M.S. *Nucl Fusion* v 27 n 11 Nov 1987 p 1918-1921.

**079539 HOT PARTICLE STABILIZATION OF BALLOONING MODES IN TOKAMAKS.** The concept of energetic particle stabilizing of ballooning modes in tokamak is extended by considering numerically generated finite aspect ratio equilibria and attempting to simultaneously stabilize all flux surfaces against ballooning modes by suitable choice of a hot particle anisotropic pressure. To achieve access to the second stability regime at as low as beta value as possible, tokamaks with circular cross-section and an aspect ratio of ten are considered. Global stabilization of ballooning modes is demonstrated, even though the drift reversal constraint requires careful tailoring of the anisotropic pressure profile. A prescription for determining the optimum anisotropic pressure profiles for any equilibrium is provided. (Author abstract) 28 refs.

Miller, R.L. (Applied Microwave Plasma Concepts Inc, Carlsbad, CA, USA); Van Dam, J.W. *Nucl Fusion* v 27 n 12 Dec 1987 p 2101-2112.

**079540 TURBULENT STABILIZATION OF COLLISIONLESS TEARING INSTABILITIES.** Using oscillation center formalism the electron kinetic response to high frequency fields is derived. Only the non-resonant interaction is renormalized. It is shown that this can lead to a reduction of the growth rates of  $m \geq 2$  collisionless tearing modes. (Author abstract) 25 refs.

Avinash (Euratom/UKAEA Fusion Associates, Abington, Engl). *Nucl Fusion* v 27 n 12 Dec 1987 p 2131-2138.

**079541 EMISSION-BASED FEEDBACK SYSTEM FOR STABILIZING AN INDUCTIVELY COUPLED PLASMA.** An emission-controlled feedback system for stabilizing an ICP (Inductively Coupled Plasma) has been investigated. Unlike previous stabilization methods which monitor only the power being sent to the plasma, the present one uses an emission signal from either argon or an internal reference element as a stability indicator. Using a previously constructed power-modulation circuit for rf power control, the feedback network adjusts the plasma power to compensate for changes in the emission level of the reference element. It is shown to be particularly useful for reducing or eliminating the drift that occurs when the plasma is warming up. Results with several combinations

of argon, barium, calcium, iron, manganese, sodium, and strontium lines are presented. (Edited author abstract) 10 refs.

Marks, M.A. (Indiana Univ, Bloomington, IN, USA); Hietje, G.M. *Appl Spectrosc* v 42 n 2 Feb 1988 p 277-280.

**079542 TEMPORAL EVOLUTION OF REACTIVE AND RESISTIVE NONLINEAR INSTABILITIES.** A kinetic theory for nonlinear processes involving Langmuir waves, developed in an earlier paper, is extended through consideration of three aspects of the temporal evolution: (i) Following Falk & Tsytovich (1975), the dynamic equation for the rate of change of one amplitude at  $t$  is expressed as an integral over  $\tau$  of the product of two amplitudes at  $t-\tau$  and a kernel function  $f(\tau)$ ; two generalizations of Falk & Tsytovich's form  $f(\tau) \propto \tau$  that satisfy the requirement  $f(\infty)=0$  are identified. (ii) It is shown that the low-frequency or beat disturbance may be described in terms of fluctuations in the electron number density, and that its time evolution involves an operator that is essentially the inverse of  $f(t)$ . (iii) The transition from oscillatory evolution in the reactive or 'coherent-wave' version of the three-wave instability to the secular evolution of the resistive of 'random-phase' version is discussed qualitatively. (Author abstract) 8 refs.

Melrose, D.B. (Univ of Sydney, Sydney, Aust). *J Plasma Phys* v 38 pt 3 Dec 1987 p 473-481.

**079543 STABILITY OF SHORT-AXIAL-WAVELENGTH INTERNAL KINK MODES OF AN ANISOTROPIC PLASMA.** The double adiabatic equations are used to study the stability of a cylindrical Z-pinch with respect to small axial wavelength, internal kink ( $m \geq 1$ ) modes. It is found that marginally (ideally) unstable, isotropic equilibria are stabilized. Also, constant-current-density equilibria can be stabilized for  $P_{\perp} > P_{\parallel}$  and large  $\beta_{z23}$ . (Author abstract) 9 refs.

Faghihi, M. (Royal Inst of Technology, Stockholm, Sweden); Scheffel, J. *J Plasma Phys* v 38 pt 3 Dec 1987 p 495-499.

**079544 FINITE LARMOR RADIUS EFFECTS ON THE STABILITY PROPERTIES OF INTERNAL MODES OF A Z-PINCH.** From the Vlasov-fluid model a set of approximate stability equations describing the stability of a cylindrically symmetric z-pinch is derived. The equations are derived in the limit of small gyroradius and include first order kinetic effects such as finite ion Larmor radius effects and resonant ion effects. Neglecting the resonant ion terms, we explicitly solve this set of equations for a constant current density profile leading to a dispersion relation. FLR effects are shown for the case of  $m = 1$  internal mode to be stabilizing and for large wavenumbers  $k$ , using a trial function approach, absolute stabilization is found. (Author abstract) 24 refs.

Akerstedt, Hans O. (Uppsala Univ, Uppsala, Sweden). *Phys Scr* v 37 n 1 Jan 1988 p 117-130.

**079545 REDUCTION OF RAYLEIGH-TAYLOR GROWTH DUE TO VISCOSITY EFFECTS.** The effect of viscosity on the growth reduction of Rayleigh-Taylor modes is studied. It is shown that short wavelength perturbations are strongly damped; however the growth of the most relevant modes in fusion pellets is nearly unaffected. (Author abstract) 4 refs.

Mulser, P. (Technische Hochschule Darmstadt, Darmstadt, West Ger). *Laser Part Beams* v 6 pt 1 Feb 1988 p 119-120.

**079546 EFFECTS OF BALLOONING INSTABILITY ON TOKAMAK CONFINEMENT.** Using the ballooning-mode transport model proposed by Connor, Taylor & Turner (1984), we derive the thermal conductivity induced by ideal ballooning instability and compare it to experimental observations from auxiliary-heated tokamaks. We show how this model can be improved by means of a finite-beta equilibrium and also apply it to obtain a confinement scaling law for high-beta, purely Ohmically heated tokamaks. Finally, we employ this transport mode

to find that tokamaks with supplemental stabilization, for example due to gyroradius, energetic particle or shaping effects, can self-consistently access the second stability regime at rather high heating power. (Author abstract) 18 refs.

Fu, Guoyong (Univ of Texas at Austin, Austin, TX, USA); Van Dam, J.W. *J Plasma Phys* v 39 n 1 Feb 1988 p 11-25.

**079547 STABILITY OF THE IDEAL  $m=1$  MODE IN A TOKAMAK.** The condition for stability of the ideal  $m=1$  mode in toroidal tokamak geometry is calculated for safety factor profiles which are flattened inside the  $q=1$  surface. It is shown that for such profiles the critical  $\beta_p$  for stability goes to zero as the safety factor on axis approaches unity. The critical  $\beta_p$  may therefore be small enough to explain sawtooth observations on JET. (Author abstract) 8 refs.

Nave, M.F.F. (JET Joint Undertaking, Abingdon, Engl); Wesson, J. *Nucl Fusion* v 28 n 2 Feb 1988 p 297-301.

**079548 INTERCHANGE STABILITY OF NON-CIRCULAR REVERSED FIELD PINCHES.** The interchange (Mercier) stability of toroidal reversed field pinch plasmas with non-circular cross-section has been evaluated numerically. Marginally stable pressure profiles and beta values have been produced. Most shapes, such as indented or vertically elongated, reduce the stability by making the net magnetic curvature of the poloidal field dominated plasmas yet worse than that of circular configurations. The stability of horizontally elongated plasmas is slightly enhanced compared with that of circular plasmas as a result of increased shear produced by toroidicity. This shear enhancement by toroidal shift of magnetic surfaces might be exploited in future, more comprehensive studies. (Author abstract) 7 refs.

Skinner, D.A. (Univ of Wisconsin, Madison, WI, USA); Prager, S.C.; Todd, A.M.M. *Nucl Fusion* v 28 n 2 Feb 1988 p 306-311.

**079549 EFFECTING THE CONDITION OF QUASISTATIONARY THERMONUCLEAR BURNING IN TOKAMAKS WITH A HIGH PLASMA DENSITY.** In the controlled thermonuclear fusion program, tokamaks with a strong magnetic field and high plasma density (Alcator, FT) are important; projects of such tokamaks of the following generations - IGNITOR-A, BCX, and T-14 - are considered. The main advantages of these tokamaks are that the energy losses caused by the heat conduction of the electrons decrease in inverse proportion to the plasma density. Obviously, a high plasma density implies operation on the left (low-temperature) branch of the ignition curve where there is the problem of the stability of thermonuclear burning. The authors analyze in the present work this stability and make numerical one-dimensional calculations of the plasma parameter changes for both unstabilized burning and for stabilized burning with feedback obtained by introducing a timewise modulated additional heating. 8 refs.

Vasil'ev, N.N.; Lukash, V.E.; Mariinskii, M.N.; Nedospasov, A.V. *Sov At Energy* v 63 n 2 Aug 1987 p 661-664.

**079550 SUPERLATTICE OF MICROHETEROGENEITIES IN THE MATERIAL OF A LASER TARGET AND PLASMA STABILITY WITH SPHERICAL COMPRESSION.** The results of experimental investigations of the possibility of increasing the stability of spherical compression of a plasma by creating a superlattice of microheterogeneities inside the wall of a spherical shell target are presented. (Author abstract) 8 refs.

Borisenko, N.G.; Dorogotovtsev, V.M.; Isakov, A.I.; Merkulev, Yu.A.; Mikhailov, Yu.A.; Nikitenko, A.I.; Fedotov, S.I. *Sov Phys Lebedev Inst Rep* n 10 1987 p 10-13.



**079551 STABILIZATION OF THE TARA TANDEM MIRROR PLASMA BY MHD ANCHORS.** The effectiveness of a warm ion and hot electron population in the Tara outboard minimum-B anchors in stabilizing MHD flute-like modes in the central cell and axioids is assessed. With a combination of ECH and ICRF heating in the anchors,  $\beta_{he} > 15\%$  and  $\beta_i$  approximately 0.5% have been obtained. The ICRF component has a generally stabilizing effect on global MHD activity, but the stabilization is not linear in ion beta. Pinhole camera pictures indicate that the hot electron density profile is radially peaked. The resulting creation of a deeper magnetic well for the warm ions was expected to enhance the MHD stabilizing properties of the anchor. However, the addition of hot electron beta to an ICRF heated anchor plasma was observed to have no beneficial effect on MHD stability. (Author abstract). 23 Refs.

Brau, K. (MIT, Cambridge, MA, USA); Golovato, S.; Lane, B.; Casey, J.; Horne, S.; Irby, J.; Kesner, J.; Post, R.S.; Seviliano, E.; Smith, D.K. *Nucl Fusion* v 28 n 5 May 1988 p 759-768.

**079552 KINETIC THEORY OF THE  $m=1$  KINK INSTABILITY IN Z-PINCHES.** The kinetic theory of the  $m=1$  kink instability of a Z-pinch with Bennett profile is presented. The dominant particle trajectories in the equilibrium field are the large excursion betatron orbits. To deal with these orbits, an integral formulation of the stability analysis is adopted. In this case, the dispersion relation is expressed as the determinant of a matrix. In the limit where the electrostatic perturbation is neglected, the eigenmodes are computed numerically from this dispersion relation. Two methods are used to obtain the growth rates, and the computed values agree very well. The Landau damping of the mode is found to be strong enough to stabilize the mode at shorter wavelengths. This may explain the stability of the kink mode in some experiments. (Author abstract). 23 Refs.

Krishnamurthi, U. (Inst for Plasma Research, Gandhinagar, India); Sharma, A.S.; Sen, A. *Nucl Fusion* v 28 n 5 May 1988 p 789-797.

**079553 RESISTIVE BALLOONING STABILITY OF ASDEX EQUILIBRIA.** Experiments on the maximum attainable beta values of ASDEX discharges show that the limits for this parameter lie in the range of theoretical predictions. In a previous publication a theoretical identification of the corresponding instabilities has been attempted. No significant correlation with global plasma instabilities could be found, but the two-dimensional MHD equilibria calculated on the basis of ASDEX experimental parameters turned out to be close to the marginal ideal ballooning limit. In the work presented here, the previous investigation on resistive ballooning modes is extended. (Edited author abstract). 12 Refs.

Zehrfeld, H.-P. (Max-Planck-Inst fuer Plasmaphysik, West Ger); Grassie, K. *Nucl Fusion* v 28 n 5 May 1988 p 891-898.

**079554 TOROIDAL INTERNAL KINK STABILITY IN TOKAMAKS WITH ULTRA FLAT  $q$  PROFILES.** Linear stability properties of the ideal internal kink mode in toroidal geometry are calculated for equilibria in which the  $q(r)$  profile is very flat and  $q \approx 1$  in the core region of the plasma. Marginal stability criteria and growth rates are calculated analytically in the large aspect ratio limit and compared with numerical results from the FAR code. The theory is developed for  $m=n=1$  modes and for higher  $m(=n)$  modes. The temperature perturbation due to adiabatic expansion in the linear phase of the  $1/1$  mode is calculated and compared with experimental data, showing that the predictions from ideal MHD theory cannot account for the observed temperature increase on JET. Comparison with collisionless theory suggests that the observed temperature increases can be accounted for by compression of the trapped particles. (Author abstract). 17 Refs.

Hastie, R.J. (Euratom-UKAEA Fusion Assoc, Abingdon, Engl); Hender, T.C. *Nucl Fusion* v 28 n 4 Apr 1988 p 585-594.

**079555 OBSERVATION OF TILT STABILITY OF FIELD REVERSED CONFIGURATIONS AT LARGE  $s$ .** Experiments were carried out on the TRX field reversed theta pinch in which  $s$ , the number of ion gyroradii between the magnetic null and the separatrix of a field reversed configuration, was increased significantly compared with previous experiments where  $s \leq 2$ . Sustained values of  $s > 4$  were obtained in hydrogen discharges with configuration lifetimes as long as twenty tilt growth times, where the calculated growth rate reduction due to ion kinetic effects has been accounted for. (Author abstract). 18 Refs.

Slough, J.T. (Spectra Technology Inc, Bellevue, WA, USA); Hoffman, A.L. *Nucl Fusion* v 28 n 6 Jun 1988 p 1121-1125.

**079556 LARGE  $m=3n=1$  LOCKED MODE IN JT-60 AND ITS STABILIZATION.** An  $m=3/n=1$  locked mode has been observed in JT-60 at safety factors slightly below three during the current ramp-up phase of high plasma current discharges. The locked mode grows suddenly and there is no Mirnov oscillation just before the onset of this mode. The maximum plasma current of Ohmic discharges is restricted to approximately 2.4-2.45 MA by disruptions, which are preceded by a large  $m=3/n=1$  locked mode. The locked mode is stabilized by high power neutral beam injection. The stabilizing effect depends on neutral beam heating power, plasma density, plasma current ramp-up rate and divertor/limiter configuration. (Author abstract). 8 Refs.

Ninomiya, H. (JAERI, Naka-gun, Jpn); Itami, K.; Neyatani, Y.; Naito, O.; Yoshino, R. *Nucl Fusion* v 28 n 7 Jul 1988 p 1275-1281.

**079557 OBSERVATION OF POTENTIAL RELAXATION INSTABILITY IN A BOUNDED DISCHARGE PLASMA.** A potential relaxation instability (PRI), which causes a periodic motion of a potential jump and plasma expansion accompanying a high-density fluctuation level ( $\approx 60\%$ ), is observed in a bounded discharge plasma. The instability is found to create a high electron-drift velocity and a spatial growth of density and potential fluctuations, and to accelerate a test wave. An additional injection of a plasma into the boundary suppresses the instability. At the same time, the fluctuation decreases ( $< 5\%$ ) and the frequency difference of the wave spectrum between  $n$ th and  $(n-1)$ th ( $n$  is an integer) higher harmonics decreases as the frequency increases. However, when the potential relaxation instability is excited, this frequency difference remains constant. 22 refs.

Fujita, Hiroharu (Saga Univ, Saga, Jpn); Yagura, Shinya; Harada, Tatsuya; Matsuo, Hisao. *IEEE Trans Plasma Sci* v PS-15 n 4 Aug 1987 p 445-451.

**079558 COMPRESSIONAL EFFECTS ON DRIFT-RESISTIVE INSTABILITIES IN GENERAL TOROIDAL PLASMA.** The drift-resistive modes in general toroidal geometry are studied analytically and numerically. The effects of ion acoustic couplings, ion polarization drift, and perpendicular resistivity are included. These effects can completely stabilize the drift-resistive modes. The perpendicular resistivity is effective mainly in stabilizing the drift interchange modes, while the ion-acoustic couplings are the dominant mechanism for the stabilization or the drift-tearing modes. From the ion polarization drift effects of the perpendicular compression, the critical value of magnetic  $\Delta_c$  saturates for a moderate diamagnetic drift frequency region. The favorable average curvature is a stabilizing factor for the drift-tearing modes with  $\Delta' < \Delta_c$ , but an instability from unfavorable curvature exists in the semicollisional region, even for  $\Delta' < 0$ . 19 refs.

Cho, Guang-Sup (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Choi, Eun-Ha; Choi, Duk-In. *IEEE Trans Plasma Sci* v PS-15 n 4 Aug 1987 p 452-459.

**079559 AXIAL FEEDBACK STABILIZATION OF FLUTE MODES FOR MIRROR MACHINES.** A novel

scheme of feedback stabilization of the  $m=1$  flute mode for axisymmetric mirror machines is proposed that has potential for reactor extrapolation. A three-region plasma model is analyzed, consisting of a hot core surrounded by a warm transition annulus, which in turn is surrounded by a warm halo annulus that is in contact with segmented annular feedback plates at the two end walls. For plasma parameters characteristic of the TMX-U and MFTF-B devices at the Lawrence Livermore National Laboratory and the MMX device at the University of California, Berkeley, the required feedback power is calculated. The results show that stability can be achieved in the MMX and TMX-U devices with a modest feedback gain and power. The power requirement for the near-reactor conditions of MFTF-B is more severe, but can be reduced by a modified choice of plasma parameters. 23 refs.

Kang, B.K. (Univ of California, Berkeley, CA, USA); Lieberman, M.A.; Sen, A.K. *IEEE Trans Plasma Sci* v 16 n 1 Feb 1988 p 27-38.

## Surfaces

**079560 COMPUTER SIMULATION OF THE DYNAMICS OF PLASMA-SURFACE INTERACTIONS IN VACUUM ARC CATHODE SPOTS.** The theory of the vacuum arc cathode spot is reviewed, covering the E-diagram method as well as advanced nonstationary cathode spot models. The cathode spot model used for the computer simulation is described in detail. The simulation results show that within the model assumptions, a steady-state self-sustaining cathode spot does not exist. On the one hand, plasma-wall interactions with steady-state thermal equilibrium exist below the balance conditions of mass and energy, while on the other hand, real cathode spots that meet the requirements of both mass and energy balance never show thermal equilibrium but are characterized by thermal runaway. Therefore, instability is an inherent feature of cathode spots. Computational values and representative experimental results for cathode spot characteristics show a rather good agreement, further supporting the validity of the model. 36 refs.

Mitterauer, J. (Technical Univ Wien, Austria); Till, P. *IEEE Trans Plasma Sci* v PS-15 n 5 Oct 1987, XIIth Int Symp on Discharges and Electr Insul in Vac, Shores, Isr, Sep 22-25 1986 p 488-501.

## Switching

**079561 PLASMA OPENING SWITCH DEVELOPMENT FOR THE PARTICLE BEAM FUSION ACCELERATOR II (PBFA II).** Plasma opening switch (POS) experiments have been conducted on Sandia National Laboratories' Particle Beam Fusion Accelerator II (PBFA II) (12 MV, 100 TW, 50 ns), on the Supermite accelerator (2 MV, 2 TW, 50 ns) and on the US Naval Research Laboratory's Gamble II accelerator (1.8 MV, 1.6 TW, 70 ns). In the Supermite experiments, the POS conducted currents of up to 1 MA before opening in less than 10 ns into an electron beam load. These experiments achieved significant voltage gain relative to the voltage across a matched load. In experiments on Gamble II, power gains of up to 1.7 were achieved using a POS in a strongly coaxial geometry with a large magnetic field at the cathode. The POS system on PBFA II is unique because of its size and voltage. This POS system is designed to conduct over 6 MA before opening. Experiments are presented in which it has conducted currents of 4-5 MA for over 50 ns. 17 refs.

Stinnett, R.W. (Sandia Natl Lab, Albuquerque, NM, USA); McDaniel, D.H.; Rochau, G.E.; Moore, W.B.; Gray, E.W.; Renk, T.J.; Woodall, H.N.; Hussey, T.W.; Payne, S.S.; Commisso, R.J.; Grossmann, J.M.; Hinshelwood, D.D.; Meger, R.A.; Neri, J.M.; Oliphant, W.F.; Ottinger, P.F. *IEEE Trans Plasma Sci* v PS-15 n 5 Oct 1987, XIIth Int Symp on Discharges and Electr Insul in Vac, Shores, Isr, Sep 22-25 1986 p 557-563.



**079562 LOW-JITTER LASER-TRIGGERED VACUUM SWITCH USING A COMPOSITE TARGET.** A laser-triggered high-voltage vacuum switch with a composite KCl/Ti target pellet is described. The switch triggers reliably for 532-nm laser input energies of 20  $\mu$ J corresponding to a peak irradiance of 1 MW/cm<sup>2</sup>. Jitter times of less than  $\pm 15$  ns and delay times of less than 100 ns are observed. Several experiments were performed to explore the operation of the switch. It was found that the amount energy needed to trigger the switch and the jitter time was strongly dependent on the position of the pellet relative to the cathode. It is noted that the mechanism responsible for the operation of the switch is not completely understood. 12 refs.

Brannon, P.J. (Sandia Natl Lab, Albuquerque, NM, USA); Cowgill, D.F. *IEEE Trans Plasma Sci* v 16 n 2 Apr 1988 p 325-327.

## Temperature Measurement

**079563 TAKING INTO ACCOUNT THE RADIATION FROM THE CHANNEL WALLS IN OPTICAL MEASUREMENT OF THE TEMPERATURE OF SOLID-FUEL COMBUSTION-PRODUCT PLASMA.** A model of the method of spectral-line reversal (emission-absorption method) for measuring the temperature of a plasma with a condensed phase taking into account the scattering of radiation by the channel walls is studied. An approximate analytical solution is obtained for the problem of radiation transfer for a layer of absorbing and scattering medium, bounded by emitting walls. It is shown that the corresponding correction reduces the measured temperature and depends strongly on the geometry of the system. (Author abstract) 8 refs.

Vladimirov, V.I. (OP Energotekhnika, USSR); Gorshkov, Yu.A.; Krymasov, A.V. *High Temp* v 25 n 3 May-Jun 1987 p 444-452.

**079564 COMPARATIVE STUDY OF ROTATIONAL TEMPERATURES IN A MICROWAVE PLASMA: OH RADICAL VERSUS  $N_2^+$ .** A rotational temperature comparative study of OH radical vs.  $N_2^+$  was carried out on a low-power helium microwave-induced plasma. Under the prevailing conditions,  $N_2^+$  was found to provide twice as many usable lines for temperature measurement than did hydroxyl radical. For the particular torch design used, both species exhibited slightly increasing rotational temperatures at low flow rates. At fixed conditions, OH consistently indicated higher rotational temperatures than those of the molecular nitrogen ion. Positional studies revealed a slightly increasing temperature near the center of the plasma. (Edited author abstract) 18 refs.

Workman, John M. (Univ of Cincinnati, Cincinnati, OH, USA); Fleitz, P.A.; Fannin, Harry B.; Caruso, Joseph A.; Seliskar, C.J. *Appl Spectrosc* v 42 n 1 Jan 1988 p 96-100.

**Theory** See Also MATHEMATICAL TECHNIQUES—Differential Equations; PROTECTIVE COATINGS—Plasma Spraying; TOKAMAK DEVICES—Design.

**079565 ESTABLISHMENT OF DEBYE POTENTIAL IN A SLIGHTLY NONIDEAL PLASMA.** A multiparticle dynamic method is used to investigate the dependence of the time correlation functions of micropotential on the parameters of a plasma. It is shown the Debye potential is the result of averaging in an interval of time which exceeds the time for covering the mean interparticle distance. In this case the concept of the Debye potential retains its sense even if on the average less than a single particle is located in the Debye sphere. (Author abstract) 3 refs.

Maierov, S.A.; Tkachev, A.N.; Yakovlenko, S.I. *Sov Phys Lebedev Inst Rep* n 12 1987 p 44-46.

**079566 ELECTRON CYCLOTRON ABSORPTION FOR OBLIQUE PROPAGATION IN LOSS-CONE PLASMAS.** The components of the dielectric tensor for a plasma described by a relativistic loss-cone electron distribution are written in a simple way, which takes full account of relativistic effects, harmonics and Larmor

radius, for perpendicular and oblique propagation. For sufficiently oblique propagation and temperatures in the thermonuclear range, a still simpler form of the dielectric tensor is derived. The role of the wave parameters in the absorption is discussed, and some comments are made about the weakly relativistic and non-relativistic approaches. A numerical example is given for both the extraordinary and ordinary modes. (Author abstract). 28 Refs.

Ziebell, L.F. (Univ Federal do Rio Grande do Sul, Porto Alegre, Braz). *J Plasma Phys* v 39 n 3 Jun 1988 p 431-446.

**079567 ON THE EFFECT OF LANDAU DAMPING IN A RELATIVISTIC ELECTRON ACOUSTIC PLASMA.** We have considered the effect of damping generated due to streaming electrons in a relativistic electron plasma. It is observed that due to the relativistic effect the amplitude of the soliton gets smaller and it becomes more widened. But for a high-temperature electron plasma, the effect is not considerable. The KdV equation with the damping term is solved via the Bogoliubov-Krylov perturbation theory, whence the amplitude and width of the soliton are expressed in terms of the parameters of the plasma. Lastly we discuss how higher order effects can be incorporated. (Author abstract). 17 Refs.

Chowdhury, A.Roy (Jadavpur Univ, Calcutta, India); Pakira, Govinda; Paul, S.N. *Physica B & C* v 151 n 3 Aug-I 1988 p 518-526.

## Thermal Conductivity

**079568 THERMAL CONDUCTIVITY OF THE CLASSICAL ONE-COMPONENT PLASMA BY NONEQUILIBRIUM MOLECULAR DYNAMICS.** We extend the Evans-Gillan algorithm for the calculation of the thermal conductivity by nonequilibrium molecular dynamics, introduced for systems with short-range interactions, to the case of the classical one-component plasma. Excellent agreement between NEMD and EMD results is obtained. (Author abstract) 17 refs.

Pierleoni, C. (Univ La Sapienza, Rome, Italy); Ciccotti, G.; Bernu, B. *Europhys Lett* v 4 n 10 Nov 15 1987 p 1115-1120.

## Thermodynamic Properties

**079569 CALCULATION OF SOME THERMODYNAMIC PROPERTIES OF AIR PLASMAS: INTERNAL PARTITION FUNCTIONS, PLASMA COMPOSITION, AND THERMODYNAMIC FUNCTIONS.** The thermodynamic properties of air plasmas are calculated in the framework of the C.L.T.E. hypothesis, for pressures varying from 1 to 200 atm, in a temperature range from 1000 to 30,000 K. In these calculations, the neutral mono-, di-, and triatomic species, as well as their positive and negative ions, are taken into account. From the internal partition function values, the plasma compositions and the thermodynamic functions (specific enthalpy, Gibbs and Helmholtz free energies and entropy) are calculated. (Author abstract) 23 refs.

Bacri, J. (CNRS, Toulouse, Fr); Raffanel, S. *Plasma Chem Plasma Process* v 7 n 1 Mar 1987 p 53-87.

**079570 DISTURBANCE OF LOCAL THERMAL EQUILIBRIUM IN AN ELECTRIC-ARC ARGON PLASMA.** Calculations of the characteristics of electric arcs made by a two-temperature model revealed the role of the nonequilibrium properties of the transfer and reabsorption of radiation in the process of establishment of a single temperature in the system, and they showed that the characteristics of an argon electric-arc plasma at  $P = 0.1$  MPa can be calculated from the LTE model if the currents are higher than 10 A. At a pressure of 0.01 MPa the two-temperature model of the plasma must be used for such calculations, regardless of the current strength, at least in the investigated range of arc parameters. 12 refs.

Panasenko, L.N. (Acad of Sciences of the Byelorussian SSR, Minsk, USSR); Sevast'yanenko, V.G. *J Eng Phys* v 52 n 4 Apr 1987 p 442-447.

## Thin Films

**079571 CORRELATIONS ENTRE LA NATURE DU PLASMA DE DECHARGE ET LES CARACTERISTIQUES METALLURGQUES DES DEPOTS DE COMPOSES METALLIQUES REFRACTAIRES DANS LES SYSTEMES DE DEPOTS IONIQUES.** [Correlations within the Nature of Discharge Plasma and Metallurgical Characteristics of Deposition of Refractory Metallic Depositions in the Systems of Ionic Depositions]. In order to obtain a good correlation between the nature of the plasma present in the VPD and ion plating systems and metallurgical properties of thin films, the problem of the reproducibility of the measurements has been studied. For the high deposition rate apparatus (more than 1 gram per hour), one can observe a very important and fast evolution of the physical nature of the system with running time. This evolution is connected to the variations of the physical parameters of the deposition system which can be connected to the spectroscopic observations and to the analysis of the coating. For example, the evolution of the deposition rate can be characterized by the running parameters with the spectroscopic measurement of the metallic specimen density. (Edited author abstract) 7 refs. In French.

Dupont, L. (ETCA CMCM/SM, Arcueil, Fr); Degout, D.; Farges, G. *Vide Couches Minces* v 41 n 230 Jan-Feb 1986, C R des Journ d'Etude sur les Depots Ioniques, Limoges, Fr, Sep 25-26 1985 p 55-59.

**Torches** See STEELMAKING—Plasma Arc Remelting.

**Transport Properties** See Also ELECTRIC ARCS; TOKAMAK DEVICES—Computer Simulation.

**079572 TRANSPORT ANALYSIS OF INJECTED IMPURITIES IN CURRENTLESS HELIOTRON E PLASMAS.** Impurity transport in currentless Heliotron E plasmas is examined. The main aim of the experiment is to clarify the density dependence of impurity transport both in electron cyclotron heated (ECH) and neutral beam injected (NBI) plasmas. In experiments with a stationary electron density, the confinement time of impurities is determined as a function of the line averaged electron density. The inherent difference between ECH and NBI plasmas, observed in an earlier measurement, seems to have been masked by the operating conditions. From a direct comparison between NBI plasmas and simultaneous ECH and NBI heated plasmas of the same density, a pumping-out effect of impurities by the ECH pulse is established. (Edited author abstract) 25 refs.

Kaneko, H. (Kyoto Univ, Uji, Jpn); Kondo, K.; Motojima, O.; Zushi, H.; Mizauchi, T.; Sudo, S.; Besshou, S.; Sato, M.; Okada, H.; Takeiri, Y.; Sano, F.; Mutoh, T.; Obiki, T.; Iiyoshi, A.; Uo, K.; Rice, J.E. *Nucl Fusion* v 27 n 7 Jul 1987 p 1075-1090.

**079573 GLOBAL PARTICLE CONFINEMENT IN THE TEXAS EXPERIMENTAL TOKAMAK.** Particle transport in an ohmically heated tokamak plasma was investigated in the Texas Experimental Tokamak (TEXT). Spectroscopic measurements of the electron source were used with electron density measurements to derive particle confinement times from the continuity equation. Scalings were developed for particle confinement time with electron density, plasma current, toroidal field, and plasma positioning. Simultaneous measurement of electrostatic fluctuations with Langmuir probes may suggest a correlation between edge particle transport in TEXT and electrostatic turbulence. In addition, two major features of transport were isolated. (Edited author abstract) 26 refs.

Rowan, W.L. (Univ of Texas at Austin, Austin, TX, USA); Klepper, C.C.; Ritz, C.P.; Bengtson, R.D.; Gentile, K.W.; Phillips, P.E.; Rhodes, T.L.; Richards, B.; Wootton, A.J. *Nucl Fusion* v 27 n 7 Jul 1987 p 1105-1118.



**079574 ON STEADY-STATE CLASSICAL TRANSPORT IN COLLISION-DOMINATED TOROIDAL SYSTEMS.** Starting from classical transport theory, equations for particle density, particle momentum and electron and ion temperatures are derived for steady-state, toroidal plasma configurations in a parameter regime like that of ACT-I. A set of simplified equations for particle density and electron and ion temperatures are solved numerically. Radial density and temperature profiles are shown and compared with experiments. (Author abstract) 6 refs.

Oien, Alf H. (Dep of Applied Mathematics, Bergen, Norw.). *J Plasma Phys* v 38 pt 2 Oct 1987 p 245-262.

**079575 NEOCLASSICAL RESONANT PLATEAU TRANSPORT CALCULATION IN AN EFFECTIVELY AXISYMMETRIZED TANDEM MIRROR WITH FINITE ENDPLATE RESISTANCE.** Calculations are made for neoclassical resonant plateau transport in the geometry of the effectively axisymmetrized tandem mirror GAMMA 10 magnetic field, which has minimum B inboard anchors inside the axisymmetric plug/barrier mirror cells. Azimuthal drifts in the local, non-axisymmetric regions are included. The radial potential profile is determined by solving the charge neutrality equation self-consistently. A finite resistance connecting the end plate to the machine ground provides appropriate boundary conditions on the radial electrostatic potential distribution so that it can be determined uniquely. The calculation is consistent with experimental results of GAMMA 10. (Author abstract) 23 refs.

Katanuma, I. (Univ of Tsukuba, Ibaraki, Jpn); Kiyamoto, Y.; Adachi, S.; Inutake, M.; Ishii, K.; Yatsu, K.; Sawada, K.; Miyoshi, S. *Nucl Fusion* v 27 n 12 Dec 1987 p 2041-2053.

**079576 MODELLING OF PELLET INJECTION EXPERIMENTS WITH ONSAGER-SYMMETRIC TRANSPORT RELATIONS.** The formalism of non-equilibrium thermodynamics is applied to the problem of radial transport in tokamak plasmas. Phenomenological relations between generalized forces and fluxes, consistent with the empirical Alcator scaling, are suggested. A simple 1-D transport model incorporating these relations is shown to reproduce the salient features of recent pellet injection experiments on Alcator-C; a drop in the central temperature preceding pellet penetration, rapid ( $< 1$  ms) peaking of the density profile, a marked rise in the energy confinement time immediately following injection and persistence of the state of high confinement and peaked density for a time longer than the initial confinement time. The same model reproduces a saturation of Alcator scaling when the density profile becomes that, as is observed in high density, edge fuelled Alcator-C discharges. (Author abstract) 17 refs.

O'Rourke, J. (JET Joint Undertaking, Abington, Engl). *Nucl Fusion* v 27 n 12 Dec 1987 p 2075-2083.

**079577 DETERMINATION OF AMBIPOLAR RADIAL TRANSPORT FROM THE PARTICLE BALANCE IN THE TMX-U TANDEM MIRROR.** Ambipolar radial transport (equal ion and electron flux) is not directly measured in tandem mirror experiments because the particle flow does not produce a net electrical current. The first absolute measurements of the ionization source in the tandem mirror experiment upgrade (TMX-U) plasma have been obtained. These have permitted the determination of magnitude of ambipolar radial transport from the particle balance. Furthermore, comparisons of the source measurements with a Monte Carlo neutral transport code have shown reasonable agreement. Measurements of the particle balance under several operating conditions are presented. For some of these cases, the ambipolar radial transport is smaller than the other measured losses. (Author abstract) 26 refs.

Allen, S.L. (Lawrence Livermore Natl Lab, Livermore, CA, USA); Correll, D.L.; Hill, D.N.; Kaiser, T.B.; Heifetz, D.B. *Nucl Fusion* v 27 n 12 Dec 1987 p 2139-2152.

**079578 KINETIC AND TRANSPORT THEORY FOR A NON-NEUTRAL PLASMA TAKING ACCOUNT OF STRONG GYRATION AND NON-UNIFORMITIES ON THE COLLISIONAL SCALE.** From the BBGKY equations for a pure electron plasma a derivation is made of a collision integral that includes the combined effects of particle gyration in a strong magnetic field and non-uniformities of both the distribution function and the self-consistent electric field on the collisional scale. A series expansion of the collision integral through the distribution function and the electric field on the collisional scale is carried out to third order in derivatives of the distribution function and to second order in derivatives of the electric field. For the strong-magnetic-field case when collision-term contributions to only first order in  $1/B$  are included, a particle flux transverse to the magnetic field proportional to  $1/B^2$  is derived. The importance of long-range collective collisions in this process is shown. The result is in contrast with the classical  $1/B^4$  proportionality, and is in accordance with earlier studies. (Author abstract) 9 refs.

Oien, Alf H. (Univ of Bergen, Norw.). *J Plasma Phys* v 38 pt 3 Dec 1987 p 351-371.

**079579 TRANSPORT SIMULATION OF A FIELD-REVERSED CONFIGURATION PLASMA.** A numerical simulation of the evolution of a field-reversed configuration (FRC) plasma is described. The calculation proceeds by alternating between a two-dimensional axisymmetric equilibrium calculation and a one-dimensional transport calculation. The equilibrium calculation uses flux-surface coordinates and finite elements. The transport calculation consists of the simultaneous solution of three one-dimensional equations for the differential ion density, electron entropy, and ion entropy. The transport calculation includes classical transport processes, loss on open field lines, radiation cooling due to impurities, and lower hybrid drift anomalous transport. Examples of FRC simulations are presented. (Author abstract) 25 refs.

Shumaker, D.E. (Lawrence Livermore Natl Lab, Livermore, CA, USA). *Fusion Technol* v 13 n 4 May 1988 p 555-576.

**079580 ANOMALOUS TRANSPORT EFFECTS OF THE NEOCLASSICAL MODEL FOR THE H-MODE TRANSITION.** The influence of enhanced ('anomalous') thermal transport on the neoclassical picture for confinement near the separatrix of a divertor tokamak is investigated. When such transport is taken into account, it is found that the beneficial effects associated with single-null configurations, where the ion grad-B drift direction is towards the x-point, can still persist under realistic conditions. (Author abstract) 11 refs.

Tang, W.M. (GA Technologies Inc, San Diego, CA, USA); Hinton, F.L. *Nucl Fusion* v 28 n 3 Mar 1988 p 443-447.

**079581 BALDUR: A ONE-DIMENSIONAL PLASMA TRANSPORT CODE.** A version of the BALDUR plasma transport code which calculates the evolution of plasma parameters is documented. This version uses an MHD equilibrium which can be approximated by concentric circular flux surfaces. Transport of up to six species of ionized particles, of electron and ion energy, and of poloidal magnetic field is computed. A wide variety of source terms are calculated including those due to neutral gas, fusion and auxiliary heating. The code is primarily designed for modeling tokamak plasmas. (Author abstract) 52 refs.

Singer, C.E. (Princeton Univ, Princeton, NJ, USA); Post, D.E.; Mikkelsen, D.R.; Redi, M.H.; McKenney, A.; Silverman, A.; Seidl, F.G.P.; Rutherford, P.H.; Hawryluk, R.J.; Langer, W.D.; Foote, L.; Heifetz, D.B.; Houlberg, W.A.; Hughes, M.H.; Jensen, R.V.; Lister, G. *Comput Phys Commun* v 49 n 2 May 1988 p 275-398.

**079582 STANDARD TEST CASES FOR THE BALDUR TRANSPORT CODE.** Fourteen test cases have been developed to benchmark the BALDUR code. This report documents these test cases and results of simulations

run with BALDUR version BALDP47M (March 1986). Five of the test cases are based on analytical solutions of the diffusion equations. The analytical test cases check the accuracy of the numerical simulation of particle diffusion as well as energy convection and conduction. Additional benchmark cases were developed to exercise the four impurity capabilities of BALDUR, especially the neutral impurity influx model; and the semiempirical formulation of transport coefficients, and to document BALDUR's simulation of specific tokamaks. Most of the cases were verified by comparison with the test cases run with version BALDP17M. 3 refs.

Redi, Martha H. (Princeton Univ, Princeton, NJ, USA). *Comput Phys Commun* v 49 n 2 May 1988 p 399-407.

**079583 DEVELOPMENT OF A TWO-DIMENSIONAL FLUID CODE AND ITS APPLICATION TO THE DOUBLET III DIVERTOR EXPERIMENT.** A two-dimensional time dependent fluid code has been developed for transport processes in the edge plasma of a tokamak, coupled with a Monte Carlo method for neutral gas behavior. The code employs a particle-in-cell method for the numerical solution of fluid equations. A simulation of the Doublet III divertor experiment has been performed with this code. It has been confirmed that the radial profiles of temperature and density in the scrape-off and divertor region can be simulated fairly well. (Author abstract) 30 Refs.

Ueda, N. (Mitsubishi Atomic Power Industries Inc, Tokyo, Jpn); Kasai, M.; Tanaka, M.; Sugihara, M.; Sengoku, S. *Nucl Fusion* v 28 n 7 Jul 1988 p 1183-1193.

**Turbulence** See Also MAGNETOHYDRODYNAMICS—Spectrum Analysis; PLASMA DEVICES—Guns.

**079584 SOME REMARKS ON SPONTANEOUS MAGNETIC FIELD GENERATION AND THE NON-LINEAR DYNAMICS OF A LANGMUIR PLASMA.** It is shown that, in the hydrodynamic approximation, the spontaneous generated magnetic field does not act directly on the development of Langmuir plasma turbulence. It is shown that besides the magneto-modulational effects, it is necessary to take into account the purely relativistic effect, i.e. the dependence of the electron mass on velocity. In most cases the contribution of this relativistic effect prevails over the spontaneous magnetic field contribution to the development of the modulational instability of HF waves. (Author abstract) 15 refs.

Berezhiani, V.I. (Acad of Sciences of the Georgian SSR, Tbilisi, USSR); Tskhakaya, D.D.; Auer, G. *J Plasma Phys* v 38 pt 1 Aug 1987 p 139-153.

**079585 CHARACTERIZATION OF TOKAMAK EDGE TURBULENCE BY FAR-INFRARED LASER SCATTERING AND LANGMUIR PROBES.** The spectra, magnitude and spatial distribution of low-frequency density fluctuation have been measured by two independent experimental methods in the edge plasma of the TEXT tokamak. Good agreement between far-infrared laser scattering and Langmuir probe measurements has been achieved and the strengths of each technique are evaluated. Langmuir probes are used to directly determine the particle flux induced by edge fluctuations and collective Thomson scattering permits an extension of these observations to the plasma interior. Results are presented for typical discharge conditions in a tokamak. (Edited author abstract) 26 refs.

Ritz, C.P. (Univ of Texas at Austin, Austin, TX, USA); Brower, D.L.; Rhodes, T.L.; Bengtson, R.D.; Levinson, S.J.; Luhmann, N.C. Jr.; Peebles, W.A.; Powers, E.J. *Nucl Fusion* v 27 n 7 Jul 1987 p 1125-1134.

**079586 TOWARDS A THEORY OF INSTABILITY OF A TURBULENT PLASMA.** In conditions of the new hydrodynamics which qualitatively differ from the normal and are characterized by paired collisions, it follows that the anomalous transfer and anomalous redistribution of heat leads to a new hydrodynamic instability of the



potential type with which there is oscillation of the perturbations at a frequency close to the frequency of ionic sound. This report shows the possibility of another hydrodynamic instability which is responsible for the rise in perturbations at frequencies lower than the ionic-sonic frequency. Conditions are identified at which the state of the plasma is unstable with respect to the oscillation of such perturbations. 4 refs.

Bychenkov, V.Yu.; Silin, V.P. *Sov Phys Lebedev Inst Rep* n 3 1987 p 46-50.

**079587 SPECTRUM, SPATIAL DISTRIBUTION AND SCALING OF MICROTURBULENCE IN THE TEXT TOKAMAK.** Strong asymmetries in the spectrum and magnitude of low frequency ( $\omega \ll \omega_{ci}$ ) density fluctuations in the Texas Experimental Tokamak (TEXT) are described. Microturbulence is investigated under a variety of plasma parameters and a comparison with mixing length theory is made. Broadband fluctuations are observed throughout the plasma cross-section, but they peak at the limiter and possess a strong up-down asymmetry which inverts with reversal of plasma current direction. The spatial distribution of these fluctuations can be dramatically altered by the introduction of a point limiter. Inside the magnetic axis, a large-magnitude quasi-coherent fluctuation is seen to dominate the ubiquitous broadband microturbulence. This type of fluctuation peaks on the midplane. For high density discharges, a distinct ion mode (density fluctuations propagating in the ion diamagnetic drift direction) is observed in the microturbulence spectra. Onset of the ion feature occurs at plasma densities where a clear saturation is evident in the global energy confinement time. (Edited author abstract) 40 refs.

Brower, D.L. (Univ of California at Los Angeles, Los Angeles, CA, USA); Peebles, W.A.; Luhmann, N.C. Jr. *Nucl Fusion* v 27 n 12 Dec 1987 p 2055-2073.

**079588 TURBULENT FLUCTUATIONS AND CONFINEMENT IN JET.** High frequency fluctuations are observed in JET by edge magnetic probes and arrays of visible radiation detectors even in the absence of Mirnov activity (typical frequency: approximately 1 kHz); cross-correlation techniques are applied in order to study the broadband activity. Magnetic fluctuations ( $b \approx 2$ ) in the range 1 to 20 kHz are strongly correlated along a direction parallel to the edge magnetic field lines; above approximately 10 kHz, a substantial fraction of these fluctuations (30-60%) have low wavenumbers ( $m \leq 5$ ,  $n \approx 1$ ). Fluctuations in visible radiation coming from the edge are detected by soft x-ray diodes (without absorptive foil) up to approximately kHz: correlation analysis indicates the presence of rather high  $m$  numbers ( $m$  approximately 10-100) with a correlation time of  $\tau_c$  approximately 100  $\mu$ s. This type of activity is also seen by the magnetic probes and a good correlation between the two diagnostics is observed. (Author abstract) 29 refs.

Malacarne, M. (JET Joint Undertaking, Abingdon, Engl); Duprex, P.A. *Nucl Fusion* v 27 n 12 Dec 1987 p 2113-2130.

**079589 MEASUREMENTS OF EDGE TURBULENCE WITH LANGMUIR PROBES IN CURRENTLESS HELIOTRON E PLASMAS.** A study of microscopic fluctuations of density  $n$  and  $\phi$  in the scrape-off layer has been performed. The frequency spectra of  $n$  and  $\phi$  show a strongly turbulent character, as observed in many tokamaks. The fluctuation levels of  $n$  and  $\phi$  are consistent with predictions based on non-linear collisional drift wave models. The line average density and heating power dependences of  $n$  and  $\phi$  are studied in two types of currentless plasma, namely electron cyclotron resonance heating plasmas and neutral beam injection heating plasmas. Their parametric dependences are compared with the trends of the energy confinement time. Finite beta effects on  $\phi$  and  $n$  are also discussed. (Author abstract) 39 refs.

Zushi, H. (Kyoto Univ, Kyoto, Jpn); Mizuuchi, T.; Motojima, O.; Wakatani, M.; Sano, F.; Sato, M.; Iiyoshi, A.; Uo, K. *Nucl Fusion* v 28 n 3 Mar 1988 p 433-441.

**079590 ANGULAR DISTRIBUTION OF PULSATIONS OF AN IONIC-SONIC TURBULENCE IN A PLASMA.** Regularization of the Rudakov-Korabely feature in angular distribution is determined with low values of the Knudsen turbulence number and in the absence of a regularizing turbulence from the resonant ions. (Author abstract) 8 refs.

Silin, V.P. *Sov Phys Lebedev Inst Rep* n 10 1987 p 77-80.

**Vacuum Applications** See Also SEMICONDUCTOR MATERIALS—Processing.

**079591 XIITH INTERNATIONAL SYMPOSIUM ON DISCHARGES AND ELECTRICAL INSULATION IN VACUUM.** This issue contains 21 conference papers dealing with various aspects of vacuum discharge plasmas. In the most common form of vacuum discharge, namely, the vacuum arc, the plasma consists of evaporated and ionized electrode material, with plasma generation typically not uniform over all boundary surfaces, but tending to concentrate in a characteristic manner at selected surfaces, and defining a variety of arc modes, like cathode and anode spot arcs. Various properties of plasmas and the utilization of vacuum discharges in a wide spectrum of technological applications are considered, including switching, thin film deposition, ion and plasma sources, metal refining, X-ray generation, isotope separation and spacecraft propulsion. Plasma transport in vacuum arcs and high current vacuum diodes, power frequency vacuum interrupters, nanosecond-speed pulses power devices, and critical phenomena are also discussed. All of the papers are abstracted and indexed separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10793 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Boxman, Raymond L. (Ed.) (Tel Aviv Univ, Faculty of Engineering, Dep of Disciplinary Studies, Tel Aviv, Isr); Goldsmith, S. (Ed.); Ecker, G. (Ed.); Rieder, W. (Ed.); Chatterton, P. (Ed.); Hackam, R. (Ed.). *IEEE Trans Plasma Sci* v PS-15 n 5 Oct 1987, XIth Int Symp on Discharges and Electr Insul in Vac, Shores, Isr, Sep 22-25 1986 p 474-602.

**Wave-Plasma Interactions** See Also ANTENNAS—Optimization; ELECTROMAGNETIC WAVES—Propagation in Plasma; ELECTROMAGNETIC WAVES—Scattering; ELECTRONS—Diffusion; ELECTRONS—Spectrum Analysis; ELECTRONS—Transport Properties; MAGNETOHYDRODYNAMICS—Wave Effects.

**079592 HIGH-POWER (3-MW) LONG-PULSE (3-s) RADIO-FREQUENCY SYSTEM FOR ION CYCLOTRON RESONANCE HEATING EXPERIMENTS ON TEXTOR.** A megajoule ion cyclotron resonance heating (ICRH) experiment was installed on the Torus Experiment for Technology-Oriented Research (TEXTOR) tokamak. The system consists of two independent power lines each designed to generate and launch 1.5 Mw of radio-frequency (rf) power into the machine during a 3-s period in the 25- to 29-MHz frequency range. Each power line consists of the following items: (a) a 1.5-Mw transmitter, (b) a transmission line system, including a two-stub tuner, made of pressurized 155.6-mm (6.125-in.) and 228.6-mm (9-in.) rigid coaxial line components, and (c) an interface linking the transmission line to the antenna of the shielded stripline type placed along the tokamak's hot liner. Details of the line and antenna diagnostics and data acquisition system together with the subsequent impedance characteristic calculations are given. The rf radiation shielding for the ICRH experiment is explained. The control of the rf setup as a TEXTOR subsystem and the generator pulse control and operation modes are outlined. The antenna loading and power limitation in the presence of plasma and the conditioning procedure are discussed. Finally, the new rf system compatible with the toroidal pump limiter Advanced Limiter Test-II is presented. (Author abstract) 27 refs.

Van Oost, G. (Ecole Royale Militaire, Brussels, Belg); Bhatnagar, V.P.; Delvigne, T.; Descamps, P.; Duroid, F.; Koch, R.; Messiaen, A.M.; Pearson, D.I.C.; Vandenplas, P.E.; Vanderstraeten, A.; Van Nieuwenhove, R.; Kohl-

haas, W.; Stickelmann, C.; Cosler, A. *Fusion Technol* v 12 n 3 Nov 1987 p 449-475.

**079593 LIGHT PRESSURE INDUCED MODULATIONS IN A PLASMA.** The modulation of electron densities in a plasma introduced by a standing electromagnetic wave is studied theoretically. The transmissivity of a probe monochromatic wave through the plasma gives, according to the theoretical analysis, 'bands' of stable and unstable regions of frequencies, with properties which are related to Mathieu's or Hill's type equations. (Author abstract) 16 refs.

Ben-Aryeh, Y. (Israel Inst of Technology, Haifa, Isr); Mulser, P.; Hora, H. *Opt Commun* v 64 n 3 Nov 1987 p 269-273.

**079594 PONDEROMOTIVE FORCE NEAR CYCLOTRON RESONANCE.** The ponderomotive force in a magnetized plasma is derived by carrying out the renormalization of wave-particle interactions based on the Vlasov equation. A significant feature of the result is non-singular behaviour at resonance even in the case of perpendicular propagation. This is shown to be related to the onset of the diffusive motion of particles due to the orbit instability near resonance, where the ponderomotive force is eventually small. (Author abstract) 7 refs.

Kono, M. (Kyushu Univ, Fukuoka, Jpn); Sanuki, H. *J Plasma Phys* v 38 pt 1 Aug 1987 p 43-51.

**079595 NON-RELATIVISTIC THERMAL EFFECTS ON PARALLEL-PROPAGATING ION CYCLOTRON WAVES.** We investigate strictly non-relativistic thermal effects on the dispersion of left-handed (LH) ion cyclotron waves (ICW's) with real frequency and complex wave vector, propagating parallel to a uniform ambient magnetic field. Changes to the topology of the cold-plasma dispersion relations in the vicinity of the ion gyrofrequencies are studied in plasmas consisting predominantly of protons with a small admixture of a heavy ion. This work is relevant to theories of ion heating and acceleration in multi-ion plasmas as are found in the solar wind, in solar and stellar flares, and in the Earth's magnetosphere. In particular, strongly species-dependent heating and acceleration can arise from wave-particle interactions between the various ionic species, and ICW's at frequencies near the respective ion gyrofrequencies. These interactions depend critically on the wave dispersion. (Edited author abstract) 17 refs.

Ball, L.T. (Univ of Sydney, Aust). *J Plasma Phys* v 38 pt 1 Aug 1987 p 117-138.

**079596 NUMERICAL ANALYSIS OF ALFVEN CURRENT DRIVE AND PLASMA IMPEDANCE DYNAMICS TAKING INTO ACCOUNT TRANSPORT PROCESSES.** Absorption of radiofrequency (RF) waves within the Alfvén range of frequencies ( $\Omega \leq \omega_{H_i}$ ) and current drive generation by Alfvén waves are studied in a cylindrical plasma column, with particle, heat and magnetic field diffusion processes taken into account. To this end a 1-D numerical code describing RF field propagation, absorption and current drive processes has been developed, with a self-consistent evolution of the plasma parameters. The code structure includes electrodynamic and transport equations that are solved alternately with a 1 ms time order step. Two different regimes have been found in the model, depending on the direction of the RF field rotation. (Edited author abstract) 18 refs.

Sidorov, V.P. (I.N. Vekua Inst of Physics & Technology, Sukhumi, USSR); Nekrasov, F.M.; Komoshvili, K.G.; Elfmov, A.G.; Favorskij, A.P.; Tishkin, V.F.; Dmitrieva, M.V. *Nucl Fusion* v 27 n 9 Sep 1987 p 1411-1420.

**079597 CONVECTIVE INSTABILITY OF ALFVEN ION CYCLOTRON WAVES IN FINITE BETA TURBULENT PLASMAS WITH ANISOTROPIC IONS.** The full dispersion equation for linear Alfvén ion cyclotron waves propagating along a uniform magnetic field in a finite beta turbulent plasma with anisotropic ions is



solved numerically for complex wavenumbers. The influence of a stationary, small scale Langmuir background turbulence on the real part of the wavenumber and the spatial growth rate of the Alfvén ion cyclotron instability is investigated. It is found that the presence of turbulence makes the spatial growth substantial before the wave comes out of a finite length laboratory plasma. The applicability of the results to a tandem mirror machine is discussed. (Author abstract) 11 refs.

Gupta, G.P. (BARC, Bombay, India); Mittal, M.L. *Nucl Fusion* v 27 n 9 Sep 1987 p 1488-1491.

**079598 EXACT AND APPROXIMATE SOLUTIONS TO THE FINITE TEMPERATURE WAVE EQUATION IN A ONE-DIMENSIONAL PERPENDICULARLY STRATIFIED PLASMA.** The sixth order wave equation which results from a finite temperature expansion of the Vlasov equation is solved globally in the ion cyclotron range of frequencies. A perpendicularly stratified, one-dimensional slab plasma is assumed. The diamagnetic drift and the associated anisotropy are included in the unperturbed distribution function to ensure a self-adjoint system. All  $x$ -dependence in the plasma pressure and magnetic field is retained along with the electric field parallel to  $B$ . Thus, Landau damping of the ion Bernstein wave is included self-consistently. (Edited author abstract) 26 refs.

Jaeger, E.F. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Batchelor, D.B.; Weitzner, H. *Nucl Fusion* v 28 n 1 Jan 1988 p 53-72.

**079599 STABILIZATION OF SAWTEETH BY LOWER HYBRID WAVES IN THE ALCATOR C TOKAMAK.** Sawteeth have been suppressed by lower hybrid current drive in high density Alcator C plasmas. The experiments discussed in this paper demonstrate the possibility of decoupling temperature and partially RF driven current profiles in subtle ways. Further studies along these lines may help us to find new and perhaps more efficient ways to stabilize MHD modes in a toroidal plasma (it is estimated that in the present experiments  $I_{RF}/I_{Total} = 0.2$  when stabilization is achieved). Furthermore, these studies help to improve our understanding of the MHD stability of toroidal plasma systems, as well as elucidate the limitations of partially toroidal MHD models compared with fully toroidal MHD codes, which have gained favor in recent studies. 17 refs.

Knowlton, S. (MIT, Cambridge, MA, USA); Porkolab, M.; Takase, Y. *Nucl Fusion* v 28 n 1 Jan 1988 p 99-106.

**079600 ION CYCLOTRON WAVE EFFECTS ON THE ION VELOCITY DISTRIBUTION IN A TANDEM MIRROR.** Experiments have been conducted in the end cells of a tandem mirror to determine the effect of ion cyclotron resonance heating (ICRH) on the ion pitch angle and velocity distribution. An ICRH power of  $2.4 \text{ W} \cdot \text{cm}^{-3}$  was measured to have both a directed and a diffusive velocity space effect on the mirror trapped plasma ions, which have densities of  $(4-6) \times 10^{12} \text{ cm}^{-3}$  and average perpendicular energies of 600-1000 eV. On low energy streaming ions, the ICRH has a directed pitch angle effects which causes a dominant number of the eventually trapped ions to reflect or to mirror near the resonant magnetic field and to generate a sloshing ion like velocity distribution. However, a sloshing ion like axial density profile was not measured. These observations are discussed in the context of RF kick-per-pass and quasi-linear theory. (Edited author abstract) 28 refs.

Ross, S. (Univ of Wisconsin, Madison, WI, USA); Breun, R.A.; Santarius, J.F.; Persing, H.; Scharer, J.E. *Nucl Fusion* v 28 n 1 Jan 1988 p 125-137.

**079601 PLASMA CURRENT STARTUP BY LOWER HYBRID WAVES IN THE JIPP T-IIU TOKAMAK.** In this paper, the authors report on the characteristics of lower hybrid current startup in JIPP T-IIU. In section 2, the experimental conditions are specified. Section 3 describes the global behavior of the RF startup discharge. The detailed behavior is set forth in Section 4. In Section 5, a simple power balance is

discussed. 20 refs.

Toi, K. (Nagoya Univ, Nagoya, Jpn); Ohkubo, K.; Kawahata, K.; Kawasumi, Y.; Matsuo, K.; Noda, N.; Ogawa, I.; Ogawa, Y.; Sato, K.; Tanahashi, S.; Tetsuka, T.; Kako, E.; Hirokura, S.; Taniguchi, Y.; Kitagawa, S.; Hamada, Y. *Nucl Fusion* v 28 n 1 Jan 1988 p 147-156.

**079602 SLIT RADIATOR AT THE EDGE OF AN IMPEDANCE WEDGE IN A UNIAxIAL PLASMA.** A rigorous analytical solution is derived for the problem of the excitation of electromagnetic waves by a magnetic flux source located at the top of a wedge with impedance boundaries. The wedge is placed in a uniaxial anisotropic plasma that has been magnetized transverse to the edge of the wedge direction. (Author abstract) 8 refs.

Bobrovnikov, M.S. (Tomsk State Univ, Siberia, USSR); Fisanov, V.V. *Sov Phys J* v 30 n 5 May 1987 p 438-441.

**079603 THREE WAVE SOLITON INTERACTIONS IN WARM MAGNETIZED PLASMAS.** In the nonlinear interaction between three waves described by coupled-mode equations, the waves interact by continuously transferring energy between themselves, resulting in bounded periodic solutions for the individual wave envelopes. However, when three waves interact with pulse widths sufficiently narrow so that their pulse durations are commensurate with the characteristic time for the interaction, steady state pulse profiles result and the three wave envelopes propagate as solitons. This latter aspect of nonlinear wave propagation is studied. Starting with the couple-mode equations, these soliton solutions are derived and the theory is applied to the nonlinear interactions between upper- and lower-hybrid waves and electron and ion Bernstein modes propagating in a warm magnetized plasma. Half widths for the solitons are calculated together with estimates of their speed of propagation which are computed for some typical laboratory plasmas. (Author abstract) 20 refs.

Turner, John G. (Polytechnic of Central London, London, Engl); Baldwin, Mark. *Phys Scr* v 37 n 4 Apr 1988 p 549-554.

**079604 NONLINEAR ION-ACOUSTIC WAVES IN MULTICOMPONENT PLASMAS.** By applying the reductive perturbation technique to the basic system of equations governing plasma dynamics, a modified Korteweg-de Vries (KdV) equation is derived. The inclusion of nonisothermality, together with its reduction to a small magnitude, yields various interesting characteristics relating to the existence of solitons in multicomponent plasmas that include several ionic species and multiple nonisothermal electrons. The mathematical development shows that a closed relation among the solitons existing in the various plasma arises due to the different magnitude of nonisothermality. (Author abstract) 16 refs.

Das, G.C. (Manipal Univ, Canchipur, India); Karmakar, B. *Can J Phys* v 66 n 1 Jan 1988 p 79-81.

**079605 LOWER HYBRID EXPERIMENTS ON PLT USING GRILLS WITH VARIOUS  $n_{\perp}$  SPECTRAL WIDTHS.** Coupling structures for lower hybrid current drive experiments have, until now, been smaller than a free space wavelength and have had a correspondingly broad wavenumber spectrum. The paper reports the results of experiments on the PLT tokamak using a 16-waveguide grill (2.2 wavelengths) which produces a very narrow  $n_{\perp} = k_{\perp} c/\omega$  spectrum. Experimental results from the 16-waveguide grill are compared with results from three other PLT grills with less sharply defined  $n_{\perp}$  spectra. The experimental results are consistent with the first-pass damping of a large fraction of the launched spectrum. (Edited author abstract) 47 refs.

Stevens, J.E. (Princeton Univ, Princeton, NJ, USA); Bell, R. E.; Bernabel, S.; Cavallo, A.; Chu, T.K.; Colestock, P.L.; Hooke, W.; Hosea, J.; Jobs, F.; Luce, T.; Mazzucato, E.; Motley, R. *Nucl Fusion* v 28 n 2 Feb 1988 p 217-230.

**079606 ION RADIAL TRANSPORT INDUCED BY ICRF WAVES IN TOKAMAKS.** The wave induced

fluxes of energetic trapped ions during ICRF heating of tokamak plasmas are calculated by using quasi-linear equations. A simple single particle model of this transport mechanism is also given. Both a convective flux proportional to  $k_{\perp} |E_{\perp}|^2$  and a diffusive flux proportional to  $k_{\perp}^2 |E_{\perp}|^2$  are found. Here,  $k_{\perp}$  is the toroidal wavenumber and  $E_{\perp}$  is the left hand polarized wave field. The convective flux may become significant for large  $k_{\perp}$  if the wave spectrum is asymmetric in  $k_{\perp}$ . But for  $k_{\perp} \rho \ll 1$ , a conditioned satisfied in most previous and planned experiments, radial transport driven directly by the ICRF wave is unimportant. (Author abstract) 15 refs.

Chen, Liu (EURATOM, Lausanne, Switz); Hammett, G.W.; Vacklavik, J. *Nucl Fusion* v 28 n 3 Mar 1988 p 389-398.

**079607 FULL-WAVE CALCULATIONS OF THE O-X MODE CONVERSION PROCESS.** A two-point boundary-value problem has been formulated that describes the conversion between ordinary (O) and extraordinary (X) wave modes in a cold inhomogeneous plasma. Numerical solutions to this problem have been obtained for various values of the WKB parameter  $k_0 L$ , where  $k_0$  is the vacuum wavenumber and  $L$  the density-gradient scale length. The results are compared with three different theoretical expressions for the O-X mode conversion efficiency derived by others in the WKB limit of  $k_0 L \ll 1$ . Most of the results presented in this paper are obtained for a collisionless plasma with finite density near the plasma cut-off density. However, some examples are also given of wave propagation from vacuum. In these examples, collision effects are added to the equations in order to remove the singularity otherwise present at the position of the upper hybrid resonance layer. (Author abstract) 20 refs.

Hansen, F.R. (EURATOM, Roskilde, Den); Lynov, J.P.; Maroli, C.; Petrillo, V. *J Plasma Phys* v 39 pt 2 Apr 1988 p 319-337.

**079608 DECAY OF A WHISTLER WAVE IN A HOT-ION PLASMA.** The decay of a whistler wave into an electron acoustic wave and lower hybrid wave in a hot-ion plasma is considered. The growth rate of the decay instability is calculated and shown to be comparable to those of other parametric instabilities. The importance of whistler waves in ionospheric and space physics is well known. These waves can sometimes be generated at very large amplitudes by beams of anisotropies in the plasma. It is therefore of interest to study the non-linear behavior of the whistler waves. (Edited author abstract) 11 refs.

Saleem, H. (Quaid-i-Azam Univ, Islamabad, Pak); Yu, M.Y. *Phys Scr* v 36 n 6 Dec 1987 p 940-941.

**079609 ANCHOR PLASMA BUILDUP BY USING CENTRAL CELL ICRF ANTENNAS IN THE TANDEM MIRROR GAMMA 10.** The paper presents a study of anchor cell plasma buildup in the tandem mirror GAMMA 10 with the use of central cell ICRF antennas. For plasma buildup, it is demonstrated that an ion cyclotron resonance layer exists within the closed mod-B surface in the minimum-B anchor cell. The experimental plasma buildup rate in the anchor cell is compared with a one-dimensional Fokker-Planck simulation. A rapid increase in the anchor plasma density is observed and an associated reduction of the end-loss current when radio-frequency is applied. (Author abstract) 19 refs.

Ichimura, M. (Univ of Tsukuba, Ibaraki, Jpn); Inutake, M.; Adachi, S.; Sato, D.; Tsuboi, F.; Nakashima, Y.; Katanuma, I.; Itakura, A.; Mase, A.; Miyoshi, S. *Nucl Fusion* v 28 n 5 May 1988 p 799-807.

**079610 INFLUENCE OF A SUPERHERMAL TAIL UPON ECRH IN THETJ-II FLEXIBLE HELIAC - A THEORETICAL STUDY.** A superthermal tail is simulated by adding a drifted Maxwellian distribution to a bulk Maxwellian distribution  $f_0 = (1-\mu)f_b + \mu f_t$ . The values of the tail temperature ( $T_t$ ), drift velocity ( $v_0$ ) and weight coefficient ( $\mu$ ) are chosen so as to reproduce the



experimental residual current observed in the Wendelstein VII-A stellarator. An analytical expression for the resulting dielectric tensor coefficients is obtained. It is shown that, even for small tails, the global absorption coefficient increases for both the first harmonic ( $\omega = 28$  GHz) and the second harmonic ( $\omega = 56$  GHz) propagation. The effect is more dramatic for wave propagation in the first harmonic. The spatial bandwidth of the absorption region increases sensibly with respect to the pure Maxwellian distribution in both harmonics. (Author abstract) 16 refs.

Alejaldre, C. (Centro de Investigaciones Energéticas Medioambientales y Tecnológicas, Madrid, Spain). *Nucl Fusion* v 28 n 5 May 1988 p 849-857.

**079611 ON REFLECTION FROM A SUDDENLY CREATED PLASMA HALF-SPACE: TRANSIENT SOLUTION.** The reflection by a suddenly created plasma half-space of a time-harmonic plane electromagnetic wave propagating in free space is considered. The problem involves a temporal discontinuity, a spatial discontinuity, and a dispersive medium. The steady-state solution is obtained by considering the basic features of the scattering processes due to each of the discontinuities in terms of analogous transmission-line models. The electric field of the reflected wave consists of two components. One component (called component A) is of the same frequency as the incident wave frequency and is due to the spatial discontinuity. The other component (called component B) is of a different frequency and arises because of the temporal discontinuity. The B component is damped out even if the plasma is only slightly lossy. The damping rate of the B component is calculated. The transient solution is obtained through the use of Laplace transforms. The solution is given in terms of Bessel-like functions. The limiting value of this solution is shown to agree with the steady-state solution. Numerical results illustrating the transient effects are for two typical cases. 8 refs.

Kalluri, Dikshitulu K. (Univ of Lowell, Lowell, MA, USA). *IEEE Trans Plasma Sci* v 16 n 1 Feb 1988 p 11-16.

**079612 PROPAGATION OF SOLITARY WAVES IN RELATIVISTIC PLASMAS.** By applying a reductive perturbation technique to the basic system of equations governing the plasma dynamics, a modified Korteweg-de Vries (K-dV) equation has been derived in relativistic plasma that includes cold ions and warm nonisothermal electrons. By reducing the effect of nonisothermality, the authors demonstrate the modification of the K-dV equation into different forms which show how to link the behavior of ion-acoustic waves in nonisothermal plasmas with that in isothermal plasmas. 31 refs.

Das, G.C. (Manipal Univ, Canchipur, India); Karmakar, B.; Paul, S.N. *IEEE Trans Plasma Sci* v 16 n 1 Feb 1988 p 22-26.

**Waves** See Also EXTRATERRESTRIAL ATMOSPHERES; FLOW OF FLUIDS—Supersonic; ION ACOUSTIC WAVES—Mathematical Models; LASERS, GAS.

**079613 TEORIA E PROPRIEDADES DE PLASMAS PRODUZIDOS POR ONDAS DE SUPERFÍCIE.** [Theory and Properties of Plasmas Produced by Surface Waves]. This paper discusses the basic processes occurring in a plasma column sustained by a surface wave. The theoretical model here developed treats in a self-consistent way the radial distributions of the plasma density and of the SW field intensity and provides detailed predictions concerning the radial and the axial variations in the plasma properties as a function of the discharge parameters. It also predicts the existence of simple similarity laws which enable the extension of the results to different experimental circumstances. (Edited author abstract) 40 refs. In Portuguese.

Ferreira, Carlos Matos (INIC, Port). *Tecnica (Lisbon)* n 3-4 Apr 1987 p 24-39.

**079614 DISPERSION EQUATION FOR ELECTROSTATIC WAVES IN A BEAM-PLASMA SYSTEM IMMERSED IN AN INHOMOGENEOUS MAGNETIC FIELD.** A dispersion equation is derived for electrostatic waves propagating in a beam-plasma

system immersed in a practically axial and slowly varying magnetic field. The dispersion equation is deduced for a general stratified medium, defined by its dielectric tensor. The dielectric tensor and the dispersion equation for the stratified beam-plasma system are then obtained and a typical dispersion diagram is analyzed. 15 refs.

Varandas, C.A.F. (Centro de Electrodinamica, Port); Cabral, J.A.C. *Tecnica (Lisbon)* n 3-4 Apr 1987 p 100-104.

**079615 NONLINEAR STAGE OF THE MODULATIONAL INSTABILITY OF A WHISTLER WAVE. PART 1.** The development of the modulational instability of a whistler wave is investigated in the linear and subsequent nonlinear stages. It is shown that some predictions of the linear theory remain valid up to the time when the wave amplitude modulation rate is of the order of unity. (Author abstract) 14 refs.

Karpman, V.I. (IZMIRAN, Moscow, USSR); Shagalov, A.G. *J Plasma Phys* v 38 pt 1 Aug 1987 p 155-167.

**079616 OPTIMUM TOROIDAL PHASING FOR STABLE LOADING OF AN ICRF WAVE IN JT-60.** The propagation and absorption of the ion cyclotron range of frequencies (ICRF) waves, which are launched by toroidal-phased antennas, were studied in a JT-60 plasma. The second ion cyclotron resonance in a one-dimensional pure hydrogen plasma was considered by solving the kinetic wave equation. The dependence of the loading resistance on the antenna phasing as well as on the plasma parameters was obtained by numerical calculation. A model of a transmission line was introduced in our analysis. The optimum phasing and the plasma parameter region were obtained for a stable loading. Furthermore, it is shown that a combined heating with the neutral beam injection (NBI) makes the stable loading region wider. (Author abstract) 18 refs.

Hamamatsu, Kiyotaka (JAERI, Naka, Jpn); Kishimoto, Yasuaki; Fukuyama, Atsushi; Itoh, Kimitaka; Itoh, Sanae I.; Azumi, Masafumi. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1525-1533.

**079617 STABILITY OF QUASILONGITUDINALLY PROPAGATING SOLITONS IN A PLASMA WITH HALL DISPERSION.** By analogy with the generalization obtained for the Korteweg-de Vries equation, the derivative nonlinear Schrödinger equation is extended to the weakly non-one-dimensional case. On the basis of the equation obtained, the stability of solitons propagating at small angles to the undisturbed magnetic field relative to non-one-dimensional perturbations is investigated. (Author abstract) 18 refs.

Ruderman, M.S. *Fluid Dyn* v 22 n 2 Mar-Apr 1987 p 299-305.

**079618 SPECTRAL CHARACTERISTICS OF HYDROMAGNETIC WAVES IN THE MAGNETOSPHERE.** This work is intended to explain why the resonant response of the magnetosphere prefers to have discrete frequencies. Using a cylindrical model for the outer magnetosphere with a plasma density profile proportional to  $1/r^3$ , we show that the eigenequation characterizing the eigenmodes of the hydromagnetic waves in this model has two turning points along the radial axis. The locations of the turning points depend upon the values of the eigenperiod and the associated east-west wavenumber of the eigenmode. The energy spectrum of the excited cavity modes is seen to have sharp peaks at discrete frequencies when the surface perturbations have a uniform spectrum in the frequency range of interest. The most likely values of east-west wavenumbers and wave period range are determined. (Edited author abstract) 24 refs.

Kuo, S.P. (Polytechnic Univ, Farmingdale, NY, USA); Lee, M.C.; Wolfe, A. *J Plasma Phys* v 38 pt 2 Oct 1987 p 235-243.

**079619 EFFECT OF ION TEMPERATURE ON ION-ACOUSTIC SOLITARY WAVES: A PSEUDOPOTENTIAL APPROACH.** Using the pseudopotential approach of Sagdeev, we have found

analytically exact conditions for the existence of solitary waves for a system of collisionless plasmas with a mixture of warm ion-fluid and hot isothermal electrons. The analytical soliton solution for small amplitudes has also been obtained and has been compared with the published result. It is found that the finite ion temperature considerably modifies the restriction on the Mach number obtained for cold ions. (Author abstract) 11 refs.

Roychoudhury, R.K. (Indian Statistical Inst, Calcutta, India); Bhattacharyya, Sikha. *Can J Phys* v 65 n 7 Jul 1987 p 699-702.

**079620 NONLINEAR REGULAR STRUCTURES OF DRIFT MAGNETO-ACOUSTIC WAVES.** Nonlinear regular structures in a magnetized plasma connected with drift magneto-acoustic waves (DMA) are investigated theoretically. Three-dimensional nonlinear equations of weakly dispersive DMA waves are obtained. These equations contain both the scalar nonlinearity and the vector one, and generalize the two-dimensional Kadomtsev-Petviashvili (KP) equation. The existence is shown of regular stationary structures due to the scalar nonlinearity: one-dimensional solitons, two-dimensional rational solitons, chains of solitons and so-called 'crosses'. The stability of one-dimensional DMA solitons is investigated. It is shown that soliton stability depends on the sign of the wave dispersion as in the case of systems described by the KP-type equation. (Author abstract) 24 refs.

Aburdzhaniya, G.D. (Tbilisi State Univ, Tbilisi, USSR); Lakhin, V.P.; Mikhailovskii, A.B. *J Plasma Phys* v 38 pt 3 Dec 1987 p 373-386.

**079621 DISPERSION ION-DRIFT HYDRODYNAMICS.** The set of hydrodynamic equations for the ion component of a magnetized low-pressure plasma, including the nonlinear ion drift and waves related to it, taking into account dispersion effects of order  $k_1^2 p_i^2$  ( $k_1$  is the characteristic transverse wavenumber and  $p_i$  is the ion Larmor radius), is obtained. The reduction of these equations using the standard assumptions of vortex theory is given. The problem of the integrals of motion of the simplified equations is discussed. Account is taken of the gravitational force (which models curvature of the magnetic field lines), the three-dimensionality of the perturbations (drift-Alfven effects) and plasma rotation. It is suggested that the ion-drift hydrodynamics discussed here should be the basis for the analysis of the ion drift and the vortices related to it, as well as for the theory of decay processes with participation of the ion-drift waves. (Author abstract) 23 refs.

Lakhin, V.P. (Space Research Inst, Moscow, USSR); Makurin, S.V.; Mikhailovskii, A.B.; Onishchenko, O.G. *J Plasma Phys* v 38 pt 3 Dec 1987 p 387-405.

**079622 VORTICES OF ION-DRIFT AND RELATED WAVES.** The problem of vortices of ion-drift and related flute-drift, balloon-drift and drift-Alfven waves is analyzed, taking into account the finiteness of the Larmor radius of the ions. It is shown that the structure of the stationary ion-drift vortices is similar to that of the Alfven waves. It is found that the stationary ion-drift vortices in a plasma confined in a curvilinear magnetic field are characterized, generally speaking, by two different spatial scales. The role of plasma rotation in the vortex problem is investigated. (Author abstract) 22 refs.

Lakhin, V.P. (Space Research Inst, Moscow, USSR); Makurin, S.V.; Mikhailovskii, A.B.; Onishchenko, O.G. *J Plasma Phys* v 38 pt 3 Dec 1987 p 407-425.

**079623 ENVELOPE SOLITONS OF SURFACE WAVES IN A PLASMA COLUMN.** The problem of envelope solitons of surface waves is considered on the basis of results for the nonlinear dispersion relation of the waves in a plasma column. The soliton solutions are derived as particular cases of the general solutions obtained by a universal procedure and expressed in terms of Jacobi elliptic functions. Since the two types of



interactions, namely the  $(\omega + \omega) - \omega$  and the  $(\omega - \omega) + \omega$  interactions (where  $\omega$  is the frequency of the carrier wave) included in the nonlinear dispersion relation act in opposite ways, existence both of bright and dark solitons is shown to be possible. The effect of the ponderomotive force that in our case is expressed through the contribution of the  $(\omega - \omega) + \omega$  interaction leads to the formation of dark solitons. The effect of the losses is also considered. (Author abstract) 21 refs.

Grozev, D. (Sofia Univ, Sofia, Bulg); Shivarova, A.; Boardman, A.D. *J Plasma Phys* v 38 pt 3 Dec 1987 p 427-437.

**079624 TWO-DIMENSIONAL ION ACOUSTIC SOLITARY WAVE IN A WEAKLY RELATIVISTIC PLASMA.** The two-dimensional Korteweg-de Vries equation is first derived for a weakly relativistic ion acoustic wave propagating in a collisionless plasma. We show that the relativistic effect greatly influences the phase velocity, the amplitude and the width of a solitary wave solution, and that the presence of streaming ions gives rise to the formation of a precursor. We also discuss three limiting cases of the present results. (Author abstract) 10 refs.

Nejoh, Yasunori (Hachinohe Inst of Technology, Hachinohe, Jpn). *J Plasma Phys* v 38 pt 3 Dec 1987 p 439-444.

**079625 OBSERVATION OF LARGE-AMPLITUDE ION ACOUSTIC SOLITARY WAVES IN A PLASMA.** Propagation of nonlinear ion acoustic waves in a multi-component plasma with negative ions is investigated in a double-plasma device. When the density of negative ions is larger than a critical value, a broad negative pulse evolves to rarefactive solitons, and a positive pulse whose amplitude is less than a certain threshold value becomes a subsonic wave train. In the same plasma, a positive pulse whose amplitude is larger than the threshold develops into a solitary wave. The critical amplitude is measured as a function of the density of negative ions and compared with predictions of the pseudo-potential method. The energy distribution of electrons in the solitary wave is also measured. (Author abstract) 17 refs.

Nakamura, Yoshiharu (Inst of Space & Astronautical Science, Tokyo, Jpn). *J Plasma Phys* v 38 pt 3 Dec 1987 p 461-471.

**079626 NONLINEAR STAGE OF THE MODULATIONAL INSTABILITY OF A WHISTLER WAVE. PART 2.** Nonlinear structures in the developed stage of the two-dimensional modulational instability of a whistler wave are investigated. On the basis of the results obtained, some suggestions are made regarding the nonlinear dynamics of three-dimensional modulational instability and three-dimensional whistler solitons. (Author abstract) 9 refs.

Karpman, V.I. (IZMIRAN, USSR); Shagalov, A.G. *J Plasma Phys* v 39 n 1 Feb 1988 p 1-10.

**079627 RELATIVISTIC THEORY OF ABSORPTION AND EMISSION OF ELECTRON CYCLOTRON WAVES IN ANISOTROPIC PLASMAS.** The weakly relativistic theory of absorption and emission of electron cyclotron waves in hot magnetized plasmas is developed for a large class of anisotropic electron distribution functions. The results are expressed in terms of the weakly relativistic plasma dispersion functions, and therefore of the well-known plasma Z-function. The particular case of a loss-cone electron distribution function is presented as a simple example. (Author abstract) 9 refs.

Orefice, A. (CNR, Milan, Italy). *J Plasma Phys* v 39 n 1 Feb 1988 p 61-70.

**079628 ION-ACOUSTIC SOLITONS IN MULTI-COMPONENT PLASMAS INCLUDING NEGATIVE IONS AT CRITICAL DENSITIES.** Ion-acoustic solitons in a plasma with different adiabatic ion constituents and isothermal electrons are studied via a reductive perturbation method. The basic fluid equations then give

rise to KdV or modified KdV equations, depending upon the relative ion densities. At critical densities, rarefactive and compressive fast ion-acoustic solitons are possible. Explicit stationary solutions are discussed in the special case of cold ions, in a plasma containing two species of negative ions and one of positive ions. The inclusion of heavier ions, even at low densities, increases the amplitudes of the critical solitons. (Author abstract) 9 refs.

Verheest, Frank (Rijksuniversiteit Gent, Ghent, Belg). *J Plasma Phys* v 39 n 1 Feb 1988 p 71-79.

**079629 HAMILTONIAN THEORY OF THE GENERALIZED OSCILLATION-CENTRE TRANSFORMATION.** The theory of the slow reaction of a charged particle in the combined presence of a strong quasi-static magnetic field and a high-frequency electromagnetic field (generalized oscillation-centre motion) is constructed by using a Hamiltonian formalism with non-canonical variables and pseudo-canonical transformations. The theory combines the features studied in our previous works for the case in which only one of the previously mentioned fields is present. The new averaging transformation is based on the fact that the Larmor frequency of the quasistatic field is of the same order as the external frequency of the high-frequency field. Our theory is manifestly gauge-invariant and involves only physical quantities (particle velocity and electromagnetic fields). Explicit expressions for the drift velocity of the oscillation centre and for the ponderomotive force are derived. (Author abstract) 14 refs.

Weyssow, B. (EURATOM, Brussels, Belg); Balescu, R. *J Plasma Phys* v 39 n 1 Feb 1988 p 81-102.

**079630 ELECTROSTATIC ROSSBY-TYPE ION PLASMA WAVES.** It is shown that a plasma in which the background magnetic field varies in a direction perpendicular to its line of action can support 'Rossby-type' electrostatic waves at frequencies very much less than the ion gyrofrequency. The interesting dispersive and anisotropic features of these waves are revealed by the properties of their wave operators and described in terms of the geometry of their wavenumber surfaces. Since these surfaces intersect, inhomogeneity or nonlinearity will give rise to strong mode-mode coupling in regions where the phases of both modes nearly match. (Edited author abstract) 13 refs.

McKenzie, J.F. (Univ of Natal, Durban, S Afr); Dougherty, M.K. *J Plasma Phys* v 39 n 1 Feb 1988 p 103-114.

**079631 MEAN-FIELD MAGNETOHYDRODYNAMICS ASSOCIATED WITH RANDOM ALFVEN WAVES IN A PLASMA WITH WEAK MAGNETIC DIFFUSION.** Using first-order smoothing theory, Fourier analysis and perturbation methods, a new equation is derived governing the evolution of the spectrum tensor (including the energy and helicity spectrum functions) of the random velocity field as well as the ponderomotive and mean electromotive forces generated by random Alfvén waves in a plasma with weak magnetic diffusion. The ponderomotive and mean electromotive forces are expressed as series involving spatial derivatives of mean magnetic and velocity fields whose coefficients are associated with the helicity spectrum function of the random velocity field. The effect of microscale random Alfvén waves, through ponderomotive and mean electromotive forces generated by them, on the propagation of large-scale Alfvén waves is also investigated by solving the mean-field equations, including the transport equation of the helicity spectrum function. (Author abstract) 7 refs.

Hamabata, Hiromitsu (Osaka City Univ, Osaka, Jpn); Namikawa, Tomikazu. *J Plasma Phys* v 39 n 1 Feb 1988 p 139-149.

**079632 EFFECTS OF PARALLEL ION DYNAMICS ON DRIFT-ALFVEN VORTICES IN PLASMAS.** Drift-Alfvén vortices are investigated, taking into account the nonlinear ion dynamics parallel to the external magnetic field. It is found that the parallel ion motion restricts the vortex speed. The dipolar vortices, as described here, may be considered as new coherent nonlinear

structures and may arise in a low- $\beta$  plasma such as the earth's magnetosphere as well as the polar ionosphere. (Edited author abstract) 8 refs.

Shukla, P.K. (Ruhr Univ Bochum, Bochum, West Ger). *J Plasma Phys* v 39 n 1 Feb 1988 p 151-155.

**079633 NONLINEAR EXCITATION OF CONVECTIVE CELL BY DRIFT WAVE AND SPECTRUM CASCADE PROCESS IN FINITE ION TEMPERATURE PLASMA.** A nonlinear drift mode equation for finite ion temperature plasma is derived. Possibilities of explosive instabilities for the drift wave are obtained. To discuss the modulational instability of drift wave, a nonlinear evolution equation for the drift mode is deduced from a third-order secularity elimination condition using the multiple time and space scales technique. The effect of low-frequency localized structure on particle transport has been investigated and the diffusion tensor is calculated using Ficks law. (Author abstract) 9 refs.

Majumdar, D. (Jadavpur Univ, Calcutta, India). *J Plasma Phys* v 39 n 1 Feb 1988 p 169-179.

**079634 EXCITATION OF LONGITUDINAL WAVES BY A SPREADING PACKET OF ELECTROMAGNETIC RADIATION.** The influence of dispersion spreading of a packet of transverse electromagnetic radiation on its excitation of plasma waves is examined. It is shown that quite short packets by spreading continue to excite a plasma wave with essentially unchanged amplitude. (Author abstract) 6 refs.

Kirsanov, V.I. *Sov Phys Lebedev Inst Rep* n 8 1987 p 49-53.

**079635 SOLITONS IN AN ION-BEAM PLASMA.** It is shown that the conservation law for total momentum of an ion-beam plasma system can be cast in the form of a classical energy integral of a particle in a potential well. By using boundary conditions appropriate to a solitary pulse, we derive conditions for the existence of finite-amplitude solitons propagating in the system. Under suitable conditions, as many as three forward-propagating solitary waves can exist. It is interesting to note that the criterion for their existence is intimately related to the absence of convective instabilities in an ion-beam plasma. Exact 'sech<sup>2</sup>' type solutions are available in the weakly nonlinear regime. Solitary-wave profiles for the general case are obtained numerically. (Author abstract) 9 refs.

Zank, G.P. (Univ of Natal, Durban, S Afr); McKenzie, J.F. *J Plasma Phys* v 39 pt 2 Apr 1988 p 183-191.

**079636 PROPERTIES OF WAVES IN AN ION-BEAM PLASMA SYSTEM.** In this paper a multi-fluid approach is used to describe electrostatic interactions in an ion-beam plasma system. The structure of the wave equation governing the system exhibits the anisotropic and dispersive nature of the waves, whose properties are analysed in terms of the dispersion relation. The main purpose of this paper is to classify the different waves that can arise in an ion-beam plasma system in a systematic fashion. The classification is facilitated by introducing a three-parameter CMA diagram that illustrates the topological changes in not only the wavenumber, or refractive-index, surface but also the ray-velocity surface. Furthermore, an analytic expression governing wave amplification in an ion-beam plasma is incorporated within the framework of a generalized CMA diagram. Such a description provides a simple interpretation for the onset of wave amplification in terms of a topological change in the refractive-index surface. (Edited author abstract) 35 refs.

Zank, G.P. (Univ of Natal, Durban, S Afr); McKenzie, J.F. *J Plasma Phys* v 39 pt 2 Apr 1988 p 193-213.

**079637 NONDISSIPATIVE ELECTROSONIC WAVES IN A NONUNIFORM AND NONSTATIONARY PLASMA.** The problem about nondissipative electrosonic s-polarized waves for a nonuniform and nonstationary plasma in the region of linear transparency is



solved. The equations of the plasma and the electromagnetic field are spatially averaged. A closed system for equations is found for the mean values, whose self-modeling asymptotics result in a monotonic reduction in the field amplitude with a rise in plasma density. (Author abstract) 6 refs.

Krokhin, O.N.; Tsybenko, S.P. *Sov Phys Lebedev Inst Rep* n 10 1987 p 31-33.

**079638 THEORY OF BERNSTEIN WAVE COUPLING WITH LOOP ANTENNAS.** Coupling to ion Bernstein waves near the first harmonic of the ion cyclotron resonance with coil antennas is investigated by using a plane layered model of a tokamak plasma. The boundary conditions in vacuum are solved analytically for arbitrary orientation of the antenna and Faraday screen conductors, in terms of the surface impedance matrix of the plasma for plane waves. The latter is evaluated by solving the wave equations in the plasma by taking into account finite Larmor radius and finite electron inertia effects, cyclotron and harmonic damping by the ions, and Landau and collisional damping by the electrons. Applications to the Alcator C tokamak give reasonable agreement between the calculated and measured radiation resistance when the first ion cyclotron harmonic is just behind the antenna; outside this range, the calculated resistance is lower than the experimental one. In general, the coupling efficiency is found to be very sensitive to the edge plasma density, good coupling requiring a low density plasma layer in the vicinity of the Faraday screen. (Edited author abstract). 40 Refs.

Brambilla, M. (Euratom-IPP Assoc, Garching, West Ger). *Nucl Fusion* v 28 n 4 Apr 1988 p 549-563.

**079639 INTERACTION OF HIGH-FREQUENCY AND LOW-FREQUENCY WAVES IN MAGNETIZED PLASMAS.** The interaction of high-frequency and low-frequency waves in magnetized plasmas is considered. The narrowness of high-frequency wave packets makes possible a concise Hamiltonian description of the problem. Some concrete problems are studied with the help of the derived equations. The competitive role of scattering in self-consistent density and magnetic-field fluctuation are considered. The self-focusing and solitons of potential plasma waves and magnetohydrodynamic waves are studied. (Author abstract). 21 Refs.

Relke, I.V. (Inst of Automation & Electrometry, Novosibirsk, USSR); Rubenchik, A.M. *J Plasma Phys* v 39 n 3 Jun 1988 p 369-384.

**079640 NEAR-MAGNETOSONIC ENVELOPE UPPER-HYBRID WAVES.** A systematic analysis of envelope upper-hybrid wave propagation near the magnetosonic speed has been presented. Using the full set of fluid equations for the low-frequency dynamics, we obtain various model nonlinear equations describing the magnetosonic response to the envelope waves. In particular, we derive driven KdV as well as driven Boussinesq equations that are valid for near-magnetosonic propagation. Exact stationary solutions of the coupled equations are explicitly obtained. It is shown that a new class of upper-hybrid solitons with antisymmetric wave envelope exist for near-magnetosonic propagation. Integral invariants for the driven KdV case have been obtained and evaluated for localized solutions. A set of stationary governing equations is derived that takes account of the full nonlinearity in the low-frequency response as well as departures from the frozen-in-field approximation. A detailed comparison of the various model equations as well as their validity has been made. (Edited author abstract). 28 Refs.

Rao, N.N. (Physical Research Lab, Ahmedabad, India). *J Plasma Phys* v 39 n 3 Jun 1988 p 385-405.

**079641 THERMODYNAMIC PROPERTIES AND WAVES IN A DIPOLE PLASMA.** A low-temperature plasma containing polar molecules with constant electric dipole moment as the neutral component is considered. The thermodynamic functions and the dispersion properties of such a plasma are investigated. (Author abstract).

4 Refs.

Mulugeta, Solomon (Addis Ababa Univ, Addis Ababa, Ethiop); Malnev, V.N. *J Plasma Phys* v 39 n 3 Jun 1988 p 475-483.

**079642 ANALYTICAL SOLUTIONS FOR OBLIQUE WAVE GROWTH FROM A RING-BEAM DISTRIBUTION.** Analytical solutions are presented for the linear growth rate of oblique plasma waves in a magnetized plasma due to resonant interactions with a model ring-beam distribution. Explicit closed-form solutions for the angular dependence are obtained in terms of modified Bessel functions of the first kind. In the limits of either quasi-longitudinal or quasi-transverse propagation the analytical solutions take the form of simple algebraic expansions. The results can be applied, for instance, to the growth of waves following ionization of neutrals originating from cometary, planetary, or interstellar material in the solar wind. In a weakly unstable plasma the analytical results also provide an important check on the complex numerical codes that hitherto constituted the only method available for evaluating the growth of oblique plasma waves. (Edited author abstract). 20 Refs.

Thorne, Richard M. (Univ of California, Los Angeles, CA, USA); Summers, Danny. *J Plasma Phys* v 39 n 3 Jun 1988 p 485-502.

**079643 RENORMALIZATION-GROUP THEORY FOR ALFVEN-WAVE TURBULENCE.**  $\epsilon$ -Expansion renormalization-group theory is applied to a model Alfvén-wave turbulence equation. In particular, the effect of small 'unresolvable' subgrid scales on the large scales is computed. It is found that the removal of the subgrid scales leads to a renormalized response function  $\nu$ . The Lorenzian wavenumber spectrum of Chen & Mahajan can be recovered for finite  $\epsilon$ , but the nonlinear coupling constant still remains small, fully justifying the neglect of higher-order nonlinearities introduced by the renormalization-group procedure. (Author abstract). 10 Refs.

Zhou, Ye (Coll of William & Mary, Williamsburg, VA, USA); Vahala, George. *J Plasma Phys* v 39 n 3 Jun 1988 p 511-520.

**079644 ELECTROSTATIC ION-CYCLOTRON WAVES IN A TWO-ION COMPONENT PLASMA.** The excitation of electrostatic ion cyclotron (EIC) waves is studied in a single-ended Q machine in a two-ion component plasma ( $\text{Ca}^+$  and  $\text{K}^+$ ). Over a large range of relative concentrations of  $\text{Cs}^+$  and  $\text{K}^+$  ions, two modes are excited with frequencies greater than the respective cyclotron frequencies of the ions. The results are discussed in terms of a fluid theory of electrostatic ion cyclotron waves in a two-ion component plasma.

Suszcynsky, David M. (Univ of Iowa, Iowa City, IA, USA); Merlino, Robert L.; D'Angelo, Nicola. *IEEE Trans Plasma Sci* v 16 n 3 Jun 1988 p 396-398.

**079645 STOCHASTIC WAVE-KINETIC THEORY OF RADIATIVE TRANSFER IN THE PRESENCE OF IONIZATION.** The stochastic wave-kinetic theory at the level of the first-order smoothing approximation is used to construct a radiative transfer equation for a simple model of a weakly inhomogeneous, weakly nonstationary, and locally isotropic cold turbulent plasma. All the coefficients in the resulting equations are expressed in terms of the electrodynamic and statistical properties in the medium without the usual recourse to phenomenological arguments. (Edited author abstract) Refs.

Besieris, Ioannis M. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA). *Radio Sci* v 22 n 6 Nov 1987, Int Symp on Electromagn Theory, Budapest, Hung, Aug 25-29 1986 p 885-888.

**PLASTER** See Also BUILDING MATERIALS—Moisture; BUILDINGS—Restoration.

**079646 SPACHTEL-SYSTEM OHNE BEWEHRUNGSTREIFEN JETZT BAUAUFSICHTLICH ZUGELASSEN.** [Filler Pasting System without Reinforcing Strips Now Officially Approved]. Knauf has

developed a technique which makes it possible to coat gypsum boards without reinforcing strips. The result is a more attractive and smoother wall surface. Furthermore, there is no need for labor-intensive reinforcement. (Author abstract) In German.

Anon. *Stahlbau Rundsch* n 69 Oct 1987 p 55.

**Aging** See BUILDINGS—Facings.

**Applications** See CASTINGS—Models; CERAMIC PRODUCTS—Manufacture.

**Fiber Reinforcement**

**079647 EFFECT OF CASTING PRESSURE ON THE PROPERTIES OF WOOD FIBRE-REINFORCED PLASTER.** In the preparation of wood-pulp fiber-reinforced plaster (WFRP), by the slurry/vacuum dewatering technique, it was noted that casting pressure had an effect on the properties of the composites formed. This study reports the effects casting pressures have on the mechanical and physical properties of the WFRP composites. Increasing the casting pressure up to 3.2 MPa resulted in an increase in fracture toughness and in an increase in flexural strength for a given formulation of WFRP. 14 Refs.

Coutts, R.S.P. (CSIRO, Clayton, Aust); Warden, P.G. *J Mater Sci Lett* v 7 n 9 Sep 1988 p 918-921.

**Manufacture** See GYPSUM PLANTS—Construction.

**pH Effects**

**079648 DIE VERZOEGERUNGSWIRKUNG VON GIPSVERZOEGERERN VERSCHIEDENER CHEMISCHER ZUSAMMENSETZUNG IN ABHÄNGIGKEIT VOM pH-WERT DES GIPSES.** [Retarding Action of Gypsum Plaster Retarders of Various Chemical Composition in Relation to the pH Value of the Plaster]. The retarding action of gypsum plaster retarders of various chemical composition was investigated in relation to the pH value of the plaster. Tartaric acid and tartrates were found to be capable of fully developing their retarding action only in the strongly alkaline range. Citric acid and sodium citrate achieve their optimum action in the neutral and weakly alkaline range. Protein decomposition products show behavior similar to that of citric acid and sodium citrate with regard to their pH dependence. They attain the longest retardation times in the neutral and weakly alkaline range, with Retardan P occupying a leading position in respect of the retarding action. (Edited author abstract). 1 Ref. In German.

Mallon, Th. *ZKG Int Engl Transl* v 41 n 6 Jun 1988 p 309-311.

**Processing** See GYPSUM—Evaluation.

**PLASTIC AND RUBBER MOLDS**

**Computer Aided Design**

**079649 CAD/CAM CAPABILITIES: SURFACE MODELLING FOR PLASTICS MOULDED PARTS.** This paper discusses the various means of describing the curved surfaces of objects with geometric modelling techniques used in many contemporary CAD/CAM systems. The data input aspects for surface modelling are presented. Ways of evaluating the Numerical Control (NC) tool paths of these complex shapes are also described for subsequent computer aided manufacturing on Computer Numerical Control (CNC) machines. (Edited author abstract) 18 refs.

Tan, S.T. (Univ of Hong Kong, Hong Kong); Yuen, M.M.F.; Sze, W.S. *Hong Kong Eng* v 16 n 4 Apr 1988 p 9-13.



**PLASTICITY** See Also CELLULOSE—Stresses; CO-BALT AND ALLOYS—Magnetic Properties; COMPOSITE MATERIALS—Elasticity; CRYSTALS—Deformation; CRYSTALS—Hardening; DOMES AND SHELLS—Deformation; FATIGUE OF MATERIALS; MATERIALS—Anisotropy; MATERIALS—Hardening; MATERIALS SCIENCE; MATHEMATICAL TECHNIQUES—Finite Element Method; MECHANICS; METAL FORMING—Deformation; METALS AND ALLOYS—Deformation; METALS AND ALLOYS—Strain; PIPING SYSTEMS—Structural Design; REFRACTORY MATERIALS—Zirconia; SOIL MECHANICS; SOILS—Mathematical Models; SOLIDS—Deformation; SPHERES—Failure; STAINLESS STEEL—Fatigue; STAINLESS STEEL—Hardening; STAINLESS STEEL—Stresses; STEEL—Hardening; STRAIN—Analysis; STRAIN—Measurements; STRAIN—Theory; STRUCTURAL ANALYSIS—Dynamic Response; ZINC ALUMINUM ALLOYS—Deformation.

**079650 ON THE VALIDITY OF SAINT VENANT'S PRINCIPLE IN FINITE STRAIN PLASTICITY.** Diffusion of effects from a local disturbance in a homogeneous stress field is analyzed within the framework of continuum plasticity. An axial rate of decay for the variability of the effects of a nonuniform disturbance imposed on one end of a long circular cylinder is determined as a function of the axial stress (or stretch). The analysis considers constitutive equations corresponding to incompressible, finite strain versions of  $J_2$  flow and deformation theories. Both theories result in effects that oscillate and decay exponentially with distance from the imposed disturbance; the rate of decay decreases as the uniaxial tension increases. Deformation theory predicts a larger rate of decay than flow theory except within a small range of stress near the ultimate (necking) load; at necking the rate of decay vanishes. (Author abstract) 7 refs.

Durban, D. (Univ of Cambridge, Cambridge, Engl); Stronge, W.J. *J Appl Mech Trans ASME* v 55 n 1 Mar 1988 p 11-16.

**079651 STUDY AND APPLICATION OF SLIP LINE METHOD.** In many plastic deformation cases the velocity field is rather easily solved by analytical method. It is thus not difficult to obtain analytically the slip line field by using the similarity between slip line field and velocity field; the limit load of structure or technological processes can also be obtained. The proposed method is convenient for calculation and effective for improving precision. (Author abstract). 7 Refs. In Chinese.

Fanghui, Jiang (Tsinghua Univ, China); Bingye, Xu. *Ching Hua Ta Hsueh Hsueh Pao* v 26 n 3 1986 p 95-103.

**Analysis** See Also ALUMINUM AND ALLOYS—Superplasticity; DOMES AND SHELLS—Steel; SPHERES—Pressure Measurement; STEEL—Structural; STRUCTURAL FRAMES—Structural Analysis.

**079652 PANPENALTY FINITE ELEMENT PROGRAMMING FOR PLASTIC LIMIT ANALYSIS.** A unified panpenalty finite element programming method for limit analysis is established based on the theory of convex analysis, and a penalty-quality finite element model is constructed, which provides an efficient algorithm for the exact solution of the safety factor. In order to reduce the number of degrees-of-freedom in nonlinear programming, a generalized matrix inverse technique is suggested, resulting in a decrease in computer time. Several numerical results for structural analysis are presented. (Author abstract) 15 refs.

Yang, Gao (MIT, Cambridge, MA, USA). *Comput Struct* v 28 n 6 1988 p 749-755.

**Composition Effects** See NICKEL ALUMINUM ALLOYS—Plasticity.

## Computation

**079653 PLASTICITY COMPUTATIONS USING THE MOHR-COULOMB YIELD CRITERION.** The paper describes the derivation and application of a range of numerical algorithms for implementing the Mohr-Coulomb yield criterion in a non-linear finite element computer program. Emphasis is placed on the difficulties associated with the corners of the yield surface. In contrast to the more conventional forward-Euler procedures, a backward-Euler integration technique is

adopted. A range of methods, including a 'consistent approach' are used to derive the tangent modular matrix. Numerical experiments are presented which involve solution algorithms including the modified and full Newton-Raphson procedures, 'line-searches' and the arc-length method. It is shown that the introduction of efficient integration and tangency algorithms can lead to very substantial improvements in the convergence characteristics. (Author abstract) 28 refs.

Crisfield, M.A. (Transport & Road Research Lab, Crowthorne, Engl). *Eng Comput (Swansea Wales)* v 4 n 4 Dec 1987 p 300-308.

**Deformation** See SILVER AND ALLOYS—Plasticity.

**Evaluation** See Also MATERIALS TESTING—Crack Propagation.

**079654 RESEARCH NOTE ON A REEXAMINATION OF NEUTRAL LOADING EXPERIMENTS.** In the examination of the published results from neutral loading experiments, the question as to whether plastic deformation occurs is found to depend on both the material and initial loading strain. Provided that initial loading is elastic, then a subsequent stress path that follows the boundary of the initial yield surface for a hardening material is truly neutral with a wholly elastic response. However, when initial loading is elastic-plastic, then further plastic deformation is produced from a subsequent stress path that follows an isotropic expansion of the initial yield surface. These results enable the appropriateness of the kinematic hardening rule and more recent developments in plasticity theory to be appraised. Neutral loading of a non-hardening material produces plastic flow. Whether the absence of hardening is inherent or induced by plastic prestrain, it is shown that the Prandtl-Reuss theory then represents the observed behavior. In general, the purely elastic and nonhardening solutions provide respectively lower and upper bounds on the deformation. (Author abstract) 15 refs.

Rees, D.W.A. (Brunel Univ of West London). *Int J Plast* v 4 n 1 1988 p 91-102.

**High Temperature Effects** See STAINLESS STEEL—Hardening.

**Low Temperature Effects** See CERAMIC MATERIALS—Plasticity.

**Mathematical Models** See Also COMPOSITE MATERIALS—Fiber Reinforced; DOMES AND SHELLS—Plasticity; GRANULAR MATERIALS—Deformation; MATERIALS—Creep; MATERIALS SCIENCE—Deformation; METALS AND ALLOYS—Deformation; POLYPROPYLENE—Deformation; SOLIDS—Elasticity; SPHERES—Plasticity; STRESSES—Analysis; SURFACES—Friction.

**079655 UNIQUENESS IN CLASSICAL ELASTO-STATICS.** It is shown that the displacement problem of homogeneous, isotropic,  $n$ -dimensional elastostatics ( $n=2,3$ ) in unbounded domains has at most one regular solution in the classes of vector fields which behave at large distances as  $r^{-k}$  ( $k=3$ ) and  $\log r$  ( $k=2$ ), with  $r=|x-0|$  and  $\xi \in (0,1)$ , provided the elasticities are positive definite and satisfy some inequalities closely linked to  $\xi$ . (Author abstract) 10 refs.

Russo, Remigio (Univ Napoli, Napoli, Italy). *Int J Eng Sci* v 25 n 9 1987 p 1087-1091.

**079656 PHENOMENOLOGICAL MODEL OF CREEP AND PLASTIC DEFORMATION.** A generalized model of creep and plastic strain which is based on the concept of the material damage is developed. Failure of the material is considered first of all as a state of complete exhaustion of the local plasticity of the material caused both by concentration of strain which is induced by the material inhomogeneity and by concentration of strain which is induced by relaxation of the stress peaks formed during the inhomogeneous material loading. This effect is strengthened by other physical and chemical processes of degradation, formation of discontinuities and microcracks caused by the exhaustion of the deformation ability of the material. (Author abstract) In Russian. 48

refs.

Pospishil, B. *Probl Prochn* n 9 1987 p 3-11.

**079657 CYCLIC PLASTICITY: THE CYCLIC NONHARDENING REGION MODEL.** With a set of material constants determined from strain-controlled experiments, predictions of a constitutive model are calculated for several kinds of stress- and strain-controlled cyclic loadings, and compared with the corresponding experimental results. The model describes accurately the cyclic plastic behavior of 304 stainless steel at room temperature. The cyclic stress-strain curve calculated for constant stress-ranges coincides with that for constant strain-ranges, as observed in the experimental results. (Author abstract) 13 refs.

Ohno, N. (Toyoohashi Univ of Technology, Toyohashi, Jpn); Kachi, Y. *Res Mech* v 22 n 3 1987 p 199-212.

**079658 ADVANCED APPLICATIONS OF BEM TO THREE-DIMENSIONAL PROBLEMS OF MONOTONIC AND CYCLIC PLASTICITY.** An advanced formulation of the boundary-element method (BEM) has been developed for three-dimensional inelastic analysis under both monotonic and cyclic loading. The analysis uses isoparametric shape functions to model complex geometries and rapid functional variations accurately. The numerical integration of the kernels are carried out by devising suitable automatic sub-segmentation which controls the error in the integration. The formulation has been applied to a number of three-dimensional elastoplastic problems involving monotonic and cyclic loading to demonstrate that it can be used for realistic engineering plasticity problems. (Author abstract) 29 refs.

Banerjee, P.K. (State Univ of New York at Buffalo, Amherst, NY, USA); Wilson, R.B.; Raveendra, S.T. *Int J Mech Sci* v 29 n 9 1987 p 637-653.

**079659 METHODS OF ELASTIC SOLUTIONS.** The method of elastic solutions has been proposed for the solution of problems of the theory of small elastic-plastic deformations. This iterative process has proved to be an efficient method of solving boundary value problems for systems of quasi-linear differential equations of elliptic type. This paper considers a specific version of a method previously proposed as applied to the solution of quasi-static problems of the theory of small elastic-plastic deformations and offers a practical comparison of their convergence. 34 Refs.

Pobedrya, B.E.; Sheshenin, S.V. *Mech Solids* v 22 n 5 1987 p 55-68.

**079660 INCORPORATION OF YIELD SURFACE DISTORTION INTO A UNIFIED CONSTITUTIVE MODEL, PART I: EQUATION DEVELOPMENT.** The multiaxial MATMOD-4V model has been modified to enable the predictions of distorted small strain offset yield surfaces. This has been achieved by using a variable Hill-type anisotropy tensor, which modifies the yield function in the model. Allowing  $M_{ij}$  to be a function of both the short and long range back stresses (the kinematic hardening variables in the model) results in an evolution of anisotropy during deformation. This improved model retains its capability to predict expansion and translation of the yield surface, as well as a wide variety of mechanical behavior described previously. The derivation of this model is presented. This work is pertinent to metal forming. (Edited author abstract) 16 refs.

Helling, D.E.; Miller, A.K. *Acta Mech* v 69 n 1-4 Dec 1987, Ser Pap on the Found and Future Dir of Plast, the Aris Phillips Meml Vol, Gainesville, FL, USA, Jan 28-30 1987 p 9-23.

**079661 MODEL FOR FINITE-DEFORMATION PLASTICITY.** We propose a new large deformation viscoplastic model which includes the effects of static and dynamic recovery in its strain rate response as well as the plastic spin in its rotational response. The model is directly obtained from single slip dislocation consider-



ations with the aid of a maximization procedure and a scale invariance argument. It turns out that the evolution of the back stress and the expression for the plastic spin are coupled within the structure of the theory. The model is used for the prediction of non-standard effects in torsion, namely the development of axial stress and strain as well as the directional softening of the shear stress. (Edited author abstract) 25 refs.

Bammann, D.J. (Sandia Natl Lab, Livermore, CA, USA); Aifantis, E.C. *Acta Mech* v 69 n 1-4 Dec 1987, Ser Pap on the Found and Future Dir of Plast, the Aris Phillips Meml Vol, Gainesville, FL, USA, Jan 28-30 1987 p 97-117.

**Measurements** See ALUMINUM TITANIUM ALLOYS—Superplasticity; CERAMIC MATERIALS—Rheology.

## Radiation Effects

**079662 BASIC STUDY OF PLASTIC STRAIN FREEZING BY PHOTOPLASTIC EXPERIMENT.** It is difficult to solve the problem of stress-strain distribution in plastic regions in comparison with elastic bodies. Thus, an attempt to expand and apply stress-strain analysis by photoelasticity, with regard to polycarbonate resin in plastic photoelasticity, has been promoted so far and many significant achievements have resulted therefrom. This study is an examination of the possibilities of the plastic strain freezing method in comparison with the elastic stress freezing method. First, we attempted to determine the best temperature for plastic strain freezing. Further, it became apparent from systematic experimental results that it is 'strain' and not 'stress' which is frozen in plastic regions. In other words, it was made clear that the Birefringence  $N$  in strain freezing was proportional to the difference in the principal strains ( $\epsilon_1 - \epsilon_2$ ). (Author abstract) 7 refs.

Takahashi, Susumu (Kanto Gakuin Univ, Yokohama, Jpn); Suetsugu, Masahiro; Shimamoto, Akira. *JSME Int J* v 30 n 266 Aug 1987 p 1237-1242.

**Stability** See MATERIALS SCIENCE; METALS AND ALLOYS—Deformation.

## Strain

**079663 RESEARCH NOTE ON A COMPLIANCE APPROACH TO ANALYSIS OF PLASTIC STRESS-STRAIN RELATIONSHIPS.** The dependence of normalized compliance on strain is shown to be a discriminating pointer to the type of equation that can best match stress-strain data and also to the limit of stable uniform strain. An objective solution of the general power equation may be obtained by a relatively simple numerical analysis of the compliance strain relationship. The compliance approach permits valid statistical analysis of normally incremented test data (whereas analysis of logarithmic relationships properly requires exponential selection of the measured values). (Edited author abstract) 18 refs.

Atkinson, M. (Univ of Wollongong, Aust). *Int J Plast* v 4 n 2 1988 p 183-194.

**Theory** See Also COMPOSITE MATERIALS—Fiber Reinforced; DOMES AND SHELLS—Structural Analysis; FRACTURE MECHANICS; MATERIALS—Hardening; METAL EXTRUSION—Rheology; METAL EXTRUSION—Thermal Effects; METALS AND ALLOYS—Deformation; METALS AND ALLOYS—Hardening; PRESSURE VESSELS—Pressure Effects; SOLIDS—Deformation; SOLIDS—Physical Properties; STEEL—Strain; STRESSES—Analysis.

**079664 NOTE ON PLASTICITY THEORY IN MATRIX NOTATION.** In the matrix formulation of continuum mechanics, stress and strain tensors are contracted to vectors, and this lower order formulation has some advantages. However, due to an inconvenient contraction, the matrix formulation cannot be fully utilized in the theory of plasticity. The traditional contraction with engineering strains is rather artificial, and in the present note it is shown how the natural  $\sqrt{2}$  contraction for both stresses and strains makes a very clean formulation

possible. The importance of projection matrices is pointed out. (Author abstract) 2 refs.

Pedersen, Pauli (Technical Univ of Denmark, Lyngby, Den). *Commun Appl Numer Methods* v 3 n 6 Nov-Dec 1987 p 541-546.

**079665 ON THE APPLICATION OF THE PLASTIC SPIN CONCEPT FOR THE DESCRIPTION OF ANISOTROPIC HARDENING IN FINITE DEFORMATION PLASTICITY.** The aim of the paper is to fill the gap between the general theoretical formulation of the constitutive relations for plastic spin and practical applications for proper prediction of material behavior at finite plastic deformations and anisotropic hardening. An approximation to the representation of the general constitutive equation for plastic spin is considered and the pertinent substructure corotational rate is applied to formulate the relation for rigid-plastic material with kinematic hardening. The simple shear traction problem is analysed and the proposed model is verified with the experimental results of Swift. The merits of the present proposal vis-a-vis the existing theories are discussed. (Author abstract) 31 refs.

Paulun, Juergen E. (Univ Hannover, West Ger); Pecherski, Ryszard B. *Int J Plast* v 3 n 4 1987 p 303-314.

**079666 COROTATION DERIVATIVES AND DEFINING RELATIONS IN THE THEORY OF LARGE PLASTIC STRAINS.** Interest in elastoplasticity with large strains, by which the author means deformations with strain gradients exceeding (componentwise) 0.1, has increased markedly in the last decade. The main problem addressed by the theory of large elastoplastic strains in the derivation of the defining relations, in whose formulation some types of objective differential measures of the stressed and strained states, called corotational in the literature published abroad, are widely used. In this paper corotational derivatives are defined in an unified manner, and A.A. Il'yushin's theory of elastoplastic processes is extended to the case of large plastic deformations. 15 refs.

Trusov, P.V. *J Appl Mech Tech Phys* v 28 n 2 Mar-Apr 1987 p 311-316.

**079667 ON THE KINEMATICS OF FINITE-DEFORMATION PLASTICITY.** A theory of finite deformation plasticity is developed which involves a multiplicative decomposition of the deformation gradient through the assumption that there exists a stress-free configuration which can be used to separate the elastic and plastic components of the response. By using the polar decomposition on the usual indeterminate elastic and plastic deformation tensors, two uniquely defined stress-free configurations can be identified. The structure of this theory is compared with that of a spatial theory involving the polar decomposition of the total deformation gradient. (Edited author abstract) 19 refs.

Bammann, D.J.; Johnson, G.C. *Acta Mech* v 70 n 1-4 Dec 1987 p 1-13.

**079668 ISOMORPHISM OF TRINOMIAL RELATIONS OF THE PLASTICITY THEORY AND SOLVABILITY CONDITIONS OF BOUNDARY VALUE.** For a trinomial relation of the general theory of plasticity, the theorem is proved of the isomorphism of the images of the process in the spaces of stresses and strains under certain constraints expressed as material functions. The sufficient unique existence conditions in the small have been obtained for a generalized solution of the boundary value problem. Based on experimental data, material functions have been suggested that satisfy the conditions of the isomorphism theorem. (Author abstract) 6 refs.

Peleshko, V.A. *Moscow Univ Mech Bull* v 42 n 4 1987 p 36-39.

**079669 APPLICATIONS OF TENSOR FUNCTIONS TO THE FORMULATION OF YIELD CRITERIA FOR ANISOTROPIC MATERIALS.** Yielding of anisotropic materials can be characterized by yield criteria which are scalar-valued functions of the stress

tensor and of material tensors, for instance, of rank two or four, characterizing the anisotropic properties of the material. Because of the requirement of invariance, a yield criterion can be expressed as a single-valued function of the integrity basis. In finding an integrity basis involving the stress tensor and material tensors, the constitutive equations are first formulated based on the tensor function theory. Since the plastic work characterizes the yield process, it is read from this scalar expression the essential invariants to formulate a yield criterion. Some examples for practical use are discussed in detail. (Edited author abstract) 33 refs.

Betten, Josef (Technical Univ Aachen, West Ger). *Int J Plast* v 4 n 1 1988 p 29-46.

**079670 THEORY OF PARTICLE-REINFORCED PLASTICITY.** A simple, albeit approximate, theory is developed to determine the elastoplastic behavior of particle-reinforced materials. The elastic, spherical particles are uniformly dispersed in the ductile, work-hardening matrix. The method proposed combines Mori-Tanaka's concept of average stress inelasticity and Hill's discovery of a decreasing constraint power of the matrix in polycrystal plasticity. Under a monotonic, proportional loading the latter was characterized, approximately, by the secant moduli of the matrix. The theory is established for both traction and displacement-prescribed boundary conditions, under which, the average stress and strain of the constituents and the effective secant moduli of the composite are explicitly given in terms of the secant moduli of the matrix and the volume fraction of particles. (Edited author abstract) 33 refs.

Tandon, G.P. (Rutgers Univ, New Brunswick, NJ, USA); Weng, G.J. *J Appl Mech Trans ASME* v 55 n 1 Mar 1988 p 126-135.

**079671 NUMERICAL STUDY OF HOLONOMIC APPROXIMATIONS TO PROBLEMS IN PLASTICITY.** The incremental holonomic boundary-value problem in elastoplasticity has been shown to be characterized by a variational inequality. The problem may be approximated, however, by a perturbed minimization problem, characterized by a variational equality. This formulation is used as the basis for constructing finite element approximations of the original boundary-value problem, leading to a system of non-linear algebraic equations. Procedures for solving these equations are described and numerical results are presented and compared with those obtained using a conventional approach. (Author abstract) 11 refs.

Griffin, T.B. (Univ of Cape Town, Rondebosch, S Afr); Reddy, B.D.; Martin, J.B. *Int J Numer Methods Eng* v 26 n 6 Jun 1988 p 1449-1466.

**079672 NUMERICAL SOLUTION OF THE EVOLUTION EQUATIONS OF DAMAGE AND RATE-DEPENDENT PLASTICITY.** The evolution equations of damage theory and viscoelasticity are stiff ordinary differential equations and present numerous difficulties when one attempts to solve them numerically. This is particularly true when cyclic loading effects are to be simulated as few numerical schemes are stable when significant jumps in stresses occur. The present paper explores the performance of several numerical schemes for solving these evolution equations and presents methods which provide both accurate and stable simulations of large classes of rate-dependent problems. (Author abstract) 41 refs.

Bass, Jon M. (Univ of Texas at Austin, Austin, TX, USA); Oden, J.T. *Int J Eng Sci* v 26 n 7 1988 p 713-740.

**079673 TWO-SURFACE PLASTICITY THEORY AND ITS APPLICATION TO MULTIAXIAL LOADING.** A two-surface theory based upon experimental results is presented. The theory utilizes the concept of a yield surface and a loading surface to describe the essential features of the time-independent inelastic behavior of materials. The theory is implemented in a computer



program and its predictions are compared to a variety of axial-torsional experimental data including both proportional and nonproportional loading. (Edited author abstract) 17 refs.

Lu, W.Y.; Mohamed, Z.M. *Acta Mech* v 69 n 1-4 Dec 1987, Sel Pap on the Found and Future Dir of Plast, the Aris Phillips Meml Vol, Gainesville, FL, USA, Jan 28-30 1987 p 43-57.

**079674 OFFSET YIELD CRITERION FROM PRECURSOR DECAY ANALYSIS.** A yield criterion for waves of uniaxial strain generated under planar impact conditions is proposed. A plastic strain offset of 0.0002 produces values of the Hugoniot Elastic Limit (HEL) which are consistent with those obtained from computed stress-time profiles in a strain-rate dependent material. Numerical computations using a finite difference computer code illustrate that the decay of the amplitude of the propagating precursor elastic wave is a consequence of material strain-rate dependence. The HEL at distances far from the impact plane is shown to be independent of impact velocity and the form of the constitutive equation. (Edited author abstract) 7 refs.

Nicholas, T.; Rajendran, A.M.; Grove, D.J. *Acta Mech* v 69 n 1-4 Dec 1987, Sel Pap on the Found and Future Dir of Plast, the Aris Phillips Meml Vol, Gainesville, FL, USA, Jan 28-30 1987 p 205-218.

**Thermal Effects** See Also STRUCTURAL ANALYSIS.

**079675 ZUR BERECHNUNG DER RESTSPAN- NUNGEN BEIM ABKUEHLEN THERMISCH BEANSPRUCHTER ELASTISCH-PLASTISCHER BAUTEILE.** [On the Determination of Residual Stress in Thermally Loaded Elastic-Plastic Parts]. In some problems of thermoplasticity, the difficult task of determining the exact residual stresses remaining in a body after complete cooling can be avoided. It is suggested to approximately establish the residual stresses by subtracting the fictitious elastic stresses from the elastic-plastic ones occurring at the instant of switching off the heat source. As a criterion for the admissibility of this procedure the difference of the equivalent elastic stress and the yield stress is considered. (Author abstract) 10 refs. In German.

Mack, Werner (Technische Univ Wein, Vienna, Austria); Gamer, Udo. *Forsch Ingenieurwes* v 54 n 2 Mar 1988 p 48-52.

**PLASTICIZERS** See Also CONCRETE—Hot Weather Problems; COPOLYMERS—Permeability, Mechanical; ORGANIC CHEMICALS—Environmental Impact; PLASTICS—Injection Molding; POLYVINYL CHLORIDE—Diffusion; POLYVINYL CHLORIDE—Dispersions; POLYVINYL CHLORIDE—Mechanical Properties; TEXTILE FIBERS—Processing.

**079676 DEVELOPMENT AND STUDY OF A SCREW PLASTICIZER FOR ASBESTOS-FILLED MATERIALS.** To design a screw-type plasticizer, the authors investigated different variants of charging of asbestos-filled materials into a plasticizing cylinder (or into a material cylinder), determined the dependence of the productivity on the screw rotation speed and on the plasticization pressure, and studied the mechanism of material movement in the screw channel and its effect on the temperature of the dose accumulated. The experimental data obtained show that the calculation and selection of the geometric dimensions of the conical screw should be made with due consideration for the particle size of the material and the compression characteristics of the asbestos-filled materials being processed. Investigations of the pattern of movement and compaction of the materials showed that the asbestos-filled material can be compacted in the charging area 3-5-fold by a conical screw. Based on the studies made, it can be concluded that a screw plasticizer should be used for processing the asbestos-filled materials 143-63L and 328-303. The experimental data can be used for designing new equipment for processing fiber-filled materials and for calculating the productivity and capacity of the charging area (depending on its design) of the plasticizer. 4 refs.

Petrov, B.A.; Sokolov, A.D.; Makarov, V.L.; Volkov, A.A. *Chem Pet Eng* v 22 n 9-10 Sep-Oct 1986 p 427-430.

**Absorption** See POLYVINYL CHLORIDE.

**Applications** See Also AROMATIC POLYMERS—Glass Transition; POLYVINYL CHLORIDE—Crosslinking; POLYVINYL CHLORIDE—Fillers.

**079677 INTERACTIONS AND PARTITIONING OF LOW MOLECULAR WEIGHT POLYETHYLENE GLYCOLS AND DIETHYL PHTHALATE IN ETHYLCELLULOSE/HYDROXYPROPYL METHYLCELLULOSE BLENDS.** The interactions and partitioning of diethyl phthalate and low molecular weight polyethyleneglycols in blends of ethylcellulose/hydroxypropyl methylcellulose have been studied. Both plasticizers were shown to diffuse in both phases according to the overall volume composition. The plasticizers interacted preferentially with one polymer component of the blend as predicted from studies of the individual polymers. Diethyl phthalate, a preferential plasticizer for ethylcellulose, demonstrated increased partitioning in the ethylcellulose-rich phase only at 80/20 w/w ethylcellulose/hydroxypropyl methylcellulose compositions. Polyethylene glycols, PEG200 and PEG400, preferential plasticizers for hydroxypropyl methylcellulose, showed increased partitioning in the hydroxypropyl-methylcellulose-rich phase also in blends containing 80% w/w ethylcellulose. (Edited author abstract) 12 refs.

Sakellariou, P. (UMIST, Manchester, Engl); Rowe, R.C.; White, E.F.T. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2507-2516.

**079678 PLASTICISERS.** Demand for PVC in Western Europe totalled 4.24 million tons in 1986 of this, 1.53 million t (36%) was destined for plasticised PVC. The chief fields of application are cable insulation (0.38 million t/p.a.), film production (0.35 million t/p.a.) and the flooring industry (0.23 million t/p.a.). The different plasticisers on the market essentially fulfil the technical requirements placed on the service properties of plasticised PVC. Fundamentally new developments - like the development a few years ago of a di-isononylphthalate with properties previously unattained in this group - are the exception. Progress is being achieved in small steps with the improvement of existing products (such as improved alkyl sulphonic acid ester from phenol). In plasticised PVC processing, the aim is for compounding and processing to be carried out on an increasingly continuous basis. The technical advances in mixing units can be cited as an example of this. 11 refs.

Luetzel, G. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 96-99.

**Composition Effects** See POLYVINYL CHLORIDE—Additives.

**Concentration** See PLASTISOLS—Rheology.

**Efficiency** See POLYVINYL CHLORIDE—Blending.

**Extrusion** See POLYVINYL CHLORIDE—Processing.

**Manufacture** See STEEL CORROSION—Electrochemical.

**Materials** See Also POLYVINYL CHLORIDE—Degradation.

**079679 PROZESSOELE ALS MINERALOEL-WEICHMACHER IN KAUTSCHUKMISCHUNGEN.** [Process Oils as Mineral Oil Plasticisers in Rubber Compounds]. The plasticizing effect of process oils is explained using definitions of plasticisers and the gel theory. The influence of individual process oil parameters on the properties of polymer compounds such as processibility, low temperature characteristics, type of crosslinking, material adhesion and colour fastness is discussed in detail. A discussion is presented of the use of process oils in rubber compounds from the technical point of view. Their use for the production of oil-extended natural and synthetic rubbers, tires, mechanical parts, vulcanised

material made from Norbornen-rubber, dipped articles, commodities as defined by German legislation as well as articles made from block-polymers are described. Comments are also made about health aspects arising from the use of process oils. (Edited author abstract) 18 refs. In German.

Wommelsdorff, R. *Kautsch Gummi Kunstst* v 41 n 3 Mar 1988 p 248-253.

**Mixing** See CONCRETE PRODUCTS—Manufacture; POLYVINYL CHLORIDE—Processing.

**Physical Properties** See POLYVINYL CHLORIDE—Processing.

**Structure**

**079680 PHASE EQUILIBRIUM AND THE STRUCTURE OF THE SYSTEMS POLYMETHYL-METHACRYLATE-PHOSPHATE PLASTICIZERS.** Refractometry, light scatter and the turbidity spectrum methods have been used to study the phase equilibrium and structure of polymethylmethacrylate-alkyl halogen phosphate plasticized systems. The material presented indicates that the dependence of light scatter of plasticized systems on concentration is of an extremal character. The fall in  $T_g$  on introducing plasticizers into PMMA due to the breakdown and disordering of the supramolecular structures of the polymer is accompanied by increase in light scatter and the size of the concentration fluctuations. The maximum values of light scatter and the concentration fluctuations correspond to solutions of critical composition. (Edited author abstract) 12 refs.

Vshivkov, S.A. (Gorkii Urals State Univ, USSR); Isakova, I.I. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2762-2768.

**Testing** See COPOLYMERS—Mechanical Properties.

**Toxicity**

**079681 DEHP AND TOXICITY.** DEHP has a widespread use in flexible vinyls, serving as the workhorse plasticizer. Extensive studies have shown that DEHP has a very low order of toxicity. Originally, concern developed over the effect DEHP might have on the environment. In 1980 results of two-year feeding studies on rats and mice by NCI caused the emphasis to shift to health aspects of DEHP. Although evidence to date shows DEHP has extremely low order of toxicity (acute), is a minimal irritant to skin or eyes, and poses no hazard to the environment, the chemical industry will continue investigations of phthalate plasticizers. (Author abstract). 8 refs.

Murphy, Sandra R. (BASF Chemicals, Wyandotte, MI, USA); Wade, Brian L. *J Vinyl Technol* v 10 n 3 Sep 1988 p 121-124.

**PLASTICS** See Also AGRICULTURAL MACHINERY—Plastics Applications; COMPOSITE MATERIALS—Non-metallic Matrix Composites; ELECTRIC BATTERIES—Electrodes; EPOXY RESINS—Light Scattering.

**079682 POTENTIAL OF COMPARATIVELY NEW ENGINEERING PLASTICS IN THE INDIAN CONTEXT.** The expression 'Engineering Plastics' is defined and areas of applications delineated. Polyacetal and polycarbonate plastics are examined. The basic principle involved in the manufacture of these materials consists in reacting Bisphenol-A with phosgene in presence of a base, most commonly caustic soda. A review is presented of injection molded parts and extruded parts. Consumption patterns are traced.

Barar, Romesh (Nuchem Plastics Ltd, Faridabad, India); Singh, Ajit. *Chem Age India* v 38 n 4 1987 p 155-158.

**079683 ANTEC 87 CONFERENCE PROCEEDINGS - SOCIETY OF PLASTICS ENGINEERS 45TH ANNUAL TECHNICAL CONFERENCE & EXHIBIT.** This conference proceedings contains 361 papers arranged in 20 divisions. Topics presented include color and



appearance; extrusion; injection molding; electrical and electronic aspects of plastics; thermoforming; engineering properties and structure; vinyl plastics; thermosets; thermoplastic materials and foams; blow molding; plastics in automobiles; plastics analysis; decorating; moldmaking and mold design; medical plastics; marketing; polymer modifiers and additives; alloys and blends; advanced composites; and computers in the plastics industry. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10585 in the Ei Engineering Meeting (TM) database produced by Engineering Information, Inc.

Anon (Soc of Plastics Engineers, Brookfield Center, CT, USA). *Annu Tech Conf Soc Plast Eng* 45th, ANTEC 87 Conf Proc, Los Angeles, CA, USA, May 4-7 1987. Publ by Soc of Plastics Engineers, Brookfield Center, CT, USA, 1987 1576p.

**Additives** See Also EPOXY RESINS—Mechanical Properties; NYLON POLYMERS—Degradation; PLASTICS, FOAMED—Rigid; POLYETHYLENES—Antistatic Agents; POLYMERS—Chromatographic Analysis.

**079684 LMW POLYPROPYLENES CAN CARRY THE LOAD.** Low-molecular-weight polypropylene resins have low, stable, melt viscosities and high melting points, and are highly dispersive in composite base resins. Used as carriers for high loadings of pigments and fillers, LMWPPs help composites retain physical strength and open up possibilities for rheological tailoring. (Author abstract)

Bourland, Larry (ARCO, Newtown Square, PA, USA). *Plast Eng* v 43 n 5 May 1987 p 40-42.

**079685 NEW ACCESSORY FOR THE INFRARED ANALYSIS OF PLASTIC MATERIALS.** When confronted with the problem of having to analyse an unknown plastic material, there can be little doubt that infrared spectroscopy is the ideal technique, and the hot pressed film method the most convenient means of sample preparation. The sample is heated until molten, then pressed into a thin film and allowed to solidify. As additive concentration are often low - perhaps 0.1% m/m - much thicker films are necessary and, if a quantitative analysis is required, films prepared from both the samples and standards must also be of constant thickness. Now, a new sample handling accessory has been introduced that can prepare films to various thicknesses and of accurate reproducibility, allowing full qualitative and quantitative analyses. The Philips Analytical Precision Plastics Film Press is a complete, compact system for the analysis of plastic materials. Dies are supplied for creating films of 20, 50, 100, 200 and 500 mm thicknesses.

Osland, R. (Philips Analytical, Cambridge, Engl). *Plast Rubber Int* v 13 n 1 Feb 1988 P 19-20, 22.

**Adhesion** See JOINTS, ADHESIVE; POLYMERS—Diffusion.

## Adhesives

**079686 ETUDE DES LOIS DE COMPORTEMENT DE L'ADHESIF EPOXYDIQUE AV-118.** [Study of Mechanical Behaviour of Epoxy AV-118 Adhesive]. The design of an adhesive bonded joint requires the knowledge of both mechanical and environmental solicitations, and the mechanical properties of the assembly constituents, in order to establish critical levels of solicitations and life duration predictions. All the parameters useful to design and realise an adhesive bonded assembly are shown. In this work, the mechanical behaviour of the adhesive as a bulk material has been studied in order to design and to predict the properties of adhesive bonded joints. 7 refs. In French.

Balle, D. (Etablissement Technique Central de L'Armement, Arcueil, Fr). *Mem Etud Sci Rev Metall* v 85 n 3 Mar 1988 p 151-158.

**079687 ASE 85: ADHESIVES, SEALANTS AND ENCAPSULANTS CONFERENCE - CONFERENCE PROCEEDINGS.** This conference proceedings contains

61 papers arranged in three volumes. Topics presented in volume I include adhesive materials for electronic applications; role of plastics adhesives and sealants and encapsulants. Topics presented in volume II include stress analysis, test methods; applications in building industry; bonding of fiber composites and mechanics of wedge test. Topics presented in Volume III include environmental effects; offshore applications; hot melt assembly and adhesives heat curing. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 09468 in the Ei Engineering Meeting (TM) database produced by Engineering Information, Inc.

Anon (Plastics & Rubber Inst, London, Engl). *ASE 85: Adhes, Sealants and Encapsulants Conf - Conf Proc*, London, Engl, Nov 5-7 1985 Publ by Network Events Ltd, Buckingham, Engl, 1985 3 vol, 783p.

**Aging** See GEARS—Plastics Applications; PLASTICS, REINFORCED—Mechanical Properties; POLYETHYLENES—Mechanical Properties.

**Amorphous** See POLYMERS—Structure.

**Antioxidants** See POLYETHYLENES—Stabilizers; POLYMERS—Stabilizers.

**Antistatic Agents** See Also POLYETHYLENES—Oxidation; POLYETHYLENES—Stability.

**079688 NONBLOOMING ANTISTATS BASED ON COMBINED NEOALKOXY ORGANOMETALLICS.** A new class of antistatic agents based on combined neoalkoxy titanates and/or zirconates can be added in minor amounts during compounding to form a nonbloom- ing organometallic electron-transfer circuit resulting in an antistatic effect that works independently of atmospheric moisture. Relative merits and inherent chemistries of the different antistats are discussed here, and applications data are provided on the new materials. 3 refs.

Monte, S.J. (Kenrich Petrochemicals, Bayonne, NJ, USA); Sugerman, G. *Plast Compd* v 10 n 2 Mar-Apr 1987 p 33-34, 36-37.

**079689 ANTISTATISTIC AGENTS.** High volume and surface resistivity values have given plastics an important position as an insulating material in the electrical and electronics sector. However, in all processes in which plastics are separated from other media, these same structure-related properties result in the accumulation of high electrostatic charges on the surface. There are three ways in which the conductivity of plastics can be increased in order to avoid static charge: by surface application of an 'external' antistatic agent from a solution, by incorporating an 'internal' antistatic agent into the plastic and by incorporating additives with electronic conductivity (graphite, metals, organic semi-conductors). External and internal antistatic agents, together with the moisture from the air, usually produce a film with ionic conductivity. Additives with electronic conductivity are used when the surface resistance has to be below  $10^8 \Omega$ . For the conventional antistatic agents a growth rate parallel to that of the bulk plastics can be assumed. 12 refs.

Pfahler, G. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 89-90.

**Applications** See Also ADHESIVES—Materials; AUTOMOBILE MATERIALS—Steel; CONCRETE CONSTRUCTION—Forms; ELECTRIC INSULATING MATERIALS—Composition Effects; GASKETS—Materials; METALLOGRAPHY—Microstructures; PLASTICS INDUSTRY—Research; PLASTICS PRODUCTS; POLYMERS—Synthesis; POLYOLEFINS—Stabilizers.

**079690 POLYUREA BODY PANEL FOR ON-LINE PAINTING.** Polyurea technology, combined with proven RIM processing, allows economically viable production of vertical exterior body panels for volumes under 200,000 vehicles. The Dow Chemical Company has developed a series of polyurethane and polyurea materials to meet the specific assembly and paint oven requirements of the automotive industry. Polyurea HT can be utilized to produce body panels which can be on-line painted and assembled without major modification to most current

assembly plants. 9 refs.

Vanderhider, J.A. (Dow Chemical Co, Freeport, TX, USA); Hemphill, J.J. *J Elastomers Plast* v 19 n 4 Oct 1987 p 287-312.

**079691 WHAT IS NEW IN PERFORMANCE PLASTICS?** The field of performance plastics is showing remarkable vitality and growth, even though the participants find the price to be high in terms of technical and sales support required, together with high capital investment for plants. High-performance requirements exist in virtually all segments of the plastics field; the major end uses are in aerospace, automotive, business machines, electrical/electronics, food packaging, and medical applications. There will be continued pressure on the performance plastics from the lower priced materials which are countering with upgraded, modified, alloyed versions of their own. There is also increased competition between thermoplastics and thermosets as the result of material developments and process refinements.

Lantos, Peter R. (Target Group Inc, Philadelphia, PA, USA). *Polym Plast Technol Eng* v 26 n 3-4 Sep-Dec 1987 p 313-331.

## Biocompatibility

**079692 SHORT-TERM CELL-ATTACHMENT RATES: A SURFACE-SENSITIVE TEST OF CELL-SUBSTRATE COMPATIBILITY.** Mechanisms of cell deposition from a sessile liquid phase and adherence to various plastic substrates have been investigated by measurement of short-term (<120 min) cell-attachment rates. Sigmoidal attachment-rate curves were fit with a three-parameter variant of a logistic equation to quantify parameters related to initial rate and equilibrium-adherence. Comparison of adherence parameters for ionomer and polyethylene films, both with and without adsorbed fetal-bovine-serum proteins, demonstrated that surface carboxyl groups were important in protein adsorption and cellular adherence. (Edited author abstract) 41 refs.

Vogler, E.A. (DuPont, Wilmington, DE, USA); Bussian, R.W. *J Biomed Mater Res* v 21 n 10 Oct 1987 p 1197-1211.

## Biodegradation

**079693 MICROBIAL DEGRADATION OF SYNTHETIC POLYMERS, NYLON, POLYAMIDES, POLY(ETHYLENE OXIDE), POLY(VINYL ALCOHOL), AND POLY(PROPYLENE OXIDE).** Polycondensations of dimethyl L-tartrate or diethyl mucate with hexamethylenediamine were carried out in solution to form polyamides having pendant hydroxyl groups. Strain PA9-4 was isolated from soil, which utilizes the polyamides as the sole source of carbon. The degradation of the polyamides by this bacterium was examined and compared with that of nylon 1, nylon 3, nylon 6, and nylon 66. The strain also degraded other water-soluble synthetic polymers such as poly(ethylene oxide) (PEO) and poly(vinyl alcohol) (PVA). The relation between bio-degradation and the equilibrium hygroscopic degree of these synthetic polymers was also discussed. The strain was tentatively classified as a Corynebacterium bacterium on the basis of its morphological and cultural characteristics. (Author abstract) 29 refs. In Japanese.

Aikawa, Takashi (Sophia Univ, Tokyo, Jpn); Otsuka, Hisako; Sanui, Kohei; Kurusu, Yasuhiko; Sato, Akio. *Kobunshi Ronbunshu* v 45 n 4 1988 p 347-355.

**Blending** See Also IONOMERS—Mechanical Properties; PLASTICS MACHINERY—Extruders; POLYMERS—Glass Transition; POLYMERS—Viscoelasticity.

**079694 COMPATIBILITY OF POLY(VINYL CHLORIDE) WITH POLYALKYLENEOXIDES. I. POLY(METHYLENE OXIDE) AND POLY(ETHYLENE OXIDE).** The compatibility of poly(vinyl chloride) (PVC) with linear polyethers is examined over the entire composition range. This study examines blends with



poly(methylene oxide) (PMO) and poly(ethylene oxide) (PEO) of medium (MMW) and high (HMW) molecular weight. The techniques used are dynamic mechanical analysis, DSC, and optical microscopy (phase contrast and polarizing). The results indicate that all polyethers show limited miscibility in the melt at high PVC contents. Proper analysis of the  $T_m$  data using the Kwei-Frisch and Hoffman-Weeks procedures allows the determination of the thermodynamic interaction parameter to be made, which is found to be close to zero for all pairs of blends. (Edited author abstract). 47 Refs.

Margaritis, A.G. (Univ of Patras, Patras, Greece); Kalfoglou, N.K. *J Polym Sci Part B* v 26 n 8 Aug 5 1988 p 1595-1612.

## Blow Molding

**079695 AUTOMATED IN-MOULD WALLTHICKNESS MEASUREMENT (IMM).** The plastic industry produces a variety of large containers for which special safety regulations apply. Among these are canisters and drums for dangerous goods, shock-proof drums, and especially motor-vehicle fuel tanks. A minimum wall thickness is laid down in all acceptance specifications for these containers. Thus thickness measurement is an important element of the production process and in quality testing and control. Cooperation between Elbatainer, Ettlingen, a plastics processor, and Krautkramer, Huerth, a manufacturer of testing equipment, had the objective of automating ultrasonic thickness measurement, an operation previously carried out manually. The target is to carry out the measurement at the earliest possible time on the production line. The ideal position making the measurement is within the blowing mould itself. On the basis of results from comprehensive practical trials, a system of measurement has now been developed that delivers reproducible results under these difficult conditions.

Buchscheidt, W.K.; Walker, D. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 5-7.

**079696 BELIEVE IT OR NOT, ALL THESE PARTS ARE BEING BLOW MOLDED.** Designers increasingly are looking to blow molding for components that may be too costly to make in relatively short runs by injection molding or structural foam molding, or which require more strength and rigidity than can be developed in thermoforming. The most obvious advantage of the process (that it can make hollow parts of almost any shape) is being exploited in many new applications. The fact that such versatile performance is achieved in a structure with just two parts indicates the ability of blow molding to take advantage of the cost/performance benefits of parts consolidation. Although the great bulk of blow molded parts are made of polyethylene, structural designers now can choose from a broadening range of blow moldable engineering resins. One of the innate advantages of blow molding is that its tooling is lighter in weight and costs less than that of other processes.

Smoluk, George R. *Mod Plast* v 65 n 3 Mar 1988 p 72-74, 76.

**079697 ON-LINE MEASUREMENT AND ESTIMATION OF PARISON DIMENSIONS IN EXTRUSION BLOW MOLDING.** An optical on-line parison profile thickness estimation technique has been devised and found to agree well with data obtained from a pinch-off mold. The dynamic response of thickness distribution to steps of various magnitude, direction, and locations along the extrusion has been obtained. The technique will be utilized to obtain dynamic models required for closed loop control of parison dimensions. The technique was applied to the blow molding of polyethylene. 14 Refs.

DiRaddo, R.W. (McGill Univ, Montreal, Que, Can); Patterson, W.I.; Kamal, M.R. *Adv Polym Technol* v 8 n 3 Fall 1988 p 265-274.

**Blowing Agents** See PLASTICS, FOAMED—Processing.

**Bonding** See POLYVINYL CHLORIDE—Mechanical Properties; SPORTING GOODS—Plastics.

## Calendering

**079698 A NUMERICAL ANALYSIS OF CALENDERING.** An analysis of calendering of inelastic (power-law) and viscoelastic sheets of finite initial thickness has been carried out using (i) a perturbation method based on lubrication theory; (ii) an approximate treatment including normal stress effects; (iii) a full numerical analysis using the boundary element method. The N. Phan-Thien - R.I. Tanner (PTT) fluid model was used in the viscoelastic analyses. Attention is focused on the separation criterion at the roll exit plane. While it is usual to assume in the inelastic case that separation occurs when the pressure and pressure gradient vanish simultaneously, it is not clear that this is appropriate in the viscoelastic model. The main new results are (a) a method of determining the separation point numerically using the criterion of zero tangential traction; (b) a computation of walling (approximately 5 percent) after the sheet leaves the nip; (c) a demonstration that the roll force first decreases as Weissenberg number (roll speed) rises, and then increases. (Author abstract). 24 Refs.

Zheng, R. (Univ of Sydney, Aust); Tanner, R.I. *J Non Newtonian Fluid Mech* v 28 n 2 Jun 1988 p 149-170.

**Casting** See MEMBRANES—Manufacture.

**Chromatographic Analysis** See POLYMERS—Chromatographic Analysis; POLYMERS—Pyrolysis; POLYMERS—Theory.

## Cleaning

**079699 NIEDERDRUCKPLASMA TECHNOLOGIE IN DER PRAXIS.** [Low Pressure Plasma Technology in Practice]. Low pressure plasma treatment is a simple, sure and at the same time versatile method for cleaning, modifying and conditioning the surfaces of a very wide range of materials. Microwave excitation can be used to effectively treat plastics without causing visible changes at the surface. Owing to the short processing times and the small amount of materials needed for running the equipment, the method is economical, the freedom from problems with respect to waste disposal and the safety of the workplace playing a significant role. (Author abstract) In German. 5 refs.

Liebel, Gerhard (Technics Plasma, Kirchheim bei Muenchen, West Ger). *Adhaesion* v 32 n 1-2 Jan-Feb 1988 p 21-23.

**Coextrusion** See Also ELECTRIC CABLES—Insulation; PLASTICS MACHINERY—Dies and Presses; PLASTICS MACHINERY—Molding Machines; POLYMERS—Rheology.

**079700 BARRIER COEXTRUSION GOES PUSH-BUTTON.** A discussion is presented of a new online spectrophotometric selective layer gage. The gage is designed for selective measurement of 3- and 5-layer films from 0.5-10 mils. It is claimed to provide measurement accuracies for barrier layers (plus two other layers) of  $\pm 10\%$  in films from 0.5 to 2 mils, and  $\pm 5\%$  in gages of 2 to 10 mils. The gage's sensor head contains a 16-bit microprocessor that conditions raw infrared wavelength signals via software programmed for spectrophotometric analysis. Also discussed is new sheet-specific coextrusion equipment including dual-lip profiling dies, split-entry feedbacks, plug-in supplier written software and, coex lines equipped with gear pumps.

Sneller, Joseph A. *Mod Plast* v 64 n 1 Jan 1987 p 34-37.

**079701 GEAR PUMP ASSISTED COEXTRUSION.** The gear pump, although not a cure-all, can offer definite benefits in many extrusion applications. In general, a gear pump should be considered for an extrusion process if one or more of the following conditions are present: poor

output stability; critical gauge dimensions; low extruder output; expensive resins; frequent product changes; regrind materials; high melt temperature or temperature sensitive processes; high head pressures; and coextrusion. Coextrusion is an ideal candidate for the melt pump due to the need for precise metering of layers, use of expensive resins, regrind materials, high head pressures, and temperature sensitive products. The use of multiple extruders presents special problems such as longer melt transition piping, which dictates higher head pressures. Multiple extruders also create special control and coordination requirements. The gear pump's linearity and predictable output make it an ideal candidate for this type of application. With the predictable output of the gear pump, line stability can be achieved in a much shorter time, resulting in decreased setup time, decreased scrap generation, and higher productivity. 6 refs.

Smith, Daniel J. (Luwa Corp, Charlotte, NC, USA). *J Plast Film Sheeting* v 4 n 1 Jan 1988 p 72-80.

**079702 COEXTRUDIERTE SPERRSCHICHTROHRE FÜR KRAFTSTOFFLEITUNGEN.** [Coextruded Barrier Layers in Fuel-line Tubing]. Length increase and fuel diffusion are disadvantages accompanying the use of polyamide (PA) 11 and polyamide 12 tubing for fuel lines. These problems have to be solved before steel tubing can be replaced by plastics tubing for this function. By coextrusion of suitable materials with barrier properties it is now possible to reduce the diffusion of fuels, and the length increases due to particular components of fuels. However, to achieve optimum technical and economic solutions by coextrusion, specific combinations of polymers are required for each type of fuel. (Author abstract) In German and English.

Brunnhöfer, Erwin (Caprano & Brunnhöfer KG, Fulda-bruck, West Ger); Egen, Uwe. *Kunstst Ger Plast* v 78 n 5 May 1988 p 407-410.

**079703 NEW TIE LAYERS BRIGHTEN LIFE FOR COEXTRUDERS.** The compatibility problem between the non-polar and polar materials - that is, the tie-layer base resin and the barrier resins - typically is handled by chemically modifying the tie layer backbone with 'functionality,' a molecule or chemical group having polar properties. The expansion in hot-fill and retortable applications has spurred the development of higher-temperature (or higher-strength) alternatives to ethylene-vinyl acetate (EVA) for bonding barrier resins and polypropylene (PP) for PP-EVOH or PP-nylon coextrusions. Du Pont now offers a new series; several resins for PVdC have been developed for rigid PP coextrusion; several tie-layer clear resins for PC have surfaced; for coextrusion-lamination with a variety of materials - PC, PP, PET and copolymers, EVOH, and nylon; Shell Chemical has developed a PP-PP elastomeric tie resin based on its styrene-butadiene block copolymer chemistry. Other newer developments in resins are described.

Miller, Bernie (Plastics World, Newton, MA, USA). *Plast World* v 46 n 7 Jul 1988 p 57-59.

**079704 TAPPI NOTES: COEXTRUSION SEMINAR.** This conference proceedings contains 22 papers. Topics presented include emerging countries and coextrusion; commodity coextrusion markets; aseptic packaging market trends; commodity polymers, LDPE, HDPE, EAA, Ionomer, EVA/21; Slot dies for coextrusion; coextrusion dies design and maintenance; effects of melt rheology in coextrusion; feedback coextrusion systems; coextruded structures quality control and new barrier polymers. The application of plastic packaging materials in food industry and packaging cost is reported. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10787 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (TAPPI, Atlanta, GA, USA). *TAPPI Notes* 1986 Coextrusion Semin, Hilton Head, SC, USA, Apr 1-3 1986. Publ by TAPPI Press, Atlanta, GA, USA, 1986 134p.



**Coloring** See Also DYES AND DYEING—Color Matching.

**079705 SPC ON INCOMING COLORANTS.** This paper deals with just one segment of SPC, namely capability studies and analysis of incoming colorants. The need for capability studies originates from renewed drive by customers for acceptable quality products at all times. By applying SPC techniques to incoming colorants, the customer can determine if the vendors process is in control, if the vendor is using lot selection, and what kind of reject rate the vendor is experiencing among other things. (Edited author abstract)

Deem, D.G. (Borg-Warner Chemicals Inc, Washington, WV, USA). *J Vinyl Technol* v 9 n 3 Sep 1987 p 124-128.

**079706 ASPECTS OF ORGANIC-COLORANT SELECTION FOR ENGINEERING POLYMERS IN THE AUTOMOTIVE INDUSTRY.** Where heavy-metal-containing pigments must be avoided, growing attention has been focused on organic colorants, especially in Europe. In the face of high melt temperatures, the boundary between organic pigments and dyes blurs, and products must be selected with great care. Migration-related problems are particularly troublesome. TGA screening procedures can be used to predict some aspects of migration behavior, as reported here for a series of dyes in polycarbonate and nylon. (Author abstract)

Sykes, Roger (Ciba-Geigy, Basel, Switzerland). *Plast Compd* v 10 n 2 Mar-Apr 1987 p 13-16, 18, 20-22.

**079707 COLORANTS.** Colorants include individual inorganic and organic pigments, soluble dyes and so-called programmed colorants. The latter are specific preparations or combinations for a particular plastic intended to provide a specified tone with the required light fastness. Individual colorants are used by plastics producers, compounders and plastics processors with in-house color laboratories. In addition there are companies who manufacture programmed colorants as a service to processors. Two developments have placed considerable demands on all manufacturers and users of colorants. The first is the vigorous development of engineering and high performance plastics which require better physical properties, particularly heat resistance. The second is caused by limitations resulting from legislation or discussions on ecological, physiological or toxicological aspects. 11 refs.

Lenz, H.J. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 94-96.

**Combustion** See Also POLYMERS—Degradation.

**079708 COMBUSTION PRODUCTS OF POLYMERIC MATERIALS VERSUS HEAT RELEASED BY POLYMER COMBUSTION IN THE CAB 650 CHAMBER.** This work describes the results of an experimental study carried out in order to determine whether the combustion chamber CAB 650 can be used to determine the amount of heat released during combustion. The results of such tests would permit characterization of polymeric materials with respect to the three most important effects of fire - heat, smoke and the toxicity of the combustion products. A method has been developed enabling comparison of polymeric materials on the basis of the heat evolved during combustion. The calculated heat index yields information on the heat capacity of the material compared with cellulose as a standard material. (Edited author abstract) 1 ref.

Michal, J. (Ore Research Inst, Czech); Pokova, E. *Fire Mater* v 11 n 2 Jun 1987 p 105-108.

**079709 FEATURES OF EPOXY COMPOSITE IGNITION BY CONTINUOUS LASER RADIATION.** A study of the modified fire-resistant polymers with a solid-phase inhibitor action that alters the structure and properties of coke is of special interest. Tests were conducted on the effect of continuous laser radiation on the epoxy resin ED-20 solidified by metaphenylene diamine and containing a vanadium compound ( $V_2O_4$  and  $VC_3$ ) which are effective inhibitors of combustion. It should be noted that the mechanism of the action of these

admixture reduces to the acceleration of dehydrogenation and dehydration processes, whereupon the coke yield is increased significantly. 7 refs.

Bychkov, S.G.; Desyatkov, A.V.; Biketov, A.A.; Ksan-dopulo, G.I.; Minazhaeva, G.S. *Combust Explos Shock Waves* v 22 n 6 Nov-Dec 1986 p 664-665.

**Compounding** See Also PLASTICS INDUSTRY—Marketing; PLASTICS MACHINERY—Control; POLYMERS—Compounding; POLYVINYL CHLORIDE—Fillers; POLYVINYL CHLORIDE—Injection Molding.

**079710 COMPUTER OPTIMIZATION OF FORMULATIONS.** Formulation, balancing the portfolio of additives to obtain the target level on each key physical property, is a difficult art. With recent advances in personal-computer hardware and software it can become more of a science; the problem can be transformed into a mathematical form suitable for solution on a computer. First, an experimental design technique is developed to generate data for modeling. Then each property can be modeled as a function of the level of each of the additives, constraints can be set on property values, and the problem can be structured to find the minimum cost formulation for a given set of physical-property constraints. This article demonstrates the methodology, with real examples using engineering resins and various levels of glass fiber and microspheres, and considers such properties as tensile and flexural strength and modulus, impact strength, density, warpage, and cost. 10 refs.

Bohl, Alan H. (PQ Corp, Valley Forge, PA, USA). *Plast Compd* v 10 n 6 Sep-Oct 1987 p 12-14, 16, 18.

**079711 HIGH INTENSITY COMPOUNDING OF MICA-FILLED THERMOPLASTICS.** High-speed turbine mixers have been adapted for compounding filled thermoplastics by the partial flux method. The extreme shearing forces exerted by the mixing impellers simultaneously mixes and delaminates mica fillers to form finely dispersed compounds in a granular, partially fused state which can be directly injection molded without pelletizing. The partial flux method permits compounding to be accomplished at peak sensor temperatures that are considerably below the resin softening or melting transitions, frequently 50°C less than normal compounding temperatures. The short residence times and reduced energy requirements possible with partial fluxing results in substantial cost reduction without compromising quality or performance. Examples are provided for polypropylene, nylon 66, poly(butene terephthalate), poly(ethylene terephthalate) and poly(phenylene oxide) alloys. (Edited author abstract) 11 refs.

Cacoutis, Spyridon (Dehavilland Aircraft Co); Woodhams, Raymond T.; Kleyn, Peta Gay; Van De Poll. *Polym Compos* v 9 n 1 Feb 1988 p 51-59.

**079712 SPOTLIGHT: SOFTWARE CUSTOMIZES COMPOUND FORMULAS.** Roscom Inc., a compounder with a manufacturing facility in Trenton, N.J., has recently developed a custom software package that generates compound formulas to meet specific needs. For example, a client may require that a compound retain UV resistance for a specified period and remain within certain cost parameters. The requirements are keyed into a computer, and a customized software program works out a formula. Development of this program is part of a general upgrade under way to improve compounding capabilities, flexibility, and traceability.

Anon. *Plast Compd* v 11 n 2 Mar-Apr 1988 33, 35.

**Compression Molding** See Also LENSES—Manufacture; PLASTICS LAMINATES—Failure; PLASTICS MACHINERY; PLASTICS SHEETS—Sheet Molding Compounds; POLYETHYLENES—Processing.

**079713 BOUNDARY ELEMENT SIMULATION OF COMPRESSION MOLD FILLING.** This paper presents the development of the boundary element equations for the compression molding process of isothermal Newtonian fluids. It shows the numerical implementation of the boundary element equations and presents a simple method of carrying out the domain integral present in the

governing equations. The results and accuracy of a boundary element simulation are discussed, and the numerical results compared to experimental values. (Author abstract) 13 refs.

Osswald, Tim A. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Tucker, Charles L. III. *Polym Eng Sci* v 28 n 7 Mid-April 1988 p 413-420.

**Computer Aided Analysis**

**079714 MOLDING OF A PLASTIC DATA BASE.** As blends and alloys proliferate, the task of selecting materials is becoming increasingly complex. A computer data base helps design engineers to predict how plastics will perform in actual operating conditions. Computers are an essential tool in tracking complex material and part behavior, but it is up to engineers to predict the performance of specific molded parts under actual operating conditions. In order to do so, they must have at their disposal accurate and relevant engineering data. (Edited author abstract)

Trantina, Gerald G. (GE Plastics, Pittsfield, MA, USA); Ysseldyke, David A. *Mech Eng* v 110 n 6 Jun 1988 p 82-86.

**Computer Aided Design** See POLYURETHANES—Reaction Injection Molding.

**Computer Integrated Manufacturing**

**079715 CIM CONCEPT FOR INJECTION MOULDING.** A concept for the automation of injection moulding is described. To achieve fully automatic injection moulding production, the whole environment of the injection moulding machine must be incorporated into the automation concept. This begins at the mould store and extends from transport and preheating of the moulds and the automatic mould changing, through automated injection moulding with handling units for removing the mouldings, to automatic materials changing at the injection moulding machine and removal of the palettes filled with finished mouldings. The authors show such an automated production plant installed in the development, demonstration and training centre for injection moulding technology, with two injection moulding machines. This plant has also proved to be a test plant for implementation of accessories. It permits the user-friendliness to be examined and the use with new development techniques to be learnt, especially in the field of software technology. In English and German.

Dato, M. Actis; Di Dio, L.; Godlo, C. *Kunstst Ger Plast* v 78 n 3 Mar 1988 p 8-11.

**Concentration** See POLYMERS—Concentration.

**Conductive** See Also POLYMERS—Electric Conductivity; POLYMERS—Synthesis.

**079716 EFFECT OF CHEMICAL EXPOSURE ON THE EMI SHIELDING OF CONDUCTIVE PLASTICS.** The electrical properties of a number of filled plastics were examined after subjecting the materials to exposure to isopropyl alcohol, a 25°C detergent/water solution, an 80°C detergent/water solution, and at various chemical plant sites. Compositions which contained metal fillers maintained their conductivity only when a high temperature thermally stable polymer was used as the polymer matrix, while compositions which are made conductive through a carbon filler network maintained their conductivity under most of the exposure conditions examined even when low temperature polymers were used as matrices. (Author abstract) 13 refs.

Bigg, D.M. (Battelle Columbus Div, Columbus, OH, USA). *Polym Compos* v 8 n 1 Feb 1987 p 1-7.

**079717 HIGHLY ELECTROCONDUCTIVE POLYPYRROLE COMPOSITES.** Following up our work on polypyrrole (PP), one of the few synthetic metals having a fairly good stability in air, we have tried to overcome



some of the limitations of its synthesis and handling. In the course of the study on the chemical polymerization of pyrrole to highly conducting PP we have found that by supporting the monomer on a porous substrate before contacting it with an oxidant solution, it was possible to improve the conductivity of the polymer formed. In terms of conductivity per gram of electroactive material, an improvement by a factor of up to 3 or 4 was achieved. 9 refs.

Bocchi, V. (Univ di Parma, Parma, Italy); Gardini, G.P.; Rapi, S. *J Mater Sci Lett* v 6 n 11 Nov 1987 p 1283-1284.

**079718 THERMAL STABILITY OF SHIELDING EFFECTIVENESS OF ELECTROMAGNETIC INTERFERENCE OF COMPOSITES.** A series of composites were prepared using polyethylene and various chatter-machined metal fibers (aluminum, copper, steel and brass) and carbon fiber, and the effects of the concentration of the fillers and the thermal treatment of the composites at 80°C in air on the shielding effectiveness (SE) of electromagnetic interference were examined. Thermal degradation of SE was scarcely observed in the carbon fiber system and very slightly in the brass and steel systems, while remarkable degradation was observed in the copper and aluminum systems. This degradation was assumed to be due to the formation of an oxidized surface to increase the contact resistance between fillers. Stabilization of the thermal degradation of SE of the aluminum composite was possible to some extent when the aluminum surface was pretreated with certain reagents. (Edited author abstract) 20 refs.

Osawa, Zenjiro (Gunma Univ, Kiryu, Jpn); Kobayashi, Kazunaga. *J Mater Sci* v 22 n 12 Dec 1987 p 4381-4387.

**079719 FILLER-CONTAINING, ELECTRICALLY CONDUCTIVE PLASTICS.** The objective of using plastics in increasingly new fields of technology has led in recent years to demands for plastics with custom-made electrical properties. The great interest in electrically conductive (and thermoplastically processable) plastics is explained by the fact that housing with integrated shielding can be produced in a single processing step. A step in the direction of achieving this objective is the incorporation of electrically conductive fillers into thermoplastically processable plastics. A conductive network of filler particles in the finished article is essential for the functioning of the shielding. The physical conditions and the problems involved in the formation of such a network are discussed. In English and German.

Moebius, K.-H. *Kunstst Ger Plast* v 78 n 1 Jan 1988 p 17-20.

**079720 ELEKTROMAGNETISCHE ABSCHIRMUNG MIT ELEKTRISCH LEITFAEHIGEN KUNSTSTOFFEN.** [Electromagnetic Shielding with Electrically Conductive Plastics]. Starting out with the objective of preventing mutual electromagnetic interference between electronic instruments with housings made from electrically conductive plastics, some fundamental principles of the shielding of electromagnetic fields and waves are discussed and a coaxial method of measurement for the determination of shielding efficiency under far field conditions is explained. For an interpretation of the corresponding measurements in the context of the properties of the shielding materials, consistent treatment of reflection and absorption of plane waves in the shield is necessary. This is explained by the use of a carbon black-filled model system. An ASA/PC-blend filled with Al-flakes is presented as an example of a construction material having high shielding efficiency. (Author abstract) 12 refs. In German.

Moebius, Karl Heinz (BASF, Ludwigshafen, West Ger). *Kunstst Ger Plast* v 78 n 4 Apr 1988 p 345-350.

**079721 STABILIZATION OF SHIELDING EFFECTIVENESS OF ELECTROMAGNETIC INTERFERENCE OF ALUMINIUM FIBRE AND POLYAMIDE COMPOSITES.** We have examined the thermal stability of the shielding effectiveness of composites prepared with various conductive fillers and polyamide,

Nylon 12. We found that in the case of aluminum fiber composites their functional stability was improved remarkably by the surface treatment of the fillers with commercial polymers and oligomers. Because the treatment is very simple (i.e. just dip and dry), this method seems to be interesting from the industrial point of view for the preparation of thermally stabilized shielding composites for electromagnetic interference. 5 Refs.

Osawa, Zenjiro (Gunma Univ, Kiryu, Jpn); Yamanaka, Shigeyuki. *J Mater Sci Lett* v 7 n 9 Sep 1988 p 983-984.

**Crack Propagation** See Also ELECTRONICS PACKAGING—Thermal Effects; POLYMERS—Fracture.

**079722 EFFECT OF PHYSIOLOGICAL SALT WATER ON FATIGUE CRACK PROPAGATION RATE FOR GLASS FIBER REINFORCED POLYCARBONATE.** The fatigue crack propagation in physiological salt water was investigated in polycarbonate and glass fiber reinforced polycarbonate. The effects of physiological salt water, glass fiber content and stress ratio on fatigue crack growth rate were determined. These effects in physiological salt water could be considered by dividing the crack growth rate into two regions: I and II. The crack growth rate in region I was accelerated by the physiological salt water and stress ratio. In region II, the crack growth rate increased by increasing the content of glass fiber. The crack opening level in the physiological salt water decreased rapidly with increasing  $\Delta K$ . This transition behavior may result from the physiological salt water penetrating the fatigue crack, which deforms itself like a viscous fluid against a viscous elastic crack, and divides the crack growth rate into two regions. (Edited author abstract). 15 Refs. In Japanese.

Murakami, Ri-ichi; Noguchi, Shinji; Akizono, Koichi. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 501 May 1988 p 917-924.

**Crazing** See POLYMERS—Deformation.

**Creep** See Also POLYMERS—Stresses.

**079723 CREEP INDUCED BUCKLING OF PLASTIC MATERIALS.** In this work, creep induced buckling was studied for a number of thermoplastic materials. The effect was observed by monitoring top displacements of thermoplastic bars a function of time under static loading conditions. The recorded times to failure were averaged and correlated with the applied loads. The experiments, conducted for different materials, established an exponential dependence between the critical time and the load. The evolution of the buckling eigenvalues was modeled numerically. The simulations of eccentric columns behavior under compressive loads were coupled with the eigenvalue analyses. The correlation of the time-load predictions obtained from the numerical simulations followed the experimental results within acceptable limits. The observed phenomenon of creep induced buckling was explained by damage accumulation leading to an effective reduction of the load carrying capability. (Author abstract) 12 refs.

Cohen, A. (Dow Chemical Co, Midland, MI, USA); Arends, C.B. *Polym Eng Sci* v 28 n 8 Apr 1988 p 506-509.

**079724 TEMPERATURE DEPENDENCE OF LIFETIME STATISTICS FOR SINGLE KEVLAR 49 FILAMENTS IN CREEP-RUPTURE.** Experimental data are presented for the strength and lifetime under constant stress of single Kevlar 49 aramid filaments at 80 and 130°C. As seen in previously published work performed at room temperature (21°C), the strength data could be fitted to a two-parameter Weibull distribution; increasing the temperature caused a decrease in the Weibull scale parameter while the shape parameter remained relatively constant, indicating a decrease in the mean strength but no change in strength variability. Lifetime experiments were performed at different filament stress levels ranging from 55 to 92.5% of the Weibull scale parameter for short-term strength at that temperature. These data were fitted to a two-parameter Weibull distribution with large variability and evaluated using an

exponential kinetic breakdown model. Using this model, activation energies in the neighborhood of 80 kcal mol<sup>-1</sup> ( $3.35 \times 10^5$  J mol<sup>-1</sup>) were obtained, suggesting that scission of the C-N bond plays the dominant role in fibre failure at longer times under constant stress. (Author abstract) 36 refs.

Wu, H.F. (Cornell Univ, Ithaca, NY, USA); Phoenix, S.L.; Schwartz, P. *J Mater Sci* v 23 n 5 May 1988 p 1851-1860.

**Crosslinking** See Also RUBBER—Crosslinking; RUBBER—Vulcanization.

**079725 TERMINAL RETARDATION TIMES AND WEIGHTS FOR THE ROUSE MODEL FOR A CROSSLINKED NETWORK.** Reference is made to author's previous computation of the retardation times  $\lambda_i$  corresponding to the rouse model of a polymer fluid, with the result  $\lambda_1 \approx (\tau_1 \tau_{1+1})^{1/2}$ , where  $\tau_i$  are called relaxation times, with  $\tau_1 > \tau_{1+1}$ . Since values of  $\lambda_i$  do not appear to be available for the Rouse model of a crosslinked polymer solid, it is the purpose of this article to present the  $\lambda_i$  for this case. 5 refs.

Berry, G.C. (Carnegie-Mellon Univ, Pittsburgh, PA, USA). *J Polym Sci Part B* v 25 n 10 Oct 1987 p 2203-2205.

**Crushing and Grinding** See PLASTICS PRODUCTION—Recycling.

**Crystallization** See POLYETHYLENE TEREPHTHALATE—Stresses.

**Curing** See Also ADHESIVES; ADHESIVES—Curing; COATINGS—Curing; POLYMERS—Crosslinking; VINYL RESINS—Modification.

**079726 ACCESSORY MATERIALS FOR HIGH TEMPERATURE AUTOCLAVE OPERATIONS.** Success in high temperature curing and thermoforming autoclave operations cannot be achieved without vacuum bags and sealants which will retain their integrity throughout severe time/temperature/pressure cycles. This paper describes experience in using specially formulated, high temperature resistant, vacuum bag films and sealants in autoclave operations up to 840°F. Bagging and operating techniques are described. Statistics are presented on the success rate experienced with these materials and techniques. (Author abstract)

Keller, Brian (Programmed Composites Inc, Brea, CA, USA); Castillo, Arturo; Grasty, Joseph. *SAMPE J* v 24 n 1 Jan-Feb 1988 p 50-51.

**079727 STUDY ON THE ELECTRON IRRADIATION CURING MECHANISM OF POLYCARBOSILANE FIBRES BY SOLID-STATE <sup>29</sup>Si HIGH-RESOLUTION NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY.** Silicon carbide fibre is obtained from the fibre of polycarbosilane by heating at high temperature in an inert gas flow. Before heating, the PC fibre must be cured to maintain a fibrous shape during the heating process. This letter discusses the applications of solid-state <sup>29</sup>Si-NMR spectroscopy to the irradiation curing mechanism of polycarbosilane fibres. Analysis of <sup>29</sup>Si-NMR and <sup>13</sup>C spectra indicates that the Si-H and C-H bond in a polycarbosilane molecule are broken and that the Si-C or Si-Si bond is formed. 8 refs.

Taki, T. (Tokushima Univ, Tokushima, Jpn); Okamura, K.; Sato, M.; Seguchi, T.; Kawanishi, S. *J Mater Sci Lett* v 7 n 3 Mar 1988 p 209-211.

**079728 MAGNET WIRE DISSIPATION FACTOR—ONE LAYER AT A TIME.** The use of dissipation factor as a test to establish the degree of cure of polymers used as dielectric materials in magnet wire coatings is considered. The data used were collected for a sole coat configuration, a single polymer applied in multiple layers. Guidelines are given for incorporating dissipation factor measurement as an inspection tool in magnet wire manufacture.

Klug, Richard S. (A/Z-Tech Inc, Fort Wayne, IN, USA). *IEEE Electr Insul Mag* v 4 n 2 1988 p 24-26.



**Cutting** See CUTTING TOOLS—Applications; LASER BEAMS—Applications.

## Database Systems

**079729 ENGINEERING DESIGN DATABASE FOR PLASTICS.** A readily-accessed data base provides valuable design information on a wide range of engineering resins, with properties keyed to application-specific conditions. GE Plastics has developed such a system and recently announced its availability to the design engineering community. This database will provide data on GE Plastics' Noryl modified polyphenylene oxide (PPO), Lexan polycarbonate (PC), Valox polyesters (PET, PBT), Ultem polyetherimide (PEI), Gelyo acrylonitrile-styrene-acrylic (ASA), Noryl GTX PPO/nylon alloy, Gemax PPO/PBT, Xenoy PC/PBT alloys, and Lomod thermoplastic copolyester elastomers. The Engineering Design Database (EDD) also includes GEFOAMS data on filled and unfilled structural foams.

Trantina, Gerald G. (GE Plastics, Pittsfield, MA, USA); Yseldyke, David A. *Mater Eng (Cleveland)* v 104 n 10 Oct 1987 p 35-38.

**Decomposition** See Also POLYMERS—Stability; POLYMERS—Thermal Effects; SHIPBUILDING MATERIALS—Fire Resistance.

**079730 SUMMARY OF THE NBS LITERATURE REVIEWS ON THE CHEMICAL NATURE AND TOXICITY OF THE PYROLYSIS AND COMBUSTION PRODUCTS FROM SEVEN PLASTICS: ACRYLONITRILE-BUTADIENE-STYRENES (ABS), NYLONS, POLYESTERS, POLYETHYLENES, POLYSTYRENES, POLY(VINYL CHLORIDES) AND RIGID POLYURETHANE FOAMS.** A series of literature reviews was undertaken by the National Bureau of Standards to examine the toxicity and chemistry of the effluents produced when seven plastics were decomposed under various thermal and atmospheric conditions. These plastics are: acrylonitrile-butadiene-styrenes, nylons, polyesters, polyethylenes, polystyrenes, poly(vinyl chlorides) and rigid polyurethane foams. The English-language literature on each of these was reviewed and published as a separate report of the National Bureau of Standards. Over 400 different thermal decomposition products, many common to more than one plastic, were identified. The toxicity of most of these individual products is unknown and an assessment of the toxicity of the multitude of possible combinations is not feasible at this time. Therefore a variety of bioassay toxicity protocols have been used to assess the toxicity of the gaseous atmospheres generated by the thermal decomposition of these plastics. (Edited author abstract) 20 refs.

Levin, Barbara C. (NBS, Gaithersburg, MD, USA). *Fire Mater* v 11 n 3 Sep 1987 p 143-157.

## Decoration

**079731 INNOVATIVE DECORATING CUTS COSTS, BOOSTS VALUE.** Many of today's decorating innovations are in response to the challenges posed by automotive style changes. Imaginative use of new in-mold decorating technology is helping automotive companies meet their goals to improve aesthetics and produce more cost-effective decorated plastic parts. Innovative decorators are also taking advantage of advances in hot stamp foils and heat transfer to eliminate decorating steps and reduce costs. The sublimation and Hydro GraFix processes and laser marking are finding new applications that make the most of their inherent advantages.

Lodge, Charles (Plastics World, Newton, MA, USA). *Plast World* v 45 n 9 Aug 1987 p 26-30.

**Deformation** See Also PLASTICS PRODUCTS—Viscoelasticity; POLYETHYLENES—High Density; POLYMERS—Degradation; POLYMERS—Mechanical Properties; POLYMERS—Structure; POLYPROPYLENE—Mechanical Properties; POLYPROPYLENE—Order-Disorder.

**079732 DEFORMATION BEHAVIOR OF HDPE/(P-PEC/PS)/SEBS BLENDS.** Immiscible blends of high

density polyethylene (HDPE) and an amorphous glassy phase consisting of either pure polystyrene (PS) or a miscible blend of PS and a polyether copolymer (PEC) were compatibilized with various amounts of a styrene-hydrogenated butadiene block copolymer (SEBS). Using a liquid displacement stress dilatometer, the volume change of samples during uniaxial mechanical straining was determined and related to the various modes of deformation. Blends were fabricated by both injection and compression molding. Microscopic evidence of the improved adhesion and modes of deformation agrees with the results obtained by dilatometry. The volume dilatation of compression-molded materials do not seem to be similarly affected by the composition of the glassy phase which may reflect morphological differences between injection- and compression-molded blends. (Edited author abstract) 28 refs.

Schwarz, M.C. (Univ of Texas at Austin, Austin, TX, USA); Keskkula, H.; Barlow, J.W.; Paul, D.R. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 653-677.

**079733 ACOUSTIC-EMISSION ANALYSIS OF THE DEFORMATION AND FRACTURE OF PLASTICS.** Relationships are found to link the structural parameters, type of manufacturing technology, loading conditions (strain rate) and acoustic-emission (AE) data for composites. The results of tests run at a constant loading speed on three types of plastics with various adhesion characteristics and differing manufacturing technologies are reported. Simultaneously with the mechanical parameters, AE data were recorded: the total number of signals and the acoustic-emission intensity. (Author abstract) 7 refs.

Viktorova, I.V.; Dobrynin, V.S. *Sov Mach Sci* n 4 1987 p 108-111.

**079734 STEADY STATE PENETRATION OF COMPRESSIBLE RIGID PERFECTLY PLASTIC TARGETS.** Steady state axisymmetric deformations of a homogeneous, isotropic, compressible and rigid perfectly plastic target being penetrated by a rigid cylindrical penetrator with a hemispherical nose are studied by the finite element method. The steady state is reached with respect to an observer situated on the penetrator nose and moving with it. Tillotson's equation, restricted to mechanical deformations, is used to express the pressure as a function of the mass density. Contact between the penetrator and the target is assumed to be smooth. The effect of compressibility of the material is delineated by comparing results for compressible and incompressible materials. Also studied is the effect of the penetrator speed on target deformations. (Author abstract). 10 Refs.

Batra, R.C. (Univ of Missouri-Rolla, Rolla, MO, USA); Gobinath, T. *Int J Eng Sci* v 26 n 7 1988 p 741-751.

**Degradation** See PLASTICS, REINFORCED—Wear; POLYMERS—Elasticity; POLYMERS—Mechanical Properties; POLYMERS—Pyrolysis; POLYMERS—Thermal Effects; POLYVINYL CHLORIDE—Applications.

**Dielectric Properties** See Also POLYMERS—Electric Conductivity; POLYMERS—Solutions.

**079735 USING SIX-PORT REFLECTOMETER MEASUREMENT OF COMPLEX DIELECTRIC CONSTANT.** The principle of measurement of complex dielectric constant using a six-port reflectometer and the mathematical model of computer software to perform this measurement are presented. The experimental results of measuring teflon using the six-port reflectometer at X-band are given. The complex dielectric constant of the teflon is also measured using the resonant cavity technique. Good agreement of the results supports the validity of the presented theory. 6 refs.

Hu, Xi-Ping (Natl Inst of Metrology, Beijing, China). *IEEE Trans Instrum Meas* v IM-36 n 2 Jun 1987, Sel Pap - Conf on Precis Electromagn Meas (CPEM/86), Gaithersburg, MD, USA, Jun 23-27 1986 p 537-539.

**Discoloration** See POLYVINYL CHLORIDE—Stabilizers.

**Doping** See POLYMERS—Conductive; POLYMERS—Electric Conductivity; POLYMERS—Electrochemistry.

**Drawing and Stamping** See Also POLYMERS—Deformation.

**079736 NECKING AND NECK PROPAGATION IN POLYMERIC MATERIALS UNDER PLANE-STRAIN TENSION.** Necking and neck propagation as observed in cold-drawing polymers is analyzed for plane-strain tensile loading. Approximate one- and two-dimensional analyses are presented for quasi-static neck propagation along an infinitely long spectrum. In addition, the entire load-deformation behavior of finite length specimens is computed using the finite element method. Various models describing effects such as rate dependence and anisotropic (kinematic) hardening are considered. (Author abstract) 10 refs.

Tugcu, P. (Univ de Sherbrooke, Sherbrooke, Que Can); Neale, K.W. *Int J Solids Struct* v 23 n 7 1987 p 1063-1085.

**Drying** See DRYERS—Automation.

**Elasticity** See POLYMERS—Crosslinking; POLYMERS—Deformation.

## Elastoplasticity

**079737 ANALYSES OF THE YIELD BEHAVIOR AND THE STRESS PATHS UNDER THE COMBINED STRESS LOADING IN POLYMERIC MATERIALS.** Non-plasticized PVC, ABS, and PMMA bars were subjected to various rates of stretch and twist. Experimental results were analyzed using the corrected Gaydon's equation. The results were applied to ideal elasto-plastic bodies that obeyed Hooke's law and Reuss's equation with yield points undergoing von Mises and Tresca criteria. Interaction curves were drawn in two dimensional stress space; these showed good agreement with the stress values of yield points obtained from the experiment. A method was derived to draw the interaction curves so as to satisfy, in a broad sense, the elasto-plastic model. The intersecting points between these curves and the stress state in stress space under the loading conditions suggest that a change in elasto-plastic state occurred during the deformation along the stress-strain curves. (Edited author abstract) 9 refs. In Japanese.

Hibi, Sadao (Nagoya Inst of Technology, Nagoya, Jpn); Torii, Takashi; Yoshida, Ikuo; Nakanishi, Eiji; Maeda, Matsuo. *Kobunshi Ronbunshu* v 45 n 3 Mar 1988 p 229-236.

**Electric Breakdown** See ELECTRIC INSULATING MATERIALS—Plastics.

**Electric Conductivity** See Also AIRCRAFT MATERIALS—Plastics; POLYMERS—Conductive; POLYMERS—Doping; POLYMERS—Molecular Structure; POLYMERS—Structure; POLYMERS—Synthesis.

**079738 CONDUCTIVE PLASTICS CHARGE INTO NEW ELECTRONICS MARKET.** Conductive plastics are employed in the protection of electronic components and products, 5 to 25% of whose failures are related to electrostatic discharge (ESD). Conductive plastics are used to shield against electromagnetic interference and to dissipate ESD. Virtually all plastic materials can be made conductive with additives. However, some plastics are inherently conductive, but they are currently available only for special applications. There are two ways to measure the conductivity, or resistance, of a material: by the volume resistivity and the surface resistivity of the material. Some approaches to making inherently conductive plastics are described.

Salamone, Salvatore (Plastics World, Newton, MA, USA). *Plast World* v 46 n 5 May 1988 p 5p.



**079739 PLASTICS THAT CONDUCT ELECTRICITY.** Cheap, durable, lightweight and versatile plastics have a host of commendable properties, but conductivity is usually not counted among them. To make a polymer conduct electricity, small quantities of certain chemicals are incorporated into the polymer by a process called doping. This article discusses the phenomenon.

Kaner, Richard B.; MacDiarmid, Alan G. *Sci Am* v 258 n 2 Feb 1988 p 106-111.

**079740 DIELECTRIC STUDY OF POLY(ETHYLENE-CO-VINYL ACETATE)-POLY(VINYL CHLORIDE) BLENDS. III. DIRECT CURRENT CONDUCTIVITY AND ELECTRODE POLARIZATION.** The large direct current (dc) conductance observed at low frequencies and high temperatures in conjunction with a simple electrical circuit model was used to calculate specific conductivities in PVC and mixtures of PVC with a poly(ethylene-vinyl acetate) copolymer. Activation energies for dc conduction and dipole relaxation in PVC and the blends were found to be in reasonable correspondence. The effects of different electrode materials on the dc conductance as well as on electrode polarization are discussed. (Author abstract). 13 Refs.

Rellick, G.S. (Pennsylvania State Univ, University Park, PA, USA); Runt, J. *J Polym Sci Part B* v 26 n 7 Jul 1988 p 1425-1438.

**Electric Properties** See PIEZOELECTRIC MATERIALS—Evaluation; POLYMERS—Optical Properties; POLYMERS—Structure; POLYMERS—Synthesis.

**Electrochemistry** See POLYMERS—Doping.

**Electronic Properties** See POLYMERS—Blending; POLYMERS—Doping; POLYMERS—Structure.

**Electroplating** See COMPUTERS, MICROCOMPUTER.—Electromagnetic Shielding.

## Environmental Impact

**079741 VYUZITI PLASTU PRI DOPRAVE ZPRACOVANI GEOTERMALNICH VOD.** [Use of Plastics in Transport and Processing of Geothermal Water]. Results obtained by testing twelve samples of plastics in thermal water are presented in this paper. The results showed a high affinity of inorganic substances to plastics. Adhesion of the inorganic substances to the material and changes in mechanical properties of these materials were evaluated. The tendency of plastics towards incrustation is higher than that of steel. When incrustation inhibitors are used, the application of plastics does not give any advantages as the consumption of inhibitors in plastics is higher than that in steel. The advantage of plastics lies in their resistance to corrosive environment. (Edited author abstract) In Czech.

Stepankova, Kamila (Vyzkumny Ustav Geologického, Brno, Czech). *Plasty Kauc* v 24 n 10 Oct 1987 p 289-292.

## Evaluation

**079742 ZUR BEANSPRUCHUNGSBEWERTUNG VON PLASTKONSTRUKTIONEN FUER DEN APPARATE- UND ROHRLEITUNGSBAU.** [Evaluation of Strain for Constructions Made of Polymeric Materials Applicable to Chemical Plant Equipment and Piping Systems]. Practicable aids are placed at the constructing and the projecting engineer's disposal to improve the safe, reliable, and economical use of polymeric materials. This paper deals with proposals about calculation of stress and evaluation of strain on condition of static and temporal variable loads on the understanding of an approximate isotropic property of materials. (Author abstract) 14 refs. In German.

Weiss, Eckart (Technische Univ 'Otto von Guericke', Magdeburg, East Ger). *Chem Tech (Leipzig)* v 39 n 10 Oct 1987 p 417-420.

**Extrusion** See Also PLASTICS MACHINERY—Extruders; POLYMERS—Drawing and Stamping; POLYVINYL CHLORIDE—Injection Molding; TUBES—Extrusion.

**079743 TWIN-SCREW GEOMETRY A KEY TO REACTIVE EXTRUSION.** Counter-rotating, non-intermeshing (CRNI) twin-screw extruders have been used as continuous reactors for a wide range of systems. Reactive processing is particularly enhanced by the geometry of CRNI extruders, which permits extended residence time and excellent distributive mixing. (Author abstract)

Tucker, Christopher S. (Welding Engineers Inc, Blue Bell, PA, USA); Nichols, Russell J. *Plast Eng* v 43 n 5 May 1987 p 27-30.

**079744 DIMENSIONLESS CURVES FOR EXTRUDER MELT TEMPERATURE AND FLOW.** An accurate analysis of the melt flow in the metering section of an extruder typically requires a computer simulation if the interaction of the melt temperature and pressure with viscosity is to be considered. A simple isothermal calculation can estimate flow rate, but does not give any information about melt temperature. A comprehensive simulation which does contain thermal information requires access to a computer and some amount of knowledge and effort in encoding the input and decoding the output. A technique for calculating extruder melt flow is presented here. It includes thermal and viscous effects in a graphical format and does not require computer capability. The results can be used to make flow calculations and also to make general observations about melt temperature and flow in extruder melt sections. (Author abstract) 5 refs.

Derezinski, Stephen J. (Eastman Kodak Co, Rochester, NY, USA). *J Plast Film Sheeting* v 3 n 4 Oct 1987 p 274-289.

**079745 METHOD FOR ESTIMATION OF POLYMER MELT TEMPERATURE FLUCTUATION IN A SINGLE SCREW EXTRUSION PROCESS.** A method for estimating the polymer melt extrudate temperature fluctuation in the single screw extrusion process is proposed. Predictions of the melt temperature fluctuation is feasible if the extrusion process parameters are known. The method is superior to those in the literature, because it incorporates effects of the melting process on the temperature fluctuation. The method has been verified experimentally. (Edited author abstract) 14 refs.

Wilczynski, Krzysztof (Polytechnika Warszawska, Warsaw, Pol). *Polym Eng Sci* v 28 n 7 Mid-April 1988 p 429-433.

**079746 PROCESS CONTROL OF PROFILE EXTRUSION USING THERMAL METHOD. PART I: MATHEMATICAL MODELING AND SYSTEM ANALYSIS.** An analytical model based on the heat penetration through the die wall was proposed to calculate the effect of die wall temperature on the flow of polymer melt in profile dies. Model prediction matched well with the experimental data measured from a modified Instron capillary rheometer. The model was applied to an extrusion line with an L-shaped profile die. Dynamic responses of the profile extrusion line based on this die were measured and modeled. The pairing of manipulated variables and controlled variables was analyzed. (Author abstract) 52 refs.

Yang, B. (Ohio State Univ, Columbus, OH, USA); Lee, L.J. *Polym Eng Sci* v 28 n 11 Mid-Jun 1988 p 697-707.

**079747 PROCESS CONTROL OF PROFILE EXTRUSION USING THERMAL METHOD. PART II: CLOSED LOOP CONTROL.** A rubberized polystyrene was extruded through a simple L-shaped profile die with one thin section and one thick section. Takeup speed was used to control the size of the extrudate, and die temperature was used to control algorithms, a dual single-loop feedback PI controller and a multivariable feedforward plus feedback control method (FFC), were carried out for set point changes of the extrudate shape and size, and load disturbances of screw speed. Results showed that the PI feedback controller was satisfactory

for long-term set point changes but not for load changes. The FFC worked well for load disturbances lower than 10 cycles/min. Owing to the slow dynamic response of die temperature, the shape loop can only be controlled for long-term disturbances. (Edited author abstract) 24 refs.

Yang, B. (Ohio State Univ, Columbus, OH, USA); Lee, L.J. *Polym Eng Sci* v 28 n 11 Mid-Jun 1988 p 708-717.

**079748 MODELING OF EXTRUSION WITH SLIP BOUNDARY CONDITIONS.** Slip at boundaries is possible in viscous flows; for instance, in the extrusion of foodstuffs, water-containing materials, and some polymers. There are two phenomenological descriptions of slip: The first is based on the presence of a very thin, low viscosity boundary layer and has been derived for capillary flow and extrusion; the second is based on a Coulomb-friction mechanism and has been derived for capillary flow only. After a survey of these results, the friction model is derived for the extrusion process. All calculations are as simple as possible: two-dimensional, Newtonian, isothermal, and with constant boundary layer parameters or coefficients of friction. A strong dependence of pumping characteristics and efficiency on the slip boundary conditions, and also on the extruder length in the case of friction, was found, especially when slip is only allowed for at the screw surface. Exercises like these may help in understanding abnormal extrusion behavior of slippery materials in practice. (Author abstract) 38 refs.

Meijer, H.E.H. (DSM Research, Geleen, Holland); Verbraak, C.P.J.M. *Polym Eng Sci* v 28 n 11 Mid-Jun 1988 p 758-772.

**079749 EXTRUSION PLANT FOR COEXTRUDED FILM.** A newly designed plant is described which produces five-layer film and is suitable for all kinds of technical packaging films with high barrier properties, particularly meant for the extended storage of foods. Thanks to its progressive design, this coextrusion plant has numerous processing technological facilities to offer. The extruders are mounted on a rotating platform. One extruder of 65 mm screw diameter (model 65CV/D) and two extruders of 50 mm screw diameter (model 50CV/24D) are capable of producing composite film consisting of five layers to the pattern A/B/C/B/A. With multi-layer film of the A/B/C/B/D extrusion pattern, the system is complemented by adding another extruder model 50CV/24D. Take-off equipments are designed to suit the following film dimensions: reel-widths of 1200 and 1500 mm (with or without calender haul-off); reel widths of 2000, 2500 and 3000 mm. These plants can produce all kinds of technical packaging films of high barrier properties, e.g. PE/coupling agent/PA/coupling agent/ionomer. At film thicknesses of 40 to 140 µm and a film width of 1 m, the output rate is approximately 120 kg/h. Some of the plant components are described subsequently. Various pieces of equipment are described. In English and German.

Anon. *Kunstst Ger Plast* v 78 n 3 Mar 1988 p 12-13.

**079750 OCENA SPRAWNOSCI UKLADOW UPLASTYCZNIJACYCH W PROCESIE WYTŁACZANIA: CZ. I. KRYTERIA OCENY SPRAWNOSCI.** [Evaluation of the Efficiency of Plasticating Systems in the Extrusion Process: Part I. Criteria of Efficiency Evaluation]. The basic categories in the evaluation of efficiency of plasticating systems in extruders are output and cost of the extrusion process, as well as product quality. In relation to the last-mentioned category, the effect of the extrusion process parameters (temperature, pressure and flow intensity), with allowance for their variation in time, the effect of homogeneity of material composition (quality of intermixing) and the effect of rheological characteristics of the material (viscosity and elasticity), has been isolated. On this basis, the main criteria of the efficiency evaluation for plasticating systems



have been characterized and methods of their measurement are discussed. (Edited author abstract) 22 refs. In Polish.

Wilczynski, Krzysztof (Politechnika Warszawska, Pol). *Polimery* v 33 n 2 Feb 1988 p 55-58.

**079751 FLEX DRIVES QUALITY ROUTE TO AUTOMOTIVE SUCCESS.** The article describes some successful projects that have led to the Taguchi methods becoming standard operating procedure at Flex Technologies. A 'Taguchi experiment' is designed to identify and eliminate sources of variation and reduce their effect. A designed experiment is one that proceeds by a rational and systematic identification of variables, rather than trial-and-error varying of factors. Taguchi has also boiled down the complex mathematical task of analyzing multivariable experiments with a series of plug-in statistical tools called orthogonal arrays. One of Taguchi's innovations is to provide manufacturers with a means to quantify quality from the customer's point of view, the quality loss function (QLF), a mathematical tool that relates deviation in product characteristics to the cost that a customer incurs due to the deviation.

Schlack, Mark (Plastics World, Newton, MA, USA). *Plast World* v 46 n 7 Jul 1988 p 48-53.

**079752 HOW TO GET 'NEW' EXTRUDERS AT A FRACTION OF THE COST.** The article describes how plastics plants can modernize their existing extrusion systems quickly and economically through remanufacturing services from equipment suppliers. Extrusion Technical Services is a new one-stop shopping service supporting the extrusion machinery aftermarket. It is geared toward fast response and staffed with extrusion specialists skilled in hands-on problem solving. The ETS Div. was formally established as a separate business enterprise in 1982, and now performs a number of services for the extrusion aftermarket. Two case studies are reviewed to illustrate what remanufacturers can do.

Kirkland, Carl (Plastics World, New York, NY, USA). *Plast World* v 46 n 7 Jul 1988 p 66-67.

**079753 ABSCHAETZUNG DER ANTRIEBSLEISTUNG UND MASSETEMPERATUR.** [Conventional Single-Screw Extruders]. This paper presents approximation calculations, based on the total energy balance, for estimating the performance of conventional-model plasticizing units from the energy point of view. Apart from characteristic functions to describe the nature of heat introduction into the extrudate, the calculation also takes in geometrical characteristic values and the melt temperature at the screw tip. Experimental verification of the above calculations over a wide spread of machine and operating point data produces maximum deviation of  $\pm 15$  percent. The approximations presented are initially valid for simple multi-section screws. Only one of the screws was fitted with a Troester shear section, 2D in length. The results were within the scatter range mentioned above. It is thus possible to use the equations as a guide in this case as well. Further screw configurations with different shearing and mixing sections will need to be investigated, however, before significant statements can be made. (Author abstract). 13 Refs. In German.

Potente, Helmut; Fornefeld, Antonius; Michel, Peter. *Plastverarbeiter* v 39 n 5 May 1988 p 34-40.

**079754 UEBERWACHUNG DURCH MESSUNG DES SCHMELZEDRUCKES.** [The Extrusion Process]. The melt pressure build-up in the screw region plays a decisive role in ensuring a uniform transport of melt, in that it influences flow behaviour and the thorough mixing of the melt. Since the screw is rotating, however, periodic and non-periodic signals are superimposed on the measured pressure values. The evaluation of the measured signals can thus really only be performed with a computer. For slow-conveying or conventional extruders, characteristic pressure profiles are obtained that are a function of the geometric dimensions of the particular screw and process variables, such as melt temperature and melt state. For purposes of monitoring the long-term behaviour of

the extruder it is useful to log the steady-state pressure profile over the length of the cylinder, whilst if the dynamic processes in the pressure profile are logged, this will permit statements to be made on short-term behaviour. (Edited author abstract). 9 Refs. In German.

Dormeier, S.; Kleinhans, H. *Plastverarbeiter* v 39 n 5 May 1988 p 42-47.

**079755 INTERFACE DETERMINATION IN BI-COMPONENT EXTRUSION.** The unidirectional flow of two immiscible fluids with different viscosities in a long die of arbitrary shape is considered. Mathematically, the problem has a continuum of solutions corresponding to arbitrarily prescribed interface shapes, but experimental evidence indicates the existence of a unique interface shape with the less viscous fluid encapsulating the more viscous fluid. With the introduction of the minimum viscous dissipation principle, which postulates that the amount of viscous dissipation is minimized for a given flow rate, the problem becomes a nonlinearly constrained optimization problem. A generalized reduced gradient/finite element method combination is used to predict the interface shape when two inelastic fluids are considered. The effect of the viscosity ratio and flow-rate ratio on the interface shape is examined for different die geometries. Inner layer breakup phenomena are predicted and explained for complex die geometries. (Author abstract). 19 Refs.

Karagiannis, A. (McMaster Univ, Hamilton, Ont, Can); Mavridis, H.; Hyrmak, A.N.; Vlachopoulos, J. *Polym Eng Sci* v 28 n 15 mid-august 1988 p 982-988.

## Extrusion Molding

**079756 ABWEICHUNGEN BERUEHRUNGSLÖS MESSEN.** [Measurement and Control Unit for Profile Extrusion]. This paper presents a measurement and control unit with an optical measuring head that will monitor the swelling of the plastic upon output from the die, or the tailback of material between the die and the calibrating unit, and keep this constant by changing the take-off speed. In cases where it is necessary to regulate the extruder speed, this can be done by using a piece of equipment ancillary to the basic unit. The measurement and control unit has been developed to smooth out any proportional changes that come about during the extrusion process via the take-off speed. To ensure rapid notification of malfunctions, an outline recognition system has been incorporated which triggers an alarm when the target value has not been attained over a specific period of time. (Edited author abstract). In German.

Anon. *Plastverarbeiter* v 39 n 5 May 1988 66p.

**Fatigue** See PLASTICS, REINFORCED—Glass Fiber; POLYMERS—Mechanical Properties.

**Filament Winding** See Also COMPOSITE MATERIALS—Fabrication.

**079757 CARRIER MOTION IN A PAYOUT DEVICE FOR FILAMENTARY MATERIALS.** Causes of variation in the shapes and dimensions of packs are established. A formula is derived for determination of the speed of the carrier in a spreader that handles filamentary materials. Another formula determines the carrier speed necessary to produce a cylindrical pack. (Author abstract) 3 refs.

Pankov, V.N.; Gershon, B.S.; Bolotin, F.M. *Sov Mach Sci* n 4 1987 p 103-107.

**Fillers** See Also ADHESIVES—Physical Properties; EP-OXY RESINS—Mechanical Properties; FILLERS; PLASTICS, REINFORCED—Reaction Injection Molding; PLASTICS SHEETS—Mechanical Properties; POLYETHYLENES—Electric Properties; RUBBER, SYNTHETIC—Processing; THERMOPLASTICS—Extrusion.

**079758 FILLERS.** The development and applications of mineral and organic fillers for polymers during the last three years has followed more or less conventional lines. The steep fall in polymer prices since the middle of 1985, especially for polyolefins, has in some cases considerably reduced the economic advantages of using fillers. Despite

this, the filler manufacturers have intensified their efforts to bring improved products for increasingly specialized plastics applications on to the market. 16 refs.

Schlumpf, H.P. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 99-101.

**079759 DROP-WEIGHT TESTING: WHAT IT TELLS DESIGNERS.** Such factors as improper mixing of fillers and resin degradation lead to bimodal effects in drop-weight tests. In such cases, replacement of ASTM 'staircase method' by the Probit method-testing multiple specimens at several energy levels-helps to clarify findings. The Probit method is akin to Bruceton; apparatus and specimen failure criteria are identical. However Probit method specimens are tested in successive groups, with each group of from 20 to 40 specimens tested at the same energy level. The energy levels used must correspond to less than 10% and greater than 90% failure and three groups at energy levels between these two extremes. Test results are plotted as failure energy vs failure percentage on probability graph paper. The Probit technique requires significantly more test specimens: 100 to 150 vs 20 to 40 for the Bruceton technique. 3 refs.

Progelhof, R.C. (Univ of South Carolina, Columbia, SC, USA); Throne, J.L.; Patel, U. *Mod Plast* v 65 n 2 Feb 1988 p 106, 108, 110.

**079760 MINERALS IN PLASTICS: MEETING THE CHALLENGE OF THE FUTURE.** The authors outline the means whereby plastics producers can improve their market position. The two avenues open are to work on process improvements that will reduce operating costs or to seek product modifications that can improve performance and thus expand the range of applications. Although process improvement is certainly an important avenue, product modification may represent the greatest potential. The roles of minerals and surface-modified minerals are examined.

Haskin, Richard W.; Eckert, Carl. *Ind Miner (London)* n 234 Mar 1987 p 54-59.

**079761 NIR STUDIES OF THE SURFACE MODIFICATION IN SILICA FILLERS.** Methods of estimating the degree of condensation of the surface silanol groups of silica due to its modification by silane coupling agents are reported. Also, a procedure for estimating the surface silanol groups for the pre- and post-modified silicas for the NIR 7326  $\text{cm}^{-1}$  band is given. Using electron microscope studies and heats of immersion of silica surfaces, the silane effect on agglomeration of silica particles and, thus, on the physicochemical properties of its surface has been demonstrated. (Author abstract). 38 Refs.

Krysztakiewicz, A. (Technical Univ, Poznan, Pol); Rager, B. *Colloid Polym Sci* v 266 n 6 Jun 1988 p 485-493.

**Finishing** See Also PAPERMAKING—Finishing.

**079762 PLASMA PRETREATMENT FOR PLASTICS.** Printing, painting, decorating or bonding of plastics, especially the newer engineering plastics, can be a challenging task. The same chemical structure that gives the engineering plastics their thermal stability often makes their surface resistant to the adhesion of paint or ink. Surface treatment with cold gas plasma can improve adhesion. Cold gas plasma is a highly reactive yet perfectly safe dry chemical process that represents an interesting surface treatment alternative for finishers and decorators of plastic products. Even though the plasma is very active, the process is simple, controllable and safe.

Kaplan, Stephen L. (Plasma Science Inc, Belmont, CA, USA); Rines, Sherill. *Prod Finish (Cincinnati)* v 52 n 4 Jan 1988 p 61-67.

**Fire Resistance** See POLYMERS—Additives; POLYMERS—Flame Resistance.



**Flame Resistance** See Also FLAME RETARDANT—S—Applications; FLAME RETARDANTS—Toxicity.

**079763 OXYGEN INDEX METHOD IN FIRE RETARDANCE STUDIES OF POLYMERIC MATERIALS.** The oxygen index test is a fundamental tool in basic research on polymer combustion and on mechanisms of fire retardance. Although the oxygen index should provide an evaluation of intrinsic flammability of polymeric materials, its response may depend on geometry of the specimen. This is shown by comparing the behavior of polypropylene fire retarded with different additive systems. The implication of such mechanistic studies is discussed. Furthermore, new measurements are proposed to be carried out with the oxygen index apparatus, which give parameters related to ease of ignition, behavior on forced burning, and thermal insulating characteristics of char developed on burning the material. (Edited author abstract) 14 refs.

Camino, G. (Istituto di Chimica Macromolecolare Dell Univ, Turin, Italy); Casorati, E.; Bertelli, G.; Locatelli, R.; Costa, L. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1863-1876.

**Flammability** See Also AEROSOLS—Radioactivity; PIPE, PLASTIC—Fire Protection; PLASTICS, REINFORCED—Coloring.

**079764 FLAMMABILITY TESTING: EMERGENCE OF THE CONE CALORIMETER.** Using the oxygen-consumption principle, the cone calorimeter tests flammability of materials by exposing them to controlled levels of radiant heating to determine ignitability, heat-release rates, mass-loss rates, effective heat of combustion, and visible smoke development. (Author abstract)

Snyder, Merle (Plastics Compounding, Duluth, MN, USA). *Plast Compd* v 10 n 6 Sep-Oct 1987 p 32-34.

**079765 PACKAGING AND STORING FLAMMABLE LIQUIDS.** Newly adopted changes to the National Fire Protection Association (NFPA) fire codes address the hazard associated with the storage of flammable liquids in plastic containers. The revised fire codes will prohibit storing Class I and II flammable and combustible liquids packaged in plastic containers in general purpose warehouses. While the new change gives an effective date of September 1, 1990, those jurisdictions enforcing fire codes could institute the regulation earlier. Storage of these liquids will require isolated storage rooms or liquid warehouses conforming with the fire code.

Dunbar, Jeanne. *Prod Finish (Cincinnati)* v 52 n 9 Jun 1988 p 118-121.

## Forming

**079766 MODELLIERUNG DES VERSTRECK-PROZESSES BEIM WARMFORMEN.** [Modelling the Stretching Process in Thermoforming]. Simulation of axially symmetrical parts makes it possible to describe the stretching process during thermoforming. A model is introduced which provides information on wall thickness distribution, local degrees of stretching and frozen-in stresses. The material constants needed for this purpose are determined by means of a specially developed test method. (Author abstract) 10 refs. In German and English.

Menges, Georg (RWTH, Aachen, West Ger); Weinand, D. *Kunstst Ger Plast* v 78 n 5 May 1988 p 456-460.

## Fracture

**079767 FRACTOGRAPHY APPLIED TO POLYMERIC MATERIALS.** The practical application of fractography to the study of plastic failures is at a very early stage of development. To date, studies of plastic fracture have concentrated more on the mechanism of fracture than on the relationship of fracture-surface appearance to changes in test variables such as temperature, loading, strain rate and environmental conditions. Most research studies of the failure of plastics include

inspection of the fracture surfaces with optical and scanning-electron microscopes. Analysis of plastic failures is complicated by the viscoelastic nature of the materials. There are two predominant micro-mechanisms of deformation, called craze formation and shear yielding. If the deformation leads to breakage, the fracture surfaces can be examined for evidence of the cause.

Anon. *Mater Eng (Cleveland)* v 105 n 7 Jul 1988 p 49-52.

**Friction** See Also FORGING MACHINES—Friction.

**079768 FUNDAMENTAL STUDIES ON THE WEAR OF THE PLASTIC MATERIALS FOR SLIDING BEARINGS AGAINST ALUMINUM SHAFTS (PART 1) - FRICTION AND WEAR PROPERTIES OF VARIOUS PLASTIC MATERIALS AND SURFACE DAMAGES OF MATING ALUMINUM.** Various plastic materials such as polytetrafluoroethylene (PTFE), polyetheretherketone (PEEK) and their composites were rubbed against aluminum. Then the effects of temperature on the friction and wear of the plastic materials, and the surface damages of the mating aluminum were examined. The desirable properties of the plastic bearings sliding against aluminum shafts were investigated. In experiments carried out in the temperature range from 296 to 573 K, filled PTFEs, such as graphite-filled PTFE, polyparaoxybenzoyl (POB) - or polyphenylene sulfide (PPS) - filled PTFE, and POB - or PPS-filled PTFE containing graphite, showed low specific wear rates less than  $10^{-5}$  mm<sup>3</sup>/N m, and their coefficients of friction were lower than 0.3 without damaging the mating aluminum surfaces. PTFE-filled PEEK also showed good tribological properties at temperature of 296 K to 523 K. It seems that good sliding bearings show excellent wear resistance and form strong transferred films on the mating surfaces. When sliding experiments are carried out between plastics and their transferred films, the aluminum substrates seem not to be damaged by the plastics. (Edited author abstract) In Japanese. 16 refs.

Uchiyama, Yoshitaka (Kanazawa Univ, Kanazawa, Jpn); Yamada, Yoshinori; Miura, Hiromu. *J Jpn Soc Lubr Eng* v 33 n 1 1988 p 69-77.

**Glass Transition** See RUBBER—Viscoelasticity.

**Granulation** See Also WATER FILTRATION—Plastics Applications.

**079769 PLASTIC WET POWDER GRAINING TECHNOLOGY AND ITS ASSOCIATED EXTRUDER.** When a plastic wet powder (with a water content of less than 30%) is directly fed into an associated extruder (single-screw), it undergoes the processes of dehydrating, drying, melting, gas exhausting and grain extruding and a product of the required quality is obtained. The new technology and equipment of complete dehydration are successfully studied, based on the principles of 'phase change dehydrating' and 'flashing the exhaust'. The new technology and equipment are now used on a production device for zoot/a ABS, and has met with success in PP.AAS and PMMA wet powder granulating. According to this, it may be also expected to be suitable for HDPE, PVC and PS wet powder granulating. In Chinese.

Guanlie, Teng. *Huagong Jixie* v 14 n 4 1987, Tech Rep on 3rd Sino-Jpn Chem Equip Symp, 1986 p 340-342.

## Grinding

**079770 PULVERIZING OF PLASTICS SCRAP SOLVES QUALITY PROBLEMS.** Impact disc mills permit the pulverizing of plastics scrap at low cost and thus its recycling to the processing operation even if contaminated material is involved. The design and applications of impact disc mills are discussed. (Author abstract) In German and English.

Herbold, K. *Kunstst Ger Plast* v 77 n 11 Nov 1987 p 10-11, 1141-1142.

**Heat Resisting** See POLYMERS—Synthesis.

**Heat Transfer** See Also EPOXY RESINS—Transfer Molding.

**079771 FEM SIMULATION OF HEAT TRANSFER IN PLASTICS PROCESSING.** A description is given of the basic functions of such a system. Its application in plastics processing is then illustrated, taking the example of extrusion. Apart from the mathematical principles required to understand the finite element method, a concept is presented for converting these principles into program form. On the basis of selected examples, cooling and heating processes frequently encountered in practice are solved using this program. These involve typical combinations of initial and boundary conditions, frequently found geometries and thermal material data. 9 refs.

Menges, G.; Kalwa, M.; Schmidt, J. *Kunstst Ger Plast* v 77 n 8 Aug 1987 p 31-34.

**High Temperature Applications** See POLYMERS—Synthesis.

**High Temperature Effects** See POLYMERS—Oxidation.

**Hydrolysis** See POLYMERS—Synthesis.

**Impurities** See MICROELECTRONICS—Encapsulation.

**Injection Molding** See Also INTEGRATED CIRCUITS, HYBRID—Plastics Applications; PLASTICS MACHINERY—Costs; PLASTICS MACHINERY—Molding Machines; PLASTICS PLANTS—Automation; PLASTICS, REINFORCED—Glass Fiber; PLASTICS, REINFORCED—Mechanical Properties; POLYAMIDES; POLYMERS—Fracture; POLYMERS—Microstructure; PRODUCT DESIGN—Reliability; THERMOPLASTICS—Processing; THERMOPLASTICS—Shrinkage.

**079772 CIM IN PLASTICS INJECTION MOULDING.** A universal CIM concept presented in this paper shows that in the future it will be feasible for plastics processors to meet the challenge of their large customers. The prerequisites for introducing computer-integrated manufacture are to a large part satisfied by this concept. (Edited author abstract)

Menges, G.; Bourdon, K.; Eysmond, B.v.; Filz, P.; Gliese, F.-R.; Lauterbach, M.; Weyer, G. *IPE Int Ind Prod Eng* v 11 n 2 Jul 1987 p 74-77.

**079773 INJECTION-MOLDING PROCESS CONTROL - A REVIEW.** This paper reviews control strategies employed in the injection-molding process. For clarity, the controlled variables have been categorized into all-phase control, phase-dependent control, and cycle-to-cycle control. All-phase control includes variables that must be monitored and controlled at all times; i.e., in all the phases. Control of variables that are triggered during a specific phase are discussed under phase-dependent control. In cycle-to-cycle control, previous data are used to predict future trends and take appropriate corrective actions. The cyclic, dynamic, and unsteady state nature of the injection-molding process is discussed with respect to the conventional proportional-integral (PI) and proportional-integral-derivative (PID) controllers as well as the more advanced control schemes such as self-tuning control, optimal control, and statistical process control. (Edited author abstract) 87 refs.

Agrawal, A.R. (Univ of Maryland, College Park, MD, USA); Pandelidis, I.O.; Pecht, M. *Polym Eng Sci* v 27 n 18 Mid-Oct 1987 p 1345-1357.

**079774 DYNAMICS OF PEAK CAVITY PRESSURE IN INJECTION MOLDING.** The modification of the injection-molding machine, incorporating additional filters, an accumulator, and a servovalve, was shown to reduce the peak cavity pressure variations, inasmuch as the variations using the microprocessor system were random in comparison to the variations using



the normal mode of operation, which exhibited nonstationarity and autoregressive behavior. If the peak hydraulic pressure could be randomized, then the peak cavity pressure variations also would be random. No closed-loop control would be needed to control the peak cavity pressure. (Author abstract) 8 refs.

Haber, A. (McGill Univ, Montreal, Que, Can); Kamal, M.R. *Polym Eng Sci* v 27 n 18 Mid-Oct 1987 p 1411-1418.

**079775 COMPUTER INTEGRATED MATERIALS PROCESSING (CIMP) (NEW DESIGN ANALYSIS AND SIMULATION CAPABILITIES FOR INJECTION MOULDED PARTS).** This article describes the advantages of using an interactive software package based on solid modeling for the design and simulation of injection molded parts. An expert system assists the user in the decision making process at any time during the development of the part. With the help of interactive graphic menus, supported by a flexible database, the process begins with the solid representation of the part. Interactively, the program allows the user to analyse the filling and the cooling phases as well as the actual behavior of the mold in order to optimize the design and manufacturing parameters. The supporting database has been developed by taking into account the design and manufacturing guidelines, material characteristics and information on tooling and polymer processing. Then a complete optimization can be performed during the finite element analysis which is based on the information obtained from the results of the process simulation. (Author abstract) 4 refs.

Bata, G.L. (Nat'l Research Council of Canada, Boucherville, Que, Can); Salloum, G. *Int J Mater Prod Technol* v 2 n 2 1987 p 123-136.

**079776 MAKING METAL PARTS IN A PLASTICS MOLDING SHOP.** An innovative and cost-efficient manufacturing process using a resin binder and plastics processing methods - in this case, injection molding - produces sintered metal parts superior to those made by traditional powder metallurgy. The molded parts hardly need secondary machining, other than occasional touch-ups at gates. Metal injection molding (MIM) parts are finding applications in such areas as aerospace, biomedical/orthodontal, and computers. Again, the rewards of using the MIM process are many: parts can be made from metals difficult to machine, parts can be pre-alloyed, and more. Now new classes of metal/binder formulations have become available and optimal conditions for injection molding have been identified.

Shah, Saurin J. (Afton Plastics Molding Co, Lakeland, MN, USA); Nunn, Robert E. *Plast Eng* v 43 n 11 Nov 1987 p 33-36.

**079777 NUMERISCHES EXPERIMENT ZUM SPRITZGIEßEN: I.** [Numerical Experiment in Injection Molding: I]. This contribution to the mathematical modeling of the filling process in injection molding is based on the concept of variation equations for the description of Hele-Shaw flows with a free surface. Formulas are derived and numerical results are presented. 7 refs. (Translated author abstract) In German.

Hartwig, Karl-Heinz; Liebermann, Horst; Steinbach, Jorg; Weinelt, Wilfried. *Wiss Z Tech Univ Karl Marx Stadt* v 29 n 2 1987 p 204-208.

**079778 DATA COMMUNICATION FOR INJECTION MOLDING MACHINES.** Electronic data processing is being increasingly used to monitor the processing sequence in injection molding from a central unit. The facilities currently available for this and also the problems involved in standardizing different makes of system are presented. (Author abstract)

van Hest, R.C.M. *IPE Int Ind Prod Eng* v 11 n 3 Oct 1987 p 134, 136, 139.

**079779 BEATING THE MOLD DESIGN BLUES.** CAD/CAM promises to dramatically shorten product design, engineering, and manufacturing cycles for injection

molding. However, plastics software development has for the most part been done piecemeal, with no common link between the dozens of standalone products that solve part of the injection mold puzzle. Eventually, these products must be integrated into a cohesive system. This paper describes new attempts to improve software interfaces and integration which may be the key to a successful application.

Ondrick, Angela J. (Control Data Corp, Minneapolis, MN, USA). *Mach Des* v 58 n 18 Aug 7 1986 p 55-57.

**079780 ROBOT REDUCES REJECTS AND HALVES CYCLE TIME.** The installation of a robot-based automation system in a plastic injection molding plant is discussed. The benefits that resulted were increased yield, decreased mold maintenance, consistent dimensional results and a reduced rejection rate.

Anon. *Rob World* v 6 n 2 Feb 1988 p 24.

**079781 FLOW ANALYSIS IN INJECTION MOLDING.** Flow analysis has been studied in plastic injection molding. It can predict defects in the filling process. Computer simulation has been used for mold design. This paper describes mold filling theory and experience with a flow analysis program, 'IMAP-F'. (Edited author abstract) In Japanese. 3 refs.

Matsukawa, Takaaki; Takahashi, Hideroh; Kamigaito, Osami. *J Jpn Soc Powder Powder Metall* v 34 n 9 Nov 1987 p 387-391.

**079782 ON THE TRANSIENT MELT SOLIDIFICATION DURING MOLD FILLING IN A DISC-SHAPED CAVITY.** The problem of transient melt solidification in a disc-shaped cavity during the injection molding process is investigated by the use of a boundary-tracking based finite difference method. Simulated results indicate that the maximal thickness of the frozen layer is about 10-20% of the disc gap for different injection rates. (Edited author abstract) 27 refs.

Lin, Shaw-Wen (Nat'l Taiwan Inst of Technology, Taipei, Taiwan); Tseng, Hsiang-Cheng. *J Chin Inst Chem Eng* v 18 n 6 Nov 1987 p 385-391.

**079783 OPTIMAL ANTICIPATORY CONTROL OF RAM VELOCITY IN INJECTION MOLDING.** This paper discusses a computer control system for ram velocity of an injection molding machine using optimal state feedback based on the linear quadratic control theory. A new approach for the selection of appropriate weighting matrices is presented in this context. The simulation results reveal that the optimal controller has improved performance over the conventional PID controller presently used, having faster speed of response, significantly better tracking performance, and better noise filtering properties. The execution speed and the core storage requirements would allow implementation even on a small online computer. (Author abstract) 6 refs.

Pandelidis, I.O. (Univ of Maryland, College Park, MD, USA); Agrawal, A.R. *Polym Eng Sci* v 28 n 3 Mid-Feb 1988 p 147-156.

**079784 OBSERVERS FOR OPTIMAL ANTICIPATORY CONTROL OF RAM VELOCITY IN INJECTION MOLDING.** The application of optimal anticipatory control assumes that the entire state is available for feedback. However, in the case of injection molding this assumption is violated due to economic considerations. For that purpose, this paper discusses the effectiveness of optimal anticipatory control using estimates of the states obtained from a dynamic system, called observer. State estimation is essential to optimal control techniques since in general the states are used in some form of feedback and the number of measurable states is usually much less than the actual number of state variables, limited by the availability of cheap and rugged sensors and the ease of installation. Furthermore the measurements from the existing sensors may be corrupted by significance noise. In the present paper both the stochastic and the deterministic cases are investigated for application to optimal control of ram velocity in injection molding. (Author abstract) 2

refs.

Agrawal, A.R. (Univ of Maryland, College Park, MD, USA); Pandelidis, I.O. *Polym Eng Sci* v 28 n 3 Mid-Feb 1988 p 157-164.

**079785 STELLUNG DER SPRITZGIEßMASCHINE IM SYSTEM DER TECHNIK-WISSENSCHAFTEN.** [Position of Injection Machine in the System of Technical Sciences]. The injection machine for plastic materials is a discontinuously working processing machine. After definition of the term 'molding by injection' and explanation of structure and mode of function of this machine it is classified in the system of technical sciences. The injection machine is considered as a whole as well as taken to individual most essential components. To these components together with the sequence of functions belonging to them for realization of the total procedure for production of molded parts the most essential technical sciences required for their structure and operating mode are coordinated. The position of injection machine in the social sphere and the historical development of position in the system of technical sciences are considered. (Edited author abstract) In German. 5 refs.

Bock, D. (Technische Univ Karl-Marx-Stadt, East Ger). *Maschinenbautechnik* v 36 n 5 1987 p 226-230.

**079786 STUDY OF THE WELD LINE IN INJECTION MOULDINGS.** The different condition of the material in weld line regions may be attributed to orientation resulting from flow processes and, in the case of partially crystalline materials, to different crystallization behaviour because of molecular orientation and the considerable degree of melt cooling which has already taken place before the flow fronts meet. In addition, there are two other influencing factors relevant to moulding quality: the first is the notch effect of the weld line which as the moulding cools shrinks to form a sharp furrow; the second is the concentration of inhomogeneities in the weld line which are pushed ahead of the melt front during the mould filling operation. These inhomogeneities may be abraded particles and impurities or mould release agents.

Wendt, U. *Kunstst Ger Plast* v 78 n 2 Feb 1988 p 10-11.

**079787 COMPUTER AIDED APPLICATIONS TO INJECTION MOLDING: TRANSFINITE/FINITE ELEMENT THERMAL/STRESS RESPONSE FORMULATIONS.** The paper describes two different computational approaches for simulating the effects due to temperature variations and therein the associated thermally induced stresses and warpage with emphasis on computer aided engineering applications to 'plastic' components. One approach is the conventional finite element approach, and the other is termed as the transfinite element approach. The development of unified thermal/stress formulations for each of the aforementioned approaches is described for applications to injection molded plastic parts. Results of both computational formulations are in excellent agreement for predicting the thermal response and unified thermal/stress response and agree qualitatively with previous studies. For this study, it is found that the transfinite element formulations are computationally more efficient although the conventional formulations can still be effectively used. (Edited author abstract) 11 refs.

Tamma, K.K. (Univ of Minnesota, Minneapolis, MN, USA); Dowler, B.L.; Railkar, S.B. *Polym Eng Sci* v 28 n 7 Mid-April 1988 p 421-428.

**079788 NEW INJECTION MOLDING TECHNOLOGY USING FUSIBLE TIN ALLOYS.** In the plastics industry, tin is being used as an alloying agent for the production of a new generation of alloys for the production of plastics, automotive accessories and components. New techniques have enabled industrial plastics components - with complex internal geometry - to be mass-produced on a route basis. This has been achieved by using mechanical and thermal properties of the alloys, plus novel casting techniques developed by Fry's Metals.



Low melting point alloy cores are made, the plastics component formed and the case is melted out in an integrated machine cycle. Fry's Multi-purpose Liquid Metal Dispenser overcomes the problems of slow production rates, metal residues, oxidation and metal loss associated with previous methods.

Pascoe, Graham (Cookson Group plc, London, Engl). *Tin Its Uses* n 153 1987 p 14-15.

**079789 STUDY OF INJECTION MOLDING. (3RD REPORT, PARTIAL THERMAL SHRINKAGE IN THE BOSS STRUCTURES).** In the injection molding process, when the method resin solidified by the cooling effect from the die, non-equivalence of the cooling history caused the sink-mark growth in the resin, near boss structures. In this study, relations between Sink-Mark depth in the boss structure and some molding parameters are experimentally evaluated, and especially the effect of the forming pin is considered. Also, cooling simulation by thermal analysis is done. In considering the P-V-T characteristics and cooling history of the resin, the experimental results are quantitatively explained. (Author abstract) In Japanese. 7 refs.

Naka, Hiroyuki; Ichinagaki, Takashi; Kenmochi, Kazuei. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 500 Apr 1988 p 808-813.

**079790 INJECTION MOLDING OF AUTOMOBILE OUTER PANELS.** This report describes two applications of the FINEMELT screw system for plastic moldings of automobile outer panels and bumpers. For the former product, high mechanical strength was obtained. For the latter, the welded part was rendered defectless. These results demonstrate that Kobe Steel's FINEMELT screw system has a high intermixing capability resulting in uniform polymer blending. (Author abstract) In Japanese.

Sano, Tsutomu. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 16-18.

**079791 AUTOMATING INJECTION MOULDING - SOME ECONOMIC CONSIDERATIONS.** A visit was paid to a major manufacturer in Denmark to discuss the possible application of robots to the manufacturing processes being carried out at its factory. The particular process examined was injection moulding. As the investigation proceeded, it became apparent that the replacement of the machine operators by automation, whilst solving some problems, produced others which needed to be solved and thereby increased the costs. These areas become apparent when a detailed investigation is made of a typical operator function.

Hall, Douglas C. *Prod Eng (London)* v 67 n 4 Apr 1988 p 29-31.

**079792 QUALITAETSSTIEGERUNG BEIM SPRITZGIESSEN ALS AUFGABE DES PLASTIFIZIERSYSTEMS. [Role of the Plasticizing Systems in Improving Injection Molding Quality].** To an ever increasing degree the market requires parts of extremely high quality. In addition, these parts must be produced economically because of the intense competition. The quality level demanded results from the high performance expectations of engineered plastic parts, higher quality standards set by purchasers and expanded quality awareness on the part of end users. The factors affecting the molded part quality are presented. From a processing standpoint, requirements to be fulfilled by the plasticizing process are described. The measures available in the melting and homogenization process in the plasticizing system to optimize melt quality are discussed. 25 refs. In German.

Buerkle, Erwin (Krauss-Maffei Kunststofftechnik, Munich, West Ger). *Kunstst Ger Plast* v 78 n 4 Apr 1988 p 289-295.

**079793 EIN UEBERBLICK AM BEISPIEL EINES STOSSFAENGERWERKZEUGES. [Programs for the Rheological Design of Injection Moulded Parts].** The bumper has been taken as an example since it requires

highly comprehensive observation in order to achieve a good and precise result. With a large number of other mouldings or moulds, it will doubtless frequently be sufficient to compile a flow pattern and/or conduct an analytical calculation. The outlay required to ensure that the task is solved correctly must, however, be worked out on a case-by-case basis. The approach described makes it possible to predict the filling behaviour of injection moulds and thus introduce a greater degree of reliability into mould design. This alone, however, will not guarantee absolutely perfect results when the first sample mouldings are produced. (Edited author abstract). 6 Refs. In German.

Malz, Juergen. *Plastverarbeiter* v 39 n 5 May 1988 p 16-26.

**079794 BDE-SYSTEME DER SPRITZGIESSMASCHINEN-HERSTELLER. [Production Data Acquisition (Part 3)].** *Plastverarbeiter* is publishing a series of reports on the results of a study conducted by the Institut fuer Kunststoffverarbeitung (IKV) at the end of 1987 on 'Production Data Acquisition in Injection Moulding Shops'. The part, Part 3, presents a market analysis of production data acquisition systems supplied by eight injection moulding machinery manufacturers. Since this market analysis is based solely on data supplied without any obligation and on informatory talks with staff from different departments at the system supplier companies, the authors are unable to assume any liability for the accuracy of the information presented. This applies particularly to informative on the scope and cost of the systems, especially since the systems are subject to modification on account of constant further developments. Almost all the manufacturers have adopted a central computer concept for production data acquisition and automation of the machine environment. (Edited author abstract). 9 Refs. In German.

Menges, Georg (RWTH, West Ger); Michaeli, Walter; Eysmond, Bernd von; Mueller, Florian. *Plastverarbeiter* v 39 n 5 May 1988 p 150-160.

**079795 NON-ISOTHERMAL RADIAL FILLING OF CENTER-GATED DISC CAVITIES WITH VISCOELASTIC POLYMER MELTS.** A comprehensive two-dimensional mathematical model is developed for injection mold filling of disk-shaped cavities. The model takes into account the effects of viscoelasticity, non-isothermality, fountain flow and the shape of the flow front. A new variable slip boundary condition is used to avoid discontinuities in the flow structure and to maintain the shape of the flow front. The predictive capabilities of the model include radial and transverse velocities, pressures, temperatures, shear stresses, and the first- and second-normal stress differences throughout the filling stage. Results of the simulations, obtained using the White-Metzner (viscoelastic) and the generalized Power-law (inelastic) constitutive equations, indicate that the viscoelasticity does not significantly affect the velocity and temperature profiles; however, its effect on the stress distributions is substantial. (Author abstract). 50 Refs.

Goyal, S.K. (McGill Univ, Montreal, Que, Can); Chu, E.; Kamal, M.R. *J Non Newtonian Fluid Mech* v 28 n 3 Jul 1988 p 373-406.

**079796 PLASTICS SOUTH - CONFERENCE PROCEEDINGS.** This conference proceedings contains 29 papers. Topics covered include: molding systems for injection molding; melt delivery and runner systems; hot runner nozzles; blown film dies; integration of sequential and continuous control; greater flexibility in blown film extrusion; new developments in automatic profile control; gear pump characteristics and applications; engineering polymer alloys; properties and applications of advanced engineering thermoplastics; thermotropic liquid crystal polymer; ABS/nylon alloy; injection molding automation; integrated control systems; plastic injection molder automation; extrusion compounding; mixing of polyblends; screw and barrel wear; melt processable rubber; and nylon elastomers. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11023 in the Ei Engineering Meetings

(TM) database produced by Engineering Information, Inc.

Anon (Soc of Plastics Engineers, Brookfield Center, CT, USA). *Plast South - Conf Proc, Atlanta, GA, USA, Oct 8-10 1986* Publ by Soc of Plastics Engineers, Brookfield Center, CT, USA, 1986 368p.

**079797 SOCIETY OF PLASTICS ENGINEERS EIGHTH ANNUAL PACIFIC TECHNICAL CONFERENCE: SPE PACTEC VIII (DESIGNING - PURCHASING - PROCESSING, A TECHNICAL UPDATE: PLASTICS FOR THE MEDICAL & ELECTRONICS INDUSTRIES).** This conference proceedings contains 38 papers. 6 papers are given in abstract form only and 5 papers are given in outline form only. Topics covered include: converting metal applications to plastic applications; engineering product design; designing for performance; filter devices; thermoplastic products; just-in-time manufacture; defining material property specifications; up-to-date molding techniques; CAD/CAM technology; total plant monitoring; thermoplastic composites; engineering propylenes; foreign influence on plastic materials; mass finishing technology and its application to plastics surface finishing; RFI shielding; advantages and disadvantages of injection molding; plastics process selection; product design and mold design; tool steel applications; hot runner system design; materials characterization and processing; and quality control systems for plastics processors. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 09937 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Soc of Plastics Engineers, Brookfield Cent, CT, USA). *Soc of Plast Eng Eighth Annu Pac Tech Conf: SPE PACTEC VIII, Feb 19-21 1985* Publ by Soc of Plastics Engineers, Brookfield Center, CT, USA, 1985 247p.

## Inspection

**079798 RELIABLE PROCESS CONTROL FOR FLEXIBLE INJECTION MOULDING PRODUCTION SYSTEMS.** A reproducible process control system is highly important in the injection molding process. It is possible to determine the machine settings in advance by means of process simulation using machine, mold and material data, and then to check these on the machine. By correlating these settings with measured product properties it is then possible to conduct an analysis of processability and build indirect product-adaptable control circuits. (Author abstract)

Steinbichler, G.; Lampl, A. *IPE Int Ind Prod Eng* v 11 n 2 Jul 1987 p 68-70, 72.

## Ion Implantation

**079799 CHARACTERISTICS OF CR-39 DOPED WITH CHLORINATED COMPOUNDS.** Characteristics of CR-39 plastic containing chlorinated compounds such as HCB and DCD have been studied using relativistic heavy ions from the LBL Bevalac. These results are compared with those of pure CR-39, focusing in particular on etching properties and on whether a penetrating etch hole is produced along each particle path by a long duration etch. The relation between the reduced track etch rate and the etchant concentration for CR-39 containing HCB is quite different from that of pure CR-39. Dilute etchants gives much higher track sensitivities than do more concentrated solutions in a wide range of REL. Since type HCB/DCD CR-39 loses its sensitivity in the interior of the bulk material for low REL produced by 2.1 GeV/n Ne ions, penetrating etch holes are not produced along the particle paths after a heavy etching. (Author abstract) 10 refs.

Ogura, K. (Nihon Univ, Narashino, Jpn); Tawara, H.; Hayashi, T.; Ichinose, H.; Doke, T.; Nakamura, S.; Orito, S. *Nucl Instrum Methods Phys Res Sect B* v B30 n 4 Apr 1 1988 p 540-545.



**Machining** See ELECTRODES—Machining; PLASTICS, REINFORCED—Fibers.

## Manufacture

**079800 MRP II - WHAT IT MEANS TO YOU.** MRP II is a total manufacturing planning system that coordinates materials requirement planning with all the other costing and scheduling functions that make up a production process. The 'recipe' of materials and processes that go into a finished product, the bill-of-materials, is the key to MRP II software - this is what the software is designed to schedule and control. The three main factors to look for when using MRP II software are: 1) A materials-tracking system that breaks down recipes and the amounts of materials in finished parts by weight, including scrap, and monitors materials inventories; 2) A production monitoring system that can track machine and tooling performance, even for specific mold cavities; 3) A job quoting system that provides accurate estimates of the cost and length of a production run. And the key to a plastics MRP II system is the complete integration of these modules. A list is presented of factors to be considered before investing in a system.

Kreisher, Keith (Plastics Technology, New York, NY, USA). *Plast Technol* v 34 n 7 Jul 1988 p 64-69.

**Mathematical Models** See POLYMERS—Structure.

**Mechanical Properties** See Also ACETAL RESINS—Weathering; COPOLYMERS—Mechanical Properties; FIBERS, NONTEXTILE—Synthetics; GLASS—Polymeric Materials; PLASTICS FILMS—Extrusion; PLASTICS, REINFORCED—Carbon Fiber; PLASTICS, REINFORCED—Fibers; PLASTICS, REINFORCED—Glass Fiber; POLYESTERS—Processing; POLYMERS—Blending; POLYMERS—Crosslinking; POLYMERS—Degradation; POLYMERS—Elasticity; POLYMERS—Pressure Effects; POLYMERS—Structure; POLYMERS—Synthesis; POLYURETHANES—Casting; POLYURETHANES—Crosslinking; POLYURETHANES—Reaction Injection Molding.

**079801 EFFECTS OF RESIDUAL STRESS ON THE MECHANICAL PROPERTIES OF GLASSY POLYMERS.** Residual stresses can have either beneficial or detrimental effects on the mechanical properties of plastics. Manufacturing processes frequently impose residual stresses on plastics. In this study, controlled thermal processes were used to impose surface compressive stresses on polycarbonate beam samples (6.4 by 12.5 by 80 mm). Resistance strain gage and photoelastic techniques were developed to measure the magnitude of these stored stresses. The compressive surface stresses were found to be between 14 MPa (2000 psi) and 31 MPa (4500 psi) and to vary with process method and cooling rate. The mean fatigue life (in bending) of the treated beam samples was found to improve by a factor of 10 over that of untreated samples. (Edited author abstract) 10 refs.

Hornberger, L.E. (Univ of Utah, Salt Lake City, UT, USA); Devries, K.L. *Polym Eng Sci* v 27 n 19 Oct 1987 1473-1478.

**079802 TORSIONAL PROPERTIES AND DURABILITY OF SUPER ENGINEERING PLASTICS.** High performance engineering plastics (named 'Super Engineering Plastics'; SEP in Japan) have been considered as practical materials of great promise for not only thermal use but also mechanical use. But data on their torsional performance and endurance are particularly scanty. We studied five kinds of SEP: three liquid crystalline polymers, PPS, PES, and PEEK, and three popular engineering plastics, i.e. polyamide and polyacetal for comparison. The properties determined include thermal, torsional, bending, fatigue, and solvent stress cracking properties. 2 refs. In Japanese.

Ohishi, Fujio (Railway Technical Research Inst, Koku-bunji, Jpn); Yoshikawa, Takao; Yaguchi, Naoyuki; Takagi, Shigeki; Takahashi, Nobuo. *Kobunshi Ronbunshu* v 45 n 4 1988 p 363-366.

**079803 DYNAMIC MECHANICAL BEHAVIOR OF POLYMERS CONTAINING CARBON BLACK.** The dynamic mechanical behavior of carbon black filled polymers of styrene and butyl methacrylate was examined

at low strain amplitude and frequency in order to minimize destruction of the composite structure and elucidate the basis of yield and plasticization observed in steady shear. Yield behavior was observed most readily for the low molecular weight polystyrene. Limiting moduli for filled polystyrenes were independent of temperature, whereas, for polybutyl methacrylate, they were sensitive to temperature. It is suggested that an independent network of carbon black is strongest in the low molecular weight polystyrene and weakest in poly(butyl methacrylate). (Edited author abstract). 31 Refs.

Gandhi, Khushroo (Univ of Southern California, Los Angeles, CA, USA); Salovey, R. *Polym Eng Sci* v 28 n 14 Jul 1988 p 877-887.

## Medical Applications

**079804 TOMORROW'S PLASTICS MAY ADD YEARS TO YOUR LIFE.** Plastics have had a dramatic impact on the health care industry in the past 50 years, and the new century holds even more promise. Plastics have simplified patient care, reduced contamination, made possible new prostheses and treatment techniques, and cut medical costs. Three billion pounds of plastic will be used in the medical market by the year 2000. Resin use for monitors and analyzers housings will grow at more than 15 percent/year in the next decade. Improved plastics will make possible artificial kidneys, urinary bladders, and artificial skin. New thermoplastic elastomers will make possible better artificial heart implants.

Lodge, Charles (Plastics World, Newton, MA, USA). *Plast World* v 45 n 10 Sep 1987 5p.

**079805 TECHNICAL PAPERS - REGIONAL TECHNICAL CONFERENCE: PLASTICS FOR TOMORROW'S MEDICAL NEEDS.** This conference proceedings of 21 papers is divided into four sessions with the following subjects of interests: biocompatibility, sterilization, property assessment, and material development. Some topics discussed by the 21 papers are here cited as examples: high performance polyurethane elastomers in artificial hearts; a progress report; hydromer coatings for medical devices; wanted: radiation stable plastics; sterilization resistance of TPX; microtexturing of plastics for implantation; selection criteria for materials in medical applications; design considerations in the in vitro testing of cardiovascular prosthesis; predicting long-term performance from short-term testing; the versatility of polyurethanes; polycarbonate and medical devices - a lasting relationship; silicone RTV adhesives; and new transparent and low tensile set biocompatible thermoplastic elastomer based on polysiloxane modified block copolymers. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10905 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Soc of Plastics Engineers, Medical Plastics Div, Brookfield, CT, USA). *Tech Pap Reg Tech Conf Soc Plast Eng Reg Tech Conf - Plast for Tomorrow's Med Needs*, Cherry Hill, NJ, USA, Sep 23-24. Publ by Soc of Plastics Engineers, Brookfield, CT, USA, 1986 var pagings.

## Metallizing

**079806 VACUUM METALIZING: NOW MORE THAN JUST A DECORATING PROCESS.** For the production of floppy discs, thin-film magnetic cobalt-nickel films just 70 to 100 microns thick are applied on thin polyester substrates. Microprocessor-controlled sputter-type roll coating systems guarantee optimal layer-thickness uniformity at commercial rates, thus insuring product quality and cost-effectiveness. Sputtering techniques using reactive gases in combination with metal targets (which are essential to uniform deposition of the coating) are also being used to produce transparent conductive films. Multilayer sputtering technology is being applied to produce transparent antireflective coatings and thermal radiation blankets for aircraft and aerospace applications. In addition, metallizing is being combined with other vacuum coating technology to upgrade plastic quality. Heavier sputtered coatings of copper and gold are

used to produce metal coated plastics film and sheet for the etched printed circuit board, another growth market. Progress in equipment design and application are also discussed.

Smoluk, George. *Mod Plast* v 64 n 1 Jan 1987 p 38-40.

**Microscopic Examination** See POLYMERS—Structure.

**Microstructure** See POLYMERS—Elasticity; POLYMERS—Isomerization.

**Mixing** See POLYMERS—Morphology.

**Moisture** See Also PLASTICS, REINFORCED—Moisture.

**079807 WATER ABSORPTION OF RESINS AND COMPOSITES: III. WATER DISTRIBUTION AS INDICATED BY CAPACITANCE MEASUREMENT.** Glass fiber reinforced epoxy pultrusions were made with a range of fiber volume fractions. They were immersed in water at temperatures in the range 23 to 100°C until saturated, and their dielectric properties measured. Tests on the saturated resins themselves indicated that 60 to 75% of the water was concentrated in disk-shaped regions. The remainder of the water was probably molecularly dispersed; the proportion of this phase depended on the presence of polar groups in the polymer. In the case of the composites, the water provided conducting paths, probably caused by the interconnection of regions of water concentration at the fiber-matrix interface by the water 'disks' that exist in the resin. Dielectric tests appear thus to be a potent tool for providing information about the morphology of resins and composites containing water. (Edited author abstract) 10 refs.

Woo, Monica (Digital Equipment Canada Ltd, Kanata, Ont, Can); Pigott, Michael R. *J Compos Technol Res* v 10 n 1 Spring 1988 p 16-19.

## Mold Release Agents

**079808 SELECTIVE FATTY CHEMICALS AS MOLD-RELEASE AGENTS.** A new test measures the effectiveness of various non-metallic fatty chemicals as internal mold-release agents for several resins. Test results suggest an optimal mold-release additive for each resin. The resins tested were ABS, acetal, polybutylene terephthalate, polypropylene, HDPE, and LLDPE. (Author abstract)

Perrell, Kim S. (Witco Corp, Memphis, TN, USA); Tomlinson, Harry H.; Walp, Leonard E. *Plast Eng* v 43 n 9 Sep 1987 p 33-36.

**079809 LUBRICANTS FOR PLASTICS: SOLUTION FOR A WIDE VARIETY OF PROBLEMS.** Without the addition of lubricants many plastics would be difficult or impossible to process. The variety of their chemical composition, of the plastics to which they are added, and the processes that are used in their conversion coincides with a wide range of effects, the use of which requires in-depth experience. The market grows faster than that of plastics. (Author abstract)

Anon. *Chem Ind Int (Engl Transl)* n 3 1987 p 13, 16-19.

**Molding** See Also AUTOMOBILE MATERIALS—Plastics; ELECTRONICS PACKAGING—Plastics Applications; INTEGRATED CIRCUITS—Electronics Packaging; PLASTICS MACHINERY—Control; PLASTICS, REINFORCED—Glass Fiber; POLYMERS—Structure; PRINTED CIRCUITS—Materials; STEEL TESTING—Hardness.

**079810 LIQUID DISTRIBUTION PATTERNS IN APPLIANCE MOLDING.** This paper introduces a method which allows for direct observation of the liquid distribution pattern produced by a mix-head under conditions simulating those found in breakers-up refrigerator foaming. The method also allows for evaluation of various



mixhead attack angles and their effect on the liquid distribution pattern, as well as the influence of mold angle.

Ball, E.E. (Mobay Corp, Pittsburgh, PA, USA). *J Cell Plast* v 23 n 3 May-Jun 1987 p 248-257.

**079811 CUSTOM-MOLDING START-UP FOUNDED ON CAE.** Interplas, Ltd., Menomonee Falls, Wis., started business early in 1987, with the intention of concentrating on high-performance jobs involving engineering resins and difficult molding requirements. Interplas has just two 60-ton presses, but they are equipped with a quick-mold-change system and microcomputer controls that can be programmed remotely. Unlike most processors, the owners also installed a CAD system. At Interplas, plastic part and mold design are not considered separate entities.

Anon. *Plast Technol* v 34 n 1 Jan 1988 p 29, 31, 33.

**079812 CASE FOR ALL-STAINLESS MOLDS.** Stainless molds have made possible many of today's most demanding applications, including those where product function requires the 'ultimate' surface finish. Examples include audio CDs and video discs, optical-quality lenses, close-tolerance camera parts, intra-ocular lens implants, and optically clear medical parts. In recent times, all-stainless molds have been used in a growing number of such applications: surface-critical discs, video products, optical appliances, medical devices.

Anon (Uddeholm Corp). *Plast Technol* v 34 n 1 Jan 1988 p 63-65.

**079813 SELECTING PLASTIC PARTS FOR COMPUTER-AIDED ENGINEERING ANALYSIS.** CAE analysis can provide critical information for optimizing design and processing parameters to insure the successful molding of plastic parts. It is a cost effective alternative to the conventional 'cut and dry' methods. Since it is neither practical nor economical to conduct an analysis for every plastic part, a procedure has been developed to screen plastic parts. This screening process is intended to provide a framework which can be further developed by individual users into a customized selection process.

Litman, Alan M. (Xerox Corp, Webster, NY, USA); Chathampally, Mohan R.; Fowler, Norman E. *Polym Plast Technol Eng* v 26 n 3-4 Sep-Dec 1987 p 333-345.

**079814 NEW APPROACH TO LOW THERMAL INERTIA MOLDING.** This paper investigates a new approach to the implementation of the LTIM (Low Thermal Inertia Molding) concept. Thermoelectric modules are used to form the mold cavity. By controlling the magnitude and polarity of the power input to these modules, the mold cavity surface can be heated and cooled rapidly. An experimental simulation of the mold cavity requirements is conducted on the thermoelectric modules to test the feasibility of using these modules to form the mold cavity. To obtain precise temperature control of the mold cavity surface, a special temperature control system is designed and custom built. Experimental results show that a temperature response of 4 s is obtained for heating the mold cavity surface from 40 to 125°C with a power density of 58 W/in.<sup>2</sup>. The module endured more than 135,000 thermal cycles from 40 to 125°C with a heating time of 10 s and a power density of 37 W/in.<sup>2</sup>. The compressive strength of the modules was only 500 psi. 2 refs.

Kim, Byung H. (Univ of Massachusetts at Amherst, Amherst, MA, USA); Wadhwa, Rajesh R. *Polym Plast Technol Eng* v 26 n 1 Mar 1987 p 1-22.

**079815 STUDY OF ISOTHERMAL SIMPLE SHEAR FLOW FOLLOWED BY NONISOTHERMAL STRESS RELAXATION IN A LOW THERMAL INERTIA MOLDING.** In order to analyze the stress relaxation in the molded part, a rheological constitutive equation that can characterize the nonlinear viscoelastic flow behavior of the polymer melt must be used. M.H. Wagner's integral-type constitutive equation is utilized in predicting the stress relaxation from the instant the mold is filled isothermally by fully developed simple shear flow.

Study of stress relaxation showed that the flow-induced stress can be relaxed on the order of a second. When the relaxation takes place before the vitrification, a part with the minimum residual stress can be molded. Because of the viscoelastic nature of the polymer melt, the more strain the melt undergoes within the longest relaxation time period, the faster it will relax. Hence the cavity should be filled as rapidly as possible for molecular relaxation and for decreasing total cycle time. 13 refs.

Kim, Byung H. (Univ of Massachusetts at Amherst, Amherst, MA, USA); Suh, Nam P. *Polym Plast Technol Eng* v 26 n 1 Mar 1987 p 23-44.

**079816 'EXPERT' CIM SYSTEM INTEGRATES INJECTION AND BLOW MOLDING.** Complete plantwide monitoring and control networks, with built-in SPC and SQC functions based on new 'expert system' software, are now available for injection and blow molding. This system incorporates previous releases of Hunkar's CNC-1000 total machine controller, DAT data-acquisition terminal, on-line SPC analysis software, and factory network data highway. The latest enhancements include: expert software for more sophisticated injection and blow molding statistical process and quality control; cell control that integrates the molding machine with auxiliaries; and a new and more powerful central plant control/monitoring station.

Anon. *Plast Technol* v 34 n 4 Apr 1988 p 15, 17, 19.

**079817 BLUEPRINT FOR CIM IN PLASTICS MOLDING.** The CIM plan allows the molder to use molding and auxiliary equipment of his choice and does not tie him to any one manufacturer. It employs technologies that can be retrofitted to existing molding and auxiliary equipment. While the injection molding process is taken as the model for this conceptual presentation, the plan is also being implemented in blow molding and transfer molding for semiconductor encapsulation. The elements are: process control with statistical process control; automated quality control with statistical quality control; computer-aided response program; computer-aided equipment maintenance program; production control with qualified MIS data. The physical components include: central computer; machine network; local area network; remote data-display network; data collection terminals; data-bases.

Hunkar, Denes (Hunkar Lab Inc). *Plast Technol* v 34 n 6 Jun 1988 12p.

**Molds** See Also CAMERAS—Lenses; COMPUTER AIDED MANUFACTURING; MACHINE SHOPS—Computer Integrated Manufacturing; PLASTICS, FOAMED—Reaction Injection Molding; PLASTICS PLANTS—Computer Aided Manufacturing; PLASTICS PRODUCTS—Computer Aided Design; PLASTICS, REINFORCED—Fabrication; THERMOPLASTIC ELASTOMERS—Processing.

**079818 DIMENSIONLESS CURVES FOR PRESSURE OF A HEATED DIE SLOT.** The flow of polymer melts in dies commonly involves heat transfer and temperature differences between the melt and the die lips. This results from heat conduction and viscous heat generation. The melt may also enter the die at a different temperature than the die lips, resulting in temperature changes in the melt. The melt viscosity is normally also very dependent upon temperature and shear, and it will thus vary throughout the melt. The purpose of this analysis is to present a mathematical solution for the pressure of developing flow of polymers in heated dies. A unique set of dimensionless curves is devised which can be easily used for die pressure calculations for a large range of flow conditions and melt properties. 5 refs.

Derezinski, Stephen J. (Eastman Kodak Co, Rochester, NY, USA). *J Plast Film Sheeting* v 3 n 4 Oct 1987 p 261-273.

**079819 GUIDE TO MOULD MAINTENANCE.** The article discusses the common causes and cures of problems with expensive and vital mould tools, plastic injection mould tools. The advantages of maintenance are pointed out. Some of the problems covered are worn or seized pins

and ejectors, corrosion and furring, misalignment and damaged seatings.

Atkinson, Bob (DME, Engl). *Prod Eng (London)* v 67 n 3 Mar 1988 p 19-20.

**079820 COPING WITH THE WARPED PERSONALITY OF MOLDED PLASTICS.** Because plastics shrink locally rather than globally, their patterns of warpage can be extremely complex. With the aid of software, designers can now predict the shrinkage at each area. They can then modify the part and the mold to minimize both warpage and residual stress. Engineering software modules are now available that model the molding and cooling processes and allow designers to predict shrinkage at each area of the part before a prototype is made. (Edited author abstract)

Smith, Stephen T. (Moldflow Pty Ltd, Trumbull, CT, USA). *Mech Eng* v 110 n 6 Jun 1988 p 78-80.

**079821 UK COMPANIES HELP THEMSELVES TO EXPORTS.** The author reports on how three subcontract moldmakers are exploiting technology to give them a competitive edge when the EEC trading barriers come down in 1992. All three companies are relying heavily on the use of numerically controlled machine tools using programs generated from CAD data and have invested heavily in leading-edge CAD/CAM technology for the production of complex molding dies for plastics injection molding.

Anon. *Mach Prod Eng* v 146 n 3740 Jun 3 1988 4p.

**079822 HOW YOU CAN AFFORD A QUICK-MOLD-CHANGE SYSTEM.** With a modest capital investment in a manually operated or semi-automatic quick-mold-change system, injection molders reportedly can achieve a major degree of the increased manufacturing flexibility, efficiency, and productivity provided by more technologically advanced (and expensive) fully automated QMC systems. The basic philosophy of QMC is to minimize machine downtime by carrying out the physical process of changing a mold and bringing the machine back into production as rapidly and efficiently as possible. This involves standardization of the mold/machine or automating the different steps necessary in changing a mold. Five key elements of QMC systems are examined with emphasis given to how each element might be affordably adopted. These five elements include the following: Mold handling in and around the machine. Mold locating in the machine. Mold clamping. Utility connections. Materials and color changes.

Kirkland, Carl (Plastics World, Newton, MA, USA). *Plast World* v 45 n 12 Nov 1987 9p.

**Molecular Structure** See Also POLYMERS—Molecular Structure; POLYMERS—Synthesis; POLYTETRAFLUOROETHYLENE—Wear.

**079823 STRESS OPTICAL STUDIES OF DRAWN POLY(ETHYLENE METHYL TEREPHTHALATE).** Oriented tapes of poly(ethylene methyl terephthalate) (PEMT) and a 60/40 copolymer of PEMT and poly(ethylene terephthalate) (PET) have been prepared by drawing at different temperatures above and below the glass transition temperatures. It was established that in all cases the drawn samples showed no detectable crystallinity. The development of molecular orientation was characterized by birefringence and from the magnitude of the shrinkage force observed on heating above  $T_g$ . The results can be considered in terms of the deformation of a molecular network, without introducing complications due to crystallinity, and this was shown to provide a good first-order explanation for the data on drawing above  $T_g$ . Drawing below  $T_g$ , on the other hand, is better modelled by the pseudo-affine deformation scheme. (Author abstract) 35 refs.

O'Neill, M.A. (Univ of Leeds, Leeds, Engl); Duckett, R.A.; Ward, I.M. *Polymer* v 29 n 1 Jan 1988 p 54-60.



**Molecular Weight** See POLYMERS—Degradation.

## Molten

**079824 MELT ELASTICITY INDEX: A QUALITY CONTROL MEASURE.** Melt-index data have traditionally been used to predict processability. A supplementary test of melt elasticity gives a more complete picture of processing characteristics and a more reliable route to quality control. A simple apparatus provides elasticity data in only 20 minutes, a short enough time for on-line quality control. (Author abstract)

Maxwell, Bryce (Princeton Univ, Princeton, NJ, USA). *Plast Eng* v 43 n 9 Sep 1987 p 41-44.

**Morphology** See BLOCK COPOLYMERS—Crosslinking; PHENOLIC RESINS—Aging; POLYMERS—Structure.

**Nondestructive Examination** See Also METALS AND ALLOYS—Nondestructive Examination; PLASTICS, REINFORCED—Glass Fiber; POLYPROPYLENE—Molding.

**079825 NMR PEERS INTO MATERIALS, ANALYZES NONDESTRUCTIVELY.** Pulsed nuclear magnetic resonance, when applied to composites, can reveal information about the structures of polymer matrices, additive particles, and absorbed moisture. Because of advances in magnetic technologies and microelectronics, small, portable NMR devices now hold promise for wide application in polymer analysis. (Author abstract)

Matzkanin, George A. (Southwest Research Inst, San Antonio, TX, USA). *Plast Eng* v 43 n 5 May 1987 p 37-39.

**Optical Properties** See LENSES—Plastics.

**Oxidation** See ACRYLICS—Stabilizers; POLYMERS—Reduction; POLYMERS—Stresses.

**Painting** See Also COATINGS—Materials.

**079826 PROBLEMATIKA POVRCHOVE UPRAVY PLASTU NATEROVYMI HMOTAMI.** [Problems Involved in Surface Treatment of Plastics by Painting]. General principles of painting plastics products are dealt with. Efficient painting methods including suitable types of paints are described. Polyethylene, polypropylene polyvinyl chloride, polymethyl methacrylate, polystyrene, acrylonitrile butadiene styrene, styrene acrylonitrile copolymer, polycarbonate, cellulose acetate butyrate, polyamide, phenolformaldehyde resins and glass fiber laminates are considered. (Author abstract) In Czech. 7 refs.

Jarusek, Jaroslav (Vysoka Skola Chemicko-Technologicka, Pardubice, Czech). *Plasty Kauc* v 24 n 7 Jul 1987 p 199-202.

**Pelletizing** See PLASTICS MACHINERY—Mixers; PLASTICS MACHINERY—Molding Machines.

**Permeability** See FOOD PRODUCTS—Packaging.

**Phase Transitions** See POLYMERS—Decomposition.

**Photosensitivity** See POLYMERS—Synthesis; THERMOPLASTICS—Stabilizers.

**Physical Properties** See Also COPOLYMERS—Composition Effects; EPOXY RESINS—Curing; POLYESTERS—Curing; POLYMERS—Doping; POLYMERS—Electric Properties; POLYMERS—Modification; POLYMERS—Synthesis.

**079827 PLASTICS PROPERTIES FOR DATA BANK AND DESIGN: MEANINGFUL - COMPARABLE - ECONOMICAL TO DETERMINE.** Observations show that the three basic requirements in respect of plastics properties are, at least from the viewpoint of the designer, at present only inadequately fulfilled. An improvement in the situation can only be achieved by first of all attempting step-by-step to meet the basic requirements for characteristic values permitting a comparison of

different products and preliminary selection of products for specific applications. For this purpose it is necessary to drastically reduce the number of test methods as well as the types of specimen and to standardize the preparation of the specimens and the performance of the tests. Basic values determined by these methods are specifically suited for filing in data banks. 4 refs.

Oberbach, K.; Rupprecht, L. *Kunstst Ger Plast* v 77 n 8 Aug 1987 p 23-28.

**079828 ADHEESIO- JA BARRIERMUOVIT.** [Adhesion and Barrier Plastics]. Neste Oy has been active in the development of adhesion and barrier plastics for several years. The aim has been to develop a complete line of materials, especially for gas-tight food packaging applications with low permeability to oxygen, carbon dioxide etc. At least three layers are needed for workable packaging solutions: a barrier layer, a heat-sealing layer and an adhesion layer between the barrier and heat-sealing layers. In most cases five layers are needed, to achieve a balanced structure for packages, resistant to curling and moisture. The barrier and heat-sealing layers are non-compatible because barrier materials contain polar groups and heat-sealing materials are non-polar. (Edited author abstract) In Finnish.

Villanen, Martti J. (Neste Oy Chemicals, Kulloo, Finl). *Kem Kem* v 15 n 2 1988 p 137-138.

**079829 PROBLEMS WITH PLASTICS DURABILITY IN NEW ZEALAND BUILDINGS.** The overall level of problems is low, but individual problems have been quite large. Several case histories are discussed to illustrate: the consequences of the New Zealand environment for plastics; the influence of material specification on plastics durability; the influence of design on plastics durability; and the prediction of plastics durability. There are two main conclusions from the consideration of plastics problems. The first is that there is a need for better education of building designers and specifiers about plastics properties and their implications for durability. The second is that better means of predicting plastics durability are needed. (Edited author abstract) 13 refs.

Sharman, W.R. (Building Research Assoc of New Zealand, Porirua, NZ). *NZ J Technol* v 3 n 3 1987 p 145-152.

**Polymerization** See ACRYLICS—Mechanical Properties; VINYL RESINS—Dielectric Properties.

**Porosity** See MEMBRANES—Plastics Applications.

**Pressure Effects** See POLYMERS—Solutions.

**Printing** See STRAIN GAGES—Plastics Applications.

**Processing** See Also EPOXY RESINS—Processing; PLASTICS MACHINERY; PLASTICS MACHINERY—Granulators; PLASTICS PRODUCTS—Manufacture; POLYMERS—Conductive; POLYMERS—Degradation; POLYMERS—Electric Conductivity; POLYMERS—Processing; POLYPROPYLENE—Production; POLYVINYL CHLORIDE—Rheology.

**079830 PRETREATMENT OF PLASTIC SURFACES IN THE LOW-PRESSURE PLASMA.** Treatment in the low-pressure plasma permits a reduction of the surface tension on plastics parts. This results in improved adhesion, e.g. in cementing, painting, printing and metalizing. In comparison with other methods, the low-pressure plasma process is characterized by its environmental safety. (Author abstract)

Liebel, G.; Bischoff, R. *IPE Int Ind Prod Eng* v 11 n 3 Oct 1987 p 147-149.

**079831 MECHANICAL PROPERTY ENHANCEMENT OF SEMICRYSTALLINE POLYMERS-A REVIEW.** Processing plastics below their melting points has been shown to be an effective way to significantly enhance the mechanical, chemical, and physical properties of semicrystalline thermoplastics. A number of techniques have been developed that are capable of producing highly oriented fibers, films and shapes. In general, these tech-

niques can be classified as drawing, extrusion, and rolling, with some very specific modifications having been made to each, that affect the performance of the process. Techniques have been developed which rely on strain induced crystallization to enhance the modulus of molded parts and extrudates from a melt. This paper constitutes a review of these techniques with emphasis on the process parameters, polymers investigated, and properties of the resulting materials. (Edited author abstract). 58 refs.

Bigg, D.M. (Battelle Columbus Div, Columbus, OH, USA). *Polym Eng Sci* v 28 n 13 mid-July 1988 p 830-841.

**Production** See Also ROBOTS, INDUSTRIAL—Applications.

**079832 PLASTICS IN HIGH TECH INDUSTRIES BY 2001 A.D.** The author surveys the status of polymer production in India. This is followed by an assessment of the global production of plastics. Several important plastics are discussed including: nylon, polycarbonates, polyacetals, polytetrafluoroethylene, polyurethanes and, rigid urethane foams. The present status of technology is examined. Finally, research and development requirements are outlined.

Krishnamurthy, H. (Hindustan Organic Chemicals Ltd, India). *Chem Eng India* v 39 n 3 1988 p 149-158.

**Pultrusion** See BEAMS AND GIRDERS—Space Applications; PLASTICS, REINFORCED—Fabrication; PLASTICS, REINFORCED—Structural Application; SPACECRAFT—Manufacture; THERMOSETS—Processing.

## Pulverization

**079833 PULVERIZING OF PLASTIC SCRAP SOLVES QUALITY PROBLEMS.** The design and applications of impact disc pulverizers are discussed. Essential differences from conventional pulverizing equipment are in the design of the grinding chamber. The impact pulverizer has a compact low-volume grinding chamber which ensures that only the quantity of material which is actually subjected to the size reduction process is present in the machine. This design prevents efficiency loss which otherwise arises from material being unnecessarily hurled around the grinding chamber. This unnecessary recirculation of material not only consumes much energy but also causes unnecessary overheating of the material.

Herbold, K. *IPE Int Ind Prod Eng* v 12 n 1 Jan 1988 p 40-42.

**Pyrolysis** See Also POLYMERS—Combustion; POLYVINYL CHLORIDE—Decomposition.

**079834 PYROLYSIS STUDIES OF FLAME RETARDED PLASTIC SYSTEMS.** Two pyrolysis experiments have been utilized to investigate reactions pertinent to flame retardant behavior. First, a mass spectrometric evolved gas analysis technique has been used to study the influence of the flame retardant decabromodiphenyl oxide (DBDPO) and the synergists antimony oxide and zinc borate on the activation energy for monomer (i.e., fuel) evolution from polystyrene composites. Second, the extremely fast scan capability of the time-of-flight mass spectrometer has been utilized to monitor HCl and benzene evolution from various poly(vinyl chloride) (PVC) composites subjected to a very large and rapid temperature rise due to pulsed laser heating. It is found that a decrease in the smoke density value can be associated with an increase in benzene evolution (Edited author abstract) 22 refs.

Price, D. (Univ of Salford, Salford, Engl); Milnes, G.J.; Lukas, C.; Phillips, A.M. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 499-510.

## Radiation Damage

**079835 SHELF LIFE PREDICTION OF RADIATION STERILIZED POLYMERIC MATERIALS.** The functional properties of many polymers employed in



medical disposables are unaffected by sterilizing doses of ionizing radiation. However, some materials (PVC, polypropylene, cellulose, etc.) undergo undesirable changes which continue to occur for the shelf life of the product. In many cases, conventional accelerated aging techniques do not accurately predict the real time properties of the materials. As real time aging is not generally practical, it has become necessary to develop accelerated aging techniques which can predict the functional properties of a material for the shelf life of the product. This presentation addresses issues involved in developing these tests. Real time physical property data is compared to data generated by various acceleration methods. (Author abstract) 6 refs.

Sanford, Craig (Baxter Healthcare, Round Lake, IL, USA); Woo, Leon. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 671-678.

**Radiation Effects** See Also IONS—Beam Tracking; PARTICLE DETECTORS; PARTICLE DETECTORS—Materials; POLYTETRAFLUOROETHYLENE—Thermal Properties; SCINTILLATION COUNTERS—Materials.

**079836 INDUCTION TIME IN MAKROFOL E.** Induction time in Makrofol E is evaluated applying the nuclear track replica method and electron microscopy with 10 Angstrom resolution. The induction time is observed in foils with and without pre-etching. The track diameter vs etching time curves do not follow a linear relation for small track diameters. (Author abstract) 19 refs.

Bourdin, J.C. (CNEA, Buenos Aires, Argent); Mazzei, R.; Bernaola, O.A.; Grasso, J.C.; Saint Martin, G. *Nucl Instrum Methods Phys Res Sect B* v B28 n 4 Nov 1 1987 p 548-553.

**079837 CHEMICAL AND ELECTROCHEMICAL REGISTRATION OF PROTONS IN CR-39 - IMPLICATIONS FOR NEUTRON DOSIMETRY.** In this paper we describe, first, the response of the chemically etched CR-39 detector to protons as a function of their energy. To do this we have irradiated the CR-39 polymeric detector with monoenergetic protons (from 0.6 to 6 MeV), and etched it chemically in 6M NaOH at 70°C. We find that normally-incident protons, in the whole energy range studied, are registrable in CR-39 when etched chemically. We then proceed to determine the track-to-bulk etch-rates ratio  $V_T/V_B$  as a function of proton energy and 'REL 350'. From  $V_T/V_B$  measurements we calculate the critical angle for CR-39 as a function of proton energy. Finally, we study the registration of protons by electrochemical etching, and then extend our studies to predict the best radiator-detector assembly which would provide a nearly flat dose-equivalent response for neutrons (which produce tracks chiefly through recoil protons) over the neutron energy range of approx. 0.1 to 19 MeV. (Author abstract) 16 refs.

Matiullah (Univ of Birmingham, Birmingham, Engl); Durrani, S.A. *Nucl Instrum Methods Phys Res Sect B* v B29 n 3 Dec 1987 p 508-514.

**079838 METHOD FOR MONITORING THE COLLAPSE OF PLASTIC SECTIONS AS A FUNCTION OF ELECTRON DOSE.** We present a method for monitoring the collapse of plastic sections when irradiated in the electron microscope. The two surfaces of the section are separately coated with colloidal gold particles. The section is then tilted to an angle of 45° in the microscope and a series of micrographs recorded, corresponding to increasing total electron dose. The collapse of the specimen normal to the plane of the section causes a relative movement in the image of the two sets of particles marking the two surfaces. By measuring the positions of a few gold particles on each side of the section in each exposure of the series, the collapse and also the in-plane shrinkage can be computed. The sections exhibit a rapid initial collapse, followed by a much slower phase of thinning. These effects should be taken into account when producing quantitative three-dimensional maps from tilt series of sectioned material. (Author abstract) 17 refs.

Luther, P.K. (Imperial Coll, London, Engl); Lawrence,

M.C.; Crowther, R.A. *Ultramicroscopy* v 24 n 1 1988 p 7-18.

**079839 CR-39 PLASTIC FOR MASSIVE MAGNETIC MONOPOLE SEARCH.** A new CR-39 plastic containing a small amount of antioxidants (Naugard-445) has been developed for use in a search for massive magnetic monopoles. Its characteristics have been investigated from the standpoint of the 'heavy etching method', which was proposed several years ago. The results are compared with those of pure CR-39 plastics measured under the same conditions. (Author abstract). 14 Refs.

Doke, T. (Waseda Univ, Tokyo, Jpn); Tawara, H.; Hayashi, T.; Hichinose, H.; Kuwahara, K.; Nakamura, S.; Orito, S.; Ogura, K. *Nucl Instrum Methods Phys Res Sect B* v B34 n 1 Jul 1988 p 81-88.

**079840 SURFACE MODIFICATIONS TO MINIMIZE THE ELECTROSTATIC CHARGING OF KAPTON IN THE SPACE ENVIRONMENT.** The electrostatic charging of Kapton under electron irradiation is reduced by coating it with a dispersion of indium oxide in a soluble polyimide. The proportion of oxide in the coating and its thickness are chosen to give an optimum balance between the surface resistivity and the thermo-optical properties ( $\alpha_s/\epsilon$ ) of the film. Coatings having a resistivity  $<10^7 \Omega/\text{square}$  exhibited surface voltages below 250 V when irradiated with 30 keV electrons. Implanting Kapton with ions derived from  $N_2$ ,  $H_2$  or  $CH_4$  plasmas also gave low surface resistivities and reduced its susceptibility to electrostatic charging. Hydrogen ions were the most effective, but caused greater changes in  $\alpha_s/\epsilon$  than the ions of the other gases. (Author abstract) 10 refs.

Verdin, D. (AERE, Harwell, Engl); Duck, M.J. *J Electrostatics* v 20 n 1 Oct 1987, Spacec Charging: Sel Pap Presented at the AGARD Symp on the Aerosp Environ at High Alt and Its Implic for Spacec Charging and Commun, Hague, Neth, Jun 1986 p 123-139.

**Reaction Injection Molding** See Also AUTOMOBILE MANUFACTURE—Forming; AUTOMOBILE MATERIALS—Plastics; POLYURETHANES—Modification; THERMOPLASTICS—Synthesis.

**079841 ANALYSIS OF REACTION INJECTION MOLDING PROCESS OF POLYURETHANE-UNSATURATED POLYESTER BLENDS. PART I: COMPUTER SIMULATION.** A computer simulation model was developed to analyze the reaction injection molding (RIM) process of polyurethane and unsaturated polyester blends. The reaction kinetics and viscosity functions of each component were obtained through actual experiments, and a mathematical scheme for numerical calculation was set up in cylindrical coordinates to predict the temperature and conversion profiles within a disc-type mold. The temperature change calculated from the simulation was compared with the temperature rise measured in actual RIM experiments. The effects of the feed temperature, wall temperature, and catalyst levels on the maximum exothermic temperature and the demolding time were evaluated in a search for the optimum processing conditions. (Author abstract) 24 refs.

Kim, J.H. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Kim, S.C. *Polym Eng Sci* v 27 n 16 Mid-Sep 1987 p 1243-1251.

**079842 ANALYSIS OF REACTION INJECTION MOLDING PROCESS OF POLYURETHANE-UNSATURATED POLYESTER BLENDS. PART II: MECHANICAL PROPERTIES.** The mechanical properties of polyurethane-unsaturated polyester interpenetrating polymer networks (IPNs) that were prepared by reaction injection molding (RIM) process were measured with variations in composition, cross-link density, and relative reaction rate. From dynamic mechanical analysis (DMA), it was found that the two component polymers had a good compatibility over the whole composition range. For higher cross-link density, the compatibility was enhanced and the mechanical properties were improved. When the reaction rates of the components were different, some

extent of phase separation was found in DMA and the properties were affected adversely. (Edited author abstract) 17 refs.

Kim, J.H. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Kim, S.C. *Polym Eng Sci* v 27 n 16 Mid-Sep 1987 p 1252-1257.

**079843 ASPECTS OF THE DESIGN OF RIM PLANTS FOR THE FUTURE.** The use of plastic materials for the production of automotive body parts has been steadily increasing over the years. Weight saving, corrosion resistance, sound and heat insulation and improved impact resistance are some of the reasons behind this growth. The most utilized material for these applications has been polyurethane, processed by reaction injection molding. The use of self-releasing systems has given the processor the opportunity to improve productivity by eliminating the use of release agent and, thus, the build up of release agent. The RIM process will greatly improve its competitive position against injection molding by continued development of new raw-material systems and improved processing methods. Success is in large part based on the good cooperation between raw-material suppliers, equipment manufacturers and processors. Increased clamping forces with more rigid tool-carriers will result in better molded parts. 1 ref.

Ruehmann, H.; Schaper, H. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 8-10.

**079844 RIM STAGES A COMEBACK IN PROCESSING PRODUCTIVITY.** Faster-cycling and more versatile RIM materials are the basis for a new generation of bigger, faster clamps, metering machines, and auxiliaries designed to handle large automotive parts more productively. Specifically, the advent of polyurea RIM materials - with shot times under 1 sec. and cure times of less than 20 sec. - has made it possible to cut overall reaction injection molding cycle times to well below the semi-official 1-min. cycle requirement established for automotive parts production. Translating such faster cure speeds into production-line reality, RIM machines now are capable of making, for instance, 4x6 ft., 18-lb. Class-A surface automotive body panels in consistent 40-sec. cycles.

Sneller, Joseph A. *Mod Plast* v 65 n 3 Mar 1988 p 81-83, 85.

**079845 REACTION KINETICS OF A POLYUREA REACTION INJECTION MOLDING SYSTEM.** Polyureas have the potential for improving reaction injection molding (RIM) productivity through shorter demold times and elimination of external mold release agents and post-cure. Kinetics of urea formation are necessary for process modeling of polyurea RIM systems. Adiabatic temperature rise measurements were used to monitor the extent of reaction of an aliphatic diamine and an aromatic diamine reacting competitively with a single diisocyanate. The aliphatic diamine reacted much faster; essentially complete polymerization occurred in the RIM mixhead. A similar three-component system was studied in dimethylacetamide and diethylene glycol dimethyl ether, and the sequential nature of the two competing reactions was confirmed. The RIM polymerization of the aromatic diamine, 3,5 diethyltoluene (2,4 and 2,6) diamine and 4,4'-diphenylmethane diisocyanate was studied using an unreactive polyether as the solvent. The exotherms could be fit with a third order model. (Edited author abstract) 21 refs.

Pannone, Mary C. (Univ of Minnesota, Minneapolis, MN, USA); Macosko, C.W. *Polym Eng Sci* v 28 n 10 May 1988 p 660-669.

**079846 REACTION INJECTION MOLDING OF POLYUREAS I. KINETICS STUDY.** The experimental results and mathematical modeling of processing of polyureas are covered. The experimental part includes the applications of solution polymerization to study the reaction kinetics of polyureas. The theoretical part in-



cludes a kinetic and heat transfer model that can apply solution polymerization data to predict the bulk polymerization of polyurea in the reaction injection molding process. (Edited author abstract). 17 Refs.

Hsu, T.J. (Ohio State Univ, Columbus, OH, USA); Lee, L.J. *Polym Eng Sci* v 28 n 15 mid-august 1988 p 955-963.

**079847 RIM, STIM AND RTM: UP AND COMING CHALLENGERS.** An overview of the latest develops in RIM materials and machinery include: E-coat thermal resistance, DOI and class A surface; mold release; new chain extenders; mold temperature; alternative isocyanates; new fillers; cycle time and automation; larger machinery. Newer possibilities for RIM materials including SRIM materials are enumerated. The trend in the auto industry toward lower production volumes and quick model changes has thrown the spotlight on resin transfer molding (RTM), which offers the ability to make large, complex parts, with very low tooling costs. The main obstacles RTM must overcome are exceedingly high cycle times and the difficulty of obtaining a Class A surface in a low-temperature, low-pressure process.

Burns, Robert; Rogers, Jack K. *Plast Technol* v 34 n 10 Sep 1988 6p.

**Recycling** See Also PACKAGING MATERIALS—Plastics; POLYETHYLENES—High Density.

**079848 EFFECT OF RECYCLE ON PROPERTIES AND PROFITS: ALGORITHMS.** In many plastics processes, nonvirgin materials make up relatively small percentages of materials added to the main processing stream. In thermoforming, however, as much as half the material that passes through the extrusion and thermoforming process chain is 'nonproduct' web. Economics usually dictate that this material must be reprocessed. Materials that experience high levels of shear and/or temperature usually exhibit measurable and significant property loss. This means that the mixture of materials fed to the process has properties somewhat less than those of the virgin resin. This paper presents algorithms for determining final product properties, given single-pass property loss and fraction of recycle in the resin mixture going to the process. (Edited author abstract) 4 refs.

Throne, James L. (Univ of Akron, Akron, OH, USA). *Adv Polym Technol* v 7 n 4 Winter 1987 p 347-360.

**079849 MORE PLASTICS USE MEANS MORE WASTE, WHICH MEANS...** Plastics represented 11.5% of the waste stream in 1986, according to a 1986 study done by Franklin Associates, Prairie Village, Kan. That compares to 27.1% for glass and 47.8% for paper. Legislators, environmentalists, and others, noting that the increased use of plastics means more non-degradable wastes, are pressuring the plastics industry to do something now. One solution may be a shift to more bio- and photo-degradable plastics. These materials degrade more quickly in the environment than the current widely-used plastic. Recycling, even as it is sometimes proposed as the ultimate solution for the nation's refuse disposal problem, is often proposed as another 'solution' to the problem of plastic wastes disposal. Plastics recycling is not highly successful for several reasons, but the outlook is getting better. PET, most familiarly known to consumers as the component of the soft-drink bottle, is being reclaimed at a rate of about 62,500 tons per year. When granulated, recycled PET can be sold more cheaply than virgin resins; fiberfill (stuffing) is one of its more common end-uses. These and other aspects of the subject are discussed.

Tallman, Jill W. *Waste Age* v 18 n 9 Sep 1987 p 141-142, 144, 146.

**079850 MIXED PLASTICS RECYCLING: NOT A PIPE DREAM.** Innovative firms are pioneering technologies to recycle co-mingled plastic wastes from residential and industrial sources into marketable products. This approach can provide two income streams: revenue from sale of finished products and, in some cases, from tip fees charged for this plastic 'disposal' service. Such enterprises are gaining momentum in several regions of the U.S. and

Western Europe where disposal capacity is at a premium and/or environmental pressures are prompting diversion of plastics from the waste stream. Featured in this article are three firms that lead in the development of mixed plastic recycling.

Brewer, Gretchen (Massachusetts Div of Solid Waste). *Waste Age* v 18 n 11 Nov 1987 5p between p 153 and 160.

**079851 REPROCESSING PLASTICS SCRAP.** Uniform production scrap is frequently recycled directly by plastics processors or is otherwise normally sent to reclaiming plants. Scrap from used plastics articles on the other hand requires considerably more extensive treatment before it can be converted into usable material by recycling processes. Purpose-built machinery and equipment for both categories of scrap are described and the economics of the different processes for various recycling tasks discussed. (Author abstract) In German and English.

Schalles, H. *Kunstst Ger Plast* v 77 n 11 Nov 1987 p 3-6, 1127-1133.

**079852 ECONOMIC RECYCLING OF PRODUCTION WASTE FROM PVC FILM AND SHEETING CALENDERING PLANTS.** Rational in-house upgrading of production waste is of considerable economic importance, particularly for calendaring shops that produce PVC film. Not enough attention is paid to this factor in all cases, however, despite the fact it has a considerable influence on costs. The plant concept described, which has also been built, involves a recycling system which makes optimum use of production waste employing the automatic raw material transport system that already exists and requiring minimal outlay on labour and costs. (Author abstract) 9 refs. In German and English.

Schick, J. *Kunstst Ger Plast* v 77 n 11 Nov 1987 p 7-10, 1134-1139.

**079853 FESTIGKEITSEIGENSCHAFTEN VON VERSCHMUTZTEM, WIEDERAUFBEREITETEM POLYETHYLEN. [Strength Properties of Contaminated, Reprocessed Polyethylene].** The re-use of thermo-plastics has been practised for many years. This is of considerable economic and ecological significance. What is scarcely known, however, is the extent to which contaminants influence the strength properties of a thermoplastic. Taking polyethylene as an example, the effects of specific contaminants are investigated and compared with practical experience. (Author abstract) 12 refs. In German.

Sikora, Robert (Technische Univ, Lublin, Pol); Bielinski, Marek. *Kunstst Ger Plast* v 78 n 4 Apr 1988 p 335-338.

**079854 PAIR PLAN TO PREVAIL OVER PLASTICS.** The Plastics Recycling Action Plans developed for the states of Massachusetts and Rhode Island by Recuperc, Inc. (Quebec) are described. Many parts of the plans are already being implemented in the two states. The study found that the average portion of the waste stream plastics (by weight) is 8 percent. The average American throws away 45 pounds or 1.5 cu. yds. of plastics per year. Experience in plastics recovery from the waste stream, gathered from 41 multi-material collection programs in the U.S., Canada, and Europe, was studied. The recommended strategy is summed up.

Brewer, Gretchen (Solid Waste Management, USA). *Waste Age* v 19 n 8 Aug 1988 4p.

**079855 ACTIVE RECYCLING OF PLASTICS.** Disintegration of thermoplastic particles and waste into granular matter and grains which can be directly reused is particularly important. After the method of separating plastic particles for further use, it is the most efficient recycling method for thermoplastic materials which clearly accounts for the greatest part of plastics; however, it does not preclude the application of further recycling methods based on chemical conversion which are most common with cross-linked elastomers and duroomers. As direct reprocessing constitutes an ideal, however, seldom adapted, recycling technique, research is under way at the

Plastic Engineering Institute of the Technical University of Berlin in order to identify the measures that are necessary for extensive recycling on the basis of direct reprocessing of thermoplastic materials. This paper discusses the subject in terms of materials selection and product design, properties of parts made of recycling products, recycling strategies, and others.

Kaeuffer, H. *Conserv Recycling* v 10 n 2-3 1987, Recycl of Mater, Sel Pap from the Fifth Int Recycl Congr, Berlin, West Ger, Oct 29-31 1986 p 153-167.

**079856 IMPROVING THE HOMOGENEITY AND MECHANICAL PROPERTIES OF PLASTICS WASTE CONTAMINATED BY PAPER USING A HYDROLYTIC TREATMENT.** It is the purpose of the present contribution to demonstrate the potential of a hydrolytic treatment of plastics waste contaminated with paper. Such treatment is intended to embrittle the cellulosic component so that it is easily disintegrated into small fragments in the shear field acting in normal plastics processing machinery (extrusion, injection moulding). This in turn results in significant improvement of the homogeneity of the product as reflected by its appearance, and also by its mechanical parameters. The paper illustrates the effect of hydrolysis on the mechanical parameters of injection moulded test bars produced from plastics waste obtained from two different sorting plants. 4 refs.

Klason, Carl; Kubat, Josef. *Conserv Recycling* v 10 n 2-3 1987, Recycl of Mater, Sel Pap from the Fifth Int Recycl Congr, Berlin, West Ger, Oct 29-31 1986 p 169-175.

**079857 PLASTIC MATERIAL RECYCLING AS PART OF SCRAP VEHICLE UTILIZATION - POSSIBILITIES AND PROBLEMS.** The paper discusses the title subject with particular reference to recycling in Germany. Subjects covered include development trends, plastics recycling in the automobile industry, design aids, and others. 7 refs.

Wutz, Maximilian J. *Conserv Recycling* v 10 n 2-3 1987, Recycl of Mater, Sel Pap from the Fifth Int Recycl Congr, Berlin, West Ger, Oct 29-31 1986 p 177-184.

**Removal** See PULP—Contamination.

## Reprocessing

**079858 REPROCESSING OF PLASTICS WASTES.** In-house reutilization of sorted plastics wastes is nowadays for reasons of cost largely state of the art. On the other hand it is considerably more difficult to reprocess wastes that occur from the scrapping of used parts. The problems of separation and reprocessing are illustrated with a special case. (Author abstract)

Pfaff, R.; Gneuss, D. *IPE Int Ind Prod Eng* v 11 n 3 Oct 1987 p 143-144.

**Research** See POLYMERS—Processing.

**Reviews** See METALS AND ALLOYS—Reviews.

**Rheology** See Also EPOXY RESINS—Pultrusion; PLASTICS FILMS—Drawing; PLASTICS MACHINERY—Extruders; POLYMERS—Blending; POLYVINYL CHLORIDE—Extrusion; POWDER METALLURGY—Injection Molding; THERMOPLASTICS—Injection Molding.

**079859 MODIFIED MELT-FLOW INDEXER FOR RHEOLOGICAL MEASUREMENTS OF PLASTICS.** A modified Melt-Flow Indexer is presented for estimating the flow behavior of plastics over relevant ranges of shear stresses and temperatures. (Author abstract) 2 refs.

Savov, M. (Univ of Chemical Technology, Sofia, Bulg); Lindberg, J.J.; Jaaskelainen, P. *Acta Polytech Scand Chem Technol Metall Ser* n 178 1987 p 79-84.

**079860 LOW PRESSURE RHEOLOGY OF GRANULAR POWDERS USING A DRAWING PLATE TECHNIQUE.** An analysis of a drawing plate test for easily monitoring the low-pressure frictional characteris-



tics of powders is presented. The test is performed by measuring the force required to withdraw a plate from a cylindrical bed of dry powder. The characteristics of the drawing force profile are analyzed using Janssen's classical differential element approach to relate the product  $\mu K$  of powders as a function of packing of powder medium, where  $\mu$  is the coefficient of friction of the powders against the solid drawing plate, and  $K$  is Janssen's constant, an anisotropic pressure distribution factor of a powder bed. The packing arrangement, expressed as the external void fraction, due to tapping, significantly alters the  $\mu K$  value and the effective sustaining strength of a powder bed. Experimental results on spherical glass beads having mono- and bimodal size distributions, and on three different poly(vinyl chloride) [PVC] powders are discussed. (Edited author abstract) 51 refs.

Lee, Bing-Lin (BFGoodrich Co, Brecksville, OH, USA). *Polym Eng Sci* v 28 n 7 Mid-April 1988 p 469-476.

**079861 VEREINFACHEN DER RELAXATIONS-GLICHUNG.** [Simplifying the Relaxation Equation]. The determining of relaxation times in accordance with the memory function of the linear viscoelasticity theory generally requires long calculation times. By means of a simplified model with a spring and a time-dependent damper the calculation time requirement can be appreciably reduced, thus enabling such calculations also to be performed on the PC. (Author abstract) 11 refs. In German.

Meder, Siegfried (Stahle Maschinenbau GmbH, Stuttgart, West Ger); Kaiser, Harald. *Kunstst Ger Plast* v 78 n 4 Apr 1988 p 351-354.

**Scintillation** See Also SCINTILLATION COUNTERS.

**079862 DEVELOPMENT OF PLASTIC SCINTILLATION FIBER.** We developed a plastic scintillation fiber (PSF) with a light-attenuation length as long as 2.8 m which was applied to a calorimeter. The performance of a calorimeter made of PSF and with a new method of fabrication is presented. 3 refs.

Takasaki, Fumihiko (KEK, Jpn); Saito, Hitoshi; Shimizu, Tohru; Kondo, Saburo; Shinji, Osamu. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 224-228.

**079863 SPIN COATING THIN FILMS OF PLASTIC SCINTILLATOR.** Nuclear reactions initiated by heavy-ion beams have greatly enriched the spectrum of nuclear reactions. Often these reactions are characterized by broad mass, charge, and energy distributions of the resulting fragments. The experiments must therefore be measurements with a large dynamic range of energy and either mass or charge for each of these fragments. One type of detector which has been utilized extensively is the scintillator sandwich, or phoswich. The most common type made during the last few years consists of a thin, fast plastic scintillator as the first element ( $\Delta E$ ) and a thick slow plastic scintillator as the stopping detector (E). Thin, uniform layers of plastic scintillator have been created on supporting aluminized Mylar by the use of the spin coating technique. 9 refs.

Norbeck, Edwin (Washington Univ, St. Louis, MO, USA); Dubbs, Tim P.; Sobotka, Lee G. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 546-547.

**Selection**

**079864 COMPUTER-AIDED PLASTIC SELECTION.** There is currently only one mainframe computer-aided plastic material selection program available, Plaspec, marketed and supported by Plastics Technology. When accessed via a modem, this program allows searching and review of data. There are a number of PC-based plastic material selection programs available. This article discusses a number of such programs that are available.

Blacketter, Donald (IDES Inc, Laramie, WY, USA). *Mater Eng (Cleveland)* v 105 n 7 Jul 1988 p 34-37.

**Separation** See POLYMERS—Processing.

**Sheet Molding Compounds**

**079865 CONTROLE DES RESINES POLYESTER INSATUREES POUR SMC: TEST DE LA REACTIVITE DES MAGNESIES LORS DU MURISSEMENT DES RESINES.** [Monitoring Unsaturated Polyester Resins for SMC: Testing the Reactivity of the Magnesiums Used in the Curing of the Resins]. It is important to know and control the thickening process of unsaturated polyester resins, in order to realize prepreps with the SMC (Sheet Molding Compounds) process. Magnesium oxide MgO is the thickening agent mostly used but its reaction mechanisms are still not fully understood. The authors have characterized some magnesium oxides with various macro- and microstructures. The main reactivity parameters of MgO were established: surface aspect, size and distribution of particles, carbonation and hydration, previous impasting. It was found that an acid-base reaction seems to be a good model of the reaction's first step, which leads to a gel formation. As a consequence, an easy and quick test of acid attack is suggested for estimating the thickening power of MgO. (Edited author abstract). 14 Refs. In French.

Gallet, J.P. (Ecole Supérieure du Cuir et des Peintures); Blanchard, F.; Chabert, B.; Laleg, M. *Mater Tech* v 76 n 4-5 Apr-May 1988 p 23-27.

**Shrinkage** See Also PAVEMENTS—Concrete.

**079866 ADVANCES IN HEAT-SHRINK TECHNOLOGY.** The basic technology and early developments of heat-recoverable polymers formed by so-called radiation cross-linking are described. Systems for wire identification and shielding is discussed. New markets and recent and imminent advances are examined.

Kraus, Robert (Raychem Corp, USA); Ryan, David. *IEEE Electr Insul Mag* v 4 n 3 1988 p 31-34.

**Solubility** See POLYMERS—Solutions; POLYMERS—Synthesis.

**Solutions** See POLYMERS—Computer Simulation; POLYMERS—Phase Transitions; POLYMERS—Solutions; POLYMERS—Synthesis.

**Spectroscopic Analysis** See POLYMERS—Solutions; POLYMERS—Structure; POLYMERS—Synthesis; POLYMERS—Thermal Effects; RUBBER, SYNTHETIC—Thermal Effects.

**Stability** See POLYMERS—Degradation; POLYMERS—Molecular Structure.

**Stabilizers**

**079867 STABILIZATION MECHANISMS OF HINDERED AMINES.** This paper discusses the studying interaction of hindered amine stabilizers (2,2,6,6-tetramethylpiperidines) with simple hydroperoxide, peroxy radicals, and acylperoxy radicals, the last two in AIBN-initiated oxidation experiments in chlorobenzene. 23 Refs.

Klemchuk, Peter P. (CIBA-GEIGY Corp, Ardsley, NY, USA); Gande, Matthew E. *Polym Degradation Stab* v 22 n 3 1988 p 241-274.

**Standards** See PACKAGING MATERIALS—Plastics.

**Strain** See Also POLYPROPYLENE—Drawing and Stamping.

**079868 STRESS-STRAIN PROPERTY REFERENCE POINTS FOR NON-LINEAR MATERIALS.** A graphical analysis of stress-strain data has been devised which delineates the elastic-plastic transition region giving nominal elastic and initial yield property reference points for a material. In addition an intermediate point is obtained using a tangential construction to the stress-strain curve. Possible areas of application include: design limits for lightly stressed components; measures of material toughness; hardness and damage resistance;

elastic-plastic stress analysis and adaption of design procedures to materials response changes. The materials considered are thermoplastics, a liquid-crystal polymer and polymer-bonded explosive systems. (Author abstract) 15 refs.

Roberts, J. (Royal Armament Research & Development Establishment, Fort Halstead, Engl). *Plast Rubber Process Appl* v 9 n 1 1988 p 17-21.

**Stresses** See Also PLASTICS SHEETS—Sheet Molding Compounds.

**079869 UNIAXIAL STRESS RELAXATION OF SOFTENED CELLULOSE (APPLICABILITY OF NONLINEAR VISCOELASTIC MODEL TO LARGE STRAIN).** Uniaxial stress relaxation of cellulose softened by heating was observed experimentally. The experiments consisted of the constant strain (single step) and the gradually stepup strain tests. The representation of stress relaxation was evaluated by the single integral nonlinear viscoelastic model up to the third order of strain. For the constant strain test, though residual stress at a certain duration after application of strain increases in proportion to strain in the range of small strain, it decreases with an increase in strain above a certain level of strain. The prediction of stress relaxation by the model with third order of strain agrees with the observed data. For the gradually stepup strain test, the variation of stress which occurs instantaneously under the change of strain is almost constant for the number of steps. Residual stress at the end of each step increases with the number of steps, and the hardening of the material appears. Additional study results are discussed. (Edited author abstract) In Japanese. 13 refs.

Tobushi, Hisaaki (Aichi Inst of Technology, Toyota, Jpn). *Zairyo* v 36 n 407 Aug 1987 p 861-865.

**079870 TEMPERATURE RISE OF FOIL STRAIN GAGES ON PLASTICS.** In strain measurements of plastics using foil strain gages, the temperature rise caused by power dissipated in the gage produces serious errors. A simple model for estimating the temperature rise is proposed, that is, a single strip representing a grid is bonded onto a half space made of plastic, and generates constant heat flux. A formula and diagram, by which the maximum value of the temperature rise can be estimated, are presented in this paper. The estimated temperature rise,  $T_{max}$ , is about 2 times as large as the measured one for actual gages bonded onto acrylic plates. The difference between both values is due to the incompleteness of the gage model and errors in the temperature measurement using a thermocouple. In spite of this incompleteness, the value of  $T_{min}$  is almost constant for the number of steps. Residual stress at the end of each step increases with the number of steps, and the hardening of the material appears. Additional study results are discussed. (Edited author abstract) In Japanese. 13 refs.  $a_c$  can still be used to estimate the temperature rise of the actual gages. This value is more useful than the power density which is often used as a parameter for estimating the temperature rise. (Author abstract) 8 refs.

Kojima, Yukio (Nagoya Inst of Technology, Nagoya, Jpn). *JSME Int J Ser 1* v 31 n 2 Apr 1988 p 226-232.

**079871 MEASURING METHOD ABOUT FLOW STRESS-STRAIN CHARACTERISTICS OF PLASTICS USING THE INDENTING HARDNESS TEST BY A SPHERICAL INDENTER.** This study deals with the measuring method about flow stress-strain characteristics of plastic using the indenting hardness test by a spherical indenter. First, hardness  $P_m$  (mean contact pressure)-total mean strain of an indentation  $\epsilon_{ic}$  characteristics are obtained with the indenting experiments by a spherical indenter, and flow stress  $Y$ -total strain  $\epsilon (= \epsilon_{ic})$  characteristics are measured using the uniaxial compression tests for plastic materials: PMMA, ABS, PC and PE. Second, Hardness/Flow stress ratio  $C$  is formulated,  $C = 9.8 P_m/Y$  in MPa, as the function of the ratio  $(\epsilon_{ic}/\epsilon_r)$ ,  $\epsilon_r$  is an elastic recovery strain  $(= E_0/E_s)$ ; Young's



modulus). Finally, it is shown that flow stress-strain characteristics from the elastic strain range to about the 10-15 percent strain range of plastics can be obtained using a one time indenting hardness test by a spherical indenter, by means of the calculation with the formulated equations in this paper and the former reports, and this method can be applied to the present hardness testing machines. (Author abstract). 14 Refs. In Japanese.

Ishibashi, Tatsuya; Shimoda, Shigeru; Furukawa, Tooru; Nitta, Isami; Gawasawa, Hideki. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 501 May 1988 p 1158-1164.

## Structural Application

**079872 ADVANCING STRUCTURAL PLASTICS INTO THE FUTURE.** A state-of-the-art background including the role of ASCE over the past 25 years is presented. During this time fiber-reinforced plastics (FRP) have been used effectively in civil engineering facilities such as pipes, water treatment plants, and structures exposed to highly corrosive environments. New or extended areas of research needed to provide civil engineers with the property data and structural behavioral information for structural plastics are discussed. Topics include infrastructure rehabilitation, characterization of composite materials, design guides for future materials systems, and adaptation of construction practice. Desired changes in governmental regulations and policies are offered and needed modifications to national educational programs are analyzed. (Edited author abstract) 13 refs.

McCormick, Fred C. (Univ of Virginia, Charlottesville, VA, USA). *J Prof Issues Eng* v 114 n 3 Jul 1988 p 335-343.

**Structure** See POLYMERS—Aging; POLYMERS—Deformation; POLYMERS—Doping; POLYMERS—Mechanical Properties; POLYMERS—Solutions; POLYMERS—Spectroscopic Analysis; POLYMERS—Structure; POLYMERS—Thermodynamic Properties.

**Surface Properties** See PLASTICS FILMS—Electric Properties.

**Surfaces** See POLYMERS—Chromatographic Analysis; POLYMERS—Structure.

**Synthesis** See LATEXES—Dielectric Properties; POLYMERS—Electric Conductivity; POLYMERS—Electronic Properties; POLYMERS—Forming.

**Testing** See Also COPOLYMERS—Mechanical Properties; FRICTION MATERIALS—Wear; NYLON POLYMERS—Mechanical Properties; POLYMERS—Analysis; POLYPROPYLENE—Processing.

**079873 EQUIPMENT FOR EXAMINING POLYMER MATERIALS IN CYCLIC LOADING.** Examination of the service loading of a number of plastic components of members of structures of gas transport equipment showed that they are subjected to the effect of various media and cyclic loading with various impact speeds, frequencies, and amplitudes. Therefore, in simulating their operating conditions, it is necessary to have a universal testing stand in which the loading parameters can be controlled in a wide range. The testing stand consists of equipment developing the multiple effect on the specimen in reciprocal movement of the slide block, control systems, control and measuring devices, and changeable additional devices which expand the test possibilities. Experience obtained using the proposed test unit, the loading regime, and the systems for measuring the loading parameters shows that the parameters can be regulated and controlled with sufficient accuracy. This indicates that the test unit is suitable for impact-fatigue and impact-abrasive tests of polymer materials.

Sorokin, G.M.; Petrovskii, B.S.; Yarema, I.T.; Nakonechnyi, Yu.N.; Grigor'ev, S.P. *Ind Lab (USSR)* v 53 n 6 Jun 1987 p 561-563.

**079874 HIGH SPEED COLOR PHOTOGRAPHY FOR STRAIN RATE MEASUREMENTS IN TENSILE TESTING OF PLASTICS.** Conventional high speed film photography is one of very few good methods

for strain measurement. Some reasons for this are discussed, with some comparison to the high speed video systems now on the market as the best known alternative. Cinematography had the advantage of making noncontact measurements over entire sample faces; it also provided, by definition, a permanent record of each test.

Spencer, Charles H. (Spencer Consulting Associates, Jeffersonton, KY, USA). *S V Sound Vib* v 22 n 3 Mar 1988 4p between p 6 and 12.

**079875 MEASURING METHOD ABOUT YOUNG'S MODULUS OF PLASTICS USING THE INDENTING HARDNESS TEST BY A SPHERICAL INDENTER.** This study aims at investigating the performance of a hardness testing machine. First, the phenomenon of a contact between a rigid spherical indenter and a plastic material is considered. By using Hertz's elastic contact law, the Young's modulus of plastics  $E_s$  can be calculated using the cordal diameter of an indentation  $d$ , the elastic recovery of an indentation. Furthermore, the mean strain rate under the elastic recovery by a spherical indenter is related to the strain rate under the uniaxial stress field. Finally, the indenting experiments are carried out. When the Young's moduli calculated from  $\delta t$  and  $\delta r$  using Eqs. (1)-(4) are compared to the Young's moduli measured from a compression test, their Young's values consist within an accuracy of about  $\pm 5-10\%$ . Therefore, the measuring method about Young's modulus of plastics using the indenting hardness test by a spherical indenter can be applied to the present hardness testing machines. (Edited author abstract) 19 refs. In Japanese.

Ishibashi, Tatsuya; Shimoda, Shigeru; Furukawa, Tooru; Nitta, Isami; Yoshida, Hidetoshi. *Nippon Kikai Gakkai Ronbunshu A Hen* v 53 n 495 Nov 1987 p 2193-2200.

**079876 INSTRUMENTED CHARPY IMPACT TEST OF POLYMERS.** The impact behavior of blunt and sharp-notched specimens of polypropylene (PP), polycarbonate (PC), polystyrene (PS), polyethylene (PE), poly(methyl methacrylate) (PMMA), propylene-ethylene block copolymer (PPB), and ABS plates has been studied using an instrumented Charpy impact tester. The load-time or -deflection curves of blunt-notched specimens have some oscillational load peaks before final fracture, which does not always occur at a maximum load value. The fracture origin for these specimens is located at the tip or within the plastic deformation zone which is formed at the notch root except for PS. The energy required for impact fracture corresponds well to the maximum elastic deflection energy of the specimen. (Edited author abstract) 12 refs. In Japanese.

Narisawa, Ikuo (Yamagata Univ, Yonezawa, Jpn); Ishikawa, Masaru; Sato, Katsuyoshi; Saikawa, Teturo. *Kobunshi Ronbunshu* v 45 n 2 1988 p 139-145.

## Thermal Conductivity

**079877 APPARATUS FOR MEASURING POLYMER THERMAL CONDUCTIVITIES AT HIGH PRESSURE AND TEMPERATURE.** Computer-aided design of plastic moldings requires knowledge of their thermal properties, e.g., thermal conductivity  $\lambda$ , under specific conditions. For this purpose, we constructed an apparatus that measures  $\lambda$  and functions within the 80-350°C temperature range up to a pressure of 500 bar. It was used to carry out experiments on three types of polymers (polyamide, polystyrene, and polypropylene). This paper includes a description of the experimental setup and a presentation of the numerical modeling required for simulating the thermal behavior of tested samples. (Edited author abstract) 15 refs.

Gobbe, C. (Lab Energetique et Phenomenes de Transfert, Talence, Fr); Bazin, M.; Gounot, J.; Dehay, G. *J Polym Sci Part B* v 26 n 4 Apr 1988 p 857-864.

**Thermal Effects** See POLYMERS—Deformation; POLYMERS—Rheology.

**Thermal Properties** See COMPOSITE MATERIALS; POLYMERS—Phase Transitions.

**Thermodynamic Properties** See POLYMERS—Amorphous.

**Thermoforming** See POLYMERS—Drawing and Stamping.

**Thermooxidation** See POLYOLEFINS—Stabilizers.

**Thin Films** See POLYMERS—Synthesis.

**Toughening** See EPOXY RESINS—Failure.

**Transfer Molding** See Also ELECTRONICS PACKAGING; PLASTICS, REINFORCED—Reaction Injection Molding.

**079878 GETTING THE BEST FROM TRANSFER MOLDING.** Of great importance to the process engineer is a basic understanding of the sensitivity of the molding process to variables, i.e., the parameters significantly affecting the total mold-filling history. The physical and esthetic properties of the molded part for a given mold design are directly related to molding conditions. The results of the experiments presented in this paper attempt to clarify this basic situation by monitoring the effect of the processing variable on the dynamic response of the transfer ram. All the experiments were carried out on a double-gated test-bar mold. 1 ref.

Progelhof, R.C. (AT&T Bell Lab, Murray Hill, NJ, USA); Lien, R.M. *Mod Plast* v 64 n 11 Nov 1987 p 106, 108, 110.

**Transparency** See AIRCRAFT—Windshields.

**Transport Properties** See POLYMERS—Permeability, Mechanical.

**Viscoelasticity** See Also POLYISOPRENE—Melting; POLYMERS—Creep; POLYMERS—Rheology; POLYMERS—Viscoelasticity; POLYMETHYL METHACRYLATE—Thermodynamic Properties.

**079879 CHARACTERIZATION OF PHOTOVISCOELASTIC MATERIALS BY A NONLINEAR CONSTITUTIVE EQUATION.** On the basis of a phenomenological theory which is guided by the results on the macroscopic material behavior, a nonlinear constitutive equation is derived to characterize the photoviscoelastic behavior of homogeneous, isotropic, and nonaging amorphous plastics, including large deformations. It is shown how to determine four memory functions by running creep tests in pure tension and simple shear. The testing equipment and the methods of test evaluation are explained. Results are reported for some typical materials. They show how to simplify the basic equation for applications in the analysis of plane states of stress in polymeric structures under quasistatic isothermal loading conditions. (Author abstract) 19 refs.

Weber, Herbert (Univ of Karlsruhe, Karlsruhe, West Ger). *Exp Mech* v 27 n 4 Dec 1987 p 390-397.

**Viscosity** See EPOXY RESINS—Rheology; POLYMERS—Mechanical Properties; POLYMERS—Structure.

**Waste Utilization** See Also AUTOMOBILE MATERIALS—Plastics.

**079880 COME L'ARABA FENICE? [Like the Arabian Phoenix?].** A technology based on research of thirty years on polymeric microcrystals has been reposed for the disposal of plastics wastes. This should give back a second life to any used plastic. The article, that takes up a report by Raymond Seymour at the American Chemical Society's Symposium in Chicago, reviews the present state of wastes disposal techniques and the future prospects. (Author abstract) In Italian. 5 refs.

Anon. *Mater Plast Elastomeri* n 11 Nov 1986 p 571-575.



**079881 VALUE RECOVERY FROM PLASTICS WASTE BY PYROLYSIS IN MOLTEN SALTS.** A low temperature (420°-480°C) of pyrolysis minimizes the gaseous fraction, and allows liquid and solid fractions of high economic value to be obtained; these include light oils, aromatics, paraffin waxes and monomers. Molten salts, with their excellent heat transfer properties, are interesting media for rapid and regular pyrolysis (problem of reaction kinetics); a eutectic has been selected. Chlorine-containing plastics are also dechlorinated almost completely (using basic salts, which are consumed in the process). The results of laboratory tests on polyethylene, polypropylene, polystyrene and polyvinyl chloride are given. Considering the conclusions of the experiments and the possible economic applications, further developments relating to an industrial stage are discussed. (Author abstract) 7 refs.

Bertolini, Gerard E. (CNRS, Fr); Fontaine, Jacques. *Conserv Recycling* v 10 n 4 1987 p 331-343.

## Wastes

**079882 GASIFICATION AND LIQUEFACTION FOR COVERING MATERIAL OF ELECTRIC CORD.** The covering material of an electric cord was pyrolyzed in an atmosphere up to 63wt percent and the others were produced as gases at the pyrolysis completion under the heating condition of 1°C/min. The partially combustion method and the high pressure pyrolysis method were conducted to reduce the solidified tar yield. The principal components of hydrocarbons in the partially combustion were  $C_1$ ,  $C_2$  and  $C_4$ . The hydrocarbons above  $C_5$  were not detected. The tar was reduced with increases of oxygen concentration and final temperature, while  $CO$  and  $CO_2$  increase with oxygen concentration. On the other hand, the solidified tar in the high pressure pyrolysis method was not produced on the range above 5kg/cm<sup>2</sup>, and the liquefied oil was done at 75wt percent of yield. (Author abstract). 6 Refs. In Japanese.

Tanino, Masaaki (Takasago Netsugaku Kogyo Co, Jpn); Shoji, Yoshiaki; Okada, Takao; Fukai, Jun; Miura, Takatoshi; Ohtani, Shigemori. *Nenryo Kyokai Shi* v 67 n 5 May 1988 p 337-341.

## Wear See Also PLASTICS, REINFORCED—Fibers.

**079883 HOW SHORT ARAMID FIBER IMPROVES WEAR RESISTANCE.** Super wear-resistant thermoplastic composites have been developed using short aramid fiber as reinforcement for nylon-66 and polyphenylene sulfide. The composites offer enhanced mechanical properties and higher use-temperatures, with significantly lower wear rate and essentially zero abrasive action. The article describes the test equipment, methods and results of the experiments made on nylon-66 and polyphenylene sulfide. 2 refs.

Wu, Y.T. (DuPont, Wilmington, DE, USA). *Mod Plast* v 65 n 3 Mar 1988 p 89-90, 93-94, 96.

## Weathering See ELECTRIC LAMPS, ULTRAVIOLET—Daylight Simulation; LIGHT—Spectrum Analysis.

## Welding

**079884 METALS AND/OR PLASTICS?** The growing interest of the Welding Institute in plastics materials has raised questions about their future alongside metals. Some of the answers are considered in a review of their important properties from the engineer/user's point of view. The article covers physical, chemical and mechanical properties; forming characteristics; costs; and scrap value. Some examples are given of welded plastics.

West, E.G. (Metal Construction, Cambridge, Engl). *Met Constr* v 19 n 9 Sep 1987 p 539-544.

**079885 ACOUSTIC CONTACT DURING THE ULTRASONIC WELDING OF PLASTICS.** Based on a solution of the problems of vibrations and the dissipative heating of a viscoelastic prism by a waveguide, the problem of static pressure ensuring an ideal normal acoustic contact is considered. Within the framework of a

simplified model, the mechanical behavior of a body during its separation from the waveguide is considered. A comparison is made between energy dissipation under the conditions of ideal and nonideal contacts. The problem of the effect of heating on the kinetics of contact interaction between the body and the waveguide is studied. 8 refs.

Senchenkov, I.K. (Acad of Sciences of the Ukrainian SSR, USSR); Tarasenko, O.V.; Chernyak, B.Ya.; Kozlov, V.I.; Frenkel, B.E. *Sov Appl Mech* v 23 n 2 Feb 1987 p 159-165.

**079886 WELDING TECHNIQUES FOR PLASTICS.** Thermoplastic materials can be softened by heat and be fusion welded. This article reviews the different welding techniques that are in industrial use for joining plastics and describes the equipment, its operation, special precautions necessary and joint performance achieved with reference to typical examples of production applications. Also outlined are areas requiring research and development to enable improved productivity and reliability. 10 refs.

Watson, M.N. (Welding Inst); Jones, S.B. *Met Mater (Inst Met)* v 3 n 10 Oct 1987 p 581-585.

**079887 WELDING OF PLASTIC PARTS OF ELECTRIC PUMPS.** A machine for thermal contact welding of thermoplastic parts has been designed. This machine has been used for welding the impellers of electric pumps. The process of thermal contact welding of impellers is described. The use of this machine has made it possible to use polypropylene which is cheaper than polyamide. 4 refs.

Dreishner, E.P.; Belen'kii, M.Kh. *Chem Pet Eng* v 22 n 7-8 Jul-Aug 1986 p 405-406.

**079888 CURRENT STATE AND TRENDS OF DEVELOPMENT IN THE WELDING OF PLASTICS.** One possible method of producing joints of self substance with plastics is by welding. This article considers heated tool, vibration, ultrasonic, friction, high-frequency and extrusion welding. It examines certain aspects of welding relating to processes and automation and describes the testing of welded seams and quality control. The weldability of various materials is also discussed. (Author abstract) In German and English. 44 refs.

Potente, Helmut; Tappe, Peter; Kreiter, Juergen. *Schweissen Schneiden* v 39 n 9 Sep 1987 p E135-E138.

**079889 WELDING PLASTICS: A PRIMER.** As plastics have moved from non-critical applications, they have entered areas where structural and safety factors are of importance. Their joining is crucial to their more widespread industrial exploitation. This paper reviews various welding processes, emphasizing joint qualities obtainable, welding times, and suitability for different thermoplastic applications. (Edited author abstract)

Anon. *Automot Eng (Warrendale Pa)* v 94 n 12 Dec 1986 p 55-61.

**079890 HEATED-TOOL BUTT WELDING WITH CONSTANT WELDING SPEED.** Heated-tool butt welding is used in the manufacture of pipelines in the gas and water supply industries, as well as in series production for joining mouldings. High requirements are made for the quality of these joints. It is the aim of this paper to describe the effect of limiting the welding travel, which is frequently practiced during the welding of mouldings, and of a constant welding speed on the strength of the welded seam. The experimental investigations were performed with a fully automatic heated-tool butt welding machine. The test material was semi-finished material (extruded sheets) of HDPE. In English and German.

Potente, H.; Kreiter, J.; Mohrmann, A. *Kunstst Ger Plast* v 78 n 1 Jan 1988 p 29-30.

**079891 ULTRASONIC PLASTIC WELDING WITH WELDING TIP PAIR.** Ultrasonic plastic micro-welding with transverse and longitudinal vibration welding tip pairs is studied. (1) A welding tip pair of 20 kHz vibrating

perpendicularly, and (2) a welding tip pair of 20 kHz and 27 kHz vibrating parallel to the surfaces to be welded are used for micro-welding of plastic sheet specimens. The welding tips are arranged parallel to each other with a small gap and driven at antiphase vibration mode. Using these welding tip pairs, welding specimens are joined with very narrow width from the upper part of lapped specimens according to the gap distance with no damage to the lower part of the specimens. (Author abstract) 4 refs.

Tsujino, Jiroamaru (Kanagawa Univ, Yokohama, Jpn); Kenmotsu, Kazuya; Fujita, Hiroaki; Ishikawa, Susumu. *Jpn J Appl Phys Suppl* v 25 suppl 25-1 1986, Proc 6th Symp on Ultrason Electron, Tokyo, Jpn, Dec 10-12 1985 p 168-170.

## Wetting See POLYESTERS—Processing.

## X-Ray Analysis See POLYMERS—Aging; POLYMER—S—Phase Transitions; POLYMERS—Structure.

**PLASTICS FILMS** See Also BLOCK COPOLYMERS—Surfaces; COPOLYMERS—Morphology; COPOLYMERS—Structure; CRYSTALS, LIQUID; ELECTRODES—Coatings; GASES—Permeability, Mechanical; MAIL HANDLING—Plastics Applications; MEMBRANES—Liquid; MONOMERS—Polymerization; POLYACETYLENES—Measurements; POLYETHYLENE TEREPHTHALATE—Electric Conductivity; POLYETHYLENE TEREPHTHALATE—Molecular Structure; POLYETHYLENES—Doping; POLYETHYLENES—Photochemical Reactions; POLYETHYLENES—Radiation Effects; POLYIMIDES—Metallizing; POLYIMIDES—Spectroscopic Analysis; POLYMERS—Defects; POLYMERS—Electric Properties; POLYMETHYL METHACRYLATE—Etching; POLYVINYL ALCOHOL—Physical Properties; SILVER AND ALLOYS—Structure; TIN AND ALLOYS—Thin Films.

**079892 ELECTROCHEMICAL IMPEDANCE ANALYSIS OF POLYANILINE FILMS ON ELECTRODES.** The ac response of polyaniline films on Pt electrodes in 2.0M HCl was measured at different applied dc potentials, varied in the positive and negative directions. Experimental complex capacitance plots were reproduced using a computer simulation program based upon the equivalent circuit approach. With 150 nm films the complex capacitance plots at +0.55V (vs. SCE) comprise a single capacitive element, which develops at more negative potentials into a parallel combination of two discrete elements  $C_1$  (a capacitor) and  $Z_D$  (a finite transmission line) in series with a polymer resistance  $R_p$ .  $C_1$  and  $Z_D$  are interpreted as double-layer and faradaic (diffusion-controlled) components. (Edited author abstract) 21 refs.

Rubinstein, Israel (Weizmann Inst of Science, Rehovot, Isr); Sabatani, Eyal; Rishpon, Judith. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3078-3083.

**079893 INVESTIGATION OF OPEN CIRCUIT REACTIONS OF POLYMER FILMS USING THE QUARTZ CRYSTAL MICROBALANCE. REACTIONS OF POLYVINYLFERROCENE FILMS.** Bimolecular reactions between polyvinylferrocene (PV-Fc) films at open circuit and solution species that are accompanied by mass changes in the polymer have been investigated with a quartz crystal microbalance (QCM). PV-Fc oxidation by  $I_2/I_3^-$  and PV-Fc<sup>+</sup> reduction by Fe<sup>II</sup>(CN)<sub>6</sub><sup>4-</sup> and Ru(NH<sub>3</sub>)<sub>6</sub><sup>2+</sup> can be monitored with the QCM by following the formation of PV-FcI<sub>3</sub> in the former reaction and the expulsion of counteranions from the polymer film in the latter two processes. Rate constants can be estimated and reaction mechanisms postulated based on the temporal response of the frequency shift that occurs upon switching the films to open circuit from a potential which electrochemically maintains the active redox state of the polymer. (Edited author abstract) 35 refs.

Ward, Michael D. (DuPont, Wilmington, DE, USA). *J Phys Chem* v 92 n 7 Apr 1988 p 2049-2054.



**079894 ELECTROACTIVITY OF TRANSPARENT COMPOSITE FILMS FROM CONDUCTING POLY(THIOPHENES).** Conducting composite films containing an electropolymerizable conducting polymer such as poly(3-methylthiophene) (PMeT) alloyed with poly(vinyl chloride) (PVC) have been prepared in a one-step process from synthesis media already containing dissolved PVC. This procedure based on the simultaneous electropolymerization and dip-coating processes allows a large control of the composition, morphology, optical transmittance, conductivity, and electroactivity of the composite films. The growth of PMeT in synthesis media containing dissolved PVC has been analyzed. Increasing the PVC concentration produces a slight decrease of the MeT electropolymerization rate with no apparent modification of the polymerization mechanism. The electrochemical properties of the composite films have been investigated in acetonitrile by using cyclic voltammetry and chronoamperometry. (Edited author abstract) 22 refs.

Roncali, J. (CNRS, Thiais, Fr); Garnier, F. *J Phys Chem* v 92 n 3 Feb 11 1988 p 833-840.

**079895 PERMEABILITY OF RF-PLASMA TREATED NAFION FILMS ON GLASSY CARBON ELECTRODES.** The authors describe the control of the permeability of Nafion films to various metal complexes by changing the pore size of the films by RF-plasma treatment. In the cases of  $\text{Fe}(\text{H}_2\text{O})_6^{2+}$  and dihydroxymethylferrocene, plasma-treatment for less than 40 sec had no significant effect on the peak current and the shape. Permeation of these compounds into the treated films still occurred with no significant change in the interaction between the polymer and the permeating compounds by plasma-treatment. 8 refs.

Shimazu, Katsuaki (Univ of Kansas, Lawrence, KS, USA); Kuwana, Theodore. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1603-1604.

**079896 FOOD-GRADE FILMS TAKE ON PRODUCT-SPECIFIC BENEFITS.** Changing eating habits and microwave cooking - key reasons for plastics' explosive growth in rigid and semi-rigid food containers - are now driving innovations in film development that have the potential to substantially broaden flexible packaging applications. Leading these innovations are new and reformulated resins (for monolayer, coextrusion, and laminate structures) that have greater properties and more product-specific benefits than previous film grades. Three techniques are at the forefront of upgrading film properties: the tailoring of permeation rates; broader polymer use; and proprietary chemistries.

Toensmeier, Patrick A. *Mod Plast* v 65 n 8 Aug 1988 p 66-68,70.

**079897 STUDIUM VLASTNOSTI FOLII ZE SMESI PE-LD A PE-LLD. [Properties of Films Made from LDPE/LLD-PE Blend].** The article presents results of an investigation showing that an addition of LLD-PE to LDPE, up to a certain level, does not virtually affect extrusion and blowing of films. The films manufactured from the blend of two polyethylene types possess higher tear resistance. It has also been found that thickness of packaging and agricultural films can be reduced without impairing their service properties. AX. 5 Refs. In Czech.

Klecianova, Teresa (Inst Przemyslu Tworzyw i Farb, Gliwice, Pol); Szewczyk, Pawel. *Plasty Kauc* v 25 n 5 May 1988 p 139-143.

**079898 FURTHER CONSIDERATIONS OF THE MECHANISM OF GAS DIFFUSION IN GLASSY POLYMER FILMS.** In glassy polymers, the penetrant molecules are retained in two distinct ways, namely via Henry's Law dissolution in the polymer matrix and Langmuir-type adsorption in unrelaxed microvoids (dual-mode sorption model). In terms of R.M. Barrer's suggestion that the two kinds of retained penetrants should undergo diffusive movements within the two respective modes and execute jumps between the two modes the mean permeability coefficients driven by gradients of concentration and chemical potential are

derived. From a comparison of permeability data with one of the author's equations, plausible values of diffusivities  $D_{DD}$ ,  $D_{DH}$ , and  $(D_{HD} + D_{HH})$  can be determined, but the values of both  $D_{HD}$  and  $D_{HH}$  cannot be evaluated separately. By use of Onsager's reciprocity relation, however, the value of  $D_{HD}$  can be calculated with an estimated value of  $D_{DH}$ . Consequently, the value of  $D_{HH}$  can be also calculated, and the values of all of four kinds of diffusivities can be determined. 6 Refs.

Sada, E. (Kyoto Univ, Kyoto, Jpn); Kumazawa, H.; Xu, P. *J Membr Sci* v 39 n 1 Oct 1988 p 89-92.

**Additives** See POLYMERS—Photosensitivity.

**Adhesion** See Also POLYIMIDES—Film.

**079899 STUDY OF THE ADHESION OF VACUUM EVAPORATED POLYETHYLENE FILMS TO ALUMINIUM.** The dependence of the adhesion of flash-evaporated polyethylene films to aluminium substrates on various preparation and post-preparation conditions has been investigated. The influence of the metal surface, the source and substrate temperatures during evaporation, the thickness of the layers, and the effect of UV light illumination on the adhesion of the films is discussed. (Author abstract) 11 refs.

Bekiarov, D. (Inst of Solid State Physics, Sofia, Bulg); Pashmakov, B.; Vateva, E.; Alexieva, C. *Thin Solid Films* v 157 n 1 Feb 15 1988 p 43-48.

**Aging** See CELLULOSE DERIVATIVES—Degradation; POLYETHYLENES—Film; POLYETHYLENES—Low Density.

**Analysis** See COPOLYMERS—Analysis; NYLON POLYMERS—Film; POLYSTYRENES—Film.

**Applications** See PETROLEUM PROSPECTING—Core Analysis; TRANSISTORS—Materials; WAVEGUIDES, OPTICAL—Fabrication.

**Biocompatibility** See BLOCK COPOLYMERS—Synthesis.

**Blow Molding** See Also POLYETHYLENES—Blending.

**079900 BARRIER SCREW HIKES QUALITY OF HMW-HDPE BLOWN FILM.** An efficient extruder complex for processing HMW-HDPE blown film requires better screw performance than the conventional European design can offer. Quantitative data on crucial processing parameters are now available for alternative barrier screw designs so that processors can evaluate screw performance on their machinery. (Author abstract)

Steward, Edward L. (Crompton & Knowles Corp, Pawcatuck, CT, USA); Cline, Anthony W. *Plast Eng* v 43 n 9 Sep 1987 p 45-49.

**079901 COUNTERCURRENT COOLING OF BLOWN FILM.** Presently used methods for the external cooling of blown film involve the use of an air ring located at the base of the bubble that blows air upward along the surface of the bubble. The air is heated as it rises, while the film is cooling and moving in the same direction. This is an example of occurrent heat exchange, and the result is the accumulation of heated air around the upper portion of the bubble, which interferes with the cooling in this region. While rapid initial cooling is required to maintain bubble stability, we have explored the possibility of using countercurrent cooling for the upper region of the bubble. A standard air ring is mounted at the base of the bubble, and a circular shroud surrounds the bubble above this air ring. All the heated air is collected in an upper chamber surrounding the shroud and is exhausted by means of a secondary blower. (Edited author abstract) 11 refs.

Strater, K.F. (McGill Univ, Montreal, Que, Can); Dealy, J.M. *Polym Eng Sci* v 27 n 18 Mid-Oct 1987 p 1380-1385.

**Bonding** See POLYETHYLENE TEREPHTHALATE—Adhesion.

**Casting**

**079902 DRAW RESONANCE IN FILM CASTING OF VISCOELASTIC FLUIDS: A LINEAR STABILITY ANALYSIS.** In order to understand the role of viscoelasticity on draw resonance in the isothermal film casting process, a steady state analysis and a linear stability analysis for three-dimensional flow disturbances have been conducted. The constitutive equation used is a modified convected Maxwell model, with shear-rate dependent viscosity and fluid characteristic time. The numerical results indicate that the flow is stable below a lower critical draw ratio and above an upper critical draw ratio. Shear thinning in viscosity reduces the lower critical draw ratio and somewhat increases the upper critical draw ratio - thereby enlarging the region of instability. Slower shear reduction in fluid characteristic time dramatically decreases the upper critical draw ratio but has no significant effect on the lower critical draw ratio; therefore, fluids with higher characteristic time are more stable. (Author abstract) 17 Refs.

Anturkar, Nitin R. (Univ of Maine, Orono, ME, USA); Co, Albert. *J Non Newtonian Fluid Mech* v 28 n 3 Jul 1988 p 287-307.

**Chemical Vapor Deposition** See MONOMERS—Polymerization; POLYIMIDES—Thin Films.

**Coextrusion** See Also POLYETHYLENES—Linear Low Density.

**079903 COEX COMMODITY FILMS ARE ALIVE AND GROWING.** Coextruded grocery sacks and merchandise bags combine gloss and print appeal of LLDPE with downgaged toughness of straight HMW products. High-volume IBC stabilized line at Hilex Poly is claimed to make them at rates competitive with monolayer blown film equipment. HMW/LLDPE coextrusions have retained their competitive edge because they offer unique ways to meet customer requirements without increasing product costs. Ultra-Tech Plastics, Mansfield, OH, was among the first to start up a coex line for commodity films, and has no intention of rethinking its decision. Unlike HMW monolayer, HMW/LLDPE films can be heat-sealed on conventional multilane bagmaking machines. Thus, bigger and wider-layflat coex lines are a prime thrust of equipment development. Another new coex productivity concept is application of barrier screw technology to grooved feed HMW layer extrusion. Sano Design's triple-source IBC bubble cooling system is said to double line throughput and is recommended by the company as a key element in bigger coex lines.

Sneller, Joseph R. *Mod Plast* v 64 n 9 Sep 1987 p 54-55.

**Coloring** See VINYL RESINS—Thermodynamic Properties.

**Conductive**

**079904 THIN POLYMER FILMS FROM FLUIDIZED ELECTRODE BED REACTORS.** The formation and deposition of a polymer as a thin, uniform solid film on a metal particle substrate is investigated in detail in a fluidized electrode bed reactor. Experiments were carried out in different designs of fluidized bed electrode cell reactor, using various metal particles and monomers. It was observed that diacetone acrylamide (DAA) monomer in 0.1N  $\text{H}_2\text{SO}_4$  with aluminum particles (3530  $\mu\text{m}$ ) as cathode, in a concentric dual compartment cell, appeared to yield the best films. Infrared and elemental analyses were used to characterize the polymer film on the metal particles. Scanning electron microscopy (SEM) was employed to examine the surface and cross-sectional profiles of the films. (Edited author abstract) 19 refs.

Teng, F.S. (Washington State Univ, Pullman, WA, USA); Mahalingam, R. *J Appl Polym Sci* v 34 n 8 Dec 1987 p 2837-2852.



**079905 MODIFICATION OF  $\text{SnO}_2$  ELECTRODES BY POLYPYRROLE FILM.** The present letter describes how a polypyrrole film is electrochemically deposited on an optically-transparent  $\text{SnO}_2$  electrode from  $\text{H}_2\text{SO}_4$  solutions containing pyrrole to obtain a conductive polymer. The surface resistance can be controlled by the polymerization conditions. Polypyrrole film was formed on the  $\text{SnO}_2$  electrode by electrochemical oxidation of pyrrole in a three compartment thermostable cell. The application of such films in photoelectrodes and photoelectrochemical cells is underway. 7 refs.

Rodriguez, I. (Univ Autonoma de Madrid, Madrid, Spain); Gonzalez Velasco, J. *J Mater Sci Lett* v 6 n 11 Nov 1987 p 1319-1320.

## Corona

**079906 INTERNAL POLARIZATION IN POLYTETRAFLUOROETHYLENE FILMS SUBJECTED TO THE EFFECT OF A CORONA DISCHARGE.** The presence of internal polarization (heterocharge) in nonpolar polytetrafluoroethylene films electrified in a corona discharge was found experimentally. This resulted from an analysis of graphs of the electret potential as a function of the charge imparted to the films and current of thermally stimulated depolarization in experiments with a dielectric gap and change in the potential during heating. The extremely high stability of the electret potential in charged PTFE films is explained by slow relaxation of the heterocharge. (Edited author abstract) 8 refs.

Fedosov, S.N.; Sergeeva, A.E.; Motylinskaya, M.M. *Sov Surf Eng Appl Electrochem* n 5 1987 p 66-69.

**Crosslinking** See COPOLYMERS—Photochemical Reactions; POLYETHYLENES—Blending; POLYETHYLENES—Radiation Effects.

**Crystallization** See POLYETHYLENES—Ultrahigh Molecular Weight.

**Curing** See POLYESTERS—Microstructure.

**Deformation** See MEMBRANES—Permeability, Mechanical; POLYVINYL ALCOHOL—Elasticity.

**Degradation** See POLYMERS—Thermal Properties; POLYVINYL ALCOHOL—Film.

**Diffusion** See POLYMERS—Mixing.

**Discoloration** See POLYMERS—Photochromism; POLYVINYL CHLORIDE—Stabilizers.

**Dissolution** See Also PHOTORESISTS—Dissolution; POLYMERS—Dissolution.

**079907 FORMATION OF AN ELECTRIC DOUBLE LAYER DURING THE DISSOLUTION OF A PHENOL-FORMALDEHYDE RESIN FILM.** A simplified mathematical model of the dissolution of a phenol-formaldehyde resin film in a solution of NaOH has been devised. In a first approximation to the solution of the problem it was assumed that the replacement of the hydrogen atom of one hydroxyl group by sodium is sufficient for the passage of a resin molecule into the solution. The model adopted provides a qualitatively current description of the experimentally obtained dependence of the rate of dissolution on the concentration of NaOH and on the concentration of an addition of a neutral salt. This work is pertinent to photoresists. (Edited author abstract) 5 refs.

Polman, L. (Acad of Sciences of the USSR, Moscow, USSR); Starov, V.M.; Churaev, N.V. *Colloid J USSR* v 49 n 2 Mar-Apr 1987 p 253-261.

**079908 MEASURING AND MODELLING THE TRANSITION LAYER DURING THE DISSOLUTION OF GLASSY POLYMER FILMS.** The technique of laser interferometry is now used routinely by the microelectronics industry for the measurement of the dissolution rates of thin polymer films. In addition to the rate of dissolution laser interferometry can also provide

quantitative information on the thickness of the transition layer between the dissolving glassy polymer and the liquid solvent. This paper describes how observed patterns of reflected light intensity may be analyzed to calculate the thickness of the transition layer for polymers that dissolve with little or no swelling. The technique requires knowledge of the shape of the concentration profile in the transition layer. However, by assuming various simple model profiles one may obtain a reasonable estimate. Experimental measurements of poly(methyl methacrylate) (PMMA) films dissolving in methylethyl ketone indicate transition layers of thicknesses 0 to 0.1  $\mu\text{m}$  for PMMA of molecular weights  $M_w = 37,000$  to 1,400,000. (Author abstract) 16 refs.

Krasicky, P.D. (Cornell Univ, Ithaca, NY, USA); Groele, R.J.; Rodriguez, F. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 641-651.

**Doping** See Also POLYACETYLENES—Diffusion; POLYIMIDES—Electric Properties.

**079909 POLYPYRROLE AND POLY(N-METHYLPYRROLE) FILMS DOPED WITH KEGGIN-TYPE HETEROPOLYANIONS: PREPARATION AND PROPERTIES.** Solutions of pyrrole in acetonitrile in the presence of Keggin-type heteropolyacids (HPA) such as  $(\text{SiW}_{12}\text{O}_{40})^{4-}$  and  $(\text{PW}_{12}\text{O}_{40})^{3-}$  yield soluble complexes. Oxidation of the complexes gives polypyrrole films doped by the HPA. The electrochemical behavior of the HPA immobilized in several film thicknesses is described. It is different for HPA alone in solution because of the lack of conductivity of the polypyrrole and poly(N-methylpyrrole) in the potential range of reduction and in the range of molecular dispersion of HPA in the polymer matrix. The levels of doping of the polymers by HPA are similar to those with classical anions, but here the HPA are retained in the films rather better even upon cycling. (Author abstract) 31 Refs.

Bidan, G. (CEN, Grenoble, Fr); Genies, E.M.; Lapkowski, M. *J Electroanal Chem Interfacial Electrochem* v 251 n 2 Sep 23 1988 p 297-306.

**Drawing** See Also POLYPROPYLENE—Aging.

**079910 ON THE RHEOLOGY OF COLD DRAWING. I. ELASTIC MATERIALS.** In this, the first paper in a series on neck formation and steady-state drawing of polymeric fibers and films under uniaxial tension, the emphasis is laid on those aspects of the mechanics of cold drawing that are not sensitive to viscoelastic effects and, therefore, can be treated by use of constitutive assumptions appropriate to elastic materials. It is here shown that a unidimensional theory which has been employed to model the mechanics of slender bars in tension can be derived as an approximation for three-dimensional bars and, in a sense which can be made precise, is valid to within an error of the order of the fourth power of the thickness. A particular constitutive equation for incompressible, three-dimensional, elastic materials is explored in detail and is found to yield, for such slender bars as thin fibers and wide (but thin) strips of film. (Edited author abstract) 12 Refs.

Coleman, Bernard D. (Carnegie Mellon Univ, Pittsburgh, PA, USA); Newman, Daniel C. *J Polym Sci Part B* v 26 n 9 Aug 20 1988 p 1801-1822.

**Drawing and Stamping** See Also POLYETHYLENES—Ultrahigh Molecular Weight.

**079911 ULTRADRAWING OF 'SPRINGY' POLYPROPYLENE FILMS.** It is demonstrated that in the process of ultradrawing of semicrystalline polypropylene the morphology of the initial material plays major role. Extremely high draw ratios are obtained ( $\lambda_{\text{max}} \approx 50$ ) when drawing 'hard elastic' polypropylene films perpendicular to their initial molecular orientation. This behavior is explained by the molecular processes of plastic deformation. (Author abstract) 24 refs.

Petermann, J. (Technical Univ Hamburg-Harburg, Hamburg, West Ger); Karbach, A.; Feit, K. *Polym Bull (Berlin)* v 18 n 4 Oct 1987 p 355-360.

## Electric Breakdown

**079912 BREAKDOWN OF POLYETHYLENE FILM-LIQUID NITROGEN COMPOSITE SYSTEMS.** The breakdown characteristics reported depend on the number of film layers in the sample, the electric field distribution inside the film, and the front time and polarity of the applied impulse voltage. Three effects are discussed: (1) the effect of field distribution by which a strong field at the film surface triggers a breakdown streamer and the streamer development is supported by the field inside the film; (2) the effect of front time by which the breakdown voltage is considered to be governed by the breakdown time lag and the injected charge density which increases with the front time of the applied impulse voltage; and (3) the effect of number of layers, i.e., the sample with the larger number of layers has a higher resistance to impulse voltage. 17 refs.

Mizuno, Y. (Nagoya Univ, Nagoya, Jpn); Shimizu, N.; Horii, K. *IEEE Trans Electr Insul* v EI-22 n 6 p 721-727.

**Electric Conductivity** See Also POLYACETYLENES—Electric Conductivity; POLYMERS—Conductivity; POLYMERS—Electric Conductivity; TRANSISTORS, FIELD EFFECT—Fabrication.

**079913 PREPARATION AND ELECTROCATALYTIC PROPERTIES OF CONDUCTING FILMS OF POLYPYRROLE CONTAINING PLATINUM MICROPARTICULATES.** Metallic particles were dispersed in electrically conducting polymer films in order to achieve multi-electron transfer processes in a three-dimensional matrix. Dispersions of Pt in polypyrrole were formed by several electrochemical and chemical methods, and the concentration profiles were determined by Auger Electron Spectroscopy (AES). Films were prepared in which Pt was deposited primarily at the polymer/solution interface, at the metal/polymer interface, or uniformly through the film. The electrocatalytic reduction of oxygen was investigated by rotating disk electrode studies with these films. For the homogeneous film, the catalytic current is limited by the rate of  $\text{O}_2$  permeation in the film. (Author abstract) 22 refs.

Holdcroft, Steven (Simon Fraser Univ, Burnaby, BC, Can); Funt, B. Lionel. *J Electroanal Chem Interfacial Electrochem* v 240 n 1-2 Jan 25 1988 p 89-103.

**079914 ELECTRICAL CONDUCTIVITIES OF FILMS OF POLYMER COMPLEXES BETWEEN ELECTRON-DONATING POLYMERS AND ALUMINIUM COPPER(I) CHLORIDE.** Homogeneous films of polymer complexes between aluminium copper(I) chloride and poly(p-methylstyrene), poly(p-bromostyrene), poly(p-chlorostyrene), poly(p-methoxystyrene), or poly(m-methylstyrene) were prepared. A linear relationship was observed between logarithm of direct current conductivity of the film and the corresponding Hammett substituent constants for the films of poly(p-methylstyrene), poly(p-bromostyrene), poly(p-chlorostyrene), poly(m-methylstyrene), and unsubstituted polystyrene. It has been shown that the electrical conductivities of the films of the polymer complexes are associated with the charge-transfer interactions between the electron-donating polymer and aluminium copper(I) chloride. (Edited author abstract) 4 refs. In Japanese.

Komiyama, Makoto (Univ of Tsukuba, Tsukuba, Jpn); Tanishima, Satoshi; Hirai, Hidefumi. *Kobunshi Ronbunshu* v 45 n 3 Mar 1988 p 291-293.

**079915 IN SITU CONDUCTIVITY AND PHOTOCONDUCTIVITY MEASUREMENTS OF POLYANILINE FILMS.** In situ conductivity measurements on a polyaniline film with a fourprobe electrode are performed in  $\text{NH}_4\text{F}$ , 2.3HF and in propylene carbonate in the dark and under illumination. The conductivity is also determined on a pellet of chemically prepared polyaniline mixed with carbon black as for a battery electrode. The upper values of conductivities are  $120 \text{ ohm}^{-1} \text{ cm}^{-1}$  in the hydrofluoric medium,  $25 \text{ ohm}^{-1} \text{ cm}^{-1}$  in propylene



carbonate and  $8 \text{ ohm}^{-1} \text{ cm}^{-1}$ . The increase in conductivity of the polyaniline film in the solid state upon illumination is about  $0.7 \text{ ohm}^{-1} \text{ cm}^{-1}$  (10 percent). (Author abstract). 21 Refs.

Genies, E.M. (CEN, Grenoble, Fr); Hany, P.; Lapkowski, M.; Santier, C.H.; Olmedo, L. *Synth Met* v 25 n 1 Jul 1988 p 29-37.

**079916 STRUCTURE, STRENGTH AND ELECTRICAL PERFORMANCE OF CONDUCTING POLYPYRROLES.** Polypyrrole films, typically 0.2 mm thick, were prepared by electrodeposition with p-toluene sulphate as dopant anions. Conductivities of up to  $340 \text{ S cm}^{-1}$  were found, comparing favourably with other cited examples. Conductivity along each sample was found to be much greater than across: such asymmetry may be exploitable. Electrodeposition temperatures ( $0^\circ\text{C}$ ) lead to higher conductivities than at  $25^\circ\text{C}$ . The structure was amorphous as indicated by X-ray diffraction, and the morphology was found to be nodular by using optical and scanning electron microscopy. Films were found to be quite strong and tough, although some reduction in mechanical performance was found after ageing in air. Fracture surfaces of tensile test pieces suggest a layered structure, with little evidence for viscous deformation being evident. (Author abstract). 21 Refs.

Cvetko, B.F. (Univ of New South Wales, Kensington, Aust); Brungs, M.P.; Burford, R.P.; Skyllas-Kazsacos, M. *J Mater Sci* v 23 n 6 Jun 1988 p 2102-2106.

**079917 POLYANILINE FILMS. ELECTROCHEMICAL REDOX MECHANISMS.** The different redox mechanisms proposed in the literature concerning the electron and proton transfers that occur in polyaniline (PANI) films are presented and discussed. The electrochemical behavior of PANI usually shows two pairs of current peaks on cyclic voltammeter curves in aqueous or organic medium. In situ spectroelectrochemical and EPR studies of PANI synthesized in  $\text{NH}_4\text{F}$ , 5.3HF were carried out in association with cyclic voltammetry. The results are discussed in terms of the redox reaction mechanisms. The authors propose that the complete redox mechanism involves four one-electron steps and two polaron-bipolaron states in PANI films. (Author abstract) 34 refs.

Genies, E.M. (Cent d'Etudes Nucleaire, Grenoble, Fr); Lapkowski, M. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 61-68.

**Electric Properties** See Also NYLON POLYMERS—Film; SOLVENTS—Measurements.

**079918 SPECIFIC KINETIC FEATURES OF THE REVERSIBLE REDOX REACTION OF CONDUCTING POLYPYRROLE FILMS IN AQUEOUS MEDIA.** In this work cyclic voltammetry and a radiotracer technique are used to investigate the kinetics of the reversible redox reaction of PP films in aqueous media. The PP films were obtained galvanostatically by anodic polarization of Pt electrodes in a divided cell using aqueous 0.1 M pyrrole solutions with 0.1 N  $\text{H}_2\text{SO}_4$  or  $\text{HClO}_4$  as the base electrolyte. It was found as a result of the work that the rate of PP oxidation and reduction is limited chiefly by anion diffusion in the film, that the diffusion rate depends on acidity of the electrolyte solution, and that the cycle of oxidation and reduction can be continued for several hours over practically the full depth of the PP films up to a thickness of  $40 \mu\text{m}$ , which is rather more than the thickness of the films studied in aprotic media. 4 refs.

Kras'ko, V.V. (L. Ya. Karpov Physicochemical Scientific-Research Inst, Moscow, USSR); Yakovleva, A.A.; Kolotyrlin, Ya.M. *Sov Electrochem* v 22 n 9 Sep 1986 p 1137-1140.

**079919 ANISOTROPIC ELECTRICAL AND OPTICAL PROPERTIES OF ELONGATED POLY(P-PHENYLENE VINYLENE) FILM.** Anisotropic photoconductivity of an oriented form of poly(p-pheny-

lene vinylene) has been studied. The photocurrent spectrum for the light polarized parallel to the chain direction is much enhanced in lower photon energy as compared with that for the light polarized perpendicular to that direction. The result may be originated in the difference of energies which is needed to photogenerate carriers with the light polarized parallel and perpendicular to the chain direction, respectively. There is anisotropy of the conductivity in the stretched PPV film heat-treated at  $1000^\circ\text{C}$ . This anisotropy can be explained by the difference of carrier mobilities parallel and perpendicular to the stretched direction. (Author abstract) 5 refs.

Tagiguchi, Tohru (Osaka Univ, Jpn); Park, Dae Hee; Sugimoto, Ryu-ichi; Ueno, Hideki; Yoshino, Katsumi. *Technol Rep Osaka Univ* v 37 n 1865-1888 Mar 1987 p 111-116.

**079920 ELECTRICAL PROPERTIES OF POLY(2,5-DIBUTOXY PHENYLENE) FILM.** Solid state properties, especially properties, of poly(2,5-dibutoxy phenylene) (PDBP), one of the derivatives of poly(p-phenylene) (PPP), have been studied. Tough and flexible PDBP films obtained by casting from a toluene solution were used. From the studies of dielectric relaxation and dynamic viscoelasticity, two types of molecular motion, twist motion of main chains and local motions of butoxy groups, were found. The processibility of PDBP was attributed to the presence of these molecular motions. It was concluded that the introduction of a butoxy group into phenylene rings has little effect on the electronic structure of PPP. (Edited author abstract) 15 refs. In Japanese.

Yamada, Shingetsu (Kyushu Univ, Fukuoka, Jpn); Tokito, Shizuo; Tsutsui, Tetsuo; Saito, Shogo. *Kobunshi Ronbunshu* v 44 n 5 1987 p 399-403.

**079921 ELECTRICAL CONDUCTION OF  $\text{Cu}_x\text{S}$ -TREATED FILMS.** Electrical conductivity measurements have been made on  $\text{Cu}_x\text{S}$ -treated PET and nylon 6 films in the temperature region between 20 and  $200^\circ\text{C}$ .  $\text{Cu}_x\text{S}$ -treated films have been observed to have two transition temperatures at about 100 and  $180^\circ\text{C}$ , respectively. It should be reasonable to consider that the conductivity behavior between 100 and  $180^\circ\text{C}$  is attributed to the character of a metastable structure of the cuprous sulfide. Temperature dependence of conductivity of the  $\text{Cu}_x\text{S}$ -treated PET and nylon 6 films was investigated and compared with that of original PET and nylon 6 films. The current-voltage characteristics and time dependence of conductivity of samples were investigated. Conduction mechanism of the  $\text{Cu}_x\text{S}$ -treated films was not dependent on matrix polymers but dependent on  $\text{Cu}_x\text{S}$  crystal, and the conduction is mainly electronic. (Author abstract) 12 refs.

Im, Sung Soon (Hanyang Univ, Seoul, South Korea); Kang, Eun Young. *J Appl Polym Sci* v 35 n 2 Feb 5 1988 p 475-483.

**079922 ELECTRIC PROPERTIES OF INERT POLYMER FILMS DOPED WITH ELECTROLYTES.** Polyvinyl chloride films, doped with Aliquat chloride or Aliquat ferro/ferricyanide, were studied by the ac impedance and dc polarization methods. Effects of composition variation and temperature on conductivities and capacitances were measured. It is probable for M/F/M cells, where M=metal and F=membrane film, that interfacial charge transfer is electrochemical (e.g., redox) at the interfaces for high applied voltages, regardless of the single Aliquat salt used, and charge conduction in the bulk is ionic. There is no evidence for electronic conductivity even for mixtures of ferricyanide/ferricyanide. Redox reactions of trace oxygen, water or other impurities are involved at the interfaces when there is no principal reaction possible, such as oxidation of metal or ferrocyanide, or reduction of ferricyanide. (Edited author abstract) 21 refs.

Zhao, Junguo (Univ of North Carolina, Chapel Hill, NC, USA); Buck, R.P. *J Electrochem Soc* v 135 n 3 Mar 1988 p 609-615.

**079923 CHANGE OF ELECTRICAL PROPERTIES OF PLASMA-POLYMERIZED FILMS FORMED FROM HEXAMETHYLDISILOXANE WITH TREATMENT BY ELECTRICAL DISCHARGES.** By means of a parallel-plate electrodes system, plasma-polymerized films (PPHF) formed from hexamethyl-disiloxane were treated by electric discharges in the air. The samples were examined with regard to changes in infrared absorption spectra, ESCA spectra, contact angle, surface resistivity, capacitance, and loss tangent. The results of infrared absorption spectra and ESCA spectra of treated PPHF showed that hydroxyl and carbonyl groups and nitrogen compounds were introduced, and that the atomic ratio of carbon to silicon decreased, while that of nitrogen and oxygen increased with treatment time. The contact angle of the untreated PPHF for water was  $103^\circ$ ; however, the water drop spread out after treatment. (Edited author abstract) 14 refs. In Japanese.

Kusabiraki, Minoru (Osaka City Univ, Osaka, Jpn); Ando, Keichi. *Kobunshi Ronbunshu* v 45 n 4 1988 p 309-315.

**079924 FREE-STANDING, CONDUCTING FILMS OF PYRROLE/ N-(4-FERROCENYLBUTYL)-PYRROLE BENZENESULPHONATE COPOLYMERS.** The electrochemical preparation, in a flow-through cell, of self-supporting films of a pyrrole/N-( $\omega$ -ferrocenylbutyl)-pyrrole copolymer with benzenesulphonate as a dopant anion is described. For comparison, polypyrrole benzenesulphonate was made under the same conditions. The polymer films were characterized by complete elemental analysis, i.r. spectroscopy, conductivity at various film potentials, scanning electron microscopy and dynamic elastic modulus measurements and their temperature dependence. Copolymerization is shown to be a viable method for producing redox-modified polypyrrole films when moderate conductivity and limited mechanical strength are acceptable. (Author abstract). 34 Refs.

Merz, A. (Univ Regensburg, Regensburg, West Ger); Haimel, A.; Owen, A.J. *Synth Met* v 25 n 1 Jul 1988 p 89-102.

**079925 ELECTROCHEMISTRY OF POLYPYRROLE FILMS.** Electrochemically prepared films of polypyrrole have been studied as electrode coatings in an electrochemical cell with potassium ferricyanide as the electroactive species in solution. The electrode-solution interface was studied by ac impedance measurements over the frequency range  $0.003\text{--}10^5 \text{ Hz}$ . A novel model circuit description of the electrode-electrolyte interface was devised, which consisted of seven elements (including a frequency-dependent Warburg impedance) for the bare platinum electrode and ten elements (including an additional Warburg impedance concerned with film oxidation and reduction) for the polypyrrole-coated electrodes. The values of the circuit elements were calculated by computer fitting and excellent agreement was found between measured impedances and those predicted from the calculated circuit element values. (Edited author abstract) 17 refs.

van der Sluijs, Marijke J. (Univ Coll of North Wales, Bangor, Wales); Underhill, Allan E.; Zaba, Bogumil N. *J Phys D* v 20 n 11 Nov 14 1987, Pap Presented at the Polym Phys Group Meet on Electroact Polym, London, Engl, May 14 1987 p 1411-1416.

**Electrochemistry** See Also ION EXCHANGE RESINS; POLYIMIDES—Electrochemistry.

**079926 ELECTROCHEMISTRY OF POLYTHIOPHENE AND POLYBITHIOPHENE FILMS IN AMBIENT TEMPERATURE MOLTEN SALTS.** Polythiophene and polybithiophene polymer films were deposited on platinum, tungsten, and glassy carbon electrodes by anodic oxidation of the monomer in ambient temperature molten salts, consisting of a mixture of aluminum chloride and 1-methyl-3-ethyl-imidazolium chloride. The formation reaction of polythiophene and polybithiophene is totally irreversible. The polymer films are conductive in the oxidized state and nonconductive when reduced as indicated by the shape of cyclic voltammetric curves for the polymers and for ferrocene oxidation on electrodes



covered by different thicknesses of polymer. Results of ferrocene oxidation on electrodes coated by polythiophene suggest that these polymer films are porous. (Edited author abstract) 46 refs.

Janiszewska, Laura (State Univ of New York at Buffalo, Buffalo, NY, USA); Osteryoung, Robert A. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2787-2793.

**079927 INFLUENCE OF LIGHT ON THE ELECTROCHEMICAL BEHAVIOUR OF POLYANILINE FILMS.** The electrochemical behavior of polyaniline (PANI) films under irradiation was studied in  $\text{NH}_4\text{F}$ , 2.3 HF solution and in acetonitrile, 0.5 M  $\text{LiClO}_4$ . It is found that the polymer displays a very fast photoresponse to a near-infrared light pulse (50  $\mu\text{s}$ ), which we associated with rapid modifications in its electric properties. On a longer time scale, photoelectrochemical effects were observed, with injection of electrons or holes in the solution. With chloral in  $\text{NH}_3/\text{HF}$  solution, an efficient photoreduction of the aldehyde was obtained. PANI can thus be considered as a p-type semiconductor useful for photoelectrochemical conversion of light to electricity or for photoassisted electrosynthesis. (Author abstract) 18 refs.

Genies, E.M. (Cent d'Etudes Nucleaires, Grenoble, Fr); Lapkowski, M. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 69-76.

**Extrusion** See Also GAGES—Thickness Measurement; POLYETHYLENES—Blending; POLYETHYLENES—Linear Low Density.

**079928 NOW DOWNSTREAM CALLS THE SHOTS IN BLOWN FILM PRODUCTIVITY.** Improvements in melt conditioning brought about by the first generation of blown film lines, and lifting of bubble cooling-related rate limitations by the second generation, have set the stage for better ways to handle and wind the now-faster-moving film bubble in order to reach productivity and quality goals that until very recently were considered unattainable. For virtually every type of resin, from forging low and medium density polyethylenes to progressively harder-to-handle high molecular weight PE and engineering resins like polycarbonates and nylons, there are innovative new ways to handle the melt after it leaves the extruder. What these new methods hold in the cards for the processor are blown film lines that can handle more than 2000 lb. of resin per hour at throughput rates of 700 ft./min and more - with film quality superior to that currently found on the most advanced cast film line.

Sneller, Joseph A. *Mod Plast* v 65 n 1 Jan 1988 p 52-54, 56, 58.

**079929 EXTRUSION TARGET: HIGHER QUALITY, MATERIAL SAVINGS.** Tightening the screws on product quality and 'stretching' materials utilization are the twin foci of much of the newest extrusion technology. Concrete steps being taken to achieve those goals in film, sheet, pipe and profile extrusion is the subject of this report. All major extrusion systems suppliers have been consulted for this. Much of what they revealed involves departures from prior convention. This report is necessarily selective, concentrating on those areas of extrusion identified by machinery suppliers and extrusion processors as the ones where the most new technology is being developed. Not surprisingly, those are also typically areas believed to show greatest potential market growth.

Kreisher, Keith (Plastics Technology, New York, NY, USA). *Plast Technol* v 34 n 2 Feb 1988 p 46-53.

**079930 WITH EFFICIENT DIE AND TOWER DESIGN YOU CAN CUT DOWNTIME IN FIVE-LAYER FILM EXTRUSION.** A new five-layer blown film line that was recently installed at the Applications Research Laboratories of the USI Div. of Quantum Chemical Corp. That line (one of six) has several features designed to minimize downtime for cleaning, facilitate startup, minimize floorspace requirement, and also to ensure production of high-quality film rolls. Because a

large number of multilayer blown film lines are being installed nowadays, many of them for five-layer packaging, it is hoped that a discussion of this production-scale lab line could provide a useful example for processors. This line is available for customer demonstrations, trial runs, and training.

Prall, George M. *Plast Technol* v 34 n 2 Feb 1988 p 55-57.

**079931 ORIENTATION, CRYSTALLIZATION, AND HAZE DEVELOPMENT IN TUBULAR FILM EXTRUSION.** A critical review of research on the development of crystallinity, orientation, and haze in tubular film is presented. We examine the basic methods of characterization of polymer films and interpretation of experimental techniques. Most studies in the literature relate to polyethylene, polystyrene, and polypropylene tubular film. Polymer chain and crystallographic axis orientation have been studied using x-ray diffraction and birefringence. We critically discuss the representation of such data using biaxial orientation factors. The data appear correlatable in terms of expressing orientation as a function of applied stresses at solidification. It appears that a film haze is predominantly caused by surface roughness. This is largely associated with the crystallization of the melt on the process line. (Author abstract) 145 refs.

White, James L. (Univ of Akron, Akron, OH, USA); Cakmak, Mukerrem. *Adv Polym Technol* v 8 n 1 1988 p 27-61.

**Fabrication** See POLYACETYLENES—Production.

**Fiber Reinforcement** See PLASTICS, REINFORCED—Mechanical Properties.

**Fluidity**

**079932 DISTRIBUTIA TEMPERATURII LA CURGEREA IN FILME SUBTIRI A LICHIDELOR NENEWTONIENIE CE RESPECTA MODELUL OSTWALD DE - WAELE IN CONDITILE UNUI FLUX TERMIC CONSTANT LA PERETE SI ALE UNEI VISCOZITATI MARI.** [Temperature Distribution in Thin Film Flow of Nonnewtonian Liquids Observing the Ostwald de Waele Model Under Constant Wall Heat and High Viscosity Conditions]. The dimensionless temperature distribution is determined for the thin film flow of pseudo-plastic liquids, under conditions of constant wall heat flux and high viscosity of the nonnewtonian fluid. The analysis of the theoretical temperature distribution in the film shows that the effect of the viscous dissipation may be ignored. The experimental data are satisfactorily approximated by the theoretical equations. (Author abstract). 15 Refs. In Romanian.

Tudose, Radu Z. (Inst Politehnic - Iasi, Rom); Mustata, Fanica. *Mater Plast Elastomeri Fibre Sint* v 25 n 1 Jan-Mar 1988 p 33-36.

**Forming** See Also OXYGEN—Reduction.

**079933 NUCLEAR MAGNETIC RESONANCE STUDY OF FILM FORMATION DURING HYDROLYTIC POLYCONDENSATION OF TETRAETHOXY-SILANE IN AN ACID AQUEOUS-ALCOHOLIC MEDIUM.** The objective of this investigation is to study the course of molecular processes during film formation in an aqueous-alcoholic medium in presence of an acid catalyst and a polymer dispersion. Preliminary investigations of the three-component system ethyl alcohol-water-TES showed that in a freshly prepared solution the PMR signals of ethoxy groups of the alcohol and TES are observed separately. Experimental data indicate that a polymer film is formed during the first stage, but it still contains a rather large amount of solvent. At the second stage evaporation and polycondensation processes slow down considerably because of the high viscosity of the films. After 30 h of drying at room temperature a fairly large amount of hydrogen-containing atomic groups remains in the films. 7 refs.

Kalaus, E.E.; Kenarov, A.V.; Efimov, V.N.; Yazov, A.N.;

Artamonova, O.M. *J Appl Chem USSR* v 60 n 3 pt 2 Mar 1987 p 632-633.

**079934 RADIATION-POLYMERIZATION OF HEPTYLMETHACRYLATE IN PRESENCE OF BUTADIENE-NITRILE RUBBER.** With increase in the initial concentration of SKN-18 in its composite with heptylmethacrylate auto-acceleration of the polymerization process shifts to the region of shorter  $\gamma$ -radiation times and for a content of 60 wt percent of the rubber polymerization of the monomer proceeds instantly in conditions close to those of the gel effect. The mixed character of termination of the polymer chains is observed and at the final stage of post-polymerization at 295 K linear termination predominates. The rate constant of growth of the polymer chains in the interval 170-180 K has been determined:  $k_p = 2 \times 10^{-13} \exp(-6000/RT)$   $\text{cm}^3\text{sec}$ . Introduction of small additions of the monomethacrylic ester of ethylene glycol (crosslinking agent) raises the rate of the process. (Author abstract).

Kiryukhin, D.P. (USSR Acad of Sciences, USSR); Bol'shaov, A.I.; Barkalov, I.M. *Polym Sci USSR* v 29 n 4 1987 p 778-784.

**079935 XP-SPECTRA, SPUTTEREXPERIMENTS AND UV-VIS-REFLECTION SPECTRA OF POLYANILINE.** Electrochemical formed polyaniline (PANI) films were studied both in situ and ex situ using XPS and UV/VIS spectroscopy. The samples studied ex situ were removed at given potentials and rinsed with water, with no changes in the oxidation state or concentration of counter ions. PANI-RED (0.0 V (SHE)) contained no anions and the XP-spectra showed an emeraldine-like structure and 0.27 protonated nitrogen atoms/monomer. PANI-OX (1.0 V (SHE)) contained 0.2 - 0.3 counter ions/monomer throughout the film. UV/VIS spectroscopy shows a two step redox mechanism involving radical cations. The extended conjugation of PANI-OX was followed by both reflection spectroscopy and XP-shake-up peaks accompanying the photoionisation process. At potentials above 1.0 V (SHE) overoxidation occurs with the removal of anions from the bulk film. (Author abstract). 16 Refs.

Kessel, R. (Univ Dusseldorf, Dusseldorf, West Ger); Hansen, G.; Schultze, J.W. *Ber Bunsenges Phys Chem* v 92 n 6 Jun 1988 p 710-717.

**Fracture** See POLYIMIDES—Film.

**Glass Transition** See POLYMERS—Solutions.

**Grafting** See Also GRAFT COPOLYMERS—Synthesis; MEMBRANES—Synthesis.

**079936 POST-RADIATION GRAFTING OF STYRENE TO POLYETHYLENE FILM AND DISTRIBUTION OF GRAFTED POLYSTYRENE.** Post-radiation grafting of styrene to PE film irradiated in air by  $^{60}\text{Co}$  source of  $\gamma$ -radiation and by an electron accelerator was studied. The effect of ferrous salt additives on the kinetics of this process is demonstrated. The distribution of grafted PS in PE was analyzed by IR absorption and ATR spectra in dependence on the intensity and dose of radiation. Diffusion of ferrous ions into the film was found to play a determining role in the kinetics of grafting polymerization and in distribution of PS in the film. (Author abstract) 13 refs.

Shevlyakova, N.V. (L. Ya. Karpov Physico-Chemical Research Inst, USSR); Dyakova, M.G.; Luzina, N.N.; Semenov, V.I.; Shifrina, R.R.; Tverskoi, V.A.; Pravednikov, A.N. *Polym Sci USSR* v 29 n 2 Feb 1987 p 348-353.

**Growing** See POLYMERS—Conductive.

**Ion Implantation**

**079937 EFFECTS OF ION IMPLANTATION ON POLY(DIMETHYLSILYLENE-CO-METHYLPHENYLSILYLENE).** The effects of ion implantation on the electrical and structural properties of poly(dimethylsilyl-



lene-co-methylphenylsilylene) (DMMPS) thin films have been investigated. Ionic species of krypton, arsenic, fluorine, chlorine, and sulfur were implanted at energies ranging from 35 to 200 keV and with doses of up to  $1 \times 10^{16}$  ion/cm<sup>2</sup>. The conductivity of the polymer increased upon implantation reaching a maximum value of  $9.6 \times 10^{-6}$  ( $\Omega$  cm)<sup>-1</sup> for the case of arsenic ion at a dose of  $1 \times 10^{16}$  ion/cm<sup>2</sup> and energy of 100 keV. The results showed that ion implantation induced conduction in DMMPS was primarily due to structural modifications of the material brought about by the energetic ions. Infrared analysis and Auger electron spectroscopy showed evidence for the formation of a silicon carbide-like structure upon implantation. (Author abstract) 13 refs.

Basheer, R.A. (GM, Warren, MI, USA); Hamdi, A.H.; Kwor, R.Y. *Nucl Instrum Methods Phys Res Sect B* v B30 n 4 Apr 1 1988 p 520-527.

**Ionic Conduction** See Also METALLORGANIC POLYMERS—Ionic Conduction; POLYMERS—Thin Films.

**079938 CONDUCTIVITY BEHAVIOUR OF GAMMA-IRRADIATED PEO-LIX ELECTROLYTES. I.** In an attempt to enhance the room temperature ionic conductivity of PEO-LiX films, samples have been exposed to gamma-irradiation at 78°C. The success with which cross-links have been introduced into the amorphous form has been evaluated from d.s.c. analysis and temperature-dependent conductivity data. Retardation of the recrystallization event, associated with uncomplexed poly(ethylene oxide), does not occur over a range of total doses. Changes in overall conductivity levels for the PEO-LiCF<sub>3</sub>SO<sub>3</sub> system indicate light cross-linking at 2.25 Mrad of exposure. (Edited author abstract) 8 refs.

Kronfil, Esam (Applied Physics & Electro Optics Group, RMCS, Swindon, Engl); Lovell, Keith V.; Hooper, Alan; Neat, Robin J. *Br Polym J* v 20 n 3 1988, First Int Symp on Polym Electrolytes, St. Andrews, Scotl, Jun 17-19 1987 p 275-280.

## Laser Applications

**079939 LASER MARKING OF MICROPOROUS FILMS.** The potential for microporous films as optical recording media is explored in this report. Irradiation of metallized films of microporous polypropylene and polyethylene with a HeNe laser produced marks having high contrast and which could be read without the aid of polarizing optics. The novel marking process involves melting, collapse of the microporous structure, and thinning of the film as the built-in strain relaxes. (Author abstract) 5 refs.

Kuder, James E. (Celanese Research Co, Summit, NJ, USA); Taskier, Henry T.; Hamer, E. Geoffrey. *J Appl Polym Sci* v 35 n 5 Apr 1988 p 1257-1263.

## Latex

**079940 FTIR-ATR SPECTROSCOPIC DETERMINATION OF THE DISTRIBUTION OF SURFACTANTS IN LATEX FILMS.** FTIR-ATR (Fourier Transform Infra-Red-Attenuated Total Reflection) has been used to analyze the surface composition of coalesced acrylic latex films. The behavior of two anionic surfactants has been characterized. It has been found that surfactant distribution depends on the nature of the surfactant. A comparison between the normalized absorbance in transmission and in reflection has shown an enrichment of surfactants at the surfaces of films with a coalescence time of 3 days. The surfactant concentration at the film-air interface is higher than at the film substrate interface. A concentration gradient exists through the film thickness. In addition, the incompatible surfactant migrates towards the interface as coalescence proceeds. (Author abstract) 26 refs.

Zhao, C.L. (Ecole d'Application des Hauts Polymers, Strasbourg, Fr); Holl, Y.; Pith, T.; Lamba, M. *Colloid Polym Sci* v 265 n 9 Sep 1987 p 823-829.

**Manufacture** See Also POLYPROPYLENE—Film; POLYSTYRENES—Thin Films.

**079941 NEW PRODUCTION TECHNOLOGIES AND APPLICATIONS OF POLY(VINYL ALCOHOL) FILM.** The following aspects of the manufacture, properties and applications of biaxially oriented poly(vinyl alcohol) (PV-OH) films are discussed: selection of starting PV-OH; method of production by successive biaxial orientation: technical aspects of production; characteristics and applications of the film. Biaxially oriented PV-OH films have good antistatic properties, good thermal resistance, oil and solvent resistance, and excellent gas barrier properties, and are used in food packaging applications. The manufacture properties and applications of poly(vinyl alcohol) film produced by a blown film technique are also discussed. (Edited author abstract). 5 Refs.

Moroi, Hiroyuki (Nippon Gohsei Film Co, Osaka, Jpn). *Br Polym J* v 20 n 4 1988 p 335-343.

## Mathematical Models

**079942 INTERACTION OF CRYSTALLINITY, ELASTOPLASTICITY, AND A TWO-PHASE MODEL ON BLOWN FILM BUBBLE SHAPE.** Historically, simulations of the blown film process have been carried out only to the freeze line; a point which is often well below the actual frost line for the process. This limitation in previous simulations was discovered to be related to the interaction of the process boundary conditions with the rheological equation of state used in previous analyses to represent the stretching of the polymer film. A new approach has been developed that allows the process to be simulated to the real frost line. This has been accomplished by using a two-phase model incorporating viscoplasticity and crystallization of the polymer melt into the physical description of the blown film process. Prediction of the bubble shape, temperature, and velocity from the die to the frost line agree fairly well with experimental data. (Edited author abstract) 19 refs.

Campbell, G.A. (Clarkson Univ, Potsdam, NY, USA); Cao, B. *J Plast Film Sheeting* v 3 n 3 Jul 1987 p 158-170.

## Measurements

**079943 APPARATUS FOR COMBINED ELECTROCHEMICAL, OPTICAL AND ESR STUDIES ON CONDUCTING POLYMERS UNDER CONTROLLED ATMOSPHERE.** A simple, inexpensive and portable apparatus has been designed for combined optical and ESR studies on electrochemically prepared conducting polymer films. It permits electrochemical studies to be performed as well as transferring samples to other types of measuring devices under controlled atmosphere. The apparatus presented here may easily be adapted to other applications. (Author abstract) 8 refs.

Schaerli, M. (RCA Lab Ltd, Zurich, Switz). *J Phys E* v 20 n 11 Nov 1987 p 1377-1379.

**079944 MEASUREMENT AND THE EFFECT OF DIFFERENT SOLVENTS ON THIN POLYMER FILM SURFACE RESISTANCE (I).** A method for measuring the thin polymer film surface resistance has been developed. The method uses a concentric cylindrical electrode arrangement for the measurements and has been studied analytically and experimentally. (Edited author abstract) 2 Refs.

Leonidopoulos, Georgios. *Modell Simul Control B* v 18 n 2 1988 p 29-37.

**Mechanical Properties** See Also AGRICULTURE—Plastic Applications; POLYETHYLENES—Crosslinking; POLYETHYLENES—Degradation; POLYIMIDES—Film; POLYIMIDES—Synthesis; POLYMERS—Mechanical Properties; POLYMERS—Synthesis; POLYPROPYLENE—Drawing and Stamping; POLYPROPYLENE—Thin Films; POLYURETHANES—Synthesis.

**079945 MECHANICAL PROPERTIES OF GRAFTED CASEIN FILMS.** Casein was grafted with mixtures of acrylonitrile (AN) and n-butyl methacrylate

(n-BMA). The mole ratios of AN:n-BMA were 0.9:0.1 and 0.8:0.2. The mechanical properties of the grafted casein films were studied under uniaxial and biaxial stress conditions. A reduction in longitudinal stress and elongation at break was observed with the simultaneous application of lateral stress. Scanning electron micrographs of the stretched films (uniaxial and biaxial stress) are also presented. (Author abstract) 10 refs.

Somanathan, N. (Central Leather Research Inst, Madras, India); Arumugam, V.; Sanjeevi, R.; Narasimhan, V. *J Appl Polym Sci* v 34 n 6 Nov 5 1987 p 2299-2311.

**079946 HIGH TENACITY AND HIGH MODULUS FILM FROM POLY(2,2'-DICHLORO-4,4'-BIPHENYLENEPYROMELLITIMIDE).** In-plane isotropic poly(2,2'-dichloro-4,4'-biphenylene-pyromellitimide) films were made by first adding acetic anhydride as a cyclodehydrating agent to the poly(amic acid) solution which was obtained by the reaction of 2,2'-dichlorobenzidine and pyromellitic dianhydride in N-methylpyrrolidone, and then casting the solution, and finally heating the films in bidirectionally restrained state. As polymer concentration of the fixed gel film was lowered, planar orientation and therefore initial modulus ( $M_i$ ) of the heat treated film increased. (Edited author abstract) 4 refs. In Japanese.

Jinda, Takuma (Toray Industries Inc, Otsu, Jpn); Matsuda, Toshikazu. *Kobunshi Ronbunshu* v 44 n 9 Sep 1987 p 669-673.

**079947 FLEXIBLE POLYANILINE.** Flexible polyaniline having excellent mechanical properties was prepared by electrochemical reduction of ordinary polyaniline in organic solvents. The flexibility is directly related to the polymer morphology which was definitely affected by the nature of electrolyte anion. Perchlorate or tetrafluoroborate anion were found suitable to obtain flexible polyaniline. At the same time, it is essential that the polymer so prepared should be reduced (undoped) in some suitable organic solvents before making a flexible free standing film. (Edited author abstract) 11 refs.

Kitani, Akira (Hiroshima Univ, Higashi-Hiroshima, Jpn); Kaya, Masanori; Tsujioka, Syo-Ichi; Sasaki, Kazuo. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1531-1539.

**079948 PHYSICAL AND DYNAMIC MECHANICAL PROPERTIES OF UNTRADRAWN POLYPROPYLENE FILMS.** Dynamic mechanical measurements were made on gel films of high molecular weight polypropylene prepared by gelation/crystallization from 1% (w/v) decalin solutions. The measurements were performed at different frequencies in the temperature range from -160°C to the melting point of the sample. The dry gel films were uniaxially drawn at 150°C to various draw ratios ( $\lambda$ ) between 6.5 and 48. The morphology and orientation of the samples were characterized by density, differential scanning calorimetry, infrared dichroism, wide-angle X-ray diffraction, small-angle light scattering, scanning electron microscopy, and dynamic storage modulus. WAXS studies showed that very high degrees of orientation were achieved at the higher draw ratios. (Edited author abstract) 23 refs.

Roy, S.K. (McGill Univ, Montreal, Que, Can); Kyu, T.; Manley, R. St. John. *Macromolecules* v 21 n 2 Feb 1988 p 499-504.

**079949 MECHANICAL RELAXATIONS OF ORIENTED GELATION-CRYSTALLIZED POLYETHYLENE FILMS.** The mechanical relaxations of oriented gelation-crystallized films of ultrahigh molecular weight polyethylene have been studied by dynamic mechanical measurements, in comparison with the behavior of undrawn melt-crystallized specimens. The absence of the  $\gamma$  relaxation in highly drawn gelation-crystallized samples indirectly suggests that the  $\gamma$  process may be related to the local motions of the chain segments located in the amorphous or crystal defective regions. The  $\alpha$  relaxation



in the gelation-crystallized samples is sharper as compared with that in the melt-crystallized sample. (Edited author abstract) 45 refs.

Roy, S.K. (McGill Univ, Montreal, Que, Can); Kyu, T.; Manley, R. St. John. *Macromolecules* v 21 n 6 Jun 1988 p 1741-1746.

**079950 NEW DIRECTIONS IN HIGH PERFORMANCE FILMS.** In the last few years, a growing number of high-performance resins have been made available in film form for a growing number of specialty applications. These applications generally require materials with high thermal and dimensional stability, broad chemical resistance, and an overall high balance of mechanical properties. Commercial high-performance films include hundreds of varieties of polyesters, scores of fluoropolymers, and a large number of polyimides. Polyurethanes, nylons, polycarbonates and alloys are also establishing wider acceptance. Polyetherimide, polyethersulfone, polyetheretherketone, and other exotic resins are also providing imaginative answers to engineering dilemmas. This article discusses valuable materials and applications.

English, Lawrence (Materials Engineering, Cleveland, OH, USA). *Mater Eng (Cleveland)* v 105 n 7 Jul 1988 p 43-47.

**079951 THERMAL AND DYNAMIC MECHANICAL PROPERTIES OF HYDROXYPROPYL CELLULOSE FILMS.** Differential scanning calorimetry (DSC) and dynamic mechanical thermal analysis (DMTA) were used to characterize the morphology of solvent cast hydroxypropyl cellulose (HPC) films. DSC results were indicative of a semicrystalline material with a melt at 220°C and a glass transition at 19°C ( $T_g$ ), although an additional event was suggested by a baseline inflection at about 80°C ( $T_2$ ). Corresponding relaxations were found by DMTA. A secondary relaxation at -55°C was attributed to the interaction between hydroxyl groups of the polymer and residual diluent. (Edited author abstract). 24 Refs.

Rials, Timothy G. (Virginia Tech, Blacksburg, VA, USA); Glasser, Wolfgang G. *J Appl Polym Sci* v 36 n 4 Aug 5 1988 p 749-758.

**079952 MECHANICAL RELAXATIONAL PROPERTIES OF POLYMER FILMS AS A FUNCTION OF THE PREHISTORY OF THEIR PREPARATION FROM SOLUTIONS.** The strength, deformation and relaxational properties of films of polyphenyl quinoxaline and PI have been studied as a function of the prehistory of their preparation from solution. Pure solvents and mixtures of them with a small quantity of precipitants were used as dissolving media. Addition of precipitants gave films with raised strength and considerably greater deformability. When the films are obtained from solution the rate of stress relaxation and creep may be regulated. (Edited author abstract). 8 Refs.

Matevosyan, M.S. (USSR Acad of Sciences, USSR); Askadskii, A.A.; Slonimskii, G.L. *Polym Sci USSR* v 29 n 4 1987 p 843-850.

**079953 STUDIUM RAZOVE HOUZEVNATOSTI RADIACNE SITOVANEHO ROZVETVENEHO PE TYPU BRALEN.** [Impact Strength of Electron Beam Crosslinked BRALEN Low Density Polyethylene.] A low density polyethylene film was crosslinked by electron beam technique. The film properties were found to differ considerably from those of the original unmodified film when dynamically stressed. With respect to service performance of the irradiation crosslinked film, a marked increase in biaxial impact strength, abrasion resistance and - as apparent from the equilibrium elasticity modulus data - a significant dimensional stability at increased temperatures can be considered as major changes of the film properties. A negative effect - faster ageing - is compensated entirely by much faster growth in biaxial impact strength. (Author abstract). 19 Refs. In Czech.

Kotlik, Josef (Statni Vyzkumny Ustav Textilni, Czech). *Plasty Kauc* v 25 n 6 Jun 1988 p 161-165.

## Medical Applications

**079954 MODIFICATION OF POLYETHER URETHANE FILM FOR MEDICAL APPLICATIONS BY MICROWAVE PLASMA.** Polyether urethanes are finding increasing application in medicine because of their special chemical and physical properties. By means of plasma polymerization, the surface of a polyether urethane film can be provided with functional groups. In addition to oxygen and nitrogen plasma, a vinyl acetate plasma was also used. ESCA measurements of the nitrogen and oxygen content of the surface and scanning electron micrographs show the change in the polymer surface due to the treatment. (Edited author abstract) 13 refs.

Breuers, W.; Klee, D.; Plien, P.; Richter, H.A.; Menges, G.; Mittermayer, C.; Hoecker, H. *Kunstst Ger Plast* v 77 n 12 Dec 1987 p 35-36.

## Metallizing

**079955 METALLIZED OPP FILM, SURFACE CHARACTERISTICS AND PHYSICAL PROPERTIES.** Metallized OPP (oriented polypropylene) film offers exceptional gas and water vapor barrier properties, making it one of the most cost-effective flexible protective packaging materials. Its barrier properties correlate with opacity, which, in turn, depends on the degree of coverage by the metallization. Minor defects, such as scratches, will generally represent only a small percentage of the total coverage of a package and have a proportionally small effect on the barrier properties of the package. The high-energy metal surface is extremely active and will wet well and adhere strongly when clean. In fact, it is so active that it is easily coated with trace amounts of any energy organic material with which it makes contact. For assurance of consistent wetting and bonding, metallized OPP surfaces should be cleaned in-line, such as by bare-roll corona treatment. (Author abstract) 5 refs.

Marra, J.V. (Hercules Inc, Wilmington, DE, USA). *J Plast Film Sheeting* v 4 n 1 Jan 1988 p 27-34.

**079956 INDUSTRIAL APPLICATIONS FOR SUBSTRATES OF METALLIZED FILM.** Twenty years ago, the primary uses for metallized films were in capacitors, metallic yarn and many decorative uses. During the past five years, the market for metallized films in industrial uses has experienced significant growth due to the demand for materials that satisfy requirements such as: (1) thin and lightweight; (2) specialized properties (static dissipation, light screening, reflection); (3) multi-functional properties; (4) high quality maintained within tight specifications; and (5) cost effectiveness. Broad markets have been identified and satisfied with metallized substrates because they are (a) an acceptable alternative or replacement for traditional materials; (b) able to satisfy advances in industrial technology which require performance and/or properties not available in conventional materials. These markets include electronics, automobiles, specialized industrial packaging, aerospace, reprographics and instant photography. 2 refs.

Cox, James W. (Martin Processing Inc, Martinsville, VA, USA). *J Plast Film Sheeting* v 4 n 1 Jan 1988 p 43-49.

**Microscopic Examination** See Also POLYESTERS—Morphology; POLYMERS—Conductive.

**079957 COMPLEXITIES IN STEM ANALYSES OF POLYMER BLEND THIN FILMS.** Polystyrene (PS)-polyether sulphone (PES) polymer blend thin films were prepared for examination in a scanning transmission electron microscope. The microstructures observed in 75 wt% PS-25 wt% PES films consisted of spherical inclusions, ranging from 0.2 to 1.2  $\mu\text{m}$  in diameter. X-ray spectrometric analysis in the microscope revealed that the inclusions were PES-rich, while the matrix contained only PS. Attention is paid to the contrast in the annular dark field detection (ADF) images from these films. This image contrast has a complicated dependence on both the angular range subtended by the dark field detector and mass thickness variations within the films. On microscopes with lens controls which permit the acceptance

angle of the ADF detector to be varied, it becomes possible to reverse the contrast between the two phases. (Author abstract) 16 refs.

Sickafus, K.E. (Univ of Cambridge, Cambridge, Engl); Berger, S.D.; Donald, A.M. *J Mater Sci* v 23 n 4 Apr 1988 p 1368-1378.

**Microstructure** See Also POLYETHYLENES—Film; POLYPROPYLENE—Radiation Effects.

**079958 EFFECTS OF PRESSURE AND SOLVENT ON THE DIFFUSION OF AROMATIC COMPOUNDS THROUGH POLYMERS.** The diffusion of six azo and five anthraquinone derivatives through nylon 6, poly(ethylene terephthalate) and secondary cellulose acetate films were studied under high hydrostatic pressures of up to 3000 bar and at temperatures 80-130°C, by analyzing the diffusion profiles yielded in a stacked multiple film, placed in the solution of the diffusant. It was found that the diffusion coefficient,  $D$ , of the diffusant decreased with increasing pressure, giving a linear relationship between  $\ln D$  and the pressure, the slope of which gave the activation volume for the diffusion. (Edited author abstract) 35 refs.

Ito, T. (Kyoto Inst of Technology, Kyoto, Jpn); Seta, J.; Urakawa, H. *Colloid Polym Sci* v 265 n 7 Jul 1987 p 557-573.

**Modification** See SENSORS—Design.

**Molecular Structure** See Also POLYETHYLENE TEREPHTHALATE—Film; POLYETHYLENES—Film; POLYPROPYLENE—Antioxidants.

**079959 PHOTOPHYSICAL STUDIES OF MOLECULAR MOBILITY IN POLYMER FILMS. OXYGEN MOBILITY IN POLYMER FILMS MONITORED BY QUENCHING OF THE TRIPLE-TRIPLET ABSORPTION OF BROMOPYRENE.** Oxygen mobility in several polymer films has been monitored by measuring oxygen quenching of the excited triplet state of film-incorporated bromopyrene observed via its triplet-triplet ( $T_1-T_n$ ) absorption. Cross-linking did not impose any restriction on oxygen movement in the SU8 epoxy film below the glass transition temperature, and the oxygen quenching rate increases markedly with temperature in an uncured epoxy film; the effect is relatively small in a completely cross-linked film. A significant effect of polymer chain structure on the oxygen quenching rate was observed and a possible mechanism discussed. It is found that quenching rate constants are much higher than that expected from the bulk macroviscosity of the film and are of the order  $10^6-10^9 \text{ M}^{-1} \text{ s}^{-1}$ . (Edited author abstract). 21 Refs.

Chu, Deh Ying (Univ of Notre Dame, Notre Dame, IN, USA); Thomas, J.K.; Kuczynski, J. *Macromolecules* v 21 n 7 Jul 1988 p 2094-2100.

**079960 EFFECT OF SUBSTRATES ON THE STRUCTURE OF POLYMER INTERPHASES.** Infrared spectroscopy was used to determine the effect that metal substrates such as titanium, iron, 1100-series aluminum, 2024 aluminum, and copper have on the molecular structure and properties of  $\gamma$ -aminopropyltriethoxysilane ( $\gamma$ -APS) primer films. When  $\gamma$ -APS was adsorbed onto any of the substrates from aqueous solutions at pH 10.4 for 1 min and then dried at room temperature for 30 min, the molecular structure of the primer films was similar and consisted of low-molecular-weight siloxane polymers containing a considerable amount of absorbed carbon dioxide in the form of amine bicarbonates. After the films were dried at elevated temperatures, the structures differed significantly. The reaction of primer films on iron and 2024 aluminum with epoxy resins at 75°C was slow because the temperature was too low for dissociation of the bicarbonates to occur. At 150°C, epoxies reacted readily with  $\gamma$ -APS films on iron but not with those on



2024 aluminum. For primer films on 2024 aluminum, the preferred reaction at 150°C was oxidation of the amino groups. (Edited author abstract). 17 Refs.

Ondrus, D.J. (Univ of Cincinnati, Cincinnati, OH, USA); Boerio, F.J. *J Colloid Interface Sci* v 124 n 1 Jul 1988 p 349-357.

**079961 MOLECULAR ORGANISATION OF ELECTROCHEMICALLY PREPARED CONDUCTING POLYPYRROLE FILMS.** Molecular structure-preparation condition relationships are reported for electrochemically prepared polypyrrole-toluene sulphate electrically conducting films. Polypyrrole films have been prepared from aqueous solutions employing a range of anodic potentials (0.5-1.6 V versus SCE) and at several temperatures. Consistently films grown using higher potentials and at lower temperatures exhibited greater electrical conductivities. The molecular organization in these series of films was evaluated using quantitative x-ray scattering procedures. The x-ray scattering data show that polypyrrole molecules adopt a planar-type conformation in which the planes of the pyrrole moieties have a preferred orientation with respect to the electrode surface. This anisotropy is enhanced in samples prepared at low temperatures or at high anodic potentials, and such anisotropic films have greater electrical conductivity. Structural mechanisms for these observations are discussed. (Author abstract) 27 refs.

Mitchell, G.R. (Univ of Reading, Reading, Engl); Geri, A. *J Phys D* v 20 n 11 Nov 14 1987, Pap Presented at the Polym Phys Group Meet on Electroact Polym, London, Engl, May 14 1987 p 1346-1353.

**Morphology** See Also POLYESTERS—Film; POLYPROPYLENE—Film; POLYPROPYLENE—Processing.

**079962 MORPHOLOGY OF COMPOSITE FILM PREPARED BY POLYMERIZING STYRENE IN POLY(VINYL CHLORIDE) FILM.** Styrene and the styrene-additive mixtures (kerosene, dioxane, ethylene dichloride, or diethylphthalate) were soaked into a poly(vinylchloride) film and then styrene was polymerized. Subsequently, poly(styrene) was extracted with  $\text{CCl}_4$  and the microporous membrane was obtained, of which the morphology was studied. It is elucidated that the additives affect the morphology of the resultant composite films. (Author abstract). 9 Refs.

Mizutani, Yukio (Tokuyama Soda Co, Tokuyama, Jpn); Nishimura, Toshihiko; Nishimura, Masakatsu. *J Appl Polym Sci* v 36 n 4 Aug 5 1988 p 829-835.

**Optical Properties** See Also GREENHOUSES; POLYMERS—Electric Conductivity; POLYMERS—Processing; POLYVINYL ALCOHOL—Dyeing.

**079963 ORIENTATION AND SECOND HARMONIC GENERATION IN DOPED POLYSTYRENE AND POLY(METHYL METHACRYLATE) FILMS.** Glassy polymers such as polystyrene (PS) and poly(methyl methacrylate) (PMMA) doped with optically characterized second harmonic generating dyes were examined for their nonlinear optical properties as determined by sample treatment and physical aging. The authors results can be related to the mobility in the polymer films and free volume theory for physical aging in polymer glasses. When secondary relaxations, associated with limited molecular mobility, are considered for PMMA and PS, it is seen that at room temperature the mobility of PMMA should be much greater due to the greater mobility of the acrylate side chain on the PMMA. Even though both polymers have glass transition temperatures at about 100°C or slightly above, the broad secondary transition for PMMA occurs between about -50 and -30°C and for PS at about 35-50°C. 14 refs.

Hampsch, Hilary L. (Northwestern Univ, Evanston, IL, USA); Yang, Jian; Wong, George K.; Torkelson, John M. *Macromolecules* v 21 n 2 Feb 1988 p 526-528.

**Oxidation** See COPOLYMERS—Degradation; POLYPROPYLENE—Film.

## Performance

**079964 PREDICTING THE PERFORMANCE OF LINEAR LOW-DENSITY POLYETHYLENE BLOWN FILM.** Producers of polyethylene film and resin are continually challenged to improve product performance. Several molecular characteristics of LLDPE affect the performance of films: molecular weight, molecular weight distribution, density, comonomer type, and the distribution of the comonomer along a single chain and among all chains. Blown film properties are generally improved by increasing molecular weight, narrowing molecular weight distribution, and narrowing short-chain branching distribution. 11 refs.

Bibee, D.V. (Dow Chemical Co, Freeport, TX, USA); Dohrer, K.K. *Tappi J* v 71 n 3 Mar 1988 p 199-204.

**Permeability** See Also FOOD PRODUCTS—Packaging; POLYAMIDES—Film; POLYESTERS—Modification.

**079965 TRANSPORT OF ETHYLENE OXIDE THROUGH POLYMER FILMS.** The transport of gaseous ethylene oxide (EtO) in several polymer films is studied using the carrier gas method of measurement. Permeability, solubility, and diffusion coefficients describing ethylene oxide (EtO) transport in polypropylene, polyvinylchloride, Teflon-FEP copolymer, and polyethylene films have been obtained over a 30 Celsius degree range at a low concentration of EtO using the carrier gas method of measurement. The results indicate that the diffusion of EtO in polyethylene is independent of penetrant concentration over the range of concentrations used. However, concentration-independent diffusion could not be verified directly for the other films studied. Two different techniques of determining diffusion coefficients were used, and within the precision of the data both yield the same result. An excess enthalpy of solution for the solubility of EtO in Teflon-FEP copolymer was calculated, an observation that suggests that dual-mode sorption may be taking place. (Author abstract) 45 refs.

Phatak, A. (Univ of Waterloo, Waterloo, Ont, Can); Burns, C.M.; Huang, R.Y.M. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1835-1859.

**079966 GAS PERMEABILITY MEASUREMENTS ON SCREENED EVACUATED INSULATION BASED ON PERFORATED SCREENS.** One can reduce the gas pressures in screened evacuated insulation (SEI) by the use of perforated diffraction screens (PDS). However, difficulties in manufacturing technology have limited their use. A possible way of improving SEI is to optimize the basic parameters of the perforated screens to bring the gas permeabilities up to the level of PDS. We have examined the transverse gas permeability in SEI containing perforated screens and various inserts as affected by the diameter of the holes (at constant screen porosity) and by the porosity (for a fixed hole diameter). It is shown that the screen perforation parameters influence the transverse gas permeability of the insulation under molecular-flow conditions. (Edited author abstract) 6 refs.

Mikhal'chenko, R.S. (Acad of Sciences of the Ukrainian SSR, Kharkov, USSR); Getmanets, V.F.; Klipach, L.V.; Yurchenko, P.N. *J Eng Phys* v 53 n 1 Jul 1987 p 810-812.

## Permeability, Mechanical

**079967 GAS PERMEABILITY OF PLASMA POLYMERIZED FILMS PREPARED FROM VARIOUS ORGANOSILIC COMPOUNDS.** In order to examine the effect of monomers on the gas permeability of plasma polymerized films, five kinds of organosilic compounds (tetramethylsilane and the derivatives substituted by ethoxy groups) were used as the monomer, and plasma polymerized films were deposited on porous substrates. The gas permeability and IR spectra were measured. It was found that each plasma-polymerized film retained the chemical structures of the associated mono-

mers. The ratio of oxygen to nitrogen permeation rates decreased with increasing the numbers of the substituted ethoxy groups. The membrane prepared from the monomer in which two ethoxy groups were substituted showed the highest value of the oxygen permeation rate. (Edited author abstract). 8 Refs. In Japanese.

Sakata, Jiro (Toyota Central Research & Development Lab Inc, Aichi, Jpn); Yamamoto, Minoru; Hirai, Masana. *Kobunshi Ronbunshu* v 45 n 6 1988 p 527-529.

**Photolysis** See POLYMERS—Molecular Structure.

**Physical Properties** See Also FLUORINE CONTAINING POLYMERS—Processing; OLIGOMERS—Oxidation.

**079968 ANNEALING EFFECT ON CHEMICAL STRUCTURE AND PHYSICAL PROPERTIES OF PLASMA-POLYMERIZED TRIETHYLINDIUM.** Annealing effect on chemical structure and physical properties of thin films, prepared by r.f. glow discharge of triethylindium (TEI), was investigated. The film, as deposited, contained mostly hydrocarbon, and the appearance was dark brown and opaque. The structure of the film was amorphous. On annealing in air, hydrocarbon contents in the film decreased, oxygen contents increased, and the crystallization progressed. The appearance of the film changed from opaque to transparent, and the electrical conductivity increased by annealing. (Edited author abstract). In Japanese. 19 refs.

Ide, Yukio (RICOH Co, Numazu, Jpn); Ohnuma, Teruyuki; Kageyama, Yoshiyuki. *Kobunshi Ronbunshu* v 44 n 8 Aug 1987 p 597-603.

**079969 EXPANSION COEFFICIENTS IN AVERAGING FOURTH-RANK TENSORS IN TERMS OF JACOBI'S POLYNOMIALS.** Some physical quantities, such as elastic constant (or compliance) and intensities of polarized fluorescent light and laser-Raman scattering light passed through anisotropic polymer films, are governed by the results of space-averaging weighting with the molecular distribution function  $\omega(\cos \theta, \phi, \eta)$  of the fourth rank tensor  $T_{ijkl}$  defined by a coordinate transformation of a fourth rank tensor. Some of the expansion coefficients of  $T_{ijkl}$  disappear due to the nature of symmetry in the sample. As proposed by Morris, the non-expansion coefficients remain only for the samples with symmetry higher than or equal to that of an orthogonal system. In the general case, which is represented by triclinic system, there can be imaginary parts in the remaining coefficients; these are classified into seven groups. These coefficients induced from generalization are important for evaluating molecular orientation. (Edited author abstract) 14 refs. In Japanese.

Hibi, Sadao (Nagoya Inst of Technology, Nagoya, Jpn); Katsuno, Toshiyasu; Yokoyama, Akihiro; Nakanishi, Eiji; Maeda, Matsuo. *Kobunshi Ronbunshu* v 44 n 5 1987 p 341-359.

**079970 KINETICS OF RECOVERY OF BIAXIALLY ORIENTED STYRENE-ACRYLONITRILE COPOLYMER FILMS.** Styrene-acrylonitrile copolymers were biaxially oriented to obtain a draw ratio of about 6.9 in the machine direction (length) and 2.9 in the transverse direction (width). The prepared films, 28  $\mu\text{m}$  thick, were annealed at elevated temperatures for different time periods. The length and width of the film gradually decreased, accompanied by an increase of the film thickness during recovery. The variations of the film length, width and area with time were all found to follow second-order kinetics for the later part of the recovery process. The arrhenius plots of the rate constants showed activation enthalpies in the range from 120 to 127 kcal  $\text{mol}^{-1}$ . Based on these observations, the kinetics of volume recovery were also shown to be second-order at long recovery times. (Edited author abstract) 19 refs.

Chau, C.C. (Dow Chemical Co, Midland, MI, USA); Rubens, L.C.; Rieke, J.K. *Polymer* v 29 n 1 Jan 1988 p 99-105.



**079971 SURFACE TENSIONS AND STRUCTURES OF ACRYLIC BASE FILMS EB-GRAFTED WITH METHYL METHACRYLATE.** Mixtures of acrylates were cured by electron beams. Surface tensions of those acrylic base films were controlled by changing the mixing ratio of acrylates. The grafting was carried out by coating methyl methacrylate on the base film and irradiating with electron beams. It is assumed that the grafting side chains (poly(methyl methacrylate)) exist on the base film as nearly mono-molecular layers, and that those conformations were arranged by the interaction between the base film and the grafting side chain. The conclusion is that the covering ratio of the grafting side chains on the base films was controlled to minimize interfacial tensions against the base films during the graft-polymerization. (Edited author abstract) In Japanese. 14 refs.

Mori, Koji (Nissin Steel Co, Ichikawa, Jpn); Koshiishi, Kenji; Masuhara, Ken-ichi. *Kobunshi Ronbunshu* v 44 n 10 Oct 1987 p 779-786.

**079972 POLYMERIC MOTIONS DETECTED BY WETTING MEASUREMENTS AT THE FILM/WATER INTERFACE AS INFLUENCED BY CONFORMATIONAL CHANGES AT THE FILM/SUBSTRATE INTERFACE.** This research was concerned with examining the conformational changes that a solvent produces upon a thin polymeric film. The solvent of choice was water, as it is especially indicative of the changes that occur in biological systems and water-borne coatings systems. The intent was to characterize the rates at which these conformational changes occurred, by measuring the time the water took to pass from the surface of the film to a substrate. To obtain the parameters for the characterization, contact angle and ultrasonic measurements were made. The contact angle measurements provided information on the interactions taking place at the film/air interface. The ultrasonics, on the other hand, provided a measure of the interactions that occurred at the film/substrate interface. This paper presents the theory behind the measurements that were made, as well as the manner in which the various measurements were made. It also provides insight into alternate methods for collecting the data which can be of use in future research. The information collected is then used to draw conclusions about the interactions that actually were detected in the films tested. These interactions are then related to the conformational phenomena previously mentioned and the mode of penetration is also discussed. (Author abstract) 16 refs.

Kennedy, Vance O. (Kent State Univ, USA). *J Coat Technol* v 60 n 759 Apr 1988 p 37-51.

**079973 ORIENTATION DISTRIBUTION FUNCTION IN CRYSTALLITES OF ROLLED POLYPROPYLENE AND POLY(VINYL ALCOHOL) FILMS.** A new evaluation method of the crystalline orientation distribution function is proposed. It uses the model that the lamella axis is taken as one of the principal axes in the crystalline block and that the slippages are introduced by the maximum shear direction, and that the intra-lamella slip is around the transverse direction. We applied this method to the rolled polypropylene film, and compared the results with the observed pole figures. We also discussed the orientation distribution functions of the rolled poly(vinyl alcohol) films, using the evaluating method of the orientation distribution functions applied to the bi-axially stretched PVA films. (Edited author abstract) 8 refs. In Japanese.

Hibi, Sadao (Nagoya Inst of Technology, Nagoya, Jpn); Suzuki, Kouji; Hirano, Taeko; Torii, Takashi; Fujita, Kenichi; Nakanishi, Eiji; Maeda, Matsuo. *Kobunshi Ronbunshu* v 45 n 3 Mar 1988 p 237-244.

**Porosity** See POLYETHYLENES—Film.

**Printing** See PRINTING PRESSES—Computer Applications.

**Processing** See ELECTRODES—Modification; IONOMERS—Morphology; POLYVINYL CHLORIDE—Drawing and Stamping.

**Production** See Also POLYACETYLENES—Doping; POLYETHYLENES—High Density.

**079974 HOT NIP DRAWING: A RAPID METHOD OF PRODUCING HIGH MODULUS POLYPROPYLENE FILMS.** There are many methods currently producing high modulus and high strength films and fibers in industry. This study examines the results of a hot nip drawing process to produce high modulus PP films at a relatively rapid production rate. The effects of both temperature and rate of draw on the drawn material will also be examined. (Author abstract). 18 Refs.

Laughner, M.P. (Pennsylvania State Univ, University Park, PA, USA); Harrison, I.R. *J Appl Polym Sci* v 36 n 4 Aug 5 1988 p 899-905.

**079975 PRODUCTION AND CHARACTERIZATION OF HOMOGENEOUS POROUS POLYMER FILMS.** The development of a simple and reproducible production method for thin homogeneous polymeric films is reported. By a special process, highly swollen films can be manufactured without dimensional changes as known from normal swelling processes. With regard to using these films as well-defined active layers in composite membranes, they were characterized by measuring the water flux, the salt rejection and the molecular weight cut-off. The results lead to a very useful correlation between production parameters and membrane performance. (Edited author abstract)

Heinzelmann, W. (CELEFA AG, Seewen-Schwyz, Switzerland); Toscan, M.; Ruf, A.; Christen, D. *J Membr Sci* v 36 Mar 1988, Fifth Int Symp on Synth Membr in Sci and Ind, Sel Pap, Tuebingen, West Ger, Sep 2-5 1986 p 79-84.

**Pyrolysis** See POLYIMIDES—Pyrolysis.

**Radiation Effects** See Also COPOLYMERS—Crosslinking; GASES—Permeability; Mechanical; PHOTOSENSITIZERS—Materials; POLYETHYLENES—Crosslinking; POLYETHYLENES—Low Density; POLYETHYLENES—Oxidation; POLYMERS—Conductive; POLYMERS—Photochromism; POLYPROPYLENE—Oxidation.

**079976 POSTIRRADIATION DIFFUSION OF OXYGEN INTO IRRADIATED DOSIMETRIC POLYMER FILMS.** The authors studied the influence of  $^{60}\text{Co}$  gamma radiation on the oxygen permeability both of prepared dosimetric compositions based on polyvinyl chloride (PVC) and on polymers promising for dosimetric purposes: polycarbonate (PC), aliphatic polyamide with addition of an azo dye (PA), polyarylene sulfone (PSF), and polyvinyl chloride with addition of various organic dyes. The results show that irradiation of PSF and PVC produces a sharp increase of the solubility of oxygen. In the case of PVC a dose of 0.12 MGy increases  $\sigma$  by a factor of over 30. On the other hand, in the case of PA irradiation results in decrease of  $\sigma$  for  $\text{O}_2$ . In pure PA oxygen permeability was not detected even after a dose of 0.03 MGy, while in PA with addition of the azo dye  $\sigma$  decreased by a factor of 70 after a dose of 0.05 MGy. It is found that the change of oxygen solubility corresponds to the magnitude of the post effect in irradiated polymers. 5 refs.

Kozlov, L.L. (N.M. Gubkin Inst of the Petrochemical & Gas Industry, Moscow, USSR); Khabarov, V.N.; Novopashin, A.V.; Mekhanik, T.V.; Molin, A.A. *J Appl Chem USSR* v 59 n 11 pt 2 Nov 1986 p 2390-2391.

**079977 WAXES AND SACS INVESTIGATION OF THE SUPERMOLECULAR STRUCTURE OF LDPE FILMS IRRADIATED WITH FAST ELECTRONS.** Low-density polyethylene (LDPE) films irradiated with fast electrons within the range of irradiation doses 9-40 Mrad have been studied by means of WAXS and SAXS. The degree of crystallinity, the total intensity of WAXS, and the dimension of the mosaic blocks in the [110] and [200] directions have been found to be almost independent of the irradiation dose. The SACS parameters (long period, lamella thickness, intensity of scattering from the diffuse and the discrete regions, total intensity) depend on the dose in the same way. A parallel has been made between the x-ray and the calorimetric degree of crystal-

linity. The latter shows a threefold greater decrease with the increase of the dose, in comparison with the former. (Edited author abstract) 18 refs.

Nikolova, M. (Scientific & Industrial Enterprise of Electron Processing of Materials, Sofia, Bulg); Minkova, L.; Nedkov, E. *J Macromol Sci Phys* v B27 n 1 Apr 1988 p 1-17.

**079978 EFFECT OF DIVINYLSULFONE ON THE IRRADIATION CROSSLINKING OF POLYPROPYLENE.** Polypropylene films were irradiated with  $^{60}\text{Co}$   $\gamma$ -rays in divinylsulfone (DVS) or butadiene (BD) gases. The variations of the intrinsic viscosities of the samples irradiated in vacuum or in DVS with dose showed usual patterns but the variation of the latter was somewhat more rapid. The intrinsic viscosity of the sample irradiated in BD could not be measured due to the early appearance of gel. The gel fraction of the sample irradiated in DVS appeared at lower dose than that irradiated in vacuum, but the former did not increase as much as the latter. The gel fraction of the sample irradiated in BD increased remarkably. The concentrations of the two kinds of double bonds increased in the sample irradiated in BD but levelled off gradually with dose. (Edited author abstract). 11 Refs.

Sasaki, Yusuke (Saitama Inst of Technology, Saitama, Jpn); Imai, Masahiko; Tanaka, Jun; Shimizu, Harumichi. *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2465-2473.

**079979 RADIATION EFFECT OF A HIGH ENERGY ELECTRON BEAM ON THIN FILMS OF SATURATED AND UNSATURATED FATTY ACIDS.** Studies have been carried out on electron beam induced polymerization of LB (Langmuir-Blodgett) films of saturated and unsaturated long chain aliphatic acids, in an attempt to obtain information about the dose dependence of conversion in relation to molecular arrangement. The results indicate that polymerization of unsaturated aliphatic acid LB films occurred when irradiation was carried out in a nitrogen atmosphere and that the LB films of a disordered state are more sensitive to radiation than tightly packed LB films. (Edited author abstract). 10 Refs.

OGAWA, K. (Matsushita Electric Ind Co, Osaka, Jpn); Tamura, H.; Hatada, M.; Ishihara, T. *Colloid Polym Sci* v 266 n 6 Jun 1988 p 525-531.

**079980 CHARACTERIZATION OF ELECTRON-IRRADIATED BIAXIALLY-ORIENTED POLYPROPYLENE FILMS.** Post-radiation changes in the electrical and mechanical properties of capacitor-grade isotactic polypropylene films exposed to electron radiation were previously reported by the authors (1987). Based on the data obtained, it was suggested that crosslinking, chain scission and oxidative degradation were responsible for the radiation-induced changes in the film. In the present investigations, additional electrical characterizations that included the DC breakdown voltage and AC conductivity measurements were performed. Effects of the electron radiation on the physical and chemical properties were also evaluated to identify the actual degradation mechanisms. These studies included scanning electron microscopy, X-ray diffraction, infrared spectroscopy and sol-gel measurements. The results obtained confirm that crosslinking and chain scission of the polymer are responsible for the changes in the lower dose range, whereas oxidative degradation becomes predominant at higher dose levels. 11 refs.

Hammoud, A.N. (State Univ of New York, Buffalo, NY, USA); Laghari, J.R.; Krishnakumar, B. *IEEE Trans Nucl Sci* v 35 n 3 Jun 1988 p 1026-1029.

## Research

**079981 INTERPRETATION OF POLYAZULENE ELECTROPOLYMERIZATION CONSIDERING FARADAIC CURRENT EFFICIENCY AND CAPACITIVE CURRENT EFFECTS DURING THE GROWTH AND REDOX SWITCHING STEPS.** A theoretical analysis of the electropolymerization of azulene at a rotating ring-disk electrode is presented. This analysis provides a method for determining the current



efficiency of electropolymerization. The oxidation of azulene to polyazulene in acetonitrile as solvent is a convective-diffusion controlled process that proceeds with 100% current efficiency. A positively charged site is associated with at least two non-terminal monomer units in the oxidized form of the polymer. Hydrogen ion has been identified and quantitated as a product of the electropolymerization process. No hydrogen ions are produced by the redox process involving only the polymer film. (Edited author abstract) 14 refs.

Bruckenstein, Stanley (State Univ of New York at Buffalo, Buffalo, NY, USA); Sharkey, John W. *J Electroanal Chem Interfacial Electrochem* v 241 n 1-2 Feb 10 1988 p 211-230.

**Sealing** See POLYVINYL CHLORIDE—Welding.

**Shrinkage** See POLYETHYLENES—Film; POLYPROPYLENE—Film.

**Spectroscopic Analysis** See Also AROMATIC POLYMERS—Electronic Properties; BLOCK COPOLYMERS—Synthesis; NYLON POLYMERS—Film; POLYIMIDES—Synthesis; POLYSTYRENES—Blending.

**079982 SURFACE STUDIES OF POLYMER FILMS AND FIBERS BY CIRCLE ATR FT-IR.** The advantages of the CIRCLE ATR technique for the study of films and fibers make it a simple, nondestructive method with which a good signal-to-noise ratio can be obtained. The latter is mainly due to the longer pathlength and larger effective surface area of the CIRCLE ATR element. Applications include the ability to analyze flexible materials, especially fibers which are difficult to analyze using rectangular ATR. Optical properties, such as refractive index and absorption index as a function of wavelength, can also be determined with the use of previously reported methods. 11 refs.

Tiefenthaler, Ann M. (North Dakota State Univ, Fargo, ND, USA); Urban, Marek W. *Appl Spectrosc* v 42 n 1 Jan 1988 p 163-166.

**079983 DIFFUSIVE ANION EXCHANGE IN POLYPYRROLE FILMS.** Anion-exchange experiments performed on electrochemically prepared thin films of polypyrrole/ $\text{ClO}_4^-$  demonstrate that the anions are not tightly bound to the polymer matrix. Auger electron spectroscopy reveals that  $\text{ClO}_4^-$  can be replaced by a number of different anions. In addition, certain anions will not replace  $\text{ClO}_4^-$  while others will induce only partial replacement. The relevance of entropic and steric factors is discussed in relationship to the exchange process. (Author abstract) 5 refs.

Curtin, Larry S. (Univ of Wisconsin-Madison, Madison, WI, USA); Komplin, Glenn C.; Pietro, William J. *J Phys Chem* v 92 n 1 Jan 14 1988 p 12-13.

**079984 MONOLAYER AND LANGMUIR-BLODGETT MULTILAYER SURFACE AND SPECTRAL STUDIES OF POLY-3-BCMU.** Monolayer films of poly-3-BCMU are shown to form at the air-water interface, the surface pressure/area per residue ( $\pi/A$ ) isotherms of which exhibit a horizontal plateau indicative of a phase change occurring on compression. Langmuir-Blodgett monolayer films, transferred while proceeding through this region, have visible absorption spectra indicating a conformational change from an amphipathic yellow to a nonamphipathic blue form having increased  $\pi$ -electron conjugation. A thermodynamic analysis of the temperature dependency of the compressional onset of the plateau ( $\pi_c$ ), interpreted in terms of a corrected two-dimensional analogue of the Clapeyron equation, shows a slightly exothermic transition. A comparison of isotherms obtained both by continuous compression and by a stepwise 'equilibrium' method shows considerable relaxation can take place at areas per residue less than 100 Å<sup>2</sup>. This is interpreted as reflecting the pronounced reorganization required for the highly ordered blue conformation to completely form. (Edited author abstract) 7 refs.

Biegajski, J.E. (State Univ of New York at Buffalo, NY,

USA); Cadenhead, D.A.; Prasad, P.N. *Langmuir* v 4 n 3 May-Jun 1988 p 689-693.

**079985 SPECTROELECTROCHEMICAL STUDY OF THE ELECTRODEPOSITION OF POLYTHIOPHENE FILMS.** The growth of polythiophene films has been studied using time resolved in situ transmission spectroscopy in the wavelength range 350-820 nm. Several distinct stages to the polymerisation process have been identified. In the first of these, a small quantity of intermediates, which we suggest might be short chain oligomers, was observed. At slightly longer times, which a previous electrochemically based analysis associated with the expansion of growth sites, the absorbance shifted to longer wavelengths. Finally, features normally considered to be characteristic of the 'metallic' form of the polymer predominate. Correlation of spectroscopic and electrochemical data showed these clearly, together with more subtle changes occurring in thicker films which were not apparent from the electrochemical data alone. Absorbance vs. charge plots were used to estimate optical parameters for growing films: while we found no evidence for a potential dependence of these parameters in the range 1.80-1.95 V, the values were different from those obtained at high potentials. (Author abstract) 28 refs.

Hillman, A. Robert (Univ of Bristol, Bristol, Engl); Mallen, Elizabeth F. *J Electroanal Chem Interfacial Electrochem* v 243 n 2 Mar 25 1988 p 403-417.

**079986 ORIENTATION OF POLYMER CHAINS IN FILMS OF SYNDIOTACTIC-RICH POLY(VINYL ALCOHOL).** The infrared spectra of the films of syndiotactic-rich poly(vinyl alcohol) (s-PVA) prepared by the casting, frame, and bubble methods were obtained. The band at 705  $\text{cm}^{-1}$  decreased with the increased inclination of the film plane to the direction of the irradiation of infrared rays and was related to the orientation of the molecules in the adsorbed phases of both sides of film. (Author abstract) 6 refs.

Yamaura, Kazuo (Shinshu Univ, Ueda, Jpn); Takeyama, Kuniko; Tanigami, Tetsuya; Matsuzawa, Shuji. *J Appl Polym Sci* v 36 n 4 Aug 5 1988 p 957-961.

**Stability** See POLYMERS—Synthesis.

**Strain** See THERMOPLASTICS—Strain.

**Structure** See Also MONOMERS—Polymerization.

**079987 MICROSTRUCTURES AND THEIR ORIENTATION BEHAVIOR IN A THERMOTROPIC POLYESTER.** Microstructures and their orientation behavior in quenched films of a thermotropic polyester, poly(chloro-1,4-phenylene-trans-1,4-cyclohexanedicarboxylate), were studied by electron microscopy, polarized-light microscopy, and x-ray diffraction. Oriented films were obtained by shearing the anisotropic melt of the polymer and cooling to 0°C. Fibrous structures shaped like ribbons or prisms were observed in fractured lateral surfaces of quenched films. Prismlike fibrils are composed of ribbonlike fibrils, the thickness of which is less than 0.1  $\mu\text{m}$ . Streaks suggesting the end of ribbonlike fibrils were observed on the surface of fibrils. (Edited author abstract) 12 refs.

Kyotani, Mutsumasa (Research Inst for Polymers & Textiles, Tsukuba, Jpn); Kanetsuna, Hiseaki. *J Macromol Sci Phys* v B26 n 3 Sep 1987 p 325-340.

**079988 STRUCTURE OF BLOWN PE FILM GOES WITH THE RESIN'S FLOW.** During the blowing process polymer melt is subject to stresses that are the combined result of the blowing conditions and the rheology of the resin. Thus it is the melt's thermomechanical history that determines the morphology and orientation of the crystalline and amorphous phases. This study characterized the structure and properties of tubular blown polyethylene films processed under a variety of conditions. The morphology of the film is explained on the basis of the rheological properties of the resin and its stresses during processing.

Haber, Andrew (McGill Univ, Montreal, Que, Can); Kamal, M.R. *Plast Eng* v 43 n 10 Oct 1987 p 43-46.

**079989 STRUCTURAL CHANGES IN POLYETHYLENETEREPHTHALATE FILMS ON ROLLING.** The effect of small compressions and shear strains during rolling on the properties and structural changes in PETP films is studied. The modifying rolling effect is shown to produce a change in the character of the subsequent deformation of films below  $T_g$ . In particular, below 50°C the rolled films are strained without necking and crazing. (Author abstract) 10 refs.

Pavlov, V.V. (M.V. Lomonosov State Univ, Moscow, USSR); Vlasov, S.V.; Kuleznev, V.N.; Gerasimov, V.I.; Ivanov, M.V. *Polym Sci USSR* v 28 n 8 1986 p 1790-1795.

**079990 CHEMICAL DEPTH PROFILING ANALYSIS OF POLYVINYLIMIDAZOLE FILM ON COPPER.** Molecular structural changes of poly-N-vinylimidazole (PVI(1)) and poly-4(5)-vinylimidazole (PVI(4)) films by copper initiated reactions as a function of the distance from the copper surface have been studied. The chemical depth profiling analysis involves progressive etchings of the polymeric film on copper with aqueous acidic solutions of increasing concentrations and examination of the film by Fourier transform infrared reflection-absorption spectroscopy (FT-IR RAS). The result shows that the outer layer of the thermally untreated (PVI(1)) film consists of loosely bound or unreacted PVI(1) molecules. Relatively weak complexes with random orientation fill the middle and interfacial layers. (Edited author abstract) 20 refs.

Eng, Frederick P. (Case Western Reserve Univ, Cleveland, OH, USA); Ishida, Hatsuo. *J Electrochem Soc* v 135 n 3 Mar 1988 p 603-609.

**079991 STUDY OF THE TEMPERATURE-TIME INFLUENCE ON THE PROCESS OF STRUCTURING IN NON-ORIENTED FILMS OF POLY(4,4'-OXYDIPHENYLENE)PYROMELLITIMIDE.** IR spectroscopic, X-ray and dilatometric methods have been employed to study the influence of the rate of heating and the end temperature of thermal treatment of the samples on the process of structuring and the parameters of the structure formed in non-oriented films of poly(4,4'-oxydiphenylene)pyromellitimide. The observed effect of self-elongation is a consequence of the structural rearrangements occurring on heating the samples above the softening point. The degree of ordering rises with the increase in the end temperature of thermal treatment and the heating rate. (Author abstract) 16 refs.

Strunnikov, A. Yu. (USSR Acad of Sciences, USSR); Mikhailova, N.V.; Baklagina, Yu.G.; Nasledov, D.M.; Zhukova, T.I.; Sidorovich, A.V. *Polym Sci USSR* v 29 n 2 Feb 1987 p 280-284.

**079992 SPECTROELECTROCHEMICAL STUDIES OF POLYANILINE.** The structural change and electrode reaction mechanism of polyaniline with counter anion  $\text{NO}_3^-$  were investigated on the basis of vis-n.i.r. absorption spectra at different potentials in 1 M  $\text{NaNO}_3$  aqueous solution at pH 1.5, with and without alkali treatment of the polyaniline film. Three redox stages were found in the spectra and the cyclic voltammogram in the potential range -0.4 V to 0.8 V (versus SCE). The equilibrium electrode potential of as-prepared polyaniline film is  $\approx 0.3$  V (versus SCE) in 1 M  $\text{NaNO}_3$  aqueous solution at pH 1.5 (Edited author abstract). 9 refs.

Li, Youngfang (Acad Sinica, Beijing, China); Yan, Baozhen; Yang, Jing; Cao, Yong; Qian, Renyuan. *Synth Met* v 25 n 1 Jul 1988 p 79-88.

**Sulfonation** See POLYETHYLENES—Sulfonation.

**Surface Properties** See Also POLYVINYL CHLORIDE—Film.

**079993 TEORIE ZJAWISK WYSTĘPUJĄCYCH W WARSTWIE GRANICZNEJ FOLIŹ POLIOLEFIN I FARBŹ DUKARSKIEJ.** [Theory of Phenomena Oc-



curing in the Polyolefin Film/Printing Ink Interface Layer]. The principal methods of surface treatment of polyolefin (PE, PP) films have been presented and the difficulties connected with the explanation of phenomena occurring during this treatment pointed out. A critical review of theory concerned with the interpretation of physical and chemical phenomena in the polyolefin film/printing ink interface layer has been given. The main obstacles preventing the elaboration of a uniform theory common for all these phenomena have been discussed and differences encountered in the interpretation of some facts presented. An evaluation of the individual theories from the point of their practical utilization has been attempted. (Edited author abstract) In Polish. 30 refs.

Zenkiewicz, Marian. *Polimery* v 32 n 7 Jul 1987 p 266-268.

**079994 MICROANALYSIS OF POLYMERS USING A WINDOWLESS ENERGY-DISPERSIVE X-RAY DETECTOR.** The surface compositions of various polymeric films, grown electrochemically on platinum foils, have been investigated by energy-dispersive x-ray analysis in conjunction with scanning electron microscopy (SEM/EDS). Comparison of the relative area ratios of peaks for the C and N  $K_{\alpha}$  emission lines show that the EDS may be used to study the surface composition of polymers. The evidence presented strongly suggests that there is a limited structural degradation and the elemental composition is not changed under the electron beam at relatively low accelerating voltages. This technique statistically samples the repeat units of the polymer. For samples grown in both aqueous and nonaqueous solutions. SEM/EDS provides evidence for extensive contamination with oxygen. (Author abstract) 15 refs.

Hayat, Umar (Univ of Warwick, Coventry, Engl); Bartlett, Philip N.; Dodd, George H.; Lewis, Michael H. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 201-206.

**Surfaces** See Also COPOLYMERS—Film; FLUORINE CONTAINING POLYMERS—Modification; POLYSTYRENE—Halogenation.

**079995 POLY( $\alpha$ -AMINOPHENOL) FILM PREPARED BY ELECTRO-OXIDATIVE POLYMERIZATION OF  $\alpha$ -AMINOPHENOL AND ITS ELECTROCHROMIC PROPERTIES.** A kinetic examination of the charge-transport process (i.e., (i) heterogeneous electron-transfer process at electrode-film interfaces and (ii) homogeneous charge-transport process within films) at poly( $\alpha$ -aminophenol) (PAP) film-coated electrodes, which were prepared in situ by electro-oxidative polymerization of  $\alpha$ -aminophenol in an acidic solution, has been conducted by potential-step chronoamperometry (and chronocoulometry) and normal pulse voltammetry. The kinetic parameters characterizing processes (i) and (ii) (ie, standard rate constant ( $k^*$ ) and transfer coefficient ( $\alpha$ ) for process (i) and apparent diffusion coefficient ( $D_{app}$ ) for process (iii)) were estimated. (Edited author abstract) 31 refs.

Ohsaka, Takeo (Tokyo Univ of Agriculture & Technology, Tokyo, Jpn); Kunimura, Satoshi; Oyama, Noboru. *Electrochim Acta* v 33 n 5 May 1988 p 639-645.

**079996 STUDY ON ROUGH-SURFACE BIAXIALLY ORIENTED POLYPROPYLENE FILM. I. FORMATION OF  $\beta$ -FORM CRYSTALS IN SHEET CAST WITH T-DIE EXTRUDER.** Sheets were cast by extruding polypropylenes (PP) which contained  $\gamma$ -quinacridone, a  $\beta$ -crystal nucleator, at levels of 0-10 ppm using a 30 mm  $\phi$  extruder with a T-die at extrusion temperatures of 200-260°C and chill roll temperatures of 30-90°C. The influences of raw resin characteristics such as  $\gamma$ -quinacridone content and MFI of the base PP and casting conditions such as extrusion temperature and chill roll temperature on the amount of  $\beta$ -crystals formed in the sheet were studied. The amount of the  $\beta$ -crystals formed was larger as the  $\gamma$ -quinacridone content was higher and the extrusion temperature was lower and almost independent of the chill roll temperature. (Edited author abstract) 57 Refs.

Fujiyama, Mitsuyoshi (Tokuyama Soda Co, Tokuyama,

Jpn); Kawamura, Yoshimasa; Wakino, Tetsuo; Okamoto, Tomomi. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 985-993.

**079997 STUDY ON ROUGH-SURFACE BIAXIALLY ORIENTED POLYPROPYLENE FILM. II. INFLUENCE OF STRETCHING CONDITIONS.** The production of rough-surface biaxially oriented polypropylene film (BOP) has been studied by means of casting a polypropylene which contained  $\gamma$ -quinacridone, a  $\beta$ -crystal nucleator, with a T-die extruder into a sheet which has subsequently been stretched successively in the machine direction (MD) and the transverse direction (TD) with a roll-type stretching machine and a pantograph-type stretching machine, respectively. For roughening of BOP using  $\beta$ -form crystals in a successively stretching tenter method, it is preferable to roughen in the MD-stretching process, with suppression of the recrystallization into the  $\alpha$  crystals after melting of the  $\beta$  crystals being the most important objective. (Edited author abstract) 20 Refs.

Fujiyama, Mitsuyoshi (Tokuyama Soda Co, Tokuyama, Jpn); Kawamura, Yoshimasa; Wakino, Tetsuo; Okamoto, Tomomi. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 995-1009.

**079998 STUDY ON ROUGH-SURFACE BIAXIALLY ORIENTED POLYPROPYLENE FILM. III. INFLUENCE OF MFI OF BASE RESIN.** The influences of melt flow index (MFI) of base polypropylene (PP) and machine and transverse direction stretching conditions on the roughening of BOP have been studied. Rough-surface BOPs were obtained by casting homoisotactic PPs, having MFIs of 1.3-9.8 dg/min and containing no  $\beta$ -crystal nucleator, with a T-die extruder into sheets which subsequently have been stretched successively in the machine direction (MD) and the transverse direction (TD) with a roll-type stretching machine and a pantograph-type stretching machine, respectively. The level of  $\beta$ -crystal content in the cast sheet was maximum when a PP with MFI = 8 dg/min was used as a raw material and the obtained roughness state of the BOP was the best. (Edited author abstract) 4 Refs.

Fujiyama, Mitsuyoshi (Tokuyama Soda Co, Tokuyama, Jpn); Kawamura, Yoshimasa; Wakino, Tetsuo; Okamoto, Tomomi. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 1011-1023.

**079999 STUDY ON ROUGH-SURFACE BIAXIALLY ORIENTED POLYPROPYLENE FILM IV. INFLUENCE OF ADDITION OF CRYSTAL NUCLEATOR.** In the roughening of biaxially oriented polypropylene film (BOP) by utilizing  $\beta$ -form crystals in a successively stretching tenter method, the influence of an  $\alpha$ -crystal or  $\beta$ -crystal nucleator added to base polypropylene (PP) during roughening of BOP has been studied. Rough-surface BOPs were made from homoisotactic PPs which had a melt flow index (MFI) of 8.5 dg/min and contained the  $\alpha$  or  $\beta$  nucleator at levels of 0-10 ppm. The  $\beta$  crystals formed in cast sheets and the roughness of the BOPs were analyzed. Degree of roughness and the diameter of craters on BOP decreased with increasing  $\alpha$ - or  $\beta$ -nucleator content. This stems from the fact that the diameter of the  $\beta$  spherulites formed in the cast sheet decreases with increasing nucleator content. (Edited author abstract) 4 Refs.

Fujiyama, Mitsuyoshi (Tokuyama Soda Co, Tokuyama, Jpn); Kawamura, Yoshimasa; Wakino, Tetsuo; Okamoto, Tomomi. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 1025-1034.

**080000 STUDY ON ROUGH-SURFACE BIAXIALLY ORIENTED POLYPROPYLENE FILM. V. ANALYSIS AND CONTROL OF ROUGHNESS.** The results obtained in the previous studies have been summarized. The roughness can quantitatively be represented by average roughness  $R_a$  (depth of roughness) and roughness period  $L$  (density of roughness).  $R_a$  and  $L$  can largely be changed by changing machine direction (MD)-stretching temperature and the melt flow index (MFI) of base polypropylene (PP), respectively. Furthermore, a BOP with a low roughness period (high density of roughness)

can be obtained by adding crystal nucleators to the base PP. (Edited author abstract) 5 Refs.

Fujiyama, Mitsuyoshi (Tokuyama Soda Co, Tokuyama, Jpn); Kawamura, Yoshimasa; Wakino, Tetsuo; Okamoto, Tomomi. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 1035-1048.

**080001 STUDY ON ROUGH-SURFACE BIAXIALLY ORIENTED POLYPROPYLENE FILM. VI. ROUGHENING BY LAMINATED CAST SHEET.** When the roughening of biaxially oriented polypropylene film (BOP) is performed by forming  $\beta$  crystals in a monolayer cast sheet, occasionally voids are formed in the BOP. In order to prevent this and to roughen both sides of the BOP, rough-surface BOPs were obtained by casting two-resin, three-layer sheets consisting of two surface layers with a high-melt flow index (MFI) polypropylene (PP) and a core layer with a low-MFI PP, by stretching the cast sheets five times in the machine direction (MD) with a roll-type stretching machine, and by stretching the MD-stretched sheets 10 times in the transverse direction (TD) with a pantograph-type stretching machine. (Edited author abstract) 7 Refs.

Fujiyama, Mitsuyoshi (Tokuyama Soda Co, Tokuyama, Jpn); Kawamura, Yoshimasa; Wakino, Tetsuo; Okamoto, Tomomi. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 1049-1059.

**080002 STUDY ON ROUGH-SURFACE BIAXIALLY ORIENTED POLYPROPYLENE FILM. VII. ROUGHENING BY BLENDING LOW MELTING POINT POLYMERS.** The roughening of biaxially oriented polypropylene film using polypropylene (PP) blended with low melting point polymers such as polybutene-1 and high-density polyethylene as raw resin in a successively stretching tenter method has been studied for the same reasons as has the roughening of BOP utilizing  $\beta$  crystals. Rough-surface BOPs with a low depth and a high density of roughness were obtained by using the blended PPs as raw resins. By combining this roughening method with the roughening method utilizing the  $\beta$  crystals, rough-surface BOPs with a crater-like large roughness and a fine roughness on the ground were obtained. These rough-surface BOPs showed excellent impregnation properties of insulating oils. (Author abstract) 13 Refs.

Fujiyama, Mitsuyoshi (Tokuyama Soda Co, Tokuyama, Jpn); Kawamura, Yoshimasa; Wakino, Tetsuo; Okamoto, Tomomi. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 1061-1066.

**080003 OBRADA POVRŠINE LDPE CRIJEVNOG FILMA ELEKTRICNIM LUKOM. [LDPE Tubular Film Surface Treatment by Electric Arc.]** This study describes film surface treatment by electric arc and presents the technological parameters that influence such treatment. A method of film surface treatment and its influence on LDPE tubular film welding is also described. (Author abstract) 5 Refs. In Serbo-Croatian.

Ospenica, Dane (OOUR Zagrebplast, Zagreb, Yugosl); Catic, Igor. *Polimeri (Zagreb)* v 9 n 4-5 Apr-May 1988 p 109-110.

**Swelling** See POLYVINYL ALCOHOL—Film.

**Synthesis** See Also LIGNIN—Processing; POLYACETYLENES—Film; POLYMERS—Conductive.

**080004 SYNTHESIS AND ELECTRICAL PROPERTIES OF POLY( $p$ -AZOARYLENE) FILMS.** Polymers and copolymers containing  $p$ -azoarylene and  $p$ -azoxarylene groups were synthesized by oxidative coupling of various aromatic diamines. Films were cast directly from the reaction mixtures or from the polymer solutions. The films were  $n$ -doped by sodium naphthalide or  $p$ -doped by iodine. They showed electrical conductivities of  $10^{-4}$  ohm $^{-1}$  cm $^{-1}$  to  $10^{-5}$  ohm $^{-1}$  cm $^{-1}$ . (Author abstract) 10 refs.

Kuo, Thauming (Univ of Arizona, Tucson, AZ, USA); Hall, H.K. Jr. *Synth Met* v 22 n 2 Dec 1987 p 115-120.



**Testing** See AGRICULTURAL PRODUCTS—Storage; GRAFT COPOLYMERS—Mechanical Properties; POLYETHYLENE TEREPHTHALATE—Mechanical Properties; ROOFS—Plastics Applications.

**Thermal Effects** See Also POLYETHYLENE TEREPHTHALATE—Film.

**080005 THERMAL-AGING BEHAVIOR OF BO-PP FILMS.** The variation in electrical properties and morphology of biaxially-oriented polypropylene (BO-PP) films with thermal aging is discussed, using two kinds of BO-PP films. It was found that the thermal aging behavior of those two types of films depends on their initial morphology. The thermal aging gives rise to an increase in the degree of crystallinity due to crystallization of a part of the amorphous phase in BO-PP films. Crystal reorganization was also indicated, resulting in the improvement of the crystal perfection and the thermal stability. The increase in crystallinity enhances selective morphological change and also selective degradation in the amorphous phase. The morphological change due to the thermal aging manifested itself clearly in dielectric and electrical conduction properties in the form of an increase in primary relaxation loss peak and an increase in ionic conduction loss. 22 refs.

Umamura, T. (Toshiba Corp, Jpn); Abe, K.; Akiyama, K.; Couderc, D. *IEEE Trans Electr Insul* v EI-22 n 6 p 735-743.

## Thermal Properties

**080006 DSC ANALYSIS OF EB-CURED POLYURETHANE-ACRYLATE.** The gel films obtained by electron beam (EB) solid-state polymerization of urethane-acrylate prepolymers were characterized by differential scanning calorimetry (DSC). Two kinds of urethane-acrylates were synthesized by reaction of poly(butylene adipate)diol (PBAD), 4,4'-diphenylmethane diisocyanate (MDI) and 2-hydroxyethyl acrylate (HEA) for this purpose. One is a semicrystalline prepolymer (UA-251M) with a number average molecular weight ( $M_n$ ) of 3200, and the other is an amorphous one (UA-071M) with  $M_n$  of 1450. The molecular weight between crosslinking junctions was found to be larger than the  $M_n$  of the prepolymer. The crosslinking by the EB polymerization restricted the mobility of the polymer chain less strongly than the crosslinking by the three-functional isocyanate and  $\alpha$ ,  $\phi$ -dihydroxy(polypropylene oxide) with a molecular weight of 1000 did. (Edited author abstract) In Japanese. 16 refs.

Ando, Masayuki (Dai Nippon Printing Co, Tokyo, Jpn); Uryu, Toshiyuki. *Kobunshi Ronbunshu* v 44 n 10 Oct 1987 p 787-792.

**Thermooxidation** See POLYPROPYLENE—Degradation.

## Thick Films

**080007 HIGH FIELD CONDUCTION IN SOLUTION-GROW PVB FILMS.** The dc current characteristics of solution-grown PVB films, studied as a function of voltage (30-1500 V), temperature (303-398 K) and thickness (30-70  $\mu$ m), have revealed two regions of conduction. The region governing the high-field conduction has been attributed to the space charge limited currents. The values of effective drift mobility ( $\mu_e$ ) and trapped charge carrier concentration ( $n_t$ ) which result in the build-up of space charge, have been found to be  $\approx 1.41 \times 10^{-12}$  cm<sup>2</sup>/V-s and  $6.13 \times 10^{14}$  cm<sup>-3</sup>, respectively. (Author abstract). 8 Refs.

Chand, Suresh (NPL, New Delhi, India); Kaur, Manjit; Kumar, N. *Indian J Pure Appl Phys* v 26 n 4 Apr 1988 p 326-327.

**Thickness Measurement** See ADHESIVES—Mechanical Properties; POLYPROPYLENE—Dielectric Properties.

## Vapor Deposition

**080008 PLASMA-DEPOSITED METAL-CONTAINING POLYMER FILMS.** The plasma treatment of vapors containing organometallic compounds (of Pd, Ni, Co, Sn, Au) and various alkenes has been used to prepare thin films, the composition and electrical resistivity of which could be varied over a wide range. It is found that the film composition strongly depends on experimental parameters, especially the ratio argon/alkene/organometallic in the gas phase. Since the rates of film formation from organometallics and from alkenes depend differently on temperature, the carbon/metal ratios can easily be controlled by the substrate temperature. With changing elementary composition of the films, their resistivity can be altered from insulating to metallic. (Edited author abstract) 23 refs.

Suhr, H. (Univ of Tuebingen, Tuebingen, West Ger); Eispueler, A.; Feuer, E.; Oehr, C. *Plasma Chem Plasma Process* v 8 n 1 Mar 1988 p 9-17.

## Waste Utilization

**080009 REUSE OF PLASTICS RECOVERED FROM SOLID WASTES. MODIFICATION OF PROPERTIES IN THE PE BLENDS.** In this work the authors study the realistic recycling of film plastic wastes of municipal origin (Madrid) through comparison of their properties with the HDPE/LDPE system properties. These are the majority components in the wastes that have been considered at present work. The authors have also characterized the HDPE/LDPE system in an attempt to determine variations in composition of film plastic wastes. (Edited author abstract) 24 refs.

Laguna, O. (CSIC, Madrid, Spain); Collar, E.P.; Taranco, J. *J Polym Eng* v 7 n 3 Apr 1987 p 169-195.

## Wear

**080010 FRICTION AND WEAR OF AN ELECTRICALLY CONDUCTIVE POLYESTER-CARBON FILM.** The friction and wear behavior of an electrically conductive polyester-carbon composite film was examined during dry reciprocating sliding against typical noble and base metal pins. While the frictional force was monitored continuously, the wear volume was determined at the conclusion of each test. The experimental results suggest that the carbon filler acted as an effective solid lubricant during tests against the noble metal pins. However, during tests against the base metal pins at relative humidities above about 40 percent, this lubricating mechanism was impaired, thus resulting in an increase in the friction and wear of the polyester-carbon composite. An adhesive wear mechanism is proposed to account for the observed behavior. (Author abstract). 24 Refs.

Michael, Philip C. (MIT, Cambridge, MA, USA); Saka, Nannaji; Rabinowicz, Ernest. *Wear* v 127 n 1 Oct 1 1988 p 15-29.

**Wetting** See POLYETHYLENES—Ionization.

## X-Ray Analysis

**080011 CONOSCOPIC AND X-RAY DIFFRACTION STUDY OF THE MOLECULAR AND LAMELLAR ORIENTATION IN LDPE FILMS.** By means of conoscopic and WAXS methods, the type of lamellar orientation in a LDPE blown film has been investigated. The WAXS diffractograms establish the existence of plane-axial texture, the crystallographic axis of the unit cell being predominantly parallel to the machine-processing direction (the M axis) of the film. The conoscopic data indicate that the film as a whole behaves like an optically positive biaxial monocrystal, the plane of the film being a section perpendicular to the obtuse bisectrix. (Edited author abstract) 11 refs.

Nedkov, E. (Bulgarian Acad of Sciences, Sofia, Bulg); Minkova, L.; Nikolova, M. *J Macromol Sci Phys* v B26 n 4 Dec 1987 p 465-478.

**PLASTICS, FOAMED** See Also BUILDING MATERIALS—Plastics; CERAMIC MATERIALS—Foams; COMPOSITE STRUCTURES—Fire Resistance; FIRE EXTINGUISHERS—Foam; PLASTICS—Molding; POLYURETHANES—Combustion; POLYURETHANES—Physical Properties.

**080012 DEVELOPMENT OF INTEGRAL SKIN FOAMS BASED ON MODIFIED ISOCYANATE WITH SELF-RELEASING CHARACTERISTICS.** This work describes the development of Integral Skin Foams based on modified isocyanates presenting physical properties superior to those obtained with crude MDI/MDI prepolymers which are the industry standard. Also studied is the incorporation of an IMR (Internal Mold Release) package to developmental formulations in order to minimize the need of an EMR (External Mold Release).

Pauperio, A. (Dow Chemical, Sao Paulo, Brazil); Santos, R.N. *J Cell Plast* v 23 n 5 Sep-Oct 1987 p 448-459.

**080013 AMINE CATALYSIS OF POLYURETHANE FOAMS.** The present catalysis study was confined to model systems. Using a single solvent, at a fixed temperature, with a fixed concentration and isocyanate index over 20 catalysts were characterized. The activity and selectivity of the catalysts toward the urethane and urea reactions were compared. The study is useful to the formulator inasmuch as the rankings of commercial catalyst molecules for their selectivity of the blowing, gelling and trimerization reactions can be transposed to real systems. The experimental data collected in this study and an analysis of the spatial interplay of conventional amine catalysts with isocyanate, water and polyols shows that the separation of the functional centers on a catalyst molecule determines its selectivity and to a lesser extent its activity. 59 refs.

Malwitz, N. (Sealed Air Corp, Danbury, CT, USA); Wong, S.-W.; Frisch, K.C.; Manis, P.A. *J Cell Plast* v 23 n 5 Sep-Oct 1987 p 461-502.

**080014 SOME THERMODYNAMIC OBSERVATIONS ON THE MECHANICAL PROPERTIES OF CUSHIONS.** The adequacy of the assumption that the dynamic behavior of closed-cell, low-density foams under impact may be modeled as trapped air under adiabatic compression is addressed. Using thermal convection coefficients from the literature, certain geometric properties of cushions, and the results for the impact temperature history from the adiabatic model, it is shown that the heat transferred over the duration of the impact exceeds the limit allowed by the first law of thermodynamics. The adiabatic assumption is therefore self-contradictory. A set of coupled thermodynamic relations incorporating heat transfer by convection are then developed for the impact response and used to make some general comments on the nature of cushions under dynamic loading. (Author abstract) 11 refs.

Burgess, Gary J. (Michigan State Univ, East Lansing, MI, USA). *J Cell Plast* v 24 n 1 Jan-Feb 1988 p 56-69.

**080015 MATERIALY NA BAZIPLASTU PRO TLUMENI HLUKU A VIBRACI.** [Plastics for Noise and Vibration Control]. For noise and vibration isolation, plastics foams with good relaxation properties are suitable, in which the loss factor and modulus of elasticity can be controlled by compounding. It is evident that poor sound-absorbing materials can act as good sound insulators or sound barriers. Effective acoustic properties can be obtained by optimizing frequency, temperature and character of the polymer system used. It is apparent that the energy absorption capacity of viscoelastic materials drops down markedly at temperatures considerably higher than their glass-transition temperature. The design itself of the isolation system is essential in actual cases of noise and vibration control. A good noise control is achieved when compression and tensile vibrations are converted to shear vibrations. (Author abstract). 73 Refs. In Czech.

Modrakova, Jana (Vyzkumny Ustav Gumarenske a Plastikarske Technologie, Gottwaldov, Czech). *Plasty Kauc* v 25 n 6 Jun 1988 p 176-189.



## Aging

**080016 BARRIER PACKAGING TECHNOLOGY - A NEW APPROACH TO THE THERMAL AGING PROBLEM OF RIGID FOAM INSULATION.** The authors have demonstrated that various techniques commonly used by the converting industry that supplies food packaging materials may lend themselves to the PUR and PIR foam board facer industry. The incorporation of certain polymers, in combination with other facer substrates, should markedly improve adhesion between the facer and the foam core. Work is continuing with the acid copolymer resins and other polymers coupled with the traditional PUR and PIR facer substrates to not only improve adhesion but to retard k-factor deterioration. (Edited author abstract) 9 refs.

Baitinger, S.A. (DuPont, Wilmington, DE, USA); Ascoug, M.R.; Dishart, K.T. *J Cell Plast* v 23 n 6 Nov-Dec 1987 p 611-623.

**Applications** See Also AUTOMOBILE MATERIALS—Plastics; PLASTICS LAMINATES; POLYMERS—Injection Molding; POLYURETHANES—Production.

**080017 NEW APPLICATIONS FOR STRUCTURAL FOAM.** The article reviews polymers for thin-wall structures. Foamed plastics are lightweight but selection and part design are critical in structural applications. Application trends and markets are also covered. 1 ref.

Leavey, Cynthia (GE Plastics, Pittsfield, MA, USA); Caropreso, Michael. *Adv Mater Processes* v 133 n 2 Feb 1988 p 41-45.

**Blowing Agents** See Also POLYSTYRENES—Flammability.

**080018 RECOVERY OF CHLOROFLUOROCARBON 11 BY ACTIVATED CARBON SCRUBBING ON A POLYURETHANE FOAM SLABSTOCK PLANT.** Operation of a pilot scale activated carbon CFC 11 recovery unit has been studied. For CFC 11 the trapping efficiency of the scrubber is close to 100% immediately after regeneration, falling to 95% when 12% by weight CFC has been added to the scrubber. About 10-15% of the CFC used by the plant is captured. Recovery is less efficient, due to losses in the condenser, and only 50-60% of the trapped material is obtained for re-use. Examination of this material has shown significant differences from the unused sample, but admixture of recovered with unused CFC has proved successful in plant operations. (Edited author abstract)

Nutt, A.R. (BTR Industries Ltd, Birmingham, Eng); Skidmore, D.W. *Cell Polym* v 6 n 4 1987 p 62-78.

**080019 FOAM PRODUCERS SEARCH FOR NEW BLOWING AGENTS.** Due to rising public pressure and the probability of legislative action, foam producers using fully halogenated chlorofluorocarbons as blowing agents may face cost increases in the near future. Meanwhile, suppliers of blowing agents are scrambling to come up with suitable substitutes for CFC agents as soon as possible. Basically, foam producers are caught in a no-win situation. If they switch to currently available CFC substitutes with lower ozone depletion potential, they will have to pay more for them. If the switch is made to the more flammable hydrocarbons, the manufacturing procedure must be changed to ensure personnel are protected. In addition to CFC substitutes or alternative blowing agents, other action foam producers can take to help deal with the problem include filtering the exhaust so the CFCs do not get into the atmosphere, and recycling CFCs. Industry is unlikely to pursue filtering. The cost for scrubbers and filtering systems is high, and the techniques used are not efficient.

Salamone, Salvatore L. (Plastics World, Newton, MA, USA). *Plast World* v 46 n 1 Jan 1988 p 46-48.

**Compounding** See COATINGS—Water Borne.

**Curing** See Also POLYURETHANES—Foam.

**080020 FAST DEMOLD CATALYST FOR TDI BASED MOLDED FOAM.** This paper shows how faster cure times, as low as three minutes and possibly faster at 60°C, can be achieved using standard high resilient (HR) foam polyols and normal operating temperatures with the DABCO(REGISTERED) X-540 series of amine catalysts. The DABCO family of fast cure catalysts currently consists of three; DABCO X-540, which is non acid blocked; DABCO X-542, partially acid blocked; and DABCO X-543, the most highly acid blocked version. DABCO X-540, per se, is too active to be used on its own but can be used to moderate the cream times of either DABCO X-542 or DABCO X-543.

Petrella, R.G. (Air Products & Chemicals, Trexlertown, PA, USA); McGovern, M.J. *J Cell Plast* v 23 n 3 May-Jun 1987 p 258-275.

**Decomposition** See POLYURETHANES—Foam.

## Deformation

**080021 STIFFNESS OF LIGHTWEIGHT OPEN-POROSITY FOAM PLASTICS.** A previous study proposed one of the first models of the strain properties of lightweight open-porosity foam plastics with a pronounced rod structure. The model is a system of randomly oriented rods, with the elastic moduli being calculated on the basis of an energy approach. In the case of small specimen strains it is assumed that the rods are in a state of tension or compression. The authors use the basic postulates in order to construct a model of the deformation of lightweight isotropic foam plastics with a cellular structure of the rod type. In these plastic foams, the rods may have a nearly constant cross section. The length of the rods is significantly greater than their thickness. The distribution of the rods in different directions is random. 9 refs.

Beverte, I.V. (Acad of Sciences of the Latvian SSR, Riga, USSR); Kreger, A.F. *Mech Compos Mater* v 23 n 1 Jan-Feb 1987 p 27-33.

**080022 MICRODYNAMICS OF CRUSHING IN CELLULAR SOLIDS.** Light-weight, open-celled foams and honeycombs can exhibit deformation localization during static crushing as a result of buckling and plastic collapse of cell walls. Localization of deformation is a manifestation of strain-softening behavior that limits transmitted forces through these shock-mitigating materials. Collision tests on two-dimensional cellular solids with strain-softening behavior reveal that with some microstructures, strain-rate effects can stabilize less compliant modes of deformation. When stabilization occurs, it amplifies the intensity of transmitted shocks. (Author abstract)

Stronge, W.J. (Univ of Cambridge, Cambridge, Eng); Shim, V.P.-W. *J Eng Mater Technol Trans ASME* v 110 n 2 Apr 1988 p 185-190.

**Elasticity** See POLYOLEFINS—Foam.

## Encapsulation

**080023 HEADLINER, DOOR PANEL, SOUND ABSORPTION AND WINDOW ENCAPSULATION - AUTOMATIC TURNKEY PROCESSES.** Injection, inserts, trimming, mold release, part removal, and process control are all integrated together to create a modular, automatic turnkey system to produce both exterior and interior trim parts in production quantities. Three specific interior trim parts are addressed: headliners, door panels, and sound absorption, along with window encapsulation. All of these utilize a multi-step process requiring extensive manual handling, and some require very expensive capital equipment. Currently, not all of the parts are made strictly with polyurethane. But with each part, polyurethane proves to be more conducive to producing a more competitive product by automating the process to full

turnkey system. Different methods of producing polyurethane headliners, door panels, window gasketing, and components for sound absorption are described.

Mazzoni, B.C. (Cannon USA, Warrendale, PA, USA). *J Cell Plast* v 23 n 5 Sep-Oct 1987 p 503-520.

**Extrusion** See Also PLASTICS MACHINERY—Extruders.

**080024 EXTRUSION FOAMING OF THERMOPLASTICS FOR PACKAGING MATERIALS.** The daily task of supplying people with perishable goods, hot food, foodstuffs, fruit, vegetables and transport-sensitive consumer goods requires properly adapted packaging. The choice of packaging materials is, of necessity, made from a stringent viewpoint, to which the properties, the economics and the environmental impact are of decisive importance. Packaging materials made from extrusion-foamed thermoplastics are products that meet these requirements and adapt readily to the variety of needs. (Edited author abstract)

Kolosow, K.D. *IPE Int Ind Prod Eng* v 11 n 4 Dec 1987 p 16, 18, 20.

**Flammability** See POLYURETHANES—Foam.

## Flexible

**080025 DYNAMIC COMPRESSION CHARACTERISTICS OF FLEXIBLE FOAMS. I. SIMILARITY MODEL, ANALYSIS, AND EXPERIMENTS.** A simple mathematical model is proposed, based on dimensional similarity parameters, to describe the characteristics of flexible plastic foams under impact conditions. The model assumes that the foam is rate-dependent material, when the dynamic stress is a function of the strain and the strain rate. The similarity parameters include the geometric dimension of the foam, the mass of the absorbing body, and the drop height. By using this model, one can predict the maximum deformation, the maximum decelerations, and the time-pulse period for a wide range of drop heights and masses, by conducting several drop tests. We verified the efficacy of this model by performing free-fall drop tests with flexible polyurethane foam having a uniform density of 240 kg/m<sup>3</sup>. (Author abstract) 3 refs.

Yossifon, S. (NRCN, Beer-Sheva, Isr); Szanto, M. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 2025-2036.

**080026 IMPACT TESTING OF FLEXIBLE POLYURETHANE FOAMS.** Methods of obtaining information on dynamic properties of flexible foams from a limited number of impact tests are considered. The test procedure is based on measuring acceleration and displacement during the entire impact (not only maximum values as required in current standards). Interpretation of the results uses two theoretical approaches: stress-strain relationships and similarity considerations. Each approach has its own advantages. The developed algorithm, applied presently to four commercial packaging foams, allows the plotting of cushioning diagrams and predicts the shape of time-impact dependence for an arbitrary drop height and foam thickness. Properties of composite cushioning structures can be calculated. (Author abstract) 13 refs.

Shestopal, V.O. (Natl Materials Handling Bureau, North Ryde, Aust); Chilcott, B. *J Test Eval* v 16 n 3 May 1988 p 312-318.

**080027 ENVIRONMENTAL CONSIDERATIONS IN THE PRODUCTION OF FLEXIBLE SLABSTOCK.** Total gas loss by the production of flexible polyether foam may range between 4-20 weight percent, higher densities are mainly blown with carbon dioxide - the lower densities partially with CO<sub>2</sub>, partially with either fluorocarbon and/or methylene chloride. During blow-off approx. 30% of the total gas loss will spontaneously escape from the top surface, the other 70% is contained in the block and will mainly diffuse via the



vertical sides and the bottom of the block. In view of this, trials were conducted in which recycling systems were installed in the plant. The objectives of this newly installed equipment are outlined. Test results show that the system is economically viable.

Vreenegoor, N.C. (Unifoam AG, Glarus, Switz). *J Cell Plast* v 24 n 2 Mar-Apr 1988 p 121-131.

## Ignition

**080028 INFLUENCE OF FLEXIBLE POLYURETHANE FOAMS ON UPHOLSTERY FABRIC-FOAM MOCK-UPS IGNITIONS BY CIGARETTES.** Fabric and polyurethane foam are major components in most upholstered furniture mock-up systems. Their influence on the system propensity to ignite when exposed to a lit cigarette can be estimated by means of a logistic model. The model, which estimates percent ignition, is uniquely determined by the significant physical properties of the fabric, foam and cigarette employed in the test. The logistic model development rationale along with the selection criteria for the fabrics, foams and cigarettes are presented. Weight and proclivity of the fabric, and air flow of conventional polyurethane foam, were found to be the major physical properties of the mock-up system substrate influencing ignition rates. (Edited author abstract) 13 refs.

Ihrig, A.M. (Lorillard Inc, Greensboro, NC, USA); Rhine, A.L.; Spears, A.W. *J Fire Sci* v 5 n 6 Nov-Dec 1987 p 392-415.

## Mechanical Properties See Also POLYURETHANES—Foams.

**080029 SHOCK MITIGATING FOAMS. 2. STATIC/DYNAMIC CHARACTERISTICS.** Using a selection of both commercially available and laboratory synthesized products, the shock mitigating characteristics of semi-rigid foams are systematically evaluated using both compression tests (static) and swinging pendulum tests (dynamic). It is demonstrated how parameters derived from relatively simple static compression tests may be used to predict the maximum deceleration of an impacting object when striking the foams directly. Following a review of the chemical and physical factors likely to influence energy absorption qualities of foams it is tentatively discussed how such factors may be correlated with the material parameters calculated from the static compression tests. In conclusion, the paper points the way forward to how simple static tests may be used to aid the development of foams with specific shock mitigating properties. (Author abstract) 13 refs.

Richardson, M.O.W. (Loughborough Univ of Technology, Loughborough, Engl); Al-Hassani, A.H.M. *Cell Polym* v 6 n 4 1987 p 39-61.

## Microstructure See POLYMERS—Solutions.

## Moisture

**080030 DETERMINING THE AMOUNT OF UNFROZEN WATER IN A FOAM PHENOL PLASTIC.** Foam polymers are used as insulators in wall structures, improving the thermal protection considerably while reducing the amount of material required and saving heat in operating buildings; this provides improved thermal comfort, which is particularly important for the harsh conditions in the Far North. The hygroscopicity and the amount of unfrozen water  $W_{uw}$  are major working characteristics of these for use under northern conditions, in addition to the thermophysical and mechanical parameters, a technique for determining water content in a foam phenol plastic is presented. 3 refs.

Efimov, S.S.; Dalbaeva, E.K. *Meas Tech* v 30 n 6 Jun 1987 p 605-607.

## Moisture Control

**080031 THIN FILM PARYLENE COATING OF THREE-PHASE SYNTACTIC FOAMS.** Three-phase syntactic foams composed of silica microballoons poly-

imide binder and voids have good electrical as well as mechanical properties. Consequently, they have been used for encapsulation of electrical devices. However, due to the foam porous structure, moisture may degrade their electrical properties. To reduce moisture absorption by three-phase syntactic foams they have been coated with Parylene C (200 mg·cm<sup>-2</sup>). Moisture absorption by the coated syntactic foam at 95% R.H. at 50°C was determined gravimetrically and found to be 5% wt after 60 days exposure. Diffusion of moisture through the Parylene film was found to follow Fick's law. (Edited author abstract) 21 refs.

Calahorra, A. (Armament Development Authority, Haifa, Isr); Gara, O.; Kenig, S. *J Cell Plast* v 23 n 4 Jul-Aug 1987 p 383-398.

## Molding

**080032 TDI MOLDING: OLD TECHNOLOGY, NEW TECHNOLOGY.** The use of TDI in high resilient foam molding was a natural progression from the older hot foam technology. The new HR or 'cold cure' urethane foams were characterized by high resiliency, low hysteresis on compression, and comfort factors approaching those of latex rubber. To make HR foam more compatible with the then current production techniques there was a trend by many foamers to incorporate TDI/polymeric MDI blends in place of the straight toluene diisocyanate. Recently there seems to be a trend back to an all TDI type of formulation. This paper examines the reasons behind the previously increased usage of TDI/polymeric MDI and its advantages. The major part of the paper focuses on why these reasons for changing are either no longer necessary or have been overcome. The current TDI molding technology is presented. 7 refs.

Courtney, M.H. (Mobay Corp, Pittsburgh, PA, USA); Freitag, H.-A.; Koshute, M.A. *J Cell Plast* v 24 n 1 Jan-Feb 1988 p 36-55.

## Morphology

**080033 MORPHOLOGY OF WATER-BLOWN FLEXIBLE POLYURETHANE FOAMS.** A series of four TDI-polypropylene oxide (PO) water-blown flexible polyurethane foams was produced in which the water content was varied from 2 to 5 pph at a constant isocyanate index of 110. A portion of each foam was thermally compression molded into a plaque. The morphology of both the foams and plaques was investigated. A high degree of microphase separation occurs in these foams, and its degree is nearly independent of water (hard segment) content. In the foam with the lowest water content the morphology possesses many similarities to that of typical linear segmented urethane elastomers. Small hard segment domains are present with a correlation distance of about 7.0 nm. When the water content is increased a binodal distribution of hard segment material appears. There are the small hard segment domains typical of segmented urethane elastomers as well as larger 'hard aggregates' greater than 100 nm in size. The larger domains are thought to be aggregates of rich polyurea that develop by precipitation during the foaming reaction. (Edited author abstract) 37 refs.

Armistead, James Paul (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Wilkes, Garth L.; Turner, Robert B. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 601-629.

**080034 OBJECTIVE CHARACTERIZATION OF THE CELL SIZE OF MICROCELLULAR FOAMS.** A technique to characterize the morphology of open- and micro-cellular foams is described. The technique involves measuring the BET surface area of the foam and using a rigorous stereological relationship between the surface area and the average distance between surfaces of the foam. BET surface areas are measured quickly and reproducibly and the stereological relationship enables an exact morphological property to be obtained. The average distance between surfaces can be considered a generalized 'cell size' for many open- and micro-cellular foams. (Author abstract) 11 refs.

Aubert, J.H. (Sandia Natl Lab, Albuquerque, NM, USA). *J Cell Plast* v 24 n 2 Mar-Apr 1988 p 132-145.

## Painting

**080035 COATING STRUCTURAL FOAM SYSTEMS WITH POLYURETHANE.** Processors can achieve optimal adhesion on polyurethane coatings to structural foams by allowing parts to degas before coatings are applied. However, different times are needed to obtain precise drying, or degassing, for various combinations of blowing agents and matrix resins. Here are some typical combinations. (Author abstract)

Rosis, Constantine (Nortech, Clinton, MA, USA); Leonard, Nicholas; Driscoll, Stephen; Leitch, Steven. *Plast Eng* v 43 n 9 Sep 1987 p 37-39.

## Physical Properties See Also POLYSTYRENES—Processing.

**080036 H.R. MOLDED FOAMS BASED ON A MODIFIED POLYETHER POLYOL AND ISOCYANATE BLENDS CONTAINING CRUDE TDI.** Investigations conducted at Dow's R&D Center in Brazil led to the development of Experimental Polyol XB 81230.00, a modified polyether polyol that used in conjunction with isocyanate blends containing crude TDI result in H.R. molded foams with outstanding physical properties. This paper shows the wide range of physical properties that can be achieved through the use of Experimental Polyol XB 81230.00 with different isocyanate blends containing crude TDI. Another purpose of this paper is to introduce our newly developed products, Exp. Polyol XB 81230.02 and Exp. Isocyanate UBX-0018, in response to the local market needs for lower density foams (2.2-2.6 pcf). The physical properties obtained with starting formulations based on these new products are also, herein, compared with those achieved with formulations based on two different copolymer polyols and the widely used 80/20 TDI/MDI blend.

Pauperio, A. (Dow Chemical, Sao Paulo, Braz). *J Cell Plast* v 23 n 3 May-Jun 1987 p 231-239.

## Polymerization See EMULSIONS—Phase Diagrams.

## Processing See Also POLYSTYRENES—Applications; POLYURETHANES—Foam.

**080037 LA CORSA TECNOLOGICA.** [Technological Competition]. Automation is making gigantic steps in processing expanded polyurethanes. Automated islands equipped with great flexibility permit components for the automobile industry to be made, particularly in case of not too large series and frequent production changes. (Author abstract) In Italian.

Baucia, Giovanni. *Mater Plast Elastomeri* n 4 Apr 1987 p 183-189.

**080038 PROCEEDINGS OF THE S.P.I. THIRTEENTH ANNUAL STRUCTURAL FOAM CONFERENCE.** This conference proceedings contains 26 papers. Topics covered include: selecting structural foam resins; mold technology; processing structural foam; finishing structural foam; conductive-shielding coatings; design in counterpressure structural foam; air borne sound attenuation characteristics of various engineering resins; secondary finishing operations; factors affecting surface splay and subsurface voids; evaluating chemical blowing agent concentrates; multi-nozzle equipment modernization; thinwall structural foam; RIM markets; developing new markets for growth; high impact polycarbonate structural foam; new developments in endothermic blowing agents; CAD/CAM application for building plastic injection molds; and, steel for today's plastic mold. Technical and professional papers from this conference are



indexed and abstracted with the conference code no. 11261 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (SPI, Structural Foam Div, New York, NY, USA). *Proc SPI Annu Struct Foam Conf* 13th, Dallas, TX, USA, Apr 22-24 1985. Publ by SPI, New York, NY, USA 125p.

## Reaction Injection Molding

**080039 SIMULATION OF FOAMING IN REACTION INJECTION MOLDING.** Blowing agents are often used in the reaction injection molding process to compensate for the shrinkage that occurs upon polymerization, thereby creating a structural foam part. Controlling the thickness of the solid skin and foamed core is essential to achieve the intended mechanical properties of the molded part. A numerical model was developed to predict the foaming behavior in reaction injection molding. This algorithm employs a novel primitive cell construction to enable it to analyze complex rectangular geometries, including inserts, with a two-dimensional, finite difference solution method. The analysis was applied to foaming of polyurethane in a rectangular cavity. The predicted skin thickness was found to be in good agreement with actual structural foam parts. The results can be used to formulate design guidelines for achieving desired skin/core thicknesses as a function of design, material, and process parameters. (Edited author abstract). 7 Refs.

Tighe, S.C. (AT&T Bell Lab, Murray Hill, NJ, USA); Manzione, L.T. *Polym Eng Sci* v 28 n 15 mid-august 1988 p 949-954.

**Rigid** See Also DOMES AND SHELLS—Structural Analysis; POLYURETHANES—Foam; ROOFS—Insulation.

**080040 PRZEPUSZCZALNOSC SZTYWNYCH TWORZYW POROWATYCH.** [Apparatus for Testing Tensile Impact Strength and Elongation of Vulcanized Rubber]. The construction of a testing apparatus as well as the procedure of measuring force and deformation during impact failure test for rubber has been described. The results of tests for ultimate stress and relative elongation obtained for samples of 10 different rubber mixtures have been presented. Diversification of these results proves that this apparatus and procedure can find application in comparative evaluation of impact properties of various rubbers, in particular of tyre rubbers. (Edited author abstract) In Polish. 8 refs.

Ciesielska, Danuta (Politechnika Poznańska, Pol); Kellar, Krystyna; Bratborska, Ewa. *Polimery* v 32 n 8 Aug 1987 p 325-326.

**080041 UTICAJ USPORIVACA GORENJA NA SVOJSTVA KRUTIH POLIURETANSKIH PJENA.** [Effect of Some Flame Retardants on the Properties of Rigid Polyurethane Foams]. Increased resistance to flammability and burning is achieved with the addition of flame retardants. Unreactive and reactive compounds should increase the resistance of polyurethane foams to burning. Halogenated polyether polyols in combination with polyols of different bases proved effective in this respect. Self-extinguishing polyurethane foams were produced having satisfactory physico-mechanical properties for commercial manufacture. (Author abstract) Serbo-Croatian. 7 refs.

Busuladzic, Irfan (Inst za Poliuretane, Tuzla, Yugosl). *Polimeri (Zagreb)* v 8 n 7-8 Jul-Aug 1987 p 210-212.

**080042 STORAGE STABILITY OF CFC/POLYOL PREMIXES.** One of the significant factors contributing to the commercial growth of rigid urethane foam systems was the development of stabilized chlorofluorocarbon (CFC) blowing agents. This paper describes possible reaction mechanisms in CFC-11/polyol premixes which may cause degradation during storage, the effect of formulation ingredients on storage stability, the nature of stabilizers which retard premix component degradation, and the behavior of some typical rigid urethane foam systems containing unstabilized and stabilized CFC-11. 15

refs.

Dwyer, F.J. (Allied Corp, Buffalo, NY, USA); Zwolinski, L.M.; Garman, J.M.; Brown, D. *J Cell Plast* v 23 n 6 Nov-Dec 1987 p 593-610.

**080043 NEW AMINE CATALYSTS PROVIDING LESS DISCOLORATION TO PVC COVERED SEMI-RIGID URETHANE FOAM PRODUCTS.** Common catalysts used for the production of semi-rigid foam are triethylenediamine, triethylamine, and dimethylethanolamine, which often cause several odor problems during the manufacturing process, and residual amines in the finished part which cause discoloration of the plastic PVC covering at high temperature. Catalysts which provide less odor during manufacture, less interaction with the PVC covering material, and improved part moldability have been required for the automotive interior application. Toyo Soda has developed two new tertiary amine catalysts, TOYOCAT-HX4W and TOYOCAT-HX35, which are odorless, less effective to PVC and improve flow characteristics for the semi-rigid application. The reactivity associated with TOYOCAT-HX4W is quite similar to triethylamine, however, TOYOCAT-HX35 exhibits stronger blowing tendencies than either -HX4W or triethylamine. (Edited author abstract) 4 refs.

Arai, S. (Toyo Soda Manufacturing Co, Yamaguchi-Ken, Jpn); Tamano, Y.; Tsutsumi, Y.; Lowe, D.W. *J Cell Plast* v 24 n 1 Jan-Feb 1988 p 23-35.

**080044 EFFECT OF WATER ON PHENOLIC FOAM CELL STRUCTURE.** Cell opening in phenolic foam is mainly caused by water in the resin which can produce open cells by two mechanisms. These mechanisms are: (1) phase separation of microdroplets of water that evaporate and leave holes in the cell structure and (2) curing exotherms that raise the temperature of the foaming mixture to a point where water vapor pressure exceeds the cell wall strength and the cells rupture. Lowering the resin water concentration to less than 7% (w/w) and adding both phenol, as a viscosity modifier, and polyglycol, as a heat sink, results in a resin that can be expanded to give a closed cell low K-factor phenolic foam. (Author abstract) 7 refs.

Rickel, G.K. (Dow Chemical Co, Midland, MI, USA); Denslow, K.R. *J Cell Plast* v 24 n 1 Jan-Feb 1988 p 70-78.

**080045 STUDY OF THE LOW SMOKE POTENTIAL, FLAME RESISTANCE AND PROCESSIBILITY OF HIGH INDEX POLYISOCYANURATE RIGID FOAM.** Recent advances in our isocyanate and catalyst development programmes have stimulated a re-examination of the rigid polyisocyanurate (PIR) foams, and a study has been undertaken to explore the limits of flame resistance, low smoke emission and processibility in these systems. An experimental investigation was therefore carried out to determine the influence of the main PIR formulation parameters on fire and smoke performance of the derived foam. The results demonstrated that low smoke values can be obtained in non fire retarded PIR foams at isocyanate indices of approximately 400. However, to ensure high oxygen index together with low smoke emission, it was found to be necessary to use both high weight fractions of isocyanate (above 0.8) and isocyanate indices above 600. It was demonstrated that the manufacturing difficulties that are traditionally associated with high index PIR formulations can be overcome by the use of a novel catalyst package. Thus a novel class of foam insulation having high isocyanate index and high weight fraction of isocyanate has been identified and given the name SHINDEX foam. (Edited author abstract) 12 refs.

Cunningham, A. (ICI plc, Kortenbergh, Belg); Eling, B.; Sparrow, D.J. *Cell Polym* v 6 n 6 1987 p 42-60.

**080046 WPLYW DODATKU DI(HYDROKSYMETYLO) MOCNIKA I PRODUKTOW JEGO KONDENSACJI Z DIOLAMI NA WLASTWOSC SZTYWNYCH PIAWEK POLIURETANOWO-POLIZOCYJANUROWYCH.** [Effect of Addition of Dihydroxymethyl Urea and Products of its Condensation with Diols on the Properties of Rigid Polyure-

thane-Polyisocyanurate Foams]. The effect of addition of dihydroxymethyl urea and products of its condensation with diethylene glycol and thiodiethylene glycol - as modifiers reducing flammability - on the mechanical and thermal properties of rigid polyurethane-polyisocyanurate foams has been investigated. It has been found that the application of the product of condensation reaction of dihydroxymethyl urea with thiodiethylene glycol results in reducing foam flammability without an accompanying deterioration of mechanical strength properties, as compared with standard foam without a modifier. (Edited author abstract) 15 refs. In Polish.

Czuprynski, Boguslaw (Akad Techniczno-Rolnicza, Pol); Maslowski, Henryk; Kozlowski, Kazimierz. *Polimery* v 33 n 1 Jan 1988 p 16-19.

**Structural Application** See POLYPROPYLENE—Injection Molding; POLYURETHANES—Reaction Injection Molding.

**Testing** See POLYURETHANES—Foam.

**Thermal Effects** See Also POLYVINYL CHLORIDE—Heat Resisting.

**080047 STUDIES OF TEMPERATURE AND ATMOSPHERE COMPOSITION INFLUENCE ON THERMAL DEGRADATION PRODUCTS OF POLYURETHANE FOAM.** The paper presents studies on the influence of temperature and atmosphere composition on the thermal degradation products evolved from flexible polyurethane foam. The experiments have been carried on within the temperature range 200-700°C in air atmosphere and oxygen-nitrogen-helium mixtures. The main volatile toxic products and weight losses during thermal degradation of the polyurethane foam have been determined. The test results have been presented graphically. (Author abstract) 15 refs.

Włodarczyk, Daniela (Technical Univ of Szczecin, Szczecin, Pol). *J Appl Polym Sci* v 36 n 2 Jul 5 1988 p 377-386.

**Wastes** See POLYSTYRENES—Recovery.

## PLASTICS INDUSTRY

**080048 TENDENCJE ROZWOJOWE TWORZYW POLISTYRENOWYCH: CZ. I. TWORZYWA TYPU ABS.** [Development Trends in Styrene Plastics: Part I. ABS Plastics.]. The impact of energy crises in the seventies and eighties on the world market of plastics has been discussed. The present situation and outlook until 1992 in the field of production and consumption of ABS plastics, as well as the developments in their manufacturing technology and fields of applications (transportation means - in particular automotive industry, telecommunication and electronics and various novel applications), have been presented in detail. (Edited author abstract) 61 refs. In Polish.

Karasek, Bretislav (CSRS, Pol); Soucek, Ivan; Voros, Frantisek. *Polimery* v 33 n 1 Jan 1988 p 1-8.

**Automation** See PLASTICS—Injection Molding.

**Competition** See CHEMICAL INDUSTRY—Reviews.

## Computer Aided Manufacturing

**080049 LA GPAO DANS L'INDUSTRIE PLASTIQUE.** [CAM in the Plastics Industry]. Few plastic processors are equipped with GPAO (computerized production control) though this equipment enables the whole production line from the supply of raw material to the delivery of the finished product to be regulated and coordinated. This equipment represents a relatively costly investment but leads to mastering of production time, systematic diminution of nonproductive time, maintenance of well regulated supplies, production, deliveries, respect to delays. (Edited author abstract) In French.

Maucotel, J.M. (Conseil Industries Plastiques). *Rev Gen Caoutch Plast* v 64 n 670 Jun-Jul 1987 p 73-75.



Europe See AUTOMOBILE MATERIALS—Plastics.

India See POLYMERS.

## Marketing

**080050 SPECIALTY RESINS ARE BROADENING DISTRIBUTORS' SUPPLY CAPABILITIES.** Diversification of product lines is a profits-driven trend that is paying off for customer companies in ways that include faster and simpler access to a broader range of resins and compounds. Distributors' inventory buildups are concentrated on performance materials. Coming: more marketing services. (Author abstract)

Toensmeier, Patrick A. *Mod Plast* v 64 n 10 Oct 1987 p 69-71.

## Personnel Training

**080051 ARE YOU SMART ENOUGH FOR THE 21ST CENTURY.** Plastics manufacturing is poised for unprecedented growth in key market areas, as detailed in this special issue. To exploit these opportunities, new materials and processing methods are emerging that some say represent a quantum leap in technological sophistication. Most plastics education programs focus on polymer chemistry, with very little hands-on education in manufacturing. Most machine operators learn their skills on the job. Beginners start by observing experienced operators at work. When trainees first operate a machine, they are supervised closely by more experienced workers. Support for education is tough to justify on the bottom line. Yet, there is no choice. Industry support of plastics engineering and technology programs is precisely what colleges and universities require. They survive through private donations of cash, resins, and equipment.

Kirkland, Carl (Plastics World, Newton, MA, USA). *Plast World* v 45 n 10 Sep 1987 5p.

Process Control See ELASTOMERS—Quality Control.

Quality Control See QUALITY CONTROL.

## Research

**080052 PLASTICS PREPARE FOR TOMORROW'S WORLD.** In the 1930s, phenolic bearings came into use in steel-mill rolling equipment. Their introduction sparked the steel industry to question what other steel parts plastics might displace. Those who examined the question did not foresee just how extensively plastics would compete with steel. In the next century, the position of plastics in the economy will be much more like the position of metals today. Plastics will be roughly on a par with metals in terms of usage, and will likely be a truly mature industry. Even more encouraging is the fact that plastics is not yet a mature technology. We are living in an era in which the tools used by chemists and physicists to probe the molecular world are improving by leaps and bounds. Powerful tools such as computer-aided molecular modeling will shorten the time needed to make significant advances in polymer development.

Anon. *Plast World* v 45 n 10 Sep 1987 6p.

**PLASTICS LAMINATES** See Also PRINTED CIRCUITS—Manufacture.

**080053 LIGHTER WEIGHT AND LOWER COST WITH FOAM-CORE COMPOSITES.** Foam-core sandwich panels are formed by bonding a face sheet (which may itself be a composite laminate) to a preformed, precut foam slab. Thermoplastic or thermosetting foams are prepared using ordinary foam methods, while syntactic foams are prepared by mixing reinforcing microspheres into liquid resin. The former are recognized for their particularly low cost and light weight, while the latter have remarkably high compressive properties. Their overall cost-performance makes foam-core laminates an excellent answer to many interesting engineering problems. This article discusses material characteristics, reinforcing methods, and other aspects of the subject.

English, Lawrence K. (Materials Engineering, Cleveland, OH, USA). *Mater Eng (Cleveland)* v 4 n 9 Sep 1987 p 51-54.

**080054 NEW, ONE-COMPONENT DICY-FREE EPOXY RESIN SYSTEM DEVELOPED FOR FR-4 GLASS/EPOXY LAMINATES.** This new system does not use dicyandiamide or any other amine as the curing agent and has no problems with crystallization either of the vanish or on the prepreg. The system can be used at a relatively low solvent content and the solvents used have favorable toxicity. Since it is a one-component system it reduces the number of products stored by the laminator and eliminates some blending steps in his manufacturing process. The system produces laminates with an excellent all-round performance in T<sub>g</sub>, moisture resistance, etc. Laminates also exhibit significantly increased resistance to CAF growth, a cause of long-term failure in PCBs. (Author abstract) 4 refs.

Sexton, D. (Dow Chemical Rheinwerk, Rheinmuenster, West Ger). *Circuit World* v 14 n 1 Oct 1987 p 44-46.

**080055 WATER ABSORPTION IN GLASS FIBRE-EPOXIDE RESIN LAMINATES.** Water absorption is a serious problem in all polymeric materials, including the glass fibre-epoxide resin laminates used in printed circuit board manufacture. This paper describes experiments to determine the level of water absorption in these materials under different conditions of relative humidity and temperature using thermogravimetric analysis. (Author abstract) 23 refs.

Smith, C.A. (GEC Research Ltd, Chelmsford, Engl). *Circuit World* v 14 n 3 Mar 1988 p 22-26.

**080056 COMPOSITES IN CONSTRUCTION.** The article describes a 3-layer laminated panel, as a special form of composite actions which is characterized by the use of two thin layers of strong material, denoted as faces, between which a thick layer of light-weight and comparatively weak core is sandwiched. In a structural panel of this type, the faces resist bending moments and in-plane compressive or shear forces. The shear forces normal to the plane of the panel are resisted by the core, which also stabilizes the faces against buckling. This type of construction is efficient structurally due to the large stiffness achieved by spacing apart the most highly stressed elements, namely, the faces.

Hussein, R. (Univ of the District of Columbia, Washington, DC, USA); Morsi, M. *Plast Build Constr* v 11 n 2 1987 p 6-12.

**Acoustic Emission Testing** See PLASTICS, REINFORCED—Glass Fiber.

**Anisotropy** See DOMES AND SHELLS—Theory.

**Bonding** See SPORTING GOODS—Manufacture.

**Chemical Attack** See PLASTICS, REINFORCED—Carbon Fiber.

**Coatings** See PLASTICS MACHINERY.

**Crack Propagation** See Also ALUMINUM FOIL—Mechanical Properties; PLASTICS, REINFORCED—Carbon Fiber.

**080057 SIMPLIFIED ANALYSIS OF TRANSVERSE PLY CRACKING IN CROSS-PLY LAMINATES.** This paper presents a method of analyzing transverse crack initiation and multiplication in symmetric cross-ply laminates. The method is based on the concept of a through-the-thickness inherent flaw and the energy balance principle. With a second-order polynomial assumed for the crack opening displacement, the perturbed stress field due to the presence of ply cracks is determined from the equilibrium conditions. The energy released as a result of ply cracking is then calculated and used to predict the increase in crack density. Based on an experimental correlation of the analytical result, a resistance curve is proposed to be used as measure of the resistance to crack multiplication. The resistance to crack

multiplication is shown to increase with the increasing crack density. (Author abstract) 15 refs.

Han, Y.M. (Pennsylvania State Univ, University Park, PA, USA); Hahn, H.T.; Croman, R.B. *Compos Sci Technol* v 31 n 3 1988 p 165-177.

**Curing** See COMPOSITE MATERIALS—Mechanical Properties; PLASTICS, REINFORCED—Mechanical Properties.

**Deformation** See Also PLASTICS, REINFORCED—Carbon Fiber.

**080058 THERMALLY INDUCED TWIST IN GRAPHITE-EPOXY TUBES.** This paper discusses an analytical and experimental study to investigate the thermally induced twist in laminated angle-ply graphite-epoxy tubes. Attention is focused on balanced laminates which, contrary to intuition, exhibit twist when the temperature is changed. The twisting is due to the fact that in tube a lamina with a  $+\phi$  orientation and a lamina with a  $-\phi$  orientation must be at slightly different radial positions. The lamina with the greater radial position determines the sense of the twist. Classical lamination theory does not predict this phenomenon and so a more sophisticated theory must be employed. This paper outlines such a theory, which is based on a generalized plane deformation elasticity analysis, and presents experimental data to confirm the predictions of the theory. A brief description of the experimental apparatus and procedure used to measure twist is presented. (Author abstract)

Hyer, M.W. (Univ of Maryland, College Park, MD, USA); Rousseau, C.Q.; Tompkins, S.S. *J Eng Mater Technol Trans ASME* v 110 n 2 Apr 1988 p 83-88.

## Degradation

**080059 EFFECT OF HYGROTHERMAL HISTORIES ON MATRIX CRACKING IN FIBER REINFORCED LAMINATES.** Environmental factors that affect matrix cracking in composite laminates include temperature, moisture content, and hygrothermal history. Matrix cracking in laminates exposed to aircraft environments was modeled using a fracture mechanics approach based on strain energy release rates. Residual stress relaxation due to hygrothermal history was found to alter the static mechanical strain necessary to cause matrix cracking in experiments. Depending on material type and hygrothermal history, this effect was shown to either increase or decrease the resistance to matrix cracking. Close agreement between predicted and measured strains at the onset of matrix cracking was obtained using a modification to the fracture mechanics approach. (Edited author abstract)

Rothschilds, R.J. (Boeing Commercial Airplane Co, Seattle, WA, USA); Ilcewicz, L.B.; Nordin, P.; Applegate, S.H. *J Eng Mater Technol Trans ASME* v 110 n 2 Apr 1988 p 158-168.

**Drilling** See PRINTED CIRCUITS—Drilling.

## Fabrication

**080060 CONTINUOUS LENGTH THERMOPLASTIC COMPOSITE LAMINATES.** Polyphenylene sulfide (PPS) is a thermoplastic engineering polymer with excellent thermal, chemical and electrical properties. Consequently, its use in advanced composites in many applications has been reported in recent years. As a part of our effort to use continuous fiber reinforced composite material based on PPS, authors have developed a proprietary process to form continuous length composite laminates. Laminates having fiber orientation of zero degrees as well as off-axis orientation have been produced. Continuous laminates containing various fabric forms have likewise been made. Mechanical properties of the continuous laminates are listed and compared to properties obtained on compression molded PPS laminates and typical thermoset laminates. Advantages of the continuous laminates compared to thermoset laminates are



increased toughness, reduced moisture uptake and ease of processing. One particular advantage is that due to the thermoplastic nature of these composites, subsequent application of heat and pressure permits reforming all or part of the structure if desired. This reshaping or post-forming procedure cannot be accomplished with thermo-set structures. (Author abstract) 8 refs.

Beever, William H. (Phillips 66 Co, Bartlesville, OK, USA); Rhodes, Vergil H.; Warcham, J. Robert. *SAMPE J* v 24 n 1 Jan-Feb 1988 p 8-11.

**Failure** See Also PLASTICS, REINFORCED—Carbon Fiber; PLASTICS, REINFORCED—Fibers.

**080061 DELAMINATION D'UN BARREAU COMPOSITE SOUMIS A UNE TRACTION UNIFORME.** [Delamination of a Composite Bar Under Uniform Tensile Stress]. The purpose of this paper is to study the delamination of an infinite laminate under uniform tensile stress. A numerical analysis is conducted first, leading to the computation of various energy release rates introduced in the article and to the crack shape. Then, an analytical calculation based on the classical lamination theory is performed which gives the global energy release rate and the crack shape in modes II and III. (Edited author abstract) In French. 10 refs.

Anquez, L. (ONERA, Chatillon, Fr); Nataf, F. *J Mec Theor Appl* v 6 n 3 1987 p 335-350.

**080062 MECHANISMS OF DISINTEGRATION OF COMPRESSED PARTICULATE SYSTEMS.** Disintegration of compacts in the presence of a solvent is followed by measurement of the disintegration force development as a function of time. The process is described by the delamination of the compact and the rate of expansion of the detached layers using a new equation. (Author abstract) 4 refs.

Caramella, Carla (Univ of Pavia, Pavia, Italy); Colombo, Paolo; Conte, Ubaldo; Ferrari, Franca; Gazzaniga, Andrea; La Manna, Aldo; Peppas, Nikolaos A. *Polym Bull (Berlin)* v 18 n 6 Dec 1987 p 541-544.

**080063 MODELLING STIFFNESS LOSS IN QUASI-ISOTROPIC LAMINATES DUE TO MICROSTRUCTURAL DAMAGE.** Continuous-fiber laminated composites are known to undergo substantial load-induced damage in the form of matrix cracking, interior delamination, fiber fracture, etc. These damage modes produce significant losses in component performance measures such as stiffness, residual strength, and life. The authors have previously constructed a general model for predicting the response of laminated composites with damage. This paper utilizes the model to predict stiffness loss as a function of damage in quasi-isotropic and angle-ply laminates with matrix cracks. It is shown that the model is capable of predicting the stiffness loss for any layup by utilizing the same input data, thus producing a model which is independent of stacking sequence. The favorable comparisons of the model to experimental results reported in this paper support the validity of the model. (Edited author abstract)

Harris, C.E. (Texas A&M Univ, College Station, TX, USA); Allen, D.H.; Nottorf, E.W.; Groves, S.E. *J Eng Mater Technol Trans ASME* v 110 n 2 Apr 1988 p 128-133.

**080064 DELAMINATION BUCKLING AND GROWTH IN A CLAMPED CIRCULAR PLATE.** This paper presents an elastic postbuckling analysis of a delaminated circular plate under axisymmetric compression along its clamped boundary. Von Karman's equations are assumed to govern the deformation of the delaminated layer, while the deflection of the main body of the plate is described by the linear equations of the classical plate theory. Solution of the boundary-value problem is reduced to repeated numerical integration of two initial-value problems. Certain features of the post-buckling behavior are found to be qualitatively similar to the buckling of an axially loaded beam plate containing a one-dimensional delamination. An analytical expression

for the energy-release rate is obtained in terms of the postbuckling solution. The stability of delamination growth under a fixed boundary displacement is examined. The results are compared with previous results for thin-film circular delamination. (Edited author abstract). 9 Refs.

Yin, W.-L. (Georgia Inst of Technology, Atlanta, GA, USA); Fei, Z. *AIAA J* v 26 n 4 Apr 1988 p 438-445.

**Fatigue** See PLASTICS SHEETS—Sheet Molding Compounds.

## Filament Winding

**080065 MOEGELICHKEITEN DER PROZESS-SIMULATION BEIM FASERWICKELN.** [Possibilities of Process Simulation in Filament Winding. A Step Toward Economical Component Development.]. This paper presents a concept for the process simulation of filament winding which enables the modeling, winding and production of complex components to be simulated on a computer. Advantages as against conventional procedures lie in the considerable time and material savings obtained; for the winding of nonrotationally symmetrical cores, in particular, good agreement between the winding pattern and the simulation is achieved. A concept for the optimization of machine control parameters for existing winding processes is also planned, with the objective of shortening cycle times. A further desirable feature of this is the ability to estimate flexibility requirements for the winding machine at an early stage of component development and fix them at the necessary level. (Edited author abstract). 9 Refs. In German.

Kirberg, K.W. (RWTH Aachen, Aachen, West Ger); Menges, G. *Sprechsaal* v 121 n 7 Jul 1988 p 543-547.

**080066 WERKSTOFFKUNDLICHE ASPEKTE ZUR ENTWICKLUNG VON BAUTEILEN AUS FASERVERBUNDWERKSTOFFEN.** [Material-Science Aspects of the Development of Fiber-Reinforced Composite Components.]. Fiber-reinforced composites with a polymer matrix are increasingly used for load-bearing structural components in different fields of application, in particular, in the aircraft and aerospace industries, but also in the mechanical engineering, automotive and sporting goods industries. This paper describes the special advantages of this material group and other design criteria typical of their fibrous structure. An example of the design of a truck drive shaft is used to illustrate the replacement of metals by fiber composites. Finally, the valid design principles characteristic of this material group are outlined again in general and in the particular case of a new automotive tire made out of various polymer composite materials. (Edited author abstract). 18 Refs. In German.

Friedrich, K. (Technischen Univ Hamburg-Harburg, Hamburg, West Ger). *Sprechsaal* v 121 n 7 Jul 1988 p 548-556.

**Flame Resistance** See AIRCRAFT MATERIALS—Plastics.

## Fracture

**080067 INFLUENCE OF CYCLIC LOAD AMPLITUDE ON DAMAGE ACCUMULATION AND FRACTURE OF COMPOSITE LAMINATES.** It has become a common practice in the design and certification of composite laminate components to assume that long-term in-service response can be implied from short-term test results. The variable in this extrapolation of behavior is often the cyclic or quasi-static applied load level. These variations in load level can be the source of changes in the damage accumulation and fracture modes associated with the corresponding response. The present paper brings together results from a series of investigations of several composite laminate and material system types in an effort to identify some of the fundamental differences in the damage accumulation and fracture associated with cyclic loading of continuous fiber reinforced composite laminates at high and low cyclic load amplitudes. (Author abstract) 10 refs.

Razvan, Ahmad (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Bakis, Charles E.; Wagnez, Linda; Reifsnider, Kenneth L. *J Compos Technol Res* v 10 n 1 Spring 1988 p 3-10.

**Industrial Applications** See PLASTICS FILMS—Metalizing.

**Manufacture** See Also PRINTED CIRCUITS—Manufacture.

**080068 HOW TO MAKE BETTER FR-4.** For a number of years, laminators, urged on by the circuit board industry, have been in pursuit of an improved FR-4 grade. Continuous lamination of prepreg and copper foil in a couple-belt press forms FR-4 with a uniform thickness profile and improved dimensional stability. The description of the press, laminate thickness profile, dimensional stability and automatic post-lamination handling are described.

Eliasson, Ragnar (Perstorp Electronics, Perstorp, Swed). *Electron Packag Prod* v 27 n 10 Oct 1987 p 76-77.

## Materials

**080069 COMING SOON: THE IDEAL LAMINATE.** Although today printed wiring board (PWB) laminate materials do an adequate job in most applications, improved laminate materials are still needed to meet the demands of high-performance applications cost effectively. New developments indicate that the ideal laminate of woven and nonwoven Kevlar aramid fiber may soon be available to meet the demands for increased dimensional stability and improved control of the coefficient of thermal expansion (CTE). Nonwoven reinforcements eliminates microcracking and weave print-through that can occur with woven reinforcements. And, new cyanate ester resin families with high glass transition temperatures and low dielectric constants look promising. 4 refs.

Wallig, Lyle R. (DuPont Co, Wilmington, DE, USA). *Circuits Manuf* v 28 n 1 Jan 1988 p 25-28.

**Mechanical Properties** See Also COMPOSITE MATERIALS—Fiber Reinforced; PLASTICS, REINFORCED—Carbon Fiber.

**080070 EFFECT OF TESTING METHODS ON THE SHEAR STRENGTH DISTRIBUTION IN LAMINATED COMPOSITES.** An experimental investigation was performed to study the effect of testing methods on the in situ shear strength distribution in fiber-reinforced laminated composites. T300/976 Graphite/Epoxy cross-ply laminates were used in the tests, and rail shear, Iosipescu, and short beam shear fixtures were selected for measuring the shear strengths. The results strongly indicate that the interlaminar shear strength measured from the short beam shear test has no correlation with the inplane shear strengths measured by the other two methods. The rail shear and Iosipescu fixtures provide, in general, consistent results in the measurement of the inplane shear strength. However, the consistency between the results of the two test methods strongly depends on the ply orientation of the test specimens. As shown in the paper, the resultant differences in inplane shear strengths measured from the two test methods could be as much as 50%. (Edited author abstract) 10 refs.

Chang, Fu-Kuo (Stanford Univ, Stanford, CA, USA); Tang, Jian Mao; Peterson, Douglas G. *J Reinf Plast Compos* v 6 n 4 Oct 1987 p 304-318.

**080071 EINFLUSS DER LAMINATKOMPONENTEN VON CFK-WERKSTOFFEN AUF DAS STATISCHE UND DAS DYNAMISCHE VERHALTEN.** [Effect of the Laminate Components of Carbon-Fiber-Reinforced Plastics on their Static and Dynamic Behaviors]. The static and dynamic properties of a conventional and a modified, toughened matrix system reinforced with two types of high-strength carbon fibers with different fracture elongations were investigated. Three different laminates were chosen, a unidirectional



laminate, a cross-ply laminate and a nearly quasi-isotropic laminate. It is shown that the damage development under both static dynamic loading is delayed when using a toughened matrix system. This delay in damage development results in improved mechanical properties. However, when using a toughened matrix system together with fibers with a high fracture elongation, an improvement in the static properties does not lead to an improvement of equal extent in the dynamic properties. (Edited author abstract) In German. 17 refs.

Baron, Ch.; Schulte, K. *Z Werkstofftech* v 18 n 9 Sep 1987 p 306-313.

**080072 QUERRISSBILDUNG IN 0/90/0 CFK-LAMINATEN.** [Cross-Ply Cracking in 0/90/0 Carbon-Fiber-Reinforced Laminates]. Cross-ply cracking in carbon-fiber-reinforced plastics with thermoset as well as thermoplastic matrix systems was investigated on 0/90/0 laminates with varying 90° ply thickness. Since in an angle ply laminate the 90° ply fails first, the higher strength of the other plies cannot be taken advantage of. For this reason, efforts have to be made to increase the transverse strength (strain) of fiber-reinforced plastics. In the first place, it is therefore necessary to investigate the influence of the various parameters which contribute to the transverse strength. In this work, the influence of the matrix (fracture strain), the fiber matrix interface, voids and the constraining effect of neighboring plies is investigated. With the aid of two-parameter Weibull distributions of the 90° ply fracture strain, which describe the phenomenon of multiple cracking in a specimen, it was found that the constraining effect due to neighboring plies, improved fiber/matrix adhesion and matrix ductility increase the transverse fracture strain, while voids decrease it. (Edited author abstract) In German. 16 refs.

Peters, P.W.M. *Z Werkstofftech* v 18 n 9 Sep 1987 p 313-322.

**080073 RESIDUAL FLEXURAL STRENGTH OF FRP COMPOSITE SPECIMENS SUBJECTED TO TRANSVERSE IMPACT LOADING.** Specimens made of fiber reinforced polymeric composite laminates were subjected to transverse impact loading. The brittle laminate was made of graphite/epoxy (0/90)<sub>2s</sub> and the ductile one was glass/epoxy (+45/-45)<sub>2s</sub>. An instrumented drop weight impact tester was used to load the specimens in the transverse direction with different energy and momentum levels. The residual properties were measured after the impact. It was found that properties changed drastically for the brittle material, while for the ductile material properties changes were more gradual. Damage was controlled by the impact energy level. Specimens with light or nonvisible damage almost maintain their static strength. Impact velocity has a negligible effect on the impact resistance of the material. (Edited author abstract) 16 refs.

Rotem, A. (Technion, Isr). *SAMPE J* v 24 n 2 Mar-Apr 1988 p 19-25.

**080074 NONLINEAR ELASTIC PROPERTIES OF ORGANIC MATRIX COMPOSITES AT ELEVATED TEMPERATURES.** A model is presented for describing the nonlinear, elastic behavior of unidirectional organic matrix composites at elevated temperatures. The model describes the longitudinal and transverse tensile, longitudinal and transverse compressive, and shear stress-strain relationships, as well as the Poisson ratios. Tests were performed in the temperature range 75 to 350°F using unidirectional laminates made of Fibrerite T300/976 graphite epoxy tape. The constants required in the model for this material were deduced from the data. (Author abstract)

Ha, Sung Kyu (Stanford Univ, Stanford, CA, USA); Springer, George S. *J Eng Mater Technol Trans ASME* v 110 n 2 Apr 1988 p 124-127.

**080075 TEMPERATURE-DEPENDENT DYNAMIC MECHANICAL PROPERTIES OF POLYMERIC LAMINATED BEAMS.** Polymeric composite laminates are being increasingly employed to fabricate

parts which must be designed to operate successfully in dynamic mechanical environments under various temperatures. In order to develop a set of experimental data for evaluating the predictive capabilities of new computer-aided design tools for predicting the elastodynamic response of engineering structural components operating under different temperature regimes, an experimental program was undertaken to study the elastodynamic response of E-glass/Epon cantilever specimens and AS-4 graphite/Epon cantilever specimens subjected to discrete ambient temperatures in the range of -10°F to 300°F at a constant relative humidity of 75 percent. Design charts demonstrating the variation of damping and the dynamic longitudinal elastic modulus were then plotted as a function of temperature for these specimens. (Edited author abstract)

Lee, C.Y. (Michigan State Univ, East Lansing, MI, USA); Thompson, B.S.; Gandhi, M.V. *J Eng Mater Technol Trans ASME* v 110 n 2 Apr 1988 p 174-179.

## Processing

**080076 PROCESSING SCIENCE OF THICK-SECTION COMPOSITES.** A comprehensive process model was applied successfully to the cure of thick-section laminates. The cure of these laminates provided very critical tests of the process model because of the demand for in-process control of a highly exothermic cure reaction and the problem of managing generally poor and non-isotropic thermal conductivities in the processing unit. The process model involves all aspects of chemical reactor theory; reaction kinetics, chemoviscosity, thermochemical parameters, heat and mass transfer, and fluid dynamics. It was demonstrated that the temperature-time and pressure-time cycles could be computed and an autoclave-vacuum bag process operated in accordance with these computed process conditions in real-time. (Author abstract) 7 refs.

Hanks, David E. (Lochheed-California Co, Burbank, CA, USA); Lee, Marcus C.; Young, Robert C.; Tajima, Yuji A. *SAMPE Q* v 19 n 2 Jan 1988 p 19-28.

## Radiation Effects See Also POLYMERS—Curing.

**080077 ADVANCED COMPOSITE MATERIALS MADE BY RADIATION PROCESSING.** An industrial EB (electron beam) processing line is started in Hungary to produce cement-bound (CB) chipboard with radiation cured acrylic coating. The basic features of this line are presented. The main technological parameters of coating such as the effect of oligomer and monomer reactivity, monomer functionality, dose-rate and inert atmosphere on the curing have been discussed. The EB processed CB board is an advanced composite material for the modern lightweight architecture. (Author abstract) 21 refs.

Czvikovsky, T. (FALCO Timber Co, Szombathely, Hung); Alpar, T.; Czajlik, I.; Takacs, E. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 639-645.

## Structural Design See AIRCRAFT—Computer Aided Design.

## Technology Transfer

**080078 INDUSTRY GROWTH TIED TO TECHNOLOGY, DESIGN INNOVATIONS.** U.S. consumption of every type of lamin te, for all applications, will likely increase by 50 percent or more within the next 10 years. Total laminate usage will reach 10 billion square feet in 1995. About 6.7 billion square feet of low and high pressure laminates were used in panel products manufactured in 1986. During the five-year period from 1982 to 1986, the use of low pressure overlays increased 137 percent as total consumption of vinyl films, light-weight papers, impregnated foils/papers, thermo-fused laminates and hot stamped foils rose from 1.28 to 3.03 billion square feet. Although popularity for solids and patterns is equally split, especially in the kitchen countertop market, the trend is going away from wood grains in favor of textured

styles. The majority of laminates in the home are basic solids and other patterns. Wood grain laminates are still being used in furniture and commercial case goods, but even that is swinging to solids. It is less popular because most designers are becoming purists, and if they want that look, they go for the real thing.

Koenig, Karen Malanud; Christianson, Rich. *Wood Wood Prod* v 92 n 11 Oct 1987 p 67-70, 72.

**Testing See Also COMPOSITE MATERIALS—Fiber Reinforced; PLASTICS, REINFORCED—Aging; PLASTICS, REINFORCED—Carbon Fiber; PLASTICS, REINFORCED—Glass Fiber; PLASTICS, REINFORCED—Mechanical Properties.**

**080079 EXTENSOMETER FOR FRACTURE MECHANICS TESTING OF THIN COMPOSITE LAMINATES.** In fracture mechanics testing of thin reinforced plastic laminates, an important link in the measurement chain is the displacement transducer, which must be capable of measuring crack tip opening displacement (CTOD) and/or allowing evaluation of the J-integral by the unloading compliance method. The lightweight extensometer designed and calibrated by the authors can be used without any specimen knife edges. Highly deformable, it has the advantage of not rigidifying when used on low-stiffness specimens. (Author abstract) 11 refs.

Barbieri, M. (Univ of Firenze, Florence, Italy); Corvi, A. *Eng Fract Mech* v 30 n 1 1988 p 1-4.

## Thermal Effects

**080080 THERMO-VISCOELASTIC RESPONSE OF GRAPHITE/EPOXY COMPOSITES.** The thermoviscoelastic behavior of composite materials is studied analytically using a special finite-element formulation. Numerical results on stress and deformation histories are obtained for both unnotched and notched graphite/epoxy composites subjected to mechanical and thermal spectrum loads. The results indicate that time-dependent effects are important in composites with matrix-dominated layup orientations. Such effects also strongly depend on the specific environment condition and load spectrum applied. (Edited author abstract)

Lin, Kuen Y. (Univ of Washington, Seattle, WA, USA); Hwang, I.H. *J Eng Mater Technol Trans ASME* v 110 n 2 Apr 1988 p 113-116.

**Thermoanalysis See PRINTED CIRCUITS—Thermal Effects.**

## Vibrations

**080081 NONLINEAR VIBRATION OF LAMINATED COMPOSITE PLATES IN HYGROTHERMAL ENVIRONMENTS.** This paper addresses the phenomena of nonlinear vibration of moderately thick laminated composite plates in hygrothermal environments. The shear-deformable plate theory is modified to account for midplane stretching due to large deflections, large rotations, and dimensional and constitutive changes due to moisture-induced swelling effects and temperature-induced expansions and contractions. The in-plane hygrothermal dimensional changes are accounted for by introducing fictitious forces and moments, and the hygrothermal dimensional changes along the thickness of the plate are explicitly incorporated in the assumed form of the deformation field. The free vibration of a cantilevered laminated composite beam in hygrothermal environments is discussed as an illustrative example to demonstrate the applicability of the proposed methodology. (Edited author abstract)

Gandhi, Mukesh V. (Michigan State Univ, East Lansing, MI, USA); Usman, Mohammad; Chao, Luping. *J Eng Mater Technol Trans ASME* v 110 n 2 Apr 1988 p 140-145.



## PLASTICS MACHINERY

**080082 RACIONALIZACE ZPRACOVANI PLASTU POUZITIM PRIDAVNYCH ZARIZENI U VSTRIKOVACICH A VYTACOVACICH STROJU.** [More Efficient Processing of Plastics by Using Auxiliary Equipment in Injection Molding Machines and Extruders]. Pneumatic conveyers, pellet driers, feeders and small mills are dealt with. This equipment is installed in line with injection molding machines or extruders, which improves cost efficiency of its operation. (Author abstract) In Czech.

Mueller, Peter (VEB, Gummiwerke Berlin, Halle/Salle, East Ger). *Plasty Kauc* v 24 n 8 Aug 1987 p 226-230.

**080083 WHO SAYS METER/MIX/DISPENSE IS STILL GARAGE-SHOP TECHNOLOGY?** Computerized control is a major trendline in a broad program of equipment modernization. And new dispensing efficiency is inherent in robotics, multi-component capability, and a variety of other machine upgrades. Among the major trends are: spray gun designs that optimize spray patterns; use of disposable static mixers in delivery nozzles; development of systems to handle more than two-component streams for adding special-purpose additives and new forms of catalysts; use of programmable controllers and microprocessors; for control precision and CIM compatibility.

Smoluk, George R. *Mod Plast* v 64 n 12 Dec 1987 p 65-66, 68-69.

**080084 CLEARANCE OF SHEAR EDGES AND OIL STIFFNESS ON SHORT-STROKE PRESSES.** On short-stroke presses, parallelism between upper and lower tables can be improved and table deflection reduced as compared with conventional presses, thus minimizing wear of the mould shear edges and reducing the material consumption. The effects of important press design features on the tooling and moulded part are discussed in this paper. (Edited author abstract) 4 refs. In German and English.

Franke, R. *Kunstst Ger Plast* v 77 n 11 Nov 1987 p 12-13, 1143-1145.

**080085 SPRITZGIESSWERKZEUG FUER EINEN BEHAELTERVERSCHLUSS.** [Injection Moulding Tool for Container Closure]. This article introduces an injection moulding tool for the base of a pillar-proof three-part closure for tin cans. During its design care had to be taken that the sealing area against the can is outside the parting plane in order to prevent leaks. (Author abstract) In German.

Seres, Ion (Intrepinderea de Mase Plastice Viitorul, Oradea, Rom). *Kunstst Ger Plast* v 78 n 4 Apr 1988 p 316-317.

**080086 EINSTELL- UND VERFAHRENSPARAMETER EXAKT REPRODUZIERBAR.** [Coating and Doubling Unit: Precisely Reproducible Setting and Process Parameters]. Hermann Berstorff Maschinenbau GmbH of Hanover recently presented a combined coating and doubling unit which is designed for a face width of 4500 mm and for a production width of up to 4000 mm. The unit is intended for the production of conveyor belts and drive components, made up of one or more layers of fabric with intermediate and covering layers in thermoplastics, these being primarily plasticized PVC and polyurethane. Multi-layer plastic coatings can be produced in several operations. Over and above this, the unit is basically suitable for producing a wide range of coatings, provided that these are applied to web-type carrier materials, such as loosely and tightly woven fabric, paper, nonwoven fabric, felt, foil and the like. The coating material may be in plastics or elastomer suitable for calendaring. Over and above this, the unit can be used as a doubling machine to bond together two intermediate products at a time into a finished product. (Author abstract). In German.

Anon. *Plastverarbeiter* v 39 n 6 Jun 1988 p 82-84.

**Automation** See Also PLASTICS—Injection Molding; PLASTICS, FOAMED—Processing.

**080087 FULLY AUTOMATIC ARTICLE DEMOULDING AND STORAGE ON INJECTION MOULDING MACHINES.** Within the scope of a larger automation system project, there had been a requirement for a general purpose, flexible production cell design to meet the specifications of an injection moulding shop producing various articles, mostly of large dimensions. To be more precise, these mouldings consist of seating units and dustbin parts. Particular emphasis has been put on achieving labour-saving production lines from handling point of view. (Edited author abstract) In German and English.

Bauer, R. *Kunstst Ger Plast* v 77 n 9 Sep 1987 p 15-16.

**080088 FOR 40-PLUS INJECTION MACHINE BUILDERS, IT'S 'BACK TO BASICS'.** The shift in emphasis from automation to advancements in primary machine engineering reflects what many injection machine manufacturers view as a plateau in control technology. Further control advancement awaits the arrival of artificial intelligence capabilities, or standardization of machine communication protocols. Representative of this possible new stage in electronic maturation is the current affordability, processing power, and programming flexibility of microprocessor-based controllers, now standard on virtually all machines. Moreover, injection molders in diverse industries report that the sluggish implementation of CIM technology in injection molding stems from efforts to optimize machine performance first. This has become especially important to satisfy the demands of just-in-time manufacturing for rapid production of zero-defect parts.

Wilder, Robert V. *Mod Plast* v 65 n 1 Jan 1988 p 44-48.

**080089 FULLY AUTOMATIC PART DEMOULDING AND STORAGE ON INJECTION MOULDING MACHINES.** Various sized production units had to be built for the automation of a complete injection molding shop. The clamping forces of the machines ranged from 1250 to 16,000 kN. On each line a robot demolds the articles from the machine and deposits them in compartments in transport cages. These stand on a conveying system, which also serves as buffer station next to the injection molding machine. The driverless transport system (DTS) takes the full cages away and delivers empty ones to the machine. An additional conveyor belt enables any possible rejects to be sorted out by the handling equipment. Moldings requiring finishing can be picked up from the conveyor belt and deposited in a transport cage after finishing.

Bauer, R. *IPE Int Ind Prod Eng* v 12 n 1 Jan 1988 p 14, 16-17.

**Computer Aided Manufacturing** See PLASTICS—Molds.

**Computer Applications** See PLASTICS—Compounding; PLASTICS, REINFORCED—Reaction Injection Molding.

**Control** See Also PLASTICS—Injection Molding; PLASTICS—Inspection.

**080090 PROGRAMMED AND MICROCOMPUTER CONTROL OF AN INJECTION MOULDING MACHINE.** A locally made injection moulding machine was modified for proportional hydraulic control. Improvements in the control of the parameters including injection speed, injection pressure and injection time had been achieved using a programmable controller (pc), and then by a microcomputer ( $\mu$  c) system. The control systems based on the pc and the  $\mu$  c plus its associated interfacing peripherals are described. (Author abstract) 5 refs.

Leung, T.P. (Hong Kong Polytechnic, Hong Kong); Fung, H.K.; McCall, C. *Hong Kong Eng* v 15 n 7 July 1987 p 31-39.

**080091 FEEDER OPTIONS PROLIFERATE.** The

article focuses on loss-in-weight and volumetric feeders. Many of the suppliers identified also make the well-established belt weighfeeders. Most of the equipment discussed is for continuous feeding, although batchfeeding elements can be included in continuous feeding systems. Loss-in-weight feeders offer a high degree of accuracy, while microprocessor controls and computer-communications links have enhanced volumetric feeder capabilities.

Snyder, Merle (Plastics Compounding, Denver, CO, USA). *Plast Compd* v 10 n 7 Nov-Dec 1987 p 14-16, 18, 20.

**080092 MICROPROCESSOR-CONTROLLED INJECTION MOULDING MACHINES - MODULES FOR BUILDING CIM SYSTEMS.** Injection molding machines whose control devices are based on microprocessor systems fit well into widely differing schemes for automation of production. The precondition for using such systems is that they should be capable of interfacing with higher level computer systems. Individual computer integrated manufacturing (CIM)-solutions incorporating very different partial aspects of CIM can be realized on the basis of flexible transfer protocols. (Edited author abstract) 7 refs.

Matzke, A. *IPE Int Ind Prod Eng* v 11 n 4 Dec 1987 p 10-11, 15.

**080093 FEEDING, METERING, PROPORTIONING COME UNDER TIGHTER CONTROL.** More consistent product quality, faster startup, and improved efficiency are the primary driving forces behind a growing trend to tap computer capabilities in extrusion, compounding, blow molding, injection molding, and other processes. In addition to improved accuracy, microprocessor-based equipment provides the ability to closely monitor materials consumption and to detect problems before they cause downtime. Processors are increasingly custom blending compounds with diverse formulations of virgin pellets, powders, and additives. Computerized control permits precision metering of costly additives, as well as quick startups because of the ability to program and store recipes. Accurate control of ingredients and the ability to record exact levels of material processed are paying off in coextrusion operations, including sheet products and blow molded containers with multiple layers.

Wilder, Robert V. *Mod Plast* v 64 n 11 Nov 1987 p 61-63.

**080094 WHAT'S SPECIAL ABOUT LARGE MACHINES FOR BODY PANELS?** The requirements on a body-panel molding machine are predicated by the materials and parts they are to mold. For one thing, the specialized engineering thermoplastics for body panels demand more critical molding conditions than other resins. Those conditions are made all the more critical by the nature of the parts - large-area, thin-section (and growing thinner all the time), often complexly shaped, and with critical surface appearance and dimensional tolerances. The machinery has to be capable of providing good shot-to-shot repeatability with little scrap. For these reasons, machines serving this market commonly have specialized screws, state-of-the-art controls, and fast-acting hydraulics. Hydraulics and controls need to be tightly coupled, providing varying rates of injection pressure and speed to fill the mold properly.

Fallon, Michael R. (Plastics Technology, New York, NY, USA). *Plast Technol* v 34 n 4 Apr 1988 p 68-71, 73, 75.

**080095 DEVELOPMENTS IN QUALITY IN PLASTICS MANUFACTURE.** Feedback to functions such as Design and Production Control is important to ensure improved manufacturing reliability. With the advent of automated handling and the incorporation of in-line measurement a way has been opened for the exploitation of direct statistical machine control. Advantages include the ability to anticipate out-of-control situations and to apply corrective action before defective products are produced. In tracing the development of machine control towards this goal several stages can be identified. Discrete



controllers were originally used to control processing variables within certain limits; this was followed by the use of tooling control systems involving measurements of variables such as pressures and temperatures of material; practical control systems based on direct component measurement require some form of automated handling of the product. A variety of machines is now available which incorporate the capability of handling and some form of measurement for each component. 6 Refs.

West, George (Huddersfield Polytechnic). *Plast Rubber Int* v 13 n 3 Jun 1988 p 34-36.

**Control Systems** See PLASTICS PLANTS—Quality Control; PLASTICS SHEETS—Sheet Molding Compounds.

## Costs

**080096 INJECTION MOLDING: TRYING TO LIVE UP TO EXPECTATION.** The cost of large-tonnage machinery is causing those with a stake in the market to seek alternatives. Du Pont Co.'s Automotive Products Dept., is experimenting with software that enables it to convert large injection machines for an injection-compression process. Some machinery suppliers are developing innovative alternatives to standard machines with higher productivity at a relatively lower cost in mind. Husky Injection Molding Systems, is developing its Tandem System which uses a third central platen to enable two standard molds to be installed in the machine. It also features a hot-runner system and packing cylinder in the third platen, a means to independently clamp the molds, and a robot for automated parts removal from either mold station. Stubbe GmbH, has developed a twin-station injection molding machine especially for the production of automotive exterior parts. The Giga machinery line is said to double production capacity at less than half the energy requirement.

Fallon, Michael R. *Plast Technol* v 34 n 10 Sep 1988 6p.

## Design

**080097 REFINEMENTS IN TECHNOLOGY SHARPEN COMPETITIVE EDGE.** Quality and efficiency are being improved by better machine designs, a greater use of microprocessors, particularly as control centers, and overall increased automation. Newer software packages are not only multiplying functions but are also monitoring production refinements. The equipment is becoming more user-friendly.

Wigotsky, Victor (Plastics Engineering, Brookfield Cent, CT, USA). *Plast Eng* v 43 n 12 Dec 1987 p 21-26.

**080098 REVIEW OF RECENT TRENDS IN KOBE STEEL'S PLASTIC AND RUBBER MACHINERY.** Kobe Steel's plastic and rubber machinery has developed hand in hand with the rapid advancement of the petrochemical and automobile industries. Machinery progress and improvements made to meet customer requests for higher quality, productivity, energy savings, etc. are reviewed. (Author abstract) In Japanese.

Watanabe, Shozo. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 1-2.

**Dies and Presses** See Also POLYMERS—Injection Molding.

**080099 WENDELVERTEILERWERKZEUGE IN DER ROHRPRODUKTION.** [Spiral Mandrel Distributor Dies for Pipe Production]. The use of spiral mandrel distributor dies allows narrow wall-thickness tolerances to be adhered to during pipe production. A series of three pipe die heads has been laid out to a program developed for this type of tool. The results of the calculations are compared with test data obtained. Moreover, it is shown how a once established geometry can be adapted for dies of larger or smaller diameter. (Author abstract) 3 refs. In German.

Dobrowsky, Josef (Cincinnati Milacron Austria, Vienna, Austria). *Kunstst Ger Plast* v 78 n 4 Apr 1988 p 302-307.

**080100 COEXTRUSIONSWERKZEUGE ZUM HERSTELLEN VON FLACHFOLIEN FUER DEN VERPACKUNGSBEREICH.** [Coextrusion Dies for Manufacturing Flat Films in the Field of Packaging]. With coextruded flat films the melt streams can be fed together by different processes. The different die and adaptor designs necessary for this, as well as the interaction of the two components are described. (Author abstract) 2 refs. In German and English

Reitemeyer, Paul (Reifenhaeuser GmbH, Troisdorf, West Ger). *Kunstst Ger Plast* v 78 n 5 May 1988 p 395-397.

**080101 SMC: DEFENDING CHAMP FOCUSES ON SPEED, CONSISTENCY.** The most dramatic advance in SMC technology has been the introduction of high-speed, short-stroke presses with advanced parallelism and velocity controls that have enabled molders to achieve uniform part thickness within at least 0.005 in. Microprocessor controls on these new presses permit programmed closed-loop velocity control during flow and programmed pressure profiling during curing. The industry is focusing on automating the molding process in an ongoing effort to achieve sub-60-sec part-to-part cycle times. Molders are also working to automate and more carefully monitor the bonding cycle. Several molders have installed, or are preparing to install, sophisticated materials-handling equipment and robotics, including automated charge cutting and weighing units, charge compacting and preheating systems, automatic press loaders and unloaders, robotic deflashing, and fully automated bonding systems, as well as quick-change systems for tooling.

Rogers, Jack K. *Plast Technol* v 34 n 10 Sep 1988 6p.

## Electric Drive

**080102 ALL-ELECTRIC 'CLEAN MACHINES' FIND A HIGH-TECH NICHE.** Injection machines of this type, which are powered entirely by electric servo motors rather than hydraulics, are finding a solid niche in tight-tolerance molding applications, especially those where strict requirements on cleanliness favor an oil-free molding environment. The machines have won quick acceptance from molders of small, tight-tolerance medical, electronic, and optical parts, especially those requiring 'clean-room' conditions. A key advantage of the all-electrics is that they reportedly are more precise than most hydraulic machines. This is attributed to the high accuracy of the ac servo motors and to the elimination of such variables as oil viscosity, oil breakdown, and oil compressibility.

Fallon, Michael R. (Plastics Technology, New York, NY, USA). *Plast Technol* v 34 n 4 Apr 1988 p 90-94.

**Extruders** See Also EXTRUDERS—Design; PLASTICS—Coextrusion; PLASTICS—Extrusion; PLASTICS—Granulation; PLASTICS FILMS—Extrusion; POLYETHYLENES—Extrusion; RUBBER—Extrusion; THERMOPLASTICS—Extrusion.

**080103 COMPOSITE MODELS OF MODULAR INTERMESHING COROTATING AND TANGENTIAL COUNTER-ROTATING TWIN SCREW EXTRUDERS.** Composite models of the flow rate and pressure profiles in modular intermeshing corotating and tangential counter-rotating twin screw extruders are developed. The simulation of the intermeshing corotating machine involves both screw and kneading disc elements, including left- and right-handed sections. The conditions under which starvation behavior develops in sections of the screws are discussed. (Author abstract) 32 refs.

White, James L. (Univ of Akron, Akron, OH, USA); Szydlowski, Witold. *Adv Polym Technol* v 7 n 4 Winter 1987 p 419-426.

**080104 CAVITY TRANSFER MIXER: A BLENDER FOR ALL SEASONINGS.** The Cavity Transfer Mixer (CTM) invented by Dr. G.M. Gale at Rapra Technology Limited, is described as a highly efficient add-on blending device for extruders. The basic theory and development work are described to illustrate the power law relationship which the device achieves in mixing compared with others

achieving only linear relationships. Practical applications are described illustrating the very wide range of uses. These include: achievement of a constant temperature behind the die to give consistent profile, completion mixing using masterbatch, improved electrical properties, reduction of nerve, improved output and direct injection of ingredients. The article concludes with a description of most recent modifications including separately driven CTMs to give maximum mixing efficiency. (Author abstract) 16 refs.

Hindmarch, Ron S. (Rapra Technology Ltd, Shrewsbury, Engl). *Mater Des* v 8 n 6 Nov-Dec 1987 p 331-339.

**080105 NEW COMPOUNDING EXTRUSION OPTIONS.** Inline reduced-bore discharge permits continued use of efficient high-speed twin-screw compounders without as much power consumption or polymer-temperature rise as associated with full-bore discharge. The temperature rise has been lowered by a factor of 2.5. And axial thrust can be reduced by 60 percent, increasing the service life of bearings, gears, and other drive components. Another option, the generation of pressure for melt extrusion by centrifugal force, presents the opportunity for isothermal pelletizing and lower power consumption.

Todd, David B. (Baker Perkins, South Plainfield, NJ, USA). *Plast Compd* v 11 n 1 Jan-Feb 1988 p 33-34, 36-37.

**080106 FUNDAMENTALS OF THE RESIDENCE TIME BEHAVIOUR IN EXTRUDERS.** Residence time behavior, mixing conditions and flow behavior in an extruder influence the product and the product quality. Basic principles of mixing processes for distribution purposes are described. (Edited author abstract) 18 refs.

Schuele, H.; Meder, S.; Mueller, C. *Kunstst Ger Plast* v 77 n 12 Dec 1987 p 32-34.

**080107 PRESSURE BUILDUP IN THE FEED ZONE OF A SINGLE SCREW EXTRUDER - THE EFFECT OF DENSITY COMPRESSIBILITY.** The effect of density compressibility of granular polymerized solids on the pressure development inside the feed zone of a single screw extruder was calculated. Results indicate that, for a given flow rate, density compressibility enhances pressure rise inside the extruder, remedying the underestimation of previous theory. A substantial rise in pressure buildup may result for compressibility above a certain level. This may explain observed surging during the processing of low bulk density materials. (Author abstract) 5 refs.

Sun, Tzu-Hsiung (Nat'l Ping-Tong Agriculture Inst, Ping-Tong, Taiwan). *Adv Polym Technol* v 8 n 1 1988 p 11-15.

**080108 MODELING OF CONTINUOUS MIXERS. PART I: THE COROTATING TWIN-SCREW EXTRUDER.** A simple model is developed for the hot melt closely intermeshing corotating twin-screw extruder. With this model, and more specifically with its extension to the complete nonisothermal, non-Newtonian situation, it is possible to understand the extrusion process and to calculate the energy, specific energy, and temperature rise during the process with respect not only to viscosity of the melt, but also to the screw geometry (location and number of transport elements, kneading sections and blisters, pitch, positive or negative, screw clearance, and flight width) and screw speed. To support the theoretical analysis, model experiments with a Plexiglas-walled twin-screw extruder were performed, in addition to practical experiments with melts on small-and large-scale extruders, with very reasonable results. (Edited author abstract) 46 refs.

Meijer, H.E.M. (Eindhoven Univ of Technology, Eindhoven, Neth); Elemans, P.H.M. *Polym Eng Sci* v 28 n 5 Mid-Mar 1988 p 275-290.

**080109 PERFORMANCE STUDY OF BARRIER SCREWS IN THE TRANSITION.** This paper defines through a mathematical model the advantages and disad-



vantages of barrier screws as far as their melting and mixing performances in the transition zone are concerned. The melting analysis is based on the Tadmor's original model, and the flow in the melt channel is considered to be non-Newtonian and nonisothermal. The performance of these barrier screws is investigated for the solids channel in terms of melting rate/interfacial contact area; melting efficiency; melting length; solid bed velocity profile; and power consumption in the melt film at barrel surface. For the melt channel, their performance is investigated in terms of pressure buildup; average bulk temperature; power consumption in the melt channel and in the main flight clearance at barrel surface; and average bulk mixing. (Edited author abstract) 14 refs.

Amellal, K. (Algerian Inst of Petroleum, Boumerdes, Algeria); Elbirli, B. *Polym Eng Sci* v 28 n 5 Mid-Mar 1988 p 311-320.

**080110 EXPERIENCE IN USING EXTRUDERS WITH GROOVED FEED ZONES.** Extruders with grooved bushes and appropriately designed screw feeds are now the state of the art in high performance extrusion technology. Modifications to the geometry of the bush/screw system or changes in operating conditions need to be carefully tested, as they can bring not only advantages but also disadvantages. Grooved extruders can make an appreciable contribution to economy of production in extrusion processes. In the 20 years or so since the introduction of this process technology it has undergone considerable further development. This has enabled manufacturers to process particular materials, and to make plastics components or finished products with desired properties, to an extent which would not have been possible without grooved extruders. In English and German.

Kraemer, A. *Kunstst Ger Plast* v 78 n 1 Jan 1988 p 3-6.

**080111 DETERMINING THE RESIDENCE TIME BEHAVIOUR IN EXTRUDERS.** Three methods of determining the residence time in plastics extruders are discussed. Some of the topics discussed are inductive measurements; the effects of screw speed and die inlet pressure. Other topics covered include extruder screw geometry; the twin screw performance; incineration of plastics; and plastics density determination. In English and German.

Schuele, H.; Meder, S.; Mueller, C. *Kunstst Ger Plast* v 78 n 1 Jan 1988 p 26-28.

**080112 MELT FLOW IN SCREW CHANNELS.** Finite element analysis (FEM) can be used to calculate and solve problems of fluid mechanics or heat transfer. In this paper, the FEM method is applied to the calculation of flow in screw channels of single screw extruders. The model on which the simulation is based, however, only describes flow processes in completely filled channels; solids transport and phase transition remain unconsidered. Hence this solution is applicable only for the description of transport processes in melt fed extruders and in the metering section of single-screw extruders with multi-zone screws. The advantage of FEM over approximation equations commonly used today is that both the geometry of the screw channel (front flight face angle, flight base radiusing) and material properties can be precisely described. It is not therefore necessary to start from the assumption of a rectangular screw channel and power law behaviour of the melt.

Menges, G.; Limper, A.; Schwenzer, C. *Kunstst Ger Plast* v 78 n 2 Feb 1988 p 34-36.

**080113 'KTX' TWIN-SCREW EXTRUDER.** The 'KTX' series twin-screw extruders were especially developed to satisfy customers' diverse and unique requirements for plastics compounding, complicated process conversions from batch to continuous systems, and simplification of plastics compounding plants. The barrel employs a 'building-block' system and the screw a segment system. The twin-screw is driven by a high-torque high-power drive unit employing a planetary gear reducer mechanism and a multi-tandem thrust bearing. This paper

describes the basic design principles of the KTX, the concepts of kneading and mixing, and applications of the equipment. (Author abstract) In Japanese.

Ikegami, Yoshio; Kishi, Shiro; Akita, Toshiaki; Miyake, Koichi. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 13-15.

**080114 EXTRUSION PERFORMANCE OF 'KOSMELT' MIXING SCREW.** A high-performance screw for a single-screw extruder, 'KOSMELT' has been developed and applied to wire coating, pipe extruding, and film forming facilities. In this paper the features and the excellent performance of the KOSMELT screw are discussed, focusing on its high output, low-temperature resin extrusion, high mixing efficiency, and energy savings, as well as on the mechanism of melting and mixing. (Author abstract) In Japanese.

Kishi, Shiro. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 22-24.

**080115 DER NUTBUCHSENEXTRUDER MUSS UMGEDACHT WERDEN. [Forced Feed Extruder Must Be Reconsidered].** The still common ideas concerning the principle of operation of the grooved bush are dealt with in order to contrast them with a contrary conception. The theoretical analysis of this principle leads to solutions that correctly describe reality. This is supported by experimental results. But furthermore, ways emerge from these solutions of producing increases of 30% to 50% in throughput by a consistent application of this principle. (Author abstract) 9 refs. In German.

Potente, Helmut (Univ-Gesamthochschule-Paderborn, Paderborn, West Ger). *Kunstst Ger Plast* v 78 n 4 Apr 1988 p 355-363.

**080116 COMPARISON OF THE DEGASSING EFFICIENCIES OF SINGLE-SCREW AND TWIN-SCREW EXTRUDERS.** A comparison is made of equipment for removal of low-molecular-weight substances from the molten polymer. Venting zone geometry and degassing methods are discussed. The extruders are compared on the basis of design data. In English and German.

Wobbe, H. *Kunstst Ger Plast* v 78 n 3 Mar 1988 p 6-8.

**080117 ANALIZA PULSACJI CIŚNIENIA W UKŁADZIE UPŁASTYCZNIACYM WYTLACZARKI JEDNOSŁIMAKOWEJ. [Analysis of the Pressure Pulsation in the Plasticizing System of a Single-Screw Extruder].** On the basis of analytical descriptions of mass transport in the feed and dosing zones of a single-screw extruder, the distribution of pressure along the screw pitch has been determined, and the phenomenon of pressure pulsation, as measured at defined points of the cylinder, has been characterized. The causes of pressure pulsation in the extrusion head have been described, and the possibilities of counteraction are outlined. (Edited author abstract) 11 refs. In Polish.

Diakun, Jaroslaw (Wyzsza Szkola Inzynierska, Koszalin, Pol); Sikora, Robert. *Polimery* v 33 n 1 Jan 1988 p 12-15.

**080118 LEAKAGE FLOW OF AN ISOTHERMAL POWER LAW FLUID.** A numerical technique has been developed to accurately determine the leakage flow of a power law fluid in a screw extruder. The effect of the leakage flow on total throughput becomes rather large for small values of the power law index. The contribution of the pressure flow to the leakage flow is considerable, particularly when the flight clearance is large and the power law index small. The velocity profiles in the channel and clearance are strongly affected by the pressure gradient, flight clearance, and power law index. The power consumption in the flight clearance has a large effect on the overall power consumption and energy efficiency, especially for large values of the power law index. 8 Refs.

Rauwendael, Chris (Raychem Corp, Menlo Park, CA, USA); Housz, J.F. Ingen. *Adv Polym Technol* v 8 n 3 Fall 1988 p 289-316.

**080119 ANALYSIS OF THE PERFORMANCE OF COOLING EXTRUDERS IN THERMOPLASTIC FOAM EXTRUSION.** The performance of cooling extruders widely used in thermoplastic foam extrusion was analyzed, by numerically solving the equations of motion and heat transfer. For the analysis, a power-law model was used as the constitutive rheological equation, describing the viscosities of a mixture of a fluorocarbon blowing agent and a low-density polyethylene melt (or polystyrene melt). The parameters in the rheological model were determined using the data of C.D. Han and C.Y. Ma. In obtaining numerical solutions of the equations of motion, an integration method was employed to overcome the problem of numerical instabilities. This study provides a rational basis for the design of cooling extruders widely used in thermoplastic foam extrusion and for the selection of optimum extrusion conditions in producing thermoplastic foams. (Edited author abstract). 18 refs.

Han, Chang Dae (Polytechnic Univ, Brooklyn, NY, USA). *Polym Eng Sci* v 28 n 19 MID-OCT; 1988 p 1227-1239.

## Granulators

**080120 CALCULATION OF THE POWER REQUIRED TO DRIVE ROD-PROCESSING GRANULATORS.** For purposes of the study the total power required to drive the granulator,  $N_g$ , was taken to consist of three components, i.e., the power consumed when not producing anything, viz., the power consumed when idling; the power consumed in extruding the polymer rods and passing them to the cutter, and the power consumed in cutting the rods into granules. With a view to obtaining data for calculating the idling power, granulators in two standard sizes were tested. As a result of processing the experimental results it was ascertained that the idling power can be expressed in terms of the dimensions of the main working part of the granulator, viz., the cutter and its rate of rotation. The power consumed in extruding the polymer rods and passing them to the cutter depends on the kind of material being processed, the design of the extraction system, the degree of pressure exerted by the tensioning drum, and several other factors. The force required to extrude a polymer rod depends on the physical and mechanical properties of the material to be processed, the diameter of the opening in the die, the exit velocity of the melt, and the required diameter of the granules. By using the authors expressions the power required to drive rod-processing granulators can be calculated at the design stage.

Takhtuev, B.G. *Chem Pet Eng* v 22 n 5-6 May-Jun 1986 p 186-187.

**080121 GRANULATORS ARE COMING INTO THE MAINSTREAM - AT AFFORDABLE PRICES.** Typical of the microprocessor controls in use on granulators is the Allen-Bradley SLC 150 programmable controller, which can monitor 19 sensors and transmit 22 signals. Cumberland's microprocessor control package uses thermocouples to monitor heat in the cutting chamber, bed knives, bearings, and evacuation bin. These sensors signal temperatures that could cause granulate meltdown, which can clog the machine and take it out of service. One of the more sophisticated examples of controls linked to a remote computer is the Operatorless System. It comprises a conveyor and parts separator, and an auger granulator with two throat sizes - 8 by 10 in. and 10 by 12 in. Among the controls Polymer Systems offers are two that signal backup in the cutting chamber: a zero-speed switch and an ammeter.

Toensmeier, Patrick A. *Mod Plast* v 64 n 11 Nov 1987 p 81-83.

Hydraulic See Also PLASTICS—Transfer Molding.

**080122 SEALING AND GUIDE SYSTEMS FOR INJECTION MOLDING MACHINES.** It is important that the moving platens on injection molding machines are guided accurately and move without jerking at all speeds. This can be achieved by using modified polytetrafluoroethylene (PTFE) for the sealing- and fabric reinforced



composites for the guide system. The sealing and guide systems described for hydraulic cylinders on clamping units have proved themselves in practical operation. Due to the materials excellent surface slip characteristics and high resistance to abrasion, they achieve service lives many times the service lives of conventional seals. Even after several years in operations, no wear could be found on dismantled piston seals and guides.

Roesler, H. *IPE Int Ind Prod Eng* v 12 n 1 Jan 1988 p 18-19, 22.

## Materials

**080123 USE OF ECONOMICALLY ALLOYED AND NICKEL-FREE STEELS IN POLYMER-PRODUCTION EQUIPMENT.** Inspections of the corrosion state of active equipment and tests of metallic structural materials were conducted at plants involved with the production of low-pressure polyethylene (LPPE), polypropylene (PP), polyvinyl butyryl (PVB), and propylene oxide combined with styrene (POS). The investigations that we conducted indicated that in the production of LPPE the polymerizing reaction vessels can be fabricated from steels 07Kh13AG20, 08Kh18GN2T and 08Kh22N6T without detriment to the reliability and longevity of the production equipment. In the production of PP, series-produced equipment in the zone where the catalytic agent is prepared can be built from steel 08Kh22N6T. In the production of PVB, the nickel-free steel 07Kh13AG20 and the double-layer steel with the 08Kh13 cladding layer can be used in the polymerization stage. In the production of POS, steel 08Kh21N6M2T is recommended for basic equipment. 2 refs.

Lebedev, B.I.; Prudtsovskaya, V.S.; Flerova, N.G.; Chizhenko, D.L. *Chem Pet Eng* v 22 n 7-8 Jul-Aug 1986 p 345-346.

**Mixers** See Also FLOW OF FLUIDS—Mixing; POLYMERS—Mixing; POLYPROPYLENE—Mixing; POLYVINYL CHLORIDE—Extrusion; POLYVINYL CHLORIDE—Mixing.

**080124 RECENT PROGRESS IN CONTINUOUS MIXERS AND PELLETIZERS.** Recent progress in large-size plastic mixing and pelletizing apparatus for the petrochemical industry is presented. A new type of rotor suitable for reducing the mixing temperature of high-viscosity polymer, a mixer (NCM) producing higher dispersivity, and a second type (LCM) for venting applications have been investigated and developed to practical use. Improvements in underwater pelletizers are also described. (Author abstract) In Japanese.

Fukui, Tsugushi; Fukumizu, Shin-ichi; Konno, Masashi. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 9-12.

**Molding Machines** See Also MARAGING STEEL—Research; PLASTICS—Injection Molding; PLASTICS—Molding; PLASTICS PRODUCTS—Computer Integrated Manufacturing; POLYMERS—Injection Molding; POLYPROPYLENE—Degradation; RUBBER—Molding; RUBBER—Processing; THERMOPLASTICS—Molds.

**080125 FASTER DESIGN AND FABRICATION OF PRESS-MOLDS: THE 'EXPRESS-MOLD'.** The new universal modular units developed by the special planning, design, and production-engineering bureau for relay apparatus of the Kiev Production Combine for Relays and Automation Devices for Automatic Thermosetting-Plastics Machines offer several advantages as compared with the familiar widely employed units. The system now contains four blocks, which may be used to produce up to 70% of the plastic parts. Standardized designs of mold inserts have been developed for each block. A fast design system (FDS) has been developed for all types of mold inserts. This has reduced the volume of design effort by a factor of 2-3. Operation of such press molds at the Kiev Production Combine for Relays and Automation Devices has demonstrated their convenience in operation: rapid readjustment, a lighter installation (as against 120-9 kg), less space occupied in storage, more convenience in transportation.

Diner, I.G. *Sov Electr Eng* v 58 n 2 1987 p 108-109.

**080126 DAS HELPS MAINTAIN PRECISION OF INJECTION MOLDING MACHINE.** A data acquisition system is being used by Bell Communications Research Inc. to monitor the critical process parameters of a closed-loop injection molding machine; the machine is used in the study of ultra-high precision injection molding. The process parameters incorporated so far as the screw and clamp position (or velocity), the mold temperature, and the melt temperature. The system is self-contained and portable. The equipment in the system consists of a Compaq 286 transportable computer running ASYST software, a DT-2801 A/D card, and Omega Omni-Amp battery-operated type J thermocouple amplifiers. These and other aspects of the system are discussed.

Kiss, Gabor (Bell Communications Research Inc, Morristown, NJ, USA). *Chilton's I&CS* v 61 n 1 Jan 1988 p 64-65.

**080127 STACK MOULD FOR CAPSULE PRODUCTION.** An injection moulding tool for producing a capsule whose base and lid are connected by an integral hinge, has been designed as a stack mould, in order to utilize the force of the injection moulding machine to the fullest and to achieve high production rates. This paper describes the setting and operation of this mould. (Edited author abstract) In German and English.

Braun, E. *Kunstst Ger Plast* v 77 n 9 Sep 1987 p 8.

**080128 ROBOTS FOR LARGE INJECTION MOULDING MACHINES.** Simple pick-and-place units are increasingly being replaced by free programmable and efficient robots of various designs, when it comes to handling tasks on injection moulding machines. With large machines in excess of 1500 kN clamping force there is the added factor that the mouldings are of considerable weight. Robots therefore need to be solidly constructed. The latest state of the art is described in this paper. (Edited author abstract) In German and English.

Henze, H. *Kunstst Ger Plast* v 77 n 9 Sep 1987 p 13-15.

**080129 KRMILNI SISTEM ISKRA CNC ZA OBDELOVALNE STROJE ZA PLASTICNE MASE ARB D-12.** [Iskra CNC Control System for Injection Molding Machine for ARB D-12 Plastic Masses]. This paper describes the ISKRA CNC Control System for the injection molding machine intended for production of two color footwear. The paper gives the basic characteristics of the machine based on the production technology. Next comes a description of the hardware and software of the ISKRA CNC Control System which performs many complex real time functions. (Edited author abstract) In Slovenian.

Cizman, Anton. *Elektroteh Vestn* v 54 n 4 Aug-Oct 1987 p 255-258.

**080130 SEALING AND GUIDE SYSTEMS FOR INJECTION MOULDING MACHINES.** It is important that the moving platens on injection molding machines are guided accurately and move without jerking at all speeds. How this can be achieved by using modified PTFE for the sealing- and fabric reinforced composites for the guidesystem is explained. (Edited author abstract)

Roesler, H. *Kunstst Ger Plast* v 77 n 12 Dec 1987 p 20-21.

**080131 NEW TECHNOLOGY FOR AUTOMATING DISC-MOLDING CELLS.** The whole movement toward automated disk manufacturing cells has depended on advances in metallizing equipment. What started the ball rolling was the adaptation of traditional batch units to indexing assembly-line type of processing. There are now, or soon will be, available at least five lower-priced metallizers designed specifically for monolines. The article describes three designs from Denton Vacuum, Balzers and High Vacuum Equipment Corp.

Naitove, Matthew H. (Plastics Technology, New York, NY, USA). *Plast Technol* v 34 n 3 Mar 1988 p 63-68.

**080132 NOVA KONCEPE RIZENI**

**VSTRIKOVACICH STROJU.** [Novel Control Concept for Injection Molding Machines]. The plastics injection molding process is analysed and the principles to be observed in a computer control of injection molding machines are established. A new concept is presented for the control of the above process. Though increasing costs of both the injection molding machine and the tool, the concept pays off, particularly in molding intricate products. (Edited author abstract) 6 refs. In Czech.

Trepte, Harry (Vysoka Skola Technicka). *Plasty Kauc* v 25 n 2 Feb 1988 p 33-37.

**080133 L-FORM INJECTION MOULDING MACHINE.** In L-form injection moulding machines, the injection unit is perpendicular to the clamping unit. L-machines consist of well tried and tested modules of an injection moulding machine series with microprocessor control. They are outstanding because of their increased economy. By comparison with comparable injection moulding machines of standard design and the same clamping force, they produce 90% more moulding for only 30 to 40% more procurement cost. Some of the topics discussed include machine lay-out, and two practical examples of mouldings produced on L-form injection moulding machines.

Sonntag, R. *Kunstst Ger Plast* v 78 n 2 Feb 1988 p 9-10.

**080134 MOULD CHANGING SYSTEMS FOR INJECTION MOULDING MACHINES.** This report is intended to describe the current state of the development and employment of mold changing systems. A survey both of machine manufacturers was made. These companies were: AEG, Kassel; Battenfeld Automatisierungsgesellschaft, Meinerzhagen; Ludwig Engel KG, Schwertberg/Austria; Fischer Werke, Tumlingen; Kloeckner Ferromatik Desma GmbH, Werk Maintal; Mannesmann Demag Kunststofftechnik, Schwaig; Maschinenfabrik Netstal, Naefels/Switzerland; Ninkaplast, Bad Salzufen; Preh, Bad Neustadt, as well as further unnamed injection molding firms and machine manufacturers. The article discusses the components of mold changing systems and some criteria for choosing suitable automation concepts. (Edited author abstract) 4 refs.

Benfer, W. *IPE Int Ind Prod Eng* v 12 n 1 Jan 1988 p 32, 34-39.

**080135 RECENT TRENDS IN PLASTIC MACHINERY.** Kobe Steel, Ltd. manufactures various type of plastics pelletizing and molding machinery such as continuous mixers, extruders, and injection and compression molding machines. Recent progress and improvements to these plastics machines are introduced. Requirements for the pelletizing equipment are to increase capacity, reduce energy consumption, and improve product quality. Large-sized injection and compression molding machines which can be controlled precisely shall be developed for users such as the automotive industry. (Author abstract) 4 refs. In Japanese.

Inoue, Kimio. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 3-5.

**080136 KONZEPTE FUER COEXTRUSIONS-BLASFORMANLAGEN.** [Design Aspects of Co-extrusion Blow Moulding Machines]. As a result of the increasingly high diffusion resistance requirements for packaging containers, co-extrusion blow moulding is gaining in importance. After discussing the barrier materials and adhesion promoters used in this process, the author describes the different types of melt distributor and examines various design aspects of co-extrusion blow moulding machines. (Author abstract) 6 refs. In German and English.

Eiselen, Otto (Krupp Kautex Maschinenbau GmbH, Bonn, West Ger). *Kunstst Ger Plast* v 78 n 5 May 1988 p 385-389.



**080137 COMPUTERGESTEUERTES STRECK-BLASSEN VON PET-FLASCHEN IN KLEIN- UND GROSSSERIE.** [Computer-Controlled Stretch Blow Moulding of PET Bottles in Short and Long Runs]. In a plant for stretch blow moulding PET bottles from injection moulded preforms the whole process has been fully automated. The individual units of the stretch blow moulding plant and the process control system are described. (Author abstract) In German and English.

Mank, Manfred (Herniann Berstorff Maschinenbau GmbH, Hanover, West Ger); Hofmann, Willy. *Kunstst Ger Plast* v 78 n 5 May 1988 p 391-393.

**080138 INJECTION MOULDING SURVEY: GETTING THE MACHINE TO SUIT THE WORK.** Manufacturers of injection moulding machines now customize machines to suit individual production requirements. The largest injection machine built so far is an ES3200 with 32000kN clamping force; it will be used to mould refuse containers. A second large machine, coded ES 50000/2000, with two injection units, is producing the heaviest pressure pipe fittings in the world, in polypropylene and HDPE, with shot weights of up to 40Kg. A new programme of multi-color/multi-component machines, running parallel with the NCIII series is based on the typical modular concept. The concept allows for many combinations: horizontal/vertical, parallel/horizontal, horizontal L, or piggyback. All variations can be delivered with or without a rotary table for the mould.

Anon. *Plast Rubber Int* v 13 n 2 Apr 1988 5p.

**080139 DIE FORMFUELLUNG IM VORAUS BE-RECHNEN.** [Injection Capacity of Injection Moulding Machines]. On the basis of the EUROMAP 4 recommendation, it has been possible to develop a measuring process which reliably relates the rate of injection with the melt pressure during the mould filling process of an injection moulding machine, also in the case of machines equipped with servo valves mounted directly on the injection cylinder. Particular reference is made to the necessity to correct inaccuracies of measurement caused by the pressure loss in hydraulic return lines from the injection cylinder. Test readings are utilised for the evaluation of several practical designs of hydraulic systems. (Edited author abstract). In German.

Johansen, Ole; Frederiksen, Lars S. *Plastverarbeiter* v 39 n 5 May 1988 p 122-129.

**080140 PROBLEMLÖSER IN JEDEM FALL?.** [Rapid Mould Changing Systems]. The problem of reducing set-up times in the injection moulding shop cannot be solved by rapid mould changing systems alone. Set-up times can be optimised by proper planning and systematic procedures. Large investments are not necessary. It would be desirable if a limited number of rapid changing systems could be agreed upon and these were in conformity with a specific standard and could be supplied with every make of machine. The initiative, however, must come from the injection moulders themselves. (Author abstract). 5 refs. In German.

Heuel, O. *Plastverarbeiter* v 39 n 5 May 1988 p 130-140.

**080141 NICHT NUR, UM ZEIT ZU SPAREN.** [Automatic Mould Changeover]. Automatic mould changeover on injection moulding machines has been viewed primarily from the time-saving angle to date. The greater comfort and, in particular, safety of the fitter have been of secondary importance. It is precisely the safety factor, however, that should not be forgotten, since the danger of injury whilst undoing the screws is considerable. The chief common features of semi-automatic and fully automatic mould changeover are secure mould clamping, no open-circuit operation of the hydraulic hoses, no mixing up of the heating/cooling lines and no danger of injury. Although the preference is still for the semi-automatic system at present, fully automatic mould changeover will become increasingly established in the wake of the VDMA standardisation committee's work and the associated reduction in costs. (Edited author abstract). In German.

Anon. *Plastverarbeiter* v 39 n 5 May 1988 p 148-149.

**080142 COST-CUTTING ANCILLARY EQUIPMENT-A REVIEW.** Two fundamental factors to consider in evaluating ancillary equipment are: cycle time and part quality. Five areas to look for in such equipment include: mold handling in/around the machine; mold locating in the machine; mold clamping; utility connections; material/color changes. A new range of 'low-tech' mold clamps has been introduced by TEK Machinery Ltd, covering 10-20mm size and with prices starting at just £8.00. Manufactured in hardened steel they are supplied complete with adjustable 12mm hexagonal fixing bolt and jacking screw.

Anon. *Plast Rubber Int* v 13 n 3 Jun 1988 4p.

**080143 HOT COMPETITION AMONG BUILDERS; BETTER DAYS FOR BLOW MOLDERS.** With 30 or so machinery makers vying for U.S. business, and with markets aching to be opened, blow molding equipment of every kind is undergoing transformation that is resulting in increased performance capabilities (some of them startling), faster cycles, and greater reliability. In all types of blow molding equipment, the trend is toward more advanced control systems and more automation. To make better use of advanced controls, builders are engineering in such refinements as smoother operating proportional hydraulic systems for mold clamping, clamp systems that handle heavier molds, increased sophistication in multilayer systems, and techniques for molding complex shapes with a minimum of scrap.

Smoluk, George R. *Mod Plast* v 65 n 8 Aug 1988 p 50-52, 54, 56.

**080144 BLOW MOLDING CONTROLS BEGIN TO MAKE CIM A MORE LIKELY PROSPECT.** An important factor fueling the drive for increased controls sophistication is growing interest in applying plantwide networking, statistical process control (SPC) automation, and flexible manufacturing cells to blow molding. A fundamental baseline for such advanced concepts is a system that can track machine performance, adjust for process variations, report QC parameters to a central computer, and perform other computer-integrated manufacturing functions. The drive to manage more blow molding process variables from a single interactive control unit is gaining momentum for a number of reasons. One is growing interest by blow molders in computer-integrated manufacturing techniques, which are drastically simplified by plugging into a single control unit that tracks more of the CIM-relevant functions of machines. Networking of blow molding plants is technologically at an early stage, but it can have a dramatic effect on bottom-line production performance.

Sneller, Joseph A. *Mod Plast* v 65 n 8 Aug 1988 p 57, 60, 62.

**080145 FUER SCHWERE WERKZEUGE UND HOCHWERTIGE FORMTEILE.** [Large Injection Molding Machines for Heavy Molds and High-Grade Moldings]. Krauss-Maffei Kunststofftechnik GmbH (Munich) offers a new series of injection molding machines. These M-series machines cover the clamping force range from 10,000 kN to 36,000 kN. Eight clamping units and seven injection units of the same design principle are available as modules. The characteristic features of these large-scale machines are short cycle times, short setting up times, user-friendliness, energy-saving, low-noise and suitability for the heaviest of molds. In the new type of clamping system the clamping force is introduced into the moving platen via four pressure columns. This design solution also leaves enough space between the platen for a wide range of ejector systems. The clamping cylinder is also of a new design. The clamping force is built up via a tandem cylinder, whereby two work surfaces arranged in series permit a considerably reduced cylinder diameter. (Edited author abstract). In German.

Anon. *Plastverarbeiter* v 39 n 6 Jun 1988 p 14-16.

**080146 ANALOGIEN ZWISCHEN DUROPLAST -**

**UND ELASTOMERMASCHINEN.** [Injection Molding Machines for Crosslinking Molding Compounds: Analogies Between Thermoset and Elastomer Machines]. The injection molding process now occupies an established place in the production of thermoset and elastomer molded parts. It has considerable advantages compared with the traditional compression molding and transfer molding processes, particularly when it comes to the scope for automation. The process sequence and hence machine and mold engineering are very similar for thermosets and elastomers. A non-crosslinked molding compound must be plasticized and metered 'cold' without the crosslinking reaction commencing. Following this, the molding compound is injected into a heated mold in which the crosslinking or vulcanization reaction proper takes place. The moldings can then be demolded while still hot. A more detailed observation of the individual functional units of an injection molding machine will reveal certain differences between elastomer and thermoset machines. The essential criteria to be borne in mind when selecting a machine are explained in this report. (Edited author abstract). 1 Ref. In German.

Reichstein, Helmuth. *Plastverarbeiter* v 39 n 6 Jun 1988 4p.

**080147 APPLICATION OF A MICROCOMPUTER TO THE CONTROL OF AN INJECTION MOULDING MACHINE.** This paper reports a project that modified a locally made reciprocating injection moulding machine for microcomputer control. The microcomputer control system and its associated interfacing peripherals with the machine are described. The software including the control and interactive programs is written in assembly language for the sequence control of the machine and the closed-loop control of the injection speed. (Edited author abstract). 5 Refs.

Leung, T.P. (Hong Kong Polytechnic, Hung Kom, Hong Kong); Fung, H.K.; McCall, C. *Comput Ind* v 10 n 2 Jul 1988 p 123-136.

## Pumps

**080148 GEAR-PUMPS IN EXTRUSION.** This paper covers the design of gear pumps and their applications in plastics extrusion. Some of the topics discussed are the mechanical assembly, pump delivery rate, extrusion system optimization criteria, and energy conservation of gear pumps. In English and German.

Bolder, G.; Langhorst, H. *Kunstst Ger Plast* v 78 n 1 Jan 1988 p 6-10.

Repair See PLASTICS—Extrusion.

Scheduling See PLASTICS PLANTS—Personnel.

## Temperature Control

**080149 CHILLERS GEAR UP FAST FOR THE INTEGRATION CONNECTION.** Advantage Engineering is a major source of mold temperature controllers (water and oil) and chillers (portable and central). The Intellitemp microprocessor temperature controller is an intelligent programmable controller that incorporates dual digital displays, programmable alarms and self-diagnostics. Any of three microprocessor control types are available on Advantage's portable chillers: simple solid state, Checkmate anticipating diagnostic controller, and Precision controller. Conair's contributions to the automation connection include mold temperature controllers and chillers with optional computer-compatibility. Among them are Thermolator mold temperature controllers. A computer-compatible microprocessor-based control, Compumate 3400, is a new addition to Mokon's temperature controllers. Sterling, Inc. reports that the basic operator-set unit remains the backbone of its mold temperature controller line.

Smoluk, George R. *Mod Plast* v 64 n 11 Nov 1987 p 74-76.



## Tools, Jigs and Fixtures

**080150 ATTACHING HEAVY MOLDS TO LARGE INJECTION MACHINES.** Mammoth machines and molds for automotive body panels require special procedures for secure mold mounting. DuPont has established internal standards and procedures to ensure satisfactory clamping/support of molds. The procedures include: mold acceptance; pre-mold installation; mold transportation; mold clamping; jack block support; overhead support; mold installation; mold removal.

Coleman, R.C. (DuPont Co); Masters, S.G. *Plast Technol* v 34 n 4 Apr 1988 p 78-81.

## Wear

**080151 DAMAGE OF THE WORKING ORGANS OF EXTRUDERS IN THE PROCESSING OF PLASTICS.** In order to gain actual data on the distribution of wear along the working organs, to establish the zones of maximum damage, and to determine the kind of wear in the different zones, the authors investigated the extruders in several plants. The investigations included checking of the diameters of the worm turns and depressions in every working zone; the width of the turns at the crest and at the base was measured with a micrometer, and the internal diameter of the bushings with dial inside calipers. It is found that the most efficient way of hardening of the working organs is the application of thick coatings by means of different welding or atomization processes; in comparison with nitriding, it provides a multiple increase in wear resistance. The main advantage of such coatings is their relative thickness (2-3 mm) and uniformity of mechanical properties (hardness, strength) across the layer; this allows us to exploit fully the wear tolerances during exploitation. The use of wear-resistant parts in extruders has improved their reliability and increased the unit capacity and productivity. 4 refs.

Zverlin, V.G.; Gladchenko, A.N.; Sazonov, V.V. *Chem Pet Eng* v 22 n 9-10 Sep-Oct 1986 p 445-449.

**080152 WEAR TESTS OF PLASTIC PROCESSING MACHINES BY MEANS OF KRYPTON-85-METHOD.** Since 1979 the Tisza Chemical Works and the Institute of Isotopes of the Hungarian Academy of Sciences have carried out wear tests by means of radioisotopes in order to find the wear characteristics and the expectable endurance of plastic processing tools and extruders. Authors briefly introduce the krypton-85-method for wear tests and the experiences gained by this method. In this research work the wear-rates of different kind of tools were compared as a function of the material processed. In the tests two type of plastic were processed: plastics without any ingredients (i.e. natur) and plastics containing different ingredients (i.e. composites). (Author abstract)

Szili, S. (Hungarian Acad of Sciences, Hung); Varkonyi, A.; Molnar, I.; Volk, J. *Muanyag Gumi* v 24 Special Issue 1987 p 1-4.

**PLASTICS PLANTS** See Also PLASTICS—Recycling.

**Automation** See Also BIOMEDICAL EQUIPMENT—Plastics; POLYMERS—Processing.

**080153 CHANCE UND HERAUSFORDERUNG FUER DIE KLEINEN. [Flexible Production].** Automation, rationalisation and material flow planning are vital factors, particularly when it comes to small and medium-sized plastics processing companies. The reason for this is that specialist suppliers are being increasingly tied into the purchasing and materials management schedules of the large companies. The trend towards the division of labour in production is prompting the large companies to increasingly delegate their own production out-of-house. Much of the responsibility is passed to the supplier company as well. The prerequisite here is controlled quality on the basis of guaranteed standards. Over and above this, minimum response times are also required, even for special-purpose designs. Finally, growing impor-

tance is coming to be attached to a precisely defined rastered depositing and stacking of components and assemblies, since customer companies are making increased use of robots in further processing. (Author abstract). In German.

Bauer, Reinhard. *Plastverarbeiter* v 39 n 5 May 1988 p 162-166.

**080154 SCHRITT FUR SCHRITT ZU MEHR QUALITAT. [Automation of Manufacture: Step by Step to More Quality].** Small and medium-sized manufacturing companies are finding themselves under increasing pressure to be more flexible. This applies particularly to series producers who work on the basis of time numbers, as in the injection molding sector, where customers are calling for increasingly small batch sizes within increasingly short deadlines on the basis of the 'just-in-time' principle. Competition is forcing companies to implement thorough rationalization measures, i.e. to improve their entire organizational and production engineering infrastructure by means of computer-aided automation systems. This report describes how a computer system for capturing and processing production data brought about a marked improvement in the quality and flexibility of production in an injection molding company after only a short time. (Author abstract). In German.

Anon. *Plastverarbeiter* v 39 n 6 Jun 1988 p 44-46.

**Computer Aided Manufacturing** See Also PLASTICS INDUSTRY—Computer Aided Manufacturing.

**080155 COMPUTER SIMULATION SYNERGIZES DESIGN, MOLD BUILDING, PROCESSING.** The message coming clear to more processors is that computer-aided design, engineering and manufacturing takes the costly and time-consuming trial-and-error out of designing components and molds. The shorter lead times that result also provide the mobility needed to meet competitive challenges. (Author abstract)

Wilder, Robert V. *Mod Plast* v 64 n 10 Oct 1987 p 52-54, 56.

**080156 INTRODUCTION OF UP-TO-DATE CAD/CAM TOOL PRODUCTION AT VSZM.** In the present 5-year plan-period the development of the tool production is one of the objectives of the company. The company wishes to reach her objectives of shortening the tool production period, the increasing of the quality and durability as well as the objective of increasing the productivity by the introduction of CAD/CAM system and by the starting up of further up-to-date high-performance CNC machines. The method which is established at VSZM is formulated in such a way that the introduction of CAD/CAM is to be realized with the least possible complications and losses. It is based on the existing limited hardware, and with the extensions of the users softwares and their development and practical use it trains the personnel for the application of CAD/CAM. 3 refs.

Zajtai, Csaba (Villamosszigetelo-es Muanyaggyar, Budapest, Hung). *Muanyag Gumi* v 24 Special Issue 1987 p 17-20.

**Computer Applications** See PIPE, PLASTIC—Manufacture; PLASTICS—Compounding; PLASTICS—Manufacture.

**Computer Integrated Manufacturing** See Also PLASTICS—Molding; PLASTICS MACHINERY—Control.

**080157 CIM COMPOUNDING AND PROFILE EXTRUSION.** A description is given of a new state-of-the-art PVC compounding and profile extrusion plant that features fully computer-integrated manufacturing (CIM). From bulk handling through finished profile, everything is under the control of automated subsystems that report to a central computer. The compounding part is basically a totally enclosed menu-driven electronic system making it possible to achieve a high level of quality as well as productivity.

Anon. *Plast Compd* v 11 n 5 Jul-Aug 1988 p 32-33.

## Control Systems

**080158 ACHIEVING HIGH-AVAILABILITY BATCH CONTROL.** A plastics manufacturer achieves 99,999 percent statistical availability while working with 150 different batch recipes using a triple redundancy controller - avoiding production losses from unscheduled trips (with costs of an unscheduled trip running as high as 250,000 dollars). (Author abstract).

Lengyel, Larry (Bonar August Systems, Tigrad, CA, USA). *InTech* v 35 n 8 Aug 1988 p 47-48.

**Costs** See PLASTICS—Decoration; PLASTICS—Molds.

**Design** See PLASTICS—Reaction Injection Molding.

## Energy Management

**080159 GOSPODARKA ENERGETYCZNA W ZTS 'GAMRAT-ERG'. [Energy Management at 'Gamrat-Erg' Plastics Works].** Developments of heat power engineering at the works from manually-fired boilers to the boilers with coal-slinger furnaces is presented. Industrial and potable water supply and treatment problems as well as topics of electric power supply are discussed. The results of implementation of the energy management improvement program is given. (Edited author abstract) In Polish.

Fortuna, Wladyslaw. *Przem Chem* v 66 n 3 Mar 1987 p 135-136.

## Environmental Impact

**080160 PROBLEMY DOTYCZACE OCHRONY SRODOWISKA. [Environment Protection].** Environmental protection problems, which have emerged along with the development of 'Gamrat-Erg' Plastics Works, are presented. Projects under way to protect the environment near the works are also discussed. (Author abstract) In Polish.

Pawlus, Jan; Wiatrak, Maria. *Przem Chem* v 66 n 3 Mar 1987 p 136-137.

**Equipment** See CHEMICAL EQUIPMENT—Reactors; POLYETHYLENES—Blending.

**Flexible Manufacturing Systems** See PLASTICS MACHINERY—Automation.

## Fume Control

**080161 CLEAN UP YOUR ACT WITH FUME INCINERATION SYSTEMS.** There are basically four types of fume incineration systems, all of which incorporate thermal oxidizers that destroy VOC's by high-temperature conversion of hydrocarbon-laden fumes to harmless water vapor and carbon dioxide. While all the various types of systems have acceptable cleanup efficiencies, each system is different in theory of oxidation and cost of operation; each has its own benefits and drawbacks. The purpose of this article is to illustrate the differences between incineration systems, and to provide examples of current installations. The four types of systems are: common afterburner; catalytic converter; recuperative thermal oxidizer; and the regenerative thermal oxidizer. Each is described from the equipment, cost, and performance points of view.

Renko, Ronald (Huntington Energy Systems Inc, Union, NJ, USA). *Plast Technol* v 34 n 7 Jul 1988 p 71-74.

**Management** See PHONOGRAPH RECORDS.

## Personnel

**080162 TECHNICAL NOTE: OPTIMAL MAN-POWER ASSIGNMENT TO INJECTION MOLDING MACHINES.** The Corporate Operations Research group and Plant Industrial Engineering department decided to develop a computer system that would group machines and assign them to operators in order to minimize the total operators required to attend all injection molding machines. Among the requirements of



the computer system were: the system must be executable on the plant computer hardware; the system should allow quick response to handle unexpected changes; the system should have the flexibility to vary the maximum travel distance among machines assigned to an operator, and the maximum number of machines that can be assigned to an operator; and the system should allow the user to assign operators.

Chen, Jack (American Airlines, Dallas, TX, USA); Saxena, Umesh. *Ind Manage (Norcross GA)* v 29 n 6 Nov-Dec 1987 p 31-33.

**Quality Control** See Also PLASTICS—Extrusion; PLASTICS MACHINERY—Control.

**080163 ON-LINE QUALITY CONTROL FOR IMPROVED COMPOUNDING.** Technological aspects of most compounding operations have now reached generally accepted, if not optimal, levels of precision. For this reason, research aimed at improving product quality and lowering production costs now centers on quality-control methods. The primary function of quality control in a compounding operation is the integration of pertinent process data with a feedback control system. Effective quality control reduces start-ups and shutdowns and therefore helps minimize creation of waste and non-standard material. This result is especially important to those who process a variety of plastic materials.

Dreiblatt, Adam (Werner & Pfleiderer Corp, Ramsey, NJ, USA); Herrmann, Heinz; Nettlinbreker, Hans-Jurgen. *Plast Eng* v 43 n 10 Oct 1987 p 31-34.

**080164 JUST-IN-TIME IN THE PLASTICS PROCESSING INDUSTRY.** This paper reviews the applicability of just-in-time concepts to the plastics processing industry focusing on three specific areas: quality management, technological requirements, and raw material purchasing practices. Plastics processing is inherently batch oriented, due to the time required to stabilize the molding process. Just-in-time is generally thought to apply to repetitive rather than batch processes. The authors found that a number of just-in-time concepts are quite applicable to plastics processing. (Author abstract) 15 refs.

Richmond, Lee E. (Conwed Plastics, Minneapolis, MN, USA); Blackstone, John H. Jr. *Int J Prod Res* v 26 n 1 Jan 1988 p 27-34.

**080165 GELPERMEATIONSCHROMATOGRAPHIE IN DER QUALITAETSICHERUNG.** [Gel Permeation Chromatography in Quality Control]. Gel permeation chromatography provides quantitative information on average molecular mass and molecular mass distribution; in plastics processing it can be used to monitor the quality of both the starting material and the finished articles. Taking PA, PC, and PES as examples, it is shown how gel permeation chromatography can be used to measure thermal degradation caused during processing, and the effects of incorporating reinforcing agents or adding reclaimed material. (Author abstract) 6 refs. In German and English.

Furth, Brigitte (Fochhochschule Wuerzburg-Schweinfurt, Wuerzburg, West Ger); Riedelbauch, Heinz. *Kunstst Ger Plast* v 78 n 5 May 1988 p 420-423.

## Robot Applications

**080166 WHAT'S AHEAD IN ROBOTS.** Robots for molded parts removal and other plastics applications, while still used by a minority of plastics processors, no longer carry an exotic 'high-tech' aura, but are gradually taking their place among other types of auxiliary equipment. Vendors are easing maintenance by reducing the number of parts, integrating controls with those of primary processing machines, and making robots faster with more powerful microprocessors.

Fallon, Michael (Plastics Technology, New York, NY, USA). *Plast Technol* v 33 n 11 Oct 1987 p 71-75.

**080167 PROCESSORS TAKE A SECOND, HARDER LOOK AT ROBOTS.** The learning curve for

robots is rising as processors deploy these tools to boost quality and productivity and not to trim labor costs. Reports from diverse processors show that a few such companies now find robots to be an effective weapon in the battle to retain and increase their share of the expanding worldwide market for plastics goods. Far from serving as a type of electromechanical labor substitute that works for lower pay, robots can provide: reduced reliance on disappearing low-cost unskilled labor; improved product quality with more consistent processing and handling of components; increased productivity through repeatability, accuracy, accelerated production, and integration with downstream operations; and the flexibility to meet changing manufacturing requirements.

Wilder, Robert V. *Mod Plast* v 64 n 8 Aug 1987 p 48-51.

**PLASTICS PRODUCTS** See Also PACKAGING MATERIALS—Plastics; POLYMERS—Industrial Applications.

**080168 LARGE PLASTIC PARTS ARE MAKING IT BIG.** The long-term goal of plastics to replace metals in diverse large-part markets is now more in sight than ever. Process-oriented material refinements and a widening range of processing choices are increasingly making designing with plastics the logical approach for reliable, attractive, and cost-efficient large parts. This is illustrated in this paper by a number of examples. (Edited author abstract)

Wigotsky, Victor (Plastics Engineering, Brookfield Cent, CT, USA). *Plast Eng* v 43 n 5 May 1987 p 17-26.

**080169 TALC-FILLED POLYPROPYLENE KITCHEN DRAWERS.** Drawers for kitchen furniture are produced in six different widths from 250 to 550 mm at a length of 435 mm and a height of 79 mm. The material is a 20% talc-filled, easy-flowing antistatic polypropylene homopolymer, tradename Hostalen PPX 694, manufactured by Hoechst, Frankfurt. The box drawer's wall thickness is 2 mm and the inherent weight is between 360 and 750 g. Permissible loading is given as 5 N/dm<sup>3</sup> and appropriate total loads are stated as being between 13 and 94 N/unit. Some of the topics discussed are injection molding, material rigidity, noise development, and resistance to chemicals.

Schmidt, H.; Izquierdo, R. *Kunstst Ger Plast* v 78 n 2 Feb 1988 p 25.

**Abrasion Resistance** See PAPERMAKING MACHINERY—Fourdrinier Machines.

**Applications** See IRRIGATION CANALS—Stability; POLYIMIDES—Mechanical Properties; POLYMERS—Compounding; POLYPROPYLENE—Production.

## Assembly

**080170 ULTRASONICS & MICROPROCESSORS TEAM-UP FOR EFFICIENT ASSEMBLY.** Ultrasonic assembly is a fast, clean and efficient method for assembling or processing rigid thermoplastic parts or films and synthetic fabrics. Various ultrasonic assembly techniques are used by all segments of industry to join plastic to plastic and plastic to metal parts or other nonplastic materials thereby replacing or precluding the use of solvents, adhesives, mechanical fasteners, or other consumable items. The article discusses how recent advances in controls for ultrasonic processes have greatly improved their capabilities, versatility and precision. Subjects covered include how ultrasonic assembly works, processes, joint design, equipment, and others.

Barmmer, Bonnie (Branson Ultrasonics Corp). *Assem Eng* v 30 n 11 Nov 1987 p 40-44.

**080171 FLEXIBLE AUTOMATION OF ASSEMBLY.** International competition has forced companies to work towards maintaining their positions to a far greater extent than ever before. The competition is essentially marked by the necessity of adapting to changing market needs, frequently linked to small batch size and uncertainty regarding the number of items required. From the

production angle, this means flexibility in production and flexibility in assembly. (Edited author abstract) In German and English.

Muno, H. *Kunstst Ger Plast* v 77 n 9 Sep 1987 p 12.

**Coatings** See POLYURETHANES—Molding.

**Computer Aided Design** See Also PLASTICS PLANTS—Computer Aided Manufacturing.

**080172 ANWENDUNG VON CAD/CAE BEIM AUSLEGEN EINES FORMTEILS AUS POLYACETAL.** [Application of CAD/CAE in Designing a Polyacetal Model Part]. Along with the penetration of plastics into areas which so far have been reserved to other materials, especially metals, the amount of work connected with the design and development is increasing. As an example of technical calculations involving the use of a computer, the stresses and deformations occurring in a molded part, namely a fastener clip for the automobile industry, are determined. (Edited author abstract) In German. 2 refs.

Hess, J.; Eiden, G. *F&M Feinwerktech Messtech* v 95 n 6 Sep-Oct 1987 p CA122-CA124.

**080173 USE OF CAE IN THE DESIGN OF PLASTICS COMPONENTS.** This paper covers the application of computer aided engineering in the design of plastics components. Some of the topics discussed include: computer aided design; cost reduction; reduced product development time; and improved product quality. Other topics covered are: data generation and interpretation; processing of geometrical data; data records handling; finite element method network as well as rheological, thermal and mechanical design.

Schmidt, J. *Kunstst Ger Plast* v 78 n 2 Feb 1988 p 3-8.

**080174 COMPUTER-AIDED MOLD AND DIE DESIGN.** The properties of plastics parts depend not only on the particular resin used, but also to a great extent on how it is processed. Accordingly, the flow properties of the thermoplastics to be employed must already be considered when designing the molds and dies and setting the processing conditions. The rheological behavior of plastic melts is strongly dependent on the processing conditions encountered. For the past several years, computer programs with which the flow phenomena in molds and dies can be simulated have been increasingly developed and put into practice. For these reasons, the design of new tooling should always be accompanied by computer-aided analysis. Utilizing known or assumed processing data and given tool geometry along with material data, suitable programs can be used to design or optimize molds or determine better processing parameters from the results of the calculation.

Hess, J.; Eiden, G. *Kunstst Ger Plast* v 78 n 2 Feb 1988 p 8-9.

**Computer Aided Manufacturing** See NYLON POLYMERS—Reaction Injection Molding; PLASTICS—Injection Molding.

## Computer Integrated Manufacturing

**080175 MICROPROCESSOR-CONTROLLED INJECTION MOULDING MACHINES - MODULES FOR BUILDING CIM SYSTEMS.** The realization of CIM (computer-integrated manufacturing) in injection molding operations places new demands on the machines: these are explained in terms of three basic features of automated production. One essential feature can be inferred from the term itself: integrated manufacturing requires all areas related to production to be connected together in the interests of problem-free exchange of information. A second characteristic of current CIM activity is step-by-step introduction of systems, by means of which individual areas of an operation are covered one after the other. The third aspect is the obvious fact that each CIM system must be designed quite individually for the circumstances of a specific operation. 7 refs.



Matzke, A. *Kunstst Ger Plast* v 77 n 8 Aug 1987 p 9-11.

**Defects** See PLASTICS SHEETS—Sheet Molding Compounds; POLYVINYL CHLORIDE—Processing.

**Design** See PLASTICS—Blow Molding; PLASTICS SHEETS—Coextrusion; POLYSTYRENES—Production.

**Disposability** See PACKAGING MATERIALS—Plastics.

**Electric Properties** See PLASTICS—Antistatic Agents.

**Environmental Impact** See WATER POLLUTION—Mediterranean Sea.

## Failure

**080176 ASPECTE METODOLOGICE IN DETERMINAREA DURATEI DE VIATA IN FUNCTIONARE A MATERIALELOR PLASTICE.** [Methodological Aspects in the Determination of Service Life of Plastic Materials]. The paper estimates the level of knowledge in the field of service life evaluation in order to make a correlation among: 1) the nature and the intensity of the stresses; 2) the assessment of the properties; 3) the failure criterion (f.c.). For polymers presenting the yielding point on the tensile curve, the following f.c.s. are being advanced based on the analysis of the experimental data: a) the loss of the deformation capacity in the oriented state; b) the appearance of the brittle fracture replacing the ductile one. The choice of one f.c. or another is to be done according to practical, operational requirements. (Author abstract). 14 Refs. In Romanian.

Goldenberg, Niuma; Sebe, Mircea Octavian; Memetea, Tatiana; Banica, Gabriela. *Mater Plast Elastomeri Fibre Sint* v 25 n 1 Jan-Mar 1988 p 37-43.

**Human Factors** See BOTTLES—Plastics.

**Injection Molding** See Also PLASTICS MACHINERY—Molding Machines.

**080177 INJECTION MOULDING TOOL FOR BRUSH HANDLE PRODUCTION.** The molding to be produced is the handle of a ceiling brush, designed to meet technical and practical specifications. A nuckel signed thread has been chosen for screwing the handle into the wooden body of the brush, a hook on one side allows it to be suspended in a bucket when required and two holes on either side take a piece of string by which the brush can be hung up. The surface of the handle is grooved longitudinally and crossways in order to prevent the hand from slipping during use. Polyamide is used as molding material for the handle.

Seres, I.; Oradea, Romania. *Kunstst Ger Plast* v 77 n 8 Aug 1987 p 5.

**Manufacture** See Also POLYETHYLENES—Low Density; POLYVINYL CHLORIDE—Film; ROBOTS, INDUSTRIAL—Applications.

**080178 CALIBRATION OF HIGH PRESSURE POLYURETHANE METERING UNITS WITH A COMPUTER CONTROLLED CLOSED LOOP CALIBRATION UNIT.** Production of quality polyurethane parts using high pressure impingement mixheads require reactants to be delivered to the mixhead at precisely controlled temperature, pressure and flow rates. Manual calibration of metering system flows and temperatures have been a time consuming procedure which leads to wasted chemicals, and chemical disposal expenses. Also, the accuracy of manual calibration is dependent upon the skill and care of the calibrating technician. There are basically two approaches to reducing chemical wastes, potential for worker exposure and technical errors: flow meters and closed loop weighing systems. This paper describes a 'State of the Art' weight based closed loop calibration system and compare its operation to manual calibration and flow meters.

Maytag, S.H. (Mobay Corp, Pittsburgh, PA, USA). *J Cell Plast* v 23 n 3 May-Jun 1987 p 240-247.

**080179 STAMPED METAL PARTS FOR EMBEDDING IN PLASTIC ARTICLES.** Rounded metal parts for embedding in plastics, e.g. threaded inserts, have been extensively described. Such parts are simple and cheap to make, and they can be incorporated either in an injection moulding process, by injecting the plastic around them, or by retro-fitting into mouldings, e.g. by ultrasonic techniques. In contrast to such parts as these, this article deals with parts which are flat or only slightly shaped, and are made by die-stamping of sheet metal or strip steel, then anchored into plastic mouldings. In all cases the metal parts are attached to the plastic in such a way that they cannot be pulled out.

Strasser, F. *Kunstst Ger Plast* v 78 n 2 Feb 1988 p 26-27.

**080180 ORIENTATION TECHNOLOGY AND COMMERCIAL PRODUCTS FROM A UNIQUE ROLL ORIENTATION PROCESS.** Orientation can produce, at a minimum, an order of magnitude improvement in physical properties of low cost plastic resins. A unique, large-scale, commercial rolling mill process for continuous orientation of plastic sheet has been developed. A number of oriented materials have been commercially produced by this rolling mill process with a wide variety of physical properties attained. This has resulted in large volume sales of many interesting commercial products. Over the last thirty years, numerous researchers have conducted studies to evaluate the theoretical aspects of the rolling process, and the resultant properties. Most commercial oriented products are of relatively small cross sectional size such as fibers and film. The process reported herein produces heavy cross section oriented sheet. A new class of high strength thermoplastic materials is now available for design engineers to use. Long-term strength properties are often 10 to 100 times better than with unoriented thermoplastics. (Edited author abstract).

Gould, Russell J. (ITW High Performance Plastics, Glenview, IL, USA). *Polym Eng Sci* v 28 n 13 mid-July 1988 p 857-861.

**Marketing** See PLASTICS INDUSTRY.

**Mechanical Properties** See Also POLYETHYLENE TEREPHTHALATE—Extrusion; POLYETHYLENES—Crosslinking.

**080181 IMPACT PROPERTIES OF MOLDINGS OF RIGID POLYURETHANE MADE BY RIM.** Impact properties of moldings made by Reaction Injection Molding (RIM), which are integral-skin foams and have sandwich structures consisting of high density skin and low density core layers, were investigated by Charpy impact tests. A remarkable difference in failure mode was observed depending upon the layer composition. The failure modes were classified as: tensile fracture-type, and buckling fracture-type. The Charpy impact value of the buckling fracture-type became over two times greater than that of the tensile fracture-type. In addition, the layer composition at which the fracture mode changes from the tensile fracture to the buckling fracture was predicted by using the static flexural properties of the moldings at comparatively low temperatures and the reciprocity law of time-temperature. (Edited author abstract) In Japanese. 12 refs.

Iida, Makoto (Hitachi Ltd, Yokohama, Jpn); Miyano, Yasushi; Gotoh, Masao. *Zairyo* v 36 n 407 Aug 1987 p 866-870.

**080182 CRITICAL EVALUATION OF STRESS CRACKING TESTS OF BLOW MOULDED ARTICLES.** Stress cracking tests and evaluation of the results for blow-molded plastics are covered. Some of the topics discussed include the effects of atmospheric pressure, and temperature on the test results; and the reproducibility of the measurements. In English and German.

Evenson, L.H.; Syre, A. *Kunstst Ger Plast* v 78 n 1 Jan 1988 p 24-25.

**Metallizing** See POLYAMIDES—Metallizing.

**Painting** See PAINTING.

**Performance** See POLYETHYLENES—Blow Molding.

**Physical Properties** See THERMOPLASTICS—Injection Molding.

## Planning

**080183 PLANIRANJE RAZVOJA I LANSIRANJE PROIZVODA PRERADE POLIMERA NA TRZISTE.** [Processes of Planning, Development, and Marketing of Polymer Products]. The paper deals with the phases of product planning, development and marketing. The author emphasizes the need for coordination of marketing, production and technical functions of development in polymer processing. The present state of organization of polymer product development is assessed and improvements are proposed for future work. (Edited author abstract) In Serbo-Croatian. 6 refs.

Opsenica, Dane (INA-OKI, Zagreb, Yugosl). *Polimeri (Zagreb)* v 8 n 10-11 Oct-Nov 1987 p 312-314.

## Processing

**080184 MORE FOR YOUR MONEY FROM FAST-CYCLING POLYMERS.** One of the most important and complex design decisions involved in many application-development programs is determining how to get the most parts out the door and to the consumer. Reliability, consistency, and quality simply cannot be at the expense of productivity. This article discusses how processibility can be optimized without undue sacrifice in performance. Subjects covered include polymer performance characteristics, processing considerations, molding, and others.

English, Lawrence K. (Materials Engineering, Cleveland, OH, USA). *Mater Eng (Cleveland)* v 104 n 11 Nov 1987 p 35-38.

## Quality Assurance

**080185 EXPERT ESTIMATION IN THE PRODUCTION OF PLASTIC ITEMS.** The paper is devoted to the question of organizing an expert commission. Methods of selecting the experts by using a triple test, confirmation of their competency, and consistency in the results of processing the expert estimates of three kinds are discussed: pairwise comparisons, ranking, and number estimates. Moreover, the informational iterative procedure during which the expert can refine his ranking by becoming acquainted with arguments of colleagues on the defects noted, is investigated. 6 refs.

Gorelova, N.G. (Novosibirsk Electrotechnical Inst, USSR); Khitsenko, V.E.; Khitsenko, V.P. *Ind Lab (USSR)* v 53 n 3 Mar 1987 p 266-270.

**Quality Control** See PLASTICS—Injection Molding; POLYMERS—Molding; POLYVINYL CHLORIDE—Compounding.

## Recycling

**080186 COMMINATION AND WASHING OF PLASTICS: NEW DEVELOPMENTS IN PROCESSING TECHNOLOGY.** Many plastics processors (e.g. manufacturers of bottle crates, PETP bottles or agricultural films) are being forced to an increasing extent to seek out ways for utilizing their used products. At the same time, the quality requirements for the sorted plastics reprocessed in the processing factory have increased. Fast, highly automated processing plants make the highest demands on the raw materials used, as regards their purity and uniform quality. The essential modules of the waste reprocessing plant are precommminutors, cutting mills, fine grinding mills, and washers. Further developments of these are described.

Beyer, S.; Herbold, K. *Kunstst Ger Plast* v 77 n 8 Aug 1987 p 3-5.



## Surfaces

**080187 STRUCTURE OF SKIN LAYER IN INJECTION-MOLDED POLYPROPYLENE.** The structure of skin layer in injection-molded polypropylene which displayed a clear two-phase structure of skin and core has been studied by means of wide-angle x-ray diffraction, small-angle x-ray scattering, melting behavior, density, dynamic viscoelasticity, and tensile test. In general, a polypropylene melt crystallizes under a high shear stress in injection molding. From these facts, it was concluded that the skin layer is composed of so-called 'shish-kebab'-like main skeleton structures, whose axis is parallel to MD, piled epitaxially with a -axis-oriented imperfect lamellar substructure. (Edited author abstract) 20 refs.

Fujiyama, Mitsuyoshi (Tokuyama Soda Co, Tokuyama, Jpn); Wakino, Tetsuo; Kawasaki, Youtoku. *J Appl Polym Sci* v 35 n 1 Jan 1988 p 29-49.

**Testing** See PLASTICS, REINFORCED—Mechanical Properties.

**Thickness Measurement** See PLASTICS—Blow Molding.

## Viscoelasticity

**080188 VISCOELASTIC-PLASTICS BOTTLE CRATES.** The purpose of the study is to analyze the viscoelastic-plastic behavior of bottle crates under creep load. In so doing, various components of the deformation (plastic, elastic and viscoelastic) are ascertained and described mathematically. The computation was performed on beer crates with a base area of  $425 \times 285$  mm and a height of 260 mm, but can be applied to any other type of bottle crate. 5 refs.

Brueller, O. *Kunstst Ger Plast* v 77 n 8 Aug 1987 p 20-23.

**Visibility** See TRAFFIC SIGNS, SIGNALS AND MARKINGS—Plastics Applications.

## Waste Disposal

**080189 ARE SHIPBOARD PLASTICS ALL WASHED UP.** The long-life characteristics which favored use of plastics in the marine (and other) environments are now threatening its growth and even its current usage levels, particularly as an at-sea packaging material. Close to a billion pounds of plastic are discarded into the world's waters every year; the world's merchant fleet disposes of approximately 639,000 plastic container annually; and U.S. Navy vessel's discharge four tons of plastic daily. Shippers and fishermen have begun modest voluntary efforts to rid the ocean of plastics waste. The problem of recycling of plastic products used at sea, and especially that of plastic fishing nets, 25 million pounds of which are lost or discarded at sea is considered.

Smock, Dough (Plastics World, Newton, MA, USA). *Plast World* v 46 n 9 Sep 1988 p 74-77.

**Wear** See PLASTICS, REINFORCED—Carbon Fiber.

**PLASTICS, REINFORCED** See Also COMPOSITE MATERIALS; COMPOSITE MATERIALS—Fabrication; COMPOSITE MATERIALS—Fiber Reinforced; GLASS FIBER—Surfaces; JOINTS, ADHESIVE.

**080190 EXPERIMENTAL NOSE-WHEEL DOOR OF CONTINUOUS FIBRE-REINFORCED THERMOPLASTIC.** To gain experience with continuous fiber-reinforced thermoplastics, an attractive new family of composite materials, an experimental nose-wheel door has been designed, manufactured and tested in aramid fiber-reinforced polyetherimide. (Author abstract) 3 refs.

van Dreumel, W.H.M. (Delft Univ of Technology, Neth); deGroot, M. *Composites* v 18 n 5 Nov 1987 p 405-408.

**080191 ESTABLISHING THE CRITERIA FOR SELECTING SUITABLE INTERLAYER MATERIAL FOR DOUBLE-LAYERED FILAMENT-WOUND CFRP STRUCTURES.** Choice of inter-layer material

for a double-layered carbon-phenolic/ carbon-epoxy filament wound structure has been investigated. Differential thermal contraction during cooling after the final stage of curing cycle has been determined by laminate theory. Practical problems in achieving exact matching of fiber-content in two layers have been discussed and consequences of such mismatch have been demonstrated theoretically. Typical thermal expansion behavior of three different inter-layer materials (viz. a phenolic resin, a laminating grade epoxy resin and a low molecular weight adhesive grade epoxy resin) have been studied by thermo-mechanical analysis. The criteria for selecting suitable inter-layer material for the two-layered structure have been suggested. (Author abstract) 11 Refs.

Lahiri, Jhumur (Ministry of Defence, Hyderabad, India); Rohini Devi, G.; Subrahmanyam, S.V.; Balakrishna, K. *Composites* v 19 n 5 Sep 1988 p 376-382.

**080192 COMPOSITES '86-PART 2.** This issue contains 7 papers presented at the symposium. These papers include a review on current status and future trends in reinforced plastics; thermofforming of ordered polypropylenes; liquid crystalline copolyester composites; optothermal analysis of polymer composites; weldline integrity of reinforced plastics; exfoliated-graphite filled polyester based composites; and characterization of thermoset cure behavior. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10988 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Nat'l Research Council of Canada, Industrial Materials Research Inst, Ottawa, Ont, Can). *Polym Compos* v 8 n 6 Dec 1987, *Compos '86-Part 2*, Nov 25-26 1986 p 363-436.

**080193 SURVEY OF CURRENT STATUS AND FUTURE TRENDS IN REINFORCED PLASTICS COMPOSITES.** The production of reinforced plastics has constantly increased since the Second World War. With a forecast growth rate of 8 to 12 percent annually over the next decade, composites are one of the fastest growing sectors of the plastics industry. Advanced composites will show the largest expansion, due to a strong increase in demands in aerospace and military markets. Penetration of advanced composites into big-volume markets has not occurred, but it is believed that advances in both materials and machinery will accelerate the mass-production of these materials. High-volume composites will see a less rapid growth rate but demands for these materials will continue to increase. Land transportation will remain the largest and will be also the fastest growing market for high-volume composites. Current status and future trends in the uses of various reinforcing fibers and matrix resins are presented. Hurdles to the expansion of reinforced plastics are also discussed. (Author abstract) 31 refs.

Vu-Khanh, T. (Nat'l Research Council of Canada, Boucherville, Que, Can). *Polym Compos* v 8 n 6 Oct 1987 p 363-370.

## Additives

**080194 COUPLING AGENTS AND MODIFIERS: TARGETING UPGRADES PERFORMANCE.** Trends in the development of coupling agents and surface modifiers include formulations that are more resin specific, as suppliers target opportunities for their materials in advanced composites and engineering thermoplastics. In many cases new coupling agents and modifiers not only improve the bond between polymer and filler but also upgrade aspects of resin performance beyond such traditional rheological enhancements as greater wetout and higher throughput. Suppliers seeking lucrative market niches via tailored product reformulation create a user bonus in couplers and surface modifiers that establish new and more broadly applicable levels of value.

Toensmeier, Patrick A. *Mod Plast* v 65 n 7 Jul 1988 p 50-51.

**Aging** See Also THERMOPLASTICS—Mechanical Properties.

**080195 SEM/XPS ANALYSIS OF FRACTURED ADHESIVELY BONDED GRAPHITE FIBRE SURFACE RESIN-RICH/GRAPHITE FIBRE COMPOSITES.** Samples of graphite fiber-reinforced polyimide were fabricated allowing the resin to accumulate at the composite surface. These surface resin-rich composites were then bonded together and tested for lap shear strength both before and after thermal ageing. Lap shear strength did not appear to show a significant improvement over that previously recorded for resin-poor samples and was shown to decrease with increasing ageing time and temperature. (Author abstract) 1 ref.

DeVilbiss, T.A. (Virginia Tech, USA); Progar, D.J.; Wightman, J.P. *Composites* v 19 n 1 Jan 1988 p 67-71.

**Applications** See Also BUILDING MATERIALS—Plastics; METALS AND ALLOYS—Bonding; THERMOPLASTICS—Physical Properties.

**080196 ADVANCED COMPOSITES FOR AIRFRAMES AND CAR BODIES.** Advanced composites are high-performance composites, often capable of replacing metals. Today's advanced composite technology is driven by improved resin matrices and fiber/fabric reinforcements, and advances in equipment/processes. Aero/aircraft and passenger car composite applications have more differences than common denominators. Certain processes can be used in any of these applications, such as filament winding, pultrusion, and variations of mat molding, but there are significant differences in process economics. Low production volumes and high production costs for aero/aircraft applications allow higher fabrication costs compared with passenger car production.

Margolis, James M. (Margolis Marketing & Research Co, New York, NY, USA). *Chem Eng Prog* v 83 n 12 Dec 1987 p 30-43.

**Carbon Fiber** See Also ALUMINUM AND ALLOYS—Metallic Matrix Composites; BARS—Strain; CARBON FIBER—Manufacture; CARBON FIBER—Production; CHLORINE CONTAINING POLYMERS—Curing; COMPOSITE MATERIALS—Fiber Reinforced; COMPOSITE MATERIALS—Fracture; COMPOSITE MATERIALS—Mathematical Models; COMPOSITE MATERIALS—Mechanical Properties; EPOXY RESINS—Crosslinking; EPOXY RESINS—Fiber Reinforcement; EPOXY RESINS—Flame Resistance; EPOXY RESINS—Reinforcing; LAMINATED PRODUCTS—Fabrication; POLYETHYLENES—Rheology; THERMOPLASTICS—Processing.

**080197 SURFACE PROPERTIES OF CARBON FIBERS AND THEIR ADHESION TO ORGANIC POLYMERS.** The state of knowledge of the surface properties of carbon fibers is reviewed, with emphasis on fiber/matrix adhesion in carbon fiber reinforced plastics. Subjects treated include carbon fiber structure and chemistry, techniques for the study of the fiber surface, polymer/fiber bond strength and its measurement, variations in polymer properties in the interphase, and the influence of fiber matrix adhesion on composite mechanical properties. Critical issues are summarized, and research recommendations are made. (Author abstract) 67 refs.

Bascom, W.D. (Hercules Aerospace, Magna, UT, USA); Drzal, L.T. *NASA Contract Rep* 4084 1987 96p.

**080198 STATISTISCHE BEURTEILUNG DER DATEN VON SCHWINGFESTIGKEITUNTERSUCHUNGEN AN CFK-VERBUNDSTRUKTUREN.** [Statistical Evaluation of Experimental Results from Fatigue Strength of Carbon Fiber-Reinforced Plastic Composites]. Measurement results concerning the safe life history of cyclically loaded carbon fiber-reinforced plastic composites yield a statistical frequency distribution and a resultant rate of failure. Comparison with appropriate types of distribution allow a proof whether the number of cycles to failure correlates well with fracture probability. This paper investigates the problem of estimation of the



minimum sample size required, yet sufficient for drawing precise conclusion from measured data distributions. Some calculations show that sample sizes do not need to exceed 10 to 12 samples in each test series if constant variance is assured notwithstanding their absolute magnitude. (Edited author abstract) In German. 10 refs.

von Bonin, Lutz (DFVLR, Braunschweig, West Ger). *Mitt Dtsch Forsch Versuchsanst Luft Raumfahrt* 87-08 1987 p 135-188.

**080199** SCHÄDIGUNGSMECHANISMEN VON C F K-NIETVERBINDUNGEN. [Damage Mechanisms in Riveted Carbon Fiber-Reinforced Plastics]. The behavior of carbon epoxy composite materials jointed by rivets is studied in order to evaluate the design parameters under different climate conditions. The effect of the variation of the fiber material, fabric, and tape were studied together with different rivet diameters, layer geometry, fiber angles, and laminate thickness. It is shown that riveted joints lose a part of their strength due to local deformation. (Edited author abstract) In German. 9 refs.

Wetzel, Dirk (DFVLR, Braunschweig, West Ger). *Mitt Dtsch Forsch Versuchsanst Luft Raumfahrt* 87-08 1987 p 189-209.

**080200** SCHÄDIGUNGSMECHANISMEN UND ABSCHÄTZUNG DER LEBENSDAUER VON CFK-LAMINATEN. [Damage Mechanisms and Service Life Prediction in Carbon Fiber-reinforced Laminates]. A commonly observed failure mode in laminated composites is the delamination between composite layers. Delaminations may result from interlaminar stresses that develop at the stress-free edges or discontinuities like holes, cut fibers, matrix cracks, or impact damage. Furthermore, delaminations may grow under cyclic loading up to the final damage state where the delaminated sublaminate starts to buckle. This paper describes quantitatively the growth of delaminations in unnotched and notched graphite/epoxy laminates and the final damage state. Test results are presented with analytically predicted results. (Author abstract) In German. 25 refs.

Prinz, Rudolf (DFVLR, Braunschweig, West Ger). *Mitt Dtsch Forsch Versuchsanst Luft Raumfahrt* 87-08 1987 p 211-246.

**080201** ANNEALING EFFECTS OF CARBON FIBER-REINFORCED EPOXY RESIN COMPOSITES IRRADIATED BY ELECTRON BEAMS. Carbon cloth-reinforced epoxy resin composites were irradiated with 2 Mev electrons at room temperature and then annealed in air for 2 h at temperatures up to 180°C. A considerable decrease in the three-point bending strength occurred when the irradiated composites were annealed in the temperature range of 115-135°C which is below the glass transition temperature  $T_g$  of the matrix resin, while the bending strength remained unchanged up to 180°C for the unirradiated composites. In the dynamic viscoelastic spectra of the irradiated matrix, a new relaxation appeared at the temperature extending from 50°C to just below the matrix  $T_g$  and disappeared on annealing for 2 h at 135°C. Annealing also decreased the concentration of free radicals existing stably in the irradiated matrix at room temperature. (Edited author abstract). In Japanese. 5 refs.

Udagawa, Akira (JAERI, Takasaki, Jpn); Sasuga, Tuneso; Ito, Hiroshi; Hagiwara, Miyuki. *Kobunshi Ronbunshu* v 44 n 8 Aug 1987 p 631-639.

**080202** INFLUENCE OF FIBRE AND MATRIX FAILURE STRAIN ON STATIC AND FATIGUE PROPERTIES OF CARBON FIBRE-REINFORCED PLASTICS. The potential benefits of the overall strength of carbon fiber-reinforced plastics with conventional matrix systems can only be realized to a relatively small extent in view of the fact that design criteria for CFRP components presently allow, for aerospace use, a maximum strain of about 0.4%. Under static loading conditions first matrix cracks must be expected in the transverse piles above 0.4% strain. Shifting the maximum allowable strain level to higher values would significantly increase the profitability of composites. It is shown in this paper that

increasing the matrix failure strain (ductility) yields a pronounced improvement of the mechanical properties (under static and fatigue loading) and a shift of the crack initiation level to higher strain values. (Edited author abstract) 15 refs.

Baron, Ch. (DFVLR, Cologne, West Ger); Schulte, K.; Harg, H. *Compos Sci Technol* v 29 n 4 1987 p 257-272.

**080203** EFFECT OF STRESS RATIO ON NEAR-THRESHOLD PROPAGATION OF DELAMINATION FATIGUE CRACKS IN UNIDIRECTIONAL CFRP. The effect of the stress ratio on near-threshold growth of delamination fatigue cracks was investigated with unidirectional laminates made from Ciba Geigy 914C prepregs (T300/914) and from Toray P305 prepregs (T300/#2500). Tests of delamination fatigue crack propagation were carried out under mode I opening loading by using double cantilever beam specimens. The normalized gradient of energy release rate was controlled in load-shedding tests. In the region of crack growth rates above about  $5 \times 10^{-10}$  m/cycle, the growth rate was expressed as a power function of fracture mechanics parameters. A controlling fracture mechanics parameter is discussed on the basis of fractographic observation and mechanism consideration. A new phenomenological law of fatigue crack propagation is derived. (Edited author abstract) 17 refs.

Hojo, Masaki (Industrial Products Research Inst, Ibaraki, Jpn); Tanaka, Keisuke; Gustafson, Claes Goran; Hayashi, Ryuichi. *Compos Sci Technol* v 29 n 4 1987 p 273-292.

**080204** DELAMINATION BEHAVIOR OF CARBON FIBER REINFORCED PPS. In this paper a study of the delamination behavior of unidirectional carbon fiber reinforced polyphenylene sulfide (PPS), is presented and a comparison made with two carbon/epoxy systems. The influence of a number of parameters on this behavior are evaluated. These include (a) the type of loading, Mode I and Mode II, (b) the annealing of specimens, (c) the specimen geometry, and (d) the temperature. Results are discussed both in terms of fracture mechanics parameters and failure mechanisms, and the limitations of the test methods are examined. (Author abstract) 15 refs.

Davies, P. (Univ de Technologie de Compiegne, Compiegne, Fr); Benzeqagh, M.L.; de Charentenay, F.X. *SAMPE Q* v 19 n 1 Oct 1987 p 19-24.

**080205** STUDIES ON FRACTURE MECHANISMS OF CFRP BY ACOUSTIC EMISSION METHOD. Carbon fiber reinforced plastics (CFRP), which is one of the advanced composites, have excellent properties of specific strength and rigidity. They have been used for lightening the mass of machines and the structures. It is thought that the fracture mechanisms of composite materials are so complicated that an investigation is necessary to make clear the fracture behaviors and mechanisms of the materials. Therefore, by using the results of frequency analysis of the acoustic emission of the model CFRP in the previous paper, it is found, in this paper, that the acoustic emission which is produced by the deformation and the fracture of unidirectional composite laminates and three directional ones are classified by the frequency, and that the fracture mechanisms of these composite materials can be clarified. (Author abstract) In Japanese. 4 refs.

Suzuki, Megumu; Nakanishi, Hiroshi; Iwamoto, Masaharu; Jinen, Eiichi; Maekawa, Zenichiro; Mori, Akira; Sun, Feng. *Nippon Kikai Gakkai Ronbunshu A* Hen v 53 n 492 Aug 1987 p 1459-1466.

**080206** NOTCH SENSITIVITY OF MULTIDIRECTIONAL CARBON FIBRE-REINFORCED POLYIMIDES IN FATIGUE LOADING AS A FUNCTION OF STRESS RATIO. Multidirectional laminates of carbon fibre-reinforced bismaleinimide with a central hole as a notch were examined in a fatigue loading test using various stress ratios (R). In the case of  $R = -1$ , an increase in the number of load cycles was found to diminish the notch influence on fatigue strength. At  $R = 0.1$  no complete failure was observed when the maximum

stress was less than or equal to the static tensile strength up to a load cycle range of  $2 \times 10^6$ . Damage observed that would affect mechanical behavior in fatigue loading by a faster decrease of notch sensitivity was more pronounced than in that reported for notched multidirectional carbon fibre-reinforced epoxy resin specimens. (Author abstract) 16 refs.

Maier, G. (Wehrwissenschaftliches Inst fuer Materialuntersuchungen, West Ger); Ott, H.; Protzner, A.; Protz, B. *Composites* v 18 n 5 Nov 1987 p 375-380.

**080207** FRETTING FATIGUE STUDIES OF CARBON FIBRE/EPOXY RESIN LAMINATES. PART II: EFFECTS OF A FRETTING COMPONENT ON FATIGUE LIFE. The fretting fatigue properties of carbon fiber reinforced plastic (CFRP) laminates with stacking sequence  $[\pm 45, 0, \pm 45, 90, \pm 45]_{2s}$  (Laminate A) and  $[0, 90, 0, 90]_{2s}$  (Laminate B) were examined and compared with similarly executed plain fatigue tests. With three different pressures of fretting pads and pad materials (TAl6V4, Al7475 and a CFRP laminate with mainly 0°-plies) there were 9 experimental fretting variables. Apart from strongly differing behavior of both laminates, it has been shown that there is an important influence of fretting on the number of cycles to fracture. A reduction of the number of fatigue cycles due to fretting up to three orders of magnitude was observed for Laminate B, whereas Laminate A was relatively insensitive to the fretting component. (Author abstract) 6 refs.

Schulte, K. (DFVLR, Cologne, West Ger); Friedrich, K.; Kutter, S. *Compos Sci Technol* v 30 n 3 1987 p 203-219.

**080208** POLY(PIVALOLACTONE) COMPOSITES: AN ULTRA-CRYSTALLINE THERMOPLASTIC COMPOSITE PREPARED BY MONOMER IMPREGNATION. Poly(pivalolactone) (PPL)/carbon fiber prepreps were prepared by in-situ anionic polymerization. Excellent wetout is achieved at high fiber loadings. The mechanical properties of laminates are compared with PEEK and PPS based materials. The exceptionally high crystallinity (approximately 75%) of PPL endows it with good temperature and solvent resistance despite its low  $T_g$  (approximately 10°C). Composites exhibit excellent fracture toughness and can be processed at a relatively low temperature (250°C) for a crystalline thermoplastic. However, the low  $T_g$  of PPL may limit the usefulness of this material as a composite resin. (Author abstract) 16 refs.

Paul, C.W. (Allied-Signal Inc, Morristown, NJ, USA); Akkapeddi, M.K.; Mares, F. *SAMPE J* v 24 n 1 Jan-Feb 1988 p 20-24.

**080209** CLINICAL APPROACH. Mechanical properties of strength and stiffness combined with light weight, fatigue resistance, and radiological advantages allow the usage of carbon fiber reinforced plastics in X-ray equipment, hospital furnishing, Magnetic Nuclear Resonance equipment and prosthetic limbs.

Anon. *Engineering (London)* v 227 n 12 Dec 1987 p 8-9, 11-13.

**080210** EFFECT OF SELECTIVE ADHESIVE INTERLEAVING ON INTERLAMINAR FRACTURE TOUGHNESS OF GRAPHITE/EPOXY COMPOSITE LAMINATES. Interlaminar fracture toughness (IFT) characteristics of graphite/epoxy laminates were evaluated in tests on specimens with different tough adhesive interlayers. An artificial interlaminar edge crack was forced to propagate under two modes: separation, and shear. Results indicated that the interlayer, located in front of an existing flaw, may increase IFT more than sixfold compared with an uninterleaved brittle-matrix composite reference. The effect was stronger in the separation mode than in the shear mode, and seems to increase with thickness of the interlayer. (Edited author abstract) 15 refs.

Ishai, O. (Technion-Israel Inst of Technology, Isr); Rosenthal, H.; Sela, N.; Drukker, E. *Composites* v 19 n 1 Jan 1988 p 49-54.



**080211 EFFECT OF HIGH TEMPERATURE SPIKES ON A CARBON FIBRE-REINFORCED EPOXY LAMINATES.** Carbon fiber-reinforced epoxy composite laminates were exposed to programs of temperature and humidity intended to represent the high temperature excursions (thermal spikes) caused by ground-reflected engine efflux experienced by VTOL aircraft. Measurement of the laminate weight change during the tests indicated a change in the laminate moisture kinetics resulting in increased moisture equilibrium levels at spike temperature up to 175°C. Spiking at temperatures of 200-300°C showed a marked loss of laminate weight which cannot be attributed to loss of water alone. Permanent damage such as cracking was evident in some cases. The contribution of moisture to laminate degradation is discussed. (Author abstract) 8 refs.

Collings, T.A. (Royal Aircraft, Establishment, UK); Mead, D.L. *Composites* v 19 n 1 Jan 1988 p 61-66.

**080212 EFFECT OF WOVEN FILLER TYPE ON MECHANICAL CHARACTERISTICS OF CARBON FIBER REINFORCED PLASTICS WITHIN THE TEMPERATURE RANGE OF 293-1000 K.** Carbon plastics have been studied for the effect of filler-type and temperature on changes in mechanical characteristics while short-time static loading under tension, compression and bend. Experimental techniques and procedure of conducting tests are described. Type of the filler is found to appreciably influence strength and elasticity indices especially in tensile and bending tests. (Author abstract) In Russian. 5 refs.

Eskin, E.A.; Fedchuk, V.K. *Probl Prochn* v 11 Nov 1987 p 76-82.

**080213 COMPRESSIVE PROPERTIES OF BRAIDED AND WOVEN CARBON FIBER-EPOXY COMPOSITES AFTER LOW VELOCITY IMPACT.** The reduction of the compressive properties (residual compressive strength and strain) of braided or woven carbon fiber-epoxy composites were not as sensitive as the unidirectional prepreg laminates, when subjected to low velocity impact, as the results of this study indicated. Also, unidirectional prepreg laminates hybridized with braided or woven structure layers did not show any improvement in the compressive strength, as shown by this study. The delaminated areas after impact were measured by using ultrasonic B-Scan, C-Scan and photomicrograph, and the damage area were then correlated with the strain energy release rates  $G_{IC}$ . (Author abstract)

Fang, Jiann-Shyong (Industrial Technology Research Inst, Hsinchu, Taiwan); Chen, Chun-Hung; Wu, Ru-Yu. *MRL Bull Res Dev* v 2 n 1 Mar 1988 p 15-22.

**080214 EVALUATION OF CARBON FIBER REINFORCED CORROSION RESISTANT PLASTIC LAMINATES.** Carbon fiber reinforcement was evaluated in corrosion resistant plastic laminates to determine its suitability as a surfacing mat. Chemical resistance testing was done according to ASTM C-581 in order to compare the corrosion resistance of reinforced laminates containing carbon fiber veil to glass veil and to non-woven polyester veil. The corrosion resistant resin used as the matrix was a high heat distortion temperature vinyl ester resin. The chemical environments included hydrofluoric acid because it is known to attack glass fibers. Other acids, bases and solvents were included in order to determine overall chemical resistance of carbon fiber reinforced plastic laminates. (Author abstract) 1 ref.

O'Hearn, Thomas P. (Ashland Chemical Co, Columbus, OH, USA); Kitchen, Kathy E. *SAMPE Q* v 19 n 3 Apr 1988 p 1-7.

**080215 MICROGRAPHIC STUDY OF BENDING FAILURE IN FIVE THERMOPLASTIC-CARBON FIBRE COMPOSITE LAMINATES.** The local deformation and failure sequences of five thermoplastic matrix composites were microscopically observed while bending the samples in a fixture attached to a microscope stage. The thermoplastics are polycarbonate, polysulphone, polyphenylenesulphide, polyethersulphone and poly-

theretherketone. The composites made from these plastics contain a variety of carbon fibres with similar properties and have fibre volume fractions ranging from 32 to 66%. Comparison is made to an epoxy matrix composite, 5208-T-300. The thermoplastic composites failed by abrupt longitudinal compression buckling of the outer ply. Micrographs reveal typical fibre kinking associated with longitudinal compression failure. Curved fracture surfaces on the fibres suggest they failed in bending rather than direct compression. Delamination was suppressed and the delamination that did occur was the result of compression buckling rather than vice versa. Microbuckling also caused ply splitting, transverse ply shear failure, fibre tensile failure, and transverse ply cracking. (Edited author abstract) 8 refs.

Yurgartis, S.W. (Rensselaer Polytechnic Inst, Troy, NY, USA); Sternstein, S.S. *J Mater Sci* v 23 n 5 May 1988 p 1861-1870.

**080216 RECENT CARBON FIBER ADVANCEMENTS.** Composite materials based on carbon fiber reinforcement are finding uses in aircraft structures, in high-performance rocket motors, and in precisely constructed space structures. This article outlines some of the recent developments in carbon-fiber technology and products.

Gardner, William H. (Hercules Inc, Magna, UT, USA). *Tappi J* v 71 n 6 Jun 1988 p 124-126.

**080217 WEAR OF SHORT CARBON FIBER REINFORCED PAI AND PPS.** Wear of short carbon fiber reinforced polyamide-imide and polyphenylene sulfide is described. Comparative data from thrust washer wear tests for both polymers are presented. Fibre orientation is shown to have a significant effect on wear rates. The wear mechanisms in both polymers are illustrated with optical and scanning electron micrographs. Wear is shown to be a nonlinear function of time and stress for both PPS and PAI. (Author abstract). 15 Refs.

Behrens, W.W. (McDonnell Douglas Corp, St. Louis, MO, USA); Jerina, K.L.; Hahn, H.T. *SAMPE Q* v 19 n 4 Jul 1988 p 1-9.

**080218 NEUE MATERIALIEN UND IRE EINSATZMOGLICHKEITEN.** [Carbon Fiber Surfacing Mats: New Materials and Their Possible Applications]. Carbon fibers used for the manufacture of surfacing mats are a relatively new, flake-like material which is both light in weight and low-priced and yet has properties - electrical conductivity, thermal conductivity, chemical resistance, high strength - which differ basically from those of other woven and unidirectional materials. The use of surfacing mats for the production of isotropic composites necessitates a much simpler process than that required for the production of pseudo-isotropic laminates which must be reinforced in four or more directions. The mats can be used as load-distributing layers in conjunction with woven and unidirectional fabrics in order to produce the necessary reinforcement in directions other than those which bear the main load. (Edited author abstract). 8 Refs. In German.

Walker, Nigel J. *Plastverarbeiter* v 39 n 6 Jun 1988 4p.

**080219 INFLUENCE OF FIBRE STACKING SEQUENCE ON THE HIGH VELOCITY IMPACT RESPONSE OF CFRP.** The work presented examines the influence of the laminate stacking sequence on the high velocity impact resistance of CFRP. Attention is also given to examining the effect of replacing the  $\pm 45^\circ$  layers in a  $(0^\circ, \pm 45^\circ)$  composite by a woven fabric, a technique known to enhance the low velocity impact resistance of CFRP. The laminates were manufactured from pre-impregnated sheets of Grafil XA-S high strength surface-treated carbon fibers in Ciba-Geigy BSL 914C epoxy resin. Four of the panels were prepared from sheets of 0.125 mm thick pre-impregnated unidirectional tape stacked in the desired manner. These panels are referred to as non-woven laminates. The remaining laminates were manufactured by replacing the  $45^\circ$  plies in two of the  $(0^\circ, \pm 45^\circ)$  laminates by a five-shaft satin woven fabric. These

composites are referred to as mixed-woven laminates. The results suggest that mixed-woven laminates are well suited to conditions where the propagation of high velocity impact damage must be limited to a region local to the point of impact. Conversely, in circumstances where a higher perforation resistance is required it may be necessary to use a more conventional non-woven composite. 9 Refs.

Cantwell, W.J. (Ecole Polytechnique Federale de Lausanne, Lausanne, Switz). *J Mater Sci Lett* v 7 n 7 Jul 1988 p 756-758.

Cavitation See ELASTOMERS—Reinforcing.

Coextrusion See PIPE, PLASTIC—Manufacture.

Coloring

**080220 EFFECTS OF PIGMENTS ON REINFORCED PLASTICS.** In a series of tests with a wide range of common pigments in reinforced and unreinforced nylon and reinforced polycarbonate, it was found that most of the pigments tested extended actual burning and glow times in Underwriters Laboratories Bulletin 94 flammability testing. While these changes were usually not so great as to change the flammability rating, the effect of pigment addition should nonetheless be accounted for in design considerations.

Nangrani, Khemchand J. (Wilson Fiberfil Int, Evansville, IN, USA); Wenger, R.; Daugherty, Philip G. *Mater Eng (Cleveland)* v 104 n 11 Nov 1987 p 46.

Compression Molding See Also PLASTICS SHEETS—Sheet Molding Compounds.

**080221 COMPRESSION MOLDING OF COMPOSITES: MOLD HEATING SYSTEM DESIGN.** In compression molding of composite parts, it is important to minimize the temperature variation in the part during processing for consistent quality. A mold heating analysis and optimization scheme has been developed that allows computation of temperature variation on the mold/part surface, and optimizes the location and power of heaters. The heat transfer coefficients for a given mold can also be theoretically calculated. The experimental data compared well with theory and provide a satisfactory validation of the analysis. The present work provides a useful tool to a design engineer and allows the mold heating system design on a scientific basis, thus eliminating the trial and error approach. (Edited author abstract). 9 Refs.

Upadhyay, R.K. (GE, Schenectady, NY, USA). *Adv Polym Technol* v 8 n 3 Fall 1988 p 243-264.

Conductive

**080222 SIMULATION OF THE PERCOLATION THRESHOLD IN METAL FIBRE LOADED CONDUCTIVE POLYMER COMPOSITES.** It has been generally observed that in metal loaded polymer composites, as the volume fraction of metal is gradually increased, a sharp upturn in the volume conductivity occurs when the volume fraction reaches a certain critical value. It is difficult to observe the percolation threshold experimentally. If a fibre loaded composite is inspected under the microscope, numerous successive planes must be examined to trace even a single contact, and the scanning of a sample of ordinary size across the electrode gap becomes impractical. In view of the above difficulties the author has devised a large-scale model of the electrical behaviour of a fibre-loaded composite which allows the onset of percolation to be observed directly. The critical volume fraction is readily estimated for a given aspect ratio. The article describes the construction of the model and the results achieved. 6 Refs.

Bridge, Bryan (Brunel Univ, Uxbridge, Engl). *J Mater Sci Lett* v 7 n 6 Jun 1988 p 663-665.



Corrosion See POLYAMIDES—Corrosion.

## Corrosion Resistance

**080223** METODY HODNOCENI KOROZNI ODOLNOSTI LAMINATU. [Methods of Corrosion Resistance Testing of Laminates]. Methods of corrosion resistance testing of glass-fiber laminates, as described in literature, are surveyed. Also, conclusions from experimental works are given and a test method system is recommended. (Author abstract) In Czech. 30 refs.

Beranová, Miluše (Statní Vyzkumný Ústav Materiálu, Prague, Czech); Křsava, Alena. *Plasty Kauc* v 24 n 10 Oct 1987 p 301-306.

Crack Propagation See Also COMPOSITE MATERIALS—Fiber Reinforced.

**080224** ACOUSTIC EMISSION DURING FRACTURE OF SHORT GLASS FIBER REINFORCED POLY(VINYL CHLORIDE). The fracture mechanics approach and acoustic emission (AE) analysis have been coupled in an investigation of slow crack growth of short fiber reinforced poly(vinyl chloride). It was found that AE occurs during less than one percent of the time of crack growth suggesting that so-called continuous crack propagation is based on discontinuous microscopic damage. The time dependence of various AE parameters exhibits a good linear relationship with crack speed. For a unit of newly created fracture surface, a constant amount of acoustic energy is released independent of crack speed. At very low speeds, below  $3 \cdot 10^{-3}$  mm/s, a change in mechanism from pure matrix related to fiber related crack growth is observed, which is also reflected by a change in the amplitude distribution of the AE events. (Author abstract) 19 refs.

Koenczoel, L. (Case Western Reserve Univ, Cleveland, OH, USA); Hiltner, A.; Baer, E. *Polym Compos* v 8 n 2 Apr 1987 p 109-114.

**080225** SLOW CRACK PROPAGATION IN A HEAVILY-FILLED PARTICLE REINFORCED EPOXY RESIN. The fracture property of two proprietary composite dental restorative materials and a model composite system were studied to determine the effects of filler concentration, exposure to water, and particle/polymer adhesion on subcritical crack propagation. Particle content ranged from 36 to 60 volume percent. The double torsion (DT) test was used to measure relationships between the stress intensity factor ( $K_I$ ) and the speed of decelerating cracks or the rate of loading in dry and wet materials in air at laboratory conditions. Materials with weak particle/polymer interfaces fractured by continuous crack growth in both dry and wet conditions. Observations on fracture surfaces indicate that low velocity cracks ( $< 10^{-5}$  s) propagate through regions of high stress concentrations (interfaces, corners, pores) while at higher crack velocities failure occurs by a combination of interparticle and transparticle fracture. (Edited author abstract) 22 refs.

Montes-G., G.M. (Medical Univ of South Carolina, Charleston, SC, USA); Draughn, R.A.; Simpson, T.H. Jr. *Polym Compos* v 8 n 4 Aug 1987, Pap Presented at the 1986 Annu Tech Conf of the Soc of Plast Eng, Boston, MA, USA, May 1986 p 265-270.

Crosslinking See Also POLYMERS—Mixing.

**080226** COMPORTEMENT SOUS MICRO-ONDES (2.45 GHz) DE COMPOSITES RESINE EPOXYDE - NOIR DE CARBONE. [Microwave (2.45 GHz) Effects on Epoxy Resin/Carbon Black Composites]. Continuous or pulsed microwaves (2.45 GHz) are used to activate crosslinking of epoxy/carbon black composites. A complete study, taking into account the average electrical power of the microwave beam and the concentration of carbon black, has been carried out; in case of discontinuous emission, the period and the pulse length are also considered. The main results are: the same structural changes as for the pure resins are observed; in pulsed mode two types of relaxation are working; the first,

related to the oscillations of the dipoles (dipolar relaxation) at 2.45 GHz, and the second which concerns the mobility of short chain segments with maxima of efficiency at characteristic frequencies of the mode of emission; when the concentration of carbon black is increasing, an energetic transition takes place in the crosslinked state with a maximum of absorption of microwaves, at a concentration lower than the percolation threshold. (Author abstract) 4 refs. In French.

Bouazizi, Abdelaziz (Ecole Natl Supérieure de Chimie de Toulouse, Fr); Gourdenne, Albert. *RGE Rev Gen Electr* n 5 May 1988, Appl Energ des Micro-ondes, Fr, Oct. 19-22 1987 p 27-32.

## Curing

**080227** RAPID TEST FOR EVALUATING THE DEGREE OF CURE IN CFRP COMPOSITES. A noncontact optothermal method is described for possible application to routine industrial evaluation of the degree of cure in polymeric composites. The surface of the part is heated by a laser beam or other radiative source while its temperature evolution is continuously monitored with an infrared detector. A strong exothermal peak is observed when the material is partially or totally uncured. Changes in the signal shape related to variations of the part geometry or environmental conditions are minimized by a differential approach comparing subsequent heat cycles on the same area. Results obtained with cured or uncured graphite-epoxy prepreg sheets are presented. (Author abstract) 17 refs.

Krapez, J.C. (Natl Research Council Canada, Boucherville, Que, Can); Cielo, P.; Cole, K.; Vaudreuil, G. *J Therm Anal* v 32 n 6 Nov-Dec 1987 p 1859-1865.

**080228** MICRODIELECTRIC MONITORING OF PREPREG CURE. The feasibility of using a microelectric sensor to characterize the cure behavior of a commercial prepreg roving was investigated. Chemical and physical characterization methods were first used to determine the uniformity of the prepreg material. Thermal, dynamic mechanical, and dielectric methods were then utilized to monitor the cure cycle. The dielectric response was found to be independent of the glass fibers of the prepreg and to show reproducible changes in the early part of cure over a temperature range of 80 to 135°C. The manufacturer's recommended cure temperature of 121°C (250°F) was found to correspond to the onset of the ultimate glass transition of the material. Variations in the dielectric response in the latter part of cure at this temperature and above were attributed in part to this event. (Author abstract) 7 refs.

Zukas, Walter X. (US Army Materials Technology Lab, Watertown, MA, USA); Wentworth, Stanley E. *Polym Compos* v 8 n 4 Aug 1987, Pap Presented at the 1986 Annu Tech Conf of the Soc of Plast Eng, Boston, MA, USA, May 1986 p 232-236.

Cutting See MATERIALS—Cutting.

## Deformation

**080229** UNRECOVERED DEFORMATION DUE TO CYCLIC CREEP IN POLYPROPYLENES FILLED WITH TALC AND WITHOUT TALC. The unrecovered deformations due to cyclic creep under cycles from 30 s to 606 min and stresses from 10 to 110 kgf/cm<sup>2</sup>, for variable ratios of unloading time to loading time at 22-60°C, were investigated in polypropylenes filled with talc and without talc. The results are presented. The properties of creep recovery of polypropylene filled with talc were less than those for unfilled samples under some stress or at some temperature. (Edited author abstract) In Japanese. 13 refs.

Kobayashi, Tsuguo (Hitachi Ltd, Tokyo, Jpn); Asano, Hideki. *Kobunshi Ronbunshu* v 45 n 1 1988 p 25-30.

**080230** VISCOELASTIC RESPONSE OF UNIDIRECTIONALLY REINFORCED THERMOPLASTIC COMPOSITES TO OFF AXIS DEFORMATION.

Measurements of dynamic viscoelastic in-plane shear modulus have been made for unidirectional carbon fiber composites with amorphous engineering thermoplastics as the binder resins. The viscoelastic response is modeled by a three-phase, finite-element model in which fiber placement in the plane perpendicular to the fiber axes is largely disordered. In the model, fibers tend to chain with the distance of closest approach dictated by several factors, including the tendency for the resin to wet the entire fiber surface. Polished section microscopy supports the assumed microstructure. The model includes an adsorbed primer layer at the fiber interface with perturbed viscoelastic response. The model is useful throughout the temperature range up to and including the glass transition of the binder resin. (Author abstract) 20 refs.

Tomkinson, Gayle D. (GE, Schenectady, NY, USA); Vallance, Michael A. *Polym Compos* v 8 n 4 Aug 1987, Pap Presented at the 1986 Annu Tech Conf of the Soc of Plast Eng, Boston, MA, USA, May 1986 p 237-243.

## Degradation

**080231** HYGROSCOPIC EFFECTS IN ARAMID FIBER/EPOXY COMPOSITE. Hygroscopic effects in aramid fiber composites are assessed semiempirically using a combination of micromechanics models and experimental data. It is pointed out that the in situ moisture concentration of the fiber should be known, as it affects diffusional as well as expansional properties. The micromechanics models for moisture absorption indicate that the in situ moisture concentration is lower than the bulk value. The interfacial radial stress can be tensile in wet unidirectional composites, and ply cracks are shown to increase moisture diffusion in laminates. (Author abstract)

Hahn, H.T. (Pennsylvania State Univ, University Park, PA, USA); Kim, K.S. *J Eng Mater Technol Trans ASME* v 110 n 2 Apr 1988 p 153-157.

**080232** DEGRADATION BEHAVIOR OF BULK MOLDING COMPOUND IN ACID ENVIRONMENTS. The aim of this study was to develop a new BMC (Bulk Molding Compound) with low molding shrinkage and high acid resistance. The resin system used in this study was a novolac type epoxy resin with low shrink additive and the reinforcements used were glass, carbon and aramid fibers. Firstly the mold shrinkage, the heat distortion temperature and the electric resistance of BMC were measured as the functional properties. The immersion test was carried out in a bath with a mixed solution of 25wt percent H<sub>2</sub>SO<sub>4</sub> and 7.5 wt percent HNO<sub>3</sub> at 65°C up to 3000hr. The weight change and the reduction of mechanical properties were measured in order to examine the degradation mechanism of BMC. It is concluded that Hybrid BMC which are reinforced by glass, carbon and aramid fibers show the excellent functional properties. The acid resistance of BMC developed in this study is much higher than that of BMC in which the matrix is the epoxy resin with high acid resistance. (Author abstract). 7 Refs. In Japanese.

Maekawa, Zenichiro (Kyoto Inst of Technology, Kyoto, Jpn); Hamada, Hiroyuki; Horino, Tsuneo; Yagi, Kazuo; Yokoyama, Atsushi. *Zairyo* v 37 n 416 May 1988 p 523-528.

Density See COMPOSITE MATERIALS—X-ray Analysis.

Elasticity See Also DENTAL EQUIPMENT AND SUPPLIES—Plastics Applications.

**080233** MODEL FOR PREDICTION OF THE ELASTIC RESPONSE OF REINFORCED MATERIALS OVER WIDE RANGES OF CONCENTRATION. A model for the prediction of the elastic response of reinforced materials over wide ranges of concentration is presented. The method is based on the mathematical analogy between the motion of particles suspended in viscous media and the elastic deformation of solids. The system is locally described by linearized forms of the elastic moduli. The validity of these relations is then extended to all concentrations under the assumption that



any new portion of filler 'sees' the existing structure as a noninteracting homogeneous matrix. The method predicts the behavior of reinforced materials with solid spherical inclusions and foams over wide ranges of concentration. The model, free from adjustable parameters, shows excellent agreement with existing experimental data. The extension of the method to other inclusion geometries is straightforward. (Author abstract) 30 refs.

Farber, Jorge N. (Univ of Massachusetts, Amherst, MA, USA); Farris, Richard J. *J Appl Polym Sci* v 34 n 6 Nov 5 1987 p 2093-2104.

## Electric Conductivity

**080234 ELECTRICAL CONDUCTIVITY OF POLYETHYLENE-CARBON-FIBRE COMPOSITES MIXED WITH CARBON BLACK.** The influence of the mixing procedure of the additives and material preparation is examined with regard to conductivity. The use of two filler types combines the conducting features of both. Thus, while fibers provide charge transport over large distances (several millimeters), carbon black particles improve the interfiber contacts. Results are discussed with reference to simple electrical models. For composites in which the segregated carbon black-polyethylene component lies above the percolation threshold the electrical interfiber contacts are activated through carbon black particle bridges, leading to a conductivity rise. This effect is more relevant in the case of shorter fibers. Processing involving fiber orientation such as in injection molding decreases the conductivity. (Edited author abstract) 12 refs.

Balta Calleja, F.J. (CSIC, Madrid, Spain); Bayer, R.K.; Ezquerro, T.A. *J Mater Sci* v 23 n 4 Apr 1988 p 1411-1415.

**080235 VAN DER PAUW MEASUREMENT OF METAL FIBRE ORIENTATION IN A PLASTIC-METAL COMPOSITE.** Stainless steel fibers in ABS plastic form a composite with an anisotropic resistivity. Samples are rectangular shapes with uniform thickness. By assuming two principal resistivities and by using van der Pauw's technique, the authors find  $\rho_y/\rho_x$  hence fiber direction. Results for three sample geometries agree with the theoretical predictions of the fiber patterns and with x-ray data. Samples formed by a center sprue feed are best for fabricating large, uniform samples while samples with a large length to width ratio have the most uniform density and fiber orientation. Resistivity was also measured by the two-probe technique. (Edited author abstract) 23 refs.

Kinsler, Mark (Univ of Pittsburgh, Pittsburgh, PA, USA); Hmurcik, Lawrence V.; Patton, Joyce. *J Mater Sci* v 23 n 4 Apr 1988 p 1425-1430.

**080236 ELECTRICAL CONDUCTION PHENOMENA BETWEEN ADJACENT STAINLESS STEEL FIBRES IN A THERMOPLASTIC MATRIX.** In a programme designed to elucidate the fundamental mechanisms involved in electrical conduction through a polypropylene matrix filled with non-contacting stainless steel fibres, the current flow between two individual fibres orientated perpendicularly in a polypropylene bead has been studied. The fibre diameter was 22  $\mu\text{m}$  and the gap length was 100  $\mu\text{m}$ . The resistance at low voltages was five orders of magnitude lower than could be accounted for by assuming that homogeneous conduction had taken place with tabulated values of the volume resistivity of the matrix obtaining. Transmission optical microscopy revealed that during current flow, the greatest heating and degradation of the polymer did not take place along the shortest path between the fibres. (Edited author abstract) 14 refs.

Bridge, B. (Brunel Univ, Uxbridge, Engl); Folkes, M.J.; Jahankhani, H. *J Mater Sci* v 23 n 6 Jun 1988 p 1955-1960.

Electric Properties See PLASTICS—Conductive.

## Environmental Testing

**080237 DURABILITY OF SiC FIBER REINFORCED EPOXY RESIN IN BOILING WATER.** SiC fiber and glass fiber reinforced epoxy resins (SiCFRP and GFRP), which were fabricated by using matching male and female metal molds, were immersed in boiling water for the periods from 5 to 500 hours. The amount of water absorption of SiCFRP was less than that of GFRP, and those of SiCFRP and GFRP immersed for 100 hours were 38.5 mg/cm<sup>3</sup> and 76.6 mg/cm<sup>3</sup>, respectively. The amount of water absorption at the time when the width of SiCFRP specimen began to increase was 9.5 mg/cm<sup>3</sup> against 44 mg/cm<sup>3</sup> of that of GFRP. ILSS retention of SiCFRP immersed decreased with increasing immersion time, while the diameter, weight and tensile strength of SiC fiber were not affected at all by immersion in boiling water up to 500 hours. The ILSS retention of 74% for SiCFRP immersed for 100 hours was almost the same as that of 76% for GFRP. The reason of such low durability of SiCFRP to hot water was interpreted as the bond between the fiber and resin was weak to water because the surface of SiC fiber was not treated. (Author abstract) 6 refs. In Japanese.

Nakanishi, Yoichiro (Government Industrial Research Inst of Osaka, Ikeda, Jpn); Saito, Hitoshi. *Zairyo* v 37 n 415 Apr 1988 p 460-464.

## Extrusion

**080238 THEORETICAL AND EXPERIMENTAL STUDY OF FIBRE ATTRITION DURING EXTRUSION OF GLASS-FIBRE-REINFORCED POLYPROPYLENE.** On the basis of the experimental observations described in previous work by authors, a model has been proposed to analyse the phenomenon of fiber breakage taking place when granules of short-fiber-reinforced thermoplastics are processed in an extruder. This model essentially determines the bending moment experienced by a single fiber, anchored at one end, due to drag forces produced by the flow of molten polymer past it. This model clearly brings out the effects of molten film thickness, screw speed, viscosity of the polymer melt and the fiber orientation relative to the flow direction. It is postulated that the model provides a mechanism for the breakage of fibers exposed by melting of polymer at the solid bed-molten polymer interface. For fibers which are free to move in the molten polymer, buckling introduced by the shearing motion of the molten polymer, as predicted by the Forgacs and Mason model, is responsible for their attrition. Using the extrusion data of ref. 1, the results of the combined use of the two models show good agreement with the experimental observations, in particular the fiber length distribution of various stages of extrusion. This agreement is observed in spite of several assumptions inherent in the model. Finally, the effect of fiber agglomeration on the attrition phenomenon is also studied. (Edited author abstract) 13 refs.

Mittal, R.K. (Indian Inst of Technology, New Delhi, India); Gupta, V.B.; Sharma, P.K. *Compos Sci Technol* v 31 n 4 1988 p 295-313.

## Fabrication

**080239 TOOLING UP FOR A COMPOSITE FUTURE.** Choosing the right material for mold tooling can be critical to the productivity and performance of a composite structure. Selection involves a complex balancing of many factors - initial acquisition cost, lead time, maintenance/repair feasibility and costs, compatibility with cure cycle, porosity, dimensional stability, number of parts to be produced, energy/labor demands, ease of modification, and others. The relative weighting of these different factors determines which material is best, because no single material has been universally accepted as the all-purpose tooling material. Various types of mold materials and selection factors are discussed.

English, Lawrence K. (Materials Engineering, Cleveland, OH, USA). *Mater Eng (Cleveland)* v 4 n 9 Sep 1987 p

69-71.

**080240 PULTRUSION PRESSES AHEAD.** Pultrusion is one of the better established volume production techniques for advanced composites, but ironically, also one of the least well understood. The Runcorn-based company Fibreforce, has produced a design manual for pultruded composite components which will be available direct from the company. The manual begins with an explanation of the pultrusion process, which produces profiles in composite materials by pulling resin-impregnated fibers through a heated die, and goes on to outline some of its capabilities. The manual then goes on to outline the benefits and limitations of the process. These and other aspects of the subject are discussed in the article.

Anon. *Engineering (London)* v 227 n 9 Sep 1987 suppl p 8-9.

Failure See Also COMPOSITE MATERIALS—Fiber Reinforced.

**080241 SCHADENSMECHANIK KOHLENSTOFF-FASERVERSTAERKTER KUNSTSTOFFE BEI SCHWINGBELASTUNG.** [Damage Mechanics in Carbon Fiber-Reinforced Plastics Subjected to Fatigue Loading]. This collection of papers contains 7 papers dealing with the following topics: damage mechanics in fiber-reinforced plastics; influence of different parameters on damage development in fiber-reinforced plastics; damage initiation and propagation in notched carbon fiber-reinforced laminates; damage to woven satin laminates subjected to static and fatigue loading; statistical evaluation of experimental results from fatigue strength tests of carbon fiber-reinforced plastic composites; and damage mechanisms in riveted carbon fiber-reinforced plastics. All papers are abstracted and indexed separately. In German.

Anon. *Mitt Dtsch Forsch Versuchsanst Luft Raumfahrt* 87-08 1987 246p.

**080242 SCHADENSMECHANIK FASERVERSTAERKTER KUNSTSTOFFE EIN UEBERLICK.** [Damage Mechanics in Fiber-Reinforced Plastics. A Review]. Failure mechanisms in composite laminates are quite different from those in homogeneous materials. While metal materials under fatigue fail as a result of initiation and growth of a single dominant crack, composite laminates can sustain many cracks before ultimate failure. Damage in composites can be any of the following: fiber breaks, resin cracks, interfacial debonds, and delaminations between the plies of the laminate. All these cracks are not separated but interconnect. Much of these damages occurs long before the ultimate failure. The process of composite laminate damage mechanisms under static and fatigue loading is described. It is known that this fracture process involves sequential accumulation of damage, in form of matrix-dominated transverse and longitudinal cracking and delamination. (Author abstract) In German. 11 refs.

Prinz, Rudolf (DFVLR, Braunschweig, West Ger). *Mitt Dtsch Forsch Versuchsanst Luft Raumfahrt* 87-08 1987 9-27.

**080243 EINFLUSS VERSCHIEDENER PARAMETER AUF DIE SCHADENSENTWICKLUNG.** [Influence of Different Parameters on Damage Development]. A comprehensive test program in the framework of damage mechanics under fatigue loading was performed to investigate the influence of laminate stacking sequence, fatigue loading conditions and environmental conditions such as temperature and/or humidity on damage development and fatigue properties. Results of these investigations and appropriate measuring techniques are discussed. (Edited author abstract) In German. 23 refs.

Goetting, Hans Christian (DFVLR, Braunschweig, West Ger). *Mitt Dtsch Forsch Versuchsanst Luft Raumfahrt* 87-08 1987 p 29-61.



**080244** SCHAEDIGUNGEN IN ATLASGEWEBELAMINATEN UNTER STATISCHER UND SCHWINGENDER BEANSPRUCHUNG. [Damage to Woven Satin Laminates Subjected to Static and Fatigue Loading]. The mechanical properties and the damage mechanisms of a laminate with four plies and unsymmetrical stacking sequence manufactured from eight-end sateen weave prepreps were determined in static tests as well as tension-tension and tension-compression fatigue tests. The inplane shear properties were also examined. The damage initiation and propagation up to failure were observed by optical microscope and other nondestructive testing methods. (Edited author abstract) In German. 13 refs.

Schmidt, Klaus (DFVLR, Braunschweig, West Ger). *Mitt Dtsch Forsch Versuchsanst Luft Raumfahrt* 87-08 1987 p 105-133.

**080245** ACOUSTIC EMISSION ANALYSIS IN PLASTICS. A survey of some of the developments in the characterization of failure mechanisms in particle filled and reinforced polymers by means of the acoustic emission measuring technique indicates the fields of application for this method under conditions of static and quasi-static tensile stress. Furthermore, a report is given on AE measurements performed on a modified hydraulically assisted testing machine on specimens subject to fatigue stress. The acoustic emission rate measured when testing short glass fibre reinforced polycarbonate under tensile fatigue stress gives an early indication of the imminent failure of the specimens. (Edited author abstract) 31 refs. In German and English.

Wolters, J.; Bardenheier, R. *Kunstst Ger Plast* v 77 n 9 Sep 1987 p 31-34.

**Fatigue** See Also COMPOSITE MATERIALS—Fracture.

**080246** MATRIX CONTRIBUTION TO FATIGUE BEHAVIOR OF GLASS REINFORCED POLYESTER COMPOSITES. The objective of this study was to investigate the influence of polyester toughness on longitudinal fatigue behavior of glass-fiber reinforced composites. The results show that at a high fatigue stress, the rate of increase in fatigue life with respect to decrease in fatigue stress is nearly equal for composites studied. However, in a stress range between 35 to 45 percent of the ultimate strength, the rate of increase in fatigue life with decrease in fatigue stress improves with use of the ductile polyester resin in the composite. In general, the final failure of the laminate was a combination of debonding and fiber breaks. The study shows that the toughness of the polyester helps in delaying the initiation of microdamage and offers a reliable index for measuring contribution of the matrix in FRP under fatigue loading. (Edited author abstract) 8 refs.

Joneja, Surendra K. *J Reinf Plast Compos* v 6 n 4 Oct 1987 p 343-356.

**Fibers** See Also COMPOSITE MATERIALS; COMPOSITE MATERIALS—Mathematical Models; COMPOSITE MATERIALS—Mechanical Properties; EPOXY RESINS—Adhesion; EPOXY RESINS—Fiber Reinforcement; PIPE, PLASTIC—Testing; PLATES—Vibrations; POLYMERS—Blending; POLYMERS—Molding; SPORTING GOODS—Plastics; THERMOPLASTICS—Processing; THERMOPLASTICS—Thermal Effects.

**080247** COMPOSITES TAKE THE STRAIN. Composite strands made up of pultruded fiber reinforced rods are promising candidates for use as tension members in structural applications, for example in suspension bridges or as tethers for oil platforms. This article describes a test program which aims to produce performance and design data for the use of advanced composites in this demanding application. Recognizing the growing interest in lightweight strength members, British Ropes began an investigation into the use of high strength fibers and fiber composites, with particular emphasis on structural applications. The performances of aramid, carbon and glass fiber reinforced plastics products are being evaluated against the more traditional steel strand.

Walton, John (British Ropes, Doncaster, Engl); Chin,

Yeung. *Engineering (London)* v 227 n 9 Sep 1987 suppl p 19, 21.

**080248** IMPACT PROPERTIES OF NATURAL FIBRE COMPOSITES. Little analysis has been made to correlate the impact behavior of natural fiber composites with the fiber properties. It is with this view that the present study on the impact properties of natural fiber composites has been undertaken. Unidirectionally aligned fiber/polyester composites containing ca. 0.5 volume fraction of sisal, pineapple, banana and coir fibers were prepared from unsaturated polyester prepreps. An attempt has been made to explain the variation in impact properties of various natural fiber composites in terms of microfibrillar angle of the fiber. 12 refs.

Pavithran, C. (CSIR, Trivandrum, India); Mukherjee, P.S.; Brahmakumar, M.; Damodaran, A.D. *J Mater Sci Lett* v 6 n 8 Aug 1987 p 882-884.

**080249** NEW MATERIAL CONCEPTS - FIBRE COMPOSITES SUPERIOR TO METALS. Asea Plast, with headquarters in Ojebyn outside Pitea in northern Sweden, is developing and manufacturing several interesting products having a lower weight and overall cost than corresponding products fabricated from traditional metals. The manufacture of tanks, pressure vessels, propeller shafts for trucks, leaf springs, and anti-armor weapon barrels is described. The use of CAD and expert systems is briefly outlined.

Barnheim, Bjorn. *ASEA J* v 60 n 5 1987 p 4-7.

**080250** CONTROLLED ENERGY DISSIPATION IN FIBROUS COMPOSITES. I. CONTROLLED DELAMINATION. Delamination mechanisms in continuous fiber reinforced composites were investigated. The concept of controlled interlaminar bonding (CIB) is proposed as a guideline for preparing fiber-epoxy composite laminates with enhanced fracture toughness without significant degradation in strength properties. The interlaminar bonding was manipulated by several specialized techniques including insertion of delamination promoters and surface modification of laminae. Results indicated that the plane-strain fracture toughness of E-glass-epoxy laminates could be improved by inserting perforated interlaminar films of aluminum, paper, polyester and polyimide, and fabrics. Experimental results from several composite systems are presented and discussed along with post-failure analysis data. (Edited author abstract) 19 refs.

Jang, B.Z. (Auburn Univ, AL, USA); Lieu, Y.K.; Chung, W.C.; Hwang, L.R. *Polym Compos* v 8 n 2 Apr 1987 p 94-102.

**080251** HIGH PERFORMANCE FIBER COMPOSITES WITH SPECIAL EMPHASIS ON THE INTER-FACE. The literature on high performance composites containing high strength, high modulus fibers, including glass, carbon, and aramid fibers in resin matrices is reviewed with special emphasis on the interface between fiber and matrix. The physical chemical properties of the various fibers and resin matrices are analyzed, and the manufacturing processes for making composites summarized. The effects on composite properties of fiber diameter, fiber length, fiber volume, fiber orientation, and the presence of voids are discussed. To obtain good adhesion between fiber and matrix, which is essential in high performance composites, physical interaction at the interface is important, but chemical reaction between fiber surface and matrix is desirable for optimal tensile and modulus properties. (Author abstract) 102 refs.

Cooke, T.F. (Textile Research Inst, Princeton, NJ, USA). *J Polym Eng* v 7 n 3 Apr 1987 p 197-254.

**080252** METHOD OF ESTIMATING THE ADHESION BETWEEN POLYMER AND FILLER OF FIBER REINFORCED COMPOSITE MATERIALS. The distribution of fiber lengths in injection moldings of fiber reinforced composite materials was almost normal. Under the conditions for normal distribution, i.e.,  $3\sigma$  (standard deviation)  $\approx L$  (average length), the equation of tensile strength reported by J. Yamaki becomes linear

with regard to the parameter  $\phi$  which estimates the adhesion between filler and polymer and aspect ratio. According to this equation, the  $\phi$  values of PC/GF and PP/GF prepared under various adhesive conditions were obtained. By using H.L. Cox's tensile strength equation assuming complete adhesion,  $\phi_0$  was then calculated. The results probably make possible the estimation of the effects of surface modifiers on adhesive conditions and the degree of adhesion. (Author abstract) 12 refs. In Japanese.

Suetsugu, Kenichiro (Matsushita Electric Industrial Co, Kadoma, Jpn); Sakairi, Tadashi. *Kobunshi Ronbunshu* v 44 n 5 1987 p 369-373.

**080253** CASE STUDY: TRANSPORT APPLICATIONS OF FIBRE REINFORCED PLASTICS - A CONSORTIUM APPROACH. This paper describes how a consortium of materials suppliers and end users selected components for the application of fibre-reinforced plastics composites in order to expand research into five specific areas. A brief outline of the ensuing research work on each component is given. (Author abstract) 1 ref.

Hughes, D. (Natl Engineering Lab, East Kilbride, Scotl). *Plast Rubber Process Appl* v 8 n 2 1987 p 69-78.

**080254** CRACK TIP HEATING IN SHORT-FIBRE COMPOSITES UNDER FATIGUE LOADING CONDITIONS. Crack tip heating in cyclically loaded short-fiber polymer matrix composites occurs by a combination of hysteretic heating and frictional heating. While the former mechanism is caused by plastic and viscoelastic deformations within the polymeric matrix, the latter is due to interfacial friction between matrix and fibers, and crack surface interference associated with crack closure. The relative contribution of these two principal mechanisms depends upon a number of variables including the viscoelastic and plastic characteristics and frictional properties of the matrix polymer, the degree of interfacial adhesion, the fiber content and fiber orientation distribution and the loading conditions. The results confirm that even in a tension/tension loading mode, frictional heating may play a dominant role, at least in some systems. (Author abstract) 22 refs.

Lang, R.W. (Lehigh Univ, Bethlehem, PA, USA); Manson, J.A. *J Mater Sci* v 22 n 10 Oct 1987 p 3576-3580.

**080255** STUDY OF MODEL POLYDIACETYLENE/EPOXY COMPOSITES. A model composite has been prepared consisting of a polydiacetylene single-crystal fiber in an epoxy resin matrix. The strain at points along the length of the fiber has been measured, using Raman spectroscopy, as a function of matrix strain and the post-cure temperature of the matrix. Good quantitative agreement has been found between the behavior of the cold-cured system and the shear-lag model of Cox. The critical length of the fibers was measured as a function of fiber diameter and compared with recent calculations using finite difference methods. Higher post-cure temperatures have been shown to lead to compressive deformation of the fibers due to matrix shrinkage on cooling. The deformation is manifest as twinning, which disappears reversibly during tensile deformation. The amount of matrix shrinkage was determined by measuring the level of strain required to remove the twins. (Edited author abstract) 18 refs.

Robinson, I.M. (UMIST, Manchester, Engl); Young, R.J.; Galiotis, C.; Batchelder, D.N. *J Mater Sci* v 22 n 10 Oct 1987 p 3642-3646.

**080256** FRICTION AND WEAR OF FIBER REINFORCED PPS COMPOSITES. The friction and wear properties of fiber-reinforced polyphenylene sulfide composites were investigated under abrasive and adhesive wear conditions, and an attempt was made to explain the



observed data with the friction and wear equations. The measured tribological data were also correlated with the observed microstructures. (Author abstract) 15 refs.

Lhymn, C. (Pennsylvania State Univ, Erie, PA, USA); Bozolla, J. *Adv Polym Technol* v 7 n 4 Winter 1987 p 451-461.

**080257 OBRADA PLASTICNIH VLAKNASTIH KOMPOZITA VODENIM MLAZOM.** [Machining of Fiber Composites with Water Jet]. With the growing use of composite materials, there is also an increase in interest for suitable machining possibilities, including nonconventional machining processes. This paper presents a description of water jet machining. Its significance and field of application. This process requires small cutting forces, and compared with other processes it is a 'cool' process. For this reason, water jet is used mostly to machine composites with or without fiber, rubber, glass or stone. By adding the abrasive materials into the water jet, this process can also be used for the machining of metals which are difficult to machine. (Author abstract) 16 refs. In Serbo-Croatian.

Ivancic, Ivan (Fakultet Strojarsva i brodogradnje, Zagreb, Yugosl). *Polimeri (Zagreb)* v 8 n 9 Sep 1987 p 269-272.

**080258 HIGH PERFORMANCE REINFORCEMENT FABRICS.** Commercial fiber reinforced plastics generally employ woven reinforcement fabrics to facilitate ease of handling. However, these fabrics do not fully realise the reinforcement potential of the fibers. The level of translation of the fiber properties into the composite structure, and the conformability to complex curvatures, are limited by the harshness of the weaving process and the crimp geometry of the weave. Over recent years, a number of alternative reinforcement fabrics have become available which allow more complete realization of the potential of the fibers. This paper reviews those fabrics. The paper first considers singly reinforcement fabrics (triaxial weaves, braids, knitted and non-woven materials) and then multi-ply reinforcements (stitch interlocks, through-plane weaves, and through plane random reinforcements). (Author abstract) 150 refs.

Summerscales, John (Plymouth Polytechnic, Plymouth, Engl). *Progr Rubber Plast Technol* v 3 n 3 1987 p 20-32.

**080259 MELT RHEOLOGY OF FILLED THERMOPLASTICS.** The rheological properties of filled thermoplastic melts are reviewed. The response of filled melts in steady, dynamic and transient shear follows as well as uniaxial extensional flows are studied in terms of three important material variables: the volume concentration of the fillers, filler size and shape, and polymer-filler interfacial characteristics. The fillers, the shapes of which strongly influence the overall rheology, especially the elastic behavior, can be classified into those having directionality such as fibers and those without it which we denote as particles. Within each category, increasing filler loading increases the viscous dissipation and elastic energy storage capacity of the system eventually giving rise to a yield stress at high concentrations. Decreasing filler size increases the importance of interfacial interactions and generally results in larger value of viscous dissipation and elasticity. The ratio of the normal stress difference to shear stress is smaller for a particle filled system than for the pure melt, but is larger for a fiber filled melt compared to the pure melt. (Edited author abstract) 76 refs.

Khan, S.A. (AT&T, Murray Hill, NJ, USA); Prud'Homme, R.K. *Rev Chem Eng* v 4 n 3-4 Jul-Dec 1987 p 205-270.

**080260 EFFECTS OF FILAMENT ORIENTATION ON THE LOSS FACTOR OF LAYERED COMPOSITE BEAMS - LAYERED COMPOSITE BEAMS REINFORCED IN TWO DIRECTIONS.** A damping material reinforced in two directions has been fabricated. The matrix of the damping material is an epoxy resin and a stainless steel filament is used as the reinforcing material. Experimental results show that the modulus of elasticity is more sensitive to the orientation of the reinforcing

filament than the loss factor and that the ability of the damping materials is improved by using a filament with a high modulus of elasticity for the damping material. The ability of the damping material reinforced in two directions is improved in comparison with the results for a damping material reinforced in one direction. (Edited author abstract) 4 refs. In Japanese.

Sakata, Toshiyuki; Sawaki, Teiji. *Chubu Daigaku Kogakubu Kiyo* v 23 Oct 1987 p 7-10.

**080261 POLAR-POLAR INTERACTION AND BOUNDARY PHASE STRUCTURE BETWEEN REINFORCEMENT AND MATRIX IN A POLYMER COMPOSITE.** This paper describes an attempt to correlate the nature of polar-polar interaction between the reinforcement and matrix in a polymer composite with the boundary phase structure formed in contact with the reinforcement. It is shown by analyzing the mechanical dispersion data that the reinforcement-matrix interaction of Kevlar fiber reinforced poly(hydroxypropyl ether of bisphenol A) (P) is increased by blending poly(ethylene oxide) (E) or poly(ethylene adipate) (A) as a part of matrix, and that E is more efficient than A for the increase of the interaction. These results can be supported at the molecular level from the inspection of the Fourier transform infrared spectra on the Kevlar fiber coated with matrix polymers and the mixture of matrix polymers with benzanilide, which is used as a model compound of Kevlar fiber. (Edited author abstract) 14 refs.

Kodama, Minekazu (Mitsubishi Electric Corp, Amagasaki, Jpn); Karino, Isamu; Kuramoto, Kazuo. *Polym Plast Technol Eng* v 27 n 1 Mar 1988 p 127-153.

**080262 THE STRESS-STRAIN CURVE IN FIBRE REINFORCED PLASTICS.** Recently, 'critical' composites have been made to test traditional fibre reinforcement theory. These critical composites contain short aligned fibres. They produced results which did not fit the theories. In this paper these theories are briefly reviewed and extended to include the case of fibres with debonded ends (such debonding could take place during manufacture). It is shown that such debonding will lead, under certain circumstances, to straight line stress-strain plots. (Edited author abstract). 17 Refs.

Piggott, M.R. (Univ of Toronto, Toronto, Ont, Can). *Mater Forum* v 10 n 4 1987 p 228-236.

**080263 FASERVERBUNDWERKSTOFFE (TEIL 1): FASERWICKELN MIT PREPREGS UND GMT-VERARBEITUNG.** [Fibre Composites, Part 1]. By virtue of their properties, fibre composites, which have so far been used chiefly in the classic light-weight construction sectors of the aviation and space industries, also have interesting applications to offer in mechanical engineering. This, however, calls for the development of new processes to permit sufficiently high item numbers to be rationally produced. In many cases, it is the impregnation and curing of the matrix that determine the cycle time. Direct impregnation also gives rise to qualitative shortcomings. The impregnation process can be eliminated by processing prepregs. Furthermore, cycle time can be drastically reduced by using a thermoplastic matrix. The processing methods - both winding and compression moulding - must, however, be adapted to the new materials. This is illustrated with the example of filament prepreg winding and GMT (glass mat reinforced thermoplastics) processing. (Edited author abstract). In German.

Borgschulte, K. (RWTH, West Ger); Burkhardt, G.; Effing, M.; Kirberg, K.; Mahlke, M.; Rosenbaum, U. *Plastverarbeiter* v 39 n 5 May 1988 p 48-65.

**080264 APPLICATION OF X-RAY TOMOGRAPHY IN NON-DESTRUCTIVE TESTING OF FIBRE REINFORCED PLASTICS.** Medical X-ray tomography has been used for non-destructive evaluation (NDE) of various types of polymeric products. Composites, carbon-graphites, fiber-reinforced aluminum, vulcanized rubbers and thermoplastics have been carefully examined in order to detect flaws, pores, voids and other imperfections in the materials. There is some evidence that medical

X-ray tomography can be a very sensitive instrument for registration of small density variation in polymers. (Edited author abstract). 24 Refs.

Ostman, Erik (Industrial Development Cent, Skelleftea, Swed); Persson, Sture. *Mater Des* v 9 n 3 May 6 1988 p 142-147.

**080265 QUALITÄTSVERBESSERUNG DURCH VOLLSTÄNDIGE PROZESSKONTROLLE.** [Fiber Reinforced Composite Materials - 2. Improved Quality Through Automation and Refined Process Control]. Part 1 of this three-part series on fiber composites gave a description of the processing methods. In this, the second part, a full-scale process control system is presented, taking the example of prepreg processing. It starts with the control of prepreg manufacture. Image processing systems provide good service on account of their high performance and flexibility. A second quality check is required before the prepreps are processed in order to establish the influence of storage. It goes without saying that particular attention should be paid to the curing cycle. The finished component must then be subjected to controls once again. Nondestructive test procedures will permit 100 percent control in large-scale production in the future. (Edited author abstract). In German.

Borgschulte, K. *Plastverarbeiter* v 39 n 6 Jun 1988 12p.

**080266 WIDE ANGLE X-RAY DIFFRACTION INVESTIGATIONS OF ORIENTATION OF CHOPPED FIBERS IN FABRICATED THERMOPLASTIC PARTS.** A method of determining fiber orientation in composites using wide angle X-ray diffraction (WAXD) is described. This approach is based upon examining the alignment of the highly oriented crystalline fibers. X-ray studies were carried out using Kevlar [poly(p-phenylene terephthalamide) (PPTA)] fibers suspended at a 0.31 volume fraction loading in a polycarbonate matrix. A pole figure device was used to determine the orientation distribution and average orientation factor of the PPTA crystallographic chain axes relative to reference axes located in the test specimen. We prepared ideally oriented uniaxial and biaxial composites as reference specimens using a compression molding machine. The fiber orientations in capillary extrudates, slit die extrudates, cold rolled sheets, and injection-molded specimens were examined by WAXD. The capillary extrudates showed uniaxial orientation but the slit die extrudates and cold rolled sheets exhibited biaxial orientation. Injection-molded specimens contained complex states of fiber orientation. (Edited author abstract). 14 Refs.

Lim, Soonho (Univ of Akron, Akron, OH, USA); Kikutani, Takeshi; White, James L.; Kyu, Thein. *Adv Polym Technol* v 8 n 3 Fall 1988 p 325-334.

**080267 NEW LOW COST, HIGH PERFORMANCE REINFORCING FIBER BEING DEVELOPED.** Research and development are under way at the University of Wisconsin that may have a profound influence on the fiber-reinforced plastics (FRP) industry in three years' time. A new class of reinforcement fibers has been discovered, combining some of the best features of boron, carbon, etc., with the low cost of glass. A technique has been found for melt spinning high mechanical performance fibers from ceramic compositions that need not contain boron or silica. Young's moduli well over double that of E glass have been produced. The technique is termed redrawn inviscid melt spinning (RIMS). RIMS is a two-step process, each of which is very rapid (milliseconds). The first step, inviscid melt spinning (IMS), circumvents the need for high melt viscosity, thus eliminating the need of chain formers such as silica. A transformation takes place when the glassy IMS fibers are reheated and drawn to still finer fiber diameters - the second step of the process. 4 Refs.

Dunn, Stanley A. (Univ of Wisconsin, Madison, WI, USA). *Glass Ind* v 69 n 11 Oct 1988 p 34, 39.



**Fillers** See Also COMPOSITE MATERIALS—Mechanical Properties; THERMOSETS—Dielectric Properties.

**080268 MINERAL REINFORCEMENTS: NOW THEY HELP TO EASE ADDITIVE TIGHTNESS.** The synergism that improved nonfibrous fillers and reinforcements bring to resin systems is a well-told tale. But there is a new twist in that they are beginning to be used as substitutes for scarcer or more costly ingredients...without sacrificing product quality. For example, in polypropylene outdoor furniture loadings of 40 to 80 percent of calcium carbonate and talc provide the stiffness and ceramic-like feel needed in this application. And with persistent tightness in titanium dioxide, some low-cost fillers are being tailored for service as pigment extenders. Overall, the theme in nonfibrous materials continues to be improved performance at an affordable price. The class of reinforcements that does not occur naturally gets several new entries: glass reinforced plastics macrospheres and thermoset plastic fillers.

Smoluk, George R. *Mod Plast* v 65 n 7 Jul 1988 p 46-48.

**Forming** See Also THERMOPLASTICS—Fiber Reinforcement.

**080269 DEVELOPMENT OF A PILOT AUTOCLAVE FOR POLYMERIC DIAPHRAGM FORMING OF CONTINUOUS FIBRE-REINFORCED THERMOPLASTICS.** An experimental autoclave has been designed and commissioned for polymeric diaphragm forming of continuous fiber-reinforced thermoplastic composite parts. The stand-alone autoclave is heated using a standard heater band and is pressurized by compressed nitrogen gas. Unidirectional and cross-ply stacked preregs of carbon fiber-reinforced polyetheretherketone have been successfully formed over a 90° single-curvature bend. Part reproducibility and quality is confirmed by non-destructive evaluation. Commercial opportunities for polymeric diaphragm forming techniques with thermoplastic composites are also discussed. (Edited author abstract) 7 refs.

Mallon, P.J. (Univ Coll Galway, Ire); O'Bradaigh, C.M. *Composites* v 19 n 1 Jan 1988 p 37-47.

**Fracture** See Also COMPOSITE MATERIALS—Fiber Reinforced; COMPOSITE MATERIALS—Mechanical Properties.

**080270 RELATION BETWEEN WORK OF FRACTURE AND FRACTURE TOUGHNESS OF SHORT-FIBRE REINFORCED POLYMERS.** On the basis of micromechanical failure mechanisms acting in short-fiber reinforced polymers the authors derive the crack resistance curve (R-curve) as a function of crack extension. With the conditions characterizing the point of crack instability, the critical crack extension and fracture toughness  $G_c$  are calculated. By comparing  $G_c$  to the work of fracture it is concluded that, depending on the relevant failure characteristics, two parameters are necessary to describe the failure behavior - the fracture toughness for crack instability or strength and the work of fracture as the energy necessary to drive the crack through the sample. (Edited author abstract) 4 refs.

Lauke, B. (Akad der Wissenschaften der DDR, Dresden, East Ger); Pompe, W. *Compos Sci Technol* v 31 n 1 1988 p 25-33.

**080271 EFFECT OF FIBER-MATRIX ADHESION ON THE FATIGUE FRACTURE OF GLASS-FIBER-REINFORCED POLY(VINYL CHLORIDE).** Fatigue crack propagation (FCP) of injection-molded glass-fiber-reinforced poly(vinyl chloride) was examined as a function of fiber-matrix adhesion (coupling) and fiber content at different load levels. Considering the entire FCP history, from crack initiation to critical propagation, it is shown that fatigue lifetime and fracture toughness of coupled composites increase with fiber weight fraction. Uncoupled material exhibits the highest fracture toughness at 10 wt% fiber, yet its fatigue life is considerably shorter. Damage analysis indicates that fiber debonding, pullout, and particularly fiber fracture seem to contribute to the higher fatigue lifetime noted in coupled composites.

The Crack Layer Theory is employed to describe the observed FCP behavior. The effective enthalpy to damage parameterizes the resistance of the composite to FCP in terms of the boserved mechanisms. (Author abstract) 14 refs.

Nguyen, P.X. (Case Western Reserve Univ, Cleveland, OH, USA); Moet, A. *Polym Compos* v 8 n 5 Oct 1987, Composites '86 - Part I, Nov 25-26 1986 p 298-307.

**Friction** See Also COMPOSITE MATERIALS—Fiber Reinforced.

**Glass Fiber** See Also AUTOMOBILE MATERIALS—Plastics; AUTOMOBILES—Springs and Suspensions; COMPOSITE MATERIALS—Fabrication; COMPOSITE MATERIALS—Fiber Reinforced; COMPOSITE MATERIALS—Mathematical Models; EPOXY RESINS—Applications; EPOXY RESINS—Fiber Reinforcement; GLASS FIBER—Corrosion; GLASS FIBER—Weaving; JOINTS, ADHESIVE—Corrosion; NATURAL GAS PIPELINES—Plastics Applications; NYLON POLYMERS—Reinforcing; PAPERMAKING MACHINERY—Plastics Parts; PIPELINES—Plastics Applications; PIPING SYSTEMS—Plastics Applications; PLASTICS—Crack Propagation; PLASTICS SHEETS—Sheet Molding Compounds; POLYAMIDES—Reinforcing; POLYCARBONATES—Crack Propagation; POLYESTERS—Reinforcing; POLYETHYLENE TEREPHTHALATE—Fiber Reinforcement; POLYETHYLENES—Mechanical Properties; POLYMERS—Crystallization; RECREATION CENTERS—Plastics Applications; SPORTING GOODS—Plastics; STAINLESS STEEL—Acoustic Emission Testing; TANKS—Plastics Applications.

**080272 FATIGUE BEHAVIOR OF PLAIN WOVEN GRP IMPROVED TO PREVENT FROM DAMAGE.** Measurements were made on the residual strength of glass-reinforced plastic (GRP) specimens and the strength of the constituting fiber strands in order to clarify the change in fiber strength during fatigue. It was found that the crack length obtained from A.A. Griffith strength agreed well with the predicted value calculated from the damage. Fatigue tests were made on the altered specimens whose weft strands were covered with polymer sheets. The warp strands were found to be protected from suffering damage by wefts at woven intersections. The fatigue strength increased by 2.26 times of the original value, and thus it was possible to prepare the cloth GRP of high fatigue strength. (Edited author abstract) In Japanese. 12 refs.

Hiwa, Chiaki (Kobe Univ, Kobe, Jpn); Okada, Shin-ichiro; Nakagawa, Takao. *Zairyo* v 36 n 407 Aug 1987 p 884-888.

**080273 DYNAMIC MECHANICAL PROPERTIES OF STRUCTURAL GLASS FIBRE-EPOXY COMPOSITES.** Dynamic mechanical measurements at a frequency of 1 Hz have been made from 100 to 480 K on unidirectionally aligned composites of glass fibers and epoxy resin of diglycidyl ether of bisphenol A and 4,4'-diaminodiphenylmethane, prepared under two conditions: (i) by mechanically mixing without a solvent; and (ii) by mixing their solutions in methyl ethyl ketone. The composites show the same three relaxation regions as the pure epoxies, but their relative magnitudes differ. The glass transition temperature of the composite prepared by the first method is less than that of pure epoxy but of that prepared by the second method is greater. (Edited author abstract) 12 refs.

Cavaille, J.Y. (McMaster Univ, Hamilton, Ont, Can); Johari, G.P.; Mikolajczak, G. *Polymer* v 28 n 11 Oct 1987 p 1841-1846.

**080274 DETERMINATION OF THE ORIENTATION OF SHORT GLASS FIBERS IN SHEET MOLDING COMPOUND (SMC).** A computer based semiautomatic procedure has been developed to measure the fiber orientation on the surface of Sheet Molding Compound (SMC) plaques. The principal orientation direction and the Hermann's orientation descriptor were used to summarize the fiber orientation distribution. The results show that only slight orientation was produced in the SMC plaque with a centrally placed charge occupying 40 percent of the area of the mold. Plaque to plaque, top surface to bottom surface, and region to region variability in the fiber orientation were observed. The orientation of

fibers in the four quadrants of the same plaque differed significantly. (Edited author abstract) 16 refs.

Kau, Hau-Tie (GM, Warren, MI, USA). *Polym Compos* v 8 n 2 Apr 1987 p 82-93.

**080275 NONDESTRUCTIVE METHOD TO DETERMINE MATERIAL PROPERTIES IN ORTHOTROPIC PLATES.** An electronic speckle pattern interferometer (ESPI) is used to determine modes of vibration in rectangular, orthotropic, free-free-plates; that is using a noncontact, nondestructive, optical method. It is shown, using the finite element method (FEM), that each of the first three modes of vibration in rectangular orthotropic plates has a strong dependence upon only one of the main material parameters, namely the in-plane shear modulus and the two Young's moduli, respectively. With this one-variable dependence it is a simple task to determine the effective material parameters. This method has several obvious advantages compared to the use of test bars and it can be extended to give a measure of the damping parameters and probably also be used for production control. Preliminary results are presented and discussed. (Author abstract) 7 refs.

Fallstrom, K.-E. (Lulea Univ of Technology, Lulea, Sweden); Molin, N.-E. *Polym Compos* v 8 n 2 Apr 1987 p 103-108.

**080276 WETTABILITY OF GLASS FIBRES WITH DIFFERENT SIZINGS AND THEIR ADHESION TO UNSATURATED POLYESTER MATRICES.** The wetting characteristics of unsaturated polyester resins on glass fibers with different sizings have been studied by contact angle determination periods. The styrene content of the matrix and the nature of the coatings result to be determinant in the wettability of glass fibers by the polyester matrices. Highest styrene content and styrene-soluble-coatings determine better wetting characteristics. Mechanical properties of the cured specimens and scanning electron microscopy on the fracture surfaces were also performed. Interesting correlations between the nature of the sizing agent and cohesive energy density with mechanical properties and fibre/matrix adhesion were found. (Author abstract) 7 refs.

Selliti, C. (CNR, Arcofelice Naples, Italy); Vargiu, S.; Martuscelli, E.; Fabbro, D. *J Mater Sci* v 22 n 10 Oct 1987 p 3477-3484.

**080277 ACOUSTO-ULTRASONIC TECHNIQUE FOR PREDICTING FATIGUE BEHAVIOUR OF GLASS-FIBRE REINFORCED PLASTICS.** Fatigue data for glass-fiber reinforced plastics (GRP) have even wider scatter due to inherent material and manufacturing anomalies associated with GRP. Hence, non-destructive evaluation (NDE) of fatigue behavior of GRP assumes greater significance. This paper describes an acousto-ultrasonic NDE technique, which is a combination of acoustic emission technique and ultrasonic technique, for the prediction of fatigue behavior of GRP composites. The results of the study show that the parameter commonly known as stress-wave-factor (SWF) can easily be used with fullest confidence to predict fatigue behavior of GRP composites. (Edited author abstract) 3 refs.

Prakash, R. (Banaras Hindu Univ, Varanasi, India); Srivastava, V.K. *J Inst Eng India Part Me* v 68 pt 1-2 Jul-Sep 1987 p 10-11.

**080278 ULTRASONIC DETECTION OF PERCENTAGE OF VOIDS IN GLASS-FIBRE REINFORCED PLASTIC CYLINDER.** This paper describes the results of a study undertaken to determine the relationship between ultrasonic attenuation and percentage of voids in glass-fiber reinforced plastic composite cylinders using an ultrasonic test instrument and metallurgical microscope. The validity of graph upto certain confidence level has been determined by simple library program using a computer. Correlation indicate that the ultrasonic attenuation can predict the percentage of voids



in GRP cylinder. Thus, by calculating the attenuation values one can fix the confidence limits of accepting or rejecting the material. (Author abstract) 6 refs.

Srivastava, V.K. (Banaras Hindu Univ, Varanasi, India); Shah, S.K.; Dwivedi, J.P. *J Inst Eng India Part ME* v 68 pt 1-2 Jul-Sep 1987 p 27-29.

**080279 MECHANISMS OF FATIGUE FRACTURE IN SHORT GLASS FIBRE-REINFORCED POLYMERS.** Fatigue-crack profiles and fracture surfaces of several short glass fiber-reinforced polymers were examined to gain insight into the mechanisms of cyclic damage and fatigue-crack propagation in these materials. Several distinctly different features were noted between fracture surfaces generated by stable fatigue crack growth and those produced by monotonic or unstable fracture. Among the most significant differences were the higher degree of single and multiple fiber fracture generally observed on stable fatigue-crack growth fracture surfaces, and the variations in the interfacial failure site in well-bonded systems. While the former effect is attributed to the occurrence of crack closure and the build-up of compressive stresses in the crack-tip damage zone during unloading, the differences in the interfacial bond strength. No features could be identified that would allow a quantitative correlation between the applied stress intensity factor level or the crack growth rates and characteristic fracture surface details. (Author abstract) 42 refs.

Lang, R.W. (Lehigh Univ, Bethlehem, PA, USA); Manson, J.A.; Hertzberg, R.W. *J Mater Sci* v 22 n 11 Nov 1987 p 4015-4030.

**080280 FATIGUE CRACK PROPAGATION IN GLASS-FIBRE AND GLASS-SPHERE FILLED PBT COMPOSITES.** Fatigue crack propagation has been studied in injection-molded plates of unfilled PBT and composites filled with short glass fibers of varying length and in different volume fractions. Materials filled with glass spheres and short glass fibers have also been investigated. The influence of crack propagation direction and of the microstructural composition on crack speed is discussed. It is found that a model which accounts for the fiber orientation distribution, the skin-core morphology and the change in failure mechanisms due to variations in the fiber length and aspect ratio can explain the differences observed in crack propagation behavior. (Author abstract) 16 refs.

Voss, H.; Karger-Kocsis, J. *Int J Fatigue* v 10 n 1 Jan 1988 p 3-11.

**080281 STRESS CORROSION CRACKING OF GLASS-FIBRE REINFORCED EPOXY RESINS.** Glass-fibre reinforced plastics with epoxy resin matrix (GF-EP) are known to respond with high sensitivity to a combined stress imposed by mechanical forces and mineral acids. This phenomenon is comparable with the stress corrosion cracking usually observed with metallic materials and is therefore also characterized as such in the case of GF-EP. In this paper the stress corrosion cracking of typical GF-EP insulators is determined quantitatively by fracture-mechanical experiments. From the obtained results material characteristic values are derived which can be used for the mechanical dimensioning of components and structural parts. A comparison of the material characteristic values of E- and ECR-glass fibre reinforced materials clearly exhibits the resistance of ECR glass fibres to media in composites. Thus, with respect to concentrated aqueous acids ECR glass-fibre reinforced materials exhibit a stress corrosion cracking sensitivity comparable to that of E-glass-fibre reinforced materials towards pure water. (Author abstract) 25 refs. In German and English.

Spaude, R.; Kaiser, T. *Kunstst Ger Plast* v 77 n 11 Nov 1987 p 21-23, 1161-1167.

**080282 EFFECTS OF TEMPERATURE ON STRESS-RUPTURE TIMES IN GLASS/POLYESTER LAMINATES.** The stress-rupture times of glass fiber-reinforced plastics in water are temperature-dependent. Increasing the temperature increases the diffusion

coefficient of a liquid in a given matrix, and may also increase the fracture toughness of the resin. The effects of these two parameters on the rupture lifetimes oppose each other, and so the overall outcome could be either an increase or a decrease in failure time. This problem is illustrated by experiments with glass fiber-reinforced polyester laminates in water. The failure times were greater at 45°C than at either 60°C or 30°C. Acoustic emission experiments suggested that resin microcracking was extensive at 30°C but was much less at the higher temperatures, although the glass transition temperature was outside the experimental range. The sequence of events leading to failure is described. (Edited author abstract) 15 refs.

Pritchard, G. (Kingston Polytechnic, UK); Speake, S.D. *Composites* v 19 n 1 Jan 1988 p 29-35.

**080283 POISSON'S RATIOS IN GLASS FIBRE REINFORCED PLASTICS.** The characterisation of the mechanical properties of an orthotropic composite material generally requires nine interdependent elastic constants: three Young's moduli, three shear moduli and three Poisson's ratios. In most papers it is the practice to quote only two orthogonal axial moduli, a shear modulus and a Poisson's ratio in the plane of the laminate. However, the value of Poisson's ratio is a function of the orientation of the loading axis relative to the principal axis of the reinforcement fibres, both in and through the plane of the laminate. In an earlier paper, the correlation of experimental and theoretically predicted Poisson's ratios was reported around the angles in the plane of the laminate. Both unidirectional and woven roving fibreglass panels were tested. Accurate prediction of Poisson's ratio was shown to be critically dependent on the value of shear modulus used. (Edited author abstract) 13 refs.

Craig, P.D. (Royal Naval Engineering Coll, Plymouth, Engl); Summerscales, J. *Compos Struct* v 9 n 3 1988 p 173-188.

**080284 SPECIFICATION, DESIGN AND FABRICATION OF GRP STRUCTURES FOR CORROSIVE APPLICATIONS.** Some topics discussed in connection with GRP (glass reinforced plastic) are the following: some uses of fiber-reinforced thermoset resin laminate; GRP equipment export; failures of GRP; specifications, as suitable for flue gas desulfurization scrubbers or ductwork; design and drawings of vessels and tanks in reinforced plastics; GRP fabrication for flue gas desulfurization plants; quality assurance, inspection, and testing; and in-service inspection and maintenance.

Reid, I. (Rotech Consulting Engineers, Wolverhampton, Engl). *Corros Prev Control* v 35 n 1 Feb 1988 p 16-19.

**080285 PROPERTY MODIFICATION OF BULK MOLDING COMPOUNDS FOR USE IN INJECTION MOLDING.** Although impact and flexural strength of injection-molded bulk molding compounds increase initially with glass fiber content, these properties level out at a glass volume fraction between 0.1 and 0.2, limiting the achievable properties. Use of 'special purpose' polyester resins gives no significant improvement in impact. The impact strength limitation is not worsened, however, by using the maximum processable level of filler, this being true for all fillers commonly used in polyester compounds. Replacement of a fraction of the glass by poly(ethylene terephthalate) fibers results in a substantial improvement in impact strength. (Author abstract) 9 refs.

Pritchard, M. (Univ of Liverpool, Liverpool, Engl); Gibson, A.G. *Polym Compos* v 9 n 2 Apr 1988 p 131-138.

**080286 PREPARATION AND RADIATION-RESISTANCE EVALUATION OF GLASS FIBRE COMPOSITES HAVING VARIOUS EPOXY MATRICES.** Polymer matrix composites are anticipated to be used as mechanical supporters and electrical insulators in the construction of superconducting magnets for fusion reactors. In this study the authors prepared five kinds of glass fibre composites having different epoxy matrices and evaluated the radiation resistance towards 2 MeV electrons with regard to the mechanical strength at room

temperature and at 77K. This work demonstrated that the radiation resistance depends on the type of matrix resin used. 12 refs.

Egusa, S. (JAERI, Takasaki, Jpn); Udagawa, A.; Hashimoto, O.; Ono, T.; Yamamoto, Y.; Sonoda, K. *J Mater Sci Lett* v 7 n 5 May 1988 p 503-505.

**080287 THERMAL EXPANSION OF POLYURETHANE REINFORCED WITH CONTINUOUS GLASS FIBERS.** This paper is concerned with the study of the thermal expansion properties of polyurethanes which are reinforced with randomly oriented continuous glass fibers. The thermal expansion of reinforced polymers is of prime importance since it has a significant effect on the overall dimensional stability of molded products. In this work the coefficient of linear thermal expansion (CLTE) is measured for both soft and rigid polyurethane containing various amounts of glass fibers. The experimental results show that: 1) there exists a maximum in the CLTE-temperature curves, the position of which depends on the type of resin and not on the glass content; 2) over the range of 0 to +70°C for rigid polyurethane, and -30 to +70°C for soft polyurethane, the CLTE decreases with temperature. The existence of a maximum in the above findings is confirmed with computations from a theoretical expression which was modified by the introduction of an efficiency factor. In applying this expression, parameters such as the Poisson's ratios, elastic moduli, and the CLTE's of the resins had to be evaluated at various temperatures. Based on these results, the CLTE-temperature curves were obtained and found to be in agreement with the experimental observations. (Author abstract) 12 refs.

Kia, Hamid G. (General Motors Research, Warren, MI, USA). *Polym Compos* v 9 n 3 Jun 1988 p 237-241.

**080288 UEVEGSZALAS POLIESZTERTERMEKEK JARMUIPARI ES EGYEB ALKALMAZASI IEHETOSEGEI.** [Possible Applications of Glass-Fibre Reinforced Polyester Products in the Vehicle Manufacturing and Others Industries]. The author surveys the different versions of glass-fibre reinforced polyester moulding powders and the advantages of products made of them. The Factory of Electro-Insulators and Plastics has made all preparations for manufacturing parts of large dimensions made of glass-fibre reinforced polyester moulding powder. The lamp bodies produced here enjoy increasing demand against those made of metal, and the range of moulded products is continually growing. (Edited author abstract) In Hungarian.

Vermes, Janosne. *Muanyag Gumi* v 24 n 6 1987 p 177-178.

**080289 WYTRZYMATOSC DORAZNA I ZMECZENIOWA POLIAMIDU WZMOCNIONEGO MIKROKULKAMI I WLOKNAMI SZKLANYMI.** [Immediate and Fatigue Strength of Polyamide Reinforced with Glass Microspheres and Fibers]. The immediate and fatigue strength of composites from polyamide-6 containing 58% by weight of glass reinforcement in the form of fibres and microspheres and differing in the relative amount of both reinforcements has been investigated. The exposure time in aging tests was from 1 to 24 months. It has been demonstrated that the addition of microspheres increases the fatigue strength and decreases the immediate strength of composites. A high value of the fatigue resistance coefficient for composites filled with microspheres only (much higher than the value of this coefficient for pure polymer matrix) justifies its potential applications in the construction of sliding blocks. (Edited author abstract) 10 refs. In Polish.

Nowak, Marian (Politechnika Wroclawska, Pol). *Polimery* v 33 n 2 Feb 1988 p 59-63.



**080290 BADANIE ODPORNOŚCI NA DZIAŁANIE CZYNNIKÓW KLIMATYCZNYCH SAMOGAS-NACEGO POLI(TEREFTALANU ETYLENOWEGO) WZMOCNIONEGO WŁOKNEM SZKLANYM.** [Investigation of the Weathering Resistance of Self-Extinguishing Glass-Reinforced PET]. It has been demonstrated that both artificial and natural weathering practically does not change the tensile load at fracture, notchless impact, oxygen index and tracking resistance of PET reinforced with 30% glass fibre and containing 5% red phosphorus as flame retardant. The relative elongation at fracture of this product changes slightly after weathering. It has been found that 6 months of natural weathering is equivalent to 500 h of artificial weathering. (Edited author abstract) 5 refs. In Polish.

Silin-Boranasowska, Lora (Inst Chemii Przemysłowej, Pol). *Polimery* v 33 n 1 Jan 1988 p 27-28.

**080291 SIMULATION OF LOW CYCLE FATIGUE FAILURE OF GLASS-MAT FRP BY AE METHOD.** Previously it has been shown that AE ring-down counts of glass-mat FRP in low-cycle fatigue loading become steady at the comparatively initial stage and their amounts are approximately linear with the fatigue life on a log-log diagram. In the present study, it was found that AE ring-down counts at each cycle during low-cycle fatigue could be evaluated from the strain response at the corresponding cycle by using the relation between strain and AE counts in static tests. It was also shown that the strain at each cycle during fatigue could be represented by the secant modulus and the modulus under unloading, and that both moduli at each cycle could be calculated from the applied stress and the secant modulus at the first cycle of the fatigue tests. Based on these concepts and then using the above-mentioned relation between AE counts and fatigue life, the prediction of low-cycle fatigue failure was made by a simulation method. A rather good agreement between the simulated and tested results was obtained. (Author abstract). 6 Refs. In Japanese.

Fukuda, Takehito (Osaka City Univ, Osaka, Jpn); Osaka, Katsuhiko; Fujii, Taichi; Takada, Masahiro. *Zairyo* v 37 n 416 May 1988 p 511-516.

**080292 RELATIONSHIP BETWEEN FRACTURE MECHANISMS AND AE CHARACTERISTICS OF MODEL GFRRP.** The fracture mechanisms of three kinds of model composites, such as the unidirectional glass fiber, the 0°/90° glass fiber and the plain weave cloth reinforced composites, were studied by using the acoustic emission (AE) method in tension, and by observation with optical and electron microscopes. It was found that the fracture mechanisms were different from each other because of their different types of reinforcement, and the AE event rate and the AE total energy were the effective parameters to make them clear. The fracture mechanisms could not be explained by the AE amplitude distribution, but by the power spectrum of AE waves based on the frequency analysis. The dominant frequencies in AE signals due to the matrix cracking, the debonding, the fiber breaking and the friction between fibers could be specified, and they increased in order of such phenomena. (Author abstract). 9 Refs. In Japanese.

Sun, Feng (Kyoto Inst of Technology, Kyoto, Jpn); Suzuki, Megumu; Nakanishi, Hiroshi; Iwamoto, Masaharu; Jinen, Eiichi. *Zairyo* v 37 n 416 May 1988 p 517-522.

**080293 FAILURE OF DUCTILE INTERLAYER COMPOSITES: HIGH-RESOLUTION X-RADIOGRAPHIC EXAMINATION USING AN OPAQUE PENETRANT.** The role of the interface between the components in any composite material is recognized as being of paramount importance in the determination of some properties, not least being the mechanical strength to failure. Generally this interface is the region in which bonding is achieved between the resin and the coupling agent on the fibres. The introduction of a ductile interlayer will alter the stress distribution in the regions around the fibres, thus delaying the transverse failure of the interface or resin which results in the premature weepage of pressure vessels or piping. In this study high-resolution

radiography has been utilized to study the failure of a glass fibre-epoxy composite and to examine the effects of the incorporation of a ductile interlayer. 8 Refs.

Shelton, C.G. (Shell Research Ltd, Chester, Engl); Marks, P.R. *J Mater Sci Lett* v 7 n 6 Jun 1988 p 673-675.

**080294 NEW APPROACH TO BULKED ROVING UPGRADES COMPOSITE PERFORMANCE.** A family of products designed to impart multiaxial reinforcement with uniaxial input has been created by a new approach to the manufacture of a bulked roving product. It is an outgrowth of Owens-Corning's spun roving programs in Europe, Canada, and the U.S. The new product distributes itself uniformly through a cavity over a wide range of glass contents. This allows it to fill a mold of variable cross-section - expanding and contracting within the available space to mold a solid section. It also can be made to have controlled axial extensibility ranging from high (for performing) to low (for pultrusion and filament winding). This paper outlines the process used to form the product, discusses the format and concept of the product, defines selected performance aspects, and presents property data comparing the bulked roving systems to existing products such as Fiberglas Canada 852 HC 4035 spun roving and OCF 424BA Type 30 roving. Information on the performance of Type 30 bulked roving hybrids is also presented.

Glaser, H.I. (Owens-Corning Fiberglas Technical Cent, Granville, OH, USA); Gauchel, J.V. *Mod Plast* v 65 n 8 Aug 1988 p 5.

**080295 WET-LAID PROCESS FOR THE PREPARATION OF RANDOM FIBER-REINFORCED COMPOSITES.** There are several proven methods of preparing fiber-reinforced plastics (FRP). Each of these methods has some limitations. Dow's Random Fiber Composite (RFC) process was developed to reduce the disadvantages of the slow and inefficient methods of composite-sheet or hand lay-up fabrication. The benefits of the wet-laid process, such as maximum fiber debundling during processing, minimum degradation, and complete randomization of the short fiber, as well as successful results of laboratory tests are described. Typical physical processes of glass-reinforced HDPE and polypropylene composites prepared in the laboratory are given. The process was tested on a pilot-sized fourdrinier continuous paper machine. Several advantages of the RFC process are worked out and some products, such as the EMI (electromagnetic interference) shielding composites and electrical circuit board composites, are described.

Yats, Larry, D. (Dow Chemical, Midland, MI, USA); Edens, Michael, W. *Tappi J* v 71 n 8 Aug 1988 p 81-84.

**080296 MECHANICAL PROPERTIES OF FRP WITH BRAIDED STRUCTURE PART 3: BENDING BEHAVIORS OF TUBES.** Tubes with four kinds of braiding angles were fabricated. The test method was four-point bending type. The deformation state and the stress distribution of the specimen under bending load were checked by using the finite element method. The main results are: in the case of the specimen with low braiding angle, the fracture was initiated in the compression side of the tube and then the buckling failure occurred, but the tension failure occurred in the case of the high braiding angle; the bending modulus and the bending strength of the tube were increased with decrease of the braiding angle; the through-the-thickness braided tubes could improve the bending modulus in all types of tubes. (Edited author abstract). 11 Refs. In Japanese.

Yokoyama, Atsushi (Osaka Prefectural Industrial Research Inst, Jpn); Maekawa, Zenichiro; Hamada, Hiroyuki. *J Text Mach Soc Jpn* v 41 n 6 1988 p 45-53.

**080297 PREFORMS PAVE THE WAY FOR LOWER-COST STRUCTURALS.** After several decades in the shadows, fiber glass preforms are once again becoming a factor in reinforced plastics. The action in structural parts is mostly in automotive, but once the technology is developed, similar applications will start to emerge in recreational and agricultural vehicles, industrial

equipment, and large appliances. With the advent of highspeed reactive polymers that produce Class A surfaces, moreover, these two low-pressure processes may edge into production volumes that have traditionally been SMC's turf. The combination of faster chemistry, new low-profile polymers, plus the growing demand for parts for low-volume niche vehicles, will begin pulling molders of conventional RIM parts into the arena structurals and semi-structurals.

Miller, Bernie (Plastics World, Newton, MA, USA). *Plast World* v 46 n 1 Jan 1988 p 26-29,31.

**080298 WELDLINE INTEGRITY OF REINFORCED PLASTICS: EFFECT OF FILLER SHAPE.** The paper is a preliminary report on glass fiber and glass flake orientation in the weldline zone of injection molded reinforced polypropylene. Two types of weldlines were studied using simple shape molds: one where two melt streams meet head-on and become immobilized, the other where the weldline formation is followed by additional flow. In the weldlines of the first type, which are characteristics of current standard molds used to test weldline strength, the anisometric particles are almost perfectly oriented perpendicular to flow. As a result, the weldlines of this type tend to be weak and brittle. In the second case when the weldline is formed by merging of melt streams separated by an insert, particle orientation in the weldline area remains different from other areas of the sample for long distances from the insert. It is shown that in molds where the weldline formation is followed by laterally expanding flow the change of particle orientation is faster than for unidirectional flow. (Author abstract) 21 refs.

Fisa, B. (Ecole Polytechnique de Montreal, Montreal, Que, Can); Dufour, J.; Vu-Khanh, T. *Polym Compos* v 8 n 6 Oct 1987 p 408-418.

## Glass Transition

**080299 BESTIMMEN DES GLASUEBERGANGS VON FASERVERBUNDWERKSTOFFEN IM STATISCHEN ZUGVERSUCH.** [Determination of Glass Transitions in Fibre-Reinforced Materials by a Static Tensile Test]. The maximum service temperature for fibre-reinforced materials with organic matrices is usually limited by the softening of the matrix as it approaches its glass-transition region. This can be determined approximately by a thermomechanical test. Since moisture content and rate and severity of loading affect the position of the glass transition, the test must be carried out as far as possible under conditions that lead, in practical use, to the lowest glass-transition temperature. For  $\pm 45^\circ$  laminates these conditions can best be simulated by a static tensile test, rather than by the use of the normal torsion pendulum test and dynamic mechanical analysis. (Author abstract) 10 refs. In German.

Maier, George. *Kunstst Ger Plast* v 78 n 4 Apr 1988 p 330-333.

**Graphite Fiber** See Also COMPOSITE MATERIALS—Nondestructive Examination; COMPOSITE MATERIALS—Radiation Effects; EPOXY RESINS—Fiber Reinforcement; PLATES—Vibrations.

**080300 ADHESION AT THE INTERFACE IN CURED GRAPHITE FIBER EPOXY-AMINE RESIN COMPOSITES.** The effect of high temperature curing on the interface between unsized or epoxy-sized graphite fiber tow and epoxy-amine resin was examined by scanning electron microscopy of compression and freeze fractured specimens. Little or no adhesion was found between the unsized graphite fiber tows and the epoxy-amine resin on curing at 165°C for 17 hrs. Epoxy-sized graphite fibers showed a similar lack of adhesion between the fiber tows and the epoxy-amine resin at 3 and 17 hrs. cures, although good penetration of the resin into the sized fiber tows had



occurred. Interfacial bond strengths for the composites could not be effectively measured by compression fracture of specimens. (Author abstract) 10 refs.

Needles, Howard L. (Univ of California, Davis, CA, USA); Alger, Kenneth W.; Okamoto, Robert. *J Reinforced Plast Compos* v 6 n 4 Oct 1987 p 357-366.

**080301 GRAPHITE AS AN IMBEDDED STRAIN GAUGE MATERIAL.** Graphite epoxy composite material offers a unique window into its state of strain or structural integrity. Since unidirectional graphite epoxy composites possess an electrical resistance in the direction of the fibers over four orders of magnitude less than the electrical resistance across the fibers, electrical resistance measurements can be accurately correlated with strain in the fibers. Moreover in the case of internal damage in which the graphite fibers are broken, the electrical resistance measurements can serve as a clear indicator of internal damage which might not be otherwise apparent. The actual values of strain sensitivity,  $S_A$ , as calculated from the resistance measurements, varied between 1.2 and 1.8. These values depended critically upon the exact geometry of each hand laid up specimen, and with more control over the specimens in the future, a more accurate value for  $S_A$  for this material can be expected. However, for a single, typical specimen, the apparent value of  $S_A$  stayed constant to within  $\pm 4\%$  over a wide range of strain, indicating that with calibration the graphite can serve as its own strain gauge with the same accuracy. (Author abstract)

Rask, Olaf N.; Robinson, David A. *SAMPE J* v 24 n 1 Jan-Feb 1988 p 52-55.

**080302 MANUFACTURING STRESSES AND STRAINS IN FILAMENT WOUND CYLINDERS.** Tests were performed to verify a previously developed model for simulating the manufacturing process of filament wound cylinders. The axial and hoop strains were measured during cure inside a filament wound Fiberite T300/976 graphite-epoxy cylinder. The measured strains were compared to those computed by the model. Good agreements were found between the data and the model, indicating that the model is a useful representation of the process. For the conditions of the test, the manufacturing stresses inside the cylinder were also calculated using the model. (Author abstract) 4 refs.

Calius, E.P. (Stanford Univ, Stanford, CA, USA); Kidron, M.; Lee, S.Y.; Springer, G.S. *SAMPE J* v 24 n 3 May-Jun 1988 p 7-9.

**080303 SPACE RADIATION EFFECTS ON POLY(ARYL-ETHER-KETONE) THIN FILMS AND COMPOSITES.** The purpose of this study was to assess the space durability of poly(aryl-ether-ketone) (PEEK) in the forms of films and graphite fiber reinforced composites. The influence of the film's crystallinity on electron radiation stability was evaluated using X-ray diffraction, DSC, FTIR, and mechanical property tests. The mechanical properties were evaluated after electron radiation and after electron radiation followed by thermal cycling simulating 30 years in geosynchronous orbit. (Author abstract) 14 refs.

Funk, Joan G. (NASA Langley Research Cent, Hampton, VA, USA); Sykes, George F. Jr. *SAMPE Q* v 19 n 3 Apr 1988 p 19-26.

**080304 SPACE STRUCTURES...BUILT IN SPACE.** On-orbit manufacture of large space structures could be closer to reality as the result of the development of high-temperature, high-strength thermoplastic polymers. These high-performance thermoplastics, when used as matrices with high-modulus graphite fibers, produce structures that are 35 to 40 percent lighter and two to five times stronger than conventional aluminum alloys. With the technology firmly in place, there is every practical reason that polyetherimide and polyetheretherketone composites can be cost-effectively orbit-pultruded into channels, hat sections, and I-beams to construct large space dwellings and other components. Use of coiled stock pultruded on earth can result in substantial decrease in

payload volume (and hence shuttle weight) for earth-to-orbit transport. 8 Refs.

Wilson, M.L. (NASA, Hampton, VA, USA); MacConachie, I.O.; Johnson, G.S. *Mod Plast* v 65 n 8 Aug 1988 p 102,104,108.

**Graphite Fibers** See Also COMPOSITE MATERIALS—Radiation Effects.

**080305 USE OF WEIBULL STATISTICS TO QUANTIFY SPECIMEN SIZE EFFECTS IN FATIGUE OF GRP.** Data are presented to show that changing specimen size has a considerable effect on the fatigue life of unidirectional GRP. As the volume of material under stress is increased, the probability of the existence of a severe defect also increases and so the expected fatigue life will decrease. Weibull statistics are used to calculate the magnitude of this effect, and the predictions tested against the experimental data. Within the limits of its accuracy, the model was found to account for the observed differences in the fatigue lives of specimens and large sections cut from components, in most situations. The Weibull predictions are tested against experimental data obtained for unidirectional glass reinforced epoxy composites tested in flexure. (Edited author abstract) 8 refs.

Crowther, M.F. (GKN Technology Ltd, Wolverhampton, Engl); Starkey, M.S. *Compos Sci Technol* v 31 n 2 1988 p 87-95.

**High Temperature Properties** See COMPOSITE MATERIALS—Fiber Reinforced.

#### Injection Molding

**080306 SOME FEATURES OF THE INJECTION MOLDING OF SHORT FIBER REINFORCED THERMOPLASTICS IN CENTER SPRUE-GATED CAVITIES.** This paper describes an investigation into the fiber orientation in a number of center sprue fed cavities in short glass fiber filled polypropylene and nylon. The data have been interpreted in terms of a generalized five-layer structure resulting from the frozen skin formation and the high and low shear levels in the flowing melt. The implications for scaling up the mold size are discussed from the results obtained with different short volumes. The fiber structure was observed to depend on location in the molding, local injection time, and injection rate. In addition the occurrence of fiber-free layers within the moldings using the filled polypropylene increases with an increase in short volume, which produces an inherent 'scale-up' problem. Notwithstanding the mold geometry subtleties, the fiber orientation in all the moldings follows similar patterns and trends. (Author abstract) 20 refs.

Darlington, M.W. (Cranfield Inst of Technology, Cranfield, Engl); Smith, A.C. *Polym Compos* v 8 n 1 Feb 1987 p 16-21.

**080307 MOLD-FILLING SIMULATIONS FOR THE INJECTION MOLDING OF CONTINUOUS FIBER-REINFORCED POLYMER.** Injection molding can be used to fabricate fiber-reinforced polymer composites by impregnating a continuous fabric mat preplaced in a mold cavity with a polymer resin. The mold-filling time is dependent on the flow and heat transfer behavior in the mold. A model is proposed that considers the non-Newtonian flow through the porous fabric mat and the heat transfer between mold, fabric mat, and flowing fluid. The model was simulated for the mold filling of a carbon fiber mat with a pseudoplastic polymer solution. The results from the simulation provide information for optimizing mold-filling parameters through proper selection of inlet fluid pressure, heat source temperature, and type of polymer-solvent system. (Author abstract) 12 refs.

Chan, A.W. (Univ of Cincinnati, Cincinnati, OH, USA); Hwang, S.-T. *Polym Eng Sci* v 28 n 5 Mid-Mar 1988 p 333-339.

**080308 SPRITZGIESSEN VON KOHLENSTOFFASERVERSTAERKTEM POLYCARBONAT.** [Injection Molding of Carbon-Fiber-Reinforced Polycarbon-

ate]. In order for fiber reinforcements in thermoplastics to be as effective as possible, the fibers must be firmly bonded to the matrix resin and fiber length should be as long as possible. Using carbon fibers that were specially treated to promote adhesion to polycarbonate, an investigation was conducted to determine the physical properties attainable when the fiber-matrix mixture is processed directly in an injection molding machine. It was found that higher values for tensile and flexural strength were attained in comparison with a commercially available, compounded material. (Author abstract) 2 refs. In German.

Kompalik, Dieter (Sigri GmbH, Meitingen, West Ger); Schmid, Bernd. *Kunstst Ger Plast* v 78 n 4 Apr 1988 p 308-311.

#### Inspection

**080309 ESTABLISHING CRITERIA FOR A COMPUTERIZED VISION INSPECTION OF HOLES DRILLED IN CARBON FIBER COMPOSITES.** Two basically different carbide bit designs, a dragger bit and a standard twist drill, were tested extensively in graphite/epoxy composite material. A commercially available computer vision system was utilized to evaluate hole quality as the bits wore from fraying, delamination, and hole tolerance. Methods and procedures for establishing acceptance criteria using the vision system are given. Based on manual acceptance criteria, vision system criteria were established for fraying and suggested for entrance delamination. (Author abstract) 8 refs.

Hough, Clarence L. (Texas A&M Univ, College Station, TX, USA); Lednicki, Thomas E.; Griswold, Norman. *J Test Eval* v 16 n 2 Mar 1988 p 139-145.

#### Laminating

**080310 THERMOANALYTICAL INVESTIGATION OF COMPOSITE LAMINATION.** Glass cloth reinforced epoxy resins are commonly used to make composites. The performance of these laminates depends strongly on optimizing cure kinetics and rheology for a given chemical composition and temperature/pressure profile. Aborted flow tests (weight percent resin squeezed out during a given temperature/pressure cycle) is frequently used to emulate lamination process and/or to evaluate new formulations. The cure reaction was monitored using different scanning calorimetry, rheology, and dielectrometry. Gravimetric and thickness measurement indicated a non-uniform resin distribution across the laminate, with a lower resin content found at the edges. Macroscopic flow is controlled by three dimensional heat transfer, which leads to a dynamic temperature distribution and, concomitantly, to a cure/rheology profile. (Edited author abstract) 18 refs.

Gotro, J. (IBM, Endicott, NY, USA); Appelt, B.; Yandratsits, M.; Ellis, T. *Polym Compos* v 8 n 4 Aug 1987, Paper Presented at the 1986 Annu Tech Conf of the Soc of Plast Eng, Boston, MA, USA, May 1986 p 222-231.

#### Machining

 See Also CUTTING TOOLS—Diamond.

**080311 BEARBEITUNG FASERVERSTAERKTER KUNSTSTOFFE MIT WASSER- UND LASERSTRAHL.** [Machining of Fiber-Reinforced Plastics by Means of Water Jet and Laser Beam]. The specific advantages of water jet cutting have opened up a broad field of application in machining fiber reinforced plastics. The requirements for high cutting rates without damaging the workpiece restricts the application of this technology to thin walled components. A clear improvement of the working results both on qualitative level and by shifting the limits of performance toward a higher material thickness can be achieved by adding solids to the water jet. Whereas trimming of fiber-reinforced plastics by means of the water jet has become an industrially well known method, laser beam cutting has not been introduced that widely. Reduction of the thermal damage produced by this method and the roughness of the cut surfaces can be achieved by the appropriate process parameters but also by the application of lasers of shorter wavelengths. (Edited author abstract) In German. 6 refs.



Koenig, Wilfried; Trasser, Fr.-Joachim; Schmelzer, Manfred. *VDI Z* v 129 n 11 Nov 1987 p 6-11.

**080312 TURNING OF FIBER-REINFORCED PLASTICS.** In modern day engineering high demands are being placed on components made of fiber-reinforced plastics in relation to their geometric tolerances as well as their surface quality. This paper presents a summary of the experimental results obtained when turning glass fiber-reinforced laminated materials and glass fiber, carbon fiber, and aramid fiber-reinforced filament-wound tubes in an external cylindrical manner. Surface roughnesses, cutting forces, cutting temperatures, and cutting tool wear as a function of the machine setting parameters are presented and discussed. (Edited author abstract). 13 Refs.

Spur, G. (Technical Univ Berlin, Berlin, West Ger); Wunsch, Udo E. *Manuf Rev* v 1 n 2 Jun 1988 p 124-129.

**Materials** See POLYSTYRENES—Defects.

**Mathematical Models** See Also COMPOSITE MATERIALS—Fiber Reinforced.

**080313 EQUATIONS OF STABILITY OF TECHNOLOGICALLY STRESSED ANISOTROPIC SHELLS.** We propose the rigorous construction of a mathematical model of stability of a technologically stressed shell made from composite polymer material (CPM) based on relations of nonlinear stability theory. 4 refs.

Yakovlev, V.S. (A.A. Grechko Naval Acad, Leningrad, USSR). *Mech Compos Mater* v 23 n 2 Mar-Apr 1987 p 204-208.

**080314 THERMAL STRESSES IN ROD COMPONENTS MADE OF COMPOSITES PRODUCED BY THE SPIRAL WINDING METHOD.** In producing components based on high-modulus hybrid fillers, their mechanical and service characteristics are increased and processing properties improved by introducing a layer of a reinforcing fiber placed along a spiral around the main reinforcing material. Additional stresses and strains caused by the interaction between the rod element and the winding layer with temperature variations may appear in the structure of the composite. We examine thermal deformation of an element of a rod with the length equal to the winding step  $t$ . The results of the investigations show that it is possible to control in the required direction the magnitude of the thermal stresses and strains in the rod elements and composites with spirally reinforced fillers by the rational selection of the materials of winding layers, their geometrical dimensions, and laying angles. 6 refs.

Greger, G.E. (Voroshilovgrad Engineering Inst, USSR); Ignat'ev, B.B.; Chesnokov, V.V.; Karvasarskaya, N.A.; Panfilov, A.M. *Mech Compos Mater* v 23 n 2 Mar-Apr 1987 p 225-229.

**Mechanical Properties** See Also ADHESIVES—Bonding; COMPOSITE MATERIALS—Design; COMPOSITE MATERIALS—Fiber Reinforced; EPOXY RESINS—Reinforcing; POLYMERS—Fiber Reinforcement; POLYMETHYL METHACRYLATE—Fiber Reinforcement; POLYPROPYLENE—Fiber Reinforcement.

**080315 EFFECT OF GLASS FIBER LENGTH ON THE CREEP AND IMPACT RESISTANCE OF REINFORCED THERMOPLASTICS.** Impact and flexural creep testing were conducted at temperatures between  $-22^{\circ}\text{F}$  ( $-30^{\circ}\text{C}$ ) and  $250^{\circ}\text{F}$  ( $121^{\circ}\text{C}$ ) to evaluate and compare the end-use performance of continuous long glass fiber-reinforced thermoplastic sheet composites to that of short glass fiber-reinforced thermoplastics. The matrices studied consisted of amorphous (polycarbonate and acrylonitrile-butadiene-styrene) and semicrystalline (polypropylene) polymers. Data were obtained from both injection-molded specimens (short fibers), and from specimens machine-cut from compression-molded test panels (continuous long fibers). The results of this study point to the significant property improvement of continuous long fibers vs. short fibers. (Edited author abstract) 38 refs.

Silverman, Edward M. (BFGoodrich Co, Brecksville, OH, USA). *Polym Compos* v 8 n 1 Feb 1987 p 8-15.

**080316 ULTRASONIC EVALUATION OF FILLED POLYMERS. II. ELASTIC MODULI OF A RESIN FILLED WITH IRON INCLUSIONS OF DIFFERENT ASPECT RATIOS.** An ultrasonic technique is used for the nondestructive evaluation of elastic moduli of polymer composites. Samples with varying amounts of randomly oriented iron inclusions, having aspect ratios  $p=0.20$  (flakes) and  $p=20.0$  (short fibers), were fabricated and fully characterized. The results for the moduli are discussed in terms of available theoretical models. It is demonstrated that models which account for the microscopic details of the material offer a good description of the bulk properties. Also, experimental evidence is obtained for the effect of particle contiguity and allows one to evaluate the influence of particle/particle interaction. (Author abstract) 20 refs.

Piche, L. (Nat'l Research Council Canada, Boucherville, Que, Can); Hamel, A. *Polym Compos* v 8 n 1 Feb 1987 p 22-28.

**080317 FATIGUE STRENGTH OF AROMATIC POLYAMIDEIMIDE-AROMATIC POLYAMIDE FIBER COMPOSITE FILMS.** For the purpose of making a more flexible composite, an aromatic polyamideimide (PAI) film was reinforced by aromatic polyamide fiber (Du Pont, Kevlar 49) to form a bidirectionally oriented cloth composite. The fatigue strength of this composite film was investigated by cyclic tensile stress, with respect to the direction of fiber orientation. In the cloth composite film, the fatigue behavior was anisotropic, as were the other mechanical properties. The characteristics of fatigue life at the composite film were related to the intermediate characteristics of fatigue life at both the cloth reinforcement and the PAI matrix. The fatigue strength of the composite film may be correlated with its static strength. (Author abstract) 9 refs. In Japanese.

Ohmiya, Yoshihiro (Gunma Univ, Kiryu, Jpn); Shinohara, Takeshi; Kanai, Nobuto; Kambe, Hirotaro. *Kobunshi Ronbunshu* v 44 n 5 1987 p 395-398.

**080318 EFFECTS OF WELD LINE ON STRENGTH OF FIBER REINFORCED THERMOPLASTICS INJECTION MOLDING.** The strength of fiber reinforced thermoplastics (FRTP) injection molded parts is reduced by weld lines. The aim of this study is to clarify the mechanism of weld lines and the effects on strength of molding. The materials used are fiber reinforced polycarbonate (PC) with 10, 20, and 40 wt% glass fiber content. Dumbbell-shaped tensile test specimens with weld lines were molded at various injection pressures, cavity pressure, and resin temperature were noted. Measurement of tensile strength and observation of the weld region were carried out. The ratio of strength with weld line to that without weld line decreases remarkably with increasing fiber content. The strength of the molding with weld line increases with the filling pressure and/or the holding pressure. (Edited author abstract) 10 refs. In Japanese.

Hamada, Hiroyuki (Kyoto Inst of Technology, Kyoto, Jpn); Maekawa, Zenichiro; Horino, Tunes; Tomari, Kiyotaka; Yotsutsuji, Akira; Itami, Masao; Lee, Kueichi. *Kobunshi Ronbunshu* v 44 n 9 Sep 1987 p 649-656.

**080319 TENSION AND COMPRESSION OF GLASS REINFORCED AND ORGANIC PLASTICS AT ROOM AND CRYOGENIC TEMPERATURES.** The work described in this paper is the continuation of the systematic investigations by the authors of the behavior of organic plastics in comparison with glass reinforced plastics with the same arrangement of the reinforcement, the same loading conditions, at the same temperatures. The investigations were confined to the class of wound materials with a crossed structure based on epoxy binders. The experiments were carried out at room temperature at cryogenic and elevated temperatures. The present work entailed the study of the strength, elastic, and deformation characteristics of glass reinforced and organic plastics under tension and compression at 293 and 77°K. 17 refs.

Avakyan, R.A. (Acad of Sciences of the USSR, Moscow, USSR); Danilova, I.N.; Lebedeva, O.V.; Sokolova, T.V. *Mech Compos Mater* v 23 n 1 Jan-Feb 1987 p 63-68.

**080320 EFFECT OF TREATMENT OF COUPLING AGENTS ON DYNAMIC MECHANICAL PROPERTIES OF GLASS FLAKES-FILLED EPOXY RESIN.** The affinity between glass flakes (GF) treated with silane, titanate, and phosphate coupling agent (SCA, TCA, and PCA) and epoxy resin cured with hexahydrophthalic anhydride and 4,4'-diaminodiphenylmethane was studied by dynamic modulus, compressive strength, and SEM measurements. The volume fractions of GF in the composite materials were 0.49 to approximately 0.61. SEM photographs of cut edgewise surface of the filled samples show that GF particles untreated and treated with coupling agents are aligned as a layer. Dynamic mechanical properties of the specimens were measured over the temperature range from room temperature to about 250°C. (Edited author abstract) In Japanese. 29 refs.

Adachi, Kimihiro (Government Industrial Research Inst, Midorigaoka, Jpn); Yamaguchi, Muneaki; Takahashi, Takako; Tanaka, Katsutoshi. *Kobunshi Ronbunshu* v 19 n 4 1987 p 877-884.

**080321 EFFECTS OF FIBER LENGTH AND ORIENTATION DISTRIBUTION ON THE ELASTIC MODULUS OF SHORT FIBER REINFORCED THERMOPLASTICS.** A method including the effects of fiber length and orientation distribution to predict elastic moduli of short fiber reinforced thermoplastics (FRTP) is presented. The fiber length distribution in FRTP has an asymmetric character with a tail at the long fiber end. Statistical distribution functions such as Weibull or log-normal can be used to represent this kind of distribution. Orientation distribution of fibers in FRTP can be characterized by a single parameter exponential function. The mean elastic moduli of unidirectional plies are predicted through the fiber length distribution. Then the stacking sequence of laminate is assumed to be as the fiber orientation distribution of FRTP, and the overall elastic moduli of FRTP are estimated based on the laminate-plate method. (Edited author abstract) 15 refs.

Chin, Wei-Kuo (Nat'l Tsing-Hua Univ, Hsin-Chu, Taiwan); Liu, Hsin-Tzu; Lee, Yu-Der. *Polym Compos* v 9 n 1 Feb 1988 p 27-35.

**080322 DAMAGE SUSTAINED BY A CARBON/EPOXY COMPOSITE MATERIAL SUBJECTED TO REPEATED IMPACT.** The damage sustained by 16-ply quasi-isotropic carbon/epoxy composite laminates subjected to repeated impact at various energy levels has been quantified. Composite plates 2 mm thick were fabricated using Hercules AS4/3501-6 carbon/epoxy unidirectional prepreg. Impact energy level and number of impacts were found to be major factors influencing damage. However, damage was limited to the region near the impact point. Several damage assessment techniques were evaluated and subsequently used. (Author abstract) 9 refs.

Wyrick, D.A. (Univ of Wyoming, USA); Adams, D.F. *Composites* v 19 n 1 Jan 1988 p 19-27.

**080323 PHYSICAL ADHESIVE FACTOR BETWEEN POLYMER AND FILLER WHICH AFFECTS TENSILE STRENGTH OF FIBER REINFORCED COMPOSITE MATERIALS.** The effects of shrinkage in injection molding on the tensile strength of fiber reinforced composite plastics have been investigated. Tetrafluoroethylene copolymer (ETFE) and polyethylene (PE) etc. were reinforced by glass fibers, and polyamide (PA12) and polyethylene (PE) were reinforced with glass fibers and aramid fibers, respectively. The ratio of tensile strength of fiber reinforced composite materials to that of matrix polymer tends to become higher with increasing mold shrinkage in spite of the small adhesion difference between filler and polymer. The physical adhesion of the matrix materials to fibers is improved with increasing mold shrinkage of base polymer. These results show that



the mold shrinkage is one of the factors which affect the tensile strength of filler reinforced injection moldings. (Edited author abstract) In Japanese. 11 refs.

Suetsugu, Kenichiro (Matsushita Electric Industrial Co, Kadoma, Jpn); Sakairi, Tadashi. *Kobunshi Ronbunshu* v 44 n 11 1987 p 853-856.

**080324 INFLUENCE OF WATER ON TENSILE AND FATIGUE PROPERTIES OF TWO TYPES OF ARAMID/EPOXY COMPOSITES.** An investigation has been carried out concerning the effect of water absorption on the tensile and fatigue properties of a Technora (HM50, Teijin)/epoxy and a Kevlar49 (DuPont)/epoxy composites. The effect of water on the fracture mechanism was observed using AE measurements and SEM microscopy. The weight gain for the HM50 specimens immersed in distilled water at 70°C levels off at about 2% after two months. For the Kevlar49 this is about 3.5%. Moisture does not appear to have any influence on the tensile strength. For the HM50 the elastic moduli of the dry and wet specimens are the same at the start. After a certain point the dry specimen stiffens, whereas the wet one first yields, and then stiffens. The Kevlar49 specimens do not show any yielding behavior unlike the HM50. For both composites the specimens in water exhibit a longer fatigue life than in air, though the Kevlar49 has a slightly bigger increase in life than the HM50. Additional study results are discussed. (Edited author abstract) In Japanese. 8 refs.

Komai, Kenjiro (Kyoto Univ, Kyoto, Jpn); Shiroshita, Sohei; Bruschke, Michiel V. *Zairyo* v 36 n 411 Dec 1987 p 1395-1401.

**080325 EFFECT OF MODIFICATION WITH LIQUID CARBOXYL TERMINATED NITRILE RUBBER ON PEEL STRENGTH OF CARBON FIBER/TETRAFUNCTIONAL EPOXY RESIN COMPOSITE.** With tetrafunctional epoxy resin (tetraglycidyl-4,4'-diaminodiphenylmethane) used as a matrix resin, the effect of modification with liquid carboxyl terminated nitrile rubber (CTBN) on the peel strength of carbon fiber composite was investigated. The peel strength increased with increasing CTBN content. The strengths became higher with lower measuring temperature or higher peel rate, and superposed as a function of temperature or peel rate. The observation of fracture surfaces after peel test with a scanning electron microscope (SEM) revealed that, in the region of low temperature or high peel rate, there were numerous CTBN particles of 2-20 µm diameter and numerous holes, produced by pulling out these particles from epoxy resin. (Edited author abstract) In Japanese. 15 refs.

Nakao, Kazumune (Gifu Univ, Gifu, Jpn); Yamaguchi, Takahito. *Kobunshi Ronbunshu* v 45 n 1 1988 p 1-9.

**080326 HIGH IMPACT PROPERTIES OF THERMOPLASTIC RESIN-METAL SYSTEM.** High impact resistant properties of various thermoplastic resin-metal systems were investigated. A high speed piercing test successfully simulates the fracture pattern caused by shotgun shooting. Though the thermoplastic styrene elastomer has the highest fracture energy, this energy is noticeably reduced when it is laminated with stainless steel. In this system the elongation of the thermoplastic styrene elastomer, which governs the impact-absorbing ability, is restrained by the stainless steel. Vinyl chloride-ethylene vinyl acetate graft copolymer, which has the highest fracture stress, exhibits the best impact resistant properties. (Edited author abstract) In Japanese. 7 refs.

Ishizawa, Maki (NTT, Musashino, Jpn); Ohshima, Hiroshi. *Kobunshi Ronbunshu* v 45 n 1 1988 p 31-35.

**080327 SURFACE TREATMENT OF FILLERS FOR POLYMER COMPOSITES.** The effects of surface treatment of E-glass particulate fillers and the mechanical properties of acrylic polymer composites containing the fillers have been studied. The coupling agents used were cyclohexyl trichlorosilane (CS) with strong hydrophobic group and  $\gamma$ -methacryloxy propyl trimethoxysilane ( $\gamma$ -MPS). The existence of coupling agents on the filler

surfaces was confirmed by the absorption bands of difference FT-IR diffuse reflectance spectrum. Tensile and compressive strengths of the composites were improved by the  $\gamma$ -MPS treatment of the fillers, but not by the CS treatment. (Edited author abstract) In Japanese. 7 refs.

Nakajima, Shinya (Kanagawa Dental Coll, Yokosuka, Jpn); Kurata, Shigeaki; Yamazaki, Noboru; Kurita, Kimio; Wada, Eiichi. *Kobunshi Ronbunshu* v 45 n 1 1988 p 85-90.

**080328 DESIGN IMPLICATIONS OF STIFFNESS AND THICKNESS.** Plastics reinforced with short fibres often show fibre alignment effects, which are normally introduced unintentionally during processing. An increase in thickness modifies the flow pattern during mould filling, alters the distribution of fibre orientation across the thickness of the part and reduces the effective flexural modulus of the moulding. DuPont scientists and technologists have carried out a pilot study covering glass and carbon fibres that improves understanding of the variation of flexural modulus with thickness. The information about thickness-dependent changes in the anisotropy of mechanical properties can be used in modified design formulae. 1 ref.

Anon. *Mater Des* v 9 n 2 Mar-Apr 1988 p 94-95.

**080329 EXCELLENT FLEXURAL PROPERTIES OF AMINIMIDE-CURED EPOXY RESIN AS A MATRIX FOR MICA-DISPERSED POLYMER COMPOSITES.** The flexural strength and flexural modulus have been determined as a function of the volume fraction of mica flakes for both aminimide-cured epoxy resin matrix and a conventional epoxy resin reference matrix. On the basis of microscopic observation of fractured surfaces, the effect of improving the particle-matrix interface has been analyzed using the modulus reduction factor in a modified form. There is a steady increase in the flexural modulus with the volume fraction of mica flake for the aminimide-cured epoxy resin matrix. In contrast, the increase in flexural modulus levels off at a high content of filler for the reference samples. The intact mica flakes without surface treatment exhibit a reinforcing effect on the flexural strength in the aminimide-cured epoxy resin composites. The reference epoxy resins behave like conventional matrix resins, exhibiting 30 to 40% reduction in the flexural strength when a small fraction of mica is added. These superior properties of the matrix resin are ascribed to the characteristics of aminimide-cured epoxy resins such as hardness, toughness and adhesivity. (Edited author abstract) 14 refs.

Inbushi, S. (Tokyo Inst of Technology, Yokohama, Jpn); Ikeda, T.; Tazuke, S.; Satoh, T.; Terada, Y.; Kumagai, Y. *J Mater Sci* v 23 n 4 Apr 1988 p 1182-1188.

**080330 POLYARYLAMIDES RENFORCES DE FIBRES DE VERRE PROPRIETES A PRENDRE EN COMPTE POUR LA CONCEPTION DE PIECES TECHNIQUES.** [Properties to Be Taken into Account for the Design of Glass Reinforced Polyarylamide Parts]. This paper reviews the mechanical and thermomechanical properties of polyarylamide with a 50 percent glass fiber reinforcement. In addition, the parameters which must be taken into account when designing new engineering components out of this thermoplastic material are indicated. In French.

Gioan, Paul (Solvay & Cie, Paris, Fr). *Mater Tech* v 76 n 4-5 Apr-May 1988 p 33-36.

**080331 IMPACT PERFORMANCE OF SISAL-POLYESTER COMPOSITES.** In a previous letter it was reported that a sisal fiber composite exhibits maximum impact toughness owing to the optimum microfibrillar angle of the fiber. In the course of the present study an investigation on the impact properties of sisal composite (unidirectional system) was carried out. The sisal composite shows work of fracture identical with that of an ultra high modulus polyethylene (UHMPE) composite and the toughness is only 25 percent less than that of glass fiber composite when the density of the latter is taken into account. Although the impact performance of the sisal

composite is attractive, other mechanical properties are inferior to those of synthetic fiber composites. 4 Refs.

Pavithran, C. (CSIR, Trivandrum, India); Mukherjee, P.S.; Brahmakumar, M.; Damodaran, A.D. *J Mater Sci Lett* v 7 n 8 Aug 1988 p 825-826.

**080332 MECHANICAL PROPERTIES OF JUTE REINFORCED PLASTICS.** Jute reinforced plastics are finding wider application and for efficient use the mechanical properties should be known to the designers. Experimental values of tensile strength of the composite together with that for matrix and reinforcement and the fatigue properties as affected by the volume fraction are presented. (Author abstract). 21 Refs.

Kazim, K.A. (Bangladesh Inst of Technology, Khulna, Bangladesh); Ilahi, M.F. *Mech Eng Res Bull (Dhaka)* v 10 1987 p 63-74.

**080333 DYNAMIC MECHANICAL ANALYSIS STUDIES OF THE INTERPHASE.** The dynamic mechanical properties of unidirectional glass-fiber-reinforced polyester measured along the fiber direction were recently investigated. In the same polyester, the type of organosilane coated on the glass fiber, the amount of organosilane, the fiber volume fraction, and the fiber diameter affect the value of the loss tangent,  $\tan \delta$ , at the glass-transition temperature of the glass-fiber-reinforced polyester. The interfacial shear strength and the  $\tan \delta$  at the glass-transition temperature of the glass-fiber-reinforced polyester show good correlation suggesting that the latter can be used to characterize the quality of the interphase. Factors affecting the glass-transition temperature and the application of Zorowski and Murayama's equation in the characterization of the interfacial adhesion are also discussed. (Author abstract) 11 refs.

Chua, Ping Seng (Fiberglass Canada Inc, Guelph, Ont, Can). *Polym Compos* v 8 n 5 Oct 1987, Compos '86 - Part I, Nov 25-26 1986 p 308-313.

**080334 PAPERS PRESENTED AT THE 1986 ANNUAL TECHNICAL CONFERENCE OF THE SOCIETY OF PLASTICS ENGINEERS.** This conference proceedings contains 9 papers. The papers discuss such subjects as the characterization of the cure of composite laminates, mechanical properties and fracture mechanics of composites. The new types of reinforcements for plastics are also discussed. Composite lamination analysis and prepreg cure monitoring are presented. An analysis of applications of various fillers is presented. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10596 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Weiss, Robert A. (Ed.); Fitzgerald, John J. (Ed.). *Polym Compos* v 8 n 4 Aug 1987, Pap Presented at the 1986 Annu Tech Conf of the Soc of Plast Eng, Boston, MA, USA, May 1986 p 221-286.

**080335 EFFECTS OF AMBIENT AGING OF 5245C/GRAPHITE PREPREG ON COMPOSITION AND MECHANICAL PROPERTIES OF FABRICATED COMPOSITES.** A bismaleimide modified epoxy 5245C/graphite prepreg was subjected to ambient conditions for periods up to 140 days. The effect of this ambient aging on the prepreg composition and mechanical properties of composites fabricated from aged prepreg was investigated. The results show that small but definite composition changes occur as a result of ambient aging. These compositional changes are also reflected in small decreases in shear and flexural properties at room and elevated temperatures, dry and wet. (Author abstract) 13 refs.

Scola, Daniel A. (United Technologies Research Cent, Stratford, CT, USA); Vontell, John; Feisen, Marvin. *Polym Compos* v 8 n 4 Aug 1987, Pap Presented at the 1986 Annu Tech Conf of the Soc of Plast Eng, Boston, MA, USA, May 1986 p 244-252.



## Microstructure

**080336 MICROSTRUCTURE AND FRACTURE TOUGHNESS OF SHORT FIBRE REINFORCED INJECTION-MOULDED PEEK COMPOSITES.** The fracture toughness ( $K_Q$ ) of injection-molded polyetheretherketone (PEEK) composites containing 20 and 30% glass and 30% carbon fibers, respectively, was evaluated using compact tension specimens.  $K_Q$  is regarded as a function of the microstructural efficiency factor ( $M$ ) which takes into account the anisotropic fiber orientation and layered structure caused by injection molding. Failure mechanisms for both the non-reinforced and reinforced PEEK were characterized by fractography in a scanning electron microscope. It was shown that in the knowledge of  $M$  and its additive terms, i.e. matrix stress conditions factor and energy absorption coefficient, the fracture and failure behavior of the composites can be predicted. The results are summarized in the form of failure and fracture maps. (Edited author abstract) 23 refs.

Karger-Kocsis, J. (Technical Univ Hamburg-Harburg, Hamburg, West Ger); Friedrich, K. *Plast Rubber Process Appl* v 8 n 2 1987 p 91-104.

**Moisture** See Also ACRYLICS—Reinforcing; PLASTICS—Moisture.

**080337 WATER ABSORPTION OF RESINS AND COMPOSITES. IV. WATER TRANSPORT IN FIBER REINFORCED PLASTICS.** An analysis of diffusivity of composites is described in which an electrical resistance analogy is used. This leads to an expression for diffusivity, which takes into account the contribution of fiber diffusivity, matrix diffusivity, and the diffusivity of the interphase, when this is different from that of the polymer matrix. The case involving the interphase requires numerical integration for its solution. However, the effect of the interphase can be very accurately simulated in a more approximate model; a closed form expression for composite diffusivity is obtained that agrees with the numerical analysis within better than 1% if an appropriate adjustment for interphase width is made. The same approach was used for including voids in the analysis, and it is shown that, in some experiments described previously with glass and carbon fiber pultrusions, the results can be explained on the basis of the voids in the composite providing an enhanced diffusion path for water. (Edited author abstract) 10 refs.

Woo, Monica (Digital Equipment Canada Ltd, Kanata, Ont, Can); Piggott, Michael R. *J Compos Technol Res* v 10 n 1 Spring 1988 p 20-24.

**Mold Release Agents** See COMPOSITE MATERIALS—Fabrication.

**Molding** See Also COMPOSITE MATERIALS—Forming.

**080338 OUT OF THE BAG.** Vacuum bag molding offers many advantages for the shaping of composite components. The composite material is laid on a single mold tool and then covered with a flexible membrane. The membrane is sealed onto the tool and the area under the bag evacuated. This causes the membrane to collapse and impart a uniform downward pressure on the composite molding. The next stage is to move the whole mold assembly into a large oven for heat curing of the resin. This article discusses these and describes the steps needed to apply the technique successfully.

Twist, Bernard (Tygavac Vacuum Bag Materials, Littleborough, Engl). *Engineering (London)* v 228 n 3 Mar 1988 p 19-21.

**Nonmetallic Matrix Composites** See COMPOSITE MATERIALS—High Temperature Effects.

**Processing** See Also POLYESTERS—Processing; POLYTETRAFLUOROETHYLENE—Processing; THERMOPLASTICS—Fiber Reinforcement.

**080339 MODEL FOR RESIN FLOW DURING COMPOSITE PROCESSING. PART 2: NUMERICAL ANALYSIS FOR UNIDIRECTIONAL GRAPHITE/EPOXY LAMINATES.** In this paper numerical

results are presented for resin flow during processing of unidirectional graphite/epoxy laminates. Resin pressure and velocity profiles, as well as resin loss, specific permeability, and resulting thickness changes, were computed to examine the effects of one- and two-dimensional flow, initial laminate thickness, and various curve cycles. Input data to the model are also discussed in detail. Analysis of the input data on the stress-strain behavior of graphite fiber beds showed that the bed consolidation behavior can be divided into three regions. Comparison of the predicted results for the resin mass loss and the average final thickness per ply with experimentally determined values shows good agreement. (Edited author abstract) 23 refs.

Dave, R. (Washington Univ, St. Louis, MO, USA); Kardos, J.L.; Dudukovic, M.P. *Polym Compos* v 8 n 2 Apr 1987 p 123-132.

**080340 MODEL FOR RESIN FLOW DURING COMPOSITE PROCESSING. PART 1. GENERAL MATHEMATICAL DEVELOPMENT.** A generalized three-dimensional model for resin flow during composite processing has been developed. The model is based on a theory of consolidation and flow through a porous medium, which considers that the total force acting on a porous medium is countered by the sum of the opposing forces, including the force due to the spring-like effect of the fiber network and the hydrostatic force due to the pressure of the liquid within the porous medium. The flow in the laminate is described in terms of Darcy's Law for flow in a porous medium, which requires a knowledge of the fiber network permeability and the viscosity of the flowing fluid. Unlike previous resin flow models, this model properly considers the flows in different directions to be coupled and provides a unified approach in arriving at the solution. (Edited author abstract) 40 refs.

Dave, R. (Washington Univ, St. Louis, MO, USA); Kardos, J.L.; Dudukovic, M.P. *Polym Compos* v 8 n 1 Feb 1987 p 29-38.

**080341 IMPREGNATION TECHNIQUE FOR ARAMID AND CARBON FIBRE REINFORCED THERMOPLASTICS.** This paper covers impregnation techniques for reinforcing thermoplastics. Some of the topics discussed include impregnation using yarns and woven fabrics. Other topics covered are: compression molding of polymer films; impregnation using polymer solutions, melts, and powders.

Stolze, R. *Kunstst Ger Plast* v 78 n 2 Feb 1988 p 11-14.

**080342 DIFFERENTIAL SCANNING CALORIMETRIC DETERMINATION OF THE VOLATILE CONTENT AND PROPERTIES OF EPOXY PREPREG.** Differential scanning calorimetry (DSC) is widely used to determine the B-time reduction, curing rate and state of cure of prepregs. The object of the work was to investigate whether the prepreg volatile content could be determined with DSC and to ascertain whether changes in the volatile content caused any changes in the prepreg processing characteristics through any effect it may have on the glass transition temperature. The Diverrit ML prepregs (Dielektra Grade no., 15193/106) used consisted of a thin glass fabric impregnated with epoxy polymer advanced to B-state (semicure). The prepregs which have lower volatile content and lower  $T_g$  have higher compressibility and flowability and lower viscosity during laminating. DSC can also be used to determine the volatile content. The processing, but not the curing characteristics are influenced by volatile content. 4 Refs.

Yue, C.Y. (Univ of Hong Kong, Hong Kong). *J Mater Sci Lett* v 7 n 8 Aug 1988 p 811-813.

## Protective Coatings

**080343 AIRCRAFT CONSTRUCTION: PROTECTIVE COATINGS FOR FIBRE-REINFORCED PLASTICS.** Elastomeric coatings can reduce mechanical damage caused by composites, which are rigid materials, exhibiting internal fibre breakage under hard impact during fabrication or use. The resins used in construction

are not selected for optimum erosion-resistance, but tough protective coatings can allow the use of these materials in high erosion areas. Elastomeric primers, even when used under traditional coatings, improve erosion-resistance.

Morris, Lester (Aircraft Coatings Research & Development Lab, Burbank, CA, USA); Randazzo, Santo. *Aircr Eng* v 60 n 4 Apr 1988 p 22-23.

## Pultrusion

**080344 PULTRUDED COMPOSITES: THE ALTERNATIVE STRUCTURAL MATERIAL.** Pultrusion is an extremely efficient technique for producing composite components in linear form. At present the European market for pultruded profiles is growing at a rate of 20% per annum and defence applications account for an important proportion of this, especially in the area of carbon fiber reinforced epoxy resin. The composite equivalent of extrusion, pultrusion produces profiles which are similar in the range and complexity of shapes achievable, but are structural by nature, that is, capable of load bearing.

Anon. *Eng Mater Des* v 31 n 10 Oct 1987 p 54,57.

**080345 JUST HOW BIG IS PULTRUSION'S FUTURE IN STRUCTURAL COMPONENTS.** No longer limited to aerospace components and premium sporting goods, pultrusion has evolved into a major process that consumed more than 110 million lb. of resins and reinforcements last year, according to the Composites Institute of the Society of the Plastics Industry. This trade group predicts 12 to 15 percent growth this year, as applications expand beyond driveshafts, structural shapes, and exterior/interior bus panels. Indications abound, not least of them commercial acceptance in window profiles and as I-beams in high-rise building. Process and material refinements continue to expand marketing horizons.

Wilder, Robert V. *Mod Plast* v 65 n 7 Jul 1988 p 37-39.

**Reaction Injection Molding** See Also AUTOMOBILE MATERIALS—Plastics; PLASTICS SHEETS—Mechanical Properties.

**080346 NOVEL REINFORCED REACTION INJECTION MOLDING (RRIM) PROCESSING: COMPUTER-CONTROLLED MULTIPLE-STREAM RRIM PRODUCTION OF INTERPENETRATING POLYMER NETWORK AND POLYURETHANES.** A four-stream computer-controlled reinforced reaction injection molding (RRIM) machine has been developed that attains high accuracy in dispense ratios throughout the injection process. This machine has been used for novel processing of polyurethanes, offering a route to varying product properties either throughout a shot or a shot-to-shot basis. It also has been used for what appears to be the first production on commercial scale RRIM equipment of a polyurethane-acrylic interpenetrating polymer network (IPN) in commercial cycle times of around 2 min. (Author abstract) 17 refs.

Coates, P.D. (Univ of Bradford, Engl); Johnson, A.F.; Armitage, P.D.; Hynds, J.; Leadbitter, J. *Polym Eng Sci* v 27 n 16 Mid-Sep 1987 p 1209-1215.

**080347 HIGH-STRENGTH STRUCTURAL COMPOSITES MADE BY RIM.** A reinforced resin system that combines reinforced injection molding (RIM) and resin transfer molding is an economical route to the manufacture of large high-strength automotive parts. Optimum reinforcement is achieved by precise placement of reinforcement in molds. Glass mat is most popular, but other media, such as carbon and aramid fiber, may be used.

Nelson, Don (Dow Chemical Co, North Haven, CT, USA). *Plast Eng* v 43 n 11 Nov 1987 p 29-32.



**080348 MICA AS A REINFORCEMENT FOR POLYURETHANE RIM.** Polyurethane reaction injection molding (RIM) systems are reinforced with inorganic materials to improve stiffness and structural integrity at elevated temperatures and to reduce the coefficient of thermal expansion. This work describes the reinforcement obtained with an experimental grade of mica designed to achieve low viscosity in polyol mica suspensions. The effect of mica on properties is essentially identical to that of glass flake. Compared to hammer milled glass, mica and glass flakes yield more isotropic, albeit weaker, materials. (Edited author abstract) 15 refs.

Naik, Saurabh (Marietta Resources Int, Hunt Valley, MD, USA); Fissa, B. *J Reinf Plast Compos* v 6 n 4 Oct 1987 p 319-330.

**080349 MOLDING BY REACTIVE INJECTION OF REINFORCED PLASTICS.** A model for the molding by reactive injection of reinforced plastics for systems in which fiber glass reinforcements are placed into the molds, is proposed. It allows for the determination of processing parameters and their influence on dependent variables: conversion, temperature, and pressure. Moldability areas, where premature gelling is avoided, are defined. Operating conditions are selected to reduce cycle time, produce small load losses, and provide a fairly uniform curing stage throughout the product. (Author abstract) 9 refs.

Reboredo, M.M. (Univ of Mar del Plata, Mar del Plata, Argent); Rojas, A.J. *Polym Eng Sci* v 28 n 7 Mid-April 1988 p 485-490.

## Reactive Molding

**080350 SYSTEM DEVELOPED FOR MOLDING LARGE, COMPLEX AUTOMOTIVE PARTS OF POLYMER COMPOSITE.** A new low-viscosity, glass mat-reinforced polyurethane structural foam system for automotive parts has been developed. In testing at Mobay Laboratories, the material increased productivity as much as 40% for the manufacture of automotive interior trim panels. Able to be processed by economical closed-mold reaction injection molding (RIM), the new material can also help reduce the thickness and weight of automotive parts currently made from wood fiber and plastic laminates. These improvements are made possible while maintaining the excellent physical properties of structural foam. It is possible to produce beams with the new composite system that have a stiffness approaching that of steel counterparts, but weigh considerably less.

Anon. *Ind Heat* v 54 n 12 Dec 1987 p 30-31.

## Reviews

**080351 ADVANCED POLYMER COMPOSITES: AN INTERNATIONAL PERSPECTIVE.** Due to their desirable performance properties, advanced polymer composites will continue to grow and penetrate new markets over the next ten years. This creates opportunities within each segment of the industry: resins, fibres, fabrics, prepreps and shapes. A supplier's success requires a commitment to research and application development, investment in appropriate resources and the patience to endure both long application development and approval time in certain market segments. Despite these factors, the rewards can be substantial. (Author abstract)

Belyea, Martha O. (Strategic Analysis Inc, Reading, PA, USA); Deckman, Bruce W. *Mater Des* v 9 n 2 Mar-Apr 1988 p 78-84.

**Space Applications** See COMPOSITE MATERIALS—Space Applications.

## Strain

**080352 SHEAR STRAINS IN A GRAPHITE/PEEK BEAM BY MOIRE INTERFEROMETRY WITH CARRIER FRINGES.** A multispan quasi-isotropic graphite-PEEK beam exhibited dramatic shear strains in the interlaminar region between plies. Shear strains in the

plies themselves varied in basic accord with fiber direction. The large anomalous shear strains were developed near the center of the beam height, where shear stresses were large. High-sensitivity moire interferometry with 2400  $\ell/\text{mm}$  (60,960  $\ell/\text{in.}$ ) was used. A new technique of data extraction was developed, using carrier fringes to transform the pattern to one in which fringe slopes are proportional to derivatives of displacement. This technique enhanced detection and measurement of highly localized shear-strain gradients. (Author abstract) 3 refs.

Post, D. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Czarnek, R.; Joh, D. *Exp Mech* v 27 n 3 Sep 1987 p 246-249.

## Stresses

**080353 EQUATIONS OF THE THEORY OF REINFORCED POLYMERS WITH RESIDUAL STRESSES FROM PROCESSING.** An approach is proposed for constructing equations which include the residual processing stress in reinforced polymer shells. A shell having the properties of curvilinear orthotropy is considered. 5 refs.

Tomashevskii, V.T. (A.A. Grechko Naval Acad, Leningrad, USSR); Yakovlev, V.S. *Mech Compos Mater* v 23 n 2 Mar-Apr 1987 p 199-203.

**Structural Application** See Also AUTOMOBILE MATERIALS—Plastics.

**080354 PULTRUDED STRUCTURES WIN SUPPORT.** Pultrusions could offer a viable alternative to metals in frameworks for roof supports and other applications. Their performance under load can now be predicted with some accuracy. Some possible markets for pultruded composites are: consumer/recreational products; electrical equipment; corrosion-resistance components; transport; and, construction. These are discussed in the article, with emphasis on structural applications.

Holloway, Len (Univ of Surrey, Engl). *Engineering (London)* v 227 n 9 Sep 1987 suppl p 9-10.

## Surfaces

**080355 EFFECT OF RESIN FORMULATION ON THE SURFACE APPEARANCE OF GLASS FIBER REINFORCED POLYMERS.** This paper is concerned with the effect of resin formulation on the magnitude of fiber readout for polymers reinforced with continuous glass fiber mats. The observed fiber readout is the deformation of the surface with a pattern similar to the underlying fibers. In our previous studies, it was established that one of the main factors responsible for fiber readout is the coefficient of linear thermal expansion (CLTE) of the resin in the direction normal to the cosmetic surface. In the current study, the differential thermal contraction between the resin and the glass fibers, a factor directly relatable to the magnitude of fiber readout, has been investigated. This direct relationship was examined by comparing the computed values with the measured magnitude of fiber readout for reinforced polyurethanes (filled with milled glass or hollow glass spheres) and polyesters (filled with calcium carbonate). For all experiments, the predicted values were found to be consistent with the experimental measurements for fiber readout. (Edited author abstract) 11 refs.

Kia, Hamid G. (GM Research Lab, Warren, MI, USA). *J Compos Mater* v 21 n 12 Dec 1987 p 1145-1163.

**Testing** See Also COMPOSITE MATERIALS—Fiber Reinforced; COMPOSITE MATERIALS—Mechanical Properties; COMPOSITE MATERIALS—Wear; PLASTICS LAMINATES—Mechanical Properties.

**080356 INVESTIGATION OF THE PROCESSES OF ACTIVE AND REPEATED LOADING OF REINFORCED POLYMER MATERIAL AT ELEVATED TEMPERATURE.** The nonlinear theory of the hereditary medium underlies investigation of the processes of active and repeated uniaxial isothermal and nonisothermal loading of the reinforced plastic whose properties depend

essentially on the time of its stay under conditions of elevated temperatures. A nonlinear constitutive equation with the Abel nucleus contains two parameters calculated by instant diagrams of the material strain with several values of holding time at the given temperatures and by creep diagrams at the same temperatures and one stress value. This equation has also been used to calculate certain loading processes whose results are compared with experimental data. ((Author abstract) In Russian. 5 refs.

Babeshko, M.E.; Terekhov, R.G. *Probl Prochn* n 9 1987 p 73-76.

**Thermal Conductivity** See EPOXY RESINS—Thermal Conductivity.

**Thermal Effects** See Also COMPOSITE MATERIALS—Nonmetallic Matrix Composites.

**080357 THERMAL DAMAGE EFFECTS ON DELAMINATION TOUGHNESS OF A GRAPHITE/EPOXY COMPOSITE.** The effects of overheating AS/3501-6 graphite/epoxy composite material have been examined after exposures in air up to 350°C. Degradation was assessed from measurements of the interlaminar fracture toughness in both Mode I tension and Mode II shear as well as the interlaminar shear strength and hardness. Exposures up to 30 minutes at 225°C and up to 15 minutes at 300°C did not significantly reduce the interlaminar toughness. However, longer exposure at 300°C and short exposures at 350°C produced catastrophic decreases in toughness values, shear strength and hardness. The primary origin of embrittlement was attributed to deterioration of the epoxy as opposed to any fibre or fibre-matrix interfacial weakening. (Author abstract) 13 Refs.

Street, K.N. (Defence Research Establishment Pacific, Victoria, BC, Can); Russell, A.J.; Bonsang, F. *Compos Sci Technol* v 32 n 1 1988 p 1-14.

## Thermal Properties

**080358 THERMAL AND RHEOLOGICAL PROPERTIES OF POLY(PHENYLENE SULFIDE) AND POLY(ETHER ETHERKETONE) RESINS AND COMPOSITES.** Poly(phenylene sulfide) (PPS) and poly(ether etherketone) (PEEK) are high performance engineering thermoplastics with a unique combination of excellent environmental, mechanical, and thermal properties. Research on the thermal and rheological properties of PPS and PEEK resins and carbon fiber reinforced prepreps are described. Experimental studies of the dynamic viscoelasticity and thermal properties of these materials are summarized. The effects of processing cycles and environment of the thermal and rheological properties are discussed. The effects of the processing environment and the addition of carbon fiber on the thermal stability are reported. Crosslinking of poly(phenylene sulfide) in air, enhancing thermal stability, is also investigated. (Author abstract) 16 refs.

Ma, Chen-Chi M. (Nat'l Tsing Hua Univ, Hsinchu, Taiwan); Hsia, Hung-Chung; Liu, Wen-Liang; Hu, Jiann-Tsun. *Polym Compos* v 8 n 4 Aug 1987, Pap Presented at the 1986 Annu Tech Conf of the Soc of Plast Eng, Boston, MA, USA, May 1986 p 256-264.

**Thermoanalysis** See ELASTOMERS—Mechanical Properties.

**Thermodynamic Properties** See COMPOSITE MATERIALS—Mathematical Models.

## Thermoelasticity

**080359 FIBER ORIENTATION AND ITS EFFECT UPON THERMOELASTIC PROPERTIES OF SHORT CARBON FIBER REINFORCED POLY(ETHERETHERKETONE) (PEEK).** Experimental and analytical techniques are employed in the present study to investigate the influence of microstructure on thermoelastic properties of short carbon fiber reinforced poly(etheretherketone). The test specimen geometry is an edge gated, injection molded dogbone tensile bar. Typical of injection



molded structures, three distinct layers of fiber orientation were discernable through the sample thickness. The thermoelastic properties of the surface layer (machined from the specimen) are measured for direct correlation with a micromechanics model. In addition to measuring the volume fractions and constituent properties, microstructural features such as fiber aspect ratio and the process-induced fiber orientation distribution are quantified. Correlation of experimental data with micromechanics model predictions is found to be quite good. (Author abstract) 12 refs.

Bozarth, M. Jean (Univ of Delaware, Newark, DE, USA); Gillespie, John W. Jr; McCullough, Roy L. *Polym Compos* v 8 n 2 Apr 1987 p 74-81.

## Transfer Molding

**080360 MODELING OF PRESSURE DISTRIBUTION IN RESIN TRANSFER MOLDING.** Cavity pressure distribution is the most important parameter to minimize leakage problem at the parting line, to reduce mold deformation and to assure a good quality part. In this paper, a simplified model applicable to unidirectional flow is proposed to predict that pressure. It is based on Darcy's law for flow of liquids through a porous media. The permeability of the reinforcement which is a function of the glass content and characteristic of each type of reinforcement, mat or woven roving, is evaluated. Effects on the model of parameters such as glass density, surface density of the reinforcement and number of reinforcing layers are examined. The mold and instrumentation used to collect data are described and preliminary results are presented for reinforcing mat. (Edited author abstract) 4 refs.

Gauvin, R. (Ecole Polytechnique de Montreal, Montreal, Que, Can); Chibani, M.; Lafontaine, P. *J Reinf Plast Compos* v 6 n 4 Oct 1987 p 367-377.

## Waste Disposal

**080361 MANAGING FIBERGLASS-REINFORCED POLYESTER COMPOSITE WASTES.** Fiberglass-reinforced polyester wastes are at present landfilled, which is relatively expensive due to the low bulk density. Based on the experimental results reported here, alternative waste management methods may be proposed. The wastes can be densified before landfilling. This would consist of thermolyzing wastes in the presence of an oxidizing gas at 340-370°C. The weakened composite waste can be ground to powder to increase its bulk density by a factor of 4 or 5. The powder contains fillers and short glass fibers and the mixture could be recycled for low-grade uses. The glass fibers from the waste can be recycled. This is technically feasible, notably after liquid-solid thermolysis. 8 refs.

Bouvier, J.M. (Univ de Technologie de Compiègne, Compiègne, Fr); Esperou du Tremblay, S.; Gelus, M. *Resour Conserv* v 15 n 4 Nov 1987 p 299-308.

## Wear See Also COMPOSITE MATERIALS—Wear.

**080362 EFFECT OF STRENGTH DEGRADATION ON WEAR AND FRICTION.** A theoretical expression for wear rate as a function of sliding velocity has been formulated from the concepts of crack propagation, thermal activation, and strength degradation and the analytic results have been tested against the experimental data to provide a comprehensive understanding of this complex behavior. A similar equation describing the relationship between the wear rate and normal load has also been provided. Some thoughts have been given to the atomic chain orientation effect on wear and friction, and also the boundary lubrication phenomena have been described briefly. (Edited author abstract) 29 refs.

Lhymn, C. (Pennsylvania State Univ at Erie, Erie, PA, USA). *Adv Polym Technol* v 7 n 4 Winter 1987 p 365-387.

**080363 LUBRICATED WEAR OF FIBER-REINFORCED POLYMER COMPOSITES.** The specific

wear rates of fibrous polymer composites in water and oil lubricants were investigated by means of tribological data, microscopy, and phenomenological modeling. The wear rate is a function of mechanical, tribological, and material parameters, and a theoretical expression of wear rate has been derived from the concepts of crack propagation, damage accumulation, and classical mechanics. The observed wear rate data as a function of sliding velocity or normal load appear to be explainable using the proposed wear equation. (Author abstract) 55 refs.

Lhymn, C. (Pennsylvania State Univ, Erie, PA, USA). *Wear* v 122 n 1 Feb 15 1988 p 13-31.

**080364 TRIBOLOGICAL PROPERTIES OF SILICONE-IMPREGNATED POLYMER COMPOSITES-TWO-BODY ABRASION ?.** The friction and wear behavior of silicone-impregnated fiber-reinforced thermoplastics has been investigated as a function of normal load in air, water, and oil lubricants using a two-body abrasion tester. The measured tribological data have been phenomenologically explained by a wear/friction equation derived from the concepts of crack propagation and wear failure mode. The wear characteristics of polyethylene terephthalate, polybutylene terephthalate and nylon thermoplastics reinforced with various fibers and fillers are covered. (Edited author abstract). 13 Refs.

Lhymn, Yoon (Yoon Technology, Erie, PA, USA); Lhymn, C. *Adv Polym Technol* v 8 n 3 Fall 1988 p 275-288.

## Wire See BEARINGS—Plastics Applications.

## PLASTICS SHEETS

### Adhesion

**080365 UTJECAJ NEKIH DODATAKA NA MEDUSOBNU LJEPLJIVOST SAVITLJIVIH PVC-FOLIJIA.** [Effect of Antiblocking Additives on Mutual Adhesion of Flexible PVC Sheets]. Mutual adhesion between flexible PVC sheetings is affected, among other things, by their integral components, as well as the quantities in which such components are added. The anti-blocking test has been adopted by the Jugovinil Physical Laboratory for the first time to establish adhesion forces numerically on the basis of theoretical hypotheses and practical achievements. This paper proposes formulations for some films and attempts to determine mutual adhesion numerically. (Author abstract). 10 Refs. In Serbo-Croatian.

Zulim, Jagoda (RO Jugovinil, Kastel Sucurac, Yugosl); Junakovic, Zoran. *Polimeri (Zagreb)* v 8 n 3 Mar 1988 p 63-65.

### Applications See SOILS—Stabilization.

### Coextrusion

**080366 MULTILAYER SHEET COEXTRUSION: ANALYSIS AND DESIGN.** A numerical simulation of multilayer coextrusion flows has been undertaken for polymer melts used in producing multilayered plastic sheets. Viscosity data and other material properties are used for typical melts and adhesives applied in coextrusion. Industrial designs have been employed for feedblock geometry and multimanifold vane flat dies. The analysis is based on the lubrication approximation theory (LAT), which treats the flow locally as fully developed. A Newton-Raphson iterative scheme is employed to solve the equations for a pressure-driven flow of N number of layers ( $N \leq 11$ ). Such an analysis provides a quick qualitative as well as quantitative insight into the proper design and melt combinations for multilayer sheet coextrusion. (Edited author abstract). 22 Refs.

Mitsoulis, Evan (Univ of Ottawa, Ottawa, Ont, Can). *Adv Polym Technol* v 8 n 3 Fall 1988 p 225-242.

## Crack Propagation

**080367 ANALYSIS OF CRACK-INDUCED-CRAZE IN POLYMERS.** In this paper, the viscoelastic boundary element method is used to estimate the opening displacement and the envelope stress on the surface of an isolated crack-induced-craze system. To predict the propagation history of both the crack and the craze in a polymer sheet, the material properties of the glassy polymers are represented by a generalized linear viscoelastic model. A sequence of numerical calculations of crack-induced-craze propagation by means of the boundary element method are carried out. Results are compared with the theoretical micromechanics predictions. Good agreements are obtained. This investigation illustrates that the three-step envelope stress profile is reasonably adequate for use in analysing polymer quasifracture problems. The stress concentration phenomenon is taken into consideration in the present work. (Edited author abstract). 44 Refs.

Sun, B.N. (Univ of Minnesota, Minneapolis, MN, USA); Hou, H.S.; Hsiao, C.C. *Eng Fract Mech* v 30 n 5 1988 p 595-607.

**Drawing and Stamping** See POLYETHYLENE TEREPHTHALATE—Sheet; THERMOPLASTICS—Drawing and Stamping.

**Electric Properties** See FLUORINE CONTAINING POLYMERS—Sheet.

**Fracture** See POLYMETHYL METHACRYLATE—Sheet.

**Manufacture** See POLYMETHYL METHACRYLATE—Production; POLYPROPYLENE—Processing.

**Mechanical Properties** See Also FLUORINE CONTAINING POLYMERS—Sheet; POLYETHYLENES—Sheet; POLYPROPYLENE—Drawing and Stamping.

**080368 MICROSTRUCTURE AND MECHANICAL BEHAVIOR OF REINFORCED REACTION INJECTION MOLDED (RRIM) POLYURETHANE.** A study was carried out to characterize the microstructure and distribution of some mechanical properties in reinforced reaction injection molding panels (RRIM). The panels were prepared under a variety of processing conditions. Scanning electron microscopy, differential scanning calorimetry, and Fourier transform infrared analysis were employed for microstructure characterization. The results indicate significant relationships between processing conditions, microstructure, and mechanical properties. The balance between the distributions of cure and crystallinity, which is difficult to define clearly, plays an important role in determining panel behavior. (Edited author abstract) 14 refs.

Kamal, M.R. (McGill Univ, Montreal, Que, Can); Singh, P.; Samak, Q.; Kakarala, S.M. *Polym Eng Sci* v 27 n 16 Mid-Sep 1987 p 1258-1264.

**080369 INFLUENCE OF FILLERS ON THE MECHANICAL PROPERTIES OF SMC MATERIALS.** The effects of fillers on the mechanical properties of sheet molding compounds are covered. Some of the topics discussed are quasi-static tests, fatigue tests, impact tests, and dynamic load-hysteresis measurements. The characteristic hysteresis data and micromechanical damaging process are discussed. In English and German.

Ehrenstein, G.W. *Kunstst Ger Plast* v 78 n 1 Jan 1988 p 20-23.

**Sheet Molding Compounds** See Also COMPOSITE MATERIALS—Mechanical Properties; PLASTICS MACHINERY—Dies and Presses; PLASTICS, REINFORCED—Glass Fiber.

**080370 EXPERIMENTAL AND ANALYTICAL PROCEDURES FOR FLOW DYNAMICS OF SHEET MOLDING COMPOUND (SMC) IN COMPRESSION MOLDING.** A package of procedures have been developed to collect and analyze the response of dynamic variables such as pressure, temperature, and mold separa-



tion during the compression molding of Sheet Molding Compound (SMC). The molded SMC consists of a thermoset polymeric matrix and chopped glass fibers. From the dynamic responses, the molding process was found to consist of two regions: the flow and the subsequent curing reaction region. With an R-25 formulation and a mold closing rate of 30 mm/s, these two regions are well separated and the average flow time is not significantly affected by the maturation time for the material up to 30 days. Several mechanical parameters were estimated based on relatively simple flow models. (Edited author abstract) 23 refs.

Kau, Hau-Tie (GM Research Lab, Warren, MI, USA); Hagerman, Edward M. *Polym Compos* v 8 n 3 Jun 1987 p 176-187.

**080371 SHEAR FATIGUE EVALUATION OF SMC.** The failure mode of automotive parts made of sheet molding compound often involves in-plane shear. Fatigue data are presented for three ratios of minimum/maximum shear stresses. Interpolation yields shear fatigue strength data for other stress ratios. (Author abstract)

Freeman, Richard B. (Budd Co, Fort Washington, PA, USA). *Mod Plast* v 64 n 10 Oct 1987 p 96, 98, 100.

**080372 INSERTS FOR FASTENING SHEET MOLDING COMPOUNDS.** New stainless steel inserts are developed for fastening sheet molding compound (SMC). Using these molded-in inserts, SMC components can be assembled without protrusions. The inserts consist of two mating surfaces which interlock through the existence of a shoulder male boss and a shoulder female counterbore. Repeated assembly and disassembly can take place without damaging the material being fastened. The strength of the joint, when using these interlocking inserts, is comparable to that when using bolts. Also being investigated is the strength of the joint after being immersed in water for half a month. The difference between the dry and wet strengths for the inserted samples is less than that for the bolted samples. Load versus extension plots show that these particular inserts provide a more rigid joint than a bolted connection. (Author abstract) 4 refs.

Hoa, S.V. (Concordia Univ, Montreal, Que, Can); Di Maria, A.; Feldman, D. *Compos Struct* v 8 n 4 1987 p 293-309.

**080373 BOUNDARY ELEMENT ANALYSIS OF FLOW IN SHEET MOLDING COMPOUND.** A new boundary element method has been developed for analyzing the flow of sheet molding compound (SMC) during compression molding. The boundary element equations can be used to determine the velocities on the perimeter of the charge. Successive flow front configurations are then generated by a simple explicit updating procedure. This approach was used to predict the flow front progression for elliptical, rectangular, and L-shaped charges. Comparisons with experimental data for elliptical and rectangular charges were encouraging. The fact that it was possible to obtain reasonable agreement for charges with different shapes and thicknesses lends support to the underlying flow model. Furthermore, valuable insight regarding knit line formation was acquired by analyzing the L-shaped charge. Results from the boundary element analysis showed that the initial thickness of the charge has a pronounced effect on knit line development. Even though there is considerable industrial experience in making SMC parts, the important role of charge thickness on knit line formation appears to have been largely overlooked. Prior analyses gave no indication of this effect because they were based on lubrication models that were independent of charge thickness. (Author abstract) 12 refs.

Barone, M.R. (GM, Warren, MI, USA); Osswald, T.A. *Polym Compos* v 9 n 2 Apr 1988 p 158-164.

**080374 MECHANICALLY FASTENED JOINT BEHAVIOR IN SHEET MOLDING COMPOUND (SMC).** This paper presents experimental data of mechanical joints in sheet molding compounds (SMC). Double lap specimens were employed to evaluate strength and failure

mode as a function of joint geometry, environmental temperature, and fiber contents. The failure modes are classified into three types: multiple, net tension, and bearing mode. In order to predict the load-bearing capabilities in each failure mode, a procedure with specimen strength and configuration is proposed. This method is applied to various environmental temperatures and fiber contents. (Author abstract) 12 refs. In Japanese.

Hamada, Hiroyuki (Kyoto Inst of Technology, Kyoto, Jpn); Maekawa, Zenichiro; Horino, Tunes; Kaji, Akiyoshi. *Kobunshi Ronbunshu* v 45 n 3 Mar 1988 p 221-228.

**080375 PRECISE COMPRESSION MOLDING OF SHEET MOLDING COMPOUND (SMC).** A full-load-leveling control system has been developed for sheet molding compounds of thermosetting resins. The system attains high leveling accuracy of  $\pm 0.05$  mm while simultaneously controlling the press load to an accuracy of  $\pm 5.5\%$ . Described in this report are the results of analysis based on computer simulation and field tests. (Author abstract) In Japanese.

Kimura, Nobuo; Fukushima, Kou-ichi; Kajiyama, Kazuyuki. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 19-21.

**080376 SMC-VERARBEITUNG UND QUALITÄTSSICHERUNG IN NEUER SICHT.** [New Views on SMC Processing and Quality Control]. The advantages of a process-oriented method of looking at quality control are demonstrated using SMC fabrication as an example. The necessity for greater reproducibility and transparency of processing sequences, the desire to use the material to its full potential, the demands for quality control and quality documentation, above all by the automobile industry, and the opportunities provided by modern methods of measurement and control, call for a systematic re-examination of the problem of quality control. (Author abstract) 22 refs. In German.

Derek, Heinz (Firma SMC-Technologie, Aachen, West Ger). *Kunstst Ger Plast* v 78 n 4 Apr 1988 p 296-301.

**080377 EFFECT OF ASYMMETRICAL CONFIGURATION OF RIB PARTS ON DEFECTS OF SMC PRODUCTS.** The SMC has been developed as a material for the mass production system using press moulding, but some problems arise due to its heterogeneity caused by fibre orientation. The faults observed in the products, such as the appearance of brittle regions in the resin-rich parts or at the weld lines and the surface sink produced at the convex parts, may be regarded as the moulding problems. The purpose of this study was to prevent the above troubles and to construct the CAD system for SMC press moulding process. The case of the symmetrical configuration with one rib part in full charge was treated in the previous paper. In this paper, the effect of asymmetrical configuration with one or two rib parts was investigated to solve the above problems associated with the flow state through the evaluation of flexural strength determined after observation of the material flow state. The analytical method was established by using a linear incremental finite element method. (Edited author abstract). 4 Refs. In Japanese.

Hirai, Tsuneo (Doshisha Univ, Tokyo, Jpn); Katayama, Tsutao; Yamabe, Masashi; Watanabe, Kenichi. *Zairyo* v 37 n 416 May 1988 p 498-504.

**080378 EFFECTS OF HOLE STRESS CONCENTRATION AND ITS MITIGATION ON THE TENSILE STRENGTH OF SHEET MOLDING COMPOUND (SMC-R50) COMPOSITES.** The hole stress concentration effects on the tensile strength of SMC-R50 sheet molding compound composites were studied with consideration being given to both centric and eccentric hole locations. It is shown that the tensile strength of the R50 material is improved by applying a transverse normal pressure around the hole boundary. A few preliminary experiments indicate that the fatigue life of the R50 material can also be improved by a similar technique of applying a transverse normal pressure around an open hole. (Author abstract). 7 Refs.

Mallick, P.K. (Univ of Michigan, Dearborn, MI, USA). *Composites* v 19 n 4 Jul 1988 p 283-287.

**080379 ADVANCES IN LOW-PROFILE ADDITIVES.** This article describes the development of new low-profile additives that make possible extremely smooth-surface SMC/BMC composites, even with particularly fast-cure formulations. Cure times of 30 seconds have been achieved on 100-mil-thick compression-molded parts. 4 Refs.

Atkins, K.E. (Union Carbide Corp, South Charleston, WV, USA); Grandy, R.C.; Reid, C.G.; Seats, R.L.; Rex, G.C. *Plast Compd* v 11 n 5 Jul-Aug 1988 5p.

**080380 GENERAL RESULTS ON THE FLOW OF CHOPPED FIBER COMPOUNDS IN COMPRESSION MOLDING.** Two main theorems are proved from the governing differential equations for the flow of sheet molding compounds in compression molding. The first states that among all possible velocity distributions which satisfy the incompressibility condition and the kinematic boundary condition at a fixed edge, the actual solution minimizes the instantaneous rate of work by the molding press. The second is a general representation theorem for the velocity solution in terms of two scalar potentials. One of these potentials satisfies Laplace's equation and the second satisfies Helmholtz's equation. Each of these theorems is applied to problems of practical interest. The variational theorem is used to obtain a simple approximate solution for the flow front progression in a rectangular charge which, for a limited range of parameters, agrees remarkably well with previous numerical solutions of the exact equations. The representation theorem is used to examine the form of the solution in the important practical limit of a thin cavity. (Edited author abstract). 7 Refs.

Caulk, D.A. (GM, Warren, MI, USA). *J Non Newtonian Fluid Mech* v 28 n 3 Jul 1988 p 333-347.

**080381 COST-EFFICIENT SMC BONDING THROUGH SUPPLIER TEAMWORK.** A discussion is presented of methods used to upgrade one firm's structural bonding systems. The first step involved a thorough investigation of the new adhesive systems that have revolutionized structural bonding. Given the application and the variety of problems that needed to be addressed, a two-part epoxy adhesive that can be heat cured for fast bonding or cured at room temperature was installed. The equipment that was finally settled on is air-draulically driven, providing a high degree of mixed material flow control at the dispense point. A number of other power options are available, including servo motor-driven systems for robotics applications. The systems may be stationary or portable. One of the system's most notable features is its mix-at-the-nozzle automatic dispense valve design. The two components are line-fed to the valve from the positive displacement metering cylinders. The materials come together for the first time in the nozzle, preventing the material from curing inside the valve. A special static, motionless mixer combines the two-part epoxy in the disposable nozzle as the adhesive is dispensed.

Anon. *Adhes Age* v 31 n 11 Oct 1988 p 20-21.

**080382 POLYESTER MOULDING COMPOUNDS.** Polyester moulding compounds are moulding materials that can reproduce the excellent properties of glass reinforced plastics (GRP), colloquially known as fiberglass, on a volume production basis. Whereas GRP parts are produced by a labor intensive manual process, polyester moulding compounds enable the types of moulding processes used for other plastics to be employed. The two main types of polyester compounds used are sheet moulding compound (SMC) and dough moulding compound (DMC). Both materials are based on the same basic raw materials, polyester resins, glass fibers, fillers, and other minor additives, the main difference between the two



types being the length of the glass fiber employed, the fiber length dictating both the properties of the material and the form in which it is supplied.

Wright, R.S. (Freeman Chemicals Ltd). *Sheet Met Ind* v 65 n 9 Sep 1988 p 464.

## Stability

**080383 LONG-TERM STABILITY OF WASTE LANDFILL SEALING SHEET MADE OF POLYETHYLENE.** Bottom liners of waste landfills protect the ground-water from leachate which may contain hazardous substances. Intermediate coverings installed during the operation of the landfill unit help to minimize leachate from waste and to prevent landfill gases from escaping. After the closure of the unit, the sealing system must keep functioning for as long as hazardous leachate still results. As the inaccessibility of the bottom liner rules out repair at a later date, high demands must be made on the durability of the material and the quality of the construction work. Landfill bottom liners are made of both mineral materials (clay and/or loam) and plastic sheets. Some of the topics discussed are creep-rupture strength of plastic sheet, strength of welds and chemical resistance.

Hessel, J.; Koch, R.; Gaube, E.; Gondro, C.; Heil, H. *Kunstst Ger Plast* v 78 n 2 Feb 1988 p 27-29.

## Testing

**080384 INSTRUMENTED FALLING WEIGHT IMPACT TEST OF POLYMER SHEETS.** The response of polypropylene (PP), polycarbonate (PC), polystyrene (PS), polyethylene (PE), propylene-ethylene block copolymer (PPB), and acrylonitrile-butadiene-styrene (ABS) sheets has been studied using an instrumented falling weight impact tester. Three modes of fracture occur: puncture failure, crack failure, and brittle fracture, depending on their ductility and mechanical properties. (Edited author abstract) In Japanese. 4 refs.

Narisawa, Ikuo (Yamagata Univ, Yonezawa, Jpn); Ishikawa, Masaro; Sato, Katuyoshi. *Kobunshi Ronbunshu* v 44 n 11 1987 p 845-852.

**080385 FINITE ELEMENT MODEL OF VISCOELASTIC MEMBRANE DEFORMATION.** A numerical scheme is presented for modelling the axisymmetric inflation of a thin incompressible isotropic sheet up to a rigid obstacle under the action of a uniform pressure. A membrane model is assumed for the behaviour of the sheet. When the sheet makes contact with the obstacle it is further assumed that a condition of total sticking occurs. In the scheme the equilibrium and constitutive equations are kept separate and a modified  $H^1$ -Galerkin technique using cubic Hermite approximations is employed. Numerical results are presented for the cases of both flat and elliptical obstacles and for both materials of the Mooney-Rivlin elastic type and of a viscoelastic generalization of the Mooney-Rivlin model. (Author abstract) 6 refs.

Warby, M.K. (Brunel Univ, Uxbridge, Engl); Whiteman, J.R. *Comput Methods Appl Mech Eng* v 68 n 1 May 1988 p 32-54.

**Thermal Properties** See POLYPROPYLENE—Crystallization.

**Thermoforming** See Also POLYETHYLENES—Ultra-high Molecular Weight.

**080386 DEEP DRAWING OF POLYPROPYLENE SHEETS UNDER DIFFERENTIAL HEATING CONDITIONS.** Means of improving the deep drawability of thermoplastic sheets were explored by introducing temperature gradients in the deforming material during deep drawing of initially flat sheets. The specific experimental procedure consisted of either limiting the heating to the flange section of the deforming sheet of exposing the entire material to higher temperatures. At the same time, the initial blank size and the clamping force at the flange section were varied systematically. Both polypropylene and polypropylene with 40 percent calcium carbonate in

the form of sheet were tested up to 130°C. It is demonstrated that the drawability increases markedly with increasing temperature gradient between the flange and punch sections. (Edited author abstract) 24 refs.

Machida, T. (Rensselaer Polytechnic Inst, Troy, NY, USA); Lee, D. *Polym Eng Sci* v 28 n 7 Mid-April 1988 p 405-412.

**Transparency** See SOLAR RADIATION—Collectors.

**Viscoelasticity** See CELLULOSIC RESINS—Sheet.

## PLASTISOLS

**080387 THERMODYNAMIC APPROACH TO THE FORMULATION OF PRINCIPLES FOR THE PREPARATION OF PLASTISOLS.** A thermodynamic standpoint is discussed in regard to the choice of the means whereby the introduction of solid and liquid into multicomponent plastisols may be effected. It was found that if the distribution of liquid components among solid ones during the preparation of a plastisol is carried out in such a way as to bring the system as close as possible to the thermodynamic equilibrium state, the result will be that a very significant increase in the stability of the viscosity of the plastisol will thus be obtained. (Author abstract) 4 refs.

Guzeyev, V.V. (A.M. Gorkii State Univ of the Urals, USSR); Yushkova, S.M.; Berezov, L.V.; Mozhukhin, V.B.; Vanina, G.V.; Tager, A.A. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2900-2905.

## Physical Properties

**080388 MORE MEANINGFUL MEASUREMENT OF PLASTISOL PROPERTIES.** The fundamentals of plastisol rheology must be understood in order to properly select and utilize plastisol property measurements. Useful evaluation should also be made of the rheological effects of formulation ingredients and their interrelationships. Other factors such as plastisol preparation, storage conditions, process shear rates, temperatures, dwell times, and finished product specifications will influence the design of effective test procedures. Once meaningful plastisol property measurements have been developed, better quality control assurance results, and in addition quality, productivity, and profitability improvements are effected. (Author abstract) 4 refs.

Dann, Bill (Formosa Plastics Corp, Delaware City, DE, USA). *J Vinyl Technol* v 9 n 1 Mar 1987 p 35-40.

## Rheology

**080389 ROLE OF THE PRESTATIONARY STAGE OF DEFORMATION IN THE THIXOTROPIC AND DILATANT VARIATION OF THE VISCOSITY OF POLYVINYL CHLORIDE PLASTISOLS.** The rheological properties of plastisols of polyvinyl chloride (PVC) in dioctyl phthalate with 60:40 and 65:35% concentrations have been investigated. (Edited author abstract) 11 refs.

Trapeznikov, A.A. (Acad of Sciences of the USSR, Moscow, USSR); Frolova, E.A. *Colloid J USSR* v 49 n 2 Mar-Apr 1987 p 343-348.

## Structure

**080390 STRUCTURE OF PLASTISOLS FILLED WITH AEROSIL.** The structure of plastisols containing Aerosil and two-component suspensions of PVC and Aerosil in dioctyl phthalate was studied by electron microscopy. The contributions of the PVC and Aerosil phases to the formation of the rheological properties of the plastisols were evaluated. The presence of a continuous coagulation structural network of Aerosil particles in the dispersion medium of the plastisols is the basic factor which determines these properties. (Edited author abstract) 10 refs.

Berezov, L.V.; Guzeyev, V.V.; Batueva, L.I.; Bort, D.N. *Colloid J USSR* v 49 n 5 Sep-Oct 1987 p 871-874.

**PLATES** See Also ALUMINUM SHEET—Forming; BEAMS AND GIRDERS; BOLTS AND NUTS; COMPOSITE MATERIALS—Nonmetallic Matrix Composites; COMPOSITE STRUCTURES; ELASTIC WAVES—Diffraction; ELASTIC WAVES—Propagation; ELASTICITY; ELASTICITY—Theory; FLOW OF FLUIDS—Analysis; FLOW OF FLUIDS—Bodies of Revolution; FLOW OF FLUIDS—Boundary Layer; FLOW OF FLUIDS—Flow Interactions; FLOW OF FLUIDS—Laminar; FLOW OF FLUIDS—Transonic; FLOW OF FLUIDS—Unsteady Flow; FLOW OF FLUIDS—Vortex Flow; FLOW OF WATER—Stability; FLOW OF WATER—Unsteady Flow; FOUNDATIONS—Soil Structure Interaction; HEAT TRANSFER—Convection; MAGNETIZATION—Computer Aided Analysis; MATHEMATICAL TECHNIQUES—Finite Element Method; MATHEMATICAL TECHNIQUES—Numerical Methods; MATHEMATICAL TECHNIQUES—Sensitivity Analysis; SPRINGS—Analysis; STEAM GENERATORS; STEEL STRUCTURES—Connections; STEELMAKING—Process Control; STRUCTURAL DESIGN—Optimization; TRUSSES—Wood; WAVEGUIDES; WIND TUNNELS—Supersonic Flow.

**080391 COMPRESSIVE BEHAVIOR OF GUSSET PLATE CONNECTIONS.** The compressive behavior and buckling strength of thin-walled gusset plate connections were examined on the basis of an experimental investigation of full-scale diagonal bracing connections. Such connections are commonly used to transfer forces from a bracing member to the beam and column through the gusset plate. A total of 14 tests were run on six connections specimens. Plate thickness, geometric configuration, boundary conditions, eccentricity and reinforcement were considered in planning the tests. Attempts were made to correlate the eccentric loading test results with the beam column formulas and the concentric loading test results with the finite element program BASP. Comparisons are shown to be in reasonable agreement. Current design practices are discussed briefly and found to be very unconservative compared with test results. A parametric study was undertaken by using different thickness and size of gusset plates, different thickness of splice plate and different boundary conditions. A tentative design guideline for gusset plate loaded in compression is proposed based on test results and parametric studies. (Edited author abstract) 18 refs.

Cheng, J.J. Roger (Univ of Alberta, Edmonton, Alberta, Can). *Univ Alberta Dep Civ Eng Struct Eng Rep* n 153 Jul 1987 148p.

**080392 DREISEITIG GELAGERTE RECHTECK-PLATTEN AUF ELASTISCHER BETTUNG.** [Rectangular Plates Supported on Three Sides by Elastic Bedding]. The submitted contribution offers a collection of moment tables enabling the rapid calculation of the essential plate moments of rectangular plates supported on three sides by elastic bedding. The basic analytic method of the Fourier series of sines for compiling these tables has been developed in the author's previous publications and specified in detail. This method made it possible to treat plates with two opposite hinged edges. Generally, for practical application, the determination of two settling states is required (uniform settling, linear progressive settling), to make allowance for the position of the resultant of the vertical load F. Finally, the method of calculation is illustrated by means of a detailed numerical example, and compared with the results obtained, if one presupposes that soil pressure is linearly distributed. (Author abstract) In German. 3 refs.

Hraby, Konrad. *Bautechnik* v 65 n 1 Jan 1988 p 27-31.

**080393 DYNAMIC PLASTIC RESPONSE OF CIRCULAR PLATES IN A DAMPING MEDIUM.** The motion of a simply supported circular plate of rigid-plastic material is studied. The motion is produced by a uniformly distributed impulsive velocity. The material of the plate is assumed to obey the Tresca yield criterion with the inclusion of shear yield. The effect of damping by the surrounding medium on the plate motion is examined. (Author abstract) 6 refs.

Kumar, Ashwini (IIT Kanpur, Kanpur, India). *Int J Impact Eng* v 6 n 4 1987 p 285-290.



**080394 IMPACT OF A CYLINDRICAL OR RECTANGULAR INDENTER AGAINST A THERMOELASTIC-PLASTIC PLATE WITH CAVITIES.** The present paper deals with numerical modeling of nonstationary thermoelastic-plastic processes initiated by contact interaction between axisymmetric or rectangular solids. We present the constitutive relations of the coupled theory of thermoelastoplasticity, based on the unified curve concept; to integrate them numerically, we set up an iterative difference ripple-through calculation scheme. Analysis of the numerical data makes it possible to determine the principal behavior of the stressed and kinematic state of a multilayer plate with cavities under the impact of a deformable indenter that is shaped like a cylinder of variable radius or a rectangular beam. (Edited author abstract) 7 refs.

Rimskii, V.K. *Mech Solids* v 22 n 3 1987 p 106-112.

**080395 STRESSES ROUND CIRCULAR HOLES AND INCLUSIONS.** The stress distribution around a circular hole in a plate in uniaxial tension is well known: at the ends of the diameter aligned with the tension (the 'poles') there is a hoop stress of  $-T$ ; at the ends of the transverse diameter (the 'equator') the hoop stress is  $+3T$ . By superposition of two such tensions (usually unequal) we arrive at the stresses around a hole in any uniform stress field, or, equivalently, around a small hole in an arbitrary non-uniform stress field. If the hole is not small an obvious first approximation is to apply the same stress concentration factors to the stresses at the center of the 'hole', i.e. to the stresses which exist at the center of the circle where the hole is to be. This paper addresses the question of how good this approximation is, and whether it can be improved upon. 6 Refs.

Greenwood, J.A. (Univ of Cambridge, Cambridge, Engl). *Cambridge Univ Eng Dep Tech Rep CUED/C-Mech* n 43 Mar 1988 23p.

**Acceleration** See BALLISTICS—Theory.

**Acoustic Properties** See Also ACOUSTIC WAVES—Transmission; POLYMERS—Acoustic Properties.

**080396 TRANSFER ADMITTANCE OF A POINT-EXCITED, FLUID-LOADED PLATE.** This paper concerns the evaluation of the transfer admittance of an infinite, thin, fluid-loaded, elastic plate excited by a point force as a function of radial distance between forcing and response, and frequency. The plate vibration is expressed in terms of a sum of residues and a branch-line integral. These results lend themselves to rapid numerical evaluation for specific cases. Special consideration is given to the plate response in two limits. In the first, it is shown that the major component of the surface response is a subsonic free wave, while in the second, it is shown that the response is dominated by a 'leaky' wave whose characteristics tend in the limit to those of a flexural wave of the plate vibrating in vacuo. (Edited author abstract) 17 refs.

Rothwell, D.J. (YARD Ltd, Glasgow, Scottl); Purhouse, M. *J Sound Vib* v 120 n 3 Feb 8 1988 p 431-443.

**080397 ACOUSTO-ULTRASONIC INPUT-OUTPUT CHARACTERIZATION OF UNIDIRECTIONAL FIBER COMPOSITE PLATE BY SV WAVES.** A unidirectional fiberglass epoxy composite specimen is modeled as a homogeneous transversely isotropic continuum plate medium. Acousto-ultrasonic non-contact input-output characterization by tracing SV waves in the continuum is studied theoretically with a transmitting and a receiving transducer located on the same face of the plate. The isotropic plane of the equivalent continuum plate model lies in the midplane of the plate and is parallel to the top and bottom faces of the plate. This study increases the quantitative understanding of acousto-ultrasonic nondestructive evaluation (NDE) parameters such as the stress wave factor (WSF) and wave propagation in fiber reinforced polymeric, ceramic or metallic composites. (Edited author abstract) 9 Refs.

Liao, Peter (MIT, Cambridge, MA, USA); Williams,

James H. *NASA Contract Rep* n 4152 Jun 1988 89p.

#### Acoustic Wave Effects

**080398 ETUDE EXPERIMENTALE DES EFFETS NON GEOMETRIQUES LIES A L'INTERACTION D'UN FAISCEAU ACOUSTIQUE BORNE AVEC UNE PLAQUE PLANE IMMERGEE.** [Experimental Study of Non-Geometrical Effects Resulting from the Interaction of a Bounded Acoustic Beam with a Plane Plate Immersed in Water]. When a bounded acoustic beam is incident on a plate immersed in a fluid, Lamb modes are generated at particular angles of incidence. For these critical angles non-specular effects are found; they concern the reflection and transmission coefficients and also the intensity distribution. In this paper we study these effects experimentally. Particular attention is devoted to the influence of the angle of incidence, the thickness of the plates and the beamwidth. The experimental curves are compared with the theoretical calculations developed by Ngoc and Mayer, and good agreement is observed. (Author abstract) In French. 10 refs.

de Billy, M. (Univ Paris 7, Paris, Fr); Molinero, I.; Quentin, G. *Acustica* v 64 n 1 Jul 1987 p 40-45.

#### Aerodynamics

**080399 ANALYSIS OF APPROXIMATIONS OF AERODYNAMIC COEFFICIENTS OF THIN BODIES IN A RAREFIED GAS.** A regression analysis is made of the approximation of the relationships between exchange coefficients and local incidence angle. The results of a numeric investigation of the aerodynamic characteristics of a plate are used for the analysis. The approximation contains three parameters (two for the aerodynamic longitudinal force coefficient and one for the aerodynamic lift coefficient), which must be determined from an experiment. For these parameters an analytic approximation of their dependency on the Knudsen (Reynolds) number is suggested. (Author abstract) 7 refs.

Naritsa, V.S. *Leningrad Univ Mech Bull* n 2 1987 p 67-70.

**Aluminum** See Also ALUMINUM AND ALLOYS—Welding.

**080400 NONLOCAL DAMAGE THEORY.** A nonlocal damage field theory is proposed and a response model of nonlocal elastic damage is given. A simulating experiment using aluminum alloy plates with arrays of holes shows that the load bearing capacity of a plate varies with angle  $\gamma$  between array and loading direction. The characteristics and attenuation lengths appreciably affect the constitutive equations. (Author abstract) 13 refs.

Xia, Shaobo (Huazhong Univ of Science & Technology, Wuhan, China); Li, Guangxia; Lee, Hao. *Int J Fract* v 34 n 4 Aug 1987 p 239-250.

**080401 SHEAR EFFECTIVE WIDTH OF ALUMINIUM PLATES.** The capacity of a plate to sustain shear load greater than the critical load is studied. The concept of effective width for square plates loaded in shear is developed to consider rectangular plates loaded in shear. The deformation of the plate at failure is formulated. Very good agreement is observed between the theoretical results and experimental measurements carried out on aluminum web plates. (Author abstract) 4 refs.

Vilnay, Oren (Univ Coll, Cardiff, Wales); Burt, Caroline. *Thin-Walled Struct* v 6 n 2 1988 p 119-128.

**Analysis** See Also BEAMS AND GIRDERS—Analysis; DOMES AND SHELLS—Analysis; STRUCTURAL ANALYSIS.

**080402 ON THE CRITICAL SPEED OF A ROTATING CIRCULAR PLATE.** It is well known that the response amplitude of a rotating circular plate subjected to a stationary lateral load increases rapidly as the rotation speed approaches a certain value, generally referred to as the critical speed. There are many papers which are concerned with the critical speed of rotating

plates. In this paper a simple arithmetic equation is presented for the determination of the critical speed of plates with a clamped inner boundary and free outer boundary. 8 refs.

Chonan, S. (Tohoku Univ, Sendai, Jpn). *J Appl Mech Trans ASME* v 54 n 4 Dec 1987 p 967-968.

**080403 DYNAMICS OF PLATES WITH MIXED BOUNDARY CONDITIONS.** For the calculation of plates with complicated boundary conditions a method is proposed that is based on the introduction of the parameter  $\epsilon$  into the boundary conditions so that for  $\epsilon=0$  one would get the simplest boundary problem, and for  $\epsilon=1$  the initial one. In solving the problem thus obtained, the method of perturbations is employed together with Pade approximation. A solution of the problems of dynamics of rectangular plates with mixed boundary conditions is presented. (Translated author abstract) In Russian. 6 refs.

Andrianov, I.V.; Ivankov, A.O.; Kolesnik, I.A. *Izv Vyssh Uchebn Zaved Mashinostr* n 8 1987 p 34-37.

**080404 PERFORATION OF ALUMINUM PLATES WITH CONICAL-NOSED RODS - ADDITIONAL DATA AND DISCUSSION.** Backman and Goldsmith (1978) discuss many analytical and experimental methods used to study the broad field of penetration mechanics. For plate perforation, they show eight possible mechanisms that depend on the geometry and material of the projectiles and targets. Because many perforation mechanisms are possible, experimental observations usually precede and guide engineering models. This study is limited to high strength, conical-nosed projectiles that perforate low strength, ductile targets. For the experiments conducted in this study targets were 6061-T6 aluminum plates and projectiles were machined from T-200 maraging steel. 7 refs.

Rosenberg, Z. (Univ of Dayton Research Inst, Dayton, OH, USA); Forrestal, M.J. *J Appl Mech Trans ASME* v 55 n 1 Mar 1988 p 236-238.

**080405 APPROXIMATE SOLUTION OF THE AXISYMMETRIC VON KARMAN EQUATIONS FOR A POINT-LOADED CIRCULAR PLATE.** A closed-form solution of the axisymmetric von Karman equations or their equivalent for a point-loaded circular plate continues to evade researchers. An approximate solution is presented which consists of general equations which are easy to use and which compare well with other solutions including the previously unpublished numerical results of Brodland. The transverse deflection is given by an assumed expression which contains a single parameter associated with plate shape. This parameter,  $\beta$ , is determined by minimizing a shear-related residual. Thus, the present analysis takes advantage of the ease with which assumed-form solutions can be used, while ensuring that the shape change which occurs with increasing load can be accommodated. 15 refs.

Dolovich, A.T. (Univ of Waterloo, Waterloo, Ont, Can); Brodland, G.W.; Thornton-Trump, A.B. *J Appl Mech Trans ASME* v 55 n 1 Mar 1988 p 241-243.

**080406 THIN PLATE ELEMENT WITH RELAXED KIRCHHOFF CONSTRAINTS.** An analysis of thin plates by  $C^0$  elements is presented. The fundamental part of it is the formulation of a set of constraints that relate the rotational degrees of freedom to the translational degrees of freedom and which are weaker than the usual Kirchhoff constraints. A penalty term associated with these constraints is then introduced instead of the usual expression for the shear strain energy. It is shown that the approach is effective for both quadrilateral and triangular elements. (Author abstract) 37 refs.

Stolarski, Henryk K. (Univ of Illinois at Chicago, Chicago, IL, USA); Chiang, Martin Y.M. *Int J Numer Methods Eng* v 26 n 4 Apr 1988 p 913-933.



**080407 SOME VARIANTS OF THE APPROXIMATE THEORIES OF LAMINATED PLATE CALCULATION.** The present article provides a comparison between four applied theories of laminated plate calculation, which are based on the kinematic broken-line hypothesis, the kinematic and static hypotheses for the entire pack, and the concept of a uniform stressed-strained state for the layer pack and for each layer separately. The problem of cylindrical bending of a two-layer, freely supported plate under the action of a sinusoidal load is used as the comparison standard. 5 refs.

Patlashenko, I.Yu. (Acad of Sciences of the USSR, Kiev, USSR). *Sov Appl Mech* v 23 n 7 Jul 1987 p 669-673.

**080408 SOLUTION OF CONTACT PROBLEMS FOR PLATES ON AN ELASTIC HALFSPACE.** The method of nonlinear boundary equations is used to formulate and solve problems of plate contact with an elastic halfspace. This approach, together with modern methods of operator-equation theory, allows the existence and uniqueness of solutions and also some of their properties to be investigated relatively simply in very general cases. In addition, there is the possibility of using well-known methods of solving nonlinear operator equations for the solution of these problems. 6 refs.

Galanov, B.A. (Acad of Sciences of the USSR, Kiev, USSR); Nikol'skii, Yu.V. *Sov Appl Mech* v 23 n 8 Aug 1987 p 722-728.

**080409 ON THE INTERACTION BETWEEN AN EDGE DISLOCATION AND TWO CIRCULAR INCLUSIONS IN AN INFINITE PLATE (2ND REPORT, WITH THE GLIDE PLANE INCLINED TO THE X-AXIS).** To continue the work presented in the previous paper, the solution to the problem of the interaction between two circular inclusions and an edge dislocation in an infinite plate, which are arranged in the order of inclusion-edge dislocation-inclusion, and are placed on the x-axis, having the glide plane inclined to the x-axis. Results obtained by numerical calculation indicate that, for the region near the interface, the interactions are affected by the combinations of elastic constants and the inclination of the glide plane. The dislocation has a stable equilibrium position or an unstable equilibrium position at some intermediate distance from the inclusions under some combinations of elastic constants. The equilibrium positions are also affected by the inclination of the glide plane. (Author abstract) In Japanese. 11 refs.

Sasaki, Shuichi; Shioya, Shunsuke; Yamaguchi, Hideya. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 497 Jan 1988 p 126-131.

**080410 INITIAL-VALUE ANALYSIS OF CONTINUOUS ORTHOTROPIC PLATES.** A numerical procedure is presented which is called the initial-value method to analyze continuous orthotropic plates. The method consists of integrating in one direction and using finite difference expressions for the other direction. The procedure of the initial-value method is discussed in detail. The method has proven its efficiency in the analysis of single-span beams and plates. The convergence of the method is discussed in a few examples. The effects of changing the number of elements in each direction on the percentage error and computation time are shown. Several examples are presented to compare this method with other approximate methods. Deflections and moments are presented in tabular form for various aspect ratios and degrees of orthotropy for two cases of continuous plates. (Edited author abstract). 6 refs.

Al-Khaiat, Husain (Kuwait Univ, Kuwait). *Comput Methods Appl Mech Eng* v 69 n 2 Jul 1988 p 153-165.

**080411 ANALIZA EXCENTRYCKY VYZTUZENYCH TENKYCH DESEK.** [Analysis of Thin Plates With Eccentric Stiffeners]. Thin steel isotropic and stiffened plates loaded in compression and bending are analyzed. The theory is based on the large deflection von Karman-Marguerre plate equations. Plasticity is handled by Crisfield's 'area' incremental approach using Ilyushin-Ivanov's yield surface. Bending and axial rigidities of

stiffeners were introduced into solution by interaction forces along the stiffener-plate connection. It is shown that careful formulation of stiffener boundary conditions is needed because of possible changing of mode of collapse. The numerical procedure uses finite differences and interlacing meshes solved by dynamic relaxation. (Edited author abstract). 37 Refs. In Czech.

Machacek, Josef (Stavební Fakulta CVUT, Prague, Czech). *Stavebníky Cas* v 36 n 3 Mar 1988 p 191-212.

**080412 ALGORITHM OF CONTACT PROBLEMS FOR FORMING PROCESS OF THIN PLATES - A NUMERICAL ANALYSIS FOR THE SEAMING PROCESS OF A CAN.** An algorithm of contact problems for processing thin plates is presented. In the seaming process of a can, two thin plates, an end and flange of a can slip each other and repeat contacting and separating, and are deformed by a roll. To analyze such a complex contact problem, an algorithm using penalty forces and maximum displacement control is proposed. A trial analysis of the seaming process with this algorithm is shown in this paper. (Author abstract) 13 refs.

Ishinabe, Masao (Toyo Seikan Group, Yokohama, Jpn). *Comput Struct* v 27 n 1 1987; Adv in Comput Struct and Solid Mech, Pap Presented at the First World Cong on Comput Mech, Austin, TX, USA, Sep 22-26 1986 p 23-26.

**Applications** See HEAT EXCHANGERS—Design; SOILS—Testing.

#### Assembly

**080413 FINITE STRIP METHODS FOR INSTABILITY OF PRISMATIC PLATE ASSEMBLIES.** The fundamentals and applications of the Finite Strip Method to instability of prismatic plate assemblies are reviewed. In the first part of the paper the motivation to study such stability problems in the context of civil engineering structures is stated. In the second part both the energy concepts of stability from which the equilibrium equations are obtained, and the displacement fields used for the finite strip approximations are discussed. The last part is oriented to applications of the stability and finite strip fundamentals to the solution of bifurcation buckling, post buckling equilibrium and mode interaction. The applications show that the technique is capable of handling almost every problem of stability of prismatic plate assemblies, with the restrictions of the boundary conditions that can be satisfied in global buckling problems. (Author abstract). 18 Refs.

Godoy, Luis A. (Univ Nacional de Cordoba, Cordoba, Argent). *Eng Anal* v 5 n 2 Jun 1988 p 100-107.

**Bending** See Also BEAMS AND GIRDERS—Bending; DOMES AND SHELLS—Components; ELASTICITY—Theory; MATERIALS—Deformation; MATHEMATICAL TECHNIQUES—Differential Equations; MATHEMATICAL TECHNIQUES—Finite Element Method.

**080414 CALCULATION OF ELASTIC PLATES UNDER A COMBINED LOAD.** The solution of the problem of bending under the combined effect of transverse loading and of the forces acting in the median plane is considered. The method of R-functions used successively to solve the plane problem of the theory of elasticity and then the problem of plate bending makes it possible to automate the process of solving the initial problem for plates of virtually arbitrary shape and various loading methods. Numerical results are presented for a square, freely supported plate weakened by a central circular hole, subjected to the effect of a transverse load and compressive forces. 5 refs.

Rvachev, V.L. (Acad of Sciences of the Ukrainian SSR, Kharkov, USSR); Kurpa, L.V.; Shevchenko, A.N. *Sov Appl Mech* v 23 n 3 Mar 1987 p 256-260.

**080415 NEW TYPE OF PLATE BENDING ELEMENT.** Based on a two-field generalized variational principle, a new type of arbitrary quadrilateral plate bending element, with four nodes and with the effect of transverse shear deformation taken into account, is

proposed. The element is applicable to a wide range of plate thickness and an explicit expression of stiffness matrix can be obtained. Therefore, it possesses the distinguished features of general applicability, high precision and less computer time. (Author abstract) 12 refs.

Ding Haojiang (Zhejiang Univ, China); Zhou Weiyu; Sun Libo. *Acta Mech Sin* v 3 n 1 Feb 1987 p 82-91.

**080416 ELASTIC PLATES UNDER BENDING SOLVED BY PSEUDOCAUSTICS.** The method of pseudocaustics was applied to the study of out-of-plane bending in elastic plates. It is shown that for bending problems where the loading mode is given, the method determines experimentally the complex potential function at selected points along the boundaries. A conformal mapping of the closed smooth curves of each boundary of the plate on to a unit circle allows the determination of the complex potential  $\phi(z)$ , expressed in the form of a Laurent series. This in turn yields the complete solution of the bent plate. In order to show the efficiency of the method it was applied to two typical examples of thin infinite plates in cylindrical bending, having either a circular central hole, or a square hole. (Edited author abstract) 10 refs.

Theocaris, P.S. (Athens Natl Technical Univ, Athens, Greece); Theotokoglou, E.N. *Exp Mech* v 27 n 3 Sep 1987 p 262-267.

**080417 IMPROVED DYNAMIC RELAXATION METHOD FOR THE ANALYSIS OF PLATE BENDING PROBLEMS.** An improved dynamic relaxation method is used to solve the set of simultaneous equations resulting from application of the finite element method for plate bending problems. Different weights are used as multiplying factors for each mass and damping factor in each equation representing one of the three degrees of freedom at each node. The optimum values of these weights are obtained for different cases of the bending of cantilever plates stiffened with edge beams with different sizes of stiffening edge beams. (Author abstract) 8 refs.

Al-Shawi, F.A.N. (Basrah Univ, Basrah, Iraq); Mardirozian, A.H. *Comput Struct* v 27 n 2 1987 p 237-240.

**080418 BENDING OF BIMODULUS ANNULAR PLATES.** Bending analysis of axisymmetric annular circular plates of bimodulus material subjected to uniform lateral load is dealt with in this paper. The finite element method is used to formulate the governing equations of equilibrium. An iterative technique is used to find the position of the neutral surface. Numerical work has been done for plates with different sizes and boundary conditions. (Author abstract) 8 refs.

Srinivasan, R.S. (Indian Inst of Technology, Madras, India); Ramachandra, L.S. *Comput Struct* v 27 n 2 1987 p 305-310.

**080419 TRANSVERSE SHEAR OSCILLATIONS IN FOUR-NODE QUADRILATERAL PLATE ELEMENTS.** Numerical results show that the transverse shears are free of oscillation for regular or quasi-regular meshes of four-node plate elements based on Mindlin-Reissner theory. However, even small perturbations of these meshes can introduce severe oscillations throughout the mesh. These findings apply to the underintegrated elements with and without stabilization and to the fully integrated elements which use assumed shear strains. A filtering procedure capable of recovering improved shears is presented. (Author abstract) 16 refs.

Lasry, David (Northwestern Univ, Evanston, IL, USA); Belytschko, Ted. *Comput Struct* v 27 n 3 1987 p 393-398.

**080420 BASIC STUDY OF THE ACCURACY ESTIMATION OF STRUCTURAL ANALYSIS BY THE ZOOMING METHOD [2ND REPORT, FINITE ELEMENT ANALYSIS OF THE TRANSVERSE BENDING OF THIN FLAT PLATES (PART 2)].** As a basic study for the establishment of an accuracy estimation method in structural analysis using the zooming method, this second report deals also, as previous report, with the



finite element analysis of the problems of transverse bending of thin, flat plates. In the previous report, we treated a small hole, if it was in a plate, as a hole. This treatment inconveniently led to an increase of nodal points and hence to an increase of the size of the system of simultaneous linear equations and computation time. To overcome this inconvenience, we propose in this second report a method where small holes are neglected and the whole region is divided into elements of nearly equal size at the initial two or more analyses prior to the start of the zooming method with consideration of holes. (Edited author abstract) In Japanese. 4 refs.

Yokoyama, Masaaki; Sasaki, Shigeru. *Nippon Kikai Gakkai Ronbunshu A Hen* v 53 n 493 Sep 1987 p 1833-1837.

**080421 SPREADSHEET SOLUTION OF ELASTIC PLATE BENDING PROBLEMS.** This paper discusses the use of spreadsheet programs for the analysis of slab systems. The objective is to demonstrate a practical approach which can be employed for preliminary analysis, checking of mainframe solutions, or complete analysis of less complicated slab systems. Other than word processing, the most popular use of microcomputers is for 'spreadsheet' analysis of problems. The software is inexpensive, relatively easy to learn, and a highly versatile and productive tool. This paper will develop a technique which allows engineers to easily model elastic slab bending problems using readily available microcomputer spreadsheet programs. A 'central difference' formulation of the problems is used because the operators are well suited to spreadsheet modeling. Generation of the operators is illustrated using the finite difference method. A compatibility approach is developed for the inclusion of beams in the model. Accuracy, convergence, and mesh size are all discussed. Several examples showing iterative solution of both classical and practical plate problems are shown. 10 refs.

Small, Gregory Eric (Univ of Alberta, Edmonton, Alberta, Can); Simmonds, Sidney H. *Univ Alberta Dep Civ Eng Struct Eng Rep* n 149 Jul 1987 76p.

**080422 STRESS CONCENTRATION OF A STRIP WITH A SINGLE EDGE NOTCH.** This paper deals with the stress concentration analysis of a semicircular and a 60° V-shaped single edge notch in an infinite strip under three different types of loading conditions: (a) uniform tension, (b) in-plane bending and (c) pure tension. The stress field induced by a point force in the semi-infinite plate, Green's function in a closed form, is used to solve those problems. The results show that Neuber's formula gives an underestimated stress concentration factor when the notch is sharp and shallow. The stress concentration factors of 60° V-shaped notches are represented by diagrams for wide use. (Author abstract) 5 refs.

Noda, Nao-Aki (Kyushu Inst of Technology, Kitakyushu, Jpn); Nisitani, Hironobu. *Eng Fract Mech* v 28 n 2 1987 p 223-238.

**080423 APPLICATION OF A WEIGHT FUNCTION METHOD TO PREDICT THE FATIGUE LIFE OF CORNER CRACKED HOLES LOADED IN BENDING.** Fatigue lives are calculated for corner cracked holes in plates loaded in pure bending. Stress intensity factors are computed by a three-dimensional weight function method and are adapted in a fatigue crack growth life prediction algorithm. The life predictions agree well with experimental results obtained for cracked polymer plate specimens. (Author abstract) 12 refs.

Perez, R. (Purdue Univ, West Lafayette, IN, USA); Ray, S.K.; Grandt, A.F. *Eng Fract Mech* v 28 n 3 1987 p 283-291.

**080424 FRACTURE ANALYSIS OF PLATE BENDING USING THE FINITE ELEMENT METHOD.** Since the plate is one of the commonly used structural elements, many researchers have obtained analytical solutions to fracture problems of plate bending. Recently, the finite element method has been applied to those problems. In this report, a Reissner-Mindlin type of plate

bending element is developed for fracture analysis of plate bending. 5 refs.

Kwon, Young W. (Univ of Missouri-Rolla, Rolla, MO, USA). *Int J Fract* v 35 n 4 Dec 1987 p R79-R81.

**080425 ON THE BERGAN-WANG APPROACH FOR MODERATELY THICK PLATES.** The Bergan-Wang approach for the transverse shear inclusion in thin and moderately thick plate deformation has led to an energy expression which is a function of the only lateral deflection. The corresponding Euler equation is an eighth-order partial differential equation. A variety of examples has been analyzed. Analytical solutions have been presented for different thickness to span ratios under different boundary conditions. Results show very close resemblance to solutions based on Reissner plate theory. (Author abstract) 11 refs.

Abdalla, Hamed (Military Technical Coll, Cairo, Egypt); Hassan, Kamal. *Commun Appl Numer Methods* v 4 n 1 Jan-Feb 1988 p 51-58.

**080426 REFINED HERMITIAN ISOPARAMETRIC PLATE BENDING ELEMENT.** A refined version of the Hermitian isoparametric element which avoids the difficulties with derivative parameters in the geometric mapping is presented. The accuracy of the element is compared with the DKT-triangle, which is considered to be the most accurate 9 degrees-of-freedom plate bending element. The present element compares rather well with the DKT element. Moreover, comparisons are also made in some 'non-standard' cases (circular plate with concentrated load off the centre and elliptical plate) which suggest that the accuracy of all the elements considered is slightly poorer in these than in the standard cases. (Author abstract) 13 refs.

Virtanen, S. (Tampere Univ of Technology, Tampere, Finl); Pramila, A. *Commun Appl Numer Methods* v 4 n 1 Jan-Feb 1988 p 67-77.

**080427 STUDY OF THE INFLUENCE OF THE ANGLE CONDITION ON PLATE BENDING OF TRIANGULAR FINITE ELEMENTS.** In triangulating a domain to find a finite element approximation for the solution of a specific problem, the so-called angle condition is essential. In this paper, a study of the effects of this condition on the spectral properties of the stiffness matrix has been performed for two plate bending elements: the constant moment triangle (CMT) and the discrete Kirchhoff triangle (DKT). This has been done on the element level and also for the global system. It is shown that as the smallest, rather than the largest, angle of the elements considered herein decreases, the condition number of the global stiffness matrix increases. (Author abstract) 8 refs.

Hassan, K. (Space Research Cent, Cairo, Egypt); Sarigul, N. *Commun Appl Numer Methods* v 4 n 1 Jan-Feb 1988 p 79-83.

**080428 MECHANICS OF THE FLAME BENDING PROCESS: THEORY AND APPLICATIONS.** The flame bending process can be most useful in the present effort to automate the plate bending process in shipyards. To achieve this goal, the complicated thermo-elastic-plastic behavior of the plate during the process must be understood. A review of the past analytical research efforts reveals that these attempts have been restricted to beam bending. Here a theory for the thermo-elastic-plastic plate bending is developed. Furthermore, using a boundary element method as a solution technique, the difference between the mechanics of beam bending versus plate bending is shown. Recommendations for future work are given. (Author abstract) 31 refs.

Moshaiov, Amiram (MIT, Cambridge, MA, USA); Vorus, William S. *J Ship Res* v 31 n 4 Dec 1987 p 269-281.

**080429 DYNAMIC BEHAVIOR OF DOUBLY CONNECTED POLYGONAL PLASTIC SLABS.** The solution is considered for the problem of dynamic bending of doubly connected polygonal slabs under hinged support or clamping of the separate sides of the contour, and under the effect of an impulsive load distributed uniformly

over the surface. In the general case, it is assumed that the slab rests on a viscoelastic base. The case of a contour in the form of regular convex polygons, or in the form of polygons described around circles, is considered in detail. 18 refs.

Nemirovskii, Yu.V. (Novosibirsk Univ, USSR); Romanova, T.P. *Sov Appl Mech* v 23 n 5 May 1987 p 458-464.

**080430 FLEXURAL ANALYSIS OF LAMINATED COMPOSITES USING REFINED HIGHER-ORDER C PLATE BENDING ELEMENTS.** A finite element formulation for flexure of a symmetrically laminated plate based on a higher-order displacement model and a three-dimensional state of stress and strain is presented here. The present higher-order theory incorporates linear variation of transverse normal strains and parabolic variation of transverse shear strains through the plate thickness, and as a result it does not require shear correction coefficients. A nine-noded Lagrangian parabolic isoparametric plate bending element is described. The applications of the element to bending of laminated plates with various loading, boundary conditions, and lamination types are discussed. (Edited author abstract) 26 refs.

Pandya, B.N. (Indian Inst of Technology, Bombay, India); Kant, Tarun. *Comput Methods Appl Mech Eng* v 66 n 2 Feb 1988 p 173-198.

**080431 SIMPLE MODEL FOR THE CONTACT PROBLEM OF A FINITE CRACKED PLATE IN BENDING.** In bending of a finite cracked plate, the stress intensity factor (SIF) at a cracked tip is usually negative. This means that the displacement at the vicinity of the crack tip is overlapped. However, this is not reasonable. In this paper a simple model is suggested. When the SIF is negative, some part of the crack will close. By using a collocation method the length of the closed part of the crack, and the SIF value of the other crack tip have been calculated. (Edited author abstract) 5 refs.

Woo, C.W. (Univ of Hong Kong, Hong Kong); Cheung, Y.K.; Chen, Y.Z.; Wang, Y.H. *Eng Fract Mech* v 29 n 2 1988 p 227-231.

**080432 REFINED HIGHER-ORDER GENERALLY ORTHOTROPIC C<sup>0</sup> PLATE BENDING ELEMENT.** A finite element formulation for flexure of a generally orthotropic plate based on a higher-order displacement model and a three-dimensional state of stress and strain is presented here. This higher-order theory incorporates linear variation of transverse normal strain/stress and parabolic variation of transverse shear strains through the thickness of the plate. The nine-noded quadrilateral from the family of two-dimensional C<sup>0</sup> continuous isoparametric Lagrangian elements is then developed as a generally orthotropic higher-order element. The performance of this element is evaluated on square plates with different support conditions and under uniformly distributed and central point loads. The numerical results of the present formulation are compared with thin plate, elasticity and Mindlin/Reissner solutions. The effect of degree of orthotropy of the maximum bending moment location is examined for different loading and boundary conditions. (Edited author abstract) 23 refs.

Pandya, B.N. (Indian Inst of Technology, Bombay, India); Kant, Tarun. *Comput Struct* v 28 n 2 1988 p 119-133.

**080433 ANALYSIS OF SKEW AND TRIANGULAR PLATES IN BENDING.** The objective of this paper is to develop fast converging series solutions for rectangular, parallelogram and triangular plate bending elements with arbitrary boundary conditions and arbitrary shapes, and subjected to generalized normal loading. Solutions to parallelogram and rectangular plates are obtained by representing the deformed shape of a structure by a sequence of functions that are complete and satisfy the natural and forced boundary conditions. These consist of



a combination of trigonometric and polynomial functions with undetermined coefficients. The undetermined coefficients are determined by using modified Galerkin technique, and satisfying the boundary conditions. Solutions of triangular plates for simply supported and clamped boundary conditions are obtained in a similar manner by selecting appropriate shape functions that satisfy the natural and forced boundary conditions. (Edited author abstract) 32 refs.

GangaRao, Hota V.S. (West Virginia Univ, Morgantown, WV, USA); Chaudhary, V.K. *Comput Struct* v 28 n 2 1988 p 223-235.

**080434 FINITE ELEMENT MODELS FOR STIFFENED PLATES UNDER TRANSVERSE LOADING.** Linear finite element models based on Mindlin's shear distortion theory for bending of eccentrically stiffened plates subjected to transverse loading are presented. Two models using discrete plate-beam formulations are given and the superiority of one over the other is discussed. An additional formulation applicable to technically orthotropic plates under distributed loading is included. This latter formulation may sometimes be advantageous under less demanding conditions because of reasons of economy. (Author abstract) 10 refs.

Deb, A. (Memorial Univ of Newfoundland, St. John's, Newfoundland, Can); Booton, M. *Comput Struct* v 28 n 3 1988 p 361-372.

**080435 PLATE BENDING ANALYSIS USING MACRO ELEMENTS.** A variable degree of freedom plate bending element is presented. The displacement function within an element satisfies the governing thin plate equation, substantially reducing the number of equations requiring generation and solution for the accurate analysis of beam-slab structures. Large elements corresponding to structural units bounded by beams may be used, requiring a minimum of data preparation. The examples considered show that engineering accuracy may be obtained with the generation and solution of very few equations. In addition, a modified version of the ACM element with conforming displacements is shown to be a sub-element of the proposed element. (Author abstract) 12 refs.

Petrolito, J. (Australian Defence Force Acad, Campbell, Aust); Golley, B.W. *Comput Struct* v 28 n 3 1988 p 407-419.

**080436 NEW SIMPLIFIED FINITE ELEMENT METHOD FOR ELASTIC-PLASTIC ANALYSIS OF PLATE BENDING PROBLEMS.** A new simplified finite element method for the elastic-plastic analysis of plate bending is developed from the general simplified method which the authors have proposed. Plastic nodal displacement increments of an element are derived from the yield condition as plastics potential expressed in terms of the nodal forces based on the flow rule of plasticity. Thus, the elastic-plastic stiffness matrix can be obtained without numerical integration over the domain of the element, unlike the conventional finite element method, once the elastic stiffness matrix is derived through either the displacement model or the assumed-stress hybrid model. Numerical solutions for the elastic-plastic bending problem of circular and rectangular plates demonstrates the efficiency and accuracy of the present finite element method compared with the conventional finite element method. (Edited author abstract) 17 refs.

Watanabe, Naoyuki (Inst of Space & Astronautical Science, Tokyo, Jpn); Kondo, Kyohai. *Comput Struct* v 28 n 4 1988 p 495-503.

**080437 MODIFIED SHAPE FUNCTIONS FOR THE THREE-NODE PLATE BENDING ELEMENT PASSING THE PATCH TEST.** A polynomial displacement basis for the three-node plate bending element (Zienkiewicz-triangle) is developed from a relaxed  $C^1$ -continuity requirement called the interpolation test. The test provides a general convergence criterion for non-conforming shape functions and a practical guideline to select a proper displacement basis. The resulting simple dis-

placement type element passes the patch test. Several reduced numerical integration schemes are discussed and numerical testing provides a comparisons with the standard element formulated by Zienkiewicz. (Author abstract) 9 refs.

Specht, Bernhard (Dornier Systems GMBH, Friedrichshafen, West Ger). *Int J Numer Methods Eng* v 26 n 3 Mar 1988 p 705-715.

**080438 TWO-DIMENSIONAL MODEL FOR CRACK CLOSURE EFFECT IN PLATES UNDER BENDING.** A two-dimensional model is proposed for taking into account the establishment of contact on the compression side of crack faces in plates under bending. An approximate but simple method is developed for evaluating reduction of stress intensity factor due to such 'crack closure'. Analysis is first carried out permitting interference of the crack faces. Contact forces are then introduced on the crack faces and their magnitudes determined from the consideration that the interference is just eliminated. The method is based partly on finite element analysis and partly on a continuum analysis using Irwin's solution for point loads on the crack line. (Author abstract) 23 refs.

Murthy, M.V.V. (Natl Aeronautical Lab, Bangalore, India); Viswanath, S.; Krishna Murty, A.V.; Rao, K.P. *Eng Fract Mech* v 29 n 4 1988 p 435-452.

**080439 BENDING ANALYSIS OF PLATES WITH VARIABLE THICKNESS BY BOUNDARY ELEMENT-TRANSFER MATRIX METHOD.** The combined boundary element-transfer matrix method is proposed for plate bending problems. In this method, a transfer matrix is obtained, from the system of equations derived by the procedure based on the boundary element method. This method permits the use of large number of elements, without getting involved with large matrices. A much smaller computer is therefore sufficient. Some numerical examples are presented to demonstrate the accuracy as well as the capability of the proposed method for solutions of plate bending problems. (Author abstract) 15 refs.

Ohga, M. (Ehime Univ, Matsuyama, Jpn); Shigematsu, T. *Comput Struct* v 28 n 5 1988 p 635-640.

**080440 INVESTIGATION OF BENDING OF STUDDED GASTIGHT PANELS.** In boiler construction there is a trend to create large equipment (operating on eastern brown coals) with a unit power of 500, 800, 1200, 2000 MW, widespread use of which in the future will offer the possibility of reducing capital costs and an almost twofold reduction in thermal power plant construction time, which is especially important for eastern regions of the country. Brown coals are characterized by a high ash content and, when burned, intense slagging of radiation and convective heating surfaces occurs. Studded membrane heating surfaces have become widespread in this connection in boilers that operate on eastern brown coals. In order to create a high-quality process and industrial equipment for manufacturing bent studded panels to the Scientific Production Association Atomkoltomash and the Production Association Krasnyi Kotel'shchik (Red Boilermaker) conducted experimental bending studies. 8 refs.

Krasnopol'skaya, V.L.; Markin, Yu.N.; Bondarenko, V.T. *Sov Energy Technol* n 10 1987 p 46-51.

**080441 RICHARDSON EXTRAPOLATION FOR A MIXED FINITE ELEMENT APPROXIMATION OF A PLATE BENDING PROBLEM.** It is shown that a simple 2nd-order mixed finite element scheme for approximating the simply supported Kirchhoff plate admits asymptotic error expansions on three-dimensional directional meshes. This justifies the use of Richardson extrapolation for increasing the accuracy of the computation. The proof is based on finite element techniques. 5 refs.

Rannacher, R. *Z Angew Math Mech* v 67 n 5 1987 p 381-383.

**080442 NOTE ON BENDING MOMENT DISTRIBUTIONS IN CANTILEVER PLATES IN FUNDAMENTAL MODE VIBRATION.** In an earlier paper, Dickinson and Di Blasio employed Gram-Schmidt polynomials in conjunction with the Rayleigh-Ritz method for conducting a free vibration analysis of rectangular plates. In particular, they extended their analysis of the cantilever plate to include the computation of bending moment and Kirchhoff shear force distributions. They made the correct observation that, unfortunately, there appeared to be no material published in the literature with which they could compare these latter results. The object of this brief note is to provide some results with which their data can be compared. 2 refs.

Gorman, D.J. (Univ of Ottawa, Ottawa, Ont, Can). *J Sound Vib* v 122 n 1 Apr 8 1988 p 185-187.

**080443 ANALYSIS OF SYMMETRIC CROSS-PLY LAMINATED ELASTIC PLATES USING A HIGHER-ORDER THEORY: PART I - STRESS AND DISPLACEMENT.** A simple theory for bending of composite anisotropic plates that are laminated symmetrically about their mid-plane is presented. This theory incorporates transverse shear deformation and transverse normal stress as well as the higher-order effects and fulfills the static conditions on the external boundary planes. Further on, by using Levy-type solutions considered in conjunction with the state space concept, the state of stress and displacement of rectangular plates for a variety of edge conditions is determined and the results are compared to their first-order shear deformation and classical counterparts, obtained by using the same state-space technique. (Author abstract) 11 refs.

Librescu, L. (Virginia Polytechnic Inst & State Univ, Blacksburg, Va, USA); Khdeir, A.A. *Compos Struct* v 9 n 3 1988 p 189-213.

**080444 ROBUST TRIANGULAR PLATE BENDING ELEMENT OF THE REISSNER-MINDLIN TYPE.** A new triangular plate element is presented. This new element is based on independent interpolations for slopes, displacement and shear forces, and it is shown that it does not suffer from any defect common to other Mindlin plate elements. Several examples are presented to illustrate the behavior of this new element. (Author abstract) 30 refs.

Zienkiewicz, O.C. (Univ Coll of Swansea, Swansea, Wales); Lefebvre, D. *Int J Numer Methods Eng* v 26 n 5 May 1988 p 1169-1184.

**080445 NEW METHOD FOR DERIVATION OF LOCKING-FREE PLATE BENDING FINITE ELEMENTS VIA MIXED HYBRID FORMULATION.** The shear-locking phenomenon in discrete bending analysis of Mindlin/Reissner plates is investigated. Mixed/hybrid variational principles are introduced which, unlike the rigorous displacement model, allow systematic derivation of locking-free finite elements. This is achieved by satisfaction of an auxiliary condition, having the clear physical interpretation of shear-force elimination on account of equilibrium. An example, using competitive techniques, demonstrates the applicability of the idea. (Author abstract) 18 refs.

Gellert, M. (TU Berlin, Berlin, West Ger). *Int J Numer Methods Eng* v 26 n 5 May 1988 p 1185-1200.

**080446 BENDING OF RECTANGULAR CANTILEVER PLATES OF MODERATE THICKNESS.** The conception of modified simply supported edge has been studied with complements and extension with the application of E. Reissner's plate theory by which the effect of transverse shear deformation on bending plates has been taken into account in particular. The exact solution for the bending of rectangular, cantilevering and moderately thick plates under a concentrated load acting at the middle



of the free edge parallel to the clamped edge has been obtained by the method of superposition. (Author abstract) In Chinese. 8 refs.

Fan, Jianzhong; Jia, Baofan. *Huadong Huagong Xueyuan Xuebao* v 14 n 2 1988 p 243-252.

**080447 ANALYSIS OF ELASTO-PLASTIC BENDING OF RECTANGULAR PLATE.** A discrete method for analyzing the problem of elasto-plastic bending of a rectangular plate is proposed. The solutions for partial differential equation of rectangular plate are obtained in discrete forms by applying numerical integration. An incremental variable elasticity procedure has been used for the elasto-plastic analysis of the rectangular plate. As the applications of the proposed method, elasto-plastic bending of rectangular plate with four types of boundary conditions are calculated. (Edited author abstract) 14 refs.

Matsuda, Hiroshi (Univ of Nagasaki, Nagasaki, Jpn); Sakiyama, Takeshi. *Doboku Gakkai Rombun-hokokushu* v 9 n 4 Apr 1988 p 141-149.

**080448 BENDING, VIBRATION AND STABILITY ANALYSIS OF STIFFENED PLATES.** The bending, free vibration and stability of stiffened plates are analyzed by using the finite strip method. The stiffened plate is modeled as a system consisting of plate strip elements and beam elements, incorporate torsion as well as bending effects. The effects of flexural and torsional rigidities, location and length of the stiffeners on the displacement, natural frequency, and critical load of the stiffened plate are investigated. The results are compared well with the existing analytical solutions and the finite element solutions. (Author abstract) 18 refs.

Tarn, Jiann-Quo (Nat'l Cheng Kung Univ, Tainan, Taiwan); Tsai, Yarn-Tiarn. *Chung kuo Kung Ch'eng Hsueh K'an* v 11 n 2 Mar 1988 p 177-185.

**080449 ON THE VALIDITY OF THE REDUCED BENDING STIFFNESS METHOD FOR LAMINATED COMPOSITE PLATE ANALYSIS.** The 'reduced bending stiffness' (RBS) method has been used on occasions in the past as a means of simplifying the analysis of the flexural behavior of unsymmetrically laminated composite plates. However, the validity of the method has never been established. This paper makes direct comparisons between relatively simple, exact solutions for the static deflections, buckling loads and vibration frequencies of simply-supported plates and those arising from the RBS method. Extensive calculations are made for wide ranges of the physical parameters involved (aspect ratio, moduli ratio, lamination orientation angle, numbers of plies). The RBS method is found to yield sufficient accuracy for cross-ply plates. (Edited author abstract) 9 refs.

Ewing, M.S. (US Air Force Acad, Colorado Springs, CO, USA); Hinger, R.J.; Leissa, A.W. *Compos Struct* v 9 n 4 1988 p 301-317.

**080450 NEW FINITE ELEMENT SCHEME FOR BENDING PLATES.** Using a mixed formulation a new finite element for bending plates is suggested. It appears as an extension of numerical scheme used in fluid mechanics. One of its advantages is that both triangular and quadrangular element can be used. Furthermore, it implies an accuracy  $O(h^2)$  on the bending moments or the transverse shear for a low cost. Finally, the element works for arbitrary boundary conditions. (Author abstract) 10 refs.

Destuynder, Philippe (CNRS, Chateau-Malabry, Fr); Nevers, Thierry. *Comput Methods Appl Mech Eng* v 68 n 2 May 1988 p 127-139.

**080451 NONLINEAR BENDING ANALYSIS OF THIN CIRCULAR PLATES BY DIFFERENTIAL QUADRATURE.** The behavior of thin, circular, isotropic elastic plates with immovable edges and undergoing large deflections is investigated by the numerical technique of differential quadrature. Approximate results are determined with the aid of a symbolic manipulation computer program and a Newton-Raphson technique to solve the nonlinear systems of equations. Bending stresses, mem-

brane stresses, and deflections are calculated for clamped and simply supported flexural edge conditions and for a uniform pressure load and a concentrated load at the center. (Author abstract) 32 refs.

Striz, Alfred G. (Univ of Oklahoma, Norman, OK, USA); Jang, Sung K.; Bert, Charles W. *Thin-Walled Struct* v 6 n 1 1988 p 51-62.

**080452 IMPROVED ERROR ESTIMATE FOR REISSNER'S PLATE THEORY.** This report aims at extending the validity of  $O(h^3)$  error estimates in Reissner's theory to general homogeneous, anisotropic plates with midsurface elastic symmetry, carrying arbitrarily distributed face lateral loading. Reissner's theory for the bending of anisotropic, homogeneous plates and plane stress theory are used to construct improved three-dimensional displacement and stress fields. Under specific 'regular' boundary conditions on the edge surface, these fields differ from the exact elasticity solutions by terms of the order of the plate thickness cubed. 14 refs.

Rychter, Zenon (Technical Univ of Bialystok, Bialystok, Pol). *Int J Solids Struct* v 24 n 5 1988 p 537-544.

**080453 CURVED COMPOSITE BOUNDARY ELEMENTS FOR KIRCHHOFF PLATE-BENDING PROBLEMS.** Composite boundary elements are formed for plate-bending problems by attaching a circular sector to a triangle. Elements utilizing cubic and quintic interpolation are developed for convex and concave boundaries. Smaller error and less numerical effort result when triangular elements are replaced by the composite boundary elements on clamped and most simply supported convex, boundaries. For domains with concave boundaries, greater accuracy is obtained when the quintic composite boundary element replaces the triangular element in fine mesh configuration. (Author abstract) 8 refs.

Silva, Paul J. (Univ of California, Berkeley, CA, USA); Mote, C.D. Jr. *Int J Numer Methods Eng* v 26 n 6 Jun 1988 p 1241-1264.

**080454 BENDING OF METALLIC CIRCULAR PLATES RESTING ON AN ELASTIC SUBGRADE.** Rotationally symmetric plates resting on an elastic (Winkler) subgrade are studied. They are made of an elastic, perfectly plastic material obeying Tresca's yield condition and associated flow rule. The proposed method gives closed form solutions for monotonically loaded sandwich type plate. Examples for clamped and free edge plates are given. (Author abstract) 14 refs.

Sokol-Supel, J. (Inst of Fundamental Technological Research, Warsaw, Pol). *Ing Arch* v 58 n 3 1988 p 185-192.

**080455 GENERAL SOLUTION OF THE IMPROVING THEORY OF PLATES.** In a previous paper the problem of bending of a plate was transformed into a system of three partial differential equations where the displacements of the middle plane  $u_0$ ,  $v_0$  and  $w_0$  are unknown functions and when the transverse loading  $q(x,y)$  is a polyharmonic function. In this paper we consider only the case when  $q(x,y)$  is a harmonic function. 2 refs.

Bresar, France (Univ of Maribor, Maribor, Yugosl); Kumperscak, Vitodrag. *Z Angew Math Mech* v 68 n 4 1988 p T162-T164.

**080456 BOUNDARY CONDITIONS IN THE GENERALIZED THEORY OF PLATES.** Boundary conditions are considered only for the circular plates because the consideration for a plate with any form is too extensive to be quoted in this paper. But the way to find the boundary conditions for a plate with any form is similar to that for a circular plate. The results obtained with the equations presented in this paper for an actual example yield more information about the true stress-deformation state than the results which follow from classical theory. 1 ref.

Kumperscak, Vitodrag (Univ of Maribor, Maribor, Yugosl); Bresar, France. *Z Angew Math Mech* v 68 n 4 1988 p T204-T206.

**080457 NEW BOUNDARY ELEMENT METHOD FOR BENDING OF PLATES ON ELASTIC FOUNDATIONS.** The bending of plates on a Winkler foundation, according to Kirchhoff's theory, is solved by using an original boundary integral equation method involving the fundamental solution for plate flexure problems. An integral representation for the second member (pressure of the foundation) of the equation is given. By discretizing the integral equation, it is possible to eliminate the boundary unknowns, so that one is reduced to solving a linear system the solutions of which are deflections inside the domain. To illustrate the potentialities of this method several problems with various boundary conditions, loads and values of the modulus of the foundation are successfully solved. (Author abstract). 12 Refs.

Bezzine, G. (Univ de Poitiers, Poitiers, Fr). *Int J Solids Struct* v 24 n 6 1988 p 557-565.

**080458 THREE-DIMENSIONAL ELASTIC ANALYSIS OF CRACKED THICK PLATES UNDER BENDING FIELDS.** A three-dimensional analysis is presented for the bending problem of finite thick plates with through-the-thickness cracks. A general solution is obtained for Navier's equations of the theory of elasticity. It is found that the in-plane stresses and the transverse normal stress at the crack front are singular with an inverse square root singularity, while the transverse shear stresses are of the order of unity. Results from a numerical study indicate that the stress intensity factor, which varies across the thickness, is influenced by the thickness ratio in a significant manner. Results from a parametric study and those from a comparative study with existing finite element values are presented. (Author abstract). 23 Refs.

Iyengar, K.T. Sundara Raja (Indian Inst of Science, Bangalore, India); Murthy, M.V.V.; Rao, M.N. Bapu. *Int J Solids Struct* v 24 n 7 1988 p 683-703.

**080459 CONJECTURES RELATING TO RIGID-PLASTIC PLATE BENDING.** Rigid-plastic plate bending analysis has been studied for at least 40 years and many approximate solutions are available. There are, however, very few exact solutions known, even when the simplest yield criteria are employed. In order to focus attention on certain other aspects of these problems, some conjectures have been proposed. One of these conjectures is here considered further, and is applied to obtaining lower bound estimates for the collapse loads of clamped edge, regular shaped plates. (Author abstract). 7 Refs.

Lowe, P.G. (Univ of Auckland, NZ). *Int J Mech Sci* v 30 n 5 1988 p 365-370.

**080460 FIELD- AND EDGE-CONSISTENCY SYNTHESIS OF A 4-NODE QUADRILATERAL PLATE BENDING ELEMENT.** In this paper, we demonstrate the use of two conceptual principles, the field-consistency requirement and the edge-consistency requirement, as the basis for deriving a 4-noded quadrilateral plate bending element based on Mindlin plate theory using Jacobian transformations only. The derivation is now free of the use of such devices as strain-interpolation points and Hrennikoff strain reference lines, etc., which have been the basis for many recent formulations of this element. Numerical experiments show that this synthesis produces an element that should be identical to other recent formulations of this element based on tensorial transformations or on shear constraint condensation on the edges, but now given a more complete and formal logical basis. (Edited author abstract). 19 Refs.

Prathap, G. (Nat'l Aeronautical Lab, Bangalore, India); Somashekar, B.R. *Int J Numer Methods Eng* v 26 n 8 Aug 1988 p 1693-1708.

**080461 PLATE BENDING ANALYSIS BY THE DUAL RECIPROCITY BOUNDARY ELEMENTS.** A new boundary element approach to the deflection analysis of thin elastic plates resting on Winkler-type elastic foundation is presented in this paper. Integral equations formulated using reciprocity theorem and conventional



fundamental solution to the biharmonic differential operator include domain integral relating to the reaction term of the original differential equation. The above-mentioned domain integrals are transformed into equivalent boundary integrals with further use of the reciprocity theorem. The transformed reaction is considered as an inhomogeneous term and a successive iteration scheme is employed for the solution of the integral equations. The effectiveness of the method is examined through some numerical examples for which analytical solutions are available. (Author abstract). 10 Refs.

Kamiya, N. (Nagoya Univ, Nagoya, Jpn); Sawaki, Y. *Eng Anal* v 5 n 1 Mar 1988 p 36-40.

**080462 FIELD-CONSISTENCY ANALYSIS OF THE ISOPARAMETRIC EIGHT-NODED PLATE BENDING ELEMENT.** This paper proceeds from the field-consistency paradigm to understand why the original element and even the element modified by the  $2 \times 2$  Gaussian rule cannot achieve consistently, the true shear strain constraints in the penalty limit of thin plate behaviour. It then derives the optimal shear strain definitions that leave the element free of all problems in the rectangular form, for most sets of practical boundary suppressions. From this, next is determined the optimum manner of co-ordinate transformation that preserves the true constraints even in the form of a general quadrilateral. This is achieved within the context of iso-P Jacobean transformations and without having to bring in tensorial or base vector definitions and transformations. This should be the simplest displacement type version of this element. (Edited author abstract). 29 refs.

Prathap, G. (Natl Aeronautical Lab, Bangalore, India); Naganarayana, B.P.; Somashekar, B.R. *Comput Struct* v 29 n 5 1988 p 857-873.

**080463 ULTIMATE STRENGTH OF STEEL PLATES UNDER IN-PLANE BENDING AND COMPRESSION.** This paper presents the analytical results for the ultimate strength of steel plates under in-plane stress gradient based on the elasto-plastic finite displacement theory. Ultimate strength of steel plates and the effects of various parameters such as in-plane stress gradient, plate slenderness, aspect ratio, strain hardening of steel and initial imperfections are discussed analytically. Based on the analytical results, the ultimate strength formulas for uniform compression and for pure bending are proposed with good accuracy, and the interaction equation for the combined loading of compression and bending are also proposed in an exponential form. (Edited author abstract). 22 Refs.

Nara, S. (Gifu Univ, Gifu, Jpn); Fukumoto, Y. *Stahlbau* v 57 n 6 Jun 1988 p 179-185.

**080464 HIGHER-ORDER THEORY OF HOMOGENEOUS PLATE FLEXURE.** The need for higher-order models to obtain accurate estimates to transverse shear and normal stresses and strains is well known. In this paper a higher-order shear deformation theory with provision for cubic variation of in-plane displacements and parabolic variation of the normal displacement has been considered for detailed study. Numerical results have been obtained for infinite plate strip, simply supported on opposite edges and infinitely long in the other direction, subjected to sinusoidal static load. Displacements, strains, and stresses are compared with the exact solution. Results by the classical plate theory, Levinson's theory and a higher-order theory based on partial deflections are also included. This study shows that the present model can predict all displacements, strains, and stresses reasonably accurately. Further, it is also noted that the statically equivalent estimates to transverse stresses from classical theory and the corresponding strains also agree closely with the exact solution. (Author abstract). 22 Refs.

Murty, A.V. Krishna (Indian Inst of Science, Bangalore, India); Vellaichamy, S. *AIAA J* v 26 n 6 Jun 1988 p 719-725.

**080465 BPM SOLUTION FOR ELLIPTIC PLATES SUBJECTED TO ECCENTRIC LOADS.** A high-

er-order boundary perturbation method (BPM), formulated to treat a class of problems defined in an elliptic domain, is developed to obtain the Green's function due to an eccentric source. The method, based on a dual perturbation, leads to expansion solutions expressed in terms of ellipticity and eccentricity perturbation parameters. General explicit expressions for equivalent boundary conditions on the perturbed boundary are first derived to treat the class of problems for which the associated boundary conditions are of the Dirichlet or Neumann type. The BPM is applied to investigate a clamped elliptic plate subject to eccentric loads. (Edited author abstract). 7 Refs.

Parnes, R. (Ecole Polytechnique, Palaiseau, Fr). *Int J Solids Struct* v 24 n 8 1988 p 761-776.

**080466 BENDING OF RECTANGULAR PLATES WITH VARIABLE RIGIDITIES.** A microcomputer-oriented semianalytical method of solution is presented for rectangular plates with variable rigidity or thickness. The solution procedure is based on the classical method of separation of variables. The two-dimensional governing partial differential equation is first reduced to an ordinary differential equation. The classical unidirectional finite-difference method is then employed to solve the resulting ordinary differential equation. Results are presented for plates with different edge and loading conditions. Results for partially loaded plates with variable rigidity or thickness are presented in the literature for the first time. (Author abstract). 12 Refs.

Harik, Issam E. (Univ of Kentucky, Lexington, KY, USA); Sfeir, Dorian R. *Microcomput Civ Eng* v 3 n 3 Sep 1988 p 245-255.

**080467 BOUNDARY ELEMENT BENDING ANALYSIS OF MODERATELY THICK PLATES.** In this paper the boundary element method is applied to analyze homogeneous isotropic plates in bending using Reissner's theory. This formulation involves three coupled integral equations and can be applied not only to moderately thick plates, but also to some usually analyzed by classical Kirchhoff-Love thin plate theory. It is shown that the boundary element method gives accurate results and can be applied to cases when traction discontinuity may occur or even in the presence of singularities, using double nodes or simple discontinuous elements. Numerical results are compared against analytical or finite element solutions to illustrate the accuracy of the boundary element formulation. (Edited author abstract). 17 Refs.

Long, S.Y. (Hunan Univ, China); Brebbia, C.A.; Telles, J.C.F. *Eng Anal* v 5 n 2 Jun 1988 p 64-74.

**080468 RECTANGULAR FINITE ELEMENT FOR ANALYSIS OF THICK PLATE BENDING.** The explicit form of the  $12 \times 12$  stiffness matrix of a rectangular element for analysis of thick plate bending is presented. The element is assembled from six uni-dimensional prismatic bars, and the elemental stiffness properties, are obtained through the framework concept originated by A. Hrennikoff. The shear deformations of all the bars, comprising the rectangular lattice model, are taken into account, so that rigorous analysis of thick plate bending becomes possible. The influence of shear deformations, and the effects of plate thickness, on the deflections and bending moments of a rectangular plate, are illustrated by a numerical example. (Edited author abstract). 24 Refs.

Tezcan, Semih S. (Bogazici Univ, Istanbul, Turk). *Bull Tech Univ Istanbul* v 41 n 2 1988 p 315-331.

## Blasting

**080469 BEHAVIOUR OF LAMINATED PLATES SUBJECTED TO CONVENTIONAL BLAST.** Response of simply supported anti-symmetrically laminated angle-ply plates to explosive blast loading is considered. A closed-form solution is obtained for thick plates, it being assumed that the material remains in the elastic range. The effect of transverse shear deformations on the response of thick plates is taken into consideration. The behaviour of thin laminated plates subjected to blast is studied using

geometrically non-linear theory. Initial imperfections, which can be important for thin plates, are included in the analysis. The solution for thin elastic laminated plates is obtained numerically using a Runge-Kutta method. The analysis yields the non-dimensional deflection vs time relationship which can be used to determine the stresses and strains in the layers of the plate. (Author abstract) 22 refs.

Birman, Victor (Univ of New Orleans, LA, USA); Bert, Charles W. *Int J Impact Eng* v 6 n 3 1987 p 145-155.

## Bonding See Also WELDED STEEL STRUCTURES.

**080470 VARIATIONAL METHOD OF UNDETERMINED PARAMETERS FOR BENDING OF RECTANGULAR PLATES.** A variational method utilizing undetermined parameters is presented here for the analysis of rectangular thin plates which are supported on all edges. This method allows the trial functions to depend on the some parameters to be optimized. The good results obtained for the examples considered here suggest that this method is a viable alternative to other variational methods. 11 refs.

Ly, B.L. (AECL, Mississauga, Ont, Can). *J Sound Vib* v 119 n 2 Dec 8 1987 p 385-388.

**Buckling See Also AIRCRAFT MATERIALS—Composite Materials; BEAMS AND GIRDERS—Stability; COMPOSITE MATERIALS—Fracture; COMPOSITE MATERIALS—Stresses; LAMINATED PRODUCTS—Mathematical Models; PLASTICS LAMINATES—Failure; SILICON AND ALLOYS—Viscoplasticity; STEEL STRUCTURES—Defects; WELDED STEEL STRUCTURES—Connections.**

**080471 CURVATURE EFFECTS IN THE BUCKLING OF SYMMETRICALLY-LAMINATED RECTANGULAR PLATES WITH TRANSVERSE SHEAR DEFORMATION.** It is shown that the effect of stress discontinuities from ply-to-ply must be taken into account when curvature terms are included along with shear deformation in the buckling analysis of rectangular, symmetrically-laminated plates. Such ply-stress discontinuities lead to curvature terms in the governing equations which differ considerably from those derived for homogeneous plates. Critical buckling loads are determined for orthotropic laminates subjected to biaxial inplane loading and for cylindrical bending of anisotropic plates subjected to uniaxial compression loading. Simply-supported boundary conditions are considered in conjunction with the rectangular, orthotropic laminate, while simply-supported and clamped boundaries are considered for the case of cylindrical bending of anisotropic plates. (Edited author abstract) 10 refs.

Whitney, James M. (US Air Force Wright Aeronautical Lab, Wright-Patterson AFB, OH, USA). *Compos Struct* v 8 n 2 1987 p 85-103.

**080472 STATIC, DYNAMIC AND BUCKLING FORMULATION OF A SYMMETRICALLY LAMINATED PLATE FINITE ELEMENT FOR A MICROCOMPUTER.** The purpose of this paper is to develop a simple yet efficient formulation for a symmetrically laminated composite plate finite element and to adopt some highly efficient numerical algorithms using stand-alone desktop microcomputers for structural analysis and design. It is also the purpose to further develop the numerical procedures for a previously developed beam element and to further test it on examples. To demonstrate and evaluate the present development, numerical computations on the static, free vibration, and buckling analyses of a series of anisotropic symmetrically laminated plate problems have been performed using a microcomputer. (Edited author abstract) 14 refs.

Chen, Alex T. (Purdue Univ, West Lafayette, IN, USA); Yang, T.Y. *J Compos Mater* v 21 n 5 May 1987 p 441-453.



**080473 WAVENUMBER RESTRICTION IN SYSTEMS WITH DISCONTINUOUS NONLINEARITIES AND THE BUCKLING INSTABILITY OF PLATES.** It is shown that many properties of spontaneous pattern-forming systems with discontinuous, sharply saturating nonlinearities can be calculated almost analytically even far above threshold. Besides providing insight into the mechanisms of wavenumber restriction such systems are experimentally accessible. We suggest experiments on the buckling instability of a rectangular plate with rigid, amplitude-restricting stoppers. (Author abstract) 22 refs.

Paap, H.-G. (Univ Bayreuth, Bayreuth, West Ger); Kramer, L. *J Phys (Paris)* v 48 n 9 Sep 1987 p 1471-1478.

**080474 VIBRATION AND BUCKLING OF GENERALLY LAMINATED COMPOSITE PLATES WITH ARBITRARY EDGE CONDITIONS.** A method is developed for the analysis of free vibration and buckling of generally laminated composite plates having arbitrary edge conditions, such as clamped, simply supported or free. The procedure is an extension of the Ritz method utilizing a strain energy functional containing both bending and stretching effects and accommodating arbitrary ply stacking sequences. Displacement functions are taken in the form of polynomials, and an algorithm for satisfying the geometric boundary conditions is presented. Numerical results are compared with those of other researchers in order to establish the correctness and effectiveness of the method. Some additional new results are also presented. (Author abstract) 17 refs.

Baharlou, B. (Trenton State Coll, Trenton, NJ, USA); Leissa, A.W. *Int J Mech Sci* v 29 n 8 1987 p 545-555.

**080475 BUCKLING, POSTBUCKLING, AND NONLINEAR VIBRATIONS OF IMPERFECT PLATES.** Formulations and computational procedures are presented for studying the geometrically nonlinear behavior, including buckling, postbuckling, and nonlinear vibrations of perfect and imperfect, isotropic and laminated thin plates. The finite-element method is used. The element used is a 48 degree-of-freedom thin flat plate rectangular element capable of modeling arbitrary imperfections. The incremental and total stiffness matrices for large displacement behavior are derived based on the total Lagrangian approach in conjunction with the Hamilton's principle. The geometric imperfections are treated by considering additional terms in the strain-displacement relations. Numerical results are presented for a variety of examples. (Edited author abstract) 52 refs.

Kapania, Rakesh K. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Yang, T.Y. *AIAA J* v 25 n 10 Oct 1987 p 1338-1346.

**080476 POST-BUCKLING RESPONSE OF ISOTROPIC AND LAMINATED COMPOSITE SQUARE PLATES WITH CIRCULAR HOLES.** In this paper, the authors emphasize the well-known anomalous behavior observed in buckling of square plates with centrally located cut-outs. For certain size holes and depending upon whether the loading is displacement or stress controlled, perforated square plates have higher buckling loads than equivalent solid plates. Because of this anomaly, the authors have examined the post-buckling response of such plates of both isotropic and laminated composite construction. Having concluded from their post-buckling response that such plates are imperfection-insensitive except for a slight loss of their post-buckling strength resulting from the presence of the hole, the authors go on to examine the possible weight savings in using perforated square plates to resist buckling. (Author abstract) 7 refs.

Vandenbrink, Dennis J. (Western Michigan Univ, Kalamazoo, MI, USA); Kamat, Manohar P. *Finite Elem Anal Des* v 3 n 3 Oct 1987 p 165-174.

**080477 THERMAL BUCKLING OF LAMINATED CYLINDRICAL PLATES.** Thermal buckling of a laminated cylindrical plate subjected to a temperature change is studied. The governing differential equations for Don-

nell-type laminated cylindrical shells are used and Galerkin's method is employed to determine the critical buckling temperature. Clamped and simply supported boundary conditions are both considered. The effects of various parameters on thermal buckling are examined. (Author abstract) 15 refs.

Chen, Lien-Wen (Nat'l Cheng Kung Univ, Tainan, Taiwan); Chen, Lei-Yi. *Compos Struct* v 8 n 3 1987 p 189-205.

**080478 BEYOND BUCKLING A NONLINEAR FE ANALYSIS.** For some time now, engineers have been using linear finite element analysis to determine the point of instability, or bifurcation, in buckling problems. Although linear methods often do a good job of estimating the load under which a structure buckles, they do not provide information about what happens after buckling. Neither can they account for potential nonlinearities that may have significant effects on the collapse load. In contrast, nonlinear analysis can now provide the means to follow the displacement history of a buckling structure up to the point of collapse and beyond. The paper discusses the use of Nonlinear finite element analysis for the solution of post-buckling behavior of structures.

Berry, Dale T. (Marc Analysis Research Corp, Palo Alto, CA, USA). *Mech Eng* v 109 n 8 Aug 1987 p 40-44.

**080479 THERMAL BUCKLING OF LAMINATED COMPOSITE PLATES.** Thermal buckling of laminated composite plates subjected to a temperature change is studied. The displacement equations of equilibrium are used and Galerkin's method is employed to determine the critical buckling temperature. Clamped and simply supported boundary conditions are both considered. The effects of various parameters on the thermal buckling are examined. (Author abstract) 18 refs.

Chen, Lien-Wen (Nat'l Cheng Kung Univ, Tainan, Taiwan); Chen, Lei-Yi. *J Therm Stresses* v 10 n 4 1987 p 345-356.

**080480 VIBRATION AND POST-BUCKLING OF GEOMETRICALLY IMPERFECT, SIMPLY SUPPORTED, RECTANGULAR PLATES UNDER UNI-AXIAL LOADING, PART I: THEORETICAL APPROACH.** The work described in this paper constitutes the theoretical part of a theoretical and experimental study of the post-buckling and vibration of simply supported rectangular plates having slight initial curvature (geometrical imperfection) and subject to uni-axially applied, in-plane, compressive loads. The experimental part, and the comparison with theoretical predictions, is given in a second paper. The results presented appear to suggest that an approximately linear relationship exist between a load-frequency parameter and the central deflection of the plates considered, for a substantial in-plane loading range. (Edited author abstract) 25 refs.

Ilanko, S. (Univ of Western Ontario, London, Ont, Can); Dickinson, S.M. *J Sound Vib* v 118 n 2 Oct 22 1987 p 313-336.

**080481 VIBRATION AND POST-BUCKLING OF GEOMETRICALLY IMPERFECT, SIMPLY SUPPORTED, RECTANGULAR PLATES UNDER UNI-AXIAL LOADING, PART II: EXPERIMENTAL INVESTIGATION.** The paper describes the experimental part of a theoretical and experimental study of the post-buckling and free vibrational behavior of thin, rectangular, simply supported plates having initial geometrical imperfection and subject to uni-axially applied, in-plane, compressive loads. The experimental apparatus and procedure used are described. The fundamental natural frequency and central deflection of several plates of different thickness and degree of initial imperfection, subject to loads varying from zero to several times the critical buckling value, are compared with values predicted by using the Rayleigh-Ritz solution described in the companion paper. For one plate, comparisons of theoretically predicted and experimentally measured strains are given. Close agreement is shown to exist between the theoretical and experimental results. An

approximate linear relationship between a load-frequency parameter and the central deflection, discussed in the theoretical study, is also shown to exist for the experimental plates. (Author abstract) 11 refs.

Ilanko, S. (Univ of Western Ontario, London, Ont, Can); Dickinson, S.M. *J Sound Vib* v 118 n 2 Oct 22 1987 p 337-351.

**080482 EFFECT OF BOUNDARY CONDITIONS AND RIGIDITIES ON THE BUCKLING OF ANNULAR PLATES.** The buckling analysis of multi-annular plates, with different properties, is presented. The geometry may include ring stiffeners at the common joints and the plate may be supported in various manners, simple supports, clamped supports, etc., at the loaded outer edge. The loading is uniform radial compression and static. Several parametric studies are performed in order to assess the effect of geometry, material properties of the annular sections and of the ring stiffness. Moreover, when rings are present, the ring geometry is modeled both as a curved beam and as an annular plate, for comparison purposes. (Author abstract) 13 refs.

Simitses, G.J. (Georgia Inst of Technology, Atlanta, GA, USA); Frostig, Y. *Thin-Walled Struct* v 5 n 4 1987 p 229-246.

**080483 EXPERIMENTAL STUDY ON REQUIRED FLEXURAL RIGIDITY OF STIFFENER IN LONGITUDINALLY STIFFENED PLATES SUBJECTED TO LATERAL COMPRESSION.** The elastic buckling strength of longitudinally stiffened plates subjected to biaxial compressions is analyzed by the energy method. Then, interaction curves on longitudinal and transverse buckling stresses are presented and the minimum required flexural rigidity of stiffener is examined for the square plates with two longitudinal stiffeners. Finally, the minimum required flexural rigidity of stiffener derived by the elastic buckling theory for the stiffened plates subjected to uni-lateral compression is checked experimentally. (Edited author abstract) 10 refs.

Nakai, Hiroshi (Osaka City Univ, Jpn); Kitada, Toshitsuki; Wada, Yoshihiro. *Mem Fac Eng Osaka City Univ* v 27 Dec 1986 p 271-288.

**080484 BUCKLINGS OF ELLIPTICAL LAMINATED PLATES.** This paper is concerned with an analytical study on the bucklings of elliptical laminated plates with simply supported or clamped edges. Antisymmetric cross-ply and angle-ply laminates, as well as symmetric angle-ply laminates are investigated. Hamilton's principle and Rayleigh-Ritz method are employed to obtain the solutions for buckling modes and critical loads. Numerical results for critical loads of elliptical laminated plates are obtained for various aspect ratio  $a/b$ , material property ratio  $E_L/E_T$ , ply orientation  $\theta$ , and number of layers. The coupling effects between bending and stretching are also discussed. (Author abstract) 9 refs.

Lin, Chien-Chang (Nat'l Chung-Hsing Univ, Taichung, Taiwan); Lin, Shann-Chuen. *Chung-Kuo Chi Hsueh Kung Ch'eng Hsueh Pao* v 8 n 3 Jun 1987 p 173-181.

**080485 UNCERTAINTY MODELLING IN PLATE BUCKLING.** A brief account is given of the basic principles of uncertainty modelling with first-order second-moment methods. The main features of the behavior of plates subjected to compressive loads are considered and various prediction methods are compared. The governing parameters of plate behavior are used to construct probabilistic models for the laboratory test situation, for the analysis and for the design of plates. The uncertainty of the strength predictions is quantified in the different cases. Special attention is given to the implications of problem formulation and to the methodology of uncertainty modelling. (Author abstract) 17 refs.

Guedes Soares, C. (Technical Univ of Lisbon, Lisbon, Port). *Struct Saf* v 5 n 1 Jan 1988 p 17-34.



**080486 BUCKLING AND BENDING BEHAVIOUR OF INITIALLY STRESSED SPECIALLY ORTHOTROPIC THICK PLATES.** The virtual work theorem is employed to derive the governing equations of specially orthotropic plates in a general state of non-uniform initial stress, where the effects of transverse shear are included. The equations were adjusted to a generic form by using appropriate transformations. Considering the transformations, introducing generalized parameters and employing a similarity parameter, comprehensive solutions are found to this problem; hence, the curves presented in the text are generic rather than specific. The thick plate equations are solved for a simply-supported rectangular specially orthotropic plate in a state of combined uniform uniaxial compression and bending. The results of the reduced set of equations agree with those obtained by previous investigators. (Author abstract)

Yang, I.H. (Chinese Military Acad, Feng-Shan, Taiwan); Liu, C.R. *Int J Mech Sci* v 29 n 12 1987 p 779-791.

**080487 POST-BUCKLING BEHAVIOUR OF MODERATELY THICK CYLINDRICALLY ORTHOTROPIC ANNULAR PLATES.** A finite element formulation including the effects of shear deformation and cylindrically orthotropic material properties is described for studying the post-buckling behavior of annular plates. Numerical results for the buckling load parameter and ratios of nonlinear load parameter to buckling load parameter for various values of orthotropic properties, thicknesses and radii ratios of the plates are presented. (Author abstract) 6 refs.

Raju, K. Kanaka (Vikram Sarabhai Space Cent, Trivandrum, India); Rao, G. Venkateswara. *Comput Struct* v 27 n 6 1987 p 783-786.

**080488 POST-BUCKLING BEHAVIOR OF CENTRALLY CRACKED PLATES UNDER TENSION.** The post-buckling behavior of centrally cracked rectangular plates subjected to a uniaxial tension is analyzed by the finite element method, taking into account both geometrical and material nonlinearities. The finite element formulation is based on the total Lagrangian coordinate system and the flow theory of plasticity. The effects of an initial imperfection on buckling deformation are studied in some detail. Post-buckling behavior is discussed in relation to undesirable effects on the fracture of cracked plates. The results of elastic analyses show that the magnitude of the stress intensity factor increases after buckling. The results of elastic-plastic analyses and experiments show that the residual strength of cracked plates is reduced by the interaction between buckling deformation and plastic deformation at the ends of cracks. (Author abstract) 23 refs.

Fujimoto, Takashi (Kyushu Univ, Higashiku, Jpn); Sumi, Seinosuke. *JSMSE Int J* v 30 n 269 Nov 1987 p 1714-1723.

**080489 ELASTIC BUCKLING AND FLEXURAL VIBRATION OF VARIABLE-THICKNESS ANNULAR PLATES UNDER NONUNIFORM IN-PLANE FORCES.** This paper deals with elastic buckling and flexural vibration of annular plates whose thickness vary linearly in the radial direction. The annular plate is subjected to in-plane forces along its inner and outer edges, which vary in the circumferential direction. These problems are analyzed by the Galerkin method. Eigenfunctions of the natural vibration of a constant-thickness annular plate without in-plane forces are used as admissible functions. Two types of in-plane forces are adopted; one a sinusoidally varying nonuniformity along the outer edge, and the other uniform along parts of the outer edge and zero on the remainder of the edge. The influences of the nonuniformity of the in-plane forces on the buckling load and natural frequencies are investigated. It is found that the increase of the nonuniformity decreases the buckling load and the fundamental natural frequency. This tendency becomes more evident when the thickness of the plate at the inner edge is thinner and the hole larger. (Author abstract) 10 refs.

Majima, Osamu (Sophia Univ, Tokyo, Jpn); Hayashi, Kunio. *JSMSE Int J* v 30 n 270 Dec 1987 p 1890-1897.

**080490 PRINCIPAL AXES TECHNIQUE AND UNIQUENESS CRITERION - BUCKLING.** A uniqueness criterion for solids in finite deformation is developed. The criterion is used in conjunction with the principal axes technique to calculate the buckling stress in an elastic-plastic plate under uniaxial compression. The result is found to be significantly lower than the similar result obtained from the classical analysis. (Author abstract) 21 refs.

Dubey, R.N. (Univ of Waterloo, Waterloo, Ont, Can). *Trans Can Soc Mech Eng* v 11 n 4 1987 p 245-252.

**080491 VISCOELASTIC SANDWICH PLATES WITH CROSSPLY FACES.** An energy method has been used for an elastic formulation of buckling analysis of a simply supported sandwich plate with crossply faces, including the interlayer shear deformation of adhesive layers and the transverse normal and shear deformations of the core. A quasielastic method is used for the solution of viscoelastic analysis of the sandwich plate. Results of the viscoelastic buckling analysis under in-plane loads are presented for various lay-up sequences of face plates. Dependence of buckling load on face lay-up sequence, adhesive bonding stiffness, load ratio, and plate geometry is examined, including the effect of change of buckling modes. (Author abstract) 9 refs.

Kim, Chun-Gon (KAIST, Seoul, South Korea); Hong, Chang-Sun. *J Struct Eng* v 114 n 1 Jan 1988 p 150-164.

**080492 BUCKLING OF A BIMODULUS THICK RECTANGULAR PLATE BASED ON HIGHER-ORDER PLATE THEORY.** This paper presents the governing equations of a simply supported rectangular bimodulus thick plate related to the higher order shear deformation terms. The buckling coefficients obtained by the iteration method are compared with the former results for ordinary thick plates. The Mindlin plate theory result can be obtained by simplifying the governing equation of the higher-order plate theory formulation. The effects of higher-order shear deformation terms on the neutral surface locations and the buckling coefficients are evaluated by observing the difference between present higher-order theory results and Mindlin plate theory results. Also, the bending stress is shown to reduce the buckling coefficient significantly. (Author abstract) 28 refs.

Doong, Ji-Liang (Nat'l Central Univ, Chung-Li, Taiwan); Fung, Chin-Ping; Chen, Chun-Sheng. *Chung-Kuo Chi Hsueh Kung Ch'eng Hsueh Pao* v 8 n 4 Aug 1987 p 221-229.

**080493 DYNAMIC BEHAVIOUR OF POSTBUCKLED ISOTROPIC PLATES UNDER IN-PLANE COMPRESSION.** Universal analytical formulae are derived for the resonance frequencies of a prebuckled and postbuckled plate of any boundary conditions and aspect ratio. Results are also obtained by the Rayleigh-Ritz and finite element methods for the analysis of plates with several modes of imperfection. Measured resonance frequencies of an aluminum alloy plate up to the postbuckling region are compared with theory. (Author abstract) 11 refs.

Ng, C.F. (Univ of Southampton, Southampton, Engl); White, R.G. *J Sound Vib* v 120 n 1 Jan 8 1988 p 1-18.

**080494 COMPOUND STRIP METHOD FOR THE BUCKLING ANALYSIS OF CONTINUOUS PLATES.** A special finite strip method is developed for the analysis of linear buckling of flat plate systems that are continuous over non-rigid supports. This approach incorporates the effect of support elements in a direct stiffness methodology. The stiffness contribution of the support elements adds directly to the plate strip stiffness matrices at the element level prior to assembly. This summation of plate and support stiffness contributions forms a substructure, which is termed a compound strip. The compound strip methodology may be readily employed for the enhancement of computer programs based on traditional finite strip procedures. The validity of the compound strip method for elastic buckling analysis is demonstrated in two examples. The critical loads based on compound strip

methodology compare favorably with those obtained with the finite element method. (Author abstract) 42 refs.

Puckett, J.A. (Univ of Wyoming, Laramie, WY, USA); Wiseman, D.L.; Chong, K.P. *Thin-Walled Struct* v 5 n 5 1987 p 383-400.

**080495 THERMAL POST-BUCKLING OF A SQUARE PLATE RESTING ON AN ELASTIC FOUNDATION BY FINITE ELEMENT METHOD.** A simple finite element formulation is presented for evaluating the thermal post-buckling behavior of rectangular plates. The results are presented in the form of linear thermal loads and ratios of nonlinear to linear thermal loads for various values of the central deflection and for three sets of boundary conditions. The effect of elastic foundation on the thermal post-buckling behavior is also evaluated for various of foundation stiffness parameter. (Author abstract) 8 refs.

Raju, K. Kanaka (Vikram Sarabhai Space Cent, Trivandrum, India); Rao, G. Venkateswara. *Comput Struct* v 28 n 2 1988 p 195-199.

**080496 RADIALLY COMPRESSED LAMINATED CIRCULAR PLATES.** The paper deals with buckling of complete and annular circular plates, made of symmetric laminates with general orientation of the lamina fibers. The plate is subjected to an in-plane, symmetric, destabilizing load. The load is applied at the outer edge for the complete plate and at the outer and inner edges for the annular one. The plate is supported in various ways along its boundaries. The paper includes the derivation of the governing equations and discusses the various methods of solution. Numerical results are presented for a clamped plate. (Author abstract) 14 refs.

Simitses, George J. (Georgia Inst of Technology, Atlanta, GA, USA); Frostig, Yeoshua. *Compos Struct* v 9 n 1 1988 p 1-17.

**080497 DYNAMIC BEHAVIOUR OF POSTBUCKLED COMPOSITE PLATES UNDER ACOUSTIC EXCITATION.** The Rayleigh-Ritz method was used to find the postbuckling static displacement pattern of a composite plate (CFRP) under uniaxial in-plane compression of uniform edge-shortening. The resonance frequencies and mode shapes at various postbuckled states are then evaluated by eigenvalue analysis of the dynamic matrix equation consisting of up-dated tangential stiffness matrix at corresponding static configuration. The theoretical results are compared with experimental results obtained in 16-layered CFRP laminate of aspect ratio 1.5. The resonance frequencies and mode shapes obtained are used to interpret the multimodal and nonlinear strain responses to high level of acoustic excitation. The dominance of second-mode contribution and softening-spring behavior are found in the strain response of postbuckled plates. (Author abstract) 9 refs.

Ng, C.F. (Univ of Southampton, Southampton, Engl); White, R.G. *Compos Struct* v 9 n 1 1988 p 19-35.

**080498 OPTIMAL FIBRE ORIENTATION FOR SIMPLY-SUPPORTED, ANGLE-PLY PLATES UNDER BIAXIAL COMPRESSION.** Optimum laminate configurations for laminated rectangular plates under uniaxial or biaxial compression are investigated and are obtained under buckling constraints. Complete freedom is permitted in the selection of the ply angle variation through the thickness; however, it is proved that the maximum buckling load occurs when the orientation angle in each of the layers is the same. Three types of optimal angle (direction) are obtained in terms of the material properties, the geometrical properties and the type of buckling mode. They are expressed in closed analytical form. (Author abstract) 10 refs.

Muc, Aleksander (Univ of Liverpool, Liverpool, Engl). *Compos Struct* v 9 n 2 1988 p 161-172.



**080499 SIMPLE METHOD FOR MEASURING LOCAL BUCKLING OF THIN PLATES.** A simple computer-interfaced optical system for measuring the dynamic-local-buckling deformation of thin-walled metal structural-plate elements is described in this paper with two sets of experimental results. The major advantage of this system is its simplicity and economy as well as its speedy automated process for data scanning, acquisition, and analyses by using a microcomputer. (Author abstract) 6 refs.

Sang, Z.T. (State Univ of New York at Buffalo, Buffalo, NY, USA); Chang, K.C.; Lee, G.C. *Exp Mech* v 28 n 1 Mar 1988 p 20-23.

**080500 MAGNETOELASTIC BUCKLING: WHY THEORY AND EXPERIMENT DISAGREE.** In 1968, F.C. Moon and Y.W. Pao presented a theory of the magnetoelastic buckling of a beam plate in a uniform magnetic field which differed from experimental results by a factor of two. It is shown that the assumption made by Moon and Pao - that a plate element experiences a force system consisting only of a couple, whose magnitude is proportional to the rotation of the element - is invalid for finite plates. An experiment is suggested for determining whether the assumption is valid for infinite plates. The present state of knowledge concerning magnetoelastic buckling is briefly summarized. Several types of magnetoelastic buckling are identified and briefly contrasted. Attention is directed to the importance of field discontinuities in problems involving magnetic deformation. Two paradoxical aspects of the Moon-Pao formula for the magnetoelastic buckling of beam plates are pointed out and briefly discussed. (Edited author abstract) 15 refs.

Peach, M.O. (Technical Learning Cent, Houghton, MI, USA); Christopherson, N.S.; Dalrymple, J.M.; Viegela, G.L. *Exp Mech* v 28 n 1 Mar 1988 p 65-69.

**080501 DEFLECTION OF METAL PLATES UNDER LOAD INDUCED BY THE EXPLOSION OF A CONCENTRATED CHARGE OF AN EXPLOSIVE.** The paper discusses the results of experimental studies on the deflection of round steel plates loaded by the explosion of the concentrated charge of an explosive located at a distance over the plate center. The deflections are in satisfactory agreement with the values calculated by the method developed by the authors previously. (Author abstract) 5 refs. In Russian.

Stepanov, G.V.; Kovalenko, A.V.; Mal'tsev, V.A.; Loshkomev, P.V. *Probl Prochn* n 2 Feb 1988 p 112-114.

**080502 BUCKLING OF NONUNIFORM PLATES: SPLINE METHOD.** In view of the increasing use of machined skins in aircrafts and space vehicles, consideration of more types of variation in thickness, as well as the methods of analysis, becomes desirable. In the present study, the differential equation characterizing the transverse deflection of a thin rectangular plate of variable thickness, acted upon by static edge loads along the central plane, is solved semianalytically using a quintic spline collocation technique. The buckling coefficients and the mode shapes are obtained under simply supported conditions for a pair of opposite edges and three types of boundary conditions for the other edges. 8 refs.

Navaneethakrishnan, P.V. (Anna Univ, Madras, India). *J Eng Mech* v 114 n 5 May 1988 p 893-898.

**080503 EVALUATION OF ULTIMATE STRENGTH OF STEEL PLATES WITH INITIAL IMPERFECTIONS UNDER IN-PLANE BENDING AND COMPRESSION.** There are few studies on the ultimate strength of steel plates under in-plane combined loading, and their basic strength curves in the design specifications in many countries are still based on the elastic buckling theory using relevant safety factors. Evaluation in the ultimate strength is essential to promote the ultimate limit-state design method. This paper presents the ultimate strength of plate panel under in-plane stress gradient. Based on the analytical results, the ultimate strength formulas for uniform compress and pure bending are proposed respectively, and the interaction

formula for the combined loading of compression and bending are then proposed. (Author abstract) In Japanese. 15 refs.

Nara, Satoshi; Tsuda, Makoto; Fukumoto, Yuhshi. *Doboku Gakkai Rombun-hokokushu* v 9 n 4 Apr 1988 p 259-264.

**080504 ANALYSIS OF SYMMETRIC CROSS-PLY LAMINATED ELASTIC PLATES USING A HIGHER-ORDER THEORY: PART II - BUCKLING AND FREE VIBRATION.** Using the higher-order plate theory developed in the first part of this paper, as well as the technique based on the state space concept, the free vibration and buckling problems of rectangular cross-ply laminated plates are analyzed. In this context a variety of boundary conditions is considered and comparisons with the existing literature are made. (Author abstract) 8 refs.

Khdeir, A.A. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Librescu, L. *Compos Struct* v 9 n 4 1988 p 259-277.

**080505 BUCKLING OF POLAR ORTHOTROPIC CIRCULAR PLATES ON ELASTIC FOUNDATION BY COMPUTERIZED SYMBOLIC ALGEBRA.** Buckling of polar orthotropic circular plates resting on elastic foundation is studied in the context of the Rayleigh's method. A variant of this method, suggested originally by Rayleigh and based on the use of noninteger power, is contrasted with the variant containing an undetermined multiplier (the latter being equivalent to the Rayleigh-Ritz method). Results are obtained by computerized symbolic algebra. (Author abstract) 22 refs.

Elishakoff, Isaac (US Naval Postgraduate Sch, Monterey, CA, USA); Tang, Jianguo. *Comput Methods Appl Mech Eng* v 68 n 2 May 1988 p 229-247.

**080506 OERTLICHES BEULEN EINER PARALLELOGRAMMPLATTE UNTER VERÄNDERLICHER DRUCKSPANNUNG.** [Local Buckling of Parallelogram Plates Subjected to Variable Compressive Stress]. The web of I-beams is usually elastically fixed to the flanges. The interaction of web and flanges can be assessed by way of a related torsional buckling resistance. In addition, however, it must be considered that axial compressive forces can reduce this elastic fixity considerably. In addition to this effect, the influence of geometrical tolerances of the plate is being investigated. The resultant effects are being demonstrated by way of an example. (Author abstract) 12 refs. In German.

Petlic, P. (Technische Univ, Breslau, Wroclaw, Pol). *Stahlbau* v 57 n 5 May 1988 p 142-146.

**080507 BUCKLING OF RING-STIFFENED MULTI-ANNULAR PLATES.** The buckling of multi-annular plates stiffened by rings at the common joints and loaded by in-plane symmetric forces is investigated. The plate considered is simply-supported or clamped at the outer boundary. The various annular sections are homogeneous, monolithically connected through rings, without eccentricity, and differ either in geometry or in material properties, or both. The effect of the ring extensional (in-plane) rigidity is considered, in addition to the effect of the ring flexural and torsional rigidities. These effects are substantiated through parametric studies. The presented numerical examples consist of annular plates with one or two annular sections reinforced by a single ring. (Author abstract) 12 refs.

Frostig, Yeoshua (Georgia Inst of Technology, Atlanta, GA, USA); Simitses, George J. *Comput Struct* v 29 n 3 1988 p 519-526.

**080508 EFFECTIVE WIDTHS OF ORTHOTROPIC PLATES LOADED UNIAXIALLY.** An approximate method of evaluating the post-buckling characteristics of orthotropic plates subject to uniaxial compressive loading is presented. The analysis is based on the energy method and small deflection theory and avoids any tedious calculations which would become necessary when the large deflection theory is used. Formulae for effective widths of plates under various edge conditions are derived.

Effective width curves for plates with various flexural and torsional properties are presented. (Author abstract). 14 Refs.

Shanmugam, N.E. (Nat'l Univ of Singapore, Singapore). *Comput Struct* v 29 n 4 1988 p 705-713.

**080509 POST-BUCKLING ANALYSIS OF MODERATELY THICK CYLINDRICALLY ORTHOTROPIC CIRCULAR PLATES.** A simple finite element formulation is presented to aid study of the post-buckling behaviour of moderately thick circular plates with cylindrically orthotropic material properties. Linear critical loads and ratios of nonlinear radial loads to linear critical loads are given for various values of the parameters involved. (Author abstract). 6 Refs.

Raju, Kanaka, K. (Vikram Sarabhai Space Cent, Trivandrum, India); Rao, G. Venkateswara. *Comput Struct* v 29 n 4 1988 p 725-727.

**080510 ELASTIC-PLASTIC SNAPPING-THROUGH OF A CURVED METAL STRIP COMPRESSED BETWEEN TWO RIGID PLATES (2ND REPORT, THE INFLUENCE OF THE SUPPORTED END CONDITION ON THE SNAP-THROUGH).** The quasi-static loading on a curved strip compressed by a flat, rigid plate is considered with particular reference to large deformations, the ensuring buckling behavior and the effect of the supported end condition on the snap-through. The deformation characteristics have been analyzed using an incremental finite element technique. Particular attention has been paid to modeling the situation when a node contacts the plate, and to the condition for separation of the strip from the plate. It was found that the normalized force of the clamped ends of the shell was larger than that of the pinned ends at snapping point and that the amount of plate displacement and the distance of the clamped edges of the shell between the contact point in at the central point were smaller than those of the pinned edges at snapping point. (Author abstract). 16 Refs. In Japanese.

Iseki, Hideo; Sowerby, Robert; Chandrasekaran, N.; Gatt, Paul. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 501 May 1988 p 1044-1053.

**080511 THEORETICAL FORMULATION FOR THE NATURAL FREQUENCY, BUCKLING, AND DEFLECTION ANALYSES OF PLATES USING NATURAL CO-ORDINATES AND CHARACTERISTIC ORTHOGONAL POLYNOMIALS.** A theoretical formulation for the analysis of isotropic plates is presented in which natural co-ordinates are used in conjunction with normalized characteristic orthogonal polynomials. This method enables one to analyze plates of various geometric shapes defined by natural co-ordinates. Additionally, this method will help one avoid having to resort to using the computationally costly finite element method whenever this method suffices. 6 Refs.

Geannakakes, G.N. (Polytechnic Univ, Brooklyn, NY, USA). *J Sound Vib* v 124 n 2 Jul 22 1988 p 385-387.

**080512 EFFECT OF SHEAR DEFORMATION AND ROTATORY INERTIA ON DYNAMIC BUCKLING OF ELASTIC PLATES.** The influence of shear deformation and rotatory inertia on dynamic response of elastic rectangular plates subject to in-plane loads increasing with time is discussed using Mindlin's plate theory. The qualitative effect of those factors on transverse displacements is estimated. It is shown that this effect becomes essential only if the plate is thick and the number of half-waves along the plate axes in the deformation mode is large. (Author abstract). 20 Refs.

Birman, V. (Univ of New Orleans, New Orleans, LA, USA). *J Offshore Mech Arct Eng* v 110 n 3 Aug 1988 p 282-286.



**080513 POST-BUCKLING BEHAVIOUR OF ISOTROPIC ANNULAR PLATES UNDER UNIFORM INTERNAL RADIAL LOADS.** The stability parameter and the ratios of radial load in the post-buckling range to the linear buckling load are presented for isotropic annular plates under uniform internal radial load with various radius ratios and edge conditions. A finite-element formulation is employed to obtain the results. (Author abstract). 6 refs.

Venkateswara Rao, G. (Vikram Sarabhai Space Cent, Trivandrum, India); Kanaka Raju, K.; Balabhaskar, N.V.R.C. *Comput Struct* v 29 n 5 1988 p 927-928.

**080514 ON THE GLOBAL LARGE DEFLECTION AND POSTBUCKLING OF SYMMETRIC ANGLE-PLY LAMINATED PLATES.** This paper presents studies of the global nonlinear deflection and postbuckling behavior of symmetric angle-ply laminated plates. A new transformation between on-axis and off-axis modulus is established to make a link between the stiffness of angle-ply plates and the global constants in orthotropic transformed space. All the linear and nonlinear terms in the plate equations are properly nondimensionalized, such that the results in this paper are generic rather than specific. The results indicate that with increasing generalized rigidity ratio  $D^*$ , the deflection is reduced and the buckling coefficient is increased, and naturally the post-buckling deflection is decreased. The generalized Poisson's ratio only has a small effect on the problems. The information presented in the text should be helpful to whoever is seeking a better understanding of the correlation between composite material properties and nonlinear behavior of laminated plates. (Author abstract). 17 Refs.

Kuo, W.S. (Chinese Military Acad, Feng-Shan, Taiwan); Yang, I.H. *Eng Fract Mech* v 30 n 6 1988 p 801-810.

**080515 COMPARISON OF THE POSTBUCKLING BEHAVIOR OF PLATES AND SHELLS.** There is a basic difference in the mathematical treatment of post-buckling of plates and shells. Whereas for plates the classical methods of bifurcation theory (Lyapunov-Schmidt method, Singularity Theory) in general are applicable, these methods fail for the analysis of thin-walled shells. For shells in general solutions of the boundary layer type are found and hence the methods of singular perturbation theory are required for an appropriate analysis. Applications are given for the postbuckling of a rectangular plate and a spherical shell. (Author abstract) 17 refs.

Scheidt, R. (Tu-Wien, Vienna, Austria); Troger, H. *Comput Struct* v 27 n 1 1987, Adv in Comput Struct and Solid Mech, Pap Presented at the First World Cong on Comput Mech, Austin, TX, USA, Sep 22-26 1986 p 157-163.

## Calculations

**080516 NEKONECNA ZALUZIOVA DOSKA NA PRUZNOM PODLOZI, NAMAHANA SPOJITYMI USEKOVYMI A SUSTREDENYMI KRUTIACIMI MOMENTMI.** [Infinite Louver Type Plate Resting on Elastic Foundation Loaded with Continuous Interval and Concentrated Twisting Moments]. The paper deals with bending and twisting of infinite louver type plates resting on elastic foundation loaded in a finite interval with continuously distributed moments  $m$  and concentrated twisting moments  $K$ . The author presupposes that louver type plates consist of  $n+1$ , parallel spaced with longitudinal hinges mutually connected beams resting on the Winkler type foundation which resists against bending and twisting of individual beams. Deformation of such a plate is described by  $n$  differential equations of 4th order for transformed functions of bending as well as by  $n+1$  differential equations of 2nd order for transformed functions of twisting angles of individual beams constituting the plate. (Edited author abstract) In Slovak. 4 refs.

Kollar, Pavol (SVST, Bratislava, Czech); Zirkla, Arnold; Mistrikova, Zora. *Stavebnicky Cas* v 35 n 7 Jul 1987 p 519-541.

**Cavitation** See FLOW OF FLUIDS—Cascades; FLOW OF FLUIDS—Mathematical Models.

**Composite** See Also COMPOSITE MATERIALS—Fiber Reinforced; SOLAR RADIATION—Collectors.

**080517 THICK COMPOSITE PLATES SUBJECTED TO LATERAL LOADING.** An analytical solution for an orthotropic plate subjected to general lateral loading is presented. The solution uses a stress function approach to obtain the localized stresses and strains due to the loading by an axisymmetric rigid sphere. Plots of load versus local indentation are compared with experimental test data previously reported in the literature. The analysis agrees well with the experimental data and could be used in conjunction with failure criteria to predict damage initiation in such a localized region. (Author abstract) 9 refs.

Cairns, D.S. (MIT, Cambridge, MA, USA); Lagace, P.A. *J Appl Mech Trans ASME* v 54 n 3 Sep 1987 p 611-616.

**080518 EFFECT OF IMPULSE LOADING ON A MULTILAYER PLATE IN THE SOLUTION OF A SINGLE OPTIMIZATION PROBLEM.** The problem of optimal design of multilayer plates under impulse loading is considered. The plate is described within the framework of the repaired theory of multilayer plates, which takes into account the hypothesis of broken lines for a jacket of layers. Optimization is performed numerically using a hybrid search method with adaptive control of the computation process. The effect of load intensity on the optimal design of minimum weight is investigated. The effects related to restrictions on the thickness of the packet of layers are noted. 7 refs.

Shelud'ko, G.A.; Shupikov, A.N. *Sov Appl Mech* v 23 n 3 Mar 1987 p 252-256.

**080519 THREE- AND TWO-DIMENSIONAL STRESS FIELDS NEAR DELAMINATIONS IN LAMINATED COMPOSITE PLATES.** A cluster of elliptic delaminations between the layers in an infinite laminated plate is considered. The three-dimensional elasticity problem is reduced to the solution of a set of integral equations and the nature of the stress singularities along the periphery of each disbond is discussed. The procedure for obtaining the equations for two-dimensional problems is also described. Physically meaningful quantities like stress intensity factors and energy release rates obtained from numerical solutions are reported for some three- and two-dimensional problems with single delaminations between similar layers and are compared with other approximate solutions. (Author abstract) 20 refs.

Chatterjee, Sailendra N. (Materials Sciences Corp, Spring House, PA, USA). *Int J Solids Struct* v 23 n 11 1987 p 1535-1549.

**080520 ON THE SYMMETRY OF LAMINATED COMPOSITE RECTANGULAR PLATES.** The paper presents a study of symmetrically layered laminated composite plates. Numerical experiments demonstrate that the quarter-plate model might provide wrong results if there exists biaxial symmetry with respect to geometry and loading and there is no stretching-bending coupling. Physical explanation is further given with the aid of graphics. Simple mathematical derivations suggest that the quarter-plate model is valid only if the system exhibits biaxial symmetry with respect to physical, geometric and loading conditions. 6 refs.

Cheng, Gengdong (Dalian Inst of Technology, Dalian, China). *Commun Appl Numer Methods* v 3 n 6 Nov-Dec 1987 p 547-551.

**080521 ANALYSIS OF LAYERED COMPOSITE PLATES USING A HIGH-ORDER DEFORMATION THEORY.** A high-order plate bending displacement field is developed for the analysis of layered composite plates. The parabolic distribution of the transverse shear strains is considered in the equation, and a mixed finite element model is introduced from the equation. The present finite element model is applied to thin and thick layered

composite plate bending problems and its solutions are compared with three-dimensional elasticity solutions. (Author abstract) 20 refs.

Kwon, Y.W. (Univ of Missouri-Rolla, Rolla, MO, USA); Akin, J.E. *Comput Struct* v 27 n 5 1987 p 619-623.

**080522 LIMITING THE SIZE OF COMPOSITE OPTIMIZATION PROBLEMS.** It is shown that an optimal composite structure can be obtained using a maximum of  $12N$  design variables, where  $N$  is the number of plate, membrane and end-load elements used to model the structure. This upper bound allows for variation of layer thickness and orientation and is independent of the complexity of the finite elements used and the number of load cases considered. Classical lamination theory and the equilibrium equations for each element are used to derive the upper bound which results in it also being independent of the number and form of deflection and stress constraints, with the only proviso being that the latter must be compatible with lamination theory. (Author abstract) 9 refs.

Watkins, R.I. (CSIR, Pretoria, S Afr). *Comput Struct* v 28 n 2 1988 p 237-240.

**080523 ANALYSIS OF INTERLAMINAR STRESSES NEAR CURVED FREE-EDGES OF LAMINATED COMPOSITES USING ITERATIVE FINITE ELEMENT METHOD.** In this paper, a three-dimensional iterative finite element method is applied to analyze the stress distribution near the free edge of a circular cut-out of finite laminated composite plates under biaxial loading. This finite element program is developed from a continuous nodal mixed field. The iterative procedure is very effective. Accurate numerical results normally can be obtained with only five iterations and relatively coarse meshes. Numerical results of interlaminar shear stress and hoop stress near a circular free edge are obtained under various loading cases by changing the ratio of the applied biaxial stresses. The effects of using adhesive layers (soft layers) on the stress distribution near the free edges of a free-curved boundary are also investigated. It is observed that, in general, the adhesive layers will reduce the magnitude of the interlaminar shear stress. (Edited author abstract) 18 refs.

Hwang, W.C. (Chung-Cheng Inst of Technology, Tao-Yuan, Taiwan); Sun, C.T. *Comput Struct* v 28 n 4 1988 p 461-467.

**080524 ANALYSIS OF THERMAL RESISTANCE OF A PLATE OF COMPOSITE MATERIAL.** A solution is presented for the steady-state problem of heat conductivity in a flat plate made of a composite material. The temperature field in the plate with a square-section filler is calculated. The effect of the volumetric proportion of the filler on the thermal resistance of the plate is analyzed. (Translated author abstract) In Russian. 3 refs.

Malov, Yu.I.; Martinson, L.K. *Izv Vyssh Uchebn Zaved Mashinostr* n 9 1987 p 57-59.

**080525 STABILITY OF THICK ANGLE-PLY COMPOSITE PLATES.** An eight-noded quadratic rectangular element is developed in order to study the stability aspects of a layered rectangular composite plate under biaxial loading. The element has five degrees of freedom per node. The formulation includes the Mindlin-type nonlinear strain-displacement relations. The adoptability of the element is demonstrated by solving a number of problems for which results exist in the literature. The effects of fibre orientation, material properties, layering and boundary conditions on the buckling load are studied in detail. The deficiency of earlier reported results is also pointed out. (Author abstract) 12 refs.

Singh, Gajbir (Vikram Sarabhai Space Cent, Trivandrum, India); Rao, Y. V. K. Sadasiva. *Comput Struct* v 29 n 2 1988 p 317-322.



**080526 EFFECT OF FIBRE ORIENTATION AND BOUNDARY CONDITIONS ON THE VIBRATION BEHAVIOUR OF ORTHOTROPIC SQUARE PLATES.** The effect of fibre orientation on the frequencies of thin square orthotropic plates is studied using a rectangular orthotropic plate finite element for various boundary conditions. The main purpose of the study is to find out in what way boundary conditions influence the frequencies of orthotropic square plates. (Author abstract) 6 refs.

Malhotra, S.K. (Indian Inst of Technology, Madras, India); Ganesan, N.; Veluswami, M.A. *Comput Struct* v 29 n 5 1988 p 825-829.

**080527 COMPARATIVE STUDY ON DIFFERENT LAYERED COMPOSITE PLATE THEORIES.** In recent years a considerable number of higher order theories for the analysis of layered composite plate was published. In order to gain information about their accuracy and efficiency, an exact solution for simply supported rectangular plates laid in 0° and 90° direction is set up within the scope of the three-dimensional elasticity theory. This serves as a standard of comparison for eight different plate theories. It turns out that applying these higher order theories is sensible only within a limited slenderness region, where the theories of Murthy (1981) and Reddy (1984) have proved themselves to be most effective. They show drawbacks, however, for the development of finite elements; Mindlin's theory (1951) is better suited for that purpose, provided that improved transverse shear stiffnesses are applied. (Edited author abstract) 21 Refs.

Rohwer, Klaus (DFVLR, Braunschweig, West Ger). *Forschungsber Dtsch Forsch Versuchsanst Luft Raumfahrt* v 88 n 36 1988 42p.

## Computer Aided Analysis

**080528 ANALYTICAL MODELING OF PRECURSOR DECAY IN STRAIN-RATE DEPENDENT MATERIALS.** A finite difference computer code is used to numerically simulate uniaxial strain waves generated from plate impact experiments. The incremental flow law of Bodner and Parton is used to describe the strain rate dependent plastic flow in 7039 aluminum and C1008 steel. Constants determined from Hopkinson bar tests and plate impact experiments are found adequate to predict precursor decay in these materials. A mathematical definition of the Hugoniot elastic limit (HEL) based on a plastic strain offset criterion is proposed. (Author abstract) 16 refs.

Nicholas, Theodore (Univ of Dayton, Dayton, OH, USA); Rajendran, A.M.; Grove, David J. *Int J Solids Struct* v 23 n 12 1987 p 1601-1614.

**080529 FINITE DIFFERENCE SOLUTION FOR PLATE ON ELASTIC SOLID.** A new adaptation of an existing finite difference solution to the problem of a plate resting on an elastic solid foundation is introduced (program FIDIES). Square elements are employed throughout the slab, and external distributed loads are converted to point forces applied at the center of corresponding grid squares. The accuracy of FIDIES is confirmed by comparison with closed-form solutions, when available, an earlier finite difference solution, as well as these convergence studies. The effect of slab size is investigated for each of the three fundamental loading conditions, i.e., interior, edge, and corner. Predictive equations are derived for the latter two cases. These formulas, which were previously unavailable, highlight differences in behavior exhibited by the elastic solid and dense liquid subgrade idealization. (Edited author abstract) 13 refs.

Ioannides, Anastasios M. (Univ of Illinois, Urbana, IL, USA). *J Transp Eng* v 114 n 1 Jan 1988 p 57-75.

## Computer Simulation

**080530 SEMI-LOOF SHELL, PLATE AND BEAM ELEMENTS - NEW COMPUTER VERSIONS: PART 1. ELEMENTS FORMULATION.** The semi-loof ele-

ment is one of the most efficient for the solution of thin shells of arbitrary geometry. Originally published by B.M. Irons it has been the object of much research with respect to its philosophy and performance in various structural situations. The original program is an intricate and hard to understand piece of programming. It is also very difficult to introduce changes in the program as the various steps involved are not well individualized. The new code possesses some advantages: the element program results are easier and more clear; it is easier to detect errors and introduce modifications; it is easier to delete parts of the program that may not be relevant for every particular case study; it is possible to derive simpler elements to be used in the analysis of particular types of structures. These arrays for the shell, plate and beam elements are denoted respectively by WSHEL, WPLAT and WBEAM. 10 refs.

Martins, R.A.F. (Univ of Oporto, Porto, Port); Oliveira, C.A.M. *Eng Comput (Swansea Wales)* v 5 n 1 Mar 1988 p 15-25.

**080531 SEMI-LOOF SHELL, PLATE AND BEAM ELEMENTS - NEW COMPUTER VERSIONS: PART 2. ELEMENTS PROGRAMMING.** Semi-loof shell, plate and beam elements are implemented in such a way that three independent blocks are formed to obtain the stiffness, mass, load and stress matrices. These three blocks are controlled by subroutine MSTIF, which is directly called from a standard FE program. Subroutine MSTIF is the main program for SHELSTIF, PLSTIF and BEAMSTIF. These 3 subroutines correspond to the shell, plate and beam elements, respectively. MSTIF selects which block of subroutines must be called for each element.

Martins, R.A.F. (Univ of Oporto, Porto, Port); Oliveira, C.A.M. *Eng Comput (Swansea Wales)* v 5 n 1 Mar 1988 p 26-38.

## Concrete

**080532 FAILURE MECHANISMS IN R/C PLATES CARRYING IN-PLANE FORCES.** Failures due to the yielding of reinforcement and due to the crushing of concrete are examined. In the case of yielding of steel, equations are derived which predict the ultimate load and the direction of the ultimate crack for proportional loading. In the case of crushing of concrete, the tensor of concrete stresses between the crack is derived, and the ultimate load is determined from the concrete strength under combined tension and compression. The ultimate load is predicted for both proportional and nonproportional loading. Derived equations have been applied to plate elements reinforced with steel bars in two orthogonal directions, and subjected to uniaxial or biaxial uniform loading. (Edited author abstract) 21 refs.

Zararis, Prodromos D. (Aristotle Univ, Thessaloniki, Greece). *J Struct Eng* v 114 n 3 Mar 1988 p 553-574.

**080533 GLEICHGEWICHTSKONTROLLEN BEI PUNKTGESTUETZTEN PLATTEN.** [Equilibrium Checks for Slabs Supported Pointwise]. Observations as regards equilibrium are made on rectangular slabs with continuous, interrupted and pointwise supports; the observations result in summation checks for the section sizes. The use and significance of checks such as these are illustrated using three slab systems which are supported pointwise. In the case of reinforced concrete slabs, these observations on the equilibrium are particularly important with regard to the overall amount of reinforcement required. (Author abstract) In German. 3 refs.

Eisenbiegler, Guenter (Univ Stuttgart, Stuttgart, West Ger). *Beton Stahlbetonbau* v 83 n 3 Mar 1988 p 65-69.

**080534 DIE HALBKREISRINGPLATTE.** [Semicircular Ring Slab]. Bending moments are specified as a function of the radius ratio  $r_2/r_1$  for the semicircular ring slab subjected to uniform and hydrostatic loading and fixed at the outer arc and unsupported at the straight edges and at the inner arc. The most important bending moments are compared with the loadbearing action of the

semicircular ring slab. (Author abstract) In German. 8 refs.

Molin, Gerhard (Univ fuer Bodenkultur Wien, Vienna, Austria). *Beton Stahlbetonbau* v 83 n 3 Mar 1988 p 85-88.

**080535 STABILITY OF CONCRETE PLATES.** Concrete plates supported along all edges are commonly used as structural elements in the hulls of concrete floating structures such as concrete ships, barges, pontoons, floating ports and bridges where they are subjected to combined compressive in-plane and lateral loads. Several analytical methods exist and test results are available for concrete plates under pure in-plane or pure lateral loads. A method of analysis is developed here based on the assumed deflection method. In this way calculation of the strength of a plate is reduced to a one-degree of freedom problem. A design method similar to the moment magnifier approach for slender columns is also developed based on a Fourier series expression of the deflection and lateral load. Nine reinforced concrete plate specimens were tested under in-plane and lateral loads. (Edited author abstract) 112 refs.

Aghayere, Abieyuwa O. (Univ of Alberta, Edmonton, Alberta, Can); MacGregor, James G. *Univ Alberta Dep Civ Eng Struct Eng Rep* n 157 Feb 1988 178p.

**080536 OBLICZANIE DORAZNYCH ODKSZTALCEN I SIL WEWNETRZNYCH W ZARZĄDZANYCH PŁYTACH ŻELBETOWYCH.** [Calculation of Short-Time Deflections and Stresses of Reinforced Concrete Cracked Plates]. The constitutive equations are derived taking into account crack development in the tensile zone and the pattern of failure of a cross-section. It was assumed that the directions of cracks coincide with the direction of the principal bending moments found from the linear solution. The equations are defined by using Murashov's stiffness method. The numerical solutions are obtained by means of the finite element method. (Author abstract) 23 refs. In Polish.

Piliszek, Jacek. *Arch Inz Ladowej* v 33 n 2 1987 p 153-167.

**Crack Propagation** See Also FRACTURE MECHANICS; SOLIDS—Compressibility.

**080537 CRACK KINKING IN ANTI-PLANE SHEAR SOLVED BY THE MELLIN TRANSFORM.** The problem of kinking of internal cracks in infinite plates submitted to antiplane shear at infinity was solved by using the Mellin transform. This transform allows a straightforward reduction of it to a system of second order Fredholm integral equations for a pair of functions in terms of which the stress intensity factors at the crack tips may be calculated. Of great interest and of equivocal views is the regime at the vicinity of the corner, the region where the kink is nucleated, and which reflects numerical difficulties arising in the solution of the integral equations. For this purpose an asymptotic expansion is constructed for their kernels and subsequently for the values of SIFs with respect to the length  $\epsilon$  of the kinked branch. The results were in agreement with those obtained for an in-plane loading of the cracks and for cracks in bi-phase materials whose tips are on the interface of the phases. (Edited author abstract) 20 refs.

Theocaris, P.S. (Athens Natl Technical Univ, Athens, Greece); Makrakis, G. *Int J Fract* v 34 n 4 Aug 1987 p 251-262.

**080538 STRESSED STATE OF POLYGONAL PLATE WITH CENTRAL CIRCULAR HOLLOW AND TWO LINEAR CRACKS.** This paper considers a homogeneous isotropic plate filling a doubly connected region, limited internally by the central circle and two linear cracks, and externally by a regular curvilinear polygon. In solving the problems of the elasticity theory for general case of three-dimensional media we encounter great mathematical difficulties. This circumstance leads us to seek the effective methods of solving wide classes of



particular cases of practical significance, the plane problem of the elasticity theory being one of the most important classes of such a type. It is known that the solution of the problems in plane elasticity theory is essentially simplified if one neglects the mass forces remembering that the problem with the mass forces can always be reduced to the problem without the mass forces to find any particular solution of the respective inhomogeneous differential equations. 12 refs.

Kuliyev, S.A. (Inst of the Azerbaijan SSR, Baku, USSR). *Eng Fract Mech* v 27 n 6 1987 p 601-613.

**080539 NUMERICAL STUDY OF THE TRANSIENT BEHAVIOR OF AN INTERFACIAL CRACK IN A BIMATERIAL PLATE.** In this paper we developed a numerical method to determine the transient stress intensity factor and crack opening displacement of an interfacial stationary crack in a bimaterial plate subjected to time dependent anti-plane shear stress on the surfaces of the plate. A bimaterial plate of finite length of dissimilar elastic, isotropic laminae with Griffith type of crack at the interface is analyzed. For the numerical method the finite element equations are derived in the frequency domain from a variational principle. The stress intensity factors in the frequency domain are evaluated from the displacements, which are obtained upon solving the finite element equations. The transient stress intensity factor is then obtained by numerical Fourier inversion technique using the Fast Fourier Transform (FFT) routine. Quarter point elements and transition elements are used to model the crack tip singularity. (Edited author abstract) 20 refs.

Kundu, T. (Univ of Arizona, Tucson, AZ, USA); Hassan, T. *Int J Fract* v 35 n 1 Sep 1987 p 55-69.

**080540 PATH-INDEPENDENT LINE INTEGRALS FOR STEADY-STATE, TWO-DIMENSIONAL THERMOELASTICITY.** Three path-independent line integrals  $J_k$ ,  $M'$ , and  $L_3$  are derived for steady-state, two-dimensional thermoelasticity. These integrals are similar to the  $J_k$ ,  $M$ , and  $L_3$  presented by Knowles and Sternberg, but include additional terms of either free expansion displacement vector  $u_k$  or temperature  $\theta$  and its conjugate harmonic function  $\Omega$  in their formulation. These new line integrals enable us to avoid the undesirable area integration when calculating the strain energy release rate for crack problems. Application of  $J$  and  $L_3$  is demonstrated through a sample problem of a constant heat flux disturbed by a finite crack in an infinite plate. (Edited author abstract) 14 refs.

Kuo, An-Yu (Structural Integrity Associates, San Jose, CA, USA); Riccardella, P.C. *Int J Fract* v 35 n 1 Sep 1987 p 71-79.

**080541 GENERAL SOLUTION OF A CENTRAL CRACK OFF THE CENTER LINE OF A RECTANGULAR SHEET FOR MODE III.** The purpose of this study is to use the basic theorem of the Fourier transform and Fourier series to find the general solution of the stress intensity factor of a central crack off the centre line of a rectangular sheet subjected to an arbitrary anti-plane shear. The result of the mixed boundary value problem may be expressed in terms of a Fredholm integral equation or by a particular series. It is easy to prove that the solution of a central crack off the center line of a strip and that the result of a central crack coincident with the centre line of a rectangular sheet of the mode II are the special cases of the general solution in this article. (Author abstract) 12 refs.

Zhang, X.S. (Peking Inst of Civil Engineering, China). *Eng Fract Mech* v 28 n 2 1987 p 147-155.

**080542 MIXED-MODE CRACK GROWTH PREDICTIONS.** The problem of slow stable growth of an inclined crack in a plate subjected to uniaxial tension is studied by the strain energy density criterion. The stable crack growth process is simulated by predicting a series of crack growth steps corresponding to a piecewise loading increase when material elements along the direction of crack extension absorb a critical amount of elastic strain energy density. Crack instability takes place when the last

ligament of crack extension takes a critical value which is a material constant. The critical stress at the onset of crack initiation and unstable crack extension is determined for various crack inclination angles. Three different loading step increments corresponding to three different loading rates are considered and their effect on stable crack growth is analysed. (Edited author abstract) 18 refs.

Gdoutos, E.E. (Democritus Univ of Thrace, Xanthi, Greece). *Eng Fract Mech* v 28 n 2 1987 p 211-221.

**080543 ON THE EQUIVALENT ORDER OF CRACK-TIP SINGULARITY DEFINED BY CAUSTICS.** The problem of a transverse Griffith crack in an infinite plate submitted to simple tension at infinity was studied by using its closed form solution described by the elastic potential function  $\phi(z)$ . The exact form of the caustic and its generatrix curve formed around the crack tips was exactly described by using the  $\phi(z)$ -function. These exact forms were compared with the respective forms given either by the singular one-term solution of the problem and accepting that the order of singularity at the crack tip is  $(1/2)$ , or by a solution defining the order of singularity and the respective stress intensity factor by taking into consideration the influence of the distance from the crack tip where these quantities are evaluated. It was shown by comparing the first stress invariant  $I_1$ , whose gradient defines the respective caustic, that the differences between the exact values and the values of  $I_1$  derived by the proposed method with variable order of singularity is much smaller than the differences between the exact solution and the singular solution. (Edited author abstract) 15 refs.

Theocaris, P.S. (Athens Natl Technical Univ, Athens, Greece); Petrou, L. *Int J Fract* v 35 n 4 Dec 1987 p 269-282.

**080544 DYNAMIC INTERACTION BETWEEN TWO INTERFACE CRACKS IN A THREE-LAYERED PLATE.** In this paper, the dynamic interaction between two interface cracks, in a three-layered plate subjected to antiplane stress fields, is analytically studied. The problem is formulated in terms of a coupled set of integral equations, which are then solved by expanding the unknown crack opening displacements in a complete set of Chebyshev polynomials. The method is coded in a FORTRAN program and numerical results for a sample problem are presented. The results show that for the problem studied here one crack always reduces the crack opening displacements of its neighboring crack. (Author abstract) 12 refs.

Kundu, Tribikram (Univ of Arizona, Tucson, AZ, USA). *Int J Solids Struct* v 24 n 1 1988 p 27-39.

**080545 THICKNESS CRITERION FOR FRACTURE TOUGHNESS TESTING BASED ON A PLANE STRESS COMPATIBLE SOLUTION.** In this paper, an elastic compatible plane stress solution for a thin plate with an elliptic hole or a crack is obtained by a complex variable method. The result is used to study the stress field near tensile crack-tips. It is shown that the effect of incompatibility of conventional plane stress solutions on the stress distribution near the crack tips may not be ignored. A model for the study of the thickness effect of fracture toughness in plane stress states is then proposed. Comparisons of this model with available experimental data and other models are also presented. (Author abstract) 8 refs.

Zhou, S.A. (Royal Inst of Technology, Stockholm, Sweden); Hsieh, R.K.T. *Eng Fract Mech* v 29 n 1 1988 p 41-47.

**080546 STUDY ON CRACKED PLATES, SHELLS AND THREE DIMENSIONAL BODIES.** This paper presents a summary of the authors' recent work in following areas: (1) The stress-strain fields at crack tip in Reissner's plate. (2) The calculations of the stress intensity factors in finite size plates. (3) The stress-strain fields at crack tip in Reissner's shell. (4) The calculations of the stress intensity factors and bulging coefficients in finite size spherical shells. (5) The stress-strain fields along crack tip in three dimensional body with surface crack. (6) The

calculation of stress intensity factors in a plate with surface crack. (Author abstract) 40 refs.

Liu Chuntu (Chinese Acad of Sciences, China); Li Yingzhi. *Eng Fract Mech* v 28 n 5-6 1987 p 741-760.

**080547 GENERAL SOLUTIONS OF AN INFINITE SHEET WITH DOUBLY PERIODIC CRACKS MOVING AT CONSTANT VELOCITY.** In accordance with two different methods, we shall first prove that the dynamic stress intensity factor of mode I of an infinite sheet with a central crack propagation at constant velocity is independent of material constants and the uniform velocity. Then, we may give the general solutions to the more complicated problems of an infinite plate weakened by an infinite series of doubly periodic cracks moving at constant velocity under concentrated forces  $P$  and  $Q$  in this paper. Of course, the dynamic stress intensity factors of them are also independent of material constants and the uniform velocity. (Edited author abstract) 8 refs.

Zhang, X.S. (Beijing Inst of Civil Engineering, China). *Eng Fract Mech* v 29 n 2 1988 p 219-225.

**080548 STRESS FUNCTIONS WITH FINITE STRESS CONCENTRATIONS AT THE CRACK TIPS FOR A CENTRAL CRACKED PANEL.** In this paper a plate with a central crack in uniform tension or shear is analyzed. A method is presented of forming the transition interval at the crack tip where both the crack opening displacement and the finite stress concentrations appears. The problems are solved using the weight integral method. The stress functions of this type are more suitable than Westergaard's function or Dugdale's assumption to analyze the crack problems contained in materials such as concrete or rock. The results of several possible stress distributions, the crack opening displacement shapes and the  $J$ -integrals are revealed in the numerical examples. (Author abstract) 18 refs.

Shu-Jin, Duan (North China Inst of Water Conservancy & Hydroelectric Power, Hebei, China); Nakagawa, Kenji. *Eng Fract Mech* v 29 n 5 1988 p 517-526.

**080549 ABOUT THE DUGDALE CRACK UNDER MIXED MODE LOADING.** A crack in an infinite plate is considered from a viewpoint of pure elasticity theory. The plane problem of a Dugdale crack under mixed mode loading is investigated. An exact closed form solution is given and the corresponding crack displacements are discussed. It is proposed to interrelate the tensile and shear strip yield stresses of the Dugdale model to the v. Mises equivalent stress. (Edited author abstract) 9 refs.

Becker, W. (Technische Hochschule Darmstadt, Darmstadt, West Ger); Gross, D. *Int J Fract* v 37 n 3 Jul 1988 p 163-170.

**080550 ELASTIC OVERLAPPING OF THE CRACK FLANKS UNDER MIXED-MODE LOADING.** The properties of an inclined Griffith crack in an infinite elastic plate submitted to a biaxial loading at infinity, due to the deformation of the crack flanks according to the one-term approximation, usually applied in linear elastic fracture mechanics, and the two-term approximation, were compared with the respective properties developed according to the exact solution. It has been shown that there are significant differences between the exact and the approximate solutions. Thus the one-term approximation, the so-called 'singular solution', predicts immovable crack tips, no angular displacement of the deformed crack flanks and therefore is in general inadequate for the accurate description of the mixed-mode deformed crack, and which therefore cannot be made only in terms of the two components of the stress intensity factor. The mode of displacement of the crack flanks creates their eventual overlapping, depending on the relationship between normal and shear loading of the plate. This overlapping phenomenon was systematically investigated. Mode-II deformation always develops overlapping of the crack flanks, thus violating the initial boundary values of the pose problem, and therefore



necessitates a different mode of attack and a realistic consideration of the initial boundary conditions. (Edited author abstract). 18 Refs.

Pazis, D. (Athens Natl Technical Univ, Athens, Greece); Theocaris, P.S.; Konstantellos, B. *Int J Fract* v 37 n 4 Aug 1988 p 303-319.

**080551 EFFECTIVE NUMERICAL STRESS INTENSITY FACTOR CALCULATION WITH NO CRACK DISCRETIZATION.** An effective numerical procedure for calculating stress intensity factors (SIF) in plane problems based on a modified boundary element technique not requiring any crack discretization was proposed by Snyder. Instead of the usual fundamental solution, he used Green's function for the problem of a traction-free central crack in an anisotropic plate. In the first part of the present paper, the corresponding Green's function for the isotropic problem is presented. In addition to the central crack, a semi-infinite edge crack is considered. Both Green's functions are given for the case of the anti-plane state strain as well. In the first step of the proposed procedure, the tractions and displacements along the outer boundary are calculated. In the second step, the SIF for modes I, II, and III are derived in terms of simple boundary integrals over quantities known from the previous step. Contrary to Snyder's derivation, the determination of the SIF is based on the asymptotic displacement field at the crack tip. The method can easily be extended to multiple crack problems by using the subregion technique. (Edited author abstract). 17 Refs.

Mews, H. (Lehrstuhl fuer Technische Mechanik, Erlangen, West Ger); Kuhn, G. *Int J Fract* v 38 n 1 Sep 1988 p 61-76.

**080552 EXPERIMENTAL EVALUATION OF THE PLASTIC ZONES FOR STEADY MODE-III CRACK GROWTH.** A steady state quasi-static growth of a crack in antiplane shear in a strain hardening material was studied under small-scale yielding conditions. The extent of the plastic zone from the tip of the crack was determined as function of the size and geometry of the corresponding caustic developed around the crack tip. The method can be readily extended without considerable changes for large scale yielding. The topography of the plastically deformed zone was numerically and experimentally defined, its shape resembling a spiral ramp with its ground level coinciding with the crack axis and the two flanks of the ramp on either side of the crack axis going up or down until a complete half tour is covered. (Edited author abstract) 20 refs.

Theocaris, P.S. *Acta Mech* v 69 n 1-4 Dec 1987, Sel Pap on the Found and Future Dir of Plast, the Aris Phillips Meml Vol, Gainesville, FL, USA, Jan 28-30 1987 p 271-294.

## Cracking

**080553 FINITE ELEMENTS FOR THE DETERMINATION OF PLASTIC ZONE AND MOUTH OPENING DISPLACEMENT (MOD) VALUES OF AN EDGE CRACKED THIN PLATE.** A finite element model is presented for the determination of plastic zone and Mouth Opening Displacement (MOD) values of an edge cracked thin mild steel plate. Singularity effects near the crack tip are solved by introducing 12 node cubic isoparametric elements in the crack tip region by collapsing into triangular elements. The initiation and expansion of the plastic zone is obtained by applying stepped nominal stresses of a tensile nature transverse to the crack length. The MOD values obtained by FEM are comparable with the values obtained experimentally. The stress intensity factors computed by this model are within 2-6% of the Westergaard solution. 25 refs.

Mishra, A. (Indian Inst of Technology, New Delhi, India); Singh, M.C. *Eng Fract Mech* v 29 n 5 1988 p 609-631.

**080554 STRESS INTENSITY FACTOR OF A SURFACE CRACK IN VISCOUS LUBRICATING OIL.** The squeeze effect of lubricating oil filling in a surface crack was calculated by using the finite element method.

An incremental procedure was presented to solve the two-dimensional Reynolds equation combined with the relation of the oil pressure to the crack opening displacement. As the crack is closing, the squeeze action increases the pressure of the lubricating oil, which tends to open the crack. For the constant crack depth,  $a = OD$  mm, the pressure produced by the squeeze action increases with a decrease in half-length of the crack,  $c$ . The contour lines of the pressure are roughly parallel to the surface of the plate, and so this pressure distribution is similar to those of a through crack in a thick plate. The distribution of the stress intensity factor due to the squeeze pressure is not significantly affected by the half-length of the crack,  $c$ . (Author abstract) 4 refs.

Kojima, Yukio (Nagoya Inst of Technology, Nagoya, Jpn). *JSMI Int J Ser 1* v 31 n 2 Apr 1988 p 196-200.

**080555 STRESS INTENSITY FACTOR FOR A DOUBLE EDGE CRACKED PLATE BY BOUNDARY COLLOCATION METHOD.** A set of complex functions for the double edge cracked plate is proposed. The boundary collocation method is used for estimating the stress intensity factors (SIF) and the results obtained by this method compare very favorably with existing solutions for many cases. Boundary collocation method has many advantages, such as simplicity, less computer time and sufficient accuracy for calculating SIF. (Edited author abstract). 13 Refs.

Cheung, Y.K. (Univ of Hong Kong, Hong Kong); Woo, C.W.; Wang, Y.H. *Int J Fract* v 37 n 3 Jul 1988 p 217-231.

**080556 SINGULAR FUNCTIONS SUITED TO ANALYZE A FINITE VALUE OF STRESS CONCENTRATION NEAR THE END OF A CRACK TRAVERSING A PLATE.** Two singular stress functions suited to analyze crack problems of plates are presented. One of them is a stress function of two-dimensional problems which creates a crack opening displacement due to normal loads applied along the crack (mode 1) in an infinite plate. The other is the same function as that but due to shear loads along the crack (mode 2). The authors define these two functions as elementary crack function with opening of unit length. Superposing these functions with different length of elementary crack opening, the stress concentrations due to many cracks contained in the infinite plate can be analyzed numerically with good accuracy. The characteristic of this method is that the stress softening zones at both ends of the crack can be constructed where either crack opening displacements or stress concentrations with finite magnitude appear. (Author abstract). 19 Refs. In Japanese.

Duan, Shujin; Hori, Akiyoshi; Nakagawa, Kenji. *Doboku Gakkai Rombun Hokokushu* n 396 V-9 Aug 1988 p 21-28.

## Creep

**080557 DESCRIPTION OF CREEP HARDENING BY MEANS OF INTERNAL TENSOR VARIABLE.** To describe the first and second stages of creep in the case of the complex stressed state, we employ an internal variable of a tensor nature, namely the density tensor of the dislocation moment. The kinetic equations for the creep rate and rate of change of the internal variable make it possible to describe the anisotropic nature of creep hardening: the departure from proportionality of the deviators of the stress tensors and the creep rates as the form of the stressed state changes. It turns out that the exact meaning of the internal variable is not required for adequate description of the process of creep and change in internal energy in the case of structural changes. It is sufficient merely that this internal variable qualitatively reflect all processes that take place on the microlevel during the creep times. (Edited author abstract) 27 refs.

Astaf'ev, V.I. *Mech Solids* v 22 n 2 1987 p 128-135.

## Defects See SURFACES—Welding.

## Deflection See Also PISTONS—Fluid Dynamics.

**080558 FIELD/BOUNDARY ELEMENT APPROACH TO THE LARGE DEFLECTION OF THIN FLAT PLATES.** The problem of large deflections of thin flat plates is rederived using a novel integral equation approach. These plate deformations are governed by the von Karman plate theory. The numerical solution implemented combines both boundary and interior elements in the discretization of the continuum. The formulation also illustrates the adaptability of the boundary element technique to nonlinear problems. Included in the examples are static, dynamic and buckling applications. (Author abstract) 19 refs.

O'Donoghue, P.E. (Georgia Inst of Technology, Atlanta, GA, USA); Atluri, S.N. *Comput Struct* v 27 n 3 1987 p 427-435.

**080559 WAVES PRODUCED BY THE ELASTIC IMPACT OF SPHERES ON THICK PLATES.** An experimental and theoretical investigation of the elastic normal impact of spheres on thick plates has been carried out. The coefficient of restitution has been measured very carefully by observing the flight times of successive bounces of balls on glass plates and the displacements at the bottom face have been accurately measured with a laser heterodyne optical interferometer. The analysis along the axis of impact has shown two unexpected phenomena, namely the propagation of a longitudinal displacement at the shear wave velocity and an enhancement of the amplitude of the reflected 'P' wave at the free surface of the plate. Both of these have been confirmed experimentally. (Author abstract) 20 refs.

Koller, M.G. (ETH, Zurich, Switz); Kolsky, H. *Int J Solids Struct* v 23 n 10 1987 p 1387-1400.

**080560 ANALYTICAL SOLUTION OF A REFINED SHEAR DEFORMATION THEORY FOR RECTANGULAR COMPOSITE PLATES.** The Levy type solution procedure in conjunction with the state-space concept is used to determine the deflections and stresses for symmetric laminated composite plates with rectangular geometries by using a refined shear deformation theory. Combinations of simply supported, clamped and free boundary conditions are considered. Numerical results are presented for rectangular plates with different edge conditions, aspect ratios, lamination schemes and loadings. The solution should serve as a reference for designers and practitioners of numerical/computational methods. (Author abstract) 16 refs.

Kheir, A.A. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Reddy, J.N.; Librescu, L. *Int J Solids Struct* v 23 n 10 1987 p 1447-1463.

**080561 EFFICIENT COMPUTER PROGRAM FOR THE LARGE DEFLECTION ANALYSIS OF RECTANGULAR ORTHOTROPIC PLATES.** A computer program is presented for the static analysis of rectangular specially orthotropic plates undergoing large deflections. In-plane loads and lateral pressure are both catered for, together with various combinations of boundary conditions. However, a restriction is that there must be symmetry about both plate axes. The plate can have an initial geometrical imperfection, which is represented by a double Fourier series with the same terms as that used for the lateral displacement. By specifying in the input data suitable values for the coefficients in the imperfection series, the effect of relatively complicated initial shapes can be examined. The program is called ELDAROP, a FORTRAN listing of which is given. Also given is a listing of the associated subroutine STRRES, which calculates stress resultants. (Edited author abstract) 11 refs.

Little, G.H. (Univ of Birmingham, Birmingham, Engl). *Comput Struct* v 27 n 4 1987 p 467-482.



**080562 NONLINEAR FLEXURE OF A UNIFORMLY LOADED CIRCULAR PLATE WITH AN IMMOVABLY CLAMPED EDGE.** Several new approximate solutions of this classical problem in Kirchhoff's nonlinear theory of plates have been obtained and compared with previously published results. An inadequacy associated with the application of the Rayleigh-Ritz method to this problem is noted. Some numerical results are presented. (Author abstract) 25 refs.

Schmidt, Robert (Univ of Detroit, Detroit, MI, USA). *Int Math v 37 pt 1* 1987 p 17-27.

**080563 ANALYSIS OF THE DEFORMATION IN A PARTIALLY CRACKED WELDED T-PLATE.** An innovative Dynamic Acoustic Intensity Scanning (DAIS) technique was applied to the analysis of a partially cracked welded T-plate specimen. The results showed that the fatigue crack could be clearly identified by the manner in which the energy propagated through the plate and that the modal deformation was exposed with perspicacity. In addition, DAIS detected anomalies in the intensity distribution which appear to be linked to small fatigue cracks. It is believed that this phenomenon cannot be detected by current non-destructive testing methods. (Author abstract) 3 refs.

Guigne, J.Y. (Williams, P.G.); Chin, V.H. *Mar Technol v 18 n 4* Dec 1987 p 141-143.

**080564 SOLUTION AND THEIR COMPARISONS OF THE SANDWICH PLATE ANALOGY METHOD IN TWO KINDS OF SIMPLY SUPPORTED TWO-WAY ORTHOGONAL-DIAGONAL LATTICE GRIDS.** In this paper the sandwich plate analogy method is used to analyze the two-way orthogonal-diagonal lattice grids and then the basic sixth-order differential equations of this kind of space grid are given. For the rectangular plane grids with the first and second kinds of simply supported boundary conditions, their basic differential equations are analytically solved. In solving these equations, the solutions of the space grids under the first kind, that is, taking the solution of the double trigonometric series of the first kind of space grids as the special solution, and summing up the solution of the two single trigonometric series intersecting each other as the homogeneous solution, and then by using the boundary collocation method, the general solution is obtained. The authors compare the internal forces and the deflections of the space grids under the two kinds of simply supported conditions and point out that they are different, especially at the places near the boundaries and corners. (Edited author abstract) In Chinese. 6 refs.

Dong, Shilin (Zhejiang Univ, China); Xia, Hengxi. *Tumu Gongcheng Xuebao v 21 n 1* Feb 1988 p 1-16.

**080565 STRESS ANALYSIS OF ANNULAR SANDWICH PLATES OF LINEARLY VARYING THICKNESS.** A small deflection theory is presented for stresses and deformations in variable thickness elastic annular sandwich plates that are symmetric about a middle surface. Both the energy expression and the differential equations are developed. In this analysis, the face sheets are treated as membranes, the core is assumed to be inextensible in the thickness direction, to carry only transverse shear stress on its cross sections normal to middle surface, and to be deformable in transverse shear. The theory takes into account the contribution of the face sheet membrane forces (by virtue of their slopes) to the transverse shear. (Author abstract) 6 refs.

Paydar, N. (Purdue Univ, Indianapolis, IN, USA). *Int J Solids Struct v 24 n 3* 1988 p 313-320.

**080566 FINITE LAYER ANALYSIS OF THE EFFECTS OF A SUB-SURFACE LOAD.** The finite layer method is used to obtain solutions to the problem of the deflection of a rigid circular plate embedded in a horizontally layered soil. Particular results for the case of a plate near the surface of an isotropic or an anisotropic soil mass are presented, as well as results for the case where the soil modulus increases linearly with depth. Such results have application in problems involving screw-plate in-situ

testing devices, horizontal plate anchors and sub-surface footings. (Author abstract) 9 refs.

Small, J.C. (Univ of Sydney, Aust); Brown, P.T. *v 31 n 2 Mar-Apr 1988 n R554 Oct 1987* 13p.

**080567 RESPONSE OF A DAMPED QUADRILATERAL CANTILEVER PLATE.** The steady state response of an internally damped quadrilateral cantilever plate to a sinusoidally varying point force is determined by means of the Ritz method. An arbitrary quadrilateral plate is conveniently transformed into a unit square plate by a transformation of variables. The transverse deflection of the transformed square plate can be approximately expressed in a series of beam eigenfunctions, and the driving point impedance can be derived analytically. The present method is applied to the response calculation of a skew cantilever plate driven at an arbitrary point, and natural frequencies and corresponding mode shapes are also calculated. The effects of the aspect ratio, skew angle, damping factor and location of the driving point on vibrations of a skew cantilever plate are determined quantitatively. (Author abstract) 8 refs.

Ichinomiya, O. (Hokkaido Inst of Technology, Sapporo, Jpn); Maruyama, K.; Irie, T.; Yamada, G. *J Sound Vib v 122 n 1* Apr 8 1988 p 97-106.

**080568 STEADY STATE RESPONSE OF A CANTILEVER QUADRILATERAL PLATE DRIVEN BY A TRANSVERSE DEFLECTION.** Steady state response to a sinusoidally varying transverse deflection is determined for an internally damped cantilever quadrilateral plate by means of Ritz method. A quadrilateral plate of general shape is transformed into a square plate with unit length by a transformation of variables. The transverse displacement of the transformed square plate is approximately expressed in a series of the beam eigenfunction. Substituting the expressions for the kinetic energy and strain energy of the plate into Lagrange's equation, the equation of motion is developed. The dynamic response of the plate is determined by solving the equation of motion of the plate. Numerical work is done for the skew cantilever plate driven by a sinusoidally varying transverse deflection, and the steady state response of the plate is studied. (Author abstract) In Japanese. 10 refs.

Ichinomiya, Osamu; Maruyama, Kooichi; Yamada, Gen; Irie, Toshihiro. *Nippon Kikai Gakkai Ronbunshu C Hen v 54 n 497* Jan 1988 p 3-8.

**080569 DYNAMIC STABILITY OF AN INITIALLY DEFLECTED RECTANGULAR PLATE UNDER AN INPLANE DYNAMIC MOMENT.** Vibration of an initially deflected rectangular plate under a sinusoidally time-varying inplane moment is examined from the point of view of dynamic instability. The equation of motion describing the large deflection of the initially deflected plate is analyzed by the Galerkin method. The resulting equations for time variables are integrated by using the Runge-Kutta-Gill method. The dynamic instability regions are analyzed by the small deflection theory of a thin plate, neglecting nonlinear terms. The amplitudes of unstable regions are determined by large deflection theory. Numerical results are presented in various shapes and magnitudes of the initial deflection. The effect of the initial deflection on natural frequency, dynamic instability and amplitudes is discussed. (Edited author abstract) 7 refs.

Takahashi, Kazuo (Nagasaki Univ, Nagasaki, Jpn); Konishi, Yasunori; Kawano, Ryuta; Urakawa, Shigeo. *Doboku Gakkai Rombun-hokokushu v 9 n 4* Apr 1988 p 83-91.

**080570 STATISTICAL STUDY ON ULTIMATE STRENGTH CURVES OF LONGITUDINALLY STIFFENED PLATES UNDER UNIAXIAL COMPRESSION.** By processing statistically the data of initial deflection obtained from measurement of stiffened plate members in steel box girder bridges recently fabricated in Japan, its statistical properties can be made clear. On the basis of the initial deflection data, the ultimate strength curve corresponding to the probability of nonexceedance of 5% can be provided. Finally, the conception of

determining the allowable values as well as the procedure of test measurement for the initial deflection of stiffened plates are presented. (Author abstract) In Japanese. 32 refs.

Nara, Satoshi; Komatsu, Sadao. *Doboku Gakkai Rombun-hokokushu v 9 n 4* Apr 1988 p 289-296.

**080571 FORMING A SPHERICAL SHELL FROM A CIRCULAR PLATE.** The authors propose a mathematical model and develop an algorithm for solving the problem of the deformation of an inelastic circular plate, loaded by increasing uniform pressure. An example is presented of study on a computer of the process of obtaining a spherical shell from a circular plate made of D16 material. 4 refs.

Gorlach, B.A.; Nosov, V.V. *Sov Aeronaut v 30 n 4* 1987 p 81-84.

**080572 BENDING OF SANDWICH PLATES OF VARIABLE THICKNESS.** A small deflection theory, consisting of differential equations and a total potential energy expression, is presented for determining the stresses and deformations in variable thickness elastic sandwich plates symmetric about a middle surface. The theory takes into account the contribution of the face-sheet membrane forces (by virtue of their slopes) to the transverse shear. A finite-difference formulation of the stationary total potential energy principle is presented along with an illustrative application. (Author abstract). 6 Refs.

Paydar, N. (Purdue Univ, Indianapolis, IN, USA); Libove, C. *J Appl Mech Trans ASME v 55 n 2* Jun 1988 p 419-424.

**080573 EXACT SOLUTION OF NONLINEAR CIRCULAR PLATE ON ELASTIC FOUNDATION.** A large deflection problem of a concentrated loaded circular plate on an elastic foundation is treated. By means of a step-by-step iterative method, first the exact solution's analytic forms and their convergence are obtained. Then a numerical procedure, which can be carried out by computer, is given to calculate the exact solution of the problem with an arbitrary boundary condition. Last, the numerical results of the exact solution of the problem with a rigidly clamped boundary condition and  $\nu=0.3$  are obtained in detail. The results of the exact solution are more reliable than those of other approximate solutions. (Edited author abstract). 8 Refs.

Zheng, Xiao-jing (Lanzhou Univ, Lanzhou, China); Zhou, You-he. *J Eng Mech v 114 n 8* Aug 1988 p 1303-1316.

**080574 LARGE DEFLECTIONS OF SIMPLY SUPPORTED ISOSCELES TRIANGULAR PLATES SUBJECTED TO EDGE SHEAR AND COMPRESSIVE LOADING.** The large deflection analysis of simply supported isotropic isosceles triangular plates using the principle of minimum energy is presented for two types of loading conditions. The analysis is restricted to plates whose edges are constrained to remain straight after buckling. The results of the analysis are used to estimate the ultimate loads for the plate subjected to loading under this constraint. An estimate of the ultimate loads for unconstrained isosceles triangular plates is obtained using Von Karman's effective width hypothesis. (Author abstract). 8 Refs.

Krishnakumar, S. (Univ of Tasmania, Hobart, Aust). *Int J Eng Sci v 26 n 7* 1988 p 673-685.

**080575 BENDING OF A UNIFORMLY LOADED ANNULAR PLATE WITH MIXED BOUNDARY CONDITIONS.** This paper deals with the analytical solution of a uniformly loaded annular plate in which the inner edge is free and the outer edge restricted by a system of simple and fixed supports. The boundary conditions of the annular plate are thus mixed between the simple and fixed supports. The solution is set up by using the deflection equation, and the mixed boundary conditions are written in the form of dual-series equations. By



choosing the proper finite integral transform, the dual-series equations can be written in the form of an inhomogeneous Fredholm integral equation. This equation, with a numerical technique, is then reduced to a set of simultaneous equations suitable for numerical solution. The deflections, bending moments, and moment concentration of the annular plate are calculated. (Author abstract). 11 Refs.

Kiatikomo, Kraiwood (King Mongkut's Inst of Technology, Bangkok, Thailand); Sriswasdi, Vichien. *AIAA J* v 26 n 4 Apr 1988 p 487-492.

**080576 LARGE DEFLECTION OF CIRCULAR PLATES WITH OR WITHOUT HOLE AT CENTER.** The objective of this study is to assess the accuracy and computational efficiency of the equivalent load concept in the analysis of circular and annular plates undergoing large deflection in the sense of von Karman theory. Solutions for von Karman-type circular and annular plates were obtained by considering equivalent plates with small displacements, where the nonlinear terms of lateral displacement were treated as fictitious loads acting on the plate. In this way, solutions for many difficult nonlinear elastic plate problems may be obtained by using the known solutions of the linear problems through an iteration procedure. Results for uniformly loaded circular and annular plates have been shown to be in good agreement with the available solutions. 6 Refs.

Gorji, Manouchehr (Portland State Univ, Portland, OR, USA); Akileh, Aiman R. *J Eng Mech* v 114 n 10 Oct 1988 p 1803-1809.

**080577 LARGE DEFLECTION AXISYMMETRIC ANALYSIS OF ORTHOTROPIC ANNULAR PLATES ON ELASTIC FOUNDATIONS.** Large deflection axisymmetric response of cylindrically orthotropic thin annular plates, resting on annular elastic foundations and subjected to uniformly distributed loads are presented. Static and step function loads applied to clamped and simply supported annular plates are considered. The natural boundary conditions employed at the hole are consistent with those obtained from Hamilton's principle. Von Karman type governing equations are solved using the orthogonal point collocation method in conjunction with the Newmark- $\beta$  scheme. The maximum response to step loads obtained from static analysis is shown to agree very well with that obtained from a transient analysis. Thus one static analysis is sufficient to obtain the maximum response to a whole set of step loads. (Edited author abstract). 11 Refs.

Dumir, P.C. (Indian Inst of Technology, New Delhi, India). *Int J Solids Struct* v 24 n 8 1988 p 777-787.

**080578 INCREMENTAL GALERKIN METHOD FOR PLATES AND STIFFENED PLATES.** In order to perform a detailed analysis of large deflection behavior of a rectangular plate or stiffened plate, an efficient semi-analytical method is developed. First, incremental forms of the governing differential equations of plates and stiffened plates with initial deflection are derived. These equations are linearized and may be easily solved. Secondly, these equations are solved for each load increment by the Galerkin method with a special consideration of simply supported boundaries. A procedure of equilibrium correction at intermediate load steps is presented such that good accuracy of the solution may be maintained with larger load steps. This method is successfully applied to plates with initial deflection subjected to in-plane as well as out-of-plane loads to obtain the whole histories of the behavior of these plates. (Edited author abstract) 5 Refs.

Ueda, Yukio (Osaka Univ, Osaka, Jpn); Rashed, Sherif M.H.; Jeom Kee Paik. *Comput Struct* v 27 n 1 1987, Adv in Comput Struct and Solid Mech, Pap Presented at the First World Cong on Comput Mech, Austin, TX, USA, Sep 22-26 1986 p 147-156.

**Deformation** See Also BALLISTICS; COMPOSITE MATERIALS—Vibrations; DOMES AND SHELLS—Mathematical Models; MATERIALS TESTING—Impact; MATHEMATICAL TECHNIQUES—Finite Element Method.

**080579 EFFECT OF PULSE SHAPE AND DISTRIBUTION ON THE PLASTIC DEFORMATION OF A CIRCULAR PLATE.** The dynamic plastic deformation of a simply-supported circular plate subjected to a pressure distribution, which is an arbitrary function of radius and time, is found to depend on the moment history applied by the pressure and the moment history applied by the pressure excess over a conical distribution. Each of these moment histories can be replaced by an equivalent rectangular pulse in determining the final deformation at the center of the plate. (Author abstract) 22 Refs.

Youngdahl, Carl K. (Argonne Natl Lab, Argonne, IL, USA). *Int J Solids Struct* v 23 n 8 1987 p 1179-1189.

**080580 ON HIGHER ORDER SHEAR DEFORMATION THEORY OF LAMINATED COMPOSITE PANELS.** In this paper we examine the suitability of higher order shear deformation theory based on cubic inplane displacements and parabolic normal displacements, for stress analysis of laminated composite plates including the interlaminar stresses. An exact solution of a symmetrical four layered infinite strip under static loading has been worked out and the results obtained by the present theory are compared with the exact solution. The present theory provides very good estimates of the deflections, and the inplane stresses and strains. Nevertheless, direct estimates of strains and stresses do not display the required interlaminar stress continuity and strain discontinuity across the interlaminar surface. On the other hand, 'statically equivalent stresses and strains' do display the required interlaminar stress continuity and strain discontinuity and agree very closely with the exact solution. (Author abstract) 16 Refs.

Krishna Murty, A.V. (Indian Inst of Science, Bangalore, India); Vellaichamy, S. *Compos Struct* v 8 n 4 1987 p 247-270.

**080581 R-FUNCTION METHOD IN PROBLEMS OF NONLINEAR DEFORMATION OF PLATES.** The problem of solving geometrically nonlinear problems of the theory of plates is treated in a vast literature. However, numerical results are obtained basically for plates having canonical form, e.g., disk, square. In this paper we deal with the solution of problems of bending of elastic plates and use an approach based on a simultaneous applications of the theory of R-functions, variational Ritz principle, and the method of consecutive approximations. This permits one to perform the calculation of plates of practically arbitrary form. 5 Refs.

Rvachev, V.L. (Acad of Sciences of the Ukrainian SSR, Kharkov, USSR); Kurpa, L.V.; Nasridinov, Kh. F.; Shevchenko, A.N. *Sov Appl Mech* v 23 n 9 Sep 1987 p 861-866.

**080582 ACCURATE, SIMPLIFIED METHOD FOR ANALYZING THIN PLATES UNDERGOING LARGE DEFLECTIONS.** The present analysis examines the behavior of thin, circular, isotropic plates considering geometric nonlinear behavior but not material nonlinearity. The circular plates examined were solid with a fully clamped outer boundary. An approximate solution was determined with the aid of MACSYMA, a symbolic manipulation computer program, using the energy method. The loading cases examined were: a uniform pressure load and a central point load. The solution was based upon a two-term trial function for the plate deflection, with the coefficients written in a new way. This type of trial function allows the dimensionless deflection profile to vary with the loading. This is an improvement over many existing solutions. Results are given for dimensionless plate center deflection and dimensionless radial bending stress at the plate center. (Edited author abstract) 19 Refs.

Bert, Charles W. (Univ of Oklahoma, Norman, OK, USA); Martindale, Jeffery L. *AIAA J* v 26 n 2 Feb 1988 p 235-241.

**080583 HIGHLY NON-LINEAR DEFORMATION OF UNIFORMLY-LOADED CIRCULAR PLATES.** A theory for the axisymmetric deformation of isotropic,

hyperelastic circular plates which is valid for arbitrarily large strains and rotations is developed. The theory is implemented numerically and used to perform an extensive analysis of uniformly-loaded circular plates with hinged and clamped edges. Particular attention is paid to large-strain and large-rotation effects. (Author abstract) 17 Refs.

Brodland, G. Wayne (Univ of Waterloo, Waterloo, Ont, Can). *Int J Solids Struct* v 24 n 4 1988 p 351-362.

**080584 ELASTIC-PLASTIC FINITE ELEMENT ANALYSIS FOR STIFFENED TENSION PLATE WITH ECCENTRIC CRACK.** A finite element method, which is a variable stiffness method combined with the initial stress method, is developed on the basis of the theory of plastic deformation. The method is used in the analysis of the elastic-plastic crack tip field of cracked tension plate with or without edge stiffeners. The effects of stiffeners on elastic-plastic fracture of cracked plates are analysed. The validity of the results of linear elastic fracture analysis, when the plastic region exists, is discussed. (Author abstract). 10 Refs. In Chinese.

Xuefu, Luo (Tsinghua Univ, China). *Ching Hua Ta Hsueh Hsueh Pao* v 26 n 3 1986 p 18-29.

**080585 STABILITY OF PURE HOMOGENEOUS DEFORMATIONS OF AN ELASTIC PLATE WITH FIXED EDGES.** An analysis is given of the stability of pure homogeneous deformations of an incompressible elastic plate. The two faces of the plate are free and the displacement of its edge is prescribed. Pointwise conditions for stability are derived by using Fourier transforms and constructing a special displacement field. The conditions obtained are related to a restricted rank-two convexity condition of the strain energy function. Such a condition is then studied for isotropic materials, resulting in a set of inequalities in terms of the strain energy function and principal stretches. (Author abstract). 12 Refs.

Chen, Yi-Chao (Cornell Univ, Ithaca, NY, USA). *Q J Mech Appl Math* v 41 pt 2 May 1988 p 249-264.

**Design** See Also STRUCTURAL DESIGN—Optimization.

**080586 OPTIMAL DESIGN OF PLATES RESTING ON TENSIONLESS FOUNDATION.** The problem of optimal design of thin solid plates resting on a Winkler-type tensionless elastic foundation under static loading is discussed. Having divided the plate domain into finite elements, we use the plate thickness of each element as the design variable. The volume of the plate is taken as the objective function. Some constraints related to the allowable stresses in the plate and the foundation, besides both the maximum and minimum allowable thickness of the plate, are imposed. The optimality criterion derived for the problem dealing with the displacement constraint enables us to develop an effective numerical procedure based on successive iterations. In the last stage of the procedure it is possible to eliminate elements with a thickness decreasing below a minimum point, and consequently the optimal shape of the plate domain may be formed. Some numerical examples of the optimal design of steel plates are given. (Edited author abstract) 6 Refs.

Chrosielewski, Jacek (Technical Univ of Gdansk, Gdansk, Pol); Szymczak, Czeslaw. *Modell Simul Control B* v 11 n 1 1987 p 29-37.

**080587 SIMPLE METHOD FOR DIMENSIONING THE SUPPORT ZONE OF REINFORCED CONCRETE PLATES SUPPORTED POINTWISE.** [Simple Method for Dimensioning the Support Zone of Reinforced Concrete Plates Supported Pointwise]. The paper presents a simple method for calculating the maximum loads of reinforced concrete plates supported pointwise and without shear reinforcement. The simplicity



and reliability allow this method to be applied within the scope of DIN 1045 also. (Author abstract). 6 refs. In German.

Georgopoulos, Theofanis (Gastwissenschaftler am Lehrstuhl, Munich, West Ger). *Beton Stahlbetonbau* v 83 n 7 Jul 1988 p 190-192.

## Elasticity

**080588 DEFINITION OF ELASTIC MODULI FOR PLATES MADE FROM THICKNESS-UNEVEN ANISOTROPIC MATERIAL.** A plate is interpreted as a Cosser's two-dimensional continuum. A possible construction of a set of equations describing such a continuum has been presented in a paper by P.A. Zhilin. The present paper examines only the linearized particular case from it. The definition of elastic moduli of a plate made of a thickness-inhomogeneous anisotropic material is investigated in detail. The modulus formulas derived in the paper are most general from among the expressions offered in the literature on the theory of multilayer and inhomogeneous plates. (Edited author abstract) 8 refs.

Altenbach, H. *Mech Solids* v 22 n 1 1987 p 135-141.

**080589 DEVELOPMENT OF THE BIFURCATION CONDITION FOR A THICK ELASTIC PLATE.** A consistent six-term asymptotic series is derived for the critical value of the deformation parameter as a function of aspect ratio (thickness: height), in the limit as this ratio becomes unbounded, for a plate of general incompressible isotropic material. Values for both flexural and barreling modes are obtained in the case where the loading is a thrust. The theoretically important class of Mooney-Rivlin materials is treated as a special case. (Author abstract) 11 refs.

Sawyers, K.N. (Lehigh Univ, Bethlehem, PA, USA). *Int J Solids Struct* v 23 n 10 1987 p 1425-1433.

**080590 TRANSIENT IMPACT RESPONSE OF THICK CIRCULAR PLATES.** The finite element method was used to study the transient response of thick circular plates subjected to point impact. The response of plates having different geometries and subjected to impacts of different duration was studied in both the time and the frequency domains. It is shown that the transient plate response is composed of a number of different modes of vibration including P- and S-wave thickness modes, antisymmetric flexural modes, the rod mode, and P- and S-wave diameter modes. The origin of the diameter modes is discussed. Excellent agreement was found between the calculated frequency values and those obtained from finite element analyses. (Author abstract) 16 refs.

Sansalone, Mary (NBS, Gaithersburg, MD, USA); Carino, Nicholas J. *J Res Natl Bur Stand (US)* v 92 n 6 Nov-Dec 1987 p 355-367.

**080591 LONGITUDINAL WAVE PROPAGATION IN A MICROPOLAR WAVE GUIDE.** The problem of longitudinal wave propagation in a micropolar wave guide is studied in detail. It is seen that a new wave exists and the pattern of changes of this velocity is similar to those of SH-type of wave propagating in a wave guide. For the new wave the frequency spectrum and group velocity curves are plotted. (Author abstract) 12 refs.

Mrithumyaya Rao, K. (Kakatiya Univ, Warangal, India). *Int J Eng Sci* v 26 n 2 1988 p 135-141.

**080592 PLATES ON BIPARAMETRIC ELASTIC FOUNDATION BY BDIE METHOD.** An efficient boundary differential integral equation (BDIE) method is presented for the analysis of thin elastic plates with free boundaries of any shape resting on biparametric elastic foundation. The plate, which may have holes, is subjected to concentrated loads, line loads, or distributed surface loads. The solution is achieved by converting the governing boundary value problem to an equivalent problem consisting of five coupled boundary equations, two of which are differential and three of which are integral. The boundary differential equations are derived from the boundary conditions, while the boundary integral equa-

tions are derived from the integral representations for the deflections of the plate and of the foundation region. A numerical technique based on the discretization of the boundary is developed for the solution of the boundary equations. The computational efficiency of the method is increased by converting the domain integrals attributable to loading into boundary line integrals. (Edited author abstract) 19 refs.

Katsikadelis, J.T. (Natl Technical Univ of Athens, Athens, Greece); Kallivokas, L.F. *J Eng Mech* v 114 n 5 May 1988 p 847-875.

**080593 ELASTIC ANALYSIS OF PARTIAL CONTACT PROBLEMS IN A UNIAXIALLY LOADED PLATE WITH AN INTERFERENCE-FIT ELLIPTIC PLUG.** This paper is concerned with the mixed boundary-value problems of an infinite plate with an elliptic hole, into which a smooth rigid elliptic plug is simply inserted. Since the infinite plate is subjected to a uniaxial loading (tension or compression) at infinity, apertures are produced along the boundary between the inserted plug and the hole. The contact pressure between the inserted plug and the hole is expressed in a convergent series whose differential form is also convergent, so that the stress and displacement generated along the boundary can be numerically analyzed by the point-matching method. Using the numerical results for various elliptic shapes, the influence of interferences is shown with the stress around an elliptic hole. (Author abstract) 5 refs.

Yamamoto, Terumi (Tokai Polytechnic Coll, Nagoya, Jpn); Nakagiri, Tosiaki; Tumura, Tosimitu. *JSME Int J Ser 1* v 31 n 2 Apr 1988 p 167-173.

**Elastoplasticity** See Also BEAMS AND GIRDERS—Buckling.

**080594 ELASTIC ANALYSIS OF CRACK OPENING DISPLACEMENT IN A FIXED SIDED PLATE.** The elastic analysis of crack in a finite width plate is presented. Crack opening displacements are calculated for the cases of roller-fixed type and rigid-fixed type clamps, changing the position and the length of the crack. The continuously distributed dislocations model is employed for the analysis. The results show that the profile of the crack opening displacement has peaks which exceed the applied displacement in the case of long cracks. (Author abstract) 2 refs.

Fujimoto, Koji (Tokyo Gakugei Univ, Koganei, Jpn); Shioya, Tadashi. *JSME Int J* v 30 n 267 Sep 1987 p 1383-1390.

**080595 THREE-DIMENSIONAL ELASTIC-PLASTIC J-INTEGRAL CALCULATIONS FOR SEMIELLIPTICAL SURFACE CRACKS IN A TENSILE PLATE.** Using a finite element method, in conjunction with an equivalent domain integral approach, the elastic-plastic crack-tip J-integral is computed for semielliptical surface flaws in a plate under a remote tensile load. The computed elastic-plastic values of the J-integral are compared to the elastic ones. It is concluded that a linear elastic fracture mechanics approach can be used for semielliptical cracks of relative depth of  $a/t = 0.25$  and aspect ratio of  $c/a \leq 3$ , up to load levels of  $0.9\sigma_y$  with an error of no more than 10% in the (equivalent) elastic-plastic stress intensity factor. A simple empirical equation for evaluating the elastic-plastic J-integral for surface flaws is proposed. (Author abstract) 9 refs.

Nikishkov, G.P. (Georgia Inst of Technology, Atlanta, GA, USA); Atluri, S.N. *Eng Fract Mech* v 29 n 1 1988 p 81-87.

**080596 ELASTIC PLASTIC ANALYSIS OF AN ELLIPTICAL HOLE IN AN INFINITE PLATE UNDER VARIOUS COMBINED REMOTE STRESS BY THE COMBINATION OF FINITE ELEMENT METHOD AND BODY FORCE METHOD.** A method of elastic-plastic stress analysis based on the combination (FEM+BFM) of finite element method (FEM) and body force method (BFM) is developed. FEM+BFM has the advantages of both method (FEM and BFM) and has

many possible applications. The line elements of BFM are located along the interface between the outer elastic domain and the inner elastic-plastic domains which are composed with FEM elements. In the present study, the method is applied to solve the problems of an elliptical hole contained in an infinite plate under various combined remote stress ( $\sigma_{x\infty}$ ,  $\sigma_{y\infty}$ ,  $\tau_{xy\infty}$ ). The stress and strain concentration, the extension of plastic zone and the applicability of Neuber's rule under various combined remote stress ( $\sigma_{x\infty}$ ,  $\sigma_{y\infty}$ ,  $\tau_{xy\infty}$ ) are investigated in details. (Author abstract) In Japanese. 8 refs.

Murakami, Yukitaka; Huang, Zen-Yao; Uchiyama, Yukihiko. *Nippon Kikai Gakkai Ronbunshu A Hen* v 53 n 496 Dec 1987 p 2340-2348.

**080597 ELASTIC-PLASTIC SNAPPING-THROUGH OF A CURVED METAL STRIP COMPRESSED BETWEEN TWO RIGID PLATES.** The quasi-static loading of a curved strip compressed by a flat, rigid plate is considered, with particular references to large deformations and the ensuing buckling behavior. Experiments were performed on curved strips of constant width, but of different thickness. The strips were initially deformed to a fixed radius of curvature and stress was relieved before pinning the ends. The deformation characteristics have been analyzed using an incremental finite element technique. Particular attention has been paid to modeling the situation when a node contacts the plate and the condition for separation of the strip from the plate. The predicted loads and deformation modes agreed well with experimental results from tests on steel and aluminum specimens. The experimental and theoretical procedures are pertinent to the study of dent resistance of sheet metal stampings, particularly for automotive panels. (Author abstract) In Japanese. 17 refs.

Iseki, Hideo; Sowerby, Robert; Bhattacharyya, Debesh; Gatt, Paul. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 500 Apr 1988 p 628-637.

**080598 RESEARCH ON THE TEST OF ELASTO-PLASTICITY AND FAILURE MECHANISM OF GUSSET PLATE ON PANEL POINTS OF STEEL TRUSS.** The results of 24 tested pieces of welded gusset plate in 10 different constructing forms on panel points of double-angle steel truss are introduced. The stress field on the plate is divided into tensile and compressive according to the relationship between its principal sectional stresses, and its failures are classified as yielding of the compressive region and tearing of the tensile region. Conclusion is that the yielding and tearing zones should be considered as the critical area in gusset plate design, the strain capacities of high stress area both in tearing zone of tensile region and in buckle yielding zone of compressive region should be limited and the ratio of width to thickness should be limited. (Edited author abstract) 5 refs. In Chinese.

Li, Guangxing (Yunnan Design Inst, China). *Jian Zhu Jie Gou Xue Bao* v 8 n 2 1987 w p 10-22.

**080599 RESULTS AND EXPERIMENTS OF THE FINITE ELEMENT ANALYSIS OF ELASTO-PLASTIC PLATES.** The aim of this research was to determine the factors affecting the results and to follow the behavior of the elasto-plastic thin plates under static and dynamic loading. The solution of plate problems via the classical route is limited to relatively simple plate geometry, load and boundary conditions. If these conditions are more complex numerical and approximate methods are the only approaches that can be employed. In the engineering application it is important to be aware of the magnitude of the error of solution and of its components such as error of input data, error of calculation, economy of solution, machine error, human error etc.

Lovas, A. (Technical Univ of Budapest, Budapest, Hung). *Z Angew Math Mech* v 68 n 5 1988 p T395-T397.

**Failure** See Also MATERIALS—Crack Propagation.

**080600 PROCEDURE FOR REGULARIZATION OF SINGULAR INTEGRAL EQUATION OF THE MULTIPLE CRACK PROBLEM IN AN INFINITE**



**PLATE.** The regularization of the singular integral equation arising from the crack problems in plane elasticity is an important problem in fracture analysis. Several works have been done in the field of regularizing the singular integral equation. An alternate procedure of regularizing the singular equation in the crack problem has been carried out. In this paper it is pointed out that the system of singular integral equations arising from the multiple crack problem in an infinite plate can be also converted into a system of Fredholm integral equations by the use of the second procedure. 9 refs.

Chen, Y.Z. (Jiangsu Inst of Technology, Jiangsu, China). *Int J Fract* v 34 n 3 Jul 1987 p R53-R56.

**080601 COMPRESSIVE FAILURE MODEL FOR ANISOTROPIC PLATES WITH A CUTOUT.** This paper introduces a failure model for laminated composite plates with a cutout under combined compressive and shear loads. The model is based on the kinking failure of the load-carrying fibers around a cutout, and includes the effect of local shearing and compressive stresses. Comparison of the predictions of the model with available experimental results for quasi-isotropic and orthotropic plates with a circular hole under pure compression indicated a good agreement. The predictions for orthotropic plates under combined loading are compared with the predictions of a point-stress model. (Edited author abstract) 17 refs.

Guerdal, Zafer (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Haftka, Raphael T. *AIAA J* v 25 n 11 Nov 1987 p 1476-1481.

**080602 LIMITING LOAD FOR A BRITTLE BODY WITH A THIN-WALLED ELASTIC INCLUSION.** Many works, particularly those based on general theoretical premises, have been devoted to a theoretical investigation of failure near sharp-angle and thin-walled inclusions. The possibility has been studied on the use of various criteria relationships in which failure of the matrix in the vicinity of the tip of an absolutely rigid or elastic defect was related to the maximum main, tangential, radial, or circumferential stresses, the maximum specific energy of formation or change in form, etc. This work is devoted to a study of the applicability of the criteria functions to determination of the limiting forces in an isotropic plate in a uniform field of normal stresses and containing a thin elastic inclusion located at an angle  $\alpha$  to the y axis. 10 refs.

Popina, S.Yu. (Ternopol' Finance & Economic Inst, USSR); Sulim, G.T. *Sov Mater Sci* v 23 n 2 Mar-Apr 1987 p 219-222.

**080603 DYNAMICS OF INTERACTION BETWEEN A FRACTURABLE SOLID LAYER LYING ON A LIQUID AND AN EXPANDING GAS BUBBLE.** A circular plate lying on a liquid is numerically analyzed for dynamic failure. The effect of the liquid-plate interaction is considered together with the effect of location of the pressure source in the liquid on the plate fracture. (Author abstract) In Russian. 9 refs.

Abdirashidov, A.; Galiev, Sh.U. *Probl Prochn* n 12 Dec 1987 p 59-64.

**080604 STRAIN AND FAILURE OF A PLATE FOLLOWING ABSORPTION OF HIGH-CAPACITY ELECTROMAGNETIC RADIATION.** Wave processes, damage growth and development of fractured areas in the plate under absorption of high-energy electromagnetic radiation are numerically studied in the two-dimensional axisymmetric statement. Processes of combined adiabatic expansion of plasma from the solid absorption and deformation range are analyzed together with the effect of the discharge wave cumulation, kinetics of microcrack development, effect of the system scale on dimensions of the fractured area. (Author abstract) In Russian. 28 refs.

Aptukov, V.N. *Probl Prochn* n 12 Dec 1987 p 82-87.

**080605 FRACTURE CRITERION OF NOTCHED PLATES OF FRP.** The influence of notches on static tensile strength was studied for a composite material. Tension tests of notched plate for glass cloth/epoxy

laminates have been carried out for a wide range of notch tip radii. All notched specimens failed in a brittle manner through the formation of small deformation near the notch tip. The experiment shows that the nominal stress at failure decreases with decreasing notch tip radius and it approaches a constant value when the notch tip radius is less than about 0.2 mm. It has been verified that the maximum elastic stress at the notch tip when the specimen fails is governed by notch tip radius alone, and is independent of notch depth. On the basis of the concept of linear notch mechanics, the experimental results mentioned above can be clearly explained, and the limiting condition for the fracture of notched plates of composite materials is expressed. (Edited author abstract) 15 refs. In Japanese.

Hyakutake, Hiizu; Nisitani, Hironobu; Hagio, Terutoshi. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 498 Feb 1988 p 326-332.

**080606 COLLAPSE BEHAVIOUR OF PLATES.** The paper is concerned with the theoretical prediction of the complete collapse behavior of square plates, when subjected to in-plane compression. The plates are initially imperfect and four types of boundary conditions along their unloaded edges are considered. The method is a combination of numerical and analytical solutions in which the Rayleigh-Ritz variational principle and the Prandtl-Reuss equations are used. Numerical calculations have been carried out for different geometrical and material properties in order to compare this method and its results with other theoretical and experimental works. (Author abstract) 11 refs.

Gradzki, R. (Technical Univ of Lodz, Lodz, Pol); Kowal-Michalska, K. *Thin-Walled Struct* v 6 n 1 1988 p 1-17.

**Fatigue** See Also METALS TESTING—Tensile Tests.

**080607 CONSTITUTIVE BEHAVIOR OF A MICROCRACKING BRITTLE SOLID IN CYCLIC COMPRESSION.** A constitutive formulation is presented to determine the 'driving force' for Mode I fatigue crack growth in notched plates of brittle solids stressed in uniaxial cyclic compression. For the particular case of a microcracking medium, it is demonstrated that residual tensile stresses are induced ahead of the notch during unloading from the maximum far-field compressive stress. We propose that it is the region of residual tensile stresses at the notch-tip which promotes fatigue crack growth in ceramics along the notch plane in a direction normal to the compression axis. The predictions of the analysis are compared with new experimental results on compression fatigue in brittle solids. Specifically, it is shown that the numerical estimates of the near-tip tensile zone size for microcracking ceramics compare favorably with the experimentally measured distance of stable Mode I fatigue crack growth after the first compression cycle. (Edited author abstract) 19 refs.

Brockenbrough, J.R. (Brown Univ, Providence, RI, USA); Suresh, S. *J Mech Phys Solids* v 35 n 6 1987 p 721-742.

**080608 FATIGUE LIFE AND FATIGUE CRACK THROUGH-THICKNESS BEHAVIOR OF A SURFACE-CRACKED PLATE (EFFECT OF STRESS CONCENTRATION).** Most structures have a region where stresses concentrate, and the probability of fatigue crack initiation may be higher than in other parts. Therefore, to improve the reliability of an LBB (Leak Before Break) design, it is necessary to evaluate the growth and through thickness behavior of fatigue cracks in the stress concentration region. In this paper, the fatigue crack growth behavior in a stress concentration region has been studied on 3%NiCrMo and HT80 steels. Stress concentration was caused by a fillet on the plate. Before cracking through the plate thickness, stress concentration has a remarkable effect on the fatigue crack growth behavior and it flattens the shape of a surface crack. The crack growth behavior can be explained quantitatively by using the Newman-Raju formula and the stress resolving method proposed by ASME B&P Code Sec.XI. (Edited author abstract) 14 refs.

Nam, Ki Woo (Yokohama Natl Univ, Yokohama, Jpn); Fujibayashi, Shinpei; Ando, Kotoji; Ogura, Nobukazu. *JSME Int J Ser 1* v 31 n 2 Apr 1988 p 272-279.

**080609 QUANTITATIVE PREDICTION OF GROWTH PATTERNS OF SURFACE FATIGUE CRACKS IN TENSION PLATES.** Different methods of prediction of the aspect ratio variability of growing surface fatigue cracks in tension plates are compared with experimental data. The objective is to identify the most accurate method. The comparison is based on a quantitative criterion as well as on statistical examination of the level of agreement with the data. Fifty-eight cracks are analyzed. The total number of data points is 450 taken from 20 references. The solutions evaluated include theoretical as well as empirical formulas. The comparison shows that it is possible to predict the aspect ratio variability with standard deviation  $<0.070$ . (Author abstract) 29 refs.

Mahmoud, M.A. (Univ of Bridgeport, Bridgeport, CT, USA). *Eng Fract Mech* v 30 n 6 1988 p 735-746.

**Fluid Dynamics** See Also BEARINGS—Fluid Dynamics; FLOW OF FLUIDS—Analysis; FLOW OF FLUIDS—Vortex Flow.

**080610 NONLINEAR STEADY-STATE MOTION OF AN ELASTIC PLATE FLOATING ON THE SURFACE OF A LIQUID OF INFINITE DEPTH.** The nonlinear problem of steady-state waves in an ideal fluid of infinite depth with a thin elastic plate floating on its surface is considered. The solution is found by perturbation method. Three approximations are obtained. A case of branching of the solution is investigated. (Author abstract) 3 refs.

Gladiu, O.M.; Fedosenko, V.S. *Fluid Dyn* v 22 n 2 Mar-Apr 1987 p 267-270.

**080611 INFLUENCE OF AN ABRUPT CHANGE IN THE THERMAL BOUNDARY CONDITIONS ON THE TURBULENT BOUNDARY LAYER ON A PLATE.** The development of the thermal boundary layer within a dynamic layer that has already been formed is a situation encountered in the practice of analyzing heat exchangers. The formulation of this problem is represented schematically. A homogeneous thermal flux acts on a plate. The Patankar-Spalding finite-difference method of solving the system of boundary layer differential equations is used in this paper to solve the formulated problem. The method underestimates the value of the Stanton number  $St$ , especially near the section  $x = x_0$ , where the discrepancy between the experimental results computation exists. 7 refs.

Drozova, L.N.; Sorokin, A.L. *J Appl Mech Tech Phys* v 28 n 5 Sep-Oct 1987 p 698-700.

**080612 FINAL STAGE OF A FALLING TRIANGULAR PLATE.** A plate in the shape of an equilateral triangle is initially slightly inclined to the horizontal and is then allowed to fall vertically onto another plate; there being an incompressible fluid between the plates. It is shown that in the final stage of the motion the perturbation of the inclination decays as  $t^{-3/4}$  and floating of the plate does not occur. (Author abstract). 4 refs.

Gupta, A.S. (Indian Inst of Technology, Kharagpur, India). *Wear* v 127 n 1 Oct 1 1988 p 111-115.

**080613 RIGID-PLASTIC RESPONSE OF FLOATING PLATES.** This paper presents the exact formulation and solution for the static flexural response of a rigid perfectly plastic freely floating plate subjected to lateral axisymmetric loading. The Tresca yield condition is adopted with the associated flow rule. The plate response is divided into three phases: Initially the plate moves downward into the foundation as a rigid body (Phase I). Subsequently the plate deforms in a conical mode in addition to the rigid body motion (Phase II). At a certain value of the load a hinge-circle forms which may move as the pressure increases further (Phase III). The nature of



the solution during the third phase depends upon the parameter  $\alpha=a/R$  (ratio of radius of loaded area to the plate radius). (Edited author abstract). 9 Refs.

Anastasiadis, John (Natl Technical Univ of Athens, Athens, Greece); Xirouchakis, Paul C. *J Ship Res* v 32 n 3 Sep 1988 p 168-176.

## Forging

**080614 METHOD OF FORGING PLATES.** In order to reduce metal consumption when making plate-type forgings by reducing the size of the end discard at the ingot bottom, the Energomashpetsstal Plant in Kramatorsk and the Novokramatorskii Machine Building Plant Production Association developed and implemented a new forging method. The total economic saving from the implementation of this new method forging plates at two enterprises alone from 1981 through 1984 was more than 100,000 rubles. 3 refs.

Kal'chenko, P.P.; Bykov, V.P. *Sov Forg Sheet Met Stamping Technol* n 2 1987 p 74-75.

## Foundations

**080615 UNBONDED CONTACT OF A SQUARE PLATE ON AN ELASTIC HALF-SPACE OR A WINKLER FOUNDATION.** The unbonded frictionless receding contact problem of a thin plate placed under centrally symmetric vertical loading while resting on an elastic half-space or a Winkler foundation is solved in this paper. The problem is transformed into the solution of two-coupled integral-series equations over an unknown contact region. The problem is nonlinear by virtue of unilateral contact and therefore needs to be solved iteratively. Special attention is given to the edge and corner contact pressure singularities for the plate on the elastic half-space. Comparison is made with other relevant numerical results available. (Author abstract). 29 Refs.

Hui Li (Clarkson Univ, Potsdam, NY, USA); Dempsey, J.P. *J Appl Mech Trans ASME* v 55 n 2 Jun 1988 p 430-436.

## Fracture See Also ROLLING MILL PRACTICE.

**080616 MIXED-MODE CRACK GROWTH IN PLATES UNDER THREE-POINT BENDING.** A combined theoretical and experimental study of the problem of crack growth in a plate subjected to unsymmetrical three-point bending was undertaken. The opening-mode  $K_I$  and sliding-mode  $K_{II}$  stress-intensity factors describing the local stress field around the crack tip were determined by a finite-element computer program. The crack growth was analyzed by the maximum circumferential stress and the minimum strain-energy density criteria. The critical loads for crack growth and the crack trajectories were determined both by theory and experiment. The experimental results corroborated the theoretical predictions. (Author abstract) 10 refs.

Gdoutos, E.E. (Democritus Univ of Thrace, Xanthi, Greece); Zacharopoulos, D.A. *Exp Mech* v 27 n 4 Dec 1987 p 366-369.

**080617 ASYMPTOTIC METHOD OF HOMOGENIZATION OF FISSURED ELASTIC PLATES.** This paper deals with the homogenization of thin elastic plates weakened by periodically distributed fissures. The classical Kirchhoff theory of bending plates admits five different types of unilateral fissures. To derive effective properties of fissured plates we employ the asymptotic method. As a result we obtain five effective hyperelastic plates. An illustrative example concerns the homogenization of the plate with unidirectional fissures parallel to a straight line. The constitutive equation describing the effective plate is found provided that fissures are of the flexural type resembling that observed in reinforced concrete plates in bending. (Author abstract) 35 refs.

Lewinski, Tomasz (Technical Univ of Warsaw, Warsaw, Pol); Telega, Jozef Joachim. *J Elast* v 19 n 1 1988 p 37-62.

**080618 BRITTLE FRACTURE STRENGTH OF**

**REPAIR WELDMENTS IN THICK PLATE.** Three-dimensional welding residual stress distributions in a repair welded joint were measured and wide plate tests with a surface notch at repair weldment were carried out. The brittle fracture strength of the three-dimensional crack at the repair weldment was evaluated using crack opening displacement criterion. The test results were analyzed with the aid of the fracture mechanics to evaluate quantitatively the effect of the welding residual stresses due to repair welding on the brittle fracture strength. These results were further reviewed synthetically for consideration of the fracture toughness value that would be required for repair weldments. (Edited author abstract) 13 refs.

Ueda, Yukio (Osaka Univ, Jpn); Kim, You Chu; Kajimoto, Katsuya; Fujii, Masanao; Hagiwara, Yukito; Takashima, Hironori. *Nav Archit Ocean Eng* v 24 1986 p 169-184.

**080619 STATISTICAL ANALYSIS OF FRACTURE ARREST TOUGHNESS OF VARIOUS STRUCTURAL STEEL PLATES.** A statistical investigation was made relating to the brittle fracture arrest properties of various steel plates for ship and bridge structures, low-temperature storage tanks and pressure vessels. Fracture arrest toughness ( $K_{Ia}$ ) data obtained by means of the temperature gradient type of ESSO tests on around 200 steel plates were collected and analyzed. It was found that  $K_{Ia}$  transition curves in terms of temperature for a set of steel plates possessed a 'pivot' on the temperature versus  $K_{Ia}$  diagram when the data were grouped according to their chemical composition and production methods. It was also found that the new production method of Thermomechanically Controlled Process (TMCP) for plate rolling provides an effective measure to improve the fracture arrest properties of steel plates. (Edited author abstract) 2 Refs.

Tanaka, Kiyoshi (Nippon Steel Corp, Sagami, Jpn); Sato, Mitsuo. *Int J Pressure Vessels Piping* v 33 n 2 1988 p 83-93.

## Friction See FLOW OF FLUIDS—Ducts.

## Glass

**080620 STRENGTH OF WINDOW GLASS PLATES SUBJECTED TO RAPID LOADING.** The strength of a glass plate is known to be time dependent; that is, the plate has a greater capacity to withstand pressures of brief duration than sustained pressures. This phenomenon is a very important consideration in designing window glass plates for short duration loads resulting from strong winds or blast pressures. The purpose of this research is to provide experimental data that will allow for the following: verification of the commonly accepted value of the static fatigue coefficient,  $n$ , at loading rates beyond 3.6 psi/sec; experimental verification of finite difference analytical predictions of dynamic plate response; and verification of the Norville dynamic failure prediction model. The data obtained from this experimental study will provide a bridge between present knowledge of the behavior of glass plates under static loading and that under rapid loading. 10 refs.

Pal, Himansu S. (Viggo, Bonnesen & Associates, Stamford, CT, USA); Pennington, W. *Tex Civ Eng* v 58 n 4 Apr 1988 p 11-16.

## Hardening

**080621 HEAT HARDENING OF PLATES USING ROLLING-QUENCH MACHINES.** Various heat hardening conditions have been considered for plate rolling-quench machines. It has been shown that rolling-quench machines were flexible systems capable of controlling the cooling process within broad ranges. (Author abstract) 2 refs.

Egorov, N.T.; Razumova, L.I. *Sov Mater Sci Rev* v 1 n 1 1987 p 69-71.

Heat Transfer See Also HEAT TRANSFER—Convection; SANDWICH STRUCTURES—Heat Transfer.

**080622 FREE CONVECTION FROM A VERTICAL PLATE WITH CONCENTRATED AND DISTRIBUTED THERMAL SOURCES.** An analysis is developed for the laminar free convection from a vertical plate with uniformly distributed wall heat flux and a concentrated line thermal source embedded at the leading edge. We introduce a parameter to describe the relative strength of the two thermal sources; and propose a unified buoyancy parameter to properly scale the dependent and independent variables. The variables are so defined that the resulting nonsimilar boundary-layer equations can describe exactly the buoyancy-induced flow from the dual sources with any relative strength to fluids of any Prandtl number from very small values to infinity. The effects of both relative source strength and Prandtl number on the velocity profiles, temperature profiles, and the variations of wall temperature, are clearly illustrated. (Edited author abstract) 19 refs.

Lin, H.-T.; Yu, W.-S. *Waerme Stoffuebertrag* v 22 n 5 1988 p 231-238.

**080623 NUMERICAL-ANALYTICAL METHOD OF SOLVING THE NONLINEAR HEAT-CONDUCTION PROBLEM FOR A DOUBLY CONNECTED VARIABLE-THICKNESS PLATE.** An isotropic of plate whose external and internal contours are described by equations in a dimensionless polar coordinate system is considered. The foundation of the plate is heat insulated, and the thermal characteristics of the material depend on the temperature. An approximate solution is constructed in an analytically closed form on each of the radial rays into which the plate domain is separated. (Edited author abstract) 3 refs.

Uzdalev, A.I. (Saratov Polytechnic Inst, USSR); Bryukhanova, E.N. *J Eng Phys* v 53 n 4 Oct 1987 p 1209-1213.

**080624 TRANSIENT THERMAL STRESSES IN A RECTANGULAR PLATE DUE TO NONUNIFORM HEAT TRANSFER COEFFICIENTS.** The linear problems of transient temperature and thermal stresses in a thin, finite, rectangular plate subjected to heat losses due to nonuniform heat transfer coefficients on the upper and lower plate surfaces are solved by a direct power series approach through the application of the Lanczos-Chebyshev and the discrete least-squares methods. A numerical example demonstrates the accuracies that can be achieved by using only a small number of terms. (Author abstract) 4 refs.

Chen, P.Y.P. (Univ of New South Wales, Kensington, Aust). *J Therm Stresses* v 11 n 2 1988 p 115-125.

**080625 FREE CONVECTION EFFECTS ON THE FLOW PAST AN IMPULSIVELY STARTED SEMI-INFINITE VERTICAL PLATE.** The free convection flow past a semi-infinite vertical isothermal plate started impulsively in its own plane in a viscous incompressible fluid is considered. The coupled non-linear equations governing the flow are solved numerically using two-point boundary value, shooting techniques. (Author abstract) 6 refs.

Perdikis, C. (Univ of Ioannina, Ioannina, Greece). *Model Simul Control B* v 15 n 1 1988 p 59-63.

**080626 THERMAL STABILITY OF LANDAU SLABS WITH CONSTANT AND UNEQUAL BOUNDARY TEMPERATURES.** Landau's thermal stability problem for a plane slab is resolved. Following three different paths of solution three critical solutions emerge; only one of the three agrees with Landau's 1959 finding. The present study with unequal boundary temperatures is cast along the proven path of analysis, yielding a fourth degree critical equation. Guided by



Landau's finding, one of the critical roots is recognized as the right one to yield the right stability parameter for the slab. (Author abstract). 2 Refs.

Liu, C.K. (Univ of Alabama, University, AL, USA). *J Franklin Inst* v 325 n 4 1988 p 435-442.

**080627 FREE CONVECTION ON A HORIZONTAL PLATE WITH BLOWING AND SUCTION.** In this analysis of free convection over a semi-infinite horizontal plate, both the wall temperature and transpiration rate are assumed to be power-law variations. Finite-difference solutions and local similarity and non-similarity solutions are obtained over a wide range of transpiration rate from very strong suction to very strong blowing. Special considerations are given to the most practical cases of an isothermal plate under the condition of uniform blowing or suction. 6 Refs.

Lin, Hsiao-Tsung (Nat'l Central Univ, Chungli, Taiwan); Yu, Wen-Shing. *J Heat Transfer Trans ASME* v 110 n 3 Aug 1988 p 793-796.

**Heating** See FRICTION—Heat Transfer.

**Hydrodynamics** See Also STEAM GENERATORS—Design.

**080628 ON THE HYDRODYNAMIC INERTIA AND DAMPING AT A FLUID-LOADED INFINITE PLATE SUBJECTED TO LOCAL VIBRATORY EXCITATION.** Starting from the solution for the infinite 'dry plate' at local vibratory excitation, a solution for the 'wet plate' is evaluated. Considering the vibratory pressures of the fluid loading, formulae for hydrodynamic inertia and damping are derived. The numerical evaluation shows that these effects of the fluid loading are dependent on the frequency and on the distance from the point of excitation. (Author abstract). 2 Refs.

Schwanecke, Helmut (Versuchsanstalt fuer Wasserbau und Schiffbau, Berlin, West Ger). *Ocean Eng (Pergamon)* v 15 n 3 1988 p 205-212.

**Impact** See BEAMS AND GIRDERS—Impact.

**Inclusions** See ELASTICITY—Theory.

**Magnetic Properties**

**080629 SPECTRAL STRUCTURE OF THE PROBLEM OF MAGNETIC ELASTICITY OF THIN PLATES.** Based on asymptotic analysis, approximate methods of solution of the problem of free oscillations of magnetically elastic plates of a finite size are studied. The asymptotic properties of the spectrum of eigenvalues of the problem are formulated as a function magnetic field intensity. (Author abstract) 5 refs.

Radovinskii, A.L. *Mech Solids* v 22 n 1 1987 p 160-167.

**Manufacture** See DIES—Computer Aided Design.

**Materials** See METAL CUTTING—Optimization.

**Mathematical Models**

**080630 ELASTIC-PLASTIC BEHAVIOUR OF A SIMPLY SUPPORTED CIRCULAR PLATE SUBJECTED TO STEADY TRANSVERSE PRESSURE AND CYCLIC LINEAR RADIAL TEMPERATURE VARIATION.** The behavior of a von Mises elastic-perfectly plastic material plate is examined using the finite-element method. The elements used allow general axisymmetric deformation to occur. Numerical solutions are obtained for the shakedown boundary and the two ratchetting modes. Also an upper-bound shakedown boundary is derived using the extended shakedown theory and some approximation expressions are derived for the incremental deformation which occurs at the periphery of the plate in the localized ratchetting mode. 9 refs.

Webster, J.J. (Univ of Nottingham, Nottingham, Engl); Sahari, B.B.; Hyde, T.H. *Int J Mech Sci* v 29 n 8 1987 p 533-544.

**080631 ELASTIC ANALYSIS OF PIN JOINTS IN PLATES UNDER SOME COMBINED PIN AND PLATE LOADS.** A circular pin in a circular hole in an infinitely large plate is considered. A two-dimensional plane-stress analysis of such a configuration is carried out, here, subjected to pin-bearing and/or biaxial-plate loading. The pin is assumed to be rigid compared to the plate material. The pin-hole interface is unbonded and so beyond some load levels the plate separates from the pin and the extent of separation is a non-linear function of load level. The problem is solved by inverse technique. In the situations where combined load is acting the separation-contact zone specification generally needs two parameters (angles) to be specified. The present report deals with analyzing such a situation in metallic (or isotropic) plates. Numerical results are provided for parametric representation and the methodology is demonstrated. 9 refs.

Mangalgiri, P.D. (Indian Inst of Science, Bangalore, India); Ramamurthy, T.S.; Dattaguru, B.; Rao, A.K. *Int J Mech Sci* v 29 n 8 1987 p 577-585.

**080632 DYNAMIC INSTABILITY OF SHEAR DEFORMABLE ANTISYMMETRIC ANGLE-PLY PLATES.** The effect of shear deformation on dynamic instability of simply supported antisymmetric angle-ply rectangular plates is considered. The boundaries of the principal instability region are conveniently represented in the plane 'non-dimensional excitation frequency squared-non-dimensional load amplitude'. The effects of the magnitude of the shear correction coefficients, number of layers, plate aspect ratio, and thickness-to-edge length ratio are illustrated in numerical examples. (Author abstract) 13 refs.

Bert, Charles W. (Univ of Oklahoma, Norman, OK, USA); Birman, Victor. *Int J Solids Struct* v 23 n 7 1987 p 1053-1061.

**080633 NONLINEAR MODEL FOR THE DYNAMIC TIME HISTORY RESPONSE OF AN R-C PLATE.** The paper presents an analytical model with variable stiffness based on the energy equivalence between a trilinear system and a simplified bilinear system, used in an estimation of the time-history response of a single-degree-of-freedom structure. The proposed model is tested on a rectangular R-C plate, subjected to a dynamic force, acting normally against the plate in the middle of it. Numerical results of the dynamic response in displacement, velocities and accelerations are determined by means of a 'step-by-step' integration method. (Edited author abstract) 4 refs.

Atanasiu, Gabriela. *Modell Simul Control B* v 11 n 3 1987 p 57-64.

**080634 FROM KIRCHHOFF TO MINDLIN PLATE ELEMENTS.** A procedure to generalize Kirchhoff thin plate finite elements so that they can be used for solving thick Mindlin plates is presented. Two typical discrete Kirchhoff elements, a triangular one and a quadrilateral one, are modified. Numerical results for a clamped circular plate show that the accuracy of the new Mindlin elements is the same as that of the original Kirchhoff elements and they can be used in the whole thickness range of Mindlin plate theory. (Author abstract) 10 refs.

Aalto, J. (Helsinki Univ of Technology, Finl). *Commun Appl Numer Methods* v 4 n 2 Mar-Apr 1988 p 231-241.

**080635 RESPONSE OF A FREE CIRCULAR PLATE TO A CENTRAL TRANSVERSE LOAD.** The axisymmetric response due to a point source at the center of a free circular plate is found. The forcing function is considered as both an impulsive load and as a sinusoidal load. The response is found by modal superposition of up to 500 modes generated by the Pickett plate theory. The purpose of this paper is to evaluate the response with use of a large number of highly accurate modes, and to determine if such a large number of modes must be considered in problems involving the use of control systems designed to operate at high frequencies in space

applications. (Edited author abstract) 7 refs.

Hutchinson, J.R. (Univ of California, Davis, CA, USA). *J Sound Vib* v 123 n 1 May 22 1988 p 129-143.

**080636 ANALYSIS OF CIRCULAR PLATE-ELASTIC HALF-SPACE INTERACTION USING AN ENERGY APPROACH.** An analytical formulation is developed, based on an energy approach, to predict the flexural behavior of uniformly loaded thin flexible circular plates resting in smooth and continuous contact with an isotropic elastic half-space. In this development, the deflected shape of the plate is approximated by an even power series expansion in terms of the radial coordinate. Any number of terms in the series can be considered. The coefficients associated with the series are evaluated by making use of the principle of minimum potential energy. Analytical expressions are derived for the contact stress distribution, the plate deflection, and the plate radial moment. The results obtained from the proposed procedure compare very well with the existing solutions of similar problems. (Author abstract) 15 refs.

Zaman, M.M. (Univ of Oklahoma, Norman, OK, USA); Kukreti, A.R.; Issa, A. *Appl Math Modelling* v 12 n 3 Jun 1988 p 285-292.

**080637 APPLICATION OF GENERALIZED FUNCTION THEORY ON THE COMPLETE SOLUTIONS OF PLATES AND SHELLS.** In this paper general solutions of partial differential equations with constant coefficients, especially in the theory of plates and shells, are discussed and obtained in closed integral forms by a Fourier transform method based on the theory of generalized functions. Some of these general solutions can be directly used to solve mechanics problems. (Author abstract) 8 refs.

Peng, Xiaolin (North China Univ of Technology, Beijing, China). *Appl Math Modelling* v 12 n 3 Jun 1988 p 321-327.

**080638 FREE-FORM PLATE MODELING USING OFFSET SURFACES.** This paper addresses the representation of plates within the framework of the Boundary Representation method in a Solid Modeling environment. Plates are defined as the volume bounded by a progenitor surface, its offset surface and other, possibly ruled surfaces for the sides. Offset surfaces of polynomial parametric surfaces cannot be represented exactly within the same class of functions describing the progenitor surface. Therefore, if the offset surface is to be represented in the same form as the progenitor surface, approximation is required. A method of approximation relevant to non-uniform rational parametric B-spline surfaces is described. (Edited author abstract). 14 Refs.

Patrikalakis, N.M. (MIT, Cambridge, MA, USA); Prakash, P.V. *J Offshore Mech Arct Eng* v 110 n 3 Aug 1988 p 287-294.

**Mechanical Properties**

**080639 STIFFNESS TAILORING FOR IMPROVED COMPRESSIVE STRENGTH OF COMPOSITE PLATES WITH HOLES.** A structural optimization procedure is used to obtain minimum-mass designs of compression-loaded composite plates with holes by tailoring the plate cross-sectional stiffnesses. The plate cross sections consist of two different balanced symmetric laminates with 0,  $\pm 45$ , and 90 deg piles. The plate inner laminate contains a hole and is designed from a softer material system with a higher failure strain than the plate outer laminate. All-graphite-epoxy plates and hybrid graphite/glass-epoxy plates were studied. Results for designs with different percentages of 0 and  $\pm 45$  deg piles in the outer laminate are compared with results for the optimum designs. Results for design with uniform cross-sectional stiffnesses are also compared with the results for tailored cross-sectional stiffness designs. Specimens of each design were tested to verify the analytical predictions. The results show that cross-sectional stiffness tailoring can increase the ratio of compressive strength to mass of compression-loaded laminated plates with holes.



(Edited author abstract) 9 refs.

Haftka, Raphael T. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Starnes, James H. Jr. *AIAA J* v 26 n 1 Jan 1988 p 72-77.

**080640 STUDY ON ULTIMATE COMPRESSIVE STRENGTH PROPERTIES OF LONGITUDINALLY STIFFENED CONTINUOUS PLATES UNDER UNIAXIAL COMPRESSION.** This paper clarifies the ultimate strength properties of longitudinally stiffened continuous plates simply supported by transverse stiffeners with sufficient flexural rigidity under uniaxial compression. By means of the elasto-plastic finite displacement theory, in which much reduction of degree of freedom of analytical models and computer time can be greatly expected by introducing a technique similar to the usual modal analysis making use of generalized coordinates into the conventional finite element method, many models of stiffened plates with various values of parameters are efficiently analyzed. Moreover, the numerical results are compared with the strength curves specified by several design codes, and then the safety margin included in these design codes is discussed. (Author abstract) In Japanese. 23 refs.

Nara, Satoshi; Komatsu, Sadao; Kitada, Toshiyuki. *Doboku Gakkai Ronbun-hokokushu* v 9 n 4 Apr 1988 p 273-280.

**080641 DEVELOPMENT OF HIGH-STRENGTH STEEL PLATES FOR LOW-TEMPERATURE USE.** This paper describes the metallurgical approaches for producing 415MPa and 460MPa yield strength offshore structural steel plates and the mechanical properties of the steel plates and their welded joints. A thermo-mechanical control process (TMCP) was adopted to manufacture YP415MPa and YP460MPa steel plates with weldability comparable to conventional YP355MPa steel plates. The Charpy impact and CTOD tests of the steel plates and their welded joints proved to be very good. (Author abstract) 5 refs.

Nakano, Y. (Iron & Steel Research Lab); Saito, Y.; Amano, K.; Koda, M.; Sannomiya, Y.; Kobayashi, E. *J Energy Resour Technol Trans ASME* v 110 n 3 Sep 1988 p 171-176.

**Nondestructive Examination** See Also EDDY CURRENTS—Computer Aided Analysis; MATERIALS TESTING—Fracture; NUCLEAR FUELS—Cladding.

**080642 TRANSIENT IMPACT RESPONSE OF PLATES CONTAINING FLAWS.** The finite element method was used to study the transient response to point impact of thick circular plates containing disk-shaped flaws. The response was studied in both the time and the frequency domains, and compared to the response obtained from a solid plate. The effects on the response caused by changing the diameter and depth of a flaw, the duration of the impact, and the position where the response is calculated were determined. From the results of these parameter studies, conclusions were drawn which can be used in planning and interpreting impact-echo laboratory and field test results. (Author abstract) 12 refs.

Sansalone, Mary (NBS, Gaithersburg, MD, USA); Carino, Nicholas J. *J Res Natl Bur Stand (US)* v 92 n 6 Nov-Dec 1987 p 369-381.

**080643 REFLECTION OF THE LAMB WAVE BY A FREE PLATE EDGE: VISUALIZATION AND THEORY.** In the detection of internal defects in a plate by the Lamb wave technique, edge-reflected waves are often involved. The reflection was theoretically shown to be complicated. The dynamic photoelastic visualization technique is used here to display the propagating modes reflected at the free plate end-face on incidence of  $S_0$ ,  $A_0$ ,  $A_1$ , or Lame mode, for different values of frequency times plate thickness. Theoretical curves are computed by a new approach for the relevant cases of incidence that predict reasonably the experimental results. (Author abstract) 9 refs.

Zhang, S.Y. (Acad Sinica, Beijing, China); Shen, J.Z.;

Ying, C.F. *Mater Eval* v 46 n 5 Apr 1988 p 638-641.

**080644 CALCULATION OF LAMB WAVE PARAMETERS AND PRINT-OUT OF CURVES WITH MICROCOMPUTER.** Provided are the mathematical expressions of Lamb wave parameters in different regions, which are applicable to microcomputer. The BASIC language program designed can be applied to print curves of Lamb wave parameters of any uniform metal plates. (Author abstract) 4 refs. In Chinese.

Yongqin, Xiong; Minghui, Lu; Yingqiu, Peng. *Wusun Jiance* v 10 n 4 Apr 1988 p 101-105.

## Physical Properties

**080645 RESEARCH ON CALCULATION OF STRUCTURALLY ORTHOTROPIC PLATE RIGIDITY.** A composite structure of rib-plate is always calculated as a structurally orthotropic plate. The calculating precision of such an analogy mostly depends on whether the determination of rigidity is proper or not. In this paper, the physical concept of each item in rigidity is analysed first, and the torsional rigidity and the items in rigidity used for calculating internal forces are then derived. It clears up the confusion caused by the misunderstanding of the physical meanings of rigidity. A virtual plate method for the plate strengthened by equidistant stiffeners in longitudinal direction is also recommended in this paper. It has been proved by experiments that this method is effective for improvement of calculating precision. Its extension and application may provide another way for the approximate calculation of composite structures and the numerical analysis methods. (Edited author abstract) 10 refs. In Chinese.

Hu Zhaozi (Northeast Forestry Inst, China); Qian Yinquan. *Tumu Gongcheng Xuebao* v 20 n 4 Nov 1987 p 49-61.

**Piercing** See OXYGEN CUTTING MACHINES—Reviews.

## Plasticity

**080646 APPROXIMATE EVALUATION OF PLASTIC ZONES IN PLATES WITH OPENINGS.** A load applied to a plate with an opening produces in certain conditions a local stress concentration near selected points on the opening edges. Near such points, known as stress concentrators, plasticity regions may develop. For a theoretical definition of plastic strains, a highly complex elastoplastic problem has to be studied. The difficulty is compounded by the fact that the shape of the plasticity region is not known in advance. An approximate distribution of plastic zones at the corners of a curvilinear square opening in a plate subjected to symmetric uniaxial extensions is formulated with respect to the plate's thickness. (Edited author abstract) 7 refs.

Bochkarev, A.O. *Leningrad Univ Mech Bull* n 3 1987 p 29-31.

**080647 PLASTIC WRINKLING OF AN ANNULAR PLATE UNDER UNIFORM TENSION ON ITS INNER EDGE.** This paper analyses the plastic wrinkling of an annular plate subjected to in-plane uniform tension stress on its inner edge with the combined use of the Kantorovich method and the Galerkin method, and discusses the appearance of wrinkles on the flange of a metal circular sheet during its axisymmetric deep-drawing operation. It is shown that the method provided in this paper is simple, convenient, and very suitable for engineering applications. (Author abstract) 9 refs.

Zhang, L.C. (Peking Univ, China); Yu, T.X. *Int J Solids Struct* v 24 n 5 1988 p 497-503.

**080648 DUALITY THEOREM FOR PLASTIC PLATES.** The duality theorem for a class of plastic plates is established in this paper. The family of  $\beta$ -norms is used to represent the yield functions. Exact solutions for circular plates under a uniform load are obtained for clamped and simply supported boundaries as examples of the specific duality relations. Two classical solutions

associated with H. Tresca and K.W. Johansen yield functions are also presented in the spirit of their own duality relations, providing interesting comparison to the new solutions. A class of approximate solutions by a finite element method is also presented. (Edited author abstract) 23 refs.

Yang, W.H. *Acta Mech* v 69 n 1-4 Dec 1987, Sei Pap on the Found and Future Dir of Plast, the Aris Phillips Meml Vol, Gainesville, FL, USA, Jan 28-30 1987 p 177-192.

## Pressure Effects

**080649 CIRCLE-POLYGON PARADOX IN THE LIGHT OF THE BOUNDARY-ELEMENT METHOD.** The boundary-element method (BEM) is used to study the so-called circle-polygon paradox of simply supported thin plates under uniform pressure. A collocation approach is used to show that the correct assumption of boundary conditions for this problem eliminates the paradox. The computational efficiency of the method is discussed and its simplicity emphasized. (Author abstract) 5 refs.

Ahmed, Sk. Shamim (Indian Inst of Technology, Kharagpur, India); Dey, Santi Sekhar. *Comput Struct* v 29 n 5 1988 p 919-922.

## Protective Coatings

**080650 TiB<sub>2</sub> COATINGS ON PHOSPHOR BRONZE PLATES BY CVD AND THEIR PROPERTIES.** A phosphor bronze plate was coated with a thin layer of TiB<sub>2</sub> from a gas mixture of TiCl<sub>4</sub>, BCl<sub>3</sub>, H<sub>2</sub> and argon at temperatures of 580-850°C. The oxidation and corrosion stabilities were examined. Uniform and adherent TiB<sub>2</sub> layers were obtained on the phosphor bronze plate in the temperature range of 600-700°C. The deposition rates were 1.1  $\mu\text{m h}^{-1}$  and 2.2  $\mu\text{m h}^{-1}$  at temperatures of 700°C and 750°C respectively. TiB<sub>2</sub>-coated phosphor bronze plates were stable to oxidation at temperatures below 600°C and were slightly affected by 3.2 N HNO<sub>3</sub> at room temperature and concentrated HCl at 60°C. (Author abstract) 14 refs.

Motojima, Seiji (Gifu Univ, Gifu, Jpn); Hotta, Hisashi. *J Less Common Met* v 141 n 2 Aug 1988 p 327-333.

**Repair** See IRON AND ALLOYS—Recycling.

**Rolling** See ROLLING MILLS—Computer Applications.

## Shock Waves

**080651 EFFECT OF LOCAL CONTACT BEHAVIOR ON AN IMPACT LOAD DUE TO COLLISION BETWEEN A PLATE AND A SPHERE.** In the collision between the flat surface of solid and of a sphere, it can be considered that a high stress will occur, since an impact load is applied in a small local contact area. It is important when formulating the impact load that the effect of the local plastic deformation of the contact surface on the time history of a load due to impact is investigated. On the other hand, it is revealed by Hertz's theory that the relationship between a force and the amount of approach of both solids during impact is nonlinear. In this paper, the effect of the local displacement behavior in the contact process on the impact load is shown by the experiment of a collision between a plate of mild steel and a high hardness steel ball. The impact load is evaluated by a piezoelectric plastic transducer. The limitation which the modified approach of Hertz's theory is valid, are distinguished. (Edited author abstract) In Japanese. 6 refs.

Jingu, Toshio; Matsumoto, Hiroyuki; Nezu, Kikuo; Sakamoto, Kenji. *Nippon Kikai Gakkai Ronbunshu A Hen* v 53 n 496 Dec 1987 p 2331-2335.

**Stability** See Also BEAMS AND GIRDERS—Buckling; MATERIALS SCIENCE—Mathematical Models.

**080652 ELASTIC STABILITY ANALYSIS OF THIN PLATE BY THE BOUNDARY ELEMENT METHOD - A NEW FORMULATION.** A new bound-



any integral equation formulation for the elastic stability analysis of thin plate is presented in this paper. This formulation involves only two kinds of integral equations which are similar to those employed in the linear analysis of plate bending problems by the boundary element method and are suitable to plates with arbitrary plan forms and under general boundary conditions or in-plane load conditions. A new simple boundary element discretization scheme is established based on these integral equations. Satisfactory numerical results obtained on a microcomputer with constant elements clearly show the applicability and efficiency of the approach developed in this paper. (Author abstract) 29 refs.

Liu, Yijun (Northwestern Polytechnical Univ, Xian, China). *Eng Anal* v 4 n 3 Sep 1987 p 160-164.

**080653 IMPROVING THE ELASTIC STABILITY OF SQUARE PERFORATED PLATES.** Results are presented for the elastic stability of square plates containing central square perforations under various loading conditions and for fully fixed or simply supported boundary conditions. Special attention is paid to stiffening the plates considered in order to regain the elastic critical load of the unperforated plate. (Author abstract) 7 refs.

Yettram, A.L. (Brunel Univ, Uxbridge, Engl); Brown, C.J. *J Constr Steel Res* v 7 n 5 1987 p 371-383.

**080654 CONSTRUCTION OF DYNAMIC INSTABILITY DOMAINS OF PLATES AND SHELLS.** The numerical construction of the dynamic instability domains (zones) of plates and shells under simple and combined parametric resonances caused by the action of longitudinal periodic loads are studied. Formulation of the problem assumes the unperturbed stress-strain state (SSS) to be a membrane state and determined from the solution of the linear problem. The change in the coupled-stress SSS is negligibly small when perturbations are superposed on the kinematic parameters of the system characterizing the bending. This corresponds to the traditional formulation of the problem of parametric plate and shell vibrations. 7 refs.

Dekhtyaryuk, E.S. (Kiev Structural Engineering Inst, USSR); Kovtunov, V.B.; Lumel'skii, E.D. *Sov Appl Mech* v 23 n 5 May 1987 p 452-458.

**080655 NUMERICAL-ANALYTIC STABILITY ANALYSIS OF STIFFENED RECTANGULAR PLATES.** We propose a method for calculating the critical buckling stresses of rectangular plates with an arbitrary number of stiffening elements and various edge conditions. The basic difficulties in analytic solution of the problem are associated with selecting the system of basis functions in terms of which the sought function is expanded into a series. A method is constructed using step-type basis functions, making it possible to combine the advantages of the analytic solution with the universality of the numerical approach. 2 refs.

Zotov, A.A.; Stel'mukhov, I.A. *Sov Aeronaut* v 30 n 2 1987 p 101-103.

**080656 AXISYMMETRIC DYNAMIC STABILITY OF TRANSVERSELY ISOTROPIC MINDLIN CIRCULAR PLATES.** Dynamic stability of transversely isotropic Mindlin circular plates subjected to periodic radial loads is studied. The periodic radial loads are taken to be the combination of a pulsating compressive stress and a pulsating bending stress. The Galerkin method and Bolotin's method are used to obtain the regions of dynamic instability. The effects of some parameters on the dynamic instability regions are investigated. (Author abstract) 12 refs.

Chen, L.-W. (Nat'l Cheng Kung Univ, Tainan, Taiwan); Hwang, J.-R. *J Sound Vib* v 121 n 2 Mar 8 1988 p 307-315.

**080657 DYNAMIC STABILITY OF A RECTANGULAR PLATE SUBJECTED TO DISTRIBUTED IN-PLANE DYNAMIC FORCE.** Dynamic instability of a rectangular plate subjected to an in-plane sinusoidally varying force which varies along the edges is analyzed. The

thin plate small deflection theory is used. The boundary conditions of the plate consist of combinations of simply supported edge and clamped edge. Unstable regions are presented for various boundary conditions of the plate and loading conditions. (Author abstract) 7 refs.

Takahashi, K. (Nagasaki Univ, Nagasaki, Jpn); Konishi, Y. *J Sound Vib* v 123 n 1 May 22 1988 p 115-127.

**080658 ELASTIC STABILITY OF PLATES WITH AND WITHOUT OPENINGS.** The finite element method of analysis is used to determine the elastic buckling loads for plates with and without openings. The formulation is based on Mindlin plate theory. The 8-node serendipity element was employed to model the membrane behaviour of the plate in order to determine the in-plane stress distribution throughout the plate due to the edge loading. The heterosis plate bending element was used in the formulation of the governing equations of the stability problem. The elastic buckling loads for plates with and without openings and under different edge loading conditions are determined and the results were compared with the analytical and numerical results available. The openings considered are circular and square located at the centre of the plate. Convergence of the solution for the plates considered is also discussed. (Author abstract) 10 refs.

May, I.M. (Univ of Bradford, Bradford, Engl); Ganaba, T.H. *Eng Comput (Swansea Wales)* v 5 n 1 Mar 1988 p 50-52.

**080659 STABILITY OF PURE HOMOGENEOUS DEFORMATIONS OF AN ELASTIC PLATE WITH FIXED EDGES.** An analysis is given of the stability of pure homogeneous deformations of an incompressible elastic plate. The two faces of the plate are free and the displacement of its edges is prescribed. Pointwise conditions for stability are derived by using Fourier transforms and constructing a special displacement field. The conditions obtained are found to be related to a restricted rank-two convexity condition of the strain-energy function. Such a condition is then studied for isotropic materials, resulting in a set of inequalities in terms of the strain-energy function and principal stretches. (Author abstract). 12 Refs.

Chen, Yi-Chao (Cornell Univ, Ithaca, NY, USA). *Q J Mech Appl Math* v 42 pt 2 May 1988 p 249-264.

**Steel** See Also PETROLEUM GAS, LIQUEFIED—Storage; PRESSES—Performance; ROLLING MILL PRACTICE—Plate; ROLLING MILL PRACTICE—Slab; SHIPS—Design; STEEL HEAT TREATMENT—Quenching; STRESSES—Measurements; X-RAY TUBES.

**080660 THERMOMECHANICAL TREATMENT OF STEEL PLATES.** The latest heat hardening methods used for low carbon steel plates have been analyzed and the benefits of in-line heat treatment processes emphasized. The 3600 mm plate mill in Azovstal uses a thermomechanical process which relies on a commercial cooling system placed downstream of the finishing stand. The advantages of Soviet developments in in-line hardening of plates have been demonstrated. (Author abstract) 10 refs.

Spivakov, V.I.; Orlov, E.A.; Babitskiy, M.S.; Savenkov, V.Ya. *Sov Mater Sci Rev* v 1 n 1 1987 p 63-67.

**080661 PRODUCTION OF HEAVY-GAUGE STEEL PLATES SUITABLE FOR HIGH-HEAT INPUT WELDING IN THE ARCTIC REGION.** For application to the energy resources development in the Arctic region, the YP 36 kgf/mm<sup>2</sup> class structural steel plates (maximum 70 mm in thickness), which have high toughness for high heat input welding, have been developed and manufactured using the multipurpose accelerated cooling system (MACS). This steel contains a small amount of Nb for the purpose of reducing C and Mn contents. Its carbon equivalent is reduced by utilizing MACS and its mechanical properties have satisfied the EH36 steel grade. For the each-side one-pass welding joint with a heat input of 130 kJ/cm,  $\sigma_{E-60}$  is more than 10 kgf-m at any notch position. The preheating temperature

for crack prevention has been confirmed to be below 0°C by the Y-groove restraint test. (Author abstract) 5 refs.

Deshimaru, Shin-ichi (Kawasaki Steel Corp, Jpn); Hirai, Ikuro; Amano, Kenichi; Ueda, Syuzo; Uemura, Takashi; Tsubota, Kazuya. *Kawasaki Steel Tech Rep* n 17 Oct 1987 p 34-40.

**080662 PROPERTIES OF 390- AND 415-MPA YIELD STRENGTH STEEL PLATES WITH GOOD TOUGHNESS IN LARGE HEAT INPUT WELDED JOINTS.** Ship structural 390 MPa yield strength (YP40 kgf/mm<sup>2</sup>) steels and an offshore structural 415 MPa yield strength (YP 42 kgf/mm<sup>2</sup>) steel were developed to assure good low temperature toughness in large heat input welded joints. They were produced using MACS (Multipurpose accelerated cooling system) with low N and a small amount of Nb and REM-Ti addition for the YP 415 MPa steel. Tensile, Charpy impact and fracture mechanics tests proved that the steel plates and their welded joints made by electro-gas welding and one-side one-pass submerged arc welding with heat inputs of 147 to 274 kJ/cm had sufficient properties for ship and offshore structures. (Author abstract) 8 refs.

Nakano, Yoshifumi (Kawasaki Steel Corp, Jpn); Amano, Keniti; Sannomiya, Yoshifumi; Kobayashi, Eiji; Ogawa, Takao; Yajima, Hiroshi. *Kawasaki Steel Tech Rep* n 17 Oct 1987 p 41-47.

**080663 DEVELOPMENT AND MANUFACTURE OF LOW P<sub>CM</sub> HIGH TOUGHNESS STEEL PLATES FOR API 5L-X60 UO PIPE.** A steel was developed and applied to the production of plates for UOE line pipes which are used to transport sour oil in the North Sea. The steel plates 22.2 to 38.1 mm thick were made of API 5L-X60 and weigh 50,000 tons in total. The most critical and the most difficult requirements to be met follow: The P<sub>CM</sub> which is an indicator of the susceptibility to weld cracking should be as low as 0.150% for plates 22.2 and 23.8 mm thick. These requirements were unable to be satisfied by the ordinary manufacturing process. Only the thermo-mechanical control process (TMCP) and the fine steel making process were able to do it. The present paper describes the details of the steel plate manufacturing processes and the properties obtained. (Author abstract) 5 refs.

Yoshimura, Shigehiko (Kawasaki Steel Corp, Jpn); Amano, Kenichi; Uemura, Takashi; Nishizaki, Hiroshi; Saito, Yoshiyuki; Sekizawa, Makoto. *Kawasaki Steel Tech Rep* n 17 Oct 1987 p 48-55.

**080664 MECHANICAL PROPERTIES OF 9% NI STEEL PLATES PRODUCED FROM CONTINUOUSLY CAST SLABS.** From a low-P (0.006% max), low-S(0.002% max) continuously cast slab, 9% Ni steel plates for LNG storage tanks were produced by the direct quenching and tempering process (MACS-T) and reheat-quenching and tempering process (RQ-T). In the MACS-T process, slab-reheating and finish-rolling temperatures were increased in order to increase ductile fracture energy by decreasing the amount of precipitated austenite. Reliability for LNG storage tanks was examined by conducting fracture toughness tests on these steel plates and their welded joints. As a result, it was shown that these steel plates and their welded joints had good crack initiation and arrest toughness. (Author abstract) 12 refs.

Kinaka, Ryoji (Kawasaki Steel Corp, Jpn); Furukimi, Osamu; Kubo, Takahiro; Okumura, Taketo; Shingyoji, Masahiro; Kudo, Junichi. *Kawasaki Steel Tech Rep* n 17 Oct 1987 p 64-72.

**080665 DEVELOPMENT OF HIGH TENSILE STRENGTH STEEL PLATE FOR HIGH HEAT INPUT WELDING.** Low alloyed high tensile strength steel plates for arctic offshore structures and cryogenic storage tanks are required to have high toughness in high input welds. We have already reported that Ti-Ca treated 490 N/mm<sup>2</sup> class high tensile strength steel plate have high



toughness in high heat input welds (heat input  $\leq 10$  kJ/mm). However, steel plates with high toughness in higher heat input welds (heat input  $\geq 10$  kJ/mm) are required. Investigations have been carried out to study the effect of micro alloying elements (Al, B and N) on toughness of high heat input welds (heat input  $\geq 10$  kJ/mm) of Ti-Ca treated 490 N/mm<sup>2</sup> class high tensile strength steel plates. From these results, it is concluded that the Ti-B-Ca treated low Al medium N steel could meet the specification. (Author abstract) In Japanese. 7 refs.

Furusawa, Jun; Arimochi, Kazushige; Kurayasu, Hirofumi; Nakano, Naokazu; Suzuki, Shu-ichi. *Sumitomo Met v 40 n 1 Jan 1988 p 39-48.*

**080666 RENEWAL AND OPERATION OF MAIN FACILITIES AT KASHIMA PLATE MILL.** Kashima Steel Works started the Plate Mill to operate in October, 1970. Since then, we have developed many techniques and expanded its facilities. Recently, plate customers have become to want more various steel grades, small quantity, shorter delivering time and higher quality such as thermo-mechanical-controlled-plate. In order to satisfy these demands main facilities of Kashima Plate Mill have been reconstructed. In this paper, these modernizations and operation at Kashima Plate Mill are described in detail. (Author abstract) In Japanese. 4 refs.

Yoshimatsu, Yukitoshi; Takeda, Toshihiko; Kobayashi, Yoshihei; Ushio, Kunihiko; Hashizume, Fujihiko. *Sumitomo Met v 40 n 1 Jan 1988 p 71-80.*

**080667 DEVELOPMENT OF TMCP THICK PLATE FOR SKYSCRAPERS.** The rise of welding cost which stems from the increasing carbon equivalent of steel plate is getting in the way of the application of very thick steel plates in skyscraper construction. To clear away this obstacle in manufacturing 100 mm-thick SM 50 B steel plates, we tried to introduce the TMCP, which consists of special rolling and accelerated cooling, in place of the conventional normalizing process. The application of the TMCP brought about the noticeable improvement of the weldability and toughness of weld heat affected zone. For instance, the preheat temperature at welding seemed to be decreased more than 75°C under the conventional one. (Edited author abstract) In Japanese. 7 refs.

Bessyo, Kiyoshi (Nito, Nobuaki); Someya, Ryo; Suzuki, Shuichi; Kamata, Yoshihiko. *Sumitomo Met v 40 n 1 Jan 1988 p 81-90.*

**080668 BEHAVIOUR OF BOLTED JOINTS OF CORRUGATED STEEL PLATES.** Fifteen tests of lap joints of 3, 5 and 7 mm thick corrugated steel plates were conducted under uniform moment conditions to establish the moment-rotation behavior of the joints. Low, medium and high torques were used to tighten the bolts. Laps were made with 2, 3 and 4 bolts per complete corrugation. The moment-curvature diagrams for plate specimens were established theoretically and verified experimentally. The lap joint tests show conclusively that correct and incorrect laps exist. Correct lap joints are those in which no bolt is placed on the tension side of the lap at the location where the plates tend to separate when moments are applied, i.e., where prying occurs. These laps are correct for either direction of bending. In incorrect lap joints, tearing occurs transverse to the span from the edge of the bolt holes located on the tension side where prying occurs. This results in reduced ductility. (Edited author abstract) 2 refs.

Lee, Raymond W.S. (Univ of Alberta, Edmonton, Alberta, Can); Kennedy, D.J. Laurie. *Univ Alberta Dep Civ Eng Struct Eng Rep 155 Jan 1988 83p.*

**080669 TEMPER EMBRITTLEMENT AND HYDROGEN EMBRITTLEMENT IN Cr-Mo STEEL PLATES FOR PRESSURE VESSELS.** It has been pointed out that the mechanical properties of Cr-Mo steels for pressure vessels were deteriorated by hydrogen at lower temperature after shutdown. Recently it has also been demonstrated that hydrogen embrittlement was accelerated by temper embrittlement, which occurred

during operation at elevated temperatures. The interaction between these two embrittlements in 3Cr-1Mo steel has been investigated in this study. It was found that the degree of hydrogen embrittlement of temper embrittled materials was larger than that of unembrittled material. In addition, the ratio of intergranular fractured surface area to total surface area was increased with the increase of hydrogen embrittlement and/or temper embrittlement. (Author abstract) 5 refs.

Furusawa, Jun (Sumitomo Metal Industries Ltd., Jpn); Watanabe, Seichi. *Sumitomo Search n 35 Nov 1987 p 13-20.*

**080670 LIMIT STATES DESIGN CONSIDERATIONS FOR GUSSET PLATES.** The paper discusses the design considerations that must be made when designing for ultimate strength, specifically, utilizing the limit states design formulation. Thus, limit states design models are described for tension and compression applications of gusset plates, although it is noted that much more research is needed before the criteria for compression can be considered as complete. Of particular interest are the second-order deformation effects in gusset plates; these are recent findings in experimental studies. It is demonstrated how load application and direction as well as type and orientation of the boundary connections have a major influence on the strength and behavior of these plates. A final summary itemizes the design checks that should be made. (Edited author abstract) 12 refs.

Bjorhovde, Reidar (Univ of Pittsburgh, Pittsburgh, PA, USA). *J Constr Steel Res v 9 n 1 1988 p 61-73.*

**080671 460 MPa CLASS YIELD STRENGTH STEEL PLATES FOR ARCTIC OFFSHORE STRUCTURES.** A new extra-low C-Nb-Cu-Ni steel plate with high strength and high toughness has been developed. The steel plate has high strength and good base-metal toughness because of the formation of fine acicular ferrite structure obtained by applying an accelerated cooling process, and has excellent heat-affected-zone (HAZ) toughness due to fine ferrite structure with a small amount of upper bainite structure. The plate can be welded without preheating, and with a heat input as high as 11 kJ/mm. (Author abstract) 4 refs. In Japanese.

Kaji, Haruo; Shimohata, Takashi; Shiwa, Toyooki. *R&D Res Dev Kobe Steel Ltd v 38 n 2 Apr 1988 p 73-76.*

**080672 TRAGLASTVERSUCHE AN LAENGSGESTAUCHTEN UNVERSTEIFTEN DREISEITIG GELAGERTEN RECHTECKPLATTEN.** [Ultimate Load Tests on Unstiffened Oblong Plates Supported on Three Sides, in Longitudinal Compression]. The basis of this examination are 16 ultimate load tests on unstiffened plates under uniform compression, supported on three sides. Described are the test-pieces, the test-rig and the measuring devices, the actual tests, followed by the test results. Finally, an ultimate load curve, derived from the test results, is being compared with other proposals. (Author abstract) 9 refs. In German.

Fischer, M. (Univ Dortmund, Dortmund, West Ger); Konowalzyk, R. *Stahlbau v 57 n 5 May 1988 p 135-141.*

**080673 BOUNDARY CHARACTERISTICS AND PRACTICAL USE PERFORMANCE OF ROLLED TITANIUM-CLAD STEEL PLATE.** The demand for titanium-clad steel plate is on the increase because of its excellent anticorrosion characteristics, cost-effectiveness, and easy economical availability. In recent years, ways to apply the hot rolling process to the production of titanium clad steel plate have been sought for. To this end, Sumitomo Metal Industries, Ltd. began working on the development of rolled titanium clad steel plate, and successfully put this plate into practical use after conquering problems related to the cladding boundary. This new rolled titanium clad steel plate has superior boundary characteristics and shows excellent performance when applied in head plates, tube plates and welded joints. Rolled titanium clad steel plates have been supplied to several customers, and favorable comments have been received. (Author abstract). In Japanese.

Hara, Shuichi; Nakamura, Tsuyoshi; Ando, Ryuichi; Komizo, Yuichi; Nakagawa, Hiroshi. *Sumitomo Met v 40 n 2 Apr 1988 p 141-152.*

**080674 UOSNOST OCELOVYCH DOSIEK KOTVENYCH DO BETONOVYCH DOSIEK.** [Bearing Capacity of Steel Plates Anchored in Concrete Elements]. An engineering solution of the connection between the supporting concrete structure and other elements by steel plates anchored in concrete is presented. Steel plates are loaded by a vertical force  $F_d$  and bending moment  $M_d$ . Anchorage is made by reinforcing bars welded to the steel plate. Steel elements (corbels) supporting external walls are attached to the plate. An experimental investigation of bearing capacity was conducted for various models of anchorage. Due to the vertical force  $F_d$  acting on eccentricity  $e_d$  horizontal and vertical displacements occur. The character of the stress-strain relationship is affected by the ratio of eccentricity  $e_d$ , and the arm of forces  $z$ , quality of the concrete element and by diameter, length and arrangement of the anchorage bars. (Edited author abstract). 3 Refs. In Czech.

Harvan, Ivan. *Stavebnicky Cas v 36 n 6 Jun 1988 p 487-498.*

**Strain** See Also DOMES AND SHELLS—Strain; MATHEMATICAL TECHNIQUES—Matrix Algebra.

**080675 SMALL STRAIN AND MODERATE ROTATION THEORY OF ELASTIC ANISOTROPIC PLATES.** A general nonlinear theory for the dynamics of elastic anisotropic plates that accounts for transverse shear strains and moderate rotations is presented. The theory contains, as special cases, the von Karman classical plate theory, the first-order shear deformation theory (i.e., the Reissner-Mindlin plate theory) and the third-order shear deformation plate theory. The theory is characterized, even for isotropic plates, by strong coupling between various equations of motion. (Author abstract) 29 refs.

Reddy, J.N. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA). *J Appl Mech Trans ASME v 54 n 3 Sep 1987 p 623-626.*

**080676 LEVY TYPE SOLUTIONS FOR SYMMETRICALLY LAMINATED RECTANGULAR PLATES USING FIRST-ORDER SHEAR DEFORMATION THEORY.** Closed-form solutions for the bending case of the classical laminated plate theory and the first-order shear deformation theory were previously developed for two types of simply supported boundary conditions and certain lamination schemes. These served as excellent references for comparison by numerical analysis. Such closed-form solutions of the first-order shear deformation theory for composite laminates with other types of boundary conditions are not reported in the literature. The study deals with the development of Levy-type solutions originated by Levy (1899) and approached in this paper in conjunction with the state-space concept. The analysis concerns the solution of the first-order transverse shear deformation theory of symmetrically laminated rectangular plates with two opposite edges simply supported and the remaining edges subjected to a combination of free, simply supported, and clamped boundary conditions. 10 refs.

Reddy, J.N. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Khdeir, A.A.; Librescu, L. *J Appl Mech Trans ASME v 54 n 3 Sep 1987 p 740-742.*

**080677 EXPERIMENTAL STUDY OF IRREGULAR SHAPE PLATES WITH HIGH STRAIN GRADIENT.** The recently developed irregular shape plate specimens are well reformed. They have stress-strain fields which approach those of the nozzle region of pressure vessels in the actual working situation. (Edited author abstract) In Chinese. 13 refs.

Zhao, Yong (South China Inst of Technology, Guangzhou, China); Li, Zhen. *Huagong Jixie v 14 n 2 1987 p 113-119.*



**080678 A GENERALISATION OF KO'S STRAIN-ENERGY FUNCTIONS.** An extension of Ko's strain-energy function for isotropic hyperelastic materials is presented. The implications of the Baker-Ericksen inequality the strengthened tension-extension inequality and the ordered forces inequality are discussed. Particular consideration is given to the configuration of plane stress, and the dispersion equation governing the propagation of small-amplitude waves in a pre-stressed plate is obtained. Limiting solutions are derived for thin plates for both flexural and extensional modes. Numerical results are given for configurations of marginal stability. (Author abstract) 10 Refs.

Willson, A.J. (Univ of Leicester, Engl); Myers, P.J. *Int J Eng Sci* v 26 n 6 1988 p 509-517.

**080679 VPLYV OKOLITEHO ZATAZENIA POL-PRIESTURU NA DOSKOPEPASY S PRIHLIAD-NUTIM NA REOLOGICKE VLASTNOSTI MATERIALOV DOSKY A PODLOZIA.** [Effect of Nearby Loading of Halfspace on Plate Strips with Regard to Rheological Properties of Plates and Subgrade Materials.] This paper deals with the contact problem of a plate strip and halfspace under the action of a nearby loading of the halfspace. The case of the plane strain is considered, the materials both of the plate and the halfspace having time-dependent properties. It is assumed that the plate and the halfspace represent homogeneous and isotropic bodies the creep of which is governed by different constitutive relations of the linear hereditary type. The problem is formulated by integral-differential systems of equations of the plate strip bend and vertical displacement of the halfspace boundary in which the unknown function of contact stress is determined from the conditions of plate strip balance and from the contact condition of the plate strip and halfspace in each point of the footing bottom interval. The solution is demonstrated by two numerical examples. (Edited author abstract) 21 Refs. In Czech.

Kollar, Pavol; Djubekova, Valentina. *Stavebnicky Cas* v 36 n 6 Jun 1988 p 517-538.

**Stresses** See Also DOMES AND SHELLS—Stresses; MATERIALS—Deformation; MATHEMATICAL TECHNIQUES—Finite Element Method; MECHANICS—Continuous Media; STEEL TESTING—Fatigue; STRESSES—Analysis; STRESSES—Shear; STRESSES—Thermal.

**080680 THERMAL STRESSES IN A SEMI-INFINITE PLATE WITH A HOLE DUE TO TEMPERATURE DISCONTINUITY ON ITS STRAIGHT EDGE.** A steady-state thermal stress problem is solved for a semi-infinite plate with a thermally insulated circular hole when a finite segment of its straight edge is heated with a prescribed temperature. Both the temperature and stress solutions are constructed by summing the temperature and stress fields due to point heat sources and loads distribution inside the hole. The intensity of heat sources and loads are determined from the boundary conditions on the hole using the least squares method. The boundary conditions on the straight edge are satisfied exactly. Extensive and detailed numerical calculations are carried out to clarify the effects of the length of heated segment and the distances of the hole from the straight edge and the center of the heated segment of thermal stress concentration. The results show the power and flexibility of the method. (Author abstract) In Japanese. 11 Refs.

Yamada, Katsutoshi. *Nippon Kikai Gakkai Ronbunshu A Hen* v 53 n 493 Sep 1987 p 1798-1805.

**080681 EFFECT OF MATERIAL PARAMETERS ON THE INITIATION AND GROWTH OF ADIABATIC SHEAR BANDS.** The thermomechanical problem involving simple shearing of a finite slab made of an isotropic and viscoplastic material is studied with the objective of finding the effect of the strain hardening parameter, strain-rate hardening parameters, thermal softening coefficient and thermal conductivity on the initiation and growth of adiabatic shear bands. The body is placed in a hard loading device, i.e. the velocity is prescribed at its top and bottom surfaces. A shear band is presumed to have formed if the addition of a perturbation in the temperature at the onset of plastic flow results

in a localization of the shear strain. The critical strain at which the band begins to form is found and its dependence on various material parameters is investigated. (Author abstract) 22 Refs.

Batra, R.C. (Univ of Missouri-Rolla, Rolla, MO, USA). *Int J Solids Struct* v 23 n 10 1987 p 1435-1446.

**080682 SIMPLIFIED ANALYSIS OF THE EFFECT OF TRANSVERSE SHEAR ON THE RESPONSE OF ELASTIC PLATES TO IMPACT LOADING.** This investigation deals with the problem of transverse impact on an elastic plate for which the effect of deformation due to transverse shear cannot be neglected, e.g. a thick plate or one reinforced with aligned fibers in its plane. Closed-form solutions have been obtained, after minor approximation, to determine the deflection and bending moment at the point of impact. It is shown that a single parameter can describe the influence of transverse shear on the impact force as well as on the deflection and bending moment at the impact point. Finally, numerical results are presented to show that the influence of shear on deflection is much smaller than that on impact force or bending moment. (Edited author abstract) 18 Refs.

Mittal, R.K. (Indian Inst of Technology, New Delhi, India). *Int J Solids Struct* v 23 n 8 1987 p 1191-1203.

**080683 STRESS CONCENTRATION AROUND A PART-THROUGH HOLE WEAKENING A LAMINATED PLATE.** A quasi-three-dimensional-elasticity type theory, based on the assumptions of transverse inextensibility and layerwise constant shear-angle, is presented, in the context of an assumed quadratic displacement potential energy approach, for analyzing an edge-loaded laminated plate weakened by the presence of a part-through hole. Numerical results, obtained using the C-type triangular finite element, indicate the existence of severe cross-sectional warping in the vicinity of the hole and plate boundaries. Furthermore, the three-dimensional nature of the stress concentration factor in the neighborhood of the hole boundary is clearly exhibited. Besides, very high stress concentration factors are found in the layer weakened by the part-through hole. The numerical results presented should serve as bench-mark solutions for future comparisons. (Author abstract) 31 Refs.

Chaudhuri, Reaz A. (Univ of Utah, Salt Lake City, UT, USA). *Comput Struct* v 27 n 5 1987 p 601-609.

**080684 EFFECTIVE BREADTH PROBLEMS BY AN EIGENFUNCTION APPROACH.** The problem of effective breadth of a stiffened panel with two different edge or support conditions, namely (i) stress-free edges and (ii) displacement restrained edges, has been solved for the first time, in this paper, by the eigenfunction approach to the end problem of semi-infinite strips. It is shown that these two edge conditions lead to complex eigenvalue problems and thus the plane-stress problem of the plating cannot be solved by the classical methods which have been hitherto successfully used to obtain the estimates of effective breadths for the two other possible mixed edge conditions, namely, (i) vanishing direct stress and tangential displacement and (ii) vanishing normal displacement and shear stress. It is brought out that this end eigenfunction formulation, using a generalized orthogonality of Papkovitch, provides a general analytical framework for the stress field problems of stiffened panels in bending. (Edited author abstract) 23 Refs.

Bhattacharyya, Subroto Kumar (Indian Inst of Technology, Madras, India); Vendhan, Chiruvai P. *J Ship Res* v 31 n 4 Dec 1987 217-226.

**080685 DIE ERZEUGUNG DER EIGENSPANNUNGEN AN DER KALTVERFESTIGTEN BOHRUNG.** [Generation of Residual Stresses in the Vicinity of a Cold Worked Hole]. Subject of the investigation is the influence of the diameter of the mandrel on the distribution of residual stress near a coldworked hole in an infinite elastic-plastic plate. The calculation is based on Tresca's yield criterion, the associated flow rule and the assumption of linear isotropic hardening. The range of validity of

the results presented is discussed. (Author abstract) 5 Refs. In German.

Gamer, Udo (Technische Univ Wien, Austria). *Forsch Ingenieurwes* v 53 n 6 Nov 1987 p 185-188.

**080686 ANALYSIS OF THERMAL STRESSES IN PLATES WITH BOUNDARY ELEMENT METHOD.** In this paper an integral formulation, dealing with thin plates under thermal load, is presented. The field equation is decomposed into two harmonic equations which are formulated in an integral form by application of Green Second Theorem. The domain integrals which appear in the formulation will be transformed into equivalent boundary integrals, in particular distributions of temperature as well as in a general case where this is known only in a discrete form. In this way, the main advantage of the boundary element method of reducing the dimensions of the problem, is preserved. Two examples will be studied to prove the efficiency of the formulation proposed. (Author abstract) 13 Refs.

De Leon, S. (ETS Ingenieros Industriales, Sevilla, Spain); Paris, F. *Eng Anal* v 4 n 4 Dec 1987 p 199-203.

**080687 NONLINEAR STATIC ANALYSIS OF RECTANGULAR PLATES ON ELASTIC FOUNDATIONS BY THE ORTHOGONAL POINT COLLOCATION METHOD.** In this paper, the simplicity and good accuracy of this orthogonal point collocation method is demonstrated for the solution of some geometrically nonlinear problems of moderately large deflections of rectangular plates subjected to static loads. Von Karman-type governing equations are employed. Clamped and simply supported plates with immovable inplane conditions at the edges are considered. Plates which are simply supported at two opposite edges and clamped at the other two edges are also analyzed. Winkler and Pasternak models of elastic foundation are used. The present results agree quite well with the available ones. New results are presented for orthotropic plates resting on Winkler and Pasternak foundations. (Edited author abstract) 18 Refs.

Dumir, P.C. (Indian Inst of Technology, New Delhi, India); Bhaskar, A. *Comput Methods Appl Mech Eng* v 67 n 1 Mar 1988 p 111-124.

**080688 SOLUTION OF PROBLEMS OF THE BENDING OF ORTHOTROPIC PLATES WHICH YIELD IN TRANSVERSE SHEAR.** The use of plates and shells made of composites in different areas of technology requires that they be designed on the basis of refined models which take into account their low stiffness in transverse shear. Various such models have been presented. The authors propose an approach to the solution of a class of problems concerning the stress state of rectangular orthotropic plates subjected on their faces  $z = \pm h/2$  to normal loads. They allow for both transverse shear strain and transverse normal stresses. 10 Refs.

Vasilenko, A.T. (Acad of Sciences of the USSR, Kiev, USSR); Stepanenko, N.G. *Sov Appl Mech* v 23 n 8 Aug 1987 p 772-777.

**080689 ON THE ANALOGUES RELATING PLANE PROBLEMS OF COUPLE-STRESS THEORY AND REISSNER'S PLATE THEORY.** The analogous relations between the plane problems of couple-stress theory and REISSNER'S theory are established. Then the analytical and numerical approach in REISSNER'S plate theory can be applied to the couple-stress theory. By means of analogous relations we can predict that the state of stress for the plane problem of the couple-stress theory can be also composed by three elementary parts: the classical elastic problems corresponding to the state of stress as the couple-stress constant  $l$  approaches to zero, the corrective state of stress and the



boundary layer effect. Similar to the asymptotic expansion the solutions for the couple-stress theory are obtained. 5 refs.

Wen, Yu Shou. *Z Angew Math Mech* v 67 n 4 1987 p 246-247.

**080690 FINITE NOTCHED PLATE STIFFENED BY A SMALLER CIRCULAR DISK.** In this paper, the solution of a finite notched plate stiffened by a smaller circular disk is investigated by using a partitioning plan combined with the modified generalized variational method. It is assumed that the notched plate and the disk are both under the condition of generalized plane stress. The region under consideration is then divided into three subregions and complex potentials are introduced in each subregion, whose coefficients are determined from the stationary conditions of a proposed functional. Numerical results for the effect of the disk radius on the stress concentration factors of the elliptic notch are shown in the figures. The stress distribution between the notched plate and the disk are given in a table. (Author abstract) 7 refs.

Chen Yi-Heng (Xi'an Jiao-Tong Univ, Xi'an, China). *Int J Eng Sci* v 26 n 2 1988 p 127-133.

**080691 OPTIMAL HEATING PROBLEM FOR TRANSIENT THERMAL STRESS IN A THICK PLATE.** This paper considers the optimal heating problem for transient thermal stress in a thick plate for determining the surrounding temperature under prescribed mechanical boundary conditions. In the present investigation, the Laplace transform is used, and exact solutions for the surrounding temperature and thermal stresses are obtained. The numerical results for the temperature and thermal stresses are illustrated. (Author abstract) 4 refs.

Noda, Naotake (Shizuoka Univ, Hamamatsu, Jpn). *J Therm Stresses* v 11 n 2 1988 p 141-150.

**080692 DYNAMIC FRACTURE BEHAVIOR OF ANISOTROPIC PLATES WITH AN INCLINED EDGE CRACK.** This paper is concerned with the dynamic fracture behavior of anisotropic plates with a mixed-mode crack by means of the dynamic photoelastic method using a high speed image converter camera. A rectangular plate is made of fiber reinforced plastic with an inclined edge crack parallel to the fiber direction. According to examinations, the static stress intensity factor and the dynamic stress intensity factor of the tensile stress was required, and was compared with the results for an isotropic plate by changing the fiber direction, and with an increasing crack length. (Author abstract) 10 refs. In Japanese.

Shibahara, Masao; Nishio, Shinichi. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 498 Feb 1988 p 307-311.

**080693 STEADY-STATE THERMAL STRESSES OF THE ELASTIC PLATE WITH A CIRCULAR HOLE, INCLUDING THE LINE HEAT SOURCE.** Many thermoelastic problems concerning point heat sources in the plane have already been treated by investigators, but the problems concerning the line heat sources have not yet been completely solved. In this paper, the thermal stresses are analyzed in the case that one line heat source exists on the infinite plate with a circular hole having a boundary of zero temperature, and that all the heat flowing out from the line heat source flows out from a circular hole under the steady-state heat conditions. (Author abstract) In Japanese.

Fukui, Tsuyoshi. *Nippon Kikai Gakkai Ronbunshu A Hen* v 53 n 495 Nov 1987 p 2035-2038.

**080694 DYNAMIC STRESS ANALYSIS OF PLATES OF DIFFERENT KINDS OF MATERIAL.** Structures of machine parts subjected to impact load often suffer unexpected damage, which is remarkably different from that observed in static cases. Generally, the reflection and interference of stress-wave play an important role in dynamic cases, and it is desirable to study the time variation of the stress distribution, and especially the value of dynamic stress concentration factors around the bound-

aries of different kinds of materials. Hence, we analyzed stress propagation and dynamic stress concentration phenomena around the boundary of different kinds of materials in a plate by utilizing the strain gage method, the dynamic photoelastic method and also the finite element method. We found that two-dimensional dynamic stress concentration factors obtained by the present three methods are in general agreement and if the ratio of  $E_2$  (young's modulus for the different materials)/ $E_1$  (young's modulus for the matrix) is small, the dynamic stress concentration factor is small, but the position of maximum stress occurs at the circular boundary of the matrix. (Edited author abstract) 7 refs. In Japanese.

Sugiura, Masakatsu; Ando, Zenji. *Nippon Kikai Gakkai Ronbunshu A Hen* v 53 n 495 Nov 1987 p 2050-2055.

**080695 POISSON-KIRCHHOFF PARADOX IN FLEXURE OF PLATES.** An iterative scheme is presented through which an assumed state of transverse normal and shear strains can be transformed into a new state by integration of strain-displacement relations and equilibrium equations. Starting with Kirchhoff's assumptions, the iterative process is carried out to develop expressions for displacements and stresses. In the limit, each of these expressions is in the form of an infinite series in which each term is a product of a known function of thickness coordinate  $z$  and a differential expression involving mid-plane deflection  $w_0(x,y)$ . 5 refs.

Vijayakumar, K. (Indian Inst of Science, Bangalore, India). *AIAA J* v 26 n 2 Feb 1988 p 247-249.

**080696 EXTENSION OF AN ORTHOTROPIC ELASTIC PLATE STRENGTHENED BY AN ARRAY OF RIGID INCLUSIONS.** In this paper, we obtain an approximate analytic solution for the problem of extension of an orthotropic plate strengthened by two periodic groups of rectilinear inextensible inclusions; the solution is suitable for both weak and strong interaction of the inclusions. 7 refs.

Koblik, S.G. *Mech Solids* v 22 n 4 1987 p 182-186.

**080697 QUADRILATERAL HYBRID STRESS PLATE ELEMENT BASED ON NATURAL STRAINS.** Hybrid stress-based finite elements have been shown to model plate bending behavior accurately and in some cases lead to better stress and displacement results than  $C^0$ -based finite elements that employ reduced/selective integration schemes. A procedure for the development of a hybrid stress plate bending finite element is outlined. In the formulation of the element stiffness matrix, the intra-element displacement interpolation is referenced with respect to curvilinear coordinates. The form of the strain-displacement equations for the special case of an element with isoparametric distortion utilizing a bilinear interpolation is used. It is expected that by referring strains to finite element curvilinear coordinates, element performance will be improved under arbitrary isoparametric distortion. 5 refs.

Munir, N. (Univ of Illinois at Chicago, Chicago, IL, USA); Widara, G.E.O. *J Pressure Vessel Technol Trans ASME* v 110 n 2 May 1988 p 212-215.

**080698 THEORETICAL MODELLING OF LAMINATED COMPOSITE PLATES.** Formulation of appropriate governing equations, simpler than the three-dimensional equations of elasticity yet capable of predicting, fairly accurately, all important response parameters such as stress and strain, is attempted in modelling a structural component. Several theoretical models are available in the literature for the analyses of plates. The emergence of fibre-reinforced plastics as an attractive form of structural construction added a new complexity to the modelling considerations of lamination by requiring the estimation of the interlaminar stresses and strains. In this paper, modelling considerations of laminated composite plates are discussed. The classical laminated plate theory and higher-order shear deformation models are reviewed to bring out their interlaminar stress predictive capabilities, and some new modelling possibilities are indicated. (Author abstract) 31 refs.

Krishna Murty, A.V. (Indian Inst of Science, Bangalore, India). *Sadhana* v 11 pt 3-4 Dec 1987 p 357-365.

**080699 STUDY ON AN IDENTIFICATION METHOD OF RESIDUAL STRESSES IN A PLATE BY INVERSE ANALYSIS.** Inverse analysis using the boundary element method is considered theoretically very useful for the quantitative estimation of complicated stresses in a solid material induced by machining, heating and so on. However, a more refined fundamental consideration is still needed for a reliable evaluation of the stresses. In order to find a more practical estimation method, the authors have carried out several numerical simulations by using rectangular plate models with residual stresses induced by spot heating in the plate. They have also made an improved identification program of the boundary element method. Through typical calculations using this program, they found that unknown residual stress distribution in the plate was identified with enough accuracy from input data of the boundary displacements and tractions. (Author abstract) In Japanese. 9 refs.

Tomisima, Toshihiko; Yada, Toshio. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 500 Apr 1988 p 642-648.

**080700 ANALYSIS AND MEASUREMENTS OF RESIDUAL-STRESS REDISTRIBUTION DUE TO MATERIAL REMOVAL IN A PLATE.** Residual-stress redistribution caused by making a full-depth hole in a plate with biaxial residual stresses was elastically calculated using the Finite Element Method (FEM). The initial residual stresses were introduced into each finite-element through the intermediary of the most suitable eigen-strain distribution in such a way as to accord with the X-ray residual stresses measured prior to the material removal. A new calculation method is also proposed which removes at a time all the finite-elements of the removal-area in the FEM analysis, in contrast to the conventional method in which the elements are removed one by one. The analytical results of residual-stress redistribution were in good agreement with the X-ray residual stresses measured after drilling with an end mill, in the plate with residual stress induced by welding or by water-cooling. These results show that the residual stress change due to the material removal occurs markedly in the vicinity of the removed place. (Author abstract) 7 refs. In Japanese.

Honda, Kazuo (Okayama Univ, Tsushima-naka, Jpn); Torii, Tashiyuki; Fei, Zhongmin. *Zairyo* v 37 n 415 Apr 1988 p 391-397.

**080701 NATURE OF THE FREE EDGE STRESS SINGULARITY IN COMPOSITE LAMINATED PLATES.** The variational-asymptotic formulation for the edge layer problem is implemented by mixed-hybrid finite elements. This approach is used to analyse the stress singularity at the free edge in composite laminates. Results indicate that the stress singularity (as  $r \rightarrow 0$ ) is very closely approximated by  $\log r$  instead of  $r^{-\alpha}$ . (Author abstract). 26 refs.

Bar-Yoseph, Pinhas (Technion-Israel Inst of Technology, Haifa, Isr); Avrashi, Jacob. *Int J Numer Methods Eng* v 26 n 7 Jul 1988 p 1507-1523.

**080702 OPTIMAL VERSION OF REISSNER'S THEORY.** An improved version of Reissner's theory, called Optimal version, is proposed in the case of homogeneous and isotropic plates with any edge boundary conditions. It differs from the classical theory by the value of the transverse shear deformability factor and by the boundary conditions. Three-dimensional displacement and stress distributions expressed in terms of the Optimal version are given for any point of the plate, whether within the plate itself or in the neighborhood of its edge. It is proved that these distributions are second-order approximations of the exact three-dimensional solution - relative



error  $O(h^2/L^2)$ . Consequently, Optimal version is a second-order theory; therefore it is better than Kirchhoff-Love's theory. (Author abstract). 13 Refs.

Ladeveze, P. (CNRS, Cachan, Fr); Pecastaings, F. *J Appl Mech Trans ASME* v 55 n 2 Jun 1988 p 413-418.

**080703 STRESS ANALYSIS OF CRACKS OF ARBITRARY SHAPE IN FINITE PLATE SUBJECTED TO UNIFORM TENSION.** Using finite element method (FEM) the stress field and the stress intensity factors at the crack tips are obtained for the cracks of arbitrary shape in a plate of finite width subjected to uniform tension. Different crack geometries that are considered are central angled crack, crack in the form of an arc of a circle, angled edge crack, and the angled edge crack at one edge and a straight crack at the other edge. The conclusions drawn are: (a) The finite element analysis, using singularity elements, can be used to analyse the problems involving edge cracks with arbitrary geometry. (b) The linear extrapolation method to evaluate a crack tip SIF yields better results than curvilinear extrapolation when compared with analytical solutions for cracks in plate of infinite width. (c) For predicting the path of crack extension all the three fracture criteria are in good agreement with each other. They predict the paths of crack extension lie within the experimentally observed scatter range. 8 Refs.

Ukadgaonker, V.G. (Indian Inst of Technology, Bombay, India); Hargopurkar, S.M.; Maiti, S.K. *Int J Fract* v 37 n 2 Jun 1988 p R27-R30.

**080704 RIGID BODY ROTATION SURROUNDING THE CRACK.** An analysis of the rigid body rotation is presented which is based on the conventional Westergaard function and the stress function in complex form. The crack opening displacement is obtained on the basis of rotation at points lying on the crack edge. Using an expression of rotation near the crack tip, the rotation at the Dugdale's crack tip plastic zone is shown to be a material constant. With the help of an analysis of rotation for the elastic region, the distribution of rotation in cracked plates having finite width are obtained. (Author abstract). 8 Refs.

Bhattacharya, A. (Banaras Hindu Univ, Varanasi, India); Kishor, B. *Eng Fract Mech* v 30 n 4 1988 p 451-459.

**080705 BOUNDING APPROACH TO THE BIFURCATION POINT OF ANNULAR PLATES WITH NONASSOCIATED FLOW LAW SUBJECTED TO UNIFORM TENSION AT THEIR OUTER EDGES.** A boundary approach based on numerical procedure is developed to investigate the bifurcation behavior of nonuniformly stressed solids obeying the nonassociated flow law. An improved lower bound to the bifurcation point is determined by optimizing a positive parameter  $r$  in the linear comparison solid. Accuracy of the obtained lower bound is examined by the upper bound analysis. The nonaxisymmetric bifurcation behavior of pressure-sensitive and dilatant annular plates subjected to uniform tension at their outer edges has been analyzed. The results indicate that the optimization of the parameter  $r$  is essential in achieving considerable improvement of the lower bound to the bifurcation point. Nonassociatedness always destabilizes the deformation. Furthermore, the effect of work hardening rate and yield stress on the bifurcation behaviors has been clarified. (Author abstract). 14 Refs.

Tomita, Yoshihiro (Kobe Univ, Jpn); Shindo, Akio; Fatnassi, Abdelmajid. *Int J Plast* v 4 n 3 1988 p 251-263.

**080706 ISOPARAMETRIC ECCENTRICALLY STIFFENED PLATE BENDING ELEMENT.** An 8 noded, eccentrically stiffened, plate bending element is introduced. The formulation allows for any number of stiffeners arbitrarily orientated within a plate element without disturbing their individual properties and positions. This is a distinct improvement over conventional lumped stiffener modeling and equivalent orthotropic plate theory and considerably simplifies the modeling of stiffened structures. A technique is also presented which

transforms stiffener positions defined in the global cartesian system to the local, isoparametric coordinates of the plate element which contains the given stiffener. Several examples are given which demonstrate the usefulness of the element. (Author abstract). 11 Refs.

Thompson, P.A. (Univ of Newcastle-upon-Tyne, Newcastle-upon-Tyne, Engl); Bettess, P.; Caldwell, J.B. *Eng Comput (Swansea Wales)* v 5 n 2 Jun 1988 p 110-116.

**080707 ELASTIC-PLASTIC SOLUTION FOR A NORMALLY LOADED CENTER HOLE IN A FINITE CIRCULAR BODY.** A closed-form elastic-plastic stress, displacements and residual stresses solution is given for a normally stressed or displacement-loaded hole in a finite circular plate. The Ramberg-Osgood hardening relationship and Bauschinger effect are accounted for in this solution. The solution is based on  $J_2$  deformation theory and the von Mises yielding criterion. (Author abstract). 14 Refs.

Wang, G.S. (Inst of Aeronautical Materials, Beijing, China). *Int J Pressure Vessels Piping* v 33 n 4 1988 p 269-284.

**080708 EFFECT OF A STIFFENER ON A CRACKED PLATE UNDER SKEW-SYMMETRIC LOADING.** In this paper, the title problem is studied by using Reissner's transverse shear theory. The main purpose of the paper is to investigate the effect of a stiffener on the stress intensity factors in plates under twisting moments and/or transverse shear loads. The asymptotic stress state near the crack tip terminating at the stiffener is examined, and normalized Mode II and Mode III stress intensity factors are tabulated for various crack geometries. The results also include the effect of Poisson's ratio, stiffness constants and material orthotropy for specially orthotropic materials on the stress intensity factors. (Author abstract). 8 Refs.

Yahsi, O.S. (Middle East Technical Univ, Ankara, Turk); Karakurt, A.O. *Int J Pressure Vessels Piping* v 33 n 5 1988 p 385-403.

**Structural Analysis** See Also BEAMS AND GIRDERS—Structural Analysis; COMPOSITE STRUCTURES; SANDWICH STRUCTURES—Structural Analysis; STRUCTURAL ANALYSIS—Computer Applications; WELDS—Defects.

**080709 ANALYSIS OF CONTINUUM BY THE INTEGRATED FORCE METHOD.** The novel formulation termed the integrated force method (IFM) has been established for finite element discrete analysis. In this paper we have extended the IFM for the analysis of continuum taking circular plate as the example. The primary variables of the analysis are moments. All the continuum equations (equilibrium equations and compatibility conditions) in the field and on the boundary are obtained in moments from the stationary condition of the variational functional of the IFM. A new stress function required for the functional is defined. The variational functional yields the known equations along with the novel boundary condition identified as the boundary compatibility condition. The moment solution for the plate problem is obtained without any recourse to displacements either in the field or on the boundary. From moments, displacements are obtained by integration and boundary displacement continuity conditions. The IFM solution and boundary compatibility conditions are verified using S.P. Timoshenko's work and finite element displacement method. (Author abstract) 16 Refs.

Patnaik, S.N. (ISRO, Bangalore, India); Nagaraj, M.S. *Comput Struct* v 26 n 6 1987 p 899-905.

**080710 REFINED ANALYSIS OF LAMINATED PLATES BY FINITE ELEMENT DISPLACEMENT METHODS - I. FUNDAMENTALS AND STATIC ANALYSIS.** This and a companion paper present a local finite element model based on a refined approximate theory for thick anisotropic laminated plates. The three-dimensional problem is reduced to a two-dimensional case by assuming piecewise linear variation of the in-plane displacements  $u$  and  $v$  and a constant value of the

lateral displacement  $w$  across the thickness. By using a substructuring technique the present model is demonstrated to be practical and economical. The static bending stresses, transverse shearing stresses and in-plane displacements are predicted in the present paper. (Edited author abstract) 18 Refs.

Owen, D.R.J. (Univ of Wales, Swansea, Wales); Li, Z.H. *Comput Struct* v 26 n 6 1987 p 907-914.

**080711 REFINED ANALYSIS OF LAMINATED PLATES BY FINITE ELEMENT DISPLACEMENT METHODS - II. VIBRATION AND STABILITY.** A refined anisotropic laminated plate bending analysis is presented in a companion paper to the present work. In the present paper, a refined transverse vibration and buckling analysis based on the same local model is presented. The numerical examples presented are compared with analytical solutions and classical plate theory and it is demonstrated that the present model predicts a realistic laminate global response. (Author abstract) 9 Refs.

Owen, D.R.J. (Univ of Wales, Swansea, Wales); Li, Z.H. *Comput Struct* v 26 n 6 1987 p 915-923.

**080712 ORTHOTROPIC VON KARMAN PLATES USING HIGHER ORDER ELEMENTS.** The nonlinear behavior of orthotropic plates subject to transverse loading is studied in this paper using higher order finite elements. The formulation procedure for elements with up to 25 nodes is established and derivation of the tangential stiffness matrix based on the classical von Karman nonlinear theory is presented. The Newton-Raphson method of solving nonlinear equations is adopted to obtain the final state of equilibrium of the system. (Edited author abstract) 22 Refs.

Chan, Hon Chuen (Univ of Hong Kong, Hong Kong); Chung, Wai Cheong. *Eng Struct* v 9 n 4 Oct 1987 p 225-232.

**080713 ASM SOLUTION OF STIFFENED SECTOR PLATES.** This study extends the application of the Analytical Strip Method (ASM) of solution to stiffened sector plates. The plate is idealized as a system of horizontally curved plate strips and beam or rib segments rigidly connected to each other. The behavior of the system is derived by imposing the edge and continuity conditions on the closed-form solutions of the individual plate strips and beam elements. The method is applicable to plate-stiffener systems subjected to various loading conditions and with different boundary conditions along the straight and circular edges. The advantage of the ASM solution over the 'equivalent' orthotropic plate substitute is that unequally spaced stiffeners and stiffeners of different cross-sectional properties can be introduced in the solution. Results are presented for stiffened sectors with different edge and loading conditions. (Author abstract) 18 Refs.

Harik, Issam E. (Univ of Kentucky, Lexington, KY, USA); Haddad, Bassam F. *J Eng Mech* v 113 n 12 Dec 1987 p 1809-1825.

**080714 EFFECT OF CRACK ON RIDGE OF PLATE STRUCTURE.** The present study is concerned with the membrane and bending stresses induced in a folded plate in the presence of a crack at the ridge of the folded plate. The classical method of solving dual integral equations by converting them into singular integral equations is applied for determination of stresses in a folded plate structure which is weakened by a crack. The crack is located along the ridge of the folded plate structure whose behavior is governed by the coupled set of equations pertaining to bending and stretching deformations. The presence of the crack leads to the formation of a system of dual integral equations with Cauchy



kernels. These are solved numerically by applying the Chebyshev integration formula in conjunction with certain collocation techniques. (Author abstract) 12 refs.

Gordji, Sohrab S. (Univ of Mississippi, University, MS, USA); Chatterjee, S.N.; Prasad, S.N. *J Eng Mech* v 113 n 12 Dec 1987 p 1933-1944.

**080715 VISCOELASTIC PLATE RESTING ON FLUID.** This paper concerns a specific problem in the study of dynamic response of a thin viscoelastic plate in contact with incompressible and inviscid fluid. The plate is subjected to time dependent load. Laplace transform is used to calculate the lateral displacement. The frequency is assumed to be low and the fluid is deep. Both the fluid and the applied force are always in contact with the plate. Numerical results are discussed with respect to the density ratio of the fluid and the plate and depth of the fluid. 8 refs.

Nassar, M. (Cairo Univ, Egypt). *Int Shipbuild Prog* v 34 n 397 Sep 1987 p 166-169.

**080716 3D STRESS FIELD AT THE INTERSECTION OF A HOLE AND A FREE SURFACE.** It is well known that at the vertex of a sector plate, in stretching and in bending, unbounded stresses may occur for certain vertex angles. The author in this paper investigates the analytical stress field in the neighborhood of the intersection of a hole and a free boundary. Utilizing the form of a general 3D solution, which was constructed in a previous paper, he recovers the explicit displacement and stress fields in this neighborhood. Moreover, the analysis shows the complementary solution to be proportional to  $\rho^{\alpha-2}$ , where  $\alpha$  is independent of the Poisson's ratio  $\nu$ . Interestingly enough the first root is exactly that obtained by the William's solution for a 90 deg corner with free-free of stress boundaries. (Edited author abstract) 6 refs.

Folias, E.S. (Univ of Utah, Salt Lake City, UT, USA). *Int J Fract* v 35 n 3 Nov 1987 p 187-194.

**080717 ANALYSIS OF AXISYMMETRICALLY LOADED ANNULAR PLATES USING GREEN'S FUNCTIONS.** A boundary integral formulation for the analysis of elastic annular plate bending under axisymmetrical loads is developed using Green's functions. Here, the general two dimensional plate bending integral formulation is reduced to a one dimensional problem. This is achieved using a ring-type Green's function. Several case studies are examined and the results are shown to be in excellent agreement with those obtained using analytical solutions. (Author abstract) 8 refs.

Moshaiov, A. (MIT, Cambridge, MA, USA); Eareckson, P.D. *Comput Struct* v 28 n 1 1988 p 59-66.

**080718 COMPREHENSIVE ANALYSIS OF THE STATE OF STRESS OF ELASTIC ANISOTROPIC FLAT PLATES USING REFINED THEORIES.** This paper establishes, on a quantitative basis, the correlation between two apparently different higher-order theories of anisotropic plates. In addition it provides a strong mathematical tool allowing one to determine, in an exist and unified manner, the state of stress of orthotropic shear deformable rectangular plate exhibiting a variety of edge conditions. (Author abstract) 20 refs.

Librescu, L.; Khdeir, A.A.; Reddy, J.N. *Acta Mech* v 70 n 1-4 Dec 1987 p 57-81.

**080719 FATIGUE LIFE AND CRACK THROUGH THICKNESS BEHAVIOR OF A SURFACE-CRACKED PLATE: (FOR THE CASE OF TENSILE LOAD).** A fatigue crack Propagation test was carried out on HT80 and mild steel, and crack through thickness behavior was examined in detail, both experimentally and analytically. The major results are as follows. 1) The fatigue crack shape before penetrating the whole thickness is almost semicircular, and the measured aspect ratio is larger than the value obtained by calculation using the K value proposed by Newman-Raju. 2) It is found that the crack growth behavior on the back surface, i.e., the growth behavior of cracks after they have run through the plate, is unique and can be divided into three stages, a, b and c.

3) The fatigue crack growth rate at the stage b is constant for a wide range and is in direct proportion to the n-th power of the range of stress,  $\Delta\sigma$ . 4) A new model has been proposed to evaluate the K value after cracking through the plate thickness. 5) The K value proposed by the authors makes it possible to explain quantitatively the particular behavior of cracks after they have run through the plate. (Author abstract) 10 refs.

Ando, Kotoji (Yokohama Natl Univ, Yokohama, Jpn); Fujibayashi, Shinpei; Nam, Ki Woo; Takahashi, Masayuki; Ogura, Nobukazu. *JSMIE Int J* v 30 n 270 Dec 1987 p 1898-1905.

**080720 DYNAMIC RESPONSES OF ORTHOTROPIC PLATES UNDER MOVING MASSES.** The problem considered is that of heavy masses moving on lightweight rectangular plates of orthotropic materials, slated for use in space structures. The dynamic equation of motion for orthotropic plates which contains singularities in both space and time variables is first presented. The response is expressed as a summation of double series of eigenfunctions. The equation of motion is transformed into an integro-differential equation for modal amplitudes using the Green's function. The effect of orthotropy on natural frequencies and dynamic responses is demonstrated. (Edited author abstract)

Agrawal, O.P. (Southern Illinois Univ at Carbondale, Carbondale, IL, USA); Stanisic, M.M.; Saigal, S. *Ing Arch* v 58 n 1 1988 p 9-14.

**080721 DAMPED RESPONSE OF THIN PLATES TO STEP LOADS INCLUDING GEOMETRIC NONLINEARITY.** This paper presents an approximate solution of the large deflection damped response of thin isotropic circular and rectangular plates subjected to step loads. Simply-supported and clamped plates with movable and immovable inplane conditions are considered. Von Karman-type equations are employed in terms of the transverse deflection and the stress function. The deflection is approximated by a one-term spatial shape function and Galerkin's method is used to obtain the differential equation for the central deflection. (Edited author abstract) 6 refs.

Dumir, P.C.; Bhaskar, A. *Ing Arch* v 58 n 2 1988 p 81-88.

**080722 LARGE DEFLECTION ANALYSIS OF ORTHOTROPIC PLATES - ADAPTATION OF COAN'S METHOD.** The problem considered is the elastic large deflection analysis of thin, rectangular, specially orthotropic plates with two axes of symmetry. Coan's method for allowing the prescription, for isotropic plates, of the in-plane tensile or compressive loading along two opposite edges, is adapted to deal with orthotropic plates. This analysis has been incorporated into an existing computer program (ELDAROP), and the results agree well with previous work on isotropic plates. Results are given for the post-buckling of square orthotropic plates under uniaxial in-plane compression. These confirm that if the unloaded edges are maintained straight, the post-buckled stiffness increases, and this effect decreases as the modular ratio increases. (Author abstract) 9 refs.

Little, G.H. (Univ of Birmingham, Birmingham, Engl). *Int J Mech Sci* v 30 n 1 1988 p 31-42.

**080723 BUCKLING AND VIBRATION OF SHEAR DEFORMABLE PRISMATIC PLATE STRUCTURES BY A COMPLEX FINITE STRIP METHOD.** A finite strip method is presented for the determination of buckling stresses and natural frequencies of vibration of prismatic plate structures assembled from plate flats, which generally are laminates of fibre-reinforced composite material. The finite strip method is of the single-term type, corresponding to the assumption of sinusoidal longitudinal spatial variation of displacement and force quantities. Anisotropic material behaviour and applied in-plane shear stress are accommodated by expressing the strip displacement field in terms of complex quantities. The out-of-plane properties of plate flats are based upon the use of first-order shear deformation plate theory. A family of finite strip models is described and a sub-structure

turing procedure is utilized to reduce the size of the eigenvalue problem. Presented numerical results reveal the high accuracy and good convergence characteristics of the method, as well as indicating the influence of through-thickness shear effects in a range of circumstances. (Author abstract) 27 refs.

Dawe, D.J. (Univ of Birmingham, Birmingham, Engl); Craig, T.J. *Int J Mech Sci* v 30 n 2 1988 p 77-99.

**080724 FINITE ELEMENT TRANSIENT DYNAMIC ANALYSIS OF ISOTROPIC AND FIBRE REINFORCED COMPOSITE PLATES USING A HIGHER-ORDER THEORY.** A higher-order shear deformable  $C^1$  continuous finite element is developed and employed to investigate the transient response of isotropic, orthotropic and layered anisotropic composite plates. The governing ordinary linear differential equations are integrated using the central difference explicit time integration scheme. A special mass matrix diagonalization scheme is adopted which conserves the total mass of the element and includes the effects due to rotary inertia terms. Numerical results for deflections and stresses are presented for rectangular plates under various boundary conditions and loadings. The parametric effects of the time step, finite element mesh, lamination scheme and orthotropy on the transient response are investigated. The numerical results are compared with those obtained by solving the same problems using the Mindlin plate element. (Edited author abstract) 24 refs.

Kant, T. (Indian Inst of Technology, Bombay, India); Ravichandran, R.V.; Pandya, B.N.; Mallikarjuna. *Compos Struct* v 9 n 4 1988 p 319-342.

**080725 ANALYTICAL STRIP METHOD OF SOLUTION FOR STIFFENED RECTANGULAR PLATES.** The recently developed analytical strip method of solution for bending of orthotropic rectangular plates is extended in this study to stiffened rectangular plates. In this method, the plate is idealized as a system of plate strips and beam segments rigidly connected to each other. The behavior of the system is derived by imposing the edge and continuity conditions on the closed form solution of the individual plate strips and beam elements. The analytical strip method possesses the advantages of the semi-analytical finite strip method but avoids the polynomial representation and minimization procedure associated with it. Numerical results are presented for stiffened and unstiffened rectangular plates for different edge and loading conditions. (Author abstract) 9 refs.

Harik, Issam E. (Univ of Kentucky, Lexington, KY, USA); Salamoun, Ghassan L. *Comput Struct* v 29 n 2 1988 p 283-291.

**080726 FINITE ELEMENT ANALYSIS OF A LAMINATED COMPOSITE PLATE SUBJECTED TO CIRCULARLY DISTRIBUTED CENTRAL IMPACT LOADING.** A two dimensional finite element analysis has been made for a fiber-reinforced composite laminate subjected to circularly distributed impact load which results, for example, from impacting the plate with a blunt-ended projectile. A finite element displacement model which includes the effects of transverse shear deformation and rotary inertia was used along with Hamilton's principle to derive the finite element matrices. Newmark's direct integration technique was used to integrate with respect to time. The interaction force between the projectile and the plate was calculated by using the Hertzian law of contact. Results for laminate deformations are shown to compare quantitatively with experimental results. Numerical values for stresses in the plate were calculated. (Author abstract) 16 refs.

Aggour, H. (Univ of Florida, Gainesville, FL, USA); Sun, C.T. *Comput Struct* v 28 n 6 1988 p 729-736.

**080727 CZESTOSCI WLASNE LAMINOWANYCH PLYT PROSTOKATNYCH.** [Free Flexural Oscillations of Laminated Rectangular Plates]. Free flexural vibrations of laminated rectangular plates are described



according to the theory of plates taking into consideration transverse shear deformations and rotatory inertia. The influences of fiber orientations, number of layers as well as plate stiffness on the spectrum of modes and natural frequencies are analysed by means of the Galerkin variational method. Numerical examples are presented for simply supported rectangular plates. (Author abstract) 16 refs. In Polish.

Witt, Marek. *Arch Inz Ladowej* v 33 n 1 1987 p 73-84.

**080728 WYKORZYSTANIE PEWNEGO SFOR-MULOWANIA METODY ELEMENTOW BRZEGO-WYCH W OBLICZENIACH PLYT.** [On Using a Version of the Boundary Element Method in Plate Bending Problems]. The thin plate bending problem is reduced to the problem of finding two harmonic functions. The corresponding boundary value problem is solved by a version of the boundary element method. Three examples illustrate the paper. (Author abstract) 15 refs. In Polish.

Sulisz, Wojciech. *Arch Inz Ladowej* v 33 n 3 1987 p 297-305.

**080729 PRZESTRZENNE DRGANIA WLASNE PLYTOWO-SLUPOWYCH KONSTRUKCJI WSPORCZYCH POD MASZYNY.** [Spatial Free Vibrations of Plate-Column Structures Supporting Machines]. A solution to the problem of free vibrations of a system consisting of thin isotropic rectangular plates with free edges with arbitrarily localized columns connecting them as well as of masses elastically connected to the plates is presented. Such a system can be a model for a certain class of structures supporting machines. An approximation consisting of the Ritz method combined with a finite element approach has been formulated and applied. Chebyshev's polynomials have been assumed as Ritz's approximation function. The vibration equation has been formulated basing the energy balance and Lagrange's equation of the second kind. Results of the numerical analysis are presented. (Author abstract) In Polish.

Mironowicz, Wladyslaw. *Arch Inz Ladowej* v 33 n 3 1987 p 307-317.

**080730 TWO-LEVEL FINITE-ELEMENT METHOD FOR THIN PLATES SUBJECT TO CONCENTRATED LOADS.** A thin plate subject to concentrated loads (forces or moments) is customarily analyzed either by fine finite-element mesh or by singular elements. This paper recommends an alternative method using conventional finite elements with fine mesh and reducing the number of unknowns by interpolating the nodal displacements by means of the shape functions associated with the previously mentioned singular elements. New element matrices need not be generated and integration is avoided completely. Accurate results under the point load are achieved by a substantially reduced number of unknowns. Both concentrated forces and moments are considered. Accurate superelements can be formed to study plate systems. The procedure presented in this article results in substantially reduced computational effort, and is therefore specially suited for use on microcomputers. (Author abstract) 8 Refs.

Leung, A.T. (Univ of Hong Kong, Hong Kong); Wong, S.C. *Microcomput Civ Eng* v 3 n 2 Jun 1988 p 127-136.

**080731 CIRCULAR PLATE ON TENSIONLESS WINKLER FOUNDATION.** The equilibrium configurations of a thin circular plate supported on an elastic foundation of Winkler type that reacts in compression only are investigated. The plate is assumed to be subjected to eccentric concentrated load and moment as well as a uniformly distributed load. The solution is accomplished by minimizing the total potential energy of the system. As the coordinate functions for the displacement function of the plate, the free vibration mode shapes of the completely free plate are used by including a rigid translation and a rigid rotation. It is found out that the plate will lift-off when the foundation stiffness is low. The results for the plate on a conventional and tensionless Winkler foundations are given in figures and compared. (Author ab-

stract). 18 Refs.

Celep, Zekai (Tech Univ, Istanbul, Turk). *J Eng Mech* v 114 n 10 Oct 1988 p 1723-1739.

**080732 STATIC, VIBRATION AND STABILITY ANALYSIS OF STIFFENED PLATES USING B SPLINE FUNCTIONS.** An alternative semianalytical approach using B spline functions to analyze static, vibration and stability of stiffened plates is presented. A unified computational scheme well suited for various types of boundary conditions of stiffened plates is formulated. The main features of the present method are that it requires fewer unknowns and is easier to program. Some numerical results are given. (Author abstract) 9 refs.

Shen Peng-Cheng (Hefei Polytechnic Univ, Hefei, China); Huang Dade; Wang Zongmu. *Comput Struct* v 27 n 1 1987, Adv in Comput Struct and Solid Mech, Pap Presented at the First World Cong on Comput Mech, Austin, TX, USA, Sep 22-26 1986 p 73-78.

**080733 COONS' SURFACE METHOD FOR FORMULATION OF FINITE ELEMENT OF PLATES AND SHELLS.** In this paper, we apply the Coons' surface method and fitted function interpolation to fit boundary conditions of the finite element, and obtain different displacement functions of the plate and shell rectangular element. The method is easily implemented and its geometric significance and mechanical conception are quite clear. Both computing technique and operational procedure are relatively unified. It is convenient to formulate conforming elements and high-precision elements, and also may be applied to formulate mixed and hybrid elements. (Author abstract) 15 refs.

Zheng Zhaobei (China Inst of Mining & Technology, Xuzhou, China); Xia Shiqiang. *Comput Struct* v 27 n 1 1987, Adv in Comput Struct and Solid Mech, Pap Presented at the First World Cong on Comput Mech, Austin, TX, USA, Sep 22-26 1986 p 79-88.

**Structural Design** See Also SANDWICH STRUCTURES—Stresses.

**080734 LEAST-WEIGHT DESIGN OF PERFORATED ELASTIC PLATES FOR GIVEN COMPLIANCE: NONZERO POISSON'S RATIO.** In earlier papers, least-weight solutions were derived for perforated elastic plates having (a) a constant thickness, (b) a prescribed compliance value, and (c) a Poisson's ratio of zero value. It was found that the optimal solution for axially symmetric plates always consists of (i) unperforated regions or (ii) regions with ribs in only one (i.e. the radial) direction. In view of extensive recent study of this problem by mathematicians, the conclusions have important implications. In this paper, the foregoing results are extended to plates having a nonzero Poisson's ratio and the theory is illustrated with examples. Two solutions given are valid for both prescribed compliance and prescribed deflections. This investigation shows that in some unconstrained shape optimization problems the optimal solution cannot be obtained by conventional numerical (e.g. finite element) methods. (Edited author abstract) 20 refs.

Ong, T.-G. (Monash Univ, Clayton, Aust); Rozvany, G.I.N.; Szeto, W.-T. *Comput Methods Appl Mech Eng* v 66 n 3 Feb 1988 p 301-322.

**080735 LASTUNABHAENGIGE FORMAENDERUNG VON PLATTENARTIGEN BAUTEILEN.** [Load-Independent Changes in the Shape of Slab-Like Building Components]. When manufacturing single- and multi-layer floor and wall slabs made of concrete and reinforced concrete, as well as during use of these building components, concrete shrinkage and changes in temperature result in both one-off and recurring load-independent alterations to the shape and in permanent cracks which can constitute reprehensible defects when all unfavorable influencing factors occur simultaneously. The paper describes the causes leading to these changes, as well as the measures which can be taken to prevent and remedy these defects. (Edited author abstract) In German. 22 refs.

Linder, Richard (Deutschen Beton-Vereins EV, Baden-Wuerttemberg, West Ger). *Beton Stahlbetonbau* v 83 n 3 Mar 1988 p 75-81.

**080736 NONLINEAR DYNAMIC RESPONSE OF ISOTROPIC THIN RECTANGULAR PLATES ON ELASTIC FOUNDATIONS.** An approximate analytical solution of the large deflection dynamic response of isotropic thin rectangular plates resting on Winkler, Pasternak and nonlinear Winkler foundations is presented. Von Karman type governing equations in terms of the transverse deflection and stress function are employed. The deflection is approximated by a one term shape function satisfying the boundary conditions. The Galerkin's method is used to get the differential equation for the deflection at the center. (Edited author abstract) 11 refs.

Dumir, P.C. *Acta Mech* v 71 n 1-4 Feb 1988 p 233-244.

**080737 DESIGN OF 8-BOLT STIFFENED MOMENT END PLATES.** This paper presents two design procedures for the 8-tension bolt, stiffened, extended, moment end plate. The resulting end-plate design will be satisfactory for use in Type I construction (rigid-frame) as defined in one of the paper's references or, with appropriate modifications, as an FR type (fully restrained) connection as defined in the load and resistance factor design notation. With bolt size limited to a maximum of 1 1/2 in. dia., the configuration is capable of developing the full moment capacity of most available hot rolled beam sections. The two design procedures are limited to use with A36 steel and A325 bolts. 7 Refs.

Murray, Thomas M. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Kukreti, Anant R. *Eng J Am Inst Steel Constr* v 25 n 2 1988 p 45-52.

**080738 DESIGN EQUATION FOR THE COMPRESSIVE STRENGTH OF UNSTIFFENED PLATE ELEMENTS WITH INITIAL IMPERFECTIONS.** A review is made of equations that have been proposed for the design of ship plates subjected to compressive loads. The effect of the various parameters is quantified showing that a design method should account explicitly for plate slenderness, residual stresses, initial distortions and boundary conditions. A new equation that includes all of the variables is derived and calibrated with existing results of experiments and of numerical calculations. The uncertainty associated with the use of the equation is also quantified. (Author abstract). 32 Refs.

Guedes Soares, C. (Technical Univ of Lisbon, Lisbon, Port). *J Constr Steel Res* v 9 n 4 1988 p 287-310.

**080739 OPTIMUM COMPLIANCE DESIGN OF STIFFENER LAYOUT OF THIN PLATE.** An optimum design technique of the stiffener layout which gives minimum compliance is developed. A thin plate with stiffeners is treated as an anisotropic plate of pseudo-continuous structure, and is discretized into the finite elements. The minimum compliance design subjected to the constant volume, in which the distributions of angles of the stiffener arrangement and the stiffener densities are varied, is determined by the recursive quadratic programming technique. By applying this design technique, the optimum layouts of the stiffener of the rectangular plate under some typical loading and supporting conditions are obtained. (Author abstract). 8 Refs. In Japanese.

Yamazaki, Kouetsu; Kobayashi, Atsushii. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 501 May 1988 p 1165-1171.

**Surfaces** See HEAT TRANSFER—Mathematical Models; TEMPERATURE DISTRIBUTION—Calculations.

**Testing** See COMPOSITE STRUCTURES; FOUNDATIONS—Anchorage; STEEL TESTING—Fracture; WOODEN CONSTRUCTION—Connections.

## Theory

**080740 GENERAL ASYMPTOTIC APPROXIMATION TO THE NONLINEAR THEORY OF THIN ELASTIC PLATES.** The aim of this work is to construct



the general asymptotic nonlinear theory of thin elastic anisotropic plates undergoing large transverse deflection. We try to develop a scheme which determines the terms of any desired order in the asymptotic analysis. To this end, the nonlinear field equations on which an asymptotic expansion will be briefly recapitulated. Then, assuming an appropriate asymptotic expansion for the displacement vector and the stress tensor, the consistent  $n$ th order equations are derived. For the zeroth and first order approximations the maximum deflections are given. It is observed that first order corrections to the zeroth order solution are negligible in relatively thin plates. 3 refs.

Erbay, Husnu A. (TUBITAK, Gebze, Turk); Suhubi, Erdogan S. *Bull Tech Univ Istanbul* v 38 n 2 1985 p 247-272.

**080741 ASYMPTOTIC THERMOELASTIC BEHAVIOR OF FLAT PLATES.** The present study is devoted to the dynamic behavior of a three-dimensional linearly thermoelastic flat plate. Specifically, a three-dimensional flat plate with small thickness is submitted to an arbitrary system of initial and loading conditions. The limits of the displacement, stress, and temperature fields as the thickness approaches zero are investigated. Thermoelastic behavior is characterized by a coupling between the mechanical equations of motion and the 'energy' equation. The limiting procedure is seriously affected by the presence of the coupling terms. The initial conditions are seen to play an essential role in the analysis. In particular, a change of initial condition generally occurs for the temperature field. A similar phenomenon appears in the homogenization of a thermoelastic composite. These concurring results seem to indicate that such shifts in initial data are closely linked to any kind of asymptotic problem for coupled systems. 12 refs.

Blanchard, D. (Lab Central des Ponts et Chaussées, Paris, Fr); Francfort, G.A. *Q Appl Math* v 45 n 4 Dec 1987 p 645-667.

**080742 ON THE SOLUTIONS OF CLAMPED REISSNER-MINDLIN PLATES UNDER TRANSVERSE LOADS.** The governing equations in the Reissner-Mindlin theory may be written in a form such that a small parameter  $\epsilon$  is involved. This parameter  $\epsilon$  depends on a combination of the shear modulus and the plate thickness. The governing equations are singularly perturbed with respect to  $\epsilon$ . However, as  $\epsilon$  approaches 0 one does recover the biharmonic equation of the classical plate theory. In a previous work of ours the behavior of solutions for clamped Reissner-Mindlin plates as  $\epsilon$  approaches 0 was studied and it was shown there that these solutions tend continuously, in various functional norms, to their corresponding solutions in the classical plate theory. This paper deals with two specific questions concerning the detailed dependence of these solutions on  $\epsilon$  as  $\epsilon$  approaches 0. We shall show the nonexistence of regular asymptotic expansions of the solutions in integral powers of  $\epsilon$  for general clamped Reissner-Mindlin plates. We shall also construct an exact solution for a circular plate which exhibits dependence on fractional powers of  $\epsilon$ . This latter solution shows a boundary layer phenomenon, decaying away from the boundary, often encountered in singular perturbation problems. (Author abstract) 8 refs.

Assifi, Thomas C. (EDS, Southfield, MI, USA); Yen, David H.Y. *Q Appl Math* v 45 n 4 Dec 1987 p 679-690.

**080743 THICKNESS EFFECT ON THE SPECTRAL PROPERTIES OF THICK PLATES.** This paper shows the effect of plate thickness on the spectral properties of the stiffness matrix which is obtained from finite element representation. The results confirm the very stiff properties associated with the strain energy based on Reissner and Mindlin theories in the case of thin plates. On the other hand, the Bergan and Wang approach converges to exactly the classical thin plate solution as the thickness decreases. (Author abstract) 10 refs.

Hassan, Kamal (Ministry of Higher Education, Cairo, Egypt). *Commun Appl Numer Methods* v 4 n 1 Jan-Feb 1988 p 1-4.

**080744 STIFFENED PLATES SUBJECT TO TRANSVERSE LOADING.** The generalized conditions under which stiffened plates can be approximated as a two-dimensional continuum are investigated and identified. A simplified set of constitutive equations defining the full class of problems described above, subject to elastic behavior, are then obtained by making suitable assumptions. The significance of these assumptions is investigated under a wide range of conditions, and the results calculated for typical problems using the simple theory. The simple theory is then amended to allow consistently for the effects due to Poisson's ratio in the stiffeners. A study of the resulting equations indicates that whilst the normal assumption of centroidal neutral axes is justified under all conditions, the additional strain energy generated in the stiffeners can be significant, and that under the assumption of centroidal neutral axes this is readily included in the formulation without penalty. (Edited author abstract) 19 refs.

Boot, J.C. (Univ of Bradford, Bradford, Engl); Moore, D.B. *Int J Solids Struct* v 24 n 1 1988 p 89-104.

**080745 INDIRECTLY DERIVED INTEGRAL EQUATION SYSTEM FOR SIMPLY SUPPORTED REISSNER PLATES.** Three new indirectly derived integral equations for Reissner plates with simply supported boundaries are presented. Layers of statical and of geometrical singularities are used to generate integral equations suitable for numerical applications. Based on investigations of the spectra of integral operators, some criteria for the choice of the singularities, and thus of adequate integral equations, are known in the case of plane elastostatic but not, as yet, for the equations presented here. Therefore, a known fact is used as a criterion: The numerical solution of integral equations of the first kind can be problematic. 9 refs.

Antes, H. (Ruhr Univ Bochum, Bochum, West Ger). *Mech Res Commun* v 13 n 2 Mar-Apr 1986 p 63-69.

**080746 HYBRID FINITE STRIP ANALYSIS OF MULTILAYER LAMINATED PLATES.** A rigorous analysis of the behavior of multilayer laminated plates must take into consideration the heterogeneity through the thickness of the laminate. As it well-known, negligence of the through-thickness effect by the classical laminated plate theory may result in an unreliable estimation of the stress distribution in the laminates. (Edited author abstract) 24 refs.

Tarn, Jiann-Quo (Nat'l Cheng Kung Univ, Tainan, Taiwan); Sa, Dong-Lung. *Chung kuo Kung Ch'eng Hsueh K'an* v 10 n 6 Nov 1987 p 647-656.

**080747 COMPARISON OF MINDLIN AND LEVINSON PLATE THEORIES.** The purpose of this research is to compare R.D. Mindlin and M. Levinson plate theories for the specific case of the axisymmetric vibrations of thick circular plates. Both free and clamped conditions are considered. It is shown that the two theories are identical. They simply represent different approaches which lead to identical results. (Edited author abstract) 9 refs.

Hutchinson, James R. (Univ of California, Davis, CA, USA). *Mech Res Commun* v 14 n 3 May-Jun 1987 p 165-170.

**080748 MIXED FINITE ELEMENT FORMULATION FOR REISSNER-MINDLIN PLATE THEORY: UNIFORM CONVERGENCE OF ALL HIGHER-ORDER SPACES.** A new mixed finite element formulation of Reissner-Mindlin theory is presented which improves upon the stability properties of the Galerkin formulation. General convergence theorems are proved which are uniformly valid for all values of the plate thickness, including the Poisson-Kirchhoff limit. As long as the dependent variables are interpolated with functions of sufficiently high order, the formulation is convergent. No special devices are required. (Author abstract) 23 refs.

Hughes, Thomas J.R. (Stanford Univ, Stanford, CA, USA); Franca, Leopold O.P. *Comput Methods Appl Mech Eng* v 67 n 2 Mar 1988 p 223-240.

**080749 SIMPLE INFINITE ELEMENT FORMULATION OF A HIGHER-ORDER THEORY FOR UNSYMMETRICALLY LAMINATED COMPOSITE PLATES.** A higher-order theory which satisfies zero transverse shear stress conditions on the bounding planes of a generally laminated fibre-reinforced composite plate subjected to transverse loads is developed. The displacement model accounts for non-linear distribution of in-plane displacement components through the plate thickness and the theory requires no shear correction coefficients. A  $C^0$  continuous displacement finite element formulation is presented and the coupled membrane-flexure behaviour of laminated plates is investigated. The simple isoparametric formulation developed here is capable of evaluating transverse shears and transverse normal stress accurately by using the equilibrium equations. The accuracy of the nine-noded Lagrangian quadrilateral element is then established by comparing the present results with the closed-form, three-dimensional elasticity and other finite element available solutions. 14 refs.

Kant, T. (Indian Inst of Technology, Powai, India); Pandya, B.N. *Compos Struct* v 9 n 3 1988 p 215-246.

**080750 CONTRIBUTION TO PLATE THEORY.** In this contribution a method for obtaining refined theories of elastic plates is suggested. It is an iterative method in which the three-dimensional elastic theory is approximated by a plate theory within the prescribed accuracy. The first iteration of the order  $O(h^4)$ , where  $h$  is the thickness of the plate, gives a theory identical to the classical theory. The second iteration of the order  $O(h^6)$  gives for sufficiently smooth and slowly varied pressure function  $p$  the approximation identical to the Reissner or the Khatadadjan theories.

Franek, Alexander. *Z Angew Math Mech* v 68 n 4 1983 p T184-T185.

**080751 INVERSE PROBLEM SOLUTIONS VIA PLATE THEORY WITH APPLICATIONS TO POSITION AND FORCE SENSING.** Theory of plates is employed to solve inverse problems in elasticity with specific applications to position and force sensing. The term 'inverse problems' implies the determination of position, distribution and magnitude of loads applied by an object on an elastic element, if strains are known at several locations of the element. Both analytical and numerical methods are presented. The analytical method presented is limited to rectangular plates having two opposite edges simply supported and uniform distribution in the loaded region. Inverse problems for different types of loading conditions are solved and simulated by computer. By assuming that strains at some locations are known, computer simulation results obtained by both analytical and numerical techniques are compared with exact solutions. The results thus obtained are quite good. Finally, strains were measured to verify the inverse problem solutions. 5 Refs.

Lin, P.P. (Cleveland State Univ, Cleveland, OH, USA). *J Appl Mech Trans ASME* v 55 n 2 Jun 1988 p 489-491.

**080752 ON BOUNDARY ELEMENTS FOR REISSNER'S PLATE THEORY.** A direct boundary element formulation for Reissner's plate bending theory is reviewed and found to be also applicable to external problems in infinite plates. The formulation bears close resemblance with the standard plane strain boundary element implementation producing singular integrals of the same order. The numerical implementation is carried out for quadratic elements with complete freedom of local nodal positioning within the elements (i.e. continuous, discontinuous and semi-continuous elements are used, including the possibility of double nodes). Numerical examples are presented to demonstrate the accuracy of the procedure. (Author abstract). 17 Refs.

Karam, V.J. (Univ Federal do Rio de Janeiro, Rio de Janeiro, Brazil); Telles, J.C.F. *Eng Anal* v 5 n 1 Mar 1988 p 21-27.



**080753 INVESTIGATION OF FIXED-FREE ANULAR PLATE RESONANT FREQUENCY PREDICTIONS.** Nondimensional frequency parameters for predicting the resonant frequencies of annular plates with fixed-free boundary conditions as the plate inner to outer radius ratio approaches parameters have been investigated experimentally. Frequency parameters have been determined by using modal analysis to measure resonant frequencies for annular plates of varied materials, thicknesses, and with radius ratios of 0.5 to 0.9. The data are compared to two different analytical frequency predictions which have been presented as solutions for resonance of fixed-free annular plates based on classical elastic plate theory. (Author abstract) 6 Refs.

Flatau, Alison (Univ of Utah, Salt Lake City, UT, USA); Flandro, G.A.; Van Moorhem, W.K. *J Vib Acoust Stress Reliab Des* v 110 n 3 Jul 1988 p 408-410.

**080754 OPERATOR REPRESENTATION OF THE LAME SYSTEM AND LIMITING BOUNDARY VALUE PROBLEMS FOR THIN PLATE THEORY.** An elastic problem is studied for an inhomogeneous anisotropic body in a thin region. An asymptotic representation of an exact solution is constructed. The effective characteristics of the rigidity of a thin plate are derived. (Edited author abstract) 4 Refs.

Zorin, I.S. *Leningrad Univ Mech Bull* n 4 1987 p 62-63.

#### Thermal Conductivity

**080755 THERMAL CONDUCTIVITY MEASUREMENT WITH THE PLATE APPARATUS: INFLUENCE OF THE GUARD RING WIDTH ON THE ACCURACY OF MEASUREMENT.** The temperature field in circular and square plate test specimens is calculated and thereby the error from the heat exchange at the outer edge of the guard ring derived for single and double plate devices contact. The error is shown to be proportional to the reduced temperature difference. Experiments on an extruded foam confirm the results of the analytical calculations. Diagrams and tables which are developed on the basis of the above derived relationships make possible estimation of margin of error for different measuring arrangements for plate devices of usual sizes. (Edited author abstract) 3 Refs.

Bode, K.-H. (Physikalisch-Technische Bundesanstalt, Braunschweig, West Ger). *J Therm Insul* v 11 Jul 1987 p 32-53.

#### Thermal Effects See Also STRESSES—Thermal.

**080756 RESPONSE OF SIMPLY SUPPORTED AND CLAMPED CIRCULAR PLATES TO THERMAL IMPACT.** The thermally induced vibrations of simply supported and clamped circular plates are investigated by (1) an analytical method (the method of separation of variables), (2) a numerical method (FEM) and (3) experiments. The appropriateness of the two theoretical methods are verified by comparing them with each other; the agreement with the responses obtained in the experiments is discussed. If these theoretical solutions and experimental data are in good agreement, these theories, including the classic variable-separation method, should be of significance in engineering fields. (Edited author abstract) 8 Refs.

Nakajo, Y. (Univ of Illinois, Urbana, IL, USA); Hayashi, K. *J Sound Vib* v 122 n 2 Apr 22 1988 p 347-356.

#### Thermoelasticity

**080757 THERMOELASTICITY OF A PLATE WITH A THIN-WALLED ELASTIC INCLUSION ALONG AN ARC OF A CIRCUMFERENCE.** The plane problem of heat conduction and thermoelasticity for a plate with a thin-walled elastic inclusion along an arc of a circumference is considered. The problem reduces to systems of two singular integrodifferential equations, whose solution is applicable for inclusions of arbitrary thermal conductivity and rigidity. An approach to the solution of these systems that differs from that of a

previous paper is proposed. A numerical analysis of the stress intensity coefficients is provided. (Edited author abstract) 9 Refs.

Bernar, I.I.; Opanasovich, V.K. *Mech Solids* v 22 n 3 1987 p 164-170.

**Vibrations** See Also BEAMS AND GIRDERS—Vibrations; COMPOSITE MATERIALS—Fiber Reinforced; FLOW OF FLUIDS—Two Phase; FLOW OF FLUIDS—Viscous; MATHEMATICAL TECHNIQUES—Approximation Theory; MATHEMATICAL TECHNIQUES—Variational Techniques; NOISE, ACOUSTIC—Mathematical Models; STRUCTURAL ANALYSIS—Mathematical Models; VIBRATIONS—Absorption.

**080758 AXISYMMETRIC DYNAMIC STABILITY OF A BIMODULUS THICK CIRCULAR PLATE.** The object of the present paper is to investigate the dynamic stability of bimodulus thick circular and annular plates subjected to a combination of a pure dynamic bending and a uniform dynamic extensional stress in the plane of the plate. The Mindlin plate finite element model is established to solve the dynamic stability problems of an axisymmetric circular plate. A ring type element is chosen to approach the axisymmetric problem. The obtained results of the dynamic stability region are shown to be very good when compared with the closed form solutions for ordinary plates. The influences of various parameters on the dynamic stability boundary are studied. (Author abstract) 14 Refs.

Chen, Lien-Wen (Nat'l Cheng Kung Univ, Tainan, Taiwan); Juang, Dar-Ping. *Comput Struct* v 26 n 6 1987 p 933-939.

**080759 FLEXURAL VIBRATION OF RECTANGULAR PLATES WITH POINT SUPPORTS.** Orthogonally generated polynomial functions are used in the Lagrangian multiplier method to study the free, flexural vibration problem of point supported, thin, flat, rectangular plates. The analysis applies to isotropic and specially orthotropic plates having any combination of clamped, simply supported or free edges with arbitrarily located point supports and to plates which are continuous over line supports parallel to the plate edges. Numerical results are presented for a number of specific problems, illustrating the accuracy and versatility of the approach, and which include natural frequencies and nodal patterns for a point supported plate which is continuous over two perpendicular line supports. (Author abstract) 36 Refs.

Kim, C.S. (Univ of Western Ontario, London, Ont, Can); Dickinson, S.M. *J Sound Vib* v 117 n 2 Sep 8 1987 p 249-261.

**080760 FUNDAMENTAL FREQUENCY OF TRANSVERSE VIBRATIONS OF RECTANGULAR PLATES WITH OVERSTEPPED VARIATION OF THE THICKNESS OVER A TRIANGULAR, CORNER-ADJACENT SUBDOMAIN.** The present study deals with the approximate determination of the fundamental frequency of vibration of the structural system by using polynomial co-ordinate functions which satisfy the boundary conditions. The inclusion in the co-ordinate function of an undetermined parameter  $\gamma$  as an exponent allows for minimization of the frequency coefficient when using the Rayleigh-Ritz methodology. 5 Refs.

Laura, P.A.A. (Inst of Applied Mechanics, Puerto Belgrano Naval Base, Argent); Cortinez, V.H.; Bertero, R.; Villaggi, A. *J Sound Vib* v 117 n 2 Sep 8 1987 p 387-389.

**080761 HIGHER FREQUENCIES OF TRANSVERSE VIBRATION OF RECTANGULAR PLATES ELASTICALLY RESTRAINED AGAINST ROTATION AT THE EDGES AND WITH A CENTRAL FREE HOLE.** Numerical and experimental results for the transverse vibration of elastically restrained rectangular plates are compared showing large differences. One reason for this may be the fact that clamping induces in-plane compressive stresses at the outer edge while the inner boundary is stress-free. In other words, a non-uniform state of in-plane stress is generated and this may create severe variations of the frequency values. 2 Refs.

Gutierrez, R.H. (CONICET, Puerto Belgrano Naval Base, Argent); Laura, P.A.A.; Pombo, J.L. *J Sound Vib* v 117 n 1 Aug 22 1987 p 202-206.

**080762 FREE VIBRATION AND FLUTTER OF LAMINATED QUADRILATERAL PLATES.** Free vibration and flutter of laminated quadrilateral plates with clamped edges have been investigated in this paper. Differential equations of motion in quadrilateral coordinates are derived and solved by the use of the integral equation technique. The results of free vibration analysis and flutter are compared with the values given in the available references. The behaviour of trapezoidal plates with different numbers of layers has been studied. (Author abstract) 10 Refs.

Srinivasan, R.S. (Indian Inst of Technology, Madras, India); Babu, B.J.C. *Comput Struct* v 27 n 2 1987 p 297-304.

**080763 NONLINEAR RESPONSE OF ELASTIC PLATES TO PULSE EXCITATIONS.** The dynamic analogue of the Von Karman's equation is used to study the nonlinear response of elastic plates of square and circular geometry with simply supported and clamped-in boundary conditions and immovably constrained and stress-free edge conditions subjected to exponentially decaying (used for an adequate description of a blast load) cosine and exponential asymptotic step pulse excitations. Transformation of the dependent time function such that the solution of a linear system subjected to the same pulse function is used as an additional transforming function brings the time differential equation into a form in which the ultraspherical polynomial approximation technique can be applied to get the nonlinear response. This is compared with the digital solution obtained on the WIPRO-B-200 computing system by using the classical fourth-order Runge-Kutta method. (Author abstract) 7 Refs.

Chandrasekharappa, G. (Indian Inst of Technology, Powai, India); Srirangarajan, H.R. *Comput Struct* v 27 n 3 1987 p 373-378.

**080764 IMPULSIVE RESPONSE OF AN INFINITELY LONG PRESTRESSED THICK STRIP PLATE.** This paper is a study of the dynamic response of an isotropic plate strip to an impulsive load. The plate is of infinite length, simply supported along the edges, resting on a viscoelastic foundation, and is subjected to in-plane stresses parallel and perpendicular to the edges. The problem is studied on the basis of a plate theory, in which the effects of rotatory inertias and shear deformations are retained. Governing equations are solved by applying the methods of the Laplace transform with respect to time, and the Fourier transform with respect to a space variable. The displacement, the bending moment and the dynamic coefficient of the plate are calculated and shown graphically for several values of the initial stress parameters. (Author abstract) In Japanese. 7 Refs.

Nozawa, Naotake; Chonan, Seiji. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 492 Aug 1987 p 1663-1669.

**080765 FREE VIBRATION OF CIRCULAR FOOTING ON ELASTIC FOUNDATIONS.** The free vibration of a circular plate on an elastic foundation is analyzed by using Vlasov's two-parameter model. The natural frequencies of the system under axisymmetric conditions are determined. In the region of the plate, the general solution is represented by Bessel functions. Modified wave equations are used to predict the harmonic motion of the elastic foundation. Since the region outside the plate is infinite, a reflected wave is not produced, thereby eliminating the need to consider a wave moving toward the plate. Finally, the effects of various parameters of the plate and the foundation of the natural frequencies system are discussed. (Author abstract) 6 Refs.

Sargand, S.M. (Ohio Univ, Athens, OH, USA); Sheng, Z.; Das, Y.C. *J Sound Vib* v 118 n 1 Oct 8 1987 p 141-149.



**080766 LOWEST VIBRATION FREQUENCIES OF OBLIQUE-ANGLED PLATES WITH OPENINGS.** The problem is examined of the free vibration of an elastic, isotropic oblique-angled plate restrained around the outer periphery, with random unsupported openings. To solve the problem, the method of solid models is applied using generalized functions. The lowest vibration frequency is studied as a function of the angle of slant. The effect of different shapes of opening on the natural vibration frequency of a parallelogram-shaped plate is studied. (Author abstract) 3 refs.

Abdikarimov, R.A.; Preobrazhenskii, I.N.; Rakhmatov, M.A. *Sov Mach Sci* n 2 1987 p 8-11.

**080767 MUTUAL IMPEDANCE OF AXIALLY-SYMMETRIC MODES OF A CIRCULAR PLATE.** This paper presents an exact calculation of the mutual radiation impedance of axially-symmetric modes of a fixed at the edge circular plate. Linear and harmonic processes in respect to time have been considered and it has been accepted that the plate radiates acoustic waves into a lossless gas medium. Included here expressions for the mutual impedance in the form of single integrals have been adopted on the basis of several simplifying assumptions to numerical calculations for low and high frequencies of radiated waves. Achieved results are used in the analysis of the impedance and sound power radiated by a circular plate excited to vibrate by a known (from the assumption) superficial distribution of the exciting force. (Author abstract) 9 refs.

Rdzanek, Witold (Higher Pedagogical Sch, Rzeszow, Pol). *Arch Acoust* v 11 n 3 1986 p 239-251.

**080768 ROTATORY VIBRATION OF A THIN NON-HOMOGENEOUS CIRCULAR PLATE UNDER SHEARING FORCES.** The finite Hankel transform has been used to obtain the stresses and displacements in a thin non-homogeneous transversely isotropic circular plate with a central hole when it undergoes rotatory vibration under prescribed boundary loadings. The elastic coefficients and density of the material of the plate are assumed to vary as a function of  $r$ , the radial distance from the centre of the plate. (Edited author abstract) 9 refs.

Ranjan Pal, Bhabesh (Univ of Calcutta, Calcutta, India). *Rev Roum Sci Tech Ser Mec Appl* v 32 n 4 Jul-Aug 1987 p 389-396.

**080769 SIMPLE FREQUENCY FORMULA FOR CLAMPED RECTANGULAR PLATES.** A simple formula is proposed to predict the vibration frequencies of completely clamped rectangular plates, of arbitrary aspect ratio, vibrating in any mode. The development is based on experimental evidence obtained using the technique of holographic interferometry. Comparisons are made with both published results from the literature and experimental values obtained by the authors, and show excellent agreement in all cases. (Author abstract) 8 refs.

Mitchell, A.K. (Technical Univ of Nova Scotia, Halifax, NS, Can); Hazell, C.R. *J Sound Vib* v 118 n 2 Oct 22 1987 p 271-281.

**080770 SOME DIDACTICAL AND SOME PRACTICAL REMARKS ON FREE PLATE WAVES.** It is recalled how wave equations can be generated from dispersion relations. The bending wave equation for thin plates including some higher-order terms is obtained by this general method and compared to the corresponding equation of Timoshenko. Further, the dispersion of free plate waves is derived in a concise and elementary manner without using a scalar potential and a vector potential for the displacements. Finally, as a matter of practical interest, exact and approximate expressions for the ratio of parallel to perpendicular displacements at a plate surface are calculated. Under favorable circumstances measurement of this ratio allows decomposing an observed wave into its quasi-longitudinal and bending components. (Author abstract) 12 refs.

Mayenhoelder, W. (Fraunhofer Inst fuer Bauphysik, Stuttgart, West Ger). *J Sound Vib* v 118 n 3 Nov 8 1987

p 531-538.

**080771 COMMENT ON 'LATERAL VIBRATION OF SQUARE PLATES SUBJECT TO IN-PLANE LOADINGS'.** The author of the comment refers to the dependence of the eigenvalues in flexure of a square plate on the form of the in-plane loading. The authors of the commented paper used the finite element method with the plate divided into a number of high performance elements. Some comparative results indicate the good accuracy of the resulting eigenvalues. The purpose of the comment is to give some exact results (i.e., from a theoretical solution which satisfies the governing equations and the boundary conditions), which supply further information on accuracy. 7 refs.

Warburton, G.B. (Univ of Nottingham, Nottingham, Engl). *J Sound Vib* v 118 n 3 Nov 8 1987 p 545-548.

**080772 NATURAL FREQUENCIES OF CIRCULAR PLATES AND THEIR ASYMPTOTIC SERIES.** The asymptotic series for the natural frequencies of the circular plates are first presented to obtain the approximations adequately close to the exact values. Excellent accuracy of the asymptotic series is shown compared with the exact values. For the circular plates having three types of conditions of free, simply supported and clamped boundaries, the complete numerical data with seven significant figures are listed. (Edited author abstract) 17 refs.

Kobayashi, Harutoshi (Osaka City Univ, Jpn); Sonoda, Keiichiro. *Mem Fac Eng Osaka City Univ* v 27 Dec 1986 p 207-228.

**080773 FRAMEWORK FOR EFFICIENT FE VIBRATION SOFTWARE.** A new hybrid stress finite plate vibration capability, providing high accuracy for coarse-meshes is presented with a view to enhancing the behavioral characteristics of the standard hybrid FEM (finite element method). The software meets demands of the real-life user for reliable and cost-objective identification of a wide range of vibration modes. The FE matrices are constructed through the expedient of introducing a system of algorithms which provides an efficient and easily implemented capability that can be translated into any of the existing high level computing languages, viz. FORTRAN. The computational scheme enables the development of a large number of increasingly sophisticated elements from a single element module as easily as possible by providing it with a library of datasets. (Edited author abstract) 31 refs.

Alaylioglu, Ayse (TPA, Pretoria, S Afr); Alaylioglu, H. *Adv Eng Software* v 9 n 3 Jul 1987 p 150-161.

**080774 VIBRATION OF SYMMETRICALLY LAMINATED RECTANGULAR PLATES CONSIDERING DEFORMATION AND ROTATORY INERTIA.** An analytical study was conducted using the Galerkin technique to determine the natural frequencies and mode shapes for symmetrically laminated rectangular plates, considering the effects of shear deformation and rotatory inertia. Two different graphite-epoxy symmetric plates were used in the analysis and three different boundary conditions for each plate, simply supported, clamped, and two opposite sides clamped/two opposite sides simply supported, were considered. Convergence characteristics, comparison to classical results, and the effects of length to thickness ratios were investigated. The finding indicated that as the length to thickness ratios were reduced, shear deformation effects significantly lowered the natural frequencies. (Edited author abstract) 12 refs.

Bowlus, J.A. (US Air Force Wright Aeronautical Lab, Wright-Patterson AFB, OH, USA); Palazotto, A.N.; Whitney, J.M. *AIAA J* v 25 n 11 Nov 1987 p 1500-1511.

**080775 FREE VIBRATION ANALYSIS OF MINDLIN PLATES WITH LINEARLY VARYING THICKNESS.** A method based on the variational principles in conjunction with the finite difference technique is applied to examine the free vibration characteristics of

isotropic rectangular plates of linearly varying thickness by including the effects of transverse shear deformation and rotary inertia. The validity of the present approach is demonstrated by comparing the results with other solutions proposed for plates with uniform and linearly varying thickness. Natural frequencies and mode shapes of Mindlin plates with simply supported and clamped edges are determined for various values of relative thickness ratio and the taper thickness constant. (Author abstract) 19 refs.

Aksu, G. (Univ of Petroleum & Minerals, Dhahran, Saudi Arabia); Al-Kaabi, S.A. *J Sound Vib* v 119 n 2 Dec 8 1987 p 189-205.

**080776 REFINED VIBRATION AND DAMPING ANALYSIS OF MULTILAYERED RECTANGULAR PLATES.** Refined vibration and damping analysis of a general multilayered rectangular plate consisting of an arbitrary number of layers of orthotropic materials has been developed by considering extension, bending, in-plane shear and transverse shear deformations in all the layers and taking into account the rotary and longitudinal translatory inertias along with the transverse inertia of the plate. The solution for a multilayered plate with simply supported edges has been taken in series summation form and resonating frequencies and associated loss factors for plates with alternate elastic and viscoelastic layers have been evaluated by application of the correspondence principle of linear viscoelasticity. Results for three-, five- and seven-layered plates obtained by the present refined analysis are compared with the results obtained by conventional analysis of multilayered plates. (Author abstract) 12 refs.

Alam, N. (Indian Inst of Technology, New Delhi, India); Asnani, N.T. *J Sound Vib* v 119 n 2 Dec 8 1987 p 347-362.

**080777 THREE-DIMENSIONAL HYBRID-STRESS FINITE ELEMENT FORMULATION FOR FREE VIBRATIONS OF LAMINATED COMPOSITE PLATES.** A three-dimensional eight-node hybrid stress finite element method is developed for the analysis of laminated plates. The hybrid stress model is based on the modified complementary energy principle and takes into account the transverse shear deformation effects. The displacement field is interpolated through shape functions and nodal displacements. All three displacement components are assumed to vary linearly through the thickness of each lamina. All six stresses are included and satisfy the equations of motion. Numerical results for the fundamental frequencies of cross-ply laminates are presented as functions of plate geometry ( $a/h$ ) degree of anisotropy ( $E_L/E_T$ ) and number of plies. They are also compared with numerical values obtained from the elasticity solution, the modified shear deformation theory and the classical lamination theory. (Author abstract) 20 refs.

Sun, C.T. (Univ of Florida, Gainesville, FL, USA); Liou, W.J. *J Sound Vib* v 119 n 1 Nov 22 1987 p 1-14.

**080778 INFLUENCE OF THICKNESS SHEAR DEFORMATION ON FREE VIBRATIONS OF RECTANGULAR PLATES, CYLINDRICAL PANELS AND CYLINDERS OF ANTISYMMETRIC ANGLE-PLY CONSTRUCTION.** This paper is concerned with the influence of thickness shear deformation and rotatory inertia on the free vibrations of antisymmetric angle-ply laminated circular cylindrical panels. Two kinds of thickness shear deformable shell theories are considered. For a family of graphite-epoxy angle-ply laminated plates and circular cylindrical panels, numerical results are obtained, compared and discussed and some interesting conclusions are made regarding the shell theories considered as well as the mathematical method employed. (Edited author abstract) 50 refs.

Soldatos, K.P. (Univ of Ioannina, Ioannina, Greece). *J Sound Vib* v 119 n 1 Nov 22 1987 p 111-137.



**080779 FREE VIBRATION OF A RECTANGULAR PLATE WITH ELASTICALLY RESTRAINED AND FREE EDGES.** Analytical solutions for plate structures with elastically restrained boundary conditions are limited. Since data on the non-dimensional frequency parameters of rectangular orthotropic plates is limited, this letter reports results of a study in which a direct extension on Mukhopadhyay's semi-analytical method was used to investigate the free vibrations of orthotropic plates with elastically restrained edges and free edges. 12 refs.

Liu, W.H. (Tatung Inst of Technology, Taipei, Taiwan); Huang, C.-C. *J Sound Vib* v 119 n 1 Nov 22 1987 p 177-183.

**080780 VIBRATIONS OF ORTHOTROPIC SQUARE PLATES HAVING VARIABLE THICKNESS (PARABOLIC VARIATION).** Orthotropic plates of variable thickness (parabolic variation along the x-direction) were studied for four boundary conditions: CCCC, CCFE, SSSS and CFEE. The effect of fiber orientation, boundary conditions and degree of thickness variation on the fundamental frequency were studied by using a Rayleigh-Ritz method. 4 refs.

Malhotra, S.K. (Univ of Victoria, Victoria, BC, Can); Ganesan, N.; Veluswami, M.A. *J Sound Vib* v 119 n 1 Nov 22 1987 p 184-188.

**080781 ASYMPTOTIC OF THE FREE VIBRATIONS OF A CLAMPED RECTANGULAR PLATE. FORMULATION OF THE SHORTENED PROBLEM.** The edge effect at corner points is not taken into account when applying the asymptotic method to the analysis of natural vibrations of rectangular plates. The authors show how to refine the accuracy of construction of the asymptotic with the corner boundary layers taking into account. Since the variability of the main part of the solution and the edge effect is of an identical order, it is impossible to write the boundary conditions of the original problem in canonical form, and consequently, the method of elimination is used. 15 refs.

Kornev, V.M.; Mul'kibaev, A.O. *J Appl Mech Tech Phys* v 28 n 2 Mar-Apr 1987 p 307-311.

**080782 MOIRE INTERFEROMETRY FOR VIBRATION ANALYSIS OF PLATES.** Moire interferometry is used to locate nodal regions and measure vibration amplitudes of sinusoidally vibrating square plates. The high sensitivity afforded by this technique makes possible the study of plate vibrations at high frequencies and low amplitudes. The initial pattern is modulated by the zero-order Bessel function representing the vibratory motion. The fringe (or fringes) with best contrast indicate the nodal regions, while the higher order fringes, describing loci of points vibrating with the same amplitude, have decreasing contrast which is improved by spatial filtering. (Author abstract) 6 refs.

Asundi, A. (Univ of Hong Kong, Hong Kong); Cheung, M.T. *Exp Mech* v 27 n 4 Dec 1987 p 338-341.

**080783 RESPONSE OF PLATES TO PULSE EXCITATION.** The ultraspherical polynomial approximation (UPA) technique is presented for the large-amplitude vibrations of thin plates subjected to step function loading, neglecting the longitudinal and rotatory inertia forces. The equations are solved by a one-term solution in spatial coordinates which satisfies the boundary conditions. By proper time transformation of the airy stress function, the time can be eliminated and the stress function can be found. Applying the Ritz-Galerkin method to the deflection equation yields an ordinary nonlinear differential equation in time. An additional transformation function is selected for the displacement variable, to be the solution of the linear system subjected to the same pulse. This reduces the nonlinear differential equation of motion to a form where the ultraspherical polynomial approximation (UPA) technique can be applied to obtain the nonlinear response of plates. The response plots for square and circular plates show that UPA results agree well with Runge-Kutta and linear results. 7 refs.

Chandrasekharappa, G. (Indian Inst of Technology, Bombay, India); Srirangarajan, H.R. *Mech Res Commun* v 13 n 2 Mar-Apr 1986 p 107-117.

**080784 FREE VIBRATIONS OF A ROUND ORTHOTROPIC PLATE.** The problem of vibrations of a round orthotropic plate is studied. Expressions are derived for the corrections to the first proper form and the frequency of axisymmetric vibrations. The influence of Poisson's ratio on the natural vibration frequencies is analyzed. (Author abstract) 3 refs.

Bykova, T.I. *Leningrad Univ Mech Bull* n 2 1987 p 52-55.

**080785 VIBRATION AND PARAMETRIC EXCITATION IN ASYMMETRIC CIRCULAR PLATES UNDER MOVING LOADS.** The natural frequencies and modes of transverse vibration of circular plate containing small imperfections are determined through a perturbation method. Incision of equally spaced, equal-size radial slots at the rim of the plate creates asymmetry in some but not all, of the vibration modes, and it causes the repeated natural frequencies of these modes in the symmetric plate to split into two distinct values. These vibration modes are called the split modes, and those associated with the repeated natural frequencies are called the repeated modes. A relationship identifying the split and repeated modes for any configuration of slots is presented. The vibration of a plate containing any number of thin slots cut into it at the rim and with any number of rotating linear springs is analyzed. (Edited author abstract) 13 refs.

Yu, R.C. (Univ of California, Berkeley, CA, USA); Mote, C.D. Jr. *J Sound Vib* v 119 n 3 Dec 22 1987 p 409-427.

**080786 VIBRATIONS OF INITIALLY STRESSED THICK, RECTANGULAR, ORTHOTROPIC PLATES.** Equations of motion for antisymmetric cross-ply laminates in a general state of non-uniform initial stress, where the effects of transverse shear and rotary inertia are included, are derived by the virtual work theorem. The equations are adjusted to a generic expression by using proper transformations. Then, the vibrational behavior of the laminates subjected to a state of uniform tensile or compressive stress plus a uniform bending stress is examined. By considering the transformations, introducing the generalized parameters, and employing a similarity parameter, comprehensive solutions are found to this problem; hence, the curves presented in the text are generic rather than specific. The frequency behavior prior to buckling, undergoes a transition for various mode shape numbers is also investigated. (Author abstract) 17 refs.

Yang, I.H. (Chinese Military Acad, Feng-Shan, Taiwan); Shih, J.A. *J Sound Vib* v 119 n 3 Dec 22 1987 p 545-558.

**080787 FREE VIBRATION OF CIRCULAR PLATES WITH ELASTIC EDGE SUPPORTS USING THE RECEPTANCE METHOD.** Application of the receptance method has been extended to the free vibration of circular plates restrained elastically on their boundaries. Different combinations of linear and torsional spring stiffnesses have been considered. For all these cases, frequency and mode shape equations have been obtained and numerical results for natural frequencies of vibration are presented. Solutions for some of the combinations investigated have not previously been reported in the literature. Wherever possible, the results obtained are compared with the existing values in the literature and a very good agreement is shown to exist. (Author abstract) 29 refs.

Azimi, S. (Isfahan Univ of Technology, Isfahan, Iran). *J Sound Vib* v 120 n 1 Jan 8 1988 p 19-35.

**080788 FREE VIBRATION OF CIRCULAR PLATES WITH ELASTIC OR RIGID INTERIOR SUPPORT.** The problem of free vibration of a circular plate with an elastic or rigid interior support distributed uniformly around the plate at an arbitrary radius has been considered. The case of an elastic or rigid point support at the plate center has also been studied. The frequency

and mode shape equations have been formulated by using the modal expansion technique and the receptance method. Numerical results for natural frequencies are presented, and wherever it has been possible the results obtained are compared with results given in other papers in the literature. (Edited author abstract) 10 refs.

Azimi, S. (Isfahan Univ of Technology, Isfahan, Iran). *J Sound Vib* v 120 n 1 Jan 8 1988 p 37-52.

**080789 NEW APPROACH FOR THE REPRESENTATION OF A POINT SUPPORT IN THE ANALYSIS OF PLATES.** A new approach for the representation of a point support in the analysis of plates is presented. It is based on the use of a flexibility function, representing the distribution of a fictitious elastic restraint over the boundary, which is such that it has a zero value at the point support location but assumes large values resulting in negligible restraint over the free boundary. The application of this flexibility function approach is demonstrated by considering the free vibrations of rectangular plates with two opposite edges simply supported by mid-point supports on the other two edges which are otherwise free. It is shown that the flexibility function approach as compared to the impulse function approach gives a slightly faster convergence and yields results which are generally very accurate. It is also shown that the flexibility function approach has the scope to simulate practical point support conditions in which the support reaction is spread over a definite band. (Edited author abstract) 18 refs.

Bapat, A.V. (BARC, Trombay, India); Venkatramani, N.; Suryanarayan, S. *J Sound Vib* v 120 n 1 Jan 8 1988 p 107-125.

**080790 SIMULATION OF CLASSICAL EDGE CONDITIONS BY FINITE ELASTIC RESTRAINTS IN THE VIBRATION ANALYSIS OF PLATES.** This paper presents a study of the free vibration of elastically restrained plates, aimed at identifying the ranges and the finite values of flexibilities, which can simulate classical boundary conditions to the required degree of accuracy. An assessment of the errors in the frequencies, edge forces and edge moments is also presented. 26 refs.

Bapat, A.V. (BARC, Trombay, India); Venkatramani, N.; Suryanarayan, S. *J Sound Vib* v 120 n 1 Jan 8 1988 p 127-140.

**080791 NONLINEAR FLEXURAL VIBRATIONS OF RECTANGULAR PLATES SUBJECTED TO IN-PLANE FORCES USING A NEW SHEAR DEFORMATION THEORY.** Recently developed shear deformation theory is used to analyze large amplitude, flexural vibrations of laminated rectangular plates subject to in-plane forces. Single mode approach, in conjunction with the Galerkin method, is used to reduce the five coupled equilibrium equations to a single second order ordinary differential equation in time variable by ignoring certain inertia terms. This reduced equation involves quadratic and cubic nonlinearities, the solution of which is obtained by the method of Multiple Scales. Numerical results are presented in tabular form for various parameters of the rectangular plate considered. (Author abstract) 42 refs.

Bhimaraddi, Alavandi (Indian Inst of Technology, Bombay, India). *Thin-Walled Struct* v 5 n 5 1987 p 309-327.

**080792 DISTRIBUTED CONTROL OF LAYERED ORTHOTROPIC PLATES WITH DAMPING.** Optimal control of a composite rectangular plate on an electric foundation is studied with the objective of minimizing its dynamic response in a given period of time with the minimum possible expenditure of force. The plate undergoes transient vibrations starting from specified initial displacement and velocity distributions, and the control is exercised by optimally determining the transverse distributed force. The multiple objective of the problem are taken into account by adopting a vector performance criterion comprising quadratic functionals of the deflection, veloc-



ity and distributed force. The sufficiently condition of optimality is derived using control theory results which lead to an analytic solution of the problem. Numerical results are given for simply supported plates made of specially orthotropic layers of boron-fiber-reinforced plastic material. It is demonstrated that the effectiveness of the proposed control depends on the lamination order, foundation modulus, viscous damping, aspect ratio and terminal time as well as on the weight factors attached to various cost functionals. 28 refs.

Adali, S. (Univ of Natal, Durban, S Afr); Sadek, I.S.; Sloss, J.M.; Bruch, J.C. Jr. *Optim Control Appl Methods* v 9 n 1 Jan-Mar 1988 p 1-17.

#### 080793 FINITE PANEL FOR PLATE VIBRATION.

Finite panels are large finite elements which permit plate structures to be analyzed with minimum discretization. Data preparation and computer storage requirements are significantly reduced with finite panels compared with conventional finite elements. A finite panel for the dynamic analysis of plates is presented, extending the existing application which treats the static case. Complete functions are used to represent displacements, with coefficients being chosen by using a modified variational principle. Panel matrices, which are presented in an explicit form, may be used to analyze structures by using standard finite element procedures. The panel has variable degrees of freedom, which enables convergence to be readily assessed. Four examples demonstrate the accuracy of the panel. (Edited author abstract) 14 refs.

Petrolito, J. (Australian Defence Force Acad, Canberra, Aust); Golley, B.W. *J Sound Vib* v 120 n 3 Feb 8 1988 p 473-486.

**080794 DAMPED VIBRATIONS OF ORTHOTROPIC SQUARE PLATES HAVING VARIABLE THICKNESS (LINEAR VARIATION).** Fiber Reinforced Plastics (FRP) are finding increasing applications in aerospace structures due to their high strength to weight and stiffness to weight ratios. Determination of vibration and damping behavior of structural components made of FRP is necessary for their design. In this study effect of fiber orientation on frequencies and loss factors for orthotropic square plates made of graphite/epoxy is studied by using a Rayleigh-Ritz method for two boundary conditions: all edges clamped (CCCC) and all edges simply supported (SSSS). Plates having a linear variation in thickness in one direction (the  $\chi$ -direction) are considered. 3 refs.

Malhotra, S.K.; Ganesan, N.; Veluswami, M.A. *J Sound Vib* v 120 n 3 Feb 8 1988 p 617-621.

**080795 EXPERIMENTAL AND STATISTICAL METHOD OF PREDICTING AND CONTROLLING THE VIBRATION SPECTRUM OF A ROUND PLATE.** A method is proposed for constructing a probabilistic-statistical model of variation of the frequencies of the natural vibration spectrum of a circular plate fixed at the center, the plate being weakened by holes. The experimental method of holographic spectrometry has been used to determine the frequencies and forms of vibrations. The effect of various factors (the diameter number and place of location of the holes and their interactions) was evaluated from the results of the dispersion analysis of the data of a three-factor three-level experiment. (Translated author abstract) In Russian. 5 refs.

Nanasov, M.P.; Smirnov, V.A. *Izv Vyssh Uchebn Zaved Mashinost* n 9 1987 p 13-18.

**080796 PLATE VIBRATIONS USING B.E.M.** We use the boundary element method (BEM) to solve the problem of natural vibrations of thin plates. The formulation consists of three integral equations, which we reduce to an eigenvalue form by discretizing them using boundary elements, satisfying the boundary conditions of the plate problem. Numerical results of the natural frequencies are presented and compared with previously published results for typical cases of square plates. (Author abstract) 16 refs.

Costa, Jesus Adjama Jr. (Pontificia Univ Catolica do Rio de Janeiro, Rio de Janeiro, Braz). *Appl Math Modelling* v 12 n 1 Feb 1988 p 78-85.

#### 080797 FORCED VIBRATIONS OF INFINITE PLATES.

A number of different analytical expressions are discussed for the forced out-of-plane motion of an infinite plate. The plate is excited on one side with a harmonic pressure at a fairly low frequency. The main result of the discussion is that a region of applicability in the frequency/wavenumber plane is defined for each expression. It is also shown that antisymmetric vibrations (of the bending wave type) are usually of predominant importance for thin plates. Generally, the symmetric vibrations become more important for increasing wavenumbers. However, the symmetric response can be important under coincidence conditions and for the transmission of air-borne sound at grazing incidence, even if the plate is thin compared with the bending wavelength. (Author abstract) 11 refs.

Ljunggren, S. (Ingemansson Acoustics, Stockholm, Swed). *J Sound Vib* v 121 n 2 Mar 8 1988 p 221-236.

#### 080798 NOTE ON THE ACOUSTIC POWER OUTPUT OF A CIRCULAR PLATE.

The time-average power radiated from individual normal modes of a circular plate clamped at its rim and set in a coplanar rigid baffle is analyzed on the basis of an exact integral representation suitable for frequencies above coincidence. A precise estimate of the radiation at high frequencies is given. (Author abstract) 11 refs.

Levine, H. (Stanford Univ, Stanford, CA, USA); Leppington, F.G. *J Sound Vib* v 121 n 2 Mar 8 1988 p 269-275.

**080799 STABILITY OF VIBRATIONS OF A PLATE WITH A HYSTERETIC ENERGY DISSIPATION.** In previous studies of vibrations of elastic systems with hysteretic energy dissipation in the material are carried out and expressions for the amplitudes of forced vibrations are given. The stability of stationary vibrations of such systems with concentrated parameters is discussed and it is shown that unstable stationary solutions are possible. In the present article on the example of vibrations of a plate the authors analyze the stability of stationary forced vibrations of systems with distributed parameters as a function of the form of the decrement of vibrations which characterizes energy dissipation.

Pavlovskii, M.A. (Kiev Polytechnic Inst, USSR); Ryzhkov, L.M. *Sov Appl Mech* v 23 n 7 Jul 1987 p 698-702.

**080800 GENERATION OF DYNAMICALLY CORRECTED FLAT PLATE FINITE ELEMENTS AND THEIR APPLICATION TO THE TRANSVERSE VIBRATION OF FLAT PLATES.** Theory is presented, together with a computer subroutine, which enables the properties of a thin rectangular plate element to be discretized on the basis of dynamic deflection functions. The stiffness and frequency dependent inertia properties of a square element, given in Appendices for both a non-conforming and a conforming element, are used to predict the vibration frequencies and modal shapes for a square plate subjected to four sets of boundary conditions. (Author abstract) 10 refs.

Downs, B. (Loughborough Univ of Technology, Loughborough, Engl). *J Sound Vib* v 122 n 1 Apr 8 1988 p 43-68.

#### 080801 FREE VIBRATION OF A CANTILEVER ANNULAR SECTOR PLATE WITH CURVED RADIAL EDGES.

An analysis is presented for the free vibration of a cantilever annular sector plate with curved radial edges. For this purpose, the plate is transformed into a regular sector plate with unit outer radius by a transformation of variables. The transverse deflection of the transformed plate is expressed in a power series, the dynamical energies of the plate are evaluated, and the frequency equation is derived by the Ritz method. This method is applied to annular sector plates with symmetrically or unsymmetrically curved radial edges, and the natural frequencies and the mode shapes are calculated

numerically up to higher modes. The eigenvalues obtained here are compared with experimental values of other authors. (Author abstract) 16 refs.

Irie, T. (Kansai Univ, Suita, Jpn); Tanaka, K.; Yamada, G. *J Sound Vib* v 122 n 1 Apr 8 1988 p 69-78.

#### 080802 VIBRATIONS OF INITIALLY STRESSED THICK CIRCULAR AND ANNULAR PLATES BASED ON A HIGH-ORDER PLATE THEORY.

The average stress method is used to derive the governing equations for circular and annular plates in a general state of initial stress based on a high-order plate theory. The initial stress is taken to be a combination of an extensional stress plus a pure bending stress in the plane of the plate. These equations are solved by the Galerkin method. Natural frequencies of various boundary conditions are obtained for axisymmetric circular and annular plates. The effects of some parameters on the natural frequencies are studied. The results are compared with those of the Mindlin theory. (Author abstract) 25 refs.

Chen, L.-W. (Nat'l Cheng Kung Univ, Tainan, Taiwan); Hwang, J.-R. *J Sound Vib* v 122 n 1 Apr 8 1988 p 79-95.

#### 080803 EFFECT OF FIBRE ORIENTATION AND BOUNDARY CONDITIONS ON THE VIBRATION BEHAVIOUR OF ORTHOTROPIC SQUARE PLATES.

Fiber Reinforced Plastics (FRP) are finding increasing applications in aerospace structures due to their high strength to weight and high stiffness to weight ratios. Determination of vibration behavior of structural components made of FRP is necessary for their design. The effect of fiber orientation on the frequencies of thin square orthotropic plates is studied using the Rayleigh-Ritz method for various boundary conditions. The main purpose of the study is to find out in what way boundary conditions influence the frequencies of orthotropic square plates. 5 refs.

Malhotra, S.K. (Indian Inst of Technology, Madras, India); Ganesan, N.; Veluswami, M.A. *Compos Struct* v 9 n 3 1988 p 247-255.

#### 080804 FREE VIBRATION OF ANTISYMMETRIC ANGLE-PLY LAMINATED PLATES INCLUDING VARIOUS BOUNDARY CONDITIONS.

An analytical procedure to investigate the free vibration of antisymmetric angle-ply laminated plates is developed. The procedure, based on a generalized Levy-type solution considered in conjunction with the state space concept, enables one to solve exactly the equations governing the laminated anisotropic plate theory as considered by Yang, Norris and Stavsky (YNS). The theory is a generalization of Mindlin's theory for isotropic plates to laminated anisotropic plates and includes shear deformation and rotary inertia effects. The solution is applicable to rectangular plates with two opposite edges simply supported and the remaining ones subjected to a combination of clamped, simply supported and free boundary conditions. The closed form solutions obtained are illustrated numerically in a number of figures and tables revealing the influences of the transverse shear deformation, of the degree of anisotropy, of the geometrical parameters of the plate, of the number of layers, of the ply-angles, and of the character of the boundary conditions. Comparisons with exact and finite element solutions are made. (Edited author abstract) 19 refs.

Khdeir, A.A. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA). *J Sound Vib* v 122 n 2 Apr 22 1988 p 377-388.

#### 080805 FUNDAMENTAL FREQUENCY OF VIBRATION OF A CIRCULAR PLATE WITH TWO CONCENTRIC CIRCULAR SUPPORTS.

This letter is concerned with the determination of the fundamental frequency coefficient of transverse vibrations of a thin,



circular plate in the case of clamped and simply supported edges. The present results may be of interest to designers of mechanical systems. 3 refs.

Sanzi, H.C. (ENACE SA, Buenos Aires, Argent); Laura, P.A.A.; Cortez, V.H. *J Sound Vib* v 122 n 2 Apr 22 1988 p 393-395.

**080806 ELASTIC-IN-PLANE VIBRATION OF SECTOR PLATES (DERIVATION OF A SERIES SOLUTION).** As is often pointed out, the in-plane vibration in a wedge or a sector plate is one of the most important problems in elastodynamics not to have been solved exactly so far. This problem may be related to the dynamic stress concentration and the scattering of elastic waves by cracks, notches and inclusions. This paper presents an exact series solution for the problem. The series satisfies the governing equations and the boundary conditions given at the two edges of a sector plate term by term. It is shown by use of the solution that the stress singularity at the vertex is the same to that of the corresponding problem in elastostatics. (Author abstract) 3 refs. In Japanese.

Urata, Yoshihiko. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 496 Dec 1987 p 2465-2469.

**080807 FREE VIBRATIONS OF ORTHOTROPIC PLATES ATTACHED SPRING-MASS SYSTEMS.** An approach is proposed for estimating natural frequency and mode shape of an orthotropic plate which has attached spring-mass systems. The approach consists of three steps: 1) reduction of the governing equation of the plate with attached spring-mass systems to that of a plate with concentrated masses which vary with the vibrating frequency; 2) application of the Receptance method to the reduced governing equation in order to obtain the solution for the governing equation by using the solution of a simple orthotropic plate with neither spring nor mass; and 3) estimation of the natural frequency of the plate with attached spring-mass systems by substituting the above solution into the iterative formula proposed previously by the author. This approach can be applicable to an orthotropic plate with an arbitrary shape and boundary condition. (Edited author abstract) In Japanese.

Sakata, Toshiyuki. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 496 Dec 1987 p 2477-2483.

**080808 EFFECT OF FIBRE ORIENTATION ON THE TRANSVERSE VIBRATION OF POLAR ORTHOTROPIC ANNULAR PLATES.** Composite fiber reinforced materials are replacing conventional metals and other materials in many engineering applications. The transverse vibrations of polar orthotropic circular and annular plates have been studied in many ways by various researchers. In the present work the effect of fiber orientation on the transverse vibration of polar orthotropic annular plates of uniform thickness is studied. 5 refs.

Ganesan, N. (Indian Inst of Technology, Madras, India); Soamidas, V. *J Sound Vib* v 122 n 3 May 8 1988 p 589-593.

**080809 VIBRATION OF RECTANGULAR PLATES WITH EDGE RESTRAINTS AND INTERMEDIATE STIFFENERS.** Vibrations of stiffened plates with elastically restrained edges are analyzed by the Rayleigh-Ritz method. The first lower four frequencies for restrained plates with up to six intermediate stiffeners are calculated. The results of this study are compared with existing data, and the agreement is excellent. (Author abstract) 6 refs.

Wu, J.-R. (Tatung Inst of Technology, Taipei, Taiwan); Liu, W.H. *J Sound Vib* v 123 n 1 May 22 1988 p 103-113.

**080810 VIBRATIONAL BEHAVIOUR OF AN INITIALLY STRESSED ORTHOTROPIC CIRCULAR MINDLIN PLATE.** The virtual work expression for an orthotropic circular thick plate in a general state of non-uniform initial stress, where the effects of transverse shear and rotary inertia are included, is derived. By using a transformation, the natural frequencies of axisymmetric clamped plates and simply supported plates subjected to

initial stresses are investigated in the chosen space, permitting a free vibration study for all composite materials having polar orthotropy. The initial stress is taken to be a combination of a pure bending stress plus an extensional stress in the plane of the plate. Some approximate, but very accurate, standing-wave-type mode shapes are utilized in solving the essentially double eigenvalue problem by a Ritz-Galerkin method to determine the effects of various parameters on the natural frequencies. (Author abstract) 24 refs.

Yang, I.H. (Chinese Military Acad, Feng-Shan, Taiwan); Shieh, J.A. *J Sound Vib* v 123 n 1 May 22 1988 p 145-156.

**080811 ANALYSIS OF FREE FLEXURAL VIBRATION OF RECTANGULAR PLATES BY THE FINITE DIFFERENCE TRANSFER MATRIX METHOD.** This paper is concerned with the analysis of free flexural vibration of rectangular plates by the finite difference transfer matrix method. In this method, the algebraic computations are conducted by the transfer matrices which are formulated with the use of the ordinary finite difference equations for the differential equation of plate vibration. The proposed method is efficient to reduce the size of the coefficient matrix of simultaneous equation in the ordinary finite difference method and finite element method. Some numerical results are also presented to prove that the proposed method has the wide applicability and possibility of future development of structural analysis. (Author abstract) In Japanese. 42 refs.

Migita, Yasuhiro; Enda, Yoshihiro. *Doboku Gakkai Ronbun-hokokushu* v 9 n 4 Apr 1988 p 239-247.

**080812 FREE VIBRATIONS OF A RECTANGULAR PLATE-CAVITY SYSTEM.** This paper presents a method for computing the natural frequencies and mode shapes of a rectangular plate backed by a closed rectangular cavity. The plate motion is represented by a number of admissible functions consisting of in vacuo normal modes for simply supported plates, and of beam functions for fully clamped plates. The acoustic motion is described analytically in terms of such functions. This allows the vibration of the entire system to be adequately treated in terms of a small number of plate modes. The free vibration solution for the coupled system is obtained either directly by solving the plate equation of motion or by formulating the mass and stiffness matrices of each subsystem numerically. For practical application, a simplified equation is developed to calculate the fundamental natural frequency. (Author abstract) 7 refs.

Qaisi, Mazen I. (Mutah Univ, Karak, Jordan). *Appl Acoust* v 24 n 1 1988 p 49-61.

**080813 HYBRID PLATE VIBRATION MODELS FOR COARSE-MESH ANALYSIS.** Hybrid FE combined membrane + bending rectangular plate vibration models  $(7 + 11)\beta C^0$  and  $(7 + 17)\beta C^1$  are proposed for computer assisted identification of vibration modes for high degree efficient coarse-mesh analysis. Accurate yet cost effective hierarchical FE matrix generation capability is provided through the expedient of an exact analytical integration algorithm, which circumvents many time consuming steps and associated controversies of the numerical quadrature interactions, while yielding computational economy comparable to that required by the single-point Gaussian rule. Samples of numerical experiments corroborate the present development and confirm the high accuracy with rapid convergence characteristics. (Author abstract) 10 refs.

Alayiolu, Ayse (TPA, Pretoria, S Afr); Alayiolu, H. *Comput Struct* v 28 n 6 1988 p 789-796.

**080814 CENTER OF MASS MOVEMENT OF A VIBRATION MACHINE WITH A CONTAINER WHICH HAS SIDE AND CENTRAL VIBRATION PLATES.** An inhomogeneous set of differential equations is derived, and its partial solutions are constructed. A qualitative analysis shows that the general solutions of the respective homogeneous system attenuate. By means of the partial solutions, the path of motion of the reduced center of mass of a vibration machine is determined.

(Author abstract) 4 refs.

Artsybashev, E.A.; Gazizov, B.G.; Yunusov, F.S.; Yakin, V.V. *Sov Aeronaut* v 30 n 3 1987 p 5-9.

**080815 NATURAL FREQUENCIES OF MINDLIN PLATES OF BILINEARLY VARYING THICKNESS.** The objective of the work reported in this letter is to use the method presented by G. Aksu and S.A. Al-Kaabi to examine the dynamic behaviour of rectangular plates with bilinearly varying thickness, including both transverse shear and rotary inertia. Two types of bilinear variation which are symmetric with respect to mid-axis are considered. The natural frequencies and mode shapes have been computed for various values of the thickness parameter and taper thickness ratio. New findings are presented for various boundary conditions, and the results are compared with existing solutions based on the thin plate theory. 6 refs.

Al-Kaabi, S.A. (King Fahd Univ of Petroleum & Minerals, Dhahran, Saudi Arabia); Aksu, G. *J Sound Vib* v 123 n 2 Jun 1988 p 373-379.

**080816 NUMERICAL EXPERIMENTS ON THE DETERMINATION OF THE FUNDAMENTAL FREQUENCY OF TRANSVERSE VIBRATION OF NON-UNIFORM RECTANGULAR PLATES.** This study is concerned with the determination of the fundamental frequency of vibration of the symmetric plate systems investigated by using (a) Rayleigh's optimization procedure and (b) the SAP IV finite element algorithmic procedure. The agreement between the finite elements values (presumably more accurate) and the analytical results is good, in general, from an engineering viewpoint. 4 refs.

Sanzi, H.C. (Empresa Nuclear Argentina de Centrales Electricas SA, Buenos Aires, Argent); Laura, P.A.; Valerga de Greco, B.H. *J Sound Vib* v 123 n 2 Jun 1988 p 382-386.

**080817 INFLUENCE OF VIBRATING PLATES ON POISEUILLE FLOW OF A BINARY MIXTURE.** A mixture of two incompressible Newtonian fluids is considered and the flow induced by steady vibrations of plates on poiseuille flow between two parallel plates, under a constant pressure gradient, is then investigated. Calculations are made for longitudinal vibrations of the plates. (Author abstract) 15 refs.

Gogus, M. Sinasi (Istanbul Technical Univ, Istanbul, Turk). *Int J Eng Sci* v 26 n 4 1988 p 313-323.

**080818 VIBRATION ANALYSIS OF VISCOELASTIC CIRCULAR PLATE SUBJECTED TO THERMAL GRADIENT.** An analysis of vibration of viscoelastic circular plate of variable thickness subjected to thermal gradient has been presented. Using the separation-of-variables method, the governing differential equation has been solved for free vibrations of viscoelastic circular plate which is clamped along the boundary. Galerkin's technique has been applied to obtain corresponding natural frequencies in the form of explicit formulae. Deflection, time period and logarithmic decrement at different points for the first two modes of vibration are calculated for various values of thermal gradient and taper constant and are illustrated with graphs and tables. (Author abstract) 7 refs.

Bhatnagar, N.S. (Univ of Roorkee, Roorkee, India); Gupta, A.K. *Modell Simul Control B* v 15 n 1 1988 p 17-31.

**080819 DYNAMIC ANALYSIS OF CIRCULAR PLATES WITH STIFFENERS USING LAGRANGE MULTIPLIERS.** In this paper an effective approach is presented for the investigation of the dynamic behaviour of circular plates with beam-like stiffeners from a knowledge of modal information of each component. The first part of this paper studies the variational formulation with the aid of Lagrange multipliers. The second part describes the determination of the dynamic characteristics of a



distillation tray in chemical engineering to illustrate the effectiveness of the present approach. (Author abstract) 8 refs. In Chinese.

Ziping, Zeng (Tianjin Univ, China); Tian, Huang; Hamilton, James F. *Tianjin Daxue Xuebao* n 1 1988 p 30-36.

**080820 ANALYTICAL SOLUTION FOR THE POWER EXCHANGE BETWEEN STRONGLY COUPLED PLATES UNDER RANDOM EXCITATION: A TEST OF STATISTICAL ENERGY ANALYSIS CONCEPTS.** The response of the structural components of a complex structure, subjected to random loads, is often estimated by approximate methods based on the concepts of Statistical Energy Analysis (SEA). To examine the fundamental SEA postulates and assumptions, the problem of two coupled plates is rigorously formulated and solved in terms of usual SEA variables. For randomly distributed loads, analytical results are presented for the power flow and plate vibrational energies. The formulation allows the extraction of "apparent" quantities that correspond to the coupling loss factor and modal density ratio of statistical energy analysis. It is demonstrated that this model can yield an understanding of the implications of basic SEA assumptions. Results for simply supported plates clearly show the effects of internal damping and frequency on the coupling parameters. (Author abstract). 15 Refs.

Dimitriadis, E.K. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Pierce, A.D. *J Sound Vib* v 123 n 3 Jun 22 1988 p 397-412.

**080821 POWER RADIATED BY AN INFINITE PLATE SUBJECT TO FLUID LOADING AND LINE DRIVE.** Fluid-loading effects on the acoustic and vibration response of a thin elastic plate can be specified by a phase Mach number or frequency parameter  $M = k_0/k_p$  and an intrinsic fluid-loading parameter  $\epsilon$ . In this paper asymptotic expressions are given for the acoustic power radiated by a thin plate under line force drive, covering the entire frequency range  $0 < M < \infty$  in the limit  $\epsilon \rightarrow 0$ . These expressions reflect the balance of physical mechanisms in each of four principal frequency ranges and, for the case of steel plates with water loading, are shown to agree extremely well with previously published numerical evaluations of the acoustic power. (Author abstract). 18 Refs.

Innes, D. (Univ of Cambridge, Cambridge, Engl); Crighton, D.G. *J Sound Vib* v 123 n 3 Jun 22 1988 p 437-450.

**080822 NONLINEAR FORCED VIBRATION OF ORTHOTROPIC THIN A RECTANGULAR PLATES.** This study deals with the large amplitude forced vibrations of specially orthotropic thin rectangular plates. Geometric nonlinearity is included in accordance with von Karman type large deflection plate theory. The transverse displacement is assumed to be harmonic at the same frequency as that of the uniformly distributed harmonic force. The displacements are expanded space-wise in terms of polynomial basis functions which satisfy the boundary conditions. Time is eliminated by averaging over the time-period of the harmonic force. The orthogonal point collocation method is used to obtain the discretized equations. (Edited author abstract). 11 Refs.

Dumir, P.C. (Indian Inst of Technology, New Delhi, India); Bhaskar, A. *Int J Mech Sci* v 30 n 5 1988 p 371-380.

**080823 DETERMINATION OF ELASTIC CONSTANTS OF ORTHOTROPIC PLATES BY A MODAL ANALYSIS RAYLEIGH-RITZ TECHNIQUE.** The first part of this paper describes a computer programme in which equations derived by the Rayleigh-Ritz technique are used to model the vibrations of rectangular orthotropic plates. The characteristic functions of vibrating beams were used as the assumed functions for plates with boundary conditions consisting of clamped and free edges. Natural frequencies and mode shapes from the programme were verified by finite element analysis and modal analysis for square aluminium and graphite/epoxy plates. The plate vibration model was then

incorporated into a second computer programme which was designed to use the measured natural frequencies of orthotropic plates to determine the four apparent elastic constants. Natural frequencies measured by an impulse technique were used to determine two Young's moduli, the in-plane shear modulus, and a Poisson ratio for each plate. (Author abstract). 36 Refs.

Deobald, L.R. (Univ of Idaho, Moscow, ID, USA); Gibson, R.F. *J Sound Vib* v 124 n 2 Jul 22 1988 p 269-283.

**080824 VIBRATION OF A BIMODULUS THICK PLATE ACCORDING TO A HIGHER-ORDER SHEAR DEFORMATION THEORY.** Equations of motion of a simply supported rectangular bimodulus thick plate in which the higher-order-shear deformation terms are included are derived. The governing equations using the average stress method are solved in exact form. The natural frequencies are compared with the previous results obtained for ordinary thick plates, and with the neutral surface locations and natural frequencies of bimodular plates. From those comparisons, the effects of the higher-order shear deformation terms on the neutral surface locations and the natural frequencies can be observed. Also, the percentage error sense improvement by higher-order deformation terms can be reduced from 1.4 to 0.09 percent. (Author abstract). 25 Refs.

Doong, Ji-Liang (Nat'l Central Univ, Taiwan); Fung, Chin-Ping. *AIAA J* v 26 n 5 May 1988 p 575-581.

**080825 NATURAL RESPONSE OF BIAXIALLY LOADED PLATES.** Although the characteristic equation for the natural vibration of a biaxially loaded plate is well-known, there appears to be no detailed study of this important problem. This is surprising since analytical derivations of those modal shapes of main practical interest are relatively easy to obtain, thus enabling the corresponding frequencies to be derived. In the present paper it is shown how the problem can be tackled for all four combinations of biaxially applied stress states; in addition, a full parametric study of the first four modes for the biaxial compression case is carried out. (Author abstract). 8 Refs.

Pavlovic, Milija N. (Imperial Coll, London, Engl); Baker, Graham. *Int J Struct* v 8 n 1 Jan-Jun 1988 p 15-39.

**080826 VIBRATION OF SHEAR-DEFORMABLE LAMINATED PLATE STRUCTURES BY THE FINITE STRIP METHOD.** Free vibration of prismatic plate structures of laminated composite material and having diaphragm end supports is considered using the finite strip method. Description is given of the development of stiffness and mass matrices for both out-of-plane and in-plane deformation of a family of strip models. The former deformation is based on first-order shear deformation plate theory, rather than classical plate theory. Frequency calculations are made using full sets of structure equations and using reduced sets obtained from an economization procedure. Presented results demonstrate the good convergence characteristics of the finite strip approach and reveal the relative efficiency of particular economization schemes. Comparison made with results based on the use of classical plate theory in deriving out-of-plane strip properties shows that the effects of through-thickness shear and rotary inertia on a natural frequency are heavily dependent upon the nature of the associated mode shape. (Author abstract) 31 refs.

Craig, T.J. (VSEL Consortium plc, Barrow-in-Furness, Engl); Dawe, D.J. *Comput Struct* v 27 n 1 1987, Adv in Comput Struct and Solid Mech, Pap Presented at the First World Cong on Comput Mech, Austin, TX, USA, Sep 22-26 1986 p 61-72.

## Viscoelasticity

**080827 LINEAR VOLTERRA INTEGRODIFFERENTIAL EQUATION FOR VISCOELASTIC RODS AND PLATES.** It is proved that the resolvent kernel of a certain Volterra integrodifferential equation in Hilbert space is absolutely integrable on  $(0, \infty)$ . Weaker assump-

tions on the convolution kernel appearing in the integral term are used than in existing results. The equation arises in the linear theory of isotropic viscoelastic rods and plates. (Author abstract) 12 refs.

Noren, Richard D. (Old Dominion Univ, Norfolk, VA, USA). *Q Appl Math* v 45 n 3 Oct 1987 p 503-514.

**080828 PLANE PROBLEMS OF LINEAR VISCOELASTICITY FOR PLATES WITH CURVILINEAR ANISOTROPY.** The investigation of complex problems in the mechanics of materials with curvilinear anisotropy entails considerable difficulties. These difficulties stem primarily from the fact that it is not possible to directly employ methods based on the use of the theory of analytic functions. For such problems (in relation to elastic materials), an asymptotic method has been proposed that makes it possible to separate the stress-strain state of the plate into two components, which can be determined through successive solution of boundary value problems of potential theory. In this paper, the ideas of the asymptotic method in question are generalized to the case of an orthotropic viscoelastic medium. We consider materials that display primarily shear creep (in many cases, such properties are displayed, e.g., by glass-reinforced plastics). (Edited author abstract) 6 refs.

Bichuk, A.I.; Pavlenko, A.V.; Chukhnova, L.I. *Mech Solids* v 22 n 2 1987 p 123-127.

## Wave Effects

**080829 RAYLEIGH-LAMB WAVES IN AN ELASTIC PLATE WITH VOIDS.** Rayleigh-Lamb waves in a homogeneous and isotropic linear elastic plate containing a distribution of vacuuous pores (voids) are studied. Assuming that the plate is of uniform thickness and that its faces are stress-free, it is found that the waves move, in general, in two uncoupled families, of which one is symmetrical with respect to the midplane of the plate and the other antisymmetrical; each of these families is affected by the presence of voids. If the plate is thin and the frequency is small, the voids influence only the symmetric waves and, because of this influence, the waves propagate slower than their classical counterparts. If the plate thickness and the frequency are large, each of the two families degenerates into two uncoupled waves; one of these is a classical Rayleigh wave and the other is a new wave not encountered in the classical theory. (Author abstract) 14 refs.

Chandrasekharaiah, D.S. (Bangalore Univ, Bangalore, India). *J Appl Mech Trans ASME* v 54 n 3 Sep 1987 p 509-512.

**080830 UNSTEADY LAMINAR BOUNDARY LAYERS SUBJECT OF STANDING WAVE OR TRAVELLING WAVE FREESTREAM FLUCTUATIONS.** Calculations of laminar boundary layer development on a flat plate under the influence of an unsteady freestream velocity have been conducted using the numerical procedure of Cebeci and Carr which was modified to accommodate both standing wave and travelling wave freestream conditions. Results for both types of freestream velocity fluctuations over a range of values of the reduced frequency and freestream convection velocity are reported. For the standing wave freestream conditions the velocity near the wall, and therefore the wall shear stress, exhibits a phase lead with respect to the freestream velocity, reaching a maximum value of  $45^\circ$  at high values of the reduced frequency. Under travelling wave freestream conditions the velocity near the wall shows a phase lag with respect to the freestream velocity. (Edited author abstract). 13 Refs.

Evans, R.L. (Univ of British Columbia, Vancouver, BC, Can). *Cambridge Univ Eng Dep Tech Rep CUED-A/Turbo* n 124 1988 40p.

**Welding See OFFSHORE STRUCTURES—Welding; PRESSURE VESSELS—Steel; WELDING, ELECTRIC—Electron Beam; WELDING, ELECTRIC ARC—Electrodes; WELDING, ELECTRIC ARC—Sheet Metal; WELDS—Stress Relief.**



## Wood

**080831 DE MEKANISKE EGENSKABER AF PLADER OPLIMET AF BIRKEFINER.** [Mechanical Properties of Glued Plates from Birch Veneer]. Analyses and tests have been carried out in order to determine the mechanical properties of glued plates of birch veneer. It is shown, that the elasticity theory involving the transformed cross section constants is applicable for the analysis. The E-modulus of the birch veneer has been determined to 16.700 MPa for stresses parallel to the fiber direction, and decreasing for the increasing angle between the stress and fiber direction. The compressive and tensile strengths of the veneer have been found to be approx. 50 and 110 MPa respectively, and decreasing with an increase of the angle between the stress and fiber direction. (Edited author abstract) In Danish. 3 refs.

Riberholt, H. *Ser R Dan Tek Højsk Afd Baerende Konst* 222 1987 32p.

# PLATINUM ALUMINUM ALLOYS

 See NICKEL ALUMINUM ALLOYS—Elasticity; GOLD ALUMINUM ALLOYS—Optical Properties.

**PLATINUM AND ALLOYS** See Also CATALYSTS—Deactivation; CATALYSTS—Materials; CATALYSTS—Titanium Oxide; ELECTRODES—Copper; ELECTRODES—Materials; NICKEL IRON ALLOYS—Electrodeposition; TITANIUM OXIDES—Surfaces; X-RAYS—Reflection.

## Amorphous

**080832 ELECTRICAL CONDUCTIVITY AND HALL EFFECT OF LASER QUENCHED AMORPHOUS  $Pt_3Si_{1-x}$  ALLOYS NEAR THE METAL INSULATOR TRANSITION.** We have measured the electrical conductivity  $\sigma$  and the Hall-coefficient  $R_H$  of amorphous laser quenched  $Pt_3Si_{1-x}$  thin films in the concentration range  $x=7-35\%$ . All samples were on the metallic side of the metal insulator transition (MIT). Our data show that the MIT in Pt-Si is dominated by Coulomb interaction. (Edited author abstract) 38 refs.

Loeb, P. (Technische Univ Muenchen, Garching, West Ger); Esquerro, M.; Kuess, F.; Luescher, E.; Fritsch, G.; von Allmen, M.; Kambli, U.; Schulte, A. *Solid State Commun* v 64 n 8 Nov 1987 p 1107-1111.

**Applications** See CATALYSTS—Supported; GASES—Sensors; GLASS—Metalizing; GLASS MANUFACTURE; MICROSCOPES, ELECTRON—Components.

## Chemical Analysis

**080833 EXTRACTION-FLUOROMETRIC DETERMINATION OF PLATINUM(IV) WITH RHODAMINE 6G.** Attempts to use rhodamine dyes for the extraction-fluorometric determination of platinum proved unsuccessful since rhodamine 6G in acid bromide and chloride solutions forms water-insoluble and benzene-unextractable ion associates with platinum(IV). This paper reports a comprehensive study of the fluorescent reaction of platinum(IV) with rhodamine 6G and develops an extraction-fluorometric determination of microgram amounts of platinum. 7 refs.

Mikaelyan, Dz.A. (Yerevan State Univ, USSR); Grigoryan, L.A.; Ovsepyan, E.N. *Ind Lab (USSR)* v 53 n 3 Mar 1987 p 212-214.

## Chemical Reactions

**080834 STUDY ON THE COLOUR REACTION OF PLATINUM WITH 4,4'-Bis-(DIMETHYLAMINO) THIOBENZOPHENONE.** A highly sensitive colour reaction of platinum with 4,4'-bis-(dimethylamino) thio-benzophenone (Thio-Michler's ketone, TMK) has been investigated. Maximum absorbance is attained after 15min. in boiling water in the presence of certain amounts of Triton X-100 and ascorbic acid. The colour reaction can be highly selective when EDTA and  $NH_4F$  are used as masking agents. This reaction can be applied to the spectrophotometric determination of microamounts of platinum in pure nickel or pure silver. (Edited author

abstract) 6 refs. In Chinese.

Chang, Wen-bao (Peking Univ, China); Li, Xiao-peng; Kang, Ren-yue; Ci, Yun-xiang. *Xi You Jin Shu* v 5 n 2 May 1986 p 122-125.

**080835 EFFECT OF SURFACE-ACTIVE MATERIALS ON THE REACTION OF PLATINUM(II) WITH 4-(2-PYRIDYLAZO)RESORCINOL.** The effect of cationic and anionic surface-active materials (SAM) on the reaction of Pt(II) with 4-(2-pyridylazo)resorcinol (PAR) was investigated. It was established that addition of SAM to the platinum-PAR system is very effective, since they increase not only the sensitivity of this reaction, but also shorten the time of reaching a complexing equilibrium. (Author abstract) 8 refs.

Pilipenko, A.T.; D'yachenko, N.A.; Falendysh, N.F. *Sov Prog Chem* v 53 n 2 1987 p 77-80.

**Chemical Vapor Deposition** See Also ELECTRIC CONTACTS, OHMIC—Fabrication.

**080836 GAS PHASE VERSUS SURFACE CONTRIBUTIONS TO PHOTOLYTIC LASER CHEMICAL VAPOR DEPOSITION RATES.** The rate of cw photolytic laser chemical vapor deposition (LCVD) of platinum is measured for approximately 350 nm as a function of the light intensity and the metalorganic vapor pressure. The growth of the metal films is studied in situ and in real time by monitoring their optical transmission. At low intensities the transmitted light decreases monotonically with time, and the LCVD process is photolytic with its rate limiting step in the surface adlayer. At higher intensities we observe two distinct time domains: relatively slow initial photolytic deposition with its rate limiting step in the gas phase, which is followed by much faster pyrolytic LCVD. An improved method for distinguishing between adlayer and gas-phase limiting processes is demonstrated. These observations are confirmed by studying the photolytic deposition rates while varying the thickness of the adlayer. (Author abstract) 12 refs.

Braichotte, D. (Ecole Polytechnic Federale de Lausanne, Lausanne, Switz); van den Bergh, H. *Appl Phys A* v A45 n 4 Apr 1988 p 337-343.

## Chlorination

**080837 REACTION OF PLATINUM WITH CHLORINE IN A POTASSIUM CHLORIDE MELT.** In the paper results are presented of a study of the chemical forms in which platinum is found in the products of its chlorination in a KCl melt, and also data on the kinetics of this reaction. The temperature range studied was 800-1000°C. The kinetics of the process were studied by a gravimetric method. The results of chemical analysis indicated that the change in weight of the reaction mixture was proportional to the change in the concentration of platinum ions in the melt. 13 refs.

Dubinin, B.V. (S.M. Kirov Ural Polytechnic Inst, USSR); Desyatnik, V.N.; Yurkov, V.P.; Romanova, O.A.; Beshentseva, N.V. *J Appl Chem USSR* v 60 n 1 pt 1 Jan 1987 p 8-11.

**Coatings** See IRON COMPOUNDS—Adsorption.

**Corrosion** See CORROSION—Reaction Kinetics.

## Dissolution

**080838 MATHEMATICAL DESCRIPTION OF THE CATHODIC DISSOLUTION OF METALS IN HYDROXIDE MELTS.** A mathematical model is set up which reflects the essential features of the cathodic dissolution of metals in hydroxide melts and the basic relations between the parameters of this process. The method used in the computer calculations of the rate of metal attack during cathodic polarization in the melts is described. The computed results are compared with experimental data. (Author abstract) 9 refs.

Tkalenko, D.A. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Kozhemyako, A.D.; Prisyazhnyi, V.D.;

Chmilenko, N.A. *Sov Electrochem* v 23 n 4 Apr 1987 p 416-420.

## Economics

**080839 PLATINUM: THE VIEW FROM SOUTH AFRICA.** This article discusses the properties of platinum and its applications as a high technology metal. World reserves of this strategic and precious metal are confined mostly to South Africa and to a lesser extent, the Soviet Union. An analysis is given of past trends in world platinum output. The time-path is computed for the world platinum output rate covering a period of more than 350 years. This is based on the postulate that the industrial conversion of a virgin resource progresses according to a sigmoid curve. The price dynamics are examined and forecast. 28 refs.

Feichtinger, F. (Isacor, Vanderbijlpark, S Afr); Lammer, A.; Riess, M. *Min Eng (Littleton Colo)* v 40 n 2 Feb 1988 p 91-95.

**080840 PLATINUM EXPERTS PREDICT DEMAND COULD REACH 93 t (3 MILLION oz) DESPITE PRICE FLUCTUATIONS.** For the third successive year it appears that demand for platinum will exceed supplies of newly-mined metal. Based on data available at the end of August 1987, Johnson Matthey estimates that western world demand for platinum could exceed 93t (3 million oz) for the first time in 1987. Given a likely increase in demand of 4.3t to around 94t (140,000 oz to around 3.02 million oz), up by about 5% over 1986, there would be a 1.8- to 2.2-t (60,000- to 70,000-oz) shortfall in 1987 supply.

Anon. *Min Eng (Littleton Colo)* v 40 n 2 Feb 1988 p 96.

**Electric Conductivity** See TEMPERATURE MEASURING INSTRUMENTS—Manufacture; THERMOMETERS—Analysis.

**Electrochemistry** See METALS AND ALLOYS—Electrochemistry; POLYMERS—Adsorption.

**Electrodes** See ELECTRODES, ELECTROCHEMICAL—Testing.

## Electrolytic Analysis

**080841 EXTRACTION-VOLTAMMETRIC DETERMINATION OF PLATINUM AND OSMIUM IN SULFIDE ORES BY CATALYTIC HYDROGEN CURRENTS.** Wider practical uses of platinum metals necessitate improvements in methods for analytically monitoring their products and raw materials. Difficulties arise because of their close chemical and analytical properties as well as their low contents. Catalytic hydrogen evolution currents (CHEC) in solutions of platinum-metal complexes with organic ligands permits voltammetry to be competitive with physical methods in sensitivity. Solid-phase extraction with low-melting extractants can raise selectivity and achieve considerable preconcentration. This paper shows the possibility of determining osmium and platinum in the presence of other platinum and noble metals. The reagent was sodium 2-methyl-8-mercaptoquinoline which yielded large differences in potential maxima. 6 refs.

Medyantseva, E.P. (V.I. Ul'yanov State Univ, Kazan, USSR); Romanova, O.N.; Budnikov, G.K.; Sturis, A.P.; Bankovskii, Yu.A. *Ind Lab (USSR)* v 53 n 7 Jul 1987 p 580-582.

**Electroplating** See ELECTRODES—Materials.

## Leaching

**080842 LEACHING KINETICS OF PLATINUM AND PALLADIUM FROM SPENT AUTOMOTIVE CATALYSTS.** Empirical rate expressions for both platinum and palladium were obtained from mass balances and concentration-time data in a packed bed reactor using different (HCl):(HNO<sub>3</sub>) leaching solution concentration ratios. The spent catalysts used in this study (—60+70 mesh to —120+140 mesh) were analyzed to be 3791 ppm



platinum and 1306 ppm palladium. High initial rates for both platinum and palladium were obtained for the early stages of leaching and were followed by rapid decay up to about 110 minutes and 50 minutes, respectively. Typical concentrations in the leached solution were about 40 ppm Pt and 20 ppm Pd after about 5 hours for the experimental conditions used. (Edited author abstract) 33 refs.

Tyson, David R. (Iowa State Univ, Ames, IA, USA); Bautista, Renato G. *Sep Sci Technol* v 22 n 2-3 Feb-Mar 1987, Fourth Symp on Sep Sci and Tec for Energy Appl, Knoxville, TN, USA, Oct 20-24 1985 p 1149-1167.

**Optical Properties** See Also ELECTRODES—Platinum; SEMICONDUCTING SILICON—Charge Carriers.

**080843 REFLECTANCE AND RAMAN SPECTRA OF MIXED CRYSTALS OF QUASI-ONE-DIMENSIONAL MIXED-VALENCE PLATINUM COMPLEXES**  $[Pt^{3+}P(en)_2][Pt^{3+}P(Cl_{1-x}Br_x)_2(en)_2](ClO_4)_4$  ( $0 \leq x \leq 1$ ,  $0 < p \leq 1$ ). Mixed crystals of halogen-bridged mixed-valence platinum complexes  $[Pt^{3+}P(en)_2][Pt^{2+p}(Cl_{1-x}Br_x)_2(en)_2](ClO_4)_4$  ( $0 \leq x \leq 1$ ,  $0 < p \leq 1$ ) are studied by reflectance and Raman scattering measurements. Quasi-one-dimensional charge transfer excitons in these mixed crystals are of the 'amalgamation' type with large optical bowing. The energies of the phonons related to the Peierls distortion shift with composition  $x$  and their resonant Raman intensities diminish rapidly by the introduction of different halogens. These effects are discussed in terms of modulated charge density waves in one-dimensional mixed crystals. (Author abstract) 18 refs.

Tanino, H. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Takahashi, K.; Kato, M.; Yao, T. *Solid State Commun* v 65 n 7 Feb 1988 p 643-647.

## Plating

**080844 PLATINUM COATING TECHNIQUE DEVELOPED FOR THE GLASS INDUSTRY.** The excellent oxidation and molten glass corrosion/erosion resistance of platinum (Pt) and its alloys are well known and the materials are used in a variety of ways in the glass manufacturing industry. The various methods available to produce platinum group metal coatings are reviewed. Details are presented of a new coating technique, developed by the author's company and especially suited to the coating of fine holes in base metal fiberising rotors. (Edited author abstract) 5 refs.

Johnson, D.C. (Engelhard Ltd, Chessington, Engl). *Glass* v 64 n 9 Sep 1987 p 371-372.

**Production** See PLATINUM METALS—South Africa.

## Recovery

**080845 PHYSICO-CHEMICAL BASIS OF PRODUCTION OF A HIGH-STRENGTH ABSORBENT MASS FOR RECOVERY OF PLATINUM METALS.** The purpose of this work was study of the influence of the main technological parameters (initial composition of the mixture, ratio of the amount of water to the total dry components, molding pressure) on the compressive strength of heat-treated samples of absorbent masses for recovery of platinum metals. It was shown that the mechanical strength of the absorbent mass depends significantly on its content of calcium aluminate of the composition  $12CaO \cdot 7Al_2O_3$ . Experimental production trials of the absorbent mass studied demonstrated its high selectivity for platinum and good resistance to mechanical and chemical influences. 10 refs.

Atroschenko, V.I. (V.I. Lenin Khar'kov Polytechnic Inst, USSR); Loboiko, A.Ya.; Grin', G.I.; Trusov, N.V.; Bukarov, Yu.A.; Vernigora, K.P. *J Appl Chem USSR* v 60 n 5 pt 1 May 1987 p 927-931.

## Research

**080846 SYNTHESIS AND STRUCTURE OF  $[Pt_2(\eta^5-C_5Me_5)_2(CO)_2]$ , A CONVENIENT PRECURSOR TO PENTAMETHYLCYCLOPENTADIENYL CHEMIS-**

**TRY OF PLATINUM.** The author describes a new high-yield synthetic method to this important starting material. A single-crystal X-ray structure determination of 1 revealed it to contain two  $Pt(\eta^5-C_5Me_5)(CO)$  subunits, the two adjacent terminal carbonyl groups being orientated at approximately  $105^\circ$  to each other. The carbonyl groups bend over (average angle  $79.7^\circ$ ) the platinum-platinum bond whose length of 263.6 pm is at the long end of the range reported for platinum(I) dimers, possibly as a result of steric congestion between the two pentamethylcyclopentadienyl groups. 15 refs.

Boag, Neil M. (Univ of Salford, Salford, Engl). *Organometallics* v 7 n 6 Jun 1988 p 1446-1449.

## Separation

**080847 ISOLATION AND SEPARATION OF PLATINUM METALS BY EXTRACTION CHROMATOGRAPHY.** In this paper we propose a new approach to isolation and separation of platinum metals by extraction chromatography, based on the use of extraction systems consisting of mixed hydrochloric-sulfuric acid solutions with tributyl phosphate. It is found that separation of platinum, palladium and iridium from rhodium is accompanied by, on the average, fivefold concentrations of the three former elements in a solution convenient for subsequent operations. In the fractions of these elements rhodium could not be detected in amounts down to  $10^{-2}\%$  of its content in the original mixture. 10 refs.

Grigor'ev, G.L.; Mozhukhin, A.V.; Moskvina, L.N. *J Appl Chem USSR* v 60 n 7 pt 1 Jul 1987 p 1391-1394.

**Service Life** See SPACECRAFT—Propellants.

**Spectroscopic Analysis** See Also CATALYSTS—Supported; RHODIUM AND ALLOYS—Spectroscopic Analysis; SEMICONDUCTING SILICON—Doping; UREA—Oxidation.

**080848 PARITY- AND SPIN-MIXING IN RELATIVISTIC ENERGY BANDS OBSERVED BY VECTOR ANALYSIS OF SPIN-POLARIZED PHOTOEMISSION.** The polarization vector of momentum selected photoelectrons from  $Pt(111)$ , excited by circularly polarized synchrotron radiation, has been measured outside high symmetry lines. Substantial spin polarization and a strongly varying vector orientations are found. The orientation of the polarization vector for various initial bands reveals strongly varying parity- and spin-mixing the  $\Gamma$ LUX mirror plane. (Author abstract) 19 refs.

Oepen, H.P. (KFA, Juelich, West Ger); Huenlich, K.; Kirschner, J.; Eysers, A.; Schaefer, F. *Solid State Commun* v 59 n 7 Aug 1986 p 521-524.

**Sputtering** See TIN COMPOUNDS—Sputtering.

**Surface Properties** See ACETYLENE—Adsorption; NITROGEN OXIDES—Adsorption.

**Surfaces** See Also ANODES—Materials; CATALYSTS; ORGANIC COMPOUNDS—Adsorption; POLYELECTROLYTES—Adsorption; SULFUR COMPOUNDS—Adsorption; XENON—Adsorption.

**080849 STUDY BY XENON NMR OF PLATINUM PARTICLES SUPPORTED ON ALUMINA.** The surface of platinum supported on alumina was probed by  $^{129}Xe$  NMR. In particular, the amount of adsorbed hydrogen and oxygen as well as the reaction of adsorbed hydrogen with dioxygen could be followed by NMR spectra. The results show that metals supported on nonmicroporous materials can be probed by  $Xe$  NMR as previously demonstrated for metals in zeolites. The  $Xe$  NMR method of surface probing seems to be broadly applicable to many adsorbents used in surface chemistry and heterogeneous catalysis. (Edited author abstract). 15 refs.

Boudart, M. (Stanford Univ, Stanford, CA, USA); Menorval, L.C. de; Fraissard, J.; Valence, G.P. *J Phys Chem* v 92 n 14 Jul 14 1988 p 4033-4035.

**Thin Films** See Also POLYMERS—Synthesis; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Electric Properties.

**080850 COMMENT ON 'REINTERPRETATION OF THE THICKNESS-DEPENDENT CONDUCTIVITY OF THIN PLATINUM FILMS'.** S. Messaadi et al. gave a reinterpretation of our data regarding the thickness dependence of the conductivity of platinum films. The conclusion of their letter was that the application of the Fuchs-Namba model to the mentioned results leads to wrong values of the electrical transport parameters, because this model was artificially applied to these films. In the present comment, we give the original experimental data of the films under discussion and give a corrective answer to the basic objections. 10 refs.

Vancea, J. (Univ Regensburg, West Ger); Reiss, G.; Hoffmann, H. *J Mater Sci Lett* v 6 n 8 Aug 1987 p 985-986.

**080851 ULTRATHIN PLATINUM FILMS ON MICA AND THE MEASUREMENT OF FORCES AT THE PLATINUM/WATER INTERFACE.** The chemical stoichiometry and structure of 2-10-nm-thick Pt films deposited on molecularly smooth mica have been characterized by Auger electron spectroscopy, transmission electron microscopy, electron diffraction, and direct-phase-detection microscopic interferometry. These analyses are correlated with electrical, optical, and electrochemical properties of the films with regard to their use in surface forces microbalance techniques. Large-area ( $1\text{ cm}^2$ ), 4-nm-thick polycrystalline films are sufficiently conductive and transparent to allow measurement of forces between metallic phases. Preliminary measurements of electrostatic forces between two Pt films separated by a thin layer of water are presented. (Edited author abstract) 37 refs.

Smith, Christopher P. (Univ of Minnesota, Minneapolis, MN, USA); Maeda, Mayumi; Atanasoska, Ljiljana; White, Henry S.; McClure, D.J. *J Phys Chem* v 92 n 1 Jan 14 1988 p 199-205.

**080852 NEUTRON REFLECTIVITY STUDIES FROM A PLATINUM/CARBON MULTILAYER.** The neutron reflectivity from 30 Pt/C bilayers on an Si substrate has been measured using the time-of-flight (TOF) technique. The thickness of the bilayers, the total thickness of the multilayer structure and the density of the carbon and platinum layers are determined. The influence on the reflectivity curve of different types of multilayer-substrate and air-multilayer interfaces are examined. The experimental data are fitted with a reflectivity curve calculated by using a smoothly varying density profile between the multilayer structure and the substrate. (Author abstract). 12 refs.

Harwood, N.M. (Univ of Reading, Reading, Engl); Messoloras, S.; Stewart, R.J.; Penfold, J.; Ward, R.C. *Philos Mag B* v 58 n 2 Aug 1988 p 217-228.

**080853 THIN-FILM PLATINUM FOR APPLICATION TEMPERATURE CONTROL.** The accuracy and long-term stability of platinum resistance temperature sensors is now available through thin-film technology at low cost for consumer-appliance applications. The underlying technology and methods of assembly are reviewed, along with the favorable cost basis that has accelerated the expanding application of thin-film platinum. Test data with emphasis on the most demanding application in pyrolytic ovens are presented. 5 refs.

Clayton, Wilson A. (Hy-Cal Engineering, El-Monte, CA, USA). *IEEE Trans Ind Appl* v 24 n 2 1988 p 332-336.

## PLATINUM COBALT ALLOYS

### Electrodeposition

**080854 ELECTROLYTISCH ABGESCHIEDENE PLATIN-KOBALT-LEGIERUNGSSCHICHTEN.** [Electrodeposited Platinum-Cobalt Alloy Coatings. Mechanical and Magnetic Properties]. The electrodeposition of



Pt-Co alloys from solutions based on  $\text{Pt}(\text{NO}_2)_2(\text{NH}_3)_2$  and  $\text{CoSO}_4$  has been examined in a wide range of deposition conditions. In addition to composition, internal stresses, hardness and crystallographic properties of the coatings, their magnetic properties in the deposition state were determined. (Edited author abstract) In German. 7 refs.

Baumgaertner, M.E.; Raub, Ch.J.; Cavallotti, P.; Turrilli, G. *Metalloberflaechen* v 41 n 11 Nov 1987 p 559-563.

## PLATINUM COMPOUNDS See Also OXYGEN—Reduction; POTASSIUM COMPOUNDS.

**080855 ON THE GROWTH OF  $\text{PtCl}_3$  CRYSTALS FROM THE VAPOUR PHASE.** Crystals of  $\text{PtCl}_3$  are obtained from the vapor phase in closed fused silica ampoules at temperatures near 785 K and at a chlorine pressure of about 26 atm. The thermodynamic parameters characterizing the single-phase field of solid  $\text{PtCl}_3$  are determined. The growth of the crystals results from vapor transport which is a combination of a sublimation and two dissociative reactions. The complex transport is investigated using the solubility theory of Schaefer. The theory reveals an increase in the transport rate with increasing chlorine pressure when the source is heated to the temperature which separates the fields of solid  $\text{PtCl}_2$  and  $\text{PtCl}_3$ . (Author abstract) 16 refs.

Schoenherr, E. (Max-Planck-Institut fuer Festkoerperforschung, Stuttgart, West Ger); Wojnowski, M.; Rabenau, A.; Lacher, S. *J Less Common Met* v 137 Feb 1 1988 p 277-286.

## Adsorption

**080856 ADSORPTION PROPERTIES OF PLATINUM OXIDES.** The adsorption of organic compounds having different ionization potentials (I) was studied on powdered oxides of platinum having different valences. The values of I at which chemical bonding arises between the adsorbate and adsorbent were found for each oxide. The data obtained were compared with results of adsorption studies performed at platinum at high anodic potentials. (Author abstract) 12 refs.

Nechaev, E.A. (F.E. Dzerzhinskii Chemical Engineering Inst, Dnepropetrovsk, USSR); Silina, T.F. *Sov Electrochem* v 22 n 11 Nov 1986 p 1453-1457.

## Electric Properties

**080857 ELECTRICAL PROPERTIES OF QUASI-ONE-DIMENSIONAL SEMICONDUCTOR HALOGEN-BRIDGED PLATINUM COMPLEXES.** The dark current and photocurrent of  $[\text{Pt}(\text{en})_2][\text{Pt}(\text{en})_2(\text{I}_{1-y}\text{X}_y)_2](\text{ClO}_4)_4$  ( $0 \leq y \leq 0.05$ ,  $\text{X} = \text{Cl}$  and  $\text{Br}$ ,  $\text{en} = \text{ethylenediamine}$ ), have been measured as a function of temperature and light intensity. The conductivity shows an activation-type conduction, but the carriers responsible for the conduction do not originate from the minor halogen ions. The activation energy and the photon energy where the photoconduction starts increase as the contents of  $\text{Cl}$  or  $\text{Br}$  increase. The binding energy of the charge transfer exciton is estimated to be  $0.3 \pm 0.05$  eV. (Author abstract) 10 refs.

Haruki, M. (Yokohama Natl Univ, Yokohama, Jpn); Tanaka, M.; Kurita, S. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 373-378.

## Hydrogenation

**080858 ISOTOPIC EXCHANGE REACTIONS OCCURRING IN THE HYDROGENATION OF (1,5-CYCLOOCTADIENE)DIALKYLPLATINUM(II) COMPLEXES OVER PLATINUM BLACK.** The authors examine the relative rates with which deuterium is transferred from deuterated alkyls,  $\text{R}^{\text{D}}$ , into the cyclooctane product (during hydrogenation with  $\text{H}_2$ ) as a function of the structure and position of isotopic substitution of the alkyl moiety. Based on experimental evidence, it is evident that the range of isotopomers of cyclopentane

is broader than the range of isotopomers of propane from reduction of either their parent organoplatinum complexes or alkenes. 33 refs.

Miller, Timothy M. (Harvard Univ, Cambridge, MA, USA); Whitesides, George M. *J Am Chem Soc* v 110 n 10 May 11 1988 p 3164-3170.

## Ion Implantation

**080859 INFLUENCE OF ARGON IMPLANTATION ON THE FORMATION OF PLATINUM SILICIDES.** This study used transmission electron microscopy and electron diffraction techniques to investigate structural and phase composition features of platinum silicides formed by rapid thermal annealing of argon implanted and unimplanted platinum films on monocrystalline silicon. The structures used in the experiment were 40 nm platinum films deposited onto (111) silicon substrates. Implanted and unimplanted samples were isothermally annealed in the thermal balance regime with induced temperatures of 300 to 800°C for 10 to 30 s. The stimulating role of ion implantation with small doses is probably connected with recoil atom mixing at the platinum-silicon interface. 5 refs.

Borisenko, V.E. (Minsk Radioengineering Inst, Minsk, USSR); Zarovskii, D.I.; Tokarev, V.V. *Phys Status Solidi A* v 107 n 1 May 1988 PK33-K35.

## Optical Properties

**080860 MAGNETIC-FIELD AND TEMPERATURE EFFECTS ON THE OPTICAL PROPERTIES OF DICIANO-2,2-BIPYRIDYL-PLATINUM(II) SINGLE CRYSTALS.** Studies of the polarized emission of  $[\text{Pt}(\text{CN})_2(\text{bipy})]$  single crystals as function of temperature ( $1.9 \text{ K} \leq T \leq 295 \text{ K}$ ) and homogeneous magnetic fields ( $0 \leq H \leq 6 \text{ T}$ ), and the temperature dependence of the polarized absorption spectrum are reported. Raising the temperature from 1.9 to 7 K or increasing the magnetic field from 0 to 1 T results in a blue shift of approximately  $175 \text{ cm}^{-1}$  in the ELA polarized emission (E: electric field vector, a: crystallographic axis). Between 1.9 and 295 K (at  $H=0$ ) and between 0 and 6 T (at  $T=1.9 \text{ K}$ ), the emission lifetime decreases by factors of approximately  $10^3$  and approximately  $10^2$ , respectively. The results are explained within the  $C_{2v}$  symmetry of the single complex assuming a coupling between neighboring central ions. (Author abstract) 14 refs.

Biedermann, J. (Univ Regensburg, Regensburg, West Ger); Wallfahrer, M.; Gliemann, G. *J Lumin* v 37 n 6 Oct 1987 p 323-329.

## Oxidation

**080861 OXIDATION OF  $\text{PtSi}$ ,  $\text{Pt}_2\text{Si}$  AND POLYCRYSTALLINE SILICON IN ULTRAHIGH VACUUM RESIDUAL GAS.** The effect of electron bombardment and the filament current of the ion gun on the oxidation of polycrystalline silicon (poly-Si),  $\text{PtSi}$  and  $\text{Pt}_2\text{Si}$  was studied by means of Auger electron spectroscopy. The oxidation was carried out in the residual gas ( $5 \times 10^{-8} \text{ Pa}$ ), i.e. without any oxygen introduced into the ultrahigh vacuum system. The electron bombardment was accomplished by irradiating the surfaces with 3 keV electrons at a beam current of 20  $\mu\text{A}$ . It was found that the silicon in  $\text{PtSi}$  and  $\text{Pt}_2\text{Si}$  oxidizes under the influence of electron bombardment or when the filament of the ion gun is heated. Under these conditions only the initial stage of silicon oxidation could be detected in poly-Si. (Author abstract) 11 refs.

Swart, H.C. (Univ of the Orange Free State, Bloemfontein, S Afr); Louw, C.W.; Berning, G.L.P. *Thin Solid Films* v 158 n 1 Mar 1988 p 61-67.

## Physical Properties

**080862 PHYSICAL PROPERTIES OF METAL CLUSTER COMPOUNDS. III: NMR STUDY OF PLATINUM CARBONYL CLUSTERS.** The Pt NMR line shapes for  $[\text{Pt}_3(\text{CO})_4\text{H}_2]$ ,  $[\text{N}(\text{PPh}_3)_2]_2$  and  $[\text{Pt}_{26}$

$(\text{CO})_{32}\text{H}_2]$   $[\text{PPh}_4]_2$  resemble those found in free Pt-particles of comparable size. Our analysis does not allow a discrimination between Knight or chemical shift. It is suggested that the Pt-relaxation rate, which normally gives another tool to check the mechanism of the shift, is determined by the presence of paramagnetic electronic spins as seen both in ESR and in the magnetic susceptibility. (Author abstract) 25 refs.

Pronk, B.J. (Rijksuniversiteit Leiden, Leiden, Neth); Brom, H.B.; Ceriotti, A.; Longoni, G. *Solid State Commun* v 64 n 1 Oct 1987 p 7-10.

Recovery See ION EXCHANGE RESINS—Industrial Applications.

## Reduction

**080863 ELECTROREDUCTION OF  $\text{PtCl}_4^{2-}$  IONS IN DIHYDRIC ALCOHOLS.** The authors studied  $\text{PtCl}_4^{2-}$  ion discharge in ethylene glycol (EG) as well as in 1,2- and 1,3-propanediol (propylene glycol, PG) at the dropping mercury electrode. All salts and solvents used in the work were subjected to special purification. The 1,2- and 1,3-PG after prolonged shaking with lithium hydroxide were twice distilled and stored under inert gas. Applicability of slow discharge theory to the electroreduction of  $\text{PtCl}_4^{2-}$  ions was checked quantitatively by determination of the transfer coefficient  $\alpha$  and of charge  $z_0$ . The experimental currents were corrected for concentration polarization. It is seen when investigating the electroreduction of  $\text{PtCl}_4^{2-}$  in EG and 1,2-PG that the experimental data can be explained by a slow electrochemical discharge step. Furthermore the  $\text{PtCl}_4^{2-}$  ions behave similarly in EG and 1,2-PG. 6 refs.

Shavgulidze, V.V. (Acad. Sciences of the Georgian SSR, Tbilisi, USSR); Ketiladze, D.D. *Sov Electrochem* v 22 n 9 Sep 1986 p 1188-1190.

**080864 MECHANISM OF CATHODIC  $\text{PtCl}_6^{2-}$  REDUCTION TO PLATINUM CLUSTERS ON ELECTRODES COATED WITH POLYVINYL-PYRIDINIUM FILMS.** The electrochemical reduction of  $\text{PtCl}_6^{2-}/\text{HCl}$  to  $\text{Pt}^0$  is investigated on electrodes coated with anion exchange polymer films. The first step is the cathodic reduction to  $\text{PtCl}_4^{2-}$ . Three possible routes for the reaction  $\text{PtCl}_4^{2-}$  to  $\text{Pt}^0$  are discussed: (i) a second electrochemical step; (ii)  $\text{PtCl}_4^{2-}$  disproportionation; (iii) reduction by cathodically produced  $\text{H}_2$ . It is demonstrated that route (i) is normally dominant. The  $\text{Pt}^0$  produced has a large surface area. Individual microparticles ('clusters') can be conveniently formed. As expected from the electrochemical mechanism the  $\text{Pt}^0$  produced is located at the electrode-coating interface. (Author abstract) 16 refs.

Kowal, Andrzej (Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, West Ger); Doblhofer, Karl; Krause, Siegfried; Weinberg, Gisela. *J Appl Electrochem* v 17 n 6 Nov 1987 p 1246-1253.

## Synthesis

**080865  $\beta$ - $\text{PtO}_2$ : HIGH PRESSURE SYNTHESIS OF SINGLE CRYSTALS AND STRUCTURE REFINEMENT.** Single crystals of  $\beta$ - $\text{PtO}_2$  have been grown from  $\text{Pt-KClO}_3$ -mixtures at 40 kbar, 1500°C in a modified Belt-type apparatus using Pt capsules. The crystals are orthorhombic, space group  $\text{Pnmm}$ , with  $a = 4.4839(3)$  Angstrom,  $b = 4.5385(6)$  Angstrom,  $c = 3.1360(6)$  Angstrom and  $Z = 2$ . Single crystal X-ray data confirmed the structure to be  $\text{CaCl}_2$ -type, a distorted variant of the rutile structure. The Pt-O distances are  $2 \times 1.989(4)$  and  $4 \times 2.003(4)$  Angstrom, the shortest oxygen-oxygen distance is  $2.494(5)$  Angstrom. A discussion of some geometrical features is presented. (Author abstract) 22 refs.

Range, K.-J. (Univ of Regensburg, Regensburg, West Ger); Rau, F.; Klement, U.; Heyns, A.M. *Mater Res Bull* v 22 n 11 Nov 1987 p 1541-1547.



## Thermodynamic Properties

**080866 STANDARD ENTHALPIES OF FORMATION OF PTI, PTZr, AND PTHf.** The standard enthalpies of formation of the intermetallic compounds PtTi, PtZr, and PTHf have been determined by high temperature mixing calorimetry in a new calorimeter operated at (1473  $\pm$  2) K. The following values of  $\Delta H_f^\circ$  are reported. PtTi:  $-159.3 \pm 12.9$  kJ mol $^{-1}$ ; PtZr:  $-191.9 \pm 12.4$  kJ mol $^{-1}$ ; PTHf:  $-227.3 \pm 13.2$  kJ mol $^{-1}$ . These results are compared with recent experimental values obtained by high temperature direct combination calorimetry, with predicted values and with our own recently published data for the equiatomic alloys of Ti, Zr, and Hf with Pd, Rh, and Ru. The enthalpies of formation of the Pt compounds are significantly more exothermic than the corresponding Pd, Rh, and Ru compounds. (Author abstract) 24 Refs.

Topor, Letitia (Univ of Chicago, Chicago, IL, USA); Kleppa, O.J. *Metall Trans A* v 19A n 7 Jul 1988 p 1827-1831.

**Thin Films** See SEMICONDUCTING SILICON COMPOUNDS—Synthesis; SEMICONDUCTOR DIODES—Processing.

## PLATINUM IRON ALLOYS

## Magnetic Properties

**080867 HYPERFINE INVESTIGATIONS OF THE MAGNETIC STATE IN ORDERED  $Pt_{1-x}Fe_{1+x}$ .** Mossbauer effect studies of  $Pt_{1-x}Fe_{1+x}$  fcc ordered alloys in the range 4.2 K < T < 300 K, in zero and in external magnetic field, for samples with x = 0.16 to 0.28, are reported. The low-temperature spectra show several satellite lines which are related to different excess-Fe nearest-neighbor configurations. Experiments in external fields give information on the different local spin structure at different concentrations. (Author abstract) 4 refs.

Steinbach, P. (Univ Duisburg, Duisburg, West Ger); Brand, R.A.; Keune, W. *J Magn Magn Mater* v 70 n 1-3 Dec I 1987, Proc of the Int Symp on Magn of Intermet Compd, Kyoto, Jpn, Apr 20-22 1987 p 102-104.

**PLATINUM MANGANESE ANTIMONY ALLOYS** See MAGNETOOPTICAL DEVICES—Materials; MAGNETIC MATERIALS—Thin Films.

## PLATINUM MANGANESE IRON ALLOYS

## Magnetic Properties

**080868 MAGNETIC STATE OF QUASIBINARY SOLID SOLUTIONS  $Pt_3M_{x\%}Fe_{1-x}$  NEAR THE CRITICAL CONCENTRATION.** The authors measured the magnetization of two specimens with x=0.3 and 0.4, taken from the near vicinity of the critical concentration in the range 4.2  $\leq$  T  $\leq$  300 K. The  $\sigma(T)$  curves measured at H=1.5 tesla have a maximum which practically coincides with  $T_N$  found from neutron diffraction data. Cooling specimens in a magnetic field H=1.5 tesla from T=300 K  $>$   $T_N$  to T=4.2; 20.4 and 79 K  $<$   $T_N$  has no appreciable effect on  $\sigma(T)$  for the alloy with x=0.3 but raises the magnetization of the alloy with x=0.4. Some of the properties of the alloys with x  $>$   $x_c$  and for the alloy with x=0.4 in particular at T  $<$   $T_N$  and H < 8 tesla are typical of the spin glass state. 6 refs.

Tsiovkin, Yu.N. (Acad of Sciences, USSR); Ivanov, V.Yu.I.S.; Kourov, N.I.; Volkenshteyn, N.V. *Phys Met Metallogr* v 62 n 3 1986 p 184-186.

**PLATINUM METALS** See Also GOLD AND ALLOYS; MINERALOGY; NICKEL REFINING—Physical Chemistry; PLATINUM ORE TREATMENT—Beneficiation.

**080869 PLATINUM-GROUP MINERALS FROM HOCHGROSSEN ULTRAMAFIC MASSIF, STYRIA: FIRST REPORTED OCCURRENCE OF PGM IN AUSTRIA.** The platinum-group minerals described here occur mainly in massive, schlieren-type chromitites within

serpentinites and serpentized dunites of the Hochgrossen ultramafic massif, Styria, and represent the first discovery of PGM in Austria. Two genetically and mineralogically distinct groups of PGM are present. The first comprises members of the Ru-Os-Ir sulphide system (laurites). These are largely euhedral and do not occur in the vicinity of secondary cracks or veinlets in the host chromites. They are, thus, considered to be cogenetic with chromite. The second group includes sulpharsenides and arsenides with irregular crystal shapes that occur interstitially with silicates and, less abundantly, within ferritichromite rims. They are attributed to secondary processes, i.e., serpentinization. 25 Refs.

Thalhammer, O.A.R.; Stumpf, E.F. *Trans Inst Min Metall Sect B* v 97 May 1988 p b77-b82.

## Adsorption

**080870 STUDY ON THE SORPTION BEHAVIORS OF NOBLE METALS BY BUTYLAMINE AMIDE RESIN.** The optimum conditions for separating gold from other noble metals and base metals have been studied. Most base metals are not sorbed by this resin in dilute hydrochloric acid and aqua regia solutions. Most noble metals except silver and rhodium can be sorbed completely or partially in dilute hydrochloric acid solution. Gold is strongly adsorbed for all concentrations of HCl. Successful separation has been achieved for the separation of Rh-Pd-Au and Rh-Pt-Au from each other. It is also possible to concentrate gold from seawater or different kinds of wastewater. (Edited author abstract) 6 refs. In Chinese.

Li, Ling-ying (Nankai Univ, China); Huang, Ling; Lin, Xue; Zhao, Fen-zhi. *Xi You Jin Shu* v 5 n 2 May 1986 p 126-134.

## Applications

**080871 AUFKOMMEN UND VERWENDUNG DER PLATINMETALLE.** [Extraction and Application of Platinum Metals]. Despite the high prices and attempts to substitute them, platinum metals still play a decisive role in a great number of fields of application. Considering their specific characteristics they by no means will lose their importance in the future. This paper deals with the properties, deposits, production, consumption, application, and price trends of platinum metals. (Author abstract) In German. 10 refs.

Kutzsche, Karl (VEB Mansfeld Kombinat Wilhelm Pieck, Freiberg, East Ger); Haeussler, Guenter. *Neue Huette* v 32 n 7 Jul 1987 p 266-271.

**Catalysis** See CATALYSTS—Applications.

## Flotation

**080872 PLATINUM GROUP AND ARSENIDE MINERALS IN COPPER-NICKEL SULFIDE BEARING DULUTH GABBRO AND THEIR FLOTATION RECOVERIES.** Reasons for low recoveries of platinum group metals have remained unresolved due to interferences in the analyses. Electron microprobe, scanning electron microscope, and scanning Auger microprobe analyses have identified nickel arsenide minerals in the ore and confirmed a close association of platinum group metals as minute inclusions. These results indicated a need for re-evaluation of flotation procedures that have ignored special problems related to arsenide minerals. The electrochemical and flotation behaviors of nickel arsenide and their application to the flotation recoveries of precious metals from copper-nickel bearing Duluth gabbro are presented. (Edited author abstract) 19 refs.

Iwasaki, I. (Univ of Minnesota, Minneapolis, MN, USA); Weiblen, P.W.; Reid, K.J.; Ryan, P.J.; Nakazawa, H.; Malici, A.S. *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt A 1986 p 1983-1988.

## Geochemistry

**080873 ORE DEPOSIT MODELS #12. THE PLATINUM GROUP ELEMENT DEPOSITS: CLASSIFICATION AND GENESIS.** The platinum group element deposits are subdivided within a genetic framework; the three principal deposit types are formed by (1) Orthomagmatic, (2) Alluvial or (3) Hydrothermal processes. The Orthomagmatic class can be further subdivided into three subclasses: deposits that formed as a result of (a) magma mixing, (b) contamination of magma by material from an external source, and (c) deuteric fluid activity, i.e., flow of fluids derived from the same magma as the intrusive host rocks. Hydrothermal platinum-palladium deposits include those in which a hydrothermal system has been channeled through mafic/ultramafic host rocks from which the precious metals may have been leached. (Edited author abstract) 102 refs.

Macdonald, A. James (Ontario Geological Survey, Toronto, Ont, Can). *Geosci Can* v 14 n 3 Sep 1987 p 155-166.

**Recovery** See CATALYSTS—Recovery.

## Refining

**080874 PRECIOUS REPUTATION REFINING THE EXOTICS.** The Acton refinery has a reputation as one of the world's best precious metal refineries. Platinum, palladium, rhodium, iridium, ruthenium, osmium, gold and silver are consistently produced at better than 9995+ fine. Inco began recovering precious metals (PM) identified in its Sudbury ores almost 100 years ago at a small laboratory in London, England. The nearby Acton refinery was inaugurated in 1924 to recover increasing quantities of platinum group metals (PGM). The article describes operations.

Scales, Marilyn. *Can Min J* v 109 n 6 Jun 1988 9p.

## Reviews

**080875 WORLDWIDE PGM OUTLOOK.** Platinum, iridium, osmium, palladium, rhodium, and ruthenium are known as the platinum group metals (PGM). Their unique properties, including catalytic activity, temperature and corrosion resistance, electrical conductivity and resistivity, and high purity, have promoted the use of PGM in a variety of applications in pollution control, aerospace and defense, fuel production, fertilizer production, glass and glass-fiber production, energy generation, electronics, dentistry, and jewelry. The article reviews some specific applications and examines supply and demand over the long term.

Feichtinger, F. (Int Forecasting Research Circle, S Afr); Lammer, A.; Riess, M. *Adv Mater Processes* v 133 n 4 Apr 1988 p 53-56.

## South Africa

**080876 DEMAND FOR PLATINUM.** The platinum group metals are among the scarcest of metallic elements and are critical to industry, having in the main no viable substitutes. South Africa is the Western world's major supplier, and the paper considers the action the Western world should be taking to insure against the dislocation that would arise from serious supply disruption from that source. 12 refs.

Owen, A.D. (Univ of New South Wales, Kensington, Aust). *Resour Policy* v 13 n 3 Sep 1987 p 175-188.

**080877 PLATINUM-GROUP METALS - A RESOURCE IN THE TAILINGS OF CHROMIUM MINES IN SOUTH AFRICA.** Although the concentration of platinum group elements in the LG-6 Chromitite Layer is very low - about 0.5 g/t - the minerals that contain these elements occur largely between the chromite grains. Because of their small grain size, these minerals, during washing of the ore, become concentrated together with the silicate impurities in the tailings. The platinum



group elements in the tailings are such that their extraction appears to be a profitable. It is estimated that the tailings dumps of the chromium mines in the Bushveld Complex contain close to 400,000 oz of platinum group elements, to which about 38,000 oz are added annually. (Author abstract) 12 refs.

Von Gruenewaldt, G. (Univ of Pretoria, Pretoria, S Afr); Hatton, C.J. *J S Afr Inst Min Metall* v 87 n 9 Sep 1987 p 265-268.

## Thin Films

**080878 STUDY OF THE INITIAL ALUMINIDE PHASE GROWTH IN Al/Pt COUPLES.** The thermal reaction of thin platinum films with large-grained aluminum substrates is studied with emphasis on the growth kinetics of the initial aluminate phase. In situ d.c. sputter cleaning is performed on the large-grained aluminum substrates before the platinum film is evaporated to ensure a clean interface. Uniform layer-by-layer growth of  $Pt_2Al_3$  is observed and monitored by 2 MeV  $He^+$  backscattering. The thickness  $x$  of this initial aluminate phase grows parabolically with the annealing duration  $t$  as  $x^2 = Kt$ . (Edited author abstract) 15 refs.

Zhao, X.-A. (California Inst of Technology, Pasadena, CA, USA); Ma, E.; Yang, H.-Y.; Nicolet, M.-A. *Thin Solid Films* v 153 Oct 26 1987, Pap Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 379-385.

## PLATINUM MINES AND MINING

### Analysis

**080879 REVIEW OF SOME FEATURES POTENTIALLY INDICATIVE OF THE PRESENCE OF PLATINOID MINERALIZATION AS DEDUCED FROM THE STILLWATER COMPLEX, MONTANA (USA).** The Stillwater Complex of South Montana is a layered differentiated ultramafic intrusive body of late Archean age. A number of the petrological and geochemical features of the Stillwater Complex, and particularly their geometrical distributions, are of significance for the understanding of such complexes and can be used in exploration. If in a sulfide zone, 400-1000 m above the first appearance of cumulus plagioclase, one finds: the presence of chromitite layers; that olivine is the cumulus mineral in addition to plagioclase; the presence of 'pegmatoid zones' (i.e., distinct orthocumulate texture); that there is evidence of magma injection (slump textures, etc.); that the Ni/Cu ratio is greater than 1; that there is no apparent nickel depletion of the associated reef olivine; and that rare earth element abundances and ratios of plagioclase change in a way suggesting magma replenishment; then it is highly probable that such a sulfide zone has an economically interesting platinoide content. 17 refs.

van der Veen, A. (Billiton Research BV, Arnhem, Neth). *Geol Mijnbouw* v 66 n 3 1987 p 213-220.

## Developing Countries See GOLD MINES AND MINING—Developing Countries.

## Montana

**080880 STILLWATER ADDS A NEW SOURCE TO WORLD PLATINUM SUPPLIES.** The Stillwater project design was based on an initial production rate of about 100,000 oz/yr of platinum group metals, 25,000 oz of platinum and 75,000 oz/yr of palladium, contained in concentrates grading about 50 oz of pgms/st. These objectives will probably be exceeded during the first year of production. Mine and plant designers initially made provision for an expansion to 1,000 st/d by 1992, but that goal will probably be reached by 1990, or possibly sooner. Cost of the expansion is projected at \$10 million to \$12 million. The National Research Council has estimated Stillwater Mining's PGM resources above economic mining depth at 225 million oz of contained metal, Mike Sharratt, Manville senior director, mining and exploration, states.

White, Lane (Engineering & Mining Journal, New York, NY, USA). *Eng Min J* v 188 n 10 Oct 1987 p 38-43.

**080881 STILLWATER PLATINUM-PALLADIUM MINE.** The Stillwater platinum/palladium mine and mill, lies some 5 miles south of Nye, Montana. The deposit being mined to recover platinum, palladium and other precious metals is known as the J-M reef, extending over some 40 km (28 miles). Details are given of the geology, mining and mineral processing of the Stillwater ore together with an outline of some expected future developments at the site. 7 refs.

Kennedy, Alan. *Min Mag* v 157 n 5 Nov 1987 6p between p 418 and 427.

**PLATINUM MOLYBDENUM ALLOYS** See NUCLEAR REACTORS, HIGH TEMPERATURE—Temperature Measurement; CATALYSTS—Materials.

**PLATINUM NICKEL ALLOYS** See CATALYSTS—Platinum Nickel Alloys.

## PLATINUM NICKEL IRON ALLOYS

### Electric Conductivity

**080882 ATOMIC ORDERING AND THE ELECTRICAL PROPERTIES OF PLATINUM-NICKEL ALLOYS WITH IRON IMPURITIES.** The authors studied the influence of additions of iron on resistivity and atomic structure.  $Pt_{50}Ni_{50-x}Fe_x$  ( $x=1$ ; 5 at.%) and  $Pt_{25}Ni_{75-x}Fe_x$  ( $x=5$ ; 10; 25 at.%) were investigated. During annealing of  $Pt_{50}Ni_{50-x}Fe_x$  their temperature coefficient of resistivity rises by 25-50% whereas in  $Pt_{25}Ni_{75-x}Fe_x$  the reverse process is observed. Thus, substitution of nickel by iron changes the electrophysical properties and atomic structure. 3 refs.

Karpov, Yu.G. (Urals Polytechnic Inst, USSR); Kotov, A.P.; Kuranov, A.A.; Sakhanskaya, I.N.; Chmerinskaya, L.S. *Phys Met Metallogr* v 61 n 1 1986 p 199-201.

## PLATINUM ORE TREATMENT

### Beneficiation

**080883 PLATINUM GROUP MINERALS IN THE DULUTH COMPLEX AND THEIR BENEFICIATION BEHAVIORS.** Platinum group metals were found in a Pt-Pd-rich zone in drill core within an oxide plagioclase olivine host rock with disseminated sulfide mineralization. Assay values showed over 9 g/t (0.27 oz per st) platinum plus palladium. The Pt-to-Pd ratio over the entire 3-m (10-ft) interval is nearly 1:1, and platinum and palladium contents show a correlation with chromium content. Platinum and palladium occur mostly as alloys and are associated with copper, nickel, and iron sulfides. Magnetic separation concentrates platinum and palladium into nonmagnetic tails. Further concentration will require special beneficiation techniques, particularly for such phases as Pt-Fe alloy. 14 refs.

Sabelin, T. (Univ of Minnesota, Minneapolis, MN, USA); Iwasaki, I.; Reid, K.J. *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt A 1986 p 2122-2125.

### Flotation See Also PLATINUM METALS—Flotation.

**080884 RECOVERING PLATINUM AND PALLADIUM AT STILLWATER.** Located in southern Montana, Stillwater Mining Company is the only platinum group metals mine and flotation mill in the western hemisphere. The flotation mill, built mostly with used and reconditioned equipment, has improved to recover 93-95% of the platinum and palladium from the ore. The plant has been unavailable less than five percent of the time. (Edited author abstract) 17 refs.

Hodges, Gregg J. (Stillwater Mining Co, USA); Clifford, Roger K. *J Met* v 40 n 6 Jun 1988 p 32-35.

**080885 RECOVERY OF PLATINUM-GROUP METALS FROM GABBROIC ROCKS.** Platinum-

group metals are found mainly as arsenides, sulfarsenides, sulfides and platinum-iron alloys in gabbroic rocks. Major losses of platinum group metals in extraction most frequently occur during beneficiation. In the massive sulfide rocks of Minnesota's copper-nickel bearing Duluth Complex, platinum group minerals are in close association with arsenide minerals as inclusions. Platinum group metal recoveries from the Duluth Complex can be improved by a flotation procedure developed during an investigation with artificial nickel arsenide. This research revealed that flotation recovery of nickel arsenide is highly susceptible to oxidation. It was also found that the use of nitrogen during grinding and flotation, combined with copper activation, restores floatability. (Author abstract) 31 refs.

Iwasaki, I. (Univ of Minnesota, MN, USA); Nakazawa, H.; Malicsi, A.S.; Li, Xiaowei. *J Met* v 40 n 6 Jun 1988 p 36-39.

Montana See PLATINUM MINES AND MINING—Montana.

Solvent Extraction See PLATINUM METALS—Refining.

## PLATINUM PALLADIUM RUTHENIUM ALLOYS

### Oxidation

**080886 HIGH-TEMPERATURE OXIDATION OF Pt-45Pd-10Rh.** The surfaces of Pt-45Pd-10Rh foils oxidized over the range 875-1075 K in a 20 percent  $O_2$ -Ar mixture at atmospheric pressure were examined by Auger electron, X-ray photoelectron, and Raman spectroscopy. The composition of the oxide formed on the surface was found to vary with temperature from predominantly PdO at 875 K to  $PdRhO_2$  at 1075 K. Only a few atomic percent Pt was observed, present in both the metallic and (apparently) +1 oxidation states at 875 K and in the metallic state at 1075 K. The formation of  $PdRhO_2$  (and no  $Rh_2O_3$ ) at 1075 K was found to persist upon reoxidation following a low-temperature reduction cycle in which the increased Rh concentration on the surface was retained. An oxidation-induced Rh enrichment of the surface beyond 50 at. percent does not appear likely within the temperature/pressure regime investigated. (Author abstract). 9 refs.

Graham, G.W. (Ford Motor Co, Dearborn, MI, USA); Potter, T.J.; Weber, W.H.; Gandhi, H.S. *Oxid Met* v 29 n 5-6 Jun 1988 p 487-497.

**PLATINUM RUTHENIUM ALLOYS** See CATALYSTS—Aging.

## PLATINUM RUTHENIUM ALLOYS

**080887 PREPARATION OF HIGHLY DISPERSED Pt+Ru ALLOY CLUSTERS AND THE ACTIVITY FOR THE ELECTROOXIDATION OF METHANOL.** A new method for the preparation of Pt+Ru binary catalyst has been developed which provides a simple way of obtaining a specific surface area (ca. 80 m<sup>2</sup> g<sup>-1</sup>) more than 3 times larger than that obtained by conventional methods. This method is based on the co-deposition of fine oxides of platinum and ruthenium in atomic scale in a mixed salt solution of these metals followed by reduction with hydrogen bubbling. It was revealed that the binary catalyst prepared by this method forms alloy clusters of their solid solution, in which platinum atoms are replaced by ruthenium atoms on the lattice points of a face-centered cube in the region of Ru/Pt ratios less than 0.75. The supported alloy on carbon black exhibited an extremely high catalytic activity during the electrooxidation of methanol; i.e. ca. 200 mA cm<sup>-2</sup> at 0.4 V and a limiting current of more than 1 A cm<sup>-2</sup> when Ru/Pt=1/1. From a comparison of the relationship between the composition of the alloy and the activity with that of an ad-electrode Having ruthenium ad-atoms with a well-defined coverage, it was concluded that the composition of the alloy cluster surface is



probably the same as that of the cluster bulk. (Author abstract) 20 refs.

Watanabe, Masahiro (Yamanashi Univ, Kofu, Jpn); Uchida, Makoto; Motoo, Satoshi. *J Electroanal Chem Interfacial Electrochem* v 229 n 1-2 Aug 10 1987 p 395-406.

## PLATINUM TIN ALUMINUM ALLOYS See CATALYSTS—Spectroscopic Analysis.

## PLATINUM TITANIUM ALLOYS See STAINLESS STEEL—Coatings.

## PLATINUM TUNGSTEN ALLOYS

### Heat Treatment

**080888 EFFECT OF HEAT TREATMENT ON PHYSICAL PROPERTIES OF PT-BASED ALLOY WIRES FOR HIGH TEMPERATURE STRAIN GAUGE APPLICATION.** High resistivity and low temperature coefficient of resistance as well as the best linearity in the range 0-700°C of Pt-based alloy are achieved by solution heat treatment at high temperature for a short time, and stable treatment at lower temperature for a long time. All treatment is under a hydrogen atmosphere. The best practice is 1000°C/1 min. → quench into water → 720°C/30 hr for Pt-W alloy wire; 1000°C/1 min. → quench into water → 820°C/30 hr for Pt-W-Re alloy wire. (Edited author abstract). 7 Refs.

Feng, Ben-Zheng (Inst of Precious Metals, China); Li, Ding-Xin. *Metal* v 42 n 7 Jul 1988 p 669-671.

## PLATINUM TUNGSTEN RHENIUM ALLOYS See PLATINUM TUNGSTEN ALLOYS—Heat Treatment.

## PLATINUM VANADIUM ALLOYS

### Phase Diagrams

**080889 Pt-V (PLATINUM-VANADIUM) SYSTEM.** The author reviews previous work on the system. In addition to the invariant melting temperatures of the pure elements, there is an azeotropic melting maximum in the system near 27 at.% V and 1805°C. There are also one peritectic reaction, one eutectic reaction, three eutectoid reactions, and three congruent transformations in the solid state. A tabulation of these invariant reactions with temperatures and compositions is given. The review also covers crystallography, lattice parameters, thermodynamic properties and phase relationships. 38 refs.

Smith, J.F. (Iowa State Univ, Ames, IA, USA). *J Alloy Phase Diagrams* v 4 n 1 Jan 1988 p 5-13.

## PLATINUM ZIRCONIUM ALLOYS

### Internal Oxidation

**080890 MORPHOLOGY, STRUCTURE AND STABILITY OF THE OXIDE PHASE IN INTERNALLY OXIDIZED ALLOYS OF THE PLATINUM-ZIRCONIUM SYSTEM.** Platinum and its alloys are widely used for the preparation of glass apparatus. Platinum alloys strengthened by particles of stable refractory compounds, in particular oxides, are promising in this respect. The authors investigated the structure and morphology of alloys containing 0.2-2.0% Zr. Both the dispersed and the larger precipitates consist of two modifications of ZrO<sub>2</sub> - tetragonal and monoclinic. Since during use the material is in contact with air and a glass melt, the stability of the oxide phase during annealing in those two media for 1-100 hr at temperatures from 1200 to 1700°C was also studied. 11 Refs.

Daneliya, Ye. P. (State Planning Inst for the Treatment of Non-Ferrous Metals, Moscow, USSR); Karasev, A.R. *Phys Met Metallogr* v 62 n 4 1986 p 193-196.

## PLUMBING See Also FLOW OF FLUIDS—Tubes; HEAT EXCHANGERS—Tubes.

### Design See BUILDINGS—Tall.

**Fixtures** See Also CONCRETE CONSTRUCTION—Reinforced Concrete; DIES—Design; ROOFS—Drainage; WATER HEATERS.

**080891 HOW TO KEEP VACUUM TOILETS TROUBLE FREE.** It is more than 15 years since the first vacuum toilet went to sea and the most striking experience has been how well the original principles have withstood the test of time. A variety of alternative ways of creating and maintaining vacuum have been developed, mainly with a view to greater simplicity and economy. This article reviews maintenance of these units.

Jonsson, G. (Electrolux-Enviovac). *Holl Shipbuild* v 35 n 9 Nov 1986 p 56-57.

**080892 TORQUE REQUIRED FROM ELDERLY FEMALES TO OPERATE FAUCET HANDLES OF VARIOUS SHAPES.** Contemporary housing design for the elderly features faucet handles of various shapes in the kitchen and bath. Often the elderly users cannot properly grip the faucet handle, whose shape does not allow for sufficient torque to be developed to shut off the water flow. Twenty-three elderly females turned seven different faucet handles in the clockwise and counterclockwise direction, exerting comfortable levels of torque. The only handle that consistently allowed a torque force to be developed superior to that needed to operate working installed water faucets was a medical-type paddle. A comparison of the torque needed to terminate water flow in actual water faucets with the torque developed by the standing and seated subjects showed that the nonpaddle handles did not allow subjects to generate sufficient torque to terminate the water flow. The blunt edges of the nonpaddle handles caused substantial hand pain. (Author abstract). 6 Refs.

Bordett, Harvey M. (General Dynamics, Fort Worth, TX, USA); Koppa, Roger J.; Congelton, Jerome J. *Hum Factors* v 30 n 3 Jun 1988 p 339-346.

## Hydraulic Drive See AIRCRAFT—Hydraulic Equipment.

### Standards

**080893 PLUMBING CODES AND STANDARDS: WHAT CHANGES ARE NEEDED?** Plumbing codes and standards have become an important aspect of plumbing design. They must be constantly monitored to make sure they keep up with today's needs. Water conservation requirements have to be reconciled with sanitary and safety requirements so that optimal conditions are ensured. Some examples of mistakes committed in this respect are given. As a result, e.g., model codes now require anti-scald tub/shower valves in commercial installations. Some ideas are expressed about the future of plumbing standards and codes.

Warshaw, Peter (Delta Faucet Co, Indianapolis, IN, USA). *Consult Specif Eng* v 2 n 6 Nov 1987 p 85-87.

## Water Supply

**080894 IN SEARCH OF THE PERFECT FLUSH.** By analyzing and balancing the three flows involved, mechanical engineers are designing toilets that consume only one gallon of water per flush instead of five. Various toilet designs are discussed. The optimal bowl for gravity-fed designs are evaluated. Cost-savings incentives of the various models are also aspects considered.

Cortes-Comerer, Nhora (Mechanical Engineering, New York, NY, USA). *Mech Eng* v 110 n 2 Feb 1988 p 40-47.

## PLUTONIUM AND ALLOYS See Also ATMO-SPHERIC RADIOACTIVITY—Paris, France; NUCLEAR REACTORS, PRESSURIZED WATER—Cores.

**080895 STUDIES OF A LIQUID ANODE FOR PLUTONIUM ELECTROREFINING.** A solvent anode is being developed as an alternate method for producing plutonium metal of high purity by an electrorefining process. The goal is to produce metal of 99.98% purity with an anode residue containing less than 2% of the plutonium in the feed material. If successful, a design and demonstration of a system utilizing semi-continuous and remotely controlled operations will follow. Establishing a solvent anode method should lead to improved yields and a substantial reduction in the amount of residues generated by the electrorefining process. The new method should be a viable pyrochemical technique for recovering both plutonium and uranium from spent reactor fuel. (Edited author abstract) 12 refs.

Bowersox, David F. (Los Alamos Natl Lab, Los Alamos, NM, USA); McNeese, James A.; Christensen, Dana C. *Sep Sci Technol* v 22 n 2-3 Feb-Mar 1987, Fourth Symp on Sep Sci and Tec for Energy Appl, Knoxville, TN, USA, Oct 20-24 1985 p 1183-1197.

## Analysis See RADIOACTIVE WASTES—Analysis.

### Applications

**080896 PLUTONIUMWIRTSCHAFT - SCHLAGWORT ODER REALITAET? [Plutonium Economy - a Catch Phrase or Reality?].** The laws of physics make plutonium a necessary reality in tapping nuclear power by splitting the atomic nuclei of uranium. Plutonium is an unavoidable component of the flows of nuclear materials, but in no way the undesired by-product of nuclear economy it is frequently said to be. Plutonium is a valuable nuclear fuel, the systematic utilization of which admittedly requires that spent fuel elements be reprocessed on a technical scale but which, in this way, also offers the key to the immense energy potential contained in the uranium reserves. There is agreement on the need to handle plutonium with the utmost care. However, this also applies to other radionuclides and to chemically toxic substances as well. Proper handling techniques allow the problems arising from the use of plutonium to be managed safely. In addition, there is the widespread international control, in which national and international surveillance measure supplement and intensify each other. (Author abstract) In German.

Haeefe, W. (KFA, Juelich, West Ger). *Atomwirtsch Atomtech* v 33 n 5 May 1988 p 250-255.

## Chemical Reactions See CHEMICAL REACTIONS—Redox.

### Electrodeposition

**080897 PREPARATION OF A <sup>238</sup>Pu STANDARD SOURCE. I. ISOTOPE DILUTION ALPHA-RAY SPECTROMETRY USED FOR STANDARDIZATION.** A <sup>238</sup>Pu source was prepared by electrodeposition method. For the standardization of the source, isotope dilution alpha-ray spectrometry (IDAS) was investigated. The content of <sup>238</sup>Pu in a sample solution was determined both by IDAS and by isotope dilution mass spectrometry (IDMS) using a standard reference material of <sup>239</sup>Pu as a spike. The estimated uncertainty in the determination of <sup>238</sup>Pu is 0.13 percent for IDAS, and the factor of IDAS/IDMS is calculated to be 1.000±0.00015. (Author abstract). 13 Refs.

Shinohara, Nubuo (JAERI, Tokai-mura, Jpn); Kohno, Nobuaki. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 239-242.

**080898 PREPARATION OF A <sup>238</sup>Pu STANDARD SOURCE. II. SOURCE PREPARATION AND STANDARDIZATION.** A standard source of <sup>238</sup>Pu was prepared for calibrating the counting efficiency of al-



pha-ray detector. The plutonium was electrodeposited on a platinum or tantalum disk using isopropyl alcohol-hydrochloric acid solution as an electrolyte. The absolute activity was certified by isotope dilution alpha-ray spectrometry. Several types of the source, whose areas  $^{239}\text{Pu}$ -deposited are from 2.0 to 25.0 mm in diameter, were also prepared by the method. The overall uncertainties of the certified values for the standard sources prepared are estimated to be within 0.15 to 0.25 percent ( $\sigma$ ). (Author abstract). 5 refs.

Shinohara, Nobuo (JAERI, Tokai-mura, Jpn); Kohno, Nobuaki. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 243-247.

## Environmental Testing

**080899**  $^{239,240}\text{Pu}$  IN ESTUARINE AND SHELF WATERS OF THE NORTH-EASTERN UNITED STATES. The distribution of  $^{239,240}\text{Pu}$  between dissolved and particulate forms has been measured in four estuaries on the north-east coast of the United States (Connecticut River, Delaware Bay, Chesapeake Bay, and Mullica River). The data cover the whole salinity range from freshwater input to shelf waters at 35‰ and includes one profile from a nearly anoxic basin in the Chesapeake Bay. In the organic-rich Mullica River estuary, large-scale removal of riverine dissolved  $^{239,240}\text{Pu}$  occurs at low salinities due to salt-induced coagulation, a mechanism analogous to that for iron and humic acids. Within the 0 to 25-30‰ zone in the other three estuaries, the activity of dissolved  $^{239,240}\text{Pu}$  increases almost conservatively. The dissolved  $^{239,240}\text{Pu}$  activity within each estuary appears to be inversely related to the flushing time of water. Dissolved  $^{239,240}\text{Pu}$  activities are lower in the nearly-anoxic bottom waters of Chesapeake Bay indicating enhanced removal by redox transformation of Pu. Additional study results are discussed. (Edited author abstract) 40 refs.

Sholkovitz, Edward R. (Woods Hole Oceanographic Inst, Woods Hole, MA, USA); Mann, Don R. *Estuarine Coastal Shelf Sci* v 25 n 4 Oct 1987 p 413-434.

**Extraction** See NEPTUNIUM—Extraction.

**Isotopes** See NUCLEAR ENERGY—Fission Reactions.

**Radioactivity** See Also NEUTRONS—Measurements; URANIUM AND ALLOYS—Radioactivity.

**080900** PLUTONIUM AEROSOL GENERATION IN REDUCING AND OXIDIZING ATMOSPHERES AT HIGH TEMPERATURES. Delta-phase plutonium metal pellets and foils were heated at 450°C in reducing atmospheres (3%  $\text{H}_2$  + 97% Ar or 3%  $\text{H}_2$  + 5%  $\text{N}_2$  + 92% Ar), and the respirable aerosols were collected and characterized. Residues of plutonium hydriding reactions were also heated at 450°C in air. The average percentage of initial radioactivity generated as respirable particles was 0.021% with a worst-case value of 0.46%. The particle size distribution of aerosols or powder residues was not related to the types of reaction atmosphere studied. These results support the conclusion that the major factors influencing the amount of particulate residues and their particle sizes are those that influence the integrity of a protective oxide layer, rather than the reducing or oxidizing nature of the reaction atmosphere. (Edited author abstract) 17 refs.

Edison, A.F. (Lovelace Biomedical & Environmental Research Inst, Albuquerque, NM, USA); Yeh, H.C.; Kanapilly, G.M. *J Nucl Mater* v 152 n 1 Mar 1988 p 41-52.

**080901** SELECTED RESULTS FOR MEASURING HOLDUP IN OXIDE HOODS AND TRANSFER LINES AT HANFORD. Physical inventories require quantifying the holdup in process equipment; one practical way of accomplishing this is measuring the gamma ray from plutonium ( $^{239}\text{Pu}$ ). Field measurements of plutonium holdup in dry plutonium oxide hoods or process transfer lines is frequently biased low, due to the possibility of heavy loading causing severe self-attenuation of the gamma rays. An experiment was performed to determine

the allowable loading limits for measuring plutonium holdup in dry oxide hoods. Field measurements of transfer lines in a plutonium production facility are frequently biased low due to the self-shielding of the holdup material. Fixed and portable gamma ray measurements were made of 6-ft-long sections of pipe. The results of this comparison are being used as a correction factor for routine field measurements of piping in the production facility. (Author abstract).

Jones, R.A. (Westinghouse Hanford Co, Richland, WA, USA); Kerns, R.E. *Nucl Mater Manage* v 26 n 4 Jul 1988 p 6-8.

**080902** TOTAL NEUTRON-COUNTING PLUTONIUM INVENTORY MEASUREMENT SYSTEMS (PIMS) - AND THEIR POTENTIAL APPLICATION TO NEAR REAL TIME MATERIALS ACCOUNTANCY (NRTMA). A radiometric method of determining the inventory of an operating plutonium plant is described. An array of total neutron counters distributed across the plant is used to estimate hold-up at each plant item. Corrections for the sensitivity of detectors to plutonium in adjacent plant items are achieved through a matrix approach. This paper describes our experience in design, calibration and operation of a Plutonium Inventory Measurement System (PIMS) on an oxalate precipitation-plutonium finishing line. Data from a recent trial of Near-Real-Time Materials Accounting (NRTMA) using the PIMS are presented and used to illustrate its present performance and problem areas. (Edited author abstract).

Driscoll, I. (British Nuclear Fuels plc, Sellafield, Engl); Fox, G.H.; Orr, C.H.; Whitehouse, K.R. *Nucl Mater Manage* v 26 n 4 Jul 1988 p 26-29.

**080903** MGA2: A ONE-DETECTOR CODE FOR RAPID HIGH-PRECISION PLUTONIUM ISOTOPIC MEASUREMENTS. The MGA (Multiple Group Analysis) code which we developed several years ago required two detectors when analyzing high  $^{241}\text{Pu}$  content samples. The isotopic information, which was obtained from the 300-kev regions, can now be obtained equally well from the low-energy region (50-208 kev). This breakthrough was achieved by developing a unique and highly accurate method for delineating the overall 'intrinsic' efficiency curve, including the plutonium K-shell absorption edge discontinuity. Consequently, the intense 129- and 148-kev peak intensities can now be used reliably in place of the peaks in the 300-kev regions to determine the relative abundances of  $^{239}\text{Pu}$  and  $^{241}\text{Pu}$ . The 203/208- and 148/152-kev pairs, and all of the intense 94- to 104-kev peaks, are included in the analysis to provide accurate data for the other isotopes of interest. (Author abstract) 10 refs.

Gunnink, Ray (Lawrence Livermore Natl Lab, Livermore, CA, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 352-358.

**080904** MEASUREMENT CONTROL PROGRAM FOR CALORIMETERS AND GAMMA ISOTOPIC INSTRUMENTS. The combination of the calorimetry and plutonium isotopic measurements to determine the total plutonium mass nondestructively has become increasingly more important at the Los Alamos Plutonium Facility. A measurement control program has been developed and implemented for these two types of systems. The program serves two major functions. It provides a near real-time check of the instrumental bias and precision. It also provides a data base for monitoring the systematic and random errors associated with each instrument. At the present, there are six calorimeters and four isotopic systems operating under this program. This paper describes the measurement control program and presents an assessment of 2 years of data from the 10 instruments. (Author abstract) 3 refs.

Hsue, F. (Los Alamos Natl Lab, Los Alamos, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 371-374.

## Recycling

**080905** PLUTONIUM RECYCLING IN FRANKERICH. [Plutonium Recycling in France]. In the plans for the expansion of nuclear power in France it was foreseen until 1980 that the extensive program of PWR plants would be supplemented by the fast breeder line around the turn of the century. Consequently, the use of plutonium was considered chiefly with a view to LMFBRs. Plutonium recycling in PWRs seemed to be less important by comparison. Now that it is becoming obvious that the large scale introduction of the LMFBR line will be delayed also in France, it was meaningful to revise the plans on how to use plutonium. Under the present economic conditions, and in view of the investments already made, plutonium recycling in PWR power plants has been found to be the most economic solution. Electricite de France therefore has focused entirely on this line and is developing a complete program based on this concept. (Edited author abstract) In German.

Janin, R. (Electricite de France, Paris, Fr). *Atomwirtsch Atomtech* v 32 n 10 Oct 1987 p 502-506.

**Reduction** See Also URANIUM AND ALLOYS—Reduction.

**080906** REPERCUSSIONS OF THE RADIATION AND EFFECT OF CERTAIN POLYVALENT IONS ON THE ELECTROCHEMICAL REDUCTION OF  $\text{Pu(VI)}$  IN AQUEOUS SOLUTIONS. Considerable attention has centered in recent years on the development of electrochemical methods of stabilizing the valence forms of uranium, plutonium, and neptunium in the extraction processes for reproducing spent nuclear power-plant fuel, primarily with a view to a reduction in the volumes of liquid radioactive wastes and their solutes content. In this paper are set out the results of a study of the electrochemical reduction of  $\text{Pu(VI)}$  to  $\text{Pu(IV)}$  in aqueous nitric acid solutions under the effect of ionizing radiation in the presence of uranium and certain fission products (palladium, ruthenium, and technetium). The research was carried out in a temperature-controlled electrochemical cell with a titanium cathode (2 cm<sup>2</sup>) and a platinum anode (0.4 cm<sup>2</sup>) and no division between the electrode compartments. 10 refs.

Egorov, G.F.; Marchenko, V.I.; Tkhorzhnitskii, G.P. *Sov At Energy* v 63 n 3 Sep 1987 p 672-676.

**Solutions** See URANIUM COMPOUNDS—Trace Analysis.

**PLUTONIUM COMPOUNDS** See Also RADIOACTIVE WASTES—Disposal.

**080907** NEUTRON SCATTERING AND MAGNETIZATION STUDIES OF PLUTONIUM MONOCHALCOGENIDES. Magnetic susceptibility  $\chi(T)$  measurements have been performed on single crystals of  $\text{PuS}$ ,  $\text{PuSe}$ , and  $\text{PuTe}$ . For  $T > 50 \text{ K}$ ,  $\chi(T)$  is independent of  $T$  with a small value of approx.  $300 \times 10^{-6} \text{ emu/mol}$ . For  $T < 50 \text{ K}$  increases are seen in  $\chi$ . We believe these arise because of defects in the lattice. Polarized neutron diffraction has been used to determine the form factor of 5f electrons around the Pu ion. The largest induced moment is approx.  $5 \times 10^{-3} (\mu\text{B})$  so the form factor is not accurately determined, but is clearly different from that found in the localized  $\text{PuSb}$ . The results are discussed in terms of our present understanding of the Pu monochalcogenides. A theory consistent with all the present measurements is not yet available. (Author abstract) 29 refs.

Lander, G.H. (EURATOM, Karlsruhe, West Ger); Rebizant, J.; Spirllet, J.C.; Delapalme, A.; Brown, P.J.; Vogt, O.; Mattenberger, K. *Physica B & C* v 146 n 3 Oct 1987 p 341-350.

## Chemical Analysis

**080908** DETERMINATION OF PLUTONIUM IN URINE BY RADIOCHEMICAL SEPARATION AND USE OF ETCHED CR-39 TRACK ANALYSIS.



Well-validated preparative and radiochemical procedures for separating plutonium from urine by wet-oxidation, ion-exchange and electrodeposition are outlined. Recently developed application of etched alpha track analysis using an automated image analyser is described. Experiences with this sensitive radiometric technique are reported and discussed. (Author abstract) 5 refs.

Grieve, R.S. (British Nuclear Fuels plc, Sellafield, Engl); Bates, T.H. *Sci Total Environ* v 70 Mar 1988, Environ Radiochem Anal, Proc of the Fifth Symp, Harwell, Engl, Oct 1-3 1986 p 355-371.

## Dissolution

**080909 DISSOLUTION OF  $\text{PuO}_2$  IN  $\text{HNO}_3$ -HF- $\text{N}_2\text{H}_4$  MEDIUM.** The dissolution of plutonium dioxide ( $\text{PuO}_2$ ) in nitric acid is an extensively studied subject in view of its importance in nuclear fuel reprocessing and scrap recovery. The thermodynamic solubility of  $\text{PuO}_2$  in nitric acid has been calculated, taking into account the formation of higher nitrate complexes of plutonium at higher acidities. The dissolution of  $\text{PuO}_2$  in nitric acid containing hydrofluoric acid and hydrazine has been studied. The results indicate that the presence of hydrazine in nitric acid containing hydrofluoric acid aids the dissolution of  $\text{PuO}_2$ . The destruction of hydrazine after the dissolution step is found to be easy. 11 refs.

Shakila, Abdul Majeed (Indira Gandhi Cent for Atomic Research, Kalpakkam, India); Srinivasan, Thandangorai Ganapathi; Sabharwal, Kanwal Nain; Vasudeva Rao, Polur Rangarao. *Nucl Technol* v 79 n 1 Oct 1987 p 116-119.

**Environmental Impact** See WATER SUPPLY—Water Quality.

## Measurements

**080910 ATTRIBUTES MEASUREMENTS BY CALORIMETRY IN 15 TO 30 MINUTES.** An analysis of the early portion of the power-history data collected with both of the IAEA's air-cooled bulk calorimeters has demonstrated that such calorimeters can measure the power from preheated containers of plutonium oxide with an accuracy of 2-5% in 15 to 30 minutes. Material accountability at plutonium facilities has a need for such a capability for measurement of Pu scrap. Also, the IAEA could use just two calorimeters and a gamma-ray assay system for reliable variables and attributes measurements of plutonium mass during a two-day physical-inventory verification (PIV) at a mixed-oxide (MOX) fuel-fabrication facility. The assay results would be free of the concerns about sample moisture, impurities, and geometry that previously have limited the accuracy of assays based on neutron measurements. (Author abstract) 3 refs.

Fiarman, S. (Brookhaven Natl Lab, Upton, NY, USA); Perry, R.B. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 754-759.

## Oxidation

**080911 STUDIES ON RADIOLYTIC OXIDATION OF PLUTONIUM (III) IN HYDROCHLORIC ACID MEDIUM.** The effect of  $\gamma$  radiation on plutonium (III) was studied in argon and oxygen equilibrated hydrochloric acid solutions. The initial G values of Pu (IV) and  $\text{H}_2\text{O}_2$  were found to be  $6.5 \pm 0.6$  and  $4.0 \pm 0.4$  respectively in oxygen equilibrated  $0.8 \text{ mol dm}^{-3}$  HCl solutions. While the G(Pu (IV)) increased to  $8.0 \pm 0.8$  in  $9.0 \text{ mol dm}^{-3}$  HCl solutions, G( $\text{H}_2\text{O}_2$ ) decreased to  $2.5 \pm 0.3$ . In argon equilibrated  $0.8 \text{ mol dm}^{-3}$  HCl solutions, the G values of Pu (IV) and  $\text{H}_2\text{O}_2$  were  $5.0 \pm 0.4$  and  $0.6 \pm 0.1$  respectively. It was observed that the initial yields of Pu (IV) decreased beyond a dose of  $6 \pm 0.1$  respectively. It was observed that the initial yields of Pu (IV) decreased beyond a dose of  $6 \times 10^{18} \text{ eV cm}^{-3}$  and there was incomplete oxidation of Pu (III) in  $0.8 \text{ mol dm}^{-3}$  HCl in both oxygen and argon equilibrated solutions, whereas Pu (III) in  $9.0 \text{ mol dm}^{-3}$  HCl was completely oxidized to plutonium (IV) in oxygen equilibrated solutions. The observed radiolytic

yields of Pu (IV) and  $\text{H}_2\text{O}_2$  are discussed in terms of reactions of Pu (III) with radiolytic products of water. Formation of a brown peroxy complex was observed in oxygen equilibrated solutions of Pu (III) in  $0.8 \text{ mol dm}^{-3}$  HCl. (Edited author abstract) 14 refs.

Nagar, M.S. (BARC, Bombay, India); Natarajan, P.R. *Radiat Phys Chem* v 30 n 3 1987 p 169-172.

**080912 KINETICS AND OXYGEN PRESSURE DEPENDENCE OF THE HIGH TEMPERATURE OXIDATION OF Pu-1WT.%Ga.** Oxidation of Pu-1wt.%Ga was measured between 150 and  $500^\circ\text{C}$  in oxygen pressures of 0.004 - 500 Torr. Three stages of oxidation were identified beyond the initial oxide nucleation. The effect of temperature on oxidation rates was determined at an oxygen pressure of 500 Torr. A discontinuity was observed between 300 and  $370^\circ\text{C}$  that resulted in a change in the activation energy for the Stage II and III processes. Oxygen pressure effects were measured at 200, 300 and  $400^\circ\text{C}$ . Both the parabolic rates for Stage I and the linear rates for Stage II were independent of pressure below 60 Torr and directly proportional to pressure above 60 Torr. Stage III was an interface reaction created by cracked and spalling of the oxide. (Edited author abstract) 28 refs.

Stakebake, Jerry L. (Rockwell Int, Golden, CO, USA); Lewis, Lloyd A. *J Less Common Met* v 136 n 2 Jan 1988 p 349-366.

**Physical Chemistry** See RADIOACTIVE MATERIALS—Hydrolysis.

## Radioactivity

**080913 STUDY OF IN-LINE PLUTONIUM ISOTOPIC ANALYSIS FOR GASEOUS PLUTONIUM HEXAFLUORIDE.** In-line plutonium isotopic analysis of gaseous plutonium hexafluoride ( $\text{PuF}_6$ ) is very important for process control and special nuclear material accountability in any plutonium isotope separation process that requires a gaseous phase. Although much effort had been devoted to analyze arbitrary plutonium samples, no isotopic analysis had been done on gaseous  $\text{PuF}_6$  samples. We have initiated a study on the use of a high-resolution, gamma-ray spectroscopy technique to analyze gaseous plutonium hexafluoride. For the first time,  $\text{PuF}_6$  gas samples with pressures varying from 0.15 to 31 torr, which were directly fed into a gas cell from a process flow loop, were measured. (Edited author abstract) 5 refs.

Li, T.K. (Los Alamos Natl Lab, Los Alamos, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 359-363.

**Thermodynamic Properties** See URANIUM COMPOUNDS—Thermodynamic Properties.

## PLYWOOD

### Adhesion

**080914 INSPECTION OF INTERIOR ADHESION IN PLYWOOD BY MEANS OF ACOUSTIC EMISSION.** A trial inspection was made of interior adhesion in plywood using the acoustic emission (AE) method. A bending test investigated the relation between AE characteristics and samples with and without adhesion in plywood. It was found that for sample C without adhesion AE started to count at an early stage of mechanical load. Also, sample C gave various amplitudes in the range from 30 kHz to 100 kHz even at an early stage of mechanical load. (Author abstract) 1 ref.

Yoshimura, Noboru (Akita Univ, Akita, Jpn); Ogawara, Yuji; Kodaki, Mitsukazu; Asari, Koichi; Nichida, Makoto; Okuyama, Daitaro. *Jpn J Appl Phys Suppl* v 25 suppl 25-1 1986, Proc 6th Symp on Ultrason Electron, Tokyo, Jpn, Dec 10-12 1985 p 209-211.

## Computer Aided Manufacturing

**080915 REAL TIME ADJUSTMENT OF PLYWOOD GLUE APPLICATION WITH A COMPUTER-CONTROLLED SPRAYLINE.** The capability of rapidly adjusting glue application rate offers several advantages in plywood production and laboratory test panel fabrication. A computer-controlled laboratory sprayline is described and tested. The described system provides accurate and rapid adjustment of glue application rate for test panel fabrication. Controlling flow rate through the spray nozzle by itself is not adequate to control glue application rate. Varying the flow properties of the glue mix affects the dispersion of the spray fan and the proportion of overspray. The actual measured application rate, used as feedback information, is necessary to maintain accurate and adjustable glue application control. (Author abstract) 11 refs.

Faust, Timothy D. (Univ of Georgia, Athens, GA, USA). *For Prod J* v 38 n 1 Jan 1988 p 35-41.

## Environmental Testing

**080916 WEATHERING PERFORMANCE OF FINISHED SOUTHERN PINE PLYWOOD SIDING.** Southern pine plywood siding with both roughsawn and scratch-sanded surfaces was finished with different commercial and laboratory-prepared materials and exposed outdoors on vertical test fences in Madison, Wis., Olympia, Wash., and Saucier, Miss. With one exception, transparent natural finishes gave reasonable performance for only 1 to 4 years. The transparent stain provided protection and, except for face checking, performed well for 5 years. Semitransparent and solid color stain finishes gave much better performance than transparent stains and protected roughsawn southern pine plywood for more than 7 years, but did not prevent face checking. The best finishes for southern pine plywood were acrylic latex paints, especially when applied over stain-blocking acrylic latex primer. A water-repellent preservative pretreatment improved the performance of the paints to a small extent and reduced face checking when an acrylic latex topcoat was used over an alkyl primer. Additional aspects of the study are discussed. (Edited author abstract) 22 refs.

Feist, William C. (USDA, Madison, WI, USA). *For Prod J* v 38 n 3 Mar 1988 p 22-28.

## Manufacture

**080917 TRANSIENT AND FREQUENCY RESPONSE ANALYSIS OF A GLUE APPLICATION CONTROL SYSTEM FOR PLYWOOD MANUFACTURING.** The objective of this study was to test a current spray application control system for transient and frequency response characteristics to determine if variable application rate control is feasible by simply converting the software. Transient response parameters of rise time, overshoot, settling time and steady state error were measured. The system performed well below acceptable levels even with modifications made to the control valve. The modifications did, however, improve system performance significantly. Frequency response tests indicated that in worst case conditions the control system could only output 38% of the control system input. (Edited author abstract) 11 refs.

Faust, Timothy D. (Univ of Georgia, Athens, GA, USA); McLendon, Derrell B.; Rice, James T. *Trans ASAE* v 30 n 5 Sep-Oct 1987 p 1458-1464.

**Recovery** See VENEER.

**PNEUMATIC DRIVE** See Also COMPRESSORS; ROBOTS, INDUSTRIAL—Grippers.

**Applications** See Also PRESSURE REGULATORS—Pneumatic Drive.

**080918 COMPUTER-AIDED DESIGN OF PNEUMATIC VIBRATIONPROOF SYSTEMS.** Problems of computer-aided design for pneumatic vibrationproof systems are examined at invention level in interactive mode



(designer-computer dialog). A set of applied programs is developed on a US computer. The proposed method of designing and structuring an automated system to search for the design of pneumatic vibrationproof insulators can be used to develop a system for other types of vibration-proof devices. (Author abstract) 8 refs.

Andreichikov, A.B.; Grishin, V.A.; Kamaev, V.A. *Sov Mach Sci* n 2 1987 p 1-7.

## Brakes

**080919 CALCULATING THE BRAKING CHARACTERISTICS OF HIGH-SPEED PNEUMATIC DRIVES.** The article considers the design parameters of various types of braking devices for high-speed pneumatic drives. The piston of a high-speed drive can be braked by sharply reducing the exhaust port area at some point of the stroke, or by completely closing-off exhaust port of the stroke and keeping it closed in the first stage of braking, then opening it to some area, and gradually closing it in the second stage. 3 refs.

Paroi, A.A.; Kukovincts, V.N. *Sov Eng Res* v 7 n 5 May 1987 p 40-42.

**Computer Applications** See PNEUMATICS—Robot Applications.

**Design** See GRINDING MACHINES—Pneumatic Drive.

## Mathematical Models

**080920 MATHEMATICAL MODEL OF PNEUMATIC MULTICHAMBER ROTATIONAL DRIVE.** Various aspects of the mathematical model of a pneumatic drive are covered. Some of the aspects discussed are the construction of a multichamber rotational drive; compressed air supply; piston motion, equations of motion; impact conditions; impact load elimination; and pressure variation. The assumptions made in the investigation of piston motion are stated. 2 refs.

Labuzov, N.N. (Moscow Technological Inst of Light Industry, USSR); Tishkov, A.Ya.; Afanas'ev, L.N. *Sov Min Sci* v 22 n 6 Nov-Dec 1986 p 481-485.

## PNEUMATIC TUBES

**080921 RELATION BETWEEN THE POWDER CHARGE AND THE SHAPE OF THE PIPE IN PNEUMATIC CONVEYANCE.** The electrification of a polymer powder transported through U-bend pipes was studied at particle speeds of  $v = 17.6$  m/s and 26.4 m/s, and a solid load  $\rho = 0.017$  kg/m<sup>3</sup>. The charge/mass ratio,  $q$ , of powder passing through the U-bend pipes (seven different radii of curvature) depended on the flow pattern of the powder particles after their first collision with the inner wall of the bend of the pipe. (Author abstract) 3 refs.

Masui, Noriaki (Science Univ of Tokyo, Noda, Jpn). *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 696-697.

**Applications** See IRON AND STEEL ANALYSIS—Sampling.

## Fluid Dynamics

**080922 BOUNDARY ELEMENT PREDICTION OF THE FREE SURFACE SHAPE BETWEEN TWO PARTICLE PLUGS IN A HORIZONTAL PNEUMATIC TRANSPORT PIPELINE.** A method is presented to predict the shape of the gas-particle interface between two plugs of cohesionless particles conveyed pneumatically through a horizontal pipeline. The method assumes that the moving solids are in a state of limiting equilibrium at the interface and that, therefore, the interfacial slope depends on the normal fluid pressure gradient which can be used as a boundary condition for the numerical solution of Laplace's equation. The height of stationary material between the plugs cannot be predicted by the method, since this material is not in a state of limiting equilibrium. However, an analogy with a gas-liquid system can be used to predict this height. The

method as presented is restricted to plugs of constant voidage and to systems which obey Darcy's law (packed bed Reynolds numbers less than 10). The boundary element numerical technique is used to apply the method to a 2-dimensional example of flow through a 50 mm I.D. pipe. The predictions are qualitatively in agreement with photographs of the observed shape in the true (3-dimensional) situation. However, further numerical and experimental work on the 3-D situation is required for a full assessment of the proposed method. (Author abstract) 16 refs.

Konrad, K. (Virginia Polytechnic Inst and State Univ, Blacksburg, VA, USA). *Can J Chem Eng* v 66 n 2 Apr 1988 p 177-181.

## Manufacture

**080923 EXTRUSIONS TAKE EFFECT ON AIR CYLINDERS.** Use of extrusions in the design of pneumatic cylinders is becoming more popular as the demand for flexible modular systems grows. In this review of pneumatic cylinders, it is noticeable that the conventional design of rolled stainless steel tube is losing its popularity. The alternatives are aluminium extrusions, and filament wound composites.

Anon. *Eng Mater Des* v 32 n 4 Apr 1988 p 33-34, 37.

**PNEUMATICS** See Also BEARINGS—Thrust; INFLATABLE STRUCTURES—Thermal Effects; NUCLEAR POWER PLANTS—Auxiliary Equipment; PIPELINES; PRESSURE TRANSDUCERS; PROSTHETICS—Artificial Organs; RADIOMETERS—Design; SEPARATORS—Pneumatic.

**080924 SEAL FOR PNEUMATIC APPLIANCES.** The operational characteristics of pneumatic appliances are determined to a large extent by the design of the sealing units of the sliding joints. Rubber seal rings of T-shaped cross-section are reliable and long lasting in service since only a small friction force is generated when they operate. When the air pressure rises, the ring slides along the surface of the cylinder and is thrust against the wall of the groove, and it then moves together with the piston.

Alekseev, V.P.; Galimullina, A.P. *Sov Eng Res* v 7 n 3 Mar 1987 p 71-72.

**080925 DENSE-PHASE TRANSPORT: VERTICAL PLUG FLOW.** The transport of coal particles at low velocities by forming plugs was studied in a 0.0254-m vertical pipe. The pressure drop and plug velocity were measured at different air flow rates and for different plug lengths. The conditions to produce stable plugs were studied. The pressure drop was found to be independent of the air flow rate and to vary linearly with plug length. The plug velocity was independent of plug length in the conditions studied. A model that predicts the pressure drop was in good agreement with the experimental data. It suggests that in the case of vertical plug flow at low velocities, gravitational forces are the most important ones. (Edited author abstract) 15 refs.

Borzone, L.A. (Univ of Pittsburgh, Pittsburgh, PA, USA); Klinzing, G.E. *Powder Technol* v 53 n 3 Dec 15 1987 p 273-283.

**Applications** See Also COAL MINES AND MINING—Storage; CONTROL SYSTEMS—Design; FURNACES; METALLURGICAL—Pressure Control; MECHANICAL VARIABLES MEASUREMENT.

**080926 ON A LINEAR PNEUMATIC DAMPERS. [On a Linear Pneumatic Dampers].** In the present paper a linear pneumatic damper is studied. This damper is a linear pneumatic oscillator having an auxiliary chamber commonly called a plenum chamber. This allows the gas to flow into and out of the chamber to dissipate energy without loss of gas. The root-locus of the characteristic equation is discussed in detail for several values of system parameters. The results are plotted in the complex plane with  $j\omega$  as ordinate and  $\sigma$  as abscissa. The damping ratio as a function of the parameters of the system is also determined. (Author abstract). 1 Ref. In Romanian.

Marinescu, P.V. *Bul Inst Politeh Ser Transp Aeronave* v 49 1987 p 95-103.

## Components

**080927 VENT PNEUMATIC ENCLOSURES FOR SAFETY.** The last twenty years have seen significant growth in the practice of mounting pneumatic components within sheet metal enclosures. The movement has been spearheaded by moving part logic, where the only practical way to assemble a control system has been to mount the components in an enclosure. In fact, most user specifications require this practice to protect MPL devices from dirt, oil mists and other ambient airborne contaminants. Another important trend is the combination of electronics and low-power, miniature 3-way solenoid valves - mounted on electronic racks, again in enclosures - to provide low-capacity, high-pressure signals either directly to miniature actuators or to the air pilots of larger power valves out on the machine.

Doig, G. (Doig Associates Inc, Bloomfield Hills, MI, USA). *Hydraul Pneum* v 40 n 9 Sep 1987 p 67-68.

**Design** See Also CONTROL SYSTEMS—Computer Applications.

**080928 PNEUMATIC DESIGN FOR MICRO-PROCESSOR CONTROL.** Machine designs require power components to complement the microprocessor-based control systems, but most available components do not interface well with the controls, either mechanically or electronically. The author shows how the company solved the problem with a printed circuit board concept, with pneumatic components and support solid-state electronics packaged to electronics industry specifications. (Edited author abstract). Refs.

Andres, Paul D. (LDI Pneutronics). *Power Int* v 34 n 395 May 1988 p 101-102.

**Instruments** See VIBRATIONS—Damping.

## Measurements

**080929 NEW LINEAR PNEUMATIC SENSOR FOR DISPLACEMENT MEASUREMENTS.** A simple design method for the measuring nozzle face profile of a new linear pneumatic sensor for displacement measurements is given. The procedure is efficient and produces a specially designed nozzle face profile that allows a significantly elongated linear range of the characteristic curve for the simple sensor type. There is some shifting of the experimental linear range compared with the theoretical results. (Edited author abstract). 4 Refs.

Michnikowski, P. (Technical Univ, Poznan, Pol); Popiel, Cz. O. *J Fluid Control* v 18 n 3 1988 p 25-33.

**Medical Applications** See BIOMEDICAL ENGINEERING—Surgery Applications.

## Robot Applications

**080930 DEVELOPMENT OF THE PLACEMATE PNEUMATIC ROBOT.** Initial work on microcomputer-controlled pneumatics began in 1974. The start of the robot project dates back to 1976 when the first version of the Placemate was exhibited. The aim of the project was to design a low-cost point-to-point handling machine which would be provided with a flexible teachable capability. Such a robot would be placed above the pick and place unit, which allows only a limited number of positions to be set on each axis by means of mechanical stops (e.g. Electrolux Senior). 5 refs.

Drazan, P.J. (Univ of Wales, Cardiff, Wales). *Adv Rob* v 1 n 3 1986 p 273-280.

**Stability** See BEARINGS—Thrust.



**POLARIMETERS** See Also BARS—Bending; ELECTRON BEAMS—Measurements; OPTICAL FIBERS: PROTONS—Measurements; PROTONS—Monitoring; RADAR—Cross Sections.

**080931 LIQUID-HELIUM SCINTILLATOR AS A FAST-NEUTRON POLARIMETER.** A liquid-helium neutron polarimeter was constructed and successfully used for polarization measurements in (p,n) and (d,n) reactions. Its effective analyzing power was about 0.7, in good agreement with a Monte Carlo calculation which includes the effects of multiple scattering and the finite size of the scatterer and the detectors. The response of the liquid-helium scintillator to neutrons was measured between 3 and 18 MeV. A linear relation was observed between the incident neutron energy and the maximum light output. No significant position dependence of the light output was found. (Author abstract) 19 refs.

Ieki, Kazuo (Tokyo Inst of Technology, Tokyo, Jpn); Hoshino, Naoki; Iwase, Mitsuo; Ohnuma, Hajime; Takahashi, Yutaka; Orihara, Hikonojo. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 323-328.

**080932 POLARIZERS AND POLARIMETERS IN THE X-UV RANGE.** The advantages of polarized light were largely in the visible range as opposed to the X-UV range where no polarizer was available. Using the new X-UV multilayers set at a 45° angle of incidence it is now possible to demonstrate how such polarizers work. One is now able to measure the obtained polarization rate, compare it to the theoretical value and check the influence of the material index. Description and performances of a polarimeter using such X-UV polarizers are given. (Author abstract) 16 refs.

Dhez, P. (Univ Paris XI, Orsay, Fr). *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 66-71.

**Applications** See SPECTROMETERS, ULTRAVIOLET—Applications.

## Design

**080933 ACCOUNTING FOR THE EFFECT OF ANISOTROPY OF AN INSTRUMENT WHEN STUDYING SPECTROPOLARIZATION CHARACTERISTICS OF NATURAL FORMATIONS.** Polarization characteristics of solar radiation scattered or reflected by natural objects carries information on the state and properties of an object that can be used in remote-sensing studies. We consider a technique for determining and accounting for the effect that the polarization properties of an instrument has on the parameters of radiation incident on the detector when a polarization mask is placed between the detector and the monochromator. This methodology was used for designing the MSS-2P spectropolarimeter on board the Salyut-7. The small size of the device and its simplicity were achieved because the analytic polarization block was positioned near the output slit of the monochromator. These advantages are of decisive value in many situations, especially onboard spacecraft. The optokinematic schematic of the MSS-2P spectropolarimeter is illustrated. 9 refs.

Zaitseva, V.A.; Kononovich, S.I.; Plyuta, V.E. *J Appl Spectrosc* v 46 n 2 Feb 1987 p 177-182.

**080934 NEW TYPE OF POLARIMETER FOR VECTOR- AND TENSOR-POLARIZED DEUTERONS FOR APPLICATIONS IN INTERMEDIATE ENERGY GRAPHICS.** The design, the construction and the calibration of a high-efficiency deuteron polarimeter for the simultaneous measurement of the vector polarization  $i_{11}$  and the tensor polarization  $t_{20}$ ,  $t_{21}$  and  $T_{22}$  is described. It is based on the  $^3\text{He}(d,p)^4\text{He}$  reaction and is capable to measure the polarization of secondary low intensity deuteron beams (50-1000 deuteron/s) produced in nuclear and particle physics. The usable deuteron energy range is between 15 and about 100 MeV. The calibration of the polarimeter shows only a small sensitiv-

ity with respect to the energy, position and angle of the incident deuterons. The polarimeter is particularly able to work in a high background. (Author abstract) 22 refs.

Grueebler, W. (ETH-Hoenggerberg, Zurich, Switz); Koenig, V.; Schmelzbach, P.A.; Bittcher, M.; Vuariel, B.; Forstner, Ch.; Singy, D.; Slaus, I.; Chisholm, A. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 307-322.

**080935 METHOD OF DESIGNING GRATING POLARIZATION SEPARATORS FOR QUASIOPTICAL POLARIMETERS.** A method is described and convenient expressions and graphs are obtained for calculating, with sufficient accuracy for practical purposes, the parameters of grating polarization separators for use in quasioptical submillimeter polarimeters. (Author abstract) 5 refs.

Kiselev, V.K.; Kushta, T.M.; Litvinov, D.D. *Radioelectron Commun Syst* v 30 n 5 1987 p 27-31.

## Imaging Techniques

**080936 CHARGE-COUPLED-DEVICE-BASED IMAGING POLARIMETER FOR ASTRONOMY.** Using a thinned, three-phase Texas Instruments 800×800 CCD (TI 3PCCD) and inexpensive plastic Polaroid material, we have constructed an imaging polarimeter for astronomical data collection. A unique method of image shifting, shuttering, and Polaroid rotation enables us to circumvent the sky transmission fluctuations that normally plague polarimetry. The method is possible only because of the exceedingly low dark current and exceedingly high charge-transfer efficiency of this CCD. Our observations of standard polarimetry stars have verified the operation of our imaging polarimeter and have demonstrated that polarimetry can be accurately performed below the 1% polarization level with well-behaved CCDs. (Author abstract) 12 refs.

Clemens, Dan P. (Univ of Arizona, Tucson, AZ, USA); Leach, Robert W. *Opt Eng* v 26 n 9 Sep 1987 p 923-929.

**Millimeter Waves** See REMOTE SENSING—Millimeter Waves.

**POLARISCOPES** See BOLTS AND NUTS—Analysis.

**POLAROGRAPHIC ANALYSIS** See Also ORGANIC COMPOUNDS—Reduction; ORGANIC COMPOUNDS—Solutions; PHENOLS—Reduction; URANIUM COMPOUNDS.

**080937 DIFFERENTIAL PULSE POLAROGRAPHIC STUDIES OF COPPER(II)-POLYAMINE COMPLEXES AT LOW LIGAND CONCENTRATIONS.** The application of differential pulse polarographic (DPP) experiments at low ligand concentration to the characterization of complexes has been investigated by studying three previously characterized copper(II)-polyamine systems. The DPP results were compared to cyclic voltammetry (CV) and cyclic differential pulse voltammetry (CDPV) measurements as well as to simulations. The Cu(II)-ethylenediamine system at a 1:1 concentration exhibits three DPP peaks. This is shown to be due to direct reduction of the complexes. In the case of Cu(II)-triethylenetriamine, direct observation of two protonated complexes is possible at a 1:1 concentration upon titration with strong acid. The results for Cu(II)-diethylenetriamine appear consistent with values of  $\log \beta_1 = 16$  and  $\log \beta_2 = 21$ , although detailed studies of this system were precluded by a polarographic maximum. (Author abstract) 17 refs.

Schmidt, Norman E. (Univ of South Carolina, Columbia, SC, USA); Pan, Jing Hao; Philp, Robert H. Jr. *J Electroanal Chem Interfacial Electrochem* v 241 n 1-2 Feb 10 1988 p 281-289.

**080938 CURVE-FITTING PROGRAM SET FOR HANDLING OF DIFFERENTIAL PULSE POLAROGRAMS.** DP polarograms corresponding to both first- and second-order processes are treated on the basis of

approximate equations. Overlapped peaks can also be analyzed. BASIC curve-fitting programs running on a APPLE II+ are proposed and tested. Applications to electrochemical kinetics and routine analyses are also considered. (Author abstract) 9 refs.

Rodriguez Mellado, J.M. (Univ de Cordoba, Cordoba, Spain); Blazquez, M.; Dominguez, M. *Comput Chem* v 12 n 3 1988 p 257-266.

**Applications** See BIOMEDICAL ENGINEERING—Micro-circulation.

## Computer Applications

**080939 MULTIMODE TRIPLE SAMPLING POLAROGRAPHY IN THE STUDY OF AMALGAMATION AND SPHERICITY EFFECTS AT THE STATIC MERCURY DROP ELECTRODE.** With a microprocessor-controlled polarographic analyzer and a static mercury drop electrode (SMDE), normal pulse polarograms (NPP), differential pulse polarograms (DPP), and direct current polarograms (DCP) are obtained simultaneously with the triple sampling polarographic (TSP) method. The influences of sphericity and amalgamation on the NPP and DCP current responses and half-wave potentials are shown to be in good agreement with those calculated from theory. (Edited author abstract) 27 refs.

Nyholm, Leif (Uppsala Univ, Uppsala, Swed); Wikmark, Gunnar. *Anal Chem* v 59 n 19 Oct 1 1987 p 2383-2390.

**080940 COMPUTER AUTOMATION OF POLAROGRAPHIC ANALYZER PAR 384B AND DEVELOPMENT OF SPECIFIC IMPLEMENTATION SOFTWARE.** The automation of Polarographic Analyzer PAR 384B by connecting it to an HP 9816S Technical Computer is presented. The connection itself transforms an analytically oriented instrument towards one which is more appropriate for research work. Specific implementation software is developed in order to enable and facilitate pseudopolarographic measurements and evaluation of heavy-metal complexation phenomena. As an example, the procedure for the simultaneous determination of the stability constants of lead and cadmium present in constant ionic strength medium of X mol/dm<sup>3</sup> NaCl + (4-X) mol/dm<sup>3</sup> NaClO<sub>4</sub> is presented. The results obtained for lead and for cadmium are in agreement with the literature data. (Edited author abstract). 9 Refs.

Pizeta, I. (Rudjer Boskovic Inst, Zagreb, Yugosl); Branica, M. *J Electroanal Chem Interfacial Electrochem* v 250 n 2 Aug 25 1988 p 293-299.

## Electrodes

**080941 DEVELOPMENT OF ELECTROANALYTICAL CHEMISTRY AT THE LIQUID-LIQUID INTERFACE.** More attention has been paid to polarography and voltammetry using mercury and solid electrodes to measure redox reactions occurring at the interface between a metal and the electrolyte solution than to ion transfer occurring at liquid-liquid interfaces. The study of electrochemical phenomena at the L/L interface is very significant in the development of new electroanalytical methods for analyses of substances which are difficult to determine by other methods, such as antibiotics, herbicides, medicines and Ba<sup>2+</sup>, Sr<sup>2+</sup>, Ca<sup>2+</sup> ions. 25 refs.

Wang, Erkang; Sun, Zhisheng. *TRAC Trends Anal Chem (Pers Ed)* v 7 n 3 Mar 1988 p 99-106.

**Instruments** See HEAVY METALS—Trace Analysis.

## POLES

### Concrete

**080942 PRODUCTION AND ERECTION OF PRESTRESSED CONCRETE POLES FOR A RAILROAD ELECTRIFICATION PROJECT.** A long line production method for producing prestressed concrete poles to support overhead catenary wires for a railroad electrifica-



tion project has been developed in New Zealand. The method is ideally suited to producing poles economically from a conventional multiproduct pretensioned precast concrete factory using semiskilled labor. This paper describes the evolution of the design concept, optimum pole shapes, quality assurance, production and installation methods. (Author abstract)

McSaveney, Leonard G. (Firth Industries Ltd, Auckland, NZ). *PCI J* v 32 n 5 Sep-Oct 1987 p 42-51.

**080943 DESIGN CONSIDERATIONS FOR TAPERED PRESTRESSED CONCRETE POLES.** A strength design procedure based on the ACI 318-83 Building Code is developed for circular hollow-cored and I-shaped prestressed concrete poles and is implemented in a microcomputer program for an IBM PC. Load-moment interaction diagrams are automatically generated for any input values of the main variables. Three types of prestressing tendons with nonlinear stress-strain relations are considered. The effects of tendon configuration and other design parameters such as type of prestressing tendon, average prestress, concrete compressive strength and reinforcing index are evaluated. Nondimensionalized design charts for prototype conditions are presented. 12 refs.

Bolander, J. Jr. (Univ of Michigan, Ann Arbor, MI, USA); Sowlat, Koz; Naaman, Antoine E. *PCI J* v 33 n 1 Jan-Feb 1988 p 44-66.

**Construction** See TELEPHONE LINES—Construction.

**Corrosion Protection** See STREET LIGHTING—Maintenance.

## Design

**080944 RELATIVE ECONOMICS OF PRESTRESSED CONCRETE POLES.** Prestressed concrete poles have found increasingly wide acceptance due to their viability as a factory produced unit. Advantages offered by prestressed concrete over other materials justify its usage for poles. With the popularity of using prestressed concrete poles, many manufacturers and designers are continuously trying to select a shape of pole which is economical and practical to manufacture. The shape of prestressed concrete pole reflects on the economy to manufacture it. Taking into account the limits of sizes and strengths normally used and the relative economics of manufacturing, the most widely used four shapes are discussed in this paper. (Author abstract) 5 refs.

Sharma, O.P. (Hong Leong Industries Manufacturing Ltd, Singapore). *J Inst Eng India Part CI* v 68 Jan 1988 p 204-207.

## Painting

**080945 COST EFFECTIVE MAINTENANCE PAINTING.** In street lighting poles maintenance cost effective painting schemes which tolerate a degree of substrate deterioration after the initial service period, and/or which give long durable service, should be the objective of all painting specifications. However, such objectives cannot be achieved if painting method and choice of material is left to the tenderer, and if specifications do not take cognizance of the condition and exposure environment of plant items. Salient fundamentals and practical factors as outlined herein have significant effect on selection of a maintenance painting regime. The paper assumes that there is an economic case for maintenance painting, and discusses the use of paint systems to meet certain criteria. The choice from a large number of materials/types can be rationalized if all the salient factors and criteria are assessed. Additionally, the choice of paint manufacturer can be equally difficult. 2 refs.

Forrester-Coles, T. (CEGB). *Light J (Rugby Engl)* v 52 n 3 Sep 1987 p 140-142, 144-145.

## Reliability

**080946 RELIABILITY ANALYSIS OF POLE-TYPE TRANSMISSION STRUCTURES.** The unguyed single-pole transmission structure is widely used in the U.S. to support transmission lines of up to 345 kV capacity. As part of an eight-year effort to develop reliability-based design methods for transmission structures, several methods for performing reliability analyses of single-pole transmission structures were established. (Edited author abstract) 16 refs.

Vanderbilt, M.D. (Colorado State Univ, Fort Collins, CO, USA); Criswell, M.E. *Comput Struct* v 28 n 3 1988 p 335-343.

## Standardization

**080947 L'OMOLOGAZIONE DEI SOSTEGNI DELLE LINEE MT E BT.** [Standardization Procedure Relevant to Poles for Medium Voltage and Low Voltage Lines]. After describing the various types of poles at present used by ENEL in medium voltage and low voltage overhead electric power lines, the paper, referring to specifications currently in force, shows how the standardization procedure of poles is related to their overall quality, safety, and reliability. Lastly, the paper presents the results of standardization of some types of poles, describing a methodology for analyzing these results, which provides a parameter for evaluating the quality of the poles. (Edited author abstract) In Italian.

Dazzi, N. (ENEL DSR Cent di Ricerca Elettrica, Cologno Monzese, Italy). *Energ Elettr* v 64 n 11 Nov 1987 p 449-453.

**Stresses** See ELECTRIC LINES—Mechanical Characteristics.

**Structural Design** See HIGHWAY SIGNS, SIGNALS AND MARKINGS—Structural Design.

## Wind Effects

**080948 EXCITATION OF CABLE-STAYED MASTS BY TURBULENT WIND.** The use of time-step-integration techniques to solve for the dynamic response of cable-stayed masts from wind force excitation is examined in this paper. A simulation scheme suitable for generating spatially separated wind force traces that conform to characteristics observed in nature is also demonstrated and used in the modeling procedure. The non-linear effects of cable-staying on masts are illustrated from an application of these modeling techniques to a chosen example. (Author abstract) 7 refs.

Haritos, Nicholas (Univ of Melbourne, Parkville, Aust). *Math Comput Simul* v 30 n 1-2 1988, Simul Soc of Aust 1987 Conf, Melbourne, Aust, May 11-13 1987 p 81-86.

## Wood

**080949 FIELD EVALUATION OF FOUR WOOD POLE GROUNDLINE PRESERVATIVE FORMULATIONS USING WESTERN CANADIAN WOOD SPECIES.** The objective of the study was to determine whether copper-8-quinolinolate, copper naphthenate or bis(tributyltin) oxide (TBTO) are equivalent to pentachlorophenol in extending the service life of utility poles in western Canada, when applied as a groundline 'in situ' treatment using the pressure spade. Stubs prepared from utility poles were installed in a test plot and pressure spade treated with the four preservative greases. The preservative content of each pole stub was determined prior to remedial treatment and after one and three years of exposure. Bioassays on core samples removed from the stubs assessed changes in the protection against standard wood destroying fungi. Based upon both the chemical retention data and the bioassays, it was concluded that either copper naphthenate or TBTO, or even a mixture of both, could be used as alternatives to pentachlorophenol for use in grease remedial treatment. (Edited author abstract) 22 refs.

Ruddick, J.N.R. (Forintek Canada Corp, Vancouver, BC,

Can). *Res Rep Can Electr Assoc* n 068 D 129 May 1987 var pagings.

**080950 MANAGING AMERICA'S WOOD POLE INVENTORY.** Utilities manage more than 100 million wood power poles from coast to coast. New treatment, inspection, and repair processes are enabling the industry to significantly extend the life of this multibillion dollar resource. This paper discusses safer preservatives for new poles, extending pole life better repair techniques, pole diagnostics and nondestructive testing. 5 refs.

Shepard, Michael; Kennon, Richard; Ng, Harry; Shula, William. *EPRI J* v 12 n 6 Sep 1987 p 30-37.

**080951 BENDING PERFORMANCE OF SPLICED, NAILED-LAMINATED POSTS.** This study investigated the effect of three splice variables on post stiffness and bending strength. These variables - splice length, splice location, and the presence or absence of a reinforcing metal nail plate - were evaluated by comparing their relative effect on post stiffness and strength. Increasing the splice length and adding a nail plate had the greatest individual effects on strength and stiffness, while splice location showed little relative effect on post bending performance. Interactions between variables also affected bending performance to some extent. For instance, strength and stiffness were less affected by the presence of a nail plate when a 1,220-mm (4-ft) splice was used compared to a 610-mm (2-ft) splice. Implications of the study results are discussed. (Edited author abstract) 18 refs.

Winistorfer, S.G. (Univ of Wisconsin-Madison, USA); Moody, R.C.; Cramer, C.O. *Trans ASAE* v 30 n 6 Nov-Dec 1987 p 1791-1796.

**080952 DEVELOPMENT OF AN ENVIRONMENTALLY ACCEPTABLE WOOD POLE GROUNDLINE PRESERVATIVE FORMULATION.** Many Canadian electrical utilities carry out groundline remedial preservative treatment on aged wood utility poles using a pentachlorophenol based grease. A program was undertaken to identify an environmentally acceptable wood pole preservative formulation which would meet or exceed the performance criteria of present pentachlorophenol formulations. Copper naphthenate was considered to be a suitable replacement for pentachlorophenol. Groundline preservative formulations incorporating copper naphthenate at a concentration of 2% as copper metal are expected to provide protection against decay for ten years to poles originally pressure treated with oilborne or waterborne preservatives. Copper naphthenate is a low toxicity preservative, not known to harm humans, animals, or plants and is registered as a general use wood preservative with Agriculture Canada and the United States Environmental Protection Agency. (Edited author abstract) 12 refs.

Hawthorne, S. (Ontario Hydro, Toronto, Ont, Can). *Res Rep Can Electr Assoc* 068-D-129B Nov 1987 var pagings.

**080953 ELECTRICAL CHARACTERISTICS OF WOOD POLES.** An assessment procedure has been developed to evaluate the hazards resulting from contact with wood poles. A general computer based wood pole model accounting for treatment penetration, moisture content gradients, and rain was developed from field and laboratory measurements. The relative safety of five wood pole species treated with three treatments has been evaluated under several contact scenarios. Generally, penta and untreated poles result in higher degrees of safety, from the viewpoint of body current during personnel contact with the pole, than do similar poles treated with either CCA or ACA waterborne preservatives. (Edited author abstract)

Filter, R. (Ontario Hydro Research, Toronto, Ont, Can); Mintz, J.D. *Res Rep Can Electr Assoc* 118 D 393 Mar 1987 135p.



## POLISHING

**080954 GOOD TIPS ON POLISHING AND BUFFING.** The efficiency and effectiveness of polishing and buffing are heavily influenced by what happens to the part before it ever reaches the buffing department. It is less expensive to prevent defects than to remove them by polishing and buffing. The article is a guide to how to select and use the proper belts, buffs and compounds to produce better preplate and final finishes.

Spicer, William A. (Jackson Buff, Conover, NC, USA). *Prod Finish (Cincinnati)* v 52 n 3 Dec 1987 p 64-70.

**Chemical** See Also ALUMINUM AND ALLOYS—Polishing; GLASS—Polishing.

**080955 CHEMICKY ROZBOR CERICITYCH LES-TIV.** [Chemical Analysis of Cerium(IV) Polish Media]. A procedure has been developed for the determination of the main components in polishing powders based on cerium(IV) oxide. The method consists of a determination of cerium by titration and of neodymium and praseodymium by spectrophotometry; the content of lanthanum is calculated. The method which can be supplemented by a determination of the sum of rare-earth elements is applicable also to waste sludges from polishing of glass. (Edited author abstract) 19 refs. In Czech.

Janos, Pavel (Chemopetrol, Czech); Vosicka, Ivanka. *Chem Prum* v 37 n 9 Sep 1987 p 469-471.

**Efficiency** See CRYSTALS—Polishing.

**Electrochemistry** See TUBES—Polishing.

**Electrolytic** See Also METAL FINISHING; STAINLESS STEEL—Polishing; STEEL—Machining; STEEL—Polishing.

**080956 KINEMATICS OF PLANETARY EROSION AS A BASIS FOR ELECTRO-DISCHARGE POLISHING AND PROCESS OPTIMISATION STRATEGIES.** The advantages of EDM polishing are to be found chiefly in the multidirectional processing of complex volumes without the undercuts which easily arise with manual polishing in tool- and mould-making. A considerable number of individual factors affect the polishing process, with decisive effects on the product quality which can be achieved. Particular importance may be ascribed to such pulse parameters as discharge current, pulse duration, pulse interval, open-circuit voltage and polarity, which must be carefully matched if a shining polished surface is to be achieved. (Edited author abstract) 10 refs.

Koenig, W. (RWTH, Aachen, West Ger); Joerres, L.; Behmer, U. *Adv Manuf Processes* v 2 n 1-2 1987 p 23-35.

**080957 ANODIC LEVELLING OF MODEL PROFILES WITH PULSATING CURRENT.** The rate of anodic levelling with pulsating current is being investigated with triangular model profiles made of nickel using a flow channel cell. Observed results are compared to theoretical calculations of the rate of anodic levelling of macroprofiles and of microprofiles under d.c. conditions. It follows that the rate of anodic levelling is smaller above the pulse-limiting current density than that below it, and is smaller than that predicted for an ideal macroprofile. With pulsating current the rate of levelling of macroprofiles did not depend on profile orientation with respect to electrolyte flow. (Author abstract) 11 refs.

Clerc, C. (ETH, Lausanne, Switz); Landolt, D. *J Appl Electrochem* v 17 n 6 Nov 1987 p 1144-1149.

## Robot Applications

**080958 ROBOTIC POLISHING AND DEBURRING CONCEPTS PROVIDE A NEW OPTION IN FINISHING FLEXIBILITY.** Decorative and functional parts which are plated, painted, lacquered, powder coated or anodized, may require preparatory surface finishing to meet quality standards. The use of robotics and computerized numerical controlled machine systems can offer

manufacturers a new option to satisfy many of their basic finishing requirements. The article describes application to finishing brass plumbing hardware, steel door frames, aluminum and titanium aerospace components and brass lighting fixtures.

Carlson, Glen A. Jr (Acme Manufacturing Co, Madison Heights, MI, USA). *Met Finish* v 86 n 7 Jul 1988 p 51-54.

## POLONIUM

## Chemical Reactions

**080959 NEUTRALIZATION KINETICS FOR POLONIUM-218.** In a well-defined experimental system the neutralization of polonium-218 ions was investigated as a function of the physical and chemical properties of the controlled composition atmosphere. The diffusion coefficient of polonium-218 under various concentrations of trace gas NO<sub>2</sub> in nitrogen was measured. The mobilities of Po<sup>+</sup> and PoO<sub>2</sub><sup>+</sup> are determined by combining experimental results with a computer model of the system. Three neutralization mechanisms were individually studied. The small-ion recombination rate has been found to be proportional to the square root of radon concentration. The electron-scavenging mechanism is responsible for the neutralization of Po<sup>+</sup> in NO<sub>2</sub> or H<sub>2</sub>O in nitrogen. When PoO<sub>2</sub><sup>+</sup> is formed, the electron-transfer mechanism dominates the neutralization process. (Edited author abstract) 30 refs.

Chu, Kai-Dee (Univ of Illinois, Urbana, IL, USA); Hopke, Philip K. *Environ Sci Technol* v 22 n 6 Jun 1988 p 711-717.

**Geochemistry** See LEAD COMPOUNDS—Geochemistry.

## POLYACENES

## Phase Diagrams

**080960 FEIERLIS PHASES IN POLYACENE.** Polyacene (C<sub>4</sub>H<sub>2</sub>)<sub>x</sub> is a conjugated polymer which consists of two strongly coupled polyacetylene chains. The structure of polyacene may be regular with equal bond lengths (PA1), or distorted with alternating bonds (PA2 and PA3) or different bond lengths in both chains (PA4). The PA3 and PA4 phases are quantitatively compared within a simple tight-binding model, and a phase diagram is calculated. It is shown that PA3 phase is favored for some suitably chosen sets of the relevant parameters. 10 refs.

Mertsching, J. (Akad der Wissenschaften der DDR, Berlin, West Ger). *Phys Status Solidi B* v 143 n 1 Sep 1987 p K5-K10.

**POLYACETYLENES** See Also POLYMERS—Conductive.

**080961 LIVING NON-CONJUGATED POLYACETYLENES.** The non-conjugated poly (3,3-dimethyl-1-butyne) and poly (1-trimethylsilyl)-1-propyne were prepared by metathesis catalysts and the polymerization was monitored for molecular weight by gel permeation chromatography (GPC) and monomer conversion by GC. Both the 1-(trimethylsilyl)-1-propyne and 3,3-dimethyl-1-butyne gave a linear relationship with number average molecular weight versus conversion and number average molecular weight versus monomer to initiator ratio. The 1-(trimethylsilyl)-1-propyne failed to polymerize beyond 100% conversion. The 3,3-dimethyl-1-butyne, however, gave conversion to 300%, with GPC data clearly showing the continuation of propagation from the living polymer chain. The living character of these polymerizations seems to be the result of both the lack of backbiting which can occur only from a cis-cisoidal growing chain, and the lack of interchain reactions. (Edited author abstract) 15 refs.

Kunzler, Jay F. (Case Western Reserve Univ, Cleveland, OH, USA); Percec, Virgil. *Polym Bull (Berlin)* v 18 n 4 Oct 1987 p 303-309.

**080962 SOLITONS IN POLYACETYLENE.** Polyacetylene is presented both as a prototype conducting polymer and as a prototype one-dimensional metal and semiconductor. The concepts of the physics of one-dimensional metals are demonstrated on idealized polyacetylene. A review of the chemical and physical properties of real polyacetylene is given and experimental results on electrical conductivity, magnetic behavior, optical spectroscopy and photoconductivity are discussed in the context of soliton-like excitations. (Author abstract) 500 refs.

Roth, Siegmund (Max-Planck-Institut fuer Festkoerperforschung, Stuttgart, West Ger); Bleier, Hartmut. *Adv Phys* v 36 n 4 Jul-Aug 1987 p 385-462.

**080963 CALORIMETRIC METHOD FOR DETERMINING THE ISOMER CONTENT OF POLYACETYLENE.** The change in enthalpy associated with the cis to trans isomerization of polyacetylene films has been measured by differential scanning calorimetry (d.s.c.) and compared with the initial isomer content determined by FTIR. The data indicate a linear relation independent of sample history, making calorimetry a convenient means to assess the gross isomerism of this material. (Author abstract) 7 refs.

Tober, R.L. (Univ of Texas at Dallas, Richardson, TX, USA); Ferraris, J.P. *Polym Commun (Guildford Engl)* v 28 n 12 Dec 1987 p 342-343.

**080964 NEW LOCALIZED MODE OF SOLITON AND THE INFRARED ABSORPTION IN POLYACETYLENE.** A new localized mode of soliton called 'staggered mode' is found for the first time, which is infrared active and has a peculiar vibration configuration in which all the odd atoms are fixed whereas the even atoms oscillate in alternate directions. It is proved by our theory that there only exist three infrared active localized modes around the soliton in polyacetylene. The results show that these three infrared active localized modes conform with the observed infrared absorption lines of 900, 1988 and 1395 cm<sup>-1</sup>. (Author abstract) 14 refs.

Fu, Rouli (Acad Sinica, Shanghai, China); Wu, Changqin; Shen, Xuechu; Sun, Xin. *Chin J Infrared Res Ser B (Engl Ed)* v 6 1987 p 23-26.

**080965 NORMAL VIBRATIONAL ANALYSIS OF CIS-POLYACETYLENE.** The normal vibrational calculation was carried out on cis-polyacetylene (PA) and its model compound, cis, trans-2, 4-hexadiene. Based on the observed IR and Raman frequencies, force constants relevant to the cis-structure were refined. Finally a force field common for cis-PA, trans-PA and three model molecules was obtained. The observed spectra of cis-PA were theoretically assigned and the similarities and differences between the cis- and trans- conjugate systems were discussed on the basis of normal coordinate calculation. (Author abstract) 10 refs.

Wang, Jianling (Acad Sinica, Changchun, China); Jing, Xiabin; Feng, Zhiliu. *Chin J Polym Sci (Engl Ed)* v 5 n 4 1987 p 308-315.

**080966 NORMAL VIBRATIONAL ANALYSIS OF TRANS-POLYACETYLENE.** The results of normal vibrational analyses of trans,trans-2,4-hexadiene and the backbone of trans,trans-1,4-diphenyl-butadiene were used in the normal mode computation of trans-polyacetylene (PA). Only 8 non-zero calculated frequencies were obtained which obeys the rule of 3N-4. The potential energy distribution (PED) data were in good agreement with the empirical assignment of Shirakawa et al. and Kuzmany, but most of the vibrational frequencies of trans-PA had contributions from several empirical modes, indicating the more complicity in trans-PA molecular vibration than in the model molecule case. The calculated C=C and C-C stretching frequencies of trans-PA were over 200 cm<sup>-1</sup>



higher and lower than the observed ones, respectively, due to the longer effective conjugate length in the trans-PA. (Edited author abstract) 19 refs.

Wang, Jianling (Acad Sinica, Changchun, China); Jing, Xiabin; Feng, Zhiliu. *Chin J Polym Sci (Engl Ed)* v 5 n 4 1987 p 316-324.

**080967 PHOTOINDUCED ABSORPTION OF GAP STATES IN IODINE-DOPED POLYACETYLENE.** We have studied steady-state photoinduced absorption in trans-[CH(I<sub>2</sub>)<sub>x</sub>]<sub>n</sub> from 0.1 eV to 2.5 eV. In the lightly-doped semiconducting phase we have found evidence for interband gap increase with doping, in accordance with the soliton lattice model. The photogenerated charged defects in the heavily-doped metallic phase are characterized by two correlated absorption bands and infrared-active vibrations. (Author abstract) 18 refs.

Ehrenfreund, E. (Technion-Israel Inst of Technology, Haifa, Isr); Vardeny, Z.; Brafman, O.; Weagley, R.; Epstein, A.J. *Synth Met* v 21 n 1 Aug 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part I, Vadstena, Swed, Aug 18-20 1986 p 123-128.

**080968 COULOMB CORRELATIONS IN ONE-DIMENSIONAL CONDUCTORS WITH INCOMMENSURATE BAND FILLINGS AND THE SEMICONDUCTOR-METAL TRANSITION IN POLYACETYLENE.** The one-dimensional Hubbard and Hubbard-Peierls models are studied for various regimes of band filling. A variational ansatz for the ground state is worked out for small values (on the scale of the bandwidth) of the on-site Coulomb interaction. It is shown that this term enhances the lattice dimerization in the half-filled band case, but suppresses the lattice distortion in the incommensurate case. The semiconductor-metal transition in doped polyacetylene is tentatively attributed to this effect. Parameter values extracted from properties of the undoped material yield a critical dopant concentration of about 3%. (Author abstract) 22 refs.

Baeriswyl, D. (NORDITA, Copenhagen, Den); Carmelo, J.; Maki, K. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 271-278.

**080969 FIRST PRINCIPLES INVESTIGATION ON THE VALIDITY OF THE PEIERLS MECHANISM FOR THE DIMERIZATION ENERGY OF TRANS-POLYACETYLENE.** Detailed general potential linearized augmented plane-wave calculations indicate that interchain interactions in trans-polyacetylene drastically lower the density of states near the Fermi level in the symmetric (undimerized) state. This is in fact a model-independent result arising solely from interchain coupling and the non-symorphic symmetry group of the three-dimensional unit cell. Local density total-energy studies indicate that the interchain interactions reduce the strength of the Peierls mechanism so strongly that this mechanism may not provide the majority of the symmetry-breaking force as it is generally believed to do. (Author abstract) 13 refs.

Ashkenazi, J. (Technion, Haifa, Isr); Pickett, W.E.; Klein, B.M.; Krakauer, H.; Wang, C.S. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 301-304.

**080970 MODEL CALCULATIONS OF POLYMER HETEROSTRUCTURES: QUANTUM WELLS IN CONJUGATED MOLECULAR CHAINS AND SPACER MOLECULES IN 'MOLECULAR WIRES'.** In this contribution, the authors calculate the energy band structure and the corresponding eigenfunctions of polymer heterostructures on the basis of the Hückel theory. The existence of localized states can be shown for two different model structures. The first model represents a cyclic chain built up of polyacetylene (PA) and polydiacetylene (PDA) units. The content of PA molecules in PDA is varied from 0-100%. In a wide concentration range discrete split-off states appear within the energy gap of the heterostructure, which due to their localization behavior

can be identified as quantum-well states. The structure of these quantum-well states is strongly influenced by bond alternation defects. The second model describes a benzene ring embedded in a finite PA chain. The energy structure is calculated and criteria are derived on whether or not the benzene ring can act as a spacer molecule. 3 refs.

Ruckh, R. (Univ Stuttgart, Stuttgart, West Ger); Sigmund, E.; Sixl, H.; Roth, S. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 305-312.

**080971 HOW MANY KINDS OF SOLITONS EXIST IN POLYACETYLENE?** The equations of motion resulting from the Su-Schrieffer-Heeger Hamiltonian are reviewed. The appearance of solitons connected with various theories ( $\phi^4$ -like, sine-Gordon, modified Korteweg-de Vries equation) strongly suggests that polyacetylene is also capable of supporting other non-linear excitations. (Author abstract) 17 refs.

Pesz, Karol (Technical Univ, Wroclaw, Pol). *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 331-336.

## Aging

**080972 AGEING OF ELECTRICALLY CONDUCTING ORGANIC MATERIALS.** Ageing with respect to conductivity has been investigated for a wide variety of organic materials ranging from polyacetylene and polypyrrole salts to carbon black and carbon fibers, which are conducting materials in their electrically neutral state. For two polyacetylenes of different composition and a polypyrrole phenylsulfonate the influence of temperature on conductivity and its change with time could be described quantitatively. Data on the stability of polypyrrole salts under humidity and under extreme inert conditions are given. The influence of the degree of oxidation on the stability under ambient conditions is reported for a polypyrrole perchlorate. (Edited author abstract) 7 refs.

Muenstedt, H. (BASF AG, Ludwigshafen, West Ger). *Polymer* v 29 n 2 Feb 1988 p 296-302.

## Applications See Also ELECTRODES—Materials.

**080973 APPLICATION OF SUBSTITUTED POLYACETYLENES TO SEMIPERMEABLE MEMBRANES - THE POSSIBILITY OF LOOSE RO MEMBRANE.** As an application of substituted polyacetylenes, poly(1-phenyl-2-chloroacetylene) (PPCA) which exhibits excellent thermal and chemical durability, was fabricated into asymmetric UF membranes by the conventional phase inversion method. A characteristic feature of the PPCA UF membrane was its lower molecular weight cut-off properties. When the content of acetone in the dope as a non-solvent to PPCA increased, the molecular weight cut-off value of the PPCAS membrane lowered. Another characteristic was that it could be sulfonated directly by immersion into fuming sulfuric acid. The resulting charged membrane had lower molecular weight cut-off properties than the non-sulfonated ones. The salt rejection properties were ascribed to the effect of the Donnan membrane equilibrium. (Edited author abstract) In Japanese. 11 refs.

Takada, Koichi (Sanyo Chemical Industries Ltd, Kyoto, Jpn); Nakata, Yoshiro; Ohira, Kazuaki. *Kobunshi Ronbunshu* v 45 n 1 1988 p 47-53.

**080974 APPLICATION OF SUBSTITUTED POLYACETYLENES TO SEMIPERMEABLE MEMBRANES - THE POSSIBILITY OF HOLLOW FIBER TYPE MEMBRANES.** As an application of substituted polyacetylenes, poly(1-phenyl-2-chloroacetylene) (PPCA) has been fabricated into hollow fiber type UF membranes and a module was prepared. Striking contrasts were observed between the hollow fiber type and the flat sheet type membranes as to the effect of a poor solvent in the dope on such membrane characteristics as flux and rejection. A tentative explanation of the phenomenon was made. The effect of spinning conditions such as the dope

feeding rate, inner solution rate, and towing rate on the size of hollow fibers were elucidated. The scale up of the module revealed that the feeding rate of the test solution to be separated could be an essential factor for the effective use and design of the module. This pilot module also showed an excellent separation of a mixture of poly(ethylene glycol)s of molecular weights 1000 and 6000. (Edited author abstract) In Japanese. 3 refs.

Takada, Koichi (Sanyo Chemical Industries Ltd, Kyoto, Jpn); Nakata, Yoshiro; Ohira, Kazuaki. *Kobunshi Ronbunshu* v 45 n 1 1988 p 55-62.

## Calculations

**080975 CALCULATION OF LOCALIZED VIBRATIONAL MODES AROUND A SOLITON IN TRANS-POLYACETYLENE USING THE MOLECULAR ORBITAL METHOD.** Vibrational frequencies of polyacetylene with a charged soliton are calculated for finite chain lengths using the molecular orbital method. A translational mode, an amplitude oscillation mode, a third localized mode and a staggered mode are obtained as localized modes. It is found that the frequency of the translational mode is inversely proportional to the square of the chain length, and approaches zero when the length becomes infinite. This can be explained if the soliton is regarded as a quantum particle in a box. A type of electron-hole symmetry holds, even with the Coulomb effect, between occupied orbitals of the cation and unoccupied orbitals of the anion and between unoccupied orbitals of the former and occupied orbitals of the latter. (Author abstract) 26 refs.

Mori, Yuhei (ATR Optical & Radio Communications Research Lab, Osaka, Jpn); Kurihara, Susumu. *Synth Met* v 22 n 3 Jan 1988 p 219-229.

## Computer Simulation

**080976 ANALYTICAL ENERGY GRADIENTS FOR DYNAMICAL SIMULATIONS OF TRANS POLYACETYLENE CHAINS WITHIN THE PARISER-PARR-POPLE HAMILTONIAN.** Exact analytical energy gradients for the Pariser-Parr-Pople (PPP) Hamiltonian are derived. A comparison of computer times for dynamical simulations of trans-Polyacetylene (t-PA) using analytical and numerical gradients is given. The numerical method is shown to lead to serious difficulties both computationally and from the point of view of numerical accuracy. Using the analytical method, it turned out that the computational effort for the gradient calculation is negligible compared to that for the SCF iteration in each time step of a simulation. Using the numerical method the gradient calculation is the time consuming bottleneck of a simulation. A previously presented method for the gradient calculation in the Hückel type Su-Schrieffer-Heeger (SSH) Hamiltonian, which was thought to be approximative, is shown to be exact. (Edited author abstract) 18 refs.

Förner, W. (Friedrich-Alexander Univ Erlangen-Nürnberg, Erlangen, West Ger). *Solid State Commun* v 63 n 10 Sep 1987 p 941-944.

## Defects

**080977 CONFORMATIONAL DEFECTS IN DURHAM POLYACETYLENE: PHOTO-INDUCED IR ABSORPTION.** We report here steady state photo-induced absorption (PA) measurements using an IBM Instruments (Bruker) vacuum Fourier transform spectrometer on stretch-oriented and unoriented films of Durham polyacetylene. For the stretch-aligned samples, we find that the energies of both the vibrational and the electronic absorption features are similar to those measured in 'long-chain' Shirakawa material, but for the unoriented films we find that the photo-induced charged solitons are more strongly pinned and have a larger dynamic mass. 35 refs.

Friend, R.H. (Univ of California, Santa Barbara, CA, USA); Schaffer, H.E.; Heeger, A.J.; Bott, D.C. *J Phys C Solid State Phys* v 20 n 35 Dec 20 1987 p 6013-6023.



**080978 ON THE PROBLEM OF  $\pi$  ELECTRON DELOCALISATION ACROSS  $sp^3$  CARBON ATOMS INTRODUCED AS DEFECTS IN POLYACETYLENE.** It has been recently proposed that delocalization of  $\pi$  electrons in trans-polyacetylene can occur even cross  $CH_2$  groups introduced as defects in the molecule. From quantum chemical calculations on various models it is shown that  $CH_2$  acts as barrier to conjugation. (Author abstract) 12 refs.

Lopez Navarrete, J.T. (Politecnico, Milan, Italy); Zerbi, G. *Solid State Commun* v 64 n 8 Nov 1987 p 1183-1186.

## Degradation

**080979 STABILITY AND DEGRADATION OF SOME ELECTRICALLY CONDUCTING POLYMERS.** The oxidative degradation reactions of polyacetylene, prepared from a soluble precursor polymer, are described and compared with those of more common polymers and of polyacetylene prepared by the conventional method. Doping to low levels with electron acceptors removes the electrons involved in oxygen doping and the polymer becomes much more stable in air. Doping to high levels leads to new instabilities as the polymer reacts slowly with its counter-ions. Studies of polypyrrole and polythiophene show that these polymers are much more stable than polyacetylene but still undergo degradation reactions. The general features of their degradation mechanisms are discussed. (Edited author abstract) 35 refs.

Billingham, N.C. (Univ of Sussex, Brighton, Engl); Calvert, P.D.; Foot, P.J.S.; Mohammad, F. *Polym Degradation Stab* v 19 n 4 1987 p 323-341.

## Dielectric Properties

**080980 FREQUENCY DEPENDENCE OF THE LARGE, ELECTRONIC  $\chi^{(3)}$  IN POLYACETYLENE.** The third order optical susceptibilities ( $\chi^{(3)}$ ) of trans- and cis- $(CH)_x$  have been determined in the spectral region below the gap by measuring the third harmonic generation efficiency. The magnitude of  $\chi^{(3)}$  parallel to the polymer chains in trans- $(CH)_x$  is in excess of  $10^{-9}$  esu for wavelengths larger than 1.3  $\mu m$ , and the spectrum of  $\chi^{(3)}$  in trans- $(CH)_x$  has a sharp two-photon resonance at an energy corresponding to half the semiconducting gap. Both the off resonance and the two-photon resonance enhanced values of  $\chi^{(3)}$  are explained by a simple band picture. (Author abstract) 18 refs.

Kajzar, F. (CEA, Gif-sur-Yvette, Fr); Etamad, S.; Baker, G.L.; Messier, J. *Solid State Commun* v 63 n 12 Sep 1987 p 1113-1117.

## Diffusion

**080981 DIFFUSION IN CONDUCTING POLYMERS.** The diffusion of oxidizing dopant gases into polyacetylene films has been studied. The process is complicated because it is influenced by the doping reaction, by swelling of the polymer by the gas and by degradation reactions of the polymer with the counter-ions. Electrochemical measurements of anion and cation diffusion in doped polymer give diffusion coefficients comparable with those for gaseous dopants. Diffusion coefficients for ions in polythiophene are reported. The results are discussed in terms of potential applications of these polymers. (Author abstract) 24 refs.

Foot, P.J.S. (Thames Polytechnic, London, Engl); Mohammed, F.; Calvert, P.D.; Billingham, N.C. *J Phys D* v 20 n 11 Nov 14 1987, Pap Presented at the Polym Phys Group Meet on Electroact Polym, London, Engl, May 14 1987 p 1354-1360.

**Doping** See Also SEMICONDUCTING POLYMERS—Electric Properties.

**080982  $AlCl_3$ -ASSISTED FORMATION OF CHARGE-TRANSFER COMPLEXES BETWEEN POLYACETYLENE AND TETRACYANOETHYLENE, TCNE.** Polyacetylene,  $(CH)_x$ , the simplest conjugated polymer, can be converted into a conducting

material ( $8 \Omega^{-1} cm^{-1}$ ) by treating it with a TCNE  $AlCl_3$ /benzene solution. An electron transfer  $\pi$ -complex was obtained, as shown by EPR and XPS spectroscopies. (Author abstract) 10 refs.

Kulziewicz-Bajer, I. (CNRS, Vandoeuvre-les-Nancy, Fr); Billaud, D. *Synth Met* v 22 n 3 Jan 1988 p 239-245.

**080983 EFFICIENCY, STABILITY AND SELF DISCHARGE OF ELECTROCHEMICALLY-DOPED POLYACETYLENE IN PROPYLENE CARBONATE ELECTROLYTE.** Discrepancies between the estimates of doping level of electrochemically-doped polyacetylene,  $[CH]_x$ , obtained by coulometry and elemental analysis, suggest that a significant fraction of charge is consumed in the oxidation of electrolyte. This coulombic inefficiency of charging leads to a net inefficiency on cycling. The stability of p-type  $[CH]_x$  is much greater than that of n-type  $[CH]_x$  in propylene carbonate electrolyte. In the absence of impurities and lithium, the stability of p- $[CH]_x$  is much higher than had been previously estimated for  $[CH]_x$  in batteries. The self-discharge rate in propylene carbonate is lower for high concentrations of electrolyte. A mechanism for self discharge by oxidation of solvent is presented. (Edited author abstract) 35 refs.

Schlenoff, Joseph B. (Univ of Massachusetts, Amherst, MA, USA); Chien, James C.W. *Synth Met* v 22 n 4 Feb 1988 p 349-363.

**080984 SEGMENTED POLYACETYLENE,  $(CHD)_x$ ; ELECTROCHEMICAL n-DOPING STUDIES.** Defects involving  $sp^3$  hybridized carbon atoms in the form of (HCD) units have been controllably introduced into trans- $(CH)_x$  by chemical methods to produce polymers of the type trans- $(CHD)_y$ , i.e.,  $[(CH)_{1-y}(HCD)_y]_x$  ( $y=0, 0.15$  and  $0.17$ ), in order to study the nature of these defects and their effect on the electronic and magnetic properties of trans- $(CH)_x$ . The effects of these defects on the electrochemical reduction (n-doping) of trans- $(CHD)_y$  up to 4.0 mol % reduction levels have been studied. The results are consistent with optical and Raman spectra of trans- $(CHD)_y$  species and are interpreted as showing that: (i) the band gap in trans- $(CHD)_y$  is essentially unchanged from that in trans- $(CH)_x$  because of a small but significant amount of long conjugated sequences remaining in the deuterated polymer; (ii) the maximum density of states near the conduction band edge has moved upwards from the band edge; and (iii) the (HCD) defects are clustered rather than randomly spaced in a given  $(CHD)_y$  chain. (Author abstract) 43 refs.

Wan, Mei Xiang (Univ of Pennsylvania, Philadelphia, PA, USA); Arbuckle, Georgia A.; MacDiarmid, Alan G.; Epstein, Arthur J. *Synth Met* v 24 n 4 Jun 1988 p 283-299.

**080985 IN SITU ELECTRON SPIN RESONANCE EXPERIMENTS ON POLYACETYLENE DURING ELECTROCHEMICAL DOPING.** We present results obtained from in situ e.s.r. measurements on both n-type and p-type materials during electrochemical doping. For the n-type data were obtained over an extended concentration range out to about 15 mol % (or well into the metallic regime); for p-type  $[(CH)^+y(CIO_4^-)_y]_x$  we have succeeded in achieving doping levels sufficiently high in situ to observe the abrupt first-order onset of the Pauli spin susceptibility. Comparison of the results obtained from p-type and n-type electrochemical doping shows remarkable similarities between the two. The precise symmetry of the results obtained from n-type and p-type doping demonstrates without ambiguity the charge conjugation symmetry of trans- $(CH)_x$ . The mechanism for the first-order electronic phase transition is discussed. (Edited author abstract) 29 refs.

Chen, J. (Univ of California, Santa Barbara, Santa Barbara, CA, USA); Heeger, A.J. *Synth Met* v 24 n 4 Jun 1988 p 311-327.

**080986 DOPING OF POLY(acetylene) TO THE METALLIC STATE USING THIONYL CHLORIDE.** In this report, the reaction of  $(CH)_x$  with vapor and liquid phase thionyl chloride to produce conductive poly(acety-

lene) films is described.  $SOCl_2$  is a highly oxidizing, volatile liquid that can be easily removed under dynamic vacuum following the reaction.  $SOCl_2$  has been found to be an effective oxidant for poly(acetylene), increasing the electrical conductivity by several orders of magnitude. The oxidized  $(CH)_x$  sites are thought to be compensated with chloride ion liberated by reduction of  $SOCl_2$ . 14 refs.

Calvert, Jeffrey M. (US Naval Research Lab, Washington, DC, USA); Pehrsson, Pehr E.; Milliken, Joann; Weber, David C.; Brant, Patrick; Nowak, Robert J. *Synth Met* v 25 n 2 Aug 1988 p 197-202.

**080987 KINETICS OF ELECTROCHEMICAL n-DOPING OF POLYACETYLENE INVESTIGATED BY IMPEDANCE AND GALVANOSTATIC PULSE MEASUREMENTS.** The characteristics of n- and p-doping of polyacetylene in different solvents were investigated by potentiostatic and galvanostatic charge/discharge curves, the fast Fourier transform impedance method and the galvanostatic pulse technique. The intercalated ions were  $Li^+$ ,  $Na^+$ ,  $ClO_4^-$  and  $BF_4^-$ . From the impedance measurements a rapid determination of electrochemical parameters like double-layer capacitance, electrolyte resistance and polarization resistance at different states of charge and discharge were obtained. Similarly, electrode kinetics and diffusion behavior were determined by the galvanostatic pulse technique. The doping characteristics were additionally monitored by in situ resonance Raman scattering experiments. We found strong evidence for solvent coinjection during the doping process. Ion diffusion is rate controlling to a much higher degree for undoping compared to n-doping. (Author abstract) 14 refs.

Nagele, G. (Univ Wien, Vienna, Austria); Nauer, G.E.; Kuzmany, H.; Kuerti, J. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 293-299.

**080988 ELECTROINTERCALATION OF IIIB METAL CHLORIDES  $MCl_4$  INTO POLYACETYLENE.** The electrochemical doping of polyacetylene with  $MCl_4^-$  anions ( $M=Ga, In, Tl$ ) was carried out in order to evaluate the potentials of doping and degradation, the reversibility of the reactions and the maximum doping level in each system. A parallel x-ray study performed on the three  $[CH(MCl_4)_x]$  compounds leads to the proposition of an intercalation model that is supported by the electrochemical data. Electrical resistivity and EPR measurements have been analyzed as a function of the doping level and the temperature. (Author abstract) 8 refs.

Jourdan, P. (Univ de Nancy I, Vandoeuvre-les-Nancy, Fr); Ghanbaja, J.; Billaud, D. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 15-22.

**080989 TRANSPORT AND SPIN RESONANCE IN n-DOPED POLYACETYLENE.** The EPR parameters and the electrical conductivity of vapor phase alkali metal-doped polyacetylene have been examined as a function of the doping level and temperature. Based on the calculations of Koder relating the shape of the EPR signal to the dynamic parameters of the spins responsible for these signals, the evolution of  $T_D$ , the diffusion time of the paramagnetic centers through the skin depth, is discussed. The temperature dependence of the electrical conductivity of heavily-doped trans- $(CH)_x$  is compared with our previous data concerning compounds synthesized from cis-rich  $(CH)_x$ . A  $\sigma=AT^\alpha$  relationship is confirmed over a wide temperature range with  $\alpha < 1$ . (Author abstract) 14 refs.

Billaud, D. (Univ de Nancy I, Vandoeuvre-les-Nancy, Fr); Ghanbaja, J.; Marche, J.F.; McRae, E.; Goulon, C. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 23-30.



**080990 ELECTRONIC AND STRUCTURAL PROPERTIES OF ALKALI-METAL-DOPED POLYACETYLENE: SOME e.s.r. STUDIES.** In this paper we try to unify the description of the properties of alkali-metal-doped polyacetylene samples that can be deduced from e.s.r. measurements. We point out the importance of the structural modifications appearing during doping on the observed behavior. In some cases staging has been evidenced, but in all cases the electronic properties are intimately related to the structural properties. (Author abstract) 10 refs.

Bernier, P. (GDPC-USTL, Montpellier, Fr); Rachdi, F.; El-Khodary, A.; Fite, C. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 31-33.

**080991 RAMAN SCATTERING OF DOPED POLYACETYLENE.** Experimental and theoretical results obtained by resonance Raman scattering on doped polyacetylene are presented. In the case of n-doped samples, it is shown that new vibrational mode are observed in the experimental resonance Raman scattering spectra at 1276  $\text{cm}^{-1}$  and 1600  $\text{cm}^{-1}$ . From a theoretical point of view, these features are interpreted as new vibrational modes induced by the perturbation of the chain by the dopant. This leads to an increase of the force constants with respect to the unperturbed system. The behavior of the new bands is discussed as a function of the dopant level and the exciting wavelength. Differences between n- and p-doped systems are shown and explained in terms of electronic properties induced by the dopant. (Author abstract) 20 refs.

Mulazzi, E. (Univ de Nantes, Nantes, Fr); Lefrant, S.; Faulques, E.; Perrin, E. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 35-40.

**080992 GROUND STATE OF DOPED POLYACETYLENE.** The Su-Schrieffer-Heeger model and its extensions applied to doped polyacetylene are reviewed. It is shown that a solitonic lattice is always most stable and that there is a gap in the electronic structure even at high concentrations of dopants. (Author abstract) 5 refs.

Bulka, B.R. (Polish Acad of Sciences, Poznan, Pol). *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 41-44.

**Electric Conductivity** See Also POLYMERS—Electric Conductivity; SEMICONDUCTING POLYMERS—Synthesis.

**080993 METALLIC TEMPERATURE DEPENDENCE OF CONDUCTIVITY IN HEAVILY-DOPED POLYACETYLENE.** We have studied the temperature dependence of conductivity in heavily  $\text{FeCl}_4^-$ ,  $\text{ClSO}_3^-$  and  $\text{AsF}_6^-$ -doped polyacetylene films by means of the ordinary four-probe and voltage-shortened compaction (VSC) methods. The results of the VSC measurements were interpreted by saying that the intrafibril resistance of heavily-doped polyacetylene was metallic and obeyed a  $T^2$  law through the whole temperature range 1.9-300 K. (Author abstract) 39 refs.

Masubuchi, S. (Tokyo Metropolitan Univ, Tokyo, Jpn); Mizoguchi, K.; Mizuno, K.; Kume, K.; Shirakawa, H. *Synth Met* v 22 n 1 Nov 1987 p 41-52.

**080994 ANISOTROPIC KINETICS OF OPTICALLY EXCITED CHARGE CARRIERS IN TRANS-POLYACETYLENE.** Transient photoconductivity in highly oriented polyacetylene has been investigated. A large anisotropy of  $\mu_{\parallel}/\mu_{\perp} \approx 50$  has been found for carrier motion parallel and perpendicular to the chains. The relaxation has been followed over 8 orders of magnitude in time, establishing directly the existence of a fast ( $\tau_f \approx 100$  ps) and a slow component (lasting up to seconds). An appreciable anisotropy has been observed with respect to the polarization of the incident light, indicating interchain charge creation as predominant

mechanism of the photoexcitation of carriers. (Author abstract) 22 refs.

Bleier, H. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Roth, S.; Lobentanzer, H.; Leising, G. *Europhys Lett* v 4 n 12 Dec 15 1987 p 1397-1402.

**080995 APPLICATION OF CONDUCTIVE POLYMERS TO SECONDARY BATTERY.** In August 1985, basic research was started to clarify the possibility of application of conductive polymers to a secondary battery for electrical power storage or electric vehicle use. This paper reports battery test results on conductive polymers, polyacetylene synthesized by methods different from the Shirakawa-technique, and those which can be synthesized by electropolymerization. The possibility of the polymer battery for practical use is investigated. 12 refs.

Morishita, Masao (Tokyo Electric Power Co, Tokyo, Jpn); Abe, Sueki; Nojiri, Akio; Shinozaki, Kenji. *Electr Eng Jpn* v 107 n 5 Sep-Oct 1987 p 1-9.

**080996 DC-CONDUCTIVITY OF A NEW TYPE OF HIGHLY CONDUCTING POLYACETYLENE N-(CH)<sub>x</sub>.** We present precision conductivity measurements on a new type of stretch-aligned, iodine doped polyacetylene, yielding a room temperature conductivity  $\sigma$  of about  $80,000 \Omega^{-1}\text{cm}^{-1}$ . The temperature dependence of  $\sigma$  was investigated between 3 K and 300 K parallel ( $\sigma_{\parallel}$ ) and perpendicular ( $\sigma_{\perp}$ ) to the stretching axis using both MONTGOMERY- and standard four-probe techniques. For freshly prepared samples, the results indicate a common limiting mechanism for  $\sigma_{\parallel}$  and  $\sigma_{\perp}$  and are perfectly described by the SHENG model within the entire temperature range. Deliberate aging gives information about the influence of chemical defects on the conductivity mechanism. (Author abstract) 23 refs.

Schimmel, Th. (Univ Bayreuth, Bayreuth, West Ger); Riess, W.; Gmeiner, J.; Denninger, G.; Schwoerer, M.; Naarmann, H.; Theophilou, N. *Solid State Commun* v 65 n 11 Mar 1988 p 1311-1315.

**080997 AB INITIO STUDY OF THE ROTATIONAL POTENTIAL ENERGY SURFACE OF CIS-TRANSOIDAL POLYACETYLENE.** Ab initio self-consistent field molecular orbital calculations have been performed to obtain the intramolecular rotational potential energy surface for cis-transoidal polyacetylene with simultaneous rotations about two successive single bonds. The results indicate the possibility of existence of a 'superhelix' instead of a tight  $2^3/1$  helix. Using the energy surface obtained, Monte Carlo calculations have been done to obtain the probabilities of the existence of various conformations of this polymer. (Author abstract) 17 refs.

Darsey, J.A. (Tarleton State Univ, Stephenville, TX, USA); Kuehler, J.F.; Kestner, N.R.; Rao, B.K. *J Macromol Sci Chem* v A25 n 2 1988 p 159-169.

**080998 OPTICAL SPECTRA AND OPTICAL CONDUCTIVITIES OF IODINE-DOPED POLYACETYLENE.** Reflection spectra of iodine-doped polyacetylene are studied for the wavenumber range 20-40,000  $\text{cm}^{-1}$  in order to find changes occurring in the electronic structure of the polymer upon doping. Three stages of doping are recognized from a spectral analysis of  $(\text{CHI}_3)_x$ : (1)  $0 < x < 0.10$ , where the charged soliton domain is the dominant product; (2)  $0.10 < x < 0.18$ , the free carrier is found where the hole and the unpaired electron are formed simultaneously; (3)  $0.19 < x < 0.25$ , the free carriers begin to overlap each other and metallic properties become more evident. A new type of electronic transition associated with the electron transfer (charge resonance) between the hole states is found in the far-infrared region. (Edited author abstract) 24 Refs.

Kamiya, Koji (Nagoya Univ, Nagoya, Jpn); Tanaka, Jiro. *Synth Met* v 25 n 1 Jul 1988 p 59-70.

**080999 INFLUENCE OF THE CONJUGATION LENGTH OF POLYACETYLENE CHAINS ON THE D.C. CONDUCTIVITY.** The dc conductivity of doped polyacetylene, into which  $\text{sp}^3$  defects have deliberately

been incorporated, is investigated. The  $\text{sp}^3$  defects were created by p-type doping and subsequent hydrolysis of polyacetylene samples. These defects shorten the effective conjugation length of the polyacetylene chains and therefore have a strong influence on the dc conductivity  $\sigma$ .  $\sigma$  has been measured in the temperature range 4 to 370 K. For both doping levels investigated (3.5% and 15% of iodine), the conductivity drops by three orders of magnitude for a concentration of 15% of  $\text{sp}^3$  defects. The shortening of the conjugation length can be verified by resonance Raman scattering. (Author abstract) 12 refs.

Schaefer-Siebert, D. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Roth, S.; Budrowski, C.; Kuzmany, H. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 285-291.

**081000 CONDUCTIVITY MEASUREMENTS ON DOPED POLY(SUBSTITUTED)ACETYLENES.** The attention of many authors has been focused on the electrical properties of doped polyacetylene (PA), and different theories have been developed to explain its conductivity. PA shows the simplest model for a polyenic chain and has given the best results as a conducting material upon doping. We have investigated the electrical properties of doped polyphenylacetylene (PPA), polybenzylpropargylamine (PBPA) and polyethynylferrocene (PEF) obtained by  $\text{Rh(I)}$  complexes, which are active polymerization catalysts in mild reaction conditions and give linear, soluble, air-stable polymers with a backbone similar to that of PA. (Edited author abstract) 16 refs.

Furlani, A. (Univ 'La Sapienza', Rome, Italy); Napolitano, C.; Paolesse, R.; Russo, M.V. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 337-342.

**Electric Properties** See Also POLYMERS—Conductivity.

**081001 NEGLIGIBLE PHOTOCONDUCTIVITY EFFICIENCY AND IMPURITY SENSITIVE ABSORPTION FINE STRUCTURE AT THE LOW-ENERGY TAIL OF  $\pi$ - $\pi^*$  TRANSITION IN TRANS-POLYACETYLENE.** Photocurrent spectra normalized by incident light intensity together with high-resolution optical absorption spectra have been obtained in the visible and near IR regions using carefully prepared very pure samples. The photocurrent efficiency is practically zero at the low energy tail of the  $\pi$ - $\pi^*$  absorption band and gradually increases with the photon energy, becoming very high on the high energy side. Oxygen doping produces a photocurrent peak at 1.4 eV and a corresponding series of sharp absorption bands which stick to the intrinsic absorption band edge. (Author abstract) 17 refs.

Kubo, Takaya (Tokyo Inst of Technology, Tokyo, Jpn); Sasaki, Kojo; Takezoe, Hideo; Fukuda, Atsuo. *Jpn J Appl Phys Part 2* v 26 n 12 Dec 1987 p 2030-2033.

**081002 ON THE CHARGE STRUCTURE OF POLARONS IN TRANS-POLYACETYLENE.** The charge structure of polarons (centered at long bonds) and antipolarons (centered at short bonds) is investigated on rings with  $N=4$  M sites in the SSH-model and in the continuum model. In contrast with previous statements the charge distribution has to be described by two smooth penetrating functions. They can be reasonably well obtained within the continuum theory. (Author abstract) 16 refs.

Heiner, E. (Akad der Wissenschaften der DDR, Rostenburg, East Ger); Drechsler, S.L.; Malek, J. *Phys Status Solidi B* v 145 n 1 Jan 1988 p 233-240.

**Electronic Properties**

**081003 THEORETICAL ANALYSIS OF MODEL COMPOUNDS OF SUBSTITUTED POLY(ACETYLENES): CONFORMATION VERSUS ELECTRONIC PROPERTIES.** The influence of the conforma-



tion of conjugated molecules on their electronic properties has been investigated using the extended Hückel theory. Dimers of acetylene and methylacetylene have been taken as model compounds of poly(acetylene) and poly(methylacetylene). Upon increasing the torsional angle between the two repeat units, both the band gap and the ionization potential increase, but the change is more pronounced with the former variable. This increase is not regular and becomes more important at angles larger than 30°. Non-planar conformations are then expected with poly(methylacetylene) and other n-alkyl monosubstituted poly(acetylenes) and explain their large band gap (i.e. blue shifting) in comparison with that of poly(acetylene). (Edited author abstract) 26 refs.

Leclerc, Mario (Laval Univ, Ste-Foy, Que, Can); Prud'homme, Robert E. *Polym Bull (Berlin)* v 18 n 2 Aug 1987 p 159-166.

**081004 ELECTRON SPIN DELOCALIZATION IN FEAST-TYPE (DURHAM ROUTE) POLYACETYLENE: PULSED ENDOR INVESTIGATIONS.** We have applied novel techniques of pulsed ENDOR electron-nuclear double resonance in order to determine the spin density distribution of radical electron (neural solitons) in unoriented and oriented Feast-type polyacetylene. Our experimental data are compatible with an alternating spin density distribution of full width at half maximum of 22 CH-units and with a large ratio of negative/positive spin density of  $u_g = 0.43$ . (Author abstract) 15 refs.

Kaess, H. (Univ Stuttgart, Stuttgart, West Ger); Hoefler, P.; Grupp, A.; Kahol, P.K.; Weizenhoefer, R.; Wegner, G.; Mehring, M. *Europhys Lett* v 4 n 8 Oct 15 1987 p 947-951.

**081005 MONTE CARLO COMPUTATION OF ELECTRONIC PROPERTIES OF POLYACETYLENE.** The ground state energy, spin and charge density waves and their correlation functions in polyacetylene are computed by the Monte Carlo method. Hubbard and Pariser-Parr-Pople models are employed and the results are compared with the valence bond calculation. The bond alternate system has a lower energy than the regular system both in Hubbard and PPP models. The Coulomb interaction beyond on-site assists in the formation of a charge density wave and suppresses the spin density wave. The soliton system has a lower energy than the regular system. (Author abstract) 18 refs.

Watanabe, Akihiko (Waseda Univ, Tokyo, Jpn); Iguchi, Kaoru. *Waseda Daigaku Rikogaku Kenkyusho Hokoku* n 119 1987 p 5-12.

**Film** See Also FILMS—Chemical Vapor Deposition.

**081006 SYNTHESIS AND CHARACTERIZATION OF ORIENTED POLYACETYLENE FILMS.** The physical properties of polyacetylene have been widely investigated in the last fifteen years. However, the standard Shirakawa technique provides randomly oriented fibers, so that most experimental results are averaged over the chain directions. Recently K. Araya et al. succeeded in the polymerization of oriented polyacetylene using Shirakawa's catalyst dissolved in a nematic liquid crystal. In this paper the authors compare the different methods used to achieve the liquid crystal orientation: gravitational flow, orientation induced by the glass substrate and magnetic field orientation. The properties of the resulting films were investigated by scanning electron microscopy, x-ray diffraction, polarized ir spectroscopy and dc conductivity. (Author abstract) 5 refs.

Ribet, J.L. (Univ of Montpellier, Montpellier, Fr); Roland, M.; Montaner, A.; Galtier, M.; Lakhilai, Z.; Sauvageol, J.L.; Brunet, M.; Almairac, R.; Bernier, P. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 1-5.

**Magnetic Properties** See Also POLYMERS—Conductive.

**081007 EPR STUDIES OF BINARY ALKALI**

**METAL DOPED POLYACETYLENE.** The evolution of the EPR characteristics ( $\Delta H_{pp}$ , A/B and g) of vapour phase alkali metal doped polyacetylene has been examined as a function of the doping duration and the nature of the dopant (Na, K, Rb, Cs). Different kinds of spins are responsible for the two observed signals. At intermediate doping levels, concomitant lightly and heavily doped parts of the material lead to the superposition of two signals or to an anomalous signal the form of which is discussed. For high doping levels, the linewidth  $\Delta H_{pp}$  of homogeneous samples follows a  $Z^\alpha$  law with  $\alpha = 2.9 \pm 0.5$ . Our results are compared with other data related to polyacetylene doped with alkali-metals in solvent media. (Author abstract) 20 refs.

Ghanbaja, J. (CNRS, Vandoeuvre les Nancy, Fr); Goulon, C.; Mareche, J.F.; Billaud, D. *Solid State Commun* v 64 n 1 Oct 1987 p 69-72.

## Measurements

**081008 NEUTRAL PHOTO-EXCITATIONS IN ORIENTED POLYACETYLENE.** Polarization-dependent measurements of photo-induced absorption (PA) have been carried out on highly oriented films of polyacetylene prepared by the Durham precursor route. For temperatures below 100 K, the PA spectrum exhibits an absorption peak at 1.36 eV, as observed for Shirakawa polyacetylene. This feature is due to a neutral excited state. The PA peak is independent of probe-beam polarization and some 200 times weaker than in Shirakawa samples. These results suggest that the neutral excitations are rendered metastable by interactions with existing structural defects in the polymer. (Author abstract) 33 refs.

Townsend, P.D. (Univ of Cambridge, Cambridge, Engl); Friend, R.H. *J Phys C Solid State Phys* v 20 n 26 Sep 20 1987 p 4221-4228.

## Optical Properties

**081009 OPTICAL ABSORPTION OF THE SOLITON LATTICE.** The optical conductivity for the soliton lattice solution of the continuum approximation to the Su-Schrieffer-Heeger model of doped polyacetylene is calculated for different excess electron densities. The optical sum rule is verified in each case. The resulting shifts of the absorption maxima are compared with experiment. Implications of the finiteness of  $\Delta_0/W$  (gap/bandwidth) on the nature of the phase transition and the absorption are discussed. These results are relevant to conducting polymers. (Edited author abstract) 22 refs.

Puff, H. (Akad der Wissenschaften der DDR, Berlin, East Ger); Streitzwolf, H.W. *Phys Status Solidi B* v 143 n 2 Oct 1987 p 765-775.

**081010 INFLUENCE OF PHOTOINDUCED STRUCTURAL DISTORTIONS ON INTERBAND ABSORPTION IN POLYACETYLENE.** Picosecond pump and probe experiments were carried out on fully oriented transpolyacetylene. Exciting the sample at 527 nm, photoinduced bleaching and absorption were observed at 527 nm and 1054 nm, respectively. The measurements give an upper limit of 2 ps for the relaxation time of the photogenerated 0.5 eV hot carriers to the band edges. The evaluation of the measured optical processes strongly suggests the conclusion that photoinduced structural distortions of the polyacetylene chain result in observable transient decrease of the interband absorption. This may be ascribed to the reduction of the density of electronic states and to that of the interband transition matrix element of the momentum operator. (Author abstract) 17 refs.

Krausz, F. (Technical Univ of Budapest, Budapest, Hung); Laszity, P.; Bakos, J.S.; Wintner, E.; Leising, G. *Appl Phys B* v B45 n 1 Jan 1988 p 21-25.

**081011 OPTICAL PROPERTIES OF POLYDIACETYLENE MONOLAYERS.** The topochemical polymerization of diacetylene molecules as monolayers in situ on a Langmuir trough is described via the visible

absorbance of the polymer products. Possible differences in the product structure between crystal or multilayer polymerizations and that in monolayers is investigated for two monomers. Significant differences in the visible, infrared, and resonance Raman spectra are reported and a strong dependence of visible absorbance on surface pressure is described. (Author abstract) 36 refs.

Collins, Michael A. (Australian Natl Univ, Canberra, Aust). *J Polym Sci Part B* v 26 n 2 Feb 1988 p 367-387.

**081012 ELECTRONIC PROCESSES IN EXTENDED CONJUGATED POLYMER CHAINS.** This review covers the optical and non-linear optical properties of polydiacetylenes (PDA) single crystals and the effect of disorder on optical properties and on exciton and charge carrier motion. The topic of doping PDAs to enhance electrical conductivity is discussed. 24 refs.

Bloor, D. (Queen Mary Coll, London, Engl). *Synth Met* v 21 n 1 Aug 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part I, Vadstena, Swed, Aug 18-20 1986 p 71-77.

**081013 OPTICAL PROPERTIES OF AS<sub>2</sub>F<sub>5</sub>-DOPED TRANS-POLYACETYLENE.** Measurements of the anisotropic optical properties on AsF<sub>5</sub>-doped high-oriented non-fibrous crystalline trans-(CH)<sub>x</sub> are presented. The reflectance parallel to the chain direction shows a Drude-like behavior of strongly damped carriers and no indication of any interband contributions from undoped regions. Perpendicular to the chain direction, the reflectance is very low and constant throughout the region of the plasma edge for light polarized parallel to the chains. A Kramers-Kronig analysis of the parallel reflectance data yields the complex refractive index and allows the real and imaginary parts of the dielectric function and the optical conductivity to be deduced. (Author abstract) 2 refs.

Leising, G. (Technical Univ Graz, Graz, Austria); Filzmoser, M.; Kahlert, H. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 267-270.

## Oxidation

**081014 INFLUENCE OF ADDITIVES ON THE ELECTROCHEMICAL OXIDATION OF POLYACETYLENE.** The result of the electrochemical oxidation of polyacetylene is improved by additives in the electrolyte, which suppress overoxidation of polyacetylene. The temperature dependence of the conductivity is semiconductor-like and is interpreted by Sheng's fluctuation-induced tunneling model for tunneling between metallic regions. Polyacetylene oxidized in the presence of additive (e.g., bithiophene) has a smaller intrinsic resistance of the metallic strands. (Author abstract) 7 refs.

Krische, Bernd (Royal Inst of Technology, Stockholm, Swed); Soderholm, Svante. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 319-324.

## Phase Transitions

**081015 TRANSITION TO A GAPLESS PEIERLS INSULATOR IN HEAVILY-DOPED POLYACETYLENE.** At high doping concentrations, polyacetylene undergoes a transformation into a state characterized by high d.c. conductivity, by a large Pauli susceptibility and by the absence of the interband transition of the undoped polymer. The optical spectrum shows a pseudogap at  $\approx 0.2$  eV and vibrational modes which imply that the carbon-carbon bond length is not uniform. We conclude that this state is best described as a gapless incommensurate Peierls insulator. (Author abstract) 33 refs.

Yang, X.Q. (Univ of Florida, Gainesville, FL, USA); Tanner, D.B.; Rice, M.J.; Gibson, H.W.; Feldblum, A.; Epstein, A.J. *Solid State Commun* v 61 n 5 Feb 1987 p 335-340.



## Physical Chemistry

**081016 ESR STUDY OF THE SEMICONDUCTOR-METAL TRANSITION IN ALKALI DOPED POLYACETYLENE: SPECIFICITY OF THE DOPANT.** We have described and analyzed in situ ESR measurements of the electrochemical doping of cis-rich  $(CH)_x$  with Li and Na. From the continuous evolution of the linewidth ( $\Delta H_{pp}$ ) and asymmetry ratio (A/B) with the doping level, the transition from a semiconducting to a metallic state has been observed for doping with both Li and Na. A specific behavior has been observed in each case with, in particular  $\Delta H_{pp}$  increasing with the atomic number of the dopant for the metallic complexes. (Author abstract) 17 refs.

Fite, C. (USTL, Montpellier, Fr); El Khodary, A.; Bernier, P. *Solid State Commun* v 62 n 9 Jun 1987 p 599-602.

## Physical Properties

**081017 RANDOM SOLITON DISTRIBUTION IN TRANS-POLYACETYLENE.** We investigate the electronic density of states (DOS) and the localization properties of trans-polyacetylene with a random distribution of neutral narrow soliton-type defects. The problem is treated within the renormalized virtual crystal method with triplet decimation, which preserves the soliton contribution to the DOS. The localization of the state at the Fermi energy is calculated as a function of soliton concentration, cs, and our results indicate that a significant increase of the hopping conductivity may occur for  $cs - 5 - 10\%$ . (Author abstract) 21 refs.

de Melo, C.A.R. Sa (Pontificia Univ Catolica, Rio de Janeiro, Brazil); Brandi, H.S.; Koiller, Belita. *Solid State Commun* v 61 n 3 Jan 1987 p 171-176.

**081018 BIPOLARON FORMATION AND DESORPTION FOLLOWING AUGER DECAY IN POLYACETYLENE.** The Su-Schrieffer-Heeger model has been applied to a trans-polyacetylene chain with two holes at the top of the valence band. In the kink-free chain the formation of a kink-antikink pair is observed. This is deformed to a polaron pair due to end effects and the lack of dissipation in the model. In the case of an end-kink configuration desorption may occur. The influence of a substitutional NH impurity on these phenomena has been discussed. (Author abstract) 8 refs.

Liegener, C.-M. (Friedrich-Alexander-Univ Erlangen-Nuernberg, Erlangen, West Ger); Foerner, W.; Ladik, J. *Solid State Commun* a2 p 203-206.

## Production

**081019 NEW PROCESS FOR THE PRODUCTION OF METAL-LIKE, STABLE POLYACETYLENE.** An acetylene polymerization reaction catalyzed by an aged mixture of  $Ti(OC_4H_9)_4/Al(C_2H_5)_3$  in a silicone oil reaction medium yields a homogeneous, defect-free, polyacetylene film that can be stretched mechanically by up to 550%, corresponding to stretching rates of 6.5. On being doped with iodine, the film displays an electrical conductivity of  $\approx 16,000$  S/cm per unit weight. Both washed (catalyst-free) and unwashed (catalyst-containing) films were stretched. An aged mixture of  $Ti(OC_4H_9)_4/Al(C_2H_5)_3$  in silicone oil that has been mixed with various quantities of n-butyllithium and allowed to react with acetylene yields polyacetylene that is highly regular, compact and crystalline in well-defined parallel planes. This film can be stretched by up to 400% ( $1/l_0 = 5$ ) and, after doping, gives a conductivity of  $> 100,000$  S/cm per unit weight. (Author abstract) 8 refs.

Naarmann, H. (BASF, Ludwigshafen, West Ger); Theophilou, N. *Synth Met* v 22 n 1 Nov 1987 p 1-8.

**Radiation Effects** See DOSIMETERS—Plastics Applications.

## Research

**081020 PREPARATION OF POLYACETYLENE IN LOW-POLYDISPERSITY DIBLOCK AND TRIBLOCK COPOLYMERS.** There is a need for absolute control over polymer preparation, ideally to give soluble, block copolymers with as narrow a molecular weight distribution as is possible. The authors report such a method and they believe the results are most consistent with the 'aggregate' being formed by cross-linking of the polyene portions of the diblocks or triblocks, beginning when the polyene chain length reaches approximately 15. If this is the case then the implication is that Durham polyacetylene contains a significant amount of cross-linked polyene chains. These results are consistent with other reports that solubilized polyacetylene prepared by classical methods forms 'aggregates'. 12 refs.

Krouse, Steven A. (MIT, Cambridge, MA, USA); Schrock, Richard R. *Macromolecules* v 21 n 6 Jun 1988 p 1885-1888.

## Spectroscopic Analysis

**081021 CHAIN LENGTH DEPENDENCE OF LOCALIZED VIBRATIONAL MODES AROUND A SOLITON IN TRANS-POLYACETYLENE.** Vibrational frequencies of finite polyacetylene with a charged soliton are calculated using the molecular orbital method. It is found that the frequency of the translational mode has a remarkable length effect and is inversely proportional to the square of chain length. The dependence is explained by regarding the soliton as a quantum particle in a one dimensional box. (Author abstract) 19 refs.

Mori, Yuhei (NTT, Tokai-mura, Jpn); Kurihara, Susumu. *Solid State Commun* v 64 n 6 Nov 1987 p 947-950.

**081022 CHARACTERISTICS OF LASER INDUCED LUMINESCENCE IN POLYACETYLENE.** Polyacetylene (PA) is the prototype conducting polymer because of the simplicity of its molecular structure. Its uniquely simple electronic structure has been a model for theoretical studies of 1-D semiconductors. Characteristics of trans- $(CH)_x$  luminescence near the interband absorption edge and the doping effect on luminescence by implanted erbium have been investigated for the first time. 7 refs.

Jin, Changqing (Acad Sinica, Changchun, China); Zhang, Xinyi. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 264-265.

## Spectrum Analysis

**081023 PHYSICAL MEANING OF THE CONJUGATION LENGTH IN POLYMERS.** Raman scattering experiments were performed on pristine trans-polyacetylene, on polymer samples where defects have been accommodated systematically along the chains, and on polydiacetylene. The results show that the dispersion of the satellite line strongly depends on the concentration of the defects. A calculation showed the  $sp^3$  carbons to be the most effective interruptions of the conjugation. Other physical and chemical properties like electrochemical doping, linewidth of e.s.r. signals and conductivity after doping are strongly related to the dispersion. (Author abstract) 9 refs.

Kuzmany, H. (Univ Wien, Vienna, Austria); Kurti, J. *Synth Met* v 21 n 1 Aug 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part I, Vadstena, Swed, Aug 18-20 1986 p 95-102.

**Stability** See LATEXES—Synthesis.

## Structure

**081024 ANDERSON LOCALIZATION IN A POLYACETYLENE CHAIN WITH  $SP^3$  CARBON DEFECTS.** The electronic structure of a model for a polyacetylene chain with a random distribution of  $sp^3$  carbon defects is studied by the tight-binding molecular

orbital theory. The dependence of the Anderson transition near the band center (levels around the Fermi level) and in the band wings (levels near the lowest occupied and the highest unoccupied levels) on the number of  $sp^3$  carbons introduced is examined. Even one  $sp^3$  carbon in a chain leads to localization at the band edge. Near the center of the band, both the extended and the localized states co-exist densely even if the number of  $sp^3$  carbons increases. It is concluded that conduction electrons delocalize over a chain at a finite temperature as a result of the mixing of the states near the Fermi level. (Author abstract) 23 refs.

Tanaka, Kazuyoshi (Kyoto Univ, Kyoto, Jpn); Yamanaka, Shozo; Oiji, Masaki; Yamabe, Tokio. *Synth Met* v 22 n 3 Jan 1988 p 247-256.

**081025 DISPLACEMENT VECTORS OF LOCALIZED VIBRATIONAL MODES AROUND A CHARGED SOLITON IN TRANS-POLYACETYLENE.** The localized vibrational modes of finite polyacetylene with a charged soliton are calculated taking full degrees of freedom into consideration. The displacement vectors of each localized vibrational mode are obtained and shown in this report. The vectors are discussed in connection with mode mixing. The localized modes are successfully classified into branch modes of four modes: translational, amplitude oscillation, third localized and staggered. Displacement patterns of localized modes indicate that the coupling between the two types of C-C stretching branch modes is weak, but there is a strong coupling between one of the C-C stretching modes and the C-H bending mode. Calculated frequencies and infrared intensities are found to be in good agreement with the infrared spectrum. Furthermore, it has been found that a force constant matrix obtained from a short cluster model is not suitable for calculation in the case of a long polyacetylene chain. (Author abstract) 47 refs.

Mori, Yuhei (ATR Optical & Radio Communications Research Lab, Osaka, Jpn); Kurihara, Susumu. *Synth Met* v 24 n 4 Jun 1988 p 357-370.

**081026 ELECTRONIC STRUCTURE OF CONDUCTING POLYMERS: INVESTIGATIONS OF ORIENTED SAMPLES BY ELECTRON ENERGY-LOSS SPECTROSCOPY.** The electronic structure of undoped and doped oriented polyacetylene, polyparaphenylene and polyphenylenevinylene has been studied by measuring the excitations of valence-band electrons by electron energy-loss spectroscopy. (Author abstract) 21 refs.

Fink, J. (Inst fuer Nukleare Festkoerperphysik, Karlsruhe, West Ger). *Synth Met* v 21 n 1 Aug 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part I, Vadstena, Swed, Aug 18-20 1986 p 87-94.

**081027 ORIENTATIONAL ORDER IN PARTICLES OF SOLUBILIZED POLYACETYLENE.** New insight on the correlation of structure and properties has been gained from the study of a form of polyacetylene solubilized in the common organic solvents by grafting the polyenic chains onto a soluble polymer carrier. This paper reports some results from resonance Raman and Rayleigh scattering studies carried out in solution on copolymers with different average conjugation length of the polyenic grafts. 17 refs.

Cuniberti, C. (Univ of Genoa, Genoa, Italy); Fuso, S.; Piaggio, P.; Dellepiane, G. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 313-318.

## Synthesis

**081028 FUNCTIONAL MONOMERS AND POLYMERS. CXLVII. INCLUSION COMPOUNDS OF POLY(1,3-BUTADIENE) IN DEOXYCHOLIC ACID AND APOCHOLIC ACID CANALS: SYNTHESIS AND CHARACTERIZATION.** The inclusion polymerization of 1,3-butadiene was studied at different temperatures using deoxycholic acid and apocholic acid as the host molecules. The polymers that resulted consist of predomi-



nantly 1,4-structure rather than 1,2 or acene structure as confirmed by both IR and Raman spectroscopies. The poly(1,3-butadiyne)s were found to possess unique optical properties and high electric conductivity as compared with those prepared by the usual polymerization methods. (Author abstract) 16 refs.

Tsutsumi, Hiromori (Osaka Univ, Suita, Jpn); Miyata, Mikiji; Takemoto, Kiichi. *J Polym Sci Part A* v 25 n 11 Nov 1987 p 3079-3087.

**081029 SYNTHESIS AND CHARACTERIZATION OF POLY[*o*-(TRIFLUOROMETHYL)PHENYL]ACETYLENE.** Polymerization of *o*-(trifluoromethyl)phenylacetylene initiated by 1:1 mixtures of  $WCl_6$  or  $MoCl_5$  with various organometallic cocatalysts provided in high yields a substituted polyacetylene having weight-average molecular weight ( $M_w$ ) of  $2 \times 10^5$ – $16 \times 10^5$ . A mixture of  $WCl_6$  with  $Ph_4Sn$  was especially active as catalyst and achieved a high  $M_w$  of  $16 \times 10^5$ . The product polymer was a dark brown solid, soluble in such solvents as toluene and chloroform. A tough film could be obtained by solution casting. The polymer was thermally fairly stable in air. The high molecular weight, film formation, and fair thermal stability of the present polymer are notable characteristics, which are not seen in poly(phenylacetylene). (Author abstract) 13 refs.

Masuda, Toshio (Kyoto Univ, Kyoto, Jpn); Hamano, Toshiyuki; Higashimura, Toshinobu; Ueda, Teruo; Muramatsu, Hiroshige. *Macromolecules* v 21 n 2 Feb 1988 p 281-286.

**081030 SOLUBLE POLYACETYLENE OBTAINED WITH RARE-EARTH CATALYST AND SOME ASPECTS OF POLYMERIZATION MECHANISM.** Soluble polyacetylene (PA) with well-defined nature has been synthesized with catalyst system  $Nd(i-OPr)_3/AlR_3$  ( $R = C_2H_5$ ,  $i-C_4H_9$ ) and characterized by IR, Raman and ESR Spectra etc. Number average molecular weight of the soluble specimen were determined by VPO to be about 500g/mol. or lower. The IR and NMR spectra and end group analysis of the soluble polyacetylene fully demonstrate that polymerization of acetylene with rare-earth catalyst is realized through monomer insertion between the transition metal-carbon bond. (Author abstract) 14 refs.

Hu, Xiaodong (Acad Sinica, Changchun, China); Wang, Fosong; Zhao, Xiaojiang; Yan, Deyue. *Chin J Polym Sci (Engl Ed)* v 5 n 3 1987 p 221-227.

**Theory** See Also POLYMERS—Theory.

**081031 EXACT SOLUTIONS FOR SOME PERIODIC SYSTEMS IN THE CONTINUUM MODEL OF POLYACETYLENE.** Exact solutions for some periodic systems, where a polaron lattice and a soliton lattice are included as special cases, are found in the continuum model of trans-polyacetylene. Self-consistency is proved by utilizing the analytic properties of doubly-periodic functions. These solutions are also available to the continuum model of cis-polyacetylene. (Author abstract) 11 refs.

Takahashi, A. (Kyoto Univ, Kyoto, Jpn). *Solid State Commun* v 67 n 2 Jul 1988 p 173-177.

**Thermodynamics** See POLYMERS—Models.

**Thin Films** See ACETYLENE—Polymerization; SEMI-CONDUCTING POLYMERS—Synthesis.

**Transport Properties**

**081032 TRANSPORT IN TRANS-POLYACETYLENE.** A review is presented that starts with a description of the bonding, band structure, crystal structure, and morphology of polyacetylene. The Peierls distortion and gap; the continuum model; the behavior of solitons; the behavior of polarons; photogeneration and photoconductivity; conductivity and thermoelectric power in samples with very low doping; transport in samples with interme-

diate doping; and characteristics of highly doped polyacetylene are then covered. 149 refs.

Conwell, E.M. (Xerox Webster Research Cent, NY, USA). *IEEE Trans Electr Insul* v EI-22 n 5 Oct 1987, CEIDP: Conf on Electr Insul and Dielectr Phenom - Dig of Lit on Dielectr, 1987 p 591-627.

**POLYACRYLATES** See Also CELL CULTURE—Encapsulation; POLYMERS—Physical Properties; POLY-VINYL CHLORIDE—Stabilizers.

**081033 HYDRATION OF SODIUM AND CAESIUM SALTS OF POLY(ACRYLIC ACID) IN AQUEOUS SALT SOLUTIONS.** The electrostrictive hydration numbers of sodium and caesium poly(acrylate) are estimated on the compressibility data of the aqueous salt solutions. The hydration numbers of the charged units of the polyelectrolytes decrease to different degrees within a few 10% with the increase in the charge densities. The correlation of the decreases with the counterion binding is discussed. (Author abstract) 18 refs.

Sato, Mitsuru (Tokyo Inst of Technology, Tokyo, Jpn); Hayashi, Masahiko; Komiya, Jiro; Iijima, Toshiro. *Polym Commun (Guildford Engl)* v 29 n 2 Feb 1988 p 49-51.

**Adhesives** See DENTAL EQUIPMENT AND SUPPLIES—Bone Cement.

**Applications** See Also ADHESIVES—Research.

**081034 PREVAPORATION SEPARATION OF ETHANOL-WATER MIXTURES USING IONICALLY CROSSLINKED BLENDED POLYACRYLIC ACID (PAA)-NYLON 6 MEMBRANES.** The pervaporation separation of ethanol-water mixtures was carried out through a series of ionically crosslinked polyacrylic acid (PAA)-Nylon 6-blended membranes crosslinked to varying degrees in aluminum nitrate solution. The polyacrylic acid (PAA)-Nylon 6 membranes were cast from homogeneous PAA-Nylon 6 mixtures to various thicknesses and then crosslinked. Optimum pervaporation results were obtained from crosslinked blends containing 75 wt percent Nylon 6 and 25 wt percent PAA. These membranes have separation factors (water/ethanol) of 35-40 at flux rates of 120-160 g/m<sup>2</sup> h. The optimum crosslinking time was found to be approximately 35 h to yield membranes with the best separation and flux rates at 25 wt percent PAA content. (Author abstract) 18 refs.

Xu, Y.F. (Univ of Waterloo, Waterloo, Ont, Can); Huang, R.Y.M. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 1121-1128.

**Degradation**

**081035 MECHANISM OF THERMAL DEGRADATION OF POLY(ALKYL ACRYLATES) USING PYROLYSIS GAS CHROMATOGRAPHY MASS SPECTROMETRY.** The pyrolysis of homologous poly(alkyl acrylates) is reported with identification of the major pyrolyses products. A mechanism involving random homolytic scission of the chain followed by a series of intermolecular and intramolecular transfer reactions has been proposed for poly(methyl acrylate) by Cameron and Kane and further developed by Haken, Ho, Houghton and Gunawan. This mechanism is demonstrated to be generally applicable to the poly(*n*-alkyl acrylates). Reaction mechanisms are postulated for the various products produced and ion fragmentation mechanisms for the mass spectra produced are shown. (Author abstract) 14 refs.

Haken, J.K. (Univ of New South Wales, Kensington, Aust); Tan, L. *J Polym Sci Part A* v 26 n 5 May 1988 p 1315-1322.

**Polymerization** See POLYURETHANES—Crosslinking.

**Research**

**081036 MEROCYANINE-SPIROPYRAN PHOTO-CHEMICAL TRANSFORMATION IN POLYMERS, PROBING EFFECTS OF RANDOM MATRICES.**

Isomerization kinetics of the merocyanine-spiropyran transformation in several poly(alkyl acrylates) are detected by time-resolved absorption spectroscopy. The decay of the colored merocyanine exhibits significant deviations from first-order patterns. The energy of activation can be separated into a stabilization energy for the isomer and an activation inherent to the amorphous matrix by observing the decoloration patterns for the corresponding photoisomerization. These observations can be explained by matrix effects in the isomerization modeled by statistics and fluctuations of matrix-site energies. (Edited author abstract) 24 refs.

Richert, R. (Philipps-Univ, Marburg, West Ger). *Macromolecules* v 21 n 4 Apr 1988 p 923-929.

**Solutions**

**081037 ON THE ELECTROSTATIC CONTRIBUTION TO THE PERSISTENCE LENGTH OF FLEXIBLE POLYELECTROLYTES.** Quasi-elastic light scattering methods were used to study the dynamics of dilute solutions of high molecular weight ( $M_p = 10^7$  daltons) poly(acrylate) for  $[KCl]_{added} = 0.00, 0.05, \text{ and } 0.10 \text{ M}$ . The correlation functions were analyzed by a third-order cumulant and an overlay histogram with exponential sampling methods of analysis. The histograms exhibited a bimodal distribution. It is argued that the fast mode evident in the histograms is associated with the pure translational diffusion process for PAA-K and that the slow mode may be associated with hindered diffusion through cages found by neighboring polyions. (Edited author abstract) 40 refs.

Schmitz, Kenneth S. (Univ of Missouri-Kansas City, Kansas City, MO, USA); Yu, Jae-Woong. *Macromolecules* v 21 n 2 Feb 1988 p 484-493.

**Synthesis**

**081038 REEXAMINATION OF THE SYNTHESIS OF LIQUID CRYSTALLINE SIDE-CHAIN POLYACRYLATES VIA LIQUID-LIQUID PHASE-TRANSFER CATALYSIS.** We have reexamined the synthesis of liquid crystalline side-chain polyacrylates under liquid-liquid phase-transfer conditions as first reported by D. Keller. Instead of the polymeric liquid crystals, the hydrolysis of the mesogen and a subsequent nucleophilic substitution reaction was found to predominate over the anticipated reaction between the carboxylate group and the mesogen. The present results are consistent with the high pH conditions prevailing in the poly(sodium acrylate) solution as determined previously. The control of the pH value in the reaction medium is perceived to be crucial in determining the reaction pathway. (Author abstract) 19 refs.

Chen, S.H. (Univ of Rochester, Rochester, NY, USA); Maa, Y.F. *Macromolecules* v 21 n 4 Apr 1988 p 904-907.

**Thin Films**

**081039 THERMAL BEHAVIOUR OF FILMS OF PARTIALLY NEUTRALIZED POLY(ACRYLIC ACID). 3: EFFECT OF MAGNESIUM AND CALCIUM IONS.** Partially neutralized polyacrylates of calcium and magnesium have unexpectedly been found not to undergo thermal decarboxylation at 250°C, unlike partial polyacrylates of lithium, sodium or potassium. Reflectance infrared spectroscopy has confirmed that the partial polyacrylate of calcium is predominantly ionic but as with the magnesium compound, this does not promote decarboxylation. Further study of the partial lithium salt of poly(acrylic acid) has confirmed that lithium ions exhibits some degree of covalency, and hence are probably site-bound. Despite this, they succeeded in promoting decarboxylation. It is concluded that the main factor which prevents calcium and magnesium facilitating decarboxylation is their divalency, rather than any inherent tendency to become site-bound. Reasons for this are discussed. (Author abstract) 17 refs.

Nicholson, John W. (Dep of Trade & Industry, London, Engl); Wasson, Eleanor A.; Wilson, Alan D. *Br Polym J*



v 20 n 2 1988 p 97-101.

**Ultrasonic Effects**

**081040 ETUDE PAR ULTRASONS D'UNE TRANSITION CONFORMATIONNELLE DU POLYACRYLATE DE METHYLE EN SOLUTION DANS DIFFERENTS SOLVANTS.** [Conformational Transition of Polymethyl Acrylate in Different Solvents Studied by Ultrasonic Method]. The polymeric solution is considered as a mixture of solvent and macromolecule segments. Propagation rate of the ultrasound provides direct information on the molecular interactions relative to the segments in polymeric solutions. In French. 13 refs.

Ikeda, H. (Science Univ of Tokyo, Tokyo, Jpn); Yugami, R.; Sato, F.; Komatsu, R.; Masuda, Y. *Acustica* v 64 n 2 Aug 1987 p 117-120.

**Waste Disposal**

**081041 ENVIRONMENTAL BEHAVIOR OF <sup>14</sup>C-TAGGED POLYACRYLATE POLYMER: COLUMN STUDIES OF FLOW AND RETARDATION IN SAND.** Flow columns filled with sand were used to study migration and retardation of a highly consumer-product, polyacrylate polymer material tagged with <sup>14</sup>C. Five flow column studies of a solution of the polymer demonstrated that a mobile fraction ranging between 32 and 58 percent migrated out of the columns after the passage of up to 50 pore volumes of leachate or distilled water, and most of this occurred well within the first 2 pore volumes. The remainder was highly retarded by the sand near the column inlet. When the polymer was introduced into two other columns as a simulated diaper pad, a much lower migration of 4.6 to 5.6 percent was observed, indicating a blocking phenomenon in the manufactured product form. The effect of typical landfill leachate on the migration and retention of the polymer reduced the migration and enhanced the retardation characteristics of the sand significantly. (Author abstract) 8 refs.

Martin, James E. (Univ of Michigan, Ann Arbor, MI, USA); Howard, Kenneth W.F.; King, Lawrence W. *Nucl Chem Waste Manage* v 7 n 3-4 1987 p 265-271.

**081042 ENVIRONMENTAL BEHAVIOR OF <sup>14</sup>C-TAGGED POLYACRYLATE POLYMER: FLOW TANK STUDIES OF RETENTION IN SAND.** A highly absorbent consumer-product, polyacrylate polymer material tagged with <sup>14</sup>C was dosed to a simulated diaper and buried in a horizontal flow tank containing sand. Two slightly different formulations of the polymer exhibited a mobile fraction, 1.9 percent and 3.48 percent of which was discharged in the tank effluent during the passage of 6 pore volumes. Most of the remainder was retarded along the flow path near the source by the sand. It is expected that more conventional landfill soils would provide even greater retention of the polymer materials studied. The use of a <sup>14</sup>C-tagged polymer proved to be a successful method of studying the behavior of these complex materials; pilot-scale studies are planned in lysimeters to determine if microbial decomposition affects the migration of these polymers under landfill conditions. (Author abstract) 6 refs.

Martin, James E. (Univ of Michigan, Ann Arbor, MI, USA); Howard, Kenneth W.F.; King, Lawrence W. *Nucl Chem Waste Manage* v 7 n 3-4 1987 p 273-280.

**POLYACRYLONITRILE** See Also CARBON FIBER—Mechanical Properties; CARBON FIBER—Oxidation; CARBON FIBER—Processing; CLAY MINERALS—Chemistry; POLYMERS—Blending.

**Antistatic Agents** See TEXTILE FIBERS—Modification.

**Applications** See FILTERS—Performance; TEXTILE FIBERS—Manufacture.

**Blending** See COPOLYMERS—Mixing.

**Carbonization** See Also CARBON FIBER—Manufacture.

**081043 CARBONIZATION OF POLYACRYLONITRILE IN A TWO-DIMENSIONAL SPACE BETWEEN MONTMORILLONITE LAMELLAE.** A novel method to prepare a new type of carbon from polyacrylonitrile (PAN) was developed by using the interlamellar opening of montmorillonite (MONT) as a two-dimensional space for carbonization. The complex of MONT with PAN was heat treated at 700°C to carbonize the intercalated PAN. The carbon produced was liberated from MONT by acid treatments. The carbon thus obtained looks like thin films under a scanning electron microscope and is considered to consist of planar macromolecules. Although it has a turbostratic structure at 700°C, it becomes a highly oriented graphite upon further heat treatment above 2500°C. An ordinary PAN was also prepared and heat treated for comparison. (Author abstract) 17 refs.

Sonobe, Naohiro (Tohoku Univ, Sendai, Jpn); Kyotani, Takashi; Tomita, Akira. *Carbon* v 26 n 4 1988 p 573-578.

**Chemical Reactions**

**081044 MODIFICATION OF PAN PRECURSOR - ITS INFLUENCE ON THE REACTION KINETICS.** Polyacrylonitrile (PAN) fibers of a special grade for making carbon fibers have been modified by stretching in the presence of a plasticizer to 70% maximum strain. By doing so, the diameter of the original fibers is reduced from 12.5 μ to 10 μ and the angle of orientation of the molecular chains along the fiber axis is reduced to almost half of its original value as determined by the X-ray flat-plate technique. The tensile strength and Young's modulus values of the modified samples show an improvement of about 70% and 100%, respectively. A study on the reaction kinetics up to 265°C by DSC, TGA, and TMA has revealed deviations in the characteristics of modified PAN precursors over those of the original sample. The implications of these are discussed. (Edited author abstract) 33 refs.

Mathur, R.B. (Nat'l Physical Lab, New Delhi, India); Bahl, O.P.; Matta, V.K.; Nagpal, K.C. *Carbon* v 26 n 3 1988 p 295-301.

**Degradation**

**081045 EFFECT OF PREVIOUS LASER IRRADIATION ON THE THERMO-OXIDATIVE DEGRADATION OF POLYACRYLONITRILE.** The thermo-oxidative degradation of PAN samples in the form of powders and films, previously exposed to laser irradiation, has been studied by IR and electron spectroscopy. It was shown that as a result of the laser irradiation, polyconjugated structures develop during the subsequent thermal treatment. After irradiation of powdered polymer, a new band appears in the spectrum, close to the operating frequency of the laser, but it disappears after thermal treatment. (Author abstract) 10 refs.

Klimenko, I.B. (S.M. Kirov Inst for the Textile & Light Ind, Leningrad, USSR); Platonova, N.V.; Grachev, V.I.; Vinogradov, B.A.; Arbuzov, V.R. *Polym Sci USSR* v 29 n 5 1987 p 1090-1096.

**Electronic Properties**

**081046 INFLUENCE OF COPPER-NITRILE COMPLEXING ON THE ELECTRONIC STRUCTURE OF POLYACRYLONITRILE.** The influence of copper-nitrile complexing on the chemical and electronic structure of polyacrylonitrile has been studied by X-ray photoelectron spectroscopy and infrared spectroscopy. The results indicate that the existence of the complex effectively presents the nitrile groups form participating in the thermal cyclization and degradation and reduces the inter(intra)chain dipole-dipole interactions in the polymer, allowing the nitrile chain to become more ordered. This cancels the indirect influence of the dipole field on the polymer backbone. (Author abstract) 38 refs.

Wu, C.R. (Linköping Univ, Linköping, Swed); Liedberg, B.; Akbar, Sher. *Synth Met* v 26 n 1 Oct 1 1988 p 21-32.

**Grafting** See GRAFT COPOLYMERS—Evaluation.

**Heat Treatment** See TEXTILE FIBERS—Mechanical Properties.

**Medical Applications** See DRUG PRODUCTS—Toxicity.

**Mixing**

**081047 MISCIBILITY OF POLY(ACRYLONITRILE-co-STYRENE) WITH POLY[STYRENE-co-(MALEIC ANHYDRIDE)] AND POLY[STYRENE-co-(N-PHENYLMALEIMIDE)].** Miscibility of blends of poly(acrylonitrile-co-styrene) with poly[styrene-co-(maleic anhydride)] and poly[styrene-co-(N-phenylmaleimide)] was determined by measurement of their glass transition temperatures by dynamic mechanical testing. It was found that poly(acrylonitrile-co-styrenes) are miscible with poly[styrene-co-(maleic anhydride)s] and poly[styrene-co-(N-phenylmaleimide)s] within specific ranges of copolymer composition for each blend. The boundaries between domains of miscibility and immiscibility were expressed by two straight lines intersecting at the origin, where the abscissa and ordinate represent the compositions of the respective copolymers in volume fraction. (Edited author abstract) 23 refs.

Aoki, Yuji (Mitsubishi Monsanto Chemical Co, Mie, Jpn). *Macromolecules* v 21 n 5 May 1988 p 1277-1282.

**Physical Properties** See SYNTHETIC FIBERS—Applications.

**Pyrolysis**

**081048 STUDY ON THE GASEOUS PRODUCTS OF HIGH TEMPERATURE PYROLYSIS OF ACRYLONITRILE POLYMERS BY ON-LINE FTIR METHOD.** The gaseous products of high temperature pyrolysis (300°C to 960°C) of acrylonitrile polymers were measured continuously under nitrogen atmosphere by on-line Fourier Transform Infrared Spectroscopic (FTIR) method. From the variations of characteristic peaks, it was found that the nitrogen of macromolecules evolved were mainly in the form of hydrogen cyanide and ammonia. During the pyrolysis, an amorphous carbonaceous element was formed and crosslinked to form a network structure. Three kinds of samples were used for comparison. The experimental results show that the gaseous products of volatile small molecules were HCN, NH<sub>3</sub>, CH<sub>4</sub>, C<sub>2</sub>H<sub>6</sub> and cyanide. CO and CO<sub>2</sub> were also formed when copolymers of PAN were thermally pyrolyzed. (Author abstract) 10 refs.

Zhao, Genxiang (Acad Sinica, Taiwan); Chen, Bangjie. *Chin J Polym Sci (Engl Ed)* v 5 n 2 1987 p 87-94.

**Reduction** See ZEOLITES—Reduction.

**Solutions**

**081049 SOLUTION-GROWN SINGLE CRYSTAL OF POLYACRYLONITRILE POLYMERIZED BY γ-RAY IRRADIATION ON UREA-ACRYLONITRILE CANAL COMPLEX: PREPARATION AND PRELIMINARY STRUCTURE ANALYSIS.** In this paper an attempt was made to prepare single crystals from dilute solution of highly isotactic PAN, polymerized by γ-ray irradiation, and to determine the crystallographic features such as the crystal form, its growth plane and the lattice constants. 14 refs.

Yamazaki, Hitoshi (Asahi Chemical Industry Co, Takatsuki, Jpn); Kajita, Shuji; Kamide, Kenji. *Polym J* v 19 n 8 1987 p 995-998.

**Spectroscopic Analysis**

**081050 INFRARED REFLECTION-ABSORPTION SPECTROSCOPY OF POLYACRYLONITRILE ON**



**COPPER AND ALUMINIUM SURFACES.** Infrared reflection-absorption spectroscopy has been used to study the chemical structure of thin films of pyrolyzed polyacrylonitrile (PAN) on copper and aluminum surfaces. The formation of a conjugated backbone occurs at temperatures as low as 200°C for PAN on copper, whereas the same reaction on aluminum requires pyrolysis at 300°C in order to be completed. Pyrolysis of Pan on copper at 200°C also results in diffusion of copper atoms (ions) into the polymer network followed by complexing. We propose a chemical structure of PAN on copper that is different to that in the bulk and on aluminum. (Edited author abstract) 32 refs.

Wu, C.R. (Linköping Univ, Linköping, Swed); Liedbergh, B. *J Polym Sci Part B* v 26 n 5 May 1988 p 1127-1136.

## Stability

**081051 THERMAL STABILIZATION OF POLY-ACRYLONITRILE FIBERS.** Polyacrylonitrile (PAN) fibers pretreated with potassium permanganate have reduced the activation energy of cyclization and the oxidation time, and also improved the properties of the resultant carbon fibers. The activation energy of cyclization is reduced to  $24 \pm 1$  kcal/mol from  $30 \pm 3$  kcal/mol and the tensile strength of the carbon fibers increases by about 20-40%. The method of measuring the 'aromatization index' (AI) value is modified and is recommended in checking the oxidation process. All fully stabilized PAN fibers have almost the same AI value. However, the oxidation time is decreased by 30 min when oxidation temperature is raised by 10°C. (Author abstract) 31 refs.

Ko, Tse-Hao (Feng Chia Univ, Taichung, Taiwan); Ting, Hsing-Yie; Lin, Chung-Hua. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 631-640.

## Structure

**081052 PREPARATION OF STARCH GRAFT COPOLYMERS: INFLUENCE OF SEVERAL PARAMETERS ON STRUCTURE AND PROPERTIES.** Samples of starch-g-polyacrylonitrile were prepared using the  $Ce^{4+}$  ion as initiator. We discuss the influence of the origin of the starch on the polyacrylonitrile content of the copolymer, on the frequency of the grafted chains, and on the molecular weight of the graft. Relations between alkaline hydrolysis conditions and liquid absorption were also studied. The retention increases with the molecular weight of the grafted polyacrylonitrile, and this factor depends on the origin of the starch. Higher absorptions were obtained with low amylose content samples. An absorption maximum was observed that depends on the time of hydrolysis and consequently on the carboxylate group content. (Author abstract) 18 refs.

Castel, D. (ESPCI, Paris, Fr); Ricard, A.; Audebert, R. *J Macromol Sci Chem* v A25 n 3 Mar 1988 p 235-246.

## Synthesis

**081053 ELECTRO-INITIATED POLYMERIZATION OF ACRYLONITRILE IN AQUEOUS ACETIC ACID CONTAINING  $Mn(OAc)_2 \cdot 4H_2O$  AND  $CNCH_2COOH$ .** The electro-initiated polymerization of acrylonitrile initiated by the anodic oxidation of an aqueous acid solution (80%  $HOAc + 20\% H_2O$ ) containing  $Mn(OAc)_2 \cdot 4H_2O/CNCH_2COOH$  has been investigated in the 30-40°C temperature range. The kinetics and mechanism of the process has been investigated as a function of variables and a suitable mechanism proposed. Both the initiation of polymerization by the primary radical, viz.,  $CN-CH-COOH$  as well as the oxidation of the primary radical at the electrode are equally significant reactions and neither can be neglected in comparison with the other. Predominant mutual termination accounts for all the observed data. (Edited author abstract) 7 refs.

Balasubramanian, T.R. (Indian Inst of Technology, Madras, India); Mahadevan, V. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 301-311.

**081054 INITIATION OF POLYMERIZATION OF**

**VINYL MONOMERS BY CHARGE TRANSFER MECHANISM.** The charge transfer initiated polymerization of acrylonitrile 2,4-dinitrophenylhydrazine (DNPH) and  $Cu^{2+}$  in the presence of carbon tetrachloride was studied in dimethyl sulphoxide at 60°C. The rate of polymerization became maximum when the mol ratio of [DNPH] to  $[Cu^{2+}]$  was 4:1. The polymerization was inhibited after a very short period when the above ratio was 2:1, mainly due to the liberated bromine. A suitable mechanism for the experimental observation is proposed. (Author abstract) 17 refs.

Dass, N.N. (Dibrugarh Univ, Dibrugarh, India); Begum, S.S. *Polym J* v 19 n 11 1987 p 1255-1259.

## Thin Films

**081055 A FEW ELECTRONIC PROPERTIES OF THIN FILMS OF PLASMA-POLYMERIZED ACRYLONITRILE.** The ionization potential and work function of plasma-polymerized acrylonitrile thin films have been measured using a low energy electron gun in an ultrahigh vacuum system. The optical absorption and electrical resistivity were also measured as a function of pyrolyzation temperature and doping. A change in ionization potential, work function, electron affinity and band gap was observed. This is discussed in the light of the structural modification owing to pyrolyzation and doping. The work function of indium tin oxide was also measured and its use in photovoltaic devices is illustrated. (Author abstract) 21 Refs.

Bhuiyan, A.H. (Univ of Poona, Pune, India); Rajopadhye, N.R.; Bhorkar, S.V. *Thin Solid Films* v 161 Jul 1988 p 187-195.

## Wear

**081056 BASIC STUDIES ON THE STABILITY OF FILTRATION FABRICS PART I: THE EFFECTS OF SULPHUR DIOXIDE AND NITROGEN OXIDES ON POLYACRYLONITRILE.** The paper (the first in a series) describes the deterioration of polyacrylonitrile (PAN) fibers under laboratory-simulated conditions by Fourier transform infrared spectroscopy, differential scanning calorimetry, scanning electron microscopy, and tensile strength measurements. The results indicate that the fibers are subject to oxidative degradation (chain scission, formation of  $-CO_2$ ,  $-COOH$ , etc), cyclization via the nitrile side chains, and a slight introduction of  $SO_2$  and  $SO_3$  groups to the polymer chain. All these primary and secondary reactions are basically related to thermal or alkaline degradation of PAN, and both  $SO_2$  and  $NO_2$  appear to play a catalytic role in the oxidation process. (Edited author abstract) 36 Refs.

Weber, Claudia (Beutisches Wollforschungsinstitut, Aachen, West Ger); Altenhofen, Ulrich; Zahn, Helmut. *Text Res J* v 58 n 9 Sep 1988 p 507-514.

## POLYAMIDEIMIDES

### Combustion

**081057 ENTHALPIES OF COMBUSTION OF POLYAMIDOIMIDES.** Enthalpies of combustion of polyamidoimides, obtained on the basis of trimellitimido-N-acetic and trimellitimido-N-p-benzoic acid dichlorides and also a series of aromatic diamines, were determined by the combustion method in a calorimetric bomb. A linear dependence of enthalpies of combustion on the relative hydrogen content in the polymer was found. (Author abstract) 5 refs.

Morozova, N.Yu.; Privalko, V.P.; Zamulina, L.I.; Khomenkova, K.K. *Sov Prog Chem* v 53 n 6 1987 p 97-99.

### Curing

**081058 CURING MECHANISM OF POLYAMIDEIMIDE BY HEATING.** Polyamideimide (PAI) samples containing various amounts of amide and imide bonds were prepared by the polycondensation of trimellitic anhydride and trimellitic acid with 4,4'-diphe-

nylmethane diisocyanate. To clarify the curing mechanism of PAI, the effects of heating on its chemical structure and physical properties were investigated. The results suggest that the curing of PAI by heating is due to the crosslinking reaction between functional groups or terminal groups in the main or branch chains. When PAI was heated in air, the oxidation of diphenylmethane structure in the main chain had some influence on the curing of PAI. (Edited author abstract) 14 refs. In Japanese.

Tsubokawa, Norio (Niigata Univ, Niigata, Jpn); Yamamoto, Isamu; Sone, Yasuo. *Kobunshi Ronbunshu* v 44 n 5 1987 p 389-394.

## Synthesis

**081059 HIGH MODULUS FIBERS AND FILMS FROM A WHOLLY AROMATIC POLYAMIDE-IMIDE.** Wholly aromatic polyamide-imide fibers and in-plane isotropic films were made from N,N'-bis(2-chloro-4-aminophenyl)terephthalamide and pyromellitic dianhydride. The N-methylpyrrolidone solution of its precursor, poly(amic-acid), was wet-spun into fibers, which were then imidized chemically or thermally. The chemically imidized fiber had tenacity: 12.2 g/d and initial modulus ( $M_i$ ): 1340 g/d. Films were prepared by casting.  $M_i$  of the stiffest film reached 2530 kg/mm<sup>2</sup>. (Edited author abstract) 4 refs. In Japanese.

Jinda, Takuma (Toray Industries Inc, Otsu, Jpn); Matsuda, Toshikazu. *Kobunshi Ronbunshu* v 45 n 2 1988 p 189-191.

**POLYAMIDES** See Also COPOLYMERS—Reaction Kinetics; MEMBRANES—Thin Films; PLASTICS—Biodegradation; POLYIMIDES—Mechanical Properties; POLYIMIDES—Synthesis; PROTECTIVE COATINGS.

**081060 POLYMERIZATION OF  $\epsilon$ -CAPROLACTAM IN AN EXTRUDER: PROCESS ANALYSIS AND ASPECTS OF INDUSTRIAL APPLICATION.** The polymerization of caprolactam into polyamide 6 on corotating twin-screw extruders provides the processor with technically and economically interesting aspects of application. Using the extruder as a small reactor, it is possible, on the one hand, for small batches of polyamide to be optimized for specific applications and, on the other hand, for large quantities of polymerized polyamide melts to be fed into different processes. Apart from the extrusion of filaments, films, and profiles, the continuous polymerization process also can be coupled up to discontinuous processes. This so-called rapid polymerization in the extruder not only brings price advantages as compared with standard polyamides, but also gives higher molecular weights and, hence, improved properties. (Author abstract) 16 refs.

Menges, G. (Inst fuer Kunststoffverarbeitung, Aachen, West Ger); Bartilla, T. *Polym Eng Sci* v 27 n 16 Mid-Sep 1987 p 1216-1220.

**081061 PREPARATION OF POLYACRYLAMIDE HYDROGELS BY RADIATION TECHNIQUE.** Three types of polyacrylamide hydrogel were prepared by radiation techniques and their water retention values were determined. Cobalt-60  $\gamma$ -ray source was used for radiation polymerization and crosslinking. Dose rate: 2.5 rad/s. The water retention value (WRV) was determined by measuring the quantity of water retained by PAM-HG at room temperature (g/g). 5 refs.

Zhang Zicheng (Chang Chun Inst of Applied Chemistry, Jilin, China); Li Qian; Li Donghui; Zhao Xin; Li Shuhua; Zhang Lihua. *Radiat Phys Chem* v 30 n 4 1987 p 307-308.

**081062 AROMATIC POLYAMIDE.** [Aromatic Polyamides]. The most important types of aromatic polyamides are surveyed. Also, their structure, processing,



and applications, including raw-materials used in their production, are discussed. (Author abstract) 11 refs. In Czech.

Ruzicka, Jaroslav (Vysoka Skola Chemicko-Technologicka, Pardubice, Czech). *Plasty Kauc* v 25 n 2 Feb 1988 p 37-39.

**081063 NOVE MATERIALY NA BAZI POLYAMIDU.** [New Polyamide-Based Materials]. Current developments in novel polyamide-based materials are described in detail. A classification of the materials according to their physical and chemical properties is presented. Also, processing of the materials by reaction injection molding and problems of preparation of modified polyamides are discussed. (Author abstract) 15 refs. In Czech.

Stehlíček, Jaroslav (CSAV, Prague, Czech). *Plasty Kauc* v 25 n 2 Feb 1988 p 40-42.

## Adsorption

**081064 OZNACZANIE STEZENIA POLIAKRYLAMIDU W POMIARACH ADSORPCJI.** [Determination of Polyacrylamide Concentration in Adsorption Experiments]. A viscometric and a modified nephelometric method for the determination of high-molecular-weight polyacrylamide (PAA) content in aqueous solutions have been elaborated. They have been applied in the determination of adsorption isotherms of PAA from aqueous solutions on colloidal AgI particles. The suitability of both methods for studies on PAA adsorption in highly dispersed systems has been compared and it has been found that viscometric method gives better results. (Author abstract) In Polish. 22 refs

Norwicki, Waldemar (Uniwersytet im. A. Mickiewicza w Poznaniu, Pol). *Polimery* v 32 n 7 Jul 1987 p 281-283.

## Aging

**081065 PHYSICAL TRANSFORMATIONS AND CHANGE IN MECHANICAL PROPERTIES ON THERMAL AGEING OF ALIPHATIC POLYAMIDES.** In the thermal aging of aliphatic polyamides the density and degree of crystallinity are increased, the supermolecular structure is completed, and microcracks appear in the layers near the surface, which is accompanied by a change in the mechanical properties of the specimens. A change in the angular coefficients of the rate of change of the control criterion as a function of the temperature of thermal aging must be allowed for in selecting the maximum temperature of the tests, which, in the case of aliphatic PA, should not exceed 120°C. The results obtained during thermal aging at temperatures below 120°C can be used in forecasting the time for which the control criterion (properties) can be maintained at a given level. (Edited author abstract). 7 Refs.

Pavlov, N.N. (Plastmassy Scientific Production Assoc, USSR); Kudryavtseva, G.A.; Abramova, I.M.; Vasil'Eva, V.A.; Zezina, L.A.; Kazaryan, L.G. *Polym Sci USSR* v 29 n 4 1987 p 967-973.

## Applications See Also MEMBRANES—Structure.

**081066 NEW ACRYLAMIDE- AND SILOXANE-BASED MATERIALS FOR PHOTO-MECHANICAL METHODS.** This paper covers two new optically sensitive materials, based on acrylamide and siloxane, which can be used in mining geomechanics. Discussed are polyacrylamide gel, siloxane rubbers, the optomechanical properties, elastic properties, stress-strain curves, and other physical properties. 6 refs.

Malkis, N.I. (A.A. Skochinskii Inst of Mining, Lyubertsy, USSR); Rogovina, L.Z.; Vasil'ev, V.G.; Slonimskii, G.L.; Trumbachev, V.F. *Sov Min Sci* v 22 n 5 Sep Oct 1986 p 412-415.

**081067 POLYAMIDE (PA).** With a total consumption in the western world of just under 650000 t/a, polyamide (PA) accounts for only about 1% of the total volume of all plastics. With a growth rate of around 6 to 7% this product

group is above the levels of other major plastics types. The old polyamide sector will in the foreseeable future lose none of its vitality. Apart from its balanced range of properties, it is above all the opportunities for variation, as regards the chemical structures, and the diverse possibilities for combination with additives or other polymers. An important aim of product development continues to be the improvement of processing performance and transparency. Amorphous polyamide with high glass transition temperature was developed above all for exterior applications in the automotive sector. In the group of elastomeric polyamides, the development of polyether block amides and thermoplastic polyamide 12 elastomers has enabled further progress. 22 refs.

Blinne, G.; Priebe, E. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 32-35.

**081068 RELATIONSHIP BETWEEN ELECTRON SENSITIVITY AND CHEMICAL STRUCTURES OF POLYMERS AS ELECTRON BEAM (EB) RESISTS. V: POLYAMIDES CONTAINING SULFUR GROUPS AS POSITIVE EB RESISTS.** Polyamide-thioethers were synthesized and evaluated as positive electron beam (EB) resists. The polyamidothioethers decomposed easily with EB exposure. At high doses (indicating low sensitivity), crosslinking reactions occurred for polyamidothioethers having C-S bonds produced by Michael addition, but the other polyamidothioethers did not crosslink. The C-S bonds produced by Michael addition may influence crosslinking rather than decomposition. The sensitivity of oxidized polyamidothioether was higher than that of the nonoxidized polymer with no change in resolution. The oxidized polyamidothioether had a higher sensitivity and a high resolution, and is adaptable as a positive EB resist. (Author abstract) 9 refs.

Oguchi, Kiyoshi (Sophia Univ, Tokyo, Jpn); Yoneyama, Sachiko; Sanui, Kohei; Ogata, Naoya; Takahashi, Yoichi; Nakada, Tomihiro. *Polym Eng Sci* v 28 n 1 Mid-Jan 1988 p 32-36.

## Chemical Reactions

**081069 REACTIONS OF POLYAMIDES WITH METAL SULFIDES DURING HETEROLYTIC POLYCONDENSATION.** The aim of our investigation was to study the character of the reaction of polyamides with copper and cadmium sulfides, occurring during the preparation of a composite material, by the method of interphase polycondensation in which the syntheses of the polyamide and metal sulfide take place simultaneously at the interface of two immiscible solutions. Using diffuse reflection spectroscopy, it is shown that in the reaction of polyamides with metal sulfides under interphase polycondensation conditions, a coordinational interaction takes place between the carbonyl oxygen atom of the amide group of the polyamide and the metal cation of the sulfide. IR spectroscopic analysis showed that with increase in the degree of cadmium sulfide filling of the polyamide, the number of hydrogen bonds between the carbonyl oxygen atoms and the amide hydrogen atoms decreases, and hydrogen interaction takes place between sulfide sulfur atoms and the hydrogen atoms of the amide and terminal amino groups. 4 refs.

Kabanov, D.A.; Tkachenko, A.G.; Syrkova, O.V.; Tsvetkov, V.K. *J Appl Chem USSR* v 60 n 5 pt 2 May 1987 p 1108-1110.

**081070 EFFECT OF CHIRAL GROUP CONCENTRATION ON THE GAS CHROMATOGRAPHIC RESOLUTION BY DIAMIDES [R<sub>1</sub>CONHCH(R<sub>2</sub>)CONHR<sub>3</sub>]. COMPARISON OF LOW-MOLECULAR AND POLYMERIC PHASES.** It has been found that the highest stereoselectivity for N-acyl-α-amino acid esters in GC is observed on polymeric diamide phases if the amounts of bonded selector are relatively low. On the other hand, studies on low-molecular diamides, diluted with achiral aliphatic hydrocarbons, have demonstrated that the stereoselectivity of the diluted diamide molecules is higher than that of the self-associated molecules present in concentrated solution. It was concluded that the

hydrogen bonding between the diamide molecules lowers the importance of the selector-solute interactions responsible for stereoselectivity. In analogy to the low-molecular systems, it is assumed that on the polymer, too, self-association of neighboring diamide moieties distributed along the backbone reduces resolution as the load of the selector becomes higher. (Edited author abstract)

Watabe, K. (Weizmann Inst of Science, Rehovot, Isr); Gil-Av, E.; Hobo, T.; Suzuki, S. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 339.

## Chromatographic Analysis

**081071 PRZYDATNOSC REAKCJI FLUOROACETYLOWANIA DO OZNACZANIA ROZKŁADOW MASY CZĄSTECZKOWEJ POLIAMIDOW 6 METODA CHROMATOGRAFII ZELOWEJ.** [Applicability of the Fluoroacetylation Reaction in GPC Molecular Mass Distribution Determinations for Polyamide 6]. The samples of Tarnamid resins (Polish-made polyamide 6) were made soluble by fluoroacetylation. The GPC method in THF has been used to determine the molecular mass distribution of the fluoroacetylated derivatives of PA 6. The applicability of the fluoroacetylation method in the measurements has been confirmed by a good correlation between the values of M<sub>v</sub> as determined by GPC for the fluoroacetylated samples and those of viscometrically determined η<sub>rel</sub> for the same samples before fluoroacetylation. (Edited author abstract) In Polish. 12 refs.

Członkowska-Kohutnicka, Zofia (Inst Chemii Przemysłowej, Warsaw, Pol); Pogorzelska, Zofia; Glowala, Hanna. *Polimery* v 32 n 7 Jul 1987 p 275-277.

**081072 CARACTERIZAREA PULBERII DE POLIAMIDA-R PENTRU CROMATOGRAFIA PER STRAT SUBTIRE.** [Characterization of R-Polyamide Powder for Thin Layer Chromatography]. The paper presents the physical and chemical characteristics and the chromatographical behavior of the R-polyamide powder as compared to the Merck polyamide used as a stationary phase in thin layer chromatography. (Author abstract). 11 Refs. In Romanian.

Marutoiu, Constantin (Inst de Chimie, Cluj, Rom); Gocan, Simion; Sarbu, Costel; Bodoga, Petru; Badescu, Mihail. *Mater Plast Elastomeri Fibre Sint* v 25 n 1 Jan-Mar 1988 p 16-18.

## Corrosion

**081073 STRESS CORROSION CRACKING OF AN IMPACT MODIFIED POLYAMIDE AND ITS SHORT-FIBER COMPOSITES.** An impact modified Polyamide 6.6 (PA6.6) and two short-fiber composites with different loadings of short glass fibers were tested under stress rupture conditions. It was shown that fiber reinforcement can improve the material properties, the effectiveness depending on the fiber orientation, however. A deteriorating influence on the material's strength, especially at longer times of exposure, can be detected in the aggressive environment of a solution of 5% H<sub>2</sub>SO<sub>4</sub> in water. The dependence of the time to final failure on the magnitude of the initial stress intensity factor as well as the rates of crack propagation during loading were measured. Crack advance was monitored by optical microscopy and fractographical studies were performed in the SEM. (Author abstract) 15 refs.

Voss, H. (Technical Univ Hamburg-Harburg, Hamburg, West Ger); Dolgopolsky, A.; Friedrich, K. *Plast Rubber Process Appl* v 8 n 2 1987 p 79-90.

## Crazing

**081074 ENVIRONMENTAL CRAZING IN POLYAMIDES.** Polyamides have been known to stress crack in inorganic salt solutions for two decades but the role and importance of crazing has only been referred to more recently. Illustrated in this letter are various crazes found



in polyamides stressed in certain lithium, magnesium or zinc salt solutions. The primary aim has been to illustrate the morphology of crazes formed in salt-affected polyamides. 21 refs.

Burford, R.P. (Univ of New South Wales, Kensington, Aust); Williams, D.R.G. *J Mater Sci Lett* v 7 n 1 Jan 1988 p 59-62.

## Crystallization

**081075 STIRRING-INDUCED SOLUTION CRYSTALLIZATION OF ULTRA HIGH MOLECULAR WEIGHT POLYAMIDE 6.** Unstable solutions of ultra-high molecular weight polyamide 6 have been prepared by adding a nonsolvent to the polymer solution. Crystallization of the polyamide from such a solution proceeds very slowly. It has been found, however, that vigorous stirring of the unstable solutions induces rapid fibrous crystallization of the polymer. The fiber mat consists of irregularly shaped fibers. A low temperature and a high stirring rate are among the conditions necessary to obtain a high yield of fibrous material. The fibers formed upon stirring have a higher molecular weight than the polyamide 6 molecules which remain in the solution. The melting point of the fibers depends on the speed of the paddle stirrer. (Edited author abstract). 16 Refs.

Doppert, H.L. (Enka BV, Arnhem, Neth); Van Dijk, J.G. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 1177-1189.

## Degradation

**081076 THERMAL DEGRADATION OF ALIPHATIC POLYAMIDES STUDIES BY FIELD IONIZATION AND FIELD DESORPTION MASS SPECTROMETRY.** The aliphatic polyamides nylon 6,6, 6,9, 6,10, 6,12, 12,6, 12,10, and 12,12 of the diamine dicarboxylic acid-type were pyrolyzed in the ion source of a double-focusing mass spectrometer and the thermal degradation products were recorded by field ionization (FI) and field desorption (FD) mass spectrometry (MS). In the FI mode, several series of thermal degradation products differing in the number of polymer repeating units were detected up to 1000 Daltons. The main products were oligomers and, in addition, protonated dinitriles and various protonated nitriles are formed in large amounts except for nylon 6,6 and nylon 12,6. These two polymers form, in contrast to all other samples, large amounts of protonated amines and diamines. The technique employed allows distinction between oligomers already present in the original polymer and oligomers formed by thermal fission of bonds in the polymer chain. (Edited author abstract). 11 Refs.

Schulten, Hans-Rolf (Fachhochschule Fresenius, Wiesbaden, West Ger); Plage, Bernd. *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2381-2394.

## Dielectric Properties

**081077 DIELECTRIC RELAXATIONS OF POLYAMIDE 12 STUDIED BY THERMALLY STIMULATED CURRENT (TSC) METHOD.** The glass transition temperature of PA 12 of different samples having different molecular masses has been studied by the thermally stimulated current method. The relaxation  $\beta$  observed between 43°C and 53°C for different molecular masses and a critical mass of 4000 for PA 12 has been found. The thin structure of  $\beta$  for the sample having molecular mass of 12000 has been analyzed. Maximum energy observed is 2.52 eV at 54°C. The relaxation times corresponding to the first ten elementary peaks obtained by the fractional polarization method obey a compensation law with  $T_c = 357K$  and  $\tau_c = 7.8 \times 10^{-3}s$ . (Author abstract) 17 refs.

Faruque, Hafiz S. (Univ Paul Sabatier, Toulouse, Fr); Lacabanne, C. *Indian J Pure Appl Phys* v 25 n 3 Mar 1987 p 114-117.

## Fillers

**081078 INFLUENCE OF THE INTERACTION OF POLYMERS WITH FILLERS ON THE PARAMETERS OF MECHANOEMISSION.** A correlation between the parameters of the emission of high-energy electrons and the degree of interaction between polymers and mineral fillers in composite materials has been established. It is found that when the polymer interacts with a filler, the number of functional groups responsible for adhesion decreases, since they are coordinated by chromium. The amplitude of the emission flux consequently decreases as a result of the decrease in the number of contacting functional groups per unit of area. Therefore, the nature of the functional groups and their concentration on the surface has a significant influence on the emission parameters. An analysis of the results obtained allows us to conclude that the emission parameters are sensitive characteristics of the structural changes in filled systems and that the emission of high-energy electrons can be employed as a method of nondestructive testing for evaluating the changes in the properties of the surface of a material during service. (Edited author abstract) 5 refs.

Simakov, Yu.S. (Acad of Sciences of the USSR, Moscow, USSR); Nechaeva, S.I.; Khurstalev, Yu.A. *Colloid J USSR* v 49 n 4 Jul-Aug 1987 p 723-726.

## Film

**081079 SEPARATION OF H<sub>2</sub> AND CO THROUGH POLY(SULFONE-AMIDE) MEMBRANES. II. HIGHLY PERMESELECTIVE MEMBRANES CONTAINING BIS(3-AMINOPHENYL)SULFONE AS A DIAMINE COMPONENT.** The authors have studied hydrogen separation membranes made from aromatic polyamides containing sulfone linkages in the main chain. This paper reports the permeation behavior of H<sub>2</sub> and CO through the poly(sulfone-amide) containing bis(3-aminophenyl)sulfone (3DDS) as a main diamine component. 3DDS has no ether linkage, so the poly(sulfone-amide) comprising 3DDS has a higher concentration of amide linkages in the main chain than the poly(sulfone-amide) comprising 4SED has. Moreover, the amino group of 3DDS is bonded on the m-position. This structure introduces a bent structure in the polymer chain. These effects are expected to contribute to high permselectivity. 7 Refs.

Yoshimitsu, Sakaguchi (Toyobo Co, Shiga, Jpn); Tokai, Masaya; Kawada, Hiroshi; Kato, Yasuo. *Polym J* v 20 n 5 1988 p 365-370.

## Friction

**081080 SOME TRIBOTECHNICAL CHARACTERISTICS OF POLYAMIDE FACINGS ADHESIVELY BONDED WITH A POROUS METAL MATRIX.** We study the effectiveness under conditions of rolling friction with slip of polyamide 6 (PA6) facings of thickness 0.5-2.5 mm, adhesively bonded with the aid of mark PFE 2/10 methylolpolyamide with porous reinforcing elements (RE) of sintered iron powder. Use of the facings makes it possible to improve the load capacity by 10-80% in comparison with monolithic PA6 specimens. We conclude that it is necessary to develop special adhesives for impregnation of the porous RE, capable of forming with the facing material an adhesive bond that is resistant to the action of dynamic contact loads. (Author abstract) 8 refs.

Pechera, V.V.; Pesetskii, S.S.; Meshkov, V.V.; Lukoshyute, I.A. *Sov J Frict Wear* v 8 n 5 1987 p 125-128.

## Grafting See Also PULP—Grafting.

**081081 GRAFTING OF PREFORMED POLYAMIDE ONTO CELLULOSE ACETATE.** With few exceptions, grafting of synthetic polymers onto cellulose and cellulose derivatives is carried out by mechanisms involving free radical addition. These methods give large amounts of ungrafted homopolymer, little control over the molecular weight and molecular weight distribution of the grafted polymer, and other problems. By introducing

methanesulfonyl (mesyl) groups on cellulose acetate, we have found that preformed polyamide with free carboxylate end groups will displace the mesyl group and form an ester linkage in a homogeneous phase reaction. Grafting yield is over 80 percent after reaction at 80°C for 20 hours. (Author abstract) 6 refs.

Biermann, Christopher J. (Purdue Univ, West Lafayette, IN, USA); Narayan, Ramani. *For Prod J* v 38 n 1 Jan 1988 p 27-30.

## High Temperature Effects

**081082 THERMAL EXPANSION OF THE CRYSTALLINE LATTICE OF POLYAMIDES.** X-ray structural analysis is used to study the thermodynamics of the crystalline lattice of isotropic polyamide samples: polyhexamethylenedipamide, polycapromide, polyhexamethylenesbacinamide and polydodecanamide. It is shown that change in the parameters of the lattice with rise in temperature is of a non-linear character. Break points in the dilatometric curves are observed at 100-120 and 180-200°C. In the first temperature region heavy rupture of the hydrogen bonds in the crystalline lattice begins with phase transition in the second to the hexagonal structure. (Author abstract). 14 Refs.

Kazaryan, L.G. (Plastmassy Science-Production Assoc, USSR); Zezina, L.A.; Pavlov, N.N. *Polym Sci USSR* v 29 n 5 1987 p 1052-1058.

## Hydrolysis

**081083 HYDROLYSIS AND OTHER PHENOMENA AFFECTING STRUCTURE AND PERFORMANCE OF POLYAMIDE 6 MEMBRANE.** The rate of hydrolysis of polyamide 6 in membrane casting solution containing strong mineral acid has been studied by determining changes in molecular weight, as estimated from dilute solution viscometry measurements. Hydrolysis is shown to be first order with a long half-life of about 250 days. A two-step dissolution process for polyamide 6 is proposed. The effect of extended dope maturation time upon polyamide 6 membrane preparation and performance has been examined. At short maturation times where protonation of polymer chain is occurring, flux is relatively low. A major increase in flux occurs after about 10 h, when protonation appears complete and hydrolysis has begun. Hydrolysis reduces polymer chain entanglement, and so quite different mechanisms for membrane formation exist as dope maturation time proceeds. With chains less than the critical entanglement length, nodular top layer membranes and alveolar walls lead to high water flux. However, such membranes are quite fragile. (Author abstract) 20 refs.

Yao, C.W. (Univ of New South Wales, Kensington, Aust); Burford, R.P.; Fane, A.G.; Fell, C.J.D.; McDonogh, R.M. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2399-2408.

## Injection Molding See PLASTICS PRODUCTS—Injection Molding.

## Manufacture

**081084 KIERUNKI ROZWOJU PRODUKCJI TARNAMIDOW.** [Directions of Tarnamides Production Development]. Research and development works, being carried out at Nitrogen Works in Tarnow, on polyamide-6 are presented against the background of the world trends. The share of the works in the multilateral cooperation of the countries, members of the Council of Mutual Economic Assistance, in the field of production and improvement of polyamides is presented. (Author abstract) In Polish. 7 refs.

Warchalowski, Krzysztof; Maciszewski, Leszek. *Przem Chem* v 66 n 7 Jul 1987 p 341-343.

## Mechanical Properties See Also NYLON TEXTILES—Plastics Applications.

**081085 IMPACT-RESISTANT POLYAMIDE ALLOYS: STRUCTURE AND PROPERTIES OF IM-**



**PACT MODIFIED PA 6 AND PA 66 COMPARED WITH UNMODIFIED HOMOPOLYMERS.** This paper covers the modification of polyamides to make them impact resistant. Some of the topics discussed include the marketing and conditioning costs of polyamides. Other topics covered are used of polyolefin particles as property modifiers; polyamides as multiphase systems; and mechanical and physical properties of the modified polyamides. In English and German.

Lohe, P.; Arndt, J. *Kunstst Ger Plast* v 78 n 1 Jan 1988 p 15-17.

**081086 SEGMENTAL DYNAMICS IN NYLON 66.** The authors present a preliminary account of the characterization of segmental dynamics of specifically deuterated nylon 66 polymers (polyhexamethylene adipamide) that allow us to individually identify the molecular motion that each methylene unit undergoes and thus to examine questions as to the cooperativity of motion. Furthermore, this system has the advantage of allowing us to separately examine subsystems of five and seven bonds which are nominally pinned by the hydrogen-bonding amide sites. Preliminary results for each of the methylene groups in the crystalline domains indicate that there is considerable internal rotational freedom as well as librational motion well below the melting point and the motion of all five methylene groups is quite similar at all temperatures above the Brill transition. 10 refs.

Miura, H. (DuPont, Wilmington, DE, USA); English, A.D. *Macromolecules* v 21 n 5 May 1988 p 1543-1544.

**Medical Applications** See DIALYSIS.

**Metallizing**

**081087 METALLISIERUNG VON POLYAMID-SPRITZGUSSTEILEN.** [Metallizing of Polyamide Injection Moldings]. The article reports on a process for the metallizing of polyamide developed by Bayer. By contrast with ABS, the pretreatment of polyamide consists of an activation which contains noble metal salts, light chemical etch, and sensitization. First practical experiences with this process, which is employed for shielding against magnetic waves (EMI shielding) and for decorative purposes, are described. (Edited author abstract) In German. 1 ref.

Wolf, G.D.; Seidel, J.; Sirinyan, K. *Galvanotechnik* v 79 n 1 Jan 1988 p 54-59.

**Modification** See POLYMERS—Physical Properties.

**Molecular Structure**

**081088 STRUCTURE AND PROPERTIES OF POLYAMIDE AND ITS SIDE-BY-SIDE BICOMPONENT FIBRE.** This paper is concerned with polyamide fibre, copolyamide fibre, and corresponding side-by-side bicomponent fibre. The effects of second monomer content in copolymer and the process on supermolecular structure, shrinkage and crimp were studied. The results show that the interrelation of molecular recovery ability and intermolecular force in the fibre is basic factor which affect above-mentioned fibre properties. (Author abstract) 3 refs. In Chinese.

Guo, Manli (China Textile Univ, China); Jin, Huifen; Huang, Suping. *Zhongguo Fangzhi Daxue Xuebao* v 13 n 1 Feb 1987 p 79-86.

**Molecular Weight** See NYLON POLYMERS—Physical Properties.

**Morphology** See INTERPENETRATING POLYMER NETWORKS—Morphology.

**Optical Properties**

**081089 HYDRODYNAMIC AND OPTICAL PROPERTIES OF POLYAMIDES WITH BENZIMIDAZOLE LINKS INCLUDED SYMMETRICALLY IN THE CHAIN.** Forward diffusion, intrinsic viscosity and flow birefringence in acetic acid solutions have been

investigated for polyamide benzimidazoles differing in the way in which the benzimidazole rings are incorporated in the molecular chain. It is shown that an increase in the proportion of benzimidazole rings oriented one to another in the 'head-to-head' position from 2/3 to 1 does not give rise to any appreciable change in the equilibrium rigidity of the polyamide-benzimidazole molecules in solution or to the optical anisotropy of unit chain length. (Author abstract) 11 refs.

Lavrenko, P.N. (USSR Acad of Sciences, USSR); Shtenikova, I.N.; Garmonova, T.I.; Mikryukova, O.I.; Gel'mont, M.M.; Efros, L.S. *Polym Sci USSR* v 28 n 10 1986 p 2335-2342.

**Oxidation**

**081090 NONINHIBITED AND INHIBITED OXIDATION OF POLYAMIDES.** Oxidation of polyamide-6,6 (PA-6,6) has been investigated at 150-230°C at various oxygen pressure. The oxidation reaction involves only a small fraction of the polymeric material containing 0.6 percent methylene groups at 155°, and 1.4 percent at 200°, percentages that are not a function of the O<sub>2</sub> pressure. The PA-6,6 hydroperoxide contains not less than two fractions that are quite dissimilar as to their stability. Features of oxidation of the polymer are in good agreement with a zone model of the process. According to this model the oxidation process primarily involves zones of disruption of short-range order existing in the polymer. (Author abstract). 5 Refs.

Monakhova, T.V. (USSR Acad of Sciences, USSR); Bogayevskaya, T.A.; Shlyapnikov, Yu. A. *Polym Sci USSR* v 29 n 5 1987 p 1146-1151.

**Phase Equilibria** See BLOCK COPOLYMERS—Phase Equilibria.

**Physical Properties** See Also COPOLYMERS—Physical Properties; NYLON POLYMERS—Radiation Effects; POLYSULFONAMIDES—Synthesis; YARN—Thermal Properties.

**081091 PREPARATION AND PROPERTIES OF SILICON CONTAINING COPOLYAMIDES.** Copolyamides containing siloxane moieties in main chain were prepared by a melt polycondensation with 1,3-bis(3-aminopropyl)tetramethyldisiloxane (E), hexamethylenediamine (N6), and adipic acid (6). Glass transition temperature (T<sub>g</sub>), cold crystallization temperature (T<sub>cc</sub>), and melting temperature (T<sub>m</sub>) were measured by differential thermal analysis (DTA). The depression of T<sub>m</sub> for copolyamide was fitted by the Flory curve. These DTA studies suggest that the crystallization of N66 component in copolyamide is hindered by the bulky siloxane moiety, while the micro-Brownian motion of amorphous segment is promoted by the flexible siloxane bond. (Edited author abstract) 16 refs.

Kiyotsukuri, Tsuyoshi (Kyoto Inst of Technology, Kyoto, Jpn); Tsutsumi, Naoto; Ayama, Koichi; Nagata, Minoru. *J Polym Sci Part A* v 26 n 3 Mar 1988 p 807-817.

**081092 POLYELECTROLYTE SWELLING OF POLYAMIDOBENZIMIDAZOLE.** The extreme character of swelling of PABI fibers in DMAc-water mixtures has been detected. The swelling maximum is at an alkali content of 10-12% in water. The maximum is observed in the region of a 10% water content. The peculiarity in swelling has been explained by the manifestation of a polyelectrolyte nature of the polymer. 6 refs.

Iovleva, M.M.; Kasevich, I.R.; Smirnova, V.N.; Avrorova, L.V.; Kudryatsev, G.I.; Papkov, S.P. *Fibre Chem* v 19 n 5 Sep-Oct 1987 p 334-335.

**Processing** See Also YARN—Fatigue.

**081093 DEFORMATION OF A JET OF AROMATIC POLYAMIDE SPUN BY THE DRY-WET METHOD.** The distribution of jet velocities in the air gap and of the degree of stretching between the liquid (in the air gap) and gel-form sections of the fibers being spun from solutions of an aromatic heterocyclic polyamide by

the dry-wet method has been examined. It has been shown that the distribution of jet velocities in the air gap depends on the spinneret hole diameter, the molecular weight of the polymer, and the rate of yarn take-up on the take-up device. Conditions for lengthwise shrinkage of the gel-form fiber in the precipitation bath have been determined. 2 refs.

Shorin, S.V.; Avrorova, L.V.; Kudryatsev, G.I. *Fibre Chem* v 19 n 1 Jan-Feb 1987 p 35-37.

**Production**

**081094 LINEAR A-B AND AA-BB POLYAMIDES WITH BACKBONE ARYL, ALKYL, AND ALKENYL UNITS.** High performance linear AA-BB and A-B polyamides were generated using polymerization schemes that gave polymers in higher yields and having better performance than previous methods. Polymers were characterized with FTIR, solution and solid-state <sup>13</sup>C-NMR and showed the incorporation of aryl, alkyl, and alkenyl linkages in the polymer backbone. Thermal analysis showed that a significant weight percent of the polymers remained at 1000°C. (Author abstract). 17 Refs.

Ahmed, Sharf U. (DePaul Univ, Chicago, IL, USA); Sikes, Allison M.; Mathias, Lon J.; Livant, Peter D. *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2345-2354.

**Reinforcing**

**081095 ROZDELENÍ DELEK VLAKEN V POLYAMIDU VÝZTUŽE NEM SKLEM A JEHO VLIV NA MECHANICKE VLASTNOSTI.** [Distribution of Short Fiber Lengths in Glass Fiber-Reinforced Polyamide and Its Effect on Mechanical Properties]. The paper describes a method for determining the distribution of short glass fiber lengths in a polyamide matrix. The feasibility of converting experimental data to a continuous distribution function is illustrated. The results obtained are compared with mechanical properties of the composites under investigation. (Edited author abstract) In Czech. 22 refs.

Ulrych, Frantisek; Vokrouhlecký, Jan; Sova, Milos; Turcic, Branko. *Plasty Kauc* v 24 n 9 Sep 1987 p 262-269.

**Research**

**081096 <sup>15</sup>N SOLID-STATE NMR CHARACTERIZATION OF ARAMID-CONTAINING NYLON-6 BY IN SITU POLYMERIZATION WITH BENZOYL CAPROLACTAM DERIVATIVES.** Natural abundance <sup>15</sup>N NMR of solids has been demonstrated as a useful characterization tool for polyamides. In addition to copolymer composition differences, glassy amorphous conformations and crystal forms can be examined in the solid phase which are not observed in solution. <sup>15</sup>N CP-MAS NMR provides a new method for determining the crystal structures of nylon-6 samples. The greater sensitivity of nitrogen to its environment in solid-state NMR compared to carbon opens up a broad area for study of crystalline polyamides. 13 refs.

Powell, Douglas G. (Univ of Southern Mississippi, Hattiesburg, MS, USA); Sikes, Allison M.; Mathias, Lon J. *Macromolecules* v 21 n 5 May 1988 p 1533-1536.

**Solutions**

**081097 WATER INSOLUBLE POLYACRYLAMIDE PART VI: DILUTE SOLUTION PROPERTIES OF POLY(N-ACRYLOYL-m-AMINO BENZOIC ACID).** A high molecular weight poly(N-acryloyl-m-aminobenzoic acid) (PMAB) was synthesized in a mixed solvent medium by radical polymerization. The polymer was separated into different fractions by fractional precipitation. All those eight fractions were characterized by viscometry, vapor pressure osmometry and gel permeation chromatography. Mark-Houwink-Kuhn-Sakurada relationships were established for three different solvents at 30°C. Unperturbed dimensions were estimated from the viscosity-molecular weight data using graphical methods based on approximate theories of Stockmayer



and Fixman, and of Kurata, Stockmayer, and Roig, and on a first-order perturbation treatment of the excluded volume effect. The results indicate that the PMAB chain is of intermediate stiffness. (Author abstract) 24 refs.

Desai, Trushar (Sardar Patel Univ, Vidyanagar, India); Shah, Praful; Suthar, Bhikhu. *J Polym Sci Part B v 26 n 3 Mar 1988 p 491-499.*

**081098 STEADY DIFFUSION OF ACIDS IN POLYAMIDE 6.** The diffusion characteristics in the systems polyamide 6-aqueous solutions of nitric, sulfuric and hydrochloric acids have been determined. The thickness of the polymer film was found to influence the diffusion parameters due to the inhomogeneous structure of the polyamide. To evaluate the chemical stability of the PA products a three-layer diffusion model is proposed. (Author abstract) 6 refs.

Kosenko, R.Yu. (USSR Acad of Sciences, USSR); Chalykh, A.Ye.; Iordanskii, A.L.; Zaikov, G.Ye. *Polym Sci USSR v 23 n 12 Dec 1987 p 2776-2781.*

**Spectroscopic Analysis** See Also POLYMERS—Blending; POLYMETHYL METHACRYLATE—Spectroscopic Analysis.

**081099 STRUCTURAL INVESTIGATION OF POLYAMIDE-6 AND POLYAMIDE-6 COMPOSITES USING <sup>13</sup>C CROSS POLARIZATION/MAGIC ANGLE SPINNING NMR.** Natural-abundance <sup>13</sup>C NMR spectra of pure polyamide-6 (PA6) and polyamide-6 composites were measured with CP and MAS techniques. The microcomposites were made by adding glass microspheres, a silane coupling agent, or prefunctionalized glass spheres to PA6. <sup>13</sup>C NMR spectra of these samples show the presence of three components: two crystalline phases and an amorphous component. The chemical shifts of both carbons adjacent to the amide group are sensitive to the PA6 crystal structure; in the dominant  $\alpha$  polymorph, C1 and C5 are 3 ppm downfield from their chemical shift values in the  $\gamma$  polymorph. Both the X-ray diffraction powder patterns and the <sup>13</sup>C NMR spectra show a change in the relative amounts of the two crystalline components when the composites are made. (Author abstract) 20 refs.

Weeding, T.L. (Univ of Nijmegen, Nijmegen, Neth); Veeman, W.S.; Gaur, H. Angad; Huysmans, W.G.B. *Macromolecules v 21 n 7 Jul 1988 p 2028-2032.*

**081100 STUDIUL PRIN SPECTROMETRIE IN IR AL COMPORTARIIL FIBRELOR DIN POLIAMIDA-6 LA TRATAMENT TERMIC.** [Study of the Behavior of Thermally Treated Polyamide-6 Fibers by IR Spectroscopy]. The paper proposes the study by IR spectroscopy of the crystalline characteristics of some polyamide-6-fibers, thermally treated at temperatures in the range between 180 and 220°C. In order to show the influence of the modification of a physical-chemical parameter on a physical-mechanical characteristic (tensile strength) at thermal treatment, measurements of the tensile strength were done and were correlated to the crystalline characteristics. Thus, the temperature of 210°C is defined as a temperature which modifies crystalline structure of the polymer. (Edited author abstract). 12 Refs. In Romanian.

Farsirotu, Vlad (Inst de Cercetare Stiintifica, Bucharest, Rom); Ivan, Gheorghe; Giurgina, Maria; Alexandru, Ioana; Naiman, Marian. *Mater Plast Elastomeri Fibre Sint v 25 n 1 Jan-Mar 1988 p 19-22.*

**Structural Application** See STEEL CASTINGS—Cavitation Corrosion.

**Structure** See Also COPOLYMERS—Spectroscopic Analysis; POLYETHYLENES—Structure; YARN—Structures.

**081101 STRUCTURE AND PROPERTIES OF SEGMENTED POLYAMIDES.** Segmented polyamides composed of polyether and polyamide structural units are industrially very interesting thermoplastic materials of construction, having a broad spectrum of properties. The

principal reason for this broad spectrum is the polyphase structure of the materials and the possibility of influencing this structure by choice of the ratio of oligoether to oligoamide as well as choice of the mean block lengths. In general, three phases can be detected. In addition, at relatively high oligoether contents, a crystalline oligoether phase is at times encountered to a minor degree. (Edited author abstract) 8 refs.

Bornschlegel, E. (Huels AG, Marl, West Ger); Goldbach, G.; Meyer, K. *Prog Colloid Polym Sci v 71 1985 p 119-124.*

**081102 ORIENTATION OF MOLECULAR GROUPS IN CROSS SECTION OF POLYAMIDE-6 FIBER BY INFRARED ATTENUATED TOTAL REFLECTION DICHOISM STUDIES.** The polymer fiber usually possesses typical uniaxial orientation. The molecular chains are symmetrically distributed around the fiber axis. In this work, the orientation of molecular groups in the cross section of polyamide-6 fiber has been measured by using the IR ATR method. The results indicated that the polyamide-6 fiber mainly contains  $\alpha$ -crystalline form. The direction of hydrogen bonds of amide groups is predominately parallel with the surface in the cross section of the fiber. (Author abstract) 10 refs.

Shen, Deyan (Acad Sinica, Beijing, China); Zhang, Shengqing. *Chin J Polym Sci (Engl Ed) v 5 n 2 1987 p 149-155.*

## Swelling

**081103 SWELLING OF AROMATIC POLYAMIDE FIBRES IN ACTIVE MEDIA.** It was of interest to examine the possibility of using the well-known method of fiber swelling in active media to evaluate the structural features of aromatic polyamide fibers, including the state of the surface skin. This article is devoted to an examination of this question. The authors selected two copolymeric amide fibers, differing in the proportion of imidazole and p-phenylene rings (PABI and PABI-S). It is found that for heat-stretched PABI fibers, the swelling picture does not change fundamentally, however, the rate and degree of shrinkage are significantly greater. It is suggested that this is connected with the fact that additional stresses appear in heat-stretching, plus defects, and breaks in continuity which involve mainly the interfibrillar regions and are not propagated into the depths of the fibrils. 1 ref.

Nikitina, O.A.; Avrorova, L.V.; Kudryavtsev, G.I. *Fibre Chem v 19 n 1 Jan-Feb 1987 p 45-46.*

**Synthesis** See Also CRYSTALS, LIQUID; MONOMERS—Stability; POLYMERIZATION—Condensation Reactions.

**081104 SYNTHESIS OF SOME NOVEL POLYAMIDES.** Among various high-temperature organic polymers, the aromatic polyamides have shown excellent thermal stability due to the stiffness of the polymer chain and hydrogen bonding of the amide groups, but had limited solubility in most organic solvents. With this in mind, an attempt has been made to synthesize aromatic polyamides with good thermal stability and better solubility in organic solvents. Their comparative thermal stability, inherent viscosity, solubility, etc., have been determined. (Author abstract) 7 refs.

Shukla, J.S. (Lucknow Univ, Lucknow, India); Sharma, G.K.; Rastogi, Renu. *J Macromol Sci Chem v A24 n 6 1987 p 701-706.*

**081105 NOVEL AROMATIC POLYAMIDES CONTAINING THE 1,4-PHENYLENETRICARBONYL-CHROMIUM STRUCTURE.** The authors have tried to synthesize organic soluble aromatic polyamides by complexing the p-phenylenediamine ring with tricarbonyl-chromium and preliminary results are discussed in this article. The authors believe that this is the first report describing the preparation of chromium complexed aromatic polyamides. For comparison, the corresponding uncomplexed polymers were also prepared. 6 refs.

Jin, Jung-Il (Korea Univ, Seoul, South Korea); Kim, Ranhee. *Polym J v 19 n 8 1987 p 977-980.*

**081106 SYNTHESIS AND PRELIMINARY CHARACTERIZATION OF RUBBER-POLYAMIDE MULTIBLOCK COPOLYMERS.** 'Hard-soft' multiblock copolymers, (AB)<sub>n</sub> type, have been prepared by incorporating rubbery segments into a polyamide 6,10 chain according to a two steps procedure. As soft segments, telechelic polybutadiene or poly(butadiene-co-acrylonitrile) oligomers have been used. The prepared copolymers have been characterized by IR spectroscopy and differential scanning calorimetry. Two different and well defined glass transitions have been observed indicating a phase segregation for the rubbery and polyamide segments. (Author abstract) 5 refs.

Balzano, Emilio (Naples Univ, Naples, Italy); Maglio, Giovanni; Palumbo, Rosario. *Polym Bull (Berlin) v 18 n 3 Sep 1987 p 233-238.*

**081107 HYDROGEN TRANSFER POLYMERIZATION OF ACRYLAMIDE DERIVATIVES BY SODIUM NAPHTHALENE.** The hydrogen transfer polymerization of crotonamide (CAm) and tiglinamide (TAm) catalyzed by sodium naphthalene was studied under various conditions. Pyridine, xylene and chlorobenzene served as good solvents in the polymerization of CAm, whereas, non-polar solvents such as xylene and toluene in the polymerization of TAm. The reaction products were mainly poly-( $\beta$ -amino acids) in all systems. The hydrogen transfer polymerization rates of CAm, TAm, acrylamide (AAm) and methacrylamide (MAAm) in pyridine were in the following order: AAm > CAm > MAAM > TAm > . The polymerization of N-substituted acrylamides and their derivatives were also investigated. (Edited author abstract) 15 refs. In Japanese.

Ikeda, Yoshiyuki (Konan Univ, Kobe, Jpn); Kashiwai, Kazuko; Kura, Yukio; Shimizu, Yoshikazu; Arita, Hidenobu; Kozai, Aki. *Kobunshi Ronbunshu v 44 n 6 1987 p 451-460.*

**081108 PREPARATION OF PROPERTIES OF POLYAMIDES FROM 4-PHENOXY- AND 4-PHENYLTHIO-m-PHENYLENEDIAMINE AND BOTH AROMATIC AND ALIPHATIC DIACIDS.** New soluble aramids having pendant phenoxy and phenylthio groups were prepared in high molecular weights by the polycondensation of aromatic diacids with 4-phenoxy-m-phenylenediamine and 4-phenylthio-m-phenylenediamine, respectively. Glass transition temperatures (T<sub>g</sub>) of these aramids were in the range 195-255°C, where T<sub>g</sub>s of phenoxy pendant aramids were higher than those of phenylthio substituted aramids. These properties were compared with those of the parent aramids derived from m-phenylenediamine and aromatic diacids. Aromatic-aliphatic polyamides were also prepared by the reaction of these three diamines with aliphatic diacids having 4-10 methylene groups and were characterized in detail. (Author abstract) 13 refs.

Kakimoto, Masa-Aki (Tokyo Inst of Technology, Tokyo, Jpn); Yoneyama, Masaru; Imai, Yoshio. *J Polym Sci Part A v 26 n 1 Jan 1988 p 149-157.*

**081109 SYNTHESIS AND PROPERTIES OF POLYAMIDES DERIVED FROM SYSTEMATICALLY HALOGENATED TEREPHTHALIC ACIDS WITH FLUORINE, CHLORINE, OR BROMINE ATOMS.** Aromatic polyamides were prepared from systematically halogenated terephthalic acids with hexamethylene diamine, piperazine, 4,4'-diaminodiphenylether and p-phenylene diamine by interfacial or low temperature solution polycondensation. The halogenated terephthalic acids used have mono-, di-, or tetra-substituted fluorine, chlorine, or bromine atoms on the benzene ring. The nonhalogenated terephthalic acid was also used for the comparison. The effects of halogen substitution on the benzene ring on the synthesis and some properties of polymers were examined. The flame-retardancy estimated by thermogravimetry, self-ignition, and flash-ignition test



increased with increasing halogen content of the polymers. Solubility increased remarkably by halogen substitution. (Edited author abstract) 25 refs.

Nagata, Minoru Jr. (Kyoto Prefectural Univ, Kyoto, Jpn); Tsutsumi, Naoto; Kiyotsukuri, Tsuyoshi. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 235-245.

**081110 NYLON 6,6 COPOLYAMIDES OF BIS(2-CARBOXYETHYL)METHYLPHOSPHINE OXIDE.** Copolyamides of nylon 6,6 with bis(2-carboxyethyl)methylphosphine oxide (CEMPO) were prepared by melt polycondensation of nylon 6,6 salt with CEMPO and hexamethylene diamine. The effect of CEMPO upon melting point, moisture regain, boiling water shrinkage, water wicking, tensile properties, thermal stability, static dissipation, and flammability of nylon 6,6 fibers and fabrics was determined. The fiber properties were greatly affected by the high water absorption and solubility characteristics of the phosphine oxide linkage. The copolyamides were of improved flame resistance compared to nylon 6,6 and were also found to give improved flame resistance in blends of the copolymer with various commercial plastics. (Edited author abstract) 14 refs.

Ridgway, James S. (Monsanto Chemical Co, Pensacola, FL, USA). *J Appl Polym Sci* v 35 n 1 Jan 1988 p 215-227.

**081111 SYNTHESIS AND CHARACTERIZATION OF POLYAMIDES CONTAINING HETEROCYCLIC THIAOXANTHONE UNITS.** Novel polyamides containing heterocyclic thiaoxanthone units were prepared by condensing 2,7-dichloroformylthiaoxanthone-5,5'-dioxide and 2,8-dichloroformylthiaoxanthone-5,5'-dioxide with various aromatic diamines, under low temperature solution polymerization conditions in DMAc. The model diamide, 2,8-ditolylocarbonylthiaoxanthone-5,5'-dioxide was synthesized and characterized by spectroscopic methods. The polyamides were prepared in 70-80% yield and had inherent viscosity in the 0.36-0.73 dL/g range. The polyamides have decomposition temperatures in the 425-510°C range in nitrogen. (Edited author abstract) 12 refs.

Ashok Reddy, T. (Indian Inst of Technology, Madras, India); Srinivasan, M. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 1063-1076.

**081112 DIPHENYL (2,3-DIHYDRO-2-THIOXO-3-BENZOXAZOLYL)PHOSPHONATE: A NEW, REACTIVE ACTIVATING AGENT FOR THE SYNTHESIS OF AMIDES AND POLYAMIDES.** A new activating agent for amide condensations, diphenyl (2,3-dihydro-2-thioxo-3-benzoxazolyl)phosphonate (1), was readily prepared at room temperature by the reaction of 2-benzoxazolethiol (3) with diphenyl phosphorochloridate (2) in the presence of triethylamine (TEA) in benzene. The reaction of carboxylic acids with amines in the presence of 1 was investigated by two procedures, a two-step and a one-step procedure. Both procedures gave corresponding amides in high yields under mild conditions. The direct polycondensation of dicarboxylic acids with diamines by using the activating agent 1 in the presence of TEA proceeded smoothly at room temperature to produce polyamides with inherent viscosities up to 1.2 dL g<sup>-1</sup>. (Edited author abstract) 8 refs.

Ueda, Mitsuru (Yamagata Univ, Yonezawa, Jpn); Kameyama, Atsushi; Hashimoto, Kazuyoshi. *Macromolecules* v 21 n 1 Jan 1988 p 19-24.

**081113 ZIGZAG POLYAMIDES COMPRISING RODLIKE SEGMENTS CONNECTED BY FREELY ROTATING OR STIFF JOINTS.** Six fully aromatic zigzag polyamides were synthesized and characterized. The angles between their rigid rodlike segments are all fixed at 119° and 120°. Three of the polyamides have joints between the rodlike segments with free torsional rotation, and three have rather stiff joints. In solution and the amorphous bulk they all adopt a random coil configuration. The behavior of all polymers in dilute solution is dictated by their equilibrium rigidity, with no significant difference between those having freely rotating joints and those having stiff joints. With increased concentration

effects of kinetic rigidity become more prominent because the slowness or rapidity of torsional motion interferes in varying degrees with the free movement of interpenetrated coils and their segments. Two groups of radii of gyration were measured in dilute solution for all polymers. (Edited author abstract) 40 refs.

Aharoni, Shaul M. (Allied-Signal Corp, Morristown, NJ, USA). *Macromolecules* v 21 n 1 Jan 1988 p 185-194.

**081114 POLYAMIDES BASED ON DDT DERIVATIVES.** The authors used two DDT derivatives to synthesize soluble and flame-resistant polyamides. The monomers were obtained by sequential nitration, dehydrochlorination and reduction of DDT derivatives. The polyamides were synthesized by low-temperature polycondensation of these monomers, with dichloroanhydrides of isophthalic and terephthalic acids. Their oxygen index was equal to 55.6-59.9 which proves the high flame resistance of the chlorine containing polyamides. The solubility of the synthesized products in organic solvents was several times higher than that of regular polyamides. In Russian. 13 refs.

Korshak, V.V.; Makharashvili, N.Z.; Kazakova, G.V.; Rusanov, A.L.; Margalitadze, Yu.N. *Plast Massy* n 11 Nov 1987 p 18-19.

**081115 SYNTHESIS OF AROMATIC POLYAMIDES FROM N,N'-BIS(TRIMETHYLSILYL)-SUBSTITUTED AROMATIC DIAMINES AND AROMATIC DIACID CHLORIDES.** A novel and facile method for the synthesis of high molecular weight aramids has been developed by the use of N,N'-bis(trimethylsilyl)-substituted aromatic diamines which were found to be more reactive toward aromatic diacid chlorides than the parent unsubstituted diamines. The low-temperature solution polycondensation of the N-silylated aromatic diamines with aromatic diacid chlorides afforded readily a series of aramids having inherent viscosities of 2.4-7.4 dL g<sup>-1</sup> with the elimination of trimethylsilyl chloride under neutral and milder reaction conditions, compared with the conventional diamine-diacid chloride method. (Author abstract) 15 refs.

Oishi, Yoshiyuki (Tokyo Inst of Technology, Tokyo, Jpn); Kakimoto, Masa-aki; Imai, Yoshio. *Macromolecules* v 21 n 3 Mar 1988 p 547-550.

**081116 NOVEL PHENYL-SUBSTITUTED AROMATIC POLYAMIDES.** Based on previous experimental work the authors assumed that a phenyl substituent will be effective in increasing the solubility of rigid-rod aromatic polyamides, and two types of aromatic polyamides were prepared which will be described briefly. It is shown that the phenyl substituent not only makes the aromatic polyamides more soluble, it also depresses the melting temperature. To our knowledge, this is the first report which discloses melting transitions for wholly aromatic para-linked polyamides without substitution on nitrogen. 15 refs.

Jadhav, J.Y. (Duke Univ, Durham, NC, USA); Krigbaum, W.R.; Preston, J. *Macromolecules* v 21 n 2 Feb 1988 p 538-540.

**081117 ACYLLACTAM-TYPE GROWABLE END GROUP FORMED IN THE ANIONIC POLYMERIZATION OF A BICYCLIC OXALACTAM. THE ISOLATION OF THE POLYAMIDE AND ITS USE AS AN ACTIVATOR IN THE POLYMERIZATION OF 2-PYRROLIDONE.** A bicyclic oxalactam, 8-oxa-6-azabicyclo[3.2.1]octan-7-one was anionically polymerized in dimethyl sulfoxide at room temperature and the resulting hydrophilic polyamide having an acyllactam-type growable chain end was isolated from the polymerization system. The reactive end group was found to be easily converted to other functional groups by the hydrolysis or aminolysis by suppressing the simultaneous decomposition of the polyamide chain. The terminal acyllactam group in the polyamide, which was used as an activator in the anionic polymerization of 2-pyrrolidone, was quantitatively consumed and all of the macromolecular activator could be incorporated into the resulting

copolymer. The thermal behavior and crystallization of the AB-type block copolymers composed of the hydrophilic polyamide and nylon-4 segments were influenced by the characteristics of the hydrophilic polyamide segment. (Author abstract) 21 refs.

Hashimoto, Kazuhiko (Nagoya Univ, Nagoya, Jpn); Sumitomo, Hiroshi; Shinoda, Housei. *Polym J* v 20 n 4 1988 p 321-331.

**081118 CYCLOPOLYMERIZATION OF N-ALKYL-N-ALLYLACRYLAMIDES.** Free-radical polymerization of N-alkyl-N-allylacrylamides, where N-alkyl substituents were N-methyl, N-butyl, and N-octyl, was carried out with  $\alpha,\alpha'$ -azobisisobutyronitrile (AIBN) at 60°C. Soluble polymers were prepared when the extent of conversion was low or even high in the polymerization with low monomer concentration. Residual carbon-carbon double bonds in the polymers were determined by both spectroscopic and titrimetric methods to be only allyl groups. The degree of cyclization increased either with decrease in the monomer concentration or increase in the chain length of N-alkyl groups. A suggested mechanism of cyclopolymerization is discussed. Copolymerization of mono-olefins having each counterpart of dienes was also carried out to give the copolymers containing mainly the acryloyl monomers. (Edited author abstract) 12 refs.

Fukuda, Wakichi (Yokohama Natl Univ, Yokohama, Jpn); Takahashi, Atsushi; Takenaka, Yuji; Kakiuchi, Hiroshi. *Polym J* v 20 n 4 1988 p 337-344.

**081119 NOVEL SYNTHESIS OF AROMATIC POLYAMIDES BY PALLADIUM-CATALYZED POLYCONDENSATION OF AROMATIC DIBROMIDES, AROMATIC DIAAMINES, AND CARBON MONOXIDE.** A novel and facile method for the synthesis of aramids has been developed by the carbonylation polymerization of aromatic dibromides and aromatic diamines with carbon monoxide in the presence of a palladium catalyst. A variety of aramids having inherent viscosities between 0.2 and 0.8 dL g<sup>-1</sup> were prepared readily under ordinary pressure. The effects of reaction variables such as kinds and amounts of catalyst and acid acceptor, reaction medium, and reaction temperature and time on the polycondensation were discussed in detail. (Author abstract) 11 Refs.

Yoneyama, Masaru (Tokyo Inst of Technology, Tokyo, Jpn); Kakimoto, Masa-aki; Imai, Yoshio. *Macromolecules* v 21 n 7 Jul 1988 p 1908-1911.

**081120 POLYAMIDE SYNTHESIS BY DIRECT POLYCONDENSATION WITH PHENYLPHOSPHONIC DICHLORIDE IN PYRIDINE.** The direct polycondensation of isophthalic acid (IPA) and aromatic diamines with a new phosphorus compound, phenylphosphonic dichloride (PPDC), was studied. PPDC could actually react with nearly a two molar amount of carboxyl groups, but more than 75 mol percent PPDC with respect to the carboxyl groups of IPA were satisfactorily used in the polycondensation. The initial reaction of IPA with PPDC in pyridine at room temperature and then at 120°C was needed to complete the activation, and the subsequent aminolysis at 120°C for 3 h was most effective. The polyamides of high inherent viscosity were obtained even from weakly basic aromatic diamines, and their values were more than those obtained by the conventional method. (Edited author abstract) 9 Refs.

Kigashi, Fukuji (Tokyo Univ of Agriculture & Technology, Koganei, Jpn); Lee, Yen-Nehg; Kobayashi, Akira. *J Polym Sci Part A* v 26 n 8 Aug 5 1988 p 2077-2083.

**081121 SYNTHESIS OF POLYAMIDES BASED ON 1,8-DIAMINO-P-METHANE.** The synthesis of polymeric materials from relatively inexpensive renewable resources has assumed increased importance in recent years. In this vein it would seem, from the standpoint of cost and availability, that limonene and its derivatives should be among the most promising of raw materials for resin and/or polymer synthesis. However, a survey of the



literature revealed that while some use is made of limonene itself, little use is made of its derivatives as starting materials for resin or polymer synthesis. The authors investigated the synthesis of polymers from a readily available limonene derivative, 1,8-diamino-p-menthane (DAM). The present communication concerns the synthesis of polyamides from this diamine and various acid chlorides. 9 Refs.

Trumbo, D.L. (Glidden Co, Strongsville, OH, USA). *J Polym Sci Part C* v 26 n 9 Aug 20 1988 p 405-408.

**081122 SYNTHESIS OF POLYAMIDES BY DIRECT POLYCONDENSATION WITH PROPYLPHOSPHONIC ANHYDRIDE AS AN ACTIVATING AGENT.** A 50 wt% solution of propylphosphonic anhydride in NMP as an activating agent was used for the synthesis of amides from carboxylic acids and amines. The direct polycondensation of dicarboxylic acids with aromatic diamines using the activating agent in the presence of pyridine proceeded at 100°C to produce polyamides with inherent viscosities up to 1.6 dl g<sup>-1</sup>. Furthermore, the activating agent was used for the chemoselective polyamidation; that is, polyamides from dicarboxylic acids and diamines containing various functional groups were prepared without special protection of the acylation-sensitive groups. (Author abstract). 5 Refs.

Ueda, Mitsuru (Yamagata Univ, Yonezawa, Jpn); Honma, Tsukasa. *Polym J* v 20 n 6 1988 p 477-483.

## Thermal Properties

**081123 CHANGES OF THE THERMAL CHARACTERISTICS OF POLYAMIDES DURING FILLING WITH METAL SILICATES BY INTERPHASE POLYCONDENSATION.** The authors studied the character of variation of the softening point  $T_{\text{soft}}$  of polyhexamethylenedipamide (PHMAA) and of the melting and decomposition points ( $T_m$  and  $T_{\text{dec}}$ ) of polyhexamethylenesbacamide (PHMSA) filled with copper and magnesium silicates by interphase polycondensation. It is shown that when polyamides are filled with metal silicates by the interphase polycondensation method polyamides of high molecular weight are formed at filler contents below 1.5-2.0 mass %, while at filler contents above 1.5%-2.0 mass % the molecular weight of the resultant polyamide falls sharply. It is also shown that during production of polyamides filled with silicates by the interphase polycondensation method their thermal characteristics may be raised or lowered by variation of the filler content. 5 refs.

Syrkova, O.V.; Kabanov, D.A.; Gavrilina, I.P.; Tsvetkov, V.K. *J Appl Chem USSR* v 59 n 7 pt 2 Jul 1986 p 1528-1530.

## Thermodynamics

**081124 THERMODYNAMICS OF AROMATIC POLYAMIDES, SYNTHESIS PROCESSES AND STARTING SUBSTANCES REVIEW.** The changes in the enthalpy, entropy and Gibbs function have been determined and the equilibrium constants calculated for 18 reactions of polycondensation of isomeric phenylene diamines with iso and terephthalic acids and their derivatives at 101.325 kPa and 50-400 K. The influence of the structure of the diamines molecules and also the nature of the substituent in the molecule of electrophilic reagent on the thermodynamic functions of the reactions of polyamidation has been characterized. Series of standard changes in the Gibbs function are compiled and it is shown that combination of the starting substances leads to wide variation in the equilibrium constant of the polyamidization reactions. (Author abstract). 16 Refs.

Karyakin, N.V. (Lobachevskii State Univ, Gorkii, USSR); Rabinovich, I.B. *Polym Sci USSR* v 29 n 4 1987 p 747-758.

## Viscosity

**081125 ON THE VISCOSITY PROPERTIES AND THE PHASE STABILITY OF ALIPHATIC POLYAMIDES IN VARIOUS SOLVENTS.** The viscosity

properties of aliphatic polyamides (polycapraamide and polydodecanamide) in various solvents have been investigated. Viscosity vs. concentration curves have been plotted for each of the polyamide-solvent systems. On the basis of the temperature dependence of viscosity for solutions of various concentrations, and using the interferometric data the points of phase transitions have been determined, and the phase diagrams constructed. (Author abstract) 9 refs.

Malkin, A.Ya. (Plastmassy Scientific & Industrial Assoc, USSR); Kulichikhin, S.G.; Markovich, R.Z. *Polym Sci USSR* v 28 n 9 1986 p 2177-2182.

## Welding

**081126 INJECTION WELDING OF POLYAMIDES.** In this paper, the authors discuss welding of polyamides inside the injection mold. This process is called injection welding. The process of injection welding makes it possible to bond polyamides with quite different characteristics together without adhesive. In this way, one can achieve economic as well as constructional advantages. Two different methods are discussed. The weld line strengths of injection-welded parts depend on material and process conditions. (Edited author abstract)

Maskus, Peter (EMS-CHEMIE AG, Domat/Ems, Switz); Gaehwiler, H.U. *Adv Polym Technol* v 7 n 4 Winter 1987 p 411-418.

## POLYBUTADIENES See Also LACQUER AND LACQUERING; POLYURETHANES—Structure.

**081127 PHOTOELASTIC PROPERTIES OF POLYBUTADIENE RUBBERS.** Two polybutadiene polymers were used in this investigation, one with 98% cis-1,4 units and the other with an approximately equibinary mixture of cis and trans units. A range of cross-linking densities were obtained using dicumyl peroxide as a vulcanizing agent. The experiments involved measurement of both the elastic force and birefringence (using the changes in length at constant temperature) over the temperature range -10-20°C. The force-extension curves for both rubbers were similar in form. Both showed a strong upward deviation from the Gaussian statistical theory at high extensions, especially at lower temperature in which the extension to break increases. Both polymers showed the stress-optical coefficient to be substantially independent of the degree of cross-linking. (Edited author abstract) 26 refs.

Mohsin, M.A. (Univ of Manchester Inst of Science & Technology, Manchester, Engl); Treloar, L.R.G. *J Polym Sci Part B* v 25 n 10 Oct 1987 p 2113-2125.

**081128 NOVEL DETERMINATION OF 1,4-POLYBUTADIENE ISOMERS BY USE OF J-COUPLED CONSTANT BETWEEN TWO OLEFINIC PROTONS.** In this paper, the authors attempted to observe the <sup>13</sup>C satellite signals of the olefinic protons of trans- and cis-1,4-polybutadienes in order to obtain the coupling constant between methine protons. They distinguished between cis- and trans-isomers on the basis of observed coupling constants. 2 refs.

Katoh, Tohru (Kao Corp, Minato, Jpn); Ikura, Mituhiko; Hikichi, Kunio. *Polym J* v 20 n 2 1988 p 185-187.

## Adhesion

**081129 CATHODIC DELAMINATION OF POLYBUTADIENE FROM STEEL.** The variables influencing the rate of the cathodic delamination of polybutadiene from steel in alkali halide solutions are discussed. The bond at the interface arises from the reaction of carboxyl groups in the polybutadiene with hydroxyl groups on the surface of the iron oxide at the interface. It is this bond that is broken by hydroxyl ions generated by the oxygen reduction reaction beneath the coating. The rate controlling step is the rate of charge transfer through the coating to support the oxygen reduction reaction. (Author abstract) 32 refs.

Leidheiser, Henry Jr. (Lehigh Univ, Bethlehem, PA,

USA). *J Adhes Sci Technol* v 1 n 1 1987 p 79-98.

## Adsorption

**081130 ADSORPTION OF POLYBUTADIENES WITH POLAR GROUP TERMINATIONS ON THE SOLID SURFACE. 1. INFRARED STUDY AT THE SILICA SURFACE.** Adsorption of polybutadiene terminated with a very polar functional group (T-PBR) on a silica surface from carbon tetrachloride solution has been investigated by using IR spectroscopy and compared with normal polybutadienes (PBR). Carbon tetrachloride is a good solvent for polybutadiene. The adsorbed amount,  $A$ , the surface coverage  $\theta$  of the silanol groups, and the bound fraction of a polymer chain  $p$  were observed. T-PBR has an  $A$  and  $\theta$  twice as large as those for PBR, while the  $p$  value was approximately the same for both polymers. (Edited author abstract) 24 refs.

Kawaguchi, Masami (Mie Univ, Tsu, Jpn); Kawarabayashi, Minoru; Nagata, Nobuo; Kato, Tadayu; Yoshioka, Akira; Takahashi, Akira. *Macromolecules* v 21 n 4 Apr 1988 p 1059-1062.

## Aging

**081131 INFLUENCE OF AGEING ON STRENGTH PROPERTIES AND MORPHOLOGY OF FRACTURE SURFACE OF HYDROXY TERMINATED POLYBUTADIENE RUBBER.** Vulcanizates of hydroxy-terminated polybutadiene (HPB) rubber having a range of crosslinking density have been prepared by varying the amount of curing agent, toluene-di-isocyanate (TDI). The effect of oxidative aging of these rubbers on the tensile and tear strength has been investigated. Kinetic of aging of the samples are also reported. The tensile strength, tear strength, modulus and hardness increase with the increase in the amount of TDI i.e. crosslinks. In general, there is an initial drop in the tensile strength and tear strength of these rubbers with time or temperature of aging. There is a stiffening effect afterwards, particularly for HPB rubbers cured with a lower amount of TDI. (Edited author abstract) 15 refs.

Deuri, A. Saha (Indian Inst of Technology, Kharagpur, India); Bhownick, Anil K. *Mater Chem Phys* v 18 n 1-2 Oct 1987 p 35-48.

## Applications See EXPLOSIVES—Efficiency.

## Blending See POLYSTYRENES—Blending.

## Crosslinking

**081132 VISCOELASTIC DISSIPATION AND THE TEAR ENERGY OF URETHANE-CROSS-LINKED POLYBUTADIENE ELASTOMERS.** A series of urethane-cross-linked polybutadiene elastomers of varying cross-linking levels have been investigated to determine the relationship between viscoelastic dissipation and tear (or fracture) resistance. Several points of correspondence were identified between these two properties. The first was an inverse proportionality in the terminal region between cross-link density and torsional creep behavior as well as tear energy data, with the looser networks being more dissipative and displaying the greatest resistance to tear. Second, master curves of both creep compliance and tear energy exhibited an intermediate plateau. This plateau measured approximately 13 decades in time. The temperature dependences were the same for the tear energy and creep compliance. In the terminal or long time region, the dynamic loss modulus  $G''$  could be linearly correlated with the tear energy. (Author abstract) 36 refs.

Plazek, D.J. (Univ of Pittsburgh, Pittsburgh, PA, USA); Gu, G.-F.; Stacer, R.G.; Su, L.-J.; Von Meerwall, E.D.; Kelley, F.N. *J Mater Sci* v 23 n 4 Apr 1988 p 1289-1300.

## Crystallization

**081133 CHAIN ENTANGLEMENT AND CRYSTALLIZATION OF cis-1,4-POLYBUTADIENE.** The morphological structure and mechanism of nucleation and growth of Ln-PB and Ni-PB with different molecular



weight were investigated by transmission electron microscopy. The crystallization of low molecular weight fraction is primarily from predetermined nuclei, crystallization for the high molecular weight fraction is primarily from sporadic nuclei. Two types of morphology of spherulite with different lamellar entanglement have been observed. The entanglement of higher molecular weight fractions are found to be of significance in the morphology and rate of crystallization of polymer. (Edited author abstract) 3 refs.

Zhou, Enle (Acad Sinica, Changchun, China); Jin, Guiping; Zhang, Yenshou. *Chin J Polym Sci (Engl Ed)* v 4 n 3 Jan 1987 p 207-213.

**081134 STUDY OF LOW-TEMPERATURE CRYSTALLIZATION BEHAVIOR: THE CIS-1,4 POLYBUTADIENE PREPARED WITH RARE-EARTH CATALYST SYSTEM.** The effects of molecular weight and temperature on crystallization processes at low temperature for cis-1,4 polybutadiene prepared with rare-earth catalyst (Ln-PB) have been studied by WAXD method. In the range of molecular weight from  $\langle M_n \rangle = 2.13 \times 10^5$  to  $46.8 \times 10^5$ , there are a maximum of crystallization rate at  $\langle M_n \rangle \approx 29 \times 10^5$  and a minimum at  $\langle M_n \rangle \approx 8 \times 10^5$ . The temperature related to maximum crystallization rate,  $T_{c, \max}$  is observed to be between  $-60^\circ\text{C}$  and  $-70^\circ\text{C}$ . The degree of equilibrium crystallinity of Ln-PB is independent of molecular weight at  $\langle M_n \rangle$  greater than  $10^6$ , also the linearity is shown between the correspondent temperature, degree of equilibrium crystallinity and molecular weight. (Edited author abstract) 8 refs.

Zhang, Hongfang (Acad Sinica, Changchun, China); Mo, Zhishen. *Chin J Polym Sci (Engl Ed)* v 4 n 3 Jan 1987 p 241-247.

**081135 NMR APPROACH TO THE KINETICS OF POLYMER CRYSTALLIZATION. 1. CIS-1,4-POLYBUTADIENE.** The isothermal crystallization kinetics of cis-1,4-polybutadiene (PB) in bulk, was studied over the temperature range 193 to 235 K, using  $^1\text{H}$  pulsed high-resolution FT-NMR. Analysis of the spectral line area and width, corresponding to the resonance of protons bonded to noncrystalline chain segments, yields two major results: (i) The line area variations are associated with the overall progression of crystallization in the sample, which is shown to obey an Avrami law. (ii) The line-width is assumed to be closely related to a statistical network with the average mesh size determined by a random distribution of crystallites. Finally, concomitant spin-lattice relaxation time measurements show an increase of this parameter which parallels the development of the crystalline fraction. (Edited author abstract) 39 refs.

Feio, G. (CNRS, St. Martin d'Heres, Fr); Cohen-Addad, J.P. *J Polym Sci Part B* v 26 n 2 Feb 1988 p 389-412.

**081136 STIRRING INDUCED SOLUTION CRYSTALLIZATION OF CIS-1, 4-POLYBUTADIENE.** The stirring induced solution crystallization behavior of cis-1, 4-polybutadiene polymerized with rare-earth catalyst (Ln-PB) has been studied by electron microscope, DSC and GPC. It has been found that when 0.5% Ln-PB toluene solution was stirred at a temperature within the range of  $-15^\circ$  to  $-79^\circ\text{C}$  with a speed of 180 rpm, a kind of white swollen thread-like substance wound around the stirrer was formed. It was seen under electron microscope that this swollen thread-like substance consisted of fibrillar crystals of Ln-PB parallel to each other. The amount of Ln-PB wound around the stirrer increased with the decrease in crystallization temperature. (Edited author abstract) 6 refs.

Xu, Yang (Changchun Inst of Applied Chemistry, Changchun, China); Zhou, Enle; Yu, Fusheng; Qian, Baogong. *Chin J Polym Sci (Engl Ed)* v 6 n 2 1988 p 152-158.

## Dielectric Properties

**081137 DIELECTRIC PROPERTIES OF 1,2-POLYBUTADIENES.** The dielectric permittivity and loss tangent of 1,2-polybutadienes with different chain structures were determined as a function of temperature from  $-180^\circ\text{C}$  to  $100^\circ\text{C}$  at different frequencies, and the

frequency and structure dependence of the dielectric properties of 1,2-polybutadienes have been investigated. It is found that a maximum of the permittivity occurs in the glass-transition region. The width of the glass-transition peak increases with increasing frequency while its height has little change. With a rise in the content of 1,2-units, the permittivity decreases and the height of the glass-transition peak grows slightly. A maximum of the width of the glass transition peak appears when the content of 1, 2-units is about 45%. Both the permittivity and dielectric loss drop as of the content of syndiotactic 1,2-units increases. (Author abstract) 10 refs.

Ni, Shaoru (Acad Sinica, Changchun, China); Yu, Fusheng; Shen, Lianfang; Qian, Baogong. *Chin J Polym Sci (Engl Ed)* v 5 n 2 1987 p 120-124.

**081138 FREQUENCY DEPENDENCE OF THE DIELECTRIC RELAXATION OF 1,2-POLYBUTADIENES.** The dielectric loss factor and permittivity of a series of 1,2-polybutadienes with different contents of 1,2-units and different contents of syndiotactic 1,2-units were determined over a frequency range from 30Hz to 100KHz at different temperatures. The WLF equation was evaluated for various samples with  $T_g$  at 100KHz as a reference temperature and the master curves of various samples have been constructed, which are in accordance with those calculated by Havriliak-Negami equation. The frequency dependence of the dielectric relaxation of 1,2-polybutadienes was investigated over a frequency range from  $10^0$  Hz to  $10^{12}$  Hz in terms of the experimental data and the master curves. (Author abstract) 7 refs.

Ni, Shaoru (Acad Sinica, Changchun, China); Yu, Fusheng; Shen, Lianfang; Qian, Baogong. *Chin J Polym Sci (Engl Ed)* v 5 n 1 1987 p 34-39.

## Diffusion

**081139 MUTUAL DIFFUSION IN BLENDS OF LONG AND SHORT ENTANGLED POLYMER CHAINS.** We have used infrared microdensitometry to study the mutual diffusion across an originally sharp interface between two saturated polybutadienes of degrees of polymerization  $N_A$  and  $N_B$  ( $N_B$  the entanglement length) for three different ratios  $N_A/N_B$ . The extent of diffusion broadening suggests that the mutual diffusion coefficient is controlled by the mobility of the faster moving (shorter) polymer chains, indicating that convective flow may be important in such mixing phenomena. (Author abstract) 30 refs.

Jordan, Elizabeth A. (Cavendish Lab, Cambridge, Engl); Ball, Robin C.; Donald, Athene M.; Fetters, Lewis J.; Jones, Richard A.L.; Klein, Jacob. *Macromolecules* v 21 n 1 Jan 1988 p 235-239.

Etching See POLYMERS—Etching.

## Failure

**081140 SEM STUDIES ON THE TEAR FAILURE OF FILLED THERMOPLASTIC 1,2 POLYBUTADIENE AND BLENDS OF 1,2 POLYBUTADIENE AND NATURAL RUBBER.** Scanning electron microscopic (SEM) examination of failure surfaces in various failure modes has been shown to be a valuable tool in understanding the mechanism of failure in rubber vulcanisates, blends and composites and also in studying the toughening mechanism of plastics and epoxies with the help of elastomers. However, such reports dealing with fracture mechanism in TPEs are quite few. This paper reports on the results of the SEM observations on the tear failure of 1,2 PBD and 1,2 PBD-NR blends containing clay and carbon black as fillers. Experiments show that clay reduces the tear strength of 1,2 PBD whereas carbon black increases it by 10%. Scanning electron microscopic investigations have shown that the tear fracture surfaces of unfilled and filled 1,2 PBD are entirely different. The effect of clay on the tear strength of 1,2 PBD-NR blends becomes more pronounced as the NR content in the blend increases. 18 refs.

Bhagawan, S.S. *Kautsch Gummi Kunstst* v 40 n 10 Oct

1987 p 927-930.

High Temperature Properties See THERMOPLASTIC ELASTOMERS—Fillers.

## Latex

**081141 SYNTHESIS OF A POLYDISPERSED POLYBUTADIENE LATEX. DIRECT METHOD FOR HIGH-SOLID POLYBUTADIENE EMULSION PREPARATION.** A high solid, polydispersed polybutadiene latex of large particle size was synthesized. The reaction was carried out at a high monomer/water ratio and a small quantity of emulsifier (soap). Additions of a colloidal active material with a high molecular weight and an electrolyte were effective in limiting the surface film of growing polymer particles governed by water structure or ionic environment and, also, in promoting the agglomeration of particles. A mixture of sodium alginate and magnesium sulfate was particularly effective, and provided a method with excellent reproducibility. (Author abstract) 24 refs.

Araki, Yoshihiko (Nippon Oil Co, Yokohama, Jpn). *Polym J* v 19 n 7 1987 p 863-871.

## Microstructure

**081142 INTERRELATION BETWEEN THE MOLECULAR MASS AND MICROSTRUCTURE OF POLYBUTADIENE OBTAINED WITH CIS-REGULATING SYSTEMS.** It has been established that the concentration of 1,4-cis-links and the molecular mass of polybutadiene obtained with cis-regulating systems containing nickel change in a parallel fashion. The hypothesis is expressed and experimentally confirmed that the decisive role in regulating both the molecular mass and also the structure of the polybutadiene is taken by an intermediate  $\sigma$ -organometallic derivative in which there is a  $\beta_2 - \text{H}$  bond existing in a  $\sigma$ ,  $\pi$ -hyperconjugation interaction with the transition metal. (Author abstract) 29 refs.

Azizov, A.G. (AzSSR Acad of Sciences, USSR); Nasirov, F.A.; Aliyev, V.S. *Polym Sci USSR* v 29 n 2 Feb 1987 p 434-439.

Modification See COPOLYMERS—Synthesis.

## Molecular Weight

**081143 BIMODAL MOLECULAR WEIGHT DISTRIBUTION OF CIS-POLYBUTADIENE POLYMERIZED WITH LANTHANIDE COMPLEX CATALYSTS.** The variation of the molecular weight and molecular weight distribution of cis-polybutadiene in the course of polymerization catalyzed by lanthanide complex composed of triisobutyl aluminum or diisobutyl aluminum hydride was investigated by osmometry, viscometry and size exclusion chromatography. By analyzing the experimental data, the reasons for the appearance of bimodal molecular weight distribution were elucidated and the possible mechanisms of polymerization were discussed. (Author abstract) 9 refs.

Cheng, Rongshi (Nanjing Univ, Nanjing, China); Jiang, Liansheng; Hu, Huizhen. *Chin J Polym Sci (Engl Ed)* v 5 n 2 1987 p 101-108.

## Performance

**081144 HIGH VINYL POLYBUTADIENE DYNAMIC PROPERTIES.** In this work, the authors show how the systematic use of the analytical expression of the superposition principle (WLF equation) allows them the evaluation of the viscoelastic behaviour performance as a function of frequency. So a more precise correlation between performance and chemical structure is obtained and some fundamental physical parameters have been evaluated. Some guidelines towards improved chemical structures are indicated. (Author abstract) 12 refs.

Gargani, L.; De Ponti, P.; Bruzzone, M. *Kautsch Gummi Kunstst* v 40 n 10 Oct 1987 p 935-937.



## Physical Properties

**081145 LOCAL DYNAMICS OF POLY(CIS-1,4-BUTADIENE) STUDIED BY COUPLED SPIN RELAXATION.** The dynamics of an entangled linear polymer, poly(cis-1,4-butadiene), are studied by the coupled spin relaxation of a methylene group ( $^{13}\text{CH}_2$ ). Relaxation experiments are performed on the solid, using magic-angle spinning, and in solution with  $\text{CD}_2\text{Cl}_2$  at concentrations of 10-80 mol% monomer. By extrapolating the data taken between 10 and 40 mol% monomer to infinite dilution, four unique spectral densities are measured for the methylene. These can be expressed in terms of correlation times describing the reorientation of d-orbital-like functions oriented along a Cartesian axis system. (Edited author abstract) 39 refs.

Fuson, Michael M. (Wabash Coll, Crawfordsville, IN, USA); Grant, David M. *Macromolecules* v 21 n 4 Apr 1988 p 944-949.

## Pyrolysis See Also PROPELLANTS—Materials.

**081146 EFFECT OF CARBON BLACK FILLER ON THE PYROLYSIS BEHAVIOUR OF VULCANIZED CIS-POLYBUTADIENE.** The pyrolysis-gas chromatographic analysis at 770°C of two series of vulcanized products of a standard mixture of polybutadiene Buna cis 132 as the rubber component and sulphur as the cross-linking agent, in the presence and absence of a carbon black as a filler, has been studied. In both series the density of cross-linking was varied by changing the vulcanization time. Definite correlations were found between the ratio of peak areas toluene/4-vinylcyclohexene and the degree of swelling, and the shear modulus. Curie-point pyrolysis of a third series of vulcanized products in which the carbon black content was varied between 0 and 40%, with the vulcanization time being constant (70 min), showed a distinct increase of the same ratio of peak with increasing content of carbon black and increasing mechanical strength. (Edited author abstract) 55 refs.

Haeusler, K.G. (Technical Univ 'Carl Schorlemmer', Leuna-Merseburg, East Ger); Stanford, J.L.; Stepto, R.F.T. *J Anal Appl Pyrolysis* v 13 n 4 Jun 1988 p 287-303.

## Radiation Effects

**081147 MECHANICAL PROPERTIES AND FAILURE SURFACES OF GAMMA-RAY IRRADIATED SYSTEMS BASED ON THERMOPLASTIC 1,2-POLYBUTADIENE.** The effect of  $^{60}\text{Co}$  gamma-radiation on the mechanical properties of clay filled and unfilled 1,2 polybutadiene (1,2 PBD) and 1,2 PBD-natural rubber (NR) blends has been investigated. In the case of blends the effects on blend ratio and filler have been studied with reference to absorbed radiation dose varying from 0.1 to 100 Mrad at room temperature. Radiation was found to transform the flexible samples to brittle and rigid materials especially at high dose levels. The stress-strain behavior, tensile strength, elongation, tension set and crosslink density were found to be markedly affected at dose levels of 10 Mrad and above. (Author abstract) 37 refs.

Bhagawan, S.S. (Indian Inst of Technology, Kharagpur, India); Kuriakose, B.; De, S.K. *Radiat Phys Chem* v 30 n 2 1987 p 95-104.

## Rheology

**081148 RHEOLOGICAL CHARACTERIZATION OF PROCESSABILITY OF UNVULCANIZED POLYBUTADIENE.** Rheological investigation on a series of unvulcanized polybutadiene elastomers of different processability has been carried out by means of a capillary extrusion rheometer. It is found that the processability of unvulcanized polybutadiene can be correlated with the occurrence of unsteady flow and the wall stress, dependence of the dimensionless number characterizing the entrance elongational elasticity which has been found to be sensitive to the branching structure and the molecular weight distribution of the samples. Interpreta-

tions based on the structural data of unvulcanized polybutadiene were discussed. (Author abstract) 14 refs.

Du, Xue (Acad Sinica, Beijing, China); Xu, Yuanze; Qian, Renyuan. *Chin J Polym Sci (Engl Ed)* v 5 n 1 1987 p 81-86.

## Separation See POLYSTYRENES—Separation.

**Solutions** See BLOCK COPOLYMERS—Solutions; POLYSTYRENES.

## Spectroscopic Analysis

**081149 CARBON-13 NMR STUDY ON MOLECULAR MOTION OF 1,2-POLYBUTADIENE - TEMPERATURE DEPENDENCE OF MOLECULAR MOTION.** Proton-decoupled,  $^{13}\text{C}$  FT-NMR (operating at 50.3 MHz) is used to determine spin-lattice relaxation time ( $T_1$ ), nuclear Overhauser enhancement (NOE), line-width and chemical shift of 1,2-polybutadiene as a function of temperature in  $\text{CDCl}_3$  solution and the temperature dependence of molecular motion of 1,2-polybutadiene has been investigated with these NMR relaxation parameters. It is found that jumps of NOE and linewidth vs. temperature appear between -10°C and -30°C. The minimum of  $nT_1$  vs. temperature for all carbons occur at about -45°C. (Author abstract) 7 refs.

Ni, Shaoru (Acad Sinica, Changchun, China); Shen, Lianfang; Yu, Fusheng; Qian, Baogong. *Chin J Polym Sci (Engl Ed)* v 4 n 3 Jan 1987 p 235-240.

**081150 HIGH-TEMPERATURE STRUCTURAL TRANSITION OF POLYBUTADIENES.** In cis-1,4-polybutadiene IR spectroscopy, differential scanning calorimetry and the diffusion method have revealed a structural transition in the region of 55°C due to the breakdown of ordered regions. The transition found belongs to the category of liquid-liquid type transitions. The introduction into the macromolecular chains of trans-1,4- and/or 1,2-butadiene units leads to the appearance of new structural transitions. The liquid-liquid transition for such polybutadienes is in the region T approximately  $T_g \approx 150^\circ\text{C}$  where  $T_g$  is the glass transition point of the least flexible chain homopolymer the units of which are introduced into the macrochains of cis-1,4-polybutadiene. (Author abstract) 19 refs.

Sokolova, L.V. (Lomonosov Inst of Fine Chemical Technology, Moscow, USSR); Chesnokova, O.A.; Shershnev, V.A. *Polym Sci USSR* v 29 n 1 Jan 1988 p 27-34.

## Stresses

**081151 RELAXATION TRANSITIONS IN POLYBUTADIENE AND IN POLYBUTADIENE-METHYLSTYRENES.** The relaxation transitions in polybutadiene and in its copolymers with methylstyrene were studied by the methods of mechanical relaxation in the range -150+350°. In this range, up to seventeen transitions of various nature were observed, most of them connected with the butadiene component in the copolymers. The glass transition process and some copolymer-specific relaxation processes depend on the presence of the methylstyrene component in the macromolecules. (Author abstract). 15 Refs.

Bartenev, G.M. (USSR Acad of Sciences, Moscow, USSR); Tulinova, V.V. *Polym Sci USSR* v 29 n 5 1987 p 1171-1177.

## Structure

**081152 PREPARATION OF ASYMMETRIC THREE-ARM POLYBUTADIENE AND POLYSTYRENE STARS.** The synthesis of three-armed polybutadiene and polystyrene stars is described for the case where one of the three arms differs in molecular weight from the remaining two. The preparative approach involves the reaction of methyltrichlorosilane with the chain end active centers under conditions unfavorable to chain coupling or linking, i.e., the synthesis of linear doublet chains or three-arm stars. Some observations regarding ther-

mal-induced post-polymerization side reactions that distort the near-monodisperse nature of the molecular weight distributions obtainable for polybutadiene are described. Preparative conditions must be selected to avoid such side reactions if 'model' branched polybutadienes are required. (Author abstract) 85 refs.

Pennisi, Robert W. (Univ of Akron, Akron, OH, USA); Fetters, Lewis J. *Macromolecules* v 21 n 4 Apr 1988 p 1094-1099.

## Synthesis See Also POLYSULFIDES—Synthesis.

**081153 SYNTHESIS AND CHARACTERIZATION OF RING POLYBUTADIENES.** It has been shown that butadiene initiated with potassium naphthalene in the mixture THF-n-hexane polymerizes conveniently rapidly. The active center is sufficiently stable below 0°C to produce narrow molecular weight linear polybutadiene. The two-ended living polymer has also served to prepare ring polybutadienes. The analysis of the ring polymers by a high-resolution set of SEC columns proved superior to the conventional method for the determination of the linear content in rings and in synthetic mixtures of rings and linear polymers. Dilute solution characterization of the linear and ring polymers shows that  $g' = [\eta]_r / [\eta]_l$  is less than 0.66 in a good solvent. (Author abstract) 28 refs.

Roovers, J. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Toporowski, P.M. *J Polym Sci Part B* v 26 n 6 Jun 1988 p 1251-1259.

**081154 SYNTHESIS AND PROPERTIES OF ELASTOMERIC IONENES: I. POLYBUTADIENE IONENES.** Polybutadiene ionene (PBI) carrying quaternary ammonium ions in the main chain was synthesized from dimethylamino-terminated polybutadiene and 1,4-dibromobutane. Dimethylamino-terminated polybutadiene was prepared by the reaction of isocyanate-terminated polybutadiene with 2-dimethylaminoethanol. The swelling property and the mechanical properties of PBI were compared with those of polybutadiene urethane (PBU), which was prepared by the reaction of hydroxy-terminated polybutadiene with a diisocyanate. The following points were found: (1) PBI shows almost the same solubility parameter as that of PBU; (2) PBI attains a four time greater tensile strength at break than PBU at room temperature; (3) PBI shows a thermoplastic behavior. (Edited author abstract) 16 refs.

Yamashita, Shinzo (Kyoto Inst of Technology, Kyoto, Jpn); Itoi, Masaaki; Kohjiya, Shinzo; Kidera, Akinori. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1927-1935.

**081155 FUNCTIONAL MONOMERS AND POLYMERS. CLVI. ASYMMETRIC INCLUSION POLYMERIZATION OF 1,3-BUTADIENE DERIVATIVES WITH POLAR SUBSTITUENTS IN A DEOXYCHOLIC ACID CANAL.** Asymmetric inclusion polymerization using a chiral host molecule is a convenient and excellent way for obtaining stereoregular and optically active polymers. In a series of extensive studies on the inclusion polymerization of diene monomers using deoxycholic acid (3 $\alpha$ , 12 $\alpha$ -dihydroxy-5 $\beta$ -cholan-24-oic acid; DCA) and its derivative, apocholic acid as host molecules, we found a critical role of thermally stable propagating radicals and a polymerizability of butadiene derivatives with bulky substituents. With respect to 1,3-butadiene derivatives with polar substituents, there are only a few successful studies on asymmetric polymerization, but no study on asymmetric inclusion polymerization. In this communication we report the first examples of asymmetric inclusion polymerization of the monomers in a DCA canal. 22 refs.

Miyata, Mikiji (Osaka Univ, Suita, Jpn); Akizuki, Shinya; Tsutsumi, Hiromori; Takemoto, Kiichi. *J Polym Sci Part C* v 26 n 5 May 1988 p 229-232.



**081156 SYNTHESIS OF CIS-1,4-POLYBUTADIENE WITH NICKEL CATALYST: INVESTIGATIONS ON INTERACTIONS BETWEEN THE CATALYTIC COMPONENTS BY USING UV-VIS SPECTRUM.** Ni(II) naphthenate in hydrogenated gasoline or toluene will appear light green, which is the result of absorption in the red and blue bands of the spectrum. The three peaks caused by the spin-allowed d-d transitions are 403, 680, and 1170 nm respectively, and are similar to those of  $Ni(H_2O)_6^{+2}$ . The configuration of Ni(II) complex is octahedral. In a two-component system of  $Ni(naph)_2-Al(i-Bu)_3$ , the naphthenate ligand attached to Ni(II) can be exchanged for the alkyl group on tri-isobutylaluminum, if  $Al(i-Bu)_3/Ni(naph)_2$  in a system containing metalalkyl and naphthenate does not exceed the value of 0.53. In a two-component system  $Ni(naph)_2-BF_3 \cdot OEt_2$ , a part of the naphthenate can be exchanged for halogen. A new Ni(II) complex is formed, which consists of three new d-d bands in the region 360-1660 nm. (Author abstract) 7 refs.

Chen, Dianbao (Qingdao Coll of Chemical Technology, Qingdao, China); Xu Guang; Tang, Xueming. *Chin J Polym Sci (Engl Ed)* v 5 n 1 1987 p 45-52.

## Thermal Properties

**081157 SOME SPECIFIC PROPERTIES OF DICARBOXYLATE POLYMERS BASED ON Al AND Ti METAL IONS.** Neutralization of carboxyl-terminated polybutadienes with tri- or tetravalent metal was carried out with different ratios of the corresponding neutralizing agents. The network structures of the prepared materials were investigated through their molecular, thermal, dynamic, mechanical, and dielectric properties. The nature, the density, and the efficiency of the ionic interactions influence the solubility, the formation, and the thermal stability of the three-dimensional cross-linked ion-containing polymers. (Author abstract) 23 refs.

Laleg, Maklouf (CNRS, Villeurbanne, Fr); Pascault, Jean-Pierre; Boiteux, Gisele. *J Macromol Sci Phys* v B26 n 4 Dec 1987 p 389-409.

## Viscoelasticity

**081158 EFFECTS OF POLYDISPERSITY ON THE LINEAR VISCOELASTIC PROPERTIES OF ENTANGLED POLYMERS. 3. EXPERIMENTAL OBSERVATIONS ON BINARY MIXTURES OF LINEAR AND STAR POLYBUTADIENES.** The effect of polydispersity on the viscoelastic response of entangled polymers was explored with binary mixtures of nearly monodisperse linear and 3-arm star polybutadienes. Storage and loss moduli were measured over a wide range of frequencies for one series of star-star mixtures and four series of linear-star mixtures. Results at several temperatures were reduced to master curves at 25°C, and the values of viscosity and recoverable compliance were obtained. Some observations about the influence of the matrix on the relaxation of individual components are recorded and compared with results from other laboratories. The dependences of the viscosity and recoverable compliance on composition when one or both of the components is a star polymer are described. (Author abstract) 33 refs.

Struglinski, Mark J. (Northwestern Univ, Evanston, IL, USA); Graessley, William W.; Fetters, Lewis J. *Macromolecules* v 21 n 3 Mar 1988 p 783-789.

**081159 VISCOELASTIC PROPERTIES OF POLYBUTADIENE RINGS.** The linear viscoelastic properties of a series of linear and three ring polybutadienes have been studied. It is observed that melt viscosity of a pure ring is about 10 times smaller than that of the linear polymer with the same molecular weight. The plateau modulus is similarly 5 times smaller. Rings contaminated with 20-25% linear polymer have the same melt viscosity as linear polymers, although their plateau modulus is only about one-half times that of the linear polymer. Synthetic mixtures of ring and linear polymers were used to complete a study of the effect of linear impurities on the melt properties of rings. The data are compared with data

obtained previously on polystyrene ring samples. (Author abstract) 36 refs.

Roovers, Jacques (Nat'l Research Council of Canada, Ottawa, Ont, Can). *Macromolecules* v 21 n 5 May 1988 p 1517-1521.

## POLYBUTENE

**Adhesion** See THERMOPLASTICS—Adhesion.

## Blending

**081160 POLYBUTYLENE BLENDS AS EASY OPEN SEAL COATS FOR FLEXIBLE PACKAGING AND LIDDING.** A controllable heat sealing technology, based on blends of DURAFLEX polybutylene polymer (poly-1-butene) with low density polyethylenes, ethylene-vinyl acetate copolymers (EVA) and other polyolefins is discussed. A variety of systems are described which provide easy-open or peelable seals on various substrates for both flexible packaging and lidding. The blends are 100% solid (solvent free) and can be processed on standard equipment. The peeling mechanism and variables which permit tailoring of seal strength are discussed. Examples of material structures for various applications are described, including suggested fabrication techniques. (Author abstract) 5 refs.

Hwo, Charles C. (Shell Development Co, Houston, TX, USA). *J Plast Film Sheeting* v 3 n 4 Oct 1987 p 245-260.

## Chemical Analysis

**081161 CALORIMETRIC EVIDENCE OF THE INTERCHANGE IN PHENOXY/POLY(BUTYLENE TEREPHTHALATE) BLENDS.** Interchange reactions taking place at high temperatures in phenoxy/poly(butylene terephthalate) blends have been studied by differential scanning calorimetry. Results show the influence that these types of reactions have on the thermal transitions of the blends. These results may be explained on the basis of a reaction between hydroxyl groups in phenoxy and ester groups of poly(butylene terephthalate), causing the formation of grafted and crosslinked copolymers. (Author abstract) 21 refs.

Eguiazabal, J.I. (UPV, San Sebastian, Spain); Cortazar, M.; Iruin, J.J.; Guzman, G.M. *J Macromol Sci Phys* v B27 n 1 Apr 1988 p 19-30.

## Crystallization

**081162 CRYSTALLIZATION BEHAVIOR OF POLYBUTENE-1 IN THE ANISOTROPIC SYSTEM BLENDED WITH POLYPROPYLENE.** Development of supermolecular structure in drawn polypropylene (PP)/polybutene-1 (PB-1) blends was studied. PP (matrix)/PB-1 (70/30) blend films were drawn and heat-treated at fixed length or free ends at temperatures above the melting point of PB-1. It was found that a long axis of the PB-1 lamella is aligned perpendicular to the draw direction, and the c-axis of the PB-1 crystal is oriented perpendicular both to the draw direction and the plane of the surface of the blend film. The kinetics of isothermal crystallization of PB-1 was examined by use of a DSC technique. The result supports the conclusion that the heterogeneous nucleation of PB-1 followed by 2-dimensional crystal growth prevailed in oriented PP/PB-1 blend film. (Edited author abstract) 15 refs.

Takahashi, T. (Fukui Univ, Bunkyo, Jpn); Nishio, Y.; Mizuno, H. *J Appl Polym Sci* v 34 n 8 Dec 1987 p 2757-2768.

## Fractionation

**081163 PREPARATIVE GPC IN FUNDAMENTAL POLYMER SYNTHESIS.** A simple efficient preparative gel permeation chromatography assembly (prep GPC) has been built using largely commercially available components, (i.e., pump, columns, all glass solvent recirculating system) and its usefulness in fundamental polymer synthesis was demonstrated. The operating cost of prep GPC has

been reduced and the safety much improved by the use of n-hexane as the mobile phase. Rapid one-recycle narrow fractionation ( $M_w/M_n=1.1-1.2$ ) and purification of relatively large quantities (up to 20 g/ loading) of polyisobutylene (PIB) samples is described. Operating parameters and efficiency are illustrated by examples. By the use of this equipment sufficient quantities of narrow molecular weight distribution (MWD) polyhydrocarbons can be conveniently and rapidly obtained for meaningful structure/property research. (Edited author abstract) 3 refs.

Gadkari, Avinash C. (Univ of Akron, Akron, OH, USA); Zsuga, Miklos; Kennedy, J.P. *Polym Bull (Berlin)* v 18 n 4 Oct 1987 p 317-322.

## Solutions

**081164 ANOMALOUS LATERAL MIGRATION OF A RIGID SPHERE IN TORSIONAL FLOW OF A VISCOELASTIC FLUID - EFFECT OF POLYMER CONCENTRATION AND SOLVENT VISCOSITY.** In previous papers the authors studied the behavior of a rigid sphere entrained in torsional flow of a polymer solution held between a rotating disk and a stationary plate. In this paper the authors deal with the effects of polymer concentration (c) and solvent viscosity ( $\eta_s$ ) using the same apparatus. Blends of polybutene (PB) (Amoco H-50 and H-300) were made viscoelastic by dissolving a small amount of polyisobutylene (PIB) (Enjay Vistanex L-120,  $M_w=1.5 \times 10^6$  with a large polydispersity) with reagent grade heptane as a co-solvent. Polystyrene-divinylbenzene microspheres with a density of 1.05 g/cc were used. Since it was shown that the location of the critical streamline, separating regions of inward and outward migration, was virtually identical for different sizes of particles, the authors used one particle having a diameter of 450 microns as determined by optical microscopy. 10 refs.

Choi, H.J. (Carnegie Mellon Univ, Pittsburgh, PA, USA); Prieve, D.C.; Jhon, M.S. *J Rheol* v 31 n 4 May 1987 p 317-321.

## Spectroscopic Analysis

**081165 HIGH-RESOLUTION SOLID-STATE  $^{13}C$  NMR STUDY OF THE  $\alpha$  AND  $\beta$  CRYSTALLINE FORMS OF POLY(BUTYLENE TEREPHTHALATE).** Uniaxially strained poly(butylene terephthalate) (PBT) undergoes a reversible  $\alpha$  and to  $\beta$  crystalline phase transition, where the fiber repeat distance is increased in the  $\beta$  phase. The question of what the intrachain conformations of PBT are in both relaxed  $\alpha$  and strained  $\beta$  crystalline phases has not yet received a completely satisfactory answer. We have performed variable-temperature  $^{13}C$  CP/MAS NMR measurements on both crystalline phases of PBT in the hope that their high-resolution solid-state spectra would permit us to compare the crystalline chain conformation in the  $\alpha$  and  $\beta$  phases. In the spectra recorded between ambient temperature and ca. 90-100°C, all resonances are broadened by contributions from the amorphous PBT chains. (Edited author abstract) 25 refs.

Gomez, M.A. (AT&T Bell Lab, Murray Hill, NJ, USA); Cozine, M.H.; Tonelli, A.E. *Macromolecules* v 21 n 2 Feb 1988 p 388-392.

## Synthesis

**081166 ELECTROPHILIC SUBSTITUTION OF ORGANOSILICON COMPOUNDS. II. SYNTHESIS OF ALLYL-TERMINATED POLYISOBUTYLENES BY QUANTITATIVE ALLYLATION OF TERT-CHLORO-POLYISOBUTYLENES WITH ALLYL-TRIMETHYLSILANE.** Essentially quantitative allylation of linear and three-arm star tert-chloro capped polyisobutylenes [ $^{13}C$ -PIB-Cl] and PIB(Cl) $_3$ ] has been achieved by the use of allyltrimethylsilane (AllylSiMe $_3$ ) and Friedel-Crafts acids. Quantitative allylation occurs under suitable conditions, e.g., slight molar excess of TiCl $_4$  and AllylSiMe $_3$ , polar media, -70°C. These conditions have been developed from quantitative model allylation experiments using 2,4,4-trimethyl-2-chloropentane. While allylation proceeds with great ease under the



mildest conditions, etc.,  $-70^{\circ}\text{C}$ , vinylation with vinyltrimethylsilane could not be achieved even under more forcing conditions. (Edited author abstract) 23 refs.

Wilczek, Lech (Univ of Akron, Akron, OH, USA); Kennedy, Joseph P. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3255-3265.

**081167 POLY-1-BUTENE: ITS PREPARATION, PROPERTIES AND CHALLENGES.** More than 30 years after the synthesis of isotactic poly-1-butene there is still no large commercial production of the resin, nor major applications to compare with those of the lighter olefin polymers polyethylene and polypropylene. The chief reason for the slower commercialization has been the low level of monomer availability and its higher price compared with ethylene and propylene. However, poly-1-butene has several highly attractive properties. It is tough, retains strength at elevated temperatures, is resistant to stress cracking and abrasion, and exhibits good long-term creep resistance and strength even at elevated temperatures. This paper reviews the preparation, properties and challenges of poly-1-butene. 166 refs.

Luciani, L. (Neste Oy, Kulloo, Finl); Seppala, J.; Lofgren, B. *Prog Polym Sci (Oxford)* v 13 n 1 1988 p 37-62.

**POLYCARBONATES** See Also COMPOSITE MATERIALS; DATA STORAGE, OPTICAL—Materials; EP-OXY RESINS—Chemistry; PLASTICS, REINFORCED—Injection Molding; POLYMERS—Blending; POLYMERS—Reinforcing.

**081168 HOLE TRANSPORT OF TRANS-1,2-BIS-CARBAZOLYL-CYCLOBUTANE-DOPED POLY(BISPHENOL A CARBONATE) FILM.** The hole transport of trans-1,2-biscarbazolylcyclobutane (CB)-doped poly(bisphenol A carbonate) (PC) film has been investigated in the CB concentration range of  $3.8 \times 10^{-4}$  mol  $\text{cm}^{-3}$  (912 wt%) to  $1.6 \times 10^{-3}$  mol  $\text{cm}^{-3}$  (51 wt%). The hole mobility increased drastically with increasing CB concentration. The hole mobility was analyzed by a random hopping model. The localization radius  $p_0$  of the CB/PC system was 1.9 Å, which is larger than that obtained for the N-isopropyl-carbazole-doped PC system. The highest hole mobility of  $2.9 \times 10^{-6}$   $\text{cm}^2 \text{V}^{-1} \text{s}^{-1}$  was obtained when the CB concentration was  $1.6 \times 10^{-3}$  mol  $\text{cm}^{-3}$  (51 wt%) at  $E = 1.6 \times 10^5$  V  $\text{cm}^{-1}$  and  $T = 298$  K. (Edited author abstract) 15 refs.

Tsutsumi, Naoto (Kyoto Univ, Kyoto, Jpn); Yamamoto, Masahide; Nishijima, Yasunori. *J Polym Sci Part B* v 25 n 10 Oct 1987 p 2139-2148.

## Adsorption

**081169 ADSORPTION OF OLIGO- AND POLY-CARBONATES ON THE AQUEOUS SOLUTION OF ALKALI-ORGANIC SOLVENT PHASE BOUNDARY.** The values of the surface activity and Gibbs adsorption were determined with the interfacial tension isotherms of solutions of oligo- and polycarbonates in an organic solvent on the interface with aqueous solutions of alkali. It was found that an increase in the basicity of the aqueous phase results in an increase in the adsorption capacity of the polycarbonates. The effect of the structure of the oligomers on their surface activity was examined. The dependence of adsorption of the polycarbonates on the composition of the organic solvent was studied. (Author abstract) 10 refs.

Frolov, Yu.G. (D.I. Mendeleev Inst of Chemical Technology, Moscow, USSR); Bogorodskaya, M.A.; Kim, V.; Matyukhina, O.S.; Golland, A.E. *Colloid J USSR* v 49 n 4 Jul-Aug 1987 p 635-639.

## Anisotropy

**081170 STRUCTURE AND ANISOTROPY IN PC: II. WAXS, ANISOTROPIC HEAT CONDUCTION AND BIREFRINGENCE IN ORIENTED SAMPLES.** Birefringence, anisotropic heat conduction, and wide angle X-ray scattering (WAXS) investigations have been performed on one set of uniaxially drawn samples of polycarbonate (PC). The orientation parameters from heat

conduction and from WAXS are well correlated. The intrinsic birefringence is determined to  $\Delta n_0 = 0.106$  in agreement with the monomer polarizability calculated on the basis of model structures. The short range order as evidenced by WAXS does not depend on the degree of orientation in PC. Over small regions ( $\leq 1.5$  nm) the molecular arrangement is similar to that in the crystalline state. (Author abstract) 21 refs.

Pietralla, M. (Univ of Ulm, Ulm, West Ger); Schubach, H.R.; Dettenmaier, M.; Heise, B. *Prog Colloid Polym Sci* v 71 1985 p 125-133.

Applications See NEUTRONS—Detectors.

## Biocompatibility

**081171 PROTEIN-POLYMER INTERACTION. CHANGES WITH PLASMA COMPONENTS, VITAMINS, AND ANTIPLATELET DRUGS AT THE INTERFACE.** The authors have reviewed the relevance of the surface modification of polymers to improve blood compatibility. In the present paper the authors report the need for pharmaceutical modification of blood itself to enhance the antithrombogenic character of the substrate. The totality of earlier observations with other preliminary studies carried out in the author's laboratory relevant to this system are reviewed. Such a synthesis relates both to the fundamental aspects of interaction and its relationship to blood-material interactions, interrelating this work with the established results from the literature. 150 refs.

Chandy, Thomas (Sre Chitra Tirunal Inst for Medical Sciences & Technology, Trivandrum, India); Sharma, Chandra P. *Polym Plast Technol Eng* v 26 n 3-4 Sep-Dec 1987 p 143-227.

Blending See Also COPOLYMERS—Blending; INTERPENETRATING POLYMER NETWORKS—Mechanical Properties; POLYMERS—Mechanical Properties.

**081172 MISCIBLE BLENDS OF POLYCARBONATE AND POLYMETHYL METHACRYLATE.** Solvent-cast films of polycarbonate (PC) polymethyl methacrylate (PMMA) mixtures exhibit a single-phase structure with outstanding optical clarity. Differential scanning calorimetry (DSC) studies show a single glass transition in the intermediate blends. However, the blends undergo phase separation upon heating above  $240^{\circ}\text{C}$ . The phase diagram has been established subsequently by means of a cloud point method and is reminiscent of lower critical solution temperature (LCST) in character. (Author abstract) 14 refs.

Kyu, Thein (Univ of Akron, Akron, OH, USA); Saldanha, Jeanne M. *J Polym Sci Part C* v 26 n 1 Jan 1988 p 33-40.

**081173 MORPHOLOGICAL STUDIES OF POLY-CARBONATE-POLYBUTYLENE TEREPHTHALATE) BLENDS BY TRANSMISSION ELECTRON MICROSCOPY.** The morphology of polycarbonate (PC)-poly(butylene terephthalate) (PBT) blends prepared by melt-processing in an extruder or a Brabender Plastograph was studied by Transmission Electron Microscopy. Transesterification during blending was avoided by the use of di-n-octadecyl phosphite, an efficient transesterification inhibitor. Ruthenium tetroxide was used to selectively stain the PC fraction. A preliminary study of the morphology as a function of composition and thermal annealing was carried out. (Edited author abstract) 34 refs.

Delimoy, Didier (Univ Catholique de Louvain, Louvain-la-Neuve, Belg); Bailly, Christian; Devaux, Jacques; Legras, Roger. *Polym Eng Sci* v 28 n 2 Jan 1988 p 104-112.

**081174 BLEND MISCIBILITY OF BISPHENOL-A POLYCARBONATE AND POLY(ETHYLENE TEREPHTHALATE) AS STUDIED BY SOLID-STATE HIGH-RESOLUTION  $^{13}\text{C}$  NMR SPECTROSCOPY.** Blends of poly(ethylene terephthalate) (PET) and bisphenol-A polycarbonate (BPAPC), cast as films from solution in a mixture of hexafluoro-2-propanol and dichloromethane, pressed as a film, and then quenched in ice

water, were examined with solid-state high-resolution  $^{13}\text{C}$  NMR spectroscopy and differential scanning calorimetry. As prepared, the samples contained separated domains of amorphous PET and BPAPC exceeding 150 Å in size. Heating to  $265^{\circ}\text{C}$  for about 4 min, followed by cooling in air or in a metal heating block, resulted in crystallization of part of the PET. Further heating and cooling cycles resulted in degradation of the size of the PET crystals while fragments derived from PET were mixed at the molecular level with those derived from BPAPC. (Edited author abstract) 79 refs.

Henrichs, P. Mark (Eastman Kodak Co, Rochester, NY, USA); Tribone, John; Massa, Dennis J.; Hewitt, James M. *Macromolecules* v 21 n 5 May 1988 p 1282-1291.

## Bonding

**081175 SAFER AND BETTER BONDING OF POLYCARBONATE PARTS.** Ethylene dichloride and methylene chloride are most commonly used for solvent-welding polycarbonate medical assemblies. Recent OSHA regulations restricting the use of these solvents are exerting increasing pressure on manufacturers to replace them with alternative methods and materials. One option is to use different solvents. UV-curing adhesives offer another option. Ways of joining polycarbonate to other materials, particularly in the difficult case of PVC tubing, also concurrently interest manufacturers of medical devices. Alternative solvents, cyanoacrylates, and UV-curing adhesives hold out special promises for these applications too.

Licata, Mark (Mobay Corp, Pittsburgh, PA, USA); Glogovsky, Todd; Haag, Earl. *Plast Eng* v 43 n 10 Oct 1987 p 35-38.

## Calculations

**081176 CHAIN CONFORMATIONS OF POLY-CARBONATE FROM AB INITIO CALCULATIONS.** Ab initio calculations with full geometry optimization on diphenyl carbonate (DPC) and diphenylpropane (DPP) are carried out to determine the bond geometries and the conformational energies and then to compute the unperturbed chain dimensions of the polycarbonate of 2,2-bis(4-hydroxyphenyl)propane, or bisphenol A polycarbonate. The bond geometries calculated with the 6-31G\* basis sets are in excellent agreement with the experimental values. The conformational energy contours exhibit a rather low energy barrier (ca. 1.9 kcal/mol) in DPP and a nearly flat profile in DPC for the rotations of phenylene groups. (Edited author abstract) 22 refs.

Laskowski, Bernard C. (Analatom Inc, San Jose, CA, USA); Yoon, Do Y.; McLean, Doug; Jaffe, Richard L. *Macromolecules* v 21 n 6 Jun 1988 p 1629-1633.

## Crack Propagation

**081177 FATIGUE CRACK PROPAGATION AND CRACK CLOSURE BEHAVIOR IN POLYCARBONATE AND FIBER REINFORCED POLYCARBONATE.** Fatigue crack propagation was investigated in polycarbonate and glass fiber reinforced polycarbonate and the effect of stress ratio and glass fiber content determined. The addition of glass fiber increases the tensile strength, but does not always contribute to an increase in fatigue crack propagation resistance. For polycarbonate, the effect of stress ratio can be partly explained by using crack closure concepts as other researchers have suggested, but for glass fiber reinforced polycarbonate this was not possible. Fractography revealed a void growth process, which occurred by decohesion at the interface of the glass fibers and the base material, which was dependent on the maximum stress intensity factor. (Edited author abstract) 10 refs.

Murakami, R. (Univ of Tokushima, Tokushima, Jpn); Noguchi, S.; Akizono, K.; Ferguson, W.G. *Fatigue Fract Eng Mater Struct* v 10 n 6 1987 p 461-470.



## Crystallization

**081178 CRYSTALLINE MEMORY ON POLYCARBONATE.** A significant reduction on the time for thermal crystallization of Bisphenol-A polycarbonate has been achieved by means of a previous crystallization step of the polymer in acetone, followed by a capillary extrusion processing at temperatures above its melting range (230-280°C). The crystallinity of PC was corroborated qualitatively by means of WAXS and quantitatively by means of DSC. The acetone-crystallized polymer showed higher values of dynamic viscosity than its amorphous counterpart. Such difference decreased with the increase of the test temperature and disappeared at 280°C. The degree of crystallinity of thermally crystallized PC increased with the decrease of the capillary extrusion temperature of the acetone-crystallized material. It is inferred that the time-temperature-dependent long range molecular diffusion necessary for the total melting of the crystal fractions could not take place entirely for the short times employed ( $\approx 4$  min), allowing the extruded polymer to behave as a self-nucleated material. (Author abstract) 11 refs.

Di Filippo, Giuseppe V. (Univ Simon Bolivar, Caracas, Venez); Gonzalez, Maria E.; Gasiba, Maria T.; Muller, Alejandro V. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1959-1966.

## Deformation

**081179 DEVELOPMENT OF ORIENTATION IN GLASSY POLYCARBONATE AT HIGH STRAINS.** Birefringence has been measured on yielded specimens of polycarbonate in simple tension in creep and stress relaxation. The pseudo-affine and random-chain affine models both fail to describe the experimental relationship between birefringence (or orientation) and strain. A new model assuming affine deformation of chain ends and non-random chains is presented, adequately describing the trends of experimental data. (Author abstract) 37 refs.

Heymans, Nicole (Univ Libre de Bruxelles, Brussels, Belg). *Polymer* v 28 n 12 Nov 1987 p 2009-2017.

**081180 REVERSAL AND ACTIVATION OF PHYSICAL AGING BY APPLIED DEFORMATIONS IN SIMPLE COMPRESSION AND EXTENSION.** The differential (incremental) storage modulus  $E'$  was measured intermittently at 1 Hz during the stress relaxation of cylindrical specimens of polycarbonate subjected to finite static strains in both simple compression and extension. (In measuring  $E'$ , the amplitude of the applied sinusoidal strain was 0.2%). Application of each static strain gave a value of  $E'/E'$  less than unity, where  $E'_0$  is the storage modulus at 1 Hz of the undeformed specimen. This behavior results from an increase in the mobility of short molecular segments; it signifies a partial erasure of the state of physical aging, a change also termed de-aging or rejuvenation. After a static strain had been applied,  $E'$  increased continuously, a reflection of physical aging that results from a progressive decrease in segmental mobility. Plots of  $E'/40$  at an aging time of 100 s against the absolute value of the static strain show that simple extension de-ages a specimen somewhat more than does a strain of the same magnitude in compression. (Edited author abstract) 18 refs.

Smith, T.L. (IBM, San Jose, CA, USA); Levita, G.; Moonan, W.K. *J Polym Sci Part B* v 26 n 4 Apr 1988 p 875-881.

**081181 SUBSTRATE DEFORMATION STUDIES ON IMPACT EROSION AND PLOWING BY PHOTOELASTICITY.** Static and dynamic photoelasticity methods were applied in studying the mechanisms of erosion. A multiple spark camera and a linear gas gun were used to photograph impact-induced dynamic stress waves. The propagation of stress waves in a polycarbonate material was analyzed upon impact of a 3-mm-diameter rigid ball traveling at 50 m/s velocity. The role of pressure, shear, and Rayleigh waves in causing damage was found to be low. The residual stress field generated due to particle impact was determined using a circular polariscope. It was found that the plastic deformation at

impact-induced high strain rates and the residual stress field generated by repeated impacts produce cracking, and the interaction of these cracks results in erosion loss. Impact on brittle Columbia resin, produced lateral, circumferential, and radial cracks, resulting in material removal. The stress gradient and cracking were also studied during plowing on the above two materials. (Author abstract) 11 refs.

Naim, M. (Iowa State Univ, Ames, IA, USA); Bahadur, S. *J Elastomers Plast* v 20 n 1 Jan 1988 p 21-35.

## Degradation

**081182 SYNTHESIS, CHARACTERIZATION, AND WEATHERING BEHAVIOR OF POLYCARBONATES DERIVED FROM 3,3'-DIHYDROXYDIPHENYL ETHER.** Previous studies of the photodegradation of bisphenol A polycarbonate (BPA PC) indicate that both alkyl side chain and ring oxidation play significant roles. In order to determine the relative importance of these two pathways in the photoyellowing that accompanies photodegradation, side chain free polycarbonates based on 3,3'-dihydroxydiphenyl ether were synthesized and tested. Both accelerated weathering experiments using a QUV test apparatus and outdoor weathering indicated that these polymers photoyellowed faster than BPA PC. This suggests that ring oxidation is an important source of photoyellowing of aromatic polycarbonates. (Author abstract) 8 refs.

Factor, A. (GE, Schenectady, NY, USA); Lynch, J.C.; Greenberg, F.H. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3413-3422.

## Drawing and Stamping

**081183 LATENT ENERGY OF DEFORMATION OF BISPHENOL A POLYCARBONATE.** The thermodynamic behavior of poly(bisphenol A carbonate) (PC) during uniaxial cold drawing and the properties of the drawn polymer were examined. Isothermal deformation calorimetric measurements were made during the drawing process. The deformation calorimeter measures heat, work, and internal energy changes for deformation. It was found that PC exhibited nonideal plasticity with approximately 50-80% of the work of deformation dissipated as heat. The remainder of the work of deformation was stored as a latent internal energy change. The value of the internal energy change was dependent on strain rate at 20°C but was not strongly dependent on temperature in the range 20-65°C. Thermomechanical measurements on cold-drawn PC samples demonstrated striking behavior at temperatures far below the glass transition temperature  $T_g$ . Stress-temperature experiments showed that the stress increased for uniaxially constrained samples, and this stress increase began at temperatures just above the deformation temperature. Additional experiments indicated that the changes which took place during cold drawing were physical in nature and were thermoreversible. These changes in physical properties are related to those which occur due to physical aging below  $T_g$ . (Author abstract) 37 refs.

Adams, G.W. (Univ of Massachusetts, Amherst, MA, USA); Farris, R.J. *J Polym Sci Part B* v 26 n 2 Feb 1988 p 433-445.

## Elasticity

**081184 STRUCTURE AND ANISOTROPY IN POLYCARBONATE. III. STUDY OF ELASTIC AND OPTICAL PROPERTIES OF ORIENTED SAMPLES WITH THE METHOD OF HIGH RESOLUTION BRILLOUIN SPECTROSCOPY.** High resolution Brillouin spectroscopy (BS) has been used to investigate elastic and optical properties of uniaxially drawn samples of polycarbonate (PC). The results are discussed in the framework of the single phase aggregate model (SPAM) of Ward. According to a recently developed evaluation technique, the SPAM parameters of PC are determined, resulting in the elastic constants of the structural units. A nearly quadratic dependence of the orientation parameter  $P_4$  on  $P_2$  results, which can be explained by a modified

pseudoaffine deformation scheme. (Edited author abstract) 22 refs.

Peez, L. (Univ des Saarlandes, Saarbruecken, West Ger); Krueger, J.K.; Pietralla, M. *Colloid Polym Sci* v 265 n 9 Sep 1987 p 761-773.

## Etching

**081185 INTERNAL HEATING EFFECT DURING ELECTROCHEMICAL ETCHING OF LEXAN POLYCARBONATE.** An internal heating effect has been observed during electrochemical etching of Lexan polycarbonate even at low frequencies ( $< \text{kHz}$ ). There is a correlation between the registration efficiency or detector response and the heating rate in Lexan and the two maxima occur at the same ac field frequency. The detector response also depends upon temperature, and at higher temperatures the maxima shifts towards higher frequencies. The study reveals that dielectric polarization exhibits a resonance type phenomena with applied ac field. (Author abstract) 9 refs.

Singh, Ravi Chand (Guru Nanak Dev Univ, Amritsar, India); Virk, H.S. *Nucl Instrum Methods Phys Res Sect B* v B29 n 3 Dec 1987 p 579-582.

**081186 RELATION BETWEEN INTERNAL HEATING EFFECT & TRACK DENSITY DURING ELECTRO-CHEMICAL ETCHING OF LEXAN POLYCARBONATE.** During electro-chemical etching of Lexan polycarbonate, heat generation takes place even at low frequencies ( $< \text{kHz}$ ). A correlation between detector response (tracks/cm<sup>2</sup>) and the heating rate has been observed. The study indirectly reveals the relation between track density and polymer loss index ( $\epsilon' \tan \delta$ ). (Author abstract) 4 refs.

Chand, Ravi (Guru Nanak Dev Univ, Amritsar, India); Virk, H.S. *Indian J Pure Appl Phys* v 25 n 5-6 May-Jun 1987 p 237-238.

## Film

**081187 PROPERTIES OF CONDUCTIVE POLYCARBONATE FILMS RETICULATE DOPED WITH MPHT(TCNQ)<sub>2</sub> AND PrPht(TCNQ)<sub>2</sub> SALTS: A HIGHLY-CONDUCTIVE FORM OF PrPht(TCNQ) BY CRYSTALLIZATION IN A POLYMER MATRIX.** Conductive polymer films obtained by reticulate doping with N-methyl phthalazinium (MPht) and N-propyl phthalazinium (PrPht) TCNQ complex salts are investigated. It is found that the spectral, electrical and magnetic properties of the MPht(TCNQ)<sub>2</sub> in a polymer matrix are not significantly different from the properties of single crystals, while in the case of PrPht a new highly-conductive form is obtained by rapid crystallization during film casting. It is concluded that the dimerization of the TCNQ stacks in the new form is not as strong but the disorder is higher as compared with single crystals of PrPht(TCNQ)<sub>2</sub>. It is possible that the stoichiometry is also different. (Author abstract) 9 refs.

Tracz, A. (Polish Acad of Sciences, Lodz, Pol); Jeszka, J.K.; Kryszewski, M.; Ulanowski, J.; Boiteux, G.; Firlej, L.; Graja, A. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 107-114.

## Flame Resistance

**081188 INTUMESCENT FLAME RETARDANTS FOR POLYMERS. IV. THE POLYCARBONATE-AROMATIC SULFONATES SYSTEM.** The mechanism of action of aromatic sulfonates as flame retardant (FR) agents on poly(bis-phenol-A carbonate) (PC) has been investigated. These compounds are capable of inducing a self-extinguishment in PC even when present in very low amounts (0.2-1%). Thermogravimetric and flash pyrolysis-GC-MS data show the thermal degradation rate of PC was enhanced and the distribution of the volatile pyrolysis products was modified by these additives. Oxygen Index (OI) and Nitrous Oxide Index (NOI)



measurements indicate a FR condensed-phase mechanism of these additives. (Edited author abstract). 26 Refs.

Ballistreri, Alberto (Univ di Catania, Catania, Italy); Montaudo, Giorgio; Scamporrino, Emilio; Puglisi, Conetto; Vitalini, Daniele; Cucinella, S. *J Polym Sci Part A v 26 n 8 Aug 5 1988 p 2113-2127.*

## Fracture

**081189 UNIFIED TREATMENT OF STATIC FRACTURES IN NOTCHED AND CRACKED SPECIMENS OF POLYCARBONATE.** The brittle fracture behavior in the static tension of notched specimens of polycarbonate has been studied for a wide range of notch tip radii. The nominal stress at the brittle fracture decreases with decreasing notch tip radius, and it approaches a constant value when the notch tip radius is less than about 0.1 mm. For notch tip radii less than 0.1 mm, the fracture is well explained on the basis of linear elastic fracture mechanics. For notch tip radii larger than 0.1 mm, the specimens failed in an apparently brittle manner after the formation of a small plastic zone at the notch tip. The experimental results of these specimens have been discussed in terms of a combination of the critical maximum elastic stress and the notch tip radius from the standpoint of linear notch mechanics. It is shown that the maximum elastic stress for brittle fracture is governed by the notch tip radius alone. (Author abstract) In Japanese. 15 refs.

Hyakutake, Hiizu; Nisitani, Hironobu. *Nippon Kikai Gakkai Ronbunshu A Hen v 53 n 494 Oct 1987 p 1893-1897.*

**081190 POLYMER FATIGUE FRACTURE DIAGRAMS: BPA POLYCARBONATE.** A fatigue fracture diagram for BPA polycarbonate has been created from fatigue lifetime data obtained from knit line notched samples. This fatigue fracture diagram maps out stress-temperature zones where fatigue fracture is dominated by crack growth through leading crazes and zones where fatigue fracture occurs through shear fracture at 45 degrees to the load direction. Both craze and shear planes coexist in the fatigue crack tip plastic zone, and both compete to determine the ultimate crack growth behavior. The shear planes preferentially develop (and fracture) at higher temperatures and stresses, but this fracture process is quite slow. Consequently, an inversion in the fatigue lifetime curve is observed, with longer lifetimes at higher stresses. (Edited author abstract) 14 refs.

Takemori, Michael T. (GE, Schenectady, NY, USA). *Polym Eng Sci v 28 n 10 May 1988 p 641-647.*

## Heat Treatment

**081191 ANNEALING OF REJUVENATED POLYCARBONATE.** The effect of mechanically rejuvenated samples of polycarbonate below  $T_g$  has been investigated by differential scanning calorimetry. All the traces exhibited a broad sub- $T_g$  exotherm, preceded in some cases by a small sub- $T_g$  endothermal peak. The position of the exotherm on the scan is strongly dependent on the annealing conditions. A method is proposed to obtain the value of the structural temperature characterizing any annealed rejuvenated sample, since in the authors' opinion this is the chief quantity to be adopted in annealing investigations. Basic relations are chosen to be as simple as possible, containing only three parameters optimized using previous enthalpy relaxation data obtained on samples annealed after quenching. From the same relations, traces related to annealed rejuvenated samples are computed. (Edited author abstract) 12 refs.

Bauwens-Crowet, C. (Univ Libre de Bruxelles, Brussels, Belg); Bauwens, J.-C. *Polymer v 28 n 11 Oct 1987 p 1863-1868.*

## Hydrolysis

**081192 POLYMERIZATION BY PHASE TRANSFER CATALYSIS: 7. EFFECT OF THE CATALYST ON THE HYDROLYSIS OF BISPHENOL A POLY-**

**THIOCARBONATE.** The hydrolysis of bisphenol A polythiocarbonate is studied under phase transfer conditions, and occurs principally in the organic phase, influenced by the catalysts according to their structure. (Author abstract) 3 refs.

Tagle, L.H. (Catholic Univ of Chile, Santiago, Chile); Diaz, R.; De La Maza, M.P. *Polym Bull (Berlin) v 18 n 6 Dec 1987 p 485-486.*

**081193 HYDROLYSIS OF POLYCARBONATE/POLYBUTYLENE TEREPHTHALATE BLEND.** The hydrolysis of a polycarbonate/polybutylene terephthalate (PBT) blend (50/50) was investigated by immersing molded samples in water baths between 21 and 98°C. Samples were also placed in a 100°C air circulating oven (dry environment). Changes in impact properties, dynamic mechanical properties, molecular weight, and thermal properties were followed. In 80°C water bath the material was found to embrittle in five to six days, and in circulating air oven at 100°C in less than 90 days. A sharp decline in molecular weight and changes in thermal and mechanical properties were observed. The activation energy for the embrittlement process in water was found to be 22 kcal/mole. This value is between the activation energy for the hydrolysis of PC and that of PBT. (Author abstract) 13 refs.

Golovoy, A. (Ford Motor Co, Dearborn, MI, USA); Cheung, M.F.; Van Oene, H. *Polym Eng Sci v 28 n 4 Feb 1988 p 200-206.*

## Measurements

**081194 DISTRIBUTION OF CORRELATION TIMES IN GLASSY POLYMERS FROM PULSED DEUTERON NMR.** Pulsed deuteron NMR offers new possibilities for the determination of the distribution of correlation times for local motions in glassy polymers. The NMR line shape is a superposition of spectra corresponding to the different values of the correlation times. The weighting factors of these single spectra depend on the distribution function, which therefore can be characterized by a line shape analysis. Moreover, by combination with spin-lattice relaxation experiments the motional behaviour can be probed on a much longer time scale than by a line shape analysis alone. In this way homogeneous and heterogeneous distributions can clearly be distinguished. The method is explained in detail and is demonstrated by a simple example involving the methyl group rotation in glassy polycarbonate. (Edited author abstract) 26 refs.

Schmidt, C. (Univ Mainz, Mainz, West Ger); Kuhn, K.J.; Spiess, H.W. *Prog Colloid Polym Sci v 71 1985 p 71-76.*

**Mechanical Properties** See POLYETHYLENES—Morphology; POLYMERS—Blending.

## Mixing

**081195 PHASE SEPARATION BY SPINODAL DECOMPOSITION IN POLYCARBONATE/POLY(METHYL METHACRYLATE) BLENDS.** Early and late stages of phase separation by spinodal decomposition in mixtures of polycarbonate (PC) and poly(methyl methacrylate) (PMMA) were investigated by time-resolved light scattering. The PC/PMMA blend reveals a miscibility window reminiscent of an LCST (lower critical solution temperature) character. A high level of interconnectivity in the domain structure was observed in optical microscopic investigations. The time evolution of scattering halo was followed as a function of temperature jump ( $\Delta T$ ). The early stage of spinodal decomposition at low  $\Delta T$  reasonably follows the linearized Cahn-Hilliard's theory; however, deviations are seen at large temperature jumps. (Edited author abstract) 42 refs.

Kyu, Thein (Univ of Akron, Akron, OH, USA); Saldanha, Jeanne M. *Macromolecules v 21 n 4 Apr 1988 p 1021-1026.*

**Morphology** See POLYMERS—Morphology.

**Optical Properties** See DATA STORAGE; OPTICAL Storage Devices; FIBER OPTICS—Plastics Applications; OPTICAL FIBERS—Materials; POLYMETHYL METHACRYLATE—Optical Properties.

**Physical Properties** See Also MEMBRANES—Transport Properties.

**081196 THE WORLD OF POLYCARBONATES.** Polycarbonates (PCs), known for toughness in molded parts, typify the class of polymers known as engineering thermoplastics (ETPs). These materials, designed to replace metals and glass in applications demanding strength and temperature resistance, offer advantages of light weight, low cost, and ease of fabrication. Other dominant members in this class are polyamides, modified polyphenylene oxide, acetal, and polyester. This article looks at the properties of PCs, at the uses these properties engender, and finally at the chemistry used to generate these properties. 39 refs

Sikdar, Subhas K. *CHEMTECH v 17 n 2 Feb 1987 p 112-118.*

**081197 PHENYLENE MOTION IN POLYCARBONATE AND POLYCARBONATE/ADDITIVE MIXTURES.** Pulsed deuteron NMR line shapes have been analyzed to characterize type and time scale of the phenylene group motion in glassy bisphenol-A polycarbonate. The motional mechanism involves  $\pi$ -flips about the  $C_1C_4$  axis augmented by small angle fluctuations about the same axis, reaching a rms amplitude of  $\pm 35^\circ$  at 380 K. The distribution of correlation times for the  $\pi$ -flips is heterogeneous in nature and can be described either by a log-Gaussian or an asymmetric distribution with a more rapid decay at high correlation times comparable to the Williams-Watts distribution. From both distributions essentially the same mean activation energy of 37 kJ/mol is obtained, whereas the temperature dependence width of the highly asymmetric distribution is somewhat smaller compared to the log-Gaussian distribution. The results of this work strongly suggest that the secondary mechanical relaxation and the large amplitude motions of the phenylene groups in polycarbonate are related. (Edited author abstract) 16 refs.

Wehrle, M. (Univ Mainz, Mainz, West Ger); Hellmann, G.P.; Spiess, H.W. *Colloid Polym Sci v 265 n 9 Sep 1987 p 815-822.*

**081198 POSITRON ANNIHILATION LIFETIME STUDY OF ISOTHERMAL STRUCTURAL RELAXATION IN BISPHENOL-A POLYCARBONATE.** Positron annihilation lifetime spectroscopy has been used to study the isothermal relaxation response of compression molded bisphenol-A polycarbonate at temperatures of 263, 273, and 303 K. The temperature dependence of both the lifetime and intensity of the ortho-Positronium (o-Ps) pickoff component is discussed in terms of ductile-to-brittle transition behavior and free volume theory. An additive exponential model and the Williams-Watt model were used to analyze the relaxation as a function of temperature and provided results consistent with the anticipated molecular mobility of polycarbonate at sub- $T_g$  temperatures. (Author abstract) 40 refs.

Hill, A.J. (Duke Univ, Durham, NC, USA); Jones, P.L.; Lind, J.H.; Pearsall, G.W. *J Polym Sci Part A v 26 n 6 Jun 1988 p 1541-1552.*

**Plasticity** See EXTRUSION—Deformation.

## Polymerization

**081199 DEVELOPMENT STUDY OF POLYCARBONATE REACTORS II. SCALE-UP AND DESIGN OF CONTINUOUS REACTORS.** For the polymerization process controlled by mass transfer in the production of polycarbonate, the performance of continuous operations by using 4 cascades of stirred tanks and a premixing tank has been studied. It was proposed that the uniform dispersion and constant size distribution of liquid drops can be considered as the scale-up criteria. Experimental



results showed that the molecular weight of polymers can be well controlled by using these principles. (Edited author abstract) 8 refs. In Chinese.

Han Jie (UNILAB, China); Lu Renjie; Zhu Zongnan; Le Huihui; Zhang Hao; Jing Yehong; Dai Gance. *Huaxue Fanying Gongcheng Yu Gongyi* v 3 n 3 Sep 1987 p 76-81.

## Solutions

**081200 SOLUTION PROPERTIES OF POLY(THIOCARBONATES).** Poly(thiocarbonates) with alkyl side chains have been prepared, and the solution properties of these polymers were studied in different solvents. Comparison with other poly(thiocarbonate) analogs and poly(carbonates) shows that the conformational parameter ( $K_\theta$ ) and rigidity factor increase as the volume of the side chain increases. The effect of the side-chain structure on the solution properties is analyzed. (Author abstract) 20 refs.

Gargallo, Ligia (Pontifica Univ Catolica de Chile, Santiago, Chile); Soto, Elia; Tagle, Luis H.; Radic, Deodato. *J Appl Polym Sci* v 35 n 4 Mar 1988 p 1103-1113.

## Spectroscopic Analysis

**081201 SOLID STATE DYNAMICS OF GLASSY POLYCARBONATE-DILUENT SYSTEMS.** The molecular origin of relaxations in glassy polymers remains a subject of considerable discussion. In this work, the sub- $T_g$  motions in bisphenol-A polycarbonate (BPAPC) are investigated with the aid of high-resolution solid state carbon-13 nuclear magnetic resonance (NMR) spectroscopy. The NMR results are correlated with those from dynamic mechanical and dielectric spectroscopies. The multi-technique approach to characterize the solid state dynamics of BPAPC-diluent blends verifies the cooperative nature of micro-Brownian chain motions. (Edited author abstract) 27 refs.

Belfiore, Laurence A. (Colorado State Univ, Fort Collins, CO, USA). *J Elastomers Plast* v 19 n 4 Oct 1987 p 238-251.

**081202 <sup>2</sup>NMR ANALYSIS OF THE MOLECULAR ORIGIN OF THE THERMAL RELAXATIONS IN POLYCARBONATES.** <sup>2</sup>H NMR spectroscopy has been utilized to characterize the molecular dynamics associated with the thermal relaxations in amorphous polycarbonate materials. The methyl and phenyl groups of bisphenol A polycarbonate (BPAPC) and poly(ester carbonates) derived from BPA and tere- or isophthalic acid were independently deuterium labeled so as to characterize the molecular dynamics of each group as a function of temperature. The phenyl motions of both the BPA and terephthalate units were characteristic of 180° ring flips and large angle rocking motions. These motions ceased (relative to 100 KHz) between 40 and -30°C. The terephthalate phenyls were more motionally restricted at temperatures between -30 and 120°C than the BPA phenyls. (Edited author abstract). 12 Refs.

Smith, P.B. (Dow Chemical Co, Midland, MI, USA); Bubeck, R.A.; Bales, S.E. *Macromolecules* v 21 n 7 Jul 1988 p 2058-2063.

## Stability

**081203 POLYCARBONATES (PC).** As amorphous material PC is characterized by a high transmission, high deflection temperature under load (135 to 145°C) high toughness, high dimensional stability and electrical insulation resistance and, as reinforced product, by its stiffness with an even higher dimensional stability. By the addition of fire retardants PCs are resistant to ignition sources of various kind. The curve of the shear modulus versus temperature shows a distinct decrease only above 140°C. The high purity and the negligible migration of additives and colorants lead to a wide range of application in the food packaging sector and in medical technique. For unreinforced thermoplastics the creep modulus is unusually high. Existing or generated stresses are therefore only very slowly reduced by creeping, as compared with other

plastics. Due to the excellent balance of its properties and acceptable expenses, PC offers a wide and steadily growing range of applications. The world production capacity of PC is estimated to be 420000 to 440000 t/a. 10 refs.

Kirchner, K. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 35-37.

**081204 SHRINKAGE AND RELATED RELAXATION OF INTERNAL STRESSES IN ORIENTED GLASSY POLYMERS.** Stability of oriented glassy polycarbonate and poly(ethylene terephthalate) subjected to physical aging has been investigated in terms of shrinkage forces measurements. It was shown that the temperature and time dependent traces of shrinkage forces are very sensitive to the aging effects and when compared with the results of other experiments concerning instabilities of oriented polymers throw some light on the nature of internal stresses relaxation. Observed shrinkage behavior was qualitatively described on the basis of a multi-state mechanical model. (Edited author abstract) 19 refs.

Trznadel, M. (Polish Acad of Sciences, Lodz, Pol); Kryszewski, M. *Polymer* v 29 n 3 Mar 1988 p 418-425.

## Structure See Also MONOMERS—Polymerization.

**081205 RING DYNAMICS IN A CRYSTALLINE ANALOGUE OF BISPHENOL-A POLYCARBONATE.** A polycarbonate has recently been reported. We prepared a deuterated form of this material in the hope that ring flipping could be detected in a system related to polycarbonate for which the molecular conformation and the packing structure are well established. Characterization of motion in the model system may help to differentiate between alternate schemes for motion in the polymer. It is found that at 350 K, most of the rings flip rapidly on the time scale set by the deuterium spectral width. The experimental spectrum was fit reasonably well with the assumption of a single rate constant for ring flipping of  $5.0 \times 10^6$  s<sup>-1</sup>, although the sharp edges of the spectrum signal that some rigid material remains even at the elevated temperature. The spectrum is best fit with a quadrupole coupling interaction slightly reduced in magnitude from that of the rigid crystal form. 6 refs.

Henrichs, P. Mark (Eastman Kodak Co, Rochester, NY, USA); Luss, Henry R. *Macromolecules* v 21 n 3 Mar 1988 p 860-862.

## Synthesis

**081206 POLYMERIZATION BY PHASE TRANSFER CATALYSIS: 6. SYNTHESIS AND THERMAL DEGRADATION OF PHENOLPHTHALEIN POLYTHIOCARBONATE.** Phenolphthalein polythiocarbonate was obtained by phase transfer catalysis using several catalysts and characterized by inherent viscosity, i.e. spectroscopy, differential scanning calorimetry, and thermogravimetric analysis. From the thermogravimetric curve, the kinetics parameters were determined. Glass transition temperature, thermal decomposition temperature, activation energy, and preexponential factor were lower than those determined for the corresponding polycarbonate. (Author abstract) 12 refs.

Tagle, L.H. (Catholic Univ of Chile, Santiago, Chile); Diaz, F.R.; Valdebenito, N. *Polym Bull (Berlin)* v 18 n 6 Dec 1987 p 479-483.

**081207 POLYCARBONATES FROM CYCLIC CARBONATES, CARBANIONS, AND DIHALO COMPOUNDS.** A new route for the synthesis of polycarbonates in reactions of cyclic carbonates with potassium naphthalene and  $\alpha, \omega$ -dihalo compounds is presented. The mechanism of carbonate linkage formation involving 1,3-dioxolan-2-one ring opening is discussed. When oxiranes and CO<sub>2</sub> were used instead of cyclic carbonates a product containing inbuilt polyether segments of various lengths was formed. It was found that the reaction of 'living' polystyrene with cyclic carbonates and dihalo compounds gives products containing polystyrene blocks in the polymer chains. The effects of various agents activating carbonate anions on yield and molecular weight

of polycarbonates are examined. (Author abstract). 13 Refs.

Rokicki, Gabriel (Technical Univ (Politechnika), Warsaw, Pol); Jezewski, Piotr. *Polym J* v 20 n 6 1988 p 499-509.

## Testing See Also PLASTICS—Mechanical Properties; PLASTICS, REINFORCED—Failure.

**081208 FLEXED PLATE IMPACT TESTING V: INJECTION MOULDED POLYCARBONATE DISCS.** A program of impact tests on injection-molded edge gated discs of polycarbonate and on thinner discs derived by a machining operation have shown that the peak force is proportional to the specimen thickness, that a hole through the specimen at the point of impact reduces the strength by about 45% and that a sharp notch induces brittleness. The results are discussed in relation to the test method and in relation to the impact resistance of poly(ether sulphone). Experimental data also prove that a set of stress concentrators can be used in the flexed plate impact method to evaluate and compare materials systematically and to produce 'derating factors' for use in design. The consequential enhanced versatility of the test method has important implications for the future course of impact testing and for the translation of laboratory test data into predictions about serviceability. (Edited author abstract) 6 refs.

Reed, P.E. (Queen Mary Coll, London, Engl); Turner, S. *Plast Rubber Process Appl* v 8 n 3 1987 p 173-179.

## Thermal Properties

**081209 MOTIONAL BEHAVIOR AND CORRELATION TIMES OF NITROXIDE SPIN PROBES IN POLYMERS ABOVE AND BELOW THE GLASS TRANSITION.** The reorientational motions of nitroxide spin probes have been investigated in several polymers above and below the glass transition temperature,  $T_g$ . Three amine-cured epoxy resins having differential cross-link densities and the thermoplastics bisphenol A polycarbonate and poly(dimethylphenylene oxide) were studied. At sub- $T_g$  temperatures from 100 to 300 K the reorientational correlation times were the same for two small spherical probes and one large cylindrical probe in all the epoxy systems. Below  $T_g$  the activation energies for the nitroxide correlation times were typically -11 kJ/mol, whereas above  $T_g$  the corresponding value was 24 kJ/mol after a correction for temperature-dependent changes in free volume. (Edited author abstract) 27 refs.

Sandreczki, T.C. (McDonnell Douglas Research Lab, St. Louis, MO, USA); Brown, I.M. *Macromolecules* v 21 n 2 Feb 1988 p 504-510.

## Welding See Also THERMOPLASTICS—Welding.

**081210 VIBRATION WELDING OF THERMOPLASTICS. PART III. STRENGTH OF POLYCARBONATE BUTT WELDS.** In vibration welding of thermoplastics, frictional work done by vibrating two parts under pressure, along their common interface, is used to generate heat to effect a weld. The main process parameters are the weld frequency, the amplitude of the vibratory motion, the weld pressure, and the weld time or weld penetration. The effects of these parameters on weld quality were systematically studied by butt-welding polycarbonate specimens under controlled conditions over a wide range of process parameters, and then determining the strengths and ductilities of these welds by tensile tests. A significant result is the apparent existence of a weld-penetration threshold above which high weld strengths are attained, but below which the strength drops off. Under the right conditions, the strengths of polycarbonate butt welds are shown to equal the strength of the virgin polymer. (Edited author abstract). 5 Refs.

Stokes, V.K. (GE, Schenectady, NY, USA). *Polym Eng Sci* v 28 n 15 mid-august 1988 p 989-997.



**POLYCHLORINATED BIPHENYLS** See Also ELECTRIC TRANSFORMERS—Maintenance; MARINE BIOLOGY; WATER POLLUTION—Marine Pollution.

**081211 MANAGING PCB SPILLS.** To assist utilities in their efforts to deal with PCBs, three Electric Power Research Institute (EPRI) divisions are sponsoring a wide range of projects. Studies sponsored by the Environmental Control Systems (ECS) Department have addressed PCB spill assessment and remediation. Early work resulted in development of a commercially available portable analyzer capable of identifying the type and concentration of PCBs at a spill site. More recently, efforts have focused on investigating PCB migration in soils to help utilities determine appropriate spill response times, and on investigating and evaluating cleanup technologies for PCB spills on soils and porous surfaces (e.g., asphalt, concrete, and brick). This article discusses such cleanup technologies as in-situ vitrification, soil washing, and mechanical removal.

McLearn, Mary (EPRI, Palo Alto, CA, USA). *Pollut Eng v 20 n 6 Jun 1988 p 50, 52.*

## Accident Prevention

**081212 LES MESURES DE PREVENTION CONTRE LES RISQUES DES PCB.** [Preventive Measures Against PCB Risks]. The harmful effects of PCB's can appear as a result of direct contact by individuals, dispersion in the environment or thermal decomposition. The preventive measures must take into account these three situations. Electrical protection of equipment is important in preventing PCB leakage and thermal decomposition. Fire fighting should allow for the possibility of energization. (Author abstract) In French. 6 refs.

Beau, Philippe (Electricite de France, Fr); Boyer, Michel; Gain, Emile. *RGE Rev Gen Electr n 8 Sep 1987 p 63-66.*

## Accidents

**081213 LA DECONTAMINATION DES SITES ET DES LOCAUX.** [Decontamination of Sites and Premises]. The decontamination of premises following an accident involving PCB's is a difficult operation calling for very careful preparation in order to specify correctly the work to be performed. Such work might call for diversified techniques of which several, according to the situation, might be applied simultaneously or one after another. Especially after a hot pollution situation, numerous precautions must be taken for the protection of the site and staff: above all, the contaminated areas must be isolated, access checked and air movements channelled. The sanction of work after checking and reception is the declassification process which signifies that the site is no longer considered to be dangerous. (Author abstract) In French.

Faisantieu, Daniel (PECSIE, Fr); Lalueque, Didier. *RGE Rev Gen Electr n 8 Sep 1987 p 71-77.*

## Applications

**081214 PCB: LEURS PROPRIETES ET LEURS APPLICATIONS DANS L'ELECTRONIQUE.** [PCBs: Their Properties and Applications in Electrical Engineering]. The polychlorobiphenyls or PCB's have been in industrial production since 1930. Their remarkable properties, especially their chemical stability and non-inflammability, have led to their utilization in numerous industries. After having reviewed the foregoing, the author offers an analysis more particularly as regards the situation in electrical engineering. (Author abstract) In French. 17 refs.

Gervason, Pierre (PRODELEC, Fr). *RGE Rev Gen Electr n 8 Sep 1987 p 5-11.*

## Chemical Analysis

**081215 L'ANALYSE DES PCB DANS L'INDUSTRIE ELECTRIQUE.** [PCB Analysis in the Electrical Industry]. The application of regulations often imposes the identification and titration of PCB's in dielectric fluids,

in various materials and in the environment. There are several methods present - essentially colorimetry and gaseous phase chromatography - but each one has its application field as well as its limits. Although analyses are currently carried out, difficulties exist, notably due to the fact that standardization is insufficient. (Author abstract) In French. 2 refs.

Carballeira, May (Lab Central des Industries Electriques, Fr); Gal, Jean-Yves. *RGE Rev Gen Electr n 8 Sep 1987 p 39-45.*

**081216 DETERMINATION OF BYPRODUCT POLYCHLOROBIPHENYLS IN COMMERCIAL PRODUCTS AND WASTES BY HIGH-RESOLUTION GAS CHROMATOGRAPHY/ELECTRON IMPACT MASS SPECTROMETRY.** A gas chromatography/electron impact mass spectrometry (GC/EIMS) method for the determination of byproduct polychlorobiphenyls (PCBs) measures the recovery of four <sup>13</sup>C-labeled PCBs to assure adequate recovery of the native PCBs from diverse matrices. Byproduct (i.e., non-Aroclor) PCBs differ from most other PCB mixtures in that no recognizable chromatographic pattern can be anticipated. In addition, many matrices may contain similar chlorinated organics. Since diverse sample matrices must be analyzed, various appropriate extraction/cleanup techniques must be applied to each matrix. A set of four <sup>13</sup>C-labeled PCBs are employed as recovery surrogates. Additional aspects of the subject are discussed. (Edited author abstract) 31 refs.

Erickson, Mitchell D. (Midwest Research Inst, Kansas City, MO, USA); Stanley, John S.; Turman, J. Kay; Going, John E.; Redford, David P.; Heggem, Daniel T. *Environ Sci Technol v 22 n 1 Jan 1988 p 71-76.*

**081217 MULTILABORATORY STUDY OF AUTOMATED DETERMINATIONS OF POLYCHLORINATED BIPHENYLS AND CHLORINATED PESTICIDES IN WATER, SOIL, AND SEDIMENT BY GAS CHROMATOGRAPHY/MASS SPECTROMETRY.** Polychlorinated biphenyls (PCBs) and chlorinated pesticides were determined in two water, three soil, and two sediment samples by six laboratories that used uniform calibration solutions and analytical procedures. Target analytes were identified and measured with special software operating on minicomputers that controlled mass spectrometer operation. PCBs were determined by level of chlorination, not as Aroclor formulations. All samples, except one soil sample, were fortified with pesticides. Water samples were fortified with PCBs (mixtures of Aroclors), but solid samples were known to be environmentally contaminated with PCBs. Results obtained with four combinations of extraction and analyte enrichment procedures (cleanup) for solid samples were compared, but no combination could be selected as best for all five samples. Several factors affecting data quality were identified. (Author abstract) 6 refs.

Alford-Stevens, Ann L. (US EPA, Cincinnati, OH, USA); Eichelberger, James W.; Budde, William L. *Environ Sci Technol v 22 n 3 Mar 1988 p 304-312.*

## Chemical Reactions

**081218 OCTANOL-WATER PARTITION COEFFICIENTS OF POLYCHLORINATED BIPHENYL CONGENERS.** Octanol-water partition coefficients ( $K_{ow}$ ) for 13 polychlorinated biphenyl (PCB) congeners were accurately determined by the generator column technique. These values were used to confirm a highly significant linear relationship between  $\log K_{ow}$  and the logarithm of the relative retention time on a nonselective gas chromatographic stationary phase. The total surface areas (TSA) for all the PCB congeners were determined by assuming planar molecules, van de Waal's radii for component atoms, and appropriate values for solvent radius, bond angles, and distances. The TSA was highly significantly correlated with  $\log K_{ow}$  and the relationship used to calculate  $\log K_{ow}$  values for all the PCB congeners. Further development of these relationships gave an expression for aqueous solubility which can be used to calculate the solubility for those PCB's where

appropriate data are available. (Author abstract) 43 refs.

Hawker, Darryl W. (Griffith Univ, Nathan, Aust); Connell, Des W. *Environ Sci Technol v 22 n 4 Apr 1988 p 382-387.*

## Chemistry

**081219 EXPERIMENTALLY DETERMINED HENRY'S LAW CONSTANTS FOR 17 POLYCHLOROBIPHENYL CONGENERS.** Henry's law constants (HLCs) have been experimentally determined for 17 polychlorobiphenyl (PCB) congeners by a gas-purging technique, with results ranging from  $0.3 \times 10^{-4}$  to  $8.97 \times 10^{-4}$  atm·m<sup>3</sup>/mol and an average value of  $3.53 \times 10^{-4}$  atm·m<sup>3</sup>/mol for the congeners studied. The experimental results are in good agreement with previously published values. For the entire group of congeners studied, measured HLCs were not correlated with molecular weight but did appear directly related to chlorine substitution pattern. Increasing HLCs coincided with greater degrees of ortho-chlorine substitution within a molecular weight class. This trend may be useful to relate individual HLCs to chlorine substitution patterns for the remaining PCB congeners. (Author abstract) 30 refs.

Dunnivant, Frank M. (Clemson Univ, Clemson, SC, USA); Coates, John T.; Eizerman, Alan W. *Environ Sci Technol v 22 n 4 Apr 1988 p 448-453.*

## Chromatographic Analysis See Also LUBRICANTS—Additives.

**081220 SOLVENT REMOVAL/THERMAL DESORPTION (SRTD) FOR EXTRACT CONCENTRATION AND CAPILLARY COLUMN INJECTION.** Many solvent extracts must be concentrated prior to analysis. Both Kuderna-Danish (K-D) concentration and inert gas blowdown are commonly used. Significant losses often occur with the latter. Solvent removal/thermal desorption (SRTD) on a precolumn was investigated as an alternative or supplement to these methods. The compounds studied included polychlorinated biphenyls (PCBs) and polybrominated biphenyls (PBBs). The mean total recoveries and mean standard errors obtained were 109 and  $\pm 12\%$ , respectively. SRTD was found to give sharper peaks than were obtainable with on-column injection. (Edited author abstract) 39 refs.

Hart, K.M. (Oregon Graduate Cent, Beaverton, OR, USA); Pankow, J.F. *HRC & CCJ High Resolut Chromatogr Chromatogr Commun v 10 n 9 Sep 1987 p 484-492.*

**081221 ANALYSE DE PCB PAR CHROMATOGRAPHIE EN PHASE GAZEUSE.** [PCB Analysis by Gaseous Phase Chromatography]. Gaseous phase chromatography is certainly the best analysis method for PCB's. The article describes the equipment and operating modes used, and then specifies the conditions applicable to various cases that might be encountered, such as mixtures of PCB families, mineral oils and other insulating fluids, analysis in water, soils and other materials. (Author abstract) In French. 14 refs.

Grob, Robert (Ecole Natl Supérieure de Chimie de Toulouse, Fr). *RGE Rev Gen Electr n 8 Sep 1987 p 55-62.*

**081222 DETERMINATION OF POLYCHLORINATED BIPHENYLS IN SEDIMENT BY ON-LINE NARROW-BORE COLUMN LIQUID CHROMATOGRAPHY/CAPILLARY GAS CHROMATOGRAPHY.** Narrow-bore column liquid chromatography coupled on-line with capillary gas chromatography (LC/GC) is used for the determination of polychlorinated biphenyls (PCBs) in sediment via a heart-cutting technique. This method is compared with a method in which two off-line column clean-up steps are used with subsequent analysis by capillary gas chromatography. For the LC/GC analysis the recovery of PCBs was 90-100%.



For two sediment samples from the river Meuse the LC/GC and the other, more laborious method showed good agreement. (Author abstract) 17 refs.

Maris, F.A. (Free Univ, Amsterdam, Neth); Noroozian, E.; Otten, R.R.; van Dijk, R.C.J.M.; de Jong, G.J.; Brinkman, U.A.Th. *HRC & CC J High Resolut Chromatogr Chromatogr Commun* v 11 n 2 Feb 1988 p 197-202.

## Cleaning

**081223 CONTROLLING SOLVENT LOSSES.** With the advent of legislation on their production and use, it is important that CFC-113 and other solvents used in PCB cleaning operations are handled in such a way as to minimise wastage. The author offers some guidelines to help users reduce emissions and operate their plants more economically. He discusses installation or movement of industrial cleaning equipment, storage and transfer of solvents, and operation of the cleaning plant. (Edited author abstract).

Campbell, Nick. *Electron Prod (London)* v 17 n 6 Jun 1988 p 48-49.

## Combustion

**081224 LA DESTRUCTION DES PCB: LE PROCEDE PAR INCINERATION.** [Destruction of PCBs: Incineration Process]. Destruction of PCB's or equipment comprising PCB's, without environmental pollution can be efficiently carried out by decontamination and incineration under proper conditions. The paper points out the parameters allowing a good incineration and describes TREDI company's facilities. (Edited author abstract) In French.

Milleret, Georges (TREDI). *RGE Rev Gen Electr* n 8 Sep 1987 p 151-155.

## Decomposition

**081225 EFFICIENCIES OF ALUMINUM, MAGNESIUM, AND THEIR OXIDES IN THE DESTRUCTION OF VAPOR-PHASE POLYCHLOROBIPHENYLS.** The destruction efficiencies of aluminum metal and oxide surfaces toward polychlorobiphenyls (PCBs) and related systems, including decachlorobiphenyl and hexachlorobenzene, have been measured from 500 to 800°C. Chlorocarbon destruction efficiencies > 99.99% were frequently obtained. The principal reaction products were aluminum chloride and carbonaceous char. It is proposed that metals showing the most effective dechlorination activities toward PCBs are those that have the highest standard heats of formation for the metal chlorides. (Edited author abstract) 7 refs.

Anderson Ross, Robert (Alcan Int Ltd, Kingston, Ont, Can); Lemay, Rejean. *Environ Sci Technol* v 21 n 11 Nov 1987 p 1115-1118.

## Decontamination

**081226 TECHNICAL/ECONOMIC ASSESSMENT OF SELECTED PCB DECONTAMINATION PROCESSES.** Eleven emerging alternative treatments for polychlorinated biphenyl (PCB) contaminated sediments have been compared and ranked using technical performance, status of development, test and evaluation data needs, and cost as factors. The emerging treatment processes are based on six different technologies: one on low-temperature oxidation, two on chlorine removal, one on pyrolysis, three on removing and concentrating, one on vitrification, and three on microorganisms. Types of technologies not developed are chlorinolysis, stabilizing, and enzymes. On the basis of the comparisons made, the treatment processes were ranked in the following order from highest to lowest: KPEG, LARC, Acurex, Bio-Clean, Supercritical Water, Advanced Electric Reactor, Vitrification, OHM Extraction, Soilex, Composting, and Dybron Bi-Chem 1006. (Edited author abstract) 88 refs.

Carpenter, Ben H. (Research Triangle Inst, Research Triangle Park, NC, USA); Wilson, Donald L. *J Hazard*

*Mater* v 17 n 2 Feb 1988 p 125-148.

## Degradation

**081227 ZUR ENTGIFTUNG VON POLYCHLORIRERTEN BIPHENYLEN UND DIBENZODIOXINEN - EINE UBERSICHT.** [Detoxification of Polychlorinated Biphenyls and Dibenzodioxins - A Review]. A review is given on the state of the art for the destruction and detoxification of polychlorinated biphenyls (PCB) and polychlorinated dibenzo-p-dioxins (PCDD) including thermal and chemical techniques, photolytic, radiolytic and catalytic processes, destruction in supercritical fluids, and biochemical degradation. (Edited author abstract) In German. 71 refs.

Martinetz, Dieter (Akad der Wissenschaften der DDR, Leipzig, East Ger). *Chem Tech (Leipzig)* v 39 n 11 Nov 1987 p 466-470.

## Dehalogenation

**081228 BOROHYDRIDE, MICELLAR, AND EXCIPIEX-ENHANCED DECHLORINATION OF CHLOROBIPHENYLS.** The photodechlorination of polychlorinated biphenyls (PCBs) has been studied in the presence of sodium borohydride, detergents, and excipient-forming additives. In a family of 13 representative PCBs these variations generally led to a dramatically increased rate of photodegradation. Further, the products of photoreaction in the presence of sodium borohydride are more cleanly the simple dechlorinated aromatics, with fewer side reactions than observed with ordinary photolysis. (Author abstract). 32 Refs.

Epling, Gary A. (Univ of Connecticut, Storrs, CT, USA); Florio, Emily M.; Bourque, Andre J.; Qian, Xhi-Hong; Stuart, James D. *Environ Sci Technol* v 22 n 8 Aug 1988 p 952-956.

**081229 DEGRADATION AND DEHALOGENATION OF POLYCHLOROBIPHENYLS AND HALOGENATED AROMATIC MOLECULES BY SUPER-OXIDE ION AND BY ELECTROLYTIC REDUCTION.** Polyhalogenated aromatic hydrocarbons (e.g., PCB's and hexachlorobenzene) are rapidly degraded by superoxide ion in dimethylformamide to carbonate and halide ions. The efficient destruction of such materials is accomplished via the in situ electrolytic reduction of dissolved oxygen to generate superoxide ion, which reacts with polyhalo aromatics by nucleophilic substitution. The reaction stoichiometries have been determined by cyclic voltammetric measurements, and the reactant/product profiles have been assayed by capillary gas chromatography and potentiometric titrations. Study results are discussed. Electrochemical studies confirm that all PCB's can be dehalogenated via anaerobic electrolysis. (Edited author abstract). 24 Refs.

Sugimoto, Hiroshi (Texas A&M Univ, College Station, TX, USA); Matsumoto, Shigenobu; Sawyer, Donald T. *Environ Sci Technol* v 22 n 10 Oct 1988 p 1182-1186.

Desorption See SEDIMENTATION—Suspensions.

Environmental Impact See Also HYDROCARBONS—Environmental Impact.

**081230 L'EMPLOI DES PCB DANS LES TRANSFORMATEURS ELECTRIQUES PRESENTE-T-IL DES RISQUES?** [Are There Risks Involved in the Use of PCBs in Electric Transformers?]. By means of a historical review, the authors recount the problems raised by the operation of PCB transformers following the revelations in 1966 of environmental pollution by these compounds, and then the discovery of the presence of furans and dioxins in a building in Binghamton (1981). Basing themselves on an analysis of transformer failures occurring during operation, the authors examine the risks that the environment runs in the presence of furans and dioxins as well as those of the PCB's. The reader is reminded that such other furan and dioxine sources - as incinerators, herbicides, chlorophenols - and organo-chlorinated products comparable to the PCB's (DDT, di-

drine) represent ecological and public health problems that are far more worrisome than those arising from transformer operation. (Author abstract) In French. 66 refs.

Fournie, Robert (Electricite de France, Fr); Peyrichou, Francois. *RGE Rev Gen Electr* n 8 Sep 1987 p 13-22.

**081231 COMPARISON OF SOME SPECIFIC POLYCHLORINATED BIPHENYL ISOMERS IN HUMAN AND MONKEY MILK.** This paper compares the relative amounts of 29 selected PCB isomers in human and monkey milk samples. The selection of isomers was based on the most prevalent PCB isomers in human milk as reported by S. Safe et al. and represented approximately 80% of all reported isomers. In addition, Aroclor 1254, whose toxicity in monkeys has been investigated recently by several investigators was analyzed for the same 29 selected PCB isomers. Study materials, methods and results are discussed. 11 refs.

Mes, Jos (Health & Welfare Canada, Ottawa, Ont, Can); Marchand, Lorrie. *Bull Environ Contam Toxicol* v 39 n 5 Nov 1987 p 736-742.

**081232 POLYCHLORINATED BIPHENYLS IN BLUE CRABS FROM SOUTH CALIFORNIA.** During the spring of 1985, commercial crab fishermen in Beaufort County, South Carolina contacted the South Carolina Wildlife and Marine Resources Department (SCWMD) concerning their perceptions of significantly declining catch rates. Using knowledge of previously documented elevated polychlorinated biphenyls (PCB) levels in the sediments of the upper portion of Campbell Creek the SCWMD initiated analysis of crab tissue from the area to ascertain the body burdens of PCBs. The subsequent work reported here was conducted between June and October 1985. The initial response by SCWMD to concerns of local commercial crabbers documented the presence of PCBs in the backfin tissue of crabs from the Campbell Creek area. The expanded sampling effort indicated that the PCB contamination of crab tissue was a near-field effect in Campbell Creek related to the off-marsh industrial facility operations. Additional aspects of the study are discussed. 10 refs.

Marcus, James M. (South Carolina Dep of Health & Environmental Control, Columbia, SC, USA); Mathews, Thomas D. *Bull Environ Contam Toxicol* v 39 n 5 Nov 1987 p 857-862.

**081233 PCB CONCENTRATIONS IN WINTER FLOUNDER FROM LONG ISLAND SOUND, 1984-1986.** PCBs (polychlorinated biphenyls) pollutants of concern in Long Island Sound have been studied previously. Initial studies at this laboratory focused on levels of PCBs and metals in tissues from windowpane flounder (*Scophthalmus aquosus*) collected from various stations in the Sound. In the present study, winter flounder (*Pseudopleuronectes americanus*) were collected from several stations in Long Island Sound and the gonads and livers analyzed for PCBs. Winter flounder were selected because they are both commercially and recreationally important in northeast Atlantic waters, including Long Island Sound. Study materials, methods and results are discussed. 8 refs.

Greig, Richard A. (Natl Marine Fisheries Service, Milford, CT, USA); Sennfelder, George. *Bull Environ Contam Toxicol* v 39 n 5 Nov 1987 p 863-868.

**081234 PCB PROBLEMS IN THE FUTURE: FORESIGHT FROM CURRENT KNOWLEDGE.** From a global point of view, PCB levels in the environmental media and biota are unlikely to decline in the near future due to the greater quantities of PCBs still in use than the quantity that has already escaped into the open environment. Considering all the information on the occurrence, distribution and behaviour of PCBs in the ecosystems, the marine mammals are probably the most vulnerable and possible target organisms in forthcoming long-term PCB toxicity. The recent isomer-specific analy-



ses suggest that the intrinsic toxicity of PCBs principally resulted from the coplanar PCB congeners which may impose a greater toxic threat than chlorinated dioxins and furans to humans and wildlife. (Edited author abstract) 130 refs.

Tanabe, Shinsuke (Ehime Univ, Matsuyama, Jpn). *Environ Pollut* 1987 v 50 n 1-2 1988 p 5-28.

**081235 PCBs IN THE ENVIRONMENT.** Polychlorinated biphenyls (PCBs) were extensively used in electrical equipment as lubricants, coolants and as fireproofing agents until their toxicity and persistence were recognised in 1966. PCBs are no longer manufactured in the UK but we have a legacy of production and other wastes. This article describes the first attempt to assess the scale of UK environmental pollution by PCBs. (Author abstract) 28 refs.

Edujee, G.H. (Environmental Resources Ltd, London, Engl). *Chem Br* v 24 n 3 Mar 1988 p 241, 243-244.

**081236 POLYCHLORINATED BIPHENYLS IN FISH-EATING SEA BIRDS - MOLECULAR FEATURES AND METABOLIC INTERPRETATIONS.** Residue analysis of the adipose tissue of five species of fish-eating sea birds from British and Irish coastal waters revealed the presence of up to 60 different congeners. It was possible to identify and quantify 40 different congeners. Despite the large number of PCB congeners identified only 10 accounted for >80% of the total PCBs. A PCB congener was identified accounting for 5% of the total PCBs (2,3',4,4',5',6-hexachlorobiphenyl) not usually reported in biological samples. Comparison of the molecular structure for the persistent PCB congeners revealed the lack of meta-para unsubstituted adjacent carbon atoms. It has been shown that meta-para unsubstituted adjacent carbon atoms facilitate the metabolism of PCBs and it is hypothesised that the formation of hydroxy derivatives may depend upon such a requirement. (Edited author abstract) 9 refs.

Borlakoglu, J.T. (Univ of Reading, Reading, Engl); Wilkins, J.P.G.; Walker, C.H. *Mar Environ Res* v 24 n 1-4 1988, Fourth Int Symp on Responses of Mar Org to Pollut, Woods Hole, MA, USA, Apr 22-24 1987 p 15-19.

## Environmental Testing

**081237 DISPOSITION OF TOXIC PCB CONGENERS IN SNAPPING TURTLE EGGS: EXPRESSED AS TOXIC EQUIVALENTS OF TCDD.** Toxicological studies have demonstrated that the most toxic PCB congeners, isosteromers of tetrachlorodibenzo-p-dioxin (TCDD), require no metabolic activation. The structures of PCB congeners and isomers which favor induction of cytochrome P-448 are also those which are toxic and resist metabolism. These compounds possess a minimum of four chlorine atoms and therefore highly lipophilic. This paper reports on a study to determine if the heavy fat bodies of the female turtle provide a sufficiently large sink to retain the toxic congeners and prevent their incorporation into the eggs. Study materials, methods and results are discussed. 13 refs.

Bryan, A.M. (State Univ of New York at Albany, Albany, NY, USA); Stone, W.B.; Olafsson, P.G. *Bull Environ Contam Toxicol* v 39 n 5 Nov 1987 p 791-796.

**081238 DEPOSITION AND EVAPORATION OF POLYCHLOROBIPHENYL CONGENERS TO AND FROM SISKIWIIT LAKE, ISLE ROYALE, LAKE SUPERIOR.** The relative importance of polychlorobiphenyl (PCB) transport into and out of lakes was studied by constructing a mass balance of PCB congeners in Siskiwit Lake, a remote lake in the Isle Royale National Park in Lake Superior. Measurements of winter and summer air, rain, snow, water, and sediments were obtained over several months and used to determine PCB fluxes to and from the lake, assuming steady-state conditions over 1 year. By solving the mass balance equation under selected conditions, we estimated the deposition velocity and the overall liquid water-to-air mass transfer coefficient for PCBs to be 0.16 cm/s and 0.1 m/day,

respectively. Wet deposition was generally 3 times as great as dry deposition and was dominated by particle washout. Removal from the lake by volatilization was more important than sedimentation for most congeners. (Author abstract) 62 refs.

Swackhamer, Deborah L. (Indiana Univ, Bloomington, IN, USA); McVeety, Bruce D.; Hites, Ronald A. *Environ Sci Technol* v 22 n 6 Jun 1988 p 664-672.

## Fires

**081239 PCBs IN ELECTRICAL EQUIPMENT - A GROWING CONCERN.** Polychlorinated biphenyls, better known as PCBs, have been widely used in power distribution systems and electrical equipment. They are part of the family of synthetically manufactured organic chemicals known as chlorinated hydrocarbons. They were once prized for their stability and fire resistance before it was discovered that when PCBs are exposed to heat or flames producing temperatures ranging from 570 to 1100 degrees Fahrenheit (and some scientists report at temperatures at or below 300 degrees F.) they form extremely toxic substances. Electrical equipment containing 50 parts per million (ppm) or greater of PCBs located in or near a facility can pose a serious risk to that facility, and its occupants in the event they become involved in a fire. 24 refs.

Alderman, Forrest R. *Prof Saf* v 32 n 5 May 1987 p 13-16.

## Legislation

**081240 LA REGLEMENTATION DES PCB. [PCB Regulations].** Over the past twelve years or so, more than twenty legislative and regulatory texts, as much European as French have been published on PCB's. Essentially, the texts are intended for the prevention of accidents and to limit consequences thereof - this includes management and destruction of wastes - as well as protection of the workers. This article contains an analysis of these texts or at least their principal provisions. These are presented in resume form in a table appearing in the appendix. (Author abstract) In French. 21 refs.

Delpirou, Dominique (Electricite de France, Fr); Coin, Remy. *RGE Rev Gen Electr* n 8 Sep 1987 p 79-82.

## Manufacture

**081241 ADDITIVE LEITERPLATTENHERSTELLUNG. [Manufacturing PCBs by the Additive Process].** Starting point for manufacturing PCBs by the additive process are base materials coated with bonding agents, viz. phenol resin paper laminates, epoxy resin laminates. They are similar to those used for the subtractive system, except that the laminates are not coated with copper but with a bonding agent. Details of the process are explained by drawing comparison with the semiadditive system. (Author abstract) In German. 5 refs.

Steffen, H. *F&M Feinwerktech Messtech* v 96 n 3 Mar 1988 p 95-97.

## Oxidation

**081242 CATALYTIC OXIDATION OF POLYCHLORINATED BIPHENYLS IN A MONOLITHIC REACTOR SYSTEM.** Air containing 200-1000 ppm of Aroclor 1254 vapors [a mixture of polychlorinated biphenyls (PCBs)] was passed through a 22.86 cm long heated section of 0.64 cm i.d. monolithic  $\alpha$ -alumina support, which had been previously treated with one or more catalytic agents. At 600°C, with a residence time of about 9.4 s, results showed that the overall PCB destruction efficiency ranged from a high of 97.3% for supported CuO to a low of 69.3% for Cr<sub>2</sub>O<sub>3</sub>. Supported catalysts of Co<sub>3</sub>O<sub>4</sub>, CuCr<sub>2</sub>O<sub>4</sub>, and Pt-Pd were intermediate in activity. Relative activity for this group of p-type catalysts in deep oxidation was in accordance with Sabatier's principle, decreasing with increasing heats of O<sub>2</sub> chemisorption. Selectivity toward oxidation of the more toxic high-chlorine-containing PCBs was found to be greater for catalysts made from transition metal oxides than for noble metal

systems or homogeneous (thermal) decomposition. (Author abstract) 15 refs.

Subbanna, Prasad (Univ of Akron, Akron, OH, USA); Greene, Howard; Desai, Fareedoon. *Environ Sci Technol* v 22 n 5 May 1988 p 557-561.

## Solubility

**081243 AQUEOUS SOLUBILITY OF POLYCHLORINATED BIPHENYLS RELATED TO MOLECULAR STRUCTURE.** Aqueous solutions of polychlorinated biphenyls show a linear relationship between logarithms of aqueous activity coefficients and total surface areas (TSA) or total molecular volumes (TMV). The aqueous activity coefficients were calculated from experimental solubility data and values taken from the literature. The correlations improved substantially if a differential heat capacity between supercooled liquid and solid chemical equal to the entropy of fusion was assumed. In addition, it was found that dissolution of 2,2',4,4'-tetra- and 2,2',4,4',5,5'-hexachlorobiphenyl was accompanied by positive enthalpy and entropy changes, the entropy being dominant at room temperature. Additional study results are discussed. (Edited author abstract) 65 refs.

Oppehuizen, Antoon (Univ of Amsterdam, Amsterdam, Neth); Gobas, Frank A.P.C.; Van der Steen, Jan M.D.; Hutzinger, Otto. *Environ Sci Technol* v 22 n 6 Jun 1988 p 638-646.

## Sorption

**081244 SORPTION AND DESORPTION DYNAMICS OF AROCLOR 1242 TO NATURAL SEDIMENT.** Sediment sorption and desorption processes are important in determining the movement and fate of persistent organic compounds in aquatic systems. Batch experiments show that after an initial one week uptake period, continual release of Aroclor 1242 from sediment occurs over a six-month period. These observations suggest that a two-stage kinetic model, rather than the conventional equilibrium model, is more appropriate for representing sediment uptake and release processes. Additional batch studies were used to measure short- and long-term rate coefficients for these processes. Simulation studies, with multiple sediment and contaminant inputs, indicate that over a 16-day period a kinetic model better matches the experimental data than do three other equilibrium-based sorption/desorption models. (Edited author abstract). 50 Refs.

Witkowski, Patrick (Princeton Univ, Princeton, NJ, USA); Jaffe, Peter; Ferrara, Raymond. *J Contam Hydrol* v 2 n 3 Jul 1988 p 249-269.

## Spectroscopic Analysis

**081245 DIRECT QUANTITATION OF PCB CONGENERS USING A HELIUM DISCHARGE DETECTOR AND INTERNAL STANDARD TECHNIQUES.** Individual PCB congeners have been quantitated at ppm levels, with an average error of  $\pm 3.2\%$ , with the use of a helium discharge detector (HDD) for element-selective detection of Cl emission. Chlorinated internal standards of known concentrations were added to each solution determined to establish the relative peak areas per unit concentration of Cl present. No detector precalibration or response factor formulations were required, since the detector response is based solely on the moles of Cl present. The same methodology was utilized to determine the % Cl in Aroclor samples without prior identification of the PCB congeners present. (Author abstract) 18 refs.

McAteer, Peter J. (Coll of William & Mary, Williamsburg, VA, USA); Ryerson, Tom B.; Argentine, Mark D.; Ware, Margaret L.; Rice, Gary W. *Appl Spectrosc* v 42 n 4 May-Jun 1988 p 586-588.

**Toxicity** See Also INSULATING OIL—Oxidation; LIQUIDS—Dielectric Properties.

**081246 HIGHLY TOXIC COPLANAR PCBs: OCCURRENCE, SOURCE, PERSISTENCY AND**



**TOXIC IMPLICATIONS TO WILDLIFE AND HUMANS.** Isomer-specific determinations of PCB congeners in a wide variety of animal species such as fish, marine mammals (whale, dolphin and porpoise) and terrestrial mammals (dog, cat and human) revealed the environmental occurrence of highly toxic coplanar 3,3',4,4'-tetrachlorobiphenyl (T<sub>4</sub>CB), 3,3',4,4', 5-pentachlorobiphenyl (P<sub>5</sub>CB) and 3,3',4,4',5,5'-hexachlorobiphenyl (H<sub>6</sub>CB) within a range of few pg g<sup>-1</sup> to several ten ng g<sup>-1</sup> in fat tissues (except fish) on a wet weight basis. The sources of coplanar PCB contamination to the environment are mainly commercial PCB preparations. Marine mammals seem to have lower potency to metabolize the coplanar PCBs in comparison with terrestrial mammals. In human adipose tissues, the concentrations of coplanar PCBs were found to be much higher than 2,3,7,8-tetrachlorodibenzo-p-dioxin (T<sub>4</sub>CDD), 2,3,4,7,8-pentachlorodibenzofuran (P<sub>5</sub>CDF) and other toxic congeners. 'T<sub>4</sub>CDD-equivalent' analysis based on the enzyme induction potencies and the residues of these toxic chemicals indicates that 3,3',4,4',5-P<sub>5</sub>CB may impose a greater toxic threat than dioxins and furans to the humans and probably to wildlife also. (Edited author abstract) 31 refs.

Tanabe, S. (Ehime Univ, Matsuyama, Jpn); Kannan, N.; Subramanian, A.; Watanabe, S.; Tatsukawa, R. *Environ Pollut* (1987) v 47 n 2 1987 p 147-163.

**081247 LES PCB ET LEURS PRODUITS DE DECOMPOSITION — THERMIQUE: PEUT-ON EVALUER UN SEUIL DE TOXICITE? [Can a Toxicity Threshold be Assessed for PCBs and Their Decomposition Products?].** After offering an account of the experimental toxicological properties of PCBs, polychlorobiphenyls (PCB), polychlorodibenzodioxins (PCDD) and polychlorodibenzofurans (PCDF), the author takes up the problem of extrapolation to man of the experimental results obtained on animals. The large number of isomers, displaying highly-different toxicological intensities, and the large dispersion of the sensitivities of the animals tested render uncertain a quantitative assessment of toxic risk for man, especially as regards PCDD's and PCDF's. (Author abstract) In French. 40 refs.

Millischer, Rene-Jean (Toxicologie Industrielle, Fr). *RGE Rev Gen Electr* n 8 Sep 1987 p 23-37.

**081248 SURVEILLANCE MEDICALE DES TRAVAILLEURS EXPOSES AUX PCB.** [Medical Surveillance of Workers Exposed to PCBs]. Medical surveillance is indispensable for workers likely to be exposed professionally to PCB's or their deterioration products due to these workers' daily activities or as a result of accidents. Such surveillance consists, first, of removal from exposed employment of those individuals who display certain counter-indications and then the conduct of periodical visits and examinations of various nature. (Author abstract) 4 refs.

Folliot, Dominique (EDF, Fr). *RGE Rev Gen Electr* n 8 Sep 1987 p 68-69.

**081249 TOXIC EFFECTS OF PCBs AND RELATED COMPOUNDS IN HUMANS AND ANIMALS.** For the general public, the expression PCBs is synonymous with danger. Given their persistence in the environment and in living organisms, people fear their effects on health and more specifically their consequences for reproduction and breast-fed babies, and their carcinogenic effects. The greatest health risk is fire in equipment insulated with PCBs, incomplete combustion of which leads to the formation of substances deemed to be extremely toxic, primarily furans and, where there is an associated solvent (polychlorobenzene), dioxins. In light of documentation available on PCBs, their contaminants and combustion products, this article attempts to answer a number of questions about the persistence of these products in the environment and their toxicity for humans. (Edited author abstract)

Carrier, G. (Maisonnette-Rosemont Hospital, Montreal, Que, Can). *Pulp Pap Can* v 88 n 10 Oct 1987 p 79-82.

**081250 POLYCHLORINATED BIPHENYLS: A TOXICOLOGICAL REVIEW.** This report discusses the chemical and physical properties of PCBs, their biological disposition, and their reported toxicologic effects including carcinogenic potential. Specific comparisons are made between toxicity of PCBs in animals with effects observed in humans following exposure. Other areas covered include governmental regulation and permissible levels of exposure. Indeed, as a result of passage of the Toxic Substances Control Act in 1976, Congress singled out PCBs for regulation as required by law and the U.S. EPA banned further production in 1979. It is concluded that there are significant adverse effects of PCBs when administered to animals under laboratory conditions. However, with the exception of the development of chloracne, there is little evidence suggesting significant toxicity to man including carcinogenic effects resulting from the chronic exposure to PCBs in the workplace or environment. (Edited author abstract) 120 refs.

George, Camille J. (Tulane Univ, New Orleans, LA, USA); Bennett, Gary F.; Simoneaux, Denise; George, William J. *J Hazard Mater* v 18 n 2 May 1988 p 113-144.

## Trace Analysis

**081251 DETERMINATION OF POLYCHLORINATED BIPHENYLS IN HUMAN FOODSTUFFS AND TISSUES: SUGGESTIONS FOR A SELECTIVE CONGENER ANALYTICAL APPROACH.** Based on a literature review of the occurrence of polychlorinated biphenyl (PCB) congeners in commercial formulations, environmental and biological samples and human tissues, and a consideration of the relative toxicity and persistence of the congeners, suggestions are made as to the most relevant components to be quantified by a selective congener analytical approach to human foodstuffs and tissues. These criteria suggest congener numbers 28, 74, 77, 99, 105, 118, 126, 128, 138, 153, 156, 169, 170, 179 and 180 will give a measure of > 70% of the total PCB tissue burden in a sample and be of greatest toxicological significance. Additionally, congeners 8, 37, 44, 49, 52, 60, 66, 70, 82, 87, 101, 114, 158, 166, 183, 187 and 189 are considered because of their reported occurrence or toxicity. (Author abstract) 58 refs.

Jones, K.C. (Univ of Lancaster, Lancaster, Engl). *Sci Total Environ* v 68 Jan 1988 p 141-159.

## Transportation

**081252 TRANSPORT OF POLYCHLORINATED BIPHENYLS (PCBs) IN FRESHWATER MESOCOSMS FROM SEDIMENT TO WATER AND AIR.** With sediment as a source the flux of PCBs to water and air was followed in mesocosms with and without fish for two vegetation seasons. The fish represented the largest lipid pool in the mesocosm, and their presence increased the flux of PCBs across the sediment/water interface. The flow of PCBs from sediment to water followed a seasonal pattern with higher rates during summer than in the winter. The rates were governed by the turbation activity of benthic invertebrates, the extent of gas production in the sediment, the amount and quality of the lipid pools in the water column, and the solubility of the PCBs. The greatest amount of PCBs among the lipid pools was found in the dissolved extractable lipids, which also showed the highest concentration of PCBs calculated on a lipid basis. After about 1.5 yr, > 90% of the PCBs added was still in the sediment. (Edited author abstract) 44 refs.

Larsson, Per (Univ of Lund, Lund, Swed); Sodergren, Anders. *Water Air Soil Pollut* v 36 n 1-2 Nov 1987 p 33-46.

## Waste Disposal

**081253 DESTRUCTION DES PCB: PROCEDES EN COURS DE DEVELOPPEMENT.** [PCB Destruction: Processes Now Under Development]. Aside from incineration cited elsewhere in this issue, numerous destruction processes for PCB have been the subject of research and testing in different countries without resulting as yet in industrial applications. Those considered are either ther-

mal methods (plasma, vapor-cracking, pyrolysis, vitrification, etc.) or chemical or biotechnical methods. (Edited author abstract) In French. 6 refs.

Groo, Jean-Paul (Societe des Techniques en Milieu Ionisant, Fr). *RGE Rev Gen Electr* n 8 Sep 1987 p 156-162.

**POLYELECTROLYTES** See Also COLLOIDS—Flocculation; COLLOIDS—Glass; COLLOIDS—Structure; ELECTROLYTES—Materials; MONOMERS—Polymerization; POLYSTYRENES—Encapsulation; PROTEINS—Precipitation; SUSPENSIONS—Flocculation; WASTEWATER—Treatment; WATER TREATMENT—Flocculation.

**081254 ADIABATIC COMPRESSIBILITY AND APPARENT MOLAL VOLUME OF IONIC MONOMERS, POLYMERS, AND COPOLYMERS IN AQUEOUS AND NONAQUEOUS SOLUTIONS.** In this review we are primarily concerned with the use of apparent molal volume and apparent molal compressibility of polyelectrolytes along with their corresponding monomers in elucidating the ion-ion and ion-solvent interactions in aqueous and nonaqueous solutions. Though the main emphasis will be given to synthetic polyelectrolytes, the biochemical significant (natural) ones are not excluded. Most of the works on molal volumes and ultrasonic velocity measurements were confined to solutions of simple electrolytes. These works gave valuable information about the structure of solutions as well as about the fundamental properties of solutions. 80 refs.

Roy-Chowdhury, Phanibhusan (Natl Chemical Lab, Poona, India). *J Macromol Sci Rev Macromol Chem Phys* v C27 n 2 May 1987 p 219-252.

**081255 ELECTROCHEMICAL MEASUREMENT OF TRANSFERENCE NUMBERS IN POLYMER ELECTROLYTES.** Electrochemical methods for the determination of transference numbers in polymer electrolytes are considered and a new technique which overcomes some of the problems associated with other methods in current use is described. Results are given of measurements of the transference numbers of lithium and trifluoromethanesulfonate ions in poly(ethylene oxide) at 90°C. A mean value of 0.46±0.02 is reported for lithium. (Author abstract) 17 refs.

Evans, James (Univ of St. Andrews, St. Andrews, Scotl); Vincent, Colin A.; Bruce, Peter G. *Polymer* v 28 n 13 Dec 1987 p 2324-2328.

**081256 NON-STOICHIOMETRIC POLYELECTROLYTE COMPLEXES OF POLYACRYLIC ACID AND CATIONIC SURFACTANTS.** The macromolecular reactions of cationic surfactants with polyacrylic acid have been studied. In acid media (pH 3) as a result of these reactions non-stoichiometric PECs of constant composition insoluble in aqueous media form. In neutral and weakly alkaline media (pH ≥ 7) where the polyacid units are heavily ionized both water-soluble non-stoichiometric and stoichiometric insoluble PECs may form. The conditions for the formation of water-soluble non-stoichiometric PECs as a function of the length of the non-polar radical of the SA molecule have been studied. It is shown that increase in the length of the non-polar radical reduces the values of the composition of the mixture for which soluble non-stoichiometric PECs form. (Edited author abstract) 12 refs.

Ibragimova, Z.Kh. (Lomonosov State Univ, Moscow, USSR); Kasaikin, V.A.; Zeein, A.B.; Kabanov, V.A. *Polym Sci USSR* v 28 n 8 1986 p 1826-1833.

**081257 PHOTO PHYSICAL PROPERTIES OF PYRENE COVALENTLY BOUND TO POLYELECTROLYTES.** Copolymers of methacrylic acid, acrylic acid, and poly(styrenesulfonate) have been prepared with small mole fractions of 1-vinylpyrene. The fluorescence properties and quenching efficiencies in water have been measured for high and low pH with methylviologen, sulfonated propylmethylviologen, and a neutral zwitterionic viologen. It has been found that static (or contact)



quenching plays a significant role. Formation of a pyrene-viologen charge-transfer complex was observed at high and low pH. Charge separation following redox quenching does not occur for the viologens, unlike the analogous vinylidiphenylanthracene polymers. The absence of charge separation is tentatively ascribed to the formation of a relatively tightly bound complex during the quenching event. (Author abstract) 17 refs.

Stramel, R.D. (Univ of Texas, Austin, TX, USA); Nguyen, Chinh; Webber, S.E.; Rodgers, M.A.J. *J Phys Chem* v 92 n 10 May 19 1988 p 2934-2938.

**081258 FREE ENERGY CHANGE IN HYDROPHOBIC INTERACTIONS INVOLVING A POLYELECTROLYTE AND RUTHENIUM TRIS(BIPYRIDINE). A PULSED LASER STUDY.** Comparison between the effects of inert salts on the distribution of  $\text{Ru}(\text{bpy})_3^{2+}$  ions around three negative polyelectrolytes, poly(styrenesulfonate) (PSS), poly(vinyl sulfate) (PVS), and poly(acrylate) (PAA), is reported. Much higher ion concentrations are required in order to remove  $\text{Ru}(\text{bpy})_3^{2+}$  from PSS, as compared to removal from a PVS or PAA. Attributing the difference between these systems to the effect of hydrophobic interactions in the PSS enables the calculation of the free energy change involved in the formation of  $\text{Ru}(\text{bpy})_3^{2+}$ -PSS. The results show a definite distinction between  $\text{Ru}(\text{bpy})_3^{2+}$  'inside' and 'outside' the polymer, with no exchange during the lifetime of the excited state of the ruthenium tris(bipyridine),  $\text{Ru}(\text{bpy})_3^{2+}$  found to be much higher than 2,3,7,8-tetrachlorodibenzo-p-dioxin ( $\text{T}_4\text{CDD}$ ), 2,3,4,7,8-pentachlorodibenzofuran ( $\text{P}_5\text{CDF}$ ) and other toxic congeners. ' $\text{T}_4\text{CDD}$ -equivalent' analysis based on the enzyme induction potencies and the residues of these toxic chemicals indicates that 3,3',4,4',5,5'- $\text{P}_6\text{CB}$  may impose a greater toxic threat than dioxins and furans to the humans and probably to wildlife also. (Edited author abstract) 31 refs. +. The  $\text{Ru}(\text{bpy})_3^{2+}$  ions are located more deeply 'inside' the PSS as compared with the PVS. (Author abstract) 23 refs.

Slama-Schwok, Anny (Hebrew Univ of Jerusalem, Jerusalem, Isr); Rabani, Joseph. *Macromolecules* v 21 n 3 Mar 1988 p 764-768.

**081259 POLYELECTROLYTE SOLUTIONS: EQUILIBRIUM CONFORMATIONS OF THE MICROSTRUCTURE WITHOUT AND WITH EXTERNAL FIELDS.** The work presents a thorough discussion of the stable equilibrium states of conformation and electric polarization which may be obtained, in dilute polyelectrolyte solutions, in the absence or presence of external forcing. In the absence of forcing it is shown, for various plausible forms of quadratic and higher-order energies, that only the fully isotropic, nonpolarized state is stable. When an electric field is applied, stable axisymmetric ellipsoidal conformations may exist with the electric polarization response colinear with both the applied field and the axis of conformation. The whole discussion is based on a previously developed continuum model of polyelectrolyte solutions where the conformation is governed by a thermodynamically admissible evolution equation that contains entropy-nonproducing contributions involving the strain rate of the flow. Only shear-like changes of conformations are considered in the present work. (Edited author abstract) 27 refs.

Drouot, R. (CNRS, Paris, Fr); Maugin, G.A. *Int J Eng Sci* v 26 n 3 1988 p 225-241.

**081260 STUDY OF THE MICRO-ENVIRONMENT OF POLYELECTROLYTIC COMPLEXES OF SODIUM DODECYLSULPHATE IN AQUEOUS SOLUTIONS BY THE DYE SPECTRAL-SHIFT METHOD.** The dye-spectral shift method (using methyl orange) has been used to assess the micro-environment of polyelectrolytic complexes formed by sodium dodecylsulphate with a copolymer of N-vinylpyrrolidone and the iodethyrate of N,N-diethylamino-ethylmethacrylate. It has been established that, in aqueous solutions of the complexes, depending on the proportions of the components and the ionic strength, two types of ordered structures are formed, which are characterized by different degrees of hydrophobicity of the micro-environment. It has been established by viscometry that complexes with enhanced hydrophobicity of the micro-environment are characterized by smaller hydrodynamic dimensions. (Author abstract) 13 refs.

Kopeikin, V.V. (USSR Acad of Sciences, USSR); Afanagina, N.A.; Fazil, G.A.; Santuryan, Yu.G. *Polym Sci USSR* v 29 n 2 Feb 1987 p 413-420.

**081261 QUATERNARY AMMONIUM POLYELECTROLYTES. V. AMINATION STUDIES OF CHLOROMETHYLATED POLYSTYRENE WITH N,N-DIMETHYLALKYLAMINES.** The amination reactions of chloromethylated polystyrene with N,N-dimethyldecylamine, N,N-dimethyltetradecylamine, and N,N-dimethylhexadecylamine were studied. The physical properties, particularly the solubility properties of the resulting polymers, are influenced by the hydrophobic properties of the long alkyl chain on the  $\text{N}^+$  atoms. The main factor that influences the kinetics of the reactions is the polymer-solvent interaction parameter. (Author abstract) 12 refs.

Luca, Cornelia (P. Poni Inst of Macromolecular Chemistry, Iasi, Rom); Avram, Ecaterina; Petariu, I. *J Macromol Sci Chem* v A25 n 4 1988 p 345-361.

**081262 SCALING LAWS AND THE EFFECTS OF CONCENTRATION POLARIZATION ON THE PERMEABILITY OF HYALURONIC ACID.** Investigators have modeled the hydraulic permeability of hyaluronic acid using a fiber matrix model such as developed by J. Happel. However, C.R. Ethier found that the concentration dependence of the sedimentation rate of hyaluronic acid is inconsistent with the predictions of the fiber matrix model and with perfusion measurements of the hydraulic permeability. These discrepancies are investigated and a tentative explanation provided. The discrepancy found between the predictions of the fiber matrix model and the results of perfusion studies may be due to concentration polarization. This process was modeled and examined experimentally. The experimental results are in qualitative agreement with the theory. (Edited author abstract) 21 refs.

Johnson, Mark (MIT, Cambridge, MA, USA); Kamm, Roger; Ethier, C. Ross; Pedley, Tim. *PCH PhysicoChem Hydrodyn* v 9 n 3-4 1987, 6th Int Conf, Oxford, Engl, Apr 6-8 1987 p 427-441.

#### Adsorption See Also KAOLIN—Flocculation.

**081263 ON THE CHARGE STOICHIOMETRY UPON ADSORPTION OF A CATIONIC POLYELECTROLYTE ON CELLULOSIC MATERIALS.** Adsorption isotherms and adsorption stoichiometry of a low-molecular-weight ( $M_w = 5.9 \cdot 10^3$ ) cationic polyelectrolyte, 3,6-ioneone (Polybrene), on cellulosic fibers were studied. The charge density of the fibers was varied by means of carboxymethylation. It is shown that the adsorption isotherms are of the high-affinity type with a pronounced plateau level. The charge of the polymer adsorbed at this plateau level provide a relatively good measure of the charge (in meq  $\text{g}^{-1}$ ) on both the fibers and the MFC, except for the unsubstituted fiber sample. (Edited author abstract) 17 refs.

Wagberg, Lars (Swedish Pulp & Paper Research Inst, Stockholm, Swed); Winter, Lars; Oedberg, Lars; Lindstrom, Tom. *Colloids Surf* v 27 n 1-3 Oct 1987 p 163-173.

**081264 EXCHANGE AND COMPETITIVE ADSORPTION OF POLYELECTROLYTES ON BARIUM SULPHATE.** The desorption of polyelectrolyte molecules adsorbed on barium sulphate in the presence of various displacing species is reported. When polyacrylate (PAA) was both the adsorbed and displacing species, no significant desorption occurred when the dispersion medium was water. However, significant desorption occurred in 0.1 mol  $\text{dm}^{-3}$  NaCl, but only when the displacing PAA had a higher molecular mass than that adsorbed. The simultaneous adsorption of PAA and polystyrene sulphate (PSS) is also reported as a function of the molecular

mass of the two species and at different relative concentrations. In  $\text{H}_2\text{O}$ , there was a critical ratio of the weight of barium sulphate to the volume of polymer solution below which there was no detectable adsorption of PSS. The amount of PSS excluded from the surface increased as the ratio of PAA to PSS concentrations increased. The results indicate that the diffusion rate of PAA is the dominating factor in determining the surface composition. This suggests that the PSS must require a significant time from first contact of the molecule to complete adsorption, and in this time, newly arriving PAA molecules displace the PSS. 13 refs.

Wright, J.A. (North East Wales Inst, Deeside, Wales); Harrop, R.; Williams, P.A.; Pass, G.; Robb, I.D. *Colloids Surf* v 24 n 2-3 May 15 1987 p 249-258.

**081265 STRUCTURE OF THE ELECTRIC DOUBLE LAYER IN ADSORPTION OF A POLYELECTROLYTE FROM NONAQUEOUS MEDIA.** The problem of the structure of the double layer in adsorption of a polyelectrolyte is examined to establish methods of controlling the electrokinetic potential, particularly with respect to the problem of optimizing electrokinetic information converters. The distribution of the potential in the double layer was calculated as a function of the conformation of adsorbed macroions, the degree of dissociation of ionogenic groups, and the concentration of the indifferent electrolyte. (Author abstract) 29 refs.

Mishchuk, N.A. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Dukhin, S.S. *Colloid J USSR* v 49 n 2 Mar-Apr 1987 p 239-245.

**081266 EFFECT OF APPLIED POTENTIAL ON THE ELLIPSOMETRIC THICKNESS OF SODIUM POLY(STYRENESULFONATES) ADSORBED ON A PLATINUM SURFACE.** The thickness of a sodium poly(styrenesulfonate) (NaPSS) layer adsorbed on a platinum plate was measured by ellipsometry in aqueous NaCl solutions as a function of molecular weight, solvency, and applied potential. The applied potentials correspond to cathodic and anodic potential differences relative to the rest potential. At the negative potential differences, with an increase in potential difference the thickness of the adsorbed layer increases and its variation with the molecular weight decreases. (Edited author abstract) 22 refs.

Kawaguchi, Masami (Mie Univ, Tsu, Jpn); Hayashi, Kasumi; Takahashi, Akira. *Macromolecules* v 21 n 4 Apr 1988 p 1016-1020.

**081267 ENHANCED POLYELECTROLYTE ADSORPTION.** The amounts of hydrolysed polyacrylamide adsorbed onto cationic polystyrene latex have been compared after achieving the same final conditions of the dispersion medium via different experimental routes. The configuration of the adsorbed polymer molecules, following the different procedures, has also been assessed. For example, adsorption from 0.5 mol  $\text{dm}^{-3}$  NaCl followed by redispersion in 0.002 mol  $\text{dm}^{-3}$  NaCl leads to significant enhancement in the amount adsorbed compared to direct adsorption from the latter medium. In addition, the configuration, as indicated by ESR spectral data, has a much greater proportion of segments in loops and tails following the indirect route. (Edited author abstract) 24 refs.

Meadows, J. (North East Wales Inst of Higher Education, Deeside, Wales); Garvey, M.J.; Harrop, R.A.; Phillips, G.O. *Colloids Surf* v 32 n 3 pt 4 Jul 1988 p 275-288.

**081268 POLYELECTROLYTE INTERACTIONS AT THE HEMATITE/WATER INTERFACE. PART 1.** Displacement of adsorbed polyelectrolytes at the hematite/water interface is investigated as a function of molecular weight, ionic strength and order of addition using monodisperse polystyrenesulfonate (PSS) (MW 4600 and 1,200,000) as the polymer. At low ionic strength, 0.001 kmol  $\text{m}^{-3}$ , adsorption isotherms of single polymer was independent of molecular weight. At 1 kmol  $\text{m}^{-3}$



NaCl, adsorption increased significantly with molecular weight. Polydispersity effects were studied by examining adsorption of premixed monodisperse samples of two molecular weights, 4600 and 1,200,000, on hematite, and analyzing using size exclusion chromatography. (Edited author abstract). 12 Refs.

Ramachandran, R. (Columbia Univ, New York, NY, USA); Somasundaran, P. *Colloids Surf* v 32 n 3 pt 4 Jul 1988 p 307-317.

**081269 POLYELECTROLYTE INTERACTIONS AT THE HEMATITE/WATER INTERFACE. PART 2.** Interactions of anionic polyacrylamide (PAM, MW 3 to 5 million) and monodisperse polystyrenesulfonate (PSS, MW 4600 and 1,200,000) at the hematite/water interface are examined. At low ionic strength, PAM displaced adsorbed PSS (MW 4600), but could not displace adsorbed 1,200,000 PSS. Increasing the ionic strength led to enhanced displacement of 4600 PSS by PAM. The entropic driving force at high ionic strength was sufficient to overcome the salting-out forces that led to lower adsorption of PAM alone at 1 kmol m<sup>-3</sup>. PAM, due to its lower anionicity, was not as good a displacer of 4600 PSS as 1,200,000 PSS. (Author abstract). 4 Refs.

Ramachandran, R. (Columbia Univ, New York, NY, USA); Somasundaran, P. *Colloids Surf* v 32 n 3 pt 4 Jul 1988 p 319-329.

**081270 VARIATION OF ELLIPSOMETRIC ADSORBED POLYELECTROLYTE LAYER THICKNESS WITH POTENTIAL.** The ellipsometric thickness of sodium poly(styrene sulfonate) (NaPSS) layers adsorbed from aqueous NaCl solution onto a platinum plate was measured as a function of molecular weight and applied potential. A cathodic potential with respect to the rest potential was applied. At rest potential the ellipsometric thickness scales as M<sup>0.5</sup> and M<sup>0.4</sup> in theta and good solvents, respectively, and increases with increasing solvent power (decreasing ionic strength). The variation of the ellipsometric thickness with the molecular weight at applied potentials differs markedly from that without applied potential and becomes weaker with increasing applied potential. (Edited author abstract) 31 refs.

Kawaguchi, Masami (Mie Univ, Tsu, Jpn); Hayashi, Kasumi; Takahashi, Akira. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 73-88.

**081271 KINETICS OF ADSORPTION AND ION-EXCHANGE REACTIONS DURING ADSORPTION OF CATIONIC POLYELECTROLYTES ONTO CELLULOSIC FIBERS.** The kinetics and stoichiometry of adsorption of a cationic polyacrylamide (C-PAM) and a 3,6-ionene on a carboxymethylated bleached cellulose pulp were investigated. The initial rate of adsorption of C-PAM was very fast, and approximately 50% of the equilibrium adsorption level had already been reached within 10 s after polymer addition. The degree of ion exchange between the C-PAM and the anionic charged groups on the fiber was initially small, but increased substantially when the equilibrium polymer adsorption level was approached. As the amount of polymer added was increased, a lower stoichiometry was reached both after 10 s and after 30 min. (Edited author abstract) 3 refs.

Wagberg, Lars (STFI, Stockholm, Sweden); Odberg, Lars; Lindstrom, Tom; Aksberg, Rein. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 119-124.

**Applications** See DYES AND DYEING—Solutions; ORE TREATMENT—Separation; SOILS—Conditioners.

**Biodegradation** See POLYMERS—Biodegradation.

**Chemical Reactions**

**081272 POLYELECTROLYTES CONTAINING DIHYDRONICOTINAMIDE. III. FLUORESCENCE QUENCHING BY NICOTINAMIDE-CONTAINING**

**POLYMERS IN AQUEOUS SOLUTION.** Charge-transfer (CT) interaction of N-benzyl-1,4-dihydronicotinamide (BNAH) and poly(sodium styrene-p-sulfonate) containing 6 mol % of BNAH groups (PNAH) with several types of nicotinamide-containing polyelectrolytes in aqueous solution was investigated by fluorescence quenching. The experimental data were analyzed in terms of a kinetic model including both static and dynamic quenching. Hydrophobic association of BNAH with the polymers led to more effective quenching than the monomer [N-benzylnicotinamide (BNA)] system. Electrostatic attraction of PNAH and BNA also resulted in the remarkably large value of apparent quenching constant. (Edited author abstract) 29 refs.

Itoh, Yoshihiro (Shinshu Univ, Ueda, Jpn); Abe, Koji; Senoh, Saburo. *J Polym Sci Part A* v 25 n 10 Oct 1987 p 2871-2880.

**081273 INTERACTION OF FLUORESCENT SPERMINE DERIVATIVE WITH A NUCLEIC ACID POLYION.** The interaction of multivalent counterions with polyelectrolytes is investigated with a new probe prepared by reaction of spermine tetrachloride with 4-chloro-7-nitrobenz-2-oxa-1,3-diazole (NBD). The resulting conjugate, NBD-Sp, is a fluorescent trivalent ion at neutral pH. This species binds to poly(dG)-poly(dC) (PGC), a double-stranded synthetic polynucleotide, with a concomitant reduction in fluorescence yield. The isotherm for reduction of the fluorescence has been utilized to determine the binding constant. Electrophoretic light scattering has been used to measure the reduction of the charge density on the PGC molecule as the NBD-Sp condensed. Fluorescence photobleaching recovery (FPR) has been used to determine the tracer diffusion coefficients of the fluorescent NBD-Sp species in solution as a function of added PGC. The results are interpreted to determine the relative strength of the interaction between NBD-Sp and the mobility of the NBD-Sp ions that are not tightly bound to the PGC. For the latter data it is shown that the tracer diffusion coefficient approaches a limiting value one-third of the diffusion coefficient in the absence of the polyion, in agreement with a model that assumes restricted motion radial to the polyion and unhindered motion along the isopotential lines defined by the polyion backbone. (Author abstract) 40 refs.

Ware, Bennie R. (Syracuse Univ, Syracuse, NY, USA); Klein, James W.; Zero, Karl. *Langmuir* v 4 n 2 Mar-Apr 1988, Mol Process at Solid Surf: Spectrosc of Interned and Adsorbate Interact, Denver, CO, USA, Apr 6-8, 1987 p 458-463.

**Chemistry** See IONOMERS—Chemistry.

**Composition Effects** See ACIDS—Organic.

**Concentration**

**081274 SOLUTION PROPERTIES OF POLYELECTROLYTES. III. EFFECT OF SODIUM POLYSTYRENE SULFONATE CONCENTRATION ON VISCOMETRIC AND SIZE EXCLUSION CHROMATOGRAPHIC BEHAVIOR AT DIFFERENT IONIC STRENGTHS.** The effect of sodium polystyrene sulfonate concentration on the shape of its molecules in aqueous solution at different NaNO<sub>3</sub> ionic strengths has been analyzed by viscometry and size-exclusion chromatography (SEC). An equation has been developed which predicts the intrinsic viscosity at finite concentration of both polyion ( $c_p$ ) and electrolyte ( $c_e$ ). The experimental results obtained by both techniques can be accounted for in terms of the theory. Several factors involved in the elution mechanism have been considered and the variation of the slopes of SEC calibration curves with  $c_p$  and  $c_e$  has been discussed in terms of polyion conformation changes. (Edited author abstract) 40 refs.

Soria, Vicente (Univ de Valencia, Burjassot, Spain); Garcia, Rosa; Campos, Agustin; Braco, Lorenzo; Abad, Concepcion. *Br Polym J* v 20 n 2 1988 p 115-123.

**Condensation Reactions**

**081275 NEW MODEL OF COUNTERION CONDENSATION IN POLYELECTROLYTE SOLUTIONS. I. COMPARISON WITH OTHER CONDENSATION THEORIES AND EXPERIMENTAL DATA ON COUNTERION ACTIVITY COEFFICIENTS.** A new model of counterion condensation (Intermediate Model, IMM) is proposed as a modification of a corrected previous model (CPM). The theoretical predictions of IMM and CPM for the degree of condensation,  $\theta$ , and the counterion activity coefficient,  $\gamma$ , are compared with those of Manning and Iwasa et al. It is found that  $\gamma$ 's in the absence of added salts estimated by IMM and CPM for infinitely long polyions are hardly dependent on the polymer concentration,  $C_p$ , while those for polyions with finite length increase with decreasing  $C_p$ . It is the latter that is experimentally observed. This fact indicates that polymer models, in which end effects are considered, should be employed to treat the dependence of the condensation phenomena on the ionic strength. (Edited author abstract) 35 refs.

Satoh, Mitsuru (Tokyo Inst of Technology, Tokyo, Jpn); Kawashima, Takehito; Komiya, Jiro; Iijima, Toshiro. *Polym J* v 19 n 10 1987 p 1191-1200.

**081276 NEW MODEL OF COUNTERION CONDENSATION IN POLYELECTROLYTE SOLUTIONS. II. APPLICATION TO POTENTIOMETRIC TITRATION OF WEAK POLYACIDS.** The apparent dissociation constants,  $pK_a$ , of weak polyacids in aqueous salt solutions are estimated as a function of the degree of dissociation,  $\alpha$ , by a new model for counterion condensation (Intermediate Model, IMM) and a corrected previous model (CPM). Both models predict smooth titration curves free from a break point which is a defect in the prediction by Manning theory. Titration curves obtained by CPM show a maximum, indicating that CPM overestimates the degree of condensation with increasing  $\alpha$ . Sigmoidal titration curves are predicted by IMM; the underestimation for a lower  $\alpha$  region of poly(acrylic acid) is corrected through effective charge densities estimated from the counterion activity data, and that observed for a higher  $\alpha$  region is interpreted as caused by hydration changes of the polyion with  $\alpha$ . (Edited author abstract) 24 refs.

Satoh, Mitsuru (Tokyo Inst of Technology, Tokyo, Jpn); Komiya, Jiro. *Polym J* v 19 n 10 1987 p 1201-1208.

**Diffusion**

**081277 EFFECTS OF POLYELECTROLYTES ON THE DIFFUSION OF LOW MOLECULAR WEIGHT IONIC SOLUTES.** The diffusion of sodium sulfate in dilute solutions of carboxymethylcellulose sodium salt (CMC) was studied using the porous frit technique. It was found that at relatively low CMC concentrations, the diffusivity of sodium sulfate (D) is higher than that in water ( $D_0$ ); with increasing CMC concentration, the diffusivity of sodium sulphate decreases gradually and reaches a value lower than that in water. The relation between salt diffusivity ratio ( $D/D_0$ ) and CMC concentration (C) is represented by the equation:  $D/D_0 \times a - bC$ . The effect of temperature on the diffusivity of sodium sulfate in CMC solutions was found to obey the Arrhenius equation with an activation energy of 2600 cal mol<sup>-1</sup>. (Author abstract) 16 refs.

El-Abd, Mohamed Z. (Alexandria Univ, Alexandria, Egypt); Zatout, Ahmed A.; Sedahmed, Gomaa H.; Negm, Ahmed H. *Polym J* v 20 n 4 1988 p 345-349.

**Dispersions**

**081278 DETERMINATION OF EFFECTIVE CHARGE NUMBERS OF A POLYDISPERSE POLYELECTROLYTE: AN IMPROVED METHOD.** An improved method for the determination of effective charge numbers of polydisperse polyelectrolyte is presented. Instead of an earlier used zero-flux condition we now solve the mathematical model of convective diffusion in the case of non-zero fluxes. This is done in a binary supporting



electrolyte system where the solution can be obtained in closed form. Even though the charge numbers have to be iterated from this closed form solution, it is reasonable to use the present method due to experimental reasons if the supporting electrolyte system is binary. The measurements for both the ionic diffusion coefficients and the effective charge numbers were done when the supporting electrolyte was 0.01 M NaCl and the polydisperse polyelectrolyte was lignosulfonate present in trace-ion concentration  $1 \text{ g dm}^{-3}$ . The results were in accordance with those obtained earlier. (Author abstract) 5 refs.

Kontturi, Anna-Kaisa (Helsinki Univ of Technology, Espoo, Finl); Kontturi, Kyosti. *Acta Polytech Scand Chem Technol Metall Ser n* 178 1987 p 143-151.

## Effects

**081279 EFFECT OF POLYELECTROLYTES ON THE ELECTROKINETIC POTENTIAL OF MELAMINE-FORMALDEHYDE PARTICLES.** It is shown that with an increase in the adsorption of sodium salts of carboxymethylcellulose (CMC) on the surface of oppositely charged melamine-formaldehyde particles there is a decrease in their  $\zeta$ -potential and a subsequent charge exchange, the efficiency of this decrease increasing with an increase in the molecular weight and charge of the macroion and with an increase in the radius of curvature of the adsorbing surface. A relationship is shown between the electrokinetic potential of the particles with the adsorbed CMC layers and the geometric structure of the layers. (Author abstract) 12 refs.

Velichanskaya, L.A.; Solomentseva, I.M. *Sov Prog Chem v* 53 n 8 1987 p 31-34.

Efficiency See WATER TREATMENT—Flocculation.

## Electric Field Effects

**081280 ANOMALOUS CHEMOMECHANICAL CHARACTERISTICS OF ELECTRO-ACTIVATED POLYELECTROLYTE GELS.** In a previous article we reported the first model of an electrically activated chemomechanical (mechanochemical) system consisting of mildly crosslinked polyelectrolyte gels. This article reports the anomalous behavior of these and other electro-activated polyelectrolyte gels regarding their rate of contraction under an increasing tensile stress applied to the ends of the gel samples. The rate at which a weight attached to bottom end of the gel was lifted increased with increasing weight. This behavior is believed to be associated with the spontaneous ionization of the polyelectrolyte network due to stretching (reverse-chemomechanical reaction). The article illustrates the contraction behavior of the PMAA gel. 11 refs.

Osada, Yoshihito (Ibaraki Univ, Mito, Jpn); Kishi, Ryoichi; Hasebe, Mariko. *J Polym Sci Part C v* 25 n 12 Dec 1987 p 481-485.

Hydration See POLYACRYLATES.

Ionic Conduction See Also DIELECTRIC MATERIALS—Electric Field Effects.

**081281 PREPARATION AND CHARACTERISATION OF PEO-Hg(ClO<sub>4</sub>)<sub>2</sub> COMPLEXES AND SOME THOUGHTS ON ION TRANSPORT IN POLYMER ELECTROLYTES.** A new solid polymer electrolyte, PEO-Hg(ClO<sub>4</sub>)<sub>2</sub>, has been prepared and characterized over a composition range  $100 \leq x \leq 4$ , where  $x$  represents the molar ratio of EO units to salt. Films of this material are amorphous at high salt concentrations and there is no evidence for the formation of a crystalline polymer-salt complex over the entire composition range studied. Electrical measurements indicate that both cations and anions are mobile, with a cation transference number of  $0.25 \pm 0.05$  at  $52^\circ\text{C}$  for an EO/salt molar ratio of 20:1. The overall conductivity of PEO-Hg(ClO<sub>4</sub>)<sub>2</sub> is significantly higher than that of other strictly anhydrous polymer electrolytes containing mobile divalent cations, previously reported. The variation of conductivity with temperature and composition is discussed, and cation mobility in

general is considered in terms of hard and soft character, and in relation to the lability of the coordinated ether oxygens. (Author abstract). 17 Refs.

Bruce, P.G. (Heriot-Watt Univ, Edinburgh, Scotl); Krok, F.; Vincent, C.A. *Solid State Ionics v* 27 n 1-2 Jun 1988 p 81-88.

## Moisture

**081282 MOISTURE SORPTION OF POLYELECTROLYTE COMPLEX BETWEEN POLY(ACRYLIC ACID) AND POLY(4-VINYLPYRIDINE).** Successive differential sorptions have been measured for the system polyelectrolyte complex of poly(acrylic acid)/poly(4-vinylpyridine) + water vapor. The sorption data revealed that the sorption process of water vapor in the complex is controlled not only by diffusion mechanism but also by relaxation mechanism of polymer chains. It has been considered that the complex is composed of a loosely crosslinked, slightly ionized, and relatively homogeneous network structure. The sorption-desorption kinetics have also been investigated for the region of intermediate and high vapor pressures. The interval sorption-desorption curves demonstrated that the complex has the nature of the hysteresis effect in sorptions. (Edited author abstract) 20 refs.

Hirai, Yoshiyuki (Ochanomizu Univ, Tokyo, Jpn); Nakajima, Toshinari. *J Appl Polym Sci v* 35 n 5 Apr 1988 p 1325-1332.

Molecular Structure See MEMBRANES—Ion Selective.

Molecular Weight See Also ACIDS—Organic.

**081283 DETERMINATION OF AVERAGE MOLECULAR WEIGHTS OF A POLYELECTROLYTE BY MENISCUS-DEPLETION SEDIMENTATION EQUILIBRIUM.** This paper describes the application of the method to a high molecular weight sample of the anionic polyelectrolyte sodium poly(styrene sulphonate) (NaPSS), and discusses some particular problems associated with the characterization of polyelectrolytes. Experiments show that number-, weight- and z-average molecular weights of high molecular weight polyelectrolytes may be determined by long-column meniscus-depletion sedimentation equilibrium. Normally it is necessary to utilize a density increment determined on solutions of the polyelectrolyte which have been brought into dialysis equilibrium with a solution of a low molecular weight salt. However, dialysis is not required for the special case of a salt having zero buoyancy factor and having an ion in common with the polyelectrolyte. 29 refs.

Budd, Peter M. (BP Research Cent, Sunbury-on-Thames, Engl). *Br Polym J v* 20 n 1 1988 p 33-37.

## Optical Properties

**081284 STATIC LIGHT SCATTERING STUDIES OF SUSPENSIONS OF CHARGED RODLIKE TOBACCO MOSAIC VIRUS.** In this paper we report on the results of static light scattering. The scattered intensity  $I(q)$  has been measured as a function of scattering vector  $q$  for the five samples. The authors have presented clear evidence of local ordering in dilute suspensions of charged rodlike macromolecules in the light scattering regime. The static structure factor exhibits a pronounced peak even in the neighborhood of  $c$ , where the length of the particles becomes comparable to their mean distance. Since spatial correlations are known to affect considerably the dynamical properties of charged Brownian particles at low ionic strength, our results also help one to understand the dynamic light scattering spectra.

Maier, Erich E. (Univ Konstanz, Konstanz, West Ger); Schulz, Susanne F.; Weber, Reinhart. *Macromolecules v* 21 n 5 May 1988 p 1544-1546.

## pH Effects

**081285 EFFECT OF pH ON THE STATE OF THE MICRO-ENVIRONMENT OF POLYELECTROLYTE COMPLEXES FORMED BY SODIUM ALKYL SULPHATES IN AQUEOUS SOLUTIONS.** Spectrophotometric titration of methyl orange has been used to assess the micro-environment of various structural types of complexes with different values of pH in aqueous solutions of polyelectrolyte complexes of the higher alkylsulphates of sodium based on the copolymer formed by N-vinylpyrrolidone and the iodethylate of diethylamino-ethylmethacrylate. It has been shown that the hydrophilic-hydrophobic balance in the microenvironment may be regulated by varying the length of the chain of the sodium alkylsulphate, and by varying the pH and ionic strength of the solution. (Author abstract) 15 refs.

Kopeikin, V.V. (USSR Acad of Sciences, USSR); Gavrilova, I.I. *Polym Sci USSR v* 29 n 2 Feb 1987 p 421-427.

Physical Properties See POLYAMIDES—Physical Properties.

Selection See WATER TREATMENT—Flocculation.

Solutions See Also EMULSIONS—Thin Films; OXYGEN—Diffusion.

**081286 ADSORPTION ENHANCED LUBRICATION BY THIN LIQUID FILMS OF SYNTHETIC AND BIOLOGICAL POLYELECTROLYTE SOLUTIONS.** Lubrication properties of three polyelectrolytes such as Na-poly(acrylate), Na-chondroitin sulfate, and Na-hyaluronate were studied by measuring the static friction coefficient  $\mu_s$  of thin liquid films of these aqueous polyelectrolyte solutions between glass surfaces. Adsorption isotherms of the polyelectrolytes onto the glass surface were also measured. Thin liquid films of polyelectrolyte solutions with added NaCl definitely show lubricity. The  $\mu_s$  vs. bulk concentration curves have relevance to the adsorption isotherm and lead to the conclusion that the adsorbed polyelectrolyte layer has the ability to reduce the  $\mu_s$  value of glass-water-glass interface to the extent of 40-60%. (Edited author abstract) 12 refs.

Takahashi, Akira (Mie Univ, Tsu, Jpn); Kozaki, Norio. *Polym J v* 19 n 8 1987 p 945-949.

**081287 EXPERIMENTAL STUDY OF DILUTE POLYELECTROLYTE SOLUTIONS IN STRONG FLOWS.** Flow-induced changes in the conformation of polymer molecules in dilute polyelectrolyte solutions were studied, using birefringence techniques, as a function of molecular weight and added salt concentration in laminar, two-dimensional extensional flows produced in four- and two-roll mills. Overshoots in the flow birefringence during startup of simple-shear flow are presented. Of particular interest is the so-called coil-stretch transition. It is shown that the electrostatic expansion of the polyelectrolyte has a dramatic effect on the onset shear rate for the coil-stretch transition and also on the shape of the flow birefringence versus shear rate curves during the stretching process. A reasonable description of the coil-stretch transition and its dependence on equilibrium configuration is obtained theoretically using a charged dumbbell model with conformation-dependent bead friction. (Edited author abstract) 44 refs.

Dunlap, P.N. (California Inst of Technology, Pasadena, CA, USA); Wang, C.-H.; Leal, L.G. *J Polym Sci Part B v* 25 n 11 Nov 1987 p 211-2238.

**081288 SOLUTION PROPERTIES OF POLYELECTROLYTES. I. EXCLUSION CHROMATOGRAPHY OF SODIUM POLYSTYRENE SULPHONATE IN SALT-FREE WATER AS ELUENT.** The effect of concentration of sodium polystyrene sulphonate on the elution volume in exclusion chromatography has been investigated using salt-free water as eluent. A non-linear increase in the elution volume has been observed with increasing injected sample concentration. Concentra-



tion-dependent calibrations have been obtained which approach the universal calibration for uncharged polymers (dextran) as polyelectrolyte concentration increases. The separation mechanisms are interpreted in terms of electrostatic and hydrodynamic interactions. A semi-empirical model is proposed to predict concentration effects of linear polyions in exclusion chromatography and good agreement has been found between experimental and calculated elution volumes. (Author abstract) 51 refs.

Abad, Concepcion (Univ de Valencia, Valencia, Spain); Soria, Vicente; Braco, Lorenzo; Garcia, Rosa; Campos, Agustin. *Br Polym J* v 19 n 6 1987 p 489-500.

**081289 SOLUTION PROPERTIES OF POLYELECTROLYTES. II. COMPARISON OF THE EFFECTS OF BOTH POLYION AND ELUENT SALT CONCENTRATIONS ON THE CALIBRATIONS IN AQUEOUS EXCLUSION CHROMATOGRAPHY.** The elution behaviour of charged water-soluble polymers (sodium polystyrene sulphonate) in both salt-free and NaCl-containing aqueous mobile phases has been investigated by size-exclusion chromatography. A comparative analysis has been established between the results as a function of polyion and salt concentrations, which demonstrates that the chromatographic behaviour is similar in both cases. The variation of the slopes of the different concentration-dependent calibration curves is discussed in terms of polyelectrolyte conformational changes. (Edited author abstract) 23 refs.

Abad, Concepcion (Univ de Valencia, Valencia, Spain); Braco, Lorenzo; Soria, Vicente; Garcia, Rosa; Campos, Agustin. *Br Polym J* v 19 n 6 1987 p 501-508.

**081290 RHEOLOGY OF XANTHAN GUM: SALT, TEMPERATURE, AND STRAIN EFFECTS IN OSCILLATORY AND STEADY SHEAR EXPERIMENTS.** Dynamic oscillatory shear testing has been used to study the rheology of xanthan gum in the moderate concentration regime ( $500 < c < 5000$  ppm). The dynamic moduli of two industrial grade xanthan gums (a dried powder and a fermentation broth) have been compared in deionized, distilled water (low salt) and in 0.5% NaCl solutions (high salt). Detailed studies of the effects of salt, temperature, and high shear on 5000 ppm xanthan gum solutions in dynamic, steady, and transient shear have been conducted. A master curve of the dynamic properties covering six decades of frequency has been obtained for xanthan gum in highly saline solutions. (Edited author abstract) 32 refs.

Rocheffort, Willie E. (Univ of California, La Jolla, CA, USA); Middleman, Stanley. *J Rheol* v 31 n 4 May 1987 p 337-369.

**081291 VISCOSITIES OF COPOLYPHOSPHATES IN SALT-FREE AQUEOUS SOLUTIONS AND THETA SOLVENTS.** The results of viscosity measurements on several samples of lithium-potassium copolyposphates (Li:K ratio ranging from 9:1 to 5:5) in salt-free aqueous solutions and in theta solvents are reported. Molecular weights determined by end-group titration ranged from 4000-10,000. In aqueous solutions the Fuoss equation parameter A was found to be nearly proportional to the square of molecular weights, indicating rod-like structures of the poly-ions at infinite dilution. The concentrations of NaBr solutions acting as theta solvents at 35°C were determined for all cases and the viscosity data in  $\theta$ -solvents were utilized in calculating unperturbed dimensions which were found to lie in the range  $4.7 \times 10^{-7}$  cm to  $7.4 \times 10^{-7}$  cm. (Author abstract) 19 refs.

Bhargava, H.N. (Gorakhpur Univ, Gorakhpur, India); Srivastava, Rita Rani; Singh, Manju. *Polym J* v 19 n 11 1987 p 1285-1292.

**081292 COUNTERION ACCUMULATION IN ROD-LIKE POLYELECTROLYTE SOLUTIONS WITH ADDED SALT AND MANNING'S CONDENSATION THEORY.** The Poisson-Boltzmann equation in the cylindrical cell model is solved numerically for charged polyelectrolyte solutions containing mono- or

divalent counterions and monovalent coions. The results, which describe the ion distribution around the polyion, are compared with those derived from the Poisson-Boltzmann equations for salt-free solutions in the limit of infinite dilution and with the Manning counterion condensation theory. The general conclusion drawn not only supports further evidence that the Manning condensation theory can be deduced from the Poisson-Boltzmann equation but also suggests that counterion binding changes progressively from a free to condensed phase, as the polyion charge density parameter increases. (Edited author abstract) 19 refs.

Bizzarri, A.R. (Univ di Roma 'La Sapienza', Rome, Italy); Cametti, C.; Di Biasio, A. *Ber Bunsenges Phys Chem* v 92 n 1 Jan 1988 p 17-21.

**081293 COUNTERION SELECTIVITY IN CATIONIC POLYELECTROLYTES.** Chloride ion activity coefficients in aqueous solutions of several cationic copolymers have been determined using ion-selective electrodes in both the absence and the presence of simple univalent and divalent salts. Without added salt, the activity coefficient depends on the polymer concentration. It increases with increasing concentration of the added salt. The extent of interaction between counterions and polyions at a given polymer concentration, as estimated from chloride anion activity, is greater for bivalent than for univalent anions. Experimental data are in good agreement with theory. (Edited author abstract) 46 refs.

Boussouira, B. (CNRS, Paris, Fr); Ricard, A.; Audebert, R. *J Polym Sci Part B* v 26 n 3 Mar 1988 p 649-661.

**081294 ELECTROLYTIC CONDUCTIVITY OF POLY(1,3-PROPYLENE PHOSPHATE) SOLUTIONS CONTAINING MONO- AND DIVALENT-COUNTERIONS.** The results of conductivity measurements for aqueous solutions of poly(1,3-propylene phosphate) (PPP), which can be considered as a synthetic analogue of naturally occurring teichoic acids, are reported. Experiments were carried out with oligomeric fractions of a polymer in acidic, sodium, potassium, magnesium and calcium forms. The concentration and molecular weight dependence of the equivalent conductivity of PPP was analysed and the limiting equivalent conductivity determined. From the conductivity data, the polyion-counterion interaction parameter F and the equivalent conductivity of a polyion  $\lambda_p$  were calculated. It was shown that both F and  $\lambda_p$  depend on polyelectrolyte solution concentration and molecular weight of PPP. Conclusions concerning mono- and divalent metal ions binding to PPP are drawn. (Author abstract) 32 refs.

Ostrowska-Czubenko, J. (Nicolaus Copernicus Univ, Torun, Pol); Wodzki, R. *Colloid Polym Sci* v 266 n 1 Jan 1988 p 35-40.

**081295 INVESTIGATION OF ION BINDING PROPERTIES OF SYNTHETIC POLYELECTROLYTES USING A TERBIUM (III) PROBE: ELUCIDATION OF THE NUMBER OF COORDINATED WATER MOLECULES ON METAL POLYELECTROLYTE COMPLEXES.** Determination of the hydration state of a metal ion bound in a polymer matrix can be used to deduce its coordinative environment. Consequently, we have studied the fluorescence properties of Tb(III) bound to polycarboxylates, as well as to simpler monomeric carboxylate ligands. The results of these investigations are the subject of this work. Upon addition of poly(sodium acrylate) to an aqueous solution of Tb(III), it was found that the Tb(III) fluorescence intensity was greatly increased. Repeat of the same experiment in  $D_2O$  led to an approximate order of magnitude increase in emission intensity. 21 refs.

Kido, J. (Polytechnic Univ, Brooklyn, NY, USA); Brittain, H.G.; Okamoto, Y. *Macromolecules* v 21 n 6 Jun 1988 p 1872-1875.

**081296 VISCOSITY OF POLYELECTROLYTE SOLUTIONS-THE GENERALIZED FUOSS LAW.** Early studies of the viscosity of semidilute and moderately dilute 'salt-free' polyelectrolyte solutions have led to the

empirical relation between the reduced viscosity and the monomeric concentration known as the Fuoss law. The anomalously large values of the intrinsic viscosity obtained by this method are taken as an indication that polyions become fully stretched in the dilute limit. In fact, the intrinsic viscosity is of the same order of magnitude as that of neutral polymers of similar molecular weight, indicating that, even in this limit, the macroion conformation bears a closer resemblance to an expanded coil than to a rigid rod. Using a modified version of the theory originally developed by Hess and Klein for suspensions of highly charged, spherical particles, the authors obtained the new expression for the viscosity, the generalized Fuoss formula for analyzing the results of experiments on the viscosity of the dilute and semidilute polyelectrolytes. 21 Refs.

Rabin, Y. (Weizmann Inst of Science, Rehovot, Isr); Cohen, J.; Priel, Z. *J Polym Sci Part C* v 26 n 9 Aug 20 1988 p 397-399.

## Stability

**081297 THERMAL STABILITY OF SUBSTITUTED POLY-XYLENES.** The insertion of meta units in the chain of poly-p-xylylene decreases both the onset temperature of oxidative degradation and the rate of decomposition. Functionalization of the polymer with chlorine and sulphonic groups makes the chain more resistant to high temperature treatments, notwithstanding the low stability of the substituent groups. (Author abstract). 6 Refs.

Modica, G. (Politecnico di Milano, Milan, Italy); Di Renzo, F.; Tempesti, E.; Mazzocchi, C. *J Therm Anal* v 34 n 2 Mar-Apr 1988 p 473-477.

Statistical Mechanics See POLYMERS—Magnetic Field Effects.

## Structure

**081298 PERMEABILITY CONTROL OF POLYELECTROLYTE COMPLEX MEMBRANE INCLUDING CHITOSAN DERIVATIVE AS A COMPONENT.** The properties of polyelectrolyte complexes (PEC) and PEC membranes were investigated in the systems of glycol chitosan (GC)-poly(vinyl sulfate) (PVSK) and methyl glycol chitosan (MGC)-(carboxymethyl)dextran (CMD). The degree of dissociation and the conformation of GC and CMD depend upon pH, because GC and CMD are weak polybase and weak polyacid, respectively. On the basis of this knowledge, a research into the pH dependence of dissociation and viscosity of GC and CMD was carried out. PEC including chitosan derivative as a constituent was synthesized at the adequate pH, pH 3.0 in the GC-PVSK system and pH 7.0 in the MGC-CMD system. PEC membranes were prepared, and the permeability of KCl, urea, and sucrose through the GC-PVSK membrane was determined under various pH. It was revealed that the permeability of KCl, urea, and sucrose varies with the solution pH. This work is pertinent to drug delivery systems. (Edited author abstract). 19 refs.

Kikuchi, Yasuo (Oita Univ, Oita, Jpn); Kubota, Naoki. *Bull Chem Soc Jpn* v 61 n 8 Aug 1988 p 2943-2947.

## Surfaces

**081299 ELECTROSTATIC POTENTIAL AND POLARITY AT THE MOLECULAR SURFACE OF POLYELECTROLYTES AS PROBED BY pH-SENSITIVE CHROMOPHORES COVALENTLY ATTACHED TO THE MAIN CHAIN.** The purpose of the present paper is to report on the quantitative estimation of the electrostatic potential as well as the local polarity at the molecular surface of polyelectrolytes with pH-sensitive chromophores covalently incorporated into the polymer main chain. The authors describe in detail the spectroscopic investigation on anionic, cationic, and non-ionic water-soluble polymers tagged with a small fraction of the merocyanine optical probes. We demonstrate the usefulness of this chemical modification of polyions for a quantitative estimation of the surface potential and



polarity. 27 refs.

Morishima, Yotaro (Osaka Univ, Toyonaka, Jpn); Kobayashi, Takaomi; Nozakura, Shun-ichi. *Macromolecules* v 21 n 1 Jan 1988 p 101-107.

## Synthesis

**081300 CHEMICAL RESISTANCE OF MATERIALS IN SYNTHESIS OF POLYELECTROLYTE PKB-1.** A process has been developed for the synthesis of a highly efficient cationic polyelectrolyte (polydimethyldiallylammonium chloride), product designation PKB-1. In the synthesis process, the starting materials and also the products are corrosive. With the aim of determining the resistance of materials and developing a material design specification for the process of manufacturing the polyelectrolytes, the authors tested the corrosion resistance of a number of materials. 6 refs.

Danilov, I.N. (Bashkirian Scientific-Research Inst for Petroleum Processing, USSR); Ishmaeva, A.M.; Kuznetsov, V.A. *Chem Technol Fuels Oils* v 23 n 3-4 Mar-Apr 1987 p 123-125.

**081301 POLYELECTROLYTES CONTAINING IMIDAZOLYL GROUPS PREPARED FROM POLYSTYRENE FOR HYDROLYSIS OF PHENYL ESTERS.** Polyelectrolytes containing imidazolyl groups, which are soluble in water, have been prepared by treating chloromethylated polystyrene first with triethylamine to convert a part of chloromethyl groups to quaternary ammonium groups and then with histamine or histidine. Hydrolyses of several phenyl esters in the presence of the polyelectrolytes were much faster than those in the presence of small molecules containing an imidazolyl group such as histamine, histidine, or imidazole. The hydrolyses catalyzed by the polyelectrolytes conformed to Michaelis-Menten kinetics, except for the case of 3-acetoxy-N,N,N-trimethylanilinium iodide. The higher rate in the presence of the polyelectrolytes was due to the lowering of free energy by the formation of associated complexes between the polyelectrolytes and the substrate. The driving force of the complex formation was substantially hydrophobic interaction; however, hydrogen bonding and electrostatic attraction are suggested in some cases. (Edited author abstract) 34 refs. In Japanese.

Kawabe, Hiroshi (Chiba Inst of Technology, Narashino, Jpn). *Kobunshi Ronbunshu* v 45 n 2 1988 p 177-184.

**081302 NEW CLASS OF CATION CONDUCTORS: POLYPHOSPHAZENE SULFONATES.** The authors report the synthesis and conductivity of a new class of polyelectrolytes having phosphazene backbone and with sulfonate and oligoether side chains. As a model system for the analogous reaction with linear poly(dichlorophosphazene),  $[\text{NPCl}_2]_n$ , the authors investigated the equimolar reaction of hexachlorocyclotriphosphazene,  $\text{N}_3\text{P}_3\text{Cl}_6$ , with the disodium salt of 2-hydroxyethanesulfonic acid,  $\text{NaOC}_2\text{H}_4\text{SO}_3\text{Na}$ , in THF in the presence of 15-crown-5. The alkoxysulfonate acts as a difunctional reagent toward  $\text{N}_3\text{P}_3\text{Cl}_6$ .  $^{31}\text{P}$  NMR spectra gave no indication of the presence of spirocyclic or ansa products. Also, intensities in the  $^{31}\text{P}$  NMR gave no evidence for intermolecular condensation products. The ratio of the sulfonate group to the ether side groups is established by the ratio of the integral intensities of  $\text{OCH}_2$  protons with  $\text{CH}_2\text{S}$  protons from  $^1\text{H}$  NMR spectra. In addition, qualitative tests using  $\text{Ag}^+$  demonstrated the lack of appreciable chloride in the product. The general synthetic procedure employed should permit the attachment of a wide variety of pendant charged groups to the phosphazene backbone. 16 refs.

Ganapathiappan, S. (Northwestern Univ, Evanston, IL, USA); Chen, Kaimin; Shriver, D.F. *Macromolecules* v 21 n 7 Jul 1988 p 2299-2301.

**POLYESTERS** See Also ADHESIVES—Hot Melt; COMPOSITE MATERIALS; COMPOSITE MATERIALS—Electric Properties; COPOLYMERS; COPOLYMERS—Synthesis; DYES AND DYEING—Spectrum Analysis; DYES AND DYEING—Synthetic Fibers; EPOXY RESINS—Reinforcing; GEOTEXTILES—Synthetic Materials; KNIT FABRICS; PLASTICS, REINFORCED—Mechanical Properties; POLYETHYLENE TEREPHTHALATE—Crystallization; POLYETHYLENE TEREPHTHALATE—Thermal Effects; POLYMERIZATION—Photochemical Reactions; TEXTILE FIBERS—Synthetics; TEXTILES—Flame Resistance; THERMOSETS—Curing; YARN—Inspection.

**081303 WPLYW STOPNIA POLIMERYZACJI NA WLASCIWOSCI FOTOCHIMICZNE POLIESTRU NA PODSTAWIE BEZWODNIKA KWASU 3-AZIDO-O-FTALOWEGO I POLI(ALKOHOLU WINYLOWEGO).** (Effect of the Degree of Polymerization on the Photochemical Properties of a Polyester on the Basis of 3-Azido-Orthophthalic Anhydride and Poly(Vinyl Alcohol).) In polyesterification of PVA fractions of different molecular mass with 3-azido-orthophthalic anhydride, samples of poly(vinyl ortho-azidophthalate) of different degrees of polymerization ( $n$ ) have been prepared. It has been found that an increase of the degree of polymerization of this photopolymer which absorbs radiation in the range 220-350 nm is accompanied by an increase in the total sensitivity, whereas after exceeding a defined value of  $n$  its sensitivity becomes independent of the degree of polymerization. An addition of 2,6-dichloro-4-nitroaniline as a sensitizer shifts the spectral sensitivity of this polymer in the direction of longer waves and increases its total sensitivity. (Edited author abstract). 7 Refs. In Polish.

Sierocka, Michalina (Akad Techniczno-Rolnicza, Bydgoszcz, Pol); Toczec, Maria; Cwiklinska, Danuta. *Polimery* v 33 n 3 Mar 1988 p 92-94.

**Additives** See Also PLASTICS SHEETS—Sheet Molding Compounds.

**081304 CHAIN EXTENDERS FOR POLYESTERS. VI. PROPERTIES OF THE POLYESTERS CHAIN-EXTENDED BY 2,2'-BIS(4H-3,1-BENZOXAZIN-4-ONE).** Some properties of polymers derived by treating poly(ethylene terephthalate) (PET) with such hydroxyl-addition-type chain extenders as 2,2'-bis(4H-3,1-benzoxazin-4-one) (BNZ) were investigated. Compared with ordinary PET, the chain-extended PET has a slightly lower melting point and nearly equal molecular size distribution, which indicate that BNZ reacts to form linear chain-extended polymers without branching. Oxalyl bis(anthranelate) unit copolymerized in the polyester chain showed little influence on thermal and hydrolytic stabilities. In addition, benzoxazinone groups remaining unreacted can act as a heat stabilizer to prevent the decrease in the molecular weight by the chain-extending reaction in the solid phase. But they showed adverse effect on the hydrolytic stability by promoting hydrolysis of the polymer as much as the carboxyl groups. (Author abstract) 4 refs.

Inata, Hiroo (Teijin Ltd, Iwakuni, Jpn); Matsumura, Shunichi. *J Appl Polym Sci* v 34 n 8 Dec 1987 p 2769-2776.

**Applications** See Also CONCRETE CONSTRUCTION—Protective Coatings; ELECTRIC WINDINGS—Plastics Applications; ELECTRIC WINDINGS, MACHINE; OPTICAL FIBERS—Coatings; PROTECTIVE COATINGS—Powder.

**081305 UNSATURATED POLYESTER RESINS AND VINYL ESTER RESINS.** Discovered over 50 years ago and on the market for nearly 40 years, unsaturated polyester resins have long ranked among the —mature products—. Nevertheless, consumption in the Federal Republic of Germany rose from 58 000 t in 1984 to 63 000 t in 1986. New or increased applications in the transport sector and environmental protection more than compensate for the further decline in conventional applications such as corrugated sheeting and in boatbuilding. The vinyl ester resins (VE) used in the polyesters are condensation resins, which like UP resins cure by free-radical copolymerization with styrene. Their proper-

ties lie between the UP and epoxy resins. In German standardization groups it has been proposed that they be known as phenacrylate resins. The VE resins open up new fields of application for GRP, e.g. in the form of clean-gas pipes and flue gas scrubbers used in coal-fired power stations. In line with the increased environmental awareness, sewage treatment tanks are being increasingly fitted with large-span GRP covers. 30 refs.

Koser, W. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 65-68.

**081306 BIOLOGISESTI ABSORBOITUVAT POLYESTERIT.** [Biologically Absorbable Polyesters]. Biologically absorbable polyesters are synthetic or biotechnically manufactured linear polymers, which are degraded by means of water and enzymatic activity to natural monomers and in that form metabolized by micro-organisms or in tissues of mammals. These materials are therefore environmentally compatible. Absorbable polyesters have already gained special applications in medicine, and a significant increase in applications can be expected. (Author abstract) In Finnish. 41 refs.

Tormala, Pertti; Rokkanen, Pentti; Vainonpaa, Seppo; Helevirta, Pertti. *Kem Kem* v 13 n 10 Oct 1986 p 836-840.

## Biocompatibility

**081307 STUDY OF THERMAL AND GROSS MORPHOLOGIC PROPERTIES OF POLYGLYCOLIC ACID UPON ANNEALING AND DEGRADATION TREATMENTS.** The objective of this study is to alter fiber morphology of a linear aliphatic polyester, polyglycolic acid, by annealing treatment and to examine the changes of its degradation properties. The annealing was done at 150°C, 170°C, and 190°C, and specimens were annealed in four different strained conditions, freely hung, 0, 1, and 10 percent. After annealing, specimens were subject to in vitro hydrolytic degradation by immersion in phosphate-buffer solution of pH 7.4 at 37°C for up to 28 days. The thermal properties and gross morphology of the specimens were obtained. It was found that annealing treatments resulted in initial higher levels of crystallinity, which, in turn, influenced the hydrolytic degradation of the fiber. Among all the annealing conditions, the freely hung specimens annealed at 190°C exhibited the most pronounced annealing effect on hydrolytic degradation, consistent with observed gross morphologic changes. The change to a less oriented conformation was thought to be the cause. (Edited author abstract). 20 Refs.

Chu, C.C. (Cornell Univ, Ithaca, NY, USA); Browning, A. *J Biomed Mater Res* v 22 n 8 Aug 1988 p 699-712.

## Biodegradation

**081308 SYNTHESIS AND BIODEGRADATION OF COPOLYESTERS DERIVED FROM GLUTAMIC ACID.** Copolymers of glutamic acid hydrochloride and 1,2-ethane diol, 1, 3-butane diol, 1,4-butane diol, 1,6-hexane diol and glycerol have been synthesized and characterized by number average molecular weights, I.R. spectra and elemental analysis. Microbial degradation of the co-polyesters has been studied using the fungus *aspergillus niger* and the bacterium *E.coli*. All the polymer samples are degraded by these microorganisms. The less polar copolymers are more readily degraded by the fungus while the bacterium more efficiently degrades the polymers having a higher proportion of  $\alpha\text{-NH}_2$  group. The facile attachment of a suitable drug through the free amine groups of the copolymers has been illustrated to indicate their possible use as carrier polymers for drugs. (Edited author abstract) 11 refs.

Pramanick, Dinabandhu (Kalyani Univ, Kalyani, India); Ray, Tarun Tapan. *Polym Bull (Berlin)* v 18 n 4 Oct 1987 p 311-315.

**Blending** See Also SYNTHETIC FIBERS—Processing; TEXTILE FIBERS—Synthetics.

**081309 COMPATIBILITY AND MESOPHASE SEPARATION IN BLENDS OF  $\alpha$ -HELICAL POLY-**



**GLUTAMATES.** Blends composed of the  $\alpha$ -helical polymers, poly-L-glutamates  $[(\text{NHC}^{\alpha}\text{HRC}^{\alpha}\text{O})_n]$ ,  $R = \text{CH}_2\text{CH}_2\text{COO}-(\text{CH}_2)_m\text{C}_6\text{H}_5]$  (Lm) and the corresponding D enantiomers (Dm), have been studied by x-ray diffraction and viscoelastic measurements. Binary blends of L2, D2, L3, and D3 are compatible and form isomorphous mixed crystals at all compositions, whereas other pairs, with the exception of L1/D1, are incompatible. The demixing process is described for a ternary system consisting of L1, D3, and a diluent chloroform at 40°C. The phase diagram comprises four regions, I, IA, A, and AA, with increasing polymer concentration; I: isotropic, A: anisotropic, IA: I-A biphasic, and AA: A-A biphasic. The IA biphasic gap is greater in the ternary system than in the binary ones. The high-molecular-weight component (D3) is partitioned into the A phase in the IA region. The AA separation originates from incompatibility of the polymers. The phase behavior is discussed on the basis of the Abe-Flory theory by incorporating the polymer-polymer interaction parameter. (Author abstract) 40 refs.

Sasaki, S. (Tokyo Inst of Technology, Tokyo, Jpn); Nagao, M.; Gotoh, M.; Uematsu, I. *J Polym Sci Part B* v 26 n 3 Mar 1988 p 637-648.

**Blow Molding** See FOOD PRODUCTS—Filtration.

**Chemical Reactions** See ION EXCHANGE RESINS—Synthesis.

**Chromatographic Analysis**

**081310 SIMULTANEOUS DETERMINATION OF PHTHALIC ACIDS AND POLYOLS IN LINEAR SILICONE POLYESTERS.** A procedure is described which simplifies previously reported methods applicable to hydrolysis-resistant polyesters. Elimination of the extraction steps has been achieved in an attempt to provide a simultaneous estimation of polyol acetates and dimethyl carboxylates, to remove errors introduced by the extraction steps, and accordingly to improve the quantitative nature of the analysis. The degradation was conducted using an acetic anhydride-acetic acid reagent. Acetic acid present and formed during the reaction was removed by distillation and the dicarboxylic acids esterified with boron trifluoride-methanol reagent. Complete acetylation of the polyols was achieved by reaction in the presence of 1-methylimidazole. The organic pendant groups of the siloxane components are split off as the corresponding hydrocarbons by both acid or alkaline reaction. The methane and benzene thus formed are estimated by gas solid chromatography using a head space technique. (Author abstract) 23 refs.

Haken, J.K. (Univ of New South Wales, Kensington, Aust); Harahap, N.; Burford, R.P. *J Coat Technol* v 60 n 759 Apr 1988 p 53-56.

**Crosslinking** See Also ELASTOMERS—Curing; EPOXY RESINS—Research; ION EXCHANGE RESINS—Synthesis.

**081311 FOTONICJOWANE SIECIOWANIE NIENASYCONYCH ZYWIC POLIESTROYCH TYPU POLIMAL WOBEC ETTEROW BENZOINY JAKO FOTONICJATOROW.** [Photoinitiated Crosslinking of Polimal Type Unsaturated Polyester Resins in the Presence of Benzoic Ethers]. The Polish-made unsaturated polyesters of the Polimal type have been photopolymerized in UV-range with the use of lower alkyl ethers of benzoic as initiators. For the system of Polimal 103 - benzoic isobutyl ether the dependence of the surface hardness, impact strength and softening temperature of the cured samples on photoinitiator concentration has been determined. Using an original measuring system the thermal effects of the photoinitiated polymerization in the presence of various amounts of initiator have been measured. The course of the photo- and thermoinitiated by benzoyl peroxide crosslinking of Polimal resins as well as the properties of crosslinked resins from both processes have been compared. (Author abstract) In Polish. 7 refs.

Sierocka, Michalina (Akad Techniczno-Rolnicza, Bydgoszcz, Pol); Wasilewski, Wojciech; Lyk, Bernadeta;

Szymanska, Lucyna. *Polimery* v 32 n 7 Jul 1987 p 272-274.

**081312 PHOTOCROSSLINKABLE VINYL POLYESTER.** The authors prepared a vinyl polyester resin from a photocurable diepoxide, such as the diglycidyl ether of 4,4'-dihydroxychalcone with acrylic end groups. This resin's photofastness was compared to that of the parent diepoxide. The results obtained are discussed and the method of synthesis can be extended to a large number of photocrosslinkable vinyl polyesters. 9 refs.

Sadafule, D.S. (Inst of Armament Technology, Pune, India); Raghuraman, R.N.; Navale, N.G.; Kumbhar, C.G.; Panda, S.P. *J Macromol Sci Chem* v A25 n 1 1988 p 121-126.

**081313 POSTCROSSLINKING OF LINEAR POLYESTERS. I. MELT-BLEND-TYPE UV-INDUCED CROSSLINKING AGENTS.** Postcrosslinking of such linear polyesters as poly(ethylene terephthalate) (PET) and poly(butylene terephthalate) (PBT) are known to be attractive means to improve their thermal resistance without sacrificing their melt processibilities. Effective melt-blend-type ultraviolet-induced crosslinking agents were investigated among allyl compounds. Such polyallyl compounds as triallyl cyanurate and triallyl isocyanurate were found to be practically promising agents from the viewpoints of crosslinkability and stability in the polyester melt. The crosslinkability of the allyl compounds increased with increasing the number of the allyl groups in the molecule and electron-withdrawing property of the neighboring group to which the allyl group was attached. The crosslinked PET and PBT showed good mechanical properties even above the melting points of the ordinary PET and PBT. (Edited author abstract) 13 refs.

Inata, Hiroo (Teijin Ltd Iwakuni, Jpn); Morinaga, Tsutou; Matsumura, Shunichi. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1705-1714.

**Crystallization** See Also POLYETHYLENE TEREPHTHALATE—Crystallization.

**081314 CRYSTALLIZATION AND MORPHOLOGY OF POLY( $\beta$ -HYDROXYBUTYRATE) AND ITS COPOLYMER.** The morphology and structure of the bacterial plastics of poly( $\beta$ -hydroxybutyrate- $\beta$ -hydroxyvalerate) P(HB-HV) were studied as well as the reference homopolymer, poly( $\beta$ -hydroxybutyrate) (PHB). Because of bacterial origins they are exceptionally pure. The solution-grown single crystals of PHB and P(HB-HV) showed linear increase in melting points and hyperbolic increase in long spacings as the crystallization temperature increased. The HV component in the polymer chain was inclined to be excluded outwards as much as possible from the crystal of HB component during the crystallization. A small part of the HV component included in the HB component crystal acts as a defect, by which small expansion of the a-parameter of the unit cell is mainly caused with increasing HV content. The severe effect of the HV component was observed on crystallization characteristics and morphological changes. (Edited author abstract) 32 refs.

Mitomo, Hiroshi (Gunma Univ, Kiryu, Jpn); Barham, Peter J.; Keller, Andrew. *Polym J* v 19 n 11 1987 p 1241-1253.

**Curing** See Also COMPOSITE MATERIALS—Modification; INTERPENETRATING POLYMER NETWORKS—Molecular Structure; PLASTICS—Sheet Molding Compounds; PROTECTIVE COATINGS—Weathering.

**081315 EFFECT OF PRESSURE ON THE CURING BEHAVIOR OF UNSATURATED POLYESTER RESINS.** The effect of pressure on the curing behavior of unsaturated polyester resin was investigated, both experimentally and theoretically. The resin used was a general-purpose unsaturated polyester resin and the initiator used was t-butyl perbenzoate. A series of isothermal runs with differential scanning calorimetry (DSC) were made at various levels of cure pressure. It was found that the rate of cure was retarded under pressure, and that the ultimate degree of cure went through a maximum at a certain

pressure at the cure pressure was increased from atmospheric pressure to 6.21 MPa (900 psi). It was interpreted that pressure has two competing effects on the curing behavior of unsaturated polyester resin; one is a free volume effect that hinders the curing reaction and the other is a thermodynamic effect that favors it. (Edited author abstract) 15 refs.

Lee, Dai-Soo (Polytechnic Univ, Brooklyn, NY, USA); Han, Chang Dae. *Polym Compos* v 8 n 3 Jun 1987 p 133-140.

**081316 EB CURING LABORATORY UNIT SPEEDS PSA RESIN DEVELOPMENT.** This application case history discusses the development of a line of radiation curable polyester-based pressure sensitive adhesives using an electron beam laboratory unit. The benefits of the new pressure sensitive adhesives (PSA) resins are briefly described. The benefits of the lab unit are also covered.

Anon. *Adhes Age* v 31 n 4 Apr 1988 p 24.

**081317 ESR STUDY OF THE CURING REACTION OF UNSATURATED POLYESTER WITH VINYL MONOMERS AND THE THERMAL BEHAVIOR OF THE CURED POLYMERS.** The curing reaction of an unsaturated polyester (BAPM), prepared by polycondensation of Bisphenol A-di-(2-hydroxypropyl)ether and maleic anhydride, with vinyl monomers was investigated by IR and ESR. Thermal properties of the resulting polymer were studied by DSC and TMA. For the curing reaction of BAPM with styrene initiated with the cobalt naphthalate/1-hydroxycyclohexyl hydroperoxide system, the copolymerization process could be satisfactorily analyzed by the Mayo-Lewis integral equation for the usual homogeneous copolymerization. The reaction mixtures contained long-lived polymer radicals, the ESR spectra of which gave important information on the curing reaction. (Edited author abstract) 21 refs.

Zheng, Anna (Nanjing Inst of Chemical Technology, Nanjing, China); Ota, Tadatoshi; Sato, Tsuneyuki; Tanaka, Hitoshi; Sasai, Kensuke; Zhou, Runpei. *J Macromol Sci Chem* v A25 n 1 1988 p 1-26.

**081318 INFLUENCE OF FUNCTIONAL RUBBERS ON THE CURING PROCESS OF UNSATURATED POLYESTER RESINS.** The influence of an elastomeric second-phase on the kinetics of the curing reaction and the gel-time of a standard unsaturated polyester resin, by using the isothermal and dynamic techniques of differential scanning calorimetry (DSC) and a thermocouple was investigated. In particular we examined two different rubbers (polybutadiene hydroxyl-terminated and polybutadiene isocyanate-terminated), that, in the presence of polyester resins, affect the overall curing reaction kinetics in two ways: the former reduces the rate of reaction whilst the latter increases it. (Author abstract). 9 refs.

Avella, M. (Inst di Ricerche su Tecnologia, Naples, Italy); Martuscelli, E.; Volpe, M.G. *J Therm Anal* v 34 n 2 Mar-Apr 1988 p 441-450.

**Decomposition** See COPOLYMERS—Thermal Properties.

**Deformation** See ELASTOMERS; THERMOPLASTICS—Deformation.

**Degradation**

**081319 DEGRADATION OF POLYESTER WASTE BY ALIPHATIC AND AROMATIC ALCOHOLS.** Polyester waste is generated (4-6% of total production) during the manufacturing process of polyester yarn and fibers. Polyester waste was degraded with ethanol, n-propanol, and benzyl alcohol in an autoclave at 280°C under pressure to give seven unknown compounds. The products of each reaction were isolated by using column chromatography and were identified on the basis of elemental analysis and spectral data. (Edited author abstract) 7 refs.



Joshi, K.A. (Fibre Research Lab, Bombay, India); Naik, G.A.; Nevrekar, N.B. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1921-1926.

**081320 THERMODYNAMIC ASPECTS OF DEGRADATION WITH PARTICULAR REFERENCE TO UNSATURATED POLYESTER RESINS.** Like the concept of ceiling temperature, which allows the prediction of when a depolymerization reaction can occur from the thermodynamic point of view, it is pointed out that degradation reactions other than depolymerization can be treated in an analogous manner. Calculations on the basis of increments are particularly useful because the increments of parts of the molecule which are not involved in the reaction process do not occur explicitly in the calculation. Thus, for certain types of reaction, typical thermodynamic data can be obtained. Thermodynamic data of some typical reactions which are of importance in the field of the thermal degradation of unsaturated polyester resins are calculated. The results are compared with experimental results obtained from previously published research in the field of polyesters. (Edited author abstract). 12 Refs.

Fink, J.K. (Inst fuer Chemische und Physikalische Technologie der Kunststoffe, Leoben, Austria). *Polym Degradation Stab* v 21 n 4 1988 p 345-354.

**081321 COMPARATIVE STUDY OF THE THERMAL DEGRADATION OF UNSATURATED POLYESTER RESINS CONTAINING VARIOUS CHLORINATED NORBORNENE DICARBOXYLIC ACID UNITS IN THE BACKBONE.** The Diels-Alder adducts of hexachlorocyclopenta-1,3-diene, 1,2,3,4,5-pentachlorocyclopenta-1,3-diene and 1,2,3,4-tetrachlorocyclopenta-1,3-diene with maleic anhydride are incorporated in the backbone of the unsaturated polyester containing further 1,2-propanediol and maleic anhydride as co-monomers. The thermal degradation behavior of these polyesters is investigated by analyzing the degradation products obtained in vacuum pyrolysis using gas chromatography coupled with mass spectrometry techniques. The evolution of hydrogen chloride and the appearance of the different chlorocycloienes in the course of programmed heating are measured by single ion detection techniques in a mass spectrometer for both uncured and styrene-cured polyester. (Edited author abstract) 8 refs.

Irlz, G.H. (Montanuniversitaet Leoben, Leoben, Austria); Vijayakumar, C.T.; Fink, J.K.; Lederer, K. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 277-286.

**Dyeing** See Also DYES AND DYEING—Synthesis; DYES AND DYEING—Synthetic Fibers.

**081322 VESICLE PRECURSORS IN THE DYEING OF POLYESTER WITH DISPERSE DYES.** The use of double tailed surfactants suitable for the preparation of synthetic vesicles and the resort to sonication for the setting up of dyebaths in the dyeing of polyester fabrics with a disperse dye is proposed. The dye, having excellent fastnesses, belongs to the diethylamino-azobenzene series and has been designed by chemometric procedures. In a selected number of experiments, excellent results are obtained from both the points of view of dyebath exhaustion and uniformity of coloration. (Edited author abstract) 9 refs.

Barni, E. (Univ di Torino, Turin, Italy); Carpinano, R.; Di Modica, G.; Savarino, P.; Viscardi, G. *J Dispersion Sci Technol* v 9 n 1 Feb 1988 p 75-87.

## Electric Properties

**081323 ELECTRICAL PROPERTIES OF POLYESTER POLYMER-QUINOLINE SALT OF TETRACYANOQUINODIMETHANE COMPOSITES.** The purpose of this note is to present preliminary measurements of the electrical properties of polyester polymer-quinoline salt of tetracyanoquinodimethane composites which are also characteristic of a low critical

concentration of the conducting component ( $< 1$  wt%). The polyester polymer compositions have been obtained by polymerization of styrene solution of unsaturated polyester (Polimal 109). The electrical conductivity of polyester polymer Polimal 109 is thermally activated and of ionic character and amounts of  $10^{-17} \Delta^{-1} \text{ cm}^{-1}$  at room temperature. By adding  $> 1$  wt% needle-like crystals an abrupt increase of the electrical conductivity by ten orders of magnitude has been observed. Classic bond or site percolation models cannot account for threshold concentrations as low as 1% nor for a critical exponent as large as 7.6 which were observed in this work. The comparison of two  $c = 10^{-2}$  data points demonstrates the importance of the shape factors for the formation of a conducting network and percolative charge transport. 7 refs.

Kuczkowski, A. (Technical Univ of Gdansk, Gdansk, Pol). *Phys Status Solidi A* v 105 n 1 Jan 1988 p K61-K65.

**Electrodeposition** See POWDERS—Explosions.

## Environmental Impact

**081324 TIGHTER RULES ON ALLOWABLE EMISSIONS YIELD SAFER MATERIALS AND EQUIPMENT.** On July 1 four southern California counties will enact a regulation limiting the amount of volatile organic compounds that reinforced polyester fabricators can release into the air. The target of the measure (Rule 1162) is styrene monomer emissions that occur during fabrication, chiefly sprayup and layup. Efforts to reduce styrene emissions and improve properties may lead some fabricators to consider hybrid polyesters. Spray equipment is a factor in controlling volatile organic compounds - thus codes/regulations have led equipment suppliers to lower sprayup pressures and redesign guns.

Toensmeier, Patrick A. *Mod Plast* v 65 n 3 Mar 1988 p 56-57, 59.

## Extrusion

**081325 INDUCTION OF PREFERRED ORIENTATION IN A LIQUID CRYSTAL CO-POLYESTER BY EXTRUSION AND DRAWING.** It is shown that liquid crystal polyester can be extruded and drawn from the melt into fine fibers which possess stiffnesses up to 68 GPa. Thicker fibers with smaller draw ratios have correspondingly lower stiffnesses, which are correlated with molecular alignments characterized by flat plate X-ray diffraction. Fibers with a range of diameters were heat-treated over a range of temperatures to determine the effect of annealing on preferred orientation and stiffness. Heat-treatment of as-spun fibers produced maxima in axial stiffness at 170°C, corresponding to an increase in preferred orientation, and 270°C, corresponding to the development of quasi-crystalline order which is analyzed. Scanning electron microscopy showed the existence of needle-like domains of approximately circular cross section up to 0.8  $\mu\text{m}$  in diameter. These were aligned in the direction of drawing in contrast to being haphazardly arranged in a hot rolled specimen displaying no preferred orientation. (Author abstract) 14 refs.

Jenkins, J.C. (Univ Coll of Swansea, Swansea, Wales); Jenkins, G.M. *J Mater Sci* v 22 n 10 Oct 1987 p 3784-3792.

**081326 EXTRUSION, FIBER FORMATION, AND CHARACTERIZATION OF THERMOTROPIC COPOLYESTERS.** The flow behavior and the effect of the spinning conditions on the fiber properties and structure of poly(ethylene terephthalate) modified with 60 mol% p-hydroxybenzoic acid (PET/60PHB) were investigated. PET and its copolymers with 28 and 80 mol% PHB were used as control samples. The melt of PET/60PHB at temperatures above 265°C exhibited extremely low viscosity and low flow activation energy. High birefringence, indicating the presence of a mesophase, was observed between 265 and 300°C on a hot-stage polarizing light microscope. The maximum tensile strength and initial modulus, 438 MPa and 37 GPa, respectively, were

obtained at 275°C for a 0.69 IV polymer. The fiber strength and modulus were significantly lowered when extrusion was conducted at temperatures below 265°C. The fiber properties could also be improved when a high extrusion rate and/or a high draw down ratio was used. Scanning electron microscopy revealed that the fibers spun at temperatures above 265°C had a well-developed, highly oriented fibrillar structure. The fibers spun at lower temperatures, however, were poorly oriented and nonfibrillar in character. The high orientation and superior mechanical performance achieved at high temperatures were attributed to the presence of the nematic mesophase in the polymer melt. (Author abstract) 31 refs.

Cuculo, John A. (North Carolina State Univ, Raleigh, NC, USA); Chen, Gao-Yuan. *J Polym Sci Part B* v 26 n 1 Jan 1988 p 179-200.

## Fiber Reinforcement

**081327 DIFFUSION OF HYDROCHLORIC ACID IN POLYESTER THERMOSETTING RESINS.** The possibility of diffusion of corrosive media in polyester resins is considered as a contributor to the process of stress corrosion cracking in glass reinforced polyester composites. It is shown that neither the saturation levels reached nor the rate of diffusion achieved for hydrochloric acid is sufficient for this mechanism to be considered a significant contributor to the process of low stress induced corrosion. It is believed that the corrosive medium will attack the fibers by a process of percolation through stress induced microcracks. (Author abstract) 13 refs.

Caddock, B.D. (Univ of Liverpool, Liverpool, Engl); Evans, K.E.; Hull, D. *J Mater Sci* v 22 n 9 Sep 1987 p 3368-3372.

## Filaments

**081328 MELT SPINNING OF THERMOTROPIC LIQUID-CRYSTAL POLYESTERS TO FORM ULTRAHIGH-MODULUS FILAMENTS.** The properties and structure of ultrahigh-modulus filaments were investigated for wholly aromatic copolymers (WACPs) containing 60 and 70 mol percent p-oxybenzoate, based on p-hydroxybenzoic acid, p, p'-biphenol, terephthalic acid, and isophthalic acid and for poly(ethylene terephthalate co-p-oxybenzoate) containing 60 mol% p-oxybenzoate. As-spun filaments with varying degrees of molecular orientation were spun from melts by taking the spin-extension ratio as a variable at given temperatures. The as-spun filaments were further subjected to thermal annealing. Changes in the structural ordering with the extension ratio were monitored by wide-angle x-ray scattering, scanning electron microscopy, viscoelastic properties, and measurements of the thermal expansion coefficient. The increase in modulus is correlated well with the crystallite orientation at a relatively low extension ratio. (Edited author abstract) 19 Refs.

Itoyama, Kuniyoshi (Research Assoc for Basic Polymer Technology, Tokyo, Jpn). *J Polym Sci Part B* v 26 n 9 Aug 20 1988 p 1845-1863.

## Fillers

**081329 MOISTURE ABSORPTION IN UNFILLED AND GLASS-FILLED, CROSS-LINKED POLYESTER.** The moisture uptake characteristics of unfilled and filled polyester resin at 60°C are reported. The objective was to determine the influence of filler on the moisture uptake properties of unfilled polymer. Diffusivity in the filled polyester is lower than in the plain resin. However, the filled resin absorbs significantly more water than unfilled polyester. Tensile load was found to have no effect on the water uptake in plain polyester. However, moisture absorption was affected by tensile load in 20% (by volume) bead-filled polyester and in SMC-R65. In bead-filled polyester, the diffusion coefficient was accurately predicted when microstructural effects were accounted for. (Edited author abstract) 26 refs.

Janas, V.F. (Univ of Delaware, Newark, DE, USA); McCullough, R.L. *Compos Sci Technol* v 29 n 4 1987 p



293-315.

**081330 PARTICULATE FILLED POLYESTER COMPOSITES.** In this note we examine the effect of two different fillers, one hard and the other a soft filler, on some physical properties of an unsaturated polyester resin. An unsaturated polyester resin prepared from maleic anhydride, ethylene glycol and isophthalic acid in styrene monomer was employed. Sand particles with dimensions of approximately 100  $\mu\text{m}$  were used. Cryogenically ground rubber (CGR) from old tires of approximately 250  $\mu\text{m}$  was also employed. This study showed that the final properties of particulate composites are strongly affected by the intrinsic nature of the filler. The acoustic emission, an indication of the microcracking activity in the composite during deformation, showed that the hard filler (sand) gave more acoustic emission than a soft filler (CGR). 2 refs.

Rodriguez, E.L. (B.F. Goodrich Chemical Co, Avon Lake, OH, USA). *J Mater Sci Lett* v 6 n 11 Nov 1987 p 1280-1282.

## Film

**081331 MORPHOLOGY OF A LIQUID-CRYSTALLINE POLYESTER FILM.** Morphological studies are reported for a thermotropic liquid crystalline polyester. Small angle light scattering studies were carried out as a function of temperature. The size of the morphological features responsible for SALS patterns were calculated and were found not to change significantly with temperature ranging from glass transition temperature to the solid-nematic transition temperature of the polyester. (Edited author abstract) 10 refs.

Bhattacharya, S.K. (Indian Inst of Technology, New Delhi, India); Misra, A.; Stein, R.S. *J Polym Sci Part B* v 26 n 3 Mar 1988 p 515-526.

## Flame Resistance

**081332 REDUCTION IN THE COMBUSTIBILITY OF UNSATURATED POLYESTER RESINS.** Halogen- or phosphorus containing organic compounds or synergistic metal oxides are the main means of imparting flame retardancy to unsaturated polyester resins. They are intended not only to inhibit combustion but also to reduce the formation of toxic gases and smoke development. Commercial flame retardants for UP resins and their model of action are reviewed. (Author abstract) 44 refs. In German and English.

Krolkowski, W.; Nowaczek, W.; Penczek, P. *Kunstst Ger Plast* v 77 n 9 Sep 1987 p 19-23.

**081333 FLAMEPROOF POLYESTERS PREPARED BY DIRECT POLYCONDENSATION OF AROMATIC DICARBOXYLIC ACIDS AND BROMINATED BISPHENOLS WITH TOSYL CHLORIDE AND N,N'-DIMETHYLFORMAMIDE IN PYRIDINE.** Brominated aromatic polyesters were successfully prepared by reacting isophthalic acid and terephthalic acid with p-toluenesulfonyl chloride in pyridine in the presence of N,N'-dimethylformamide, followed by treating with a pyridine solution of tetrabromobisphenols. The tetrabromobisphenols were synthesized by a facile bromination of their corresponding bisphenols in aqueous acetic acid solution under mild conditions. The polycondensation was significantly affected by the reactivity of bisphenols and the solubility of the resulting polymers in the reaction media. Tetrabromobisphenols with positive linking groups between the aromatic rings and better solubility of the resulting polymers give a more favorable result. The products were nonflammable having limiting oxygen index 59-62 (ASTM D2863-77) without much sacrifice in thermal stability. (Author abstract). 13 Refs.

Yang, Chin-Ping (Tatung Inst of Technology, Taipei, Taiwan); Hsiao, Sheng-Huei. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 1221-1232.

## Forming

**081334 POLYESTERS FROM  $\alpha,\alpha'$ -DICARBOMETHOXY- $\alpha,\alpha'$ -DIPHENYL-P-XYLYLENE AND THE SYNTHESIS AND PROPERTIES OF A NEW QUINODIMETHANE.** A film forming polyester was obtained from the title compound and 1,4-butanediol. In addition oxidation of the title compound gave rise to 7,8-dicarbomethoxy-7,8-diphenylquinodimethane as a mixture of Z and E isomers. The <sup>1</sup>H-NMR and the electronic characterization of this polymer are discussed. The quinodimethane will undergo 1,6-nucleophilic addition to form an aromatic compound. (Author abstract). 8 Refs.

Mulvaney, J.E. (Univ of Arizona, Tucson, AZ, USA); Green, G. David. *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2597-2602.

## Fracture See SYNTHETIC FIBERS—Mechanical Properties.

## Heat Treatment

**081335 THERMOTROPIC POLYESTER CARBONATES. II. POLYESTER CARBONATES AS HIGH PERFORMANCE FIBERS.** The fiber spinning and heat treatment of spun fibers from thermotropic polyester carbonates are described. Thermotropic polyester carbonates derived from t-butylhydroquinone, methylhydroquinone, diphenyl terephthalate, and diphenyl carbonate in the molar ratios of 50:50:55:45; 50:50:57.5:42.5; can be spun successfully, and after proper heat treatment, yield fibers with tenacity as high as 20 g/denier. Normally the best spinning temperature is 10-20°C above melting. (Author abstract). 4 Refs.

Lai, Y.C. (Allied-Signal Inc, Morristown, NJ, USA); Debona, B.T.; Prevorsek, D.C. *J Appl Polym Sci* v 36 n 4 Aug 5 1988 p 805-817.

## Hydrolysis See AROMATIC POLYMERS—Hydrolysis; TEXTILE FIBERS—Synthetics.

## Mechanical Properties See Also VINYL RESINS.

**081336 AROMATIC POLYESTERS AND POLYESTER CARBONATES.** With aromatic polyesters and polyester carbonates a new family of plastic materials has been available for a few years which is closely related to polycarbonates and can be regarded as a further development of the latter. Aromatic polyesters are mainly prepared by polycondensation of Bisphenol A with terephthalic or isophthalic acid derivatives. For the manufacture of polyester carbonates carbonic acid derivatives are in addition used. Owing to their property profile polyarylates offer application possibilities in many areas. The transparency and weak natural colour with a high deflection temperature under load allow these plastics to be used in lighting technique for highly stressed light coverings, lenses and scattering discs. In the technical development emphasis is on the use of polyarylates for polyblends with special property combinations and the adaption of the products to meet the demands of the processor. 4 refs.

Rathmann, D. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 57-59.

**081337 STUDIES ON THERMOTROPIC AROMATIC COPOLYESTERS: P-HYDROXYBENZOIC ACID 2, 3, 5-TRIMETHYLBENZOIC ACID, 2, 6-NAPHTHALENE DICARBOXYLIC ACID SYSTEM.** A series of aromatic copolymers based on the p-hydroxybenzoic acid (HBA), 2,3,5-trimethylhydroquinone (TMHQ), and 2,6-naphthalene dicarboxylic (NDA) system was synthesized. The effect of composition of aromatic copolymers on their liquid crystalline behavior, rheological property, thermal stability and crystal structure was studied. It was found that they exhibited a threaded schlieren texture in a quiescent melt state and formed banded structure under shearing conditions, manifesting that a nematic mesophase existed. The thermal stability of the copolymers containing 15-20mol percent

TMHQ and NDA was considerably improved. As the ratios of PET/HBA increased both the melting point and degradation temperature of the copolymers having the same amounts of TMHQ and NDA decreased. The extrudates from the capillary die for them exhibited highly oriented morphologies. (Author abstract). 13 Refs.

Liang, Borun; Ke, Jiaqin; Huang, He; Yu, Hu. *J China Text Univ Engl Ed* v 5 n 1 Mar 1988 p 79-86.

**081338 POLYESTER: TECHNICAL AND COMMERCIAL VIEW.** Polyester is the world's second largest fiber in production tonnage and is in a growth position owing to its recent (1982-86) high rate of increase (15 percent p/a) in developing and centrally-planned countries. Moreover, about 70 percent of immediately-planned new fiber capacity is for polyester. The reasons for this success lie in a combination of technical and commercial merits of the fiber-making system, and of the wide applicability of polyester fibers to textile products. Comparisons of the major uses of the principal man-made fibers (polyester, polyamide, acrylic, viscose etc.) show that polyester has the widest scope of usage both in fiber and yarn types and in end-products.

Ford, John (British Textile Technology Group, Manchester, Engl). *Text Mon* Oct 1988 p 27, 29-32.

## Melting

**081339 MULTIPLE ENDOTHERMIC MELTING BEHAVIOR IN POLY(TETRAMETHYLENE TEREPHTHALATE)-CONTAINING POLYESTERS AND BLOCK COPOLYETHER-ESTERS.** The multiple endothermic behavior of poly(tetramethylene terephthalate) (PTMT) and its random and block copolymers with poly(tetramethylene isophthalate) (PTMI) and poly(tetramethylene oxide) (PTMO) is described. The differential scanning calorimetry heating scans of these polymers exhibit up to four endotherms. Endotherm I, the lowest-temperature endotherm, is an annealing peak and is ascribed to a clustering of PTMT sequences. Endotherms II, III, and IV are associated with crystal populations originated during periods of isothermal crystallization, cooling, and heating, respectively. The dependence of the endotherms on sample composition, crystallization and annealing temperatures, crystallization and annealing times, and sample cooling and heating rate is discussed. (Author abstract) 7 refs.

Stevenson, Janis Castles (Univ of Wisconsin-Madison, Madison, WI, USA); Cooper, Stuart L. *J Polym Sci Part B* v 26 n 5 May 1988 p 953-966.

## Microscopic Examination

**081340 RUTHENIUM TETRAOXIDE STAINING TECHNIQUE FOR TRANSMISSION ELECTRON MICROSCOPY OF SEGMENTED BLOCK COPOLYETHERESTER.** Lamellar morphology of melt-crystallized polyetherester (PBT-PTMO) has been investigated by extending the technique of ruthenium tetroxide (RuO<sub>4</sub>) as a staining agent for the observation of the cast films using transmission electron microscope (TEM). The excellent image contrast obtained indicates that the RuO<sub>4</sub> staining technique is very effective and simple for the study of the lamellar structure of segmented block copolyetherester. (Author abstract) 6 refs.

Chen, Shouxi (Acad Sinica, Beijing, China); Cao, Ti; Jin, Yongze. *Polym Commun (Guildford Engl)* v 28 n 11 Nov 1987 p 314-315.

## Microstructure

**081341 STRUCTURE AND PROPERTIES OF p-CARBOXYSUCCINANILIC POLYESTER RESINS.** Polyester resins were prepared by the reaction of p-carboxysuccinanic acid ethyl ester with ethylene glycol and 1, 4-butanediol. Also, unsaturated polyester resins were prepared by the copolymerization of p-carboxysuccinanic acid ethyl ester and maleic anhydride with ethylene glycol, 1,6-hexanediol, 1, 4-butanediol, and 2-butene-1,4-diol. All the polyester resins and the copoly-



esters have been characterized and were found to cure with styrene, except those prepared in the absence of maleic anhydride. The properties of the cured products in the form of films were determined. Infrared and nuclear magnetic resonance (NMR) spectroscopy were used for both qualitative and quantitative analyses of the polyester resins and their hydrolyzate products after curing with styrene. (Author abstract) 8 refs.

Nosseir, Michael H. (Nat'l Research Cent, Cairo, Egypt); Doss, Ninette L.; Taufik, Sohair Y. *J Appl Polym Sci* v 35 n 1 Jan 1988 p 75-83.

## Modification

**081342 TOUGHENED POLYESTER FOR BARRIER FILMS.** A new, patented technique to chemically toughen polyester (PET) has led to a new resin family that is close to amorphous PET in barrier properties. Selar PT can be heat sealed, and it provides enhanced elongation and better melt strength. The orientation step that is used to produce most PET film can thus be avoided. Given this unique combination of properties, Selar PT should find many applications in the packaging field as a cost-effective barrier film. Chemically toughened polyester resins have excellent heat sealability and can be used in blown and cast coextrusions.

McCauley, D.L. (DuPont, Wilmington, DE, USA). *Tappi J* v 71 n 6 Jun 1988 p 159-163.

**Molecular Structure** See Also SYNTHETIC FIBERS—Mechanical Properties.

**081343 CONFORMATIONAL CHARACTERISTICS OF AROMATIC POLYESTERS: COMPARATIVE STUDY OF THE POLARITY OF POLY(PROPYLENEGLYCOL TEREPHTHALATE) AND POLY(ETHYLENEGLYCOL TEREPHTHALATE).** Aromatic polyesters constitute a class of polymers having conformational characteristics strongly dependent on both the number of methylene groups of the glycol residue and the nature (terephthalic, isophthalic, phthalic) of the acid residue. The most prominent feature of the terephthalic and isophthalic acid-based polyesters is the coplanarity of the ester and phenyl groups. By substituting a methyl group for a hydrogen atom in the glycol residue of poly(ethyleneglycol terephthalate) (PET), an amorphous polyester, poly(propyleneglycol terephthalate) (PPT) is obtained, whose conformational properties differ from those of PET. Simple scrutiny of structural characteristics of PPT chains indicates that certain conformations that are accessible in PET are suppressed in PPT. In this work, the dipole moment of these chains and its temperature coefficient were measured and the results compared with those calculated using statistical mechanics. A comparative study of the polarity of PPT and PET was also made. 11 refs.

Riande, Evaristo (CSIC, Madrid, Spain); Guzman, Julio; de la Campa, Jose G.; de Abajo, Javier. *J Polym Sci Part B* v 25 n 11 Nov 1987 p 2403-2407.

**081344 THERMOTROPIC POLYESTERS OF 4'-HYDROXYPHENYL-4-HYDROXYBENZOATE: A STUDY OF THE TRANSITION TEMPERATURES.** Polyesters based on 4'-hydroxyphenyl-4-hydroxybenzoate and dichlorides of dibasic acids, prepared using a high-temperature solution polycondensation in 1-chloronaphthalene, exhibit enantiotropic nematic mesomorphism. The range of temperatures for the nematic phase  $\Delta T_N$  can be controlled by changing the number of methylene units in the repeating polymer unit. For  $n=4$ ,  $\Delta T_N=97^\circ\text{C}$  is the largest that can be obtained. Higher  $n$  leads to smaller values of  $\Delta T_N$ . When  $n=12$ , the polyester exhibits only one single C-I transition. For  $n>12$  a smectic mesophase can be expected in this system. Strzelecki and Liebert reported a wide range of temperatures of  $\Delta T_N$  (70-160°C) for the Sn polymers made by the transesterification of 4'-acetoxyphenyl-4-acetoxybenzoate and the dicarboxylic acids. Authors believe the latter reaction occasionally involves the internal ester linkage in the monomer unit, producing a copolyester having a random distribution of hard segment lengths and changed

polymer mesomorphic properties. (Author abstract) 14 refs.

Kotek, R. (BASF Corp, Enka, NC, USA); Krigbaum, W.R. *J Polym Sci Part B* v 26 n 6 Jun 1988 p 1173-1186.

## Molecular Weight

**081345 MOLECULAR WEIGHT DISTRIBUTION MEASUREMENTS OF LIQUID CRYSTALLINE AROMATIC POLYESTERS BY GEL PERMEATION CHROMATOGRAPHY.** A GPC method was developed to measure molecular weight distributions (MWDs) of liquid crystalline aromatic polyesters (LCPs) which cannot be dissolved by ordinary organic solvents. The combination of pentafluorophenol (PFP) and polystyrene gel columns was found to give reproducible GPC curves of LCPs at 60°C by using a temperature-controlled instrument made at our laboratory. This GPC method revealed heretofore unrecognized features of the MWDs of LCPs: LCP-A, LCP-B, LCP-C (Fiber). GPC-LALLS method was utilized to make absolute molecular weight calibration curves for LCPs. (Author abstract). 5 Refs. In Japanese.

Kinugawa, Akio (Toray Research Cent, Otsu, Jpn); Kise, Yoshitsugu. *Kobunshi Ronbunshu* v 45 n 6 1988 p 531-534.

## Morphology

**081346 MORPHOLOGY OF POLYESTERS FORMED FROM SMECTIC LIQUID CRYSTAL.** The solid-state morphology of poly(hexamethylene p,p'-bibenzoate) (BB-6) and its dependence on the liquid-crystalline texture was studied by transmission electron microscopy. Thin films of BB-6 were prepared by casting a solution of the polymer in tetrabromoethane onto mica at 150°C. The temperature of the thin film was controlled on a hot-plate. The thin, liquid-crystalline films (210°C) which formed from the isotropic melt (260°C) were cooled gradually to room temperature. Long, plate-like structures composed of stacked lamellar crystals were formed in a thin film prepared from the thermotropic melt. An attempt was made to explain such a morphology in terms of Dupan's cyclide by assuming that a hyperbola in the cyclide is parallel to the surface of the BB-6 film. (Edited author abstract) In Japanese. 8 refs.

Takahashi, Toshisada (Fukui Univ, Fukui, Jpn); Nagata, Hidefumi. *Kobunshi Ronbunshu* v 19 n 4 1987 p 893-896.

## Optical Properties

**081347 BIREFRINGENCE, THERMOELASTIC, AND DIELECTRIC STUDIES OF CYCLOALIPHATIC POLYESTERS.** Poly(diethylene glycol 1,4-trans-cyclohexanedicarboxylate) was synthesized by polycondensation of dimethyl 1,4-trans-cyclohexanedicarboxylate and diethylene glycol. The mean-square dipole moment  $\langle \mu^2 \rangle$  of the chains was measured in solutions of the polymer in benzene at several temperatures between 30 and 60°C. The experimental values of  $\langle \mu^2 \rangle$ , expressed in terms of the dipole moment ratio  $\langle \mu^2 \rangle / (\text{nm}^2)$ , changed from 0.588 to 0.608 in the temperature interval indicated above. Elastomeric networks were prepared by cross-linking of cycloaliphatic polyester with an aromatic triisocyanate. (Edited author abstract). 28 Refs.

Riande, E. (CSIC, Madrid, Spain); Guzman, J.; Campa, J.G. de la. *Macromolecules* v 21 n 7 Jul 1988 p 2128-2132.

## Permeability

**081348 TRANSPORT OF CARBON DIOXIDE AND METHANE IN GLASSY AROMATIC POLYESTERS.** Solubilities and diffusivities of  $\text{CO}_2$  and  $\text{CH}_4$  in aromatic polyesters generated from independent sorption and permeation measurements at 35°C and up to 25 atm, are compared. Less than 21% change in the glass diffusivity was observed. The data are interpreted qualitatively in terms of changes in the calculated packing density, chain torsional mobility of the polymer, and gas-polymer attraction. (Edited author abstract) 20 refs.

Sheu, F.R. (North Carolina State Univ, Raleigh, NC, USA); Chern, R.T.; Stannett, V.T.; Hopfenberg, H.B. *J Polym Sci Part B* v 26 n 4 Apr 1988 p 883-892.

## Phase Transitions

**081349 DEPRESSIONS OF THE CRYSTAL-NE-MATIC PHASE TRANSITION IN THERMOTROPIC LIQUID CRYSTAL COPOLYESTERS.** The crystal-nematic phase transition of a copolyester consisting of 20 mol% poly(ethylene terephthalate) and 80 mol% p-hydroxybenzoic acid (PHB) was characterized by depression of the crystal-nematic transition by the addition of a liquid crystal diluent. This copolyester contains blocks of crystalline PHB. Its transition behavior was compared with that of a random copolyester with diluent of the same composition. From the extrapolated transition temperature depression data, the heat of transition per mole of p-oxybenzoate was calculated as about 1.3 kcal/mol, with an entropy of about 2 cal/deg mol. This assumes that only the p-oxybenzoate unit crystallized from the nematic state. The validity of the Flory-Huggins model for this transition point depression was confirmed graphically by comparison with two different thermotropic-liquid crystal polyesters. These results may represent the first reported crystal-nematic temperatures and heats generated by the dilution method for liquid crystal copolymers of this type. (Author abstract) 20 refs.

George, Eric R. (Univ of Massachusetts, Amherst, MA, USA); Porter, Roger S. *J Polym Sci Part B* v 26 n 1 Jan 1988 p 83-90.

**Physical Properties** See POLYURETHANES—Physical Properties.

## Pressure Effects

**081350 PRESSURE-INDUCED PHASES IN A THERMOTROPIC POLYESTER.** In an effort to broaden the range of materials that might exhibit liquid crystallinity, we have examined the role of pressure on a copolyester of 20% hydroxybenzoic acid, 40% isophthalic acid, and 40% hydroquinone, 'HIQ-20', whose composition lies just inside of the mesophase range. This work was motivated by observations that low molar mass (isotropic) liquids may be transformed into mesophases at elevated pressures. The 'HIQ-20' thermotropic polyester is a rather complicated polymorphic system with high transition temperatures and narrow mesophase ranges. Additionally, this polyester exhibits a pressure-induced crystal phase. Generally speaking, these findings indicate that it may be possible to broaden the range of materials (copolyester composition) that will form mesogenic polymers: materials ruled out as candidates for liquid crystallinity at atmospheric pressures may be driven into ordered phases at elevated pressures. 18 refs.

Hsiao, B.S. (Univ of Connecticut, Storrs, CT, USA); Shaw, M.T.; Samulski, E.T. *Macromolecules* v 21 n 2 Feb 1988 p 543-545.

**Processing** See Also COMPOSITE MATERIALS—Fiber Reinforcement; POLYETHYLENE TEREPHTHALATE—Physical Properties; TEXTILE FINISHING—Chemical Treatment.

**081351 CHAIN EXTENDERS FOR POLYESTERS. V. REACTIVITIES OF HYDROXYL-ADDITION-TYPE CHAIN EXTENDER; 2,2'-BIS(4H-3,1-BENZOXAZIN-4-ONE).** In a previous study, 2,2'-bis(4H-3,1-benzoxazin-4-one) (BNZ) was found to be the most effective among the tested chain extenders in coupling hydroxyl terminals of linear polyesters through addition reaction. Detailed studies on BNZ chemistry have been made using poly(ethylene terephthalate) and poly(butylene terephthalate) as the polyester. It has been observed that use of BNZ, equivalent amount to the hydroxyl terminals of the initial polymer, resulted in the highest molecular weight. In contrast with the case of 2,2'-bis(2-oxazoline), which was found to be the most effective carboxyl-addition type chain extender and a wide



range of its excess use was allowed, an excessive use of BNZ resulted in lower molecular weight polymer. Thus, when an equivalent amount of BNZ to the hydroxyl terminals was used, the molecular weight of the resulting polymer could be determined by the carboxyl content of the initial polymer, regardless of its initial molecular weight. (Author abstract) 8 refs.

Inata, Hiroo (Teijin Ltd, Iwakuni, Jpn); Matsumura, Shunichi. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2609-2617.

**081352 ADDITIVES FOR OPEN-MOLD RP PROCESSES.** Air-release agents can reduce air inclusions by 60 to 90 percent in gelcoats and hand layup and achieve similar results in sprayup, filament winding, and pultrusion to improve processing and part quality. Wetting agents and styrene suppressants bring further improvements. A well-designed air-release agent should help prevent air entrapment during and after mixing. It should promote rapid air release so that all entrapped air can escape before gelling or setup occurs.

Cope, Donald E. (ByK-Chemie, Wallingford, CT, USA); Heilmann, Holger. *Plast Compd* v 10 n 7 Nov-Dec 1987 p 45-46, 48, 50.

**081353 PREPARATION OF AROMATIC POLYESTERS OF HINDERED PHENOLS BY ACID-INTERCHANGE POLYCONDENSATION. 2. METAL SALT CATALYSIS.** The effect of the addition of metal salts as catalysts for the acid interchange polycondensation of tetrachlorobisphenol A diacetate with phthalic acids was examined. The acetate salts of some transition metals were found to have an effect upon the molecular weights of the polyesters produced, but inherent viscosities above 0.50 dL/g were not achieved with these catalysts. Modification of the nature of the salts by either the use of a mixture of acetate and strong acid anionic species, or by addition of an equivalent of strong acid to the metal acetate, to generate a mixed salt in situ, gave the most effective catalyst for the polycondensation. (Edited author abstract) 7 refs.

Stackman, Robert W. (Celanese Research Co, Summit, NJ, USA). *J Macromol Sci Chem* v A25 n 1 1988 p 65-82.

**081354 EFFECT OF CATALYST AND EMULSIFIER ON THE WATER CONTENT AND THE MECHANICAL PROPERTIES OF SOME WATER COMPOSITES.** Two unsaturated polyester resins were prepared and used to form stable emulsion prepolymers. Different emulsifiers were used to attain the optimal conditions of a stable emulsion. The stability of the emulsion were measured and the results were discussed, in relation to gelation time. Subsequent polymerization of the most stable emulsions by the use of styrene monomer, was studied in the presence of different types of catalysts in order to obtain water composites with improved mechanical properties. The water content of the cured composites was also studied. (Author abstract) 9 refs.

Doss, N.L. (Natl Research Cent, Cairo, Egypt); Mohsen, R.M.; Ikladious, N.E. *J Elastomers Plast* v 20 n 2 Apr 1988 p 156-162.

**081355 THERMOTROPIC POLYESTER CARBONATES. III. THERMOTROPIC POLYESTER CARBONATES AS SELF-REINFORCED PLASTICS.** Thermotropic polyester carbonates derived from t-butylhydroquinone, methylhydroquinone, diphenyl terephthalate, and diphenyl carbonate in the molar ratio of 50:50:55:45; 50:50:57.5:54.2.5 and 50:50:60:40 can be injection molded successfully from temperatures 10°C below melting to 30-40°C above melting. Normally the best molding temperatures are 10-20°C above melting. If the molding conditions are controlled properly, tensile strengths as high as  $1.8 \times 10^4$  psi, tensile moduli as high as  $7.4 \times 10^5$  psi, and flex moduli as high as  $1.1 \times 10^6$  psi can be obtained. (Author abstract) 3 refs.

Lai, Y.-C. (Allied-Signal Corp, Morristown, NJ, USA); Debona, B.T.; Prevorsek, D.C. *J Appl Polym Sci* v 36 n 4 Aug 5 1988 p 819-827.

**Production** See Also PHOTORESISTS—Materials; THERMOPLASTICS.

**081356 SATURATED POLYESTERS (PET, PBT).** In the sector of thermoplastic polyesters, the last three years can be described as a period of application-oriented development of new materials. In competition with other engineering plastics, polyalkylene terephthalates are gaining increasing market shares. Whereas PET and PBT are similar in chemistry and commercially produced along the same principles, they differ in their processing techniques. Rapidly crystallizing PBT is an excellent injection moulding material for engineering applications, the less rapidly crystallizing PET is easier to stretch and is preferably extruded. The property profile of PET is similar to that of PBT and characterized by slightly higher mechanical data and a higher heat deflection temperature. Recent developments in the PET are copolyesters for transport applications with increased thermal stability. The chemistry and production process of PET and PBT also form the basis on which a variety of other polyesters are obtainable, e.g. thermoplastic polyester elastomers, polyacrylates and thermotropic 'liquid crystal' polyesters. PET and PBT are important components for polymer blends. 22 refs.

Caesar, H.M. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 41-44.

#### Pultrusion

**081357 DEVELOPMENT OF A MATHEMATICAL MODEL FOR THE PULTRUSION OF UNSATURATED POLYESTER RESIN.** A mathematical model is developed for simulating the pultrusion process of unsaturated polyester resin, using a mechanistic kinetic model based on free radical polymerization. In their previous publications, Han and Lee used the mechanistic model to simulate the curing behavior of unsaturated polyester resins under isothermal conditions, employing the differential scanning calorimetry data obtained for a range of single initiators and multiple initiator systems. For the sake of mathematical convenience, a pultrusion die of cylindrical geometry was considered. The mathematical model developed permits one to choose any number of initiators when predicting the distributions of the degree of cure and temperature in both the radial and axial directions of the die. (Edited author abstract) 8 refs.

Han, C.D. (Polytechnic Univ, Brooklyn, NY, USA); Chin, H.B. *Polym Eng Sci* v 28 n 5 Mid-Mar 1988 p 321-332.

#### Pyrolysis

**081358 A STUDY OF THE THERMAL DEGRADATION BEHAVIOUR OF POLYESTERS BASED ON HEXOLIC ANHYDRIDE.** The degradation behaviour of unsaturated polyesters containing hexolic anhydride has been studied. Pyrolysis experiments were performed using the TVA technique and the analysis of the products of pyrolysis was carried out utilising the gas chromatography-mass spectrometry technique. The formation of the various degradation products is discussed in the light of previously established mechanisms for polyester degradation. Special attention is devoted to a comparison of the present results on hexolic anhydride-based polyesters with previously studied HET-acid based polyesters, which are similar structural characteristics in the chlorinated part of the molecule. The major degradation product from the hexolic moiety is hexolic anhydride. The degradation products resulting from the 1,4-butanediol components are similar for both hexolic- and HET-based polyesters. Contrary to the HET-acid based systems, the hexolic-based polyesters yield considerably smaller quantities of hexachlorocyclopentadiene, which originates from the retro-Diels-Alder reaction. (Author abstract) 19 refs.

Sivasubramanian, G. (Ayya Nadar Janaki Ammal Coll, Sivakasi, India); Sivasamy, P.; Vijayakumar, C.T.; Fink, J.K. *Polym Degradation Stab* v 21 n 2 1988 p 151-163.

#### Radiation Damage

**081359 ELECTRON MICROSCOPY OBSERVATIONS OF A NEMATIC POLYESTER.** The authors report electron microscope observations of thin films of a polyester prepared in the nematic phase and quenched or slowly cooled. At low voltage (75 keV) the sample suffers irradiation damage and becomes amorphous in a few seconds. However, one observes the remnants of a striped structure. At high voltage (2000 keV) and low beam intensity the nematic structure is conserved, and the stripes consist of alternating disordered and aligned polymeric chains perpendicular to the striped structure. The repeat distance is on the order of a polymer length. Filamentary growth of a low temperature hexagonal phase is also reported. (Edited author abstract) 11 refs.

Mazelet, G. (Univ de Paris-Sud, Orsay, Fr); KJeman, M. *J Mater Sci* v 23 n 9 Sep 1988 p 3055-3060.

#### Recycling

**081360 RECYCLING OF POLYESTER FROM FABRIC WASTE.** This paper deals with the recycling of polyester (PET) from polymer cotton (P/C) blended fabric waste. For this purpose, the P/C waste, both carbonized and un-carbonized, is processed through a licker-in type opener. The fibers so obtained are characterized and hand spun to 10<sup>8</sup>-16<sup>8</sup> count. These yarns are used as weft and woven with 100 percent cotton warp on a hand loom. Suitable end uses have been suggested for these fabrics. Attempts have been made to produce adhesive bonded and needle punched non-wovens with these fibers. The work is in progress to recycle the PET and cotton by chemical/thermal dissolution techniques. (Author abstract).

Venkata Rao, J. (Anna Univ, Madras, India). *J Inst Eng India Part TE* v 68 n 1-2 Dec-Jun 1987-88 p 36-38.

#### Regain

**081361 FABRIC-CAUSED CHANGES IN HUMAN SKIN: IN VIVO STRATUM CORNEUM WATER CONTENT AND WATER EVAPORATION.** A focused microwave probe was used to assess stratum corneum water content, an Evaporimeter for water evaporation. With a covering of plastic film, water content and evaporation increased as the fabric/film remained on the forearm for longer periods of time. Stratum corneum water content was generally greater at polyester/film covered forearm sites than at triacetate/film covered sites, but there was not a significant statistical difference due to fabric type. Forearm water evaporation after fabric removal was also greater for polyester/film sites than triacetate/film sites; the difference was statistically significant. Occluded fabric placed on the skin surface therefore influences stratum corneum water content and water evaporation from its surface. (Edited author abstract) 35 refs.

Hatch, Kathryn L. (Univ of Arizona, Tucson, AZ, USA); Wilson, Donald R.; Maibach, Howard I. *Text Res J* v 57 n 10 Oct 1987 p 583-591.

**Reinforcing** See Also COMPOSITE MATERIALS—Fiber Reinforced; PLASTICS, REINFORCED—Fatigue.

**081362 CELLULOSE FIBER-POLYESTER COMPOSITES WITH REDUCED WATER SENSITIVITY (1) - CHEMICAL TREATMENT AND MECHANICAL PROPERTIES.** Formaldehyde and di-methylol-melamine were used to modify the surfaces of cellulose fibers. Composites were prepared with unsaturated polyester and treated cellulose as the reinforcing material. The tensile strength and the elongation of the cellulose fibers were determined in dry and wet conditions as well as the tensile strength and the tensile modulus of the cellulose-polyester composites. The water uptake of the composites was reduced by 46 to 52 percent. The wet strength of the composites was improved by more than 50 percent. (Author abstract) 16 refs.

Hua, Li (Chalmers Univ of Technology, Gothenburg,



Swed); Zadorecki, Pawel; Flodin, Per. *Polym Compos* v 8 n 3 Jun 1987 p 199-202.

**081363 CELLULOSE FIBER-POLYESTER COMPOSITES WITH REDUCED WATER SENSITIVITY (2) - SURFACE ANALYSIS.** The water absorption of cellulose fibers has been reduced after the cellulose surface was treated by mono- or di-methylolmelamine (DMM) resin. The wet strength of cellulose-polyester composites was also enhanced considerably. Scanning electron microscopy, transmission electron microscopy, and electron spectroscopy for chemical analysis were used as the tools for surface analysis in this study. The surface composition and micro morphology have been characterized. Quantitative and semiquantitative results have been obtained for the cellulose fiber surfaces treated with DMM. (Author abstract) 6 refs.

Hua, Li (Chalmers Univ of Technology, Gothenburg, Sweden); Flodin, Per; Ronnhult, Tore. *Polym Compos* v 8 n 3 Jun 1987 p 203-207.

**081364 USE OF EXTENDERS IN POLYESTER RESINS - A MATERIAL-SAVING CONCEPT OF PROCESSING GLASS FIBRE-REINFORCED POLYESTERS.** Preliminary tests revealed that the hollow-sphere fraction of the fly-ash from the Banhida Power-Station (BPH) Hungary, was suitable for preparation of syntactic polyester foams without any further purification or refinement. Morphological and physical studies on this BPH material as a filler of polyester resins are covered in this paper. The upper limit proportion of BPH was determined for the manual lamination technology. It was established by mechanical investigations on composites reinforced with glass mat or woven roving that a real sandwich structure with thickness of some millimeters could be formed in a single technological step. (Edited author abstract) 4 refs.

Hirschberg, P. (Research Inst for the Plastics Industry, Budapest, Hung); Novotny, Gy.; Kalló, A.; Vámos, Gy. *J Cell Plast* v 23 n 4 Jul-Aug 1987 p 399-418.

**Research** See Also THERMOPLASTICS—Biodegradation.

**081365 MECHANICAL AND DIELECTRIC RELAXATIONS IN CYCLOALIPHATIC POLYESTER NETWORKS.** Dielectric and mechanical loss tangent measurements performed on networks prepared from the cis (PCCS), trans (PTCS), and cis/trans (50/50, PCC) isomers of poly(oxyethylene-1,4-cyclohexylenemethyleneoxysebacoyl) present a well-defined  $\alpha$  absorption associated with the glass-rubber transition, whose location and strength depends on the presence of crystallites on the samples. The  $\alpha$  mechanical absorption at 1 Hz corresponding to amorphous PCCS and PCC networks is centered at  $-26^\circ\text{C}$  in both cases; however, the maximum of the peak is shifted to  $-17^\circ\text{C}$  for PTCS networks quenched from the melt. (Edited author abstract) 26 Refs.

Díaz-Calleja, Ricardo (Lab de Termodinámica y Físico-Química, Valencia, Spain); Gómez, José L.; Ribes, Amparo. *Macromolecules* v 21 n 7 Jul 1988 p 2121-2127.

## Rheology

**081366 ORGANOCLAY THICKENERS: ADVANCES IN TECHNOLOGY.** Advances in process technology have resulted in a new organoclay that exhibits a very open structure, plus high surface area and low density. With tailored chemical compatibility, it disperses readily enough in unsaturated polyester systems to permit incorporation as a dry powder, eliminating the need for preparing styrene pregs. The new material allows the full performance advantages of organonics because it is easily incorporated into the resin and is effective at low concentrations.

Pachuta, John (NL Chemicals, Highstown, NJ, USA); Van Doren, Robert; Johnson, John. *Plast Compd* v 11 n 3 May-Jun 1988 5p.

## Solubility

**081367 PREPARATION AND SURFACE ACTIVITY OF WATER-SOLUBLE POLYESTERS.** A novel series of water-soluble polyester surfactants has been prepared by the polymerization of SIPM, PA, and PEG. The unique structural features of these surfactants have been confirmed by IR and NMR analyses. These water-soluble polyester surfactants have been found to exhibit excellent surface active properties including surface tension, low-foaming, solubilization, and dispersant properties for disperse dyes. (Author abstract) 17 refs.

Chen, K.M. (Nat'l Taiwan Inst of Technology, Taipei, Taiwan); Liu, H.J. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1879-1888.

## Solutions

**081368 SALT EFFECTS ON CLOUD POINTS AND VISCOSITIES OF POLYMETHACRYLATES WITH PENDANT OLIGO-OXYETHYLENE CHAINS.** Comblike polymethacrylates with oligo-oxyethylene side chains were synthesized from the commercially available monomers  $\text{CH}_2=\text{C}(\text{CH}_3)\text{COO}(\text{CH}_2\text{CH}_2\text{O})_n\text{CH}_3$ , the average  $n$  being 4, 8, and 22. The three polymers exhibited lower critical solution temperatures in aqueous media. Cloud points were determined as a function of the nature and concentration of salt. For salts that destabilize the polymer solutions, the cloud points decrease linearly with salt concentration, the extent of the decrease being strongly anion dependent. Salt effects on the viscosity of the polymers were measured in water, methanol, and acetonitrile. In water the viscosity decreases on adding salt, but in methanol and acetonitrile the neutral polymers are converted to polycations as cations form stable adducts with the oligo-oxyethylene side chains. The increase in viscosity is both cation and anion dependent. The general behavior of the comblike polymers resembles that reported for aqueous or methanolic salt solutions of poly(ethylene oxide) and nonionic surfactants. (Author abstract) 46 refs.

Nwankwo, Ifeoma (State Univ of New York, Syracuse, NY, USA); Xia, Du Wei; Smid, Johannes. *J Polym Sci Part B* v 26 n 3 Mar 1988 p 581-594.

## Spectroscopic Analysis

**081369 DETERMINATION OF ORDER PARAMETERS IN THERMOTROPIC AROMATIC POLYESTERS CONTAINING MESOGENIC AND FLEXIBLE FRAGMENTS IN THE MAIN CHAIN.** The order parameters of mesogenic ( $S_m$ ) and flexible ( $S_f$ ) fragments are determined for a range of aromatic thermotropic polyesters containing the same mesogenic and various flexible fragments in the main chain. The  $S_m$  values are almost independent of the chemical nature and length of the flexible spacer. The relative positions of the axes of the mesogenic and flexible fragments in various states of aggregation are determined. (Author abstract) 15 refs.

Volchek, B.Z.; Kholmuradov, N.S.; Purkina, A.V.; Bilibin, A.Yu.; Skorokhodov, S.S. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1674-1682.

## Stresses

**081370 EFFECT OF PARTICULATE AGGLOMERATION AND THE RESIDUAL STRESS STATE ON THE MODULUS OF FILLED RESIN. PART 1. MODULUS OF UNTREATED GRADED SAND-FILLED Composite.** An untreated graded sand-filled polyester resin has been found to exhibit a higher modulus than previously reported for a particulate composite. A discontinuity in the stress-strain curve, which was dependent upon the volume fraction of sand, was observed. A residual stress mechanism is proposed to explain these results and the behavior of the composite at different curing temperatures. Fractography demonstrated the presence of trans-granular and inter-granular fractures. The former confirmed the presence of a strong matrix-particle interface bond even though the latter could only be explained by the expected poor 'chemical' adhesion in the

absence of a coupling agent. These apparent contrasting results are considered to arise from the presence of residual compressive stresses around agglomerates of irregularly shaped particles. (Author abstract) 20 Refs.

Ahmed, S. (Univ of Sheffield, Sheffield, Engl); Jones, F.R. *Composites* v 19 n 4 Jul 1988 p 277-282.

**Structure** See Also COPOLYMERS—Thermoanalysis; PLASTICS FILMS—Structure; TEXTILE FIBERS—Synthesis; TEXTILE FIBERS—Testing; TEXTILES—Spinning; YARN—Heat Treatment.

**081371 CHOLESTERIC LIQUID CRYSTALLINE POLYESTERS. 1. CHOLESTERIC LIQUID CRYSTALLINE COPOLYESTERS BASED ON POLY(CHLORO-1,4-PHENYLENE TRANS-1,4-CYCLOHEXANEDICARBOXYLATE).** Thermotropic copolymers exhibiting cholesteric mesophases were prepared by introducing chiral (R)-3-methyladipate units into rigid poly(chloro-1,4-phenylene trans-1,4-cyclohexanedicarboxylate), and a morphology study of the solid cholesterics was examined by using a transmission electron microscopy method. The transmission electron micrographs showed a series of dark and bright striation lines which were attributed to the periodic structure of the cholesteric helix. Defects or imperfections such as disclinations and edge dislocations of the cholesteric layer texture were elucidated from the micrographs. These cholesteric copolymers were also characterized by DSC, spectroscopic, and optical microscopic methods. (Edited author abstract) 26 refs.

Hara, Hajime (Nippon Oil Co, Yokohama, Jpn); Satoh, Tetsuo; Toya, Tomohiro; Iida, Shigeki; Orii, Shingo; Watanabe, Junji. *Macromolecules* v 21 n 1 Jan 1988 p 14-19.

**081372 LIGHT SCATTERING STUDY OF POLYPHENYLHYDROQUINONE-CO-TEREPHTHALIC ACID.** The above wholly aromatic polyester, poly(phenylhydroquinone-co-terephthalic acid) is studied by differential scanning calorimetry, and dilute solutions of fractions are examined by static and dynamic light scattering techniques. This polyester has two crystal modifications and exhibits a thermotropic nematic phase over the temperature range  $350-450^\circ\text{C}$ . Values for the persistence length calculated by three methods range from 60 to 150 Angstrom, with an average of 100 Angstrom. Space-filling models indicate that the substituent phenyl group prevents the benzene ring and the adjacent carbonyl group from being planar, which may explain the small persistence length. (Edited author abstract) 43 refs.

Krigbaum, William R. (Duke Univ, Durham, NC, USA); Tanaka, Takumi. *Macromolecules* v 21 n 3 Mar 1988 p 743-749.

**081373 SOLID-STATE CROSS POLARIZATION/MAGIC ANGLE SPINNING  $^{13}\text{C}$  NMR STUDY OF THERMOTROPIC AROMATIC POLYESTER CONTAINING A FLEXIBLE SPACER IN THE MAIN CHAIN.** The solid-state structure of a thermotropic aromatic polyester containing an aliphatic flexible spacer based on terephthalic acid and 4,4'-dihydroxy-1,6-diphenoxyhexane has been investigated by high-resolution solid-state CP/MAS (cross polarization/magic angle spinning)  $^{13}\text{C}$  NMR. Samples of the polymer with different thermal histories, i.e., an original sample as obtained by low-temperature solution polymerization and once-melted samples with different cooling conditions have been prepared. For the original sample, the solid-state spectrum shows that a conformation of the hexamethylene spacer is all-trans in the plane of the phenoxy group and that the ester linkage is nearly perpendicular to the plane of the aromatic ring. (Edited author abstract) 33 refs.

Uryu, Toshiyuki (Univ of Tokyo, Tokyo, Jpn); Kato, Takashi. *Macromolecules* v 21 n 2 Feb 1988 p 378-384.



**081374 TWO-DIMENSIONAL NMR AND PROTON SPIN-LATTICE RELAXATION STUDIES OF THERMOTROPIC HOMOPOLYESTERS CONTAINING A BICYCLO[2.2.2]OCT-2-ENE RING SYSTEM.** In this paper, we describe the detailed proton nuclear magnetic resonance, homonuclear two-dimensional shift correlation (COSY) and proton spin-lattice relaxation studies to determine the structures of homopolymers. The proton NMR spectrum of homopolymer II in deuteriotrifluoroacetic acid is shown. It is of interest to note that the olefinic protons of bicyclo[2.2.2]oct-2-ene appear as a singlet and also as a double doublet centered at  $\delta$  6.45. The fact that the doublet centered at  $\delta$  6.55 is coupled to the doublet centered at  $\delta$  6.34 is confirmed by a two-dimensional shift correlation experiment. This suggests that there are two sets of vinyl protons, one being equivalent ( $\delta$  6.64) and the other being nonequivalent. 31 refs.

Balakrishnan, Pattabiraman (Atlanta Univ, Atlanta, GA, USA); Harruna, Issifu I.; Polk, Malcolm B. *Macromolecules* v 21 n 5 May 1988 p 1538-1541.

**081375 HYDROGEN-BONDED HIGHLY REGULAR STRICTLY ALTERNATING ALIPHATIC-AROMATIC LIQUID-CRYSTALLINE POLYESTER AMIDES.** Forty-seven highly regular strictly alternating poly(ester amides) typified by each aromatic ring being bracketed by several methylene groups were prepared and studied. It was found that when the methylene sequences were sufficiently long, the poly(ester amides) exhibited multiple reproducible first-order transitions upon heating, which did not all reappear upon cooling. Many of the polymers with long alkylene groups grew ordered batonnet-like structures upon cooling from the isotropic melt, but not upon heating. The ordered structures grew upon cooling at temperatures far higher than the uppermost major endotherm in the heating cycle. A combination of DSC and hot-stage cross-polarized light microscopy revealed, upon heating, broad temperature intervals where spontaneous flow and intense or dull birefringence coexisted. (Edited author abstract). 68 refs.

Aharoni, Shaul M. (Allied-Signal Corp, Morristown, NJ, USA). *Macromolecules* v 21 n 7 Jul 1988 p 1941-1961.

**081376 NEW THERMOTROPIC HOMO- AND COPOLYESTERS CONTAINING  $\alpha$ ,  $\alpha'$ -DIETHYLSTIBENE AS A MESOGEN.** New thermotropic homo- and copolymers (IV) have been prepared from 4,4'-dihydroxy- $\alpha$ , $\alpha'$ -diethylstilbene (I) and aliphatic diacid chlorides (adipoyl and sebacoyl chlorides) [(II) and (III)] by interfacial polycondensation, and their liquid crystallinity was evaluated. The mesogenic properties of homo- and copolymers were investigated by the observation of texture by means of a polarizing microscope equipped with hot stage and with DSC. The maximum temperatures of endothermal peaks in DSC curves on a first heating run were taken as phase-transition temperature. It is found that the introduction of longer alkyl chain into  $\alpha$ , $\alpha'$ -position lowers the phase-transition temperatures of stilbene-type polymers and widens their mesophasic ranges, although the molecular weight and the wide molecular-weight distribution of the polyesters may affect the liquid crystalline behavior. 12 refs.

Sato, Moriaki (Kogakuin Univ, Tokyo, Jpn). *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2613-2617.

## Synthesis See Also POLYMERIZATION.

**081377 THERMOTROPIC POLYESTERS: SYNTHESIS AND PROPERTIES OF POLY(CHLORO-1,4-PHENYLENE TEREPHTHALATE-CO-4,4'-OXYBISBENZOATES).** Poly(chloro-1,4-phenylene terephthalate), poly(chloro-1,4-phenylene 4,4'-oxybisbenzoate), and their copolymers are synthesized and the effect of composition on thermal transitions is evaluated. All the materials are nematogenic; copolymer compositions from 75/25 to 25/75 display a nematic temperature range in excess of 100°C which is sufficient for melt processing. The crystal-nematic transition temperature of the 50/50 copolymer is strongly affected by the molecular weight, but the glass transition, although low,

is molecular weight independent. Brief annealing at temperatures below the crystal-nematic transition does not reduce the nematic temperature range of this copolymer. (Author abstract) 18 refs.

McIntyre, J.E. (Univ of Leeds, Leeds, Engl); Maj, P.E.P.; Sills, S.A.; Tomka, J.G. *Polymer* v 28 n 11 Oct 1987 p 1971-1976.

**081378 SYNTHESIS AND CHARACTERIZATION OF POLYESTERS CONTAINING HETEROCYCLIC THIAOXANTHONE UNITS.** Several polyesters containing thiaoxanthone rings were prepared from 2,7-dichloroformylthiaoxanthone-5,5'-dioxide (IVa), 2,8-dichloroformylthiaoxanthone-5,5'-dioxide (IVb), and bisphenols by solution polycondensation. The 2,8-diethoxycarbonylthiaoxanthone-5,5'-dioxide (V) was prepared and characterized by spectral methods to confirm the formation of 2,8-thiaoxanthonedicarboxylic acid-5,5'-dioxide (IVb). Prior to polymer synthesis two model compounds, 2,7-diphenoxycarbonylthiaoxanthone-5,5'-dioxide (MDE-1) and 2,8-diphenoxycarbonylthiaoxanthone-5,5'-dioxide (MDE-2), were synthesized and characterized by spectral methods. The polyesters were obtained in 62-78% yield and had inherent viscosities in the range 0.42-0.90 dL/g. The effect of thiaoxanthone rings on solubility, crystallinity, and thermal stability of the polyesters are also discussed. The polyesters have decomposition temperatures in the range 372-438°C. (Author abstract) 18 refs.

Reddy, T. Ashok (Indian Inst of Technology, Madras, India); Srinivasan, M. *J Polym Sci Part A* v 25 n 11 Nov 1987 p 2987-3003.

**081379 SYNTHESIS OF POLYMERS THAT UNDERGO NO SHRINKAGE ON CROSSLINKING.** This article describes the preparation of a new type of copolymers that contain spiroorthoester and sulfonium salt moieties in the same polymer backbone and an estimation of volume change during crosslinking by self-catalyst (attacking of spiroorthoester by sulfonium salt). The copolymers containing spiroorthoester and sulfonium salt structure were synthesized by ternary copolymerization of 2-methylene-1,4,6-trioxaspiro [4.6]undecane with vinyl benzyl sulfonium salt and vinyl monomers (acrylonitrile (AN) and methyl acrylate). 6 refs.

Tagoshi, Hirotaka (Tokyo Inst of Technology, Yokohama, Jpn); Endo, Takeshi. *J Polym Sci Part C* v 16 n 2 Feb 1988 p 77-81.

**081380 SYNTHESIS AND CHARACTERIZATION OF SOME NEW POLYESTERS FROM 4,4'-DICARBOXYACETYLIDIPHENYL ETHER AND ITS DIMETHYL ESTER.** A description is given of the synthesis of structurally related polyketoothers in which the ether linkage is in the acid moiety of the repeat unit. The polyesters presented were prepared by polycondensation of equimolar amounts of 4,4'-dicarboxyethyl-diphenyl ether (DCADPE) and the required diacetate of dihydroxyarenes and/or of the dimethyl ester of DCADPE and the required aliphatic diol or arene diol in the presence of zinc acetate. (Edited author abstract) 6 refs.

Patel, H.G. (Sardar Patel Univ, Vallabh Vidyanagar, India); Patel, R.M.; Patel, S.R. *J Macromol Sci Chem* v A24 n 11 Nov 1987 p 1385-1389.

**081381 DIRECT POLYESTERIFICATION WITH THIONYL CHLORIDE IN PYRIDINE IMPROVED BY A MODIFICATION OF MONOMER SEQUENCES IN COPOLYMERS.** The direct polyesterification with thionyl chloride (SOCl<sub>2</sub>) in pyridine was investigated. Copolycondensations of dicarboxylic acids, bisphenols, and hydroxybenzoic acids were significantly affected by the reaction temperatures and combinations of monomers which could change relative rates of alcoholyses of the activated dicarboxylic acids and the hydroxyacids consequently to vary monomer sequences in the copolymers resulted. The sequences were varied more directly by stepwise reactions of monomers in copolycondensations of dicarboxylic acids, bisphenols, and p-hydroxybenzoic acid (PHB), as well as PHB and m-hydroxybenzoic acid

(MHB). The reactions proceeded smoothly and satisfactorily when carried out by initial reaction of dicarboxylic acids and PHB followed by bisphenols likely to favor sequential to random distributions of monomers. (Edited author abstract) 8 refs.

Higashi, Fukuji (Tokyo Univ of Agriculture & Technology, Koganei, Jpn); Sugimori, Shigeru; Mashimo, Toshio. *J Polym Sci Part A* v 26 n 5 May 1988 p 1277-1283.

**081382 LINEAR POLYESTERS PRODUCTS OF INTERFACIAL POLYCONDENSATION OF BIS(4-HYDROXYPHENYL)ETHER WITH SOME ALIPHATIC ACID DICHLORIDES.** New polyesters were obtained by interfacial polycondensation of bis(4-hydroxyphenyl)ether with succinyl, adipoyl, suberoyl, or sebacoyl chlorides. To define the optimal conditions of the process, the polyesters of diol and adipoyl or sebacoyl chlorides were chosen as a model system. Yield for all reaction products and reduced viscosity were found. The following factors were studied: organic phase, contribution of catalyst, concentration and molar ratio of reagents, rate of addition of acid chloride, temperature of reaction and concentration of hydrochloride acceptor. The structures of all polyesters were determined by means of elementary analysis, infrared spectra, and X-ray. Initial decomposition and initial intensive of decomposition temperatures were defined by the curves of thermogravimetric analysis. Thermal and electrical properties of polyesters from diol and adipoyl or sebacoyl chlorides were studied. The molecular weights for these polymers were also determined by gel chromatography. (Edited author abstract) 8 refs.

Podkościelny, Wawrzyniec (Maria Curie-Skłodowska Univ, Lublin, Pol); Wdowicka, Danuta. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1779-1789.

**081383 LINEAR POLYTHIOESTERS. XIV. PRODUCTS OF INTERFACIAL POLYCONDENSATION ISOMERIC DIMERCAPTOMETHYL-TRIMETHYLBENZENES WITH SOME ALIPHATIC ACID DICHLORIDES.** New polythioesters by interfacial polycondensation of 4, 6-di(mercaptomethyl)-1,2,3-trimethylbenzene, 3, 5-di(mercaptomethyl)-1,2,4-trimethylbenzene and 2, 4-di(mercaptomethyl)-1,3,5-trimethylbenzene with adipoyl and sebacoyl chlorides were obtained. The structures of all polythioesters were determined by elementary analysis, infrared spectra, and X-ray analysis. Initial decomposition and initial intensive decomposition temperature were defined by the curves of thermogravimetric analysis. The molecular weights for these polymers were determined by gel chromatography. (Edited author abstract) 10 refs.

Podkościelny, Wawrzyniec (Maria Curie-Skłodowska Univ, Lublin, Pol); Szubinska, Stanisława. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1853-1861.

**081384 CONDENSATION POLYMERIZATION OF MULTIFUNCTIONAL MONOMERS AND PROPERTIES OF RELATED POLYESTER RESINS. I. POLYESTER VARNISHES.** This article discusses optimum conditions for polycondensation of multifunctional monomers. Reaction variables such as monomer concentration, temperature, and time were studied to optimize reaction conditions. The influence of the nature and concentration of catalysts was also investigated. Polycondensation of ethylene glycol, 1,4-butanediol, pentaerythritol, and trifunctional monomers (glycerin or trimethanolpropane) with dimethyl terephthalate was carried out in m-cresol to produce polyester prepolymers. The synthesized prepolymers were mixed with commercial Desmodur CT-stable (a phenol-blocked polyisocyanate) to form one-component varnishes which were characterized by thermogravimetric analysis. Polyester modified with trimethanolpropane has higher thermal stability than the one modified with glycerin. After being coated onto treated copper wires, the magnetic wires were character-



ized according to the specification of Japanese Industrial Standards (JIS-C-2538) and were found to be acceptable. (Edited author abstract) 8 refs.

Chiang, Wen-Yen (Tatung Inst of Technology, Taipei, Taiwan); Chiang, Wen-Chang. *J Appl Polym Sci* v 35 n 6 May 5 1988 p 1421-1432.

**081385 CONDENSATION POLYMERIZATION OF MULTIFUNCTIONAL MONOMERS AND PROPERTIES OF RELATED POLYESTER RESINS. II. THERMAL PROPERTIES OF POLYESTER-IMIDE VARNISHES.** Polyester-imide prepolymers containing synthesized N,N'-bis(hydroxyethyl)pyromellitic diimide (PMDI) or N,N'-bis(hydroxyethyl)-3,3',4,4'-benzophenone tetracarboxylic diimide (BTDI) were synthesized under conditions previously reported. One-component varnishes were obtained by mixing the synthesized prepolymers with commercial Desmodur CT-stable. Thermal behavior of these varnishes was investigated using thermogravimetric analysis. Activation energy of cured film, which was a polyester-imide varnish, was determined by using a multiple heating rate method. Polyester-imides coated copper wires were characterized, and were found to be acceptable, according to the specification of Japanese Industrial Standard (JIS-C-3214). (Author abstract) 10 refs.

Chiang, Wen-Yen (Tatung Inst of Technology, Taipei, Taiwan); Chiang, Wen-Chang. *J Appl Polym Sci* v 35 n 6 May 5 1988 p 1433-1439.

**081386 NEW POLYMER SYNTHESES. XIX. SYNTHESIS OF AROMATIC POLYESTERS FROM PHENOXYTEREPHTHALIC ACID.** The synthesis of bisphenol-A phenoxyterephthalate was chosen as model system to find the optimum method for polycondensations of aryloxyterephthalic acids. It is demonstrated that phenoxyterephthalic acid or its acid chloride may cyclize at temperatures above 180°C yielding anthrone-3-carboxylic acid which causes termination steps. The highest yield and molecular weight was obtained by interfacial polycondensation of phenoxyterephthaloylchloride. (Author abstract) 7 refs.

Kricheldorf, Hans R. (Univ of Hamburg, Hamburg, West Ger); Schwarz, Gert; Ruhser, Frank. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1621-1628.

**081387 POLYMERIC ACTIVE ESTER INCORPORATING TETRACHLOROHYDROQUINONE GROUPS.** Merrifield resin was reacted with tetrachlorohydroquinone to give a polymeric monobenzyl ether of tetrachlorohydroquinone. The esters of this functionalized polymer, like the esters of other polyhalogenated phenols, act as polymeric active esters. These have been used for transacylation of amines, where acylated products were obtained in high yields in a clean reaction. Synthesis of some peptides has also been achieved using the polymeric active esters of N-protected amino acids. (Author abstract) 12 refs.

Narang, C.K. (Univ of Jodhpur, Jodhpur, India); Kachhawaha, V.; Mathur, N.K. *React Polym Ion Exch Sorbents* v 8 n 2 Apr 1988 p 189-192.

**081388 A STUDY ON THE KINETICS OF POLYCONDENSATION OF BISPHENOL-A DIACETATE AND ISOPHTHALIC ACID.** The kinetics of melt polycondensation of bisphenol-A diacetate and isophthalic acid at 247°C, 257°C and 267°C were investigated respectively. The degree of polymerization (DP)<sub>n</sub> as a function of time was obtained by titrating the evolved acetic acid from the reaction system. By means of the Runge-Kutta method, the kinetic differential equations were solved numerically by computer. The experimental and simulated curves were compared. The reaction rate constants of the elementary reactions are presented. The polycondensation mechanism could involve transesterification as a side reaction. (Edited author abstract). 8 Refs.

Zhou, Zhenglong; Wu, Xiuge; Zhang, Zhongxing; Ren, Li; Mon, Dan. *J China Text Univ Engl Ed* v 4 n 2 Dec 1987 p 75-81.

**081389 CATIONIC RING-OPENING ISOMERIZATION POLYMERIZATION OF BICYCLO ORTHO ESTERS INITIATED BY CARBON BLACK.** The cationic ring-opening isomerization polymerization of bicyclo ortho esters (BOE) initiated by carbon black was investigated. The polymerization scarcely proceeded in the absence of carbon black. But in the presence of channel black having carboxyl groups, the polymerization of BOE was initiated at 130°C to give a polyether containing an ester group in the side chain. The initiating ability of carbon black increased with increase in its carboxyl group content. Furnace black having no carboxyl group was unable to initiate the polymerization. Based on these results, it was concluded that the carboxyl group on carbon black is capable of initiating the polymerization of BOE. During the polymerization, a part of the polymers formed was grafted onto carbon black via the termination of growing polymer chain. Furthermore, the ring-opening isomerization polymerization of BOE was found to be initiated by an acylium perchlorate group introduced onto the carbon black surface. (Edited author abstract). 22 Refs.

Tsubokawa, Norio (Niigata Univ, Niigata, Jpn); Ohshima, Shingo; Sone, Yasuo; Endo, Takeshi. *Polym J* v 20 n 5 1988 p 413-420.

**081390 ISOCYANATE TECHNOLOGY SPAWNS NEW BREED TPE FOR HIGH TEMPERATURES.** For the synthesis of the polyesteramide (PESA) a process was developed based on isocyanate technology, wherein the isocyanate was reacted with carboxylic acids to yield amide plus carbon dioxide. Variations in properties could be achieved by varying the type of soft segment-polyether, or polyester, and the amount of soft segment vs. hard segment. PESA can be processed readily on conventional thermoplastic processing equipment; however, it must be thoroughly dried to a moisture content of less than 0.02 percent. This is accomplished in a dehumidifying hopper dryer at 100-110°C for 4 to 6 hours. PESA exhibits outstanding chemical resistance and is relatively unaffected by ASTM oils, greases and transmission fluids, or dilute acids and bases. Some swelling is observed in alcohol and aromatic solvents. In part because of its aromatic amide backbone, PESA exhibits outstanding resistance to ultraviolet radiation. 3 Refs.

Farrissey, William J. (Dow Chemical, North Haven, CT, USA); Rausch, Karl W. *Elastomerics* v 120 n 7 Jul 1988 p 22-25.

**081391 NEW POLYMER SYNTHESIS. 24. LIQUID CRYSTAL POLY(ESTER IMIDES) DERIVED FROM BENZOPHENONETETRACARBOXYLIC DIANHYDRIDE AND  $\omega$ -AMINO ACIDS.** Six dicarboxylic acids were prepared from benzophenone-3,3',4,4'-tetracarboxylic dianhydride (BTA) and 4-amino-butyric acid, 5-aminovaleric acid, 6-aminocaproic acid, 7-aminoheptanoic acid lactam, 11-aminoundecanoic acid, and 12-aminododecanoic acid. These diacids were condensed with the diacetates of hydroquinone, 2,6-dihydroxynaphthalene or 4,4'-dihydroxybiphenyl. The resulting poly(ester imides) were characterized by inherent viscosity elemental analyses, differential scanning calorimetry (DSC), observation under polarized light, and WAXS measurements. Formation of a smectic melt was found for almost all polymers containing 4,4'-dihydroxybiphenyl. These thermotropic poly(ester imides) were also characterized by thermomechanical and thermogravimetric analyses, and an odd-even effect was found for the heat-distortion temperatures. (Edited author abstract). 11 Refs.

Kricheldorf, Hans R. (Inst fuer Technische und Makromolekulare Chemie der Univ, Hamburg, West Ger); Pakull, Ralf; Buchner, Stefan. *Macromolecules* v 21 n 7 Jul 1988 p 1929-1935.

**081392 POLYMORPHISM IN A LIQUID CRYSTALLINE POLYESTER BASED ON 4, 4'-BIPHENOL, TEREPHTHALIC ACID, AND p-HYDROXYBENZOIC ACID(1:1:2).** The polyester from 1 mol of 4,4'-biphenol, 1 mol of terephthalic acid, and 2 mol of p-hydroxybenzoic acid, synthesized by the acidolysis condensation reaction of the acetylated mixture, was

studied by using wide-angle X-ray diffraction and differential scanning calorimetry (DSC). X-ray diffraction demonstrated a reversible crystal-crystal transition at about 100°C. The transition was also observed with DSC as a small endotherm. The most prominent calorimetric feature is an endotherm at about 427°C corresponding to the crystal-nematic transition. There is also a small endotherm at about 472°C which may correspond to the nematic-isotropic transition. On cooling from 450°C at 10 deg/min, there is observed about 40 deg of supercooling before crystallization occurs. (Edited author abstract). 12 Refs.

Field, N.D. (Dartco Manufacturing Inc, Augusta, GA, USA); Baldwin, R.; Layton, R.; Frayer, P.; Scardiglia, F. *Macromolecules* v 21 n 7 Jul 1988 p 2155-2160.

**Thermal Effects** See Also POLYMERS—Blending.

**081393 COMPARATIVE STUDY OF THE THERMAL DEGRADATION OF UNSATURATED POLYESTER RESINS CONTAINING VARIOUS CHLORINATED NORBORNENE DICARBOXYLIC ACID UNITS IN THE BACKBONE.** Pure polystyrene and styrene-cure unsaturated polyesters made from different chlorinated norbornene dicarboxylic acids, 1,2-propanediol and maleic anhydride were pyrolysed in vacuo and in a nitrogen atmosphere. The pyrolysis products were separated and identified with a gas chromatograph coupled with a mass spectrometer. The results showed the influence of the chlorine radicals evolved during pyrolysis on the products and the product distribution pattern resulting from the styrene moiety. (Author abstract) 12 refs.

Irzl, G.H. (Montanuniv Leoben, Leoben, Austria); Vijayakumar, C.T.; Lederer, K. *J Anal Appl Pyrolysis* v 13 n 4 Jun 1988 p 305-317.

**Thermal Properties** See Also COPOLYMERS—Thermal Properties; POLYMERS—Rheology.

**081394 THERMAL BEHAVIOR OF THE SMECTIC/NEMATIC THERMOTROPIC LIQUID CRYSTALLINE POLYESTER BLENDS.** Crystalline and liquid crystalline behavior of the mesogenic binary blends consisting of smectic and nematic liquid crystal polyesters were investigated by differential scanning calorimetry and by polarizing microscope. The blends did not form eutectic mixture and the homopolymers were partially miscible in the solid state. The liquid crystalline phase of the blend showed coexisting nematic and smectic phases at a certain composition. (Author abstract)

Yoo, Young Deuk (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Kim, Sung Chul. *Polym Bull (Berlin)* v 18 n 3 Sep 1987 p 247-252.

**081395 THERMAL PROPERTIES OF A SERIES OF SIDE-CHAIN LIQUID CRYSTALLINE POLY(METHACRYLATES).** The thermal behavior of a series of side-chain liquid crystalline poly(methacrylates) has been investigated by thermogravimetry, differential scanning calorimetry, polarizing optical microscopy, and dilatometry. The DSC study has shown that long times are required to reach equilibrium even at temperatures above the glass transition. The thermotropic polymorphism has been determined as a function of the length of the flexible spacer. Glass transitions in the mesomorphic state have been discussed. Dilatometry has shown that, for the 'glassy' mesomorphic phases, the partial specific volume of the flexible spacer is close to that corresponding to the crystal and the isotropic liquid; and that, for the isotropic polymer, it is close to that of a liquid. (Author abstract) 22 refs.

Duran, R. (CRM, Strasbourg, Fr); Guillon, D.; Gramain, Ph.; Skoulios, A. *J Phys (Paris)* v 49 n 1 Jan 1988 p 121-129.

**Thin Films**

**081396 MEASUREMENT OF INFRARED OPTICAL CONSTANT DISPERSION CURVES OF**



**FREE-STANDING THIN POLYESTER FILM BY KRAMERS-KRONIG RELATIONSHIP.** The transmittance spectrum of free-standing thin polyester film is recorded with Fourier transform infrared spectroscopy. The interference fringes present in the above spectrum have been used to measure refractive index in high wavenumber region and the film thickness. The dispersion curves of extinction coefficient  $K(\nu)$  and refractive index  $n(\nu)$  (3100 approximately  $700\text{ cm}^{-1}$ ) are obtained on the basis of the continuous Kramers-Kronig analysis and the spectroscopic simulative calculation from the observed spectrum. The disturbance of interference fringes is thoroughly eliminated in these dispersion spectra. This method is suitable for all kinds of free-standing solid films. (Author abstract) 8 refs. In Chinese.

Wang, Yongtai (Nankai Univ, China); Xu, Jinmin; Lin, Chui. *Hongwai Yanjiu A-Ji* v 7A n 1 1988 p 15-21.

## Viscoelasticity

**081397 EFFECTS OF PHYSICAL AGING ON THE VISCOELASTIC BEHAVIOR OF A THERMOSET POLYESTER.** The effect of physical aging on the viscoelastic behavior of a cross-linked polyester resin is reported. Tensile creep and dynamic mechanical analysis (DMA) tests yielded creep compliance and dynamic shear complex compliance of the polymer. Thermoreversible physical aging was found to have significant effects in the creep response of the polyester. Physical aging shift factors were determined at 60, 80, 100 and  $120^\circ\text{C}$ . Standard frequency-temperature superposition procedures were used to construct master curves or the dynamic mechanical data. The shift constants  $c_1=(70)$  and  $c_2=(450^\circ\text{C})$  determined from DMA data were used to construct a smooth master curve for creep data. (Edited author abstract) 22 refs.

Janas, V.F. (Univ of Delaware, Newark, DE, USA); McCullough, R.L. *Compos Sci Technol* v 30 n 2 1987 p 99-118.

**081398 DYNAMIC MECHANICAL RELAXATIONS OF POLYTEREPHTHALATES BASED ON TRIMETHYLENE GLYCOLS.** The dynamic mechanical relaxations of poly(trimethylene glycol terephthalate) (PTMT), poly(ditrimethylene glycol terephthalate) (PDMT) and two copolymers obtained from them have been studied between  $-150$  and  $200^\circ\text{C}$  with a dynamic viscoelastometer. The four polymers show three relaxations that are designated  $\alpha$ ,  $\beta$ , and  $\gamma$  in order of decreasing temperature. The  $\alpha$  relaxation is considered to be the glass transition of the polymers. The  $\beta$  relaxation is wider and weaker than the  $\alpha$ , as normally occurs in the polyester series. The  $\gamma$  relaxation takes place at temperatures below  $-100^\circ\text{C}$  and is usually overlapped by the  $\beta$  relaxation. The influence of thermal and mechanical histories on the nature, location, and intensity of the three relaxations is studied and discussed. (Author abstract) 19 refs.

Gonzalez, Cesar Carlos (CSIC, Madrid, Spain); Perena, Jose Manuel; Bello, Antonio. *J Polym Sci Part B* v 26 n 7 Jul 1988 p 1397-1408.

## Weathering See COATINGS—Plastics.

## POLYETHERIMIDES

### Applications

**081399 EFFECTS OF FLUIDS IN THE AIRCRAFT ENVIRONMENT ON A POLYETHERIMIDE.** Fluid absorption studies have been made for a polyetherimide thermoplastic film and a unidirectional composite of the thermoplastic with graphite fibers immersed in water, JP4 jet fuel, ethylene glycol, and hydraulic fluid. The changes in the weight, thickness, and tensile properties were measured for the film. The changes in the flexural properties of the composite were measured for specimens whose fiber orientation was transverse to their length. Only the hydraulic fluid, which caused an erosion or dissolution of the resin at the specimen surface, affected

the film's properties. Both the water and the hydraulic fluid affected the flexural properties of the composite, due to capillary absorption along the fiber-resin interface. (Edited author abstract) 9 refs.

Long, Edward R. Jr (NASA, Hampton, VA, USA); Collins, William D. *Polym Eng Sci* v 28 n 12 Jun 1988 p 823-828.

### Mechanical Properties See THERMOPLASTICS—Rheology.

### Performance See AIRCRAFT MATERIALS—Composite Materials.

**POLYETHERS** See Also ELASTOMERS—Curing; ELECTROLYTES—Materials; ISOTOPES—Separation; POLYMERS—Blending; POLYMERS—Solutions.

### Aging

**081400 PHYSICAL AGING CHARACTERISTICS OF POLYETHER ETHER KETONE.** Creep studies and differential scanning calorimetry (DSC) indicate that physical (thermal) aging affects viscoelastic properties of polyether ether ketone (PEEK) at all achievable levels of crystallinity. The phenomenon has been observed over a range of crystallinity (2%-33% by volume) at several test temperatures. When the glass transition temperature ( $T_g$ ) are different, even for the same undercooling ( $T_g-T$ ), the parameters are significantly different. Dependence of enthalpy relaxation on aging time was obtained from DSC thermograms for the amorphous polymer. (Edited author abstract) 18 refs.

Ogale, A.A. (Univ of Delaware, Newark, DE, USA); McClough, R.L. *Compos Sci Technol* v 30 n 2 1987 p 137-148.

### Applications See BIOMATERIALS—Plastics Applications.

### Blending See POLYSTYRENES—Blending.

### Chemical Reactions See Also ION EXCHANGE RESINS—Synthesis.

**081401 HEMOLYTIC ACTIVITY OF POLYOXYETHYLENE CHOLESTERYL ETHERS.** Hemolytic activity of nonionic surfactants, polyoxyethylene cholesteryl ethers,  $\text{C}_{27}\text{H}_{45}\text{O}(\text{CH}_2\text{CH}_2\text{O})_n\text{H}$  (Chol- $E_n$ ,  $n = 8, 25, 30, 50$ ) and polyoxyethylene dihydrocholesteryl ethers,  $\text{C}_{27}\text{H}_{47}\text{O}(\text{CH}_2\text{CH}_2\text{O})_n\text{H}$  (DHChol- $E_n$ ,  $n = 15, 30, 50$ ) were measured, changing the concentration of surfactant and erythrocyte at  $37^\circ\text{C}$ . Maximum hemolytic activity was observed in these cholesteryl derivatives with 25-30 oxyethylene units. The time course of hemolysis was also measured as a function of the concentrations of surfactant and erythrocyte. Hemolysis started after a certain induction period,  $\tau$ , and then apparently proceeded as a first-order reaction with respect to the erythrocyte concentration. The surfactant inducing 50% hemolysis at low concentration had a small  $\tau$  value and large rate constant. The maximum amount of adsorption without inducing hemolysis,  $a_0$ , decreased with increasing polyoxyethylene chain length. Chol- $E_{25}$  has the maximum activity for the solubilization of egg yolk lecithin at  $37^\circ\text{C}$ . Based on these results, the mechanism of hemolysis by these surfactants was quantitatively discussed. (Author abstract) 23 refs.

Miyajima, K. (Kyoto Univ, Jpn); Baba, T.; Nakagaki, M. *Colloid Polym Sci* v 265 n 11 Nov 1987 p 943-949.

**081402 FUNCTIONALIZED POLYETHYLENE GLYCOLS AND POLYPEPTIDES IN ORGANIC SYNTHESIS AND CATALYSIS.** A survey of recent developments in the synthesis, modification and potential applications of polyethylene glycol (PEG-OH) based functional polyethers is presented. New procedures for the preparation of (i) polyethers with equidistant functional groups as well as (ii) liquid PEG-COOH and PEG-NH<sub>2</sub> applying polymer-analogous reactions are described. The exceptional physico-chemical properties of these polyethylene glycol derived polymers are used for enzyme solubilization and enzyme modelling, organic synthesis

and catalysis. (Author abstract) 38 refs.

Mutter, M. (Univ of Basel, Basel, Switz); Altmann, K.-H.; Gehrhardt, H. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 99-107.

### Chemical Resistance See POLYSULFONES—Heat Resisting.

### Crosslinking See ELECTROLYTES—Materials.

### Deformation

**081403 PLASTIC DEFORMATION OF POLYTETRAMETHYLENE OXIDE. I. INFLUENCE OF MOLECULAR WEIGHT DISTRIBUTION, CRYSTALLINITY, AND STRUCTURE.** Polytetramethylene oxide with a planar zig-zag structure similar to polyethylene can be obtained with narrow molecular weight distributions. The plastic deformation of samples differing in molecular weight, molecular weight distribution, crystallinity, and structure has been studied. The low natural draw ratios and low Young's modulus of the drawn samples, together with the effect of blending a small amount of high molecular weight material into a low molecular weight sample, highlight the role of the flexibility and of the high molecular weight tail of the distribution in the plastic deformation process. The stress required for the propagation of the neck and the tensile strength are found to be linear functions of, respectively, the natural and maximum draw ratio. (Edited author abstract) 23 refs.

Kretz, M. (CNRS, Strasbourg, Fr); Meurer, B.; Lotz, B.; Weill, G. *J Polym Sci Part B* v 26 n 3 Mar 1988 p 663-675.

### Forming

**081404 ROLE OF MACROMOLECULES IN PROCESSES OF POLYETHER FORMATION USING ALUMINIUM-CONTAINING INITIATORS.** Experimental data were obtained proving the participation of macromolecules in the process of  $\alpha$ -oxide polymerization. By  $^1\text{H}$  and  $^{27}\text{Al}$  NMR methods the formation of 'autosolvents' between the growing polyether chain and the catalytic centre was established. Possible methods of catalytic system activation in  $\alpha$ -oxide polymerization are proposed. (Author abstract) 16 refs.

Khvostik, G.M. (S.M. Lebedev All-Union Research Inst of Synthetic Rubber, USSR); Rodina, E.I.; Lazarev, S.Ya.; Ventseslavskaya, K.K.; Shupik, A.N.; Larina, L.L.; Kondratenkov, G.P. *Polym Sci USSR* v 29 n 1 Jan 1988 p 175-182.

### Heat Resisting See AROMATIC POLYMERS—Modification.

### Mechanical Properties See BLOCK COPOLYMERS—Mechanical Properties.

### Modification See POLYMERS—Synthesis.

### Optical Properties See FLUORESCENCE.

### Phase Diagrams See SURFACE ACTIVE AGENTS.

### Phase Transitions

**081405 ROTATING FRAME PROTON SPIN-LATTICE RELAXATION MEASUREMENTS OF POLY(ETHYLENE OXIDES).** Recently the technique of measuring spin-lattice relaxation times  $T_{1\rho}$  in the rotating frame has been used widely for the investigation of molecular motion and phase changes in a variety of solid materials, including polymers. In this work, measurements of  $T_{1\rho}$  as a function of temperature have been made on two polyethylene oxides (PEO) with molecular masses of 5,000 and 30,000. The  $T_{1\rho}$  measurements show biexponential behavior of the relaxation function in the temperature range from 170 K to 350 K. The intensities of the components of the relaxation function are constant over this temperature range in agreement with the crystallinity



ties of the samples. The two relaxation times can be associated with the crystalline and amorphous component; the relaxation time mining describe the  $\alpha$  relaxation in the crystalline regions of PEO and the glass transition in amorphous PEO. (Edited author abstract) 7 refs.

Wobst, M. (Technical Univ Leuna-Merseburg, Merseburg, East Ger). *J Polym Sci Part B* v 26 n 3 Mar 1988 p 527-531.

## Physical Properties

**081406 INFLUENCE OF LiClO<sub>4</sub> ON THE PROPERTIES OF POLYETHER NETWORKS: SPECIFIC VOLUME AND GLASS TRANSITION TEMPERATURE.** A series of networks based on different polyether chains (PEO homopolymer, block and graft copolymers) joined by different urethane cross-links were prepared. Their specific volume and  $T_g$  were determined in the absence and in the presence of LiClO<sub>4</sub> as a function of various structural parameters and of salt concentration. Quantitative correlations were obtained and interpreted on the basis of specific interactions between the ether groups and the ionized salt. Chain partitioning and physical cross-linking occurred as a consequence of these associations. (Author abstract) 9 refs.

Le Nest, Jean-Francois (EFP (INPG), St. Martin d'Heres, Fr); Gandini, Alessandro; Cheradame, Herve; Cohen-Addad, Jean-Pierre. *Macromolecules* v 21 n 4 Apr 1988 p 1117-1120.

**Processing** See PLASTICS, FOAMED—Flexible.

## Reduction

**081407 TRI-N-BUTYL TIN HYDRIDE REDUCTION OF THE END GROUP OF A POLYPHENYLENE ETHER.** A method using tri-n-butyltin hydride to reduce the 2-methyl-6-(N,N-di-n-butylamino)methyl phenol end group on PPO (4) was developed. It generated a polyphenylene ether (PPE) with 2,6-xylenol as the only phenolic end group without causing any significant increase in molecular weight. The reduction was carried out in diphenyl ether under nitrogen overnight at 250°C. The reduced PPE was collected and dried. A control experiment was also conducted. (Edited author abstract) 9 refs.

Chao, Herbert S.-I. (GE Corporate Research & Development Cent, Schenectady, NY, USA). *Polym Bull (Berlin)* v 18 n 2 Aug 1987 p 131-135.

**Solutions** See Also CELLULOSE DERIVATIVES—Physical Chemistry.

**081408 VISCOSITY B COEFFICIENTS OF POLYETHYLENEGLYCOLS IN WATER.** The viscosity B coefficients of polyethylene glycols ( $M = 62-1000$ ) are determined at 25 °C. The B coefficient increases non-linearly with the number of ethyleneoxide (EO) units. The increase of the B coefficient per EO (0.111 dm<sup>3</sup>/mole) is less than the B value for two methylene groups (0.160 dm<sup>3</sup>/mole). This is discussed in terms of changes in the configurations of polyethylene glycols with long EO chains. Molecular size is the major factor that contributes to B at shorter chains, but solvation (hydration) becomes dominant as the number of ethyleneoxide groups increases. The hydration parameter shows a linear dependence on B at low mass followed by a non-linear increase at high molecular mass and the viscosity C coefficient accounts for the solute-solute interactions. (Author abstract) 28 refs.

Bahri, H. (Univ Pierre et Marie Curie, Paris, Fr); Guveli, D.E. *Colloid Polym Sci* v 266 n 2 Feb 1988 p 141-144.

**Structure** See Also POLYMERS—Structure.

**081409 SYNTHESIS AND PROPERTIES OF NON-CYCLOC POLYETHER COMPOUNDS. XV. NONCYCLIC POLYETHER CARRIERS EXHIBITING POTASSIUM-ION-SELECTIVE TRANSPORT THROUGH LIQUID MEMBRANES: THEIR**

**STRUCTURES AND CATION SELECTIVITY.** The effects of the structure of noncyclic polyethers on potassium-ion-selective transport have been investigated using several synthetic noncyclic polyethers as carriers for transport through liquid membranes. The K<sup>+</sup> selectivity of a polyether with an oxytrimethylene group instead of an oxyethylene group decreased significantly. The position of the introduced o-phenylene group affects the cation selectivity of the polyethers. A polyether with a quinolyl terminal group exhibits superior K<sup>+</sup> selectivity to otherwise identical polyethers with naphthyl or n-butyl terminal groups. (Edited author abstract) 18 refs.

Hiratani, Kazuhisa (Industrial Products Research Inst, Tsukuba, Jpn); Taguchi, Kazuhiro; Sugihara, Hideki; Iio, Kokoro. *J Membr Sci* v 35 n 1 Dec 15 1987 p 91-102.

**Structures** See POLYAMIDES—Structure.

## Suspensions

**081410 DEFORMATION OF VISCOUS DROPLETS IN AN ELECTRIC FIELD: POLY(PROPYLENE OXIDE)/POLYDIMETHYLSILOXANE SYSTEMS.** Deformation of droplets in an alternating electric field of 60 Hz was investigated for drops of poly(propylene oxide) (PPO) and water suspended in poly(dimethylsiloxane) (PDMS). Under a low field strength E, the droplet deformed into an ellipsoid. The equilibrium shape and the rate of deformation were analyzed in terms of the degree of deformation. Under a strong field, drops became unstable and were elongated to a thin thread or bursted into fine droplets. We classified these burst behaviors into four classes. (Edited author abstract) 18 refs.

Nishiwaki, Tsuyoshi (Osaka Univ, Toyonaka, Jpn); Adachi, Keiichi; Kotaka, Tadao. *Langmuir* v 4 n 1 Jan-Feb 1988 p 170-175.

**Synthesis** See Also AROMATIC POLYMERS—Synthesis; EPOXY RESINS—Curing; POLYESTERS—Synthesis.

**081411 END-FUNCTIONALIZED POLYMERS BY LIVING CATIONIC POLYMERIZATION: 3. RING-SUBSTITUTED ANILINES AS FUNCTIONAL END-CAPPING AGENTS FOR THE SYNTHESIS OF POLYISOBUTYL VINYL ETHER) WITH A TERMINAL AMINE, CARBOXYLIC ACID, OR ESTER GROUP.** End-functionalized poly(isobutyl vinyl ether) with a terminal amine, carboxylic acid, or ester group was prepared by quenching the HI/I<sub>2</sub>-initiated living polymer ends with ring-substituted anilines. The living polymerization of isobutyl vinyl ether and the subsequent end-capping reaction were carried out at -15°C in methylene chloride. The resulting polymers exhibited a narrow molecular weight distribution and carried one terminal function (aniline residue) per chain, according to <sup>1</sup>H NMR structural analysis. (Edited author abstract) 7 refs.

Sawamoto, Mitsuo (Kyoto Univ, Kyoto, Jpn); Enoki, Takashi; Higashimura, Toshinobu. *Polym Bull (Berlin)* v 18 n 2 Aug 1987 p 111-115.

**081412 LIQUID CRYSTALLINE COPOLY(VINYLETHERS) CONTAINING 4(4')-METHOXY-4'(4')-HYDROXY- $\alpha$ -METHYLSTILBENE CONSTITUTIONAL ISOMERS AS SIDE GROUPS.** Ethoxy vinyl ethers containing 4-methoxy-4'-hydroxy- $\alpha$ -methylstilbene and 4-hydroxy-4'-methoxy- $\alpha$ -methylstilbene constitutional isomers as side groups were synthesized by phase transfer catalyzed etherification of a mixture containing the above mentioned isomers with 2-chloroethyl vinyl ether. Cationic copolymerization of various ratios between the two constitutional isomeric monomers led to a mixture of two copolymers which were separated by fractional precipitation. One copolymers which were separated by fractional precipitation. One copolymer exhibits a nematic mesophase, the other exhibits two smectic mesophases. (Author abstract) 8 refs.

Percec, Virgil (Case Western Reserve Univ, Cleveland, OH, USA); Tomazos, Dimitris. *Polym Bull (Berlin)* v 18

n 3 Sep 1987 p 239-246.

**081413 FUNCTIONAL POLYMERS AND SEQUENTIAL COPOLYMERS BY PHASE TRANSFER CATALYSIS. XXVI. SYNTHESIS AND CHARACTERIZATION OF THERMOTROPIC LIQUID CRYSTALLINE POLYPODANTS.** Thermotropic liquid crystalline (LC) polyethers and copolymers have been synthesized from 4,4'-dihydroxy- $\alpha$ -methylstilbene (HMS) and  $\alpha,\omega$ -dichlorooiligo(oxyethylene)s having between 2 and 5 as well as 8.7 oxyethylene units. Copolyethers were prepared from a 1:1 mol/mol ratio of two dissimilar spacers. These polymers have been prepared by a phase transfer catalyzed (PTC) polyetherification of bisphenols with these electrophiles by utilizing 50 mol% tetrabutylammonium hydrogen sulfate per phenol group. Kinetic experiments with either 5 or 50 mol% catalyst vs phenol groups in the polyetherification of 4,4'-isopropylidenediphenol with 2-chloroethyl ether have shown that a change in catalyst primarily affects the rate of reaction, with 50 mol% being faster. (Edited author abstract) 46 refs.

Shaffer, Timothy D. (Case Western Reserve Univ, Cleveland, OH, USA); Percec, Virgil. *J Polym Sci Part A* v 25 n 10 Oct 1987 p 2755-2779.

## Thermal Expansion

**081414 THERMAL EXPANSION OF POLYOXYMETHYLENE.** The thermal expansivities of polyoxymethylene crystals in the direction parallel and perpendicular to chain axis have been measured from 160 to 400 K using wide-angle X-ray diffraction. Although polyoxymethylene has a helical chain structure, it exhibits a thermal expansion behavior similar to that of polymer crystals with planar zigzag chains. The thermal expansivity is found to vary linearly with crystallinity, thus allowing the expansivity of the amorphous phase to be derived by extrapolation. With the thermal expansivities of the crystalline and amorphous phases known, the draw ratio dependence can be calculated in terms of existing models and is found to agree reasonably with experimental data. (Edited author abstract) 26 refs.

Choy, C.L. (Chinese Univ of Hong Kong, Hong Kong); Nakafuku, C. *J Polym Sci Part B* v 26 n 4 Apr 1988 p 921-934.

**Thermal Properties** See ALKALI METAL COMPOUNDS—Thermal Properties.

## Thermodynamic Properties

**081415 PRESSURE-VOLUME-TEMPERATURE RELATIONSHIP AND THE HEAT OF FUSION OF POLYOXYMETHYLENE.** The pressure-volume-temperature relation of polyoxymethylene was measured at pressures from 100 to 2000 kg/cm<sup>2</sup> and from room temperature to 220°C. The dependence of the melting and crystallization temperatures on pressure was also determined. The unit cell parameters were measured up to 170°C by x-ray diffraction. These data were combined through the use of the Clapeyron equation to compute a heat of fusion of 92.9 cal/g. This value is considerably higher than those previously reported. The weight fraction crystallinity of an injection molded sample was 48% by calorimetry and 66% by interpolation between the specific volumes of the crystal and the amorphous phase. It is suggested that a simple two-phase model is inadequate to describe this polymer. (Author abstract) 19 refs.

Starkweather, Howard W. Jr. (DuPont, Wilmington, DE, USA); Jones, Glover A.; Zoller, Paul. *J Polym Sci Part B* v 26 n 2 Feb 1988 p 257-266.

**POLYETHYLENE TEREPHTHALATE** See Also BOTTLES—Plastics; GRAFT COPOLYMERS—Mechanical Properties; POLYESTERS—Crosslinking; POLYESTERS—Processing; POLYMERIZATION—Condensation Reactions; POLYMERS—Blending; TEXTILE FIBERS—Synthetics.



**081416 EFFECT OF CRYSTALLINITY ON THE EXCIMER FLUORESCENCE OF POLY(ETHYLENE TEREPHTHALATE) FILM.** An increase in the intensity ratio of the monomer-to-excimer fluorescence with crystallinity has been found in semicrystalline poly(ethylene terephthalate) films, while in the amorphous film the emission was almost exclusively from excimers. This is easily understandable as the molecular packing in the crystalline lattice precludes excimer formation. From morphological considerations we are led to the conclusion that the range of energy migration must be much shorter than ca. 10 nm. (Edited author abstract) 9 refs.

Cao, Ti (Acad Sinica, Beijing, China); Magonov, Sergei N.; Qian, Renyuan. *Polym Commun (Guildford Engl)* v 29 n 2 Feb 1988 p 43-44.

**081417 MEASUREMENT OF THE MELTING POINTS OF OLIGOMERS OBTAINED IN THE MANUFACTURE OF POLY(ETHYLENE TEREPHTHALATE).** The melting points ( $T_m$ ) were measured for oligomers obtained by a direct continuous esterification process between terephthalic acid and ethylene glycol. Multiple regression analyses of data were carried out, and an equation was obtained for predicting melting points with correlation coefficient of approx. 0.99. (Author abstract) 3 refs.

Yamada, T. (Toyobo Co, Shiga, Jpn); Mizuno, Y.; Imamura, Y. *Polym Eng Sci* v 28 n 6 Mar 1988 p 377-380.

**081418 RELATION BETWEEN CHARACTERISTICS AND MELTING POINT OF OLIGOMERS IN POLY(ETHYLENE TEREPHTHALATE) MANUFACTURING.** The applicable range of the regression equation proposed by Yamada, et al. expressing oligomer melting point by oligomer characteristics and relations derivable from the equation correlating each oligomer characteristic and melting point were studied. It was confirmed that the equation is applicable not only to poly(ethylene terephthalate) (PET) oligomer but also to the extent of polymerization. As number-average degree of polymerization ( $P_n$ ) increases, the influence of end groups on melting point becomes weak, and when  $P_n$  exceeds 50, the influence of end groups becomes negligibly small. On the other hand, when  $P_n$  is below 2, it was confirmed that the influence of end groups on melting point is very strong. (Author abstract) 6 refs.

Yamada, T. (Toyobo Co, Shiga, Jpn); Imamura, Y. *Polym Eng Sci* v 28 n 6 Mar 1988 p 381-384.

**081419 MOGUCNOST USMERAVANJA TOPOHEMIJE REAKCIJE KALEM POLIMERIZACIJE PRETHODNOM NISKOTEMPERATURNOM PLAZMENOM AKTIVACIJOM POLIMERA.** [Possibilities for Controlling the Topochemical Reaction of Graft Polymerization by Low Temperature Plasma Pretreatment of the Polymer Matrix]. The possibilities of low-temperature plasma pretreatment (5 min 0.133 Pa) of PETP (polyester fiber) and its effects on topochemistry in acrylamide graft polymerization initiated by benzophenone have been studied. It was shown that the process of surface grafting of acrylamide is favoured by increased sorption ability and wetting of the fiber, due to its increased specific surface in the process of plasma pretreatment. Following the morphological changes of PETP after plasma pretreatment and/or in the grafting process (ESM method), a decrease of microporosity on the fiber surface was observed as a result of micropores filling with polyacrylamide. Surface grafting was proved by the IR method of the multiply disturbed entire internal reflection. (Author abstract) 26 refs. In Serbo-croatian.

Bogoeva-Gaceva, Gordana (Tehnolosko-metalurski fakultet, Skopje, Yugosl); Lozinski, Dimitrije; Petrov, Gjuro. *Polimeri (Zagreb)* v 9 n 1-2 Jan-Feb 1988 p 12-14.

**081420 FUNCTIONALIZATION OF POLY(ETHYLENE TEREPHTHALATE) BY MEANS OF GLOW-DISCHARGE-INITIATED POLYMERIZATION OF ACRYLIC ACID.** Glow-discharge-initiated polymerization of acrylic acid incorporated in poly(ethylene terephthalate) (PET) films was investigated. An

increase in polymerization yield with plasma treatment duration and power was found. Polymerization was not confined to the film surface. At high power and long treatment time, polymerization in the bulk of the PET also took place. Water regain and contact angle of the PET-treated films were affected by the presence of poly(acrylic acid) (PAA). The carboxyl groups of the PAA chains incorporated in the PET matrix were utilized for further chemical modification of the PET film. (Edited author abstract). 18 Refs.

Cohn, Daniel (Hebrew Univ of Jerusalem, Jerusalem, Isr); Tal-Atias, Ilana; Avny, Yair. *J Macromol Sci Chem* v A25 n 4 1988 p 373-388.

## Adhesion

**081421 ADHESION OF POLY(ETHYLENE TEREPHTHALATE) FILM BY NOVOLAK TYPE EPOXY RESIN.** The adhesion of poly(ethylene terephthalate) (PET) is generally difficult without surface treatment. The peel strength of untreated biaxial stretching PET film laminate bonded with a novolak type epoxy resin was measured at 20°C, and the texture of the fracture surface after the peel test was observed with a scanning electron microscope. When the epoxy resin was fully cured, the PET film of thickness of 350  $\mu$ m broke, and, before breaking, the delaminating fracture of PET film surface occurred. The effects of testing temperature and rate on the peel strength were investigated. (Edited author abstract) In Japanese. 15 refs.

Nakao, Kazumune (Gifu Univ, Yanagido, Jpn); Takahashi, Yoshinobu. *Kobunshi Ronbunshu* v 44 n 11 1987 p 803-809.

## Aging

**081422 STARZENIE PET.** [Aging of Polyethylene Terephthalate]. The theoretical aspects of PET ageing have been presented and the importance of free volume relaxation in this process accentuated. The results of studies on the effect of time, relative humidity and storage temperature as well as of relative viscosity of polymer on the changes in tensile yield and Dart impact of PET have been presented and discussed. It has been shown that free volume relaxation has a detrimental effect on the mechanical properties of bottles, films and preforms of amorphous PET. In general, it can be concluded that it is a poor practice to store PET articles in hot humid conditions. (Author abstract) In Polish.

Knight, Delane M. (Eastman Chem Int AG, Liverpool, Engl); Wickham, Raymond S. *Polimery* v 32 n 8 Aug 1987 p 319-321.

## Analysis

**081423 PHOTOCHEMICAL TRANSIENT SPECIES OF POLY(ETHYLENE TEREPHTHALATE) POWDERS AS REVEALED BY THE DIFFUSE REFLECTANCE LASER PHOTOLYSIS METHOD.** Direct measurements of transient species in nanosecond and picosecond time domains provided detailed information on primary photoprocesses and a high excitation intensity of laser pulse opened a new field of nonlinear photochemical behavior of polymers. For non-transparent materials, this laser photolysis method cannot be used. However, a diffuse reflectance laser photolysis method was developed recently and has been applied to scattering powder samples such as organic microcrystals, CdS, organic molecules adsorbed on silica, gel, zeolite, etc. In the present work the authors applied this method to powder samples of representative polymers. 7 refs.

Imagi, Keiji (Kyoto Inst of Technology, Kyoto, Jpn); Ikeda, Noriaki; Masuhara, Hiroshi; Nishigaki, Masahiko; Isogawa, Masataka. *Polym J* v 19 n 8 1987 p 999-1001.

## Applications See Also POLYESTERS—Production.

**081424 SHELF LIFE EVALUATION OF AN ORIENTED POLYETHYLENE TEREPHTHALATE PACKAGE FOR USE WITH HOT-FILLED APPLE**

JUICE. A year-long storage study was undertaken to evaluate an oriented polyethylene terephthalate (OPET) container for use with hot-filled juice. Freshly-made juice as well as single-strength juice reconstituted from commercial apple juice concentrate were evaluated. The results indicated that the oxidation of the juice by way of oxygen permeation through the OPET barrier was slow enough to allow for a satisfactory shelf life as compared to glass-packaged samples over a 6-9 month period. Surface-to-volume effects did not become significant until late in the study. Difference and preference tests were used to establish shelflife comparison between OPET packages and glass-packaged products. (Edited author abstract) 9 refs.

McLellan, M.R. (Cornell Univ, Geneva, NY, USA); Lind, L.R.; Kime, R.W. *J Food Sci* v 52 n 2 Mar-Apr 1987 p 365-368.

**Blending** See CRYSTALS, LIQUID—Physical Properties; NYLON POLYMERS—Blending; POLYCARBONATES—Blending; POLYMERS—Blending; TEXTILE FIBERS—Synthesis.

## Chemical Reactions

**081425 AMINOLYSIS OF PET FIBERS WITH ETHYLENEDIAMINE VAPOR.** Aminolysis of poly(ethylene terephthalate) (PET) fibers with ethylenediamine (ED) of vapor phase was carried out at a temperature range from 60 to 120°C. Contents of primary amino group and bonded ED (nitrogen wt%) in the aminolyzed PET fibers were analyzed by the Ninhydrin method and an elemental analysis method. The content of amino group increased proportional to the vapor concentration of ED. Molar ratio of amino group to bonded ED was not virtually affected by the reaction temperature but by the vapor concentration of ED. (Author abstract) In Chinese. 3 refs.

Ukita, Minoru (Government Industrial Research Inst, Osaka, Jpn); Yoshida, Matayasu; Ando, Tadanao; Wakano, Hiromitsu. *Chem Express* v 2 n 12 Dec 1987 p 763-766.

**Crystallization** See Also SYNTHETIC FIBERS—Spinning.

**081426 CRYSTALLIZATION IN POLYMER MELT SPINNING.** The crystallization behavior of poly(ethylene) terephthalate (PET) melt spun into fiber monofilaments was examined using a laboratory set-up. The wind-up speeds ranged from free fall under gravity to 1500 m/min. The major additional variables that were manipulated included the mass flow rate and the filament temperature profile. The structure of the as-spun fibers was probed using tensile tests, differential scanning calorimetry, optical birefringence, and x-ray diffraction. It was found that while the filaments that had been spun nonisothermally were essentially amorphous, those that had been made under isothermal conditions at temperatures ranging from 180°C to 240°C were oriented and crystalline. In addition, the rate of oriented crystallization was much greater than that under quiescent conditions at the same temperature. (Edited author abstract) 21 refs.

Gupta, Rakesh K. (State Univ of New York, Buffalo, NY, USA); Auyeung, Kim F. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2469-2484.

**081427 MULTIPLE MELTING ENDOTHERMS OF POLY(ETHYLENE TEREPHTHALATE).** Poly(ethylene terephthalate) samples were isothermally crystallized from the melt on a differential scanning calorimeter. Subsequent fusion showed three endotherms under many crystallization conditions. These three peaks are attributed to melting of crystallites formed during primary and secondary crystallization processes and to fusion of crystals formed during recrystallization during the melting scan. (Author abstract) 21 refs.

Zhou, Chixing (Univ of Lowell, Lowell, MA, USA); Clough, S.B. *Polym Eng Sci* v 28 n 2 Jan 1988 p 65-68.



**081428 ULTRA-HIGH-FLOW PP SPEEDS UP PET CRYSTALLIZATION.** Low-molecular-weight polypropylene resins have exceptionally low melt viscosities and high melting points. When added in small quantities to polyethylene terephthalate melts, these polypropylenes act as nucleating agents, speeding up PET crystallization and permitting high-speed processing. (Author abstract)

Bourland, Larry (ARCO, Newtown Square, PA, USA). *Plast Eng* v 43 n 7 Jul 1987 p 39-41.

**081429 STUDY ON THE EFFECT OF DIBENZYLIDENE SORBITOL AS A NUCLEATING AGENT ON THE CRYSTALLIZATION AND MORPHOLOGY OF POLY(ETHYLENE TEREPHTHALATE).** The effect of dibenzylidene sorbitol (DBS) as a nucleating agent on the crystallization of poly(ethylene terephthalate) (PET) has been studied. It has been found that DBS, when incorporated into the polyester, at a 0.5-1.0 wt% level, significantly lowers the induction period and reduces the half-time of crystallization. Thermal studies clearly show that the addition of DBS results in decreasing the temperature of crystallization,  $T_{ch}$ , when heated from the glassy state as well as increasing the temperature of crystallization,  $T_{cc}$ , when cooled from the melt. (Edited author abstract)

Mitra, Debaprasad (Indian Inst of Technology New Delhi, India); Misra, Ashok. *J Appl Polym Sci* v 36 n 2 Jul 5 1988 p 387-402.

**081430 CRYSTALLIZATION AND MULTI-MELTING BEHAVIOR OF POLY(ETHYLENE TEREPHTHALATE) MODIFIED BY SODIUM SALT OF 5-SULPHO-ISOPHTHALIC ACID.** The crystallization kinetics of the copolyester, poly(ethylene terephthalate) (PET) modified by sodium salt of 5-sulpho-isophthalic acid (SIPM), was investigated by means of differential scanning calorimeter. The experimental results and polar-microscopy observation all showed that the introduction of SIPM did not affect the nucleation of crystallization. Within the temperature range between their glass transition temperature  $T_g$  and melting point  $T_m$ , the crystallization rate of the copolyester sample decreased with increasing content of SIPM. The relative crystallization rate constant  $Z$  of SIPM/DMT (dimethyl terephthalate) 4 mol% sample was about 1% pure PET's  $Z$  value. For isothermal crystallized copolyester samples, DSC heating curves displayed multi-melting behavior. This was interpreted by molecular weight fractionation during crystallization and premelting-recrystallization mechanism. (Edited author abstract) 18 refs.

Hu, Hengliang (Tianjin Coll of Textile Technology, Tianjin, China); Mu, Xiangqi; Wu, Shizhen. *Chin J Polym Sci (Engl Ed)* v 5 n 1 1987 p 53-60.

**081431 THERMOFORMING CRYSTALLIZING POLY(ETHYLENE TEREPHTHALATE) (CPET).** Nonisothermal crystallizing kinetics for nucleated polyethylene terephthalate (PET) are combined with transient heat transfer models to predict crystalline levels throughout the process of extruding and thermoforming crystallizing PET (CPET). The analysis compares distributed parameter finite difference analysis with a lumped parameter method. Material-environmental parametric studies are conducted using the lumped parameter method. The patent literature data are confirmed using an expanded version of the lumped parameter method. (Edited author abstract). 74 Refs.

Throne, James L. (Univ of Akron, Akron, OH, USA). *Adv Polym Technol* v 8 n 2 Summer 1988 p 131-176.

**Deformation** See Also POLYSULFONES—Deformation.

**081432 EFFECTS OF INITIAL MORPHOLOGY AND MOLECULAR WEIGHT ON THE DEFORMABILITY OF POLY(ETHYLENE TEREPHTHALATE).** Solution-grown crystal (SGC) mats and solution-cast (SC) films of poly(ethylene terephthalate) (PET) were drawn by solid-state coextrusion followed by tensile drawing of the coextrudates. Drawabilities and properties

of the drawn films, such as mechanical and thermal properties, were investigated as functions of molecular weight, initial morphology, and drawing conditions. The initial morphology and molecular weight have a marked effect on the drawability and tensile properties of the resultant drawn films. The attainable maximum draw ratio increases with increasing molecular weight, and the highest draw ratio of 11.5 can be achieved by two-stage drawing of SC films prepared from pellets with an intrinsic viscosity of 1.43 dl/g. Such highly drawn films exhibit a tensile modulus of 17.5 GPa and strength at break of 400 MPa. At a given molecular weight, the drawability of SGC mats is lower than that for SC films; however, the efficiency of drawing is higher for the former than for the latter. (Edited author abstract) 23 refs.

Ito, Masayoshi (Science Univ of Tokyo, Tokyo, Jpn); Tanaka, Koji; Kanamoto, Tetsuo. *J Polym Sci Part B* v 25 n 10 Oct 1987 p 2127-2138.

**081433 ON STRUCTURAL FEATURES OF LARGE DEFORMATIONS OF ORIENTED AMORPHOUS POLYETHYLENE TEREPHTHALATE.** Structural features of the reorientation of oriented amorphous samples of PETP in the glassy state have been investigated. The methods used included wide angle X-ray diffraction, polarizing microscopy and the use of a coordinate datum point network. It is shown that during the initial drawing and subsequent stretching at various angles deformation of the samples is uniform in relation to the initial isotropic state. The relations obtained are described well within the framework of a model of a stable network of physical crosslinks with extension of the network in various directions under deformation. (Author abstract) 28 refs.

Zanegin, V.D. (Lomonosov State Univ, Moscow, USSR); Myasshokova, N.V.; Ronzhin, N.K.; Gerasimov, V.I. *Polym Sci USSR* v 29 n 2 Feb 1987 p 322-330.

**Dielectric Properties** See POLYESTERS—Molecular Structure.

## Diffusion

**081434 SORPTION OF METHYLENE CHLORIDE IN POLYETHYLENE TEREPHTHALATE.** Sorption of methylene chloride in polyethylene terephthalate has been performed at three different temperatures: 21, 34, and 48°C. The solubility data are explained through dual sorption. The diffusivities are more difficult to explain since some anomalous effects were present. (Author abstract) 12 refs.

Liu, C.-P. Anthony (Univ of Missouri-Rolla, Rolla, MO, USA); Neogi, P. *J Appl Polym Sci* v 35 n 1 Jan 1988 p 21-27.

**Electric Conductivity** See Also PLASTICS FILMS—Electric Properties.

**081435 ELECTRICAL CONDUCTION IN POLYETHYLENE TEREPHTHALATE FILM.** The dc electrical conductivity ( $\sigma$ ) of polyethylene terephthalate (PET) has been investigated as a function of thickness (125 to 250  $\mu$ m) and applied fields at different temperatures ranging from 294 to 424 K with M-P-M sandwich configuration. The plots in  $\sigma$  versus  $1/T$  and current thermogram reveal that there are three regions of conduction separated by two transient zones of metallic nature. The regions I and II occurred in the glassy state having two temperature transitions recorded at 333 and 378 K. This has been explained on the basis of the cluster model. Activation energy ( $E_a$ ) of different conduction regions is correlated with the thickness of the sample and the applied field. These samples of the polymer also exhibit a hysteresis loop at and above 348 K indicating the polar nature of the sample. The low values of the activation energy ( $E_a \leq 1$ ) indicate predominance of electronic conduction. (Author abstract) 12 refs.

Karimi, N.A. (N.B. Coll, Patna, India); Gupta, D.; Prasad, Premalata. *Indian J Pure Appl Phys* v 25 n 2 Feb 1987 p 83-86.

**081436 PRZEWODNICTWO ELEKTRYCZNE KRAJOWEJ FOLII Z POLI(TEREFTALANU ETYLENU).** [Electrical Conductivity of Domestic Poly-(Ethylene Terephthalate) Film.] The electric conductivity of samples of Estrofol PET film differing in the degree of orientation and crystallinity has been investigated. The current-voltage characteristics of the film in an electrostatic field of the intensity of up to  $6.5 \times 10^7$  V·m<sup>-1</sup> have been determined. An analysis of these characteristics reveals a high probability of an ionic mechanism of electrical conductivity of PET film. This conductivity only slightly depends on the molecular orientation and degree of crystallinity of PET. (Edited author abstract). 15 Refs. In Polish.

Wieslawa Urbaniak-Domagala (Politechnika Lodzka, Pol); Urbanczyk, Grzegorz. *Polimery* v 33 n 3 Mar 1988 p 84-88.

**Etching** See POLYMERS—Structure.

## Extrusion

**081437 PROPERTIES OF POLY(ETHYLENE TEREPHTHALATE) EXTRUDATE PREPARED BY HYPERBOLIC CONVERGENT FLOW AND HIGH PRESSURE.** The structure and properties of poly(ethylene terephthalate) segments prepared by high-pressure extrusion in a pseudohyperbolic die were examined. The translucent segments showed relatively high levels of orientation, crystallinity, and modulus. Higher melting point, larger crystal size, and higher loss modulus peak temperature ( $T_g$ ) were observed for these segments as compared with those prepared earlier in our laboratory using the conventional 90° conical die. This seems to indicate that a hyperbolic profile is very effective in producing and maintaining a highly aligned chain network in a flowing melt. (Author abstract) 11 refs.

Dae Woo Ihm (North Carolina State Univ, Raleigh, NC, USA); Cuculo, John A. *J Polym Sci Part B* v 25 n 11 Nov 1987 p 2331-2343.

## Fiber Reinforcement

**081438 GLASS FIBER REINFORCED POLYETHYLENE TEREPHTHALATE.** A discussion is presented of the mechanical properties of glass fiber reinforced polyethylene terephthalate. The factors affecting compounding are outlined. The trends in technical development are also noted. In English and German.

Yamashiro, S. *Kunstst Ger Plast* v 78 n 3 Mar 1988 p 19-20.

**Filaments** See SYNTHETIC FIBERS—Physical Properties; SYNTHETIC FIBERS—Spinning.

**Film** See Also SUPERCONDUCTING MAGNETS—Plastics Applications.

**081439 NEW METHOD FOR QUICK DETERMINATION OF MOLECULAR ORIENTATION IN POLY(ETHYLENE TEREPHTHALATE) FILMS BY USE OF POLARIZED MICROWAVES.** A new polarized microwave method for determining the orientation of polymer molecules in films without contact and its application to poly(ethylene terephthalate) (PET) are presented. The angular dependence of transmitted microwave intensity allowed the orientation angle, the maximum to minimum intensity ratio, and the ratio of intensities in the transverse to the machine direction to be determined in as a short time as ca. 30s. With the results obtained from X-ray diffraction, mechanical breaking strength, infrared absorption, refractive index, and thermal shrinkage measurements, it was concluded that the orientation angle and the maximum to minimum ratio determined by the microwave method reflect, respectively, the direction and the degree of the orientation of PET chains. (Edited author abstract) 15 refs.

Osaki, Shigeyoshi (Kanzaki Paper Manufacturing Co, Amagasaki, Jpn). *Polym J* v 19 n 7 1987 p 821-828.



**081440 EFFECTS OF THERMAL TREATMENT ON BIAXIALLY ORIENTED POLY(ETHYLENE TEREPHTHALATE). II. THE ANISOTROPIC GLASS TEMPERATURE.** Thermal properties of an anisotropic biaxially oriented poly(ethylene terephthalate) (PET) were determined before and after further deformation of the Mylar film. Film shrinkage in different planar directions was monitored during and following initial heating. After stabilization for three days at 140°C, glass temperatures  $T_g$  were determined from the decrease in length of film strips and were found to vary in the different in-plane directions. An increase in anisotropy brought about by additional deformation in the direction of the greatest orientation enhanced the  $T_g$  difference from 8 to 16°C.  $T_g$  is highest in the direction of greatest orientation. (Author abstract) 8 refs.

Vallat, M.-F. (Univ of Pittsburgh, Pittsburgh, PA, USA); Plazek, D.J. *J Polym Sci Part B* v 26 n 3 Mar 1988 p 545-554.

**081441 EFFECTS OF THERMAL TREATMENT ON BIAXIALLY ORIENTED POLY(ETHYLENE TEREPHTHALATE). III. CREEP BEHAVIOR FOLLOWING VARIOUS THERMAL HISTORIES.** Elongational creep measurements were carried out on a biaxially oriented poly(ethylene terephthalate) (PET) film parallel to, orthogonal to, and at 45° to the principal optic axis. Measurements made after various thermal treatments which were intended to stabilize the physical state of the PET were shown to be ineffective. Samples were annealed at 140°C for 12 days and aged at 95°C for over 24 days before measurement without success. Thermal Cycling between 41 and 91°C which was also employed to stabilize the mechanical response also failed. Significant deceleration of the creep rate caused by densification of amorphous regions of the samples during storage below the glass temperature  $T_g$  is illustrated. Because of physical aging below  $T_g$  and morphological changes occurring above  $T_g$  during the various thermal treatments and histories, time-scale shift factors were found to be not unique. (Author abstract) 40 refs.

Vallat, M.-F. (Univ of Pittsburgh, Pittsburgh, PA, USA); Plazek, D.J.; Bhushan, B. *J Polym Sci Part B* v 26 n 3 Mar 1988 p 555-567.

**081442 PHOTOPHYSICAL STUDIES OF AMORPHOUS ORIENTATION IN POLY(ETHYLENE TEREPHTHALATE) FILMS.** The effects of uniaxial and biaxial extension on the intrinsic fluorescence of poly(ethylene terephthalate) (PET) films have been investigated. A power law relationship, valid for both uniaxially and biaxially deformed samples, was found between the fluorescence emission at 368 nm and the planar extension, which is defined as the product of the extension ratios in the transverse and machine directions. Dimethyl terephthalate (DMT) model compound studies indicate that the fluorescent species in the PET films is not the monomeric unit. A model incorporating energy migration in the non-crystalline region has been proposed to explain these results. (Edited author abstract) 28 refs.

Hemker, David J. (Stanford Univ, Stanford, CA, USA); Frank, Curtis W.; Thomas, Jule W. *Polymer* v 29 n 3 Mar 1988 p 437-447.

**081443 STUDY ON THE MECHANISM OF STAINING BY ALLYLAMINE/OsO<sub>4</sub> ON PET FILM.** It was proposed that in the staining process allylamine diffuses into amorphous region of PET film, reacting slightly with ester bond on PET chain and connecting with it and remaining in the amorphous area, then OsO<sub>4</sub> reacts with C = C group in allylamine, deposits in that region and hence, increases the contrast between amorphous and crystalline regions. (Author abstract) 8 refs.

Wen, Zaiqing (Acad Sinica, Beijing, China); Zhu, Lilan. *Chin J Polym Sci (Engl Ed)* v 5 n 3 1987 p 205-210.

**081444 OPTICAL INTERFERENCE METHOD FOR THE STUDY OF MOISTURE SWELLING IN PET FILMS.** A method for measuring moisture swelling

of amorphous PET films by using Rayleigh interferometer is reported. Plots of the optical path of light transmission in the polymer vs. soaking time were obtained, and from the same curves, the dependence of time on the moisture swelling, saturated water absorption and diffusion coefficient of PET films were estimated. These results are in agreement with those obtained by weighing method. It is shown that optical interference method is a simple but sensitive method for the study of water absorption and swelling in transparent polymer films. (Author abstract) 6 refs.

Li, Changjiang (Beijing Inst of Chemical Technology, Beijing, China); Gao, Junying. *Chin J Polym Sci (Engl Ed)* v 5 n 3 1987 p 261-264.

#### Flammability

**081445 FLAME-RETARDATION STUDIES OF POLY(ETHYLENE TEREPHTHALATE) FABRICS TREATED WITH tris DIBROMO ALKYL PHOSPHATES.** The flammability characteristics of tris(2,3-dibromopropyl) phosphate (TRIS-BP), a known carcinogen, has been compared with other tris dibromo alkyl phosphates which show reduced mutagenic responses in experimental studies. The effectiveness of these alternative chemicals in releasing hydrogen bromide (HBr), a recognized combustion inhibitor, has been measured and the results compared with flammability evaluation of polyester fabrics treated with these chemicals. Results indicate that tris(2,3-dibromo-3,3-dimethyl propyl) phosphate, while having reduced mutagenicity and nephrotoxicity in comparison to TRIS-BP, exhibits excellent flame-retardant characteristics when applied to polyester fabrics. Meanwhile, other chemicals studied show comparable flame retardation to TRIS-BP, but with substantial reduced mutagenicity. (Author abstract) 21 refs.

Day, M. (Nat'l Research Council of Canada, Ottawa, Can); Suprunchuk, T.; Omichinski, J.G.; Nelson, S.D. *J Appl Polym Sci* v 35 n 2 Feb 5 1988 p 529-535.

#### Forming

**081446 INVESTIGATION OF THE FORMATION OF POLY(ETHYLENE TEREPHTHALATE) WITH MODEL MOLECULES: KINETICS AND MECHANISM OF THE CATALYTIC ESTERIFICATION AND ALCOHOLYSIS REACTIONS. I. CARBOXYLIC ACID CATALYSIS (MONOFUNCTIONAL REACTANTS).** Monofunctional compounds (benzoic acid, heptyl alcohol, and 2-butoxy-ethanol) were used to investigate the kinetics of the esterification and the alcoholysis reactions. Carboxylic acids (benzoic acid) are the only catalysts present in the reaction medium. The factors which influence the kinetics of the esterification reaction were studied: the nature of the carboxylic acid (substituents on the benzene ring), the nature of the alcohol, the composition of the reaction medium (alcohol alone or with another solvent, ester, or water). The results point to an acyl type ( $A_{AC2}$ ) mechanism. (Edited author abstract) 7 refs.

Otton, Jean (Cent de Recherches des Carrieres, St.-Fons, Fr); Rattton, Serge. *J Polym Sci Part A* v 26 n 8 Aug 5 1988 p 2183-2197.

**081447 INVESTIGATION OF THE FORMATION OF POLY(ETHYLENE TEREPHTHALATE) WITH MODEL MOLECULES: KINETICS AND MECHANISMS OF THE CATALYTIC ESTERIFICATION AND ALCOHOLYSIS REACTIONS. II. CATALYSIS BY METALLIC DERIVATIVES (MONOFUNCTIONAL REACTANTS).** The reactions of model molecules were considered to study the kinetics and the mechanism of the esterification and the alcoholysis reactions catalyzed by various metal compounds (Li, Na, K, Zn, Co, Mn, Ti). Ti was found to be the most active catalyst for both reactions and to be acting via a different mechanism (concerted). The possible structure of the active titanium intermediate was investigated by means of <sup>1</sup>H- and <sup>13</sup>C-NMR spectroscopy, FT-IR spectroscopy, and electroconductivity. (Author abstract) 7

Refs.

Otton, Jean (Cent de Recherches des Carrieres, St.-Fons, Fr); Rattton, Serge; Markova, Gali D.; Nametov, Kahirman M.; Bakmutov, Vladimir I.; Komarova, Lidiya I.; Vinogradova, Svetlana V.; Korshak, Vasilii V. *J Polym Sci Part A* v 26 n 8 Aug 5 1988 p 2199-2224.

#### Mechanical Properties

**081448 EFFECT OF STRETCHING CONDITIONS ON PROPERTIES OF AMORPHOUS POLYETHYLENE TEREPHTHALATE FILM.** The effect of stretching conditions on stress-induced crystallization of amorphous polyethylene terephthalate (PET) film has been studied. Cast PET film was stretched at 85°C with stretching rates ranging from 100% per minute to 600% per minute for various stretching ratios. The stretched film samples were annealed at 140°C both under tension as well as under relaxed conditions. Tensile properties were determined using Instron Tensile and results were compared. Tenacity, yield stress, and initial modulus were found to increase while elongation at break decreased with the increase in stretching rate. The degree of crystallinity was measured by x-ray diffraction as well as density methods. Birefringence and crystalline orientation factor values were determined experimentally and using these, amorphous orientation factor values were calculated. (Edited author abstract) 24 refs.

Sharma, S.K. (Indian Inst of Technology Delhi, New Delhi, India); Misra, A. *J Appl Polym Sci* v 34 n 6 Nov 5 1987 p 2231-2247.

#### Medical Applications See Also PROSTHETICS—Blood Vessel Prostheses.

**081449 HYDROGELS FOR ARTIFICIAL TENDONS.** Natural tendon is a form of the connective tissues of the body which connects the muscle to the bone, so that the force produced in the muscle is transmitted to the bone. This function is mainly due to the bundles of fibers of collagen, a long-chain protein which imparts tensile strength and inextensibility to the tendon. The collagen fiber bundles, oriented in the longitudinal direction, have a rather complex structure which results in a waviness along their axis. The bundles are embedded in a gel of mucopolysaccharide acid, containing fibroblast cells which are the principal cellular components of tendon and are responsible for deposition of collagen. In this chapter, results of research on the use of fiber-reinforced hydrogels as tendon prostheses, jointly performed at the Institute of Macromolecular Chemistry (Prague, Czechoslovakia) and at the University of Naples, where further work is in progress, are reported and reviewed. 32 refs.

Migliarese, Claudio (Univ of Naples, Naples, Italy); Nicodemo, Luigi; Nicolais, Luigi. *Hydrogels in Med and Pharm Publ by CRC Press Inc, Boca Raton, FL, USA*, 1986 v 3, p 83-94.

#### Molecular Structure

**081450 CRYSTAL MODULUS AND STRUCTURE OF ORIENTED POLY(ETHYLENE TEREPHTHALATE).** Crystal modulus measurements have been made on a number of samples of drawn poly(ethylene terephthalate) tape. The apparent crystal modulus was found to vary systematically with the degree of tilt of the crystalline c axis from the fiber axis. Using this fact, a value of 110±10 GPa was deduced for the intrinsic crystal modulus in the chain direction. It is considered that this value is more realistic than previously reported values since specimen morphology has been taken into account carefully in a systematic fashion. (Author abstract) 26 refs.

Thistlethwaite, T. (Univ of Leeds, Leeds, Engl); Jakeways, R.; Ward, I.M. *Polymer* v 29 n 1 Jan 1988 p 61-69.



**081451 MOLECULAR ORIENTATION BY MEANS OF BIREFRINGENCE AND POLARIZED FLUORESCENCE IN ORTHOGONAL BIAXIAL STRETCHED POLY(ETHYLENE TEREPHTHALATE) FILMS.** In a previous report, we developed a generalized orientation evaluation method with polarized fluorescence measurements. In this report, we evaluate the orientation of fluorescent molecules in the biaxially stretched film of poly(ethylene terephthalate) using the previous method. This evaluation was performed by the fluorescence intensity of the inclined transmitting measurements and was obtained by the solution of simultaneous equations with conjugate inclined methods. Such calculations were completed on three absorbing and emitting unit models in the fluorescent molecule. (Author abstract). 22 Refs. In Japanese.

Hibi, Sadao (Nagoya Inst of Technology, Nagoya, Jpn); Satoh, Makoto; Tanaka, Akira; Torasawa, Yuuji; Makiyama, Yasuyuki; Maeda, Matsuo. *Kobunshi Ronbunshu* v 45 n 5 1988 p 383-390.

**Morphology** See SYNTHETIC FIBERS—Thermal Properties.

**Physical Properties** See Also POLYESTERS—Additives.

**081452 PROCESSING-STRUCTURE-PROPERTY RELATIONSHIPS IN POLY(ETHYLENE TEREPHTHALATE) BLOWN FILM.** An investigation was undertaken to establish processing-structure-property relationships in poly(ethylene terephthalate) (PET) blown film. For the study, a commercial grade of PET was used to fabricate the film specimens by means of a tubular film blowing process. In this process, the stretch temperature was accurately controlled by an oven. The structure of the blown film samples was characterized by density, bulk birefringence, flat plate wide-angle X-ray scattering, and pole figure analysis. The processing variables, namely, takeup ratio, blowup ratio, and stretch temperature were found to significantly affect the bulk birefringence and density of the oriented PET blown film samples. It was found that both the bulk birefringence and density of the specimens increased upon annealing at an elevated temperature. Both the crystalline and amorphous orientation functions were calculated from the data of bulk birefringence, density, and the pole figure analysis. (Edited author abstract) 49 refs.

Ma, Tung Chan (Polytechnic Univ, Brooklyn, NY, USA); Han, Chang Dai. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1725-1757.

**Recycling** See BOTTLES—Waste Utilization.

**Rheology** See SYNTHETIC FIBERS—Spinning.

**Sheet**

**081453 POLARIZED REFLECTION SPECTRUM AND MOLECULAR ORIENTATION IN UNIAXIAL DRAWN POLY(ETHYLENE TEREPHTHALATE).** The polarized electronic spectrum of oriented poly(ethylene terephthalate) (PET) sheets was obtained from the specular reflection spectrum using the Kramers-Kronig relationship. The surface orientation function of drawn and drawn/annealed PET sheets was determined. The bulk orientation functions in the crystalline and amorphous regions were evaluated from wide-angle X-ray diffraction and sonic modulus measurements. On annealing of drawn PET sheets, the crystalline orientation and crystallinity were much improved, but the amorphous orientation function showed a minor decrease. The overall molecular orientation in the surface of the drawn PET sheet was shown to be approximately equivalent to the molecular orientation in the bulk. (Edited author abstract). 35 Refs.

Kaito, Akira (Research Inst for Polymers and Textiles, Ibaraki, Jpn); Nakayama, Kazuo; Kanetsuna, Hiseaki. *J Polym Sci Part B* v 26 n 7 Jul 1988 p 1439-1455.

**Shrinkage** See POLYCARBONATES—Stability.

**Sorption**

**081454 SORPTION BEHAVIOR OF POLY(ETHYLENE TEREPHTHALATE) FOR n-CARBOXYLIC ACID.** Sorption behavior of poly(ethylene terephthalate) (PET) was studied over a wide temperature range by using the method of Gas Chromatography. PET was used as a stationary phase in the column; mobile phases (probes) were a series of carboxylic acids with carbon numbers of 2, 3, 4, and 5: acetic acid, propionic acid, butyric acid and valeric acid. Results of previous work, in which the probes were a series of linear alcohols, i.e., ethanol, n-propanol, n-butanol, n-pentanol and o-chlorophenol, were compared. The sorption isotherms were determined from the peak profile. For carboxylic acid, the amount of the probe adsorbed decreased with temperature and with increasing chain length of the probe. The sorption behavior of three systems were analysed using the adsorption isotherms, B.E.T. plot, and Flory-Huggins parameters. (Edited author abstract) 10 refs. In Japanese.

Nakajima, Toshinari (Ochanomizu Univ, Tokyo, Jpn); Iida, Kaoru. *Kobunshi Ronbunshu* v 44 n 5 1987 p 383-388.

**Stabilizers**

**081455 STABILIZED POLYETHYLENE TEREPHTHALATE STRENGTH.** The field of polyethylene terephthalate (PET) application may be extended by chemical modification resulting in an increase of its film and fiber strength. The modern theory of polymer mechanical fracture makes it possible to determine the proper ways of PET strengthening. The aim of the present paper is to consider one of the most important ways of polymer strengthening (taking PET as an example)-selective inhibition of macromolecular radical reactions occurring in the field of mechanical forces in air. 11 refs.

Prokopchuk, N.R. (Byelorussian Acad of Sciences, Minsk, USSR); Matusevich, Yu.I.; Krul, L.P. *J Polym Sci Part C* v 25 n 12 Dec 1987 p 503-507.

**Stresses** See Also TEXTILE FIBERS—Synthetics.

**081456 ASPECTS OF THE RELAXATIONAL PROPERTIES OF ORIENTED POLYETHYLENE TEREPHTHALATE.** Stress relaxation with subsequent elastic restoration of the biaxially oriented PETP film in the isothermal regime is analysed. The relaxation process may be divided into parts due to the elastic aftereffect and forced-elastic deformation. A safe region of deformations and the time of their action has been identified. The relaxation process in this region is characterized by the distinct non-linearity of the viscoelastic properties to describe which a deformation-time analogy may be used. For the quantitative evaluation of the boundaries of the safe region the Aleksandrov-Gurevich kinetic equation may be used. (Author abstract) 3 refs.

Romanov, V.A. (Leningrad Technological Inst of the Cellulose-Paper Industry, USSR); Matveyeva, T.N.; Akim, E.L. *Polym Sci USSR* v 29 n 2 Feb 1987 p 274-279.

**081457 FUNDAMENTAL ASPECTS OF STRESS, DEFORMATION, AND PHASE TRANSITIONS IN CRYSTALLIZABLE POLYMERS: EXPERIMENTS WITH POLY(ETHYLENE TEREPHTHALATE) IN UNIAXIAL STRESS FIELDS.** Interactions between rheology and fluid → solid transformation through crystallization are demonstrated through an experimental study of crystallization of polyethylene terephthalate in uniaxial stress fields. Effect of the strength of the stress field on the kinetics of crystallization is shown to diminish greatly beyond the initiation of crystallization. Consequences of crystallization in anisotropic stress fields in the generation of mechanical properties are also described. This experimental study points clearly to the deficiencies in current theoretical formulations of kinetics of crystallization. (Author abstract). 23 Refs.

Desai, Prashant (Georgia Inst of Technology, Atlanta, GA, USA); Abhiraman, A.S. *J Polym Sci Part B* v 26 n 8 Aug 5 1988 p 1657-1675.

**Structure**

**081458 EFFECT OF ANNEALING AND DRAWING ON THERMOLUMINESCENCE OF POLY(ETHYLENE TEREPHTHALATE).** As a fundamental study on the structure and properties of poly(ethylene terephthalate) (PET), thermoluminescence (TL) of X-ray irradiated PET films at both low temperatures (starting from liquid-nitrogen temperature) and high temperatures (starting from room temperature) was investigated by means of the glow curve and thermal decay. It is concluded that most of the electron traps in X-ray irradiated PET films are located in the amorphous region in both low- and high-temperature TL. It is especially emphasized that crystal interfaces also contribute to the high-temperature TL of annealed samples and that the relaxed state of amorphous chains is more favorable to TL than the tensioned state. (Author abstract) 16 refs.

Liu, Liang Bao (Tokyo Inst of Technology, Tokyo, Jpn); Hiyama, Kunio; Miyasaka, Keizo. *Polymer* v 29 n 2 Feb 1988 p 286-291.

**Synthesis**

**081459 FORMATION OF DIETHYLENE GLYCOL BY DEHYDRATION OF GLYCOL IN THE PRESENCE OF TEREPHTHALIC ACID.** The amount of diethylene glycol (DEG) formed as a result of the dehydration reaction of ethylene glycol (EG) in the presence of terephthalic acid (TPA) was measured. It became clear that the amount of DEG formed at the boiling point of EG can be expressed by a regression equation. It was confirmed that by this equation, the amount of DEG formed under the carboxylic end group concentration of 0.0 to 0.6 Eq/kg and the reaction time of 0 to 20 h can be estimated with high accuracy. (Author abstract) 8 refs.

Yamada, Toshiro (Toyobo Co, Shiga, Jpn). *Polym Eng Sci* v 28 n 1 Mid-Jan 1988 p 37-41.

**Thermal Effects** See Also POLYMERS—Mechanical Properties.

**081460 THERMAL ANALYSIS OF HEAT SET POLY(ETHYLENE TEREPHTHALATE) AND THE HEAT SETTING TEMPERATURE.** In our examination of the differential scanning calorimetry (DSC) curve of annealed or heat set polyester samples from textile mills, we have observed three kinds of thermograms. The first type of curve shows an endotherm prior to melting and the second type exhibits an exothermic curve. The third type of curve is a combination of the first two. We thought that the exo-shifts in these curves might be caused by some oligomers present in the fiber. We used two separate methods to remove the oligomers: extraction of the polyester with a mixture of methanol and chloroform, and heating the material to a high temperature. The experiments show that the exo-shift in the DSC curve might be due to oligomers present in the commercial fabric, which are washed out on extraction with a solvent mixture or polymerized when heated beyond the melting point of polyester. 5 Refs.

Sarma, T.S. (Ahmedabad Textile Industry's Research Assoc, Ahmedabad, India); Patel, N.B. *Text Res J* v 58 n 7 Jul 1988 p 429-430.

**Thermal Properties**

**081461 THERMAL DIFFUSIVITY OF POLY(ETHYLENE TEREPHTHALATE) BY FLASH RADIOMETRY.** Thermal Diffusivity, D, of poly(ethylene terephthalate) (PET) has been measured by flash radiometry. D increases stepwise with increasing temperature of heat treatment, and also increases with increasing time of heat treatment. The thermal diffusivity vs. temperature curve has some inflection points. The correlation between D and the fine structure of PET is discussed. (Author



abstract) 8 refs.

Tsutsumi, Naoto (Kyoto Inst of Technology, Kyoto, Jpn); Takizawa, Tomoki; Kiyotsukuri, Tsuyoshi. *Polym Commun (Guildford Engl)* v 29 n 2 Feb 1988 p 28-30.

## Thermodynamic Properties

**081462 TSC STUDIES ON SUB-T<sub>g</sub> STORAGE OF POLYETHYLENE TEREPHTHALATE.** The Thermally Stimulated Current (TSC) spectra of a series of Sub-T<sub>g</sub> annealed polyethylene terephthalate (PET) specimens have been measured. It is found that there is only one peak at 80°C above room temperature, which related to the thermo-relaxation of frozen-in dipoles. The activation energy of such dipole motion has been calculated. The relation between the maximum current and the storage time can be explained by the free volume theory and agrees with the results from the excess thermodynamic properties. Compared with differential scanning calorimeter (DSC) and tensile stress-strain method, TSC is a simpler and more sensitive method in studying Sub-T<sub>g</sub> annealed polymers. (Author abstract) 14 refs.

Li, Wei (Univ of Science & Technology of China, Hefei, China); Tong, Gang; Zhou, Yiqin; Qi, Zongneng. *Chin J Polym Sci (Engl Ed)* v 5 n 4 1987 p 285-291.

## Thick Films

**081463 LONGITUDINAL MAGNETORESISTANCE IN POLYETHYLENE TEREPHTHALATE FILM.** The longitudinal magnetoresistance ( $\Delta\rho/\rho_0$ ) of polyethylene terephthalate (PET) film of thickness 125  $\mu\text{m}$  has been measured both in glassy and rubbery state in electric field up to  $80 \times 10^5$  V/m and in magnetic field up to 0.27 kG. The sample showed negative magnetoresistance at 393 K at a low electric field. The explanation of negative magnetoresistance is made in terms of scattering by localized spins. The electric field produces an opposite effect in glassy and rubbery state of the polymer, i.e. the magnetoresistance decreases with electric field at and below 378 K, on the other hand  $\Delta\rho/\rho_0$  increases with electric field above 378 K. The energy gap at zero magnetic field is widened and shortened with electric field, in glassy and rubbery state respectively, which affects the carrier mobility and hence the magnetoresistance. (Author abstract) 11 refs.

Karimi, N.A. (BN Coll, Patna, India); Gupta, D.; Prasad, Prem Lata. *Indian J Pure Appl Phys* v 26 n 4 Apr 1988 p 297-299.

**Weathering** See PLASTICS, REINFORCED—Glass Fiber.

**POLYETHYLENE TEREPHTHALATE** See COPOLYMERS—Mechanical Properties.

**POLYETHYLENES** See Also COMPOSITE MATERIALS; DRUG PRODUCTS—Synthesis; ELECTRIC CABLES—Insulation; ELECTRIC CABLES—Manufacture; ELECTROLYTES—Materials; EPOXY RESINS—Aging; GREENHOUSES—Heat Transfer; MONOMERS—Polymerization; ORGANIC COMPOUNDS—Synthesis; PLASTICS FILMS—Adhesion; POLYMERS—Blending; POLYMERS—Grafting; POLYMERS—Solutions; STARCH—Hydrolysis; WATER PIPELINES—Plastics Applications.

**081464 EFFECTS OF PREIRRADIATION DOSE AND GRAFTING ON THE ANTITHROMBOGENICITY OF POLYETHYLENE RADIATION-GRAFT COPOLYMERIZED WITH ACRYLAMIDE.** To clarify the optimal preparative conditions for the polyethylene (PE) radiation-graft copolymerized with acrylamide (AAM) in terms of the surface antithrombogenicity, the effects of preirradiation dose in air and grafting percentage on the antithrombogenicity were evaluated by implantation of the tubes (3 mm i.d.) into canine peripheral veins. The lowest contact angle of water, 23°, was found at 28% grafting regardless of the dose. The overall antithrombogenicity increased in the order of  $1.8 < 5.6 < 3.6 < 7.2$  MR and showed a peak at about 25% grafting, where contact angle was 26°, independent of dose. The ratios of  $N_{1s}/C_{1s}$  obtained from ESCA data at a photoelectron takeoff angle of 15° corresponded well to

the trend of their antithrombogenicities. The surface roughness varying with both dose and grafting percentage was considered to enhance the peaks appeared in their ratios. (Edited author abstract) 12 refs. In Japanese.

Hayashi, Kazuko (Government Industrial Research Inst, Ikeda, Jpn); Fukumura, Hiroshi; Yamamoto, Noboru; Yamashita, Iwao. *Kobunshi Ronbunshu* v 44 n 9 Sep 1987 p 681-688.

**081465 POLYETHYLENE MODIFICATIONS.** The article discusses history, technology, structural characteristics, and basic properties of the individual types of polyethylene. Possibilities of polyethylene modifications and prospects of this polymer are also discussed. (Translated author abstract) In Czech. 144 refs.

Raab, Miroslav (Ceskoslovenska Akademie Ved, Prague, Czech). *Plasty Kauc* v 24 n 11 Nov 1987 p 334-352.

**081466 NEW STAINING TECHNIQUE OF RuO<sub>4</sub> SOLUTION IN ORGANIC SOLVENTS FOR RESOLVING THE LAMELLA STRUCTURE IN POLYMERS.** A solution of ruthenium tetroxide (RuO<sub>4</sub>) in carbon tetrachloride has been used as a staining medium for resolving the lamella structure in both polyethylene and polypropylene with the transmission electron microscope. Staining in the organic medium is more efficient than in the vapor phase of an aqueous solution of RuO<sub>4</sub> and more convenient than in the vapor of solid crystalline RuO<sub>4</sub> for both polymers. The organic solution of RuO<sub>4</sub> seems to be a universal staining medium for revealing the fine morphology in hydrophobic polymers. (Author abstract) 6 refs.

Cao, Ti (Acad Sinica, Beijing, China); Chen, Shouxi; Jin, Yongze. *Polym Commun (Guildford Engl)* v 29 n 3 Mar 1988 p 66-67.

**081467 COMPARISON OF OLIGO(ETHYLENE OXIDE)-SUBSTITUTED POLYSILOXANES WITH POLY(ETHYLENE GLYCOL) AS STATIONARY PHASES FOR CAPILLARY CHROMATOGRAPHY.** The gas-chromatographic properties of a new oligo(ethylene oxide)-substituted (glyme) polysiloxane stationary phase and an 18-crown-6-substituted (crown) polysiloxane phase were compared to Carbowax 20M and a bonded poly(ethylene glycol) (Bondable PEG). The glyme polysiloxane was found to have an operational temperature range of 20-280°C and a selectivity similar to that of Carbowax 20M. The crown polysiloxane was found to have unique selectivity, partly because of the size and shape of the crown ether cavity and the structures of solute molecules. Selected applications including the analysis of alcohols, fusel oils, and nitrogen heterocycles are demonstrated. (Author abstract) 15 refs.

Rouse, Christine A. (Brigham Young Univ, Provo, UT, USA); Finlinson, Ann C.; Tarbet, Bryon J.; Pixton, Jennifer C.; Djordjevic, Nebojsa M.; Markides, Karin E.; Bradshaw, Jerald S.; Lee, Milton L. *Anal Chem* v 60 n 9 May 1 1988 p 901-905.

**081468 COMPLEX FORMATION OF POLY(ETHYLENE GLYCOL) WITH ALKALI METAL AND AMMONIUM THIOCYANATES.** By the methods of IR, Raman, <sup>13</sup>C, <sup>23</sup>Na and <sup>7</sup>Li spectroscopy, wide-angle X-ray scattering and viscosimetry, the interaction of PEG of various molecular mass with alkali metal and ammonium thiocyanates was investigated. The effect of cation nature and size on the complex forming reaction was established. The role of the rhodanide anion in the formation of molecular complexes is discussed. (Author abstract) 15 refs.

Bekturov, Ye.A. (KazSSR Acad of Sciences, USSR); Kudaibergenov, S.Ye.; Ushanov, V.Zh.; Saltybayeva, S.S. *Polym Sci USSR* v 29 n 1 Jan 1988 p 190-195.

**081469 POLY(ETHYLENE OXIDE) AND RELATED HYDROGELS.** Poly(ethylene glycols) (PEG) and poly(ethylene oxides) (PEO) are terms for materials containing a multiplicity of connected units of the structure -CH<sub>2</sub>CH<sub>2</sub>O-. PEGs are a subset of PEOs being those which contain a hydroxyl group on each end of their chain

HO(CH<sub>2</sub>CH<sub>2</sub>O)<sub>n</sub>H. They are a fascinating group of nonionic water soluble materials which appear simple but are quite complex in their solubility behavior and interaction with solvents and other polymer molecules. Their industrial significance enhances the value of any understanding which fundamental research can reveal of their molecular structure in the solid state or in association with solvents or solutes. This chapter provides a selective and necessarily brief overview of PEO hydrogels with special reference to their application in drug delivery. 76 refs.

Graham, Neil B. (Univ of Strathclyde, Glasgow, Scotl). *Hydrogels in Med and Pharm Publ* by CRC Press Inc, Boca Raton, FL, USA, 1986 v 2, p 95-114.

**Additives** See POLYPROPYLENE—Stabilizers.

## Adhesion

**081470 HOT-MELT ADHESION AND WETTABILITY OF POLYETHYLENE/METAL IN THE VICINITY OF THE METAL MELTING POINT.** The effect of polyethylene temperature on the bonding strength and the wettability between polyethylene and a metal was investigated. The results were compared with the already reported results for polymer/polymer systems. It was clarified that the bonding strength showed a peak when bonding was performed at a temperature near the melting point of the metal and that the wettability of the metal surface by the molten polyethylene drop reached a minimum at this temperature. It was previously confirmed that the same tendency also occurred for the polymer adherend. In other words, it is proved that the interaction between polymer and polymer and between polymer and metal undergoes similar changes near the melting point of the adherend of each system, though polymer and metal have different structures. A Sn-Pb alloy and a Sn-Bi alloy were used in the experiment. 5 refs.

Imachi, Masaki (Fukui Univ, Fukui, Jpn). *J Polym Sci Part C* v 26 n 3 Mar 1988 p 129-133.

## Adsorption

**081471 ORGANIZATION OF THE LAYERS OF POLYETHYLENE OXIDE GRAFTED WITH DIFFERENT DENSITIES ON SILICA.** EPR spectroscopy of labeled grafted polyethylene oxide chains has been used to estimate the ratio of the population of free end segments in solution to that of adsorbed segments on a silica surface as a function of temperature. The configurations of the chains have been studied in the case of certain extreme coverages. Grafted molecules of mol wt 2000 with grafting ratios of 0.045, 0.057, 0.126, and 0.42 molecules/nm<sup>2</sup> were in contact with benzene. DSC thermograms are also shown. At low grafting ratios the chains lie very flat, whereas at higher grafting ratios the layer is more organized. (Author abstract) 22 refs.

Quada, H. Ben (CNRS, Paris, Fr); Hommel, H.; Legrand, A.P.; Balard, H.; Papirer, E. *J Colloid Interface Sci* v 122 n 2 Apr 1988 p 441-449.

## Aging

**081472 AGING OF POLYETHYLENE FOR CABLE INSULATION.** Electrical and spectrographic measurements were made of various characteristics of polyethylene aged using various aging methods. The results show correlation between aging time and electrical parameter degradation, and a correlation between aging time and the infrared absorption spectra. This performance implies relationships between measurable changes in infrared absorption spectra and electrical degradation due to aging. Specifically, the data obtained for both polyethylene sheet and foil samples imply the following: that (1) aging caused by multifactor stresses causes a degradation of electrical properties such as dielectric loss factor and breakdown strength; and (2) the degradation in electrical properties is associated with an increase in infrared absorption in the 1720-cm<sup>-1</sup> band. 6 refs.

Grzybowski, S. (Mississippi State Univ, MS, USA); Rakowska, A.; Thompson, J.E. *IEEE Trans Electr Insul*



v EI-22 n 6 p 729-734.

**Amorphous** See Also SOLIDS—Magnetic Field Effects.

**081473 OPTICAL ABSORPTION COEFFICIENT OF AMORPHOUS POLYETHYLENE IN THE REGION 450-725 nm.** The optical absorption coefficient of amorphous polyethylene sheets was measured in the wavelength range 450-725 nm using a monomode ring dye laser. The incident laser power was 100 mW and the single sheet thickness used was 0.039 mm. The measured value of the absorption coefficient was  $103.85 \text{ cm}^{-1}$  and is substantially constant over the wavelength range used. (Author abstract) 6 refs.

Ismail, L.Z. (Cairo Univ, Cairo, Egypt). *Polym Test* v 7 n 4 1987 p 299-303.

**Antioxidants**

**081474 STUDIUL UNOR ADITIVI DE ANTIOXIDARE UTILIZATI IN RETICULAREA POLIETILENEI CU RADIATIE IONIZANTA.** [Study of Some Antioxidants Used in Crosslinked Polyethylene Subjected to Ionizing Radiation]. The protective effects of some amine and phenolic antioxidants on oxidation of polyethylene irradiated by both low-density gamma rays and accelerated electrons were studied. Irradiated samples were aged for 168 hours at 135°C and for 240 hours at 150°C. The infrared protective effect of various antioxidants was evaluated by different methods such as infrared spectroscopy, DTA and mechanical properties and gel fraction determination. In Romanian. 14 refs.

Mihalcea, I.; Jipa, S.; Contineanu, V. *Bul Inst Politeh Bucuresti Ser Chim* v 48 1986 p 61-68.

**Antistatic Agents**

**081475 INFLUENCE OF NON-IONIC NITROGEN CONTAINING ANTISTATIC AGENTS (TENSIDES) ON THE OXIDATIVE STABILITY OF POLYETHYLENE: PART I - PHOTO-OXIDATION OF TENSIDES AND OF LIQUID HYDROCARBON IN THE PRESENCE OF TENSIDES.** The effects of alkylamide and alkylamine compounds as antistatic agents (tensides) on the photo-stability of a liquid hydrocarbon model have been studied. The inherent photo-stability of tensides has been verified. Both tensides influence the hydrocarbon photo-oxidation and each undergoes structural changes. (Author abstract) 14 refs.

Porubska, M. (Plastics Processing & Application Research Inst, Nitra, Czech); Zahradnickova, A.; Sedlar, J. *Polym Degradation Stab* v 21 n 1 1988 p 29-41.

**Applications** See Also COTTON FABRICS—Performance; ELECTRIC CABLES—Insulation; ELECTRIC CABLES—Manufacture; ELECTRIC INSULATING MATERIALS—Plastics; ENZYMES—Modification; ORE TREATMENT—Leaching; PHOSPHATE ORE TREATMENT—Flocculation; PIPE, STEEL—Lining; PROTECTIVE COATINGS—Plastics.

**081476 NEW HORIZONS IN ADVANCED ORIENTED FIBER.** Achievement of exceptional properties in films/fibers generally requires very high to ultra high molecular weights and very high degrees of orientation. A brief description of the fiber related technologies used to maximize orientation in high performance fibers, e.g., solid state extrusion, special drawing methods, gel spinning, and liquid crystal spinning are reviewed. A detailed comparison of the fiber properties resulting from these technologies is also shown. Particular emphasis is placed on describing the upgrading of polyethylene to a high performance fiber product through several of these technologies. Gel/solution spinning of ultra high molecular weight polyethylene (UHMWPE) is especially highlighted. The latest worldwide efforts to commercialize gel spun fibers are discussed as well as the applicability of the process to other thermoplastics. Applications illustrating the use of high performance fibers in various end use areas are summarized. The primary properties critical to each are also outlined. (Author abstract). 5 Refs.

Tam, T.Y. (Allied-Signal Technologie Inc, Petersburg, VA, USA); Boone, M.B.; Weedon, G.C. *Polym Eng Sci* v 28 n 13 mid-July 1988 p 871-874.

**Biodegradation**

**081477 BIODEGRADATION OF POLYETHYLENE AND THE INFLUENCE OF SURFACTANTS.** Low density polyethylene (LDPE) samples were exposed to UV irradiation for 27 days. Thereafter they were added to an abiotic and a biotic environment. By increasing the amount of polyethylene added to a soil system it was possible to compare how different amounts of irradiated PE affect the degradation rate and the evolution of  $\text{CO}_2$ . The degradation rate seems to be independent of the amount of PE added to the soil system but dependent on the biotic activity. The amount of  $\text{CO}_2$  evolved follows close to a linear relationship. The addition of a surfactant to a nutrient solution containing PE results in an increased degradation rate. In contrast to the behaviour of similar samples without surfactant, this sample sinks to the bottom of the flask instead of floating on the surface of the solution. (Author abstract). 16 Refs.

Karlsson, Sigbritt (Royal Inst of Technology, Stockholm, Sweden); Ljungquist, Olle; Albertsson, Ann-Christine. *Polym Degradation Stab* v 21 n 3 1988 p 237-250.

**Blending** See Also COMPOSITE MATERIALS—Mechanical Properties; PLASTICS FILMS; PLASTICS FILMS—Waste Utilization; POLYMERS—Blending; POLYOLEFINS—Thermal Properties; POLYSTYRENES—Blending; POLYVINYLIDENE CHLORIDES—Blending.

**081478 POLYOLEFIN BLENDS: 1. EFFECT OF EPR COMPOSITION ON STRUCTURE, MORPHOLOGY AND MECHANICAL PROPERTIES OF HDPE/EPR ALLOYS.** Differential scanning calorimetry, wide-angle X-ray diffraction, morphology, and mechanical and impact properties of a high-density polyethylene (HDPE)/ethylene-propylene copolymer (EPR) blend (80/20 weight ratio), with the EPR copolymer having various compositions, have been investigated. The results show no evidence of cocrystallization between HDPE and the EPR copolymers even at the highest  $\text{C}_2$  content. During blend mixing, the copolymers are able to dissolve HDPE low-molecular-weight chains, giving rise to a system with lower crystallinity and higher HDPE crystallite perfection. The observed behavior is very similar to that of an isotactic polypropylene/ethylene-propylene copolymer studied. (Edited author abstract) 13 refs.

Greco, R. (CNR, Naples, Italy); Mancarella, C.; Martuscelli, E.; Ragosta, G.; Yin, Jinghua. *Polymer* v 28 n 11 Oct 1987 p 1922-1928.

**081479 PRODUCTION OF BLOWN FILM FROM LDPE WITH ADDITIONS OF LLDPE.** Currently the major field of applications of LLDPE is the film sector, with film for heavy-duty sacks as well as stretch and shrink film ranging on top. The substitution of LLDPE or LDPE/LLDPE blends for LDPE leads to an improved profile of film properties and to reduced costs of film production while retaining the required quality. The study under discussion uses an LDPE type and an LLDPE type as well as blends to demonstrate the influence of the mixing ratio of these two polyethylenes on the thermal and rheological behavior of the materials, their processing properties and the property profile of blown film. 20 refs.

Schuele, H.; Wolff, R. *Kunstst Ger Plast* v 77 n 8 Aug 1987 p 6-8.

**081480 LLDPE/LDPE BLENDS FOR EXTRUSION COATING.** The first part of this paper deals with the extrusion coating processability of low linear density polyethylene (LLDPE) LDPE blends. Various LLDPEs and LDPEs mixed in different ratios were tested for processability on Exxon Chemical's pilot extrusion coating line. This testing resulted in a set of useful correlations between the blend composition and its processability. The second part covers the end-use performance of extrusion coatings with selected LLDPE/LDPE blends. Typical

coatings onto paper as well as onto aluminum were tested for some expected property improvements. The results give a positive outlook for the use of LLDPE blended with LDPE in extrusion coating. (Edited author abstract)

Leroy, Brigitte (Exxon Chemical Int Marketing Inc, Brussel, Belg). *Plast Rubber Process Appl* v 8 n 1 1987 p 37-47.

**081481 MISCIBILITY OF CHLORINATED POLYMERS WITH EPOXIDIZED NATURAL RUBBER: 3. BLENDS WITH CHLORINATED POLYETHYLENES.** The miscibility of epoxidized natural rubber (ENR) at two levels of epoxidation (25 and 50 mol%) with chlorinated polyethylene containing 25 and 48 wt% chlorine was investigated over the complete composition range. The techniques used were dynamic mechanical analysis, differential scanning calorimetry, phase-contrast microscopy and stress-strain properties. Miscibility can be traced to specific interactions involving the chlorine atom and the oxirane group, in analogy to low-molecular-weight compounds. The results are in line with previous work on the miscibility of ENR with other chlorinated polymers. All the above ENR/chlorinated polymer compatibility data were used to test a compatibility prediction scheme based on the copolymer-copolymer miscibility theory. (Author abstract) 41 refs.

Margaritis, Antonis G. (Univ of Patras, Patras, Greece); Kallitsis, John K.; Kalfoglou, Nikos K. *Polymer* v 28 n 12 Nov 1987 p 2122-2129.

**081482 MODIFIED BLEND CHAMBER SOLVES CRITICAL START-UP PROBLEMS.** In 1984, shortly after startup of E.I. du Pont de Nemours & Company's high density polyethylene (HDPE) plant in Matagorda, Tex., plant personnel discovered that the pellet blenders were not performing as expected. As a result, DuPont conducted an extensive test of the blenders' performance and collaborated with the blenders' supplier to develop a modification of the blend chamber. Unmodified blenders produced product whose ratio of fill to unload variance was 2.2, which is unacceptable blending. After modification, the ratio was 68.7, which constitutes outstanding blending.

Anon. *Powder Bulk Eng* v 1 n 12 Dec 1987 p 22-25.

**081483 CROSS-LINKING EFFECT OF POLYETHYLENE-POLYPROPYLENE BLEND FILMS PREPARED BY GELATION/CRYSTALLIZATION FROM SOLUTION.** Cross-linking of polyethylene-polypropylene blend films, prepared by gelation/crystallization from solutions, was done according to the following two methods. One was carried out under elongation of the blend gel films containing dicumyl-peroxide. The other was with electron-beam irradiation of the undrawn specimens and subsequently the specimens were elongated. The mechanical properties of the resultant specimens in undrawn and drawn states were found to become much weaker with increasing polypropylene content. (Edited author abstract) 25 refs.

Sawatari, Chie (Nara Women's Univ, Nara, Jpn); Matsuo, Masaru. *Polym J* v 19 n 12 1987 p 1365-1376.

**081484 ELONGATIONAL BEHAVIOR OF LOW DENSITY/LINEAR LOW DENSITY POLYETHYLENES.** Rheological data have been collected in isothermal elongational flow for three different types of blends, made from one low density polyethylene and three linear low density samples. In addition to the transient curves, elongation at break data are also reported. The influence of the composition and of the molecular weight of the linear low density polyethylene is discussed. (Author abstract) 22 refs.

La Mantia, F.P. (Univ of Palermo, Palermo, Italy); Valenza, A.; Acierno, D. *Polym Eng Sci* v 28 n 2 Jan 1988 p 90-95.



**081485 MICROSTRUCTURAL CHANGES IN POLYETHYLENE-POLYPROPYLENE BLENDS AS REVEALED BY MICROHARDNESS.** Microhardness is used to examine the microstructural changes of a series of polyethylene (PE)/polypropylene (PP) blends in a wide composition range. This study complements previous hardness results obtained on high-density/low-density polyethylene systems. The use of isotactic polypropylene, as a blend component allows investigation of a material in which the hardness of the amorphous phase, contrary to PE, differs from zero. The influence of treatments such as crystallization of the PP-phase in the presence of molten PE, within the blend, or annealing the PE phase, while leaving the PP component unmodified, are discussed. (Edited author abstract) 17 refs.

Salazar, J. Martinez (CSIC, Madrid, Spain); Tijero, J.M. Garcia; Calleja, F.J. Balta. *J Mater Sci* v 23 n 3 Mar 1988 p 862-866.

**081486 CRYSTALLIZATION KINETICS OF LDPE/Ny6 BLENDS.** The crystallization behaviour of low density polyethylene/nylon 6 blends has been investigated as a function of the composition. The melting points of the polymers are almost uninfluenced by the presence of the other homopolymers except for blends with a nylon content of 75-90%. Blends with 10% nylon content do not exhibit the crystallization peak during the cooling step probably because of the low concentration and high viscosity of the low density polyethylene matrix. The crystallinity degree of the polyethylene is independent of the composition, while some variations are shown by the polyamide. Finally the rate of nucleation is strongly affected by the composition, in particular for the nylon phase. (Author abstract). 11 Refs.

La Mantia, F.P. (Univ di Palermo, Palermo, Italy); Valenza, A. *J Therm Anal* v 34 n 2 Mar-Apr 1988 p 497-502.

## Blow Molding

**081487 LARGE-PARTS BLOW MOLDING TAKES ON A NEW MEASURE OF COST-EFFICIENCY.** Tighter resin tailoring (involving performance-enhancing engineering grades as well as polyethylene) teams up with problem-solving advances in equipment (involving faster cycling and greater automation) to galvanize growth in traditional markets and open up a broad variety of new opportunities. (Author abstract)

Smoluk, George R. *Mod Plast* v 64 n 10 Oct 1987 p 61-64.

## Bonding

**081488 HOT-MELT ADHESION AND WETTABILITY BETWEEN POLYETHYLENE AND OTHER POLYMERS IN THE VICINITY OF THE ADHEREND MELTING POINT.** The effect of bonding temperature on the bonding strength of polyethylene to polypropylene or other polymers was investigated. It became clear that the interfacial bonding strength reached maximum strength at a bonding temperature in the vicinity of the melting point of the adherend (i.e., the polymer having the higher melting point). The effect of temperature on the contact angle of the molten polymer having the lower melting point on the adherend surface was also investigated. The wettability of the adherend by the molten polymer drop was considerably reduced at the temperature near the melting point of the adherend. The relationship between increasing adhesiveness and decreasing wettability was found out. (Author abstract) 9 refs.

Imachi, Masaki (Fukui Univ, Fukui, Jpn). *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2485-2491.

**Chemical Analysis** See SYNTHETIC FIBERS—Mechanical Properties.

**Chemistry** See POLYMERS—Decomposition.

## Chlorination

**081489 CHLORINATED HIGH DENSITY POLYETHYLENE. I. CHAIN CHARACTERIZATION.** High density polyethylene has been chlorinated by three different methods: in suspension and in solutions of two different solvents. Carbon-13 NMR and infrared analysis show that chlorination in chlorobenzene solution leads to statistically random distribution while chlorination in suspension gives highly blocky substitution. An intermediate distribution was obtained by chlorination in tetrachloroethane solution. (Author abstract). 6 Refs.

Chang, B.H. (Case Western Reserve Univ, Cleveland, OH, USA); Zeigler, R.; Hiltner, A. *Polym Eng Sci* v 28 n 18 Sep 1988 p 1167-1172.

**081490 CHLORINATED HIGH DENSITY POLYETHYLENE. II. SOLID STATE STRUCTURE.** Chlorination of high density polyethylene results in polymers which consist of unmodified methylene units and chlorinated methylene co-units. The effect of the concentration and distribution of chlorinated units on the solid state structure has been examined by thermal, wide angle X-ray diffraction and dynamic mechanical analysis. As the substitution becomes more random, the crystallinity, crystallite size, and crystalline perfection decrease for a given chlorine content. The chlorinated units are shown to be capable of co-crystallizing, and the concentration of chlorine in the crystalline phase increases as the distribution is made more random. (Edited author abstract). 31 Refs.

Chang, B.H. (Case Western Reserve Univ, Cleveland, OH, USA); Dai, J.W.; Siegmund, A.; Hiltner, A. *Polym Eng Sci* v 28 n 18 Sep 1988 p 1173-1181.

## Chromatographic Analysis

**081491 CHROMATOGRAPHIC-MASS-SPECTROMETRIC STUDY OF THE COMPOSITION OF COMMERCIAL POLYETHYLENEPOLYAMINES.** The authors report the results of a study, with the aid of gas chromatography in conjunction with mass spectrometry (GC-MS), of the compositions of distilled polyethylenepolyamines (PEPA). Experimental results indicate that the main components of distilled polyethylenepolyamines and PEPA type B produced in the USSR are the corresponding linear oligomers. Technical polyethylenepolyamines types A, C, and D are mixtures mainly of compounds containing piperazine and dipiperazine. 9 refs.

Bobylev, V.A.; Dalin, A.R.; Utsal', V.A. *J Appl Chem USSR* v 59 n 7 pt 2 Jul 1986 p 1452-1455.

**081492 ADSORPTION-EXCLUSION BEHAVIOUR OF POLYETHYLENE GLYCOL MACROMOLECULES DURING CHROMATOGRAPHY.** The authors have investigated the chromatography of polyethylene glycols on crosslinked copolymer Solose K sorbents with varied hydrophobic-hydrophilic properties. The experimental data as a whole are described by the theoretical dependences of the distribution coefficient on M. It is proposed that the chromatographic regime be characterized by the parameter of adsorption interaction  $\tau$ , a measure of the deviation of the system from critical conditions. The critical conditions are found delineating the regimes of exclusion and adsorption chromatography. It is shown that the transition from exclusion to adsorption comes about with increase in the content in the sorbent of the hydrophobic components and for sorbents with fixed composition with fall in pH or with rise in temperature. (Edited author abstract) 18 refs.

Gorbunov, A.A. (All-Union Research Inst for Specially Pure Biopreparations, USSR); Solov'eva, L.Ya.; Pasechnik, V.A.; Luk'yanov, A.Ye. *Polym Sci USSR* v 28 n 9 1986 p 2067-2073.

**081493 HPTLC SEPARATION OF HOMOLOGOUS AND ISOMERIC POLYETHYLENEAMINES.** A simple, reliable HPTLC method has been developed for analysis of poly-

ethyleneamine)s (PEA)s. Ethylenediamine and all dimeric, trimeric, and tetrameric PEAs are separated without prior derivatization. Treatment with fluorescamine and visualization under ultraviolet light detects each PEA in quantities as low as 100 ng. (Author abstract) 34 refs.

Premecz, J.E. (Air Products & Chemicals, Allentown, PA, USA); Ford, M.E. *J Liq Chromatogr* v 10 n 16 1987 p 3575-3584.

## Coating

**081494 SLIP MIGRATION IN EXTRUSION COATINGS.** This article presents the results of timed CoF studies and examines the migration rates and surface modifications of five commonly used slip agents as a function of slip-agent type, substrate porosity, slip concentration, and coating thickness. The ability of a slip agent to reduce the coefficient of friction on a polymer surface depends on the type and concentration of amide being used, the porosity of the substrate, and the thickness of the polyethylene coating.

Glover, James H. (Texas Eastman Co, Longview, TX, USA). *Tappi J* v 71 n 3 Mar 1988 p 188-192.

**Components** See PARAFFINS—Diffusion.

## Compressibility

**081495 THERMODYNAMIC INVESTIGATION OF UNIAXIAL TENSION OF POLYETHYLENE ORIENTED IN HEPTANE.** The processes of uniaxial tension and compression of polyethylene subjected to drawing in heptane, which has a plasticizing action, are studied by deformational calorimetry. On the basis of the relations obtained for the work done, the thermal effect, and the changes in internal energy as a function of elongation, a thermodynamic analysis of the deformation process is presented. It is found that the ability of PE to store internal energy under irreversible tension is inversely related to the drawing elongation factor of the PE previously drawn in heptane. Accordingly, the transition from the stage of elastic tension to that of transition to oriented drawing is accompanied by the appearance of residual elongations and evolution of a considerable quantity of heat. The structural rearrangements thus taking place are characterized by accumulation of internal energy. (Edited author abstract) 9 refs.

Godovskii, Yu.K. (L.Ya. Karpov Physicochemical Research Inst, USSR); Semerkova, I.B. *Polym Sci USSR* v 29 n 1 Jan 1988 p 195-202.

**Concentration** See NYLON POLYMERS—Concentration.

**Conductive** See COMPOSITE MATERIALS—Injection Molding.

**Contamination** See Also ELECTRIC INSULATION—Thermodynamics.

**081496 NUCLEATION OF ELECTRICAL TREES IN POLYETHYLENE.** The inception voltage for 1-pC partial discharges has been measured for vacuum-molded needle-plane samples of low-density polyethylene. The principal parameters studied are needle radius  $R$  ( $3 < R < 100 \mu\text{m}$ ), ambient gas (air,  $\text{N}_2$ , Ar,  $\text{SF}_6$ ), and frequency of the applied ac voltage (60 Hz, and 1 kHz). Experimental results during this nucleation phase indicate that electrons, field-emitted from the needle tip, transit through microvoids in the polymer before being stopped by collision with polymer chains. During transit they interact with molecules of the particular ambient gas that permeate the polymer's 'free volume'. In spite of the extremely small size of microvoids, Townsend avalanche-like behavior is inferred. 25 refs.

Andrianjohaninarivo, J. (Ecole Polytechnique, Montreal, Que, Can); Wertheimer, M.R.; Yelon, A. *IEEE Trans Electr Insul* v EI-22 n 6 p 709-713.



## Corrosion Protection

**081497 EFFECT OF NDA AND G-2 CORROSION INHIBITORS ON THERMO- AND PHOTOOXIDATIVE DEGRADATION OF POLYETHYLENE FILM.** The protective capacity of polyethylene films containing volatile inhibitors of metal corrosion is up to 20 times higher than that of conventional films. Taking into account the known processes of degradation of PE the authors examined the effect of volatile corrosion inhibitors on the basis of low-molecular amines on the stability of its properties. Industrial inhibitors of metal corrosion NDA and G-2 were added to high-density and low-density polyethylene. The compounds act as inhibitors of metal corrosion and also processes of photo- and thermal oxidation of polyethylene and stabilize its strength properties. 6 refs.

Domantsevich, N.I. (Special Design & Technological Bur of Analytical Instrument Construction, Gomel, USSR); Zolotovskii, Ya.M.; Golubova, L.S.; Zaborskaya, L.V. *Prot Met* v 23 n 4 Jul-Aug 1987 p 528-530.

**Crack Propagation** See Also PIPE, PLASTIC—Testing.

**081498 J-INTEGRAL CORRELATION OF THE INITIATION OF SLOW CRACK GROWTH IN LINEAR POLYETHYLENE.** In previous investigations it has been shown that the regime of slow crack growth and the time to failure depend directly on the initial rate of crack-tip opening and damage. In this paper we demonstrate that a more appropriate fracture parameter to correlate various load levels, crack lengths, and specimen geometries under small-scale-yielding conditions is the J-integral rather than K. Since the initial rate of damage depends directly on the J-integral, the phenomenon of long-time failure by slow crack growth should be correlated by the J-integral for linear PE. (Author abstract). 14 Refs.

Bassani, J.L. (Univ of Pennsylvania, Philadelphia, PA, USA); Brown, N.; Lu, X. *Int J Fract* v 38 n 1 Sep 1988 p 43-59.

## Crazing

**081499 DIRECT MEASUREMENTS OF THE STRAIN ON THE BOUNDARY OF CRAZES IN POLYETHYLENE.** The strain distribution was measured on the boundary of crazes in polyethylene by a new technique where the crazes were produced under plane strain conditions. The strain distribution indicated that crazes in a linear homopolymer are weaker than those in a copolymer. The stress-strain curves of these polymers were used to obtain information about the stress field associated with the observed strain field. These results represent the first direct measurements of the strain field on the boundary of the craze without recourse to theory or arbitrary assumptions. (Author abstract) 14 refs.

Brown, Norman (Univ of Pennsylvania, Philadelphia, PA, USA); Wang, Xue-qin. *Polymer* v 29 n 3 Mar 1988 p 463-466.

**081500 MICROMECHANISMS OF DEFORMATION IN POLYETHYLENE.** It is widely accepted that crazes form in polymers on a plane which is always normal to the direction of maximum principal tensile strength. In this work both fracture surfaces and stress-whitened appearance of the shear crazes suggest that void growth occurred during their formation. A mechanism for the growth of voids in polyethylene due purely to the action of an applied shear stress is proposed. Mackerel markings on craze surfaces are discussed. It is also proposed that the polymer-substrate combinations which show good peel strength are those which can blunt the advancing peel front. 14 Refs.

Reynolds, P.T. (Univ of Bath, Bath, Engl). *J Mater Sci Lett* v 7 n 7 Jul 1988 p 759-762.

**Crosslinking** See Also ELECTRIC INSULATING MATERIALS—Measurements; PIPE, PLASTIC—Manufacture.

**081501 ESTIMATION OF INTERNAL STRESSES IN ORIENTED POLYETHYLENE FILMS CROSS-LINKED BY RADIATION.** The purpose of this work is to study heat shrinkage in irradiated oriented LDPE both under isothermal conditions and during dynamic heating. An explanation of the observed effects is put forward. A correlation between the heat-shrinkage and strength properties of products fabricated from LDPE is demonstrated. It is shown that the shrinkage stresses and tensile strength increase with increase of the absorbed radiation dose in the case of 'first irradiated, then oriented' specimens, and decrease in the case of 'first oriented, then irradiated' specimens. This may be attributed to differences in the relative contents of load-holding chains. There exists for each specimen (depending on the absorbed radiation dose and on the degree of orientation) a certain critical temperature in the region of which the shrinkage stresses reach a maximum. 5 refs.

Shirinyan, V.T.; Pukshanskii, M.D.; Khlyabich, P.P. *J Appl Chem USSR* v 60 n 1 pt 2 Jan 1987 p 157-160.

**081502 RELATIONSHIP BETWEEN DEGREE OF CROSSLINKING AND LONG-TERM STRENGTH IN POLYETHYLENE TUBES.** The specifications for manufactured crosslinked tubes are laid down in DIN 16892. According to this standard, the degree of crosslinking achieved is determined by measuring the gel fraction. There is, however, no universally valid correlation between gel fraction and long-term strength, with the consequence that different gel fractions have to be specified according to method of manufacture. This paper reports on previous studies in which long-term behavior was investigated, without specifying the degree of crosslinking. The degree of crosslinking was such that the gel fractions were fairly close to the minimum specified by DIN 16892, and in addition, when the production method allowed, about 20% above and below this level. 7 refs.

Poschet, G. *Kunstst Ger Plast* v 77 n 8 Aug 1987 p 28-31.

**081503 FLOW BEHAVIOUR OF POLYBLEND: CROSSLINKABLE POLYETHYLENE AND CROSSLINKED BUTYL RUBBER.** The rheological behavior of polymer blends consisting of crosslinkable polyethylene (XLPE) and crosslinked butyl rubber (XL-20) were studied with the help of a capillary rheometer at four shear rates and three temperatures. The viscosity of the blends increased with increasing elastomer content. The rubber microgel was broken down at high shear rate with consequent viscosity decrease which was predominant at higher XL-20 content. The flow activation energy showed inversion above 50% XLPE and decreased with the shear rate. Recoverable deformation and the Weissenberg number related linearly to the swelling ratio. The stored elastic energy and relaxation time increased with the increase in XL-20 content. Phase inversion seems to occur at the 50:50 ratio. (Author abstract) 24 refs.

Das, C.K. (Indian Inst of Technology, Kharagpur, India). *Plast Rubber Process Appl* v 8 n 1 1987 p 59-63.

**081504 POLYETHYLENE. KINETICS OF CROSSLINK FORMATION AS OBSERVED IN A SEMILO-CAL SPACE-SCALE USING NMR.** This work deals with the kinetics of gelation of high molecular weight polyethylene as it can be observed 'in situ' from the magnetic relaxation of protons attached to polymer chains. The gelation process starts from strongly entangled chains in a melt where they determine a temporary network structure. One of the features of this study is the observation of the gelation process from its effects on this network structure; in other words, crosslinks are not directly perceived from NMR because their concentration is too low. Covalent bridges induce topological constraints exerted on chain segments in addition to those created by entanglements; the kinetics of crosslink formation is detected from the progressive variation of statistical properties of chain segments defining the initial network structure. These serve as 'amplifiers' of properties at a point. 9 refs.

Cohen-Addad, J.P. (CNRS, St. Martin D'Heres, Fr); Schmit, C. *J Polym Sci Part C* v 25 n 12 Dec 1987 p 487-493.

**081505 PEROXIDE-CATALYZED GRAFTING OF MALEIC ANHYDRIDE ONTO MOLTEN POLYETHYLENE IN THE PRESENCE OF POLAR ORGANIC COMPOUNDS.** The crosslinking of LDPE resulting from reaction with dicumyl peroxide at 180°C is increased in the presence of maleic anhydride (MAH). The presence of electron-donating nitrogen-containing compounds (amides, lactams, disubstituted aromatic amines, and amine oxides), phosphorus-containing compounds (phosphites, phosphates, phosphonates, phosphoramides, and phosphine oxides) and sulfur-containing compounds (sulfoxides, aryl disulfides, and thiazyl disulfides) which inhibit the homopolymerization of MAH but not that of methyl methacrylate, prevents crosslinking and yields soluble PE containing MAH units. (Edited author abstract) 8 refs.

Gaylord, Norman G. (Gaylord Research Inst, New Providence, NJ, USA); Mehta, Rajendra. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 1189-1198.

**081506 TEMPERATURE-DEPENDENCE OF MECHANICAL AND MORPHOLOGICAL PROPERTIES OF ULTRA-HIGH MOLECULAR WEIGHT POLYETHYLENE CROSS-LINKED BY ELECTRON BEAM IRRADIATION.** Cross-linking of ultra-high molecular weight polyethylene was performed with electron-beam irradiation in the range of radiation dose from 12 to 96 Mrad under nitrogen. Dry gel films and melt films were used as specimens. Two kinds of cross-linked specimens could be kept at 200°C for a prolonged time in an undeformed state and this tendency was independent of radiation dose. The elongation of the gel films hampered the heat-resistant effect and the drawn specimens were broken at temperatures lower than 175°C. The elongation of the melt films could not be realized, because of a marked fixation of chains in the fiber network, even at a dose of 12 Mrad. (Author abstract) 26 refs.

Sawatari, C. (Shizuoka Univ, Shizuoka, Jpn); Nishikido, H.; Matsuo, M. *Colloid Polym Sci* v 266 n 4 Apr 1988 p 316-323.

**081507 UNTERSUCHUNGEN ZUR ELEKTRO-STRALH-VERNETZUNG VON PE MIT DER FT-IR-SPEKTROSKOPIE.** [Investigation of PE Crosslinking by Electron Beams Using Fourier Transform Infrared Spectroscopy]. This investigation concerned the possibility of determining the gel content of the polymers crosslinked by electron beams by means of Fourier transform infrared spectroscopy. The investigations were carried out on extruded low density polyethylene (LDPE) foils crosslinked by electron beams of different doses in air. Determination of the gel content was made by means of xylol. It was found that by using special abrasive paper linings it was possible to obtain good polymer preparation for quantitative IR spectroscopy. The absorption rate is correlative with the gel content in LDPE. 7 Refs. In German.

Beyer, G. (Kabelwerk Eupen AG, West Ger). *Gummi Fasern Kunstst* v 41 n 9 Sep 1988 4p.

## Crystal Lattices

**081508 TEMPERATURE DEPENDENCE OF THE CRYSTAL LATTICE MODULUS AND THE YOUNG'S MODULUS OF POLYETHYLENE.** The temperature dependence of the crystal lattice modulus of polyethylene was measured by X-ray diffraction with use of ultradrawn films produced by gelation/crystallization from dilute solution. Measurements were carried out in the temperature range 20-150°C for specimens with draw ratios > 300. The measured crystal lattice modulus was in the range 211-222 GPa, and the values were independent of temperature. In contrast, the storage modulus of an ultradrawn film with a draw ratio of 400, 216 GPa at 20°C, decreased to 130 GPa at 140°C. This discrepancy was related to an increase in the amorphous content and a decrease of the amorphous modulus with increasing



temperature. (Author abstract) 27 refs.

Matsuo, Masaru (Nara Women's Univ, Nara, Jpn); Sawatari, Chie. *Macromolecules* v 21 n 6 Jun 1988 p 1653-1658.

**081509 MATHEMATICAL TREATMENT OF THE TEMPERATURE DEPENDENCE OF THE CRYSTAL LATTICE MODULUS AND THE YOUNG'S MODULUS OF POLYETHYLENE.** A mathematical representation based on linear elastic theory is proposed for investigating the temperature dependence of the crystal lattice modulus in the chain direction and the Young's modulus. Mathematical formulation was carried out for a composite model of crystalline and amorphous phases. This description indicates that the crystal lattice modulus and the linear thermal coefficient as measured by X-ray diffraction are different from the intrinsic crystal lattice modulus and the coefficient. The calculated results are in good agreement with the experimental results for an ultradrawn polyethylene film with a draw ratio of 400, showing that the crystal lattice modulus is independent of temperature while the Young's modulus decreases with increasing temperatures. (Author abstract) 16 refs.

Matsuo, Masaru (Nara Women's Univ, Nara, Jpn); Sawatari, Chie. *Macromolecules* v 21 n 6 Jun 1988 p 1658-1664.

## Crystalline

**081510 SMALL DEFECTS IN CRYSTALLINE POLYETHYLENE.** A family of five crystallographic defects of three classes (two dislocations, two dispirations and one disclination) which primarily involve only one polymer chain is described for polyethylene. The extra energy associated with each defect in a perfect polyethylene crystal was computed. The crystal model used consisted of a central chain containing the defect with 18 zig-zag chains in two shells around the central chain. The zig-zag chains each had 60 carbon atoms. The conformation of each defect, placed near the center of the central chain, was adjusted to minimize the sum of the interatomic interactions. A closely related procedure was used to calculate the energy per chain at boundaries where each chain contains an identical 'partial' dislocation or disclination. The characterization of these well defined defects and partial defects greatly simplifies the establishment of connections between atomic and macroscopic scale phenomena in crystalline polyethylene. (Author abstract) 19 refs.

Reneker, Darrell H. (NBS, Gaithersburg, MD, USA); Mazur, Jacob. *Polymer* v 29 n 1 Jan 1988 p 3-13.

**Crystallization** See Also POLYMERS—Crystallization; POLYMERS—Diffusion.

**081511 HIGH PRESSURE CRYSTALLIZATION OF ULTRA-HIGH MOLECULAR WEIGHT POLYETHYLENE.** The morphology of pressure-crystallized ultra-high molecular weight ( $2.5 \times 10^6$ ) polyethylene samples was studied by scanning electron microscopy. The DSC and small angle X-ray analyses were also performed. High pressure crystallization (HPC) (at a cooling rate of  $2\text{ K min}^{-1}$  from the melt at 590 MPa), of an as-polymerized powder sample gives a fibrous band morphology. Though the lamellar thickness of powder and bulk samples increases by HPC, that of the pressure-crystallized bulk is not so large, and its distribution is wide. (Edited author abstract) 19 refs.

Yasuniwa, Munehisa (Fukuoka Univ, Fukuoka, Jpn); Nakafuku, Chitoshi. *Polym J* v 19 n 7 1987 p 805-813.

**081512 DENSITY, ENERGY AND ENTROPY OF DEFECTS IN THE CRYSTALLINE REGIONS OF CROSSLINKED POLYETHYLENE.** By comparison of small angle X-ray scattering, thermal analytical and electron microscopic investigations, it is shown that crosslinked polyethylene crystallizes according to the usual folded chain scheme up to defect densities of 0.9% and crystallizes micellarly for higher ones. The energy needed for the insertion of a crosslink into the lattice was

estimated to be 3.3 eV, indicating a strong deterioration of the crystal. Similarly, the calculated entropy change due to crosslinks in the crystalline regions, 7 meV/K per crosslink, is rather high. This value can be explained by assuming that crosslinks are incorporated into the crystals in a variety of conformational and configurational different ways. (Author abstract) 23 refs.

Jaeger, E. (Deutsches Kunststoff-Inst, Darmstadt, West Ger); Mueller, J.; Jungnickel, B.J. *Prog Colloid Polym Sci* v 71 1985 p 145-153.

**081513 ON THE FRACTIONATION OF HOMO-POLYMERS DURING CRYSTALLIZATION FROM THE PURE MELT.** The question as to whether fractionation occurs during the crystallization of homopolymers from the pure melt has been addressed by studying linear polyethylene mixtures. Two methods were used. In one procedure, mixtures of well-defined fractions were crystallized under controlled conditions and the subsequent fusion process was analyzed. In the other procedure, a selective extraction was carried out on an isothermally crystallized polydisperse whole polymer, and the residue was analyzed by gel permeation chromatography. Both methods lead to the same conclusion, namely that during isothermal crystallization only the very low molecular weight species crystallize separately. An extreme upper limit to fractionation corresponds to  $M = 7000$ . More likely, fractionation in linear polyethylene during bulk crystallization is restricted to molecular weights of 5000 or less. (Author abstract) 21 refs.

Glaser, Raymond H. (Florida State Univ, Tallahassee, FL, USA); Mandelkern, Leo. *J Polym Sci Part B* v 26 n 2 Feb 1988 p 221-234.

**081514 MECHANICAL PROPERTIES OF ORIENTED CRYSTALLIZATION POLYETHYLENE.** The method of oriented crystallization has been used in recent years on the basis of flexible-chain polymers, especially polyethylene, to develop materials with high mechanical properties. To evaluate possible areas of use of these materials - such as reinforcement elements - a detailed study of the dependence of the mechanical properties of oriented polyethylene on temperature and time is carried out and measured. 7 refs.

Boiko, Yu.M. ('Norplast' Scientific-Industrial Assoc, Moscow, USSR); Gol'dman, A.Ya.; Myasnikov, G.D.; Kuznetsova, I.G.; Tarasov, A.M.; Kovriga, V.V.; Artem'ev, V.A. *Mech Compos Mater* v 23 n 2 Mar-Apr 1987 p 134-140.

**081515 MELT TRANSCRYSTALLIZATION OF POLYETHYLENE ON HIGH MODULUS POLYETHYLENE FIBERS.** A polyethylene composite was prepared and tested. It consisted of a high-density polyethylene (HDPE) matrix and uniaxial gel-spun high-modulus PE fiber. Aided by the similarity between matrix and fiber, transcrystallization of HDPE melt on the PE fiber surface was generated. Nucleating agents were not employed. The transcrystalline growth of HDPE on the PE fiber surface was found to consist of an inner and an outer zone. The inner zone, 2-3  $\mu\text{m}$  thick, is composed of HDPE crystals nucleated on the PE fiber surface. Photomicrographs showed a well-defined region on row-nucleated HDPE on the surface of PE fiber. This means the fibrils of HDPE were found to grow out from the PE fiber axis and HDPE crystallites are oriented in planes perpendicular to the PE fiber axis. The fiber in the composite induced the transcrystalline growth of HDPE on the PE fiber surface at higher temperature than on cooling the melt. (Edited author abstract) 19 refs.

He, Tianbai (Univ of Massachusetts, Amherst, MA, USA); Porter, Roger S. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1945-1953.

**Curing** See Also ELASTOMERS—Crosslinking.

**081516 SIMULATIONS ON RADIATION-CURED POLYETHYLENE.** Simulations of the simultaneous crosslinking and chain scission reactions that are induced in bulk amorphous polyethylene by irradiation have been

implemented with a computer. A detailed study of the various defect structures in the network is reported, to show that dangling ends have the highest population among these defects, especially at higher crosslink densities. The calculated sol fractions compare very favorably with previously published experimental studies. We find that there is about 1 chain scission for every 9 crosslinked units, i.e., one scission per 4.5 crosslinks. This is fewer scissions than had previously been deduced by application of the Charlesby-Pinner method. (Author abstract) 26 refs.

Galiatsatos, V. (Univ of Washington, Seattle, WA, USA); Eichinger, B.E. *J Polym Sci Part B* v 26 n 3 Mar 1988 p 595-602.

## Decomposition

**081517 LITERATURE REVIEW OF THE CHEMICAL NATURE AND TOXICITY OF THE DECOMPOSITION PRODUCTS OF POLYETHYLENES.** The literature on polyethylenes has been reviewed with an emphasis on the identification of gaseous products generated under various thermal decomposition conditions and the toxicity of those products. This review is limited to publications in English through 1984. The analytical chemical studies of the thermal decomposition products generated under vacuum, inert and oxidative experimental conditions are described. In oxidative atmospheres, which most closely simulate real fire conditions, carbon monoxide (CO) was found to be the predominant toxicant. Acrolein was another toxicant often noted in these reviewed studies. Results from seven different test procedures were considered in assessing the acute inhalation toxicity of combustion products from various polyethylene formulations. (Edited author abstract) 59 refs.

Paabo, Maya (NBS, Gaithersburg, MD, USA); Levin, Barbara C. *Fire Mater* v 11 n 2 Jun 1987 p 55-70.

## Deformation

**081518 INVESTIGATION OF THE DEFORMATION AND RELAXATION OF VARIOUS POLYETHYLENES BY X-RAY DIFFRACTION.** Three different PE samples (linear, branched, very high molecular weight) are investigated for different draw ratios (uniaxial deformation) by wide and small angle X-ray diffraction. Crystallite sizes and lattice distortions show qualitatively the same behaviour, but quantitative differences occur. There is a remarkable difference in the superstructure between 'normal' and very high molecular weight samples. The relaxation at different temperatures is investigated for linear PE. The degree of rebuilding of the original structure depends on the draw ratio and relaxation temperature (by fixed relaxation time). The results are discussed within the framework of dislocation concepts. (Author abstract) 25 refs.

Reck, E.-M. (Univ Ulm, Ulm, West Ger); Schenk, H.; Wilke, W. *Prog Colloid Polym Sci* v 71 1985 p 154-163.

**081519 ORIENTATION IN LOW-DENSITY POLYETHYLENE DUE TO AN ELEMENTARY SLIP PROCESS.** A simple, physical model has been developed to describe orientation in thermoplastic polymers, involving the boundary slip and rotation of rod-like structural elements. Orientation parameters have been calculated, and expressions for the birefringence and elastic mechanical anisotropy deduced. Results on cold-drawn, low-density polyethylene agree well with this model. (Author abstract) 12 refs.

Owen, A.J. (Univ Regensburg, West Ger). *Colloid Polym Sci* v 266 n 4 Apr 1988 p 311-315.

## Degradation

**081520 PHOTO-OXIDATIVE DEGRADATION OF POLYETHYLENE: EFFECT OF POLYMER CHARACTERISTICS ON CHEMICAL CHANGES AND MECHANICAL PROPERTIES. PART I - QUENCHED POLYETHYLENE.** Photo-oxidative degradation of quenched samples of linear low density (LLD),



medium density (MD) and two kinds of high density (HD) polyethylene (PE) films was studied using a medium-pressure mercury lamp. Greater amounts of crosslinking and build up of oxidation products were noticed in LDPE than the other samples. The primary products of interaction between dienes and oxygen are considered to participate in the initiation of the photo-oxidation reactions. Using the FT-IR difference spectrum technique, the amount of branch concentration in the photo-irradiation PE samples was determined. Oxidation damage at the boundary region between crystalline and amorphous phases is considered to be important in determining the embrittlement time. (Author abstract) 21 refs.

Geetha, R. (Nagoya Univ, Nagoya, Jpn); Torikai, A.; Nagaya, S.; Fueki, K. *Polym Degradation Stab* v 19 n 3 1987 p 279-292.

**081521 DEGRADATION OF HDPE AND LDPE IN CLOSED MIXING CHAMBER: A COMPARISON. I. CHANGES IN THE CHEMICAL STRUCTURE.** Degradation of linear high density polyethylene (HDPE) and butyl branched linear low density polyethylene (LLDPE) was studied during molding in a closed mixing chamber. At the beginning of the process the rate of oxidative degradation was found faster for LLDPE than for HDPE but later this relation reversed. The degradation mechanism was the same for both types of polyethylenes but the rate of elementary steps depended on the chemical structure of the polymer chain. The differences were attributed to the structural differences in the original materials and the products formed during degradation. (Author abstract) 30 refs.

Foldes, E. (Hungarian Acad of Sciences, Budapest, Hung); Iring, M.; Tudos, F. *Polym Bull (Berlin)* v 18 n 6 Dec 1987 p 525-532.

**081522 PHOTSENSITIZING ACTION OF COMPLEX COMPOUNDS OF TRANSITION-METAL SALTS WITH AROMATIC NITROGEN CONTAINING VINYL MONOMERS.** Production of photosensitizers for degradation of high-pressure polyethylene (HPPE) and its technological wastes is of great importance for solving the problem of development of polymers having controllable life. In order to extend the range of photosensitizing additives for degradation of HPPE, we have studied aromatic nitrogen-containing vinyl monomers and their complexes with iron and cobalt chlorides. It was found that an iron-containing complex compound of the quinoline series has higher photosensitizing activity than the corresponding cobalt complex. 8 refs.

Garashchenko, Z.M. (Acad of Sciences of the USSR, USSR); Borodulina, M.Z.; Skvortsova, G.G.; Domnina, E.S.; Andriyankov, M.A.; Loginova, V.P.; Zelenkova, T.N. *J Appl Chem USSR* v 60 n 3 pt 2 Mar 1987 p 607-609.

**081523 THREE STAGES IN DEGRADATION OF POLYMERS - POLYETHYLENE AS A MODEL SUBSTANCE.** Data relating to the degradative conversion of  $^{14}\text{C}$  present in low density polyethylene (LDPE) film to respiratory  $^{14}\text{CO}_2$  during a 10-year aerated cultivation with soil are presented. The degradation was performed with two sets of LDPE samples, one without additive (PE) and the other containing UV sensitizer (NDPE). Samples were exposed to UV irradiation for 0, 7, 26, and 42 days. The degradation is characterized by three stages: (I) a constant degradation rate, (II) a parabolic decline in the rate of degradation, and (III) a subsequent final increase in the rate of degradation. (Edited author abstract) 19 refs.

Albertsson, Ann-Christine (Royal Inst of Technology, Stockholm, Swed); Karlsson, Sigbritt. *J Appl Polym Sci* v 35 n 5 Apr 1988 p 1289-1302.

**081524 TERMOOKSIDACIJSKA RAZGRADNJA POLIETILENA NISKE GUSTOCE.** [Thermooxidative Decomposition of Low-Density Polyethylene]. Several procedures for the preparation of polyethylene waxes of controlled molecular mass by thermooxidation are described. The degradation was performed in melt, in a

torsional rheometer at  $150^\circ\text{C}$ , in dichlorobenzene solution at  $130\text{--}150^\circ\text{C}$ , in a mixture of low molecular mass which appears as a by-product of free radical high-pressure polymerization of ethylene, and in aqueous dispersion under the prepressure of 1 MPa. Oxidation was performed with air or in a stream of oxygen. Due to the limited contact with oxygen, the thermooxidation of LDPE in melt is accompanied by crosslinking. Oxidation in solution enables a good contact between LDPE and oxygen, so that oxidative degradation takes place without crosslinking. However, at a high level of oxidation, the recombination of reactive low molecular mass fragments occurs, yielding products of a high molecular mass. (Edited author abstract). In Serbo-Croatian.

Jerman, Marija Biserka (INA-Razvoj i Istrazivanje, Zagreb, Yugosl); Fles, Dragutin. *Polimeri (Zagreb)* v 8 n 3 Mar 1988 p 55-57.

**081525 OXIDATIVE DEGRADATION OF POLYETHYLENE IN THE PRESENCE OF PHASE TRANSFER CATALYST: PART 1 - INFRARED STUDIES.** Oxidative degradation of polyethylene has been carried out with phase transferred permanganate as oxidant. The degradation products have been characterized by infrared spectroscopy in an attempt to elucidate the probable degradation mechanism. The oxidized polyethylenes are found to possess carbonyl, ether, hydroperoxy and several types of olefinic groups. Using FT-IR spectra, the quantitative determination of the different functional groups has also been carried out. While the initiation and termination steps are common to all PTC oxidations of low density polyethylene, the propagation in the tetrabutyl ammonium bromide (TBAB)-catalysed process occurs through intramolecular hydrogen abstraction and chain scission. (Author abstract). 19 Refs.

Konar, J. (Indian Inst of Technology, Kharagpur, India); Ghosh, R. *Polym Degradation Stab* v 21 n 3 1988 p 263-275.

**081526 DEGRADATION OF DIELECTRIC PROPERTIES OF POLYETHYLENE BY COMBINED  $\gamma$ -IRRADIATION AND THERMAL STRESSES.** Degradation of dielectric properties polyethylene under the combined environment of  $\gamma$ -irradiation and thermal aging was studied. To exclude the effect of additive agents and to minimize the effect of the process limited by diffusion of oxygen on the degradation, a 25- $\mu\text{m}$ -thick low-density polyethylene film, free from additives, was used. Dielectric relaxation was used as a tool to study the oxidative degradation. It was found that the primary dispersion of polyethylene shifts to higher temperatures with oxidation. There is some difference in temperature of primary dispersion according to the order of application of thermal aging and  $\gamma$ -irradiation. The reason for it is explained in terms of chain scission, cross linking and dipole-dipole interaction. 15 refs.

Nakamura, S. (Mie Univ, Tsu, Jpn); Murabayashi, F.; Iida, K.; Sawa, G.; Ieda, M. *IEEE Trans Electr Insul* v EI-22 n 6 p 715-720.

## Dielectric Properties

**081527 TEMPERATURE EFFECTS IN CRYSTALLINE POLYETHYLENES DIELECTRIC RELAXATION.** Recently we proposed a soliton model for the crystalline  $\alpha$ -relaxation in polyethylene. The continuum limit theory accounted reasonably well for the observed dielectric data at low temperatures, but failed to explain the change in the shape of the Cole-Cole plots (increase in the Cole-Cole width parameter  $\beta$ ) with temperature. We extend the theory by considering the effects of both conformational defects and soliton interactions. In the defect barrier model the conformational defects are modelled as infinite reflecting or absorbing barriers to soliton motion. This results in a  $\beta = 0.48$  Williams-Watts dielectric decay function not significantly different from the defect-free result, which predicts no change in the shape of the Cole-Cole plot with temperature. (Edited author abstract) 29 refs.

Wahlstrand, Karna J. (NBS, Gaithersburg, MD, USA). *Polymer* v 29 n 2 Feb 1988 p 263-267.

**081528 INFLUENCE DES METHODES DE MISE EN OEUVRE DU POLYETHYLENE (PEBD) SUR SON COMPORTEMENT SOUS HAUTE TENSION CONTINUE.** [Influence of the Manufacturing Process of LDPE on its Behaviour under Electric Stress]. In order to improve the insulating properties of low density polyethylene (LDPE) under electric stress, a systematic study of LDPE based materials has been conducted. This investigation has been made by measuring, using the pressure wave propagation method, the evolution of charge or dipole distributions in samples submitted to a high voltage gradient. Two "pure" LDPE resins of different origins were used to prepare planar geometry samples, identical in any other respects. The behaviour of these samples is compared, for various applied fields, temperatures and chemical formulation of the electrodes. From these results, new informations relative to charge storage and transport in these materials are obtained. It is shown that, by studying directly the influence of the chemical composition of materials on their electrical properties, it will be possible to define highly performing insulations. (Author abstract). 8 Refs. In French.

Chapeau, F. (Ecole Supérieure de Physique et Chimie Industrielles, Fr); Alquie, C.; Lewiner, J.; Auclair, H.; Jocteur, R. *RGE Rev Gen Electr* n 3 Mar 1988 p 44-49.

**081529 ETUDE COMPARATIVE DU COMPORTEMENT SOUS TENSION CONTINUE, DE DEUX TYPES DE POLYETHYLENE PAR LA METHODE DE L'ONDE DE PRESSION.** [Comparative Study of the Behavior of Two Polyethylene Types under DC Voltage, by the Pressure Wave Method]. In order to develop extruded DC high voltage cables, it is necessary to improve the understanding of charge storage and transport phenomena occurring in insulants such as polymer materials, when they are submitted to high DC voltages. A comparison of the behaviour of two types of polyethylene, LDPE and XLPE, is presented. This study is based on the measurement, using the pressure wave propagation method, of the evolution of charge distributions in samples under electric stress. Important characteristics of these two materials are obtained, such as the internal field distribution, its distortion as compared to the applied field, and the localization of the charges responsible of these effects. For the materials under test, some regions of the samples are submitted to a field exceeding the applied one by 80%. Nevertheless the localization of the space charges observed in some situations indicates that there is no particular risk during a reversal of the polarity of the applied voltage. (Author abstract). 5 Refs. In French.

Chapeau, F. (Ecole Supérieure de Physique et Chimie Industrielles, Fr); Ditchi, T.; Alquie, C.; Lewiner, J.; Perret, J.; Dalle, B. *RGE Rev Gen Electr* n 3 Mar 1988 p 50-55.

## Doping

**081530 CONNECTIVITY OF CONDUCTING CRYSTALLINE NETWORKS IN RETICULATE DOPED POLYMERS.** Measurements of temperature dependences of conductivity for morphologically different samples of reticulate doped polymers containing dendrite-like microcrystals of a conducting charge-transfer (CT) complex demonstrate that there is no difference in the mechanism of charge carrier transport along dendrite branches, perpendicular to them or across interdendrite boundaries. Comparison of the conductivity behavior, as measured along polymer films and perpendicular to the surfaces ('sandwich' samples), suggests that the same mechanism of conductivity operates in both directions. It is also demonstrated that lowering of the CT complex content, even to 0.003 vol. fraction, leads to some decrease of the conductivity but does not change its temperature dependence. The results demonstrate the high connectivity of the crystalline CT complex network and support the hypothesis that continuity of this network is due to submicroscopic dendritic structures scaling from microns,



probably down to tens of angstroms. (Author abstract) 15 refs.

Ulanis, J. (Technical Univ of Lodz, Lodz, Pol); Tracz, A.; Debrue, G.; Deltour, R. *J Phys D* v 20 n 11 Nov 1987 p 1512-1518.

#### Drawing and Stamping See Also POLYMERS—Deformation.

**081531 TEMPERATURE RISE ON NECK FORMATION OF POLYMERS: POLYPROPYLENE AND POLYETHYLENE.** Polymeric materials drawn in different surrounding media show different drawing stresses. Based on these differences in drawing stress, drawn under water as against drawing in air, a simple approximate method is proposed for the measurement of temperature rise of polypropylene and polyethylene during drawing. (Author abstract) 16 refs.

Liu, Tuomin (Pennsylvania State Univ, University Park, PA, USA); Harrison, I.R. *Polymer* v 28 n 11 Oct 1987 p 1860-1862.

#### Elasticity

**081532 ELASTIC MODULUS OF POLY(ETHYLENE TEREPHTHALATE-CO-P-OXYBENZOATE).** The article concerns a polyethylene terephthalate modified by p-hydroxybenzoic acid (PET/PHB 60). The authors determined the mechanical properties of fibres of PET/PHB 60 spun at 260°C. The high modulus found is related to the high level of orientation obtained from the large values of the order parameters calculated from X-ray diffraction patterns. Higher values of orientation and elastic modulus can be obtained if one prevents the loss of orientation reached during processing. This can be attained by positioning the takeup machine as close as possible to the spinneret. 14 Refs.

Carfagna, C. (Piazzale Tecchio, Naples, Italy); Amendola, E.; Nobile, M.R.; Nicolais, L. *J Mater Sci Lett* v 7 n 6 Jun 1988 p 563-566.

#### Electric Breakdown

**081533 SIMULTANEOUS MEASUREMENT OF MICROSCOPIC IMAGE AND DISCHARGE PULSES AT THE MOMENT OF ELECTRICAL TREE INITIATION.** This paper reports some experimental results concerning the tree initiation from a semiconductive needle electrode in polyethylene under a 50 Hz AC voltage. With a newly developed measuring system, the correspondence between partial discharge pulses and tree initiation and growth up to 10-20 µm in length was clarified for the first time. Tree observation and pulse measurement were made simultaneously. At the moment of tree initiation, positive pulses (current from the needle towards the grounding electrode) of 0.05-0.1 pC were first observed. A very small shade of the initial tree was observed when continuous positive pulses appeared; it grew rapidly to about 10 µm in length, along with the positive and negative pulses. After the tree branched, the growth rate dropped for a while. In many cases, the negative pulses disappeared during this stage. (Author abstract) 4 refs.

Hozumi, Naohiro (Central Research Inst of Electric Power Industry, Yokosuka, Jpn); Okamoto, Tatsuki; Fukagawa, Hiromasa. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 572-576.

**081534 VERBESSERUNG DER ELEKTRISCHEN DAUERFESTIGKEIT VON POLYETHYLEN.** [Improvement of the Electric Breakdown of Polyethylenes]. Power cables that use polyethylenes as insulators are discussed, along with techniques to improve the electric breakdown characteristics. Such improvement can be realized by incorporating solid, liquid or gas additives. These three methods are compared. Experimental results are included. 25 refs. In German.

Sachs, Gerhard (King Mongkut's Inst, Bangkok, Thai). *ETZ Elektrotech Elektron Fuehrungskraefte* v 109 n 4 Feb 1988 p 142-144, 146-147.

#### Electric Conductivity

**081535 SIMULTANEOUS THERMALLY STIMULATED LUMINESCENCE AND CONDUCTIVITY IN LOW-DENSITY POLYETHYLENE.** Thermally stimulated luminescence (TSL) and conductivity (TSC) in low-density polyethylene samples were measured simultaneously, while the sample was being heated to room temperature after x-ray irradiation at -190°C. The TSC curves of samples from which absorbed air had been removed showed five peaks, labelled C<sub>1</sub>-C<sub>5</sub> in order of increasing temperature, while the TSL glow curves showed only three peaks (L<sub>1</sub>-L<sub>3</sub>). The effects of these peaks of (i) immersing the samples in fuming nitric acid, (ii) annealing them in vacuum, and (iii) exposing them to an oxygen/ozone mixture, were investigated. When the samples contain absorber air, a hitherto unreported peak is observed in the TSC curve, corresponding to the TSL 'gas' peak. (Edited author abstract) 23 refs.

Markiewicz, A. (Monash Univ, Clayton, Aust); Fleming, R.J. *J Phys D* v 21 n 2 Feb 14 1988 p 349-355.

#### Electric Field Effects See PLASTICS FILMS—Electric Breakdown.

#### Electric Properties See Also ELECTROLYTES—Materials.

**081536 ELECTRICAL PROPERTIES OF MAGNETITE-LOADED POLYETHYLENE COMPOSITES.** Magnetite-polyethylene composites containing various concentrations of magnetite have been prepared and their electrical properties have been investigated. The electrical resistivities of the specimens were studied as function of filler concentration and temperature. The current density-electric field characteristic and the current variation with time were measured. The thermionic and field emission models provide good explanations for the electrical conduction in the specimens; and space-charge-limited conduction is discussed based on the results. (Author abstract) 23 refs.

Sung Han Lee (Yonsei Univ, Seoul, South Korea); Heo, Gweon; Keu Hong Kim; Jae Shi Choi. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2537-2545.

**081537 THERMALLY STIMULATED CURRENT MEASUREMENT IN HIGHLY ELONGATED POLYETHYLENE FILM.** The trap depth and density in highly elongated polyethylene have been studied by thermally stimulated current (TSC) measurements. Three discrete traps with depths of 0.13, 0.3 and 0.5 eV have been evaluated using the initial rise method in the temperature region from 77 to 330 K; these change slightly with the elongation ratio. A trap density of the order of 10<sup>13</sup> approx. 10<sup>14</sup>/cm<sup>3</sup> has been calculated from the area of the TSC peaks. The trap density increases upon increasing the elongation ratio and again decreases at a higher elongation ratio; this is consistent with the elongation dependence of the electric conductivity and carrier mobility. The results are discussed in terms of the molecular orientation examined by X-ray diffraction measurements. (Edited author abstract) 10 refs.

Park, Dae Hee (Osaka Univ, Suita, Jpn); Matsuo, Masaru; Yoshino, Katsumi. *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 196-199.

#### Electrochemistry See ELECTRIC CABLES—Insulation.

#### Extrusion See Also PLASTICS—Blow Molding; PLASTICS MACHINERY—Extruders.

**081538 INFLUENCE OF WALL SLIP ON EXTRUDATE SWELL: A BOUNDARY ELEMENT INVESTIGATION.** This paper reports a numerical study of the extrudate swell by a transient Boundary Element Method (BEM). Furthermore the fluid, which is modeled by a differential constitutive equation, is allowed to slip at the wall, where the slip velocity is a prescribed function of the wall shear stress. This function is a curve fit of the extensive data of A.V. Ramamurthy on linear low density polyethylene which incorporates two parameters: a critical

wall shear stress above which slip occurs, and another parameter which governs the shape of the slip velocity versus shear stress curve. The results show that wall slip reduces both the amount of extrudate swell and the critical Weissenberg number above which our numerical scheme no longer converges. (Author abstract) 15 refs.

Phan-Thien, N. (Univ of Sydney, Aust). *J Non Newtonian Fluid Mech* v 26 n 3 Jan 1988 p 327-340.

**081539 INFLUENCE OF SCREW CLEARANCE ON PROCESSING PARAMETERS FOR SINGLE-SCREW PLASTICISING EXTRUDERS.** When LLDPE was processed on an air-cooled, single-screw extruder, an increase in the screw clearance  $\delta$  led, contrary to expectations, to a clear rise in the mean melt temperature and to a slight increase in the specific mechanical energy consumption. The mechanical and thermal homogeneity of the melt that was produced, the axial pressure profile and also the torque and the melt throughput are scarcely influenced by the amount of screw clearance. When a high-molecular HDPE, highly susceptible to wall slippage was processed, screw clearance was seen not to have any notable influence on the process parameters under investigation. The results are explained by wall slip effects and by heat and material transport phenomena in the gap region. (Author abstract) 15 refs. In German and English.

Gruenschloss, E. *Kunstst Ger Plast* v 77 n 9 Sep 1987 p 29-31.

**081540 CORRELATION OF THE PROCESSING PARAMETERS AND THE PHYSICAL-MECHANICAL PROPERTIES OF ARTICLES IN EXTRUSION OF POLYETHYLENE.** Regression equations which correlate the technological parameters of processing of the polymer with the deformation-strength properties of extruded polyethylene were obtained. It was found that the brand of raw material has a very large effect on  $\sigma$ , which is in agreement with the a priori data. These brands probably have different molecular-weight distribution. Significant effects of paired interactions of the factors were observed in the determination of  $\epsilon$ . Information was also obtained on the character of the change in the molecular structure of the industrial brands of PE used during extrusion, and the role of the factors which influence these changes was also examined. 5 refs.

Leitland, V.V. (Plastics Processing Plant, Olaine, USSR); Strantse, R.I.; Sakainis, A.I. *Mech Compos Mater* v 23 n 2 Mar-Apr 1987 p 239-243.

**081541 DIE SWELL-MOLECULAR STRUCTURE MODEL FOR LINEAR POLYETHYLENE.** An empirical relation between capillary die swell and molecular structure, defined by total weight average molecular weight, molecular weight distribution (MWD), and fraction high molecular weight content is established. Via a Box-Behnken experimental design setup blends of Ziegler-Natta catalyzed linear polyethylenes are prepared to allow a statistical analysis of the die swell-molecular structure relation. The contradicting results of M.G. Rogers and R.A. Mendelsen et al. for the die swell-molecular structure relation are shown to be compatible and are to be considered as special cases of the general model presented. The existence of a die swell maximum is shown. (Edited author abstract) 26 refs.

Koopmans, R.J. (Dow Chemical BV, Terneuzen, Neth). *J Polym Sci Part A* v 26 n 4 Apr 1988 p 1157-1164.

#### Failure

**081542 INFLUENCE OF THE MOLECULAR WEIGHT OF LOW DENSITY POLY(ETHYLENE) ON WATER TREING IN RELATION TO MECHANICAL DAMAGING.** The influence of the molecular weight of low density poly(ethylene) on the propagation of water trees is studied and compared with environmental stress cracking data. Water treing is interpreted as a mechanical damaging of the polymer due to the action of local stresses of electrical origin. The propagation of water trees is discussed in terms of plastic deformations of



the amorphous inter- or intraspherulitic spaces, induced by stretching action of dynamic forces of electrical origin on the tie molecules. (Author abstract) 8 refs.

Poggi, Y. (CNRS, Grenoble, Fr); Filippini, J.C.; Raharimalala, V. *Polymer* v 29 n 2 Feb 1988 p 376-379.

**Fiber Reinforcement** See PLASTICS, REINFORCED—Electric Conductivity.

## Filaments

**081543 INFLUENCE OF SURFACE TREATMENT ON ADHESION OF POLYETHYLENE FIBRES.** A detailed examination has been undertaken of the influence of surface treatment on the adhesion of polyethylene fibres to epoxy resin. The pull-out adhesion has been determined for untreated, chromic acid treated, and plasma etched monofilaments with different draw ratios and thermal annealing treatments. In a few cases, additional chemical treatments were applied to plasma treated fibres before the pull-out test. The polyethylene surface energy also has been determined by measurement of contact angle. The results, taken together, suggest that the adhesion depends on three factors: (i) the wettability (or physicochemical interactions), which is affected by the extent and nature of the surface treatment as well as the fibre draw ratio; (ii) the surface roughness, after plasma etching only, where a honeycomb structure of pits permits mechanical keying between the fibre and the resin (this structure has been examined by scanning electron microscopy); and (iii) the number of chemical bonds per unit area between the fibre and the resin. It is concluded that these three factors can be regarded as additive and that optimum results are obtained when their respective pull-out strengths reach their maximum values, approximately 2, approximately 3, and approximately  $1.7 \text{ MN m}^{-2}$ . (Author abstract) 21 refs.

Nardin, M. (Univ of Leeds, Engl); Ward, I.M. *Mater Sci Technol* v 3 n 10 Oct 1987 p 814-826.

**081544 PORE FIBERS OF POLYETHYLENE OBTAINED BY SPINNING AND CRYSTALLIZATION FROM ORIENTED MELT OF MIXTURES WITH PARAFFIN.** A method for the preparation of pores in high molecular weight polyethylene (PE) fibers was examined. Mixtures of PE and liquid paraffin (Pa) with various composition ratios were spun from the melt at various temperatures and rates, and then PE was extracted in organic solvent. The fine structure of these pores in PE fiber was investigated through the measurements of apparent specific volumes, specific surface areas and small angle X-ray scattering. Layer-like pores were formed under the conditions of a mixing ratio of PE and Pa in the range of 0.10 to 0.50 at a spinning draft ratio 6 to 50 times at 110 to 125°C. (Edited author abstract) In Japanese. 13 refs.

Sakami, Hiroshi (Government Industrial Research Inst, Nagoya, Jpn); Kawase, Kaoru; Suzuki, Kenji; Iida, Shozo. *Kobunshi Ronbunshu* v 44 n 7 1987 p 545-550.

**081545 DIRECT ELECTRON MICROSCOPE INVESTIGATION OF THE MORPHOLOGY OF SURFACE-GROWN POLYETHYLENE FILAMENTS BEFORE AND AFTER ZONE-DRAWING.** The supermolecular structure of surface-grown and surface-grown/hot-drawn PE has been the subject of numerous detailed studies. However, a clear characterization of the different morphologies has not so far been achieved. The present TEM study is to provide convincing evidence of the microfibrillar structure of as-spun surface-grown fibers and of morphological changes fibers experience during high-temperature zone drawing. Under these conditions of fiber spinning and drawing, large-scale disturbed regions within the fiber structure may arise, such as kink bands, agglomerations of fibril ends, or boundary layers of longitudinal voids which separate fibrillar aggregates laterally. 21 refs.

Schaper, A. (Acad of Sciences, Teltow-Seehof, East Ger); Hirte, R.; Zenke, D.; Hillebrand, R. *J Mater Sci Lett* v 6 n 11 Nov 1987 p 1336-1338.

**Fillers** See Also BIOPOLYMERS—Nondestructive Examination.

**081546 INFLUENCE OF MIXED FILLERS ON THE RESISTANCE TO EXTRUSION OF MOLTEN POLYMERS THROUGH NOZZLES AND ON THE SMOOTHNESS OF THE EXTRUDATE SURFACE.** The objective of the present work was to establish the effect of the concentration and composition of a combined filler, consisting of a mixture of different dispersed particles, on the viscosity and strength of the melt in the case of shear flow at shear rates close to those used in actual processing. The addition to the molten polymer of a filler of spherical shape, which is not inclined to agglomeration and aggregation of the particles (for instance, glass spheres or steel balls), increases the viscosity of the compositions only slightly, particularly in the region of high shear rates. The combined fillers used were mixtures of glass spheres with chalk or limestone powder. 11 refs.

Faitel'son, L.A. (Acad of Sciences of the Latvian SSR, Riga, USSR); Yakobson, E.E. *Mech Compos Mater* v 23 n 1 Jan-Feb 1987 p 100-105.

**Film** See Also PLASTICS FILMS—Structure.

**081547 MOLECULAR ORIENTATION AND LASER RAMAN SCATTERING INTENSITY OF STRETCHED POLYETHYLENE FILMS.** Measurements of the intensity of polarized laser Raman scattering have been used to investigate the distribution of orientations of the structural units (molecular segments or crystallites) of an oriented solid polymer. In this paper, the orientation of polymeric chain is evaluated more quantitatively on the basis of the fundamental relation between Raman scattering intensity and molecular orientation in anisotropic solids of polymer. This evaluation is performed by expanding the addition theorem of generalized Legendre's function. Improvements over previous works are also discussed. (Edited author abstract). In Japanese. 13 refs.

Hibi, Sadao (Nagoya Inst of Technology, Nagoya, Jpn); Katsuno, Toshiyasu; Katayama, Hiroyuki; Saito, Mikiyasu; Torasawa, Yuji; Maeda, Matsuo. *Kobunshi Ronbunshu* v 44 n 8 Aug 1987 p 573-582.

**081548 CONTROL OF FINE PORES IN POLYETHYLENE FILMS FROM ITS PARAFFIN MIXTURE BY ROLLING COMPRESSION.** A method to control the fine pores in high molecular weight polyethylene (PE) films from its mixture with liquid paraffin (Pa) by rolling compression has been examined. The mixtures with various ratios were hot rolled, and then PE was extracted in organic solvent. The fine structure of these films was investigated via measurements of the apparent specific volume, the surface area using the after  $\text{N}_2$  gas adsorption-desorption method, and the small angle X-rays. (Edited author abstract). In Japanese. 8 refs.

Sakami, Hiroshi (Government Industrial Research Inst, Nagoya, Jpn); Kawase, Kaoru; Suzuki, Kenji; Iida, Shozo. *Kobunshi Ronbunshu* v 44 n 8 Aug 1987 p 583-587.

**081549 EFFECT OF ENTANGLEMENTS ON THE SUPER STRUCTURE GENERATED BY DRAWING GEL PROCESSED FILMS OF ULTRA-HIGH MOLECULAR WEIGHT POLYETHYLENE.** The super-drawn structure of gel processed films of ultrahigh molecular weight polyethylene was studied by these methods: differential scanning calorimetry (DSC) in relation to the elastic property, the morphology after melting, and the wide angle X-ray diffraction at high temperature. Two kinds of endothermic peaks were observed, around 153°C and above 160°C, in the DSC curves of fixed-end films. The lower temperature peak includes the heat of fusion of orthorhombic crystallites and the heat of transition from the orthorhombic to hexagonal phases. The higher temperature peak corresponds to the melt of hexagonal parts. (Edited author abstract). In Japanese. 20 refs.

Kyotani, Hiroko (Research Inst for Polymers & Textiles,

Tsukuba, Jpn); Iguchi, Masatoshi. *Kobunshi Ronbunshu* v 44 n 8 Aug 1987 p 589-596.

**081550 APPLICATION OF  $\text{C}_8$  LLDPE IN FLEXIBLE PACKAGING.** An extensive market survey indicated that the qualities of packaging films needed to be improved regarding easier and more reliable film sealing properties and better puncture resistance. To meet these requirements a new range of very low density (below  $918 \text{ kg m}^{-3}$ )  $\text{C}_8$  linear polyethylenes (Stamylux) LLDPE was developed. Linear low density PE has a linear molecular structure with short chain branches. It is a copolymer with a higher  $\alpha$ -olefin as comonomer. It has a narrow molecular weight distribution (MWD). LLDPE has a molecular structure with both short and long chain branches. It is a homopolymer with a broad MWD. (Edited author abstract)

Swinnen, H.P.M. (DSM Polymers Int, Sittard, Neth). *Plast Rubber Process Appl* v 8 n 1 1987 p 17-21.

**081551 LLDPE AND UV AGEING.** This paper deals with the ultra-violet (UV) ageing of low linear density polyethylene (LLDPE) films with an without UV stabilizer. Pure LLDPE and LLDPE, and blends of these two materials have been compared by outdoor exposure or artificial ageing in a Xenotest 150. Parameters influencing the lifetime of LLDPE films have been examined, such as film thickness, melt index and catalyst residue level of LLDPE, nature of the comonomer (butene-1,4-methylpentene-1, hexene-1), and backing during outdoor exposure. (Edited author abstract)

Cordonnier, Michel (Usine de Lavera, Lavera, Fr). *Plast Rubber Process Appl* v 8 n 1 1987 p 23-27.

**081552 EFFECT OF PROCESSING CONDITIONS ON THE MICROSTRUCTURE OF EMBOSSED POLYETHYLENE FILMS.** A variety of techniques were employed to characterize the properties and microstructure of the embossed film in relation to: crystallinity, orientation, mechanical properties, and dimensions of the embossed films. The thermal treatment of the polymer film was shown to be the most significant factor in the process. By controlling the thermal treatment of the film, it is possible to manipulate the properties and dimensions of the embossed film. The important aspects influencing thermal treatment include the radiation heater temperature, preheat roll temperature, line velocity, and film thickness. The initial film orientation and embossing pressure have a minor effect on the final properties of the embossed film. The main effect of the embossing pressure is on the bulk thickness of the embossed film. (Edited author abstract) 8 refs.

Kamal, M.R. (McGill Univ, Montreal, Can); Haber, A.; Li, Song. *Polym Eng Sci* v 28 n 3 Mid-Feb 1988 p 165-169.

**081553 SHEAR YIELD BEHAVIOR OF HIGHLY DRAWN LINEAR POLYETHYLENE SHEETS ALONG THEIR ORIENTATION DIRECTION: MORPHOLOGICAL CONSIDERATIONS.** This paper considers the geometric aspects of the shear deformation of highly drawn linear polyethylene sheets parallel to the principal orientation direction, concentrating on the morphological aspects relating to the deformation, in terms of both the initial drawing and the subsequent shear. It relates directly to previous studies of the shear strength and mechanical behavior of these materials. (Author abstract) 17 refs.

Chaoting, Y. (Univ of Leeds, Leeds, Engl); Ladizesky, N.H.; Ward, I.M. *J Macromol Sci Phys* v B27 n 1 Apr 1988 p 41-77.

**081554 SHRINKAGE OF LOW-DENSITY POLYETHYLENE FILM.** When blown films of low-density polyethylene are heated above their melting point ( $T_m$ ) they shrink to an unoriented state at a conveniently measurable rate. Curves of contraction as a function of time have been measured at different temperatures ranging



from 120°C to 200°C. The contraction curves for shrinkage in the machine direction obtained at different temperatures are superimposable by a lateral shift along the log-time axis. A master contraction curve, a portion of the retardation spectrum, and the activation energy are obtained. Shrinkage data for low-density polyethylene films with different thicknesses were analyzed and a correlation was found between contraction and dichroic ratio. The correlation indicates that thermal contraction data can be used as a qualitative measurement of orientation in low-density polyethylene film. (Author abstract) 12 refs.

Liu, Tuomin (Pennsylvania State Univ, University Park, PA, USA); Harrison, I.R. *Polym Eng Sci* v 28 n 8 Apr 1988 p 517-521.

Fractionation See POLYMERS—Fractionation.

Fracture See Also PIPE, PLASTIC—Testing.

**081555 EFFECTS OF DETERGENT CONCENTRATION AND ETHYLENE OXIDE CHAIN LENGTH OF THE DETERGENT MOLECULE ON STRESS-CRACKING OF LOW-DENSITY POLYETHYLENE.** Stress-cracking behavior of low-density polyethylene is investigated using a fracture mechanics approach. It is experimentally observed that  $K_{Ic}$  independent crack speed is directly proportional to the concentration of Igepal CO-630 up to 25% concentration.  $K_{Isc}$  is found to increase with detergent concentration; and the increase in  $K_{Isc}$  is attributed to the larger amounts of detergent absorption in the higher concentrations, which decreases the strain localization at the crack tip. Micelle formation of detergents in water is thought to enhance the rate of cracking because of their ability to increase plasticization efficiency at the local area because the micelles contain larger amounts of aggressive molecules. In contrast to Williams' model, the cracking behavior in the constant crack speed region is found to be not controlled by the flow properties of the environment. (Author abstract) 16 refs.

Tonyali, Koksai (Washington State Univ, Pullman, WA, USA); Brown, Hugh R. *J Mater Sci* v 22 n 9 Sep 1987 p 3287-3292.

**081556 SLOW FRACTURE IN A HOMOPOLYMER AND COPOLYMER OF POLYETHYLENE.** The slow crack growth behaviours of a high-density polyethylene and an ethylene-hexene copolymer with 4.5 butyl chains per 1000 carbon atoms are compared. The slow crack growth rate in the copolymer is about  $10^2$  to  $10^3$  times slower than that for the homopolymer. The two polymers are compared with respect to their kinetics of crack growth, morphology of the damage zone that grows from a notch, stress-strain behaviour and temperature dependence of the rate of damage. The results suggest that the major effect of the butyl branches is to decrease the rate of disentanglement which governs the process of slow crack growth. (Author abstract) 11 refs.

Lu, Xici (Univ of Pennsylvania, Philadelphia, PA, USA); Wang, Xuqing; Brown, Norman. *J Mater Sci* v 23 n 2 Feb 1988 p 643-648.

Glass Transition

**081557 GLASS TRANSITION OF POLYETHYLENE AS STUDIED BY BRILLOUIN SPECTROSCOPY.** The Brillouin spectrum of polyethylene has been measured as a function of temperature. Slope discontinuities of opposite directions have been observed in the Brillouin shift and width near the glass transition temperature. The former is attributed to a corresponding discontinuity in the temperature coefficient of specific volume, while the latter to the onset of long-range coordinated molecular motion near the transition region. (Author abstract) 7 refs.

Ng, S.C. (Natl Univ of Singapore, Singapore); Hosea, T.J.C.; Goh, S.H. *Polym Bull (Berlin)* v 18 n 2 Aug 1987 p 155-158.

**High Density** See Also COMPOSITE MATERIALS; CO-POLYMERS—Mechanical Properties; CRYSTALS—Orientation; HAZARDOUS MATERIALS—Packaging; PACKAGING MATERIALS—Plastics; PLASTICS—Deformation; POLYMERS—Friction; SEMICONDUCTING POLYMERS—Charge Carriers; WASTE DISPOSAL—Plastics Applications.

**081558 ORIENTATION DISTRIBUTION FUNCTION IN CRYSTALLITES OF ROLLED HIGH DENSITY POLYETHYLENE FILMS.** An evaluation method of the crystalline orientation distribution function is proposed, based on the model that the lamella axis is one of the principal axes in the crystalline block and that the slippages are introduced along the maximum shear direction and the intra-lamella slip around the  $0-x_2$  axis. This method was applied to rolled high density polyethylene film, and the results compared with observed pole figures. Expansion coefficients as far as the 8th were employed for the elevation of pole figure calculation. (Edited author abstract) In Japanese. 11 refs.

Suzuki, Kouji (Nagoya Inst of Technology, Nagoya, Jpn); Hibi, Sadao; Torii, Takashi; Kobayashi, Masaaki; Nakanishi, Eiji; Maeda, Matsuo. *Kobunshi Ronbunshu* v 44 n 7 1987 p 491-502.

**081559 RE-ORIENTATION OF MOLECULAR CHAIN AXIS AND BEHAVIORS OF PLASTIC DEFORMATION IN THE OFF-ANGLE RE-STRETCHING OF ROLLED HIGH DENSITY POLYETHYLENE.** The mechanisms of plastic deformations were further investigated in connection with the re-oriented molecular chain axis in the off-angle re-stretching of the rolled high density polyethylene (RHPE). The slippery or kinky deformation caused by off-angle re-stretching was analyzed on the basis of the strain ellipsoid, molecular chain vectors and a local coordinate system. The deformation is caused by the slip of inter- and intra-lamella. The molecular chain axis can be easily re-oriented in the film by a pure shear stress which is much larger than the simple shear stress. The kink band formation markedly promotes the re-orientation of the molecular chain axis. (Author abstract) 16 refs. In Japanese.

Torii, Takashi (Nagoya Inst of Technology, Nagoya, Jpn); Sumita, Katsuhiko; Hibi, Sadao; Nakanishi, Eiji; Maeda, Matsuo; Kouichi, Fujimoto. *Kobunshi Ronbunshu* v 44 n 5 1987 p 331-339.

**081560 ANALYSES OF DEFORMATION BAND WITH CHARACTERISTIC CURVES AND RE-ORIENTATION BEHAVIORS OF MOLECULAR CHAIN AXIS WITH THE MODEL OF PLASTIC SLIPPAGE.** The authors analyzed the re-orientation angle of molecular chain axes in the plastic deformation and the angles of kink band in the off-angle re-stretching of rolled high density polyethylene (RHPE). The authors evaluated the kink band angles using the characteristic curves. As the strain yield points in polymers became much greater than those of the metals, the change of orientation angles must be corrected due to elasto-plastic deformation. The re-orientation mechanisms of the chain axis during the off-angle stretching may be divided into the slipping and kinky deformations. These were given by the slippage of the inter-lamella and by the chain slip in the intra-lamella, respectively. The orientation of the molecular chain axis in the chain slip was much greater than that of the inter-lamella slip. (Author abstract) 17 refs. In Japanese.

Torii, Takashi (Nagoya Inst of Technology, Nagoya, Jpn); Hibi, Sadao; Sumita, Katsuhiko; Nakanishi, Eiji; Maeda, Matsuo; Fujimoto, Kouichi. *Kobunshi Ronbunshu* v 44 n 5 1987 p 361-368.

**081561 SYNERGISM OF ANTIOXIDANTS IN HIGH DENSITY POLYETHYLENE.** The effect of several commercial antioxidants (viz. phosphites and hindered phenols) used in synergistic formulations in two grades of high density polyethylene (HDPE) has been examined using infra-red (ir) spectroscopy. The results show that, in general and, as expected, synergism is obtained between hindered phenols and phosphites in HDPE films during oven aging and uv irradiation condi-

tions. However, the degree of synergism is not the same for both grades of HDPE, which differ mainly in their unsaturation and metal impurity content. In some cases, antagonism is observed in one of the HDPE samples while synergism is exhibited by the other. There is also a difference regarding the optimum concentration ratio of the antioxidants in each polymer. Formulations which include a commercial metal deactivator (Nauard XL 1) also show synergistic behavior. The reasons for the observed behavior are discussed on the basis of the mode of action of the antioxidants and their rate of consumption in the polymer medium. (Edited author abstract) 7 refs.

Chirinos-Padron, Alfonso J. (Inst Venezolano de Investigaciones Cientificas, Caracas, Venez); Hernandez, Petra H.; Allen, Norman S.; Vasilion, Constantine; Marshall, G.P.; de Poortere, Michell. *Polym Degradation Stab* v 19 n 2 1987 p 177-189.

**081562 HIGH-DENSITY POLYETHYLENE (HDPE).** To assess the market situation and its development, Western Europe (WE) must be looked at as a unit. After the persistent recession of 1980 to 1982, there was a sudden improvement in 1983, and between 1984 and 1986 consumption increased some 28%. (HDPE production over the same period rose only about 18%. At present there are 16 producers of HDPE in Western Europe. In the percentage breakdown on HDPE consumption into the individual processing areas the blow moulding and injection moulding are still the most important sectors. In quantity terms they have lost market share. The film sector is still recording powerful growth in proportionate and absolute terms. Continuous growth is perceived for pipe and sheet. Usage of tapes and monofilms is developing at an average rate: their share of the HDPE market as a whole has scarcely altered for several years. HDPE is produced by suspension, solution, and gas-phase processes with Ziegler or Phillips catalysts. Specially tailored catalysts have been developed for this purpose, which make it possible to produce a specific molecular weight distribution in one simple process. 7 refs.

Gondro, C. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 18-20.

**081563 INFRA-RED STUDY OF BOND RUPTURE DURING PLASTIC DEFORMATION IN HIGH-DENSITY POLYETHYLENE.** The effects of elongation, time and temperature upon the concentrations of carbonyl and vinyl groups formed during the plastic deformation of high-density polyethylene have been studied using infra-red spectroscopy. Samples drawn in various atmospheres are also described. The morphology of lamellar crystallized polymers is now taken to involve both folded chains and those linking adjacent lamellar cores. We propose an alternative explanation for the processes that occur when spherulitic materials become oriented and fibrillar. We propose and provide evidence that mechanical work is concentrated into very small volumes in the neck region leading to localized melting and subsequent recrystallization. (Edited author abstract)

Hammond, C.L. (Univ of Southampton, Southampton, Engl); Hendra, P.J.; Lator, B.G.; Maddams, W.F.; Willis, H.A. *Polymer* v 29 n 1 Jan 1988 p 49-53.

**081564 ORIENTATION DISTRIBUTION FUNCTIONS OF OFF-ANGLE REDRAWING IN ROLLED HIGH DENSITY POLYETHYLENE FILMS, CALCULATED WITH THE PLASTIC SLIP MODEL.** We evaluated the orientation distribution functions of each plane normal for off-angle re-drawing in rolled high density polyethylene films. The pole figures' device familiar in X-ray diffraction was used. These distribution functions were compared with the schematic simulation of orientation in crystallites after such re-drawing, by assuming polycrystalline aggregations. We analyzed the mechanism of re-orientation for a re-drawing process in which



the [110], <001> slip system dominated in three types of chain slip systems by the maximum work principle. (Author abstract). 12 Refs. In Japanese.

Torii, Takashi (Nagoya Inst of Technology, Nagoya, Jpn); Hibi, Sadao; Sumita, Katsuhiko; Kuryu, Yoshito; Maeda, Matsuo; Nakanishi, Eiji. *Kobunshi Ronbunshu* v 45 n 5 1988 p 391-399.

**081565 HDPE RECYCLE: IT'S A BIG-VOLUME OPPORTUNITY WAITING TO HAPPEN.** A mere 2.4 percent of 3.3 billion lb of amenable blow and injection molded rigid containers was recycled last year; and the price of virgin high density polyethylene (HDPE) blow molding has risen by 70 percent since early 1987. As a result, HDPE containers have emerged as the most promising candidate for recycling especially since they are easily identifiable. The best strategy for the re-use of HDPE appears to be in the area of nonfood applications, such as pipes, flower pots, and plastic lumber.

Leaversuch, Robert. *Mod Plast* v 65 n 8 Aug 1988 p 44-47.

**081566 NAVETE DIN POLIETILENA DE INALTA DENSITATE REPRELUCRATE DIN NAVETE UZATE. III. [High Density Polyethylene Containers Recycled from Waste Containers. III].** The present paper analyzes from the viewpoint of quality and economical efficiency the recycling of the recovered materials obtained from waste containers for the manufacturing of new containers. The paper also presents the technological variants which permitted: the selection of the optimal recycling methods by compounding, the sorting of colors, the removal of impurities, the crumbling, the washing, the thermal stabilization and homogenization in extruder-granulating mill used for the degasing in the melt and being provided with devices for the filtration of impurities. (Edited author abstract). 34 Refs. In Romanian.

Sebe, Mircea Octavian (Cent de Cercetari Pentru Materiale Plastice, Bucharest, Rom); Constantinescu, Elena; Frangu, Octavian. *Mater Plast Elastomeri Fibre Sint* v 25 n 1 Jan-Mar 1988 p 44-48.

## Ion Implantation

**081567 CHEMICAL CHANGES CREATED BY HIGH ENERGY IONS IN POLYETHYLENE.** Argon and oxygen ions were accelerated with energies of 50 to 150 keV and rastered across high-density polyethylene. The free radicals formed in the ion-implanted polyethylene were studied using an electron spin resonance spectrometer. The free radicals formed were stable in air and even survived solvent separation of the undamaged polymer from the ion-damaged polymer. Chemical characterizations indicated that pregraphitic or graphitic-like particles are formed with defect sites which are, in effect, free radicals stabilized by a polyaromatic system. 48 refs.

Schaible, Max (Univ of Connecticut, Storrs, CT, USA); Hayden, Howard; Tanaka, John. *IEEE Trans Electr Insul* v EI-22 n 6 p 699-708.

## Ionization

**081568 WETTING OF FUNCTIONALIZED POLYETHYLENE FILM HAVING IONIZABLE ORGANIC ACIDS AND BASES AT THE POLYMER-WATER INTERFACE: RELATIONS BETWEEN FUNCTIONAL GROUP POLARITY, EXTENT OF IONIZATION, AND CONTACT ANGLE WITH WATER.** This paper examines the wetting by water of low-density polyethylene film modified at the polymer-water (air) interface by introduction of polar organic functional groups (carboxylic acids, amines, and others). Water/polymer contact angles were determined for each of these interfaces; for interfaces containing acidic or basic functional groups, the contact angle was determined as a function of the pH. The observed contact angle was related to the hydrophilicity of these functional groups: as the hydrophilicity (as measured by Hansch  $\pi$  parameters) increased up to a certain point, the contact angle decreased. Beyond that point, increased hydrophilicity had

little additional influence on the contact angle. The paper rationalizes the change in contact angle with pH in terms of the relative areas of the interface occupied by the functional groups in different ionization states and in terms of the extent of ionization of acidic and basic groups. (Edited author abstract). 39 Refs.

Holmes-Farley, Stephen Randall (Harvard Univ, Cambridge, MA, USA); Bain, Colin D.; Whitesides, George M. *Langmuir* v 4 n 4 Jul-Aug 1988 p 921-937.

**Linear Low Density** See Also ELASTOMERS—Applications; PLASTICS FILMS—Performance; POLYMERS—Blending; POLYMERS—Extrusion; POLYMERS—Rheology.

**081569 PREPARATION OF LINEAR LOW DENSITY POLYETHYLENE WITH TITANIUM TETRA-N-BUTOXIDE-DIETHYALUMINUM CHLORIDE CATALYST IN SLURRY PHASE.** The authors report the preparation of LLDPE by copolymerization of ethylene and 1-butene in the slurry phase using titanium tetra-n-butoxide-diethylaluminum chloride catalyst and the effects of aging time and concentration of catalyst components on catalytic activity and 1-butene content of copolymer produced. 10 refs.

Lee, Dong-ho (Kyungpook Natl Univ, Taegu, South Korea); Min, Kyung-eun; Ahn, Tae-oan. *Polym J* v 19 n 8 1987 p 973-975.

**081570 FRACTIONATION AND THERMAL BEHAVIOUR OF LINEAR LOW DENSITY POLYETHYLENE.** An ethylene/1-octene copolymer has been fractionated by molecular weight using successive solution fractionation (s.f.f.). The fractions obtained and the original copolymer were analysed with respect to the short chain branching distribution using analytical temperature rising elution fractionation (a.t.r.e.f.). A bimodal, very wide branching distribution is observed, both for the non-fractionated polymer and for the s.f.f. fractions. A decrease of the average degree of branching with increasing average molecular weight of the fractions is observed. The melting behaviour of isothermally crystallized samples was studied using differential scanning calorimetry (d.s.c.). (Edited author abstract) 12 refs.

Schouterden, P. (Katholieke Univ Leuven, Louvain, Belg); Groeninckx, G.; Van der Heijden, B.; Jansen, F. *Polymer* v 28 n 12 Nov 1987 p 2099-2104.

**081571 MECHANICAL BEHAVIOUR OF LINEAR LOW DENSITY POLYETHYLENE FIBRES.** The mechanical behavior of linear low density polyethylene fibers has been investigated by means of uniaxial elongation tests and thermomechanical measurements. A mechanical model initially introduced by for HDPE fibers is proposed to account for the experimental results. In this model based on the crystalline continuity, it is interrupted by adjunction of a small fraction of amorphous phase in series with the mechanically active crystals. This fraction is determined by means of an original theoretical treatment of the stress-strain curves of the fibers. Correlations have been set up between this additional parameter and the mechanical properties of the fibers. (Edited author abstract) 23 refs.

Rossignol, J.M. (Univ des Sciences et Techniques de Lille, Villeneuve d'Ascq, Fr); Seguela, R.; Rietsch, F. *Polymer* v 29 n 1 Jan 1988 p 43-48.

**081572 LES PROGRES EN POLYETHYLENE BASSE DENSITE LINEAIRE POUR FILM. [Progress in Linear Low Density Polyethylene for Films].** LLDPE continues to progress in Western Europe. Its percent of the film market has increased from 5% in 1983 to 12% in 1986. LLDPE is mainly used for films, and progression in this market will depend on the competitiveness of the quality of resins. General properties of LLDPE are at least equivalent, only and often superior to those of LDPE. Only optical properties are inferior to those of classical LDPE. This problem has now been solved by the development of highly transparent grades. (Edited author abstract) In French.

Querou, Y. (BP Chimie, Fr). *Rev Gen Caoutch Plast* v 64 n 673 Nov 1987 p 39-43.

**081573 LINEAR LOW DENSITY POLYETHYLENE.** Following a brief process description, fundamental product advantages are explored. Market implications of the improved properties of LLDPE are assessed. Commercial applications and experience are discussed. Processing LLDPE and the various conversion processes are examined. 2 refs.

Nijhawan, V. (Union Carbide India Ltd, India). *Chem Age India* v 38 n 4 1987 p 135-138.

**081574 LINEAR LOW DENSITY POLYETHYLENE - AN OVERVIEW OF CdF CHIMIE'S DEVELOPMENTS.** A description is given of the CdF CHIMIE process for producing linear polyethylenes. The ISBL cost for a plant is discussed. The major manufacturers of polyacetal are detailed as are consumption patterns.

Marthe, J.P. (CdF CHIMIE, Fr). *Chem Age India* v 38 n 3 1987 p 121-127.

**081575 EQUIPMENT AND PROCESSING UPDATE FOR THE BLOWN-FILM EXTRUSION OF LINEAR LOW-DENSITY POLYETHYLENE.** LLDPE molecule has no long-chain branching and only a few short side chains, primarily the result of copolymerizing polyethylene with certain  $\alpha$ -olefins. These short side chains alter the processing characteristics chiefly by changing the molecular-weight distribution. This provides a film with superior mechanical properties, no entanglement, and good draw-down ability, but it reduces the ease of extrusion and bubble stability. There are arguments for both narrow and wide die gaps for processing LLDPE. Narrow gaps generally result in better machine-direction (MD) tear resistance, downgauging potential, and orientation balance in the film than wide gaps. However, the benefits are obtained by adding processing aids to the resin to prevent melt fracture. Wide die gaps offer reduced costs while providing higher extrusion rates, lower pressures, and better optics. Die-lip heating zones are sometimes added to provide additional heat to delay the onset of melt fracture. This eliminates the processing aids.

Bode, William W. (Battenfeld Gloucester Engineering, Co, Gloucester, MA, USA). *Tappi J* v 71 n 6 Jun 1988 p 133-137.

**081576 TEHNOLOSKI ASPEKTI PRERADLJIVOSTI LINEARNOG POLETILENA NISKE GUSTOCE. [Technological Aspects of Linear Polyethylene Processability].** A description is given of the most important physico-mechanical and processing properties of LLDPE obtained via solution polymerization in the presence of fluorocarbon processing additives. The impact of LLDPE introduction in Europe and the approaches adopted in order to facilitate its processing are also discussed. (Edited author abstract). 3 Refs. In Serbo-Croatian.

Branaccio, Aldo (EniChem Anic SpA, Milan, Italy); Sorta, Ennio. *Polimeri (Zagreb)* v 8 n 3 Mar 1988 p 58-62.

**081577 STRUCTURAL DISTRIBUTION OF LINEAR LOW-DENSITY POLYETHYLENES.** Molecular and crystalline structures of linear low-density polyethylenes (LLDPE) were investigated by a series of characterization techniques. Molecular structural characteristics were elucidated by temperature-rising elution fractionation (TREF) and solvent-gradient elution fractionation (SGEF). A bird's eye view and a contour map of LLDPE obtained by a combination of TREF and size exclusion chromatography exhibited a broad and multimodal chemical composition distribution (CCD), in contrast to a sharp and single CCD of conventional high-pressure low-density polyethylene (HP-LDPE). Short chain branching (SCB) was found to decrease with increase of molecular weight by SGEF technique. Thermal analysis of cross-fractions proved that a characteristic broad endothermic curve of LLDPE is attributable to its broad and



multimodal CCD. Then, using DSC results, an indicative index (DI) which expresses the degree of the distribution of lamellar crystal thickness is proposed. DI was found to be sensitive both to CCD and to a kind of SCB. (Edited author abstract). 31 Refs.

Hosoda, Satoru (Sumitomo Chemical Co, Chiba, Jpn). *Polym J* v 20 n 5 1988 p 383-397.

**081578 MORPHOLOGICAL EXPLANATION OF THE EXTRAORDINARY FRACTURE TOUGHNESS OF LINEAR LOW DENSITY POLYETHYLENES.** The fracture toughness of commercial linear low-density polyethylenes (LLDPE) has been found to be extraordinarily high relative to commercial low-density (LDPE) and high-density (HDPE) polyethylenes in previously reported investigations. The present investigation shows that this extraordinary fracture toughness cannot be explained by differences in molecular structure variables, such as molecular weight, long-chain and short-chain branching, fractional crystallinity, and comonomer content. Instead, the presence of a second soft phase, which was extractable with a weak solvent, in a hard semicrystalline matrix was discovered by morphological investigations. This second phase arises from the extreme compositional heterogeneity of the copolymers which comprise these LLDPE resins. No evidence for a similar morphological entity was found in LDPE and HDPE resins. This finding provides persuasive evidence that this very-low-crystallinity second phase performs a function similar to that of the rubberlike second phase in other high impact resins and, thus, leads to the observed extraordinary fracture toughness of LLDPE resins. Evidence for the nature and existence of this second phase is given from temperature-rising elution fractionation and scanning electron microscopy investigations. (Edited author abstract). 7 Refs.

Mirabella, Francis M. Jr. (USI Chemicals Co, Rolling Meadows, IL, USA); Westphal, Stanley P.; Fernando, Priya L.; Ford, Emory A.; Williams, J.G. *J Polym Sci Part B* v 26 n 9 Aug 20 1988 p 1995-2005.

**081579 LINEAR LOW DENSITY POLYETHYLENES AND THEIR BLENDS: PART 5. EXTENSIONAL FLOW OF LLDPE BLENDS.** The uniaxial extensional flow at 150°C of two series of blends: I. LLDPE/LLDPE and II. LLDPE/LDPE was examined in full range of concentrations as well as that of accessible in the rheometer strains and strain rates. It was concluded that Series-I blends containing different LLD-type polymers are miscible. Their properties can be predicted on the basis of molecular weight and molecular weight distribution. By contrast, excepting low concentration limits, blends of Series-II are immiscible. Both series show strain hardening, due to higher values of the maximum strain at break. Series-II seems to be superior (under the test conditions). The stress growth function in shear, computed from the frequency relaxation spectrum, provided a good prediction of the linear viscoelastic component of the stress growth function in uniaxial extension. (Author abstract) 37 refs.

Schlund, B. (Nat'l Research Council Canada, Boucherville, Que, Can); Utracki, L.A. *Polym Eng Sci* v 27 n 20 Mid-Nov 1987 p 1523-1529.

**081580 LLDPE IN EUROPE - WORLD PERSPECTIVES AND DEVELOPMENTS, PROCEEDINGS OF AN INTERNATIONAL CONFERENCE.** This conference contains 20 papers concerned with polyolefins and especially polyethylenes, from raw material supplier through processor to end user. The papers are arranged by sessions: polymer development; processing and properties; market developments, and future trends. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11522 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Plastics & Rubber Inst, London, Engl). *LLDPE in Eur - World Perspective and Dev, Proc of an Int Conf, Madrid, Spain, Nov 3-5 1986* Publ by Plastics & Rubber Inst, London, Engl, 1986 var pagings.

**Low Density** See Also COPOLYMERS—Structure; GRAFT COPOLYMERS—Synthesis; PLASTICS FILMS—Mechanical Properties; PLASTICS FILMS—Radiation Effects; PLASTICS FILMS—X-Ray Analysis; POLYMERS—Blending; POLYTETRAFLUOROETHYLENE—Oxidation; STYRENE—Diffusion; THERMOPLASTICS—Fracture; WIRE—Coatings.

**081581 LA DURATA DI UN FILM DI POLIETILENE: DIECIMILA ORE.** [Duration of a Polyethylene Film]. Through the study of natural aging it is possible to foresee the useful life of a low density stabilized polyethylene film. The results of the investigation are of great topical interest at a moment in which degradation phenomena are at the center of the legislators' attention. (Author abstract) In Italian. 6 refs.

Severini, Febo; Gallo, Raffaele; Ipsale, Salvatore; del Fanti, Natalino. *Mater Plast Elastomeri* n 11 Nov 1986 p 575-578.

**081582 DETERMINATION OF THE POLARITY OF CARRIER TRAPS IN  $\gamma$ -IRRADIATED POLYETHYLENE BY TEMPERATURE GRADIENT THERMALLY STIMULATED CURRENT.** Thermally stimulated current (TSC) and thermoluminescence (TL) measurements have been used widely to study trapped carriers in insulating films under high electric field or irradiation (X-ray or  $\gamma$ -ray). However, in insulating films, the polarity of carrier traps whether electron traps or hole traps, has not been clarified. Some investigations of the polarity of trapped carriers in  $\gamma$ -irradiated polymers by using a temperature gradient increasing with time have been reported, and the forementioned problem has been pointed out. Therefore, the authors have examined whether or not a space-charge field is formed in  $\gamma$ -irradiated polyethylene films. 8 refs.

Kato, Keizo (Tokyo Inst of Technology, Jpn); Iwamoto, Mitsumasa; Hino, Taro. *Electr Eng Jpn* v 107 n 2 Mar-Apr 1987 p 12-21.

**081583 RELATIONSHIP BETWEEN THE MECHANICAL RELAXATIONS IN THE  $\alpha$  ZONE AND THE CALORIMETRIC TRANSITIONS IN LOW DENSITY POLYETHYLENE.** The  $\alpha$ -relaxation spectra of LDPE, irradiated and unirradiated, has been compared with their calorimetric thermograms. There exists a correlation between the two mechanical relaxations that appear in the  $\alpha$  zone and the two fusion peaks observed in the calorimetric thermograms, confirming that the parameter that governs the temperature of the relaxations  $\alpha_1$  and  $\alpha_{II}$  is the most probable crystallite thickness, whereas the height of the  $\alpha$ -relaxation zone, as measured by means of  $\tan \delta_{max}$ , depends on the total crystalline content of the sample. (Author abstract) 16 refs.

Ribes-Greus, Amparo (Univ Politcnica de Valencia, Valencia, Spain); Diaz-Calleja, Ricardo. *J Appl Polym Sci* v 34 n 8 Dec 1987 p 2819-2828.

**081584 SURFACE MODIFICATION. I. GRAFT POLYMERIZATION OF ACRYLAMIDE ONTO LOW-DENSITY POLYETHYLENE BY  $Ce^{4+}$ -INDUCED INITIATION.** Polyacrylamide was grafted onto a hydroxylated LDPE (low-density polyethylene) surface yielding a highly hydrophilic and stable new surface. LDPE was first oxidized by chromic acid and then reduced with diborane to form a hydroxyl-rich surface. Polymerization was then initiated by  $Ce^{4+}$ /HNO<sub>3</sub> solution. X-ray photoelectron spectroscopy and Fourier transform-IR/attenuated total reflection were used for elemental analysis and identification of the functional groups introduced. (Author abstract) 17 refs.

Batch, Christopher (Univ of Florida, Gainesville, FL, USA); Yahiaoui, Ali. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3479-3488.

**081585 LOW DENSITY POLYETHYLENE (LDPE/LLDPE).** Low density polyethylene (LDPE) continues to be the standard plastic with the highest tonnage figures alongside PVC. In 1986, worldwide installed production capacity for LDPE was some 14 m.t. Present-day LLDPE capacity in Western Europe can be expected to double by the start of the 1990s. After an

increase in the consumption of LDPE of some 20% per annum in the 1960s and up to the first oil crisis in 1973, the period from 1974 to 1979 still saw an average annual growth of 5 to 6%, up to more than 4 m.t. The range of different low-density polyethylenes available (LDPE, EVA and EA copolymers, LLDPE, VLDPE) means that processors and users have a broad basis of materials from which to fulfil the requirements of different applications. The combination of individual products, either by blending or by coextrusion, will serve to open up further fields of application for low density polyethylene.

Hemer, M.; Wolter, H.J. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 16-17.

**081586 UTJECAJ TEMPERATURE PROIZVODNJE LDPE - A NA UDIO NISKOMOLEKULARNIH VOSKOVA.** [Effect of Polymerization on Wax Content of Low Density Polyethylene]. The paper examines the effects of temperature in the tubular reactor for the production of low density polyethylene (LDPE) on the finished product's characteristics. Since a larger part of the low molecular weight polymer remains in the finished product, it is necessary to determine optimal production conditions in order to reduce the wax content in the finished product. Experimental data have been systematized by statistical data processing. (Edited author abstract) In Serbo-Croatian. 8 refs.

Grkovic, Veljko (INA-OKI, Zagreb, Yugosl); Jelencic, Jasenka. *Polimeri (Zagreb)* v 8 n 10-11 Oct-Nov 1987 p 303-306.

**081587 BRANCHING IN LOW DENSITY POLYETHYLENE BY  $^{13}C$ -NMR.** An optimized experimental procedure has been developed for the  $^{13}C$ -NMR analysis of polyethylenes. These analyses were performed at 62.5 MHz in 60-80 (w/w)% mixtures in trichlorobenzene. Signal sensitivity is enhanced by operating at 100°C rather than higher temperatures. Solutions were prepared by holding the polymer-solvent mixtures at 155-160°C before cooling to the analysis temperature. This solution procedure, which is used also in size exclusion chromatography of polyethylenes, reduces NMR line widths and increases carbon spin-spin relaxation times. Branch concentrations measured are qualitatively similar but quantitatively different from those in earlier reports where shorter NMR delay times were employed. (Edited author abstract) 43 refs.

Bugada, Daniele C. (Univ of Waterloo, Waterloo, Ont, Can); Rudin, Alfred. *Eur Polym J* v 23 n 10 1987 p 809-818.

**081588 DEVELOPMENT OF CRYSTALLINE STRUCTURE DURING TUBULAR FILM BLOWING OF LOW-DENSITY POLYETHYLENE.** Development of crystalline structure during the tubular film blowing of low-density polyethylene was investigated, using wide-angle X-ray diffraction technique, low-angle light scattering, and scanning electron microscopy. In the study, commercial grades of both high-pressure low-density polyethylene (HP-LDPE) and low-pressure low-density polyethylene (LP-PDPE) (also, commonly referred to as linear low-density polyethylene, LLDPE) were used. The applied stresses at the freeze line were determined using theoretical expressions. These applied stresses were used to interpret the crystalline axes orientation in the tubular blown films. It was found that the magnitude of  $S_{11F}$  is an important process parameter to be a determining factor in the distribution of fibrillar nuclei and crystalline texture, as well as film anisotropy. (Edited author abstract) 30 refs.

Kwack, Tae Hoon (Polytechnic Univ, Brooklyn, NY, USA); Han, Chang Dae; Vickers, M.E. *J Appl Polym Sci* v 35 n 2 Feb 5 1988 p 363-389.



**081589 STUDY OF POLYOLEFIN GEL IN ORGANIC SOLVENTS: II. STRUCTURE AND MORPHOLOGY OF BRANCHED LOW DENSITY POLYETHYLENE GEL IN ORGANIC SOLVENTS.** Two kinds of branched low density polyethylene (LDPE) gels were prepared by cooling a solution rapidly (a rapid cooling gel) and slowly (a slow cooling gel), and the morphology as well as the structure of the gels were studied. Moreover, gel-melting temperature  $T_m^g$  was measured and its dependence on polymer concentration, molecular weight, and branching degree was also investigated. A range of weight-average molecular weight of samples used is from  $8.7 \times 10^4$  to  $17.5 \times 10^4$ . For both rapid and slow cooling gels,  $T_m^g$  increases with increasing polymer concentration as well as molecular weight, but decreases with increasing branching degree. The minimum polymer concentration  $C^*$  for gel formation and the form of crystallites in gels depend on the cooling rate of a solution considerably, though the difference in  $T_m^g$  between the rapid cooling gel and the slow cooling one for a same sample is little. (Edited author abstract) 37 refs.

Matsuda, Hideomi (Shinshu Univ, Ueda, Jpn); Kashiwagi, Ryoichi; Okabe, Masaru. *Polym J* v 20 n 3 1988 p 189-199.

**081590 INFLUENCE DES METHODES DE MISE EN OEUVRE DU POLYETHYLENE (PEBD) SUR SON COMPORTEMENT SOUS HAUTE TENSION CONTINUE.** [Influence of the LDPE Manufacturing Process on Its Behavior under Electric Stress]. In order to improve the insulating properties of low density polyethylene (LDPE) under electric stress, a systematic study of LDPE based materials has been conducted. This investigation has been made by measuring, using the pressure wave propagation method, the evolution of charge or dipole distributions in samples submitted to a high voltage gradient. Two pure LDPE resins of different origins were used to prepare planar geometry samples, identical in any other respects. The behavior of these samples is compared, for various applied fields, temperatures and chemical formulations of the electrodes. From these results, new information relative to charge storage and transport in these materials is obtained. It is shown that, by studying directly the influence of the chemical composition of materials on their electrical properties, it will be possible to define high performance insulations. (Author abstract) In French. 8 refs.

Chapeau, F. (Ecole Supérieure de Physique et Chimie Industrielles, Fr); Alquier, C.; Lewiner, J.; Auclair, H.; Jocteur, R. *RGE Rev Gen Electr* n 3 Mar 1988 p 44-49.

**081591 DSC AND THERMOMECHANICAL INVESTIGATIONS OF LDPE FILMS IRRADIATED WITH FAST ELECTRONS.** LDPE films irradiated with fast electrons at doses in the range 0-40 Mrad have been investigated by DSC and thermomechanical methods. The irradiated films do not flow in the melt state. The temperature of melting of the films does not change with the radiation dose. The material which is obtained as a result of melting possesses high elasticity. The modulus of compression changes proportionally to the radiation dose. The enthalpies of melting and crystallization of the irradiated films decrease with increasing of the radiation dose. (Edited author abstract) 25 refs.

Minkova, L. (Bulgarian Acad of Science, Sofia, Bulg); Nikolova, M.; Nedkov, E. *J Macromol Sci Phys* v B27 n 1 Apr 1988 p 99-118.

**081592 POLYOLEFIN POLYMERS FOR CABLE SHEATHING.** The excellent electrical and mechanical properties of low density polyethylene (LDPE) have long been recognised by the wire and cable industry. The ease of processing has opened up applications in the insulation and sheathing of both telecommunication and power cable systems. Properties have been further enhanced in terms of resistance to thermal deformation by various crosslinking processes involving peroxide and silane additives. This article provides examples of performance optimisation which has been achieved. 5 refs.

Williams, H.A. (BP Chemicals, Switz). *Wire Ind* v 55 n

654 Jun 1988 p 430-433.

**081593 NUCLEATION OF LOW DENSITY POLYETHYLENE BY HIGH DENSITY POLYETHYLENE.** A nucleating agent produced from the same monomeric unit as the polymer to be nucleated has similar chemical and physical properties and can be used to direct the morphology of LDPE regardless of the size of the spherulites. It is also possible to generate a modified shish-kebab structure with a macroscopic core of high density polyethylene surrounded by a LDPE matrix or a transcrystalline morphology in LDPE due to the high nucleation density of the HDPE surfaces in contact with LDPE. This letter deals with the principle of the PE-PE nucleation and some basic results. 11 Refs.

Wendt, U. (Technical Univ, Magdeburg, East Ger). *J Mater Sci Lett* v 7 n 6 Jun 1988 p 643-645.

## Manufacture

**081594 SUROVINOVA ZAKLADNA PRO VYROBU ETHENU.** [Raw Material Base for the Production of Ethylene]. The progress of the raw material base for the production of ethylene is analyzed on the basis of available literature data. Although pyrolysis represents a process exceptionally demanding with regard to both energy and raw materials, in the foreseeable future it will remain the basic process in petrochemical industry, essentially in the same form as today. Progress will be directed to its innovation aimed at achievement of higher energy efficiency, higher yield, and an expedient utilization and combination of the processed raw materials, or resources of light hydrocarbons isolated from natural gas, and the development of new resources by utilization of heavy petroleum fractions. (Edited author abstract) In Czech. 27 refs.

Pragrova, Marie (Vysoka Skola Chemickotechnologicka, Prague, Czech); Horak, Josef. *Chem Prum* v 37 n 10 1987 p 505-510.

**081595 DEVELOPMENTS IN POLYETHYLENE AND POLYPROPYLENE TECHNOLOGIES.** A brief process description is given of methods for manufacturing polyethylene and polypropylene. Reactor safety is discussed. Operating costs in the Low Density and Linear Low Density polyethylenes are briefly noted.

Shah, Sunil I. (Indian Petrochemicals Corp, Gujarat, India). *Chem Age India* v 38 n 3 1987 p 111-119.

**Mathematical Models** See MATHEMATICAL TRANSFORMATIONS—Fourier Transforms.

**Measurements** See POLYPROPYLENE—Measurements.

**Mechanical Properties** See Also PLASTICS—Recycling; PLASTICS FILMS—Mechanical Properties; RUBBER, SYNTHETIC—Mechanical Properties.

**081596 RELATIONSHIP BETWEEN TENSILE STRENGTH AND MOLECULAR WEIGHT OF HIGHLY DRAWN POLYETHYLENES.** Recently, we reported a series of tensile tests on a wide range of highly drawn polyethylenes made from commercially available polymers of differing polydispersity. It is of great importance to be able to calculate the strength of a polymer from a knowledge of the molecular weight distribution, but it is then necessary to postulate a model for the strengthening effect of the different weight components. The excellent correlation between the calculated and experimental values shows that the simple weight-average Flory model is adequate to determine the strength of polydispersed polyethylenes. 6 refs.

Hallam, M.A. (Univ of Leeds, Leeds, Engl); Pollard, G.; Ward, I.M. *J Mater Sci Lett* v 6 n 8 Aug 1987 p 975-976.

**081597 STRUCTURAL ORGANIZATION AND MECHANICAL PROPERTIES OF HIGH DENSITY POLYETHYLENE FILLED WITH SHORT GLASS FIBRES.** The influence of the structural organization of a short-fiber filler (effect of agglomeration, average length,

orientation) on the strengthening of high density polyethylene has been analyzed. Mechanical properties of the material under impact loads and in tensile tests at a constant rate of stretching have been investigated. The degree of agglomeration of fibers was found to grow with increase in their relative length, and with increasing degrees of filling. (Author abstract) 8 refs.

Tovmasyan, Yu.M. (USSR Acad of Sciences, USSR); Topolkarayev, V.A.; Berlin, A.I. *Polym Sci USSR* v 28 n 6 1986 p 1292-1299.

**081598 DYNAMIC MECHANICAL PROPERTIES OF POLYETHYLENE AND POLYBUTYLMETHACRYLATE COMPOSITES OBTAINED BY STRETCHING POLYETHYLENE IN A LIQUID MONOMER FOLLOWED BY ITS POLYMERIZATION.** From analysis of the temperature dependence of dynamic mechanical properties, the authors make a comparative study of the phase structures of mixtures of PE with polybutylmethacrylate formed by mechanical mixing in an extruder or as interpenetrating polymer networks. The continuity of both phases for a high degree of dispersion in the interpenetrating networks determines the higher indices of the physicomechanical properties as compared with mechanical mixtures with a grossly dispersed structure. (Edited author abstract) 10 refs.

Semerikova, I.B. (Karpov Physicochemical Research Inst, USSR); Godovskii, Yu.K. *Polym Sci USSR* v 28 n 9 1986 p 2079-2085.

**081599 NEW MODEL FOR THE HIGH MODULUS AND STRENGTH PERFORMANCE OF ULTRADRAWN POLYETHYLENES.** A new morphological model is discussed which is based on the relation of tensile modulus and strength to the macrofibrillar dimensions (aspect ratio) and the shear modulus of ultrahigh molecular weight polyethylene fibrillar structures of draw ratio  $DR \leq 200-300$ . Such structures were obtained by solid state deformation of the as-received powder and solution grown crystals using an extrusion-drawing process. According to this model, the highest tensile modulus and tensile strength values that can be obtained are 212 GPa and 13.3 GPa, i.e., significantly close to the theoretically calculated values. (Author abstract) 23 refs.

Zachariades, Anagnostis E. (IBM, San Jose, CA, USA); Kanamoto, Tetsuo. *J Appl Polym Sci* v 35 n 5 Apr 1988 p 1265-1281.

**081600 NEW ASPECTS OF YIELDING IN SEMICRYSTALLINE POLYMERS RELATED TO MICROSTRUCTURE: BRANCHED POLYETHYLENE.** The application of thermodynamics of eutectoid copolymers and a generalized Tabor relation to relationships between mechanical properties (microhardness, yield stress) and microstructure in semicrystalline polymers is considered. The approach is illustrated by results on melt-crystallized low density polyethylene, investigated near the yield point at different temperatures. The success of the approach emphasizes that semicrystalline polymers, despite being viscoelastic heterogeneous systems, give rise to a yielding process entailing the irreversible deformation of a larger number of crystals within cooperative super-structure units. Microhardness provides, within this context, a unique measure of the crystal size average. Comparison of calculated and experimental data favors the view of deformed crystals containing basal defective surface boundaries ('meso-crystals') which yield cooperatively. (Author abstract) 22 refs.

Balta-Calleja, F.J. (CSIC, Madrid, Spain); Kilian, H.G. *Colloid Polym Sci* v 266 n 1 Jan 1988 p 29-34.

**081601 RELATIONSHIP BETWEEN MECHANICAL PROPERTIES AND FIBER STRUCTURE FOR ZONE-DRAWN POLYETHYLENE FIBERS.** Mechanical properties of highly drawn polyethylene fibers produced by a continuous zone-drawing method were studied and related to fiber structure. Young's modulus and tenacity increased linearly with an increase in the



drawing stress and also showed a good linear relationship with the amorphous birefringence. The stress-optical coefficient in amorphous phase depended strongly on the drawing temperature; its value was  $0.5 \text{ GPa}^{-1}$  for the fibers drawn at the temperature above  $115^\circ\text{C}$ . Linkages of the crystalline blocks formed at degrees of crystallinity beyond 77%, and this resulted in the high Young's modulus. Tenacity was dependent mainly on the degree of crystallinity. (Edited author abstract) 21 refs. In Japanese.

Takahashi, Tetsuya (Showa-Denko Co, Kawasaki, Jpn); Tanaka, Toyooki; Kamei, Ryosuke; Okui, Norimasa; Takahiro, Masahiko; Umemoto, Susumu; Sakai, Tetsuya. *Kobunshi Ronbunshu* v 45 n 3 Mar 1988 p 201-207.

**081602 POLIETILENSKE MJESAVINE - MEHANICKA SVOJSTVA I STRUKTURA.** [Polyethylene Mixtures - Mechanical Properties and Structure]. This paper discusses the compatibilities of polymer blends prepared by the melt blending process: low density with high density polyethylene (LDPE/HDPE blends) and low density with medium density polyethylene (LDPE/MDPE blends). The mechanical and dynamic mechanical properties and crystal structure of polyethylene blends have been examined over the whole range of concentrations. The results of mechanical testing have been elaborated and systematized statistically and presented graphically. The results are discussed according to the rule of additivity, while the structural models are discussed in terms of the compatibility of the two systems. The systems behave differently in different concentration ranges: up to 50 percent weight of LDPE the systems are compatible or partially compatible, and over 50 percent weight of LDPE they are incompatible. (Edited author abstract) 26 Refs. In Serbo-Croatian.

Mihovilić, Branko (INA-OKI, Zagreb, Yugosl); Janovic, Zvonimir; Smith, Ivan. *Polimeri (Zagreb)* v 8 n 3 Mar 1988 p 49-54.

**081603 AGEING EFFECTS AND INTERNAL STRESSES IN QUENCHED UNFILLED AND CLAY-FILLED HIGH DENSITY POLYETHYLENE.** The stress relaxation and creep behaviour of high density polyethylene (HDPE), unfilled or filled with clay particles, were measured after different ageing times after quenching from  $120^\circ\text{C}$ . The measurements were performed at room temperature in the uniaxial extension mode. Ageing time had a pronounced influence on the viscoelastic properties, e.g. the creep curves shifted to longer times with increasing ageing time. The internal stresses, as evaluated from stress relaxation data, were found to increase markedly when the ageing period was extended, and it was suggested that this behaviour may be associated with relaxation of thermal residual stresses. It was furthermore suggested that the change in residual stresses, in addition to the physical ageing process, could also affect the ageing behaviour of HDPE, i.e. the change in viscoelastic properties with ageing time. Clay addition changes the ageing behaviour of HDPE, which could be attributed to a change in the internal stress dependence of the ageing time and/or to a difference in the physical ageing process. (Edited author abstract) 27 Refs.

Kubat, J. (Chalmers Univ of Technology, Goteborg, Sweden); Rigdahl, M.; Welander, M. *Colloid Polym Sci* v 266 n 6 Jun 1988 p 509-517.

**081604 DELAYED ELASTIC RECOVERY OF HARDNESS INDENTATIONS IN POLYETHYLENE.** The depth of Vickers microindentations in high density, low density and linear low density polyethylenes has been studied by two-wave interferometry. The evolution of the delayed depth recovery is explained in terms of the Burgers model of viscoelastic behavior. The numerical parameters associated with the model are related to the crystallinity, elastic modulus and yield stress of the polyethylenes studied. (Author abstract) 16 Refs.

Lorenzo, V. (ETS de Ingenieros Industriales, Madrid, Spain); Perena, J.M.; Fatou, J.G.; Mendez-Morales, J.A.; Aznarez, J.A. *J Mater Sci* v 23 n 9 Sep 1988 p 3168-3172.

## Medium Density

**081605 EFFECT OF RESIDUAL STRESS ON CRACK PROPAGATION IN MDPE PIPES.** Crack propagation behavior in single edge notched specimens prepared from medium-density polyethylene (MDPE) pipe is examined under creep condition. The crack grown from an exterior notch (inbound) initiated faster than that grown from an interior notch (outbound). Subsequently, the outbound crack propagated monotonically to ultimate failure. The inbound crack showed anomalous behavior involving two arrest stages prior to ultimate failure. The pipe is found to possess substantial residual stresses. The energy release rate for each case was calculated taking into account the respective residual stress distribution. The fact that the rates of crack propagation are not a unique function of the energy release rate indicates that the fracture is also influenced by morphological gradients imposed by processing conditions. (Author abstract) 24 refs.

Chaoui, K. (Case Western Reserve Univ, Cleveland, OH, USA); Chudnovsky, A.; Moet, A. *J Mater Sci* v 22 n 11 Nov 1987 p 3873-3879.

## Melting

**081606 EFFECT OF ORIENTATION ON MELTING OF POLYETHYLENE.** Uniaxial orientation induced by cold drawing has a marked effect on the properties of crystalline polymers. Not least among these changes are the observed melting points with draw ratio, and the alterations to the crystalline morphology. In the present paper, the effect of uniaxial orientation on the melting point (m.p.) of polymers is discussed in general and applied to polyethylene. The increase in m.p. with orientation is attributed to the increase in configurational entropy of the extended melt into which the crystallite melts. An equation is derived relating the observed m.p. to draw ratio. (Edited author abstract) 10 refs.

Story, E.R. (Univ of Birmingham, Birmingham, Engl); Hay, J.N. *Polym Commun (Guildford Engl)* v 29 n 1 Jan 1988 p 9-10.

**081607 THERMODYNAMIC CHARACTERISTICS OF LAMELLAS AND THEIR SURFACES IN BULK POLYETHYLENE FROM DIFFERENTIAL SCANNING CALORIMETRY DATA.** The melting of specimens of isotropic linear polyethylenes of different MM, crystallized under different conditions, and also of specimens in which the non-ordered component has been removed by etching is studied by differential scanning calorimetry, and the thermodynamic characteristics are compared with the geometrical parameters of the lamellas. The non-ordered component of polyethylene has hardly any effect on its true melting point. The inter-chain cooperative melting parameter corresponding to the thickness of the crystalline core of a lamella is evaluated. It is confirmed that double folds can be formed. (Edited author abstract) 19 refs.

Marikhin, V.A. (USSR Acad of Sciences, USSR); Bershtein, V.A.; Yegorov, V.M.; Myasnikova, L.P. *Polym Sci USSR* v 28 n 9 1986 p 2207-2215.

**081608 CRYSTALLIZATION AND MELTING OF POLYETHYLENE OXIDE IN SYSTEM WITH A JOINTLY CURED DENSELY CROSSLINKED POLYMER.** The calorimetric method has been employed to study the patterns of crystallization and melting of polyethylene oxide in a system with a melamine formaldehyde polymer cured jointly with it. The topology of the spatial densely crosslinked polymer network and chemical binding of the terminal groups of polyethylene oxides were found to have a strong influence on its behavior on crystallization and melting. The sharp difference in the chemical structure of PEO and MF(Melamine Formaldehyde)-polymers ensures phase separation in the MF-PEO systems even for a length of the linear component corresponding to the dimer. The formation of the phase composition in such systems occurs in conditions of the chemical curing reaction at the end of which the disperse phase of the linear component is trapped in the rigid MF

matrix, which determines some aspects of its behavior. 8 refs.

Godovskii, Yu.K. (Karpov Physicochemical Research Inst, USSR); Volegova, I.A. *Polym Sci USSR* v 28 n 10 1986 p 2282-2289.

## Microscopic Examination

**081609 FURTHER ELECTRON MICROSCOPE OBSERVATIONS ON POLYETHYLENE. I. GRANULE STRUCTURE OF THE MELT AS AN ARTIFACT.** There are still two opinions on the fine structure of polymer melts and glasses: (a) that the structure is similarly homogeneous to that in lower molecular weight materials and (b) that the structure shows larger short-range order regions (2-20 nm), which consist of bundled segments of the chain molecules. Whereas opinion a relies more on indirect methods of investigation, opinion b is based mainly on fine granular structures which become visible in electron microscope investigations of surfaces of glassy solidified polymers. Such a fine structure can now be observed directly in a polyethylene melt. However, the structure is exposed as an artifact, so opinion a is supported. (Edited author abstract) 35 refs.

Kanig, G. (BASF Aktiengesellschaft, Ludwigshafen am Rhein, West Ger). *Colloid Polym Sci* v 265 n 10 Oct 1987 p 855-859.

## Microstructure

**081610 EFFECTS OF CONDITIONS OF CHLORINATION ON THE MICROSTRUCTURE OF CHLORINATED POLYETHYLENE.** The microstructure of specimens of polyethylene (PE) chlorinated in solution and suspension are subjected to a comparative study by PMR and IR spectroscopy. The content of methylene groups occupying different positions in the chlorinated polyethylene chain was compared with the theoretically expected values from the course of chlorination in solution and in suspension with respect to the type of 'hindered' substitution reaction. Double substitution at any repeating unit is completely excluded in the case of chlorination in solution. (Author abstract) 14 refs.

Pancheshnikov, R.B. (Bashkirsk State Univ, USSR); Antonova, Ye.D.; Pasti, D.; Marishka, D.; Gershenovich, A.I.; Minsk, K.S. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2813-2818.

Mixing See POLYPROPYLENE—Mixing.

Modification See Also POLYMERS—Blending.

**081611 KEMIJSKE MODIFIKACIJE POLIETILENA.** [Chemical Modifications of Polyethylene]. Polyethylene is one of the most important mass produced plastic materials available in a wide variety of types. Modification makes it even more valuable. Although chemically a paraffinic hydrocarbon chain, it is reactive and suitable for chemical modification. Industrially more important methods of chemical modification, including copolymerization and chemical reactions on ethylene polymers, are reviewed. (Author abstract) 14 refs. In Serbo-Croatian.

Jerman, Marija Biserka (INA-Research & Development, Zagreb, Yugosl). *Polimeri (Zagreb)* v 8 n 9 Sep 1987 p 273-275.

## Molecular Structure

**081612 STRUCTURE AND MOLECULAR MOBILITY OF POLYMER CARRIERS AND METALLOCOMPLEXES BASED ON THEM AS REVEALED BY NMR RELAXATION.** Using NMR pulse methods the authors have studied from the drops in free induction and the relaxation times the structure and molecular mobility of HDPE, polymer carriers based on polyacrylic acid grafted to PE and the metallocomplexes Cu(II), Ni(II) and V(IV) fixed on them in the temperature interval 333-403 K. It was established that the initial PE contains a crystalline and two amorphous phases -



intermediate and surface. Grafting the acid and formation of the metallocomplexes did not change the polymer structure. It is shown that the metallocomplexes form in those loose surface layer of the polymer carrier. (Author abstract). 12 Refs.

Nazarova, I.I. (USSR Acad of Sciences, USSR); Pomogailo, A.D.; Nazarov, V.B.; Baturin, S.M. *Polym Sci USSR* v 29 n 4 1987 p 791-798.

**Molecular Weight** See Also HYDROCARBONS—Crystallization; POLYMERS—Solubility; POLYOLEFINS—Molecular Weight.

**081613 PROPERTIES OF ORIENTED FIBERS OF HIGH-MOLECULAR-WEIGHT POLYETHYLENES.** Fibers with a set of unique properties can be obtained by formation from 2-5% solutions of PE with mol. wt. =  $(1-2) \cdot 10^6$  and subsequent orientational drawing: high tensile strength, including 'unit' strength, a high modulus of elasticity, low compliance, and small changes in length on heating to temperatures  $\leq 140^\circ\text{C}$ . These properties are due to the high orientation of the macromolecules which can be attained in optimum conditions of formation of the initial structure and drawing. 11 refs.

Gorshkova, I.A. (Acad of Sciences of the USSR, Leningrad, USSR); Andreeva, G.N.; Savitskii, A.V.; Frolova, I.L. *Mech Compos Mater* v 23 n 2 Mar-Apr 1987 p 243-246.

## Molten

**081614 TIME-RESOLVED EXPERIMENTS ON THE EXCITON TRANSFER PHENOMENON IN MOLTEN POLYETHYLENE.** The paper presents a time-resolved study of rapid exciton migration in polyethylene (PE) by means of pulse radiolysis and laser photolysis experiments. Despite the high viscosity of molten PE blended with substances such as a phenol, diphenylamine or benzophenone the most important part of the radiation-generated scavenger radicals is formed in times  $< 40$  ns. By comparison with laser photolysis experiments with molten PE and liquid-state pulse radiolysis in alkanes the rapid radical formation is explained in terms of the intramolecular exciton migration with subsequent dissociative transfer to the additive. (Author abstract). 14 Refs.

Brede, Ortwin (Acad of Sciences of the GDR, Leipzig, East Ger); Naumann, Wolfgang. *Radiat Phys Chem* v 32 n 3 1988 p 475-478.

**Morphology** See Also COPOLYMERS—Structure; POLYPROPYLENE—Morphology.

**081615 SPHERULITIC MORPHOLOGY IN POLYETHYLENE AND ISOTACTIC POLYSTYRENE: INFLUENCE OF DIFFUSION OF SEGREGATED SPECIES.** Morphological consequences of a localized diffusion of segregated species at crystal growth fronts have been studied in two specific contexts: (1) variation of texture in spherulites grown in unfractionated polyethylene over a range of crystallization temperatures mostly in regime II, and (2) development of elongated lamellar habits in spherulites of a polymer (isotactic polystyrene) whose native crystal habit is regularly polygonal. In relation to (1) it is shown that, as crystallization temperature is varied, there is a correlation between mean thickness of stacks of lamellae and an averaged diffusion range of segregated molecules of lower molecular weight. It is noted that the lamellar organization appears to be significantly different in polyethylene fractions. In relation to (2) it is shown that principal contributors to the evolution of spherulitic texture from hedritic precursors are fragmentation of lamellae by screw dislocations and radially biased growth under the influence of concentration gradients of segregated species. (Author abstract) 31 refs.

Keith, H.D. (AT&T Bell Lab, Murray Hill, NJ, USA); Padden, F.J. Jr. *J Polym Sci Part B* v 25 n 11 Nov 1987 p 2371-2392.

**081616 MORPHOLOGY AND MECHANICAL**

**PROPERTIES OF POLY(ETHYLENE TEREPHTHALATE)-POLY(HYDROXYBENZOIC ACID) AND POLYCARBONATE BLENDS.** Blends of an engineering plastic; polycarbonate (PC) and a liquid crystalline polymer; random copolymers of the poly(ethylene terephthalate) and the poly(hydroxybenzoic acid) were prepared in an internal mixer. Fibers were extruded from the capillary rheometer and spin-drawn at varying draw ratios. The morphology and the mechanical properties were investigated by DSC, SEM, polarizing optical microscopy, X-ray diffraction, and tensile tests. SEM studies revealed that the liquid crystalline polymer (LCP) formed finely dispersed spherical domains with a diameter of 0.2-2.0 micron in the PC matrix and the inclusions were deformed from the spherical droplets to fibrils as the draw ratio increased. (Edited author abstract) 18 refs.

Jung, Sang Hoon (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Kim, Sung Chul. *Polym J* v 20 n 1 1988 p 73-81.

**081617 MOLECULAR SEGREGATION AND NUCLEATION OF POLY(ethylene OXIDE) CRYSTALLIZED FROM THE MELT. III. MORPHOLOGICAL STUDY.** Solvent extraction followed by DSC, optical microscopy, and transmission electron microscopy show morphological evidence of molecular segregation for binary mixtures of poly(ethylene oxides) (PEO). Two segregation types, namely microscopic and macroscopic segregation, have been found. A special etching method for PEO has been developed, and the crystalline textures of bulk samples crystallized at different temperatures for different molecular-mass mixtures are reported. A linkage between optical and electron microscopy is suggested. The morphology of PEO binary mixtures is crystallization-temperature and molecular-mass dependent. (Author abstract). 20 Refs.

Cheng, Stephen Z.D. (Rensselaer Polytechnic, Troy, NY, USA); Bu, H.S.; Wunderlich, Bernhard. *J Polym Sci Part B* v 26 n 9 Aug 20 1988 p 1947-1964.

## Optical Properties

**081618 COMPARISON OF THE OPTICAL PROPERTIES OF ELECTRON-IRRADIATED AND THERMALLY-TREATED POLYETHYLENE.** The authors examine the optical properties of electron-irradiated and thermally-treated LDPE, UV and IR spectroscopy and luminescence have shown that on electron irradiation and thermal treatment of PE the processes of formation of the oxygen-containing groupings and conjugated bonds take a different course. Thermal treatment of PE leads to more profound changes in the polymer structure. (Edited author abstract). 12 Refs.

Bogdan, L.S. (Shevchenko State Univ, Kiev, USSR); Lisovenko, V.A.; Pas'ko, S.P.; Sandul, G.A. *Polym Sci USSR* v 29 n 4 1987 p 785-790.

**Oxidation** See Also COATINGS—Adhesion; TEXTILES—Aging.

**081619 DIELECTRIC STUDY OF OXIDATION IN THE AMORPHOUS AND CRYSTALLINE REGIONS OF LOW DENSITY POLYETHYLENE WITH ANTIOXIDANT.** The effect of antioxidant on oxidation both in the amorphous and crystalline regions of low density polyethylene (PE) was investigated. Degradation was carried out by oxidation using thermal aging below the melting point of PE subsequent to  $\gamma$ -irradiation. Dielectric measurement was carried out to compare the oxidation in the amorphous region and that in the crystalline. It was found that the antioxidants had little effect on oxidation in the crystalline region, though the oxidation in the amorphous region was suppressed by antioxidant. This is interpreted in terms of dispersion of the antioxidant in PE, which is suggested by DTA study. (Edited author abstract) 11 refs.

Iida, Kazuo (Mie Univ, Tsu, Jpn); Nakamura, Shuhei; Ieda, Masayuki; Ito, Kazumi; Sawa, Goro. *Polym J* v 19 n 8 1987 p 905-913.

**081620 NEW APPROACH TO THE MEASUREMENT OF POLYMER PHOTOOXIDATION.** In an attempt to eradicate many of the problems associated with outdoor and accelerated testing of polymeric formulations, an apparatus was constructed for the sensitive measurement of oxygen uptake into a polymer during its incipient stages of photooxidation. The photooxidation curves of certain HDPE and LDPE formulations demonstrate a first order asymptotic approach to a limiting value which corresponds to the initial number of reactive centers that are available in the material for oxygen attack. An equation for oxygen uptake as a function of time is derived which incorporates the asymptotic value together with a constant whose value reflects the rate at which the asymptote is approached. (Edited author abstract) 40 refs.

Bigger, S.W. (Univ of Melbourne, Parkville, Aust); Delatycki, O. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3311-3323.

**081621 OXIDATION OF SOLID POLYETHYLENE FILMS: EFFECTS OF BACKBONE BRANCHING.** The oxidation rates and product distribution of a series of linear and branched polyethylene films have been studied when initiated by  $\gamma$ -irradiation. Branch groups in laboratory-synthesized samples ranged from ethyl to  $\text{C}_{16}$ -H<sub>33</sub> - and were at levels comparable with those found in commercial linear-low and low-density polyethylenes. In the complete absence of stabilizers and at the controlled rates of radical formation possible with  $\gamma$ -irradiation, all of the polyethylene samples oxidized at essentially the same rate to give the same mixture and distribution of products. (Edited author abstract) 29 refs.

Carlsson, D.J. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Bazan, G.; Chmela, S.; Wiles, D.M.; Russel, K.E. *Polym Degradation Stab* v 19 n 3 1987 p 195-206.

**081622 POLY(ETHYLENE OXIDE) DERIVATIVES WITH SEMIACETAL GROUPS.** Reaction products have been analyzed that result from oxidation at ambient temperature of terminal hydroxyl groups of poly(ethylene oxides) differing in molar mass by the mixture dicyclohexylcarbodiimide, dimethylsulphoxide, and o-phosphoric acid in  $\text{CHCl}_3$  or  $\text{CCl}_4$  (Pfitzner-Moffatt reaction). Depending on polymer concentration the reaction proceeds either as intermolecular condensation or results in cyclic semiacetals being formed intramolecularly. The cyclic structure of the latter was proved by GPC and by chemical cleavage of the semiacetal group. (Edited author abstract) 11 refs.

Topchieva, I.N. (M.V. Lomonosov Moscow State Univ, USSR); Romanova, V.S.; Kuzayev, A.I.; Zubov, V.P. *Polym Sci USSR* v 28 n 8 1986 p 1958-1964.

**081623 STUDY OF THE CHANGE OF CRYSTALLINITY OF POLYETHYLENE ON OXIDATION BY INVERSE PHASE GAS CHROMATOGRAPHY.** Inverse-phase gas chromatography has been used for monitoring the oxidative degradation of low density polyethylene, which has great industrial importance. Polyethylene was oxidized in a gas chromatographic column at  $145^\circ\text{C}$  with an oxygen flow of 10 mL/min for different periods. After oxidation for a specified period, the crystallinity and solvent interaction parameters were monitored. For crystallinity studies, the solvent probe was n-decane, and for solvent interaction these were n-decane, o-xylene, n-butanol, and n-butyl acetate. With oxidation, there was a gradual fall in crystallinity, and after 15 h the crystallinity was practically nil. Total loss of crystallinity also occurred at  $175^\circ\text{C}$  with 1 h passage of oxygen. This has also been confirmed by differential scanning calorimetry. The specific retention volumes of polar solvents showed a sharp increase with oxidation. The results, which are different from that reported in the literature, have been explained. (Author abstract) 13 refs.

Sen, A.K. (Defence Materials and Stores Research Development Establishment, Kanpur, India); Ramesh Kumar. *J Appl Polym Sci* v 36 n 1 Jun 20 1988 p 205-213.



**081624 SURFACE AND BULK OXIDATION OF LOW-DENSITY POLYETHYLENE UNDER UV-IRRADIATION.** The bulk and surface effects of UV-irradiation are compared in relation to oxidative degradation in blow-extruded films of low-density polyethylene. These studies were carried out using transmission and reflectance infrared spectrophotometry films of different thickness and ATR prisms of different incident angles were used. The results indicate that at the very beginning of the reaction the concentration of oxidation products is higher in the bulk of the films than on the upper surface layer penetrated by the infrared beam. With increase of irradiation time the situation is reversed, with an increase of oxidation product concentration on the surface. These results are in contrast to the generally accepted idea that photo-oxidation phenomena are restricted to a thin surface layer of polymers. (Author abstract). 11 Refs.

Giesse, Ralf (Univ Estadual de Campinas, Campinas, Brazil); De Paoli, Marco. *Polym Degradation Stab* v 21 n 2 1988 p 181-187.

**081625 INFLUENCE OF NON-IONIC NITROGEN CONTAINING ANTI-STATIC AGENTS (TENSIDES) ON THE OXIDATIVE STABILITY OF POLYETHYLENE. PART IV. THE INFLUENCE OF TENSIDES ON THE WEATHERING OF POLYETHYLENE FILM.** The influence of non-ionic alkylamide and alkylamine tensides on the weathering of films made from both additive-free and stabilized low density polyethylene (LDPE) has been studied. The results of our previous studies carried out in the liquid phase apply also to the solid polymer. Alkylamide tenside accelerates PE degradation whereas alkylamine tenside shows a favourable effect. (Author abstract). 8 Refs.

Porubska, M. (Plastics Processing & Application Research Inst, Nitra, Czech); Krb, R.; Welnitz, L. *Polym Degradation Stab* v 21 n 3 1988 p 191-204.

**081626 OXIDATION BEHAVIOR OF HIGH STRENGTH CHAIN-EXTENDED POLYETHYLENE FIBERS.** The resistance of oxidation of polyethylene fiber intended for engineering applications has been compared with that of conventional polyethylene films. The highly ordered fiber was appreciably more resistant to  $\gamma$ -initiated oxidation and somewhat more resistant to photo-oxidation. Oxidation products from the  $\gamma$ -initiated oxidation were highly ordered with respect to the fiber axis as shown by polarized infrared spectroscopy. Photo-oxidation products showed random orientation, possibly as a result of the more extensive chain scission and that must accompany the photo-process. Despite the higher resistance of  $\gamma$ -radiation damage of the chain-extended fiber structure as compared to unoriented film, the irradiated fiber did show a slow post-irradiation oxidation. (Author abstract). 17 Refs.

Carlsson, D.J. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Colin, G.; Chmela, S.; Wiles, D.M. *Text Res J* v 58 n 9 Sep 1988 p 520-526.

**081627 RECONSTRUCTION OF THE INTERFACE OF OXIDATIVELY FUNCTIONALIZED POLYETHYLENE AND DERIVATIVES ON HEATING.** Oxidation of low-density polyethylene film with aqueous chromic acid results in a material having hydrophilic carboxylic acid and ketone groups in a thin oxidatively functionalized interface. This interface is indefinitely stable at room temperature. On heating under vacuum, it rapidly becomes hydrophobic and similar in its wettability to unfunctionalized polyethylene film. The progression of the contact angle with water from the initial value to the final value follows kinetics that suggest that the polar functional groups disappear from the interface by diffusion. The magnitude of the apparent diffusion constant derived from these studies can be described approximately by an Arrhenius equation over a significant portion of the temperature range explored, with an Arrhenius activation energy of diffusion of  $\approx 50$  kcal/mol. Comparison of the properties of interfaces composed of carboxylic acid groups with those containing other species demonstrates that the structure of the interfacial groups also significantly influences the rate of reconstruction.

(Edited author abstract) 38 refs.

Holmes-Farley, Stephen Randall (Harvard Univ, Cambridge, MA, USA); Reamey, Robert H.; Nuzzo, Ralph; McCarthy, Thomas J.; Whitesides, George M. *Langmuir* v 3 n 5 Sep-Oct 1987 p 799-815.

## Phase Transitions

**081628 GLASS TRANSITION AND MELTING BEHAVIOR OF POLY(ETHYLENE-2,6-NAPHTHALENEDICARBOXYLATE).** On the basis of thermal analysis the heat capacities of both solid (230-350 K) and liquid (390-600 K) poly(ethylene-2,6-naphthalenedicarboxylate) (PEN) have been established by measurements on over 30 samples. The heat capacity of the solid is structure-independent to 300 K. Between 300 and 390 K, a pre-glass transition increase in heat capacity is observed for the amorphous samples of the polymer. Above the glass transition temperature (390 K), poorly crystallized PEN shows a rigid-amorphous fraction (up to 0.2). The rigid-amorphous fraction starts to gain mobility at about 430 K and reaches zero after melting of the low melting fraction of the polymer. The glass transition temperature on cooling changes logarithmically. The hysteresis of amorphous samples has been analyzed. The crystallization range was studied from 450 to 530 K by crystallizing on cooling from the melt and heating from the glass. (Edited author abstract) 26 refs.

Cheng, Stephen Z.D. (Rensselaer Polytechnic Inst, Troy, NY, USA); Wunderlich, Bernhard. *Macromolecules* v 21 n 3 Mar 1988 p 789-797.

## Photochemical Reactions

**081629 EFFECTS OF ELONGATION ON THE PHOTOCHEMISTRY OF POLY[ETHYLENE-co(CARBON MONOXIDE)].** Films of poly[ethylene-co(carbon monoxide)], P(E/CO), were cold drawn to various extensions. IR dichroism measurements showed that the molecular chains in the amorphous region were oriented along the direction of drawing. After UV irradiation the percent crystallinity and average crystallite size, as determined by X-ray diffractometry, increased for both undrawn and drawn samples. Also, the orthorhombic form in drawn samples increased at the expense of the monoclinic form during UV exposure. The formation of vinyl end groups increased with exposure and with extent of elongation as determined by IR spectroscopy, while the formation of acetyl end groups was strongly suppressed by orientation as determined by NMR spectroscopy. (Edited author abstract) 27 refs.

Gooden, Robert (AT&T Bell Lab, Murray Hill, NJ, USA); Davis, Don D.; Hellman, Molly Y.; Lovinger, Andrew J.; Winslow, Field H. *Macromolecules* v 21 n 5 May 1988 p 1212-1217.

## Physical Properties See Also GAS PIPELINES—Plastics Applications.

**081630 PHYSICAL PROPERTIES OF THE SYSTEM POLY(ETHYLENE OXIDE)-RESORCINOL.** Physical properties of the system poly(ethylene oxide)-resorcinol have been investigated by X-ray diffraction, small-angle light scattering, polarization microscopy with crossed Nicols, and differential scanning calorimetry. Formation of a molecular complex is accompanied by changes in the crystalline and supermolecular spherulitic structure. Temperatures and heats of phase transformations have been determined. (Author abstract) 13 refs.

Skazka, V.S.; Nikolayev, V.Ya.; Bekturov, Ye.A.; Kudabergenov, S.; Petrenko, K.D.; Privalko, V.P. *Polym Sci USSR* v 28 n 9 1986 p 2128-2135.

**081631 LOW-DENSITY POLYETHYLENE DEPTH PROFILE ANALYSIS BY PHOTOACOUSTIC SPECTROSCOPY.** Near-infrared photoacoustic spectra of polyethylene (1 mm slab) were taken in the modulation range 10-240 Hz, which corresponds to thermal diffusion layers in the 56-11  $\mu$ m range. Thick-layer spectra are very similar to polyethylene film transmission

spectra, but large differences are observed between the spectra taken at various modulation frequencies. The analysis of spectral intensity as a function of modulation frequency shows that peak intensity ratios of  $-\text{CH}_3$ ,  $=\text{CH}_2$ , and  $-\text{OH}$  groups, relative to that of methylene groups, increase as thinner, closer-to-surface polymer layers are sampled. From this we conclude that near-to-surface layers of solid polyethylene are richer in  $-\text{CH}_3$ ,  $=\text{CH}_2$  and  $-\text{OH}$  groups than the polymer bulk. (Edited author abstract) 42 refs.

Ganzarolli de Oliveira, Marcelo (Univ Estadual de Campinas, Campinas, Brazil); Pessoa, Osvaldo Jr.; Vargas, Helion; Galembeck, Fernando. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1791-1802.

**081632 AMORPHOUS ORIENTATION IN ZONE-DRAWN POLYETHYLENE FIBERS.** The amorphous orientation in highly drawn polyethylene fibers produced by a continuous zone-drawing method was studied by birefringence, X-ray and infrared measurements. Birefringence of the highly-drawn fibers exceeded the intrinsic birefringence of the crystals. Birefringence of the amorphous phase increased with the draw ratio, the ultimate value was 0.10. But birefringence of the crystalline phase remained at the constant value of the almost perfect orientation, 0.057. The reciprocal of amorphous birefringence was directly proportional to the value of the draw ratio squared. The extrapolated value according to the above relationship was found to be 0.21 for the intrinsic amorphous birefringence. A model of deformation mechanism in the zone-drawing process was proposed on the basis of shear or sliding deformation between the chain folded ribbons (interribbon unfolding) and within the chain folded ribbons (intraribbon unfolding). (Edited author abstract) 19 refs. In Japanese.

Takahashi, Tetsuya (Showa-Denko Co, Kawasaki, Jpn); Tanaka, Toyooki; Kamei, Ryouosuke; Okui, Norimasa; Takahiro, Masahiko; Umemoto, Susumu; Sakai, Tetsuya. *Kobunshi Ronbunshu* v 45 n 3 Mar 1988 p 209-213.

**081633 MEMORY OF SUPERSTRUCTURE OF DRAWN ULTRA-HIGH MOLECULAR WEIGHT POLYETHYLENE.** Ultra-high molecular weight polyethylene (UHMWPE) was drawn at 120°C and cooled to room temperature. The samples were annealed at various temperatures above the melting point at constant length. The superstructure which appeared when samples were cooled from the melt state was studied by small- and wide-angle X-ray analyses. The sample which had the highest molecular weight showed the strongest memory of structure even when it was kept in the melted state for a long time. But the samples with lower molecular weights did not show the memory so much. In general, the higher the temperature, the longer the treating time, and the lower the molecular weight of sample, the less the memory of structure was. The memory thus depended on the molecular weight of the samples. This memory could be attributed to the degree of entanglements in the amorphous molecular chains and to the tie molecules between fibrils formed in the sample before annealing. (Edited author abstract) 6 refs. In Japanese.

Sakurai, Kensuke (Fukui Univ, Fukui, Jpn); Hayakawa, Kooji; Takahashi, Toshisada. *Kobunshi Ronbunshu* v 45 n 2 1988 p 155-160.

## Polymerization See POLYOLEFINS—Crosslinking.

## Processing

**081634 PROCESSING OF ULTRAHIGH MOLECULAR WEIGHT POLYETHYLENE.** The extent of recrystallization of nascent UHMWPE power is easily measured by calorimetry. Melting and recrystallization of nascent UHMWPE at 140°C can be suppressed by compression molding. Crystals of UHMWPE prepared from dilute solution show a peak melting temperature of 140°C and exhibit crystallinity up to 75.5% depending on crystallization temperature. Large changes in crystallinity result from drawing single crystal mats or compression-molded films. (Author abstract) 14 refs.



Wang, Xi-You (Univ of Southern California, Los Angeles, CA, USA); Li, Sheng-Ying; Salovey, R. *J Appl Polym Sci* v 35 n 8 Jun 1988 p 2165-2171.

**081635 DRAWING-INDUCED CHANGES IN THE PROPERTIES OF POLYETHYLENE FIBERS PREPARED BY GELATION/CRYSTALLIZATION.** Fibers of ultrahigh molecular weight polyethylene were prepared by drawing dry specimens obtained by gelation/crystallization from solution. The maximum draw ratio ( $\lambda$ ) attained was 250. The properties of the fibers were assessed by measurements of density, birefringence, differential scanning calorimetry, infrared dichroism, sonic velocity, and dynamic modulus. The results have been analyzed in terms of a two-phase model of crystalline and amorphous regions. All properties approach a limiting value at a draw ratio of about 100. The degree of crystallinity and melting point decrease initially (for  $\lambda < 12$ ) and then increase rapidly with  $\lambda$  up to their limiting values. (Edited author abstract) 35 refs.

Anandakumaran, K. (McGill Univ, Montreal, Que, Can); Roy, S.K.; Manley, R. St. John. *Macromolecules* v 21 n 6 Jun 1988 p 1746-1751.

**081636 SCREW DESIGN IMPROVEMENTS FOR UNFILLED CROSS LINK POLYETHYLENE.** Over the last 10 years or more there has been no improvement seen in screw performance for the processing of crosslinkable polyethylenes like Union Carbide's HFDE 4201 and the newer-4202 material. This paper will give the results of the studies done with these popular materials. It will include performances as compared to the typical conventional mixing screws with respect to output rate, extrusion stability, melt temperature level, power usage and melt quality.

Steward, Edward L. (Davis-Standard Div). *Fastener Age* v 2 n 3 May-Jun 1988 p 35-37, 40.

**Radiation Effects** See Also NEUTRONS—Transport Properties; POLYMERS—Aging.

**081637 VISCOELASTIC BEHAVIOUR OF STABILIZED POLYETHYLENES IRRADIATED WITH GAMMA RAYS.** Two-cycle creep recovery penetration measurements at 150°C are used to determine the viscoelastic parameters for irradiated low density and linear low density polyethylenes, pure and with 0.5% antioxidant. The amplitudes and the time factors of each cycle are calculated using the mechanical model expression. From the differences between the creep parameters of the first and the second cycle, the contribution of the nonelastic component is considered. The efficiency of radiation crosslinking of different systems is discussed on the base of the corresponding compliances. (Author abstract) 6 refs.

Novakovic, Lj. ('Boris Kidric' Inst of Nuclear Sciences, Belgrade, Yugosl); Gal, O.; Stannett, V.T. *Radiat Phys Chem* v 30 n 2 1987 p 113-118.

**081638 CHARGE TRANSPORT IN IRRADIATED LOW-DENSITY POLYETHYLENE.** A study has been made of the remanent effects of nuclear radiation on charge transport in additive-free low-density polyethylene (LDPE) at 323 K. It was found that irradiation increased the conductivity of LDPE, with pure gamma radiation having a greater effect for a given absorbed dose than the mixed radiation of a thermal nuclear reactor. This increase in conductivity may be ascribed to an increase in trap density based on a trap-hopping conduction model. The measured current density also appears to be a function of  $F/n+1$ , where F is the applied field and n a positive number. (Author abstract) 16 refs.

Banford, H.M. (Scottish Univ Research & Reactor Cent, Glasgow, Scot); Frame, R.I.; Siew, W.H.; Tedford, D.J. *IEE Proc Part A* v 134 n 9 Nov 1987 p 727-730.

**081639 MAGNETIC RESONANCE STUDIES ON CROSS-LINKS IN POLYETHYLENE AND ITS MODEL COMPOUND.** Difference in mobility was detected between the  $\gamma$ -irradiated and neutron-irradiated

eicosane by analysis of ESR spectra obtained by the spin-trapping method. Three kinds of cross-linked dimers were found by FI mass spectroscopy: saturated cross-linked dimers, cross-linked dimers having either one double bond or two. The relative intensities of these dimers were also different between the  $\gamma$  and neutron irradiated ones.  $^{13}\text{C}$ -NMR spectra were observed from the cross-linked n-eicosane.  $\text{CH}_2$  peaks in the NMR spectrum were clearly distinguished from others by the INEPT method. The analysis of the NMR spectra indicated that the majority of the cross-links formed were the H-type.  $^{13}\text{C}$ -NMR of irradiated PE obtained by the CP-MAS method was also discussed. (Edited author abstract) 5 refs.

Tabat, M. (Hokkaido Univ, Sapporo, Jpn); Sohma, J.; Yang, W.; Yokota, K.; Yamaoka, H.; Matsuyama, T. *Radiat Phys Chem* v 30 n 3 1987 p 147-149.

**081640 EFFECT OF DOSE ON CREEP AND RECOVERY OF POLYETHYLENE.** The effect of high energy radiation on polyethylene is to crosslink it, and connect it into an elastic network above the melting point. In this paper the creep and recovery properties of a stabilized polyethylene subjected to doses from 100 to 870 kGy are measured at 150°C. Two cycles are measured - Creep I + Recovery I, and Creep II + Recovery II - mainly over period of 20 min. The creep or recovery behavior falls into three steps - immediate, fast and slow, and data are given for these steps together with the time parameter. The first cycle includes a non-recoverable creep which is almost absent in the second cycle. (Author abstract) 6 refs.

Novakovic, Lj. ('Boris Kidric' Inst of Nuclear Sciences, Belgrade, Yugosl); Gal, O.; Charlesby, A.; Stannett, V.T. *Radiat Phys Chem* v 30 n 3 1987 p 177-182.

**081641 INFLUENCE OF THE NATURE OF LIQUID MEDIA ON THE MECHANICAL PROPERTIES OF IRRADIATED FILLED POLYETHYLENE.** In connection with the increase in heterogeneity of the modified polyethylene, evaluation of the stability of the acquired properties under conditions approaching service, under the combined action of liquid media and mechanical loads, was investigated. Type 15803-020 high-pressure polyethylene was used for the investigation. The fillers were highly dispersed silicon dioxide  $\text{SiO}_2$  (type A-175 aerosol) and titanium dioxide ( $\text{TiO}_2$ ) of the rutile form. The strength and deformation properties in tension of the modified polyethylene were investigated on a tensile machine in water, normal alcohols, dioxane and carbon tetrachloride. Modification of polyethylene by filling and ionizing radiation provides a positive result under conditions of the action of adsorption-active liquid media characterized by low solubility in the polymer (alcohols, dioxane). 5 refs.

Grigor'ev, V.I. (Acad of Sciences of the USSR, Lvov, USSR); Gordienko, V.P. *Sov Mater Sci* v 23 n 3 May-Jun 1987 p 308-311.

**081642 FEATURES OF STRUCTURAL CONVERSIONS IN ORIENTED POLYETHYLENE AS A RESULT OF EXPOSURE TO IONIZING RADIATION.** The features of structural conversions in oriented samples of high density polyethylenes following irradiation at 20 and 100°C have been investigated. The character of the change in the structural parameters suggest that in oriented polyethylene radiation degradation makes a considerably greater contribution than in the non-oriented polymer. A possible reason for the effect observed is the presence of a large number of stressed communicating molecules in the amorphous phase. (Author abstract) 19 refs.

Abramova, I.M. ('Plastmassy' Science-Production Assoc, USSR); Kazaryan, I.G.; Vatagina, V.A.; Vasil'ev, V.A.; Tikhomirov, V.S. *Polym Sci USSR* v 28 n 10 1986 p 2239-2245.

**081643  $\gamma$ -IRRADIATION OF POLYETHYLENE STUDIED BY POSITRON ANNIHILATION.** Investigations were performed on polyethylene of about 170 mg  $\text{cm}^{-2}$  thickness. The equipment used for  $\gamma$ -irradiation in

air was either a  $^{60}\text{Co}$  source or irradiated fuel elements with dose rates of 0.1 and 12.5 kGy  $\text{h}^{-1}$ , respectively, up to doses of 1000 kGy. For positron lifetime measurements a conventional fast-slow coincidence circuit was used with a time resolution of 350 ps (FWHM) for  $^{22}\text{Na}$  energy windows. It was possible to describe the distinguishable influence of dose and dose rate by logarithmic functions. 9 refs.

Brauer, G. (Acad of Sciences of the GDR, Dresden, East Ger); Hertle, W.; Balogh, A.G. *Phys Status Solidi A* v 105 n 1 Jan 1988 p K7-K12.

**081644 DSC OF  $\gamma$ -IRRADIATED ULTRA-HIGH MOLECULAR WEIGHT POLYETHYLENE AND HIGH DENSITY POLYETHYLENE OF NORMAL MOLECULAR WEIGHT.** The melting and the crystallization of  $\gamma$ -irradiated (doses: 0-6 Mrad) ultra-high molecular weight nascent polyethylene (UHMWPE) and high density nascent polyethylene with normal molecular weight (NMWPE) were investigated by DSC (differential scanning calorimetry). The heat of melting of the nascent UHMWPE (DSC degree of crystallinity, respectively) increases up to a dose of 3 Mrad, after which it slightly decreases. The heat of the second melting of UHMWPE and of the first and second melting of NMWPE increases slightly up to a dose of 3 Mrad, after which it does not change. The X-ray degree of crystallinity of the nascent non-irradiated and irradiated polymers was  $0.62 \pm 0.02$ . The calorimetric crystallinity was compared to the X-ray one. The results show that radiation does not affect the polymer crystallinity, but influences the thermodynamic heat of melting. (Edited author abstract) 19 refs.

Minkova, L. (Bulgarian Acad of Science, Sofia, Bulg). *Colloid Polym Sci* v 266 n 1 Jan 1988 p 6-10.

**081645 NETWORK PROPERTIES OF MIXTURES OF PROTONATED AND DEUTERATED POLYETHYLENE.** Mixtures of protonated and deuterated polyethylene were irradiated in the melt. The degree of crystallinity, the degree of crosslinking, as well as the enthalpy and the melting point were determined. No significant differences in the degree of crosslinking between protonated and deuterated chains were found. The mass specific entropy of the uncrosslinked samples remained constant and independent of the deuterium concentration. For the crosslinked samples, a netpoint entropy was postulated. A weaker Van der Waals interaction could explain the decrease in melting temperature by deuteration (for weakly crosslinked samples). (Author abstract) 11 refs.

Kreitmeier, S. (Univ Regensburg, Regensburg, West Ger); Goeritz, D. *Colloid Polym Sci* v 266 n 3 Mar 1988 p 235-240.

**081646 MOEGELICHKEITEN EINER ECHTZEIT-KONSISTENZANALYSE ZUR STRAHLENEXPOSITION VON POLYETHYLEN.** [Possibilities of a Real-time State-of-Matter Analysis during Irradiation of Polyethylene]. Plastics used in nuclear engineering applications are subject to special radiation-resistance requirements. The effects of high energy radiation on material characteristics are studied, and a procedure, independent of time of exposure, is suggested that allows predictions to be made about the effect of radiation on polyethylene. From this, the possibilities of a real-time state-of-matter analysis and the reliable prediction of the utility of polyethylene in nuclear engineering practice are developed. (Author abstract) 12 refs. In German and English.

Brauer, Gerhard (Technischen Univ Dresden, Dresden, East Ger); Hertle, Wolfgang. *Kunstst Ger Plast* v 78 n 5 May 1988 p 424-426.

**081647  $^{13}\text{C}$  CP-MAS NMR STUDY OF IRRADIATED POLYETHYLENE.** Solid-state  $^{13}\text{C}$ -NMR was used to analyze several polyethylene samples, irradiated at room temperature with gamma rays in vacuum or with electrons in air up to a maximum dose of 200 Mrad. The



main observed events were the formation of methyl ends and interior double bonds (vinylenes), as well as the disappearance of the initial vinyl ends. No signals associated with 'H' or 'Y' crosslinks were found in any of the samples. The partitioning of methyl ends and interior vinylenes between the crystalline and noncrystalline regions was determined only for the irradiated ultrahigh-molecular-weight polyethylene (UHMWPE) samples. Although concentration of methyl ends in the crystalline regions was approximately half that in the noncrystalline regions, the vinylenes had very similar concentrations in the two phases. Although some evidence for both cis and trans vinylenes appears in the spectrum of the noncrystalline regions, only one configuration (trans) seems to exist in the crystalline regions. (Edited author abstract). 37 Refs.

Perez, E. (NBS, Gaithersburg, MD, USA); Vanderhart, D.L. *J Polym Sci Part B* v 26 n 9 Aug 20 1988 p 1979-1993.

**081648 CROSSLINKING OF POLYETHYLENE IRRADIATED IN A MULTILAYER SYSTEM.** Polyethylene films characterized by different thickness and crosslinking efficiencies were irradiated with 1.5 mev electrons at an average current density of 0.016 ma/cm<sup>2</sup>. The samples were in the form of film stacks with or without distance supports between the polymer layers. Some of the samples were irradiated in an N<sub>2</sub> atmosphere. The absorbed dose in a given polymer layer was estimated from the gel content. From the dose-gel dependence estimated for each polymer layer and the dose-depth dependence based on the literature data, the gel-depth and dose-depth curves were plotted. From the comparison of these curves with experimental data, it was concluded that the absorbed dose depends on the polymer film thickness and the presence or absence of the gas phase between polymer layers. (Edited author abstract). 10 Refs.

Jaworska, E. (Inst of Nuclear Chemistry & Technology, Warsaw, Pol); Piskorz, W. *Radiat Phys Chem* v 32 n 5 1988 p 715-718.

**081649 INFLUENCE OF IONIZING IRRADIATION IN AIR AND NITROGEN FOR STERILIZATION OF SURGICAL GRADE POLYETHYLENE FOR IMPLANTS.** The influence of the atmosphere and the applied dose during ionizing gamma radiation treatment on selected properties of ultra high molecular weight polyethylene (UHMWPE) have been investigated. A linear correlation between extinction coefficient and applied doses in air from 6 to 125 kGy was found, while oxidation was not linear with irradiation in nitrogen. Bacteria survival rate shows a necessary minimum dose of 15 kGy for assured sterility of the product. Post reaction of latent free radicals in UHMWPE created during irradiation has also been investigated after storage of UHMWPE-films in air and nitrogen at 21°C and in water at body temperature 37°C for up to nine months. Results show that the properties of UHMWPE after radiation-sterilization change depend on time, absorbed dose, atmosphere where irradiation took place and environment of storage. UHMWPE, which mainly crosslinks during irradiation, degrades by an oxidation process after sterilizing when stored in air and even more in water. So irradiation and storage in nitrogen before implantation in the human body is beneficial. (Author abstract) 23 refs.

Streicher, R.M. (Sulzer Brothers, Winterthur, Switz). *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 693-698.

## Reinforcing

**081650 INFRARED ANALYSIS AND IZOD IMPACT TESTING OF MULTICOMPONENT POLYMER COMPOSITES: POLYETHYLENE/EPDM/FILLER SYSTEMS.** Various multicomponent polyethylene/rubber/filler composites have been characterized by diffuse reflectance infrared spectroscopy (DRIFT) and notched Izod impact testing. The fillers used were an oxidized silicon powder and calcium carbonate. The rubbers were ethylene propylene diene (EPDM) rubber

and a maleic anhydride grafted EPDM (EPDM-MA). DRIFT is useful for investigating the structure of these multicomponent composites on the molecular level. The Izod impact testing shows that impact properties of both the oxidized silicon powder and calcium carbonate composites are improved by rubber addition. The use of EPDM-MA results in greater improvement than EPDM. (Edited author abstract) 16 refs.

Scott, C. (Case Western Reserve Univ, Cleveland, OH, USA); Ishida, H.; Maurer, F.H.J. *J Mater Sci* v 22 n 11 Nov 1987 p 3963-3973.

## Rheology See Also POLYMERS—Rheology.

**081651 ROLE OF SLIP ADDITIVES IN BLOWN FILM EXTRUSION OF LOW DENSITY POLYETHYLENES.** Slip additives are low viscosity additives, which are compounded to modify the surface properties of polyolefin films and reduce the friction coefficient of the films. In this study, the effects of the slip additives on the rheology of low density polyethylene resins and the mechanical, optical and surface characteristics of blown films were investigated. It is determined that the slip additive remains dispersed in the matrix during flow through the capillaries. At relatively high concentrations the slip additive adversely affects some of the ultimate film properties including tensile strength and haze. (Author abstract) 9 refs.

Kalyon, Dilhan M.; Khemis, Mustapha. *Plast Rubber Process Appl* v 8 n 3 1987 p 157-164.

**081652 RHEOLOGICAL CHARACTERISTICS, THERMODYNAMICS, AND MORPHOLOGIES OF POLYETHYLENE BINARY BLENDS.** Steady and dynamic melt viscoelasticity, thermodynamics and morphologies were investigated for linear/linear, branched/branched and linear/branched polyethylene blends. Elastic parameters such as the first normal stress difference ( $P_{11}-P_{22}$ ) and storage modulus ( $G'$ ) have large positive dependence on blend composition and show much higher values than those calculated from the following mixing rule which is valid for the linear/linear and branched/branched polyethylene blends at a constant shear rate. The deviation from this mixing rule is sensitive to shear rate in case of linear/branched polyethylene blends. The Flory-Huggins interaction parameter which is calculated from melting temperature depression suggests these blends to be miscible. (Edited author abstract) 22 refs.

Hosoda, Satoru (Sumitomo Chemical Co, Ichihara, Jpn); Gotoh, Yuji. *Polym J* v 20 n 1 1988 p 17-30.

**081653 RHEOLOGICAL PROPERTIES OF POLYETHYLENE MELTS FILLED WITH METAL- AND CARBON-FIBER.** The rheological properties under steady shear flow were examined for polyethylene melts filled with one of three metal fibers (two aluminum fibers of different fiber length and a 6-4 brass fiber) or one carbon fiber. For these four kinds of melts, shear stress and viscosity increased with the increase of fiber content and aspect ratio; large changes were found at lower shear rate. Similarly, relative viscosity and yield stress also increased, but the relative viscosity decreased with the increase of shear stress. An empirical equation of the relative viscosity considering fiber volume fraction and average aspect ratio was discussed. The first normal stress difference of the metal fiber dispersed systems became slightly larger than that of polyethylene matrix at a constant shear rate, while the effect of fiber content was extremely small. That of the carbon fiber system, however, increased with the increase of fiber content. (Author abstract) 18 refs. In Japanese.

Sakai, Hiroshi (Industrial Research Inst of Nagano, Nagano, Jpn); Kitano, Takeshi; Nishimura, Tetsuo. *Kobunshi Ronbunshu* v 45 n 2 1988 p 123-131.

**081654 VŠEOBECNÁ TOKOVÁ KRIVKA SEKUNDARNEHO POLYETYLENU.** [General Flow Curve of Secondary Polyethylene]. The article describes a method for establishing a rheograph of a thermoplastic melt, namely that of low density polyethylene. The method,

using a general flow curve, assumes that the melt flow index for various grades of the low density PE at various temperatures is known. The general flow curve created by combining more rheographs into one is shown for the low density PE. The measurements are used to calculate flow curves of secondary low density PE samples. (Author abstract). 9 Refs. In Czech.

Grom, Jan (Vyskumný Ústav Spracovania a Aplikácie Plastičkových Latok, Nitra, Czech); Zajac, Marian; Pinter, Jozef. *Plasty Kauc* v 25 n 5 May 1988 p 148-151.

## Sheet

**081655 SHEAR STRENGTH OF HIGHLY DRAWN LINEAR POLYETHYLENE SHEETS.** The shear strength of highly drawn linear polyethylene (HDLPE) sheets has been measured using sample shapes suggested by the lap joint technique. Several variables were investigated, including different parent polymers, irradiation dose, draw ratio, drawing methods and geometrical parameters. The lap joint theory has been successfully applied to several qualitative aspects of these experiments. (Author abstract) 18 refs.

Ladizesky, N.H. (Univ of Leeds, Leeds, Engl); Ward, I.M. *J Mater Sci* v 23 n 1 Jan 1988 p 72-82.

## Shrinkage

**081656 HEAT SHRINKING BEHAVIOUR OF  $\gamma$ -RADIATION CROSSLINKED POLYETHYLENE.** Heat shrinking material of  $\gamma$ -radiation crosslinked polyethylene is widely used for various application in industry. In this study, DSC, TMA, WAXD and density measurement techniques were used to investigate the influence of MI and thermal history of LDPE on the effectiveness of network formation. Based on the results of heat stretching and heat shrinkage tests, it is found that the formation of a network as perfect as possible is indispensable to the irradiated material if good heat shrinkage property is desired. To this end, quenching technique and polyethylene with appropriate MI must be used so that an effective radiation effect will be obtained with a minimum amount of radiation dose. In spite of that the mechanical property of the irradiated polyethylene in the rubbery state is basically in agreement with the classical expression of the theory of high elasticity, only about 90% shrinkage can be reached. Besides, the heat shrinkage temperature  $T_s$  and the % shrinkage  $S$  are both related to the radiation dose. (Author abstract) 13 refs.

Qi, Yuchen (Acad Sinica, China); Jia, Lianda; Song, Yongxian; Wu, Suyun; Li, Lixia; Chen, Donglin. *Chin J Polym Sci (Engl Ed)* v 6 n 1 1988 p 20-29.

## Solutions

**081657 SOLUTION PROPERTIES OF POLY(ETHYLENE OXIDE) AS DETERMINED BY VISCOMETRIC MEASUREMENTS IN AQUEOUS SALT SOLUTIONS.** The properties of dilute solutions of poly(ethylene oxide)(PEO) in aqueous salt solutions are studied by measurements of intrinsic viscosity in theta and nontheta solvents. The unperturbed dimensions in various salt solutions were found larger than those in pure water. These results are attributed to a change in the polymer hydration sheath, in the gauche-trans equilibrium in the PEO chain in aqueous solutions, and in the water structure because of the added salt. Also, for carboxylic anions, similar behavior is expected due to the interaction of the ether oxygens of PEO with the weak acids through hydrogen bonding. (Edited author abstract) 36 refs.

Ataman, Mualla (Hacettepe Univ, Ankara, Turk). *J Macromol Sci Chem* v A24 n 8 1987 p 967-976.

**081658 INTERPRETATION OF INTRINSIC VISCOSITY/TEMPERATURE DATA FOR SOLUTIONS OF POLY(PHENYL ACRYLATE) AND POLY(ETHYLENE OXIDE).** Measured intrinsic viscosities ( $[\eta]$ ) at several temperatures ( $T$ ) within the interval



280-350 K have been found to increase with T for solutions of poly(phenyl acrylate) (PPA) in ethyl lactate. A decrease of  $[\eta]$  with T was observed for aqueous solutions of poly(ethylene oxide) (PEO) at several temperatures within the range 276-358 K. The results have been treated on the basis of eight excluded volume theories, among which the best consistency was afforded by those of M. Kurata-W.H. Stockmayer-A.J. Roig, M. Fixman, and W.H. Stockmayer. (Edited author abstract) 29 refs.

Gregory, Peter (Univ of Salford, Salford, Engl); Huglin, Malcolm B.; Khorasani, Mohamad K.H.; Sasia, Pedro, M. *Br Polym J* v 20 n 1 1988 p 1-8.

**081659 SEPARATION OF AQUEOUS SOLUTIONS OF POLYETHYLENE GLYCOL BY ULTRAFILTRATION.** Effect of concentration (2.0-60.0 kg/m<sup>3</sup>) of polyethylene glycol with molecular weight 40,000 on the separation of its aqueous solutions by a UAM-500 membrane at pressures of 0-500 kPa is investigated. It is shown experimentally that there is a significant increase in rejection and a decrease in bulk flow on an increase in polymer concentration. It is suggested that the increase in rejection in the investigated pressure range is due principally to leveling of the transmembrane flow orienting the macromolecules. (Author abstract) 7 refs.

Tsapyuk, E.A.; Bryk, M.T. *Sov Prog Chem* v 53 n 8 1987 p 51-53.

**Spectroscopic Analysis** See Also ELECTRIC DISCHARGES—Research.

**081660 INVESTIGATION OF THE EFFECT OF GAMMA-RADIATION ON HIGH-DENSITY POLYETHYLENE BY SOLID-STATE MAGIC-ANGLE <sup>13</sup>C NMR SPECTROSCOPY.** The structural and morphological changes occurring in high-density polyethylene when exposed to gamma-radiation have been investigated by high-resolution solid state <sup>13</sup>C NMR. NMR measurements are used to study the effect of gamma-radiation on crystalline and amorphous components. In addition, resonance peaks due to direct cross-links have been detected. The changes in main chain unsaturation are also studied. (Author abstract) 26 refs.

Cholli, Ashok L. (Case Western Reserve Univ, Cleveland, OH, USA); Ritchey, William M.; Koenig, Jack L. *Appl Spectrosc* v 41 n 8 Nov-Dec 1987 p 1418-1421.

**081661 POLYETHYLENE STRUCTURE IN THE SOLID STATE AS STUDIED BY VARIABLE-TEMPERATURE <sup>13</sup>C CP/MAS nmr SPECTROSCOPY.** High-resolution <sup>13</sup>C nmr spectra of melt-quenched polyethylene sample were measured within the temperature range of -120 to 90°C by means of variable temperature/magic angle spinning technique. Based on these results, the temperature change of polyethylene structure in the solid state was discussed. (Author abstract) 14 refs.

Ando, I. (Tokyo Inst of Technology, Tokyo, Jpn); Yamanobe, T.; Akiyama, S.; Komoto, T.; Sato, H.; Fujito, T.; Deguchi, K.; Imanari, M. *Solid State Commun* v 62 n 11 Jun 1987 p 785-788.

**081662 MEASUREMENT OF THE DEGREE OF CRYSTALLINITY OF POLYETHYLENE WEAR DEBRIS BY MEANS OF RAMAN SPECTROSCOPY.** The Raman spectroscopic method for measuring the degree of crystallinity of polyethylene, developed by Strobl and Hagedorn and by Glotin and Mandelkern, has been applied to the wear debris arising from a continuous dry friction experiment which consisted of friction of high density polyethylene (HDPE) on glass. The analytical method was first tested on two reference HDPE samples having a known degree of crystallinity. The degree of crystallinity of the wear debris is higher than that of the initial non-rubbed material (HDPE,  $M_w = 4 \cdot 10^6$ ). The results are consistent with the conclusions of a previous tribological and rheological study. (Author abstract) 7 refs.

Dothee, Daniel (Ecole Natl Supérieure de Mécanique et des Microtechniques, Besançon, Fr); Berjot, Maurice; Marx, Jean. *Polym Degradation Stab* v 20 n 2 1988 p

149-155.

**081663 CARBON-13 NMR STUDY OF THE SOLID-STATE PHOTOCHEMISTRY OF POLY-(ETHYLENE-co-CARBON MONOXIDE).** The structure of an (E/CO) copolymer (1.4 wt% CO) has been studied by 50.3-MHz carbon-13 NMR spectroscopy. With model compounds, assignments of new structures and previously undetected products of photodegradation and photooxidation in the solid state were made. About 4% of the CO groups were accounted for as ethyl ketones with the remainder being randomly distributed along the polymer backbone chain. Evidence is presented for the formation of cis, trans-cyclobutanols, which have not been detected previously in the solid-state irradiation of ketone-containing polymers. A novel  $\alpha$ -branched ketonic structure was also found. (Edited author abstract) 40 refs.

Bovey, Frank A. (AT&T Bell Lab, Murray Hill, NJ, USA); Gooden, Robert; Schilling, Frederic C.; Winslow, Field H. *Macromolecules* v 21 n 4 Apr 1988 p 938-944.

**081664 EFFECT OF POST-IRRADIATION STORAGE CONDITION ON THERMOLUMINESCENCE FROM ULTRA-HIGH MOLECULAR WEIGHT POLYETHYLENE.** The effect of post-irradiation storage conditions such as liquid nitrogen (LN), saline solution at 37°C, and a dry atmosphere at RT on thermoluminescence (TL) from ultra-high molecular weight polyethylene (UHMWPE) has been investigated. A broad TL glow curve with peaks near 140 and 220°C was observed from the samples stored in LN. In the TL from the samples stored in saline solution or a dry atmosphere, the 140°C peak disappeared and a new peak near 240°C appeared. Electron spin resonance (ESR) measurements suggest that oxygen diffusion and subsequent quenching of free radicals (alkyl type) are the major cause of the disappearance of the 140°C peak, and that the thermal decay of the more stable free radicals (allyl type) produces glow peaks near 220 and 240°C. (Author abstract) 3 refs.

Jahan, M.S. (Memphis State Univ, Memphis, TN, USA); Tessema, G.X.; Campbell, B.W.; Davidson, J.A.; Schwartz, G. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 242-243.

## Stability

**081665 STABILIZATION OF SELF-EXTINGUISHING TALC-FILLED POLYETHYLENE.** The investigation was carried out on a filled composition of 115-73 base type consisting of the following components (mass %): low-density polyethylene (LDPE) type 12002—200, 70; talc filler type A, grade 1, 20; fireproofing agents (antimony oxide + chlorinated paraffin), 5 of each. The following substances were introduced as stabilizers into the filled compositions: Tinuvin 326 (5-chloro-2-(3-hydroxy-3-tert-butyl-methylphenyl) benzotriazole) and 'oxaphenamide' (p-hydroxyphenylsalicylamide). Experiments show that the optimal stabilizer concentration, found by mathematical design of experiments ensures protection of talc-filled self-extinguishing LDPE during aging. The action of the mixture is not additive in comparison with the individual stabilizers. 7 refs.

Razen'kov, V.I. (S.M. Kirov Byelorussian Polytechnic Inst, USSR); Revyako, M.M.; Lukin, D.M.; Sokolov, A.N. *J Appl Chem USSR* v 59 n 7 pt 2 Jul 1986 p 1535-1537.

**081666 INFLUENCE OF NON-IONIC NITROGEN CONTAINING ANTI-STATIC AGENTS (TENSIDES) ON THE OXIDATIVE STABILITY OF POLYETHYLENE: PART II - INTERACTION BETWEEN TENSIDES AND HYDROPEROXIDE IN EQUIMOLAR SOLUTIONS.** The behaviour of CCl<sub>4</sub> solutions of alkylamide and alkylamine tensides and their interaction with tert-butyl-hydroperoxide have been studied at ambient temperature. Under these conditions, both tensides associate with hydroperoxide through hydrogen bonds but their ability to associate is different. (Author abstract). 5 Refs.

Porubska, M. (Plastics Processing & Application Research Inst, Nitra, Czech); Krkoskova, M. *Polym Degradation Stab* v 21 n 2 1988 p 121-137.

**081667 INFLUENCE OF NON-IONIC NITROGEN CONTAINING ANTI-STATIC AGENTS (TENSIDES) ON THE OXIDATIVE STABILITY OF POLYETHYLENE: PART III - INTERACTION BETWEEN TENSIDES AND HYDROPEROXIDE OVER A WIDE RANGE OF MOLAR RATIOS.** The interaction of alkamide and alkamine tensides with tert-butyl-hydroperoxide at ambient temperature has been studied over a wide range of molar ratios. While amide bonded with hydroperoxide through weak hydrogen bonds, temporary bonding of hydroperoxide with amine continued in a chemical reaction. (Author abstract). 9 Refs.

Porubska, M. (Plastics Processing & Application Research Inst, Nitra, Czech); Antos, K.; Hodul, P. *Polym Degradation Stab* v 21 n 2 1988 p 139-150.

**Stabilizers** See Also PIPE, PLASTIC—Degradation.

**081668 ASPECTS OF L-LDPE STABILIZATION.** Some aspects of low linear density polyethylene (L-LDPE) stabilization and stability are presented. Stabilization formulations are discussed, satisfying all major requirements. It is shown that the light stability of L-LDPE and L-LDPE/LDPE blends is comparable to that of classic LDPE. (Edited author abstract) 4 refs.

Meyer, Felix K. (Ciba-Geigy Ltd, Basel, Switz); Pedrazzetti, Enea. *Plast Rubber Process Appl* v 8 n 1 1987 p 29-36.

**Stresses** See Also ELECTRIC CABLES—Insulation; POLYPROPYLENE—Stresses.

**081669 INVESTIGATION ON THE LONG-TERM BEHAVIOR OF POLYETHYLENE AND POLY(VINYL CHLORIDE) UNDER STATIC LOAD.** The long-term behavior of high density polyethylene (HDPE) and poly(vinyl chloride) (PVC) under static mechanical load is investigated. The long-term behavior is determined as a function of stress and temperature. The applicability of the equation proposed by the authors which describes the dependence between the time-dependent failure, stress, and temperature of the two polymers is examined. The equation, derived from theoretical considerations, represents a modification of the Arrhenius equation for the chemical reaction rate. It is found that there is a complete agreement between the experimentally determined long-term behavior of PVC and HDPE and that calculated by the equation over the whole examined range of temperatures and stresses. (Edited author abstract) 15 refs.

Natov, M. (Higher Inst of Chemical Technology, Sofia, Bulg); Vassileva, St.; Evtimova, S. *J Appl Polym Sci* v 35 n 5 Apr 1988 p 1161-1167.

## Structure

**081670 EFFECT OF OXIDATION ON THE DYNAMIC AND STRUCTURAL PARAMETERS OF ORIENTED POLYETHYLENE IN THE DEFORMED STATE.** ESR spectroscopy using a radical probe and X-ray analysis have been employed to study the behavior under a load of oriented HDPE samples with narrow and wide MD first oxidized with an ozone-oxygen mixture. Loosening of the amorphous phase on reversible loading of the polymer films increases with rise in the degree of oxidation. The elasticity modulus E in the initial stage rises but falls for deeper degrees of oxidation. For oxidation of short duration no appreciable changes were found in the orientation; for longer oxidation times the orientation considerably diminishes. Oxidation leads to a sharp increase in the correlation time of the radical-probe. (Author abstract) 14 refs.

Karpova, S.G. (USSR Acad of Sciences, USSR); Popov, A.A.; Chvalun, S.N.; Zubov, Yu.A.; Zaikov, G.Ye. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1562-1568.



**081671** <sup>13</sup>C NMR STUDY OF THE STRUCTURE OF POLYETHYLENE-POLYAMINES. The signals in the <sup>13</sup>C NMR spectrum of a commercial sample of polyethylene-polyamine have been assigned and an additive scheme for calculating the chemical shifts proposed. The content in the technical product of all possible 18 structural fragments (linear and cyclic) has been determined from the spectrum. The number of primary, secondary and tertiary nitrogen atoms in the polyethylene-polyamine molecule has been calculated and the number average M determined. (Author abstract) 6 refs.

Bulai, A.Kh. (Plastmassy' Science-Production Assoc, USSR); Slonim, I.Ya.; Urman, Ya.G.; Vakulenko, V.A.; Chetverikova, A.T. *Polym Sci USSR* v 28 n 8 1986 p 1854-1858.

**081672** CHANGES IN THE VARIOUS ELEMENTS OF THE STRUCTURE OF POLYETHYLENE INDUCED BY IONIZING RADIATIONS (AS REVEALED BY DIFFERENTIAL SCANNING CALORIMETRY). The DSC (Differential Scanning Calorimetry) method has been used to measure the heat capacity at 100-430 K of linear and branched PE exposed to irradiation with fast electrons (5-700 Mrad). The changes in the various elements of the unordered regions (four regions of relaxation) and the radiation stability of the PE crystallites have been investigated. The authors demonstrate the specific influence of irradiation in each case due to the prevalence of crosslinking of portions of the chains with sufficient segmental mobility and the prevalence of the processes of degradation in conditions of 'suppressed' mobility. Sharply marked dependence of the radiation stability of the crystallites of PE on its prehistory was found. (Edited author abstract) 31 refs.

Bershtein, V.A. (USSR Acad of Sciences, USSR); Yegorov, V.M.; Yegorova, L.M.; Sirotkina, V.A.; Sirota, A.G. *Polym Sci USSR* v 28 n 9 1986 p 2012-2020.

**081673** PREDICTION OF POLYMER CRYSTAL STRUCTURES AND PROPERTIES. POLYETHYLENE AND POLY(OXYMETHYLENE). Molecular mechanics is used to calculate in a unified manner, from transferable conformational energy functions, the packing parameters and energy, vibrational dispersion curves, heat capacity, and thermodynamic functions, elastic constants, and refractive indices of polyethylene (PE) and poly(oxyethylene) (POM). PE was chosen as a 'standard' to illustrate the method and POM because it occurs in two crystal forms occasioned by the effect of packing forces in distorting the intramolecular torsion angles and because its crystal properties are of interest. Compared to the free -GG- the helix in the orthorhombic form is under compression and that in the hexagonal form under tension. Good agreement between calculated and experimental structures was found. (Edited author abstract) 41 refs.

Sorensen, R.A. (Univ of Utah, Salt Lake City, UT, USA); Liao, W.B.; Kesner, L.; Boyd, R.H. *Macromolecules* v 21 n 1 Jan 1988 p 200-208.

**081674** STUDY OF THE STRUCTURE OF POROUS POLYETHYLENE BY VARIATION IN CONTRAST. Wide and small angle X-ray scatter in the systems porous polyethylene-low molecular weight liquid has been used to investigate the features of supramolecular organization of the matrix of porous polyethylene and establish the character of the micropores. The peculiarity of the microporous samples consisting in the presence of thin layers and lamellae of polymeric material between pores filled with low molecular weight liquid results in the penetration of its molecules into the amorphous regions of structure even in the case of liquids comparatively inert in relation to polyethylene such as piperidine, dimethylformamide and dibutyl phthalate. (Author abstract) 13 refs.

Lipatov, Yu.S. (UKrSSR Acad of Sciences, USSR); Pakhomov, S.I.; Shilov, V.V.; Gomza, Yu.P.; Oranskaya, Ye.I.; Felin, M.G.; Andrianova, G.P. *Polym Sci USSR* v 29 n 1 Jan 1988 p 19-26.

**081675** PLASMA INDUCED CHEMICAL TRANS-

FORMATIONS IN POLYETHYLENES OF DIFFERENT SUPERMOLECULAR STRUCTURE. The structural and chemical changes taking place in various specimens of polyethylene on treatment in a low temperature plasma are studied by spin probe, X-ray diffraction analysis, and IR spectroscopy. It is established for the first time that during plasma treatment the supermolecular polymeric structure undergoes significant changes, the intensity and direction of which ('ordering', 'disordering') are closely bound up with plasma induced changes in chemical structure and with the initial morphology of the specimen. It is shown that the temperature of the polymer under treatment has a significant effect on the result of plasma treatment. (Author abstract) 22 refs.

Kalachev, A.A. (USSR Acad of Sciences, USSR); Klyushina, T.A.; Shapiro, A.M.; Kofman, V.L.; Artamonova, S.D.; Plate, N.A. *Polym Sci USSR* v 29 n 1 Jan 1988 p 202-211.

**081676** EFFECTS OF CHAIN STRUCTURE AND NETWORK CONSTITUTION ON SEGMENTAL ORIENTATION IN DEFORMED AMORPHOUS NETWORKS. Segmental orientation in deformed networks is analyzed in terms of configurational properties of constituent chains and of the network structure. Configurational evaluation by using the rotational isomeric state approximation with the polyethylene chain as an example shows that orientation depends strongly on (i) the direction of the investigated label relative to a chain bond, (ii) chain length, (iii) label location along the chain, (iv) configurational perturbations due to presence of a label along the chain, and (v) polydispersity. A molecular model of the network is required for the analysis of the effect of network constitution on segmental orientation. The constrained junction theory of rubber elasticity is employed to estimate the contributions to segmental orientation from the network structure. (Author abstract) 20 refs.

Erman, Burak (Bogazici Univ, Istanbul, Turk); Bahar, Ivet. *Macromolecules* v 21 n 2 Feb 1988 p 452-457.

**Sulfonation** See Also ORGANIC COMPOUNDS—Photochemical Reactions.

**081677** FORMATION AND REACTION OF POLYENESULFONIC ACID. I. REACTION OF POLYETHYLENE FILMS WITH SO<sub>3</sub>. The surface of polyethylene (PE) film was sulfonated by reaction with gaseous SO<sub>3</sub>. The structure of the sulfonated PE films was determined on the basis of spectroscopic data such as IR, UV, and resonance Raman spectra. It was confirmed that a PE film and SO<sub>3</sub> gave unsaturated sulfonic acids and that, as the reaction proceeded, the elimination of sulfurous acids took place to form sulfonic acids having highly conjugated C=C unsaturated bonds. (Author abstract) 9 refs.

Ihata, Jyoji (Asahi Chemical Industry Co, Fuji, Jpn). *J Polym Sci Part A* v 26 n 1 Jan 1988 p 167-176.

**081678** FORMATION AND REACTION OF POLYENESULFONIC ACID. III. PREPARATION AND PHOTOREACTION OF 1,3,5-HEXATRIENE-1,6-DISULFONIC ACID. As a model for the reaction of between polyethylene films and gaseous SO<sub>3</sub>, n-hexane was allowed to react with gaseous SO<sub>3</sub> to give 1,3,5-hexatriene-1,6-disulfonic acid (HTDS), which was isolated from the reaction products by column chromatography. Furthermore, it was found that an aqueous solution of HTDS-Na was sensitive to UV, which eliminated one of the sulfonic acid groups by a radical mechanism. Sulfonic acids having less than three conjugated double bonds were not sensitive to UV. (Author abstract) 12 refs.

Ihata, Jyoji (Asahi Chemical Industry Co, Fuji, Jpn). *J Polym Sci Part A* v 26 n 1 Jan 1988 p 187-194.

## Surface Properties

**081679** SURFACE LAYER OF FIBRILLAR MATERIALS OF HIGH MOLECULAR WEIGHT POLYETHYLENE. Linear polyethylene of high molecular

weight formed micro-fibrils when it was crystallized above the melting point under suitable stretching. The fibrils thus obtained have circular cross-section and even surface. The changes of surface structure of these fibrils by heat treatment were investigated by means of electron microscopies, differential scanning calorimetry, and X-ray diffractions. It was found that the crystals on a surface layer of the high oriented fibrils grew in the direction parallel to the oriented direction, while the crystallites of lowly oriented fibrils disordered with decreasing in the rate and ratio of stretching. In a surface layer of these low oriented fibrils, unevenness owing to many crystallites was observed. It is concluded that the larger surface area on this fibril resulted from the unevenness of irregular crystallites in the surface layers. (Edited author abstract) 13 refs. In Japanese.

Sakami, Hiroshi (Government Industrial Research Inst, Nagoya, Jpn). *Kobunshi Ronbunshu* v 44 n 6 1987 p 477-482.

**Surfaces** See TUBES—Plastics Applications.

## Tapes

**081680** IMPROVING THE OPERATIONAL CHARACTERISTICS OF AM-2-50M UNIT FOR MAKING ADHESIVE TAPES. To meet the requirements of adhesive materials, tow AM-2-50M units for making adhesive tapes were designed and fabricated. The use of synthetic-material grid eliminated the need for installing in the final dryer a collector and storage required for its operation which in turn helped reduce the number of rollers on the tape-transmitting line, the sizes and weight of the final dryer, and also the weight of the unit as a whole.

Silin, V.P.; Astafev, V.A. *Chem Pet Eng* v 23 n 3-4 Mar-Apr 1987 p 118-119.

## Testing

**081681** ETUDE COMPARATIVE DU COMPORTEMENT SOUS TENSION CONTINUE, DE DEUX TYPES DE POLYETHYLENE PAR LA METHODE DE L'ONDE DE PRESSION. [Comparative Study of the Behavior of Two Polyethylene Types under DC Voltage by the Pressure Wave Method]. In order to develop extruded high voltage dc cables it is necessary to improve the understanding of charge storage and transport phenomena occurring in insulators such as polymer materials, when they are submitted to high dc voltages. A comparison of the behavior of two types of polyethylene, LDPE and XLPE, is presented. This study is based on the measurement, using the pressure wave propagation method, of the evolution of charge distribution in samples under electric stress. Important characteristics of these two materials are obtained, such as the internal field distribution, its distortion as compared to the applied field, and the localization of the charges responsible for these effects. For the materials under test, some regions of the samples are submitted to a field exceeding the applied one by 80%. Nevertheless, the localization of the space charges observed in some situations indicates that there is no particular risk during a reversal of the polarity of the applied voltage. (Author abstract) In French. 5 refs.

Chapeau, F. (Ecole Supérieure de Physique et Chimie Industrielles, Fr); Ditchi, T.; Alguie, C.; Lewiner, J.; Perret, J.; Dalle, B. *RGE Rev Gen Electr* n 3 Mar 1988 p 50-54.

**081682** REOLOSKO ISPITIVANJE HDPE-A U OSLOVIMA DINAMICKI NAMETNUTIH DEFORMACIJA. [Rheological Examination of HDPE Under Conditions of Mechanically Induced Deformations]. Results are reported of testing a series of homo- and copolymers of high density polyethylene, mass flow rate 0.20...0.30 g/10 min, density 0.938...0.965 g/cm<sup>3</sup>, and molecular weight distributions 3...30. The tests were made by means of a rheological measurement instrument, with periodically imposed deformations. The determined val-



ues were the shear modulus, storage and loss,  $G'$ ,  $G''$  and complex viscosity as a function of oscillation frequency. On the basis of rheological measurements, it is possible to establish their importance for the determination of the type of material best suited to individual processing techniques. At the same time, statistical processing of rheological parameters establishes a correlation between the shear modulus and distribution of molecular weights. (Edited author abstract) 3 refs. In Serbo-croatian.

Perovic, Ivan R. (HIP RO Petrohemija, Pancevo, Yugosl). *Polimeri (Zagreb)* v 8 n 12 Dec 1987 p 347-352.

**081683 WATER TREEING TEST USING THE WATER NEEDLE METHOD: THE INFLUENCE OF THE MAGNITUDE OF THE ELECTRIC FIELD AT THE NEEDLE TIP.** The initial growth kinetics of water trees in polyethylene is measured for different values of the radius of curvature of the needle tip and for different applied voltages. The initial propagation rate is shown to be determined by the magnitude of the electric field at the needle tip, except at its highest values. The local electric field at the solution/polymer interface or in its vicinity plays an essential role in the growth mechanisms of water trees; it determines the initial propagation rate up to values of about 100 to 300 V/ $\mu\text{m}$ . Above these field values the water tree growth is found to be controlled by slower processes, e.g., the migration of the liquid through the polymer. These results are used in discussing some experimental conditions which are required to get reproducible results in water needle tests. 6 refs.

Filippini, J.C. (CNRS, Grenoble, Fr); Meyer, C.T. *IEEE Trans Electr Insul* v 23 n 2 Apr 1988 p 275-278.

**Thermodynamic Properties** See Also MOLECULES—Thermodynamic Properties.

**081684 CALORIMETRIC INVESTIGATIONS OF THE SYSTEM HIGH MOLECULAR WEIGHT POLYETHYLENE OXIDE-WATER.** The binary system PEO-water has been studied by differential microcalorimetry over the temperature range 150-380 K. From analysis of the experimental findings on the character of the change in the temperature and concentration functions of the specific heat capacity of the system and the thermodynamic characteristics of its components in the regions of phase conversions and the kinetic transition (vitrification-softening) an explanation is given for the exothermal transition manifest in the system at a temperature above softening. The presence of this transition is related to the ability of water to form a part of the secondary hydrate layer for vitrification at relatively low cooling and crystallization rates on subsequent heating. (Edited author abstract) 12 refs.

Bagatskii, N.A. (Shevchenko State Univ, Kiev, USSR); Svintitskii, N.I.; Pas'ko, S.P.; Uskov, I.A.; Zelenov, Yu.V. *Polym Sci USSR* v 28 n 8 1986 p 1846-1853.

**Thermodynamics**

**081685 THERMODYNAMICS OF ISOTOPIC POLYMER MIXTURES: POLY(VINYLETHYLENE) AND POLY(ETHYLETHYLENE).** Binary mixtures of normal (protonated) and perdeuterated poly(vinylethylene), and of poly(ethylethylene), containing 50% by volume deuterated polymer, have been examined by small-angle neutron scattering (SANS). Evaluation of SANS data obtained between 26 and 100°C, using the RPA theory for binary polymer mixtures, reveals that both isotopic systems are characterized by a small positive Flory-Huggins segment-segment interaction parameter,  $5 \times 10^{-4} < \chi < 10^{-3}$ , and an upper critical solution temperature (UCST). This isotope effect primarily derives from the reduction in carbon-hydrogen bond length that results from substituting deuterium for hydrogen in nonpolar organic liquids. The authors conclude that nonideal mixing is a universal characteristic of deuterated and protonated polymers. (Edited author abstract) 31 refs.

Bates, F.S. (AT&T, Murray Hill, NJ, USA); Fetters, L.J.; Wignall, G.D. *Macromolecules* v 21 n 4 Apr 1988 p

1086-1094.

**Thin Films** See Also COBALT CHROMIUM ALLOYS—Thin Films; CRYSTALS—Orientation.

**081686 COLLAPSE OF POLY(ETHYLENE OXIDE) MONOLAYERS.** Surface pressure  $\pi$  has been measured as a function of surface concentration for poly(ethylene oxide) (PEO) surface films, spread onto deionized water at temperatures  $T$  from 8 to 28°C. At fixed surface coverage, the temperature coefficient of surface pressure  $d\pi/dT$  was negative at submonolayer coverages and positive at higher surface coverages. This suggests, respectively, a peculiar increase and decrease of surface entropy with increasing surface coverage. A degree of ordering of water molecules with the PEO repeat unit in the surface layer is suggested as a reason for the negative value. These findings illustrate that a polymer monolayer should not in all respects be considered as two-dimensional. (Edited author abstract) 27 refs.

Kuzmenka, Daniel J. (Univ of Illinois, Urbana, IL, USA); Granick, Steve. *Macromolecules* v 21 n 3 Mar 1988 p 779-782.

**Transport Properties** See COMPOSITE MATERIALS—Transport Properties.

**Ultrahigh Molecular Weight** See Also MACHINE COMPONENTS—Plastics Applications.

**081687 ROLE OF COUNTERFACE IMPERFECTIONS IN THE WEAR OF POLYETHYLENE.** A study was made of the effect of single imposed imperfections in stainless steel counterfaces on the wear of ultrahigh molecular weight polyethylene wear pins in linear reciprocating wear tests. The imperfections were in the form of either transverse or longitudinal scratches or single indentations, all generated by diamond markers. It was found that a single transverse scratch can increase the wear rate of the polymer to a remarkable extent; the major factor being the piled-up steel along the edge of the scratch. When the piled-up material was removed by remedial lapping, the wear rate returned to its initial value corresponding to the isotropic roughness of the undisturbed counterface. Longitudinal scratches yielded a less marked, yet recognizable, increase in the wear rate of the polyethylene. Single diamond indentations did not generate piled-up edges of steel and had little effect upon the wear rate of the polymer. The findings demonstrate the severe effect which simple imperfections on a hard counterface can have upon the wear of polymers. Even shallow transverse scratches can increase the wear rate by an order of magnitude. (Edited author abstract) 10 refs.

Dowson, D. (Univ of Leeds, Leeds, Engl); Taheri, S.; Wallbridge, N.C. *Wear* v 119 n 3 Oct 15 1987 p 277-293.

**081688 EFFECT OF ANNEALING ON FIBER STRUCTURE OF ULTRA-HIGH MOLECULAR WEIGHT POLYETHYLENE.** Ultra-high molecular weight polyethylene (UHMWPE) was drawn at 150 °C (above melting point) and immediately quenched at 0°C. Samples of film were annealed at various temperatures at constant length. The fine structures were studied by wide- and small-angle X-ray analyses. Crystallites with a-axis orientation predominated for the quenched film with a high draw ratio of 12, in which the so-called bi-component crystallization might occur: most crystals were folded chain type, with a small number of extended chain crystals. The crystallites become rotated by thermal stress at annealing temperatures above 80°C. The crystallites took the c-axis orientation by annealing above 130°C. No large change in the crystallite length  $D_{002}$  by annealing was observed. The voids between fibrils for quenched film decrease with increasing of annealing temperature; in other words, fibrils pack more closely. (Edited author abstract) 32 refs. In Japanese.

Sakurai, Kensuke (Fukui Univ, Fukui, Jpn); Hayakawa, Kooji; Takahashi, Toshisada. *Kobunshi Ronbunshu* v 44 n 5 1987 p 375-382.

**081689 EFFECT OF HIGH ENERGY RADIATION**

**ON THE STRESS-REELAXATION OF ULTRA-HIGH MOLECULAR WEIGHT LINEAR POLYETHYLENE.** Stress-relaxation behavior was studied in ultra-high and normal molecular weight linear polyethylenes (UHMWPE and NMWPE) as a function of radiation dose over the range 0-128 Mrad. Irradiation up to 16 Mrad raises the crystallinity in both types of PE, as demonstrated previously, and thus increases the initial modulus. Also, the initial modulus of NMWPE is higher than that of UHMWPE because the former has a higher crystallinity. To eliminate the effect of this initial difference on relaxed stress, the stress-relaxation data were normalized with respect to the initial stress and plotted as the fraction, retained stress after time  $t$ /initial stress. The normalized plots show no significant difference between NMWPE and UHMWPE in their stress-relaxation behavior. (Edited author abstract) 21 refs.

Bhateja, S.K. (Dow Chemical Co, Midland, MI, USA); Andrews, E.H. *J Appl Polym Sci* v 34 n 8 Dec 1987 p 2809-2817.

**081690 INVESTIGATING THE THERMOFORMABILITY OF UHMW-POLYETHYLENE.** The formability of UHMW-polyethylene is examined by combining the concept of uniaxial testing at various temperatures at constant rate or constant load with a standardizable thermoforming method that employs molds with variable geometry. Preliminary results analyze and define processing parameters such as: heating time, vacuum pressure, and draw ratio, among others. Finished material properties of the resultant thermoformed parts are presented. (Author abstract) 5 refs.

Gauvin, Raymond (Ecole Polytechnique de Montreal, Montreal, Que, Can). *J Plast Film Sheeting* v 3 n 4 Oct 1987 p 312-324.

**081691 SUPERDRAWING OF ULTRAHIGH MOLECULAR WEIGHT POLYETHYLENE. 1. EFFECT OF TECHNIQUES ON DRAWING OF SINGLE CRYSTAL MATS.** Single crystal mats of ultrahigh molecular weight polyethylene (UHMW-PE) have been uniaxially drawn by three techniques: solid-state coextrusion, tensile drawing, and the combination of the two. The drawability and the resultant structure and properties of superdrawn films were found to be sensitive to drawing technique. Tensile drawing was markedly influenced by the coherency of the mats and the draw temperature and rate. Draw ratios (DR) over 200 at  $\geq 90^\circ\text{C}$  under controlled rates have been achieved for coherent mats. Effective draw was not possible for less coherent mats and for all drawn at  $\leq 60^\circ\text{C}$ . (Edited author abstract) 41 refs.

Kanamoto, Tetsuo (Science Univ of Tokyo, Tokyo, Jpn); Tsuruta, Akeharu; Tanaka, Koji; Takeda, Masatami; Porter, Roger S. *Macromolecules* v 21 n 2 Feb 1988 p 470-477.

**081692 DYNAMIC MECHANICAL STUDIES ON CRYSTAL DISPERSION USING ULTRADRAWN POLYETHYLENE FILMS.** The anisotropy of crystal dispersion was investigated by use of ultrahigh molecular weight polyethylene ( $M_v = 6 \times 10^6$ ) gel films which were prepared by gelation/crystallization from solution. The temperature dependence of the complex dynamic modulus was measured in the frequency range from 0.1 to 100 Hz, using undrawn and drawn gel films with various draw ratios up to 400. Superposition is realized by a combination of horizontal and vertical shifts resulting in apparent master curves of the storage and loss modulus functions. The Arrhenius plots of log shift factor versus the reciprocal of the absolute temperature indicates that there exist two mechanical dispersions corresponding to the  $\alpha_1$  and  $\alpha_2$  mechanisms, for drawn specimens whose draw ratios are lower than 100. (Edited author abstract) 40 refs.

Matsuo, Masaru (Nara Women's Univ, Nara, Jpn); Sawatari, Chie; Ohhata, Tomoko. *Macromolecules* v 21 n 5 May 1988 p 1317-1324.



**081693 EFFECT OF COUNTERFACE SURFACE ROUGHNESS ON THE WEAR OF UHMWPE IN WATER AND OIL-IN-WATER EMULSION.** This paper examines the effect of the type of lubricant and the counterface surface roughness on the wear of ultrahigh molecular weight polyethylene (UHMWPE). A reciprocating sliding wear rig was used with UHMWPE sliding against AISI 431 at an average speed of 0.25 m/s. The contact pressure was 10 N/mm<sup>2</sup>. Tests were conducted in water and in a 5% oil-in-water emulsion (5:95). The results of the tests in water showed that the logarithm of the specific wear rate is proportional to the surface roughness. The results of the tests in 5:95 showed that there is a significant transition in specific wear rate at a surface roughness of approximately 0.35  $\mu$ m. At surface roughnesses less than 0.35  $\mu$ m the specific wear rate in 5:95 is considerably lower than the specific wear rate in water, while at surface roughnesses greater than 0.35  $\mu$ m the specific wear rate in 5:95 approaches that in water. (Edited author abstract) 9 refs.

Lloyd, A.I.G. (Univ of Capetown, Rondebosch, S Afr); Noel, R.E.J. *Tribol Int* v 21 n 2 Apr 1988 p 83-88.

**081694 COEXTRUSION DRAWING OF REACTOR POWDER OF ULTRAHIGH MOLECULAR WEIGHT POLYETHYLENE.** Certain nascent polymers have been shown to have unusual thermal and morphological properties that are irretrievably lost once the polymer has been melted or otherwise reduced to the isotropic state. We show further that nascent ultrahigh molecular weight polyethylene 'reactor powder' exhibits a remarkable ductility when uniaxially drawn by coextrusion techniques after initial compaction in film form at 110°C. When drawn at a temperature of 110°C, draw ratios of 56 have been obtained, resulting in an enhanced tensile modulus of 58 GPa. Thermal analyses and dynamic mechanical measurements were also made towards understanding the initial and final morphologies. (Author abstract) 17 refs.

Pawlikowski, Gregory T. (Juniata Coll, Huntingdon, PA, USA); Mitchell, Donald J.; Porter, Roger S. *J Polym Sci Part B* v 26 n 9 Aug 20 1988 p 1865-1870.

**081695 SINGLE-CRYSTAL-LIKE ORIENTATION OF ULTRAHIGH-MOLECULAR-WEIGHT POLYETHYLENE BY UNIAXIAL STRETCHING.** Dried gel film of ultrahigh-molecular-weight polyethylene (UHMW PE) can be drawn to 370 times its original length at 135°C. Single-crystal mats and dried gel film of UHMW PE develop double orientation despite uniaxial stretching. This is unique for preferentially oriented UHMW PE systems. To elucidate the origin of this single-crystal-like orientation, precursors with different aspect ratios were prepared and drawn uniaxially. The degree of double orientation was measured by infrared spectroscopy. The origin of single-crystal-like orientation seems to reside in the necking region. The stacked lamellar structure is transformed into a fibrillar structure in a two-dimensional fashion. This condition is easily provided when UHMW PE single-crystal mat or dried gel film is drawn uniaxially. A draw ratio of 40 and aspect ratio of 40 are the optimal conditions to obtain a doubly oriented structure from UHMW PE single-crystal mat or gel film at 135°C. (Author abstract) 18 refs.

Seoul, Chang (Chonbuk Natl Univ, Chonju, South Korea); Kim, Sang Yong. *J Polym Sci Part B* v 26 n 9 Aug 20 1988 p 1965-1978.

**Viscoelasticity** See PLASTICS—Rheology.

**Wear** See POLYOLEFINS—Mechanical Properties.

**Welding** See Also GAS PIPELINES—Plastics Applications.

**081696 INFRARED MICROSPPECTROMETRIC STUDY OF THE THERMAL HISTORY OF FUSION WELDING OF POLYETHYLENE.** Thermal history of a polyethylene-welded assembly has been determined by measuring the crystallinity via absorbance ratio ( $R_{OD}$ ) measurements. Fourier transform infrared microspec-

trometry has been used because it allows a space-localized analysis within a diameter of 200  $\mu$ m. A linear relation between  $R_{OD}$  and local crystallinity has been obtained using reference samples for calibration. Samples were calibrated by differential thermal analysis and density measurements. This relationship and the simulation of the various thermal treatments by calorimetric analysis allow us to characterize the different phases of the thermal history during the welding experiment. (Author abstract) 10 refs.

Gueugnaut, D. (Cent d'Etudes et de Recherches sur les Sciences et Techniques Appliquées, Fr); Forgerit, J.P. *J Appl Polym Sci* v 35 n 6 May 5 1988 p 1683-1694.

## X-Ray Analysis

**081697 TIME-RESOLVED SAXS ON CRYSTALLIZATION OF A LOW-DENSITY POLYETHYLENE/HIGH-DENSITY POLYETHYLENE POLYMER BLEND.** In this paper, we report our time-resolved SAXS patterns of a blend of low-density polyethylene (LDPE) and high-density polyethylene (HDPE) and of the respective homopolymers. It is concluded that the fine structural changes during the early stage of crystallization, observed through SAXS with synchrotron radiation, suggest the following clues: The single Bragg reflection does not necessarily mean that the two components have cocrystallized to form a single lamella structure, as has been interpreted previously. The observation could be interpreted as a separation between the two (LDPE/HDPE) components on an interlamella scale. 13 refs.

Song, H.H. (State Univ of New York at Stony Brook, Stony Brook, NY, USA); Stein, R.S.; Wu, D.-Q.; Ree, M.; Phillips, J.C.; LeGrand, A.; Chu, B. *Macromolecules* v 21 n 4 Apr 1988 p 1180-1182.

**POLYIMIDES** See Also ADHESIVES—Aerospace Applications; COMPOSITE MATERIALS—Thermal Properties; DISPLAY DEVICES—Liquid Crystal; LASERS, SEMICONDUCTOR—Performance; PLASTICS, REINFORCED—Carbon Fiber; POLYMERS—Differential Thermal Analysis; POLYMERS—High Temperature Applications; PRINTED CIRCUITS—Manufacture; VANADIUM COMPOUNDS.

**081698 POSITIVE PHOTOREACTIVE POLYIMIDES. II. PREPARATION AND CHARACTERIZATION OF POLYIMIDE PRECURSORS CONTAINING  $\alpha$ -(2-NITROPHENYL)ETHYL ESTER SIDE CHAINS.** The monomers were derived from pyromellitic dianhydride and  $\alpha$ -(2-nitrophenyl)ethanol, which was prepared by selective reduction of 2-nitroacetophenone. Polyimide precursors were synthesized by an interfacial polycondensation technique. Their thermal properties in nitrogen were studied by dynamic thermogravimetry. The photorearrangement of 2-nitrobenzyl ester having a methyl group at the  $\alpha$ -position compared to that of the unsubstituted ester was investigated by infrared spectrophotometry. The polymers obtained in this study gave a high proportion of photorearrangement to show high sensitivity. (Edited author abstract)

Kubota, Shigeru (Mitsubishi Electric Corp, Amagasaki, Jpn); Moriwaki, Toshimoto; Ando, Torahiko; Fukami, Akira. *J Macromol Sci Chem* v A24 n 12 Dec 1987 p 1407-1422.

**081699 PREPARATION AND MONOLAYER THICKNESS OF LANGMUIR-BLODGETT FILMS OF POLYIMIDES HAVING VARIOUS CHEMICAL STRUCTURES.** Four kinds of Langmuir-Blodgett (LB) films were newly prepared to investigate the relationship between monolayer thickness of the films and the chemical structures of the polyimides. Polyimides used in this work can be classified into three groups: a) polyimides and having rigid rod-like structure, b) polyimides possessing flexible oxygen linkage, and c) polyimides having pendant bulky phenyl groups. 4 refs.

Nishikata, Yasunari (Tokyo Inst of Technology, Tokyo, Jpn); Konishi, Toru; Morikawa, Atsushi; Kakimoto, Masa-aki; Imai, Yoshio. *Polym J* v 20 n 3 1988 p 269-272.

## Additives

**081700 IMIDE SILANES: ADHESION PROMOTERS FOR POLYIMIDES.** The investigation of adhesion promoters prepared by the reaction of amino-functional silanes with dianhydrides (or diester-diacid chlorides) of tetracarboxylic aromatic acids is reported. The new coupling agents, designed to exhibit superior thermo-oxidative stability were applied under conditions determined from kinetic studies of hydrolysis and condensation reactions, and their coupling effectiveness for polyimides was evaluated by peel tests. For a wholly aromatic imide silane (CA-25), adhesion retention after prolonged exposure to elevated temperature was far greater than obtained with adhesion promoters previously evaluated in polyimide systems. (Author abstract) 15 refs.

Tesoro, G.C. (Polytechnic Univ, Brooklyn, NY, USA); Rajendran, G.P.; Park, C.; Uhlmann, D.R. *J Adhes Sci Technol* v 1 n 1 1987 p 39-51.

## Adhesion

**081701 ADHESIVE INTERFACE INTERACTIONS BETWEEN PRIMARY ALIPHATIC AMINE SURFACE CONDITIONERS AND POLYAMIC ESTER POLYIMIDE RESINS.** The interface reactions of 3-aminopropyltriethoxysilane treated surfaces, with a polyamic alkyl ester/polyimide resin formed from pyromellitic dianhydride and oxydianiline, were defined by Fourier Transform Infrared (FTIR) analysis on the surface layers of germanium internal reflection plates. Adhesion between these interfacial layers is the result of chemical bonding, which apparently proceeds through initial amide formation between the amino function of the silylated surface and the alkyl ester group present in the polyamic ester. Heating results in diamide formation by a second alkyl, surface-bound amine displacing the aromatic polymer amine. Heating the more stable dialkyldiamide to 300°C imidizes both the polymer and the interfacial region, producing a strong laminate composite. Polymer scission at the aromatic amide linkages occurs in this adhesion process, bonding surface-bound alkyl amines to one end of a shortened polymer chain. (Author abstract) 2 refs.

Linde, H.G. (IBM, Essex Junction, VT, USA). *J Polym Sci Part B* v 26 n 6 Jun 1988 p 1149-1158.

## Adhesives

**081702 ADHESIVE EVALUATION OF WATER-SOLUBLE LARC-TPI.** A water-soluble version of the linear thermoplastic polyimide LARC-TPI, prepared by United Technologies Research Center, East Hartford, CT, USA from the polyamic-acid/diglyme solution commercially marketed by Mitsui Toatsu Chemicals Incorporated (MTCI), Tokyo, Japan, was evaluated as a high temperature thermoplastic adhesive. This report details a study to evaluate the water-soluble polyimide, identified as TPI(MTC)/H<sub>2</sub>O, as a high temperature thermoplastic adhesive for bonding Ti-6Al-4V. The results are compared primarily with those reported in earlier work with the polyamic-acid/diglyme material supplied by MTCI. (Edited author abstract) 10 refs.

Progar, D.J. (NASA, USA); Pike, R.A. *Int J Adhes Adhes* v 8 n 1 Jan 1988 p 25-32.

**Applications** See Also INTEGRATED CIRCUIT MANUFACTURE—Metallizing; LUBRICANTS—Solid Films; MICROELECTRONICS—Plastics Applications; SEMICONDUCTOR DEVICES—Plastics Applications; SOLAR CELLS—Protective Coatings.

**081703 SCREEN-PRINTABLE POLYIMIDE COATING FOR SILICON WAFERS.** A new surface passivation technology, based on a unique screen-printable polyimide coating combined with a high precision, screen-printing machine is described. Discussion is focused on the physical and performance characteristics required of the printable polyimide for maximum protec-



tion of the device, and the processing characteristics (both material and equipment related) necessary to implement this new technology in production.

Kulesza, Frank W. (Epoxy Technology Inc, Billerica, MA, USA); Estes, Richard H.; Spanjer, Keith. *Solid State Technol* v 31 n 1 Jan 1988 p 135-139.

**081704 PATTERN GENERATION IN POLYIMIDE COATINGS AND ITS APPLICATION IN AN ELECTROPHORETIC IMAGE DISPLAY.** Direct photo-patterning of polyimide (PI) films was done in two ways, both based upon the modification of the PI-precursor, the polyamic acid (PAA), by derivatives of methacrylic amide. In the first method, a photoreactive PAA is prepared by partially (25 mole percent) neutralizing PAA with N-(N',N'-dimethylamino) propylmethacrylic amide and completing the neutralization with methacrylic amide (75 mole percent). In the second method, the PAA is esterified, e.g. with N-hydroxyethyl-N-methylmethacrylic amide, through its isourea derivative. The modified PAAs are processed like conventional negative photoresists. In the first method, the photopolymer formed by selective UV exposure is bound to the PAA by intermolecular complexation, causing insolubility in the developer. The second method, which was investigated only qualitatively, provides crosslinked patterns. In both cases a pure PI film is left upon imidization at 350°C. The first method proved to be well-suited to making the potential well structure in an electrophoretic image display. (Edited author abstract). 20 Refs.

Minema, L. (Philips Research Lab, Eindhoven, Neth); Van Der Zande, J.M. *Polym Eng Sci* v 28 n 12 Jun 1988 p 815-822.

**Blending** See Also AROMATIC POLYMERS—Blending; POLYMERS—Spectroscopic Analysis.

**081705 HIGH TEMPERATURE POLYIMIDE BLENDS.** In a continuing effort to synthesize polymers that are readily processable and that exhibit state-of-the-art characteristics, LARC-TPI (Mitsui) and polyimidesulfone (PISO<sub>2</sub>) were blended and subjected to a limited melt flow and thermal properties characterization. Mitsui Toatsu of Japan, working under a licensing agreement with NASA, synthesized an imidized version of LARC-TPI molding powder that exhibited an extraordinarily high level of softening when heated to 300°C. Subsequently, a study of the calorimetric and rheological properties was accomplished by NASA-Langley on that material. The thermoplastic polyimidesulfone that possesses processability similar to polysulfones and the solvent resistance of the polyimides was synthesized and characterized at NASA-Langley in the early 1980's. (Author abstract) 9 refs.

Burks, Harold D. (NASA, Hampton, VA, USA); St. Clair, Terry L. *SAMPE Q* v 19 n 1 Oct 1987 p 1-6.

**081706 MISCIBLE BLENDS OF POLYBENZIMIDAZOLE AND A DIISOCYANATE-BASED POLYIMIDE.** The thermal and i.r. spectral properties of the blends formed from polybenzimidazole (PBI) and polyimide have been studied. Single, composition-dependent  $T_g$  values occur, indicating miscibility over the entire composition range. Because of the sensitivity of the glass transition to the thermal history, it is not possible to determine the onset, if any, of high temperature phase separation by thermal measurements based on  $T_g$  determination. However, the N-H stretching band of PBI shifts with composition; the shift is up to 50  $\text{cm}^{-1}$  and an estimate of the phase-separation temperatures was obtained by following the disappearance of the N-H stretching band shifts as a function of annealing temperature. The results suggest that this system displays lower critical solution type phase behavior. (Edited author abstract) 6 refs.

Stankovic, Slavka (Univ of Massachusetts, Amherst, MA, USA); Guerra, Gaetano; Williams, David J.; Karasz, Frank E.; MacKnight, William J. *Polym Commun (Guildford Engl)* v 29 n 1 Jan 1988 p 14-16.

**Bonding** See PRINTED CIRCUITS—Manufacture.

## Chemical Reactions

**081707 FT-IR ANALYSIS OF HIGH-TEMPERATURE SOLID-PHASE REACTIONS USING GC-IR SOFTWARE.** A method for following chemical reactions in polymers, using the GC-IR software on an FT-IR spectrometer and a high-temperature thermal cell, is discussed. The method reduces disk access time between the collection of each spectrum, allowing many more data points for kinetic experiments to be collected. The imidization reaction of polyimides above 200°C is given as an example. (Author abstract) 13 refs.

Snyder, Randy W. (IBM, Endicott, NY, USA); Sheen, C. Wade. *Appl Spectrosc* v 42 n 2 Feb 1988 p 296-298.

## Coatings

**081708 MODIFICATION OF POLYIMIDE COATINGS BY HIGH ENERGY ION BOMBARDMENT.** Exposure of 25- $\mu\text{m}$  films of polyimide and polyamideimide to high doses ( $> 10^{15}/\text{cm}^2$ ) of energetic ions (energy  $\geq 100$  keV) resulted in physical and chemical modification of the film surface. Cross-section microscopy revealed damaged layers extending beyond the projected ion range; conductivity in this damaged layer was found to be as high as  $10^3 \Omega^{-1} \text{cm}^{-1}$ . Surface conductivity was found to be a function of ion energy and dose, with an exponential energy dependence from 200 to 900 keV. The temperature dependence and thermal stability of the surface conductivity were determined. (Author abstract) 15 refs.

Zussman, M.P. (Westinghouse R&D Cent, Pittsburgh, PA, USA); Wood, S.; Scala, L.C.; Bartko, J.; Vincenz, A. *J Appl Polym Sci* v 35 n 8 Jun 1988 p 2183-2191.

## Crosslinking

**081709 ON THE CROSS-LINKING MECHANISM OF BENZOPHENONE-CONTAINING POLYIMIDES.** A group of fully imidized polyimides containing benzophenone as well as alkyl-substituted biphenylmethane in the main chain were prepared. In these materials cross-links are formed on exposure to UV radiation through hydrogen abstraction by triplet benzophenone from the alkyl groups acting as hydrogen donors and subsequent coupling of the radicals so formed. The involvement of radicals in the process is supported by ESR spectra of the films under irradiation. The quantum yield of cross-linking is  $\phi = 0.027$ , and less than half of the benzophenone units in the solids are reactive. Even at the reactive sites the reaction probability is a mere 3%. (Edited author abstract) 23 refs.

Lin, Anshyang A. (Polytechnic Univ, Brooklyn, NY, USA); Sastri, Vinod R.; Tesoro, Giuliana; Reiser, Arnost; Eachus, Raymond. *Macromolecules* v 21 n 4 Apr 1988 p 1165-1169.

## Curing

**081710 TIME-TEMPERATURE-TRANSFORMATION (TTT) CURE DIAGRAMS: RELATIONSHIP BETWEEN  $T_g$  AND THE TEMPERATURE AND TIME OF CURE FOR A POLYAMIC ACID/POLYIMIDE SYSTEM.** Glass transition temperatures ( $T_g$ ) were obtained vs. isothermal temperature ( $T_{\text{cure}}$ ) and time of cure for a polyamic acid/polyimide system. A time-temperature-transformation (TTT) isothermal cure diagram was constructed to include the time to vitrification and iso- $T_g$  curves. As for epoxies, the relationship between  $T_{\text{cure}}$  and the time to vitrification is S-shaped. Plots of  $T_g$  vs.  $T_{\text{cure}}$  show that solvent evaporation and chemical reaction are controlled by vitrification. (Author abstract) 11 refs.

Palmese, G.R. (Princeton Univ, Princeton, NJ, USA); Gillham, J.K. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1925-1939.

**081711 FTIR STUDIES OF PMR-15 POLYIMIDES.** Fourier-transform infrared spectroscopy (FTIR)

shows that during the curing of PMR-15 polyimide, formation of an anhydride intermediate occurs prior to the formation of polyamic acid, suggesting that its origin is the diester diacid starting material, as has recently been proposed by Johnston and coworkers. These results disagree with some previous literature reports that have attributed formation of the anhydride to a degradation pathway of polyamic acid and confirm the validity of a recently published paper by Johnston and coworkers. (Author abstract) 21 refs.

Garcia, Dana (BF Goodrich Co, Brecksville, OH, USA); Serafini, Tito T. *J Polym Sci Part B* v 25 n 11 Nov 1987 p 2275-2282.

**081712 CURING REACTION AND GLASS TRANSITION TEMPERATURE OF MALEIMIDE RESIN CONTAINING EPOXY GROUPS.** Investigation was made of the glass transition temperature ( $T_g$ ) and the curing reaction mechanism of a new maleimide resin containing epoxy groups. It was found that the  $T_g$  of the cured product depended on the reaction temperature and a good heat-resistant product could be obtained under appropriate conditions. This  $T_g$  was above 200°C. The reaction mechanism is discussed using measured activation energy and infrared spectra. The primary reaction changed at about 180°C. Both the addition of diamine to the double bond and epoxy group occurred below 180°C. The polymerization of double bonds of bismaleimide took place simultaneously with the above-mentioned two reactions above 180°C. (Author abstract) 7 refs.

Nagai, Akira (Hitachi Ltd, Hitachi, Jpn); Takahashi, Akio; Wajima, Motoyo; Tsukanishi, Kenji. *Polym J* v 20 n 2 1988 p 125-130.

**Defects** See ACIDS—Processing.

## Degradation

**081713 INHOMOGENEOUS THERMO-OXIDATIVE DEGRADATION DURING HEAT AGEING OF ALIPHATIC POLYAMIDES IN BULK.** Changes of molecular mass (MM) and contents of COOH and  $\text{NH}_2$  end groups in blocks of aliphatic polyamides were studied during thermal ageing in the temperature range 50-160°C; it was shown that the largest changes of these characteristics occur in the 200-300  $\mu\text{m}$  thick surface layer in consequence of thermo-oxidative degradation. A satisfactory agreement was obtained between the calculated and experimental thickness of the oxidized layer. Together with thermo-oxidation, in PA-6 samples some additional condensation was also observed accompanied by an increase in MM which is most pronounced in the central part of the sample. (Author abstract) 13 refs.

Vasil'ev, V.A. (Research & Production Unit 'Plastmassy', USSR); Kudryavtseva, G.A.; Pavlov, N.N. *Polym Sci USSR* v 28 n 10 1986 p 2373-2379.

## Doping

**081714 ADDITIVE SELECTION CRITERIA FOR METAL-DOPED POLYIMIDES.** The use of metal dopants has been the focus of much activity, primarily aimed at enhancing the electrical properties of polymeric materials. A series of copper additives have been investigated for their suitability as potential dopants in polyimide films. In all instances where the additives meet the solvent and thermal decomposition requirements, good polymer films with reasonable thermal stability have been produced which suggests that they are useful criteria in dopant selection. 7 refs.

Khor, Eugene (Nat'l Univ of Singapore, Singapore); Chan, Hardy S.O.; Hor, T.S. Andy; Lusty, James R. *J Polym Sci Part C* v 25 n 12 Dec 1987 p 471-475.

## Elasticity

**081715 DYNAMIC MECHANICAL PROPERTIES OF POLYAMIDOIMIDES BASED ON TRIMELITIMIDO-N-ACETIC ACID.** It was shown that a change in chemical structure of the amine fragment of a



polyamidoimide leads to broadening or splitting of the relaxation peak, which is explained by structural microheterogeneity of the polymer. It was established that PAI are characterized by high moduli elasticity, the values of which remain quite high for individual polymers at elevated temperature, and retain elasticity and high stability at low temperatures. (Author abstract) 6 refs.

Zamulina, L.I.; Rosovitskii, V.F.; Babkina, N.V.; Khomenkova, K.K.; Privalko, V.P. *Sov Prog Chem* v 53 n 2 1987 p 118-120.

**081716 ELASTICITY OF CRYSTAL LATTICE AND CHAIN RIGIDITY OF POLYIMIDE PM.** On the basis of X-ray diffraction data and simple geometrical considerations, chain conformations that can exist in the crystalline phase of polyimide PM have been analysed. It is demonstrated that a more folded conformation than the known trans-zig-zag is possible. Geometrical parameters and chain compliance were estimated from equations derived by T. Miyazawa. Formulae that relate the overall chain compliance, geometrical parameters, and elastic properties of individual constitutive units have been derived in analytical form. Contributions individual elements to the chain compliance have been estimated. (Edited author abstract) 9 refs.

Ginzburg, B.M. (USSR Acad of Sciences, USSR); Magdalyov, Ye.T. *Polym Sci USSR* v 29 n 2 Feb 1987 p 377-382.

## Electric Properties

**081717 EFFECT OF METAL HALIDES ON THE ELECTRICAL PROPERTIES OF POLYIMIDES.** This paper describes the effect of metallic salts, Sn(II), Hg(II), Co(II) chlorides, on the electrical properties of polyimide films derived from 3,3',4,4'-benzophenone tetracarboxylic acid dianhydride (BTDA) and 4,4'-diaminodiphenyl ether (E). The effect of temperature/field on the electrical conductivity of the films was studied. An ohmic/sublinear behavior in undoped film and a non-ohmic behavior at high field and temperature was observed in doped films. Dielectric characteristics ( $\epsilon$  and  $\tan \delta$ ) as a function of frequency and temperature were also investigated. (Edited author abstract) 18 refs.

Varma, I.K. (Indian Inst of Technology, Delhi, India); Saxena, Sneh; Tripathi, Anita; Varma, D.S. *Polymer* v 29 n 3 Mar 1988 p 559-565.

**081718 COMPARISON OF THE ELECTRICAL PROPERTIES OF POLYIMIDE FILMS CONTAINING SURFACE METAL OXIDE: COBALT OXIDE VS. TIN OXIDE.** In this paper, the thermal, electrical and spectroscopic data regarding anhydrous cobalt(II) chloride and tin(II) chloride dihydrate modified polyimide films is compared and contrasted. A more complete understanding of the various synthetic parameters which act to produce these interesting materials is also presented. Finally, the applicability of the model, which had been proposed for the  $\text{Co}_3\text{O}_4$  containing polyimides, to the tin oxide containing polyimides is evaluated. 32 refs.

Rancourt, J.D. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Porta, G.M.; Taylor, L.T. *Thin Solid Films* v 158 n 2 Apr 1988 p 189-206.

## Electrochemistry

**081719 ELECTROCHEMISTRY OF THERMALLY CYCLIZED POLYIMIDE FILMS.** An electrochemical study of poly(4,4'-oxydiphenylene-pyromellitimide), better known as Kapton, was conducted. The cyclic voltammetric response of the thermally cyclized polymer in aqueous electrolytes shows two chemically reversible electron transfers. Electrochemical methods indicate the rate of charge propagation in this polymer is principally dependent upon mass transfer. Surprisingly, the investigation of this polymer in nonaqueous electrolytes showed exceedingly poor electrochemical behavior relative to the aqueous electrolytes. The difference between the electrochemistry of the polymer in aqueous vs. nonaqueous electrolytes is believed to be due to solvent effects on the electron

transfer properties rather than mass-transfer effects. (Author abstract) 25 refs.

Krause, L.J. (3M Co, St. Paul, MN, USA); Bales, J.L. *J Electrochem Soc* v 135 n 5 May 1988 p 1137-1142.

**Electronics Packaging** See COPPER AND ALLOYS—Thin Films.

## Etching

**081720 CO<sub>2</sub> LASER CLEANING OF BLACK DEPOSITS FORMED DURING THE EXCIMER LASER ETCHING OF POLYIMIDE IN AIR.** Pulsed CO<sub>2</sub> laser cleaning of black debris formed during the excimer laser ablation of polyimide in air is demonstrated. The 10.6  $\mu\text{m}$  CO<sub>2</sub> laser radiation is strongly absorbed in the debris but only weakly absorbed in polyimide thus enabling the clean removal of the debris without damaging the polyimide. (Author abstract) 5 refs.

Koren, G. (IBM, Yorktown Heights, NY, USA); Donelson, J.J. *Appl Phys B* v B45 n 1 Jan 1988 p 45-46.

**Film** See Also COATINGS—Physical Properties.

**081721 EVALUATION OF POLYIMIDE FILMS AS ADHESIVES.** A commercially available LARC-TPI film and an experimentally prepared film of LARC-TPI with 5 mol% of 4,4'-oxydianiline (ODA), designated as LARC-TPI/ODA in the paper supplied by Mitsui Toatsu Chemicals, Incorporated (MTCI), Japan, were evaluated as thermoplastic adhesive films for bonding Ti-6Al-4V. The LARC-TPI/ODA had been shown by MTCI to possess more flow than thermoplastic LARC-TPI and was, therefore, evaluated and compared to the LARC-TPI. Lap shear strength was used to evaluate the materials as adhesives. The mode of failure is also reported. (Edited author abstract) 11 refs.

Progar, Donald J. (NASA, Hampton, VA, USA). *J Adhes Sci Technol* v 1 n 1 1987 p 53-68.

**081722 MECHANICAL PROPERTIES AND TRANSITION TEMPERATURES OF A COMBINED POLYIMIDE FILM.** The use of pure polymeric materials has now decreased in industry due to the extensive use of composites, which combine the best properties of the individual components. For this reason, the evaluation of the mechanical properties of heterogeneous systems from the properties of the individual components is an especially important problem. An a priori evaluation of the set of mechanical characteristics and transition temperatures of a combined polyimide film (layered polymer-polymer composite) based on the corresponding parameters of the individual layers and their ratios was conducted in the present study. PM-1 and PM-4 films were prepared by the method of pouring lac on a solid support with subsequent heat treatment. The combined PM-414 film was prepared by layered pouring of the corresponding lacs. 10 refs.

Gurinovich, L.N. (Plastmassy Scientific & Industrial Assoc, Moscow, USSR); Kovriga, V.V.; Lur'e, E.G. *Mech Compos Mater* v 23 n 1 Jan-Feb 1987 p 123-128.

**081723 TEARING OF THIN POLYIMIDE FILMS.** Films of BTDA-ODA polyimide up to 58  $\mu\text{m}$  thick were torn at constant cross-head speed in 'trousers' tests. In common with previous results on polyolefins, the work of tearing was found to increase markedly with specimen thickness. A model for the increase, based on the volume of plastically deformed material adjacent to the crack plane, was found to be only qualitatively valid. The experimental slope of a plot of tearing energy (per unit area) against thickness was 70  $\text{MJm}^{-3}$ . Optical and scanning electron micrographs of torn films are discussed in regard to the modes of failure. (Author abstract) 12 refs.

Hinkley, J.A. (NASA, Hampton, VA, USA); Hoogstraten, C.A. *J Mater Sci* v 22 n 12 Dec 1987 p 4422-4425.

**081724 SOLVENT-INDUCED LOCAL DEFORMATION ZONES IN POLYIMIDE FILMS ADHERED TO A RIGID SUBSTRATE.** Thin films of a polyimide (Ciba-Geigy XU293) adhered to rigid substrates devel-

oped special type of local deformation zones when immersed in xylene. These deformation zones were initiated because of the presence of the combination of xylene and the equi-biaxial tension resulting from the drying process. Their microstructure was strongly influenced by the local bonding to the substrate. In the bonded regions, the zones resembled a narrow trench containing deformed but unvoided material. In the unbonded regions, complicated fibrillar structure was observed in the much wider zones. Although they retained a smooth surface on the face in contact with the substrate in the bonded regions, the deformation zones released a significant amount of stress. The stress release was measured by a photo-elastic method and was found to be in excellent agreement with that calculated from the local thickness change assuming simple elasticity. Although not cracked, there were lines of weakness; after long soaking times the films cracked and delaminated along the defects. (Author abstract) 18 refs.

Yang, A.C.M. (IBM, San Jose, CA, USA); Brown, H.R. *J Mater Sci* v 23 n 1 Jan 1988 p 65-71.

**081725 HIGH STRENGTH AND HIGH MODULUS AROMATIC POLYIMIDE/POLYIMIDE MOLECULAR COMPOSITE FILMS.** Recently we obtained high strength, high modulus aromatic polyimide films having a maximum modulus of 60 GPa by thermal imidization of cold drawn poly(amic acid) precursor films. The polyimides giving high modulus and high strength seem to have a rather rigid chemical structure, while the polyimides having a flexible structure do not give high strength and high modulus under the same processing conditions. In the present study, we report the preparation of molecular composite films of these strong, rigid aromatic polyimides embedded in a ductile matrix of flexible polyimides. 8 refs.

Yokota, Rikio (Ministry of Education, Tokyo, Jpn); Horiuchi, Ryo; Kochi, Masakatu; Soma, Hideya; Mita, Itaru. *J Polym Sci Part C* v 26 n 5 May 1988 p 215-223.

**081726 STRENGTH OF RUBBING WORKED ON POLYIMIDE FILMS FOR ALIGNING NEMATIC AND CHIRAL SMECTIC LIQUID CRYSTALS: CONTROLLING PRETILT ANGLES AND SOME ELECTROOPTIC PERFORMANCES OF LCDs.** The degree of work done on polyimide films in the rubbing process with a nylon fabric was detected and evaluated in terms of induced birefringence. Strong and weak rubbing (effecting two extremes) gave rise to the optical retardation of 1 degree and 0.1 degree, respectively, with a resolution of 0.1 degree. Generation of a pretilt angle of up to 10 degrees (even up to 30 degrees) for nematic liquid crystals was achieved by performing weak rubbing on a specially synthesized polyimide which was successfully used to fabricate supertwisted nematic liquid crystal displays. Fairly good bistability in a ferroelectric liquid crystal device was also obtained by weak rubbing. (Author abstract) 8 refs.

Kuniyasu, Seiyu (Tokyo Univ of Agriculture & Technology, Tokyo, Jpn); Fukuro, Hiroyoshi; Maeda, Shigeo; Nakaya, Kenji; Nitta, Michio; Ozaki, Norihiko; Kobayashi, Shunsuke. *Jpn J Appl Phys Part 1* v 27 n 5 May 1988 p 827-829.

## Friction

**081727 FRICTION AND WEAR STUDIES OF A BISMALEIMIDE.** Bismaleimides are thermally stable thermosetting polyimides. They are brittle in nature, because of their high cross-link density, which can be reduced by certain chain extension reactions. The authors have previously studied the friction and wear properties of 4,4'-(bismaleimido) diphenyl methane. This compound has a high rate of wear. This paper discusses the friction and wear properties of a chain-extended product of 4,4'-(bismaleimido) diphenyl methane. Chain extension improves the wear characteristics of the bismaleimide, particularly at high loads. (Author abstract) 16 refs.

Tewari, U.S. (Indian Inst of Technology, New Delhi, India); Sharma, S.K.; Vasudevan, P. *Tribol Int* v 21 n 1



Feb 1988 p 27-30.

**081728 EFFECTS OF TEMPERATURE AND AMBIENT PRESSURE ON FRETTEING PROPERTIES OF POLYIMIDE.** In order to study the dependence of tribological properties of polyimide on the environment, the fretting properties of polyimide against SUS316L stainless steel were examined under a normal load of 14 N, a peak-to-peak slip amplitude of 80  $\mu\text{m}$ , a frequency of 16.7 Hz and  $10^5$  cycles by varying the temperature from 20 to 300°C and an ambient pressure in the range  $10^5$  -  $10^{-3}$  Pa. There were two distinct regimes of wear surface morphology dependent on temperature and ambient pressure. One was of an overall transfer layer, with a very smooth surface and some cracking, along with plate-like debris formed at pressures above 10 Pa at 20°C, and temperatures to 300°C at  $10^5$  Pa. The other regime was one of island transfer, an abraded surface and very fine wear debris formed at pressures below  $10^3$  Pa at 300°C, and temperatures to 300°C at  $10^{-3}$  Pa. (Edited author abstract) 17 Refs.

Iwabuchi, Akira (Iwate Univ, Ueda, Jpn); Hori, Kiyoshi; Sugawara, Yasuhiro. *Wear* v 125 n 1-2 Jul 1988 p 67-81.

## Heat Resisting

**081729 THERMO-OXIDATIVELY STABLE CONDENSATION POLYIMIDES CONTAINING 1,1,1-TRIARYL-2,2,2-TRIFLUOROETHANE DIANHYDRIDE AND DIAMINE MONOMERS.** Nine new condensation polyimides containing the trifluorophenylthylidene linkage were synthesized by the amic-acid route. Several other polyimides, including some with the hexafluoroisopropylidene linkage, were also prepared as controls. Amic-acid solutions were characterized by determining their inherent viscosities prior to thermal conversion into polyimide films. Glass transition temperatures ( $T_g$ ), thermogravimetric analysis (TGA), and isothermal weight loss data (at 316°C, 371°C, and 371°C under 0.5 MPa air pressure) were obtained for the films. The films were pulverized into molding powders which, in turn, were thermally processed under pressure into neat resin discs. The discs were also characterized by  $T_g$ s and 316 and 371°C isothermal weight losses. The film study identified two new polyimides with  $T_g$ s greater than 371°C and two new polyimides with low rates of weight loss. (Edited author abstract) 3 refs.

Alston, William B. (NASA, Cleveland, OH, USA); Gratz, Roy F. *NASA Tech Memo* 89875 1987 5p.

## Heat Treatment

**081730 STRUCTURE AND PROPERTIES OF HIGHLY CRYSTALLIZED GRAPHITE FILMS BASED ON POLYIMIDE KAPTON.** Highly crystallized graphite films were prepared by heat treatment of carbonized polyimide films (Kapton) at temperatures of 2700 and 3050°C. Interlayer spacing  $d_{002}$  at room temperature and electrical resistivity, magnetoresistance and Hall coefficient at room and liquid nitrogen temperatures were measured. For the graphite films heat treated at 3050°C mean square mobilities were estimated from the magnetoresistance data at 1 T to be  $0.91 \text{ m}^2 \text{V}^{-1} \text{sec}^{-1}$  at room temperature and  $2.3 \text{ m}^2 \text{V}^{-1} \text{sec}^{-1}$  at liquid nitrogen temperature; the value at liquid nitrogen temperature corresponds to that for a pyrolytic graphite heat treated at 3200°C for 1 h (PG 3200). Magnetic field dependence of the Hall coefficient at liquid nitrogen temperature agrees well with that for PG 3200. Scanning electron micrographs show that the graphite films consist of grains of large crystallites, and grain size increases as the crystallinity of the material improves. (Edited author abstract) 7 Refs.

Hishiyama, Yoshihiro (Musashi Inst of Technology, Tokyo, Jpn); Yasuda, Satoru; Yoshida, Akira; Inagaki, Michio. *J Mater Sci* v 23 n 9 Sep 1988 p 3272-3277.

**Mechanical Properties** See Also AROMATIC POLYMERS—Mechanical Properties.

**081731 PROPERTIES OF POLYIMIDES.** Due to the stability of the imide group and aromatic molecular chains, polyimides distinguish themselves by a series of interesting properties. In spite of their high price these plastic materials are increasingly used in the electric and electronics industry, automotive industry, aeronautics and space travel, construction of plants and apparatus, nuclear engineering plants as well as in military engineering. Two-figure growth rates are to be expected within the next few years. The mechanical and tribologic properties as well as the behaviour at high temperatures are studied on a representative material of this plastic material class. (Author abstract) 8 refs. In German and English.

Bieringer, H.; Korb, G.; Mair, H.J. *Kunstst Ger Plast* v 77 n 11 Nov 1987 p 26-28, 1173-1176.

**081732 NOVEL POLYAMIDE-IMIDES.** A series of thermally stable, tough, linear polyimides containing amide linkages were prepared. These materials have potential as high temperature films and coatings as well as matrix resins in graphite reinforced structures. The new polyamide-imides were prepared by reacting a group of isomers of diaminobenzanilide (DABA) with 3,3',4,4'-benzophenonetetracarboxylic dianhydride (BTDA) to form the polyamide-acid with subsequent thermal conversion to the polyamide-imide (PAI). Four polymers were synthesized from unsubstituted amide diamines and two others from N-substituted amide diamines. The properties of these polyamideimides were compared to those of the polyimide of benzophenonetetracarboxylic polyamideimide dianhydride/3,3'-diaminobenzophenone (LARC-TPI) because their structures are similar except for the presence of the more flexible amide linkages. These polymers exhibited high inherent viscosities and glass transition temperatures. They were made into tough, flexible films which showed good thermal stability and good resistance to organic solvents. Mechanical properties of the PAI films were better than those of LARC-TPI. Films of the 4,4'-isomer polyamide-imide exhibited an exceptionally high modulus and toughness during impact evaluation. (Author abstract) 9 refs.

Dezern, James F. (NASA, Hampton, VA, USA). *SAMPE J* v 24 n 2 Mar-Apr 1988 p 27-31.

**081733 POLIURETANOIMIDY Z DIIZOCYJANIANU TOLILENU. I. WŁASCIWOSCI MECHANICZNE I STABILNOSC TERMICZNA.** [Polyurethaneimides from Toluene Diisocyanate. Part I. The Mechanical Properties and Thermal Stability]. The mechanical and thermal properties of polyurethaneimides (PUI) prepared from pyromellitic dianhydride, toluene diisocyanate (TDI) and polyesterdiol of the type of poly(ethylene adipate) have been presented. These properties have been compared with those of PUI from 4,4'-diphenylmethane diisocyanate and of other polymers containing thermostable groupings of aromatic imide and advantages of TDI-PUI have been stated. The influence of concentration of time of storage of PUI solutions on their viscosity has been determined. The IR analysis has been applied in the determination of the progress of thermal imidization reaction. (Author abstract) In Polish. 24 refs.

Masiulanis, Bogumila (Politechnika Gdanska, Pol). *Polimery* v 32 n 10 Oct 1987 p 401-405.

**081734 EFFECT OF MOLECULAR WEIGHT ON THE MECHANICAL PROPERTIES OF POLYAMIDEIMIDE.** Aromatic polyamideimide (PAI) was prepared by the polycondensation of trimellitic anhydride with 4,4'-diphenylmethane diisocyanate. The PAI was fractionated by fractional precipitation. The effect of molecular weight on the tensile strength and elongation of PAI was investigated. The relationship between tensile strength or elongation of fractionated PAI and the degree of polymerization is presented. The tensile strength of a mixture of fractionated PAI with a different molecular weight was found to be given by the sum of the product of mass fraction and tensile strength of their fractions. (Edited author abstract) 10 refs. In Japanese.

Tsubokawa, Norio (Niigata Univ, Niigata, Jpn); Sakaguchi, Miki; Sone, Yasuo. *Kobunshi Ronbunshu* v 45 n 3 Mar 1988 p 263-267.

**081735 CHAIN CONFORMATION AND STIFFNESS OF AROMATIC POLYIMIDES CONTAINING ONE FLEXIBLE JOINT IN THE DIANHYDRIDE CONSTITUENT.** Highly oriented fibres made of aromatic polyimides prepared from aromatic diamines and dianhydrides of tetracarboxylic acids containing one flexible joint between benzene rings were investigated by X-ray diffraction combined with elastic deformation directly in the diffractometer. A single method based on the relationships derived by T. Miyazawa was employed to determine chain conformations and compliance of chains in the crystal lattice. The calculated compliance parameters agree well with values determined experimentally from the modulus of elasticity of crystal lattice deformed along the direction of polymer chains. Parameters characterizing deformation of internal rotation angles have been estimated. (Edited author abstract) 15 refs.

Ginzburg, B.M. (USSR Acad of Sciences, USSR); Magdalyov, Ye.T. *Polym Sci USSR* v 29 n 2 Feb 1987 p 369-376.

## Metallizing

**081736 ROLE OF COLLOID FORMATION, IMIDIZATION, AND AGGREGATION IN THE STRUCTURE OF BTDA-ODA POLYIMIDE FILMS MODIFIED WITH GOLD.** High-temperature polyimide films with metallic gold surfaces can be fabricated by the incorporation of a soluble metal salt into a solution of polyamic acid. Thermal treatment of these solutions produces the polyimide, decomposes the metal salt to metallic gold, and promotes the formation and growth of the metallized surface. What appeared to be a continuous metallic surface was actually composed of large gold aggregates. It is suspected that the formation of colloidal gold during the initial thermal treatment provides precursors to the large metal aggregates. Thermal treatment has been shown to influence the size and distribution of the aggregates. The shape of the aggregates suggests that diffusion-limited aggregation may be responsible for the unique shape of some of the gold aggregates. (Author abstract) 13 Refs.

Madeleine, D.G. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Ward, T.C.; Taylor, L.T. *J Polym Sci Part B* v 26 n 8 Aug 5 1988 p 1641-1655.

## Optical Properties

**081737 PYROLYSATION KINETICS AND OPTICAL PROPERTIES OF POLYIMIDE FOIL.** This paper is devoted to the pyrolysis kinetics of polyimides as evidenced by changes in the optical transmittance. The main result is to show that the pyrolysis can be understood as a thermally activated process with an activation energy governed by the optically observed fundamental bandgap of polyimide. The optical measurements are probing the bulk of the foils, and are believed to be adequate for testing the chemical bond breaking in the initial phase of pyrolysis, whereas the electrical and mechanical properties change strongly only when a percolation threshold is exceeded. 12 refs.

Serbinov, I.A. (Chalmers Univ of Technology, Gothenburg, Sweden); Niklasson, G.A.; Granqvist, C.G. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1113-1114.

## Photosensitivity

**081738 SYNTHESIS AND CHARACTERIZATION OF PHOTOCSENSITIVE POLYIMIDES.** All aromatic polyimides bearing diarylsulfide linkages in the main chain were prepared either by condensation of sulfur containing dianhydride with an aromatic diamine or the condensation of a sulfur containing aromatic diamine with a dianhydride. Phenylation with diphenyl iodonium salts was then used to convert the diarylsulfide groups to triarylsulfonium salts. The resulting photosensitive polyimides were shown to undergo main chain cleavage during



photolysis using UV irradiation. These new polyimides are candidates for positive working, high temperature photoresist materials. (Author abstract) 11 refs.

Crivello, J.V. (GE, Schenectady, NY, USA); Lee, J.L.; Conlon, D.A. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3293-3309.

**Physical Chemistry** See AROMATIC POLYMERS—Blending.

## Physical Properties

**081739 DAMAGE TOLERANT COMPOSITES.** Recently, researchers at duPont recognized the need for a material with capabilities beyond those of high grade epoxies, in terms of toughness and damage tolerance. The result is a composite material designated Avimid K-III, a new polyimide composition of pyromellitic dianhydride and aromatic diamine. (The diamine was designed to lower the glass transition temperature and retard crystallization.) The composite expands the range of structural shapes that can be fabricated through thermoplastic molding processes.

Spiegelman, Phillip P. (DuPont Inc, USA); Aldrich, Donald C.; Waughtal, Richard F. *Aerosp Eng (Warrendale PA)* v 7 n 12 Dec 1987 p 8-11.

**081740 SUPER TOUGH POLYIMIDE.** SP polyimide material has no observable glass transition temperature or melting point below a decomposition temperature which is in excess of 400°C. Although this behavior is a key feature in performance, because of the resin's intractability, it also represents a major obstacle to the effective fabrication of complex structural parts. Researchers at duPont overcame this problem by using powder metallurgy forming techniques which changed the morphology of the molding resin. The result is Vespel ST, a high temperature polyimide with significantly increased strength and toughness. An already tough Vespel SP was made super tough.

Spiegelman, Phillip P. (DuPont Inc, USA); Aldrich, Donald C.; Waughtal, Richard F. *Aerosp Eng (Warrendale PA)* v 7 n 12 Dec 1987 p 16-22.

## Processing

**081741 MATERIAL AND PROCESSING TECHNOLOGIES OF POLYIMIDE FOR ADVANCED ELECTRONIC DEVICES.** Advanced material and processing technologies of polyimide applied to various substrates were investigated and studied for high density electronic devices. Precisely controlled temperature profiles in each processing step can realize required chemical structures of polyimide materials and the excellent polyimide films. Thick film patterning of photosensitive polyimide is extremely difficult because the exposed top layer is dissolved before the unexposed area is developed as the result of UV absorption and reaction at the bottom being less than that of the top layer. For removing the thin film residue on copper and/or copper containing alloys, a simple patterning process using a solution containing hydrazine has been developed. Newly developed techniques such as screen printing, shower developing, and microwave-assisted curing enable the realization of more precise patterning of photosensitive polyimide. (Edited author abstract) 8 refs.

Endo, Atsushi (Mitsubishi Electric Corp, Amagasaki, Jpn); Takada, Mitsuyuki; Adachi, Kohei; Takasago, Hayato; Yada, Toshio; Onishi, Yoichiro. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2522-2527.

**081742 PROCESSING OF PHOTOSENSITIVE POLYIMIDES FOR PACKAGING APPLICATIONS.** Photosensitive polyimides have been investigated as substitutes for a standard aqueous base-etchable polyimide. The application uses a ceramic base module on which two layers of metal circuits are separated by a polyimide dielectric. Using a photosensitive polyimide reduces the number of steps and shortens the process time required to form the via interconnections. Processing properties and

material properties were studied to select a material which would give optimum throughput. The photosensitive polyimides investigated were primarily developed for IC processing; adaption to packaging applications requires adjustment of processes. Polyimide application, drying, baking, exposure, developing, and final cure must be optimized to use these materials successfully. 8 refs.

Rickerl, Paul G. (IBM, Endicott, NY, USA); Stephanie, John G.; Slota, Peter Jr. *IEEE Trans Compon Hybrids Manuf Technol* v CHMT-10 n 4 Dec 1987, Contrib from the 37th Electr Compon Conf, Boston, MA, USA, May 1987 p 690-694.

**Pyrolysis** See Also POLYMERS—Heating.

**081743 STRUCTURAL DETERMINATION OF PYROLYZED PI-2525 POLYIMIDE THIN FILMS.** Polyimide was pyrolyzed in an argon atmosphere at various temperatures, and thermally converted to amorphous carbon films. The irreversible change of polyimide under progressive heat treatment is characterized by three successive structural changes: pyrolysis, carbonization, and graphitization. X-ray photoelectron spectroscopy (XPS) studies show that the polyimide starts to dissociate at pyrolysis temperatures above 500°C. At temperatures higher than 650°C most functional groups of polyimide decompose to evolve gases from the sample. The polyimide then gradually becomes more carbon rich. It is believed that at pyrolysis temperature higher than 650°C the polyimide starts to form heterocyclic structures with residual oxygen and nitrogen incorporated into the heterocyclic carbon rings. (Edited author abstract) 23 refs.

Hu, C.Z. (Univ of Utah, Salt Lake City, UT, USA); Andrade, J.D.; Dryden, P. *J Appl Polym Sci* v 35 n 5 Apr 1988 p 1149-1160.

**081744 SURFACE STRUCTURE OF PYROLYZED POLYIMIDE.** X-ray photoelectron spectroscopy analysis shows that polyimide is thermally converted to glassy carbon during pyrolysis. Scanning tunneling microscopy gives direct evidence of the existence of small graphitic domains in the amorphous carbon matrix, and we believe that those surface graphitic structures may play a major role in the biocompatibility of carbon surfaces. (Author abstract). 15 Refs.

Hu, C.Z. (Univ of Utah, Salt Lake City, UT, USA); Feng, L.; Andrade, J.D. *Carbon* v 26 n 4 1988 p 543-545.

## Radiation Effects

**081745 NEW CONDUCTING AND OPTICAL PROPERTIES INDUCED IN POLYIMIDE BY ION BEAM IRRADIATION.** Ion beam irradiation of polyimide films leads to the formation of new materials exhibiting enhanced electrical conductivity (of the order of  $10^2 \Omega^{-1} \text{cm}^{-1}$ ) and an increase of the optical absorption in the visible. The formation of these carbon-rich products has been studied by the kinetics of hydrogen evolution during irradiation, which can be described by an exponentially decreasing law. The modification of the optical absorption for different wavelengths is in agreement with this variation. These results imply the existence of a saturated stage reached when the overlap between the strongly disordered cylindrical volumes formed around the individual tracks is complete. (Author abstract) 12 refs.

Davenas, J. (Univ Claude Bernard (Lyon I), Villeurbanne, Fr); Xu, X.L.; Boiteux, G. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 81-87.

## Spectroscopic Analysis

**081746 REACTIONS AT THE POLYIMIDE-METAL INTERFACE.** Ultra-high-vacuum spectroscopic techniques are utilized to investigate the mechanism of the interfacial reactions of copper and titanium with polyimides. Ultra-violet photoemission spectroscopy of in situ deposited Cu on polyimides suggests that

covalent interaction between the metal and the polymer is absent. Model studies confirm this finding. Alternatively, deposition of Ti onto polyimides shows the presence of strong covalent interaction between the imide moiety of the polymer backbone and the metal. Solution model studies support a mechanism for the Ti-polyimide reaction involving initial Ti-O bond formation followed by Ti-C bonding at higher coverages of material. (Author abstract) 13 refs.

Freilich, S.C. (DuPont, Wilmington, DE, USA); Ohuchi, F.S. *Polymer* v 28 n 11 Oct 1987 p 1908-1914.

**081747 SPECTROSCOPIC STUDY OF THE CHEMICAL CONVERSIONS OF AROMATIC POLYIMIDES CONTAINING DOUBLE AND TRIPLE CARBON-CARBON BONDS.** Infrared spectroscopy and high resolution NMR in a solid body have been used to study the opening of the double and triple bonds contained in the diamine fragments of some aromatic polyimides at 20-400°C. The consumption of the double and triple bonds on heating begins simultaneously and occurs synchronously by more than 80-95%. A small number of triple bonds remains even at 400°C. (Author abstract) 9 refs.

Kol'tsov, A.I. (USSR Acad of Sciences, USSR); Mikhailova, N.V.; Gribanov, A.V.; Koton, M.M.; Zhukova, T.I.; Bobasheva, A.S.; Kheinmaa, A.I.; Lippmaa, E.T. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2800-2804.

**081748 MOLECULAR ORBITAL ANALYSIS OF THE XPS SPECTRUM OF A FLUORINE CONTAINING POLYIMIDE: PMDA-BDAF.** The results of XPS measurements and molecular orbital calculations performed on the fluorine containing polyimide, PMDA-BDAF, are presented. The calculated carbon 1s (C1s) core energy level positions are compared with the level positions inferred from the XPS measurements. Within Koopman's approximation, the observed shape of the main XPS peak is consistent with the calculated distribution of C1s levels under this peak. Comparison of the magnitude of the carbonyl XPS peak intensity with the main peak intensity indicates a carbonyl C1s signal deficiency compared with that expected for 'ideal bulk stoichiometry' i.e., for a polymer with no crosslinks or chain terminations. (Edited author abstract) 17 refs.

Silverman, B.D. (IBM, Yorktown Heights, NY, USA); Sanda, P.N.; Clabes, J.G.; Ho, P.S.; Hofer, D.C.; Rossi, A.R. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 1199-1205.

**081749 EFFECT OF TEMPERATURE ON THE INFRARED SPECTRA OF A POLYIMIDE.** The effect of high temperature on the infrared spectra of fully cured PMDA/ODA polyimide is discussed. Changes in some bands can be explained by Boltzmann effects on the distribution of excited states. Other bands, in particular the  $1780\text{-cm}^{-1}$  band that is often used for cure measurements, change in ways that cannot be related to Boltzmann's equation. These band position and intensity changes are explained as configurational changes occurring during heating. Determination of correction factors for integrated peak areas from spectra taken at elevated temperature are discussed. (Author abstract) 14 refs.

Snyder, Randy W. (IBM Endicott, NY, USA); Sheen, C. Wade; Painter, Paul C. *Appl Spectrosc* v 42 n 3 Mar-Apr 1988 p 503-508.

**081750 FT-IR METHOD FOR PERFORMING DYNAMIC KINETIC EXPERIMENTS.** A method is shown for the determination of kinetic parameters from dynamic FT-IR experiments. The effect heating rate has on the reproducibility of the calculated activation energy is discussed. The curing of PMDA/ODA polyimide at several heating rates is given as an example. (Author abstract) 10 refs.

Snyder, Randy W. (IBM, Endicott, NY, USA); Sheen, C. Wade. *Appl Spectrosc* v 42 n 4 May-Jun 1988 p 655-658.



**081751 FOURIER TRANSFORM IR REFLECTION TECHNIQUES FOR CHARACTERIZATION OF POLYIMIDE FILMS ON COPPER SUBSTRATES.** In this study, we have used Fourier transform IR spectroscopy to study the copper-catalyzed degradation of polyimide and its precursor, polyamic acid. We have examined the system in both air and nitrogen and with both copper and chromium as test substrates. Also discussed in this paper is the application of two new spectroscopy techniques: surface electromagnetic wave spectroscopy and grazing-angle incident metal overlayer attenuated total reflection spectroscopy. The combined use of all three experimental methods allows us to examine the interfacial regions of the polyimide/copper system fully. (Edited author abstract) 25 refs.

Kelley, Kristen (Case Western Reserve Univ, Cleveland, OH, USA); Ishino, Yuichi; Ishida, Hatsuo. *Thin Solid Films* v 154 n 1-2 Nov 12 1987, Pap Presented at the Int Conf on Metall Coat - Part II, San Diego, CA, USA, Mar 23-27 1987 p 271-279.

## Structure

**081752 CHEMICAL STRUCTURES AND PROPERTIES OF LOW THERMAL EXPANSION COEFFICIENT POLYIMIDES.** The relationships between chemical structures of various aromatic polyimides and their thermal expansion coefficients, were investigated and the properties of low thermal expansion polyimides were elucidated. Such low values were observed for polyimides obtained from pyromellitic dianhydride or 3,3',4,4'-biphenyltetracarboxylic dianhydride and aromatic diamines, which included only benzene or pyridine rings fused at para-positions without a flexible linkage. It was proposed that these low thermal expansion coefficients were related to the linearity of their polymer molecular skeletons. In particular, PIQ-L100 (Hitachi Chemical Co. Ltd) is one such low thermal expansion polyimide and it has excellent mechanical properties, thermal stability, and low absorbed moisture content. (Author abstract) 21 Refs.

Numata, Shunichi (Hitachi Ltd, Hitachi, Jpn); Kinjo, Noriyuki; Makino, Daisuke. *Polym Eng Sci* v 28 n 14 Jul 1988 p 906-911.

**Synthesis** See Also GASES—Permeability, Mechanical.

**081753 PMR POLYIMIDE COMPOSITIONS FOR IMPROVED PERFORMANCE AT 371°C.** Studies were conducted to identify matrix resins which have potential for use at 371°C (700°F). Utilizing PMR methodology, neat resin moldings were prepared with various monomer reactants and screened for thermo-oxidative stability at 371°C (700°F) under both ambient and four atmospheres air pressure. The results of the resin screening studies indicate that high molecular weight (HMW) formulated resins of first (PMR-15) and second (PMR-II) generation PMR materials exhibit lower levels of weight loss at 371°C (700°F) than PMR-15 and PMR II resins. (Author abstract) 2 refs.

Vannucci, Raymond D. (NASA, Cleveland, OH, USA). *SAMPE Q* v 19 n 1 Oct 1987 p 31-36.

**081754 NOVEL BISMALIMIDES VIA EPOXY-CARBOXY ADDITION REACTION: SYNTHESIS CHARACTERIZATION AND THERMAL STABILITY.** The present paper describes the synthesis and characterization of bismaleimides containing epoxy backbone between the maleimide ends. In this synthesis, a preformed maleimide containing carboxylic acid function is reacted with an epoxy resin by melt condensation. The resin products were analyzed by gel permeation chromatography. Infrared and C NMR spectroscopy were used for characterization of these materials. Differential scanning calorimetry and thermogravimetric analysis were used to establish cure characteristics and thermal stability of these materials. 16 refs.

Rao, B.S. (Nat'l Chemical Lab, Poona, India). *J Polym Sci Part C* v 26 n 1 Jan 1988 p 3-10.

**081755 SYNTHESIS AND CHARACTERIZATION OF AROMATIC POLYIMIDE AND POLYAMIDE-IMIDE FROM 2,5-BIS(4-ISOCYANATOPHENYL)-3,4-DIPHENYLTHIOPHENE AND AROMATIC TETRA- AND TRICARBOXYLIC ACIDS.** Soluble polyimide having an inherent viscosity up to 1.4 dL/g was synthesized by the high-temperature solution polycondensation of 2,5-bis(4-isocyanatophenyl)-3,4-diphenylthiophene with 3,3',4,4'-benzophenonetetracarboxylic dianhydride. The polycondensation of the tetraphenylthiophene diisocyanate with trimellitic anhydride afforded polyamide-imide with an inherent viscosity up to 0.9 dL/g. These polymers showed limited solubility in organic solvents and had glass transition temperatures around 320°C. (Author abstract) 9 refs.

Kakimoto, Masa-Aki (Tokyo Inst of Technology, Tokyo, Jpn); Akiyama, Reiko; Negi, Yuvraj Singh; Imai, Yoshio. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 99-105.

**081756 POLYIMIDES FROM 2,5-BIS(p-AMINOPHENYL)PYRIMIDINE AND AROMATIC DIANHYDRIDES.** The synthesis and properties of polyimides obtained by the polycondensation of 2,5-bis(p-aminophenyl)pyrimidine with a variety of aromatic dianhydrides has been examined. The linear structure of this diamine, which is a heterocyclic analog of terphenyl, enables films to be obtained which possess high mechanical strength and thermal stability. It is shown that the deformation-strength properties of polyimide films are highly dependent on the proportion of isoimide units in the prepolymer, before thermal treatment. Lower proportions of isoimide units correspond to higher physicochemical characteristics. For example, in the case of the polyimide obtained by thermal treatment of the prepolymer containing 23% of the isoimide units, the strength at rupture is 200 MPa, and extension at rupture is 12%. The polyimide obtained from the prepolymer containing 7% of isoimide units has a strength of 220 MPa and extension 25%. 7 refs.

Koton, M.M.; Nekrasova, E.M.; Borovik, V.P.; Meshko, T.K.; Artem'eva, V.N.; Dergacheva, E.N.; Kudryavtsev, V.V.; Mamaev, V.P. *J Appl Chem USSR* v 60 n 8 pt 2 Aug 1987 p 1727-1731.

**081757 SYNTHESIS AND CHARACTERIZATION OF POLYIMIDES CONTAINING HETEROCYCLIC UNITS.** Five new polyimides containing phenoxaphosphine as well as dibenzothiophene, phenoxathiin, and thianthrene units have been synthesized from 10-phenylphenoxaphosphine-2,3,7,8-tetracarboxylic dianhydride-10-oxide and heterocyclic diamines by the cyclopolycondensation method. These polyimides had inherent viscosities in the 0.75-1.10 dL/g range in conc. H<sub>2</sub>SO<sub>4</sub> at 30°C. All the polymers were characterized by elemental analysis, density, solubility, crystallinity, IR spectra, and thermal methods. (Author abstract) 12 refs.

Subramaniam, Prema (Indian Inst of Technology, Madras, India); Srinivasan, Mahalingam. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1553-1560.

**081758 SYNTHESIS AND CHARACTERIZATION OF A SERIES OF POLYIMIDES DERIVED FROM 4,4'-[2,2,2-TRIFLUORO-1-(TRIFLUOROMETHYLE)ETHYLIDENE]-bis[1,3-ISOBENZOFURANDIONE].** The dianhydride, 4,4'-[2,2,2-trifluoro-1-(trifluoromethyl)ethylidene]bis[1,3-isobenzofurandione] (6FDA)<sup>2a</sup> was reacted with a series of diamines, viz., 4,4'-oxybis[benzencamine] (ODA),<sup>2b</sup> 4,4'-methylene-bis[benzencamine] (MDA),<sup>2c</sup> 4,4'-(2-propylidene)bis[benzencamine] (IPDA),<sup>2d</sup> 2,7-diaminofluorene (DAF),<sup>2e</sup> 3,3'-[2,2,2-trifluoro-1-(trifluoromethyl)ethylidene]bis[aniline] (6FmD-A),<sup>2f</sup> and 1,5-diaminonaphthalene (NDA),<sup>2g</sup> to form clear, tough, thermally stable polyimides which could be cast into clear, tough films. Characterization of these films by infrared spectroscopy, thermogravimetric analysis, differential scanning calorimetry, viscometry, density, and birefringence studies is reported. (Author abstract) 23 refs.

Husk, G. Ronald (Southwest Texas State Univ, San Marcos, TX, USA); Cassidy, Patrick E.; Gebert, Karen L. *Macromolecules* v 21 n 5 May 1988 p 1234-1238.

**081759 HIGH TENACITY AND HIGH MODULUS FIBERS FROM WHOLLY AROMATIC POLYESTERIMIDES.** Wholly aromatic polyesterimide fibers were prepared from rigid aromatic diamines and 4,4'-(arylene-dioxydicarbonyl)diphthalic anhydride by wet-spinning the N-methylpyrrolidone solutions of their precursor poly(amic acids) and then imidizing the fibers chemically. In general, higher crystalline polymers gave fibers having higher initial modulus (Mi), but lower tenacity (T) than lower crystalline polymers. For example, the fiber from p-phenylenediamine and 4,4'-(p-phenylenedioxydicarbonyl)diphthalic anhydride (TmHTm) showed T of 12.6 g/d and Mi of 1420 g/d. Random copolymers composed of a rigid diamine, TmHTm and pyromellitic dianhydride (PMDA) were also spun, and 2-chloro-p-phenylenediamine-TmHTm-PMDA (100 : 60 : 40) copolymer yielded a fiber with T of 20.9 g/d and Mi of 1350 g/d. (Edited author abstract) 4 refs. In Japanese.

Jinda, Takuma (Today Industries Inc, Otsu, Jpn); Matsuda, Toshikazu. *Kobunshi Ronbunshu* v 45 n 3 Mar 1988 p 215-220.

**081760 STUDY OF THE FORMATION CONDITIONS OF AROMATIC POLYIMIDES AND OF BENZOXAZOLE-IMIDE COPOLYMERS BASED ON 3,3'-DIHYDROXY-4,4'-DIAMINODIPHENYL METHANE.** Optimum conditions were found for the synthesis of aromatic polyimides based on 3,3'-dihydroxy-4,4'-diaminodiphenylmethane and pyromellitic or 3,3',4,4'-tetracarboxydiphenyl oxide dianhydrides. Benzoxazole-imide copolymers based on polyhydroxyamide and polyamide acid were obtained. The effect of the method of preparation and of the initial ratio of components on the copolymer properties was studied. The processes occurring during thermal treatment of the obtained polymers were studied by IR spectroscopy. (Author abstract) 9 refs.

Koton, M.M. (USSR Acad of Sciences, USSR); Chernikhov, A.Ya.; Shcherbakova, L.M.; Mikhailova, N.V.; Laius, L.A.; Reutova, G.V.; Bobasheva, A.S.; Fedorova, G.N. *Polym Sci USSR* v 29 n 2 Feb 1987 p 382-387.

**081761 SYNTHESIS AND CHARACTERIZATION OF BTDA-BASED POLYAMIDE-IMIDES.** A series of thermally-stable, tough, linear polyimides containing amide linkages were prepared. These materials have potential as high temperature films and coatings as well as matrix resins in graphite reinforced structures. The new polyamide-imides were prepared by reacting a group of isomers of dianaminobenzanilide (DABA) with 3,3',4,4'-benzophenonetetracarboxylic dianhydride (BTDA) to form the polyamide-acid with subsequent thermal conversion to the polyamide-imide (PAI). They were made into tough, flexible films which showed good thermal stability and good resistance to organic solvents. Mechanical properties of the PAI films were better than those of LARC-TPI. (Edited author abstract) 10 Refs.

Dezern, James F. (NASA Langley Research Center, Hampton, VA, USA). *J Polym Sci Part A* v 26 n 8 Aug 5 1988 p 2157-2169.

**081762 PROCEEDINGS OF SECOND INTERNATIONAL CONFERENCE ON POLYIMIDES: SYNTHESIS, CHARACTERIZATION AND APPLICATION.** This conference proceedings contains 53 papers, eight of which are in abstract form only. The main topics of the conference are polyimide synthesis, its characterization and its application. Methods of surface modification for enhanced surface reactivity, which provides new functionalities, are described. Preparation of polyimides for specific electronic applications are reported. The characterization of new polyimides, such as new photosensitive polyimide device-grade polyimide etc; is discussed. Synthesis of copolyimides with different groups are also discussed. Technical and professional papers from this conference are



indexed and abstracted with the conference code no. 10207 in the Ei Engineering Meeting (TM) database produced by Engineering Information, Inc.

Anon (Soc of Plastics Engineers, Mid-Hudson Section, USA). *Proc of Second Int Conf on Polyimides. Polyimides: Synth, Charact and Appl, Ellenville, NY, USA, Oct 30-Nov 1 1985* Publ by Soc of Plastics Engineers, Brookfield Center, CT, USA, 1985 751p.

## Synthetics

**081763 SYNTHESIS AND CHARACTERIZATION OF O-NITROSUBSTITUTED POLYIMIDES.** Poly(o-nitro)imides have been synthesized by one-stage polycondensation in DMAc at 130°C of 1,3-dichloro-4,6-dinitrobenzene with the di-potassium salt of pyromellitic or 3,3',4,4'-benzophenonetetracarboxylic acid dimide. The structure was confirmed by elemental analysis, IR, and UV-Vis spectroscopy, and the influence of the o-nitrosobstituents on the solubility and the thermal stability of the prepared polymers was studied. These polymers could be used as pyrone precursors. The model compound for these polymers has been also prepared by condensation of 1,3-dichloro-4,6-dinitrobenzene with potassium phthalimide. (Author abstract) 21 refs.

Annidou, I. Sideridou-Karay (Aristotelian Univ of Thessaloniki, Thessaloniki, Greece); Karayannidis, G.P. *J Macromol Sci Chem v A24 n 6 1987 p 689-700.*

**Thermal Effects** See POLYMERS—Thermal Effects.

## Thermal Expansion

**081764 RE-EXAMINATION OF THE RELATIONSHIP BETWEEN PACKING COEFFICIENT AND THERMAL EXPANSION COEFFICIENT FOR AROMATIC POLYIMIDES.** The existence of a possible relationship between molecular packing coefficient and thermal expansion coefficient for various aromatic polyimides was investigated. Rod-like low-thermal-expansion polyimides without side groups were seen to have very high packing coefficients, pointing to free volume as a factor in lowering their thermal expansion coefficients. But the small packing coefficients for low-thermal-expansion polyimides with side groups indicated that this was not so. Also, even if the large packing coefficients tended to increase the Young's moduli for these polyimides without side groups, the rod-like polyimides with side groups have small packing coefficients and large Young's moduli. The polyimides with low packing coefficients were found to have very small diffusion coefficients for water vapor. (Author abstract) 24 refs.

Numata, Shunichi (Hitachi Ltd, Hitachi, Jpn); Fujisaki, Koji; Kinjo, Noriyuki. *Polymer v 28 n 13 Dec 1987 p 2282-2288.*

**Thin Films** See Also POLYMERS—Thin Films.

**081765 POLYIMIDE FILM PROPERTIES AND SELECTIVE LPCVD OF TUNGSTEN ON POLYIMIDE.** du Pont PI-2575-D polyimide films were characterized to determine their suitability for use as an interlevel dielectric with a selective tungsten via fill process. Polyimide films cured at 400° and 440°C were found to breakdown at voltages greater than  $1 \times 10^6$  V/cm. The pinhole density, when processed in a non-cleanroom environment, is below  $1 \text{ per cm}^2$ . The dielectric constant for 1.6  $\mu\text{m}$  films is 3.9. Adhesion to thermal oxide is 100% for films in boiling water up to 1h. The maximum moisture absorption is 1.7 w/o at 90% relative humidity. Perfect tungsten selectively was achieved in the absence of nearby tungsten surfaces at 216°C, 0.75-7.5 torr total pressure, 15:1 H<sub>2</sub>:WF<sub>6</sub> and times to 210 min. (Edited author abstract) 22 refs.

Pattee, R.W. (Colorado State Univ, Fort Collins, CO, USA); McConica, C.M.; Baughman, K. *J Electrochem Soc v 135 n 6 Jun 1988 p 1477-1483.*

**081766 CHEMICAL ASPECTS OF REACTIVE METAL AND ENERGETIC ION INTERACTIONS**

**ON POLYIMIDE.** [X-ray photoemission and in situ oxygen uptake studies have been performed on polyimide surfaces exposed to controlled ion etching, reactive metallization, or the two acting in concert. Although the ion etching process utilized in the current study was highly destructive in terms of bond scission and was found to exhibit enhanced selectivity for the removal of carbonyl oxygen atoms, the resulting surface was not observed to be reactive to a subsequent in situ oxygen exposure. This observation suggests that the bond cleavage induced by energetic ions does not produce a surface containing significant densities of stable organic radicals but, rather, results in the extensive cross-linking of the surface with the concomitant formation of highly unsaturated or graphitelike residues. Exposure of an unspattered polyimide surface to Al deposited under UHV conditions results in the reduction of surface carbonyl functional groups. (Edited author abstract)] 15 refs.

Nuzzo, Ralph G. (AT&T Bell Lab, Murray Hill, NJ, USA); Wong, Y.-H.; Schwartz, G.P. *Langmuir v 3 n 6 Nov-Dec 1987 p 1136-1140.*

**081767 XPS STUDY OF THE COMPOSITION OF THIN POLYIMIDE FILMS FORMED BY VAPOR DEPOSITION.** Films of polyimide (<8 nm) were formed on a polycrystalline silver surface following heating of a vapor-deposited layer of 4,4'-oxydianiline (ODA) and 1,2,4,5-benzenetetracarboxylic anhydride (PMDA). The imidization reaction leading to polymer formation was followed in situ with X-ray photoelectron spectroscopy. The uncertainties inherent in a quantitative analysis of the composition of the top 8 nm of the surface layer (corresponding to the sampling depth of the technique) are discussed with respect to thick films of ODA and PMDA adsorbed on a clean Cu(111) surface at 200 K. The fully cured polyimide film contains excess ODA-like and PMDA-like constituents as trapped molecules or terminal groups. (Author abstract) 15 refs.

Lamb, R.N. (Univ of Maine, Orono, ME, USA); Baxter, J.; Grunze, M.; Kong, C.W.; Uneril, W.N. *Langmuir v 4 n 2 Mar-Apr 1988, Mol Process at Solid Surf: Spectrosc of Intermed and Adsorbate Interact, Denver, CO, USA, Apr 6-8, 1987 p 249-256.*

## Transport Properties

**081768 SORPTION AND DIFFUSION OF CARBON DIOXIDE IN POLYIMIDE FILMS.** The sorption isotherms of carbon dioxide in a polyimide film sample were measured by a pressure decay method at 30, 40, 50, and 60°C and pressures up to 1.7 MPa. The mean permeability coefficients at the same temperatures were measured by a variable volume method at applied upstream pressures up to 3 MPa. The sorption equilibria at these temperatures were found to be well described in terms of a dual-mode sorption model. The pressure dependence of the mean permeability coefficients at these four levels of temperatures did not satisfactorily follow a dual-mode mobility model, but could be well simulated by a modified mobility model. (Edited author abstract) 9 refs.

Sada, E. (Kyoto Univ, Kyoto, Jpn); Kumazawa, H.; Xu, P. *J Appl Polym Sci v 35 n 6 May 5 1988 p 1497-1509.*

## POLYISOPRENE

### Aging

**081769 KINETICS AND MECHANISM OF STRESS RELAXATION OF POLYISOPRENE VULCANIZATES UNDER OZONE AGING.** The paper deals with the kinetics of the decrease in stress ( $\Delta_p$ ) in polyisoprene vulcanizates at 22°C and in an ozone concentration of  $(1.8-7.3) \times 10^{-8} \text{ mol litre}^{-1}$  and the kinetics of degradation of polyisoprene macromolecules in solution. It has been found that the number of ruptured macromolecules increases linearly with time, whereas the time dependence of  $\Delta_p$  is more complex. A mechanism has been proposed, which links the stress relaxation with the chemical processes which occur during the action of ozone on vulcanizates. It has been shown that  $\Delta_p$  involves two

components possessing a common chemical nature, but different localization; namely, weakening of the sample by growing cracks and chain degradation on the surface of uncracked sites on the sample. (Edited author abstract) 14 refs.

Razumovskii, S.D. (Acad of Sciences of the USSR, Moscow, USSR); Podmasteriev, V.V.; Zaikov, G.E. *Polym Degradation Stab v 20 n 1 1988 p 37-47.*

**Applications** See FOUNDRY PRACTICE—Patternmaking.

### Degradation

**081770 SIMULATION OF MOLECULAR WEIGHT DISTRIBUTION AFTER POLYMER BREAKDOWN. II. DEGRADATION OF cis-POLYISOPRENE BY ULTRASOUND AND OZONOLYSIS.** cis-Polyisoprene was degraded by two different methods, ultrasound and ozonolysis. Monte Carlo simulation of the molecular weight distribution after breakdown gave very poor fits to the observed data when the extent of degradation was estimated from number-average molecular weight data. Much improved fits were obtained when the degradation index was estimated by a least-squares method. (Author abstract) 15 refs.

Plaumann, Heinz P. (Polysar Ltd, Sarnia, Ont, Can); Ho, Kam W. *J Macromol Sci Chem v A24 n 10 Oct 1987 p 1175-1182.*

### Melting

**081771 ASSOCIATION BEHAVIOR OF END-FUNCTIONALIZED POLYMERS. 2. MELT RHEOLOGY OF POLYISOPRENES WITH CARBOXYLATE, AMINE, AND ZWITTERION END GROUPS.** Viscoelastic behavior in the melt state was investigated for polyisoprenes with associating groups on the ends of the chain and compared with the behavior of their nonfunctionalized counterparts. Narrow distribution samples were prepared with a range of molecular weights by anionic polymerization; functional groups such as tertiary amine, zwitterion, carboxylic acid, and sodium carboxylate were introduced through the initiator as well as by appropriate postpolymerization reactions. Melt viscosities of the monofunctional samples were examined for evidence of end group clustering. (Edited author abstract) 64 refs.

Fetters, Lewis J. (Exxon Research & Engineering Co, Annandale, NJ, USA); Graessley, William W.; Hadjichristidis, Nikos; Kiss, Andrea D.; Pearson, Dale S.; Younhouse, Lawrence B. *Macromolecules v 21 n 6 Jun 1988 p 1644-1653.*

**Microstructure** See POLYMERS—Microstructure.

**Molecular Weight** See RUBBER—Composition Effects.

### Morphology

**081772 MORPHOLOGY OF SOLUTION CRYSTALLIZED TRANS-1,4-POLYISOPRENE.** The film formation method has been successfully used to grow single crystals and other complex morphological features of low melting form (LMF) and high melting form (HMF) of trans-1,4-polyisoprene (TPIP). Below 40°C dilute amyl acetate solution gave hexagonal shaped LMF crystals. Thick and elongated hexagonal shaped morphology was shown by HMF crystals at temperatures above 40°C. Straight faces and sharp corners of the single crystals, and also of complex crystals, acquired round shapes when highly polydispersed TPIP was used for crystallization. (Author abstract) 19 refs.

Chaturvedi, P. (Indian Inst of Technology, Kharagpur, India); Patel, M.J.; Patel, K.C.; Patel, R.D. *Colloid Polym Sci v 265 n 7 Jul 1987 p 592-596.*



## Oxidation

**081773 INFLUENCE OF MECHANICAL STRESS ON OXIDATIVE-DEGRADATIVE PROCESSES IN POLYISOPRENE.** The oxidation of SKI rubber under the action of mechanical stress has been investigated. The kinetics of oxidation of SKI under conditions where high stress levels alternate with periodic rest results in marked inhibition of the process compared with oxidation under lower stress level. The molecular composition of carbonyl compounds was found to depend on the magnitude of the applied stress. (Author abstract). 20 Refs.

Saidov, D. (USSR Acad of Sciences, USSR); Narzulloyev, N.; Nel'son, K.V. *Polym Sci USSR* v 29 n 5 1987 p 1141-1146.

Phase Transitions See RUBBER—Phase Transitions.

Photolysis See RUBBER, SYNTHETIC—Chemistry.

## Radiation Effects

**081774 DEVELOPMENT OF TRANS-1,4-POLYISOPRENE FOR SUTURELESS VASCULAR ANASTOMOSIS.** Radiation crosslinked trans-1,4-polyisoprene (t-PIP) is shown to be effective as a heat shrinkable connector for severed blood vessels. The sutureless vascular anastomosis system (SVAS) requires a plastic sleeve with the following requirements: biocompatibility, heat shrinkability, melting point 50 to 60°C, and proper mechanical properties. The effect of irradiation by cobalt-60 gammas on pertinent physical properties were determined. The results show no change in the gel fraction and mechanical strength. An in-vitro test of the processed t-PIP with intravenous saline solution demonstrates that the material undergoes no physical property changes after five months. Also, biocompatibility of the crosslinked t-PIP sleeve was established by tests. The results of all the tests demonstrated that the procedure and the t-PIP sleeve were effective and safe. (Edited author abstract) 9 refs.

Yang, Hou-Ching (PPG Industries Inc, Barberton, OH, USA); Silverman, Joseph. *Radiat Phys Chem* v 31 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 721-726.

## Solutions

**081775 ASSOCIATION BEHAVIOR IN END-FUNCTIONALIZED POLYMERS. 1. DILUTE SOLUTION PROPERTIES OF POLYISOPRENES WITH AMINE AND ZWITTERION END GROUPS.** The dilute solution properties of linear polyisoprenes with a highly polar sulfo-zwitterion group on one end of the chain were examined in several solvents by osmometry, light scattering, and viscometry. The polymers were prepared by anionic polymerization with initiation by (3-(dimethylamino)propyl)lithium. The terminal tertiary amine groups were converted to zwitterions by treatment with cyclopropane sulfone. A few linear and star materials with all ends functionalized were also prepared. The zwitterion-capped polymers were found to associate strongly in aliphatic hydrocarbons. (Edited author abstract) 58 refs.

Davidson, Neil S. (Exxon Research & Engineering Co, Annandale, NJ, USA); Fettes, Lewis J.; Funk, Walter G.; Graessley, William W.; Hadjichristidis, Nikos. *Macromolecules* v 21 n 1 Jan 1988 p 112-121.

**081776 DIELECTRIC NORMAL MODE PROCESS IN SEMIDILUTE AND CONCENTRATED SOLUTIONS OF cis-POLYISOPRENE.** The dielectric normal mode process was studied for semidilute and concentrated solutions of cis-polyisoprene (cis-PI) dissolved in a good solvent, benzene, and a  $\Theta$  solvent, dioxane. The mean-square end-to-end distance  $\langle r^2 \rangle$  of cis-PI was determined from the dielectric relaxation strength. The relaxation time in solutions of low molecular weight cis-PI (PI-09) with weight-average molecular weight  $M_w$  of  $8.6 \times 10^3$  was converted to the friction coefficient  $\zeta$  per monomeric unit by using the Rouse theory. It is found that the exponent for benzene solutions was slightly higher

than that predicted by the dynamic scaling theory proposed by P.G. de Gennes, while the exponent in dioxane solutions was lower than the theoretical value. The widths of the loss curves for solutions of PI-164 increased with increasing concentration. The factors affecting the breadth of the loss curve are discussed. (Edited author abstract) 40 refs.

Adachi, Keiichiro (Osaka Univ, Toyonaka, Jpn); Kotaka, Tadao. *Macromolecules* v 21 n 1 Jan 1988 p 157-164.

**081777 DILUTE SOLUTION PROPERTIES OF cis-POLYISOPRENE IN CYCLOHEXANE AND 1,4-DIOXANE.** Static light scattering and viscosity measurements were made on five cis-polyisoprene fractions of weight-average molecular weight  $M_w$  ranging from  $0.33 \times 10^6$  to  $7.2 \times 10^6$  in cyclohexane (good solvent) at 25°C and 1,4-dioxane ( $\Theta$  solvent) at 34.7°C. The maximum values for static and dynamic (=Stokes radius,  $R_H$ ) expansion factors  $\alpha_3^3$  and  $\alpha_H^3$  of the highest molecular weight sample were 13 and 8, respectively, and were the largest ones obtained so far for light scattering. With these large values, excluded-volume effects and hydrodynamic interaction on chain segments of highly swollen flexible polymers in dilute solutions were tested through the two-parameter theory. (Edited author abstract) 46 refs.

Tsunashima, Yoshisuke (Kyoto Univ, Uji, Jpn); Hirata, Masukazu; Nemoto, Norio; Kurata, Michio. *Macromolecules* v 21 n 4 Apr 1988 p 1107-1117.

**081778 NMR RELAXATION CROSSOVER FROM MELTS TO DILUTED SOLUTIONS OF POLYISOPRENE IN THE LIGHT OF THE TUBE CONCEPT.** In a series of previous papers we have developed the three-component concept of chain fluctuations. It takes into account the special structure/dynamics relationship caused by topological restraints such as the tube. The application of this formalism permitted us the description of the frequency, molecular weight and temperature dependences of the NMR relaxation times in polymer melts. In particular, limiting cases characteristic for motions restricted by the tube topology could well be verified. The existence of characteristic molecular weights, for instance, could thus be explained. The purpose of the present paper is to probe experimentally the effect of dilution on the tube restraints. If the increase of the tight-tube diameter can be considered as the predominant consequence of swelling, all fluctuation components determined by the tube properties are expected to be modified by dilution. 10 Refs.

Kopf, M. (Univ Ulm, Ulm, West Ger); Kimmich, R. *J Polym Sci Part C* v 26 n 7 Jul 1988 p 319-323.

## Spectroscopic Analysis

**081779 SOLID-STATE  $^{13}\text{C}$  NUCLEAR MAGNETIC RESONANCE SPECTRA OF THE  $\alpha$  AND  $\beta$  CONFORMERS OF TRANS-1,4-POLYISOPRENE.** Solid-state  $^{13}\text{C}$  nuclear magnetic resonance (nmr) was used to study the two different conformers of trans natural rubber (NR). The  $\alpha$  and  $\beta$  conformers of trans NR were observed to give different  $^{13}\text{C}$  chemical shifts. The relative magnitude and direction of the chemical shift for the methyl carbon on the  $\beta$  conformer are predicted by a steric perturbation model. The  $\alpha$  conformer gave longer relaxation times than the  $\beta$  conformer. For this highly mobile semicrystalline polymer, spin diffusion was not a major contributor to the relaxation process. (Author abstract) 25 refs.

Patterson, Dwight Juan (Case Western Reserve Univ, Cleveland, OH, USA); Koenig, Jack L. *Polymer* v 29 n 2 Feb 1988 p 240-244.

**081780 INFRARED SPECTRAL CORRELATIONS FOR CRYSTALLINE AND AMORPHOUS TRANS-1,4-POLYISOPRENE.** The infrared spectra for  $\alpha$ - and  $\beta$ -trans-1,4-polyisoprene are compared, and a correlation is found between both the frequencies of their observed vibrational modes and their potential energy distribution from normal coordinate calculations for a single chain. Each band in the  $\beta$  spectrum corresponds to

either one or two bands in the  $\alpha$  spectrum. Correlation between each of the spectra of the two crystalline forms and the amorphous TPI is used to assign the infrared bands of the latter. (Author abstract). 18 Refs.

Gavish, Michal (City Univ of New York, New York, NY, USA); Brennan, Peter; Woodward, Arthur E. *Macromolecules* v 21 n 7 Jul 1988 p 2075-2079.

**081781 FTIR INVESTIGATIONS OF CRYSTALLINITY AND SURFACE REACTION FOR TRANS-1,4-POLYISOPRENE LAMELLAR STRUCTURES CRYSTALLIZED FROM SOLUTION.** Infrared studies of trans-1,4-polyisoprene (TPI) and of block copolymer derivatives were carried out. TPI lamellar structures were reacted in suspension so that their surfaces were modified while their crystalline cores remained unchanged. The reactions used were epoxidation and hydrochlorination of the double bond. The infrared spectra of the modified surface were obtained, and tentative band assignments were made. A procedure was developed to obtain the percent crystallinity of TPI lamellar structures from the infrared spectrum by using measurements of the relative intensity of the 1664-1670  $\text{cm}^{-1}$  band in the crystalline and semicrystalline spectra. Effects of pressure on as-prepared and surface-modified TPI lamellar structures were observed. (Author abstract). 21 Refs.

Gavish, Michal (City Univ of New York, New York, NY, USA); Corrigan, Joseph; Woodward, Arthur E. *Macromolecules* v 21 n 7 Jul 1988 p 2079-2083.

## Stresses

**081782 STRAIN-INDUCED CRYSTALLIZATION IN CIS- AND TRANS-POLYISOPRENE BLENDS.** Strain-induced crystallization (SIC) is studied in blends of cis-1,4-polyisoprene (Hevea rubber) and synthetic trans-1,4-polyisoprene (t-PI). Uncrosslinked solution blends were uniaxially stretched at room temperature, and the dependence of stress and birefringence on time, elongation, and t-PI content was analyzed. Stress and birefringence follow power-law decays. The rates of relaxation decrease with elongation and t-PI content, and the rates of stress relaxation are higher than the rates of birefringence relaxation for the blends studied. (Edited author abstract) 17 refs.

Manzur, Angel (Univ Autonoma Metropolitana-Iztapalapa, Mexico City, Mex); McIntyre, Donald. *J Macromol Sci Phys* v B27 n 1 Apr 1988 p 79-98.

Structure See Also IONOMERS—Structure.

**081783 QUANTITATIVE INVESTIGATION OF THE AMORPHOUS AND CRYSTALLINE COMPONENTS IN TRANS-1,4-POLYISOPRENE FROM SOLUTION.** Trans-1,4-Polyisoprene structures in the  $\alpha$  and  $\beta$  crystalline forms with various morphologies were prepared by using different crystallization procedures. The effects of molecular weight, crystallization temperature, and annealing treatment on the crystalline stem length and the noncrystalline traverse length were investigated by using epoxidation in suspension followed by carbon-13 solution NMR. Preliminary studies were carried out to determine the optimum conditions for quantitative reaction of the double bonds at the lamellar surfaces. Results were obtained suggesting that for many liquids penetration of partially reacted lamellae can take place from the lateral surfaces. (Edited author abstract) 21 refs.

Xu, Jia-rui (City Coll, New York, NY, USA); Woodward, Arthur E. *Macromolecules* v 21 n 1 Jan 1988 p 83-89.

**081784 CARBON-13 NUCLEAR MAGNETIC RESONANCE OF 3,4-/cis-1,4-POLYISOPRENES PREPARED WITH  $\text{Fe}(\text{acac})_3\text{-Al}(\text{i-Bu})_3$  CATALYST.** 3,4-/cis-1,4-polyisoprenes were prepared with  $\text{Fe}(\text{acac})_3\text{-Al}(\text{i-Bu})_3$  catalyst. These polymers are of interest because of their higher 3,4 content and different degree of



crystallinity. The  $^{13}\text{C}$ -NMR spectra of these polymers were much more complex than those previously reported and were assigned using slightly modified empirical parameters based on Gronski et al. In order to further clarify the assignments, hydrogenation of the polymers was carried out, and the  $^{13}\text{C}$ -NMR spectra of the hydrogenated polymers were partially assigned. Based on these assignments, it was found that the existence of long sequences of vinyl monomer units might be a favorable factor for the formation of partially crystallized polymer. (Edited author abstract) 15 refs.

Qiu, Zu Wen (Jilin Univ, Changchun, China); Chen, Xiaohong; Zhou, Zinan; Wang, Fosong; Sun, Boqin. *J Macromol Sci Chem* v A25 n 2 1988 p 127-141.

**081785 EFFECT OF n-BUTYLLITHIUM CONCENTRATION ON THE STEREOREGULARITY OF POLYISOPRENE IN NON-POLAR MEDIA.** Homogeneous polymerization of isoprene is carried out in a bench scale 2L reactor at 30°C using different concentrations of n-butyllithium as an initiator in bulk and n-heptane, cyclohexane, n-hexane, benzene and toluene. The stereoregularity of polyisoprene is determined using  $^1\text{H}$  and  $^{13}\text{C}$  NMR spectroscopy. The percentage of cis-1,4 structure increased with the decrease of initiator concentration at constant monomer concentration. The range of initiator concentration is  $10^{-2}$ – $10^{-6}$  mol/l. The cis-1,4 content is also dependent on the nature of solvent(s). A new explanation of the influence of initiator concentration on the stereoregularity of polyisoprene is discussed. (Edited author abstract). 37 Refs.

Al-Jarrah, Mustafa M.F. (Council of Scientific Research, Baghdad, Iraq); Apikian, Rita L.; Salman, Salman R. *J Pet Res* v 7 n 1 Jun 1988 p 113-128.

**POLYMERIZATION** See Also ACETYLENE—Phase Transitions; ACRYLIC MONOMERS—Stabilizers; AMINES—Polymerization; AROMATIC COMPOUNDS—Polymerization; CATALYSTS; CATALYSTS—Supported; CHEMICAL EQUIPMENT—Reactors; COAL TAR—Oxidation; COMPOSITE MATERIALS—Morphology; COPOLYMERS—Synthesis; DATA STORAGE, OPTICAL; GELS; MEMBRANES; MIXING; MONOMERS—Polymerization; ORGANIC COMPOUNDS—Polymerization; ORGANIC COMPOUNDS—Synthesis; ORGANIC COMPOUNDS—Thin Films; POLYACETYLENES—Synthesis; POLYETHYLENES; POLYETHYLENES—Low Density; POLYIMIDES—Optical Properties; POLYMERS; POLYMERS—Conductive; POLYMERS—Electric Conductivity; POLYMERS—Electric Properties; POLYMERS—Mixing; POLYMERS—Physical Properties; POLYMERS—Synthesis; POLYMETHYL METHACRYLATE; POLYPROPYLENE—Manufacture; POLYSTYRENES; RUBBER, SYNTHETIC—Applications; SILICATES—Classification; SUGARS—Polymerization; SULFUR COMPOUNDS—Polymerization.

**081786 SOME FEATURES OF HETEROPHASE GRAFT POLYMERIZATION ON SYNTHETIC FIBERS FROM THERMOPLASTIC POLYMERS.** A considerable effect of structural-physical properties and molecular dynamics of the polymer as a solid on the process of radical graft polymerization to fibers from thermoplastic polymers which have been spun from the melt has been found. In the case of heterophase graft polymerization of vinyl monomers to polypropylene fiber, it has been shown that orderedness of the polymer structure primarily affects the initiation stage. High kinetic parameters of heterophase graft polymerization in oriented systems from thermoplastic polymers can be realized only at temperatures which exceed the glass point of the polymer matrix. 12 refs.

Druzhinina, T.V. (Moscow Textile Inst, USSR). *Fibre Chem* v 19 n 1 Jan-Feb 1987 p 1-4.

**081787 HOMO- AND COPOLYMERIZATION OF SOME NORBORNADIENE DIMER MONOMERS.** The exo-exo- and endo-endo norbornadiene dimers were synthesized and homopolymerized using the  $\text{Re}(\text{CO})_5\text{Cl}/\text{EtAlCl}_2$  catalyst system. The exo-exo dimer was copolymerized with norbornene, both as a random polymer and as a diblock. In all cases, the polymers obtained were mainly of the ring-retained, rather than ring-opened type, even though  $\text{Re}(\text{CO})_5\text{Cl}/\text{EtAlCl}_2$  is an olefin metathesis catalyst and the monomers are strained

ring systems. (Author abstract) 6 refs.

Alonso, Maria A. (Univ of Akron, Akron, OH, USA); Faron, Michael F. *Polym Bull (Berlin)* v 18 n 3 Sep 1987 p 203-207.

**081788 NEW NONHYDROLYZABLE ETHER CROSSLINKING AGENT CONTAINING TWO METHACRYLATE UNITS LINKED THROUGH THE  $\alpha$ -METHYL CARBONS.** A report is made on the use of a diester ether and its diacid analog, produced by the hydrolysis of the ether, as crosslinking agents in vinyl polymerization. It is concluded that the diester ether and the diacid are highly reactive crosslinking agents for vinyl polymers. Their superiority to commercially available bis-acrylate esters lies in the fact that the crosslinks formed consist of carbon and ether linkages, which are less susceptible to hydrolysis than the ester linkages of most currently available crosslinking agents. 4 refs.

Mathias, Lon J. (Univ of Southern Mississippi, Hattiesburg, MS, USA); Kusefoglu, Selim H. *J Polym Sci Part C* v 25 n 11 Nov 1987 p 451-453.

**081789 FIBRILAR MORPHOLOGY OF THE ELECTROCHEMICALLY POLYMERIZED POLYANILINE IN TETRAFLUOROBORIC ACID AQUEOUS SOLUTION.** This work reports the fibrillar network morphology of the polyaniline (PAN) produced by using the electrochemical method with a tetrafluoroboric acid ( $\text{HBF}_4$ ) aqueous solution as the supporting electrolyte. If acetonitrile is used to replace the water, the PAN layer formed on the electrode surface is a stack of irregular lumps. If the protonic acid is replaced by HCl or  $\text{H}_2\text{SO}_4$  in the aqueous system, the PAN is granular. 9 refs.

Chen, Show-An (Nat'l Tsing-Hua Univ, Hsinchu, Taiwan); Lee, Tein-San. *J Polym Sci Part C* v 25 n 11 Nov 1987 p 455-460.

**081790 MODIFICATION OF ELECTRODES BY THE DEPOSITION OF PLASMA POLYMERIZED DIMETHYLAMINOMETHYLFERROCENE.** Dimethylaminomethylferrocene has been plasma polymerized as the neat vapour and in the presence of argon. The resulting films were characterized by ESCA, which indicated that the surface composition of the films were essentially independent of the method of preparation. Differences in the corresponding electrochemistry as revealed by cyclic voltammetry were observed. All the CV responses decay on continued cycling. (Edited author abstract) 16 refs.

Munro, H.S. (Univ of Durham, Durham, Engl); Eaves, J.G. *Polym Commun (Guildford Engl)* v 28 n 12 Dec 1987 p 339-341.

**081791 GAS-PHASE POLYMERIZATION: ULTRASLOW CHEMISTRY.** The mechanism of formation of polymer molecules in the gas phase is difficult to study because the involatile polymers tend to condense out of that phase. However, new techniques, involving the use of cloud chambers, have enabled workers to use the nucleation of liquid drops in supersaturated monomer vapors to detect single polymer molecules and therefore to work with so few simultaneously growing polymers that aggregation and condensation are avoided. Chain polymerization in which the chain carriers are either radicals or ions can therefore be studied in the vapor. Furthermore, the ability to work with such small concentrations of growing polymeric radicals, for example, makes it possible to avoid encounters between them that lead to recombination and formation of 'dead' polymers that are incapable of further growth. Many aspects of gas-phase polymerization can be studied including, besides radical and ion chains, especially 'ultraslow' chemistry. (Edited author abstract) 48 refs.

Reiss, Howard (Univ of California, Los Angeles, CA, USA). *Science* v 238 n 4832 Dec 4 1987 p 1368-1373.

**081792 COMPARISON OF MICROWAVE AND LOWER-FREQUENCY DISCHARGES FOR PLASMA POLYMERIZATION.** A plasma sustained by surface waves (SW) has been used to study the

deposition rate R of hydrocarbon and fluorocarbon plasma polymer films as a function of excitation frequency  $f = \omega/2\pi$  in the range 12-400 MHz. The SW technique allows one to vary only f while keeping constant all other parameters known to influence R, for example, power density in the plasma P. A plot of R/P at a total pressure of 200m Torr (27 Pa) displays two plateaus, that at  $f < 30$  MHz being about five times lower than that at  $f \geq 100$  MHz. This is attributed to the fact that electron energy distribution functions differ fundamentally at ratio- and 'microwave' frequencies, for the gas pressure range considered. (Edited author abstract) 16 refs.

Claude, R. (Univ de Montreal, Montreal, Que, Can); Moisan, M.; Wertheimer, M.R.; Zakrzewski, Z. *Plasma Chem Plasma Process* v 7 n 4 Dec 1987 p 451-464.

**081793 SPECTROELECTROCHEMICAL EVIDENCE FOR AN INTERMEDIATE IN THE ELECTROPOLYMERIZATION OF ANILINE.** Polyaniline, a polymer exhibiting high electronic conductivity, has attracted significant research interest in recent years. However, only a few experiments have dealt with the mechanisms of electropolymerization. Spectroelectrochemical studies of aniline ( $\text{C}_6\text{H}_5\text{NH}_2$ ) oxidation in  $\text{NH}_4\text{F} + 2.3 \text{ HF}$  at 1 V vs.  $\text{Cu}/\text{CuF}_2$  have shown that a short living intermediate is created before the formation of polyaniline. The intermediate is diamagnetic and on the basis of the experiments, we propose that it must be the nitrenium cation ( $\text{C}_6\text{H}_5\text{NH}^+$ ). The mechanism of polyaniline formation is rediscussed in view of the reaction of  $\text{C}_6\text{H}_5\text{NH}^+$  with aniline, which follows a pseudo-first-order kinetics and also results in the formation of a polymer with at least two non-equivalent structures. 14 refs.

Genies, E.M. (CEN, Grenoble, Fr); Lapkowski, M. *J Electroanal Chem Interfacial Electrochem* v 236 n 1-2 Oct 23 1987 p 189-197.

**081794 RHEOLOGICAL CHANGES FOR URETHANE POLYMERIZATIONS IN BULK AND IN SOLUTION.** Viscosity rise and extent of reaction were followed during the step growth polymerization of linear and branched urethanes in bulk and in solution. Results indicate that intra-molecular reaction may exist in both linear and branched systems. Adding solvent increases the extent of intra-molecular reaction. The system viscosity was found to correlate with  $\text{CgM}_w$ , where C is polymer concentration, g is the ratio of the branch to linear polymer radii of gyration, and  $M_w$  is the weighted-average molecular weight. (Author abstract) 31 refs.

Lee, Yeh-Ming (Ohio State Univ, Columbus, OH, USA); Lee, L. James. *Polymer* v 28 n 13 Dec 1987 p 2304-2309.

**081795 COMPOUNDING OF HIGH PERFORMANCE POLYMERS.** After polymerization high performance polymers have to be compounded for the subsequent converting steps. Filler and reinforcing agents or pigments have to be incorporated or solvents or similar volatiles have to be removed. These process tasks will be described using various examples. (Author abstract)

Kapfer, K. *IPE Int Ind Prod Eng* v 11 n 3 Oct 1987 p 128-130, 132.

**081796 POLYMERIZATION OF OPTICALLY ACTIVE  $\beta$ -SUBSTITUTED  $\beta$ -PROPIOLACTONES. IV.  $\beta$ -1,1-DICHLOROALKYL  $\beta$ -PROPIOLACTONES POLYMERIZED WITH ALUMINUM TRIISOPROPOXIDE.** The polymerization of three optically active  $\beta$ -1,1-dichloroalkyl  $\beta$ -propiolactones has been investigated in toluene, at 55°C, using aluminum triisopropoxide ( $\text{Al}(\text{OiPr})_3$ ) as initiator in a range of monomer/initiator molar ratios smaller than 150.  $\beta$ -1,1-dichloroethyl  $\beta$ -propiolactone polymerizes according to a living mechanism. However, the ability to polymerize decreases with an increase in the length of the alkyl substituent. Each of the lactones investigated reacts with  $\text{Al}(\text{OiPr})_3$  in an initiation step that obeys a coordination-insertion mechanism. However, the size of the chloroalkyl substituent



ent has a critical effect on the propagation: when the alkyl group contains more than two methylene units, the insertion of a second monomer becomes exceedingly slow. (Edited author abstract) 28 refs.

Voyer, Richard (Univ Laval, Que, Can); Prud'Homme, Robert E.; Jerome, Robert; Teysse, Philippe. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 117-129.

**081797 ON THE COPOLYMERIZATION REACTIVITY OF MACROMONOMERS.** In this paper, we study the copolymerization behavior of a macromonomer to examine the effect of the thermodynamic repulsive interaction on the copolymerization reactivity of macromonomer, and discuss the results in terms of the interpenetration of macromonomer coils and unlike propagating comonomer chains in the homogeneous solution. 24 refs.

Tsukahara, Yasuhisa (Nagoya Univ, Nagoya, Jpn); Tanaka, Minoru; Yamashita, Yuya. *Polym J* v 19 n 9 1987 p 1121-1125.

**081798 HIGHLY ENHANCED POLYMERIZABILITY OF ETHYLENE GLYCOL METHACRYLATE n-BUTYL FUMARATE COMPARED WITH COMMON METHACRYLATES.** Ethylene glycol methacrylate n-butyl fumarate (EGMBF) was synthesized and radically polymerized. The rate and degree of polymerization were quite high compared with those of common methacrylates. The methacrylic double bond in EGMBF was exclusively responsible for polymerization to give a polymer having almost quantitative unreacted fumaric double bonds, resulting in a greatly delayed gelation. (Author abstract) 10 refs.

Matsumoto, Akira (Kansai Univ, Suita, Jpn); Nishikawa, Masanobu; Oiwa, Masayoshi; Murata, Yoshishige. *Polym Commun (Guildford Engl)* v 29 n 2 Feb 1988 p 31-32.

**081799 COORDINATION RING-OPENING POLYMERIZATION.** The concept that the coordination of monomer to catalyst is important in some ring opening polymerizations stems mainly from the stereospecificity observed in the polymerization of epoxides with organometallic catalyst systems. Recently, some organometallic catalyst systems with well-defined structure as well as high efficiency have been developed for the ring-opening polymerization of epoxides and lactones. This paper describes the recent advancements made with these catalyst systems on coordination and stereoselective ring-opening polymerizations. 30 refs.

Inoue, Shohei (Univ of Tokyo, Tokyo, Jpn). *Prog Polym Sci (Oxford)* v 13 n 1 1988 p 63-81.

**081800 INFLUENCE OF AGITATION ON THE CREATION OF COAGULUM DURING THE EMULSION POLYMERIZATION OF THE SYSTEM STYRENE-BUTYLACRYLATE-ACRYLIC ACID.** This paper gives the results of the estimated coagulum content in the final sample of a dispersion based on styrene-butylacrylate-acrylic acid, prepared by semicontinuous emulsion polymerization. The dependence of the amount of coagulum on the agitation intensity was studied. It was found that it is necessary to divide the results into two regions: (a) for specific power input smaller than 80 W/m<sup>3</sup>; (b) for specific power input greater than 80 W/m<sup>3</sup>. It was found that polymerization scaling up from the point of constant coagulum content in the system studied is possible under the conditions of constant specific power input. For the existence of two regions we propose the following hypothesis according to which increasing mixing intensity improves the temperature and concentration nonuniformity which results in the decrease of coagulum content. From the certain value of specific power input, which is specific for each system, the amount of coagulum starts to increase due to increasing shear stress. (Edited author abstract) 12 refs.

Matejicek, Alois (Research Inst of Synthetic Resins & Varnishes, Pardubice, Czech); Pivonkova, Alena; Kaska, Jiri; Dittl, Pavel; Formanek, Leopold. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 583-591.

**081801 DYNAMIC STABILITY OF LIQUID-LIQUID DISPERSIONS CONTAINING POLYMERIC SUSPENSION STABILIZERS.** The authors present an experimental study on the dynamic stability of suspended oil droplets such as those found in suspension polymerization processes. The system used in the present study was a mixture of ethylbenzene and 1,2-dichloroethane as a substitute for vinyl chloride monomer. The suspending agents included hydroxypropyl methylcellulose and polyvinyl alcohol and their blends. We have measured the interfacial tension and the dynamic interfacial properties, such as shear viscosity and shear modulus or rigidity at the oil-water interfaces containing suspending agents in order to examine their effects on the droplet dynamic stability. (Edited author abstract) 12 refs.

Chung, S.I. (Illinois Inst of Technology, Chicago, IL, USA); Wasan, D.T. *Colloids Surf* v 29 n 3 Feb 15 1988 p 323-336.

**081802 PHOTOREACTION OF AMPHIPHILIC DIOLEFINS IN MONOLAYERS FORMED ON AN AIR-WATER INTERFACE.** Polymerization in the monolayer or multilayer films has received a considerable amount of attention as one of the methods of controlling molecular arrangement and accordingly, of controlling chemical reactions. We have studied four-center type photopolymerization of diolefinic compounds, which is controlled by the molecular arrangement in the crystal. In order to investigate this reaction in monolayer or multilayer systems, amphiphilic diolefins, i.e., long-chain mono-alkyl esters of p-phenyl-enediacrylic acid (p-PDA), were prepared. Among the p-PDA monoesters prepared, p-PDA mono-n-dodecyl ester (p-PDAmC<sub>12</sub>) and p-PDA mono-n-tetradecyl ester (p-PDAmC<sub>14</sub>) 4) were found to form stable monolayers on aqueous CdCl<sub>2</sub> solution. In this paper, we report on the photoreaction of these monolayers formed on air-water interface and its reaction mechanism suggested by the remarkable increase in surface pressure during irradiation. 12 refs.

Nakanishi, Fusae (Research Inst for Polymers & Textiles, Tsuchuba, Jpn). *J Polym Sci Part C* v 26 n 3 Mar 1988 p 159-163.

**081803 MINIMUM END-TIME POLICIES FOR BATCHWISE RADICAL CHAIN POLYMERIZATION. VIII. PIECEWISE TEMPERATURE POLICY.** The method of the Lagrangian multiplier was applied to minimizing the total reaction time for the general model of radical chain polymerization in the presence of a chain-transfer agent by considering initial initiator concentration and piecewise constant temperature as control variables. Development of this discrete policy makes finding the continuous optimal temperature path for solution polymerization in the presence of a chain-transfer agent possible. The calculation results show that the initial initiator concentration should be kept at the lowest possible value (by which the reaction is strongly dead-ended) and the reaction temperature rises from its lowest in Stage 1 to its highest in the final stage. The reaction time interval decreases from stage to stage. The greater the number of time intervals, the shorter is the total reaction time. Experimental verification of styrene solution polymerizations in the presence and absence of chain-transfer agent shows that the present method is applicable. (Edited author abstract) 12 refs.

Hsu, Ken-Ying (Nat'l Tsing Hua Univ, Hsinchu, Taiwan); Chen, Show-An. *Polym Process Eng* v 5 n 2 1987 p 151-178.

**081804 EMULSION POLYMERIZATION: ON THE CHARACTERIZATION OF THE PARTICLE SIZE DISTRIBUTION.** In emulsion polymerization, the polymer particles generated exhibit a size distribution. Broadness of the distribution is usually characterized by the uniformity ( $D_p$ ), a ratio of weight to number average particle sizes, and is found to decrease with reaction time despite the fact that the particle volume distribution is usually broadened. Based on the mathematical model proposed by G. Lichti, R.G. Gilbert, and D.H. Napper, detailed analysis using the method of moment shows that standard deviation of the particle volume distribution

increases with time, while that of the particle diameter distribution decreases with time.  $D_p$ 's of both volume and diameter distributions all show a decrease with reaction time. These results are in agreement with those found experimentally. (Edited author abstract) 22 refs.

Chen, Show-An (Nat'l Tsing Hua Univ, Hsinchu, Taiwan); Wu, Kuo-Wei. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 1143-1155.

**081805 ASYMMETRIC SELECTIVE POLYMERIZATION OF  $\beta$ -BUTYROLACTONE CATALYZED BY OPTICALLY ACTIVE COBALT COMPLEX/TRIETHYLALUMINUM SYSTEM.** This paper reports a new aspect of Co<sup>I</sup> chemistry, catalyst as an asymmetric selective polymerization, taking the polymerization of  $\beta$ -butyrolactone as an example by the combination of Co<sup>+</sup> and AlEt<sub>3</sub>. The optically active polyester obtained here by the catalysis of Co<sup>+</sup>/AlEt<sub>3</sub> is essentially the same material as the naturally occurring optically active poly- $\beta$ -hydroxybutyrate. 6 refs.

Takeichi, Tsutomu (Toyoashi Univ of Technology, Toyohashi, Jpn); Hieda, Yoshihiro; Takayama, Yuzi. *Polym J* v 20 n 2 1988 p 159-162.

**081806 MODELING OF BATCH AND CONTINUOUS EMULSION POLYMERIZATION REACTORS. PART II: COMPARISON WITH EXPERIMENTAL DATA FROM CONTINUOUS STIRRED TANK REACTORS.** A detailed model for emulsion polymerization is compared with extensive data from continuous stirred tank reactors. Model predictions are compared with both steady-state and dynamic data for polymerization of styrene, methyl methacrylate, and vinyl acetate. Good agreement between model and experiment is achieved with one set of parameters and without any data fitting. The results show that the model is capable of predicting all of the experimentally observed phenomena including steady-state multiplicity, sustained oscillations, ignition and extinction dynamics, and overshoot during start-up. (Author abstract) 40 refs.

Rawlings, J.B. (Univ of Wisconsin, Madison, WI, USA); Ray, W.H. *Polym Eng Sci* v 28 n 5 Mid-Mar 1988 p 257-274.

**081807 PHOTOINITIATION REACTION OF WATER-SOLUBLE MONOMER WITH BENZOIN ETHYL ETHER INCLUDED IN CYCLODEXTRIN.** Presently, water-soluble photoreagents are preferred for immobilization of enzymes in biosensors. Because conventional oil-soluble photoinitiators were dispersed in such hydrophilic photoreagents, they were unstable and their polymerization rate was small. Proposed here is a new water-soluble photoinitiator that is composed of benzoine ethyl ether (BEE) and cyclodextrin (CD). In one case the organic substance is made stable by inclusion in CD, but in the other case it is made unstable by inclusion in CD. It may be considered that the organic substance is made stable when electron delocalizes with inclusion in CD, but it is made unstable in the opposite case. Asymmetric inclusion polymerization of (z)-2-methyl-1,3-pentadiene with deoxycoale acid is one example of inclusion polymerization, but BEE included in CD differs from it in the respect that CD only supports BEE. The author investigated the stability of BEE included in CD and the polymerization reaction of bifunctional monomer initiated with BEE included in CD. (Edited author abstract) 7 refs.

Enmanji, Koe (Mitsubishi Electric Co, Amagasaki, Jpn). *J Polym Sci Part A* v 26 n 5 May 1988 p 1465-1470.

**081808 CATIONIC GRAFT POLYMERIZATION OF 2-OXAZOLINES ON CELLULOSE DERIVATIVES.** Cationic graft polymerization of 2-oxazolines on cellulose derivatives such as chlorinated cellulose (Cell-Cl), cellulose acetate halogenacetate (AcCell-AcX), and cellulose tosylate (Cell-OTs) was investigated. With Cell-Cl the successful graft polymerization of 2-methyl-2-oxazoline (MeOXZ) required the presence of potassium salt but with AcCell-AcX and Cell-OTs it proceeded



without the salt. The reactivity of halogens in graft polymerization of MeOXZ ion halogenated cellulose derivatives increased in the order of  $I^- > Br^- > Cl^-$ . This is explained by the nucleophilicity of halogen ions compared with that of MeOXZ. (Edited author abstract) 18 refs.

Ikeda, Isao (Fukui Univ, Bunkyo, Jpn); Kurushima, Yoshiaki; Takashima, Hisataka; Suzuki, Kimihiro. *Polym J* v 20 n 3 1988 p 243-250.

**081809 THERMAL DECOMPOSITION OF POTASSIUM PERSULFATE IN AQUEOUS SOLUTION AT 50°C IN AN INERT ATMOSPHERE OF NITROGEN IN THE PRESENCE OF ACRYLONITRILE MONOMER.** The rate of thermal decomposition of persulfate in aqueous solution in the presence of acrylonitrile (AN) monomer (M) and of nitrogen is given. It was observed that the pH of the solution containing persulfate and monomer did not alter during polymerization if the monomer concentrations were close to its solubility under the experimental conditions. Conductance of the aqueous solutions of persulfate and monomer was found to decrease during the reactions. In an unbuffered aqueous solution containing only persulfate, however, the pH was found to decrease continuously at 50°C with time, while the conductance of the solution was found to increase. The monomer (AN) had no effect on the glass electrodes of the pH meter in aqueous solutions, and also on the electrodes of the conductivity cell. (Edited author abstract) 51 refs.

Sarkar, Swati (Regional Engineering Coll, India); Adhikari, Mukti Sadhan; Banerjee, Monoranjan; Konar, Ranajit Singha. *J Appl Polym Sci* v 35 n 6 May 5 1988 p 1441-1458.

**081810 SPECTROSCOPIC STUDIES OF PHOTOCHEMICAL REACTIONS IN ORGANIC SOLIDS: PHOTOPOLYMERIZATION AND PHOTODIMERIZATION OF TRANS  $\beta$ -2 FURYL ACRYLIC ACID.** In trans  $\beta$ -2 furyl acrylic acid crystal both photopolymerization and photodimerization occur in the crystalline state. Lahav et al. have proved the presence of both dimer and polymer with the help of NMR and UV spectroscopy. The authors have studied this solid state photoreaction by electronic infrared, and Raman spectroscopic techniques to see if this reaction is also phonon-mediated. Laser Raman phonon spectroscopic technique has been used to study the mechanism of reaction. It has been shown that the reaction proceeds by a heterogeneous mechanism. 4 refs.

Ghosh, Urmi (Indian Assoc for the Cultivation of Science, Calcutta, India); Misra, T.N. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1681-1686.

**081811 KINETIC TREATMENT OF IRREVERSIBLE CYCLOOLIGOMERIZATION OF BIFUNCTIONAL CHAINS AND ITS RELEVANCE TO THE SYNTHESIS OF MANY-MEMBERED RINGS.** The reaction of a bifunctional reactant A-B under batchwise conditions to give macrocycles has been simulated by numerical integration of the proper system of differential rate equations. This was set up considering all the possible processes of concurrent cyclization and polymerization up to a polymerization degree of 12. In order to obtain meaningful yield data for the cyclooligomers, realistic sets of effective molarities (EM) have been considered. The results show how the yields of the various cyclooligomers vary as a function of the initial monomer concentration and provide useful guidelines to achieve maximum selectivity in the synthesis of a given ring. It is clearly shown that the yield of any cyclooligomer is a function of the whole set of EM values. (Edited author abstract) 19 refs.

Ercolani, Gianfranco (CNR, Rome, Italy); Mandolini, Luigi; Mencarelli, Paolo. *Macromolecules* v 21 n 5 May 1988 p 1241-1246.

**081812 KINETICS OF FISCHER-TROPSCH SELECTIVITY.** The kinetic model of Fischer-Tropsch chain growth as a non-trivial surface polymerization is developed and applied to discuss olefin/paraffin selectivity. The

probability of the olefin chemisorption-reaction, which controls primary olefin selectivity, is derived from experimental data as a function of temperature and total pressure. Secondary olefin hydrogenation and olefin double bond shift are identified in the system as interrelated reactions. (Author abstract) 16 refs.

Schultz, Hans (Univ of Karlsruhe, Karlsruhe, West Ger); Beck, Klaus; Erich, Egon. *Fuel Process Technol* v 18 n 3 May 1988 p 293-304.

**081813 EFFECT OF SEED ON POLYMER PARTICLE SIZE AND SIZE DISTRIBUTION IN SEED EMULSION POLYMERIZATION OF VINYL CHLORIDE.** In the emulsion polymerization process whether the problem about the average seed size, the size distribution and the seed amount used will exert any action on the average size as well as size distribution of the final polymer particles formed has been studied. Considering from the concept in respect to desorption and resorption of the free radicals from the polymers in vinyl chloride emulsification polymerization process, it is believed that the major controlling factor on the particle size and its distribution depends most likely upon the magnitude of the total external surface of the seed particles. Experimental results show that either the increase of the average seed size or the decrease of the quantity of the seed used gives no sensible increase of the particle size of the polymer particle formed. Hence, in order to have an appropriate particle size as well as the desired size distribution, seed quantity used should not be decreased and, in general, it should take the amount about 3-5 PERCENT of the total amount of the monomer used by weight. (Author abstract). 8 Refs. In Chinese.

Sun, Liqing; Yu, Hezu; Wang, Shuzhong; Zhao, Deren. *Huadong Huagong Xueyuan Xuebao* v 14 n 3 1988 p 379-384.

**Addition Reactions** See Also AMINES—Polymerization; BLOCK COPOLYMERS—Synthesis; EPOXY RESINS—Polymerization; NYLON POLYMERS—Processing; POLYMERS—Photosensitivity.

**081814 BENZOCYCLOBUTENE IN POLYMER SYNTHESIS. II. SOLID STATE DIELS-ALDER POLYMERIZATION UTILIZING AN IN SITU GENERATED DIENE AND AN ALKYNE.** A novel class of aromatic imide AB-monomers with benzocyclobutene and an alkyne (primarily phenylethynyl group) as the reactive units have been prepared. The monomers have been utilized in thermally induced Diels-Alder polymerizations. The differential scanning calorimetric study of the AB-monomers provided two observations: (i) primary acetylene began its homopolymerization (202°C max.) before the electrolytic ring opening of benzocyclobutene (270°C max.); (ii) the phenoxy group connecting between phenylacetylenyl group and the aromatic imide fragment suppressed polymerization in Diels-Alder fashion. Furthermore, thermoxidative stability evaluation on the cured samples (250°C for 8 h and then 350°C for another 8 h under N<sub>2</sub> atmosphere), carried out at 650°F (air) for 200 h, indicated the more rigid phenylethynyl phthalimide system was the most heat-resistant. (Author abstract) 15 refs.

Tan, Loon-Seng (Univ of Dayton Research Inst, Dayton, OH, USA); Arnold, Fred E. *J Polym Sci Part A* v 25 n 11 Nov 1987 p 3159-3172.

**081815 MODEL FOR X-RAY-INDUCED SOLID-STATE POLYMERIZATION.** The solid-state polymerization of disubstituted 1,3-diacetylenes proceeds via a 1,4 addition reaction yielding extended conjugated polymer chains possessing three-dimensional long range order. The reaction can be initiated by thermal annealing, by ultraviolet, visible, e-beam, x-ray, or  $\gamma$ -ray irradiation, or by mechanical stress. Upon initiation, the polymerization reaction proceeds exothermically. A model for x-ray-induced solid-state polymerization based on experimental results obtained with the disubstituted diacetylene, 10,12-pentacosadiynoic acid, is presented. 21 refs.

Kuzyk, Mark G. (AT&T, Princeton, NJ, USA); Sohn, John E.; Garito, Anthony F. *J Polym Sci Part B* v 26 n

2 Feb 1988 p 277-287.

**Additives** See POLYMERS—Synthesis.

**Analysis** See POLYAMIDES.

**Anionic Polymerization** See Also AROMATIC COMPOUNDS—Polymerization; MONOMERS—Polymerization; POLYAMIDES—Synthesis.

**081816 SYNTHESIS AND CHARACTERIZATION OF IN SITU ANIONICALLY POLYMERIZED p-AMINOBENZOYLCAPOROLACTAM USING DI- AND TRI-FUNCTIONAL INITIATOR SYSTEMS.** p-Aminobenzoylcaprolactam has been polymerized anionically in a two-step process to produce amide-amide copolymers. Both drawn fibers and unoriented films may be produced using this method. The samples were characterized using FTIR, solution NMR, thermal analysis, viscosity, and mechanical testing. FTIR and NMR revealed the incorporation of both the aramid and amide linkages into the polymer backbone. TGA results gave a lower decomposition temperature than that of both aramid and nylon 6 materials. Intrinsic viscosities averaged 0.5 dL/g for the drawn copolymer samples polymerized by the di-functional initiator. Light microscopy displayed crystalline domains that did not appear to melt even up to 300°C. Mechanical testing showed that the initial moduli of drawn fiber samples to be in the range of 30-80 MPa, while homopolymers of nylon 6 and p-benzamide possessed values of 25 MPa and 2.70  $\times 10^3$  MPa, respectively. (Author abstract) 8 refs.

Sikes, Allison M. (Univ of Southern Mississippi, Hattiesburg, MS, USA); Mathias, Lon J. *Polym Bull (Berlin)* v 18 n 5 Nov 1987 p 397-401.

**081817 STUDIES ON SOME RADICAL TRANSFER REACTIONS BY ENTRAPPING THE RADICALS AS POLYMER ENDGROUPS. III. REACTION OF OH RADICAL WITH HALIDE IONS.** The reactions of OH radical with  $Cl^-$ ,  $Br^-$ ,  $I^-$ , and  $F^-$  ions have been studied by entrapping the product radicals as polymer endgroups which have been detected and estimated by the sensitive dye partition technique. The rate constants of the reactions with  $Br^-$ ,  $Cl^-$ , and  $F^-$  ions have been determined to be  $1.51 \times 10^9$ ,  $1.32 \times 10$  and  $0.92 \times 10^9$  L mol<sup>-1</sup> s<sup>-1</sup>, respectively at 25°C and pH 1.00. Oxidation of  $I^-$  ions liberates  $I_2$  which inhibits the polymerization and the reaction could not be followed by polymer endgroup analysis. The observed order of reactivity  $Br^- > Cl^- > F^-$  is in accordance with the electron affinities of the halide ions. The acidity of the reaction medium has a strong influence on the rate of reaction. (Edited author abstract) 20 refs.

Pramanick, Dinabandhu (Kalyani Univ, Kalyani, India); Sarkar, Jyotish; Bhattacharyya, Ramanath. *J Polym Sci Part A* v 26 n 5 May 1988 p 1457-1463.

## Calculations

**081818 CONSISTENT VALUES OF RATE PARAMETERS IN FREE RADICAL POLYMERIZATION SYSTEMS.** Inspection of tabulated rate coefficients shows that there is a wide divergence in literature values of kinetic parameters for free radical polymerizations under ostensibly the same conditions. This communication is an attempt to initiate a solution to this problem by seeing if agreement exists on the values of some fundamental kinetic parameters for simple monomers, determined using quite different experimental techniques (e.g., comparing bulk versus emulsion data, 'classical' rate studies versus ESR studies, etc.) 17 Refs.

Bsuback, M. (Inst fuer Physikalische Chemie der Univ, Goettingen, West Ger); Garica-Rubio; Gilbert, R.G.; Napper, D.H.; Guillot, J.; Hamielec, A.E.; Hill, D.; O'Driscoll, K.F.; Olaj, O.F.; Shen, Jiacong; Solomon, D.; Moad, G.; Stickler, M.; Tirrell, M.; Winnik, M.A. *J Polym Sci Part C* v 26 n 7 Jul 1988 p 293-297.



**Catalysts** See Also AROMATIC COMPOUNDS—Polymerization; BUTADIENE—Polymerization; BUTANE—Polymerization; CATALYSTS—Supported; COPOLYMERS—Synthesis; EPOXY RESINS—Curing; GRAFT COPOLYMERS—Processing; MONOMERS—Polymerization; OLEFINS—Polymerization; OXIDES—Polymerization; POLYCARBONATES—Hydrolysis; POLYETHERS—Reduction; POLYETHYLENES—Linear Low Density; POLYMERS—Electric Conductivity; POLYMERS—Photochromism; POLYMERS—Synthesis; PROPYLENE—Polymerization.

**081819 KATALIZATORY DO POLIMERYZACJI PROPYLENU.** [Catalysts for Propylene Polymerization]. A literature review concerning developments in the field of catalyst systems for the stereospecific polymerization of propylene is presented. Efficiency of these systems and stereospecificity of polypropylene prepared with their use have been compared. Individual catalysts used in full-commercial scale installations by the main manufacturers of polypropylene in the world have been characterized. The present situation in the manufacture of polypropylene in Poland has been discussed. (Edited author abstract) In Polish. 61 refs.

Bukowski, Andrzej (Politechnika Warszawska, Pol); Osowiecka, Blandyna. *Polimery* v 32 n 8 Aug 1987 p 301-305.

**081820 MAGNESIUM CHLORIDE SUPPORTED HIGH-MILEAGE CATALYSTS FOR OLEFIN POLYMERIZATIONS. XVIII. EFFECT OF HYDROGEN AND LEWIS BASES.** Hydrogen has been found earlier to increase the initial rate of polymerization by  $\text{MgCl}_2/\text{EB}/\text{PC}/\text{AlEt}_3/\text{TiCl}_4\text{-AlEt}_3/\text{MPT}$ , CW-catalyst ( $+\text{B}_1$ ,  $+\text{B}_2$ ) (EB, ethyl benzoate; PC, p-cresol; MPT, methyl-p-toluate), but decays more rapidly as compared to polymerizations in the absence of  $\text{H}_2$ . In this study the effect of  $\text{H}_2$  was studied when either the internal Lewis base, EB  $\text{B}_1$ , or the external Lewis base, MPT  $\text{B}_2$ , or both are deleted from the CW-catalyst.  $\text{H}_2$  does not affect the stereospecificity of all the catalysts, but causes a slight increase of polymer yield, whereas the yield is virtually unchanged by  $\text{H}_2$  for the catalysts activated with  $\text{B}_2$ . (Edited author abstract) 14 refs.

Chien, James C.W. (Univ of Massachusetts, Amherst, MA, USA); Hu, Youling. *J Polym Sci Part A* v 25 n 10 Oct 1987 p 2881-2892.

**081821 MODIFICATION OF OLEFIN POLYMERIZATION CATALYSTS. I. MECHANISM OF THE INTERACTION BETWEEN  $\text{AlEt}_3$  AND Silyl ETHERS.** The interaction between  $\text{AlEt}_3$  and silyl ethers,  $\text{Ph}_n\text{Si}(\text{OMe})_{4-n}$  ( $n=0-3$ ), was followed by  $^{13}\text{C}$ - and  $^{29}\text{Si}$ -NMR techniques in conditions close to those typical for an olefin polymerization reaction with supported Ziegler-Natta catalysts ( $\text{AlEt}_3$ :silyl ether ratios from 1 to 10, temperature range 25-75°C).  $\text{AlEt}_3$  and silyl ethers form instantaneously at ambient temperature a donor-acceptor complex, which is stable at 1:1 molar ratio. In the presence of excess  $\text{AlEt}_3$  the complex decomposes via a mechanism consisting, in the case of  $\text{PhSi}(\text{OMe})_3$ , of five consecutive steps. The decomposition was not inhibited by the presence of 1-hexene. (Edited author abstract) 15 refs.

Vahasarja, Eila (Univ of Joensuu, Joensuu, Finl); Pakkanen, Tuula T.; Pakkanen, Tapani A.; Iiskola, Eero; Sormunen, Pekka. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3241-3253.

**081822 HIGHLY ACTIVE SUPPORTED CATALYSTS FOR OLEFIN POLYMERIZATION: PREPARATION AND CHARACTERIZATION OF THE CATALYST.** With use of the support prepared by the reaction of a Grignard reagent with reaction mixture of  $\text{AlCl}_3$  and  $\text{CH}_3\text{Si}(\text{OC}_2\text{H}_5)_3$ , an immobilized active stereospecific titanium catalyst was prepared by the three-step treatment of the support, first with  $\text{TiCl}_4$ , second with ethylbenzoate, and third with  $\text{TiCl}_4$  again. The catalyst was also prepared by the two-step treatment of the support, with the mixture of  $\text{TiCl}_4$  and ethylbenzoate, and with  $\text{TiCl}_4$ . The experimental data support the idea that both  $\text{TiCl}_4$  and ethylbenzoate as donors are immobilized on the surface of the active stereospecific catalyst without any interaction between them. (Edited author abstract) 19 refs.

Yano, Takefumi (Ube Industries Ltd, Ichihara, Jpn); Inoue, Tokuji; Ikai, Shigeru; Shimizu, Michimasa; Kai, Yoshiyuki; Tamura, Masanori. *J Polym Sci Part A* v 26 n 2 Feb 1988 p 477-489.

**081823 OLIGOMERIZATION OF ALKYNES BY HAFNOCENE DICHLORIDE/ETHYLLALUMINUM DICHLORIDE.** The  $\text{Cp}_2\text{HfCl}_2/\text{C}_2\text{H}_5\text{AlCl}_2$  system ( $\text{Cp}=\eta^5\text{-cyclopentadienyl}$ ) was found to be an active homogeneous catalyst for the oligomerization of both terminal and internal alkynes. Apparently, the mechanism of oligomerization occurs by successive insertion of the alkene into the hafnium-carbon bond of a cationic intermediate, as evidenced by the interception of the highly substituted, sterically bulky, 1-trimethyl-silyl-1-propyne. (Author abstract) 11 refs.

Sabade, Milind (Univ of Akron, Akron, OH, USA); Farona, Michael F. *Polym Bull (Berlin)* v 18 n 5 Nov 1987 p 441-446.

**081824 IR STUDY OF THE POLYMERIZATION MECHANISM OF THE PHILLIPS CATALYST.** The IR investigation of the catalytic center of the chromium-(II) surface compound on silica gel (the active center of the Phillips catalyst) showed a broad band at  $2750\text{ cm}^{-1}$ , assigned to the stretching vibrations, and a new IR band at  $1448\text{ cm}^{-1}$ , assigned to the deformation vibration of a methylene group at the chromium(II) surface ion. The known alkylchromium dichloride complexes ( $\text{Cl}_2\text{CrR}(\text{THF})_3$ ), which are the best models at the moment for the Phillips catalyst, show C-H vibrations from the alkyl group between  $2790$  and  $2800\text{ cm}^{-1}$ . (Edited author abstract) 18 refs.

Rebenstorf, Bernd (Univ of Lund, Lund, Swed). *J Mol Catal* v 45 n 2 May 9 1988 p 263-274.

**081825 MIXED ORGANO/OXIDE CHROMIUM POLYMERIZATION CATALYSTS.** Supported chromium oxide catalysts are activated by calcination in dry air at  $400-900^\circ\text{C}$ , which dehydrates the carrier and binds chromium(VI) to the surface. A reduction by ethylene then provides the active species. Alternatively, the carrier can be calcined alone and afterward impregnated with an organochromium compound. Both procedures can produce an active catalyst for ethylene polymerization, but the two types differ considerably in their behavior. A third type is made by reacting an organo-chromium compound with the activated chromium oxide catalyst. (Edited author abstract) 29 refs.

Benham, E.A. (Philips Research Cent, Bartlesville, OK, USA); Smith, P.D.; Hsieh, E.T.; McDaniel, M.P. *J Macromol Sci Chem* v A25 n 3 Mar 1988 p 259-283.

**081826 ISOTACHOPHORESIS FOR THE MICRODETERMINATION OF POTASSIUM PERSULPHATE AS INITIATOR IN EMULSION POLYMERIZATION.** Isotachophoresis (IP) was applied to determine the decomposition rate of potassium persulphate (KPS) as initiator in emulsion polymerization, in comparison with conventional iodometry and ferrometry. For the exact determination, the latter methods needed several milliliters of the emulsion pipetted from the polymerization system, whereas IP did only a few microliters. Moreover, the amount of sulphuric acid produced as the decomposition by-product was simultaneously determined by IP, which is impossible for iodometry and ferrometry. (Author abstract) 13 refs.

Okubo, M. (Kobe Univ, Kobe, Jpn); Mori, T. *Colloid Polym Sci* v 266 n 4 Apr 1988 p 333-336.

**Cationic Polymerization** See Also ETHERS—Polymerization; MONOMERS—Polymerization; OLIGOMERS—Polymerization; POLYACETYLENES; POLYETHERS—Synthesis; POLYMERS—Synthesis; POLY-OLEFINS—Synthesis; POLYSACCHARIDES; VINYL RESINS—Synthesis.

**081827 INICIJATORY FOTOPOLIMERYZACJI I FOTOSIECIOWANIA. CZ. II. INICIJATORY POLIMERYZACJI KATIONOWEJ.** [Initiators for Photopolymerization and Photocrosslinking: Part II.

Initiators for Cationic Polymerization]. The literature data in the field of photoinitiated cationic polymerization and photosensibilizers as well as the mechanisms of transformations taking place in the photoinitiating systems under the action uv-vis-light have been reviewed. The photoinitiated hybrid polymerization, i.e. a process of simultaneous radical and cationic polymerization, has been characterized in a similar range. (Author abstract) In Polish. 208 refs.

Prot, Tomasz (Wyzsza Szkoła Inzynierska im. K. Pulaskiego, Radom, Pol); Karpinski, Krzysztof. *Polimery* v 32 n 8 Aug 1987 p 306-314.

**081828 SELECTIVE VINYL CATIONIC POLYMERIZATION OF MONOMERS WITH TWO CATIONICALLY POLYMERIZABLE GROUPS. II. P-VINYLPHENYL GLYCIDYL ETHER: AN EPOXY-FUNCTIONALIZED STYRENE.** p-Vinylphenyl glycidyl ether (VPGE), a styrene derivative with an epoxy pendant, was polymerized by various cationic initiators, and its selective vinyl polymerization was investigated at low temperatures below  $-15^\circ\text{C}$ .  $\text{BF}_3\text{OEt}_2$  (a metal halide) and  $\text{CF}_3\text{SO}_3\text{H}$  (a strong protonic acid) polymerized both vinyl and epoxy groups of VPGE, and produced cross-linked insoluble polymers. The  $\text{HI}/\text{I}_2$  initiating system and iodine, in contrast, polymerized its vinyl group in polar solvents ( $\text{CH}_2\text{Cl}_2$  and nitroethane) highly selectively in the temperature range of  $-15$  to  $-40^\circ\text{C}$  to give soluble polymers with a polystyrene backbone and epoxy pendants; however, under these conditions, 10-15% of the epoxy groups of the polymers were consumed during the polymerization by the reaction with the growing species. The differences between the polymerizations of VPGE and p-isopropenylphenyl glycidyl ether, an  $\alpha$ -methylstyrene-type counterpart of VPGE, were also discussed with an emphasis on the effects of the  $\alpha$ -methyl group in the latter monomer. (Edited author abstract) 8 refs.

Hashimoto, Tamotsu (Kyoto Univ, Kyoto, Jpn); Sawamoto, Mitsuo; Higashimura, Toshinobu. *J Polym Sci Part A* v 25 n 10 Oct 1987 p 2827-2838.

**081829 CATIONIC RING-OPENING POLYMERIZATION OF 2-SUBSTITUTED-2-OXAZOLINES INITIATED BY CARBON BLACK SURFACE.** Carbon blacks were found capable of initiating the ring-opening polymerization of 2-substituted-2-oxazolines at relatively high temperatures. The activation energy of the polymerization of 2-methyl-2-oxazoline was estimated to be  $13.4\text{ kcal/mol}$ . Carbon black lost the initiating activity of the polymerization upon the blocking of carboxyl groups on the surface by the treatment with potassium hydroxide or diazomethane. Therefore, it was concluded that carboxyl groups on carbon black play an important role in the initiation of the polymerization. Furthermore, it was found that during the polymerization, poly(N-acetylthyleimine) was grafted onto carbon black by the termination of growing polymer chain with the surface. (Author abstract) 12 refs.

Tsubokawa, Norio (Niigata Univ, Niigata, Jpn); Asano, Itaru; Sone, Yasuo. *Polym Bull (Berlin)* v 18 n 5 Nov 1987 p 377-384.

**081830 DIMERIZATION OF THE METHYLVIOLOGEN CATION RADICAL IN ANIONIC MICELLAR AND POLYELECTROLYTE SOLUTIONS.** The dimerization behavior of the methylviologen cation radical ( $\text{MV}^{+}$ ) in the presence of sodium dodecyl sulfate (SDS), sodium decyl sulfate (SdecS), and sodium poly(styrenesulfonate) (PSS) was examined by using the visible spectral characteristics of solutions containing electrogenerated  $\text{MV}^{+}$ . The results indicate that the concentration of either SDS or SdecS micellar aggregates exerts a strong effect on the extent of dimerization. Thus, negligible dimerization was found at high levels of surfactant while extensive dimerization was observed at surfactant concentrations slightly above the corresponding critical micelle concentrations. This behavior was reasonably well simulated by a simple computational model based on the Poisson distribution. The dimerization



pattern in the presence of PSS was quite different. The polyelectrolyte was found to increase the dimerization level, throughout the entire concentration range surveyed (5-100 mM), over that found in isotropic aqueous solutions. This was interpreted as the result of MV<sup>+</sup> clustering triggered by the polyelectrolyte chains. (Author abstract) 16 refs.

Quintela, Pablo A. (Univ of Miami, Coral Gables, FL, USA); Diaz, Abigail; Kaifer, Angel E. *Langmuir* v 4 n 3 May-Jun 1988 p 663-667.

**Chemical Reactions** See Also ETHERS—Polymerization; ORGANIC COMPOUNDS—Polymerization; PHOSPHORUS COMPOUNDS—Polymerization; POLYPEPTIDES—Synthesis.

**081831 MODELING OF DIFFUSION-CONTROLLED FREE-RADICAL POLYMERIZATION REACTIONS.** The present paper introduces a new fundamental approach to the modeling of diffusion-controlled free-radical polymerization reactions. Our analysis follows the original work of W.V. Chiu, G.M. Carratt, and D.S. Soong (CCS), according to which the termination and propagation rate constants are expressed in terms of both a purely reaction-limited term and a diffusion-limited one. The contribution of the latter term to the apparent rate constants is described in terms of the polymer and monomer effective diffusion coefficients and an effective reaction radius. It is shown that all parameters appearing in the original CCS model can be calculated from first principles using available data on the physical and transport properties of a particular monomer-polymer binary system. (Edited author abstract) 51 refs.

Achiliadis, D. (Univ of Thessaloniki, Thessaloniki, Greece); Kiparissides, C. *J Appl Polym Sci* v 35 n 5 Apr 1988 p 1303-1323.

**Condensation Reactions** See Also BLOCK COPOLYMERS—Synthesis; CHEMICAL REACTIONS—Esterification; COPOLYMERS—Synthesis; FLUORINE CONTAINING POLYMERS—Synthesis; MATHEMATICAL TRANSFORMATIONS—Z Transforms; OLIGOMERS—Polymerization; OLIGOMERS—Spectroscopic Analysis; POLYAMIDES—Synthesis; POLYESTERS—Synthesis; POLYIMIDES—Synthesis; POLYIMIDES—Synthesis; POLYMERS—Research; POLYMERS—Synthesis; POLYPEPTIDES—Production; THERMOSETS—Synthesis.

**081832 FRIEDEL-CRAFTS POLYMERS. 10. POLYCONDENSATION OF 4,4'-DICHLOROMETHYLDIPHENYL ETHER WITH PHENOL AND ISOMERIC CRESOLS.** Friedel-Crafts polycondensations of 4,4'-dichloromethyldiphenyl ether (DDE) with phenol and isomeric cresols were carried out under different experimental conditions. The molecular weight of the polymer products was estimated by end group analysis, that of soluble products by VPO, and they were characterized by TGA and solution viscosity. DMF solutions of samples prepared from phenol and p- and m-cresols, but not those from o-cresol, showed abnormal viscosity behavior. However, the viscosity behavior of DMF-water solutions was normal. Abnormal viscosity data of DMF solutions were correlated by an empirical relation. (Edited author abstract) 16 refs.

Amin, Pradip T. (Sardar Patel Univ, Vallabhi Vidyanagar, India); Patel, Pradip S.; Patel, Shanti R. *J Macromol Sci Chem* v A24 n 8 1987 p 891-899.

**081833 INVERSE GAS CHROMATOGRAPHY USED TO FOLLOW KINETICS OF EPOXY-AMINE REACTIONS IN THE MOLTEN STATE.** Polycondensation kinetics of epoxy-amine model systems were investigated with inverse gas chromatography. The results obtained were applied to the study of cross-linking kinetics of two epoxy prepolymers, tetraglycidyl diamino diphenyl methane and diglycidyl ether of bisphenol A, with diamino diphenyl sulfone. Data furnished by inverse gas chromatography showed zones of gelation and of vitrification. Based on kinetics established by isothermal microcalorimetry, it was possible to determine reaction advancement in these transition zones. The results show that advancement of both reaction systems to the transition points T<sub>1</sub> and T<sub>2</sub> is very sensitive to curing tempera-

ture and to the stoichiometry of the mixture. Finally, the vitreous transition temperatures of the cross-linked systems were determined and compared to those determined with differential scanning calorimetry. (Author abstract) 14 refs.

Grenier-Loustalot, Marie-Florence (Inst Universitaire de Recherche Scientifique, Pau, Fr); Mouline, Ghita; Grenier, Philippe. *Polymer* v 28 n 13 Dec 1987 p 2275-2281.

**081834 DIRECT POLYCONDENSATION REACTION USING POLYMERIC TRIPHENYLPHOSPHINE AS AN INITIATOR.** Triphenylphosphine which is known as an effective initiator for direct polycondensation, was immobilized into polymers by polymerizing and copolymerizing with diphenylstyrylphosphine. Copolymerization behavior of diphenylstyrylphosphine with 4-vinylpyridine was analyzed. Polymeric triphenylphosphine could initiate the direct polycondensation to form either polyamide or polyester and a recycling system for the regeneration of triphenylphosphine moiety was proposed. (Author abstract) 6 refs.

Ogata, Naoya (Sophia Univ, Tokyo, Jpn); Sanul, Kohei; Watanabe, Masayoshi; Sakai, Hideko. *Polym J* v 19 n 12 1987 p 1351-1357.

**081835 ON THE CURING THEORY AND THE SCALING STUDY OF THE POLYCONDENSATION REACTION OF A<sub>2</sub>...A<sub>3</sub>...B<sub>1</sub>...B<sub>2</sub>...TYPE.** For the polycondensation reaction of A<sub>2</sub>...A<sub>3</sub>...B<sub>1</sub>...B<sub>2</sub> type, the sol fraction above the gel point is investigated in detail by taking Stockmayer's gelation condition as a criterion. Furthermore, the scaling behavior near the gel point is revealed to reach an asymptotic form of Stockmayer's equilibrium number distribution from which a generalized scaling law is deduced. (Author abstract) 14 refs.

Tang Au-chin (Jilin Univ, Changchun, China); Li Ze-sheng; Sun Chia-chung; Tang Xin-yi. *Macromolecules* v 21 n 3 Mar 1988 p 797-804.

**081836 OPTIMAL STATE ESTIMATION IN THE TRANSESTERIFICATION STAGE OF A CONTINUOUS POLYETHYLENE TEREPHTHALATE CONDENSATION POLYMERIZATION PROCESS.** This paper describes an application of the extended Kalman filter algorithm to the state estimation of the melt transesterification stage of a continuous polyethylene terephthalate condensation polymerization process. When only two on-line measurements of reaction variables are used for state estimation, the prediction of reaction rates and product concentrations are unsatisfactory. When such limited on-line measurements are supplemented by five additional off-line measurements of various functional group concentrations, the system is completely observable and the overall performance of the state estimator is greatly improved. It has been shown that the analysis delay of 24 h is quite adequate for accurate state estimation of the process. In particular, the concentration of unwanted side product such as diethylene glycol (DEG) was predicted precisely. (Edited author abstract) 23 refs.

Choi, Kyu-Yong (Univ of Maryland, College Park, MD, USA); Khan, Afeef A. *Chem Eng Sci* v 43 n 4 1988 p 749-762.

**Control Systems** See CHEMICAL EQUIPMENT—Reactors.

**Coordination Reactions** See POLYMETHYL METHACRYLATE—Polymerization.

**Copolymerization** See Also BLOCK COPOLYMERS—Synthesis; BUTADIENE—Polymerization; CATALYSTS; CELLULOSE—Processing; CELLULOSE DERIVATIVES—Degradation; COPOLYMERS—Mechanical Properties; COPOLYMERS—Molecular Structure; COPOLYMERS—Optical Properties; COPOLYMERS—Polymerization; COPOLYMERS—Synthesis; DYES AND DYEING—Synthesis; EMULSIONS—Polymerization; GELS—Forming; GRAFT COPOLYMERS; HYDROCARBONS—Processing; ION EXCHANGE RESINS—Production; LATEXES—Synthesis; MONOMERS—Photochemical Reactions; MONOMERS—Polymerization; MONOMERS—Processing; MONOMERS—Radiation Effects; OLEFINS—Polymerization; ORGANIC COMPOUNDS—Polymerization; ORGANIC COMPOUNDS—Process-

ing; POLYAMIDES—Physical Properties; POLYETHYLENES; POLYMERS—Photosensitivity; POLYMETHYL METHACRYLATE; POLYSTYRENES—Synthesis; POLYSULFONES; PROTEINS—Purification; RUBBER—Grafting; STYRENE—Polymerization; SYNTHETIC FIBERS—Modification; THERMOPLASTICS—Grafting; VINYL RESINS; VINYL RESINS—Crosslinking; VINYL RESINS—Synthesis.

**081837 COPOLYMERIZATION OF CHLOROMETHYLSTYRENE AND DIVINYLBENZENE IN THE ABSENCE OR PRESENCE OF POLY(VINYL CHLORIDE).** Studies of the copolymerization of chloromethylstyrene (CMS) and divinylbenzene (DVB) were done in the presence of absence of poly(vinyl chloride) (PVC) in order to prepare anion-exchange membranes of excellent performance by the paste method. The copolymerization rate decreases when PVC is added and increases when the DVB quantity is increased in the presence of PVC. The copolymerization rate of the isomers of CMS and DVB increases in the following order: p-DVB > m-DVB > p-ethylvinylbenzene > p-CMS > m-CMS > m-ethylvinylbenzene. This order is not affected by the presence of PVC. The copolymerization of CMS and DVB takes place partially in PVC particles. (Author abstract) 17 refs.

Takata, Kuniaki (Tokuyama Soda Co, Tokuyama, Jpn); Kusumoto, Koshi; Sata, Toshikatsu; Mizutani, Yukio. *J Macromol Sci Chem* v A24 n 6 1987 p 645-659.

**081838 COPOLYMERIZATION OF N-ARYLMALEIMIDES WITH METHYL METHACRYLATE.** The results of studies on the copolymerization of methyl methacrylates and three N-arylmaleimides are reported. The copolymerization was carried out in benzene at 70°C by using AIBN as initiator with a monomer-to-initiator ratio of 50. To determine the reactivity ratios, the copolymerization was carried out starting with different mole ratios of the monomers and stopping the reaction by adding an excess of methanol before 10% conversion. The reactivity ratios were determined by the Kelen-Tudos (KT) method. The T. Alfrey and C.C. Price parameters Q<sub>2</sub> and e<sub>2</sub> of the N-arylmaleimides were calculated by using the standard values of Q(0.74) and e(0.40) of MMA. 9 refs.

Kumar, Ajay (Cent for Cellular & Molecular Biology, Hyderabad, India). *J Macromol Sci Chem* v A24 n 6 1987 p 711-715.

**081839 ANALYSIS OF THE ROLE OF COMPLEX IN THE ALTERNATING COPOLYMERIZATION OF N-VINYLPYRROLIDONE AND MALEIC ANHYDRIDE.** Heterogeneous copolymerization of 1-vinyl-2-pyrrolidone (NVP) and maleic anhydride (MA) initiated with AIBN was studied in benzene at 60°C, at two different total monomer concentrations. The existence of a charge transfer complex between the comonomers has been shown and its equilibrium constant determined. The chemical composition of the copolymer was examined as a function of the initial monomer ratio, and it was found nearly equimolecular in a wide range of relative monomer concentrations. The compositional equation for the NVP/MA copolymerization system was derived with the consideration of the effect of the complex. (Edited author abstract) 19 refs.

Fehervari, Flora (Hungarian Acad of Sciences, Budapest, Hung); Azori, Maria; Foldes-Berezsnich, Tamara; Tudos, Ferenc. *Polym Bull (Berlin)* v 18 n 3 Sep 1987 p 225-232.

**081840 POLYMERIZATION OF N-(P-AMINO-BENZOYL)CAPROLACTAM: BLOCK AND ALTERNATING COPOLYMERS OF AROMATIC AND ALIPHATIC POLYAMIDES.** The polymerization behavior of N-(p-aminobenzoyl)caprolactam was studied. It was found that polymerization could proceed by either elimination of caprolactam or by ring opening. Polymers prepared at temperatures above 200°C showed a greater tendency for ring opening to produce alternating aromatic/aliphatic copolymers than did polymers prepared at lower temperatures. Block copolymers of poly(p-benzamide) and nylon 6 were prepared by a two-stage hydrolytic polymerization process or by anionic polymerization



at temperatures  $> 200^{\circ}\text{C}$ . Polymer microstructures were determined using  $^{13}\text{C}$ -NMR spectroscopy by comparison with homopolymers and model alternating copolymers. (Edited author abstract) 12 refs.

Mathias, Lon J. (Univ of Southern Mississippi, Hattiesburg, MS, USA); Moore, D. Roger; Smith, Charles A. *J Polym Sci Part A* v 25 n 10 Oct 1987 p 2699-2709.

**081841 MODEL COPOLYMERIZATION REACTIONS: EVIDENCE AGAINST PARTICIPATION OF A DONOR-ACCEPTOR COMPLEX IN REACTIONS OF THE 1-BUTYL RADICAL WITH N-PHENYLMALIMIDE AND STYRENE.** The participation of electron donor-acceptor (EDA) complexes in radical copolymerizations has been the subject of hundreds of research papers. Complex participation has been invoked to explain the formation of alternating copolymers, as well as the variations in overall copolymerization rate with changes in temperature, solvent, or monomer concentration, that are frequently observed in copolymerizations of donor (D) and acceptor (A) olefins. The essence of the complex-participation hypothesis is the idea that the growing polymeric radical 1 adds not only to the free olefinic monomers A and D, but also to an EDA complex 2 formed from them. The present paper addresses the reactions of styrene and NPM with the 1-butyl radical, a simple model for the propagating macroradicals involved in the styrene-NPM copolymerization. Specifically, the authors examine the possibility that this simple alkyl radical might undergo concerted addition to a 1:1 complex of styrene and NPM. 21 refs.

Jones, Sharon A. (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Tirrell, David A. *J Polym Sci Part A* v 25 n 11 Nov 1987 p 3177-3180.

**081842 EQUILIBRIUM COPOLYMERIZATION. III. SEQUENCE DISTRIBUTION IN EQUILIBRIUM COPOLYMER.** The sequence distributions for the copolymers generated in three cases of binary equilibrium copolymerization, including the effect of the ultimate unit, are studied theoretically. From the equilibrium sequence distribution functions, the copolymer sequence structure, the number- and weight-average sequence lengths of monomer units, the run number, the randomness parameter, and the fractions of different diads in the copolymer are derived. According to the relation between the parametric variables introduced in the formulas and the equilibrium copolymerization conditions, all of the structural sequence parameters of the resulting copolymers can be predicted from the comonomer feed composition and the equilibrium constants for initiation and propagation. (Edited author abstract) 12 refs.

Cai, Gang-Feng (Shanghai Inst of Building Materials Industry, Shanghai, China); Yan, De-Yue. *J Macromol Sci Chem* v A24 n 8 1987 p 869-890.

**081843 CATIONIC COPOLYMERIZATION OF 3-METHYLTETRAHYDROFURAN AND 3,3-DIMETHYLOXETANE: STRUCTURAL STUDY OF THE COPOLYMERS.** The bulk cationic copolymerization of 3-methyltetrahydrofuran and 3,3-dimethyloxetane was studied at  $0^{\circ}\text{C}$  using acetylhexafluoroantimonate as initiator. Values of the composition of the copolymers and the dyad and triad probabilities were obtained by  $^1\text{H}$ - and  $^{13}\text{C}$ -NMR spectroscopy. A kinetic scheme was proposed for this copolymerization and the values of the reactivity ratios were directly determined from the dyad probabilities. The experimental values of the triad probabilities were found to be in good agreement with those calculated from the reactivity ratios. (Author abstract) 23 refs.

Guzman, J. (CSIC, Madrid, Spain); Garcia, M.; Riande, E. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 207-221.

**081844 COPOLYMERIZATION OF N-VINYLL-2-PYRROLIDONE AND 2-PHENYL-1,1-DICIANOETHENE.** Radical copolymerization of N-vinyl-2-pyrrolidone (NVP) with 2-phenyl-1,1-dicyanoethene (PDE) was studied in benzene at  $70^{\circ}\text{C}$ . Terminal, penultimate, and monomer complex participation kinetic models were applied to compositional data for

best prediction of the copolymer composition. Both penultimate and complex models described satisfactorily the deviation from the terminal copolymerization model, although the complex model did not predict as well as the penultimate model at high NVP/PDE monomer feed ratios. Copolymerization reactivity ratios indicated substantial effect of penultimate PDE monomer unit associated with polar repulsion of cyano groups. Equilibrium constant of NVP-PDE comonomer complex formation was found to be  $0.08 \text{ L/mol}$  as estimated by proton nuclear magnetic resonance (NMR) analysis of PDE's vinylic proton chemical shift upon complexation. Rate constants of propagation reactions were estimated by applying terminal complex copolymerization model. (Author abstract) 22 refs.

Kharas, Gregory B. (Polysar Inc, Leominster, MA, USA). *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 733-741.

**081845 ALTERNATING COPOLYMERIZATION OF N-PHENYLMALIMIDE WITH CYCLOHEXYLVINYLBUTYRONE.** Complex formation between N-phenylmaleimide and cyclohexylvinylketone was studied by the proton magnetic resonance method (PMR), and the complex equilibrium constant was determined:  $K_c = 0.021 \text{ l./mole}$ . It was found that by radical copolymerization of the studied monomers, copolymers of equimolar composition are formed. By the 'shift of rate maximum' kinetic method, participation of donor-acceptor complexes in the chain-growth reaction could be quantitatively determined, and the statistical parameters of the N-phenylmaleimide-cyclohexylvinylketone copolymerization could be characterized. (Edited author abstract) 11 refs.

Rasulov, N.Sh. (Azerbaijan SSR Acad of Sciences, USSR); Medyakova, L.V.; Kuliyeva, E.Yu.; Rzaev, Z.M.; Zubov, V.P. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2887-2893.

**081846 EMULSION POLYMERIZATION: THEORY OF PARTICLE SIZE DISTRIBUTION IN COPOLYMERIZATION SYSTEM.** A mathematical model for describing the particle size distribution (PSD) in emulsion copolymerization systems is developed by analogy to that in emulsion homopolymerization systems as proposed by Lichti and co-workers. By use of the appropriate combinations of the kinetic parameters of the comonomers, the complicated equations for copolymerization systems can be reduced to simpler equations identical to those of homopolymerization systems. The two calculation examples, styrene-methyl methacrylate and styrene-butadiene systems, are given to demonstrate the applicability of the proposed theory. The conditions for producing bimodal PSD from a seeded emulsion polymerization are discussed. (Author abstract) 20 refs.

Chen, Show-An (Nat'l Tsing Hua Univ, Hsinchu, Taiwan); Wu, Kuo-Wei. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1487-1506.

**081847 HIGH-CONVERSION DIFFUSION-CONTROLLED COPOLYMERIZATION KINETICS.** Simultaneous polymerization of two or more monomers is a commercially important process for tailor making polymer properties. A major problem with this technique, however, is the well-known copolymer composition drift resulting from reactivity differences between the component monomers. During the course of copolymerization, the product formed becomes progressively depleted in the faster reacting monomer. In addition to intrinsic reactivity differences, diffusional processes exert a strong influence on the instantaneous molecular weight and possibly on the copolymer composition produced. The purpose of this work is to develop a high-conversion diffusion-controlled copolymerization model to predict the molecular weight and composition evolution. The model incorporates free-volume based diffusion theories of polymers as before in a homopolymerization model for high conversions. (Edited author abstract) 39 refs.

Sharma, D.K. (Univ of California, Berkeley, CA, USA); Soane, D.S. *Macromolecules* v 21 n 3 Mar 1988 p 700-710.

**081848 CYCLIZATION AND REDUCED REACTIVITY OF PENDANT VINYL DURING THE COPOLYMERIZATION OF METHYL METHACRYLATE AND ETHYLENE GLYCOL DIMETHACRYLATE.** Methyl methacrylate was copolymerized with small amounts of ethylene glycol dimethacrylate. Monomer and pendant vinyl conversion as a function of time was measured up to the gel point. Pendant vinyl conversion was determined by  $^1\text{H}$  NMR. Plots of pendant conversion versus monomer conversion exhibit a positive y-intercept indicating the tendency to cyclize during the formation of a primary chain. For bulk systems, this amounted to approximately 3-4% of pendant vinyls and the cyclic proportion increased with dilution. The slope of the pendant versus monomer conversion plot is attributed to the formation of cross-links and subsequent cycles. A kinetic model is developed which includes constants for cyclization and pendant reactivity. Values for these constants for the chemical systems studied are evaluated. The average pendant vinyl reactivity is found to be approximately half that of monomeric vinyl reactivity. (Author abstract) 21 refs.

Landin, D.T. (Univ of Minnesota, Minneapolis, MN, USA); Macosko, C.W. *Macromolecules* v 21 n 3 Mar 1988 p 846-851.

**081849 GRAFT COPOLYMERIZATION OF ACRYLAMIDE ONTO THE UV-RAY IRRADIATED FILM OF POLYESTER-POLYETHER.** In this paper the  $\text{Ce(IV)}$  salt initiated graft copolymerization of acrylamide onto the film of polyester-polyether block copolymer irradiated by UV-ray was reported. The UV-irradiation of the film and its graft process have been investigated by UV spectrum, ESR and ESCA and the influence of other factors on the graft copolymerization has been discussed. (Author abstract) 14 refs.

Chen, Chuanfu (Acad Sinica, Beijing, China); Li, Xuefen; Li, Zhifen. *Chin J Polym Sci (Engl Ed)* v 6 n 1 1988 p 14-19.

**081850 EFFECTS OF SOLVENT POLARITY ON FREE RADICAL COPOLYMERIZATION OF 5-HEXENOIC ACID AND ACRYLONITRILE.** The effects of solvent polarity on free radical copolymerization of 5-hexenoic acid and acrylonitrile at  $60^{\circ}\text{C}$  were studied. It was observed that as the polarity of solvents enhanced, both the copolymerization rate and the reactivity ratios  $r_1$ ,  $r_2$  increased, while the alternating tendency of monomer units in the copolymer chain decreased. It is believed that the solvent polarity raises the reactivities of acrylonitrile monomer and its growing chain radical, but causes no distinct variation in those of 5-hexenoic acid. (Author abstract) 15 refs.

Wang, Bing (Acad Sinica, Chengdu, China); Xie, Shishan; Cao, Mengjun. *Chin J Polym Sci (Engl Ed)* v 5 n 2 1987 p 141-148.

**081851 MECHANISM OF COPOLYMERIZATION OF VINYL AND DIVINYL MONOMER VI: A STUDY ON THE MECHANISM OF THE STRUCTURE FORMATION OF CROSSLINKED POLYSTYRENE.** In order to study the mechanism of the formation of macroporous copolymer, the overall reaction kinetics, phase separation and gelation of the S/EGDM in the presence of inert solvents and the physical properties of the copolymer were investigated and compared with the corresponding system of S/DVB and S/DVB/MMA. The formation of the network structure of the macroporous polymer was studied and a model of the mechanism suggested. (Author abstract) 6 refs.

Wang, Shouting (Nankai Univ, Tianjin, China); Chen, Weizhu; Jiang, Lu; He, Binglin. *Chin J Polym Sci (Engl Ed)* v 5 n 1 1987 p 26-33.



**081852 KOPOLIMERYZACJA ZWIĄZKÓW ALILIOWYCH Z BEZWODNIKIEM MALEINOWYM.** [Copolymers of Allylic Compounds and Maleic Anhydride]. On the basis of theoretical considerations concerning monomers capable of forming complexes with maleic anhydride, a general equation of copolymerization rate for such reactions has been derived, as well as its modifications for the case of an allylic monomer containing two double bonds of equal reactivity. An algorithm for the solution of these equations has been prepared, and on the basis of experimental results the values of rate constants of elementary reactions of chain growth in the system bis(allylcarbonate) of diethylene glycol (monomer 1)-maleic anhydride (monomer 2) have been determined. The knowledge of these values makes it possible for the first time to consider the participation of each elementary stage of chain growth in the overall rate of the process. (Edited author abstract) 10 refs. In Polish.

Zajcev, Ju.S. (Instytut Fizycznej Chemii Organicznej, Donetsk, USSR); Bojko, N.N.; Alekseev, N.N.; Zajceva, V.V.; Smirnov, Ju.I. *Polimery* v 33 n 2 Feb 1988 p 51-54.

**081853 MINIEMULSION COPOLYMERIZATION OF VINYL ACETATE AND BUTYL ACRYLATE. II. MATHEMATICAL MODEL FOR THE MONOMER TRANSPORT.** A mathematical model is presented to describe the monomer transport between monomer droplets, aqueous phase, and polymer particles during the course of an emulsion polymerization. The model was used to investigate the role of the cosurfactant (hexadecane) in the miniemulsion copolymerization of 50:50 molar ratio vinyl acetate-butyl acrylate monomer mixture, as well as the effect of the different components and process variables on the rate of copolymerization, monomer distribution between phases, and composition of the copolymer. (Author abstract) 22 Refs.

Delgado, Joaquin (Lehigh Univ, Bethlehem, PA, USA); El-Aasser, Mohamed S.; Silebi, Cesar A.; Vanderhoff, John W.; Guillet, Jean. *J Polym Sci Part B* v 26 n 7 Jul 1988 p 1495-1517.

**081854 POLYMERIZATION AND COPOLYMERIZATION OF N-ALLYLCITRACONIMIDE.** Homopolymerization and copolymerization of N-allylcitraconimide (ACI) were carried out at 60°C by using azobisisobutyronitrile as an initiator. The initial overall rate of polymerization was proportional to the square root of the initiator concentration. The overall activation energy measured was 23.7 kcal/mol. In the copolymerization of ACI ( $M_1$ ) with styrene ( $M_2$ ), alternating-type copolymers were obtained. All the citraconyl groups participated in copolymerization and all the allyl groups remained as residual double bonds. The reactivity ratio was determined. (Edited author abstract) 22 Refs. In Japanese.

Urushido, Kunio (Shinshu Univ, Nagano, Jpn); Yokoyama, Masaaki; Shiratori, Yoshifumi; Matsumoto, Akira; Oiwa, Masayoshi. *Kobunshi Ronbunshu* v 45 n 5 1988 p 435-440.

**Decomposition** See GASES—Spectroscopic Analysis.

## Dissolution

**081855 EXCHANGE REACTIONS IN SEGMENTED POLYESTER-URETHANE POLYMERIZATION AND RELATIONSHIPS BETWEEN HARD SEGMENT DISTRIBUTIONS AND POLYMERIZATION CONDITIONS.** The segmented polyurethanes obtained from polyester, 4,4'-diphenylmethane diisocyanate and 1,4-butanediol were dissolved in dimethylformamide and precipitated into ten fractions by adding a mixture of n-hexane and diethyl ether. The hard segment distributions were studied by means of solution viscosity, nitrogen content, and IR measurements for these fractions and also by measuring mechanical properties of elastic fibers. The ester and the urethane exchange reactions were studied by melt viscosity. The former reaction was completed in 60 min at 170°C, while the latter reaction took 400 min. (Author abstract) 11 Refs. In Japanese.

Yamashiro, Seiichi (Teijin Ltd, Yamaguchi, Jpn). *Kobunshi Ronbunshu* v 45 n 6 1988 p 519-525.

**Efficiency** See ORGANIC COMPOUNDS—Photolysis.

**Electrochemistry** See POLYMERS—Synthesis.

## Electrolytic

**081856 ELECTROINITIATED JOINT POLYMERIZATION OF PHENYL ISOCYANATE AND METHYL METHACRYLATE.** It is seen from the presented experimental data that phenyl isocyanate (PI) is the more active monomer upon electrochemically initiated polymerization of a mixture of PI with methyl methacrylate (MMA), which is associated with the easier reduction of the isocyanate group, in comparison with the unsaturated MMA bond. The half-wave potential for PI is equal to 1.54 V, while it is 1.78 V for MMA; therefore, isocyanate groups participate primarily in the growth reaction. Upon electrochemical polymerization reduction at the isocyanate group occurs at a more positive potential with formation of TPI, after precipitation of which the PI concentration in solution falls to 0.3-0.4 mole/l. The first fractions of PI and MMA copolymer (fraction II) are still enriched with PI, in comparison with the composition of the initial reaction mixture, and then at later stages of the reaction, when PI is significantly depleted, its content in the copolymer decreases to several percent. 14 refs.

Matyushova, V.G. (Inst of Chemistry of High-Molecular Compounds, Kiev, USSR); Lipatova, T.E.; Khramova, T.S.; Gomza, Yu.P. *Sov Prog Chem* v 53 n 10 1987 p 111-115.

## Equipment

**081857 MOLECULAR MASS DISTRIBUTION IN ISOTHERMAL RADICAL POLYMERIZATION IN A CASCADE OF IDEAL MIXING REACTORS.** The macrokinetics of initiated radical polymerization in a cascade of ideal mixing continuous reactors is described. The degree of polymerization and the MMD (Molecular Mass Distribution) range are analyzed as a function of the effective polymerization and initiation constants and of the reaction mixture feed rate. It is shown that within the technological region of change of the parameters the degree of polymerization is decreased along the cascade steps. A non-steady change in the degree of polymerization and in the MMD range with change in reagent consumption is observed. (Author abstract) 5 refs.

Zhirkov, P.V. (USSR Acad of Sciences, USSR). *Polym Sci USSR* v 28 n 10 1986 p 2442-2448.

**081858 EFFECT OF HYDRODYNAMIC FACTORS ON MOLECULAR-WEIGHT DISTRIBUTION DURING FREE RADICAL POLYMERIZATION IN A SCREW REACTOR.** The process of free-radical polymerization in a screw reactor is considered together with an account of the viscosity of the reacting medium as a function of temperature, monomer conversion, and weight-average degree of polymerization. It is shown that the relationship between the molecular-weight distribution and macro-kinetic factors leads to new laws for the process. The author shows that large energy dissipation leads to a strengthening of the anisothermality of the process and a fall in the polymerization degree of the reaction product. The viscosity is considerably depressed, the pressure drop across the reactor is significantly reduced, and the form of the  $\Delta p(q)$  curve may be changed. 14 refs.

Zhirkov, P.V. (Acad of Sciences of the USSR, Chernogolovka, USSR); Boyarchenko, V.I. *Theor Found Chem Eng* v 21 n 4 Jul-Aug 1987 p 293-300.

**Friedel-Crafts Reaction** See ALLYL RESINS—Synthesis.

## Heat Transfer

**081859 HEAT TRANSFER DURING POLYMERIZATION IN MOTIONLESS MIXERS.** Investigation of

the performance of a large-diameter conventional motionless mixer used as a continuous reactor for styrene polymerization showed that it behaved adiabatically. Computer simulation (in which the mixer is treated as an ideal plug-flow reactor having perfect radial mixing) predicts this tendency in terms of axial temperature profile. To avoid adiabatic polymerization, with its attendant problems of plant operability and polymer quality, the use of motionless mixers having internal heat transfer surface is indicated. (Author abstract) 26 refs.

Craig, T.O. (Fordel Ltd, Hyde, Engl). *Polym Eng Sci* v 27 n 18 Mid-Oct 1987 p 1386-1389.

**081860 DISTRIBUTION OF VOLATILE SPECIES IN A REFLUXING POLYMER COLLOID.** A unique two-chamber vapor-liquid equilibrium cell was used during this investigation to obtain an in situ separation of the aqueous phase from the latex, thus permitting a direct determination of the compositions of the aqueous, polymer, and vapor phases in a latex, even under refluxing conditions. Thermodynamic analysis of the vapor-liquid equilibrium problem allows the prediction of the composition of all phases from measured values of the temperature and pressure only. These predictions agreed well with data from other investigations. (Edited author abstract) 15 refs.

Zollars, Richard L. (Washington State Univ, Pullman, WA, USA); Chen, Chien-Tai; Jones, D. Adrian. *AIChE J* v 34 n 5 May 1988 p 733-742.

**Materials** See POLYMERS—Synthesis.

**Mathematical Models** See Also ETHYLENE—Polymerization; OLEFINS—Polymerization; STYRENE—Polymerization.

**081861 POLYMER COMMUNICATIONS: UNIFORM STAR POLYMERS OF DAOUD AND COTTON: AN APPRAISAL.** The principal geometrical properties of uniform self-avoiding star polymers are determined in the iterative convolution (IC) approximation. The predictions are found to be in good agreement with Monte Carlo (MC) simulations. Neither the IC nor the MC analysis appears to support the scaling predictions of M. Daoud and J.P. Cotton. Instead, a more highly structured interior is found and a new scaling relation for the dependence of the relative radii of gyration upon the degree of branching is proposed. 7 refs.

Croxtton, Clive A. (Univ of Newcastle, Aust). *Polym Commun (Guildford Engl)* v 29 n 1 Jan 1988 p 2-4.

**081862 MODELING OF BATCH AND CONTINUOUS EMULSION POLYMERIZATION REACTORS. PART I: MODEL FORMULATION AND SENSITIVITY TO PARAMETERS.** A detailed model for the prediction of the behavior of batch or continuous emulsion polymerization reactors has been formulated, and an efficient numerical scheme for simulation developed. The model makes use of population balance equations and detailed mechanisms for chemical and physical rate processes. The numerical procedure chosen for its solution is orthogonal collocation on finite elements. In this paper, a few comparisons with experimental data are presented to demonstrate the model validity. Finally, a parametric sensitivity study is carried out to identify the most important kinetic and physical parameters. In the sequel, a comprehensive comparison of model predictions with a wide variety of experimental data will be presented. (Author abstract) 91 refs.

Rawlings, J.B. (Univ of Wisconsin, Madison, WI, USA); Ray, W.H. *Polym Eng Sci* v 28 n 5 Mid-Mar 1988 p 237-256.

**081863 MODELING DIFFUSION AND REACTION IN EPOXY-AMINE LINEAR POLYMERIZATION KINETICS.** Three mathematical models of reaction and diffusion in linear addition polymerizations were developed and compared to experiments with n-butylamine (NBA) and the diglycidyl ether of bisphenol A (DGEBA). The first model served as a control and was



based on the standard approximation that a single rate constant holds for reaction between all species at all levels of polymerization. In the second model, a single but average rate constant was a function of the number- and weight-averaged molecular weights. Finally, the third model replaced this single, globally averaged rate constant with a matrix of rate constants accounting for the reactions of individual molecular species. Experimental kinetics data, obtained through FTIR, GPC, and DSC analyses, aided in model discrimination. Either model 2 or 3 provides a suitable account of the influence of diffusion limitations on linear polyaddition reactions. (Author abstract) 19 refs.

Rohr, Donald F. (Univ of Delaware, Newark, DE, USA); Klein, Michael T. *Ind Eng Chem Res* v 27 n 8 Aug 1988 p 1361-1366.

**Monitoring** See EPOXY RESINS—Curing.

**Photochemical Reactions** See Also ETHYLENE—Derivatives; FATTY ACIDS—Polymerization; MONOMERS—Films.

**081864 INICJOWANIE POLIREAKCJI W FAZIE STALEJ.** [Initiation of Solid-State Polyreactions. Part IV. Photochemical Polymerization]. Achievements in the field of photochemical initiation of the solid-state polymerization have been reviewed. The review material has been grouped according to the commonly accepted division of photochemical polymerizations into photoinitiated polymerizations and cycloaddition photopolymerizations. Within each group the sensitized and non-sensitized polyreactions have been characterized. The topochemical character of some photochemical solid-state polyreactions has been emphasized and examples of practical realization of this type of reactions given. (Author abstract) In Polish. 102 refs.

Zurakowska-Orszagh, Janina (Inst Przemyslu Gumowego 'Stomil', Piastow, Pol); Bartnik, Jozef. *Polimery* v 32 n 7 Jul 1987 p 261-265.

**081865 PHOTOPOLYMERIZATION AND PHOTOCYCLOADDITION REACTIONS IN THE 2-VINYLNAPHTHALENE - MALEIC ANHYDRIDE SYSTEM.** Photochemical reaction of the 2-vinylnaphthalene (VN) (electron-donor monomer) - maleic anhydride (MAN) (electron-acceptor monomer) system has been studied in order to elucidate reaction pathways and the correlation between them and the multiplicity of an excited-state molecule. It was found that direct irradiation of the VN - MAN system both in benzene and acetonitrile produces predominantly copolymers probably via ion radicals generated by electron transfer in the electronically excited singlet state, whereas benzophenone-sensitized reaction yields a cycloadduct of VN with MAN as a main product via the electronically excited triplet state. (Author abstract) 8 refs.

Oh, Sin-Chol (Osaka Univ, Suita, Jpn); Yamaguchi, Kentaro; Shirota, Yasuhiko. *Polym Bull (Berlin)* v 18 n 2 Aug 1987 p 99-104.

**081866 REVERSIBLE PHOTOCHEMICAL PROCESS IN THE SOLID STATE: PHOTOPOLYMERIZATION OF 5,5'-1,4-PHENYLENE-BIS(2-CYANO-2,4-PENTADIENOIC ACID) DERIVATIVES AND PHOTODEPOLYMERIZATION OF THEIR POLYMERS.** This report is concerned with the photoreversible process between the polymer (white) and the oligomer (yellow) of 5,5'-1,4-phenylene-bis(2-cyano-2,4-pentadienoic acid) (PCPA) derivatives, both of which have been prepared by the solid state photopolymerization of PCPA derivatives. For comparison, irreversible photodepolarization of the polymer from PCPA derivatives in solution is also described. (Edited author abstract) 7 refs.

Nakanishi, Fusae (Research Inst for Polymers & Textiles, Tsukuba, Jpn); Yamada, Kyoko; Nakanishi, Hachiro. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 329-333.

**081867 PHOTOINDUCED POLYMERIZATION AND OLIGOMERIZATION OF 4-VINYLBEN-**

**ZOPHENONE.** The photopolymerizations of 4-vinylbenzophenone (VBP) in various solvents were investigated to make clear the photoinitiation characteristics. It was found that direct photoirradiation produces polymers, oligomers (trimers), and dimers. The dimers were identified as trans- and cis-1,2-bis(4-benzoylphenyl)cyclobutanes. The fraction of trans-form in the cyclobutane dimers produced was about 80%, and was little affected by the reaction conditions. The quantum yields [VBP] = 0.1M in benzene) were estimated to be  $3 \times 10^{-2}$  for the dimerization and  $2 \times 10^{-4}$  for the initiation of polymerization. The photoreactions via  $\pi, \pi^*$  triplet state of the monomer were suggested from the results. (Author abstract) 14 refs.

Tsubakiyama, Kyoji (Fukui Univ, Fukui, Jpn); Yamamoto, Masahide; Nishijima, Yasunori. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 1231-1237.

**Pressure Effects** See POLYMETHYL METHACRYLATE—Synthesis.

**Radiation Effects** See Also ACIDS—Polymerization; EPOXY RESINS—Curing; GRAFT COPOLYMERS—Synthesis; MONOMERS—Polymerization.

**081868 RADIATION POLYMERISATION OF CYCLOHEXYL METHACRYLATE - I.** Radiation polymerization of cyclohexyl methacrylate has been carried out at various doses, dose rates and temperatures. The radical yield determined by induction period method using benzoquinone as a scavenger is 6.25. The dose rate exponent is found to be 0.517 indicating a bimolecular termination. The  $(K_p/K_t^{1/2})$  value is 0.268, which is an order of magnitude higher than for methyl methacrylate under identical conditions of dose rate and temperature. Energy of activation calculated on the basis of kinetic data is found to be 2.06 kcal/mol, which is also quite low. These results indicate the probability of the existence of an anionic initiation in addition to free radical initiation. (Edited author abstract) 14 refs.

Kumar, Manmohan (BARC, Bombay, India); Rao, M.H.; Rao, K.N. *Radiat Phys Chem* v 30 n 1 1987 p 21-25.

**081869 RADIATION POLYMERISATION OF CYCLOHEXYL METHACRYLATE - II. ROLE OF IONIC AND RADICAL SCAVENGERS.** Radiation polymerization of cyclohexyl methacrylate has been carried out in the presence of scavengers, i.e., biphenyl, cyclohexanol and benzoquinone. In the presence of biphenyl and cyclohexanol which are scavengers for electrons and anions no induction period was observed and the rates of polymerization and molecular weights decreased to the same extent. In presence of benzoquinone, a scavenger for both anions and free radicals, an induction period was observed, decreasing both the molecular weights and the rates of polymerization. From these results it is evident that the polymerization takes place both by anions and free radicals. A very high chain transfer constant to benzoquinone equal to 23.06 was obtained. (Edited author abstract) 5 refs.

Kumar, Manmohan (BARC, Bombay, India); Rao, M.H.; Rao, K.N. *Radiat Phys Chem* v 30 n 1 1987 p 27-30.

**081870 CHARACTERISTICS OF POLYMER MICROSPHERES PREPARED BY RADIATION-INDUCED POLYMERIZATION IN THE PRESENCE OF ORGANIC SOLVENTS.** Radiation-induced polymerization of diethylene glycol dimethacrylate (2G) was carried out in methyl orthoformate (MOF) in the range of 25 to  $-78^\circ\text{C}$ , to obtain the polymeric microspheres. A transparent solution consisting of 2G and MOF showed an emulsified state after irradiation. This means that the colloidal particles of poly(2G) are deposited from monomer solution during the irradiation because of poor solubility. It was confirmed by microscopic observation that the shape of obtained polymer is composed of a complete sphere. The preparation of poly(2G) microspheres was further tried using various organic solvents under such conditions as 10 kGy and  $25^\circ\text{C}$ . According to this experiment, poly(2G) microspheres of the smallest size were obtained in the presence of ethyl caproate, while

the largest size was obtained when tetrahydrofuran was used. (Edited author abstract) 13 refs.

Yoshida, Masaru (JAERI, Takasaki, Jpn); Asano, Masaharu; Kaetsu, Isao; Morita, Yasushi. *Radiat Phys Chem* v 30 n 1 1987 p 39-45.

**081871 NEW FUNCTIONAL MICROSPHERES WITH ACTIVE SUCCINIMIDE GROUPS.** Radiation-induced polymerization of monomers, for example N-methacryloxysuccinimide (MASu) and diethylene glycol dimethacrylate (2G), in ethyl propionate, was performed from  $+25^\circ\text{C}$  to  $-78^\circ\text{C}$ . The copoly(MASu/2G) microspheres were obtained in MASu monomer compositions of 30 wt% or below. The average particle diameter of copoly(MASu/2G), 20/80 wt% microspheres obtained at irradiation temperatures of  $25^\circ\text{C}$ ,  $0^\circ\text{C}$ , and  $-43^\circ\text{C}$  were  $0.81 \pm 0.29$ ,  $0.63 \pm 0.26$ , and  $0.90 \pm 0.43$   $\mu\text{m}$ , respectively. No microspheres were formed when irradiated at  $-78^\circ\text{C}$ . The reactivity of the succinimide groups on the surface of copoly(MASu/2G, 20/80 wt%) microspheres was checked by reacting with ethylene diamine. The maximal amounts of reacting succinimide groups was  $9.4 \pm 0.5$   $\mu\text{mol/g}$ , which corresponds to about 1% of the total number of succinimide groups in the microsphere. (Author abstract) 23 refs.

Morita, Y. (Senju Pharmaceutical Co, Hyogo, Jpn); Yoshida, M.; Asano, M.; Kaetsu, I. v 265 n 10 Oct 1987 p 916-921.

**081872 MECHANISTIC ASPECTS OF POLYMER CHEMISTRY FOR RADIATION CURING.** The chemistry of polymer production has been reviewed for the purpose of identifying suitable uses for high-energy electron accelerators in the plastics industry. High-energy radiation produces free radicals, electrons and ions in irradiated materials. These species initiate polymerization and cross-linking reactions in a manner analogous to that of chemical agents. The chemical mechanisms of radiation-induced polymerization, co-polymerization and cross-linking are compared with those of chemical and thermal initiation. Radiation polymerization can be a very fast process, but the polymerization reactions are quite exothermic, and temperature increases of up to  $400^\circ\text{C}$  may result if insufficient cooling is provided. Several approaches to reducing the temperature increase during radiation curing are presented. Chemical kinetic simulations of the radiation-induced cationic polymerization of styrene have shown that the effect of water inhibition on the rate of polymerization may be eliminated at the high dose rates available from high power accelerators. (Author abstract) 25 refs.

Dickson, Lawrence W. *At Energy Can Ltd AECL Rep* n 9557 1988. Publ by AECL, Scientific Documentation Distribution, Chalk River, Ont, Can, 1988 29p.

**081873 POLYMERIZATION UNDER ELECTRON BEAM: STABILITY PROBLEM OF GRAFTED POLYMER SYSTEMS.** In order to clarify the stability of grafted polymer systems the permeability and diffusion coefficient of low-molecular substances have been investigated as a function of temperature and organic solvent attacks. It is shown that the stability of some grafted acrylic polymers can be improved significantly by varying the irradiation regime and preliminary cross-linking of the polyethylene matrix. (Author abstract) 3 refs.

Babkin, I.Yu. (Karpov Inst of Physical Chemistry, Moscow, USSR); Burukhin, S.B. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 599-605.

**081874 SYNTHESIS OF POLYMER MATERIALS BY LOW ENERGY ELECTRON BEAM. IV. EB-POLYMERIZED URETHANE-ACRYLATE, -METHACRYLATE AND -ACRYLAMIDE.** Electron beam (EB)-processing has the advantages of high production efficiency and low energy cost. In this study, the effects of EB-reactive terminal group on the structure and properties of EB-reactive urethane prepolymers and their



EB-polymerized polymers were examined, considering the characteristics of EB solid-state polymerization. Three kinds of urethane prepolymers with different terminal groups, that is, urethane-acrylate, -methacrylate and -acrylamide were synthesized for this purpose. It is reported that terminal groups strongly influence the phase structure and tensile properties of the prepolymers and EB-polymerized polymers. 13 refs.

Ando, Masayuki (Dai Nippon Printing Co, Tokyo, Jpn); Uryu, Toshiyuki. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 607-614.

**081875 ACTIVITY DEPENDENCE OF IMMOBILIZED YEAST CELLS ON THE VARIOUS NATURES OF POLYMER CARRIERS FOR IMMOBILIZATION PRODUCED WITH RADIATION POLYMERIZATION AT LOW TEMPERATURES.** Yeast cells were immobilized by the physical adsorption and multiplication method using polymer carriers produced by gamma radiation polymerization at low temperatures. The activity of immobilized yeast cells was investigated on some of the polymer carriers whose hydrophilicity, water content, swellability and morphological factors were observed. (Edited author abstract) 4 refs.

Fujimura, T. (JAERI, Takasaki, Jpn); Carenza, M.; Kaetsu, I. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 653-655.

**081876 INFLUENCE OF MATRIX POROSITY ON THE IMMOBILIZATION OF PENICILLIN ACYLASE BY RADIATION-INDUCED POLYMERIZATION.** Penicillin acylase was immobilized by low temperature gamma radiation-induced polymerization into polymer matrices obtained from monomers of different hydrophilicities, at various ratios of monomer to enzyme solution and at different polymerization conversions. It was found that the penicillin acylase retention (60-85% of the starting enzyme) is independent of the monomer used in the polymerization, of the polymerization conversion and of the porosity of the polymer matrix. On the other hand, the penicillin acylase retention strongly depends on the presence in the irradiation mixture of the hydrophobic crosslinking agent, trimethylolpropane trimethacrylate, even in small amounts. The data suggest that the enzyme is bound to the polymer matrix by hydrophobic interactions through crosslinking agent molecules. (Author abstract) 8 refs.

Carenza, M. (CNR, Padua, Italy); Lora, S.; Palma, G.; Boccu, E.; Largajolli, R.; Veronese, F.M. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 657-662.

**081877 IMMOBILIZATION OF PEROXIDASE ON SPEU FILM VIA RADIATION GRAFTING.** The acrylic acid or acrylamide was grafted via gamma radiation onto segmented polyetherurethane (SPEU) film which is a biocompatible material. Then the Horse radish peroxidase was immobilized on the grafted SPEU film through chemical binding. Some quantitative relationships between the percent graft and the amount of immobilized enzyme are given. The properties and application of the biomaterial were studied. (Author abstract) 6 refs.

Ha, Hongfei (Peking Univ, Beijing, China); Wang, Guanghui; Wu, Jilan. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 761-767.

**081878 RADIOLYTIC METHOD OF PREPARATION OF SEMICONDUCTOR ASSEMBLIES SUPPORTED ON POLYMERIC MEMBRANES.** Radiation induced grafting of hydrophilic acrylic monomers onto polymeric films and fabric has been employed to prepare supports for catalytic assemblies, which are highly permeable to water and low molecular weight solutes. Transition-metal-oxide semiconductor clusters embedded within the grafted membranes were formed by swelling the

membranes with a solution of metal alkoxides followed by gradual hydrolysis. Photolytic methods have been employed to form  $Pt^0$  clusters onto the semiconductor aggregates. Kinetic aspects of the radiation induced grafting of the polymeric supports and the mechanistic features of the preparation of polymer-anchored  $TiO_2$  clusters loaded with  $Pt^0$  are described. The photocatalytic effectiveness of the  $TiO_2$ - $Pt$  assemblies embedded in recoverable polymeric grids was demonstrated in hydrogen generation from aqueous solution and in the degradation of environmental pollutants. (Author abstract) 26 refs.

Haruy, Y. (Soreq Nuclear Research Cent, Yavne, Isr); Gratzel, M.; Rajbenbach, L.A. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 843-852.

**Reaction Kinetics** See Also AROMATIC COMPOUNDS—Polymerization; BLOCK COPOLYMERS—Synthesis; ESTERS—Polymerization; MONOMERS—Polymerization; PLASTICS—Reaction Injection Molding; POLYESTERS—Synthesis; POLYMERS—Synthesis; POLYMETHYL METHACRYLATE—Synthesis; SILICON COMPOUNDS—Polymerization; STYRENE—Polymerization.

**081879 RING-OPENING POLYMERIZATION.** This three-volume book with 14 papers provides a comprehensive survey of the field of ring-opening polymerization. Topics include: thermodynamic and mechanistic features of ring-opening polymerization; polymerization of cyclic compounds containing only carbon atoms in the ring; various types of heterocyclic monomers where the heteroatom may be oxygen, nitrogen, phosphorus, sulfur, and silicon. Three general topics are explored throughout the book: the exploration of new catalysts; the elucidation of mechanisms; and the characterization of products.

Ivin, K.J. (Ed.) (Queen's Univ of Belfast, Dep of Chemistry, North Ireland); Saegusa, T. (Ed.). *Ring-Opening Polym* v 1, Publ by Elsevier Applied Science Publ, London, Engl and New York, NY, USA, 1984 3 vol, 1227p.

**081880 KINETIC STUDY ON THE POLYMERIZATION REACTION INITIATED BY AROMATIC TERTIARY AMINE AND BENZYL CHLORIDE.** A binary mixture of N,N-dimethylaniline (DMA) and benzyl chloride ( $BzCl$ ), or ammonium salts of such compounds, are capable of initiating free radical polymerization reactions of vinyl monomers. Such initiating techniques had been employed for modifying cellulose through graft copolymerization reactions. Further investigation was conducted on the initiative characteristics of such a system. A dilatometric method was used to measure the polymerization rate ( $R_p$ ) of methyl methacrylate (MMA) (degassed under high vacuum) in benzene solvent at 60°C. The effects of substituted groups at the benzene ring of DMA on the polymerization rate were also studied. It is found that when the electron-withdrawing groups were attached on the benzene ring of DMA, then the  $R_p$  of MMA initiated by them would drop. The effects of such electron-withdrawing groups could be described by the Hammett equation. (Edited author abstract) 10 refs. In Chinese.

Cheng, Haitao (East China Inst of Chemical Technology, China); Zhang Weisheng; Yang, Quanxing; Li, Shijin. *Huagong Xuebao* v 3 n 3 Sep 1987 p 328-333.

**081881 KINETICS OF POLYURETHANE FORMATION IN POLYURETHANE-POLY(METHYL METHACRYLATE) INTERPENETRATING POLYMER NETWORKS.** The kinetics of formation of polyurethane in polyurethane/ poly(methyl methacrylate) interpenetrating polymer networks (IPNs) were investigated by Fourier transform infra-red spectroscopy. The influence of different parameters was examined: catalyst concentration, polyurethane content in the IPNs, reaction temperature. It was found that the overall reaction rate is related to the concentration of isocyanate by a 1.5th order exponential expression for the catalyzed polyurethane formation. (Author abstract) 19 refs.

Jin, S.R. (CRM, Strasbourg, Fr); Widmaier, J.M.; Meyer, G.C. *Polym Commun (Guildford Engl)* v 29 n 2 Feb 1988 p 26-28.

**081882 MONTE CARLO ESTIMATION OF KINETIC PARAMETERS IN POLYMERIZATION REACTIONS.** A general method for estimating kinetic parameters in polymerization reactions using Monte Carlo simulation to represent the models of the reactions is developed. From a statistical point of view, the procedure is a Bayesian one in which a posterior probability density surface (PPDS) is calculated for points on a grid in the parameter space. A smoothing function is fitted to the PPDS, then a posterior probability region, which is similar to a confidence region, is calculated for the parameters. An application to a relatively trivial example, the Mayo-Lewis copolymerization model, is shown in detail. Many other potential applications are suggested. (Author abstract) 15 refs.

Duever, T.A. (Univ of Waterloo, Waterloo, Ont, Can); O'Driscoll, K.F.; Reilly, Park M. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 965-971.

**081883 EFFECT OF IMPURITIES OF EMULSION POLYMERIZATION: CASE II KINETICS.** The effects of water-soluble and monomer-soluble impurities on the kinetics of emulsion polymerization of monomers following Case II kinetics (e.g., styrene) are investigated. Experimental studies reveal that impurities can have an appreciable effect on both polymer particle nucleation and growth. These effects are shown to be well predicted by a mathematical model. (Author abstract) 11 refs.

Huo, B.P. (McMaster Univ, Hamilton, Ont, Can); Campbell, J.D.; Penlidis, A.; MacGregor, J.F.; Hamielec, A.E. *J Appl Polym Sci* v 35 n 8 Jun 1988 p 2009-2021.

**081884 EFFECT OF IMPURITIES ON EMULSION POLYMERIZATION: CASE I KINETICS.** The effect of water and monomer-soluble impurities on the kinetics of emulsion polymerization for Case I systems (e.g., vinyl acetate and vinyl chloride) was investigated. Model predictions on the effect of these impurities on polymer particle nucleation and growth rate are shown to be in satisfactory agreement with experimental results. The effect of monomer-soluble impurities is shown to be quite different from that observed in Case II emulsion polymerization systems. (Author abstract) 15 refs.

Penlidis, A. (McMaster Univ, Hamilton, Ont, Can); MacGregor, J.F.; Hamielec, A.E. *J Appl Polym Sci* v 35 n 8 Jun 1988 p 2023-2038.

**081885 MINIMUM END-TIME POLICIES FOR BATCHWISE RADICAL CHAIN POLYMERIZATION: THE PIECEWISE INITIATOR ADDITION POLICY.** For the radical chain polymerization in a presence of chain transfer agent, piecewise initiator addition and piecewise reaction temperature are considered as two control actions in N unequal time intervals for minimizing the total reaction time under a given final monomer conversion and the number average chain length. It is found that only one of the two actions are needed to be chosen in the bulk or solution polymerization without chain transfer agent. The initiator addition control is found to be better than the temperature control at the expense of lower polydispersity. The optimal policy of the piecewise initiator addition under the best isothermal temperature is that which gives the highest possible reaction temperature and the least possible total amount of initiator charged just enough for the polymerization to reach the predetermined number average chain length and conversion. (Edited author abstract) 12 refs.

Hsu, Keh-Ying (Nat'l Tsing Hua Univ, Hsinchu, Taiwan); Chen, Show-An. *Chem Eng Sci* v 43 n 6 1988 p 1311-1321.



**081886 KINETIC STUDY ON MMA POLYMERIZATION INITIATED BY A TRI-COMPONENT SYSTEM OF DIMETHYLANILINE-BENZYL CHLORIDE-ACETIC ACID.** The radical polymerization of MMA can be accomplished by the initiation of N,N-dimethylaniline (DMA)-benzyl chloride (BC)-acetic acid (HAc) tri-component system. HAc in the mentioned system plays the role of catalyst and which will reduce the activation energy of polymerization notably. The overall apparent activation energy of this system  $E_a$  is 36.8 kJ/mol. Under the same reaction conditions, the polymerization rate is faster than that in DMA-BC-MMA system by one order of magnitude. The molecular weight of polymer is inversely proportional to  $[I]^{1/2}$  and temperature. The results are in good agreement with the performance of radical polymerization. It has been found experimentally that any oxygen present will bring certain rather complicated but remarkable effects upon the polymerization of the given system. From these experimental results, the mechanism of initiating reaction of DMA-BC-HAc system was discussed. (Edited author abstract). 11 Refs. In Chinese.

Yang, Quanxing; Sun, Yunpu; Zhang, Li; Zhang, Weisheng. *Huadong Huagong Xueyuan Xuebao* v 14 n 3 1988 p 385-392.

**081887 PARTICLE FORMATION IN EMULSION POLYMERIZATION: TRANSIENT PARTICLE CONCENTRATION.** A general kinetic model of particle formation in emulsion polymerization is presented. This model takes into account homogeneous, micellar, and monomer droplet nucleation mechanisms. Chain transfer and termination in the aqueous phase, capture of oligomer radicals by particles, and coagulation of particles are also considered. A three-parameter analytical solution is obtained. The model parameters  $N_s$ ,  $A_2$ , and  $\tau$  can be estimated from basic kinetic parameters and reaction conditions. Model predictions are in agreement with experimental data obtained from the literature. (Edited author abstract). 49 Refs.

Song, Zhigang (Georgia Inst of Technology, Atlanta, GA, USA); Poehlein, Gray W. *J Macromol Sci Chem* v A25 n 4 1988 p 403-443.

**081888 EMULSION POLYMERIZATIONS. II. KINETICS, MOLECULAR WEIGHT DISTRIBUTIONS, AND POLYMER MICROSTRUCTURE OF EMULSION COPOLYMERS.** The kinetics of emulsion copolymerizing systems during intervals II and III (i.e., after completion of latex particle formation) has been studied through the pseudo-homopolymerization approach. The Smith-Ewart equations for copolymers are reduced to the corresponding equations for homopolymers by introducing suitable pseudo-homopolymerization parameters. Analogies and differences between our results and those of previously reported treatments are critically discussed. Explicit algebraic relationships are reported for both the two-dimensional molecular weight distribution and the unidimensional marginal distribution functions of molecular weight and chemical composition. (Edited author abstract). 38 Refs.

Giannetti, Enzo (CRS, Milan, Italy); Storti, Giuseppe; Morbidelli, Massimo. *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2307-2343.

**081889 ESTIMATION OF THE MOLECULAR WEIGHT DISTRIBUTION IN BATCH POLYMERIZATION.** A filtering technique is proposed for on-line estimation of the temperature, monomer conversion, initiator conversion, and the entire molecular weight distribution in a batch methyl methacrylate polymerization reactor. The technique uses a detailed polymerization model combined with on-line measurements of conversion, temperature, and the molecular weight distribution, taken at different discrete time intervals. The polymerization model includes a chain-length-dependent termination rate constant which allows the prediction of the molecular weight distribution for common free-radical polymerization conditions. Comparisons between modeling and experimental results show that the polymerization model gives good predictions of the monomer conversion and the

molecular weight distribution in the polymerization system. The performance of the estimation scheme is tested for cases of strong gel effect conditions leading to a bimodal molecular weight distribution, and poor initial conditions. Finally, off-line experimental data are used to test the algorithm under actual reactor operating conditions. (Author abstract). 39 Refs.

Ellis, Mark F. (Univ of Minnesota, Minneapolis, MN, USA); Taylor, Tad W.; Gonnzalez, Victor; Jensen, Klavs F. *AIChE J* v 34 n 8 Aug 1988 p 1341-1353.

**081890 POLIMERIZAREA CLORURII DE VINIL IN PREZENTA DIALILMALEATULUI.** [Polymerization of vinyl chloride in the presence of diallylmaleate]. A small addition of diallylmaleate (DAM) (0.02-0.03 percent of the monomer quantity) in the suspension or emulsion polymerization medium of the vinyl chloride enhances Fikentscher's K value and increase the molecular mass distribution as well as the  $M_w/M_n$  polydispersion degree. The efficiency of increasing the molecular masses depends on the polymerization conditions (temperature, DAM concentration and impurities in the system) and on the nature of the process (suspension or emulsion). The DAM molecule is supposed to be linked with both allylic ends to the growing molecular chains, accompanied by the formation of two inactive radicals incapable of continuing the polymerization reaction. The mechanism explains the decrease of the polymerization rate in the presence of DAM quantities larger than the optimal ones, and the standstill of the K value growth. (Edited author abstract). 3 Refs. In Romanian.

Boiesan, Valentina; Pal, Maria; Cosaveanu, Adrian. *Mater Plast Elastomeri Fibre Sint* v 25 n 1 Jan-Mar 1988 p 9-12.

## Research

**081891 STUDIES ON TEMPLATE POLYMERIZATION.** In recent years, polymerization of monomer molecules organized in various ways has been studied in the crystalline state, as mono- and multilayers, in oriented aggregates in solution, as clathrates, in the liquid-crystalline state, and on templates. The templates are linear polymer molecules carrying groups which interact with monomer molecules, ideally to produce a predetermined linear array of the latter. This review is an account of the progress made in the field of template polymerization for the last 20 years. In template polymerization we seek to achieve polymerization of monomer units attached to a template in a predetermined manner and thus to synthesize polymers or copolymers having precise structures and microstructures complementary to those of the template. The three component steps in template polymerization are: template monomer complexation, template polymerization and, separation of the template from daughter polymer. 38 refs.

Srivastava, A.K. (Harcourt Butler Technological Inst, Kanpur, India); Nigam, S.K.; Shukla, A.K.; Saini, S.; Kumar, P.; Tewari, N. *J Macromol Sci Rev Macromol Chem Phys* v C27 n 2 May 1987 p 171-180.

**081892 CONTINUOUS MINIEMULSION POLYMERIZATION.** The authors examine the basic elements of both emulsion polymerization and suspension polymerization. In addition, the kinetics of miniemulsion polymerization are also discussed. Stabilization effects are also studied. The effect of cosurfactants and gels is outlined. 17 refs.

Barnette, Darrell T. (Georgia Inst of Technology, Atlanta, GA, USA); Schork, F. Joseph. *Chem Eng Prog* v 83 n 6 Jun 1987 p 25-30.

**081893 EFFECT OF IMPURITIES IN CONTINUOUS 'LIVING' ANIONIC POLYMERIZATIONS.** The aim of this work is to theoretically investigate the effect of impurities on the MWDs of the polymers produced when anionic polymerizations are carried out in SS and periodic CSTRs. The effect of impurities contained in the monomer feed is theoretically investigated, in relation to 'living' anionic homopolymerizations carried

out in isothermal and homogeneous CSTRs. In the SS operation, the total produced polymer always exhibits a Schulz-Flory distribution, with a NACL which decreases as the impurities are increased. The result is reasonable bearing in mind that the system is dynamically equivalent to a continuous free-radical polymerization with initiation, propagation and termination by disproportionation. 10 refs.

Allassia, L.M. (CONICET, Santa Fe, Argent); Frontini, G.L.; Vega, J.R.; Meira, G.R. *J Polym Sci Part C* v 26 n 4 Apr 1988 p 201-206.

**081894 NONTERMINATED CHAIN POLYMERIZATION IN A CONVECTIONLESS GAS.** We have investigated the steady-state distribution, with respect to degree of polymerization and location within the reaction chamber, of polymeric radicals produced by a gas-phase free radical chain reaction, under the following conditions. Initiating free radicals are produced, uniformly and at a constant rate, throughout a uniform monomer vapor in a reaction chamber in which the gases are free of convection, and the concentration of radicals is so low that recombination termination is absent. The free radicals propagate into polymeric radicals which diffuse to the walls of the chamber where they are irreversibly adsorbed. (Edited author abstract) 6 refs.

Rabeony, H. (Univ of California, Los Angeles, CA, USA); Reiss, H. *Macromolecules* v 21 n 4 Apr 1988 p 912-918.

**081895 MICRODISPERSIVE INTERFACIAL MIXING IN FAST POLYMERIZATIONS.** Interfacial activity between liquid reaction injection molding (RIM) reactants was observed using light microscopy. Diisocyanates were brought into contact with various diols and diamines in a thin (250  $\mu$ m) gap. A dynamic phenomenon, rapidly producing a well-mixed, intermaterial phase, was discovered. It was revealed that the rate of growth of this newly formed region was dependent on both the rate of reaction and the physical properties of the initially formed product species at the reaction interface. Spontaneous interfacial mixing also occurred without chemical reaction when a reaction product was dissolved in 'capped' contacting reactant liquids. It is believed that strong interfacial intermolecular forces, inducing flow through the polymerization product layer formed immediately upon reactant contact, are responsible for the initial explosiveness of this microscopic process. (Edited author abstract). 22 Refs.

Machuga, Steven C. (Univ of Minnesota, Minneapolis, MN, USA); Midje, Heather; Peanasky, John S.; Macosko, Christopher; Ranz, William E. *AIChE J* v 34 n 7 Jul 1988 p 1057-1064.

**081896 TERMINATION IN FREE-RADICAL POLYMERIZING SYSTEMS AT HIGH CONVERSION.** A theory for the termination rate coefficient in high-conversion free-radical polymerization systems, based on the concept of chain-end diffusion by propagational growth ('reaction diffusion' or 'residual termination' mechanism), is proposed. This is used to formulate the appropriate diffusion coefficient of a macroradical, which yields in turn a diffusion-controlled termination rate coefficient. Expressions for an upper and lower bound of this rate parameter result, depending on whether the polymer chains are rigid or dynamically flexible. All parameters used in the model (such as entanglement spacing and unperturbed chain dimensions) can be readily determined. (Edited author abstract). 45 Refs.

Russell, Gregory T. (Univ of Sydney, Sydney, Aust); Napper, Donald H.; Gilbert, Robert G. *Macromolecules* v 21 n 7 Jul 1988 p 2133-2140.

**081897 INITIATOR EFFICIENCIES IN HIGH-CONVERSION BULK POLYMERIZATIONS.** By consideration of relative rates of diffusion and of propagation, it is shown that, in some bulk polymerizations, there exists a certain weight fraction of polymer ( $w_p$ ) beyond which initiator efficiency ( $f$ ) must rapidly



decrease. At this critical  $w_p$ , the two free radicals formed from initiator decomposition are immobilized by propagation faster than they can diffuse apart; consequently, their likely fate is to become trapped in close proximity to each other and undergo geminate recombination. A quantitative theory for the onset of this phenomenon is derived. (Edited author abstract). 26 Refs.

Russell, Gregory T. (Univ of Sydney, Sydney, Aust); Napper, Donald H.; Gilbert, Robert G. *Macromolecules* v 21 n 7 Jul 1988 p 2141-2148.

**081898 LIMITING STAGE OF SORPTION AND DESORPTION PROCESSES OF RADICALS BY PARTICLES IN EMULSION POLYMERIZATION.** The equilibrium, diffusional, and kinetic approaches to determining the limiting stages of processes of sorption and desorption of free radicals by micelles and latex particles are considered. Analysis of available data indicates that the assumption that the rate of the sorption and desorption processes are limited by resistance to mass transfer at the particle-water interface is applicable, i.e. that the kinetic approach is applicable. (Author abstract). 31 Refs.

Lukhovitskii, V.I. (L. Ya. Karpov Physicochemical Inst, USSR). *Polym Sci USSR* v 29 n 4 1987 p 960-967.

**081899 EFFICIENT ALGORITHM OF COMPUTATION OF MOLECULAR WEIGHT DISTRIBUTIONS AND ITS MOMENTS FOR REVERSIBLE STEP GROWTH POLYMERIZATION IN HOMOGENEOUS CONTINUOUS FLOW STIRRED TANK REACTORS.** The reversible step growth polymerization in homogeneous continuous flow stirred tank reactors (HCSTRs), in which the condensation product (W) leaves the reactor through flashing, has been analyzed. The molecular weight distribution (MWD) of the polymer formed is governed by nonlinear coupled algebraic relations to be solved simultaneously. To find the MWD numerically a large number of these algebraic relations are normally solved simultaneously using a suitable iterative procedure. These have been decoupled using the technique proposed in earlier works and the MWD can now be obtained sequentially without any trial and error. This leads to considerable saving in computation time compared to methods currently used. (Edited author abstract). 33 Refs.

Kumar, Anil (Indian Inst of Technology, Kanpur, India). *Polym Eng Sci* v 28 n 19 MID-OCT; 1988 p 1240-1247.

## Solutions

**081900 USE OF LOW TEMPERATURE OZONOLYSIS FOR DETERMINING THE DEPTH OF POLYMERIZATION IN SOLUTION.** The use of the method of low temperature ozonolysis is proposed for determining the heat of polymerization of vinyl monomers in solutions active to ozone at 273 K. The heat of polymerization of methyl methacrylate in 50% benzene is 58.82 kJ/mole. According to four measurements obtained, the mean values of the extent of polymerization and heat evolution are  $99.63 \pm 0.04\%$  and  $569.57 \pm 9.2$  J/g respectively, which enables the heat of polymerization  $q = 57.23 \pm 0.96$  kJ/mole to be calculated. This value is close to the value found in the polymerization of MMA in bulk, i.e.,  $q = 58.82 \pm 0.67$  kJ/mole, which confirms the published data on the absence of anomalies in the polymerization of MMA in benzene. (Edited author abstract) 4 Refs.

Poznyak, T.I. (USSR Acad of Sciences, USSR); Karapetyan, Z.A.; Lisitsyn, D.M. *Polym Sci USSR* v 29 n 1 Jan 1988 p 228-229.

## Spectrum Analysis

**081901 USE OF A FLUORESCENCE METHOD FOR ASSESSING THE PROPERTIES OF POLYMERS AND THEIR COMPOSITES AND FOR ADAPTING THEIR PRODUCTION TECHNOLOGY.** Correlation of relaxation and diffusion processes in polymers and their composites with the kinetic patterns shows the possibilities of the fluorescence method for

monitoring the process of polymerization of polymeric composites, and hence for adapting their production technology. Analysis of relaxation and diffusion processes in polymeric composites reveals the possibilities of using the fluorescence method not only for assessing their structural features (micrononhomogeneity, stratification) and physical properties such as microviscosity, but also to follow their evolution in the course of the polymerization process. 11 Refs.

Kalechits, I.I. (M.V. Lomonosov Moscow State Univ, USSR); Kuz'min, M.G.; Kozlov, P.V.; Zubov, V.P.; Kabanov, V.A. *Mech Compos Mater* v 23 n 2 Mar-Apr 1987 p 247-251.

Stability See POLYSTYRENES.

## Stabilizers

**081902 PARTICULATE STABILISERS FOR DROPS IN SUSPENSION POLYMERISATION: USE OF A WAX MODEL.** Finely divided inorganic solids can be used for drop stabilization in suspension polymerization. In order to clarify the role of these solids, experiments have been carried out using a model system in which wax drops were dispersed in water in the presence of magnesium hydroxide. Drop sizes were reduced if the hydroxide was precipitated in situ before dispersion of the wax. As the loading of this precipitate increased, the average drop size passed through a minimum. The presence of a surfactant modified the effect of the hydroxide. (Edited author abstract) 14 Refs.

Brooks, Brian W. (Loughborough Univ of Technology, Loughborough, Engl); Bygate, Fiona; Lane, Andrew C. *Br Polym J* v 20 n 1 1988 p 19-24.

Terpolymerization See ACRYLICS—Synthesis; MONOMERS—Polymerization; VINYL RESINS.

## Theory

**081903 KINETIC THEORY ON CATIONIC POLYMERIZATION WITH TERMINATION BY COMBINATION WITH A NEGATIVE FRAGMENT.** The cationic polymerization with instantaneous initiation and termination by combination with a negative fragment, which is the product formed during initiation reaction with some component of the polymerization system, has been studied by means of a non-steady-state method. The molecular weight distribution function and a series of important molecular parameters of the polymer generated from mono-bi-, and multifunctional initiators are rigorously derived. The theoretical results obtained are applicable to any ionic polymerization with second-order termination. A procedure is described for calculating the molecular weight distribution curve and the values of the various molecular parameters directly from the polymerization conditions. (Author abstract) 37 Refs.

Cai, Gang-Feng (Case Western Reserve Univ, Cleveland, OH, USA); Yan, De-Yue; Litt, Morton. *Macromolecules* v 21 n 3 Mar 1988 p 578-584.

**081904 MOLECULAR WEIGHT DISTRIBUTION AND MOMENTS FOR CONDENSATION POLYMERIZATION WITH VARIANT REACTION RATE CONSTANT DEPENDING ON CHAIN LENGTHS.** A new model for the chain length dependence of the reaction rate constant is proposed for the molecular weight distribution and averaged molecular weights obtained in linear condensation polymerization. An infinite molecular weight for a finite time is predicted if the reaction rate constant is increasing with chain length. The moments method is used and Gupta's model is reconsidered for analytic solutions. Both models are compared with available experimental data. (Author abstract) 7 Refs.

Park, O Ok (Korea Advanced Inst of Science & Technology, Seoul, South Korea). *Macromolecules* v 21 n 3 Mar 1988 p 732-735.

Thermodynamics See Also OLEFINS—Polymerization.

**081905 GENERAL THERMODYNAMIC AND MECHANISTIC ASPECTS OF RING-OPENING POLYMERIZATION.** In order to illustrate the operation of both thermodynamic and kinetic restrictions on ring-opening polymerizations, the polymerizability of the cycloalkanes and cycloalkenes is considered. The standard free energy change associated with any ring-opening polymerization is made up of an enthalpy term and an entropy term. The values of these two terms are determined by a number of chemical and physical factors which are described along with other thermodynamic aspects in the ring-chain equilibria, copolymerization, ionic and radical mechanisms, and metallocarbene intermediates. 228 Refs.

Ivin, K.J. (Queen's Univ of Belfast, North Irel); Saegusa, T. *Ring-Opening Polym* v 1. Publ by Elsevier Applied Science Publ, London, Engl and New York, NY, USA, 1984 1-81.

**081906 RING-OPENING POLYMERIZATIONS VIA CARBON-CARBON  $\sigma$ -BOND CLEAVAGE.** The relief of strain energy realized upon formation of an acyclic polymer from strained ring monomers can provide a thermodynamic driving force for polymerization. Unfortunately, carbon-carbon  $\sigma$ -bond cleavage is usually associated with a high energy of activation. Researchers in this area have attempted to find ways in which carbon-carbon  $\sigma$ -bond cleavage in strained rings can occur cleanly so as to form polymers. In this review the mechanistic insights available from the physical organic chemical literature are used to interpret the observed polymer chemistry of carbon-carbon bond cleavage. 83 Refs.

Hall, H.K. Jr. (Univ of Arizona, USA); Snow, L.G. *Ring-Opening Polym* v 1. Publ by Elsevier Applied Science Publ, London, Engl and New York, NY, USA, 1984 p 83-119.

**POLYMERS** See Also ALCOHOLS; AROMATIC COMPOUNDS—Applications; BIOCHEMISTRY—Computer Applications; CARPET MANUFACTURE; CATALYSTS—Supported; COATINGS; COMPOSITE MATERIALS—Fiber Reinforced; DETERGENTS—Environmental Impact; ELECTRIC BATTERIES; SECONDARY—Materials; ELECTRIC INSULATING MATERIALS—Plastics; ELECTRODES; ELECTROCHEMICAL—Chemical Modification; ELECTROLYTES—Materials; ENZYMES; ENZYMES—Immobilization; EQUATIONS OF STATE—Liquids; FLOW OF FLUIDS; FLOW OF FLUIDS—Channel Flow; FLOW OF FLUIDS—Friction; FLOW OF FLUIDS—Non Newtonian; FLOW OF FLUIDS—Pipes; FLOW OF FLUIDS—Turbulent; FLOW OF FLUIDS—Viscous; FOAMS—Stability; GELS; GLUCOSE—Diffusion; HYDROCARBONS—Chromatographic Analysis; LASER OPTICS—Materials; LEATHER; LIQUIDS—Bubble Formation; LITHOGRAPHY; LUBRICANTS—Solid Films; MEMBRANES—Materials; OIL WELL DRILLING—Blow-out Prevention; OXYGEN—Mass Transfer; PHOTOELECTRICITY—Synthesis; PIEZOELECTRICITY; PLASTICS FILMS—Forming; PLASTICS PRODUCTS—Processing; POLYTETRAFLUOROETHYLENE—Reviews; PROTEINS—Adsorption; RUBBER—Thermal Effects; RUBBER COMPOUNDING—Additives; SEMICONDUCTOR DEVICE MANUFACTURE; SEMICONDUCTOR DEVICES—Heterojunctions; SOILS—Reinforcement; SOLUTIONS—Optical Properties; SOLUTIONS—Rheology; SOLUTIONS—Thermodynamic Properties; SUBSTRATES—Forming; SURFACE ACTIVE AGENTS; SURFACE ACTIVE AGENTS—Solutions; SURFACES—Electric Properties; THERMOPLASTICS; TRANSISTORS; FIELD EFFECT—Fabrication; ULTRASONIC TRANSDUCERS—Analysis; ULTRASONIC TRANSDUCERS—Design; VISCOSITY—Mathematical Models.

**081907 INFLUENCE OF CHEMICAL STRUCTURE ON NONELASTIC MECHANICAL PROPERTIES IN POLYSTYRYL-PYRIDINE RESINS.** We propose a micromechanical characterization of the chemical structure (i.e., the state of cure) of polystyryl-pyridine (PSP) resin. The nonelastic work-hardening rate  $K$  is measured in the preyield stage during compression tests at constant strain rate. The nonelastic deformation is analyzed from a metallurgical point of view; the parameter  $K$  varies as the inverse of the nucleation rate for dislocations and thus is a measure of the ability of the material to deform plastically. The comparison with high-resolution



solid-state carbon-13 NMR experiments shows that, at room temperature, the ability of PSP resin to deform plastically depends mainly on the degree of crosslinking, whatever the length of prepolymer molecule; however, at high temperatures ( $T=200^{\circ}\text{C}$ ) it is affected by the length of prepolymer molecular during curing, whatever the degree of crosslinking. (Edited author abstract) 16 refs.

Caux, X. (CNRS, Villeneuve D'Ascq, Fr); Coulon, G.; Escaig, B. *J Polym Sci Part B* v 25 n 10 Oct 1987 p 2189-2201.

**081908 MOLAR MASS DISTRIBUTION OF THE POLYOXYETHYLENE DERIVATIVES OF ALCOHOLS, ALKYLPHENOLS AND ALKYLAMINES.** Numerical integration technique using the Runge-Kutta method of the fourth order and optimization algorithms using the Monte Carlo method and the simplex Nelder and Mead method were applied for computing the distribution coefficients for polyoxyethylene derivatives of dodecanol, p-octylphenol and hexylamine. The validity of the proposed more general and quicker computing technique was proven. (Author abstract) 12 refs.

Szymanowski, Jan (Technical Univ of Poznan, Poznan, Pol); Atamanczuk, Bronislaw; Szweczyk, Henryk. *J Chem Technol Biotechnol* v 40 n 1 1987 p 1-10.

**081909 CHARACTERIZATION AND SPECTRO-ELECTROCHEMICAL STUDIES OF SOLUBLE POLYMERIZED 3-METHOXYTHIOPHENE.** 3-Methoxythiophene was polymerized anodically on glassy carbon or carbon felt electrodes. The resulting polymer was reduced cathodically and then isolated as a red solid, soluble in a variety of organic solvents. Following purification, the product was characterized by  $^1\text{H}$  and  $^{13}\text{C}$  NMR, UV-VIS, IR, HPLC and gel-permeation chromatography. These measurements indicated that the product is an oligomeric mixture  $n \approx 5-10$ , composed primarily of linearly linked 3-methoxythiophene units. The reduced polymer was coated onto various electrode materials and studied using cyclic voltammetry and spectroelectrochemistry. Details of electrolyte effects are reported. The reduced polymer absorbed light with  $\lambda_{\text{max}}$  480 nm. Upon oxidation over the range of 0.2-0.8 V (SCE) it was converted to an oxidized film which had a broad band with  $\lambda_{\text{max}}$  635 nm extending into the near-IR region. The  $A_{635}$  increased linearly with the charge passed, eventually leading to films that had about 10-20 cationic charges/100 monomer units. The electrochemical and optical behavior of this soluble oligomeric mixture is quite similar to insoluble polythiophenes. (Author abstract) 16 refs.

Chang, An-Cheng (Univ of Minnesota, Minneapolis, MN, USA); Blankespoor, Ronald L.; Miller, Larry L. *J Electroanal Chem Interfacial Electrochem* v 236 n 1-2 Oct 23 1987 p 239-252.

**081910 BOUNDARY EFFECTS ON POLYMER DYNAMICS IN DILUTE SOLUTIONS.** The motion of chainlike bead-spring molecules in dilute solution under the influence of a neighboring boundary is studied. Without restricting the problem to a specific flow regime or confining geometry, the Fokker-Planck equation for the polymer distribution in configuration space is treated in a mathematically formal way. A diffusion equation for the polymer concentration can be obtained if the hydrodynamic interactions among the solid surfaces are neglected. The work is useful in the fundamental treatment for the restricted transport of flexible macromolecules in dilute solution. (Edited author abstract) 23 refs.

Keh, Huan J. (Nat'l Taiwan Univ, Taipei, Taiwan). *J Chin Inst Chem Eng* v 18 n 5 Sep 1987 p 309-313.

**081911 HIGHLY ASYMMETRIC-SELECTIVE AND STEREoselective POLYMERIZATION OF (RS)- $\alpha$ -METHYLBENZYL METHACRYLATE WITH CYCLOHEXYL-MAGNESIUM BROMIDE-AXIALLY DISSYMMETRIC 2,2'-DIAMINO-6,6'-DIMETHYLBIPHENYL SYSTEM.** Enantiomer-selective polymerization of (RS)- $\alpha$ -methylbenzyl methacrylate [(RS)-MBMA] was investigated in toluene at  $-30^{\circ}\text{C}$ . Reaction products between cyclohexylmagnesium bro-

mide (cHexMgBr) and axially dissymmetric 2,2'-diamino-6,6'-dimethylbiphenyl (AMB) in the mole ratio of 1.5:1 were used as a chiral initiating system. The polymer produced contained a biphenyl group from the catalyst fragment. In the copolymerizations between (RS)-MBMA and achiral methacrylates, the catalyst also showed high selectivity toward (RS)-MBMA. Each of the copolymers from methacrylates of methyl, benzyl, and diphenylmethyl alcohols was coisotactic, and the enantiomer selections were consistent with that observed for the homopolymerization. On the other hand, both the isotacticity of copolymer and the selection greatly decreased in the copolymerization with  $\alpha$ -dimethylbenzyl methacrylate which has no hydrogen at the  $\alpha$ -carbon of the ester group. (Edited author abstract) 36 refs.

Kanoh, Shigeyoshi (Kanazawa Univ, Kanazawa, Jpn); Goka, Sakae; Murose, Nobutsugu; Kubo, Hideo; Kondo, Masao; Sugino, Tomoaki; Motoi, Masatoshi; Suda, Hiroshi. *Polym J* v 19 n 9 1987 p 1047-1065.

**081912 NARROWLY SPACED COMB-LIKE POLYMERS.** In this note we report the side chain crystallization of polydialkyl fumarates and itaconates. We designate these polymers as narrowly spaced comb-like polymers because each of them has two long alkyl side chains on every 2 main chain carbon atoms. 9 refs.

Hirabayashi, Tadamichi (Nagoya Inst of Technology, Nagoya, Jpn); Yokota, Kenji. *Polym J* v 19 n 9 1987 p 1115-1119.

**081913 POLY(PHENYLENVINYLEN); ENTWICKLUNG EINES ELEKTROAKTIVEN POLYMER-MATERIALS VOM UNSCHMELZBAREN PULVER ZUM TRANSPARENTEN FILM.** [Poly(phenylenevinylene): Development of an Electroactive Polymeric Material from Unmeltable Powder to Transparent Film]. The development of PPV systems has moved from intractable powders to flexible films. This opens new uses as thin film insulation material, as photoconductive electrophotographic recording material, and as novel electrochemical electrode material for polymer batteries. Tractable films were readily achieved either by transformation of a soluble precursor polymer or by introduction of solubilizing phenyl substituents. Contrary to widespread expectations PPV is not a metal-like conductor, but rather a broad-band gap photoconductor ( $E_g=2.4$  eV). However, it can be made highly conducting upon appropriate chemical or electrochemical treatment, thus forming several salt-like redox stages. (Edited author abstract) In German. 106 refs.

Hoerhold, Hans-Heinrich (Friedrich-Schiller Univ Jena, Jena, East Ger); Helbig, Manfred; Raabe, Dietrich; Opfermann, Johannes; Scherf, Ullrich; Stockmann, Regina; Weiss, Dieter. *Z Chem* v 27 n 4 Apr 1987 p 126-137.

**081914 WORLD OF POLYMERS - NEWER DEVELOPMENTS.** The status of the plastic industry in India is briefly examined with reference to its current status worldwide and to identify strategies required for an orderly growth of this industry in India in the coming years. Some topics discussed are these: the current world scene in the polymer industry; the future scenario of the polymer industry; the world scene in polymer research and development; the Indian scene in the polymer industry; the current status and some future directions of polymer research and development in India; process and technology development; and product and application development.

Ganguly, S. (Indian Petrochemicals Corp, Vadodara, India). *J Sci Ind Res* v 46 n 4 Apr 1987 p 145-153.

**081915 PREDICTION OF POLYMER-MELT RHEOLOGY FROM STRESS-RELAXATION MEASUREMENTS.** The ability of three viscoelastic theories to model the rheological behavior of cis-polyisoprene has been investigated. The material functions in the theories were determined from stress-relaxation measurements. The response of the polymer to ramp loading and unloading, and to several types of double-step deformation were measured, and the observations compared with

predictions calculated from the theories. The theory that was the simplest to use gave predictions that were the closest to the observations. (Edited author abstract) 22 refs.

Fuller, K.N.G. (Malaysian Rubber Producers' Research Assoc, Brickendonbury, Engl). *Philos Mag A* v 57 n 2 Feb 1988 p 225-234.

**081916 BIDIRECTIONAL CHARGE TRANSFER IN REPEATED CONTACTS TO POLYMERS.** The contact charging of polymers by metals is thought to be a consequence of electron transfer; the direction of transfer appears to be influenced by the relative position of the fermi level of the metal and some energy level characteristics of the polymer. What determines the amount of charge transfer is not definitely known at present. In this note we report experiments which show that charge accumulation is not always monotonic: although the magnitude of the charge always increases on average, the charge transfer in any particular contact can be of either sign. We think this effect is important because it puts strong constraints on possible mechanisms of contact electrification. 15 refs.

Lowell, J. (UMIST, Manchester, Engl). *J Electrostatics* v 20 n 2 Dec 1987 p 233-238.

**081917 SYNTHESIS AND CHARACTERIZATION OF A WATER-SOLUBLE AFFINITY POLYMER FOR TRYPSIN PURIFICATION.** A specific ligand bound polymer has been synthesized for the purpose of purification and stabilization of trypsin, an easily autolytic enzyme. The affinity polymer was formed by copolymerizing N-acryloyl-m-aminobenzamide, a strong trypsin inhibitor, and acrylamide in the absence of oxygen. Kinetic studies on the trypsin inhibition revealed that there was a strong binding between this enzyme and the polymer and the mechanism was of a competitive manner with an inhibition constant of  $0.6 \times 10^{-3}$  M. Such an affinity polymer was also very effective in preventing trypsin from auto-digestion at  $4^{\circ}\text{C}$ . Based on this finding and the principle of cross flow filtration, a new process has been developed for purification of trypsin from a solution containing chymotrypsin. The experimental data indicated that trypsin was bound to the polymer ( $\text{MW} > 10^5$ ) and remained in the retentate while unbound chymotrypsin was collected in the filtrate. This purification process has a capability of recovering 98% pure trypsin at 90% yield. (Author abstract) 11 refs.

Luong, J.H.T. (Male, K.B.); Nguyen, A.L. *Biotechnol Bioeng* v 31 n 5 Apr 5 1988 p 439-446.

**081918 MULTINUCLEAR MACROMOLECULAR METAL COMPLEXES: III. PREPARATION AND PROPERTIES OF POLY(VINYLAMINE)COPPER-(II) COMPLEX COORDINATELY BONDED WITH HEXACYANOFERRATE(II).** A new multinuclear macromolecular metal complex, poly(vinylamine)copper(II) complex coordinately bonded with hexacyanoferrate(I), has been prepared by mixing aqueous solutions of poly(vinylamine)copper(II) and potassium hexacyanoferrate(II) in order to investigate the effects of macromolecularization of a mixed metal complex. The interactions between metals in different complex moieties of poly(vinylamine)copper(II) and hexacyanoferrate(II) were studied spectroscopically. A mixed metal polymer complex which has Fe(II), Cu(II), and vinylamine of the poly(vinylamine) repeating unit in the ratio of 1:1:20 has been prepared. The spectral data suggest that this mixed metal polymer complex has a cyanide bridged structure and interactions between metals of different complex moieties through the cyanide bridges. (Edited author abstract) 12 refs.

Koyama, Toshiaki (Shinshu Univ, Ueda, Jpn); Kurose, Akio; Hanabusa, Kenji; Masuda, Etsuko; Shirai, Hirofusa; Hayakawa, Tadao; Hojo, Nobumasa. *Polym J* v 20 n 3 1988 p 207-211.



**081919 HELICAL POLY(AMINO ACID) HAVING CARBAZOLE SIDE CHAINS: A CANDIDATE FOR A PHOTOELECTRIC LIQUID CRYSTAL. 3. A CONFORMATIONAL STUDY.** The conformation of a carbazole-substituted poly( $\alpha$ -amino acid), poly(N<sup>ε</sup>-(carbazolyl-carbonyl)-L-lysine) (PKL), has been studied in solid films and solutions by Fourier transform infrared spectroscopy. In all samples investigated the main chain assumes the  $\alpha$ -helical conformation. The side chains are strongly hydrogen bonded in the solid state, with approximately 20% unbound groups. A side-chain conformation is proposed, where the major part of the side chains are stacked in three stacks almost parallel to the molecular axis. The average stack length exceeds 10 units and can in principle be infinite. The carbazole groups in the stacks are efficiently locked-in conformationally in a structure which probably favors effective energy transfer and photoconduction. In solution the hydrogen bonding of the side chains is disrupted. (Author abstract) 43 refs.

Marcher, Bjorn (Technical Univ of Denmark, Lyngby, Den); Chapoy, L. Lawrence; Christensen, Daniel H. *Macromolecules* v 21 n 3 Mar 1988 p 677-686.

**081920 EQUATIONS OF STATE FOR POLYMER LIQUIDS.** There are numerous equations of state in the literature which propose to describe polymer liquids. We examine the assumptions on which these various equations are based and compare them using PVT data for a wide range of polymer data. We demonstrate that those theories based on the Lennard-Jones and Devonshire cell model best describe the polymer liquid state. The simple cell model provides a tractable and analytically simple equation of state for the analysis of polymer liquids. (Author abstract) 17 refs.

Dee, G.T. (DuPont, Wilmington, DE, USA); Walsh, D.J. *Macromolecules* v 21 n 3 Mar 1988 p 811-815.

**081921 MODIFIED CELL MODEL EQUATION OF STATE FOR POLYMER LIQUIDS.** The authors modify the cell model equation of state and demonstrate how such an equation can provide a better description of polymer liquids. This equation provides the analytical simplicity of the P.J. Flory, R.A. Orwoll, and A. Vrij (FOV)<sup>2</sup> equation of state and an accuracy, which for most polymer liquids, exceeds the Simha-Somcynsky equation. They show that a modification of the free volume term in the free energy for the cell model of polymer liquids results in these enhanced properties. 6 refs.

Dee, G.T. (DuPont, Wilmington, DE, USA); Walsh, D.J. *Macromolecules* v 21 n 3 Mar 1988 p 815-817.

**081922 POINT OF A LINEAR POLYMER IN 2 DIMENSIONS: A RENORMALIZATION GROUP ANALYSIS OF MONTE CARLO ENUMERATIONS.** Using a renormalization group method of analysis of series, in which the order of truncation plays the role of a scale parameter, we study accurate Monte Carlo enumerations for SAW with attractive n.n. interaction on the square lattice. The theta point is located and its exponents are determined as  $\nu_t = 0.570 \pm 0.015$ ,  $\gamma_t = 1.10 \pm 0.04$  and  $\phi_t = 0.52 \pm 0.07$ . These values are compared with others previously proposed in the literature, and seem to support recent theoretical conjectures. (Author abstract) 24 refs.

Seno, F. (Univ di Padova, Padua, Italy); Stella, A.L. *J Phys (Paris)* v 49 n 5 May 1988 p 739-748.

**081923 SEGMENT DISTRIBUTION ABOUT THE CENTER-OF-MASS IN AN ISOLATED POLYMER COIL. A RENORMALIZATION GROUP STUDY.** We analyse the segment density distribution about the center of mass in an isolated self-interacting polymer chain. We find that the center-of-mass operator is renormalizable without introducing new renormalization factors. The segment density distribution is calculated to one loop order. The interaction reduces the density in the center of the chain. This effect, which was to be expected, is due to a somewhat surprising mechanism: the interaction suppresses fluctuations of individual segments away from their average position. (Author abstract) 10 refs.

Schaefer, Lothar (Univ Essen, Essen, West Ger); Krueger, Brunhilde. *J Phys (Paris)* v 49 n 5 May 1988 p 749-758.

**081924 ACID-BASE INTERACTIONS BETWEEN POLYMERS AND FILLERS.** Inverse gas chromatography (IGC) and Fourier-transform infrared (FT-IR) techniques were applied to determining the relative acid-base strength of polymers and coupling agents. The acid-base characteristics of fillers such as CaCO<sub>3</sub> could be altered by treatment with different coupling agents. It was shown that some mechanical properties of filled polymers were obviously associated with acid-base interactions between polymers and fillers. (Author abstract) 10 refs.

Wang, Qingguo (Nanjing Univ, China); Chen, Fute; Huang, Yuanfu; Zhou, Qingli. *Chin J Polym Sci (Engl Ed)* v 5 n 3 1987 p 186-190.

**081925 POLY ETHYLENE GLYCOL DERIVATIVES AS PHASE TRANSFER CATALYSTS AND SOLVENTS FOR ORGANIC REACTIONS.** The use of polyethers, specifically poly(ethylene glycol)s (PEG), as reagents in organic synthesis can be arbitrarily divided into three areas: 1) phase transfer catalysts, 2) supported catalysts, and 3) reaction solvents. The authors examine each of these areas in detail. It is shown that PEG's are excellent catalysts and solvents for a wide variety of organic reactions. In fact, contrary to conventional wisdom, they may be used in most applications where crown ethers are currently used. While it is true that the reactivity of PEG's is often less than that of crown ethers, this may be compensated for by simply raising the level of PEG concentration. PEG's appear to offer a number of very substantial advantages over the more commonly used crown ethers, e.g., lower cost and minimal, if any, toxicity. In general, when used as PTC's (Phase Transfer Catalysts) it has been shown that there is usually a minimum molecular weight for catalytic activity, > 200 g/mol. 53 Refs.

Totten, G.E. (Union Carbide Corp, Tarrytown, NY, USA); Clinton, N.A. *J Macromol Sci Rev Macromol Chem Phys* v C28 n 2 1988 p 293-337.

**Ablation** See LASERS, EXCIMER—Applications.

## Absorption

**081926 APPROACH FOR ESTIMATING THE PERMEATION OF PHOSPHONOFUORIDATES INTO A HIGH POLYMER MATRIX PART 1. DEVELOPMENT OF THE APPROACH.** An approach has been developed to estimate the solubility and diffusivity of toxic phosphonofluoridates in high-molecular weight polymeric matrices based upon experimentation with nontoxic simulants. This approach is based on Gee's relation for estimating solubility (equilibrium swelling) from knowledge of the solubility parameters for the polymer and the simulant liquids concerned and on Van Krevelen's relation between diffusivity and activation energy of diffusion. The latter is interpolated from a standard plot of activation energy of diffusion against penetrant molar volume. Equilibrium swelling values and diffusivities for toxic alkyl phosphonofluoridates in styrene-butadiene rubber (SBR) and low density polyethylene (LDPE) were estimated from results of swelling measurements. (Edited author abstract) 9 refs.

Mangaraj, D. (Battelle Columbus Div, Columbus, OH, USA); Pfau, J.P.; Luttinger, M.; Block, F.; Magee, W.S. *Polym Eng Sci* v 27 n 17 Sep 1987 p 1338-1343.

**081927 POLYMER ADSORPTION NEAR THE SURFACE OF A POLYMER SOLUTION: A UNIVERSAL BEHAVIOUR.** A universal property of good solutions of long polymers near an attractive surface is studied under the assumption that there is saturation on the surface and that the monomer concentration vanishes at infinity. The generalization of an argument given by P.G. de Gennes indicates that, at a distance  $x$  from the surface, the kuhnian concentration (monomer concentration)  $C_k(x) = A(d)x^{-d+1/4}$  where  $d$  is the space dimension and  $\nu$  the critical size exponent. It is shown that a mean field theory is valid for small values of  $\epsilon = 4 -$

$d$  and that it leads to the result  $A(4 - \epsilon) = 2/\pi^2\epsilon$ , for  $0 < \epsilon \ll 1$ . (Author abstract) 3 refs.

des Cloizeaux, J. (CEN-Saclay, Gif sur Yvette, Fr). *J Phys (Paris)* v 49 n 5 May 1988 p 699-703.

## Acoustic Properties

**081928 ACOUSTIC PROPERTIES OF POLYMERS USED IN UNDERWATER ACOUSTICS.** After a general introduction to the subject, the dynamic modulus of polymers is discussed, its variation with frequency and temperature, and its relation to molecular structure. The use of cellular structures is then described in anechoic sound absorbers and reflectors and the application of polymers in structural damping. Reference is made to the stability of acoustic properties and to the manufacture of acoustic polymers. The review concludes with a forecast of future developments. (Author abstract) 24 refs.

Lane, R. (Admiralty Research Establishment, Poole, Engl); Bowditch, M.R.; Ochiltree, B.C. *Progr Rubber Plast Technol* v 1 n 4 Oct 1985 p 61-74.

**081929 AKUSTISCHES UEBERTRAGUNGSVERHALTEN VON PLATTEN AUS POLYMERBETON. [Acoustic Performance of Plates of Polymer Concrete].** Vibro-acoustic studies of polymer concrete plates of area of 620 mm  $\times$  620 mm and of thicknesses of 40 mm and 70 mm are described. The sound output level referred to forces shows similar frequency responses as that of a steel plate of equal flexural rigidity. The polymer concrete plates have a coefficient of loss greater by a factor 7 at the polymer plates in comparison with steel plates. (Edited author abstract) In German. 11 refs.

Haustein, B.-G. (Zentralinst fuer Arbeitsschutz Dresden, East Ger). *Maschinenbautechnik* v 36 n 7 Jul 1987 p 320-323.

**Additives** See ALSO CEMENT—Additives; EPOXY RESINS—Curing; KETONES—MONOMERS—Polymerization; PLASTICS—Mold Release Agents; POLYACETYLENES—Oxidation; POLYESTERS—Flame Resistance; POLYETHYLENE TEREPHTHALATE—Crystallization; POLYETHYLENES—Linear Low Density; POLYOLEFINS—Oxidation; POLYURETHANES—Manufacture; POLYURETHANES—Reaction Injection Molding; RUBBER—Crystallization.

**081930 EFFECT OF SMALL ADDITIONS OF METHACRYLIC OLIGOMERS ON THE PROPERTIES OF POLYMETHACRYLATES.** The effect of additions of methacrylic oligomers and the mode of formation of composites on the rheological properties of polymer-oligomer systems has been studied. The extremal dependence of the viscosity on the content of additives of systems obtained by polymerization of the corresponding monomers in presence of oligomers has been established. Information is presented pointing to the non-equilibrium nature of the polymer-oligomer composites formed. (Author abstract). 17 Refs.

Myasninkova, L.I. (Gorkii State Univ, USSR); Yemel'yanov, D.N.; Irzhak, V.I.; Panova, G.D.; Bogdanova, L.M. *Polym Sci USSR* v 29 n 5 1987 p 1039-1046.

**081931 PERFORMANCE AND MECHANISMS OF FIRE RETARDANTS IN POLYMERS - A REVIEW.** The fundamental mechanisms by which fire retardant additives can interrupt the self-sustained combustion cycle of organic polymers are reviewed. Evaluation of fire retardant performance and methods used for mechanism assessment are discussed. Examples are given of recent mechanistic studies of halogen-based and intumescent systems indicating that some previous generalizations should be revised. It is shown that a deeper understanding of fire retardance mechanisms acquired through detailed thermal degradation studies is the only way to answer the



ever increasing demand for polymeric materials characterized by minimised overall fire hazard. (Author abstract) 80 refs.

Camino, G. (Univ Torino, Turin, Italy); Costa, L. *Polym Degradation Stab* v 20 n 3-4 1988, Polym Addit in Stab: Perform and Mech, Birmingham, Engl, Sep 2-4 1987 p 271-294.

## Adhesion

**081932 LIJEPLJENJE POLIMERNIH MATERIJA.** [Adhesion of Polymeric Materials]. The known theories of adhesion (mechanical, fracture, adsorption, diffusion, electrostatic and chemical interactions) of polymeric materials are presented in the paper and treatment of the polymeric surface by some physical and chemical methods is described. The most important adhesion systems for polymeric and other technical materials are also considered. (Edited author abstract) 68 refs. In Serbo-Croatian.

Hegedic, Damir (INA, Zagreb, Yugosl). *Polimeri (Zagreb)* v 8 n 6 Jun 1987 p 175-178.

**Adsorption** See Also OIL WELL PRODUCTION—Enhanced Recovery; SILICA—Flocculation; SURFACE ACTIVE AGENTS—Adsorption.

**081933 ADSORPTION OF A THETA POLYMER: COMPETITION BETWEEN MEAN-FIELD AND MULTICRITICAL BEHAVIOUR.** We analyze the behavior of a 3d theta polymer in the presence of an attracting wall. We find that the multicritical crossover exponent at the adsorption temperature  $T_a$  is the mean-field  $\phi = 1 - \nu_{MF} = 1/2$ . However, one only finds a consistent estimate of  $T_a$  if logarithmic corrections are taken into account. This is the first example of numerical data of walks where logarithmic corrections clearly dominant all other possible corrections to scaling. The monomer density near the surface is reduced compared to the mean-field and good-solvent case. (Author abstract) 33 refs.

van Dieren, F. (Max Planck Inst fuer Polymerforschung, Mainz, West Ger); Kremer, K. *Europhys Lett* v 4 n 5 Sep 1 1987 p 569-576.

**081934 CHARACTERIZATION OF THE ADSORPTION OF POLY(ACRYLAMIDE), POLY(4-METHOXYSTYRENE), AND POLY(ACRYLIC ACID) ON ALUMINUM OXIDE BY INELASTIC ELECTRON TUNNELING SPECTROSCOPY.** The adsorptions of polystyrene, poly(methoxystyrene), poly(acrylamide), and poly(acrylic acid) on aluminum oxide are investigated with inelastic electron tunneling spectroscopy. Comparison with infrared data for thin polymer films of the polymer samples gives insight into the adsorbed polymer configuration. Data indicate that poly(styrene) is weakly physisorbed to aluminum oxide, while poly(methoxystyrene), poly(acrylamide), and poly(acrylic acid) react to form strong bonds with the oxide surface. On the basis of this data, adsorption mechanisms are suggested for each of the polymers. (Edited author abstract) 42 refs.

Colletti, Ronald F. (Univ of Delaware, Newark, DE, USA); Gold, Harvey S.; Dybowski, Cecil. *Appl Spectrosc* v 41 n 7 Sep-Oct 1987 p 1185-1189.

**081935 INTERFACIAL BEHAVIOUR OF BINARY POLYMER MIXTURES II. COMPETITIVE POLYMER ADSORPTION AND ITS EFFECT ON THE STABILITY OF COLLOIDAL DISPERSIONS.** This paper describes the adsorption of methylcellulose (MC), polyvinyl alcohol (PVA) and polyvinyl pyrrolidone (PVP) and of their binary mixtures on arsenic trisulphide sol and polystyrene latex, and the effect of these polymers and polymer mixtures on the stability of the dispersions. The conditions for binary polymer mixtures resulting in a synergistic effect and the relation of this phenomenon to competitive adsorption of the polymers were studied. Upon simultaneous adsorption from binary mixtures, the order of preferential adsorption for the polymers is as follows: PVP > MC > PVA on the arsenic trisulphide

sol, and MC > PVP > PVA on the polystyrene latex. At high surface coverage, the weakly adsorbed polymers can be displaced from either interface by the preferentially adsorbed polymers. The effectiveness of the polymer mixtures, both as flocculants and stabilizers, closely correlates with the order of preferential adsorption for the polymers. Synergism in the flocculating effect of MC-PVP mixtures with components of different molecular mass on arsenic trisulphide sol was found. At the onset of the stabilizing region, some increase in the effectiveness of MC-PVP and PVA-PVP mixtures on arsenic trisulphide sol was also observed. These phenomena are attributed to irregularly extended adsorption layers formed by the competitive adsorption of the polymers. (Edited author abstract) 13 refs.

Csmpesz, S. (Lorand Eotvos Univ, Budapest, Hung); Rohrsetzer, S.; Kovacs, P. *Colloids Surf* v 24 n 2-3 May 15 1987 p 101-117.

**081936 POLYMER ADSORPTION: CONCENTRATION EFFECTS.** We consider the various adsorption regimes of flexible chains in a good solvent when the bulk concentration is changed. As the latter is increased, first we find a very dilute bulk regime where the surface coverage increases fast. This is followed by a plateau with much slower increase for  $\Gamma$ , the bulk solution being still dilute. In the bulk semi-dilute regime, we consider the adsorption of blobs. For high bulk volume fraction  $\phi_b > \delta^4/3$ , where  $\delta$  is the dimensionless excess energy per monomer on the surface, the blobs are not adsorbed. The interfacial tension is calculated in the different regimes. Our approach closely follows the scaling theory of de Gennes and Pincus. (Author abstract) 29 refs.

Bouchaud, E. (CEN, Gif-sur-Yvette, Fr); Daoud, M. *J Phys (Paris)* v 48 n 11 Nov 1987 p 1991-2000.

**081937 CONTRIBUTION OF ADSORBED POLYMERS TO THE STABILITY OF COLLOIDAL SYSTEMS.** A review is presented of contemporary ideas concerning adsorption of polymers and polyelectrolytes and their effect on colloid interaction. A discussion is also presented of the following topics: the effect of important parameters is well understood, including molecular mass, adsorption energy, solvent quality, polydispersity, and, in the case of polyelectrolytes, the effect of charge and concentration of the electrolyte. (Edited author abstract) 10 refs.

Lyklema, J. (Agricultural Univ, Wageningen, Neth); Fleer, G.J.; Scheutjens, J.M.H.M. *Colloid J USSR* v 49 n 2 Mar-Apr 1987 p 181-185.

**081938 CHEMISORPTION GEOMETRY OF POLY-3-METHYLTHIOPHENE ELECTROCHEMICALLY DEPOSITED ON Pt AS OBSERVED BY NEXAFS.** NEXAFS measurements have been employed to investigate the Pt-poly-3-methylthiophene (PMeT) interface. The C 1s and S 2p edge characteristics reveal that the polymeric chains are well ordered on the metallic surface even for thicknesses up to 50 Å. In its undoped semiconducting state, the polymeric layers lie flat on the Pt with a strong interaction between electron states of the metal and the antibonding  $\Pi^*$  band of the PMeT. When PMeT is electrochemically doped to its conducting state, the NEXAFS spectra exhibit changes as a function of thickness. The first layer lies essentially flat on Pt, while the other ones are randomly oriented, according to the intercalation of anions during the oxidation process. The ordering and the homogeneity of the first layers strongly depend on the electric field applied at the Pt-electrolytic medium interface during the electrochemical synthesis. (Author abstract) 16 refs.

Tourillon, G. (CNRS, Orsay, Fr); Dartyge, E.; Fontaine, A.; Garrett, R.; Sagurton, M.; Xu, P.; Williams, G.P. *Europhys Lett* v 4 n 12 Dec 15 1987 p 1391-1396.

**081939 ELECTROPHORETIC STUDY OF POLYMER ADSORPTION: DEXTRAN, POLYETHYLENE OXIDE AND POLYVINYL ALCOHOL ON SILVER IODIDE.** The adsorption of polyvinyl alcohol (PVA), dextran (DEX), and polyethylene oxide (PEO) on

silver iodide has been measured together with the electrophoretic mobilities of the polymer-covered particles and the surface charge. The combined information from these three sources allows a detailed analysis of the composition of the polymeric adsorbate and the electrical double layer to be made. Polydispersity is accounted for and a special method has been developed to cover particles with a thick polymer layer. Electrophoretic layer thicknesses  $\delta_E$  are established under conditions where they are identical to the hydrodynamic thicknesses. For a given polymer,  $\delta_E$  depends only on the amount adsorbed and not on the molecular weight (molecular weight congruency). The solvent quality for the three polymers is reflected in  $\delta_E$  and in the extent to which train segments displace ions from the Stern layer. (Author abstract) 36 refs.

Koopal, L.K. (Agricultural Univ Wageningen, Wageningen, Neth); Hladý, V.; Lyklema, J. *J Colloid Interface Sci* v 121 n 1 Jan 1988 p 49-62.

**081940 ADSORPTION OF PARTIALLY HYDROLYZED POLYACRYLAMIDES ON TITANIUM DIOXIDE.** The adsorption of partially hydrolyzed (0, 4, 16%) polyacrylamides on titanium dioxide in an aqueous medium was studied to analyze the influence of pH, ionic strength, and the presence of  $\text{Ca}^{2+}$  complexing ions. Experimental results cannot be explained solely by considering the variation of the polymer's and surface's charge densities. An important parameter concerning the polymer's affinity for the surface could be the variation of its solubility in the medium. (Author abstract) 19 refs.

Girod, G. (CNRS, Besancon, Fr); Lamarche, J.M.; Foissy, A. *J Colloid Interface Sci* v 121 n 1 Jan 1988 p 265-272.

**081941 SURFACE-ENHANCED RAMAN SPECTROSCOPY OF POLY(2-VINYLPYRIDINE) ADSORBED ON SILVER ELECTRODE SURFACES.** Surface-enhanced Raman scattering (SERS) of partially protonated poly(2-vinylpyridine) (P2VPy) adsorbed onto an electrochemically roughened silver electrode is reported as a function of applied potential. The species on the electrode surface is predominantly pyridinium ion when the electrode potential is positive of the point of zero charge ( $E_z$ ) and predominantly neutral pyridine near  $E_z$ . Orientation effects involving the polymer chain are visible in the fingerprint region of these spectra. The species vs potential dependence is different for the polymer compared with low molecular weight probe molecules of pyridine and 2-methylpyridine. The presence of the polymer substantially improves the stability of the active sites responsible for SERS activity to cathodic excursions to  $E_z$  in chloride electrolyte. The differences observed with the polymer are explained on the basis of its lower solubility and the 'anchoring' of positive charges within the double-layer region. (Author abstract) 42 refs.

Lippert, Joseph L. (Eastman Kodak Co, Rochester, NY, USA); Brandt, E. Steven. *Langmuir* v 4 n 1 Jan-Feb 1988 p 127-132.

**081942 ADSORPTION OF BUTYLIMINE POLYMER ON A COPPER ELECTRODE.** Study of the electrode potential drops after application of polarizing current showed that the adsorption of butylimine polymer on a copper electrode in 11 M phosphoric acid solution increases in the presence of hydrogen peroxide. The adsorption film formed, containing hydrogen peroxide and PB-5, improves the quality of copper polishing. (Author abstract) 5 refs.

Drozd, N.A.; Gordienko, N.A. *Sov Prog Chem* v 53 n 8 1987 p 59-62.

**081943 POLYACRYLAMIDE Na-KAOLINITE INTERACTIONS: EFFECT OF ELECTROLYTE CONCENTRATION ON POLYMER ADSORPTION.** The variation in polyacrylamide adsorption on Na-kaolinite as a function of electrolyte concentration of the clay suspension, was determined under three pH conditions, where the clays display varying charge characteristics. Interpre-



tation of the results is based on two arguments: non-charged polyacrylamide adsorption is restricted to the edge faces of the colloidal platelets and hydrogen bonding between the amide groups of the polymer and the 'isolated' hydroxyl sites of these faces is the mode of surface attachment. At constant pH, when Na-kaolinite bears charged surface groups, the polymer adsorption, which is related to the density of the anchoring sites, parallels the state of ionization of the edge surface. (Edited author abstract) 36 refs.

Pefferkorn, E. (CNRS-ULP Strasbourg, Strasbourg, Fr); Nabzar, L.; Varoqui, R. *Colloid Polym Sci* v 265 n 10 Oct 1987 p 889-896.

**081944 SHORT TERM KINETICS OF POLYMER ADSORPTION ON GLASS SUBSTRATE.** Short term kinetics (1 to 60 s) of polymer adsorption on glass and the variation of the adsorption density along the surface have been studied using a new technique. This method also gives information on how the polymer is distributed spatially along the interface. The effect of polymer concentration and chemical pretreatment of the substrate with an inorganic on polymer adsorption is discussed. It appears that polymer adsorption does not take place uniformly and linearly with time. Initiation of polymer adsorption by some surface controlled factors appears to be necessary before it is followed by a rapid polymer uptake. (Author abstract) 1 ref.

Somasundaran, P. (Columbia Univ, New York, NY, USA); Sivakumar, A. *Colloids Surf* v 30 n 3-4 Apr 1988 p 401-403.

**081945 SELF-CONSISTENT FIELD MODEL OF POLYMER ADSORPTION: GENERALIZED FORMULATION AND GROUND-STATE SOLUTION.** We formulate a general self-consistent field model of polymer adsorption and consider the case of nonionic homopolymer adsorption on a single, planar surface. Our approach is closely related to those of S.F. Edwards, K.F. Freed, and P. de Gennes in that we obtain a diffusion equation for the configuration probability of an idealized chain of polymer segments. We solve the general field equation through an eigenfunction expansion, keeping only the first, or ground state, function in the expansion. Comparison with experimental data and the results of the Scheutjens-Fleer lattice model demonstrate that the solution precludes the prediction of long, dangling tail configurations that influence many of the interactions of the adsorbed layer. (Edited author abstract) 41 refs.

Ploehn, Harry J. (Princeton Univ, Princeton, NJ, USA); Russel, William B.; Hall, Carol K. *Macromolecules* v 21 n 4 Apr 1988 p 1075-1085.

**081946 HYDRODYNAMIC THICKNESS OF ADSORBED POLYMERS IN STEADY SHEAR FLOW.** The effective hydrodynamic thickness (EHT) of adsorbed polystyrene in toluene and cyclohexane and poly(acrylamide) in aqueous NaCl solvent, both at the adsorption plateau, was determined in a steady laminar shear flow in an array of fused glass capillaries. Effective hydrodynamic thicknesses were determined for a shear rate range of 170-800 s<sup>-1</sup>, with an EHT resolution of about ±50 Å. The EHT for polystyrene in toluene, and for poly(acrylamide) in a 1200 ppm aqueous NaCl solvent, was found to decrease from the zero shear EHT values with increasing shear rate. The zero shear limit of the EHT in a Θ solvent (cyclohexane at 34.8°C) was found to be lower than in a good solvent (toluene). This work is pertinent to ultrafiltration, wastewater treatment, and enhanced oil recovery. (Edited author abstract) 41 refs.

Cohen, Yoram (Univ of California, Los Angeles, Los Angeles, CA, USA). *Macromolecules* v 21 n 2 Feb 1988 p 494-499.

**081947 SELECTIVITY OF ADSORPTION FROM MELTS OF POLYMER MIXTURES.** The compositional and filler dependence of molecular mobility in the melts of polyethylene (PE), polybutylmethacrylate (PBMA), and their mixtures was examined by NMR spectroscopy. The fraction of immobilized segments p in

the chain of each polymer was determined. In the melts of PE-PBMA mixtures a predominant adsorption of PBMA onto a solid surface was revealed. The composition and thickness of a boundary layer were calculated. (Author abstract) 11 refs.

Lipatov, Yu.S. (Acad of Sciences, Kiev, USSR); Khramova, T.S.; Todosijchuk, T.T.; Gudova, E.G. *J Colloid Interface Sci* v 123 n 1 May 1988 p 143-147.

**081948 REACTIONS WITH COMPETITION IN THE THREE-COMPONENT POLYMER SYSTEM AEROSIL SURFACE-COPOLYMER OF STYRENE AND MALEIC ACID-POLYOXYETHYLENE.** The three-component system an aerosil silica-copolymer of styrene with maleic acid (CSMA)-polyoxyethylene (POE) has been studied by potentiometric titration, IR spectroscopy and viscometry. The reaction of macromolecular substitution occurring in solution on making CSMA with POE adsorbed on SiO<sub>2</sub> stops at the stage of formation of the POE CSMA polycomplex on the surface of the aggregated aerosil; the amount of CSMA in the mixed 'complex' depends on M<sub>POE</sub>. On introducing POE into a system of competing and interacting polyacids SiO<sub>2</sub> + CSMA it reacts not with the 'rigid' surface of the aggregated SiO<sub>2</sub> particles but with the flexible CSMA chains which is due to the greater gain in energy on formation of the polycomplex as compared with adsorption of the macromolecular on the surface. (Author abstract) 17 refs.

Zheltonozhskaya, P. (Shevchenko State Univ, Kiev, USSR); Yermenko, B.V.; Nuzhdina, Yu.A.; Uskov, I.A. *Polym Sci USSR* v 29 n 2 Feb 1987 p 291-299.

**081949 DYNAMICS OF ADSORBED POLYMERS. 1. THICKNESS RELAXATION OF POLY(VINYL-PYRROLIDONE) ON GLASS.** The authors present kinetic data that give a rather direct insight into the time scale of rearrangement processes occurring inside an adsorbed polymer layer. In particular, they were able to measure the hydrodynamic thickness of a freshly deposited adsorption layer as a function of time, and found it to decrease over a time of the order of minutes. The authors present data for this relaxation process, which show that it is not simply exponential and that it strongly depends on the thickness increment prior to relaxation. They also present data on the relaxed thickness as a function of the number of deposition steps, polymer concentration, and molecular weight. The results can be qualitatively understood in terms of a simple two-stage adsorption. (Edited author abstract) 18 refs.

Cohen Stuart, Martinus A. (Lab for Physical & Colloid Chemistry, Wageningen, Neth); Tamai, Hisashi. *Macromolecules* v 21 n 6 Jun 1988 p 1863-1866.

**081950 FLUORESCENCE STUDIES OF POLYMER ADSORPTION. 1. REARRANGEMENT AND DISPLACEMENT OF PYRENE-TERMINATED POLY(ETHYLENE GLYCOL) ON COLLOIDAL SILICA PARTICLES.** Adsorption of pyrene end-labeled poly(ethylene glycols) (Py-PEG-Py) on colloidal silica particles and their subsequent rearrangement and/or displacement by the addition of unlabeled PEG are studied in water by using photostationary fluorescence and time-resolved fluorescence decay. The tagged polymers we use in this study have molecular weights 4250 and 8650 based on the PEG backbone. The molecular weight of the displacing polymer (PEG) ranges from 1470 to 22000. Experimental conditions for the adsorption of Py-PEG-Py are chosen to ensure that a negligible amount of Py-PEG-Py exists in free solution. The measurement of excitation spectra and time-resolved fluorescence decays for both monomer and excimer emission provides insight into the state of the Py-PEG-Py when adsorbed on a silica surface. (Edited author abstract) 36 Refs.

Char, Kookheon (Stanford Univ, Stanford, CA, USA); Gast, Alice P.; Frank, Curtis W. *Langmuir* v 4 n 4 Jul-Aug 1988 p 989-998.

**081951 INVESTIGATION OF THE ADSORPTION CONFIGURATION OF POLY(ETHYLENE OXIDE)**

**AND ITS COPOLYMERS WITH POLY(PROPYLENE OXIDE) ON MODEL POLYSTYRENE LATEX DISPERSIONS.** Theoretical prediction of the performance of adsorbed polymeric dispersion stabilizers requires information on the configuration of polymers at the solid/liquid interface. Parameters describing polymer adsorption configuration on aqueous polystyrene latices are evaluated for representative linear homopolymers, block copolymers, and random copolymers of poly(ethylene oxide) and poly(propylene oxide). Effective hydrodynamic adsorption layer thicknesses, determined with photon correlation spectroscopy, are reported for the different polymer systems as a function of molar mass, concentration, and time from initial mixing. Specific adsorption isotherms are also determined. The data suggest that the polymers adsorb in the extended configuration, as loops and/or tails. (Author abstract) 37 Refs.

Baker, James A. (Univ of Washington, Seattle, WA, USA); Berg, John C. *Langmuir* v 4 n 4 Jul-Aug 1988 p 1055-1061.

**081952 ADSORPTION/DESORPTION OF A PEO-RICH COMB-LIKE POLYMER AT A SILICA/AQUEOUS SOLUTION INTERFACE.** The adsorption isotherm of a polymethacrylate of monoethoxy-poly(ethylene glycol) from aqueous solutions on silica was found to be of high affinity type. Homogeneous and heterogeneous [with linear poly(ethylene oxide), PEO] exchange between adsorbed and dissolved molecules was performed with radiolabeled polymers: results suggest the anchoring of the polymer by the backbone, the tails of PEO protruding into the bulk solution. Pretreatment of silica with such a polymer reduces the adsorption of fibrinogen to 5 percent of the value observed with bare silica. (Author abstract) 28 Refs.

Orgeret-Ravanat, C. (CNRS, Strasbourg, Fr); Gramain, Ph.; Dejardin, Ph.; Schmitt, A. *Colloids Surf* v 33 n 1-2 Aug 1988 p 109-119.

**081953 COMPETITIVE AND DISPLACEMENT ADSORPTION OF POLYELECTROLYTE AND WATER-SOLUBLE NONIONIC POLYMER AT THE SILICA SURFACE.** Individual, competitive, and displacement adsorption of poly(ethylene oxide) (PEO) with a narrow molecular weight distribution and poly(4-vinyl-N-n-propylpyridinium bromide) (PVPP) with complete quaternization onto a nonporous silica (Aerosil 130) from an aqueous KBr solution, pH 4, at 25°C was studied as a function of KBr concentration and molecular weight of PEO. In individual adsorption, adsorbed amount of both PEO and PVPP increases with increasing KBr concentration due to a decrease in excluded volume effects of polymer chains. In competitive adsorption, PEO adsorbs preferentially over PVPP due to the strong hydrogen bonds between PEO and silanol groups. In displacement adsorption PVPP molecules are desorbed from the silica surface by addition of PEO molecules. Both competitive adsorption and exchangeability slightly increase with increasing molecular weight of PEO. (Author abstract) 29 Refs.

Kawaguchi, Masami (Mie Univ, Mie, Jpn); Kawaguchi, Hisato; Takahashi, Akira. *J Colloid Interface Sci* v 124 n 1 Jul 1988 p 57-62.

**081954 POLYMERS IN COLLOID SYSTEMS: ADSORPTION, STABILITY AND FLOW, PROCEEDINGS OF AN INTERNATIONAL CONFERENCE.** This conference proceedings contains 29 papers. All papers are indexed and abstracted separately. Topics covered include: progress in polymer adsorption; random copolymer adsorption; block copolymer adsorption; hydrodynamic layer thicknesses; polymer desorption; adsorbed fibrinogen layer structural changes; ion exchange reactions during adsorption of cationic polyelectrolytes; forces between surfaces bearing polymer chains; forces between adsorbed layers; static and dynamic forces across polymer liquid films; flocculation of cellular suspensions by electrolytes; studying polymer interfacial dynamics; adhesive hard sphere colloidal dispersions; solvent in-



duced flocculation of polymer colloids; depletion flocculation of concentrated sterically stabilized polystyrene latex dispersions; use of concentration profiles in creaming emulsions; and a mean field theory for the rheology of phase-separated or flocculated dispersions. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11533 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Tadros, Th.F. (Ed.) (Imperial Chemical Industries Ltd, Bracknell, Engl). *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 412p.

**081955 THEORETICAL PROGRESS IN POLYMER ADSORPTION, STERIC STABILIZATION AND FLOCCULATION.** The range of validity of scaling and mean field models for polymers at interfaces is discussed. According to a recent analysis by D.W. Schaefer, mean field theories describe the properties of polymers in solution correctly over a wider range of concentration and solvency than does scaling. Only for flexible polymers in very good solvents at concentrations below a few percent are scaling methods preferred. In polymer adsorption, high segment densities occur and therefore mean field theories are more appropriate than scaling. The most detailed mean field theory for polymers at interfaces has been proposed by J.M.H.M. Scheutjens and G.J. Fleer. The distribution of segments as a function of ranking number and, consequently, end effects (tails) are taken fully into account. (Edited author abstract) 53 refs.

Fleer, G.J. (Agricultural Univ, Wageningen, Neth); Scheutjens, J.M.H.M.; Cohen Stuart, M.A. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 1-29.

**081956 EXTENSIONS OF THE SELF-CONSISTENT FIELD THEORY OF POLYMER ADSORPTION: MATCHED ASYMPTOTIC SOLUTION DESCRIBING TAILS.** Near the surface, the polymer is grossly distorted from the ideal state due to the effect of adsorption; the characteristic length is the segment length, and the groundstate solution is roughly correct. Far from the surface, polymer configurations are more nearly random walks with a characteristic length given by the square root of the chain length (number of segments per polymer chain). Asymptotic matching yields a uniformly valid approximate solution for the end segment probability as just the sum of the groundstate solution and the error function. The simplicity of the solution allows calculation of analytical volume fraction profiles; furthermore, the contributions due to segments contained in trains, loops, tails, and free polymer can be identified. 5 refs.

Ploehn, Harry J. (Princeton Univ, Princeton, NJ, USA); Russel, William B. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 31-32.

**081957 HYDRODYNAMIC LAYER THICKNESSES OF VARIOUS ADSORBED POLYMERS ON PRECIPITATED SILICA AND POLYSTYRENE LATEX.** Hydrodynamic layer thicknesses of adsorbed polyethylene oxide (PEO), polyethylene oxide-polypropylene oxide-polyethylene oxide (PEO-PPO) block copolymers, and polyvinyl alcohols (PVA) of different molar mass and composition are determined by photon correlation spectrometry (PCS) and ultracentrifugation (UC). The adsorbents used are precipitated silica and polystyrene latex. The increase of the diffusion coefficient,  $D$ , of the bare silica particles with reduction of the electrostatic double layer is related to the existence of immobilized water near the charged interface. At high PEO adlayer thicknesses no influence of the extension of the double layer exists. (Edited author abstract) 26 refs.

Killmann, E. (Technische Univ Muenchen, Garching, West Ger); Maier, H.; Baker, J.A. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow,

Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 51-71.

**081958 SURFACE FORCE MEASUREMENTS FOR POLY-L-LYSINE: EFFECT OF IONIC STRENGTH.** The authors have carried out measurements, using the surface forces apparatus, for the interaction of poly-L-lysine (PLL) chains adsorbed on mica from electrolyte solution. The results agree well with earlier work by P.F. Luckham and J. Klein and form part of a more detailed study carried out for a range of molecular weights for this polyelectrolyte. In the highest electrolyte concentration, 0.1 mol dm<sup>-3</sup> KNO<sub>3</sub>, there is no background double-layer repulsion due to the electrolyte, and so any observed repulsion is entirely due to the polymer adsorbed on the mica surface. 5 refs.

Dix, L.R. (Cavendish Lab, Cambridge, Engl); Toprakcioglu, C.; Davies, R.J. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 147-149.

**081959 POLYMER ADSORPTION AND FLOCCULATION IN SHEARED SUSPENSIONS.** Dynamic aspects of polymer adsorption and flocculation are considered and their relevance to the testing of polymeric flocculants is emphasised. In particular, the adsorption of polymer on particles can be slow compared to the flocculation rate in sheared suspensions, and this can lead to some uncertainties in the interpretation of results from continuous tests. Results using a newly-developed flocculation monitor are presented, with a variety of suspensions and polymers, which illustrate some of the important points. (Author abstract) 26 refs.

Gregory, John (Univ Coll London, London, Engl). *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 231-253.

**081960 ELLIPSOMETRIC STUDY OF POLYMER MONOLAYERS SPREAD AT THE AIR-WATER INTERFACE. 1. THICKNESS OF MONOLAYERS.** In this paper the applicability of ellipsometry for investigating the behavior of polymer monolayers spread at the air-water interface is explored. Polymer monolayers used in this study are poly(ethylene oxide) (PEO), poly(tetrahydrofuran) (PTHF), poly(vinyl acetate) (PVAc), poly(methyl methacrylate) (PMMA), and poly( $\gamma$ -methyl-L-glutamate) (PMLG). Their interfacial properties are discussed as a function of surface concentration and surface pressure. Moreover, the calculation of the thickness and refractive index of the polymer monolayers is performed and the conformation of polymer chains at the air-water interface is also discussed in terms of the hydrophilicity or hydrophobicity of polymers. 25 refs.

Kawaguchi, Masami (Mie Univ, Tsu, Jpn); Tohyama, Masahiro; Mutoh, Yuhji; Takahashi, Akira. *Langmuir* v 4 n 2 Mar-Apr 1988, Mol Process at Solid Surf: Spectrosc of Intermed and Adsorbate Interact, Denver, CO, USA, Apr 6-8, 1987 p 407-410.

**081961 ELLIPSOMETRIC STUDY OF POLYMER MONOLAYERS SPREAD AT THE AIR-WATER INTERFACE. 2. ADSORBED AMOUNT OF POLYMERS.** Ellipsometry has been used to calculate the refractive index and thickness of polymer monolayers of poly(ethylene oxide) (PEO), poly(tetrahydrofuran) (PTHF), poly(vinyl acetate) (PVAc), and poly(methyl methacrylate) (PMMA) spread at the air-water interface as a function of surface concentration and surface pressure. From the refractive index and thickness of the adsorbed monolayers we attempted to calculate the adsorbed amounts of polymers in the monolayers in terms of the Lorentz-Lorenz relation for an ideal mixed layer of polymer and surrounding media as a function of the refractive index  $n_s$  of the surrounding media. The adsorbed amount of polymer so calculated for  $n_s = 1$  corresponding to air is much larger than that for  $n_s = 1.334$  corresponding to water. The latter adsorbed amount is in agreement with the real spread amount of polymer in the entire surface concentration range irrespective of polymer species. This agreement indicates that the poly-

mer chains are surrounded by water molecules by taking an extended conformation normal to the water surface for PTHF and PVAc and a flattened one for PEO and PMMA at higher surface concentration. (Author abstract) 17 refs.

Kawaguchi, Masami (Mie Univ, Tsu, Jpn); Tohyama, Masahiro; Takahashi, Akira. *Langmuir* v 4 n 2 Mar-Apr 1988, Mol Process at Solid Surf: Spectrosc of Intermed and Adsorbate Interact, Denver, CO, USA, Apr 6-8, 1987 p 411-413.

**Aging** See Also DIELECTRIC MATERIALS—Aging; JOINTS—Sealants; POLYAMIDES—Aging; POLYMETHYL METHACRYLATE—Electric Properties; POLYPROPYLENE—Antioxidants.

**081962 MULTIORDERING PARAMETER MODELS OF VOLUME AND ENTHALPY RECOVERY GENERALIZED TO TREAT PHYSICAL AGING; A QUANTITATIVE INVESTIGATION.** Multiordering parameter models have been quite successful in rationalizing volume and enthalpy behavior of glasses subjected to various thermal histories in the glass transition range and even at lower temperatures. In the past we suggested a generalization of such models to encompass what is now termed physical aging, i.e., recovery as monitored by mechanical experiments such as creep and stress relaxation. Our initial investigation indicated qualitative agreement between the generalized model and experimental behavior. We have now more completely investigated this area and found a convenient approximation through which behavior can be calculated in most situations without using a distribution of mechanical relaxation or retardation times. Using this technique, we find that essentially quantitative agreement between this model and experimental results is possible only when a very sharp distribution of volumetric recovery times, like that of a single ordering parameter model, is used. (Edited author abstract) 22 refs.

Chen, Y.P. (Univ of Southern California, Los Angeles, CA, USA); Aklonis, J.J. *Polym Eng Sci* v 27 n 17 Sep 1987 p 1275-1283.

**081963 ASPECTS OF THE THERMAL AGEING OF POLYDODECANAMIDE IN A HUMID ATMOSPHERE.** Wide and small angle X-ray analysis, IR spectroscopy, viscometry and electron microscopy for chemical analysis have been employed to study the changes in the physical and chemical structure of isotropic and oriented polydodecanamide during moist heat aging. It is shown that the degradative processes occurring in the volume and on the surface of the polymer are fundamentally different. Uniaxial orientation of polydodecanamide films enhances the stability of the polymer to the action of temperature and moisture. (Author abstract) 16 refs.

Tsvankina, A.L. (USSR Acad of Sciences, USSR); Dubovik, I.I.; Neverov, A.N.; Papkov, V.S. *Polym Sci USSR* v 28 n 6 1986 p 1299-1309.

**081964 ACCELERATED AGEING OF POLYMERS UNDER THE EFFECT OF SUPERHIGH FREQUENCY RADIATION.** The results are presented of investigations into accelerated ageing of silicon-organic materials under the effect of coherent superhigh frequency radiation in the centimeter wavelength range. The experimental procedure is described. The phenomena detected are analyzed and the probable thermoelectric mechanism of accelerated ageing of silicon-organic polymers (oligomers) in the superhigh frequency field is explained. It is proposed to use decelerating systems for ageing only the surface layers of the polymer. A method of calculating the surface life of the polymer in the component on the basis of the results of superhigh frequency irradiation is proposed. (Author abstract) 28 refs.

Kuklev, Yu.I. *Phys Chem Mater Treat* v 21 n 4 Jul-Aug 1987 p 407-413.



**081965 PHYSICAL AGING OF AMORPHOUS POLY(ETHERETHERKETONE) (PEEK).** Thermal treatment of amorphous poly(aryl-ether-ether ketone) below the glass transition temperature has been studied. The extent of aging was measured by differential scanning calorimetry. X-ray and Fourier transform infrared spectra were used to study both melt-cast and annealed samples. The effect of the thermal treatment of viscoelastic response was evaluated using creep tests. Aging has been shown to be accompanied by a marked change in the transport properties of the material. (Author abstract). 19 Refs.

Carfagna, C. (Univ of Naples, Naples, Italy); Amendola, E.; D'Amore, A.; Nicolais, L. *Polym Eng Sci* v 28 n 18 Sep 1988 p 1203-1206.

**081966 MECHANISM OF AGEING IN IRRADIATED POLYMERS.** Samples of ultra-high molecular weight polyethylene (UHMWPE) and nylon 66, of grades suitable for use in medical prostheses, were subjected to irradiation using a  $^{60}\text{Co}$  source. The effects of a 10 Mrad dose on percentage crystallinity, tensile behavior and dynamic mechanical response were established 3 days after irradiation, and irradiated samples were then retested at intervals over a one year period. Crystallinity in UHMWPE was found to increase progressively during this period with consequent changes in mechanical behavior. It is proposed that the observed ageing process arises from the breakdown of metastable groups in the polymer, which are formed from the breakdown of metastable groups in the polymer, which are formed on irradiation with consequent release of long inter-lamella tie chains. This removes an inhibition to crystal perfection processes, which can occur at room temperature in polyethylene. It is proposed that the metastable species introduced on irradiation is peroxy or hydroperoxy and that this decomposes on ageing to a carbonyl group, which concurrent chain scission. (Edited author abstract). 12 Refs.

Birkinshaw, C. (Nat'l Inst for Higher Education, Irel); Buggy, M.; Daly, S.; O'Neill, M. *Polym Degradation Stab* v 22 n 3 1988 p 285-294.

**Agricultural Applications** See SOILS—Conditioners.

**Amorphous** See Also VISCOELASTICITY—Mathematical Models.

**081967 VOLUME RELAXATION AND SECONDARY TRANSITIONS IN AMORPHOUS POLYMERS.** For a number of polymers, the volume relaxation occurring after quenching from above to below glass transition temperature,  $T_g$  has been studied by length dilatometry. By varying the test temperature between  $-180^\circ\text{C}$  and  $T_g$ , the temperature regions of several secondary transitions were covered. Volume relaxation rate was found to show similar (secondary) peaks as the mechanical damping. The theoretical implications of these findings are discussed. (Edited author abstract) 23 refs.

Struik, L.C.E. (TNO, Delft, Neth). *Polymer* v 28 n 11 Oct 1987 p 1869-1875.

**081968 CONTRIBUTION OF A DIFFUSIONAL MECHANISM TO THE RELAXATION OF FREE VOLUME IN AMORPHOUS POLYMERS.** The ratio of local and diffusional mechanism of relaxation of excess free volume in amorphous polymers is discussed. On the basis of ideas on the finite lifetime of holes, a model is formulated for the relaxation of volume in accordance with a diffusional mechanism. The diffusion mechanism can be important for the volume relaxation of specimens of linear dimensions of the same order as the  $(D\tau)^{0.5}$  value, where  $\tau$  is the lifetime of a hole, and  $D$  is the effective diffusion coefficient, i.e. the contribution of the diffusional mechanism to the mechanism of relaxation depends on the specimen size. (Author abstract) 25 refs.

Bogdanova, L.M. (USSR Acad of Sciences, USSR); Irzhak, V.I.; Rozenberg, B.A. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1690-1697.

**081969 DENSIFICATION AND ORIENTATION ON POLING IN COPOLY(VINYLIDENE CYA-**

**NIDE/VINYL ACETATE) WITH THE AID OF  $^{13}\text{C}$  CP/MAS NMR SPECTROSCOPY.** Since high piezoelectricity was observed in copoly(vinylidene cyanide/vinyl acetate) [P(VDCN/VAc)], amorphous polymers have received attention as new piezoelectric materials. Recently, information concerning the molecular structure of amorphous polymers in the solid state has been successfully obtained by using cross-polarization (CP) magic-angle spinning (MAS) NMR experiments with high-power dipolar decoupling (DD). Previously, we reported the molecular dynamics of P(VDCN/VAc) and P(VDCN/MMA), (MMA = methyl methacrylate) by  $^{13}\text{C}$  CP/MAS NMR spectroscopy, where the nonequivalence of piezoelectricity in these two copolymers is found to originate from the difference of the segmental mobilities. In this communication, we report the  $^{13}\text{C}$  CP/MAS spectra of powder, drawn, and poled P(VDCN/VAc) samples and discuss the effects of drawing and poling in terms of the proton spin-lattice relaxation times in the rotating frame and the linewidths of  $^{13}\text{C}$  CP/MAS NMR spectra. Also the poling effect is elucidated by DSC measurements. 16 refs.

Tasaka, Shigeru; Miyata, Seizo. *J Polym Sci Part B* v 26 n 2 Feb 1988 p 463-466.

**081970 ELECTRICAL CONDUCTIVITY OF SOME AMORPHOUS POLYMERS.** ac Conductivity of two acrylates, namely, polymethyl methacrylate (PMMA) and polyethyl methacrylate (PEMA) have been evaluated using dielectric data in the frequency range of  $10^2$ - $10^5$  Hz and the temperature regions of 311-337.6 K and 89-114 K. A relation of the type  $\sigma = \epsilon_0 \epsilon'' \omega$  has been used for the purpose. A correlation of  $\sigma$  with the frequency of measurement has been studied. This seems to obey a relation of the type  $\sigma = A(\omega)^S$  where  $S$  lies between 0.86 to 1.0. This is in agreement with the results obtained by earlier workers on amorphous solids. An estimate of activation energy has also been made in the lower temperature region. In the higher temperature region where the cooperative phenomena occur, the variation of  $\sigma$  has been found to be nonlinear. (Author abstract) 17 refs.

Shukla, J.P. (Lucknow Univ, Lucknow, India); Gupta, Manisha. *Indian J Pure Appl Phys* v 25 n 5-6 May-Jun 1987 p 242-244.

**081971 ELECTRONIC TRANSPORT IN AMORPHOUS SILICON BACKBONE POLYMERS.** Measurements of hole transport in polysilylenes have been carried out over an extended range of temperature and field. This extended data facilitates detailed comparison to extensively characterized glassy carbon backbone polymers like poly(N-vinylcarbazole)(PVK). Hole transport data in polymethylphenylsilylene (PMPS) serves as a model and has been analyzed in both a modified Arrhenius framework and in terms of a picture of hopping in a Gaussian distribution of states broadened by disorder. The principal conclusion is that respective transport properties observed in PMPS and PVK are surprisingly similar despite the following key difference: hole or hole polaron transport in PVK does not involve states derived from the carbon backbone but rather direct hopping among pendant carbazole sidegroups which can be thought of as isolated small molecules (chromophores). Other results indicate that in polysilylenes generally, transport states probably associated with the chain backbone still remain relatively localized. (Edited author abstract) 14 refs.

Abkowitz, M. (Xerox Webster Research Cent, Webster, NY, USA); Knier, F.E.; Yuh, H.-J.; Weagley, R.J.; Stolka, M. *Solid State Commun* v 62 n 8 May 1987 p 547-550.

**081972 EFFECT OF COMBINED PRESSURE AND TEMPERATURE CHANGES ON STRUCTURAL RECOVERY OF GLASS-FORMING MATERIALS. I. EXTENSION OF THE KAHR MODEL.** There have been several basically equivalent phenomenological approaches to the modeling of the behavior of polymeric and inorganic glass-forming materials. This paper presents an extension of the KAHR model, put forward by Kovacs, Aklonis, Hutchinson, and Ramos. The KAHR model of

structural relaxation has been extended to include the effects of pressure upon the retardation times of glass-forming materials. The previously used methodology is applied with a continuous distribution of retardation times of the fractional exponential form. Several forms of the pressure dependence are examined. The combined temperature and pressure changes on structural recovery of glasses are addressed in this paper. (Edited author abstract) 23 refs.

Ramos, A.R. (Cent de Recherches sur les Macromolecules, Strasbourg, Fr); Kovacs, A.J.; O'Reilly, J.M.; Tribone, J.J.; Greener, J. *J Polym Sci Part B* v 26 n 3 Mar 1988 p 501-513.

**081973 TEMPERATURE DEPENDENCE OF RELAXATION PROCESSES IN AMORPHOUS POLYMERS.** Recently it was pointed out by Prof. D.J. Plazek that the various empirical expressions used in literature until today, to describe the temperature dependence of the relaxation processes in amorphous polymers above the glass transition temperature, failed to describe the experimental data correctly. The most widely used expression is the Vogel-Fulcher equation (V-F equation). The author used a new empirical equation used by M. Shablaikh and others to describe dielectric relaxation processes which is known in critical phase transition theory. The results of new computations taking into account the thermodynamic properties and effects on viscosity of the polymers are presented and discussed. 39 Refs.

Murthy, S.S.N. (Old Pattabhipuram, Andhra Pradesh, India). *J Polym Sci Part C* v 26 n 8 Aug 5 1988 p 361-370.

**081974 ON THE NATURE OF THE FREE VOLUME IN AMORPHOUS POLYMERS.** In a previous publication it was shown that the free volume in amorphous polymers cannot consist of empty sites according to the quasilattice model. In this paper it is demonstrated why theories which are based on the assumptions of this model are nevertheless partly successful. It is even possible to calculate all three jumplike alterations in the second derivatives of Gibbs free energy at the glass transition in accordance with the experimental results. As far as we know, this is the first time that, in addition to the steplike changes in the thermal expansion coefficient  $\Delta\alpha$  and the specific heat  $\Delta c_p$ , the analogous change in the compressibility  $\Delta\kappa_{ch}$  can also be described correctly by a theory. The parameters for accommodation however reveal, that the quasilattice model does not apply. Consequently better-founded equations are derived, which despite their simplicity, give excellent agreement with the experimental data. (Edited author abstract). 26 Refs.

Brather, A. (Univ Erlangen-Nuernberg, Erlangen, West Ger). *J Polym Sci Part B* v 26 n 9 Aug 20 1988 p 1823-1844.

**Analysis** See Also COPOLYMERS—Optical Properties; COPOLYMERS—Synthesis; MONOMERS—Polymerization; POLYMETHYL METHACRYLATE—Analysis; POLYPEPTIDES—Synthesis.

**081975 BRILLOUIN SCATTERING STUDIES OF STRUCTURAL RELAXATIONS IN POLY(PROPYLENE GLYCOL).** Structural relaxation processes in poly(propylene glycol) (PPG), molecular weight 10,000, have been examined at the high frequencies of Brillouin scattering. By combining the high-frequency results with reported photon correlation data, the relaxation time  $\tau$  is established over a wide timescale of  $1 \cdot 10^{-11}$  s. Over the whole range, the relaxation times can be described by a single equation. Single relaxation time theory does not fit the experimental results; the width is characterized by  $\beta = 0.4$  in a Williams-Watts distribution of relaxation times. The observed behavior is explained in terms of restricted local intrachain motions. (Edited author abstract) 17 refs.

Borjesson, L. (Chalmers Univ of Technology, Goteborg, Sweden); Stevens, J.R.; Torell, L.M. *Polymer* v 28 n 11 Oct 1987 p 1803-1808.



**081976 CRYSTAL STRUCTURE OF POLY(ETHYLENE OXIDE)-SODIUM IODIDE COMPLEX.** The crystal structure of poly(ethylene oxide)-sodium iodide (PEO-NaI) complex, a highly ionic conductor, was determined by the X-ray diffraction method. The crystals belong to the monoclinic system of space group  $P2_1/a$ . The molar ratio (EO:NaI) is 3:1, and there are 12 monomer units (two chains) and four NaI ion pairs in the unit cell. (Edited author abstract) 31 refs.

Chatani, Yozo (Tokyo Univ of Agriculture & Technology, Koganei, Jpn); Okamura, Sigeru. *Polymer* v 28 n 11 Oct 1987 p 1815-1820.

**081977 RELATION BETWEEN EXCIMER FORMATION IN SMALL PROBES AND FREE-VOLUME THEORY IN POLYMER MELTS.** Intramolecular excimer formation of meso-2,4-di(N-carbazolyl)pentane dissolved in different elastomers has been investigated. The intramolecular conformational change required for the excimer sampling process is shown to be controlled by the segmental motions of the polymer matrix involved in the glass transition phenomenon. The results show that, at a fixed frequency of the probe motion, the fractional free volume as well as the free volume per atomic group vary from one polymer to another. (Author abstract) 12 refs.

Bokobza, L. (ESPCI, Paris, Fr); Pham-Van-Cang, C.; Giordano, C.; Monnerie, L.; Vandendriessche, J.; De Schryver, F.C.; Kontos, E.G. *Polymer* v 28 n 11 Oct 1987 p 1876-1880.

**081978 TRENDER INOM MODERN POLYMERANALYTIK.** [Trends in Present Day Polymer Analysis]. The review describes new trends in polymer analysis, testing norms and teaching. 'Wet' methods, except for those used in fractionation, have definitely been superseded by solid state analysis methods. Data banks are increasingly being consulted, and more use is being made of semiempirical methods to correlate physical parameters with chemical reactivity and structures. However, although the theoretical methods are available already, the use of quantum chemistry as a full-fledged tool in practical applications must await the future. (Edited author abstract) In Finnish. 16 refs.

Lindberg, J. Johan (Helsingfors Univ, Helsingfors, Swed). *Keim Kem* v 13 n 10 Oct 1986 p 843-847.

**081979 TERMICKI STIMULIRANA DEPOLARIZACIJE POLIMERA.** [Thermally Stimulated Depolarization of Polymers]. A general review of thermally stimulated depolarization (TSD) analysis, a technique that has significantly contributed to the understanding of the charge behavior and molecular mobility in polymers is presented. The basic aspects of TSD are discussed: the mechanism of thermally stimulated depolarization; physical models and theories for thermally stimulated processes; manipulation and mathematical analysis of TSD data for retrieval of activation energies and related relaxation parameters; equipment devised to perform TSD current measurements; various applications of TSD. The investigations of polymers by TSD are emphasized and reviewed. 83 refs. In Serbo-Croatian.

Jelcic, Zelimir (Inst Ruder Boskovic, Zagreb, Yugosl). *Polimeri (Zagreb)* v 8 n 9 Sep 1987 p 265-268.

**081980 <sup>13</sup>C-NMR CHARACTERIZATION OF POLY(1,5-HEXADIENE).** Poly(1,5-hexadiene) was prepared and its structure characterized by high-field <sup>13</sup>C nuclear magnetic resonance. The polymer was shown to contain repeating five-membered rings separated by methylene bridges, with both cis and trans placements present in a 54:46 ratio. The result is compatible with the Marvel-Garrison two-step reaction mechanism. (Author abstract) 10 refs.

Cheng, H.N. (Hercules Inc, Wilmington, DE, USA); Khasat, N.P. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 825-829.

**081981 POLYMER-POLYMER MISCIBILITY AND ENTHALPY RELAXATIONS.** Annealing of poly-

ymers below the glass transition temperature results in a decrease in enthalpy that is recovered during heating. The enthalpy recovery is visible as an endothermic peak in a differential scanning calorimetry (DSC) scan. The position of this peak depends on the thermal treatment given and on the structure of the material itself. Because different polymers behave differently, the phenomenon can be utilized to investigate polymer-polymer miscibility of polymers with similar  $T_g$  values. Therefore, by annealing the blends at the temperature of interest and subsequent sub- $T_g$  annealing, one can monitor phase behavior resulting from the initial treatment by inspection of the enthalpy recovery. (Edited author abstract) 36 refs.

Bosma, Martin (State Univ of Groningen, Groningen, Neth); Ten Brinke, Gerrit; Ellis, Thomas S. *Macromolecules* v 21 n 5 May 1988 p 1465-1470.

**Antioxidants** See Also POLYOLEFINS—Stabilizers.

**081982 POLYMER ADDITIVES IN STABILISATION: PERFORMANCE AND MECHANISMS.** This issue of the journal contains 10 papers presented at a conference on Polymer Additives in Stabilisation: Performance and Mechanisms. Topics presented include: phenolic additives in polymers; fire retardants in polymers; oxidation processes in blue water pipe; antioxidant corrosive effects; chemiluminescence and inhibited oxidation of polypropylene; PVC degradation and thermal behaviour of bromine-metal fire retardant systems. All papers are individually abstracted. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11564 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *Polym Degradation Stab* v 20 n 3-4 1988, *Polym Addit in Stab: Perform and Mech*, Birmingham, Engl, Sep 2-4 1987 p 181-363.

**081983 MECHANISTIC ACTION OF PHENOLIC ANTIOXIDANTS IN POLYMERS - A REVIEW.** Hindered phenols are used as radical scavengers during fabrication, storage, processing and end-use of various polymers. Modern HMW antioxidants have very sophisticated molecular architectures, combining intrinsic chemical activity and the requirements of physical persistence. The mechanism of action has been discussed using the results of the elucidation of the chemical transformations which occur during the stabilisation process. Mechanisms responsible for co-operation phenomena, regenerative processes involved in homo- and heterosynergism, intramolecular co-operation in bifunctional phenolic antioxidants and co-operation pathways between hindered phenols and HALS are shown. Various catalytic species and some pigments are able to induce chemical transformation of hindered phenols and reduce their efficiency. (Author abstract) 48 refs.

Pospisil, Jan (Czechoslovak Acad of Sciences, Prague, Czech). *Polym Degradation Stab* v 20 n 3-4 1988, *Polym Addit in Stab: Perform and Mech*, Birmingham, Engl, Sep 2-4 1987 p 181-202.

**Antistatic Agents** See CARBON BLACK—Electric Conductivity.

**Applications** See Also ADHESIVES—Bonding; CATALYSTS—Materials; CERAMIC MATERIALS—Injection Molding; CHEMICALS—Synthesis; COATINGS—Curing; COATINGS—Stability; COMPOSITE MATERIALS—Nonmetallic Matrix Composites; DATA STORAGE, OPTICAL—Materials; ELECTRODES—Materials; ELECTRODES—Modification; ELECTROLYTES—Materials; ELECTROLYTES—Phase Diagrams; FLUID MECHANICS—Mathematical Models; GELS—Modification; ION EXCHANGERS—Materials; LEATHER—Tanning; LI THOGRAPHY—Materials; LUBRICANTS—Viscoelasticity; MEMBRANES—Ionic Conduction; MEMBRANES—Materials; MOISTURE DETERMINATION—Sensors; OIL WELL DRILLING—Drilling Fluids; OIL WELL PRODUCTION—Enhanced Recovery; OIL WELL PRODUCTION—Flooding; OIL WELLS—Drilling Fluids; PIGMENTS—Thin Films; RUBBER—Research; SEPARATION; SEWAGE TREATMENT—Flocculation; SILVER COMPOUNDS—Composition Effects; SOLID STATE DEVICES—Materials; STEEL HEAT TREATMENT—Quenching; TELECOMMUNICATION CABLES—Design; TEXTILES—Nonwovens; URANIUM AND ALLOYS—

Separation; WAVEGUIDES, OPTICAL—Fabrication.

**081984 SPECTROSCOPIC STUDY OF OXYGEN SORPTION AND DIFFUSION IN A MEMBRANE CONTAINING A COBALT PORPHYRIN COMPLEX.** The kinetics and equilibrium of molecular oxygen sorption in the membrane containing [α,α',α'',α'''-meso-tetrakis(o-pivalamidophenyl) porphyrinato]cobalt(II)-1-methylimidazole (CoPlm) complex which forms oxygen adduct rapidly and reversibly are studied spectroscopically. Oxygen sorption in the membrane containing the complex is interpreted in terms of dual mode sorption, whereby the sorbed oxygen exists as two populations: one sorbed to a polymer matrix according to Henry's law and the other to the fixed complex according to the Langmuir isotherm. The diffusion of oxygen in the membrane is found to be Fickian. Apparent oxygen diffusivity increases with an increase in the upstream oxygen pressure, which is in accordance with the dual mode transport model. (Author abstract) 16 refs.

Nishide, Hiroyuki (Waseda Univ, Tokyo, Jpn); Ohyanagi, Manshi; Okada, Osamu; Tsuchida, Eishun. *Polym J* v 19 n 7 1987 p 839-844.

**081985 POLYMERS AS SUBSTRATES AND MEDIA FOR DATA STORAGE.** Technological developments in the 1990s will be determined by progress in the field of microelectronics, particularly with regard to information processing and data storage. Progress in information storage is directly related to the ability to store large amounts of data in the smallest possible space, preferably in erasable form. Polymers are used as components in the standard storage systems of today: as carrier films for magnetic tapes, as photoresists and electron beam resists, and as substrates for magnetic and optical discs used for music or video replication and data storage. This progress report describes the current state of the art and compares the various developments in an attempt to forecast the possible significance of polymer memories with high data packaging densities in relation to the established technologies. (Edited author abstract) 64 refs.

Kaempf, G. (Bayer AG, Leverkusen, West Ger); Loewer, H.; Witman, M.W. *Polym Eng Sci* v 27 n 19 Oct 1987 p 1421-1435.

**081986 THERMOTROPIC LIQUID CRYSTAL POLYMERS.** Small organic molecules can form liquid crystals, at or close to room temperature; as commonly known, these find many applications in the fabrication of electrooptical devices. This paper is not about those compounds; it is instead about a new class of polymeric materials that melt at high temperatures into fluids exhibiting liquid crystalline order. 28 refs.

Stupp, Samuel I. (Univ of Illinois, Urbana-Champaign, IL, USA). *Chem Eng Prog* v 83 n 12 Dec 1987 p 17-22.

**081987 POLYUREA RIM: NOVEL APPLICATIONS AND TECHNICAL ADVANCES.** Polyurea RIM systems with an almost limitless degree of versatility can be formulated using a wide variety of amine chain extenders and isocyanates. Formulations have been developed to make soft elastomers as well as stiff, hard elastoplastics. The authors hope that the polyurea RIM materials discussed here will interest product designers to the point where they will test the limits of application of these materials by their imagination. 18 refs.

Dominguez, R.J.G. (Texaco Chemical Co, Austin, TX, USA); Rice, D.M.; Grigsby, R.A. Jr. *J Elastomers Plast* v 19 n 4 Oct 1987 p 275-286.

**081988 WB MULTIPOLYMERS HAVE BETTER THERMAL STABILITY AND ADHESION.** New multipolymer latex systems have been produced to aid in the formulation of high performance waterborne adhesives. Acrylated silicone, acrylated silicone-urethanes and acry-



lated urethane resins have been shown to have increased thermal stability and improved adhesion to a variety of substrates.

Kelly, Robert R. (Harwick Chemical Corp, Akron, OH, USA); Alexander, Robert R. *Adhes Age* v 31 n 2 Feb 1988 p 26-27.

**081989 PRIMJENA POLIMERA U NAFTNOJ INDUSTRIJI.** [Application of Polymers in the Petroleum Industry]. The paper describes the use of polymers as additives in many phases of drilling, crude production, transportation and processing, production of motor gasolines, distillates and heavy fuel oils, engine oils, industrial oils, greases, waxes, asphalts, and in pollution abatement. Some of the author's results are presented relating to the synthesis and application of polymer additives for improved drilling and flow behavior of crude also and as viscosity modifiers in lubricants. (Edited author abstract) In Serbo-Croatian. 188 refs.

Kurešević, Vjera (INA-Research & Development, Zagreb, Yugoslavia). *Polimeri (Zagreb)* v 8 n 10-11 Oct-Nov 1987 p 307-311.

**081990 APPLICATIONS OF POLYMERS IN SOLAR ENERGY UTILIZATION.** During the last decade, considerable interest has developed in both research institutions and industry, in the application of polymers in the following areas of solar energy utilization: solar energy technologies, solar energy storage, photosensitized reduction of water in microheterogeneous systems, photoelectrochemical systems, and artificial photosynthesis. This review describes these areas and shows where polymers and polymeric materials (plastics) can be employed. The interfaces of the different disciplines such as photochemistry and polymer chemistry (or polymer materials science) provide new productive areas of science and technology. This review also gives new ideas to polymer chemists and polymer technologists as to how and where to apply polymers for solar energy utilization. 406 refs.

Rabek, Jan F. (Royal Inst of Technology, Stockholm, Sweden). *Prog Polym Sci (Oxford)* v 13 n 2 1988 p 83-188.

**081991 SPECIAL POLYMERS SAVE ENERGY.** Many advances have been made in internal boiler water chemistry since the time potato peels, chestnut barks, and seaweed were first used to inhibit scale in boilers. These types of compounds leached naturally occurring polymers to help distort the crystalline structure of calcium carbonate. Operators of boilers and locomotive engines found that incrustation of boiler tubes was reduced with these commonly available additives. The paper discusses how modern dispersing polymers coupled with surveillance software reduce high blowdown rates that waste large amounts of heat in boiler water.

Binkowski, R.O. (Metropolitan Refining Co, Long Island City, NY, USA). *Heat Piping Air Cond* v 60 n 7 Jul 1988 p 99-100.

**081992 MATHEMATICAL MODEL FOR PREDICTING CYCLIC VOLTAMMOGRAMS OF ELECTRONICALLY CONDUCTIVE POLYPYRROLE.** Polypyrrole is an attractive polymer for use as a high energy density secondary battery because of its potential as an inexpensive, lightweight, and noncorrosive electrode material. A mathematical model to simulate cyclic voltammograms for polypyrrole is presented. The model is for a conductive porous electrode film on a rotating disk electrode (RDE) and is used to predict the spatial and time dependence of concentration, overpotential, and stored charge profiles within a polypyrrole film. The model includes both faradaic and capacitive charge components in the total current density expression. (Edited author abstract). 17 Refs.

Yeu, Taewhan (Texas A&M Univ, College Station, TX, USA); Nguyen, Trung V.; White, Ralph E. *J Electrochem Soc* v 135 n 8 Aug 1988 p 1971-1976.

## Association

**081993 ASSOCIATION PHENOMENA IN MACROMOLECULAR SYSTEMS - INFLUENCE OF MACROMOLECULAR CONSTRAINTS ON THE COMPLEX FORMATION.** A theoretical model is presented to describe the association behavior of interacting units attached to a polymer chain. A polymer chain of  $i$  functional groups distributed statistically along the chain is considered. A mean field approach is used to derive the probability that the  $k$ th functional group forms a complex, if  $k - 1$  groups are already complexed. As a result of the fact that the associating units are linked to the polymer chain, the fraction of complexed units is reduced compared to the corresponding association behavior of low molecular weight compounds. The magnitude of these topological restrictions depends on the molecular weight, the concentration of the functional groups, the equilibrium constant for the 'free' association, and the conformational properties of the chain. (Author abstract) 25 refs.

Stadler, Reimund (Inst fuer Makromolekulare Chemie, Freiburg, West Ger). *Macromolecules* v 21 n 1 Jan 1988 p 121-126.

**Biocompatibility** See Also PROSTHETICS—Blood Vessel Prostheses.

**081994 STUDY ON IN VITRO THROMBUS FORMATION IN A MOVING STREAM OF BLOOD FOR EVALUATING HEMOCOMPATIBILITY OF POLYMERIC BIOMATERIALS.** In 1958 Chandler invented an apparatus for in vitro thrombus formation. The apparatus consists of a small ring formed by joining the two ends of a plastic tube a few millimeters in diameter. In operation about half of the ring is filled with blood and the ring is spun vertically. At the lower part of the arc of the ring the thrombus can be formed. In employing the Chandler apparatus, the present investigation employed blood from a healthy subject instead of blood from a patient as the standard. At the same time, instead of the standard plastic tube employed in clinical tests, some materials are tested to determine the influence of parameters such as spin velocity and contact time on the compatibility of medical polymers to blood in relation to in vitro thrombus formation. In Chinese.

Xi, Ting-fei (Nat'l Inst for the Control of Pharmaceutical & Biological Products, Beijing, China); Tian, Wu-hua; Wang, Chun-ren; Chang, Yia-jiu; Chang, Wen-long; Zhou, Cheng-fei; Lei, Xue-hui. *Zhongguo Shengwu Yixue Gongcheng Xuebao* v 6 n 4 Dec 1987 p 245-247.

**081995 HUMAN MONOCYTE/MACROPHAGE ACTIVATION AND INTERLEUKIN 1 GENERATION BY BIOMEDICAL POLYMERS.** In vitro cell culture techniques were used to evaluate the effect of several clinically significant biomedical polymers on monocyte activation and Interleukin 1 (IL1) production. Isolated human peripheral blood monocytes were cultured in the presence of a panel of five biomedical polymers routinely used in a variety of clinical applications: Polyethylene (PE), silica-free polydimethylsiloxane (PDMS), woven Dacron fabric, expanded polytetrafluoroethylene (ePTFE) and the segmented polyurethane, Biomer. Monocytes generated IL1 in the presence of all five materials. Maximal levels of IL1 were generated at 24 h in monocyte-polymer cultures supplemented with serum and additionally stimulated with lipopolysaccharide (LPS). Statistically significant differences in IL1 production were observed between polymers, allowing their classification according to reactivity. (Edited author abstract). 58 Refs.

Miller, K.M. (Case Western Reserve Univ, Cleveland, OH, USA); Anderson, J.M. *J Biomed Mater Res* v 22 n 8 Aug 1988 p 713-731.

**081996 FIFTH INTERNATIONAL CONFERENCE: POLYMERS IN MEDICINE AND SURGERY.** This conference contains 48 papers. Some of the topics covered included polymer biocompatibility, rubber and hydrogel biomaterials, surgical implants, plastic implant mechanical properties, cell-polymer interactions, infection-resistant plastics, biodegradable materials, dextran plasma

volume expander, polymer surface properties, cell adhesion in vascular graft materials, heparin conjugate treated polymer, membrane biocompatibility, blood complement activation, extracorporeal blood purification, polyether biomaterials, silicone gel scar treatment, ocular implant polymers, arterial wall regeneration, artificial heart valve leaflets, pharmaceutical interactions, targeted conjugate blood polymers, polymer-modified enzymes, suture biocompatibility and in-vitro alternative techniques to in-vivo toxicologic evaluation of biomedical polymers. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11134 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Plastics & Rubber Inst, London, Engl). *Fifth Int Conf: Polym in Med and Surgery, Noordwijkerhout, Neth, Sep 10-12 1986* Publ by Plastics & Rubber Inst, London, Engl, 1986 var pagings.

**Biodegradation** See Also POLYETHYLENES—Biodegradation; POLYPEPTIDES—Biodegradation; POLYSULFIDES—Sealing.

**081997 BIODEGRADATION OF POLY(SODIUM VINILOXYACETATE) AND ITS COPOLYMERS.** Poly(sodium vinylxyacetate) (PVOA) was prepared and the biodegradation was studied to develop a polyvinyl-type biodegradable polyelectrolyte. PVOA may be converted readily to biodegradable poly(vinyl alcohol) by ordinary microbial reactions such as hydrolytic splitting of the pendant oxyacetic acid group. PVOA was found to be biodegraded by many microbial strains in soil and activated sludge obtained from a municipal sewage plant. *Bacillus cereus* LC, *Agrobacterium* sp. SC, *Cellulomonas* sp. Y1C and Y2C, *Aeromonas* sp. WC, *Pseudomonas* sp. T10 as bacterial strains and *Trichosporon cutaneum* RC as a yeast strain were isolated as PVOA-degrading strains. Copolymers containing vinylxyacetate units showed improved biodegradability, suggesting the vinylxyacetate unit to be useful as a biodegrading unit in copolymers. (Author abstract) 8 refs. In Japanese.

Matsumura, Shuichi (Keio Univ, Yokohama, Jpn); Takahashi, Jun; Maeda, Shuichi; Yoshihara, Sadao. *Kobunshi Ronbunshu* v 45 n 4 1988 p 325-331.

## Biosynthesis

**081998 POLYMER SYNTHESIS BY MICROORGANISMS: TECHNOLOGY AND ECONOMICS.** Although biopolymers are of much interest in industry, only a small number of biopolymers are employed by industry. Poly-β-hydroxybutyrate (PHB) is a biodegradable, biocompatible thermoplastic made by microorganisms. It can be formed into films, fibers and sheets and molded into shapes and bottles. *Alcaligenes eutrophus*, among several other microorganisms, appears to be the most satisfactory candidate for synthesizing the polymer, and glucose appears to be the best substrate. Through solvent extraction, recoveries of greater than 90% of the polymer in cells can be achieved. The PHB, a low bulk density white powder, is finally vacuum dried.

Byrom, D. (Imperial Chemical Industries PLC, Billingham, Engl). *Trends Biotechnol* v 5 n 9 Sep 1987 p 246-250.

**Blending** See Also BLOCK COPOLYMERS—Crystallization; CARBON FIBER—Mechanical Properties; CRYSTALS, LIQUID; CRYSTALS, LIQUID—Mixing; ELECTROLYTES—Materials; FLUORINE CONTAINING POLYMERS—Phase Transitions; HYDROGEN—Bonding; PACKAGING MATERIALS—Permeability; POLYESTERS—Thermal Properties; POLYETHYLENES—Linear Low Density; POLYMETHYL METHACRYLATE—Physical Properties; POLYSTYRENES—Blending; POLYURETHANES—Mechanical Properties; POLYVINYL ALCOHOL—Physical Properties; RUBBER, SYNTHETIC—Mechanical Properties; SYNTHETIC FIBERS—Spinning; YARN—Synthetic Materials.



**081999** MISCIBILITY AND THERMAL DECOMPOSITION IN PHENOXY/POLY(ETHYLENE TEREPHTHALATE) AND PHENOXY/POLY(BUTYLENE TEREPHTHALATE) BLENDS. In this work the thermal decomposition of blends of a copolymer of bisphenol-A and epichlorohydrin (phenoxy) with two polyesters, poly(ethylene terephthalate) (PET) and poly(butylene terephthalate) (PBT) has been studied by means of thermogravimetric analysis. The possible influence of the degree of miscibility on the degradation processes has been considered. (Author abstract) 7 refs.

Eguiazabal, J.I. (Univ del Pais Vasco, San Sebastian, Spain); Iruin, J.J. *Mater Chem Phys* v 18 n 1-2 Oct 1987 p 147-154.

**082000** THERMALLY STIMULATED DISCHARGE CURRENT STUDIES ON PMMA-PVAc BLENDS. Thermally stimulated discharge current (TSDC) studies have been carried out on blends of polymethyl methacrylate (PMMA) and polyvinyl acetate (PVA). The effects of polarization temperature and field on the TSDC peaks of polyblends indicate that the polarization in the polyblends is due to charge-carrier trapping in deep traps which leads to induced dipole formation. The results of a.c. dielectric bridge measurements are also compared with the TSDC results. The dielectric relaxation parameters are also reported. (Author abstract) 16 refs.

Sekar, R. (Indian Inst of Technology, New Delhi, India); Tripathi, Anita; Goel, T.C.; Pillai, P.K.C. *J Mater Sci* v 22 n 9 Sep 1987 p 3353-3360.

**082001** ESCA AND FT-IR STUDIES ON BOUNDARY-PHASE STRUCTURE BETWEEN BLEND POLYMERS AND POLYAMIDE SUBSTRATE. Electron spectroscopy for chemical analysis (ESCA) and Fourier-transform infrared (FT-IR) attenuated total reflection (ATR) studies have been made on the film of blend polymers consisting of poly(hydroxypropyl ether) of bisphenol A (P) and poly(ethylene oxide) (E) or P and poly(ethylene adipate) (A) formed on nylon-6 (Ny) substrate to investigate the boundary-phase structure between the substrate and the polymer blends. For the case of P/A blend, A is enriched to the depths probed by both ESCA (below ca. 60 Å) and FT-IR-ATR (below ca. 0.7 µm) from the nylon-6 surface. For the P/E blend, though P is enriched to the depth probed by ESCA from the Ny surface, the enrichment of neither of the blend components can be found to the depth probed by FT-IR-ATR. These results indicate the different susceptibility between P/A and P/E blends to the influence from the Ny substrate. (Author abstract) 16 refs.

Kodama, Minekazu (Mitsubishi Electric Corp, Amagasaki, Jpn); Kuramoto, Kazuo; Karino, Isamu. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1889-1900.

**082002** CHARACTERIZATION OF RIGID-ROD MOLECULAR COMPOSITES BY PHOTOTHERMAL AND ULTRASONIC IMAGING. Data are presented with demonstrate that photothermal and ultrasonic imaging can resolve the components of a phase-separated molecular composite with 55% poly(p-phenylene benzobisthiazole) (PBT) and 45% nylon 66. PBT-rich particles in the 10-50 µm size range are present after heating above the melting temperature of nylon. Other types of morphological, thermal and elastic information about the composite could be obtained by both techniques for a variety of samples. (Author abstract) 17 refs.

MacLachlan, J.W. (Johns Hopkins Univ, Baltimore, MD, USA); Madey, M.; Eby, R.K.; Adams, W.W. *Polym Commun (Guildford Engl)* v 28 n 12 Dec 1987 p 326-329.

**082003** PHASE BEHAVIOUR OF POLYSULPHONE WITH POLY(ETHYLENE OXIDE) AND PHENOXY POLYMERS. Polysulphone, PSn, is shown to have only limited miscibility with relatively low molecular weight poly(ethylene oxide), PEO. In this study, clear, homogeneous blends were only obtained for high PSn contents (> 40 wt%) for temperatures between the melting temperature of the PEO component and the

cloud point curve. With higher molecular weight PEO, heterogeneous blends were obtained over the whole range of compositions. Blends of PSn with a phenoxy polymer were found to be heterogeneous over the entire composition range. (Author abstract) 15 refs.

Swinyard, B.T. (Imperial Coll, London, Engl); Barrie, J.A.; Walsh, D.J. *Polym Commun (Guildford Engl)* v 28 n 12 Dec 1987 p 331-333.

**082004** ON THE COMPATIBILITY AND THERMALLY INDUCED BLENDING OF POLY(STYRENE PHOSPHONATE DIETHYL ESTER) WITH CELLULOSE ACETATE. The miscibility of poly(styrene phosphonate diethyl ester) (PSP) with cellulose acetate (CA) was studied. Experiments were designed to prove that these polymers are a miscible pair. The study revealed that when blends were prepared from a solution with partially phosphorylated polystyrene, favourable conditions for crystallization of the cellulose acetate prevailed. Upon conversion of the crystalline regions into amorphous domains - as done by heating the sample in a differential scanning calorimeter - an amorphous homogeneous blend spontaneously formed. The results of this study revealed that PSP is miscible with CA at a lower degree of phosphorylation than previously thought; thus, one phosphoryl ester per six styrene units in PSP will still render this polymer miscible with cellulose acetate. (Edited author abstract) 8 refs.

Gardiner, Eric (State Univ of New York, Syracuse, NY, USA); Cabasso, Israel. *Polymer* v 28 n 12 Nov 1987 p 2052-2056.

**082005** ENTANGLEMENT, FRICTION, AND FREE VOLUME BETWEEN DISSIMILAR CHAINS IN COMPATIBLE POLYMER BLENDS. Dynamic oscillation, shear creep, and time-temperature superposition are used to study the entanglement, friction, and free volume between dissimilar chains in compatible polymer blends: PMMA/PEO, PMMA/PVDF, PMMA/SAN, and PS/PPO. It is found that interchain specific interactions, responsible for the compatibility tend to reduce the entanglement but increase the friction between dissimilar chains. The former appears to arise from local reduction of chain convolution due to segmental alignment and the latter from increased interchain attraction. The entanglement probability and the friction coefficient between dissimilar chains correlate with the strength of specific interactions. On the other hand, the free volume tends to be linearly additive but may deviate either positively or negatively, apparently influenced by segmental conformation and packing rather than specific interactions. The reduced entanglement and the free volume additivity tend to reduce the melt viscosity, while the increased friction tends to increase it. (Edited author abstract) 28 refs.

Wu, Souheng (DuPont, Wilmington, DE, USA). *J Polym Sci Part B* v 25 n 12 Dec 1987 p 2511-2529.

**082006** HOW WELL DO VARIOUS BLENDS OF LCP AND NYLON 12 WORK? Liquid-crystal polymers (LCPs) represent a new class of materials with unique chemical and physical properties based on unique molecular relationships. Although many macroscopic properties of LCPs are extremely advantageous, the costs associated with production of these materials are high. The blending of a conventional resin with an LCP can produce improvements in cost effectiveness and can yield novel chemical and physical results. The blending of a thermotropic LCP with less expensive nylon 12 has yielded a spectrum of materials exhibiting a wide range of interesting properties.

Chung, Tai-Shung (Celanese Specialties Operation, Summit, NJ, USA). *Plast Eng* v 43 n 10 Oct 1987 p 39-41.

**082007** X-RAY AND NEUTRON SCATTERING STUDIES OF POLY(ESTER CARBONATE)/POLY(ETHYLENE TEREPHTHALATE) ALLOYS. Quenched blends of poly(ester carbonate) (PEC) and poly(ethylene terephthalate) (PET) have a single  $T_g$  and behave as single-phase amorphous alloys up to 67% PET. However, small-angle neutron scattering (SANS) data

show that the PET molecules are not statistically distributed as classical Gaussian coils in the PEC matrix. In quenched amorphous PEC-rich films (a single phase), PET-rich domains of varying PET concentration appear to be randomly distributed in the PEC matrix, and the excess SANS intensity is attributable to fluctuations in PET concentrations. Wide- and small-angle X-ray scattering data and SANS results show incomplete phase separation of PET and PEC molecules upon annealing. A possible model for annealed blends (two phases) might be domains of folded-chain, crystalline PET with interlamellar amorphous regions composed of a mixture of PET and PEC molecules. These domains are dispersed in the amorphous PEC matrix. (Author abstract) 8 refs.

Murthy, N.S. (Allied Corp, Morristown, NJ, USA); Aharoni, S.M. *Polymer* v 28 n 13 Dec 1987 p 2171-2175.

**082008** POLYMER-POLYMER INTERACTION PARAMETER DETERMINED BY INVERSE GAS CHROMATOGRAPHY. Inverse gas chromatography was employed to determine the apparent polymer-polymer interaction parameter for the following blends using them as binary stationary phases: poly(vinyl acetate)-poly(n-butyl methacrylate) at 100 and 120°C, poly(vinyl acetate)-atactic-poly(vinyl isobutyl ether) at 70°C, and poly(n-butyl methacrylate)-atactic poly(vinyl isobutyl ether) at 70°C. The interaction parameter depended significantly on the chemical nature of the solvent (probe) used and the composition of the stationary phase. The lowest values were obtained when aromatic and chlorinated-alkane probes were eluted on stationary phases having weight fractional compositions of the component polymers in the range 0.4-0.6. The results predict a better compatibility for poly(n-butyl methacrylate)-atactic poly(vinyl isobutyl ether) than for the other blends. (Edited author abstract) 32 refs.

Tyagi, O.S. (CSIR, Hyderabad, India); Sajjad, S.M.; Husain, Sajid. *Polymer* v 28 n 13 Dec 1987 p 2329-2334.

**082009** STUDIES ON THE MORPHOLOGY OF BLENDS OF POLY(VINYL CHLORIDE) AND SEGMENTED POLYURETHANES. Solution-cast specimens of poly(vinyl chloride)/polyurethane (PVC/PU) blends were studied by means of infra-red, differential scanning calorimetry and dynamic mechanical measurements. Polyurethanes with polycaprolactone, poly(tetramethylene adipate), poly(tetramethylene oxide) and poly(propylene oxide) of the same molecular weight (1000) were used. The results indicate that it is possible to change the morphology of the blends significantly by proper selection of the structure of the soft segments. The polyester soft segments are more compatible with PVC than are the polyether ones. Hydrogen bonding of NH groups with the urethane carbonyl of the hard segments and with the ester carbonyl and ether oxygen of the soft segments was studied by applying a curve resolution technique to the NH and carbonyl stretching vibration absorption peaks of the blends. (Edited author abstract) 30 refs.

Xiao, Fengfei (Acad Sinica, Beijing, China); Shen, Deyan; Zhang, Xian; Hu, Shiru; Xu, Mao. *Polymer* v 28 n 13 Dec 1987 p 2335-2345.

**082010** THERMAL CHARACTERIZATION OF BISMALEIMIDE BLENDS. 4,4'-bismaleimidophenyl methane (BM) and 3,3'-bismaleimidophenyl sulfone (BS) were blended in solution using weight ratios 3:1 (MS31), 2:1 (MS21), 1:1 (MS11), 1:2 (MS12) and 1:3 (MS13). Chain extended bismaleimide resins were also prepared by treating BS/BM with 4,4'-diaminodiphenyl ether in molar ratios of 1:0.3 (BM-E and BS-E resins). These resins were also blended with bismaleimides and the curing characteristics were evaluated by differential scanning calorimetry. Increase in BM content in BM:BS blends or increase in chain extended bismaleimide content in BM-E:BS or BS-E:BM blends resulted in a reduction of melting and curing temperatures. Indication about the extent of cross-linking was obtained from solubility measurements (in DMF) of isothermally cured resins (180°C, 1h and



220°C, 1h in an air oven). Thermogravimetric analysis of samples isothermally cured at 180°C and 220°C (1h each) was carried out in nitrogen atmosphere. Improvement in thermal stability of chain extended bismaleimides was observed on blending. (Author abstract) 16 refs.

Varma, I.K. (Indian Inst of Technology, New Delhi, India); Tiwari, R. *J Therm Anal* v 32 n 4 Jul-Aug 1987 p 1023-1038.

**082011 POLYMER BLENDING CAN YIELD STRONG FILMS.** Dow's 'Saran' family of vinylidene chloride polymer and copolymers (PVDC) exhibit fine qualities but also low melt strength and a lack of toughness and rigidity. On the other hand, polystyrene is inexpensive and has good melt strength and rigidity. In this article, we discuss blends of PVDC copolymers with styrenic polymers and copolymers. For this purpose, we studied blend morphology, as well as barrier, optical, and physical properties. In the case we have studied, the polystyrene and styrene/MMA methyl methacrylate polymer added to the polyvinylidene chloride copolymer have led to increased melt strength and greater rigidity than had previously been possible in a transparent polymer. Not only was the product thermoformable, but it also was a good oxygen barrier - an excellent candidate for a good-packaging material. 5 refs.

Sun, Yun C. (Dow Chemical Co). *Res Dev (New York)* v 29 n 8 Aug 1987 p 78-81.

**082012 POLYBLENDS.** In 1983, the consumption of thermoplastic polyblends in West Europe was estimated at about 450000 t. The volume consumed in 1986 has climbed to about 580000 t, corresponding an average growth of 9% per annum. Basically, three categories of starting products are available for the formation of polyblends: semicrystalline thermoplastics amorphous materials and the various modifiers and mixing aids. The presented description of technically efficient polyblends shows that blend technology continues to make possible significant advances in engineering thermoplastics, and it can reliably be assumed that the possibilities of achieving new improvements in properties or new combinations of properties by the tailored combination of more or less well known thermoplastics are by no means exhausted. 2 refs.

Witt, W. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 45-46.

**082013 THERMODYNAMIC PROPERTIES OF CHAIN LIQUID MIXTURES WITH STRONG, LOCAL INTERACTIONS.** This paper addresses the effect in chain liquids on thermodynamic behavior of a large change in the strength of local interactions on mixing. We classified real systems according to the ability of the Flory equation of state (FES) theory to predict the excess volume. The FES theory enables reliable estimates provided the mixture is nearly athermal and the pure components obey the Flory equation of state. (Edited author abstract) 32 refs.

Durning, C.J. (Columbia Univ, New York, NY, USA); Secor, R.M. *J Polym Sci Part B* v 26 n 1 Jan 1988 p 91-112.

**082014 INFLUENCE OF MOLECULAR WEIGHT DISTRIBUTION ON THE LINEAR VISCOELASTIC PROPERTIES OF POLYMER BLENDS.** Literature data for the dynamic viscoelastic properties of binary blends of nearly monodisperse polybutadienes, polystyrene, and poly(methyl methacrylate)s was analyzed using logarithmic plots of dynamic storage modulus  $G'$  versus loss modulus  $G''$ , based on a recent theoretical study by C.D. Han and M.S. Jhon. The experimentally observed dependence of  $G'$  on blend composition in  $\log G' - \log G''$  plots is favorably compared to the theoretical prediction of a blending law proposed by J.P. Montfort and co-workers. (Edited author abstract) 52 refs.

Dae Han, Chang (Polytechnic Univ, Brooklyn, NY, USA). *J Appl Polym Sci* v 35 n 1 Jan 1988 p 167-213.

**082015 VISCOSITY OF HOMOGENEOUS POLYMER BLENDS: AN ALTERED FREE-VOLUME STATE MODEL.** An altered free-volume state (AFVS)

model was developed for the zero-shear viscosity of homogeneous polymer blends. The model involves a single adjustable parameter and is capable of predicting several complex features of the blend viscosity-composition behavior. These include negative and positive deviations from additivity, maxima, minima, and sigma-shaped curves. The validity of the model was tested by comparison of the model predictions with experimental data for several homogeneous blend systems. It is shown that the model is valid within a broad molecular weight range and is more accurate than some of the currently accepted models such as the kinetic network model. (Edited author abstract) 43 refs.

Sood, R. (Natl Chemical Lab, Poona, India); Kulkarni, M.G.; Dutta, A.; Mashelkar, R.A. *Polym Eng Sci* v 28 n 1 Mid-Jan 1988 p 20-31.

**082016 INTERCHAIN ELECTRON DONOR-ACCEPTOR COMPLEXES. DETERMINATION OF EQUILIBRIUM CONSTANT AND THERMODYNAMIC PARAMETERS IN THE SOLID STATE.** The interpolymeric electron donor-acceptor (EDA) complex of donor poly[(N-ethylcarbazol-3-yl)methyl methacrylate] (PHMCM-2) with acceptor poly-2-[(3,5-dinitrobenzoyloxy)ethyl methacrylate] (PDNBM-2) presents a single glass transition temperature and a decomplexation endotherm on different scanning calorimetric (DSC) thermograms. This system is considered a 'polymer blend model' which exhibits a lower critical solution temperature (LCST). Phase separation of this blend is kinetically controlled and positive deviations of the glass transition temperatures from weight average values suggest that it behaves as a thermally reversible crosslinked network. The results are supported by a composition-independent, 'horizontal line' phase diagram, thus resembling the completely complexed/denaturation process in DNA. (Edited author abstract) 49 refs.

Percec, Virgil (Case Western Reserve Univ, Cleveland, OH, USA); Schild, Howard G.; Rodriguez-Parada, Jose M.; Pugh, Coleen. *J Polym Sci Part A* v 26 n 3 Mar 1988 p 935-951.

**082017 MECHANICAL PROPERTIES OF POLY(VINYL CHLORIDE)-POLY(ACRYLONITRILE-COBUTADIENE) BLENDS WITH MODULATED STRUCTURE.** Mechanical properties were investigated by the uniaxial tensile test combined with small angle light scattering. A 50:50 plastic-rubber blend has a high initial modulus which is close to that of the rigid plastic. Nevertheless, it can deform to a large extension ratio up to 6. It cannot immediately recover to its original length after the stress-strain test. However, after release from the instrument the film gradually shrinks to its original length at room temperature. After strain recovery the film shows a stress-strain curve almost identical to the original. The stretched film healed by resting at room temperature. A helical spring model interprets well the dependence of Young's modulus on the blend composition and the periodic distance of the modulated structure. (Edited author abstract) 10 refs.

Ougizawa, Toshiaki (Tokyo Inst of Technology, Tokyo, Jpn); Inoue, Takashi. *J Mater Sci* v 23 n 2 Feb 1988 p 718-722.

**082018 UPPER CRITICAL SOLUTION TEMPERATURE BEHAVIOUR IN POLY(ETHER ETHER SULPHONE)/POLY(ETHER ETHER KETONE-CO-ETHER ETHER SULPHONE) BLENDS.** Upper critical solution temperature phase behavior was found in blends of the homopolymer poly(oxy-1,4-phenyleneoxy-1,4-phenylenesulphonyl-1,4-phenylene) (PEES) with the copolymer poly(oxy-1,4-phenyleneoxy-1,4-phenylenecarbonyl-1,4-phenylene-co-oxy-1,4-phenyleneoxy-1,4-phenylenesulphonyl-1,4-phenylene) (CO-PEESK) for copolymer compositions ranging from 43 to 56 mol% of ether ether ketone (EEK) repeat units. Blend compositions studied ranged from 25 to 75 wt% of PEES. The consolute temperature was found to occur at a PEES/COPEESK blend composition of about 50/50 wt% and to increase with the EEK repeat unit content of the copolymer. This miscibility behavior was interpreted,

using a mean-field theoretical approach, in terms of a single positive segmental interaction parameter which ranged from 0.054 to 0.032. (Edited author abstract) 28 refs.

Sham, C.K. (Univ of Massachusetts, Amherst, MS, USA); Lau, C.H.; Williams, D.J.; Karasz, F.E.; MacKnight, W.J. *Br Polym J* v 20 n 2 1988 p 149-155.

**082019 COMPATIBILIZER-AIDED TOUGHENING IN POLYMER BLENDS CONSISTING OF BRITTLE POLYMER PARTICLES DISPERSED IN A DUCTILE POLYMER MATRIX.** Blending brittle polymer particles in a ductile polymer matrix is a new way to obtain toughened plastics. Although the nylon-6/poly(acrylonitrile-co-styrene) (SAN) system is a ductile/brittle combination, the blend does not result in a toughened plastic. We have investigated the effect of adding a small amount of a third component, poly(styrene-co-maleic anhydride) (SMA), to the nylon/SAN system. SMA significantly improves; the tensile and impact strength of the blend. Morphological observations indicate a finer dispersion of the SAN particles when SMA is present in the blend. The improved dispersion is attributed to the formation of nylon-SMA graft copolymer. (Edited author abstract) 13 refs.

Angoa, Juan C. (Tokyo Inst of Technology, Tokyo, Jpn); Fujita, Yuji; Sakai, Tetsuya; Inoue, Takashi. *J Polym Sci Part B* v 26 n 4 Apr 1988 p 807-816.

**082020 RHEOLOGY OF A MISCIBLE POLYMER BLEND.** Difference spectra of blends of cis-1,4-polyisoprene and atactic poly(vinylethylene), obtained from the measured FTIR spectra of the pure components and the blends, indicate that mixing of these polymers is not accompanied by any specific chemical interactions. Miscibility in this system arises solely due to the small combinatorial entropy of mixing. The conformation and configuration of the polymer chains in the blends are, therefore, identical to those in the pure melts. As a consequence it was found that the entanglement density of the blends varied monotonically with composition. This variation, however, was not in accordance with predictions based simply on the mechanical interaction density. The principle rheological effect of miscible blending was a large change in the monomeric friction coefficient, which arises from the strong dependence of free volume on composition. The zero shear viscosity and the terminal relaxation time of the blends reflected this change in local chain mobility. Empirical relations, which have previously been proposed for the properties of miscible polymer mixtures, were found to be without merit in describing the obtained experimental results. (Author abstract) 35 refs.

Roland, C.M. (US Naval Research Lab, Washington, DC, USA). *J Polym Sci Part B* v 26 n 4 Apr 1988 p 839-856.

**082021 HYDROGEN BONDING IN POLYMER BLENDS. 1. FTIR STUDIES OF URETHANE-ETHER BLENDS.** The most common strong interaction in polymers, and one that is central to the properties and phase behavior of a range of important materials, is hydrogen bonding. Infrared spectroscopy is uniquely sensitive to, and considered diagnostic for, the formation of such bonds, and in recent publications we have explored the problems of using this technique to quantitatively measure the fraction of hydrogen-bonded groups in polyamides and polyurethanes. In this paper we will consider the mixing of a simple amorphous polyurethane with a polyether. This system was chosen because of its relevance to the more complicated segmented polyurethanes and in its essentials is focused upon the spectroscopic characteristics of the interaction of urethane N-H with ether functional groups. (Author abstract) 16 refs.

Coleman, Michal M. (Pennsylvania State Univ, University Park, PA, USA); Skrovanek, Daniel J.; Hu, Jiangbin; Painter, Paul C. *Macromolecules* v 21 n 1 Jan 1988 p 59-65.



**082022 HYDROGEN BONDING IN POLYMER BLENDS. 2. THEORY.** Recent work in this laboratory has focused on FTIR studies of a range of polymer blends. Although various 'rules of thumb' have been formulated as a guide to miscibility in these systems, we have not, until now, been able to use our spectroscopic measurement in the framework of the usual thermodynamic theories of mixing. This is because of the well-known inadequacies of the Flory-Huggins theory in handling strong, specific, directional interactions. We present an equilibrium approach based largely on theoretical work described in the chemical engineering literature for the self-association of alcohols in hydrocarbon solutions. The adoption to polymers is straightforward and we consider the potential of the equations for describing the phase behavior of polymers that hydrogen bond. (Author abstract) 31 refs.

Painter, Paul C. (Pennsylvania State Univ, University Park, PA, USA); Park, Yung; Coleman, Michael M. *Macromolecules* v 21 n 1 Jan 1988 p 66-72.

**082023 MECHANICAL PROPERTIES OF POLY(ETHYLENE/ETHYLENE VINYL ACETATE FILLED WITH CALCIUM CARBONATE).** The tensile behavior of polyethylene/ethylene vinyl acetate (PE/EVA) polymer blends filled with calcium carbonate ( $\text{CaCO}_3$ ) was studied using tensile and viscoelastic tests. The relations between tensile properties (modulus, strength, etc) of oriented and unoriented PE/EVA- $\text{CaCO}_3$ , and void volume of polymer/ $\text{CaCO}_3$  interface, PE/EVA blend ratio, and  $\text{CaCO}_3$  content were investigated. The results indicated that the tensile strength and elongation of PE/EVA- $\text{CaCO}_3$  decreased with  $\text{CaCO}_3$  content and PE blend ratio for unoriented PE/EVA- $\text{CaCO}_3$  systems. In the case of oriented samples, the relative modulus ( $E_d^0/E_d^p$ ), where  $E_d^0$  and  $E_d^p$  are the modulus of oriented composites and the modulus of oriented matrix, respectively) of PE/EVA- $\text{CaCO}_3$  is larger than that of PE/ $\text{CaCO}_3$  by increasing the EVA content relative to PE and  $\text{CaCO}_3$ . The value of  $E_d^0/E_d^p$  can be simply expressed as the function of void volume and  $\text{CaCO}_3$  modulus to polymer matrix modulus. (Author abstract) 20 refs.

Mitsubishi, K. (Industrial Technology Cent of Okayama Prefecture, Okayama, Jpn); Kodama, S.; Kawasaki, H. *Polym Compos* v 9 n 2 Apr 1988 p 112-118.

**082024 THEORY OF COALESCENCE IN IMMISCIBLE POLYMER BLENDS.** The theory of coalescence in melts of polymer blends was derived on the basis of the Smoluchowski theory for colloid systems. An approximation for a flux of particles used for solutions of colloids in water was analyzed. It is shown that this approximation cannot be used for polymer blends, and an approximation is suggested that could be justifiably used for them. A system of equations was derived for the time dependence of the number of individual i-mers, using the relation suggested for the diffusion flux of particles. In an approximation of the uniform increase in particle size, equations were found for the time dependence of the number of particles, the average radius of the particle, and the interface area in the volume unit of the blend. The suggested theory predicts measurable coalescence in considerably more viscous systems than mechanically applied relations of the Smoluchowski theory for aqueous colloid solutions. (Author abstract) 9 refs.

Fortelny, I. (Czechoslovak Acad of Sciences, Prague, Czech); Kovar, J. *Polym Compos* v 9 n 2 Apr 1988 p 119-124.

**082025 LCST AND UCST BEHAVIOR OF POLYMER BLENDS.** Using light scattering, the phase behavior of polymer blends containing random copolymers has been studied. Miscible polymers tend to phase separation at elevated temperatures. This lower critical solution temperature (LCST) behavior is typical for miscible polymer blends. The phase behavior is discussed in terms of an equation-of-state theory. For a miscible high molecular mass system the interactional parameter  $X_{AB}$  has to be negative. In polymer/copolymer systems, however, miscibility does not require any specific interactions. Repulsion between the segments comprising the

copolymer can lead to  $X_{AB} < 0$ , which favors miscibility. Some miscible polymers also exhibit phase separation at low temperatures. This upper critical solution temperature (UCST) behavior is rather uncommon for high molecular mass systems in the case of  $X_{AB} < 0$ . (Edited author abstract) 11 refs.

Kammer, H.W. (Univ of Technology of Dresden, Dresden, East Ger). *Plast Rubber Process Appl* v 9 n 1 1988 p 23-27.

**082026 PROCESSABILITY, MECHANICAL PROPERTIES AND FAILURE MODES OF XLPE/EPDM BLENDS.** Blends of uncrosslinked but crosslinkable polyethylene (XLPE) and ethylene-propylene diene rubber (EPDM) were prepared in a Brabender plasticorder by melt mixing of the components. Processing characteristics and mechanical properties of the blends were evaluated as a function of blend composition. It was observed that the viscosity of the blends increased with an increase in the EPDM content. The proportion of XLPE in the blend was found to have a profound influence on the physicomechanical properties of the composites. In order to study the mechanism of failure, the tensile and tear-fractured surfaces were examined under a scanning electron microscope. The fractographs have been correlated with the strength and type of failure of the blends. (Author abstract) 17 refs.

Nando, G.B. (Indian Inst of Technology, Kharagpur, India); Thomas, S.; Patra, B.B. *Plast Rubber Process Appl* v 9 n 1 1988 p 29-36.

**082027 CHARACTERIZATION OF POLY(CARBOXYLIC ACID)/POLY(ETHYLENE OXIDE) BLENDS FORMED THROUGH HYDROGEN BONDING BY SPECTROSCOPIC AND CALORIMETRIC ANALYSES.** The solid state of the complex between poly(acrylic acid) (PAA) and poly(ethylene oxide) (PEO), and that between poly(methacrylic acid) (PMAA) and PEO formed via hydrogen-bonding was studied by differential-scanning calorimetric (DSC) and by Fourier-transform infrared (FT-IR) spectroscopic measurements. Melting temperature  $T_m$  and the degree of the crystallinity  $X_c$  of PEO in the systems PAA (or PMAA)/PEO blends obtained from aqueous or dimethyl sulfoxide (DMSO) medium were measured. It was found that 50 unit mol % of PEO is a critical composition, which gives new evidence for the 1:1 complex formation between PAA (or PMAA) and PEO. From the FT-IR spectroscopic analysis in conjunction with DSC measurements we also found that the effects of solvent and of hydrophobic interaction (due to the  $\alpha$ -methyl group of PMAA) are the important factors controlling the complexation in the solution and solid systems. These factors also affect the crystallization behavior and the microstructure of the PAA (or PMAA)/PEO blend in solid state. (Edited author abstract) 26 refs.

Jeon, Seung Ho (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Ree, Taikyue. *J Polym Sci Part A* v 26 n 5 May 1988 p 1419-1428.

**082028 MISCIBILITY OF POLYESTER/NITROCELLULOSE BLENDS: A DSC AND FTIR STUDY.** The miscibility of polyester/nitrocellulose blends was investigated by differential scanning calorimetry and Fourier-transform infrared (FTIR) spectroscopy. Two nitrocelluloses (NC) derived from wood and having different nitrogen contents (12.62 and 13.42%) were used. On the basis of the glass transition temperature criterion, poly( $\epsilon$ -caprolactone) (PCL), poly(valerolactone), poly(ethylene adipate), and poly(butylene adipate) are miscible with nitrocellulose, whereas poly( $\alpha$ -methyl  $\alpha$ -propyl  $\beta$ -propiolactone) and poly( $\alpha$ -methyl  $\alpha$ -ethyl  $\beta$ -propiolactone) are immiscible. The  $T_g$  versus composition curves of PCL/NC blends do not follow a monotone function but exhibit a singular point at a critical PCL volume fraction of 0.51 for NC-1342 and 0.45 for NC-1262 in agreement with Kovacs' theory. A shift of  $17\text{ cm}^{-1}$  of the carbonyl stretching band was observed with PCL/NC blends and is taken as evidence for hydrogen bonding interaction between the PCL carbonyl group and NC hydroxyl group. (Edited author abstract) 43 refs.

Jutier, Jean-Jacques (Univ Laval, Que, Can); Lemieux, Even; Prud'Homme, Robert E. *J Polym Sci Part B* v 26 n 6 Jun 1988 p 1313-1329.

**082029 MICROSTRUCTURAL INVESTIGATIONS OF PBT/NYLON 6,6 COMPOSITES.** The microstructure of composites made from blends of poly(p-phenylene benzobisthiazole) [PBT] and nylon 6,6 has been investigated with wide-angle X-ray diffraction, selected area electron diffraction, and small-angle X-ray scattering techniques. The composite samples investigated were spun in both fiber and film forms from dilute solutions of methane sulfonic acid. The structure of the composites was found to be a microfibrillar network of PBT in a matrix of partially crystalline nylon 6,6. (Edited author abstract) 10 refs.

Nehme, O.A. (Univ of Massachusetts, Amherst, MA, USA); Gabriel, C.A.; Farris, R.J.; Thomas, E.L.; Malone, M.F. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1955-1965.

**082030 EFFECT OF CHARGE GROUPS IN POLYSTYRENE AND POLYVINYL ACETATE IONOMERIC BLENDS.** The introduction of charge group into polystyrene and poly(vinyl acetate) chains had significantly influenced the physical and mechanical properties of the resultant polymers and the polyblends. The softening point and glass transition temperature of the resultant polymers were increased with an increase of the charge group content in the polymers. The results from dynamic mechanical analysis showed that the transitional peak of loss modulus-temperature curve of the ionic blends shifted inwardly to a temperature between the two glass transition temperatures of the straight polymers as the charge group content increased. The microphotographs of the polyblends from scanning electron microscopy showed two-separated phases for the blend of polystyrene and poly(vinyl acetate). Polystyrene was the dispersed phase in the poly(vinyl acetate) matrix. However, the domain size of the dispersed phase became smaller and smaller as the charge group content increased in the ionic polyblend. A homogeneous phase was found as the content of charge groups exceeded 10 mole% in the ionic polyblends. (Author abstract) 21 refs.

Hsieh, K.H. (Nat'l Taiwan Univ, Taipei, Taiwan); Wong, B.J. *J Chin Inst Chem Eng* v 19 n 1 Jan 1988 p 17-22.

**082031 ESTIMATION OF THE INTERFACIAL FRACTION IN PARTIALLY MISCIBLE POLYMER BLENDS FROM DIFFERENTIAL SCANNING CALORIMETRY MEASUREMENTS.** While the Fried ratio may provide a qualitative measure of the extent of the actual diffuse interface in the polymer blends, it is only an approximation since the contribution of the interface is overestimated by use of the total weight fractions. The use of the actual weight fractions contributing to the  $\Delta C_{pu}$  and  $\Delta C_{pl}$  can provide an analytical expression for the amount of material in the interface. A qualitative picture of the actual interface and the resulting DSC thermogram are given. It is shown that in the interfacial zone I, the composition in the layers changes relatively rapidly from the lower phase to the upper phase such that  $T_g$  varies smoothly from  $T_{gl}$  to  $T_{gu}$ . The  $\Delta C_p$ s of the layers in this region are too small to be distinguished individually; the result is a smooth curve with positive slope between  $\Delta C_{pl}$  and  $\Delta C_{pu}$ . 4 refs.

Beckman, E.J. (Univ of Massachusetts, Amherst, MA, USA); Karasz, F.E.; Porter, R.S.; MacKnight, W.J.; Van Hunsel, J.; Koningsveld, R. *Macromolecules* v 21 n 4 Apr 1988 p 1193-1194.

**082032 MISCIBILITY OF POLY(2-OXAZOLINES) WITH COMMODITY POLYMERS.** Poly(N-acyl-ethylenimines) (PMeOZO, PEtOZO, and PPrOZO) have been examined for miscibility with commodity polymers of poly(vinyl chloride) (PVC), polystyrene (Pst), polypropylene (PP), and poly(vinylidene fluoride) (PVF<sub>2</sub>). The miscibility of polymer blends has been investigated by three methods: dynamic viscoelastic behaviors by rheovi-



bron for all commodity polymer blends, differential scanning calorimetry, and wide-angle X-ray scattering, the latter two being for PMeOZO-PVF<sub>2</sub> blends. PMeOZO-PVC and PMeOZO-PVF<sub>2</sub> blends are miscible at the range of the PMeOZO fraction lower than 50 wt%. With the PMeOZO-PVF<sub>2</sub> blend system, miscibility is discussed for the amorphous and crystalline parts of PVF<sub>2</sub>. PPrOZO is miscible with PSt when the PPrOZO is up to at least 25 wt %. (Edited author abstract) 20 refs.

Kobayashi, Shiro (Kyoto Univ, Kyoto, Jpn); Kaku, Mureo; Saegusa, T. *Macromolecules* v 21 n 2 Feb 1988 p 334-338.

**082033 HYDROGEN BONDING IN POLYMER BLENDS. 3. BLENDS INVOLVING POLYMERS CONTAINING METHACRYLIC ACID AND ETHER GROUPS.** In this paper we present the results of Fourier transform infrared studies of EMAA copolymer blends containing poly(vinyl methyl ether) and ethylene oxide-co-propylene oxide copolymers. The blends studied were found to be extensively mixed at the molecular level in the amorphous state. Quantitative measurements of the fraction of EMAA carboxylic acid groups that are hydrogen bonded to ether groups have been obtained in blends of different compositions, and the results are discussed in terms of competing equilibria. (Edited author abstract) 23 refs.

Lee, Joon Y. (Pennsylvania State Univ, University Park, PA, USA); Painter, Paul C.; Coleman, Michael M. *Macromolecules* v 21 n 2 Feb 1988 p 346-354.

**082034 NEUTRON AND X-RAY SCATTERING STUDIES ON SEMICRYSTALLINE POLYMER BLENDS.** Mixtures of poly(ethylene oxide), PEO, with protonated or deuterated poly(methyl methacrylate), PMMAH or PMMAD, respectively, crystallized at 50°C have been investigated by small-angle X-ray scattering, SAXS, and small-angle neutron scattering, SANS. It is shown that PMMA is incorporated into the amorphous phase between the crystalline lamellae. In addition, the thickness of the crystalline lamellae remains constant as a function of temperature which is in keeping with a small interaction parameter between the PEO and PMMA. The diffuse-phase boundary between the crystalline and amorphous phase is ca. 15 Å greater for the SAXS measurements than that measured by SANS. (Edited author abstract) 29 refs.

Russell, T.P. (IBM Research, San Jose, CA, USA); Ito, H.; Wignall, G.D. *Macromolecules* v 21 n 6 Jun 1988 p 1703-1709.

**082035 ELECTRONIC PROPERTIES OF AN ELECTRON DONOR-ACCEPTOR POLYMER BLEND.** The authors have studied the phase-separation behavior of the photoconductive polymer blends containing electron donor-acceptor (EDA) complexes, because they can have interfaces similar to the p-n junctions of semiconductors and may have unusual electronic properties different from those of doped polymer systems. It is shown that when the films were heated, another phase separation started in the matrix, and islands were finally absorbed into the newly separated phase. The phase-separation structure changed to a reticular tetrapod structure which was retained after being cooled to room temperature at ca. 7 deg/min. Examination of these films under a phase-contrast microscope with different varying focal point across the film thickness showed that each of two phases in this tetrapod structure was highly interconnected. 7 refs.

Uryu, Toshiyuki (Univ of Tokyo, Tokyo, Jpn); Ohkawa, Haruki; Furuichi, Takashi; Oshima, Ryuichi. *Macromolecules* v 21 n 6 Jun 1988 p 1888-1890.

**082036 MONTE CARLO SIMULATION OF A LATTICE MODEL FOR TERNARY POLYMER MIXTURES.** Monte Carlo studies of symmetrical polymer mixtures AB, modelled by self-avoiding walks on a simple cubic lattice, are presented for arbitrary concentrations of vacancies and chain lengths. The authors obtained the phase diagrams and the equation of state. Flory-Hug-

gins theory provides only a qualitative understanding of these results. If the equation of state is 'fitted' with an effective Flory-Huggins parameter, the latter turns out to be strongly dependent on both concentration and temperature. (Edited author abstract) 15 refs.

Sariban, A. (Johannes-Gutenberg-Univ, Mainz, West Ger); Binder, K. *Colloid Polym Sci* v 266 n 5 May 1988 p 389-397.

**082037 PHASE MORPHOLOGY OF A MODEL POLYBLEND FABRICATED IN INDUSTRIAL MIXERS: TIME AND MELT FLOW DEPENDENT SUPRADOMAIN STRUCTURES.** A study is made of the effects of the mixing process on phase morphology of the polyblend/alloy, in an industrial mixer, for which a prediction of the streamline pattern is feasible. While the authors report some semiquantitative results of the attempted correlation between the streamlines and the supradomain aggregates pattern, they also follow the MIXERIU program routing in seeking a relationship between the minor phase domain size and the mixing process description such as stress level, stretch rate, residence time, etc. Experimental data indicate that the goals and scope of the polyblend/alloy characterization as well as the selection of the component polymers were discussed earlier. 21 Refs.

Valsamis, L.N. (Farrel Corp, Ansonia, CT, USA); Kearney, M.R.; Dagli, S.S.; Merhta, D.D.; Polchocki, A.P. *Adv Polym Technol* v 8 n 2 Summer 1988 p 115-130.

**082038 FLOW BEHAVIOR AND MICROSCOPIC-STRUCTURE OF BINARY POLYMER BLENDS WITH A THERMOTROPIC LIQUID CRYSTALLINE POLYMER.** Two binary blend systems (polycarbonate (PC) or polyamide (PA) blended with a thermotropic liquid crystalline polymer of the wholly aromatic polyester (LC)) were prepared through the extrusion involving melt-blending. The measurements of the flow behavior of these blend systems of LC/PC and LC/PA using a capillary extrusion rheometer clarified that the apparent viscosity  $\eta_a$  is strongly governed by shear stress  $\tau_w$  as well as by blending ratio, but does not follow the logarithmic rule of mixtures. For the LC/PC systems, the mechanical properties of the extrudate after viscometric testing and of the injection-molded specimen are independent of the blending ratio. Characteristics of the blend are considered to be strongly affected by the dispersion state. A scanning electron microscope showed that there exists an obvious relation between the phase-structure and the state of melt or molecular orientation due to the shear flow. (Author abstract). 13 Refs. In Japanese.

Nishimura, Tetsuo (Industrial Research Inst of Nagano, Nagano, Jpn); Sakai, Hiroshi. *Kobunshi Ronbunshu* v 45 n 5 1988 p 401-408.

**082039 NR/PRP TRIBLOCK POLYMER BLENDS: PART 2. MATHEMATICAL APPROACH TO COMPOUND DESIGN AND PROPERTY OPTIMIZATION.** Ridge analysis is an effective method for the evaluation of optimum properties of the studied blend system and it is documented by hardness and swelling resistance properties. On the basis of this method, the influence of blend composition and cure conditions on the vulcanizate properties were estimated. It is inferred that the experimental design demonstrates the reliability of the optimization technique for polymer product design. (Edited author abstract). 11 Refs.

Sain, M.M. (Slovak Technical Univ, Bratislava, Czech); Simek, I.; Beniska, J.; Rosner, P. *Kautsch Gummi Kunstst* v 41 n 6 Jun 1988 p 538-540.

**082040 COOPERATIVE CHAIN RELAXATION IN MISCIBLE POLYMER BLENDS.** The orientation relaxation of dissimilar chains in the molten miscible blends, poly(methyl methacrylate)/poly(vinylidene fluoride) and poly(methyl methacrylate)/poly(vinylidene fluoride-co-trifluoroethylene), was investigated by measuring (1) the change of infrared dichroic ratio with time after the uniaxial stretching of film specimens, (2) the shear stress relaxation spectrum, and (3) the birefringence relaxation

in shear. The dissimilar polymers showed an identical time variation of the normalized Hermans orientation function. The blend showed a relaxation spectrum with a single characteristic relaxation time  $\tau_{\infty}$  depending on the blend composition. The birefringence relaxed monotonically, remaining positive. These results suggest that the dissimilar polymers do not relax independently but cooperatively. This behavior may be induced by a constraint due to the specific interactions between the dissimilar polymers, e.g., weak hydrogen bonding. For the cooperative chain relaxation, a third power relationship was found. (Edited author abstract). 14 Refs.

Saito, Hiromu (Tokyo Inst of Technology, Tokyo, Jpn); Takahashi, Mamoru; Inque, Takahashi. *J Polym Sci Part B* v 26 n 8 Aug 5 1988 p 1761-1768.

**082041 THERMODYNAMICS OF MISCIBLE POLYMER BLENDS USING A CONCENTRATION-DEPENDENT  $\chi$  PARAMETER.** The Flory equation-of-state theory, as expressed by D. Patterson and co-workers, has been applied to two miscible polymer blends: poly(vinyl chloride)/poly( $\epsilon$ -caprolactone) and poly(methyl methacrylate)/poly(vinylidene chloride). For both blends, the variation of the polymer-polymer interaction parameter,  $\chi'_{23}$  as a function of composition, is mostly small and can be accounted for by the Flory theory. However, for poly(vinyl chloride)/poly( $\epsilon$ -caprolactone) blends, at high poly( $\epsilon$ -caprolactone) content, the large variation of  $\chi'_{23}$  as a function of concentration can be explained by a variation of the surface-to-volume ratio of the polymers in the mixture with blend composition. The variations of the surface-to-volume ratios determined in this study agree with those reported in the literature using small-angle x-ray scattering. (Edited author abstract). 46 Refs.

Riedl, Bernard (Univ Laval, Ste.-Foy, Que, Can); Prud'homme, Robert E. *J Polym Sci Part B* v 26 n 8 Aug 5 1988 p 1769-1780.

**082042 POLYBLENDS-87 (8TH SYMPOSIUM IN THE SERIES ON POLYMER ALLOYS AND BLENDS).** These two issues contain 18 papers from the symposium on polymer alloys and blends. The papers report methods of improving the interfacial adhesion between the matrix and the dispersed phase; understanding of structure development during processing; flow of LLDPE blends; and characterization of polyethylene-based blends. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10715 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Nat'l Research Council of Canada, Industrial Materials Research Inst, Ottawa, Ont, Can). *Polym Eng Sci* v 27 n 20 Mid-Nov and n 21 Nov 1987, Polyblends-87, 1987 2 vol, 167p.

**082043 CONTRIBUTION TO THE UNDERSTANDING OF POLYETHYLENE/IONOMER/POLYAMIDE-6 BLENDS.** Binary polyethylene/EMA and EMA/polyamide-6 blends were studied with the hope that the role of EMA as a compatibilizer in polyethylene/EMA/polyamide-6 ternary blends might be better understood. Differential scanning calorimetry (DSC), laser small-angle light scattering, and mechanical property results are discussed. DSC measurements show that one component of the binary blends does not modify the crystallinity of the other. However, laser small-angle light scattering shows that the morphology of the mixtures changes under similar conditions. Tensile properties of polyethylene/EMA binary blends vary linearly as a function of composition, whereas those of EMA/polyamide-6 blends deviate slightly from linearity. These results



indicate no interaction between the crystalline components of the mixtures, and weak interactions in the amorphous phase. (Edited author abstract) 65 refs.

Fairley, Gary (Univ Laval, Quebec, Que, Can); Prud'homme, Robert E. *Polym Eng Sci* v 27 n 20 Mid-Nov 1987 p 1495-1503.

**082044 NUCLEAR MAGNETIC RESONANCE STUDIES OF IONOMERS. 6. POLYURETHANE-POLYPHOSPHONATE BLENDS.** Blending of a poly(ether urethane) with a polyphosphonate obtained by phase transfer catalyzed polycondensation of 4,4'-biphenol and chloromethylphosphonic dichloride generates a phase-separated material. One phase contains the soft segment of the polyurethane. This has been excluded from a high- $T_g$  phase that contains ionic species formed mainly by proton transfer and elimination reactions between the hard segment of the polyurethane and the polyphosphonate. Two glass transitions appear in the blend: one close to the  $T_g$  of the polyphosphonate and one belonging to the excluded soft segment of the polyurethane. The low temperature  $T_g$  decreases with the increasing content of the polyphosphonate, whereas the high temperature transition increases slightly, indicating an increasing purity of the soft segment and the presence of ionic interactions in the hard segment. The presence of ionic interactions is confirmed by NMR analysis of the blend. Comparison of the spectra of the blends with those of the pure components, along with two-dimensional experiments, indicate a reaction involving the chloromethyl groups of the polyphosphonate and the nitrogens of the polyurethane. (Author abstract) 16 refs.

Natansohn, Almeria (McGill Univ, Montreal, Que, Can); Rutkowska, Maria; Eisenberg, Adi. *Polym Eng Sci* v 27 n 20 Mid-Nov 1987 p 1504-1511.

**082045 LINEAR LOW DENSITY POLYETHYLENES AND THEIR BLENDS: PART 4. SHEAR FLOW OF LLDPE BLENDS WITH LDPE AND LDPE.** The steady state and dynamic shear behavior of linear low density polyethylenes (LLDPE) blended with low density polyethylene (LDPE) and with another LLDPE resin were measured in capillary and parallel plate geometries at  $T=150, 190$ , and  $230^\circ\text{C}$ . The extrudate swell and the Bagley correction were determined. It was observed that the pressure correction plays a significant role in capillary flow of LLDPE/LDPE blends - an indication of immiscibility. Several other rheological functions also suggested a phase separation for the system. Nevertheless, the blend behaved as a 'compatible' mixture of emulsion type. By contrast, blends of two LLDPE resins show expected miscibility. However, even in this case additivity was not always observed. A new simple method of calculating the relaxation spectrum was developed. The method is analytical and its accuracy depends on adequacy of the semiempirical relation (proposed previously) to describe dynamic viscosity dependence on the test frequency. For all samples the spectrum allowed computation of storage modulus in good agreement with experimental findings. (Author abstract) 66 refs.

Utracki, L.A. (Nat'l Research Council Canada, Boucherville, Que, Can); Schlund, B. *Polym Eng Sci* v 27 n 20 Nov 1987 p 1512-1522.

**082046 BLENDS OF POLYCARBONATE AND POLY(HEXAMETHYLENE SEBACATE): II. EFFECT OF MOLECULAR WEIGHT ON COMPATIBILITY.** Blends of polycarbonate (PC) and poly(hexamethylene sebacate) (HMS) with two different molecular weights were prepared and their thermal properties were studied via differential scanning calorimetry. It was found that the high molecular weight PC (HPC) and high molecular weight HMS (HHMS) were partially miscible as evidenced by the decrease in glass transition temperature of HPC in the blends. This partial miscibility is attributed to the interaction of the carbonyl dipole of the ester group and the highly polarizable aromatic carbonate structure. When the low molecular weight PC or HMS was used, the compatibility was enhanced because of the increased entropic contribution to the Gibbs free energy of mixing. In all the blends prepared, the PC crystallized

as a result of the plasticizing effect of HMS. Bisphenol-A diphenyl carbonate (dimer) was synthesized and used as the dimeric model of PC. This material was found to be an excellent diluent for HPC. (Edited author abstract) 30 refs.

Shih, K.S. (Univ of Florida, Gainesville, FL, USA); Beatty, C.L. *Polym Eng Sci* v 27 n 20 Nov 1987 p 1530-1541.

**082047 STRUCTURE-PROPERTY-PROCESSING RELATIONSHIPS OF POLYPROPYLENE-POLYBUTYLENE BLENDS.** In this paper we discuss PP-PB blends in which both components are highly crystallizable. It was our intention to try to prepare homogeneous PP-PB blends, assuming miscibility in the melt, by using the ultraquenching technique and to study the properties of the resulting blends following crystallization from the glass. Due to the possibility of preparing homogenous blends by ultraquenching, it should be interesting to compare the morphology, properties, and crystallization of the glass-crystallized blends with the melt-crystallized blends. We conclude that, in general, the above results suggest there is a considerable degree of compatibility, possibly even miscibility, of PP and PB in the melt, but that miscibility is difficult to obtain by ordinary melt mixing processes. (Author abstract) 29 refs.

Hsu, C.C. (Univ of Illinois, Urbana, IL, USA); Geil, P.H. *Polym Eng Sci* v 27 n 20 Nov 1987 p 1542-1556.

**082048 CHARACTERIZING POLYETHYLENE-BASED BLENDS WITH TEMPERATURE. RISING ELUTION FRACTIONATION (TREF) TECHNIQUES.** The temperature rising elution fractionation (TREF) short chain branches (SCB) technique has been applied to blends of PE by recognizing that the two commercial types of low density polyethylene, high pressure (HP-LDPE) and linear low density (LLDPE), have different short chain branching distributions. We have constructed a TREF apparatus that can be used in a number of different types of blend studies. The first is an Analytical-TREF, which gives a profile of the amount of polymer with a given SCB level and can be used to quantify HP-LDPE/LLDPE blends. We have also modified the technique to construct a stop-flow TREF apparatus, which enables one to separate fractions on the basis of the branching levels. The fractions can then be analyzed by size exclusion chromatography, IR,  $^{13}\text{C}$  NMR, or DSC. The use of these TREF techniques to characterize blends of HP-LDPE/LLDPE, LLDPE/EVA, PE/EPDM, and PE/polyisobutylene is discussed. (Edited author abstract) 12 refs.

Kelusky, Eric C. (DuPont Canada Inc, Kingston, Ont, Can); Elston, Clay T.; Murray, Ron E. *Polym Eng Sci* v 27 n 20 Nov 1987 p 1562-1571.

**082049 POLY(ETHYLENE TEREPHTHALATE) BLENDS FOR PERMEABILITY BARRIER APPLICATIONS.** Poly(ethylene terephthalate) (PET) offers good properties as a material of choice for various packaging, electronic, and other applications. In these applications in general, the PET articles achieve improved toughness and other physical properties through molecular orientation resulting from stretching at temperatures slightly above its  $T_g$ . Without such orientation, these articles suffer from poor impact toughness. We have been investigating modifications of PET for improving toughness and retaining the permeability properties. PET having intrinsic viscosities of 0.5 to 0.7 has been modified with low modulus polymers, particularly ethylene copolymers such as ethylene-methacrylic acid (EMAA) copolymers. The effect of crystallinity on toughness was determined. The crystallinity was established by Differential Scanning Calorimetry (DSC) techniques. Many of these modified PET compositions have good toughness and permeability barrier properties for various packaging and other controlled permeability applications such as containers and films. (Author abstract) 12 refs.

Subramanian, P.M. (DuPont, Wilmington, DE, USA). *Polym Eng Sci* v 27 n 21 Nov 1987 p 1574-1581.

**082050 STRUCTURE-PROPERTY RELATIONSHIPS IN POLYAMIDE/ACRYLONITRILE-BUTADIENE-STYRENE (ABS) BLENDS.** The structures and physical properties of four blends of poly(acrylonitrile-co-styrene-g-butadiene) (ABS) materials with polycaprolactam (PA6) have been characterized. The blends were separated into components by selective solvent extraction and were found to contain different structures. Blend A contained no PA6 grafts. Blend B contained PA6 grafted onto both soluble and insoluble ABS. Blend C contained PA6 grafted onto soluble poly(styrene-co-acrylonitrile) (p-SAN). In Blend D, PA6 was grafted on both the insoluble ABS and the p-SAN phases. Transmission electron microscopy showed different morphologies in the blends. Blend A had a co-continuous, somewhat laminar structure, while Blend D consisted of an ABS phase dispersed in a PA6 continuum. Blends B and C had intermediate structures. All four blends, however, had very similar rheological and physical properties despite the variation in structure. (Author abstract) 10 refs.

Howe, David V. (Borg-Warner Chemicals, Washington, WV, USA); Wolkowicz, Michael D. *Polym Eng Sci* v 27 n 21 Nov 1987 p 1582-1590.

**082051 EFFECT OF VISCOSITY RATIO ON THE MORPHOLOGY OF POLYPROPYLENE/ POLYCARBONATE BLENDS DURING PROCESSING.** The size of the minor phase in an immiscible polymer blend can have a significant effect on properties such as the impact strength. Few studies, however, have quantitatively considered the parameters controlling the size of the dispersed phase. In this paper, light and scanning electron microscopy have been used to examine the size of the minor phase in polypropylene/polycarbonate blends after melt processing. The size was examined as a function of both the viscosity ratio ( $\eta$ ) and the torque ratio (TR). The viscosity ratio is studied in the regions of  $\eta > 1$  and  $\eta < 1$ .  $\eta$  has a marked effect on the morphology of the dispersed phase with the phase size increasing by a factor of 3 to 4 times from  $\eta = 4.5$  to  $\eta = 17.3$ . Reduction in the size of the minor phase was achieved below  $\eta = 1$  with the minimum particle size occurring at  $\eta = 0.15$ . The results for these systems indicate the presence of upper and lower limits of  $\eta$  beyond which deformation becomes difficult. This is shown to be similar in some respects to the behavior of Newtonian fluids in shear flow, although the upper limit extends beyond that observed in the Newtonian fluid studies. (Author abstract) 24 refs.

Favis, B.D. (Nat'l Research Council Canada, Boucherville, Que, Can); Chalfoux, J.P. *Polym Eng Sci* v 27 n 21 Nov 1987 p 1591-1600.

**082052 LIGHT-SCATTERING CHARACTERIZATION OF POLYBLENDS IN THE PRESENCE OF MULTIPLE-SCATTERING CONDITIONS.** A novel approach is described for the noncontact evaluation of structural morphology in polyblends by light scattering. Optical methods are attractive for the on-line characterization of translucent materials because they are noninvasive, rapid, and applicable to high temperature materials. One limitation of conventional light-scattering techniques is their requirement for relatively thin samples in order to avoid multiple-scattering effects that smear out the details of the light diffraction pattern. The approach described in this paper is meant to circumvent this limitation by resorting to turbidimetric measurements, which provide useful information on the average size, shape, concentration, and orientation of the dispersed phase particles even in the presence of multiple scattering. The sample thickness is no longer restricted, and methods are described by which the near-surface volume of infinitely thick parts may be inspected with access to a single side of the material. Results are presented for polypropylene-polycarbonate (PP/PC) samples of different thicknesses and microstructural morphology, including fibrillar-type oriented structures. (Author abstract) 31 refs.

Cielo, P. (Nat'l Research Council Canada, Boucherville, Que, Can); Favis, B.D.; Mالدague, X. *Polym Eng Sci* v 27 n 21 Nov 1987 p 1601-1610.



**082053 POLYSTYRENE-POLYETHYLENE MELT BLENDS OBTAINED THROUGH REACTIVE MIXING PROCESS.** Reactive polystyrene (OPS) and reactive polyethylene (CPE) with oxazoline and carboxylic acid functionality, respectively, were melt blended in a Rheomix mixer under a variety of conditions. The properties of these blends were examined and correlated with the compositions and mixing conditions such as shear rate, time, and temperature. Mechanical properties such as elongation at break of reacted blends are improved over the nonreactive polyethylene (PE) and polystyrene (PS) blends. An intermolecular reaction between the OPS and CPE results in a graft polymer, which imparts improvement in the overall properties of these reacted blends. The maximum grafting reaction corresponds to 40% CPE blend, which is being evaluated as a potential compatibilizer. (Edited author abstract) 17 refs.

Baker, W.E. (Queen's Univ, Kingston, Ont, Can); Saleem, M. *Polym Eng Sci* v 27 n 21 Nov 1987 p 1634-1641.

**082054 PHASE BEHAVIOR AND MECHANICAL PROPERTIES OF POLYARYLATE AND POLYCARBONATE BLENDS.** The phase behavior and mechanical properties of a series of polyarylate/polycarbonate blends were studied. The polymers are known to transesterify, the extent of which depends upon the thermal and shear history and affects phase behavior and properties. Single screw extrusion, twin screw extrusion, and solution casting were employed for blend preparation. Two transition temperatures, corresponding to a polycarbonate-rich phase and to a polyarylate-rich phase, were seen in blends that were solution cast or compounded in a single screw extruder at 285°C. But after injection molding a single  $T_g$  was observed. When annealed at 180°C for several hours the molded blend was found to phase separate. Blends that were compounded in a twin screw extruder exhibited a single  $T_g$  and could not be phase separated. The flexural and tensile properties of blends that were prepared in a twin screw extruder show a small positive synergism. But the impact properties were substantially below the rule of mixtures values, probably the result of advanced exchange reaction and thermal degradation. (Author abstract) 12 refs.

Golovoy, A. (Ford Motor Co, Dearborn, MI, USA); Cheung, M.F.; van Oene, H. *Polym Eng Sci* v 27 n 21 Nov 1987 p 1642-1648.

**Blow Molding** See POLYETHYLENES—Low Density.

**Blowing Agents** See PLASTICS, FOAMED—Rigid.

**Calculations** See Also POLYCARBONATES—Calculations.

**082055 ATOMISTIC CALCULATION OF CHAIN CONFORMATIONS AND CRYSTAL STRUCTURES OF POLYOXYMETHYLENE.** A set of potential functions for hydrocarbons has been extended to oxygen interactions by fitting the parameters to a large number of experimental data of small ether molecules. This set is applied to the conformational and packing analysis of polyoxymethylene (POM). The energy minimization yields several helix conformations of the unperturbed chain. It is shown that there is an influence of crystalline packing on chain conformation. The lattice calculations give some further hexagonal and triclinic modifications of POM, which have not yet been observed experimentally. (Edited author abstract) 18 refs.

Aich, R. (Univ Ulm, Ulm, West Ger); Haegele, P.C. *Prog Colloid Polym Sci* v 71 1985 p 86-95.

**082056 INVESTIGATION ON POLY(VINYLENE SULPHIDE): AB INITIO ENERGY BAND STRUCTURE, USE OF EFFECTIVE CORE POTENTIALS, LATTICE SUM TRUNCATION.** The energy band structures of two structural isomers of poly(vinylene sulphide) are calculated using the ab initio Hartree-Fock crystal orbital method. The basis set dependence and the convergence of quantities like the total energy per elementary cell and the atomic electron population with the number of interactions with neighbours are investigated.

The band structure calculations are repeated employing effective core potentials first for sulphur atoms only and then for all non-hydrogen atoms. The results of the valence-electron only and the mixed computations agree very well with the all-electron calculations. (Edited author abstract) 23 refs.

Otto, P. (Friedrich-Alexander-Univ Erlangen-Nuernberg, Erlangen, West Ger). *Synth Met* v 22 n 2 Dec 1987 p 129-143.

**082057 CONFORMATIONAL FEATURES OF POLY(METHYLPHENYLSILYLENE).** The conformational energies and helix parameters were calculated for the various states of the poly(methylphenylsilylene) (PMPS) chain, in terms of the rotations around two successive skeletal bonds. The calculations were performed for the three different relative dispositions of the phenyls attached to three successive silicon atoms. The minima are invariably shifted from perfectly staggered positions. The significant shift of the minimum in the  $tt$  state results in a nonrectilinear shape for the chain segment. The possible correlations between the a priori probability of bond conformations and the spectroscopic observation on the variation of UV absorption maximum with degree of polymerization for the oligomers and the change in the peak characteristics upon reducing the temperature to 77 K are explored. (Edited author abstract) 19 refs.

Sundararajan, P.R. (Xerox Research Cent of Canada, Mississauga, Ont, Can). *Macromolecules* v 21 n 5 May 1988 p 1256-1261.

**082058 HEAD-HEAD INTERACTIONS IN ZWITTERIONIC ASSOCIATING POLYMERS.** Theoretical calculations are presented, both at the molecular mechanics empirical level and at the Hartree-Fock semiempirical level (MNDO), on molecules containing (ammonioalkyl)sulfonate zwitterions as models for semitelechelic associating polymers. In particular the interactions between the zwitterionic head groups and the evolution of the energetics and structures of the molecules are examined as a function of their aggregation. The clustered zwitterions adopt an extended (all-trans) conformation with their dipoles aligning in an antiparallel fashion in order to favor interchain electrostatic interactions. For large aggregation numbers in apolar solvents, associating polymers with zwitterionic head groups are predicted to form reverse micelles that possess either a tubelike or a disklike structure. (Edited author abstract) 39 refs.

Bredas, J.L. (Exxon Research & Engineering, Annandale, NJ, USA); Chance, R.R.; Silbey, R. *Macromolecules* v 21 n 6 Jun 1988 p 1633-1639.

**082059 CALCULATION OF THE MOLECULAR MASS CHARACTERISTICS OF POLYMERS FROM NON-TERMINATING POLYMERIZATION BY POLYFUNCTIONAL INITIATORS IN CONDITIONS OF CHAIN TRANSFER TO THE SOLVENT.** The authors have calculated the form of the MD, the mean degrees of polymerization  $P_n^-$ ,  $P_w^-$  and  $P_z^-$  of the global polymer and also separately the primary (formed on the initial initiator) and secondary (resulting from chain transfer) fractions for the case of non-terminating polymerization with chain transfer to the solvent using polyfunctional initiators. The dependences of these characteristics on the degree of functionality of the initial initiator and the intensity of chain transfer have been determined. The limits of the desirability of using polyfunctional initiators in real technological processes of synthesis of high molecular weight polymers are evaluated. (Author abstract) 6 refs.

Litvinenko, G.I. (Karpov Physicochemical Research Inst, USSR); Arest-Yakubovich, A.A.; Zolotarev, V.L. *Polym Sci USSR* v 29 n 4 1987 p 811-818.

**Carbonization** See THERMOPLASTICS—Carbonization.

**Casting** See PLASTICS FILMS—Mechanical Properties.

**Cavitation**

**082060 EFFECT OF VISCOELASTICITY ON BUBBLE COLLAPSE AND INDUCED IMPULSIVE PRESSURE.** The effect of viscoelasticity on the collapse of a gas bubble and the impulsive pressure induced by the bubble is found by numerically analyzing the bubble motion in viscoelastic fluids of a three-constant Oldroyd model. The computational results show that the relaxation effect in a viscoelastic fluid increases the impulsive pressure while the retardation effect decreases it. The damping of the bubble oscillation decreases with increasing relaxation time or with decreasing retardation time. The amplitude of the bubble oscillation is a maximum when the retardation time equals zero. The mechanism of cavitation damage in polymer aqueous solutions is discussed. (Edited author abstract) 25 Refs.

Tsujino, T. (Tohoku Univ, Sendai, Jpn); Shima, A.; Tanaka, J. *Rep Inst High Speed Mech Tohoku Univ* v 55 1988 p 1-15.

**082061 COLLAPSE OF BUBBLES IN VISCOELASTIC FLUIDS (THE CASE OF JEFFREYS MODEL FLUID).** A theoretical study is made concerning the collapse of a bubble in a Jeffreys model of viscoelastic fluids. The equation of motion for the bubble in the Jeffreys model fluid and the pressure equation are derived. The numerical calculations of these equations are carried out. Then the effects of relaxation time, retardation time and viscosity on the behavior of the bubble and the maximum pressure generated at first rebound are clarified. The pressure distributions around the bubble are also examined. (Edited author abstract) 9 Refs.

Shima, A. (Tohoku Univ, Sendai, Jpn); Tsujino, T.; Oikawa, Y. *Rep Inst High Speed Mech Tohoku Univ* v 55 1988 p 17-34.

**Chemical Analysis**

**082062 RELATIVE REACTIVITIES OF AMYLOSE HYDROXYL GROUPS IN THE REACTION WITH DIKETENE.**  $^{13}\text{C}$  nuclear magnetic resonance (n.m.r.) spectra at 75.4 MHz of partially modified amylose with  $\beta$ -ketone ester groups (degree of substitution (DS) ranging from 0.52 to 2.42) were studied in order to evaluate the selectivity of the reaction of amylose with diketene in the homogeneous phase. Analysis of the spectra of ring carbons in the anhydroglucose units shows that the reactivity of individual hydroxyl groups decreases in the order C-6 > C-3 > C-2 for DS values up to approximately 1.8. For higher DS values a negative deviation is observed for the hydroxyl group at C-6 and a positive deviation for the hydroxyl groups at C-2 and C-3. The DS values determined by  $^{13}\text{C}$  n.m.r. spectra are in good agreement with those found by chemical analysis. (Author abstract) 24 refs.

Arranz, Felix (CSIC, Madrid, Spain); Sanchez-Chaves, Manuel; Riofrio, Alicia. *Polymer* v 28 n 11 Oct 1987 p 1829-1832.

**Chemical Reactions** See Also AROMATIC COMPOUNDS—Polymerization; COPOLYMERS—Synthesis; ION EXCHANGE RESINS—Synthesis; POLYURETHANES—Waste Utilization.

**082063 XPS STUDY OF THE PENETRATION AND REACTION SPEED OF POLYMER DERIVATIZATION REAGENTS.** Functionalized polymer surfaces were prepared by electropolymerizing substituted phenols and were used to study the penetration depth and speed of reaction of derivatization reagents (trifluoroacetic anhydride and pentafluorophenylhydrazine). Depth information was obtained by angular variations of XPS intensities and lineshape analysis according to Tougaard's method. The penetration of both reagents into the test



polymers is rapid, but the reaction of pentafluorophenylhydrazine with carbonyl groups is slow. (Author abstract) 17 refs.

Zeggane, Samia (CNRS, Paris, Fr); Delamar, Michel. *Appl Surf Sci* (1985) v 31 n 1 Jan 1988 p 151-156.

**082064 SURFACE DERIVATIZATION OF POLY(ACRYLIC ACID).** X-ray photoelectron spectroscopy has been used to monitor the surface reaction of trimethylsilyl imidazole with the carboxylic acid functionality in poly(acrylic acid) films. The reaction was found to be quantitative and has potential for use in the determination of the acid composition of polymer surfaces. (Author abstract) 11 refs.

Davies, C. (Univ of Durham, Durham, Engl); Munro, H.S. *Polym Commun (Guildford Engl)* v 29 n 2 Feb 1988 p 47-49.

**082065 POLYMER-SUPPORTED DIPYRIDYLMETHANE DICARBOXYLIC ACIDS - PREPARATION AND COMPLEXATION WITH METAL IONS.** Polymeric 1,1-di(6-carboxy-2-pyridyl)methanes, bispicolinic acids, have been prepared by O-alkylation of 1,1-di(6-cyano-2-pyridyl)methanol with macroporous chloroacetylated and chloromethylated poly(divinylbenzene). Attempts to prepare reagents by C-alkylation of the silyl ether of this alcohol failed. A ligand attached to the polymer via a C-8 spacer arm generated from 1-(tetrahydropyran-2-yloxy)-8-octyl magnesium bromide has been prepared by substitution of an animated polymer. The capability of the ligands to extract metal ions from aqueous solutions has been determined and they have been found to be efficient reagents for the complexation of several metal ions, in particular copper and nickel ions. Their coordinating behavior is somewhat dependent upon the structure of the spacer connecting the ligand with the polymeric support. (Author abstract) 11 refs.

Elman, Bjorn (Royal Inst of Technology, Stockholm, Swed); Moberg, Christina; Rakos, Laszlo. *React Polym Ion Exch Sorbents* v 8 n 1 Feb 1988 p 41-49.

**082066 FOURIER TRANSFORM INFRARED SPECTROSCOPIC STUDY OF THE REACTION BETWEEN POLY(VINYL PYRIDINE)S AND EPOXY COMPOUNDS.** Chemical reactions between poly(vinyl pyridine)s and 1,4-butanediol diglycidyl ether and other epoxy compounds were studied by Fourier transform infrared spectroscopy and other techniques. The epoxy group was found to react with the pyridine side group of poly(4-vinyl pyridine), forming crosslinked networks which contain cyclic amide structures. The reaction was also observed in the interfacial region of poly(vinyl pyridine) and  $\gamma$ -glycidyloxypropyl trimethoxysilane hydrolyzate (y-GPS) coatings on PET fiber substrates. Poly(2-vinyl pyridine) does not show the same reaction. (Author abstract) 25 refs.

Xue, Gi (Nanjing Univ, Nanjing, China); Jiang, Shankeng. *Chin J Polym Sci (Engl Ed)* v 5 n 2 1987 p 133-140.

**082067 SELECTED PAPERS PRESENTED AT THE 3RD INTERNATIONAL CONFERENCE ON POLYMER-SUPPORTED REACTIONS IN ORGANIC CHEMISTRY.** This issue contains 64 selected conference papers of which 38 appear in abstract form only. The papers deal with polymer-supported reactions in organic chemistry. The main topics include: synthesis and characterization of polymeric reagents; polymer-supported reagents in synthesis; polymeric reagents in catalysis; polymer conjugated biocatalysts; polymers in peptide synthesis; polymers in nucleotide synthesis; special polymeric assemblies; polymer-assisted recognition and separation; diagnostic and pharmaceutical applications; and biomimetic chemistry. All the papers are abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10541 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Patchornik, Abraham (Ed.) (Weizmann Inst of Science, Rehovot, Isr); Warshawsky, Abraham (Ed.). *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented

at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 271p.

**082068 INSOLUBLE POLYMER-SUPPORTED 2,2'-BITHIAZOLINYLIDENES.** Polymer-supported thiazolium salts can be conveniently prepared by quaternizing thiazoles with Merrifield resins or by building up the thiazole ring around the nitrogen of an amino resin. Chiral polymer-supported salts result when the amino group is that of an amino acid previously anchored to a polymeric frame. Polymer-supported thiazole salts treated with aqueous sodium hydrogencarbonate solutions afford resins which, by themselves, are active as benzoin condensation catalysts. This activity is best explained, according to analytical and spectral data, by the presence of polymer-supported 'dimers' (2,2'-bithiazolinylidenes). 18 refs.

Bassedas, M. (Univ de Barcelona, Barcelona, Spain); Carreras, M.; Castells, J.; Lopez-Calhorrá, F. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 109-116.

**082069 ELECTRICAL CONTROL OF IMMOBILIZED ENZYME SYSTEMS: APPLICATIONS TO INFORMATION PROCESSING.** Artificial systems containing an enzyme and monitored by electric signals have been studied to create some functions with applications in biotechnology and 'bioelectronics'. These systems were characterized by their structure, the enzyme kinetics involved, the conductivity level and the nature of the boundary conditions. The control of these systems by electric signals (dc or pulses) has led to various results: regulation of enzyme activity, a 'conductivity effect' leading to amplification of regulatory effects, reaction-separations and commutations. (Author abstract) 19 refs.

Valleton, Jean-Marc (CNRS, Mont-St. Aignan, Fr); Selegny, Eric. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 117-126.

**082070 PERSPECTIVES IN ULTRA-HIGH LOAD SOLID (GEL) PHASE PEPTIDE SYNTHESIS.** A novel approach to ultra-high load solid (gel) phase peptide synthesis is reviewed and some recent developments discussed. The approach utilizes a phenolic bead-form core network at an initial matrix loading of 5.0 mmol g<sup>-1</sup>, the theoretical maximum. Consecutive repeating units along the polymer backbone each form a point of attachment for a growing peptide chain, synthesis proceeding via the stepwise elaboration of a series of quasi-homogeneous peptide gel networks. The success of the method, which has proved effective in the laboratory preparation of gram and multi-gram quantities of peptides, is ensured by the judicious choice of reaction conditions, reagents and solvents, so as to secure efficient gelation for all intermediate peptide gel networks. These may be regarded as quasi-homogeneous, both in covalent network architecture and in network distribution within the gel particles. (Author abstract) 17 refs.

Epton, Roger (Wolverhampton Polytechnic, Wolverhampton, Engl); Wellings, Donald A.; Williams, Angela. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 143-157.

**082071 MODERN METHODS OF NUCLEIC ACID SYNTHESIS ON POLYMERIC SUPPORTS.** Deoxyoligonucleotides can be synthesized rapidly and in high yield because of recent advances in nucleic acid chemistry. Key innovations include solid phase synthesis of silica-based supports and the development of stable deoxynucleoside phosphoramidites as synthons. When incorporated into manual, semiautomatic, or automatic instruments, these new procedures can be used to prepare probes, mixed probes, deoxyoligonucleotides for priming DNA synthesis, analogues of deoxyoligonucleotides, and genes. Oligoribonucleotides have also been prepared. The

most successful approach so far developed involves using 2'-protected nucleosides as synthons and bis(diisopropylamino)methoxyphosphine as a phosphorylating reagent. A regioselective condensation route leading to the exclusive synthesis of 3'-5' internucleotide linkages is possible. (Author abstract) 36 refs.

Caruthers, M.H. (Univ of Colorado, Boulder, CO, USA). *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 159-174.

**082072 SPACER EFFECT ON THE SYNTHESIS OF OLIGODEOXYNUCLEOTIDES BY THE PHOSPHITE METHOD.** Nineteen oligonucleotides of 15-27 bases long were synthesized on aminoalkyl spacers of various chain lengths, Si-O(CH<sub>2</sub>)<sub>n</sub>NHCONH(CH<sub>2</sub>)<sub>n</sub>NHCO(CH<sub>2</sub>)<sub>m</sub>NH<sub>2</sub>, linked to Fractosil silica gel supports (F6, F12, F15, F18, F21, F24, F32, F38), to Porasil (P15) silica gel support, and to modified controlled pore glass (CPG17, CPG24). The purity and the homogeneity of the end product in the reaction mixture was quantitatively determined from the autoradiograph pattern of bands on polyacrylamide sizing gel. The data indicated that the most pure products are obtained either on the shortest spacer, F6, or on the 24, 32, or 38 atom length spacers. Spacer lengths of 15, 18 and 21 atoms gave very poor results, with large amounts of impurities. The results are interpreted on the basis of conformational changes in the spacer alkyl chain as a function of its length. (Author abstract) 57 refs.

Katzhendler, J. (Hebrew Univ of Jerusalem, Jerusalem, Isr); Cohen, S.; Weisz, M.; Ringel, I.; Camerini-Otero, R.D.; Deutsch, J. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 175-187.

**082073 POLYMERS AS SUPPORTS FOR ENZYMIC OLIGO- AND POLYSACCHARIDE SYNTHESIS.** Polymer-supported enzymic oligosaccharide synthesis may lead to products of biological interest otherwise not readily attainable. Thanks to the 'polymer handle', the products are readily isolated, purified and characterized. This makes it possible to deal efficiently with comparative acceptor specificity and demonstrate de novo synthesis: the specific example of glycogen synthetase is discussed. The derivatised polymers used were crosslinked polyacrylamide gel beads, water-soluble poly(vinyl alcohol) and water-soluble polyacrylamide. The saccharide products were removed from the polymer supports by photolysis of substituted o-nitrobenzyl linkages or by enzymic hydrolysis using  $\alpha$ -chymotrypsin. (Author abstract) 38 refs.

Zehavi, Uri (Hebrew Univ of Jerusalem, Rehovot, Isr). *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 189-196.

**082074 COMPARISON OF ENANTIOMER SEPARATION BY INCLUSION CHROMATOGRAPHY AND BY RESOLUTION VIA DIASTEREOISOMERIC SALT FORMATION.** Enantiomers of 6,7-dihydroxy-(3,4,5-trimethoxybenzyl)-1,2,3,4-tetrahydroquinoline hydrochloride were separated via diastereoisomeric salt formation using optically active tartaric acid, by inclusion-complex formation using water-soluble cyclodextrin polymer, and by inclusion chromatography on  $\beta$ -cyclodextrin bead polymer. On a microscale, the chromatographic resolution has significant advantages over the traditional methods. (Author abstract) 20 refs.

Zsádon, B. (Eotvos L. Univ, Budapest, Hung); Acs, M.; Fogassy, E.; Faigl, F.; Novák, Cs.; Pokol, Gy.; Ujhazy, A. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 197-202.



**082075 ANTIAROMATIC ANNULENONES.** The existence of several unstable annulenones has been demonstrated by using polymeric reagents. Furthermore, a 'polyphasic dynamic reactor' allowed determination of the lifetime of such annulenones. Thus, the relation between structure and stability for those compounds is established. (Author abstract) 5 refs.

Gavina, F. (Univ de Valencia, Castellon de la Plana, Spain); Costero, A.M.; Gonzalez, A.M.; Luis, S.V. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 203-206.

**082076 DESIGN OF CHIRAL POLYMERS FOR THE KINETIC RESOLUTION OF RACEMIC CONGLOMERATES.** The design of chiral polymers as stereospecific inhibitors for efficient kinetic resolution of conglomerates by crystallization is described. The selection of the polymers is done on the basis of the crystal structure and the morphology of the substrate. The resolutions with the polymers are better than those previously obtained with low molecular weight additives. This is illustrated for the comparative resolutions of (R,S)-glutamic acid Glu-HCl, (R,S)-threonine, (Thr), (R,S)-asparagine monohydrate, (Asn-H<sub>2</sub>O), and (R,S)-p-hydroxyphenylglycine-p-toluenesulfonate, (pHP-gTs). Further, (R,S)-histidine, which could not be resolved with the low molecular weight inhibitors, was successfully resolved with two polymeric reagents. A simultaneous resolution of the enantiomers in a device composed of two compartments separated by a membrane is described. (Edited author abstract) 39 refs.

Zbaida, D. (Weizmann Inst of Science, Rehovot, Isr); Weissbuch, I.; Shavit-Gati, E.; Addadi, L.; Leiserowitz, L.; Lahav, M. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 241-253.

**082077 POLYMER-PENDANT LIGAND CHEMISTRY, 2: REACTIONS OF VANADYL ACETYLACETONATE WITH CATECHOL LIGANDS BONDED TO POLYSTYRENE-DIVINYLBENZENE RESINS AND STRUCTURAL DETERMINATION OF THE VANADIUM CATECHOLATES ON THE POLYMER.** The reactions of catechol ligands, bonded to either 2% or 20% crosslinked methylated polystyrene-divinylbenzene resins (CAT-PS-DVB), with vanadyl acetylacetonate [VO(AcAc)<sub>2</sub>] were studied. Vanadyl ion removal from solution at equilibrium was 0.104 mmol V/g of resin and 0.075 mmol V/g of resin for the 2% and 20% CAT-PS-DVB resins, respectively. It was found that the 20% crosslinked modified resin was limited in the vanadyl ion ligand exchange reaction by diffusion into the resin, while this was not the case for the 2% crosslinked modified resin. The effect of the base, triethylamine, dramatically increased the amount of vanadyl ion removed from solution, via ligand exchange; this is thought to occur by deprotonation of the catechol ligand. The bidentate ligand, bipyridine, had no effect on the removal of vanadyl ion in the ligand exchange reaction and thus apparently does not form a 1:1 complex with the vanadium catecholate bonded complex. The structures of the vanadium catecholates on the resin were tentatively established by infrared and electron paramagnetic resonance (EPR) spectroscopy. (Edited author abstract) 19 refs.

Fish, Richard H. Jr. (Lawrence Berkeley Lab, Berkeley, CA, USA); Thormodsen, Arne D.; Belser, Robert B.; Friedman, Gad; Reynolds, John G. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 255-266.

**082078 NOVEL MICROCAPSULES FOR DELIVERY SYSTEMS.** Two controlled release systems are described: a photochemical controlled release system, made of polyamide microcapsules, which releases its contents only during exposure to UV light, and an erodible delivery system which is made of polyhydride microspheres and which was developed in order to release macromolecules. (Author abstract) 9 refs.

Mathiowitz, E. (MIT, Cambridge, MA, USA); Cohen, M.D.; Langer, R. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 275-283.

**082079 ENZYME-MIMICKING POLYMERS EXHIBITING SPECIFIC SUBSTRATE BINDING AND CATALYTIC FUNCTIONS.** This report describes the first attempts to combine two approaches, that of molecular imprinting and the preparation of polymer-bound catalysts. This leads to reactive polymers showing enzyme properties, i.e., substrate specificity and catalytic activity. Polymers were prepared by radical co-polymerization of 4-(5)-vinylimidazole with a crosslinker (divinylbenzene) and a guest molecule (derivatives of N-protected amino acids) in the presence of transition metal ions (Co<sup>2+</sup>). Thus, a transition metal ion complex is formed together with vinylimidazole and the guest molecule. (Edited author abstract) 10 refs.

Leonhardt, Andreas (ETH, Zurich, Switz); Mosbach, Klaus. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 285-290.

**082080 POLYMER-BOUND PRECURSORS OF DIIMINE: PERICYCLIC REACTIONS.** Diimine has been generated from two insoluble polymeric precursors: polymer-bound sulfonyl hydrazine and poly(phenylsulfonallyl) hydrazide. The reducing behavior of these resins is presented. Pericyclic ene- and Diels-Alder reactions of the produced diimine were also studied. (Author abstract) 19 refs.

Gavina, F. (Univ de Valencia, Castellon de la Plana, Spain); Luis, S.V.; Costero, A.M.; Gil, P. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 291-298.

**082081 ENZYME-ANALOGUE BUILT POLYMERS, 24: ON THE DISTANCE ACCURACY OF FUNCTIONAL GROUPS IN POLYMERS AND SILICAS INTRODUCED BY A TEMPLATE APPROACH.** Polymers exhibiting molecular recognition can be prepared by imprinting with templates. The selectivity observed is a result of the combination of the accuracy of cavity-shape fitting and the exactness of the arrangement of the functional groups introduced. We have now studied whether the arrangement of the functional groups alone can cause selectivity by virtue of the distinct distance between two such groups. By incorporation of polymerizable bisazomethines with different distances between the functional groups into crosslinked polymers and subsequent removal of the template, polymers bearing two amino groups fixed at a definite distance were obtained. In rebounding experiments with different dialdehydes the polymers showed a strong preference for the template used. The concept was broadened significantly by using for the first time a similar imprinting procedure on a silica surface through the formation of siloxane bonds. (Edited author abstract) 26 refs.

Wulff, Guenter (Univ of Duesseldorf, Duesseldorf, West Ger); Heide, Barbara; Helfmeier, Georg. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 299-310.

**082082 REAGENTS AND CATALYSTS DERIVED FROM POLYBENZIMIDAZOLE AND POLYSTYRENE RESINS WITH IMIDAZOLE PENDANT GROUPS.** Poly(benzimidazole) beads and similar reactive polymers containing benzimidazole groups attached to polystyrene resins have been used to prepare a variety of polymer-supported reagents and catalysts. For example, the polymers can be used to prepare supported palladium catalysts which are effective in the catalytic hydrogenation of nitro compounds or alkenes at room temperature. Poly(benzimidazole) has also been used to prepare a supported regenerable dichromate oxidizing agent. The great thermal stability of poly(benzimidazole)

can be used advantageously in other applications such as the gas-phase dehydrohalogenation of trichloroethane to vinylidene chloride. (Edited author abstract) 33 refs.

Li, Nai-Hong (Univ of Ottawa, Ottawa, Ont, Can); Frechet, Jean M.J. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 311-321.

**082083 REACTIONS OF SUBSTRATES HYDROPHOBICALLY BOUND TO POLYMER SUPPORTS: STEREOCHEMICAL EFFECTS.** Reactions of substrates covalently bound to polymer supports usually proceed with essentially the same stereochemical result as non-supported reactions. However, reactions of substrates hydrophobically bound to polymer supports can produce substantially different stereochemical results from non-supported reactions. These effects are greatest when macroporous polymers with high internal surface areas are used, probably because the substrate molecules adsorb onto the internal surfaces of the polymers. (Author abstract)

Briggs, Josie C. (Univ of Lancaster, Lancaster, Engl); Hodge, Philip. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 331.

**082084 MILD SYNTHESIS OF AZIDES BY MEANS OF A POLYMERIC REAGENT.** Organic azides are useful intermediates in the synthesis of pharmaceuticals, pesticides and photoaffinity labels. However, most methods leading to alkyl azides require either heating during their synthesis or purification by distillation, which is undesirable because of the thermal instability of these compounds. We have discovered a method that permits clean conversion of alkyl halides or sulfonates into alkyl azides by means of a polymeric reagent. The reaction proceeds under mild conditions at room temperature in a variety of solvents. The reaction can be monitored by GC or TLC. The polymer is removed by filtration and can be easily regenerated, and azide products are obtained cleanly without heating. Specific examples are discussed. (Author abstract)

Hassner, Alfred (Bar-Ilan Univ, Ramat-Gan, Isr); Stern, Meir. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 331.

**082085 ENANTIOSELECTIVE CATALYSIS BY POLYMER-SUPPORTED METAL PHOSPHINE COMPLEXES.** Because of the increasing demand for enantiomerically pure chemicals, the interest in methods for their preparation is growing. An elegant solution is offered by enantioselective catalysis, in which the chiral information is transferred from a very small to a very large amount of substrate. The academic interest manifests itself in the large number of homogeneous catalysts investigated, mainly based on chiral phosphine complexes. However, the difficulties in using such homogeneous noble-metal catalysts in industrial processes are well known. Homogeneous catalysts which are heterogenized by means of polymers are expected to contribute to overcoming these difficulties. The development of enantioselective catalysts of this type is reviewed. (Edited author abstract)

Kaschig, J. (Ciba-Geigy AG, Basel, Switz). *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 331.

**082086 POLYMER SUPPORTED MICROORGANISMS AS BIOCATALYSTS.** Immobilization of microorganism on polymeric supports for bioreactions was first reported in 1959. Initiated additionally by a first attempt of ours in 1966 to entrap whole cells in polyacrylamide gels, a large number of immobilization methods was developed, and our laboratory contributed to this field in



a number of ways. Polymeric beads of different sizes and porosities can be prepared, and materials with other geometries such as membranes or solid and hollow fibers can be obtained as well. Mechanical and diffusional transport properties of such support materials can be determined in a quantitative way. With respect to the biocatalytic application of microorganisms, biotransformation and bioconversion reactions can be distinguished. (Edited author abstract)

Klein, J. (Technical Univ, Braunschweig, West Ger); Vorlop, K.D.; Becke, J.W.; Kressdorf, B.; Steinert, J. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 332.

**082087 GEL PHASE  $^{13}\text{C}$  NMR SPECTROSCOPY AS AN INVESTIGATIVE TOOL IN ULTRA-HIGH LOAD SOLID (GEL) PHASE PEPTIDE SYNTHESIS.** Solid (gel) phase peptide synthesis involves successive organic reactions on a matrix-peptide network. It is difficult to effect characterization at intermediate stages during the course of peptide assembly and so it can be difficult to obtain direct information on the status of hydrocarbon protecting groups, loading and de-loading phenomena, side reactions and their avoidance. The object of the present study has been to evaluate gel phase  $^{13}\text{C}$  NMR spectroscopy as a method for alleviating this problem. The method has been applied to determine the limiting stabilities of common acid-labile and base-labile N-terminal protecting groups in a reaction protocol which has been devised for use with phenolic supports. It has been possible to investigate concurrently the stability of the anchoring linkage under deprotection conditions. Valuable practical information has been obtained. (Edited author abstract)

Epton, Roger (Wolverhampton Polytechnic, Wolverhampton, Engl); Wellings, Donald A. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 333.

**082088 MATRIX EFFECT IN THE CATALYTIC ACTIVITY OF POLYMER-BOUND SULPHONIC ACIDS.** Polymer-supported acids and bases are widely employed as catalysts for organic reactions. However, very few systematic studies have been published on the influence of physical and chemical parameters on their catalytic activity. We have tackled this problem using polymeric sulfonic acids as catalysts. In order to study reactions in organic solvents, macroporous-type polymers with different surface areas were prepared. The catalytic activities of these polymer-supported acids were tested in electrophilic aromatic substitution reactions and rearrangement processes. In some cases a strong dependence of the catalyst efficiencies on the surface area of the polymer has been observed, but in other reactions this factor does not seem to be important. Studies on solvent effects in these reactions and on the interactions of the polymeric catalyst with Hammett bases have been performed. The results obtained, together with available data on similar systems, allow a molecular interpretation of the catalytic activity to be given. (Edited author abstract)

Arduini, A. (Univ of Parma, Parma, Italy); Pochini, A.; Ungaro, R. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 333-334.

**082089 SYNTHESIS, REACTIONS AND C-13 PFT-NMR SPECTROSCOPY OF POLYMER-BOUND STEROIDS.** The attachment of polymer-supported cholic acid derivatives with keto and hydroxy functionalities and the transformation of these groups are presented. Examination of the influence of the polymer support and spacer groups upon the stereochemistry of these reactions is discussed. In addition to the usual methods for analysis of polymer-bound reactions, C-13 PFT-NMR spectroscopy was employed to detect, on a qualitative basis, the changes in functional groups attached to the support. Limitations of the C-13 NMR spectral method are illustrated. (Edited author abstract)

Blossey, Erich C. (Oklahoma State Univ, Stillwater, OK, USA); Ford, Warren T.; Periyasamy, Mookkan; Mohanraj, S.; Cannon, Randall G. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 334.

**082090 SOLID-PHASE SYNTHESIS OF  $\alpha$ ,  $\omega$ -UNDECANEDIOL MONOMESYLATE.** Insect sex attractants by binding symmetrical  $\alpha$ ,  $\omega$ -diols to polymer supports, but the extent of double binding was substantial (ca.40%). We report an improved procedure. By optimization of reaction conditions, polymer-supported tritryl chloride was prepared with a capacity (up to 2.5 mmol/g) higher than obtained by previous workers. Polymer-supported  $\alpha$ -undecanediol monomesylate was then prepared. The procedure, which can be carried out efficiently, avoids double binding problems. (Author abstract)

Chen, Jiawei (Wuhan Teachers' Coll, Wuhan, China); Xu, Zhang-Huang; Li, Jianzong; Cheng, Shiyan. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 334.

**082091 PREPARATION OF A POLYMER-SUPPORTED HYDROXYTHIOL AND ITS REACTION WITH CARBONYL COMPOUNDS.** Polymer-supported diols have been used as protecting groups for aldehydes and ketones. We report the preparation of polymer-supported hydroxythiol. Polymer was prepared with a capacity of up to 2.5 mmol/g. Several dialdehydes and diketones were bound to polymer in loadings of 0.3-1.7 mmol/g. Various reactions, including Wittig reactions, were carried out on the free carbonyl groups of singly bound dicarbonyl compounds. After release from the polymer the ratio of Wittig product to starting material indicated that terephthalaldehyde was 70% single bound and 30% doubly bound. These results are similar to those obtained for polymer-supported acetals and ketals by other workers. (Edited author abstract)

Chen, Jiawei (Wuhan Teachers' Coll, Wuhan, China); Li, Jianzong; Qin, Yongnian. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 334-335.

**082092 STUDIES ON POLYMERIC REAGENTS. I. SYNTHESIS OF DICROCROCIS PUNCTIFERALIS GUENUEE, TRANS-10-HEXADECENE-1-AL, USING A POLYMERIC REAGENT.** cis-10-Hexadecene-1-ol was synthesized from polymer-bonded Wittig reagent. The sodium salt of  $\text{Me}_2\text{SO}$  in  $\text{Me}_2\text{SO}$  was used as base. Then, Dichrocrocis Punctiferalis Guenuee, trans-10-hexadecene-1-al, was synthesized after isomerization and oxidation. The structures of the product and intermediates were identified by IR,  $^1\text{H}$  NMR, MS and elemental analysis. The ratio of cis- to trans-10-hexadecene-1-ol before and after isomerization was determined as well. The results indicate that the above polymeric Wittig reaction has high cis-selectivity and that the ratio of cis- to trans-product corresponds with the requirement of biological activity of the sex pheromone. (Author abstract)

Chen, Hiawei (Hubei Univ, Wuhan, China); Jiang, Jilong; Wu, Yinqiu. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 335.

**082093 ENZYMIC PROCESS FOR THE PREPARATION OF D(+)-NAPROXEN.** D(+)-Naproxen [D-2-(6-methoxy-2-naphthyl)propionic acid] is well-known as an anti-inflammatory agent. We developed an enzymatic two-step process for obtaining D(+)-Naproxen from a mixture of D- and L-2-(6-methoxy-2-naphthyl)propionic acid lower alkyl esters by the asymmetric hydrolysis of the L-ester with microbial enzymes, separation of the L-acid from the D-alkyl ester and enzymatic saponification of the latter with esterase from hog liver and some other sources. Product yield is high and optical purity of the D(+)-Naproxen is 98%. The enzymes for this

process are preferably used as immobilized catalysts. Application of the enzymatic two-step process for technical production of D(+)-Naproxen seems feasible. We present data for: the L-specific enzymes; the immobilization of the enzymes and microorganisms used in this process; reactors in laboratory scale; and stability of the catalysts. (Edited author abstract)

Gloger, M. (Boehringer Mannheim GmbH, Tutzing, West Ger); Maier, J.; v. Hoerschelmann, D. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 336.

**082094 FUNCTIONAL POLYMERS IN PHOTOGRAPHY.** This presentation is in two parts. In the first part, the broad significance of functional polymers in photography is discussed. Included are polymer science applied to supports, vehicles which may be natural (especially gelatin), synthetic, water-soluble or water-insoluble, mordants, timing layers, acid layers, and polymeric reagents. In the second part, a more in-depth treatment of polymers for the control of static electricity is presented. This includes a discussion of organic microgel polyionomers, both highly anionic and highly cationic, and an organic polyaniline semiconductor which, when sorbed to latex polymers, provides humidity-independent conductivity at exceptionally low surface coverages. (Edited author abstract)

Upson, Donald A. (Eastman Kodak Co, Rochester, NY, USA). *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 337.

**082095 OPTICALLY ACTIVE POLYMERS AS ADSORBENTS FOR DIRECT CHROMATOGRAPHIC RESOLUTION OF DRUGS.** Many chiral therapeutic agents are still used in therapy as racemates although enantiomers mostly differ in their pharmacological activities. In many cases, the reason is the difficulty of resolving the racemates via diastereoisomeric derivatives. Many of these racemates can be separated very efficiently by chromatography on optically active polymers such as polyamides. These polymers, having a wide range of applications, can be used repeatedly on an analytical as well as preparative scale without losing their resolution efficiency. Adsorbents for enantiomeric resolution can be obtained from natural polymeric products. Many examples for enantiomeric resolutions, especially of drugs, on an analytical as well as on a preparative scale are demonstrated. (Edited author abstract)

Blaschke, Gottfried (Univ of Muenster, Muenster, West Ger). *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 338-339.

**082096 DIAGNOSTIC APPLICATIONS OF COMPARTMENTALIZED POLYMER REAGENTS.** In the past decade, a variety of homogeneous immunoassay methodologies have evolved in which the reactivity of an analyte-enzyme, analyte-cofactor, or analyte-inhibitor conjugate is modulated in the presence of a specific antibody. We describe an alternate approach in which enzymic reactivity is modulated by sequestering the enzyme within a liposome whose accessibility to substrates is increased by lysis in the presence of antibody and complement. This approach employs only two reagent formulations, does not require any sample pretreatment, and has high sensitivity. Therefore, it can be readily automated on random access clinical analyzers. (Edited author abstract)

Hedaya, Eddie (Technicon Instruments Corp, Tarrytown, NY, USA). *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 340.



**082097 INTRODUCTION OF PRIMARY HYDROXYL GROUPS INTO POLYMERS FOR IMPROVED AFFINITY CHROMATOGRAPHY AND PROTEIN IMMOBILIZATION.** Polymers containing hydroxyl groups such as polysaccharides are commonly used as carriers for affinity chromatography and protein immobilization after activation with appropriate reagents. We have recently shown that efficient activation of such polymers is achieved mainly through primary hydroxyl groups. This was indicated by the observation that the amount of active groups on the polymers correlates well with the amount of primary hydroxyl groups. It also made no difference whether the activation was performed with CNBr or with chloroformates. Since the activation was performed mainly on polysaccharides, there is a possibility that a vicinal hydroxy group interacts with the active group forming five-membered rings. Cheap and high-capacity columns are badly needed in industry in order to reduce the size of columns used for protein purification and immobilization. (Edited author abstract)

Wilchek, M. (Weizmann Inst of Science, Rehovot, Isr); Ernst-Cabrera, K.; Miron, T. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 341.

**082098 CHARACTERIZATION OF HUMAN INTERFERONS BY HPLC.** In recent years HPLC (high performance liquid chromatography) has become the preferred mode of protein isolation and characterization. Several types of HPLC sorbents based on various separation mechanisms were developed. These include gel permeation, hydrophobic interactions, polar interaction, ion exchange and chromatofocusing. Moreover, sorbent porosity was adjusted to allow efficient protein fractionations. Reversed-phase HPLC was employed for the isolation of human interferon as early as 1978. Recently, this method was used in an analytical mode to study the expression of individual subtypes of the interferon- $\alpha$  gene family. It was found that these genes are regulated individually. Moreover, different cells will express a different repertoire of subtypes. Interferon- $\gamma$ , which lacks any homology to interferons- $\alpha$  or - $\beta$ , is a product of a single gene. Nevertheless, post-translational processing yields a family of subtypes which can be resolved by cation exchange HPLC. These subtypes were found to differ in molecular weight and potency as antiviral and immunoregulatory agents. (Author abstract)

Rubinstein, Menachem (Weizmann Inst of Science, Rehovot, Isr); Goren, Tamar; Fischer, Dina G. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 342.

**082099 SOLID PHASE DERIVATIZATION APPROACHES FOR IMPROVED DETECTION IN HIGH PERFORMANCE LIQUID CHROMATOGRAPHY (HPLC).** Derivatizations for improved detection in high performance liquid chromatography have become more and more popular in the past few years. We describe here some of these newer, off-line and on-line, solid phase derivatizations for various classes of compounds, all of which have been developed in order to improve analyte selectivity and sensitivity in HPLC. Alkyl halides, epoxides, and related classes have been hard to detect by direct HPLC, but the use of an off-line, picric-acid-on-silica supported reagent has proven useful as a derivatization reagent. This has been used for tagging ethylene dibromide, leading to one or two picryl ether products. The analogous reaction has been shown for simpler alkyl monohalides, such as alkyl iodides, bromides, and chlorides. Application to biologically active amines or polyamines is in progress. (Edited author abstract)

Krull, I.S. (Northeastern Univ, Boston, MA, USA); Colgan, S.T.; Chou, T.-Y.; Gao, C.-X.; Dorschell, C.; Bidingmeyer, B. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 342.

**082100 POLYMERIC LIPOSOMES - ATTEMPTS**

**TO MIMIC BIOMEMBRANE PROCESSES.** The contribution deals with the stabilization of membrane model systems (monolayers, black lipid membranes, vesicles) in general. The desired further biological functionalization of these stabilized polymeric membranes is possible via incorporation of proteins. Addition of natural lipids to polymerizable membranes and enzymatic degradation of the unpolymerized component after polymerization makes selective opening of otherwise stable compartments possible. Cell-cell recognition - of vital importance in immunological reactions - can be mimicked with polymeric vesicles carrying sugar headgroups. Finally, attempts are made to unite biological specification of natural cells and toughness of polymerized membranes via cell-vesicle fusion. (Edited author abstract)

Ringsdorf, H. (Univ of Mainz, Mainz, West Ger). *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 343.

**082101 REVERSIBLY POLYMERIZED LIPOSOMES.** Phospholipid bilayer vesicles are of considerable current interest as models for biomembranes, as carriers of drugs, and as devices for photochemical solar energy conversion. In this paper we describe two unique classes of synthetic vesicles which can be transformed into a polymerized state via oxidation and macrocyclic ring opening, respectively. These membranes are based on the thiol-bearing molecules, 1,2-bis(11-mercaptopentadecanoyl)-sn-glycero-3-phosphocholine, 1,2-bis(16-mercaptopentadecanoyl)-sn-glycero-3-phosphocholine, 1,2-bis(2-mercaptopentadecanoyl)-sn-glycero-3-phosphocholine, as well as a macrocyclic disulfide derivative of the first of these. Two key features of these assemblies, which distinguish them from other forms of polymerized phospholipid vesicles, are that they can be depolymerized via mild chemical reduction and that they are potentially biodegradable. (Author abstract)

Regen, Steven L. *Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986* (Lehigh Univ, Bethlehem, PA, USA). *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 343.

**Chemistry** See CATALYSTS—Supported; PROTECTIVE COATINGS—Plastics; VINYL RESINS—Structure.

**Chlorination** See POLYETHYLENES—Microstructure.

**Chromatographic Analysis** See ALSO COPOLYMERS—Separation; MEMBRANES—Forming; MOLECULES—Chromatographic Analysis; POLYBUTENE—Fractionation; POLYELECTROLYTES—Solutions; POLYETHYLENE TEREPHTHALATE—Sorption; POLYETHYLENES—Chromatographic Analysis; POLYETHYLENES—Oxidation; POLYURETHANES—Crosslinking.

**082102 ANALYSIS OF COMPOSITIONAL AND STRUCTURAL HETEROGENEITIES OF POLYMERS BY NON-EXCLUSION HPLC.** High performance liquid chromatography (HPLC) of polymers is often thought to be synonymous with Size Exclusion Chromatography for separation by molar size. The present article deals with non-exclusion chromatography of polymers which enables separation by differences in the chemical structure and composition. (Author abstract) 142 refs.

Gloekner, Gottfried (Technische Univ Dresden, Dresden, East Ger). *Adv Polym Sci* 79, Publ by Springer-Verlag, Berlin, West Ger and New York, NY, USA, 1987 p 159-214.

**082103 TESTING FOR PURITY: NEEDS, METHODS, PROBLEMS.** A variety of instrumental techniques have been used for the analysis of semiconductor coatings and molding compounds or extracts of these materials. A review of the instrumental techniques available has indicated that ion chromatography is the method of choice in terms of applicability to the ions of interest, detection limits, precision, and cost of instrumentation. (Edited author abstract) 33 refs.

Gaul, Michael D. (Dow Corning Corp, Midland, MI, USA); Boyes, George W.; Kookootsedes, Gust; Waldern, Alan M. *SAMPE J* v 23 n 6 Nov-Dec 1987 p 22-25.

**082104 SCALING THEORY OF CHROMATOGRAPHY OF LINEAR AND RING MACROMOLECULES.** Scaling concepts are used to obtain the distribution coefficients of linear and cyclic macromolecules in narrow pores in the GPC region. The distribution coefficients of self-nonintersecting linear chains and macrocycles in conditions of 'critical' chromatography are discussed. The authors also examine the problem of the behavior of self-non-intersecting linear and ring chains in conditions of so-called critical chromatography when the losses of the conformational entropy of the chain are compensated by the energy gain from the adsorption of the units on the pore walls. (Edited author abstract) 6 refs.

Skvortsov, A.M. (Leningrad Chemico-Pharmaceutical Inst, USSR); Gorbunov, A.A. *Polym Sci USSR* v 28 n 8 1986 p 1878-1885.

**082105 DETERMINATION OF FUNCTIONAL TYPE DISTRIBUTION OF OLIGOCAPROLACTONEDIOLS BY LIQUID CHROMATOGRAPHY UNDER CRITICAL CONDITIONS.** Functional type separation of oligocaprolactonedioles by liquid chromatography of macromolecules under critical conditions was investigated. The analysis was performed with the aid of a novel variant of HPLC in the critical region on the boundary of the exclusion and adsorption separation modes. This method is characterized by practically complete disappearance of separation by molecular masses thus giving only information on the type of functionality. The critical conditions have been found on two systems. The first consists of a Lichrospher Si 100 column and a hexane-acetone mixture as eluent, while the second consists of a Zorbax NH2 column and a diethylether-acetone mixture. (Author abstract) 3 refs.

Gorshkov, A.V. (USSR Acad of Sciences, Moscow, USSR); Overem, T.; Evreinov, V.V.; van Aalten, H.A.A. *Polym Bull (Berlin)* v 18 n 6 Dec 1987 p 513-516.

**082106 HIGH-SPEED AND SUPER-SPEED SIZE-EXCLUSION CHROMATOGRAPHY OF POLYMERS FOR PROCESS ANALYSIS.** Super-speed high-performance liquid chromatography (HPLC) is becoming a popular analytical tool. Application of super-speed HPLC in process analysis may provide near real-time feedback control. Nonaqueous size exclusion chromatography (SEC) with silica-based stationary phase columns was studied in the high-speed and super-speed regimes. The dependency of solute resolution and chromatographic analysis time on experimental parameters, such as column back pressure, was investigated. A column selection procedure is proposed and applied by extrapolating information from the high-speed regime to the super-speed regime. (Edited author abstract) 18 refs.

Renn, Curtiss N. (Univ of Washington, Seattle, WA, USA); Synovec, Robert E. *Anal Chem* v 60 n 3 Feb 1988 p 200-204.

**082107 POLYMER ADDITIVE CHARACTERIZATION BY CAPILLARY SUPERCRITICAL FLUID CHROMATOGRAPHY/FOURIER TRANSFORM INFRARED MICROSCOPY.** High-resolution capillary supercritical fluid chromatography (SFC) is shown to be an efficient separation technique for the qualitative analysis of chemical additives in polymers. Twenty-one compounds varying in chemical composition and molecular mass from 225 to 1178 are separated on a nonpolar capillary column by using carbon dioxide as the mobile phase. A polypropylene extract is analyzed to exemplify the method and highlight the limitation of using retention time data for identifying unknown compounds. The use of Fourier transform infrared spectrometry



(FTIR) as a detector provides unique spectroscopic information for identification purposes. (Edited author abstract) 23 refs.

Raynor, Mark W. (Univ of Leeds, Leeds, Engl); Davies, Ilona L.; Williams, Alan; Clifford, Anthony A.; Chalmers, John M.; Cook, Bernard W.; Bartle, Keith D. *Anal Chem* v 60 n 5 Mar 1988 p 427-433.

**082108 UNIVERSAL CALIBRATION IN EXCLUSION CHROMATOGRAPHY OF POLYVINYLPIRROLIDONE IN DIMETHYL FORMAMIDE.** A universal calibration relation is obtained for the chromatographic separation of PVP and PS in DMFA on Microsyrigel columns of pore size  $10^3$ ,  $10^4$ , and  $10^5$  Angstrom. The proposed chromatographic system was used to analyze high dispersion grade NBS 706 PS, narrow dispersion grade NBS 705 PS, and wide dispersion PVP, the characteristics of which were determined by independent methods. The data from the analysis are given. The good correspondence between the molecular characteristics as found independently with those calculated by means of UCR is a good indication that UCR are useful for application to PVP and PS. (Edited author abstract) 24 refs.

Boimirzayev, A.S. (USSR Acad of Sciences, USSR); Nesterov, V.V.; Belenkii, B.G. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2920-2923.

**082109 DYNAMIC HEADSPACE ENRICHMENT/REINJECTION FOR OPEN TUBULAR GC/FTIR ANALYSIS OF VOLATILES IN POLYMERS.** An analytical system for the analysis of volatiles entrained in polymers is described. This system is based on a thermal desorption oven connected to a cold trap. After enrichment of headspace vapor, trapped material is reinjected and analyzed by open tubular gas chromatography/Fourier transform infrared spectroscopy, OTGC/FTIR. The thermal desorption oven is designed to provide different modes of sample introduction: use of a pyroprobe; insertion of a piece of quartz tubing with applied sample; or syringe injection. (Edited author abstract) 21 refs.

Schmidt, S. (Univ of Stockholm, Stockholm, Swed); Blomberg, L.; Waennman, T. *HRC & CCJ High Resolut Chromatogr Chromatogr Commun* v 11 n 3 Mar 1988 p 242-247.

**082110 THERMODYNAMIC STUDIES ON POLY[N-(n-OCTADECYL)MALEIMIDE] (PMI-18)/SOLVENT SYSTEMS BY INVERSE GAS CHROMATOGRAPHY WITH CAPILLARY COLUMNS.** An open tubular column (capillary) coated with poly[N-(n-octadecyl)maleimide] (PMI-18) has been used above its glass transition temperature for estimating polymer-solvent interaction parameters by means of inverse gas chromatography (IGC). Experimental retention volumes corrected to zero flow rate  $V_g^0$  are reported for nonpolar and polar solute probes. Activity coefficients ( $a_1/\omega_1$ ), the Flory-Huggins parameter  $\chi$ , and mixing functions were derived and discussed with respect to the chain length and polarity in the solute molecules. (Edited author abstract) 56 refs.

Barrales-Rienda, J.M. (CSIC Juan de la Cierva, Madrid, Spain); Gancedo, J. Vidal. *Macromolecules* v 21 n 1 Jan 1988 p 220-228.

**082111 RESOLUTION OF ELECTROSTATIC AND STERIC FACTORS IN AQUEOUS SIZE EXCLUSION CHROMATOGRAPHY.** Size exclusion chromatography of sodium poly(styrenesulfonate) (NaPSS) on CPG porous glass has been studied in order to elucidate the influence of intermacrolon expansion and polyion-stationary phase interaction on elution behavior. Measurement of the diminution of the chromatographic partition coefficient,  $K'_{SEC}$ , for the polyion, relative to that of a nonionic polymer (pullulan) of identical molecular volume makes it possible to isolate the contribution of polyion-substrate repulsive forces to  $K'_{SEC}$ . This effect may be approximately attributed to a volume within the pore from which the polyion is repelled. (Edited author abstract) 31 refs.

Dubin, Paul L. (Indiana-Purdue Univ, Indianapolis, IN, USA); Speck, Catherine M.; Kaplan, Jerome I. *Anal Chem* v 60 n 9 May 1988 p 895-900.

**082112 STUDY OF ACCEPTOR-DONOR INTERACTIONS AT THE POLYMER INTERFACE BY INVERSE GAS CHROMATOGRAPHY DATA ANALYSIS.** Analysis of inverse gas chromatography (IGC) data supports Fowkes's theory of acceptor-donor (acid-base) interactions at the polymer interface. Moreover, this analysis allows one to estimate Drago parameters of some polymers and IGC probes. The Drago parameters of copolymers of vinyl acetate and vinyl alcohol were found to vary linearly with copolymer composition. (Edited author abstract) 10 refs.

Chen, Fute (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA). *Macromolecules* v 21 n 6 Jun 1988 p 1640-1643.

**082113 ANALYSIS OF WATER-SOLUBLE POLYMERS USING HYDRODYNAMIC CHROMATOGRAPHY.** Hydrodynamic chromatography (HDC) has been successfully applied to measurements of the molecular size and molecular size distribution of high molecular weight, water-soluble polymers. The scope of the method has been probed by experiments with xanthan, a comparatively stiff polysaccharide, and hydrolyzed polyacrylamide, which possesses a more flexible backbone. Separation occurs during convection of dissolved polymer through the interstitial volume of a chromatography column packed with nonporous beads. Nonequilibrium polymer configurations are readily created by the complex flow between these beads. Such altered configurations strongly affect molecular size measurements. (Edited author abstract). 39 Refs.

Hoagland, D.A. (Princeton Univ, Princeton, NJ, USA); Prud'homme, R.K. *J Appl Polym Sci* v 36 n 4 Aug 5 1988 p 935-955.

**082114 CHARACTERIZATION OF THE FUNCTIONALIZATION REACTION PRODUCT OF POLY(STYRYL)LITHIUM WITH ETHYLENE OXIDE.** The functionalization reaction of poly(styryl)lithium with ethylene oxide in benzene proceeds quantitatively (> 99%) to produce the corresponding hydroxyethylated polymer as determined by vapor phase osmometry, size exclusion chromatography, end-group titration, thin layer chromatography, and  $^1H$ - and  $^{13}C$ -NMR spectroscopy.  $^{13}C$ -NMR spectral analysis of the functionalized polystyrene with  $M_n = 1.3 \times 10^3$  was consistent with addition of only one ethylene oxide unit to poly(styryl)lithium, i.e., no evidence for ethylene oxide oligomerization was observed. (Edited author abstract). 23 Refs.

Quirk, Roderic P. (Univ of Akron, Akron, OH, USA); Ma, Jing-Jing. *J Polym Sci Part A* v 26 n 8 Aug 5 1988 p 2031-2037.

**082115 DETERMINATION OF THE POLYDISPERSITY OF POLYMERS IN DIFFERENT CHROMATOGRAPHIC REGIMES.** A method is proposed for evaluating the MD not requiring preliminary calibration against standards and based exclusively on the use of parameters of the recorded chromatogram. For this the authors employ the theoretical dependence relating the slope of the calibration curve to the distribution coefficient. The influence of adsorption effects on the widening of the chromatograms is considered. A new way of evaluating the instrumental widening is proposed using the form of the chromatograms close to critical conditions. (Author abstract). 9 Refs.

Gorbunov, A.A. (Leningrad Chemicopharmaceutical Inst, USSR); Skvortsov, A.M. *Polym Sci USSR* v 29 n 5 1987 p 1018-1025.

**082116 DETERMINATION OF CONSTANTS OF THE MARK-KUHN-HOUWINK EQUATION USING MICROAMOUNTS OF POLYMERS ON THE BASIS OF MICROCOLUMN EXCLUSION CHROMATOGRAPHY.** A chromatographic method of determin-

ing the Mark-Kuhn-Houwink constant for polymers in a new solvent, based on the use of narrow-dispersion samples of known MM is proposed. The use of microcolumn exclusion chromatography enables the results to be obtained with only 1 mg of polymer. It is shown that the values obtained for dichloroethane are in good agreement with published information. (Edited author abstract). 9 Refs.

Kever, Ye. Ye. (USSR Acad of Sciences, USSR); Vilenchik, L.Z.; Gankina, E.S.; Belenkii, B.G. *Polym Sci USSR* v 29 n 5 1987 p 1238-1240.

**082117 DETERMINATION OF REACTIVE COMONOMERS AND/OR AMINO RESINS IN ACRYLIC COPOLYMERS USED IN TEXTILE INDUSTRY, BY PYROLYSIS-GAS CHROMATOGRAPHY-MASS SPECTROMETRY.** Acrylic copolymers are used in the textile industry as binders for nonwoven fabrics, pigment printing or finishing. These binders must stabilize the fabrics during treatments such as washing and dry cleaning. For this purpose self-crosslinking acrylic copolymers or mixtures of acrylic copolymers and amino resins are often used. In this work, a method has been developed to determine whether reactive acrylic comonomer and/or amino resin are present in the acrylic copolymers. The technique applied, based on coupled pyrolysis-gas chromatography-mass spectrometry, can be used to separate and identify all the pyrolysis products of the polymer. (Author abstract) 23 refs.

Casanovas, A.M. (Hispano Quimica SA, Barcelona, Spain); Rovira, X. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 227-232.

## Cleaning

**082118 REMOVAL OF TRIGLYCERIDES FROM POLYMER SURFACES IN RELATION TO SURFACTANT PACKING. ELLIPSOMETRY STUDIES.** The removal of triglycerides from polymer surfaces by surfactant mixtures and by surfactants combined with inorganic salts or organic solvents has been studied by ellipsometry. Important results are that the efficiency of ionic surfactants can be enhanced by addition of inorganic salts and that the efficiency of ionic surfactants can be enhanced by addition of hydrocarbons. The removal process starts with the adsorption and aggregation of surfactant molecules at the soil/water interface. This aggregation is affected by the geometric properties of the surfactant molecules in the aggregates, such as head group area, hydrocarbon chain length, and volume. It is postulated that maximal removal is related to the packing of the surfactant molecules. The optimal packing is obtained in planar layers, i.e., zero curvature toward water and soil. The results show that a decrease in curvature corresponds to an increase in the soil removal, and can predict the detergency of surfactant solutions. (Edited author abstract). 49 Refs.

Backstrom, Kjell (Chemical Cent, Lund, Swed); Lindman, Bjorn; Engstrom, Sven. *Langmuir* v 4 n 4 Jul-Aug 1988 p 872-878.

## Coagulation

**082119 PREPARATION OF COMPOSITE FINE PARTICLES BY HETEROCOAGULATION.** To prepare regular composite particles comprised of organic and inorganic compounds, based on heterocoagulation theory, the properties of the mixture of small amphoteric latices and large spherical silica were investigated as a function of pH, particle number ratio, particle size ratio, particle size ratio and electrolyte concentration in the medium. It is apparent that under suitable conditions, we may prepare a stable mixed suspension comprising uniform composite particles, which are made up of many latices regularly adsorbed on silica surfaces, and each composite particle is undergoing Brownian motion as an isolated unit. This new composite particle is very stable for electrolyte, base and acid medium, and its surface charges (sign and magnitude) can be controlled by changing the pH of the medium. (Edited author abstract) 7 refs.



Furusawa, K. (Univ of Tsukuba, Ibaraki, Jpn); Anzai, C. *Colloid Polym Sci* v 265 n 10 Oct 1987 p 882-888.

## Coatings

**082120 POLYMER COATINGS WITH A DESTABILIZING ACTION ON SUSPENSIONS.** The rheological behavior of concentrated suspensions of spherical glass particles can be influenced drastically by surface pretreatment of the particles. This treatment consisted of silanization with mono- or difunctional organo-silicon compounds. Results from ESCA, IR and SEM analysis strongly suggest that silanization with the reagent dimethyldichlorosilane (DMDCS) results in a more or less homogeneous layer of oligomer and/or polymer depending on the processing. The particles were suspended in an apolar liquid (DOP) and in a polar liquid (glycerol/water). All suspensions exhibited perfect or nearly Newtonian behavior except DMDCS-coated glass in glycerol/water. (Edited author abstract) 17 refs.

Laven, J. (Eindhoven Univ of Technology, Eindhoven, Neth); Huisman, F.J.; Lalicu, L.J.; Stein, H.N. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 385-405.

## Combustion See Also FLAME RESEARCH; GASES—Toxicity.

**082121 TOXICITY DEPENDENCE OF POLYMER COMBUSTION PRODUCTS ON THE LENGTH OF THEIR EFFECT ON ANIMALS.** Products of polymeric material combustion have toxic properties, dependent on the time of burning. This study investigates oxidation induced decomposition of polymeric materials and generation of toxic compounds in the zone of fire. Effect of toxic compounds in mouse experiments is described. Relationship between the combustion time and toxic product volume is assessed. In Russian. 3 refs.

Ivanova, L.A. *Gig Tr Prof Zabol* n 11 Nov 1987 p 60-62.

**082122 POLYMER COMBUSTION: A REVIEW.** The study of polymer combustion is important first to the use of polymers as fuel binders in composite solid propellants and secondly to the understanding of polymer flammability so that fire retardants can be developed effectively. Polymer combustion is mainly associated with two phenomena, viz.: ignition and burning. This review aims at giving a complete picture of the process of polymer combustion. This paper covers the process of polymer combustion, specifically the reactions occurring in the condensed and gas phases. Some of the topics discussed are combustion chemistry, thermal degradation, oxidative degradation, surface reactions, oxygen index, smoke evolution, and smoke abatement. 129 refs.

Kishore, K. (Indian Inst of Science, Bangalore, India); Nagarajan, R. *J Polym Eng* v 7 n 4 Oct 1987 p 319-349.

**082123 ROLE OF PYROLYSIS IN POLYMER COMBUSTION AND FLAME RETARDANCE.** The authors conducted thermoanalytical studies of polymer pyrolysis in the absence and presence of oxygen; and, in particular, the behavior observed with polymer-flame retardant systems can provide valuable information about the complex physical and chemical interactions which may take place between the polymers and additives. Examples are given showing how the effects of certain bromine, phosphorus and metal compounds on polymer combustion can be interpreted in the light of the thermoanalytical behavior of mixtures of these compounds with selected polymers. Finally it is pointed out that studies of the controlled pyrolysis of polymers and polymer-flame retardant systems using conventional thermoanalytical equipment may have only limited relevance to the combustion of these same materials, since the total heat fluxes involved are so much greater during combustion than in thermal analysis. (Edited author abstract) 24 refs.

Cullis, C.F. (City Univ, London, Engl). *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal

and Appl Pyrolysis Reading, Engl, Sep 15-19 1986 p 451-463.

## Components See ORGANIC COMPOUNDS—Processing; SOLVENTS.

## Composition Effects See Also BLOCK COPOLYMERS—Synthesis.

**082124 POLYMER MICROHETEROGENEITY AND CONCENTRATION DEPOLARIZATION OF DYE FLUORESCENCE.** Concentration depolarization of fluorescence has been investigated with two dyes embedded in layers of poly(N-vinylcarbazole) or poly(N-epoxypropylcarbazole) of different molecular weight. The spatial distribution of dye molecules in the polymers - in contrast to the case of low-molecular-weight compounds and ethanol-glycerol mixtures - shows substantial microheterogeneity induced by non-equilibrium microheterogeneity of the polymeric matrix. (Author abstract) 8 refs.

Rumyantsev, B.M. (Research Inst of Organic Intermediates & Dyestuffs, USSR); Semenova, L.V.; Dubinin, N.V. *Polym Sci USSR* v 28 n 6 1986 p 1440-1446.

## Compounding See Also PLASTICS; POLYMERIZATION.

**082125 TWIN-SCREW COMPOUNDING.** In the U.S. plastics industry, there is a growing trend toward the modification of polymers as a way of improving their physical properties and cost competitiveness. A wide variety of additives are available to reduce or eliminate the various types of degradation (thermal, mechanical, chemical, environmental). The availability of improved processing equipment has had a major influence on the type and levels of additives used today. The improved dispersion obtained with multiscrew extruders has actually allowed a reduction in the amount of additives required. This lowers additive costs and in many cases results in improved physical and processing properties. The author examines: continuous compounding, twin screw compounding; commercial compounding requirements; fiber reinforcing; fillers; color concentrates; alloying; liquid injection; and, two-stage compounding systems.

Mielcarek, Daniel F. (Werner & Pfleiderer Corp, Ramsey, NJ, USA). *Chem Eng Prog* v 83 n 6 Jun 1987 p 59-67.

**082126 DEVELOPMENT OF DISPERSION IN THE MIXING OF CALCIUM CARBONATE INTO POLYMER BLENDS IN AN INTERNAL MIXER.** An experimental study of agglomeration tendency and the compounding of calcium carbonates of varying particle size into polypropylene and polystyrene melts in an internal mixer and in a two roll mill is described. The tendency of particles to agglomerate was studied using the sedimentation volume method. Agglomeration increased with decreasing particle size. It was sharply reduced by coating with stearic acid. Agglomerate size distributions in thermoplastic matrices were measured using optical microscopy. Stearic acid coating reduced the number of large agglomerates. (Edited author abstract) 16 refs.

Suetsugu, Yoshiyuki (Univ of Akron, Akron, OH, USA); White, James L.; Kyu, Thein. *Adv Polym Technol* v 7 n 4 Winter 1987 p 427-449.

**082127 COMPOUNDED RESINS SEARCH OUT GLOBAL MARKETS.** Designers everywhere, always on the lookout for new materials that are cost-effective, strong in function, and readily processable on existing equipment, are recognizing the enormous potential of compounded resins. The demand for new materials is rapidly growing worldwide. This paper reviews the status of compounding in polymer industry and the applications of compounded resins. (Edited author abstract)

Wigotsky, Victor (Plastics Engineering, Brookfield Cent, CT, USA). *Plast Eng* v 43 n 7 Jul 1987 p 21-29.

## Compressibility

**082128 INFLUENCE OF HYDROSTATIC PRESSURE ON MOLECULAR DYNAMICS IN POLYMERS. REVIEW.** The patterns of segmental dynamics of macromolecules and the dynamics of low molecular weight particles on volumetric compression of solid polymers are discussed. Experimental evidence indicates that the view long prevalent on the different scale of the kinetic elements involved in the  $\alpha$  and  $\beta$  processes (dipole-segmental and dipole-radical) has not been confirmed. It has been established that the existence of these processes is a common property of amorphous substances, both polymers and liquids, including rigid ones without internal rotations of the molecules. It was also found that the ratio of the charges released in the  $\alpha$  and  $\beta$  processes on thermal disruption of polarization brought about in the polymer by a constant electric field concurs with the ratio of the activation volumes of these processes. 62 refs.

Kovarskii, A.L. (USSR Acad of Sciences, USSR). *Polym Sci USSR* v 28 n 7 Jul 1987 p 1497-1514.

## Computer Simulation

**082129 MOLECULAR MODELING OF POLYMERS - II. ESTIMATION OF MELT TRANSITION TEMPERATURES.** Computer-aided molecular modeling methods are presented to estimate the melt transition temperature,  $T_m$ 's, of polymers in solution and in the crystalline state. A calibration-based melt transition model can be used on a congeneric series of polymers where at least one known  $T_m$  is available to scale the computation. This model is applied to a set of collagen triple-helix tripeptide and hexapeptide analogs, and to four classes of crystalline synthetic polymers. (Edited author abstract) 24 refs.

Hopfinger, A.J. (Univ of Illinois at Chicago, Chicago, IL, USA); Pearlstein, R.A.; Taylor, P.L.; Boyle, F.P. *J Macromol Sci Phys* v B26 n 3 Sep 1987 p 359-386.

**082130 MOLECULAR DYNAMICS OF A MODEL POLYMER ON A HYPERCUBE PARALLEL COMPUTER.** In this paper, we discuss the implementation and solution of molecular dynamics polymer models on the Intel iPSC Hypercube parallel computer. We first describe a model problem whose inherent parallelism can be exploited effectively and which is therefore amenable to parallel solution. We next discuss the salient features of the hypercube programs that were used to solve the model problem. Finally, we present results which demonstrate that the efficiencies of the solutions approach 100% as the number of atoms in the polymer and the number of hypercube processors are increased for the problem in question. The results demonstrate that parallel solutions of polymer problems using a hypercube architecture offer potentially significant savings over sequential solutions. (Author abstract) 25 refs.

Drake, J.B. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Hudson, A.K.; Johnson, E.; Noid, D.W.; Pfeiffer, G. A.; Thompson, S. *Comput Chem* v 12 n 1 1988 p 15-20.

**082131 MODELING OF NETWORK SYSTEMS.** This study deals with polymers which react by a stepwise reaction. Properties such as cross-link density, which rely on the reactivity of the functionalities and types of chemical bonds formed by the cross-linking of the monomers, have been modeled. Computer modeling is employed to predict the number of functionalities reacted on each multifunctional monomer, cross-link density, and reactivity of functionalities in the cross-linked system. The computer model calculates data from networks formed by a stepwise reaction and includes corrections for substitution effects. The polymer used to illustrate the model is the network formed by the tetrafunctional epoxy, tetra-



glycidyl(diaminodiphenyl)methane, and the tetrafunctional amine, diaminodiphenyl sulfone. (Edited author abstract) 43 refs.

Mertzel, Elaine A. (Case Western Reserve Univ, Cleveland, OH, USA); Perchak, Dennis R.; Ritchey, William M.; Koenig, Jack L. *Ind Eng Chem Res* v 27 n 4 Apr 1988 p 580-586.

**Concentration** See Also CHROMATOGRAPHIC ANALYSIS—Gel Permeation; GRANULAR MATERIALS—Adhesion; IONOMERS—Solutions; MOLECULES—Diffusion; POLYSTYRENES—Reaction Kinetics; POLYSTYRENES—Research; SOILS—Moisture; SOILS—Moisture Control.

**082132 DEPENDENCE OF POLYMER CHAIN ENTANGLEMENTS ON THE SOLUTION CONCENTRATION.** Attempt to establish the permissible limits of polymer concentration for dilute solutions of several polymers of different molecular weights. Experimental data indicate that under the theta condition, the entanglement concentration is a combined function of the molecular weight and the structure of the molecules. The values of  $C_e$  are different for different polymers of the same  $M_n$ . 6 refs.

Khan, H.U. (Indian Inst of Petroleum, Dehradun, India); Bhattacharyya, K.K. *J Macromol Sci Chem* v A24 n 7 1987 p 841-852.

**082133 ANTIPLASTICIZATION AND VOLUMETRIC BEHAVIOR IN GLASSY POLYMERS.** A model is proposed for understanding changes in the volumetric and the free-volume properties of a glassy polymer upon addition of a low molecular weight diluent. The proposed theory for volumetric behavior appears to describe the negative departures from volume additivity that have been observed experimentally in glassy polymer-diluent systems. An expression is derived for the concentration dependence of the specific hole free volume in a glassy polymer-diluent mixture. This expression is used to explain antiplasticization behavior in glassy polymers and to rank the antiplasticization effectiveness of various diluents that are added to a particular polymer glass. (Author abstract) 15 refs.

Vrentas, J.S. (Pennsylvania State Univ, University Park, PA, USA); Duda, J.L.; Ling, H.-C. *Macromolecules* v 21 n 5 May 1988 p 1470-1475.

**Conductive** See Also AROMATIC POLYMERS; AROMATIC POLYMERS—Electric Conductivity; AROMATIC POLYMERS—Electronic Properties; AROMATIC POLYMERS—Films; AROMATIC POLYMERS—Spectrum Analysis; AROMATIC POLYMERS—Structure; ELECTROLYTES, SOLID—Ionic Conduction; POLYACETYLENES; POLYACETYLENES—Degradation; POLYACETYLENES—Doping; POLYACETYLENES—Electric Conductivity; POLYACETYLENES—Spectrum Analysis; POLYMERS—Doping; POLYSTYRENES—Fillers.

**082134 SYNTHESIS AND CHARACTERIZATION OF ABA BLOCK COPOLYMER-BASED POLYMER ELECTROLYTES.** The synthesis and some of the properties of a novel ion-conducting polymer are described. The polymer, based on a styrene-butadiene-styrene ABA triblock copolymer has pendant, short-chain poly(ethylene oxide) (PEO) grafted onto the B block. The concentration of PEO in the polymer can be controlled by varying either the number of pendant groups per molecule or the molecular weight of the PEO chain. The polymers were combined with  $\text{LiCF}_3\text{SO}_3$  to form ion-conducting phases. The conductivities of films of these materials were found to be sensitive to preparation technique, and especially to casting solvent. The temperature dependence of the conductivity suggested that the materials were essentially amorphous over the range studied. (Edited author abstract) 25 refs.

Giles, J.R.M. (Royal Aircraft Establishment, Farnborough, Engl); Gray, F.M.; MacCallum, J.R.; Vincent, C.A. *Polymer* v 28 n 11 Oct 1987 p 1977-1981.

**082135 THIOPHENE ELECTROPOLYMERIZATION BY CYCLIC VOLTAMMETRY: TEMPERATURE INFLUENCE.** The influence of temperature on the thiophene oxidation-polymerization was studied by

cyclic voltammetry. The temperature increase up to 15-20°C promotes a faster surface polymerization. At higher temperatures the formation and growth of the polymer layer is slower due to the lower conductivity of the polymer layer formed at the first potential cycle. This decrease in polymer conductivity may be related to the increase of mobility of the monomer ion radicals (formed by monomer oxidation) in the diffusion layer, as shown by a rotating disk electrode. (Author abstract) 15 refs.

Otero, Toribio Fernandez (Basque Country Univ, San Sebastian, Spain); de Larreta-Azelain, Enrique. *Polym Commun (Guildford Engl)* v 29 n 1 Jan 1988 p 21-24.

**082136 GRAFTING OF POLY( $\alpha$ -CHLOROACRYLONITRILE) ( $\alpha$ -PCIAN) ON CARBON BLACK AND ELECTRICAL PROPERTIES OF  $\alpha$ -PCIAN-GRAFTED CARBON BLACK COMPOSITIONS.** The electrical properties of poly( $\alpha$ -chloroacrylonitrile) (PCIAN) carbon black compositions were determined. These materials were prepared by polymerizing  $\alpha$ -chloroacrylonitrile in the presence of carbon black (GC resistors). Resistivity measurement of GC resistors shows a semiconductor-like behavior. Moreover, the resistance change of GC resistors with electrical field strength is very large. It is concluded that the conduction of GC resistors is controlled by the thin polymer layer present at the surface of the carbon black particles. Heat degradation of such compositions was also investigated. (Edited author abstract) 7 refs.

Miyauchi, Shin'Nosuke (Technological Univ of Nagaoka, Nagaoka, Jpn); Mino, Nobuhiro; Balard, Henri; Papirer, Eugene; Donnet, Jean Baptiste. *J Appl Polym Sci* v 35 n 1 Jan 1988 p 127-134.

**082137 CHAIN RIGIDITY-PROCESSABILITY CORRELATION IN INHERENTLY CONDUCTING POLYMERS.** The author investigated the problem of how to introduce processability into conducting polymeric materials while preserving their conjugated character. The author focused on one approach to achieve such progress, which is the use of Lewis acid coupling reactions and an extensive characterization to understand the materials properties. It can be concluded that a certain degree of crystallinity is needed to achieve high conductivities. Since it is quite possible that the spin localization is due to the presence of a large amount of arsenic, it might be of interest to use other catalytic systems such as  $\text{SbF}_3/\text{SbF}_5$ ,  $\text{SO}_3/\text{H}_2\text{SO}_4$ ,  $\text{BF}_3/\text{HBF}_4$ ,  $\text{PF}_5/\text{HPF}_6$ , etc. as solvent/catalyst couples. 26 refs.

Aldissi, M. (Los Alamos Natl Lab, Los Alamos, NM, USA). *Polym Plast Technol Eng* v 26 n 1 Mar 1987 p 45-70.

**082138 STUDY OF POLYPYRROLE SYNTHESIZED WITH OXIDATIVE TRANSITION METAL IONS.** Polypyrrole powder and films were chemically synthesized by the reaction of  $\text{AgNO}_3$ ,  $\text{FeCl}_3$ ,  $\text{Fe}(\text{NO}_3)_3$ ,  $\text{Cu}(\text{NO}_3)_2$ , or  $\text{Cu}(\text{NO}_3)_2\cdot\text{AlCl}_3$  with pyrrole in an aqueous solution or a water-toluene two-phase system. Products were characterized by elemental analysis, IR, scanning electron microscopy with energy dispersive x-ray analysis (SEM with EDAX), and conductivity measurements. The polypyrrole synthesized from pyrrole with  $\text{FeCl}_3$  had a composition of  $\text{C}_{4.00}\text{H}_{3.05}\text{N}_{0.99}\text{Cl}_{0.25}$ . All the other metal salts produced films that had the same organic backbone, morphology, and conductivity as the polymer synthesized using  $\text{Fe}(\text{III})$  salts, regardless of the considerable differences in the reduction potentials of the metal ions. The nature of the anions of the transition metal salts had no effect on the reaction. (Edited author abstract) 10 refs.

Chao, Taina H. (SUNY Purchase, Purchase, NY, USA); March, Juan. *J Polym Sci Part A* v 26 n 3 Mar 1988 p 743-753.

**082139 STUDIES ON SOME PROPERTIES OF PRISTINE AND IODINE-DOPED POLY(PHENYLENE SULPHIDE).** Some properties of poly(phenylene sulphide) prepared by direct synthesis from benzene and sulphur are discussed in the light of thermal analysis,

X-ray, SEM, and infrared data. Pristine poly(phenylene sulphide) is characterized by large thermal stability; it loses only 22.5% of its mass during dynamic heating to 873 K. Mass loss for iodine-doped samples increases to 41% depending on the iodine content. Doping with iodine also changes crystallinity and morphology and brings about a rise of electrical conductivity by several orders of magnitude. A conductivity of  $1.45 \times 10^{-2} \text{ S m}^{-1}$  was obtained in air at room temperature for the sample containing 22.6% iodine. (Author abstract) 12 refs.

Kreja, Ludwik (N. Copernicus Univ, Torun, Pol); Warszawski, Andrezej. *J Mater Sci* v 23 n 2 Feb 1988 p 497-500.

**082140 ELECTROCHEMICAL DOPING REACTIONS OF THE CONDUCTING LADDER POLYMER BENZIMIDAZOBENZOPHENANTHROLINE (BBL).** The electrochemical reactivity of films of the polymer is examined by using cyclic voltammetry, coulometry, and spectroelectrochemistry. In contact with acidic aqueous ( $\text{Bu}_4\text{N})_2\text{SO}_4$  buffer, BBL voltammetry exhibits two redox steps corresponding to the sequential reduction of the unprotonated and the protonated forms of BBL connected by a  $\text{pK}_a = 2.2$ . The reductions consume overall one electron and one proton per BBL monomer site. The (more positive) reduction of unprotonated BBL is proposed to involve protonation at the carbonyl to yield a quinone/hydroquinone form; reduction of the protonated BBL is proposed to involve protonation of imine sites to yield a quinone/quinimine form of the polymer. The quinone/quinimine form is the more electrically conductive form of doped BBL. (Author abstract) 10 refs.

Wilbourn, K. (Univ of North Carolina, Chapel Hill, NC, USA); Murray, Royce W. *Macromolecules* v 21 n 1 Jan 1988 p 89-96.

**082141 NEW CHEMICALLY PREPARED CONDUCTING 'PYRROLE BLACKS'.** A series of electrically conducting pyrrole 'black' polymers has been prepared by chemical oxidation of pyrrole with a variety of ferric salts. The synthesis and properties of these materials are described and compared with electrochemically-prepared analogs. Pyrrole 'blacks' with strong acid anion 'dopants' exhibited the highest conductivities, up to  $62 \Omega \text{ cm}^{-1}$  for the triflate-doped polymer. The adjustability and ease of synthesis of the ferric-derived polypyrroles render these particularly promising for large-scale processing of conducting polymers. (Author abstract) 17 refs.

Walker, John A. (Rockwell Int Science Cent, Thousand Oaks, CA, USA); Warren, L.F.; Witucki, E.F. *J Polym Sci Part A* v 26 n 5 May 1988 p 1285-1294.

**082142 OPTICAL PROPERTIES OF CONDUCTING POLYMERS.** In this review the authors have summarized the optical studies of some of the key conducting organic polymers that have become important in recent years. Conducting polymers can be broadly divided into two types, namely, those with a degenerate ground state and solitons as the important excitations and those where the ground-state degeneracy is lifted so that polarons and bipolarons are the important excitations and the dominant charge-storage configurations. Polyacetylene,  $(\text{CH})_n$ , is the extensively studied example with a degenerate ground state (the double and single bonds can be interchanged with no cost of energy). Poly(p-phenylene), poly(p-phenylene sulfide), and polyheterocycles (polypyrrole, polythiophene, etc.) each have a nondegenerate ground state (for example, in poly(p-phenylene) the quinoid form has a higher energy than the benzenoid form). 68 refs.

Patil, A.O. (Univ of California, Santa Barbara, CA, USA); Heeger, A.J.; Wudl, F. *Chem Rev* v 88 n 1 Jan-Feb 1988 p 183-200.

**082143 PERCOLATION PHENOMENA IN POLYMER/CARBON COMPOSITES.** Samples of polyester, polyvinylchloride or polycarbonate with various amounts



of carbon black were studied. Percolation phenomena in electrical and dielectric properties have been systematically studied. Critical exponents from the resistivity of conductive samples ( $t=1.9$ ) and the dielectric constant of insulative samples ( $s=0.8$ ) agree well with theoretical predictions (2.0 and 0.7, respectively) and experimental values (2.0 and 0.7, respectively from inorganic composites). Critical behavior in the loss factor of insulative samples has also been demonstrated for the first time. Factors affecting the percolation threshold are briefly discussed. 25 refs.

Hsu, William Y. (DuPont, Wilmington, DE, USA); Holtje, Wilfried G.; Barkley, John R. *J Mater Sci Lett* v 7 n 5 May 1988 p 459-462.

**082144 ELECTRICAL AND THERMAL STABILITY OF CHEMICALLY SYNTHESIZED CONDUCTIVE POLYPYRROLE-HALOGEN COMPLEXES.** Conductive polypyrrole (PPY)-halogen complexes were obtained via the simultaneous chemical polymerization and oxidation of pyrrole by bromine ( $\text{Br}_2$ ), iodine ( $\text{I}_2$ ) or chlorine ( $\text{Cl}_2$ ). The thermal stability of these complexes was studied by thermogravimetry while the electrical stability was characterized by electrical conductivity measurements at various temperatures and current loadings, as by cyclic voltammetry. Although the PPY- $\text{I}_2$  complex shows the best thermal-physical stability, the PPY- $\text{Br}_2$  complex has the most favorable electrical properties. The room temperature electrical conductivity of the PPY- $\text{Br}_2$  complex is about 33 S/cm and the complex can sustain a current density of at least 6 A/cm<sup>2</sup> for more than 100 h without any degradation in conductivity. The weight and electrical conductivity of the sample, however, decrease when heated above 140°C. Both the PPY- $\text{I}_2$  and PPY- $\text{Br}_2$  complexes show good stability upon repeated redox cycling in both aqueous and organic electrolytes. (Author abstract). 18 Refs.

Neoh, K.G. (Nat'l Univ of Singapore, Kent Ridge, Singapore); Kang, E.T.; Tan, T.C. *Polym Degradation Stab* v 21 n 2 1988 p 93-103.

**082145 ESCA ANALYSIS OF POLYMER-ACCEPTOR INTERACTIONS IN CHEMICALLY SYNTHESIZED POLYPYRROLE-HALOGEN COMPLEXES.** X-Ray photoelectron spectroscopy (XPS) studies have been performed on conductive polypyrrole (PPY)-halogen complexes, such as PPY- $\text{I}_2$ , PPY- $\text{Br}_2$ , and PPY- $\text{Cl}_2$  complexes, prepared by the simultaneous chemical polymerization and oxidation of pyrrole by the respective halogens. Substantial halogenation of the pyrrole ring was observed in the case of PPY- $\text{Cl}_2$  and PPY- $\text{Br}_2$  complexes. In the case of PPY- $\text{Br}_2$  complex, the ratio of covalent to ionic bromide content can be effectively varied over a wide range by varying the bromine to monomer ratio used for polymerization. The increase in covalent bromide content causes a decrease in the electrical conductivity of the complex. (Edited author abstract). 22 Refs.

Kang, E.T. (Nat'l Univ of Singapore, Kent Ridge, Singapore). *Polym J* v 20 n 5 1988 p 399-406.

**082146 MAGNETIC SUSCEPTIBILITY OF POLYPYRROLE AND POLYTHIOPHENE CONDUCTING POLYMERS.** Conducting polymers have been a subject of great interest almost for a decade due to their outstanding electronic properties. A wide variety of electrically conducting polymers exhibiting nearly conductivity of metallic type have been investigated. The electrical behavior of these polymers is strongly influenced by the presence of counter-anion, solvents etc., in the conducting state. Apart from their conducting properties, these polymers should also exhibit interesting magnetic properties since dynamic defects formed during the electrooxidation polymerization are intrinsic to the polymer. The ESR measurements have been conducted on polythiophene and polypyrrole in order to study the conduction mechanism. 34 Refs.

Nalwa, Hari S. (State Univ of New York at Buffalo, Buffalo, NY, USA). *J Polym Sci Part C* v 26 n 8 Aug 5 1988 p 351-355.

**082147 PREVODNI POLIMERI. [Conducting Polymers].** A review of conducting organic polymers is given. The mechanisms of conductivity of polymers with conjugated double bonds, of aromatic and heterocyclic polymers and of polymers with charge on the side group are discussed. The synthesis of some conducting polymers is described along with their use in electronics. (Author abstract). 11 Refs. In Slovenian.

Sebenik, Anton (Kemijski Inst Boris Kidric, Ljubljana, Yugoslavia); Osredkar, Uci. *Elektroteh Vestn* v 55 n 1 Jan-Mar 1988 p 49-51.

**082148 ORGANIC CONDUCTORS.** Scientists from many disciplines are now combining expertise to study organic solids that exhibit remarkable conductivity properties. Organic chemistry, X-ray crystallography, solid state physics, material science and microelectronic engineering have found a unique meeting ground. These novel materials, which may be crystalline or polymeric, have the advantage that they are structurally versatile and potentially cheaper and easier to fabricate than the traditional inorganic conductors - but the industrial success of conducting organic materials may well depend on the ingenuity of the synthetic organic chemists as they learn to become molecular engineers. Subtle variations in the chemical structure of molecules can regulate the bulk electrical, optical or magnetic properties of the material. 14 Refs.

Bryce, Martin R. (Univ of Durham, Durham, Engl). *Chem Br* v 24 n 8 Aug 1988 p 781-785.

**082149 SYNTHESIS AND ANALYSIS OF SOME SULPHUR AND NITROGEN CONTAINING CONDUCTING POLYMERS INCLUDING CONDUCTING POLYMER BLENDS OF POLY(3-OCTYLTHIOPHENE).** This thesis deals with inherently conducting polymers and has been divided into two parts. The first part deals with the synthesis, characterization and electrical conductivities of the derivatives of poly(p-phenylene sulfide) and poly(p-azophenylene), poly(2,4-azotoluene), poly(ethylene vinylene sulfide), poly(2,6-pyridine), poly(2,6-pyridine sulfide), poly(3,6-pyridazine) and poly(3,6-pyridazine sulfide). Undoped polymers are insulators (conductivity  $<10^{-8}$  S/cm) but during doping the conductivities rise as high as  $10^{-3}$  S/cm. The doped polymers were studied using IR and ESR spectrometry. The second part describes the preparation of poly(3-octylthiophene) (POT) and the polymer blends of it. POT is solution and melt processable and when doped with iodine the conductivity rises to 20 S/cm. POT has been hot pressed onto a polymer substrate which after doping has a conductivity of 20 S/m blended and blow molded with different processable polymers (PE, PP, EVA, EBA). When doped the conductivities of the blends are 1 S/cm. Blends of this type might be useful in applications such as electromagnetic interference (EMI) shielding, electrostatic discharge (ESD) elimination and semiconducting layers in high voltage cables. (Edited author abstract). 99 Refs.

Laakso, Jukka (Neste Oy Technology Cent, Kullo, Finl). *Acta Polytech Scand Chem Technol Metall Ser* n 184 1988 48p.

**082150 CONDUCTION MECHANISM OF POLYANILINE: EFFECT OF MOISTURE.** It has recently been shown that the emeraldine base polymer form of polyaniline undergoes a transition from an insulating to a metallic state upon protonation with HCl. The conductivity of the protonated polymer is sensitive to the moisture content of the polymer, varying by as much as a factor of five upon pumping the samples. The authors report the temperature-dependent microwave frequency ( $10^{10}$  Hz) conductivity and dielectric constant as a function of environmental history. The results are consistent with the effect of moisture on the barriers between small metallic polymer grains. Texture of granular metal particles and localization within metallic islands are decisive in the frequency- and temperature-dependence of the conductivity and dielectric constant. (Author abstract). 35 Refs.

Javadi, H.H.S. (Ohio State Univ, Columbus, OH, USA); Angelopoulos, M.; Macdiarmid, A.G.; Epstein, A.J. *Synth Met* v 26 n 1 Oct 1 1988 p 1-8.

**082151 ELECTROCHEMICAL BEHAVIOUR OF POLYPYRIDAZINE AND o-, m-, p-DIAZINES.** The electrochemical behaviors of polypyridazine (PPd), an electrically conducting polymer, its monomer pyridazine, and isomers pyrazine and pyrimidine, have been studied by cyclic voltammetry. When the electrochemical behaviors of the three diazines in acetonitrile (MeCN) solution with different supporting electrolytes (such as  $\text{LiClO}_4$ ,  $\text{NH}_4\text{BF}_4$ ,  $\text{KPF}_6$ ,  $\text{KAsF}_6$ ) are compared, it is found that under each of the above conditions the oxidation peak potential of pyridazine is the lowest, but its peak current is the highest. When  $\text{LiClO}_4$  or  $\text{NH}_4\text{BF}_4$  is used as the supporting electrolyte, pyridazine can be polymerized to form a dark greenish-blue PPd film on the anode, while pyrimidine or pyrazine is oxidized only to produce a yellowish powdery precipitate. (Edited author abstract). 9 Refs.

Baozhen, Yan (Acad Sinica, Beijing, China); Jing, Yang; Yong, Cao. *Synth Met* v 26 n 1 Oct 1 1988 p 9-20.

**082152 ELECTROCHEMICAL COPOLYMERIZATION OF BENZO[b]THIOPHENE.** Many attempts have been made to produce new conducting polymers such as polypyrrole, polythiophene and polyaniline by electrochemical polymerization. This paper reports on the electrochemical copolymerization of benzo[b]thiophene with pyrrole and the conditions for producing flexible and transparent conductive films. Highly conducting polymer films that are stable to ambient conditions and have good mechanical properties can be obtained by the electrochemical copolymerization of benzo[b]thiophene with pyrrole if a suitable supporting electrolyte, solvent, current density and copolymer composition are selected. (Edited author abstract). 7 Refs.

Seki, Mihar (Chiba Inst of Technology, Chiba, Jpn); An, Heishoku; Sato, Kojiro; Yosomiya, Ryutoku. *Synth Met* v 26 n 1 Oct 1 1988 p 33-39.

**082153 PHOTOINDUCED LOCALIZED CHARGED EXCITATIONS IN POLYANILINE.** The authors report the infrared photoinduced absorption spectra of polyaniline in the 'emeraldine' base form while pumping into the two optical transitions at 2.0 eV and 4.0 eV, respectively. For optical pumping at energies near 2.0 eV, they found photoinduced infrared-active vibrational (IRAV) modes that are essentially identical to those observed subsequent to protonation. They propose that the optical absorption at 2.0 eV in the emeraldine form is due to an  $n-\pi^*$  transition from the non-bonding nitrogen lone-pair to the conduction ( $\pi^*$ ) band. With 4.0 eV optical pumping, the IRAV modes are significantly different, demonstrating that a different species is produced when pumping into the  $\pi-\pi^*$  transition. The analysis, based on the amplitude mode formalism, indicates that the charged photoexcitations and the polarons that are generated through protonation are localized and not highly mobile. (Author abstract). 16 Refs.

Kim, Y.H. (Univ of California, Santa Barbara, Santa Barbara, CA, USA); Foster, C.; Chiang, J.; Heeger, A.J. *Synth Met* v 26 n 1 Oct 1 1988 p 49-59.

**082154 IMPROVEMENT IN THE QUALITY OF POLYPYRROLE FILMS PREPARED ELECTROCHEMICALLY ON A MERCURY ANODE.** The synthesis and some properties of polypyrrole formed on a mercury anode are described. Conductivity values in the range 40-90 S/cm compare favorably with those of films produced on other electrodes. Use of the p-toluenesulfonate anion at a concentration of 0.3 M, pH of 4.8, and a temperature of 0°C led to the best conductivity observed



in free-standing films produced on a mercury anode. A maximum thickness of about 280  $\mu\text{m}$  was achieved under optimum conditions. (Author abstract). 12 Refs.

Bradner, F.P. (Macquarie Univ, Aust); Shapiro, J.S. *Synth Met* v 26 n 1 Oct 1 1988 p 69-77.

**082155 ELECTROCHEMICAL CONTROL OF THE MORPHOLOGY, ADHERENCE, APPEARANCE AND GROWTH OF POLYPYRROLE FILMS.** The influence of the electrochemical method employed to electrogenerate polymer films on morphology, appearance and adherence to a platinum electrode was studied. The use of a potential step or cyclic voltammetry and square waves of potential at different frequencies, respectively, allows one to obtain a dendritic structure with low adherence and presence of supporting electrolyte between the polymer and the metal, or flat shiny, homogeneous and adherent polymer films. Variations in height or width of the potential steps and limits of the potential sweeps and sweep rate allowed the physical properties of the layer to be controlled progressively. (Author abstract). 30 Refs.

Otero, T.F. (Univ del Pais Vasco, San Sebastian, Spain); De Larreta, E. *Synth Met* v 26 n 1 Oct 1 1988 p 79-88.

**082156 ELECTRICAL CONDUCTIVITY AND THERMOELECTRIC POWER OF POLYPYRROLE WITH DIFFERENT DOPING LEVELS.** The electrical conductivity and absolute thermoelectric power of the conducting polymer polypyrrole have been measured between approximately 4 K and 350 K. Normally doped films had a conductivity of  $26 \Omega^{-1} \text{cm}^{-1}$ , while lightly doped films had a conductivity of  $8 \Omega^{-1} \text{cm}^{-1}$ . The Mott variable range hopping model for electrical conductivity is obeyed at higher temperatures for both types. The thermoelectric power is approximately linear in temperature, reaching about  $5 \mu\text{V K}^{-1}$  at 200 K, but is sublinear at higher temperatures and becomes constant above about 300 K. The Kuivalainen model which explains the reported anomaly between optical and dc electrical conductivity gives a good fit to the experimental data. (Author abstract). 20 Refs.

Maddison, D.S. (Macquarie Univ, Aust); Unsworth, J.; Roberts, R.B. *Synth Met* v 26 n 1 Oct 1 1988 p 99-108.

**082157 PROCEEDINGS OF THE CONFERENCE ON ELECTRONIC PROCESSES IN CONDUCTING POLYMERS (A SATELLITE CONFERENCE ON THE 18TH INTERNATIONAL CONFERENCE ON THE PHYSICS OF SEMICONDUCTORS (ICPS-86)).** These volumes contain 54 papers. All these papers are abstracted and indexed individually. These papers report the new results in conducting polymer research and the future trends in conducting polymers. The topics covered are: polyaniline; electronic structure of conducting polymers; doped polyacetylenes; sulfur containing conducting polymers; halogen-bridged platinum complexes; and electrochemical results on the properties of conducting polymers. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10550 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Salaneck, W.R. (Ed.); Lundstrom, I. (Ed.). *Synth Met* v 21 n 1 Aug, n 2 Sep and n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Vadstena, Swed, Aug 18-20 1986 3 vol, 374p.

**082158 FRONTIERS IN THE DEVELOPMENT OF POLYMERS AS ELECTRONIC MATERIALS.** Current applications of polymers as electronic materials are reviewed. Salient differences between the physics of electronic processes in polymers as opposed to those in network semiconductors are indicated, with emphasis on active research frontiers. Finally, promising technological and scientific opportunities are noted within the context of assessing the prospects for the growth of research and development efforts on conducting polymers. (Edited author abstract) 40 refs.

Duke, C.B. (Xerox Webster Research Cent, Webster, NY, USA). *Synth Met* v 21 n 1 Aug 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part I, Vad-

stena, Swed, Aug 18-20 1986 p 5-12.

**082159 SOME POTENTIAL APPLICATIONS FOR CONDUCTIVE POLYMERS.** The list of potential applications for conductive polymers has grown slightly over the years since the inception of research activities. Two examples are described: all-solid-state polymer secondary batteries utilizing composites of electroactive and ion-conductive polymers, and photoelectrochromic devices based on combinations of semiconductors and electroactive polymers. Both of these applications utilize the electroactivity of the polymer, but in different manners. 16 refs.

Inganas, Olle (Linköping Inst of Technology, Linköping, Swed); Lundstrom, Ingemar. *Synth Met* v 21 n 1 Aug 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part I, Vadstena, Swed, Aug 18-20 1986 p 13-19.

**082160 POLYANILINE: PROCESSABILITY FROM AQUEOUS SOLUTIONS AND EFFECT OF WATER VAPOR ON CONDUCTIVITY.** The chemically-synthesized emeraldine base form of polyaniline is soluble in aqueous acetic acid solutions, in which it presumably exists as the 'doped' emeraldine acetate salt. Films having a conductivity of approx.  $0.5\text{--}2 \text{S/cm}$  may be cast from the solutions. These films may be converted to relatively flexible, free-standing, lustrous, copper-colored films of emeraldine base, which can in turn be converted to free-standing, lustrous, dark blue films of emeraldine hydrochloride ( $\sigma$  approx.  $1\text{--}2 \text{S/cm}$ ). The resistance of films of both emeraldine base and 50% protonated emeraldine hydrochloride decreases by a factor of approx. 2 when exposed to approx. 4 Torr of water vapor. The resistance increases only very slowly on removing the water vapor under dynamic vacuum, consistent with the postulated structure of emeraldine hydrochloride involving 'islands' of heavily-doped emeraldine base in a matrix of undoped or slightly-doped material. (Author abstract) 12 refs.

Angelopoulos, Marie (Univ of Pennsylvania, Philadelphia, PA, USA); Ray, Anjan; MacDiarmid, Alan G.; Epstein, Arthur J. *Synth Met* v 21 n 1 Aug 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part I, Vadstena, Swed, Aug 18-20 1986 p 21-30.

**082161 SOLUBLE CONDUCTING POLYMERS: THE POLY(3-ALKYLTHIENYLENES).** The conjugated poly(3-alkylthiénylenes) can be processed from solution and subsequently used as semiconducting and metallic polymers. Both as-synthesized and solution-cast films can be readily doped to give electrical conductivities that are quite high:  $\sigma$  approx.  $30\text{--}100 \text{S/cm}$ . Ultraviolet-visible absorption spectra of the neutral and doped forms have been obtained for solid films (as-synthesized and solution-cast) and for the polymers in solution. Excitation into the  $\pi\text{--}\pi^*$  transition (peak at  $\approx 2.8 \text{eV}$ ), leads to photoluminescence (peak at  $2.16 \text{eV}$ ). The Stokes' shift is consistent with radiative decay from photogenerated neutral bipolarons (exciton-polarons). From electron spin resonance measurements and spectroscopic data on the doped polymer in solution, we have determined the nature of the charge storage configurations. The results indicate that the spinless bipolaron is the lowest energy charge storage configuration on single poly(3-hexylthiénylene) macromolecules in solution. (Edited author abstract) 19 refs.

Rughooputh, S.D.D.V. (Univ of California, Santa Barbara, Santa Barbara, CA, USA); Nowak, M.; Hotta, S.; Heeger, A.J.; Wudl, F. *Synth Met* v 21 n 1 Aug 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part I, Vadstena, Swed Aug 18-20 1986 p 41-50.

**082162 UHV-COMPATIBLE PROCESSING OF CONDUCTING POLYMERS: POLYTHIOPHENE.** The motivation for the study of the underlying physics and chemistry of the 'dry' processing of electrically-conducting organic polymers is discussed. Some details of the study of the radiation polymerization of thiophene under ultra-high vacuum (UHV) conditions are then presented. (Author abstract) 12 refs.

Salaneck, W.R. (Linköping Univ, Linköping, Swed); Wu, C.R.; Nilsson, J.O.; Bredas, J.L. *Synth Met* v 21 n 1 Aug 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part I, Vadstena, Swed, Aug 18-20 1986 p 57-61.

**082163 CONDUCTING POLYMERS: WHAT DOES THE FUTURE HOLD?** The conducting polymer field has continued its rapid expansion during the past 10 years since the discovery that an organic polymer, polyacetylene, could be doped to the metallic regime. A number of new conducting polymers have since been synthesized and many chemical, structural and physical studies have helped in elucidating the doping processes and electronic and magnetic properties of these materials; however, an adequate understanding of many fundamental phenomena will only be attained by further research. Such understanding will be assisted by the synthesis and study of new types of conducting polymers and composites. The first significant signs of technological applications of these polymers now appearing are expected to stimulate even more basic and applied research in this field in the future. (Author abstract) 83 refs.

MacDiarmid, Alan G. (Univ of Pennsylvania, Philadelphia, PA, USA). *Synth Met* v 21 n 1 Aug 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part I, Vadstena, Swed, Aug 18-20 1986 p 79-83.

**082164 EFFECTS OF MAGNETIC ORDER ON CHARGE TRANSPORT IN CONDUCTING POLYMERS.** We have studied the effect of charge carrier spin-magnetic ion interactions on charge transport in inhomogeneous polymers where the highly-conducting regions of the material order magnetically. This is the case of example in heavily  $\text{FeCl}_3$ -doped  $(\text{CH})_x$  or in polymer composites consisting of a magnetic metal or a magnetic semiconductor embedded in an insulating polymer. Our calculated results show that when the conduction is dominated by thin potential barriers as in the fluctuation-induced tunneling mechanism, the changes in magnetic order due to temperature or magnetic field cause large changes in resistivity. The possibility that the present mechanism can explain the measured positive magnetoresistance in  $\text{FeCl}_3$ -doped  $(\text{CH})_x$  is discussed. (Author abstract) 10 refs.

Kuivalainen, P. (Technical Research Cent of Finland, Espoo, Finl); Stubb, H.; Isotalo, H.; Lindberg, K. *Synth Met* v 21 n 1 Aug 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part I, Vadstena, Swed, Aug 18-20 1986 p 109-116.

**082165 OVERDOPING AND THE CAPACITIVE EFFECT IN POLYPYRROLE.** Analyzing the nature of the changes stored in chemically synthesized polypyrrole by ac impedance and cyclic voltammetry, we have decomposed the total current into two components: a capacitive current and a non-capacitive one. The non-capacitive charge is found to be approximately constant, whereas the capacitive one can vary widely from one sample to another. We conclude that the interesting overdoping effect observed in polypyrrole can essentially be attributed to the capacitive charge. (Author abstract) 9 refs.

Tanguy, J. (CEN, Gif-sur-Yvette, Fr); Mermilliod, N. *Synth Met* v 21 n 2 Sep 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part II, Vadstena, Swed, Aug 18-20 1986 p 129-134.

**082166 WATER EFFECTS IN POLYANILINE: A NEW CONDUCTION PROCESS.** We present NMR and conductivity measurements on polyaniline, which show that upon applying water vapor pressure: (i) protons exchange between the polymer and an adsorbed water phase; (ii) conduction is favored. The diffusion process of water in a pellet is investigated. Finally, we propose a



conduction mechanism based upon electron hopping between localized states, assisted by proton exchange. (Author abstract) 14 refs.

Travers, J.P. (CNRS, Grenoble, Fr); Nechtschein, M. *Synth Met* v 21 n 2 Sep 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part II, Vadstena, Swed, Aug 18-20 1986 p 135-141.

**082167 OPTICAL SPECTROSCOPY AND RESONANCE RAMAN SCATTERING OF POLYANILINE DURING ELECTROCHEMICAL OXIDATION AND REDUCTION.** In situ optical absorption and resonance Raman measurements are reported for the salt form of polyaniline. The Raman spectra show a strong dependence of the intensities on the electrochemical potential for blue laser excitation. Line shifts and new peaks were observed for green laser excitation. The behavior observed for the blue laser excitation is consistent with a decrease in preresonance molecular due to an upshift of the fundamental absorption during oxidation. The spectra for green and red laser excitations are characteristic of a change in benzoid-quinoid ring concentrations. Hysteresis behavior observed for the transmission of light at constant photon energy during cycling is interpreted as being due to diffusion processes of heavy counter-ions. (Author abstract) 9 refs.

Sariciftci, N.S. (Univ Wien, Vienna, Austria); Kuzmany, H. *Synth Met* v 21 n 2 Sep 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part II, Vadstena, Swed, Aug 18-20 1986 p 157-162.

**082168 POLYPYRROLE PREPARED BY CHEMICAL VAPOR DEPOSITION USING HYDROGEN PEROXIDE AND HYDROCHLORIC ACID.** Electrically conducting polypyrrole films have been synthesized from the vapor phase using hydrogen peroxide, hydrochloric acid and pyrrole monomers. Electrical conductivities as high as  $10 (\Omega\text{cm})^{-1}$  have been achieved. XPS and uv/vis optical absorption spectroscopy have been carried out to investigate these films. (Author abstract) 6 refs.

Mohammadi, A. (Linköping Inst of Technology, Linköping, Swed); Lundström, I.; Salaneck, W.R.; Inganäs, O. *Synth Met* v 21 n 2 Sep 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part II, Vadstena, Swed, Aug 18-20 1986 p 169-173.

**082169 ELECTRONIC STRUCTURE OF CONDUCTING POLYMERS FROM HETEROAROMATIC BICYCLIC COMPOUNDS.** A series of conjugated polymers based on indole and heteroaromatic bicyclic compounds (X, Y = NH, S, Se) is obtained as thin films on gold or conducting glass electrodes, using controlled-potential electrochemical methods. Synthesized in an oxidized state, most of them can be reduced electrochemically, accompanied by a color switching. X-ray photoelectron spectroscopy clearly shows the differences in electronic structure between the derivatives: two distinct redox states exist only when the conjugation pattern allows effective electron delocalization. (Author abstract) 16 refs.

Lazzaroni, R. (Facultes Univ Notre-Dame de la Paix, Namur, Belg); de Pryck, A.; Debaisieux, Ch.; Riga, J.; Verbiest, J.; Bredas, J.L.; Delhalle, J.; Andre, J.M. *Synth Met* v 21 n 2 Sep 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part II, Vadstena, Swed, Aug 18-20 1986 p 189-195.

**082170 ELECTRONIC STRUCTURE OF POLYTHIOPHENE.** We have used ultraviolet and X-ray photoelectron spectroscopy (UPS and XPS respectively) to study the electronic structure of the electrically conducting polymer polythiophene (PT) prepared electrochemically. The UPS and XPS valence band spectra of electrochemically reduced, insulating PT (i.e., PT<sup>0</sup>) are compared with corresponding spectra of thiophene in the gas phase and in the condensed phase, with the spectra of pure radiation polymerized PT<sup>0</sup>, and with the results of quantum chemical calculations based upon the Valence Effective Hamiltonian (VEH) and CNDO/S3 models. Excellent agreement is obtained between theory and

experiment. We have also noticed some unusual effects in XPS valence spectrum of PT<sup>0</sup>, and in the XPS core level spectra of doped PT (i.e., PT<sup>+</sup>) due to exposure of the samples to air. (Author abstract) 14 refs.

Wu, C.R. (Linköping Univ, Linköping, Swed); Nilsson, J.O.; Inganäs, O.; Salaneck, W.R.; Osterholm, J.-E.; Bredas, J.L. *Synth Met* v 21 n 2 Sep 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part II, Vadstena, Swed, Aug 18-20 1986 p 197-202.

**082171 EFFECT OF AMMONIA ON THE PHYSICAL PROPERTIES OF POLYPYRROLE.** Electrical measurements and uv/vis/nir spectroscopy are used to investigate the influence of ammonia on electrochemically prepared polypyrrole. It is demonstrated that both a reversible and an irreversible change of the electronic properties of the polymer occur. Some possible origins of these changes are discussed, such as the formation of ammonia-anion complexes and a breaking of the polymer chains. (Author abstract) 11 refs.

Gustafsson, G. (Linköping Inst of Technology, Linköping, Swed); Lundström, I. *Synth Met* v 21 n 2 Sep 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part II, Vadstena, Swed, Aug 18-20 1986 p 203-208.

**082172 SOME NEW ELECTROCHEMICAL RESULTS ON THE PROPERTIES OF CONDUCTING POLYMERS.** Electrochemical measurements were carried out with a PAR 176 potentiostat and a PAR 173 waveform generator. It is concluded that the electropolymerization is not only a linear chain growth with successive addition of monomers, but a complex reaction pattern with the competing addition of monomers, dimers and other oligomers at different reactive sites. 13 refs.

Heinze, J. (Univ Freiburg, West Ger); Mortensen, J.; Hinkelmann, K. *Synth Met* v 21 n 2 Sep 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part II, Vadstena, Swed, Aug 18-20 1986 p 209-214.

**082173 FOURIER TRANSFORM INFRARED STUDY OF LIGHTLY DOPED POLYTHIOPHENE UNDER D.C. ELECTRIC FIELDS.** We have studied the effect of a strong dc field on the IR absorbance bands of lightly FeCl<sub>4</sub><sup>-</sup>-doped polythiophene (PT) thin films. Application of a dc electric field <4 kV/cm caused large changes in the absorbances of the IR modes, especially in the C-H stretching, C-H in- and out-of-plane vibrational modes and in the bands corresponding to the thiophene ring stretching. Also the absorbances of the doping-induced bands changed substantially, but they relaxed close to the original values faster than the other modes after the field was switched off. Special care was taken to study the contribution of heating of the film to the observed results by measuring the temperature of the films both by using a thermocouple and by using the film itself as a sensitive temperature sensor. Various mechanisms including, e.g., structural changes in the disordered PT material, charge injection-induced polaron or bipolaron formation and doping continuation may contribute to the observed large changes in the IR modes of PT. (Edited author abstract) 8 refs.

Ivaska, A. (Neste Oy, Kulloo, Finl); Osterholm, J.-E.; Passiniemi, P.; Kuivalainen, P.; Isotalo, H.; Stubb, H. *Synth Met* v 21 n 2 Sep 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part II, Vadstena, Swed, Aug 18-20 1986 p 215-221.

**082174 ELECTRONIC STRUCTURE OF SULPHUR-CONTAINING CONDUCTING POLYMERS.** Core and valence levels of various sulfur-containing conducting polymers, such as poly-p-phenylene sulfide, polybenzothienophene, polythiophene, polythieno[2,3-b]thiophene and polydithienophene, have been investigated by X-ray photoelectron spectroscopy (XPS). Their electronic structures (atomic charge, band gap and the nature of the highest occupied band) are deduced from XPS spectra and compared to Valence Effective Hamiltonian calculations. (Author abstract) 12 refs.

Riga, J. (Facultes Univ Notre-Dame de la Paix, Namur, Belg); Snauwaert, Ph.; de Pryck, A.; Lazzaroni, R.;

Boutique, J.P.; Verbiest, J.J.; Bredas, J.L.; Andre, J.M.; Taliani, C. *Synth Met* v 21 n 2 Sep 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part II, Vadstena, Swed, Aug 18-20 1986 p 223-228.

**082175 ELECTRONIC STATES AND ELECTRICAL CONDUCTIVITIES OF POLYVINYLENE-SULFPHIDES.** A new method of synthesizing polyvinylsulfide by condensation polymerization of disodiumthioethylene and dichloroethylene is presented. Trans rich-polyvinylsulfide was synthesized by this method. The characterization and electrical conductivity are discussed. A novel conducting polymer that contains pyridine rings in the main chain of polyvinylsulfide was synthesized using disodiumthioethylene. Its characterization and electrical conductivity are also discussed. (Author abstract) 7 refs.

Ikeda, Y. (Research Assoc for Basic Polymer Technology, Tokyo, Jpn); Nagoya, I.; Ozaki, M. *Synth Met* v 21 n 2 Sep 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part II, Vadstena, Swed, Aug 18-20 1986 p 235-240.

**082176 RAMAN SPECTROSCOPY OF CONDUCTIVE POLYPYRROLES.** Raman spectra observed for different polypyrroles indicate the potential of the technique as a tool for characterization of molecular structures. Further analysis of spectra-property relationships and model calculations are required to allow precise band assignments to be made. 9 refs.

Cheung, K.M. (Queen Mary Coll, London, Engl); Smith, B.J.E.; Batchelder, D.N.; Bloor, D. *Synth Met* v 21 n 2 Sep 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part II, Vadstena, Swed, Aug 18-20 1986 p 249-253.

**082177 FUNCTIONALIZED CONDUCTING POLYMERS FOR DEVELOPMENT OF NEW POLYMERIC REAGENTS.** We previously established a hybridization procedure for synthesis of conducting polymers with functional molecules by electrochemical or chemical polymerization. These functionalized conducting polymers show both the native function of the functional molecule and native conductivity. The present paper describes typical functions of conducting polymers incorporating functional molecules, methods of their preparation, and their utilization as polymeric reagents and in polymer-supported reactions. 18 refs.

Shimidzu, Takeo (Kyoto Univ, Kyoto, Jpn). *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 221-227.

**082178 ELECTROCHEMICALLY CONTROLLED RELEASE OF DRUGS AND OTHER CHEMICALS.** Exploration of new methods for the timed release of drugs in which the release rate could be varied at will has led to the invention of an electrochemical device. A polymer film is coated on an electrode, the film is loaded with drug by covalent or ionic bonds, and as needed the drug is released by passing a small current through the film. The current level controls the release rate. An approach of current interest involves the use of conducting polymers which in one redox state have charged backbones and bind counter-ions. If the counter-ion is a drug ion it can be bound and released by neutralizing the charge on the polymer backbone. This has been demonstrated using polypyrroles and certain polythiophenes which will bind either anions such as acetylsalicylate or cations such as dopamine. (Author abstract)

Miller, Larry L. (Univ of Minnesota, Minneapolis, MN, USA). *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 341.



**082179 ELECTRON MICROSCOPIC EVIDENCE FOR THE LAYERED STRUCTURE OF A CONDUCTING POLYPYRROLE LANGMUIR-BLODGETT FILM.** A transmission electron micrograph of a section of a conducting polypyrrole Langmuir-Blodgett (LB) film prepared by the electropolymerization of the LB film of octadecyl 4-methylpyrrole-3-carboxylate and octadecane in a 2:1 ratio is presented. A clear image of the layered structure of conducting polypyrrole and insulating alkyl chain layers is observed over the entire cross section. (Author abstract) 9 refs.

Iyoda, Tomokazu (Kyoto Univ, Kyoto, Jpn); Ando, Masanori; Kaneko, Takehira; Ohtani, Akira; Shimidzu, Takeo; Honda, Kenichi. *Langmuir* v 3 n 6 Nov-Dec 1987 p 1169-1170.

**082180 EFFECT OF SOLVATION IN CONDUCTING POLYMERS.** The incorporation of solvent molecules into solid-state organic conductors affects both electrical and mechanical properties of the conducting complexes. Evidence for this has been appearing from the numerous laboratories currently involved in conducting polymer research. On compiling these examples, common rationale for the observed effects can be formulated based largely on the behavior of smaller molecules as found in the organic literature. Nonetheless, the examples must be considered on a case-to-case basis. In assigning the source of solvent effects, the determination of whether solvation is occurring on the charged polymer backbone or on the (oppositely charged) dopant counterion is critical. Among the proposed causes of solvent effects are solvent-separated ion pairing, charge depinning, and plasticization. (Author abstract) 15 refs.

Frommer, Jane E. (Allied Corp, Morristown, NJ, USA). *J Macromol Sci Chem* v 24 n 3-4 1987, Macromol-Met Complexes: Sel Pap from the US-China-Jpn Jt Semin, Beijing, China, Oct 20-24 1985 p 449-454.

**Contamination** See DUST—Spectroscopic Analysis.

**Cooling** See RUBBER PRODUCTS—Curing.

**Crack Propagation** See Also DENTAL EQUIPMENT AND SUPPLIES—Dental Composites; EPOXY RESINS—Curing.

**082181 DYNAMIC CRACK GROWTH IN A VISCOELASTIC MATERIAL.** Dynamic crack growth in a viscoelastic material is investigated. The present work concentrates on a Maxwell liquid. A new feature of the present analysis is the consideration of the effects of a finite cohesive zone, in which a constant cohesive stress  $\sigma_0$  acts, whose extent may be comparable with the length scale of the applied loads. A critical crack opening displacement fracture criterion is used. When  $\sigma_0$  is sufficiently large, this is demonstrated to reduce to the energy release rate criterion, while finite  $\sigma_0$  provides a rudimentary model of a craze zone such as exists adjacent to a crack tip in a viscoelastic polymer. The solution to be presented thus serves the dual purpose of providing an explicit realization of the near-tip situation, and of assessing the influence of a craze zone during dynamic fracture of a polymer. 10 Refs.

Goleniewski, G. (Univ of Bath, Bath, Engl). *Int J Fract* v 37 n 3 Jul 1988 p R39-R44.

**082182 SPIRAL CRACK PROPAGATION CONFINED TO A SURFACE ZONE OF A CROSS-LINKED POLYMER.** The purpose of this letter is to report an unusual mode of crack propagation observed in the course of dynamic mechanical analysis of crosslinked samples prepared by radiation polymerization of liquid triethylene glycol dimethacrylate which was confined between glass sheets. Samples were subjected to a small sinusoidal strain which alternated between frequencies of 1.1, 11, and 110 Hz during heating from  $-100^\circ\text{C}$  at  $2.5^\circ\text{C min}^{-1}$ . Unusual fracture modes were observed in the case of samples prepared with doses in the range 0.4 to 2.0 Mrad. In the region above the glass transition temperature ( $T_g=120^\circ\text{C}$ ) some samples suddenly disintegrated into fragments. It would appear that

heating results in samples in which a crack propagates more readily in a surface zone than in the interior. 7 Refs.

Wilson, T.W. (Univ of North Carolina, Chapel Hill, NC, USA); Turner, D.T. *J Mater Sci Lett* v 7 n 8 Aug 1988 p 875-876.

**Cracking** See FRACTURE MECHANICS—Mathematical Models.

**Crazing** See Also POLYSTYRENES—Fatigue.

**082183 POLYMER DEGRADATION BY CRAZING AND ITS STUDY BY SMALL ANGLE SCATTERING TECHNIQUES.** Craze formation and breakdown in polymers is reviewed. Small angle scattering, particularly when combined with information obtainable from transmission electron microscopy, has proved to be a powerful technique for the study of crazes. The existence of X-rays, neutrons and electrons has helped both in the interpretation of the basic form of craze scattering patterns and in permitting the study of a range of problems. The intensity of X-rays from synchrotron sources has permitted the study of such failure processes as mechanical fatigue and impact in real-time. Neutron radiation has proved useful in the study of environmentally-induced crazes while electron radiation is used for the examination of crazes in thin films. The majority of the work on crazing has been done in single phase amorphous polymers, particularly polystyrene and polycarbonate, but the rubber toughened styrenics in which crazing is an important toughening mechanism offer a fruitful field of study. It is in these latter systems that impact processes can be studied by small angle scattering. (Edited author abstract) 134 refs.

Brown, H.R. (IBM, San Jose, CA, USA). *Mater Sci Rep* v 2 n 7 Nov 1987 p 315-370.

**082184 CRAZES AND FRACTURE IN POLYMERS.** A review of crazes in glassy thermoplastic polymers is presented with particular emphasis on those aspects of craze properties that influence and control fracture behavior. Both crazes as they normally occur, and crazes at the top of cracks are covered. The occurrence of crazes, their microstructure, the stress distribution within them and the nature of craze fibrils are discussed. Theoretical treatments of the effect of crazes on polymer fracture are reviewed. (Author abstract) 113 refs.

Passaglia, Elio (NBS, Gaithersburg, MD, USA). *J Phys Chem Solids* v 48 n 11 1987 p 1075-1100.

**082185 ANALYZING POLYMER CRAZING AS QUASIFRACTURE.** This paper deals with a viscoelastic boundary element method for analyzing a polymer quasifracture usually called a craze in polymers. A time-dependent boundary stiffness is considered on the quasifracture envelope surface. The viscoelastic property of the glassy polymer is represented by a generalized Kelvin model with multiple retardation times. According to the linear viscoelastic correspondence principle, the associated elasticity solution can be solved by applying the general integral boundary element method. Then the viscoelastic solution in the time domain can be obtained by applying a collocation Laplace inversion transformation. Using these methods, the quasifracture problem composed of an isolated craze opening with time-dependent stiffness traction in a stressed rectangular plate is analyzed. The displacement profile and the stress distribution around the craze envelope surface are computed. (Author abstract) 19 refs.

Sun, B.N. (Univ of Minnesota, Minneapolis, MN, USA); Hsiao, C.C. *J Polym Sci Part B* v 26 n 5 May 1988 p 967-979.

**Creep** See Also POLYETHYLENES—Radiation Effects.

**082186 MATHEMATICAL MODEL OF CREEP OF PHENYLONE IN WATER.** A study has been made of the creep of phenylone in water and a mathematical model of the process is proposed. It is shown that in the temperature interval  $20-60^\circ\text{C}$   $\text{H}_2\text{O}$  adsorption plays a

limiting role in this process. It was found that the coefficient of  $\text{H}_2\text{O}$  diffusion is a function of the load. (Author abstract) 4 refs.

Rudakova, T.Ye. (USSR Acad of Sciences, USSR); Askadskii, A.A.; Brin, E.F.; Moiseyev, Yu.V.; Porchkhidze, A.D.; Kazantseva, V.V. *Polym Sci USSR* v 28 n 6 1986 p 1287-1292.

**082187 INFLUENCE OF PHYSICAL AGING AT CONSTANT TEMPERATURE ON THE SHEAR CREEP OF AMORPHOUS POLYMERS.** The theory of linear viscoelastic behaviour under the influence of aging at constant temperature is briefly reviewed. Emphasis is placed on the evaluation of the retardation time - age shift relation from creep experiments under proceeding aging. The shear behaviour of a technical polystyrene was carefully measured at four temperatures just below the glass transition temperature, systematically varying the time elapsed between the temperature quench and the start of the creep experiment. The result could be accurately described by Struik's theory of viscoelastic behaviour under aging. The dependence of the retardation times on age and temperature in the vicinity of the glass transition is discussed. (Author abstract) 13 refs.

Schwarzl, F.R. (Univ Erlangen-Nuernberg, West Ger); Link, G.; Greiner, R.; Zahradnik, F. *Prog Colloid Polym Sci* v 71 1985 p 180-190.

**082188 CONSTITUTIVE EQUATION FOR CREEP IN POLYMER CONCRETES AND THEIR RESIN BINDERS.** We present here a method for superposing creep measurements on polymer concrete (PC), taken at different temperatures, imposed stresses, and resin contents, onto master curves, which describe the respective responses of various PC systems and their resin binders, to compressive, tensile, and flexural loads. This treatment is extended to systems reinforced with chopped glass fiber and montmorillonite (MMT). The general applicability of this superposition is tested with creep measurements by other investigators under tensile, compressive, and flexural loads. (Edited author abstract) 12 refs.

Dharmarajan, N. (Univ of Houston, Houston, TX, USA); Kumar, S.; Armeniades, C.D. *J Appl Polym Sci* v 36 n 2 Jul 5 1988 p 353-364.

**082189 STRESSED POLYMERS IN PHYSICALLY ACTIVE MEDIA.** The simultaneous action of physically active media and mechanical stress has been studied. Creep of polymers in physically active media was investigated. An equation for the prediction of tensile creep of several polymers in physically active media was investigated. (Author abstract) 47 Refs.

Rudakova, T.E. (USSR Acad of Sciences, Moscow, USSR); Zaikov, G.E. *Polym Degradation Stab* v 21 n 2 1988 p 105-120.

**Crosslinking** See Also CATALYSTS—Supported; COATINGS—Mechanical Properties; COATINGS—Plastics; COMPOSITE MATERIALS—Hardening; ELECTRON BEAMS—Applications; EPOXY RESINS—Curing; GELS—Medical Applications; GELS—Temperature Measurement; INTERPENETRATING POLYMER NETWORKS—Computer Aided Analysis; LATEXES—Structure; MEMBRANES—Synthesis; PLASTICS—Crosslinking; PLASTICS FILMS—Thermal Properties; POLYETHYLENES—Processing; POLYURETHANES—Reaction Injection Molding; RUBBER—Vulcanization; SILICONES—Synthesis.

**082190 SYNTHESIS AND ESTEROLYTIC REACTIONS OF LINEAR AND CROSS-LINKED ASYMMETRIC IMIDAZOLE-CONTAINING POLYMERS.** Asymmetric linear and cross-linked imidazole-containing polymers were prepared from 1-[2(S)-methylbutyl]-4-vinylimidazole and 1-[2(S)-methylbutyl]-5-vinylimidazole. The esterolytic reactions of these linear and cross-linked asymmetric polymers with the enantiomeric substrates (R)- and (S)-4-(3-methylpentadecanoyl)-3-nitrobenzoic acid (R)- and (S)- $3\text{-Me}_{15}$  were studied by measuring the pseudo-first order kinetics of the solvolysis of these enantiomeric substrates in the presence of these



asymmetric polymers. The linear homopolymers and copolymers of 1-[2(S)-methylbutyl]-4- and 5-vinylimidazole showed hydrophobic and electrostatic effects in the solvolysis of the enantiomeric substrates with these linear asymmetric polymers. Cross-links were introduced into these asymmetric polymers to increase the rigidity and reduce the number of conformations available to the polymer. Neither the linear nor the cross-linked asymmetric polyvinylimidazoles showed enantioselectivity in the solvolysis of these enantiomeric substrates. The hydrophobic interactions and the reduced conformational mobility through crosslinking were not strong enough to bring about enantioselectivity in the solvolysis of these enantiomeric substrates. (Edited author abstract) 21 refs.

Tomono, T. (Univ of Michigan, Ann Arbor, MI, USA); Schiavone, R.J.; Overberger, C.G. *J Polym Sci Part A* v 25 n 11 Nov 1987 p 2963-2985.

**082191 RUBBER ELASTICITY: A SCALING APPROACH.** A scaling analysis of the rubber-like elastic behavior of a crosslinked polymer network is presented which incorporates the two most salient contributions to the free energy of deformation: the chain connectivity of the segments and the restrictions on the chain configurations due to entanglements. The affine deformation of the junction points is assumed. A tube model is used to discuss the deformation dependence of the entanglement constraint parameter. (Edited author abstract) 18 refs.

Gaylord, Richard J. (Univ of Illinois, Urbana, IL, USA); Douglas, Jack F. *Polym Bull (Berlin)* v 18 n 4 Oct 1987 p 347-354.

**082192 MOLECULAR WEIGHT RELATIONS FOR CROSSLINKING OF CHAINS WITH LENGTH AND SITE DISTRIBUTION.** Many polymer networks are formed by crosslinked polymer chains through reactive sites distributed along the chains. How these sites are distributed as well as the chain length distribution can have a significant effect on properties like the gel conversion and molecular weight. Previous treatments have used simplifying approximations. This paper eliminates these approximations and derives computational formulae for weight average molecular weight and gel point for polymer chains of any length and reactive site distribution. Three types of crosslinking are considered: direct coupling of chains (homopolymerization), direct coupling through propagation, and coupling through copolymerization with small monomers. (Edited author abstract) 29 refs.

Miller, Douglas R. (George Washington Univ, Washington, DC, USA); Macosko, Christopher W. *J Polym Sci Part B* v 25 n 12 Dec 1987 p 2441-2469.

**082193 THEORETICAL CONSIDERATIONS OF SCISSION AND ENDLINKING REACTIONS IN IRRADIATED POLYMERS.** The pros and cons of the experimental and theoretical techniques used for following the crosslinking and scission reactions in irradiated polymers are briefly discussed. Special emphasis is given to the role of the reactions of main chain scission and endlinking and its influence on the analysis based on gelation theories. It is shown that increased initial scission could have a significant effect as well as the restricted or unlimited endlinking reaction which is not distinguished from the conventional reaction of crosslinking. Modified theoretical concepts could bring more insight into the nature of radiation induced reactions in polymers. (Author abstract) 21 refs.

Babic, D. ('Boris Kidric' Inst of Nuclear Sciences, Belgrade, Yugoslavia); Stannett, V.T. *Radiat Phys Chem* v 30 n 3 1987 p 183-187.

**082194 METHODS AND APPLICATIONS OF PHOTOCALORIMETRY.** In light-cured polymer systems the process variables often have a considerable effect on the properties of the end product. Photocalorimetry can be used to investigate the effects of light intensity, wavelength, atmosphere and irradiation time on crosslinking. The data so obtained can be used to optimize the product for a specific application. (Edited author abstract) In German and English.

Theweleit, E.; Kunze, W. *Kunstst Ger Plast* v 77 n 9 Sep 1987 p 23-25.

**082195 SIETOVANIE PLNENYCH POLYMEROV ZJEDNODUSENOU TECHNOLOGIJOU.** [Simplified Crosslinking Process for Filled Polymers]. Peroxide crosslinking of polymers has been developed to replace that based on organo-functional silanes. The new process combines advantages of both the silane and peroxide crosslinking methods. (Author abstract) In Slovak. 5 refs.

Rado, Rudolf (Vyskumny ustav Kablov a Izolantov, Bratislava, Czech); Zelenak, Pavel. *Plasty Kauc* v 24 n 12 1987 p 357-360.

**082196 PHOTOCHEMICAL CROSSLINKING OF POLY(PHENYLQUINOXALINES) IN THE PRESENCE OF AROMATIC AZIDES.** Crosslinking of several poly(phenylquinoxalines), induced photochemically in the presence of 2,6-di(4'-azidobenzal)cyclohexanone, has been studied by EPR spectroscopy, using a paramagnetic probe, and by sensitometry. In some poly(phenylquinoxalines) photochemical crosslinking resulting in a loss of solubility has been found to proceed exclusively within a relatively narrow interval of oxygen partial pressure, delimited by lower and upper critical values. This mode of crosslinking is possible because of the chemical structure of the repeat unit. (Author abstract) 11 refs.

Treushnikov, V.M. (N.I. Lobachevskii Gor'kii State Univ, USSR); Telepneva, T.V.; Oleinik, A.V.; Sorin, Ye.L.; Korshak, V.V.; Krongauz, Ye.S.; Belomoina, N.M. *Polym Sci USSR* v 28 n 10 1986 p 2366-2373.

**082197 CURING THEORY AND SCALING STUDY: CROSSLINKING REACTION OF THE A<sub>n</sub> TYPE.** For the A<sub>n</sub>-crosslinking reaction, the behavior of polymer moments below and above the gel point, which is regarded as the threshold of the sol-gel transition, is discussed in detail. From the Flory-Stockmayer distribution a reasonable approach to the threshold of sol-gel transition is proposed. It is shown that without Stirling's approximation it is possible to reach the asymptotic form of the equilibrium number fraction distribution of n-mer. 10 refs.

Tang, Au-Chin (Jilin Univ, Changchun, China); Li, Ze-Sheng; Sun, Chia-Chung; Tang, Xin-Yi. *J Macromol Sci Chem* v A25 n 1 1988 p 41-54.

**082198 EFFECT OF CROSSLINK DENSITY ON THE MOLECULAR RELAXATIONS IN DIEPOXIDE-DIAMINE NETWORK POLYMERS. PART 1. THE GLASSY REGION.** The effects of systematically varying the crosslink density on the mechanical relaxations in the glassy region of typical highly crosslinked diepoxide-diamine polymers are reported. Activation enthalpies and intensities for the  $\beta$  relaxation have been measured using a torsion pendulum at 1 Hz. The glyceryl groups, which are thought to be responsible for this process, are divided into a number of categories defined by the structure of the surrounding matrix. Concentrations of these units are calculated using probability theory, and a correlation is obtained with three measures of the relaxation intensity. In the case of nonstoichiometric networks, variations in the intensity of the  $\beta$  relaxation are interpreted in terms of the simultaneous motion of each class of glyceryl group. The manner in which these processes combine to produce a composite peak appears to be unimportant. For the  $\gamma$  relaxation ( $-140^\circ\text{C}$ ), it is shown that at least four methylene units are needed in the diamine component before the process is observable, whereas only two consecutive methylene units in the center of the diepoxide molecule produce the relaxation. (Author abstract) 33 refs.

Charlesworth, John M. (Melbourne Univ, Parkville, Aust). *Polym Eng Sci* v 28 n 4 Feb 1988 p 221-229.

**082199 EFFECT OF CROSSLINK DENSITY ON MOLECULAR RELAXATIONS IN DIEPOXIDE-DIAMINE NETWORK POLYMERS. PART 2. THE RUBBERY PLATEAU REGION.** A comparison of the

predictions of the theory of rubber elasticity with the experimentally observed variation of the shear storage modulus, G, as a function of crosslink concentration shows that deviations occur when the network strand concentration in diepoxide-diamine polymers exceeds approximately 1.5 mole kg<sup>-1</sup>. The rapid rise in G above this level is accounted for in terms of the increasing importance of non-Gaussian chain statistics and steric interactions. It is also established that the contribution from entanglements is significant and the behavior over the entire crosslink density range can be described by an equation. (Edited author abstract) 46 refs.

Charlesworth, John M. (Melbourne Univ, Parkville, Aust). *Polym Eng Sci* v 28 n 4 Feb 1988 p 230-236.

**082200 RANDOM HYPERGRAPHS AND TOPOLOGICAL GELATION CRITERION FOR CROSSLINKED POLYMER SYSTEMS.** A class of hypergraphs named polygraphs, especially suitable for modeling polymer systems, is defined and we discuss in detail the conditions which give rise to the Giant Component in the polygraph. This problem is analogous to gel formation in a crosslinked polymer system. To this end an equivalence class of polygraphs with given connectivity is defined and characterized by a specially introduced probabilistic representation. Our Topological Gelation Criterion is applicable to systems that may be far from thermodynamic equilibrium and need not necessarily be random. The criterion applies to polymers, superpolymers, cell aggregates, immunocyto-chemical systems and other systems. (Author abstract) 26 refs.

Klonowski, Wlodzimierz (McMaster Univ, Hamilton, Ont, Can). *Discrete Appl Math* v 19 n 3 Mar 1988 p 271-288.

**082201 DETERMINATION OF CROSS-LINK DENSITY IN THERMOSET POLYMERS BY USE OF SOLID-STATE <sup>1</sup>H NMR TECHNIQUES.** Solid-state <sup>1</sup>H NMR techniques were used to determine the cross-link density of highly cross-linked polymers common in the aerospace industry. As the temperature was increased, the spin-spin relaxation times of cross-linked epoxy polymers were observed to reach a plateau value which increased linearly with increasing molecular weight between cross-links, as predicted by theory. The results show that, for the epoxy system studied, approximately 10 rotatable backbone bonds are needed to form a statistical segment, the portion of the polymer backbone that moves independently of the other backbone motions. (Author abstract) 13 refs.

Fry, Charles G. (McDonnell Douglas Research Lab, St. Louis, MO, USA); Lind, Arthur C. *Macromolecules* v 21 n 5 May 1988 p 1292-1297.

**082202 PREPARATION METHODS AND STRUCTURE OF HYDROGELS.** Hydrogels are water-swollen networks (cross-linked structures) of hydrophilic homopolymers or copolymers. They are three-dimensional and the cross-links can be formed by covalent or ionic bonds. Often, weaker forces such as van der Waals forces and hydrogen bonds can serve as cross-links, thus forming swollen networks which behave as hydrogels. Finally, semicrystalline, uncross-linked hydrophilic polymers may form hydrogels upon swelling since the crystallites act as physical cross-links and do not dissolve in water. Hydrogels may be classified in various ways depending on their chemical or physical structure. A common classification, especially useful in biomedical applications, includes neutral hydrogels, ionic hydrogels, and swollen interpenetrating polymeric networks (IPN). 53 refs.

Peppas, Nikolaos A. (Purdue Univ, West Lafayette, IN, USA); Mikos, Antonios G. *Hydrogels in Med and Pharm Publ* by CRC Press Inc, Boca Raton, FL, USA, 1986 v 1, p 1-26.

**082203 HYDROGEL SURFACES.** The surface region of hydrated hydrogel polymers represents a unique environment different from the surfaces of almost all other



materials. This surface region is characterized by high chain mobility, gradients of composition, heterogeneous chain lengths, amphiphilic character, and unique water structuring. These are all properties that also contribute to the difficulty in precisely analyzing and characterizing hydrogel surfaces. This chapter will attempt to sum up some of the generally accepted ideas about hydrogel surfaces and will consider aspects of hydrogel surfaces that are presently the subject of some controversy. 51 refs.

Ratner, Buddy D. (Univ of Washington, Seattle, WA, USA). *Hydrogels in Med and Pharm* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 v 1, p 85-94.

**082204 NOVEL METHOD FOR CROSSLINKING POLYETHERETHERKETONE.** A novel method for crosslinking polyetheretherketone via imine formation at carbonyl groups is presented. In polyetheretherketone these Schiff bases form short, stiff crosslink junctions which are stable up to 630°C. Dynamic mechanical and thermal properties of polyetheretherketone and imine crosslinked polyetheretherketone are reviewed. A large reduction in the temperature sensitivity of the material stiffness has been achieved. Increases in the glass transition temperature from 143°C to greater than 280°C have been obtained. (Author abstract). 15 Refs.

Thompson, S.A. (Univ of Massachusetts, Amherst, MA, USA); Farris, R.J. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 1113-1120.

**082205 EFFECT OF CONTENT OF CROSSLINKING AGENT ON THE POROUS STRUCTURE AND PROPERTIES OF THE CARBOXYLIC CATION EXCHANGERS SOLOSE K.** The structure and sorption properties of Solose K biosorbents have been studied as a function of the content of crosslinking agent. It is shown that the latter acts most strongly on the formation of the porous structure of the cation exchangers for a content of 25-50 mole percent. The highest permeability of the cation exchangers is observed for protein. Increase in the content of crosslinking agent above 50 mole percent is not desirable since the specific surface, the value of sorption capacity for protein and interaction with water diminish. (Author abstract). 11 Refs.

Mal'ko, Ye. I. (Gorkii Ural State Univ, USSR); Tager, A.A.; Vorob'ev, V.P.; Pozhivilko, K.S.; Dumpis, Yi. Ya.; Fedorova, N.M.; Pasechnik, V.A. *Polym Sci USSR* v 29 n 5 1987 p 1064-1069.

**082206 REACTIVE POLYMERS: DESIGN CONSIDERATIONS, NOVEL PREPARATION AND SELECTED APPLICATIONS IN ORGANIC CHEMISTRY.** Crosslinked reactive polymers with novel structures have been prepared from the corresponding monomers or by newly developed chemical modification reactions. These include the preparation of polymers with two or three carbon spacer groups between backbone and functionality, the first preparation of a Grignard reagent on an insoluble polymer, and some new copper mediated chemical modification reactions resulting in C-C bond formation. Novel applications of these polymers in asymmetric synthesis regenerable polymeric protecting groups, super-nucleophilic catalysts, polymeric separation media for HPLC, as well as aids in the determination of reaction mechanisms, have been investigated. Microenvironment effects within the polymer beads are shown to be important when considering the use of an insoluble reactive polymer. (Author abstract) 103 refs.

Frechet, Jean M.J. (Univ of Ottawa, Ottawa, Ont, Can); Darling, Graham D.; Itsuno, Shinichi; Lu, Pei-Zhi; de Meftahi, Marina Vivas; Rolls, Wesley A. Jr. *Pure Appl Chem* v 60 n 3 Mar 1988, Invited Lect Presented 30th Microsymp on Macromol - Polym Supported Org Reagents and Catal, Prague, Czech, Jul 6-9 1987 p 353-364.

**082207 POLYMER SUPPORTS WITH HIGH ACCESSIBILITY.** The parameters governing the accessibility of functional groups in catalysts or organic reagents supported on polymer resins are discussed. They include the microenvironment contribution of the polymer chain, the viscosity and crosslink density inside the gel or

microgel particles, as well as thermodynamic compatibility of the reaction medium with the polymer structure. They also include the texture of a porous resin which is fully described by the synthesis process that may be used, as well as the methods already used to obtain the pore size distribution in the swollen state. Some recent directions worked out in order to improve the accessibility are described and all the discussions are illustrated by a few selected examples. (Author abstract) 61 refs.

Guyot, Alain (CNRS, Vernaison, Fr). *Pure Appl Chem* v 60 n 3 Mar 1988, Invited Lect Presented 30th Microsymp on Macromol - Polym Supported Org Reagents and Catal, Prague, Czech, Jul 6-9 1987 p 365-376.

**Crystal Lattices** See Also POLYETHYLENES—High Density; POLYURETHANES—Photolysis.

**082208 MOLECULAR ORIENTATION IN LIQUID FIBERS OF NEMATIC POLYMERS.** The degree of macroscopic orientation of molten fibrous samples of nematic semiflexible polymers has been investigated by X-ray diffraction. Melting of highly oriented fibers is followed by a partial loss of macroscopic orientation but does not produce collapse of the fiber. The residual orientational order remains unaltered for a considerable time. The degree of orientational order depends on the temperature and undergoes odd-even fluctuations according to the parity of the number of carbon atoms contained in the flexible part of the monomer unit. Extrapolation of the order parameter to the isotropization temperature leads to a value of about 0.63 for even-type polymers and to about 0.47 for odd-type polymers. An intermediate value is found for a copolymer containing equal amounts of even and odd monomer units along the polymer chain. (Author abstract) 13 refs.

Capasso, R. (Univ de Napoli, Naples, Italy); Roviello, A.; Sirigu, A.; Iannelli, P. *J Polym Sci Part B* v 25 n 12 Dec 1987 p 2431-2440.

**Crystallization** See Also BIOPOLYMERS—Morphology; ELASTOMERS—Deformation; POLYETHYLENES—Radiation Effects; POLYETHYLENES—Surface Properties; POLYETHYLENES—X-Ray Analysis; POLYISOPRENE—Morphology; POLYISOPRENE—Stresses; POLYSTYRENES—Blending; POLYVINYL ALCOHOL—Solutions; SYNTHETIC FIBERS—Defects; SYNTHETIC FIBERS—Spinning.

**082209 INVERSION OF THE TEMPERATURE DEPENDENCE OF CRYSTALLIZATION RATES DUE TO ONSET OF CHAIN FOLDING.** Crystallization rate experiments performed on the uniform alkanes C<sub>24</sub>H<sub>49</sub> and C<sub>19</sub>H<sub>39</sub>, by both differential scanning calorimetry and in situ X-ray diffraction (using a synchrotron source), have revealed that these rates, including both primary nucleation and growth, pass through a minimum with increasing supercooling. The first (expected) increase and subsequent (unsuspected) decrease correspond to extended-chain (E) crystallization, the renewed increase beyond the minimum corresponding to chain-folded crystallization with the fold period *l* being smaller than *L* but larger than *L*/2, where *L* is the extended chain length. The observed effects, which have come to light owing to the availability of ultra-long and uniform n-alkanes, help to provide new insight into the primary stages of chain-folded crystallization, with many potential consequences, some of which are discussed. (Edited author abstract) 15 refs.

Ungar, G. (Univ of Bristol, Bristol, Engl); Keller, A. *Polymer* v 28 n 11 Oct 1987 p 1899-1907.

**082210 SOLVENT-INDUCED CRYSTALLIZATION OF A COMPATIBLE POLYMER BLEND.** We studied solvent-induced crystallization (SINC) in a compatible blend of poly(butylene terephthalate) (PBT) and a polyarylate (PAr) over a range of blend compositions and temperatures; liquid acetone was the crystallizing agent. Acetone transport kinetics were followed by mass uptake measurements in thin films and by optical microscopy. Crystallization kinetics were followed by density measurements. For the 0.2 mm thick films used, those with higher weight fractions of PBT (50 to 60 percent by weight) exhibit diffusion controlled transport and crystallization

over the entire range of temperatures studied (0 to 55°C). Those with lower weight fractions of PBT (approx. 30 percent by weight) display Case II sorption and crystal growth controlled crystallization at 0°C. (Edited author abstract) 24 refs.

Waywood, W.J. (Columbia Univ, New York, NY, USA); Durning, C.J. *Polym Eng Sci* v 27 n 17 Sep 1987 p 1265-1274.

**082211 SOME FEATURES OF THE CRYSTALLIZATION OF POLYVINYLIDENEFLUORIDE.** Differential scanning calorimetry has been used to investigate differences in the structure of PVDF specimens synthesized at various temperatures. The thermograms obtained for melting and crystallization give evidence that there are differences between the specimens investigated with respect to the degree of order in the crystalline structure. It is suggested that the differences established are caused not so much by a change in the regularity of the polymer chain's structure of the 'head-to-tail' type but rather by branching of the polymers which can increase substantially as the temperature of synthesis of the initial polymer is raised. (Author abstract) 5 refs.

Madorskaya, L.Ya. (Plastopolimer, Okhtinsk, USSR); Loginova, N.N.; Kastorskii, L.P.; Kuz'michev, O.V.; Maksimov, V.L.; Lobanov, A.M. *Polym Sci USSR* v 28 n 6 1986 p 1433-1440.

**082212 CRYSTALLIZATION, THERMAL BEHAVIOR, AND COMPATIBILITY IN ISOTACTIC POLYSTYRENE/POLY(O-CHLOROSTYRENE-CO-P-CHLOROSTYRENE) BLENDS.** The dependence of the kinetics of crystallization and melting behavior in isotactic polystyrene/ poly-o-chlorostyrene-co-p-chlorostyrene (iPS/P(o-CIS-co-p-CIS) blends on temperature, thermal history, and blend composition has been investigated. The crystallization rate at a given temperature and copolymer composition decreases with increasing copolymer content in the blend when the samples are premelted. These effects can be ascribed to the reduction of mobility of the crystallizable chains due to the presence of the copolymer and to the decrease in the number of heterogeneous iPS nuclei as a result of the premelting process. The Avrami exponent values and the analysis of the blend morphology indicate that the growth mechanism of the crystals is strongly influenced by thermal treatment. From the comparison of the phase diagram for the isotactic polystyrene-containing blend with that of the atactic-containing blend, it can be concluded that in the amorphous state polystyrene with a regular configuration is slightly less compatible with the P(o-CIS-co-p-CIS) than is polystyrene with random configuration. (Edited author abstract) 21 refs.

Silvestre, C. (Univ of Massachusetts, Amherst, MA, USA); Cimmino, S.; Karasz, F.E.; MacKnight, W.J. *J Polym Sci Part B* v 25 n 12 Dec 1987 p 2531-2540.

**082213 CRYSTALLIZATION KINETICS OF POLY(P-PHENYLENE SULPHIDE): EFFECT OF MOLECULAR WEIGHT.** The crystallization behavior of poly(p-phenylene sulfide) (PPS) has been studied in terms of linear crystal growth rates and overall rates of bulk crystallization as functions of molecular weight and temperature. In addition, nucleation densities were estimated for PPS crystallized from the melt. The overall rate of bulk crystallization was described by the Avrami equation. In the range of molecular weights studied (24000-63000), crystal growth rates and overall rates of bulk crystallization decreased as the molecular weight increased. However, the effect was not particularly large. The estimated nucleation densities indicated a decrease by a factor of 32 as the molecular weight decreased. The linear crystal growth rate data were analyzed in terms of several proposed models. The data seemed to conform



very well to an 'inverse' logarithmic function of the number-average molecular weight recently proposed by Cheng and Wunderlich. (Author abstract) 30 refs.

Lopez, Leonardo C. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Wilkes, Garth L. *Polymer* v 29 n 1 Jan 1988 p 106-113.

**082214 THEORETICAL ASPECT OF CRYSTALLIZATION TEMPERATURE AT MAXIMUM CRYSTAL GROWTH RATE.** The ratio of the temperature at which the nucleation rate or the crystal growth rate is maximum to the melting temperature was predicted theoretically as a function of two parameters: one is the ratio of the activation energy of migration through the nucleus-melt interface to the heat of fusion and the other is the ratio of the mean surface energy of a mole of repeat unit to the heat of fusion. The ratios of  $T_{c, max}/T_m$  were evaluated from the above two parameters. (Edited author abstract) 61 refs.

Okui, Norimasa (Tokyo Inst of Technology, Tokyo, Jpn). *Polym J* v 19 n 11 1987 p 1309-1315.

**082215 HETEROGENEOUS NUCLEATION.** [Heterogeneous Nucleation]. Author's contribution to the explanation of heterogeneous nucleation during cooling of a polymer melt is presented. The heterogeneous nucleation process may be started by various nuclei, such as residues of the crystalline phase after melting, oriented macromolecules, solid heterogeneous matter, and other substances. Various effects of the nucleation mechanism are also discussed. (Edited author abstract) 15 refs. In Czech.

Rybníkar, Frantisek (Vysoke Ucení Technické v Brně, Czech). *Plasty Kauc* v 25 n 2 Feb 1988 p 42-45.

**082216 KINETICS OF POLYMER CRYSTALLIZATION. I. DISCRETE AND CONTINUUM MODELS.** The kinetics of growth of lamellar crystals by chain folding of polymer molecules are described by Markov rate processes whose states are representations of the edge of a lamella. The dynamic reversibility of these processes allows their equilibrium distributions to be found and these describe states of steady crystal growth. (Edited author abstract) 23 refs.

Gates, D.J. (CSIRO, Canberra, Aust); Westcott, M. *Proc R Soc London Ser A* v 416 n 1851 Apr 8 1988 p 443-461.

**082217 KINETICS OF POLYMER CRYSTALLIZATION. II. GROWTH REGIMES.** Exact expressions are found for the steady-state growth rate of a portion of the edge of a lamellar crystal in terms of the number of polymer segments in the portion, the nucleation rate on the edge and the folding rate of polymer chains. Both hexagonal and square crystal structures are analysed. Simpler expressions are given in various limiting cases. (Edited author abstract)

Gates, D.J. (CSIRO, Canberra, Aust); Westcott, M. *Proc R Soc London Ser A* v 416 n 1851 Apr 8 1988 p 463-476.

**082218 THERMAL AND CRYSTALLIZATION BEHAVIOR OF ENGINEERING POLYBLEND. I. GLASS REINFORCED POLYPHENYLENE SULFIDE WITH POLYETHYLENE TEREPHTHALATE.** The thermal and crystallization behavior of blends of glass fiber reinforced polyphenylene sulfide (PPS) with polyethylene terephthalate (PET) has been reported. The blends showed two overlapping melting peaks and two separate crystallization peaks. The heat of crystallization of PPS was found to decrease continuously with increasing PET content, whereas the heat of crystallization of PET was found to increase with increasing PPS content. This indicates that the degree of crystallinity of PPS is reduced whereas that of PET is increased as a result of blending. (Edited author abstract) 9 refs.

Shingankuli, V.L. (Nat'l Chemical Lab, Poona, India); Jog, J.P.; Nadkarni, V.M. *J Appl Polym Sci* v 36 n 2 Jul 5 1988 p 335-351.

**082219 ON CRYSTALLIZATION OF COMBLIKE POLYMETHACRYLATES.** The authors examined the

crystallization of poly(octadecyl methacrylate) and a copolymer of octadecyl methacrylate and hexadecyl methacrylate. While we were able to identify two distinct melting endotherms in these materials as described by I. Sobotnik and I.V. Sochava, we believe that they exist in just a single crystalline modification and the two melting points are the result of different crystallization processes. The data show no evidence for polymorphism and thus are incompatible with this interpretation. A different interpretation has to be sought, therefore, for the double melting peaks. It is reasonable to postulate that quenching leads to extremely rapid nucleation and crystallization, resulting in many small crystals of poor quality with a low melting point. The broader X-ray diffraction peaks and more pronounced amorphous halo of the quenched sample in comparison with that of the high melting polymer support this view. 8 refs.

Anon (Texaco Research Cent, Beacon, NY, USA). *J Appl Polym Sci* v 36 n 2 Jul 5 1988 p 445-448.

**082220 PACKING OF LONG-CHAIN CYCLOALKANES IN VARIOUS CRYSTALLINE MODIFICATIONS: AN ELECTRON DIFFRACTION INVESTIGATION.** The structure and thermal behavior of long-chain cycloalkanes  $(CH_2)_n$  with  $n = 48, 72, 96, 144$  and 288 have been investigated by electron diffraction, WAXS and SAXS analysis. Five different modifications have been characterized by their subcells as a function of ring size, crystallization conditions and temperature. The rings adopt, in all modifications, a conformation with two straight stems connected by folds. Similarity with the polyethylene lattice is achieved only for  $n \geq 144$ . In this case, the stems are perpendicular to the layer surface and pack in the well-known orthorhombic subcell regardless of whether the rings are crystallized from solution or melt.  $(CH_2)_{96}$  forms the same type of subcell when crystallized from the melt, but the stems are oblique to the layer surface. Rings of all sizes undergo a transition into a phase in which the stems are arranged similarly as in the 'rotator phase' of linear paraffins.  $(CH_2)_{72}$  and  $(CH_2)_{96}$  exhibit additional transitions at lower temperatures. One significant feature of some transitions is the change of conformation and length of the folds. (Author abstract) 21 refs.

Lieser, G. (Max-Planck-Institut fuer Polymerforschung, Mainz, West Ger); Lee, K.-S.; Wegner, G. *Colloid Polym Sci* v 266 n 5 May 1988 p 419-428.

**082221 SOLID STATE REACTIONS AND TRANSITIONS IN HIGH POLYMERIC SYSTEMS III. THE BULK CRYSTALLIZATION OF LANTHANIDE-CATALYTICALLY POLYMERIZED POLYDIENES.** For the mechanism of isothermal bulk crystallization of high polymers, beside the nucleation and growth steps, the unimpingement of growing crystal aggregates should be taken into account for the modification of the Avrami equation. The derived equation is satisfactorily verified by the isothermal bulk crystallization of lanthanide-catalytically polymerized polybutadiene (Ln-PB), polyisoprene (Ln-PIR) and their copolymers (Ln-PB/IR). Furthermore, the proposed mechanism is identified by the change of morphological state during the course of crystallization of the corresponding cast film of Ln-PB/IR (92/8) at  $-60^\circ\text{C}$ . Upon examination of the influence of entanglement on crystallization rate is found that two entanglement stages exist. (Edited author abstract). 27 Refs.

Qian, Baogong (Acad Sinica, Changchun, China); Chien, Pao-Kung; Xu, Yan; Zhou, Enle. *Chin J Polym Sci (Engl Ed)* v 6 n 2 1988 p 97-116.

**082222 APPLICATION OF THE PARALLEL AVRAMI MODEL TO CRYSTALLIZATION OF POLY(ETHERETHERKETONE).** A reexamination has been made of the parallel Avrami model recently proposed by C. Velisaris and J. Seferis to describe the non-isothermal crystallization of poly(etheretherketone), PEEK. Results show that, based on considerations of morphology development, the crystallization process with the larger Avrami exponent has the higher melting point, whereas the process with the smaller Avrami exponent has the lower melting point. In addition, the author used the

infinite crystal melting point, as required by crystallization theory, to determine the Avrami rate parameters for the two processes. (Edited author abstract). 28 Refs.

Cebe, Peggy (JPL, Pasadena, CA, USA). *Polym Eng Sci* v 28 n 18 Sep 1988 p 1192-1197.

**Curing** See Also BLOCK COPOLYMERS—Crosslinking; COPOLYMERS—Crosslinking; EPOXY RESINS—Manufacture; PLASTICS LAMINATES—Processing; POLYIMIDES—Curing; POLYMERIZATION—Condensation Reactions; POLYMERIZATION—Radiation Effects; RUBBER—Blending; RUBBER—Vulcanization; RUBBER, SYNTHETIC—Vulcanization; SUPERCONDUCTING MATERIALS; THERMOSETS—Mechanical Properties; THERMOSETS—Thermal Properties; VINYL RESINS—Physical Properties.

**082223 CURING KINETICS OF EPOXY-ANHYDRIDE SYSTEMS USING QUATERNARY AMMONIUM GUAR AND HYDROXYETHYL GUAR AS CATALYSTS.** The kinetic parameters for the curing reactions of initially uncured and partly cured samples of the diglycidyl ether of bisphenol-A (DGEBA) with phthalic anhydride and quaternary ammonium of guar gum or quaternary ammonium compounds of hydroxyethyl guar gum as catalyst, with or without n-butanol as diluent, were determined using the differentials scanning calorimetry technique with a dynamic scan. To evaluate the kinetic parameters, four different computational methods were applied. The reaction was found to be first-order, with activation energy in the range 65-96 kJ mol<sup>-1</sup>. (Author abstract) 20 refs.

Patel, Shailesh P. (Sardar Patel Univ, Vallabh Vidyanagar, India); Patel, Ranjan G.; Patel, Vital S. *Br Polym J* v 20 n 1 1988 p 43-47.

**082224 HYDROSILYLATION CURE OF POLYISOBUTENE.** A liquid polyisobutene oligomer with unsaturated chain ends undergoes hydrosilylation with  $\text{HMe}_2\text{SiOMe}_2\text{SiOMe}_2\text{SiH}$  or  $\text{Si}(\text{OMe}_2\text{SiH})_4$  to give higher molecular weight polymers or elastomers. A major side reaction consumes SiH to give redistributed siloxane in the resulting polymers and gaseous silanes and siloxanes as by-products. A second side reaction results in loss of reactivity in the oligomer due to a shift of the terminal double bond to an internal position. If the side reactions are taken into account, it is possible to forecast quantitatively molecular weight, gel point and modulus from the conversions of SiH,  $\text{C}=\text{CH}_2$  and the chain entanglement concentration reported for polyisobutene in the literature. (Author abstract) 10 refs.

Macosko, C.W. (Univ of Minnesota, Minneapolis, MN, USA); Saam, J.C. *Polym Bull (Berlin)* v 18 n 5 Nov 1987 p 463-471.

**082225 VISIBLE LIGHT CURING PROVIDES LOW SHRINKAGE AND GOOD DEPTH.** Visible light curing resins are designed to offer rapid cure to good depths with low shrinkage. This article discusses light curing resins developed for opto-electronic applications and compares their performance with that of UV curing products. Opto-electronic application procedures using visible light curing are also detailed.

Rogers, S.C. (ICI Reactive Resins Technology, Runcorn, Engl). *Adhes Age* v 31 n 4 Apr 1988 p 20-21.

**082226 KINETIC DATA ON THE CURING OF AN EPOXY POLYMER IN THE PRESENCE OF LIGNIN.** In this study dynamic differential scanning calorimetry has been used to investigate the effect of an alkali lignin in amounts up to 20% by weight on the crosslinking kinetics of an epoxy prepolymer cured with an aliphatic polyamine. Lignin presence does not significantly affect the overall reaction order, but the activation energy increases and the slowing of the overall curing process with lignin content could be explained by the interaction between lignin and the polyamine hardener. The possibil-



ity of having a 'false compensation' in the case of the use of single DSC scans is also discussed. (Author abstract) 21 refs.

Feldman, D. (Concordia Univ, Montreal, Que, Can); Banu, Dorina. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 973-983.

**082227 MICROWAVE AND RADIO-FREQUENCY CURING OF POLYMERS.** The objectives of this study were to (i) identify suitable polymers and their conventional curing systems; (ii) estimate market potential for microwave/radio frequency curing of these selected materials; (iii) compare conventional and microwave/radio frequency technologies. In this report, the polymers produced and consumed in Canada and their conventional curing methods are reviewed, potential curable polymers are identified and their volumes are determined; then, energy requirements for polymer curing using various conventional curing methods are calculated; costs for raw material and process related preparation and relevant energy consumptions are determined. Based on the results of these studies, finished product costs by conventional curing methods are calculated using a cost & economics model. The microwave/radio frequency curing of polymers are reviewed, the characteristics of curable polymers are discussed and the energy requirements for microwave/radio frequency curing are calculated. Finally, using these findings, a market penetration study is carried out to determine the potential Canadian market for microwave/radio frequency curing of polymers. (Author abstract) 54 refs.

Bilgen, E. (Exergy Research Corp, Pointe Claire, Que, Can). *Res Rep Can Electr Assoc* 634 v 577 Jan 1988 89p.

**082228 NEW METHODS FOR PREPARING ORGANIC LAYERED PHOTOCONDUCTORS.** As E.P.A. emission requirements become more stringent with regard to effluents entering the atmosphere, and as the cost of solvents escalates, high energy radiation curing becomes a much more attractive alternative for the fabrication of layered organic photoconductors (OLP) compared to high volume thermal curing. The OLP may be composed of several layers coated sequentially on a substrate: a binder layer, a charge generation layer (CGL) and charge transport layer (CTL). The binder layer improves adhesion of the CGL to the substrate. We have employed electron beam curing to formulate the binder layer and CGL. For the latter, charge generation compounds such as chlorodiane blue (CDB) or squaraine dyes were dispersed in radiation conversion acrylates and electron beam cured at 5-10 Mrad. A CTL was overcoated, and the electrical properties of the resulting photoconductors measured on a tester used to simulate the photocopying process. The photoconductors derived from radiation cured CGLs held charge during dark decay and discharged upon illumination. These data were compared with a commercial OLP and found to behave similarly. (Author abstract) 31 refs.

Pacansky, J. (IBM, San Jose, CA, USA); Waltman, R.J.; Coufal, H.; Cox, R. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 853-875.

**082229 PERMEABILITIES OF RADIATION CURED MATERIALS.** The permeability of radiation cured materials to oxygen and water molecules was investigated. Several classes of radiation curable materials were studied, including: epoxy, urethane, polyether, polyester, and aliphatic acrylates. Permeabilities were measured as a function of irradiation dose for Ultra-Violet and Electron Beam sources. The effect of cross-link density on permeability was examined by varying the functionality of the molecule and the degree of cure. The results were interpreted in terms of structure/property relationships. (Author abstract) 7 refs.

Sax, J.E. (3M, St. Paul, MN, USA); Thalacker, V.P.; Boettcher, T.E.; Larson, E.G. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 887-896.

## Decomposition

**082230 SOME CHARACTERISTIC DEPENDENCES IN THE ANALYSIS OF THE THERMAL DECOMPOSITION AND GLASS TRANSITION OF AMORPHOUS POLYMERS.** An attempt was made in this study to find some correlations between the kinetic parameters of thermal decomposition based on the free volume theory, which are analogous in form to the correlations for the glass transition process. Based on experimental evidence, the following conclusions can be drawn: the series of characteristic dependences, tested for the glass transition process, is also valid for the thermal decomposition of polymers analyzed by thermal analysis if the corresponding values of  $T_d$  and  $U_d$  are substituted for  $T_g$  and  $U_g$ . In the thermal analysis of the thermal decomposition of a polymer, we can determine the kinetic parameters, for example  $U_d$ , which are organically correlated with the glass transition of the polymer and are a function of ratio  $f_d/f_g$  as for the glass transition. 21 refs.

Ostrovskii, V.V. *J Appl Chem USSR* v 60 n 5 pt 2 May 1987 p 1035-1039.

**082231 SPINODAL DECOMPOSITION OF THE POLYMER BLEND DEUTERIUM POLYSTYRENE (d-PS) AND POLYVINYL METHYLETHYLETH (PVME) STUDIED WITH HIGH RESOLUTION NEUTRON SMALL ANGLE SCATTERING.** Decomposition of a polymer blend in the miscibility gap has been studied by small angle scattering of neutrons, using a double crystal diffractometer. It covers a range which connects the region of elastic light scattering and, at the upper end, the region of conventional neutron small angle scattering instruments. The decomposed structure in the miscibility gap can be described by a characteristic length  $R$  which increases with time between 7 and 25 min. At longer times, the growth follows a more linear power law. This behavior is consistent with predictions of the domain growth for liquid mixtures and is estimated by using the self diffusion constant, viscosity, and the surface energy of the polymer. (Edited author abstract) 15 refs.

Schwahn, D. (KFA, Juelich, West Ger); Yee-Madeira, H. *Colloid Polym Sci* v 265 n 10 Oct 1987 p 867-875.

**082232 PRIMARY THERMAL FRAGMENTATION PROCESSES IN POLY(ETHYLENE OXALATE) INVESTIGATED BY MASS SPECTROMETRY.** The primary thermal decomposition mechanism of poly(ethylene oxalate) (PEO) has been investigated by pyrolysis-mass spectrometry. Several mass spectrometric techniques have been used in order to identify compounds present in the pyrolysis mixture: comparison of electron impact and chemical ionization spectra, high resolution accurate mass measurements and tandem mass spectrometry (daughter and parent ion spectra). The results obtained indicate that intramolecular exchange reactions predominate in the primary thermal fragmentation processes yielding cyclic oligomers up to tetramer. No other pyrolysis products were detectable under our experimental conditions. PEO, prepared by condensation polymerization, was shown by  $^1\text{H-NMR}$  to contain up to 7% of diethyleneglycol (DEG) units along the polymer chain. A small amount of cyclic oligomers containing DEG units was detected among the pyrolysis products from PEO. (Edited author abstract). 15 Refs.

Ballistreri, Alberto (Univ di Catania, Italy); Garozzo, Domenico; Impallomeni, Giuseppe; Montaudo, Giorgio. *Polym Degradation Stab* v 21 n 4 1988 p 311-321.

**082233 GAS CHROMATOGRAPHIC AND CAPILLARY GAS CHROMATOGRAPHIC-MASS SPECTROMETRIC ANALYSIS OF THERMAL DECOMPOSITION PRODUCTS OF LIQUID CRYSTAL POLYMERS.** The thermal decomposition products of a series of liquid crystalline poly(azomethine ester)s and their model compounds of low molecular mass were investigated. The volatile gaseous products evolved in Curie-point pyrolysis at 500°C were analyzed using a Porapak S column and a thermal conductivity detector of high sensitivity. The less volatile aliphatic and aromatic products evolved in flash pyrolysis of 500°C were analyzed

by gas chromatography-mass spectrometry. The decomposition of the ester group resulted in carbon monoxide and carbon dioxide. The polymers containing methoxy substituent groups gave higher amounts of carbon monoxide and methane, indicating cleavage of the methoxy group. The phenyl undecanoate moiety of the polymers resulted in phenol and p-cresol. (Edited author abstract) 10 refs.

Blazso, M. (Hungarian Acad of Sciences, Budapest, Hung); Zelei, B.; Gandhe, B.R.; Sek, D. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 233-244.

**082234 THERMAL DECOMPOSITION OF SEGMENTS WITH TWO AROMATIC RINGS IN THERMOSTABLE MACROMOLECULES.** Pyrolysis-gas chromatographic-mass spectrometric studies on a series of pseudo-ladder polymers were performed. The pyrolysis at 650°C affects only the aryl ether segments of aryl ether derivatives of the poly[bis(benzimidazobenzisquinoxinones)]. The formation of the volatile thermolysis products are interpreted by the chemistry of the segments decomposed. The pyrolysis of 4,4'-dioxiphenylene segments results in 4-phenylphenol, analogously to the thermolysis of 1,4-dioxiphenylene which produces phenol. In contrast, 2,7-dihydroxynaphthalene segments decompose producing 2,7-dihydroxynaphthalene and 2-naphthol, analogously to the decomposition of 1,3-dioxiphenylene which releases resorcinol and phenol. (Edited author abstract) 6 refs.

Blazso, M. (Hungarian Acad of Sciences, Budapest, Hung); Jakab, E. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 245-250.

**Defects** See Also POLYETHYLENES—Crystalline; POLYETHYLENES—Dielectric Properties.

**082235 STRUCTURE AND DEFECTS OF A LINEAR CHAIN POLYMER FILM; GeO PHTHALOCYANINE EPITAXIALLY GROWN ON KCl.** Epitaxial film of GeO phthalocyanine polymer grown on KCl has been investigated by direct observation of molecular images and electron diffraction. The film is composed of many crystallites oriented in two directions. The mechanism of the epitaxial growth of an organic crystal has been related to the determination of a staggering angle of the molecules stacked in polymer chains. Prominent diffuse scatterings have been observed and their origin has been revealed to be the existence of stacking faults in the crystal. The molecular orientation at the fault is discussed. (Author abstract) 12 refs.

Kobayashi, Takashi (Kyoto Univ, Uji, Jpn); Uyeda, Natsuo. *J Cryst Growth* v 84 n 4 Oct 1987 p 589-597.

**082236 DETERMINATION OF DEFECTS IN THE STRUCTURE OF POLYMER MATERIALS.** Sorption methods are the simplest and most accessible methods of nondestructive inspection of materials and components. Penetrant flaw inspection is the most extensively used method. In this method, light- or color-contrast liquid penetrants sorbed by defective areas, cracks, and microcavities are deposited on the surface of the specimen. In this work the authors utilize the sorption of flaw inspection liquids by the specimens of polymer materials in thermostatically controlled gradient column. The selection of the pair of the liquids is determined by the initial density of the polymer and by the number, size, and characteristics of defects. The position of the specimen in the gradient column is fixed using the cathetometer. The variation of the position of the specimen indicates that the



liquid is sorbed without causing swelling of the polymer, and corresponds to the amount of the liquid sorbed by the defective areas. 5 refs.

Shreder, V.L. (All-Union Scientific-Research & Design Inst of Chemical Industry, Kiev, USSR); Chalykh, A.E.; Krivoshei, V.N. *Ind Lab (USSR)* v 53 n 9 Sep 1987 p 842-844.

**082237 CALORIMETRIC DETERMINATION OF HEAD-TO-HEAD DEFECT IN POLY(VINYLIDENE FLUORIDE).** Differential scanning calorimetric analyses were conducted on samples of poly(vinylidene fluoride) polymerized in an autoclave by tributylborane-oxygen by free-radical initiation at low temperature ( $-70^{\circ}\text{C}$ ). The peak melting points and the percent head-to-head defect in each polymer sample were determined by a reported calorimetric method. A commercial sample showed a melting temperature in the range  $157\text{--}162^{\circ}\text{C}$  and a percent head-to-head defect of 7.7%; whereas two experimental samples showed melting temperatures in the range  $172\text{--}179^{\circ}\text{C}$  with a percent head-to-head defect of 4.4 and 4.9%. The calorimetric procedure was modified by reducing annealing times to only 2 h, which saves time and, as shown in this study, avoids thermal polymer degradation. (Author abstract) 15 refs.

Millich, F. (Univ of Missouri-Kansas City, Kansas City, MO, USA); Hauber, B.F. *J Polym Sci Part B* v 26 n 6 Jun 1988 p 1217-1225.

**Deformation** See Also EPOXY RESINS—Structure; GLASS—Polymeric Materials; POLYETHYLENES—Film; POLYETHYLENES—Physical Properties; POLYMETHYL METHACRYLATE—Swelling; POLYSTYRENES—Deformation; POLYSTYRENES—Swelling.

**082238 ANALYTICAL FORM OF THE DYNAMOMETRIC CURVES FOR POLYMERS IN ISOTHERMAL CONDITIONS OF DEFORMATION.** A model of the cold stretching of polymers has been devised yielding a differential equation relating the stress in the sample to time or relative deformation. The solution obtained describes the experimental data on uniaxial isothermal stretching of polymers and also relaxation of the stresses after arrest of deformation. Ignoring the process of generation and development of the zone of the oriented conversion in the sample the main process determining the form of the dilatometric curve in isothermal conditions of development of deformation is the orientation of the polymer. The proposed model allows one with the aid of numerical methods of solution to investigate the whole dynamometric curve in the traditional terms of polymer mechanics. (Author abstract) 9 refs.

Lukovkin, G.M. (Lomonosov State Univ, Moscow, USSR); Volynskii, A.L.; Bakeyev, N.F. *Polym Sci USSR* v 28 n 6 1986 p 1396-1402.

**082239 ORIGINAL METHOD FOR STUDYING THE TENSILE DRAWING BEHAVIOUR OF POLYMERS BY INFRARED SPECTROSCOPY AT HIGH-STRAIN RATES.** This communication deals with the description and experimentation of an original method for studying the molecular processes of deformation in polymers by means of infrared spectroscopy under high-speed drawing conditions. The equipment is based on the model of an industrial drawing bench which involves the pulling of a continuous tape or yarn between two sets of feed rolls and draw rolls, in combination with a Fourier Transform Infrared spectrometer. Preliminary light-polarized measurements concerned with a linear low density polyethylene have been undertaken. Well-resolved infrared spectra are reported for a sample drawn at a take up velocity  $V_d = 39\text{m/min}$ , with a draw ratio  $\lambda = 7.8$ . (Author abstract) 20 refs.

Dupuis, J. (Univ de Lille 1, Villeneuve d'Ascq, Fr); Seguela, R.; Sombret, B.; Legrand, P.; Rietsch, F. *Polym Bull (Berlin)* v 18 n 4 Oct 1987 p 323-327.

**082240 DEFORMATION RECOVERY BEHAVIOUR OF A SOLID POLYMER AFTER TENSILE YIELDING. II. EFFECT OF TEMPERATURE.** The

deformation recovery behavior of an amorphous polymer after large tensile deformation is studied at different temperatures. The effect of three parameters other than temperature has been pointed out in previous works. The data presented indicate that the influence of all parameters, including temperature, on recovery behavior can be related to the residual stress,  $\sigma^*$ , at the beginning of recovery test. This suggests to plot the recovery versus time curves, relative to different sets of parameters including temperature, by means of the same normalizing groups which were adopted, thus shifting all curves towards a single master curve. (Edited author abstract) 14 refs.

Rizzo, Giovanni (Univ of Palermo, Palermo, Italy); Spadaro, Giuseppe. *Polym Bull (Berlin)* v 18 n 4 Oct 1987 p 361-368.

**082241 ROLE OF STRUCTURAL FACTORS IN RESISTANCE TO INELASTIC DEFORMATION OF NETWORK POLYMERS.** From analysis of the activation parameters of deformation determined in the transitional region on continuous loading the author examines the special aspects of deformation of network polymers on compression in different relaxation regions. The possibility of qualitative prediction of the prolonged deformative properties on the basis of the activation parameters found in short-term tests is demonstrated. The author's findings indicate that the elementary acts of the process of deformation are identical for different loading regimes. The deformations corresponding to  $\sigma_1$  and the start of sharp increase in the rate of creep are close in the case considered. It is known that the deformation criterion of long-term strength is based on the independence of the value of limiting deformation from the test conditions. (Edited author abstract) 15 refs.

Filyanov, Ye.M. (All-Union Synthetic Resin Research Inst, USSR). *Polym Sci USSR* v 28 n 8 1986 p 1833-1840.

**082242 EXPERIMENTAL-THEORETICAL STUDY OF THE EFFECT OF HYDROSTATIC PRESSURE ON THE CREEP OF STRUCTURAL POLYMERS IN TENSION.** Study of the deformation of polymeric structural materials in a hydrostatic stress state is important in the construction of the governing equations of the mechanical state, as well as for a whole range of practical applications. We study a nonlinear model of viscoelasticity which takes into account the effect of hydrostatic pressure on the creep of structural polymers in tension under conditions of steady and programmed loading. 5 refs.

Gol'dman, A.Ya. (Okhtinsk Scientific-Industrial Assoc 'Plastpolimer', Leningrad, USSR); Mesh, G.E.; Murzakhanov, G.Kh. *Mech Compos Mater* v 23 n 2 Mar-Apr 1987 p 129-134.

**082243 FEATURES OF PLASTIC DEFORMATION OF AMORPHOUS GLASSY POLYMERS IN STRESS RELAXATION AND CREEP REGIMES.** The features of plastic flow of an amorphous glassy polymer (polyarylate) in the stress relaxation and creep regimes are examined. The influence of preliminary deformation and annealing on the behavior of the material in these regimes is shown. A mathematical model of plastic flow qualitatively describing the processes occurring in the polymer on deformation is proposed. (Author abstract) 5 refs.

Berlin, A.A. (USSR Acad of Sciences, USSR); Grineva, N.S.; Aleksanyan, G.G.; Karpenko, Yu.P.; Manevich, L.I. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2781-2786.

**082244 IR SPECTROSCOPIC STUDY OF THE DEFORMATION OF POLYMERS.** It has been shown that a reversible shift in the IR bands corresponding to skeletal vibrations of the polymeric chain occur during the elastic deformation of polymers. The intensity of deformation-sensitive bands and their dichroism change during elastic deformation. The intensity of IR bands corresponding to end-molecular groups increases during plastic deformation (chemical flow) or the intensity and dichroism of the conformation-sensitive and 'degradation' bands

remain unchanged (physical flow). (Author abstract) 18 refs.

Pakhomov, P.M. (Khimvolokno Scientific & Production Unit, USSR); Shablygin, M.V. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2852-2859.

**082245 METHOD OF DESCRIBING KINETIC CURVES FOR THE ACCUMULATION OF CRAZES IN THE DEFORMATION OF AMORPHOUS POLYMERS UNDER CREEP CONDITIONS IN ADSORPTION ACTIVE MEDIA.** An equation describing the kinetics of accumulation of crazes as a function of time or deformation under creep conditions is proposed. The equation is based on the assumption of the threshold character of craze appearance and the presence of a craze growth rate function. The expression obtained is a good description of the kinetic curves for the accumulation of crazes and the limiting number of crazes as a function of the stress. (Author abstract) 8 refs.

Lukovkin, G.M. (M.V. Lomonosov State Univ, Moscow, USSR); Yarysheva, L.M.; Kabal'nova, L. u.; Volynskii, A.L.; Kozlov, P.V.; Bakeyev, N.F. *Polym Sci USSR* v 29 n 1 Jan 1988 p 224-227.

**082246 DEFORMATION OF SEMICRYSTALLINE POLYMERS VIA CRYSTAL-CRYSTAL PHASE TRANSITION.** A classification is given of flexible, semicrystalline polymers based on the early stage deformation behavior in the solid state. The criteria of each category are discussed with experimental evidence from the literature on 17 polymers. The central aim of this classification is to point out the possibility of ductility induced during deformation. The understanding of the induced ductility in a given semicrystalline polymer suggests a systematic route to optimize solid-state deformation processes for achieving high draw ratios. (Author abstract) 65 refs.

Saraf, Ravi F. (Univ of Massachusetts, Amherst, MA, USA); Porter, Roger S. *J Polym Sci Part B* v 26 n 5 May 1988 p 1049-1057.

**082247 EFFECT OF THERMAL HISTORY ON THE DEFORMATION MECHANISMS OF 2,6-DIMETHYLPOLY(PHENYLENE OXIDE).** Stress-strain relationships of 2,6-dimethyl poly(phenylene oxide) (2,6 MPPO) was established simultaneously with optical micrographic examination as a function of thermal history. Films ( $5\text{--}7\text{ }\mu\text{m}$ ) were solvent cast and annealed below their glass transition and melting point. As-cast film showed ductile behavior associated with shearband formation, whereas thermally treated material exhibited marked embrittlement; the slower it cooled the more brittle it became. Thermally treated material showed mixed mode deformation; crazing and shearbanding. The correlation between the deformation mechanism and its solid state structure was studied using differential scanning calorimetry, wide angle x-ray diffraction, and density measurement. (Author abstract) 16 refs.

Dalal, V.F. (Case Western Reserve Univ, Cleveland, OH, USA); Moet, A. *Polym Eng Sci* v 28 n 8 Apr 1988 p 544-549.

**082248 DEFORMATION-DEPENDENT PROPERTIES OF POLYMER NETWORKS CONSTRUCTED BY ADDITION OF CROSS-LINKS UNDER STRAIN.** Final network properties (elasticity and structure factor) are calculated for polymer networks which are constructed by addition of cross-links at a series of deformations. It is shown that the m-network hypothesis is valid as an interpretation of the free energy of deformation. A simple modification of this hypothesis allows for a similar interpretation of the structure factor. (Edited author abstract) 10 refs.

Baxandall, L.G. (Cavendish Lab, Cambridge, Engl); Edwards, S.F. *Macromolecules* v 21 n 6 Jun 1988 p 1763-1772.



**082249 KINETIC MODEL FOR TENSILE DEFORMATION OF POLYMERS. 2. EFFECTS OF ENTANGLEMENT SPACING.** A new kinetic model for deformation of polymers, introduced previously, is employed to study the orientational and morphological changes that occur during tensile drawing of high molecular weight polyethylene. In the model, the polymer solid is represented by a loose network of entangled chains that are tied together through numerous weak (van der Waals) bonds. This study focuses on the effect on the deformation behavior of the entanglement spacing which can be experimentally varied by using solution crystallization techniques. Calculated stress-strain curves are found to be in excellent agreement with experimental results. Apart from quantitatively predicting the stress-strain behavior, the present model also reveals the various morphological changes that are observed in tensile deformation of polymers. (Edited author abstract). 19 refs.

Termonia, Yves (DuPont, Wilmington, DE, USA); Smith, Paul. *Macromolecules* v 21 n 7 Jul 1988 p 2184-2189.

**082250 LINK BETWEEN THE ACTIVATION PARAMETERS OF DEFORMATION OF NETWORK POLYMERS IN THE TRANSITIONAL REGION AND THE PROPERTIES OF THE GLASSY STATE.** It is shown that the activation parameters of deformation in the transitional region reflect the structural features and properties of glassy epoxide polymers. An analogy is drawn between thermal and deformation softening. The temperature intervals determining the different patterns and mechanisms of strain have been found. The structure factors of the network polymer determining the sign of plastic strain characteristic of crystalline bodies have been identified. (Author abstract). 5 refs.

Filyanov, Ye. M. (All-Union Synthetic Resin Research Inst, USSR). *Polym Sci USSR* v 29 n 5 1987 p 1082-1089.

**Degradation.** See Also ACETAL RESINS—Hydrolysis; BLOCK COPOLYMERS—Synthesis; COPOLYMERS—Photosensitivity; COPOLYMERS—Pyrolysis; COPOLYMERS—Stability; ELECTRIC INSULATING MATERIALS—Plastics; POLYESTERS—Pyrolysis; POLYESTERS—Thermal Effects; POLYETHYLENES—Degradation; POLYETHYLENES—Oxidation; POLYETHYLENES—Radiation Effects; POLYISOPRENE—Oxidation; POLY-METHYL METHACRYLATE—Thermal Effects; POLYPROPYLENE—Extrusion; POLYSTYRENES—Thermal Effects.

**082251 FREE RADICALS GENERATED IN POLY(4-METHYLPENTENE-1) BY MECHANICAL DEGRADATION.** Structure of free radicals formed by mechanical degradation in poly(4-methylpentene-1) was elucidated from an analysis of EPR spectra. Radicals with free valency localized on tertiary carbon atoms either in the main chain or in the side group were identified. The radicals of the first type assume different conformations in the crystalline and liquid phase. Simple hydrocarbons (methane etc.) have been found in the products of low-temperature mechanical degradation of poly(4-methylpentene-1). (Author abstract) 8 refs.

Radtsg, V.A. (USSR Acad of Sciences, USSR). *Polym Sci USSR* v 28 n 6 1986 p 1488-1493.

**082252 THERMAL DECOMPOSITION OF POLY(ARYL ETHER KETONES).** Thermogravimetry has been used to study the isothermal decomposition of poly(aryl ether ether ketone) and poly(aryl ether ketone) and the kinetics of decomposition established from the evolved volatiles. Both products and measured activation energies were consistent with a chain scission process occurring at ether and carbonyl linkages. The volatile decomposition products were analysed by mass spectroscopy and were found to contain various oligomers together with phenol and dibenzofuran. The volatile products were richer in hydrogen than the parent polymers, at the expense of a carbon-like insoluble residue. The degradation products are accounted for in terms of random chain scission and transfer reactions. (Author abstract) 2 refs.

Hay, J.N. (Univ of Birmingham, Birmingham, Engl); Kemmish, D.J. *Polymer* v 28 n 12 Nov 1987 p 2047-2051.

**082253 INDUSTRY WEIGHS NEED TO MAKE POLYMER DEGRADABLE.** In the 'post-berge' era, biodegradable and photodegradable plastics get more sophisticated. Expectations about their role in keeping the environment clean are also up. Yet most in the industry see them as just one more weapon in the fight against waste. (Author abstract)

Leaversuch, Robert. *Mod Plast* v 64 n 8 Aug 1987 p 52-55.

**082254 KINETICS OF MECHANICAL DEGRADATION IN MELTS UNDER MODEL CONDITIONS AND DURING PROCESSING OF POLYMERS - A REVIEW.** The mechanodegradation of polymers in melts has been studied in terms of free radical processes. It is suggested that changes in molecular weight only occur at the chain propagation step. It is shown that the kinetic scheme accounts for the following characteristics: smooth dependence of molecular weight on temperature in model conditions and a sinusoidal dependence in processing, a decrease in the width of the Molecular Weight Distribution function, a quantitative correlation between ruptures and cross links on the one hand and change in double bond concentration on the other and an increase in long-chain branching due to the reaction of chain-side radicals. The effects of processing conditions (oxygen, inhibitor, fillers, type of equipment, etc.) are shown. (Author abstract) 33 refs.

Gol'dberg, V.M. (Acad of Sciences of the USSR, Moscow, USSR); Zaikov, G.E. *Polym Degradation Stab* v 19 n 3 1987 p 221-250.

**082255 PHOTO-OXIDATIVE STABILITY OF ELECTRON BEAM AND UV CURED ACRYLATED EPOXY AND URETHANE ACRYLATE RESIN FILMS.** The post-cured photo-oxidative stability of urethane and bisphenol-A epoxyacrylate resins in mixed compositions with triacrylate and amine diacrylate resins are examined using UV and reflectance infra-red absorption spectroscopic techniques. Overall electron-beam cured resin films are more photostable than UV cured films, indicating the high photo-activity of residual photoinitiator in the latter case. Regarding the UV cured systems benzophenone is found to be a more photo-active residual photoinitiator than the benzoyl ester photofragmenting types. Films containing the amine diacrylate resin are more photostable than those containing the triacrylate resin. This stabilizing effect is associated with the oxygen and radical scavenging ability of the terminal amine groups. Photo-yellowing is observed only in resin films containing the amine diacrylate resin and is associated with the formation of unsaturated carbonyl groups. (Edited author abstract) 8 refs.

Allen, N.S. (Manchester Polytechnic, Manchester, Engl); Robinson, P.J.; White, N.J.; Swales, D.W. *Polym Degradation Stab* v 19 n 2 1987 p 147-160.

**082256 SIMULATION OF MOLECULAR WEIGHT DISTRIBUTION AFTER POLYMER BREAKDOWN. I. A LEAST-SQUARES PARAMETER ESTIMATION METHOD ON MONTE CARLO MODELS.** The degradation index (DI) has been used in previous work for Monte Carlo simulation of breakdown of polymers with narrow initial molecular weight distribution. However, the definition of DI is inadequate for polymers of broader molecular weight distribution. A least-squares method for estimating DI for such systems is described. (Author abstract) 5 refs.

Plaumann, Heinz P. (Polysar Ltd, Sarnia, Ont, Can). *J Macromol Sci Chem* v A24 n 10 Oct 1987 p 1167-1174.

**082257 IN VIVO DEGRADATION CHARACTERISTICS OF POLY( $\beta$ -PROPIOLACTONE) PREPARED BY RADIATION-INDUCED POLYMERIZATION AT LOW TEMPERATURE.** The polymerization rate of  $\beta$ -propiolactone (PL) by irradiation at  $-78^\circ\text{C}$  in vacuo increased markedly with the irradiation dose of up to 50 kGy and then gradually increased at an irradiation dose of up to 200 kGy. The yields of poly (PL) obtained at irradiation doses of 50 and 200 kGy were 22 and 25%,

respectively. The polymer was shaped into a cylindrical form with high rigidity and density by pressing at 200 kg/cm<sup>2</sup> in a range of 50°C to 75°C. The in vivo degradation of cylindrical specimens was checked by implanting subcutaneously in the back of the male Wistar rats. The data of X-ray diffraction patterns and DSC curves showed that the in vivo degradation is influenced by a change in the crystallinity or by a decrease in the melting point of poly(PL). (Edited author abstract) In Japanese. 11 refs.

Asano, Masaharu (JAERI, Takasaki, Jpn); Yoshida, Masaru; Kaetsu, Isao; Morita, Yasushi; Fukuzaki, Hironobu; Mashimo, Tooru; Yuasa, Hisako; Imai, Kyoichi; Yamanaka, Hidetoshi; Kawaharada, Umeko; Suzuki, Keiji. *Kobunshi Ronbunshu* v 19 n 4 1987 p 897-903.

**082258 UV DEGRADATION OF POLY[1-(TRIMETHYLSILYL)-1-PROPYLENE] AND EFFECTS OF SENSITIZERS ON THE DEGRADATION.** UV degradation of poly[1-(trimethylsilyl)-1-propylene] denoted as PMSP and effects of sensitizers on the degradation were studied. PMSP was degraded by UV irradiation under air and in vacuo. The rate of degradation was enhanced in a presence of oxygen. The degradation was random chain scission as found from the relationship between the applied dose and the reciprocal of molecular weight of PMSP degraded. PMSP polymerized by NbCl<sub>5</sub> turned out to be more degradable than that polymerized by TaCl<sub>5</sub>. The energy transfer between composite sensitizers plays a role in the sensitization. (Edited author abstract) In Japanese. 9 refs.

Takada, Koichi (Sanyo Chemical Industries Ltd, Kyoto, Jpn); Matsuya, Hidehiko; Kishiki, Hiroshi. *Kobunshi Ronbunshu* v 19 n 4 1987 p 905-910.

**082259 DEGRADATION AND STABILIZATION OF POLYMERS.** The main types of degradation are thermal, mechanical, oxidative, radiative, biochemical, high energy and solvent, with strong interconnections among them, not yet fully clarified. This paper describes the more important of these types of degradation, and a look is taken at the possibility of recovering polymers from municipal solid wastes, as a policy of 'prolonging' their utilization in the form of energy. 51 refs.

Maltese, Paolo. *Kem Kem* v 15 n 2 1988 p 115-121.

**082260 POLYMER DEGRADATION DURING COMBUSTION.** A novel driven-rod, radiant pyrolysis technique has been used to study the steady-state linear regression of vertically mounted poly(methyl methacrylate) and polypropylene rods degrading from the top under high-flux, nonflaming conditions that simulate those of combustion. With this technique reliable temperature-depth and oxygen-depth profiles have been obtained and used to calculate the observed mass loss rates and to elucidate the mode of polymer degradation during combustion, respectively. For poly(methyl methacrylate) burning in this rod configuration, condensed phase oxidation is unimportant and the degradation mechanism is similar to that under more conventional slow-heating conditions in the absence of air. In contrast, for burning polypropylene condensed phase oxidation occurs; the lack of oxygen incorporation suggests that the polymer degrades by oxygen-promoted pyrolysis. (Author abstract) 18 refs.

Brauman, S.K. (Sri Int, Menlo Park, CA, USA). *J Polym Sci Part B* v 26 n 6 Jun 1988 p 1159-1171.

**082261 DEGRADATION OF POLYMERS BY MECHANICAL FORCES AND CHEMICALLY ACTIVE MEDIA.** Available data on the correlation between processes in polymers brought about by the action of chemically active aggressive media and their mechanical properties under stress are summarized and systematized. Particular attention is paid to the degradation of polymers



by mechanical forces and to the influence of the degradation on the mechanical properties of polymeric materials. (Author abstract) 51 refs.

Rudakova, T.E. (Acad of Sciences of the USSR, Moscow, USSR); Zaikov, G.E. *Polym Degradation Stab* v 21 n 1 1988 p 73-90.

**082262 CATALYTIC SELECTIVITY OF DIAZONIUM TETRAFLUOROBORATE FOR POLYMER DEGRADATION.** Highly reactive photoinitiators afford very sensitive photopolymer systems at the expense of thermal stability. The catalytic selectivity of p-substituted benzene diazonium tetrafluoroborate was studied by using polyacetaldehyde (APA) as a degradable polymer. APA containing p-dimethylaminobenzene diazonium tetrafluoroborate  $[(CH_3)_2NBD]$  photodegraded above 60°C, but did not above 40°C in spite of the actual photodecomposition of  $[(CH_3)_2NBD]$  as detected by UV spectroscopy. The phenomenon was ascribed to the coordination of  $BF_3$ , which was generated from  $(CH_3)_2NBD$ , to the dimethylamino group, since the dimethylamino group and  $BF_3$  work as an electron donor and an acceptor, respectively. Above 60°C,  $BF_3$  coordinated to the dimethylamino group was dissociated to degrade the APA. Photolysis of  $(CH_3)_2NBD$  above 60°C generated free  $BF_3$  to catalyze the degradation. Therefore  $BF_3$  generated from  $(CH_3)_2NBD$  in APA showed catalytic selectivity. (Edited author abstract) 15 refs. In Japanese.

Harada, Kieko (Chiba Univ, Chiba, Jpn); Ueno, Nobuo; Sugita, Kazuyuki. *Kobunshi Ronbunshu* v 45 n 4 1988 p 295-302.

**082263 THERMAL PROPERTIES OF POLY-N-VINYLCARBAZOLE DERIVATIVES.** Thermal studies were carried out on some products of chemical modification of poly-N-vinylcarbazole (PNVC). The effect of a substituent introduced into the carbazole ring on the thermal stability of the polymers was investigated. The kinetic parameters of the thermal degradation process were computed. (author abstract) 4 refs.

Trebacz, E. (Polytechnical Univ, Cracow, Pol). *J Therm Anal* v 32 n 6 Nov-Dec 1987 p 1773-1776.

**082264 INVESTIGATION OF THE INFLUENCE OF METAL OXIDES ON THE THERMAL DEGRADATION OF CHLORINE-CONTAINING POLYMERS BY THERMOGRAVIMETRY.** The influence of oxides of zinc, magnesium, antimony and aluminium on the thermal degradations of polychloroprene, chlorinated polyethylene and epichlorohydrin homopolymer has been investigated. The investigations showed that these metal oxides can change the thermal stabilities and degradation processes of chlorine-containing polymers. A considerable acceleration of the dehydrochlorination of these polymers was found in the presence of zinc oxide. (Author abstract) 5 refs.

Kleps, T. (Inst of Rubber Industry, Pol); Piskiewicz, M. *J Therm Anal* v 32 n 6 Nov-Dec 1987 p 1785-1789.

**082265 CATALYTIC DEGRADATION OF POLY(A-METHYLSTYRENE) IN THE PRESENCE OF SILICA-ALUMINA.** Catalytic degradation of poly(a-methylstyrene) in the presence of silica-alumina catalyst was investigated. Volatile main products were cumene (17.8 mol% based on the monomer-unit in sample-feed) and benzene (14.1 mol%) after 1 h reaction at 240°C. Indane skeletons were formed on the chain ends of degraded oligomers. Propylene units were detected on the degraded polymer chains. It was clear from the relationship between the composition of reaction products and scission-number of polymer chains that the catalytic reactions were mainly dephenylation as initiation reaction,  $\beta$ -scission of carbonium ions produced on the main chain, and depolymerization by  $\beta$ -scission of chain-end carbonium ions. (Edited author abstract). 20 Refs. In Japanese.

Nambu, Hidesaburo (Nihon Univ, Tokyo, Jpn); Kikawa, Hiroaki; Shimada, Shunji; Kouno, Yukiko; Ishihara, Yumiko; Takesue, Tomoyuki; Ikemura, Tadashi. *Kobunshi Ronbunshu* v 45 n 5 1988 p 409-416.

**082266 THERMAL DEGRADATION OF SOME POLYMERS BASED ON ETHYLENE GLYCOL DIMETHACRYLATE.** Thermogravimetric analysis and pyrolysis in combination with gas chromatography were used to study the thermal behavior of some cross-linked polymers of ethylene glycol dimethacrylate. The investigated polymers show a complex thermal degradation mechanism. The complexity of the reaction increases together with increase of the ethylene glycol chain in the macromolecule and with increase of the pyrolysis temperature. At low temperature, the thermal decomposition products of analyzed polymers are mainly the constituent monomers. At high temperatures, besides the monomer, other decomposition products are formed as a result of thermal cracking reactions, i.e. secondary reactions of decomposition and recombination. (Author abstract). 17 Refs.

Cascaval, C.N. (Petru Poni Inst of Macromolecular Chemistry, Iasi, Rom); Hurdud, N.; C Poinescu, Ig. *J Therm Anal* v 34 n 1 Jan-Feb 1988 p 311-317.

**082267 DEGRADABLE POLYMERS. IV. DEGRADATION OF ALIPHATIC THERMOPLASTIC BLOCK COPOLYESTERS.** Three block copolymers of poly(ethylene succinate) and poly(tetramethylene glycol) with about 20, 54, and 59 mol% polyether have been prepared and subjected to hydrolytic degradation at 37°C. The sample containing 59 mol% showed drastic changes in the properties after 3 months of degradation, whereas the other samples exhibited only minor changes. The tensile strength was completely lost, the molecular weight had decreased to 7% of the original value, and the crystallinity (measured as heat of fusion) had more than doubled. IR and  $^1H$ -NMR analyses showed that the rates of release of the different polymeric blocks varied throughout the period of hydrolytic degradation. (Edited author abstract). 15 Refs.

Albertsson, Ann-Christine (Royal Inst of Technology, Stockholm, Swed); Ljungquist, Olle. *J Macromol Sci Chem* v A25 n 4 1988 p 467-498.

**082268 CONVERSIONS OF POLYMERS WITH A SYSTEM OF CONJUGATED BONDS UNDER THE INFLUENCE OF COMPLEX METATHESIS CATALYSTS.** It is shown that polymers with a system of conjugated bonds, in particular, polyphenylacetylene on complex catalysts based on  $WCl_6$  and  $Re_2O_7$  undergo degradation a consequence of which is fall in MM (Molecular Mass) (approx. 10 times) with widening of the MD of the polymer. Enrichment of the polymer with saturated aliphatic groups when the reaction is run in the presence of heptene-1 and also inhibition of the reaction on addition of trimethylvinylsilane indicate that the process studied involves carbene active centers and is a metathesis reaction. This work also opens the way to the use of the reaction of metathesis and comethathesis for modifying the CBPs. (Author abstract). 13 Refs.

Serverina, Ye. N. (USSR Acad of Sciences, USSR); Mavrenkova, G.V.; Geiderikh, M.A.; Davydov, B.E. *Polym Sci USSR* v 29 n 4 1987 p 818-823.

**082269 DEGRADATION OF SYNTHETIC POLYMERS: APPLICATION OF SOME PYROLYSIS METHODS IN AN INVESTIGATION OF THE DEGRADATION BEHAVIOUR OF IONOMERS CONTAINING METHACRYLATE SALT UNITS.** Three commercial ionomers, comprising a zinc ion and two sodium ion derivatives of ethylene-methacrylic acid copolymer have been studied; the corresponding homopolymers, polyethylenes, sodium polymethacrylate and zinc polymethacrylate have also been examined under the same experimental conditions as a basis for comparison. Infra-red spectra of the ionomers indicate the presence in the chains of COOH groups as well as the carboxylic salt structure. Thermogravimetry, differential scanning calorimetry and thermal volatilization analysis (TVA) are the pyrolysis methods which have been used. The last of these techniques gives the greatest amount of information, since it provides access to each of the various product fractions. (Edited author abstract) 13 refs.

McNeill, I.C. (Univ of Glasgow, Glasgow, Scotl); Barbour, M. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 163-179.

**082270 ROLE OF METALS AND METAL-DEACTIVATORS IN POLYMER DEGRADATION.** The interaction between metals or metallic compounds and polymers is inevitable in the practical use of polymeric articles, and the stability of the polymers is often modified by these materials. Furthermore, the effect of the metallic compounds on the degradation of the polymers is extremely complicated, and is influenced by various factors. This contribution deals with the possible role of metals or metallic compounds in the degradation of polymers, and this is followed by some typical examples of degradation by metallic compounds, mostly commercial pigments and transition metal compounds of stearic acid and acetylacetone, in typical commercial polymers. Recent studies of the inhibition of the copper-catalyzed thermo-oxidative degradation of polyolefins by deactivators, both commercial reagents and novel products, are discussed. (Author abstract) 40 refs.

Osawa, Zenjiro (Gunma Univ, Kiryu, Jpn). *Polym Degradation Stab* v 20 n 3-4 1988, Polym Addit in Stab: Perform and Mech, Birmingham, Engl, Sep 2-4 1987 p 203-236.

Desorption See POLYSTYRENES—Adsorption.

**Dielectric Properties** See Also POLYOLEFINS—Structure; RUBBER, SYNTHETIC—Dielectric Properties.

**082271 OPTIMAL DESIGNS FOR ESTIMATING DIELECTRIC CONSTANTS OF POLYMERS.** A statistical design criterion is applied to the problem of estimating dielectric constants in the model proposed by S. Havriliak and S. Negami. Under this criterion, the volume of the joint inference region of the parameter estimates is minimized. Because a computer program must be used to determine the optimal design points, simple approximating equations are presented for more practical use. (Edited author abstract) 12 refs.

Zhu, Yiliang (Queen's Univ, Kingston, Ont, Can); Watts, Donald G. *Polymer* v 29 n 2 Feb 1988 p 325-328.

**082272 STUDY ON DIPOLE MOMENTS OF MACROMOLECULES. I. APPARATUS FOR DIELECTRIC MEASUREMENTS AND DIPOLE MOMENT OF POLY(p-METHOXYSTYRENE).** A three-terminal cell for the dielectric measurement of liquid was made and the cell capacitance was determined using a capacitance bridge. The accuracy of the dielectric constant measurement with the apparatus was examined by measuring standard materials such as benzene and cyclohexane. The mean square dipole moments of poly(p-methoxystyrene) in benzene were determined by accurate measurements of dielectric constants on the polymer dilute solutions and the values were estimated according to two procedures, i.e., one based on Debye and Halverstadt-Kumler equations (DHK method) and the other on Guggenheim and Smith equations (G-S method). The average dipole moments per repeat unit  $\mu$  were obtained as 1.214 (25°C) and 1.221 (40°C) by the DHK method and 1.204 (25°C) and 1.209 (40°C) by the G-S method (in debye unit). The slight disagreement in  $\mu$  values obtained by two different procedures was interpreted as arising from differences in assumptions used in the DHK method and the G-S method. (Author abstract) 28 refs.

Yamaguchi, Noriko (Tokyo Woman's Christian Univ, Tokyo, Jpn); Sato, Mari; Shima, Mikiko. *Polym J* v 20 n 2 1988 p 97-105.

**082273 MULTIPLE DIELECTRIC RELAXATIONS IN SOLID POLYORGANOPHOSPHAZENES.** Dielectric properties of solid films of poly(dichloro phosphazene) (PCPN), poly(diphenoxy phosphazene) (PPPN), and poly(difluoroethoxy phosphazene) (PFPPN) were studied.



ied in the frequency range from 0.1 to 100 kHz. PCPN exhibited only one relaxation peak (named as  $\alpha$  process), while PPN and PFPN exhibited two loss maxima ( $\alpha$  and  $\beta$ ) in the dielectric loss  $\epsilon''$  curve within the temperature range between 90 and 460 K. The  $\alpha$  process for the each sample was seen just above its glass transition temperature  $T_g$ , while the  $\beta$  relaxation was observed only for PPN and PFPN in the region far below their  $T_g$ . This result indicates that the  $\beta$  process is due to rotation of the side groups. Based on the simplest two site model, we estimated the amplitude of the rotational oscillation of the side groups and the energy difference between the two sites. (Edited author abstract) 20 refs.

Uzaki, Shunsuke (Osaka Univ, Toyonaka, Jpn); Adachi, Keiichiro; Kotaka, Tadao. *Polym J* v 20 n 3 1988 p 221-229.

**082274 DIELECTRIC BEHAVIOUR OF STANDARD AMINO RESIN.** Dielectric behavior of standard amino resin urea-formaldehyde has been studied as a function of frequency at room temperature in the frequency range 60 Hz to 10 kHz. Temperature dependence of dielectric constant and dielectric loss has also been studied at various frequencies in the temperature range 30 to 90°C. The increase in dielectric constant and dielectric loss with temperature has been interpreted in terms of the movement of polymeric chains as well as segmental movement. (Author abstract) 7 Refs.

Swarup, S. (Harcourt Butler Technological Inst, Kanpur, India); Chandra, S.; Zulfuekar, M.; Kumar, A. *Indian J Pure Appl Phys* v 26 n 5 May 1988 p 370-372.

**082275 PRECISION MILLIMETER-WAVE MEASUREMENTS OF COMPLEX REFRACTIVE INDEX, COMPLEX DIELECTRIC PERMITTIVITY, AND LOSS TANGENT OF COMMON POLYMERS.** An improved dispersive Fourier transform technique applied to a polarizing two-beam interferometer was used to provide high-precision continuous spectra of complex refractive index, complex dielectric permittivity, and loss tangent for common nonpolar and polar polymers over a frequency range of 50-300 GHz. The nonpolar polymers are polyethylene, polypropylene, poly-4-methyl pentene-1 (TPX), and polytetrafluoroethylene. Plexiglas, acrylic, and nylon and the polar polymers. The nonpolar polymers exhibit extremely low-loss characteristics. The polar polymers are typical polar polymers, but they exhibit nearly 20 to 30 times higher loss compared to nonpolar polymers. 20 refs.

Nurul Afsar, Mohammed (City Coll, New York, NY, USA). *IEEE Trans Instrum Meas* v IM-36 n 2 Jun 1987, Sel Pap - Conf on Precis Electromagn Meas (CPM/86), Gaithersburg, MD, USA, Jun 23-27 1986 p 530-536.

**082276 USE OF POLYACRYLAMIDE AS A TISSUE-EQUIVALENT MATERIAL IN THE MICRO-WAVE RANGE.** The use of polyacrylamide gel to simulate biological tissues at microwave frequencies is presented. Formulation and preparation procedures are discussed. Measurements of complex permittivity in the range from 0.75 to 5.5 GHz, together with its temperature sensitivity, are reported. Thermal and optical properties have also been measured: the polyacrylamide is transparent and may be used as a phantom material in designing and testing applicators for microwave hyperthermia and for dosimetry studies. 13 refs.

Andreuccetti, D. (CNR, Florence Italy); Bini, M.; Ignesti, A.; Olmi, R.; Rubino, N.; Vanni, R. *IEEE Trans Biomed Eng* v 35 n 4 Apr 1988 p 275-277.

## Differential Thermal Analysis

**082277 DIFFERENTIAL SCANNING CALORIMETRY OF POLYMER GLASSES: CORRECTIONS FOR THERMAL LAG.** In differential scanning calorimetry (d.s.c.), a peak in the specific heat capacity is observed during the heating stage, occurring at a temperature  $T_p$  which depends upon both the cooling and the heating rates. For a fixed ratio of these rates, such intrinsic cycles yield heating isobars of identical shape, but shifted along

the temperature scale by an amount which depends upon the heating isobars of identical shape, but shifted along the temperature scale by an amount which depends upon the heating (or cooling) rate. The invariance of the peak shape, and in particular the peak width, is shown to provide a means of correcting d.s.c. data for thermal lag on heating. Experimental data for a low molecular weight polystyrene, when corrected for thermal lag in this way, are shown to agree with the predictions of the kinetic model for structural recovery. An analytical treatment of heat transfer in the d.s.c. cell is also described, and the theoretical results are compared with the experimental data. (Edited author abstract) 18 refs.

Hutchinson, J.M. (Aberdeen Univ, Aberdeen, Scott); Ruddy, M.; Wilson, M.R. *Polymer* v 29 n 1 Jan 1988 p 152-159.

**082278 THERMAL ANALYSIS OF POLYAMIC ACID-FURYL ALCOHOL COMPOSITIONS.** Polyamic acid (PAA), feryl alcohol (FA) and their mixtures in different ratios were investigated by DTA. The effects of the solvent and the component ratio on the thermal characteristics of the final products were estimated. It was shown that when the PAA-FA composition is heated, PAA is the initiator of the polymerization of FA, and the interaction in the system is profoundly affected by the component ratio and the temperature. The existence of an interaction between the components of the system was confirmed by TG, IR and NMR spectroscopy. (Author abstract) 8 Refs.

Simanovich, I.E. (Acad of Sciences of the USSR, Leningrad, USSR); Fedorova, G.N.; Mikhailova, N.V.; Bobasheva, A.S.; Gribov, A.V.; Sazanov, Yu. N. *J Therm Anal* v 34 n 1 Jan-Feb 1988 p 289-295.

**Diffusion** See Also ELASTOMERS—Chemical Reactions; POLYPROPYLENE—Oxidation.

**082279 INTERACTION VIA DIFFUSION OF POLYMER CRYSTALS IN GROWING SPHERULITES.** Previous calculations of how diffusion ranges should be averaged when polymer molecules of various lengths are segregated at crystal growth fronts have been extended. Crystals of acicular or lamellar habit are addressed directly, necessarily using more approximate methods, and earlier conclusions regarding appropriate averaging are reaffirmed. Results also lead to a better understanding of why crystalline texture in polyethylene spherulites appears to scale with the averaged diffusion range at crystallization temperatures within regime II but not at higher temperatures within regime I. (Author abstract) 6 refs.

Keith, H.D. (AT&T Bell Lab, Murray Hill, NJ, USA); Padden, F.J. Jr. *J Polym Sci Part B* v 25 n 11 Nov 1987 p 2265-2273.

**082280 ANOMALOUS POLYMER DIFFUSION IN TWO DIMENSIONS.** Diffusion and Brownian motion of a flexible polymer of length  $N$  between fixed impenetrable obstacles in two dimensions have been investigated using Monte Carlo simulations. Anomalous diffusion of the centre of mass is observed. The results are discussed with respect to the reptation model and the anomalous diffusion of a particle on percolating clusters in two dimensions. (Edited author abstract) 14 refs.

Baumgaertner, A. (KFA, Juelich, West Ger). *Europhys Lett* v 4 n 11 Dec 1 1987 p 1221-1225.

**082281 APERIODIC CRYSTAL DESCRIPTION OF DIFFUSION IN CONCENTRATED POLYMER-SOLVENT SYSTEMS.** The aperiodic crystal picture is used to predict the solvent number fraction dependence of the mutual diffusion coefficient for two dense polymer-solvent systems. This theory, which has been applied successfully to diffusion in one component glasses, gives results that are distinct from previous free volume theories. The theory provides a way to calculate the free energy surface for a dense disordered system, from which the barrier heights to diffusion can be estimated. (Author abstract) 21 refs.

Hall, Randall W. (Louisiana State Univ, Baton Rouge, LA, USA). *Macromolecules* v 21 n 1 Jan 1988 p 239-243.

**082282 POLYMER DIFFUSION IN MELT BLENDS OF LOW AND HIGH MOLECULAR WEIGHT.** Forward recoil spectrometry (FRES) was used to measure the tracer diffusion coefficient  $D^*$  of deuterated polystyrene (d-PS), of molecular weight 255,000 daltons, into a matrix blend of high and low molecular weight polystyrene (PS), as a function of the volume fraction  $\Phi$  of the high molecular weight polymer. The low molecular weight PS, 10,000, was too short to entangle, whereas the three different PS's of high molecular weight  $P = 20,000, 000, 250,000$ , and 93,000 blended with the low molecular weight sample were well above the entanglement molecular weight  $M_e$  of the melt. (Edited author abstract) 26 refs.

Tead, Stanley F. (Cornell Univ, Ithaca, NY, USA); Kramer, Edward J. *Macromolecules* v 21 n 5 May 1988 p 1513-1517.

**082283 INTERRELATION OF SORPTION, DIFFUSION AND ADHESION IN EPOXIDE POLYMERS OF DIFFERENT TOPOLOGY.** The effect of crosslink density of epoxide polymers on diffusion and sorption of organic solvents was studied. An increase in crosslink density leads to a change in the mechanism of polymer plasticization by the solvent. The reduction of joint strength of an assembly epoxide polymer/aluminum results from prevailing diffusion of the low-molecular-weight compound along the boundary of the system, where the crosslink density is lower. Principles involved in the formulation of cleansing liquid mixtures for removing polymers from solid surfaces are discussed. (Author abstract) 12 Refs.

Arslanov, V.V. (USSR Acad of Sciences, USSR); Lipson, G.A. *Polym Sci USSR* v 29 n 4 1987 p 922-928.

**082284 FREE VOLUME CONCEPTS CONNECTING PVT BEHAVIOR AND GASEOUS DIFFUSION THROUGH POLYMERS.** Free volume concepts in polymers are extended to describe gaseous diffusion. This paper gives the initial formulation for diffusion, but much work still needs to be done. (Edited author abstract) 19 refs.

Litt, Morton (Case Western Reserve Univ, Cleveland, OH, USA). *J Rheol* v 30 n 4 Aug 1986, Symp on Appl of Equat of State Rheol at the 57th Annu Meet of the Soc of Rheol, Ann Arbor, MI, USA, Oct 1985 p 853-868.

**Dispersion** See Also SOILS—Solutions.

**082285 SYNTHESIS AND PROPERTIES OF NEW NON-AQUEOUS DISPERSION POLYMERS.** New block copolymers of a non-aqueous dispersion type which had both hydrocarbon-soluble and -insoluble segments and were soluble or dispersible in non-aromatic solvents were synthesized with polymeric peroxides. Poly(2-ethylhexyl methacrylate-block-methyl methacrylate) is an example. A polymerization process to prepare stable dispersions of low viscosity and high solid content was established by selecting appropriate monomers, molecular weights of block polymer, and solvents of appropriate solubility parameters. It became possible to prepare non aqueous dispersion polymers which have high content of insoluble polymer segment and high solid content in dispersion. (Edited author abstract) 12 refs. In Japanese.

Ohmura, Hiroshi (Nippon Oil & Fats Co, Aichi, Jpn); Yamamoto, Takashi. *Kobunshi Ronbunshu* v 44 n 6 1987 p 461-468.

## Dispersions

**082286 POLYDISPERSITY EFFECTS IN POLYMER SELF-DIFFUSION MEASURED BY SMALL-ANGLE NEUTRON SCATTERING.** The small-angle neutron scattering (SANS) method for measuring the self-diffusion coefficient  $D$  has been analyzed for effects of polydispersity in degree of polymerization for the case of linear polymers diffusing by reptation. Polydis-



persities corresponding to  $M_w/m_n = 1.0-10$  were considered. It is shown that in all cases a meaningful effective diffusion coefficient  $D_e$  can be obtained from the short time recovery of the SANS intensity. This quantity  $D_e \leq 1.3 D(M_w)$ , where  $D(M_w)$  is the diffusion coefficient of a monodisperse polymer having molecular weight  $M = M_2$ . The method relies on SANS intensities extrapolated to zero scattering angle; realistic extrapolation is shown to give rise to quite acceptable errors on the order of 0.05  $D_e$ . (Author abstract) 22 refs.

Finerman, T. (Northwestern Univ, Evanston, IL, USA); Crist, B. J. *J Polym Sci Part B* v 25 n 11 Nov 1987 p 2283-2292.

**082287 IMMUNOCHEMICAL STUDIES WITH POLYMER MICROSPHERES CONSISTING OF HYDROPHILIC/HYDROPHOBIC COMPONENTS PRODUCED UNDER VARIOUS EMULSION POLYMERIZATION CONDITIONS.** Three kinds of polymer microspheres consisting of styrene and 2-hydroxyethyl methacrylate components were produced by different emulsifier-free emulsion polymerization methods. They had similar surface hydrophilicities, based on saturating adsorption of an anionic emulsifier. By using these microspheres, the colloidal stability at the step of sensitization with antibodies, security of immunologic agglutination and suppression of nonspecific agglutination, which are main fundamental requirements for immunomicrospheres, were studied. The results were very different among the three kind of microspheres. The differences were assumed to be caused by the differences in the surface characteristics of microspheres. (Edited author abstract) In Japanese. 18 refs.

Okubo, Masayoshi (Kobe Univ, Kobe, Jpn); Uno, Masanari; Yamamoto, Yasumasa; Kamei, Shigeru; Matsumoto, Tsunetaka. *Kobunshi Ronbunshu* v 44 n 11 1987 p 825-830.

**Dissolution** See Also CELLULOSE—Dissolution.

**082288 KINETICS OF SWELLING AND DISSOLUTION OF POLY(PYROMELLITIMIDE IN AQUEOUS SOLUTIONS OF ALKALI HYDROXIDE.** Swelling and dissolution of polyimide films prepared from pyromellitic dianhydride and 4,4'-diaminodiphenyl ether have been studied in aqueous solutions of alkali hydroxide. The experimental data are generalized into kinetic equations which describe quantitatively the interrelated processes of swelling and dissolution, thus supplementing and augmenting the existing knowledge on polyimide hydrolysis in alkaline media. The authors show that one can obtain meaningful information on thermodynamics and kinetics only by considering simultaneously the interrelated phenomena of swelling and dissolution of polyimide films. (Edited author abstract). 5 Refs.

Kitayev, G.A. (S.M. Kirov Ural Polytechnic Inst, USSR); Krupina, T.L. *Polym Sci USSR* v 29 n 4 1987 p 905-910.

**Doping** See Also AROMATIC POLYMERS—Conductive; AROMATIC POLYMERS—Electronic Properties; GLASS—Doping; PLASTICS—Electric Conductivity; POLYACETYLENES; POLYACETYLENES—Electric Conductivity; POLYACETYLENES—Optical Properties.

**082289 INFLUENCE OF DOPANT ION AND SYNTHESIS VARIABLES ON MECHANICAL PROPERTIES OF POLYPYRROLE FILMS.** Oxidized, conductive poly(pyrrolylium anion) films [poly(pyrrolylium) = PP+ where there exists about one cation per three pyrrole rings] have been prepared electrochemically in an effort to study the effect of counteranion structure and preparation conditions on the composition, order (crystallinity), and mechanical properties of the films. The counteranion principally employed was p-toluene-sulfonate (OTs<sup>-</sup>). It was found that the amount of OTs<sup>-</sup> incorporated increased with increasing potential during synthesis, suggesting a parallel increase in the extent of oxidation of the polymer. Mechanical testing of the same films demonstrated that the ultimate tensile strength decreased as the electrode potential and current density during synthesis increased. (Edited author abstract) 14 refs.

Buckley, L.J. (MIT, Cambridge, MA, USA); Roylance, D.K.; Wnek, G.E. *J Polym Sci Part B* v 25 n 10 Oct 1987 p 2179-2188.

**082290 COVALENT BOND TO BROMINE IN HBr-TREATED POLYANILINE FROM X-RAY DIFFRACTION.** When the emeraldine base form of polyaniline is doped by aqueous HBr, the conductivity is increased to 2 (ohm cm)<sup>-1</sup> for a compressed pellet. X-ray diffraction results on the conducting polymer together with elemental analysis indicate that a significant portion of the bromine is covalently bound. (Author abstract) 21 refs.

Annis, B.K. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Narten, A.H.; MacDiarmid, A.G.; Richter, A.F. *Synth Met* v 22 n 3 Jan 1988 p 191-199.

**082291 TRANSIENT OCCURRENCE OF POLARONS IN ELECTROCHEMICALLY DOPED POLY(3-METHYLTHIOPHENE) VIA A DISCRETE ELECTRON LEVEL.** Time-resolved in situ reflection spectra at Pt/poly-1/PMET [poly-1: ruthenium(II) complex polymer; PMET: poly(3-methylthiophene)] electrodes have been measured during the electrochemical doping of PMET via a discrete electronic level of poly-1 layer. Transient occurrence of polarons has been detected in PMET together with the anomalously rapid relaxation of the charged states. (Author abstract) 15 refs.

Murao, K. (Hitachi Ltd, Kokubunji, Jpn); Suzuki, K. *Solid State Commun* v 62 n 7 May 1987 p 483-486.

**082292 EFFECT OF DOPING ON THE CRYSTALLINE STRUCTURE OF POLYPARAPHENYLENE.** The authors observed an increase of about 50% in the diameter of the fibres of Kovacic PPP after AsF<sub>5</sub> doping. This suggests penetration of the dopant molecules inside the fibre. This is confirmed by the lowering of the crystallinity and the disappearance of a distinct crystallite texture. The nature of the crystalline phase responsible for the diffraction pattern is not clear and is likely to be of paracrystalline character. An intercalation model could account for the new diffraction peaks as an average cell. 11 refs.

Pradere, P. (CNRS, Toulouse, Fr); Boudet, A. *J Mater Sci Lett* v 7 n 1 Jan 1988 p 10-12.

**082293 EFFECT OF POLYMERIZATION ANION ON ELECTROCHEMICAL PROPERTIES OF POLYPYRROLE AND ON Li/LiClO<sub>4</sub>/POLYPYRROLE BATTERY PERFORMANCE.** Electrochemical doping-undoping kinetics of electropolymerized polypyrrole (PPy) and the charge-discharge characteristics of Li/LiClO<sub>4</sub>/PPy battery were found to show an interesting dependency on the kind of anions used for the preparation of PPy film. The relationship between the doping charge (anodization charge estimated from cyclic voltammogram) of PPy film and the polymerization potential revealed that the optimum potential for getting the largest doping capacity depends strongly on the kind of anions. The optimum potential for PF<sub>6</sub><sup>-</sup> and CF<sub>3</sub>SO<sub>3</sub><sup>-</sup> formed PPy films was 0.32V vs. Ag/Ag<sup>+</sup>. On the other hand, ClO<sub>4</sub><sup>-</sup> formed PPy film had the largest doping charge at 0.84V preparation over an examined potential range (0.30-0.84V). (Edited author abstract) 15 refs.

Osaka, Tetsuya (Waseda Univ, Tokyo, Jpn); Naoi, Katsumi; Ogano, Satoshi. *J Electrochem Soc* v 135 n 5 May 1988 p 1071-1077.

**082294 THERMODYNAMICALLY REVERSIBLE UPTAKE OF ELECTRICALLY ACTIVE DOPANTS IN CONDUCTING POLYMERS: IODINE IN POLYTHIOPHENE.** The absorption isotherm, at 50°C, for I<sub>2</sub> vapor in polythiophene film is determined by both absorption and desorption measurements and can be reproduced (repeatedly) after I<sub>2</sub> has been fully desorbed. There is no obvious hysteresis, and the evidence in favor of the achievement of reversible thermodynamic equilibrium with respect to the distribution of the electrically active dopant I<sub>2</sub> between the conducting polymer and the vapor phase, is overwhelming. The experimental results of

this paper contradict the widespread notion that doping processes in conducting polymers cannot be brought to thermodynamic equilibrium. Since analyses of molecular level phenomena, based on equilibrium studies, are both more reliable and easier to perform than analyses involving nonequilibrium studies, it is important to discover other conducting polymer systems that exhibit similar reversible equilibria. (Edited author abstract) 11 refs.

Kim, Dai-uk (Univ of California Los Angeles, Los Angeles, CA, USA); Reiss, H.; Raebony, H.M. *J Phys Chem* v 92 n 9 May 5 1988 p 2673-2679.

**082295 THEORETICAL ANALYSIS OF PROTONIC ACID DOPING OF THE EMERALDINE FORM OF POLYANILINE.** The measurements of J.C. Chiang and A.G. MacDiarmid on the pH dependence of the 'equilibrium' proton doping of the emeraldine form of polyaniline are considered. A statistical thermodynamic theory is developed for the proton adsorption isotherm, based on a strong repulsive interaction between protons on nearest-neighbor nitrogen atoms, and, also, the pH dependence of the pK<sub>a</sub> for adsorption is calculated. The derived isotherm exhibits the necessary 'saturation' at the 50% doping level, while the derived pK<sub>a</sub> exhibits the necessary 'constancy' at high pH. (Edited author abstract) 10 refs.

Reiss, H. (Univ of California, Los Angeles, CA, USA). *J Phys Chem* v 92 n 12 Jun 16 1988 p 3657-3662.

**082296 DOPING BEHAVIOUR OF POLY(2,5-PYRIDINEDIYL).** Poly(arylene)s such as poly(p-phenylene) and poly(2,5-thienylene) having  $\pi$ -conjugation along the polymer chain are converted into electrically-conducting materials by oxidation (p-doping) or reduction (n-doping). The doping behaviour of the polymer is considered to reflect the chemical and physical properties of the recurring unit of poly(arylene). The results described indicate that poly(2,5-pyridinediyl) is easily reduced to give the electrically-conducting n-doped material, but oxidation is not easy. This is in sharp contrast to the reducing and oxidizing behaviour of the five-membered heterocyclic polymer, poly(2,5-pyrrolylene). (Edited author abstract). 17 Refs.

Yamamoto, Takakazu (Tokyo Inst of Technology, Yokohama, Jpn); Ito, Takayori; Sanechika, Kenichi; Hishinuma, Masakazu. *Synth Met* v 25 n 1 Jul 1988 p 103-107.

**082297 VARIABLE BAND FILLING AND AN INSULATOR-TO-METAL TRANSITION IN A STRUCTURE-ENFORCED MOLECULAR METAL.** Slurry electrochemical doping of the cofacially-joined phthalocyanine polymer [Si(Pc)O]<sub>n</sub> in Et<sub>4</sub>N<sup>+</sup> tosylate<sup>-</sup>/acetonitrile yields doped polymers of stoichiometry {[Si(Pc)O](tosylate)<sub>y</sub>]<sub>n</sub>, where y=0.00 to 0.67. Charge transport data show a continuous evolution of properties, from those of an insulator to those (at y<sub>0.20</sub>) of a molecular metal. (Author abstract) 10 refs.

Almeida, Manuel (Northwestern Univ, Evanston, IL, USA); Gaudiello, John; Marks, Tobin J.; Butler, John C.; Marcy, Henry O.; Kannewurf, Carl R. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polymers, Part III, Vadstena, Swed, Aug 18-20 1986 p 261-266.

**082298 ROLE OF DOPANT ENVIRONMENT IN ELECTRET-FORMING POLYMERS.** Poly-(2-vinylpyridine), P2VP, poly-(2-vinylquinoline), P2VQ, and their 4-vinyl isomers have been synthesized and chemically doped under different conditions. The materials have been characterized by a variety of techniques to establish synthesis-structure-doping correlations, which seem helpful clues in analyzing current work on their electric properties. In particular, the dopant environment within one or more inequivalent sites inside the polymeric lattice plays an important role in transport mechanisms. To study this effect properly, it proved necessary to relate doping conditions to the structure of the polymer (molecu-



lar and supramolecular, macro- and micro-structure), which in turn depends on synthetic conditions. (Edited author abstract) 13 refs.

Castineira, M. (Univ de Alcala, Madrid, Spain); Conesa, J.C.; Palacios, J.M.; Castaneda, E. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 361-372.

**082299 VAPOUR PHASE DOPING OF POLYPARAPHENYLENE WITH POTASSIUM.** New binary compounds  $(K_xC_6H_4)_x$  synthesized after reaction of gaseous potassium with polyparaphenylene have been characterized by x-ray diffraction and elemental analysis. The heavily-doped materials exhibit very high room temperature conductivity ( $\sigma=200$  S/cm). The evolution of the EPR spectra as a function of the doping time shows the appearance of different kinds of spins, in agreement with the formation of polarons and bipolarons. (Author abstract) 21 refs.

Bakhtali, A. (Univ de Nancy, Vandoeuvre-les-Nancy, Fr); Ghanbaja, J.; Billaud, D.; Goulon, C. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 47-52.

**082300 TEMPERATURE DEPENDENCE OF A.C. CONDUCTIVITY IN POLYMER/ORGANIC METAL SYSTEMS.** The a.c. conductivity of several reticulate doped systems was investigated in the frequency range  $10^2$  to  $10^7$  Hz at temperatures between 95 and 300 K. No frequency-dependent conductivity was found in the investigated temperature range, unless discontinuities in the conducting network were intentionally introduced. Conclusions concerning the mechanism of charge-carrier transport in the investigated materials are discussed. (Author abstract) 18 refs.

Ulanski, J. (Technical Univ of Lodz, Lodz, Pol); Kryszewski, M.; Tracz, A.; Kremer, F. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 89-94.

**Drawing and Stamping** See Also POLYETHERS—Deformation.

**082301 PRODUCTION OF ORIENTED POLYMER TUBE BY THE DIE-DRAWING PROCESS.** Three modes of drawing are described. Tubes can be drawn axially with a simultaneous large reduction of diameter, which is useful for making clad and filled products with high axial stiffness. Tubes can be drawn axially with little change of bore and this gives uniform products with increased axial stiffness and improved barrier properties. A novel way of pressure-testing such tubes is described. Tubes can also be produced with a combination of axial draw and hoopwise expansion. These products have a biaxially oriented structure, and consequently show improvements in hoop ductility. (Edited author abstract) 8 refs.

Selwood, A. (Univ of Leeds, Leeds, Engl); Ward, I.M.; Parsons, B. *Plast Rubber Process Appl* v 8 n 1 1987 p 49-58.

**082302 UNIAXIAL DRAW OF POLY(ARYL-ETHER-ETHER-KETONE) BY SOLID STATE EXTRUSION.** Poly(aryl-ether-ether-ketone) (PEEK) films and rods have been solid-state extruded at 154 and 310°C, respectively. The crystal orientation functions, melting behavior, density, and tensile properties of the drawn PEEK films (EDR  $\leq 3.7$ ) and rods (EDR  $\leq 505$ ) have been measured. As extrusion draw ratio (EDR) was increased, the c-axis orientation function, melting temperature, and tensile modulus and strength increased. Moduli up to 6.5 GPa and the strengths up to 600 MPa, 3 and 6 times the values of undrawn films, respectively, were obtained for the drawn films. (Edited author abstract) 30 refs.

Lee, Youngchul (Univ of Massachusetts, Amherst, MA, USA); Lefebvre, Jean-Marc; Porter, Roger S. *J Polym Sci Part B* v 26 n 4 Apr 1988 p 795-805.

**Drying** See Also ADHESIVES—Peeling.

**082303 TROCKNEN VON KUNSTSTOFF-GRANULATEN MIT ENTFEUCHTETER LUFT.** [Drying of Polymer Granules with Dehumidified Air]. To avoid a reduction of quality during processing, thermoplastics should be dried beforehand. Drying with atmospheric air often does not achieve the desired result, and so dehumidified air has to be used. The principles of the dehumidification of air by adsorption, absorption, and chemisorption are explained, and a typical example of an adsorption dryer and one of an absorption dryer are described. (Author abstract) 8 refs. In German.

Owerfeldt, Guenter (Simar Foerdertechnik GmbH, Markgroeningen, West Ger); Kurz, Manfred. *Kunstst Ger Plast* v 78 n 4 Apr 1988 p 318-322.

**Dyeing** See DYES AND DYEING—Mathematical Models.

**Education**

**082304 POLYMERS - AN EXPANDED SCIENCE?** Just over 14 years ago the Macro Group UK surveyed for the first time the teaching of macromolecular science in the chemistry departments of universities, polytechnics and colleges of higher education in the UK and found disquieting features. A second survey has recently been done which reveals that there has been a significant expansion in macromolecular science teaching in the polytechnics and colleges of higher education but much less of a change in the universities. Particularly worrying is a marked reduction in the number of macromolecular science 'specialists' in university chemistry departments, which is likely to inhibit growth in this important area of applied chemistry even further. (Author abstract) 3 refs.

Ebdon, J.R. (Univ of Lancaster, Lancaster, Engl). *Chem Br* v 24 n 3 Mar 1988 p 245-247.

**Elasticity**

**082305 ULTRASONIC MEASUREMENTS OF THE ELASTIC MODULI OF ULTRADRAWN POLYOXYMETHYLENE.** We have employed an ultrasonic method to measure from  $-40$  to  $60^\circ\text{C}$  the five independent elastic moduli  $C_{11}$ ,  $C_{13}$ ,  $C_{33}$ ,  $C_{44}$ , and  $C_{66}$  of polyoxymethylene with draw ratio  $\lambda$  from 1 to 26 prepared by continuous drawing under microwave heating. The elastic moduli are controlled by three major factors: molecular orientation in the crystalline regions, fraction of noncrystalline taut tie molecules, and void content. The steep rise in the axial extension modulus  $C_{33}$  and axial Young's modulus  $E_0$  with increasing draw ratio results from the alignment of chains in the crystalline blocks and an increase in the number of disordered taut tie molecules. Below the  $\gamma$  relaxation, these two factors also give rise to a slight decrease in the transverse extensional modulus  $C_{11}$ , Young's modulus  $E_{90}$ , and shear modulus  $C_{66}$ . (Edited author abstract) 19 refs.

Leung, W.P. (Chinese Univ of Hong Kong, Hong Kong); Choy, C.L.; Nakagawa, K.; Konaka, T. *J Polym Sci Part B* v 25 n 10 Oct 1987 p 2059-2072.

**082306 COLLISION OF POLYMER PARTICLE WITH RIGID BARRIER.** Impact of polymer particles against a rigid barrier is encountered in many technological processes: in the application of polymer coatings by spraying, in the production of composite materials, in dispersion, etc. The article establishes a correlation of the relaxation spectrum with the dissipation of kinetic energy of a polymer particle upon impact. This article examines impact without adhesion, and in which case the particle rebounds from the barrier. The decrease of its kinetic energy is determined by body viscous losses in the polymer. (Edited author abstract) 11 refs.

Khusid, B.M. (Belorussian Polytechnic Inst, Minsk, USSR). *J Eng Phys* v 51 n 6 Dec 1986 p 1387-1393.

**082307 TEMPERATURE-TIME DEPENDENCE OF THE ELASTIC MODULUS FOR ORIENTED POLYMERS.** An experimental study was made of the

temperature time dependence of the elastic modulus  $E$  for 30 oriented polymers differing in chemical structure. The formula derived to describe the temperature-time dependence of the elastic modulus is given. It appears from the experimental results that a common basis underlies the nature of processes of relaxation of the elastic modulus on the one hand and fracture of a loaded polymer body on the other hand. It should be noted that the magnitude of the mechanical stress developing in a body in the process of determination of  $E$  Elastic Modulus particularly when acoustic and dynamic methods are used is small, like the duration of their influence. This means that there is insufficient time for fracture processes to develop to the point where they would need to be taken into account in an analysis of the results obtained. (Edited author abstract) 16 refs.

Bronnikov, S.V. (USSR Acad of Sciences, USSR); Vettegren, V.I.; Korzhavin, L.N.; Frenkel, S.Ya. *Polym Sci USSR* v 28 n 9 1986 p 2183-2192.

**082308 ELASTIC CONSTANTS OF SPHERULITIC POLYMERS.** The elastic behavior of a polymer with spherulitic microstructure is considered. Using a self-consistent formulation the spherulite and macroscopic elastic properties are related. Expressions for the bulk and shear moduli are obtained for freely-slipping and welded interfaces. The asymptotic behavior when there is a large degree of spherulite anisotropy is given. A comparison is made between the self-consistent, Voigt and Reuss estimates. (Author abstract) 19 refs.

Dryden, John R. (Univ of Western Ontario, London, Ont, Can). *J Mech Phys Solids* v 36 n 4 1988 p 477-498.

**Elastoplasticity** See PLASTICS FILMS—Mathematical Models.

**Electric Conductivity** See Also ELECTROLYTES. SOLID—Materials; FIBERS, NONTEXTILE—Spinning; GRINDING WHEELS—Wear Resisting; ORGANIC COMPOUNDS—Electric Properties; PLASTICS FILMS—Ion Implantation; PLASTICS FILMS—Measurements; POLYACETYLENES—Doping; POLYCARBONATES—Film; POLYIMIDES—Radiation Effects.

**082309 FREQUENCY DEPENDENT CONDUCTIVITY IN LIGHTLY DOPED POLYPYRROLE.** Frequency ( $f$ ) and temperature ( $T$ ) dependence of electrical conductivity  $\sigma(f, T)$  in lightly doped polypyrrole is presented. The behavior of  $\sigma(f, T)$  is different from those of disordered semiconductors and insulating polymers, with considerably strong temperature and frequency dependence of  $\sigma_{ac}$ .  $\sigma_{ac}$  changes with  $\alpha f^{0.7}$ . These results can be described by slightly modified Kivelson's model, that is, the interpolaron hopping process between the polaron and bipolaron states. (Author abstract) 12 refs.

Hirai, Yoshinori (Univ of Tokyo, Tokyo, Jpn); Tanaka, Hajime; Nishi, Toshio. *Jpn J Appl Phys Part 2* v 26 n 8 Aug 1987 p 1401-1403.

**082310 SELF-DOPED WATER-SOLUBLE CONDUCTING POLYMERS.**  $\alpha$ -Terthienyl and pyrrole, substituted with alkylsulfonate side chains, can be polymerized electrochemically without the addition of a conduction salt. This gives rise to self-doped conducting polymers that are soluble in water in the doped state. These polymers are obtained by electrochemical polymerization of alkylsulfonate substituted  $\alpha$ -terthienyl and pyrrole, respectively, from solutions without any additional conduction salt. The aqueous solution of the substituted pyrrole is stable in the self-doped state. (Edited author abstract) 9 refs.

Havinga, Edsko E. (Philips Research Lab, Eindhoven, Neth); van Horssen, Leen W.; ten Hoeve, Wolter; Meijer, E.W.; Wynberg, Hans. *Polym Bull (Berlin)* v 18 n 3 Sep 1987 p 277-281.

**082311 SINGLE-TRAP-CONTROLLED TRANSIENT HOPPING PROCESS IN MOLECULARLY DOPED POLYMERS.** Time-of-flight measurements on molecularly doped polymers have revealed that the tran-



sient current shapes change from being virtually non-dispersive to highly dispersive (featureless) and back to non-dispersive as the shallow trap concentration is increased from 0 to approximately 1 mol%. The shallow traps were introduced into the molecularly doped system by mixing the charge-transporting molecule with small amounts of another transporting molecule having a significantly lower ionization potential. The results support the model of F. Schmidlin for single-trap-controlled transport. Based on this model, the attempt-to-escape frequency and the activation energy for escape from the trap are found to be approximately  $4 \times 10^{12} \text{ s}^{-1}$  and 0.56 eV, respectively. (Author abstract) 11 refs.

Yuh, H.J. (Xerox Webster Research Cent, Webster, NY, USA); Abramsohn, D.; Stolka, M. *Phil Mag Lett* v 55 n 6 Jun 1987 p 271-282.

**082312 PROPERTIES OF  $\text{SbCl}_5$ -DOPED PPP/PPS COMPOSITES I. ELECTRICAL CONDUCTIVITY STUDY.** In this set of two papers the electrical and surface mechanical properties for sintered polyparaphenylene/polyparaphenylene-sulfide (PPP/PPS) composites, in a wide range of compositions, are reported. The present paper deals with a conductivity study of these materials. PPP, before and after annealing at  $400^\circ\text{C}$ , was used as a potential conductive component. It is shown that these  $\text{SbCl}_5$ -doped sintered composites undergo a discontinuous transition from non-conductor to conductor at 20% PPP. The surface of the sintered materials and the dopant distribution across the thickness were characterized by scanning electron microscopy and energy dispersive X-ray analysis respectively. Morphological aspects are discussed in the light of conductivity measurements. In addition, the electrical stability after storage of the composites in air and in dry nitrogen atmosphere is examined. Finally, the influence of the annealing behavior of the PPP component upon the limiting conductivity level is highlighted. (Author abstract) 21 refs.

Rueda, D.R. (CSIC, Madrid, Spain); Cagiao, M.E.; Balta Calleja, F.J.; Palacios, J.M. *Synth Met* v 22 n 1 Nov 1987 p 53-61.

**082313 CHEMICAL OXIDATIVE POLYMERIZATION OF SOME BENZODIPYRROLES TO ELECTROCONDUCTIVE MATERIALS.** Conductive polymers obtained from pyrrole and thiophene derivatives have received special attention because of their electrical properties and environmental stability. The authors report on the oxidative polymerization of benzodipyrroles in MeOH at room temperature, with anhydrous  $\text{FeCl}_3$  (three moles per mole of substrate); in each case black, insoluble and infusible powders precipitate from the reaction medium. Composition and conductivity data of the obtained polymers are reported. Although no structural data are available to identify the positions at which the polymerization occurs, the fact that the benzodipyrroles undergo electrophilic substitution at the  $\beta$ -positions of the pyrrole rings, suggests that these same sites might well also be involved in the oxidative coupling. 8 refs.

Berlin, A. (CNR, Milan, Italy); Ferraccioli, R.; Pagani, G.A.; Sanniccolo, F. *Synth Met* v 22 n 1 Nov 1987 p 89-91.

**082314 INFLUENCE OF IONIC DOPANTS ON THE CONDUCTIVITY OF ELECTROCHEMICALLY SYNTHESIZED POLYPYRROLE.** Comparison of elemental analytical, XPS and SIMS data allows a semi-quantitative assessment of the dopant and oxidation states of polypyrrole synthesized using a variety of potentials and electrolyte concentrations. Studies of polypyrrole grown in aqueous solution indicate, contrary to previous reports, that a maximum in the conductivity is observed for films grown close to the oxidation-reduction potential and in agreement with out previous observations on organically grown polypyrrole. Treatment of electrochemically synthesized polypyrrole with sodium hydroxide leads to a reduction in the electrical conductivity by three orders of magnitude and similarly the addition of hydrochloric acid causes an increase in the electrical conductivity by several orders of magnitude. (Edited author abstract) 11 refs.

McLeod, Gordon G. (Univ of Strathclyde, Glasgow, Scotland); Jeffreys, Kathleen; MacAllister, John M.R.; Muddell, John; Affrossman, Stanley; Pethrick, Richard A. *J Phys Chem Solids* v 48 n 10 1987 p 921-926.

**082315 ELECTROCHEMICAL PROPERTIES OF CONDUCTING POLYMERS.** Prior to describing the electrochemical behavior of the various conducting polymers, the author summarizes current theories on their electronic properties. The various oxidation and reduction processes of selected polymers are also presented. In addition, the author discusses optical properties of doped polymers, the diffusion of dopant in polymer films, the electrochemical doping process in polymers, the kinetics of the electrochemical doping processes of polypyrrole, polythiophene and their derivatives, the electrochemical stability of polymer electrodes, and the application of polymers to organic electrolytes batteries. 118 refs.

Scrosati, Bruno (Univ of Rome La Sapienza, Rome, Italy). *Prog Solid State Chem* v 18 n 1 1988 p 1-77.

**082316 CONDUCTIVITY MEASUREMENTS OF ELECTRODEPOSITED POLYPYRROLE.** Thick, freestanding, flexible films of polypyrrole have been prepared from propylene carbonate solutions of pyrrole monomer containing tetra-ethyl ammonium p-toluene sulphonate electrolyte. The conductivity of the films was found to vary with orientation of the sample, deposition temperature and time. Conductivities of up to  $338.4 \text{ S cm}^{-1}$  were attained with samples prepared at  $0^\circ\text{C}$ . XRD analyses have revealed a difference in structure with sample orientation which affects the conductivity of the material significantly. (Author abstract) 25 refs.

Cvetko, B.F. (Univ of New South Wales, Kensington, Aust); Brungs, M.P.; Burford, R.P.; Skyllas-Kazacos, M. *J Appl Electrochem* v 17 n 6 Nov 1987 p 1198-1202.

**082317 SELECTIVE 1,2-POLYMERIZATION OF TRIETHYLSILYLBUTADIENE AND ITS ELECTRICAL CONDUCTIVITY.** Triethylbutadienyldisilane was polymerized selectively at the 1, 2-position by a Ziegler-Natta catalyst. The polymer obtained was soluble in non-polar organic solvents, and the average molecular weight of 4600 was found by vapor pressure osmometry. It showed an electrical conductivity of  $32.2 \times 10^{11} \text{ S cm}^{-1}$  and  $6.0 \times 10^{11} \text{ S cm}^{-1}$  without and with  $\text{I}_2$  doping, respectively. Bulky silyl groups on the polymer were eliminated by tetrabutylammonium fluoride treatment to give poly(ethynyl acetylene). The conductivity of poly(ethynyl acetylene) was  $6.4 \times 10^{-8} \text{ S cm}^{-1}$  without doping. It was considerably improved by heat-treatment at temperatures higher than  $600^\circ\text{C}$ . Heat-treatment at  $800^\circ\text{C}$  for 2 h attained to provide  $7.8 \times 10^{-1}$  without doping. A partial acene structure was suggested in the heat-treated poly(ethynyl acetylene). (Author abstract) 9 refs.

Kobayashi, Norihisa (Waseda Univ, Tokyo, Jpn); Nakada, Mikitoshi; Ohno, Hiroyuki; Tsuchida, Eishun; Matsuda, Hiro; Nakanishi, Hachiro; Kato, Masao. *New Polym Mater* v 1 n 1 1987-88 p 3-11.

**082318 PRESSURE DEPENDENCE OF ELECTRICAL CONDUCTIVITY IN POLYPYRROLE.** The electrical conductivity as a function of pressure to about 1.1 GPa is determined for p-toluenesulfonate-doped polypyrrole at two different doping levels and also for tetrafluoroborate-doped polypyrrole. A second-order polynomial is found to fit the observed data better than either of the existing models. The polynomial is of the form  $\sigma(P) = aP^2 + bP + \sigma(0)$ . (Author abstract) 8 refs.

Maddison, D.S. (Macquarie Univ, North Ryde, Aust); Unsworth, J.; Lusk, J. *Synth Met* v 22 n 3 Jan 1988 p 257-264.

**082319 XPS STUDIES OF CHEMICALLY SYNTHESIZED POLYPYRROLE-HALOGEN CHARGE TRANSFER COMPLEXES.** Simultaneous polymerization and doping of pyrrole have been carried out in the presence of a halogen electron acceptor, iodine ( $\text{I}_2$ ) or bromine ( $\text{Br}_2$ ), in aqueous dispersion or in acetonitrile at

0 to  $4^\circ\text{C}$  to give PPY- $\text{I}_2$  and PPY- $\text{Br}_2$  charge transfer complexes. X-ray photoelectron spectroscopy (XPS) has been used to evaluate the degree of oxidation of the polypyrrole nitrogen atoms. The XPS results show that in both cases, not all the halogen dopants are available for oxidation. In the case of PPY- $\text{I}_2$ , as much as 34% of the total iodine present has undergone ring substitution in the polymer chain. (Edited author abstract) 20 refs.

Chan, H.S.O. (Nat'l Univ of Singapore, Kent Ridge, Singapore); Munro, H.S.; Davies, C.; Kang, E.T. *Synth Met* v 22 n 4 Feb 1988 p 365-370.

**082320 INTRINSIC CONDUCTIVITY OF CONDUCTING POLYMERS.** Because the charged dopant ions are spatially separated from the quasi-one-dimensional conduction path in conducting polymers, resistive back scattering is suppressed. In the case of high molecular weight and relatively few  $\text{sp}^3$  defects, even relatively weak interchain coupling is sufficient to avoid one-dimensional localization; this leads to coherent transport with a mean free path that is limited by either the mean separation between chain imperfections or by phonon scattering. The authors emphasize that although their results were presented in the context of polyacetylene, the conclusions are general and should be applicable to the entire class of conducting polymers. (Edited author abstract) 20 refs.

Kivelson, S. (Univ of California at Santa Barbara, Santa Barbara, CA, USA); Heeger, A.J. *Synth Met* v 22 n 4 Feb 1988 p 371-384.

**082321 THERMOPOWER AND CONDUCTIVITY OF METALLIC POLYANILINE.** The temperature dependences of conductivity and thermopower of the metallic polyaniline salts are presented, along with the dependence of conductivity on chemical potential and doping level. As the degree of protonation increases, the sign of the thermopower changes from positive to negative. Although the structure of the polyaniline is known to be complex, we propose a model which can interpret the thermopower sign-cross-over behavior is a relatively simple way. (Author abstract) 19 refs.

Park, Y.W. (Seoul Nat'l Univ, Seoul, South Korea); Lee, Y.S.; Park, C.; Shacklette, L.W.; Baughman, R.H. *Solid State Commun* v 63 n 11 Sep 1982 p 1063-1066.

**082322 EFFECT OF THE OXIDATION CONDITIONS ON THE CHEMICAL POLYMERIZATION OF POLYANILINE.** Chemical polymerization of aniline with four oxidizing agents ( $\text{NH}_4)_2\text{S}_2\text{O}_8$ ,  $\text{H}_2\text{O}_2$ ,  $\text{K}_2\text{Cr}_2\text{O}_7$  and  $\text{KIO}_3$  was studied in HCl solutions. It was established that the redox potential of the oxidizing agent is not a dominant parameter. Products of similar quality have been obtained with  $(\text{NH}_4)_2\text{S}_2\text{O}_8$ ,  $\text{K}_2\text{Cr}_2\text{O}_7$  and  $\text{KIO}_3$ . However,  $\text{KIO}_3$  seems the most convenient, because it yields good quality samples in a wide range of polymerization conditions. (Author abstract) 5 refs.

Pron, A. (CEN, Grenoble, Fr); Genoud, F.; Menardo, C.; Nechtschein, M. *Synth Met* v 24 n 3 May 1988 p 193-201.

**082323 OBSERVATION OF ELECTROCHEMICAL POLYMERIZATION PATTERN OF CONDUCTING POLYMER AND ITS INTERPRETATION BY FRACTAL DIMENSION.** Characteristic growth patterns of conducting polymers prepared by the electrochemical polymerization method have been found to be strongly dependent on the polymerization conditions and undergo dramatic change during their growth. In polypyrrole, three types of growth one-, two- and three-dimensional growth, have been observed depending on the condition. These are discussed in terms of fractal dimension. (Author abstract) 14 refs.

Fujii, Masaharu (Osaka Univ, Suita, Jpn); Yoshino, Katsumi. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 457-460.



**082324 ELECTROCHEMICAL BEHAVIORS OF POLYPYRROLE, POLY-3-METHYLTHIOPHENE, AND POLYANILINE DEPOSITED ON NAFION-COATED ELECTRODES.** Anodic polymerization of pyrrole, 3-methylthiophene, and aniline at Nafion-coated electrodes gives conducting polymer-Nafion composite films. The composite films show better reversibility in the film redox process than conducting polymer films alone, owing to different charge compensation mechanisms in the redox reaction; electrolyte cations are involved in the redox process of the composite films, whereas electrolyte anions are in the ordinary conducting polymers. The fast kinetics of the redox process of the composite films are effectively demonstrated by an improvement of the polypyrrole electrochromic response and by the efficient utilization of stored charge by the composite film electrodes. (Author abstract) 22 refs.

Hirai, Takayuki (Osaka Univ, Suita, Jpn); Kuwabata, Susumu; Yoneyama, Hiroshi. *J Electrochem Soc* v 135 n 5 May 1988 p 1132-1137.

**082325 DYNAMIC PERCOLATION IN AN INSULATOR-CONDUCTOR COMPOSITE: POLYETHYLENEOXIDE-POLYPYRROLE, AS STUDIED BY A.C. CONDUCTIVITY MEASUREMENTS.** We report measurements of a.c. conductivity in the insulator-conductor polymeric system polyethylenoxide-polypyrrole for frequencies between d.c. and 9.4 GHz. The a.c. conductivity is shown to follow the general law  $\sigma(\omega) \approx \omega^x$  for frequencies higher than a critical frequency. For every concentration of polypyrrole a frequency region has been found where the predictions for anomalous diffusion in three-dimensional fractal percolating clusters ( $x = 0.6$ ) can be considered as fulfilled. The calculated critical frequencies exhibit a dependence on the concentration of the conducting polypyrrole additive as expected by the theory through the expression for the correlation length of the random resistor network of Miller and Abrahams. This model was previously employed to describe the d.c. behavior of these composite systems. (Author abstract) 17 refs.

Kremer, F. (Max-Planck-Inst fuer Polymerforschung, Mainz, West Ger); Esqueria, T.A.; Mohammadi, M.; Bauhofer, W.; Vilgis, T.A.; Wegner, G. *Solid State Commun* v 66 n 2 Apr 1988 p 153-157.

**082326 CLASS OF CONDUCTING POLYMERS HAVING NONCONJUGATED BACKBONES.** Having a conjugated backbone is usually considered to be a necessary condition for a polymer to be electrically conducting. This paper will demonstrate that, in association with appropriate substituents, a nonconjugated polymer system may also become electrically conducting. The chemical constitution, electrical transport, and optical properties of the conducting complexes of a specific class of such nonconjugated systems are discussed in this paper. The details of the origin of conductivity for such nonconjugated systems are studied for a specific example, 1,4-cis-polyisoprene, which is considered to be a prototype for this class. This is the first time that conducting complexes having isolated double-bond structures are reported. (Author abstract) 15 refs.

Thakur, M. (AT&T, Murray Hill, NJ, USA). *Macromolecules* v 21 n 3 Mar 1988 p 661-664.

**082327 BROMINE TREATMENT OF POLY[ $\alpha$ -(5,5'-BITHIOPHENEDIYL)BENZYLIDENE] (PBTB) AND POLY[ $\alpha$ -(5,5'-BITHIOPHENEDIYL)-p-ACETOXY-BENZYLIDENE] (PBTAB): A COMPLEX REACTION.** In this paper we report that the reaction of both PBTB (2) and PBTAB (3) with bromine vapor depends on the phase (solid-gas versus solution-gas), and the product of either reaction condition is not the simple dehydrogenated product reported before but a brominated material containing covalently bonded as well as ionic halogen. Once the bromination product of 2 is reduced with hydrazine to remove the dopant bromide, it exhibits a bandgap of 1.53 eV (presumably dehydrogenated, partially brominated material) and not 0.83 eV as claimed before. Based on experimental evidence the purported brominative dehydrogenation of methine-

linked polythiophenes does not lead to simple products but is a complicated reaction, leading to products which are probably dehydrogenated but which also contain bromine bonded covalently and ionically. 10 refs.

Patil, A.O. (Univ of California, Santa Barbara, CA, USA); Wudl, F. *Macromolecules* v 21 n 2 Feb 1988 p 540-542.

**082328 BAND STRUCTURES OF POLYFULVENE AND RELATED POLYMERS. A MODEL FOR THE EFFECTS OF BENZANNULATION ON THE BAND STRUCTURES OF POLYTHIOPHENE, POLYPYRROLE, AND POLYFULVENE.** At the level of Hückel theory, polyfulvene (PF) has a valence band/conduction band degeneracy much like that seen in polyacetylene. Higher levels of theory remove the degeneracy, but the band gap ( $E_g$ ) is predicted to be significantly smaller than analogous structures such as polythiophene and polypyrrole at a fulvenoid geometry. An alternative geometry, which we have termed quinoid, is also conceivable for PF, and it is predicted to have a much larger  $E_g$ . The effects of benzannulation to produce analogues of polyisothianaphthene (3) have been evaluated. We propose a new model for such structures based on conventional orbital-mixing arguments. Several of the proposed structures have quite interesting properties, which suggest that they are excellent candidates for conducting polymers. (Author abstract) 20 refs.

Pranata, Julianto (California Inst of Technology, Pasadena, CA, USA); Grubbs, Robert H.; Dougherty, Dennis A. *J Am Chem Soc* v 110 n 11 May 25 1988 p 3430-3435.

**082329 MOBILITY OF CHARGE CARRIERS IN POLYMERS.** The mobility of the charge carriers has been investigated for a number of polymers by the flight-time method at room temperature. It is shown that in PS it is the holes that are mobile and in PETP the electrons. The absolute values of the drift mobility measured in the polymers indicated in the regime of dispersion transport are low even in strong electric fields approximately  $10^2$  V/m and higher. The results are well consistent with the data on the effect of additives on the non-steady radiation electrical conductivity of the polymers studied. (Edited author abstract) 6 refs.

Abramov, V.N. (USSR Acad of Sciences, USSR); Pozhidayev, Ye.D.; Tyutnev, A.P.; Sayenko, V.S.; Vannikov, A.V. *Polym Sci USSR* v 29 n 2 Feb 1987 p 285-290.

**082330 DIRECT CURRENT REDOX VERSUS ELECTRONIC CONDUCTIVITY OF THE LADDER POLYMER POLY(BENZIMIDAZOBENZOPHENANTHROLINE).** Direct current electron conduction in films of electrochemically poly(benzimidazobenzophenanthroline) (BBL) is explored to show that this polymer, depending on the choice of environment, can satisfy experimental current-voltage criteria commonly associated with both redox conductivity and electronic conductivity, showing that such conductivity properties are not necessarily polymer specific. The electron conductivity of BBL is maximized when it is doped in a 1:1 mixed-valent state, at the formal potential for its electrochemical reduction. (Edited author abstract) 25 refs.

Wilbourn, K. (Univ of North Carolina, Chapel Hill, NC, USA); Murray, Royce W. *J Phys Chem* v 92 n 12 Jun 16 1988 p 3642-3648.

**082331 ELECTRICALLY CONDUCTIVE POLYMERS.** The author reviews the general science of conductive organic polymers, addresses some advances in bringing these polymers from intractable powders to useful materials, and describes some potential applications. A discussion is presented of conducting polymer solutions and self-doped conductive polymers. 24 refs.

Reynolds, John R. (Univ of Texas at Arlington, Arlington, TX, USA). *CHEMTECH* v 18 n 7 Jul 1988 p 440-447.

**082332 CONDUCTIVE POLYMERS BASED UPON RIGID-ROD ULTRAHIGH-MODULUS MACROMOLECULES. ELECTROCHEMICAL DOPING OF POLY(P-PHENYLENEBENZOBIS-**

**THIAZOLE-2,6-DIYL) (PBT).** The authors provide the first evidence that PBT can be electrochemically doped and undoped, either as thin coatings or as extruded, highly oriented free-standing films and fibers, to yield an electrically conductive polymer. A  $1.5 \times 0.75 \times 0.002$  cm strip of heat-treated uniaxial PBT film can be reversibly doped within two hours at  $-2.10$  V versus SCE (in TBABF<sub>4</sub>/THF using pressure contacts) to yield a flexible, copper-black, air-sensitive film. As doping proceeds, the black coloration is observed to spread most rapidly in the orientation parallel to the fiber extrusion (chain axis) direction. Similar observations obtain for heat-treated PBT fibers. These results demonstrate that a rigid-rod, ultrahighmodulus macromolecule such as PBT can be electrochemically doped and that the resulting electronic structure can support facile charge transport. Equally noteworthy is the observation that the doping process can be effected for such a polymer in a highly ordered and closely packed crystalline microstructure. 14 refs.

DePra, Patricia A. (Northwestern Univ, Evanston, IL, USA); Gaudiello, John G.; Marks, Tobin J. *Macromolecules* v 21 n 7 Jul 1988 p 2295-2297.

**082333 STRUCTURE OF A NOVEL POLYMERIC METAL: ACCEPTOR-DOPED POLYANILINE.** Key structural features of acceptor-doped polyaniline (polymeraldine salt) are deduced from the crystal structures for the ClO<sub>4</sub><sup>-</sup> and the BF<sub>4</sub><sup>-</sup> dication salts of H-(C<sub>6</sub>H<sub>4</sub>-NH)<sub>4</sub>C<sub>6</sub>H<sub>5</sub>, radical cation salts of shorter oligomers and neutral H<sub>5</sub>C<sub>6</sub>-NC<sub>6</sub>H<sub>4</sub>-N-C<sub>6</sub>H<sub>5</sub>. Contrary to the previous conclusion that the rings in acceptor-doped polyaniline are largely benzoid, strong quinoid distortions are observed for all rings except terminal phenyls. (Edited author abstract) 51 refs.

Baughman, R.H. (Allied-Signal Inc, Morristown, NJ, USA); Wolf, J.F.; Eckhardt, H.; Shacklette, L.W. *Synth Met* v 25 n 2 Aug 1988 p 121-137.

**082334 ELECTRICAL CONDUCTIVITY BEHAVIOR OF POLY(ETHYLENE OXIDE) IN AQUEOUS ELECTROLYTE SOLUTIONS.** The electrical conductivity of poly(ethylene oxide) of different molecular weights in 0.1 M KCl electrolyte solution has been measured in the temperature interval from 0 to 55°C. The data have been interpreted on the basis of the Looyenga equation for heterogeneous systems, found to apply with good approximation also for other transport properties. The hydration number deduced from these measurements has been estimated to be lower than that reported elsewhere. Its dependence on temperature, however, supports the occurrence of a cloud point temperature which agrees with the values observed in similar systems. These findings are consistent with the measured activation enthalpy values, which are very similar to that of the pure solvent, indicating that poly(ethylene oxide)-water interactions give rise to a structure that would form a rather open hydrogen-bonded network. (Author abstract) 22 refs.

Bordi, F. (Univ di Roma La Sapienza, Rome, Italy); Cametti, C.; Di Biasio, A. *J Phys Chem* v 92 n 16 0811 1988 p 4772-4777.

**082335 EFFECT OF PHASE SEPARATION ON DIELECTRIC RELAXATION AND THE ELECTRICAL CONDUCTIVITY OF THE BUTADIENE-STYRENE RUBBER-POLYETHYLENEIMINE SYSTEM.** It is shown that precipitation in the system butadiene-styrene rubber-polyethyleneimine occurring in the region of low concentrations of polyethyleneimine (0.2 wt percent) corresponds to the minima in the concentration functions of the specific volumetric resistance  $\rho$  and the dielectric constant  $\epsilon$ . For 3 wt. percent polyethyleneimine and higher anomalous rise in  $\rho$  is observed as compared with that of the initial rubber accompanied by heavy increase in low frequency dispersion of  $\epsilon$  and the appearance of additional maxima in the thermogram of the currents of thermostimulated depolarization due to the



multiplicity of the relaxational processes in polyethyleneimine and the effects at the phase-matrix boundary. (Author abstract). 3 Refs.

Kolesov, I.S. (Brezhnev Metallurgical Inst, USSR). *Polym Sci USSR* v 29 n 5 1987 p 1059-1063.

**082336 SEEING THROUGH SYNTHETIC METALS.** Cheap, lightweight, durable and easy to make: these are the principal characteristics expected of polymer conductors that endear them to the electronics industry. Practice has not yet matched theory, but developments discussed at a recent meeting suggest that there are grounds for hoping that polymers will replace metals as conductors in the next century. In particular, new, nearly transparent polymers have been synthesized that require less energy to excite electrons into the conducting state. Although these have lower conductivities than other polymers at present, they offer greater promise and are easily processed. The usual polymers for these studies, polyacetylene, polythiophene, polypyrrole and polypara-phenylene, are formed by electrochemical or chemical polymerization of the monomer units. By mechanically aligning the polymer chains of polyacetylene, conductivities as high as  $10^3 \text{ Scm}^{-1}$  have been achieved, comparable to that of copper ( $10^6 \text{ Scm}^{-1}$ ).

Bryce, Martin R. (Univ of Durham, Durham, Engl). *Nature* v 335 n 6185 Sep 1 1988 p 12-13.

**082337 HIGH-PERFORMANCE, ELECTRICALLY CONDUCTIVE POLYMERS.** Three methods have been used to obtain most conductive polymeric materials. With the first method, macroscopic pieces of conducting materials such as metal flakes or carbon black particles are incorporated into polymeric matrices to form conducting composites. The second method involves the addition of either electron donor or acceptor dopants to highly conjugated systems. The third method involves modifying the intrinsic bulk properties of polymers by pyrolysis. The author focuses on pyrolysis as a method for producing conductive materials. He discusses the thermal conversion of a new high-temperature phthalonitrile resin. The synthesis and process ability of electrically conducting compositions are examined along with the conversion of the polymer into a conductive material. 18 refs.

Keller, Teddy M. (US Naval Research Lab, Washington, DC, USA). *CHEMTECH* v 18 n 10 Oct 1988 p 635-639.

**082338 PRESSURE AND TEMPERATURE DEPENDENCE OF ELECTRICAL CONDUCTION IN POLYMERS.** The major purpose of this paper is to show that the pressure and temperature dependence of the dc ionic conductivity in polymers can be described by a free volume dependence. A further purpose is to show that the usual definition of free volume is not adequate to correlate pressure dependence, in contrast to temperature dependence. 16 refs.

Hartmann, Bruce (US Naval Surface Weapons Cent, Silver Spring, MD, USA). *J Rheol* v 30 n 4 Aug 1986, Symp on Appl of Equat of State Rheol at the 57th Annu Meet of the Soc of Rheol, Ann Arbor, MI, USA, Oct 1985 p 843-852.

**082339 NEW CONDUCTING POLYMERS OF SOME BITHIOPHENE- AND BIS-N-METHYLPYRROLE POLYENES, THEIR PROPERTIES AND THEIR APPLICATION IN MICROELECTROCHEMICAL DEVICES.** The authors have investigated the oxidative polymerization of some new bifunctional polyene heterocycles, which have an extended conjugated  $\pi$ -framework in comparison to the chosen parent compounds 2,2'-bithiophene and N-methylpyrrole. The experimental data led to the following conclusions: (1) certain compounds have more negative oxidation potentials and form (visibly) more stable radical cations due their extended  $\pi$ -system; (2) 3,3'-connectivity leads to insulating higher molecular weight products although the  $\pi$ -framework is completely conjugated. 6 refs.

Baeuerle, Peter (Univ Stuttgart, Stuttgart, West Ger); Wrighton, Mark S.; Chyan, Oliver M.R.; Spangler, Charles W. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987,

Discuss Meet: Phys and Chem, of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 889.

**082340 PROCEEDINGS OF THE SECOND FRENCH-POLISH COLLOQUIUM ON LOW DIMENSIONAL ORGANIC CONDUCTORS AND ELECTROACTIVE POLYMERS.** This issue of the journal contains 21 papers arranged in 3 sections presented at a conference. Topics presented include: conducting polymers, polyacetylene; conducting polymers, other polymers and conducting organic crystals. The progress in the study of low dimensional organic conductors and electroactive polymers in France and Poland is reported. All papers are abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11401 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Billard, Denis (Ed.) (Univ de Nancy, Nancy, Fr); Lefrant, Serge (Ed.); Bernier, Patrick (Ed.). *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 166p.

**082341 ION RANGES IN PPP AND CONDUCTIVITY EFFECTS.** In this paper, the authors present a theoretical and experimental study of ion ranges in a PPP (polyparaphenylene) target and the effect on the conductivity of the material, which is an intrinsic insulator. (Author abstract) 7 refs.

Duroux, J.L. (LEPOFI, Limoges, Fr); Hejduk, A.; Moliton, A.; Froyer, G.; Ganeau, M. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 53-60.

**082342 OPTICAL INVESTIGATIONS OF CONJUGATED POLYMERS.** Conjugated polymers, with delocalized  $\pi$ -electron systems along the polymer chain, show high electronic mobilities along the chains and can behave as semiconductor or, when appropriately doped, as metals. As such, they form an important class of materials for the study of electronic engineering at a molecular level. There are some important differences between these polymeric materials and conventional, inorganic semiconductors which are discussed here. Firstly, charges added to the polymer chain cause a local reorganization of the  $\pi$ -electron bonding, and are localized to form polaron-like states. Secondly, charge transport is inherently anisotropic, with easy motion along chains and slower motion across chains. Some experimental work that has been carried out on well oriented films of these materials that illustrate these aspects of their behaviour is reported. (Author abstract) 51 refs.

Friend, R.H. (Cavendish Lab, Cambridge, Engl). *J Mol Electron* v 4 n 1 Jan-Mar 1988, Symp on Mol Electron and Biocomput, Budapest, Hung, Aug 24-27 1987 p 37-46.

**082343 D.s.c., ELECTRICAL CONDUCTIVITY, AND n.m.r. STUDIES OF SALT PRECIPITATION EFFECTS IN PPO COMPLEXES.** Differential scanning calorimetry (d.s.c.) and electrical conductivity measurements of poly(propylene oxide), PPO, complexed with the salts NaI and KSCN are reported. In addition,  $^{23}\text{Na}$  n.m.r. measurements on PPO-NaI ( $x = 8$ ), both at ambient and elevated pressure (2kbar), have been performed. The d.s.c. data clearly indicate that the salt precipitates out of the complexes at about  $85^\circ\text{C}$  for NaI and  $60^\circ\text{C}$  for KSCN. These effects are manifested by a dramatic departure of the conductivity from Vogel-Tammann-Fulcher (VTF) behaviour, and a relatively sharp drop in mobile  $\text{Na}^+$  concentration, as deduced from n.m.r. measurements, above about  $80^\circ\text{C}$ . (Edited author abstract) 5 refs.

Wintersgill, Mary C. (US Naval Acad, Annapolis, MD, USA); Fontanella, John J.; Greenbaum, Steven G.; Adamic, Kresimir J. *Br Polym J* v 20 n 3 1988, First Int Symp on Polym Electrolytes, St. Andrews, Scotl, Jun 17-19 1987 p 195-198.

## Electric Field Effects

**082344 ELECTROOPTICAL EFFECTS IN COMB-LIKE LIQUID CRYSTALLINE POLYMERS.** The mechanism of the action of an ac field on comb-like LC polymers of the cholesteric type is discussed. The combination of cholesterol- and cyanobiphenyl-containing units in the copolymers provides for helical twisting of supermolecular structure, and enables structural rearrangement to occur in the copolymers in the presence of an ac field. The effect of field untwisting of the cholesteric helix has been discovered. The phase transition induced by the field is interpreted as a transition from cholesteric to nematic type ordering. The polymer structure of the liquid crystals (LCs) makes its own contribution, determining both the type of structural transitions and their kinetics. (Author abstract). 8 Refs.

Korobeinikova, I.A. (Lomonosov State Univ, Moscow, USSR); Tal'Roze, R.V.; Shibayev, V.P.; Plate, N.A. *Polym Sci USSR* v 29 n 5 1987 p 1151-1158.

**Electric Properties** See Also ALUMINUM COMPOUNDS; ELECTROLYTES—Materials; METALS AND ALLOYS—Coatings; PIEZOELECTRIC MATERIALS.

**082345 RELAXATION PHENOMENA AND ELECTRICAL FLUCTUATIONS IN NONCRYSTALLINE POLYMERS.** A study has been made of electrical fluctuations in PVC, PS and PMMA in the temperature region relating to  $\alpha$  and  $\beta$  relaxation processes. Activation energies of the corresponding relaxation transitions and the intervals in keeping with their appearance have been determined. The state of structural disorder of the studied polymers leads to the manifestation of excessive electrical fluctuations during release of molecular mobility of the various kinetic units. (Author abstract) 16 refs.

Zelenev, Yu.V. (Dzerzhinskii Inst of Military Aviation Engineering, Tambov, USSR); Ivanovskii, V.A.; Minkin, Ye.V. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1712-1719.

**082346 EVALUATION AND CHARACTERISATION OF CHEMICALLY MODIFIED POLYMERS AS SECONDARY ELECTRON EMITTERS.** Measurements of secondary electron emission coefficient and surface work function  $\phi$  are reported for polyacrylonitrile (PAN) and polytetrafluoroethylene (PTFE) in the virgin and chemically modified forms. A single pulse method was used for SEE measurements and a retarding field method for estimating the work function. Doping of PTFE with alkali metals (Na and Li) and pyrolysis of PAN at  $300^\circ\text{C}$  led to an increase in the surface conductivity. The processing of the surface effectively increased the SEE yield in these polymers. Electrical conductivity and XPS results were used to explain the chemical structures of modified polymers. (Author abstract) 27 refs.

Dake, Sujata B. (Univ of Poona, Poona, India); Rajopadhye, Nagesh R.; Bhoraskar, S.V. *J Phys D* v 20 n 12 Dec 14 1987 p 1631-1636.

**082347 ELECTROACTIVE CHARGE TRANSFER POLYMERS FROM ANODIC COUPLING OF DIBENZO-CROWN ETHERS: PART III, INTRINSIC REDOX PROPERTIES AND PRELIMINARY USE AS ELECTRODE MODIFIERS.** The intrinsic electrochemical properties of the poly(dibenzo-crown ethers) have been investigated. Thus, five different redox states have been pointed out and a detailed analysis of the doping and dedoping processes has been performed. Furthermore, a short account of these polymers as electrode modifiers is presented. (Author abstract) 16 refs.

Le Berre, V. (Univ de Rennes I, Rennes, Fr); Angely, L.; Simonet-Gueguen, N.; Simonet, J. *J Electroanal Chem Interfacial Electrochem* v 240 n 1-2 Jan 25 1988 p 117-132.

**082348 PYROELECTRIC AND PIEZOELECTRIC PROPERTIES OF POLYMER COMPOSITES.** Composites of a polymer (PE, PVDF) and the powder of the ferroelectric ceramic ZLT-19 have been



obtained by hot pressing. The pyroelectrical and piezoelectrical coefficients of the composites depending on the volumetric content of the ferroelectric ceramic within the limits 20-60% and the conditions of polarization have been investigated. These properties of the composites are influenced not only by the heterocharges of the residual polarization of the ferroelectric ceramic but also the homocharges localized at the separation boundary of the two phases. (Edited author abstract) 8 refs.

Shakhtakhtinskii, M.G. (AzSSR Acad of Sciences, USSR); Petrov, V.M.; Guseinov, B.A.; Kurbanov, M.A.; Gazaryan, Yu.N.; Lebedin, A.A.; Guliyev, A.O. *Polym Sci USSR* v 29 n 2 Feb 1987 p 264-269.

**082349 INTERCHAIN COUPLING IN CONDUCTING POLYMERS: ANISOTROPIC FIELD THEORY.** The effect of interchain coupling of parallel chains of conducting polymers is investigated with the help of a continuum model. Ground state properties and the kink wall excitation are discussed. It is found that the one-dimensional gap is decreased through a renormalization of the electron-phonon coupling constant and that the mid-gap state for a single kink is broadened to a band. (Author abstract) 11 Refs.

Fesser, K. (Univ Bayreuth, Bayreuth, West Ger). *Synth Met* v 25 n 1 Jul 1988 p 1-9.

**082350 EFFECT OF THERMAL HISTORY ON ELECTRICAL FLUCTUATIONS IN POLYMERS.** Thermal treatment of polymers changes the intensity of electrical fluctuations. The position of the maximum in fluctuation voltage in the region of the  $\alpha$ -relaxation process shifts to higher temperatures in annealed but to lower temperatures in quenched samples of poly(methyl methacrylate). Annealing of PMMA not only shifts the  $\beta$ -relaxation to higher temperatures, but also changes the character of the process, and these phenomena are clearly reflected in the intensity of electrical fluctuations. (Author abstract) 9 Refs.

Zelenev, Yu. V. (F.E. Dzerzhinskii Military Acad of Aviation Engineering, Tambov, USSR); Ivanovskii, V.A. *Polym Sci USSR* v 29 n 4 1987 p 893-898.

**082351 FREE TRANSITION PHENOMENA AND ELECTRICAL BIREFRINGENCE IN THE ISOTROPIC PHASE OF LIQUID CRYSTALLINE POLYMERS HAVING MESOGENIC GROUPS IN THE SIDE CHAIN.** The electrical birefringence (Kerr effect) in the isotropic phase of thermotropic liquid crystalline comb-like polyacrylic polymer having cyanobiphenyl groups in the side chains is studied. The presence of pretransition effects over several degrees before the temperature of transition into the nematic state in both its equilibrium electrooptical properties and in relaxation phenomena is established. On the basis of a comparison of the electrooptical properties of the polymer and its low molecular weight analogues, conclusions are arrived at on the mechanisms of motion of the polymer chain responsible for the electrical birefringence. Two mechanisms of the Kerr effect dispersion of various types and having different relaxation times and different relaxations with the temperature are observed. (Author abstract) 15 Refs.

Ryuntsev, Ye. I. (A.A. Zhdanov State Univ, Leningrad, USSR); Agafonov, M.A.; Tsvetkov, V.N. *Polym Sci USSR* v 29 n 5 1987 p 1211-1217.

**082352 DISCUSSION MEETING: PHYSICS AND CHEMISTRY OF UNCONVENTIONAL ORGANIC MATERIALS.** This conference proceedings contains 26 papers. Topics covered are: charge carrier generation and transport in polyvinyl carbazole; kinetics of geminate pair recombination in polyvinylcarbazole; configurational dynamics of doped glasses and polymers; impurities in organic glasses; light-induced hole transfer; low-temperature phase of the organic conductor; conducting polymers; new conducting polymers; electrochemically prepared radical salts; microwave conductivity in iodine-doped organic conductor; Knight shift in organic conductor; pyroelectricity of solid aromatic compounds; properties of unsymmetrically substituted diacetylenes; ferroelectric

liquid crystals; phase transitions of aromatic radical cation salts; conducting polymers; polymeric phthalocyanines; and, single crystals from optically active diacetylenes and polydiacetylenes. All papers are indexed and abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10583 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 140p.

**082353 CHARGE CARRIER GENERATION AND TRANSPORT IN POLYVINYL CARBAZOLE: A MODEL SYSTEM FOR POLYMERIC PHOTOCONDUCTORS.** The problem of electron-hole separation in polyvinylcarbazole (PVK) is discussed, based on new 'time of flight' data, covering a time range from 10 nanoseconds to about 10 minutes. The experimental data are analyzed with the aid of the Onsager theory of electron-hole recombination and yield an Onsager radius  $r_0$  of  $18 \pm 2$  Å. Due to the high sensitivity of the method, it is possible to reproduce the low field regime of the Onsager recombination scheme. There are still sizeable deviations between the theoretical and the experimental quantum yields in the midfield regime. These differences do not enter into the determination of the  $r_0$ -value to a great extent because  $r_0$  shows a weak logarithmic dependence on the extrapolated low and high field values of the charge carrier yields. This work is pertinent to xerography and electro-printing. (Edited author abstract) 28 Refs.

Kaul, H. (Univ Bayreuth, Bayreuth, West Ger); Haarer, D. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 845-852.

**082354 KINETICS OF GEMINATE PAIR RECOMBINATION IN POLYVINYL CARBAZOLE.** Recombination of geminate electron hole pairs (GP) in polyvinylcarbazole (PVK) has been investigated by (i) monitoring the decay of delayed luminescence (DL) following pulse excitation with 4.02 eV photons at temperatures between 20 K and 294 K and (ii) Monte Carlo computer simulation. It is found that the decay of the GP reservoir obeys at  $t \rightarrow 0$  law with  $s$  being close to unity and exhibiting small yet systematic variations depending on temperature and time domain. DL extends up to seconds even at 294 K delineating GP lifetimes accordingly long. It is concluded that recombination kinetics is controlled by both the intrinsic energetic disorder of the bulk hopping sites, i.e., the carbazole groups, and by intermediate trapping at presumably incipient carbazole dimers. (Edited author abstract) 31 Refs.

Stolzenburg, F. (Philipps-Univ Marburg, Marburg, West Ger); Ries, B.; Baessler, H. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 853-858.

**082355 ELECTRICAL PROPERTIES OF POLYMERS PREPARED FROM IODO-(4-NITROPHENYL)ACETYLENE.** Iodo-(4-nitrophenyl)acetylene was thermally polymerized at 400°C. Chemical analysis, mass, IR and UV spectroscopy showed that the polymers are built up by polyacene units resulting from crosslinking and intramolecular cyclization of linear oligomers. Iodine is largely lost during polymerization, leading to in situ doping of the polymers. The temperature dependence of the dc conductivity,  $\sigma_{dc}$ , can be represented by  $94 \sigma_{dc} = \sigma_0 \exp[-(T_0/T)^{1/4}]$ . The thermopower shows small positive values, slightly increasing with increasing temperature. The ac conductivity,  $\sigma_{ac}$ , exhibits a strong frequency dependence of the form  $\sigma_{ac} = A\omega^s$  with  $s=0.63$ . The electrical behavior of the polymers is explained in the framework of a variable-range hopping model. (Edited author abstract) 7 Refs.

Rotti, M. (Univ of Antwerp, Antwerp, Belg); Krikor, H.; Nagels, P. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 343-352.

**082356 PAPERS PRESENTED AT THE POLYMER PHYSICS GROUP MEETING ON ELECTROACTIVE POLYMERS.** This issue contains 8 of the papers presented at the conference. Some of the specific topics discussed are: electronic energy levels of polyaniline; diffusion in conducting polymers; photo-excitation in conjugated polymers; and electrochemistry of polypyrrole films.

Anon (Inst of Physics, Polymer Physics Group, London, Engl). *J Phys D* v 20 n 11 Nov 14 1987, Pap Presented at the Polym Phys Group Meet on Electroact Polym, London, Engl, May 14 1987 p 1337-1416.

**082357 HUMIDITY-SENSITIVE AND WATER-RESISTIVE POLYMERIC MATERIALS.** Four types of polymers with pyridinium groups were prepared and their electrical properties as humidity sensors were studied. The polymers are quaternized vinylpyridine and styrene copolymers, partially quaternized polyvinylpyridine, polytetrafluoroethylene grafted with quaternized polyvinylpyridine and polyvinylpyridine crosslinked with dibromobutane. The latter two polymers showed excellent water resistivity as well as a sensitivity to humidity. (Author abstract) 16 Refs.

Sakai, Y. (Ehime Univ, Matsuyama, Jpn); Sadaoka, Y.; Fukumoto, H. *Sens Actuators* v 13 n 3 Mar 1988, Pap Presented at the 2nd Int Meet on Chem Sens, Bordeaux, Fr, Jul 7-10 1986 p 243-250.

**Electrochemistry** See Also ELECTRODES—Materials.

**082358 FORMATION AND ELECTROCHEMISTRY OF POLYFLUORENE IN AMBIENT TEMPERATURE IONIC LIQUIDS.** Polyfluorene films were deposited on platinum, tungsten, and glassy carbon electrodes by the anodic oxidation of the monomer in ambient temperature molten salts consisting of a mixture of aluminum chloride and 1-methyl-3-ethylimidazolium chloride. The polymer films are conductive in the oxidized state and nonconductive when reduced. The collection efficiency measured by rotating ring-disk voltammetry melts suggests that two protons per monomer are released during the polymerization process for both polyfluorene and polypyrrole formation. The polyfluorene films obtained in these molten salts are more stable and their electrochemical behavior less complicated than those prepared in acetonitrile. (Author abstract) 27 Refs.

Janiszewska, L. (State Univ of New York at Buffalo, Buffalo, NY, USA); Osteryoung, R.A. *J Electrochem Soc* v 135 n 1 Jan 1988 p 116-122.

**082359 ELECTROACTIVE POLYANILINE DEPOSIT FROM A NONAQUEOUS SOLUTION.** The authors report on a successful preparation of electroactive polyaniline deposited from non-aqueous propylene carbonate solution containing both organic acid ( $\text{CF}_3\text{COOH}$ ) and electrolyte ( $\text{LiClO}_4$ ), and on its polymerization curves under various conditions. 5 Refs.

Osaka, Tetsuya (Waseda Univ, Tokyo, Jpn); Ogano, Satoshi; Naoi, Katsuhiko. *J Electrochem Soc* v 135 n 2 Feb 1988 p 539-540.

**082360 ELECTROLYTE EFFECTS ON THE SWITCHING REACTION OF POLYANILINE.** This report describes the electrochemical behavior of polyaniline prepared in aqueous solution with various acid electrolytes. Electroactive polyaniline with two different cyclic voltammograms, i.e., with and without the additional peak at 500 mV, can be produced by controlling the current densities during the preparation. The oxidation reaction is coulombically reversible, and the rate depends on the acidity of the solution but is independent of the nature of the counter anion. In solutions more acidic than 0.1M, the charge is linear with time in the initial period. In  $10^{-3}$ M acid solutions, the charge has a  $t^{1/2}$  dependence. The films are also electroactive in nonaqueous solvents,



and voltammograms with well-defined waves result when the solution contains both organic salt and protic acid electrolyte. (Edited author abstract) 35 refs.

LaCroix, Jean-Christophe (IBM, San Jose, CA, USA); Diaz, A.F. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1457-1463.

**082361 ELECTROCHEMICAL STUDY OF POLY(3-METHYLSELENOPHENE).** The authors describe the electrochemical behavior of poly(3-methylselenophene) in acetonitrile. The level of doping  $\delta$  is determined by chronocoulometric measurement. Cyclic voltammetry, chronoamperometry and chronocoulometry are used to study the response time and the stability of the polymer. The results show that poly(3-methylselenophene) is very promising for possible applications. (Author abstract) 5 refs.

Merlet, N. (UFR des Sciences de Rouen, Mont-Saint-Aignan, Fr); Dian G.; Barbey, G.; Outurquin, F.; Paulmier, C. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 77-80.

**Electrodeposition** See Also COATINGS—Electrodeposition.

**082362 LASER INTERFEROMETRY OF THE ELECTRODEPOSITION OF POLYPYRROLE ON A POLYCARBAZOLE ANODE: BILAYER CONDUCTING ELECTRODES.** The electrodeposition of an electronically conducting layer of polypyrrole on a polycarbazole anode was performed galvanostatically in N,N-dimethyl formamide containing tetra-n-butyl ammonium perchlorate as the electrolyte in the medium. The deposition was followed by holographic interferometry and laser interferometry to estimate the diffusion layer. The bilayer polymeric material was examined by scanning electron microscopy and it revealed structural features, i.e., the polycarbazole film appears fibrous in form. The electrodeposition was also conducted by the potential sweep technique in the above medium. (Edited author abstract) 13 refs.

O'Brien, R.N. (Univ of Victoria, Victoria, BC, Can); Santhanam, K.S.V. *Mater Chem Phys* v 18 n 1-2 Oct 1987 p 19-34.

**082363 CATALYTIC ELECTROSYNTHESIS OF CONDUCTING POLYMERS.** A novel catalytic electrodeposition of several kinds of conducting polymers in aqueous solutions is described. The anodic deposition potentials of pyrrole, N-methylpyrrole and aniline were shifted in the negative direction by 140-200 mV in the presence of tiron (4,5-dihydroxy-1,3-benzenedisulfonic acid) as a catalyst in the reaction mixture. The catalytic depositions of polypyrrole and polyaniline, and the compositions of the produced films, were investigated. The conductivity of the catalytically prepared free-standing polypyrrole films was smaller than that of the directly prepared films. This one-step process was used to produce films holding anions (such as carboxylates) which cannot play the role of dopant in the direct oxidation of the monomers, and thus to simplify the preparation of drug-loaded conducting polymers for a drug release device. (Author abstract) 12 refs.

Zinger, Baruch (SOREQ Nuclear Research Cent, Yavne, Isr). *J Electroanal Chem Interfacial Electrochem* v 244 n 1-2 Apr 8 1988 p 115-121.

**Electronic Properties** See Also POLYACETYLENES—Doping.

**082364 ON THE ELECTRONIC PROPERTIES OF POLYISOTHIANAPHTHENE.** Results of the electronic structure and conduction properties of the recently synthesized polyisothianaphthene (PITN), a conjugated organic polymer with the smallest energy gap, obtained with the aid of the ab initio Hartree-Fock crystal orbital method are presented. Comparison of its electronic properties with those of polythiophene (PTP) shows PITN to be a better candidate than PTP for forming conductive materials through doping. The effect of the heterosubstitu-

tion and the substitution at the carbon skeleton on the conduction properties of PITN is discussed. (Edited author abstract) 10 refs.

Bakhshi, A.K. (Friedrich-Alexander-Univ Erlangen-Nuernberg, Erlangen, West Ger); Ladik, J. *Solid State Commun* v 61 n 1 Jan 1987 p 71-73.

**082365 ELECTRONIC STRUCTURE AND PHOTO-INDUCED STRUCTURE CHANGE OF POLYDIACETYLENE CRYSTAL.** A self-consistent calculation of the electronic structure is performed for a model polydiacetylene crystal by using the local density functional method. The wave function and the energy eigenvalues of excitons are calculated and the third order susceptibility is shown to be enhanced by the large oscillator strengths of the excitons. A mechanism of photo-isomerization of polydiacetylene crystals is proposed. (Author abstract) 21 refs.

Tanaka, H. (Univ of Tokyo, Tokyo, Jpn); Inoue, M.; Hanamura, E. *Solid State Commun* v 63 n 2 Jul 1987 p 103-107.

**082366 ELECTRONIC PROPERTIES OF POLY(1-METHYLCYCLOHEXA-1,3-DIENE-2,3-DIYL-5,6-DIYLDIENE-5-METHYLIDYNE-6-NITRIL).** Poly(1-methylcyclohexa-1,3-diene-2,3-diyl-5,6-diylidene-5-methylidene-6-nitril) (PMQ), prepared at four different temperatures from 250 to 385°C, was studied. There is 1 spin per 200 to 400 repeats. The temperature dependence of unpaired spin concentration for PMQ4 condensed at 385°C implies that a phase transition from magnetic disorder to order may occur near 74 K. PMQ3 condensed at 345°C was doped with nitrosyl hexafluorophosphate (NFP) and iodine. Iodine intercalated between the layers but hexafluorophosphate did not. EPR studies suggest that NO<sup>+</sup> oxidized the polymer to produce charged spinless species. (Edited author abstract) 46 refs.

Ruan, J.Z. (Case Western Reserve Univ, Cleveland, OH, USA); Litt, M.H. *Macromolecules* v 21 n 4 Apr 1988 p 882-890.

**082367 AB-INTO≡ SELF-CONSISTENT FIELD THEORY FOR THE TREATMENT OF INTERFACE BETWEEN TWO DIFFERENT QUASI-ONE-DIMENSIONAL CHAINS.** The solution of the problem how to treat an interface between two quasi-one-dimensional polymers has been formulated combining Dyson's equation with the mutually consistent field (self-consistent field solutions for the change of the bulk states of the polymers and for the extraband 'interface' states) method. A numerical procedure for the implementation of an appropriate program (which needs as input only the ab initio self-consistent field crystal orbital solutions of the two infinite periodic polymers as well as some cluster calculations of the interface and its neighbors at both sides) is outlined. The necessary program is under development. (Author abstract). 16 Refs.

Ladik, Janos (Friedrich-Alexander-Univ Erlangen-Nuernberg, Erlangen, Engl). *Prog Surf Sci* v 26 n 1-4 1987 p 135-143.

**082368 MODEL CALCULATION OF POLYMER HETEROSTRUCTURES.** The energy bands and corresponding eigenfunctions of polymer heterostructures are calculated on the basis of a Hückel-like theory. The underlying physical models are coupled conjugated polymer systems consisting (i) of polydiacetylene (PDA)-polyacetylene (PA) units and (ii) of cis-trans PA units. Discrete split-off states within the energy gaps are analyzed with respect to their energies and localization of the corresponding wavefunction. Criteria for one-dimensional molecular quantum well structures and molecular electronic devices are discussed. A model describing the electronic transport is developed. (Author abstract). 15 Refs.

Ruckh, R. (Univ Stuttgart, Stuttgart, West Ger); Heine, B.; Sigmund, E. *Phys Scr* v 38 n 1 Jul 1988 p 122-124.

**082369 ELECTRONIC PROPERTIES AND RE-**

**DOX CONDUCTION OF FERROCENE-SUBSTITUTED HIGH POLYMERIC PHOSPHAZENES.** The authors present the first thermodynamic and kinetic data obtained for the electrochemical oxidation and reduction of ferrocene-substituted polyphosphazenes. 9 Refs.

Saraceno, Reginaldo A. (Pennsylvania State Univ, University Park, PA, USA); Riding, Geoffrey H.; Allcock, Harry R.; Ewing, Andrew G. *J Am Chem Soc* v 110 n 21 Oct 12 1988 p 7254-7255.

**082370 POLYENE CHAINS IN MOLECULAR ELECTRONICS.** The idea of 'soliton switching' in polyene chains is reviewed. Chains with built-in donor and acceptor groups and spacers for modulation are presented and some aspects of future molecular electronic devices are discussed. (Author abstract) 7 refs.

Roth, S. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger). *Synth Met* v 21 n 1 Aug 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part I, Vadstena, Swed, Aug 18-20 1986 p 51-55.

**082371 PRECURSOR-ROUTE POLY(p-PHENYLENEVINYLENE): POLYMER CHARACTERISATION AND CONTROL OF ELECTRONIC PROPERTIES.** In this paper we review the results of extensive studies that have been reported by the author and by other workers on the preparation and properties of the conjugated polymer poly(p-phenylenevinylene) (PPV). The use of the sulphonium polyelectrolyte precursor-route synthesis gives considerable flexibility for materials processing and it is shown that high-quality samples of controlled morphology, crystallinity, orientation and length of uninterrupted conjugated sequences can be obtained through a suitable choice of preparation conditions. Where applicable, the experimental results are compared with those obtained from theoretical calculations and any discrepancies are discussed. (Author abstract) 90 refs.

Bradley, D.D.C. (Cavendish Lab, Cambridge, Engl). *J Phys D* v 20 n 11 Nov 14 1987, Pap Presented at the Polym Phys Group Meet on Electroact Polym, London, Engl, May 14 1987 p 1389-1410.

## Emulsions

**082372 ELECTROPHORETIC, DYNAMIC, AND STATIC LIGHT SCATTERING ON CHARGED POLYMER EMULSIONS.** Light scattering studies on dispersions formed by phase separation of a polymer-solvent-non-solvent mixture show that the dispersions comprise charged droplets of the polymer-rich phase. The charge number is not large, and data on the electrophoretic-scattering and the dynamic scattering in the absence of an external electric field are both consistent with distribution of charge among the droplets. Data on the dependence of the static scattering on concentration and scattering angle show that the droplets are also disperse in radius. The data are discussed in terms of an interaction potential among the charged droplets relating the electrostatic interactions to the charge number and radius of the droplets, and the ionic strength of the solvent. (Author abstract) 22 refs.

Lin, F.-M.C. (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Berry, G.C.; Frye, R.L.; Scala, L.C. *J Appl Polym Sci* v 35 n 5 Apr 1988 p 1377-1397.

**Environmental Impact** See POLYURETHANES—Manufacture.

## Esterification

**082373 TRANSESTERIFICATION REACTIONS IN MOLTEN POLYMERS.** The transesterification reaction of molten ethylene and vinyl alcohol copolymers (EVA), in presence of paraffinic alcohols and basic catalysts, leads to high conversion of the ester groups to secondary alcohol in both discontinuous and continuous processing equipment. Various kinds of alcohols and two different catalysts were used. Sodium methoxide is a powerful catalyst for the equilibrated transesterification



reaction, but the authors also observed side reactions, such as cross-linking with low-molecular-weight alcohols and hydrolysis of the catalyst followed by partial saponification of the EVA. Kinetic studies were performed in the presence of dibutyltin dilaurate, an efficient catalyst without any side reactions. The solubility of the main alcohol reagents was verified by diffusion measurements. The general reaction scheme and the related kinetics, corresponding to a homogeneous system, lead to a fair evaluation of the rate constants. (Edited author abstract) 10 refs.

Lambila, M. (Ecole D'Application des Hauts Polymeres, Strasbourg, Fr); Druz, J.; Bouilloux, A. *Polym Eng Sci* v 27 n 16 Mid-Sep 1987 p 1221-1228.

**Etching** See Also LITHOGRAPHY.

**082374 LASER-PHOTOETCHING CHARACTERISTICS OF POLYMERS WITH DOPANTS.** The photoetching behavior of poly(methylmethacrylate), poly(dimethylglutaramide) and chlorinate poly(methylstyrene) doped with pyrene and 4-aminobenzoylhydrazide excited by 308 nm excimer-laser pulses has been studied. Some common laser-etching characteristics including the reduction of the threshold fluence for ablation, the enhancement of etching efficiency and the existence of optimal conditions regarding the laser fluence and dopant concentration for generating clean and smooth etching patterns are identified. The photoetching mechanism and the potential application of the doping technique to material processing are discussed. (Author abstract) 26 refs.

Chuang, T.J. (IBM, San Jose, CA, USA); Hiraoka, H.; Modl, A. *Appl Phys A* v A45 n 4 Apr 1988 p 277-288.

**082375 DECREASE IN THE ETCH RATE OF POLYMERS IN THE OXYGEN AFTERGLOW WITH INCREASING GAS FLOW RATE.** In this paper we report the variation of the etch rate of polymers in the afterglow of a radio frequency discharge in oxygen as a function of total flow rate in the range 2-10 cm<sup>3</sup> (STP)/min. The measurements were made at ambient temperature with the O(3P) concentration held essentially constant. We report results on three polymers: cis-polybutadiene, a polybutadiene with 33% 1,2 double bonds, and a polybutadiene with 40% 1,2 double bonds. We have observed that the etch rate of these polymers decreases significantly with increasing flow rate, strongly suggesting that the vapor-phase products of polymer degradation contribute to the degradation process. (Author abstract) 11 refs.

Lerner, N.R. (NASA, Moffett Field, CA, USA); Wydeven, T. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1903-1908.

**Evaluation** See OIL WELL PRODUCTION—Enhanced Recovery.

**Extraction** See CHEMICAL OPERATIONS—Extraction.

**Extrusion** See Also GLASS—Polymeric Materials; POLYPROPYLENE—Extrusion.

**082376 INSTRUMENTATION DEVELOPMENT OF SENSING MODES OF BUBBLE MOTION OF A BLOWN-FILM PROCESS.** We have developed instrumentation using an internal-bubble pressure transducer with a data acquisition system to sense LLDPE bubble stability on a commercial blown-film line. Real-time bubble instability was also recorded using a video camera at a speed of 30 frames/s. The pressure signal analyzed using a fast-Fourier-transform (FFT) computer program to determine the frequency of bubble oscillation. Since bubble instability often consists of large-scale oscillation and bubble flutter, and both motions affect gauge and layflat uniformity, the pressure signal was decomposed to determine the frequency of each oscillation mode. To obtain a stable bubble, the amplitudes of both oscillation modes must be reduced to a minimum. Initial results indicated that the trace of the pressure can provide a warning to the stability of a blown-film process. (Edited author abstract) 8 refs.

Huang, T.A. (Mobil Chemical Co.). *Adv Polym Technol* v 8 n 1 1988 p 69-75.

**082377 PRODUCTION OF ULTRAHIGH-MODULUS LIQUID-CRYSTAL POLYMER RODS.** Since thermotropic liquid-crystal polymers (LCPs) consist of rigid backbone molecules, high-modulus/high-strength fibers with a high degree of molecular orientation can be easily fabricated by a melt-spinning process. However, LCP strand properties decrease with an increase in the strand diameter. A less oriented structure is formed in the core of a strand due to molecular relaxation as well as less orientational stresses imposed on the LCP molecules in the core area. In this note we report another approach to producing high-modulus/high-strength LCP rods. Rods were extruded using conical converging die. 9 Refs.

Chung, Tai-Shung (Hoechst Celanese Corp, Summit, NJ, USA). *J Polym Sci Part B* v 26 n 7 Jul 1988 p 1549-1552.

**Failure** See Also CELLULOSE DERIVATIVES—Degradation; COMPOSITE MATERIALS—Radiation Effects.

**082378 FLEXED PLATE IMPACT TESTING OF POLY(ETHER SULPHONE). PART III FLOW GEOMETRY EFFECTS.** Tests on various sample shapes moulded from poly(ether sulphone) show that the response to an excess energy impact may be brittle failure, ductile failure or mixed mode failure, depending on the geometrical features and the associated flow geometries at or near the point of impact. Flow irregularities and local anisotropies caused by the overall flow geometry can be as detrimental to the toughness as conventional stress concentrators are. The results, which are unlikely to be unique to poly(ether sulphone), imply that the procedures currently followed for the evaluation of impact resistance are generally insufficient for their purpose since materials are likely to differ in their susceptibility to embrittlement. (Author abstract). 5 Refs.

Reed, P.E. (Queen Mary Coll, London, Engl); Turner, S. *J Mater Sci* v 23 n 6 Jun 1988 p 1985-1994.

**082379 FAILURE-MECHANISM MAPS FOR ENGINEERING POLYMERS.** This paper reports on progress in assembling experimental data and simplified theoretical models for the deformation and fracture of engineering polymers into diagrams which summarize their inelastic response to stress. A number of regimes are identified: brittle fracture initiated by crazing or shear-banding; plasticity terminated by ductile fracture; cold-drawing; rubbery and viscous flow; a regime in which deformation is purely elastic; and one in which adiabatic heating influences deformation. Data for a number of commercial polymers (polymethylmethacrylate, polystyrene, polycarbonate, polyisobutylene and an epoxy resin) are fitted to simplified constitutive equations for each regime. The equations are then used to construct diagrams, one for tension and one for compression, which relate strength to temperature T and strain rate  $\dot{\epsilon}$ , over a wide range of these variables. (Author abstract). 79 Refs.

Ahmad, Bin Z. (Sime Derby Berhard, Kuala Lumpur, Malays); Ashby, M.F. *J Mater Sci* v 23 n 6 Jun 1988 p 2037-2050.

**Fatigue** See POLYCARBONATES—Fracture; POLYSTYRENES—Crack Propagation; POLYVINYL CHLORIDE—Crack Propagation.

**Fiber Reinforcement** See Also CRYSTALS, LIQUID—Morphology.

**082380 TOUGHNESS OF A COMPOSITE CONTAINING SHORT BRITTLE FIBRES.** A method is presented whereby various potential contributions to the toughness of a polymer containing short brittle fibers can be quantified. It relies on a model for predicting the cumulative probability distribution of fiber pull-out lengths. The method reveals that toughness increases to a maximum value with increasing fiber length. Good agreement between theory and experiment supports the validity of the approach. (Author abstract) 7 refs.

Wells, J.K. (Cambridge Univ, Cambridge, Engl); Beau-

mont, P.W.R. *J Mater Sci* v 23 n 4 Apr 1988 p 1274-1278.

**Filaments**

**082381 MOLECULAR-KINETIC MODEL OF UNIAXIAL TENSION AND COMPRESSION OF HIGHLY ORIENTED POLYMER FIBERS.** A number of special features of the mechanical behavior of high-modulus polymer fibers are associated with a high degree of orientation ordering of the macromolecules comprising these fibers. These special features include, for example, the large increase of the dynamic modulus of elasticity of the fibers during their loading with tensile forces and additional orientation effects in tensile loading. The authors use the simplest model as an example to investigate the conditions of existence of macromolecules of the fiber in the highly oriented state and certain relationships governing tension and compression along its axis. The paper examines a section of an arbitrary polymer chain consisting of N elastic links joined together by hinged consecutive connection; the chain is positioned among similar chains inside the fiber to which the external tensile or compressive force P is applied in the direction of its x axis. 10 refs.

Abramchuk, S.S.; Protasov, V.D. *Mech Compos Mater* v 23 n 1 Jan-Feb 1987 p 1-7.

**Fillers** See Also COMPOSITE MATERIALS—Extrusion; EPOXY RESINS—Crosslinking; GLYCOLS—Viscosity; PLASTICS—Conductive; PLASTICS, REINFORCED—Fibers; PLASTICS, REINFORCED—Mechanical Properties; POLYPROPYLENE—Compounding; POLYVINYL CHLORIDE—Dielectric Properties; RUBBER—Electric Conductivity; RUBBER—Fillers; RUBBER—Strain; SYNTHETIC FIBERS—Morphology; THERMOPLASTICS—Mechanical Properties; TITANIUM COMPOUNDS.

**082382 MODE OF CRACK PROPAGATION IN RUBBER-CRUMB-FILLED POLYMER COMPOSITION.** We have previously reported how rubber crumb modulus and crumb to matrix adhesive affect the performance of rubber-containing soft fillers. The tensile and tear properties of these two-phase elastomer composites were correlated with variations in the tear energy of the matrix and crumb and the adhesive energy. Further, the effect of rubber-crumb loading upon breaking stress and strain of filled polystyrene composites was reported. This work was further extended to an examination of fracture roughness. It is now possible to utilize a simple model to predict the mode of crack propagation for these systems. 13 refs.

Burford, R.P. (Univ of New South Wales, Kensington, Aust); Pittolo, M. *J Mater Sci Lett* v 6 n 8 Aug 1987 p 969-971.

**082383 INFLUENCE OF PARTICULATE FILLERS ON THE INDENTATION HARDNESS OF A GLASSY CROSS-LINKED POLYMER.** The indentation hardness of a glassy cross-linked network was decreased to a minimum value by a low volume fraction (0.03 to 0.05) of each of six fillers having rigid particles varying in size and surface. This 'minimum' effect was eliminated after specimens were more highly cross-linked by prolonged exposure to  $\gamma$ -rays. These results are consistent with an earlier suggestion that filler particles act as stress concentrators which may cause increased localized plastic deformation and hence a decreased indentation hardness. In the case of larger particles, morphological evidence of localized plastic deformation was obtained by fractography. (Author abstract) 19 refs.

Haque, Z.U. (Univ of North Carolina, Chapel Hill, NC, USA); Turner, D.T. *J Mater Sci* v 22 n 9 Sep 1987 p 3379-3384.

**082384 CONFORMATION OF MACROMOLECULES IN FILLED POLYMERS.** A split plane densely packed with macromolecules is considered to be an appropriate model for interlayers in filled polymers. The structure of amorphous chains among the filler particles is assumed to be the same as the conformation of isolated Gaussian chains in critical conditions corresponding to



the beginning of adsorption of chains from the solution. In this case the thickness of the boundary layer is comparable with the dimension of the chain in bulk. The chains in the layer are flattened parallel to the filler surface. The number of contacts between the chains and the filler is proportional to  $M^{1/4}$  and decreases with increasing distance between the chains and the surface, while the end-to-end distance does not change monotonously. (Author abstract) 11 refs.

Skvortsov, A.M. (Chemico-Pharmaceutical Inst, Leningrad, USSR); Gorbunov, A.A. *Polym Sci USSR* v 28 n 9 1986 p 2159-2165.

**082385 SELF-TEMPERATURE-CONTROL HEATERS BY GRAPHITE-POLY(ETHYLENE GLYCOL) MIXED SYSTEMS: MECHANISM OF ELECTRICAL CONDUCTION.** The authors have found that graphite-poly(ethylene glycol) mixed systems constitute self-temperature-control heaters and that the self-controlled constant temperatures depend on the molecular weight of the poly(ethylene glycol). The mechanism of self-temperature-control for these systems cannot be explained in terms of volume expansion of the total system, which has hitherto been suggested for the self-temperature-control mechanism for systems such as carbon-rubber mixtures. It is found that the temperature dependence of the electrical resistance in a graphite-poly(ethylene glycol) system corresponds well to that of the dielectric constant in the corresponding pure poly(ethylene glycol) system. This leads to a model by which the mechanism of electrical conduction and self-temperature-control can be explained. The voltage dependence of the electric currents in graphite-poly(ethylene glycol) systems supports this model. (Edited author abstract) 16 refs.

Kimura, Toyooki (Nagoya Univ, Nagoya, Jpn); Yasuda, Shigeyuki. *Polymer* v 29 n 3 Mar 1988 p 526-534.

**082386 COMPOSITION DEPENDENCE OF TENSILE YIELD STRESS IN FILLED POLYMERS.** Filled polymers are the simplest type of composite polymeric materials, which consist of a matrix polymer as a continuous phase and a generally inorganic filler dispersed in the matrix. Among the mechanical properties yield stress of the composite ( $\sigma_{yc}$ ) has primary importance, giving information on the maximum allowable load without considerable plastic deformation. A simple model for calculating the composition dependence of this tensile yield stress is presented. 6 refs.

Turcsanyi, B. (Hungarian Acad of Sciences, Budapest, Hung); Pukanszky, B.; Tudos, F. *J Mater Sci Lett* v 7 n 2 Feb 1988 p 160-162.

**082387 MOLECULAR MOTIONS IN FILLED POLYDIMETHYLSILOXANES.** Molecular motions in filled polydimethylsiloxanes (PDMS) have been investigated. Frequencies of the most low temperature motions (rotation of  $\text{CH}_3$  groups about the Si-C bond) are scarcely dependent on the filler content. Motions of chain units are severely inhibited in an adsorption layer of thickness approximately 8 Angstrom. Motions of chain fragments adjoining the adsorption layer are also inhibited to some extent. In PDMS with a high loading of filler a fraction of the nonadsorbed units are highly mobile below  $T_g$ , apparently on account of defects in the packing of individual chain fragments. Frequencies of rapid reoriented motions of nonadsorbed units some distance away from filler particles approximate to those of motions in the unfilled PDMS. At the same time slow translational motions of the units are inhibited. (Author abstract) 18 Refs.

Litvinov, V.M. (USSR Acad of Sciences, USSR); Zhdanov, A.A. *Polym Sci USSR* v 29 n 5 1987 p 1133-1140.

**082388 CHARACTERIZATION OF CARBON BLACK FILLED POLYMERS USING SMALL ANGLE X-RAY SCATTERING AND TRANSMISSION ELECTRON MICROSCOPY: A COMPARATIVE STUDY.** This study has shown that small-angle x-ray scattering and transmission electron microscopy produce

similar results for the average agglomerate sizes of carbon black dispersions. These sizes are characteristic of the degree of dispersion present in various materials such as reinforced rubber. In addition to the average sizes, the inner specific surface areas, distribution of particle sizes, and shapes of the agglomerates may be important parameters in determining the ultimate physical properties. The inner specific surface areas and average agglomerate sizes are conveniently determined from SAXS measurements. Detailed information about the agglomerate size distributions and shapes are obtainable from TEM micrographs. 7 Refs.

Deslandes, Yves (Xerox Research Cent of Canada, Mississauga, Ont, Can); Whitmore, Mark D.; Bluhm, Terry L.; Hokansson, Anna. *J Dispersion Sci Technol* v 9 n 3 Jun 1988 p 235-257.

**Film** See Also PLASTICS FILMS—Physical Properties; POLYIMIDES—Thermal Expansion; SOLAR CELLS—Silicon.

**082389 ANISOTROPIES OF OPTICAL ABSORPTION AND PHOTOLUMINESCENCE IN STRETCHED POLYTHIOPHENE FILMS.** By stretching polythiophene films, optical anisotropy around the interband transition is studied. An anisotropy ratio larger than 14 for absorption coefficients parallel and perpendicular to the polymer chain directions is estimated. Photoluminescence is confirmed to originate from a  $\pi^*-\pi$  transition of a free intrachain exciton. (Author abstract) 14 refs.

Kaneto, K. (Osaka Univ, Suita, Jpn); Uesugi, F.; Yoshino, K. *Solid State Commun* v 65 n 8 Feb 1988 p 783-786.

**082390 UNUSUAL STRESS-STRAIN BEHAVIOR IN ULTRA-DRAWN FILMS OF HIGH MOLECULAR WEIGHT POLY(4-METHYL-1-PENTENE).** In this communication, the authors report unusual stress-strain behavior observed in ultradrawn films of UHMW-P4M1P and studied in relation to the specific morphology and the crystal structural or conformational changes that occurred during extension at room temperature. 26 refs.

Kanamoto, Tetsuo (Science Univ of Tokyo, Tokyo, Jpn); Ohtsu, Osamu. *Polym J* v 20 n 2 1988 p 179-183.

**082391 SPECTRAL CHANGE OF POLYMER FILM CONTAINING POLY(3-ALKYLTHIOPHENE) WITH TEMPERATURE AND ITS APPLICATION AS OPTICAL RECORDING MEDIA.** A remarkable absorption spectral change has been observed in polymer films containing poly(3-alkylthiophene) with temperature which is explained in terms of the transition of conformation of poly(3-alkylthiophene) in polymer matrix. By quenching the sample from a high temperature, the high-temperature spectrum has been maintained even at room temperature. The spectral change by laser irradiation and its memory have also been confirmed. The applications of these phenomena as optical recording and memory elements are also proposed. (Author abstract) 7 refs.

Yoshino, Katsumi (Osaka Univ, Suita, Jpn); Nakajima, Shigeaki; Park, Dae Hee; Sugimoto, Ryu-ichi. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 454-456.

**082392 STATIC AND DYNAMIC FORCES ACROSS POLYMER LIQUID FILMS.** The author describes some recent results on two different polymeric liquids obtained using the Israelachvili surface force apparatus. In this apparatus the force between two mica surfaces is measured by the deflection of a spring on which one of the surfaces is mounted. By monitoring the transient response of the surfaces to a known displacement of the reference end of the spring, it is possible to measure the drag force which results from viscous coupling between the surfaces. The equilibrium surface force shows a repulsion extending approximately 15 nm, which is nearly ten times the estimated radius of gyration (1.6 nm). Dynamic force measurements show that the polymer melt has a viscosity equal to its bulk value (54 cP) even in very thin films, but the stick boundary conditions apply at a

distance 2-3 nm from each surface. 7 refs.

Horn, Roger (Australian Natl Univ, Canberra, Aust). *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 211-214.

**Films** See Also AROMATIC POLYMERS—Structure.

**082393 PHOTOACOUSTIC MEASUREMENTS OF THERMAL DIFFUSIVITY OF PYROLYZED POLY( $\alpha$ -CHLOROACRYLONITRILE) FILMS.** The thermal diffusivity of poly( $\alpha$ -chloroacrylonitrile) (PCAN) films heat-treated at temperatures from 140°C to 1300°C was measured by a photoacoustic method. Measurements were also made of infrared spectrum and electrical conductivity. The thermal diffusivity of PCAN film did not change by heat-treatment at temperatures below 600°C, but increased above 700°C from a value of  $4 \times 10^{-7} \text{ m}^2/\text{s}$  for the untreated film to a value of  $2 \times 10^{-6} \text{ m}^2/\text{s}$  for the film heat-treated at 1300°C. IR spectra showed that the formation of carbeneous structure becomes evident by heat-treatment above 700°C. This indicates that the increase in thermal diffusivity is due to the development of graphite-like layers. The correlation between the changes in thermal conductivity and electrical conductivity did not fit Wiedemann-Franz's law. It was concluded that the carriers in the PCAN pyrolyzates investigated are not electrons but phonons. (Author abstract) 5 refs. In Japanese.

Hashimoto, Toshimasa (Tokyo Inst of Technology, Tokyo, Jpn); Okuno, Kei; Kinoshita, Mizuhito; Takaku, Akira. *Kobunshi Ronbunshu* v 44 n 6 1987 p 445-449.

**Fire Resistance** See ELECTRIC CABLES—Fire Resistance.

**Flame Resistance** See Also PLASTICS, FOAMED—Rigid.

**082394 FIRE TESTING OF POLYMERS.** Fire tests are carried out to determine the fire behaviour of a material or a product. The ultimate use of such a test is to reduce or control the fire hazard of the material or product in its end-use environment. The fire behaviour of a product may be defined in terms of its ignition resistance, rates flame spread, heat release, smoke production and toxic gas generation. These parameters are not fundamental material properties but may be significantly affected by interactions of materials, design and with their end-use environment. The actual fire hazard of a product or material will also involve human and other factors. There are a great many standardised tests to determine the fire performance of materials and products but before selecting a particular test, it is necessary to assess the end-use hazards and also the performance needed to provide the level of safety required. This paper reviews the various tests of fire against a background of material and product applications. (Author abstract) 74 refs.

Paul, K.T. (Rapra Technology Ltd, Shrewsbury, Engl). *Progr Rubber Plast Technol* v 3 n 2 1987 p 23-43.

**Flammability** See Also BUILDING MATERIALS—Fire Resistance.

**082395 BURNING POLYMERS—RELIABLE TEST FOR THE CORROSIVE EFFECTS?** Properties of materials in combustion are described. A test method conceived by the centre National d'Etudes des Telecommunications (CNET) may now represent an unique approach to determine the corrosive effects of vapours emitted by burning polymeric materials used for wire and cable jacketing and insulation. Results obtained with different samples are claimed to correlate very closely with experience gained under actual fire conditions. (Edited author abstract) 2 refs.

Anon. *Mater Des* v 9 n 2 Mar-Apr 1988 p 96-97.



**082396 THERMAL BEHAVIOUR OF BROMINE-METAL FIRE RETARDANT SYSTEMS.** Chemical reactions which occur on heating fire retardant mixtures of decarboxymodiphenyloxide (DBDPO) with antimony trioxide (AO) or bismuth carbonate (BC) have been studied by means of weight loss, elemental analysis, X-ray diffraction, scanning electron microscopy (SEM) and energy dispersive system (EDS) microanalysis. It has been shown that on rapid heating to 700°C, DBDPO volatilisation competes with debromination by AO or BC leading to volatile  $\text{SbBr}_3$  or  $\text{BiBr}_3$  which are formed by different mechanisms. BC is rapidly transformed into  $\text{BiOBr}$  which gives  $\text{BiBr}_3$  by further debromination of DBDPO. At high conversion (high temperature), this process is in competition with reduction of  $\text{BiOBr}$  to metallic bismuth. In the case of AO slower formation of progressively bromine-rich antimony oxybromides takes place which liberates  $\text{SbBr}_3$  by thermal degradation. (Edited author abstract) 14 refs.

Bertelli, G. (Himont Italia, Ferrara, Italy); Costa, L.; Fenza, S.; Marchetti, E.; Camino, G.; Locatelli, R. *Polym Degradation Stab* v 20 n 3-4 1988, Polym Addit in Stab: Perform and Mech, Birmingham, Engl, Sep 2-4 1987 p 295-314.

## Flocculation

**082397 MOLECULAR DETAILS OF THE SOLVENT INDUCED FLOCCULATION OF DILUTE STERICALLY STABILISED POLYMER COLLOIDS.** The incipient flocculation behavior of sterically stabilized nonaqueous dispersions has been extensively investigated. These studies have identified the flocculation conditions either visually or using turbidity measurements. Such techniques identify the gross flocculation behavior of the colloid but do not furnish any information about the flocculation process at the molecular level. In this paper, the authors outline fluorescence energy transfer experiments which allow the opportunity to follow the change in conformation of the steric barrier as the solvency of the dispersion medium is varied. It is concluded from such experiments that in dilute sterically stabilized dispersions, the steric barrier collapses in the vicinity of the flocculation point. (Edited author abstract) 11 refs.

Croucher, M.D. (Xerox Research Cent of Canada, Mississauga, Ont, Can); Winnik, M.A.; Egan, L. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 311-323.

**Fluid Dynamics** See FLOW OF FLUIDS—Pipes.

**Forming** See Also CELLULOSE DERIVATIVES—Synthesis; MONOMERS—Polymerization.

**082398 THERMAL EFFECTS IN THE NECKING OF POLYMERS.** A certain fraction of the mechanical work performed on a specimen is converted into heat during necking of plastic material. A method for measuring this fraction is proposed when specimens are drawn in two different surroundings, air and water. Differences in the heat transfer coefficients of these two media influence the temperature rise during necking. The fraction ( $\alpha$ ) of mechanical work converted into heat can be calculated using data determined at only one draw rate. The value of  $\alpha$  calculated for polypropylene is 0.55 and for polyethylene it is 0.48. (Author abstract) 5 refs.

Liu, Tuo-Min (Pennsylvania State Univ, University Park, PA, USA); Harrison, I.R. *Polym Eng Sci* v 27 n 18 Mid-Oct 1987 p 1399-1402.

**082399 SPATIAL PATTERNS FORMED BY GROWING TEOS POLYMERS.** Silicon tetraethoxyde (TEOS) monomers are dissolved in a water/ethanol mixture. Through hydrolysis and condensation they aggregate to form branched siloxane polymers; in a few hours these polymers build a gel throughout the solution. The patterns formed by the growing polymers are studied through small angle neutron scattering. In the reaction bath, these patterns result from repulsive interactions,

whose range  $\zeta$  is controlled by the smaller polymers of the bath. In diluted solutions, the patterns give the size  $R_z$  of the largest polymers, which limits the connectivity of the reaction bath. As the polymers recombine, the connectivity length diverges, whereas the interaction length remains microscopic and keeps growing regardless of the gel point. This growth leaves the network with a set of self similar heterogeneities similar to those found in many other gels. (Author abstract) 44 refs.

Cabane, B. (CEN Saclay, Gif-sur-Yvette, Fr); Dubois, M.; Duplessix, R. *J Phys (Paris)* v 48 n 12 Dec 1987 p 2131-2137.

**082400 EXTREMELY HIGH MOLECULAR WEIGHT POLYMER FORMATION USING A PHOTOINITIATION SYSTEM OF XANTHATE FIXED AT AN ORIENTED BILAYER SURFACE.** The authors show a new polymerizable bilayer system in which a photoinitiator consisting of two long alkyl chains and a xanthate group which are coupled via a glutamate connector is fixed near polymerizable groups in a bilayer matrix. It is shown that when the aqueous bilayer solution and the aqueous poly(sodium styrene sulfonate) separately prepared were mixed, the instantaneous precipitation due to formation of polyanion complex of the polyanion and the cationic bilayer component was observed. Since no precipitate was observed during polymerization for the mixed bilayer systems in spite of the formation of high molecular weight polymers, the resulting polymers would have a suitable conformation for maintaining an aqueous bilayer state. Experiments indicate that extremely high molecular weight polymers can be produced under mild conditions in a bilayer state by taking advantage of the well-defined bilayer surface and fixation of the photoinitiator at the most effective position for initiation. 10 Refs.

Higashi, Nobuyuki (Doshisha Univ, Kyoto, Jpn); Adachi, Takato; Niwa, Masazo. *Macromolecules* v 21 n 7 Jul 1988 p 2297-2299.

**082401 REACTIVITY OF MACROMOLECULES IN THE PROCESSES OF POLYMER FORMATION. REVIEW.** This review systematizes and generalizes the main causes and conditions of change in the reactivity of the functional groups of macromolecules with increase in chain length. Attention is focussed on the polycondensation processes of polymer synthesis. It is shown that violation of the principle of unchanged activity of the functional groups may be related to the action of physical (excluded volume effect, diffusion control) and chemical (far order effect) factors. (Edited author abstract). 114 Refs.

Ignatov, V.N. (USSR Acad of Sciences, USSR); Vasnev, V.A.; Vinogradova, S.V. *Polym Sci USSR* v 29 n 5 1987 p 903-1009.

## Fractionation

**082402 FRACTIONATION OF SYNTHETIC POLYMERS USING SUPERCRITICAL NITROUS OXIDE.** The use of supercritical fluids for processing of synthetic polymers has recently been receiving considerable attention in the chemical industry. In a previous paper, fractionation of synthetic oligomers using light hydrocarbon supercritical fluids was described. This manuscript reports the use of supercritical nitrous oxide for the fractionation of synthetic polymers according to molecular weight. The authors felt it would be beneficial to briefly describe methods used to fractionate synthetic polymers using supercritical  $\text{N}_2\text{O}$  and to present properties of the resulting fractions. 8 refs.

Scholsky, K.M. (S.C. Johnson & Son Inc, Racine, WI, USA); Morgan, L.W. *J Polym Sci Part C* v 26 n 4 Apr 1988 p 181-184.

**082403 EFFICIENCY OF POLYMER FRACTIONATION - A REVIEW.** With respect to molecular masses, polymers are polydisperse. Since many of their properties depend on the distribution of molecular masses, to study this correlation it is necessary to have samples of narrow molecular mass distribution or samples with

accurately defined distribution. In spite of the developmental progress of fast instrumental methods (analytical and preparative gel chromatography) used to determine the molecular mass distribution curve and to obtain higher amounts of fractions of narrow molecular mass distributions, there still exists an interest in classical methods of fractionation. On the basis of a survey of monographs on polymer fractionation, numerous publications and personal experience, this review describes primarily what is an efficient fractionation. Afterwards, factors that affect fractionation efficiency according to the type of effects are given and causes of their action are described. Conditions under which efficient fractional precipitation and fractional solution methods are applied are considered separately. At the end of the review, criteria on the basis of which fractionation efficiency is evaluated are considered in detail. (Author abstract) 81 refs.

Mencer, H.J. (Univ of Zagreb, Zagreb, Yugosl). *Polym Eng Sci* v 28 n 8 Apr 1988 p 497-505.

**082404 FRAKTIONTI - UDELEEN LOEYDETTY POLYMERIEN KARAKTERISOINTI-MENETELMA. [Fractionation - A Rediscovered Method for the Characterization of Polymers].** Interest in polymer fractionation has grown during the last 10 years, as the relatively simple plastics used earlier have been supplanted by complicated multicomponent systems, copolymers and polymer blends. The basis of fractionation can be chemical composition, molecular structure or molecular size. The desirability of fractionating polymers has resulted in the development of many useful analytical and preparative methods. In this paper classical and newer polymer fractionation methods are reviewed. Some examples of the fractionation of polyethylenes are given. (Edited author abstract). 27 Refs. In Finnish.

Lehtinen, Arja (Konsernin T&K, Kulloo, Finl); Jaaskelainen, Prio. *Kem Kem* v 15 n 5 1988 p 472-476.

**Fracture** See Also ELASTOMERS—Fracture; GLASS, METALLIC—Fracture; SYNTHETIC FIBERS—Stresses.

**082405 FRACTURE TESTING OF POLYETHER-SULPHONE INJECTION MOULDINGS.** Single-edge-gated injection molded discs of PES have been subjected to three types of fracture mechanisms test. Two methods previously found to give consistent results on other polymers, three-point bending and single-edge notch tension, gave  $K_{Ic}$  values which were questionable: the bend test results were functions of molding depth, while tensile specimens showed evidence of yielding. Fractography indicated that the conditions of plane strain were not fulfilled during crack propagation in these specimens, the fracture surfaces being very rough and the crack fronts highly curved. Accordingly the ASTM compact disc test was adapted as a whole-mold test, since this is particularly suitable for investigating orientation effects and allows stable crack propagation. (Edited author abstract) 16 refs.

Whitehead, R.D. (Univ of Surrey, Guildford, Engl); Moore, D.R.; Leach, D.C.; Puttick, K.E.; Rider, J.G. *Plast Rubber Process Appl* v 8 n 2 1987 p 115-126.

**082406 DYNAMIC EFFECTS ON FRACTURE SURFACE FORMATION IN BRITTLE POLYMERS (2ND REPORT, EXAMINATION OF SURFACE MARKINGS).** The dynamic fracture surface formation of PMMA and epoxy was studied. Fracture parameters such as crack velocity  $a$  and crack extension resistance  $R$  were obtained by high-speed photography of fracture caustic images. The density of surface marking was also obtained by examination of the fracture surfaces. Correlations between the density  $\mu$  and the fracture parameters have shown that, although  $\mu$  depends on  $a$  or on  $R$ ,  $\mu$  is not a unique function of one of those parameters. It is found that  $\mu$  has the best correlation with the product  $Ra$ , i.e., dissipated energy per unit crack front and unit time. (Author abstract) 7 refs. In Japanese.

Arakawa, Kazuo; Takahashi, Kiyoshi. *Nippon Kikai Gakkai Ronbunshu A Hen* v 53 n 495 Nov 1987 p 2128-2133.



**Friction** See Also METALS AND ALLOYS—Friction; POLYETHYLENES—Ultrahigh Molecular Weight.

**082407 ON FRICTION INTERACTION OF SOME POLYMER MATERIALS WITH A HARD ALLOY.** We present the results of experimental studies of friction interaction of thermoplastic (LDPE, PP, PTFCE, PTFE, PMMA, PCA) and thermoreactive (EDS, PFR, EPFP) polymers with the VK6M hard alloy. We analyze the polymer transfer films on the hard-alloy counterbody and show the influence of the chemical structure of the polymer on the friction properties. We establish the connection between the relative area of the friction transfer layers and the content of chemically active groups in the polymer. (Author abstract) 9 refs.

Zaitsev, A.L.; Sysoev, P.V. *Sov J Frict Wear* v 8 n 2 1987 p 124-128.

**082408 SLURRY ABRASION OF POLYMERS UNDER SIMULATED SUBMARINE CONDITIONS.** The present study was initiated to gain relevant data on the behavior of some candidate commercial polymers when abraded by typical submarine rock particles. Samples of high density polyethylene, polypropylene, poly(vinyl chloride), poly(methyl methacrylate), Delrin and polytetrafluoroethylene were abraded by slurries of crushed submarine rocks (pillow lava and coral). Comparison tests were made with slurries of quartz abrasives and with a pin-on-disk apparatus using SiC sandpaper. It was found that the various polymers tested showed the same general ranking independent of the abrasive used, even though the rates of wear varied by several orders of magnitude between the different tests and even though there was a distinct change in wear mechanism from almost pure surface fatigue to almost pure cutting from one end of the spectrum to the other. (Edited author abstract) 11 refs.

Larsen-Basse, Jørn (Georgia Inst of Technology, Atlanta, GA, USA); Tadjvar, Ahmad. *Wear* v 122 n 2 Mar 1 1988 p 135-149.

**082409 RECENT STUDIES ON FRETTEING WEAR OF POLYMERIC MATERIALS.** A critical review of recent studies is presented from the standpoint of the fundamental aspects of fretting wear of polymeric materials. Experimental results concerning fretting damage of polycarbonate, polytetrafluoroethylene, polyethylene, polyvinylidene fluoride, polychlorotrifluoroethylene, polyvinylchloride, polymethyl methacrylate and polyhexamethylene adipamide are cited. The mechanism of fretting damage is discussed from the standpoint of the direct observations of the fretting of polymethyl methacrylate against steel with an optical microscope. These results indicate that the coefficient of friction, the melting or welding temperature, and the thermal conductivity are important factors in the fretting wear of polymeric materials. (Edited author abstract) In Japanese. 15 refs.

Sato, Jun'iti (Tokyo Univ of Mercantile Marine, Tokyo, Jpn). *J Jpn Soc Lubr Eng* v 33 n 1 1988 p 26-32.

**082410 ELASTIC-PLASTIC STRESS ANALYSIS OF A POLYMERIC SUBSURFACE WITH A THIN LAYER UNDER NORMAL AND TANGENTIAL LOADING.** A finite element method was employed to investigate the stress and strain distributions in the subsurface of high density polyethylene (HDPE) by an elastic-plastic analysis. Various equivalent stress and strain contours in the subsurface area under the asperity contact were obtained for three kinds of HDPE, i.e., gamma-ray-irradiated HDPE, helium-plasma-treated HDPE, and untreated HDPE. It was assumed that the untreated HDPE has a soft surface layer over the bulk, the plasma-treated HDPE has a hard surface layer, and the gamma-irradiated HDPE has a homogeneous surface area owing to uniform crosslinking. The wear mechanisms of untreated and irradiated HDPE were explained qualitatively on the basis of the plastic deformation and strength of the material. (Edited author abstract) 39 refs.

Su, Ching-Lo (Univ of South Carolina, Columbia, SC, USA); Youn, Jae R. *Wear* v 123 n 3 May 1988 p 355-367.

**082411 PARAMETRIZATION OF THE FRICTION CONSTANT FOR STOCHASTIC SIMULATIONS OF POLYMERS.** A method is developed for determining the values of the friction constants for atoms in polymers for Langevin and Brownian dynamics simulations. The method is based on calculating effective hydrodynamic radii that take into account the reduction of the atomic surface area accessible to solvent. The resulting friction constants are shown to give satisfactory translational and rotational diffusion coefficients when compared with experimental data. Analysis of the effect of hydrodynamic interaction on translational and rotational dynamics shows that it is significantly smaller for the latter than the former. Limitations of point-source frictional models are briefly discussed. (Author abstract) 48 refs.

Pastor, Richard W. (Harvard Univ, Cambridge, MA, USA); Karplus, Martin. *J Phys Chem* v 92 n 9 May 5 1988 p 2636-2641.

**082412 COEFFICIENT OF FRICTION OF A POLYAMIDE/POLYMETHYL METHACRYLATE BLEND SYSTEM.** The coefficient of friction is an important tribological property of polymer materials. In this work, values for the coefficient of friction of a polyamide (nylon 6,6)/polymethyl methacrylate (PMMA) blend system have been measured under various compressive stresses. The results show that the coefficient of friction of the amorphous polymer, PMMA, increases with increasing compressive stress; while the coefficient of friction of the crystalline polymer, nylon 6,6, either stays constant or decreases with increasing compressive stress. For crystalline polymers, the coefficient of friction measured parallel to the flow direction is lower than that measured perpendicular to the flow direction. The effect of sample orientation on the coefficient of friction of the amorphous polymer, PMMA, is insignificant. Values for the coefficient of friction of the blends measured are lower than those calculated from the additive rule for the coefficient of friction of the blend system. (Edited author abstract) 10 refs.

Lee, Michael C.H. (GM, Warren, MI, USA); Golden, Mark A. *J Elastomers Plast* v 20 n 2 Apr 1988 p 163-186.

**Glass Transition** See Also ACRYLICS—Chemistry; ACRYLICS—Curing; EPOXY RESINS—Curing; MONOMERS—Polymerization; POLYCARBONATES—Physical Properties.

**082413 APPROACH TO THE COMPOSITION DEPENDENCE OF THE GLASS TRANSITION TEMPERATURE OF COMPATIBLE POLYMER BLENDS: 1.** Starting with the idea that, besides conformational energy barriers, surface contacts are responsible for both conformation and 'free' volume distribution, a new concept is developed to describe the glass transition in compatible polymer blends. An extended Gordon-Taylor equation results if both the effective contact probabilities of the blend components and the effect of molecular surroundings on the contact contribution to the glass transition of the blend are considered. Free volume redistribution due to surface contacts is included. The Gordon-Taylor constant K of the relation obtained is now not a fitting parameter, but is related to the ratio of the different expansion coefficients of the free volume. The relation introduces two fitting parameters, K<sub>1</sub> and K<sub>2</sub>, which are related to the intensity of polymer-polymer interaction and to the effect of immediate molecular surroundings on the interaction. Data analysis suggests that these fitting parameters are not only polymer-specific, but also molecular-weight-dependent. (Author abstract) 24 refs.

Brekner, M.-J. (Inst fuer Makromolekulare Chemie, Freiburg, West Ger); Schneider, H.A.; Cantow, H.-J. *Polymer* v 29 n 1 Jan 1988 p 78-85.

**Grafting** See Also COLLOIDS; GRAFT COPOLYMERS—Biocompatibility; GRAFT COPOLYMERS—Synthesis; POLYURETHANES—Synthesis.

**082414 GRAFTING ONTO CARBON BLACK BY THE REACTION OF REACTIVE CARBON BLACK HAVING MASKED ISOCYANATE OR ACYL AZ-**

**IDE GROUP WITH FUNCTIONAL POLYMERS.** Although isocyanate group (NCO) introduced onto carbon black surface was inactivated rapidly upon storage, it could be stabilized by masking the NCO group with active hydrogen compounds such as acetylacetone, diethyl malonate, and sodium hydrogensulfite. Upon heating these carbon blacks having masked NCO group at 150°C, the NCO group was regenerated on carbon black by the decomposition of the masked NCO group. On the other hand, acyl azide (CON<sub>3</sub>) group introduced onto carbon black was stable at below 20°C, but readily decomposed to NCO group by heating. By means of the reaction of NCO group on carbon black with functional polymers having hydroxyl, amino, and carboxyl group, these polymers were effectively grafted onto carbon black surface. (Edited author abstract) 8 refs.

Tsubokawa, Norio (Niigata Univ, Niigata, Jpn); Kobayashi, Kazuhisa; Sone, Yasuo. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 223-233.

**082415 COLLAPSE OF GRAFTED CHAINS IN POOR SOLVENTS.** A mean field theory of the collapse of grafted chains (consisting of N monomers) in a poor solvent is presented. The collapse behavior of nonoverlapping grafted chains is identical to that of free coils but with no phase separation. This 'strong' collapse, in which the coil radius R decreases continuously from R approximately N<sup>3/5</sup> in a good solvent to R approximately N<sup>1/3</sup> in a poor solvent, is replaced by 'weak' collapse for densely grafted layers. Such a layer when undergoing 'weak' collapse becomes thinner, yet the chains remain stretched even in poor solvents, and the layer thickness is linear in N past the collapse. For low densities the 'weak' collapse is associated with a first order phase transition. An increase in grafting density takes the system through a critical point into a gradual collapse regime. (Author abstract) 16 refs.

Halperin, A. (Univ of California, Santa Barbara, CA, USA). *J Phys (Paris)* v 49 n 3 Mar 1988 p 547-550.

**082416 GRAFTING OF VINYL ACETATE ONTO POLY(VINYL CHLORIDE) IN SOLUTION.** Radiation-induced grafting of vinyl acetate (VAc) onto poly(vinyl chloride) (PVC) was performed in solution with dimethylformamide (DMF). Grafting was studied as a function of dose, dose rate, and VAc/PVC ratio. The amount of grafting was measured by IR spectroscopy on the graft copolymer fraction insoluble in hot methanol. The homopolymerization of VAc was also studied in the same conditions, in order to check the influence of the solvent on radiochemical reactions leading to graft copolymers. The results show that the grafting can be easily obtained. The graft copolymer was tested for the preparation of ultrafiltration membranes. (Edited author abstract) 20 refs.

Vigo, Fernando (Univ of Genoa, Genoa, Italy); Uliana, Claudio. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1893-1901.

**082417 FACTORS AFFECTING PHOTOGRAFTING OF METHACRYLIC ACID ON POLYETHYLENE FILM IN LIQUID PHASE SYSTEM.** Factors affecting photografting of methacrylic acid on low-density polyethylene film were investigated in liquid-phase system with water. Benzophenone was used as a sensitizer by coating it on the film surface. Factors examined were monomer concentration, polymerization temperature and film thickness. It was found that grafted polymer is formed preferentially as compared with homopolymer under conditions such as monomer concentration higher than 6.0 wt%, polymerization temperature higher than 50°C, and film thickness of 30 µm. The structure of the grafted samples obtained in the above systems was characterized by the grafted chains distributing over the film and the flat appearance of film surface. (Edited author abstract) 13 refs.

Ogiwara, Yoshitaka (Gunma Univ, Kiryu, Jpn); Koike, Noriyuki; Kubota, Hitoshi; Hata, Yasuo. *J Appl Polym Sci* v 35 n 6 May 5 1988 p 1473-1481.



**Hardening** See ADHESIVES—Thermal Effects.

## Heat Resisting

**082418 THERMAL STABILITY OF SOME POLYQUINAZOLONE POLYMERS: EFFECT OF ACID CATALYSIS.** Thermal properties of polyquinazolones (PQ) polymers prepared from 4,4'-diaminodiphenyl-3,3'-dicarboxylic acid (BDC) and 4, 6-diaminoisophthalic acid (DAIA) with diacetamido derivative of a number of diamines have been studied by thermogravimetry (TG) and differential scanning calorimetry (DSC). The effect of acid catalysis was also investigated. The results show that polyquinazolones prepared from DAIA have higher thermal stabilities and glass transition temperatures compared to those prepared from BDC. This can be attributed to the more stable and rigid fused quinazalone backbone unit in the PQ/DAIA system. Both polymer systems show improved thermal stability in the presence of catalyst which is a direct result of increased number of fully cyclized quinazalone rings in the polymer. (Author abstract) 6 refs.

Chan, Hardy S.O. (Nat'l Univ of Singapore, Kent Ridge, Singapore); Lai, Yee-Hing; Lusty, J.R.; Khor, E. *J Therm Anal* v 32 n 3 May-Jun 1987 p 893-900.

**082419 BIS- OR TETRA-MALEIMIDES OF SUBSTITUTED s-TRIAZINES CHAIN-EXTENDED BY IMIDE, AMIDE, AND UREA GROUPS FOR FIRE- AND HEAT-RESISTANT APPLICATIONS.** Novel phosphorylated bismaleimides and nonphosphorylated tetramaleimides containing substituted s-triazine rings (chain-extended by imide, amide, or urea groups) were prepared and polymerized. These polymer precursors were prepared by reacting 2,4-bis(4-aminophenoxy)-6-diethoxyphosphinyl-s-triazine or 2,4,6-tris(4-aminophenoxy)-s-triazine with maleic anhydride in combination with a bridging agent such as pyromellitic or benzophenone tetracarboxylic dianhydride, terephthaloyl chloride, and tolylene diisocyanate. The structure of polymer precursors was confirmed by infrared and proton nuclear magnetic resonance spectroscopy and their curing behavior was investigated by differential thermal analysis. The phosphorylated bismaleimides were thermally polymerized at a lower temperature than did the corresponding nonphosphorylated tetramaleimides. Dynamic thermogravimetric analysis showed that the nonphosphorylated and phosphorylated cured resins were stable up to 320-370 and 312-327°C, respectively, in nitrogen or air atmosphere. (Edited author abstract) 17 refs.

Mikroyannidis, John A. (Univ of Patras, Patras, Greece); Melissaris, Anastasios P. *J Polym Sci Part A* v 26 n 5 May 1988 p 1405-1418.

**082420 HIGH-PERFORMANCE POLYMERS.** A process description given of a range of aromatic polymers manufactured by condensation polymerization in an aprotic aromatic solvent. The monomers themselves may be formed in the reaction stage or prepared and isolated as a separate stage. A key aspect of the process is easy molecular weight control. This permits us to manufacture materials having good processability and mechanical properties. In the process, molecular weight is controlled primarily by varying the mole ratios of halogen ends on the monomers to the hydroxyl or -OM ends. This control of molecular weight by varying the stoichiometry has allowed easy tailoring of the molecular weight to meet commercial requirements. Also discussed is the production of the ketone family of polymers. This commercial polymerization process for world-scale manufacture of aromatic polymers has proved itself robust and versatile, allowing the exploitation of a wide range of polymer types. This technology has been extended to amorphous and crystalline polymers suited for markets that require easier processability, higher temperature performance, and specialist applications.

Smith, Clive P. (ICI Advanced Materials, Cleveland, Engl). *CHEMTECH* v 18 n 5 May 1988 p 290-291.

**Heat Transfer** See Also INTERPENETRATING POLYMER NETWORKS—Curing.

**082421 STUDY OF HEAT ENERGY TRANSFER IN LINEAR POLYMERS AND COMPOSITES BASED ON THEM AS A FUNCTION OF THEIR MICROSCOPIC PROPERTIES.** Change in the kinetic elements of the structure of linear polymers and composites based on them on exposure to a temperature field has been studied. The role of the boundary layers in the energy exchange processes is defined. Ways of targeted regulation of the thermophysical properties of the systems are indicated. (Edited author abstract) 14 refs.

Kolupayev, B.S. (Acad of Sciences of the Ukrainian SSR, USSR); Lipatov, Yu.S. *Polym Sci USSR* v 28 n 8 1986 p 1901-1907.

**082422 HEAT TRANSFER AND TURBULENT FLOW OF DILUTE SOLUTIONS OF HIGH-MOLECULAR-WEIGHT POLYMERS.** A survey of analytic and experimental studies on the effect of dilute solutions of high-molecular-weight drag-reducing polymers on heat and mass transfer and on turbulent friction is presented, and specific examples of the use of polymers in various engineering applications are described. (Author abstract). 42 Refs.

Kozlov, L.F. (Ukrainian Acad of Sciences, Kiev, USSR). *Fluid Mech Sov Res* v 17 n 2 Mar-Apr 1988 p 8-22.

**Heat Treatment** See POLYTETRAFLUOROETHYLENE—Crystal Lattices.

**Heating** See Also POLYAMIDEIMIDES—Curing; POLYOLEFINS—Mechanical Properties.

**082423 THERMAL BEHAVIOUR OF POLYBENZHYDROLIMIDES.** Simultaneous measurements of weight loss and rate of evolution of either organic products or water using a specially designed thermogravimetry-evolved gas analysis technique have been employed to study the evolution of small amounts of residual solvent and water formed in reactions occurring on heating polybenzhydrolimides (PBHI). On heating PBHI to 400°C, a redox reaction takes place involving the elimination of water from =CHOH groups. Diarylketone moieties were identified in the polymer as one of the products of this reaction. (Author abstract) 4 refs.

Costa, L. (Univ of Turin, Turin, Italy); Camino, G.; Quennesson, M.E.; Bartholin, M. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 251-261.

**High Pressure Effects** See POLYMETHYL METHACRYLATE—Phase Transitions.

## High Temperature Applications

**082424 ADDITION POLYMERS FROM 1,4,5,8-TETRAHYDRO-1,4,5,8-DIEPOXYANTHRACENE AND BIS-DIENES: PROCESSABLE RESINS FOR HIGH TEMPERATURE APPLICATIONS.** 1,4,5,8-Tetrahydro-1,4,5,8-diepoxyanthracene reacts with various anthracene end-capped polyimide oligomers to form Diels-Alder cycloaddition copolymers. The polymers are soluble in common organic solvents, and have molecular weights of approximately 21,000 to 32,000. These resins appear to be more stable in air than in nitrogen; this is shown to be due to a unique dehydration (loss of water ranges from 2 to 5 percent) at temperatures of 390 to 400°C to give thermo-oxidatively stable pentiptycene units along the polymer backbone. Because of their high softening points and good thermo-oxidative stability, the polymers have potential as processable, matrix resins for high-temperature composite applications. (Edited author abstract) 7 refs.

Meador, Mary Ann B. (NASA, Lewis Research Cent, Cleveland, OH, USA). *NASA Tech Memo* 89838 1987 6p.

**High Temperature Properties** See POLYIMIDES—Blending; THERMOPLASTICS—Mechanical Properties.

**Hydration** See ION EXCHANGE RESINS—Drying.

**Hydrodynamics** See FLOW OF FLUIDS—Laminar.

## Hydrogenation

**082425 PARTICLE SIZE EFFECT ON ENANTIOSELECTIVE HYDROGENATION OF METHYLACETOACETATE OVER SILICA-SUPPORTED NICKEL CATALYST.** The effect of metal particle size on the enantioselective hydrogenation of methylacetoacetate (MAA) to methyl 3-hydroxybutyrate (MHB) in the gas and the liquid phases was studied over Ni/SiO<sub>2</sub> modified with R,R-tartaric acid. The Ni particle size of the catalyst at controlled Ni load was increased from 3.3 nm up to about 11 nm by Ostwald ripening, due to the formation and decomposition of gaseous Ni(CO)<sub>4</sub>. The experimental data showed no significant particle size effect on enantioselectivity within this size range. (Edited author abstract) 19 refs.

Fu, L. (Northwestern Univ, Evanston, IL, USA); Kung, H.H.; Sachtler, W.M.H. *J Mol Catal* v 42 n 1 Sep 1987 p 29-36.

**082426 HETEROGENEOUS CATALYTIC HYDROGENATION OF POLY(VINYLETHYLENE).** The hydrogenation of poly(vinylethylene) in cyclohexane (1% w/v) at 70°C with use of a calcium carbonate supported palladium catalyst has been investigated. Evaluation of partially hydrogenated polymer by size-exclusion chromatography and <sup>1</sup>H NMR spectroscopy reveals that this reaction initially proceeds by the concerted hydrogenation of approximately 85% of the unsaturated repeat units in individual polymer molecules during a single adsorption step from solution. This finding is qualitatively explained on the basis of the unique adsorption characteristics of polymers, in conjunction with the estimated heats of adsorption for unsaturated and saturated hydrocarbons on group VIII metal surfaces. (Author abstract) 18 refs.

Rosedale, J.H. (AT&T Bell Lab, Murray Hill, NJ, USA); Bates, F.S. *J Am Chem Soc* v 110 n 11 May 25 1988 p 3542-3545.

**Hydrolysis** See Also CELLULOSE—Hydrolysis; MONOMERS—Polymerization; OIL WELL PRODUCTION—Enhanced Recovery.

**082427 STEREOSELECTIVE ESTER HYDROLYSIS OF MONOMERIC AND POLYMERIC METHACRYL DERIVATIVES CONTAINING METHIONINE BY PIG LIVER ESTERASE (PLE).** In this study N-methacryloyl-D,L-methionyl-D,L-methioninemethylester and the corresponding polymers were synthesized. The PLE catalyzed hydrolysis of these products was then analyzed under stereochemical aspects. It is shown that PLE can stereoselectively hydrolyse L-ester functions bound to a polymer. (Author abstract) 6 refs.

Korp, Gabriele (Bergische Univ-Gesamthochschule Wuppertal, Wuppertal, West Ger); Ritter, Helmut. *Polym Bull (Berlin)* v 18 n 3 Sep 1987 p 271-276.

## Ignition

**082428 INITIATION OF COMBUSTION FOR CHLORINATED POLYETHYLENES.** The existence of a different mechanism for self-ignition of solids and gases is due to the more limited role of reaction temperature for the medium as a result of the diffusion nature of combustion for a solid. The specific nature of warmup during ignition of solid materials has induced authors to modify the system of evaluating their combustibility. In order to determine the self-ignition temperature a modified method and equipment for carrying it out is suggested. The incombustibility of highly chlorinated polymers makes them candidate materials for fire proofing. 13 refs.



Mal'tseva, A.S.; Ronkin, G.M.; Frolov, Yu.E.; Yakushina, E.P.; Rozlovskii, A.I. *Combust Explos Shock Waves* v 23 n 3 May-Jun 1987 p 315-320.

Impurities See RUBBER—Oxidation.

## Industrial Applications

**082429 DESIGN IN POLYMERS.** The paper reviews the engineering and design of products using polymers. The sequence of steps in the design process, manufacturing methods and materials selection are described. 18 refs.

Lewis, Peter (Open Univ, Milton Keynes, Engl). *Plast Rubber Int* v 12 n 5 Oct 1987 p 36-38, 40-41.

**Injection Molding** See Also COMPOSITE MATERIALS—Fiber Reinforced; ELASTOMERS—Injection Molding; ELECTROMAGNETS—Design; LENSES—Manufacture; MIXERS; PLASTICS—Computer Integrated Manufacturing; PLASTICS—Molds; PLASTICS MACHINERY—Automation; POLYURETHANES—Injection Molding.

**082430 TABLES TRACANTES ET PRESSES A INJECTER.** [Plotting Tables and Injection Presses]. Fine adjustment of molding parameters can be obtained with microprocessor presses. However, the transition between the filling stage and the pressure stage, essential for the quality of the part, is not always clearly defined. By means of the plotting table, it is possible to measure or determine the point of transition between the filling and pressure stages, the values of decreasing pressure during the pressure stage, the injection pressure, the reproducibility of the cycle, whether or not the stopvalve of the screw is leakproof, and feed losses. This plotting table is easy to use in order to visualize, optimize and record all molding parameters. (Edited author abstract) In French.

Maucotel, J.M. (Conseil Industries Plastiques). *Rev Gen Caoutch Plast* v 64 n 672 Oct 1987 p 113-120.

**082431 SIMULATION OF INJECTION MOLD FILLING OF VISCOELASTIC POLYMER WITH FOUNTAIN FLOW.** Viscoelasticity, nonisothermality, and fountain flow influence the microstructure development during injection mold filling of polymer melts and, therefore, the ultimate properties of a molded article. A comprehensive two-dimensional mathematical model is developed to evaluate the effects of these factors on the structure of the flow field. Special consideration is given to the shape of the flow front, which is crucial in determining the structure of flow in the fountain region. The effects of slip and crystallization are also considered and their influence on mold predictions are analyzed. (Edited author abstract) 38 refs.

Kamal, M.R. (McGill Univ, Montreal, Que, Can); Goyal, S.K.; Chu, E. *AIChE J* v 34 n 1 Jan 1988 p 94-106.

**082432 Co-INJECTION CHARTING NEW TERRITORY AND OPENING NEW MARKETS.** The process was developed more than 15 years ago by ICI in the UK. Battenfeld, in those days Schloemann-Siemag incorporated the process with machine technology in the early 1970s. The process has been commercially used since 1975. Two materials, one for skin and one for core, are injected in such a way that one material forms the skin and the other forms the core. To make sure that an even distribution of skin and core can be achieved without any visible marks on the surface, Battenfeld developed the two-channel technique. With the two-channel nozzle, parts can be produced with surface qualities which are as good as straight injection molded parts.

Eckardt, Helmut. *J Cell Plast* v 23 n 6 Nov-Dec 1987 p 555-592.

**082433 TRANSIENT FREE-SURFACE FLOWS IN INJECTION MOLD FILLING.** This paper describes a numerical technique for the simulation of transient free-surface flows. The algorithm combines a Galerkin/finite-element discretization of the governing equations with a predictor-corrector scheme for integration in time, and determines simultaneously the flow field and the free surface at every time step. The method is applied to the

start-up of a fluid flow initially at rest and impingement of two flow fronts to form a weldline. Comparison of simulation with available experiments on the start-up problem shows very good agreement. (Edited author abstract) 27 refs.

Mavridis, H. (McMaster Univ, Hamilton, Ont, Can); Hrymak, A.N.; Vlachopoulos, J. *AIChE J* v 34 n 3 Mar 1988 p 403-410.

**082434 RHEOLOGICAL DESIGN OF AN INJECTION MOLD FOR AN AUTOMOTIVE FENDER.** This article describes how a fender mold was rheologically designed and what is to be expected from rheological aids when working with large-area parts. (Edited author abstract) 2 refs.

Bangert, H.; Dung, T.; Staebelin, P. *Kunstst Ger Plast* v 77 n 12 Dec 1987 p 12-14.

**082435 PRESSURE TRANSFER DURING THE INJECTION MOLDING PROCESS ACCORDING TO IMPROVED CHANGE-OVER TO HOLDING PRESSURE.** When changing over from the injection process to the follow-up pressure phase, pressure peaks can result in flashing of the mold. Perfect closed-loop control is rendered difficult, because the pressure profile in the injection cylinder is usually not proportional to the pressure profile in the screw ante-chamber. Results of pressure measurements taken in the injection cylinder, the screw ante-chamber and a spiral flow mold of a machine equipped with a newly developed follow-up pressure change-over system are illustrated and discussed. (Edited author abstract) 3 refs.

Ries, H.; Stillhard, B. *Kunstst Ger Plast* v 77 n 12 Dec 1987 p 15-18.

## Ion Implantation

**082436 CONDUCTING POLYMERS BY ION IMPLANTATION.** An electrically conductive surface can be created by using the ion implantation process on nonconducting polymeric sheet. The resulting conductivity was measured and correlated to ion beam parameters, such as ion species, dose, and energy. Additionally, a reaction model, in both physical and chemical terms, was proposed, which can assist in understanding of the underlying mechanisms during the ion implantation of polymers. The surface microscopic structure of the ion-implanted polymer specimens was evaluated by x-ray photoelectron spectroscopy (XPS), electron spin resonance (ESR), Rutherford backscattering spectroscopy (RBS), and infrared spectroscopy (IR). The experimental results indicated that the ion bombardment process leads to a carbon-enriched material in a manner akin to the carbonization of organic films observed upon pyrolytic processing. (Author abstract) 14 refs.

Loh, I.H. (Spire Corp, Bedford, MA, USA); Oliver, R.W.; Sioshansi, P. *Nucl Instrum Methods Phys Res Sect B* v B34 n 3 Sep 1988 p 337-346.

**Ionic Conduction** See Also ELECTROLYTES—Ionic Conduction; ELECTROLYTES—Materials; ELECTROLYTES, SOLID—Phase Diagrams; ELECTROLYTES, SOLID—Synthesis; SOLIDS—Order-Disorder.

**082437 CROWN ETHER ENHANCEMENT OF IONIC CONDUCTIVITY IN A POLYMER-SALT SYSTEM.** Crown ethers are a class of organic compounds that form complexes with inorganic cations. When crown ethers are added to poly(vinylene carbonate) containing dissolved lithium salt, ionic charge transport in the solid electrolyte is assisted. The ionic conductivity of the polymer containing 12-crown-4 is three orders of magnitude greater than the conductivity in the polymer without crown ether. The conductivity of this system at room temperature is approximately  $2.5 \times 10^{-4} \text{ S cm}^{-1}$ , higher than any polymer-lithium salt system yet reported. The effects of various crown compounds as well as their concentration effects are examined. (Author abstract) 13 refs.

Kaplan, M.L. (AT&T Bell Lab, Murray Hill, NJ, USA);

Rietman, E.A.; Cava, R.J.; Holt, L.K.; Chandross, E.A. *Solid State Ionics* v 25 n 1 Oct 1987 p 37-40.

**082438 ALKALI METAL ION-POLY(ETHYLENE OXIDE) COMPLEXES. II. EFFECT OF CATION ON CONDUCTIVITY.** In order to aid understanding of the mechanism of ionic conductivity the authors have examined systematically complexes of poly(ethylene oxide) (PEO) with the alkali metal salt series of  $\text{Li}^+$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Rb}^+$  and  $\text{Cs}^+$  with both tetrafluoroborate ( $\text{BF}_4^-$ ) and trifluoromethanesulfonate ( $\text{CF}_3\text{SO}_3^-$ ) anions. The ratio of monomer to salt was 10:1 in all cases. Complex impedance measurements were made on all samples in the temperature range 40°-125°C. with  $\text{CF}_3\text{SO}_3^-$  as the anion a definite trend was apparent with the smallest cation  $\text{Li}^+$  being the worst conductor and  $\text{Cs}^+$ , the largest cation, being the best. When  $\text{BF}_4^-$  salts are used, the  $\text{Na}^+$  complex is found to be the best conductor and  $\text{Rb}^+$  the worst. This study, in connection with earlier studies, has shown that synergy between cation and anion in the polymer matrix is an important consideration in determining the ionic conductivity. (Edited author abstract) 12 refs.

Rietman, E.A. (AT&T Bell Lab, Murray Hill, NJ, USA); Kaplan, M.L.; Cava, R.J. *Solid State Ionics* v 25 n 1 Oct 1987 p 41-44.

## Isomerization

**082439 NEW ISOMERS OF POLY(VINYL FLUORIDE) WITH CONTROLLED REGIOSEQUENCE MICROSTRUCTURE.** A novel synthetic procedure is described to adjust regiosequence defects (caused by monomer reversals during chain propagation) by reductive dechlorination of precursor copolymers of vinyl fluoride, VF, with suitable chlorofluoroethylenes, using tributyltin hydride to replace chlorine quantitatively with hydrogen. The products are regioisomers of PVF with defect levels depending on the identity of the chlorofluoroethylene monomer, and the composition of the precursor copolymer, which is selected by adjusting the comonomer feed ratio. We measure the regiosequence distribution of these various PVF isomers by 470 MHz  $^{19}\text{F}$  nuclear magnetic resonance, and show that the polymers are stereoirregular (atactic) as well. The crystalline melting temperature of PVF increases as the polymer becomes more isoregic. 10 refs.

Cais, Rudolf E. (AT&T Bell Lab, Murray Hill, NJ, USA); Kometani, Janet M. *Polymer* v 29 n 1 Jan 1988 p 168-172.

**082440 BACKBONE-ASSISTED REACTIONS OF POLYMERS. VII. KINETICS OF ISOMERIZATION OF POLY[(CHLOROMETHYL)THIIRANE] IN THE ABSENCE OF SOLVENT.** The kinetics of the repeating unit isomerization of poly[(chloromethyl)thiirane] have been determined at four temperatures in the absence of solvent. The reaction can be treated as a reversible first-order process with rate constants and activation energies similar to those observed in analogous reactions of  $\beta$ -chlorosulfides of low molecular weight. These observations are consistent with a mechanistic scheme that involves rate determining cyclization to a thiiranium ion intermediate, followed by rapid ring opening by chloride ion attack. (Author abstract) 11 refs.

Zussman, Melvin P. (Univ of Massachusetts, Amherst, MA, USA); Tirrell, David A. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 313-319.

## Latex See Also COATINGS—Plastics.

**082441 HETEROCOAGULATION OF POLYMER LATICES WITH SPHERICAL SILICA; SYNTHESIS OF THE COMPOSITE PARTICLE SYSTEM AND ITS PROPERTIES.** The properties of heterocoagulations consisting of monodispersed amphoteric latices with a diameter of 250 nm and much larger spherical silica (diameter, 1590 nm) of narrow size distribution, were investigated as a function of pH, particle number concentration, the ratio of their concentrations and ionic concentration. Under a suitable mixing condition, i.e., the condition including dilute silica particles and a large



excess of the latex particles of dissimilar charge, a stable system consisting of composite particles formed by the regular deposition of the latex particles on the silica can be prepared. Analyses of the conditions for forming such a regular heterocoagulation and of the properties of the products have been done using the theories of D.L.V.O. and heterocoagulation. (Author abstract) 7 refs. In Japanese.

Furusawa, Kunio (Univ of Tsukuba, Sakura-mura, Jpn); Anzai, Chikai. *Kobunshi Ronbunshu* v 44 n 6 1987 p 483-489.

**082442 HETEROCOAGULATION OF POLYMER LATTICES WITH SPHERICAL SILICA; ADSORPTION OF LATEX PARTICLES ONTO SILICA PARTICLE SURFACE AND ITS DESORPTION BEHAVIOR.** The adsorption behavior of amphoteric polymer lattices with a radius of 125 nm on large spherical particles of silica was studied as a function of pH, electrolyte concentration and the particle number concentration. Under the usual conditions, the adsorption isotherms are of a high affinity type with a pronounced plateau; the plateau value increases with increasing the electrolyte concentrations. Desorption experiments show that the adsorption is essentially irreversible except for the adsorption which occurred under high alkaline conditions (pH > 11.5). (Author abstract) In Japanese. 4 refs.

Furusawa, Kumio (Univ of Tsukuba, Sakura-mura, Jpn); Anzai, Chikai. *Kobunshi Ronbunshu* v 44 n 11 1987 p 839-843.

**082443 STUDY ON LATEX STABILITY AND PERMEATION OF COAGULANT IONS ON SEED COAGULATION OF POLYMER LATEX.** The decrease of latex stability during the step of growing particles in the seed coagulation of polymer latex was studied and the following results were obtained. The decrease of the stability is caused by the permeation of coagulant ions from particles into latex dispersion medium. The rate of the ion permeation is proportional to the rate of growing particles. The rate of the ion permeation increased with temperature corresponds to the increase of diffusion coefficient of the ion. (Author abstract) In Japanese. 4 refs.

Yasui, Hideo (Kanegafuchi Chemical Industry Co, Takasago, Jpn); Douno, Yoshihisa; Okada, Wataru; Morikawa, Hisashi. *Chem Express* v 3 n 3 Mar 1988 p 199-202.

**Light Scattering** See Also ULTRAVIOLET RADIATION—Absorption.

**082444 APPLICATION OF INTERACTIVE IMAGE ANALYSIS TO LIGHT SCATTERING PATTERNS OF SOME POLYMER SYSTEMS.** In this paper we describe a system for interactive picture analysis useful for extraction of various types of physical information from both real- and Fourier-space images. The possibility of hardware and software operations are illustrated, with examples of applications such as analysis of light scattering patterns from phase separated systems, semicrystalline polymer films with significant supermolecular morphology and from less regular polymer systems with a pronounced 'speckle effect'. The analysis concentrates on both spatial and time dependent scattering processes and measurements of intensity correlation of scattered light. Although the present examples of application are limited to light scattering patterns of polymer systems, the technique of interactive picture analysis is useful for quantitative extraction of information from real- and Fourier-space images of arbitrary structure. (Author abstract) 27 refs.

Krug, H. (Max-Planck Inst fuer Polymerforschung, Mainz, West Ger); Holoubek, J.; Fischer, E.W. *Colloid Polym Sci* v 265 n 9 Sep 1987 p 779-785.

**082445 ELONGATIONAL FLOW BIREFRINGENCE OF POLY(STYRENE SULFONATE).** The elongational flow birefringence of aqueous poly(styrene sodium sulfonate) solutions has been measured in a crossed-slot flow cell. The relaxation times calculated

from the onset of birefringence were significantly longer than relaxation times determined from intrinsic viscosity measurements or reported for transient electric birefringence measurements. Direct observation of the flow birefringence patterns showed a more complex pattern than expected for simple non-interacting flexible polymers. A molecular connectedness of the flow-elongated polymers, was the most plausible explanation for the longer relaxation times, even for polymer concentrations well below the overlap concentration. (Author abstract) 15 refs.

Farinato, R.S. (American Cyanamid Co, Stamford, CT, USA). *Polymer* v 29 n 1 Jan 1988 p 160-167.

**Low Temperature Properties** See Also POLYVINYL CHLORIDE—Viscoelasticity.

**082446 POLYMERS AT LOW TEMPERATURES.** This conference proceedings contains 13 papers. Low temperature properties and applications of polymers are covered. Some of the properties discussed are mechanical properties, chemical resistance, dielectric properties, physical properties, microstructure, glass transition, fracture, and thermal effects. The low temperature applications include rubber products, plastic foams as insulation for liquefied natural gas tanks; polymer tapes for superconducting cables; and elastomeric seals. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11284 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Plastics & Rubber Inst, Polymer Properties Group, Engl). *Polym at Low Temp, London, Engl, Jan 20 1987* Publ by Plastics & Rubber Inst, Engl, 1987 var pagings.

**Lubrication**

**082447 LUBRICATION OF MINIATURE POLYMERIC SYSTEMS - A REVIEW.** The lubrication of miniature polymeric systems, i.e., metal-polymer or polymer-polymer material combinations is a very effective way to improve their tribological properties, and especially to reduce their wear as compared to the wear during unlubricated sliding. The oil should effectively wet the polymers used, have a different solubility parameter and consist of a high-molecular-weight substance (e.g., fluorinated polyether having a molecular weight ranging from 5000 to 10,000). To achieve a large reduction in adhesion by introducing oil between the rubbing surfaces, and to minimize spreading, the surface tension of the oil should be as high as possible. For the lubrication of metal-polymer systems it is reasonable to use oil having a dielectric constant higher than that of the polymer, and in the case of a polymer-polymer or any other dielectric-polymer contact, the dielectric constant of the oil should be kept between the dielectric constants of the materials used. 39 refs.

Rymuza, Zygmunt (Warsaw Technical Univ, Warsaw, Pol). *ASLE Trans* v 30 n 4 Oct 1987 p 520-525.

**Machining** See CUTTING TOOLS—Stresses.

**Magnetic Field Effects**

**082448 STATISTICS OF POLYMER CHAINS IN ORIENTING FIELDS.** The theory of a freely jointed polymer chain is modified by introduction of interactions between dipole chain segments and an orienting field. Such a field results either from external forces (e. g. external electric or magnetic fields) or represents interactions between dipole segments of chains (molecular mean-field). The distribution of orientations of chain segments and the free energy of a chain in such orienting fields are calculated and discussed. (Author abstract). 13 Refs.

Walasek, Janusz (Technical Univ, Radom, Pol). *J Polym Sci Part B* v 26 n 9 Aug 20 1988 p 1907-1922.

**Magnetic Properties**

**082449 FERROMAGNETISM IN A NEW TYPE OF ORGANIC POLYMER BASED ON BENZENE RINGS BRIDGED BY CARBONS.** A new organic polymer with a three-dimensional network of carbons is proposed as a prototype organic ferromagnet. It is composed of benzene rings bridged by carbon atoms. The ground and the excited states of  $\pi$  electrons of this polymer are studied within the Hubbard model combined with the mean-field theory, and it turns out that this polymer becomes a ferromagnet (a ferrimagnet). The one-electron energy band and the spin density at each carbon atom as well as the magnon spectrum are calculated. (Author abstract) 16 refs.

Mishima, A. (Kanazawa Inst of Technology, Nonoichi, Jpn); Nasu, K. *Synth Met* v 22 n 1 Nov 1987 p 23-33.

**Manufacture** See Also POLYETHYLENES—Linear Low Density; RUBBER, SYNTHETIC—Physical Properties.

**082450 CORROSION RESISTANCE OF STRUCTURAL MATERIALS IN MEDIA FOR PRODUCTION OF POLYVINYL BUTYRAL FOR OPTICAL APPLICATIONS.** Investigations were conducted into the corrosion of working equipment for production of PVB, (adhesive and varnish grades). In addition to this, specimens of various steel and alloys with coatings and without coatings were tested in the industrial conditions of production of PVB and in experimental equipment for production of PVB. Examination of equipment and the results of the corrosive tests show that the carbon steels cannot be used for the manufacture of equipment used in the production of PVB, since it is necessary to ensure the cleanliness of the final production with respect to their iron ion content; 12Kh18N10T corrosion-resisting steel used for the manufacture of certain members of equipment used in various stages of polymerization, saponification, dissolution of PVS, and preliminary drying of PVS is not recommended for this application. For equipment where various protective coatings cannot be used, or the use of these coatings is inefficient because of the service conditions, it is recommended that corrosion-resisting nickel-containing steels, clad steels, KhN65MV alloy, and titanium be used. 3 refs.

Tarakanovskaya, O.A.; Zhil'tsov, N.P.; Vericheva, L.A.; Nikolaeva, I.N. *Chem Pet Eng* v 22 n 7-8 Jul-Aug 1986 p 392-393.

**Mass Transfer**

**082451 RADIOISOTOPE TECHNIQUES FOR THE STUDY OF DIFFUSION IN POLYMERS.** Radioisotopes can serve as a suitable tool for the study of diffusion in polymers. Two different methods have been used for this purpose: radiometric measurements, which enables to determine the total amount of substance diffused into polymers and to compute diffusion coefficients, and autoradiographs, which can yield the distribution of substances in polymer and also the local concentration of diffused substances. (Edited author abstract) 3 refs.

Joks, Z. (Natl Research Inst for Materials, Prague, Czech). *Polymer* v 28 n 11 Oct 1987 p 1821-1823.

**Materials**

**082452 NEW ORGANOMETALLIC POLYMERS CONTAINING TUNGSTEN CARBENE COMPLEXES.** The authors report on the polymerization of the tungsten-carbene vinyl monomer 1, which affords the first polymeric material 2 to contain repeating transition-metal carbene fragments, the characterization of this new polymer, and some initial findings dealing with its reactivity. It is shown that upon preparing the  $\alpha,\beta$ -unsaturated tungsten carbene complex 1, an insoluble orange solid was frequently observed. Nevertheless, this orange solid could be avoided if complex 1 was purified immediately after preparation and then stored at  $-30^\circ\text{C}$ . Purification involved chromatography on silica gel at  $-20^\circ\text{C}$  with the resulting pentane eluent collected at  $0^\circ\text{C}$ . It was subse-



quently found that if complex 1 was allowed to melt (ca. 10°C) and then stand at this temperature in a nitrogen atmosphere for 7 days, a dark red polymeric glass formed. 31 refs.

Macomber, David W. (Kansas State Univ, Manhattan, KS, USA); Hung, Mu-Huang; Liang, Mong; Verma, Akhilkumar G.; Madhukar, Puttannachetty. *Macromolecules* v 21 n 4 Apr 1988 p 1187-1189.

## Mathematical Models

**082453 MECHANICAL INSTABILITY OF AMORPHOUS POLYMERIC NETWORKS: ASYMMETRIC DEFORMATION UNDER SYMMETRIC BIAxIAL TENSION.** Asymmetric deformation of a symmetrically loaded rubber sheet was observed, many years ago, by L.R.G. Treloar in his experiments on natural rubber. The problem has recently been studied by E.A. Kearsley, and the possibility of asymmetric deformations in an equi-biaxial state of force is predicted by the use of phenomenological constitutive relations. In the present study, the problem is analyzed in relation to the molecular constitution of rubber networks. It is shown that mechanical instability in symmetrically loaded networks may be possible only for limited choices of molecular parameters such as junction functionality, degree of crosslinking, and the degree of swelling during crosslinking and during deformation. Stability of multiple valued deformations is discussed by thermodynamic considerations of the elastic potential. (Edited author abstract) 12 refs.

Erman, Burak (Bogazici Univ, Istanbul, Turk). *J Polym Sci Part B* v 26 n 6 Jun 1988 p 1297-1305.

**082454 STATISTICAL MODEL FOR THE UV LASER ABLATION MECHANISM OF POLYMERS.** A fundamental understanding of UV ablation of polymers is still missing. A microscopic model is presented illustrating the basic mechanism and the existence of threshold of ablation. It is realized that a proper model has to consider the random nature of quantum physical photon absorption. (Edited author abstract) 10 refs.

Kiss, L.B. (JATE Univ, Szeged, Hung); Simon, P. *Solid State Commun* v 65 n 10 Mar 1988 p 1253-1254.

**082455 CONCENTRATION PROFILES OF ROD-LIKE POLYMERS IN NARROW CHANNELS.** The concentration profiles of a rod-like polymer in a channel of width less than twice the polymer length are determined under the condition that Brownian forces are dominant. The constraints posed by a second wall are a new feature to the previously described solution for such polymers near a single, nonadsorbing wall (L. Auvray, *J. Phys. (Paris)* 42, 79 (1981)). The simple method of counting configurations outlined here could be extended to more complex geometries or to rod-like polymers experiencing long range interactions from a nearby surface. (Author abstract) 15 refs.

Hoagland, David A. (Univ of Massachusetts, Amherst, MA, USA). *J Colloid Interface Sci* v 123 n 1 May 1988 p 117-121.

**082456 MONTE CARLO SIMULATION OF LATTICE MODELS FOR MACROMOLECULES.** This article reviews various methods for the Monte Carlo simulation of models for long flexible polymer chains; namely self-avoiding random walks at various lattices. This problem belongs to the classical applications of Monte Carlo methods since more than thirty years, and numerous techniques have been devised. Nevertheless, there are still many open questions, relating to the validity of the algorithms in principle, as well as to the accuracy of the results that can be obtained in practice. This review presents a brief introduction to these problems, discusses the basic ideas on which the various algorithms are based as well as their limitations, and describes a few typical physical applications. Most emphasis is on the simulation of single, isolated chains representing macromolecules in dilute solution, but the simulation of many-chain systems is also dealt with briefly. An outlook on related problems (simulation of off-lattice chains, branched instead of linear

polymers, etc.) is also given, as well as a discussion of prospects for future work. (Author abstract). 222 Refs.

Kremer, Kurt (Johannes-Gutenberg-Univ Mainz, Mainz, West Ger); Binder, Kurt. *Comput Phys Rep* v 7 n 6 Jun 1988 p 261-310.

**082457 EFFECTS OF FREE VOLUME ON STRESS RELAXATION WITH BOND BREAKING IN POLYMERIC MATERIALS.** This work is a part of a program aimed at understanding the response of polymer chains to external mechanical forces. The response may be nondestructive or destructive, and competition between the two types exists. Molecular dynamics was used to simulate systems of polymer chains on a computer. A constant strain was imposed, as in experimental stress relaxation tests. Free volume was varied, and its effect on relaxation rate and on bond breaking was studied. A crossover exists between the region in which the chain relaxation capability is sufficient and the region where the breaking of a small number of bonds leads to crack propagation. The results are significant for polymers, conventional polymer-based composites, and liquid-crystalline molecular composites. (Author abstract) 24 refs.

Brostow, Witold (Drexel Univ, Philadelphia, PA, USA); Turner, David P. *J Rheol* v 30 n 4 Aug 1986, Symp on Appl of Equat of State Rheol at the 57th Annu Meet of the Soc of Rheol, Ann Arbor, MI, USA, Oct 1985 p 767-780.

## Measurements See Also GELS—Research.

**082458 EXPERIMENTAL AND THEORETICAL STUDIES ON THE REDOX PROPERTIES OF CONDUCTING POLYMERS.** Voltammetric measurements on selected polypyrrole (PPy) films and defined soluble oligomers belonging to the oligo-p-phenylene and the oligo-p-phenylenevinylene series provide new insights into the charging/discharging properties of conducting polymers. It turns out that the current response in the whole accessible potential range of conventional conducting polymers is mainly caused by faradaic charge transfer reactions rather than capacitive effects. This is supported by digital simulations which are based on a model of n-fold electron transfers within a finite layer. In addition, from the data of defined oligomers it becomes clear that the number and energies of accessible redox states in such materials depend on the extension of conjugation in the monomeric unit and on the chain length of the polymer. (Edited author abstract) 33 refs.

Heinze, Juergen (Univ Freiburg, Freiburg, West Ger); Stoerzbach, Michael; Mortensen, John. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem, of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 960-967.

**Mechanical Properties** See Also AROMATIC POLYMERS—Hydrolysis; BLOCK COPOLYMERS—Physical Properties; BLOCK COPOLYMERS—Synthesis; COATINGS—Plastics; ELASTOMERS—Degradation; ELASTOMERS—Fillers; ELASTOMERS—Physical Properties; EPOXY RESINS—Curing; EPOXY RESINS—Modification; MATERIALS TESTING—Fracture; MELAMINE FORMALDEHYDE RESINS—Curing; NYLON POLYMERS—Anisotropy; PLASTICS—Coextrusion; PLASTICS—Molecular Structure; PLASTICS—Processing; POLYCARBONATES—Hydrolysis; POLYETHYLENE TEREPHTHALATE—Deformation; POLYIMIDES—Elasticity; POLYPROPYLENE—Viscoelasticity; POLYURETHANES—Morphology; POLYVINYL CHLORIDE—Mechanical Properties; SYNTHETIC FIBERS—Deformation; THERMOPLASTICS—Physical Properties; THERMOSETS—Curing; THERMOSETS—Elasticity.

**082459 DETERMINATION OF THE FLEXIBILITY PARAMETER OF POLYMERS.** This paper deals with the determination, in theta conditions, of the flexibility parameter  $\lambda$  defined by Kratky-Porod for random-coiled polymers, using three different methods: (a) from hydrodynamic data in  $\theta$  conditions, (b) by using a new form of extrapolation to zero of the corresponding values for the average molecular weight, and (c) by extrapolation of  $\lambda$  tending to zero. From method (b), values of the interaction parameter, B, were in agreement with those from Stockmayer-Fixman theory. (Edited author abstract) 48 refs.

Guzman, Gonzalo M. (Univ del Pais Vasco, Spain); Zamora, Fernando; Gonzalo, Guzman M.; Leon, Luis M. *J Macromol Sci Phys* v B26 n 3 Sep 1987 p 257-279.

**082460 WYCISKANIE HYDROSTATYCZNE JAKO METODA MODYFIKACJI MECHANICZNYCH WLASTCIWOSCI POLIMEROW.** [Modification of Mechanical Properties of Polymers by Hydrostatic Extrusion]. On the basis of selected papers from technical literature the method of hydrostatic extrusion of plastics has been presented as a way of modifying some mechanical properties of plastics. The methods of hydrostatic extrusion have been classified. Criteria of applicability of this process to polymers and methods of their preliminary preparation have been presented. (Edited author abstract) In Polish. 10 refs.

Bielefeldt, Karol (Wyzsza Szkola Inzynierska, Zielona Gora, Pol); Kurpiewski, Janusz. *Polimery* v 32 n 7 Jul 1987 p 284-287.

**082461 MOLECULAR WEIGHT DEPENDENCE OF MECHANICAL PROPERTIES OF POLY(p,p'-OXYDIPHENYLENE PYROMELLITIMIDE) FILMS.** The mechanical properties, i.e., Young's modulus, elongation, and tensile stress, were determined as functions of the molecular weight for films of poly(oxydi-p-phenylene pyromellitimide) prepared by thermal cyclization of the precursor poly(amic acid). The molecular weights of the samples were controlled by the monomer stoichiometry employed for the solution condensation of pyromellitic dianhydride and p,p'-oxydianiline. Weight-average molecular weights were determined by light scattering of the precursor poly(amic acid) as well as the fully cyclized polyimide. (Edited author abstract) 14 refs.

Volksen, W. (IBM, Jan Jose, CA, USA); Cotts, p.; Yoon, D.Y. *J Polym Sci Part B* v 25 n 12 Dec 1987 p 2487-2495.

**082462 POLYMERS IN PURSUIT OF STRENGTH.** The author discusses the three techniques for achieving the desired stiffness in plastics: cross-linking, achieving order in the melt or in solution; and chain-entanglement two incompatible polymers. Liquid crystal characteristics are summarized and lyotropic and thermotropic liquid crystal are examined. Incompatible polymer combinations are discussed from the viewpoint of their forming and processing. 13 refs.

Wittcoff, Harold A. *CHEMTECH* v 17 n 3 Mar 1987 p 156-160.

**082463 METHODS OF INVESTIGATION: THE TECHNIQUE FOR THE DETERMINATION OF THE DISCONTINUOUS LEVELS OF STRENGTH ON POLYMERS.** The aim of this paper is to show on the basis of a more statistically significant range of samples that the reproducibility of the discrete levels of strength is real. It is to be verified at the same time that the nature of the results is connected with the structure of the polymer films and that the results are not dependent on random variation in processing of experimental results. The reproducibility of the distribution curves for the strength of PET films obtained by statistical methods during repeated testing has been analyzed. With a sufficient number of samples, seven distinct levels of strength were reproducibly detected. (Edited author abstract) 6 refs.

Bartenev, G.M. (USSR Acad of Sciences, USSR); Tsoi, B. *Polym Sci USSR* v 28 n 8 1986 p 1991-1993.

**082464 STRUCTURE AND PROPERTIES OF FATIGUED SEGMENTED POLY(URETHANEUREA)S II. STRUCTURAL ANALYSES OF FATIGUE MECHANISM.** The fatigue mechanism of segmented poly(urethaneurea)s due to a sinusoidal strain was investigated from the structural point of view by means of small angle light scattering (SALS), small angle X-ray scattering (SAXS), and infrared dichroism (IRD) and was compared with the uniaxial deformation mechanism. The SALS



patterns of the original sample films indicated the existence of a spherulite texture. There appeared a ring diffraction pattern in the SAXS photograph for the as-cast sample. The fatigued mechanism is proposed in order to account for the experimental results based on the spherulite deformation model. It was also found that samples having longer soft segments have higher degree of phase separation at the beginning and that these mechanical properties and orientational behavior are less sensitive to fatigue time. (Edited author abstract) 25 refs.

Shibayama, Mitsuhiro (Kyoto Inst of Technology, Kyoto, Jpn); Ohki, Yuichi; Kotani, Tetsuo; Nomura, Shunji. *Polym J* v 19 n 9 1987 p 1067-1080.

**082465 EFFECT OF METHYLENE CHLORIDE SORPTION ON THE MECHANICAL PROPERTIES OF POLY(ARYL-ETHER-ETHER-KETONE) (PEEK).** The effect of sorbed methylene chloride on the tensile strength and fatigue crack growth (FCG) resistance of PEEK were determined. PEEK sorbs up to 23 wt% methylene chloride; the transport process is essentially Case II, that is, the methylene chloride advances as a sharp front. Sorbed methylene chloride significantly reduces the tensile strength of neat PEEK and the strength reduction is linearly proportional to the amount of solvent sorbed. FCG rates in neat PEEK are increased by the methylene chloride sorption. At saturation, the FCG rates are two orders of magnitude higher than in dry PEEK. Methylene chloride plasticizes the resin, thereby reducing its glass transition temperature ( $T_g$ ), tensile strength, and FCG resistance. (Author abstract) 4 refs.

Pao, Peter S. (McDonnell Douglas Research Lab, St. Louis, MO, USA); Grayson, Michael A.; Wolf, Clarence J. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 727-732.

**082466 PLATEAU VALUE OF ELASTIC MODULUS OF A LINEAR AMORPHOUS POLYMER USING INTERMOLECULAR FORCES.** An expression is derived from the intermolecular force theory for the plateau modulus of a linear amorphous polymer. The entanglement hypothesis need not be invoked. (Edited author abstract) 4 refs.

Porter, D. (Dow Chemical (Nederland) BV, Terneuzen, Neth). *Polym Commun (Guildford Engl)* v 29 n 3 Mar 1988 p 75-76.

**082467 EFFECTS OF MECHANICAL DRAWING ON THE STRUCTURE AND PROPERTIES OF PEEK.** This study examines the effects of crystallinity and temperature on the mechanical properties of PEEK. Crystallinity in PEEK increases with annealing temperature up to a maximum of 28 percent with a melting point at 335°C. A minor melting peak also occurs about 10°C above the annealing temperature. In cold drawing the samples exhibited a yield stress and necking followed by homogeneous drawing. The yield stress increases with crystallinity, but there is no change in the modulus. The extension in the necking process also increases with crystallinity, however there is only a slight increase in extension-to-break since necking is compensated by the final amount of homogeneous drawing. The yield stress of PEEK when drawn at  $T_g(145^\circ\text{C})$  is significantly lower than at room temperature indicating a reduction in mechanical properties at temperatures approaching  $T_g$ . After mechanical drawing the minor melting peak disappears and on heating the material undergoes cold crystallization near the onset of  $T_g$ . (Edited author abstract) 16 refs.

Lee, Lidia H. (US Army Materials Technology Lab, Watertown, MA, USA); Vanselow, Janice J.; Schneider, Nathaniel S. *Polym Eng Sci* v 28 n 3 Mid-Feb 1988 p 181-187.

**082468 ENGINEERING RESINS GO TO HIGHER PERFORMANCE.** Engineering polymers are thermoplastics to which standard metal engineering equations can be applied. They are capable of sustaining high loads and stresses. They can perform for long periods over wide temperature ranges and in difficult chemical and physical environments. This survey assesses the status and poten-

tial for engineering materials in replacing metals for a wide variety of structural applications. It projects an average 8% growth through the end of this century.

Fleming, Richard A. (Dupont Co, Wilmington, DE, USA). *Mod Plast* v 64 n 11 Nov 1987 p 112, 114, 116.

**082469 EFFECT OF AN AGGRESSIVE MEDIUM AND MECHANICAL STRESS ON POLYMERS. REVIEW.** The published material on the problem of the action of an aggressive medium and mechanical stress on polymers is reviewed and systematized. Special attention is paid to the degradation of polymers resulting from mechanical stress and also the effect of degradation on the mechanical properties of polymer materials. It is shown that to evaluate the mechanical performance of polymers in aggressive media it is necessary to represent the relationship between the process occurring in aggressive media and the mechanical properties and stress in polymers. (Edited author abstract) 66 refs.

Rudakova, T.Ye. (USSR Acad of Sciences, USSR); Zaikov, G.Ye. *Polym Sci USSR* v 29 n 1 Jan 1988 p 1-19.

**082470 TOUGHENED BLENDS OF POLY(BUTYLENE TEREPHTHALATE) AND BPA POLYCARBONATE. PART 2: TOUGHENING MECHANISMS.** The toughening mechanisms of blends of poly(butylene terephthalate) (PBT) and bisphenol-A polycarbonate (PC) toughened with core/shell impact modifier have been studied by transmission electron microscopy, notched impact testing and uniaxial tensile dilatometry. In toughened PBT and toughened PBT/PC blends, shear deformation is the major toughened mechanism. Brittleness at low temperatures is caused by a reduction in the major toughening mechanism. Brittleness at low temperatures is caused by a reduction in the ability of the matrix to undergo shear deformation. In tensile dilatometry this effect is indicated by an increase in the internal cavitation of the impact modifier particles. The low temperature impact toughness of toughened PBT/PC blends is greater than that of toughened PBT. Modification of PBT with partially miscible PC appears to have a beneficial effect on the ability to undergo shear deformation. This effect has been attributed to the PC residing in the amorphous interlamellar regions of the PBT spherulites, thus facilitating interlamellar slip. (Author abstract) 8 refs.

Dekkers, M.E.J. (GE, Schenectady, NY, USA); Hobbs, S.Y.; Watkins, V.H. *J Mater Sci* v 23 n 4 Apr 1988 p 1225-1230.

**082471 METHODS OF INVESTIGATION USE OF THE TEMPERATURE WAVE METHOD FOR INVESTIGATING THERMAL RELAXATIONAL PROCESSES IN POLYMERS.** The method of temperature waves is used for the first time to determine the complex thermophysical characteristics of materials, and the advantages of the method are considered. In the case of flat temperature waves, the solution of the linear problems of heat conductivity, making due allowance for the finite character of the rate of heat dissipation, provides a means of deriving expression for calculating the moduli and arguments of complex thermophysical characteristics. In the region of the glass transition temperature of polyvinyl acetate (PVA) its thermophysical characteristics are complex quantities depending on the frequency of the temperature vibrations, which reflects the relaxational character of the heat accumulation and transfer processes associated with segmental mobility. (Author abstract) 11 refs.

Polikarpov, Yu. I. (M.I. Kalinin Polytechnical Inst, Leningrad, USSR). *Polym Sci USSR* v 29 n 2 Feb 1987 p 476-479.

**082472 METHOD FOR CALCULATING DYNAMIC MECHANICAL PROPERTIES USING FOURIER TRANSFORMS OF PULSE DEFORMATION EXPERIMENTS.** A general method for determining the dynamic mechanical properties of a material is presented. It involves Fourier transforms of the stress and strain responses of a material subject to arbitrary deformation. As an example, uniaxial pulse-strain deformations were used to calculate the dynamic properties of a cured

epoxy. A comparison of the properties calculated from uniaxial sinusoidal deformations and those obtained by Fourier transform analysis of the uniaxial pulse-strain indicate excellent agreement over a wide range in mechanical behavior. These results suggest that dynamic mechanical properties may be obtained when deformations other than that of a sine wave are used. (Author abstract) 4 refs.

Vratsanos, Menas S. (Univ of Massachusetts, Amherst, MA, USA); Farris, Richard J. *J Appl Polym Sci* v 36 n 2 Jul 5 1988 p 403-413.

**082473 EXPERIMENTAL VERIFICATION OF A MICROBUCKLING MODEL FOR THE AXIAL COMPRESSIVE FAILURE OF HIGH PERFORMANCE POLYMER FIBRES.** A previously derived theoretical compressive strength for fibres composed of uniaxially oriented and extended polymer chains is compared with the measured strengths of several high performance fibres. For failure initiated by elastic microbuckling of polymer chains or fibrils, the maximum fibre strength is predicted to be equal to the minimum longitudinal shear modulus of the fibre. An excellent linear correlation between measured strengths and torsion moduli was obtained for four liquid crystalline polymer fibres and high modulus graphite fibres. The correlation shows that measured strengths are 30% of the corresponding torsion moduli for these fibres. A high modulus, high strength polyethylene fibre exhibited a compressive strength-torsion modulus ratio that was lower than the value 0.3 obtained for the other fibres examined. (Author abstract) 39 refs.

DeTeresa, Steven J. (Univ of Massachusetts, Amherst, MA, USA); Porter, Roger S.; Farris, Richard J. *J Mater Sci* v 23 n 5 May 1988 p 1886-1894.

**082474 MAKING THE PLASTICS CONNECTION.** Improvements in the performance of engineering plastics has made them ideal materials for use in the electronics industry, and particularly for use as connectors. Good dimensional stability, high electrical insulation properties, and improved thermal properties have all combined to expand the opportunities available to the plastics suppliers in the electronics industry. With liquid crystal polymers (LCPs), the effect is to produce an anisotropic structure which is stronger and stiffer than other types of plastic. Significant properties of this material include the ability to tune the thermal expansion to zero, positive, or even negative values, and so match virtually any substrate. The material also has a very high temperature tolerance. Vectra is the best known of the LCPs, and a case-study of the selection of Vectra for a parallel interconnect indicates some of the key properties of this material.

Anon. *Eng Mater Des* v 32 n 6 Jun 1988 p 25-26, 28-29.

**082475 NEW METHOD FOR WORKING OUT  $\alpha_T$  (T) FROM DYNAMIC MECHANICAL TEMPERATURE SPECTRA.** A method is developed for determining  $\alpha_T(T)$  from dynamic mechanical temperature spectrum. This method provides a new and simple means for obtaining  $\alpha_T(T)$  of polymers. It is shown that viscoelastic properties predicted by calculation are in agreement with the experimental results. The combination of previous and present papers has established the theory and method for determining relaxation and retardation spectra and other viscoelastic functions from dynamic mechanical temperature spectrum at a constant frequency. The results for polyethylene terephthalate fibers are presented. 3 refs.

Huang, Jianhua (China Textile Univ, China); Guan, Guihe; Sun, Tong. *J Polym Eng* v 7 n 4 Oct 1987 p 305-318.

**082476 TYPES AND MECHANISMS OF NON-LINEARITY IN THE MECHANICAL BEHAVIOUR OF POLYMERS.** The concepts of possible types of non-linear mechanical behavior of polymeric materials and of different mechanisms responsible for the non-linearity are generalized. The weak (geometrical) non-linearity depends on an intrinsic material function



(relaxation spectrum) which characterizes the linear behavior of the material. The strong (physical) non-linearity is associated with reorganization of structure, although in some instances it is also governed by the linear relaxation spectrum. The ultimate non-linearity, reflected in a stepwise change of properties, appearance of instabilities, and a loss of material integrity, is given by phase or relaxation transitions induced by deformation. (Edited author abstract). 19 Refs.

Malkin, A. Ya. (Scientific-Production Union Plastmassy, USSR). *Polym Sci USSR* v 29 n 4 1987 p 886-892.

**Medical Applications** See Also BIOMATERIALS—Reviews; COPOLYMERS—Molecular Weight; DRUG PRODUCTS—Synthesis.

**082477 POLIMERI IN MEDICINA: II RILASCIO GUIDATO DEI FARMACI.** [Polymers in Medicine]. Tablets to be taken orally, plasters to be put on the skin, and pills to be injected under skin ensure the prolonged and controlled release of various medical products. This new frontier of pharmaceutical chemistry has been achieved thanks to the pharmaceutical properties and the use of polymers. (Author abstract) In Italian. 6 refs.

Anon. *Mater Plast Elastomeri* n 2 Feb 1987 p 67-71.

**082478 REACTION OF  $\alpha,\beta$ -POLY(N-HYDROXYETHYL)-DL-ASPARTAMIDE WITH DERIVATIVES OF CARBOXYLIC ACIDS.** Benzoic acid, acetylsalicylic acid, and 4-acetamidobenzoic acid have been covalently linked by ester bonds to  $\alpha,\beta$ -poly(N-hydroxyethyl)-DL-aspartamide (PHEA), a water soluble and nontoxic polymer, in order to study PHEA as a drug carrier. (Author abstract) 10 refs.

Giammona, Gaetano (Univ de Palermo, Palermo, Italy); Carlisi, Bianca; Palazzo, Salvatore. *J Polym Sci Part A* v 25 n 10 Oct 1987 p 2813-2818.

**082479 PREDICTION OF DRUG SOLUBILITIES IN POLYMERS.** We have recently discussed the correlation of octanol-water and polymer-water partition coefficients and the use of such correlations as a tool to estimate solubilities in polymers. The correlation permits determination of the relative solubilities of a solute in different polymers as a function of solute lipophilicity; when combined with the aqueous solubility of the solute, it may be used to estimate absolute solubilities in polymers. This ability to estimate relative and absolute solubilities is useful in such technologies as membrane separations, drug delivery, and polymer packaging. In this letter, we report more complete correlation data, analysis of which shows that the slope of the correlation equation for six polymers is proportional to the solubility parameter of the polymer, while the intercept can be derived from the solubility of water in the polymer bulk. 19 refs.

Bao, Y.T. (Research Triangle Inst, Research Triangle Park, NC, USA); Samuel, N.K.P.; Pitt, C.G. *J Polym Sci Part C* v 26 n 1 Jan 1988 p 41-46.

**082480 BIOMEDICAL APPLICATIONS OF SYNTHETIC POLYMERS.** Synthetic polymers are fast replacing conventional engineering materials in many fields. And the field of medicine is no exception. This article is an attempt to review the current status and the future prospects. A survey of the various medically useful polymers shows that no homopolymer can ever functionally mimic a given biological material. As a rule, all biological materials are composites with unique hierarchical organizations. It is solely because of this architectural style that they exhibit a combination of diverse engineering characteristics. Consequently the right way to design a synthetic substitute for a given biological tissue is to gain a thorough comprehension of the structural organization of the tissue at the molecular level. The next step is to try to reproduce that hierarchical organization with the medically selective materials. Attempts to produce carbon fiber reinforced composites of UHMWPE and HDPE are steps towards this goal. 58 refs.

Chatterji, Prabha R. (Banaras Hindu Univ, Varanasi, India). *J Sci Ind Res* v 46 n 4 Apr 1987 p 168-171.

**082481 SURFACE MODIFICATION BY A TWO-LIQUID PROCESS DEPOSITION OF A-B BLOCK COPOLYMERS.** The surface modification technique presented here involves the deposition of an A-B block copolymer onto the surface of a hydrophobic polymer. By employing a two-liquid method, the block copolymers are deposited onto the hydrophobic surface in such a way that the hydrophobic block is embedded into the solid while the hydrophilic block remains exposed at the surface. The deposition of the block copolymer increases the polar component of the solid's surface free energy and decreases the dispersion component. By depositing a block copolymer containing either polyethylene-oxide or polyvinylpyrrolidone as the hydrophilic block, the biocompatibility of that surface could be enhanced through the reduction of the solid-liquid interfacial free energy, and through the inhibition of protein adsorption by the steric repulsion by the polymeric chains. 18 refs.

Ruckenstein, Eli (State Univ of New York, Buffalo, NY, USA); Chung, Dennis Byungip. *J Colloid Interface Sci* v 123 n 1 May 1988 p 170-185.

**082482 HYDROGELS AS CONTACT LENS MATERIALS.** The contact lens does have certain unique features which set it apart from other areas of biomedicine. The design and fitting of the lens can play an overriding part in governing the patient's response to a given material, although this is to a large extent offset by the relative ease of insertion and removal of the device, which means that the clinician can optimize the 'fit' of the lens. Thus, it is much easier in this than most other fields to compare the response of reasonably large numbers of patients to different materials under conditions in which variables related to design and fitting have been isolated. For this reason, the research carried out in recent years into the use of polymers in contact lenses has provided information on a range of materials which will greatly assist future work on their use in other biomedical applications. 170 refs.

Tighe, Brian J. (Univ of Aston, Birmingham, Engl). *Hydrogels in Med and Pharm* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 v 3, p 53-82.

**082483 BIOERODIBLE HYDROGELS.** The major driving force for the development of bioerodible hydrogels is a need for materials that are useful in surgical procedures and in improved methods for the administration of therapeutic agents. A majority of bioerodible hydrogels are based on natural polymers. However, a number of systems based on synthetic polymers have also been described. 63 refs.

Heller, Jorge (SRI Int, Menlo Park, CA, USA). *Hydrogels in Med and Pharm* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 v 3, p 137-150.

**Melting** See Also MOLECULES—Research; POLYCARBONATES—Crystallization; POLYETHYLENE TEREPHTHALATE—Crystallization; RELAXATION PROCESSES—Theory.

**082484 USE OF A CONTINUUM MODEL FOR CALCULATING POLYMER MELTING CHARACTERISTICS.** The conformational entropy and the conformational free energy of melting of polymethylene and its oligomers are calculated on the assumption that the spectrum of the conformations is continuous. The estimates of the intermolecular and intramolecular contributions to the entropy (24 and 76% respectively) and the enthalpy (60.5 and 39.5% respectively) of melting of polymethylene are in agreement with experiment. The feasibility of theoretical calculation of the melting points of polymers is discussed. (Author abstract) 43 refs.

Rabinovich, A.L. (USSR Acad of Sciences, USSR); Dashevskii, V.G. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2819-2827.

**082485 POLYMER MELT DYNAMICS MODEL WITH A RELAXATION TIME EXPONENT OF 10/3.** In this paper we present a more precise calculation for the time it takes a group of chains to empty a sphere for the

first time. In view of the Scher-Shlesinger hypothesis, this is related to the rate of junction loss and, hence, stress relaxation in the terminal zone. Within de Gennes's original reptation model of kink-generated motion, we follow Scher-Shlesinger to treat the measured polymer melt diffusion constant as a single chain quantity and the reptation time as a multichain quantity to reconcile for the first time the experimentally observed and theoretical compatible results  $D \approx M^{-2}$  and  $\tau_r \approx M^{10/3} / (\ln M)^{2/3}$  in which the logarithmic term would not ordinarily be detectable. 17 refs.

Weiss, George H. (NIH, Bethesda, MD, USA); Bendler, John T.; Shlesinger, Michael F. *Macromolecules* v 21 n 2 Feb 1988 p 521-523.

**082486 ERRORS IN OMITTING RADIAL CONVECTION IN POLYMER MELT FLOW SIMULATIONS.** In the past the numerical simulation of polymer melt flows in channels has usually been carried out by neglecting the radial velocity component in both the momentum and energy equations. Attempts to include it showed temperature oscillations becoming more severe for convection-dominated flows. New results based on a finite-element streamline-upwind/Petrov-Galerkin method to treat the convective and viscous dissipation terms show that in nonisothermal studies of polymer melt flows, the temperature gradients due to the temperature dependence of the shear viscosity create radial velocity components that cannot be ignored even in cases of straight channels. The errors in omitting radial convection from the calculations are examined by comparison with available results in the literature based on such simplifications for the wire-coating process. (Author abstract) 29 refs.

Heng, F.L. (Univ of Ottawa, Ottawa, Ont, Can); Mitsoulis, E. *Numer Heat Transfer* v 13 n 4 Jun 1988 p 499-513.

**082487 3-D FINITE ELEMENT MODEL FOR POLYMER MELT FLOW.** A finite element investigation of 3-dimensional polymer melt flows in a sudden contraction is presented. In continuity with the 2-dimensional work of the authors, this study uses the augmented Lagrangian method to cope with the nonlinear rheological behavior of melts. Two kinds of situation are considered: the flow of a nonisothermal melt obeying the Carreau A model of viscosity; the isothermal flow of a Bingham fluid. (Edited author abstract). 23 Refs.

Tanguy, Philippe A. (Univ Laval, Laval, Que, Can); Fortin, Andre; Bertrand, Francois. *Adv Polym Technol* v 8 n 2 Summer 1988 p 99-113.

**Metallizing** See POLYIMIDES—Thin Films.

**Microscopic Examination** See Also EMULSIONS—Polymerization; POLYMERIZATION—Radiation Effects.

**082488 ON THE STRUCTURE OF GLASSY POLYMERS. VIII. USE OF Z CONTRAST TO ELUCIDATE THE MICROSTRUCTURE OF EPOXY AND POLYIMID RESINS.** The technique of ultramicrotomy of polymers, followed by staining of the resulting thin sections with heavy metal ions and viewing with Z enhancement in the scanning transmission electron microscope is described. When applied to anhydride-cured epoxy resins, the structure is found to be heterogeneously crosslinked on a scale of a few hundred angstrom. When the technique is applied to amine-cured epoxy resins, the microstructure is found to change from homogeneous to inhomogeneously crosslinked, depending on stoichiometries and cure cycles. For amine-cured resins whose cure conditions are within the range of microstructural change, the bright field of the stained specimens alone does not detect heterogeneities, and the Z contrast becomes crucial to discern the kind of microstructure. A commercial



polyimide film examined in the same way is found to exhibit systematic variations in structure through the thickness of the film. (Author abstract) 18 refs.

Di Filippo, G.V. (MIT, Cambridge, MA, USA); Vander Sande, J.B.; Uhlmann, D.R. *J Appl Polym Sci* v 35 n 2 Feb 5 1988 p 485-505.

**082489 ELECTRON MICROSCOPY STUDIES OF THE COFACIAL PHTHALOCYANINE POLYMERS (AlPcF)<sub>n</sub> AND (SiPcO)<sub>n</sub>.** (AlPcF)<sub>n</sub> and (SiPcO)<sub>n</sub> (Pc = phthalocyanine ligand), both of which are cofacial polymers, have been studied by electron microscopy. (AlPcF)<sub>n</sub> has been examined after being sublimed onto glass or KCl. (SiPcO)<sub>n</sub> has been examined as synthesized. Films formed by heating (SiPcO)<sub>n</sub> and condensing the resulting vapors on KCl have also been studied. It is concluded that some of the molecules in (AlPcF)<sub>n</sub> have molecular weights in the range 18000-23000 and that the rings in the molecules are eclipsed. It is also concluded that the molecules in (SiPcO)<sub>n</sub> have quite variable molecular weights. (Edited author abstract) 26 refs.

Fryer, John R. (Univ of Glasgow, Glasgow, Scotl); Kenney, Malcolm E. *Macromolecules* v 21 n 1 Jan 1988 p 259-262.

**082490 MICROFIBRILLAR NETWORK OF A RIGID ROD POLYMER. 1. VISUALIZATION BY ELECTRON MICROSCOPY.** In the coagulation stage of the spinning process of fibers and films from solutions of a rigid polymer, poly[p-phenylene(benzo[1,2-d,4,5-d'] (PBT), a monodomain nematic solution undergoes a transition to the solid state by the action of a nonsolvent. The morphology of coagulated PBT fibers and films is studied by electron microscopy, after impregnation with an epoxy resin. The basic structure formed during coagulation is observed to be an interconnected network of oriented microfibrils, having a typical width of about 100 Angstrom. Visualization of regions which have buckled under compression suggests the relevance of the buckling of the individual microfibrils to the ultimate compressive properties of PBT fibers and films. (Author abstract) 13 refs.

Cohen, Yachin (Univ of Massachusetts, Amherst, MA, USA); Thomas, Edwin L. *Macromolecules* v 21 n 2 Feb 1988 p 433-435.

**Microstructure** See Also MONOMERS—Polymerization; POLYBUTADIENES—Crystallization.

**082491 INFLUENCE OF MICROSTRUCTURE ON ELASTIC AND VISCOELASTIC PROPERTIES OF POLYETHER ETHER KETONE.** Dynamic, creep and static tests were conducted to characterize experimentally the linear elastic and viscoelastic properties of polyether ether ketone (PEEK) as a function of the degree of crystallinity. The semicrystalline polymer was modeled as a two-phase composite material. Values for crystalline modulus and effective crystallite aspect ratios have been extracted from the model. These values together with experimental creep compliance values for amorphous PEEK have been used to predict the creep response for intermediate levels of crystallinity, which compare well with the experimental data. Time-temperature shifting parameters obtained from dynamic mechanical studies compare well with those from creep experiments. At temperatures below 140°C, the shifting parameters were found to be approximately equal for all levels of crystallinity. Prediction for long-term creep has been made from these tests by properly accounting for physical aging phenomenon. (Author abstract) 23 refs.

Ogale, A.A. (Univ of Delaware, Newark, DE, USA); McCullough, R.L. *Compos Sci Technol* v 30 n 3 1987 p 185-201.

**082492 <sup>13</sup>C-NMR SPECTRA OF cis-POLYMER-CENE AND cis-POLYFARNESENE.** Homopolymers of myrcene and farnesene were prepared anionically in pure cyclohexane. The microstructure, determined from an analysis of the <sup>13</sup>C-NMR spectrum and spin-lattice relaxation times, indicates the polymers are at least 85%

cis-1,4, 10% cis-3,4, and under 3% trans-1,4. All NMR spectra were obtained on concentrated solutions (about 15 wt %) in chloroform-d on a Varian XL-200 NMR spectrometer operating at 25.16 MHz for <sup>13</sup>C. Chemical shifts are in ppm. (Edited author abstract) 22 refs.

Newmark, Richard A. (3M, St. Paul, MN, USA); Majumdar, Ramendra N. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 71-77.

**082493 REVIEW AND CRITICAL ANALYSES OF THEORIES OF AGGREGATION IN IONOMERS.** This review will be confined to a discussion of linear organic polymers having fixed ionic sidechains of exclusively either positive or negative charges, examples of these would include the ethylene-methacrylic acid copolymer salts, sulfonated polystyrene, and Nafion perfluoro-sulfonate salts. A number of molecular-based theories of polar/nonpolar microphase separation have evolved since 1970. It is the goal of this paper to review these theories critically within a historical context. 32 refs.

Mauritz, Kenneth A. (Univ of Southern Mississippi, Hattiesburg, MS, USA). *J Macromol Sci Rev Macromol Chem Phys* v C28 n 1 Feb 1988 p 65-98.

**082494 MICROSTRUCTURE IN INJECTION MOLDED SAMPLES OF LIQUID CRYSTALLINE POLY(p-HYDROXY-BENZOIC ACID-Co-ETHYLENE TEREPHTHALATE).** The microstructure of injection molded bars (2.9 and 5.8 mm thick) of thermotropic liquid crystalline poly(p-hydroxy-benzoic acid-co-ethylene terephthalate) has been studied by SEM on samples etched with n-propylamine. SEM fractography, DSC, IR, ESCA, WAXS and polarized microscopy. The 2.9 mm bar consists of three different layers: a highly oriented surface skin, an oriented intermediate layer and a non-oriented core. The 5.8 mm bar has a more complex microstructure and is composed of five different layers: a highly oriented surface skin, an oriented layer just beneath, a non-oriented layer, another oriented layer and a non-oriented core. (Edited author abstract) 28 refs.

Hedmark, Per G. (Royal Inst of Technology, Stockholm, Sweden); Rego Lopez, J. Manuel; Westdahl, Marianne; Werner, Per-Erik; Jansson, Jan-Fredrik; Gedde, Ulf W. *Polym Eng Sci* v 28 n 19 MID-OCT; 1988 p 1248-1259.

#### Microstructures

**082495 FLUORESCENCE PROBE INVESTIGATION OF ANIONIC POLYMER-CATIONIC SURFACTANT INTERACTIONS.** Pyrene and pyrene-labeled poly(acrylic acid) were used as fluorescence probes to investigate the interactions between poly(acrylic acid) and dodecyltrimethylammonium bromide. The polarity dependence of the vibrational structure of the pyrene emission spectrum indicated the formation of micelle-like surfactant aggregates at concentrations that are significantly below the critical micelle concentration (cmc). The extent of excimer formation of the polymeric probe was found to depend significantly upon the surfactant concentration. These results were interpreted in terms of polymer conformational changes induced by surfactant as well as the static versus dynamic nature of excimer formation. (Author abstract) 10 refs.

Chandar, Prem (Columbia Univ, New York, NY, USA); Somasundaran, P.; Turro, N.J. *Macromolecules* v 21 n 4 Apr 1988 p 950-953.

**Mixing** See Also ADHESIVES—Quality Control; CONCRETE—Manufacture; EQUATIONS OF STATE—Liquids; POLYETHYLENES—Thermodynamics; POLYSTYRENES—Spectroscopic Analysis.

**082496 DIFFUSION OF MISCIBLE POLYMERS IN MULTILAYER FILMS.** Thermal and optical properties of multilayer films of miscible polyethyloxazoline (PEOx) and poly(styrene-co-acrylonitrile) have been studied as a function of time and temperature. Differential scanning calorimetry showed that the distinct, characteristic T<sub>g</sub>'s of the component polymers of the original films disappear after only short heating periods above T<sub>g</sub>, and a single transition appears. The new transition region is

broad at first, but narrows on subsequent heating. The measurement of light transmittance as a function of wavelength through the heat-treated films also confirms the diffusion of the miscible polymers and gives results which are comparable to the thermal measurements. Films from immiscible polymers of polystyrene and PEOx retain their properties after various heat treatments. A qualitative discussion of the diffusion process as examined by the thermal measurements is presented. (Author abstract) 33 refs.

Keskula, H. (Univ of Texas at Austin, Austin, TX, USA); Paul, D.R.; Young, P.; Stein, R.S. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1861-1877.

**082497 ELECTRON BEAM CHARACTERISTICS OF POLY(METHYL METHACRYLATE)-POLY(VINYL CHLORIDE) MIXTURES.** This communication describes the electron beam characteristics of mixtures of PVC and poly(methyl methacrylate). The poly(vinyl chloride) changes the character of the films from being degradative to crosslinking and indicates that it is not possible to achieve successful lithography using this approach to resist formulation. (Author abstract) 8 refs.

Hayward, David (Univ of Strathclyde, Glasgow, Scotl); Affrossman, Stanley; Petrick, Richard A. *Polym Commun (Guildford Engl)* v 28 n 12 Dec 1987 p 344-345.

**082498 INFLUENCE OF CHLORINATION OF POLY(VINYL CHLORIDE) ON MISCIBILITY WITH POLY(METHYL METHACRYLATE).** The improvement of the miscibility of poly(methyl methacrylate) (PMMA) and poly(vinyl chloride) (PVC) with moderate chlorination of PVC was demonstrated by determination of cloud-point curves and glass transitions of the mixtures. Heats of mixing of low-molar-mass analogues for PMMA and for the various structural units present in chlorinated PVC (CPVC) were determined in a microcalorimeter along with Fourier transform infra-red spectroscopy of these mixtures. The results show that the improvement of miscibility is caused by a specific interaction between the carbonyl group of PMMA and predominantly the CHCl group of CPVC. The decrease in miscibility observed when more strongly chlorinated PVC is used can be ascribed to the relatively high concentration of CCl<sub>2</sub> groups, which have a less favorable interaction with the carbonyl groups. (Edited author abstract) 24 refs.

Vorenkamp, E.J. (State Univ of Groningen, Groningen, Neth); Challa, G. *Polymer* v 29 n 1 Jan 1988 p 86-92.

**082499 THERMODYNAMIC AFFINITY OF OLIGOMERIC DIMETHYLSILOXANE FOR TOLUENE AS REVEALED BY RAYLEIGH LIGHT SCATTER AND STATIC SORPTION.** Rayleigh light scatter has been used to study the general scatter and degree of depolarization of scattered light of solution of oligo-dimethylsiloxane in toluene over the whole concentration range. Static isothermal sorption of toluene vapors on the oligomer at 298 K was investigated. The concentration functions of the differences in the chemical potentials of the components Δμ<sub>i</sub> and the Gibbs mixing energy ΔG<sub>m</sub> of the oligomer with toluene have been calculated in the whole range of compositions. (Author abstract) 15 refs.

Koridze, N.V. (Gorkii Urals State Univ, USSR); Tager, A.A.; Andreyeva, V.M.; Adamova, L.V.; Nefedov, S.A. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2757-2762.

**082500 STRUCTURAL FEATURES AND PROPERTIES OF POLYMER MIXTURES IN THE LAMINATION REGION.** Experimental and theoretical results are systematized regarding the laws governing the lamination process in polymer-polymer systems in the transitional region between the binodal and spinodal lines. An explanation is given for the drop in viscosity in the region and it is proposed that the observed laws are a consequence of differences between the conditions of segregation of macromolecules of the polymer components forming the mixture and segments of these molecules in the interphase layer. It is shown that a characteristic



feature of the liquid-liquid phase transition in polymer-polymer systems is that the macromolecules segregate at a point on the binodal line, while their segments remain fully compatible. The macromolecular segments also begin to segregate with a further change in external conditions, this segregation corresponding to a point on the spinodal line - the transition of the system to a normal unstable emulsion. (Edited author abstract) 10 refs.

Kuleznev, V.N. (M.V. Lomonosov Inst of Chemical Refining, Moscow, USSR). *Colloid J USSR* v 49 n 5 Sep-Oct 1987 p 774-780.

**082501 MORPHOLOGY CONTROL OF BINARY POLYMER MIXTURES BY SPINODAL DECOMPOSITION AND CRYSTALLIZATION. 2. FURTHER STUDIES ON POLYPROPYLENE AND ETHYLENE-PROPYLENE RANDOM COPOLYMER.** Morphology control of binary polymer mixtures through spinodal decomposition and crystallization was studied by using polypropylene and ethylene-propylene random copolymer as a model system. A criterion for conservation of the modulated structure developed in the demixing liquid during and after the crystallization is discussed, and the locking-in phenomenon of the demixing processes by crystallization is clearly presented in some certain cases and was found to be responsible for the conservation of the structure existing in the liquid. (Edited author abstract) 10 refs.

Inaba, Nobuyuki (Idemitsu Petrochemical Co, Ichihara City, Jpn); Yamada, Takeshi; Suzuki, Shyunichi; Hashimoto, Takeji. *Macromolecules* v 21 n 2 Feb 1988 p 407-414.

**082502 DISTRIBUTION OF INTERACTIONS IN BINARY POLYMER MIXTURES: A MONTE CARLO SIMULATION STUDY.** Phase transitions from miscibility to immiscibility were observed in simulations of binary polymer mixtures on a planar square lattice using reptation sampling techniques. The relationship between the phenomenological interaction parameter,  $\chi$ , and the true molecular interaction energy was followed, and the dependence of the number and distribution of heterocontacts in the mixture on the applied heterosegment interaction energy was determined. Deviations from the results of mean-field treatments, which overestimate the number of heterocontacts, were observed even for athermal mixtures. Kinetically driven hysteresis governed by a temperature equilibrium time scale was examined for the phase transitions. An important prediction of expansion of the polymer chains in the miscibility region can be made on the basis of the results of chain end-to-end distance calculations. (Author abstract) 16 refs.

Cifra, Peter (Univ of Massachusetts, Amherst, MA, USA); Karasz, Frank E.; MacKnight, William J. *Macromolecules* v 21 n 2 Feb 1988 p 446-451.

**082503 MODEL MIXING OF POLYMER MATERIAL.** Relationships among shape of mixer, mixing condition, and mixing performance for polymer material were experimentally investigated using three model mixers. Mixing parameters that could link quality of mixture with mixer shape and mixing condition were determined from analysis of model mixing. High-performance mixers have been developed through these investigations. (Author abstract) 7 refs. In Japanese.

Asai, Toshihiro. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 42-45.

**082504 MISCIBILITY OF POLY(VINYL METHYL ETHER) WITH STYRENE-METHYL METHACRYLATE COPOLYMERS.** The miscibility of poly(vinyl methyl ether) (PVME) with a series of styrene-methacrylate copolymers was studied. It was found that the critical copolymer composition for achieving miscibility with PVME at room temperature was about 60 mol% styrene. The blends underwent phase separation at elevated temperatures, but the LCST passed through a maximum as the methyl methacrylate content of the copolymer was increased. The maximum value of LCST exceeded that of the PS-PVME pair. The significance of the observed

miscibility window is discussed in terms of recent theories. (Author abstract) 17 refs.

Chien, Y.Y. (Polytechnic Univ, Brooklyn, NY, USA); Pearce, Eli M.; Kwei, T.K. *Macromolecules* v 21 n 6 Jun 1988 p 1616-1619.

**082505 NEW MATRIX RESINS FOR STRUCTURAL COMPOSITES.** Synthetic organic polymers need fiber reinforcement to improve their strength, stiffness, toughness and creep resistance. The maximum strength and stiffness are obtained when continuous fibers are aligned parallel with the applied load. Compromise is also necessary in the selection of the matrix. The matrix can consist of a mixture of two polymers. New methods of crosslinking involve: epoxide rings, vinyl or ethylenic unsaturation, acetylene groups, cyanide groups, and isocyanate groups. 7 refs.

Pritchard, Geoffrey (Kingston Polytechnic). *Plast Rubber Int* v 13 n 2 Apr 1988 p 26, 28-31.

**082506 ANALYSIS OF THE THERMODYNAMIC COMPATIBILITY OF INTERPENETRATING NETWORKS DURING THEIR SYNTHESIS.** A thermodynamic analysis of interpenetrating polymer networks (IPNs), at any extent of reaction during their synthesis, is presented for both simultaneous and sequential procedures. A model IPN is assumed to be built up by the independent stepwise homopolymerization of two monomers: a tetrafunctional one,  $A_4$ , and a trifunctional one,  $A_3$ . No reaction of copolymerization or grafting is allowed between the two types of polymers. For the case of semi-IPNs,  $A_3$  is replaced by  $A_2$ , i.e., a bifunctional monomer leading to a linear polymer. The free energy of mixing is described by a Flory-Huggins lattice model, whereas the elastic contribution is calculated by assuming affine deformation of an ideal elastic network. Results show that a sequential polymerization gives a more incompatible system (i.e., it enters the metastable region at lower conversions) than a simultaneous polymerization starting from the same monomers. (Edited author abstract) 18 refs.

Cuadrado, T.R. (Univ of Mar del Plata, Mar del Plata, Argent); Borrajo, J.; Williams, R.J.J. *J Polym Sci Part B* v 26 n 8 Aug 5 1988 p 1735-1749.

**082507 GLASS TRANSITION OF POLYMERS MADE FROM SLURRIES OF POLY(ETHYL METHACRYLATE) AND METHYL METHACRYLATE.** Some biomedical materials are made from a slurry of a polymeric powder and a liquid methacrylate monomer. Conveniently, at the processing stage, the monomer acts as a plasticizer before it is polymerized to provide a service product. The question addressed here is whether products made from poly(ethyl methacrylate) (PEMA)/methyl methacrylate (MMA) slurries are miscible. Slurry systems PEMA and MMA yield rather homogeneous products on free radical polymerization, despite the immiscibility of PEMA and poly(methyl methacrylate). It is not known whether homogeneity is due to limitations on microphase separation by entanglements or to compatibilization by graft polymer formation. In any event, the products are inherently unstable and undergo phase separation on heating. 20 refs.

Singh, D.P. (Univ of North Carolina, Chapel Hill, NC, USA); Kalachandra, S.; Turner, D.T. *J Polym Sci Part B* v 26 n 8 Aug 5 1988 p 1795-1799.

## Models

**082508 MNDO CLUSTER MODEL CALCULATIONS ON ORGANIC POLYMERS.** Heats of formation and unit cell translation vectors for several organic polymers are calculated using the MNDO method. The results compare favorably with experiment; the magnitude of the errors is comparable to those of the MNDO method when applied to molecules. (Author abstract) 16 refs.

Stewart, James J.P. (USAF Acad, Colorado Springs, CO, USA). *New Polym Mater* v 1 n 1 1987-88 p 53-61.

**Modification** See Also COPOLYMERS—Processing; COPOLYMERS—Swelling; GRAFT COPOLYMERS—Synthesis; OIL WELLS—Fracturing Fluids; PLASTICS FILMS—Medical Applications; POLYETHYLENE TEREPHTHALATE—Stabilizers; POLYSTYRENES—Additives; POLYSTYRENES—Structure; POLYVINYL CHLORIDE—Heat Transfer; POLYVINYL CHLORIDE—Modification; RUBBER, SYNTHETIC—Polymerization.

**082509 MODIFICATION OF CROSSLINKED POLY-(2,6-DIMETHYL-1,4-PHENYLENE OXIDE) WITH LARGE CYCLIC AND LINEAR POLY-(DIMETHYL-SILOXANE).** Poly-(2,6-dimethyl-1,4-phenylene oxide) (PPO) can be crosslinked by reacting selectively the methyl groups with N-bromo-succinimide and condensing the bromide with ethylene diamine splitting out hydrogen bromide. This can be done in the presence of large poly(dimethyl siloxane) rings composed of 92 repeating units. Approximately 26% by weight of the cyclics can be threaded and permanently captured by the polymer network producing a polymeric catenane. The author has also synthesized the pseudo IPN (or semi IPN) crosslinked PPO and linear poly(dimethyl siloxane). He compares the physical properties of this material with the polymeric catenane. (Edited author abstract) 8 refs.

Frisch, H.L. *Kautsch Gummi Kunstst* v 40 n 8 Aug 1987 p 739-740.

**082510 <sup>13</sup>C NUCLEAR MAGNETIC RESONANCE SPECTRAL STUDY ON THE DISTRIBUTION OF SUBSTITUENTS IN RELATION TO THE PREPARATION METHOD OF PARTIALLY ACETYLATED DEXTRANS.** <sup>13</sup>C nuclear magnetic resonance (n.m.r.) spectra of partially modified dextrans with acetyl groups prepared by reaction with acetyl chloride or acetic anhydride in the homogeneous phase were analyzed at 75.4 MHz. It was found that the distribution of substituents in the anhydroglucose units of these partially acetylated dextrans can be estimated from their ring carbon spectra. The results showed that for acetylated dextrans prepared by reaction with acetyl chloride, the reactivity of individual secondary hydroxyl groups decreases in the order C-2 > C-4 > C-3. For these modified dextrans prepared with acetic anhydride, the ease of acetylation was C-2 > C-3 > C-4. The results were explained by considering the formation of intramolecular hydrogen bonds as well as by steric considerations. (Author abstract) 24 refs.

Arranz, Felix (CSIC, Madrid, Spain); Sanchez-Chaves, Manuel. *Polymer* v 29 n 3 Mar 1988 p 507-512.

**082511 TOUGHENING BISMALEIMIDE RESINS BY REACTIVE LIQUID RUBBERS.** The modification of bismaleimide resins with carboxyl-terminated butadiene-acrylonitrile rubbers (CTBN) was studied. The effects of the rubbers on mechanical and thermal properties such as flexural strength, tensile strength, fracture toughness, glass transition temperature, and decomposition temperature of the rubber-modified bismaleimide resins are discussed. The morphology of these resins were investigated by means of scanning electron microscopy and dynamic mechanical analysis. Addition of the rubbers improved the toughness of the bismaleimide resins without significant reductions in heat resistance of the resins. (Author abstract) 20 refs.

Takeda, Shinji (Yokohama Natl Univ, Yokohama, Jpn); Kakiuchi, Hiroshi. *J Appl Polym Sci* v 35 n 5 Apr 1988 p 1351-1366.

**082512 CHEMICAL MODIFICATION OF POLY(2,6-DIMETHYL-1,4-PHENYLENE OXIDE) VIA PHASE TRANSFER CATALYSIS.** The chemical modification of poly(2,6-dimethyl-1,4-phenylene oxide) (PPO) has been performed under phase transfer catalyzed (PTC) conditions. Four types of reactions: Williamson etherification, cyanide displacement, esterification, and heterocyclic group transfer have been identified as positive reactions involving the nucleophilic displacement on PPO. In reaction with alcohols, under PTC conditions, functional yields as high as 100% were obtained while for the esterification reaction functional yields of 92% were



reached. Low conversions were found in reactions with cyanides and heterocyclic compounds. (Edited author abstract) 18 refs.

Percec, Simona (BP, Cleveland, OH, USA). *J Appl Polym Sci* v 36 n 2 Jul 5 1988 p 415-427.

**Moisture** See POLYSTYRENES—Crazing; PROTECTIVE COATINGS—Plastics.

**Moisture Determination** See RUBBER COMPOUNDING—Moisture.

**Molding** See Also RUBBER PRODUCTS—Molding.

**082513 BOUNDARY INTEGRAL EQUATIONS FOR ANALYZING THE FLOW OF A CHOPPED FIBER REINFORCED POLYMER COMPOUND IN COMPRESSION MOLDING.** The flow of a chopped fiber reinforced polymer compound during compression molding is analyzed as a transient moving boundary problem. A special boundary integral formulation is used to calculate flow front velocities. The derivation involves the determination of fundamental solutions for the newly developed equations of motion. A generalized Green's formula is used in conjunction with these solutions to produce the final expressions which incorporate the boundary tractions and velocities directly. The major advantage in adopting a boundary integral approach is that there is no need to solve for interior pressures and velocities. An approximate boundary element representation of the basic integral equations is used to predict flow front progression for elliptical and rectangular charges. Based on a comparison with available analytic solutions for the elliptical charges, we conclude that the method performs well over the entire range of physical and geometric parameters. A further examination of numerical solutions shows that practical convergence can be obtained for both quadratic and constant boundary elements with moderate mesh spacings. (Edited author abstract) 14 refs.

Barone, M.R. (GM, Warren, MI, USA); Osswald, T.A. *J Non Newtonian Fluid Mech* v 26 n 2 Dec 1987 p 185-206.

**082514 TROUBLESHOOTING TECHNIQUE SHORTENS PATH TO QUALITY.** A familiar statistical technique can be a time-saving preliminary to on-line testing by screening out non-significant causes when processing problems arise. Any molding process using any material can be improved to acceptable tolerances by increasing or decreasing the levels of the variables found to be significant. (Author abstract)

Schleckser, James (Rogers Corp, Manchester, CT, USA). *Plast Eng* v 43 n 7 Jul 1987 p 35-38.

**Molds** See Also PLASTICS—Molding.

**082515 DISTRIBUTED MODEL OF FLOW IN SPIRAL MANDREL DIE.** Spiral mandrel dies are widely employed in the processing of polymeric films in the blown extrusion process. The flow dynamics in spiral mandrel dies is modeled in conjunction with a lubrication assumption. The model permits the determination of velocity, rate of deformation, shear stress, and first normal stress difference distributions. It should generate a better understanding of the thermomechanical history experienced by polymeric melts during extrusion in spiral mandrel dies, and should thus facilitate better die design and/or optimization of operating conditions. (Edited author abstract) 35 refs.

Kalyon, Dilhan M. (Stevens Inst of Technology, Hoboken, NJ, USA); Yu, Jeong S.; Du, Chi-Chung. *Polym Process Eng* v 5 n 2 1987 p 179-207.

**Molecular Structure** See Also CELLULOSE DERIVATIVES—Synthesis; COATINGS—Synthesis; COPOLYMERS—Synthesis; CRYSTALS, LIQUID—Polymerization; ELASTOMERS—Microstructure; EPOXY RESINS—Crosslinking; FLOW OF FLUIDS—Non Newtonian; FLUORINE CONTAINING POLYMERS—Crosslinking; ION EXCHANGE RESINS—Synthesis; POLYBUTADIENES—Synthesis; POLYETHYLENES—Linear Low Density; POLYMERIZATION—Mathematical Models; POLYPEPTIDES—Solutions; POLYPROPYLENE—Radiation Ef-

fects; POLYSACCHARIDES—Polymerization; POLYSTYRENES—Solutions.

**082516 DETERMINATION OF THE STRUCTURE OF POLYETHYLARYLMETHYLENES BY <sup>13</sup>C NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY.** Ethyl-substituted polyarylmethylenes have been prepared by reacting ethylbenzene with bis(chloromethyl)benzene (BCMB) under Friedel-Crafts conditions. The nature of the substitution patterns in the aromatic rings has been established using <sup>13</sup>C Fourier transform nuclear magnetic resonance spectroscopy. The ethyl groups can be used to distinguish between those benzene rings derived from ethylbenzene and those from BCMB and can thus facilitate an understanding of polymerization mechanisms. The structure of the products consists of di-, tri- and tetra-substituted benzene rings. (Edited author abstract) 10 refs.

Blinco, P.J. (Kingston Polytechnic, Kingston Upon Thames, Engl); Pritchard, G. *Polymer* v 28 n 11 Oct 1987 p 1824-1828.

**082517 STRUCTURE OF PLASMA-POLYMERIZED OCTAFLUOROCYCLOBUTANE.** Plasma-polymerization of octafluorocyclobutane was carried out in a capacitively coupled tubular reactor with external electrodes. The number-average molecular weight, melting temperature, decomposition temperature and solubility in tetrafluorodibromomethane of the products were measured and the polymer structure was characterized by ESR, IR and <sup>19</sup>F-NMR methods. The experimental results show the absence of the highly crosslinked structure but a fluorine-deficient structure caused by free-radicals, carbonyl groups, double bonds and multicage-like segments in the polymer. (Author abstract) 4 refs.

Ye Mu (Acad Sinica, Changchun, China); Chen, Jie; Lu, Lizhen; Hu, Huizhen; Xiao, Yanwen; Liu, Guizhen. *Chin J Polym Sci (Engl Ed)* v 4 n 3 Jan 1987 p 256-261.

**082518 EVALUATION OF THE ORIENTATION OF NON-CRYSTALLINE POLYMERIC CHAINS WITH A POLARIZED FLUORESCENCE METHOD.** The polarized fluorescent intensity is affected by two factors: the optical properties of the optically biaxial substance, which give rise to extraordinary lights in the sample, and the molecular structures of the optically anisotropic polymer solid dyed with fluorescent dyestuff. The effects of these factors on this intensity are introduced into formulae used for evaluating the molecular orientation. In these formulae, the fluorescent intensity has been expressed in terms of measurable values by separating into two terms: one depends on the molecular orientation and the other concerns the nature of the molecular structures and the device of optical measurement. It has thus been possible to pick up the terms associated with the fourth moment of direction cosines of the non-crystalline molecular chain axis. How the electric amplitude difference between the refracted extraordinary lights influences the fluorescent intensity is also considered. (Author abstract) 10 refs. In Japanese.

Hibi, Sadao (Nagoya Inst of Technology, Nagoya, Jpn); Yokoyama, Akihiro; Itoh, Keiko; Nakanishi, Eiji; Maeda, Matsuo. *Kobunshi Ronbunshu* v 44 n 6 1987 p 409-419.

**082519 FIRST CUMULANT OF THE DYNAMIC STRUCTURE FACTOR FOR RIGID RINGS.** The first cumulant of the dynamic structure factor is evaluated for rigid polymers. The results, together with those for flexible polymers, suggest that a careful experimental intercomparison of rings and open-chain polymers at low magnitudes of the scattering vector could serve to assess the degree of validity of the preaveraging approximation for the hydrodynamic interactions. (Author abstract) 18 refs.

Huber, Klaus (Dartmouth Coll, Hanover, NH, USA); Stockmayer, Walter H. *Polymer* v 28 n 12 Nov 1987 p 1987-1989.

**082520 LIQUID CRYSTALLINE POLYMERS.** Just recently it was found possible to produce polymers using the structural principles of liquid crystalline compounds. The resulting materials have, as expected, unusual proper-

ties. Numerous applications, not only in opto-electronics, are already anticipated for such materials. The intention of this article is to show, with a knowledge of the structural principles of low molecular weight liquid crystals, how various types of polymers with potentially liquid crystalline phases can be synthesized. Each structural type shows in specific ways the liquid crystalline phase and the properties of the polymer. The peculiarities of selected examples are outlined and their properties and application perspectives discussed. 54 refs.

Finkelmann, Heino (Univ of Freiburg, Freiburg, West Ger). *Angew Chem (Int Ed Engl)* v 26 n 9 1987 p 816-824.

**082521 INTERPRETATION OF LIGHT SCATTERING FROM SUPERMOLECULAR STRUCTURES IN LIQUID SYSTEMS BY MASTER CURVES.** By a detailed analysis of light scattering curves, a more complete characterization of colloidal particles may be achieved. For this purpose, a fitting procedure based on theoretical master curves for models of polydisperse systems of homogeneous spheres and Gaussian coils is presented. The use of a suitable logarithmic distribution function makes it possible to separate the influence of polydispersity from that of particle size on the shape of the scattering curve. A double logarithmic plot of master curves reduces the fitting procedure to translations of the experimental curves. The reliability and accuracy of this procedure are demonstrated by light scattering results on solutions of a polyelectrolyte complex with variation of salt content. (Author abstract) 18 refs.

Dautzenberg, H. (Acad of Sciences of the GDR, Teltow, East Ger); Rother, G. *J Polym Sci Part B* v 26 n 2 Feb 1988 p 353-366.

**082522 MOLECULAR STRUCTURE AND PHOTOREACTION OF POLY(METHYLPROPYLSILANE).** The molecular structure and photoreaction of poly(methylpropylsilane) (PMPrS) are investigated. The <sup>29</sup>Si-NMR spectra reveal that PMPrS is a linear polymer with no branches. Fine multiple splitting of <sup>29</sup>Si-NMR is observed at room temperature. This multiple splitting is thought to be due to molecular conformation. The photo-oxidation reaction of the PMPrS film is found to be caused by light irradiation at the UV absorption band, 330 nm. Quantum efficiencies of scission and crosslink related to photodegradation are evaluated. There is little difference in either the molecular structure or photoreactivities between the high and the low molecular weight portions of the bimodal molecular weight distributions of PMPrS. (Author abstract) 21 refs.

Ban, Hiroshi (NTT Electrical Communications Lab, Tokai, Jpn); Sukegawa, Ken. *J Polym Sci Part A* v 26 n 2 Feb 1988 p 521-527.

**082523 STRUCTURE-PROPERTY BEHAVIOR OF NEW HYBRID MATERIALS INCORPORATING OLIGOMERIC POLY(TETRAMETHYLENE OXIDE) WITH INORGANIC SILICATES BY A SOL-GEL PROCESS. 3. EFFECT OF OLIGOMERIC MOLECULAR WEIGHT.** Novel transparent hybrid materials incorporating triethoxysilane endcapped poly(tetramethylene oxide) with tetramethoxysilane have been successfully prepared by a sol-gel process. The molecular weight of PTMO has been varied to study its effect on the structure-property behavior of these hybrid materials. Mechanical properties and dynamic mechanical behavior have been measured; small angle X-ray scattering (SAXS) has been utilized to obtain structural information. Based on the experimental results, a simplified morphological model has been suggested to describe these new hybrid systems. (Author abstract) 12 refs.

Huang, Hao-Hsin (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Wilkes, Garth L. *Polym Bull (Berlin)* v 18 n 5 Nov 1987 p 455-462.



**082524 STRUCTURE CHARACTERISTICS OF HALOURACILS CONTAINING CHIRAL CENTERS AND THEIR POLYMERS WITH POLYETHYLENIMINE.** Uracil esters and acids containing both a chiral center and a halogen atom at the 5-position (fluoro, chloro and bromo) were prepared. The esters of these species were then grafted onto polyethylenimine via an amide bond. The precise nature of this bond was examined using  $^1\text{H}$ ,  $^{13}\text{C}$ ,  $^{19}\text{F}$ , and  $^{13}\text{C}$ - $^1\text{H}$  coupled spectroscopies. The results show that the polymers obtained under the experimental conditions of this study possess both covalent and ionic bonds at the grafting position. (Edited author abstract) 5 refs.

Ye, Dakeng (Univ of Michigan, Ann Arbor, MI, USA); Overberger, C.G. *J Polym Sci Part A* v 26 n 3 Mar 1988 p 765-781.

**082525 HOCHEMPFFINDLICHE CHARAKTERISIERUNG VON POLYMEREN. [A Highly Sensitive Way of Characterizing Polymers].** The technique of dynamic dielectric spectroscopy, which is employed to comprehend the molecular structure of polymers and their cure behavior is described. The dielectric data dielectric constant  $\epsilon'$  and loss factor - obtained with the help of a capacitance bridge spanned a temperature range of  $-150^\circ\text{C}/+350^\circ\text{C}$  and frequency range of 5 Hz/13 MHz. The experimental results of thermal-, UV- and electron beam curable systems are elucidated with respect to the molecular structure. Molecular and chain movements of polar groups can be correlated with the results obtained. (Author abstract) In German. 9 refs.

Hussain, Amir (Siemens AG, Munich, West Ger); Pflugbeil, Christa; Winkelmair, Dieter. *Adhesion* v 31 n 10 Oct 1987 p 22-26.

**082526 X-RAY EVIDENCE FOR SHARP CHAIN FOLDS IN CRYSTALLINE LINEAR ALKANES.** In this note a typical straightforward small-angle X-ray scattering (SAXS) example is presented of once-folded solution-crystallized paraffins having layer periodicities exactly one half the extended chain length. Moreover, the very good order in the stacking of layers is indicated by the presence of high-order reflections.  $n\text{-C}_{198}\text{H}_{398}$  was crystallized from 0.8 percent solution in toluene for 6 h at  $81.5 \pm 0.2^\circ\text{C}$  to obtain crystals with purely extended chains, and from 0.01 percent solution in toluene for 1.5 hours at  $73.2 \pm 0.4^\circ\text{C}$  for crystals with purely once folded chains. 12 refs.

Ungar, G. (H.H. Wills Physics Lab, Bristol, Engl); Organ, S.J.; Keller, A. *J Polym Sci Part C* v 26 n 6 Jun 1988 p 259-262.

**082527 IMPORTANCE OF THE FRONTIER ORBITAL PATTERNS IN THE MOLECULAR DESIGN OF POLYMERS WITH METALLIC PROPERTIES.** We discuss the importance of the pattern analysis of the frontier orbital as a guiding principle in the course of theoretical molecular design of polymers intrinsically showing metallic properties. Moreover, we perform actual calculations on the polyperimesoanthracene (PPMA) and several kinds of nitrogen-substituted PPMA's (NPPMA) as examples to test the criterion discussed. The result of the actual calculations agrees well with what is predicted from this guiding principle in the molecular design of polymers showing intrinsically metallic properties. (Author abstract) 12 refs.

Tanaka, Kazuyoshi (Kyoto Univ, Kyoto, Jpn); Mura-shima, Masatoshi; Yamabe, Tokio. *Synth Met* v 24 n 4 Jun 1988 p 371-377.

**082528 DIPOLE MOMENT AND CONFORMATIONAL ANALYSIS OF ITACONATE POLYMERS.** The dipole moments ( $\mu$ ) of poly(monobenzyl itaconate) (PMBzI), and of poly(dibenzyl itaconate) (PDBzI), of known tacticity ( $w_m$ ), have been determined in dioxane at  $25^\circ\text{C}$ :  $\mu = 1.96\text{ D}$ ,  $w_m = 0.50$  (PMBzI); and  $\mu = 1.52\text{ D}$ ,  $w_m = 0.25$  (PDBzI). The dipole moment and the unperturbed dimensions (characteristic ratio,  $C_\infty$ ) of polyitaconate chains are calculated theoretically, as a function of polymer tacticity, by matrix multiplication

methods. The polymer  $\mu$  calculated is scarcely sensitive to tacticity. Comparison with experimental  $\mu$  shows excellent agreement in the case of PDBzI. For PMBzI, the experimental  $\mu$  is higher than calculated, and agreement requires modification of the conformational parameters (but within the precision limits of the calculation). (Edited author abstract) 44 refs.

Saiz, Enrique (Univ de Alcala, Madrid, Spain); Horta, Arturo; Gargallo, Ligia; Hernandez-Fuentes, Irma; Radic, Deodato. *Macromolecules* v 21 n 6 Jun 1988 p 1736-1740.

**082529 MOLECULAR STRUCTURE AND HYDROLYTIC STABILITY OF POLYURETHANE ACETALS.** The dependence of the MD of non-isocyanate polyurethane acetals on the methods of their synthesis, nature and ratio of the starting co-monomers, depth of hydrolysis and the type of stabilizer of hydrolytic degradation has been studied. The optimal conditions of synthesis have been determined. The nature of the active centres of polymerization is discussed. The hydrolytic degradation of polyurethane acetals proceeds by the law of chance. The possibility of inhibiting hydrolytic degradation of the polyurethane acetals with the aid of hydrophobizing additives is demonstrated. (Author abstract). 14 refs.

Pchelintsev, V.V. (USSR Acad of Sciences, USSR); Sokolov, A. Yu.; Kamenev, Yu. G.; Drach, V.A.; Ryzhova, V.N.; Zaikov, G. Ye. *Polym Sci USSR* v 29 n 5 1987 p 1076-1081.

**082530 PLASTIC DEFORMATION OF POLY(TETRAMETHYLENE OXIDE).II. MOLECULAR ORIENTATION AS MEASURED BY X-RAY DIFFRACTION AND NMR MEASUREMENTS.** The orientation of the crystalline and amorphous phases in uniaxially drawn samples of polytetramethylene oxide has been studied by x-ray and NMR methods. Pole figure measurements give the orientation of the crystalline phase. Its dependence on the draw ratio does not obey the pseudoaffine model. The crystalline fraction is derived from NMR measurements at temperatures between  $T_g$  and  $T_m$ , where the free induction decay (FID) of the unoriented sample can be analyzed in terms of a rigid (crystalline) phase, a constrained phase, and an amorphous phase. Low temperature ( $T < T_g$ ) measurements of the NMR second-moment anisotropy in protonated and deuterated samples give a mean orientation of the chains higher than that corresponding to the crystalline phase. The lack of anisotropy in the tail of the FID at temperatures between  $T_g$  and  $T_m$  indicates no appreciable anisotropy in the truly amorphous interlamellar phase. From this and from the ratio of the  $P_4/P_2$  orientations, factors which obey the 'most probable distribution', it is concluded that the amorphous orientation is due to the layer of constrained chains at the surface of the lamellae. (Edited author abstract). 17 refs.

Kretz, M. (CRM, Strasbourg, Fr); Meurer, B.; Spegt, P.; Weill, G. *J Polym Sci Part B* v 26 n 8 Aug 5 1988 p 1553-1568.

**082531 OPTICAL SECOND-HARMONIC GENERATION AS AN ORIENTATIONAL PROBE IN POLED POLYMERS.** Optical second-harmonic generation is discussed as a technique to measure molecular bond orientations and their second-order hyperpolarizabilities in electrically poled polymer thin films. The method is illustrated using polyvinylidene fluoride to deduce the main chain and C-F bond ordering. The dynamics of the bond rotation were also monitored during the poling process. (Author abstract) 21 refs.

Boyd, G.T. (3M, St. Paul, NM, USA). *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym. Davis, CA, USA, Feb 18-20 1987 p 295-304.

**Molecular Weight** See Also ACRYLICS—Polymerization; AMMONIUM COMPOUNDS—Radiation Effects; AROMATIC POLYMERS—Synthesis; CELLULOSE DERIVATIVES—Evaluation; COPOLYMERS—Degradation; COPOLYMERS—Morphology; COPOLYMERS—Physical Properties; ELASTOMERS—Extrusion; EPOXY RESINS—Dispersions; MONOMERS—Polymerization;

POLYETHYLENES—Extrusion; POLYETHYLENES—Mechanical Properties; POLYETHYLENES—Physical Properties; POLYIMIDES—Synthesis; POLYISOPRENE—Degradation; POLYMERIZATION—Radiation Effects; POLYMERIZATION—Research; POLYMERIZATION—Theory; POLYMERS—Spectroscopic Analysis; POLYMETHYL METHACRYLATE—Degradation; POLYPROPYLENE—Physical Properties; POLYSTYRENES—Surface Properties; POLYVINYL ACETATE—Degradation; POLYVINYL ALCOHOL—Synthesis; POLYVINYL CHLORIDE—Synthesis.

**082532 ANALYSIS OF THE ACCURACY OF DETERMINING MOLAR-MASS AVERAGES OF POLYMERS BY GPC WITH AN ON-LINE LIGHT-SCATTERING DETECTOR.** The effect of errors of concentration and molar-mass detectors in GPC on the accuracy of determining molar-mass averages  $M_n$  and  $M_w$  was analyzed. Model calculations show that by means of GPC with an on-line low-angle laser light-scattering (LALLS) photometer only  $M_w$  can be determined with acceptable accuracy.  $M_n$  can be determined with acceptable accuracy only for polymers that have very small polydispersities.  $M_n$  can be determined with greater accuracy from data of a concentration detector and chromatographic-column-calibration data. The most suitable procedure for the determination of  $M_w$  seems to be a direct integration of the molar-mass detector output, even if the error due to neglecting the second virial coefficient term is significant. Compared with the inaccuracy of detectors, axial dispersion appears not to be the main source of errors in GPC with an on-line molar-mass detector. (Author abstract) 10 refs.

Prochazka, Ondrej (Czechoslovak Acad of Sciences, Prague, Czech); Kratochvil, Pavel. *J Appl Polym Sci* v 34 n 6 Nov 5 1987 p 2325-2336.

**082533 MOLECULAR CHARACTERISATION OF OXYMETHYLENE-LINKED POLY(OXYETHYLENE).** Tetraethylene glycol (TEG) or polyethylene glycol 200 (PEG200) was reacted with  $\text{CH}_2\text{Br}_2$  in a modified Williamson synthesis to form oxymethylene-linked chains. Analytical and preparative gel permeation chromatography plus nuclear magnetic resonance spectroscopy were used to show that the product of reaction consisted of rings with degree of condensation  $n = 1-15$  or more (i.e., 14 to 210 or more atoms in the rings formed from TEG) and chains with molecular weights up to  $10^6$  and a wide molecular weight distribution. (Author abstract) 8 refs.

Craven, John R. (Univ of Manchester, Manchester, Engl); Nicholas, Christian V.; Webster, Robert; Wilson, David J.; Mobbs, Richard H.; Morris, Gareth A.; Heatley, Frank; Booth, Colin; Giles, Jeremy R.M. *Br Polym J* v 19 n 6 1987 p 509-516.

**082534 CALCULATION OF INTRINSIC VISCOSITY OF LOW POLYMER WITH BROAD MOLECULAR WEIGHT DISTRIBUTION THROUGH GEL PERMEATION CHROMATOGRAPHY TO DETERMINE THE MOLECULAR WEIGHT.** The experimental intrinsic viscosity of a low polymer with a broad molecular weight distribution is in good agreement with that calculated through gel permeation chromatography (g.p.c.), by using the Dondos-Benoit equation. Then, a calibration curve for a low polymer is modified by using the data for the intrinsic viscosity. (Edited author abstract) 4 refs.

Ito, Katsukiyo (Government Industrial Research Inst, Nagoya, Jpn); Aoyama, Takeshi. *Polym Commun (Guildford Engl)* v 29 n 3 Mar 1988 p 68-69.

**082535 MOLECULAR WEIGHT DISTRIBUTION CONTROL IN A BATCH POLYMERIZATION REACTOR.** This paper proposes a new method for getting the reactor temperature and initiator concentration in order to obtain a final product of polymer which has a prescribed molecular weight distribution (MWD) in a free-radical polymerization batch reactor. At first, profiles of instantaneous average chain length and polydispersity are obtained so as to get the desired MWD. Next, time



profiles of reactor temperature and initiator concentration are determined from the profiles of instantaneous average chain length and polydispersity based on the mathematical model of the reactor. As the final step, the time profile of reactor temperature is realized by the Adaptive Internal Model Controller (AIMC) developed by us. (Edited author abstract) 13 refs.

Takamatsu, Takeichiro (Kyoto Univ, Kyoto, Jpn); Shi-oya, Suteaki; Okada, Yoshiki. *Int Eng Chem Res* v 27 n 1 Jan 1988 p 93-99.

**082536 NEW HORIZONS FOR LATEX.** The making of water borne multicomponent polymer systems (MPS), both as latices and reactive oligomers, creates new opportunities for developing polymers with enhanced performance to meet the needs of the future. Much developmental activity is now being conducted to provide water-borne reactive oligomers since starting at a low molecular weight and building in-site can meet certain demands where the high new resins, because of their high molecular weight, cannot penetrate and wet certain surfaces. Highly innovative process and formulation techniques have engineered some latex systems that dry in three to eight seconds and gel in eight minutes - far faster than solvent systems. The resulting film is waterproof because there is no free surfactant or soap to rewet.

Alexander, Robert R. (Harwick Chemical Corp, Akron, OH, USA); Kelly, Robert L. *Elastomerics* v 120 n 3 Mar 1988 p 10-14.

**082537 MOLECULAR-WEIGHT DISTRIBUTIONS OF POLYMERS BY THERMAL FIELD FLOW FRACTIONATION WITH EXPONENTIAL TEMPERATURE PROGRAMMING.** Thermal field flow fractionation (TFFF) is a promising quantitative method for determining the molecular-weight distribution (MWD) of polymers. Separations are carried out by applying a thermal gradient across a single flowing mobile phase in a thin, highly polished channel formed with parallel plates. Wide MWD's are conveniently characterized by the technique of time-delay, exponential-decay TFFF (TDE-TFFF). This approach produces a linear calibration plot of log MW vs retention time for accurate MWD measurements. Accuracy of the method is limited only by the quality of the standards required for the calibration. (Edited author abstract) 14 refs.

Kirkland, J.J. (DuPont, Wilmington, DE, USA); Rementer, S.W.; Yau, W.W. *Anal Chem* v 60 n 7 Apr 1 1988 p 610-616.

**082538 ONE-POINT METHOD TO CALCULATE MOLECULAR WEIGHT FROM LOW-ANGLE LASER LIGHT SCATTERING DATA. I. APPLICATION TO ACRYLAMIDE POLYMERS.** A new method for the calculation of the weight-average molecular weight from low-angle laser light scattering data has been developed which only requires the measurement of the Rayleigh factor at a single concentration. The method requires the knowledge of the dependence of the second virial coefficient on molecular weight and has been applied to polyacrylamides ranging in molecular weight from 10,000 to 9,000,000. The new method improves the accuracy of light scattering measurements to  $\pm 4.7\%$  compared with  $\pm 11.2\%$  for the conventional procedure and requires only one-fourth the time. The effect of polydispersity has been included in the procedure. The method is general and is recommended for all linear polymers. (Author abstract) 40 refs.

Hunkeler, D. (McMaster Univ, Hamilton, Ont, Can); Hamielec, A.E. *J Appl Polym Sci* v 35 n 6 May 5 1988 p 1603-1620.

**082539 DETERMINATION OF NUMBER-, WEIGHT-, AND Z-AVERAGE MOLECULAR WEIGHTS BY MENISCUS-DEPLETION SEDIMENTATION EQUILIBRIUM.** Sedimentation equilibrium (SE) in the analytical ultracentrifuge, unlike most other absolute methods of molecular weight determination, can in principle provide several types of average molecular weight for a polydisperse polymer. In practice,

however, this potential has not been fully realized. In this note it is demonstrated that a long-column meniscus-depletion SE procedure is of value for the determination of number-, weight- and z-average molecular weights. This method is applied to the National Bureau of Standards' (NBS) polystyrene sample 706, which has a broad distribution of molecular weights. 13 refs.

Budd, Peter M. (BP Research Cent, Sunbury-on-Thames, Engl). *J Polym Sci Part B* v 26 n 5 May 1988 p 1143-1147.

**082540 CHARACTERIZATION OF POLYMER MOLECULAR WEIGHT DISTRIBUTION BY TRANSIENT VISCOELASTICITY: POLYTETRAFLUOROETHYLENES.** The relationship between the relaxation time spectrum  $H(\tau)$  in the terminal zone and the volume-fraction differential molecular-weight-distribution function  $P(M)$  is derived by considering binary chain contacts for stress transmission. This is used to determine the molecular-weight-distribution curves from the stress relaxation modulus spectrum (above the crystal melting point) at  $370^\circ\text{C}$  for a number of commercial and experimental poly(tetrafluoroethylenes) (PTFEs). It is found that PTFEs typically have bimodal molecular-weight distributions. The lower-molecular-weight peak conforms essentially to the 'most-probable' distribution, and the higher-molecular-weight peak to the binary coupling distribution. The entanglement molecular weight  $M_e$  is 5490, and the number of main-chain atoms between entanglement points is 110, consistent with a flexible chain. (Edited author abstract) 19 refs.

Wu, Souheng (DuPont, Wilmington, DE, USA). *Polym Eng Sci* v 28 n 8 Apr 1988 p 538-543.

**082541 ROLE OF EXCLUDED VOLUME IN THE CONFIGURATIONAL PROPERTIES OF UNIFORM STAR POLYMERS: ITERATIVE CONVOLUTION AND MONTE CARLO SIMULATION.** The dimensional properties of three-dimensional uniform athermal self-avoiding star polymers of small to intermediate molecular weight are determined in the iterative convolution (IC) approximation. The results are compared with continuum Monte Carlo (MC) simulations and with lattice-based and renormalization group (RG) estimates that relate to the large-N limit. In particular, the present analysis provides direct structural and dimensional assessment of the interior star regimes proposed by M. Daoud and J.P. Cotton, which are inaccessible to the lattice-based and RG treatments. We find no evidence to support the Daoud-Cotton proposals. On the basis of the iterative convolution approximation, the central core structure of the star terminates at a density discontinuity followed by secondary radial structural features. (Edited author abstract) 22 Refs.

Croxtan, Clive A. (Univ of Newcastle, Aust). *Macromolecules* v 21 n 7 Jul 1988 p 2269-2278.

**082542 EFFECT OF HIGH MOLECULAR WEIGHT POLYETHYLENE OXIDE ON THE STRUCTURE AND PROPERTIES OF POLYPROPYLENE FIBRES.** The effect of micro amounts of PEO with  $M=4 \times 10^6$  and  $5 \times 10^6$  on the structural features and properties of PP fibers has been studied. On addition of 0.15-0.2 percent PEO slight rise in fluidity is observed linked with increase in the degradation of the melt, decline in orientation of the macromolecules and a slight fall in the degree of crystallinity and melting point of the fibers. Pigment is also a component which may change the pseudoplasticity of the melt due to the structure resulting from its agglomeration and steric immobilization. (Author abstract) 6 Refs.

Kaloforov, N. Ya (Dimitrov Chemical Plant, Bratislava, Czech). *Polym Sci USSR* v 29 n 4 1987 p 857-861.

**Morphology** See Also BLOCK COPOLYMERS—Microstructure; NYLON POLYMERS—Blending; PLASTICS, FOAMED—Morphology; POLYBUTADIENES—Crystallization; POLYCARBONATES—Blending; POLYETHYLENE TEREPHTHALATE—Film; POLYETHYLENES—Mechanical Properties; POLYSULFONES—Phase Transitions; POLYVINYL ACETATE—Blending; POLYVINYL CHLORIDE—Aging.

**082543 EFFECT OF THE INITIATOR ACETYL PERCHLORATE UPON THE MORPHOLOGY, KINETICS AND MECHANISMS OF CRYSTAL GROWTH OF POLY(OXYMETHYLENE).** The kinetics of the cationic polymerization of trioxane initiated by different concentrations of acetyl perchlorate in dichloromethane solution is analyzed. Hexagonal single crystals of poly(oxyethylene) (POM), are obtained after an induction period. The kinetic of the crystal growth have been followed by electron and light microscopic techniques. The influence of the initiator concentration on the morphology of the POM-crystals, together with the fact that the initiator is adsorbed on the crystal surface, enabled the discussion of possible reaction mechanisms of polymerization and crystallization. (Edited author abstract) 35 refs.

Rodriguez-Baeza, M. (Univ de Concepcion, Chile); Catalan Saravia, R.E. *Prog Colloid Polym Sci* v 71 1985 p 49-58.

**082544 ON THE INTERPRETATION OF MULTIPLE MELTING PEAKS IN POLY(ETHER ETHER KETONE).** The double-peak differential scanning calorimetry melting endotherms from isothermally crystallized poly(ether ether ketone) have been scrutinized in terms of two hypotheses: (i) they are due to two separate crystal morphologies; (ii) they are attributable to recrystallization effects. Supplementary data from density, wide-angle X-ray scattering and small-angle X-ray scattering suggest that (ii) is the most appropriate. (Author abstract) 7 refs.

Blundell, D.J. (ICI Int Materials Cent, Middlesbrough, Engl). *Polymer* v 28 n 13 Dec 1987 p 2248-2251.

**082545 INFLUENCE OF THE PROCESSING CONDITIONS ON MORPHOLOGY AND DEFORMATION BEHAVIOR OF POLY(BUTYLENE TEREPHTHALATE) (PBT).** This paper discusses the effect of varying cooling rates during crystallization on the spherulitic structure of poly(butylene terephthalate). Light microscopy, transmission electron microscopy, and differential scanning calorimetry were used to examine specimens. The mechanical properties of the polymers studied were examined by a variety of methods. (Author abstract) 7 refs.

Ludwig, H.-J. (Univ Stuttgart, Stuttgart, West Ger); Eyerer, P. *Polym Eng Sci* v 28 n 3 Mid-Feb 1988 p 143-146.

**082546 MORPHOLOGICAL STRUCTURE OF A POLYMER COATING ON POLYMERIZATION-MODIFIED FILLERS.** The morphological types of a polymer coating on mineral fillers for the polymerization modes of modification carried out by radical polymerization of vinylchloride in presence of fillers have been investigated and reviewed. From the results it follows that the morphology of the polymer coating of PVC on fillers in all variants of polymerization modification is determined by the conditions of polymerization. The main factors influencing the morphology of the coating are the site of the polymerization reaction, the nature of the interaction of the coating with filler and the structure of the filler surface. The reaction site determines the basic type of morphology of the coating - smooth or granular - while different combinations of this factor with the nature of interaction between polymer coating and filler and the structure of the filler itself lead to the variety of morphological forms of coatings. (Edited author abstract) 6 refs.

Vishnevskaya, I.N. (Lomonosov State Univ, Moscow, USSR); Batuyeva, L.I.; Bort, D.N.; Popov, V.A.; Zhil'tsov, V.V.; Marinin, V.G.; Grishin, A.N.; Zvereva, Yu.A.; Zavodchikova, N.N.; Potepalova, S.N.; Guzeyev, V.V.; Zubov, V.P.; Kabanov, V.A. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2786-2793.



**082547 TOUGHENED BLENDS OF POLY(BUTYLENE TEREPHTHALATE) AND BPA POLYCARBONATE.** The morphologies of melt blends of poly(butylene terephthalate) (PBT) and bisphenol A polycarbonate (PC) toughened with a core/shell impact modifier have been characterized by transmission and scanning electron microscopy. Selective staining with ruthenium and osmium tetroxide and etching with diethylene triamine have been used to assess the distribution of the various blend components and investigate the effects of thermal history on morphology. Evidence for partial melt miscibility and rate-dependent segregation during cooling is presented. (Author abstract) 11 refs.

Hobbs, S.Y. (GE, Schenectady, NY, USA); Dekkers, M.E.J.; Watkins, V.H. *J Mater Sci* v 23 n 4 Apr 1988 p 1219-1224.

**082548 PHASE MORPHOLOGY OF A MODEL POLYBLEND.** The systematic study of the melt mixing process and its effects on the phase morphology and melt properties were carried out on a model polyblend and polyalloy. The polyblend consisted of PE-LD and PS at a 70:30 ratio, respectively. The corresponding polyalloy contained an additional five parts of SEB block co-polymer to act as a compatibilizing agent. The experiments were made on six different brands of industrial compounding extruders under well defined process parameters. The authors report on the preliminary yet quantitative relationships between the mixing process, melt rheology and the related phase morphology as found on the twin screw extruder type ZE 40. It is shown that these results will allow a strategy to be developed for controlling the mixed process during the creation of polyblends, by selecting the proper geometries in compounding extruders. Results indicate a good correlation between the shear stress and the domain size of the minor phase as predicted from the software Simulblend. In English and German.

Plochocki, A.P.; Dagli, S.S.; Mack, M.H. *Kunstst Ger Plast* v 78 n 3 Mar 1988 p 30-32.

**082549 INCORPORATION OF MOLECULAR ORIENTATION INTO SYSTEM OF LAMELLAR MORPHOLOGY. 1. EFFECT OF PACKING ENTROPY ON THE LAMELLAR THICKNESS OF BLOCK COPOLYMERS.** Equations for the dimensions of the A and B regions of monodisperse diblock copolymers with lamellar morphology are obtained. An important feature of the treatment is the incorporation of the orientation-dependent packing entropy into the formalism. The equations are believed to be accurate over the whole range of orientation of bonds, from random orientation to perfect alignment. Copolymer thicknesses vary as the 2/3 power of molecular weight to the first power depending on the amount of orientation induced by the packing entropy and the energetics. The amount of bond orientation in stretched molecules in bulk material is twice what the molecules would have if they were stretched (by the same stretch ratio) in solvent. (Edited author abstract) 42 refs.

DiMarzio, E.A. (NBS, Gaithersburg, MD, USA). *Macromolecules* v 21 n 7 Jul 1988 p 2262-2269.

## Nitration

**082550 YELLOWING MECHANISM OF AROMATIC URETHANES AND UREAS EXPOSED TO NO<sub>x</sub> GAS AND ACTION OF ANTIYELLOWING AGENT.** Model systems using phenyl isocyanates and 4,4'-diphenylmethane diisocyanates (MDI) were investigated to analyze the nitrogen oxides (NO<sub>x</sub>) induced yellowing mechanism of aromatic polyurethane and polyurea. Nitrations of aromatic rings, especially those of p-position of the urethane and urea linkages, play an important role of the NO<sub>x</sub> induced yellowing. The bond cleavage at the central methylene bridge of MDI molecule took place with nitrations of the benzene rings, and some high molecular weight products were formed. The mechanism of the stabilization of polyurethane and polyurea against the NO<sub>x</sub> induced yellowing was also studied. Tertiary amines and magnesium oxide were found to be

efficient stabilizers of these polymers against the NO<sub>x</sub> induced yellowing. These stabilizers reacted very rapidly with NO<sub>x</sub> and efficiently converted to inactive compounds for the yellowing. The experimental results show that these stabilizers really act as good chemical absorbers of NO<sub>x</sub> within the polymers. 7 refs. In Japanese.

Ohzeki, Hiroshi (Asahi Chemical Industry Co, Fuji, Jpn); Takano, Hiroshi; Fujimoto, Yoshihisa; Kondo, Kunio. *Kobunshi Ronbunshu* v 45 n 4 1988 p 339-346.

**Nondestructive Examination** See AIRCRAFT MATERIALS—Composite Materials.

**Optical Properties** See Also OPTICAL FIBERS—Materials; POLYCARBONATES—Elasticity; POLYETHYLENES—Amorphous; POLYSTYRENES—Physical Properties; POLYSULFIDES—Doping; SPECTROMETERS, INFRARED.

**082551 LOW-POWER OPTICAL BISTABILITY AND PHASE CONJUGATION IN POLYDIACETYLENE.** Optical bistability is reported at 514 nm using a Fabry-Perot cavity filled with a polydiacetylene/toluene solution or a polydiacetylene/polyvinylchloride film. Switch-up powers of less than 4 mW are observed. The nature of the nonlinearity is a thermally induced refractive index change. Simultaneous degenerate four-wave mixing shows corresponding bistable behavior of the phase conjugate signal. (Author abstract) 14 refs.

Blau, W. (Trinity Coll, Dublin, Irel). *Opt Commun* v 64 n 1 Oct 1 1987 p 85-88.

**082552 EFFECT OF THE SIZE OF STRUCTURAL BULK INHOMOGENEITIES ON THE SPECULAR TRANSMITTANCE OF POLYMER FILMS.** This paper is confined to the effect of optical inhomogeneities in polymer films on the scattering or specular transmittance of light. Potential causes for the presence of scattering entities in the bulk phase of polymers are discussed. It is shown that practical transmittance measurements are greatly influenced by the angular width of the instrument receptor aperture. The choice of larger receptor apertures will tend to include some of the scattering at small angles due to large inhomogeneities in the measurement of specular transmittance. As a consequence, the transmittance measured is not necessarily increased by reducing the size of the inhomogeneities in the polymer films, but there is a critical size when the specular transmittance is a minimum. (Author abstract) 22 refs.

Neidinger, Hermann H. (Solar Energy Research Inst, Golden, CO, USA). *Sol Energy Mater* v 16 n 5 Nov 1987, *Sol Energy Mater Relat Pap of the Proc of the Mater and Opt for Sol Energy Convers and Adv Light Technol Conf*, San Diego, CA, USA, Aug 19-21 1986 p 393-402.

**082553 SPECULAR REFLECTANCE PROPERTIES OF SILVERED POLYMER MATERIALS.** The specular reflection properties of transparent cast polymer sheets and extruded polymer films, silvered and unsilvered, have been characterized with a newly designed specular reflectometer. The results obtained with this instrument are either absolute reflectance or a measure for the Fourier transform of the reflection function of the specimen in one dimension. Cast polymer sheets are investigated before and after silvering, and silvered polymer films are evaluated by mounting them with an adhesive onto aluminum or glass substrates, or by suspending the thin, silvered polymer as a taut membrane. Silvered polymers have attained a specularly such that over 90% of the incident beam is contained in a 1-2 mrad full-cone angle when mounted on a good substrate or suspended as a membrane. This value is well within the current goals for solar concentrators but silvered polymer mirrors are currently less specular than glass mirrors. The image quality of these mirrors does not change significantly over the wavelength range 400-1000 nm and angles of incidence between 20° and 60°. A principal limiting factor to the initial specularity of the polymer mirrors was waviness and/or curvature of the surface. Hence, the material being used as a substrate plays an important role in the optical performance of the mirror. (Edited author abstract) 17 refs.

Susemihl, Ingo (Solar Energy Research Inst, Golden, CO, USA); Schissel, Paul. *Sol Energy Mater* v 16 n 5 Nov 1987, *Sol Energy Mater Relat Pap of the Proc of the Mater and Opt for Sol Energy Convers and Adv Light Technol Conf*, San Diego, CA, USA, Aug 19-21 1986 p 403-421.

**082554 INFRARED ACTIVITY OF PHOTOEXCITATIONS IN POLYTHIOPHENE.** A careful measurement of the photoinduced infrared absorption of polythiophene is reported. The observation of new spectral features below the level of previous doping and photogeneration experiments provides evidence for weakly infrared active bipolaron shape oscillations predicted by recent calculations based on the continuum model for conjugated polymers. In addition, four new photoinduced absorptions, not described by existing theories for defect vibrations, demonstrate the coupling of photogenerated charged nonlinear excitations to ring vibrations of the aromatic thiophene monomer. (Author abstract) 25 refs.

Schaffer, H.E. (Univ of California, Santa Barbara, CA, USA); Heeger, A.J. *Solid State Commun* v 59 n 7 Aug 1986 p 415-421.

**082555 THERMOCHROMIC AND SOLVATOCHROMIC EFFECTS IN POLY(3-HEXYLTHIOPHENE).** We report thermochromic and solvatochromic effects in the soluble conductive polymer poly(3-hexylthiophene). Thin solid films of the polymer change color at higher temperatures. The color of solutions of the polymer can be changed by varying the composition of the solvent. Optical absorption in good solvents is similar to that of thin solid films at higher temperatures, while in poor solvents, absorption features similar to those found in solid films at low temperatures are observed. We discuss these effects with reference to the existence of a hitherto disregarded type of conformational defect, conformons. (Edited author abstract) 26 refs.

Inganas, O. (Univ of Linköping, Linköping, Swed); Salaneck, W.R.; Osterholm, J.-E.; Laakso, J. *Synth Met* v 22 n 4 Feb 1988 p 395-406.

**082556 COULOMB INTERACTION AND OPTICAL SPECTRA IN CONJUGATED POLYMERS.** Solitonic excitations in conjugated polymers are studied under the influence of Coulomb interactions. In addition to stabilizing bipolarons these effects change the characteristics of the optical spectra. The results are compared with recent experiments in polythiophene and good agreement is found. (Edited author abstract) 11 refs.

Sum, U. (Univ Bayreuth, Bayreuth, West Ger); Fesser, K.; Buettner, H. *Solid State Commun* v 61 n 10 Mar 1987 p 607-610.

**082557 INTERCHAIN OPTICAL TRANSITIONS IN CONDUCTING POLYMERS.** Interchain optical absorption ( $\alpha_I$ ) in oriented conducting polymers is found to depend significantly on the type of three-dimensional order in the dimerization pattern:  $\pi-\pi^*$  transitions are induced by E.I. light between out-of-phase chains, normally being suppressed for in-phase chains.  $\alpha_I$  is demonstrated to give large contribution to the photogeneration of long-lived charges if interchain hopping is non-adiabatic. The formation of interchain excitons (IE) for oppositely charged polarons or solitons on adjacent chains is considered to be due to strongly anisotropic Coulomb attraction. The optical creation of polaronic IE by E.I. and its conversion into solitonic IE in trans-(CH)<sub>x</sub> are discussed. (Edited author abstract) 36 refs.

Garstein, Yu.N. (UzSSR Acad of Sciences, Tashkent, USSR); Zakhidov, A.A. *J Mol Electron* v 3 n 4 Oct-Dec 1987 p 163-171.

**082558 OPTICAL ABSORPTION FROM POLARONS AND BIPOLARONS IN POLYTHIOPHENE.** The authors present a theoretical calculation, within the one-electron Hückel model, of the optical absorption due to polarons and bipolarons in doped polythiophene. The results are used to describe the absorption spectra at



thermal equilibrium, when the two kinds of excitation are present. Comparison with experimental data obtained in the case of doping shows that the Coulomb effects must be taken into account and the binding energy to the dopant is estimated to be about 0.14 eV. Although the bipolaron still remains the lowest-lying charged excitation, the contribution of Coulomb effects is shown to increase the proportion of polarons at thermal equilibrium. (Edited author abstract) 25 refs.

Bertho, D. (Univ des Sciences et Techniques du Languedoc, Montpellier, Fr); Jouanin, C. *Synth Met* v 24 n 3 May 1988 p 179-192.

**082559 THERMOCHROMISM, PHOTOCHROMISM AND ANOMALOUS TEMPERATURE DEPENDENCE OF LUMINESCENCE IN POLY(3-ALKYLTHIOPHENE) FILM.** Thermochromism and anomalous temperature dependence of emission spectra have been observed in poly(3-alkylthiophene) films, and are explained in terms of the transition of poly(3-alkylthiophene) conformation. The spectral change by laser irradiation and its memory have also been confirmed. The application of this phenomenon as an optical active element is proposed. (Author abstract) 12 refs.

Yoshino, Katsumi (Osaka Univ, Suita, Jpn); Nakajima, Shigeaki; Park, Dae Hee; Sugimoto, Ryu-ichi. *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 716-718.

**082560 PHOTOPHYSICS OF THE PHASES OF POLY (di-n-HEXYLSILANE).** Time-resolved fluorescence and fluorescence anisotropy measurements have been performed on solution, glass, film and powdered phases of the high molecular weight polysilane poly(di-n-hexylsilane). The emission lifetime is 4 times longer in the crystalline phase compared to solution phases of the polymer, but the decay of anisotropy is essentially unchanged. Evidence is presented for an isolated rodlike phase at a low temperature. (Edited author abstract) 17 Refs.

Thorne, J.R. G. (Univ of Pennsylvania, Philadelphia, PA, USA); Hochstrasser, R.M.; Zeigler, J.M. *J Phys Chem* v 92 n 15 Jul 28 1988 p 4275-4277.

**082561 CIRCULAR DICHROISM BAND SHAPES FOR HELICAL POLYMERS.** Three approaches are discussed for handling band shapes in circular dichroism (CD) and absorption spectra calculations for helical polymers. The effect of interaction between chromophores upon polymer transition band shapes is explored by employing Gaussian band shapes for isolated chromophore transitions in the classical coupled oscillator scheme. The results are compared to those obtained from using Lorentzian band shapes and to those obtained by using  $\delta$  function line shapes that are replaced by Gaussians after interactions are taken into account. The three approaches yield very different calculated  $\pi^*$  absorption and circular dichroism spectra for an  $\alpha$ -helix. Skewing of band shapes derived from input Gaussians is analyzed by employing input bands that are composite bands of several Lorentzians and mimic the input Gaussians. Skewing is shown to result from coupling of different vibronic components. (Edited author abstract) 29 Refs.

Rabenold, David A. (Iowa State Univ, Ames, IA, USA). *J Phys Chem* v 92 n 17 Aug 25 1988 p 4863-4868.

**082562 OPTICAL ABSORPTION AND SYMMETRIES IN CONDUCTING POLYMERS.** Various extensions of the original Su-Schrieffer-Heeger model for conducting polymers are discussed. The main emphasis lies on mechanisms which break fundamental symmetries of the one-dimensional electron-phonon system, esp. charge conjugation symmetry and supersymmetry are considered. It is shown that the optical spectra are characteristically changed by breaking these symmetries. (Author abstract) 12 refs.

Sum, U. (Univ Bayreuth, Bayreuth, West Ger); Fesser, K.; Buettner, H. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem, of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 957-959.

**Order-Disorder** See Also ARSENIC COMPOUNDS—Amorphous.

**082563 NEMATIC ORDER OF SEMIFLEXIBLE THERMOTROPIC POLYMERS FROM NMR DATA. FURTHER DEVELOPMENTS OF A PREVIOUS ANALYSIS.** The approach adopted in a previous paper for interpreting the observed  $^2\text{H}$  NMR spectra of poly(oxyphenylene-carbonyloxyphenyleneoxydodecanediyl- $d_{20}$ ) in the nematic state is developed in order to take into account the different time scales affecting conformational jumps and uniaxial reorientations of the chain around the director. Results show that by decoupling these two kinds of motion, the model is no longer critical to geometry. A very local additional order parameter is in fact required and it accounts for all geometrical features which describe the connection of the spacer to the mesogen unit while the structure of the  $^2\text{H}$  NMR spectrum is solely determined by the conformational mobility of  $\text{CD}_2$  groups. (Author abstract) 6 refs.

Brueckner, Sergio (Politecnico di Milano, Milan, Italy). *Macromolecules* v 21 n 3 Mar 1988 p 633-635.

**082564 CHEMICAL DISORDER AND PHASE SEPARATION: A STUDY OF TWO LIQUID CRYSTAL POLYMERS.** This work is pertinent to bipolymers. We have used a theoretical model to calculate transition temperatures for 10,000 different chemical sequences of a random terpolymer analogous to one synthesized in our laboratory. We have also analyzed by optical microscopy the phase separation of the experimental polymer into two fluids, one anisotropic and one isotropic. These experimental results are discussed in the context of the calculations. This work is pertinent to bipolymers. 15 refs.

Stupp, S.I. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Moore, J.S.; Martin, P.G. *Macromolecules* v 21 n 5 May 1988 p 1228-1234.

**Oxidation** See Also COATINGS—Materials; ELASTOMERS—Crosslinking; PHENOXY RESINS—Degradation; POLYAMIDES—Oxidation.

**082565 RETARDATION OF HIGH-TEMPERATURE OXIDATION OF POLYDIMETHYLPHENYLENE OXIDE BY DECABROMODIPHENYLOXIDE.** The role of non-uniformity in a polymer substance and the part played by low-molecular mass free-valency transfer agents, formed in the polymer, during high-temperature oxidation of the polymer are discussed. It is shown that, in the oxidation of polydimethylphenylene oxide at 240-260°C, only some of this polymer's monomeric links take part in the reaction. The rate of the oxidation process may be slowed down by additions of decabromodiphenyloxide, which is a precursor of the low-molecular mass radicals. (Author abstract) 11 refs.

Serenkova, I.A. (Acad of Sciences USSR, USSR); Sakharova, L.N.; Shlyapnikov, Yu.A. *Polym Sci USSR* v 28 n 8 1986 p 1931-1936.

**082566 RATE CONSTANTS OF CHAIN PROPAGATION AND TERMINATION REACTIONS DURING OXIDATION OF POLYETHYLBENZENES.** The initiated liquid-phase oxidation by molecular oxygen of mono-, di-, tri-, tetra-, penta- and hexaethylbenzenes was studied; the rate constants of chain propagation ( $k_p$ ) and chain termination ( $k_t$ ) were determined. With increase in the number of ethyl groups in the benzene rings from 3 to 6, the value of  $k_t$  decreases by a factor of more than 20, and for hexaethylbenzene it is equal to  $4.5 \cdot 10^5$  liters/mole-sec. A similar tendency is also observed for the values of  $k_p$ , calculated per a  $-\text{C}_2\text{H}_5$  group. (Edited author abstract) 13 refs.

Efimova, I.V. (Acad of Sciences of the Ukrainian SSR, Donetsk, USSR); Matyienko, A.G.; Kachurin, I.O.; Opeida, I.A. *Kinet Catal* v 28 n 2 pt 2 Mar-Apr 1987 p 418-421.

**082567 ESR TOMOGRAPHY AS A METHOD OF STUDYING DIFFUSIONAL OXIDATION OF POLYMERS.** The possibility of using ESR tomography to study the diffusional oxidation of polymers, using the

reaction  $\text{R} + \text{O}_2 \rightarrow \text{RO}_2$  has been examined. The applicability of the 'frontal diffusion' of oxygen model during the post-radiational oxidation of PTFE has been verified. A dependence of permeability on  $\gamma$ -radiation dose has been found. (Author abstract) 6 refs.

Yakimchenko, O.Ye. (USSR Acad of Sciences, USSR); Gal'Tsena, Ye.V.; Degtyarev, Ye.N.; Lebedev, Ya.S. *Polym Sci USSR* v 28 n 9 1986 p 2091-2096.

**082568 REACTION OF 2,4-DINITROPHENYLHYDRAZINE WITH OXIDIZED POLYMERS: A CAUTIONARY NOTE.** The reaction of 2,4-dinitrophenylhydrazine (DNPH) with model hydroperoxides has been investigated. Under conditions typically employed for carbonyl determination in oxidized polymers, the hydroperoxides undergo acid-catalyzed rearrangement to form additional carbonyl groups which subsequently react with DNPH. The rearrangement is particularly efficient for tertiary allylic hydroperoxides, although even t-butyl hydroperoxide gives some 2,4-dinitrophenylhydrazone. (Author abstract) 23 refs.

Boon, Andrew J. (Malaysian Rubber Producers' Research Assoc, Hertford, Engl). *Polym Commun (Guildford Engl)* v 29 n 2 Feb 1988 p 45-47.

**082569 KINETIC MODEL OF THE MECHANISM OF HIGH-TEMPERATURE INHIBITED OXIDATION OF POLYMERS.** A kinetic model has been presented for the mechanism of the inhibited autooxidation of polymers. In addition to the reaction of the peroxide radical  $\text{RO}_2^\cdot$  with the radical  $\text{In}^\cdot$  (stage 8) and the molecule  $\text{InH}$  (stage 7) of the inhibitor, which are typical of this process, the model also involves kinetic chain propagation by the radical  $\text{In}^\cdot$  (stage 10). Theoretical analysis of the model has been performed, which shows the basic difference between the model and the conventional kinetic schemes of inhibited oxidation in which the  $\text{RO}_2^\cdot + \text{InH}$  reaction (stage 7) is considered to be the kinetic chain termination step. The model allows the quantitative description of the inhibited autooxidation in general, viz. the kinetic curves of oxygen absorption and hydroperoxide accumulation during induction, inhibitor consumption and the concentration dependence of induction. The fact that the model fits the real process adequately is corroborated by the quantitative and qualitative agreement between calculations and experimental data on the oxidation of polyethylene in the presence of various spatially-hindered phenols and that of polypropylene in the presence of Nonox WSP. (Edited author abstract) 25 refs.

Gol'dberg, V.M. (USSR Acad of Sciences, Moscow, USSR); Vidovskaya, L.A.; Zaikov, G.E. *Polym Degradation Stab* v 20 n 2 1988 p 93-121.

**Performance** See SEWAGE TREATMENT—Sludge Drying; WATER TREATMENT—Coagulation.

**Permeability** See Also PLASTICS, FOAMED—Rigid.

**082570 THERMOCONTROL OF ELECTRON TRANSPORT THROUGH TERNARY COMPOSITE MEMBRANES COMPOSED OF POLYMER/LIQUID CRYSTAL/ELECTRON CARRIERS.** We selected vitamin  $\text{K}_1$  and hydrophobic viologen as electron carriers (ECs) and prepared ternary composite membranes composed of polymer/liquid crystal/EC. As reference membranes we used polymer/dibutyl phthalate/EC membranes which have no phase transition at the experimental temperature range. The redox-coupled electron transport for the vitamin  $\text{K}_1$  mediated system is illustrated. We have found that the rate of electron transport across the polymer/CPB/EC membranes changes distinctly at the crystal-liquid crystal phase transition temperature of CPB, and that the rate of electron transport can be controlled by an on-off-type temperature switch. 21 refs.

Shinkai, Seiji (Nagasaki Univ, Nagasaki, Jpn); Shimamoto, Katsuhiko; Nakamura, Shinichiro; Manabe, Osamu; Kajiyama, Tisato. *J Polym Sci Part C* v 25 n 12 Dec 1987 p 495-501.



**082571 GAS TRANSPORT IN POLYMERS BASED ON BISPHENOL-A.** Permeation measurements for  $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{O}_2$ ,  $\text{N}_2$ , and He were made with three polymers based on bisphenol-A, namely a polyhydroxyether, a polyetherimide, and a polyarylate. Measurements were also made for  $\text{CO}_2$  and  $\text{CH}_4$  in polysulfone. The data for  $\text{CO}_2$ ,  $\text{CH}_4$ , and  $\text{N}_2$  plus previous data for these gases in polycarbonate and polysulfone were combined with equilibrium gas sorption data and analyzed with the dual mode/partial immobilization model and the more recent gas-polymer-matrix model. A comparison of the two models was done on the basis of physical interpretations of the resulting parameters. The diffusion coefficient for the Henry's law population was related to the kinetic diameter of the gas. The infinite dilution, Henry's law population was related to the kinetic diameter of the gas. The infinite dilution, Henry's law, and Langmuir diffusion coefficients were related to the free volume of the polymer. The work suggests a means of order-of-magnitude estimation of diffusion coefficients from polymer density and molecular structure. (Author abstract) 28 refs.

Barbari, T.A. (Univ of Texas, Austin, TX, USA); Koros, W.J.; Paul, D.R. *J Polym Sci Part B* v 26 n 4 Apr 1988 p 709-727.

**082572 GAS SORPTION IN POLYMERS BASED ON BISPHENOL-A.** Equilibrium gas sorption measurements for  $\text{CO}_2$ ,  $\text{CH}_4$ , and  $\text{N}_2$  were made with three polymers based on bisphenol-A, namely a polyhydroxyether, a polyetherimide, and a polyarylate. These data plus previous results for two other bisphenol-A polymers, polycarbonate and polysulfone, were analyzed using the dual-mode sorption model and the more recent gas-polymer-matrix model. The models were compared on the basis of physical interpretations of the unrelaxed volume of the glassy polymer. The Henry's law sorption parameter from the dual-mode model was related to the internal pressure of the polymer and to its tensile stress at yield. The work suggests a means for estimation of gas sorption levels from thermal and mechanical properties of the polymer. (Author abstract) 37 refs.

Barbari, T.A. (Univ of Texas, Austin, TX, USA); Koros, W.J.; Paul, D.R. *J Polym Sci Part B* v 26 n 4 Apr 1988 p 729-744.

**082573 ON THE DUAL MODE GAS TRANSPORT MODEL FOR GLASSY POLYMERS.** The present paper is concerned with a detailed examination of the formalism and the physical basis of the dual mode mobility model used for the theoretical description of gaseous transport in glassy polymers in the light of recent theoretical and experimental work. It is shown that there are no really major differences among the original formulation of the model and later variants. A major modification becomes necessary, however, if the Langmuir sorption mode is assumed to exist in the form of patches or domains extensive enough to constitute a macroscopically recognizable phase rather than in the commonly accepted form of scattered individual adsorption sites. It is shown that the proper treatment of this case reduces to the familiar dual mode mobility formalism only under certain conditions. The interpretation of the experimental results thus far available is considered in some detail, and the usefulness of each of the aforesaid approaches in this respect is discussed. (Author abstract) 20 refs.

Petropoulos, J.H. (Democritus Natl Research Cent, Athens, Greece). *J Polym Sci Part B* v 26 n 5 May 1988 p 1009-1020.

**082574 TEST OF A MODEL OF STRESS-DEPENDENT DIFFUSION BY MEANS OF COMBINED COLORED TRACER AND BIREFRINGENCE PROFILE MEASUREMENTS.** In the present paper we further test a model of stress-dependent diffusion previously used with success to simulate the variation from Case I to Case II penetration kinetics in the system liquid methylene chloride-uniaxially oriented cellulose acetate film, according to whether penetration occurs across or along the axis of preferred macromolecular orientation. Data on penetration rates, optical density profiles (using a colored tracer), and the corresponding birefringence

profiles, characteristic of these penetration modes in the aforesaid system, are presented and compared with appropriate model uptake kinetic curves and penetrant concentration and compressive differential swelling stress profiles. It is shown that the salient features of the observed experimental behavior are in general accord with model predictions based on physically realistic assumptions. (Author abstract) 19 refs.

Petropoulos, J.H. (Democritus Natl Research Cent, Athens, Greece); Sanopoulou, M. *J Polym Sci Part B* v 26 n 5 May 1988 p 1087-1099.

**082575 APPLICATION AND DEVELOPMENT OF SYNTHETIC POLYMER MEMBRANES, PART III. SEPARATION OF WATER-ETHANOL MIXTURE THROUGH SYNTHETIC POLYMER MEMBRANES CONTAINING AMMONIUM MOIETIES.** The pervaporation technique through a membrane is considered to be one of suitable methods for separation of aqueous ethanol solution. Selective separation of aqueous ethanol solution has been attracting attention, since the formation of ethanol via fermentation of biomasses will be in the near future an important industrial process, which relates to the energy problem. In the present article, attention is focused on the selective separation of water from aqueous ethanol solution in terms of coulombic interaction. Membranes having ammonium moieties as cationic charge sites, quaternized poly[3-(N',N'-dimethyl)aminopropylacrylamide-co-acrylonitrile] membranes, were prepared and the selective separation of water-ethanol mixtures through the present membranes were investigated. 31 refs.

Yoshikawa, Masakazu (Kyoto Univ, Kyoto, Jpn); Ochiai, Satoshi; Tanigaki, Masataka; Eguchi, Wataru. *J Polym Sci Part C* v 26 n 6 Jun 1988 p 263-268.

**082576 GAS PERMEABILITY OF POLY(ORGANOPHOSPHAZENES).** The gas permeability and oxygen to nitrogen selectivity were determined for some poly(organophosphazenes). The membrane having the highest gas permeability was  $[\text{NP}(\text{NPH}_2)_2 \text{NE}_2(2)]_n$ , which had  $1.5 \times 10^{-6} \text{ cm}^3 (\text{cm cm}^{-2}) \text{ s}^{-1} (\text{cm Hg})^{-1}$  to oxygen or  $2.2 \times 10^{-6} \text{ cm}^3 (\text{cm cm}^{-2}) \text{ s}^{-1} (\text{cm Hg})^{-1}$  to nitrogen. The membrane having the highest oxygen to nitrogen selectivity of about 3 had the formula  $[\text{N}(\text{OC}_6\text{H}_4\text{Cl-p})_2]_n$ . The selectivity did not depend on the glass transition temperature of the membranes. The membrane prepared from  $[\text{NP}(\text{PC}_6\text{H}_4\text{CH}_3\text{-p})_2]_n$  had a negative activation energy for oxygen and nitrogen permeability. (Author abstract) 9 refs.

Kajiura, Meisetsu (Nagoya Univ, Nagoya, Jpn). *J Mater Sci* v 23 n 4 Apr 1988 p 1360-1362.

**Permeability, Mechanical** See Also GASES—Mixing.

**082577 GAS PERMEABILITY OF POLYVINYL-TRIMETHYLSILANE MODIFIED BY THE RADIATION GRAFTING OF ACRYLONITRILE.** The permeability and diffusion of a number of gases at 20-80°C through homogeneous membranes made from polyvinyl-trimethylsilane modified by the radiation grafting of acrylonitrile have been investigated. An increase in the proportion of PAN in the membranes leads to an increase in the selectivity of the permeability of pairs of gases such as  $\text{He-CH}_4$ ,  $\text{He-N}_2$ ,  $\text{He-CO}_2$  and  $\text{H}_2\text{-CH}_4$ . In the system studied, there is a correlation between the diffusion coefficient and the effective cross-section of the gas molecules and between the solubility coefficient and their characteristic force constants of the Lennard-Jones potential. (Author abstract) 9 refs.

Starannikova, L.E. (AV Topchiyev Inst for Petrochemical Synthesis, USSR); Teplyakov, V.V.; Durgar'yan, S.G. *Polym Sci USSR* v 28 n 6 1986 p 1411-1416.

**082578 INVESTIGATION OF THE HIGH GAS PERMEABILITY OF POLY(1-TRIMETHYLSILYL-1-PROPYLENE).** The permeability of poly(1-trimethylsilyl-1-propylene), PMSP, to light gases is higher than that of any other nonporous synthetic polymer at ambient

temperatures. PMSP is in the glassy polymer state at these temperatures. Permeability, diffusion, and solubility coefficients were determined for  $\text{N}_2$ ,  $\text{O}_2$ ,  $\text{CH}_4$ , and  $\text{CO}_2$  in PMSP, and are compared with values reported for these gases in poly(dimethyl siloxane). The higher gas permeability of PMSP results primarily from a substantial gas solubility, which appears to be due, in turn, to a large 'excess' free volume in the unrelaxed (Langmuir) domains of this glassy polymer. (Edited author abstract) 29 refs.

Ichiraku, Y. (Syracuse Univ, Syracuse, NY, USA); Stern, S.A.; Nakagawa, T. *J Membr Sci* v 34 n 1 Nov 1987 p 5-18.

**082579 GAS TRANSPORT IN POLY(VINYL CYCLOHEXANECARBOXYLATE).** Low-pressure gas permeation measurements were performed on poly(vinyl cyclohexanecarboxylate) to evaluate its transport characteristics. The transport data of  $\text{CO}_2$ ,  $\text{O}_2$ ,  $\text{N}_2$ , He, and Ar were presented as a function of temperature ranging from 15 to 85°C. The apparent transport parameters were determined by the time lag method above and below the glass transition temperature and they were compared with other polymers of similar chemical structures. The side chain of the polymer has a bulky cyclohexyl group, which seemed to increase gas diffusivity. The activation energy for diffusion seemed to be related with the polarity of side chain. The relationships between gas diffusivity, physical properties, and chemical structure were qualitatively discussed in comparison with the data on poly(vinyl benzoate) and poly(vinyl acetate). (Author abstract) 17 refs.

Hirose, Takuji (Industrial Products Research Inst, Tsukuba, Jpn); Mizoguchi, Keishin; Kamiya, Yoshinori. *J Appl Polym Sci* v 35 n 2 Feb 5 1988 p 517-528.

**Phase Diagrams** See CRYSTALS, LIQUID—Polymerization.

**Phase Equilibria** See POLYSTYRENES—Solutions.

**Phase Transitions** See Also COPOLYMERS—Synthesis; EPOXY RESINS—Viscoelasticity; PLASTICS FILMS—Spectroscopic Analysis; POLYVINYL CHLORIDE—Mechanical Properties.

**082580 QUANTITATIVE THEORY AND INTERPRETATION OF THE EXPERIMENTAL DATA ON THE COIL-GLOBULE TRANSITION IN THE PERSISTENT MACROMOLECULE.** The theory of the globular state and the coil-globule transition has been constructed for a persistent macromolecular. The reasons for the universality of the picture of this transition have been explored (its independence from the microscopic characteristics of the polymer). A method of seeking the parameters of the bead model equivalent to a given persistent chain is indicated. A way of evaluating the axial ratio of the macromolecule (ratio of the persistent length  $l$  to the thickness  $d$  from the experimental data on the coil-globule transition has been found. In cyclohexane and dioctylphthalate  $l/d \approx 2$  has been found for PS. The orientation ordering of portions of the chain in the surface layer of the globule is analyzed numerically. (Author abstract) 15 refs.

Grosberg, A.Yu. (USSR Acad of Sciences, USSR); Zhestkov, A.V.; Kuznetsov, D.V. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1554-1562.

**082581 SCATTERING FUNCTION AND THE DYNAMICS OF PHASE SEPARATION IN POLYMER MIXTURES UNDER SHEAR FLOW.** The phenomenological mean-field theory describing concentration fluctuations and spinodal decomposition of binary mixtures of long flexible macromolecules is generalized to mixtures under steady shear flow. This shear flow leads to a partial orientation and stretching of the coils, as well as to an anisotropic deformation of concentration fluctuations. We obtained the collective scattering function describing these concentration fluctuations in the mixture under shear flow. Both the steady-state situation in the one-phase



region and the initial stages of spinodal decomposition for concentrations within of the spinodal curve are considered. (Author abstract) 29 refs.

Pistoor, N. (Johannes-Gutenberg Univ, Mainz, West Ger); Binder, K. *Colloid Polym Sci* v 266 n 2 Feb 1988 p 132-140.

**082582 DEPENDENCE OF THE GLASS TRANSITION TEMPERATURE OF POLY[N-(n-ALKYLOXY-CARBONYL-METHYL) MALEIMIDES] AND POLY[N-(5-n-ALKYLOXYCARBONYL-n-PENTYL) MALEIMIDES] ON n-ALKYL SIDE-CHAIN LENGTH.** The glass transition temperature has been determined by a refractometric techniques for two homologous series of poly[N-(n-alkyloxycarbonyl-methyl) maleimides] (PEMIS 1) and poly[N-(5-n-alkyloxycarbonyl-n-pentyl) maleimides] (PEMIS 5) with the outer part of the n-alkyl side-chain ranging in length from ethyl to dodecyl for PEMIS 1 and from ethyl to decyl for PEMIS 5 and including only the even members of the series. The glass transition temperature is directly related to the number of methylene groups in the outer part of the n-alkyl side-chain (including terminal methyl) of the repeating unit. A semiempirical equation is presented that affords estimates of  $T_g$  that are in good agreement with the experimental data. (Author abstract) 47 refs.

Barrales-Rienda, J.M. (CSIC, Madrid, Spain); Mazon-Arechederra, J.M. *J Polym Sci Part B* v 26 n 4 Apr 1988 p 935-947.

**082583 INSULATOR-TO-METAL TRANSITION IN POLYANILINE.** A study of the magnetic susceptibility of the emeraldine form of polyaniline shows the presence of a Pauli susceptibility approximately linearly proportional to the degree of protonation in agreement with phase segregation into metallic and nonmetallic phases. A model based upon the transition upon protonation from isolated doubly charged protonated diimine groups to a polaronic metal is suggested, together with the role of localization of polarons at the surface of and within the disordered small metal particles formed. (Author abstract) 34 refs.

Ginder, J.M. (Ohio State Univ, Columbus, OH, USA); Richter, A.F.; MacDiarmid, A.G.; Epstein, A.J. *Solid State Commun* v 63 n 2 Jul 1987 p 97-101.

**082584 INFLUENCE OF THE GLASS TRANSITION ON SOLVENT SELF-DIFFUSION IN AMORPHOUS POLYMERS.** The free-volume theory of diffusion is used to analyze the temperature dependence of solvent self-diffusion coefficients both above and below the glass transition temperature at concentrations removed from the pure polymer limit. The glass transition can have a pronounced effect on the temperature dependence of solvent self-diffusion coefficients at small solvent concentrations, but the theory predicts a decreased effect of the transition on the diffusion process with increasing solvent concentration. (Author abstract) 9 refs.

Vrentas, J.S. (Pennsylvania State Univ, University Park, PA, USA); Duda, J.L.; Ling, H.-C. *J Polym Sci Part B* v 26 n 5 May 1988 p 1059-1065.

**082585 STATISTICAL THERMODYNAMIC THEORY FOR THE PHASE TRANSITION OF THE LIQUID CRYSTALLINE POLYMERS CONSISTING OF MESOGENIC UNITS AND FLEXIBLE SPACERS IN THE MAIN CHAINS.** A model for the polymers consisting of mesogenic units and flexible spacers in the main chains is proposed and then treated by statistical thermodynamics. A general expression for the order degree D of the liquid crystalline polymers is derived. From this expression the physical meaning of the clearing point  $T_c$  of the liquid crystals is illustrated. When the value of energy parameter is negative, the polymer exhibits the liquid crystalline behavior. In Chinese. 6 refs.

Wang, Xueqiu; Wu, Herong; Li, Shijin. *Huadong Huagong Xueyuan Xuebao* v 14 n 2 1988 p 127-134.

**082586 PHOTOACOUSTIC STUDY OF PTS (BIS-P-TOLUENE SULFONATE OF 2, 4-HEX-**

**ADIENE-1,6-DIOL) SINGLE CRYSTAL AND ITS THERMAL PROPERTIES.** The photoacoustic signal and phase angle of a single crystal of polybis(p-toluene sulfonate) of 2,4-hexadiene-1,6-diol (PTS) were measured in the temperature range of 175-225 K. The jump of the photoacoustic signal and phase angle, and the presence of a peak in  $C_p/K_s$  (here  $C_p$  and  $K_s$  are the specific heat and thermal conductivity of PTS, respectively) near 200 K can be attributed to the second-order phase transition in PTS. The thermal conductivity of PTS, which is given for the first time, is directly proportional to the temperature in the above temperature range. This anomalous behavior is discussed. (Author abstract) 23 refs.

Yinglei, Du (Univ of Science & Technology of China, Hefei, China); Baimei, Wu; Pingsheng, He. *J Phys Chem Solids* v 49 n 5 1988 p 499-503.

**082587 IGNITION PHASE TRANSITION OF A POLYMER: CONVECTIVE EXPOSURE.** The ignition of a semi-infinite solid polymer under convective exposure is investigated. A quasi-steady approximation is used for the gas phase and the transient effect is accounted for in the solid phase only. Both surface and gas phase chemical reactions are included simultaneously. The ignition mechanism is studied in terms of the concurrent heat transfer, mass transfer and chemical processes at the surface as well as in the gas phase. The gas phase governing equations are integrated independently from the solid phase energy equation using the Adams-Moulton subroutine. Corrections to the iterative procedure are carried out by establishing a set of perturbation equations and using the Newton-Raphson and least-squares methods. The results indicate that ignition occurs in the heterogeneous mode within a narrow range of low flow velocities and high temperatures. An ignition phase transition point exists, and within a wide range of high flow velocities, ignition switches to the homogeneous mode. (Author abstract) 32 Refs.

Durbetaki, P. (Georgia Inst of Technology, Atlanta, GA, USA); Phuoc, T.X. *Int J Numer Methods Eng* v 25 n 2 Jun 1988 p 373-386.

**082588 THEORY OF THE PHASE TRANSITION UNDER STRESS IN POLY(BUTYLENE TEREPHTHALATE).** Poly(butylene terephthalate) undergoes a reversible phase transition when subjected to a longitudinal stress. The temperature dependence of the critical stress is examined in terms of a model of nucleation and growth and is related to the temperature dependence of the width in stress of the hysteresis loop. Experimental evidence shows that while contributions to the entropy from changes in phonon frequencies at the transition and internal stresses caused by morphological effects may play some role, they do not appear capable of accounting for the observed temperature dependence of the critical stress. A model of nucleation and growth on the other hand, appears consistent with the observed data in that a predicted relation between the critical stress and the width of the hysteresis loop is obeyed. (Edited author abstract) 8 Refs.

Al-Jishi, Radi (California State Univ, Los Angeles, CA, USA); Taylor, P.L. *Macromolecules* v 21 n 7 Jul 1988 p 2240-2243.

**082589 MULTINUCLEAR SOLID STATE NMR STUDY OF PHASE TRANSITIONS IN POLY[BIS(4-ETHYLPHENOXY)PHOSPHAZENE]** The authors report preliminary results from  $^{13}\text{P}$  and  $^{13}\text{C}$  NMR studies on the phase transitions of poly[bis(4-ethylphenoxy)phosphazene] (PBEP) along with the results of DSC thermal analysis and X-ray diffraction analysis. The temperature dependence of the  $^{31}\text{P}$  MAS/DD spectra of PBEP is presented. At low temperatures, there are three components with different chemical shifts, which correspond to the crystalline, interfacial, and amorphous phases. This assignment has been confirmed by the real time observation of the crystallization process from the mesophase at 75°C. The chemical shift of the crystalline phase is least shielded, that of the amorphous phase is most shielded, and that of the interface is intermediate. A discussion is also presented of the nature of the liquid

crystalline phase in poly(organophosphazenes). 34 Refs.

Tanaka, Hajime (AT&T, Murray Hill, NJ, USA); Gomez, M.A.; Tonelli, A.E.; Chichester-Hicks, S.V.; Haddon, R.C. *Macromolecules* v 21 n 7 Jul 1988 p 2301-2304.

**Photochemical Reactions** See Also COATINGS—Plastics; COPOLYMERS—Synthesis; HYDROCARBONS—Photochemical Reactions; PLASTICS—Stabilizers; POLYMERIZATION—Cationic Polymerization.

**082590 PHOTODECOMPOSITION AND CHARACTERISATION OF POLYMERS BY UV-LASER INTERACTION.** Ultraviolet-laser-induced emission from various commercial and additive-free polymers were characterized. The olefinic polymers gave a strong Raman emission line corresponding to the H-C-H stretching vibration ( $2875\text{ cm}^{-1}$ ) along with a broad fluorescence which was common to all the samples. The fluorescence was attributed to the chromophoric impurities inherently present in all the polymers. Quenching of emission under uv irradiation was related to the processes of transformation of the chromophores through excited-state reaction and the formation of links between polymer chains. (Author abstract) 13 refs.

Ahmad, S. Rafi (Royal Military Coll of Science, Swindon, Engl). *J Phys D* v 20 n 10 Oct 14 1987 p 1315-1317.

**082591 PHOTOCHEMICAL REARRANGEMENT OF POLYMERIC N-(1-PYRIDINIO) AMIDATES. A NOVEL, AQUEOUS PHOTORESIST SYSTEM.** The application of photochemistry to polymer science is especially interesting when the photochemical alteration of solubility is extremely pronounced. One approach the authors have taken is to look for photochemical isomerization reactions that are accompanied by a large change in polarity. One of the interesting reactions, described in a review article on aminimides (or ammonio-amidates), is the photochemical rearrangement of N-(1-pyridinio) amidates, I, to N-acyldiazepines, II. It occurred to the authors that conventional polymer films, containing pyridinio amidate groups, might exhibit large solubility changes after irradiation. This paper describes the implementation of this chemistry as the basis of a new, interesting type of photoresist. 9 refs.

Taylor, Lloyd D. (Polaroid Corp, Cambridge, MA, USA); Kolesinski, Henry S.; Edwards, Brooks; Haubs, Michael; Ringsdorf, Helmut. *J Polym Sci Part C* v 26 n 4 Apr 1988 p 177-180.

## Photochromism

**082592 FORMATION OF MOLECULAR H- AND J-STACKS BY THE SPIROPYRAN-MEROCYANINE TRANSFORMATION IN A POLYMER MATRIX.** Kinetic and spectral properties of merocyanine dyes, formed on irradiation of spiropyran dissolved in a polymer matrix, depend on the spiropyran concentration. The observed properties are explained by a model in which the merocyanine molecules form molecular H-stacks. A method for formation of molecular J-stacks in the polymer matrix was also developed. Stabilization of the merocyanine dye in the J-stacks completely prevents the conversion back to spiropyran. (Author abstract) 19 refs.

Eckhardt, H. (Allied-Signal Inc, Morristown, NJ, USA); Bose, A.; Krongauz, V.A. *Polymer* v 28 n 11 Oct 1987 p 1959-1964.

**082593 ORGANIC SOLID PHOTOCROMISM BY PHOTOREDUCTION MECHANISM: ARYL VILOGENS EMBEDDED IN POLY(N-VINYL-2-PYRROLIDONE).** In this paper the authors report the reversible photocolor development (photochromism) of N,N'-diaryl-y,y'-dipyridylum dichlorides (aryl viologens) in a PVP matrix. Green colors appeared in this case because of the extension of delocalization of electrons of the cation radical caused by the conjugation of aryl



groups. Sensitivities to UV light were generally higher than those of conventional benzyl-type viologens. 6 refs.

Kamogawa, Hiroyoshi (Yamanashi Univ, Kofu, Jpn); Satoh, Shigeki. *J Polym Sci Part A* v 26 n 2 Feb 1988 p 653-656.

**082594 SPIROPYRAN-ODONIUM SALT SYSTEM AS A TWO PHOTON RADICAL PHOTOINITIATOR.** A variety of radical photoinitiators sensitive to visible light have been attracting interest with respect to the application of photosensitive resins to laser imaging technology. It has been reported that a photochromic spiroopyran conjugated with a benzophenone moiety acts as a photoinitiator for radical polymerization under simultaneous irradiation with both uv and visible light. Recent work has revealed that some dyes including merocyanines and cyanines are effective radical photoinitiators when coupled with iodonium salts. This prompted the authors to study the efficiency of radical photoinitiation using the ring opened, colored form of a spirobenzopyran which has a cyanine dylike structure. This paper deals with the enhancement of radical photopolymerization initiated with readily available 1,3,3-trimethylindolino-6-nitrospirobenzopyran (SP) combined with diphenyliodonium hexafluorophosphate (DPI) by subsequent exposure of the uv irradiate film to a He-Ne laser beam. 12 refs.

Ichimura, Kunihiro (Research Inst for Polymers & Textiles, Tsukuba, Jpn); Sakuragi, Masako. *J Polym Sci Part C* v 26 n 4 Apr 1988 p 185-189.

**Photoconductivity** See Also COPOLYMERS—Photoconductivity; PLASTICS FILMS—Electric Conductivity.

**082595 HOLE TRANSPORT IN POLYMERS OF (N-ETHYLCARBAZOL-3-YL)METHYL ACRYLATE AND METHACRYLATE.** (N-Ethylcarbazol-3-yl)-methyl acrylate and methacrylate were polymerized anionically and radically. Anionically-polymerized polyacrylate using ethylmagnesium chloride-benzalacetophenone as catalyst is an isotactic rich polymer with 85% isotactic dyad. All polymers except anionically polymerized polymethacrylate showed good film forming property. Hole drift mobilities measured by the time-of-flight method at room temperature and at  $5 \times 10^5$  V/cm are in the following order: isotactic polyacrylate ( $1.0 \times 10^{-5}$  cm<sup>2</sup>/V s) > atactic polyacrylate ( $1.8 \times 10^{-6}$  cm<sup>2</sup>/V s) > atactic polymethacrylate ( $1.2 \times 10^{-6}$  cm<sup>2</sup>/V s) at  $5 \times 10^5$  V/cm. These results are discussed in terms of the hopping model between localized sites. (Author abstract) 14 refs.

Uryu, Toshiyuki (Univ of Tokyo, Tokyo, Jpn); Ohkawa, Haruki; Oshima, Ryuichi. *J Polym Sci Part B* v 26 n 6 Jun 1988 p 1227-1236.

**082596 TRANSIENT PHOTOCONDUCTIVITY OF POLYSILOXANE WITH PENDANT CARBAZOLE GROUPS.** We report measurements of transient photocurrents in polysiloxane polymers with pendant carbazole groups. The experiments agree well with the continuous-time random-walk theory with an algebraic waiting-time distribution  $\psi(t) \approx t^{-1-\alpha}$ . Our experiments yield  $\alpha = 0.58$  for polysiloxane. (Author abstract). 16 Refs.

Schnorer, H. (Univ Bayreuth, Bayreuth, West Ger); Domes, H.; Blumen, A.; Haarer, D. *Philos Mag Lett* v 58 n 2 Aug 1988 p 101-105.

**Photoreactivity** See Also EPOXY RESINS—Crosslinking; POLYSTYRENES—Synthesis.

**082597 NEW MATERIALS WHICH RESPOND TO VISIBLE LIGHT: FUNCTIONAL POLYMERS CONTAINING ZIRCONIUM.** Photoresponsive polymers which change their magnetic properties when illuminated by visible light have been found. n-Butyl zirconate was polymerized in tetrahydrofuran and other solvents. The polymer, when illuminated, changes its conformation and a new spin-nuclear interaction in the electron spin resonance spectrum is observed. These polymers, when 1 wt% Pt was added, exhibited photocatalytic activities and photolysed a 1:1 methanol-H<sub>2</sub>O mixture and a 0.24 M Na<sub>2</sub>S aqueous solution, using visible light of wavelength

480 to 730 nm. (Author abstract) 6 refs.

Ueda, Hisashi (Tsukuba Research Center, Yatabemachi, Jpn); Yonemura, Michiko; Sekine, Tadao. *J Mater Sci* v 22 n 9 Sep 1987 p 3349-3352.

**Photosensitivity** See Also MEMBRANES—Photochemical Reactions.

**082598 PHOTOSENSITIVE POLY(METHACRYLATES) HAVING STYRYLPYRIDINIUM AND STYRYLQUINOLINIUM GROUPS.** Three methods to introduce photodimerizable styrylpyridinium or styrylquinolinium groups to methacrylate polymers are described. Among these, copolymerization of methacrylate monomers with methacrylated styrylpyridine or styrylquinoline offered the most convenient procedure to prepare photosensitive polymers because of the excellent solubility of the polymers having the photofunctional groups in high content. Subsequent treatment with p-toluenesulfonic acid to quaternize the pyridine or quinoline moiety made the polymer highly photosensitive. The polymers having a styrylquinolinium group were found to be sensitive to 488 nm light of an Ar laser, and the sensitivity was about 3 mJ/cm<sup>2</sup> when the content of the photosensitive group was 15 mol %. (Author abstract) 8 refs.

Ichimura, Kunihiro (Research Inst for Polymers & Textiles, Tsukuba, Jpn); Oohara, Noboru. *J Polym Sci Part A* v 25 n 11 Nov 1987 p 3063-3077.

**082599 PHOTOSENSITIVE RESINS CONTAINING p-DIMETHYLAMINO BENZYLIDENE DERIVATIVES AND DIPHENYLIODONIUM SALT AS PHOTOINITIATORS.** A series of p-dimethylaminobenzylidene derivatives was able to sensitize the photodecomposition of diphenyliodonium salt to afford highly photosensitive negative-type resins. When a polymer-bearing methacryloylated group in the side chain was sensitized with a combination of the p-dimethylaminobenzylidene compounds and the iodonium salt, the polymer demonstrated high sensitivity even to 488 nm light emitted from an Argon laser. The same photoinitiator systems were applicable to insolubilize poly(glycidyl methacrylate) through cationic photopolymerization. The storage stability of these types of photoinitiators depends on the structure of the benzylidene compounds; decreasing the basicity of the amino group enhanced the thermal stability. (Author abstract) 9 refs.

Ichimura, K. (Research Inst for Polymers & Textiles, Tsukuba, Jpn); Kameyama, A.; Hayashi, K. *J Appl Polym Sci* v 34 n 8 Dec 1987 p 2747-2756.

**082600 SYNTHESIS OF PHOTOPOLYMERS CONTAINING PENDANT CHALCONE MOIETIES BY ADDITION REACTION OF PENDANT EPOXIDE GROUP WITH ESTER COMPOUNDS.** New photosensitive polymers containing pendant chalcone moieties as photosensitive groups were synthesized by addition reaction of pendant epoxide group in poly(glycidyl methacrylate) (PGMA) with esters having chalcone moieties using tetraethylammonium bromide as a catalyst in diglyme at 100°C. The polymer obtained by this method showed high photochemical reactivity and practical photosensitivity, and those having an absorption maximum in a longer wave length region or a high molecular absorption showed high photochemical reactivity. (Edited author abstract) In Japanese. 15 refs.

Saita, Seiji (Kanagawa Univ, Yokohama, Jpn); Nishikubo, Tadatoshi. *Kobunshi Ronbunshu* v 44 n 10 Oct 1987 p 737-743.

**082601 PHOTORESIST CHARACTERISTICS OF THE SENSITIZED POLY[1-(TRIMETHYLSILYL)-1-PROPENE].** Photoresist characteristics of the sensitized poly[1-(trimethylsilyl)-1-propene] denoted as PMSP were extensively evaluated. PMSP sensitized by 2-ethylanthraquinone became a positive working photoresist having a sensitivity of 100 mJ/cm<sup>2</sup>. The sensitivity, resolution and linewidth dimensionality depend on the developers employed. When

ketone compounds were used as a developer, linewidth dimensionality after developing reached a practical level. Addition of nonionic surfactant to the resist enhanced the sensitivity. (Edited author abstract) In Japanese. 5 refs.

Takada, Koichi (Sanyo Chemical Industries Ltd, Kyoto, Jpn); Matsuya, Hidehiko; Kishiki, Hiroshi. *Kobunshi Ronbunshu* v 19 n 4 1987 p 911-916.

**082602 STUDY OF POLYMERIC PHOTOSENSITIZER. 2. SYNTHESIS OF MULTIFUNCTIONAL POLYMERIC PHOTOSENSITIZERS CONTAINING A PENDANT NITROARYL GROUP AND A QUATERNARY PHOSPHONIUM SALT AND THEIR APPLICATION TO THE PHOTOCHEMICAL REACTION OF POTASSIUM CINNAMATE.** The authors report on the successful syntheses of multifunctional polymeric photosensitizers containing pendant nitroaryl moieties as a chromophore and a pendant quaternary phosphonium salt as a substrate-attracting group and investigate the photochemical reaction of potassium cinnamate by using those multifunctional polymeric photosensitizers in water. It was found that the multifunctional polymeric photosensitizer PTBT-NP (Pendant 4-nitrophenoxy) has excellent efficiency. The control of content of pendant photosensitizer moiety in the polymer and of concentration of the photosensitizer in the reaction system is very important to get high efficiency. (Edited author abstract) 22 refs.

Nishikubo, Tadatoshi (Kanagawa Univ, Yokohama, Jpn); Kubo, Jiro; Matsui, Kenkichi; Iizawa, Takashi. *Macromolecules* v 21 n 6 Jun 1988 p 1583-1589.

**Physical Chemistry** See Also CELLULOSE DERIVATIVES—Research; CRYSTALS, LIQUID—Nematic; LATEXES—Adsorption; POLYSTYRENES—Solutions.

**082603 LOW-PRESSURE CO<sub>2</sub> SORPTION IN POLY(VINYL BENZOATE) CONDITIONED TO HIGH-PRESSURE CO<sub>2</sub>.** Sorption of CO<sub>2</sub> in poly(vinyl benzoate) was gravimetrically measured at pressures up to 1 atm. Sorption isotherms were determined above and below the glass transition temperature T<sub>g</sub> from 5 to 85°C. The isotherms were analyzed by the dual-mode sorption model assuming that the plasticizing effect of sorbed CO<sub>2</sub> is negligible at this pressure range. The solubilities and Henry's law dissolution parameters were compared with those obtained by the high-pressure sorption and permeation measurements. Henry's law dissolution parameters were in good agreement with one another. However, the solubilities first determined here were smaller than those determined by the high-pressure sorption experiment at the same temperature. It was clear that the Langmuir capacity of the present specimen was smaller in spite of similar high-pressure CO<sub>2</sub> exposure. Relaxation of the polymer was expected to be one of the reasons. This expectation was confirmed from the observation and analysis of sorption isotherms after two kinds of treatments. (Edited author abstract) 17 refs.

Hirose, Takuji (Industrial Products Research Inst, Ibaraki, Jpn); Mizoguchi, Keishin; Naito, Yasutoshi; Kamiya, Yoshinori. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1715-1724.

**Physical Properties** See Also ACETYLENE—Physical Properties; ACRYLICS—Solutions; AROMATIC POLYMERS—Conductive; AROMATIC POLYMERS—Synthesis; BLOCK COPOLYMERS—Synthesis; COAL—Suspensions; ETHERS—Synthesis; INORGANIC POLYMERS—Synthesis; INTERPENETRATING POLYMER NETWORKS—Synthesis; IONOMERS—Microstructure; MELAMINE FORMALDEHYDE RESINS—Synthesis; MONOMERS—Polymerization; PLASTICIZERS—Materials; POLYACETYLENES—Electronic Properties; POLYAMIDES—Synthesis; POLYBUTADIENES—Synthesis; POLYBUTADIENES—Thermal Properties; POLYBUTYLENE—Synthesis; POLYESTERS—Synthesis; POLYETHYLENES—Chlorination; POLYETHYLENES—Crystallization; POLYETHYLENES—Degradation; POLYETHYLENES—High Density; POLYETHYLENES—Spectroscopic Analysis; POLYIMIDES—Synthesis; POLYMETHYL METHACRYLATE—Chemistry; POLYMETHYL METHACRYLATE—Synthesis; POLYPEPTIDES—Synthesis; POLYURETHANES—Synthesis; RUBBER—Production; TEXTILE FIBERS—Structure; THERMOPLASTIC ELASTOMERS—Physical Properties; URANIUM AND ALLOYS—Adsorption.



**082604 POLY(SULPHOPROPYLBETAINES): 3. BULK PROPERTIES.** The bulk properties of a series of five atactic aliphatic and aromatic poly(sulphopropylbetaines) have been studied by u.v. and broad line n.m.r. spectroscopy, differential scanning calorimetry (d.s.c.), X-ray scattering (WAXS, SAXS) and thermally stimulated depolarization currents (t.s.d.c.) (Edited author abstract) 43 refs.

Galim, M. (ULP Strasbourg, Strasbourg, Fr); Marchal, E.; Mathis, A.; Meurer, B.; Monroy Soto, Y.M.; Galim, J.C. *Polymer* v 28 n 11 Oct 1987 p 1937-1944.

**082605 DIFFERENTIATION BETWEEN CONFORMATIONAL TRANSITIONS OF POLYMERS AND THE TRANSITION OBSERVED NEAR THE THETA CONDITIONS.** The differentiation between the conformational transitions of polymers and the transition observed near the  $\theta$  conditions has been investigated. The conformational transitions are related with side-group effects and vanish under the influence of an appropriate amount of a polar solvent. In the contrary, the transition observed in the vicinity of the  $\theta$  temperature is related with chain-backbone effects. The addition of a polar solvent shifts this transition to a different temperature in accordance with the resulted change of the  $\theta$  temperature of the system. (Author abstract) 21 refs.

Tsitillianis, Constantinos (Univ of Patras, Patras, Greece). *Polym Bull (Berlin)* v 18 n 2 Aug 1987 p 183-188.

**082606 CONDUCTING POLYMER COMPOSITES OF SOLUBLE POLYTHIOPHENES IN POLYSTYRENE.** We report optical and electronic properties of composites of soluble polythiophene derivatives and polystyrene over the full range of composition. The composite films were prepared by evaporating the solvent in an inert atmosphere from a solution containing both polymers. The films, made conducting by charge transfer doping (reaction with NOPF<sub>6</sub> in acetonitrile), display an insulator-metal transition at the percolation threshold: a volume fraction of  $\approx 16\%$  conducting polymer in polystyrene. (Author abstract) 22 refs.

Hotta, S. (Univ of California, Santa Barbara, CA, USA); Rughoputh, S.D.D.V.; Heeger, A.J. *Synth Met* v 22 n 1 Nov 1987 p 79-87.

**082607 EFFECTS OF FLOW AND THERMODYNAMIC SWELLING ON THE TRANSLATIONAL MOBILITY OF MOLECULES OF MODERATELY RIGID POLYMERS.** The values of the Kuhn segment and the hydrodynamic cross-section are determined for a series of polymer-solvent systems, with due allowance for the effects of flow and volume swelling on the translational mobility of the molecules. The polymer-solvent thermodynamic interaction parameters for the same system are evaluated. Failure to allow for volume effects results in an apparent increase in the equilibrium rigidity and to a decrease in the hydrodynamic cross-section of the molecules. (Author abstract) 18 refs.

Bushin, S.V. (USSR Acad of Sciences, USSR); Astapenko, E.P. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1667-1673.

**082608 MOLECULAR WEIGHT DEPENDENCE OF INTERFACIAL TENSION OF POLY(ETHYLENE GLYCOLS).** The surface tensions ( $\gamma$ ) of Poly(ethylene glycol) (PEG) are almost independent of molecular weight (M). However its interfacial tension ( $\gamma_{12}$ ) is expected to show some M dependence, because of the different affinities of the repeating unit ( $-\text{CH}_2-\text{CH}_2-\text{O}-$ ) and the end group ( $-\text{OH}$  or  $-\text{CH}_2-\text{CH}_2-\text{OH}$ ) to the contacting liquids. This dependence was proved. (Edited author abstract) 13 refs. In Japanese.

Kasemura, Tomoyuki (Gifu Univ, Gifu, Jpn); Yamaguchi, Seiji; Hata, Toshio. *Kobunshi Ronbunshu* v 44 n 9 Sep 1987 p 657-662.

**082609 HELICAL POLYMERS.** A number of natural and synthetic helical polymers are briefly described. The relationship between polymer helicity and optical activity is discussed. The synthesis of optically active polymers

based solely on macromolecular asymmetry is emphasized. (Author abstract) 54 refs.

Vogl, Otto (Polytechnic Univ, Brooklyn, NY, USA); Jaycox, Gary D. *Polymer* v 28 n 13 Dec 1987 p 2179-2182.

**082610 LASER DESORPTION/FOURIER TRANSFORM MASS SPECTRA OF POLY(PHENYLENE SULFIDE), POLYANILINE, POLY(VINYL PHENOL) POLYPYRENE, AND RELATED OLIGOMERS: EVIDENCE OF CARBON CLUSTERS AND FEASIBILITY OF PHYSICAL DIMENSION MEASUREMENT.** Lasers desorption/Fourier transform mass spectra of poly(phenylene sulfide), polyaniline, poly(vinyl phenol), polypyrrole, poly(p-phenylene), poly(1-methyl-2,5-pyrrolylene), poly(1-phenyl-2,5-pyrrolylene), and poly(2,5-thienylene) are compared. Poly(phenylene sulfide) fragments at C-S bonds during analysis, but rearrangement is minor. Evidence is found for dibenzothio-phenone moieties within the polymer chains. Unambiguous determination of the structure of polyaniline is not possible. Rearrangement appears to accompany chain scission. Completely aromatic polymers do not undergo similar reactions during analysis. Species with more carbons than can be accounted for by an integer multiple of six-membered rings arise from side reactions during dehydrocoupling of aromatic monomers. Carbon clusters, which are observed in the spectra of some aromatic polymers, appear to arise from laser volatilization and multiphoton ionization of large polynuclear components that are formed during synthesis. (Edited author abstract) 66 refs.

Brown, Charles Eric (Medical Coll of Wisconsin, Milwaukee, WI, USA); Kovacic, Peter; Welch, Kenneth J.; Cody, Robert B.; Hein, R.E.; Kinsinger, James A. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 131-148.

**082611 SYNTHESIS, PHYSICAL, AND THERMAL PROPERTIES OF LINEAR POLYDIALKOXYPHOSPHINYL-S-TRIAZINES.** A novel class of linear poly(dialkoxyposphinyl-s-triazines) were prepared by interfacial or solution polycondensation reactions of various diamines such as ethylenediamine, hexamethylenediamine or bis(4-aminocyclohexyl)methane with 2-dialkoxyposphinyl-4, 6-dichloro-s-triazines. The latter were synthesized by reacting cyanuric chloride with an equimolar amount of trialkyl phosphite. The phosphorus-containing polymers were characterized by inherent viscosity measurements as well as by infrared (IR) and proton nuclear magnetic resonance (<sup>1</sup>H-NMR) spectroscopy. The thermal properties of polymers were investigated by differential thermal analysis (DTA) and thermogravimetric analysis (TGA). (Edited author abstract) 22 refs.

Mikroyannidis, John A. (Univ of Patras, Patras, Greece). *J Polym Sci Part A* v 26 n 2 Feb 1988 p 583-593.

**082612 POLY(ARYLENE ETHERS).** Several new arylene ether homopolymers and copolymers have been prepared by the nucleophilic displacement of aromatic dihalides with aromatic potassium bisphenates. Polymer glass transition temperatures ranged from 114 to 310°C and a few of the polymers were semicrystalline. Two ethynyl-terminated poly(arylene ethers) were synthesized by reacting hydroxy-terminated oligomers with 4-ethynylbenzoyl chloride. Heat induced reaction of the acetylenic groups provided materials with good solvent resistance. The chemistry, physical and mechanical properties of the polymers are discussed. (Author abstract) 15 refs.

Hergenrother, P.M. (NASA, Hampton, VA, USA); Jensen, B.J.; Havens, S.J. *Polymer* v 29 n 2 Feb 1988 p 358-369.

**082613 PACKING DENSITY OF THE AMINE-CROSSLINKED STOICHIOMETRIC EPOXY NETWORKS.** The packing densities (Van der Waals volume/molar volume) were determined at 293 K for various epoxide-amine stoichiometric networks. They are noticeably higher than those of linear polymers except strongly hydrogen bonded ones [polyamides, poly(vinyl

alcohol)]. By extrapolation of the dilatometric data it was found that the packing densities at the frontiers of the glassy state (0 K and T<sub>g</sub>) of the epoxy networks are comparable to those of linear polymers having the same theoretical hydrogen bond density (polyamides). However, for a given packing density at 0 K, the packing density at T<sub>g</sub> is higher for a network than for the corresponding linear polymer. (Author abstract) 25 refs.

Bellenger, J. (ENSAM, Paris, Fr); Dhaoui, W.; Morel, E.; Verdu, J. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 563-571.

**082614 POLYMER COMPATIBILITY AND INTERPOLYMER ASSOCIATION IN THE POLY(ACRYLIC ACID)-POLYACRYLAMIDE-WATER TERNARY SYSTEM.** Polyacrylamide and poly(acrylic acid) form a water-insoluble phase when solutions of the two having concentrations that are not too low are mixed. The insoluble complex contains nearly stoichiometric 1:1 ratios of acrylamide and acrylic acid. The phase behavior of the ternary system was studied as a function of the degree of neutralization,  $\alpha$ , of poly(acrylic acid). The complex is not formed when  $\alpha$  is high. The formation of the complex was studied by measurement of pH increases observed when poly(acrylic acid) was titrated with polyacrylamide to infer a degree of linkage,  $\theta$ , between the two polymers. A Hill plot of the data showed that the association was cooperative when the molecular weight was high. (Author abstract) 10 refs.

Eustace, D.J. (Exxon Research & Engineering Co, Annandale, NJ, USA); Siano, D.B.; Drake, E.N. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 707-716.

**082615 ATROPISOMERISM IN POLYMERS. SCREW-SENSE SELECTIVE POLYMERIZATION OF ISOCYANIDES BY INHIBITING THE GROWTH OF ONE ENANTIOMER OF A RACEMIC PAIR OF HELICES.** The authors describe a method for the preparation of a polymer with an excess of either left- or right-handed helices, starting from an achiral isocyanide. To this end, they added a slowly polymerizing optically active isocyanide as comonomer to a rapidly polymerizing achiral isocyanide. CD spectra and optical rotation indicate that the screw sense of the resulting polymer samples is opposite to the one preferred by the homopolymer of the optically active comonomer. A mechanism is proposed according to which the optically active comonomer is preferentially incorporated in one of the two helices formed from the achiral isocyanide, viz. the one that corresponds to its own homopolymer. (Edited author abstract) 46 refs.

Kamer, Paul C.J. (Univ at Utrecht, Utrecht, Neth); Cleij, Marco C.; Nolte, Roeland J.M.; Harada, Tadao; Hezemaans, Alphons M.F.; Drenth, Wiendelt. *J Am Chem Soc* v 110 n 5 March 1988 p 1581-1587.

**082616 NEW TELECHELIC POLYMERS AND SEQUENTIAL COPOLYMERS BY POLYFUNCTIONAL INITIATOR-TRANSFER AGENTS (INIFERS).** The unsaturated aliphatic dichlorides cis and trans Cl(CH<sub>2</sub>)<sub>2</sub>C-CH=CH-C(CH<sub>2</sub>)<sub>2</sub>Cl in conjunction with BCl<sub>3</sub> have been found to be excellent binifers and yield tert.-Cl capped polyisobutylenes PIB in CH<sub>2</sub>Cl at -30°C. Intramolecular cyclization is absent and terminal chlorine functionality is F<sub>n</sub>=2.0±0.1. The normalized inifer constants have been determined for the first and second allylic chlorines in the cis isomer. The inequality of the chlorines have been analyzed. The cis and trans isomers have identical relative termination constants. The structure of the PIBs obtained has been analyzed by a variety of techniques. (Edited author abstract) 18 refs.

Mah, Soukhil (Univ of Akron, Akron, OH, USA); Faust, Rudolf; Zsuga, Miklos; Kennedy, Joseph P. *Polym Bull (Berlin)* v 18 n 5 Nov 1987 p 433-440.



**082617 INSTABILITY OF POLARONS AND BIPOLARONS IN CONDUCTING POLYMERS AT VARIOUS 3-d ORDERING TYPES.** Interchain electron hopping  $t_1$  in conducting polymers with the small confinement parameter  $\gamma$  leads to the antiferromagnetic (AF) 3-d ordering of the dimerization pattern only at  $2t_1^2 > \gamma\Delta^2$  (2d being the Peierls gap), otherwise the ferromagnetic (AA) one occurs. Polarons (Ps,  $v=1$ ) and bipolarons (BPs,  $v=2$ ) stability areas:  $t_1/\Delta < t_c(v, \gamma)$  are found in the phase plane  $-t_1$  vs  $\gamma$  with critical  $t_c$  being larger in the AB phase and for BPs. At the AA-AB transition interface, —deconfinement— of kink-solitons is possible. Photogeneration of Ps and BPs may proceed via metastable free states separated by the self-trapping barriers (STBs) which are also different in AA and AB (in the latter STBs exist even in 2-d systems) and are lower for BPs. (Author abstract) 24 refs.

Gartstein, Yu.N. (UzSSR Acad of Sciences, Tashkent, USSR); Zakhidov, A.A. *Solid State Commun* v 62 n 4 Apr 1987 p 213-220.

**082618 INTERFACIAL TENSION OF POLY(PROPYLENE GLYCOLS) AND THEIR BLOCK COPOLYMERS WITH POLY(ETHYLENE GLYCOL)S AGAINST POLYETHYLENE AND POLY(VINYL ACETATE).** Interfacial tensions ( $\gamma_{12}$ ) were measured at various temperatures for poly(propylene glycol)s (PPG) with different molecular weights (M) and copolymers of propylene oxide (PO) and ethylene oxide (EO) in contact with polyethylene (PE) and poly(vinyl acetate) (PVAc).  $\gamma_{12}$  of PPG/PE systems did not depend on M, while for PPG/PVAc systems it increased with M. The linear relationship of  $\gamma_{12}$  to  $1/M$  was found.  $\gamma_{12}$  of copolymer/PE systems slightly increased with increasing mole fraction of EO ( $X_2$ ), while  $\gamma_{12}$  of copolymer/PVAc systems decreased rapidly with  $X_2$ , because of selective adsorption of EO block onto the polar PVAc interface. Contact angles ( $\theta$ ) of copolymers were also measured on polypropylene (PP), paraffine and polytetrafluoroethylene (PTFE). (Edited author abstract) In Japanese. 4 refs.

Kasemura, Tomoyuki (Gifu Univ, Gifu, Jpn); Yamaguchi, Seiji; Hattori, Kiyomi; Hata, Toshio. *Kobunshi Ronbunshu* v 45 n 1 1988 p 63-68.

**082619 PHOTOELASTICALLY ACTIVE POLYMERS WITH DIFFERENT MODULI PREPARED FROM BIS(CYCLOPENTADIENYL) OLIGOMERS FOR USE IN PHOTOELASTIC MODEL ANALYSIS.** Crosslinked, photoelastically active polymers having different transition temperatures and different moduli in the rubberlike state have been prepared by Diels-Alder polyaddition from bis(cyclopentadienyl) oligomers and diallyl esters of various dicarboxylic acids. The polymers are intended for use as materials with controlled Young's modulus in photoelastic model analysis. The authors conclude that the obtained results demonstrate the possibility to prepare crosslinked polymeric materials with controlled values of  $T_g$ ,  $E$ , and  $C_p$  from bis(cyclopentadienyl) oligomers by varying systematically the composition and structure of the copolymers. For almost any temperature interval of 20 to 30°C width, materials can be selected with a given ratio of moduli (up to about 10:1); this broadens the scope of problems that can be solved by photoelastic model analysis. 16 refs.

Goleneva, L.M. (V.V. Kuibyshev Inst of Civil Engineering, Moscow, USSR); Marshalkovich, A.S.; Askadskii, A.A.; Latsysh, E.G. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2873-2879.

**082620 PRESENT AND FUTURE OF LIQUID-CRYSTAL POLYMERS.** A discussion is presented of the progress attained in the area of liquid crystal polymers over the past 10 to 15 years. The author presents a diagram of the micromolecules of polymers which are able to go over in the LC state. Mechanical and physical properties are outlined and discussed. Factors pertinent to polymer processing are also given. 40 refs.

Shibaev, V.P. *Fibre Chem* v 19 n 3 May-Jun 1987 p 157-170.

**082621 PROPERTIES OF POLYQUINOLINES AND OF FIBRES BASED ON THEM.** The properties of PQ (Polyquinolines) of various chemical structures and the conditions for preparing fibers from them are examined. Synthesis of the PQ was carried out in a mixture of m-cresol and phosphorus pentoxide at 140°C by polycondensation of 3,3'-dibenzoyl-4,4'-diaminodiphenyl ether with a series of diacetyl compounds. The polymers were isolated from the polycondensation solutions by precipitation into a mixture of ethanol and triethylamine; they were extracted with boiling ethanol, and were dried to constant weight under vacuum. Experimental data indicate that it is advisable to use this dry-spinning method to obtain fibers from polyquinolines which have satisfactory physicochemical properties. 5 refs.

Baulina, T.A.; Frenkel', G.G.; Shchetinin, A.M.; Batik'yan, B.A.; Zarubkina, E.N.; Khudoshv, I.F. *Fibre Chem* v 19 n 4 Jul-Aug 1987 p 280-282.

**082622 QUANTITATIVE DESCRIPTION OF SMALL MOLECULE BINDING TO ABIOTIC POLYMERS.** The variation of equilibrium constants for the binding of small molecules to abiotic polymers as a function of structure is quantitatively described by the intermolecular force (IMF) equation and relationships derived from it. Structural variations in both the small molecules and in the polymers were studied. The data were taken from the literature. The results obtained suggest that the IMF equation may be generally useful for modeling the effect of structural variation on polymer properties which depend on the difference in intermolecular forces between initial and final states. They also provide model for nonspecific binding to biopolymers. (Author abstract) 14 refs.

Charton, Marvin (Polytechnic Univ, Brooklyn, NY, USA). *J Polym Sci Part A* v 26 n 5 May 1988 p 1265-1275.

**082623 PORE STRUCTURE OF POROUS POLYMERS BY DIFFERENT METHODS.** The pore structure of modified polymeric sorbents based on copolymers of styrene with divinylbenzene and 2,3-epoxypropyl methacrylate with ethylene dimethacrylate was studied. The study was conducted by methods of thermal desorption of nitrogen, analysis of the adsorption-desorption isotherms of perfluorooctane vapor, absorption of liquid cyclohexane, and mercury porosimetry. The applicability of these methods to the study of the structure of porous polymers was analyzed. (Author abstract) 18 refs.

Belyakova, L.D. (Acad of Sciences of the USSR, Moscow, USSR); Shevchenko, T.I.; Blega, M.; Votavova, E.; Kalal, Ya. *Colloid J USSR* v 49 n 5 Sep-Oct 1987 p 747-751.

**082624 <sup>13</sup>C-NMR SEQUENCE DETERMINATION FOR MULTICOMPONENT POLYMER MIXTURES.** A general treatment is developed for the <sup>13</sup>C-NMR analysis of polymers which contain several components. Reaction probability models and computer optimization techniques are used to resolve the NMR spectral data into separate components. The use of generalized multistate statistical models is introduced and is found to be very suitable for such systems. The computations are simplified by means of computer programs. The need for, and the relevance of, this approach are illustrated by the tacticity problems in polybutylene and polypropylene where two-state and three-state models are used, and copolymer triad sequence analysis for several olefin and acrylic copolymers where two-state models are needed. Three copolymer examples are given: propylene/butylene, ethylene/propylene, and acrylamide/acrylate. (Author abstract) 40 refs.

Cheng, H.N. (Hercules Inc, Wilmington, DE, USA). *J Appl Polym Sci* v 35 n 6 May 5 1988 p 1639-1650.

**082625 SHORT POLYMER CHAIN STATISTICS AND THE RELATIONSHIP TO END TO END ELECTRONIC EXCITATION TRANSPORT: RANDOM WALKS WITH VARIABLE STEP LENGTHS.** The problem of the distribution of distances between the ends of a polymer chain for short chains (a small number

of statistical segments) is considered. A formalism developed by Rayleigh is utilized to calculate the exact end to end distribution functions for random walks with a small number of steps and variable step lengths. In particular, distribution functions for walks in which the first and last step differ in length from the intervening steps are obtained. These are used as models for low molecular weight polymers in which the first and last statistical segments are different from internal segments because of chain end effects or chromophores attached to the chain termini. The results are used to calculate the ensemble averaged time dependence of end to end electronic excitation transport. (Edited author abstract) 17 refs.

Zimmt, M.B. (Stanford Univ, Stanford, CA, USA); Peterson, K.A.; Fayer, M.D. *Macromolecules* v 21 n 4 Apr 1988 p 1145-1154.

**082626 CONTROLLED ACTIVITY POLYMERS. V. COPOLYMERS OF 2-(1-NAPHTHYLACETYL)ETHYL ACRYLATE WITH HYDROPHILIC COMONOMERS: RELEASE BEHAVIOR.** Release properties of the copolymers of 2-(1-naphthylacetyl)ethyl acrylate with hydrophilic comonomers of known molecular weight have been studied as a function of pH, composition, comonomer type, and copolymer microstructure. Fluorescence and solid-state <sup>13</sup>C-NMR studies have also been performed. Neighboring group effects for the hydrolysis were observed by the concentration of auxin released; the release mechanism differed with the comonomer type. In addition, the release behavior of the ionic copolymers is affected by the presence of intramolecular hydrophobic interactions. (Author abstract) 20 refs.

McCormick, Charles L. (Univ of Southern Mississippi, Hattiesburg, MS, USA); Kim, Kisoo. *J Macromol Sci Chem* v A25 n 3 Mar 1988 p 307-326.

**082627 MEMORY EFFECTS IN POLYMERS. I. ORIENTATIONAL MEMORY IN THE MOLTEN STATE; ITS RELATIONSHIP TO POLYMER STRUCTURE AND INFLUENCE ON RECRYSTALLIZATION RATE AND MORPHOLOGY.** The influence of polymer structure on the orientational memory in the molten state has been studied by observing the crystallization behavior of the molten polymer through differential scanning calorimetry. It is shown that polymers with strong intermolecular forces (e.g., H-bonding) retain the orientation memory even at temperatures above their equilibrium melting temperatures. The retained orientation memory of the polymer melt is shown to influence its recrystallization rate and the morphology. Some of the polymers covered include nylon polymers, polyethylenes, and polyethylene terephthalate. 3 refs.

Khanna, Y.P. (Allied-Signal Inc, Morristown, NJ, USA); Reimschuessel, A.C. *J Appl Polym Sci* v 35 n 8 Jun 1988 p 2259-2268.

**082628 PROPERTIES OF POLYMERS BASED ON MODIFIED POLYAMIDES.** Results are reported of the research in the mechanisms of the chemical modification of polyamides by N,N'-maleimide and the effects of the chemical structure and content of N,N'-bis-maleimide on the properties of the materials produced. It was found that the incorporation of 0.5 mass% of BMI bis-maleimides (the relative viscosity of the original sample being 2.3) in the polyamide results in the relative viscosity of the soluble fraction of the sample rising to 2.8 and in the emergence of a gel fraction amounting to 3 mass%. Increasing the quantity of BMI (I) to 5 mass% results in the relative viscosity of the soluble fraction rising to 3.2 and in the gel fraction rising to 29 mass%. 5 refs.

Volzoin, A.I. (Acad of Sciences of the Byelorussian SSR, USSR); Sointsev, A.P.; Mironovich, L.L.; Yurkevich, O.R. *J Appl Chem USSR* v 60 n 7 pt 2 Jul 1987 p 1510-1512.



**082629 MECHANICAL SELF-SIMILARITY OF POLYMERS DURING CHEMICAL GELATION.** Network polymers near their gel point exhibit self-similar mechanical behavior, as expressed by power law relaxations. The range of self-similarity is defined by two limiting length scales. The upper limit is the correlation length, defined by the linear size of the typical cluster, and a lower limit, roughly given by the size of one preformed linear chain, i.e., the mean distance between crosslinks. The correlation length increases with the approach to the gel point, and diverges at the critical extent of reaction, i.e., the gel point where the infinite cluster is formed. Above the gel point, it decreases again with further crosslinking. Dynamic mechanical measurements of the complex modulus at the gel point show a power law in the frequency dependence over the entire frequency range, monitoring self-similarity. Swelling effects reduce the fractal dimension of the percolation cluster from 2.5 to 2. (Edited author abstract). 30 Refs.

Vilgis, T.A. (Max-Planck-Inst, Mainz, West Ger); Winter, H.H. *Colloid Polym Sci* v 266 n 6 Jun 1988 p 494-500.

**082630 UNIFIED STUDY OF THE DIFFERENT PHYSICAL PROPERTIES OF AMORPHOUS POLYMERS.** A phenomenological model is proposed which tries to explain the mechanical, optical and thermal properties (both thermal conductivity and expansivity) of amorphous polymers. The model has similarities with the composite model, proposed by the present authors, which has proved to be successful in interpreting the different physical properties of semicrystalline polymers. The present model considers the bulk form of the polymer as an aggregate of microscopic units possessing intrinsic physical properties. On drawing, the development of anisotropy in different physical properties is supposed to be due to the development of preferred orientation of these units. The development of the preferred orientation has been estimated directly from birefringence data. The agreement between the calculated and experimental values of the elastic modulus, thermal conductivity and thermal expansivity of PVC, PMMA and PS is found to be reasonably good. (Edited author abstract). 37 Refs.

Biswas, P.K. (Presidency Coll, Calcutta, India); Sengupta, S.; Basu, A.N. *Colloid Polym Sci* v 266 n 6 Jun 1988 p 501-508.

**082631 PREDICTION OF PHYSICAL PROPERTIES OF POLYMERS FROM ELECTRICAL FLUCTUATIONS MEASURED OVER A BROAD TEMPERATURE INTERVAL.** The relationship between thermal expansion and electrical fluctuations in polymers is discussed. The variation of fluctuation voltage in the region of transition to the liquid state and at the onset of the process of chemical relaxation correlates well with specific features of the dilatometric curve. Values of physical characteristics obtained by means of the proposed method for poly(vinyl chloride) and a nitrile rubber vulcanizate are in good agreement with results of traditional methods. (Author abstract). 15 Refs.

Zelenev, Yu. V. (F.E. Dzerzhinskii Military Acad of Aviation Engineering, Tambov, USSR); Ivanovskii, V.A. *Polym Sci USSR* v 29 n 4 1987 p 898-904.

**082632 GROUP CONTRIBUTION ANALYSIS OF THE DAMPING BEHAVIOR OF HOMOPOLYMERS, STATISTICAL COPOLYMERS, AND INTERPENETRATING POLYMER NETWORKS BASED ON ACRYLIC, VINYL, AND STYRENIC MONOMERS.** The integral of loss modulus versus temperature plots in the vicinity of the glass transition temperature (loss area, LA) was characterized for various homopolymers, statistical copolymers, and interpenetrating polymer networks (IPNs), based on acrylics, vinyls, and styrenic monomers. The quantity LA was found to be a molecular characteristic, governed by the structure of the molecular chains. The LA of both IPNs and statistical copolymers obeys an additive relation of the component polymers. A group contribution analysis for LA was developed in which each moiety contributes a specific value to LA. A table derived via this group-contribution analysis permits the prediction of LA values. The results show that

backbone motions and the moieties attached directly to the backbone contribute the most to the damping peak, and that long side chains act as diluents. (Author abstract). 49 Refs.

Chang, M.C.O. (Lehigh Univ, Bethlehem, PA, USA); Thomas, D.A.; Sperling, L.H. *J Polym Sci Part B* v 26 n 8 Aug 5 1988 p 1627-1640.

## Plasticity

**082633 PLASTIC DILATATION DUE TO COMPRESSION IN POLYMER SOLIDS.** For the purpose of studying a constitutive equation and inferring a yield mechanism in polymer solids, dilatational strain due to inelastic deformation must be investigated. In general, it is assumed in the empirical constitutive laws of metals that volume expansion does not occur due to plastic deformation. This may be proved to be true since the plastic deformation of metals is induced by the motions of dislocations subjected to shear stresses. Yielding in polymer solids, however, is strongly influenced not only by the second invariant of deviatoric stress, but also the first stress invariant. The yield condition in polymers is known to be well explained by a modified Mises theory. 5 refs.

Kitagawa, Masayoshi (Kanazawa Univ, Kanazawa, Jpn); Yoneyama, Takeshi. *J Polym Sci Part C* v 26 n 4 Apr 1988 p 207-212.

Polymerization See MONOMERS—Polymerization.

## Porosity

**082634 SEPABEADS FP SERIES: NEW HIGHLY POROUS HYDROPHILIC SUPPORTS FOR PROTEIN SEPARATION.** The use of the new chromatographic packing material, Sepabeads FP series, has been examined in industrial-scale separations. They showed sufficient stability and have a highly porous hydrophilic nature which makes them suitable for the purification of biopolymers such as proteins. It was found that the protein adsorption capacity strongly depends on the porosity, i.e., mean pore radius, of the packing as well as on the type of attached functional groups. Using Sepabeads FP series, industrial-scale separations of biopolymers in various chromatographic modes have become practical. Basic properties of Sepabeads FP series and some applications to the separation of proteins are briefly described. (Author abstract) 7 refs.

Kusano, Hiroshi (Mitsubishi Chemical Industries Ltd, Yokohama, Jpn); Miyata, Eiji; Takayanagi, Hiroaki; Itagaki, Takaharu. *React Polym Ion Exch Sorbents* v 8 n 2 Apr 1988 p 235-243.

**082635 NATURE AND STRUCTURE OF POROUS ORGANIC POLYMERS.** Macroporous organic polymers of both aliphatic and aromatic structures can be prepared with various internal properties and surface selectivities. Specific surface areas (by BET) of 0.1 to 1000 m<sup>2</sup>/g can be achieved with concomitant ranges in pore diameters from less than 20 Å to about 500,000 Å. The method of synthesis provides for the great latitude within the internal structure; and the surface selectivity is regulated by the nature of the monomer compositions, or post-reaction of the polymers, or both. The impact of pores and channels within a polymer is examined. Following a scrutiny of the impact of pores and channels within a polymer, guidelines are presented to allow a best selection of porous polymers. (Edited author abstract)

Albright, Robert L. (Rohm & Haas Co, Philadelphia PA, USA). *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 329.

Precipitation See Also COPOLYMERS—Solubility; POLYISOPRENE—Spectroscopic Analysis.

**082636 FOLOSIREA POLIACRILAMIDELOR HIDROLIZATE IN APE DE ZACAMINT CU IONI DIVALENTI.** [Utilization of Hydrolyzed Polyacrylic

Amides in Deposit Waters with Divalent Ions]. The main parameters conditioning the stability of the hydrolyzed polyacrylic amides in the injection and deposit waters containing divalent ions are presented. The viscosity behavior of the polymers and their precipitation or insolubilization tendency, under field conditions, can be predicted by taking into account the whole ionic load of the solution, and not from the divalent ion contents only. In the vicinity of the solubility curve the decreased of the Huggins' constant indicate the reaching of quasi  $\theta$  conditions. (Authors abstract) In Romanian. 9 refs.

Blank, Lelia (ICPPG, Cimpina, Rom); Constantin, Valeria. *Mine Pet Gaze* v 38 n 4 Apr 1987 p 177-189.

Preforming See CONCRETE CONSTRUCTION—Plastics Applications.

## Pressure Effects

**082637 TENSILE PROPERTIES OF POLYVINYLIDENE FLUORIDE (PVDF) UNDER HYDROSTATIC PRESSURE.** For polymers, in general, the effects of hydrostatic pressure on mechanical properties are considerably different from those for metals: the yield stress and elongation at fracture have been reported to change with hydrostatic pressure to various degrees, depending on temperature and strain rate. Results of tension tests on PVDF under pressures up to 392 MPa, at temperatures up to 90°C, and with strain rates up to 1 s<sup>-1</sup> are reported in this paper. As pressure increased, the yield stress increased and the elongation decreased; as temperature was raised the yield stress became lower and the elongation higher. The brittle-to-ductile transition was observed near 30 MPa. Empirical formulas for the stress-strain curves were obtained in the post yield region. The glass-transition temperature T<sub>g</sub> of PVDF was found to be -35°C. When the pressure was raised from 300 to 400 MPa, T<sub>g</sub> shifted to 35°C. (Author abstract) 5 refs. In Japanese.

Umeki, Kazunobu; Takashima, Norio; Nakayama, Toshio; Inoue, Nobuo. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 498 Feb 1988 p 279-284.

Printing See PLASTICS—Finishing.

Processing See Also CERAMIC MATERIALS—Fibers; COAL TAR—Applications; ELASTOMERS—Injection Molding; ELASTOMERS—Processing; ELECTRIC EQUIPMENT—Manufacture; FLUORINE CONTAINING POLYMERS—Processing; POLYETHYLENE TEREPHTHALATE—Crystallization; RUBBER—Additives; RUBBER MACHINERY—Mixers; THERMOPLASTICS—Fabrication.

**082638 POLYMER PROCESSING: AN OVERVIEW.** Polymer processing is discussed in terms of mechanisms, equipment, and transport and reaction phenomena. The purpose of this article is to familiarize chemical engineers with polymer processing by noting both the common roots of the transport and reaction phenomena involved and the differences in mechanisms, and therefore the equipment used, by which the corresponding processes are carried out in the two fields. A discussion is presented of: the handling of particulate solids; melting, softening and solidification of polymers; pressurization and pumping; mixing; and, devolatilization and reactive processing. 33 refs.

Gogos, Costas G. (Stevens Inst of Technology, Hoboken, NJ, USA); Tadmor, Zehev; Kalyon, Dilhan M.; Hold, Peter; Biesenberger, Joseph A. *Chem Eng Prog* v 83 n 6 Jun 1987 p 33-58.

**082639 POWDER PROCESSING OF IRON-FILLED UHMWPE.** An alternative to compression molding is described. When iron filler is incorporated, rapid induction heating and consolidation result - cutting composite processing time from hours to a matter of minutes. Experimentation involved the use of UHMWPE from Hercules Inc. (Hi Fax 1900) with an average particle size of 330  $\mu$  and pure iron from Haeganaes Corp. (grade MH-100) with particle size <44  $\mu$  were blended together



in a V-mixer for 10 to 12 hours. The iron particles, being finer, adhered well to the bigger polymer particle surfaces, forming a metallic coating. The polymer particles were coated completely and uniformly, and compacts made from the coated particles resulted in a segregated distribution of the metal particles within the specimen (referred to as 'segregated Fe network'). 8 refs.

Krishnamurthy, V. (Drexel Univ, Philadelphia, PA, USA); Kamel, I.L. *Mod Plast* v 64 n 12 Dec 1987 p 96, 98-99.

**082640 CRITICAL ASPECTS OF INDUSTRIAL AND ACADEMIC COLLABORATION.** It is not enough to have shown that there is a broad and exciting range of potential applications of a new idea; even where the process route has been established and the product proved in exhaustive trials, the innovator still has a formidable task ahead. The introduction of strong polymeric grid materials for long-term applications in civil engineering and general construction provides a typical example of the hard road that must be travelled to reach success. A case history demonstrates some of the ways in which the difficulties can be overcome by a major cooperation between a British company and the research capabilities of five British universities. (Edited author abstract)

Mercer, F.B. (Netlon Ltd, Blackburn, Engl). *Progr Rubber Plast Technol* v 3 n 3 1987 p 1-19.

**082641 DIE SWELL FROM CAPILLARY DIE AND SLIT DIE: A THEORETICAL STUDY.** Assuming polymer fluids obey the CEF (Criminate-Ericksen-Filbty) equation, equations concerning die swell from capillary die and slit die were derived. The die swell of polymer increased with increasing shear rate and recoverable shear. Our theoretical predictions conformed well with the experimental data of die swell for PP (Polypropylene) and PS. (Author abstract) 12 refs.

Chiu, Wen-Yen (Nat'l Taiwan Univ, Taipei, Taiwan); Shyu, Goang-Ding. *J Appl Polym Sci* v 35 n 4 Mar 1988 p 847-862.

**082642 ANALYSIS OF THE ROLE OF STRIPPING AGENTS IN POLYMER DEVOLATILIZATION.** A comprehensive model has been developed to analyze the process of polymer melt devolatilization in the presence of a stripping agent, which performs the function of enhancing the molecular diffusion of the desorbing monomer and reducing the interfacial concentration. The problem leads to a coupled set of non-linear partial differential equations with time dependent boundary conditions. This problem has not been solved in the literature so far. The model enables the prediction of the influence of diffusivity ratios, relative volatility, hydrodynamic conditions, etc. on the devolatilizer performance and provides useful guidelines for the selection of a suitable stripping agent. The strategy developed in this work can be also used for related problems of multicomponent desorption in other systems. (Author abstract) 18 refs.

Ravindranath, K. (Nat'l Chemical Lab, Pune, India); Mashelkar, R.A. *Chem Eng Sci* v 43 n 3 1988 p 429-442.

**082643 PROCESS POLYMERS WITH SUPERCRITICAL FLUIDS.** Examples are presented that demonstrate the effectiveness of SCFs (Supercritical Fluids) for purification and fractionation of multicomponent polymer mixtures. This makes possible production of high-purity materials with much more precisely controlled physical-chemical properties. SCFs offer considerable potential for other types of polymer processing. For example, R.C. Peterson et al. have described the use of rapid decompression of SCF polymer solutions for preparation of finely divided polymer powders. S. Kumar et al. have also reported the use of SCFs as precipitation polymerization media where the degree of polymerization can be controlled by varying the SCF density. 24 refs.

Scholsky, Kevin M. (S.C. Johnson & Sons Inc, Racine, WI, USA). *CHEMTECH* v 17 n 12 Dec 1987 p 750-757.

**082644 CONTINUOUS PREPARATIVE METHOD OF RELATIVELY LARGE AND UNIFORM POLYMER BEADS AND THEIR APPLICATION TO IMMOBILIZATION OF UREASE.** An apparatus for continuous preparative method of polymer beads was investigated. Monomer droplets formed in glycerol were continuously introduced to a rotating glass tube which was filled with warmed glycerol and polymerized. Polymer beads of around 4 mm diameter were obtained. As an application of the polymer beads, urease was immobilized on the beads and their properties were evaluated. Macroreticular type of beads prepared with a mixture of maleic anhydride, styrene, and divinylbenzene showed the highest enzymatic activity among the beads tested, and the urease immobilized beads could be successfully applied for determination of blood urea nitrogen in human sera. (Author abstract) 6 refs.

Ogawa, N. (Kumamoto Univ, Kumamoto, Jpn); Kawachi, Y.; Nishimura, K.; Sugii, A. *J Appl Polym Sci* v 35 n 5 Apr 1988 p 1283-1288.

**082645 SURFACE PLASMON STUDY OF ELECTROCHEMICALLY PREPARED POLYMERS: POLYAZULENE.** The work reported shows that by using a modified gold working electrode, the surface plasmon technique can successfully be used to obtain information on the optical constants and the film thickness of electropolymerized films. Polyazulene films deposited at three different surface charge densities are investigated in the oxidized and corresponding reduced forms. The authors results shows that the refractive index, and hence the dielectric constant at 632 nm, is complex, the imaginary part being larger for the oxidized form compared to that for the corresponding reduced form. (Edited author abstract) 18 refs.

Huang, X. (State Univ of New York at Buffalo, Buffalo, NY, USA); Zhao, M.T.; Janiszewska, L.; Prasad, P.N. *Synth Met* v 24 n 3 May 1988 p 245-253.

**082646 AMPHIPHILIC NETWORKS. I. NETWORK SYNTHESIS BY COPOLYMERIZATION OF METHACRYLOYL-CAPPED POLYISOBUTYLENE WITH 2-(DIMETHYLAMINO)ETHYL METHACRYLATE AND CHARACTERIZATION OF THE NETWORKS.** New amphiphilic networks have been synthesized by free-radical copolymerization of hydrophobic methacryloyl-capped polyisobutylenes (MA-PIB-MA) with hydrophilic 2-(dimethylamino)ethyl methacrylate. Two MA-PIB-MA have been prepared with  $M_n = 4920$  and 10,200, and two series of networks were prepared with MA-PIB-MA contents between 48 and 71.5%. Variation of the molecular weight of MA-PIB-MA and its concentration in the network allows for a wide range of mechanical properties and swellability in hydrophilic and hydrophobic solvents. Differential scanning calorimetry shows the existence of two glass transitions in these networks and thus indicates a phase-separated domain structure. (Edited author abstract). 23 Refs.

Chen, Dianjia (Univ of Akron, Akron, OH, USA); Kennedy, Joseph P.; Allen, Anthony J. *J Macromol Sci Chem* v A25 n 4 1988 p 389-401.

**082647 EFFECT OF HYDROGEN BONDS ON THE SOLID PHASE CYCLODEHYDRATION OF POLYAMIC ACIDS.** By X-ray structural analysis of the complexes of pyromellitimide acid with amide solvents it was found that the character of the system of hydrogen bonds and the structure of the solvates depend on the nature of the amide solvent. It was shown that in the case of polyamic acid solvates, the hydrogen bonds formed in the solid polyamic acid films can be studied by mass-spectrometric thermal analysis; from the obtained data, the mechanism may be determined by the function of additives catalyzing the solid phase cyclodehydration of polyamic acids. (Author abstract). 10 Refs.

Shibayev, L.A. (USSR Acad of Sciences, USSR); Dauengauer, S.A.; Stepanov, N.G.; Chetkina, L.A.; Magomedova, Bel'Skii, V.K.; Sazanov, Yu. N. *Polym Sci USSR* v 29 n 4 1987 p 875-881.

**082648 AUTOMATION '86: THE PLASTICS AND RUBBER INSTITUTE'S SECOND INTERNATIONAL CONFERENCE ON COMPETITIVE MANUFACTURING SYSTEMS - POLYMER PROCESSING.** This conference contains 21 papers and 3 panel presentations on advanced manufacturing technology for polymer processing. Specific topics covered include: competitive manufacturing systems; Japanese methodology; computer aided/computer integrated manufacture; and advanced manufacturing technology for thermoset molding, blow molding, and filament winding. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10881 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Plastics & Rubber Inst, Processings & Engineering Group, London, Engl). *Autom '86: the Plast and Rubber Inst Second Int Conf on Compet Manuf Syst - Polym Processing, Sandown Park, Engl, Jun 24-25 1986* Publ by Plastics & Rubber Inst, London, Engl, 1986 var pagings.

**Production** See Also ESTERS—Synthesis; ORGANIC COMPOUNDS—Chemical Reactions; PLASTICS—Production.

**082649 PRODUCTION OF WATER-SOLUBLE POWDERED SURFACE-ACTIVE POLYMERS BASED ON STYROMAL.** The purpose of this work is to produce water-soluble powdered polymers based on styrene-maleic anhydride copolymer (Styromal) with a definite ratio of hydrophobic and hydrophilic groups and having surface activity. Investigations showed that the polymers can be obtained in the form of fine powders only at certain ratios of hydrophobic to hydrophilic groups in the macromolecular chains. Decrease of the ester-group content also leads to weakening of surface activity of the polymers. Thus, by regulating the ratio of hydrophilic and hydrophobic groups in the macromolecular chains of the synthesized polymers, it is possible to confer surface activity on them and to obtain them in the form of fine powders, convenient to use and making it possible to extend the range of available surface-active polymers. 4 refs.

Adylova, K.M. (Abu Raikhan Beruni Polytechnic Inst, Tashkent, USSR); Akhmedov, U.K.; Niyazova, M.M. *J Appl Chem USSR* v 60 n 3 pt 2 Mar 1987 p 653-655.

**Purification**

**082650 HIGH PURITY FLUOROPOLYMER MATERIALS: TRACE ELEMENT CONTENT AND LEACHING.** Many problems in analytical chemistry are shared by the high purity crystal growth community since both are greatly concerned with the effects of impurities either upon an analysis or upon a device. Fluoropolymers are widely used today in applications where inertness or high purity or both are needed. The behavior of these polymers in high purity solvent systems has been investigated by several analytical techniques. Both the resin from which finished parts are made as well as blow molded bottles have been evaluated to determine cationic impurities in both the resin and in leachates. (Author abstract) 7 refs.

Moody, J.R. (NBS, Gaithersburg, MD, USA); Beary, Eilyn S.; Bushee, Diane S.; Paulsen, Paul J. *J Cryst Growth* v 89 n 1 Jun 1988, Purif of Mater for Cryst Growth and Glass Process - Proc of the Second Workshop, Champion, PA, USA, Sept 28-Oct 1 1987 p 43-48.

**Pyrolysis** See Also CHEMICAL REACTIONS—Pyrolysis; COATINGS—Chromatographic Analysis; COPOLYMERS—Decomposition; COPOLYMERS—Degradation; HYDROCARBONS—Chemical Analysis; POLYESTERS—Degradation; SOLIDS—Pyrolysis; THERMOPLASTICS—Degradation.



**082651 POLYMER PYROLYSIS: A RESOLUTION OF ANOMALIES IN KINETIC SCHEMES FOR THE RATE OF EVOLUTION OF VOLATILE PRODUCTS.** Kinetic schemes proposed by three groups of workers for polymer pyrolysis have been critically examined, in order to resolve apparent anomalies, especially in the way in which the overall first-order rate constant for volatile evolution by depropagation mechanisms, involving different modes of initiation and termination, have been interpreted. These schemes lead to identical expressions for the initial rate of evolution of a volatile product, provided the symbols are defined specially according to the conventions chosen. These expressions are to be recommended for studies of this kind. (Edited author abstract) 11 refs.

Hammond, Timothy (Univ of Birmingham, Birmingham, Engl); Lehrle, Roy S. *Br Polym J* v 19 n 6 1987 p 523-525.

**082652 DETERMINING TEMPERATURE LIMITS FOR POLYMER PYROLYSIS BY MASS SPECTROMETRY.** It is important to determine the temperatures representing the start, peak and end of decomposition in research on polymer stability, as well as the mass loss and the products. These temperatures enable one to forecast working conditions and to some extent facilitate determining destruction mechanisms. These temperatures have been determined for vinyl and allyl copolymers made by free-radical polymerization with various monomer ratios at 75°C in the presence of 0.001 mole of benzoyl peroxide per mole; the specimens were heated in a device coupled to the valve unit in an MKh-1320 mass spectrometer. 4 refs.

Litvinenko, I.G. (Ukrainian Plastic Research Inst, Donetsk, USSR); Andreev, A.P.; Zaitseva, V.V. *Ind Lab (USSR)* v 53 n 6 Jun 1987 p 535-537.

**082653 CURIE-POINT PYROLYSIS-CAPILLARY GAS CHROMATOGRAPHY-MASS SPECTROMETRY OF POLYHYDROXYALKYLPIRAZINES.** Examination of eight different polyhydroxyalkylpyrazines by Curie-point pyrolysis-capillary gas chromatography-mass spectrometry resulted in the identification of 44 compounds including 32 pyrazine derivatives. Among these were some pyrazinecarboxaldehydes, which had never before been found in the pyrolyzates of substances formed by reactions of sugars with ammonia. Mass spectrometric fragmentation patterns of these compounds are given. (Author abstract) 6 refs.

Hardt, R. (Technische Univ Berlin, Berlin, West Ger); Baltes, W. *J Anal Appl Pyrolysis* v 13 n 3 Apr 1988 p 191-198.

**082654 SONOLYSIS OF POLYMERS IN AQUEOUS SOLUTION. NEW OBSERVATIONS ON PYROLYSIS AND MECHANICAL DEGRADATION.** Aqueous solutions of DNAM pectin, poly(acrylamide), poly(vinyl alcohol), poly(vinylpyrrolidone), poly(methacrylic acid), and poly(ethylene glycol) were sonicated under argon and the yields of CO and H<sub>2</sub>O<sub>2</sub> determined. The CO yield is a measure of the pyrolysis of the polymers. DNA is least sensitive toward thermal decomposition, while poly(ethylene glycol) decomposes most rapidly. The H<sub>2</sub>O<sub>2</sub> yield is most strongly decreased by polymers producing the most CO. These polymers also decrease the surface tension of water the strongest. It is concluded that pyrolysis and OH radical scavenging require the accumulation of polymer molecules in the interfacial region around the cavitation bubbles. The mechanical degradation of poly(acrylamide) under various gases (He, Ar, H<sub>2</sub>, CH<sub>4</sub>, C<sub>2</sub>H<sub>4</sub>, CO<sub>2</sub>, N<sub>2</sub>O, air) was also studied. (Edited author abstract) 12 refs.

Henglein, Armin (Hahn-Meitner-Inst Berlin GmbH, Berlin, West Ger); Gutierrez, Maritza. *J Phys Chem* v 92 n 13 Jun 30 1988 p 3705-3707.

**082655 CHARACTERIZATION OF SOME PYROLYSED POLYCARBOSILANES BY TRANSMISSION ELECTRON MICROSCOPY.** Four different polymers were pyrolyzed up to 1000°C. The techniques of transmission electron microscopy (TEM) use one of all the

scattered beams emitted by the specimen, selected by a suitable objective aperture displaced relative to the selected area electron diffraction (SAD) pattern. The regions emitting a given beam or portion of a diffraction ring appear in the image as bright domains in a dark field. The various radial positions of the aperture used are indicated. In position 1 turbostratic carbons and various forms of silica can be imaged in DF; SiC is excluded. In position 2, a crystalline SiC 111 DF image is formed, superimposed to a weak carbon 10 DF image. In position 3, only SiC crystals can be imaged. If the material is amorphous, small and faintly bright dots appear for any aperture centering and any focusing value. They correspond to the statistical distribution of couples of atoms within the specimen. 11 Refs.

Ayache, J. (CNRS, Fr); Bonnamy, S.; Bourrat, X.; Deurbegue, A.; maniette, Y.; Oberlin, A.; Bacque, E.; Birot, M.; Diunogues, J.; Pillot, J.-P. *J Mater Sci Lett* v 7 n 8 Aug 1988 p 885-890.

**082656 POLYMER PYROLYSIS MECHANISMS: EXPERIMENTAL APPROACHES FOR INVESTIGATING THEM.** Choice of pyrolysis conditions for any particular investigation is determined by whether the objective is to assess the thermal behavior of the polymer for a particular application or whether the molecular degradation mechanism is sought. In this connection the effects of nature of the sample, its size, and the heating procedure are discussed. Choosing experimental methods of investigating the degradation depends on which categories of pyrolysis behavior occur; different techniques are required for examining insoluble residues, soluble residues, and evolved volatiles. Processes producing volatiles can be studied with greatest sensitivity, especially by pyrolysis-gas-liquid chromatography. A sequence of experimental approaches is suggested; the target of this is to obtain the most detailed interpretation of the pyrolysis mechanism. (Edited author abstract) 29 refs.

Lehrle, R.S. (Univ of Birmingham, Birmingham, Engl). *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 55-64.

**082657 SOME EMPIRICAL CONSIDERATIONS ON THE PYROLYSIS-GAS CHROMATOGRAPHIC CONDITIONS REQUIRED TO OBTAIN CHARACTERISTIC AND RELIABLE HIGH-RESOLUTION PYROGRAMS FOR POLYMER SAMPLES.** The fundamental pyrolysis-gas chromatographic conditions required to obtain characteristic and reliable high-resolution pyrograms for various polymeric materials are discussed on the basis of empirical data. Among various experimental factors discussed are the additional maintenance heating effect encountered in conventional pulse-mode pyrolyzers, the nature of the carrier gas, the inertness of capillary column materials and the protection of the inert capillary column from tarry, less volatile and/or reactive pyrolytic products. (Author abstract) 8 refs.

Tsuge, Shin (Nagoya Univ, Nagoya, Jpn); Ohtani, Hajime; Matsubara, Hideki; Ohsawa, Masahiro. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 181-194.

**Radiation Damage** See Also METALS AND ALLOYS—Fabrication.

**082658 POSITRON ANNIHILATION IN CORROSION PROTECTIVE POLYMERIC COATINGS. II.** Positron annihilation was studied in four commercial polymeric coatings on iron. Positron lifetime measurements were performed before and after exposure of the coatings to boiling water for 1 h. A correlation was observed between the effect of water exposure on the lifetime spectra and the protective properties of the coatings when exposed to 0.1M sulfuric acid at 60°C for 1010 h. The coatings that provided good corrosion protection in the acid showed minor changes in the positron lifetime spectra upon exposure to water. The spectra of coatings that showed poor corrosion protection, on the other hand, exhibited considerable changes in the

positron lifetime spectra upon exposure to water. (Author abstract) 6 Refs.

Szeles, Cs. (Eotvos Univ, Budapest, Hung); Vertes, A.; White, M.L.; Leidheiser, H. Jr. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 688-692.

**082659 EFFECTS OF RADIATION ON POLYMERS.** The present paper is a brief overview of aspects of the damaging effects of radiation on nuclear plant components manufactured from organic polymers. The paper briefly mentions some general nuclear plant applications of polymers, describes how the properties of polymers are affected by radiation, outlines some of the basic mechanisms which cause these effects, and explains how other environmental parameters, such as temperature, the presence of oxygen or other reactive chemicals, and the rate at which materials are irradiated, interact. Finally, procedures which are being developed to predict the behaviour in the long term from short term accelerated tests are outlined. (Author abstract) 17 refs.

Phillips, D.C. (AERE, Harwell, Engl). *Mater Sci Technol* v 4 n 1 Jan 1988 p 85-91.

**Radiation Effects** See Also COATINGS—Curing; DO-SIMETERS—Plastics Applications; ELECTRIC INSULATING MATERIALS—Radiation Effects; IONS; MONOMERS—Polymerization; PARTICLE DETECTORS—Materials; POLYACRYLONITRILE—Degradation; POLYETHYLENES—Structure; ULTRASONIC WAVES—Measurements; WOOD—Creep.

**082660 SEMIDYNAMIC STUDY OF POLYMER SURFACE MORPHOLOGY DEVELOPMENT IN KAPTON-H™ SPUTTER ETCHED BY 6 keV XENON ATOMS.** A semidynamic study of the surface morphology development on 6 keV Xenon atom bombarded polyimide (Kapton-H™) is presented and discussed in light of present models of polymer sputtering and material surface morphology development. Using a series of particle bombardment-gold coating-SEM investigation-gold layer stripping cycles, the whole process of the surface morphology development can be studied in a greater detail. Kapton-H is extremely resistive to particle bombardment. Under high fluence particle bombardment, the surface morphology development proceeds from uniform rows of submicron protrusions to flat-top columns which later disintegrate into long thin fiberlike structures. The average sputtering yield of Kapton-H is about 30 amu/atom (i.e., 0.08 [—C<sub>22</sub>H<sub>10</sub>N<sub>2</sub>O<sub>5</sub>—] monomer units/atom). This value is very low when compared to other polymer materials. (Author abstract) 50 refs.

Michael, R. (Washington State Univ, Pullman, WA, USA); Stulik, D. *Nucl Instrum Methods Phys Res Sect B* v B28 n 2 Sep 1987 p 259-263.

**082661 RELAXATION OF IMPURITY MOLECULES IN NETWORK POLYMER SYSTEMS BY THE ACTION OF LIGHT.** The possibility was discovered of changing the photochemical activity of impurity molecules in network polymer systems under conditions in which the photon absorbing molecule does not undergo a photochemical reaction. It was found that the photooxidation of anthracene was a photochemical action of light on the state of impurity molecules in the polymer matrix as the result of removal of one of the process components, namely, molecular oxygen. The present work was undertaken in order to determine the influence of temperature and the degree of crosslinking of the polymer systems on the change in the photochemical activity during such treatment. 10 refs.

Rumyantseva, Yu.I.; Anisimov, V.M.; Zhbakov, R.G.; Karpukhin, O.N. *J Appl Spectrosc* v 46 n 3 Mar 1987 p 304-307.

**082662 SOFT X-RAY IRRADIATION EFFECTS IN POLYMER FILMS.** Monochromatic synchrotron radiation (250 eV < hv < 350 eV) has been used to study the core level electronic excitation processes in solid polymer films of PE, PB, PS and PMMA. The electron yield spectra are closely related to the absorption spectra of the polymer



surface and reveal characteristic core to valence (Cl $\rightarrow\pi^*$ ) and core to Rydberg (Cl $\rightarrow$ R) transitions. These excitations, however, do not produce significant bond rupture and ion desorption contrary to excitations induced by photons of energy  $\geq 290$  eV. For those energies a significant ion yield is obtained. Possible excitation mechanisms are discussed in detail. (Author abstract) 17 refs.

Przybylski, M. (Max-Planck-Institut fuer Polymerforschung, Mainz, West Ger); Stamm, M.; Zietz, R. *J Phys (Paris)* v 48 n 8 Aug 1987 p 1351-1356.

**082663 INVESTIGATIONS ON ENHANCEMENT IN TRACK REVELATION SENSITIVITY OF ALLYL DIGLYCOL CARBONATE (CR-39) DUE TO LASER TREATMENT.** It is shown that for 6 MeV  $\alpha$ -particles, the track revelation sensitivity is higher in the polymer of allyl diglycol carbonate (CR-39) treated with a CO $_2$  laser beam at 25 J/cm $^2$ . With increasing etching time the sensitivity of the laser treated CR-39 increases relative to that of the untreated polymer and for an etching time of about 10 h it becomes twice that of the untreated polymer. The bulk etch rate of about 200  $\mu$ m/h has been estimated at the surface of the laser treated CR-39 and it decreases very rapidly with the time of etching. The track etch rate is also found to be very large in the treated CR-39 and it decreases in the laser affected region as the etching progresses. At the same depth in the polymer sheet, sensitivity of the treated CR-39 is only slightly larger than that of the untreated polymer. Laser induced structural transformation explains most of the observed effects. Laser treatment is shown to increase the sensitivity without reducing the resolution of the polymeric track detector. (Author abstract) 24 refs.

Kukreja, L.M. (BARC, Bombay, India); Joshi, V.B.; Bhagwat, A.M.; Chatterjee, U.K.; Bhawalkar, D.D. *Nucl Instrum Methods Phys Res Sect B* v B28 n 3 Oct 1987 p 369-376.

**082664 ELECTRON BEAM EFFECTS ON POLYMERS.** Numerous advances have been made in the understanding and implementation of electron beam (E-beam) technology in the areas of resist materials, coatings, adhesives, films, etc. Yet for today's E-beam practitioner, or those contemplating entering the field, an appreciation of the basic interactions of electron beam radiation with polymeric materials is useful. This article presents an overview of the chemical and physical changes which occur in polymers as a result of electron beam irradiation. 15 refs.

Sidney, LuAnn (3M). *Radiat Curing* v 14 n 3 Aug 1987 p 20, 22-23.

**082665 KINETICS OF THE RELAXATION OF THE SPACE-CHARGE FIELD IN POLYMER DIELECTRICS IRRADIATED WITH GAMMA RAYS.** Research on the relaxation kinetics of the space charge induced by ionizing radiation in dielectrics is of interest for practical applications related to radiation stability, the development of stable high-frequency materials and of materials of electronic and electrotechnical installations operated in fields of ionizing radiation. The details of their relaxation of the electric field of the space charge generated by gamma radiation in a thick plane-parallel dielectric plate has been insufficiently studied until a short time ago. The authors report in the present paper on a solution to the problem of nonisothermal relaxation of the electric field in thick plane-parallel dielectric plates which had been exposed to a gamma-radiation pulse, when a large temperature gradient was present over the sample thickness after the irradiation had ended. 7 refs.

Arkhipov, V.I.; Gromov, V.V.; Mamonov, M.N.; Rozno, A.G.; Rudenko, A.I. *Sov At Energy* v 62 n 2 Feb 1987 p 170-173.

**082666 INTERACTION OF ENERGETIC HEAVY IONS WITH PROBLEMS.** The chemical and physical modifications of linear polymers induced by energetic heavy ions have been compared to those obtained with other electronic excitations. The observed final chemical states are quantitatively the same as those obtained with

X-rays,  $\gamma$ -rays, though a better control of the evolution of the structure of the polymer seems to be achieved by adjusting the experimental conditions (Z, dE/dX, dose rate...). For a given polymer, it is still difficult to predict which modifications will result from the heavy ion irradiation, because of the complex interaction between ions,  $\delta$ -rays and polymers. The desorption of a polar and asymmetric molecule triggers the reorganization of the modified polymer by giving multiple conjugated bonds (allenes, dienes, cycles). On the other hand, the stimulated desorption of a symmetric gas molecule (H $_2$ , F $_2$ , Cl $_2$ ...) will generally lead to non conjugated compounds. Moreover, the nature of the irradiation atmosphere may change the evolution of the irradiated polymers. 39 refs.

Le Moel, A. (CEN, Gif-sur-Yvette, Fr); Duraud, J.P. *Scanning Micros* v 1 n 2 Jun 1987 p 535-543.

**082667 KINETICS AND MECHANISMS OF FREE RADICAL DECAY REACTIONS IN IRRADIATED SOLIDS.** A new second order kinetic equation is given which takes into account the fraction of free radicals which cannot react in solids at the observation temperature. This corresponds to the situation when solids irradiated at liquid nitrogen temperature are then heated to a temperature where only some of the free radicals disappear by recombination. This equation is applied to data for isotactic polypropylene, polybutadiene, linear low density polyethylene, etc. (Author abstract) 7 refs.

Dole, Malcolm (Los Gatos Meadows, Los Gatos, CA, USA). *Radiat Phys Chem* v 32 n 2 1988 p 191-192.

**082668 ESR APPLICATION TO RADIATION CHEMISTRY OF POLYMERS.** Important results obtained in our group in the field of ESR application to the study of irradiated polymers are summarized. They are an analysis of the decay reaction of free radicals, the spur-like trapping of the free radicals and related discussions. A diffusion-controlled bimolecular reaction scheme was a good way of analyzing data of the decay reaction. The power saturation phenomenon of the ESR spectra of free radicals showed the spur-like trapping of free radicals in irradiated polyethylene. The phenomenon of spur-like trapping was quite consistent with an interpretation of the decay reaction of free radicals. (Edited author abstract) 20 refs.

Kashiwabara, H. (Nagoya Inst of Technology, Nagoya, Jpn). *Radiat Phys Chem* v 32 n 2 1988 p 203-208.

**082669 MICROWAVE ENHANCED DIFFUSION IN POLYMERIC MATERIALS.** A process is described using microwave radiation (2.45 GHz) which, for temperature equivalence, greatly accelerates the diffusion of ethylene oxide (EO) in polymeric materials compared to that using conventional heating. The mechanism of action was investigated in detail by examining the desorption of EO from polyvinylchloride (PVC). The diffusion coefficient was found to be dependent upon diffusant concentration. (Edited author abstract) 12 refs.

Gibson, C. (Univ of Wales Coll of Medicine, Cardiff, Wales); Matthews, I.; Samuel, A. *J Microwave Power Electromagn Energy* v 23 n 1 1988 p 17-28.

**082670 DETERMINATION OF THE RADIATION YIELD OF HYDROGELS CROSSLINKING.** The ability of polymer to crosslink on exposure to radiation is frequently represented by a G value, the number of crosslinks per 100 eV absorbed. Several methods are available for its determination, the most frequent being the dose D $_g$  required to form an incipient network since (with many systems) this corresponds to one crosslinked unit per weight average molecular. Its determination therefore depends on a knowledge of the molecular weight of the starting polymer. An alternative method, far less frequently used, is to measure the degree of swelling of a crosslinked network. It is shown that, for a series of polymers, irradiated either as liquids or in solution, the theoretical relation between swelling and crosslink density is followed, and the G(X) values derived from swelling compare well with those given in the literature, and based on gel fraction. (Edited author abstract) 15 refs.

Rosiak, J. (Inst of Applied Radiation Chemistry, Lodz, Pol); Olejniczak, J.; Charlesby, A. *Radiat Phys Chem* v 32 n 5 1988 p 691-694.

**082671 PULSE RADIOLYSIS OF POLY(STYRENE) IN AQUEOUS SOLUTIONS.** Various radical species have been identified in the pulse radiolysis of aqueous solutions of poly(styrenesulfonate) (PSS). OH radicals react with PSS to produce predominantly a mixture of OH adducts. An intrapolymer biradical decay of the OH adducts takes place when several OH radical adducts are produced on the same polymer molecule. This decay reaction competes with a first-order formation of a positive radical ion ( $k=(160\pm40)$  s $^{-1}$  at pH 5.6). The formation reaction is acid catalyzed. It is slowed down by addition of inert salts. The positive radical ion decays in the time range of hours, obeying a first-order rate law. This decay is attributed to an intramolecular conversion of the positive radical ion to a benzyl type radical, which subsequently decays to produce stable recombination products. (Edited author abstract) 16 refs.

Behar, David (Hebrew Univ, Jerusalem, Isr); Rabani, Joseph. *J Phys Chem* v 92 n 18 Sep 8 1988 p 5288-5292.

**082672 POLYVINYLIDENE FLUORIDE MICRO-FILTER FORMATION BY  $^{35}\text{Cl}^+$  AND  $^{58}\text{Ni}^+$  ION BOMBARDMENT AND ALKALI ETCHING.** We have studied the process of producing microfilters of polyvinylidene fluoride by Cl, Ni, and Cu ion bombardment and alkali etching. The effects of ion energy and mass on the resulting hole diameters were examined. The hole diameter perforated in PVDF increases with increasing mass and decreases with increasing kinetic energy of the ions. The hole diameters on the surface of the film change little, but the effective hole diameter, which depends on the narrowest site along the long tube, decreases with increasing kinetic energy of ion. This is inferred from the angle of taper in the canal. The axial and lateral etching rates of the long canal were obtained by measurements of gaseous flow through the holes. Clear-cut entrances for the holes were observed by SEM and the cylindrical and parallel canals were shown by TEM. The doses per film are calculated to be about 2-6 Mrad at a hole density of  $3\times10^8$ /cm $^2$ . (Author abstract) 15 refs.

Komaki, Yoshihide (JAERI, Ibaraki, Jpn); Ishikawa, Niro; Sakuri, Tsutomu; Morishita, Norio; Iwasaki, Matae. *Nucl Instrum Methods Phys Res Sect B* v B34 n 3 Sep 1988 p 332-336.

**082673 METHOD FOR DETERMINING THE FRACTION OF UNREACTIVE FREE RADICALS IN IRRADIATED SOLID POLYMERS.** Free radicals are frozen into solid polymers when the latter are irradiated at liquid nitrogen temperature. On heating to higher temperatures the free radicals will then disappear by recombination. However, in some polymers some free radicals are situated in locations where they cannot react at temperatures where other free radicals in the solid do react. Equations are given for the kinetics of the decay reactions from which the fraction of the non-decaying species can be accurately calculated. From the results of this work, it appears that the new forms of the second order reaction kinetic equation enable estimates to be made of the fraction of non-decaying free radicals in irradiated solid polymers and also of the extent to which the free radical recombination reactions are diffusion controlled. 5 refs.

Dole, Malcolm. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 595-597.

**Reaction Injection Molding** See Also POLYURETHANES—Viscoelasticity; UREA—Copolymerization.

**082674 SPACE-TIME DISTRIBUTION IN FILLING A MOLD.** The residence time of a fluid particle in mold filling is total time spent in the mold. Displaying curves of constant residence time in the mold gives the space-time distribution during the filling process. A simple method to calculate space-time distributions is



presented. Applications to mold filling in reaction injection molding (RIM) are illustrated. (Author abstract) 22 refs.

Manas-Zloczower, I. (Univ of Minnesota, Minneapolis, MN, USA); Blake, J.W.; Macosko, C.W. *Polym Eng Sci* v 27 n 16 Mid-Sep 1987 p 1229-1235.

**Reaction Kinetics** See Also PAPERMAKING—Sizing.

**082675 KINETICS OF ISOCYANATE AMINE REACTIONS.** Development of polyurea-urethane and polyurea reaction injection molding systems has created a need for kinetics of polyurea formation. Adiabatic batch reactions in solution were used to determine heats of reaction and relative reactivity of several aromatic amines and n-butanol with phenyl isocyanate. In addition to comparing times required to reach 25, 50 and 75% conversion for both catalyzed and uncatalyzed reactions, n-th order models with Arrhenius rate constants were used to fit some of the exotherms. (Edited author abstract) 30 refs.

Pannone, Mary C. (Univ of Minnesota, Minneapolis, MN, USA); Macosko, Christopher W. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2409-2432.

**082676 KINETIC STUDY OF POLYOXYETHYLENE GLYCOL CYCLIZATION UNDER CONDITIONS OF THE PFITZNER-MOFFAT REACTION.** The kinetics was studied of the polyoxyethylene glycol cyclization in the presence of dicyclohexylcarbodiimide, dimethyl sulfoxide and ortho-phosphoric acid in  $\text{CCl}_4$  at room temperature (the Pfitzner-Moffat reaction). For polymers of various molecular mass, the rate constants of this reaction were determined by IR-spectroscopy. The rate constant of oxidation of a low-molecular mass monofunctional analogue (ethanol) was determined by GLC. It was found that in all cases the constants have similar values, in the range  $(4-7) \times 10^{-6} \text{ sec}^{-1}$ . The polymer cyclization rate appears to be limited by the hydroxyl group oxidation to aldehyde. (Author abstract) 8 refs.

Topchieva, I.N. (M.V. Lomonosov Moscow State Univ, USSR); Zuyev, P.S.; Kuchanov, S.I.; Romanova, V.S.; Zubov, V.P. *Polym Sci USSR* v 28 n 8 1986 p 1964-1970.

**Reactions** See Also POLYBUTENE—Synthesis.

**082677 REACTIVITIES OF POLYMER RADICALS TOWARDS STILBENE; THE CASES OF VINYL METHYL KETONE, ISOPROPENYL METHYL KETONE, STYRENE AND  $\alpha$ -METHYLSTYRENE.**  $^{14}\text{C}$ -stilbene has been used for measurement of the incorporation of stilbene in polymers of vinyl methyl ketone, isopropenyl methyl ketone and styrene, and in copolymers of the two ketonic monomers and of styrene with  $\alpha$ -methylstyrene. It has been confirmed that the introduction of an  $\alpha$ -methyl group into a monomer significantly reduces the reactivity of the derived polymer radical towards stilbene. (Author abstract)

Barson, C.A. (Univ of Birmingham, Birmingham, Engl); Behari, K.; Bevington, J.C. *Polym Bull (Berlin)* v 18 n 3 Sep 1987 p 265-269.

**082678 SOLID-LIQUID-SOLID TRIPHASE TRANSFER REACTION OF POLY(CHLOROMETHYLSTYRENE).** Recently, phase transfer catalysis has been widely used in polymer chemistry such as polymeric phase transfer catalysts, polymer syntheses, and chemical modification of polymers. This paper reports the reaction mechanism in the solid-liquid-solid triphase transfer reaction of PCMS with nucleophilic reagents in the poor solvents, and discusses in detail suitable quaternary salts used as a phase transfer catalyst (PTC) and effect of stirring rate. 15 refs.

Iizawa, Takashi (Kanagawa Univ, Yokohama, Jpn); Akatsuka, Shoji; Nishikubo, Tadatomi. *Polym J* v 19 n 12 1987 p 1413-1416.

## Recovery

**082679 RECOVERY PROCESSES IN AMORPHOUS POLYMERS.** The release of stored energy and the recovery of dimension and volume of cold compressed polystyrene (PS), polymethyl methacrylate (PMMA) and polycarbonate (PC) were studied. The release of stored energy has two peaks, one broad peak at 70°C (PS), 55°C (PMMA) and 85°C (PC) and one sharp peak at 113°C (PS,  $T_g = 105^\circ\text{C}$ ), 123°C (PMMA,  $T_g = 117^\circ\text{C}$ ) and 157°C (PC,  $T_g = 152^\circ\text{C}$ ). The recovery of dimension has only one peak at 114°C (PS), 124°C (PMMA) and 157°C (PC). This peak agrees very well with the second peak in the release of stored energy. The recovery of volume has a broad peak similar to the first peak in stored energy. Thus there are probably two recovery processes in these polymers: one releases energy and recovers volume below  $T_g$  and the other releases energy and recovers dimension above  $T_g$ . (Edited author abstract) 48 refs.

Kung, Teh-Ming (Univ of Rochester, Rochester, NY, USA); Li, J.C.M. *J Mater Sci* v 22 n 10 Oct 1987 p 3620-3630.

**Recycling** See POLYSTYRENES—Waste Utilization.

## Reduction

**082680 ESR STUDY OF THE ELECTROCHEMICAL REDUCTION AND OXIDATION OF POLY(p-NITROSTYRENE).** Electron spin resonance (ESR) spectroscopy is applied to study the electrochemical oxidation and reduction of poly(p-nitrostyrene) solutions in situ. The electrochemical reduction in dimethylformamide solution leads to production of the anion radical of poly(p-nitrostyrene). The ESR spectrum of the reduced polymer is unusual in that it consists of a single homogeneously narrowed line, with no observed hyperfine couplings. On the basis of the temperature and concentration behavior of the ESR spectrum, it is concluded that the electron spin is involved in an intramolecular hopping along the pendant nitrophenyl groups in the polymer. At room temperature the rate of this process is approximately 55 MHz. The activation energy for this process is 1.5 kJ/mol in solution and 0.18 kJ/mol in the solid state. (Edited author abstract) 26 refs.

Veregin, R.P. (Xerox Research Cent of Canada, Mississauga, Ont, Can); Harbour, J.R. *Macromolecules* v 21 n 5 May 1988 p 1340-1353.

## Reinforcing

**082681 SELF-REINFORCED MELT PROCESSIBLE POLYMER COMPOSITES: EXTRUSION, COMPRESSION, AND INJECTION MOLDING.** Rheological properties, extrusion, fiber spinning, compression, and injection molding of blends of polycarbonate and two thermotropic liquid crystal polymers based on wholly aromatic copolyesters have been studied. Based upon differential scanning calorimetry and dynamic mechanical measurements, these blends have been shown to be incompatible in the entire range of concentrations. During extrusion and injection molding at high strain rates, it has been observed that thermotropic liquid crystal polymer at concentrations, 2.5, 5, and 10 percent by weight in situ forms high modulus and high strength fibers within the polycarbonate matrix leading to self-reinforced polymer composites. The tensile strength of the composite containing 10 percent of liquid crystal polymer exceeds that of the pure components. In addition, anisotropy of properties of the injection molded parts has been found to substantially reduce in a comparison with that of liquid crystal polymer. The processing conditions and technique for the production of self-reinforced polymer composite during processing of the blends have been identified. (Edited author abstract) 37 refs.

Isayev, A.I. (Univ of Akron, Akron, OH, USA); Modic, M. *Polym Compos* v 8 n 3 Jun 1987 p 158-175.

**Research** See Also MEMBRANES—Permeability, Mechanical; MIXTURES—Thermodynamics; OLIGOMERS—Processing; OLIGOMERS—Research.

**082682 INTERPOLYMER COMPLEXES: STUDY OF INTERACTION OF POLY(VINYLPYRROLIDONE) WITH P-HYDROXYBENZOIC ACID-FORMALDEHYDE COPOLYMER IN NONAQUEOUS MEDIA.** Interactions between poly(vinylpyrrolidone) (PVP) and p-hydroxybenzoic acid-formaldehyde copolymer have been studied in methanol solution. The component polymers appear to form interpolymer complexes in distinct stages. The results are interpreted in terms of 1) hydrogen bonding, 2) ion-dipole interaction, 3) tacticity of PVP, and 4) multiple coordinating positions of component polymers. (Author abstract) 12 refs.

Chatterjee, S.K. (Delhi Univ, Delhi, India); Sethi, K.R.; Riess, G. *J Macromol Sci Chem* v A24 n 8 1987 p 859-868.

**082683 POLYMERITIEENEN NYKYTILA JA TULEVAISUUDEN NAKYMAT.** [Current Topics of Polymer Science]. The review describes topics central to polymer science in the eighties, in particular theories of the liquid and solid state and their transitions, polymer liquid crystals, fractal theory, the electrical conductivity of polymers, and specialty polymers in construction materials and medicine. (Author abstract) In Finnish. 27 refs.

Lindberg, J. Johan. *Kem Kem* v 14 n 10 1987 p 863-867.

**082684 ACTIVATION VOLUME DISTRIBUTION OF RELAXATIONAL PROCESSES IN POLYMERS.** In this paper activation volume distributions are obtained on the basis of an analysis of thermally stimulated depolarization currents (TSD) at hydrostatic pressures up to 200 MPa in the regions of  $T_g$  ( $\alpha$ -relaxational process) for polyvinylchloride (PVC), polymethyl methacrylate (PMMA), polyvinyl acetate (PVA), polychlorotrifluoroethylene (PCTFE), and nylon 6, and also in the region of  $T < T_g$  ( $\beta$ -relaxational) in the case of PMMA. The data obtained in this work indicate that structural rearrangement which accompanies the transition from the glassy to the high elastic state and which results in a sharp increase in the amplitude of rotary segmental motions, produces narrowing of the distribution functions with respect to activation parameters and a change in their form. 15 refs.

Mansimov, S.A. (USSR Acad of Sciences, USSR); Kovarskii, A.L.; Kerimov, M.K. *Polym Sci USSR* v 28 n 9 1986 p 2226-2232.

**082685 COMPUTER SIMULATION STUDIES OF THE SOLITON MODEL: 3. NON-CONTINUUM REGIMES AND SOLITON INTERACTIONS.** The authors study of the sine-Gordon soliton model, performing stochastic molecular dynamics computer simulations for a wide range of both temperatures and coupling constants. We find three general regimes of behavior: the continuum limit or non-interacting regime; the pinned or transition-state-theory (TST) limit, where soliton-phonon interactions are important; and the general non-continuum regime, where soliton-soliton interactions of 'multiple soliton effects' are important. In the non-continuum regime, the correlation function changes as a function of temperature and coupling constant. We expect that this will lead to deviations from the continuum limit temperature scaling and soliton energy scaling observed in the dynamics of sine-Gordon systems. (Edited author abstract) 20 refs.

Wahlstrand, Karna J. (NBS, Gaithersburg, MD, USA). *Polymer* v 29 n 2 Feb 1988 p 256-262.

**082686 NUCLEAR MAGNETIC RELAXATION IN THE POLYDIALKOXYPHOSPHAZENE SERIES.** The pulse NMR method in a wide temperature range has been employed to investigate the processes of molecular mobility in the polydialkoxyposphazene series with a variable length of the side alkyl chain. The NMR characteristics have been determined and the observed temperature transitions identified. The structure of the



main inorganic chain was found to influence the character of the motion of the terminal methyl groups of the polydialkoxypolyphosphazenes. It is shown that the main features of the molecular motion in them are determined by the weak dependence of the motion of the side and main chains thanks to the raised flexibility of the latter. (Author abstract) 18 refs.

Sokol'skaya, I.B. (Lomonosov Inst of Fine Chemical Technology, Moscow, USSR); Kireyev, V.V.; Zelenov, Yu.V. *Polym Sci USSR* v 28 n 10 1986 p 2298-2306.

**082687 RELAXATIONAL TRANSITIONS IN NON-ORIENTED AND ORIENTED CAPRONE.** The nature of the  $\beta$ - and  $\alpha$ -groups of the relaxational transitions in crystalline polymers of the caprone, PE and PP type is similar and associated with the molecular motions of the  $\text{CH}_2$  groups in the amorphous phase in the glassy state ( $\beta$ - and  $\beta_1$ -transitions), segmental motion ( $\alpha$ -,  $\alpha_1$ - and  $\alpha_2$ -transitions) and also with the mobility of the  $\text{CH}_2$  groups in the crystalline breakdown of the local intermolecular bonds formed by the hydrogen and dipole-dipole bonds. (Edited author abstract) 9 refs.

Bartenev, G.M. (USSR Acad of Sciences, Moscow, USSR); Koblyakov, A.I.; Brateneva, A.G. *Polym Sci USSR* v 28 n 10 1986 p 2306-2314.

**082688 STUDIES OF SYNTHETIC POLYMERS BY NONRADIATIVE ENERGY TRANSFER.** Non-radiative energy transfer between fluorescent labels attached to polymers has been used to characterize polymer miscibility, the interpenetration of chain molecules in solution, micelle formation in graft copolymers, the unfolding of collapsed chain molecules in polymer melts, and the transfer of energy absorbed by a large number of donor labels to a small number of acceptors by an 'antenna effect.' The change in the emission spectrum after ionomer solutions with different fluorescent counterions were mixed provided rate constants for counterion interchange. The fluorescence behavior of dispersions of donor-labeled polymers stabilized by a graft copolymer with acceptor fluorophores in the solution phase led to inferences about the morphology of the dispersed particles. (Author abstract) 47 refs.

Morawetz, Herbert (Polytechnic Univ, Brooklyn, NY, USA). *Science* v 240 n 4849 Apr 8 1988 p 172-176.

**082689 STUDY OF POLYMER/WATER INTERACTIONS USING SURFACE ACOUSTIC WAVES.** Application of surface acoustic waves to the study of fundamental properties of hygroscopic polymer/water systems is reported. The basic device used is a surface acoustic wave (SAW) delay-line oscillator, the propagation path of the delay line being coated with a film of the polymer to be studied. The frequency of the SAW oscillator is measured as a function of temperature at various relative humidities. Thermodynamic functions of free energy, enthalpy, and entropy are then determined. The transient response of the SAW oscillator to step changes in humidity is also studied, and may be described by a generalized relaxation equation containing two additive terms. The utility of these data for analyzing the thermodynamics and kinetics of water-vapor sorption and desorption is discussed. (Edited author abstract) 34 refs.

Brace, John G. (Johnson Controls Inc, Milwaukee, WI, USA); Sanfelippo, Thomas S.; Joshi, Shrinivas G. *Sens Actuators* v 14 n 1 May 1988 p 47-68.

**082690 DEVELOPMENT OF LOOPS, TRAINS, AND TAILS IN A SELF-AVOIDING POLYMER SEQUENCE AT A RIGID BOUNDARY AS A FUNCTION OF SOLVENT COMPOSITION.** The development of loops, trains, and tails in a self-avoiding hard-sphere sequence terminally attached to a rigid boundary is determined as a function of solvent particle diameter, packing fraction, and chain length: the analysis is made on the basis of the convolution integral approximation. It is found that the introduction of a solvent drastically modifies their development in comparison to the zero solvent case, and the results are analyzed in terms of the attritional processes associated with the introduc-

tion of the boundary and the replacement of segment by solvent particles. (Author abstract) 9 refs.

Croton, Clive A. (Univ of Newcastle, Newcastle, Aust). *Macromolecules* v 21 n 1 Jan 1988 p 244-249.

**082691 HOW DOES THE POLYMER MAIN CHAIN INFLUENCE THE SIDE-CHAIN MOBILITY? A FLUORESCENCE PROBE STUDY BY MEANS OF TWISTED INTRAMOLECULAR CHARGE-TRANSFER PHENOMENA.** The authors prepared poly(methyl methacrylate) (PMMA) containing a very small amount of DMAB chromophore attached to the side chain via an alkyl chain of variable length. Close study of TICT (Twisted Intramolecular Charge-Transfer) fluorescence in dilute solution revealed that the fluorescence behaviors are dependent on the length of spacer as well as on the chain conformation. It is apparent that small rotational motion in the side chain is controlled by the polymer main chain even in very dilute solutions. 17 refs.

Tazuke, Shigeo (Tokyo Inst of Technology, Yokohama, Jpn); Rong Kun, Guo; Hayashi, Ryuichi. *Macromolecules* v 21 n 4 Apr 1988 p 1046-1051.

**082692 MOLECULAR MOTIONS IN MODEL NETWORK POLYMERS.** Molecular motions in network polymers of monodisperse PPO,  $\alpha,\omega$ -dihydroxypropylene oxide, cross-linked with TIPTP, tris(4-isocyanatophenyl) thiophosphate, were compared with those of linear polymers of the same molecular weight PPO chains extended with diisocyanates. The linear polyurethanes have a single exponential decay for  $T_{1\rho}(C)$  with well-defined  $T_{1\rho}(C)$  minima that occur at lower temperatures for longer PPO segments. Samples of 1000 MW PPO chains extended with phenylene-1,4-diisocyanate show the same  $T_{1\rho}(C)$  values by cross polarization or direct polarization while these values are different for toluene-2,4-diisocyanate linked polymers, indicating the presence of regions of dissimilar rigidity. (Edited author abstract) 27 refs.

Dickinson, L. Charles (Univ of Massachusetts, Amherst, MA, USA); Morganello, P.; Chu, C.W.; Petrovic, Z.; MacKnight, William J.; Chien, James C.W. *Macromolecules* v 21 n 2 Feb 1988 p 338-346.

**082693 BISMALEIMIDE-OLIGOPHENOL DISULPHIDE BINDER AND MATERIALS BASED ON IT.** The interaction of bismaleimide and oligophenol disulphide has yielded a new thermosetting binder cured by the polymerization mechanism and the properties of which within wide limits may be regulated by the comonomer ratio. From this binder glass-filled composite materials have been obtained and the regimes of their processing and properties investigated, which establish that the greatest heat stability and best physicomechanical properties are displayed by a material based on the binder with the ratio bismaleimide: oligophenol disulphide=1:0.1. (Author abstract) 15 refs.

Sergeyev, V.A. (Nesmeyanov Inst of Elemento-Organic Compounds, USSR); Nedel'kin, V.I.; Yuferov, Ye.A.; Yuferov, A.M.; Yerzh, B.V. *Polym Sci USSR* v 29 n 2 Feb 1987 p 252-258.

**082694 MANIFESTATION OF REPTATION MOTIONS OF MACROMOLECULES ON DIFFUSIONAL ATTENUATION OF THE STIMULATED SPIN ECHO SIGNAL.** The effect of fluctuations in the characteristics time of motion of defects and the length of the force pipe on the diffusional attenuation profile of the spin echo signal in the long wave region is discussed. When the correlation times of these fluctuations are more than the average time of pipe regeneration the diffusional attenuation has an essentially non-exponential character and can be described in terms of a random fluctuating coefficient of self-diffusion. The true coefficient of self-diffusion can be determined from the initial inclination of the diffusional attenuation profile. (Author abstract) 10 refs.

Fatkullov, N.F. (V.I. Ulyanov-Lenin State Univ, Kazan, USSR). *Polym Sci USSR* v 29 n 2 Feb 1987 p 447-454.

**082695 EFFECT OF PLASTICIZATION ON MASS DIFFUSION OF CAMPHORQUINONE IN POLYSTYRENE.** Mass diffusion coefficients of camphorquinone (CQP) in the polystyrene-diethyl phthalate (plasticizer) system are measured at various temperatures and concentrations of diethyl phthalate (DOP) by using the laser-induced holographic grating relaxation technique. The mass diffusion coefficient of CQP shows a strong dependence on the concentration of DOP, which is explained in terms of the free volume increase introduced by the plasticizer. At a given temperature, the diffusion coefficient of CQP in polystyrene (PS) containing 12.4% of DOP is more than  $10^4$  times higher than that in pure PS. The apparent activation energy is found decreasing as the plasticizer concentration increases. (Author abstract) 6 refs.

Zhang, J. (Univ of Utah, Salt Lake City, UT, USA); Wang, C.H. *Macromolecules* v 21 n 6 Jun 1988 p 1811-1813.

**082696 EFFECT OF AN INHOMOGENEITY ON LOCAL CHAIN DYNAMICS: CONFORMATIONAL AUTOCORRELATION FUNCTION.** The influence of an inhomogeneity such as a fluorescence or ESR label on local polymer main chain dynamics is investigated theoretically by using a bistable conformational model including isolated transitions and correlated pair transitions. The conformational autocorrelation function is determined by a perturbative treatment within the limit of a far chain end inhomogeneity. The model suggests two types of behavior according to the dynamic properties of the inhomogeneity. A flexible inhomogeneity yields a decrease of the cooperative relaxation time and an increase of the main-chain mobility while the opposite case is obtained with a rigid one. The results are compared with Hall-Helfand's model, generalized diffusion and loss model, and the recent study of B.B. Pant et al. relative to the effect of a probe on polymer chain dynamics. (Edited author abstract) 8 refs.

Veissier, Valerie (ESPCI, Paris, Fr); Vivoy, Jean-Louis. *Macromolecules* v 21 n 6 Jun 1988 p 1813-1818.

**082697 NEWER DEVELOPMENTS OF POLYMER ALLOYS.** Alloying, which is a recent technique, is considered one of the convenient techniques to make up technical or economical deficiencies of commercially available polymers. Moreover, it renders the system flexible to suit the specific end-use by selecting and/or adjusting the components or their proportions. A review is presented of various alloys and their techniques of preparation. Alloy preparation is discussed. The following alloys are briefly examined: acrylonitrile-butadiene-styrene copolymers; ABS-polycarbonate alloys; ABS-poly-sulfone alloys; ABS-polyurethane alloys; ABS-polyvinyl chloride (PVC) alloys; PVC-acrylate alloys; PVC-chlorinated polyethylene alloys; thermoplastic polyester alloys; polyphenylene oxide-polystyrene alloys, and nylon alloys. 21 refs.

Sharma, K.K. (Shri Ram Inst for Industrial Research, Delhi, India); Saroop, M.; Bahl, M.K. *Chem Age India* v 38 n 4 1987 p 149-154.

**082698 SVOJSTVA VODOTOPOLJIVIH POLIMERA. [Properties of Water-Soluble Polymers].** The properties of water-soluble polymers and biopolymers have recently attracted much attention. For these polymers specific methods of investigation are discussed followed by a demonstration of some examples of research of water soluble polymers and biopolymers, e.g. poly(vinyl alcohol), poly(ethylene-oxide) and dimyristoyl-lecithin. Treatment of experimental results with different theories is indicated. (Edited author abstract) 14 refs. In Serbo-croatian.

Lechner, Dieter M. (Univ Osnabrueck, Osnabrueck, West Ger). *Polimeri (Zagreb)* v 8 n 12 Dec 1987 p 341-346.



**082699 POLYUREAS CONTAINING DIAZA CROWN ETHER UNITS: SYNTHESIS AND INFLUENCE OF RING SIZE ON THE GLASS TRANSITIONS AND SECONDARY RELAXATION PROCESSES.** A series of polyureas have been prepared by linking together diaza crown ether units of sizes 12, 18, and 24 atoms by using diisocyanates of differing rigidity. Measurement of the glass transition temperature,  $T_g$ , showed that as the ring size increased from 12 to 24 atoms,  $T_g$  decreased in polymers with a common linking unit. When the ring size was held constant,  $T_g$  varied with the flexibility of the spacing unit. Several secondary relaxations were located. It was possible to identify intramolecular relaxation processes in the diaza crown ring that occurred at decreasing temperatures as the ring size increased in the order 200 K (12-crown) > 152 K (18-crown) > 148 K (24-crown) when methylenedi-p-phenylene diisocyanate was the linking unit. (Edited author abstract). 15 Refs.

Cowie, J.M.G. (Univ of Stirling, Stirling, Scotl); Wu, H.H. *Macromolecules* v 21 n 7 Jul 1988 p 2116-2121.

**082700 EFFECT OF LATTICE COORDINATION NUMBER ON THE DYNAMICS OF MODELS OF DENSE POLYMER SYSTEMS.** Dynamic Monte Carlo simulations of both simple cubic and face-centered cubic lattice models of dense polymer systems have been performed and analyzed by studying the autocorrelation functions of the first three Rouse coordinates. A significant difference between the two lattices is found in the concentration dependence of the scaling exponent that describes the chain length dependence of the relaxation times. This difference is due to the necessity of using bead movement rules with two different length scales in the simple cubic lattice model, while in the face-centered cubic model elementary motions with a single length scale are sufficient. Implications of this result are discussed. The normal mode analysis also provides some insight into the nature of the entanglement constraint in dense polymer systems. (Author abstract). 19 Refs.

Crabb, Charles C. (Rohm & Haas Co, Bristol, PA, USA); Hoffman, David F. Jr.; Dial, Michelle; Kovac, Jeffrey. *Macromolecules* v 21 n 7 Jul 1988 p 2230-2235.

**082701 POLYARYLATES. V. THE INFLUENCE OF PHASE TRANSFER AGENTS ON THE INTERFACIAL POLYCONDENSATION.** The effect of various phase transfer agents on the interfacial polycondensation of bisphenol A with isophthaloyl chloride was investigated. It was found that the transfer rate of bisphenolate and, thus, the reaction rate of polycondensation were increased with an increasing lipophilicity of the phase transfer agent, i.e. TBAC > TEAC > TEAC, whereas the equilibrium of bisphenolate between the organic phase and the aqueous phase was hardly affected. Moreover, experimental evidence indicated that a phase transfer agent of high lipophilicity reduced the hydrolysis of the acid chloride, an important aspect in interfacial polycondensation. (Author abstract). 7 Refs.

Lee, Yu-Der (Nat'l Tsing Hua Univ, Hsinchu, Taiwan); Tsai, Hong-Bing; Jeng, Jaw-Tang. *J Polym Sci Part A* v 26 n 8 Aug 5 1988 p 2039-2046.

**082702 KINETICS OF EXCIMER FORMATION IN CHOLESTERIC MESOPHASES CONTAINING CHOLESTERYL 3-(1-PYRENYL)PROPANOATE.** The kinetics of excimer formation in cholesteric liquid crystalline (CLC) mixtures containing 3-25 mol % of cholesteryl 3-(1-pyrenyl)propanoate (Py-2) was examined. Fluorescence rise and decay curves of monomer and excimer emissions were fitted to the Birks kinetics, and the elementary rate constants were determined at different temperatures in the cholesteric and isotropic phases. The rate constant of excimer formation was much smaller than that reported for a dilute solution of pyrene and a little smaller than that for pyrene molecules dispersed in a CLC mesophase. Only a small effect of the phase change from cholesteric to isotropic was observed on the excimer formation rate constant. But the activation energy for the excimer dissociation was significantly decreased in the cholesteric mesophase. (Edited author abstract). 12 Refs.

Sisido, Masahiko (Kyoto Univ, Kyoto, Jpn); Wang, Xing-fan; Kawaguchi, Koji; Imanishi, Yukio. *J Phys Chem* v 92 n 16 0811 1988 p 4797-4801.

**082703 EXCIPLEX FORMATION IN CHOLESTERIC LIQUID CRYSTALS CARRYING CARBAZOLYL AND TEREPHTHALOYL GROUPS.** Exciplex formation was observed in cholesteric liquid crystals (CLCs) containing cholesteryl 3-(9-carbazolyl)propanoate (9Cz-2) or 3-[3-(N-ethylcarbazolyl)propanoate (3Cz-2)] as a donor, and cholesteryl methyl terephthalate (CMT) or dimethyl terephthalate (DMT) as an acceptor. The exciplex formation was more efficient when CMT was used as an acceptor than when DMT was used. The efficient exciplex formation of CMT in the CLC phase was interpreted by an arrangement of terephthaloyl groups of CMT molecules close to carbazolyl groups. An exciplex of high energy was detected when 9Cz-2 was used as the electron donor and CMT as the acceptor. The high-energy exciplex was observed only in the CLC phase at low temperatures. It was concluded that a constraint on the orientation of carbazolyl and terephthaloyl groups in the CLC phase leads to the unstable exciplex, which cannot be formed in isotropic media. (Edited author abstract). 17 Refs.

Sisido, Masahiko (Kyoto Univ, Kyoto, Jpn); Wang, Xing-fan; Kawaguchi, Koji; Imanishi, Yukio. *J Phys Chem* v 92 n 16 0811 1988 p 4801-4806.

**082704 CARDIC CARBORANE-CONTAINING POLYPHOSPHAZENES.** Using the reaction between polydichlorophosphazene and bis-(hydroxy-methyl)-o-carborane in the presence of triethylamine as an example, it has been shown to be possible to replace two chlorine atoms at a single phosphorus atom in the carborane-containing group. An investigation has been made of certain properties of polyphosphazenes, having diverse links, that are formed and which contain, in addition to the cardiac carborane-containing groups, tetrafluoropropoxy groups. (Edited author abstract). 11 Refs.

Korshak, V.V. (USSR Acad of Sciences, USSR); Bekasova, N.I.; Vinogradova, S.V.; Solomatina, A.I.; Bulycheva, Ye. G. *Polym Sci USSR* v 29 n 4 1987 p 935-941.

**082705 EFFECT OF POLYMER BRIDGING ON THE FLOCCULATION KINETICS OF COLLOIDAL DISPERSIONS.** Relative coagulation and flocculation rates of negatively charged colloidal dispersions (silver iodide sol, arsenic trisulphide sol, polystyrene latex) in the presence of electrolyte and small amounts of methylcellulose (MC), polyvinyl pyrrolidone (PVP) or 1:1 (w/w) MC-PVP mixture, have been determined by measuring the change in optical density of the dispersion with time. It was found that the adsorbed polymer may enhance or diminish the rate of successful encounters between particles, even at low surface coverages, depending on the magnitude of the interparticle electrostatic repulsion. (Edited author abstract) 17 Refs.

Csmpesz, Ferenc (Lorand Eotvos Univ, Budapest, Hung); Rohrer, Sandor. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 215-230.

**082706 NOVEL METHOD TO STUDY POLYMER INTERFACIAL DYNAMICS.** The author's have developed a technique to determine the rate of reconfigurations of polymers on surfaces. The principle of this measurement is to study the streaming potential of a capillary and then to inject polymer into the electrolyte stream in short pulses. The streaming potential essentially gives the hydrodynamic layer thickness, and one observes, between pulses, the time dependence of the adsorbed layer thickness as it approaches the equilibrium state. The results are indicative of an unfolding going on (10 to several hundred seconds) and were found to depend strongly on effective segmental adsorption energy.

Cohen Stuart, M.A. (Agricultural Univ, Wageningen, Neth); Tamai, H. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int

Conf, Veldhoven, Neth, Sep 7-9 1987 p 265.

**082707 POLYMER PREPRINTS - PAPERS PRESENTED AT THE NEW ORLEANS, LOUISIANA MEETING.** This conference proceedings contains 241 papers of which 20 appear in abstract form only. Topics covered include: modification of surface - surface forces; self-consistent field theory; thin film liquid polymer behavior; polymer blend theory; surface controlled hydroxyl groups; photodegraded polymer surface analysis; immiscible polymer blends; polymer melts; oriented polymer properties; polymer interface strength; block copolymer properties; properties of silica filled ethylene-vinyl acetate (EVA) copolymer composite; composite materials; homopolymer blends; monolayer surfaces; lipid bilayers; photochemical surface modification; polymer diffusion; polymer conformation; conformational transitions; excimer formation; polyureas; polymer-diluent blends; polymer-polymer miscibility; ternary polymer blends; interpenetrating polymer networks; thermoplastic composites; multiblock copolymers; copolymer synthesis; siloxane oligomers; carbanion chemistry; graft copolymers; thermoplastic crystallization; macro monomers; microgravity research projects; and, electro kinetic analysis of micromolecules. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11485 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Culbertson, Bill M. (Ed.) (Ashland Chemical Co, Dublin, OH, USA); Riffle, Judith S. (Ed.); Blum, Frank D. (Ed.); Gibson, Harry W. (Ed.). *Polym Prepr Div Polym Chem Am Chem Soc* v 28 n 2 Aug 1987, Polym Prepr - Pap Presented at the New Orleans, LA Meet, New Orleans, LA, USA, Aug 30 - Sep 4 1987. Publ by Div of Polymer Chemistry Inc, Newark, NJ, USA, 1987 477p.

## Reviews

**082708 POLYARYLATE RESINS.** A new family of resins offers high temperature resistance, dimensional stability and low toxic smoke output. The world's automobile industry is seen as a major market. Because they are injection mouldable, the new materials can readily produce complex shapes with precise dimensions and high-grade surfaces. (Edited author abstract) 1 ref.

Evans, R.K. *Mater Des* v 9 n 2 Mar-Apr 1988 p 70-71.

**082709 HIGH PERFORMANCE POLYMERS: THEIR ORIGIN AND DEVELOPMENT, PROCEEDINGS OF THE SYMPOSIUM (PRESENTED AT THE 91ST MEETING OF THE AMERICAN CHEMICAL SOCIETY).** This conference proceedings contain 41 papers that review the historical and development aspects of high-performance engineering thermoplastics. Physical properties and performance characteristics are also discussed. The classes of polymers covered include: Polyamides; Polyesters; Acetals; styrenics; Sulfur containing Polymers; Polyarylether ketone; Polyetherimides; Blends and Alloys; Liquid crystalline polymers; Fluoroplastics; Thermosets; Fibers; High-performance Elastomers; and High barrier packaging materials. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11094 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Seymour, Raymond B. (Ed.) (Univ of Southern Mississippi, Hattiesburg, MS, USA); Kirshenbaum, Gerald S. (Ed.). *High Perform Polym: Their Origin and Dev, Proc of the Symp, New York, NY, USA, Apr 15-18 1986* Publ by Elsevier, New York, NY, USA, 1986 461p.

**Rheology** See Also ACRYLICS—Solutions; AS-PHALT—Rheology; CRYSTALS, LIQUID—Viscoelasticity; PLASTICS, REINFORCED—Processing; POLYBUTENE—Solutions; POLYELECTROLYTES—Solutions; POLYSTYRENES—Solutions; POLYURETHANES—Reaction Injection Molding; RUBBER TESTING—Elasticity.



**082710 CONSTRUCTIONS OF MASTER CURVES AND MASTER SURFACES STARTING WITH EXPERIMENTAL DATA.** Starting with the theoretical considerations of authors' previous papers, some practical aspects concerning the shift procedures of rheological data are analysed. The latter can be used for the construction of both isotherm and isochrone master curves as well as of master surfaces, with the condition of experimental verification of the validity of the time-temperature superposition principle. Thereby any empirical shift procedure is omitted. Examples are presented for a very large frequency-temperature range, including the glass transition zone. (Edited author abstract) 5 refs.

Brekner, M.-J. (Univ of Freiburg, West Ger); Cantow, H.-J.; Schneider, H.A. *Prog Colloid Polym Sci* v 71 1985 p 173-179.

**082711 SIMULATION OF PLANAR WELDING FLOWS: PART 2. STRAIN HISTORY, STRESS CALCULATION, AND EXPERIMENTAL COMPARISON.** Welding flows occur in polymer processing when two streams of molten polymer meet to form a weld interface. In this paper, a numerical method is described for calculating the stress a viscoelastic melt exhibits in a flow, based on approximate kinematics. The method assumes that the kinematics are reasonably close to those of a shear-thinning fluid such as the Carreau model. The strain history of a given flow and the resulting stress are calculated via a tracking method from finite element kinematics. Full-field flow birefringence experiments were done for low-density polyethylene and polystyrene flowing past a thin plate divider in a 1.254-mm planar slit die. By digitally analyzing birefringence photographs of the flow field, the birefringence was measured over two dimensions. The flow fields were most highly oriented in a region surrounding the weld interface just downstream of the plate divider. (Edited author abstract) 25 refs.

Wei, K.H. (Univ of Massachusetts, Amherst, MA, USA); Nordberg, M.E. III; Winter, H.H. *Polym Eng Sci* v 27 n 18 Mid-Oct 1987 p 1390-1398.

**082712 PREDICTION OF ELASTIC STRAINS OF POLYMER MELTS IN SHEAR AND ELONGATION.** The aim of this paper is to relate recoverable strains in shear and elongation to the relaxation time spectrum of the melt. For that purpose, the state of stress for a given strain history is calculated on the basis of a single integral constitutive equation with strain-dependent memory function as proposed by Wagner (cf. Refs. 2 and 3). In the limit of small shear or elongation rates, this reduces to Lodge's rubberlike liquid constitutive equation (cf. Ref. 4). 42 refs.

Laun, H.M. (BASF Aktiengesellschaft, Ludwigshafen am Rhein, West Ger). *J Rheol* v 30 n 3 June 1986 p 459-501.

**082713 MAXIMUM LOADING LEVELS IN FILLED LIQUID SYSTEMS.** Ouchiya and Tanaka have recently published a series of articles aimed at estimating the porosity of random packings of spherical particles having various sizes, and it is the purpose of this note to show that their work can be applied directly to the prediction of  $\phi_m$  in polydisperse suspensions, given the  $\phi_m$  for the monodisperse samples. This procedure is illustrated using the suspension viscosity data obtained by Chong et al. 11 refs.

Gupta, R.K. (State Univ of New York at Buffalo, Amherst, NY, USA); Seshadri, S.G. *J Rheol* v 30 n 3 June 1986 p 503-508.

**082714 TRANSIENT BEHAVIOR OF LIQUID CRYSTALLINE SOLUTIONS OF POLY(BENZYL-GLUTAMATE).** Polymeric liquid crystals (PLCs) constitute a class of complex but interesting materials. The purpose of the present paper is to explore systematically various aspects of the rheological behavior of a single polymeric liquid crystalline material, with emphasis on the transient behavior after cessation of flow. 28 refs.

Moldenaers, P. (Katholieke Univ, Louvain, Belg); Mewis, J. *J Rheol* v 30 n 3 Jun 1986 p 567-584.

**082715 STUDIES ON THE TRANSIENT SHEAR FLOW BEHAVIOR OF LIQUID CRYSTALLINE POLYMERS.** First, we want to determine whether the transient shear flow properties of liquid crystalline polymers are due to orientation changes of the rigid molecules or some other structural changes. Second, we would like to know whether the theories of Ericksen and even Leslie and Ericksen can at least qualitatively account for the transient behavior of LCP's. In this paper we present studies on the steady and transient shear flow properties of a thermotropic copolyester of 60- and 80-mole% PHB/PET and a lyotropic system of PPT in 100% H<sub>2</sub>SO<sub>4</sub>. We compare these results with the predictions of Ericksen's transversely isotropic fluid theory. 22 refs.

Viola, G.G. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Baird, D.G. *J Rheol* v 30 n 3 Jun 1986 p 601-628.

**082716 RHEOLOGICAL PROPERTIES OF POLYMERIC LIQUID CRYSTALS.** The theoretical framework of Doi and Marrucci for predicting the rheological properties of polymeric liquid crystals is considered in some detail. Previous limitations of the analysis, which restricted the theory to asymptotically low deformation rates, have been removed. The resulting predictions were compared with experimental data using both shearing and extensional flow configurations; for the latter a new fiber spinning apparatus was constructed with an order-of-magnitude increase in sensitivity over that of the best previously reported extensional devices. The agreement between theoretical prediction and experimental result is excellent for steady state deformations over the full range of conditions studied for both extensional and shearing modes of deformation. However, this excellent agreement between theory and experiment does not appear to extend to transient behavior, nor is it expected at very high deformation rates. (Edited author abstract) 47 refs.

Metzner, A.B. (Univ of Delaware, Newark, DE, USA); Prilutski, G.M. *J Rheol* v 30 n 3 Jun 1986 p 661-691.

**082717 EXAMPLE OF SPONTANEOUS SYMMETRY BREAKING IN POLYMER PHYSICS.** A polymer chain subject to certain constraints (slip-link plus fixed end points) is considered. It is shown that this system exhibits spontaneous symmetry breaking when the end-to-end distance of the chain is lowered below a certain critical value. Various implications of this effect are mentioned. (Author abstract) 6 refs.

Rieger, J. (Univ des Saarlandes, Saarbruecken, West Ger). *Polym Bull (Berlin)* v 18 n 4 Oct 1987 p 343-346.

**082718 COMPARISON OF SIMPLE CONSTITUTIVE EQUATIONS FOR POLYMER MELTS IN SHEAR AND BIAXIAL AND UNIAXIAL EXTENSIONS.** Experimental melt data are compared with differential constitutive equations that contain only a single adjustable parameter, besides the parameters describing the linear relaxation spectrum. The deformations are step shear, step biaxial extension, and start up of steady uniaxial extension of HDPE without long side branches and LDPE with long side branches. The Johnson-Segalman and White-Metzner models fail to predict the experimental data accurately. The equation of Acierno et al. shows strong oscillations in elongation and shear. The Giesekus equation fits the uniaxial extension and shear data but fails to do so for biaxial extension regardless of the choice of the adjustable parameter. The models of Phan-Thien and Tanner and of Larson seem to fit the data best. These two equations give a reasonably good fit to the data in all three deformations for the HDPE for a single value of the adjustable parameter. For the branched LDPE, a fit is only obtained if the parameter is separately adjusted for each of the three types of deformation. (Edited author abstract) 20 refs.

Khan, S.A. (AT&T Bell Lab, Murray Hill, NJ, USA); Larson, R.G. *J Rheol* v 31 n 3 Apr 1987 p 207-234.

**082719 MODEL OF DILUTE POLYMER SOLUTIONS WITH HYDRODYNAMIC INTERACTION AND FINITE EXTENSIBILITY. I. BASIC EQUA-**

**TIONS AND SERIES EXPANSIONS.** A bead-spring chain model is used to describe dilute polymer solutions. Two important effects, the hydrodynamic interaction between the beads of a single chain and the finite extensibility of the springs connecting the beads, are treated in a self-consistently averaged form. For the resulting model, a rheological equation of state, a third-order retarded-motion expansion, and a second-order codeformational memory-integral expansion are derived. Furthermore, the parameters characterizing the model and the limit of infinitely long chains are discussed in great detail. (Author abstract) 64 refs.

Ottinger, Hans Christian (Univ of Wisconsin-Madison, Madison, WI, USA). *J Non Newtonian Fluid Mech* v 26 n 2 Dec 1987 p 207-246.

**082720 RHEOLOGICAL PROPERTIES OF THERMOTROPIC LIQUID CRYSTALLINE AROMATIC COPOLYESTERS.** A series of thermotropic liquid crystalline polyesters based on p-acetoxybenzoic acid, naphthalene dicarboxylic acid, hydroquinone diacetate, and poly(ethylene terephthalate) were prepared via melt polycondensation. The anisotropic melts were studied by means of thermal optical testing, differential scanning calorimetry, scanning electron microscopy, x-ray diffraction, and rheological methods. It was found that the copolymers in the mesomorphic state exhibit drastic shear-thinning and the experimental results indicate that the non-Newtonian Index  $n$  is in the range of 0.17 to 0.50, the flow-activation energies  $\Delta E$  are 297.1 to 182.0 KJ/mol over the shear rate of 10 to 1000 S<sup>-1</sup> at temperature 225 to 270°C; and the mesomorphic copolymers are readily oriented during processing, resulting in highly oriented as-spun fibers. (Author abstract) 14 refs.

Zhou, Zhenglong (China Textile Univ, Shanghai, China); Wu, Xiuge; Wang, Meirong. *Polym Eng Sci* v 28 n 3 Mid-Feb 1988 p 136-142.

**082721 TIME-TEMPERATURE SUPERPOSITION IN NONISOTHERMAL FLOW.** The principle of time-temperature superposition provides the basis for understanding how rheological properties of polymeric liquids vary with temperature. However, the formulation of this principle and its justification by overwhelming experimental evidence are for isothermal flows only. As the molecular theory justification for time-temperature superposition in isothermal flow is provided by the Rouse theory, the author explores the implications of that theory in nonisothermal flow. 11 refs.

Wiest, John M. (Univ of Sydney, Sydney, Aust). *J Non Newtonian Fluid Mech* v 27 n 1 Feb 1988 p 127-131.

**082722 FULLY DEVELOPED MULTILAYER POLYMER FLOWS IN SLITS AND ANNULI.** A numerical method has been developed for simulating fully developed multilayer shear flows of non-Newtonian fluids with arbitrary viscosity functions. Poiseuille and combined Poiseuille/Couette flows in both slits and annuli may be modeled. The method employs a finite difference system where grid points lie on streamlines and move to their correct positions as the solution procedure converges. Interfaces are easily handled as particular streamlines with the equation of motion replaced by a boundary condition. The method is stable for high interface viscosity ratios and readily handles a large number of layers. Many authors have employed power law models to model multi-layer non-Newtonian flows. We find that the power law is sufficient to predict pressure gradients and interface positions in most cases, but gives unrealistically flat velocity profiles, even when truncated at finite viscosity. Results are presented for the Carreau fluid and for the rubber-like liquid with shear thinning via Wagner's strain functional. (Author abstract) 21 refs.

Nordberg, M.E. III (Univ of Massachusetts, Amherst, MA, USA); Winter, H.H. *Polym Eng Sci* v 28 n 7 Mid-April 1988 p 444-452.



**082723 MOLECULAR RHEOLOGY OF H-POLYMERS.** The rheological behavior of branched polymer melts contrasted with that of linear melts motivates a discussion of a molecular model of a melt of H-polymers. Concentrating on the dynamics of the 'backbone', we derive and discuss the linear viscoelastic properties in the light of experiments by J. Roovers. The model is extended to treat nonlinear deformations, with path-length extension treated in a self-consistent way, and compared with rheological behavior of branched LDPE. (Edited author abstract) 34 refs.

McLeish, T.C.B. (Cavendish Lab, Cambridge, Engl). *Macromolecules* v 21 n 4 Apr 1988 p 1062-1070.

**082724 RHEOLOGICAL PROPERTIES OF POLY(1,3-DIMETHYL-1-BUTENYLENE) AND MODEL ATACTIC POLYPROPYLENE.** A series of atactic polypropylene polymers were prepared by anionic polymerization of 2-methyl-1,3-pentadiene followed by saturation with hydrogen. The polymers were nearly monodisperse in molecular weight distribution and covered a wide range of molecular weights. Measurements before and after hydrogenation were used to establish the molecular weight and temperature dependence of rheological properties. When the results were compared with data on commercial isotactic polypropylene it was found that the viscosities of the two types of polymers are essentially the same. (Edited author abstract) 37 refs.

Pearson, Dale S. (Exxon Research & Engineering Co, Annandale, NJ, USA); Fetters, Lewis J.; Younghouse, Lawrence B.; Mays, Jimmy W. *Macromolecules* v 21 n 2 Feb 1988 p 478-484.

**082725 TORSION IMPREGNATED CLOTH ANALYSIS FOR RESIN RHEOLOGICAL STUDIES.** This paper describes the utility of Torsion Impregnated Cloth Analysis, a very versatile technique to characterize resin behavior during cure or after repeated thermal and environmental treatment. Multi-frequency scan data have been shown to help tremendously in interpreting the behavior during experimentation. The technique is also very useful in defining the cure conditions for new resin chemistry/systems. (Author abstract) 13 refs.

Lee, Charles Y.-C. (US Air Force, Wright Aeronautical Lab, Wright-Patterson AFB, OH, USA). *Polym Eng Sci* v 28 n 9 Mid-May 1988 p 578-582.

**082726 REOLOGICZNY MODEL MIKROSTRUKTURALNY DEGRADACJI POLIMERU W STANIE STOPIONYM.** [Rheological Microstructural Model of the Mechanical Degradation of Polymer Melts]. The rheological constitutive equation was derived for polymer melt undergoing the mechanical degradation. For the calculation of polymer molecules motion and its contribution to the stress tensor, the statistical methods were applied using probability distribution function of the polymer chains. The continuity equation and the equation of balance of forces influencing the motion of the statistical molecule were formulated taking into account the assumptions concerning mechanism of the chain shortening. A definition of structural parameter was stated as a measure of the degradation degree and the relationship between it and the number-average molecular weight was determined. The rheological constitutive equation derived in this way was verified in the simple shearing experiment. (Author abstract) 16 refs. In Polish.

Petera, Jerzy (Inst Inżynierii Chemicznej Politechniki Łódzkiej, Łódź, Pol). *Inż Chem Procesowa* v 9 n 1 1988 p 111-126.

**082727 THEORETICAL STUDY OF NON-ISOTHERMAL MULTI-LAYER STRATIFIED FLOWS BETWEEN PARALLEL PLATES.** An implicit finite difference method with the stream function as the cross-stream coordinate has been employed to study non-isothermal multi-layer stratified flows. The stream function is used to locate the interface positions so that the numerical computation for multi-layer stratified flows can be performed more efficiently. Numerical computations are made in the range,  $10^2 \leq Pe \leq 10^4$  and  $0.1 \leq Na \leq 10$ .

Several cases with various flow rate ratios and non-uniform entrance temperatures have been investigated as well. The fluid viscosity is described by the power law for the shear rate dependence and by the Arrhenius relationship for the temperature dependence. For the Nusselt number greater than or equal to unity, viscous dissipation leads to significant temperature rise adjacent to the wall. The pressure gradient along the die axis may thus be affected. (Author abstract) 20 refs.

Shu, Y.H. (Univ of Lowell, Lowell, MA, USA); Charnchi, M.; Chen, S.J. *J Polym Eng* v 7 n 4 Oct 1987 p 255-274.

**082728 OF SPIDERS AND SPINNING.** Many fluids used in the chemical industry have peculiar flow properties, especially polymer melts and solutions. The processes of blow molding films, spinning fibers, vacuum forming sheets and flow through porous media are all controlled mainly by elongational flow (stretching). Even spiders depend upon this phenomenon to make their webs. Elongational measurements are, however, tricky to make and special techniques are needed to help chemists to understand these flow properties. (Author abstract) 3 refs.

Ferguson, J. (Univ of Strathclyde, Glasgow, Scotl); Walters, K. *Chem Br* v 24 n 1 Jan 1988 p 39, 41-42.

**082729 RHEOLOGY OF A TWIN LIQUID CRYSTALLINE POLYMER.** Phase transitions of a twin liquid crystalline polymer (TLCP), which was synthesized from 4-[(4'-alkoxybenzoyloxy)benzoyl chloride and  $\alpha,\omega$ -dihydroxy-telechelic polytetrahydrofuran, have been determined by measurements of linear viscoelastic properties. In the phase-separated mesophase state, the TLCP displayed high elasticity to small-amplitude deformation, due to mesogen-induced physical cross-linking. As the strain amplitude increased, shear thinning affected both dynamic and steady flow properties. This effect is assumed to be due to a reduction of tie molecules and an increase of loops in the physical network. (Edited author abstract). 18 refs.

Lin, Y.G. (Univ of Massachusetts, Amherst, MA, USA); Zhou, R.; Chain, J.C.W.; Winter, H.H. *Macromolecules* v 21 n 7 Jul 1988 p 2014-2018.

**082730 RHEOLOGICAL PROPERTIES OF LINEAR LOW DENSITY POLYETHYLENE/POLYPROPYLENE BLENDS. PART 2: SOLID STATE BEHAVIOR.** This second paper of a series continues the examination of the tensile properties of two series of linear low density polyethylene/polypropylene (LLDPE/PP) blends. The blends were prepared using a twin-screw extruder and cover the whole concentration range. An Instron Universal Tensile Tester was used to measure the tensile properties of the blends between 10 and 70°C, and the temperature and composition dependences of the modulus were examined. A comparison is established between the solid state and melt properties to underline the behavior in the PP rich region. Results of dynamic mechanical experiments and differential scanning calorimetry on the same materials are also given, and the mechanical behavior is discussed in terms of the variation of the system's crystallinity. (Author abstract) 20 refs.

Dumoulin, M.M. (Ecole Polytechnique, Montreal, Que, Can); Carreau, P.J.; Utracki, L.A. *Polym Eng Sci* v 27 n 21 Nov 1987 p 1627-1633.

**Selection See CONCRETE MIXERS AND MIXING—Plastics Applications; MEMBRANES—Materials.**

## Separation

**082731 PHASE SEPARATION OF POLYMER MIXTURES IN THE PRESENCE OF SOLVENT.** A model of a symmetrical polymer mixture, where both polymers A and B are modeled by self-avoiding walks of  $N_A = N_B = N$  steps on the simple cubic lattice and a lattice site is taken by either an A monomer, a B monomer, or a solvent molecule (or a vacancy V, respectively), is analyzed by Monte Carlo simulations, in order to analyze the validity of the predictions of the Flory-Huggins theory. We attribute huge discrepancies found between the

'exact' critical temperature of phase separation for this model and those predicted by the Flory-Huggins approximation to the crude treatment of chain configurational statistics in this approximation. We also obtain binodal curves and a scattering function and discuss the crossover from Ising-like critical behavior to mean-field critical behavior as  $N$  approaches  $\infty$ . Consequences for experimental work are briefly discussed. (Edited author abstract) 71 refs.

Sariban, A. (Johannes-Gutenberg-Univ Mainz, Mainz, West Ger); Binder, K. *Macromolecules* v 21 n 3 Mar 1988 p 711-726.

**082732 PRESSURE-PULSE-INDUCED CRITICAL SCATTERING OF OLIGOSTYRENE IN N-PENTANE.** An experimental method has been developed for the determination of binodal and spinodal points in the temperature-pressure-concentration phase diagram of demixing systems. Intensities of scattered and transmitted light are measured as a function of pressure. It is shown that the intensity of the experimentally determined scattered light is completely different from the corrected light scattering intensity, which is calculated by turbidity corrections. Slow changes of the pressure can be used for isothermal experiments and fast pressure pulses for adiabatic procedures. These methods based on the theory of Debye are explained for two concentrations of the system oligostyrene/n-pentane. (Author abstract) 75 refs.

Kiepen, F. (Univ Duisburg, Duisburg, West Ger); Borchard, W. *Macromolecules* v 21 n 6 Jun 1988 p 1784-1790.

**082733 GASCHROMATOGRAPHISCHE TRENNUNG VON ETHOXYLIERTEN ALKOHOLEN.** [Separation of Polymer Homologues of Low Ethoxylated Alcohols by GLC]. GLC analysis of non-derivatized ethoxylated fatty alcohols (alkyl =  $C_8, C_{12}, C_{16}$ ) on short, packed columns was investigated. Retention times of the polymer homologues with identical alkyl chain up to MW 500 depend linearly on ethoxylation degree. Because peak areas, corrected by FID factors, correspond to the mol ratios a quantitative evaluation is possible. The reliability of the obtained results was examined by defined test compounds. (Author abstract). 11 refs. In German.

Czichocki, G.; Gerhardt, W.; Blumberg, D. *Tenside Surfactants Deterg* v 25 n 3 May-Jun 1988 p 169-173.

**Shrinkage See COPOLYMERS—Curing.**

**Solubility See Also FLUORINE CONTAINING POLYMERS—Swelling.**

**082734 SOLUBLE POLYMERS IN ORGANIC CHEMISTRY: 5. PREPARATION OF CARBOXYL- AND AMINO-TERMINAL POLYETHYLENE GLYCOL OF LOW MOLECULAR WEIGHT.** The transformation of polyethylene glycol monomethyl ether (MPEG-OH), of molecular weight 550 to carboxyl- and amino-terminal derivatives is described. Applying polymer-analogous reactions for the functionalization, the final products are isolated by pH-controlled extraction procedures. The surprisingly high solubilizing power in water together with their convenient handling demonstrates, that reactive polyethylene glycols of low molecular weight have considerable potential for applications in organic and biorganic chemistry. (Author abstract) 14 refs.

Gehrhardt, H. (Univ Basel, Basel, Switz); Mutter, M. *Polym Bull (Berlin)* v 18 n 6 Dec 1987 p 487-493.

**082735 DETERMINATION OF SOLUBILITY PARAMETER OF POLYMER BY MICROWAVE ABSORPTION IN WAVEGUIDE.** Microwave absorption of mixed solutions of: 1) the hydrogen bonding solvents (methanol, ethanol, propanol, butanol, amyl alcohol, and octyl alcohol) and each of a number of hexane, carbon tetrachloride, benzene, and methanol; and 2) aprotic polar solvents (nitromethane, acetonitrile, nitrobenzene, and



dimethyl sulfoxide) and polar or nonpolar solvents was measured at 9.3 GHz in a waveguide. At the same time, the magnitude of microwave decayed energy by various solvents in polymer films at 9.3 GHz was estimated. We estimated the solubility parameter of various polymers: polystyrene, poly(butadiene), poly(vinyl alcohol), and nylon-6,6. The results suggest that the microwave absorption is dependent on a hydrogen bonding or a dipole-dipole interaction between the polymer and solvent. (Edited author abstract) 14 refs. In Japanese.

Tatsumi, Masakazu (Kansai Univ, Suita, Jpn); Yamaguti, Yoshiteru; Moriaki, Shiro; Usami, Shinichi; Yamamoto, Seika. *Kobunshi Ronbunshu* v 45 n 2 1988 p 161-168.

**Solutions** See Also CELLULOSE DERIVATIVES—Molecular Weight; COPOLYMERS—Synthesis; FLOW OF FLUIDS—Channel Flow; FLOW OF FLUIDS—Non Newtonian; GELS; LIQUIDS—Phase Equilibria; MEMBRANES; MEMBRANES—Forming; MOLECULES—Solutions; MONOMERS—Synthesis; OIL WELL PRODUCTION—Enhanced Recovery; POLYAMIDES—Synthesis; POLYCARBONATES—Adsorption; POLYELECTROLYTES—Diffusion; POLYESTERS—Optical Properties; POLYETHYLENES—Solutions; POLYPEPTIDES—Molecular Structure; POLYSACCHARIDES—Viscosity; POLYSTYRENES—Crosslinking; POLYSTYRENES—Solutions; POLYVINYL ALCOHOL—Aging; SILANES—Physical Properties; SOLUTIONS—Structure; WATER—Structure.

**082736 DIFFUSION IN CONCENTRATED POLYMER SOLUTIONS: ENCAPSULATED FENE DUMBBELL MODEL RESULTS.** Structure-property relations for the encapsulated FENE dumbbell correlate well with experimental observations for concentrated polymer solutions. Relying on rigorous kinetic theory results, we derive an expression for the polymeric mass flux relative to the mass-average velocity (diffusive flux). The form of this flux implies non-Fickian diffusion with its own intrinsic time scale. For steady flow in an infinitely long tube nonuniform concentration profiles are predicted. (Author abstract) 14 refs.

Brunn, P.O. (Univ Erlangen-Nuernberg, Erlangen, West Ger). *J Polym Sci Part B* v 25 n 10 Oct 1987 p 2085-2093.

**082737 OPTICAL PROPERTIES OF SOLUTION OF POLYTHIOPHENE DERIVATIVES AS FUNCTIONS OF ALKYL CHAIN LENGTH, CONCENTRATION AND TEMPERATURE.** Optical transmission through the cell of solutions of polythiophene derivatives such as poly(3-octylthiophene), poly(3-dodecylthiophene) and poly(3-dodecylthiophene) has been found to change drastically with temperature and concentration. This transmission change is also dependent on the alkyl chain length. The critical temperature of  $T_c$  of the transition between two transmission states (opaque and transparent) increases with increase in both concentration and chain length. This phenomenon has been conjectured to originate in the change of light scattering due to some conformational transition of polymers in the solvent. An application of this phenomenon has also been proposed. (Author abstract) 10 refs.

Yoshino, Katsumi (Osaka Univ, Suita, Jpn); Nakajima, Shigeaki; Gu, Hal Bon; Sugimoto, Ryu-ichi. *Jpn J Appl Phys Part 2* v 26 n 8 Aug 1987 p 1371-1373.

**082738 MICROCELLULAR FOAMS: PHASE BEHAVIOR OF POLY(4-METHYL-1-PENTENE) IN DIISOPROPYLBENZENE.** Microcellular foams are an important component of Inertially Confined Fusion (ICF) targets. The spatial distribution of the material is critical as the target implodes. In an effort to improve the spatial uniformity, the authors have explored the phase separation behavior of poly(4-methyl-1-pentene) solutions with diisopropylbenzene solvent. The cloud-point phase-separation diagram from pure solvent to pure polymer is discussed. Microstructures of the various density foams and the need for a three-dimensional phase diagram are presented. (Edited author abstract) 19 refs.

Williams, Joel M. (Los Alamos Natl Lab, Los Alamos, NM, USA); Moore, Joyce E. *Polymer* v 28 n 11 Oct 1987 p 1950-1958.

**082739 CONCENTRATION, TEMPERATURE AND DEFORMATION EFFECTS IN CONCENTRATED POLYMER SOLUTIONS WITH VOLATILE SOLVENTS.** A novel high-pressure polymer solution viscometer has been experimentally evaluated using the polystyrene/ethylbenzene system. The polymer solutions range in concentration from 60 weight percent polystyrene to the pure melt. The overall temperature range is 132°C to 240°C. The shear rates range from roughly  $5 \text{ s}^{-1}$  to  $2000 \text{ s}^{-1}$ . It has been concluded that the present method is useful in determining the shear dependent behavior of these volatile solutions. The shear dependent nature of this system is consistent with accepted non-Newtonian viscosity theory. (Author abstract) 16 refs.

Foster, R.W. (Univ of Pittsburgh, Pittsburgh, PA, USA); Lindt, J.T. *Polym Eng Sci* v 27 n 17 Sep 1987 p 1292-1299.

**082740 USE OF QUASI-ELASTIC LIGHT SCATTER TO DETERMINE THE SIZE DISTRIBUTION FUNCTION IN SOLUTIONS OF POLYDISPERSE POLYMERS.** The authors consider the problems associated with the use of the method of quasi-elastic light scatter to determine the size of polymers in solution. A way of passing from the experimentally measured spectra of optical mixing to the size distribution function of the coils of macromolecules is described. An algorithm for solving the task is proposed using the Tikhonov method of regularization and allowing for the positivity of the solution. Computer modelling gives distribution functions of different form. (Author abstract) 15 refs.

Braginskaya, T.G. (USSR Acad of Sciences, USSR); Klyubin, V.V. *Polym Sci USSR* v 28 n 6 1986 p 1361-1369.

**082741 PHASE EQUILIBRIUM IN POLYMER + POLYMER + SOLVENT TERNARY SYSTEMS III. POLYSTYRENE + POLYISOPRENE + CYCLOHEXANE SYSTEM REVISITED.** The polystyrene (PS) + polyisoprene (PIP) + cyclohexane ternary system was further studied by light scattering and phase separation experiments, using for the PS component a sample whose molecular weight was about ten times higher than that used before. Cloud point curves and binodals of the present system were appreciably displaced toward the solvent apex and highly distorted, compared with the previous ones. The light scattering data were analyzed using the authors' recent expression for the interaction function. (Edited author abstract) 17 refs.

Tong, Zhen (Osaka Univ, Toyonaka, Jpn); Einaga, Yoshiyuki; Fujita, Hiroshi. *Polym J* v 19 n 8 1987 p 965-971.

**082742 ON POLYMER SOLUTION THERMODYNAMICS.** Various solution properties have been selected for testing the usefulness of the classic lattice model. The analysis leads to the inclusion of improvements such as different contact numbers for molecules and repeat units, distinction between concentration regimes, dilute and concentrated in polymer. The extensions of the simple model supply an adequate description of the data provided the free enthalpy of mixing in the concentrated region is made temperature- and molar mass-dependent. Part of the latter contribution can be attributed to the chains bending back on themselves. The other part is not easily accommodated in the model and might be related to free volume effects that have been left out of the present consideration. (Edited author abstract) 65 refs.

Koningsveld, R. (Univ of Antwerp, Wilrijk, Belg); Kleintjens, L.A. *Prog Colloid Polym Sci* v 71 1985 p 2-14.

**082743 ADSORPTION-ENTANGLEMENT LAYERS IN FLOWING HIGH-MOLECULAR WEIGHT POLYMER SOLUTIONS.** This work is concerned with the formation and nature of thick multimolecular layers and with the effect they have on fluid transport in general and viscosity measurements in particular. In the present first part the existence of such layers is established through a flow visualization method and the layer formation diagnosed in situ is correlated with macroscopic flow

effects. Two flow geometries are used, Couette and channel flow. It is demonstrated that owing to the fact that adsorption entanglement layers alter the geometry of the flow channel the time dependence of flow effects, per se need not indicate shear thickening (or thinning), in fact that there is any departure from Newtonian flow behaviour. (Edited author abstract) 32 refs.

Hikmet, R.A.M. (Univ of Bristol, Bristol, Engl); Narh, K.A.; Barham, P.J.; Keller, A. *Prog Colloid Polym Sci* v 71 1985 p 32-43.

**082744 SOLUTION PROPERTIES OF WATER-SOLUBLE NONIONIC POLYMERS.** This review summarizes reported data on the properties of nonionic water-soluble polymers in solutions. Main attention is paid to thermodynamic and hydrodynamic properties as well as to the phenomenon of selective sorption observed in solutions of these polymers in binary solvents. The review also gives a brief description of the principal applications of the polymers under discussion. 267 refs.

Bekturov, Esen A. (Acad of Sciences of the Kazakh SSR, Alma-Ata, USSR); Khamzamalina, Rimma E. *J Macromol Sci Rev Macromol Chem Phys* v C27 n 2 May 1987 p 253-312.

**082745 PROPERTIES OF CELLULOSE ACETATE BUTYRATE FILM OBTAINED BY FORCED LEVELING OF A CONCENTRATED SOLUTION.** The purpose of this work was to examine the possibility of forming cellulose acetate butyrate films for optical purposes with the aid of the so-called 'leveling rule' and to study their properties. The optical, mechanical, and shrinkage properties of CAB films are given. Light transmission of all the films is high and in distinction from films described earlier, it is independent of the nature of the solvent medium. The probable explanation is that the procedure devised for film formation and removal of the liquid phase, and the smaller thickness of our films (70 as compared with  $150 \mu\text{m}$ ) level out the structural differences influencing the optical properties of the films. 10 refs.

Khar'kova, A.M.; Shul'gina, E.S.; Nikolaev, A.F. *J Appl Chem USSR* v 59 n 11 pt 2 Nov 1986 p 2393-2395.

**082746 MESURES DE LA CONDUCTIVITE THERMIQUE DE SOLUTIONS AQUEUSES DE POLYMERES HYDROSOLUBLES.** [Thermal Conductivity Measurements for Aqueous Solutions of Water-soluble Polymers]. Measurements of thermal conductivity of aqueous solutions of water soluble polymers have been conducted by utilizing a transient method based on a needle-type thermal probe. The thermal conductivity variations, at 20°C, versus concentration of the aqueous solution are, given for three commercially available carboxymethyl-celluloses of sodium carboxymethyl celluloses, which provide increased viscosity to the solution. Thermal conductivity variations versus temperature are also given. (Edited author abstract). In French. 4 refs.

Antonini, G. (Univ de Technologie de Compiègne, Compiègne, Fr); Napitupulu, F.; Pain, J.P. *Rev Gen Therm* v 26 n 308-309 Aug-Sep 1987 p 419-421.

**082747 PHOTON CORRELATION SPECTROSCOPY OF DILUTE POLYMER SOLUTIONS: INFLUENCE OF CROSSOVER BETWEEN THE FIRST AND HIGHER RELAXATION MODES ON DYNAMIC ZIMM PLOTS.** Dynamic Zimm plots of photon correlation spectra from dilute solutions of polystyrene (PS) in tetrahydrofuran were performed. The shape of the plots show a significant deviation from their theoretically predicted form. The observed distortion is interpreted by applying scaling considerations for the first cumulant of PC spectra with the scattering vector. (Author abstract) 15 refs.

Vancso, G. (ETH, Zurich, Switz). *Polym Commun (Guildford Engl)* v 28 n 11 Nov 1987 p 305-307.



**082748 ASSESSMENT OF ELONGATIONAL STRESSES OF DILUTE POLYMER SOLUTIONS AND A RELATED EXAMINATION OF SOME CONSTITUTIVE EQUATIONS.** Elongational stresses of dilute polymer solutions have been assessed by utilizing the flow through small orifices under the condition of no vortex upstream of the orifice plane. The flow was approximated with a linearly converging flow toward an apex of a cone, its propriety being confirmed by the measured velocities, and the elongational stresses were determined from the measured thrusts of dilute polymer solutions. On the other hand, elongational stresses were theoretically obtained with the modified Maxwell model and the second order fluid. A comparison was made between the experimental and the theoretical results and the following points were clarified; below the elongational rate  $2 \times 10^4 (\text{s}^{-1})$  the modified Maxwell model gives elongational stresses close to the experimentally determined ones, but above the elongational rate it deviates from the experimental results. (Edited author abstract) In Japanese. 10 refs.

Hasegawa, Tomiichi; Fukutomi, Kiyoshi; Narumi, Takatsune. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 492 Aug 1987 p 2295-2302.

**082749 EXPERIMENTAL INVESTIGATION OF TRANSITION IN PLANE POISEUILLE FLOW (2ND REPORT, DILUTE POLYMER SOLUTIONS).** Transition in dilute polymer solutions was investigated in the same manner as in the first report. At first we investigated natural transition at a minimum critical Reynolds number. The result suggested that the structural change of a turbulent spot resulted in polymer drag reduction. Subsequently, we maintained the flow laminar above the minimum critical Reynolds number and visualized the evolving process of spots artificially created in the laminar flow. The result showed that polymer additives reduced the spreading half angle. The striped streak lines of ink were observed around the spots. This phenomenon is supposedly caused by the instability of polymer solutions. (Author abstract) In Japanese. 9 refs.

Mizunuma, Hiroshi; Kato, Hiroshi. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 492 Aug 1987 p 2303-2312.

**082750 PRESHEARED EXTENSIONAL FLOW OF DILUTE POLYMER SOLUTIONS.** Dilute solutions of polyethylene oxide (PEO) and polyacrylamide (PAM) were subjected to shearing and then extensional motion in order to determine the influence of prior shear on the extensional resistance of these fluids. The work was originally motivated by the explanation of drag reduction by polymer additives and so the tests were conducted in a flow cell designed to simulate the ejection event (burst) in a turbulent boundary layer flow. The results show that prior shear had a considerable effect on the PEO solutions, causing significant extensional resistance at strain rates of order  $10^2 \text{ s}^{-1}$ , while rates one order higher were necessary to generate an extensional effect when there was no prior shear. For the PAM solutions, on the other hand, extensional resistance depended only weakly on prior shear, and onset strain rates and resistance magnitudes depended more markedly on the ionic strength of the solvent. A flow visualization study revealed that the flow patterns for water and PEO solutions were the same but those for PAM solutions were always unsteady. (Edited author abstract) 24 refs.

James, David F. (Univ of Toronto, Toronto, Can); McLean, Brian D.; Saringer, John H. *J Rheol* v 31 n 6 Aug 1987 p 453-481.

**082751 STRESS JUMP AT THE INCEPTION OF SHEAR AND ELONGATIONAL FLOWS OF DILUTE POLYMER SOLUTIONS DUE TO INTERNAL VISCOSITY.** All versions of the internal viscosity (IV) model for polymer chain dynamics lead to the prediction that the inception of flow from a rest state is accompanied by a stress jump at  $t=0$ . For the general case of long chains (large number of submolecules,  $N$ ), the jump is predicted here for the onsets of simple shear flow and elongational flow at constant deformational rate. The exact model formulation (i.e., following Boijj and van

Wiechen) is used, without the need to approximate deformational velocities in the Cerf/Peterlin sense, and rigorous closed-form solutions are presented. This is apparently the only rheological prediction now available for the large  $N$  IV model using the rigorous formulation. Intermediate steps in the analysis demonstrate the extent to which the motions of beads are correlated with those of neighbors at various distances in the linear sequence. 28 refs.

Manke, Charles W. (Univ of California at Berkeley, Berkeley, CA, USA); Williams, Michael C. *J Rheol* v 31 n 6 Aug 1987 p 495-510.

**082752 KINETICS OF SPINODAL SEPARATION IN POLYMER SOLUTIONS.** In this work an analytical solution is given for the general characteristic of spinodal separation: the Fourier component of the correlation fluctuation for both the random forces of thermal motion and for interactive fluctuation. The solution thus obtained has been analyzed in the homogeneous and heterogeneous composition regions, in the initial and final process stages. The limitations of the known solutions for this process have been demonstrated. A particular expression for the energy density of polymer solutions has been proposed. The influence of molecular characteristics on the parameters of the spinodal process is discussed. (Author abstract) 17 refs.

Budtov, V.P. ('Plastpolimer'). *Polym Sci USSR* v 28 n 7 Jul 1987 p 1592-1602.

**082753 GLASS TRANSITION, CRYSTALLIZATION AND THERMOREVERSIBLE GELATION IN TERNARY PPO SOLUTIONS: RELATIONSHIP TO ASYMMETRIC MEMBRANE FORMATION.** The phase equilibrium behaviour of PPO (poly 2,6-dimethyl-1,4-phenylene oxide) in mixtures of trichloroethylene with non-solvents ethanol, methanol or octanol has been studied. Attention has been given to the phenomena of glass transition, crystallization and thermoreversible gelation. The effect of solvent-non-solvent mixtures on the glass transition temperature depression was studied using differential scanning calorimetry (d.s.c.) and found to be well described by a ternary form of the Kelley-Bueche equation, using a modified best fit value of 3.67 for the solvent/polymer thermal expansivity ratio. Crystallization and gelation behaviour was studied using both d.s.c. and falling ball methods. (Edited author abstract) 39 refs.

Burghardt, W.R. (Univ of Illinois, Urbana, IL, USA); Yilmaz, L.; McHugh, A.J. *Polymer* v 28 n 12 Nov 1987 p 2085-2092.

**082754 PREDICTION OF THERMODYNAMIC PROPERTIES OF POLYMER SOLUTIONS USING THE UNIFAC GROUP-CONTRIBUTION METHOD.** The UNIFAC group-contribution method has been applied to solutions of polydimethylsiloxane in a number of solvents. In the region of high polymer concentration, the predicted Flory-Huggins interaction parameters are not in good agreement with experimental values and the predicted variation with molecular weight is the opposite to that measured. However, it has been shown that, if a single experimental result is available, the UNIFAC predictions can be improved to within a few per cent. (Author abstract) 26 refs.

Price, G.J. (City Univ, London, Engl); Ashworth, A.J. *Polymer* v 28 n 12 Nov 1987 p 2105-2109.

**082755 CRITICAL-POINT EQUATIONS FOR POLYDISPERSE POLYMER SOLUTIONS.** Based on the generalized Flory-Huggins concept replacing Huggins's  $X$ -term by a function depending on a finite number of moments of the molar mass distribution, a simple form of the necessary conditions for the critical state of a polydisperse polymer solution is established in the framework of classical Gibbs theory. The derived critical-point equations permit a substantial diminution of the order of the corresponding determinants. (Author abstract) 10 refs.

Beerbaum, S. (Wolfgang Ratke Pedagogical Univ, Koethen, East Ger); Bergmann, J.; Kehlen, H.; Ratzsch, M.T.

*Proc R Soc London Ser A* v 414 n 1846 Nov 9 1987 p 103-110.

**082756 ESTIMATION OF THE LIMITING VISCOSITY NUMBER AND HUGGINS CONSTANT OF POLYACRYLAMIDES IN WATER AND 1 M AQUEOUS SODIUM CHLORIDE.** Four procedures have been checked to estimate the limiting viscosity number (intrinsic viscosity)  $[\eta]$  and the Huggins constant  $k'$  accurately. The four equations involved are named after Huggins, after Nagy, Kelen and Tudos, and after Chee (two equations). Viscometric data for polyacrylamide samples, up to high conversion, in distilled water and 1 M NaCl solution, were analyzed by the above-mentioned methods, the accuracies of which are compared. The variation of Huggins constant  $k'$  with respect to percentage conversion and intrinsic viscosity  $[\eta]$  was also studied. (Author abstract) 7 refs.

Rafi'ee Fanood, M.H. (Imperial Coll of Science & Technology, London, Engl); George, Maurice H. *Polymer* v 28 n 13 Dec 1987 p 2241-2243.

**082757 SINGLE-POINT DETERMINATION OF LIMITING VISCOSITY NUMBERS OF POLYACRYLAMIDES IN WATER AND 1 M SODIUM CHLORIDE SOLUTION.** Several methods of calculation of the limiting viscosity number (intrinsic viscosity),  $[\eta]$ , from a single viscosity measurement for polymer solutions have been applied in this paper for polyacrylamide-water and polyacrylamide-1 M NaCl. It is shown that various forms of the Kraemer and Huggins equations, singly or combined, can be used successfully for single-point determinations of limiting viscosity numbers. (Author abstract) 11 refs.

Rafi'ee Fanood, M.H. (Imperial Coll of Science & Technology, London, Engl); George, Maurice H. *Polymer* v 28 n 13 Dec 1987 p 2244-2247.

**082758 STUDY OF INTERPENETRATION USING FLUORESCENCE QUENCHING OF CHROMOPHORE-LABELLED POLYMERS.** Fluorescence quenching was used to investigate the onset and extent of overlap and interpenetration in poly(vinyl methyl ether) (PVME) solutions using polystyrene with a dilute level of anthracene labeling (APS) as a probe. A low, constant concentration of APS was added to solutions varying in PVME concentration. The critical overlap concentration,  $c^*$ , was taken to be the PVME concentration at which quenching of the probe anthracene-labeled polymer molecules commenced. Variations in probe molecular weight and concentration produced no significant changes in  $c^*$  or in the rate of decrease in fluorescence intensity above  $c^*$ , lending credibility to the idea that the APS is simply probing the PVME system. The values of  $c^*[\eta]$  from these experiments were found to lie in the range of 0.87-1.7 which agrees with the results from previous studies. The sensitivity of this method to small differences in solvent quality for PVME was also investigated. (Author abstract) 32 refs.

Schwimmer, William H. (Northwestern Univ, Evanston, IL, USA); Torkelson, John M. *Polymer* v 28 n 13 Dec 1987 p 2257-2261.

**082759 DETERMINATION OF THERMODYNAMIC INTERACTION IN MIXED POLYMER SOLUTIONS BY A RAPID AND PRECISE OSMOTIC METHOD. THE SYSTEM DEXTRAN /POLYVINYLPYRROLIDONE/WATER.** An accurate and simple osmotic method for determination of thermodynamic interaction in ternary solutions (polymer A/polymer B/solvent) is described. The equipment consists of a membrane osmometer of a special design with small chambers and a pressure-sensing device to monitor the pressure difference across the membrane. A procedure has been developed to measure osmotic pressures up to rather high concentrations in both quasi-binary and quasi-ternary systems. The osmotic method is compared with results from light scattering. Different methods are utilized to extract ordinary virial coefficients as well as mixed



virial coefficients from the primary data. The system dextran/polyvinylpyrrolidone/water (two different molecular weights of dextran) was chosen as a model. (Author abstract) 15 refs.

Edsman, K. (Uppsala Univ, Uppsala, Swed); Sundelof, L.-O. *Polymer* v 28 n 13 Dec 1987 p 2267-2274.

**082760 POLY(SULPHOPROPYLBETAINES): 4. BINDING PROPERTIES TOWARDS REPORTER ANIONIC PROBES AND LOCAL POLARITY CLOSE TO THE ZWITTERIONIC CHAIN IN AQUEOUS SOLUTION.** The binding properties of a representative poly(sulphopropylbetaine) towards a series of optical (methyl orange (MO) and 2-(4-hydroxybenzenazo)benzoate (HABA)), fluorescent (8-anilino-naphthalene-1-sulfonate (ANS)) and chemically reactive (6-nitrobenzoxazole-3-carboxylate (S)) anionic probes have been studied in dilute aqueous solution. The slight ultra-violet spectra modification for MO and HABA, the enhanced fluorescence of ANS and the moderate increase of the decarboxylation rate of S induced by the poly(zwitterion) show that binding of the various anionic probes to the macromolecular chain actually occurs through specific ion-dipole interactions, but that the intrinsic properties of the bound species are only weakly modified with respect to those of the free ones. (Edited author abstract) 33 refs.

Zheng, Y.L. (CNRS, Strasbourg, Fr); Knoesel, R.; Galin, J.C. *Polymer* v 28 n 13 Dec 1987 p 2297-2303.

**082761 OPTICAL AND HYDRODYNAMIC STUDY OF POLY-P-DECYLSTYRENE SOLUTIONS.** The effect of the length of the aliphatic side chain of polycyclic styrenes on their interaction with solvents is considered. Because of bifilarity the rigidity of the main chain of polycyclohexylstyrene in a good solvent is higher by a factor of 1.3 than in a  $\theta$ -solvent. Evaluation of the transverse dimensions of macromolecules, their optical anisotropy, and also the splitting of the 820  $\text{cm}^{-1}$  band in the IR-spectra of poly-p-decylstyrene and its monomer indicate the low rigidity of the side chains. (Author abstract) 11 refs.

Magarik, S.Ya. (USSR Acad of Sciences, USSR); Baranovskaya, I.A.; Dyakonova, N.V.; Solovskaya, N.A.; Filipov, A.P.; Andreyev, D.N.; Eskin, V.Ye. *Polym Sci USSR* v 28 n 8 1986 p 1783-1789.

**082762 BEHAVIOUR OF A CHOLESTERIC SOLUTION OF POLY- $\gamma$ -BENZYL-L-GLUTAMATE IN AN ELECTRIC FIELD.** The electrooptic cholesteric-nematic phase transition and the appearance of electrodynamic instability in the form of domains is studied by optical polarization microscopy and small-angle polarized light scattering in a lyotropic cholesteric polymer. From the morphology point of view the stages of texture relaxation and subsequent untwisting of the cholesteric structure into the nematic structure, the process is a detailed analogue of the same magnetotropic transition. In fields close to the critical, during this transition there is a strong increase in the dispersion of the spacing of the cholesteric structure, which, it is suggested, should be taken into account in the model for the untwisting of this structure. (Edited author abstract) 7 refs.

Shepelevskii, A.A. (USSR Acad of Sciences, USSR); Aljmyan, Yu.A.; Ginzburg, B.M.; Ovsyannikova, L.A.; Vlasov, G.P.; Frenkel, S.Ya. *Polym Sci USSR* v 28 n 8 1986 p 1796-1802.

**082763 HYDRODYNAMIC PROPERTIES AND CONFORMATIONAL CHARACTERISTICS OF POLY-m-PHENYLENE ISOPHTHALAMIDE IN DIMETHYLACETAMIDE AND THE EFFECT ON THEM OF LITHIUM CHLORIDE.** The authors have investigated the fast sedimentation, translational diffusion and viscosity of solutions of poly-m-phenylene isophthalamide in DMAA in the range  $M = (4.2-230) \times 10^3$ . They obtained the equations  $[\eta] = 0.0956 M^{0.65}$ ,  $D = 1.13 \times 10^{-4} M^{-0.56}$  and  $S_0 = 1.72 \times 10^{-15} M^{0.44}$ . The hydrodynamic invariant is equal to  $A_0 = 3.4 \times 10^{-10} \text{ erg. degree}^{-1} \cdot \text{mole}^{-1/3}$ . Addition of 3% LiCl to DMAA led to rise in  $[\eta]$ , fall in the magnitude  $\eta_0 D$  and the partial

specific volume and increase by about one quarter in  $M$ . The latter tells in favour of the solvation of LiCl by the macromolecules and their swelling. However, the conformation of the macromolecule does not materially change. The length of the Kuhn segment is  $A = 40 \pm 8 \text{ Angstrom}$ . (Edited author abstract) 20 refs.

Lavrenko, P.N. (USSR Acad of Sciences, USSR); Ashtapenko, E.P.; Bushin, S.V.; Okatova, O.V. *Polym Sci USSR* v 28 n 8 1986 p 1858-1867.

**082764 INTERFACIAL TENSION OF DEMIXED POLYMER SOLUTIONS.** A model is described which permits the estimation of interfacial tensions of demixed polymer solutions from knowledge of the polymer coil size, the intrinsic viscosity and chemical potential data. The latter is most conveniently determined from equilibrium phase diagrams. The model is used for demixed polystyrene in methylcyclohexane solutions, and the results are compared to literature data on interfacial tension. Qualitative agreement is good over a large molecular weight and temperature range. (Author abstract) 12 refs.

Aubert, J.H. (Sandia Natl Lab, Albuquerque, NM, USA). *Polymer* v 29 n 1 Jan 1988 p 118-122.

**082765 DENSITY AND THERMAL EXPANSION OF A TRIFLUOROPROPYLSILOXANE POLYMER IN SOLUTION.** The partial specific volume of polymers in solution is a quantity required for many of the standard techniques of polymer characterization. Of the siloxane family of polymers, the one most widely studied is poly(dimethylsiloxane) (PDMS). The partial specific volume has also been reported for poly(methylphenylsiloxane) (PMPS). Here, the authors report the partial specific volume and its temperature variation for another unsymmetrical siloxane polymer: poly(methyltrifluoropropylsiloxane) (PMTFPS). 8 refs.

Anon. *J Appl Polym Sci* v 35 n 1 Jan 1988 p 273-275.

**082766 DETERMINATION OF UNPERTURBED DIMENSIONS OF POLYMERS IN BINARY SOLVENT MIXTURES FROM VISCOSITY MEASUREMENTS.** Intrinsic viscosity measurements were carried out on poly(vinyl pyrrolidone) and poly(vinyl alcohol) in various solvents and solvent mixtures. Intrinsic viscosities, and the Huggins constant ( $k$ ) for representative fractions at various temperature in various solvents are given. Perusal of the result indicates that the values of the unperturbed dimension are higher in pure solvents than in solvent mixtures, in both the polymers. The changes in 'apparent' unperturbed chain dimensions, under  $\theta$ -conditions in binary solvent mixtures, are due solely to the interactions between unlike solvent molecules surrounding the chain. 11 refs.

Mohanty, J.N. (Ravenshaw Coll, Cuttack, India); Nayak, P.L.; Lenka, S. *Colloid Polym Sci* v 265 n 11 Nov 1987 p 982-985.

**082767 OSMOTIC PRESSURE OF DEXTRAN T10 SOLUTIONS.** Using asymmetric cellulose acetate membranes, annealed at 75 and 85°C, the osmotic pressure of a dextran T10 solution (20 wt% dextran T10) is measured as a function of time. It is shown that the comparatively high osmotic pressure, obtained with the dextran T10 solution, is caused by the low molecular weight components of dextran T10 and not by the high molecular weight components. (Author abstract) 4 refs.

Pusch, Wolfgang (Max-Planck-Inst fuer Biophysik, Frankfurt am Main, West Ger). *Desalination* v 68 n 1 Jan 1988 p 69-73.

**082768 RELATIONSHIP BETWEEN DYNAMIC MECHANICAL PROPERTY AND THERMODYNAMIC INTERACTION PARAMETER OF CONCENTRATED POLYMER SOLUTIONS.** The use of concentrated polymer solutions is one of the basic techniques in the application of polymers. They may be coating materials, plasticized polymers, and oil-extended rubber. In these applications the solubility relation is one of the key requirements. The polymer-solvent interaction

is expected to influence the mechanical property of the mixture. It is the intent of this study to explore how the dynamic mechanical property is affected by the change of thermodynamic interaction parameter in concentrated polymer solutions. (Edited author abstract) 10 refs.

Nakajima, N. (Univ of Akron, Akron, OH, USA); Huang, C.D. *J Macromol Sci Phys* v B26 n 4 Dec 1987 p 411-425.

**082769 FLUCTUATION EFFECTS ON THE COEXISTENCE CURVE FOR BINARY POLYMER-SOLVENT SYSTEMS.** The phase equilibrium in polymer-solvent systems has been described in terms of the Landau-Ginzburg-Wilson model. The scaling law for the coexistence curve which has been derived in the present article is in good agreement with the experimental data. The prediction of the present theory that the scaling region narrows with increasing degree of polymerization, is consistent with the experimental data. (Author abstract) 11 refs.

Stepanow, S. (Technische Hochschule 'Carl Schorlemmer' Leuna-Merseburg, Merseburg, East Ger). *J Phys (Paris)* v 48 n 12 Dec 1987 p 2037-2039.

**082770 CLOSE ANALOGY BETWEEN THE PREFERENTIAL SOLVATION OF POLYMERS IN MIXED SOLVENTS AND ADSORPTION FROM LIQUID MIXTURES AT SOLID/LIQUID INTERFACES.** In this work a comparison of some phenomenological aspects of sorption and solvation, the role of the sorbent as a component, and a critique of the traditional plot of isotherms are discussed. It was pointed out that a sorbent-sorbate system can be characterized in a correct way only by a set of isotherms involving a limiting case when the mass of sorbent tends to zero. The treatment was extended to cases when more than one sorbent or more than two mixture components are present in the system. (Author abstract) 21 refs.

Nagy, M. (Lorand Eotvos Univ, Budapest, Hung). *Langmuir* v 4 n 1 Jan-Feb 1988 p 93-96.

**082771 INTERACTION BETWEEN POLYVINYL-PYRROLIDONE AND SURFACTANT FROM VISCOMETRIC DATA.** The intrinsic viscosities of solutions of polyvinylpyrrolidone (PVP) in water-sodium dodecyl sulfate have been measured, for four different molecular weights of PVP, and different concentrations of sodium dodecyl sulfate at temperatures between 20 and 35°C. The exponent  $\alpha$  of the Mark-Houwink-Sakurada equation has been determined, and the values of the short range interaction parameter  $K_\theta$  and expansion factor  $\alpha_\eta$  derived. Above a certain concentration the sodium dodecyl sulfate is adsorbed on the polymer by means of hydrophobic attractions, and the consequent repulsion between anionic heads provokes expansion of the macromolecule. (Author abstract) 20 refs.

Lopez de Sa, Teresa Garcia (Univ Complutense de Madrid, Madrid, Spain); Garrido Fernandez, Luis M.; Allende Riano, Jose L. *Br Polym J* v 20 n 1 1988 p 39-42.

**082772 EFFECTS OF THERMODYNAMIC MODELS ON THE PREDICTIONS OF FREE VOLUME DIFFUSION THEORY FOR CONCENTRATED POLYMER SOLUTIONS.** Three thermodynamic models were used to demonstrate the effects of model choice on solvent-polymer binary diffusion coefficients predicted by free volume theory. Poly(vinyl acetate) and four solvents were used as typical solutions for these calculations. Thermodynamic models affect the predictions the most at high solvent weight fractions and for solutions which exhibit positive enthalpic interactions. For solutions dilute in solvent where Henry's law might describe phase equilibria, diffusion coefficients can be estimated without reference to thermodynamic data. (Author abstract) 35 refs.

Mossner, Linda S. (Michigan State Univ, East Lansing, MI, USA); Grulke, Eric A. *J Appl Polym Sci* v 35 n 4 Mar 1988 p 923-936.



**082773 ABSORPTION AND EMISSION SPECTRAL CHANGES IN A POLY(3-ALKYLTHIOPHENE) SOLUTION WITH SOLVENT AND TEMPERATURE.** A remarkable change of the absorption spectrum has been observed in poly(3-alkylthiophene) solutions with changing temperature, which is tentatively interpreted in terms of a conformation change of polymer chains such as a rod-coil transition due to the change of the entanglement of alkyl chains with temperature. The emission intensity has been found to decrease remarkably at low temperature due to this transition. (Author abstract) 11 refs.

Yoshino, Katsumi (Osaka Univ, Suita, Jpn); Nakajima, Shigeaki; Gu, Hal Bon; Sugimoto, Ryu-ichi. *Jpn J Appl Phys Part 2* v 26 n 12 Dec 1987 p 2046-2048.

**082774 EFFECT OF PHASE SEPARATION IN SOLUTIONS OF CELLULOSE ACETATE AND POLYARYLATE ON POROSITY AND STRENGTH OF THEIR CAST FILMS.** Phase diagrams of three-component solutions containing cellulose acetate or polyarylate F-2 have been investigated. The homogeneous region in ternary systems containing cellulose acetate gradually shrinks when acetic acid is replaced by dioxan and then by acetone. The dependences of porosity and strength of cast films on the content of water in the solution show minima and maxima: films prepared from solutions with composition lying on the binodal curve in the phase diagram have maximum porosity and minimum strength. (Author abstract) 20 refs.

Andreyeva, V.M. (A.M. Gor'kii Ural State Univ, USSR); Tsilipotkina, M.V.; Tager, A.A.; Safronova, V.A.; Shil'nikova, N.I. *Polym Sci USSR* v 28 n 10 1986 p 2387-2392.

**082775 SOLUBILITY AND MISCIBILITY OF POLY(ETHYL OXAZOLINE).** The solubility of poly(ethyl oxazoline) in aqueous solutions was studied. The cloud points decreased in the presence of sodium chloride but increased by the addition of tetrabutylammonium bromide or dioxane. Solution-cast films of blends of the polymer and poly(acrylic acid) were miscible, but mutual precipitation occurred in water, methanol, and dioxane. The compositions of the complexes correspond in most cases to simple molar ratios of the interacting groups. The glass transition temperatures of the complexes are higher than the values for blends of the same compositions, and the high values are attributed to hydrogen bonds acting as physical crosslinks. Complex formation also occurs when the polymer is mixed with a styrene-acrylic acid copolymer and with low weight polymers containing phenol groups. (Author abstract) 24 refs.

Lin, Pinyen (Polytechnic Univ, Brooklyn, NY, USA); Clash, C.; Pearce, Eli M.; Kwei, T.K.; Aponte, M.A. *J Polym Sci Part B* v 26 n 3 Mar 1988 p 603-619.

**082776 ON THE POSSIBILITY OF QUANTITATIVE EVALUATION OF THE POLYMER-SOLVENT INTERACTION FROM THE HUGGINS VISCOSITY CONSTANT.** The author discusses the possibility of evaluation of the 'goodness' of solvents for polymers and eventually of the extent of association in polymer-solvent systems from the Huggins constant, as a function of the viscosity expansion factor. However, this method does have some problems and therefore an analogous method has been suggested, i.e. the dependence of the Huggins constant on the slope of Heller's relationship. For non-associating systems, this dependence is defined by a generalized linear equation, which, unlike the dependence on expansion factor, is independent of both the polymer and its molecular weight. For associating systems, this dependence is described by a quadratic function. Its steepness is dependent on both the polymer and its molecular weight. (Edited author abstract) 54 refs.

Dort, Ivan (Rubber & Plastics Technology Research Inst, Gottwaldov, Czech). *Polymer* v 29 n 3 Mar 1988 p 490-499.

**082777 INTERACTION VIRIAL COEFFICIENTS IN SOME MIXED POLYMER SOLUTIONS.** The concentration dependence of the osmotic pressure for

some aqueous ternary systems (polymer 2/polymer 4/water) has been studied up to relatively high concentrations. The interaction in the ternary systems has been evaluated in terms of mixed virial coefficients up to the third order ( $A_{24}$ ,  $A_{224}$ ,  $A_{244}$ ). Data are also given for the corresponding binary systems. The polymers used were dextran, poly(N-vinyl-2-pyrrolidone), Ficoll, hydroxypropylcellulose and ethylhydroxyethylcellulose. An analysis of the relative contributions to the total osmotic pressure of various terms as a function of concentration is made. (Edited author abstract) 21 refs.

Edsman, K. (Uppsala Univ, Uppsala, Sweden); Sundeloef, L.-O. *Polymer* v 29 n 3 Mar 1988 p 535-540.

**082778 FLORY ENTHALPY PARAMETER AT INFINITE DILUTION OF POLYMER SOLUTIONS DETERMINED BY VARIOUS METHODS.** The Flory enthalpy parameter at infinite dilution  $K_0$  was evaluated for atactic polystyrene (PS)-cyclohexane (CH) and -trans-decalin (D) systems by applying the following four methods from literature data: (1) Temperature dependence of vapor pressure and membrane osmotic pressure, (2) critical solution temperature  $T_c$  and critical solution concentration  $v_{pc}$  for a series of solutions of polymers, (3) temperature dependence of the second virial coefficient in the vicinity of the Flory theta temperature  $\theta$ , and (4) calorimetry. Excellent agreement ( $\pm 0.02$ ) was confirmed between  $K_0$  values at  $\theta$  deduced by various methods when  $M_w$  (or  $M_n$ ) of the polymer was the same. This fact strongly supports the validity of the modified Flory-Huggins solution theory, in which the polymer-solvent interaction parameter  $\chi$  depends on the polymer concentration and its molecular weight. (Edited author abstract) 31 refs.

Kamide, Kenji (Asahi Chemical Industry Co, Takatsuki, Jpn); Matsuda, Shigenobu; Saito, Masatoshi. *Polym J* v 20 n 1 1988 p 31-43.

**082779 PARTICIPATION OF WATER IN CONFORMATIONAL CHANGE OF ISOTACTIC POLY(2-HYDROXYETHYL METHACRYLATE) AS STUDIED BY VISCOMETRY IN VARIOUS ELECTROLYTIC SOLUTIONS.** Conformational properties of isotactic poly(2-hydroxyethyl methacrylate) (PHEMA) have been studied by viscometry in various electrolytic solutions. The intrinsic viscosity of isotactic PHEMA at 0.01M salt solution increases with decreasing B coefficient in Jones-Dole's equation. To investigate the influences of denaturing agents on solvent structures, the authors also compared the guanidine hydrochloride effect with the tetrabutylammonium chloride effect in isotactic PHEMA solution. (Edited author abstract) 26 refs.

Kim, Whan Gun (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Jhon, Mu Shik. *J Polym Sci Part A* v 26 n 3 Mar 1988 p 859-864.

**082780 DISSOCIATION OF 2,2'-SUBSTITUTED THIOINDIGO WHITES, AND RECOMBINATION OF THEIR RADICALS IN SOLUTION AND IN POLYMER MATRIX.** The dissociation of 2,2'-substituted thioindigo whites into captodative radicals and the recombination of these radicals have been examined in solution and in polymeric matrix. For the methyl- and ethyl-substituted TIW the quantum yield of dissociation in solution is equal to  $4 \times 10^{-4}$  and  $5 \times 10^{-4}$ , respectively. The behavior of these compounds was studied in three different matrices: polymethyl methacrylate (PMMA), polypropyl methacrylate (PPMA), and polystyrene (PST). The decay kinetics of the radicals after photolysis of the TIWs below  $T_g$  were interpreted on the basis of Waite's equations for diffused controlled reactions. (Edited author abstract) 32 refs.

Leest, Yvo (Katholieke Univ Leuven, Louvain, Belgium); Smets, Georges. *J Polym Sci Part A* v 26 n 3 Mar 1988 p 913-933.

**082781 VORTEX MOTION IN DILUTE POLYMER SOLUTIONS.** Vortex-dynamic equations have been derived and applied to two problems concerning annular vortices. It has been found that an important part is played by the behavior of individual vortex structures

in turbulent transport from measurements on turbulent boundary layers and friction reduction by polymers. The author presents a quasi-one-dimensional approach to vortex dynamics (vortex filaments of finite thickness) in dilute polymer solutions. This paper considers a vortex whose core is subject to a longitudinal elastic stress (the liquid is considered as incompressible). We assume as a first approximation that this stress is constant over the cross section of the core. (Edited author abstract) 15 refs.

Yarin, A.L. (Acad of Sciences of the USSR, Moscow, USSR). *J Eng Phys* v 53 n 2 Aug 1987 p 897-902.

**082782 PHASE EQUILIBRIUM OF POLYMER SOLUTIONS IN STATIC CONDITIONS AND IN A FLOW REGIME.** The aim of this work is to study the phase equilibrium in the shear field of systems with amorphous (PS-di-(2-ethylhexyl)phthalate (DEHP), cellulose diacetate (CDA)-acetone-water) and crystalline (PE-p-xylene) phase separation which allowed us to identify, having regard to the already known experimental data, some general patterns of the influence of the mechanical field on the phase equilibrium of polymer solutions. The role of the hydrodynamic field is considered in relation to the rate of shear, concentration and surface energy of the components. (Edited author abstract) 21 refs.

Vshivkov, S.A. (Urals Gorkii State Univ, USSR); Safronov, A.P. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2794-2799.

**082783 COMPLEX FORMATION IN 2-POLYVINYLPIRIDINE-IODINE SOLUTIONS.** The purpose of this investigation was to compare the PVP-I<sub>2</sub> system with the Py-I<sub>2</sub> system in a quantitative manner. In the PVP-I<sub>2</sub> system, a polymer backbone is present and the pyridine groups are clustered. The  $((PVP)_2I^+)_n$  ions are very large. In the formula for the complex ion,  $((PVP)_2I^+)_n$ , the letters, PVP, refer to the repeat unit in the polyvinylpyridine macromolecule. It is likely that the complex ion is primarily intramolecular considering the relatively low concentration of polymer and the low mole ratio of iodine to PVP repeat units. The authors conclude from the three sets of data presented above that pyridine and 2-polyvinyl-pyridine interact with iodine in an almost identical manner. This statement applies to complex formation in nonpolar and polar solvents and to ionic dissociation in polar solvents. 10 refs.

Aronson, S. (Brooklyn Coll, Brooklyn, NY, USA); Wilensky, S.B. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 1259-1262.

**082784 WORMLIKE CHAIN PARAMETERS OF POLY(HEXYL ISOCYANATE) IN DILUTE SOLUTION.** Intrinsic viscosity-molecular weight relationships were determined for poly(hexyl isocyanate) in toluene and dichloromethane using a number of narrow-distribution samples covering a wide molecular weight range. The data were analyzed according to the Yamakawa-Fujii-Yoshizaki theory of viscosity of wormlike cylinders, yielding the following values for the persistence length  $q$  and molar mass  $M_L$  per unit contour length:  $q=41-34$  nm and  $M_L=730-760$  nm<sup>-1</sup> in toluene between 10 and 40°C and  $q=21$  nm and  $M_L=750$  nm<sup>-1</sup> in dichloromethane at 20°C. These parameter values are favorably compared with those reported for other solvent conditions for the same polymer. (Author abstract) 16 refs.

Itou, Takashi (Osaka Univ, Osaka, Jpn); Chikiri, Hideaki; Teramoto, Akio; Aharoni, S.M. *Polym J* v 20 n 2 1988 p 143-151.

**082785 DOPING EFFECT IN SOLUTION OF POLY(3-ALKYLTHIOPHENE).** Poly(3-alkylthiophene) in solution can be doped just as in the case of polythiophene films, resulting in the suppression of the interband absorption and the appearance of absorption peaks in the infrared region originating in the transitions between polaron states and from the valence band to the low-lying polaron state. Enhancement of the spin density by doping



in an ESR measurement was also observed, which supports the polaron formation but not bipolaron formation. From these results, it has been clearly demonstrated that even a single polymer chain has the characteristics of conducting polymers. (Author abstract) 10 refs.

Gu, Hal Bon (Osaka Univ, Suita, Jpn); Nakajima, Shigeaki; Sugimoto, Ryu-ichi; Yoshino, Katsumi. *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 311-313.

**082786 EXPERIMENTAL ESTIMATION OF ELONGATIONAL STRESSES OF DILUTE POLYMER SOLUTIONS AND RELATED EXAMINATION OF SOME CONSTITUTIVE EQUATIONS.** Elongational stresses of dilute polymer solutions have been estimated by utilizing the flow through small orifices under the condition of no vortex upstream of the orifice plane. The flow was approximated with a linearly converging flow toward an apex of a cone, its validity being partially confirmed by the measured center velocities, and the elongation stresses are determined from the measured thrusts of dilute polymer solutions. On the other hand, elongational stresses were theoretically obtained with the modified Maxwell model and the second order fluid. A comparison was made between the experimental and the theoretical results and the following points were clarified; below an elongational rate of  $2 \times 10^4 \text{ s}^{-1}$  the modified Maxwell model gives elongational stresses close to the experimentally determined ones, but above that elongational rate it deviates from the experimental results. (Edited author abstract) 16 refs.

Hasegawa, T. (Niigata Univ, Niigata, Jpn); Fukutomi, K.; Narumi, T. *J Non Newtonian Fluid Mech* v 27 n 2 Mar 1988 p 133-151.

**082787 ROLE OF SOLUTION STRUCTURE IN APPARENT THICKENING BEHAVIOR OF DILUTE PEO/WATER SYSTEMS.** An experimental investigation was undertaken to determine the role of solution structure on the apparent thickening behavior exhibited by 'dilute' polyethylene oxide/water solutions in extensional flow. As the wall shear rate was increased, slightly shear thinning behavior was observed up until a critical wall shear rate was exceeded at which point a large increase in relative viscosity was seen. Other researchers have observed these apparent thickening effects and have interpreted them in terms of individual polymer molecules undergoing coil-stretch transitions. However, in the systems used in this study, the critical wall shear rate and the degree to which relative viscosity increased were both seen to be strong functions of solution aging time and concentration. These results are inconsistent with the simple picture of individual polymer coils undergoing a coil-stretch transition and instead are consistent with the picture of aggregated systems or microneetworks being stretched from their equilibrium configurations. (Edited author abstract) 28 refs.

Georgelos, Paul N. (Northwestern Univ, Evanston, IL, USA); Torkelson, John M. *J Non Newtonian Fluid Mech* v 27 n 2 Mar 1988 p 191-204.

**082788 MODEL OF DILUTE POLYMER SOLUTIONS WITH HYDRODYNAMIC INTERACTION AND FINITE EXTENSIBILITY. II. SHEAR FLOWS.** The results from numerical calculations for steady shear, the start-up and cessation of steady shear, and the stress relaxation after a step shear strain are discussed in detail for a bead-spring chain model with consistently averaged hydrodynamic interaction between the beads and consistently averaged finitely extensible springs. Calculations are made for a large range of spring stiffness  $10 \leq b \leq \infty$  and a hydrodynamic interaction strength  $h^* = 0.15$ , a value which has been estimated from experimental results. This model is found to satisfy the O. Hassager-R.B. Bird and A.S. Lodge-J. Meissner relations. (Author abstract) 20 refs.

Wedgewood, L.E. (Univ of Wisconsin-Madison, Madison, WI, USA); Ottinger, H.C. *J Non Newtonian Fluid Mech* v 27 n 2 Mar 1988 p 245-264.

**082789 DIELECTRIC RELAXATION IN DILUTE**

**SOLUTIONS OF POLY(ORGANOPHOSPHAZENES): EVIDENCE OF THE LOCALIZED ELECTRONIC STRUCTURE OF THE P=N DOUBLE BONDS.** Dielectric measurements were carried out on dilute benzene solutions of fractionated poly(diphenoxyphosphazene) at a concentration of ca. 0.1%. Loss maxima were observed in the audiofrequency range at 303 K. The relaxation times  $\tau$  determined from the frequencies of these loss maxima increased with increasing (weight-average) molecular weight  $M_w$  of the fractions in proportion to  $M_w^{1.7}$ . This molecular weight dependence and the absolute values of  $\tau$  were in agreement with the prediction of the Zimm theory evaluated by using the experimental intrinsic viscosity values. Thus, poly(phosphazene) can be classified as a type A polymer which has components of the moment aligned in the same direction parallel to the chain contour. (Edited author abstract) 18 refs.

Uzaki, Shunsuke (Osaka Univ, Toyonaka, Jpn); Adachi, Keiichi; Kotaka, Tadao. *Macromolecules* v 21 n 1 Jan 1988 p 153-156.

**082790 SOME UNSOLVED PROBLEMS ON DILUTE POLYMER SOLUTIONS.** In contrast to the prevailing notion, our understanding of polymer behavior in dilute solutions still leaves much to be desired. This fact is illustrated by discussing some typical unsolved problems regarding the following subjects: intrinsic viscosity, hydrodynamic factors, second virial coefficient, and the onset of the excluded-volume effect on the statistical radius. (Edited author abstract) 46 refs.

Fujita, Hiroshi. *Macromolecules* v 21 n 1 Jan 1988 p 179-185.

**082791 DYNAMICS OF SEMIDILUTE POLYMER SOLUTIONS: HYDRODYNAMIC SCREENING.** A study is made of the hydrodynamic screening effect on polymer solution dynamics in the semidilute regime. Starting from the time-dependent Ginzburg-Landau equations, the explicit crossover behavior of transport properties is calculated. Difficulties of existing theories are critically reviewed. (Edited author abstract) 27 refs.

Shiwa, Y. (Univ of Illinois, Urbana, IL, USA); Oono, Y.; Baldwin, P.R. *Macromolecules* v 21 n 1 Jan 1988 p 208-214.

**082792 UBIQUITY OF STRETCHED-EXPONENTIAL FORMS IN POLYMER DYNAMICS.** Literature results on the zero-shear viscosity  $\eta$ , rotational diffusion coefficient  $D_R$ , and sedimentation coefficient  $s$  of polymers in good,  $\Theta$ , and marginal solvents are reanalyzed in terms of the universal scaling equation  $A = A_0 \exp(-ac^v)$ , where  $A$  is a transport coefficient,  $c$  is the polymer concentration, and  $a$  and  $v$  are scaling constants. This equation gives reasonably good descriptions of almost all results on  $\eta$ ,  $D_R$ , and  $s$ , a single pair of parameters ( $a, v$ ) sufficing for results from all concentrations. There is apparently no qualitative change in transport behavior between the dilute and semidilute regimes. (Author abstract) 37 refs.

Phillips, George D.J. (Worcester Polytechnic Inst, Worcester, MA, USA); Peczak, Pavel. *Macromolecules* v 21 n 1 Jan 1988 p 214-220.

**082793 ENTANGLEMENTS IN POLYMER SOLUTIONS UNDER ELONGATIONAL FLOW: A COMBINED STUDY OF CHAIN STRETCHING, FLOW VELOCIMETRY, AND ELONGATIONAL VISCOSITY.** The progressive development of entanglements can be detected by observing strain patterns during increasing elongational strain rate where each stage is attributable to a transient network with a lifetime appropriate to the corresponding strain rate. The flow velocities are affected locally by transient network stretching, and this has pronounced influence on the macroscopic flow resistance (elongational viscosity). The latter should be highly relevant to the interpretation of continuum hydrodynamics of polymer solutions within elongational flow fields in terms of molecular behavior. This work shows that this will only be possible by taking account of the 'microstructure' in molecular strain and in the correspondingly

modified flow velocities, arising as a consequence of the long relaxation times associated with the stretching of transient networks. (Edited author abstract) 17 refs.

Chow, A. (Univ of Bristol, Bristol, Engl); Keller, A.; Mueller, A.J.; Odell, J.A. *Macromolecules* v 21 n 1 Jan 1988 p 250-256.

**082794 VISCOSITY OF POLY(HEXAZOCYCLANE) SOLUTIONS.** Viscosity of poly(hexazocyclanes) was measured in a non-protonic (N-methylpyrrolidone) and a protic solvent (formic acid). In amidic solvents poly(hexazocyclanes) form metastable aggregates and their solutions are in a transition state to colloid systems. In formic acid they dissolve molecularly; viscosity in this solvent is higher than in N-methylpyrrolidone by a factor of 2.5 to 3, and increases upon dilution (polyelectrolyte effect). Gelation sets in at concentrations above 10 to 15%. It is shown that one of the main reasons for the formation of aggregates in N-methylpyrrolidone is apparently a negligible polymer-solvent interaction, given by the chemical structure of the studied polymers. The properties of polymer solutions change very markedly when the macromolecules contain amidic groups which bring about substantial intermolecular interaction between the polymer and the solvent. (Edited author abstract) 9 refs.

Siling, S.A. (USSR Acad of Sciences, USSR); Ponomarev, I.I.; Vasil'ev, V.G.; Rogovina, L.Z.; Slonimskii, G.L.; Vinogradova, S.V.; Korshak, V.V. *Polym Sci USSR* v 29 n 1 Jan 1988 p 182-189.

**082795 ENTROPY OF INHOMOGENEOUS POLYMER-SOLVENT SYSTEMS.** The entropy of inhomogeneous polymer solutions has been evaluated using a lattice model. Previous models for polymer solutions considered only the enthalpic contributions, and a more complete expression for the free energy is obtained by adding the entropic term. The resulting expression is used to predict the characteristics of spinodal decomposition of polymer solutions and the interfacial tension between demixed polymer solutions. There is general improvement in the agreement between theory and experiment when the entropic effects are included. (Author abstract) 14 refs.

Balsara, Nitash P. (Rensselaer Polytechnic Inst, Troy, NY, USA); Nauman, E.B. *J Polym Sci Part B* v 26 n 5 May 1988 p 1077-1086.

**082796 REMARKS ON A RELATION AMONG THE INTRINSIC VISCOSITY, THE RADIUS OF GYRATION, AND THE TRANSLATIONAL FRICTION COEFFICIENT.** The intrinsic viscosity is frequently expressed in terms of the molecular root-mean-square radius of gyration. This paper presents several models, including linear and branched flexible chains, ellipsoids of revolution (spheroids), and wormlike chains. Some analytically convenient representations are also noted. 10 refs.

Berry, G.C. (Carnegie-Mellon Univ, Pittsburgh, PA, USA). *J Polym Sci Part B* v 26 n 5 May 1988 p 1137-1142.

**082797 DIMENSIONS OF A POLYMER CHAIN IN A MIXED SOLVENT.** The equilibrium behavior of a flexible polymer in a binary solvent mixture is investigated via Monte Carlo simulation. The mixed solvent is molded as an Ising fluid occupying the sites of a simple cubic lattice, with the polymer described as a self-avoiding random walk on the same lattice. The solvent has a critical consolute point, and the polymer preferentially adsorbs the better solvent component. A coupling between preferential adsorption and the solvent correlations present near the consolute temperature of the solvent causes the chain to contract, as predicted by F. Brochard and P.-G. de Gennes. However, preferential adsorption, also causes chain contraction far from the critical temperature. At



large values of preferential adsorption, the chain contracts below the dimensions it would have in either of the pure solvent components. (Author abstract) 29 refs.

Magda, J.J. (AT&T, Murray Hill, NJ, USA); Fredrickson, G.H.; Larson, R.G.; Helfand, E. *Macromolecules* v 21 n 3 Mar 1988 p 726-732.

**082798 PHASE SEPARATION IN TERNARY SYSTEMS SOLVENT-POLYMER 1-POLYMER 2, 3. HOMOGENEOUS DOUBLE CRITICAL POINTS.** A number of quantitative relations have been developed for homogeneous double critical points (HODCP's) in Flory-Huggins ternary systems solvent-polymer 1-polymer 2 with interactions characterized by polymer-polymer parameter  $g_1$  and solvent-polymer parameters  $g_1$  and  $g_2$ . Their location in the composition diagram is restricted to three linear segments, and they can exist only for combinations of  $g_1$  and  $\Delta g$  ( $\Delta g \equiv g_2 - g_1$ ) limited to double-sector areas of the  $g_1$ ,  $\Delta g$  plane. The lower sectors contain exclusively elliptic HODCP's marking disappearance of closed-loop binodals, while the upper sectors are divided between hyperbolic (marking confluence of two binodal regions) and unstable elliptic types. Sector vertices represent unique systems where the effect of unequal chain lengths is just balanced by interactions to produce a constant critical temperature, independent of composition. Conditions for multiple occurrence of HODCP's and relations for orientation of spinodals at HODCP's are derived. (Author abstract) 10 refs.

Solc, K. (Michigan Molecular Inst, Midland, MI, USA); Yang, Y.C. *Macromolecules* v 21 n 3 Mar 1988 p 829-840.

**082799 DIFFUSION-LIMITED PHOSPHORESCENCE QUENCHING INTERACTIONS IN POLYMER SOLUTIONS: SMALL MOLECULE-SMALL MOLECULE INTERACTIONS INTERPRETED BY FREE VOLUME THEORY.** Diffusion-limited interactions between benzil and anthracene were studied by phosphorescence quenching in polystyrene-cyclohexane, polystyrene-toluene, poly(methyl methacrylate)-toluene, and poly(butadiene-cyclohexane) solutions. Values of the bimolecular diffusion-limited quenching rate constant,  $k_q$ , were obtained by measuring benzil phosphorescence lifetime as a function of anthracene concentration and applying a Stern-Volmer analysis. Besides polymer species and solvent,  $k_q$  was measured as a function of polymer molecular weight and concentration, up to 560 g/L.  $k_q$  was found to be independent of polymer molecular weight in polystyrene-cyclohexane solutions and exhibited a slight molecular weight dependence in polystyrene-toluene solutions. (Edited author abstract) 52 refs.

Yu, Daniel H.-S. (Northwestern Univ, Evanston, IL, USA); Torkelson, John M. *Macromolecules* v 21 n 4 Apr 1988 p 1033-1041.

**082800 CHAIN CONFORMATION IN TERNARY POLYMER SOLUTIONS.** This paper presents a theoretical study on chain conformation of a solute polymer P in a mixture of different chemical species A and B, where A is a good solvent and B is a nonsolvent or an incompatible polymer. In the case of B being a nonsolvent, particular attention is drawn in the vicinity of the critical point of the A/B solvent mixture. On the basis of a lattice theory extended to inhomogeneous three-component polymer systems, it is found that the polymer chain P is swollen in the concentration region close to the critical demixing point. We present quantitative calculation and compare it with the experimental results obtained for the poly(tetrahydrofuran)/methanol/cyclohexane system. (Edited author abstract) 21 refs.

Tanaka, Fumihiko (Tokyo Univ of Agriculture & Technology, Fuchu, Jpn); Ushiki, Hideharu. *Macromolecules* v 21 n 4 Apr 1988 p 1041-1046.

**082801 BEAD-SPRING MODEL PREDICTIONS OF SOLUTION DYNAMICS FOR FLEXIBLE HOMOPOLYMERS INCORPORATING LONG-CHAIN BRANCHES AND/OR RINGS.** A generalization of the model of Zimm is presented which predicts solution

dynamics for chains composed of any assortment of identical spherical beads connected by identical Hookean springs. The model is formulated in a coordinate system that translates with the chain to ensure that the predicted dynamic properties may be computed, regardless of chain size or degree of hydrodynamic interaction, with the efficient eigenvalue algorithm applied by A.S. Lodge and Y. Wu to linear chains. Several new block-diagonal matrices, which further improve the computation efficiency for linear ring, and regular H structures, also arise from this formulation. (Edited author abstract) 32 refs.

Sammler, Robert L. (Univ of Wisconsin, Madison, WI, USA); Schrag, John L. *Macromolecules* v 21 n 4 Apr 1988 p 1132-1140.

**082802 ON THE APPARENT RADIUS OF GYRATION OF LINEAR POLYMERS AND THE EXPERIMENTAL DETERMINATION OF THE EXCLUDED-VOLUME PARAMETER.** The structure factor for linear polymers in the  $\Theta$  state is given by the well-known Debye function. In a good solvent the chain is subject to excluded volume; however, the form of the structure factor still closely resembles that of the Debye function. As a result, one is tempted to interpret the structure factor as a Debye function whose argument is scaled by the radius of gyration of the swollen chain. We present here rigorous and numerical arguments which demonstrate that such an interpretation is legitimate only for small values of the argument. An asymptotic expression for the structure factor suggests a method of measuring the value of the excluded-volume variable  $Z$  by experiment. (Author abstract) 16 refs.

Barrett, A.J. (Royal Military Coll of Canada, Kingston, Ont, Can); Skolnick, J. *Macromolecules* v 21 n 4 Apr 1988 p 1141-1145.

**082803 DEMIXING OF AQUEOUS POLYMER TWO-PHASE SYSTEMS IN LOW GRAVITY.** When polymers such as dextran and poly(ethylene glycol) are mixed in aqueous solution, biphasic systems often form. On Earth the emulsion formed by mixing the phases rapidly demixes because of phase density differences. Biological materials can be purified by selective partitioning between the phases. In the case of cells and other particulates the efficiency of these separations appears to be compromised by the demixing process. To modify this process and to evaluate the potential of two-phase partitioning in space, experiments on the effects of gravity on phase emulsion demixing were undertaken. Results indicate that demixing can occur rather rapidly in space, although more slowly than on Earth. We have examined the demixing process from a theoretical standpoint by applying the theory of Ostwald ripening. (Edited author abstract) 38 refs.

Bamberger, S. (Oregon Health Sciences Univ, Portland, OR, USA); Van Alstine, J.M.; Harris, J.M.; Baird, J.K.; Snyder, R.S.; Boyce, J.; Brooks, D.E. *Sep Sci Technol* v 23 n 1-3 1988 p 17-34.

**082804 LASER-DOPPLER MEASUREMENTS OF TURBULENCE STRUCTURE IN A DRAG-REDUCING PIPE FLOW WITH POLYMER INJECTION.** Aqueous solutions of polyethylene oxide were injected into a pipe flow through a small tube at the center of a pipe. The turbulent characteristics in drag-reducing flow with polymer injection were measured by means of a Laser Doppler Velocimeter (LDV). The experimental results were compared with measurements both in a Newtonian fluid (water) flow and in a premixed flow with 300 ppm homogeneous polymer solution. The experimental results suggested that the polymer injection caused a thickening of the buffer layer, enlargement of macroscale turbulent eddy and suppression of fine turbulent eddy. A difference in turbulent characteristics between premixed and polymer injected systems was observed in the distributions of turbulent macroscale, skewness factor and flatness factor. (Edited author abstract) 17 refs.

Usui, Hiromoto (Yamaguchi Univ, Ube, Jpn); Kodama, Matsuru; Sano, Yuji. *J Chem Eng Jpn* v 21 n 2 Apr 1988 p 134-140.

**082805 SURFACE INTERACTIONS IN COMPATIBLE POLYMER (AND BLOCK COPOLYMER) SOLUTIONS.** We study theoretically the effects of competing surface interactions in a system of two miscible polymers (A and B) in a good solvent, using the self-consistent mean-field formulation with ground-state dominance, as is appropriate to moderately concentrated systems. We take the A chains to be attracted to the surface and the B chains to be repelled. From susceptibility arguments, one expects a wide A-rich zone to appear at the surface, close enough to the A-B demixing transition. This (and several other qualitative expectations) is confirmed by explicit numerical and analytic calculations of (1) concentration profiles and (2) interfacial energies, for various values of the excluded volume parameters and bulk concentrations. (Edited author abstract) 19 refs.

Rossi, Giuseppe (Univ of California, Santa Barbara, CA, USA); Cates, M.E. *Macromolecules* v 21 n 5 May 1988 p 1372-1377.

**082806 RANDOMLY BRANCHED POLYMERS: SEMIDILUTE SOLUTIONS.** We study the conformation of randomly branched polydisperse polymers in semidilute solutions. Starting from the dilute case, when the different macromolecules are far apart from each other, we suggest that above a concentration  $C^*$ , where the polymers come into contact, a semidilute regime occurs. In this regime, one may separate the distribution of molecular weights into two parts. The smaller molecules behave as in the dilute regime. They penetrate the larger ones and screen out the excluded-volume interaction. Thus large polymers behave as in the reaction bath. (Edited author abstract) 25 refs.

Daoud, M. (CEN, Saclay, Fr); Leibler, L. *Macromolecules* v 21 n 5 May 1988 p 1497-1501.

**082807 PREDICTION OF SOLVENT ACTIVITIES IN POLYMER SOLUTIONS USING AN EMPIRICAL FREE VOLUME CORRECTION.** A recent correlation for solvent activities in polymer solutions is extended in scope to provide a methodology for modeling nonideal effects in polymer solutions. This new method allows the use of any expression for the residual (enthalpic) interaction between polymer and solvent in conjunction with a standard (Flory-Huggins) expression for the combinatorial entropy. An empirical free volume correction uses the infinite dilution weight fraction activity coefficient of the solvent as an adjustable parameter. The new method is applied using one residual term given by the analytical solution of groups (ASOG) technique, one similar to the Flory-Huggins interaction term, and one which yields no residual interaction. (Edited author abstract) 23 refs.

Misovich, Michael J. (Michigan State Univ, East Lansing, MI, USA); Grulke, Eric A. *Ind Eng Chem Res* v 27 n 6 Jun 1988 p 1033-1041.

**082808 DYNAMICS OF POLYMER CHAINS IN THE PROCESSES OF STRUCTURAL AND CHEMICAL CONVERSIONS OF MACROMOLECULES. REVIEW.** Polarized luminescence in polymer solutions observed with the aid of attached anthracene labels has been studied. The high sensitivity of the intramolecular mobility of the macromolecules to the changes in the intramolecular interactions and structure in the transitions coil-compact structure, coil-globule and coil- $\alpha$ -helix is demonstrated. Changes in the dynamics of different regions of the polymer chains for a new structural transition, coil-isotropically liquid globule-LC globule, is analyzed. (Edited author abstract) 33 refs.

Anufriyeva, Ye.V. (USSR Acad of Sciences, USSR); Krakovyak, M.G. *Polym Sci USSR* v 29 n 2 Feb 1987 p 231-244.

**082809 INFLUENCE OF PRESSURE ON THE TRANSITION PHENOMENON IN DILUTED SOLUTIONS OF POLY(DIACETYLENES).** Hydrostatic pressure in the range from 1 to 3400 bar induces the



transition phenomenon in diluted solutions of polydiacetylenes. With respect to the influence of pressure on the absorption bands, the transition was studied by UV spectroscopy. The transition is shown to depend strongly on the hydrogen bonds between the sidegroups. In the case of P-DDD which is free of H-bonds, the temperature and pressure effect on the transition is first-order-like in that temperature range where no precipitation occurs. Transient processes, except those involving precipitated particles, occur below the experimental time scale of minutes. In P-4BCMU, a polydiacetylene with H-bonds between the sidegroups, the pressure-induced isothermal transient phenomena are slowed down, and exhibit a nonexponential time law. (Edited author abstract) 12 refs.

Hennecke, Manfred (TU Clausthal, Clausthal-Zellerfeld, West Ger); Duell, Ines; Fuhrmann, Juergen. *Ber Bunsenges Phys Chem* v 92 n 5 May 1988 p 596-600.

**082810 DIFFUSION PERMEABILITY IN CONCENTRATED POLYMER SOLUTIONS: THE FLUORESCIN-DEXTRAN-WATER SYSTEM.** The diffusion of fluorescein as a dilute solute in more concentrated (matrix) solutions of sucrose, raffinose, different fractions of dextran in a molecular weight range from 1000 to 500,000 and Ficoll has been measured as a function of matrix concentration over an extended interval (2.5-20% w/w matrix). The presence of a macromolecule at 20% w/w could reduce the diffusion rate between four and five times. At small molecular weights the effect was less pronounced. (Edited author abstract) 4 refs.

Haglund, Bert-Ola (Uppsala Univ, Uppsala, Swed); Elisson, Magnus; Sundelof, Lars-Olof. *Chem Scr* v 28 n 2 Jun 1988 p 129-131.

**082811 SOLUTE DIFFUSION IN POLYMERS. 2. FOURIER ESTIMATION OF CAPILLARY COLUMN INVERSE GAS CHROMATOGRAPHY DATA.** In this paper, we present two improvements that overcome these limitations: (1) a model that accounts for a nonuniform polymer film and (2) a method for parameter estimation in the Fourier domain. The usefulness of the improvements is demonstrated by measuring the diffusivity and activity of benzene, toluene, and ethylbenzene in polystyrene, between 110 and 140°C, the system investigated in part 1, and of methanol, methyl acetate, and methyl methacrylate in poly(methyl methacrylate) at temperatures above the glass transition temperature. (Edited author abstract) 30 refs.

Pawlisch, Craig A. (Univ of Massachusetts, Amherst, MA, USA); Bric, John R.; Laurence, Robert L. *Macromolecules* v 21 n 6 Jun 1988 p 1685-1698.

**082812 LATTICE MODELS OF BRANCHED POLYMERS: DYNAMICS OF UNIFORM STARS.** We report exact enumeration and Monte Carlo results on the dynamics of uniform star polymers. The treatment is at the level of the Zimm rigid body approximation and we use a lattice model incorporating the effects of excluded volume. We have calculated the sedimentation velocity and intrinsic viscosity, and hence the hydrodynamic radius, as a function of the number of branches in the star and the number of monomers in each branch. We have varied the bare friction by changing the effective bead radius ( $a$ ) and we discuss the sensitivity of the results to the value of  $a$ . We compare our results, for appropriate ratios of quantities for branched and linear polymers, with those of other theoretical treatments and with experimental results. (Author abstract) 26 refs.

Wilkinson, M.K. (King's Coll, London, Engl); Gaunt, D.S.; Lipson, J.E.G.; Whittington, S.G. *Macromolecules* v 21 n 6 Jun 1988 p 1818-1822.

**082813 COMPARISON OF DIFFUSION COEFFICIENTS IN TERNARY POLYMER SOLUTIONS MEASURED BY DYNAMIC LIGHT SCATTERING AND FORCED RAYLEIGH SCATTERING.** In this work we report further measurements of PS diffusion in Poly(Vinyl Methyl Ether) (PVME) solutions, by both Dynamic Light Scattering (DLS) and forced Rayleigh scattering (FRS), as a function of matrix concentration. In

addition, as fixed PVME concentrations the DLS measurements have been repeated as a function of PS concentration. The main conclusion from the experimental results is that the magnitude of  $k_D$  in ternary solutions is less than or equal to that in pure solvent, and no substantial error is incurred by equating  $D_{meas}$  and  $D_r$ . A remarkable feature of these data is that the transition from good to apparently  $\theta$ -like quality occurs at very low PVME concentrations. 32 refs.

Chang, T. (NBS, Gaithersburg, MD, USA); Han, C.C. *Macromolecules* v 21 n 6 Jun 1988 p 1870-1872.

**082814 PHOTOSENSITIVE POLYMERS. PHOTOSTIMULATED VISCOSITY CHANGE OF POLY(3-VINYL-10-METHYLPHENOTHIAZINE) IN 1,2-DICHLOROETHANE IN THE PRESENCE OF CARBON TETRACHLORIDE.** The solution viscosity of poly(3-vinyl-10-methylphenothiazine) in 1,2-dichloroethane was found to decrease by as much as 50 percent on exposure to ultraviolet light in the presence of carbon tetrachloride. The reduced viscosity again returned to the initial value by the addition of reductants, such as sodium dithionite. Absorption and ESR measurements of the solution suggested the formation of radical cations of pendant methylphenothiazine (MPT) groups by the interaction of the photoexcited MPT with carbon tetrachloride. Aggregation of ion-pairs of the cations and chloride ions due to dipole-dipole interactions is considered to be the driving force of the chain contraction. The addition of sodium dithionite reduces the radical cations to neutral forms and the chain again returns to the initial random conformation. (Author abstract). 8 Refs.

Kungwachakun, Dawan (Osaka Univ, Osaka, Jpn); Hayashi, Koichiro; Irie, Masahiro. *Polym J* v 20 n 5 1988 p 377-381.

**082815 CARBON-13 NMR INVESTIGATION OF LOCAL DYNAMICS IN BULK POLYMERS AT TEMPERATURES WELL ABOVE THE GLASS TRANSITION TEMPERATURE. 1. POLY(VINYL METHYL ETHER).** Carbon-13 spin-lattice relaxation time determinations have been performed on poly(vinyl methyl ether) in solution and in bulk above the glass transition temperature. The high experimental value of the minimum of  $T_1$  as a function of temperature cannot be accounted for by the specific orientation autocorrelation functions for polymers. The authors postulate the existence of an additional fast anisotropic motion, which they have assigned to librations of limited extent of the internuclear CH vectors about their rest position. Comparison of solution and bulk data has established that molecular motions of poly(vinyl methyl ether) are of the same nature in solution and in bulk at temperatures above  $T_g$ . (Edited author abstract). 39 Refs.

Dejean de la Batie, R. (CNRS, Paris, Fr); Laupretre, F.; Monnerie, L. *Macromolecules* v 21 n 7 Jul 1988 p 2045-2052.

**082816 PARTIAL DRAINING AND UNIVERSALITY OF DILUTE SOLUTION POLYMER DYNAMICS: COMPARISON OF THEORY AND EXPERIMENT.** Previous renormalization group calculations predict that the conventional Flory ratios  $P/P_0$  and  $\Phi/\Phi_0$  are not universal functions of excluded volume alone in dilute solutions because of a partial draining effect (finite hydrodynamic interactions) that splits the scaling functions into a family of curves. The theory also predicts that the ratio presented is almost independent of draining and is more nearly a universal function of excluded volume (i.e., the expansion factor  $a_3$ ). These predictions are tested against experimental data for polystyrene, poly( $\alpha$ -methylstyrene), and polyisobutylene, a sequence that is interpreted as having increasing relative nondraining behavior. Procedures are outlined for more quantitative tests of the theory. (Edited author abstract). 39 Refs.

Freed, Karl F. (Univ of Chicago, Chicago, IL, USA); Wang, Shi-Qing; Roovers, Jacques; Douglas, Jack F. *Macromolecules* v 21 n 7 Jul 1988 p 2219-2224.

**082817 ISOTROPIC-LIQUID CRYSTAL PHASE**

**EQUILIBRIUM IN SOLUTIONS OF SEMIFLEXIBLE POLYMERS: POLY(HEXYL ISOCYANATE).** The isotropic-liquid crystal phase equilibrium was investigated for solutions of poly(hexyl isocyanate) (PHIC) in toluene and dichloromethane. Substantially monodisperse samples were used to determine the dependence of the phase diagram on molecular weight, temperature, and solvent. The determined molecular weight dependence greatly differed from the prediction of the theories of L. Onsager and of P.J. Flory for rigid rods. This was attributed to the flexibility of PHIC characterized by the persistence length  $q$  of 21-41 nm in these solvents. The data for the solutions of PHIC in toluene, together with those for aqueous schizophyllan (a triple helical polysaccharide,  $q=200$  nm), were compared almost quantitatively with the prediction of the theory of A.R. Khokhlov and A.N. Semenov for wormlike cylinders with hard-core repulsive potential. (Edited author abstract). 37 Refs.

Itou, Takashi (Osaka Univ, Toyonaka, Jpn); Teramoto, Akio. *Macromolecules* v 21 n 7 Jul 1988 p 2225-2230.

**082818 RELAXATION TIMES OF POLYMER SOLUTION IN THE SEMIDILUTE REGION FOR ZERO-SHEAR VISCOSITY.** Relaxation times  $\tau_w$  and  $\tau_0$  of polymer solutions in the semidilute region for the zero-shear viscosity  $\eta'$  were studied in good and  $\Theta$  solvents. Here,  $\tau_w$  is the weight-average relaxation time evaluated from the product of  $\eta'$  and the steady-state compliance  $J_e$ , and  $\tau_0$  is the relaxation time specifying shear rate dependence of viscosity. It is found that  $\tau_0$  is proportional to  $\tau_w$  regardless of concentration and solvent power, and the concentration and molecular weight dependences of both relaxation times can be well understood if the semidilute region for  $\eta'$  is divided into two regions, i.e., the dilute and entangled regions for  $J_e$ . (Author abstract). 19 Refs.

Takahashi, Yoshiaki (Nagoya Univ, Nagoya, Jpn); Umeda, Masanari; Noda, Ichiro. *Macromolecules* v 21 n 7 Jul 1988 p 2257-2262.

**082819 EXTENDED UNIVERSAL COEXISTENCE CURVE FOR POLYMER SOLUTIONS.** The symmetrized universal coexistence (COEX) curve for binary polymer/solvent solutions, as proposed by I.C. Sanchez has been extended based on the Wegner expansion. Together with empirical relationships between the polymer molecular weight ( $M$ ) and the critical volume fraction as well as between  $M$  and the critical solution temperature, all the high-precision COEX curve data for polystyrene (PS) in methylcyclohexane (MCH) and in cyclohexane (CH) can be represented by an expression that is presented by the authors. Results of the extended universal COEX curve permit us to distinguish phase-separation behavior from polymer coil-to-globule transition. (Edited author abstract). 15 Refs.

Chu, Benjamin (State Univ of New York at Stony Brook, Stony Brook, NY, USA); Wang, Zhulum. *Macromolecules* v 21 n 7 Jul 1988 p 2283-2286.

**082820 NEWTONIAN VISCOSITY OF POLYMER SOLUTIONS.** Viscosity measurements of cellulose acetate and polyisobutylene over a wide range of concentrations and molecular weights have been made. The data so obtained and the data taken from literature for schizophyllan show that the viscosity varies smoothly with the concentration of the polymer for the whole range of concentrations and molecular weights investigated. The characteristic concentrations,  $c_{ch}$ , of the polymers are calculated by the following equations:  $c_{ch}=0.77/[\eta]$  or  $c_{ch}=1.08/[\eta]$ . The relationship between molecular weight and intrinsic viscosity is obtained by fitting the data by the method of least squares. (Edited author abstract). 20 Refs.

Baloch, Musa Kaleem (Gomal Univ, Dera Ismail Khan, Pak). *J Macromol Sci Chem* v A25 n 4 1988 p 363-372.



**082821 LIQUID CRYSTALLINE STRUCTURE OF SOLUTIONS OF POLY- $\gamma$ -BENZYL-L-GLUTAMATE.** Over a wide interval of change in concentrations, temperature and MM (Molecular Mass) from the texture of the 'fingerprints' the authors have determined the pitch of the cholesteric helix P for LC solutions of poly- $\gamma$ -benzyl-L-glutamate in DMFA. The experimentally obtained dependences of the pitch of the cholesteric helix on temperature, concentration and MM are discussed in relation to various theories. In relation to the kinetic approach, an explanation offered for the experimentally discovered maximum in the dependence of the pitch on MM according to which non-monotonic change in pitch is a consequence of change in the form of the molecule with increase in its contour length to a value equal to and beyond the persistent length. (Edited author abstract). 21 Refs.

Syromyatnikova, T.A. (USSR Acad of Sciences, USSR); Sikora, A.M.; Ginburg, B.M.; Frenkel, S. Ya.; Vlasov, G.P.; Rudkovskaya, G.D.; Ovsyannikova, L.A.; Shab-sei's, B. M. *Polym Sci USSR* v 29 n 4 1987 p 804-810.

**082822 INVESTIGATION OF TRANS-POLYPIPERYLENE IN SOLUTION BY MOLECULAR-OPTICAL METHODS.** Flow birefringence, light-scattering and viscometry have been used to study structural features of the macromolecules of trans-poly(piperylene). Its segmental anisotropy has been determined and it has been shown that reversible structural changes occur in solutions in toluene around a temperature of approximately 50°C. Dynamo-optical, hydrodynamic and molecular characteristics obtained from measurements in heptane, as well as the dependence of these characteristics on preliminary heat treatment, give evidence that the molecules of trans-poly(piperylene) in this solvent have a supermolecular structure which is not completely disrupted even upon heating to 70°C. (Edited author abstract). 9 Refs.

Mekenitskaya, L.I. (USSR Acad of Sciences, USSR); Sokolova, V.L.; Shul'Pina, L.M. *Polym Sci USSR* v 29 n 4 1987 p 954-960.

**082823 SPIN-COATING PROCESS MECHANISM RELATED TO POLYMER SOLUTION PROPERTIES.** Coating the substrate with an amorphous polymer layer is a very common process in the manufacturing of integrated circuits, but the fundamental spin-coating mechanism has not yet been precisely determined. This study examines the influence of the macromolecular characteristics on the spin-coating process both experimentally and from a phenomenological point of view. It is concluded that the weight-average molecular weight of the spun-on solution is a pertinent parameter, and that chain entanglements in polymer solutions may be considered as the basic phenomenon responsible for the formation of the solid polymer layer. (Author abstract). 17 Refs.

Weill, A. (CNET, Meylan, Fr); Dechenaux, E. *Polym Eng Sci* v 28 n 15 mid-august 1988 p 945-948.

**082824 EXTENSION OF THE CURTISS-BIRD THEORY FOR THE RHEOLOGICAL PROPERTIES OF CONCENTRATED POLYMER SOLUTIONS AND MELTS.** The constitutive equation for the elastic reptating rope model is considered in the limit at which the rope becomes inextensible. It is shown that in this limit a constitutive equation is obtained which differs essentially from the Curtiss-Bird theory if the correlation length is much smaller than the contour length of the rope. This constitutive equation contains an extra term related to correlations between segments. The differences between this result and the Curtiss-Bird theory are considered, and consequences are indicated. (Author abstract). 17 Refs.

Geurts, Bernard J. (Twente Univ, Enschede, Neth.). *J Non Newtonian Fluid Mech* v 28 n 3 Jul 1988 p 319-332.

**082825 MOLECULAR MASS DEPENDENCE OF THE KERR EFFECT IN SOLUTIONS OF RIGID POLYMERS.** This work is devoted to the further development of the theory of the Kerr effect in solutions of rigid polymers, the molecules of which are simulated by worm-like chains. A relation expressing the dependence of

the Kerr constant on polymer chain length was obtained by taking into account the difference between the longitudinal-dipole and transverse-dipole rigidities of the molecular chain. It was shown that the difference essentially affects the character of the molecular mass dependence of the Kerr effect in polymer solution. (Author abstract). 12 Refs.

Tsvetkov, V.N. (USSR Acad of Sciences, USSR). *Polym Sci USSR* v 29 n 5 1987 p 1104-1111.

**082826 WAVE-NUMBER DEPENDENT INSTANTANEOUS RELAXATION FREQUENCY CONCEPT IN POLYMER SOLUTION DYNAMICS.** Time and wave number dependent relaxation frequency concept has been introduced into polymer solution dynamics as an extension of the first cumulant, commonly used in the interpretation of dynamic scattering experiments. The utility of this concept has been demonstrated by calculating the dynamic scattering function explicitly in the small-q limit. The use of  $\Gamma(q,t)$  and the integral equation determining its time evolution may provide a potentially powerful approach to the interpretation of dynamic scattering experiments also in higher q-regions. (Edited author abstract). 8 Refs.

Akcasu, A. Ziya (Univ of Michigan, Ann Arbor, MI, USA). *Bull Tech Univ Istanbul* v 39 n 3 pt 4 1986 p 283-290.

**082827 THERMODYNAMIC MODEL FOR TWO-PHASE AQUEOUS POLYMER SYSTEMS.** The main objective of this work is the development of a predictive model for the liquid-liquid equilibrium of aqueous solutions containing two chemically different polymers. The authors show that this can be done by using the UNIQUAC model with the interaction parameters for the water-dextran and water PEG systems obtained from osmotic pressure data for these binary aqueous polymer solutions, and by fixing the dextran PEG parameters, or almost as well as using the parameters reported here in the absence of osmotic pressure data. It is shown that the UNIQUAC model leads to predictions of better accuracy than the Flory-Huggins model and, indeed, the predictive (zero-parameter) UNIQUAC model is almost as accurate as the correlative (three-parameter) Flory-Huggins model. This work is pertinent to liquid extraction processes involving biological materials. 18 Refs.

Kang, C.H. (Univ of Delaware, Newark, DE, USA); Sandler, S.I. *Biotechnol Bioeng* v 32 n 9 Oct 20 1988 p 1158-1164.

**082828 ENHANCEMENT OF ENERGY TRANSFER BETWEEN DYE SOLUBILIZATES IN A POLYMER/SURFACTANT COLLOID SYSTEM.** Energy transfer from excited proflavine (PF) to rhodamine 6G (R6G) was measured in sodium dextran sulfate/dodecyltrimethylammonium bromide mixed solutions by monitoring both the quenching of PF emission and the enhancement of R6G emission as a function of concentrations of surfactant and acceptor. A strong correlation was observed between the quenching of donor emission and the enhancement of acceptor emission. Remarkable enhancement of energy transfer was found in polyion/surfactant mixed solution, while no or very little energy transfer was observed in the polyion solution in the absence of surfactant. This enhancement of energy transfer is attributed to the solubilization of the donor/acceptor dye pair in monomeric form into a surfactant cluster bound in the polyion domain. (Author abstract) 26 refs.

Hayakawa, Katumitu (Kagoshima Univ, Kagoshima, Jpn); Ohyama, Takeshi; Maeda, Tamaki; Satake, Iwao; Sato, Masako; Kwak, Jan C.T. *Langmuir* v 4 n 2 Mar-Apr 1988, Mol Process at Solid Surf: Spectrosc of Intermed and Adsorbate Interact, Denver, CO, USA, Apr 6-8, 1987 p 481-484.

Specific Heat See POLYSTYRENES—Specific Heat.

**Spectroscopic Analysis** See Also COPOLYMERS—Electronic Properties; COPOLYMERS—Microstructure; COPOLYMERS—Synthesis; EPOXY RESINS—Thermal Effects; FLUORINE CONTAINING POLYMERS—Crosslinking; INTERPENETRATING POLYMER NETWORKS—Viscoelasticity; LIPIDS—Polymerization; MONOMERS—Polymerization; OLIGOMERS—Structure; POLYACETYLENES—Optical Properties; POLYAMIDES—Production; POLYCARBONATES—Spectroscopic Analysis; POLYETHYLENES—Chromatographic Analysis; POLYETHYLENES—Optical Properties; POLYETHYLENES—Physical Properties; POLYETHYLENES—Structure; POLYIMIDES—Chemical Reactions; POLYMETHYL METHACRYLATE—Spectroscopic Analysis; POLYPROPYLENE—Spectroscopic Analysis; POLYPROPYLENE—Structure; POLYSULFONES—Spectroscopic Analysis; RUBBER—Chlorination; RUBBER INDUSTRY—Chemical Analysis; SPECTROSCOPY.

**082829 SYNTHESIS AND SOME SPECTROSCOPIC PROPERTIES OF POLYANIONS WITH PENDANT MERCOCYANINE DYES.** Polymers tagged with a local pH reporter were synthesized. A methacrylate-type monomer containing a merocyanine dye residue as a reporter dye was synthesized. Its homopolymer and copolymers with sodium 2-acrylamido-2-methylpropane-sulfonate were prepared by free radical polymerization. These polymers showed a characteristic color change in aqueous solutions from yellow to red with increasing pH from acidic to basic conditions according to the acid-base equilibria of the merocyanine dye residues. Since the electrostatic potential and polarity of media have a strong effect on the acid-base equilibria, the pendant merocyanine residues are expected to serve as a reporter to provide information on the local environments around the polymer chain at which the dye molecules are incorporated. (Author abstract) 12 refs.

Kobayashi, Takaomi (Osaka Univ, Toyonaka, Jpn); Morishima, Yotaro; Nozakura, Shun-ichi. *J Polym Sci Part A* v 25 n 10 Oct 1987 p 2839-2845.

**082830 SPECTRAL STUDIES ON THE INTERACTIONS BETWEEN RESORCINOL-FORMALDEHYDE RESIN AND PYRIDINES.** The interactions between resorcinol-formaldehyde (RF) resin and pyridines have been studied by infrared and ultraviolet spectrometry of model compound systems. Besides the formation of hydrogen bonds and pyridinium salts, it was found that 4-ethylpyridine can react with RF resins forming cyclic amide structures. Based on the spectral studies, a possible reaction scheme is proposed. (Author abstract) 22 refs.

Xue, GI (Nanjing Univ, Nanjing, China). *J Macromol Sci Chem* v A24 n 9 1987 p 1107-1120.

**082831 CONCERNING THE NATURE OF MOLECULAR MOVEMENT IN EPOXY-AMINE NETWORK GLASSY POLYMERS.** The NMR impulse method has been used to study the relaxation properties of a number of model epoxy-polymers based on the diglycidyl ether of resorcinol with various concentrations of crosslinks, degrees of branching and with crosslinking fragments of various types. During glass formation, molecular movement in the network polymers is accomplished by segments of at least two types: nodes with adjacent chain fragments and chain fragments respectively. (Author abstract) 22 refs.

Zakirov, I.N. (USSR Acad of Sciences, USSR); Lantsov, V.M.; Derinovskii, V.S.; Smirnov, Yu.N.; Yefremova, A.I.; Irzhak, V.I.; Rozenberg, B.A. *Polym Sci USSR* v 28 n 8 1986 p 1916-1925.

**082832 TWO-DIMENSIONAL MAS NMR: NEW PROSPECTS FOR THE INVESTIGATION OF PARTIALLY ORIENTED POLYMERS.** Single crystals are difficult if not impossible to obtain. Examples are synthetic liquid crystalline and biological polymers. Often such materials can, however, be partially oriented. If a set of rotor-synchronized <sup>13</sup>C MAS NMR spectra is taken of a macroscopically anisotropic sample for different initial rotor phases, a two-dimensional sideband spectrum can be generated by a subsequent second Fourier transformation over the rotor phase. From the sideband intensities in the



new dimension the orientational distribution function can be derived for the individual carbon positions. The method is reviewed and demonstrated on samples of liquid crystalline polymers and drawn polyethylene terephthalate. (Edited author abstract) 15 refs.

Blumich, B. (Max-Planck-Institut fuer Polymerforschung, Mainz, West Ger); Boeffel, C.; Harbison, G.S.; Yang, Y.; Spiess, H.W. *Ber Bunsenges Phys Chem* v 91 n 11 Nov 1987 p 1100-1103.

**082833 SPECTROELECTROCHEMICAL STUDIES OF ELECTROCHEMICALLY PREPARED POLY-3-METHYLTHIOPHENE.** Electrochemically prepared poly-3-methylthiophene has been characterized employing spectroelectrochemical techniques. Results indicate that both oxidized and reduced forms of the polymer are stoichiometrically stable and the doping process is chemically reversible. The anodic doping level is between 0.12 to approx. 0.19 as determined from spectroelectrochemical measurements, and several different functional groups appear to undergo redox reactions. (Author abstract) 21 refs.

Hoier, S.N. (Sandia Natl Lab, Albuquerque, NM, USA); Ginley, D.S.; Park, Su-Moon. *J Electrochem Soc* v 135 n 1 Jan 1988 p 91-94.

**082834 CHARACTERIZATION OF NEUTRAL SOLITON DYNAMICS IN PRISTINE TRANS-POLYACETYLENE BY MEANS OF ANISOTROPIC ESR T<sub>1</sub> AND LINE WIDTH.** Anisotropy patterns for ESR T<sub>1</sub> and line width at 300K and at 50, 500 MHz and X-band were reported. Phases and frequency dependences of all patterns were understood by rapid 1-D diffusion of neutral solitons, except for line width of t-(CH)<sub>x</sub>, which could be reasonably interpreted by the trapping effect. This result means that in analysis on the neutral soliton dynamics, effects by trapping should be taken into account. (Author abstract) 14 refs.

Mizoguchi, K. (Tokyo Metropolitan Univ, Tokyo, Jpn); Kume, K.; Masubuchi, S.; Shirakawa, H. *Solid State Commun* v 59 n 7 Aug 1986 p 465-468.

**082835 TWO-DIMENSIONAL <sup>1</sup>H AND <sup>13</sup>C NUCLEAR MAGNETIC RESONANCE STUDIES OF POLY(VINYL ALCOHOL).** The <sup>1</sup>H and <sup>13</sup>C nuclear magnetic resonance spectra of atactic poly(vinyl alcohol) in D<sub>2</sub>O at a temperature of 353 K were analyzed by various two-dimensional NMR (2D NMR) methods including <sup>1</sup>H J-resolved spectroscopy, <sup>1</sup>H F<sub>1</sub>-axis broad-band decoupled correlation spectroscopy, <sup>1</sup>H broad-band decoupled <sup>13</sup>C-<sup>1</sup>H chemical shift correlation spectroscopy, and two-dimensional INADEQUATE spectroscopy. The combined use of these two-dimensional NMR methods provided absolute assignments of <sup>1</sup>H and <sup>13</sup>C spectra at triad-tetrad and pentad-hexad levels, respectively. The polymerization of PVA follows Bernoulli statistics with P<sub>nn</sub> = 0.47 at the triad-tetrad level, but does not follow any statistics at the pentad-hexad level. (Author abstract) 33 refs.

Hikichi, Kunio (Hokkaido Univ, Sapporo, Jpn); Yasuda, Manabu. *Polym J* v 19 n 9 1987 p 1003-1012.

**082836 LASER DESORPTION FOURIER TRANSFORM MASS SPECTROMETRY OF POLYMERS: COMPARISON WITH SECONDARY ION AND FAST ATOM BOMBARDMENT MASS SPECTROMETRY.** A series of alkoxyated pyrazole and hydrazine polymers with average molecular weights between 600 and 1300 were studied by using laser desorption Fourier transform mass spectrometry. Spectra primarily contain +• and Na<sup>+</sup>-attached intact oligomer ions and show little evidence of fragmentation. LD-FTMS spectra are compared with previously reported secondary ion and fast atom bombardment spectra of the same polymers. In general, laser desorption spectra show more regular polymer distributions, fewer fragment ions, and less mass discrimination. (Author abstract) 9 refs.

Nuwaisir, Lydia M. (Univ of California, Riverside, CA, USA); Wilkins, Charles L. *Anal Chem* v 60 n 3 Feb 1988 p 279-282.

**082837 NUCLEAR MAGNETIC RESONANCE STUDY OF POLY(ARYL ETHER ETHER KETONE).** Amorphous and crystalline samples of poly(aryl ether ether ketone) have been studied in the solid state by both <sup>13</sup>C high-resolution cross-polarization/magic-angle spinning (CP/MAS) nuclear magnetic resonance (nmr) and wide-line <sup>1</sup>H nmr. The <sup>13</sup>C spectrum was assigned using the dipolar dephased and variable-contact-time experiments. The CP/MAS spectrum of the amorphous sample displays much broader signals than does the crystalline sample. The <sup>1</sup>H wide-line spectra were measured at temperatures from 295 to 440 K. The <sup>1</sup>H spectra appeared as two superimposed signals having different spin-lattice relaxation times. At all temperatures below the glass transition, the lines of the crystalline spectra were wider and showed longer spin-lattice relaxation times than those of the amorphous spectra. (Author abstract) 24 refs.

Clark, J.N. (Univ of British Columbia, Vancouver, BC, Can); Jagannathan, N.R.; Herring, F.G. *Polymer* v 29 n 2 Feb 1988 p 341-345.

**082838 E.S.R. OF BF<sub>4</sub><sup>-</sup>-DOPED POLYTHIOPHENE.** We have studied poly(3-methylthiophene) doped electrochemically with BF<sub>4</sub><sup>-</sup> by electron spin resonance. The spin concentration increases linearly by about one spin per injected charge up to quite high doping levels (about 10 mol% at room temperature). The magnetic susceptibility χ<sub>m</sub>(T) gradually changes from a Curie to a Pauli-type behavior with increasing doping concentration. The results demonstrate that polarons are the dominant charge states in poly(3-methylthiophene) doped with BF<sub>4</sub><sup>-</sup>. (Edited author abstract) 26 refs.

Schaerli, M. (RCA Lab Ltd, Zurich, Switz); Kiess, H.; Harbeck, G.; Berlinger, W.; Blazey, K.W.; Mueller, K.A. *Synth Met* v 22 n 4 Feb 1988 p 317-336.

**082839 ELECTRON ENERGY LOSS SPECTROSCOPY: APPLICATION TO SYNTHETIC ORGANIC POLYMERS.** Electron energy loss spectroscopy has been examined as a possible tool for measuring the atomic composition of polymers on a local scale in the transmission electron microscope. Thin films of nylon 6,6 and single crystal lamellae of poly(chlorotrifluoroethylene) were investigated as model systems. Spectra were obtained using a 100 kv electron beam. Results for nylon 6,6 gave fairly good quantitative agreement between the measured relative atomic contents of carbon, nitrogen, and oxygen (77, 9 and 14%, ±5%, respectively) and the calculated values (75, 12.5, and 12.5%, respectively). Spectra obtained for poly(chlorotrifluoroethylene) single crystals revealed significant mass loss of chlorine as a function of electron dose. (Edited author abstract) 25 refs.

Briber, Robert M. (NBS, Gaithersburg, MD, USA); Khoury, F. *J Polym Sci Part B* v 26 n 3 Mar 1988 p 621-636.

**082840 DIRECT PYROLYSIS MASS SPECTROMETRY OF CHLORINE-CONTAINING POLYMERS USING CAPILLARY GC/MS.** A direct pyrolysis mass spectrometric technique has been developed and applied to several chlorine-containing polymers. The capillary column in the gas chromatograph has been replaced by uncoated fused silica tubing to avoid the problem of column degradation induced by the polymer pyrolyzates. Under appropriate conditions, the pyrolysis mass spectra were found to be highly reproducible and to serve as 'fingerprints'. The technique can be readily applied to carbon-black-filled, crosslinked elastomers, as well as polyblends and composites. The quantitative aspects of the technique have also been addressed. (Author abstract) 16 refs.

McGuire, Jeffrey M. (Hercules Inc Research Cent, Wilmington, DE, USA); Bryden, Charles C. *J Appl Polym Sci* v 35 n 2 Feb 5 1988 p 537-548.

**082841 <sup>29</sup>Si NUCLEAR MAGNETIC RESONANCE OF DIMETHYL AND PHENYLMETHYL CONTAINING POLYSILANES.** The <sup>29</sup>Si-NMR spectra are reported for poly(methylphenylsilylene) (1), poly(1,1,2-trimethyl-2-phenyldisilene) (2), two samples of poly-

dimethylsilylene-co-phenylmethylsilylene) (3a) and (3b), and poly(phenylmethylsilylene-co-n-hexylmethylsilylene) (4). The spectra of 3a, 3b, and 4 indicate that these polymers contain blocklike regions with considerable segregation of RMeSi and PhMeSi groups. The spectrum of 2 shows no evidence for stereospecific or regiospecific polymerization. The preparation of 2 from 1,1,2-trimethyl-2-phenyldichlorosilane is also described. (Author abstract) 16 refs.

Wolff, Andrew R. (Univ of Wisconsin, Madison, WI, USA); Nozue, Ikuo; Maxka, Jim; West, Robert. *J Polym Sci Part A* v 26 n 3 Mar 1988 p 701-712.

**082842 <sup>29</sup>Si NUCLEAR MAGNETIC RESONANCE OF DIALKYLPOLYSILANES.** The silicon-29 nuclear magnetic resonance spectra of a number of dialkyl- and alkylmethylpolysilanes are reported. Polysilanes composed of asymmetrically substituted silylenes (i.e., alkylmethylsilylenes) exhibited very broad resonance lines attributed to diastereomeric chemical shifts of stereogenic silylenes alpha and beta to the observed nucleus. Symmetrically substituted polysilanes showed a single narrow peak. The <sup>29</sup>Si chemical shifts for these polysilanes decrease with increasing steric bulk of the substituents, varying inversely with the electronic excitation energy. (Author abstract) 18 refs.

Wolff, Andrew R. (Univ of Wisconsin, Madison, WI, USA); Maxka, Jim; West, Robert. *J Polym Sci Part A* v 26 n 3 Mar 1988 p 713-720.

**082843 ANALYSIS OF POLYMER SURFACES BY SIMS: 12. ON THE FRAGMENTATION OF ACRYLIC AND METHACRYLIC HOMOPOLYMERS AND THE INTERPRETATION OF THEIR POSITIVE AND NEGATIVE ION SPECTRA.** The positive and negative ion spectra from homologous series of alkyl methacrylate, hydroxyalkyl methacrylate and alkyl acrylate polymers; poly(methacrylic acid) and poly(methacrylic anhydride) are reported. A systematic interpretation of the spectra can be accomplished on the basis of fragmentation pathways consistent with the known effects of other ionizing radiations. The negative ion spectra, previously little studied, are a powerful probe of structure for this class of polymer. (Author abstract) 14 refs.

Hearn, M.J. (ICI PLC, Middlesbrough, Engl); Briggs, D. *Surf Interface Anal* v 11 n 4 Feb 1988 p 198-213.

**082844 APPLICATION OF FIELD DESORPTION MASS SPECTROMETRY TO POLYMER AND OLIGOMER ANALYSIS.** This review discusses the application of field desorption mass spectrometry (FDMS) to the determination of molecular weight distributions, the characterization of oligomer mixtures, the analysis of the reaction mechanism of styrene, and the analysis of thermal behavior. It is demonstrated that FDMS is effective for the analysis of polymers or oligomers, allowing the determination of molecular weight distributions, the characterization of oligomeric mixtures, and the analysis of reaction mechanisms and thermal behaviors in polymeric or oligomeric systems. However, this method has some drawbacks. Hence, for example, since FDMS only provides one item of information (the molecular ion), it is incapable of distinguishing isomers that may coexist in the system and is incapable of deducing their structures. Secondly, FDMS is not applicable to polymers with molar masses greater than 10,000 daltons. Thirdly, the fact that FDMS is compound-selective provides some problems, since desorption rates and ionization efficiencies depend quite closely on molecular weight, volatility, chemical structure, and similar factors. Nevertheless, despite these difficulties, FDMS has been applied to various fields of polymer analysis, and has provided a complement to structural data obtained by IR and NMR spectroscopy. 44 refs.

Saito, Jun (Mitsui Toatsu Chemicals Inc, Yokohama, Jpn); Waki, Hiroshi; Teramae, Norio; Tanaka, Shigeyuki. *Prog Org Coatings* v 15 n 4 Feb 29 1988 p 311-335.



**082845 FACTORS AFFECTING THE SAMPLING OF POLY(ETHYLENIMINES) BY ELECTROHYDRODYNAMIC MASS SPECTROMETRY.** The effects of polymer structure and solution chemistry on sampling by electrodynamical (EH) mass spectrometry were studied by using poly(ethylenimines) (PEIs). In contrast with results for poly(ethylene glycols), number average molecular weight calculated from desorption ionization mass spectra of PEIs are generally too low, with the discrepancy becoming greater with increasing molecular weight. The effects of adding acid and transition-metal ions indicate that sampling bias in EH mass spectrometry is in part due to strong solvent-ion interactions resulting from poor shielding of charge sites in multiply charged adducts, with a contribution from hydrogen bonding interactions between polymer and solvent. (Edited author abstract) 40 refs.

Cooke, Kelsey D. (Univ of Tennessee, Knoxville, TN, USA); Callahan, John H.; Man, Victor F. *Anal Chem* v 60 n 7 Apr 1 1988 p 706-713.

**082846 MOTION OF JUNCTION POINT IN NETWORK SYSTEMS BY  $^{31}\text{P}$ -NMR LINESHAPES AND RELAXATION.** Advances in magnetic resonance techniques over the past ten years have made accessible many details of insoluble systems. In favorable cases it was possible to delineate some specific molecular interactions and motions. The authors have performed  $^{13}\text{C}$  MAS-CP NMR studies on a number of network polymers derived from  $\alpha$ ,  $\omega$ -dihydroxy poly(propylene oxide) MW=400, 1000, 2000, 3000, or 4000 crosslinked with tris(4-isocyanatophenyl)thiophosphate. They began these studies with the intention of characterizing both spatial and time parameters of the junction point motion as a function of  $M_c$ , the molecular weight between crosslinks. This preliminary report shows that  $^{31}\text{P}$ -NMR is acutely sensitive to details of motion of the junction and that the resultant powder patterns and relaxation times can be used to greatly extend our knowledge of junction point constraints. The results shown here clearly indicate the need for broader study of these networks under swelling and/or extension conditions and of similar networks with different crosslinking agents. 6 refs.

Dickinson, L. Charles (Univ of Massachusetts, Amherst, MA, USA); MacKnight, William J.; Chien, James C.W. *J Polym Sci Part C* v 26 n 4 Apr 1988 p 191-194.

**082847 CONFORMATION AND DYNAMIC ASPECTS OF POLY( $\gamma$ -N-OCTADECYL L-GLUTAMATE) IN THE SOLID STATE AND LIQUID-CRYSTALLINE STATE AS STUDIED BY VARIABLE-TEMPERATURE  $^{13}\text{C}$  CP/MAS NMR SPECTROSCOPY.**  $^{13}\text{C}$  CP/MAS NMR experiments are carried out for poly( $\gamma$ -n-octadecyl L-glutamate) as a function of temperature, in order to elucidate dynamic and conformational features in the solid state and liquid-crystalline state. From these experimental results, it is found that the main chain of the polymer takes on a right-handed  $\alpha$ -helical conformation within the temperature range from 27 to 100°C, while long n-alkyl side chains take on an all-trans zigzag conformation in the crystalline state at room temperature and are in a mobile state above 35°C. Further, it is found that at about 40°C the  $\alpha$ -helical main chain in the liquid-crystalline phase is undergoing molecular motion at a frequency of ca. 60 kHz. (author (Author abstract) 25 refs.

Yamanobe, Takeshi (Tokyo Inst of Technology, Tokyo, Jpn); Tsukahara, Makoto; Komoto, Tadashi; Watanabe, Junji; Ando, Isao; Uematsu, Ichitaro; Deguchi, Kenzo; Fujito, Teruaki; Imanari, Mamoru. *Macromolecules* v 21 n 1 Jan 1988 p 48-50.

**082848 RADICAL IONS OF POLYSILASTYRENE.** The absorption spectra of radical ions of polysilastyrene have been measured in rigid matrices at 77 K as well as in solution at room temperature by using  $\gamma$ -irradiation and pulse radiolysis methods. The radical anion with  $\lambda_{\text{max}}$  at 365 nm was observed in irradiated 2-methyltetrahydrofuran, while the radical cation with two absorption bands at 358 and 2000 nm was observed in irradiated n-butyl chloride at 77 K. Upon thermal annealing, the

infrared band showed a blue shift to 1700 nm, which is attributed to the geometrical reorientation of pendant phenyl groups from the unrelaxed to relaxed dimer radical cation conformation. (Edited author abstract) 14 refs.

Irie, Setsuko (Radiation Cent of Osaka Prefecture, Sakai, Jpn); Oka, Kunio; Irie, Masahiro. *Macromolecules* v 21 n 1 Jan 1988 p 110-112.

**082849 FOURIER TRANSFORM INFRARED SPECTROSCOPY OF SOME MISCIBLE POLYBENZIMIDAZOLE/POLYIMIDE BLENDS.** The IR spectra of representative miscible aromatic polybenzimidazole/aromatic polyimide (PBI/PI) blends have been studied. Composition-dependent frequency shifts of up to 55  $\text{cm}^{-1}$  in the N-H stretching band of PBI and up to 6  $\text{cm}^{-1}$  in the carbonyl stretching bands of PI were observed. These shifts were removed by thermally induced phase separation. The results suggest that the miscibility of these blends derives from specific intermolecular interactions involving the >NH and carbonyl groups. (Author abstract) 15 refs.

Guerra, Gaetano (Univ of Massachusetts, Amherst, MA, USA); Choe, Soonja; Williams, David J.; Karasz, Frank E.; MacKnight, William J. *Macromolecules* v 21 n 1 Jan 1988 p 231-234.

**082850 CARBON-13 NUCLEAR MAGNETIC RESONANCE CHARACTERIZATION OF NETWORK SYSTEMS.** Solid-state C-13 NMR measurements are utilized to characterize the tetrafunctional epoxy, tetraglycidyl(diaminodiphenyl)methane, and the tetrafunctional amine, diaminodiphenyl sulfone. Intermolecular effective ether cross-links, amine junction points, and extent of reaction of the amine and epoxy are measured for the polymerization. Chemical reactions in the epoxy-amine system are discussed, and the reactivity ratio of the epoxy-amine system is calculated. Junction point measurements are made by the use of the dipolar dephasing relaxation experiment. The experimental data collected with C-13 NMR are then compared with the calculated data from a model developed in this laboratory. The information obtained in this study is sufficient to calculate the molecular weight between cross-links. (Author abstract) 33 refs.

Mertzel, Elaine A. (Case Western Reserve Univ, Cleveland, OH, USA); Perchak, Dennis R.; Ritchey, William M.; Koenig, Jack L. *Ind Eng Chem Res* v 27 n 4 Apr 1988 p 586-593.

**082851 INFRARED SPECTRA OF SOLUBLE POLYANILINE.** The infrared spectra of soluble polyaniline (PAn) have been studied. It is found that the IR spectrum of the soluble PAn gives more structural information than those of insoluble samples. A tentative assignment is given based on the observed effects of HCl concentration in the polymerization system on the IR spectra of the PAn obtained and on the spectral changes during HCl or  $\text{I}_2$  doping and  $\text{NH}_3$  undoping. (Author abstract) 13 refs.

Tang, Jinsong (Acad Sinica, Changchun, China); Jing, Xiabin; Wang, Baochen; Wang, Fosong. *Synth Met* v 24 n 3 May 1988 p 231-238.

**082852 ELECTROCHEMICAL BEHAVIOUR OF SOLUBLE POLYANILINE AND ITS CHROMATIC REACTION IN SOLUTIONS.** A chromatic reaction of soluble polyaniline (SPA) in various pH buffer solutions has been studied using UV-VIS spectroscopy. The colour change of SPA in solutions appears at pH 3-4 and an acid-base equilibrium is established, which could possibly be used as a new pH indicator. The electrochemical behaviour of SPA film coated on a glassy carbon electrode was investigated. The electrode reaction of SPA in DMSO (Dimethylsulfoxide) solvent was studied using rotating disk and rotating ring disk electrodes, indicating a quasi-reversible process controlled by the diffusion of SPA species in solution. (Edited author abstract) 12 refs.

Jiang, Rongzhong (Acad Sinica, Jilin, China); Dong, Shaojun. *Synth Met* v 24 n 3 May 1988 p 255-265.

**082853 INTERPRETATION OF THE FRAGMENTATION PATTERNS IN STATIC SIMS ANALYSIS OF POLYMERS. PART I. SIMPLE ALIPHATIC HYDROCARBONS.** A number of simple aliphatic hydrocarbon polymers have been studied by static SIMS. The low-mass positive spectra reflect structural differences in the polymeric structure, which result in characteristic fingerprint spectra. Unsaturation and differences in branching lead to very distinct spectral features which show promise for the application of SIMS as an analytical technique in polymer-related areas. An attempt is made to interpret the spectra in terms of molecular structure, fragmentation mechanisms and ion stabilities. The chemical nature of ion beam damage in PE and PP was studied to some extent. (Author abstract) 27 refs.

van Ooij, W.J. (Colorado Sch of Mines, Golden, CO, USA); Brinkhuis, R.H.G. *Surf Interface Anal* v 11 n 8 May 1988 p 430-440.

**082854 RAMAN SPECTRA OF POLYPYRROLE AND ITS 2,5- $^{13}\text{C}$ -SUBSTITUTED AND C-DEUTERATED ANALOGUES IN DOPED AND UNDOPED STATES.** Raman and optical absorption spectra were studied on electrochemically polymerized polypyrrole in as-polymerized doped (highly conductive), partially undoped and substantially undoped 'neutral' (insulating) states. Vibrational assignments were made on the basis of data of 2,5- $^{13}\text{C}$ -substituted and C-deuterated derivatives. The Raman result of the neutral polymer is consistent with the  $\alpha,\alpha'$ -linked all-s-trans coplanar and conjugated structure. In the as-polymerized polymer there exist both radical cation and dication in which the bond orders of  $\text{C}_3\text{C}_4$  and inter-ring CC are increased as compared to those in the neutral polymer. The structural distortion in the dication is greater than that in the radical cation. Changes in optical absorption and Raman spectra during reduction (undoping) were explained by the conversions of the dication to the radical cation and the radical cation to the neutral species. (Author abstract) 45 refs.

Furukawa, Y. (Tohoku Univ, Sendai, Jpn); Tazawa, S.; Fujii, Y.; Harada, I. *Synth Met* v 24 n 4 Jun 1988 p 329-341.

**082855 INTERFACIAL TENSION AND SURFACE HYDROPHILICITY IN SYSTEMS OF SOLID POLYMERS IN CONTACT WITH AQUEOUS SOLUTIONS.** The nondispersive part of the interfacial tension between polymer solids and aqueous solutions has been determined by contact angle measurements on photooxidized polystyrene (PS). It is shown from contact angle measurements in air and in octane that the expression for  $\gamma_{\text{saq}}$  includes a term that is proportional to  $\gamma_{\text{saq}}^n$  and not to  $\sqrt{\gamma_{\text{saq}}}$  as is often assumed. The proportionality factor is taken as an expression of the hydrophilicity of the surface. The development of oxidized surface groups was followed by ESCA. It is concluded that the degradation of PS upon UV curing includes an attack on the aromatic groups followed by a ring opening. The hydrophilicity shows a sharp increase at a certain oxidation level, which we interpreted to be due to the ring opening. (Author abstract) 30 refs.

Strom, Goran (Inst of Technology, Stockholm, Swed); Fredriksson, Monica; Klason, Tomas. *J Colloid Interface Sci* v 123 n 2 Jun 1988 p 324-338.

**082856 RHEO-OPTICAL FOURIER-TRANSFORM INFRARED SPECTROSCOPY OF POLYMERS: 14. SEGMENTAL ORIENTATION AND STRAIN-INDUCED CRYSTALLIZATION OF A POLY(ETHER URETHANEUREA) ELASTOMER.** The versatility and potential of rheo-optical Fourier-Transform infrared (FTIR) spectroscopy is demonstrated with reference to the characterization of segmental orientation in a poly(ether urethaneurea) elastomer. The rheo-optical data show that the soft and hard segments of the polymer deform by different orientation mechanisms. Thus, the soft segments exhibit an almost perfect reversibility of orientation and disorientation in loading and unloading cycles, whereas the deformation of the hard



segments is dominated by a significant reorganization of their morphology. Furthermore, rheo-optical FTIR spectroscopy provided an extremely sensitive tool for detecting the onset, progress and decay of strain-induced crystallization of the soft segments during the mechanical treatment of the elastomer. (Author abstract) 30 refs.

Siesler, H.W. (Univ Essen, Essen, West Ger). *Ber Bunsenges Phys Chem* v 92 n 5 May 1988 p 641-645.

**082857 POLY(N-BROMOACRYLAMIDE): A NEW POLYMERIC RECYCLABLE OXIDIZING AND BROMINATING REAGENT.** Poly(N-bromoacrylamide) was conveniently prepared from commercially available polyacrylamide and was developed as a new insoluble polymeric oxidizing and brominating reagent for organic substrates. The polymer was characterized by elemental analysis and IR spectra. The reagent, which was prepared by the reaction of potassium hypobromite with polyacrylamide, has a capacity of 5.2-5.7 mmol of bromine per gram. Alcohols were oxidized to the corresponding carbonyl compounds in near quantitative yields at room temperature with this reagent. The reagent was also used to brominate unsaturated and aromatic substrates in high yields. (Edited author abstract) 25 refs.

George, Benny K. (Univ of Calicut, Kerala, India); Rajasekharan Pillai, V.N. *Macromolecules* v 21 n 6 Jun 1988 p 1867-1870.

**082858 <sup>13</sup>C-NMR STUDY ON THE CHAIN TERMINAL STRUCTURE OF POLY-1, 3-PENTADIENE POLYMERIZED WITH RARE EARTH CATALYST.** The sequence distribution and the terminal structures of poly-1, 3-pentadiene chains obtained by rare earth catalyst and the effect of polymerization temperature on the microstructure of the polymer have been investigated by the <sup>13</sup>C-NMR method. According to experimental results, it was supposed that the terminal active growing chain of the polymer would be four types of anti- and syn- $\eta^3$ -allyl structures. When polymerization temperature was reduced, the content of cis-1,4-poly-1,3-pentadiene increases. It can be explained by isomerization between anti- and syn- $\eta^3$ -allyl. The process forming the trans-1,2 unit instead of the 3,4-unit was also described. (Author abstract) 6 refs.

Xie, Demin (Acad Sinica, Changchun, China); Gong, Zhi; Wang, Fosong. *Chin J Polym Sci (Engl Ed)* v 5 n 2 1987 p 109-113.

**082859 STUDY ON SEQUENCE DISTRIBUTION OF 3,4-POLYISOPRENE BY <sup>13</sup>C-NMR.** Isoprene can be polymerized with an Fe(acac)<sub>3</sub>-phen-AlEt<sub>3</sub> catalyst system into a polymer mainly containing a 3,4-unit and capable of crystallizing to some extent. The <sup>13</sup>C-NMR spectra of 3, 4-polyisoprene synthesized with an Fe-catalyst system were investigated, and the sequence distribution of cis-1,4 and 3,4-units was discussed. Results showed that the contents of cis-1,4, trans-1,4 and 3,4-units calculated from different carbon types were satisfactorily identical, indicating correct assignments of these peaks. (Author abstract) 8 refs.

Xie, Demin (Acad Sinica, Changchun, China); Sun, Qing. *Chin J Polym Sci (Engl Ed)* v 5 n 2 1987 p 114-119.

**082860 HOLE-BURNING EXPERIMENTS IN DOPED POLYMERS UNDER UNIAXIAL AND HYDROSTATIC PRESSURE.** The hole-burning technique makes possible the study of extremely small strain-induced shifts and broadenings of quasi-homogeneous optical lines of dye molecules in polymer matrices. The polymers polyethylene, polymethylmethacrylate and polystyrene were doped with free base phthalocyanine and investigated under unidirectional and hydrostatic pressure. Since the pertinent equations for pressure-induced shifts can be linearized at the small pressures used (<0.1 MPa), one can calculate values for the hydrostatic compressibility  $\kappa$  if one assumes that a  $R^{-6}$ -law governs the molecular interactions responsible for the solvent shift. The optically determined compressibility values agree with the mechanically measured values within 10-20%. (Author abstract) 30 refs.

Sesselmann, Th. (Univ Bayreuth, Bayreuth, West Ger); Richter, W.; Haarer, D. *J Lumin* v 36 n 4-5 Jan-Feb 1987 p 263-271.

**082861 ELECTRON DELOCALIZATION IN POLY(ANILINE).** The appropriate quantum-mechanical description for electron-conducting polymers hinges upon whether behavior is better explained with delocalized wave functions, the band model approach, or by localized states confined to small segments of the polymer. Previous electron spin resonance studies of poly(aniline) have suggested that the energy band description is more appropriate. The authors examine theoretically and experimentally the ESR, voltammetric, and spectroscopic properties of poly(aniline) and its shortest oligomer, N,N'-diphenyl-p-phenylenediamine. Using an empirical Hamiltonian matched to the oligomer's hyperfine structure, the authors find it possible to describe the properties of both oligomer and polymer, supporting the validity of the delocalized representation. (Edited author abstract). 34 refs.

Glarum, S.H. (AT&T, Murray Hill, NJ, USA); Marshall, J.H. *J Phys Chem* v 92 n 14 Jul 14 1988 p 4210-4217.

**082862 INFRARED STUDIES OF OPTICALLY EXCITED POLYDIACETYLENE.** Photo-induced absorption (PA) is observed for the polydiacetylene PDA-10H in the infrared which is found to be consistent with the photogeneration of charged bipolarons. No comparable PA is seen in PDA-TS, a result that is consistent with photo-excitation leading to the formation of triplet excitonic bipolarons. Persistent effects are observed for PA in PDA-10H indicating a long carrier lifetime due to trapping. Electron correlation is significant and shifts the electronic transitions to lower energy in PDA-10H so that overlap of electronic and vibrational transitions occurs. This overlap leads to strong anti-resonances in the PA due to electron-photon interaction. (Author abstract) 26 refs.

Pratt, F.L. (Univ of Oxford, Oxford, Engl); Wong, K.S.; Hayes, W.; Bloor, D. *J Phys D* v 20 n 11 Nov 14 1987, Pap Presented at the Polym Phys Group Meet on Electroact Polym, London, Engl, May 14 1987 p 1361-1366.

**082863 PHOTOLUMINESCENCE OF CONDUCTING POLYMER P3MT.** The photoluminescence spectra of conducting polymer P3MT with different doping densities and temperatures are reported and the photoluminescence mechanisms of P3MT are discussed. It is demonstrated experimentally that there are three kinds of radiative transitions, the direct interband transition, the recombination of exciton and radiative transition between bipolaron level and edge of band for the conducting polymer at excitation of 5145 Angstrom laser. The photoinduced bipolaron and the pinning effect of ionized dopant on bipolaron have been observed. 3 refs.

Yuan, Renhuan (Acad Sinica, China); Huang, Zhenchun; Tang, Wengguo; Li, Ziyuan; Zheng, Youdou; Shen, Xuechu. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 294-295.

## Spectrum Analysis

**082864 PMR-, IR-, AND UV-SPECTROSCOPIC STUDIES OF PRODUCTS OF REACTION OF DICYANDIAMIDE WITH FORMALDEHYDE, METHYLOL AND METHYLENE ETHER DERIVATIVES.** Amido- and amino-formaldehyde resins comprise an important class of polymers. The least investigated are the dicyandiamide-formaldehyde resins (DFR), whose use is promising for the preparation of hydrophobic, fireproof and other polymers. From the study of the spectra of DFR, certain conclusions can be made on their composition. Facts show that the polymerization of DFR proceeds mainly with the formation of methylene-ether bridges, and the methyl groups remain as the terminal groups. This is indicated by the high content of oxygen in the polymer - 26.6% (determined in a CHN-3 analyzer). 10 refs.

Trub, E.P.; Boitsov, E.N.; Mushkin, I. *J Appl Spectrosc* v 46 n 3 Mar 1987 p 281-285.

**082865 CALCULATION OF FREQUENCIES AND INTENSITIES IN THE IR ABSORPTION SPECTRUM OF POLY(TETRAFLUOROETHYLENE).** Among the vibrational spectra of polymers, the spectrum of poly(tetrafluoroethylene) (PTFE) is of special interest for theoretical analysis. Observed vibrational spectra of PTFE have a number of characteristics not yet satisfactorily explained. Together with the doubling of the IR bands at 640-625  $\text{cm}^{-1}$  and the Raman lines at 595-575  $\text{cm}^{-1}$  repeatedly discussed in the literature, we note the large half-width and complex shape of the absorption bands near 1210 (half-width about 52  $\text{cm}^{-1}$ ) and 520  $\text{cm}^{-1}$  (half-width of 25-35  $\text{cm}^{-1}$ ) and also the relation of the shape of these bands to the method of sample preparation. It is possible to enumerate a series of possible reasons for the appearance of wide bands in the polymer spectrum. For quantitative evaluation of the effect of the enumerated factors on the polymer spectrum. The frequencies and intensities in the vibrational spectra of the PTFE models were calculated. 14 refs.

Pirozhnaya, L.N.; Zubkova, O.B.; Gribov, L.A. *J Appl Spectrosc* v 46 n 3 Mar 1987 p 285-289.

**082866 MOLECULAR MOTIONS IN POLY(ETHYLENE OXIDE) SOLUTIONS.** The motions of solvent and solute molecules in solutions of poly(ethylene oxide) have been investigated by neutron inelastic scattering measurements. Both the concentration dependence and the influence of the molecular weight of the PEO molecules were studied. It is shown that there exists a strong concentration dependent interaction between a PEO molecule and the surrounding water which affects both the translational and the rotational motions of the water molecules. Thus there is a clear indication of the presence of a hydration shell around each PEO molecule within which the motions of the water molecules are strongly hindered. In carbon tetrachloride solutions the results indicate that there exists a weak interaction of hydrodynamic origin between solvent and solute molecules. (Author abstract) 37 refs.

Dahlborg, U. (Univ E. Kardelj, Ljubljana, Yugosl); Dimic, V.; Cvikel, B. *Phys Scr* v 37 n 1 Jan 1988 p 93-101.

**082867 FIR REFRACTIVE INDEX OF POLYMERS DETERMINED BY THE ABBE TECHNIQUE.** The FIR refractive index can be determined quite accurately using laser radiation and Abbe's prism technique. Experimental data for polyethylene and TPE are presented. The refractive indices turn out to be a good means for determining the density of the polymers. The refractive index of polyethylene is determined in the temperature range 4.2-300 K. (Author abstract) 10 refs.

Stuetzel, P. (Univ Wuerzburg, Wuerzburg, West Ger); Tegtmeyer, H.D.; Tacke, M. *Infrared Phys* v 28 n 2 Mar 1988 p 67-71.

**082868 OPTICAL ABSORPTION OF METAL-LOADED POLYMER FILMS PREPARED BY VACUUM EVAPORATION.** We have previously reported some properties of complex thin films prepared by co-evaporating polypropylene (PP) and metals so as to include of the order of 0.1 wt% of copper or gold. The gold-loaded films are less contaminated than copper. In the present work we have studied the optical absorption edges of thin PP films and films containing gold to see whether some estimate of the nature of the energy bands in vicinity of the absorption edge could be made. 9 refs.

Al-Ismael, S.A.Y. (Brunel Univ, Uxbridge, Engl); Horgan, C.A. *J Mater Sci Lett* v 7 n 2 Feb 1988 p 135-136.

**Stability** See Also MONOMERS—Polymerization; MONOMERS—Synthesis; POLYAMIDES—Synthesis; POLYVINYL CHLORIDE—Curing.



**082869 COMPUTER-AIDED MOLECULAR MODELING OF POLYMERS. III. ENTHALPY OF POLYMERIZATION AS A MEASURE OF STABILITY.** A formalism of computational chemistry methods is presented to estimate the stability of vinyl polymers. This approach takes into account changes in electronic energy upon polymerization using quantum mechanical methods and contributions of the conformational energetics of the polymerized state using a molecular mechanics force field. A work term, PAV, based upon the molecular volume difference between the monomer and the reactant, is shown to be negligible. (Edited author abstract) 14 refs.

Mabilia, Massimo (Intersoft Inc, Lake Forest, IL, USA); Pearlstein, R.A.; Koehler, M.G.; Hopfinger, A.J. *J Macromol Sci Phys* v B26 n 4 Dec 1987 p 495-508.

**082870 APPLICATION OF CONTINUOUS THERMODYNAMICS TO THE STABILITY OF POLYMER SYSTEMS. II.** A determinant criterion for the critical state in solutions and mixtures of polydisperse polymers is established within the general framework of Gibbs theory. The treatment continues an earlier paper by considering more general Gibbs free energy relations: The function replacing the  $\chi$ -term in the classic Flory-Huggins equation is permitted to depend on a finite number of moments of the polymer distribution(s) so as to embrace most Gibbs free energy relations of practical use. The new criterion leads to a very large reduction of computer time and of needed storage capacity compared to the traditional Gibbs determinant criterion. (Edited author abstract) 14 refs.

Beerbaum, Sibille (Wolfgang Ratke Pedagogical Univ, Koethen, East Ger); Bergmann, Joachim; Kehlen, Horst; Ratzsch, Margit T. *J Macromol Sci Chem* v A24 n 12 Dec 1987 p 1445-1463.

**082871 THERMAL STABILITY AND KINETICS OF DECOMPOSITION OF POLYPHENYLSILSES-QUIOXANES AND SOME RELATED POLYMERS.** The thermal stability and the mechanism and kinetics of decomposition of the ladderlike polymer polyphenylsilses-quioxane (PPS) and some related polyorganosiloxanes were studied by means of thermal analysis, pyrolysis GC, GC-MS, and other methods. The experimental results show that ladderlike PPS is thermally more stable than the analogous single chain polymer PDPS. Above 505°C, PPS decomposes by mechanisms of phenyl group elimination and carbonization. The apparent activation energy of the decomposition of PPS is about 270 kJ/mol, which is much higher than those of other polyorganosiloxanes studied. Copolymers of PPS with PDPS and PDMS have intermediate thermal properties. MW and MWD have a negligible effect on the stability of PPS while chlorination lowers the heat-resistant properties significantly. (Author abstract) 11 refs.

Zhang, Xinseng (Acad Sinica, Beijing, China); Shi, Lianghe; Li, Shuqing; Lin, Yizhen. *Polym Degradation Stab* v 20 n 2 1988 p 157-172.

**082872 ESTIMATE OF THE STABILIZATION ENERGY OF CATION RADICALS FORMED IN POLY(N-VINYLCARBAZOLE) AND ITS DIMER MODEL COMPOUNDS BY AN ION RADICAL TRANSFER METHOD.** The stabilization energies of the carbazole cation radicals were estimated by the ion radical transfer method. The carbazole cation radicals ( $Cz^+$ ) were formed photochemically in poly(N-vinylcarbazole) (PVCz) and its dimer model compounds, and they were stabilized by the interaction with neighboring carbazole ( $Cz$ ) chromophores. Due to the stabilization, the  $Cz$  cation radical in PVCz is not transferred to a cation radical acceptor, 4-(dimethylamino)styrene (DMASt), which has a lower oxidation potential than the  $Cz$  chromophore, whereas the cation radical of monomeric N-ethylcarbazole is transferred to DMASt easily. The stabilization energies of  $Cz^+$  were evaluated from the rate constants of cation radical transfer to DMASt. (Edited author abstract) 42 refs.

Tsujii, Yoshinobu (Kyoto Univ, Kyoto, Jpn); Tsuchida, Akira; Yamamoto, Masahide; Nishijima, Yasunori. *Macromolecules* v 21 n 3 Mar 1988 p 665-670.

**082873 THERMALLY STABLE POLYMERS BY CONDENSATION OF DIPHENOLS WITH GLYOXAL.** Polycondensation of bisphenol A, hydroquinone, or dihydroxynaphthal with glyoxal using methanesulphonic acid as condensing agent leads to polymeric materials having linear and ladder structure and high thermal stability. These polymers were characterized by NMR and TG. Oligomers (from dimer to tetramer) were isolated by GPC and their structures characterized. (Author abstract).

Maravigna, Pietro (Univ di Catania, Catania, Italy). *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2475-2485.

**Stabilizers** See Also POLYOLEFINS—Degradation; POLYOLEFINS—Stability.

**082874 MAKROMOLEKULARNI STABILIZATORNI POLYMERU; VYZNAM, TYPY, VYUZITELNOST.** [Macromolecular Stabilizers of Polymers; Importance, Types, and Usage]. The state-of-the-art of macromolecular stabilizers is described. Reasons for their use, synthesizing possibilities, and typical examples are given. Attention is drawn to some unsolved problems and obstacles hindering their wider usage in the industry. (Edited author abstract) In Czech. 10 refs.

Pospišil, Jan (CASV, Prague, Czech). *Plasty Kauc* v 24 n 6 Jun 1987 p 161-164.

**082875 BADANIA NAD STABILIZACJĄ POLITRIOKSANU PRODUKCJI KRAJOWEJ.** [Studies on the Stabilization of Polish-Made Polytroxane]. The effect of different amounts of Irganox 259 (a phenolic stabilizer) and of Irganox 259/Dicyanodiamide mixtures of various compositions on the thermal stability of a trioxane/dioxolane copolymer of POM type has been determined at 200, 220 and 240°C. The optimum composition of stabilizers mixtures has been established. The effect of commercial UV-stabilizers (Tinuvin 326 and Dastib 846 S) on changes in mechanical strength properties of thermally stabilized POM after accelerated ageing for 200, 400, and 600 h has also been determined and advantageous action of these additives confirmed. (Edited author abstract) In Polish. 11 refs.

Burno, Ewa (Inst Chemii Przemysłowej, Warsaw, Pol); Bukowski, Andrzej; Kosinska, Wanda. *Polimery* v 32 n 7 Jul 1987 p 277-281.

**082876 DETERMINATION OF SMALL AMOUNTS OF ORGANIC HYDROPEROXIDES IN THE PRESENCE OF HINDERED AMINE LIGHT STABILIZERS AND THEIR NITROXYLS.** A method for the quantitative determination of hydroperoxide (ROOH) in the presence of hindered amine light stabilizers (HALS) and/or their nitroxyl free radical derivatives has been elaborated. The method is based on the quantitative reduction of hydroperoxides by triphenyl phosphine. The resulting compounds (alcohols) are then determined by GLC using the internal standard technique. The method has been tested on the hydroperoxides derived from 2,4-dimethylpentane. Its sensitivity and reproducibility appear to be comparable with other methods for ROOH determination but, unlike the latter, it has the advantage that its results are not influenced by the presence of HALS and/or their nitroxyl radical derivatives in the analyzed medium. (Author abstract) 23 refs.

Sedlar, J. (CNRS, Strasbourg, Fr); Marchal, J. *Polym Degradation Stab* v 19 n 3 1987 p 251-262.

**082877 POLYMER DURABILITY - AN ESSENTIAL DESIGN PARAMETER.** The word 'plastic' has been a byword for a lack of durability in products, yet modern polymers often are so durable as to defy degradation in the environment. With these facts in mind, the following topics are discussed: polymer materials design; antioxidants and stabilizers; mechanisms of antioxidant action; physical requirements of antioxidants and stabilizers; polymer-bound antioxidants; and durability in perspective. 26 refs.

Scott, Gerald (Aston Univ, Birmingham, Engl). *Chem Ind (London)* n 24 Dec 21 1987 p 841-845.

**082878 PHOTOSTABILIZING EFFECT OF 5-HYDROXY-3-PHENYL-AMINO-1-PHENYL-3,5-DIHYDROBENZENE DERIVATIVES IN POLYCHLOROPRENE.** The photostabilization of polychloroprene in the presence of four derivatives of 5-hydroxy-3-phenylamino-1-phenyl-3,5-dihydrobenzene was studied. The inhibitory activity of the added compounds is proportional to their extinction coefficient values. The addition of singlet oxygen quenchers such as  $\beta$ -carotene reduces the rate of degradation of polymer solutions. This means that singlet oxygen may involve the photooxidation process. The influence of the most effective stabilizer was also examined using Differential Scanning Calorimeter (DSC) technique; the obtained results indicate the photostabilizing effect of it. (Author abstract). 6 refs.

Abdel-Razik, E.A. (Mansoura Univ, Mansoura, Egypt). *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2359-2367.

**082879 POLYMER STABILISATION AND DEGRADATION: PROBLEMS, TECHNIQUES AND APPLICATIONS.** This conference proceedings contains 19 papers of which 9 papers appear in abstract form only. The papers cover polymer degradation and stabilization. Some of the topics discussed include ozone resistance of rubber and plastics; thermoset degradation; polyolefin oxidation; plastics photodegradation; weathering of paints; polypropylene degradation; and polyacetylene stabilization. Other topics covered are coloring reduction of plastics; antioxidants; stabilizers; biocatalyst immobilization; and medical applications of polyesters. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10210 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *Polym Stab and Degrad: Probl, Tech and Appl, Manchester, Engl, Sep 18-20 1985* Publ 1985 var pagings.

**Strain** See Also PLASTICS—Drawing and Stamping; POLYURETHANES—Mechanical Properties; RUBBER—Elasticity.

**082880 CRITICAL STRAIN TO DEAD BEND.** This letter is an attempt to show the relationship between fibrillar morphology, compressive weakness, shear banding, inelastic deformation, and dead bending. In doing so a model for estimating fibril lengths is presented. The model provides a reasonable and semi-quantitative description of the requirements for dead bending - well-defined fibrils with diameters up to a few hundred micrometers and little lateral interaction. The model also suggests the relationship of shear banding to the onset of compressive inelastic deformation in fibrillar polymers. 8 refs.

Warner, S.B. (Georgia Inst of Technology, Atlanta, GA, USA). *J Mater Sci Lett* v 6 n 8 Aug 1987 p 951-952.

**082881 ANALYSIS OF PLANE-STRAIN NECK PROPAGATION IN VISCOPLASTIC POLYMERIC FILMS.** The influence of material strain-rate sensitivity on neck propagation during the cold drawing of polymeric films is examined. The entire load-deformation behavior of a rectangular specimen as well as the evolution of the specimen profile and the stress and strain distributions at various stages of the deformation process are computed. The numerical analysis is based on the implementation of a finite-element scheme via the virtual work principle for elastic-viscoplastic material behavior. Parametric studies are also performed to investigate the effects of various variables on necking and neck propagation. Comparisons with rate-independent material response are also presented. (Author abstract) 7 refs.

Tugcu, P. (Univ de Sherbrooke, Sherbrooke, Que, Can); Neale, K.W. *Int J Mech Sci* v 29 n 12 1987 p 793-805.



**082882 NONLINEAR CONSTITUTIVE EQUATION FOR VISCO-ELASTIC DAMAGE MEDIA AND DEWETTING DAMAGE MODEL FOR HIGHLY FILLED POLYMERS.** A nonlinear constitutive equation is presented from the point of view of damage mechanics for visco-elastic damage media. A composite solid propellant with gradual dewetting damage is studied under the condition of uniaxial tension with constant strain rate. The calculated theoretical results are in fairly good agreement with experimental ones. (Edited author abstract) 20 refs. In Chinese.

Shen Huairong (Univ of Natl Defense Technology, China). *Ku Ti Li Hsueh Hsueh Pao* n 1 1987 p 41-47.

**082883 TORSIONAL POTENTIAL AND STRAIN ENERGY DISTRIBUTION IN AN EXTENDED CHAIN UNDER STRESS.** Torsional potential  $V(\phi)$  for the single bond transformation in an extended hexadecane, subjected to elongation, has been determined by molecular mechanics calculations. The stored elastic energy significantly modifies the potential  $V(\phi)$ , the conformational energies and the barriers of transition. Apart from the 'soft' torsional coordinate, elastic energy is also dissipated considerably by bond stretching and angle bending. Maximal variations of the valence coordinates occur in the vicinity of the torsional defect and dampen along the chain. At higher elongation, the gauche minimum on the potential  $V(\phi)$  disappears and the calculations predict the abrupt gauche to trans transition. The energetics of torsion of a deformed chain are compared with the experimental data on the hydrodynamic extension of polymers in dilute solution by elongational flow. The calculations also provide details of a single bond transformation mechanism at conformational interconversions in a long chain, proposed by E.Helfand. (Author abstract) 15 refs.

Bleha, T. (Slovak Acad of Sciences, Bratislava, Czech); Gajdos, J. *Colloid Polym Sci* v 266 n 5 May 1988 p 405-410.

**Stresses** See Also PLASTICS FILMS—Structure; POLYSTYRENES—Solutions.

**082884 THERMAL STRESS IN POLYMER SPHERULITES.** The aim of this letter is to show that the curvilinear anisotropy of the spherulite causes a peculiar thermal stress distribution. To make the problem tractable it is assumed that in cases where the spherulites are equiaxed, the actual deformation due to thermal strain can be deduced by analyzing the deformation within a prototype spherical 'test' spherulite. The 'test' spherulite is embedded in an isotropic matrix to which is assigned the bulk polymer properties. Within an unconstrained spherically anisotropic solid, thermal stresses will arise. These thermal stresses may be partially responsible for fatigue cracking which has been observed in pipelines made of semi-crystalline polymers. These materials are susceptible to corrosion cracking which may be accelerated by hydrostatic tensile stresses. 7 refs.

Dryden, J.R. (Univ of Western Ontario, London, Ont, Can). *J Mater Sci Lett* v 6 n 10 Oct 1987 p 1129-1130.

**082885 STUDIES ON BIREFRINGENCE AS A FUNCTION OF STRAIN IN CROSSLINKED POLYMERS UNDER CREEP CONDITIONS.** It is shown that the interconnection between the strain and birefringence for certain crosslinked polymers under creep conditions is described by a linear equation. In the case of the polymers studied, the change in optical sensitivity to the stress differs as between the time and temperature. The authors consider the results in connection with the isochronic thermo-optical curves for the total  $C_{\sigma}$  constructed by treatment of a family of creep curves in the region of times of existence of a provisionally equilibrium state and additional branch 3' reflecting the change in the total  $C_{\sigma}$  in the specimen during cooling. Apart from generally known information which follows from these curves they are also useful for plotting the elastic character of the stress  $C_{\sigma}$  against the temperature. (Edited author abstract) 12 refs.

Zuyev, B.M. (USSR Acad of Sciences, USSR); Chistyakov, Ye.V.; Filippova, A.P.; Arkhireyev, O.S. *Polym Sci USSR* v 28 n 10 1986 p 2472-2479.

**082886 STRESS RELAXATION AND CHEMICAL KINETICS IN PAIRWISE ASSOCIATING POLYMERS.** Within the framework of the tube model, a theoretical study is made of the dynamics of a concentrated system of long flexible macromolecules, each of which has a single functional end group that can associate with another such group to make a dimer. When the dissociation time of the dimer ( $T_{\text{break}}$ ) is very large compared with  $T_d$ , the disengagement time of an undimerized chain (or 'monomer'), the zero-shear viscosity of the system approaches  $\eta = (16q + 1)\eta_0/(2q + 1)$ , with  $\eta_0$  the viscosity of pure monomers and  $q$  the equilibrium ratio of dimers to monomers. (Edited author abstract) 16 refs.

Cates, M.E. (Univ of California, Santa Barbara, CA, USA). *Macromolecules* v 21 n 1 Jan 1988 p 256-259.

**082887 EFFECT OF STRESSES ON POLYMER OXIDATION. QUANTITATIVE ASPECTS. II. PLASTICS.** The authors examine semicrystalline polymers in a highly elastic state, viz., high-density polyethylene (HDPE), low-density polyethylene (LDPE), isotactic polypropylene (PP), polyamides of different chemical structure, PE/PP mixtures, and a few others. Besides, data for polymers in the glassy state will also be presented, although they are of lesser interest in regard of the effect of structural strains on reactivity because of the long relaxation times involved. Also analyzed is the effect of stresses on the structural parameters and properties of polymer. To take into account these data, it is possible to describe quantitatively the peculiarities of the chemical reaction kinetics in stressed polymers. Experimental results show that the nature of structural stresses are the same in both small and large molecules. Therefore, the regularities obtained for the model objects should be valid for more complicated polymer systems. Naturally, appropriate corrections must be made to take into account the specific state of the polymers. 96 refs.

Popov, A.A. (USSR Acad of Sciences, Moscow, USSR); Zaikov, G.E. *J Macromol Sci Rev Macromol Chem Phys* v C27 n 3-4 1987-1988 p 343-377.

**082888 EFFECT OF STRESSES ON POLYMER OXIDATION. QUANTITATIVE ASPECTS. III. KINETICS.** The main purpose of this review is consideration of the chemical reaction kinetics in stressed polymers on the quantitative level and description of the reasons for and mechanism of stress effect on kinetics. Therefore we compare the stress effect on the reaction kinetics of model and polymer compounds and take into account variations of structural, physical, and dynamic parameters in stressed polymers. It is shown that the stresses applied during the experiment may considerably affect the initial morphology of the polymer specimen. The primary effect is irreversible deformation involving either a complete change of the initial submolecular structure (from spherulitic to fibrillar) or some alteration of the existing structure (post-orientation). One consequence is the variation of the permeability and mobility parameters. 139 refs.

Popov, A.A. (USSR Acad of Sciences, Moscow, USSR); Zaikov, G.E. *J Macromol Sci Rev Macromol Chem Phys* v C27 n 3-4 1987-1988 p 379-457.

**082889 COMPUTER SIMULATION OF POLYMERIC MATERIALS. I. STRESS-STRAIN BEHAVIOR.** A model of polymeric materials has been developed that includes many of the features of condensed-phase polymer chain dynamics, central among them chain relaxation via conformational motion. The model consists of a number of chains of particles that are connected by bonds with multiwelled potentials to approximate the energetics of conformational motion. Interactions between particles on adjacent chains are modeled by short range repulsive potentials. We have examined the stress-strain behavior of the model using molecular dynamics simulations and find qualitative agreement with the observed experimental behavior of polymeric materials. (Author abstract) 6 refs.

Cook, Robert (Lawrence Livermore Natl Lab, Livermore, CA, USA). *J Polym Sci Part B* v 26 n 7 Jul 1988 p 1337-1347.

**082890 ENERGY STORAGE IN POLYMER CHAINS UNDER STRESS.** The local conformation and storage of energy in individual polymer chains during a deformation of a bulk polymer sample are examined by the computer simulation of a relatively simple model. It is shown that as the interaction between the chain atoms and surrounding medium increases, rotational angle motion is suppressed during the deformation, and large amounts of energy are stored in backbone bond angle and bond length distortions. The relationship of this phenomenon to  $T_g$  and the implications for chain relaxation are discussed. (Author abstract) 17 refs.

Cook, Robert (Lawrence Livermore Natl Lab, Livermore, CA, USA). *J Polym Sci Part B* v 26 n 7 Jul 1988 p 1349-1359.

**Structure** See Also CELLULOSIC RESINS—Thermal Effects; COMPOSITE MATERIALS—Processing; COPOLYMERS—Radiation Effects; COPOLYMERS—Thermodynamic Properties; COPOLYMERS—Viscosity; ELASTOMERS—Mechanical Properties; ELECTRIC BATTERIES—Performance; EPOXY RESINS—Structure; FILLERS—Concentration; FLOW OF FLUIDS—Theory; INTERPENETRATING POLYMER NETWORKS—Physical Properties; MEMBRANES—Permeability, Mechanical; MONOMERS—Polymerization; PLASTICS FILMS—Structure; POLYACENES—Phase Diagrams; POLYCARBONATES—Anisotropy; POLYCARBONATES—Solutions; POLYETHYLENES—Chlorination; POLYETHYLENES—Mechanical Properties; POLYETHYLENES—Structure; POLYOLEFINS—Physical Properties; POLYPROPYLENE—Spectroscopic Analysis; POLYPROPYLENE—Spectrum Analysis; POLYURETHANES—Morphology; POLYURETHANES—Spectroscopic Analysis; POLYVINYL CHLORIDE—Degradation; VAPORS—Adsorption; VINYL RESINS—Thermo-oxidation.

**082891 FORM OF THE LINE OF PROTON MAGNETIC RESONANCE AND THE IRREGULARITY OF THE NETWORK STRUCTURE OF CROSSLINKED POLYDIMETHYLSILOXANES.** An analysis is made of the form of the PMR signal of weakly crosslinked polydimethylsiloxanes swelling in a solvent. The line of complex form observed may be represented by the superposing of two signals. One belongs to the chains of the network the degree of crosslinking of which determined by the PMR method corresponds to the degree of crosslinking determined from the equilibrium swelling of the sample. The narrower component apparently corresponds to a sparse network with a mean distance between nodes greater by at least one order than for the first. The free ends of the macromolecules must contribute to the second signal. With the approach it is possible to evaluate the fraction of macromolecules responsible for the two signals. (Author abstract) 8 refs.

Lifshits, M.I. (Leningrad Technological Inst, USSR); Katurkin, N.A.; Klochkov, V.I. *Polym Sci USSR* v 28 n 6 1986 p 1326-1331.

**082892 STRUCTURE AND SPECIAL FEATURES OF THE SWELLING AND TITRATION OF POLYCOMPLEXES - PRODUCTS OF THE MATRIX POLYCONDENSATION OF UREA AND FORMALDEHYDE ON POLYACRYLIC ACID.** The structure of urea-formaldehyde polymer formed as a result of the matrix polycondensation of urea and formaldehyde in the presence of polyacrylic acid depends on the pH. At pH > 3.8, its chains contain mainly N,N'-substituted fragments or urea (as when there is no matrix), and at pH < 3.8, an appreciable amount of N,N'-substituted fragments. The effect of the stability of the complex formed between the growing chain and the matrix on the structure of the daughter chain formed as a result of the matrix polyreaction is discussed. The kinetics of the swelling and titration of polycomplexes of polyacrylic acid with urea-formaldehyde are studied, and it is shown that



there are essential differences in the behavior of polycomplexes obtained at pH values above and below 3.8. (Author abstract) 9 refs.

Litmanovich, A.A. (Moscow Automobile-Road Inst, USSR); Markov, S.V.; Papisov, I.M. *Polym Sci USSR* v 28 n 6 1986 p 1417-1426.

#### 082893 TRY LIQUID CRYSTAL POLYMERS.

Physical properties and applications are presented for liquid crystal polymers, or LCPs, which are made of rigid, rod-like ordered molecules that maintain a crystalline order even on melting. They can be classified by the type of molecular orientation that they display, either nematic (crystals are all aligned in the same direction but in random order) or smectic (crystals are all aligned in the same direction and are in distinct layers). LCPs have dimensional stability that is superior to other high-performance engineering plastics, thermoset epoxy, and ceramics. The tensile strength of LCP compounds actually increases at reduced thicknesses because of orientation effects. It is shown that their features make metal and thermoset replacement and displacement of traditional engineering resins both feasible and cost-effective.

Dole, John R. *CHEMTECH* v 17 n 4 Apr 1987 p 242-245.

#### 082894 FORMATION OF SUPRAMOLECULAR STRUCTURES IN AMORPHOUS POLYMERS.

A scheme of the formation of the elements of the supramolecular structure of polymers on the basis of the Lifshits theory of the 'coil-globule' transition is proposed and analyzed. The scheme helps to explain a number of phenomena observed experimentally during the formation of polymer bodies from solutions (the influence of the quality of the solvent on the properties, plasticization and antiplasticization, etc.) and to predict ways of obtaining polymer bodies with the desired structure and properties. (Author abstract) 12 refs.

Matveyev, Yu.I. (Kuibyshev Engineering-Construction Inst, Moscow, USSR); Askadskii, A.A. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1518-1527.

#### 082895 COMPARATIVE STUDY OF PROPERTIES OF POLY(IMIDOPHENYLQUINOXALINES) AND POLY(AMIDOPHENYLQUINOXALINES).

Mechanical and thermal properties have been compared for two pairs of isomeric poly-(imidophenylquinoxalines) and poly(amidophenylquinoxalines), the polymers of each pair differing in the localization of phenyl substituents in the side groups. The chemical structure affects the deformation and ultimate characteristics owing to the fact that specific interaction between the phenylquinoxaline groups are realized between adjacent macromolecules in one polymer but inside the repeat unit in the second polymer; as a result, the deformation parameters are worsened and the glass-transition temperature is lowered in the second instance. (Author abstract) 5 refs.

Krongaus, Ye.S. (USSR Acad of Sciences, USSR); Belomoina, N.M.; Askadskii, A.A.; Kazantseva, V.V.; Bychko, K.A.; Slonimskii, G.L.; Korshak, V.V. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1639-1644.

#### 082896 EFFECT OF CHEMICAL STRUCTURE AND CRYSTALLINITY ON SORPTION, DIFFUSION AND CHEMICAL STABILITY OF POLYURETHANEACETALS.

The diffusion of water in non-isocyanate polyurethaneacetals (PUA) of various kinds and compositions has been studied. The direct relationship between the composition of polymers, their degree of crystallinity, morphology and diffusional characteristics has been demonstrated. It has been shown that by changing the polymer composition one can obtain hydrated polymer systems of every type, hydrophobic, hydrophilic and moderately hydrophilic. The kinetics of hydrolytic degradation of PUA in HCl solutions (pH=0.1) between 20 and 75°C has been investigated. Hydrolysis of acetal bonds has been found to occur in the amorphous phase of a polymer sample, which is mostly formed by the fragments of urethane glycol. The influence of morphology on PUA diffusional characteristics and

their stability to hydrolysis has been determined. It has been shown that the physico-chemical properties of PUA can be regulated without the introduction of new compounds. (Author abstract) 19 refs.

Pchelintsev, V.V. (S.V. Lebedev All-Union Scientific & Research Inst of Synthetic Rubber, Leningrad, USSR); Sokolov, A.Yu.; Zaikov, G.E. *Polym Degradation Stab* v 19 n 2 1987 p 125-134.

#### 082897 POLYMER COMPLEXES STABILIZED THROUGH HYDROGEN BONDS. INFLUENCE OF 'STRUCTURE DEFECTS' ON COMPLEX FORMATION: VISCOMETRY AND FLUORESCENCE POLARIZATION MEASUREMENTS.

The structure of polymer complexes stabilized through hydrogen bonds can be much influenced by the presence of nonactive groups (structure defects) on the polymer chains. In this paper, two very simple homopolymer/copolymer systems are studied: the homopolymer is a polybase, polyoxyethylene (PEO) or polyvinylpyrrolidone (PVP), and the copolymer a partially neutralized poly(acrylic acid) (PAA). The acrylate groups on PAA chain behave as structure defects. Viscometry provides information about macroscopic structure of polymer complex in solution while fluorescence polarization is especially adapted for the study of the local mobility of polymer chains. Two kinds of structure are found: the first one is compact and implies a low viscosity of the mixture, eventually precipitation occurs. The second one is a highly branched structure, close to a gel, which leads to a very high increase in viscosity. (Edited author abstract) 21 refs.

Iliopoulos, I. (Univ Pierre et Marie Curie, Paris, Fr); Halary, J.L.; Audebert, R. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 275-284.

#### 082898 NETWORK CHARACTERIZATION OF A POLYFUNCTIONAL CROSSLINKED SYSTEM.

In this paper a method proposed recently by D.R. Miller and C.W. Macosko is used for calculation of the network structure of a polyfunctional amine polymerizing with a bifunctional epoxy resin. Finite chain probabilities are derived for amine functionalities, taking the values of 5 and 6. The values of  $v_c$  derived by this method are tested with those obtained from the equation for rubber elasticity. Some further assumptions for networks with short chains are made for both this method and the classical theory of rubber elasticity. A satisfactory approximation between theoretical and experimental values of  $v_c$  is then obtained. (Edited author abstract) 16 refs.

Spathis, G. (Nat'l Technical Univ of Athens, Athens, Greece); Kontou, E.; Theocaris, P.S. *J Macromol Sci Phys* v B26 n 4 Dec 1987 p 509-524.

#### 082899 STRUCTURE OF ONE CRYSTAL MODIFICATION OF POLY(3,3-DIETHYL OXETANE).

The determination of the crystalline structure of one of the two forms of poly(3,3-diethyl oxetane) detected by calorimetric and X-ray analysis is described. The unit cell is monoclinic with parameters:  $a=1.333(7)$  nm,  $b=0.577(2)$  nm,  $c$  (fiber axis)= $0.474(2)$  nm and  $\gamma=91.1(5)^\circ$ . After computerized refinement, the final model has a crystallographic R-value of 0.18. The molecular conformation is a planar zigzag, and two chain segments pass through the unit cell. The chain conformation and the packing of chains are discussed in detail and compared with other polyoxetanes. (Author abstract) 9 refs.

Gomez, M.A. (Univ of Bristol, Bristol, Engl); Atkins, E.D.T.; Upstill, C.; Bello, A.; Fatou, J.G. *Polymer* v 29 n 2 Feb 1988 p 224-228.

#### 082900 STRUCTURE OF POLY(P-PHENYLENE SULPHIDE).

We have examined the unit-cell structure of the import high-strength polymer, poly(p-phenylene sulfide) (PPS); this has recently been in dispute, with two different models proposed from oriented and unoriented polycrystalline specimens, respectively. Having obtained single crystals of PPS from solution and from thin films of the melt (the latter in both flat-on and edge-on orientations), we determined the lattice dimensions of the orthorhombic unit cell using electron diffraction. These

are  $a=8.68$  Å,  $b=5.66$  Å and  $c=10.26$  Å, in agreement with the original model based upon alternating  $\pm 45^\circ$  inclinations of the phenyl rings to the plane of the sulfur bonds. (Edited author abstract) 15 refs.

Lovinger, Andrew J. (AT&T Bell Lab, Murray Hill, NJ, USA); Padden, F.J. Jr.; Davis, D.D. *Polymer* v 29 n 2 Feb 1988 p 229-232.

#### 082901 MECHANICAL AND DIELECTRIC RELAXATIONS OF POLY(HYDROXY ETHERS): 1. LOW-TEMPERATURE RELAXATIONS.

Mechanisms for the low-temperature relaxations were investigated for poly(hydroxy ethers) prepared by the polyaddition reaction of diglycidyl ethers with diphenols. Two relaxations, denoted  $\beta$  and  $\beta'$ , are observed at  $-70$  and  $+40^\circ\text{C}$  (for a frequency of approx. 1 Hz), respectively. It is revealed by comparing the mechanical relaxation with the dielectric relaxation that the  $\beta$  relaxation is a complex relaxation, that is, the overlap of the relaxation of hydroxy ether segment with that of other parts in the polymer chain, and that the  $\beta'$  relaxation is due to the motion of the phenylene group in the polymer chain. In the acetylated poly(hydroxy ethers), the relaxation of the hydroxy ether segment disappears and a new relaxation due to the motion of the acetylated segment appears near  $0^\circ\text{C}$ . This new relaxation is superimposed upon the  $\beta'$  relaxation. (Author abstract) 30 refs.

Ochi, Mitsukazu (Kansai Univ, Suita, Jpn); Kageyama, Hiroyuki; Shimbo, Masaki. *Polymer* v 29 n 2 Feb 1988 p 320-324.

#### 082902 CHANGES IN THE SEGMENTED POLYETHERAMIDOURETHANE STRUCTURE UNDER THE ACTION OF POLAR LOW-MOLECULAR WEIGHT LIQUIDS.

The paper gives the results of a study of changes occurring in the domain structure of segmented polyetheramidourethane under the action of low-molecular weight liquids (alcohols, ketones) that are subsequently evaporated. Orientational characteristics of the treated films were determined from the dichroism of characteristic bands in the IR spectra ( $\nu_{C=O}$  for self-associated amide groups and  $\nu_{CH_2}$ ). It was found that such treatment results in the orientation of rigid segments changing from positive (horizontal to the stretching direction) to negative (perpendicular to the stretching direction). (Edited author abstract) 12 refs.

Laptii, S.V. (UkrSSR Acad of Sciences, USSR); Kercha, Yu.Yu.; Lipatov, Yu.S.; Gaiduk, R.L.; Vatulov, V.N. *Polym Sci USSR* v 28 n 10 1986 p 2420-2428.

#### 082903 CONFORMATION AND OPTICAL ANISOTROPY OF SHORT CHAIN MOLECULES WITH MESOGENIC SIDE GROUPS.

Translational diffusion, sedimentation, characteristic viscosities and flow birefringence of samples and fractions of new comb-like polymers - series of alkoxyphenylacryloylox-ybenzoates - have been investigated. Relations have been obtained linking the molecular mass with viscosity, diffusion and sedimentation for polymethyl-phenyl-n-acryloylbenzoate. The Kuhn segments and the hydrodynamic diameter of the molecules have been determined. The value of the optical anisotropy of the segment of the macromolecules studied depends on the length of the chain side group and reflects the high intramolecular orientation order determined by the interaction of the mesogenic side groups. 12 refs.

Shtennikova, I.N. (USSR Acad of Sciences, USSR); Korneyeva, Ye.V.; Kolbina, G.F.; Bushin, S.V.; Smirnov, K.P.; Hardy, D.; Cser, F.; Nytrai, K. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2768-2776.

#### 082904 $T_{1\rho}$ FROM THE TEMPERATURE DEPENDENCE OF CARBON-13 NMR CORRELATION TIMES $\tau_c$ .

We demonstrate that carbon-13 NMR average correlation times reach a visibly apparent asymptotic limit,  $(T/T_g)_{as}$  for 9 amorphous polymers and 4 semicrystalline polymers. The average value of  $T_c/T_g$  is 1.21, where  $T_c$  is the carbon-13 NMR collapse tempera-



ture. A linear correlation of  $T_c$  or  $T_{as}$  against  $T_g$  is demonstrated. This correlation can be used to define  $T_g$  in crystalline polymers if their  $T_c$  is known. (Edited author abstract) 26 refs.

Boyer, Raymond F. (Michigan Molecular Inst, Midland, MI, USA). *J Polym Sci Part B* v 26 n 4 Apr 1988 p 893-910.

**082905 STRUCTURE OF THE ENZYME-RESISTANT FRACTION OF TUSSAH SILK (ANTHRAEA PERNYI) FIBROIN.** This paper deals with the structural characteristics of the chymotrypsin-resistant and phosphatase-resistant fractions obtained by the action of these enzymes on tussah fibroin in solution. The relationship between the amount of the enzyme-resistant fraction and its chemical stability is also discussed. The results indicate that the enzyme-resistant fractions consist mainly of  $\alpha$  helix and  $\beta$  structures arising directly from the corresponding conformation of original tussah fibroin and that the  $\alpha$  helix is characterized by high chemical and thermal stability, regardless of the conditions of preparation and treatment, including enzyme treatment, thermal treatment, and immersion in methanol. 11 refs.

Tsukada, M. (Ministry of Agriculture, Forestry, & Fisheries, Tsukuba, Jpn). *J Polym Sci Part B* v 26 n 4 Apr 1988 p 949-952.

**082906 SOME APPLICATIONS OF GRAPH THEORY TO THE STUDY OF POLYMER CONFIGURATION.** The spatial configuration of polymer molecules in an Euclidean space depends on the adjacency of their units. The configuration dependent properties of the so called Gaussian polymer molecules of different structures can be expressed in terms of graph-theoretical categories such as the number of spanning trees, path lengths, generalized inverses and spectra of the Kirchhoff matrices of their graphs. We review here the methods and results concerning the distribution function of the square radius of gyration and its first moment, the mean square radius of gyration, for various types of polymer molecules. (Author abstract) 27 refs.

Galina, Henryk (Technical Univ, Wroclaw, Pol); Syslo, Maciej M. *Discrete Appl Math* v 19 n 3 Mar 1988 p 167-176.

**082907 NEW POLYCARBOSILANE MODELS. 1. POLY(METHYLCHLOROSILYLENE)METHYLENE, A NOVEL, FUNCTIONAL POLYCARBOSILANE.** The aluminum trichloride catalyzed interchange of methyl and chlorine on silicon has been applied for the first time to the polycarbosilane series. Thus, poly[(dimethylsilylene)methylene] has been converted into a poly[(methylsilylene)methylene] the first functional polycarbosilane possessing an unambiguous linear skeleton. The considerable lowering of the average molecular weight, a consequence of the backbone cleavage, was accompanied by the formation of dimethylchlorosilyl groups as the chain terminals. These were characterized by  $^1H$ ,  $^{13}C$ , and  $^{29}Si$  NMR. (Edited author abstract) 8 refs.

Bacque, Eric (CNRS, Talence, Fr); Pillot, Jean-Paul; Birot, Marc; Dunogues, Jacques. *Macromolecules* v 21 n 1 Jan 1988 p 30-34.

**082908 HOMOPOLYGLACTURONAN NITROXYL AMIDES: HYDRATION-INDUCED MOTION.** In order to understand the relationship between the degree of polymer hydration, axis of rotation, and rotational frequency as well as rotational anisotropy, we measured the EPR spectra of variably hydrated nitroxyl amide spin-labeled plant homopolylacturonan (PGA) solids from 77 to 342 K. Detailed spectroscopic simulations using stochastic Liouville theory gave the best fit for experimental spectra assuming a moderate jump model with a rotational anisotropy of 3. The axis of rotation was the magnetic y axis of the nitroxyl amide which corresponds to rotational motion about the polymer's main chain. (Edited author abstract) 47 refs.

Chamulitrat, W. (USDA, Philadelphia, PA, USA); Irwin, P.L.; Sivieri, L.M.; Schwartz, R.N. *Macromolecules* v 21 n 1 Jan 1988 p 141-146.

**082909 PREDICTION OF POLYMER CRYSTAL STRUCTURES AND PROPERTIES. A METHOD UTILIZING SIMULTANEOUS INTER- AND INTRAMOLECULAR ENERGY MINIMIZATION.** A method is described for using molecular mechanics to calculate in a unified manner, from transferable conformational energy functions, the packing parameters and energy, vibrational dispersion curves, heat capacity and thermodynamic functions, elastic constants, and refractive indices of polymer crystals. The inter- and intramolecular conformational energies are simultaneously minimized. This allows assessment of the effect of packing forces on the polymer helix parameters and the intramolecular geometry. In addition, the converged Newton-Raphson coefficient matrix used in minimization allows convenient vibrational analysis and calculation of the elastic constants of the crystal. (Author abstract) 18 refs.

Sorensen, R.A. (Univ of Utah, Salt Lake City, UT, USA); Liao, W.B.; Boyd, R.H. *Macromolecules* v 21 n 1 Jan 1988 p 194-199.

**082910 SYNTHESIS, PROPERTIES, AND STRUCTURE OF SULFONATE IONOMERS.** In the past decade an extensive body of literature concerning sulfonated ionomers has appeared. This is reviewed by the authors. A discussion is presented of the synthesis of sulfonate ionomers. This is followed by a discussion dealing with structure and properties. An examination is also made of the properties of telechelic ionomers. 166 refs.

Fitzgerald, J.J. (Univ of Connecticut, Storrs, CT, USA); Weiss, R.A. *J Macromol Sci Rev Macromol Chem Phys* v C28 n 1 Feb 1988 p 99-185.

**082911 ELECTRONIC STRUCTURE OF POLYIMINOVINYLENE AS A TRACTABLE MODEL FOR POLYANILINE.** The electronic structures of polyiminovinylene (PIV) as well as polyaniline (PAN) are studied theoretically using the one-dimensional tight-binding self consistent field-crystal orbital (SCF-CO) method. PIV was employed as a tractable model for PAN to inspect the electronic process when the redox states of PAN are changed. The conduction mechanism caused by partial protonation (oxidation) is discussed and the possibility of the formation of bipolaron in the partially protonated polymer skeleton is examined. (Author abstract) 28 refs.

Tanaka, Kazuyoshi (Kyoto Univ, Kyoto, Jpn); Shichiri, Tokushige; Kobashi, Masahiro; Yamabe, Tokio. *Synth Met* v 24 n 3 May 1988 p 167-178.

**082912 RELAXATIONAL PROPERTIES AND STRUCTURE OF COMPOSITIONS BASED ON AN EPOXY RESIN MODIFIED WITH MONOEPoxide ESTERS OF FATTY ACIDS.** A relationship has been found between the position of dielectric loss peaks and the structure of epoxy polymers modified with monoepoxide esters, i.e., with products of epoxy oligomer esterification with fatty acids. It is shown that phase separation accounts for a second peak appearing in epoxy-epoxide ester polymers in the region for a relaxation. Parameters of dipole-segmental processes have been determined for structural elements of the studied systems. It was found that a lengthening of the fatty acid radical in the additive molecule leads to increased segmental mobility and to a fall in the glass-transition temperature. (Author abstract) 9 refs.

Arslanov, V.V. (USSR Acad of Sciences, USSR); Lipson, G.A.; Smekhov, F.M.; Priutskaya, N.V.; Ogarev, V.A. *Polym Sci USSR* v 29 n 1 Jan 1988 p 141-146.

**082913 POSITRON ANNIHILATION METHOD OF STUDYING THE MICROSTRUCTURE OF POLYMERS IN RELATION TO THEIR DIFFUSIONAL PROPERTIES.** A wide selection of amorphous polymers in the high elastic and glass-like state is studied by a positron annihilation method. The parameters of the positron and positronium lifetime spectra are compared with the coefficients of diffusion of gases ( $H_2$ ,  $CH_4$ ) in the polymers and also with the glass transition temperatures

of the polymers. A correlation is established between the glass transition temperature and the free volume in the unordered regions of the polymer calculated on the basis of positron data. The coefficients of diffusion of gases in the rubbers are determined by the free volume in the unordered regions. (Author abstract) 24 refs.

Volkov, V.V. (USSR Acad of Sciences, USSR); Gol'danskii, A.V.; Durgar'yan, S.G.; Onishchuk, V.A.; Shantorovich, V.P.; Yampol'skii, Yu.P. *Polym Sci USSR* v 29 n 1 Jan 1988 p 217-224.

**082914 STUDY OF THE STRUCTURE OF CROSS-LINKED POLYMERS - ADDITIVE BATCHES - BY MERCURY POROSIMETRY.** Diffusion of additives from cartridges prepared from oligoether acrylates, divinylbenzene and styrene, and a concentrate of commercial additives was studied and characterized by mercury porosimetry of the structure of the cross-linked polymer matrix. It was shown that the rate of discharge of the additives from the cartridge can be regulated by using monomers which produce a cross-linked matrix with a different pore size for synthesis. It follows from the analysis of the data obtained that the rate of discharge of additives can be regulated by synthesizing cartridges of different structure. To obtain macroporous samples with a high diffusion rate, it is necessary to use divinylbenzene or a mixture of divinylbenzene and styrene for synthesis. Addition of butyl methacrylate to divinylbenzene (1:1) decreases the rate of discharge of the additives by approximately 2 times. 6 refs.

Kochina, E.G. (Leningrad Technological Inst, USSR); Cherpilova, T.M.; Zaichenko, L.P.; Proskuryakov, V.A. *J Appl Chem USSR* v 60 n 8 pt 2 Aug 1987 p 1779-1783.

**082915 CRYSTAL STRUCTURE OF ISOTACTIC TRANS-1,4-POLY(1,3-PENTADIENE). AN ANALYSIS BY CONFORMATIONAL AND PACKING ENERGY CALCULATIONS.** Conformational and packing energy calculations have been performed on isotactic trans-1,4-poly(1,3-pentadiene). Two different minimum energy conformations in agreement with the experimental chain axis have been found. One of them corresponds to a chain having the side methyl groups in a skew arrangement and the other to a chain having the side methyl groups in a cis arrangement with respect to adjacent double bonds. The two chains have been independently packed in the space group  $P2_12_12_1$  and two corresponding packing energy minima have been found. The calculations show that the skew arrangement, corresponding to the lowest conformational and packing energies, is preferred as opposed to the cis arrangement, even if the latter should be partially present in the crystal structure of oriented samples of the polymer. (Author abstract) 20 refs.

Napolitano, Roberto (Univ di Napoli, Naples, Italy). *Macromolecules* v 21 n 3 Mar 1988 p 622-625.

**082916 STRUCTURE OF POLY(D-(-)- $\beta$ -HYDROXYBUTYRATE). A REFINEMENT BASED ON THE RIETVELD METHOD.** The crystal structure of optically active microbial poly(D-(-)- $\beta$ -hydroxybutyrate) has been refined with the Rietveld whole-fitting method applied to powder X-ray diffraction data. This naturally occurring polymer gives rise to a very crystalline phase and therefore to very detailed and resolved powder profiles. Reliability of the refinement is discussed in relation to results obtained from previous studies on oriented-fiber diffraction patterns. The conclusion is that well-detailed powder profile data are highly discriminatory toward structural models not very dissimilar from each other. This result is considered an encouraging step toward a more general assessment of the accuracy of structural parameters obtained from best fitting of powder X-ray diffraction profiles. (Author abstract) 18 refs.

Brueckner, S. (Politecnico, Milan, Italy); Meille, S.V.; Malpezzi, L.; Cesaro, A.; Navarini, L.; Tombolini, R. *Macromolecules* v 21 n 4 Apr 1988 p 967-972.



**082917 VIBRATIONAL SPECTRA AND STRUCTURE OF POLYANILINE.** In this paper Raman and infrared spectra of polyaniline 1A, acid-treated 1A (1S), oxygen-treated 1A (1A(O<sub>2</sub>)), and doped 1A are studied. Assignments of vibrational spectra are made referring to the data of <sup>15</sup>N-substituted and C-deuterated polyanilines, N,N'-diphenyl-1,4-benzenediamine, and its derivatives. Key bands that are useful in determining the structures of various forms are elucidated and the relation between vibrational spectra, structures, and electrical properties is discussed. It is found that semiquinone radical cations of IP units exist only in the conducting forms of polyaniline, 2S and doped 1A, indicating that semiquinone radical cations play an important role in electrical conduction in polyaniline. (Edited author abstract) 36 refs.

Furukawa, Y. (Tohoku Univ, Sendai, Jpn); Ueda, F.; Hyodo, Y.; Harada, I.; Nakajima, T.; Kawagoe, T. *Macromolecules* v 21 n 5 May 1988 p 1297-1305.

**082918 LATTICE MODELS FOR BULK POLYMERS AT INTERFACES.** Lattice models for the prediction of conformational characteristics and thermodynamic properties at bulk polymer/solid and bulk polymer/gas interfaces are critically examined. Existing models are shown to fall into two broad categories: bond models, in which the probability of a chain conformation is expressed as a product of bond transition probabilities, and site models, in which the probability of a conformation is proportional to a product of probabilities characteristic of the sites occupied by successive chain segments. A general mathematical formulation is developed for bond models, which includes K.A. Dill and P.J. Flory's model of liquid bilayer membranes and E. Helfand's model of a pure homopolymer at an interface as special cases. (Edited author abstract) 11 refs.

Theodorou, Doros N. (Univ of California, Berkeley, CA, USA). *Macromolecules* v 21 n 5 May 1988 p 1391-1400.

**082919 STRUCTURE AND THERMODYNAMICS OF BULK HOMOPOLYMER/SOLID INTERFACES: A SITE LATTICE MODEL APPROACH.** A site lattice model for pure homopolymers at interfaces is derived, based on J.M. Scheutjens and G.J. Fleer's formulation for polymer solutions. Techniques are developed for the exploration of bond orientational characteristics at the interface. The model is implemented for monodisperse homopolymer systems of various molecular weights. Surface free energy is found to increase with chain length, as a result of entropic constraints at the interface. Bond orientation deviates from isotropy only within a narrow interfacial region, approximately six lattice layers (25 Angstrom) thick; it alternates from layer to layer between a parallel and a perpendicular arrangement with respect to the surface. (Edited author abstract) 17 refs.

Theodorou, Doros N. (Univ of California, Berkeley, CA, USA). *Macromolecules* v 21 n 5 May 1988 p 1400-1410.

**082920 DYNAMIC LIGHT SCATTERING STUDY OF A 2311 BASE PAIR DNA RESTRICTION FRAGMENT.** Dynamic light scattering time correlation functions from a solution of monodisperse, blunt-ended 2311 base pair DNA restriction fragment were measured at 20°C, in 100 mM NaCl, 10 mM Tris-HCl, and 1 mM EDTA (pH 8) at DNA concentrations ranging from 90 to 450 µg/mL. The correlation functions were analyzed by using CONTIN, a constrained inverse Laplace transform program. At scattering angles of 16° and 22° the correlation functions are consistent with single exponential decays representing the translational motion of the DNA. (Edited author abstract) 59 refs.

Sorlie, Susan S. (Stanford Univ, Stanford, CA, USA); Pecora, R. *Macromolecules* v 21 n 5 May 1988 p 1437-1449.

**082921 STUDY OF THE INTERACTION IN THE SYSTEMS CELLULOSE NITRATES-URETHANE RUBBERS.** DTA, X-ray diffraction and IR spectroscopy have been used to study the changes in the crystalline structure of polymers and the intermolecular interactions

in combined composites of cellulose nitrates with urethane rubbers. The value of the energy of the new system of hydrogen bonds between the C=O groups of the rubbers and the OH groups of cellulose nitrate has been determined. A correlation between the physicochemical characteristics of the combined systems and their structure and the character of the intermolecular interactions is demonstrated. (Author abstract) 7 refs.

Kostochko, A.V. (Kirov Chemic-Technological Inst, Kazan, USSR); Vasil'eva, G.A.; Maklakova, L.N.; Kuleznev, V.N. *Polym Sci USSR* v 29 n 2 Feb 1987 p 269-274.

**082922 <sup>13</sup>C NMR STUDY OF THE STRUCTURE OF POLYVINYL METHYL DI(ALKOXY) SILANES.** The present work explores by the <sup>13</sup>C NMR method the structure of polyvinylmethyl di(methoxy)silane, polyvinylmethyl di(propox)silane and polyvinylmethyl di(isopropox)silane in order to study the general patterns of polymerization of vinyl and the influence of the structure of the alkoxy substituent on the structure of the polymer. The rate of detachment of hydrogen from the α-carbon atom of the alkoxy group in the series OCH<sub>3</sub>, OCH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub> and OCH(CH<sub>3</sub>)<sub>2</sub>. It is found that the polymers studied represent extremely branched systems in which the centres of branching are the silicon atoms via two alkoxy groups and additionally each alkoxy group. (Edited author abstract) 10 refs.

Lavrukhin, A.D. (USSR Acad of Sciences, USSR); Strelkova, T.V.; Chernyavskaya, N.A.; Zhdanov, A.A. *Polym Sci USSR* v 29 n 2 Feb 1987 p 299-310.

**082923 CHARACTERIZATION OF THE CROSS-LINKED STRUCTURE OF HYDROGELS.** The theoretical study of a hydrogel network has the purpose of revealing the structure and configuration of its chains by use of appropriate theoretical models. The knowledge of the cross-linking density (in other words the effective number of cross-linked subunits,  $v_e$  and/or the number average molecular weight between cross-links,  $M_c$ ) is of great importance because of its effect on the mechanical and physical properties of the produced materials and their behavior in practical applications. In order to determine the cross-linking density of a hydrogel, use is made of mainly two theories, the equilibrium swelling theory and the rubber elasticity theory. The published literature in these areas is voluminous. Therefore, in this chapter we have taken more of a tutorial approach instead of reviewing all the existing literature. As for the methods of analysis, we concentrate only on references discussing the structural analysis of biomedical, especially hydrophilic, swollen networks. 38 refs.

Peppas, Nikolaos A. (Purdue Univ, West Lafayette, IN, USA); Barr-Howell, Barbara D. *Hydrogels in Med and Pharm* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 v 1, p 27-56.

**082924 STRUCTURE ANALYSIS OF A COMBINED MAIN-CHAIN/SIDE-GROUP LIQUID CRYSTALLINE POLYMER BY ELECTRON MICROSCOPY.** The distribution and growth of smectic planes in a combined main-chain/side-group liquid crystal polymer have been demonstrated by dark-field electron microscopy and the orientation of the molecule with respect to the smectic planes has been determined by electron diffraction. In addition, the smectic planes have been imaged by high-resolution electron microscopy. Undulations and defects have been observed. (Author abstract) 11 refs.

Voigt-Martin, I.G. (Univ Mainz, Mainz, West Ger); Durst, H.; Reck, B.; Ringsdorf, H. *Macromolecules* v 21 n 6 Jun 1988 p 1620-1626.

**082925 HIGHLY ORDERED MAIN CHAIN IN A LIQUID CRYSTALLINE SIDE-GROUP POLYMER.** The molecular order of the polymer chain in a liquid crystalline side-group polymer was studied by solid-state <sup>2</sup>H NMR in the frozen smectic phase. In this system the chain is highly extended perpendicular to the mesogens. The NMR data show that the link between the polymer chain and the mesogens is provided by the conformation-

ally ordered quaternary carbon in the polymer chain. The width of the orientational distribution of the C-CH<sub>3</sub> bonds with respect to the director was determined to be ±20°. The <sup>2</sup>H NMR results are in good agreement with small-angle neutron-scattering studies on the same system. (Author abstract) 19 refs.

Boeffel, C. (MPI fuer Polymerforschung, Mainz, West Ger); Spiess, H.W. *Macromolecules* v 21 n 6 Jun 1988 p 1626-1629.

**082926 MACROMOLECULAR STEREOCHEMISTRY: EFFECT OF PENDANT GROUP STRUCTURE ON THE CONFORMATIONAL PROPERTIES OF POLYISOCYANIDES.** The authors have prepared, using Ni<sup>II</sup> initiation, three polyisocyanides without α-substituents, one of which is optically active. They have also prepared poly(α-phenylethyl isocyanide) from both racemic and optically active monomer. The results show that some form of stereoirregularity, which could involve syn-anti isomerism about the carbon-nitrogen double bond, is seen in each of the polymers studied. In addition, the chain dimension is strongly dependent on the pendant group structure. (Edited author abstract) 47 refs.

Green, Mark M. (Polytechnic Univ, Brooklyn, NY, USA); Gross, Richard A.; Schilling, Frederic C.; Zero, Karl; Crosby, Charles III. *Macromolecules* v 21 n 6 Jun 1988 p 1839-1846.

**082927 CALCULATING THE MOLECULAR INTERNAL ROTATING STERIC FACTOR OF POLYMERS BY THE RADIATION CROSSLINKING METHOD.** In this paper, calculating the molecular internal rotating steric factor of polymers by the radiation crosslinking method is studied and a relationship between the molecular internal rotating steric factor (σ) and crosslinking parameter β is established by taking account of the effect of polymer chain flexibility on β value. σ value of polymer obtained by this method is in agreement with that given with other method. (Author abstract) 7 refs.

Zhang, Wanxi (Acad Sinica, Changchun, China); Sun, Jiazhen. *Chin J Polym Sci (Engl Ed)* v 5 n 3 1987 p 265-268.

**082928 A STUDY ON CHANGE OF FIBER STRUCTURES CAUSED BY PLASMA ACTION.** The degree of change of fibre structure due to plasma etching was studied. Various methods, including DSC, X-ray diffraction, ESCA and IR were employed, birefringence and wettability of the fibres were also studied. The degree of crystallization and orientation of the fibres were altered by plasma etching action. Differences in atom groupings within the fibres were observed, the water absorption property of the fibres increased. The authors investigated the character of both surfaces of the film which had been subjected to the plasma etching action from one side and also that of the film underneath, and concluded that the surface as well as the bulk of the fiber were affected by plasma action. It is suggested that the properties of the bulk fiber were influenced mainly by radiation of ultraviolet light. (Edited author abstract). 7 Refs.

Yan, Haojing; Guo, Wuyuan. *J China Text Univ Engl Ed* v 4 n 2 Dec 1987 p 1-9.

**082929 APPLICATION OF SCALING TO THE STUDY OF POLYMERS AT INTERFACES.** The structure of polymer solutions at interfaces has been the object of intensive study: scaling analysis has provided many theoretical results. We present a survey of the work initiated by de Gennes and Alexander, and followed by Eisenriegler, Kremer and Binder using the magnetic analog. We compare the surface multicritical state at absorption edge to the bulk tricritical state at the Flory temperature. We give some of the detailed results obtained in Saclay. From the experimental point of view, test of scaling is given by the molecular weight dependences of the observables. However, more recently, deeper insight



has been gained by use of neutron scattering techniques developed by the Saclay Group. (Author abstract). 30 Refs.

Bouchaud, E. (CEN-Saclay, Gif-sur-Yvette, Fr); Auvray, L.; Cotton, J.P.; Daoud, M.; Farnoux, B.; Jannink, G. *Prog Surf Sci* v 27 n 1-2 1988 p 5-23.

**082930 PARTIAL CHARACTERIZATION OF THE STRUCTURE OF CRYSTALLINE POLYMER MOLDINGS.** Thermal and flow gradients present during thick polymer molding processes can produce layered structures through the thickness which vary in crystallinity, orientation, and axiality. Such structural complexity is difficult, expensive, and time consuming to characterize and presently impossible to predict. In order to overcome these problems emphasis in our laboratory has been directed toward the development of rapid, nondestructive techniques for the quantitative characterization of the structure of thick polymer samples. This includes the characterization of the average structure, the surface structure, and the internal layer structure. The present paper discusses some of these techniques and illustrates their application. (Author abstract). 12 Refs.

Samuels, Robert J. (Georgia Inst of Technology, Atlanta, GA, USA). *Polym Eng Sci* v 28 n 13 mid-July 1988 p 852-856.

**082931 CONFORMATION AND ELECTRONIC STRUCTURE OF HETEROCYCLIC RING CHAIN POLYMERS.** A theoretical study is presented of the conformation and electronic properties of the polypyrrole, polythiophene and polyfuran chain polymer systems. These results are compared with experimental results and other theoretical studies, as well as with our previous model studies indicating the importance of the heteroatom in the  $\pi$ -band structure of these systems. The studies were performed in two steps. First, the authors calculated geometries for the three polymers using a semiempirical technique well known for its usefulness in predicting the bond lengths of organic systems. Second, they calculated the band structure and total energies of infinite single-chain polymers using the geometries calculated in the first step. (Edited author abstract). 34 Refs.

Mintmire, J.W. (US Naval Research Lab, Washington, DC, USA); White, C.T.; Elert, M.L. *Synth Met* v 25 n 2 Aug 1988 p 109-119.

**082932 MODELLING NETWORK CLUSTERS OF FINITE SIZE. EVALUATION OF REACTIVITY, SPATIAL FORM AND TOPOLOGICAL STRUCTURE.** A model of the gradual formation of branched and network statistical macromolecules is proposed and clusters consisting of 50 elementary units are modelled by the Monte Carlo method. Information is obtained on the reactivity, form and topology of the clusters formed from units with different functionality. It is shown that increase in the fraction of bifunctional units lessen reactivity, increases the asymmetry of form and looseness, reduces the crosslinkage of the macromolecule and raises the heterogeneity of the cycles. (Author abstract). 23 Refs.

Ozol'-Kalnin, V.G. (Latvian SSR Acad of Sciences, USSR); Kokorevich, A.G.; Gravitis, Ya. A. *Polym Sci USSR* v 29 n 5 1987 p 1069-1076.

**082933 TWO-DIMENSIONAL PROPERTIES OF SUFACANT-LIKE POLYMER MONOLAYERS.** A functional polymer monolayer at an air/water interface has been studied systematically by substituting a hydrophobic backbone with a hydrophilic moiety (OH) by measuring the surface pressure as a function of surface concentration for different molecular weight polymers. The characteristic scaling exponent ( $\nu$ ) estimated from the isotherms and the overlap surface concentration suggests that the air/water interface becomes a better solvent as the amount of hydrophilic functional groups is increased. Also, the isotherms show that the area per polymer molecule increases with increasing amounts of OH groups. The surface occupied area per OH group ( $\sigma_{\text{OH}}$ ) is estimated with the ideal gas law at a dilute surface concentration. The results show that the  $\sigma_{\text{OH}}$  is a minimum at the same

substitution level at which the reduction of water surface tension is a maximum. (Edited author abstract). 7 Refs.

Kim, Mahn Won (Exxon Research & Engineering Co, Annandale, NJ, USA); Chung, T.C. *J Colloid Interface Sci* v 124 n 1 Jul 1988 p 364-370.

**082934 ANALYSIS OF CHEMICAL STRUCTURES OF ISOCYANURATE-OXAZOLIDONE RESINS BY INFRARED ABSORPTION SPECTROSCOPY.** Isocyanurate-oxazolidone resins were prepared from 2,4-tolylene diisocyanate (TDI) and 2,2-bis[(2,3-epoxypropylene)phenyl]propane (BPAGE) using N-methylmorpholine as a catalyst. Model polymers containing isocyanurate, oxazolidone, and uretidindione rings were prepared from TDI, diphenylmethane diisocyanate (MDI), triphenyl isocyanurate and BPAGE in order to form calibration curves for infrared spectrum. Composition of hetero rings in the cured product varied with curing temperature, time, and compound ratio. Isocyanate groups changed mainly to isocyanurate rings with ca. 20 mol% of the groups becoming oxazolidone rings. Product contents of uretidindione rings were less than 6 mol%. Reaction routes were analyzed from conversion ratios. (Edited author abstract). 25 Refs. In Japanese.

Yokoyama, Takashi (Hitachi Ltd, Hitachi, Jpn); Kouyama, Toru; Kinjo, Noriyuki; Narahara, Toshikazu. *Kobunshi Ronbunshu* v 45 n 6 1988 p 491-498.

**082935 THERMODYNAMIC BASE FOR THE STRESS ACTIVATED PHASE TRANSITION DEFORMATION MODEL.** The three essential factors of the Juska-Harrison stress activated phase transition (SAPT) deformation model are analyzed. Based on the concept of 'mechanical melting', a formula for the theoretical melting stress is derived from thermodynamics. A comparison of experimental and calculated results for a number of polymers shows that the strain energy is high enough to induce isothermal 'mechanical melting' during extension, and the observed yield stress has the same order of magnitude as the theoretical melting stress. (Author abstract). 19 Refs.

Liu, Tuomin (Pennsylvania State Univ, University Park, PA, USA); Harrison, I.R. *Polym Eng Sci* v 28 n 18 Sep 1988 p 1162-1166.

**082936 POLYANILINE; MODEL STUDIES.** In order to gain a better understanding of the structure of polyaniline, some model studies have been performed including calculations of the band gap as a function of the degree of oxidation and planarity of polyaniline as well as spectroscopic studies of model compounds of low molecular weight. 17 refs.

Hjertberg, Thomas (Chalmers Univ of Technology, Goteborg, Sweden); Sandberg, Mats; Wennerstrom, Olof; Lagerstedt, Ingvar. *Synth Met* v 21 n 1 Aug 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part I, Vadstena, Sweden, Aug 18-20 1986 p 31-39.

**082937 MESOGENIC STRUCTURES AND CHARGE-TRANSFER REACTIONS IN POLY(ETHYLENE OXIDE) COMPLEXES.** After discussion of a schematic model for the crystalline phases of some poly(ethylene oxide) (PEO)-Na<sup>+</sup> complexes with organic anions, three types of material are discussed. Complexes of sodium salts of organic acids substituted by hydrophobic groups are deposited from methanol as macrodomains of uniaxially oriented material; these rearrange to microdomain morphologies on heating above ca. 60°C. Similar anions substituted by polar groups form spherulitic complexes or they rearrange thermotropically to microdomain structures. (Edited author abstract) 18 refs.

Mussarat, Bushra (Univ of Sheffield, Sheffield, Engl); Conheaney, Kevin; Siddiqui, Jamil A.; Wright, Peter V. *Br Polym J* v 20 n 3 1988, First Int Symp on Polym Electrolytes, St. Andrews, Scotland, Jun 17-19 1987 p 293-297.

**Sulfonation** See ELASTOMERS—Modification.

**Surface Properties** See Also CELL CULTURE—Adhesion; CELL CULTURE—Immobilization; GLOW DISCHARGES—Applications; POLYMETHYL METHACRYLATE—Radiation Effects.

**082938 SWOBODNA ENERGIA POWIERZCHNIOWA NIEKTORYCH POLIMEROW.** [Free Surface Energy of Some Polymers]. The wetting contact angle in the systems polymer-water drop-air and polymer-methylene iodide drop-air has been measured for PTFE, PE, PET, PMMA, PVC, PA, PP and PA 6. Using the wetting angle values obtained, literature data of the components of the surface tension of water and measured by values of components of surface tension of methylene iodide, the dispersion and no-dispersion components of the surface free energy have been calculated for the above mentioned polymers on the basis of modified Girifalco-Good-Fowkes-Young equation. It has been found that the free surface energy of Polish-made polymers is practically similar to that of the corresponding foreign-made polymers. (Edited author abstract) In Polish. 17 refs.

Janczuk, Bronislaw (Uniwersytet Marii Curie-Sklodowskiej, Lublin, Pol); Biapietrowicz, Tomasz. *Polimery* v 32 n 7 Jul 1987 p 269-271.

**082939 IDENTIFICATION OF POLYMER SURFACE FUNCTIONALITIES BY SIMS. DERIVATIZATION USING ISOTOPICALLY SUBSTITUTED REAGENTS.** The purpose of this report is to demonstrate a new approach to the identification of functionalities on polymer surfaces. The combination of extreme surface sensitivity and isotopic resolution of secondary ion mass spectrometry (SIMS) can be used with advantage to study functional groups following their derivatization by gas-phase reagents. (Author abstract) 8 refs.

Briggs, D. (ICI PLC, Middlesbrough, Engl); Munro, H.S. *Polym Commun (Guildford Engl)* v 28 n 11 Nov 1987 p 307-309.

**082940 SURFACE TENSION OF POLYTRIFLUOROPROPYLMETHYLSILOXANE.** Surface tension studies of the most common fluorosilicone, poly(3,3,3-trifluoropropylmethylsiloxane) (PTFPM), give unexpected results. Compared to polydimethylsiloxane (PDMS) the liquid surface tension is higher, the critical surface tension of wetting similar, and the solid surface tension, determined by water and methylene iodide contact angles and the method of D.K. Owens and R.C. Wendt, considerably lower. As the outermost surface of the lowest energy materials are comprised of close-packed perfluoromethyl groups and as a flexible polymer backbone should aid in the adoption of the lowest surface energy configuration, fluorosilicones could in principle be the lowest surface energy polymers. (Edited author abstract) 16 refs.

Owen, Michael J. (Dow Corning Corp, Midland, MI, USA). *J Appl Polym Sci* v 35 n 4 Mar 1988 p 895-901.

**082941 APPLICATIONS OF DIFFUSE REFLECTANCE OPTICS FOR THE CHARACTERIZATION OF POLYMER SURFACES BY FOURIER TRANSFORM INFRARED SPECTROSCOPY.** The surface chemistry of polymeric materials plays an important role in many applications and technologies. With the aid of Fourier transform infra-red spectroscopy (FTIR) using diffuse reflectance optics, surface related phenomena of polymeric materials and products and deposits on stainless steel mold insert pieces have been characterized quickly and non-destructively without the need for sample preparation. Despite distortions of absorption bands, the resulting spectra are representative for the analyzed layers up to nanometre level thickness. (Author abstract) 8 refs.

Jansen, J.A.J. (Nederlandse Philips Bedrijven BV, Eindhoven, Neth); Haas, W.E. *Polym Commun (Guildford Engl)* v 29 n 3 Mar 1988 p 77-80.



**082942 HYDROGELS FOR BLOOD CONTACT.** In this chapter, the most relevant issue is the surface, and the interaction of components of blood with the surface. The interior is, or should be, inaccessible to the macromolecular components of plasma and to all the cells (red cells, white cells, platelets). Therefore, we consider hydrogels in a revised sense for purposes of discussion of blood contact: a hydrogel presents a surface layer of bound molecules which by reason of their chemical nature hold a large fraction of water, in which the molecules are predominantly in an amorphous, water-solvated state, and in which the thickness of the layer is of the order of 30 Å minimum up to any indefinitely higher limit. In the chapter, the properties of blood-contacting hydrogels not having the anticoagulant heparin will be discussed. 89 refs.

Merrill, Edward W.; Pekala, R.W.; Mahmud, N.A. *Hydrogels in Med and Pharm* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 v 3, p 1-16.

**082943 STUDY OF SURFACE DYNAMICS OF POLYMERS. II. INVESTIGATION BY PLASMA SURFACE IMPLANTATION OF FLUORINE-CONTAINING MOIETIES.** Macromolecules at the surface of a polymeric solid have considerable mobility, and the specific arrangement of functional groups of macromolecules at the surface is dictated by the environmental conditions in which the surface is placed. Consequently, the change of environmental conditions, such as immersion in water or placement in a biological surrounding, could cause a considerable degree of change in the surface characteristics of a polymer from those evaluated in the laboratory against ambient air. The mobile nature of a polymer surface can be investigated by surface-implanting fluorine-containing moieties, mainly  $-\text{CF}_3$ , by the plasma implantation technique and following the disappearance and reappearance of fluorine atoms on the surface. The disappearance rates (based on the immersion time in water at room temperature) of ESCA  $\text{F}_{1s}$  signals, the decay rates of (advancing) contact angle of water, and the recovery of these values on heat treatment of water-immersed samples were measured as a function of crystallinity of polymer samples (at three levels of crystallinity) for poly(ethylene terephthalate) and nylon 6. (Author abstract). 17 refs.

Yasuda, T. (Univ of Missouri-Rolla, Rolla, MO, USA); Yoshida, K.; Yasuda, H. *J Polym Sci Part B* v 26 n 8 Aug 5 1988 p 1781-1794.

**Surfaces** See Also BLOCK COPOLYMERS—Adsorption; MASS SPECTROMETERS; URANIUM AND ALLOYS—Adsorption.

**082944 ADHESION PROBLEMS AT POLYMER SURFACES.** Adhesion to polymer surfaces is important to many technologies, but many problems arise depending on the surfaces to be joined. The review discusses pretreatments and primers as well as methods of studying polymer surfaces before examining in detail problems with individual polymers. The review concludes with a general discussion on methods of achieving good adhesion. (Author abstract) 103 refs.

Brewis, D.M. (Leicester Polytechnic, Leicester, Engl). *Progr Rubber Plast Technol* v 1 n 4 Oct 1985 p 1-21.

**082945 FLUORIERUNG VON KUNSTSTOFF-OBERFLÄCHEN. [Fluoridation of Plastic Surfaces].** Fluoridation of surfaces with elementary fluorine serves to reduce the permeability of polyethylene and polypropylene with regard to specific organic liquids or gases, or to greatly improve the pastability and printability of the surfaces. This paper provides a survey of the properties, handling, determination and disposal of elementary fluorine, of the properties of fluorinated polyhydrocarbons, and of methods of fluoridation and their applications. (Edited author abstract) 31 refs. In German.

Briefert, Claus. *Metalloberfläche* v 41 n 8 Aug 1987 p 371-374.

**082946 RECENT ADVANCES IN ION AND ELECTRON SPECTROSCOPY OF POLYMER SURFACES.** The structure of microdomains and bonding at

multicomponent polymer material interfaces has been studied using a variety of surface sensitive spectroscopic techniques. In the author's laboratory, low energy ion scattering spectroscopy (ISS) and static secondary ion mass spectrometry (SIMS) serve to complement results from angular dependent X-ray photoelectron spectroscopy (XPS or ESCA), Fourier transform infrared (FTIR) with attenuated total reflectance (ATR) sampling and SEM techniques to provide a quantitative picture of the relationships between structure, bonding, morphology and microdomain formation in near surface regions of polymer systems. The added surface sensitivity of ISS can yield quantitative information at a sampling depth of 3-5 Å, which, with ESCA and FTIR analysis yields a 'nondestructive' depth profile of domain formation in copolymer and blend systems. These studies are illustrated with results from siloxane and siloxane/polycarbonate copolymer systems, where a complete picture of surface domain formation and morphology as a function of composition and polymer crystallinity has been developed. 32 refs.

Gardella, Joseph A. Jr. (Univ of Buffalo, SUNY, Buffalo, NY, USA). *Appl Surf Sci* (1985) v 31 n 1 Jan 1988 p 72-102.

**082947 PHOTO-MODIFICATION OF POLYMER SURFACE BY THE USE OF PHOTO-FRIES REARRANGEMENT AND PHOTO-OXIDATION AND APPLICATIONS.** It is possible to introduce pendant phenol groups on polymer chains by photo-Fries rearrangement of the pendant phenyl ester groups. These phenol groups are expected to be available as functional groups for dyeing polymer films. Copolymers of phenyl methacrylate (PMA) or S-phenyl thiomethacrylate (SPMA) with methyl methacrylate (MMA) (or styrene (St)) were prepared and their photoreactions were investigated. The functional groups which were produced by the photo-oxidation of SPMA units were deduced to play an important role in the dyeing. (Edited author abstract) In Japanese. 10 refs.

Tsunooka, Masahiro (Univ of Osaka Prefecture, Sakai, Jpn); Uenishi, Shinjiro; Tanaka, Makoto. *Kobunshi Ronbunshu* v 44 n 10 Oct 1987 p 745-751.

**082948 RELAXATION AND SPECIFIC ORIENTATION OF SURFACE LAYERS OF EPOXY-EPOXIDE ESTER POLYMERS.** A method whereby relaxation properties of surface layers of solid network polymers near the interfaces with air and with the support may be carried out is proposed. The method is based on wetting as a means of determining orientational changes occurring in hydrocarbon fragments of a biphilic probe that is chemically bound to a matrix during annealing of the system. Features of relaxation processes occurring in surface layers of epoxy-epoxide ester polymers have been investigated. (Author abstract) 12 refs.

Arslanov, V.V. (USSR Acad of Sciences, USSR). *Polym Sci USSR* v 29 n 1 Jan 1988 p 146-152.

**082949 SURFACE MODIFICATION OF POLYMERS. I. VAPOR PHASE PHOTOGRAFTING WITH ACRYLIC ACID.** Surfaces of low density polyethylene, high density polyethylene, and polystyrene have been modified by grafting with acrylic acid. Benzophenone and acrylic acid in the vapor phase were UV-irradiated in the presence of a polymer substrate. Grafting with acrylic acid took place in a thin layer on the surface, thus increasing the wettability of the polymer. After 5 min of irradiation, the contact angle against water had decreased to 20° for polystyrene and 50° for the polyethylene samples. ESCA measurements on samples irradiated for 5 min showed a 90% poly(acrylic acid) coverage of the surface for polystyrene, 63% for low density polyethylene, and 56% for high density polyethylene. (Edited author abstract). 17 refs.

Allmer, K. (Royal Inst of Technology, Stockholm, Swed); Hult, A.; Ranby, B. *J Polym Sci Part A* v 26 n 8 Aug 5 1988 p 2099-2111.

**082950 DETERMINATION OF SURFACE FREE**

**ENERGY COMPONENTS OF POLYMERS FROM CONTACT ANGLE DATA USING NONLINEAR PROGRAMMING METHODS.** A nonlinear method was applied to determine the surface free energy components  $\gamma_{\text{Psv}}$  and  $\gamma_{\text{dsv}}$  of ethylene-vinyl acetate and ethylene-vinyl alcohol copolymers from contact angle data by using the geometric-mean approximation. With this method, the 'actual' surface free energy components of the probe liquids,  $\gamma_{\text{PLV}}$  and  $\gamma_{\text{dLV}}$ , which reflect the fullest extent of liquid-polymer interactions and the interaction parameters,  $\Phi$ , were also simultaneously determined. The critical surface free energy  $\gamma_c$  of the copolymers was calculated from  $\Phi_{\text{av}}$  values by using Good's equation. (Author abstract). 13 refs.

Yildirim Erbil, H. (Research Inst for Basic Sciences, Gebze, Turk); Alsan Meric, R. *Colloids Surf* v 33 n 1-2 Aug 1988 p 85-97.

**Surfensions** See POLYVINYL CHLORIDE—Morphology.

**Swelling** See Also CELLULOSE DERIVATIVES—Mechanical Properties; CELLULOSE DERIVATIVES—Medical Applications; FLOW OF FLUIDS—Jets.

**082951 ANOMALOUS PENETRANT TRANSPORT IN GLASSY POLYMERS: 4. STRESSES IN PARTIALLY SWOLLEN POLYMERS.** The equilibrium swelling process and stress evolution of glassy systems undergoing Case-II penetrant transport were examined using a rubber elasticity theory. Considerations of coupling between stresses and penetrant concentration permitted calculation of equilibrium stress and concentration profiles for a variety of molecular and geometric factors. (Author abstract) 18 refs.

Klier, John (Purdue Univ, West Lafayette, IN, USA); Pappas, Nikolaos A. *Polymer* v 28 n 11 Oct 1987 p 1851-1859.

**082952 DIE SWELL RESPONSE OF SEVERAL POLYMERS AND CARBON BLACK TYPES.** One of the major problems associated with the extrusion process is, as the extruded tread exits from the extruder die, the tread will normally shrink in length and increase in cross-sectional area. This increase in cross-sectional area is known as die swell. A number of evaluations were conducted to determine the extent and direction that die swell will be moved by such factors as black and polymer type, extruder equipment and operating conditions. Die swell was influenced by such variables as carbon black structure, black loading, oil level, polymer type, degree of mixing, extruder temperature, and work on the black during manufacturing. (Edited author abstract) 10 refs.

Wilder, C.R. (Phillips Petroleum Co). *Rubber World* v 197 n 1 Oct 1987 p 18-19, 21-22, 24-26.

**082953 SWELLING AND SORPTION IN POLYMER-CO<sub>2</sub> MIXTURES AT ELEVATED PRESSURES.** Experimental data on gas sorption and polymer swelling in glassy polymer-gas systems at elevated pressures are presented for CO<sub>2</sub> with polycarbonate, poly(methyl methacrylate), and polystyrene over a range of temperatures from 33 to 65°C and pressures up to 100 atm. The swelling and sorption behavior were found to depend on the occurrence of a glass transition for the polymer induced by the sorption of CO<sub>2</sub>. Two distinct types of swelling and sorption isotherms were measured. One isotherm is characterized by swelling and sorption that reach limiting values at elevated pressures. The other isotherm is characterized by swelling and sorption that continue to increase with pressure and a pressure effect on swelling that is somewhat greater than the effect of pressure on sorption. Glass transition pressures estimated from the experimental results for polystyrene with CO<sub>2</sub>



are used to obtain the relationship between  $\text{CO}_2$  solubility and the glass transition temperature for the polymer. (Edited author abstract) 33 refs.

Wissinger, R.G. (Univ of Delaware, Newark, DE, USA); Paulaitis, M.E. *J Polym Sci Part B v 25 n 12 Dec 1987 p 2497-2510.*

**082954 ELASTIC PROPERTIES OF SWOLLEN REAL POLYMER NETWORKS.** In this paper a new set of stress-strain relations (uniaxial, equi-biaxial, uniaxial extensions and pure shear) for swollen networks were presented. They are derived from the molecular theory of rubber elasticity with constraints of junctions and trapped entanglements and with crosslinks, trapped entanglements and carbon black-polymer interactions. They succeeded in relating the elastic equation of state to the volume fraction of polymer  $V_2$  in swollen networks by three molecular parameters  $C_1$ ,  $C_2$  and  $C_3$ . The relation of stress-strain for uniaxial extension was verified by experiments. It is shown that this relation can successfully predict the dependence of  $V_2$  on the  $C_1$ ,  $C_2$  and  $C_3$ , and the contribution of modulus for swollen networks from the trapped entanglement. It shows that role of entanglements can only approach to a limited value, never to zero. (Edited author abstract) 10 refs.

Song Mingshi (Beijing Inst of Chemical Technology, Beijing, China); Lin Hanguang; Ni Jianlong. *Polym Bull (Berlin) v 18 n 6 Dec 1987 p 545-552.*

**082955 STUDY OF THE SWELLING OF STAR-LIKE POLYMERS IN A GOOD SOLVENT BY THE COMPUTER EXPERIMENT METHOD.** The Monte-Carlo method has been used to study the swelling of star-like polymers in a good solvent. The swelling coefficients calculated in relation to the unperturbed dimensions of the chains rise while the relative swelling coefficients drop with increase in functionality. The results are compared with the predictions of various analytical theories and quantitative agreement established with the results of the scaling approach. (Author abstract) 30 refs.

Romantsova, I.I. (Inst of Fossil Fuels, USSR). *Polym Sci USSR v 29 n 1 Jan 1988 p 62-68.*

**082956 HYDROGELS IN MEDICINE AND PHARMACY (V 1, FUNDAMENTALS; V 2, POLYMERS; V 3, PROPERTIES AND APPLICATIONS).** This set of three volumes contains twenty chapters about the chemistry, physics and applications of hydrogels. Some of the topics covered in Vol 1 are: preparation and structure of hydrogels; hydrogel surfaces; and immobilization of biomolecules and cells within hydrogels. Vol 2 is concerned with the structure and function of the medically important hydrogels: they are polyvinylalcohol; polyhydroxyethyl-methacrylate; polyethylene oxide; and cellulose. Vol 3 describes biomedical and pharmaceutical applications of hydrogels. Some of the topics covered are: blood compatibility; heparinized surfaces; contact lenses; artificial tendons; and bioerodible gels.

Peppas, Nikolaos A. (Ed.) (Purdue Univ, West Lafayette, IN, USA). *Hydrogels in Med and Pharm* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 3v.

**082957 IMMOBILIZATION OF BIOMOLECULES AND CELLS ON AND WITHIN SYNTHETIC POLYMERIC HYDROGELS.** The study and application of immobilized biologically active molecules and cells have become increasingly important endeavors in both medicine and industry. Biomolecules and cells can be immobilized on and within many different supports using a variety of techniques. Hydrogels have some properties which make them particularly suitable for this purpose. A hydrogel can be defined as a polymeric material which exhibits the ability to swell in water and retain a significant fraction of water within its structure without dissolving. Small hydrophilic molecules can readily diffuse through hydrogels. Hydrogels exhibit good tissue biocompatibility and may interact less strongly with immobilized species than more hydrophobic materials. Thus molecules and cells immobilized on or within hydrogels may be more likely to retain their biological activity for longer periods

of time. Hydrogels may also have a large number of polar reactive sites on which biomolecules and cells can be immobilized by relatively simple chemistries. 191 refs.

Gombotz, Wayne R. (Univ of Washington, Seattle, WA, USA); Hoffman, Allan S. *Hydrogels in Med and Pharm* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 v 1, p 95-126.

**082958 EQUILIBRIUM SWOLLEN HYDROGELS IN CONTROLLED RELEASE APPLICATIONS.** Controlled release systems represent a relatively new development that evolved out of a continuing need to prolong and better control drug administration. In conventional drug delivery modes such as a spray, an injection, or the taking of a pill, each time a person takes medicine, the drug concentration in the blood rises, peaks, and then declines. Since each drug has a therapeutic range above which it is toxic and below which it is ineffective, the plasma drug concentration in any patient at a particular time depends on compliance with the prescribed routine. This is particularly problematic if the toxic and minimum effective levels are close together. The goal of a controlled release system is to maintain the drug concentration between these two levels for a prolonged time using a single dosage form. 82 refs.

Kost, Joseph (Ben Gurion Univ, Beer Sheva, Isr); Langer, Robert. *Hydrogels in Med and Pharm* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 v 3, p 95-108.

**082959 DYNAMICALLY SWELLING HYDROGELS IN CONTROLLED RELEASE APPLICATIONS.** The physical properties of hydrogels make them attractive for controlled release applications. Their biocompatibility allows them to be considered for medical or pharmaceutical applications and their hydrophilicity can impart desirable release characteristics to controlled and sustained release formulation. This chapter is concerned primarily with materials which are in a dry or glassy state before being placed at the release site, whether this site is the buccal, gastric, nasal, or intestinal area, or a subdermal location. This allows the designer to take advantage of the swelling properties of the material and to control the rate of active release. 123 refs.

Peppas, Nikolaos A. (Purdue Univ, West Lafayette, IN, USA); Korsmeyer, Richard W. *Hydrogels in Med and Pharm* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 v 3, p 109-136.

**082960 BIOADHESIVE HYDROGELS.** A hydrogel is defined as a polymeric material which has the ability to swell in water without dissolving, and to retain water within its structure. There are a variety of synthetic and natural polymers that can be included in this definition. In this chapter, attention will be focused on particular hydrogels possessing bioadhesive properties. It is appropriate to begin this discussion with definitions of bioadhesion and bioadhesive. One distinctive feature of bioadhesion is that adhesion almost always occurs in the presence of water. In contrast to numerous studies on adhesion in artificial systems, where both adhesive and adherend are nonbiological materials, there are very few useful research surfaces. For this reason, bioadhesion has been described from a phenomenological point of view, almost exclusively, rather than from a molecular perspective. 128 refs.

Park, Kinam (Purdue Univ, West Lafayette, IN, USA); Cooper, Stuart L.; Robinson, Joseph R. *Hydrogels in Med and Pharm* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 v 3, p 151-176.

**Synthesis** See Also AROMATIC POLYMERS—Conductive; AROMATIC POLYMERS—Molecular Structure; BLOCK COPOLYMERS—Synthesis; CERAMIC MATERIALS—Processing; COPOLYMERS—Physical Properties; COPOLYMERS—Structure; CRYSTALS, LIQUID—Synthesis; DRUG PRODUCTS—Controlled Delivery; EPOXY RESINS—Flame Resistance; MEMBRANES—Oxygen Permeable; MONOMERS—Polymerization; NITRILE RESINS—Polymerization; OLIGOMERS—Solutions; ORGANIC COMPOUNDS—Polymerization; ORGANIC COMPOUNDS—Synthesis; PHENOLS—Polymerization; PHOTORESISTS; PLASTICS—Conductive; PLASTICS FILMS—Mechanical Properties; PLASTICS FILMS—Radiation Effects; PLASTICS FILMS—Synthesis; POLYAMIDES—Thermodynamics; POLYMERIZATION—Ani-

onic Polymerization; POLYMERIZATION—Research; POLYMERS—Heat Resisting; SILANES—Optical Properties; UREA—Chemistry; UREA FORMALDEHYDE RESINS—Structure; WATER TREATMENT—Flocculation.

**082961 SYNTHESIS AND CHARACTERIZATION OF CONDUCTING POLYPYRROLE-CONTAINING IRON COMPLEXES.** Electrochemical or chemical oxidation of pyrrole-containing complex anions of iron cyanide or iron chloride results in the formation of films or powders of conducting polypyrroles. Freshly prepared films exhibit an additional IR band at ca 1630-1640  $\text{cm}^{-1}$ , slowly disappearing in air and not observed in previous studies of polypyrrole-based systems. It is possible that this new band is associated with the existence of a C=N bond in dehydrogenated pyrrole rings which are transformed into regular pyrrole rings, probably due to the protonation reaction occurring in air and simultaneous bond rearrangement. The polypyrrole structure favors the presence of  $\text{Fe}(\text{CN})_6^{4-}$  over  $\text{Fe}(\text{CN})_6^{3-}$  since the former is the only iron species detected by Moessbauer spectroscopy in electrochemically prepared samples. (Edited author abstract) 19 refs.

Przytulski, J. (Warsaw Univ of Technology, Warsaw, Pol); Zagorska, M.; Pron, A.; Kucharski, Z.; Suwalski, J. *J Phys Chem Solids v 48 n 7 1987 p 635-640.*

**082962 TWO-STAGE METHOD OF SYNTHESIZING POLYANTHANTHROYLENEBENZIMIDAZOLE AND PREPARATION OF A FIBRE BASED ON IT.** Polyanthanthroylenebenzimidazole has been prepared by a two-stage method. Some principles have been studied, and optimum conditions have been established for the first stage of the synthesis - preparation of the prepolymer. The possibility of cyclizing the prepolymer to polyanthanthroylenebenzimidazole has been demonstrated. Model yarn specimens have been prepared and a preliminary evaluation of their properties has been given. 6 refs.

Sadekova, R.A.; Pronichkina, I.K.; Perepechkin, E.P.; Kalashnikova, B.O.; Efros, L.S.; Khan, I.G.; Vorozhtsov, G.N.; Kudryavtsev, G.I. *Fibre Chem v 19 n 1 Jan-Feb 1987 p 38-42.*

**082963 LIVING CARBOCATIONIC POLYMERIZATION - V. LINEAR TELECHELIC POLYISOBUTYLENES BY BIFUNCTIONAL INITIATORS.** The synthesis of  $\alpha,\omega$ -di-1-chloropolyisobutylene has been accomplished by living polymerization using aliphatic and aromatic tert-diacetate initiators in conjunction with  $\text{BCl}_3$  coinitiator in various solvents in the  $-20$  to  $-70^\circ\text{C}$  range. The living nature of the polymerizations was demonstrated with the instantaneous initiators 2,4,4,6-tetramethylheptane-2,6-diacetate and 1,4-di(2-propyl-2-acetate)-benzene by linear  $M_n$  versus amount of PIB formed ( $W_{PIB}$ ) plots starting at the origin. The formation of undesirable indanyl structures that arise with the aromatic initiator can be suppressed by decreasing the temperature and the polarity of the polymerization medium (i.e., by using  $\text{CH}_2\text{Cl}_2/\text{n-C}_6\text{H}_{14}$  mixtures). (Edited author abstract) 18 refs.

Faust, R. (Univ of Akron, Akron, OH, USA); Nagy, A.; Kennedy, J.P. *J Macromol Sci Chem v A24 n 6 1987 p 595-609.*

**082964 SYNTHESIS AND CHARACTERIZATION OF NEW POLYETHERAMIDES.** Polyetheramides (PEAs) are prepared by polycondensation of N,N'-diacetyl-o-tolidide with Bisphenol A, C, or F, phenolphthalein, resorcinol, catechol, hydroquinone, or 1,5- or 2,7-dihydroxynaphthalene or ethylene, butylene, propylene, diethylene, or triethylene glycol. The fusible and soluble oligomers are characterized. An attempt is made to bring out the relationship between various properties of PEAs and their structures. (Author abstract) 11 refs.

Patel, Pradip S. (Sardar Patel Univ, Vallabh Vidyanagar, India); Shah, Praful P.; Patel, Shanti R. *J Macromol Sci Chem v A24 n 6 1987 p 623-630.*



**082965 CHEMOTHERAPEUTIC POLYMER: XVII. THE SYNTHESIS AND ANTITUMOR ACTIVITY OF POLYPHOSPHATES CONTAINING BOTH NUCLEIC ACID BASE AND NITROGEN MUSTARD.** Seven new polyphosphates containing both nucleic acid base and nitrogen mustard were prepared by reacting the monomers i.e., 1,3-dihydroxyalkyl-5-fluorouracil, 1,3-dihydroxyalkyluracil and 1,3-dihydroxyalkylthymine with N,N-bis(2-chloroethyl)phosphoramide dichloride. The monomers and polymers were characterized by <sup>1</sup>H-NMR, IR spectra and elemental analysis. All of the polymers obtained are soluble in water. The antitumor activity of some of these polymers were tested against Ehrlich Ascites in mice. The results showed that the polyphosphates containing both 5-fluorouracil and nitrogen mustard exhibit lower toxicity and higher antitumor activity. The inhibition ratio of the polymer is 66%. (Edited author abstract) 5 refs.

Zhou, Nianen (Wuhan Univ, Wuhan, China); Chen, Qusheng; Zhuo, Renxi. *Chin J Polym Sci (Engl Ed)* v 4 n 4 Feb 1987 p 316-321.

**082966 SYNTHESIS AND PROPERTIES OF POLYPHENYLQUINOXALINES CONTAINING CHLORO-ATOM.** Several polyphenylquinoxalines (PPQs) containing chloro-atom in the side chain have been synthesized and characterized by IR, TGA, ITGA and DTA. High quality, flexible, glass-cast films and varnished wires have been obtained. The T<sub>g</sub>'s values and thermal stabilities of these polymers were greater than those without any chloro-atom substituent. (Author abstract) 10 refs.

Bai, Luna (Acad Sinica, Beijing, China); Xing, Lanmin; Lu, Fengcai. *Chin J Polym Sci (Engl Ed)* v 4 n 4 Feb 1987 p 336-340.

**082967 SYNTHESIS AND CHARACTERIZATION OF POLYMER DERIVATIVES OF cis-PLATINUM COMPLEXES.** Cis-platinum complexes used as antitumor drugs were attached onto preformed polymers to reduce the toxicity. Either alternating copolymer of styrene and maleic anhydride (CPSMA) or polyacrylic acid (PAA) is readily dissolved in alkaline solution. The cis-platinum complexes are easily converted into water soluble species when treated by silver nitrate in water. The expected products could be obtained when the two aqueous solutions were brought together. The products were characterized by elementary analysis, IR and XPS. The polymer derivatives could exchange ligands with nucleophilic groups in biological environment and also exhibit antineoplastic activity. (Author abstract) 10 refs.

Wang, Zhuting (Acad Sinica, Beijing, China); Zhang, Peiming; Sun, Shumen. *Chin J Polym Sci (Engl Ed)* v 4 n 4 Feb 1987 p 359-369.

**082968 STUDY OF SELF-SPLITTING WATER SOLUBLE IONOGENIC POLYMERS.** Water-soluble readily self-splitting ionogenic polymers may be created through the synthesis of macromolecules which along with ester groups susceptible to hydrolytic splitting also contain groups that are capable of catalyzing this process. Polymers of this type include polyaminoesters based on primary and secondary aliphatic diamines and glycol diacrylates. The polyaddition reaction is carried out in an aqueous medium, as a heterogeneous process, with cooling (−5 to −10°) in air for 15-30 min. In this way polyaminoesters are obtained in quantitative yields. A study of the hydrolytic stability of polyaminoesters showed that the initial rate of hydrolysis of the polymers largely depends on the pH<sub>0</sub> of the medium. (Edited author abstract) 5 refs.

Kargina, O.V. (USSR Acad of Sciences, USSR); Mishustina, L.A.; Kiselev, V.Ya.; Kabanov, V.A. *Polym Sci USSR* v 28 n 6 1986 p 1265-1272.

**082969 CHEMICAL INDIVIDUALS AND UNIT HETEROGENEITY OF POLYMERS.** The concepts of the chemical individual and unit heterogeneity of polymers are considered. It is shown that polymers represent mixtures of macromolecules of different size and composition and are, therefore, not chemical individuals. How-

ever, each such mixture consists of a large number of chemical individuals which are polymer homologues and contain unit heterogeneous chains. The unit heterogeneity of polymers is determined by the presence of secondary reactions and the content of stable isotopes statistically distributed over the chain of the macromolecule. The processes of polymer synthesis by polymerization, polycondensation and modification represent complexes of diverse reactions determining the advent of unit heterogeneity of the polymers. (Edited author abstract) 18 refs.

Korshak, V.V. (USSR Acad of Sciences, USSR); Kozyreva, N.M.; Korshak, Yu.V. *Polym Sci USSR* v 28 n 6 1986 p 1309-1318.

**082970 SYNTHESIS AND PROPERTIES OF UNSATURATED HALOGEN-CONTAINING POLYARYLATES.** Unsaturated, halogen-containing polyarylates of different chemical structure were synthesized by acceptor-catalyzed polycondensation, some physico-chemical properties of the resulting polymers were measured and correlated with their chemical structure. The polyarylates can be cured at elevated temperatures. It is shown that depending on their chemical structure, the prepared polyarylates can possess favorable mechanical and thermal properties, and can find application as chemically inert and fire-retarding materials capable to be cured at elevated temperatures. (Edited author abstract) 7 refs.

Kharayev, A.M. (Kabardino-Balkarsk State Univ, USSR); Mikitayev, A.K.; Shustov, G.B.; Vologirov, A.K.; Dorofeyev, V.T.; Belousov, V.N.; Kalmykov, K.V.; Korenyako, V.A. *Polym Sci USSR* v 28 n 6 1986 p 1478-1483.

**082971 CONVENIENT SYNTHESIS OF POLYMER CONTAINING PENDANT GROUPS AND PHOTOCHEMICAL PROPERTIES OF THE RESULTING POLYMER.** Poly(propargyl methacrylate) was synthesized by the reaction of poly(methacrylic acid) and propargyl bromide using DBU in DMSO. The reaction proceeded quantitatively at room temperature within 10 minutes. Photochemical properties of the resulting polymer were measured by IR spectroscopy and practical photosensitivity with several photosensitizers or photogenerated cationic catalysts as crosslinking reagents. The polymer showed the highest photosensitivity when 2-alkylanthraquinone or 4-morpholino-2,5-dibutoxybenzenediazonium salts were used as crosslinking reagents. (Author abstract). In Japanese. 24 refs.

Shimokawa, Tsutomu (Kanagawa Univ, Yokohama, Jpn); Nishikubo, Tadatoshi. *Kobunshi Ronbunshu* v 44 n 8 Aug 1987 p 641-647.

**082972 SYNTHESIS OF POLYMERS CONTAINING PENDANT NORBORNADIENE DERIVATIVES BY A PHASE TRANSFER CATALYSIS AND THEIR PHOTOCHEMICAL VALENCE ISOMERIZATION.** In this paper, the authors report the successful syntheses of a polymer containing a pendant NB moiety by substitution reactions of PCMS with potassium salts of 2,5-norbornadiene-2,3-dicarboxylic acid (NBDA) and 3-(phenyl)norbomadiene-2-carboxylic acid (PNBA) using PTC. Also the rate of photochemical valence isomerization of the pendant NB moieties to the QC moieties and the rate of catalytic reversion of QC moieties to the NB moieties are evaluated. 12 refs.

Nishikubo, Tadatoshi (Kanagawa Univ, Yokohama, Jpn); Sahara, Akemi; Shimokawa, Tsutomu. *Polym J* v 19 n 8 1987 p 991-994.

**082973 SYNTHESIS AND CHARACTERIZATION OF BIPHASIC LIQUID CRYSTALLINE POLYSILOXANES CONTAINING 4-UNDECANYLOXY-4'-CYANOBIPHENYL SIDE-GROUPS.** The synthesis and characterization of liquid crystalline polysiloxanes and copolysiloxanes containing 4-undecanyloxy-4'-cyanobiphenyl side-groups is presented. The polysiloxane presents a single glass transition temperature followed by a S<sub>c</sub> and a S<sub>a</sub> mesophase. Copolysiloxanes presenting around 50% weight fraction of side-groups exhibit two

glass transition temperatures i.e., one due to the independent motion of the main chain and the other due to the cooperative but independent motion of the side groups, and in addition to the S<sub>c</sub> and S<sub>a</sub> phases exhibited by the homopolymer, present also side-chain crystallization. (Author abstract) 15 refs.

Hsu, Chain S. (Case Western Reserve Univ, Cleveland, OH, USA); Percec, Virgil. *Polym Bull (Berlin)* v 18 n 2 Aug 1987 p 91-98.

**082974 PREPARATION OF (VINYL-BENZYLIMINO)OLIGO(DL-PHENYLALANINE NCA) MACROMER WITH NARROW MOLECULAR WEIGHT DISTRIBUTION.** Polymerization conditions of DL-phenylalanine N-carboxyanhydride (NCA) by m,p-vinylbenzylamine were examined for the preparation of (vinylbenzylimino)oligo(DL-phenylalanine NCA) macromer (VB-OPhe) with narrow molecular weight distribution. According to the results obtained, i.e., under the condition of short polymerization time (ca. 2 h) and in relatively high concentrations of the NCA in THF, the polymerizations of the NCA were carried out to give VB-OPhe macromers, which were found to have very narrow molecular weight distributions. Furthermore, their functionalities were proved to be approximately unity by the polymerization method. (Author abstract) 10 refs.

Takaki, Mikio (Nagoya Inst of Technology, Nagoya, Jpn); Asmai, Ryuzo; Hanada, Yoichiro; Ochiai, Nobuyuki. *Polym Bull (Berlin)* v 18 n 2 Aug 1987 p 105-110.

**082975 SYNTHESIS AND ELECTRICAL CONDUCTIVITIES OF SOME NITROGEN- AND SULPHUR-CONTAINING POLYMERS.** We have synthesized poly(p-azophenylene) (PPN), poly(2,4-azotoluene) (PMT), poly(2,6-pyridine) (PPy), poly(2,6-pyridine sulphide) (PPyS) and poly(ethylene vinylene sulphide) (PEVS), doped them with iodine and ferric chloride and measured the electrical conductivities. The doped polymers were also studied with ESR and IR. (Author abstract) 20 refs.

Laakso, J. (Neste Oy, Kulloo, Finl); Osterholm, J.-E.; Lindberg, J.J. *Polym Bull (Berlin)* v 18 n 3 Sep 1987 p 195-201.

**082976 QUASILIVING CARBOCATIONIC POLYMERIZATION. XVII. SYNTHESIS OF POLY[STYRENE-β-ISOBUTYLENE-β-STYRENE].** Poly(styrene-β-isobutylene-β-styrene) has been synthesized by sequential carbocationic polymerization under quasiliving conditions at −90°C. The quasiliving synthesis was effected by first continuously and slowly condensing gaseous isobutylene (IB) to a bifunctional initiating system (p-dicumyl chloride/TiCl<sub>4</sub>) dissolved in a hexane-methylene chloride (60:40 v/v) mixture. After the quasiliving polyisobutylene (PIB) sequence had reached a desired molecular weight, styrene (St) was continuously and slowly added to produce the polystyrene (PSt) sequence. The products consisted of the target triblock. (Edited author abstract) 12 refs.

Fodor, Zs. (Hungarian Acad of Sciences, Budapest, Hung); Kennedy, J.P.; Kelen, T.; Tudos, F. *J Macromol Sci Chem* v A24 n 7 1987 p 735-747.

**082977 SYNTHESIS AND PROPERTIES OF NEW POLYBENZIMIDAZOLES AND N-PHENYL POLYBENZIMIDAZOLES WITH FLEXIBILIZING SPACERS ON THE POLYMER BACKBONE.** Several new polybenzimidazoles (PBIs) and N-phenyl PBIs were synthesized by high temperature solution polycondensation techniques. Four model benzimidazoles (MBI) were also synthesized to confirm the formation of polybenzimidazoles. The PBIs and MBIs were characterized by infrared spectroscopy and elemental analysis. The proper-



ties of the polymers such as solubility, density, crystallinity, and thermal, thermoxidative, and isothermal stabilities were studied. (Edited author abstract) 21 refs.

Scariah, K.J. (Vikram Sarabhai Space Cent, Trivandrum, India); Krishnamurthy, V.N.; Rao, K.V.C.; Srinivasan, M. *J Polym Sci Part A* v 25 n 10 Oct 1987 p 2675-2687.

**082978 STUDIES IN THE FORMATION OF POLY(OXAZOLIDONES). II. SELECTIVITY OF CATALYSTS AND KINETICS IN THE SYNTHESIS OF 2-OXAZOLIDONE FROM BUTYL ISOCYANATE AND PHENYLGLYCIDYL ETHER.** The reaction of butyl isocyanate with phenylglycidyl ether was selected as a model reaction for the synthesis of aliphatic isocyanate-based poly(2-oxazolidones). The selectivity of different metal halides and aluminum trichloride/triphenylphosphine oxide ( $AlCl_3$  TPPO) and aluminum hexamethylphosphoramide ( $AlCl_3$  HMPA) complexes were investigated for oxazolidone formation. Both FTIR and mass spectrographic methods were employed for characterization of the reaction products. The kinetics of the model reaction was studied using  $AlCl_3$  TPPO in o-dichlorobenzene at 120 and 140°C. (Author abstract) 11 refs.

Sehovic, Hajrija (Univ of Tuzla, Tuzla, Yugosl); Sendjarevic, Aisa; Sendjarevic, Vahid; Frisch, Kurt C. *J Polym Sci Part A* v 25 n 10 Oct 1987 p 2729-2736.

**082979 POLYMERIZATION OF N-METHYLPYRROLE WITH BIS-TRIAZOLINEDIONES VIA ELECTROPHILIC AROMATIC SUBSTITUTION.** The reaction of N-methylpyrrole with 4-substituted-1,2,4-triazoline-3,5-diones (4R-TDs), i.e., MeTD (4-methylsubstituted) and PhTD (4-phenyl substituted), at room temperature without use of any catalyst was investigated. The reaction is instantaneous and leads to the formation of a 2:1 adduct in high yield, with substitution occurring at the 2 and 5 positions of the pyrrole moiety via electrophilic aromatic substitution. These compounds were fully characterized by IR,  $^{13}C$ -NMR,  $^1H$ -NMR, and elemental analysis, and were used as model compounds for the polymerization reaction. The reaction of bis-triazolinediones with N-methylpyrrole was carried out in dimethylformamide at room temperature. The reactions are fast and give novel polymer structures. Some structural characterization and physical properties of these new polymers are reported. (Author abstract) 20 refs.

Mallakpour, Shadpour E. (Univ of Florida, Gainesville, FL, USA); Butler, George B. *J Polym Sci Part A* v 25 n 10 Oct 1987 p 2781-2790.

**082980 SYNTHESIS AND PROPERTIES OF POLY(AROMATIC KETONES).** W.H. Bonner reported the first preparation of poly(aromatic ketones) (PAK) by aluminum chloridocatalyzed acylation of diphenyl ether with aromatic diacid chlorides. These were low molecular weight materials because of solubility limitations. In the intervening years, significant progress has been made in synthetic methodology, and now a large variety of structures is available for study. Unlike poly(aryl sulfones) which are typically amorphous, most PAK's exhibit partial crystallinity, usually with melting points above 300°C. Like the sulfones, the ketone polymers possess high thermal stability and exhibit excellent electrical and mechanical properties. The development of this polymer family is the subject of this review. 62 refs.

Mullins, M.J. (Dow Chemical Co, Midland, MI, USA); Woo, E.P. *J Macromol Sci Rev Macromol Chem Phys* v C27 n 2 May 1987 p 313-341.

**082981 PROPERTIES OF ELECTROCHEMICALLY SYNTHESIZED POLYMERS - V. THE POLYMER ELECTRODE/POLYMER ELECTROLYTE INTERFACE.** A solid-state lithium-polyrrole cell having a polymeric electrolyte based on the lithium perchlorate-poly(ethylene oxide) complex, has been assembled. Results based on cyclic voltammetry, frequency response analyses and charge-discharge cycles, show that the polymer/polymer interface is characterized by favourable

kinetics in the temperature range where the conductivity of the electrolyte is sufficiently high. Therefore using proper cell design, the solid-state polymeric systems may be considered for the realization of interesting devices, such as ultrathin batteries, electrochromic displays and thermal sensors. (Author abstract) 10 refs.

Panero, S. (Univ di Roma, Rome, Italy); Proserpi, P.; Scrosati, B. *Electrochim Acta* v 32 n 10 Oct 1987 p 1461-1464.

**082982 PREPARATION OF WATER-SOLUBLE POLYMERS VIA THE MANNICH REACTION.** It was the objective of this research to utilize the Mannich reaction between formaldehyde, selected amines, and the nitroparaffins as the active hydrogen compounds to synthesize amine-containing and/or quaternary ammonium-containing polymers. Nitroethane, as well as 1-nitropropane, was utilized as the active hydrogen compound. It is shown that by varying the ratio of the two nitro compounds, one can theoretically control the length of the chain. As shown, the  $^1H$  spectra of these compounds were utilized to determine the actual number of repeating units by integration of the different methyl peaks. 14 refs.

Butler, George B. (Univ of Florida, Gainesville, FL, USA); Hong, Seok H. *J Macromol Sci Chem* v A24 n 8 1987 p 919-931.

**082983 NEW ORGANIC POLYMERS. 5. SYNTHESIS OF POLY(2-VINYL-3-SUBSTITUTED-4-QUINAZOLONES).** This paper deals with the synthesis of polyquinazolones from poly[1-(2-carboxyanilino-carbonyl)ethyl]. The IR spectra of these polymers show the characteristic features that correspond to those of the corresponding model compound, 2-methyl-4-quinazolone. All the products gave a band around 1680  $cm^{-1}$  characteristic of C=O stretching, a band around 1600  $cm^{-1}$  due to C=N stretching vibration, and bands around 1520  $cm^{-1}$  due to C=C stretching and in-plane bending vibrations of the aromatic moiety. (Edited author abstract) 7 refs.

Patel, Kishore (Sardar Patel Univ, Vallabh Vidyanagar, India); Desai, Trushar; Suthar, Bhikhu. *J Macromol Sci Chem* v A24 n 8 1987 p 1005-1009.

**082984 SYNTHESIS OF POLY(DIMETHYLSILOXANE-b-ISOBUTYLENE-b-DIMETHYLSILOXANE) AND POLY(DIMETHYLSILOXANE-b-ISOBUTYLENE-b-DIMETHYLSILOXANE), FROM ALCOHOL-TELECHELIC POLYISOBUTYLENES.** The purpose of these studies was to combine polydimethylsiloxane (PDMS) and polyisobutylene (PIB) sequences into novel triblock, PDMS-b-PIB-b-PDMS, and multiblock, (PDMS-b-PIB-b-PDMS) $_n$  copolymers. The key toward syntheses was the definition of conditions for the initiation of living anionic polymerization of hexamethylcyclotrisiloxane ( $D_3$ ) at the  $-CH_2OLi$  termini of well-defined telechelic PIB sequences. Subsequent deactivation of living  $D_3$  polymerization charges with  $Me_3SiCl$  yielded the target triblock whereas stoichiometric amounts of  $Me_2SiCl_2$  gave the multiblock copolymer. (Author abstract) 34 refs.

Wilczek, Lech (Univ of Akron, Akron, OH, USA); Mishra, Munmaya K.; Kennedy, Joseph P. *J Macromol Sci Chem* v A24 n 9 1987 p 1033-1049.

**082985 SYNTHESIS AND STUDY OF POLYMERIC ULTRAVIOLET ABSORBERS. II. POLYMERIC UV absorbers have been prepared by free-radical solution copolymerization at 75°C of methyl methacrylate and 2-hydroxy-4-methacryloyloxybenzophenone monomers at low conversion (around 10%).** The composition of the copolymers was determined by UV, IR, and NMR studies. The molecular weight was estimated by GPC. The reactivity ratios were determined by several methods. Viscosity was used to study the effect of copolymer composition and solvents. The copolymers were also analyzed by TGA and DSC, and DSC was used to study the effect of copolymer composition on  $T_g$ . (Author abstract) 20 refs.

Patel, Mahendra (Sardar Patel Univ, Vallabh Vidyanagar, India); Parmar, J.S.; Patel, M.R.; Patel, M.M. *J Macromol Sci Chem* v A24 n 9 1987 p 1085-1097.

**082986 ENTHALPIES OF THE REACTIONS OF SYNTHESIS OF ISOMERIC POLY- $\alpha$ -HYDROXYAMIDES IN SOLUTION.** The authors have determined the enthalpies of the reactions of polycondensation of 3,3'-dihydroxy-4,4'-diaminodiphenylmethane (DHDA) with the diacid chlorides of iso- and terephthalic acids in different solvents. Energetics of the interaction of the amino and hydroxy groups in the molecules of DHDA with the diacid chlorides of dicarboxylic acids and the mutual dependence of the amino groups of DHDA during polycondensation are examined. (Author abstract) 4 refs.

Karyakin, N.V. (Lobachevskii State Univ, Gorkii, USSR); Chernikhov, A.Ya.; Kazakova, G.V.; Tseitlin, G.M.; Rusanov, A.L.; Korshak, V.V. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1569-1573.

**082987 NAUKA O MAKROZASTECZKACH. [Science of Macromolecules].** General characteristics of the methods of polymer synthesis have been presented with particular attention paid to structure control in the synthesis. The specific features of conformation of natural and synthetic polymers have been discussed and the consequences of conformational features to the physical and mechanical properties of polymers presented. The importance of macromolecular compounds in living organisms has been indicated and an example of the capability of muscles to move has been used to illustrate the excellent adaption of natural polymeric structures to the biological functions performed by them. (Edited author abstract) In Polish.

Flory, Paul J. (Stanford Univ, CA, USA). *Polymer* v 32 n 9 1987 p 346-361.

**082988 PREPARATION OF POLY(MALIC ACID) AND ITS ESTER DERIVATIVES BY DIRECT POLYCONDENSATION OF MALIC ACID AND  $\beta$ -ETHYL MALATE.** Direct polycondensations of d,l- and l-malic acids and d,l, $\beta$ -ethyl malate were studied. The dehydrative condensation of d,l-malic acid occurred at 110 approximately 140°C in vacuo to give poly( $\alpha$ ,  $\beta$ -malic acid) with a molecular weight of ca. 2000 (by GPC). This polymer had a random sequence of both  $\alpha$ - and  $\beta$ -type units in equal ratio. The molecular weight, however, did not become higher owing to irreversible depolymerization. By similar dehydrative polycondensation of d,l, $\beta$ -ethyl malate, poly( $\beta$ -ethyl malate) with a molecular weight of ca.1300 was produced. The copolycondensation of d,l-malic acid and d,l, $\beta$ -ethyl malate was also investigated to prepare malic acid- $\beta$ -ethyl malate copolymer. In addition, hydrolysis of poly( $\alpha$ ,  $\beta$ -malic acid) was examined in deuterium oxide by  $^1H$  NMR spectroscopy. (Author abstract) 27 refs. In Japanese.

Ohtani, Noriyoshi (Fuso Chemical Co, Osaka, Jpn); Kimura, Yoshiharu; Kitao, Toshio. *Kobunshi Ronbunshu* v 44 n 9 Sep 1987 p 701-709.

**082989 RECENT DEVELOPMENT OF SYNTHETIC POLYMERS FROM THE VIEWPOINT OF SYNTHETIC CHEMISTRY.** The contents of this article are as follows: some new heat resistant polymers and the improvement methods of their processabilities; some new conductive polymers; and some new polymers with chiral pendant. In each section the following three points are taken into consideration: the starting compounds are easily available; the synthetic methods must be new; and the obtained results are good or excellent. (Edited author abstract) In Japanese. 20 refs.

Oda, Ryohei. *Yuki Gosei Kagaku Kyokaiishi* v 45 n 9 Sep 1987 p 822-836.

**082990 SYNTHESIS AND CHARACTERIZATION OF POLY ([3H]-THIAZOLE-2-THIONE)s.** The reaction of dithiocarbamate salts with  $\alpha$ -haloketones is extended to (i) dithiocarbamate salts with bis( $\alpha$ -haloke-



tones), (ii) bis(dithiocarbamate salts) with  $\alpha$ -haloketones, and (iii) bis(dithiocarbamate salts) with bis( $\alpha$ -haloketones). Both (i) and (ii) give bis([3H]-thiazole-2-thiones) in high yields, and (iii) gives the corresponding polymers which are described and characterized. (Author abstract) 22 refs.

Katritzky, Alan R. (Univ of Florida, Gainesville, FL, USA); Tarr, Richard D.; Heilmann, Steven M.; Rasmussen, Jerald K.; Krepski, Larry R. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3205-3214.

**082991 POLYANHYDRIDES. I. PREPARATION OF HIGH MOLECULAR WEIGHT POLYANHYDRIDES.** Polyanhydrides composed of the following diacids - sebacic acid, bis(p-carboxyphenoxy)propane, bis(p-carboxyphenoxy)hexane, isophthalic acid, 1,4-phenylene dipropionic acid, and dodecanedioic acid - were synthesized by a melt polycondensation process. Polymers of molecular weight up to 137,010 (weight average) and intrinsic viscosity of 0.92 dL/g were achieved. Polymers of higher molecular weights were synthesized in shorter times by using heterogeneous coordination catalysts. Films made of high molecular weight bis(p-carboxyphenoxy)propane-sebacic acid copolymers showed tensile strengths of 40-160 kg/cm<sup>2</sup>; the strength increased as a function of the bis(p-carboxyphenoxy)propane content and molecular weight. (Edited author abstract) 20 refs.

Domb, A.J. (MIT, Cambridge, MA, USA); Langer, R. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3373-3386.

**082992 STUDIES OF POLY(ortho-ACYLSTYRENES). I. SYNTHESIS AND CHARACTERIZATION.** The syntheses of a number of *o*-acylstyrene (*o*-acetyl through *o*-hexanoyl) have been described. Polymerizations were carried out radically at 80°C under high vacuum. While all polymerizations conform to the usual free radical kinetic scheme, rates are sensitive to the nature of the acyl substituent, and this has been ascribed to steric effects, the bulky substituents adjacent to the propagating radicals inhibiting the approach of monomer. Molecular weight and polydispersity data indicate that both combination and disproportionation occur during terminations. UV spectra consist of two absorptions associated with  $n \rightarrow \pi^*$  and  $\pi \rightarrow \pi^*$  transitions. <sup>13</sup>C-NMR spectra have been analyzed and assignments made on the basis of spectral editing. The considerable variation of glass transition temperatures has been accounted for in terms of a combination of steric and dipolar interactions. (Author abstract) 20 refs.

Weir, N.A. (Lakehead Univ, Thunder Bay, Ont, Can); Whiting, K. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3459-3468.

**082993 PREPARATION OF POLYPHOSPHAZENE WITH OLIGO(OXYETHYLENE) BRANCHES.** In view of the high costs of polymer syntheses involving immobilized crown-ether units, polymers containing functional oligo(oxyethylene) branches seem to be very attractive. This paper brings first findings on the synthesis of polyphosphazenes containing linear oligo(oxyethylene) branches, partly loosely pendant on the polyphosphazene branch and partly in the form of intermolecular branches and intramolecular branches (pseudocrown-ether structures). 16 refs.

Janout, V. (Czechoslovak Acad of Sciences, Prague, Czech); Cefelin, P.; Provotorova, N.P.; Tur, D.R.; Vinogradova, S.V. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3489-3493.

**082994 GRAFTING OF PARTIALLY HYDROLYSED POLY(METHYL METHACRYLATE) ONTO MESYLATED CELLULOSE ACETATE.** A new synthetic route to cellulose graft polymers by nucleophilic displacement of mesylate groups from mesyl cellulose acetate (MCA) by the polystyrylcarboxylate anion has been recently reported by us. This approach to cellulosic graft polymers overcomes the drawbacks of the radical polymerization methods and allows for precise control of parameters such as the molecular weight and molecular weight distribution of the grafted side chains, higher

degree of substitution on the cellulose backbone, the number and nature of grafted side chains and overall better control and reproducibility of the grafting process. In this report, partially hydrolyzed poly(methyl methacrylate) was successfully grafted on to mesylated cellulose acetate in excellent yields by nucleophilic displacement of mesylate groups in less than 60 min at 75°C. (Author abstract) 10 refs.

Biermann, Christopher J. (Purdue Univ, West Lafayette, IN, USA); Narayan, Ramani. *Polymer* v 28 n 13 Dec 1987 p 2176-2178.

**082995 LINEAR, SOLUBLE POLY(BISMETHYLENE HYDROQUINONE), A LADDER POLYMER: SYNTHESIS AND CHARACTERIZATION.** A route to prepare a soluble linear ladder of poly(bismethylene hydroquinone) was developed. 2,3,5,6-Tetramethylol hydroquinone was reacted with hydroquinone in sulfolane with acid catalysis. Gel formation was prevented by removing the water generated during the condensation, and by preventing oxidation of the polymer during reaction. Polymers with intrinsic viscosities as high as 5.0 were obtained; viscosity depended on the mole ratio of the starting materials and the reaction conditions. Polymer structure was characterized by Fourier transform infra-red spectroscopy, nuclear magnetic resonance spectroscopy, polarizing microscopy and X-ray diffraction. (Author abstract) 23 refs.

Bi, Xian-Tong (Case Western Reserve Univ, Cleveland, OH, USA); Litt, Morton H. *Polymer* v 28 n 13 Dec 1987 p 2346-2352.

**082996 PRESENT TRENDS IN THE SYNTHESIS OF THERMOSTABLE POLYMERS BY POLYCONDENSATION METHODS. REVIEW.** A study was made of present-day trends in the development of polycondensation methods for the synthesis of thermostable heterocyclic polymers, in particular polybenzazoles and PIs. Subjects of major interest were catalytic methods that could be used for the synthesis of polybenzazoles and variants of these polymers by precipitative, and reduction methods, as well as by 'direct' polyheterocyclization. The study also covered complex reactions in the synthesis of polybenzazoles leading to 'ladder' polyheteroarylenes of the polyazoloquinazoline series. A promising trend in the development of PI chemistry has resulted in polynaphthylimides and their derivatives, viz. polynaphthylenebenzimidazoles. (Edited author abstract) 74 refs.

Rusanov, A.L. (USSR Acad of Sciences, USSR). *Polym Sci USSR* v 28 n 8 1986 p 1745-1760.

**082997 ELECTROCHEMICAL SYNTHESIS AND SPECTROSCOPIC STUDY OF POLY(3-ALKYLTHIENYLENES).** The class of poly(3-alkylthienylenes) [P3ATs] has been synthesized by an improved method of electrochemical polymerization carried out under a rigorously oxygen-free and moisture-free environment. Within this class, the highest conductivity (750 S/cm) was obtained for poly(3-methylthienylene). The P3ATs (carrying hydrocarbon chains with carbon numbers of four or more) also show relatively high conductivities ranging from about 1 to 10<sup>2</sup> S/cm. The P3ATs with relatively longer hydrocarbon chains show good solubility in various organic solvents and can be readily processed from solution both in the neutral and in the conducting (oxidized) form. (Edited author abstract) 21 refs.

Hotta, S. (Univ of California, Santa Barbara, CA, USA). *Synth Met* v 22 n 2 Dec 1987 p 103-113.

**082998 CONFORMATION AND ELECTRONIC STRUCTURE OF POLY (3,4-DIISOPROPYLIDENECYCLOBUTENE), A CROSS-CONJUGATED CONDUCTIVE POLYMER.** It has been reported recently that poly(3,4-diisopropylidenecyclobutene) 1, synthesized by a novel olefin-metathesis route, can be oxidatively doped to yield materials with moderate conductivities. Theoretical studies reveal that, due to steric crowding, polymer 1 cannot achieve a planar, fully-conjugated structure in either its undoped or doped states. Rather, the structure consists of essentially orthog-

onal tetramethylhexatriene units. Such a structure is incompatible with conventional conduction mechanisms involving polarons or bipolarons. It is proposed that, instead, conduction involves intra- and/or inter-chain charge transfer. (Edited author abstract) 11 refs.

Pranata, Julianto (Columbia Inst of Technology, Pasadena, CA, USA); Dougherty, Dennis A. *Synth Met* v 22 n 2 Dec 1987 p 171-178.

**082999 SYNTHESIS AND CONDUCTIVITY STUDIES OF POLY(2,5-DIMETHOXY-1,4-PHENYLENE VINYLENE).** Given the simplicity of preparation of high molecular weight PPV (poly(p-phenylene vinylene)) via the quinodimethane route and the ease of synthesis of the starting monomers, we chose to investigate the applicability of this route to the preparation of substituted PPV. We have prepared high molecular weight PDMPV (poly(2,5-dimethoxy-1,4-phenylene vinylene)) via a processable precursor polymer and report its unusual oxidative and reductive behavior. The conductivity and electrochemical potential versus doping level behavior for PDMPV was determined by in situ four-probe conductivity measurements recorded at intervals during electrochemical oxidation, and are presented. We have also found that PDMPV can be reversibly reduced (n-type doped) in an electrolyte of sodium tetraphenylborate in 2-methyltetrahydrofuran. In this case, sodium ions are inserted into the polymer. 11 refs.

Jen, Kwan-Yue (Allied Signal Inc, Morristown, NJ, USA); Shacklette, Lawrence W.; Elsenbaumer, Ronald. *Synth Met* v 22 n 2 Dec 1987 p 179-183.

**083000 HIGH ION SELECTIVE ELECTROCHEMICAL SYNTHESIS OF POLYANILINE.** Polyaniline was deposited onto platinum foil in aqueous electrolyte containing the polymer electrolyte. ESCA (electron spectroscopy for chemical analysis) spectra revealed that the polymer electrolyte was selectively incorporated into the polyaniline matrixes. The selectivity was assumed to be more than hundred times. (Edited author abstract) 4 refs.

Hyodo, Kenji (Mitsubishi Paper Mills Ltd, Tokyo, Jpn); Nozaki, Masaaki. *Electrochim Acta* v 33 n 1 Jan 1988 p 165-166.

**083001 POLY(LACTATE) III. STEREOSELECTIVE POLYMERIZATION OF MESO-DILACTIDE.** In a previous paper, it was shown that Bernoullian statistics apply to the polymerization of racemic dilactide catalyzed with stannous octoate. In the present paper, we report that under identical reaction conditions meso-dilactide forms a highly stereoregular polymer. The ring-opening polymerization of dilactide proceeds by triad addition involving acyl cleavage with retention of chirality. 4 refs.

Schindler, A. (Research Triangle Inst, Research Triangle Park, NC, USA); Gaetano, K.D. *J Polym Sci Part C* v 26 n 1 Jan 1988 p 47-48.

**083002 SYNTHESIS AND BIOMEDICAL PROPERTIES OF POLY-[(ETHYLENE-VINYL ALCOHOL)-g-ACRYLAMIDE].** This paper deals with the graft copolymerization of acrylamide (AM) onto ethylene-vinyl alcohol copolymer (EVAL) film initiated by cerium(IV) ion. It was found that both the chemical and diffusion factors had influences on the graft reaction. The reaction was initiated on the surface and then penetrated inward as the grafting percentage was increased. The permeability of urea through the grafted EVAL film was improved compared to that of the original film as was the blood compatibility. (Author abstract) 18 refs.

Yao, Kang De (Tianjin Univ, Tianjin, China); Liu, Zhu Fang; Gu, Han Qin; Fan, Ting Yu. *J Macromol Sci Chem* v A24 n 10 Oct 1987 p 1191-1205.

**083003 REACTIONS AND POLYMERIZATION OF 1-TRITYL-4-VINYLMIDAZOLE.** 1-Trityl-4-vinylimidazole was prepared by direct tritylation of 4(5)-vinylimidazole and polymerized using a free radical initiator. Poly(1-trityl-4-vinylimidazole) was hydrolyzed



using aqueous acetic acid to give poly[4(5)-vinylimidazole]. The poly[4(5)-vinylimidazole], which was obtained from the hydrolysis of poly(1-trityl-4-vinylimidazole), was compared with poly [ prepared directly from 4(5)-vinylimidazole for differences in stereochemistry. The stereochemistry of both polymers was found to be similar by high-resolution NMR. Thus, the trityl does not influence the stereochemistry of poly [ . The reaction of 1-trityl-4-vinylimidazole with *n*-butyllithium gave 2-lithio-1-trityl-4-vinylimidazole. This intermediate was used to prepare 2-substituted 4(5)-vinylimidazoles, which are new monomers that can be polymerized using free radical initiators. (Author abstract) 5 refs.

Schiavone, R.J. (Univ of Michigan, Ann Arbor, MI, USA); Overberger, C.G. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 107-115.

**083004 SYNTHESIS OF POLY(1,3,4-OXADIAZOLES) BY DIRECT POLYCONDENSATION OF DICARBOXYLIC ACIDS WITH HYDRAZINE SULFATE USING PHOSPHORUS PENTOXIDE/METHANESULFONIC ACID AS CONDENSING AGENT AND SOLVENT.** A convenient method for the synthesis of poly(1,3,4-oxadiazole)s of high molecular weights has been developed. These polymers were prepared readily by the direct polycondensation of dicarboxylic acids with hydrazine sulfate (1) using phosphorus pentoxide/methanesulfonic acid (PPMA) as both a condensing agent and solvent. Polycondensation of aliphatic dicarboxylic acids with 1 proceeded even at room temperature and produced poly(1,3,4-oxadiazole)s with inherent viscosities up to 1.4 dL/g. The synthesis of aromatic poly(1,3,4-oxadiazole)s from aromatic dicarboxylic acids containing phenyl ether structures was carried out by a one-pot procedure because the preactivation of dicarboxylic acids was required. The synthesis of 2,5-disubstituted-1,3,4-oxadiazoles by the reaction of carboxylic acids with 1 in PPMA was studied to demonstrate the feasibility of the reaction for polymer formation. (Edited author abstract) 13 refs.

Ueda, Mitsuru (Yamagata Univ, Yonezawa, Jpn); Sugita, Hiroo. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 159-166.

**083005 SYNTHESIS AND REACTIONS OF UNIFORM SIZE POLY(DIMETHYLSILOXANE) WITH VARIOUS REACTIVE END GROUPS.** The reaction of monofunctional living poly(dimethylsiloxane), poly(DMS), with dimethylchlorosilane (2), followed by the hydrosilylation of the polymer end SiH group with allyl alcohol was performed. The hydroxyl end group of poly(DMS) (4) thus obtained was subsequently converted to the tosylate ester group through treatment with tosyl chloride in the presence of 4-dimethylaminopyridine (DMAP). The tosylate ester end group of poly(DMS) (5) was found to initiate the cationic ring opening polymerization of 2-methyl-2-oxazoline (OXZ) to produce the poly(DMS)/poly(OXZ) block copolymer (7). (Author abstract) 16 refs.

Kazama, Hideki (Technological Univ of Nagaoka, Nagaoka, Jpn); Tezuka, Yasuyuki; Imai, Kiyokazu. *Polym J* v 19 n 9 1987 p 1091-1100.

**083006 FUNCTIONAL MONOMERS AND POLYMERS - CLVIII. ASYMMETRIC INCLUSION POLYMERIZATION OF CYCLIC DIENE MONOMERS IN A DEOXYCHOLIC ACID CANAL.** Asymmetric inclusion polymerization has become one of the most interesting subjects in this decade. In an asymmetric canal formed from a chiral host such as deoxycholic acid (DCA) or apocholic acid, polymerization reactions can be regulated by a host-guest relationship in size, shape, chirality, and polarity. In this communication we report the asymmetric inclusion polymerization of cyclic diene monomers in a DCA canal. Optically active poly(cyclodienes) were first obtained by inclusion polymerization via a radical mechanism, using DCA as a host molecule. 6 refs.

Tsutsumi, Hiromori (Osaka Univ, Suita, Jpn); Miyata, Mikiji; Takemoto, Kiichi. *Polym J* v 19 n 11 1987 p 1321-1323.

**083007 SYNTHESIS OF POLY-[BENZ-(DI-PYRIMIDOBENZIMIDAZOLES)] BY COMBINED REDUCTIVE POLYHETEROCYCLIZATION.** Poly-[benz-(di-pyrimidobenzimidazoles)] have been synthesized by the method of combined reductive polyheterocyclization based on the interaction of 4,6-dinitroisophthalic acid dichloride with bis-(*o*-nitro)anilines, conversion of the *o*-nitro-substituted polyamides obtained to poly-(*o*-amino)benzimidazoles, benzooylation of the latter via the free amino groups and catalytic cyclodehydration of the poly-(*o*-benzamido)benzimidazoles formed. The synthesized poly-[benz-(di-pyrimidobenzimidazoles)] possess raised solubility in organic solvents. (Author abstract) 15 refs.

Korshak, V.V. (USSR Acad of Sciences, USSR); Rusanov, A.L.; Tugushi, D.S.; Tsotadze, M.V.; Kipiani, L.G. *Polym Sci USSR* v 28 n 9 1986 p 2028-2033.

**083008 SYNTHESIS OF POLY [BENZ(DI(SYMM-TRIAZOLOPYRIMIDINES))] BY THE METHOD OF MODIFIED REDUCTIVE POLYHETEROCYCLIZATION.** Poly[benz(di(symm-triazolopyrimidines))] have been synthesized by the method of modified reductive polyheterocyclization based on the interaction of 4,6-dinitroisophthalic acid dichloride with the bis-amidrazones of dicarboxylic acids, conversion of the *o*-nitrosubstituted heterochain polymers to poly-(*o*-amino)-symm-triazoles, benzooylation of the latter through the free amino groups and catalytic cyclodehydration of the poly-(*o*-benzamido)-symm-triazoles formed. The synthesized poly[benz(di(symm-triazolopyrimidines))] possess raised solubility in organic solvents; their thermal characteristics are comparable with those of the previously obtained poly[benz(di(symm-triazolopyrimidines))]. (Author abstract) 14 refs.

Korshak, V.V. (USSR Acad of Sciences, USSR); Rusanov, A.L.; Tugushi, D.S.; Kereselidze, M.K. *Polym Sci USSR* v 28 n 9 1986 p 2034-2040.

**083009 LINEAR POLYTHIOESTERS. XIII. PRODUCTS OF POLYCONDENSATION OF ISOMERIC Di(MERCAPTOMETHYL)-DIMETHYLBENZENES WITH ADIPOYL AND SEBACOYL CHLORIDES.** The synthesis of a new aliphatic-aromatic polythioesters obtained by polycondensation of 4,5-di(mercaptomethyl)-1,2-dimethylbenzene, 4, 6-di(mercaptomethyl)-1,3-dimethylbenzene and 2, 5-di(mercaptomethyl)-1,4-dimethylbenzene with adipoyl and sebacyl chloride is described. To define the optimal condition of the process, the polythioester from 2,5-di(mercaptomethyl)-1, 4-dimethylbenzene and sebacyl chloride was chosen as a model system and obtained by interfacial polycondensation as well as by low- and high-temperature solution polycondensation. The quality of the obtained polycondensates was estimated on the basis of values of the reduced viscosity and yield. The structure of the aliphatic-aromatic polythioesters was determined from elementary analysis, infrared spectra, and x-ray analysis. Some thermal, mechanical, electrical, and chemical properties as well as molecular weights of obtained polycondensates have been determined. (Edited author abstract) 8 refs.

Podkoscilny, Wawrzyniec (Maria Curie-Skłodowska Univ, Lublin, Pol); Szubinska, Stanisława. *J Appl Polym Sci* v 35 n 1 Jan 1988 p 85-101.

**083010 POLYMERIZATION KINETICS OF POLYSILAZANE BY TRANSITION METAL CATALYZED DEHYDROCOUPLING REACTION.** Transition metal catalyzed polymerization of polysilazanes has been reported as one of potential routes to silicon nitride precursor synthesis. In this communication, we report a study of the polymerization kinetics of poly-*N*-methylsilazane (PNMS) catalyzed by Ru<sub>3</sub>(CO)<sub>12</sub>. The polymerization reaction of PNMS proceeds from oligosilazanes. This communication demonstrates the importance of molecular and structural characterization of the reacting medium to better understand the reaction mechanism of the polysilazane preceramic polymers. These characterization results will also serve as a database for establishing a

structure-property-processing relationship for better molecular design of inorganic and organometallic polymers. 6 refs.

Chow, Andrea W. (SRI Int, Menlo Park, CA, USA); Hamlin, Richard D.; Blum, Yigal; Laine, Richard M. *J Polym Sci Part C* v 16 n 2 Feb 1988 p 103-108.

**083011 SYNTHESIS OF FUNCTIONALIZED LINEAR POLY(DIVINYLBENZENE). III. SYNTHESIS OF POLYMERIC DELOCALIZED CARBANION OF POLY(DIVINYLBENZENE) AND ITS REACTIONS.** A polymeric delocalized carbanion of poly(divinylbenzene) [poly(DVB)](2) was obtained by the proton abstraction with alkyllithium from the acidic methine moieties (H<sub>A</sub>) of linear poly(DVB) (1), which was prepared by the polymerization of DVB initiated by acetyl perchlorate. The formation of polyanion 2 was confirmed by UV-visible spectroscopy (λ<sub>max</sub>=630 nm) and the reaction with methyl iodide to give methylated poly(DVB). Delocalized polyanion 2 reacted with various electrophilic reagents in THF at 60°C, to yield poly(DVB) derivatives having pendant trimethylsilyl, vinyl, vinyloxy, hydroxyl, and carboxyl groups. Proton abstraction with base and subsequent reactions with electrophiles were also studied with the linear unsaturated dimer of styrene (1,3-diphenyl-1-butene), as a model for poly(DVB) 1. (Author abstract) 9 refs.

Aoshima, Sadahito (Kyoto Univ, Kyoto, Jpn); Higashimura, Toshinobu. *J Polym Sci Part A* v 26 n 2 Feb 1988 p 393-403.

**083012 SYNTHESIS AND ELECTRICAL PROPERTIES OF SUBSTITUTED PARACYCLOPHANE POLYMERS.** The authors report the synthesis of three new substituted [6.2]paracyclophane-1,5-dienes and their conversion to medium molecular weight polymers by an intra/intermolecular cyclopolymerization. These materials can be oxidatively doped by exposure to iodine vapor to give semiconductor properties. (Edited author abstract) 7 refs.

Longone, Daniel T. (Univ of Michigan, Ann Arbor, MI, USA); Glans, Jeffrey H. *J Polym Sci Part A* v 26 n 2 Feb 1988 p 405-417.

**083013 PREPARATION OF POLYSILOXANES FROM SILICIC ACID. X. PREPARATION AND PROPERTIES OF ALLYLDIMETHYLSILYLATED SILICIC ACIDS.** In order to obtain polysiloxanes capable of forming a film, the preparation and properties of allyldimethylsilylated silicic acid was investigated. The reaction in variable molar ratios of allyldimethylchlorosilane to silicic acid gave partially silylated silicic acids with different degrees of silylation. They provided not only fibrous polysiloxanes but also films from concentrated polymer solutions. Spinnability and film formation depended on the solvent, degree of silylation, molecular weight, and allyl group. (Author abstract) 3 refs.

Abe, Yoshimoto (Science Univ of Tokyo, Noda, Jpn); Kaijou, Akira; Nagao, Yukinori; Misono, Takahisa. *J Polym Sci Part A* v 26 n 2 Feb 1988 419-427.

**083014 SYNTHESIS, MICROSTRUCTURE, AND COPOLYMERIZATION STUDIES OF 2-CHLOROETHYL α-CHLOROACRYLATE.** Poly(2-chloroethyl α-chloroacrylate) was synthesized by radical initiation, and its microstructure was evaluated using carbon-13 NMR. Methyl methacrylate (M<sub>1</sub>) and 2-chloroethyl α-chloroacrylate (M<sub>2</sub>) were copolymerized in toluene at 55°C using azobisisobutyronitrile as initiator. The reactivity ratios are 0.37±0.28 and 1.21±2.26. The thermal properties of these copolymers have also been reported. (Author abstract) 18 refs.

Pathak, Chandrashekar P. (Indian Inst of Technology, Bombay, India); Patni, Mahendra J.; Babu, Gaddam N. *J Polym Sci Part A* v 26 n 2 Feb 1988 p 503-510.



**083015 SYNTHESIS OF POLYMER MATERIALS BY LOW-ENERGY ELECTRON BEAMS: 5 EFFECTS OF PREPOLYMER MOLECULAR WEIGHT ON STRUCTURE AND PROPERTIES OF ELECTRON-BEAM-CURED GEL FILMS.** The effects of prepolymer molecular weight on the structure and properties of electron-beam-cured (EB-cured) gel films were investigated. The molecular weight of the urethane-acrylate prepolymer, which was synthesized by reaction of poly(butylene adipate) diol (PBAD), 4,4'-diphenylmethane diisocyanate (MDI) and 2-hydroxyethylacrylate (HEA), was varied between 1,450 and 3,200 by changing the molecular weight of PBAD. Above a prepolymer molecular weight of 2,700, the crystallinity arising from PBAD moieties decreased with decreasing molecular weight for both the prepolymer films and EB-cured gel films. Below a molecular weight of 1,700, these films had no crystallinity and gave an amorphous film. (Edited author abstract) 14 refs.

Ando, M. (Dai Nippon Printing Co, Tokyo, Jpn); Uryu, T. *Polymer* v 29 n 2 Feb 1988 p 370-375.

**083016 SYNTHESIS AND CHARACTERISATION OF POLY(ARYLENE SULPHIDES): PART 10. A COMPARATIVE EVALUATION OF THE THERMOANALYTICAL BEHAVIOUR AND CURING OF POLY(1,4-PHENYLENE SULPHIDE) AND COPOLYMERS CONTAINING 1,4-PHENYLENE SULPHIDE AND 2-METHYL-1,4-PHENYLENE SULPHIDE REPEAT UNITS.** Thermogravimetry, differential scanning calorimetry and curing studies were used to assess the viability of random and block copolymers comprising 1,4-phenylene sulphide and 2-methyl-1,4-phenylene sulfide repeat units as alternatives to poly(1,4-phenylene sulfide) (PPS). The properties of the copolymers are discussed critically and compared with those of the parent homopolymers PPS and poly(2-methyl-1,4-phenylene sulfide) (PMPS). The results suggest that (a) random copolymers with low PMPS contents would offer the best compromise between PPS and PMPS properties, and (b) more desirable physical properties might be achieved from systems containing a less reactive 2-substituted-1,4-phenylene sulfide comonomer repeat unit. (Author abstract) 20 refs.

Lovell, Peter A. (UMIST, Manchester, Engl); Still, Richard H. *Br Polym J* v 20 n 1 1988 p 69-75.

**083017 SYNTHESIS AND REACTIONS OF POLYMERS WITH PHOTOACTIVE TERMINAL GROUP - 3. THE USE OF RADICAL PROMOTED CATIONIC POLYMERIZATION FOR THE SYNTHESIS OF POLY(n-BUTYL VINYLETHYL) WITH N-ACYL DIBENZ(b, f)AZEPINE TERMINAL UNITS.** The free radical promoted cationic polymerization of n-butyl vinyl-ether (BVE) was achieved by the thermal decomposition of N-[4,4'-azobis-(4-cyanopentanol)]-bis(dibenz(b, f)azepine (ADBA) in the presence of diphenyliodonium hexafluorophosphate ( $\text{Ph}_2\text{I}^+\text{PF}_6^-$ ) or silver hexafluorophosphate ( $\text{AgPF}_6$ ). Polymer samples prepared in the presence of  $\text{AgPF}_6$  contained a significant number of terminal dibenzazepine units. Chain extension via dimerization of the dibenzazepine units occurred upon irradiating these polymers with u.v. light ( $\lambda = 366 \text{ nm}$ ) in  $\text{CH}_2\text{Cl}_2$  solution containing a triplet sensitizer (benzophenone or benzil). (Edited author abstract) 9 refs.

Yagci, Yusuf (Hahn-Meitner-Inst Berlin GmbH, Berlin, West Ger); Schnabel, Wolfram; Ledwith, Anthony. *Eur Polym J* v 23 n 10 1987 p 737-740.

**083018 SYNTHESIS AND CHARACTERIZATION OF POLY(KETO-AMINES) CONTAINING IMINO-BZ-DIMETHYL PHENACILS.** Poly(keto-amine)s, designated as poly(imino-bz-dimethylphenacils), were prepared by self-polycondensation of 2,4-dimethyl-5-aminophenacyl, 2,5-dimethyl-4-aminophenacyl, 3,4-dimethyl-5-aminophenacyl and 2,4-dimethyl-3-aminophenacyl chlorides using nitrobenzene as solvent and pyridine,  $\text{K}_2\text{CO}_3$  and quinoline as acid acceptors. All the poly(keto-amine)s were characterized by estimation of nitrogen content, i.e. spectral study, estimation of  $M_n$  by non-aqueous conductometric titration, viscosity mea-

surements in formic acid and by TGA in air. Polyamines, prepared from selected poly(keto-amine)s of each series by Wolf-Kishner reduction, are characterized. (Author abstract) 6 refs.

Patel, S.V. (Sardar Patel Univ, Vallabh Vidyanagar, India); Patel, H.S.; Patel, S.R. *Eur Polym J* v 23 n 10 1987 p 795-797.

**083019 SYNTHESIS, PHYSICAL AND THERMAL CHARACTERIZATION OF PHOSPHORUS-CONTAINING HOMOPOLYMERS AND COPOLYMERS BASED ON 2,4-BIS(4-AMINOPHENOXY)-6-DIETHOXYPHOSPHINYL-1,3,5-TRIAZINE.** Novel phosphorus-containing homopolymers and copolymers are prepared. These polymers were characterized by inherent viscosity measurements, infrared (IR) and proton nuclear magnetic resonance ( $^1\text{H-NMR}$ ) spectroscopy as well as by differential thermal analysis (DTA) and dynamic thermogravimetric analysis (TGA). Their thermal properties were compared with those of the corresponding nonphosphorylated polymers. The copolymers were stable up to 233-272°C in nitrogen or air atmosphere. The homopolymers showed a relatively lower thermal stability. Furthermore, a model diimide, diamide, and diurea were synthesized from the reactions of BADT with phthalic anhydride, benzoyl chloride, and phenyl isocyanate, respectively. The physical and thermal characteristics of these model compounds were correlated with those of the corresponding homopolymers. 12 refs.

Melissaris, Anastasios P. (Univ of Patras, Patras, Greece); Mikroyannidis, John A. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 831-845.

**083020 PROTECTIVE GROUP SYNTHESIS OF POLY-N-HYDRO-(3,6-CARBAZOLYL).** Poly-N-trityl-(3,6-carbazolyl), PNTPMCZ, has been synthesized in pyridine solution using an activated nickel catalysts. 9-Trityl-3,6-dihydrocarbazole was polymerized and the triphenylmethyl group subsequently removed by acid hydrolysis. The N-protected monomer was made by a phase-transfer reaction employing 3,6-dihydrocarbazole, a benzotriethylammonium chloride catalyst, basic solution and triphenylmethyl chloride. A wide variety of N-substituents can be obtained in this way, allowing the molecular design of polycarbazolyls to be controlled. Poly-N-hydro-(3,6-carbazolyl), PNHCZ, obtained from PNTPMCZ, forms iodine complexes with conductivities of  $10^{-1} \text{ ohm}^{-1} \text{ cm}^{-1}$  at room temperature. The visible-near-i.r. spectra suggest that the same radical cations responsible for conductivity in poly-N-methyl-(3,6-carbazolyl) are present. (Edited author abstract) 14 refs.

Racchini, Joel R. (Univ of Minnesota, Minneapolis, MN, USA); Wellinghoff, Stephen T.; Jenekhe, Samson A. *Synth Met* v 22 n 4 Feb 1988 p 291-303.

**083021 CHEMICAL SYNTHESIS AND CHARACTERIZATION OF POLYPYRROLE-CHLORINE COMPLEX.** Simultaneous chemical polymerization and oxidation of pyrrole have been initiated by chlorine ( $\text{Cl}_2$ ) in various organic solvents. The polypyrrole-chlorine (PPY- $\text{Cl}_2$ ) complex so produced is granular in nature and has a room-temperature direct-current (d.c.) electrical conductivity ( $\sigma$ ) that varies from  $<10^{-7}$  to  $0.5 \text{ S cm}^{-1}$  depending on the solvent medium used for polymerization. The physicochemical and thermal properties of this sample were also examined in some detail. (Edited author abstract) 23 refs.

Neoh, K.G. (Natl Univ of Singapore, Singapore); Tan, T.C.; Kang, E.T. *Polymer* v 29 n 3 Mar 1988 p 553-558.

**083022 SYNTHESIS OF POLYMER MATERIALS BY LOW ENERGY ELECTRON BEAM. III. EFFECTS OF POLYMERIZATION TEMPERATURE IN EB SOLID-STATE POLYMERIZATION OF SEMICRYSTALLINE URETHANE-ACRYLATE FILM.** In an electron beam (EB) polymerization of a urethane-acrylate prepolymer, the polymerization temperature greatly affected the structure and properties of the resulting gel film. Urethane-acrylate, which was synthe-

sized by the reaction of poly(butylene adipate)diol, 4,4'-diphenylmethane diisocyanate, and 2-hydroxyethyl acrylate, was used as a prepolymer. The prepolymer was semicrystalline and showed a melting point in the region of 50-60°C. The maximum polymerization rate of the prepolymer was obtained when the prepolymer film was irradiated in the temperature range of 25-40°C. EB polymerization below the melting point ( $T_m$ ) of the prepolymer produced semicrystalline polyurethane-acrylate gel films with a spherulitic texture. On the other hand, EB polymerization above the  $T_m$  destroyed the crystalline phase of the prepolymer to give transparent gel films. The gel film cured below the  $T_m$  had higher stress at yield, Young's modulus, and tensile strength than those cured above the  $T_m$ . Such temperature effects are attributed to whether or not the EB polymerization proceeds with retention of crystalline structure of the prepolymer. (Author abstract) 16 refs.

Ando, Masayuki (Dai Nippon Printing Co, Tokyo, Jpn); Uryu, Toshiyuki. *J Appl Polym Sci* v 35 n 2 Feb 5 1988 p 397-406.

**083023 SYNTHESIS AND CHARACTERIZATION OF POLYISOBUTYLENE PROPELLANT BINDERS.** Substantial gains in rocket motor cost-effectiveness or performance can be achieved through improved propellant aging characteristics or better and more reproducible mechanical properties. The approach is achieving these goals is the development of a new binder based on ideal networks formed from polyisobutylene (PIB) prepolymers. PIB prepolymers evaluated in this study were synthesized using the 'inifer' process which allows close control of molecular weight distribution, functionality and types of end group. Hydroxy-terminated PIB's with molecular weights that varied from 1500 to 6000 and functionalities of 2 or 3 were synthesized. After a thorough characterization, gumstocks were prepared with isocyanate curatives of controlled functionality. The effect of  $M_c$  and plasticizer content on mechanical properties were determined in addition to the aging characteristics of the systems. Accelerated aging studies of the gumstocks were conducted. (Edited author abstract) 2 refs.

Hartman, K.O. (Hercules Inc, Cumberland, MD, USA); Bohrer, E.K. *Polym Bull (Berlin)* v 18 n 5 Nov 1987 p 403-410.

**083024 SOLUBLE POLY(BISMETHYLENE HYDROQUINONE): SYNTHESIS AND PROPERTIES.** Soluble poly(bismethylene hydroquinone) (PBHQ) of two different intrinsic viscosities and degrees of ring closure were synthesized. The polymers were chemically oxidized using bromine. The oxidation process was studied by comparison of the unoxidized and oxidized polymers using Fourier transform infrared,  $^{13}\text{C}$  solid-state CP/MAS NMR, elemental analysis, UV spectroscopy, and electron spin resonance. The oxidation-reduction processes of the polymers were studied using cyclic voltammetry. (Author abstract) 35 refs.

Dalal, V.F. (Case Western Reserve Univ, Cleveland, OH, USA); Bi, X.T.; Daroux, M.L.; Litt, M.H.; Rickert, S.E. *J Electrochem Soc* v 135 n 3 Mar 1988 p 578-586.

**083025 SYNTHESIS OF ALKENYLATED POLYAMINES AND STUDY OF THEIR PHYSICO-CHEMICAL PROPERTIES.** A series of oligoisobutylenes (OIB) with a different molecular weight and degree of unsaturation were used as the starting reagents for synthesis of the alkenylated polyamines. Oligoisobutylpolyamines (OIBPA) were synthesized by bromination of the starting OIB with subsequent substitution of the halogen by triethylenetetramine (TETA). As a result of the experiment performed, a series of alkenylated polyamines with a different concentration of nitrogen was obtained. The dispersing and anticorrosion properties were determined in a composite with M-11 base-stock oil for all of the compounds obtained. The results of these tests are reported and an analysis of the data showed that the dispersing capacity is a function of the concentration



of nitrogen in the compounds studied: the higher the concentration of nitrogen, the higher the dispersing capacity. 15 refs.

Sokolova, O.S. (Leningrad State Univ, USSR); Belysheva, M.V.; Ostroukhov, N.N.; Popovich, T.D. *J Appl Chem USSR* v 60 n 6 pt 2 Jun 1987 p 1286-1291.

**083026 FUNCTIONAL POLYMERS; 47. SYNTHESIS OF VARIOUS DERIVATIVES OF  $\omega$ -ALKENOATES.** A number of derivatives of  $\omega$ -alkenoates was synthesized in preparation for the synthesis of functional polymers based on  $\alpha$ -olefins. For the preparation of most of the methyl esters, the regular esterification of  $\omega$ -alkenoic acids, specifically 10-undecenoic acid with methanol and sulfuric acid as the catalyst, was most effective. (Edited author abstract) 46 refs.

Purgett, Mark D. (Univ of Massachusetts, Amherst, MA, USA); Xie, Shishan; Bansleben, Donald A.; Vogl, Otto. *J Polym Sci Part A* v 26 n 3 Mar 1988 p 657-675.

**083027 FUNCTIONAL POLYMERS; 48. POLYMERIZATION OF  $\omega$ -ALKENOATE DERIVATIVES.** Esters of  $\omega$ -alkenoic acids have been homopolymerized with transition metal initiating systems. The key to the successful polymerization was the complexation of the monomer prior to its addition to the initiating system. Titanium trichloride, aluminum activated, was found to be best as the transition metal part of the initiator systems, with diethyl-, or better, diisobutylaluminum chloride as the reducing agents and *n*-hexane or toluene as the solvents. Best results for polymerizations were obtained with 2,6-dimethylphenyl esters of the functional  $\alpha$ -olefin monomers; however, other phenyl esters also polymerized well. (Edited author abstract) 48 refs.

Purgett, Mark D. (Univ of Massachusetts, Amherst, MA, USA); Vogl, Otto. *J Polym Sci Part A* v 26 n 3 Mar 1988 p 677-700.

**083028 SYNTHESIS OF POLYPHTHALOCYANINES BY AN OXIDOREDUCTION REACTION INITIATED BY THE BENZHYDROL FUNCTION GROUP. 1. MODEL STUDY.** A novel route for the thermal conversion of bis(phthalonitrile)monomers into metal-free phthalocyanine network polymers was investigated on the basis of a model study on the tetramerization reaction of 4-benzoylphthalonitrile and benzhydrol derivatives into metal-free phthalocyanine compounds. This procedure of conversion of phthalonitrile derivatives involved an oxidoreduction reaction initiated by the alcohol functional group of benzhydrol coreactant. The influence of molar ratio of phthalonitrile and benzhydrol functional groups, chemical environment of the benzhydrol reducing group has been studied by microcalorimetry and electronic spectroscopy. (Edited author abstract) 25 refs.

Pascal, Thierry (CEMOTA, Vernaison, Fr); Malinge, Jean; Sillion, Bernard; Claudy, Pierre; Letoffe, Jean-Marie. *J Polym Sci Part A* v 26 n 3 Mar 1988 p 865-883.

**083029 DECOMPOSITION RATE STUDIES OF AZOBISNITRILES CONTAINING FUNCTIONAL GROUPS.** The paper reports the results of studies on the thermal decomposition of the azo initiators of close structural similarity. The decomposition rate studies have been carried out in dioxane solution at four different temperatures by nitrogen evolution technique. The activation energies and half-lives for these azo initiators have been determined. The effect of structure of an azo compound on the decomposition rate has been discussed. 18 refs.

Vernekar, S.P. (Natl Chemical Lab, Poona, India); Ghatge, N.D.; Wadgaonkar, P.P. *J Polym Sci Part A* v 26 n 3 Mar 1988 p 953-958.

**083030 AMORPHOUS POLYARAMIDES WITH LOW GLASS TRANSITION TEMPERATURES.** Amorphous polyaramides with  $T_g$ s as low as 120°C have been prepared through the polycondensation of 3,3'-(sulfonylbis(1, 4-phenylenoxy))dibenzoic acid ( $Z=SO_2$ ) and

3,3'-(carbonylbis(1,4-phenylenoxy))dibenzoic acid ( $Z=CO$ ) with 3,3'-(1,3-phenylenedioxy)dianiline. The polymers were obtained by direct polycondensation of the aromatic diacids with the aromatic diamine and, alternatively, via the low-temperature polycondensation of the corresponding diacid chlorides with the aromatic diamine. 4 refs.

Abraham, Tonson (Univ of Dayton Research Inst, Dayton, OH, USA); Soloski, Edward J.; Evers, Robert C. *J Polym Sci Part A* v 26 n 3 Mar 1988 p 959-962.

**083031 SYNTHESIS OF GRAFT POLYMERS BY COPOLYMERIZATION OF MACROMONOMER. III. PREPARATION AND COPOLYMERIZATION OF STYRENE-TERMINATED POLY(OXYETHYLENE) MACROMONOMER.** Styrene-terminated poly(oxyethylene) macromonomers (SOE) with narrow molecular weight distribution and quantitative styrene monofunctionality were synthesized. In homopolymerization of SOE, conversion of monomer to polymer was shown to be low in spite of high consumption of the vinyl groups of the SOE molecules. Free-radical copolymerization of the macromonomer with methyl methacrylate and styrene occurred smoothly, as opposed to homopolymerization. Cumulative copolymer composition and total conversion were determined from the conversions of macromonomer and comonomer (by weight changes) and by proton NMR of the copolymer. (Edited author abstract) 9 refs.

Niwa, Masazo (Doshisha Univ, Kyoto, Jpn); Akahori, Masahiko; Nishizawa, Shigetoshi. *J Macromol Sci Chem* v A24 n 12 Dec 1987 p 1423-1444.

**083032 SYNTHESIS AND CHARACTERIZATION OF POLY(BENZIMIDAZOLYL)THIAANTHONES.** Novel polybenzimidazoles containing thiaanthone heterocyclic units were synthesized from 2,7-thiaanthonedicarboxylic acid-5,5'-dioxide and 2,8-thiaanthonedicarboxylic acid-5,5'-dioxide and two aromatic tetramine hydrochlorides by PPA solution polycondensation in 60-70% yield. Two model compounds, 2,7-bis(2-benzimidazolyl)thiaanthone-5,5'-dioxide and 2,8-bis(2-benzimidazolyl)thiaanthone-5,5'-dioxide, were prepared and characterized by spectral methods. The polybenzimidazoles have inherent viscosities in the range 1.13-1.50 dL/g and decomposition temperatures of 495-560°C. The effects of thiaanthone units on polymer properties are discussed. (Author abstract) 9 refs.

Ashok Reddy, T. (Indian Inst of Technology, Madras, India); Srinivasan, M. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 1051-1061.

**083033 SULPHUR-CONTAINING POLYARYLENEQUINODIIMIDES.** Different synthetic approaches have been used for preparing some new polymers relating to sulphur-containing polyarylenequinodiimides. The latter have been obtained both from quinodiimidedichloride and aromatic dithiols and directly from 1,4-phenylenediamine and disulphenylchlorides. The mechanism of this process has been proposed on the basis of studying a model reaction of phenylsulphenylchloride with 1,4-phenylenediamine. Polyarylenequinodiimides have been obtained by selective oxidation of polyarylenesulphonamides with phenyliodooacetate. Their structure has been proved by IR, PMR, and <sup>13</sup>C-NMR spectroscopies. Electrophysical properties of synthesized polymers have been studied. (Author abstract) 24 refs.

Sergeev, V.A. (Acad of Sciences of the USSR, Moscow, USSR); Nedel'kin, V.I.; Arnavtsov, S.A. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 1125-1141.

**083034 BISMALEIMIDES CHAIN-EXTENDED BY IMIDIZED BENZOPHENONE TETRACARBOXYLIC DIANHYDRIDE AND THEIR POLYMERIZATION TO HIGH TEMPERATURE MATRIX RESINS.** Heat-resistant polymers were obtained by thermal polymerization of several bismaleimides or their substituted derivatives. The chain of the polymer precursors was extended by incorporation of imidized benzophenone tetracarboxylic dianhydride between the

maleimide rings in order to impart a degree of flexibility in the polymers. The bismaleimides and their corresponding tetraamic acids were characterized by infrared (IR) and proton nuclear magnetic resonance (<sup>1</sup>H-NMR) spectroscopy. The differential thermal analysis (DTA) thermograms of the monomers showed exotherms at 200-340°C attributed to the thermally induced polymerization reactions. (Edited author abstract) 7 refs.

Melissaris, Anastasios P. (Univ of Patras, Patras, Greece); Mikroyannidis, John A. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 1165-1178.

**083035 SYNTHESIS AND CHARACTERIZATION OF SOME POLYQUINAZOLINEDIONES.** This paper presents the syntheses and characterization of polyquinazolinediones derived from methylene-4,4'-diaminodiphenyl-3,3'-dicarboxylic acid and four different diisocyanates. The polymers exhibit a sharp, well-defined endotherm in the region of 230-320°C and a broad exotherm in the region of 570-650°C. The exotherm could be due to polymer decomposition. 3 refs.

Padma, S. (Indian Inst of Technology, Madras, India); Mahadevan, V.; Srinivasan, M. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 1253-1257.

**083036 SYNTHESIS AND CHARACTERIZATION OF PHOTOCONDUCTIVE POLYMERS. II. CARRIER INJECTION FROM Se IN BLEND POLYMERS AND COPOLYMERS OF CARBAZOLE BASED VINYL ETHERS.** A number of papers have appeared on carrier injection efficiency in polymers sensitized with a thin layer of selenium. There is no report on the injection efficiency of poly[2-(9-carbazolyl)ethyl 1-propenyl ether] and their copolymers with vinyl ethers. This paper presents the surface potential photodecay characteristics and a comparative study of the carrier injection efficiency of the films of these polymers, their blends and copolymers. 8 refs.

Haque, Shah A. (Univ of Tokyo, Tokyo, Jpn); Uryu, Toshiyuki. *Polym J* v 20 n 2 1988 p 163-167.

**083037 SYNTHESIS AND PROPERTIES OF BISMALEIMIDE RESINS CONTAINING ETHER BONDS.** New bismaleimides containing ether bonds were prepared. The thermal properties of the bismaleimides were investigated by differential scanning calorimetry (DSC). The effects of structure of the bismaleimides and curing conditions on the thermal and mechanical properties of the cured resins such as initial decomposition temperature ( $T_d$ ), glass transition temperature ( $T_g$ ), and flexural strength were studied. The introduction of ether bonds to bismaleimide resins decreased the brittleness of the resins without reductions in their heat-resistant properties. (Author abstract) 9 refs.

Takeda, Shinji (Yokohama Natl Univ, Yokohama, Jpn); Akiyama, Hiromi; Kakiuchi, Hiroshi. *J Appl Polym Sci* v 35 n 5 Apr 1988 p 1341-1350.

**083038 ELECTROCHEMICAL SYNTHESIS AND OPTICAL ANALYSIS OF POLY[(2,2'-DIETHYNYL)-5,5'-DIYLVINYLENE].** The electrochemical synthesis of poly[(2,2'-dithienyl)-5,5'-diylvinylene tetrafluoroborate] (PDTE/BF<sub>4</sub>) has been accomplished and provides copper-black free-standing films with a room temperature four-probe conductivity as high as 15 (Ohm cm)<sup>-1</sup>. The conductivity and morphology of the films were found to be strongly dependent on synthetic conditions. The oxidized form of PDTE is not air stable, as evidenced by a rapid, three order of magnitude drop in the conductivity. Optoelectrochemical experiments demonstrate that bipolarons are the main charge-carrying species in conductive PDTE and allow their evolution to be followed as a function of oxidation. (Author abstract) 35 refs.

Martinez, Maria (Univ of Texas at Arlington, Arlington, TX, USA); Reynolds, John R.; Basak, Sanjay; Black, Douglas A.; Marynick, Dennis S.; Pomerantz, Martin. *J Polym Sci Part B* v 26 n 4 Apr 1988 p 911-920.



**083039 NEW POLYCARBOSILANE MODELS. 2. FIRST SYNTHESIS OF POLYSILAPROPYLENE.** Linear polycarbosilanes containing (methyl- and methyl-deuteriosilylene)methylene units were synthesized for the first time and characterized by  $^1\text{H}$ ,  $^{13}\text{C}$ , and  $^{29}\text{Si}$  NMR. These polymers provide convenient models for studying both configurational sequence effects and Yajima's thermal polydimethylsilane-polycarbosilane rearrangement. Their terminal reticulation was investigated and the main gas evolved characterized. (Author abstract) 14 refs.

Bacque, Eric (CNRS, Talence, Fr); Pillot, Jean-Paul; Bilot, Marc; Dunogues, Jacques. *Macromolecules* v 21 n 1 Jan 1988 p 34-38.

**083040 NEW FAMILIES OF MULTIBRANCHED MACROMOLECULES SYNTHESIZED.** Branching approach allows the construction of 'starburst dendrimers' and 'arborols' - new compounds that resemble polymers but exhibit precisely controlled size, shape and molecular weight. They have three distinguishing structural features: an initiator core, interior layers of repeating units radially attached to the core, and an outer surface of terminal functionality. Dendrimer synthesis is a stepwise process. The new macromolecules could be used right now to calibrate ultrafiltration membranes or to measure the submicron apertures of biomembranes.

Worthy, Ward (C & EN Chicago, IL, USA). *Chem Eng News* v 66 n 8 Feb 22 1988 p 19-21.

**083041 ONE-STEP CHEMICAL SYNTHESIS OF DOPED POLYTHIOPHENE BY USE OF COPPER(II) PERCHLORATE AS AN OXIDANT.** A reaction of 2,2'-bithiophene with copper(II) perchlorate in acetonitrile achieved polymerization and doping in one step, and yielded polythiophenes,  $[(\text{C}_4\text{H}_2\text{S})(\text{ClO}_4)_x \cdot y\text{H}_2\text{O}]_n$ . The polymers with x approximately 0.17 and y approximately 0.3 exhibited a high electrical conductivity in the range  $3\text{--}8\text{ S cm}^{-1}$  at 300 K and a small activation energy of 0.04 eV. The IR and ESR spectra showed the characteristics of doped polythiophenes. (Author abstract) 18 refs.

Inoue, M.B. (Univ de Sonora, Hermosillo, Mex); Velazquez, E.F.; Inoue, M. *Synth Met* v 24 n 3 May 1988 p 223-229.

**083042 CHEMICAL RELEASE CONTROL: SCHIFF BASES OF VINYLALDEHYDE AND FUNCTIONAL AMINES.** Schiff base (SB) monomers of vinylaldehyde with functional amines were prepared. Copolymers of SB monomers with N-vinyl-2-pyrrolidone soluble in aqueous solutions were obtained in most cases. However, p-aminobenzenesulfonamide monomer resulted in gel formation. Thus, the reaction of vinylaldehyde copolymer with the sulfonamide was used instead of the copolymerization. The hydrolytic behaviors of SB monomers and copolymers to liberate respective amines were structure dependent and, for most copolymers, the rates were lower than those of the corresponding monomers. (Author abstract) 3 refs.

Kamogawa, Hiroyoshi (Yamanashi Univ, Kofu, Jpn); Sakai, Tsuyoshi; Sohma, Hirohito. *J Polym Sci Part A* v 26 n 5 May 1988 p 1335-1341.

**083043 INDENE-COUMARONE RESINS: SYNTHESIS AND APPLICATIONS.** Technical indene-coumarone resins are mixed polymers of indene, coumarone, styrene and their alkyl homologues. These resins are essentially low-molecular weight polymers varying in color from light yellow to dark brown and are usually hard and brittle. Indene-Coumarone (I-C) resins were introduced in the market in 1930 for the preparation of light-colored asphalt tiles. With improved techniques in the selection of raw material and assessment of its purity as well as in polymerization technique using newer catalysts, it has been possible to produce harder resins of better color and superior quality. Considerable R&D work is being done in several countries to improve the polymerization technique as well as to modify polymer properties by incorporating additives like acenaphthene, phenols and carbazole. The earlier cationic polymerization method is being gradually replaced by a novel radical

polymerization technique in the USSR. This paper reviews the R&D efforts on the synthesis of I-C resins during the last three decades and discusses the possibility of producing these resins from coal carbonization byproducts in India. 54 refs.

Prasad, H.L. (Central Fuel Research Inst, Dhanbad, India); Bhattacharya, R.N. *J Sci Ind Res* v 46 n 11 Nov 1987 p 505-511.

**083044 APPLICATION OF POLYALCOHOLS PREPARED FROM DIOLS. I. ELASTIC POLYMERS WITH FUNCTIONAL GROUPS PREPARED BY CHEMICAL MODIFICATIONS.** An elastic polymer with hydroxymethyl side chains, which contains some crosslinked structure, has been prepared by treating its prepolymer with maleic anhydride and styrene in the presence of an initiator. Its mechanical properties depended on the molar ratio of the hydroxyl group: maleic anhydride:styrene. A typical example of the polymer showed elongation 69%, tensile strength  $0.85\text{ kgf/mm}^2$ , and Young's modulus  $9.4\text{ kgf/mm}^2$ . Some other modifications are also examined. (Author abstract) 6 refs.

Kito, Taketoshi (Kyushu Inst of Technology, Kitakyushu, Jpn); Ota, Koki; Yamaye, Makoto; Yoshinaga, Kohji. *J Appl Polym Sci* v 35 n 6 May 5 1988 p 1593-1601.

**083045 POLY(SCHIFF BASE) POLYMERS BASED ON SUBSTITUTED BISPHENYL.** The authors have been interested in the syntheses of novel poly(Schiff base) chelates because of their conductive and metal-coordinating properties. In principle, these polymers may incorporate catalytically-active redox functionalities which can be continually regenerated via electronic conduction through the polymer. Recent efforts of Elliot et al. to synthesize an electronically-conducting bipyridyl polychelate prompted the authors to investigate poly(Schiff bases) of the type reported in this paper. Some of the topics covered are cyclic voltammetry, physical, and spectral data. 13 refs.

Rudzinski, W.E. (Southwest Texas Univ, San Marcos, TX, USA); Guthrie, S.R.; Cassidy, P.E. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1677-1680.

**083046 SYNTHESIS AND CHARACTERIZATION OF POLY[2,6-DIAMINOTOLUENE-3, 5-DIYL-METHYLENE] AND ITS CONDENSATION PRODUCT, POLY(1-METHYLCYCLOHEXA-1,3-DIENE-2,3-DIYL-5, 6-DIYLIDENE-5-METHYLDIYNE-6-NITRILLO), A LINEAR LADDER AROMATIC POLYMER.** 2,6-Diaminotoluene reacts with formaldehyde in aqueous solution with acid catalysis to produce a crystallizable prepolymer, poly[2,6-diaminotoluene-3,5-diyl-methylene]. The prepolymer can be crystallized from DMF or DMSO solution. A unit cell for the crystalline polymer was determined. The reaction temperature and time substantially affect its molecular weight. The structure of the polymer was analyzed and confirmed by NMR spectra, IR spectra, and element analysis. Further condensation in poly(phosphoric acid) at high temperature ( $345^\circ\text{C}$ ) produces a soluble linear ladder aromatic polymer, poly(1-methylcyclohexa-1,3-diene-2,3-diyl-5, 6-diylidene-5-methyldiyl-6-nitrilo). The condensed polymer was characterized by using UV/vis/near-IR, IR, and X-ray diffraction. (Author abstract) 29 refs.

Ruan, J.Z. (Case Western Reserve Univ, Cleveland, OH, USA); Litt, M.H. *Macromolecules* v 21 n 4 Apr 1988 p 876-882.

**083047 PHOTORESPONSIVE VINYL POLYMER BEARING NORBORNADIENE AS A PENDANT GROUP.** The synthesis of a novel class of photoreactive polymers is reported. The norbornadiene unit in the polymer was found to be converted in the film state under nitrogen atmosphere to a quadricyclane unit reversibly with irradiation by UV light of two different wavelengths. Polymers bearing norbornadiene units having carboxylate and/or substituted amide groups at the 2- and 3-positions and having a vinyl group at the end of the 2-substituent were prepared by the polymerization of respective mono-

mers. Polymers bearing an amide substituent at the 2-position indicated a much higher photosensitivity in the film state as well as a larger red shift in the absorption spectrum than those bearing a carboxylate substituent. (Author abstract) 6 refs.

Kamogawa, Hiroyoshi (Yamanashi Univ, Kofu, Jpn); Yamada, Makoto. *Macromolecules* v 21 n 4 Apr 1988 p 918-923.

**083048 POLYMERIZATION AND BLOCK COPOLYMERIZATION INITIATED BY UNUSUALLY STABLE LIVING PROPAGATING SPECIES FORMED IN THE CATIONIC POLYMERIZATION OF SPIRO ORTHO CARBONATE.** The cationic polymerization of spiro ortho carbonate (SOC) forming a polyether-carbonate alternative copolymer is believed to proceed via trialkoxycarbonium ion (A) as a possible propagating species. Since this type of carbonium ion is well known to be quite stable as reported by Olah et al., this growing end should still remain living after the completion of the polymerization. We confirm the stability of the end species and disclose the preliminary results of it. It is shown that the polymerization of SOC is not the ideal living polymerization but has a few of the characteristics of living polymerization. Most interesting is the great stability of the growing end species. The authors believe that this study should provide a new polymerization process involving stable propagating species as well as an attractive entry to synthesize a wide variety of new block copolymers of considerably controlled molecular weights. 16 refs.

Endo, Takeshi (Tokyo Inst of Technology, Yokohama, Jpn); Sato, Hiroyuki; Takata, Toshikazu. *Macromolecules* v 21 n 4 Apr 1988 p 1186-1187.

**083049 SYNTHESIS OF POLYPHENYLENE FROM A cis-DIHYDROCATECHEOL, A BIOLOGICALLY PRODUCED MONOMER.** Benzene is oxidized by oxygen utilizing the dioxygenase enzyme contained in the microorganism *Pseudomonas putida*. Genetic manipulation produced a variant that gave exclusively the initial oxidation product of benzene the cis-dihydrocatechol in practical quantities. Derivatives of the latter, in particular the methyl carbonate, can be obtained pure and very stable. They polymerize in the absence of solvent with radical initiators to give a polymer. The latter is soluble in solvents such as acetone and methylene chloride and readily forms coherent coatings and films. On heating methanol and  $\text{CO}_2$  are expelled and polyphenylene is formed as a coating or film. (Edited author abstract) 16 refs.

Ballard, D.G.H. (ICI PLC, Runcorn, Engl); Courtis, A.; Shirley, I.M.; Taylor, S.C. *Macromolecules* v 21 n 2 Feb 1988 p 294-304.

**083050 HIGH MOLECULAR WEIGHT POLYSILANES WITH PHENOL MOIETIES.** High molecular weight polysilanes substituted with pendant phenol moieties were prepared by sodium condensation of dichlorosilanes, whose phenolic OH groups were protected with trimethylsilyl ethers. However, monomers substituted with 4-hydroxyphenyl moieties did not give high polymers. The position of the OH in the benzene ring and the number of carbons between Ph and Si seem to determine whether or not the polymer has polysilane structure. The polymer (P(Me-m-1) ( $M_w$  110,000)) with 3-hydroxyphenyl moieties was prepared by gentle hydrolysis of PSI(Me-m-1) in methanol without serious molecular weight decrease. (Edited author abstract) 23 refs.

Horiguchi, Rumiko (Toshiba Corp, Kawasaki, Jpn); Onishi, Yasunobu; Hayase, Shuzi. *Macromolecules* v 21 n 2 Feb 1988 p 304-309.

**083051 EFFECTS OF ORGANIC SIDE GROUP STRUCTURES ON THE PROPERTIES OF POLY(ORGANOPHOSPHAZENES).** Methods are reported for the synthesis of three new classes of poly(organophosphazenes) via the substitution reactions of poly(dichloro-



phosphazene). The first class consists of single-substituent polymers with aromatic rings separated from the main chain by methyleneoxy-spacer groups. The second and third classes comprise mixed-substituent polymers that contain aryloxy and aryl ester or aryl Schiff's base side groups. The variations in glass transition temperature with changes in side groups are discussed and are compared with the values for various alkoxy and alkoxy ether side group systems. (Edited author abstract) 33 refs.

Alcock, Harry R. (Pennsylvania State Univ, University Park, PA, USA); Connolly, Mark S.; Sisko, John T.; Al-Shali, Saman. *Macromolecules* v 21 n 2 Feb 1988 p 323-334.

**083052 ELECTROCHEMICAL SYNTHESIS AND PROPERTIES OF POLYCARBAZOLE FILMS IN PROTIC ACID MEDIA.** Conductive films are deposited onto Au by anodic oxidation of carbazole dissolved in aqueous alcoholic  $\text{HClO}_4$ . Cyclic voltammetry of film electrodes in aqueous  $\text{HClO}_4$  prepared in this way shows the occurrence of two main redox processes; an intermediate system becoming less important on cycling is ascribed to dimers or trimers. The polymer is remarkably stable when cycling involves only the first peak, while the second oxidation leads to degradation. An acid environment appears to be essential for film electrochemistry. ESR data confirm that protonation ensures conductivity of the material. On this basis, structure and conduction mechanisms similar to those of emeraldine are suggested. (Author abstract) 14 refs.

Mengoli, Giuliano (CNR, Padua, Italy); Musiani, Marco M.; Schreck, Berthold. *J Electroanal Chem Interfacial Electrochem* v 246 n 1 May 10 1988 p 73-86.

**083053 POLY([1.1.1]PROPELLANE)<sup>1</sup>. A NOVEL RIGID-ROD POLYMER OBTAINED BY RING-OPENING POLYMERIZATION BREAKING A CARBON-CARBON  $\sigma$ -BOND.** Treatment of the [1.1.1]propellane 1 with lithium organic initiators such as tert-butyllithium and phenyllithium leads to anionically induced ring-opening polymerization of 1. In the course of the polymerization only the central  $\sigma$ -bond in monomer 1 was opened, leading to an entirely new rigid-rod structure - the poly([1.1.1]propellane) 2, whose degree of polymerization was determined to be greater than 20. The rigidity of polymer 2 is due to constraints inherently associated with its multicyclic structure. The structure of the poly([1.1.1]propellane) 2 was proved by means of solid-state NMR spectroscopy and was further confirmed by an investigation of soluble, oligomeric material having analogous constitution. (Author abstract) 13 refs.

Schluter, Arnulf-Dieter (Max-Planck-Institut fuer Polymerforschung, Mainz, West Ger). *Macromolecules* v 21 n 5 May 1988 p 1208-1211.

**083054 SYNTHESIS OF A CHEMICALLY ORDERED LIQUID CRYSTAL POLYMER.** Links between chemical sequence structure in self-ordering polymers and their physics are still to be established. In order to address this problem we have proceeded to synthesize a sequentially ordered and regioregular terpolymer which exhibits liquid crystallinity. Neglecting end groups, this polymer is a constitutional isomer of a chemically random liquid crystal polymer reported previously. The synthesis of ordered-disordered chemical analogues has been difficult in the past either because of the absence of liquid crystallinity in highly regular chains or because of difficulties in developing regioregular polyesters. (Edited author abstract) 9 refs.

Moore, J.S. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Stupp, S.I. *Macromolecules* v 21 n 5 May 1988 p 1217-1221.

**083055 SYNTHESIS AND SOLID-STATE POLYMERIZATION OF A NEW DIACETYLENE: 1-(N-CARBAZOLYL)PENTA-1,3-DIYN-5-OL.** A new unsymmetrical diacetylene having a carbazoyl group directly bound to an acetylene moiety, i.e., 1-(N-carbazoyl)penta-1,3-diyn-5-ol, was synthesized. This diacetylene can be topochemically polymerized in the solid

state and the visible absorption edge of the polymer is expanded to nearly 800 nm, suggesting longer  $\pi$ -conjugation than the so-far-known polydiacetylenes. It is shown that the nonlinear optical susceptibility of poly-CPDO is larger than that of other polydiacetylenes. (Edited author abstract) 26 refs.

Matsuda, Hiro (Resarch Inst for Polymers & Textiles, Tsukuba, Jpn); Nakanishi, Hachiro; Hosomi, Takeshi; Kato, Masao. *Macromolecules* v 21 n 5 May 1988 p 1238-1240.

**083056 SYNTHESIS OF POLY(ADIPIC ANHYDRIDE) BY USE OF KETENE.** Polyadipic anhydrides were prepared (a) from the mixed anhydride of adipic acid and acetic acid, (b) from the mixed anhydride of adipic acid and ketene in tetrahydrofuran solution (0°C), (c) by melt polycondensation of adipic acid with ketene, and (d) from the seven-membered ring adipic anhydride. The polymers were characterized by means of NMR, IR, DSC, and GPC. The polymer with the highest melting temperature was obtained by melt polycondensation of adipic acid with ketene ( $T_{\text{peak}}$  76°C). The heat of fusion was approximately 40 J/g in all four methods. (Edited author abstract) 11 refs.

Albertsson, Ann-Christine (Royal Inst of Technology, Stockholm, Sweden); Lundmark, Stefan. *J Macromol Sci Chem* v A25 n 3 Mar 1988 p 247-258.

**083057 CONTROLLED ACTIVITY POLYMERS. IV. COPOLYMERS OF 2-(1-NAPHTHYLACETYL)ETHYL ACRYLATE WITH HYDROPHILIC COMONOMERS: SYNTHESIS AND CHARACTERIZATION.** 2-(1-Naphthylacetyl)ethyl acrylate (NAEA) was synthesized by esterification of 1-naphthylacetic acid (NAA) and 2-hydroxyethyl acrylate (HEA) and then polymerized to obtain the polymer-bound auxin NAA. The resulting polymer is potentially useful as a plant growth regulator through hydrolytic release of NAA. Copolymers of NAEA with hydrophilic comonomers were prepared by solution polymerization. The copolymer compositions were determined from elemental analysis, <sup>13</sup>C-NMR, and UV spectroscopy. (Edited author abstract) 25 refs.

McCormick, Charles L. (Univ of Southern Mississippi, Hattiesburg, MS, USA); Kim, Kisoo. *J Macromol Sci Chem* v A25 n 3 Mar 1988 p 285-305.

**083058 SYNTHESIS OF POLY(ARYL ETHER-PHENYLQUINOXALINES).** As a means of preparing the quinoxaline-based analogue of the poly(ether-imides), we have investigated PPQ synthesis through a halo displacement approach. The results demonstrate that quinoxaline-based poly(aryl ethers) can be synthesized via a halo displacement polymerization, where the fused pyrazine ring is the activating group. The polymerization provides a general method for the preparation of aryl ether based PPQs, where the structure of the aryl ether moiety is readily controlled by varying the bisphenol used. 16 refs.

Hedrick, James L. (IBM, Almaden Research Cent, San Jose, CA, USA); Labadie, Jeff W. *Macromolecules* v 21 n 6 Jun 1988 p 1883-1885.

**083059 NOVEL SYNTHESIS OF POLY(1-t-BUTYLPYRROLIDIN-2-ONE-3, 4-DIYLETHYLENE) BY CYCLOPOLYMERIZATION OF N-t-BUTYL-N-ALLYLACRYLAMIDE.** This article describes an example of completely cyclized polymer with a unique ring size, i.e. 5-membered ring, which was prepared by the cyclopolymerization of N-t-butyl-N-allylacrylamide (t-BAA) as an unsymmetrical 1,6-diene. A mono-olefin, N-t-butyl-N-propylacrylamide (t-BPA), containing acryloyl moiety of t-BAA was shown also to polymerize well. As a model reaction, telomerization of t-BAA was carried out in the presence of benzenethiol as a telogen to give mainly 5-membered ring compound, 1-t-butyl-3-benzethioethyl-4-methylpyrrolidin-2-one, which suggested the structural unit of poly(t-BAA). 8 Refs.

Fukuda, Wakichi (Nat'l Univ, Yokohama, Jpn); Suzukim, Yoshiko; Kakiuchi, Hiroshi. *J Polym Sci Part C* v 26 n

7 Jul 1988 p 305-311.

**083060 SYNTHESIS OF FUNCTIONAL HYDRO-CARBON POLYMERS WITH WELL-DEFINED MOLECULAR STRUCTURES.** The preparation of well-defined functional polymers with narrow molecular weight distributions and functional groups homogeneously distributed along the polymer chains is described. The chemistry involves the hydroboration of polydienes. Since both thermodynamics and kinetics are favorable for this reaction, a completely homogeneous modification is obtained. The hydroborated polymers are valuable intermediates that can be converted to a variety of functional polymers. Polyalcohol is one of the examples that will be discussed in detail in this paper. To retain the narrow molecular weight distribution, several experimental methods, including vacuum techniques, low reaction temperatures, and boric acid removal, were employed during the reaction. The resulting functional polymers have molecular weight distributions of 1.07. (Edited author abstract) 27 refs.

Chung, T.C. (Exxon Research & Engineering Co, NJ, USA); Raate, M.; Schulz, D.N. *Macromolecules* v 21 n 7 Jul 1988 p 1903-1907.

**083061 POLY(ANHYDRIDES). 2. ONE STEP POLYMERIZATION USING PHOSGENE OR DIPHOSGENE AS COUPLING AGENTS.** Two approaches for one-step solution polymerization of poly (anhydrides) at ambient temperature were developed. In the first approach highly pure polymers (> 99.7 percent) were obtained by the use of sebacyl chloride, phosgene, or diphosgene as coupling agents and poly(4-vinylpyridine) or  $\text{K}_2\text{CO}_3$  as insoluble acid acceptors. The second approach for one-step synthesis of pure poly (anhydrides) was the use of an appropriate solvent where the polymer is exclusively soluble but the corresponding polymerization byproduct (e.g.,  $\text{Et}_3\text{N} \cdot \text{HCl}$ ) is insoluble. Under this condition polymerization of sebacic acid gave the best results in N,N-dimethylformamide and in toluene. (Edited author abstract) 19 Refs.

Domb, Abraham J. (MIT, Cambridge, MA, USA); Ron, Eyal; Langer, Robert. *Macromolecules* v 21 n 7 Jul 1988 p 1925-1929.

**083062 GLYCERYL POLYPHOSPHAZENES: SYNTHESIS, PROPERTIES, AND HYDROLYSIS.** Methylene-, isopropylidene-, and methoxymethylene-protected glyceryl units have been linked to cyclic and high polymeric phosphazenes. The structures and physical properties of these protected glyceryl-substituted phosphazenes were investigated by <sup>31</sup>P NMR, <sup>1</sup>H NMR, and IR spectroscopy and thermal analysis. Hydrolytic deprotection reactions in acidic media yielded the water-soluble cyclic trimeric and high polymeric glycerylphosphazenes. Cross-linking of the protected high polymers was accomplished by  $\gamma$  irradiation. The deprotected polymer cross-linked in the presence of adipoyl chloride or hexamethylene diisocyanate to yield systems that absorbed water to form hydrogels. Slow hydrolysis of poly(di-glycerophosphazene) occurred in neutral aqueous media at 37 °C to yield glycerol, phosphoric acid, and ammonia. (Author abstract). 36 Refs.

Alcock, Harry R. (Pennsylvania State Univ, University Park, PA, USA); Kwon, Sukky. *Macromolecules* v 21 n 7 Jul 1988 p 1980-1985.

**083063 PHENYLTHIAZYL POLYMERS WITH FLEXIBLE SPACERS: SYNTHESIS AND ELECTRICAL PROPERTIES.** A series of polymers with (phenylthio)phenyldithiazyl (PTPD series) and phenylenedithio-bis(phenyldithiazyl) (PDBPD series) segments have been synthesized by using a novel route involving the in situ chlorinolysis of a benzyl-protected precursor monomer. These polymers can be transformed from an insulating to a semiconducting state upon oxidation with bromine. The PTPD polymer made with a triethylene glycol spacer is soluble and fusible, while the ones with shorter spacers are



insoluble. The polymers attain conductivities in the range of  $10^{-3}$ – $10^{-5}$  ( $\Omega$  cm) $^{-1}$  on doping with bromine. (Author abstract). 16 Refs.

Chien, James C.W. (Univ of Massachusetts, Amherst, MA, USA); Ramakrishnan, S. *Macromolecules* v 21 n 7 Jul 1988 p 2007-2010.

**083064 [2,2]PARACYCLOPHANE END-CAPPED POLYQUINOLINE PREPOLYMERS: SYNTHESIS, PROCESSING, AND THERMAL PROPERTIES.** Flexible polyquinolines containing [2,2]paracyclophane end caps were prepared, using 4-acetyl[2,2]paracyclophane as the capping agent. Thermal analysis of the oligomers showed the [2,2]paracyclophane ring-opening exothermic maximum to be near 350 °C. The oligomers were melt-pressed at 350°C under a 5000-lb load for various times, giving high-quality films which exhibited good Young's moduli. Film quality and moduli were higher for the DP = 22 oligomer. TGA analysis showed the films to be stable to about 550°C in both air and argon. Oxidation aging at 320°C for 100 h gave moderate weight losses, relative to various quinoline oligomers end capped with biphenylene. (Edited author abstract). 13 Refs.

Upshaw, Thomas A. (Colorado State Univ, Fort Collins, CO, USA); Stille, J.K. *Macromolecules* v 21 n 7 Jul 1988 p 2010-2014.

**083065 ELECTROSYNTHESIS AND PROPERTIES OF RING-SUBSTITUTED POLYANILINES.** Electrochemical polymerization of ring-substituted anilines, with electron donor and acceptor substituents in the 2- and 3-positions, was investigated in 2.0 M sulfuric acid. Polymerization is mostly effective with sigma- and pi-donor substituents, the latter in the 2-position. Polymeric deposits were obtained from 2- and 3-methylaniline (toluidines), 2-methoxyaniline (anisidine) and 2-chloroaniline, and were characterized by cyclic voltammetry, elemental analysis, ir spectroscopy, uv-vis spectroelectrochemistry and electrical conductivity. Polytoluidine and polyanisidine are reversibly oxidized in two steps as polyaniline, whereas polychloroaniline is oxidized in a single one-electron process. Polymerization was found to be more effective on polyaniline-modified electrodes. (Author abstract). 17 Refs.

Cattarin, S. (CNR, Padua, Italy); Doubova, L.; Mengoli, G.; Zotti, G. *Electrochim Acta* v 33 n 8 Aug 1988 p 1077-1084.

**083066 SYNTHESIS AND CHARACTERIZATION OF LIQUID CRYSTALLINE COPOLYMETHACRYLATES, COPOLYACRYLATES, AND COPOLYSILOXANES CONTAINING 4-METHOXY-4'-HYDROXY- $\alpha$ -METHYLSTILBENE AND 4-HYDROXY-4'-METHOXY- $\alpha$ -METHYLSTILBENE CONSTITUTIONAL ISOMERS AS SIDE-GROUPS.** The synthesis of methacrylates and acrylates containing 4-methoxy-4'-hydroxy- $\alpha$ -methylstilbene and 4-hydroxy-4'-methoxy- $\alpha$ -methylstilbene constitutional isomers attached to the polymerizable group through flexible spacers containing 11, 8, 6, 3, and respectively 2 methylenic units is described. The radical copolymerization of a 1/2 or 2/1 mole ratio of the two constitutional isomeric monomers led to thermotropic side-chain liquid crystalline polymers in all cases. The synthesis of copolysiloxanes based on the same constitutional isomeric mesogens as side groups, and flexible spacers containing 11, 8, 6, 5, and respectively 3 methylenic units is also described. All polymers were characterized by differential scanning calorimetry and optical polarization microscopy. (Edited author abstract). 35 Refs.

Percec, Virgil (Case Western Reserve Univ, Cleveland, OH, USA); Hsu, Chain Shu; Tomazos, Dimitris. *J Polym Sci Part A* v 26 n 8 Aug 5 1988 p 2047-2076.

**083067 SYNTHESIS AND CHARACTERIZATION OF POLY(METHYLENE TEREPHTHALATE).** Poly(methylene terephthalate) (IGT) has been synthesized via the reaction of cesium or potassium terephthalates with dibromomethane or bromochloromethane in N-methylpyrrolidone at temperatures of 80-125°C. The

polymerization was relatively slower with the latter substrate, though the potassium salt was found to be equally as efficient as its cesium counterpart with dibromomethane. The polymer is insoluble in all common polyester solvents, and its high molecular weight nature ( $D/P_n \geq 25$ ) was inferred from elemental analyses and its fiber forming capacity. (Edited author abstract). 31 Refs.

Cimecioglu, A.L. (Univ of Leeds, Leeds, Engl); East, G.C.; Morshed, M.; Zeronian, S.H. *J Polym Sci Part A* v 26 n 8 Aug 5 1988 p 2129-2139.

**083068 NEW TELECHELIC POLYMERS AND SEQUENTIAL COPOLYMERS BY POLYFUNCTIONAL INITIATOR-TRANSFER AGENTS (INIFERTS). LIII. LITHIATION OF 2,4,4-TRIMETHYL-1-PENTENE AND ISOPROPYLIDENE-CAPPED POLYISOBUTYLENES BY BUTYLLITHIUMS IN THE PRESENCE OF COMPLEXING AGENTS.** This report concerns model lithiation experiments of 2,4,4-trimethyl-1-pentene (TM1P) that guided us toward the subsequent quantitative lithiation of isopropylidene-telechelic PIBs. Thus, lithiation of TM1P with n-, s-, and t-butyllithium, in the presence of various complexing agents followed by silylation with Me<sub>3</sub>SiCl (for the purpose of quantitation) gave three products: 2(trimethylsilylmethyl)-4,4-dimethyl-1-pentene (TM1P-Si), 2(trimethylsilylmethyl)-4,4-dimethyl-2-pentene (TM2P-Si) and 1,1-di(trimethylsilylmethyl)-3,3-dimethyl-1-butene (TM2P-Si<sub>2</sub>). The relative product composition strongly depends on the BuLi/complexing agent ratio and temperature. (Edited author abstract). 29 Refs.

Peng, K.L. (Univ of Akron, Akron, OH, USA); Kennedy, J.P.; Wilczek, L. *J Polym Sci Part A* v 26 n 8 Aug 5 1988 p 2235-2250.

**083069 POLYMER-SUPPORTED BASES. IX. SYNTHESIS AND CATALYTIC ACTIVITY OF POLYMER-BOUND 4-(1-PYRROLIDINO)PYRIDINE MOIETIES.** Polystyrene-bound 4-(1-pyrrolidino)pyridine moieties were prepared by the reaction of chloromethylated polystyrene resins with pyrrolidinopyridine derivatives containing hydroxyl groups. The supported amines were effective catalysts for acylations of tert-alcohols or enols, acyl rearrangements, and diester synthesis from epoxides and anhydrides. Some of the low ring-substituted (8-15%) catalysts exhibited high activity comparable to that of 4-(N,N-dimethylamino)pyridine, though the activity was a little lower than that of 4-(1-pyrrolidino)pyridine. The recovered catalysts can be re-used, except for acyl rearrangements, without significant decrease in activity. (Author abstract). 34 Refs.

Tomoi, Masao (Yokohama Natl Univ, Yokohama, Jpn); Ishigaki, Satoru; Arita, Yasushi; Kakiuchi, Hiroshi. *J Polym Sci Part A* v 26 n 8 Aug 5 1988 p 2251-2261.

**083070 SYNTHESIS OF ORGANOTIN POLYMERS BY THE REACTION OF DIALLYL CARBONATES WITH Bu<sub>3</sub>SnH.** Tri-n-butyltin hydride (bu<sub>3</sub>SnH) was employed for the synthesis of organotin polymers via radical process. The polymers having both organotin and carbonate groups were obtained by the reaction of Bu<sub>3</sub>SnH with monomers such as diallylcarbonate and diethylene glycol bis(allyl carbonate) via hydrosulfation. The copolymerization of diethylene glycol bis(allyl carbonate) and the mono-hydrostannated derivative was also conducted to obtain the corresponding polymers. (Author abstract). 10 Refs.

Moriya, Osamu (Tokyo Inst of Technology, Yokohama, Jpn); Arai, Seiji; Endo, Takeshi. *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2573-2579.

**083071 POLY(PHENYLENE SULFIDE): SYNTHESIS FROM 1,4-DIBROMOBENZENE AND SODIUM SULFIDE.** A new route to synthesize poly(p-phenylene sulfide) by nucleophilic substitution of 1,4-dibromobenzene with sodium sulfide in N-methylpyrrolidone is described. Kinetic evaluation shows the reaction to be of second order with two distinctive rate constant regimes. The first rate constant is higher and is operative until 50% conver-

sion, whereas in the second regime (between 50 and 92% conversion) the rate is slower. The kinetics of this route is compared under identical conditions with the conventional synthesis based on 1,4-dichloro benzene and sodium sulfide. (Author abstract). 9 Refs.

Rajan, C.R. (Natl Chemical Lab, Pune, India); Nadkarni, V.M.; Ponrathnam, S. *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2581-2588.

**083072 ORGANOTIN POLYMERS. XII. AZEOTROPY IN BINARY AND TERNARY COPOLYMERIZATION REACTIONS OF DI(TRI-N-BUTYLITIN) ITACONATE WITH ACRYLIC ACID ESTERS, STYRENE, AND ACRYLONITRILE.** Binary and ternary copolymerizations of di(tri-n-butyltin) itaconate (TBTI) with methyl acrylate (MA), ethyl acrylate (EA), n-butyl acrylate (BA), styrene (ST), and acrylonitrile (AN) were carried out in solution at 70°C in the presence of a free-radical initiator. Experimental terpolymerization data agreed well with calculations based on the Alfrey-Goldfinger equation. The determination of unitary, binary, and ternary azeotropies of the various systems studied was easily handled by a computer. Ternary azeotropic compositions for TBTI-MA-AN and TBTI-EA-AN systems were 37:48:15 and 9:80:11 mol percent, respectively. Also, 'Pseudo-azeotropic' regions were identified where the deviation between feed and polymer compositions is very small. (Author abstract). 15 Refs.

Shaaban, A.F. (Benha Univ, Benha, Egypt); Mahmoud, A.A.; Messiha, N.N. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 1191-1203.

**083073 FORMATION OF MIXED THERMOTROPIC LIQUID CRYSTALLINE SYSTEMS BASED ON AROMATIC POLYESTERS WITH MESOGENIC AND FLEXIBLE FRAGMENTS IN THE MAIN CHAIN.** The effects of polymolecularity and heterogeneity of the chemical structure of the flexible fragments on the conditions of formation and the order parameter of mixed liquid crystal systems are discussed, using aromatic polyesters with mesogenic and flexible fragments in the main chain as examples. It is shown that at close values of the temperature ranges over which liquid crystal order of the mixed components of different molecular weight exists, the order parameter of the mesogenic fragments of the mixture in the liquid crystal state is less than the corresponding values for homopolymers. In the case of a mixture of components with flexible fragment of different length and the same mesogenic fragments, the components of the system are completely incompatible in the liquid crystal state. (Author abstract). 16 Refs.

Volchek, B.Z. (USSR Acad of Sciences, USSR); Kholmuradov, N.S.; Purkina, A.V.; Bilibin, A. Yu.; Skorokhodov, S.S. *Polym Sci USSR* v 29 n 5 1987 p 1217-1224.

**083074 SYNTHESIS AND CHARACTERIZATION OF PHENYL SUBSTITUTED POLYPHENYLENE-VINYLENES.** A new polymerization process was successfully employed to synthesize defined structure, soluble, fusable, film forming, thermally stable and photoconductive poly-phenyl substituted phenylene-vinylene. The photoconductivity of these polymers, in term of spectral distribution and intensity of photocurrent, correlated with their structure. The thermal stability was high and increased as the H-value in polymer was decreased. The combination of photoconductivity with high temperature stability, however, is a new and interesting aspect of phenylated poly-phenylene vinylenes. 4 Refs.

Aliwi, Salah M. (Council of Scientific Research, Baghdad, Iraq). *J Pet Res* v 7 n 1 Jun 1988 p 141-156.



**083075 SYNTHESIS AND CHARGE-TRANSPORT PROPERTIES OF POLYMERS DERIVED FROM THE OXIDATION OF 1-HYDRO-1'-(6-PYRROL-1-YL)-4, 4'-BIPYRIDINIUM BIS (HEXA-FLUOROPHOSPHATE) AND DEMONSTRATION OF A pH-SENSITIVE MICROELECTROCHEMICAL TRANSISTOR DERIVED FROM THE REDOX PROPERTIES OF A CONVENTIONAL REDOX CENTER.** This article describes the synthesis and electrochemical properties of redox polymers, having a polypyrrole backbone and viologen subunits, derived from oxidative electropolymerization of 1-methyl-1'-(6-pyrrol-1-yl)-hexyl)-4,4'-bipyridinium (P-V-Me<sup>2+</sup>) and 1-hydro-1'-(6-pyrrol-1-yl)hexyl)-4,4'-bipyridinium (P-V-H<sup>2+</sup>). Closely spaced Au microelectrode arrays modified with the polymers can be used to study aspects of the charge-transport behavior of the viologen redox system. Poly(P-V-Me<sup>2+</sup>) and poly(P-V-H<sup>2+</sup>) have been used to investigate the characteristics of microelectrochemical transistors based on a viologen redox center and a similar redox center, protonated monoquaternized bipyridinium, which is pH dependent. The device based on poly(P-V-H<sup>2+</sup>) shows a pH-dependent  $I_p$  at fixed  $V_G$ , as expected from the electrochemical behavior from reversible protonation of the terminal N of the bipyridinium group of poly (P-V-H<sup>2+</sup>). (Edited author abstract). 25 Refs.

Shu, Ching-Fong (MIT, Cambridge, MA, USA); Whighton, Mark S. *J Phys Chem* v 92 n 18 Sep 8 1988 p 5221-5229.

**083076 QUARTZ MICROBALANCE STUDY OF THE ELECTROSYNTHESIS OF POLYPYRROLE.** An electrochemical quartz crystal microbalance has been used to study the anodic electropolymerization of pyrrole and concurrent deposition of polypyrrole onto gold in acetonitrile and propylene carbonate using tetraethylammonium tosylate, tetrabutylammonium tetrafluoroborate, and lithium perchlorate. Simultaneous dynamic measurements of charge and mass have been used to monitor the efficiency of the polymerization/deposition process as a function of film thickness and electrodeposition rate. This work demonstrates that the early stages of film formation are affected by the solubility of the oligomers formed and that the ultimate efficiency is electrolyte dependent. Additionally, it is shown that the polymerization process exhibits second-order reaction kinetics with respect to monomer concentration. (Author abstract). 40 Refs.

Baker, Charles K. (Univ of Texas at Arlington, Arlington, TX, USA); Reynolds, John R. *J Electroanal Chem Interfacial Electrochem* v 251 n 2 Sep 23 1988 p 307-322.

**083077 POLYMERIC PHthalOCYANINES AND THEIR PRECURSORS. 13. SYNTHESIS, STRUCTURE AND ELECTROCHEMICAL PROPERTIES OF THIN FILMS OF POLYMERIC PHthalOCYANINES FROM TETRACARBONITRILES.** Thin films (45-1200 nm thickness) of polymeric phthalocyanines were prepared by the reaction of copper films on various carriers with gaseous aromatic tetracarbonitriles. The films were characterized by IR, UV/VIS, and ESCA spectra. The electrical conductivity is in the order of  $10^{-2}$ - $10^{-5}$  S cm<sup>-1</sup>. The electrochemical activity of the films on graphite was studied in acid and alkaline electrolyte. The films exhibit rapid reduction and reoxidation. The pH dependence corresponds to that of the hydrogen electrode approximately. (Author abstract) 28 refs.

Wohrle, Dieter (Univ Bremen, Bremen, West Ger); Schmidt, Volker; Schumann, Bernd; Yamada, Akira; Shigehara, Kiyotaka. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem, of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 975-981.

**083078 HIGHLY CONDUCTING IODINE-DOPED POLY(COPPER-YLENE) FROM PHENYLACETYLENE.** Poly(phenylethynylcopper) (PPECu) was synthesized by reaction of the corresponding acetylenic compound with cuprous iodide. Infrared, Raman and ultraviolet spectroscopy showed that PPECu is a coordination polymer having substantial back coordination from the

filled metal d-orbitals to the antibonding orbitals of the acetylene groups. PPECu is a good insulator. On doping with iodine, the dc conductivity of PPECu is enhanced by about 13 orders of magnitude. The conductivity slightly decreases with increasing temperature. The thermopower is small and nearly temperature independent. Based on electron impact, IR, and uv spectroscopy it is concluded that charge-transfer complexes are formed between phenylethynylcopper and iodine. The conduction mechanism of iodine-doped PPECu can be understood in the framework of the theory that describes electrical conduction in quasi-one-dimensional mixed-valence stacked complexes. (Edited author abstract) 4 refs.

Krikor, H. (Univ of Antwerp, Antwerp, Belg); Rotti, M.; Nagles, P. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 353-359.

**083079 POLYMERIZED MICELLES - FACT OR FANCY?** Many micro particles have been examined as encapsulation and support materials for both physical and chemical applications. Particles of different sizes from nm downwards have presented a wide range of opportunities. Recently emphasis has been focussed on synthetic vesicles. This work deals with a large number of quaternary ammonium amphiphiles. The micellar character of the monomers has been demonstrated and polymerization attempted. Though the results show superficially facile polymerization in the micellar state and the formation of oligomers consistent with a topochemical process, in fact the reactions are much more complex than this. The results are discussed in terms of the known dynamics of micellization and polymerization processes and a narrow window within which a polymerized micelle might be achievable is defined. (Edited author abstract)

Sherrington, D.C. (Univ of Strathclyde, Glasgow, Scotl); Hamid, S.M. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 338.

**083080 RESOLUTION OF ENANTIOMERS BY HPLC ON CHIRAL POLYMERS.** A useful chiral polymer was prepared by asymmetric anionic polymerization of triphenylmethyl methacrylate. The chirality of the optical active polymer arises only from the isotactic rigid helix polymer chain. The polymer was adsorbed to about 20 wt% on macroporous silica gel (10  $\mu$ m). The resulting chiral stationary phase gave an efficient HPLC (high performance liquid chromatography) column able to resolve more than 150 enantiomers including hydrocarbons, ethers, esters, ketones, amides, metal complexes etc. Methanol or aqueous methanol was found to be the best eluent, suggesting that hydrophobic interactions are important for chiral recognition. (Edited author abstract)

Okamoto, Yoshio (Osaka Univ, Toyonaka, Jpn). *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 339-340.

**083081 NEW ORGANO-MINERAL REACTIVE COMPOSITE, PREPARATION AND PROPERTIES OF SILICA GEL-SUPPORTED POLYMERS WITH IMMOBILIZED CROWN ETHERS.** Presented are the results of radiation polymerization of methylmethacrylate, acrylonitrile and divinylbenzene adsorbed onto silica gel in the presence of two extractants: dicyclohexyl-18-crown-6 and diethylphosphoric acid (DEHPA). The selectivity of dicyclohexyl-18-crown-6 ether towards potassium was established earlier, as was the significant effect of DEHPA on complexation by crown ethers. Extraction experiments were conducted by batch and column methods. The capacity of sorbents towards potassium was calculated from the potassium concentration in solution before and after contact with sorbent (batch experiments). (Edited author abstract)

Belfer, S. (Ben-Gurion Univ of the Negev, Beer-Sheva, Isr); Zolotov, S.; Lati, J. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr,

Jul 6-11 1986 p 340.

**083082 DESIGN OF SUBMICROSCOPIC POLY-ALDEHYDE MONOSPHERES FOR BIOLOGICAL APPLICATIONS.** Monodisperse polyaldehyde microspheres, e.g., polyglutaraldehyde and polyacrolein microspheres were formed by polymerization of the monomers in the presence of an appropriate surfactant which has both steric and electrostatic stabilizing effects. The conditions and the mechanism for obtaining monodisperse systems were studied. The microspheres were prepared via several mechanisms, in various sizes and with designated physical and chemical properties. The reaction of these microspheres through their aldehyde groups with ligands containing various functional groups, e.g., amine, thiol and carboxylate, is discussed. The effect of temperature and pH on these reactants is illustrated. The polyaldehyde microspheres with the desired properties were used for applications such as specific cell labeling and separation, cell culturing, affinity chromatography and specific hemoperfusion. (Author abstract)

Margel, S. (Weizmann Inst of Science, Rehovot, Isr); Marcus, L.; Meshulam, H.; Wiesel, E. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 343.

**083083 SYNTHESIS, CHARACTERIZATION, AND APPLICATIONS OF POLYMERS CONTAINING LANTHANIDE METALS.** This paper reviews the author's work on polymers containing lanthanide metals. The discussion focuses on the use of lanthanide-metal-ion probes to investigate the structures of ionomers and the ion-binding properties of polyelectrolytes. Preliminary fluorescence results of europium and terbium in chelating polymers are also discussed. (Author abstract) 33 refs.

Okamoto, Yoshiyuki (Polytechnic Univ, Brooklyn, NY, USA). *J Macromol Sci Chem* v 24 n 3-4 1987, Macromol-Met Complexes: Sel Pap from the US-China-Jpn Jt Semin, Beijing, China, Oct 20-24 1985 p 455-477.

**083084 SYNTHESIS AND SPECTROSCOPIC STUDIES OF (CH<sub>2</sub>)<sub>n</sub> FROM PVC.** Polyacetylene-like materials can be prepared by dehydrochlorination of PVC. Spectroscopic investigations reveal the existence of carbon atoms in the sp<sup>2</sup> configuration with a subsequent disappearance of C-Cl bonds. Raman spectra are characteristic of a (CH<sub>2</sub>)<sub>n</sub>-like polymer with a large concentration of short conjugated segments. Upon exposure to air, the compound is rather unstable, but can be stabilized by an appropriate treatment with sulfur. (Author abstract) 15 refs.

Perichaud, A. (Univ de Provence, Marseilles, Fr); Dhainaut, S.; Bernier, P.; Lefrant, S. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 7-13.

**083085 IMPROVED SYNTHESIS OF OXYMETHYLENE-LINKED POLY(OXYETHYLENE).** Polyethylene glycol 400 was reacted with CH<sub>2</sub>Cl<sub>2</sub> in the presence of KOH to form oxymethylene-linked chains. The method gave a high yield of colourless high-molecular-weight elastomer. The ionic conductivity of a mixture of the polymer with LiCF<sub>3</sub>SO<sub>3</sub> ([O]/[Li] = 25) was about 5 × 10<sup>-5</sup> S cm<sup>-1</sup> at 25°C. (Author abstract) 7 refs.

Nicholas, Christian V. (Univ of Manchester, Manchester, Engl); Wilson, David J.; Booth, Colin; Giles, Jeremy R.M. *Br Polym J* v 20 n 3 1988, First Int Symp on Polym Electrolytes, St. Andrews, Scotl, Jun 17-19 1987 p 289-292.

## Synthetics

**083086 POLYMERIC PHOTOINITIATORS CONTAINING SIDE CHAIN BENZOPHENONE CHROMOPHORES: RELATIONSHIPS BETWEEN STRUCTURE AND ACTIVITY.** The synthesis of new benzophenone containing polymers and their behavior as initiators for the polymerization under UV irradiation of



acrylic monomers, is reported. Poly(4-vinylbenzophenone) [poly(VBP)] shows the same activity as that of poly(4-acryloxybenzophenone) [poly(ABP)] but much higher activity than the low molecular weight model compound, 4-isopropylbenzophenone (PPB). Even higher activity is observed for copolymers of VBP or ABP with (—)-methyl acrylate (MA) and 2-hydroxyethyl acrylate (HEA). The results are discussed in terms of intramolecular hydrogen abstraction by excited benzophenone moieties from the co-units having hydrogen donating groups and of conformational rigidity. Photophysical properties of the polymeric samples confirm that the intramolecular hydrogen abstraction is the main mechanism of activation of the polymeric systems. (Edited author abstract) 44 refs.

Carlini, Carlo (Univ di Bologna, Bologna, Italy); Toniolo, Lucia; Rolla, Pier Angelo; Barigelletti, Francesco; Bortolus, Pietro; Flamigni, Lucia. *New Polym Mater* v 1 n 1 1987-88 p 63-83.

**Testing** See Also COMPOSITE MATERIALS—Mechanical Properties; ELECTRIC INSULATING MATERIALS—Electric Breakdown; LAMINATED PRODUCTS—Fatigue; LUBRICANTS—Solid Films; POLYCARBONATES—Testing; POLYETHYLENES—Oxidation; POLYPROPYLENE—Strain.

**083087 OVERLOADING AND DEGRADATION STUDY IN GPC USING LOW ANGLE LASER LIGHT SCATTERING DETECTOR (LALLS).** The unique macromolecular compression effect or delayed GPC elution of high M.W. material was observed using the GPC+LALLS technique for a polystyrene standard of M.W. 5.0 E5. Further overloading which resulted in nonlinear fractionation is also described. The degradation of a 4.2 E6 standard after elution was detected by LALLS with calculated M.W. of 1.0-1.1 E6 but not by GPC, as indicated by normal GPC retention time and the shape of the chromatogram. (Edited author abstract) 6 refs.

Wang, Paul J. (3M, St. Paul, MN, USA); Glasbrenner, Brian S. *J Liq Chromatogr* v 10 n 14 1987 p 3047-3057.

**083088 SIMULTANEOUS EPR ELECTROCHEMICAL MEASUREMENTS ON POLYFLUORENE IN AMBIENT TEMPERATURE IONIC LIQUIDS.** Simultaneous electron paramagnetic resonance (EPR) and electrochemical measurements have been carried out on polyfluorene prepared by monomer oxidation and utilized in an ambient temperature ionic liquid consisting of 1-methyl-3-ethylimidazolium chloride-aluminum chloride. A considerable EPR signal is observed in both the reduced and oxidized states; the EPR signal achieves a maximum value coincident with the peak current during a cyclic voltammogram. Assuming that the process is two one-electron steps, initially forming a radical cation, the difference between the two  $E^0$  values is estimated as less than 70 mV. (Author abstract) 16 refs.

Oudard, J.F. (State Univ of New York, Buffalo, NY, USA); Allendoerfer, R.D.; Osteryoung, R.A. *Synth Met* v 22 n 4 Feb 1988 p 407-414.

**083089 PRECISION IN POLYMER TESTING: AN IMPORTANT WORLD-WIDE ISSUE.** This paper gives an overview of the action on precision assessment currently being conducted in ASTM Committee D11 and ISO/TC-45, both of these being devoted to Rubber and Rubber Product testing. Definitions for precision, i.e. repeatability and reproducibility, are given in addition to details on the organization of interlaboratory programs needed to acquire the basic precision data. A precision example using the Mooney viscosity test is presented as well as a discussion of the uses of precision parameters and the problems currently being encountered in this work. (Edited author abstract) 7 refs.

Veith, A.G. (Uniroyal-Goodrich Tire Co, Brecksville, OH, USA). *Polym Test* v 7 n 4 1987 p 239-267.

**083090 CAN THE ASTM HEAT DISTORTION TEST PROVIDE MORE THAN JUST A SINGLE-POINT MEASUREMENT?** It is shown that the single-point heat distortion temperature value obtained under ASTM D648-72 can be used as a normalizing factor

to coalesce heat distortion temperature versus stress curves for a generic type of polymer. The advantage of such curves lies in their ability to provide a quick estimate of the behavior of the material at other stress levels useful for design purposes. (Author abstract) 5 refs.

Saini, D.R. (Nat'l Chemical Lab, Pune, India); Shenoy, A.V. *Polym Test* v 7 n 4 1987 p 293-297.

**083091 STUDIES OF THE FRICTION OF POLYMERIC MATERIALS.** The static and dynamic coefficients of friction of seven polymers in polymer-on-polymer and polymer-on-steel contact have been measured. It appears that the dynamic friction is independent of the sliding velocity and temperature, provided the temperatures attained are not sufficient to soften the polymer thermally; continued sliding, however, can modify the polymer surface and so affect the friction. The static friction coefficients were determined before and after the dynamic measurements and after the specimens had stood overnight. All the coefficients of friction obtained in these various ways were related functionally to one another and, presumably, for a given polymer, the values were influenced by adsorption or desorption from the polymer surface. The friction increased fairly regularly with the critical surface energy of the polymer. (Author abstract) 20 refs.

Vaziri, M. (Univ of Manchester, Manchester, Engl); Stott, F.H.; Spurr, R.T. *Wear* v 122 n 3 Mar 15 1988 p 313-337.

**083092 INVESTIGATION OF THE WEAR OF POLYMERIC MATERIALS.** A study has been made of the wear of the polymers, polytetrafluoroethylene, polypropylene, polyoxymethylene, high density polyethylene, poly(vinyl chloride), polyamide and poly(methyl methacrylate), during sliding against abrasive papers, polished steel and like polymer counter-surfaces. With the exception of poly(methyl methacrylate) and, to a lesser extent, polytetrafluoroethylene, there is a reasonable correlation between the wear rate of the polymer against abrasive paper and an expression involving the ploughing component of friction, the hardness, the tensile strength and the elongation to failure of the polymer as measured in tensile tests. Adhesive wear rates for like-on-like sliding are approximately proportional to the abrasive wear rates against SiC abrasive papers, although the absolute values are about  $10^5$  times smaller. (Edited author abstract) 12 refs.

Vaziri, M. (Univ of Manchester, Manchester, Engl); Spurr, R.T.; Stott, F.H. *Wear* v 122 n 3 Mar 15 1988 p 329-342.

**083093 FRACTURE MECHANICS OF POLYMERS. CRITICAL EVALUATION FOR LINEAR ELASTIC BEHAVIOUR AT HIGH SPEED TESTING.** Over the last few years considerable effort has been made to obtain reliable stress intensity factor and strain energy release rate ( $K_{IC}$  and  $G_{IC}$ ) data on polymeric materials. Experience has shown that a valuable method to minimize viscoelastic losses and plastic deformation is to work at high speed. However, some problems remain for this experimental method which have to be solved before standard methods can be defined. On the basis of measurements done with 3-point bending geometry on poly(vinylchloride) (PVC) and poly(propylene) (PP) at room temperature and over a range of notch depths, the work demonstrates that the linearity of experimental data both in the load ( $F$ ) and in the energy ( $U$ ) against  $(2BW^2/3LY)^{1/2}$  and  $(BW\phi)$  plot is not a critical test for linear elastic behaviour so that  $K_{IC}$  and  $G_{IC}$  values can be affected by large errors. Only the knowledge of the experimental curves which can be obtained by means of instrumented pendula in optimized test conditions allows a critical test to be applied for linear elastic behaviour based on comparison between experimental and predicted data for load, displacement and energy. These tests show that the linear elastic fracture mechanics, LEFM, criterion is satisfied for PVC but not for PP. This conclusion is further supported by the morphologies of the fracture surfaces. (Author abstract) 15 refs.

Casiraghi, T. (MONTEFLUOS, Milan, Italy); Castig-

lioni, G.; Ronchetti, T. *J Mater Sci* v 23 n 2 Feb 1988 p 459-466.

**083094 AUTOMATIC MEASURING ARRANGEMENT FOR COMPLEX YOUNG'S AND SHEAR MODULI OF POLYMERS AT INFRALOW FREQUENCIES.** In the present article an automatic arrangement is described for determining the complex Young's and shear moduli at frequencies from  $10^{-3}$  up to 1 Hz by means of forced, nonresonance vibrations at temperatures from 90 up to 700 K. Owing to the employment of new methods to determine the amplitudes and phase differences of harmonic ILF signals with changing mean levels the arrangement that has been developed is able to measure the complex moduli with high accuracy, not only with a stable but also with a varying static stress in a test specimen. 6 refs.

Polikarpov, Yu.I. (M.I. Kalinin Leningrad Polytechnic Inst, USSR); Bernikov, Yu.L.; Fedorov, Yu.N.; Burtsev, V.G. *Ind Lab (USSR)* v 53 n 9 Sep 1987 p 876-879.

**083095 EFFECT OF THE NATURE OF THE POLYMERIC MATRIX ON THE EFFICIENCY OF BROMINE-CONTAINING FLAME RETARDANTS.** Processes occurring in the pre-flame zone of the condensed phase between  $Sb_2O_3$  and the bromine-containing antipyrines in compositions with polyolefins have been studied. The composition of the solid products of thermal decomposition and combustion of these compositions was investigated using X-ray, atomic emission and chemical methods of analysis. During the reaction of  $Sb_2O_3$  with hydrogen halide, halides and oxides of antimony are formed. It was shown that formation of antimony metal in the condensed phase had a negative effect on antipyrine efficiency. (Author abstract) 10 refs.

Bogdanova, V.V. (V.I. Lenin White Russian State Univ, USSR); Klimovtsova, I.A.; Surtayev, A.F.; Fedeyev, S.S.; Filonov, B.O.; Lesnikov, A.I. *Polym Sci USSR* v 29 n 1 Jan 1988 p 101-106.

**083096 METHODS OF INVESTIGATION METHODS OF MEASURING THE ELASTICS MODULUS IN IMPACT TESTS ON POLYMERS.** It is shown that the results of determining the elastic modulus of polymethyl methacrylate in impact tests by means of the free methods currently available are completely in agreement provided allowance is made for weakening of the intermolecular bonds during deformation arising from their non-linearity (anharmonicity). Various methods have been proposed recently for measuring the elastic modulus of polymers, E under the conditions obtaining in impact tests. The values of E obtained by various methods differ in absolute value. Thus, the values of E for polymethyl methacrylate (PMMA) as determined previously are 2.16, 4.87, and 7.2 GPa respectively, for the same test conditions. The use of these methods thus requires interpretation and refinement, which is the object of this work. (Edited author abstract) 8 Refs.

Kozlov, G.V. (Kabardino-Balkarsk State Univ, USSR); Shetov, R.A.; Mikitayev, A.K. *Polym Sci USSR* v 29 n 5 1987 p 1231-1233.

## Theory

**083097 THEORY OF THE BEHAVIOUR OF FLEXIBLE POLYMERS IN LIMITED VOLUMES.** The proposed theory describes the equilibrium properties of flexible Gaussian chains in slot-like pores for any ratio of chain dimensions R, slot width D and arbitrary energies of adsorption of units on pore walls. It is shown that there are five characteristic modes of behavior covering the entire range of the R and D values and the adsorption energies. For each mode of behavior analytical expressions were derived for the free energy of a chain, the density profile for units inside a pore and the fraction of units located on pore walls. (Author abstract) 11 refs.

Gorbunov, A.A. (Leningrad Pharmaceutical Inst, USSR); Skvortsov, A.M. *Polym Sci USSR* v 28 n 10 1986 p 2412-2419.



**083098 SCALING CONCEPT AND THE WILLIAMS-LANDEL-FERRY RELATIONSHIP.** The superposition properties of the Williams-Landel-Ferry relationship when obtained empirically for different polymer systems and different temperature are formulated in terms of more general function with a scaling property. An analytical description of these superposition properties is given. The influence of the selected reference temperature on the translations needed to obtain the universal  $a_T(T-T_g)$  curve is discussed. (Author abstract) 10 refs.

Povolo, F. (CEN de Grenoble, Grenoble, Fr); Hermida, Elida. *J Mater Sci* v 23 n 4 Apr 1988 p 1255-1259.

**083099 ON THE THEORY OF LINEAR DIATOMIC POLYMERS.** The model of linear diatomic polymers is considered. Both the ground state and the phonon spectrum of a discrete AB chain are investigated. Taking into account the electron-phonon coupling as well as the finite-band corrections, an expression for the sound velocity is derived. The continuum equations of motion in the finite-band scheme are constructed. The kink solution is analyzed when the effects of an order of  $O(1/L)$ , where  $L$  is a chain length, are included. It is shown that the low-lying electronic excitations of an AB chain with fixed end atoms are the kink pairs where each kink has an irrational charge and a spin  $\sigma=0$  (or  $\sigma=1/2$ ). Depending on the value of the parameter  $\alpha$  the odd-membered chain with a free boundary is obtained to contain either a soliton or an electron-hole pair in its ground state. At  $\alpha=0$  all results obtained are valid for the trans-polyacetylene model. (Edited author abstract) 17 Refs.

Fedyanin, V.K. (Joint Inst for Nuclear Research, Dubna, USSR); Osipov, V.A. *Phys Status Solidi B* v 147 n 1 May 1988 p 199-209.

**083100 SOLITONS AND POLARONS IN POLYLYNE DISCRETE LATTICE AND BROKEN ELECTRON-HOLE SYMMETRY EFFECTS.** A SSH-like Hamiltonian proposed by M.J. Rice et al. for polylyne extended by second neighbor hoppings is investigated. The discrete system of electron eigenvalue equations together with self-consistency conditions for relative atomic displacements is numerically solved for a rich variety of soliton and polaron states. In particular, it is found that various degeneracies inherent for the model mentioned above are lifted due to terms which break the charge conjugation symmetry. Discrete lattice effects enhance the symmetry breaking. For polarexcitons and neutral solitons (antisolitons) an internal charge structure is found. (Author abstract) 18 Refs.

Malek, J. (Joint Inst for Nuclear Research, Dubna, USSR); Drechsler, S.L.; Heiner, E.; Kahnt, R. *Phys Status Solidi B* v 147 n 1 May 1988 p 281-295.

## Thermal Conductivity

**083101 WATER-CONTENT DEPENDENCE OF THE THERMAL CONDUCTIVITY FOR A PHENOLIC FOAM PLASTIC COMPOSITE.** Polymeric insulating materials are widely used in maintaining heat in building structures. Calculations on such structures under various conditions require reasonably complete data on the thermophysical characteristics, but there are difficulties in examining these because the materials are of low density and low conductivity. The article gives results on a new composite foam plastic based on a phenolic composition containing suspended polystyrene granules. 4 refs.

Shamaeva, A.P.; Tolstyakov, D.N.; Fedorova, F.G. *Meas Tech* v 30 n 5 May 1987 p 464-465.

**083102 SET-UP FOR DETERMINING THE THERMAL CONDUCTIVITIES OF ORIENTED POLYMERS.** A set-up is described for determining the main thermal conductivity coefficient of oriented polymer films in the direction of oriented polymer films in the direction of the macromolecular structure orientation. The operation is based on the stationary comparative method. Heat losses are eliminated by placing the measuring cell into a vacuum chamber. (Author abstract) 6 refs.

Novichyonok, L.N.; Ovchinnikova, S.M. *Heat Transfer Sov Res* v 19 n 5 Sep-Oct 1987 p 128-132.

**Thermal Effects** See Also AROMATIC POLYMERS—Degradation; COPOLYMERS—Degradation; CRYSTALS, LIQUID—Physical Properties; GELS—Materials; POLYETHYLENES—Glass Transition; POLYIMIDES—Degradation; POLYIMIDES—Spectroscopic Analysis.

**083103 THERMAL DEPOLYMERIZATION OF LINEAR POLYMERS.** A model is presented to understand thermal-depolymerization process of as-polymerized poly-DSP (2, 5-distyrylpyrazine), one of poly-diolefin crystals. We can explain why the rigid linear chains with free ends are thermally scissored at the middle parts as well as the chain length and temperature dependences of this scission process. (Author abstract) 4 refs.

Hanamura, Eiichi (Univ of Tokyo, Tokyo, Jpn). *Solid State Commun* v 63 n 12 Sep 1987 p 1097-1099.

**083104 STUDY ON THE THERMOSTABILITY OF POLYETHERIMIDE.** Polyetherimide (PEI) was synthesized from Bisphenol A and 4,4'-bis(3-nitrophthalimido) diphenyl ether by the nitro-displacement reaction in a polar aprotic solvent, and its structure was identified. The thermal degradation kinetics of PEI was studied by thermogravimetric analysis under the protection of nitrogen, while the data were fitted with a double-variable regression. The estimated kinetic parameters were 5.33 th, 192 kJ/mol,  $1.45 \times 10^{12} \text{ min}^{-1}$  for the apparent order, activation energy and pre-exponential factor of reaction respectively. The good agreement with the results from H.L. Friedman method justified this mathematical approach to calculating the kinetic parameters for thermal decomposition. (Edited author abstract) In Chinese. 12 refs.

Huang Farong; Wang Xueqiu; Li Shijin. *Huadong Huang Xueyuan Xuebao* v 14 n 1 1988 p 22-30.

**083105 THERMALLY STIMULATED CURRENTS IN POLY(BIS(P-FLUOROPHENOXY)PHOSPHAZENE).** Thermally stimulated currents (TSC) were examined for poly(bis(p-fluorophenoxy)phosphazene) (PBFP) film. TSC showed peaks at the glass transition temperature ( $T_g = -4^\circ\text{C}$ ) and at  $T(1)$  ( $160^\circ\text{C} - 170^\circ\text{C}$ ), where  $\alpha$ -form crystal phase transformed to mesophase of  $\gamma$ -form structure. Another peak was found at  $T_{cc}$  between  $T_g$  and  $T(1)$ . Linear relationship between polarization field and peak current of  $T_{cc}$ -peak was found, which shows that  $T_{cc}$ -peak was caused by motion of dipolar groups in crystalline phase. When heating (up to  $200^\circ\text{C}$ ) and cooling (down to  $20^\circ\text{C}$ ) thermal process was repeated,  $T_{cc}$ -peak shifted to higher temperature region approaching  $T(1)$  and simultaneously, the peak current of  $T(1)$ -peak became smaller. Activation energy, time constant of dipolar relaxation and charge mobility were evaluated for  $T_{cc}$ -peak. From these results, it was concluded that  $\alpha$ -form and more ordered  $\beta$ -form crystalline phases coexisted in PBFP once heated above  $T(1)$  and the content of  $\beta$ -form phase increased by repeated thermally hysteresis. (Author abstract) 9 refs.

Ohara, K. (Shinshu Univ, Ueda, Jpn); Matsuzawa, S.; Higuchi, M. *Colloid Polym Sci* v 265 n 10 Oct 1987 p 860-866.

**083106 THERMAL BREAKDOWN OF POLYBIS-MALEIMIDAMINES.** The authors have attempted to perform a detailed study of the PBMA (Polybis-maleimidamines) thermal breakdown process, using dynamic and isothermal thermogravimetry on small samples (4-10 mg) of polymer prepared from purified monomers, and also using mass spectrometry and IR spectroscopy. It is found that in the initial stage of thermal and thermooxidative breakdown ( $300-350^\circ$ ) of polybismaleimidamines, regardless of their chemical structure, the predominant reaction is the reverse of the reaction of nucleophilic addition of active hydrogen of the primary amino group of the aromatic diamine to the double bond of the maleimide ring. The weakest bond proves to be the N-C bond between the amino group and the succinimide ring. The main product of thermal breakdown is the diamine. 12 refs.

Khabenko, A.V.; Titkova, Z.L.; Dolmatov, S.A. *J Appl Chem USSR* v 60 n 6 pt 2 Jun 1987 p 1281-1286.

**083107 NATURE OF THE THERMAL STABILITY OF POLYHETEROOARYLENES.** The dependence between structure and thermal stability of polyheteroarylenes has been examined. It has been shown that the thermal stability of polymers depends on the two basic factors - an energy factor, determined by the breaking energy of skeletal bonds in the polymer chain, and an entropy factor, which characterizes the probability of effecting the elementary acts of chemical reactions and is expressed via the mobility of the macromolecules. Symmetry of the monomeric units in a chain, regularity in the macromolecules, the absence of bulky substituents, and a high degree of crystallinity aid in reducing the molecular mobility of heterocycloaromatic polymers and in increasing their thermal stability. Analysis of the factors which aid in thermal stability has made it possible to arrive at the conclusion that the polymer glass transition point or melting point can serve as a criterion of the thermal stability of polyheteroarylenes. 21 refs.

Kalashnik, A.T. *Fibre Chem* v 19 n 4 Jul-Aug 1987 p 251-257.

**083108 VIBRATIONAL SPECTROSCOPIC STUDY OF THE THERMAL DEGRADATION OF POLYARYLENE METALLOSULPHIDES.** The authors have studied the processes of thermal degradation of polyarylene metallosulphides in vacuo and in presence of oxygen by IR spectroscopy in the region  $150-4000 \text{ cm}^{-1}$ . From analysis of the low-frequency vibratory spectra ( $290-400 \text{ cm}^{-1}$ ) it has been established that thermal degradation begins with rupture of the sulphur-metal bond. The differences in thermal degradation in vacuo and in presence of oxygen depending on the nature of the metal and the presence in the chain of a heteroatomic bridge are discussed. (Author abstract) 10 refs.

Shubina, Ye.S. (Nesmeyanov Inst of Elemento-Organic Compounds, USSR); Epshtein, L.M.; Kravtsov, D.N.; Shevlyakova, N.P.; Nedel'kin, V.I.; Gribkova, P.N.; Pavlova, S.-S.A.; Sergeev, V.A. *Polym Sci USSR* v 29 n 2 Feb 1987 p 244-252.

**083109 THERMAL DEGRADATION OF POLY(ARYL-ETHER-ETHER-KETONE) (PEEK): A DIFFERENTIAL SCANNING CALORIMETRY STUDY.** Differential scanning calorimetry (DSC) has been used to study the crystallization kinetics and thermal characteristics of poly(aryl-ether-ether-ketone) (PEEK) samples heated under a variety of conditions. Samples were heated in nitrogen and air at temperatures between  $380$  and  $420^\circ\text{C}$  for times up to 120 min. The results indicate that as the holding time and temperature of the melt increased, the amount of recrystallizable material decreased, especially when heated in air. Isothermal crystallization kinetics confirmed the presence of a two-stage crystal nucleation and growth process with Avrami exponents of the order of about 2.4 and 1.5 for the first and second processes, respectively. (Edited author abstract) 17 Refs.

Day, M. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Suprunchuk, T.; Cooney, J.D.; Wiles, D.M. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 1097-1106.

**083110 THERMAL DEGRADATION OF HIGH NITRILE BARRIER POLYMERS.** Effects of absorbed moisture on degradation behavior of high nitrile barrier polymers were monitored using thermogravimetric analysis techniques. Non-modified and 10 percent rubber modified samples were heated isothermally at nitrile processing temperatures ( $200$  to  $240^\circ\text{C}$ ) in air and nitrogen environments. Degradation was evaluated in terms of weight loss as a function of heating time and sample coloration. It was determined that complete removal of moisture, as well as high moisture concentration, contribute to increased degradation at the temperatures evalu-



ated. Moisture levels in the range of 0.15 to 0.5 percent were found to minimize degradation. (Edited author abstract). 13 Refs.

Jabarin, S.A. (Univ of Toledo, Toledo, OH, USA); Lofgren, E.A. *Polym Eng Sci* v 28 n 18 Sep 1988 p 1152-1155.

**Thermal Properties** See Also BLOCK COPOLYMERS—Synthesis; COPOLYMERS—Synthesis; IONOMERS—Synthesis; MONOMERS—Polymerization; PLASTICS—Combustion; PLASTICS FILMS—Mechanical Properties; POLYCARBONATES—Synthesis; POLYURETHANES—Flame Resistance; POLYURETHANES—Physical Properties; STYRENE—Thermal Properties.

**083111 THERMAL STABILITY OF POLY(PYRROLE).** In this letter authors report the thermal degradation behavior of PPy heated to 700°C in air and in nitrogen atmosphere. The thermal degradation of the same sample takes place with an activation energy of 40.9 kJ mol<sup>-1</sup> when heated to 600°C. This shows that during the initial stages of thermal treatment in nitrogen after the breakage of some weak bonds, PPy acquires a structure with increased thermal stability. 6 refs.

Arca, M. (Hacettepe Univ, Ankara, Turk); Arca, E.; Yildiz, A.; Guven, O. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1013-1015.

**083112 NONDESTRUCTIVE EVALUATION OF POLYMERS WITH OPTICALLY GENERATED THERMAL WAVES.** Periodic illumination of an absorbing sample results in a surface temperature modulation which propagates into the sample as a highly attenuated and slow 'thermal wave'. Thermal wave propagation depends on thermal properties and on their anisotropy. Boundaries affect both the phase and magnitude of the temperature modulation. Since thermal wave detection can be performed in a remote way, one can monitor the orientation of fibers and molecules without touching the sample. Scanned local inspection allows mapping of layer delamination caused by mechanical stress of electrical heating. (Author abstract) 13 refs

Busse, G. (Univ Stuttgart, Stuttgart, West Ger); Rief, B.; Eyerer, P. *Polym Compos* v 8 n 4 Aug 1987, Pap Presented at the 1986 Annu Tech Conf of the Soc of Plast Eng, Boston, MA, USA, May 1986 p 283-286.

## Thermoanalysis

**083113 FEW CHARACTERIZATION STUDIES ON SOME POLY(METHYL ARYLOXYMETHACRYLATES).** High polydispersity values obtained for the molecular weights, as determined by light scattering, osmometry, and GPC, of polymers prepared by different methods from the monomers recently synthesized indicate the presence of large quantities of low molecular weight species besides the high molecular weight species. Intrinsic viscosity data were used to evaluate Mark-Houwink constants K and 'a' for this new series of monomers. DSC analyses show that the polymers have low T<sub>g</sub>. X-ray diffraction studies made on the fibers show a high percentage of crystallinity in poly(methyl a-phenoxy-methacrylate). (Author abstract) 15 refs.

Devarajan, R. (Univ of Madras, Madras, India); Balakrishnan, T.; Santappa, M. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3183-3190.

**083114 NUMERICAL STUDY OF THE THERMALLY-INDUCED RESPONSE OF DECOMPOSING, EXPANDING POLYMER COMPOSITES.** A numerical study of the thermally-induced response of two similar decomposing, expanding glass-filled polymer composites has been conducted. The study was performed using a newly developed numerical model, the accuracy of which was established by comparing predicted and experimental temperature profiles for one of the composites of interest. The results of the study were used to evaluate the effects of composition and processing history on the response of the materials. (Author abstract) 19 refs.

Henderson, J.B.; Wiecek, T.E. *Waerme Stoffuebertrag* v 22 n 5 1988 p 275-284.

**Thermodynamic Properties** See Also NYLON POLYMERS—Blending; POLYCARBONATES—Drawing and Stamping.

**083115 EQUILIBRIUM FLEXIBILITY OF POLYMETHYLENE CHAINS, CONTINUUM-MODEL.** Comparative calculations are made of the unperturbed dimensions of 'realistic' polymethylene chains on the assumption of a continuous spectrum of the conformations having regard to the braking and mutual dependence of the internal rotations; to calculate the energy of the near interactions by the method of atom-atom potential functions the authors employ 11 different sets of parameters of the potentials of the non-valent interactions. The use of a continuum model allows one to extract from the map of the conformational energy practically complete information on the mean statistical characteristics of the chain and provides an objective criterion in the choice of potentials adequate to a given class of polymers. (Author abstract) 37 refs.

Dashevskii, V.G. (USSR Acad of Sciences, USSR); Rabinovich, A.L. *Polym Sci USSR* v 28 n 6 1986 p 1340-1348.

**083116 ON THE THERMODYNAMIC POTENTIALS OF AN ISOLATED POLYMER CHAIN IN SOLUTION.** The thermodynamic functions of an isolated polymer chain in solution are obtained by using a somewhat refined form of Fisher's and Hiley's partition function. The entropy change upon changing the temperature from Flory's theta temperature to T is found to be the sum of three terms, the first of these terms being equivalent to Flory's equation for the elastic energy of an isolated polymer chain. (Edited author abstract) 13 refs.

Dayantis, Jean (CNRS, Strasbourg, Fr). *Polym Commun (Guildford Engl)* v 29 n 3 Mar 1988 p 73-75.

**083117 STRUCTURE, PROPERTIES, AND THERMODYNAMICS OF POLY(CARBON DICHALCOGENIDES).** Structural studies indicate that poly(carbon diselenide) has a head-to-head structure rather than the previously assumed head-to-tail structure. Thermodynamic properties and structure are investigated by using dual approaches for poly(carbon dichalcogenides): analysis of results for model compounds and quantum chemical calculations. Calculations using model compounds indicate that the head-to-tail structure has much lower energy than the head-to-head structure for poly(carbon dioxide), the energy difference is small for poly(carbon disulfide), and the head-to-head structure has much lower energy than the head-to-tail structure for poly(carbon diselenide) - which is consistent with the observation of the head-to-head structure for the latter polymer. (Edited author abstract) 51 refs.

Baughman, R.H. (Allied-Signal Inc, Morristown, NJ, USA); Iqbal, Z.; Eckhardt, H.; Okamoto, Y. *Macromolecules* v 21 n 6 Jun 1988 p 1832-1838.

**083118 ACTIVITY COEFFICIENTS IN POLYMER SOLUTIONS.** Infinite dilution activity coefficient is introduced as a practical tool for characterizing the thermodynamic interactions in coatings. The application of this quantity to describe phenomena such as polymer solubility, solvent distribution in two-phase systems, colloidal stability, network swelling and drying is indicated. Finally, the values of around 500 estimated activity coefficients of organic solvents in water and various polymers are presented. (Author abstract) 26 refs.

Holten-Andersen, J. (Scandinavian Paint & Printing Ink Research Inst, Horsholm, Den); Eng, K. *Prog Org Coatings* v 16 n 1 May 1978 p 77-97.

**Thermodynamics** See Also POLYETHYLENES—Rheology; POLYVINYL ACETATE—Aging.

**083119 UTILIZATION OF THE CONCEPT OF QUASI SOLUTIONS IN THE THERMODYNAMICS OF POLYMER HOMOLOGUES.** It is proposed that an infinite sequence of linear polymer homologues be described as an open thermodynamic system whose equilibrium state is characterized by an additional param-

eter, i.e. by the length of macromolecules. Thus idea has led to the derivation of basic equations of the energy of a system: the repeat-units of chain molecules and the endgroups figure as independent components, like other substances present in the system. An analysis of the phase equilibria led to the derivation of an analogue of the known generalized differential van der Waals equation. (Author abstract) 5 refs.

Golubev, V.M. (Zhdanov State Univ, Leningrad, USSR); Rusakov, A.I. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1734-1737.

**083120 ASPECTS OF THERMODYNAMICS OF POLYMER MIXTURES.** In this brief review article some aspects of the thermodynamics of polymer mixtures are discussed, mainly based on the author's research. The studies of poly(methyl methacrylate)/chlorinated polyethylene (CPE), poly(butyl acrylate)/CPE and CPE/CPE (different chlorine content) mixture verify the 'dissimilarity' and 'similarity' principles for predicting miscibility of polymer mixtures. The sign of heat of mixing of oligomeric analogues is not sufficient in predicting the miscibility. The Flory equation of state theory has been applied to simulate the phase boundaries of polymer mixtures. The empirical entropy parameter Q<sub>12</sub> plays an important role in the calculation, this reduces the usefulness of the theory. With energy parameter X<sub>12</sub> ≠ 0 and Q<sub>12</sub> ≠ 0 the spinodals so calculated are reasonable compared to experiments. A hole model was suggested for the statistics of polymer mixtures. The new hole theory combines the features of both the Flory equation of state theory and the Sanchez lattice fluid theory and can be reduced to them under some conditions. (Author abstract) 20 refs.

Chai, Zhikuan (Acad Sinica, Beijing, China). *Chin J Polym Sci (Engl Ed)* v 5 n 3 1987 p 175-185.

**083121 NEW PVT EQUATIONS FOR POLYMERIC LIQUIDS AND GLASSES.** New equations of state have been derived from our multiple hole energy model that describe the pressure-volume-temperature (PVT) behavior of amorphous polymers in both the equilibrium liquid and nonequilibrium glassy states. Good agreement between the theoretical and experimental results is achieved over a broad range of temperatures and pressures with a single set of molecular parameters. Significantly, all molecular parameters are independent of temperature and pressure and can be determined separately. (Edited author abstract) 17 refs.

Chow, T.S. (Xerox Corp, Webster, NY, USA). *J Rheol* v 30 n 4 Aug 1986, Symp on Appl of Equat of State Rheol at the 57th Annu Meet of the Soc of Rheol, Ann Arbor, MI, USA, Oct 1985 p 729-740.

**083122 IMPORTANCE OF ENTHALPIC INTERACTIONS IN POLYMERIC SYSTEMS.** Enthalpic interactions between blend components primarily determine the state of miscibility and many of the physical properties of the blend. Recent applications of these thermodynamic considerations are reviewed for a variety of systems, including binary and ternary blends of homopolymers, binary blends of copolymers with homopolymers, and polymer-solvent mixtures. Recent advances toward predicting polymer blend miscibility through use of a modified quasicheical thermodynamic model and heats of mixing data for liquids are also discussed. (Author abstract) 115 refs.

Barlow, J.W. (Univ of Texas at Austin, Austin, TX, USA); Paul, D.R. *Polym Eng Sci* v 27 n 20 Mid-Nov 1987 p 1482-1494.

## Thermoelasticity

**083123 THEORY OF THERMOELASTIC PROPERTIES FOR POLYMER GLASSES.** We derive expressions for the extensional elastic moduli as functions of temperature and pressure by a generalization of the equation of state theory. Our previous efforts in this direction were confined to the low-temperature region, where the characteristic free volume function, defined by theory, is effectively frozen. We proceed now to higher



temperatures, where the temperature and pressure dependence of this function play a decisive role. The static Young's and shear modulus and the Poisson ratio are computed, based solely on equation of state information. This is illustrated by means of applications to poly(vinyl acetate) glasses at low and elevated pressures and for different formation histories. (Edited author abstract) 23 refs.

Papazoglou, Elisabeth (Case Western Reserve Univ, Cleveland, OH, USA); Simha, Robert. *Macromolecules* v 21 n 6 Jun 1988 p 1670-1677.

Thick Films See PRINTED CIRCUITS—Fabrication.

### Thickness Measurement

**083124 HYDRODYNAMIC THICKNESSES OF POLYETHYLENE OXIDES ADSORBED IN POROUS MEDIA UNDER POOR SOLVENT CONDITIONS.** The hydrodynamic thickness  $L_H$  of an adsorbed polyethylene oxide (PEO) layer on the wall of a porous filter was determined by measuring volume flow rates of aqueous 0.45 M  $K_2SO_4$  solution corresponding to a poor solvent for PEO through the pores as a function of molecular weight  $M_w$ .  $L_H$  increased with adsorption time and well attained its equilibrium value after 1 week for each sample. The time required to attain the equilibrium value became longer with increasing molecular weight. The plateau  $L_H$  values are comparable to the radii of gyration of free PEO chains in aqueous 0.45 M  $K_2SO_4$  solution and scale as  $M^{0.68}$ . The absolute value of the plateau  $L_H$  was larger than that in water (good solvent condition). The larger value of  $L_H$  is in qualitative agreement with calculated results. (Edited author abstract) 25 refs.

Kawaguchi, Masami (Mie Univ, Tsu, Jpn); Suzuki, Chikara; Takahashi, Akira. *J Colloid Interface Sci* v 121 n 2 Feb 1988 p 585-589.

Thin Films See Also CATHODES—Materials; DIELECTRIC MATERIALS—Thin Films; ELECTRODES—Coatings; ELECTRODES—Thin Films; EPOXY RESINS—Sorption; HARMONIC GENERATION; NEUTRONS—Optical Properties.

**083125 LIGHTGUIDING IN LANGMUIR-BLODGETT FILMS OF PREFORMED POLYMERS.** Preformed polymers, made from derivatives of vinyl-maleic anhydride copolymers, have been used to produce thick (300-400 layers; 0.5-0.6  $\mu$ m) Langmuir-Blodgett multilayers. The thermal stability of the films is shown to depend on the relative positions of the side-groups. Those materials which deposited well for large numbers of layers and possessed thermal stability were investigated for evidence of optical waveguiding using light at a wavelength of 633 nm. An attenuation of approximately 10 db  $cm^{-1}$  was observed in films having a thickness of about 0.5  $\mu$ m after suitable precautions were taken to exclude dust and bacteria. (Author abstract) 16 refs.

Tredgold, R.H. (Univ of Lancaster, Lancaster, Engl); Young, M.C.J.; Hodge, P.; Khoshdel, E. *Thin Solid Films* v 151 n 3 Aug 1977 p 441-449.

**083126 FORMATION OF  $Si(PH_2THALOCYANINATO)(OH)_2$  AND  $[Si(PH_2THALOCYANINATO)_2]_n$  FILMS AND THEIR OPTICAL AND ELECTRICAL PROPERTIES.** In this study we investigate the substrate temperature  $T_s$  dependence of the properties of films obtained by the evaporation of  $Si(Pc)(OH)_2$ . It is found that  $[Si(Pc)(OH)_2]_n$  films can be obtained when  $T_s > 240^\circ C$  and  $Si(Pc)(OH)_2$  films when  $T_s < 200^\circ C$ . Several interesting features are found in the absorption spectra and photoelectrical properties of the films obtained. 12 refs.

Yudasaka, M. (Yokohama Natl Univ, Yokohama, Jpn); Kawai, M.; Kurita, S.; Nakanishi, K.; Kuwae, Y. *Thin Solid Films* v 151 n 3 Aug 1977 p L115-L119.

**083127 SURFACE RESTRUCTURING OF POLYMERS.** Time-dependent contact angle measurements are employed to follow the dynamics of surface modifications

of various polymeric surfaces of different hydrophilicities. The equilibration of a hydrophilic polymer in a strong polar environment (such as water) induces an increase in the polarity of the surface; the subsequent exposure of the restructured solid to a nonpolar environment decreases the polarity of the surface. The dynamics of these processes depends on the history of the specimen. Various phenomena, such as surface restructuring by the reorientation of the buried polar or nonpolar moieties, water penetration into the polymer, and the reorganization of water in the neighborhood of the surface, are suggested to be responsible for the time evolution of the dynamic contact angles. (Author abstract) 14 refs.

Lee, Sang Hwan (State Univ of New York, Buffalo, NY, USA); Ruckenstein, Eli. *J Colloid Interface Sci* v 120 n 2 Dec 1987 p 529-536.

**083128 ENERGY STATES IN POLYVINYL-FORMAL THIN FILMS.** Electrons with 6 keV energy have been used to probe the energy of states in 100 Å thin films of polyvinyl formal. The electron energy-loss spectra at several angles show plasmon formation. The angular correlations of the scattered and ejected energy-loss electrons have been observed using the (e, 2e) technique with a transmission coplanar scattering geometry. Many states contribute to the (e, 2e) spectrum and with our overall electron energy resolution of 14.2 eV, states with binding energies of 11, 22, 32, 43, 53, 67, 80 and 93 eV have been seen but not identified. Angular correlations of the states at 22 and 43 eV were made but do not assist with identification of the states. Further measurements with a better electron energy resolution are required. (Author abstract) 28 refs.

Dey, S. (Univ of Western Australia, Perth, Aust); Williams, J.F. *J Phys D* v 21 n 1 Jan 14 1988 p 108-115.

**083129 EFFECT OF A SOLID SURFACE ON THE ELASTIC PROPERTIES OF THIN EPOXY COATINGS.** The study of the elasticity of epoxy coatings on supports with a different surface energy permitted obtaining some data on their mechanical behavior in consideration of the adhesive interaction with the surface of the solid and qualitatively examining them with the current concepts of interphase events. Regulation of the elasticity of boundary layers of an epoxy polymer during its curing on a solid surface, for example, in coatings, adhesive compounds, and composite materials, could be attained by adding small amounts of SF to the composite. 18 refs.

Veselovskii, R.A. (Acad of Sciences of the USSR, Kiev, USSR); Pavlov, V.I.; Muravskaya, T.P. *Mech Compos Mater* v 23 n 2 Mar-Apr 1987 p 155-159.

**083130 PREPARATION & ELLIPSOMETRIC STUDY OF POLYMER FILMS.** Methods of preparation of polymer thin films and their applications are presented. Ellipsometric study of films of polystyrene, polyethylene and neoprene is reported and some results are presented. (Author abstract) 29 refs.

Ashok, J. (Andhra Univ, Waltair, India); Avadhani, S.V. *Indian J Pure Appl Phys* v 25 n 5-6 May-Jun 1987 p 239-241.

**083131 SINGLE-ION CONDUCTION IN POLY[(OLIGO(OXYETHYLENE) METHACRYLATE)-co-(ALKALI-METAL METHACRYLATES)].** Thin films of poly[oligo(oxyethylene) methacrylate]-co-(alkali-metal methacrylates) were prepared from methanol solutions of oligo(oxyethylene) methacrylate and alkali-metal methacrylates by casting and polymerization on a Teflon plate under nitrogen. The ionic conductivity of the films depends on the electrolyte content, the dissociation energy of the alkali-metal methacrylate, and the degree of motion of polymer segments surrounding the ions in the polymer matrix. The ionic conductivity of the polymeric Li and K salts is  $10^{-6}$  S/cm at  $80^\circ C$ . The transient ionic current after reversing the dc bias polarity shows one sharp peak corresponding to cation migration, indicating that the polymer is a cationic single-ion conductor. (Edited author abstract) 34 refs.

Tsuchida, Eishun (Waseda Univ, Tokyo, Jpn); Kobayashi,

Norihisa; Ohno, Hiroyuki. *Macromolecules* v 21 n 1 Jan 1988 p 96-100.

**083132 OPTICAL SECOND HARMONIC GENERATION FROM LANGMUIR-BLODGETT MULTILAYERS CONTAINING PREFORMED POLYMERS.** The Langmuir-Blodgett (LB) technique has recently been used to form ultrathin noncentrosymmetric films capable of generating radiation in the visible region when irradiated in the near infra-red. Alternating LB films of polymers and monomers have been formed which have proved to be efficient second harmonic generators. (Edited author abstract) 12 refs.

Tredgold, R.H. (Univ of Lancaster, Lancaster, Engl); Young, M.C.J.; Jones, R.; Hodge, P.; Kolinsky, P.; Jones, R.J. *Electron Lett* v 24 n 6 Mar 17 1988 p 308-309.

**083133 CHARACTERIZATION OF POLYAMIC ACID/POLYIMIDE FILMS IN THE NANOMETRIC THICKNESS RANGE FROM SPIN-DEPOSITED POLYAMIC ACID.** A dilute polyamic acid solution was spin-deposited onto gold substrates and XPS analyses were performed after deposition. Evidence of the presence of organic films on the top surface of the substrates was found. A chemical characterization allowed us to identify these organic films as being polyamic acid after a  $125^\circ C$  curing and polyimide after a  $240^\circ C$  curing. From angle-dependent data we have shown that the good substrates were coated quasi-uniformly by ultra-thin films. This conclusion was confirmed by an Auger analysis. The computed thicknesses were found in a range of 1.3 to 2.9 nm depending on the sample preparation conditions. Adsorption was supposed to occur just after the deposition. Some possible mechanisms of the interfacial interaction between the polyamic acid and the surface were proposed. A thermally-activated chain cleavage was supposed to occur at the interface or near the interface. (Author abstract) 40 refs.

Russat, Jean (IBM, Corbeil-Essonnes, Fr). *Surf Interface Anal* v 11 n 8 May 1988 p 414-420.

**083134 PARAMETER MEASUREMENT OF POLYMER THIN FILM WITH QUASI-WAVEGUIDE METHOD.** A new experiment for measuring the parameters of polystyrene and polyethersulphone films using quasi-waveguide method is reported. The films were deposited on the substrates with the shape of prism. Leaky mode m-lines of the films were measured. The index and the thickness of the films were determined by using leaky mode equation. The birefringence of the film was obtained with the aid of different polarized laser beam. The measurement errors of the index and thickness are about  $\pm 1 \times 10^{-3}$ , and  $\pm 0.01 \mu$ m respectively. (Author abstract) 5 refs. In Chinese.

Ren, Bingfu (Acad Sinica, China); Ding, Tienan; Lang, Weidan. *Guangxue Xuebao* v 8 n 4 Apr 1988 p 344-347.

**083135 LANGMUIR-BLODGETT FILMS OF ACETALIZED POLY(VINYL ALCOHOL)S.** Monolayers and multilayers of amphiphilic polymers consisting of acetalized poly(vinyl alcohol) (PVA) having various linear aliphatic side chains were investigated and their electrons beam (EB) exposure characteristics were measured. It was found that monolayers of acetalized PVA having long alkyl side chains were stable on water and could be deposited onto both hydrophobic and hydrophilic substrates with a deposition ratio of 1.0. The resulting multilayers and hydrophilic substrates with a deposition ratio of 1.0. The resulting multilayers were Y type. The wettability of the multilayers changed according as there was an odd or an even number of layers. The thickness per layer increased with the length of the alkyl side chain. These results suggested that Langmuir-Blodgett (LB) films of acetalized PVA having long alkyl side



chains were rather well-ordered with the side chains directed normal to the main chains. (Edited author abstract). 15 refs.

Oguchi, Kiyoshi (Sophia Univ, Tokyo, Jpn); Yoden, Tomoko; Kosaka, Yozou; Watanabe, Masayoshi; Sanui, Kohei; Ogata, Naoya. *Thin Solid Films* v 161 Jul 1988 p 305-313.

**083136 WORKSHOP ON THE MOLECULAR ENGINEERING OF ULTRATHIN POLYMERIC FILMS.** The proceedings contains 22 papers. Some of the specific topics discussed are: experimental considerations in insoluble spread monolayers; pre-Langmuir-Blodgett monolayers; physical properties of ordered ultrathin organic films; lipid-based tubule microstructures; phase-controlled surface reactions; and thin organic films of proteins. All papers are separately indexed and abstracted. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10531 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Stroeve, P. (Ed.); Franes, E. (Ed.). *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 408p.

**083137 CHEMISTRY OF POLYMER MOLECULES FOR ULTRATHIN FILMS.** Progress in polymeric resist materials for microlithography has partly allowed the advent of very-large-scale integrated circuits. Use of conveniently oriented ultrathin films of liquid crystal polymers for non-linear optics seems very attractive since the films can be produced much faster than crystals can and at greatly reduced cost. They can be applied over very large areas relative to the crystal size and on various substrates. This paper is a review of the main families of polymers for making resists useful in microlithography and of polymers exhibiting liquid crystal properties. (Edited author abstract) 136 refs.

Le Barny, P. (Thomson-CSF, Orsay, Fr). *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 99-150.

**083138 ORIENTED ULTRATHIN MEMBRANES FROM MONOMERIC AND POLYMERIC AMPHIPHILES: MONOLAYERS, LIPOSOMES AND MULTILAYERS.** Oriented polymeric membranes were originally prepared by polymerization or polycondensation of preoriented monomers. The introduction of hydrophilic spacer groups into the polymeric amphiphiles allowed the formation of highly ordered systems (monolayers, liposomes and multilayers) from prepolymerized amphiphiles. In monolayer experiments the high degree of order of these membranes can be demonstrated by their surface pressure vs. area diagrams. Polymeric liposomes can be prepared by ultrasonication of prepolymerized lipids. In addition, the combination of the order and mobility of these polymeric amphiphiles with hydrophilic spacer groups allowed the formation of Langmuir-Blodgett multilayers with a high layer correlation. (Edited author abstract) 32 refs.

Ringsdorf, H. (Univ Mainz, Mainz, West Ger); Schmidt, G.; Schneider, J. *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 207-222.

**083139 LANGMUIR-BLODGETT FILMS MADE FROM PREFORMED POLYMERS.** A brief general review of work in this field is given. A particular family of copolymers derived from maleic anhydride is described and the way in which these copolymers behave at the air-water interface and as Langmuir-Blodgett multi-layers is discussed with particular reference to the influence of the nature of the side-chains on isotherms and structure. The application of these materials to the formation of low loss optical waveguides, electron beam resists and photo-diodes is reviewed. (Author abstract) 28 refs.

Tredgold, R.H. (Univ of Lancaster, Lancaster, Engl). *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb

18-20 1987 P 223-230.

**083140 MOLECULAR ENGINEERING IN JAPAN - A PROSPECT OF RESEARCH ON LANGMUIR-BLODGETT FILMS.** The present status of research on Langmuir Blodgett (LB) films in Japan is outlined in relation to molecular engineering. Stress is laid on the fundamentals of LB films: synthesis of novel films, advances in preparation techniques, and characterization of molecular domains. The advances in characterization are exemplified by the introduction of Penning ionization electron spectroscopy, the utilization of synchrotron radiation and analyses using the electron spin resonance technique applied to dye LB films and conducting LB films. The prospects for molecular engineering in the near future are briefly discussed. The significance of the LB technique as a tool for fabricating test structures is pointed out together with the increasing importance of theoretical guidelines. (Edited author abstract) 91 refs.

Sugi, Michio (Electrotechnical Lab, Sakura-mura, Jpn). *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 305-326.

**083141 PHASE-CONTROLLED SURFACE REACTIONS.** Discrete interfacially controlled condensation and addition reactions, including polymerization, are described in the case of conducting polymer film growth on salt crystals, as well as monolayer reactions on a water surface. It has been shown that the interface controls and limits the extent of reaction so as to minimize structural disruption of the film material. In virtually every case, the resulting polymer has a unique chemistry, structure, defect level or purity which cannot be obtained by any other method. (Author abstract) 18 refs.

Lando, Jerome B. (Case Western Reserve Univ, Cleveland, OH, USA); Rickert, Scott E. *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 327-333.

**083142 FUTURE APPLICATIONS OF ORDERED POLYMERIC THIN FILMS.** Polymeric ultrathin film systems need to be developed in the context of applications where their unique combinations of properties promise revolutionary improvements in performance or cost effectiveness. The applications examined include electron beam resists for microlithography and nanolithography, insulating films in semiconductor devices, non-linear optical elements and coatings for communications and computing, as well as highly permselective membranes in biotechnology. In this paper, we will review some of the most appealing suggestions and evaluate their current status. Improvements in film characterization and deposition based on Langmuir-Blodgett techniques are also suggested. (Author abstract) 56 refs.

Kowal, Stephen T. (Univ of California, Davis, CA, USA); Selfridge, Richard; Eldering, Charles; Matloff, Norman; Stroeve, Pieter; Higgins, Brian G.; Srinivasan, M.P.; Coleman, Lawrence B. *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 377-403.

**083143 MOLECULAR ENGINEERING OF ULTRATHIN POLYMERIC FILMS: A SYNOPSIS.** The Proceedings of the National Science Foundation Workshop on the Molecular Engineering of Ultrathin Polymeric Films, published in this issue of Thin Solid Films, are reviewed to assess the current state of the art and future research needs. Based on the discussions at the workshop, a list of research needs in the molecular engineering of ultrathin organic and polymeric films is presented. (Author abstract) 37 refs.

Stroeve, Pieter (Univ of California at Davis, Davis, CA, USA); Franes, Elias. *Thin Solid Films* v 152 n 1-2 Sep 14 1987, Workshop on the Mol Eng of Ultrathin Polym, Davis, CA, USA, Feb 18-20 1987 p 405-410.

**083144 POLYMER FILMS PREPARED BY PLASMA POLYMERIZATION AND THEIR POTENTIAL APPLICATION.** The basic features of plasma

polymerization are described and the main theoretical models briefly discussed. Principal experimental arrangements are taken into account. Physical properties of organosilicon, halocarbon, hydrocarbon and composite (metal-doped) plasma polymer films are concisely reviewed. Proposed applications of these films in optics and electronics are presented. (Author abstract) 116 refs.

Biederman, Hynek (Charles Univ, Prague, Czech). *Vacuum* v 37 n 3-4 1987, Vac 86 - Vac Sci, Technol and Appl, Glasgow, Scotl, Mar 25-27 1986 p 367-373.

**083145 THIN LAYERS OF POLY(F-FLUOROALUMINIUM-PHTHALOCYANINE).** Among the poly(metal-phthalocyanines), (AlPcF)<sub>n</sub> exhibits the property of being easily sublimated and therefore deposited as thin layers on various substrates, which makes its characterization easier. Owing to its ionization potential equal to 4.55 eV, it can be doped by oxidants such as O<sub>2</sub>, I<sub>2</sub>, NO<sub>2</sub> and Cl<sub>2</sub>. We present here the variations of dc conductivity of (AlPcF)<sub>n</sub> layers doped with NO<sub>2</sub> or O<sub>2</sub> as a function of time, temperature, gas concentration and layer thickness: the results are interpreted through Langmuir's theory on gas adsorption and desorption. (Author abstract) 8 refs.

Dugay, M. (Lab d'Electronique, Aubiere, Fr); Maleysson, C. *Synth Met* v 21 n 3 Oct 1987, Proc of the Conf on Electron Processes in Conduct Polym, Part III, Vadstena, Swed, Aug 18-20 1986 p 255-260.

Toxicity See SYNTHETIC FIBERS—Manufacture.

Transport Properties See MEMBRANES—Mathematical Models.

## Ultrafiltration

**083146 METHODS OF INVESTIGATION THE INFLUENCE OF PRESSURE ON THE ULTRAFILTRATION OF POLYVINYLPIRROLIDONE.** The practicability of dialysis has been investigated for polydisperse polymers subjected to membrane ultrafiltration with programming of pressure, taking polyvinylpyrrolidone as an example. It was found that ultrafiltration is an effective method of dialysis in the case of samples for which  $M_w/M_n > 3$ . The dialysis of narrowly disperse samples ( $M_w/M_n < 2$ ) necessitates very careful selection of the conditions of experiments. The extremal character of the effect of pressure on dialyzing properties of the membranes has been detected. (Author abstract) 27 refs.

Sudareva, N.N. (USSR Acad of Sciences, USSR); Nesterov, V.V.; Mal'tsev, V.G.; Boimirzayev, A.S.; Belen'kii, B.G. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1725-1730.

## Vibrations

**083147 NEW METHOD FOR REFINING THE VIBRATIONAL FREQUENCIES AND MODES ON CALCULATION OF THE VIBRATIONAL SPECTRA OF POLYMERS.** Based on the generalized Jacobi rotation method, we propose an effective algorithm for the transition to the first-order approximation of the theory of infrared spectra of polymers. We show that the proposed method is, on the one hand, equivalent to the second-order Rayleigh-Schrodinger perturbation theory for nondegenerate zeroth-order-approximation frequencies, and on the other hand, makes it possible to avoid the difficulties associated with the existence of degeneracies or quasidegeneracies. 3 refs.

Gribov, L.A.; Reitblat, L.I. *J Appl Spectrosc* v 46 n 5 May 1987 p 472-476.

Viscoelasticity See Also COAL—Plasticity; ELASTOMERS—Thermoelectricity; PLASTICS FILMS—Electric Properties; PLASTICS SHEETS—Crack Propagation; POLYBUTADIENES—Viscoelasticity; POLYSTYRENES—Blending; POLYVINYL CHLORIDE—Mechanical Properties; VISCOELASTICITY—Thermodynamics.



**083148 EFFECTS OF CHAIN LENGTH DISTRIBUTION ON VISCOELASTIC PROPERTIES OF ENTANGLED LINEAR POLYMERS: BLENDING LAWS FOR BINARY BLENDS.** The reptation idea of de Gennes and the tube model theory of Doi and Edwards are extended to explain the terminal viscoelastic properties of binary blends in the highly entangled state of two linear monodisperse polymers with different molecular weights  $M_1$  and  $M_2$ . A modified tube model is proposed that considers the significance of the constraint release by local tube renewal in accounting for the relaxation process of the higher molecular weight chain. Its relaxation by both reptation and the constraint release is remodeled as the disengagement by pure reptation of an equivalent primitive chain. Theoretical predictions of the zero-shear viscosity and steady-state shear compliance are shown to be in good agreement with literature data on undiluted polystyrenes and polybutadienes over a wide range of the blend composition and  $M_2/M_1$  ratio. (Edited author abstract) 21 refs.

Hee Young, Kim (Korea Advanced Inst of Science & Technology, Seoul, South Korea); In Jae, Chung. *J Polym Sci Part B* v 25 n 10 Oct 1987 p 2039-2057.

**083149 RELAXATIONAL INTERACTIONS AND VISCOELASTICITY OF POLYMER MELTS: PART II. RHEOLOGICAL PROPERTIES IN SHEAR AND ELONGATIONAL FLOWS.** The rheological equation of state derived in Part I on the basis of relaxation equations of chain dynamics is analyzed for the steady and transient shear and uniaxial elongational flows of monodisperse polymers. The effect of superslow relaxation processes associated with basic macromolecular motions that occur on a characteristic scale essentially greater than the so-called distance between entanglements was investigated in these flows. It is shown that the relaxation times in the region of linear and nonlinear viscoelasticity are self-consistent. Theoretical predictions are in good agreement with the experimental data for melts of nearly monodisperse flexible polymers. (Author abstract) 14 refs.

Volkov, V.S. (USSR Acad of Sciences, Moscow, USSR); Vinogradov, G.V. *J Non Newtonian Fluid Mech* v 25 n 3 Sep 1987 p 261-275.

**083150 VISCOELASTIC PROPERTIES OF (CELLULOSE OLIGO-OXYMETHYLENE ETHER) ACYLATES WITH BULKY SIDE CHAIN.** A series of (cellulose oligo-oxyethylene ether) acylates (COAs) are characterized by the presence of the micro-Brownian motion of the side chain ( $\beta$  process) which appears separately from that of the main chain ( $\alpha$  process). To clarify the effect of the acyl group on these processes, we investigated the dynamic mechanical properties of newly prepared COAs with acyl side chain, bulky in chemical structure (iso-butyrate, pivalate, and benzoate) in relation to those for COAs with linear acyl side chain (acetate, butyrate, and valerate). By substituting bulky acyl isomer for linear acyl group in COAs, we observed that the temperature region of both the  $\alpha$  and  $\beta$  processes moved to higher temperature. Furthermore, with an increase in molecular size of bulky acyl group, the  $\beta$  region shifts were much larger than the  $\alpha$  region, indicating that the mobility of the side chain became comparable to that of the main chain. Finally, when such a large bulky group, for example, benzoate was introduced, the micro-Brownian motion of the side chain prior to that of the main chain ceased. (Edited author abstract) 10 refs.

Morooka, Toshiro (Kyoto Univ, Uji, Jpn); Norimoto, Misato; Yamada, Tadashi; Takuma, Satoshi; Okamura, Keizo. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 717-726.

**083151 VISCOELASTIC BEHAVIOR OF AMORPHOUS POLYMERS NEAR THE GLASS TEMPERATURE.** Lack of thermorheological simplicity and possible effects of the molecular weight distribution in the softening dispersion of linear amorphous polymers are demonstrated with viscoelastic data on polymethylacrylate PMA and polyvinylacetate PVAc. Superposition of the short time portion of the softening transitions of the retardation spectra of PMA, PVAc, polystyrene, and amorphous polypropylene APP indicates that the local

molecular mobility is a constant at  $T_g$  within experimental uncertainty. The general features of the retardation spectra of linear amorphous polymers are discussed. (Author abstract) 36 refs.

Plazek, Donald J. (Univ of Pittsburgh, Pittsburgh, PA, USA); Rosner, Mark J.; Plazek, Daniel L. *J Polym Sci Part B* v 26 n 3 Mar 1988 p 473-489.

**083152 COMPARISON OF GRAPHO-ANALYTICAL AND COMPUTER METHODS OF CALCULATING THE RELAXATIONAL SPECTRA OF POLYMERS.** In the linear theory of viscoelasticity various characteristics can be obtained from the Boltzmann-Volterra equation. There is another approach to describing viscoelastic behavior, consisting essentially in expressing all the viscoelastic functions in terms of one only, i.e. the spectral density of distribution of the relaxational time. Of all the possible approaches to describing viscoelastic behavior, the spectral description allows the most natural physical treatment. Relaxation spectrograms can be obtained from various experimental data, dynamic or static. Mostly data from stress relaxation experiments are used. Relaxational spectrograms obtained by both methods are presented. It can be seen from these data that there is an extremely close correlation between the computer and 'manual' spectrograms in the position and number of the spectral lines. 10 refs.

Bartenev, G.M. (A.A. Zhdanov State Univ, Irkutsk, USSR); Valishin, A.A.; Karasev, M.V. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2913-2916.

**083153 OVERVIEW OF THE VISCOUS AND VISCOELASTIC BEHAVIOR OF IONOMERS IN BULK AND SOLUTION.** The subject of the viscous and viscoelastic behavior of ionomer systems is addressed from a general point of view. The authors consider the glassy state followed with a more complete discussion of the rubbery and viscous flow (melt) states. The viscous and viscoelastic response of ionomer systems when in solution will then be discussed. We have also attempted to compare the so-called 'random copolymer' ionomers to the telechelic systems. Emphasis is given to single component materials in contrast to blends or filled systems. 129 refs.

Tant, Martin R. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Wilkes, Garth L. *J Macromol Sci Rev Macromol Chem Phys* v C28 n 1 Feb 1988 p 1-63.

**083154 NONCOOPERATIVE RELAXATIONS.** Dynamic mechanical studies have revealed a large class of internal motions having activation entropies close to zero which appear to involve well-defined structural units acting in a noncooperative manner. Examples include rotations of methyl groups, certain side-group motions, and local-mode relaxations which are restricted to short polymethylene sequences. Other cases, including grain boundary relaxations in metals, are associated with crystalline phases. (Author abstract) 24 refs.

Starkweather, Howard W. Jr. (DuPont, Wilmington, DE, USA). *Macromolecules* v 21 n 6 Jun 1988 p 1798-1802.

**Viscosity** See Also COPOLYMERS—Microscopic Examination; PLASTICS—Extrusion; POLYPROPYLENE—Structure; POLYSTYRENES—Research; RUBBER, SYNTHETIC—Thermodynamic Properties; VISCOMETERS—Testing.

**083155 CHARACTERISTIC NUMBERS OF POLYMERS IN DILUTE SOLUTION: A UNIVERSAL DESCRIPTION OF THE CROSS-OVER EFFECTS.** The viscosimetric behavior of eleven polymer-solvent systems is analyzed in order to determine the characteristic numbers in the beginning and in the end of the cross-over region. We show that in the beginning and in the end of the cross-over region the characteristic molecular weight or the characteristic number of monomers is different for different polymers and the second is related to the stiffness of the chain. In the contrary, the characteristic number of statistical segments in the beginning and in the end of the cross-over region are about the same for all the polymers, and this result confirms the validity of

a universal description of polymer solutions. (Edited author abstract) 21 refs.

Dondos, A. (Univ of Patras, Patras, Greece). *J Phys (Paris)* v 48 n 9 Sep 1987 p 1439-1443.

**083156 ON THE TEMPERATURE-COMPOSITION SUPERPOSITION OF VISCOSITY IN POLYBLEND MELTS BASED ON THE SHEAR RATES.** Using the Vinogradov-Malkin coordinates it was found that temperature and concentration reductions (based on shear rates) of viscosity are obtainable for polyblend melts. If the components of a polyblend are similar as to their mode of flow, invariance is observed over the entire range of composition. Where there is a marked difference in the degrees of viscosity anomaly, invariance is observed for the dispersion medium whose melt is characterized by a larger viscosity anomaly and by higher elasticity. It appears from the experimental results that, despite changes occurring in the structure of the melt for a mixture of incompatible polymers during flow, steady conditions of flow appear in a capillary. (Author abstract) 20 refs.

Tsebranko, M.V. (Inst of Technology for Light Industry, Kiev, USSR). *Polym Sci USSR* v 28 n 6 1986 p 1272-1279.

**083157 LONGITUDINAL VOLUME VISCOSITY OF POLY(ETHYLENE OXIDE).** The volume flow of poly(ethylene oxide) (PEO) ( $M_n=228,000$  and  $T_m=349$  K) has been measured in an Instron Capillary Rheometer. The elastic modulus of the longitudinal wave, longitudinal volume viscosity, initial longitudinal volume viscosity, and retardation times are described at temperatures of 353-412 K, and compression rates of about  $1.2 \times 10^{-5} \text{ s}^{-1}$ . (Author abstract) 12 refs.

Aleman, J.V. (Inst de Plasticos y Caucho, Madrid, Spain). *J Non Newtonian Fluid Mech* v 25 n 3 Sep 1987 p 365-383.

**083158 ANOMALOUS TEMPERATURE DEPENDENCE OF VISCOSITY OF THERMOTROPIC POLYESTERS.** This paper is concerned with the temperature dependence of viscosity of liquid crystalline polymers. Certain compositions were observed to exhibit a positive temperature coefficient of viscosity (viscosity increasing with shear rate) over the entire shear rate range. Other compositions showed flow curves which intersected at critical shear rates. This behavior is explained by a variation in chain stiffness with composition (high hydroxybenzoic acid content resulting in stiffer chains) which results in a biphasic melt. The unusual rheological behavior is a manifestation of the competition between isotropic and anisotropic phases, which is influenced by composition, temperature, and shear. 13 refs.

Kiss, Gabor (Celanese Corp, Summit, NJ, USA). *J Rheol* v 30 n 3 Jun 1986 p 585-599.

**083159 STABILITY OF THE INTERFACE BETWEEN TWO DYNAMIC PHASES IN CAPILLARY FLOW OF LINEAR POLYMER MELTS.** Results of previous work on a theoretical explanation of the 'spurt effect' in polymer melt flow are extended. A modified Doi-Edwards liquid is shown to support axisymmetric traveling waves on an interface between high and low shear-rate phases in capillary flow. The stability of these perturbations is found to be governed by normal stress effects and may be related to certain types of melt fracture. Observed effects of varying the capillary length are explained qualitatively. (Author abstract) 10 refs.

McLeish, T.C.B. (Cavendish Lab, Cambridge, Engl). *J Polym Sci Part B* v 25 n 11 Nov 1987 p 2253-2264.

**083160 VISCOMETRIC ESTIMATION OF UNPERTURBED CHAIN DIMENSIONS OF POLYMERS.** A new expression is proposed to determine the unperturbed dimensions of coil-like polymers viscometrically by use of the P.J. Flory and O. Kratky expression. The unperturbed dimensions so estimated are compared



with the results obtained by using different expressions available in the literature. The results are comparable even for stiff chain polymers. The data obtained under theta conditions also fit this expression very well. The effect of molecular weight, its distribution, and that of the solvent has also been studied. (Edited author abstract) 27 refs.

Ahmad, Noor (Univ of Peshawar, Peshawar, Pak); Baloch, Musa Kaleem. *J Macromol Sci Chem* v A24 n 10 Oct 1987 p 1241-1261.

**083161 TRANSPORT COEFFICIENTS OF HELICAL WORMLIKE CHAINS. 4. INTRINSIC VISCOSITY OF THE TOUCHED-BEAD MODEL.** The intrinsic viscosity of the helical wormlike touched-bead model without excluded volume is evaluated by taking into account the effect of the finite volume of the bead. An empirical interpolation formula for it is presented. This formula is useful for an analysis of experimental data for flexible chains, if the data for low molecular weights are included. Some salient aspects of the behavior of the intrinsic viscosity over a wide range of molecular weight (or contour length) are discussed on the basis of the numerical results. In particular, it is found that the slope of the double-logarithmic plot of the intrinsic viscosity against the molecular weight becomes smaller than  $\frac{1}{2}$  as the helical nature becomes strong. (Edited author abstract) 25 refs.

Yoshizaki, Takenao (Kyoto Univ, Kyoto, Jpn); Nitta, Itaru; Yamakawa, Hiromi. *Macromolecules* v 21 n 1 Jan 1988 p 165-171.

**083162 COMPENSATION EFFECTS IN VISCOSITY-TEMPERATURE DEPENDENCE OF POLYMER MELTS.** The thermal dependence of the parameters of the Carreau A model of viscosity has been investigated for 13 polymeric resins. It was shown that the zero-shear viscosity and the time constant obey an Arrhenius-type law and that, for these parameters, compensation effects are exhibited. The shear-thinning index was found to be fairly independent of temperature. An important consequence of a compensation effect is that only one determination of a parameter at a given temperature gives the complete temperature-dependence of this parameter. (Author abstract) 18 refs.

Tanguy, P.A. (Univ Laval, Quebec, Can); Choplin, L.; Hurez, P. *Polym Eng Sci* v 28 n 8 Apr 1988 p 529-533.

**083163 SYNTHESIS AND PROPERTIES OF ARAMIDS AND POLYARYLATES HAVING PERFLUORO-SUBSTITUENTS ON THE BENZENE RING.** A new series of 16 aramids and 16 polyarylates having perfluoro-substituents on the benzene ring was prepared by a low temperature solution or an interfacial polycondensation. The effects of fluorine substituents on the structure and properties of polymers were examined. Fluorinated aramids exhibited higher crystallinity, while fluorinated polyarylates showed lower crystallinity. The melting point ( $T_m$ ) of aramids decreased with fluorine substitution, whereas  $T_m$  of polyarylates from fluorinated aromatic diols was higher than that of those from unfluorinated ones. The temperature of 10% weight loss and the residue at 900°C decreased with fluorine substitution except for the aramids from fluorinated diamines. (Edited author abstract). 12 Refs.

Kiyotsukuri, Tsuyoshi (Kyoto Inst of Technology, Sakyo-ku, Jpn); Tsutsumi, Naoto; Okada, Kazuya; Asai, Kunihiko; Nagata, Minoru. *J Polym Sci Part A* v 26 n 8 Aug 5 1988 p 2225-2234.

**Vulcanization** See ELASTOMERS—Structure.

**Waste Disposal** See POLYACRYLATES—Waste Disposal.

**Waste Utilization** See Also ASPHALT—Additives; POLYTETRAFLUOROETHYLENE—Pyrolysis.

**083164 RECYCLING OF POLYMER WASTE: PART 1 - PHOTO-OXIDIZED POLYPROPYLENE.** In order to recycle photo-oxidized polypropylene, blends of this polymer waste with virgin polypropylene have been

prepared with different compositions. Both rheological and mechanical properties depend on composition. Rheological properties indicate some interactions between the two polymers at low shear rates. On the other hand, at high shear rates there is evidence of incompatibility. The nominal tensile strength is almost independent of the composition, while the other mechanical properties are similar to those of the degraded material up to a virgin PP content of about 75%, after which they quickly reach the values for the virgin polypropylene. These features are correlated with the large spherulite size of these blends. (Author abstract) 14 refs.

Valenza, A. (Univ of Palermo, Palermo, Italy); La Mantia, F.P. *Polym Degradation Stab* v 19 n 2 1987 p 135-145.

**Wear** See Also LUBRICANTS—Additives.

**083165 WEAR OF POLYMER COMPOSITE MATERIALS IN CORROSIVE-ABRASIVE MEDIA.** We examine the friction and wear of modified polyamide-6 and ED-20 epoxy resin in assemblies operating under the action of the aggressive and abrasive media used in agricultural production. As a result of these studies it is found that the corrosive-abrasive medium consisting of mineral fertilizers has the greatest influence on the wear of the polymer composite materials. The nature of the wear of the materials is determined by the nature and content of the disperse and fibrous fillers and by the composition of the corrosive-abrasive medium. It is established that the introduction of modifying additives reduces the influence of the aggressive media on the magnitude of the wear of the polymer materials. (Author abstract) 11 refs.

Kononovich, I.N.; Miroevskii, M.A.; Oleshkevich, E.P.; Poluyanovich, V.Ya. *Sov J Frict Wear* v 8 n 3 1987 p 47-52.

**083166 STUDY OF THERMOPLASTIC POLYMER COATING IMPACT WEAR.** We study the nature of the variation of the adhesion and strength properties and wear of thermoplastic polymer coatings on metals, and also the nature of damage of the protective polymer layer in the case of impactive mechanical loading. It is shown that under these test conditions the service life of metal-polymer bonds is determined by the adhesive-cohesive resistance of the coatings to fatigue wear, and the contribution of each component to the loss of effectiveness of the bonds may differ, depending on the polymer coating wear resistance. (Author abstract) 8 refs.

Usovich, Yu.A. *Sov J Frict Wear* v 8 n 4 1987 p 136-139.

**083167 DEVICE FOR PRECISION MEASUREMENT OF POLYMER MATERIAL WEAR.** We describe a device that makes it possible to automatically exclude in the test process, from wear sensor indications, the systematic errors caused by test machine shaft runout and specimen thermal deformation. The smallest measurable wear magnitude is 0.05-0.1  $\mu\text{m}$ . (Author abstract) 5 refs.

Kirpichenko, Yu.E.; Nevzorov, V.V.; Kotov, V.L.; Pinchuk, L.A. *Sov J Frict Wear* v 8 n 5 1987 p 120-121.

**X-Ray Analysis** See Also COPOLYMERS—Molecular Structure; GELS—Molecular Structure; IONOMERS—Microstructure; POLYAMIDES—High Temperature Effects; POLYETHYLENES—Deformation; POLYETHYLENES—Structure; POLYPROPYLENE—Crazing.

**083168 LARGE-ANGLE X-RAY SCATTERING STUDY OF TWO AMORPHOUS INORGANIC POLYMERS, Ru(SPH)<sub>2</sub> AND Mo(SPH)<sub>2</sub>.** We present a structural model for the amorphous polymers Mo(SPH)<sub>2</sub> and Ru(SPH)<sub>2</sub> obtained from LAXS experiments and relate this model to some observed physical properties. The best description of both polymers is obtained on the basis of alternating long and short metal-metal distances leading to a distortion of the octahedral geometry around the metal atoms. Using an undistorted model with equal M-S and M-M distances, it was not possible to obtain a correct broadness of the first peak, which represents the superposition of the first three coordination spheres around the metal: two sets of each three M-S bonds and

one M-M interaction. 18 refs.

Vogt, Thomas (Inst fuer Anorganische Chemie, Tuebingen, West Ger); Straehle, Joachim; Mosset, Alain; Galy, Jean. *CHEMTECH* v 17 n 8 Aug 1987 p 577-581.

**083169 STRUCTURE OF THE CRYSTALLINE COMPLEX BETWEEN POLY-( $\gamma$ -METHYL L-GLUTAMATE) AND CHLOROFORM.** The crystal structure of the complex between poly( $\gamma$ -methyl L-glutamate) (PMLG) and chloroform was studied by X-ray diffraction method. The PMLG main chain takes the right-handed  $\alpha$ -helical conformation, which is identical with that of the dry form. The unit cell of the complex is hexagonal with lattice dimensions  $a = 12.75$  Angstrom and  $c$  (fiber axis) = 26.9 Angstrom, and contains eighteen amino-acid residues and about three molecules of chloroform. The complex assumes a statistically disordered structure, where up and down helices are distributed randomly among the lattice sites, and molecules of chloroform locate favorably between antiparallel helices. The side-chain conformation is rather contracted. (Author abstract) 18 refs.

Sasaki, Shintaro (Tokyo Inst of Technology, Tokyo, Jpn); Takigawa, Shigeki. *Polym J* v 19 n 9 1987 p 1081-1090.

**083170 DYNAMIC SMALL-ANGLE SCATTERING SYSTEM FOR THE STUDY OF MATERIALS DEFORMATION AND RELAXATION.** A dynamic small-angle X-ray scattering system (DSAXS) for the study of materials deformation and relaxation has been developed. The principles of DSAXS are outlined, including experimental procedures such as  $\pi$ -sector and Fourier expansion techniques. A few important functions required for studies of crystalline polymers, namely, static and dynamic lamellar orientation, dynamic lamellar separation, dynamic invariant function, etc., are defined. The hardware and software of the DSAXS system are described. Some preliminary results obtained for a spherulitic high-density polyethylene by  $\pi$ -sector technique and for a row-nucleated polybutene-1 by Fourier expansion techniques are demonstrated to evaluate the performance of the system. (Edited author abstract) 27 refs.

Suehiro, Shoji (Natl Cent for Small-Angle Scattering Research, Oak Ridge, CA, USA); Hendricks, Robert W.; Lin, J.S.; Kyu, Thein; Young, Ping; Stein, Richard S. *J Polym Sci Part B* v 26 n 4 Apr 1988 p 745-770.

**083171 CHANGE IN THE PHASE STRUCTURE OF POLYBLOCK NETWORKS BASED ON THE EPOXIDE AND DIENE COMPONENTS WITH VARIATION IN COMPOSITION.** The small angle X-ray method has been used to study the dependence of the microphase structure of polyblock networks based on the epoxide and diene components on the composition of the initial reacting mixture. It is shown that variation in the composition of the initial system leads to change in the dimensional characteristics and degree of segregation of the components of the polyblock network and transition from a quasi-cylindrical microphase structure characteristic of a polymer of equimolar composition to quasilamellar for a two-fold excess of the epoxide over the hydrazide groups. (Author abstract) 14 refs.

Shilov, V.V. (UkrSSR Acad of Sciences, USSR); Oranskaya, Ye.I.; Gomza, Yu.P.; Kochetov, D.P.; Lipatov, Yu.S. *Polym Sci USSR* v 29 n 1 Jan 1988 p 49-55.

**083172 MICROFIBRILLAR NETWORK OF A RIGID ROD POLYMER. 2. SMALL-ANGLE X-RAY SCATTERING.** The network of oriented microfibrils, which is formed in the coagulation stage of the spinning process of poly[p-phenylene(benzol[1,2-d;4,5-d']bis-thiazole-2,6-diyl)] (PBT) fibers and films, is characterized by small-angle X-ray scattering (SAXS) measurements. PBT films, processed by uniaxial extrusion and coagulation in water, are impregnated with an epoxy resin. SAXS measurements are performed by using a slit-collimated incident beam. The scattering pattern obtained reflects the structure in a cross-section plane perpendicular to the



extrusion direction. The theoretical framework for the analysis of such patterns in terms of the scattering from two-dimensional structures is outlined. (Edited author abstract) 26 refs.

Cohen, Yachin (Univ of Massachusetts, Amherst, MA, USA); Thomas, Edwin L. *Macromolecules* v 21 n 2 Feb 1988 p 436-441.

**083173 ANALYTICAL FORM OF THE ELECTRON DIFFRACTION SCATTERING FACTORS FOR COMMON ATOMS.** An increasing amount of structural work is being performed on crystalline polymers utilizing electron diffraction techniques. Because the data are typically sparse, computer programs such as the linked atom least squares (LALS) refinement procedure have been used which make certain assumptions and restraints in the chemical structure. The scattering factors for X-rays are entered into the computer by means of an analytical expression. This letter reports the coefficients of the expression for the diffraction of electrons for those atoms which LALS routinely handles, namely hydrogen, carbon, nitrogen, oxygen, phosphorus and sulphur. 7 refs.

Grasso, Robert P. (Case Western Reserve Univ, Cleveland, OH, USA); Lando, Jerome B. *J Mater Sci Lett* v 7 n 5 May 1988 p 495-496.

**083174 EVIDENCE BY X-RAY SCATTERING OF DEFECTS IN THE LAMELLAR STACKING OF THE  $S_{m,A}$  PHASE OF A SIDE-CHAIN POLYMER.** An X-ray diffraction pattern in the  $S_{m,A}$  phase of a mesomorphic side chain polymethacrylate displays some unusual diffuse lines in addition to the elements already described. We account for these lines by introducing some defects which disturb the lamellar order. Such defects may be the places where the polymer main chain hops from one layer to an adjacent one. (Author abstract) 7 refs.

Davidson, P. (CNRS, Orsay, Fr); Levet, A.M. *J Phys (Paris)* v 49 n 4 Apr 1988 P 689-695.

**083175 CORRELATION OF CHEMICAL STRUCTURE AND ELECTRICAL CONDUCTIVITY IN POLYPYRROLE FILMS BY X-RAY PHOTOELECTRON SPECTROSCOPY.** X-ray photoelectron spectroscopy was used to track chemical structure changes in conducting polypyrrole films which were electrochemically grown at various current densities. The film structures were correlated to changes in the film electrical conductivities. High resolution spectra of the C 1s, N 1s and O 1s regions were recorded. Concentrations of the charge compensating counter-ions used in the growth of the film were also monitored and correlated to electrical performance. Results indicated that the films grown at low current densities contained hydroxide anions and deprotonated nitrogen species, while films grown at high current densities contained no hydroxide ions or deprotonated nitrogens and exhibited higher charge removal from the pyrrole ring. At medium current densities, the amount of incorporated dopant anion was maximized. (Author abstract) 27 refs.

Zeller, M.V. (Univ of Notre Dame, Notre Dame, IN, USA); Hahn, S.J. *Surf Interface Anal* v 11 n 6 Apr 1988, Proc of the 9th Symp on Appl Surf Anal, Dayton, OH, USA, Jun 3-5 1987 p 327-334.

**POLYMETHYL METHACRYLATE** See Also ACRYLIC MONOMERS—Polymerization; ACRYLICS—Radiation Effects; BIOMEDICAL ENGINEERING—Orthopedics; BLOCK COPOLYMERS—Synthesis; GLYCOLS—Polymerization; INTERPENETRATING POLYMER NETWORKS—Mechanical Properties; PHOTORESISTS; PLASMAS—Physical Properties; POLYMERIZATION—Reaction Kinetics; POLYMERS—Blending; POLYMERS—Mixing; POLYMERS—Synthesis; POWDER METALLURGY—Sintering; PROSTHETICS—Joint Prostheses.

**083176  $^{13}\text{C}$  NMR METHOD OF INVESTIGATION IN THE STEREOCHEMICAL STRUCTURE OF METHYL METHACRYLATE BY RADIATION-INDUCED POLYMERIZATION.** This paper reports a study of a polymer sequence, and the striking changes with stereochemical configuration in polymethyl methac-

rylate (PMMA) by radiation-induced polymerization. The polymer structure was investigated by means of  $^{13}\text{C}$  NMR spectroscopy. The spectrum reveals seven separate resonance lines, which can be assigned to the ten possible pentads. Comparison of the observed and calculated intensities of the assigned resonances indicated that the Bernoulli statistics describe the radiation-induced polymerization mechanism of the PMMA sample under study. The experimental results show the radiation induced dose and the probabilities of isotactic, syndiotactic and heterotactic triads are a function of  $P_m$ , respectively. The preference of the propagation or degradation for the syndiotactic in PMMA can be found due to the activation enthalpy and dependence of radiation dose. The authors have estimated the N-ads distinction equation, and by using this distinction equation satisfactory results have been obtained. (Edited author abstract) 9 refs.

Zhang Zhi-Ping (Li-Min Research Inst of Chemical Industry, Henan, China); Shi He-Ping; Wu Yi-Ming. *Radiat Phys Chem* v 30 n 4 1987 p 303-306.

**083177 ASSIGNED COTACTIC PARAMETERS IN THE RADICAL COPOLYMERIZATION OF METHYL METHACRYLATE WITH VARIOUS METHACRYLATES.** Copolymers of totally deuterated methyl methacrylate with a small amount of various methacrylates were radically prepared in toluene and, if necessary, converted into the copolymer of MMA- $d_8$  with MMA. The assigned coisotactic parameters,  $\rho_{12}$  and  $\rho_{21}$ , were determined from their  $^1\text{H}$  NMR spectra. The values for the copolymerizations with triarylmethyl methacrylates ( $M_2$ ) such as triphenylmethyl, diphenyl-2-pyridylmethyl or phenyl-2-pyridyl-0-tolylmethyl methacrylates, were unequivocally different from each other. The results indicated that the addition of  $M_2$  to MMA radical end favored syndiotactic placement while the addition of MMA to  $M_2$  end occurred preferentially in isotactic way. The cause of this peculiar stereoregulation in radical polymerization was discussed in detail. (Author abstract) 27 refs.

Hatada, Koichi (Osaka Univ, Toyonaka, Jpn); Kitayama, Tatsuki; Ochi, Takatoshi; Yuki, Heimei. *Polym J* v 19 n 9 1987 p 1105-1113.

**083178 ANALYSIS OF THE DISTRIBUTION OF MOLECULAR MOTION WITH RESPECT TO RELAXATION TIMES IN POLYMERS ON THE BASIS OF THERMOSTIMULATION OF DEPOLARIZATION.** A method is proposed for the transformation of thermostimulated depolarization curves into distributions, with respect to relaxation times, of molecular motion in polymers. The width and form of the distribution for  $\alpha$ - and  $\beta$ -relaxation processes in PMMA are analyzed. It is shown that the method proposed for treating TSD curves can be applied successfully to obtaining distribution functions with respect to relaxation times for molecular motion in polymers. (Edited author abstract) 14 refs.

Mansimov, S.A. (USSR Acad of Sciences, USSR); Kerimov, M.K.; Gezalov, Kh.B.; Kovarskii, A.L. *Polym Sci USSR* v 28 n 9 1986 p 2221-2226.

**083179 PREPARATION OF MICRON-SIZE POLYMER PARTICLES IN NONPOLAR MEDIA.** The dispersion polymerization of methyl methacrylate has been investigated using mixtures of carbon tetrachloride and 2,2,4-trimethylpentane as the dispersion medium and polyisobutylene as the steric stabilizer. It was found that as the concentration of carbon tetrachloride in the dispersion medium increased, the particle size increased with monodisperse particles of up to 13  $\mu\text{m}$  in diameter being produced. However, the molecular weight of the resulting polymer particles and polymerization kinetics decreased with increasing carbon tetrachloride concentration. It is suggested that the locus of the particle polymerization changes as the solvency of the dispersion medium for the resulting polymer is varied with a concomitant change in the size of the final particle. (Author abstract) 9 refs.

Williamson, B. (Univ of Toronto, Toronto, Ont, Can);

Lukas, R.; Winnik, M.A.; Croucher, M.D. *J Colloid Interface Sci* v 119 n 2 Oct 1987 p 559-564.

**083180 GRAFTING ONTO CHITOSAN. I. GRAFT COPOLYMERIZATION OF METHYL METHACRYLATE ONTO CHITOSAN WITH FENTON'S REAGENT ( $\text{Fe}^{2+}-\text{H}_2\text{O}_2$ ) AS A REDOX INITIATOR.** Poly(methyl methacrylate) has been grafted onto chitosan by using Fenton's reagent as a redox initiator in an aqueous medium. Initiation by Fenton's reagent was carried out in the presence of atmospheric oxygen. The percentages of grafting, efficiency, and homopolymer were found to depend on chitosan (RchitOH), ferrous ammonium sulfate (FAS), hydrogen peroxide, monomer (MMA) concentrations, reaction temperature, and reaction time. (Author abstract) 23 refs.

Lagos, A. (Univ de Chile, Santiago, Chile); Reyes, J. *J Polym Sci Part A* v 26 n 4 Apr 1988 p 985-991.

**Ablation** See Also POLYSTYRENES—Ablation.

**083181 FEMTOSECOND UV EXCIMER LASER ABLATION.** Experiments on the ablation of polymethylmethacrylate (PMMA) with 300 fs uv excimer laser pulses at 248 nm are reported for the first time. With these ultrashort pulses, ablation can be done at fluences up to five times lower than the threshold fluence for 16 ns ablation of PMMA, and the surface morphology is improved, also for several other materials. A model for ablation is proposed, assuming a non-constant absorption coefficient  $\alpha_{\text{eff}}$  depending on the degree of incubation of the irradiated material and the intensity of the incoming excimer laser pulse. The agreement between our model and our experimental observations is excellent for 16 ns excimer laser pulses, also predicting perfectly the shape of a pulse transmitted through a thin PMMA sample under high fluence irradiation. Qualitative agreement for 300 fs excimer laser pulses is obtained so far. (Author abstract) 16 refs.

Kueper, S. (Max-Planck-Inst, Goettingen, West Ger); Stuke, M. *Appl Phys B* v B44 n 4 Dec 1987 p 199-204.

**083182 ULTRAVIOLET LASER ABLATION AND ETCHING OF POLYMETHYL METHACRYLATE SENSITIZED WITH AN ORGANIC DOPANT.** Although polymethyl methacrylate (PMMA) is essentially transparent to light to 308 or 351 nm, it can be made sensitive to photoablation and etching by excimer laser pulses (20 ns half-width) of those wavelengths by the introduction of an organic dopant. The dopant (trade name= Tinuvin) is actually a quencher of the first electronic excited state of PMMA and is therefore used commercially to stabilize the polymer against photodegradation. Laser etching of Tinuvin-doped PMMA can be shown to be a photochemical process in which the Tinuvin decomposes by the absorption of two or more photons and causes the ablation of the surrounding polymer. (Author abstract) 11 refs.

Srinivasan, R. (IBM, Yorktown Heights, NY, USA); Braren, B. *Appl Phys A* v A45 n 4 Apr 1988 p 289-292.

**Additives** See COMPOSITE MATERIALS—Mechanical Properties.

**Adhesion**

**083183 KINETICS OF ADHESION DEVELOPMENT AT PMMA-SAN INTERFACES.** The kinetics of adhesion development at interfaces between poly(methyl methacrylate) (PMMA) and styrene/acrylonitrile (SAN) copolymers of varying AN levels have been studied at 130°C by measuring the tensile fracture strength of a butt joint configuration. For miscible pairs, SANs containing about 9.5 to 33% AN, the principal mechanism of adhesion development involves interdiffusion of PMMA and SAN chains with the joint strength growing in proportion to  $\tau^{1/4}$  (where  $\tau$ = time the joint is at 130°C) as predicted by theory. The interdiffusion rate is greatest near 14.7% AN, where the interaction with PMMA is maximum as demonstrated by recent studies of phase behaviour for PMMA-SAN blends. This optimum rate of



adhesion development is consistent with a stronger thermodynamic driving force for diffusion. (Edited author abstract) 41 refs.

Fowler, M.E. (Univ of Texas, Austin, TX, USA); Barlow, J.W.; Paul, D.R. *Polymer* v 28 n 12 Nov 1987 p 2145-2150.

## Adsorption

**083184 KINETICS OF POLYMER ADSORPTION MEASURED IN SITU AT THE SOLID-LIQUID INTERFACE: UTILITY OF THE INFRARED TOTAL INTERNAL REFLECTION METHOD.** The method of infrared spectroscopy in attenuated total reflection (IR-ATR) has been used to study kinetics of polymethylmethacrylate (PMMA) adsorption from dilute carbon tetrachloride solution onto a germanium prism at 27.0°C. By using a combination of deuterated and protio PMMA, it was possible to monitor the initial buildup of the adsorbed layer of one polymer species, followed by the time-dependent displacement of this species when the ambient polymer solution was changed. Data are presented for the displacement of adsorbed deuterated polymer of molar mass 57,000 g by protio polymer of molar mass 400,000 g, and for the displacement of adsorbed protio polymer of molar mass 64,000 g by deuterated polymer of molar mass 57,000 g. (Edited author abstract) 13 refs.

Kuzmenka, Daniel J. (Univ of Illinois, Urbana, IL, USA); Granick, Steve. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 105-116.

## Aging

**083185 EFFECT OF SORBED PENETRANTS ON THE AGING OF PREVIOUSLY DILATED GLASSY POLYMER POWDERS. PART III: THE EFFECT OF EXPOSURE TO LOWER ALCOHOLS ON ENTHALPY RELAXATIONS IN POLY(METHYL METHACRYLATE).** Enthalpy relaxations in glassy poly(methylmethacrylate) have been studied through the endothermic, sub- $T_g$ , aging peak observed in differential scanning calorimetry (DSC) thermograms. Powder samples were swollen by exposure to high activity methanol vapor and then aged in vacuum and in the presence of low activities of methanol, ethanol, and n-propanol at 308 K. The position and size of the DSC aging peak, which developed during aging, were monitored as a function of aging time. The aging peaks which developed for the alcohol-aged samples were smaller than those observed for similar samples aged in vacuum. These results suggest that the presence of dissolved penetrant in the samples retarded or arrested the relaxations which were observed in otherwise identical experiments performed in vacuo. (Edited author abstract) 30 refs.

Stewart, M.E. (North Carolina State Univ, Raleigh, NC, USA); Sorrells, D.L.; McCoy, N.R.; Koros, W.J.; Hopfenberg, H.B. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2493-2505.

## Analysis

**083186 DETECTION OF ACTIVE RADICALS FORMED DURING THE SONOLYSIS OF POLYMERS.** Active radicals formed during the sonolysis of PVK (polyvinyl carbazole) and PMMA (polymethyl methacrylate) have been studied with the combination of spin trapping technique and ESR spectroscopy. The results are presented. 15 refs.

Liu, Yang (Acad Sinica, Beijing, China); Chen, Jianxin; Xu, Guangzhi; Guo, Jinliang. *Chin J Polym Sci (Engl Ed)* v 4 n 4 Feb 1987 p 377-380.

**Applications** See AUTOMOBILES—Electric; OPTICAL FIBERS—Structure; WAVEGUIDES, OPTICAL—Plastics Applications.

**Blending** See Also FLUORINE CONTAINING POLYMERS—Crystallization; POLYCARBONATES—Blending; POLYMERS—Blending; POLYVINYL CHLORIDE—Blending.

**083187 LOW FREQUENCY DIELECTRIC RELAXATION STUDY IN PMMA/PS BLENDS.** The dielectric behaviour of solution-grown films of poly (methyl methacrylate) (PMMA)-polystyrene (PS) blends has been studied as a function of frequency and temperature. The obtained results show that the  $\beta$ -process observed in the PMMA/PS system is associated with the PMMA fraction in the blend. From the dielectric results we found that the local conformational states of the PMMA chain are perturbed by blending with a PS content higher than 9-13%, as a results of the incompatibility of this system. (Author abstract) 22 refs.

Balda, R. (Univ del Pais Vasco, Bilbao, Spain); Perez Jubindo, M.A.; de la Fuente, M.R.; Katime, I. *Mater Chem Phys* v 18 n 4 Dec 1987 p 359-373.

**083188 COMPATIBILITY AND LCST BEHAVIOR IN POLY(VINYLDENE FLUORIDE-CO-HEXAFLUOROACETONE)/POLY(METHYL METHACRYLATE) BLENDS.** Compatibility in poly(vinylidene fluoride-co-hexafluoroacetone) [P(VDF-HFA)]/poly(methyl methacrylate) (PMMA) blends was investigated experimentally. Glass transition temperature and refractive index of blends depend on the volume fraction. Lower critical solution temperature (LCST) type phase diagrams were obtained from transmittance-temperature measurements. Transmittance changes of the critical concentration blends were one step decreasing by spinodal decomposition; the changes for other blends were two step decreasing, by binodal and spinodal decompositions. LCST's were 245°C and 233°C when the molecular weight of PMMA was  $4 \times 10^4$  and  $12 \times 10^4$ , respectively. The LCST was about 330°C in PVDF/PMMA system, but it was found that copolymerization of HFA with VDF caused the LCST to shift to lower temperature. (Author abstract) 24 refs. In Japanese.

Kobayashi, Satoru (Tokyo Univ of Agriculture and Technology, Koganei, Jpn); Tasaka, Shigeru; Miyata, Seizo. *Kobunshi Ronbunshu* v 44 n 9 Sep 1987 p 695-699.

**083189 NMR STUDY ON THE COMPATIBILITY OF ACR / PVC BLENDS.** A 300MHz solid NMR study on the compatibility of ACR(poly(methyl methacrylate-co-methacrylate), in the ratio of 1:1)-PVC (poly(vinyl chloride)) blends is reported. Spin-lattice ( $T_1$ ) and spin-spin ( $T_2$ ) relaxation time of ACR, PVC and their blends are recorded in the temperature range from 215K to 355K. Experimental results indicate that ACR and PVC are compatible with each other and that the domain size is smaller than 25 nm, but that heterogeneities of molecular dimensions still exist. Some problems of mechanism of compatibility and data analysis are also discussed. (Edited author abstract). 8 Refs.

Zhang, Xiaoping (East China Normal Univ, China); Qiu, Lingshi; Wang, Dongsheng; Wang, Yuanshen. *Chin J Polym Sci (Engl Ed)* v 6 n 2 1988 p 159-164.

## Chemistry

**083190 STRUCTURAL STUDY BY  $^1\text{H}$  NMR OF THE FIRST ADDUCTS OF THE TELOMERIZATION OF METHYLMETHACRYLATE WITH THIOPHENOL.** The stereoselectivity of the different steps (addition step and transfer step) of the radical telomerization of methylmethacrylate with thiophenol has been determined by preparing and analyzing the first adducts by  $^1\text{H}$  NMR analysis. (Edited author abstract) 14 refs.

Bessiere, Jean-Marie (CNRS, Montpellier, Fr); Boutevin, Bernard; Sarraf, Lena. *Polym Bull (Berlin)* v 18 n 3 Sep 1987 p 253-257.

**Combustion** See FIRE PROTECTION—Research.

## Copolymerization

**083191 QUANTUM-CHEMICAL CALCULATIONS OF THE REACTION OF ISOCYANATES WITH COMPOUNDS, CONTAINING A POLARIZED C=C BOND.** The reaction of reagents with  $=\text{N}=\text{C}=\text{O}$  and  $>\text{C}=\text{C}<$  polarized bonds was examined on the methyl isocyanate-methyl methacrylate model system. Calculations were carried out by the semiempirical CNDO/2 method with optimization of geometrical parameters of molecules. Reasons for the impossibility of occurrence of the copolymerization process between methyl isocyanate and methyl methacrylate in the absence of active centers were shown on the basis of results of calculation of their stable conformers. The electronic structure of compounds of electron-donor nature (nitrogen-containing organic bases) was examined, and their catalytic activity in the copolymerization reaction of methyl isocyanate and methyl methacrylate was discussed. (Author abstract) 16 refs.

Nizel'skii, Yu.N.; Kozak, N.V.; Lipatova, T.E. *Sov Prog Chem* v 53 n 7 1987 p 110-114.

**Crack Propagation** See Also MATERIALS TESTING—Fatigue.

**083192 APPLICATION OF THE CRACK LAYER THEORY OF FATIGUE CRACK PROPAGATION IN PMMA.** The crack layer theory has been well established as a good description of the energy dependence of fatigue crack propagation in thermoplastics associated with multiple crazes or large deformation preceding the crack tip. Since PMMA usually displays crack propagation preceded by a single craze, the applicability of the theory in such extreme cases needs to be tested. Fatigue crack propagation data obtained in a previous interferometric investigation in PMMA have been utilized here. Two different approaches are attempted for estimation of the energy dissipated in craze formation and growth. (Edited author abstract) 25 refs.

Koenczool, L. (Case Western Reserve Univ, Cleveland, OH, USA); Sehanobish, K. *J Macromol Sci Phys* v B26 n 3 Sep 1987 p 307-323.

**083193 CRACK PROPAGATION UNDER MODE II LOADING: AN EFFECTIVE STRESS INTENSITY FACTOR METHOD.** The prediction of crack propagation in brittle materials under mixed mode and particularly mode II loading requires the knowledge of the direction of crack propagation and the load that will initiate such propagation. In this paper, the maximum tensile tangential stress criterion is used to define an effective stress intensity factor. This method is applied to the Richard mode II specimen made of PMMA and a good agreement is obtained between the predicted and experimentally measured failure loads. The method presents the advantage that crack propagation can be predicted even in mixed mode by using only one material parameter. (Edited author abstract) 15 refs.

Kokini, Klod (Purdue Univ, West Lafayette, IN, USA); Maragoni, Roy D.; Dorogy, George M.; Ezzat, Hesham A. *Eng Fract Mech* v 28 n 1 1987 p 93-100.

**083194 FRACTURE OF RADIALLY EDGE-CRACKED DISCS.** The brittle fracture of thin radially edge-cracked disks has been studied in three loading situations: edge opening, pin loading and diametral compression. Theoretical equations for these configurations are given and compared critically with experimental test on polymethyl-methacrylate samples. The edge-opening geometry was the best test overall, though all three systems were advantages when compared with other common toughness tests because of their exact theory, simple sample preparation, facile machining, easy pre-cracking, straight-forward loading and low propagation forces. (Author abstract) 17 refs.

Kendall, K. (ICI, Runcorn, England); Gregory, R.D. *J Mater Sci* v 22 n 12 Dec 1987 p 4514-4517.



**083195 DEFORMATION AND STRESS ANALYSIS OF THE CRAZE AT THE FATIGUE CRACK TIP IN POLYMETHYLMETHACRYLATE.** Deformation of the craze during fatigue cycling was measured continuously at the fatigue crack tip in polymethylmethacrylate by an optical interference method. Based on the line-zone craze model proposed previously, the measured craze contour was analyzed. With various heights machined from the model material PMMA. The dynamic stress intensity factors decrease at the beginning of the crack propagation phase, remain almost unchanged in the next stage, and then increase in all specimens. After this period the behavior of the stress intensity factors varies with the specimen geometry. The values of the stress intensity factors at three characteristic points in the stress intensity factor-crack extension curve are discussed with relation to the crack arrest. (Edited author abstract) In Japanese. 10 refs.

Imai, Yasufumi; Takase, Tooru; Nakano, Ken'ichi. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 500 Apr 1988 p 711-716.

**Degradation** See Also POLYSTYRENES—Degradation.

**083196 SPANNINGSCORROSIE.** [Stress Corrosion]. The author examines the factors that lead to the onset of stress corrosion in rubber and plastics. Mechanical properties, degradation and various physical properties are examined from the viewpoint of the impact of stress corrosion. The effect of environmental factors is also assessed, particularly that of aggressive environments. In Dutch. 18 refs.

van Dijk, D.J. (TNO, Delft, Neth). *Kunstst Ruber* v 40 n 10 Oct 1987 p 20-26.

**083197 EFFECTS OF INITIAL MOLECULAR WEIGHT ON THERMAL DEGRADATION OF POLY(METHYL METHACRYLATE): PART 1 - MODEL 1.** The relationship between changes in degree of polymerization and conversion was obtained experimentally for three anionically polymerized PMMA samples with different initial degrees of polymerization (315, 1250 and 5690). Kinetic constants for random scission initiation and average zip length were determined by combined use of the experimental data and a theoretical model (Model 1) based on the same depropagation rate via  $\beta$  scission from both primary and tertiary radicals generated from random scission of backbone C-C bonds. Although the theoretically calculated activation energies for global reaction based on weight loss rates agree reasonably well with the experimentally determined activation energies, the theoretical estimates show inconsistency in the predicted value of average zip length and also do not agree well with the experimentally determined weight loss rates with temperature under dynamic heating conditions. It is suspected that the assumption of the equal reactivity of the primary and tertiary radicals is incorrect. (Author abstract) 21 refs.

Inaba, Atsushi (NBS, Gaithersburg, MD, USA); Kashiwagi, Takashi; Brown, James E. *Polym Degradation Stab* v 21 n 1 1988 p 1-20.

**Dissolution** See LITHOGRAPHY—Materials.

**Electric Properties** See Also COMPOSITE MATERIALS—Electric Field Effects; DIELECTRIC MATERIALS—Radiation Effects.

**083198 STUDIES ON THE INFLUENCE OF PHYSICAL AGING PROCESSES ON ELECTRET PROPERTIES OF AMORPHOUS POLY(METHYL METHACRYLATE).** The influence of physical aging processes on the electret properties of amorphous poly(methyl methacrylate) was investigated by the thermally stimulated discharge (TSD) technique. Aging influences the electrical polarization. The effects of aging on electret properties can be accounted for on the basis of the phenomenological aging theory. More information on the relation between relaxation properties and aging of electret properties can be obtained from an analysis of the

experimental results based on the universal law approach. (Edited author abstract) 23 refs.

Kubon, U. (Deutsches Kunststoff-Inst Darmstadt, Darmstadt, West Ger); Schilling, R.; Wendorff, J.H. *Colloid Polym Sci* v 266 n 2 Feb 1988 p 123-131.

**Etching**

**083199 O<sub>2</sub> PLASMA ETCH RATE REDUCTION ON SYNCHROTRON RADIATION EXPOSED PMMA FILM.** The etch rate of PMMA film in O<sub>2</sub> plasma is found to be reduced by synchrotron radiation (SR) exposure. This phenomenon is accompanied by a reduction in film thickness. IR and XPS analyses reveal that this thickness reduction is caused by scission and removal of the ester side chain. Etch rates of the SR-exposed film decreases to about 1/3 of the unexposed film. This characteristic makes dry-development possible. (Author abstract) 1 ref.

Saito, Kunio (NTT Electrical Communications Lab, Atsugi, Jpn); Yoshikawa, Akira. *Jpn J Appl Phys Part 2* v 26 n 9 Sep 1987 p 1428-1430.

**Failure** See GLASS—Polymeric Materials.

**Fatigue** See BIOMATERIALS—Fiber Reinforcement; MATERIALS—Crack Propagation.

**Fiber Reinforcement**

**083200 MECHANICAL PROPERTIES OF GLASS-CARBON PMMA HYBRID COMPOSITES AT VARIOUS TEMPERATURES.** The fatigue of carbon fiber reinforced poly(methyl methacrylate) (CF/PMMA) has been investigated and it was decided to extend this study the mechanical properties at various temperatures of hybrid composites, containing both carbon and glass fiber. In this work carbon and glass fibers up to a total fiber content of 70% by volume were used to reinforce a PMMA matrix. The tensile and flexural properties of carbon/glass PMMA composites were examined at various temperatures amongst the transition temperatures. Even with 70% reinforcement the temperature of the  $\beta$ -transition appears to be the maximum at which engineering properties are retained. 4 refs.

Manley, T.R. (Newcastle upon Tyne Polytechnic, Newcastle upon Tyne, Engl); Stonebanks, J.A.; Laggan, P. *Polym Commun (Guildford Engl)* v 29 n 1 Jan 1988 p 17-19.

**Flammability** See FLAME RESEARCH.

**Fracture** See Also MOLECULES—Degradation.

**083201 BRITTLE-VISCOUS TRANSITION IN LINEAR HOMOPOLYMERS.** The mechanism of the brittle-viscous transition in PVC and PMMA in conditions of impact loading has been examined. The temperature of the transition is controlled by the ratio of the forced elasticity and crazing stresses. The temperature of the transition corresponds in PVC to the  $\beta$  transition and in PMMA to vitrification. This difference is explained by the presence in PMMA of voluminous side groups. (Author abstract) 23 refs.

Kozlov, G.V. (Kabardino-Balkarsk State Univ, USSR); Shetov, R.A.; Mikitayev, A.K. *Polym Sci USSR* v 28 n 9 1986 p 2055-2061.

**083202 FRACTURE SURFACE ENERGY MEASUREMENTS OF PMMA: A NEW EXPERIMENTAL APPROACH.** The paper describes the results of experiments on notched and cracked polymethyl methacrylate (PMMA) beams which have been subjected to tensile and impact loading. The dynamic load was applied to the edge of the beam by a projectile (steel sphere) fired from an air gun. The amplitude of the stress pulse has been carefully chosen so as to create a crack propagation that could be recorded step by step. Special attention has been paid to measuring the fracture surface energy by the method of caustics using the second step of the propagat-

ing crack. A marked difference has been found in the fracture surface energy calculated by the method of caustics using the first or the second step of propagation. The influence of the notch width on the fracture surface energy has also been studied in connection with cracked specimens, where the cracks have been induced by fatigue. Finally, a comparison of the results of the present work with the corresponding experimental data of previous investigations has been made. (Author abstract) 35 refs.

Katsamanis, F.G. (Naval Acad of Greece, Piraeus, Greece); Delides, C.G. *J Phys D* v 21 n 1 Jan 14 1988 p 79-86.

**083203 FRACTURE TOPOGRAPHY OF WEDGE-LOADED SAMPLES OF POLY(METHYL METHACRYLATE).** The purpose of this communication is to report the observed fracture surface of single-edge notched (SEN) samples of PMMA under wedge loading. The intent is to support the argument that the fracture topography is strongly a function of testing. A comparison will be made between the fractographic features observed in this study and that which has been presented in the literature. 15 refs.

Dearth, R.S. (Case Western Reserve Univ, Cleveland, OH, USA). *J Mater Sci Lett* v 7 n 2 Feb 1988 p 171-172.

**Impurities**

**083204 EFFECT OF RADIATION AND IMPURITIES ON MICROSCOPIC DEFORMATION PROCESS IN PMMA.** Small-angle X-ray scattering experiments were conducted under various tensile stress levels for poly(methyl methacrylate) with different amounts of impurities and microscopic defects. Compared with a highly purified sample of optical fiber grade, the commercially available samples containing many impurities showed that the generation of submicrocracks starts at much lower stress levels. Furthermore, it was revealed that the number of size and such submicrocracks becomes larger in samples irradiated by  $\gamma$ -rays, which produce internal microscopic defects. These results suggest that such impurities and microscopic defects existing in the virgin samples tend to become nuclei for the submicrocracks upon the application of a tensile stress, causing a significant influence on the microscopic deformation process in amorphous polymers. (Author abstract) 8 refs.

Yamashita, Tomoyoshi (Kyushu Univ, Fukuoka, Jpn); Shichijyo, Shiro; Takemura, Tetuo; Matsushige, Kazumi. *Jpn J Appl Phys Part 1* v 27 n 1 Jan 1988 p 104-108.

**Mechanical Properties** See FRACTURE MECHANICS—Stresses.

**Medical Applications** See BIOMEDICAL ENGINEERING—Patient Treatment.

**Mixing** See POLYCARBONATES—Mixing.

**Modification** See DENTAL EQUIPMENT AND SUPPLIES—Bone Cement.

**Molecular Structure** See Also PHOTORESISTS.

**083205 EDGE-EXCITATION RED SHIFT OF THE FLUORESCENCE OF FLEXIBLE SOLUTE MOLECULES IN A POLY(METHYL METHACRYLATE) POLYMER MATRIX.** An excitation wavelength dependence of the fluorescence of tert-butyl and methyl esters of 9-anthracic acid and of tetraphenylbutadiene and tetraphenylmethylbutadiene in a poly(methyl methacrylate) (PMMA) polymer matrix is explained in terms of the presence of conformers that experience different free volumes at 77 K relative to room temperature. (Author abstract) 29 refs.

Al-Hassan, Khader A. (Yarmouk Univ, Irbid, Jordan). *J Polym Sci Part B* v 26 n 8 Aug 5 1988 p 1727-1733.

**Molecular Weight**

**083206 SOME EXPERIMENTAL OBSERVATIONS ON NEARLY MONODISPERSE POLY-**



**METHYL METHACRYLATE AS AN ELECTRON RESIST.** Samples of nearly monodisperse polymethyl methacrylate, PMMA, of molecular weights ranging from 30,000-500,000 have been investigated. The sensitivity to electrons was found to improve with the use of low molecular weight PMMA which is attributed to its high solvent-polymer interaction parameter. The chemical nature of the solvent present in the film pre-baked below the glass transition temperature ( $T_g$ ) was found to have an effect on the contrast value. (Author abstract) 8 refs.

Sharma, V.K. (GEC Research Ltd, Wembley, Engl); Wheeler, M.J. *Semicond Sci Technol* v 2 n 11 Nov 1987 p 753-755.

**083207 CALIBRATION OF A GEL CHROMATOGRAPH FOR DETERMINING THE MOLECULAR WEIGHTS OF POLYMETHYL METHACRYLATE AND LITTLE STUDIED POLYMERS.** A method of calibrating retention volumes according to MM in GPC using specimens of any degree of polydispersion, characterized by any mean MM or intrinsic viscosity has been developed. The method is applied to PMMA, but because of the impaired resolution of the chromatographic column in the region of high MM, it was impossible to obtain a calibration plot in the form of a linear transformation of a PS calibration true for all values of the MM range. Two calibrations are obtained for the ranges  $M < 10^6$  and  $(0.7-3.0) \times 10^6$ . On the basis of these a single calibration plot was constructed for the whole MM range, which is a non-linear transformation of the PS calibration plot. (Edited author abstract) 14 refs.

Kolegov, V.I.; Potapov, V.N.; Samarin, A.F.; Lapin, S.B.; Artemichev, V.M. *Polym Sci USSR* v 29 n 1 Jan 1988 p 212-217.

**083208 INVESTIGATION OF RELAXATION PROCESSES IN LOW AND HIGH MOLECULAR WEIGHT BULK POLY(METHYL METHACRYLATE) BY DYNAMIC LIGHT SCATTERING.** Photon correlation functions of the polarized component of the scattered light from a low molecular weight PMMA have been studied in the temperature range 65-98°C. The observed relaxation functions have been represented by a multiexponential decay by using an inverse Laplace transform analysis. The computed spectrum of retardation times reveals a two-peak structure like that observed in the high molecular weight material ( $T_g = 107^\circ\text{C}$ ). The temperature dependences of the long-time peak associated with the primary glass-rubber relaxation in the two PMMA's are similar when compared at temperatures equidistant from their  $T_g$ 's. (Edited author abstract) 19 Refs.

Fytas, G. (Univ of Crete, Crete, Greece); Wang, C.H.; Fischer, E.W. *Macromolecules* v 21 n 7 Jul 1988 p 2253-2257.

## Morphology

**083209 MORPHOLOGY CHANGES AND VOLUME DEFORMATION OF INDIVIDUAL PHASES OF POLYMER BLENDS. FLUORESCENCE STUDIES OF POLYMER COLLOIDS. 9.** Fluorescence decay measurements were carried out on micron-size nonaqueous dispersions of poly(methyl methacrylate) (PMMA) particles sterically with polyisobutylene (PIB) and labeled in the PMMA phase with naphthalene (N) groups. The decays were nonexponential and mean decay times  $\langle \tau \rangle$  were intermediate between those of similar N groups in pure PMMA (53 ns) or PIB (43 ns) samples. These mean lifetimes  $\langle \tau \rangle$  decrease with increasing local N concentration. When samples of the dispersions in isooctane or hexadecane are annealed above 60°C, their room temperature  $\langle \tau \rangle$  values increase, and when powder samples are so annealed,  $\langle \tau \rangle$  decreases. These results point to the presence of an extensive PMMA-PIB interphase, with solvent swelling, and annealing leading to changes in the extent of interphases formation. (Edited author abstract) 7 refs.

Winnik, Mitchell A. (Univ of Toronto, Toronto, Ont, Can); Pekcan, Onder; Chen, Liusheng; Croucher, Melvin

D. *Macromolecules* v 21 n 1 Jan 1988 p 55-59.

**Nondestructive Examination** See POLYMERS—Defects.

## Optical Properties

**083210 EFFECT OF VARYING POLYMER MATRICES AND GASES ON THE SINGLET AND TRIPLET BEHAVIOR OF 2-PIPERIDINOANTHRAQUINONE.** The photophysical behavior of 2-piperidinoanthraquinone (2-PAQ) was studied by embedding the solute dye in a variety of polymer matrices like poly(methyl methacrylate) (PMMA), poly(ethyl methacrylate) (PEMA), polycarbonates (Lexan), polystyrene (PS), and epoxy resins all at room temperature. A simple experimental technique for preparing the polymer blocks containing the dyes in the shape of 5- or 10-mm thick blocks is described. Employing radiation of high input laser energy ( $\lambda = 532$  nm,  $450$  mJ/cm<sup>2</sup>), we have demonstrated the occurrence of cavitation in fluid solvents like benzene or toluene whereas in thin (1 mil) polymer films such a cavitation did not occur and only smooth triplet decay curves were seen. (Edited author abstract) 19 refs.

Natarajan, L.V. (Univ of Houston, Houston, TX, USA); Becker, Ralph S. *Macromolecules* v 21 n 1 Jan 1988 p 73-78.

## Permeability

**083211 EFFECT OF TACTICITY ON PERMEATION PROPERTIES OF POLY(METHYL METHACRYLATE).** The effect of stereoregularity on gas permeation properties of poly(methyl methacrylate) (PMMA) was investigated. The gas permeability coefficients for He, H<sub>2</sub>, O<sub>2</sub>, N<sub>2</sub>, Ar, CH<sub>4</sub>, and CO<sub>2</sub> at 35°C near atmospheric pressure have been measured for three different PMMA's. Apparent diffusion and solubility coefficients were obtained from time lag data, and these were compared with data for a commercial PMMA previously reported. The permeability, solubility, and diffusion coefficients increase as the content of syndiotactic sequences increases. These observations are consistent with more dense packing of the isotactic form in the glassy state that stems in part from its lower glass transition temperature. The transport behavior for a 50:50 isotactic/syndiotactic blend was also studied. These so-called stereocomplexes exhibit permeation behavior comparable to other weakly interacting miscible blend systems. (Author abstract) 49 refs.

Min, K.E. (Univ of Texas at Austin, Austin, TX, USA); Paul, D.R. *J Polym Sci Part B* v 26 n 5 May 1988 p 1021-1033.

**Phase Diagrams** See POLYVINYL CHLORIDE—Phase Diagrams.

## Phase Transitions

**083212 GLASS TRANSITION OF POLYMETHYL METHACRYLATE AT ELEVATED PRESSURES.** The glass transition of PMMA at pressures of up to 700 MPa has been studied in the 370-400°K temperature range. Glass point depends on pressure asymptotically with  $T_g$  being practically independent of pressure above 500 MPa. The results are discussed from the viewpoint of the Gibbs-Di Marzio glass transition theory. (Author abstract) 17 refs.

Skorodumov, V.F. (L.Ya. Karpov Physical Chemistry Research Inst, USSR); Godovskii, Yu.K. *Polym Sci USSR* v 29 n 1 Jan 1988 p 127-133.

## Photochemical Reactions

**083213 THERMOLYSIS AND PHOTOCHEMICAL ACIDOLYSIS OF SELECTED POLYMETHACRYLATES.** Thermal behavior and thermolytic deprotection catalyzed by photochemically generated HSBF<sub>6</sub> in the solid state have been investigated for atactic polymethacrylates having benzyl,  $\alpha$ -methylbenzyl,  $\alpha,\alpha$ -dimethyl-

benzyl, and tert-butyl ester groups as well as cyclopropyl carbinol esters. It is shown that sensitivity of these polymethacrylates to photochemically induced acidolysis is very much reflected by the thermal deprotection temperatures except for the cyclopropyl carbinol esters, which possess the lowest deprotection temperature in the series but suffer from concomitant rearrangement to a thermally stable primary ester. The thermal rearrangement of the cyclopropyl carbinol ester, is more pronounced in the presence of acids. (Edited author abstract) 19 refs.

Itô, Hiroshi (IBM, San Jose, CA, USA); Ueda, Mitsuru. *Macromolecules* v 21 n 5 May 1988 p 1475-1482.

## Photoreactivity

**083214 PREPARATION OF THE POLYMER BEARING PENDANT QUINONOID GROUPS BY UV IRRADIATION AND ITS PHOTOCROSSLINKING.** In a previous paper we presented the mechanism of photocrosslinking of poly(methyl methacrylate) (PMMA) by bezoquinones. It was shown that the first step in the photocrosslinking was the photo-addition of the bezoquinones to PMMA and that the bound bezoquinones played an important role to promote the photocrosslinking between polymer chains in the next step. Therefore it is very interesting to prepare the polymers bearing quinone structure from the viewpoint of preparation of photocrosslinkable polymers. In this article, the photoreaction of copolymers of HEMA and MMA with tBQ was investigated and the contents of hydroquinone (HQ) units and benzoquinone (BQ) units in the copolymers were determined. Moreover the resulting polymer was proved to become photocrosslinkable by the treatment with p-benzoquinone. 3 refs.

Tsunooka, M. (Univ of Osaka Prefecture, Sakai, Jpn); Kawasaki, M.; Cha, Y.-S.; Tanaka, M. *J Polym Sci Part A* v 25 n 11 Nov 1987 p 3173-3176.

**Physical Properties** See Also POLYMERS—Additives; POLYMERS—Physical Properties.

**083215 CHARACTERIZATION OF POLY(METHYL METHACRYLATE) PREPARED BY AQUEOUS POLYMERIZATION IN PRESENCE OF CORUNDUM.** The addition of corundum (Al<sub>2</sub>O<sub>3</sub>) in the aqueous reaction medium was found to catalyze the bisulfite-initiated polymerization of methyl methacrylate. The increase in its quantity led to an increase in conversion percentage and decrease in the viscosity average molecular weights up to addition of 1.5 g; then the conversion percentage was found to decrease and the viscosity average molecular weights were found to increase. The polydispersity of the polymer samples decreased when using initiator concentrations more than 0.2 mol/liter and increased on raising the reaction temperature. Thin layer chromatographic technique employed proved to be a good and rapid technique for giving an idea about the polydispersity of the polymers obtained under different reaction conditions. (Author abstract) 10 refs.

Moustafa, A.B. (Al-Azhar Univ, Cairo, Egypt); Sayyah, S.M.; Abd-Ellatif, Z.H.; Amer, L.I. *Indian J Technol* v 25 n 5 May 1987 p 239-242.

**083216 INFLUENCE OF THE TACTICITY OF POLY(METHYL METHACRYLATE) ON ITS MISCIBILITY WITH CHLORINATED POLYMERS.** Differential scanning calorimetry was used to determine the miscibility behavior of poly(methyl methacrylate) (PMMA)/chlorinated polymer blends. Nine PMMA's differing in tacticity were blended with three chlorinated polymers: poly(vinyl chloride) (PVC), a chlorinated PVC having a chlorine content of 68 percent (CPVC), and Saran, which is a random copolymer of vinyl chloride (12 percent) and vinylidene chloride (88 percent). The results



show that all these PMMA's are miscible with PVC, CPVC, and Saran under proper thermal treatment and especially at 298 K. (Edited author abstract). 48 Refs.

Lemieux, Even (Univ of Laval, Que, Can); Prud'homme, Robert E.; Forte, Rosalia; Jerome, Robert; Teyssie, Philippe. *Macromolecules* v 21 n 7 Jul 1988 p 2148-2154.

**Polymerization** See Also POWDERS—Encapsulation.

**083217 LIVING RADICAL POLYMERIZATION OF METHYL METHACRYLATE WITH TETRAPHENYLSUCCINODINITRILE AS A THERMAL INIFERTER.** The bulk polymerization of methyl methacrylate (MMA) with tetraphenylsuccinodinitrile (TPSN) at 60 approx. 80°C was found to proceed via a mechanism close to the living radical polymerization model proposed previously, i.e. both yield and molecular weight of the polymers increased with reaction time. However, the observed living radical nature was low. The MMA oligomer which can induce further radical polymerization was formed in the initial stage. (Edited author abstract) 17 refs.

Otsu, Takayuki (Osaka City Univ, Jpn); Matsumoto, Akikazu; Tazaki, Toshinori. *Mem Fac Eng Osaka City Univ* v 27 Dec 1986 p 137-142.

**Pressure Effects**

**083218 SUSTAINED PRESSURIZATION OF POLYMETHYLMETHACRYLATE: A COMPARISON OF LOW- AND MODERATE-VISCOSITY BONE CEMENTS.** The effect of serially increasing sustained pressurization of two commercially available acrylic bone cements (Simplex-P and LVC) was evaluated in human cadaver femora. A new method for determination of the shear strength of the bone-cement interface in place of the traditional pushout tests was used. In this model, there was a significant increase in the bone-cement interfacial shear strength with increasing pressure, but no difference in the shear strength was found between the two cements. At all pressure levels, the shear strength of the cement was greater than that previously reported. Increased cement penetration into the cortical bone was demonstrated with increasing pressure and low-viscosity cement, but the extent of cement penetration did not correlate with the shear strength of the bone-cement interface. (Edited author abstract) 19 refs.

Bean, D.J. (Univ of California at San Diego, La Jolla, CA, USA); Hollis, J.M.; Woo, S.L.-Y.; Convery, F.R. *J Orthop Res* v 6 n 4 Jul 1988 p 580-584.

**Processing** See POLYMERS—Electric Properties.

**Production**

**083219 POLYMETHACRYLATES (PMMA).** The market in PMMA semi-finished products is served by cast and extruded materials with somewhat different property profiles. In the preferred applications for the two materials there have been by and large no considerable changes since the last report. Surprisingly, the overall demand for cast PMMA in Europe, after stagnating, had been stimulated somewhat more strongly. The very interesting field and technology, of optical readable storage media has with PMMA as substrate. In the USA, a material Corian, Du Pont, (PMMA as resin matrix, but aluminium trihydrate as mineral component) has already been on the market for synthetic marblelike materials for a long time. It is marketed for simple sanitary ware and semi-finished sheet. PMMA with special flame retardant formulation, very good resistance to weathering, and outstanding optical appearance has proven very suitable for transparent noise barrier walls. The tendency is as everywhere in the plastics sector, to develop tailored or multifunctional products for the individual applications. 2 refs.

Buck, M. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 47-49.

**Pyrolysis** See COAL—Pyrolysis.

**Radiation Effects**

**083220 SELF-DEVELOPMENT OF POLYMETHYLMETHACRYLATE BY SYNCHROTRON RADIATION EXPOSURE.** Polymethylmethacrylate was exposed to synchrotron radiation directly and through a polyimide film, and the phenomenon of self development was observed. It was found that the polymer was decomposed into small fragments under the irradiation, but some of them were expected to be recombined into the cross-linked polymer. The decomposition mechanism is discussed in relation with the effect of x-ray wavelength and heating of the substrate. (Author abstract) 9 refs.

Yamada, Hitomi (Nagoya Univ, Nagoya, Jpn); Hori, Masaru; Morita, Shinzo; Hattori, Shuzo. *J Electrochem Soc* v 135 n 4 Apr 1988 p 966-970.

**083221 LATEX SPHERES AS CARRIERS OF SURFACE ACTIVE CENTERS.** Poly(methyl methacrylate) spheres with surface-attached D,L- $\alpha$ -alanine were exposed to  $\gamma$ -irradiation. It was found that only one of the two known stable alanine radicals is generated on the polymer surface as a consequence of the bonding on the specific backbone group. The sensitivity of ESR spectroscopy for the determination of extremely small numbers of reactive sites was demonstrated. (Author abstract). 8 Refs.

Pavkovic, E. (Rudjer Boskovic Inst, Zagreb, Yugosl); Rakvin, B.; Veksl, Z. *Radiat Phys Chem* v 32 n 5 1988 p 665-666.

**083222 VAPOUR DEVELOPMENT OF PMMA RESISTS UNDER X-RAY EXPOSURE.** Poly(methyl methacrylate) PMMA films of approximately 3  $\mu$ m thickness have been irradiated with Al K-x-rays. The amount of vapour development is shown to increase as the initial molecular weight decreases and the rate of vapour development is shown to decrease with increasing dose. A model to describe this behaviour is presented. (Edited author abstract) 17 refs.

Lehockey, E.M. (Univ of Western Ontario, London, Can); Reid, I. *Surf Interface Anal* v 11 n 6 Apr 1988, Proc of the 9th Symp on Appl Surf Anal, Dayton, OH, USA, Jun 3-5 1987 p 302-306.

**Reactions**

**083223 STUDIES ON SOME RADICAL TRANSFER REACTIONS BY ENTRAPPING THE RADICALS AS POLYMER END GROUPS. II. REACTIONS OF OH RADICALS WITH AMINO ACIDS.** The reaction of OH radicals with a number of aliphatic amino acids has been studied by entrapping the resultant radicals as end groups of poly(methyl methacrylate) that have been detected and estimated by the sensitive dye partition technique. The rate constants of the reaction (in mol<sup>-1</sup> L S<sup>-1</sup>) of 7 amino acids at 25°C and at pH 1.00 have been determined. The change of pH did not produce any significant change in the end group profile of the polymer obtained, indicating no appreciable change in the rate of the reaction of OH radicals with the simplest amino acid glycine in the pH range studied. (Edited author abstract) 19 refs.

Pramanick, Dinabandhu (Kalyani Univ, Kalyani, India); Sarkar, Jyotish; Bhattacharya, Ramanath. *J Polym Sci Part A* v 26 n 2 Feb 1988 p 573-581.

**Research**

**083224 END GROUPS OF POLY(METHYL METHACRYLATE-co-STYRENE) PREPARED WITH tert-BUTOXY, METHYL, AND/OR PHENYL RADICAL INITIATION: EFFECTS OF SOLVENT, MONOMER COMPOSITION, AND CONVERSION.** The relative reactivities of tert-butoxy, methyl, and phenyl radicals toward styrene, methyl methacrylate, and several solvents (acetone, butan-2-one, toluene, and benzene) have been established by means of competition experi-

ments. These experiments demonstrate that when a source of tert-butoxy radicals is employed as the initiator for copolymerization and toluene or butan-2-one is used as the solvent, a majority of end groups may be solvent derived. This is a consequence of the tert-butoxy radicals' high propensity for hydrogen abstraction. Even with benzene as solvent, there is a significant proportion of solvent attack and resultant phenyl radical initiation. (Edited author abstract) 39 refs.

Bednarek, Debra (CSIRO, Melbourne, Aust); Moad, Graeme; Rizzardo, Ezio; Solomon, David H. *Macromolecules* v 21 n 5 May 1988 p 1522-1528.

**083225 MOLECULAR MOTION OF THE PMMA CHAIN IN POLY(METHYL METHACRYLATE)/POLY(VINYLIDENE FLUORIDE) BLENDS BY SPIN TRAPPING LABELING.** Spin trapping is used to study molecular motion of PMMA chains in blends of poly(methyl methacrylate) poly(vinylidene fluoride) (PMMA/PVDF). Free radicals produced by thermal degradation of PMMA chains in the blends are trapped by 2,4,6-tri-tert-butylnitrosobenzene, and the spin-labeled chain ends are studied by electron spin resonance (ESR). The temperature dependence of the ESR spectra changes substantially as a function of the PVDF content of the blend. The narrowing curve of the outermost splitting widths and the generation curve of the mobile fraction of the spin label shift to low temperatures with increasing PVDF content of the blend. (Edited author abstract). 12 Refs.

Shimada, Shigetaka (Nagoya Inst of Technology, Nagoya, Jpn); Hori, Yasuro; Kashiwabara, Hisatsugu. *Macromolecules* v 21 n 7 Jul 1988 p 2107-2111.

**083226 COMPLEXATION OF STEREOREGULAR POLY(METHYL METHACRYLATES). 11. A MECHANISTIC MODEL FOR STEREOCOMPLEXATION IN THE BULK.** The process of stereocomplexation between isotactic and syndiotactic PMMA in the bulk was studied by means of differential scanning calorimetry and wide-angle X-ray scattering as a function of annealing time and temperature. It appeared that in all cases the material obtained was partly crystalline. For low annealing temperatures the samples showed multiple endotherms with different characteristics. A mechanistic model, in which subsequent crystallization of the complexed chain sections plays an important role, is presented which accounts for the observed phenomena. (Edited author abstract). 34 Refs.

Schomaker, Elwin (State Univ of Groningen, Groningen, Neth); Challa, Ger. *Macromolecules* v 21 n 7 Jul 1988 p 2195-2203.

**083227 COMPLEXATION OF STEREOREGULAR POLY(METHYL METHACRYLATES). 12. COMPLEXATION PROCESS IN DILUTE SOLUTION.** The process of stereocomplexation between isotactic and syndiotactic PMMA in dilute solution was studied by means of differential scanning calorimetry of isolated complexed material, solution viscometry, and isothermal mixing calorimetry. The results were combined with results of investigations previously published. It appeared that essentially the same mechanism as proposed for the complexation process in bulk can account for the observed phenomena, including the previously reported association and aggregation stages following complexation. Two main processes are distinguished: complexation and subsequent crystallization of complexed chain sections, leading to the formation of complex particles. (Edited author abstract). 32 Refs.

Schomaker, Elwin (State Univ of Groningen, Groningen, Neth); Hoppen, Henk; Challa, Ger. *Macromolecules* v 21 n 7 Jul 1988 p 2203-2209.

**Sedimentation**

**083228 HYDRODYNAMIC AND TOPOLOGICAL INTERACTIONS IN SEDIMENTATION OF POLY(METHYL METHACRYLATE) IN SEMIDILUTE SOLUTIONS OF POLYSTYRENE IN THIOPHENOL.**



This work has been performed to clarify effects of two dynamical interactions, the hydrodynamic interaction and the topological interaction, on transport of a flexible chain molecule in the semidilute regime. The sedimentation velocity technique has been applied to obtain the sedimentation coefficient  $s$  of poly(methyl methacrylate). The effect of the topological interaction has been manifested on a master curve constructed, by use of the MW between entanglements,  $M_{e,PS}$ , from the  $s$  data after subtraction of the hydrodynamic screening effect. In solutions of PS with  $M_{PS} = 775,000$ , it has been found that a different transport mechanism may become dominant depending on both a ratio of  $M$  to  $M_{PS}$  and PS concentration. (Edited author abstract) 31 refs.

Nemoto, Norio (Kyoto Univ, Kyoto, Jpn); Okada, Shinichi; Inoue, Tadashi; Kurata, Michio. *Macromolecules* v 21 n 5 May 1988 p 1502-1508.

**083229 COMPARISON OF THE SEDIMENTATION DATA WITH THE HESS THEORY AND WITH SELF-DIFFUSION COEFFICIENT DATA OF POLYSTYRENE IN THE SEMIDILUTE REGIME AND IN MELTS.** The topological function  $\psi$ , obtained from analysis of sedimentation coefficient data of poly(methyl methacrylate) (PMMA) in semidilute solutions of high molecular weight (MW) polystyrene (PS) has been compared with a theory for self-diffusion of flexible polymers in the semidilute regime developed by W. Hess and also with  $\psi$  evaluated from tracer diffusion coefficient ( $D_{tr}^\infty$ ) data in the semidilute regime and from self-diffusion coefficient ( $D_s$ ) data in melts. It has been found that the Hess theory can reasonably well explain the observed dependence of  $\psi^{-1}$  on the ratio of MW of PMMA to MW between entanglements of PS,  $M_{e,PS}$ .  $\psi$  from  $D_{tr}^\infty$  data of a tracer PS in semidilute solutions of high MW PS has shown poor agreement with  $\psi$  from the  $s$  data. (Edited author abstract) 23 refs.

Nemoto, Norio (Kyoto Univ, Kyoto, Jpn); Okada, Shinichi; Inoue, Tadashi; Kurata, Michio. *Macromolecules* v 21 n 5 May 1988 p 1509-1513.

## Sheet

**083230 TEMPERATURE DEPENDENCE OF FRACTURE TOUGHNESS OF POLY(METHYL METHACRYLATE).** In this letter, the temperature dependence of the fracture toughness of PMMA, especially the variation around the  $\alpha$  relaxation temperature ( $T_g$ ), is reported. A poly(methyl methacrylate) cast sheet was used for this experiment. The measurements of the fracture toughness were carried out on a tapered double cantilever beam. The flexural modulus-temperature and the yield strength-temperature curves exhibited an obscure shoulder at 90°C. 7 refs.

Mizutani, Kiyoshi (Osaka Prefectural Industrial Research Inst, Higashi, Jpn). *J Mater Sci Lett* v 6 n 8 Aug 1987 p 915-916.

## Solutions See Also GELS—Forming.

**083231 SEDIMENTATION BEHAVIOUR OF SEMI-DILUTE SOLUTIONS OF POLY(METHYL METHACRYLATE).** Sedimentation coefficients  $S$  of poly(methyl methacrylate) for a broad range of molecular weights  $M$  and concentrations  $1 \cdot 10^{-4} < c < 2 \cdot 10^{-1}$  (c in g ml<sup>-1</sup>) in the good solvent acetone at 20°C and the theta solvent acetonitrile at 35°C are reported. The results in the dilute regime are discussed in connection with those reported on poly(methyl methacrylate) and the many data available for polystyrene. Both sets of experimental results are compared with the scaling theory. (Edited author abstract) 20 refs.

Boog, U. (Univ Mainz, Mainz-Darmstadt, West Ger); Tianbao, Huang; Meyerhoff, G. *Eur Polym J* v 23 n 10 1987 p 781-785.

**083232 CHAIN DYNAMICS OF POLY(METHYL METHACRYLATE) IN DILUTE SOLUTIONS STUDIED BY THE FLUORESCENCE DEPOLARIZATION METHOD.** Samples of poly(methyl methac-

rylate) (PMMA) labeled with anthracene in the middle of the chain were synthesized, and their local motions in dilute solutions were examined by the fluorescence depolarization technique. Theoretical functions based on various models for local motions were fitted to the data. The average anisotropy ratio became almost independent of the molecular weight above  $1.28 \times 10^5$ . At high viscosities or at low temperatures, the discrete conformation jump models such as the Jones-Stockmayer (JS) model and the generalized diffusion and loss (GDL) model were in good agreement with the experimental data compared with the models of diffusion on a continuous body such as the Bendler-Yaris (BY) model and the Skolnick-Yaris (SY) model. Plots of dynamic parameters of the Hall-Helfand (HH) model versus viscosity revealed nondiffusive small-scale motions in the higher viscosity region. (Edited author abstract) 43 refs.

Sasaki, Takashi (Kyoto Univ, Kyoto, Jpn); Yamamoto, Masahide; Nishijima, Yasunori. *Macromolecules* v 21 n 3 Mar 1988 p 610-616.

**083233 COMPARISON OF THE TRANSLATIONAL DIFFUSION OF LARGE SPHERES AND HIGH MOLECULAR WEIGHT COILS IN POLYMER SOLUTIONS.** The translational diffusion of large stearic acid coated silica spheres ( $R_H = 1595$  Angstrom) and high molecular weight polystyrene (PS) fractions in poly(methyl methacrylate) (PMMA) solutions has been examined by using dynamic light scattering (QELS) over the dilute/semidilute concentration ranges of the latter polymer. When the PMMA concentration is normalized by the overlap concentration,  $C^*$ , the reduced diffusion coefficient ( $D/D_0$ ) for the sphere is a universal function of  $C_{PMMA}$ . A similar observation applies to the data for the PS fractions. This is in accord with scaling predictions. The results indicate that there may be a significant coupling of the dynamics of the probe chain and those of the network polymer. (Edited author abstract) 5 refs.

Brown, Wyn (Univ of Uppsala, Uppsala, Sweden); Rymden, Roger. *Macromolecules* v 21 n 3 Mar 1988 p 840-846.

## Specific Heat

**083234 REINVESTIGATION OF THE HYPERSONIC PROPERTIES AND THE SPECIFIC HEAT OF PMMA AROUND THE QUASI-STATIC GLASS TRANSITION. I. HIGH PERFORMANCE BRILLOUIN INVESTIGATIONS.** The hypersonic behaviour of the longitudinal and transverse acoustic phonon frequency has been studied in the glass transition region of PMMA. An ultra slow acoustic relaxation process is reported which seems to be intimately connected to the main glass transition. The correlation with volume relaxation processes is discussed. The hypersonic frequency recovery process 20 K below  $T_g$ , reported in the literature, could not be confirmed. (Author abstract) 33 refs.

Krueger, J.K. (Univ des Saarlandes, Saarbruecken, West Ger); Roberts, R.; Unruh, H.-G.; Fruehauf, K.-P.; Helwig, J.; Mueser, H.E. *Prog Colloid Polym Sci* v 71 1985 p 77-85.

## Spectroscopic Analysis

**083235 EFFECT OF NMR SIGNAL FROM INITIATOR FRAGMENT ON TRIAD TACTICITIES OF POLY(METHYL METHACRYLATE)S FORMED BY 2,2'-AZOBISISOBUTYRONITRILE AND BENZOYL PEROXIDE.** It was reported that tacticity of the poly(methyl methacrylate) (PMMA) prepared with benzoyl peroxide (BPO) deviated slightly from Bernoullian statistics while that of PMMA formed by 2,2'-azobisisobutyronitrile (AIBN) was consistent with the Bernoullian. In this work we found using the 500MHz <sup>1</sup>H NMR spectra of the PMMA from AIBN that the two small methyl proton signals of equal intensities attributed to the initiator fragment, (CH<sub>3</sub>)<sub>2</sub>C(CN)- at the  $\alpha$ -end of the chain overlap indistinguishably with the isotactic and heterotactic  $\alpha$ -methyl proton signals, respectively, in the <sup>1</sup>H NMR spectra measured at lower frequency, namely, 100 MHz. 9 refs.

Hatada, Koichi (Osaka Univ, Toyonaka, Jpn); Kitayama, Tatsuki; Terawaki, Yoshio; Chujo, Riichiro. *Polym J* v 19 n 9 1987 p 1127-1129.

**083236 IDENTIFICATION OF POSITIVE SECONDARY IONS IN STATIC SIMS SPECTRA OF POLY(METHYL METHACRYLATE) USING THE DEUTERATED POLYMER.** Positive static SIMS spectra of poly(methylmethacrylate) (PMMA) and perdeuterated PMMA have been compared. The usefulness of this approach for the distinction between hydrocarbon and oxygen-containing secondary ions is demonstrated. For example, a major characteristic fragment like the one at 69 amu, which had been tentatively identified as C<sub>3</sub>H<sub>9</sub><sup>+</sup> by other authors, was shown to be C<sub>4</sub>H<sub>5</sub>O<sup>+</sup>. (Author abstract) 8 refs.

Brinkhuis, R.H.G. (Colorado Sch of Mines, Golden, CO, USA); van Ooij, W.J. *Surf Interface Anal* v 11 n 4 Feb 1988 p 214-216.

**083237 IDENTIFICATION OF DYES IN SOLID POLY(METHYL METHACRYLATE) BY MEANS OF LASER DESORPTION FOURIER TRANSFORM ION CYCLOTRON RESONANCE MASS SPECTROMETRY.** Laser desorption (LD) is a pulsed ionization source for which the pulsed Fourier transform ion cyclotron resonance (FT/ICR) mass spectrometer is the detector of highest mass resolution. In this paper, we show that LD/FT/ICR can detect and identify (by chemical formula) dyes in solid poly-(methyl methacrylate) (PMMA) commercial plastics at concentrations at least an order of magnitude lower (0.1% vs 1-2% by weight) than those obtained by the best currently available alternative method (attenuated total reflectance Fourier transform infrared spectrometry). Both untreated and redissolved PMMA have been characterized, in the presence and absence of up to three dyes in a single sample. (Edited author abstract) 44 refs.

Hsu, Annjia T. (Ohio State Univ, Columbus, OH, USA); Marshall, Alan G. *Anal Chem* v 60 n 9 May 1 1988 p 932-937.

**083238 RELAXATIONAL TRANSITIONS IN POLYMETHYLMETHACRYLATE AS SHOWN BY RELAXATIONAL SPECTROMETRY.** Attention in this work was focussed on the group of  $\gamma$ -transitions. It was found that below the  $\alpha$  and  $\beta$  transitions not four but five relaxational transitions are observed. This is connected with the fact that in presence of dissolved water adsorbed on the macromolecules a new relaxational  $\mu$ -transition appears in PMMA. It disappears in the dry polymer. The appearance of such transitions linked with the presence of water is characteristic of many hydrophilic polymers. To find the relaxation constants of these transitions (activation energy  $U_i$  and the pre-exponential coefficient  $B_i$ ) in the Boltzmann-Arrhenius equation allows us to construct the dependence in the coordinates  $1/T_i \cdot \log v$  for all the relaxational transitions. From the data of mechanical and structural relaxation, the author analyzes 13 different relaxational transitions in polymethylmethacrylate below and above the glass transition point. The nature of the individual transitions is considered and a classification proposed. (Edited author abstract) 28 refs.

Bartenev, G.M. (USSR Acad of Sciences, USSR). *Polym Sci USSR* v 29 n 1 Jan 1988 p 74-83.

**083239 XPS STUDY OF BOUNDARY PHASE STRUCTURE BETWEEN STEREOREGULAR POLY(METHYL METHACRYLATE) AND POLY-AMIDE SUBSTRATE.** The purpose of this work is to elucidate the boundary phase structure between nylon-6 (Ny) substrate and PMMA in relation to the difference in tacticity of PMMA by X-ray photoelectron spectroscopy (XPS). Ny was shown to be usable as a model compound for Kevlar-fiber from the Fourier-transform infrared spectroscopy. The characteristic ratios for atactic, syndiotactic and isotactic PMMA were obtained as 7.5, 7.3, and 10.3 from the solution properties in tetrahydrofuran and as 7.9, 9.2, and 10.7 from the bulk properties, respectively.



These data show that isotactic PMMA is more extended in the unperturbed state or more restricts the rotation of molecular chain compared with atactic and syndiotactic PMMA. 8 Refs.

Kodama, Minekazu (Mitsubishi Electric Corp, Amagasaki, Jpn); Kuramoto, Kazuo. *Polym J* v 20 n 6 1988 p 515-518.

**083240 DETERMINATION OF THE RANGE OF SLOW ELECTRONS IN SOLID POLYMETHYL METHACRYLATE BY MEANS OF FLUORESCENCE MEASUREMENTS.** In the present work a method is described for the determination of the effective attenuation length of photoelectrons in polymethylmethacrylate (PMMA), which is based on the excitation of solid solutions of anthracene in the polymer by radiation in the vacuum ultraviolet. This produces photoelectrons in the sample which undergo a multitude of elastic and inelastic collisions and ultimately may collide with an anthracene molecule and excite its fluorescence. 2 refs.

Sasson, R. (Hebrew Univ, Jerusalem, Isr); Arakawa, E.T.; Braitbart, O.; Weinreb, A. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 244-245.

**Structure** See Also POLYURETHANES—Structure.

**083241 LIQUID CRYSTALS FROM POLY(4,4'-METHOXYBIPHENYL) METHACRYLATE.** Side-chain liquid crystalline poly(4,4'-biphenyl) methacrylate was studied by x-ray diffraction. Three smectic phases were described using a ribbon-like structural model for the polymer chain. In the smectic  $S_p$  phase, ribbons lie flat on their sides to form layers with a spacing equal to the thickness of the ribbons. In the smectic  $S_A$  phase, the ribbons stand upright giving layers with a thickness corresponding to the length of one extended monomeric unit. In the ordered smectic  $S_C$  phase, the layer thickness also corresponds to one extended repeat unit, and the pendant groups are arranged according to a two-dimensional oblique lattice. The Schlieren texture observed in the  $S_p$  phase was analyzed in terms of symmetry. (Author abstract) 12 refs.

Duran, R. (CNRS, Strasbourg, Fr); Guillon, D.; Gramain, Ph.; Skoulios, A. *J Phys (Paris)* v 48 n 12 Dec 1987 p 2043-2047.

## Surfaces

**083242 SURFACE LAYER THICKNESS IN NON-AQUEOUS POLY(METHYL METHACRYLATE) DISPERSIONS. II. STABILIZATION WITH THE DIBLOCK COPOLYMER POLY(STYRENE-B[ETHYLENE-CO-PROPYLENE]).** Well-defined non-aqueous dispersions of poly(methyl methacrylate) in n-heptane, and in a binary liquid mixture of n-heptane and n-propanol, have been stabilized by the diblock copolymer poly(styrene-b[ethylene-co-propylene]) having a narrow molar mass distribution. The thickness of the surface layer was determined from viscosity studies of the dispersions at 298, 308, and 318 K. Solution viscosities of a narrow distribution standard of ethylene-propylene copolymer in n-heptane, and in the binary liquid mixture, at 298, 308, and 318 K were obtained in order to estimate the root-mean-square end-to-end distance of free ethylene-propylene copolymer chains. (Edited author abstract) 23 Refs.

Dawkins, J.V. (Loughborough Univ of Technology, Loughborough, Engl); Shakir, S.A. *Colloids Surf* v 32 n 3 pt 4 Jul 1988 p 345-358.

## Swelling

**083243 METHANOL TRANSPORT IN PMMA: THE EFFECT OF MECHANICAL DEFORMATION.** The effect of cold work on the transport of liquid methanol in crosslinked PMMA disks has been determined at temperatures from 35-56°C. Deformed samples absorb at fast rates with kinetics that approach those of

Fickian diffusion. Undeformed samples sorb at lower rates and the kinetics tend toward those of Case II transport. Shape recovery accompanied swelling in deformed samples. Samples saturated with methanol were desorbed in cyclohexanol. Resorption of desorbed samples showed fast rates for both deformed and undeformed samples and matched those of the absorption cycle in deformed samples. An analogy is made between the microstructure due to cold work and due to swelling. (Author abstract) 38 refs.

Harmon, Julie P. (Univ of Rochester, Rochester, NY, USA); Lee, Sanboh; Li, J.C.M. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3215-3229.

**Synthesis** See Also VINYL RESINS—Photochemical Reactions; VINYL RESINS—Synthesis.

**083244 STEREOCHEMISTRY OF THE OLIGOMERIZATION OF METHYL METHACRYLATE BY  $t\text{-C}_4\text{H}_9\text{MgBr}$  IN TOLUENE AT  $-78^\circ\text{C}$ .** Recently, we found that the polymerization of MMA by  $t\text{-C}_4\text{H}_9\text{MgBr}$  in toluene at  $-78^\circ\text{C}$  was a completely living and highly isotactic-specific system. The  $\alpha$ - and  $\omega$ -end tacticities of the PMMA were studied by 2D NMR techniques. In this work, isotactic oligo(MMA)s were prepared by the polymerization of MMA with  $t\text{-C}_4\text{H}_9\text{MgBr}$  in toluene at  $-78^\circ\text{C}$  and their configurational sequences were investigated in detail by gel permeation chromatography and 2D NMR spectroscopy to gain a more detailed understanding of stereoregulation in polymerization. 22 refs.

Hatada, Koichi (Osaka Univ, Toyonaka, Jpn); Ute, Koichi; Tanaka, Katsuji; Kitayama, Tatsuki. *Polym J* v 19 n 11 1987 p 1325-1328.

**083245 STEREOREGULARITY OF POLY(METHYL METHACRYLATE) PREPARED BY AQUEOUS POLYMERIZATION AND CATALYZED BY CORUNDUM.** The aqueous polymerization of methyl methacrylate was carried out in the absence and in the presence of corundum or carborundum at 25 and  $80^\circ\text{C}$ . In the absence of corundum and carborundum, it has been found that increasing the polymerization temperature from 25 to  $80^\circ\text{C}$  resulted in changing the tacticity of the obtained polymers. At  $25^\circ\text{C}$ , the isotactic triad was 26% while the heterotactic triad was 33.5% and the syndiotactic one was 40.5%. Increasing the polymerization temperature to  $80^\circ\text{C}$  resulted in a decrease of the isotactic structure to 0% and increased the heterotactic structure and syndiotactic structure to 48 and 52% respectively. Raising the polymerization temperature to  $80^\circ\text{C}$  in the presence of the same amount of corundum resulted in an increase in both the isotactic and heterotactic triads to 35 and 32.7%, respectively. Polymerizing at  $80^\circ\text{C}$  in presence of corundum resulted in nearly an equal percentage of each triad. (Edited author abstract) 21 refs.

Moustafa, A.B. (Nat'l Research Cent, Cairo, Egypt); Abd Ellatif, Z.H.; Amer, L.I. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1587-1591.

**083246 GRAFTING OF GELATIN DURING POLYMERIZATION OF METHYL METHACRYLATE IN AQUEOUS MEDIUM.** When methyl methacrylate is polymerized in aqueous medium in the presence of gelatin, graft copolymer macromolecules with gelatine backbones and poly(methyl methacrylate) (PMMA) grafts are formed. Due to the presence of graft copolymer, polymolecular micelles consisting of about 100 macromolecules are created. These micelles prevent macroscopic precipitation of PMMA. Fractionation in demixing solvents has been used to separate the components of the polymerization mixture, and the light-scattering method has been employed to determine their molecular weights. Each grafted macromolecule carries about one graft. The hypothesis of random grafting from gelatin backbones seems to explain most of the experimental observations. (Author abstract) 41 refs.

Stejskal, Jaroslav (Czechoslovak Acad of Sciences, Prague, Czech); Strakova, Dagmar; Kratochvil, Pavel. *J Appl Polym Sci* v 36 n 1 Jun 20 1988 p 215-227.

**083247 POLYMERIZATION OF METHYL METHACRYLATE IN MICELLAR PHASE: A KINETIC STUDY.** Polymerization of methyl methacrylate (MMA) using  $\text{Ce(IV)}$  as initiator in aqueous nitric acid solution in the presence of sodium lauryl sulfate (NaLS) has been studied kinetically at a temperature range of 25-35°C. The rate of polymerization ( $R_p$ ) increases with increasing concentration of NaLS, and it was also proportional to  $[\text{MMA}]^2$ ; but, in the presence of NaLS, the change of  $R_p$  with respect to  $[\text{Ce(IV)}]$  and  $[\text{H}^+]$  were not linear and similarly the rate of  $\text{Ce(IV)}$  disappearance was not proportional to its original concentration. The overall activation energy of the polymerization process in presence of 0.01M NaLS was found to decrease by approximately 7.0 kcal  $\text{mol}^{-1}$ . The monomer-micelle association constant has been calculated to be  $5.134 \times 10^4 \text{ mol}^{-1} \text{ L}$ . The polymer obtained in surfactant medium is sparingly soluble in benzene and DMSO. From infrared spectra clear evidence of vinyl polymerization was obtained. (Edited author abstract) 9 refs.

Panda, Rahas B. (Sambalpur Univ, Jyoti Vihar, India); Patel, N.; Sinha, B.K. *J Appl Polym Sci* v 35 n 8 Jun 1988 p 2193-2200.

**083248 EFFECT OF PRESSURE ON THE PRECIPITATION AND SOL-PHASE AQUEOUS POLYMERIZATION OF METHYL METHACRYLATE.** Effect of pressure (atmospheric to 120 kg/cm<sup>2</sup>) on the  $\text{K}_2\text{S}_2\text{O}_8\text{-Na}_2\text{S}_2\text{O}_4$ -initiated aqueous polymerization of methyl methacrylate has been studied at 25°C. When the concentrations of the redox initiator are so adjusted as to obtain the separating polymer phase as a coarse coagulum, the conversion, rate, and molecular weight of polymerization tend to rise initially with increase of pressure up to a certain value and fall subsequently to a limiting value. However, these parameters fall monotonously with an increase in pressure when the polymer phase separates out as a fine colloid at a lower concentration of the initiator. The fall in the molecular weight with pressure is explained on the basis of enhanced monomer transfer. In the colloidal range the pressure dependence trend is related to the stability of the colloidal phase. The rate is proportional to the square root of the product of  $\text{K}_2\text{S}_2\text{O}_8\text{-Na}_2\text{S}_2\text{O}_4$  and varies linearly as the first power of the monomer concentration. (Edited author abstract) 16 refs.

Mohanty, Baijayantimala (Indian Inst of Technology, Kharagpur, India); Palit, Sunanda K.; Biswas, Mukul. *J Appl Polym Sci* v 35 n 8 Jun 1988 p 2247-2258.

## Testing

**083249 INSTRUMENTED FALLING WEIGHT IMPACT TESTING OF PMMA.** Instrumented falling weight impact tests have been conducted on polymethylmethacrylate (PMMA), a model material for the application of linear elastic fracture mechanics. It is shown that the siting of a force transducer has considerable effect on the results. With the transducer attached to the falling weight, signals simply reflected resonances within the system. Attempts to filter the signal either electrically or digitally failed to extract meaningful information, and were abandoned in favor of incorporation of the transducer in the solid base of the equipment. (Edited author abstract) 14 refs.

Younan, H. (Imperial Coll of Science & Technology, London, Engl); Hodgkinson, J.M.; Williams, J.G. *Plast Rubber Process Appl* v 8 n 4 1987 p 227-233.

## Thermal Effects

**083250 THERMAL DEGRADATION OF SATURATED POLY(METHYL METHACRYLATE).** The author has determined the Arrhenius activation parameters for degradation of saturated PMMA. We believe this is the first accurate determination of these parameters for PMMA. By studying the degradation of low molecular weight PMMA (so that  $\text{zip} \gg \text{DP}$ ) that is completely saturated and has a narrow polydispersity, we have determined accurate Arrhenius parameters for random chain scission in PMMA. Experimental evidence shows that the process occurs with an Arrhenius preexponential



factor of approx.  $2 \times 10^{16} \text{ s}^{-1}$ . 11 refs.

Manning, Lewis E. (DuPont, Wilmington, DE, USA). *Macromolecules* v 21 n 2 Feb 1988 p 528-530.

## Thermodynamic Properties

**083251 ADIABATIC HEATING IN POLY(METHYL METHACRYLATE) AT HIGH HYDROSTATIC PRESSURES.** Recently we reported the adiabatic method to determine the temperature changes in poly(methyl methacrylate) (PMMA) resulting from the rapid application of hydrostatic pressures at different reference temperatures. In that report the ratio of the temperature change to the pressure change was represented by a quadratic equation. In this note we report the analysis of our experimental results for poly(methyl methacrylate). It is shown that thermoelastic experiments dealing with adiabatic heating under rapid applications of hydrostatic pressures afford a new approach to evaluate important thermal properties of viscoelastic materials. 16 refs.

Rodriguez, E.L. *J Polym Sci Part B* v 26 n 2 Feb 1988 p 459-462.

## Thin Films See PHOTORESISTS.

**POLYOLEFINS** See Also POLYAMIDES—Mechanical Properties; THERMOPLASTIC ELASTOMERS—Mechanical Properties.

## Antioxidants

**083252 ANTIOXIDANTS.** Polyolefins are usually process stabilised using a blend of phenolic antioxidants with phosphites and phosphonites. Long-term heat stability is achieved principally with high molecular weight phenolic antioxidants possibly in combination with thioether-based synergists. A more recent development of this kind is based on the increasing use of high molecular weight sterically hindered amines (HALS - hindered amine light stabilisers). Antioxidants are generally used in concentrations of between 0.03 and 0.3% w/w although higher levels may be required for special applications. It is expected that the long established commercial antioxidants will maintain their market dominance. Additional blends of phosphites with phenolic antioxidants will be introduced. For reasons of handling safety, non-dusting grades will increase in importance. Market segmentation will continue and antioxidant-stabiliser systems will be made available to meet specific requirements in special applications. High molecular weight HALS, i.e., light stabilisers, will probably be utilised increasingly to increase the thermal stability of polyolefins in particular. 9 refs.

Gugumus, F. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 84-86.

**083253 THE MECHANISM OF THE EFFECT OF HINDERED AMINES ANTIPHOTOOXIDATION OF POLYOLEFINE.** The effects of a model piperidine compound, 2,2,6,6-tetramethyl-piperidine (I), and its corresponding N-oxyl derivative, 2,2,6,6-tetramethyl-piperidinoxy, free radicals (II), on scavenging free radicals, decomposing hydroperoxide and quenching of the excited state were examined. Both compounds can scavenge the free radicals generated from cleavage of the initiator AIBN, but the effect is not significant. Both (I) and (II) can decompose t-BuOOH and play an important role in the antiphotooxidation of the polyolefines. The results imply that there is a multifunctional role played by hindered amines in protecting the light sensitive polyolefines from photodegradation. (Edited author abstract). 4 Refs.

Chen, Yanmo. *J China Text Univ Engl Ed* v 4 n 2 Dec 1987 p 24-30.

**Applications** See ADHESIVES—Hot Melt; PACKAGING MATERIALS—Plastics.

## Crosslinking

**083254 METHODS AND BENEFITS OF CROSSLINKING POLYOLEFINS FOR INDUSTRIAL APPLICATIONS.** The silane grafting route to the crosslinking of polyolefins can open up wide areas of application not easily attained by the conventional techniques of peroxide addition or irradiation. The thermal limitations on processing and cure rates imposed by the former; and the high capital cost, thickness and shape limitations imposed by the latter are dispelled when a two step grafted system is employed. The technology involves the chemical grafting of an easily hydrolysable vinyl silane onto a polyolefin chain. This paper outlines property levels attainable with specific reference to well established as well as developing areas of application. A wide range of products is covered including electrical cable insulation, hot water pipe, adhesives, floorings, foams, heat shrink products and packaging. (Edited author abstract)

Beveridge, Colin (AEI Cables Ltd, Gravesend, Engl); Sabiston, Andrew. *Mater Des* v 8 n 5 Sep-Oct 1987 p 263-268.

## Crystallization

**083255 X-RAY INVESTIGATIONS OF THE FORMATION OF CORE-FIBRILS CRYSTALLIZED OUT OF THE ORIENTED MELT.** Crystallization models for the formation of core-fibrils crystallized from the oriented melt are discussed by comparing results from X-ray experiments with theoretical predictions. The systems isotactic polypropylene-poly (1-butene) and isotactic polypropylene - atactic polypropylene have been chosen. From wide angle X-ray scattering, the thicknesses of the core-fibrils, lattice distortions, and unit-cell parameters have been determined. Interface distribution functions have been used to evaluate the axial morphology of the fibers from meridional small angle X-ray scattering curves. It appears that the morphological predictions made by the crystallization models of Pennings and of Hoffman cannot be confirmed by the experimental findings. The diffusion model proposed by Petermann partially describes the morphological properties of the core-fibrils. (Edited author abstract) 25 refs.

Wenig, W. (Univ-GH-Duisburg, Duisburg, West Ger); Schoeller, T. *Colloid Polym Sci* v 266 n 5 May 1988 p 411-418.

## Curing See RUBBER, SYNTHETIC—Processing.

**Degradation** See Also POLYMERS—Degradation; POLYPROPYLENE—Thermooxidation.

**083256 OXIDATION OF HINDERED AMINE LIGHT STABILIZERS TO NITROXY RADICALS IN SOLUTION AND IN POLYMERS.** Cyclohexane and three polyolefins (PE, PP and EPM) have been oxidized by  $\gamma$ -irradiation, and the concentration of nitroxyl radicals derived from a typical HALS added either before or after irradiation has been studied by ESR spectroscopy. The results indicate that HALS is rapidly oxidized by peroxy radicals under irradiation and that afterwards it can be oxidized more slowly by hydroperoxides. This last reaction is, however, very limited. (Author abstract) 13 refs.

Geuskens, G. (Univ Libre de Bruxelles, Brussels, Belg); Nedelkos, G. *Polym Degradation Stab* v 19 n 4 1987 p 365-378.

## Extrusion See PIPE, STEEL—Protective Coatings.

## Filaments

**083257 POLYOLEFIN FIBRILS OBTAINED FROM HIGH PRESSURE SPINNING AND THEIR PAPER-LIKE SHEETS FORMED BY SOLVENT PROCESS.** The production process of microfibrillar materials or fibrils in which polyolefinic polymers are spun through an orifice under high temperature and high pressure is called flash spinning. A study was made to determine the high strength fibril producing conditions by dry-spinning a solution of polypropylene in dichlorometh-

ane through an orifice at high temperature and high pressure. The water system used in conventional paper forming processes is not applicable in forming a sheet of polyolefin fibrils. In order to develop a solvent system for a sheet forming process capable of dealing with hydrophobic fibrils, a comparative study of various solvents was made to determine how the solvent might facilitate the sheet-forming operation. Solvents having solubility parameters near those of polypropylene promoted the formation of paper-like sheets of fibrils with satisfactory physical properties. (Edited author abstract) In Japanese. 6 refs.

Sakai, Kiyoshi (Mitsubishi Rayon Engineering Co, Tokyo, Jpn); Okumura, Munehiro; Kawamura, Tomohiko; Nakatsui, Hiroshi. *Kobunshi Ronbunshu* v 44 n 7 1987 p 523-530.

## Fillers

**083258 SYNTHESIS OF ALUMINOTITANATE DRESSINGS FOR FILLED POLYOLEFIN COMPOSITIONS.** The authors have developed complex aluminotitanate dressing agents. The compounds are viscous liquids or waxy solids with relatively low melting points; they are soluble in most organic solvents and are sufficiently resistant to hydrolysis. The compounds were prepared by reacting a mixture of tetraalkyltitanate and trialkyl-aluminate with a higher aliphatic acid in the required ratio in an aromatic solvent, with simultaneous azeotropic distillation of the alcohols formed in the ester interchange. The dressing activity of the aluminotitanate acylates was evaluated on the system liquid petrotulatum-aluminum hydroxide (filler content 50 mass%), used to simulate polyolefin compositions with high filler contents. It is shown that preliminary modification of the aluminum hydroxide with the synthesized compounds (1% of the filler mass) efficiently reduces the dynamic viscosity of the compositions: at minimum shear rates the viscosity of the system decreased approximately by a factor of 100. 10 refs.

Sosnovskii, G.M. (V.I. Lenin Byelorussian State Univ, USSR); Priytskaya, T.S.; Astapovich, I.V. *J Appl Chem USSR* v 60 n 7 pt 2 Jul 1987 1507-1509.

## Film See PLASTICS FILMS—Surface Properties.

## Flame Resistance

**083259 USE OF WATER-GROUND MICA IN POLYOLEFINS.** Highly delaminated muscovite mica products (WG-1 and WG-2) have been developed by J.M. Huber Corp. The micas are characterized as a 325-mesh product having high brightness and very narrow particle size distribution. At 40% loading in polypropylene, WG-1 mica provides substantial improvement in tensile modulus and equal tensile strength to unfilled polymer; in high-density polyethylene (HDPE), WG-1 provides four times the tensile modulus and a 50% increase in tensile strength over unfilled polymer. Surface modification of the water-ground mica (SM) provides substantial improvement in tensile strength over untreated mica at greater than 20% loading in polypropylene; in HDPE, tensile strength is twice that of unfilled polymer. (Author abstract) 3 refs.

Marshall, C.J. (J.M. Huber Corp, Macon, GA, USA); Kunkle, A.C. *Min Eng (Littleton Colo)* v 39 n 11 Nov 1987 p 1021-1026.

## Foam

**083260 COMPRESSION MODULI OF SOME PMP MICROCELLULAR FOAMS.** The elastic moduli of poly(4-methyl-1-pentene) foams made by several processes are measured. The results reveal that several terms need to be added to the currently accepted mathematical representation. Thus, the amount of noncontributing mass and the efficiency of the contributing mass must be considered along with the isotropic reduction in total mass. The mathematical equation derived gives new insight into the structure and properties of microcellular foams. (Author abstract) 9 refs.



Williams, Joel M. (Los Alamos Natl Lab, Los Alamos, NM, USA). *J Mater Sci* v 23 n 3 Mar 1988 p 900-904.

## Injection Molding

**083261 PROJEVY STRUKTURY REALNYCH VYSTRIKU Z POLYOLEFINU.** [Manifestations of Structure in Polyolefin Injection Mouldings]. Gate area structure of real HDPE and PP injection moldings of an intricate shape was investigated by light microscopy in polarized light. Three types of arrangements were distinguished in this particular area, namely closed, half-open, and open interconnections of layers. Such an arrangement gives rise to a greater number of defects depending on process and design conditions. Also, the gate region of the injection moldings studied turned out to be the only sensitive place capable of responding structurally to changes in technology. (Edited author abstract) In Czech. 3 refs.

Krsova, Alena (Statni Vyzkumny Ustav Materialu, Prague, Czech); Neuhausl, Emil. *Plasty Kauc* v 24 n 10 Oct 1987 p 292-296.

## Manufacture

**083262 RETEC POLYOLEFINS V: FIFTH INTERNATIONAL CONFERENCE ON POLYOLEFINS.** This conference proceedings contains 55 papers of which 1 is given in abstract form only. Topics covered include: grade change flexibility; additive addition; ethylene copolymer market developments; recent developments in powder to pellets conversion; the rotary extruder; corotating disk processor; the Dray concept in screw design; polyolefin additives; polyolefin processing aids; synthetic liners; HDPE fuel tanks; chlorinated polyethylene elastomers; rheological measurements for quality control; statistical process control; quality problems of multi-component plastic products; specialty polyolefins for use in flexible packaging; Exxon's melt blowing process; stabilization of polypropylene fibers and tapes for textile and geotextile applications; rigid polyolefin containers; scrap regeneration; and, coextrusion of polycarbonate with polyolefins in blow molding applications. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11636 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Soc of Plastics Engineers, South Texas Section, USA). *RETEC Polyolefins V: Fifth Int Conf on Polyolefins, Houston, TX, USA, Feb 1987* Publ by Soc of Plastics Engineers, Brookfield Cent, CT, USA, 1987 796p.

## Mechanical Properties See Also COPOLYMERS—Oxidation.

**083263 PROPERTY CORRELATIONS FOR DOUBLY ORIENTED POLYMERS PREPARED BY THE ROLLTRUSION TECHNIQUE.** The authors comment on some of the salient features which have been found for polyethylene and polypropylene and which have not yet been emphasized. Tensile strength and wear behavior are chosen to illustrate relationships. It is apparent that the trends observed in these engineering properties can be related primarily to changes in the 'amorphous' intercrystallite regions of the materials, the orientation and properties depending primarily upon processing conditions. 17 refs.

Magill, J.H.; Sun, D.C.; Shankernarayanan, M.J. *J Appl Polym Sci* v 34 n 6 Nov 5 1987 p 2337-2343.

**083264 MECHANICAL PROPERTIES AND MOLECULAR MOBILITY IN ORIENTED POLYOLEFINS.** The temperature dependence of the static elastic modulus and correlation time of rotation of 2, 2, 6, 6-tetramethylpiperidine-1-oxyl has been studied at  $210 < T < 370$  K for oriented films of isotactic polypropylene and low- and high-density polyethylene. A parallel trend has been demonstrated in the changes in elastic modulus and correlation time of rotation during the heating and orientation of the polymer, which is evidence that the most defective part of the amorphous phase where

the probes are located plays an important part. The proportion of tie chains has been assessed and does not exceed 7%. (Author abstract) 20 refs.

Krisyuk, B.E. (USSR Acad of Sciences, USSR); Popov, A.A.; de Candia, F.; Vittoria, V.; Russo, R. *Polym Sci USSR* v 23 n 12 Dec 1987 p 2844-2851.

## Melting

**083265 HEAT OF FUSION OF POLY(4-METHYLPENTENE-1).** The heat of fusion of perfectly crystalline poly(4-methylpentene-1) (P4MP1),  $\Delta H_u$ , has been determined by two methods. Melting point depressions (A) in concentrated solutions in naphthalene and cyclododecane, and in infinitely dilute solutions in 39 solvents, led to  $\Delta H_u = 5.5 \pm 0.3$  kJ mol<sup>-1</sup> ( $65 \pm 4$  J g<sup>-1</sup>). The second method (B) involved new measurements of the crystalline volume  $V_{uc}$  as a function of temperature, in order to calculate  $\Delta H_u$  from the Clausius-Clapeyron equation: extrapolation to the melting point gave  $V_{uc} = 109.2$  cm<sup>3</sup> mol<sup>-1</sup>. There is at present no reason to prefer one set of values to the other, although the degree of crystallinity estimated from the low  $\Delta H_u$  and the experimental heat of fusion is in the 75-85% range, in excellent agreement with x-ray diffraction data. Depending on the selected  $\Delta H_u$ , the entropy of fusion is either similar or lower than for other branched polyolefins. The results are discussed in terms of order in the melt, order seemingly relevant to the understanding of the mechanism of formation of the noncrystalline thermoreversible gels of P4MP1. (Edited author abstract) 45 refs.

Charlet, Gerard (Univ Du Quebec, Montreal, Can); Delmas, Genevieve. *J Polym Sci Part B* v 26 n 5 May 1988 p 1111-1125.

## Microstructure

**083266 ETHYLENE-CHLOROTRIFLUOROETHYLENE COPOLYMERS. II. EFFECTS OF STRUCTURE ON RESISTANCE TO THERMAL STRESS CRACKING.** Copolymers of ethylene and chlorotrifluoroethylene that contain small amounts of units derived from perfluorohexylethylene show improved resistance to thermal stress cracking. This is a consequence of effects of these units on structural parameters of both the crystalline and amorphous phases. Those of the crystalline phase entail growth and organization of lamellae, whereas those of the amorphous phase are related to conformation and packing of polymer chains. The crystalline phase consists exclusively of alternately arranged units of ethylene and chlorotrifluoroethylene. The amorphous phase is characterized by chain segments composed of randomly distributed units derived from ethylene, chlorotrifluoroethylene, pairs of these two units, and units derived from perfluorohexylethylene. (Author abstract) 3 refs.

Reimschuessel, H.K. (Allied-Signal Corp, Morristown, NJ, USA); Marti, J.; Murthy, N.S. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 43-59.

## Molecular Structure See POLYPROPYLENE—Radiation Effects.

## Molecular Weight

**083267 MOLECULAR WEIGHTS OF POLYETHYLENE AND POLYPROPYLENE BY VAPOR PRESSURE OSMOMETRY AT ELEVATED TEMPERATURES.** The Wescan Model 232-A VPO was modified with a 12-volt regulated power supply for supplying bridge current and with thermocouples to allow for direct digital readout of the syringe box and measuring chamber temperatures. The modified instrument was used to measure number-average molecular weights ( $M_n$ ) of standard (NBS) polyethylenes. Agreement with NBS values was good (within 10%) for  $M_n < 3 \times 10^4$  and fair (within 20%) for  $M_n = 1 \times 10^5$ . Results on  $M_n$  of commercial polypropylenes are also reported. (Author abstract) 3 refs.

Mays, J.W. (Hercules Inc, Wilmington, DE, USA); Gregory, E.G. *J Appl Polym Sci* v 34 n 7 Nov 20 1987

p 2619-2622.

## Morphology See POLYETHYLENES—Linear Low Density; POLYPROPYLENE—Radiation Effects.

## Oxidation

**083268 ON THE NATURE OF PURPLE HYDROCARBON - THE OXIDANT FOR POLYOLEFINS.** Phase-transferred permanganate is found to be an oxidant for polyolefins. The nature of this oxidant, which is an ion pair comprising a lipophilic cation and permanganate ion—depends upon the catalyst cation used. The lower is the stability constant, the greater is the oxidizing capacity. (Edited author abstract) 7 refs.

Konar, J. (IIT, Kharagpur, India); Ghosh, R.; Banthia, A.K. *Polym Commun (Guildford Engl)* v 29 n 2 Feb 1988 p 36-37.

**083269 MODEL STUDIES OF THE INTERACTION OF Cu<sup>2+</sup> IONS WITH ETHANEDIOIC ACID BIS[(1-PYRENYLMETHYLENE)HYDRAZIDE].** The chelating properties of ethanedioic acid bis[(1-pyrenylmethylene)hydrazide] (OAPH) with Cu<sup>2+</sup> and Pb<sup>2+</sup> in solution are investigated by fluorescence quenching measurements. In ethanol, the formation of ground-state complexes is observed with association constants of  $K_c = 1.5 \times 10^6$  M<sup>-1</sup> and  $1.3 \times 10^6$  M<sup>-1</sup> for Cu<sup>2+</sup> and Pb<sup>2+</sup>, respectively. Pb<sup>2+</sup> ions retard the excimer-like emission of OAPH in favor of monomer emission, indicating a conformational change upon chelation. The importance of these results in determining the mechanism of the inhibition of Cu<sup>2+</sup> catalyzed thermal oxidation in polyolefins by the addition of bis-hydrazides is discussed. (Author abstract) 44 refs.

Blatt, Edward (CSIRO, Melbourne, Aust); Hodgkin, Jonathan; Loder, John; Mau, Albert W.-H.; Sasse, Wolfgang H.F.; Ghiggino, Kenneth P. *Polym Degradation Stab* v 20 n 1 1988 p 75-88.

**083270 OXIDATION PROCESSES IN BLUE WATER PIPE.** The thermal, hydrolytic and photochemical oxidation of blue water pipe material has been studied using Fourier Transform infra-red microscopy, differential scanning calorimetry (DSC) and hydroperoxide analysis. The results indicate that oxidation of the pipe occurs predominantly on the outer surface and to a lesser extent on the bore, often with little or no change in the middle layers. FTIR analysis of microtomed sections of the pipe supports the DSC analysis (oxidation induction time at 200°C - OIT) and indicates leaching and consumption of the polymer antioxidants at the outer surface of the pipe. Oxidation profiles at 80°C in water, as measured using carbonyl index, indicate an unusual hydrolytic oxidation and extraction of the carboxylic oxidation products only at the outer pipe surface to a depth of about 0.5 mm resulting in high hydroperoxidation levels. These oxidation analyses are consistent with density profile changes through the pipe. (Edited author abstract) 7 refs.

Allen, N.S. (Manchester Polytechnic, Manchester, Engl); Marshall, G.P.; Vasilou, C.; Moore, L.M.; Kotecha, J.L.; Luc-Gardette, J.; Valange, B. *Polym Degradation Stab* v 20 n 3-4 1988, Polym Addit in Stab: Perform and Mech, Birmingham, Engl, Sep 2-4 1987 p 315-324.

## Physical Properties See Also POLYMERS—Physical Properties.

**083271 RHEOLOGICAL PROPERTIES AND CRYSTALLINE STRUCTURE OF THE DYNAMICALLY CURED EPDM AND PP/HDPE TERNARY BLENDS.** The rheological properties and crystalline structure of the polyolefin ternary blends of EPDM/polypropylene/high density polyethylene were studied. Blends were prepared in a laboratory internal mixer by two different methods. In blend-cure process, blending and curing were performed simultaneously and EPDM was cured by dicumyl peroxide (DCP) in the presence of PP/HDPE under shear. The cure-blend was to cure EPDM alone first under shear (dynamic curing) and then mix the cured EPDM with P and HDPE. The effect of



DCP concentration, intensity of the shear mixing, and the rubber/plastic composition were studied using capillary rheometer and X-ray diffractometer. The PP-rich ternary blends showed the effect of the mechanooxidative degradation of PP by shear and peroxide. The melt viscosity increased with increasing DCP concentration in blends of EPDM-rich compositions. (Edited author abstract) 21 refs.

Ha, Chang Sik (Pusan Natl Univ, Pusan, South Korea); Kim, Sung Chul. *J Appl Polym Sci* v 35 n 8 Jun 1988 p 2211-2221.

**083272 MORPHOLOGY AND RHEOLOGICAL PROPERTIES OF POLYPROPYLENE-LINEAR LOW DENSITY POLYETHYLENE BLENDS.** The dynamic shear viscosity and the morphology of polypropylene homopolymer and copolymer blended with linear low density polyethylene are studied. A maximum in the dynamic shear viscosity vs. blend composition is reported for the polypropylene copolymer, linear low density polyethylene system. The increasing dynamic shear viscosity is in accordance with the occurrence of a morphology of polyethylene inclusions in rubber surrounded by a polypropylene matrix. (Edited author abstract) 39 refs.

Levij, M. (DSM Research BV, Geleen, Neth); Maurer, F.H.J. *Polym Eng Sci* v 28 n 10 May 1988 p 670-678.

**083273 POLYOLEFIN PROPERTIES FOR RIGID FOOD PACKAGING.** Some of the physical and sorption properties of polyolefins that are critical to rigid plastic packages are discussed. Initially, a brief review of the performance requirements of plastic food packages will be presented. This is followed by discussions of specific properties of polyolefins such as impact resistance, adhesion and thermal resistance, and how they may be enhanced by coextrusion. Additionally, the sorption of food components such as flavors into polyolefin walls of packages is discussed. Here, the applicable theoretical considerations for sorption and their value for analyzing experimental data are presented. (Edited author abstract). 9 Refs.

Jabarin, S.A. (Univ of Toledo, Toledo, OH, USA); Kollen, W.J. *Polym Eng Sci* v 28 n 18 Sep 1988 p 1156-1161.

## Radiation Effects

**083274 STRUCTURAL CHANGES INDUCED BY  $\gamma$ -RAYS ON MODEL LINEAR ETHYLENE-BUTENE COPOLYMERS.** Well characterized model copolymers are used to study the effects of ionizing radiation. Linear copolymers of ethylene and butene-1 with uniform chemical microstructure and very narrow molecular weight distributions are irradiated at room temperature with  $\gamma$ -rays from a  $^{60}\text{Co}$  source. Changes in the molecular hydrodynamic volume can be readily detected by GPC. Changes in molecular weight averages  $M_n$  and  $M_w$  are measured by membrane osmometry and light scattering. Cross linking seems to be the main effect of radiation and chain scission is negligible up to the gel point. The very uniform molecular structure and size in the non-irradiated polymer allows for the use of a completely general model to correlate changes in molecular weight averages and branching. The model is suitable for linear polymers with reactive groups randomly distributed along the chain, and contains no simplifying approximations. (Author abstract) 23 refs.

Andreucetti, N.A. (Lab de Radioisotopos, Bahia Blanca, Argent); Curzio, O.A.; Valles, E.M.; Carella, J.M. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 663-670.

**Reaction Kinetics** See POLYPROPYLENE—Oxidation.

**Research** See ORGANIC COMPOUNDS—Synthesis.

## Spectroscopic Analysis

**083275 TWO-DIMENSIONAL INADEQUATE NMR SPECTRA OF ETHYLENE-PROPYLENE COPOLYMER.** Recently,  $^{13}\text{C}$  double quantum two-dimensional spectroscopy (2D INADEQUATE) has been reported and proved to be useful for elucidation of the connectivity of carbon atoms. This method detects a pair of  $^{13}\text{C}$  atoms in natural abundance coupled to each other by suppressing large singlet signals arising from single  $^{13}\text{C}$  atoms. In this paper we report the results of the application of the 2D INADEQUATE to assign the  $^{13}\text{C}$  signals of ethylene-propylene copolymer. 13 refs.

Hikichi, Kunio (Hokkaido Univ, Sapporo, Jpn); Hiraoki, Toshifumi; Ikura, Mitsuhiro; Higuchi, Keiichi; Eguchi, Keiji; Ohuchi, Muneki. *Polym J* v 19 n 11 1987 p 1317-1320.

## Stability

**083276 MECHANISM OF SYNERGISTIC STABILIZATION BY HINDERED AMINES.** Tetramethyl piperidine (TMP) and several derivatives have been studied for their activities in various modes of polymer stabilization. The derivatives are tetramethyl piperidinoxyl (TMPO), N-hydroxy tetramethyl piperidine (TMPOH), N-butoxy tetramethyl piperidine (TMPOB) where R is n-butyl and t-butyl, and N-methyl tetramethyl piperidine (TMPOMe moiety of Tinuvin 292) as well as some commercial HALS (hindered amine light stabilizer). The results showed that all the TMP derivatives, with perhaps the lone exception of TMPOB, exhibit individually only modest stabilization of some kind. For certain stabilizer functions there are combinations of compounds which are strongly synergistic. If these derivatives were produced during processing or aging of polyolefins containing HALS, their combined actions could explain the outstanding effectiveness of HALS. (Edited author abstract) 58 refs.

Yang, Xun-Zhuan (Univ of Massachusetts, Amherst, MA, USA); Chen, Yanmo; Dickinson, L. Charles; Chien, James C.W. *Polym Degradation Stab* v 20 n 1 1988 p 1-35.

## Stabilizers

**083277 STABILIZATION OF POLYOLEFINS FOR APPLICATIONS IN EXTRACTIVE MEDIA.** Polyolefins have long passed the stage where they were regarded as a low-price material for short-life articles with throwaway character. By developing efficient antioxidants and sophisticated formulations, it has become possible to control one of their major disadvantages, namely the oxidation sensitivity during processing and long-term service. An interesting combination of interesting technological properties such as good processability due to low melt viscosity, considerable hardness and stiffness in the cooled stage, high toughness and elasticity, high chemical resistance and good slip properties has opened the way for polypropylene (PP) and high density polyethylene (HDPE) into fields of application which can certainly be described as 'high-performance'. In numerous cases, polyolefins used as container materials or as a component part of transport systems are not only exposed to oxygen-containing atmosphere, but are temporarily or over their entire service life exposed to a more or less pronounced extraction behaviour.

Pfahler, G.; Loetzsch, K. *Kunstst Ger Plast* v 78 n 2 Feb 1988 p 21-24.

**083278 CRITIQUE ON STABILIZATION TECHNOLOGY IN POLYOLEFINS.** Unstabilized polyolefins are prone to several degradation reactions during the different stages of compounding/processing/fabrication, with catastrophic consequences on product stability and in-service performance. The level of protection afforded by a stabilizer system against the deleterious effects of mechanical, thermal, thermo- and photooxidative degradation reactions is governed by several factors which include both physical and chemical characteristics of the substrate and stabilizer, the environment, and the applica-

tion of stress. In considering the practical aspects for the selection of a stabilizer system, due regards must be given to the structural nonhomogeneity of polyolefins, and to stabilizer substantivity and stability as well as its intrinsic activity. The stabilizer function is examined here in the light of current understanding of the behavior of functions of antioxidants and stabilizers. Several examples are included to reinforce the mechanistic aspects of different classes of antioxidants. (Edited author abstract) 14 refs.

Al-Malaika, S. (Aston Univ, Birmingham, Engl). *Polym Plast Technol Eng* v 27 n 2 Jun 1988 p 261-301.

**083279 INTERACTION OF  $\text{Cu}^{2+}$  WITH ETHANEDIOIC ACID BIS-HYDRAZIDES.** The chelating properties of oxalyl dihydrazide and a series of ethanedioic acid bis-hydrazides with  $\text{Cu}^{2+}$  in solution have been investigated by UV absorption and fluorescence quenching measurements. The UV absorption data indicate 1:1 complexation with equilibrium constants in the range  $K_C = 0.57\text{--}2.1 \times 10^6 \text{ mol}^{-1}$  for the bis-hydrazides and  $K_C = 8 \times 10^4 \text{ mol}^{-1}$  for oxalyl dihydrazide. The fluorescence quenching data for the 1-pyrenyl derivative confirm  $\text{Cu}^{2+}$  complexation. The relevance of these finds to the role of ethanedioic acid bis-hydrazides as  $\text{Cu}^{2+}$  chelating agents in polymers is discussed. (Author abstract). 28 Refs.

Blatt, E. (CSIRO, Victoria, Aust); Griesser, H.J.; Loder, J.W.; Mau, A.W.-H. *Polym Degradation Stab* v 21 n 4 1988 p 335-343.

**Structure** See Also COMPOSITE MATERIALS—Oxidation.

**083280 EFFECT OF CRYSTALLIZATION CONDITIONS ON STRUCTURE AND DIELECTRIC PROPERTIES OF POLYOLEFINS.** An increase in the cooling rate of a melt of PE and PP leads to a substantial drop in the  $T_g$ , degree of crystallinity, inductive capacity and in the tangent of the angle of dielectric losses at low frequencies. The non-equilibrated structure of PE and PP films prepared by quenching the melt at  $77^\circ\text{K}$ , is transferred to an equilibrium state after heating up to room temperature. This transition is accompanied by an increase in the tangent of the angle of dielectric loss as  $T_g$  decreases due to a relaxation of internal stresses and an increase in the degree of crystallinity. (Author abstract) 15 refs.

Barinov, M.A. (Azerbaijan Acad of Sciences, USSR); Nikol'skii, V.G.; Magerramov, A.M.; Fazlyev, F.A.; Kochervinskii, V.V.; Mironov, N.A. *Polym Sci USSR* v 29 n 1 Jan 1988 p 95-100.

## Synthesis

**083281 LIVING CARBOCATIONIC POLYMERIZATION: XV. TELECHELIC POLYISOBUTYLENES BY THE  $\text{CH}_3\text{O}(\text{CH}_2)_2\text{C-pC}_6\text{H}_4\text{C}(\text{CH}_3)_2\text{OCH}_3 \cdot \text{TiCl}_4$  INITIATING SYSTEM.** The synthesis of symmetrical linear telechelic polyisobutylenes (PIB) carrying  $-\text{CH}_2\text{C}(\text{CH}_3)_2\text{Cl}$  end groups has been accomplished by living isobutylene (IB) polymerization using the  $\text{CH}_3\text{O}(\text{CH}_2)_2\text{C-pC}_6\text{H}_4\text{C}(\text{CH}_3)_2\text{OCH}_3 \cdot \text{TiCl}_4$  initiating system in  $\text{CH}_2\text{Cl}/n\text{-C}_6\text{H}_{14}$  (40/60 v/v) at  $-80^\circ\text{C}$ . The living nature of the polymerization was demonstrated by linear  $M_n$  versus amount of PIB formed plots starting at the origin. Polymers with up to  $M_n = 126,000$  and  $M_w/M_n = 1.1$  have been prepared. The effect of temperature on the polymer structure has been investigated. Undesirable indanyl end groups which form in polymerizations even at  $-80^\circ\text{C}$  can be eliminated by preparing the initiating di-tert-ether  $\cdot \text{TiCl}_4$  complex in the presence of monomer. (Edited author abstract) 14 refs.

Kaszas, Gabor (Univ of Akron, Akron, OH, USA); Puskas, Judit; Kennedy, Joseph P. *Polym Bull (Berlin)* v 18 n 2 Aug 1987 p 123-130.



**083282 FUNCTIONAL POLYMERS LI: CHARACTERIZATION AND PROPERTY ANALYSIS OF  $\omega$ -FUNCTIONALLY SUBSTITUTED POLYOLEFINS: NOVEL POLYOLEFIN IONOMERS.** Homopolymers of 2,6-dimethylphenyl 10-undecenoate and copolymers of 2,6-dimethylphenyl 10-undecenoate with  $\alpha$ -olefins, prepared by coordination initiators using aluminum activated titanium trichloride, and the corresponding sodium carboxylate and carboxylic acid derivatives have been characterized. IR and NMR investigations gave the normal spectral characteristics typical for ester-substituted polyolefins and their derivatives. The thermal behavior of the polymeric esters, investigated by differential scanning calorimetry, showed glass transitions characteristic of poly( $\alpha$ -olefins). Polymeric acids and salts presented quite different behavior. (Edited author abstract) 21 refs.

Purgett, Mark D. (Univ of Massachusetts, Amherst, MA, USA); Macknight, William J.; Vogl, Otto. *Polym Eng Sci* v 27 n 19 Oct 1987 p 1461-1468.

## Thermal Properties

**083283 THERMAL PROPERTIES OF BINARY POLYOLEFIN BLENDS.** The thermal properties of binary polyolefin blends (LDPE/HDPE, LDPE/PP, HDPE/PP) were examined by differential scanning calorimetry. The addition of a second polymer lowers the melting temperature although the melting temperature depression is not a defined function of the blend composition. DSC curves show two melting and two crystallization temperatures. The difference between crystallization temperatures for blends containing PP is smaller than the difference between melting temperatures. The enthalpies of fusion are nearly monotonic functions of blend composition. (Author abstract). 6 Refs.

Malavasic, T. (Boris Kidric Inst of Chemistry, Maribor, Yugoslavia); Musil, V. *J Therm Anal* v 34 n 2 Mar-Apr 1988 p 503-508.

**Thermooxidation** See POLYPROPYLENE—Antioxidants.

**Wetting** See POLYETHYLENES—Bonding.

## POLYPEPTIDES

### Adsorption

**083284 FORCES BETWEEN MODEL POLYPEPTIDES AND PROTEINS ADSORBED ON MICA SURFACES.** The forces of interaction between proteins and model polypeptides adsorbed onto mica have been measured as a function of the distance of separation between the mica surfaces in aqueous solution. Results were obtained for the basic polypeptide, poly-L-lysine, of molecular weight 4,000 and 75,000, cytochrome c, concanavalin A and myelin basic protein. For cytochrome c, no interaction between the adsorbed protein layers was noted until the surfaces were separated by 12.5 nm whereupon an attraction was measured, indicating that the negatively charged mica had been neutralized by adsorption of the positively charged cytochrome c. (Edited author abstract) 32 refs.

Afshar-Rad, T. (Imperial Coll, London, Engl); Bailey, A.I.; Luckham, P.F. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 125-146.

### Biodegradation

**083285 PREPARATION AND PROPERTIES OF CHARGED COPOLYPEPTIDE MEMBRANES AS BIODEGRADABLE MATERIALS.** Three component random copolypeptides consisting of N-hydroxyalkyl L-glutamine, L-glutamic acid, L-lysine were prepared by carrying out aminolysis reactions with aminoalcohols, such as 3-amino-1-propanol (P) or 5-amino-1-pentanol (Pe), followed by crosslinking reaction with octamethylenediamine (OMDA) on starting polymer membranes consisting of  $\gamma$ -methyl-L-glutamate (M), L-glutamic acid

(B), and L-lysine (K). The effective crosslink density was shown to be proportional to the content of the crosslinker (OMDA) in the reaction mixture. Biodegradation of the samples in vitro by pronase E and pepsin indicated that the degradation could be regarded as a bulk rather than a surface phenomenon. The rate of degradation was also highly dependent on the degree of swelling of membranes, as well as on the hydrophobicity and effective charge density of side chains of the samples. (Edited author abstract) 22 refs.

Hayashi, Toshio (Kyoto Univ, Kyoto, Jpn); Nakanishi, Eiji; Nakajima, Akio. *Polym J* v 19 n 9 1987 p 1025-1032.

**083286 ENZYMATIC DEGRADATION OF SEQUENTIAL POLYMERS CONTAINING A TRIPEPTIDE SEQUENCE L-ALANINE-L-LEUCINE- $\gamma$ -ETHYL L-GLUTAMATE AND AN  $\alpha$ -HYDROXY ACID L-LACTIC ACID OR  $\alpha$ -AMINO ACID L-ALANINE.** A study was made with the objective to obtain sequential polymers having good biocompatibility and biodegradability. For this purpose, a sequential polydepeptide of three  $\alpha$ -amino acids such as L-alanine (Ala), L-leucine (Leu), and  $\gamma$ -ethyl L-glutamate (Glu(OEt)) and one  $\alpha$ -hydroxy acid such as L-lactic acid (Lac), poly(Ala-Leu-Glu(OEt)-Lac), was synthesized by polycondensation of tetradepsipeptide active ester. The sequential polymers were then degraded by three kinds of enzymes, lipase as an esterase, papain as an endopeptidase, in order to learn the differences in enzymatic degradation between two polymers. The in vivo degradation was attempted by implanting the polymers subcutaneously in the back of rats, for the comparison with the above enzymatic degradation. 7 refs.

Asano, Masaharu (JAERI, Takasaki, Jpn); Yoshida, Masaru; Kaetsu, Isao; Katagai, Ryoichi; Mashimo, Tooru; Yuasa, Hisako; Imai, Kyoichi; Yamanaka, Hidetoshi. *Polym J* v 20 n 3 1988 p 281-284.

**Chemical Reactions** See PALLADIUM COMPOUNDS—Synthesis; POLYETHERS—Chemical Reactions.

### Crystallization

**083287 STUDIES ON SIDECCHAIN CRYSTALLIZATION OF POLY( $\gamma$ -N-ALKYL L-GLUTAMATE).** The sidechain crystallization of poly( $\gamma$ -n-alkyl L-glutamate)s (PALG) with n=10 to 18 has been studied. X-ray diffraction analysis indicates that the crystalline structures are triclinic for polymers with n  $\geq$  14. Crystalline spacings were found to be nearly the same for all the samples investigated. A small odd-even oscillation with n was observed in thermodynamics quantities such as melting temperature, and the associated enthalpy and entropy changes. The observed enthalpy  $\Delta H_f$  and entropy of melting  $\Delta S_f$  are compared with those reported for the other polymer systems including poly(alkyl acrylate)s and poly(alkyl maleimide)s. It is concluded that the disorientation of sidechains is the major contributor to observed values of  $\Delta H_f$  and  $\Delta S_f$ . (Edited author abstract) In Japanese. 13 refs.

Ono, Hirofumi (Tokyo Inst of Technology, Tokyo, Jpn); Watanabe, Junji; Abe, Akihiro. *Kobunshi Ronbunshu* v 45 n 1 1988 p 69-77.

### Elasticity

**083288 THEORETICAL STRESS-STRAIN ISOTHERMS FOR ELASTIN MODEL NETWORKS.** A theoretical analysis was carried out for polypeptides composed exclusively of one of the three highly conserved repeat sequences present in the biolastomer elastin. Conformational energy maps of the relevant amino acids were generated and a standard matrix method used. Various levels of intramolecular hydrogen bonding were studied. Monte Carlo techniques were used to evaluate the distribution functions of the end-to-end distance vector, from which the modulus as a function of elongation was calculated. With minor exception, the resulting stress-strain isotherms for chains having degree of polymerization 5 and 10 showed little deviation from Gaussian

behavior for elongation ratios up to 2. (Edited author abstract) 34 refs.

Debolt, L.C. (Univ of Cincinnati, Cincinnati, OH, USA); Mark, J.E. *J Polym Sci Part B* v 26 n 4 Apr 1988 p 865-874.

**Molecular Structure** See Also SURFACE ACTIVE AGENTS—Chemical Reactions.

**083289 TEMPERATURE-DEPENDENT  $\beta$  STRUCTURE-RANDOM COIL CONVERSION OF POLY(S-CARBOXYMETHYL-L-CYSTEINE).** The effect of temperature on the  $\beta$  structure-random coil conversion of poly(S-carboxymethyl-L-cysteine) has been examined on the following well defined systems: folded-chain  $\beta$  and extended-chain  $\beta$  structures. The conversion was reversible but the rate of  $\beta$  formation was very slow for both types of  $\beta$  structure. For folded-chain  $\beta$  structure, the rate of  $\beta$  formation decreased with decreasing polymer concentration. Optical activity associated with the  $n\pi^*$  transition of peptide chromophore scarcely changed with the temperature-induced  $\beta$ -coil conversion. (Author abstract) 31 refs.

Fukada, Kazuhiro (Nagoya Univ, Nagoya, Jpn); Maeda, Hiroshi; Ikeda, Shoichi. *Polymer* v 28 n 11 Oct 1987 p 1887-1892.

**083290 POLYMERIZATION AND CONFORMATIONAL STUDIES OF POLY(TRANS-3-ETHYL-D AND L-PROLINE).** Poly (L-trans-3-ethylproline), L-PT3EP, and poly(D-trans-3-ethylproline), D-PT3EP, were prepared by ring opening polymerization of the corresponding N-carboxyanhydrides (NCA) using triethylamine as an initiator. Using circular dichroism spectroscopy, it was shown that the incorporation of an ethyl group at the 3 position of the pyrrolidine ring caused a noticeable change in the conformational behavior of the polymer in solution. The ethyl group limited to some extent rotation of the polymer chain around the C $\alpha$ -CO bond and prevented the mutarotation between the two forms found in poly-L-proline polymers. (Author abstract) 18 refs.

Tiba, Omar (Univ of Michigan, Ann Arbor, MI, USA); Overberger, C.G. *J Polym Sci Part A* v 25 n 11 Nov 1987 p 2941-2952.

**083291 MIXED MONOLAYERS OF POLYPEPTIDES.** Mixed monolayers of two polypeptides, poly- $\gamma$ -methyl-L-glutamate and poly-L-alanine, in the same  $\alpha$ -helix surface conformation, were studied at the water/air interface. From a comparison of the experimental  $\pi$ -A isotherms with Huggins' theory and from the examination of the MIR spectra for the two components and their mixtures, it was possible to deduce that poly- $\gamma$ -methyl-L-glutamate and poly-L-alanine were totally miscible at the surface with prevalently attractive interactions and that the mixtures maintained the conformation of the two components. The low values of the interaction parameters, deduced by applying Joos' theory to the collapse pressures of the mixtures, demonstrated that the interactions were prevalently hydrophobic. (Author abstract) 16 refs.

Gabrielli, G. (Univ of Florence, Florence, Italy); Puggelli, M.; Dei, L.; Domini, C. *Colloid Polym Sci* v 266 n 5 May 1988 p 429-436.

### Processing

**083292 POLYMERIC PHOSPHOLIPID ANALOGS. XXII. A SYNTHETIC POLYPEPTIDE WITH PHOSPHOLIPID ANALOGS.** The authors prepared a synthetic polypeptide containing phospholipid analogs in the side chain. It is shown that in the IR spectrum of the reaction product, new absorption bands due to the stretching vibration of the hydroxy group and to the methylene groups appeared at 3250 and 2930 cm $^{-1}$ , respectively. The polymer was soluble in DMF, but almost insoluble in chloroform and acetone, and it exhibited a liquid crystalline phase from room temperature to 170°C. The same polymer was insoluble even in



DMF when dried completely in vacuo. 13 refs.

Nakaya, Tadao (Osaka City Univ, Osaka, Jpn); Shoji, Hajime; Imoto, Minoru. *J Macromol Sci Chem* v A25 n 1 1988 p 115-119.

## Production

**083293 PHOTOINDUCED CONFORMATIONAL TRANSITION OF POLYPEPTIDES CONTAINING AZOBENZENESULFONATE IN THE SIDE CHAINS.** Photoresponsive polypeptides, poly(L-glutamic acids) containing 1.9, 9.3 and 46.3 mol% azobenzenesulfonate moieties in the side chains (azo-S-PGA), have been prepared by condensation reaction of poly(L-glutamic acid) (PGA,  $M_v = 1.19 \times 10^5$ ) with 4-amino-1,1'-azobenzene-4'-sulfonic acid sodium salt in dimethylformamide solution and the photoresponsive behavior of the copolypeptides obtained was investigated. The dark-adapted azo-S-PGAs containing 1.9 and 9.3 mol% azobenzenesulfonate (azo-S) moieties showed a pH-dependent  $\alpha$ -helix to coil transition; however, the copolypeptide containing 46.3 mol% azobenzenesulfonate moieties was in the random coil conformation at any pH. (Edited author abstract) 25 refs.

Sato, Morimasa (Nagoya Inst of Technology, Nagoya, Jpn); Kinoshita, Takatoshi; Takizawa, Akira; Tsujita, Yoshiharu. *Macromolecules* v 21 n 6 Jun 1988 p 1612-1616.

## Research

**083294 THERMOTROPIC POLYPEPTIDES. 5. TEMPERATURE DEPENDENCE OF CHOLESTERIC PITCHES EXHIBITING A CHOLESTERIC SENSE INVERSION.** The cholesteric pitches were determined for the thermotropic cholesteric mesophases of poly(( $\gamma$ -benzyl L-glutamate)-co-( $\gamma$ -dodecyl L-glutamate)) with the dodecyl content of 58% in the wide temperature range from 100 to 250°C. The pitches in an initial temperature range 100-130°C are comparable to the wavelength of visible color and increase with rising temperature. After the pitches diverge at 195°C, they decrease as temperature is raised further. In contrast to this anomalous behaviour of pitches, the reciprocal pitches (measuring the twisting angles) vary smoothly with the temperature along a curve. The curve exhibits a remarkable variation of twisting angle at lower temperature and seems to approach a constant value at higher temperature, passing through zero at 195°C. (Edited author abstract) 22 refs.

Watanabe, Junji (Tokyo Inst of Technology, Tokyo, Jpn); Nagase, Tatsuya. *Macromolecules* v 21 n 1 Jan 1988 p 171-175.

## Solutions

**083295 ESR STUDY OF GEL-SOL TRANSITIONS OF POLY(L-LEUCINE)-BENZENE SOLUTION BY SPIN-LABELING TECHNIQUE.** An ESR study of poly(L-leucine)-benzene solution ranging in concentration from 0.1 to 6.0 wt% was carried out by spin-labeling technique in the temperature range from room temperature to 90°C. The ESR spectra of these samples showed that radicals undergo restricted motion in this temperature range. It was found that the line separation of the ESR spectrum changes remarkably around 50 and 70°C. These temperatures correspond to the temperatures of the gel-sol transitions, suggesting the existence of two kinds of gel states in these samples. Heats of dissociation of these gels were estimated at 160 and 42 kcal for a mol of network junctions, respectively, for the poly(L-leucine) with a number-average molecular weight of  $10^4$ . (Author abstract) 11 refs

Anada, Yuichi (Hokkaido Univ, Sapporo, Jpn); Tsutsumi, Akihiro; Hideshima, Teruo; Hikichi, Kunio; Yokoi, Jun; Tokura, Seiichi. *Polym J* v 19 n 8 1987 p 939-943.

**083296 REVERSING-PULSE ELECTRIC BIREFRINGENCE OF POLY( $\gamma$ -BENZYL L-GLUTAMATE) IV. ELECTRIC, OPTICAL, AND HYDRODY-**

**NAMIC PROPERTIES IN HELIX-FORMING SOLVENTS AS EVALUATED FROM FIELD-ON AND FIELD-OFF PROCESSES.** Reversing-pulse electric birefringence (RPEB) of poly( $\gamma$ -benzyl L-glutamate), [Glu(OBzl)]<sub>n</sub>, with a weight-average molecular weight of  $1.71 \times 10^5$  was measured at 20°C and at 535 nm in four helix-forming solvents: 2-chloroethanol, cyclohexanone, pyridine, in which [Glu(OBzl)]<sub>n</sub> is dissolved molecularly, and chloroform in which it is aggregated. A standard analytical procedure is given for the RPEB signal which represents the field-on and field-off processes. The steady-state birefringence of [Glu(OBzl)]<sub>n</sub> was measured over a wide field strength range up to ca.  $20 \text{ kV cm}^{-1}$ . The Kerr law was obeyed at low fields, while a saturating trend was observed at higher fields. (Edited author abstract) 42 refs.

Yamaoka, Kiwamu (Hiroshima Univ, Hiroshima, Jpn); Yamamoto, Shinobu; Kosako, Isao. *Polym J* v 19 n 8 1987 p 951-963.

## Spectroscopic Analysis

**083297 ELECTRON SPECTROSCOPY FOR CHEMICAL ANALYSIS STUDIES ON POLYPEPTIDE SURFACE.** The outer-most surface characteristic of poly( $\gamma$ -benzyl L-glutamate) (PBLG) and poly( $\epsilon$ -N-benzoyloxycarbonyl L-lysine) (PBCL) were investigated by electron spectroscopy for chemical analysis (ESCA). These homopolypeptides exist in the  $\alpha$ -helical conformation in the solid state. The ESCA measurements showed the ratios (O/C) of atomic concentrations of both polypeptides are in accord with the bulk values for grazing angles from 45° to 60°. As the result of the evaluation of effective sampling depth estimated from the electron mean free path, we obtained  $d = 16.3$  angstrom to 19.9 angstrom for PBLG and  $d = 16.6$  angstrom to 20.4 angstrom for PBCL in the same grazing range. The diameters of the cross-section,  $\alpha$ , of PBL and PBCL helical rods have been reported as  $a = 15.0$  angstrom and 18.0 angstrom, respectively. (Edited author abstract) 22 Refs. In Japanese.

Kugo, Kohhei (Konan Univ, Kobe, Jpn); Kitaura, Tatsuhiro; Nishino, Jun. *Kobunshi Ronbunshu* v 45 n 5 1988 p 441-447.

## Stability

**083298 DIMENSIONAL CHANGES OF POLYPEPTIDES IN THE HELIX-SENSE INVERSION REGION.** Dimensional changes of polypeptides in the helix-sense inversion region are analyzed by a theory based on the three-state, nearest-neighbor interaction model. Each peptide residue in a chain is assumed to take on right- and left-handed  $\alpha$ -helical states as well as a random coil state, and the helix stabilization effect due to hydrogen-bond interactions is taken into account. Such interactions between four consecutive residues have explicitly been discussed in a  $9 \times 9$  statistical-weight matrix in a previous theory, while in the present model we simplify this matrix into the form of a  $3 \times 3$  matrix by considering the interactions only between two consecutive residues. Theoretical transition curves illustrating the general characteristics of the sense inversion phenomena suggest a method for evaluating the transition parameters. (Edited author abstract) 23 refs.

Toriumi, Hirokazu. *Polym J* v 19 n 12 1987 p 1395-1404.

**Structure** See COMPUTER SOFTWARE—Medical Applications; SURFACE ACTIVE AGENTS.

## Synthesis

**083299 N-CARBOXYANHYDRIDES.** According to the definition in the field of polymer chemistry, an  $\alpha$ -amino acid is a monomer of the A-B type, giving polypeptides by polycondensation. However, activation of the amino group or carboxyl group of the amino acid is indispensable if linear high-molecular-weight polypeptides are to be obtained by the polycondensation of  $\alpha$ -amino acids. A typical example of carboxyl group activation is the N-carboxyanhydride (NCA) method, described in this paper. Attention is mainly confined to a review of papers

about the reactions and polymerization of NCAs published since 1965. 269 refs.

Imanishi, Y. (Kyoto Univ, Jpn). *Ring-Opening Polym* v 2. Publ by Elsevier Applied Science Publ, London, Engl and New York, NY, USA, 1984 p 523-602.

**083300 SYNTHESIS AND CONFORMATION OF POLY[N<sup>ε</sup>-(4-CARBOXYBENZYL)-L-LYSINE] AND ITS PROTECTED DERIVATIVES.** Poly[N<sup>ε</sup>-benzyloxycarbonyl, N<sup>ε</sup>-(4-methoxycarbonylbenzyl)-L-lysine] (polymer 1) was prepared by the N-carboxyanhydride method. The fully protected polymer was converted into poly[N<sup>ε</sup>-benzyloxycarbonyl, N<sup>ε</sup>-(4-carboxybenzyl)-L-lysine] (polymer 2), poly[N<sup>ε</sup>-(4-methoxycarbonylbenzyl)-L-lysine] (polymer 3) and poly[N<sup>ε</sup>-(4-carboxybenzyl)-L-lysine] (polymer 4) through saponification and debenzoyloxycarbonylation. The conformation of the four polypeptides was studied by means of infrared spectroscopy and circular dichroism (CD). (Edited author abstract) 12 refs. In Japanese.

Hayakawa, Tadao (Shinshu Univ, Ueda, Jpn); Inouye, Katsuhiko; Kimura, Tadashi. *Kobunshi Ronbunshu* v 44 n 9 Sep 1987 p 711-715.

**083301 SYNTHESIS, SEPARATION, AND RESOLUTION OF cis- AND trans-3-ETHYLPROLINE.** The synthesis, separation, and optical resolution of cis- and trans-3-ethylproline are described. Two different approaches were employed: The Michael addition reaction of 2-pentenal with diethyl-N-carbobenzoyloxycarbonylmalonate gave the intermediate of 3-ethyl-5-hydroxy-N-benzyl-oxypyrrolidine. Hydrogenolysis of this intermediate followed by acid hydrolysis gave a mixture of cis- and trans-3-ethylproline. The Michael condensation of diethyl acetamidomalonic acid with 2-pentenoic acid ethyl ether produced the intermediate 5,5-bis(ethoxycarbonyl)-4-ethylpyrrolidine. The absolute configurations of the optically active isomers were determined by circular dichroism spectroscopy. (Edited author abstract) 52 refs.

Tiba, Omar (Univ of Michigan, Ann Arbor, MI, USA); Overberger, C.G. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3437-3458.

**083302 TRUE AUTOMATION OF PEPTIDE SYNTHESIS.** Solid phase techniques are now widely used for synthesis of natural macromolecules. For peptide synthesis (the linking of amino acids into long peptide chains) several companies are now producing new generation automatic synthesizers based on continuous flow principles. These enable analytical data to be gathered as the synthesis is proceeding. The next logical step is to use feedback control to establish a truly automated system - one that can operate unattended and cope - within limits - with the unexpected. (Author abstract) 5 refs.

Sheppard, R.C. (MRC Lab of Molecular Biology, Cambridge, Engl). *Chem Br* v 24 n 6 Jun 1988 p 557, 559, 561-562.

**POLYPHENYLENE OXIDES** See Also NYLON POLYMERS.

**Blending** See POLYSTYRENES—Blending.

## Crosslinking

**083303 POLY(PHENYLENE OXIDE) COMPOSITES CONTAINING CROSSLINKED POLYSTYRENE MICROSPHERES. II. DARK CROSSES OBSERVED IN MICROSCOPE.** Extinction phenomena observed between crossed polaroids in a microscope were classified into three groups, namely, poly(2,6-dimethyl-1,4-phenylene oxide)/polystyrene composite, polycarbonate composite with glass beads, and in-situ polymerized composites. There were dark crosses in the shells of the spheres. The crosses were negative in polymethyl methacrylate and polyvinyl acetate but positive in polystyrene. The disappearing temperatures are given.

Chai, Zhikuan (Acad Sinica, Beijing, China); Guo, Qipeng. *J Appl Polym Sci* v 34 n 6 Nov 5 1987 p 2223-2229.



**Flame Resistance** See TELECOMMUNICATION CABLES—Insulation.

## Modification

**083304 CRESCE LA FAMIGLIA DEI PPE. [PPE Family is Growing].** The producers of polyphenylene ether based resins are contesting the market by turning out a growing number of modified polymers and alloys. At present about 200 types of PPE can be counted. (Author abstract) In Italian.

Anon. *Mater Plast Elastomeri* n 1 Jan 1987 p 20-22.

## Structure

**083305 POLYFENYLENOXID-HODNOCENI STRUKTURY V ROZTOKU. [Polyphenylene Oxide - Structural Evaluation in Solution].** The structure of a number of polyphenyl oxide samples was investigated by solution methods in chloroform and toluene. Attention was devoted not only to the methodology but also to a confrontation of obtained results with previous data. (Edited author abstract) In Czech. 24 refs.

Hudec, Pavel (Chemopetrol kuo Vyzkumny ustav Makromolekulární Chemie, Brno, Czech); Buran, Zdenek; Lanikova, Jirina. *Chem Prum* v 37 n 8 Aug 1987 p 421-424.

## Synthesis

**083306 THEORETICAL AND EXPERIMENTAL CONSIDERATIONS ON POLYDIHALOPHENYLENE OXIDE(S).** The decomposition of copper(II) trihalophenoxides in acetonitrile yields poly(dihalophenylene oxide)s. A  $^1\text{H}$  NMR study has shown that a bromine atom in the 4-position of the trihalophenoxides results in polymers having higher linearity. Various dynamic and static methods, within the framework of Huckel molecular orbital theory, have been used to explain the product distribution. (Author abstract) 14 refs.

Turker, Lemi (Middle East Technical Univ, Ankara, Turk); Kisakurek, Duygu. *Br Polym J* v 20 n 2 1988 p 131-141.

**POLYPROPYLENE** See Also ASPHALT; ASPHALT—Thermal Properties; COMPOSITE MATERIALS—Mechanical Properties; GRAFT COPOLYMERS; MEMBRANES—Materials; PEROXIDES—Research; PLASTICS FILMS—Surfaces; PLASTICS, REINFORCED—Extrusion; POLYETHYLENES; POLYMERS—Blending; POLYMERS—Waste Utilization; SYNTHETIC FIBERS—Structure; TEXTILE FIBERS—Synthetics.

**083307 INFLUENCE OF EXPERIMENTAL CONDITIONS ON THE CHEMILUMINESCENCE FROM POLYPROPYLENE AND ABS DURING OXIDATION.** In this report we present results obtained with polypropylene (PP) and acrylonitrile-butadiene-styrene (ABS) films concerning the effect of experimental conditions on these films. They show that the prior history and shape of the sample have a significant influence on the oxidation parameters evaluated by means of chemiluminescence. Powders or very thin films have to be analyzed if one wishes to avoid complications associated with diffusion-controlled oxidation. 11 refs.

Zlatkevich, Lev (Northwestern Univ, Evanston, IL, USA). *J Polym Sci Part B* v 25 n 10 Oct 1987 p 2207-2210.

**083308 THERMOFORMING OF ORDERED POLYPROPYLENES.** Uniaxial molecular ordering of polyolefin billets by a process of roll-drawing produces clear, transparent sheets having greatly increased strength and modulus in the draw direction whereas the strength and modulus in the transverse direction remain essentially unaltered. Such sheets may be laminated together by means of ultrasonic welding, electromagnetic induction heating or simple pressure lamination using adhesive tie layers to produce multiply laminates with controlled biaxial properties. These self-reinforced laminates have mechanical properties which compare favorably with advanced aramid or carbon fiber composites. Conventional thermoforming techniques may be employed to

convert these highly ordered sheets into shaped products having potential commercial value. In these investigations examples are presented to illustrate the method of laminating and thermoforming of ordered polypropylene sheets. (Edited author abstract) 6 refs.

Iaboni, S. (Univ of Toronto, Toronto, Ont, Can); Woodhams, R.T. *Polym Compos* v 8 n 6 Oct 1987 p 371-378.

## Adhesion

**083309 ADHESION OF MOLDED POLYPROPYLENE USING POLYPROPYLENE GELS.** It is well known that securing good adhesion between polypropylene plate and other material, especially between two polypropylene plates, is difficult because of polypropylene's nonpolarity and high crystallinity. To increase the strength of the adhesion of a material to a polypropylene molding, it is necessary to activate the polypropylene surface by various methods. In this work, results of a study of the adhesion between polypropylene plates using polypropylene gels are reported. 10 refs.

Fujimatsu, Hitoshi (Shinshu Univ, Nagano, Jpn); Kuroiwa, Shigetaka. *J Colloid Interface Sci* v 123 n 1 May 1988 p 309-311.

## Aging

See Also PLASTICS FILMS—Thermal Effects.

**083310 AGING PHENOMENA IN ISOTACTIC POLYPROPYLENE DRAWN AT DIFFERENT TEMPERATURES.** Fibers of isotactic polypropylene drawn at different temperatures show aging phenomena after drawing. In particular a modulus stiffening is observed at room temperature where the modulus increases with the aging time. In the same time scale the birefringence is constant, while drastic effects on the transport properties are observed. The aging phenomenon can be explained in terms of two mechanisms: a secondary crystallization and/or a densification of the amorphous component. (Author abstract). 29 Refs.

de Candia, F. (Istituto di Ricerche su Tecnologia dei Polimeri e Reologia, Naples, Italy); Russo, R.; Tidjani, A.; Vittoria, V. *J Polym Sci Part B* v 26 n 9 Aug 20 1988 p 1897-1906.

## Analysis

**083311 APPLICATION OF THERMAL ANALYSIS FOR INVESTIGATIONS OF POLYMER POWDERS FOR COATINGS.** Polypropylene coatings obtained by the fluidized bed method were investigated. It was proved that the application of thermal analysis methods for their characterization gave many useful data, as a consequence of the similar conditions of thermal measurements and plastics powder processing. Significant correlations were found between the thermal properties and the standard coating properties. (Author abstract) 3 refs.

Gratkiewicz, J. (Technical Univ of Warsaw, Plock, Pol); Gladysiak-Kwiatkowska, A. *J Therm Anal* v 32 n 6 Nov-Dec 1987 p 1801-1804.

## Antioxidants

**083312 GAMMA-IRRADIATION OF FOOD CONTACT PLASTICS: THE RAPID DESTRUCTION OF AN ARYLPHOSPHITE ANTIOXIDANT IN POLYPROPYLENE.** In a recent communication, preliminary details were reported of a study of the effects of progressive doses of gamma-irradiation on the extractable levels of various hindered phenol antioxidants present in a range of food contact polymers. Now, a preliminary report is presented of a similar study of the effects of gamma-irradiation on polypropylene containing an arylphosphite antioxidant, Irgafos 168, either as the sole antioxidant present or as a component of synergistic mixture with the hindered phenolic antioxidant Irganox 1010. It is clear that Irgafos 168 is destroyed far more rapidly than hindered phenol antioxidants on irradiation, little remaining after a 10 kGy exposure. The rate of destruction would seem to be even greater in the presence of the hindered phenol antioxidant Irganox 1010. How-

ever, the latter suffers degradation at a very similar rate to that observed previously. 7 refs.

Allen David W. (Sheffield City Polytechnic, Sheffield, Engl); Leathard, David A.; Smith, Christine. *Chem Ind (London)* n 24 Dec 21 1987 p 854-855.

**083313 ANTIOXIDATIVE EFFICIENCY OF SUBSTITUTED N-PHENYL N-PYRAZOLYL-3, N-PHENYL N-BENZIMIDAZOLYL-2 AND N-BENZTHIAZOLYL-2 N-BENZIMIDAZOLYL-2 AMINES IN THE THERMOOXIDATION OF POLYPROPYLENE.** The antioxidative efficiency of three different series of nitrogen containing compounds derived from N-phenyl N-(1,5-diphenylpyrazolyl-3), N-phenyl N-benzimidazolyl-2 and N-benzthiazolyl-2 N-benzimidazolyl-2 amines in the thermal oxidation of polypropylene were compared on the bases of the results of chemiluminescence, dynamic thermogravimetry and differential scanning calorimetry. The effect of substituents on phenyl rings and on the 1-nitrogen of benzimidazol was examined with respect to the antioxidative behavior of the compounds. Bad dispersion of the additive and its volatility seems to have a large effect, in some cases, on the results of antioxidation tests. (Author abstract). 10 Refs.

Matisova-Rychla, L. (Slovak Acad of Sciences, Czech); Rychly, J.; Meske, M.; Schulz, M. *Polym Degradation Stab* v 21 n 4 1988 p 323-333.

**083314 INFLUENCE OF METAL IONS ON ANTI-OXIDANT BEHAVIOUR IN POLYPROPYLENE.** The effect of Cr(III), Fe(III) and Cu(II) ions, at trace levels, on the effectiveness of four commercial antioxidant systems, viz. Topanol, Santowhite, Hostanox 03 and Irganox 1425 in polypropylene (PP) films is examined using infra-red and second-order derivative uv spectroscopy. The results show that at these levels the metal ions have a minor effect on the unstabilised polymer. However, the ions can have a beneficial or adverse effect on antioxidant activity, particularly under oven ageing conditions. The observed effect depends on the metal/antioxidant system, and is attributed to an indirect interaction between the components which can delay or accelerate antioxidant decomposition in the polymer. An exception to this behaviour is the metal complex Irganox 1425, which interacts strongly with copper ions in the polymer matrix. The antioxidant is partially transformed by copper ions during the compression moulding stage. The beneficial effect present in some cases is in direct contrast with what has generally been observed in studies using unstabilised polymers. (Author abstract) 16 refs.

Chirinos-Padron, Alfonso J. (Venezolano de Investigaciones Cientificas, Caracas, Venez); Hernandez, Petra H.; Suarez, Felipe A. *Polym Degradation Stab* v 20 n 3-4 1988, Polym Addit in Stab: Perform and Mech, Birmingham, Engl, Sep 2-4 1987 p 237-255.

**083315 ANTIOXIDANT CROSSOVER EFFECT IN OVEN AGEING OF POLYPROPYLENE.** Thermal oxidative stabilities of polypropylene formulations are frequently assessed by ageing samples in circulating-air ovens. A 150°C test temperature is almost an accepted standard throughout the polymer industry although it often bears little relation to the actual service temperatures seen during the life of the polypropylene which are frequently below 100°C. Phenolic antioxidants are necessary for the extended service life of polypropylene. When the antioxidants are compared over a range of evaluation temperatures, their relative performance can change quite markedly. As evaluation temperatures are decreased and approach actual use temperature, the chemical kinetics of stabilization and the influencing physical characteristics of the antioxidant appear to change causing a reversal in the relative effectiveness between two high molecular weight antioxidants. This has been defined as the 'crossover



effect'. This understanding should allow for improved predictions of polymer service life. (Author abstract) 7 refs.

Glass, R.D. (Ethyl Corp, Baton Rouge, LA, USA); Valange, B.M. *Polym Degradation Stab* v 20 n 3-4 1988, Polym Addit in Stab: Perform and Mech, Birmingham, Engl, Sep 2-4 1987 p 355-363.

**Applications** See CAPACITORS—Plastics Applications; PLASTICS—Additives; SYNTHETIC FIBERS—Production.

**Blending** See Also JUTE—Plastics Applications; POLYBUTENE—Crystallization; POLYETHYLENES—Blending; POLYOLEFINS—Physical Properties; THERMOPLASTIC ELASTOMERS—Wear.

**083316 POLYOLEFIN BLENDS: 2. EFFECT OF EPR COMPOSITION ON STRUCTURE, MORPHOLOGY AND MECHANICAL PROPERTIES OF IPP/EPR ALLOYS.** The morphology, thermal behavior, tensile and impact properties of sheet specimens of isotactic polypropylene (iPP) blended with ethylene-propylene copolymers (EPR) containing different amounts of polypropylene or polyethylene blocks and various extents of crystallinity were investigated by means of optical and scanning electron microscopy, differential scanning calorimetry, wide-angle X-ray diffractometry, impact and tensile mechanical tests. The experimental results showed that copolymers containing polypropylene or polyethylene blocks could act as nucleating agents for iPP spherulites. It was found that the mode and state of dispersion of the EPR copolymers, as well as the thermal and mechanical behavior of the blends, depended upon the composition of the copolymer used in the blends for given crystallization conditions. (Edited author abstract) 16 refs.

Greco, R. (CNR, Naples, Italy); Mancarella, C.; Martuscelli, E.; Ragosta, G.; Yin, Jinghua. *Polymer* v 28 n 11 Oct 1987 p 1929-1936.

**Chemical Reactions** See Also CHEMICAL REACTIONS—Reaction Kinetics.

**083317 INFLUENCE OF THE CONDITIONS UNDER WHICH PHOSPHINATED POLYPROPYLENE SUPPORTS ARE PREPARED ON THE PERFORMANCE OF SUPPORTED RHODIUM(I) OLEFIN HYDROFORMYLATION CATALYSTS.** The detailed structure of the support can play a major part in influencing the specificity and selectivity of reactions catalyzed by polymer-supported catalysts. Accordingly we have examined carefully the influence of the conditions under which phosphinated polymer supports are prepared when p-styryldiphenylphosphine is grafted onto polypropylene in the presence of gamma-radiation. A number of different reactions take place simultaneously. Their relative rates can be altered by changing the solvent in which the irradiation is performed; changing their rates alters the nature and detailed structure of the phosphinated polypropylene supports. A series of phosphinated polypropylene supports prepared in benzene, tetrahydrofuran and dimethylsulphoxide were used to support rhodium(I). The activity, specificity and selectivity of these catalysts in olefin hydroformylation was studied. It was found possible to prepare polymer-supported catalysts that were more active than their homogeneous counterparts and which retained the high selectivity for straight-chain as opposed to branched aldehyde formation, as well as high specificity for hydroformylation as opposed to olefin isomerisation. (Author abstract)

Hartley, F.R. (Royal Military Coll of Science, Shrivenham, Engl); Murray, S.G.; Sayer, A.T. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 332.

**Chromatographic Analysis** See Also COPOLYMERS—Chromatographic Analysis.

**083318 QUANTITATIVE SIZE EXCLUSION CHROMATOGRAPHY OF POLYPROPYLENE I:**

**METHOD DEVELOPMENT.** Polypropylene was analyzed by size exclusion chromatography (SEC) at 145°C using a single-differential refractometer detector. The objective was to provide data for characterization of polypropylene degradation during a reactive extrusion process. Two antioxidants were tested for their ability to prevent thermal degradation of the polypropylene during sample preparation. The use of 0.20 wt% of (I) was effective during the 36-48 h required to completely dissolve the samples in trichlorobenzene for SEC analysis. 'Reshaping' of the chromatograms by resolution correction demonstrated that, while the molecular weight averages were changed by 8% because of axial dispersion, most of the individual heights of the distributions were changed by less than 2%. (Edited author abstract) 23 refs.

Lew, R. (Univ of Toronto, Toronto, Ont, Can); Suwanda, D.; Balke, S.T. *J Appl Polym Sci* v 35 n 4 Mar 1988 p 1049-1063.

**083319 QUANTITATIVE SIZE EXCLUSION CHROMATOGRAPHY OF POLYPROPYLENE II: ANALYSIS SYSTEMS.** Quantitative size exclusion chromatography (SEC) was considered a system with the following components; sample preparation, fractionation, detection, calibration, and resolution correction. Four systems were evaluated: I was 3 columns with 'conventional single detector interpretation'; II was four columns with concentration correction and detector assessment; III was concentration correction applied to the data of I; IV was two development 'mixed bed' columns. Analysis of polystyrene standards included calculation of their molecular weight averages and use of the Glockner T measure of resolution was well as 'specific resolution index'. Systems I and III provided the best high molecular weight results. (Edited author abstract) 15 refs.

Lew, R. (Univ of Toronto, Toronto, Ont, Can); Cheung, P.; Suwanda, D.; Balke, S.T. *J Appl Polym Sci* v 35 n 4 Mar 1988 p 1065-1084.

## Coloring

**083320 THERMOCHROMISM OF POLYPROPYLENE GELS.** It is found that polypropylene gels in some solvents of benzene-derivatives show a striking change of color. The color changes from blue to yellow as the temperature rises from the melting point of the solvent to around 70-80°C. The apparent characteristic of the phenomenon resembles the thermochromism of cholesteric liquid crystals although polypropylene itself is colorless and has no asymmetric carbons in the molecules. Polypropylene flakes swelled in these solvents also show similar thermochromism. (Author abstract) 30 refs.

Fujimatsu, H. (Shinshu Univ, Jpn); Kuroiwa, S. *Colloid Polym Sci* v 265 n 10 Oct 1987 p 938-941.

## Compounding

**083321 RECENT DEVELOPMENTS IN POLYPROPYLENE COMPOUNDING.** The market for polypropylene compounds is enjoying rapid expansion. Not only is the tonnage increasing but also the range of materials available. While talc fillers and elastomer rubbers such as EPR continue to be the main modifiers, growth is being seen in other compounds as well. The continued demand for polypropylene compounds in such applications as automotive parts, appliances, furniture and construction confirms their position among the engineering plastics group, and as the quality of products available improves so is their permanence assured. This paper will review these developments, paying particular attention to recent polymer and filler modifications.

Ellis, Patrick (Neste Polypropylene NV, Beringen, Belg). *Kem Kem* v 15 n 2 1988 p 127-129.

## Crazing

**083322 FORMATION OF CRAZES IN ISOTACTIC POLYPROPYLENE AND ACCOMPANYING CHANGES OF ENERGY.** Formation and growth of crazes in isotactic polypropylene with c-texture crystallites

arranged in lamellae oriented perpendicularly with respect to the texture axis have been investigated by small-angle X-ray scattering and calorimetry. Deformation of polypropylene along the texture axis leads to the formation of a great number of crazes localized in the interlamellar volume of the crystalline polymer. During the period of craze growth the mean diameter of fibrils connecting the craze walls remains practically constant while the specific surface area increases with deformation. (Edited author abstract) 8 refs.

Yefimov, A.V. (M.V. Lomonosov Moscow State Univ, USSR); Bulayev, V.M.; Ozerin, A.N.; Rebrov, A.V.; Godovskii, Yu.K.; Bakayev, N.F. *Polym Sci USSR* v 28 n 8 1986 p 1951-1958.

**Creep** See PLASTICS, REINFORCED—Deformation.

**Crosslinking** See PLASTICS FILMS—Radiation Effects.

## Crystallization

**083323 NUCLEATING ACTIVITY OF METAL SALTS OF BENZOIC ACID IN POLYPROPYLENE.** The nucleating activity of metal salts of benzoic acid in polypropylene (PP) was investigated. A nucleator of different crystallinity, aluminum benzoate hydroxide, was used. The crystal of this nucleator had a leaf-like shape, about 50 nm across. The nucleating activity of the crystal which had a layer structure was rapidly decreased when the structure was destroyed. The microstructure of PP determined by electromicroscopic observations, varied with the crystallinity of the nucleator. This nucleating activity also showed a temperature dependence. These results indicate that the nucleating activity of aluminum benzoate hydroxide is attributable to an absorption of PP on the layer of the crystal under supercooling. (Edited author abstract) In Japanese. 13 refs.

Ikeda, Kiyoshi (Industrial Research Inst of Hyogo Prefecture, Kobe, Jpn). *Kobunshi Ronbunshu* v 44 n 7 1987 p 539-543.

**083324 STRUCTURAL 'MEMORY' EFFECT IN ISOTACTIC POLYPROPYLENE MELTS.** An isotactic-polypropylene oriented sheet with the predominant  $\beta$ -crystal form which was induced by the elongational flow of polymer melts was prepared. The effects on  $\beta$ -form formation of the temperature at which the sheet was melted and of the time spent at melting temperature before crystallization have been studied by using DSC of the melting behavior of the polymer isothermally crystallized from the melt. The results show that the active crystallization center of  $\beta$ -form has a higher thermal stability beyond the melting point and that the melt does not lose its structural 'memory' during annealing for 10 min at 180°C, but this is lost during annealing for 1 min at 230-240°C. (Author abstract) 14 refs. In Japanese.

Itoyama, Kuniyoshi (Toray Industries Inc, Sonoyama, Jpn). *Kobunshi Ronbunshu* v 44 n 5 1987 p 405-408.

**083325 FAST DSC APPLIED TO THE CRYSTALLIZATION OF POLYPROPYLENE.** In an effort to find the limit of crystallization of polypropylene, a series of quantitative and semiquantitative DSC experiments at rates up to 10,000 deg/min are described. Even at these fast rates polypropylene crystallized on cooling between 350±15 K and 280±6 K. No fully amorphous polypropylene was produced. No initial stage crystallization to the cond state could be proven by quenching after partial crystallization. (Author abstract). 21 Refs.

Wu, Zong Quan (Rensselaer Polytechnic Inst, Troy, NY, USA); Dann, V.L.; Cheng, S.Z.D.; Wunderlich, B. *J Therm Anal* v 34 n 1 Jan-Feb 1988 p 105-114.

## Decomposition

**083326 COMPARISON OF THE KINETICS OF THE DECAY OF PEROXIDE RADICALS IN THE CRYSTALLINE PHASE OF POLYPROPYLENE AND POLY-4-METHYLPENTENE-1.** The kinetics of



the decay of peroxide radicals of polypropylene and poly-4-methylpentene-1 in oxygen and an inert atmosphere has been studied. It is shown that the presence of reactive mobile side groups in poly-4-methylpentene-1 removes the 'conformational prohibition' from the reaction of breakdown of the peroxide macroradical existing in the crystalline phase of polypropylene leading to its death and promotes the averaging of the kinetic non-equivalence of the peroxide macroradicals of the main polymer chain. (Author abstract) 12 refs.

Shibryayeva, L.S. (USSR Acad of Sciences, USSR); Rapoport, N.Ya.; Zaikov, G.Ye. *Polym Sci USSR* v 28 n 6 1986 p 1370-1380.

**Deformation** See Also PLASTICS FILMS—Drawing and Stamping.

**083327 MECHANICS OF EQUIBIAXIAL HYDROSTATIC DEFORMATION IN SOLID STATE: ISOTACTIC POLYPROPYLENE.** A simple model describing the process mechanics is presented. The model is verified by direct measurement of compression force versus compressive strain data. This is followed by a comparison of the theory and experiment. 31 refs.

Saraf, Ravi F. (Univ of Massachusetts, Amherst, MA, USA); Porter, Roger S. *J Rheol* v 31 n 1 Jan 1987 p 59-94.

**083328 DILATIONAL DAMAGE ACCUMULATION DURING FATIGUE OF POLYPROPYLENE.** Plastic deformation in spherulitic polypropylene includes a component of dilatational strain. Residual volume changes have been measured as a function of uniaxial strain for tension, compression and cyclic tests. In compression, the volume changes were measured during the test while the specimen was under load and the stress maximum was found to be related to the onset of rapid dilation. The dilation for all modes of mechanical testing was found to be linearly dependent on the tensile component of the strain. Microstructural changes responsible for these observations were examined using transmission electron microscopy of permanganic etched interior surfaces of the deformed specimens. Microcrazes along interlamellar planes were found in all deformed specimens. Fatigue failure in symmetric tension/compression tests occurred by accumulation of crazes, predominantly on the tensile half cycles. (Author abstract) 26 refs.

Zok, F. (Univ of Western Ontario, London, Ont, Can); Shinozaki, D.M. *J Mater Sci* v 22 n 11 Nov 1987 p 3995-4001.

**083329 EFFECT OF ANNEALING ON A HIGHLY DISPERSED POROUS STRUCTURE, FORMED IN ISOTACTIC POLYPROPYLENE UNDER DEFORMATION.** The effect of annealing on the change of microcraze structure formed during deformation of isotactic polypropylene (PP) at 20° has been studied. With annealing in the 20-100° range, the diameter of the fibrils joining the walls of the microcrazes is increased but the volume of micropores is unchanged as the treatment temperature is increased. In the temperature region above 100°, a decrease in the degree of dispersivity of the material of the microcrazes is accompanied by a decrease in the volume of the micropores. It was shown that annealing leads to stabilization of the porous structure, formed by stretching the PP. (Author abstract). 8 Refs.

Yefimov, A.V. (M.V. Lomonosov State Univ, Moscow, USSR); Bulayev, V.M.; Ozerin, A.N.; Rebrov, A.V.; Godovskii, Yu.; Bakyev, N.F. *Polym Sci USSR* v 29 n 5 1987 p 1125-1132.

## Degradation

**083330 COPPER CARBOXYLATE FORMATION IN THE THERMAL OXIDATIVE DEGRADATION OF ATACTIC POLYPROPYLENE ON COPPER OXIDE FILMS.** The thermal oxidation of atactic polypropylene on CuO<sub>0.67</sub> surfaces in air was studied using IR reflection-absorption spectroscopy. Degradative losses of primary, secondary, and tertiary alkyl hydrogens were observed. At 60 and 73°C, carboxylic acids are the primary

degradation products, while at 85 and 100°C, copper carboxylate formation predominates and CuO<sub>0.67</sub> is decomposed. The distinct change in the oxidative mechanisms between 73 and 85°C apparently is related to an irreversible thermal transition in the atactic polypropylene films, which may favor carboxylate production by increasing the permeability of the films to oxygen and water vapor. (Author abstract) 14 refs.

Webb, John D. (Solar Energy Research Inst, Golden, CO, USA); Czanderna, A.W.; Pitts, J.R. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3395-3403.

**083331 DEGRADATION OF POLYPROPYLENE IN THE PLASTIFYING UNIT OF AN INJECTION Moulding MACHINE.** Degradation phenomena, caused by thermal and/or mechanical stresses, occur in the processing of polypropylene. Insights into the degradation behaviour already gained earlier from extrusion tests are to be checked in a detailed investigation for injection moulding. (Author abstract) 13 refs. In German and English.

Menges, G.; Ries, H.; Linne von Berg, A.; Klee, D. *Kunstst Ger Plast* v 77 n 11 Nov 1987 p 32-34, 1185-1189.

**083332 PRODUCTION OF CONTROLLED-RHEOLOGY POLYPROPYLENE RESINS BY PEROXIDE PROMOTED DEGRADATION DURING EXTRUSION.** Results of experimental and modeling studies of the peroxide promoted degradation of polypropylene (PP) are presented. Experiments were carried out in glass ampoules and in a plasticating extruder. The initiator, 2,5-dimethyl-2,5-bis(tert-butylperoxy)hexane was used as a radical generator. The extruder used had a 38 mm diameter and 24:1 L/D single-screw. In these experiments, the effect of peroxide concentration and screw speed on the molecular weight distribution (MWD) of the polypropylene resin was studied. Samples collected from the experimental runs were analyzed for melt flow index (MFI), flow curve, extrudate swell, and MWD. The measured data are presented and correlations among various parameters are considered. Generally, it can be concluded that controlled-rheology (CR) resins with lower molecular weight, narrower MWD, and reduced viscosity and elasticity, can be produced. A kinetic model for the peroxide initiated degradation of PP is proposed. Simulations based on this model are compared with experimental data for the production of CR resins. Agreement between model predictions and experimental results is quite satisfactory suggesting that this model should find use in commercial practice. (Edited author abstract) 33 refs.

Tzoganakis, C. (McMaster Univ, Hamilton, Ont, Can); Vlachopoulos, J.; Hamielec, A.E. *Polym Eng Sci* v 28 n 3 Mid-Feb 1988 p 170-180.

**083333 FRACTURE MECHANICS APPROACH TO THE EFFECTS OF UV-DEGRADATION ON POLYPROPYLENE.** A fracture mechanics approach to the ultraviolet degradation embrittlement of polypropylene (PP) semi-crystalline homopolymer has been evaluated. The loss in fracture properties results mainly from embrittlement of the surface resulting in surface defects. Degradation depth was measured by Fourier transform infrared (FTIR) spectrometry. Degraded and notched specimens were tested at different deformation velocities in three-point bending. Fracture energies of degraded specimens and specimens notched with a depth equal to that of degradation are compared. Differences are accounted for by different fracture processes which were observed by studying fracture surfaces. (Edited author abstract) 22 refs.

Schoonenberg, G.E. (Technical Univ of Delft, Delft, Neth). *J Mater Sci* v 23 n 5 May 1988 p 1580-1590.

## Dielectric Properties

**083334 EFFECT OF WATER ON DIELECTRIC RELAXATIONS IN THE GLASSY STATES OF POLY(PROPYLENE OXIDE) AND PROPYLENE**

**GLYCOL.** The dielectric permittivity and loss of poly(propylene oxide),  $M_w=425$  and propylene glycol (PG) and their mixtures with water were measured in the temperature range 77-320 K and frequency range  $12.5 \times 10^5$  Hz. PPO-425 has two relaxation processes which appear as  $\beta$ - and  $\alpha$ -peaks, but the  $\beta$ -peak in PG is masked by a large contribution to the loss from the  $\alpha$ -process. Addition of water up to 1.25 wt% changes the temperature or the rate of the  $\alpha$ -process in both PPO-425 and PG, and increases the half-width of the  $\alpha$ -relaxation in PG. Water decreases both the rate and the strength of the  $\beta$ -process in PPO-425. The strength of the  $\beta$ -process increases with increase in the molecular weight of PPO. (Edited author abstract) 12 refs.

Pathmanathan, K. (McMaster Univ, Hamilton, Ont, Can); Johari, G.P. *Polymer* v 29 n 2 Feb 1988 p 303-310.

**083335 AC BREAKDOWN OF MELT-CRYSTALLIZED ISOTACTIC POLYPROPYLENE.** The effect of polymer morphology on the dielectric breakdown of isotactic polypropylene was investigated under the influence of a ramped ac voltage. Samples were prepared by melt-pressing polypropylene beads into plaques and subsequently quenching or isothermally crystallizing these plaques. Some of the quenched samples were annealed at different temperatures to induce further crystallinity. The plaques were then characterized by wide-angle X-ray diffraction, density measurements, and differential scanning calorimetry. The 60 Hz ac breakdown voltages of the samples were determined at 7, 23 and 45°C in a specially designed test cell. There was a lack of any significant effect on the ac breakdown strength of isotactic polypropylene of either the overall crystallinity or the crystallite thickness. It is postulated that the degree of crystallinity would influence the breakdown characteristics only when the amorphous regions constitute a small fraction of the total volume. (Edited author abstract) 26 refs.

Krishnakumar, B. (State Univ of New York at Buffalo, Buffalo, NY, USA); Gupta, R.K.; Forster, E.O.; Laghari, J.R. *J Appl Polym Sci* v 35 n 6 May 5 1988 p 1459-1472.

**083336 DEPENDENCE OF THE ELECTRIC STRENGTH ON THICKNESS AREA AND VOLUME OF POLYPROPYLENE.** A dependence of the electric strength on thickness, area, and volume of dielectric is demonstrated for polypropylene film. It was found that the electric strength of the polymer film decreases with volume. It is shown that the function of electric strength is not simply dependent on the volume as obtained from the theory of extreme values, but that an increase of the volume caused by increasing the thickness of the dielectric is much more significant than the same increase of the dielectric volume caused by an increase in area. The theoretical results presented are in very good agreement with the experimentally obtained values. 4 refs.

Cygan, S. (State Univ of New York, Buffalo, NY, USA); Laghari, J.R. *IEEE Trans Electr Insul* v EI-22 n 6 p 835-837.

**Drawing and Stamping** See Also PLASTICS SHEETS—Thermoforming; POLYETHYLENES—Drawing and Stamping.

**083337 DRAWING THICK SECTION POLYPROPYLENE AT HIGH STRAIN RATES.** Tensile deformation studies are reported for propylene homopolymer specimens up to 4.5 mm thick at strain rates up to  $1.67 \text{ s}^{-1}$  (process conditions pertinent to an industrial solid phase forming process). Simple models of the deformation process are used to predict the axial distribution of stress and strain rate in the neck region and the adiabatic temperature rise in an element passing through this deformation zone. The temperature rise predictions are compared with surface temperature measurements obtained by means of a thermal imaging system. (Author abstract) 16 refs.

Coates, P.D. (Univ of Bradford, Bradford, Engl); Ellis, D.I.; Pourmahnaei, S.M. *Plast Rubber Process Appl* v 8 n 3 1987 p 165-172.



**083338 ORIENTING POLYPROPYLENE SHEET BY ROLLING-DRAWING.** Rolling-drawing is a simple, effective method for manufacturing high-strength, high-modulus sheet from polymer billets. Using inexpensive equipment and straightforward controlling techniques, processors can increase the tensile modulus and strength of polypropylene by more than an order of magnitude. Polypropylene sheets 1 to 3 millimeters thick, with 20 to 40 percent of their theoretical modulus, have been produced at speeds of several meters per minute. Tensile strength can be improved from 30 to 500 megapascals and tensile modulus from 1.6 to 20 gigapascals.

Tate, K.R. (Univ of Toronto, Toronto, Ont, Can); Perrin, A.R.; Woodbams, R.T. *Plast Eng* v 43 n 12 Dec 1987 p 29-31.

**083339 ROLE OF DIFFERENTIAL SCANNING CALORIMETRY AND X-RAY DIFFRACTION IN IDENTIFYING CRYSTAL CONTINUITY IN HIGHLY ORIENTED SAMPLES OF DIE-DRAWN POLYPROPYLENE.** X-ray diffraction and differential scanning calorimetry studies of die-drawn polypropylene have indicated the presence of a crystalline structure which does not identify with any of the usual crystallographic forms and has a melting point slightly below that of the monoclinic  $\alpha$  form. The melting of this structure is stress sensitive and shows that the superheating effect expected from the melting of an extended chain structure, whose chain ends are physically constrained. It is postulated that this structure bridges the gaps between adjacent monoclinic crystal blocks and provides the framework necessary to maintain mechanical stability at temperatures well above that of the glass transition. Moreover, together with taut tie molecules, this structure is considered to be the main source of the high material stiffness. (Author abstract) 26 refs.

Taraiya, A.K. (Univ of Leeds, Leeds, Engl); Unwin, A.P.; Ward, I.M. *J Polym Sci Part B* v 26 n 4 Apr 1988 p 817-838.

**083340 MOLECULAR ORIENTATION IN DRAWN SMECTIC AND CRYSTALLINE ISOTACTIC POLYPROPYLENE.** The drawing behavior of two polypropylene films of different structures was analyzed. The two films differ as a consequence of different quenching conditions. At a low temperature, a biphasic smectic-amorphous system was obtained, when quenching at 100°C produced a biphasic crystalline-amorphous system. The drawing of samples was carried out at 110°C at which temperature the smectic phase is not stable and is transformed into the crystalline  $\alpha$ -form. The initial structure affects the drawing behavior and the properties of the drawn samples. The mechanical, optical, and X-ray analyses clearly show that high molecular orientation is achieved at lower deformations in the initially smectic sample. In particular, the amorphous phase is highly oriented, inducing higher axial elastic modulus. (Edited author abstract) 21 Refs.

De Candia, F. (CNR, Naples, Italy); Russo, R.; Vittoria, V.; Iannelli, P. *Polym Eng Sci* v 28 n 15 mid-august 1988 p 974-981.

## Dyeing

**083341 HOW TO COLOR POLYOLEFINS FOR TEXTILE APPLICATIONS.** Polyolefins employed as textile fibers cannot be colored by conventional dyeing procedures as the polymers do not have an affinity for dyes. The only way is to introduce pigments into the melt during the fiber-forming process. The pigment particles must be small so they do not disrupt the process. Sometimes such particles could affect the physical properties of the fibers. Most polypropylene fibers are colored by adding pigments to the polymer melt during extrusion. Unlike dyes, pigments are more lightfast and heat stable, and they do not tend to migrate or bleed.

Anon. *Text World* v 138 n 5 May 1988 p 91, 93.

## Electric Properties

**083342 ABSORPTION CURRENT AND SURFACE LEAKAGE IN POLYPROPYLENE.** Transient absorption and resorption currents in low-loss polypropylene at fields in the MV/cm range have been resolved into bulk and surface components. The conduction component of bulk current was almost ohmic, whereas the total measured current varied non-linearly with field. No evidence of contact effects or injected charge was found. Conduction is attributed to impurity ions. (Author abstract) 19 refs.

Tavakoli, M. (Univ of London, London, Engl); Hirsch, J. *Solid State Commun* v 63 n 1 Jul 1987 p 25-28.

## Extrusion See Also PLASTICS FILMS—Surfaces.

**083343 STUDIUM DOB SETRVANI PRI VYT-LACOVANI POLYPROPYLENU.** [Study of the Dwell Periods in Extrusion of Polypropylene]. Based on the knowledge of the character of polymer flow in the transition and metering zones of the extruder screw, novel methods have been suggested for calculating the periods of dwell of polymer particles in an extruder. In order to verify the calculations, magnetic trace substances were added to the polymer. (Edited author abstract) In Czech. 6 refs.

Stratil, Jiri (VUT, Gottwaldov, Czech); Saha, Petr; Hampl, Petr; Rozmankova, Sarka; Zabadal, Stanislav. *Plasty Kauc* v 24 n 4 Apr 1987 p 104-107.

**083344 SOLID STATE EXTRUSION OF POLYPROPYLENE AND CHANGES IN SOME OF ITS MACROSCOPIC PROPERTIES.** By the solid state extrusion of polypropylene, highly transparent extrudates have been obtained. The effect of processing conditions on the highest attainable value of extrusion ratio is discussed. The changes in density and hardness of the extrudates as a function of extrusion ratio are also reported. (Author abstract) 10 refs.

Jain, A. (Univ of Delhi, Delhi, India); Jain, P.C.; Nanda, V.S. *Indian J Technol* v 25 n 8 Aug 1987 p 350-353.

**083345 REACTIVE EXTRUSION OF POLYPROPYLENE I: CONTROLLED DEGRADATION.** Polypropylene was degraded by injection of a free-radical initiator during extrusion. Molecular weight distribution, molecular weight averages, and melt flow index were measured to see the effect of initiator concentration (0.00 to 0.04 wt%), temperature (200 and 220°C), and screw rpm (31 and 44). Initiator concentration was the most significant variable. In all cases, increased initiator concentration degraded the high molecular weight tail of the polypropylene and narrowed the molecular weight distribution. Melt flow index varied linearly with initiator concentration beyond 0.01 wt% initiator. Reaction temperature had no effect on the measured properties of the extrudate. (Edited author abstract) 29 refs.

Suwanda, D. (Univ of Toronto, Toronto, Ont, Can); Lew, R.; Balke, S.T. *J Appl Polym Sci* v 35 n 4 Mar 1988 p 1019-1032.

**083346 REACTIVE EXTRUSION OF POLYPROPYLENE II: DEGRADATION KINETIC MODELING.** A kinetic model for the free-radical-initiated molecular weight degradation of polypropylene was further developed. The model has a single variable parameter, the initiator efficiency,  $f$ . Assumptions were detailed, new comparisons with experimental data presented, and model sensitivity to the value of  $f$  evaluated. The model was found to provide a good description of both molecular weight distribution and molecular weight average data from degradations carried out in a single-screw extruder at 200 and 220°C. Data at 0.04 wt% initiator feed concentration were fit and the resulting  $f$  value used to predict results of 0.01 wt% and 0.02 wt%. (Edited author abstract) 17 refs.

Suwanda, D. (Univ of Toronto, Toronto, Ont, Can); Lew, R.; Balke, S.T. *J Appl Polym Sci* v 35 n 4 Mar 1988 p 1033-1048.

## Fiber Reinforcement

**083347 CRYSTALLIZATION BEHAVIOUR AND MECHANICAL PROPERTIES OF POLYPROPYLENE-BASED COMPOSITES.** The influence of glass fibers on the primary nucleation process, isothermal radial growth rate of spherulites and overall kinetic rate constant of isotactic polypropylene (iPP) has been examined. The polypropylene was also modified by means of acrylic acid (iPP\*) in order to improve the adhesion between the matrix and the fibers, and the relative properties were compared with those concerning the composites having as matrix plain iPP. Moreover the mechanical properties of injection-moulded composites containing iPP and iPP\* have been studied. These properties improved on increasing the fiber content. It was found that for the same glass-fiber content better values of the elongation at break and creep are observed in the case of reinforced polypropylenes having as matrix acrylic acid modified polypropylene. (Author abstract) 10 refs.

Avella, Maurizio (CNR, Naples, Italy); Martuscelli, Ezio; Sellitti, Calaudio; Garagnani, Enea. *J Mater Sci* v 22 n 9 Sep 1987 p 3185-3193.

## Filaments

**083348 FIBRILLATION AND FIBRIL NETWORK FORMATION OF POLYPROPYLENE.** The degree of fibrillation of a polypropylene flat yarn which has undergone high stretching and heat relaxation was found to be more directly representable by the longitudinal tear strength and by the length of the split which developed when the flat yarn was folded at an angle of 180 degrees along the direction of the molecular orientation, than by more fundamental factors, such as the degree of crystallization. The split yarn manufacturing conditions were defined numerically on the bases of those measured data, yielding a direct relation to the degree of fibrillation. The most important points to produce the yarn are to suppress the progressive fibrillation and to make the well-balanced properties by relaxation and heat setting after splitting. These properties include composition of material, the radiant heat for surface treatment, and the stress relaxation. (Edited author abstract) In Japanese. 7 refs.

Sukai, Kiyoshi (Mitsubishi Rayon Engineering Co, Tokyo, Jpn); Nishikawa, Nobuaki. *Kobunshi Ronbunshu* v 44 n 7 1987 p 515-521.

## Fillers See Also COMPOSITE MATERIALS—Electric Properties; PLASTICS PRODUCTS; POLYOLEFINS—Flame Resistance.

**083349 EFFECT OF FILLER SHAPE ON MODULI OF ORIENTED POLYPROPYLENE COMPOSITES.** The relations between the modulus of oriented polypropylene filled with granular (calcium carbonate), flake (talc) or fiber like (sepiolite) fillers, the void volume at the filler/polymer interface, and the filler effects were investigated. The relative moduli of oriented composites are reasonably accounted for by the modified Halpin-Tsai equation which contains the factors of: polymer matrix orientation, filler effect, void volume at filler/polymer interface for the granular, flake and fiber-like fillers. (Edited author abstract) In Japanese. 10 refs.

Mitsuishi, Kazuta (Industrial Technology Cent of Okayama Prefecture, Okayama, Jpn); Kodama, Soji; Kawasaki, Hitoshi; Tanaka, Makoto. *Kobunshi Ronbunshu* v 44 n 7 1987 p 551-555.

**083350 EFFECT OF FILLER PROPERTIES ON THE MODULUS OF ORIENTED POLYPROPYLENE FILLED WITH FLAKE-LIKE FILLERS.** Flake-like fillers with various particle sizes (talc: 0.8, 3.3, 10.0, 25.5  $\mu$ m; mica: 15, 32, 98, 320, 730  $\mu$ m) were mixed with polypropylene (PP). The effect of flake-like filler properties such as filler aspect ratio, filler size, and filler content on the modulus of oriented PP composites was investigated. The relative modulus is shown to be determined by the following factors: (1) orientation factor of



the PP matrix, (2) filler properties (filler content, aspect ratio, modulus), and (3) void properties (void volume, void length). The filler size dependence can be clearly recognized, showing an increase in  $E_c^d/E_c^d$  as filler size decreased for PP/talc and PP/mica systems. (Edited author abstract) 20 refs.

Mitsubishi, Kazuta (Industrial Technology Cent of Okayama Prefecture, Okayama, Jpn); Kodama, Soji; Kawasaki, Hitoshi. *J Macromol Sci Phys* v B26 n 4 Dec 1987 p 479-494.

**083351 POLYPROPYLENE PLNENY  $\text{CaCO}_3$  PRI-  
PRAVENYM Z ODPADOVYCH SUROVIN.** [Polypropylene Filled with Calcium Carbonate Prepared from Waste Raw-Materials]. The production of liquid magnesium fertilizers by novel inorganic processes developed by the Duslo of Sala are based on low quality magnesite raw-materials. In subsequent processing of calcareous impurities separated from the magnesite during the process, precipitated calcium carbonate can be produced. The precipitated calcium carbonate meets all the requirements imposed on polyolefin fillers with respect to both chemical purity and granulometric composition. Feasibility of using the calcium carbonate as a polypropylene filler is assessed. (Edited author abstract). 5 Refs. In Czech.

Khunova, Viera (Chemickotechnologická Fakulta SVST, Bratislava, Czech); Papp, Jozef; Beniska, Jozef. *Plasty Kauc* v 25 n 5 May 1988 p 143-147.

**083352 COUPLING OF MICA AS FILLER IN  
POLYPROPYLENE.** This letter describes attempts to find new classes of coupling agents for micapolypropylene composites. A dry ground, untreated white muscovite mica was used. This approach has selected new classes of coupling agents (chlorosulphonated polyethylene, polyvinyl butyral, carboxy terminated polybutadiene and carboxy terminated butadiene-acrylonitrile copolymer) for mica-polypropylene composites. However, a more detailed examination concerning the treated mica/matrix adhesion and the mechanical behavior of the final composites is necessary to confirm their promising properties. 11 Refs.

Kastner, E. (CNRS, Fr); Nardin, M.; Papirer, E.; Riess, G. *J Mater Sci Lett* v 7 n 9 Sep 1988 p 955-957.

**Film** See Also PLASTICS FILMS—Mechanical Properties.

**083353 MORFOLOGIA BIAKIALNE ORIEN-  
TOVANYCH FOLII.** [Morphology of Biaxially Stretched Films]. Morphology of biaxially stretched polypropylene films has been examined using an Abbe refractometer, polarizing light microscope, and scanning electron microscope. Employing the refractometric and interferometric methods, light birefringence and standardized optical parameters of anisotropy have been established for a number of films produced. In order to assess the surface quality, a scanning electron microscope has been used. (Author abstract) In Slovak. 4 refs.

Malinaric, Svetozar (Vyskumny Ustav Spracovania a Aplikacie Plastických Latok, Nitra, Czech). *Plasty Kauc* v 24 n 2 Feb 1987 p 41-44.

**083354 EFFECTS OF UNIAXIAL STRETCHING  
AND SHRINKAGE ON PROTON SPIN-LATTICE  
AND SPIN-SPIN RELAXATION TIMES OF ISO-  
TACTIC POLYPROPYLENE.** An isotactic polypropylene film was stretched at 120°C in poly(ethylene glycol) and thermally shrunk at various temperatures. Proton spin-lattice,  $T_1$ , and spin-spin,  $T_2$ , relaxation times were measured using a broad line pulse spectrometer operating at 19.8 MHz in the temperature range 40°C-100°C. The temperature of  $T_1$  minimum shifts to higher temperatures and the value of  $T_1$  minimum increases in magnitude as the stretching ratio is increased. In contrast the temperature of  $T_1$  minimum shifts to lower temperatures as shrinkage is increased, whereas the value of  $T_1$  minimum increases in magnitude because of the increase in crystallinity during shrinkage. (Edited author abstract) 23 refs.

Tanaka, H. (Yamagata Univ, Yamagata, Jpn); Saito, K.

*Colloid Polym Sci* v 266 n 1 Jan 1988 p 1-5.

**083355 SURFACE-SELECTIVE HYDROXYLA-  
TION OF POLYPROPYLENE.** Room-temperature oxidation of polypropylene film with chromium(VI) oxide in acetic acid/acetic anhydride introduces hydroxyl groups, olefins, ketones, and esters to a thin layer at the surface of the film. Analysis using a combination of analytical techniques (UV-vis, XPS, ATR IR, contact angle, and gravimetric analysis) indicates that the density of functionality increases over the first 4 h or reaction and remains essentially constant thereafter. Gravimetric analysis reveals an initial mass gain (over the first 4 h) and subsequent mass loss, indicating the gradual dissolution of modified polymer and the maintenance of a modified layer on the order of 100 Angstrom thick. (Edited author abstract) 35 refs.

Lee, Kang-Wook (Univ of Massachusetts, Amherst, MA, USA); McCarthy, Thomas J. *Macromolecules* v 21 n 2 Feb 1988 p 309-313.

**083356 VYVOJ BIAKIALNE ORIENTOVANYCH  
ELEKTROTECHNICKYCH FOLII.** [Development of Biaxially Oriented Polypropylene Films for Electrical Engineering in CSSR]. Application of plastics dielectrics in manufacture of tubular capacitors is surveyed and state-of-the-art in the production of Czechoslovak electrical engineering polypropylene films is described. A particular attention is paid to development of a suitable PP granulate, appropriate quality testing methods for both the PP resin and the electrical engineering films, film manufacturing process and last but not least to recycling of the scrap created in the film manufacture. (Author abstract). 6 Refs. In Czech.

Benc, Gabriel (Vyskumny Ustav Spracovania a Aplikacie Plastických Latok, Nitra, Czech). *Plasty Kauc* v 25 n 5 May 1988 p 133-136.

**Flame Resistance** See ORGANIC COMPOUNDS—Processing; PLASTICS—Flame Resistance.

**Forming** See CONCRETE REINFORCEMENTS—Plastics Applications; OLEFINS—Polymerization; PLASTICS—Forming; POLYMERS—Forming.

**Freezing**

**083357 IMPROVEMENT OF THE FREEZE RE-  
SISTANCE OF POLYPROPYLENE.** An examination is made of the influence of the molecular weight of the rubber and of the fabrication methods on  $T_{br}$  of freeze-resistant polypropylene compositions. The experimental results show that with the use of polysiloxane rubbers of various structures and having molecular weight of  $10^5$ - $10^6$  it is possible to obtain polypropylene compositions of improved freeze resistance, having  $T_{br} < -60^\circ$ . The greatest lowering of  $T_{br}$  was obtained with the use of polysiloxane rubbers having molecular weight  $\geq 5 \cdot 10^5$  (SKTV, E-301). The freeze resistance of compositions containing these rubbers exceeds by  $10$ - $15^\circ$  the best reported results in this field. 4 refs.

Konovalenko, N.G.; Lozhechko, Yu.P.; Milieshekevich, V.P.; Piteva, S.Ya.; Myasnikov, G.D. *J Appl Chem USSR* v 60 n 3 pt 2 Mar 1987 p 627-628.

**Glass Transition**

**083358 CALORIMETRIC RELAXATION AND  
GLASS TRANSITION IN POLY(PROPYLENE GLY-  
COLS) AND ITS MONOMER.** The glass transition temperature  $T_g$  of propylene glycol (PG) and poly(propylene glycols) (PPGs) of molecular weight up to 4000 has been measured by differential scanning calorimetry, and the activation energy and change in heat capacity  $\Delta C_p$  have been determined in the glass transition range. The activation energy increases with an increase in the molecular weight of the polymer, and  $\Delta C_p$  measured at a fixed heating rate decreases. The increase in  $T_g$  with molecular weight is remarkably more rapid for poly(propylene glycols) than for other polymers, and a limiting value of  $T_g$  is reached for a chain containing 20 monomer units.

These results are discussed in terms of the Fox-Flory and the entropy theories. The calorimetric relaxation times are comparable with the extrapolated dielectric relaxation times. The initial increases of  $\Delta C_p$  from PG to PPG 200 is attributed to the decrease of H-bonding sites from 12 in 3 monomers to 4 on polymerization to PPG 200 and further decrease with increase in molecular weight to an increasingly large amplitude of the  $\beta$ -process at  $T < T_g$ . (Author abstract). 22 Refs.

Johari, G.P. (McMaster Univ, Hamilton, Ont, Can); Hallbrucker, Andreas; Mayer, Erwin. *J Polym Sci Part B* v 26 n 9 Aug 20 1988 p 1923-1930.

**Grafting**

**083359 SYNERGISTIC EFFECTS OF UREA WITH  
POLYFUNCTIONAL ACRYLATES FOR ENHANC-  
ING THE PHOTOGRAPHING OF STYRENE TO  
POLYPROPYLENE.** The current work reports the use of urea for accelerating the photografting of styrene in methanol to polypropylene in the presence of benzoin ethyl ether as sensitizer. More importantly, when polyfunctional monomers such as trimethylol propane triacrylate (TMPTA) are included in these solutions in additive amounts, their presence is shown to induce synergistic effects with urea leading to extremely large grafting enhancement. Urea and TMPTA independently increase photografting yields when present as additives. Inclusion of both additives in the same monomer solution leads to a synergistic effect in grafting. The remarkable result in all of these studies is the very large enhancement in photograft on the addition of TMPTA, especially in the presence of urea. 11 refs.

Dworjanyn, P.A. (Univ of New South Wales, Kensington, Aust); Garnett, J.L. *J Polym Sci Part C* v 26 n 3 Mar 1988 p 135-138.

**Injection Molding** See Also PLASTICS PRO-  
DUCTS—Surfaces.

**083360 WELD-LINE PERFORMANCE IN INJE-  
TION-MOLDED PARTS.** Using a fracture-mechanics approach to study crack propagation in injection-molded polypropylene parts gives insights into part durability. Weld-line regions are particularly sensitive to the notch effect. Part thickness is also important. In brittle materials, notch effect may be even more pronounced.

Boukhili, Rachid (Ecole Polytechnique de Montreal, Montreal, Que, Can); Gauvin, Raymond; Fisa, Bohuslav. *Plast Eng* v 43 n 11 Nov 1987 p 37-39.

**083361 INJECTION-MOLDED POLYPROPYLE-  
NE STRUCTURAL FOAM.** The method of structural foam moulding permits the manufacture of moulded foam with a compact skin and a cellular core. The properties of such mouldings are dependent on the structure of the foam, among other parameters. A summarizing report is given on studies into foamed test specimens moulded from polypropylene. The relations between the structure and properties of moulded polypropylene structural foams are elucidated by the influence of the density, specimen thickness, orientation and ambient temperature on the mechanical data and the chemical resistance. (Author abstract) 5 refs. In German and English.

Hell, J.; Nezbedova, E.; Ponesicky, J. *Kunstst Ger Plast* v 77 n 9 Sep 1987 p 16-19.

**083362 NACHDRUCKFREIES SPRITZGIESSEN  
VON POLYPROPYLEN.** [Injection Moulding of Polypropylene Without Packing Effect of Cooling Rate on the pVT Diagram]. It is shown, using an example taken from a large series of measurements, that in the injection moulding of 2 mm thick polypropylene plates without packing the required pressure variation during the cooling phase cannot be correctly estimated from pVT diagrams measured for relatively low rates of cooling in the stationary melt. Measurements and calculations indicate that, because of the faster cooling rates in injection



moulding, the literature values for the temperature ranges in which crystallization occurs in the interior of the plate must be shifted to lower temperatures to obtain correct results; on the other hand, in the highly orientated outer zones of the plate, notwithstanding the very high rates of cooling, they must be shifted to higher temperatures owing to shear-induced crystallization. (Author abstract) 7 refs. In German.

Koppelman, J. (Montanuniversitaet Leoben, Leoben, Austria); Fleischmann, Ernst. *Kunstst Ger Plast* v 78 n 4 Apr 1988 p 312-315.

**083363 DAS RANDSCHICHTENPROBLEM BEIM NACHDRUCKFREIEN SPRITZGIESSEN VON TEILKRISTALLINEM POLYPROPYLEN.** [Surface Layer Problem in Injection Moulding of Semi Crystalline Polypropylene without After-Pressurization]. Rectangular panels of isotactic polypropylene are made by injection moulding in a tool fitted with a mechanically gated nozzle, with mould internal pressures up to 1600 bar and without after-pressurization. Using birefringence measurements it is shown that the after-pressure orientation effects in the interior of the plate, which usually occur in injection moulding with thermal sealing, can be avoided by increasing the pressure within the mould cavities, but the thickness of the surface layer is also increased. (Author abstract) 11 refs. In German and English.

Fleischmann, Ernst (Montanuniversitaet Leoben, Leoben, Austria); Koppelman, Jan. *Kunstst Ger Plast* v 78 n 5 May 1988 p 453-455.

## Ion Exchange

**083364 STRUCTURAL FEATURE AND EXCHANGE KINETICS OF CARBOXYLATED POLYPROPYLENE ION EXCHANGE RESIN.** The present article deals with the exchange process of bivalent metal ions, such as  $Zn^{2+}$ ,  $Cd^{2+}$  and  $Hg^{2+}$ , etc., taken up by non-crosslinked carboxylated polypropylene (CPP) resin. The control factor of the exchange rate deduced from the kinetic data is governed basically by the chemical reaction rather than the mass transfer effect particle diffusion and/or liquid film diffusion. In solution, all the graft chains in the outer shell of a CPP resin could form a —quasi-macromolecular solution— domain. The opinion further demonstrates the structural pattern of CPP resin proposed in earlier paper. (Author abstract) 6 refs.

Wu, Chinyung (Acad Sinica, Guangzhou, China); Yang, Chaoshung; Yang Chong. *Chin J Polym Sci (Engl Ed)* v 5 n 1 1987 p 12-19.

**Manufacture** See Also POLYETHYLENES—Manufacture.

**083365 ROZWOJ PRZEMYSTOWYCH METOD OTRZYMYWANIA POLIPROPYLENU.** [Developments in the Commercial Manufacture of Polypropylene]. A comparative evaluation of the commercial methods of polypropylene polymerization in solution in liquid monomers (bulk polymerization) and in the gaseous phase have been compared with regard to their technological convenience, polymer yield and capital costs. The advantages resulting from replacing the classical catalysts of generation I with much more active catalysts of generation II and in particular those of generation III ( $TiCl_4$  deposited on magnesium chloride modified with electron donors) have been discussed. These advantages consist in a significant simplification of the technological process due to elimination of a number of operations, lower consumption of raw materials and energetic media and higher yield and stereospecificity of PP. The best prospects in this respect have bulk polymerization and polymerization in the gaseous phase with the application of highly active catalysts of generation III. (Edited author abstract) 51 refs. In Polish.

Bukowski, Andrzej (Politechnika Warszawska, Pol); Osowiecka, Blandyna. *Polimery* v 33 n 2 Feb 1988 p 41-46.

## Measurements

**083366 INFRARED DICHROISM AND VISIBLE-ULTRAVIOLET DICHROISM STUDIES ON ROLLER-DRAWN POLYPROPYLENE AND POLYETHYLENE SHEETS.** The crystal and amorphous orientation functions of polypropylene (PP) and high-density polyethylene (HDPE) sheets, stretched by the roller-drawing technique, were measured by means of infrared dichroism and visible-ultraviolet dichroism. The molecular chains in the crystalline and amorphous regions lined up parallel to the draw direction in the roller-drawing process. At higher draw ratio ( $\lambda > 7-13$ ), the crystal orientation function approached a constant value, whereas the amorphous orientation function increased monotonically with draw ratio. The orientation function calculated from visible-ultraviolet dichroism decreased greatly with decreasing length of solute (dye) molecules. The reasons for this phenomenon are discussed. (Edited author abstract) 38 refs.

Kaito, A. (Research Inst for Polymers & Textiles, Tsukuba, Jpn); Nakayama, K.; Kanetsuna, H. *J Macromol Sci Phys* v B26 n 3 Sep 1987 p 281-306.

## Mechanical Properties

**083367 FLAME RETARDATION OF POLYPROPYLENE: EFFECT OF ORGANOANTIMONY COMPOUNDS ON THE STRUCTURAL AND MECHANICAL PROPERTIES.** Structural properties of polypropylene (PP) filled with flame-retardant (FR) organoantimony compounds, viz., triphenylstibinedibromide and triphenylantimony (V) derivatives of tribromo-, trichloro-, and pentachlorophenols at 5-20 phr additive loading, were investigated through differential thermal analysis (DTA), and X-ray diffraction (XRD) studies. Incorporation of flame retardant in PP has decreased the melting temperature and heat of fusion of PP. Crystallization peak and the onset temperature, crystallization rate and crystallite size are also influenced by the addition of these compounds. The percent crystallinity obtained by XRD is in good agreement with that obtained by DTA. The tensile properties of the flame-retardant-filled PP are also studied, and an attempt has been made to correlate the tensile properties with that of structural changes in polypropylene. Fracture mechanism of flame-retardant-filled PP has been investigated with the help of a scanning electron microscope. (Edited author abstract) 35 refs.

Bajaj, P. (Indian Inst of Technology, New Delhi, India); Jha, N.K.; Maurya, P.L.; Misra, A.C. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1785-1801.

**083368 RECYCLING OF POLYMER WASTE: PART II - STRESS DEGRADED POLYPROPYLENE.** Rheological and mechanical properties of blends of polypropylene and degraded polypropylene have been studied. Both properties, and particularly the elongation at break, depend on the composition and on the extent of degradation. The unusual behavior of the elongation at break is correlated with crystalline phase segregation which appears with decreasing molecular weight of the degraded component. (Author abstract) 8 refs.

Valenza, A. (Univ of Palermo, Palermo, Italy); La Mantia, F.P. *Polym Degradation Stab* v 20 n 1 1988 p 63-73.

**083369 RELATIONSHIPS BETWEEN INJECTION MOULDING CONDITIONS, MICROMORPHOLOGY AND IMPACT CONDITIONS, MICROMORPHOLOGY AND IMPACT PROPERTIES OF POLYPROPYLENE: I. A TYPICAL COMMERCIAL GRADE.** The morphology of isotactic propylene homopolymer injection moldings has been varied by systematically changing carefully controlled processing conditions. A range of analytical techniques was used to characterize the micromorphology of the injection moldings and, in particular, the surface morphology, which has a pronounced effect on impact properties. The impact properties of moldings were determined by instrumented falling-weight and instrumented Izod impact test methods and results were used to establish relationships between

processing conditions, micromorphology and impact behavior. The micromorphologies associated with poor impact toughness are clearly identified. (Author abstract) 23 refs.

Murphy, M.W. (Brunel Univ, Uxbridge, Engl); Thomas, K.; Bevis, M.J. *Plast Rubber Process Appl* v 9 n 1 1988 p 3-16.

**083370 STUDY OF VISCOELASTIC RELAXATION IN AMORPHOUS POLYPROPYLENE NEAR  $T_g$  BY DYNAMIC LIGHT SCATTERING AND SHEAR CREEP.** Polarized photon correlation measurements of completely amorphous polypropylene at temperatures between 268 and 293 K are reported. The time correlation functions of density fluctuation caused by the local segmental motion have been represented by the Kohlrausch-Williams-Watts functions. The theory of Wang and Fischer enables us to compute the longitudinal compliance from the time correlation of the density fluctuation. The retardation spectra  $L(\log \tau)$  are calculated also formally. We find the Kohlrausch exponent of longitudinal compliance from dynamic light scattering agrees rather well with that determined from the local segmental mode contribution to the shear creep. The combined light scattering and mechanical data are examined in the light of the coupling model of relaxation. The predictions of the model account for the time correlation function observed by light scattering and the time dependence of the creep compliance obtained by mechanical measurements. The extra prediction of the model can explain the occurrence of two shift factors and relate them quantitatively, in agreement with experimental data. (Edited author abstract) 35 refs.

Fytas, G. (Univ of Crete, Iraklion, Greece); Ngai, K.L. *Macromolecules* v 21 n 3 Mar 1988 p 804-811.

**083371 TENSILE FLOW STRESS MODEL FOR ORIENTED POLYPROPYLENE.** Many solid-phase processing and forming operations for polymers require tensile stretching forces to produce flow. To make forming operations practical, a knowledge of the flow stress of the polymer is required. This paper presents a simple formulation for predicting the flow stress of polypropylene in the oriented direction as a function of the controlling parameters, which are strain rate, temperature, and deformation ratio. It will be shown that the experimental flow stress data may be formulated in a way that is similar to the constitutive laws for metals. Equations for metals relating flow stress to strain rate, flow stress to strain, and flow stress to temperature are compared with an equivalent formulation for oriented polypropylene. The experimental conditions, chosen to develop the constitutive equations, reflect practical forming conditions. The deformation ratios (i.e., strains) were varied from 6 to 14. (Edited author abstract) 12 refs.

Tate, K.R. (Univ of Toronto, Toronto, Ont, Can); Perrin, A.R.; Woodhams, R.T. *Polym Eng Sci* v 28 n 11 Mid-Jun 1988 p 740-742.

## Microstructure

**083372 MICROSTRUCTURE OF ISOTACTIC POLYPROPYLENE PREPARED WITH HOMONEOUS CATALYSIS: STEREOREGULARITY, REGIOREGULARITY, AND 1,3-INSERTION.** Regioirregularly arranged units have been observed by  $^{13}C$  NMR analysis of isotactic polypropylene prepared in the presence of either racemic ethylenebis(4,5,6,7-tetrahydro-1-indenyl)dichlorozirconium or racemic ethylenebis(indenyl)dichlorozirconium and methylalumoxane. However, the stereochemical placement of the regioirregular units is controlled by the catalyst so that one can speak of more or less stereoregular placement of regioirregular units. The  $\eta^5$  ligands of zirconium affect the stereochemical and regiochemical structure of the polymer. 1,3-Propene insertion has also been observed at a relatively high polymerization temperature. (Author abstract) 32 refs.

Grassi, Alfonso (Univ di Salerno, Salerno, Italy); Zambelli, Adolfo; Resconi, Luigi; Albizzati, Enrico; Mazzocchi, Romano. *Macromolecules* v 21 n 3 Mar 1988 p



617-622.

v 22 n 9 Sep 1987 p 3118-3128.

**083373 MICROTACTICITY DISTRIBUTION OF POLYPROPYLENES PREPARED WITH HETEROGENEOUS ZIEGLER-NATTA CATALYSTS.** The microstructure of the isotactic parts of various polypropylene has been studied by  $^{13}\text{C}$  NMR spectroscopy. The isotacticity of the isotactic parts as determined by the mmmm pentad sequence ('microisotacticity') increases as the stereospecificity of the catalysts (isotactic index, II) employed increases. Several polypropylenes prepared with titanium-based catalysts were fractionated by using an elution column technique. The fractionation results show that two isospecific active centers reside in such catalysts. (Edited author abstract) 12 refs.

Kakugo, Masahiro (Sumitomo Chemical Co, Ichihara, Jpn); Miyatake, Tatsuya; Naito, Yukio; Mizunuma, Kooji. *Macromolecules* v 21 n 2 Feb 1988 p 314-319.

## Molecular Structure

**083377 DOMINANT INTERACTIONS IN THE CONFORMATION OF ISOTACTIC POLYPROPYLENE: 1. INTRACHAIN ENERGY.** A calculation is presented of the intrachain component of the conformational energy of isotactic polypropylene. Multiple minima are found for the energy as a function of the three torsional angles, with a strong dependence noted on the rotation of the methyl group. A comparison is made between the energies of ordered and disordered chain conformations constructed to produce the experimentally observed  $3_1$  helix. (Author abstract) 28 refs.

Wright, N.F. (Case Western Reserve Univ, Cleveland, OH, USA); Taylor, P.L. *Polymer* v 28 n 12 Nov 1987 p 2004-2008.

## Morphology See Also POLYMERS—Mixing.

**083378 SALS AND MORPHOLOGY OF POLYPROPYLENE SPHERULITES.** Spherulites of different morphological features have been obtained by varying the cooling rate of polypropylene melts through the crystallization temperature range from 120 to 90°C. It was found that SALS is very sensitive to the changes of internal structure of the spherulites, and information about their morphological difference can be obtained according to the model theories and statistical theories of SALS. (Author abstract) 14 refs.

Xu, Mao (Acad Sinica, Beijing, China); Hu, Shiru; Stein, Richard S. *Chin J Polym Sci (Engl Ed)* v 4 n 4 Feb 1987 p 341-345.

**083379 PHASE SEPARATION IN INCOMPATIBLE POLYMER BLENDS: POLYPROPYLENE-POLYETHYLENE SYSTEM.** The morphology of polypropylene-polyethylene blends has been investigated in the as-prepared state by employing interface distribution functions to evaluate their small angle X-ray scattering. While the morphology of the PP (within the investigated composition range) is not altered by the presence of finely dispersed PE, the morphology of the PE component is strongly dependent on composition. Below a PE weight fraction of 0.3 the PE crystal thickness increases with increasing PE content. Concurrently the lattice distortion decreases. (Author abstract) 19 refs.

Wenig, W. (Univ-GH-Duisburg, Duisburg, West Ger); Schoeller, Th. *Prog Colloid Polym Sci* v 71 1985 p 113-118.

## Order-Disorder

**083380 DEFORMATION INDUCED ORDER-DISORDER TRANSITION IN ISOTACTIC POLYPROPYLENE.** Isotactic polypropylene (i-PP) has been deformed by uniaxial compression to draw ratios up to  $16\times$ , and at draw temperatures from 30°C to 140°C. An order-disorder transition in the crystals is observed at draw temperatures well above the stability limit, 70°C, reported for the disordered phase. Furthermore, this disordered phase (called smectic) is found to induce ductility and improve the efficiency of draw. The deformation induced smectic phase has been characterized using WAXS DSC, and on-line compression load versus draw ratio measurements. In consequence, a set of process conditions are offered to optimize draw. A mechanism for plastic deformation of i-PP is also suggested, using the smectic phase as a probe. (Edited author abstract). 18 Refs.

Saraf, Ravi F. (Univ of Massachusetts, Amherst, MA, USA); Porter, Roger S. *Polym Eng Sci* v 28 n 13 mid-July 1988 p 842-851.

## Oxidation

**083381 REASONS FOR THE CHANGE IN THE EFFECTIVE REACTION CONSTANTS OF CHAIN PROPAGATION AND TERMINATION IN THE IN-**

**DUCTION PERIOD OF OXIDATION OF ISOTROPIC AND ORIENTED ISOTACTIC POLYPROPYLENE.** The rate constants of the reactions of propagation and termination of the oxidation chains of PP films with different degrees of oxidation and stretching have been determined in absence and presence of a photo-initiator with variation in the spectral composition of the light and the duration of irradiation. The value of the rate constant of death of the radicals depends on the mode of photo-initiation which is connected with the heterogeneity of the course of the reaction of death of the radicals in the polymer volume. (Author abstract) 21 refs.

Makedonov, Yu.V. (USSR Acad of Sciences, USSR); Margolin, A.L.; Rapoport, N.Ya.; Shibrayeva, L.S. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1536-1543.

**083382 SIMULATION OF POLYCHROMATIC KINETICS OF THE PROPAGATION STEP OF THE CHAIN OXIDATION REACTION IN STRAINED POLYPROPYLENE OF THE BASIS OF A ROTATIONAL ISOMER MODEL.** The change in the mean intramolecular rate constant for the propagation step of the oxidation reaction in the amorphous phase of oriented polypropylene subjected to stretching strain is simulated with a computer. The value of this constant depends on the type of function for the length distribution of the straight chains and on the size of the amorphous part, which can introduce a contribution to the structural sensitivity of the kinetic parameters for the oxidation of amorphous-crystalline polymers. The constant decreases on deformation of the thermodynamically rigid chains and passes through a minimum on deformation of the flexible chains. (Author abstract) 21 refs.

Rapoport, N.Ya. (USSR Acad of Sciences, USSR); Mostovaya, Ye.M.; Zaikov, G.Ye. *Polym Sci USSR* v 28 n 8 1986 p 1803-1813.

**083383 DIFFUSION REGIME OF THE AUTO-OXIDATION OF POLYMERS.** The factors influencing the rate of auto-oxidation of a polymer as a function of the oxygen concentration are analyzed and a formula derived describing the rate of auto-oxidation of polypropylene in a regime quasi-stationary in respect of the hydroperoxide groups. A computer is used to obtain a number of special solutions for the rate of auto-oxidation of the polymer in the diffusion regime and interpolation formulae proposed describing the kinetics of such oxidation over a wide range of change in the partial oxygen pressures. The results of the theoretical calculations agree with the experimental findings. (Author abstract) 19 refs.

Denisov, Ye.T. (USSR Acad of Sciences, USSR); Vol'pert, A.I.; Filipenko, V.P. *Polym Sci USSR* v 28 n 10 1986 p 2314-2322.

**083384 KINETIC AND DIFFUSION PARAMETERS OF OXIDATION OF POLYPROPYLENE.** The kinetic patterns of oxidation of isotactic PP have been studied in presence of the initiator dicumyl peroxide and in the auto-oxidation regime. The kinetic and diffusion parameters of oxidation have been obtained. It is established that in the course of oxidation the rate constant of breakdown of the hydroperoxide groups to radicals increases, which is due to accumulation of other oxygen-containing groups in the polymer. (Author abstract) 14 refs.

Kirgin, A.V. (USSR Acad of Sciences, USSR); Shilov, Yu.B.; Denisov, Ye.T.; Yefimov, A.A. *Polym Sci USSR* v 28 n 10 1986 p 2486-2493.

**083385 AUTOXIDATION KINETICS OF ATACTIC POLYPROPYLENE IN BULK.** The kinetics of the reaction between atactic polypropylene (APP) and oxygen in bulk at temperatures ranging from 170 to 210°C and oxygen partial pressures from 160 to 760 torr have been studied by thermal differential analysis. The reaction takes place in two successive steps, both giving hydroperoxide groups as products. Partial reaction orders with respect to APP and oxygen for the first step, which corresponds to

## Mixing

**083374 CORRELATION OF THE POWER NUMBER OF HELICAL RIBBON AGITATOR FOR POWDERY POLYPROPYLENE.** In this paper, the agitating power for powdery polypropylene has been correlated by using dimensional analysis. For helical ribbon agitator, the power number can be expressed by the same form of power number equation as for liquid. In view of the non-Newtonian characteristics of powdery material, its apparent viscosity is given as a function of the rotating speed. The result of regression showed that the difficulty in the experimental measurement of the apparent viscosity could be avoided. (Edited author abstract) 6 refs. In Chinese.

Gao, Xu (UNILAB, China); Ni, Jinfang; Zhu, Zongnan; Zhang, Jinyin. *Huaxue Fanying Gongcheng Yu Gongyi* v 12 n 1 Mar 1986 p 14-19.

**083375 STATES OF ORDER IN BLENDS OF ISOTACTIC POLYPROPYLENE AND ISOTACTIC POLY(1-ETHYLETHYLENE).** The thermodynamic miscibility of the components in the noncrystalline state is discussed with respect to the Flory Huggins interaction parameters  $\chi_{12}$ . In the blends  $\chi_{12}$  was found to be zero for any composition, thermodynamic miscibility in the melt as well as in the solid noncrystalline regions can be excluded. X-ray and thermoanalytic studies gave no evidence of the formation of mixed crystallites, but show that the lattices of the it-PP and it PB crystallites are deteriorated. From the melt it-PB crystallizes in the tetragonal modification II and it-PP in the monoclinic modification I. From solutions the orthorhombic modification III of it-PB and modification I of it-PP are obtained. (Edited author abstract) 27 refs.

Trafara, G. *Kautsch Gummi Kunstst* v 41 n 4 Apr 1988 p 334-339.

## Modification See AUTOMOBILES—Plastics Applications.

## Molding

**083376 NON-DESTRUCTIVE ULTRASONIC EVALUATION OF  $\text{CaCO}_3$ -FILLED POLYPROPYLENE MOULDINGS.** The dynamic elastic moduli and Poisson's ratio of calcium carbonate-filled polypropylene mouldings have been determined for a continuous range of filler loadings of between 0 and 40% volume fraction. Measurements were made non-destructively on bulk samples in the form of plates 2 cm  $\times$  2 cm square and 3 mm thick, at 5 MHz. The composition dependences of the elastic properties are compared with the Hashin and Shtrikman bounds for two-phase materials. All data were in close correspondence with the lower bound, suggesting that the fill particles were well dispersed, relatively free of agglomeration, well bonded to the matrix, and that particle sizes were much less than  $\lambda/4$ , i.e. much less than 100  $\mu\text{m}$ , where  $\lambda$  is the wavelength of compressional waves. (Author abstract) 13 refs.

Bridge, B. (Brunel Univ, Engl); Cheng, K.H. *J Mater Sci*



the uncatalyzed attack of a C-H tertiary bond to give a hydroperoxide, are one and two, respectively. In the second step, interpreted as another attack on a tertiary C-H by oxygen, catalyzed by a neighboring hydroperoxide group, reaction orders are one and one-half for APP and oxygen, respectively. Activation parameters have been determined and a reaction sequence is proposed. Hydroperoxidized APP subsequently decomposes via a zero-order process giving methylketone groups as its main product. An interpretation of this process is also given. (Author abstract) 23 refs.

de Andres, Jaime (Univ de Barcelona, Barcelona, Spain); Aguilar, Antonio; Domenech, Jorge. *J Polym Sci Part A* v 26 n 5 May 1988 p 1323-1334.

**083386 CHARACTERISTIC FEATURES OF SOLID-PHASE PHOTOOXIDATION OF ISOTACTIC POLYPROPYLENE AND THE EFFICIENCY OF PHOTOINITIATORS.** The rate of decay of macroperoxy radicals  $PO_2$  formed in polypropylene by photo-initiated transformations of various initiators has been measured under conditions of long reaction chains of oxidation. New effects specific for oxidation proceeding in the solid phase have been found: the dependence of the rate constant characteristic for second-order decay of  $PO_2$  on the irradiation time, on initial concentration of radicals, and on their mutual distance. A new kinetic law of radical decay, generally valid for various initiators, has been established such that the chain termination does not follow the second-order mechanism. (Edited author abstract) 21 Refs.

Margolin, A.L. (USSR Acad of Sciences, USSR); Kordonskii, L.E.; Makedonov, Yu. V.; Shlyapintokh, V. Ya. *Polym Sci USSR* v 29 n 5 1987 p 1183-1191.

**083387 CHEMILUMINESCENCE AND INHIBITED OXIDATION OF POLYPROPYLENE.** The efficiency of mixtures of the commercial antioxidants, Hostanox OSP 1, Irganox 1010 and distearylthiodipropionate was examined by chemiluminescence and oxygen uptake methods. Lower induction periods of oxidation, observed by the chemiluminescence method at 190°C, were found with samples which contain more of the less volatile additives. In accordance with earlier findings this is due to the surface nature of chemiluminescence which yields results close to those of the kinetic region. (Author abstract) 11 refs.

Rychla, L. (Slovak Acad of Sciences, Bratislava, Czech); Rychly, J.; Krivosik, I. *Polym Degradation Stab* v 20 n 3-4 1988, Polym Addit in Stab: Perform and Mech, Birmingham, Engl Sep 2-4 1987 p 325-335.

## Phase Transitions

**083388 PHASE CHANGES IN ISOTACTIC POLYPROPYLENE MEASURED BY MICROHARDNESS.** The object of the present study is to examine the influence of polymorphic changes on the values of MH. For this purpose isotactic polypropylene was selected as a material which can crystallize into two polymorphic forms: the  $\alpha$  (monoclinic) and  $\beta$  (hexagonal). Microhardness was measured at room temperature using a Leitz tester adapted with a square-pyramidal diamond indenter. The MH value was derived from the residual projected area of indentation. The results show that the MH of the material decreases from about 111 MN  $m^{-2}$  to a value of 90 MN  $m^{-2}$  when passing from the  $\alpha$ - to the  $\beta$ -phase texture. 15 refs.

Calleja, F.J. Balta (CSIC, Madrid, Spain); Salazar, J. Martinez; Asano, T. *J Mater Sci Lett* v 7 n 2 Feb 1988 p 165-166.

**Physical Properties** See Also PLASTICS FILMS—Physical Properties; PLASTICS FILMS—Surfaces; YARN—Spinning.

**083389 EFFECT OF MOLECULAR WEIGHT DISTRIBUTION ON THE PHYSICAL PROPERTIES AND MORPHOLOGY OF POLYPROPYLENE STRETCHED TAPE.** Stretched tape and film were made from isotactic polypropylene homopolymer produced

with SHAC catalyst (Shell High Activity Catalyst). The resins used were nominal 3.5 and 8.0 melt flow (MF) resins with narrow, medium, and broad molecular weight distributions (MWD). Measurements were made of tape and film physical properties as a function of MWD and process heat history. Small angle x-ray two-theta scans through the meridional direction were done to obtain Long Period Spacing (LPS). Long period spacing for an idealized semicrystalline model is the combined distance through both a crystalline lamella and the amorphous region between the lamellae. LPS was correlated to resin melt flow and MWD. Wide angle x-ray scattering techniques using pole figures and Hermans orientation functions were used to determine molecular orientation. Density and physical properties did not change significantly as a function of MWD for the 3.5 and 8 MF tapes. The tenacities of the 8 MF tapes averaged 0.8 gm/denier less than those of the 3.5 MF tapes. The density of the 8 MF tapes was higher than that of the 3.5 MF tape density indicating a higher percent crystallinity for the 8 MF tapes. (Edited author abstract) 16 refs.

Flood, J.E. (Shell Development Co, Houston, TX, USA); Hart, D.W.; Nulf, S.A.; Brown, H.S. *J Plast Film Sheeting* v 3 n 3 Jul 1987 p 171-197.

**Processing** See Also PLASTICS FILMS—Production; POLYOLEFINS—Manufacture; TEXTILE FIBERS—Spinning.

**083390 ZPRACOVATELSKA STABILITA POLYPROPYLENU.** [Processing Stability of Polypropylene]. In order to establish processing stability of polypropylene a method of combined shear and heat stressing in the presence of atmospheric oxygen has been employed. The stability of the material has been assessed by variation of the polypropylene melt flow index with stress time. (Author abstract) In Czech. 10 refs.

Nejedly, Emil (Chemopetrol, Brno, Czech); Blahutka, Ladislav. *Plasty Kauc* v 24 n 3 Mar 1987 p 73-77.

**083391 COMPUTER CONTROLLED POLYPROPYLENE STRETCHED TAPE LINE TO INVESTIGATE THE EFFECT OF PROCESSING CONDITIONS ON STRETCHED TAPE MORPHOLOGY AND PROPERTIES.** A computerized stretched tape line has recently been installed at the Shell Westhollow Research Center. Shrinkage decreased as MWD broadened and also with higher on-line annealing temperatures. (Edited author abstract) 3 refs.

Flood, J.E. (Shell Development Co, Houston, TX, USA); Nulf, S.A.; Millsbaugh, K.C.; Lehnen, P. *J Plast Film Sheeting* v 4 n 1 Jan 1988 p 8-26.

**083392 MOLECULAR ORIENTATION OF POLYPROPYLENE BY ROLLING-DRAWING.** An overview is given of the rolling-drawing of polypropylene. It is intended to answer the following questions. What is rolling-drawing? What changes in tensile properties can be expected as a result of this process? What deformation processes occur during rolling-drawing? What are the processing variables and how do these variables relate to the deformation ratio achieved by rolling-drawing? A tensile flow stress relationship was formulated from experimental data for oriented polypropylene. This constitutive equation estimates the flow stress (or yield stress) of the polymer as a function of deformation ratio, strain rate and temperature. (Edited author abstract). 12 refs.

Tate, K.R. (Univ of Toronto, Toronto, Can); Perrin, A.R.; Woodhams, R.T. *Polym Eng Sci* v 28 n 19 MID-OCT; 1988 p 1264-1269.

## Production

**083393 POLYPROPYLENE (PP).** The worldwide consumption of PP and of HDPE is roughly equal, and was some 8.4 mio.t for each in 1986, sharing third place behind LDPE/LLDPE and PVC. With an annual growth rate of 5.5%, consumption of PP in 1991 is expected to reach 11 mio. t. Future growth rates for PP are expected to be greater than those of other commodity plastics. The use of PP is limited by heat-deformation resistance, to

temperatures below 120°C, and by the need for greater stiffness and low temperature impact strength in the same material. Above average growth sectors for PP are seen in textile areas like non-wovens, in packaging (films, thin-wall injection mouldings), and in cars. Replacement of the classical suspension process in inert hydrocarbons by processes using high-activity and highly-stereospecific catalysts, and polymerisation in liquid (bulk process) or gaseous polypropylene (gas-phase process) is continuing its advance. In future, because of the many additives and processing aids employed, PP will be predominantly used in pellets. 8 refs.

Strobel, W. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 20-23.

**083394 SPHERIPOL PROCESS: MAXIMUM SIMPLIFICATION IN POLYPROPYLENE PRODUCTION.** Scientific and technical knowledge acquired in the last years by Montedison-Mitsui Research on high yield catalysts for olefin polymerization, as well as the ability to modify them as a function of the desired performances, has made it possible to design polyolefin production processes ensuring both very low production costs and high quality products. Pilot plant results confirm that the main key to the success of the new polyolefin processes is represented by the high quality, degree of activity and specialization of the catalysts. This major factor is associated with the reliability of plant technological approaches and macromolecular structures serving as model for the product synthesis. Another aspect of economic and social value is that the processes we are dealing with are absolutely irreproachable from the ecological point of view; they do not produce effluents at all. Data show conclusively that the type of catalyst and its utilization, therefore, determine the relationship between process, product quality and efficiency. Comparative investment costs are given. Homopolymer production costs are also presented.

Omicini, Gabriele (Montedison/Montopolimeri SpA, Milan, Italy). *Chem Age India* v 38 n 4 1987 p 139-144.

**083395 OUTLOOK FOR POLYPROPYLENE IN INDIA.** The basic polymer is also available in three types. These are: Homopolymers Random Copolymers and Terpolymers Impact or Heterophasic Copolymers of Ethylene and Propylene. The purpose of this paper is to: (i) Present international trends in respect of growth of this polymer; (ii) Discuss structure, properties and applications of various types of polypropylene; (iii) Analyse past growth in India; (iv) Present the outlook regarding product availability and new applications.

Chatterjea, B.D. (Indian Petrochemicals Corp Ltd, Vadodra, India). *Chem Age India* v 39 n 3 1988 p 159-164.

## Radiation Effects

**083396 DOSE RATE EFFECTS IN THE HIGH ENERGY RADIATION INDUCED STEREOREGULARITY CHANGES IN ISOTACTIC POLYPROPYLENE.** The loss of isotactic pentad sequences in predominantly isotactic polypropylene film when subjected to electron beam radiation (dose rate 720 kGy  $h^{-1}$ ) occurs with a G value of 220, i.e. 2.3 times the corresponding G value (94) for an identical sample irradiated with  $\gamma$  radiation, dose rate 4.4 kGy  $h^{-1}$ . Of equal significance, the pattern of non-isotactic pentad sequences formed during irradiation is different at the two dose rates. High dose rates lead to a greater preponderance of syndiotactic sequences. The results suggest that an energy quantum deposited at the high dose rate is more effective in promoting further stereochemical inversion in nearby monomer units. On average five inversions are promoted on mainly alternate monomer units. With  $\gamma$  radiation, an energy quantum promotes on average two inversions with a more random distribution relative to each other, the average distribution in this case being somewhere between adjacent and alternate. (Author abstract) 7 refs.

Barron, Peter F. (Griffith Univ, Nathan, Aust); Busfield, W. Ken; Hanna, John V. *Polym Commun (Guildford Engl)* v 29 n 3 Mar 1988 p 70-72.



**083397 EXTENSIVE STEREOREGULARITY CHANGES INDUCED IN MOLTEN ISOTACTIC POLYPROPYLENE BY HIGH ENERGY RADIATION AND OTHER MORPHOLOGY EFFECTS.** In a recent paper, we described the remarkably large change in tacticity which was observed in highly annealed isotactic polypropylene (PP) as a result of irradiation with gamma rays under ambient temperature and vacuum conditions. We have found that gelation does not occur in PP if the irradiation is carried out above the melting point, hence these conditions allow a more extensive study of the induced stereoregularity changes. This is a preliminary report of the even more remarkable irradiation effects observed in the high temperature experiments, together with some other morphological effects. 8 refs.

Barron, Peter F. (Griffith Univ, Nathan, Aust); Busfield, W. Ken; Hanna, John V. *J Polym Sci Part C* v 26 n 5 May 1988 p 225-228.

**083398 POSITRON ANNIHILATION LIFETIME AND DOPPLER BROADENING STUDIES OF ELECTRON-IRRADIATED POLYPROPYLENE.** The authors used positron annihilation lifetime and Doppler broadening spectra to investigate microstructural changes of polyethylene films before and after electron irradiation. The intensity of the longest lifetime and the shape parameter of Doppler broadening decrease gradually with increase of the irradiation dose. The decrease of positronium formation due to radiation induced defects such as proved by electron spin resonance measurements where a large amount of radicals are observed after irradiation. 10 refs.

Wang, G.-H. (Nanjing Univ, Nanjing, China); Teng, M.-K.; Shen, D.-X.; Yi, C.-Y.; Zhou, Y.-Y.; Lu, Y.-Y.; Wang, H.-W.; Zhu, Y.-Z.; Dou, L. *Phys Status Solidi A* v 106 n 1 Mar 1988 p K1-K6.

**083399 EFFECT OF GAMMA-IRRADIATION ON THE MORPHOLOGY OF QUENCHED ISOTACTIC POLYPROPYLENE.** Wide-angle x-ray diffraction, differential scanning calorimetry and gel-permeation chromatography measurements have been used to investigate the effect of low absorbed doses of  $\gamma$ -radiation, up to 100 kGy, on isotactic polypropylene (iPP). The bimodal endotherm for the sample quenched in iced water was attributed to the presence of both 'smectic' and monoclinic crystalline phases. The changes in the morphology, molecular weight distribution, decrease of melting temperature and heat of fusion with absorbed dose are related to the radiation processes in pure iPP. (Author abstract). 10 Refs.

Kostoski, D. (Boris Kidric Inst of Nuclear Sciences-Vinca, Belgrade, Yugosl); Stojanovic, Z.; Gal, O.; Stannett, V.T. *Radiat Phys Chem* v 32 n 5 1988 p 667-670.

**083400 ELECTRON RADIATION EFFECTS ON THE ELECTRICAL AND MECHANICAL PROPERTIES OF POLYPROPYLENE.** Capacitor-grade polypropylene film was irradiated in air with a 1-MeV electron beam to different doses up to  $10^8$  rads; the postirradiation effects on the electrical and mechanical properties included the 60-Hz ac breakdown voltage, dielectric constant, and dissipation factor. The dielectric constant and dissipation factor were obtained at five frequencies ranging from 50 Hz to 10 kHz. The tensile properties comprised the Young's modulus, elongation-at-break, and tensile strength. While the electrical and tensile properties were evaluated at room temperature, the dynamic mechanical properties were determined at a frequency of 110 Hz in a temperature range from 12 to 120°C. The results obtained indicate that while the electrical properties remain relatively stable at doses up to  $10^7$  rads, the mechanical properties exhibit a steady decline even at lower dose levels. 18 refs.

Hammoud, A.N. (State Univ of New York, Buffalo, NY, USA); Laghari, J.R.; Krishnakumar, B. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1822-1826.

**083401 RADIATION CROSSLINKING OF POLYPROPYLENE.** The radiation crosslinking of polypropylene (PP) with several kinds of polyfunctional monomers has been examined. We have found that the polyfunctional monomers can be classified into three types by the electron irradiation dose necessary for crosslinking. In particular, we have developed a new crosslinking method using a specific crosslinking coagent having an acryloyloxy group with a very low required irradiation dose. If this type of monomer is used, 0.5 Mrad is enough to saturate the crosslinking, while the other two types require more than 5 Mrad. The degree of crosslinking is estimated by the gel fraction, modulus of the molten sheet and that of degradation by elongation and oxidation induction time. The crosslinked PP obtained by this method has many good properties, such as a high modulus, large elongation, and high heat resistance. This method may be applied in the manufacture of foamy and other heat resistant materials. (Edited author abstract) 9 refs.

Sawasaki, T. (Furukawa Electric Co, Jpn); Nojiri, A. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 877-886.

**Rheology** See POLYMERS—Rheology.

## Solutions

**083402 EFFECTS OF SOLVENT TYPE ON THE CONCENTRATION DEPENDENCE OF THE COMPRESSION MODULUS OF THERMOREVERSIBLE ISOTACTIC POLYSTYRENE GELS.** Solutions of isotactic polystyrene in either trans-decalin or 1-chlorodecane were transformed into gels by quenching from a high temperature (ca. 180°C) to -20°C. The relaxation modulus in compression of these gels was measured over a range of concentrations of from 0.04 g/g to 0.40 g/g. At 22°C, the gels show a double logarithmic stress relaxation rate,  $m$ , which is higher than for PVC and gelatin gel systems. 120 s isochronal modulus concentration diagrams exhibit non-power law behavior, i.e., not only is the general trend such that the double logarithmic slope decreases with increasing concentration, but there are also regions in which abrupt changes in modulus occur over narrow ranges in concentrations. The behavior is interpreted to be inconsistent with a fringed micelle picture of the gel structure. Preliminary results are reported indicating that polymer fraction and temperature of gel formation can significantly affect the modulus of the gels. (Edited author abstract) 17 refs.

McKenna, G.B. (NBS, Gaithersburg, MD, USA); Guenet, J.-M. *J Polym Sci Part B* v 26 n 2 Feb 1988 p 267-276.

## Spectroscopic Analysis

**083403 PRISPEVOK INFRACERVENEJ ABSORPCNEJ SPEKTROSKOPIE K HODNOTENIU KOMPONITNYCH POLYPROPYLENOVYCH VLAKEN.** [Contribution of Infrared Absorption Spectroscopy to Investigation of Composite Polypropylene Fibers]. A quantitative analysis is presented of infrared spectra obtained from polypropylene fibers filled with finely ground limestone. Relationships between filler loading and crystallinity for fibers exhibiting various degrees of deformation are shown. (Author abstract) In Slovak 27 refs.

Michlik, Peter (Vyskumny ustav Chemickych Valken, Svit, Czech); Durcova, Olga; Knotek, Lubomir. *Plasty Kauc* v 24 n 1 Jan 1987 p 11-15.

**083404 TWO-DIMENSIONAL NMR CHARACTERIZATION OF PROPYLENE COPOLYMERS.** Newly developed two-dimensional NMR techniques are used to characterize homopolypropylene and copolymers of propylene with ethylene and butylene. Both homonuclear and heteronuclear shift-correlated experiments have been attempted. The most useful technique for the copolymers is  $^{13}\text{C}$ - $^1\text{H}$  shift correlation, whereby the one-dimensional  $^1\text{H}$ -NMR spectra of these copolymers are completely interpreted for the first time. Although the

$^1\text{H}$  resonances are heavily overlapped, the use of a computerized 'analytical' approach permits pertinent information to be obtained from the one-dimensional  $^1\text{H}$ -NMR spectra. (Author abstract) 38 refs.

Cheng, H.N. (Hercules Inc, Wilmington, DE, USA); Lee, G.H. *J Polym Sci Part B* v 25 n 11 Nov 1987 p 2355-2370.

**083405 STUDIES OF THE MOBILITY OF PROBES IN POLY(POLYPROPYLENE OXIDE): 1. FLUORESCENCE ANISOTROPY DECAY.** The fluorescence anisotropy decay of a rodlike probe, diphenylhexatriene (DPH), dissolved in 1,2-propanediol and in poly(propylene oxide) matrices with molecular weights 425 and 4,000, is studied using the single-photon-counting technique and synchrotron radiation as the exciting source. The monomolecular reorientation correlation times are compared with previous light-scattering results. It is shown that combining these two techniques, which explore complementary time ranges, the shift factor and WLF parameters for molecular relaxation can be obtained without any further assumptions. The results are in agreement with those obtained from viscoelastic data. (Edited author abstract) 21 refs.

Fofana, Mamadou (CNRS, Paris, Fr); Veissier, Valerie; Viovy, Jean Louis; Monnerie, Lucien; Johari, G.P. *Polymer* v 29 n 2 Feb 1988 p 245-250.

**083406 STUDIES OF THE MOBILITY OF PROBES IN POLY(PROPYLENE OXIDE): 2. EXCIMER FLUORESCENCE TECHNIQUE.** Intramolecular excimer formation of meso-2,4-di(N-carbazolyl)pentane dissolved in two poly(propylene oxides) of molecular weights 425 and 4,000 as well as in 1,2-propanediol (monomer) has been investigated. The intramolecular conformational charge required for the excimer sampling process is shown to be controlled by the segmental motions of the polymer matrices involved in the glass transition phenomenon. The data obtained in 1,2-propanediol have been fitted by a Vogel-type WLF equation. The results show that intermolecular interactions in the monomer lead to a thermal expansion coefficient of the free volume smaller by a factor of about 2 than that of the polymer. (Author abstract) 14 refs.

Bokobza, L. (CNRS, Paris, Fr); Pham-Van-Cang, C.; Giordano, C.; Monnerie, L.; Vandendriessche, J.; De Schryver, F.C. *Polymer* v 29 n 2 Feb 1988 p 251-255.

**083407 STRUCTURE OF HIGHLY ORIENTED POLYPROPYLENE AND ITS EFFECT ON PHYSICO-MECHANICAL PROPERTIES.** The structure of highly oriented polypropylene was studied by X-ray, IR-spectroscopic and thermophysical methods. At elongations  $\lambda > 15$ , the crystallites and the polymer chains in amorphous regions were shown to be fully oriented in the strain direction, while the long period, and the longitudinal and transversal crystallite dimensions were independent of  $\lambda$ . With increasing  $\lambda$ , the crystallinity growth as determined by X-ray exhibits but insignificant growth, whereas that determined by DSC measurements increases by 30%. The effect of the structure of highly oriented polypropylene on the elastic modulus was analyzed. A model of the structure of highly oriented polypropylene is proposed. (Author abstract) 17 refs.

Turetskii, A.A. (USSR Acad of Sciences, USSR); Baranov, A.O.; Chvalun, S.N.; Yerina, N.A.; Zubov, Yu.A.; Prut, E.V.; Bakeyev, N.F.; Yenikolopyan, N.S. *Polym Sci USSR* v 28 n 10 1986 p 2380-2386.

**083408 USE OF INFRARED SPECTROSCOPY FOR DETERMINATION OF POLYPROPYLENE STEREOREGULARITY.** This study examines the application of infrared (IR) spectrometry to the determination of polypropylene (PP) stereoregularity. The use of the absorption bands at  $998\text{ cm}^{-1}$  and  $841\text{ cm}^{-1}$  as indices of isotacticity and bands at  $1167\text{ cm}^{-1}$  and  $973\text{ cm}^{-1}$  as internal references have been explored. Calibration curves relating various absorption ratios to isotacticity as measured by  $^{13}\text{C}$  nuclear magnetic resonance are reported.



The ratios  $A_{998}/A_{973}$  and  $A_{841}/A_{973}$  are the most useful and provide linear correlations with isotacticity. The effect of instrument type on the calibration has been investigated for both dispersive and Fourier transform type IR spectrometers. (Edited author abstract) 23 refs.

Burfield, David R. (Univ of Malaya, Kuala Lumpur, Malaysia); Loi, Patrick S.T. *J Appl Polym Sci* v 36 n 2 Jul 5 1988 p 279-293.

**083409 CARBON-13 NMR INVESTIGATION OF LOCAL DYNAMICS IN BULK POLYMERS AT TEMPERATURES WELL ABOVE THE GLASS TRANSITION TEMPERATURE. 2. POLY(PROPYLENE OXIDE) AND LINEAR AND CROSS-LINKED POLY(ETHYLENE OXIDES).** Carbon-13 spin-lattice relaxation time measurements have been performed at two experimental frequencies on the considered polymers, and the data have been analyzed by using the orientation autocorrelation functions developed for polymers and a modified function proposed for poly(vinyl methyl ether) in the preceding paper. As observed in the latter compound, a fast motion of the internuclear vector has to be considered and has been assigned to a libration of limited extent about the rest position. The temperature dependence of the segmental motions proves that these modes are involved in the glass-rubber transition process. Furthermore, the effect of cross-linking on the dynamics of poly(ethylene oxide) segments has been studied. (Author abstract). 23 Refs.

Dejean de la Batie, R. (CNRS, Paris, Fr); Laupretre, F.; Monnerie, L. *Macromolecules* v 21 n 7 Jul 1988 p 2052-2058.

## Spectrum Analysis

**083410 HIGH-RESOLUTION SOLID-STATE  $^{13}\text{C}$  NUCLEAR MAGNETIC RESONANCE STUDY OF ISOTACTIC POLYPROPYLENE POLYMORPHS.** High-resolution  $^{13}\text{C}$  nuclear magnetic resonance spectra are reported for three solid samples of isotactic polypropylene (i-PP): (i) the  $\alpha$ -crystalline form (monoclinic), (ii) the  $\beta$ -crystalline form (hexagonal), and (iii) the mesomorphic or smectic form of i-PP. These spectra were obtained using magic angle spinning, high-power proton dipolar-decoupling and cross-polarization techniques, and for the  $\beta$ - and smectic forms of i-PP constitute the first reported high-resolution solid-state spectra. The spectrum of the  $\alpha$ -crystalline form shows well resolve splittings (1 ppm) of the methyl and methylene carbon resonances. These splittings are absent in the spectra observed for the  $\beta$ - and smectic forms of i-PP. (Edited author abstract) 30 refs.

Gomez, M.A. (AT&T Bell Lab, Murray Hill, NJ, USA); Tanaka, Hajime; Tonelli, A.E. *Polymer* v 28 n 13 Dec 1987 p 2227-2232.

**083411 HEPTAD CONFIGURATIONAL ANALYSIS OF  $^{13}\text{C}$  N.M.R. SPECTRA IN HIGHLY ISOTACTIC POLYPROPYLENE.**  $^{13}\text{C}$  nuclear magnetic resonance (n.m.r.) spectra were obtained at 67.8 MHz for highly isotactic polypropylene polymerized with a Ziegler-Natta catalyst. The tactic heptad peaks observed in the methyl region of the spectrum were assigned on the basis of the gamma effect of chemical shift and by using the Suter-Flory RIS model of polypropylene conformations. The mechanism of propylene polymerization were analyzed from the values of triad and pentad tacticities. The two-site model, with its three parameters optimized, reproduced well the observed relative areas of pentad and heptad peaks in the region of methyl carbon resonances. (Edited author abstract) 16 refs.

Hayashi, Tetsuo (Tokyo Inst of Technology, Tokyo, Jpn); Inoue, Yoshio; Chujo, Riichiro; Asakura, Tetsuo. *Polymer* v 29 n 1 Jan 1988 p 138-143.

## Stability

**083412 MEASUREMENT OF THERMO-OXIDATIVE STABILITY OF ISOTACTIC POLYPROPYLENE BY ISOTHERMAL LONG-TERM DIFFERENTIAL THERMAL ANALYSIS.** The thermo-oxidative stability of isotactic polypropylene with different antioxidant concentrations between 0% and 0.1% has been studied using isothermal long-term differential thermal analysis (ILDTA). Aging tests in a circulating-air oven at 140°C showed that the loss of thermo-oxidative stability with increasing aging time was nearly linear. So the state of thermo-oxidative deterioration of isotactic polypropylene can be estimated by measurement of residual life time in an ILDTA experiment. The end of the oven life of polypropylene coincided with the loss of mechanical properties which was confirmed by a long-term tensile test at 100°C and 120°C. (Edited author abstract) 7 refs.

Steiner, G. (Montanuniversitaet Leoben, Leoben, Austria); Koppelman, J. *Polym Degradation Stab* v 19 n 4 1987 p 307-314.

**083413 ROLE OF HINDERED PIPERIDINE (HALS) COMPOUNDS FOR THE STABILIZATION OF POLYPROPYLENE AGAINST OXIDATION REACTIONS CAUSED BY OZONE AND OXIDATIVE PRODUCTS FORMED DURING PHOTOLYSIS OF OZONE.** The role of hindered piperidine (HALS) photostabilizers for the photostabilization of polypropylene films against oxidative reactions caused by ozone and oxidative species formed during photolysis of ozone under UV irradiation (i.e., atomic oxygen and singlet oxygen) has been investigated and discussed. It has been found that ozonization and/or photoozonization of 2,2,6,6-tetramethyl-piperidine (I) and piperidinoxy radical (2,2,6,6-tetramethylpiperidino-1-oxyl) (II) gives a high yield (91-98 percent) 2,6-dimethyl-2-hydroxy-6-nitro-heptane. (Edited author abstract). 50 Refs.

Lucki, J. (Royal Inst of Technology, Stockholm, Sweden); Rabek, J.F.; Ranby, B.; Watanabe, Y. *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 1067-1085.

## Stabilizers

**083414 SYNERGISM OF HINDERED AMINE LIGHT STABILIZERS AND UV-ABSORBERS.** The synergism of hindered amine light stabilizers (HALS) and UV-absorbers is very important in the practical photo-stabilization of polymers. As very little is known, however, the relationship between the composition of the mixture of the two kinds of light stabilizer and its photo-stabilizing efficiency was investigated in four common polymers. A high level of synergism was observed in polypropylene, high density polyethylene and ABS resin. A moderate synergistic effect was obtained in polystyrene. The maximum efficiency was observed at mixing ratios of hindered amine light stabilizer to UV-absorber of about 75:25 in polypropylene and high density polyethylene, 90:10 in ABS resin and 80:20 in crystal polystyrene. (Edited author abstract) 21 refs.

Kurumada, Tomoyuki (Sankyo Co, Tokyo, Jpn); Ohsawa, Hisayuki; Yamazaki, Takaaki. *Polym Degradation Stab* v 19 n 3 1987 p 263-272.

## Strain

**083415 EVALUATION OF (RESIDUAL) STRESSES IN SEMICRYSTALLINE POLYMERS BY X-RAYS.** In this paper the principal methods of measuring strains by X-rays on semicrystalline polymeric materials are described. The XEC of PP have been measured on different (hkl) planes. With the usual reflection method and a newly developed transmission method, residual stresses within the cross section of injection molded PP plates and an extruded PP tube have been determined. 11 refs.

Hauk, V. (RWTH, Aachen, West Ger); Trobst, A.; Ley, D. *Adv Polym Technol* v 7 n 4 Winter 1987 p 389-396.

## Stresses

**083416 EFFECT OF DRAW RATE ON THE STRESS-STRAIN BEHAVIOUR OF POLYMERS.** A new phenomenon has been observed in the tensile deformation of polymers, including polypropylene, poly(ethylene terephthalate) and polyethylene. It has been seen that when draw rate is larger than a critical value, Young's modulus, yield stress and other parameters associated with the drawing response of these polymers decrease rapidly with the increasing draw rate; the normal time-temperature superposition principle does not appear to hold in this case. Further it can be shown that this decrease in modulus and yield stress is not caused by a temperature rise during drawing; the tensile deformation process before yield is largely isothermal. As an alternative, a change in the yield mechanism is suggested as a reason for the decrease in modulus and yield stress. (Edited author abstract) 14 refs.

Liu, Tuomin (Pennsylvania State Univ, University Park, PA, USA); Harrison, I.R. *Polymer* v 29 n 2 Feb 1988 p 233-239.

**Structure** See Also POLYOLEFINS—Injection Molding; TEXTILE FIBERS—Synthetics.

**083417 WHOLE-PATTERN APPROACH TO STRUCTURE REFINEMENT PROBLEMS OF FIBROUS MATERIALS. APPLICATION TO ISOTACTIC POLYPROPYLENE.** Following up an idea developed in a previous paper, the crystal structure of the  $\alpha$  form of isotactic polypropylene (IPP) has been refined by a least-square fitting procedure by using X-ray diffraction fiber data and considering the fiber spectrum as a whole. This approach represents an extension of the Rietveld method from the one-dimensional case (powders) to a two-dimensional case (fibers). In spite of structure complexity, low resolution, and reflection overlap, well-distinguishable fits have been obtained by considering the two structure models  $P2_1/c$  and  $C2/c$  which are very closely related to each other. A reliable chain model of  $3_1$  symmetry was obtained having C-C-C chain angles of 116.9 and 112.4°, chain torsion angles of 178 and 59°, and methyl-to-chain valence angles of 108.2°. (Author abstract) 22 refs.

Immirzi, A. (Univ di Salerno, Salerno, Italy); Iannelli, P. *Macromolecules* v 21 n 3 Mar 1988 p 768-773.

**083418 DISTRIBUTION OF MOLECULAR ORIENTATION AND STABILITY OF PEROXY RADICALS IN THE NONCRYSTALLINE REGION OF ELONGATED POLYPROPYLENE.** The angular dependent ESR spectra of peroxy radicals in noncrystalline regions of elongated polypropylene are successfully observed following UV and  $\gamma$ -irradiation at low temperatures. The ESR spectra of mobile radicals obtained by subtracting the ESR spectra after annealing from those before annealing can be simulated from the calculated spectra of the partially oriented paramagnetic centers. The shape of the resulting spectrum changes drastically with the annealing temperature. It is found that the more mobile radicals have the lower degree of orientation. (Edited author abstract) 8 refs.

Shimada, Shigetaka (Nagoya Inst of Technology, Nagoya, Jpn); Hori, Yasuro; Kashiwabara, Hisatsugu. *Macromolecules* v 21 n 4 Apr 1988 p 979-982.

**083419 STRUKTURA A TOKOVE CHOVANI POLYPROPYLENU.** [Structure and Flow Behavior of Polypropylene]. Bersted's empirical model for correlation of structure and flow data of polymer melts has been verified for polypropylene. Experimental results and data taken from literature were utilized for the correlation. The relationship obtained proved useful in correlating structure and viscosity of the samples of the MOSTEN polypropylene. It can be assumed that these relationships will make it possible to predict flow behavior of polypropylene compounds of known molecular weight distribution. (Author abstract). 25 Refs. In Czech.

Hudec, Pavel (Vyzkumny Ustav Makromolekulari Chemi, Brno, Czech); Janska, Jarmila; Weigllova, Irena. *Plasty Kauc* v 25 n 6 Jun 1988 p 169-172.



**Surface Properties** See PLASTICS FILMS—Metallizing.

**Thermal Conductivity** See HEAT INSULATING MATERIALS—Plastics.

**Thermal Properties** See TEXTILE FIBERS—Synthetic.

**Thermodynamic Properties**

**083420 ESTIMATION OF  $\sigma_E$  AND  $\alpha$ - AND  $\beta$ -FORM POLYPROPYLENE.** Several reports have been published on the fold surface free energy  $\sigma_E$  of  $\alpha$ -form isotactic polypropylene (PP). However, few reports can be found concerning the  $\beta$ -form. These values are necessary to the discussion of lamellar growth and also to the consideration of  $\beta$ -modification change. For this purpose, SAXS (small angle x-ray scattering) and DSC (differential scanning calorimetry) measurements were made on  $\alpha$  and  $\beta$ -form PP specimens which possess a preferred lamellar orientation. The oriented specimens were grown by temperature-gradient crystallization without addition of any  $\beta$ -nucleator. 9 refs.

Fujiwara, Y. (Shizuoka Univ, Hamamatsu, Jpn). *Colloid Polym Sci* v 265 n 11 Nov 1987 p 1027-1028.

**Thermooxidation**

**083421 THERMOXIDATIVE DEGRADATION OF POLYPROPYLENE.** The thermooxidative behavior of atactic and isotactic polypropylene under dynamical thermooxidative conditions has been studied. It has been established that, with the increase of the heating rate, the development of the oxidative processes are diminished and consequently a modification in the reaction mechanism takes place. One can notice at the same time that the oxidative processes are more intense in the case of the atactic polymer. The 5-15°C/min heating rates determine significant differences between the thermal behavior of the samples, permitting the elaboration of the standard curves useful in fast determination of the atactic content of the industrial products by routine analysis. (Author abstract) 26 refs.

Vasile, Cornelia (P. Poni Inst of Macromolecular Chemistry, Jassy, Rom); Odochian, Lucia; Agherghine, Ion. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1639-1647.

**Thick Films** See COMPOSITE MATERIALS—Dielectric Properties.

**Thin Films**

**083422 EFFECT OF THE MOLECULAR CHARACTERISTICS OF POLYPROPYLENE ON PROPERTIES OF ORIENTED FILMS.** This study is devoted to ascertaining the effect of the molecular weight (M) and molecular weight distribution (MWD) of PP films on the fibrillation process and the physicochemical properties of oriented materials. The object of study was PP films 70  $\mu$  thick, made from a melt of polymer which had various values of M and MWD. Experimental data indicate that the ability of films to fibrillate is determined by nonuniform stresses, which depend on M (Molecular Weight) and MWD (Molecular Weight Distribution). With increase in M and decrease in M<sub>w</sub>/M<sub>n</sub>, formation of a uniform inter- and intrafibrillar structure takes place, which ensures high physicochemical properties of the film materials. 4 refs.

Polovikhina, L.A.; Myasoedov, E.P.; Zverev, M.P. *Fibre Chem* v 19 n 4 Jul-Aug 1987 p 262-264.

**Viscoelasticity**

**083423 INFLUENCE OF STRUCTURAL DEFECTS ON VISCOELASTIC PROPERTIES OF POLY(POLYPROPYLENE).** Straining of annealed isotactic polypropylene beyond yield results in the formation of 0.4-4 vol% of microvoids with sizes of about 5-30 nm. The creep behaviour as well as the complex shear and tensile modulus of polypropylene are strongly influenced by the presence of the very small concentration of microvoids,

acting as structural defects. The storage modulus in the glassy state may be decreased by 30% (shear modulus) or 15% (tensile modulus) relative to the defect-free state. Possible interpretations are discussed. (Author abstract) 28 refs.

Garbella, R.W. (Deutsche Kunststoff-Inst, Darmstadt, West Ger); Wachter, J.; Wendorff, J.H. *Prog Colloid Polym Sci* v 71 1985 p 164-172.

**Welding**

**083424 UPLATNENIE METALOGRAFICKYCH METOD V PLASTOGRAFII PRI HODNOTENI ZONY TEPELNEHO OVPLYVNENIA ZVAROVEHO SPOJA POLYPROPYLENU.** [Application of Metallographic Methods in Plastography in Evaluating the HAZ of Polypropylene Welded Joint]. The article deals with plastography of polypropylene welded joints. The methods of preparation of polypropylene specimens for microscopical structural studies are described. Possibilities of determining the HAZ of polypropylene welded joints by the procedures currently used in metallographic practice are discussed. (Translated author abstract) In Slovak. 10 refs.

Martinec, L'ubomir (Strojarskotechnologicka Fakulta SVST, Trnava, Czech). *Zvaranie* v 36 n 8 Aug 1987 p 241-244.

**POLYSACCHARIDES** See Also BIOPOLYMERS—Synthesis; CELL CULTURE—Plant; DETERGENTS—Materials; ENZYMES—Production; ENZYMES—Purification; FEAT; WATER POLLUTION—Underground.

**083425 REGIOSELECTIVELY MODIFIED STEREOREGULAR POLYSACCHARIDES X. EQUILIBRIUM POLYMERIZATION OF 1,6-ANHYDRO-2-O-BENZYL-3,4-DIDEOXY- $\beta$ -D-THREO-HEXOPYRANOSE.** A synthetic linear polysaccharide having one axial hydroxyl group in position 2 in each repeating unit, 3,4-dideoxy-(1 $\rightarrow$ 6)- $\alpha$ -D-threo-hexopyranan (3), was synthesized by cationic ring-opening polymerization of 1,6-anhydro-2-O-benzyl-3,4-dideoxy- $\beta$ -D-threo-hexopyranose (1), followed by debenzoylation. The polymerization of 1 using phosphorus pentafluoride as initiator at temperatures ranging from +60 to 0°C gave the stereoregular polymer with an  $\alpha$ -anomeric configuration, 2-O-benzyl-3,4-dideoxy-(1 $\rightarrow$ 6)- $\alpha$ -D-threo-hexopyranan (2). The apparent polymerization rate and copolymerization reactivity of 1 were high, but the polymer yield was relatively low owing to the high equilibrium monomer concentration of 1 ( $[M]_e = 0.31 - 0.54 \text{ mol l}^{-1}$  at  $-60^\circ\text{C}$ ). (Edited author abstract) 21 refs.

Ichikawa, Haruo (Nagoya Univ, Nagoya, Jpn); Kobayashi, Kazukiyo; Okada, Masahiko; Sumitomo, Hiroshi. *Polym J* v 19 n 7 1987 p 873-880.

**083426 COACERVATION OF GELATIN-GELLAN GUM MIXTURES AND THEIR USE IN MICROENCAPSULATION.** Complex coacervation has been observed in gellan gum-gelatin mixtures at low total polymer concentrations. Coacervation was restricted to the pH range  $\approx 3.5$ -5.0. Procedures are described for the microencapsulation of oils and solid particles. (Author abstract) 21 refs.

Chilvers, G.R. (AFRC Inst of Food Research, Norwich, Engl); Morris, V.J. *Carbohydr Polym* v 7 n 2 1987 p 111-120.

**083427 GRAFTING OF ACRYLAMIDE ONTO GUAR GUM USING  $\text{KMnO}_4$ /OXALIC ACID REDOX SYSTEM.** The grafting of acrylamide onto guar gum in aqueous medium initiated by  $\text{KMnO}_4$ /oxalic acid redox system has been studied gravimetrically at the temperature  $35 \pm 0.2^\circ\text{C}$ . The effect of redox components, acrylamide concentration and quantity of guar gum has been studied in terms of percentage and efficiency of grafting. A plausible mechanism of grafting and a suitable rate expression has been suggested. The rate of grafting was found to increase with increase in temperature and concentrations of redox components and acrylamide, but, at high concentration of guar gum, the rate was found to

decrease. (Author abstract) 19 refs.

Bajpai, U.D.N. (Dep of Post Graduate Studies & Research in Chemistry, Jabalpur, India); Rai, Sandeep. *J Appl Polym Sci* v 35 n 5 Apr 1988 p 1169-1182.

**083428 STUDIES ON CHITIN. 13. NEW POLYSACCHARIDE/POLYPEPTIDE HYBRID MATERIALS BASED ON CHITIN AND POLY( $\gamma$ -METHYL-L-GLUTAMATE).** A new type of polysaccharide/polypeptide hybrid material, chitin derivatives having polypeptide side chains, was prepared by the graft copolymerization of  $\gamma$ -methyl-L-glutamate N-carboxy anhydride (NCA) onto water-soluble chitin in water/ethyl acetate. The polymerization proceeded quite smoothly, and both the conversion and grafting efficiency were very high owing to the homogeneous polymerization conditions which became feasible by making use of the water-soluble characteristic of the partially deacetylated chitin. The results of solubility tests, infrared spectroscopy, and X-ray analysis of the copolymers were largely dependent on the side-chain length, and influence of  $\alpha$ -helix formation by the side chains was evident. (Edited author abstract) 14 refs.

Kurita, Keisuke (Seikei Univ, Musashino, Jpn); Yoshida, Akira; Koyama, Yoshiyuki. *Macromolecules* v 21 n 6 Jun 1988 p 1579-1583.

**Applications** See CADMIUM COMPOUNDS—Removal.

**Association**

**083429 AFFINITY INTERACTIONS BETWEEN AGAROSE AND  $\beta$ -1,4-GLYCANS: A MODEL FOR POLYSACCHARIDE ASSOCIATIONS IN ALGAL CELL WALLS.** This paper reviews the extensive and previously unpublished work on the interactions between agarose and 1,4-linked  $\beta$ -D-glycans carried out at Unilever Research, Colworth Laboratory, UK. The effect of the following variables is discussed: galactose content of galactomannans; substitution patterns in the agarose molecule; structural variations in the 1,4- $\beta$ -D-glycan main chain; and molecular size of the 1,4- $\beta$ -D-glycans. In general, the higher the level of galactose substitution in the galactomannan the lower the extent of interaction with agarose. Evidence is presented, however, which indicates that the fine structural distribution of galactose along the galactomannan molecule is also an important determinant for the co-gelling interaction. (Edited author abstract) 59 refs.

Dea, Iain C.M. (Unilever Research, Bedford, Engl); Rees, David A. *Carbohydr Polym* v 7 n 3 1987 p 183-224.

**Biosynthesis** See Also CELL CULTURE—Growth Kinetics.

**083430 POTENTIAL FOR INDUSTRIAL POLYSACCHARIDES FROM ANAEROBES.** Most bacteria that have been investigated or used for commercial production of polysaccharides are either aerobic or facultatively anaerobic. Aerobic growth results in high substrate conversions, but the increase in viscosity associated with polysaccharide production increases energy requirements for agitation and aeration. Use of anaerobic bacteria, which do not require oxygen and therefore do not need aeration, would therefore significantly decrease the cost of fermentation. In this discussion the authors describe the concepts and possible advantages of producing polysaccharides by anaerobic fermentation. 31 refs.

Wachenheim, D.E. (Purdue Univ, West Lafayette, IN, USA); Patterson, J.A. *Enzyme Microb Technol* v 10 n 1 Jan 1988 p 56-57.

**083431 COACERVATION OF GELATIN-XM6 MIXTURES AND THEIR USE IN MICROENCAPSULATION.** Complex coacervation has been observed at low total polymer concentrations in mixtures of gelatin with the extracellular bacterial polysaccharide secreted by *Enterobacter* (NCIB 11870). Coacervation only occurred



within the pH range 3.0-4.5. Methods are described for the microencapsulation of oils and solid particles. (Author abstract) 5 refs.

Chilvers, G.R. (Norwich Lab, Norwich, Engl); Gunning, A.P.; Morris, V.J. *Carbohydr Polym* v 8 n 1 1988 p 55-61.

## Chemical Reactions

**083432 NEW APPROACH TO DEXTRAN DERIVATIVES WITH PENDENT ALDEHYDE GROUPS.** Polysaccharide derivatives containing aldehyde groups can be prepared easily via partial periodate oxidation of the parent polymers. These polyaldehydes have been used as intermediates in the preparation of immobilized enzymes and macromolecular drug derivatives. Soluble dextran derivatives containing aldehyde side groups were prepared by reacting 4-nitrophenyl carbonate ester of dextran with 2, 3-dihydroxypropylamine and subsequent selective periodate oxidation of the pendent diol groups. The hydrolytic stability of the polyaldehyde in acidic medium was comparable with that of unmodified dextran and superior to that of polyaldehydes obtained via partial periodate oxidation of dextran. (Edited author abstract) 15 refs.

Callant, Dominique (State Univ Ghent, Ghent, Belg); Vandormaele, Filip; Schacht, Etienne. *React Polym Ion Exch Sorbents* v 8 n 2 Apr 1988 p 129-136.

## Chromatographic Analysis

**083433 QUANTITATIVE BRANCHING OF LINEAR AND BRANCHED POLYSACCHARIDE MIXTURES BY SIZE EXCLUSION CHROMATOGRAPHY AND ON-LINE LOW-ANGLE LASER LIGHT SCATTERING DETECTION.** The quantitative branching characterization of polysaccharide via size exclusion chromatography (SEC) and on-line low-angle laser light scattering (LALLS) detection is presented from both theoretical arguments as well as direct experimental evidence. The two measurable branching parameters of a sample mixture have been related theoretically to the mixture's composition. There exist linear relationships between  $g_{v(m)}$  and  $W_{b,v}$  (the mass fraction of branched component in mixture) as well as between  $g_{v(m)}^{-1}$  and  $W_{b,v}$ . The latter correlation has been demonstrated experimentally employing a combined SEC/LALLS technique, and displays excellent agreement with the theoretical predictions. Furthermore, this polymer branching characterization method has been applied to study enzymatic starch hydrolysis products. (Edited author abstract) 23 refs.

Yu, Li-Ping (Worcester Polytechnic Inst, Worcester, MA, USA); Rollings, J.E. *J Appl Polym Sci* v 35 n 4 Mar 1988 p 1085-1102.

**083434 CAPILLARY HYDRODYNAMIC CHROMATOGRAPHY OF POLYSACCHARIDES, SCHIZOPHYLLAN, AND XANTHAN.** Capillary hydrodynamic chromatography (c-HDC) of schizophyllan (Sz, unfractionated,  $M_w \approx 250 \times 10^4$ ) and xanthan (Xa, unfractionated,  $M_w \approx 220 \times 10^4$ ) is reported. Pullulan samples ( $M_w = 84.6 \times 10^4$  and  $43.5 \times 10^4$ ) were chromatographed as a reference material. No peak separation from low marker molecules was obtained for the samples. From chromatographic peaks, the effective diameters  $R_{he}$  of Sz and Xa molecules in solution were obtained using polystyrene latex calibration. Intrinsic viscosity and molecular weight data for these polysaccharides gave hydrodynamic volumes and resulting diameters of the molecules,  $R_h$ , in solution by the Flory-Fox equation. (Edited author abstract) In Japanese. 19 refs.

Tazaki, Michiko (Ikutoku Technical Univ, Atsugi, Jpn); Maruyama, Iwao; Takase, Satoru; Homma, Terutaka. *Kobunshi Ronbunshu* v 45 n 1 1988 p 19-23.

**083435 CHARACTERIZATION OF THE SACCHARIDE COMPOSITION OF HETEROPOLYSACCHARIDES BY PYROLYSIS-CAPILLARY GAS CHROMATOGRAPHY-MASS SPECTROMETRY.** The saccharide composition of a number of heteropolysac-

charides has been successfully characterized by pyrolysis-gas chromatography. In addition, small residues of carbohydrate impurities in samples can be easily identified. The success of pyrolysis-gas chromatography to differentiate among carbohydrates was established by previous studies which found that rapid pyrolysis initiates glycosidic cleavage of saccharide units through transglycosylation thereby forming intact fragments which retain the stereoconfiguration of the saccharide, i.e., anhydro sugars. The high molecular weight product mixtures are resolved on a proper capillary column and the individual anhydro sugars identified by mass spectrometry. (Edited author abstract) 7 refs.

Helleur, R.J. (Memorial Univ of Newfoundland, St. John's, Newfoundl, Can). *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 297-311.

## Crosslinking

**083436 COMPARISON OF GALACTOMANNAN CROSSLINKING WITH ORGANOTITANATES AND BORATES.** Water-soluble polymers crosslinked with metal ions form stable gels that are used in oil and gas production processes. We present an investigation of the chemistry of the binding between guar galactomannans and both borates and titanates using NMR and dynamic light scattering. The two monosaccharides comprising guar - methyl- $\beta$ -D-galactopyranoside and methyl- $\alpha$ -D-mannopyranoside - have been studied as model compounds. High resolution  $^{13}$  CNMR detected complexation of the sugars with borate but displayed no sign of complexation with either of the two titanates even at high titanate concentrations. Dynamic light scattering studies demonstrated the existence of colloidal titanium dioxide particles for both titanate crosslinkers. Data are presented following the growth of these particles with time as a function of pH and salt concentration. The observed particle growth kinetics explains the observed sensitivity of the guar gelation process to these variables. (Edited author abstract) 39 refs.

Kramer, J. (Princeton Univ, Princeton, NJ, USA); Prud'homme, R.K.; Wiltzius, P.; Mirau, P.; Knoll, S. *Colloid Polym Sci* v 266 n 2 Feb 1988 p 145-155.

## Degradation

**083437 ENZYMIC DEGRADATION OF ISOLATED PECTIC SUBSTANCES AND CELL WALL FROM PULP OF GRAPE BERRIES.** Pectic substances sequentially extracted with water (WSP), oxalate (OX), acid (HP) and alkali (OHP) from an alcohol-insoluble residue (AIR) from pulp of grape berries, and further purified, were degraded with two pectic enzymes, namely endopolygalacturonase (endopg) and endopectinylase (endopel). Degradation products were fractionated by gel permeation chromatography (Bio-gel P2, Sephadex G100, Sepharose CL 6B) or by ion-exchange chromatography (DEAE-Sephacel). The results suggest that pectic substances from grape berries are constituted of 'smooth' homogalacturonan areas, interspersed with very densely branched 'hairy' regions where neutral sugar side-chains are located. WSP on one hand and HP, OXP, OHP on the other hand were differentiated by their side-chain length. Treatment of AIR previously extracted with water and oxalate by endopel are reported and degradation products are compared with HP 'hairy' fragments. (Author abstract) 25 refs.

Saulnier, Luc (Inst Natl de la Recherche Agronomique, Nantes, Fr); Thibault, Jean-Francois. *Carbohydr Polym* v 7 n 5 1987 p 345-360.

## Extraction

**083438 EXTRACTION AND CHARACTERIZATION OF PECTIC SUBSTANCES FROM PULP OF GRAPE BERRIES.** Pectic substances were successively extracted from the alcohol-insoluble residue (AIR) of the pulp of grape berries, by water (WSP), oxalate (OX), hot dilute HCl (HP) and cold dilute NaOH (OHP). Pectins (WSP, OXP, HP) were purified by ion-exchange chroma-

tography (DEAE-Sephacel) or precipitation with cupric ions (OHP). Total pectic substances represent 20.8% (w/w) of the AIR, WSP and HP being the main components (6% and 12% of the AIR, respectively). An alternative to oxalate extraction of the water-insoluble pectin was extraction with NaCl solutions of increasing concentrations, which had released small amounts of pectins. Each of the fractions contained mainly galacturonic acid, arabinose and galactose, lower amounts of rhamnose and xylose, and minor amounts of glucose and mannose. Ion-exchange chromatography was performed on DEAE-Sephacel,  $M_w$  distribution was checked by gel permeation on Sepharose CL-2B, and  $M_n$  was determined as well as degrees of methylesterification (DM), acetylation (DA), and protein content. (Author abstract) 40 refs.

Saulnier, Luc (Inst Natl de la Recherche Agronomique, Nantes, Fr); Thibault, Jean-Francois. *Carbohydr Polym* v 7 n 5 1987 p 329-343.

## Fermentation

**083439 COOPERATIVE BINDING OF SUCROSE IN XANTHAN GUM SOLUTIONS.** In the xanthan gum fermentation mass transfer mechanisms are complex due to the high viscosity of the broth. Diffusional mass transfer becomes very important in transport of solutes such as oxygen and sucrose in the polysaccharide solution. Nevertheless, this process can be affected by the interactions between macromolecule and solute. The present study was designed to determine if xanthan gum interacts with sucrose. The data show that xanthan gum in solution possesses two interaction sites for sucrose. These interactions are adequately described by a cooperative binding model. Changes in ionic strength and pH did not affect either the number of sites or type of interaction. (Author abstract) 22 refs.

Torrestiana, Beatriz (Univ Nacional Autonoma de Mexico, Cuernavaca, Mex); Galindo, Enrique; Brito, Edmundo. *Biotechnol Prog* v 4 n 1 Mar 1988 p 1-5.

**083440 SCALEUP FOR POLYSACCHARIDE FERMENTATION.** Design factors for scaleup in the design of fermenters for the fermentation of polysaccharides are discussed. Some of the topics covered include the use of oxygen concentration as a limiting factor; mass transfer correlations for mixing; and broth rheology. The scaleup procedure was applied to a pilot plant for the production of phosphomannan. 16 refs.

Hubbard, D.W. (Michigan Technological Univ, Houghton, MI, USA); Harris, L.R.; Wierenga, M.K. *Chem Eng Prog* v 84 n 8 Aug 1988 p 55-61.

## Filtration

**083441 FILTRABILITE DE SOLUTIONS DE POLYSACCHARIDES EN PRESENCE D'ADDITIFS RESULTATS PRELIMINAIRES.** [Filterability of Polysaccharide Solutions in the Presence of Additives. Preliminary Results]. Aqueous solutions of polysaccharides of biochemical origin contain microgels, i.e. aggregates created by the association of several polymer molecules which have a harmful influence on filterability. The author studied how this property evolves as a function of various factors (mechanical shear, addition of reagents). The amplitude of the dissolution effect of aggregates exerted by nonionic surfactants, polyoxyethylenes and anionic surfactants brings about improvement in the filterability of solutions while leaving their viscosities practically intact. (Edited author abstract) 26 refs. In French.

Mileo, J.C. (Inst Francais du Petrole, Vernaison, Fr). *Rev Inst Pet* v 43 n 2 Mar-Apr 1988 p 273-280.

## Hydrolysis

**083442 HYDROLYSIS OF BEET PULP POLYSACCHARIDES BY EXTRACTS OF SOLID-STATE CULTURES OF PENICILLIUM CAPSULATUM.** Extracts of solid-state cultures of *Penicillium capsulatum* grown on beet pulp exhibit cellulolytic, hemicellulolytic,



and pectinolytic activities. Such extracts catalyzed extensive solubilization of untreated beet pulp. The effects of pH, temperatures, and endproducts on the saccharification process were investigated. (Author abstract) 33 refs.

Considine, P.J. (Univ Coll, Galway, Ire); O'Rourke, A.; Hackett, T.J.; Coughlan, M.P. *Biotechnol Bioeng* v 31 n 5 Apr 5 1988 p 433-438.

**Ion Exchange** See CHROMATOGRAPHIC ANALYSIS—Ion Exchange.

**Mechanical Properties** See GELS—Mechanical Properties.

## Microscopic Examination

**083443 MOLECULAR ORGANIZATION OF KAPPA CARRAGEENAN IN AQUEOUS SOLUTION.** The interaction of  $K^+$  with unsegmented kappa carrageenan in aqueous solution was studied by conductimetry, optical rotation and light scattering. By comparing the results from the different techniques it is possible to propose the existence of an equilibrium between molecules as single-helix and helical-dimer depending on the ionic concentration. (Author abstract) 22 refs.

Rochas, C. (CNRS, Saint Martin d'Herès, Fr); Landry, S. *Carbohydr Polym* v 7 n 6 1987 p 435-447.

## Molecular Structure

**083444 WATER-SOLUBLE SULFATED POLYSACCHARIDES FROM THE RED SEAWEED CHAETANGIUM FASTIGIATUM. ANALYSIS OF THE SYSTEM AND THE STRUCTURES OF THE  $\alpha$ -D-(1 $\rightarrow$ 3)-LINKED MANNANS.** The water-soluble polysaccharides from *Chaetangium fastigiatum* were fractionated with cetrimide. The complexed material was subjected to fractional solubilization in solutions of increasing sodium chloride concentration and seven fractions were separated and analyzed. Two of the fractions were subjected to methylation and desulfation-methylation analyses. The results indicate that this seaweed contains a system of sulfated polysaccharides consisting in part of a galactan and an  $\alpha$ -D-(1 $\rightarrow$ 3)-linked mannan, 2- and 6-sulfated, and having single stubs of  $\beta$ -(1 $\rightarrow$ 2)-linked D-xylose. Composition dispersity of the mannan is produced by variation of the amount and disposition of the sulfate groups and of the content of the xylose side-chains. (Author abstract) 29 refs.

Matulewicz, M.C. (Univ de Buenos Aires, Buenos Aires, Argent); Cerezo, A.S. *Carbohydr Polym* v 7 n 2 1987 p 121-132.

**083445 HELICAL STRUCTURE OF  $\beta$ (1-3) XYLAN AND THE WATER MEDIATED HYDROGEN BONDING SCHEMES.** A six-fold intertwined triple helical structure for the polysaccharide  $\beta$ (1-3) xylan was generated with the axial advance of 0.306 nm per residue. A stereochemically possible site for the water molecule has been determined and water mediated intrachain and interchain hydrogen bond schemes are possible for the right-handed triple helical structure, whereas only interchain hydrogen bonding appears plausible in the left-handed triple helical structure. The water mediated hydrogen bond is almost linear. X-ray refinement using a Linked-Atom Least-Squares (LALS) procedure has enabled determination of the orientation of the molecule in the hexagonal unit cell, the position of the water molecules and a reliability index,  $R$ , of 0.35. The refined model in this study confirms the original chirality of an earlier model but differs in the water mediated hydrogen bonding scheme. (Edited author abstract) 15 refs.

Veluraja, K. (H.H. Wills Physics Lab, Bristol, Engl); Atkins, E.D.T. *Carbohydr Polym* v 7 n 2 1987 p 133-141.

**083446 STRUCTURAL CHARACTERIZATION OF A TOBACCO RHAMNOLACTURONAN.** A rhamnogalacturonan, extracted with hot water from the aqueous ethanol insoluble residue of flue-cured bright tobacco lamina, was purified by tangential flow ultrafiltration, ion chromatography and gel filtration. It was characterized by

chemical and spectroscopic methods. Fractionation revealed that the rhamnogalacturonan consisted of a series of polysaccharides with different amounts of methyl-esterified galactopyranosyluronic acid residues in the backbone and different amounts of neutral sugar residues. The average degree of polymerization of this tobacco rhamnogalacturonan was estimated to be 400. (Edited author abstract) 34 refs.

Sun, H.H. (Philip Morris USA, Richmond, VA, USA); Wooten, J.B.; Ryan, W.S. Jr.; Bokelman, G.H. *Carbohydr Polym* v 7 n 2 1987 p 143-158.

## Physical Properties

**083447 ALGINATES.** This short review covers some developments in the understanding of the structure and properties of alginates. Particular emphasis is given to discussing analytical methods for determining alginate composition, the modification and degradation of alginates by enzymes and the differences between bacterial and seaweed alginates. Alginate biosynthesis is also considered. (Author abstract) 101 Refs.

Gacesa, Peter. *Carbohydr Polym* v 8 n 3 1988 p 161-182.

## Polymerization

**083448 SELECTIVE RING-OPENING POLYMERIZATION OF DI-O-T-BUTYLDIMETHYLSILYLATED AND DI-O-P-BROMOBENZYLATED 1,4-ANHYDRO- $\alpha$ -L-ARABINOPYRANOSIDES AND STRUCTURAL ANALYSIS OF FREE ARABINANS.** The authors report herein studies of ring-opening polymerization of 1,4-anhydro-2,3-di-O-t-butylidimethylsilyl- $\alpha$ -L-arabinopyranose (ADSA) and 1,4-anhydro-2,3-di-O-p-bromobenzyl- $\alpha$ -L-arabinopyranose (ADBA) by cationic initiation in methylene chloride. Polymerization of ADSA using phosphorus pentafluoride as initiator at  $-60^\circ\text{C}$  gave stereoregular (1 $\rightarrow$ 5)- $\alpha$ -L-arabinofuranan derivatives in 85% yield. Polymerization of ADBA with various Lewis acids afforded slightly less stereoregular polymers ( $\alpha$ -content 90%) under optimum conditions. The polymer structure was characterized by  $^{13}\text{C}$  NMR spectroscopy, specific rotation, and the methylation analysis using GC-MS spectroscopy. (Edited author abstract) 13 refs.

Yoshida, Takashi (Univ of Tokyo, Tokyo, Jpn); Kida, Masuo; Uryu, Toshiyuki. *Polym J* v 19 n 8 1987 p 923-931.

**Production** See ENZYMES—Applications.

## Reviews

**083449 MICROBIAL POLYSACCHARIDES CONTAINING 6-DEOXY Sugars.** Microorganisms producing polysaccharides rich in 6-deoxysugars are widely distributed among bacteria, algae and fungi isolated from different environments and having different metabolic capabilities. Culture conditions leading to the screening of microorganisms producing these polysaccharides as well as parameters promoting their production necessitated the use of media containing high carbon-nitrogen ratios. Methods for extracting polysaccharides and for measuring their 6-deoxysugars content are either colorimetric or required the use of analytical chromatography. Successful purification procedures leading to pure 6-deoxysugars included ion-exchange chromatography. Among the different applications of these polysaccharides is their use as substrates in the chemical synthesis of flavoring agents. (Author abstract) 115 refs.

Graber, Marianne; Morin, Andre; Duchiron, Francis; Monsan, Pierre F. *Enzyme Microb Technol* v 10 n 4 Apr 1988 p 198-206.

## Separation

**083450 FRACTIONATION OF DEXTRAN USING REPETITIVE BATCH CHROMATOGRAPHY.** The fractionation of broad dextran fractions using preparative scale gel permeation chromatography has been carried

out. A batch system was used, consisting of ten borosilicate columns, each of 5.1 cm i.d. and 70 cm long and packed with Spherosil XBO75 porous silica beads. The repetitive injection technique was employed and the effects of feed, charge volume and concentration on the molecular weight distribution of the products were evaluated. (Author abstract) 17 refs.

Barker, P.E. (Aston Univ, Birmingham, Engl); England, K.; Ganetsos, G. *J Chem Technol Biotechnol* v 41 n 1 1988 p 61-68.

**Solutions** See Also SURFACE ACTIVE AGENTS.

**083451 SOLUTION PROPERTIES OF PECTIN POLYSACCHARIDES. I - AQUEOUS SIZE EXCLUSION CHROMATOGRAPHY OF FLAX PECTINS.** Crude pectin from green flax was fractionated on Sephacryl S200 in 1 M NaCl. The fractions obtained were characterized by measuring the anhydrogalacturonic acid content, the degree of esterification (DE), the intrinsic viscosity and the molecular weight  $M_w$ . Lower viscosities are found compared with pectins from other plant sources and a relationship exists between the DE and the molecular size of pectins. Mark-Houwink relationship is observed to depend on the method used for clarification of solutions before measuring  $M_w$ , due to the presence of small amount of high  $M_w$  particles which can considerably distort the light-scattering data without affecting the viscosity values. (Edited author abstract) 31 refs.

Hourdet, Dominique (CNRS, Mont St. Aignan, Fr); Muller, Guy. *Carbohydr Polym* v 7 n 4 1987 p 301-312.

**083452 GELATION OF GELLAN GUM.** The microbial polysaccharide, gellan gum, was studied in aqueous solution and in the gel state by osmometry, viscometry, light scattering, polarimetry and NMR and by measurements of gel strength and cation-exchange selectivity. In solutions of the tetramethylammonium (TMA) salt of the polymer, increasing concentrations of TMA induced contraction, ordering, and association of the chains, as revealed by viscometry and changes in optical rotation. Chain ordering occurred at ionic strengths between 0.005 and 0.5 (M), and light scattering indicated an elongated chain structure in 0.025 M TMA. Gelation was dependent upon both ionic strength and the identity of the cation. Measurements of optical rotation and NMR spectroscopy indicated that chain association and gelation were related phenomena. The results are interpreted as indicating that gelation occurs in two steps, namely, chain ordering and chain association. (Edited author abstract) 28 refs.

Grasdalen, Hans (Univ of Trondheim, Trondheim, Norw); Smidsrod, Olav. *Carbohydr Polym* v 7 n 5 1987 p 371-393.

**083453 LIGHT SCATTERING STUDIES OF SOLUTIONS OF THE BACTERIAL POLYSACCHARIDE (XM6) ELABORATED BY ENTEROBACTER (NCIB 11870).** Light scattering studies have been made on solutions of the sodium and tetra-methyl ammonium salts of the anionic heteropolysaccharide XM6. The polymers may be modeled as stiff wormlike chains. In dilute solution no conformational change was observed upon increasing the ionic strength. Models for gelation at higher polymer concentration are discussed. The measured mass per unit length of the polymer favors an ordered helical conformation and a gelation mechanism involving association and possibly crystallization of segments of the helical chains. (Author abstract) 14 refs.

Chapman, H.D. (AFRC Inst of Food Research, Norwich, Engl); Chilvers, G.R.; Morris, V.J. *Carbohydr Polym* v 7 n 6 1987 p 449-459.

**083454 CONTROLLED GELATION OF XANTHAN BY TRIVALENT CHROMIC IONS.** Addition of trivalent chromic ions to xanthan solutions gives rise to gel formation. The dynamic shear storage and loss moduli



(0.01–10 rad/s) of xanthan solutions with polymer concentrations ranging from 1 to 7 mg/ml and  $\text{Cr}^{3+}$  concentrations ranging from 0 to 50 mM have been studied. It is found that the rate of gel formation is strongly dependent on the  $\text{Cr}^{3+}$  concentration, but to a much smaller extent on the xanthan concentration. The gelation time is less than 1 h for 50  $\mu\text{M}$   $\text{Cr}^{3+}$  and about 40 h for 2 mM  $\text{Cr}^{3+}$ . It is found that the minimum  $\text{Cr}^{3+}$  concentration needed to give gelation of 1–7 mg/ml xanthan is 1–2 mM. Xanthan, and highly viscous polymer solutions in general, are used to improve the sweep efficiency in polymer-or surfactant-flooding or, in a crosslinked state, as a rock-permeability modifying agent to avoid water-channeling in heterogeneous reservoirs. (Edited author abstract) 16 Refs.

Lund, Torgeir (Univ of Trondheim, Trondheim, Norw); Smidsrod, Olav; Stokke, Bjorn Torgir; Elgsaete, Arnjot. *Carbohydr Polym* v 8 n 4 1988 p 245–256.

**083455 STUDY OF THE RHEOLOGICAL PROPERTIES OF SOLUTIONS OF FURCELLARAN DURING GELATION.** The properties of the cation-substituted samples of the natural polysaccharide-furcellaran in the course of gelation have been studied by rotation viscometry. The rheological behavior of such systems is determined by the nature of the cations forming part of their salt groups. It is assumed that the potassium sample like LC systems during deformation may reach a stable orientation state. (Author abstract) 12 Refs.

Ptchikina, N.M. (Saratov State Univ, USSR); Timofeyeva, G.N.; Kudashova, R.V.; Kulichikhin, S.G.; Chalykh, A. Ye.; Malkin, A. Ya. *Polym Sci USSR* v 29 n 5 1987 p 1046–1051.

## Spectroscopic Analysis

**083456 EFFECTS OF SEASONS ON THE CHEMICAL STRUCTURE AND GEL STRENGTH OF (GRACILIARACEAE, RHODOPHYTA).** The seasonal effects on the chemical structure and rheological properties of *Gracilaria pseudoverrucosa* agar have been investigated using a sequential solvent extraction,  $^{13}\text{C}$  NMR and infrared spectroscopy, and gel strength measurements. The results showed that agar enriched in precursor to the agarobiose repeat unit were obtained from algae collected in summer. In contrast, algae collected in winter contained agar molecules richer in alkali-stable sulfate groups attributed in part to d-galactose-4-sulfate. (Edited author abstract) 48 Refs.

Lahaye, M. (McGill Univ, Montreal, Que, Can); Yaphe, W. *Carbohydr Polym* v 8 n 4 1988 p 285–301.

**083457 PYROLYSIS-MASS SPECTROMETRY OF NATURAL GUMS, RESINS, AND WAXES AND ITS USE FOR DETECTING SUCH MATERIALS IN ANCIENT EGYPTIAN MUMMY CASES (CARTONNAGES).** Pyrolysis-mass spectrometry (Py-MS) has been applied to the study of some ancient Egyptian mummy cases (cartonnages). Samples of organic materials, used in the construction of these objects, have been collected from cartonnages housed in various museums in Europe. Fifty samples were examined by Py-MS and the pyrograms obtained were compared with those of some 70 modern natural gums, resins and waxes. The technique permitted a classification of about half of the ancient adhesives; and polysaccharide gums, waxes and rosins have been detected in samples from objects some 2000 to 4000 years old. (Author abstract) 3 Refs.

Wright, M.M. (Univ of London, London, Engl); Wheals, B.B. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15–19 1986 p 195–211.

## Stability

**083458 THERMAL STABILITY AND CHAIN CONFORMATIONAL STUDIES OF XANTHAN AT DIFFERENT IONIC STRENGTHS.** The aim of the present study was to determine the influence of the ionic strength on the thermal stability of xanthan, i.e. xanthan

resistance to chain breaking at high temperatures. Xanthan solutions of various ionic strengths were kept at 80, 90 and 95°C for periods up to 95 h. The thermal stability was determined by measuring the intrinsic viscosity after the heating periods. The experiments showed a critical ionic strength for the thermal stability of xanthan between 10 and 100 mM NaCl or KCl in this temperature range. The transition temperature ( $T_m$ ) of xanthan was determined by NMR and optical rotation measurements. (Edited author abstract) 33 Refs.

Foss, Per (Norsk Bioferm A/S, Sandnes, Norw); Stokke, Bjorn T.; Smidsrod, Olav. *Carbohydr Polym* v 7 n 6 1987 p 421–433.

## Synthesis See Also MONOMERS—Polymerization.

**083459 SELECTIVE SYNTHESIS OF POLYSACCHARIDE MACROMERS BY RING-OPENING POLYMERIZATION OF ANHYDRO SUGAR.** Two kinds of stereoregular polysaccharide macromers were prepared by cationic ring-opening polymerization of a 1,4-anhydro sugar. 1,4-Anhydro-2,3-bis(O-tert-butyl-dimethylsilyl)- $\alpha$ -D-ribofuranose was polymerized by acryloyl (or methacryloyl) chloride-silver hexafluorophosphate or silver hexafluoroantimonate complex catalyst to afford (1 $\rightarrow$ 5)- $\alpha$ -D-ribofuranan macromer or (1 $\rightarrow$ 4)- $\beta$ -D-ribofuranan macromer bearing an acryloyl (or methacryloyl) terminal group. The macromer was radically polymerized and copolymerized with methyl methacrylate. Desilylation of the copolymer gave polyribose-grafted poly(methyl methacrylate). The mechanism of the selective ring-opening polymerization was discussed from the viewpoint of the roles of the silyl group, the carbenium ion, and the gegenanion. (Author abstract) 23 Refs.

Uryu, Toshiyuki (Univ of Tokyo, Tokyo, Jpn); Yamanaka, Midori; Date, Masazumi; Ogawa, Masumi; Hatanaka, Kenichi. *Macromolecules* v 21 n 7 Jul 1988 p 1916–1920.

**083460 POLYSACCHARIDES AND FUNCTIONAL POLYSACCHARIDES: PREPARATION AND APPLICATIONS.** Polysaccharides and their derivatives have found extensive applications as polymer supports, particularly in biochemistry. Use of the galactomannan, guaran, is a relatively recent addition to the polysaccharides that are already well-established for these applications. This review describes the work in the authors' laboratories for over the past eight years on the applications of guaran and its derivatives as polymeric support materials and chromatographic media. (Author abstract) 24 Refs.

Mathur, N.K. (Univ of Jodhpur, Jodhpur, India); Narang, C.K.; Sharma, K.; Mehra, A. *React Polym Ion Exch Sorbents* v 6 n 2–3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6–11 1986 p 73–79.

## Testing See Also WATER—Absorption.

**083461 COMPARISON OF THE POLY(HEXAMETHYLENEBIGUANIDINIUM CHLORIDE) ASSAY AND A NEUTRAL EQUIVALENT METHOD FOR THE DETERMINATION OF ALGINATES IN INDUSTRIAL LIQUORS EXTRACTED FROM BROWN SEAWEED.** The poly(hexamethylenebiguanidinium chloride) assay and a neutral equivalent method have been used to estimate the sodium alginate content of industrial liquors extracted from brown seaweed. With the liquor samples examined, agreement to within 5% was achieved with the two methods under defined alginate concentration conditions. Statistical evaluation of the data using a paired comparison t-test has shown that a difference of only 0.10 $\pm$ 0.05 can be expected with 95% confidence, between the two methods in the analysis of liquor samples with sodium alginate contents in the range 2.00–3.83 mg ml $^{-1}$ . (Edited author abstract) 16 Refs.

Kennedy, John F. (Univ of Birmingham, Birmingham, Engl); Bradshaw, Ian J. *Carbohydr Polym* v 7 n 6 1987

p 409–419.

**Viscosity** See Also OIL WELL PRODUCTION—Flooding.

**083462 WEIGHTED INTRINSIC VISCOSITY RELATIONSHIPS FOR POLYSACCHARIDE MIXTURES IN DILUTE AQUEOUS SOLUTIONS.** The weighted intrinsic viscosities of polysaccharide mixtures in dilute aqueous solutions have been studied. The purpose of this investigation is to demonstrate that average intrinsic viscosities would scale with the weight fractions of the individual components for polysaccharide mixtures in 0.5N NaOH. The polysaccharides examined in this study were composed of polymers differing in their molecular weights, degree of branching, and bond linkages. Excellent agreement between theory and experiment was observed for the three different mixture polymer systems examined. This observation validates certain aspects of proposed theoretical treatments which employ this fundamental assumption and allows for further advances in experimental analytical developments of water-soluble polymer systems. (Edited author abstract) 19 Refs.

Weaver, L. (Worcester Polytechnic Inst, Worcester, MA, USA); Rollings, J.E. *J Appl Polym Sci* v 35 n 6 May 5 1988 p 1631–1637.

**083463 XANTHAN/CAROB INTERACTIONS AT VERY LOW CONCENTRATION.** Xanthan/carob interactions at very low concentration have been studied by viscosity measurements at 25°C and in 0.1 M NaCl. The existence of a weak network structure, exhibiting thixotropic behavior, has been shown, down to reduced concentrations  $C[\eta]$  much lower than that corresponding to coil overlap. Maximum synergistic effects are observed for a xanthan/carob (X/C) ratio of 5.5/4.5. The formation of the network is dependent on the aging time, and, for very dilute systems, a very low shear rate is necessary to observe a transitory network. (Edited author abstract) 41 Refs.

Cuvelier, G. (Food Science Dep ENSIA, Massy, Fr); Launay, B. *Carbohydr Polym* v 8 n 4 1988 p 271–284.

**POLYSTYRENES** See Also AEROSOLS; COMPOSITE MATERIALS—Mechanical Properties; COPOLYMERS—Chemical Reactions; COPOLYMERS—Crosslinking; FOUNDRY PRACTICE—Patternmaking; GELS—Mechanical Properties; POLYMERS—Mechanical Properties; POLYMERS—Thin Films; POLYPHENYLENE OXIDES—Crosslinking; PROPELLANTS—Pyrolysis; RHODIUM COMPOUNDS—Testing; SOLUTIONS—Phase Equilibria; SOLUTIONS—Viscosity; THERMOPLASTICS—Blending.

**083464 STABILITY ANALYSIS OF POLYMERIZATION IN CONTINUOUS, STIRRED-TANK REACTORS.** A large number of commercially available polymers such as polystyrene, HIPS (high-impact polystyrene), polyvinyl chloride, and polymethyl methacrylate are produced in continuous free-radical bulk polymerization processes. Back-mixed reactors are frequently employed which involve either a continuous stirred-tank reactor (CSTR) or a plug-flow reactor (PFR) with recycle. Inherent in such back-mixed reactors is the potential for multiple steady states (MSS). There are two graphical procedures for determining the steady-state operating point and the potential for multiplicity (MSS): one for the isothermal CSTR and the other for the nonisothermal CSTR. 26 Refs.

Henderson, Louis S. (ARCO Chemical Co, Newton Square, PA, USA). *Chem Eng Prog* v 83 n 3 Mar 1987 p 42–50.

**083465 PREPARATION OF THREE-ARMED STAR POLYSTYRENE BY REACTION OF PREPOLYMER HAVING A TERMINAL FUNCTIONAL GROUP WITH TRIISOCYANATE.** Polystyrene prepolymers having hydroxyl or amino groups at their ends were prepared by anionic polymerization techniques. The linking reactions of these prepolymers with triisocyanate



derived from lysine were carried out under various conditions and their efficiencies of conversion to three-armed star polymers were determined by GPC measurements. The reaction of the prepolymer having an -OH group with triisocyanate under catalysis of tri-*n*-butyltin oxide as well as the direct reaction of the intermediate polystyryl anion with triisocyanate was found to be most effective for preparation of star polystyrene having three arms. The star polymer thus prepared was successfully isolated by fractionation procedures after treating the reaction mixture with reactive polystyrene gels containing sulfonyl chloride or isothiocyanate groups. The number of arms of the isolated star polymer was confirmed to be virtually three by the ratio of the number-average molecular weight of the star polymer to that of the corresponding prepolymer. (Author abstract) 23 refs.

Kitano, Toshiaki (Toyohashi Univ of Technology, Toyohashi, Jpn); Yamamoto, Takashi; Okemoto, Yasuo; Itsumo, Shinichi; Ito, Koichi. *Polym J* v 19 n 9 1987 p 1013-1023.

**083466 SANS STUDY OF PARTICLE NUCLEATION IN EMULSION POLYMERIZATION.** We describe the use of small-angle neutron scattering (SANS) to measure the average radius of polystyrene particles in the early stages of emulsion polymerization. Polymerization was started by placing monomer in contact with an aqueous polyacrylamide gel containing initiator, in the absence of surfactant. Reaction was allowed to occur for 12, 24, and 48 h, and slices were removed from the gels in each system at various distances (of order 10 mm) from the interface. SANS measurements on these slices showed the presence of particles of radius  $6 \pm 1$  nm. These experiments show that, in these systems, one can halt the growth (by propagation and coagulation) of very small colloidal particles for a sufficiently long time to measure physical properties such as the amount of monomer imbibed at equilibrium swelling, surface charge, etc. (Author abstract) 9 refs.

Feeney, P. John (Inst Laue Langevin, Grenoble, Fr); Geissler, Erik; Gilbert, Robert G.; Napper, Donald H. *J Colloid Interface Sci* v 121 n 2 Feb 1988 p 508-513.

**083467 STUDY OF END GROUPS IN OLIGO- AND POLYSTYRENE PREPARED USING AZOBIS-ISOBUTYRONITRILE.** Oligo- and polystyrene were prepared at 60°C in the presence of azobisisobutyronitrile. The species in the given oligomer and polymer was estimated by  $^{13}\text{C}$  and  $^1\text{H}$  n.m.r. It is shown that primary radical termination is important when the initiator concentration is high and the monomer concentration is low, and that styrene radicals terminate mainly by combination. (Author abstract) 7 refs.

Kodaira, K. (Government Industrial Research Inst, Nagoya, Jpn); Ito, K.; Iyoda, S. *Polym Commun (Guildford Engl)* v 29 n 3 Mar 1988 p 83-85.

**083468 INTERACTIONS BETWEEN POLYSTYRENE LATEX SPHERES AND A SEMIFLEXIBLE POLYMER, HYDROXYPROPYLCELLULOSE.** We explore stiff polymer/particle interactions from both static and dynamic viewpoints. The nonionic polymer hydroxypropylcellulose (HPC) was chosen to focus on the effects of polymer stiffness in the absence of electrostatic interaction. The persistence length of HPC is about 100 Å, similar to that of many other cellulose derivatives. HPC is quite stiff enough to form lyotropic liquid crystals, even in the absence of any external alignment. In this regard, HPC is stiffer than many polymers designed to be thermotropic liquid crystals, which often only display stir opalescence in solution. Thus, there is a clear physical distinction between HPC and typical random coil polymers. We may say that HPC is 'semiflexible'. 41 refs.

Russo, Paul S. (Louisiana State Univ, Baton Rouge, LA, USA); Mustafa, Mazidah; Cao, Tin; Stephens, Levi K. *J Colloid Interface Sci* v 122 n 1 Mar 1988 p 120-137.

**083469 IMPROVED PROCESS FOR THE PREPARATION OF HIGH-IMPACT POLYSTYRENE.** A

description is given of an improved process for the preparation of high-impact polystyrene. The improved design of the reactor and its stirrer with variable controlled speed drive resulted not only in lowering the time and temperature profile of polymerization but also yielded a better quality product. The mechanism of particle formation and other phenomena occurring during the polymerization of a solution of polybutadiene in styrene is also discussed.

Geeta Unnikrishnan, P. (Shri Ram Inst for Industrial Research, Delhi, India); Mair, P.K.; Dabolkar, D.A.; Nigam, J.K. *Chem Age India* v 38 n 4 1987 p 145-147.

## Ablation

**083470 MASS SPECTROSCOPIC STUDIES OF THE ArF-LASER PHOTOABLATION OF POLYSTYRENE.** We have investigated the photoablation of polystyrene by ArF-laser radiation (193 nm) with respect to the chemical nature and energy distribution of ejected molecular species. A novel analytical technique combining photoionization by vacuum-ultraviolet laser radiation at 118.4 nm with time-of-flight mass spectrometry has been employed. At near threshold fluences above  $15\text{mJcm}^{-2}$  the main neutral photoablation product is the styrene monomer. Using direct time resolved detection the kinetic energy distribution of the product molecules has been determined, its peaks at about 0.7 eV. (Edited author abstract) 16 refs.

Feldmann, D. (Univ Bielefeld, Bielefeld, West Ger); Kutzner, J.; Laukemper, J.; MacRobert, S.; Welge, K.H. *Appl Phys B* v B44 n 2 Oct 1987 p 81-85.

**083471 TIME-RESOLVED EXPERIMENTS ON THE PHOTOABLATION OF POLYSTYRENE AND PMMA BY ArF-LASER RADIATION.** The photoablation of polystyrene (PS) and polymethylmethacrylate (PMMA) was studied in real-time during the uv laser pulse at 193 nm. The transmission and total reflection of thin polymer layers on quartz glass substrates was measured time-resolved. From the results for the strongly absorbing PS it can be concluded that the emission of material starts within the first few nanoseconds of the laser pulse. Photoablation of PMMA, which is a relatively weak absorber at 193 nm, is accompanied by strong modifications of the transmission by the first several ten laser pulses. (Author abstract) 12 refs.

Meyer, J. (Univ Bielefeld, Bielefeld, West Ger); Kutzner, J.; Feldmann, D.; Welge, K.H. *Appl Phys B* v B45 n 1 Jan 1988 p 7-12.

## Acoustic Wave Effects

**083472 EXPERIMENTAL DETERMINATION OF RESONANT FORWARD SCATTERING OF SOLID INCLUSIONS IN A FLUID.** Continuous growth over recent years of the utilization of heterogeneous materials has introduced the problem of characterization. Variations of attenuation with frequency and the physical characteristics of the media are major problems. A first approach is obtained using the classic models based on the scattering cross-section. We present results obtained for the scattering cross-section of a polystyrene obstacle immersed in water. We have concentrated on the design and realization of an experimental set-up and the results show good agreement with theory. (Edited author abstract) 26 refs.

Perdigao, J.M. (Univ de Coimbra, Coimbra, Port); Ferreira, A.; Lefebvre, J.E.; Bruneel, C. *Ultrasonics* v 26 n 2 Mar 1988 p 102-106.

## Additives

**083473 METHYL METHACRYLATE GRAFTED RUBBERS AS IMPACT MODIFIERS FOR STYRENIC POLYMERS.** The use of methyl methacrylate-grafted latex rubber (MMA-g) particles has been studied for the impact toughening of styrenic matrix polymers. It was found that the addition of MMA-g to mass made acrylonitrile-butadiene-styrene (ABS) and

high-impact polystyrene (HIPS) significantly increases their impact strength. While the effectiveness of MMA-g for enhancing the toughness of ABS was not surprising because of the miscibility of the styrene-acrylonitrile copolymer matrix and the poly(methyl methacrylate) graft, its effectiveness in HIPS was unexpected. Possible reasons for the broad effectiveness of the small methyl methacrylate-grafted rubber particles in the various systems are discussed. (Edited author abstract) 24 refs.

Keskkula, H. (Univ of Texas at Austin, Austin, TX, USA); Paul, D.R.; McCreedy, K.M.; Henton, D.E. *Polymer* v 28 n 12 Nov 1987 p 2063-2069.

## Adsorption

**083474 EFFECT OF ELONGATIONAL FLOW ON POLYMER ADSORPTION.** The adsorption and desorption of polystyrene (PS) from cyclohexane at 34.8°C (θ temperature) on a chrome mirror has been studied by using ellipsometry. Static adsorption measurements give adsorbed layer thickness and adsorbed and desorption was studied by directing a jet of polymer solution or solvent perpendicular to the mirror surface, to produce an elongational velocity field at the stagnation point on the surface. For a  $10^7$  Mw PS adsorbed under strong elongational flow conditions, the adsorbed layer was an order of magnitude thinner than a layer adsorbed under quiescent conditions and the polymer concentration in the layer adsorbed under elongational flow was 3.4 times higher. (Edited author abstract) 14 refs.

Besio, G.J. (Princeton Univ, Princeton, NJ, USA); Prud'homme, R.K.; Benziger, J.B. *Macromolecules* v 21 n 4 Apr 1988 p 1070-1074.

**083475 POLYMER MONOLAYERS PREPARED BY THE SPONTANEOUS ADSORPTION OF SULFUR-FUNCTIONALIZED POLYSTYRENE ON GOLD SURFACES.** Polystyrene containing one terminal thiol group (PS-SH) and styrene-propylene sulfide block copolymers (PS-PPS) were allowed to adsorb on evaporated gold films supported on glass. The resulting supported films were characterized by X-ray photoelectron spectroscopy, external reflectance infrared spectroscopy, and scintillation counting of radioisotope-labeled polymers. The polymers adsorb rapidly and irreversibly, and the polymer monolayers can be washed with fresh solvent without desorption. The effects of molecular weight, concentration, and solvent power on adsorbance were determined for PS-SH. The effect of propylene sulfide block size for a series of PS-PPS copolymers on the number of adsorbed chains was determined. (Author abstract) 25 refs.

Stouffer, Jan M. (Univ of Massachusetts, Amherst, MA, USA); McCarthy, Thomas J. *Macromolecules* v 21 n 5 May 1988 p 1204-1208.

**083476 THERMODYNAMIC AND KINETIC FACTORS IN ADSORPTION OF POLYMERS ON A PLANE LATTICE.** The rate of formation of an adsorbed polystyrene monolayer onto silica/carbon tetrachloride interfaces is studied by a radioactive tracer method with  $^3\text{H}$ -labeled polymers. The influence of the temperature on the amount of the polymer adsorbed is determined, and the kinetic law of the adsorption is formulated. At low solution concentrations, the polymer adsorbs with a very flattened conformation, and the kinetic parameter of the adsorption process is quantitatively analyzed with use of a mechanism corresponding to a two-dimensional lattice filling. This process may be regarded as a 'solution' process such as the mixing on a molecular scale, which involves, beside surface forces, local conformational changes and entropy of mixing effects. At higher solution concentrations, loops and/or tails emerge from the surface at a very low rate. (Author abstract). 30 Refs.

Pefferkorn, E. (CNRS, Strasbourg, Fr); Haouam, A.; Varoqui, R. *Macromolecules* v 21 n 7 Jul 1988 p 2111-2116.



Amination See POLYELECTROLYTES.

Amorphous See POLYMERS—Recovery.

Applications See Also FOUNDRY PRACTICE—Patternmaking.

**083477 EXPANDABLE POLYSTYRENE (EPS).** The economic importance of expandable polystyrene (EPS) can be seen from figures for their consumption in the western world in recent years, which in 1985 passed the 1 million tonnes mark. Of this total, 42% was in Western Europe, 27% in North America, 15% in Japan, and 16% in the remaining countries of the western world. Consumption per capita is noticeably higher where insulating materials are much used, as in the Scandinavian countries. EPS is generally made by suspension polymerization of styrene with simultaneous addition of blowing agents. Other processes are also used, especially in the manufacture of drinking cups, in which expanding ability is conferred by injecting the blowing agent at a later stage. Systems for computer-aided control of the machines, usually in conjunction with a VDU screen or LC display, are now increasingly common. 8 refs.

Gellert, R. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 26-28.

**Blending** See Also BLOCK COPOLYMERS—Morphology; BUTADIENE—Polymerization; POLYMERS—Blending; POLYMERS—Crystallization; POLYMERS—Decomposition; POLYMETHYL METHACRYLATE—Blending.

**083478 ORIENTATION AND RELAXATION IN UNIAXIALLY STRETCHED POLY(O-CHLOROSTYRENE)-POLYSTYRENE BLENDS.** Orientation and relaxation of polymer chains have been analyzed in uniaxially stretched films of poly(o-chlorostyrene) (PoCS) and of compatible PoCS/polystyrene (PS) blends. The intrinsic birefringence of PoCS is derived from fluorescence and birefringence orientation measurements. Further, using Fourier transform infra-red spectroscopy, the authors have determined the angle between the dipole moment vector of some infra-red vibrations of PoCS and the chain axis. The orientation of the benzene ring with respect to the chain axis in oriented PoCS samples is identical to that observed in PS. In PoCS/PS blends, infra-red and birefringence measurements show that chain orientation of both polymers is almost the same and independent of the presence of the second component, in agreement with mechanical relaxation measurements. (Edited author abstract) 23 refs.

Faivre, J.P. (Ecole Supérieure de Physique et Chimie Industrielles de la Ville de Paris, Paris, Fr); Xu, Z.; Halary, J.L.; Jasse, B.; Monnerie, L. *Polymer* v 28 n 11 Oct 1987 p 1881-1886.

**083479 INVESTIGATION OF THE BLEND OF PARTIALLY BROMINATED POLY(2,6-DIMETHYL 1,4-PHENYLENE OXIDE) AND POLYSTYRENE IN THE PRIMARY (GLASS-TO-RUBBER) TRANSITION REGION.** Compatible polymer blends can be used to test critically the viability of the damped Debye lattice (DDL) model of relaxation in the primary (glass-to-rubber) transition region. The model predicts an unusual sharpening of the stress relaxation master curve of a marginally two-dimensional DDL upon dilution with a plasticizer. We have prepared an appropriate two-dimensional DDL by adding modest amounts of partially brominated poly(2,6-dimethyl 1,4-phenylene oxide) to polystyrene to form compatible blends. As predicted by the model, sharpening of the stress relaxation behavior upon dilution was observed for all blend compositions and for all diluents used. However, at higher brominated poly(phenylene oxide) concentrations, the anticipated diluent concentration dependence was not always observed and the sharpening of the stress relaxation behavior was less than expected. (Edited author abstract) 18 refs.

Choe, Soonja (Univ of Southern California, Los Angeles, CA, USA); Aklonis, J.J. *Polym Eng Sci* v 27 n 17 Sep 1987 p 1284-1291.

**083480 PHASE BEHAVIOR FOR BLENDS OF**

**STYRENE CONTAINING TRIBLOCK COPOLYMERS WITH POLY(2,6-DIMETHYL-1,4-PHENYLENE OXIDE).** The extent to which the styrene end-blocks of three commercially available triblock copolymers can mix with a particular poly(2,6-dimethyl-1,4-phenylene oxide) ( $M_n=22,600$  and  $M_w=34,000$ ) or PPO has been examined by investigation of the glass transition behavior of the PPO and polystyrene (PS) portions of the blends using differential scanning calorimetry. Each block copolymer has a butadiene-based mid-block which was hydrogenated for two of these materials, but not the third. The three copolymers differ substantially in overall molecular weight and in molecular weight of the blocks. For blends of homopolymer PS with styrene-based block copolymers, the two-phase behavior of the glassy portion can be readily explained by entropic considerations. For the present case, the favorable enthalpic contribution for mixing PPO and PS is an additional factor which seems to influence the restrictions on molecular weight for complete mixing; however, additional work is needed to develop a more quantitative assessment of this new issue. (Edited author abstract) 33 refs.

Tucker, P.S. (Univ of Texas, Austin, TX, USA); Barlow, J.W.; Paul, D.R. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1817-1833.

**083481 GAS SORPTION AND TRANSPORT IN MISCIBLE BLENDS OF TETRAMETHYL BISPHENOL-A POLYCARBONATE AND POLYSTYRENE.** The permeability coefficients for He, O<sub>2</sub>, N<sub>2</sub>, CH<sub>4</sub>, and CO<sub>2</sub> in miscible blends of polystyrene (PS) and tetramethyl bisphenol-A polycarbonate (TMPC) at 35°C and 1 atm driving pressure are reported. Sorption isotherms for CO<sub>2</sub> and CH<sub>4</sub> are also presented. The isotherms were fitted to the dual sorption model. The Langmuir capacity factor was found to follow an earlier correlation based on unrelaxed volume. For each gas, the permeability was found to go through a minimum when plotted against blend composition. This behavior is primarily the result of the volume change on mixing observed for this system. The attractive interaction between TMPC and PS is relatively strong as indicated by density and solubility data. The value of the binary interaction parameter was found to be of the same magnitude as that for poly(phenylene oxide) (PPO)-polystyrene (PS) blends. Considering the similarity of structure between PPO and TMPC, it is concluded that similar phenyl-phenyl interactions and conformation changes on blending may prevail in TMPC/PS blends. (Author abstract) 37 refs.

Muruganandam, N. (Univ of Texas, Austin, TX, USA); Paul, D.R. *J Polym Sci Part B* v 25 n 11 Nov 1987 p 2315-2329.

**083482 COUPLING OF REACTIVE POLYSTYRENE AND POLYETHYLENE IN MELTS.** Polystyrene (OPS) having oxazoline groups and polyethylene (CPE) having carboxyl groups were melt blended in a Rheomix mixer. The effects of composition on the torque, thermal transitions, solubility and phase structure of these resulting polymer alloys were investigated. Differential scanning calorimetry (d.s.c.) and scanning electron microscopy (SEM) data on these alloys is compared with the corresponding melt blends of the non-reactive polymers. The torque-time relationship, phase structure and thermal properties of these polymer alloys were found to be very different from the non-reactive blends, and this was more so in an alloy with 40% CPE. (Edited author abstract) 15 refs.

Baker, W.E. (Queen's Univ, Kingston, Ont, Can); Saleem, M. *Polymer* v 28 n 12 Nov 1987 p 2057-2062.

**083483 CRYSTALLIZATION BEHAVIOUR OF POLY(PHENYLENE SULPHIDE)/POLYSTYRENE BLEND.** The crystallinity of poly(phenylene sulphide) (PPS) blended with polystyrene has been investigated as a function of composition, annealing time and temperature by an X-ray diffraction technique for samples made by three mixing techniques viz. powder blending, melt blending and solution blending. The method of blending has a pronounced effect on the crystallinity, solution

blending giving the least for a particular composition. The crystallization half time increases while the crystallite size is reduced considerably by the addition of polystyrene to PPS. These findings have been explained on the basis of partial miscibility of the amorphous phases. (Author abstract) 25 refs.

Radhakrishnan, S. (Nat'l Chemical Lab, Poona, India); Joshi, S.G. *Eur Polym J* v 23 n 10 1987 p 819-824.

**083484 STUDY OF THE COMPATIBILITY OF BLENDS OF POLYMERS AND COPOLYMERS CONTAINING STYRENE, 4-HYDROXYSTYRENE AND 4-VINYLPYRIDINE.** Differential scanning calorimetry was used to show that poly(4-vinylpyridine) is incompatible with polystyrene but compatible with poly(4-hydroxystyrene) over the entire range of composition. Compatibility between poly(4-vinylpyridine) and styrene-rich copolymers is achieved by introducing into the copolymers reactive groups which are able to complex with poly(4-vinylpyridine) through hydrogen bonding. Similarly, miscibility between poly(4-hydroxystyrene) and polystyrene, which are incompatible over the entire range of composition, is only achieved if polystyrene is modified by incorporation of large amounts of (4-vinylpyridine) units. These results confirm that for such dissimilar polymers compatibility can only be achieved through cumulative interactions of added functionalities. (Edited author abstract) 15 refs.

Vivas de Meftahi, Marina (Univ of Ottawa, Ottawa, Ont, Can); Frechet, Jean M.J. *Polymer* v 29 n 3 Mar 1988 p 477-482.

**083485 TEMPERATURE AND CONCENTRATION DEPENDENCE OF THE INTERACTION PARAMETER IN OLIGOMERIC POLYMER BLENDS FROM SMALL-ANGLE NEUTRON SCATTERING AND CALORIMETRIC MEASUREMENTS.** Small-angle neutron scattering has been used to determine the concentration and temperature dependence of the interaction parameter  $\chi$  in a blend of two polymers. The interaction parameter can be obtained either by analyzing the angular dependence of the scattering in terms of an apparent radius of gyration or by extrapolation of the data to zero scattering angle. The authors present a comparison of these two methods for two blends of oligomeric polystyrene with polybutadiene. The temperature dependence of the interaction parameter has been determined for a blend of oligomeric methoxylated poly(ethylene glycol) with methoxylated poly(propylene glycol) where the latter component contains a percentage of labeled chains. (Edited author abstract) 27 refs.

Tomlins, P.E. (Imperial Coll, London, Engl); Higgins, J.S. *Macromolecules* v 21 n 2 Feb 1988 p 425-432.

**083486 STRUCTURE RELAXATION AFTER TEMPERATURE JUMPS IN HOMOGENEOUS POLYSTYRENE/POLY(STYRENE-10% BROMOSTYRENE) BLENDS.** Concentration fluctuations in polymer blends and their change after a temperature jump were studied by time-dependent small angle X-ray scattering experiments. Measurements were conducted on homogeneous mixtures of polystyrene and a partially brominated derivative. Structure factors in thermal equilibrium show the form given by the random phase approximation. Relaxation occurs on the time scale of minutes and is nonexponential, becoming slower with time. Initial relaxation rates increase with increasing scattering vectors in accordance with theoretical predictions. (Edited author abstract) 9 refs.

Strobl, G.R. (Univ Freiburg, Freiburg, West Ger); Urban, G. *Colloid Polym Sci* v 266 n 5 May 1988 p 398-404.

**083487 FTIR STUDIES OF IONIC INTERACTIONS IN BLENDS.** Fourier-transform infrared (FTIR) spectroscopy has the potential to demonstrate and enumerate ionic interactions in polymer blends because of its sensitivity to changes in chemical and physical environment. We describe a blend of p-sulfonated polystyrene



(SPS), with 4.5 mol PERCENT sulfonation and an amine-terminated poly(alkylene oxide) (APAO) of molecular weight 900. Such a polymer pair forms a miscible blend over a limited concentration range. We conclude that ionic interactions can occur in SPS/APAO blends. 5 Refs.

Garton, Andrew (Univ of Connecticut, Storrs, CT, USA); Wang, Shiping; Weiss, Robert A. *J Polym Sci Part B* v 26 n 7 Jul 1988 p 1545-1548.

**083488 PREFERENTIAL SURFACE ADSORPTION IN MISCIBLE BLENDS OF POLYSTYRENE AND POLY(VINYL METHYL ETHER).** The surface structure and properties of miscible blends of polystyrene (PS) with poly(vinyl methyl ether) (PVME) have been studied as a function of the blend composition and constituent molecular weights. The lower surface tension of the PVME compared to that of PS results in preferential adsorption of PVME at the surface. The surface enrichment of PVME is characterized by measurements of the surface tension as a function of the temperature, accomplished with an automated pendant drop apparatus, and by X-ray photoelectron spectroscopy (XPS). Angle-dependent XPS has been used to determine the surface concentration profiles of the blend constituents. (Edited author abstract). 66 Refs.

Bhatia, Qamardeep S. (Princeton Univ, Princeton, NJ, USA); Pan, David H.; Koberstein, Jeffrey T. *Macromolecules* v 21 n 7 Jul 1988 p 2166-2175.

**083489 ENTANGLEMENT IN BLENDS OF MONODISPERSE STAR AND LINEAR POLYSTYRENES. 1. DILUTE BLENDS.** Viscoelastic properties of binary blends composed of narrow molecular weight distribution (MWD) 4-arm star polystyrenes (2-chain) of molecular weight (MW)  $M_2$  and narrow MWD linear polystyrenes (1-chain) of  $M_1$  were examined and compared with binary blends of narrow MWD linear polystyrenes of  $M_2$  and  $M_1$ . In these blends the volume fraction  $\phi_2$  of the 2-chain was kept small so that the 2-chains were entangling only with the matrix 1-chains but not with themselves. When the MW of the components of these dilute blends were such that  $M_c < M_1 \ll M_2$ , with  $M_c$  being the characteristic MW, the star 2-chain exhibited Rouse-Ham-like relaxation modes with the (weight average) relaxation time proportional to  $\phi_2^0 M_1^3 M_2^2$  and the compliance proportional to  $\phi_2^{-1} M_1^0 M_2$ . (Edited author abstract). 41 Refs.

Watanabe, Hiroshi (Osaka Univ, Toyonaka, Jpn); Yoshida, Hirotsugu; Kotaka, Tadao. *Macromolecules* v 21 n 7 Jul 1988 p 2175-2183.

**Blowing Agents** See FLUOROHYDROCARBONS—Environmental Impact.

**Chemical Reactions** See Also EPOXY RESINS—Synthesis; ION EXCHANGE RESINS—Synthesis; POLYESTERS—Synthesis.

**083490 CHARACTERIZATION OF PHOSPHINATED POLYSTYRENE-BOUND PALLADIUM(II) COMPLEXES.** Polystyrene-bound palladium(II) complexes are prepared by treatment of  $\text{PdCl}_2$  with phosphinated polystyrene. The Pd complexes are characterized by elemental analysis, FT-IR,  $^{31}\text{P}$ -MAS NMR, and XPS. The most likely structure of the Pd complexes is a tricoordinated  $\text{P-Pd(II)Cl}_2$  (P is the polymeric ligand). (Author abstract) 5 refs.

Kato, Masatoshi (Yokkaichi Research Lab, Kasumi, Jpn); Sato, Kaoru; Ito, Masuo; Kasano, Kenji; Uemura, Masaru; Kaneda, Kiyotomi; Imanaka, Toshinobu. *Chem Express* v 3 n 5 May 1988 p 303-306.

**083491 ASYMMETRIC INDUCTION IN THE CYCLOADDITION OF 1,3-BUTADIENE TO A POLYMER-BOUND CHIRAL ACRYLATE.** Crosslinked polystyrene resins containing pendant benzyl acrylate or chiral acrylates reacted with 1,3-butadiene or 2,3-dimethyl-1,3-butadiene in the presence of the Lewis acid catalysts to yield Diels-Alder adducts. The polymer-bound Diels-Alder reactions were compared with their

analogous reactions in solution. In reactions leading to optically active products the enantiomeric excesses on the polymer were at least as high as those performed in solution. (Edited author abstract) 38 refs.

Corbridge, Michael D. (York Univ, North York, Ont, Can); McArthur, Colin R.; Leznoff, Clifford C. *React Polym Ion Exch Sorbents* v 8 n 2 Apr 1988 p 173-188.

**083492 CHEMISTRY ON POLYMER SUPPORTS. 1. POLYMER-SUPPORTED WITTIG REACTIONS.** Wittig reactions were studied on a styrene/divinylbenzene (2%) copolymer support having either the oxo component (type-I reaction) or the phosphonium component (type-II reaction) attached via a covalent bond. Model studies yielding 1-p-nitrophenyl-2-polystyrylethylene showed that the product produced by two different routes was the same. Polymer-supported phosphonium salts were prepared in dipolar aprotic solvent. The Wittig reactions were carried out in dimethyl sulfoxide using sodium methylsulfinylmethanide (generated in situ by sodium hydride) as deprotonating agent. The reactions were followed by infrared spectroscopy. High percentages of conversion were achieved with both types of Wittig reaction. (Author abstract) 14 refs.

Szabo, L.F. (Simmelweis Med Univ, Budapest, Hung); Tetenyi, P. Jr. *React Polym Ion Exch Sorbents* v 8 n 2 Apr 1988 p 193-199.

**083493 PEPTIDE SYNTHESIS BY MEANS OF POLYMER-ANCHORED N-HYDROXY COMPOUND. 1. PREPARATION OF SIMPLE PEPTIDES.** 6-Acetamido-1-hydroxy-3-trifluoromethylindazole was incorporated into either a Merrifield bead-type chloromethylated copolystyrene with 2% divinylbenzene or a chloromethylated polystyrene-polypropylene composite fiber-type polymer. These compounds were examined in the synthesis of Z-Val-GlyOEt. This method was also used to synthesize an intermediate of the melanocyte stimulating hormone-release-inhibiting factor, Z-Pro-Leu-GlyOEt; the yield was comparable with that from the conventional solution method. Also described is the solvent effect on the peptide yield. (Edited author abstract) 41 refs.

Horiki, Kusuo (Shionogi & Co, Osaka, Jpn); Murakami, Atsuko; Chomei, Nobuo. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 127-142.

**083494 SYNTHESIS OF SUPPORTED 4-AMINOPYRIDINES AND HYDROXYBENZOTRIAZOLES. APPLICATIONS IN PEPTIDE CHEMISTRY.** We have previously tested a number of 4-aminopyridines anchored to polystyrene in the acetylation reaction of 1-methylcyclohexanol. New derivatives have now been synthesized in order to point out a number of factors bearing on their efficacy as catalysts: nature of the polymer, length and polar character of the spacer, apparent pK, etc. We have tested our supported catalysts. Chemical yields and degrees of racemization are compared with those given by the respective soluble reagents. (Edited author abstract)

Jacquier, R. (Univ des Sciences et Techniques du Languedoc, Montpellier, Fr); Verducci, J.; Berrada, A.; Guendouz, F. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 333.

**083495 PROPERTIES OF IMMOBILIZED TETRAZOLIUM SALTS AND FORMAZANS.** The single-step reaction of different dehydridithione derivatives with immobilized chloromethyl groups yields supports (polystyrene, silica gel) carrying sulfur-bonded tetrazolium groups. The ion exchange and redox properties of these materials find applications in analytical and preparative chemistry. The sorption behavior of the modified supports can be utilized for selective and reversible sorption of precious metal ions. Some of the modified polystyrenes can be used for the analysis of ores and

concentrates. However, the regeneration of the resins remains incomplete. Improved results were obtained with tetrazolium salts bonded ionically onto strong-base ion exchangers. (Edited author abstract)

Grote, M. (Univ of Paderborn, Paderborn, West Ger); Ketrup, A. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 337.

## Chlorination

**083496 PHASE TRANSFER CATALYZED CHLORINATION OF POLY(P-METHYLSTYRENE).** Chlorination of the methyl groups of poly(p-methylstyrene) with aqueous sodium hypochlorite and benzyltriethylammonium chloride as catalyst provides a new route to chloromethyl-substituted aromatic polymers. Conversions of up to 20% of methyl to chloromethyl groups were achieved with no detectable formation of dichloromethyl groups. Conversion of up to 73% of methyl to chloromethyl groups occurs with 12% concomitant formation of dichloromethyl groups. The method has been applied to soluble, 1% crosslinked, and 20% crosslinked macroporous polymers. Phase transfer catalyzed chlorination of poly(p-methylstyrene) is much safer than chloromethylation of polystyrene and much less expensive than the use of chloromethylstyrene monomer for preparation of functional derivatives of polystyrene. (Author abstract)

Mohanraj, S. (Oklahoma State Univ, Stillwater, OK, USA); Ford, Warren T. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 335.

## Chromatographic Analysis

**083497 CHARACTERIZATION OF CHLOROMETHYL-SUBSTITUTED POLYSTYRENE NETWORKS BY HIGH-RESOLUTION PYROLYSIS-GAS CHROMATOGRAPHY.** Three types of chloromethyl-substituted polystyrene networks prepared by different methods are studied by high-resolution pyrolysis-gas chromatography. The methods of introduction of chloromethyl groups are readily identified from the pyrolyzates characteristic of each copolymer. The degree of chloromethyl substitution is also estimated from the changes in the peak intensities of the characteristic pyrolyzates. Additionally, the thermal degradation behavior of these polystyrene networks is studied by thermogravimetric analysis. The pyrolysis-gas chromatography results can be used as a method of quantitative analysis of the amount of chlorine in these chloromethyl-substituted polystyrenes. (Author abstract) 9 refs.

Nakagawa, H. (Nagoya Univ, Nagoya, Jpn); Tsuge, S.; Mohanraj, S.; Ford, Warren T. *Macromolecules* v 21 n 4 Apr 1988 p 930-933.

**083498 DYNAMIC HEADSPACE CAPILLARY GAS CHROMATOGRAPHY: A VERSATILE ANALYTICAL TECHNIQUE.** The applicability of dynamic headspace analyses for viscous liquids and solid samples is demonstrated. Some comments on the usefulness of this technique for quantifying volatiles in polymeric matrices are made. Dynamic headspace analysis can easily be applied to viscous liquids and solid samples. Although this paper contains only illustrations based upon polymeric solids, the technique may be applied to all kinds of solid materials. The use of repeated desorption cycles of the same sample gives valuable information on the precision of the quantification of volatiles and/or their formation at the desorption temperature. 5 refs.

Venema, A. (Akzo Corporate Research Dep, Arnhem, Neth). *HRC & CCJ High Resolut Chromatogr Chromatogr Commun* v 11 n 1 Jan 1988, Eighth Int Symp on Capillary Chromatogr, Riva del Garda, Italy, May 19-21 1987 p 128-131.



Coagulation See LATEXES—Coagulation.

Coatings See COMPOSITE MATERIALS—Electric Conductivity; SEMICONDUCTING BISMUTH COMPOUNDS—Thin Films.

Combustion See MAGNESIUM COMPOUNDS—Combustion.

Concentration See COLLOIDS.

## Crack Propagation

**083499 CRAZE GROWTH AND HEALING IN POLYSTYRENE.** The kinetics of craze growth and craze healing were studied by dark-field optical microscopy in monodisperse molecular weight polystyrene (PS) that varied in molecular weight from 88,000 to 1,334,000. The following observations were made.  $G_1$ , the virgin growth rate, decreased rapidly with increasing molecular weight until  $M_n$  approx. 200,000 and then remained constant.  $G_1$  decreased with increasing craze density. The growth rates of approaching craze tips decreased when the craze tips overlapped, and the effect was less for crazes whose parallel growth paths were greater than 40  $\mu$ m apart. Complete craze healing was observed by the comparison of the nucleation times and growth rates,  $G_2$ , of healed individual crazes with the craze kinetics of the virgin sample. Craze healing studies provide insight into both crack healing and fracture of glassy polymers. (Edited author abstract) 37 refs.

McGarel, Owen J. (Univ of Illinois, Urbana, IL, USA); Wool, Richard P. *J Polym Sci Part B* v 25 n 12 Dec 1987 p 2541-2560.

**083500 ON SELF-SIMILARITY OF CRACK LAYER.** It is commonly recognized that microdefects (damage) play a significant role in the process of crack formation and growth. An important case is when the density of damage induced by a propagating crack as a response to the stress concentration at the crack tip is much greater than the density of the pre-existing damage. This strongly cooperative phenomenon is modeled by the Crack Layer Theory. In its scope 'crack layer' (CL) is defined as the system consisting of the main crack together with the surrounding damage. The objective of this report is to examine the self-similarity hypothesis for quasistatic CL propagation using polystyrene as a model material. 6 refs.

Botsis, J. (Univ of Illinois at Chicago, Chicago, IL, USA); Kunin, B. *Int J Fract* v 35 n 3 Nov 1987 p R51-R56.

**083501 CRACK AND DAMAGE PROPAGATION IN POLYSTYRENE UNDER FATIGUE LOADING.** Fatigue crack propagation experiments conducted on thin, single edge-notched polystyrene specimens demonstrate that during quasi-static propagation intense crazing surrounds and precedes the crack. The crack and its associated damage constitute a crack layer (CL). Craze accumulation within the zone ahead of the crack tip, i.e. the active zone, takes place prior to crack advance. During crack advance, the shape of the crack tip closely resembles that of the Dugdale-Barenblatt model. The experimental results demonstrate that fracture propagates by the translation, expansion and distortion of the active zone. The critical energy release rate is found to be strongly dependent on loading history. (Edited author abstract) 33 refs.

Botsis, John (Univ of Illinois at Chicago, Chicago, IL, USA). *Polymer* v 29 n 3 Mar 1988 p 457-462.

**083502 COMPARISON OF MINIMAL PRINCIPAL STRESS TRAJECTORIES WITH CRAZE DISTRIBUTION IN AN AMORPHOUS POLYMER.** Analysis of the distribution of surface crazes in the vicinity of a stationary edge crack in a polystyrene (PS) sheet in tension has shown the craze growth occurs along directions parallel to the minor principal stress axis. In this study, a correlation between the principal stress trajectories in the vicinity of notches and crazing patterns in PS under tension loading is established. Tresca's criteria are

used to compare these patterns with the experimentally observed ones. 8 Refs.

Chabaat, M. (Case Western Reserve Univ, Cleveland, OH, USA). *Int J Fract* v 37 n 4 Aug 1988 p R47-R54.

## Crazing

**083503 EFFECT OF ENVIRONMENTAL WATER ON THE CRAZE GROWTH RATE OF ATACTIC POLYSTYRENE.** The effect of water at standard temperature and pressure on the rate of craze growth in polystyrene was studied with an elapsed-time photography method. Water was found to be a mild crazing agent for polystyrene, increasing the craze velocity by somewhat more than an order of magnitude at room temperature. The craze length was found to increase proportional to the square root of time, as is expected for transport-limited solvent crazing. The interface convolution model for craze growth and thickening was found to account well for the stress dependence of the craze front velocity in both the 'dry' and the 'wet' states, and for the total effect of water on the craze velocity. The stress dependence of the craze front velocity implies that craze fibrils grow by surface drawing and that water molecules interact only with the plastically deforming fringing layer of polymer at the craze borders. (Author abstract) 17 refs.

Kefalas, V.A. (MIT, Cambridge, MA, USA); Argon, A.S. *J Mater Sci* v 23 n 1 Jan 1988 p 253-258.

Crosslinking See Also MEMBRANES—Manufacture.

**083504 POLY( $\alpha$ -AMINO ACID)-IMMOBILIZED POLYMER ADSORBENTS FOR OPTICAL RESOLUTION. I. SYNTHESIS, CHARACTERIZATION, AND EVALUATION OF POLY(L-GLUTAMIC ACID) DERIVATIVES-IMMOBILIZED POLYMER ADSORBENTS.** As a novel polymer adsorbent for optical resolution, cross-linked polystyrene gel incorporating poly( $\alpha$ -amino acids) was synthesized. The helicity of the incorporated poly( $\gamma$ -benzyl L-glutamate) (PBLG) was demonstrated by Fourier-transform infrared spectroscopy. The immobilized PBLG (I) was converted to poly(L-glutamic acid) (II) and poly(N<sup>5</sup>-benzyl-L-glutamine) (III). The ability of I-III to resolve DL-mandelic acid was evaluated by liquid chromatography using toluene/dioxane as an eluent. Of the three resins, III resolves the racemate most effectively. In order to clarify the mechanism of chiral recognition, poly(N<sup>5</sup>-benzyl-D-glutamine) and poly(N<sup>4</sup>-benzyl-L-asparagine), with opposite helicity, was incorporated. In contrast to III, these adsorbents demonstrated affinity for the L isomer. This results strongly indicates that the helical structure of the immobilized poly( $\alpha$ -amino acids) is essential for chiral recognition. (Author abstract) 23 refs.

Kiniwa, Hideaki (Mitsubishi Chemical Industries Ltd, Yokohama, Jpn); Nishikaji, Takashi; Ogata, Naoya. *J Polym Sci Part A* v 25 n 10 Oct 1987 p 2689-2698.

**083505 SOLUTION PROPERTIES AND DYNAMIC BULK BEHAVIOR OF INTERMOLECULAR CROSS-LINKED POLYSTYRENE.** Linear polystyrene (PS) molecules were intramolecularly cross-linked with p-bis(chloromethyl)benzene in dilute solution. The resulting 'microgels' were characterized in solution by static and dynamic light scattering, GPC, and viscosity measurements. We find a surprisingly small reduction of the radius of gyration and the hydrodynamic radius even for highly cross-linked PS molecules having molecular weights up to  $5 \times 10^5$  and an average number of  $P_c = 20$  monomer units between cross-links. Dynamic mechanical measurements in samples having  $P_c \geq 10$  yield no change of the plateau modulus in comparison to the linear molecules but a broadening and shift to lower frequencies of the terminal zone if compared with linear PS. Furthermore, we find that the product of the self-diffusion coefficient and the zero-shear viscosity is constant, and the diffusion of PS chains in a matrix of microgels is independent of the cross-link density. Various explanations are discussed, but no decision for a particular model (describing all experimental results) can be made. (Author abstract) 41 refs.

Antonietti, Markus (Univ Mainz, Mainz, West Ger); Sillescu, Hans; Schmidt, Manfred; Schuch, Horst. *Macromolecules* v 21 n 3 Mar 1988 p 736-742.

**083506 CROSSLINKING OF POLYSTYRENE UNDER FRIEDEL-CRAFTS CONDITIONS IN DI-CHLOROETHANE AND CARBON TETRACHLORIDE SOLVENTS THROUGH THE FORMATION OF STRONGLY COLORED POLYMER- $AlCl_3$ -SOLVENT COMPLEXES.** Polystyrene was crosslinked in either 1,2-dichloroethane or carbon tetrachloride in the presence of aluminum chloride. Apparently, the reactions involve Friedel-Crafts substitution of phenyl ring with  $CH_2CH_2Cl$  or  $CCl_3$  groups, which then participate in crosslinking, giving  $CH_2CH_2$  or  $CCl_2$ ,  $CCl$ , and C bridges. In the first stage a charge-transfer complex is formed between  $AlCl_3$ , polystyrene and the solvent. After heating this complex above 35-40°C a rapid formation of HCl inflammable. It decomposes at 400°C without melting. (Author abstract) 15 Refs.

Rabek, Jan F. (Royal Inst of Technology, Stockholm, Sweden); Lucki, Julia. *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2537-2551.

## Decomposition

**083507 POLYSTYRENES: A REVIEW OF THE LITERATURE ON THE PRODUCTS OF THERMAL DECOMPOSITION AND TOXICITY.** The current English literature through 1984 on the products of pyrolysis and combustion from polystyrenes and the toxicity of those products is reviewed. Among 57 compounds detected by chemical analyses of the thermal decomposition products produced under various atmospheric conditions (vacuum, inert and oxidative), the main volatile component is the styrene monomer. Evidence is provided that the mass fraction of styrene increases with furnace temperatures at least through 500°C. At 800°C and above, the concentration of styrene decreases. In oxidative atmospheres, carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>) and oxidative hydrocarbons are formed. The concentrations of CO and CO<sub>2</sub> are a function of temperature and combustion conditions, i.e. greater amounts are produced in the flaming than in the non-flaming mode. Eleven different test procedures were used to evaluate the toxicity of the pyrolysis and combustion atmospheres of polystyrenes. The more toxic environments produced under flaming conditions appear to be mainly attributed to CO and CO<sub>2</sub>. (Edited author abstract) 69 refs.

Curman, Joshua L. (NBS, Gaithersburg, MD, USA); Baier, Laura; Levin, Barbara C. *Fire Mater* v 11 n 3 Sep 1987 p 109-130.

**083508 EFFECTS OF HEAT AND MASS TRANSPORT ON THE RESULTS OF THERMAL DECOMPOSITION STUDIES: PART 2. POLYSTYRENE, POLYTETRAFLUOROETHYLENE AND POLYPROPYLENE.** The thermal decomposition of pure polymer samples was studied at a low heating rate (4°C/min) and with sample masses of 0.3-6 mg in a Perkin-Elmer TGS-2 thermobalance. The various transport effects were distinguished by changing the gas flow from argon to helium, varying the sample mass and geometry and by applying a self-generated atmosphere. Sample masses of 3-6 mg showed marked effects of insufficient heat transfer in a flow of argon. The concentration of the volatile products above the samples did not influence the thermal decomposition. The diffusion problems in the polymer bulk, however, changed the kinetics from first order to zero order in the case of polytetrafluoroethylene, and increased the overall reactions rate of polypropylene. (Edited author abstract) 14 refs.

Szekely, Tamas (Hungarian Acad of Sciences, Budapest, Hung); Vahgyel, Gabor; Till, Ferenc; Szabo, Piroksa; Jakab, Emma. *J Anal Appl Pyrolysis* v 11 Oct 1987, Proc of the 7th Int Symp on Anal and Appl Pyrolysis, Reading, Engl, Sep 15-19 1986 p 83-92.



## Defects

**083509 SIZE AND SHAPE OF THE CRITICAL STRUCTURAL DEFECT IN POLYSTYRENE AND POLYMERS REINFORCED WITH RUBBER.** The effect of a critical structural defect on the strength of polymers under conditions of impact loading is considered. With PS, toughened PS and an ABS plastic, the size and shape of the critical structural defect have been determined using the method proposed previously. The size of the critical structural defect is related to the polymer's supermolecular structure. It is concluded that polymers with a rounded critical structural defect have enhanced sensitivity to artificial surface defects. (Author abstract) 19 refs.

Mikitayev, A.K. (Karbardino-Balkar State Univ, USSR); Mil'man, L.D.; Kozlov, G.V. *Polym Sci USSR* v 29 n 2 Feb 1987 p 428-433.

## Deformation

**083510 STORED ENERGY OF COLD WORK IN POLYSTYRENE.** The energy stored in polystyrene after plastic deformation is measured by the differential scanning calorimetry (DSC) technique. Similar to metals, the stored energy increases with plastic straining, first rapidly, and then more slowly, and finally the stored energy seems to approach a saturation value (about 1 cal/gram). By comparing to the plastic work done, the fraction stored ranges from 30 percent after 10 percent compression to 10 percent after 60 percent compression. The fraction is about twice as large as that of copper. The release of stored energy has two distinct parts, one below  $T_g$  and the other above  $T_g$ . (Edited author abstract) 23 Refs.

Chang, Benjamin Tai-an (Univ of Rochester, Rochester, NY, USA); Li, J.C.M. *Polym Eng Sci* v 28 n 18 Sep 1988 p 1198-1202.

## Degradation

**083511 STUDY OF SOLID CHAR RESIDUES AFTER THERMAL DEGRADATION OF POLYSTYRENE, PVC AND POLYAMIDE - PART II.** In the course of thermal degradation of polymers complex pyrolytic and thermo-oxidizing processes take place. The products of these complex processes are resistant char residues, the analysis of which can be useful in fire cause investigation. Structural residues of the original polymer remain in the char portion of degraded polymer depending on the temperature and duration of the thermal degradation and the temperature. Elementary analysis and infrared spectroscopy have been used for the identification of char residues. (Edited author abstract) 3 refs.

Sevecok, P. (Mining Univ, Ostrava, Czech); Stuzka, V. *Fire Mater* v 11 n 2 Jun 1987 p 89-93.

**083512 PHOTO-DEGRADATION OF BLENDS OF POLYSTYRENE AND POLY(METHYL METHACRYLATE).** Studies of the photo-degradation of blends of polystyrene (PSt) and poly(methyl methacrylate) (PMMA) were made using ultraviolet (UV) and Fourier transform infrared (FTIR) spectroscopy and viscosity measurements. Optical density around 300 nm increases with the increase in the proportion of the PMMA component in the blend. A similar trend is also seen in the formation of oxygenated products. The number of chain scissions calculated from viscosity measurements also becomes greater as the PMMA component in the blend is increased. It has been found that the degradation of PSt-PMMA blends takes place in the PMMA. Interaction between PSt and PMMA in the component boundary regions has not been observed. (Author abstract) 10 refs.

Torikai, Ayako (Nagoya Univ, Nagoya, Jpn); Sekigawa, Yukihiko; Fueki, Kenji. *Polym Degradation Stab* v 21 n 1 1988 p 43-54.

## Desorption

**083513 POLYMER DESORPTION BY NMR.** In a recent paper, the authors used solid state and high

resolution NMR to look at the rates of adsorption and desorption of polystyrene at the carbon/chloroform interface. The authors found that the adsorption is reversible both when the polymer solution is diluted and when it is concentrated by polymer. In particular, by using deuterated and protonated polymer with the same number of monomers, the authors were able to observe adsorption in the presence of desorption and desorption in the presence of adsorption. The time scales of the results suggest that the time taken for the polymer to be displaced is greater than it is to be incorporated. (Edited author abstract) 1 ref.

Cosgrove, T. (Univ of Bristol, Bristol, Engl). *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 117.

## Differential Thermal Analysis

**083514 L'ATD DANS L'IDENTIFICATION DU POLYSTYRENE ET DE SES COPOLYMERES A USAGE ALIMENTAIRE ET PHARMACEUTIQUE.** [Use of Differential Thermal Analysis in Identification of Polystyrene and Its Copolymers Used in the Food and Pharmaceutical Industry]. Polystyrene (PS) and its copolymers (SBR, ASA, SAN and ABS) have been studied by differential thermal analysis. These five families exhibit a large endothermic decomposition peak at about 380°C. The curves exhibit also one exothermic peak (ASA, SAN, ABS) or two (PS, SBR) which are larger and nearer for SBR than for PS. ASA, SAN and ABS copolymers are characterized by an endothermic peak shape (the slope of the ascending part has been computed and expressed for one gramme of sample). This method was used for identification of alimentary package and some pharmaceutical disposables. (Author abstract). 6 Refs. In French.

Kaloustian, J. (Lab de Chimie Analytique, Marseilles, Fr); Pauli, A.M.; Pastor, J. *J Therm Anal* v 34 n 2 Mar-Apr 1988 p 465-471.

**Diffusion See Also POLYETHYLENES—Morphology; POLYMETHYL METHACRYLATE—Solutions.**

**083515 PORE SIZE EFFECTS ON DIFFUSION OF POLYSTYRENE IN DILUTE SOLUTION.** Rates of diffusion of linear polystyrene ( $MW\ 1.6-9.3 \times 10^5$ ) at dilute concentrations in tetrahydrofuran were measured as a function of pore size for thin membranes. The data for all molecular weights and pore sizes can be accurately correlated by a single relationship between  $D/D_0$  and  $R_s/R$ , where  $D$  and  $D_0$  are the diffusion coefficients for the pore and bulk solutions, respectively,  $R_s$  is the Stokes-Einstein radius of the polymer which is calculated from  $D_0$ , and  $R$  is the pore radius. Our results indicate that the hindrance effect of the pores on this linear polymer is greater than for a rigid sphere of the same Stokes-Einstein radius. (Edited author abstract) 28 refs.

Kathawalla, Imtiaz A. (Carnegie Mellon Univ, Pittsburgh, PA, USA); Anderson, John L. *Ind Eng Chem Res* v 27 n 5 May 1988 p 866-871.

**083516 CHAIN DIFFUSION OF POLYSTYRENE IN CS<sub>2</sub>.** This paper is focused on the issue of self-diffusion of polystyrene chains in CS<sub>2</sub> above and below the gelation region. By examining the self-diffusion we hope to shed some light on the nature of this gelation phenomenon. The authors show that polymer chains diffuse with a diffusion coefficient of the order of  $10^{-8}$  cm<sup>2</sup>/s, which is comparable to that of a moderately concentrated polystyrene solution at a comparable concentration. Secondly, the decay curves have 10-20% of a 'slow component' tail, which decreases in intensity as the temperature is increased and vanishes eventually above  $T_{gel}$ . 11 refs.

Lee, Jungsik (Univ of Wisconsin, Madison, WI, USA); Kim, Hongdoo; Yu, Hyuk. *Macromolecules* v 21 n 3 Mar 1988 p 858-860.

## Dissolution

**083517 DISSOLVED STATE OF ATACTIC POLYSTYRENE IN AROMATIC SOLVENTS: APPROACHES THROUGH <sup>1</sup>H NMR, FT-IR AND ADIABATIC COMPRESSIBILITY.** An attempt was made to interpret significant differences in thermodynamic parameters, including the concentration dependence coefficients  $p_1$  and  $p_2$  of the polymer-solvent interaction parameter  $\chi$ , Flory entropy parameter at infinite dilution  $\psi_0$ , Flory temperature  $\theta$ , observed between atactic polystyrene (PS) in aromatic and aliphatic solvents by the characteristic features of the dissolved state of PS in aromatic solvents. For this purpose, <sup>1</sup>H NMR spectra were measured on PS/benzene, cyclohexane, toluene, and methylcyclohexane systems and the infrared spectra and adiabatic compressibility were determined for the former two solvents. In PS/aromatic solvents H<sub>2</sub>, H<sub>3</sub>, and H<sub>4</sub>-phenyl proton peaks are shifted to a lower magnetic field than those in PS/aliphatic solvent, which was produced by hydrogenation of the aromatic solvent. The degree of solvation is slightly larger in benzene than in cyclohexane. (Edited author abstract) 15 refs.

Kamide, Kenji (Asahi Chemical Industry Co, Takatsuki, Jpn); Matsuda, Shigenobu; Kowsaka, Keisuke. *Polym J* v 20 n 3 1988 p 231-241.

**Electric Conductivity See PLASTICS FILMS—Electric Conductivity.**

## Electric Field Effects

**083518 EFFECT OF ELECTROLYTE CONCENTRATION AND CO-ION TYPE ON THE  $\zeta$ -POTENTIAL OF POLYSTYRENE LATICES.** High-frequency dielectric response measurements were performed on three monodisperse polystyrene latices at varying electrolyte concentrations. For one latex, the  $\zeta$ -potential and electrokinetic charge obtained from these measurements were compared with results obtained from microelectrophoresis. It appears that the high-frequency dielectric response technique probes the whole of the diffuse double layer and gives an estimation of the Outer Helmholtz plane potential  $\psi_d$ . To investigate the effect of co-ions on the  $\zeta$ -potential, microelectrophoresis experiments were performed on a single latex at varying electrolyte concentrations using potassium fluoride, chloride, bromide, and iodide as the indifferent electrolyte. Little difference was found among these electrolytes, suggesting the absence of adsorption of co-ions into the inner Helmholtz plane. A model is proposed for the polystyrene/electrolyte interface that invokes localized surface roughness to explain the observed electrokinetic maximum. (Edited author abstract) 21 refs.

Midmore, B.R. (Univ of Sydney, Aust); Hunter, R.J. *J Colloid Interface Sci* v 122 n 2 Apr 1988 p 521-529.

## Encapsulation

**083519 PREPARATION OF POLYELECTROLYTE-COATED p-H-SENSITIVE POLY(STYRENE) MICROCAPSULES AND THEIR APPLICATION TO INITIATION-CESSATION CONTROL OF AN ENZYME REACTION.** Poly(styrene) microcapsules, prepared by depositing the polymer around emulsified aqueous droplets, were coated with a synthesized polyelectrolyte; i.e., copolymer of maleic acid (MA) with methyl vinyl ether (MVE), copoly (MA,MVE), or with styrene (St), copoly (MA,St). The permeability of the capsule membrane was investigated under various pHs of the outer medium using n-propyl alcohol as a permeant. It became apparent that either copoly (MA,St)-or copoly (MA, MVE)-coated microcapsules function as a pH-sensitive capsule. In particular, the former showed a dramatic change of the permeability in response to small differences in pH (5-6). By reference to the viscometric and electrophoretic studies of both copolymers, these were interpreted as being due to a pH-induced alteration of the configuration of the copolymer coating on the surface of the capsule membrane. When sucrose was hydrolyzed in an aqueous suspension of the copoly (MA,St)-coated



capsules into which invertase was loaded, the hydrolytic reaction was initiated at pH 5.5 and stopped at pH 4.5. Such initiation cessation control was repeated reversibly without damaging the capsules. (Author abstract). 12 Refs.

Kokufuta, Etsuo (Univ of Tsukuba, Sakura-mura, Jpn); Shimizuk, Noboru; Nakamura, Isei. *Biotechnol Bioeng* v 32 n 3 Jul 20 1988 p 289-294.

## Fatigue

**083520 EFFECT OF DEFORMATION RATIO ON FIBRIL DEFORMATION IN FATIGUE OF POLYSTYRENE.** Small-angle X-ray scattering has been used to measure the deformation of craze fibrils during mechanical fatigue of polystyrene. The maximum deformation of the sample in the fatigue cycle was kept constant while the minimum deformation was varied. When the minimum deformation was 50% or more of the maximum, the load on the craze fibrils remained tensile. When the minimum deformation was reduced below this, the load on the fibrils became compressive and they buckled. The main effect of minimum sample deformation on fatigue life occurred in the regime where the fibrils remained straight. In this regime a decrease in minimum sample deformation caused a considerable decrease in fatigue life. At low minimum sample deformations the effects of minimum deformation on fatigue life were not large. These effects probably stem from the fibril strains involved in the deformation processes. (Author abstract) 7 refs.

Brown, Hugh R. (IBM, San Jose, CA, USA); Kramer, Edward J.; Bubeck, Robert A. *J Mater Sci* v 23 n 1 Jan 1988 p 248-252.

**Fillers** See Also PLASTICS—Mechanical Properties.

**083521 ELECTRICAL CONDUCTIVITY OF POLYMERS CONTAINING CARBON BLACK.** Changes in volume resistivity with temperature of carbon-black-filled polymers and a random copolymer of styrene and butyl methacrylate were measured. Decreases in resistivity on increasing the temperature in the quiescent state are correlated with the observation of a yield stress at low shear rates in rheological studies. It is suggested that carbon black agglomerates at elevated temperature and forms an independent conductive network that prevents flow. (Edited author abstract) 20 refs.

Ghofraniha, Mehrdad (Univ of Southern California, Los Angeles, CA, USA); Salovey, R. *Polym Eng Sci* v 28 n 1 Mid-Jan 1988 p 58-63.

**083522 POLYSTYRENE-TITANIA COMPOSITE AS A DIELECTRIC MATERIAL.** Ambient dielectric effects have been studied in rutile-polystyrene compacts as functions of frequency and composition to explore the possibility of their use as electronic materials and characterize them on the basis of existing theories. The systems reveal marked departures from the law of physical mixtures. The dielectric constant  $\epsilon'$  and loss  $\epsilon''$  increase with increasing titania content at each frequency; both parameters decrease with increasing frequency; both parameters decrease with increasing frequency. The extent of interfacial polarization is substantially augmented as the frequency is reduced. Heterodispersity evidenced from compact densities is a maximum at around 60 wt% titania where the dissimilar particles fit most loosely into one another forming fairly porous matrices. (Edited author abstract) 11 refs.

Khastgir, D. (Indian Inst of Technology, Kharagapur, India); Maiti, H.S.; Bandyopadhyay, P.C. *Mater Sci Eng* v 100 Apr 1988 p 245-253.

## Film

**083523 XPS ANALYSIS OF NH<sub>3</sub> PLASMA-TREATED POLYSTYRENE FILMS UTILIZING GAS PHASE CHEMICAL MODIFICATION.** Gas phase chemical modification (GCM) is found to be more preferable as a pretreatment for the XPS surface analysis of polymer materials than the conventional liquid phase

treatment because it can circumvent problems such as solvent contamination and swelling. The authors have tried the quantification of the surface composition successfully by estimating the yield of the reaction from model samples. GCM was then applied to correlate the surface composition of NH<sub>3</sub> plasma-treated polystyrene films with their cell-affinity. The amount of primary-amine and that of carboxylic acid were directly determined by GCM. (Edited author abstract) 12 refs.

Nakayama, Youichi (Toray Research Cent Inc, Otsu, Jpn); Takahagi, Takayuki; Soeda, Fusami; Hatada, Kenji; Nagaoka, Shoji; Suzuki, Jirou; Ishitani, Akira. *J Polym Sci Part A* v 26 n 2 Feb 1988 p 559-572.

## Flame Resistance

**083524 TOXICITY STUDIES CLEAR THE AIR FOR BROMINATED FRs.** The combustion products from a widely used flame-retardant plastic present no measurable health hazards from dioxins or furans, according to a just-released toxicity study. These findings were based on animal studies by an independent laboratory, using burn residues of FR high impact polystyrene (HIPS). The impact styrene is virtually the standard plastic for TV cabinets and a major user of decabromo diphenyl oxide (DBDPO). The work on FR-HIPS is the first phase of an industry-sponsored program to address allegations that plastics from FR systems based on polybrominated diphenyl oxides could generate toxicologically significant amounts of dioxins and furans when burned.

Miller, Bernie (Plastics World, Newton, MA, USA). *Plast World* v 45 n 12 Nov 1987 p 72-73.

**Flammability** See Also FLAME RETARDANTS—Thermal Effects.

**083525 HORLAVOST SAMOZHASIVEHO PENOVEHO POLYSTYRENU V ZAVISLOSTI NA ZBYTKOVEM NADOUVADLE.** [Flammability of Self-Extinguishing Polystyrene as a Function of Residual Blowing Agent.]. Effect of the blowing agent contained in self-extinguishing polystyrene foam on flammability of this cellular material is examined. The flammability is evaluated according to Czechoslovak Standard CSN 64 5464. The maximum permissible concentration of the residual blowing agent in the self-extinguishing polystyrene foam is established. Furthermore, effect of various factors on the time required for the blowing agent to exude from polystyrene foam molding below the permissible level is verified and discussed. (Author abstract). 4 Refs. In Czech.

Zavodska, Vera (Chemopetrol, Czech); Culkova, Astrid. *Plasty Kauc* v 25 n 6 Jun 1988 p 165-169.

## Forming

**083526 MECHANISM OF FORMATION AND PROPERTIES OF POLYTRICHLOROBUTADIENE-POLYSTYRENE PAIRED POLYMERS AT HIGH CONVERSION.** At advanced stages of the synthesis of paired polymers of poly-1,1,2-trichlorobutadiene-1,3 with polystyrene (PS) under the conditions of a Friedel-Crafts reaction, the unequal macromolecular coils already paired at earlier reaction stages further react by means of the fragments that have so far been unaffected by the reaction. Hardly soluble or insoluble paired polymers are formed in this process. In parallel with the Friedel-Crafts reaction, dehydrochlorination of the polytrichlorobutadiene component of the paired macromolecules occurs at advanced reaction stages, although it is partly inhibited by the main reaction. (Edited author abstract) 11 refs.

Korshak, V.V. (USSR Acad of Sciences, USSR); Vointseva, I.I.; Suprun, A.P.; Askadskii, A.A.; Slonimskii, G.L. *Polym Sci USSR* v 29 n 1 Jan 1988 p 158-165.

**Fractionation** See LATEXES—Fractionation.

## Fracture

**083527 CURVILINEAR CRACK LAYER PROPAGATION.** This letter describes an experiment designed to observe the effect of damage orientation on the direction of crack growth. The phenomenon reported emphasizes the influence of the stress heterogeneity on the crack-layer behavior. It also emphasizes the effects of damage on crack advance. In this experiment authors also presented a methodology to study curvilinear crack-layer propagation. Within the framework of the crack-layer formalism, the study of this phenomenon unveils new potentials for material-toughness evaluation. 10 refs.

Chudnovsky, Alexander (Case Western Reserve Univ, Cleveland, OH, USA); Chaoui, Kamel; Moet, Abdelsamie. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1033-1038.

## Grafting

**083528 ANIONIC GRAFTING OF POLYSTYRENE FROM CARBON BLACKS CATALYZED BY OLI GROUPS ON THE CARBON BLACK SURFACE IN THE PRESENCE OF CROWN ETHER.** Carbon black carrying OLI groups, which was prepared by the reaction of the oxygen-containing groups on the surface with n-butyllithium (BuLi), was unable to initiate anionic polymerization of styrene. However, anionic polymerization of styrene is initiated by OLI group on carbon black in the presence of a crown ether, such as 12-crown-4 and 18-crown-6. It was found that when carbon black was pretreated with excess BuLi, i.e., in the presence of free BuLi, the grafting ratio decreased to less than 20% because the formation of ungrafted polystyrene by free BuLi occurs preferentially to the propagation from the OLI groups on carbon black. (Edited author abstract) 17 refs.

Tsubokawa, Norio (Niigata Univ, Ikarashi, Jpn). *J Macromol Sci Chem* v A24 n 7 1987 p 763-775.

**083529 ASYMMETRIC REDUCTIONS WITH POLYMER-SUPPORTED NADH MODELS.** Hantzsch esters have been chosen as models for the reducing coenzyme NADH. Chirality was introduced on the dihydropyridine ring with substituents derived from protected sugars. Chiral and non-chiral Hantzsch esters were grafted onto chloromethylated polystyrene and the reducing action of the polymers thus obtained was studied using prochiral ketones. The reduction by soluble models is catalyzed by magnesium, but the supported models exhibit a preferential solvation effect which hinders the action of the catalyst. The effects on reactivity and enantioselectivity are discussed. (Author abstract) 31 refs.

Zehani, Sadek (CNRS, Lyon, Fr); Gelbard, Georges. *React Polym Ion Exch Sorbents* v 6 n 2-3 Oct 1987, Sel Pap Presented at the 3rd Int Conf on Polym-Supported React in Org Chem, Jerusalem, Isr, Jul 6-11 1986 p 81-87.

## Halogenation

**083530 PLASMA FLUORINATION OF POLYSTYRENE.** ESCA and contact-angle measurements were used to characterize the surfaces of polystyrene films exposed to SF<sub>6</sub>, CF<sub>4</sub>, and C<sub>2</sub>F<sub>6</sub> plasmas. SF<sub>6</sub> plasmas cause loss of aromaticity in the polystyrene surface region via saturation of the phenyl ring and/or carbon-carbon bond breakage and subsequent fluorination. C<sub>2</sub>F<sub>6</sub> plasmas graft CF<sub>x</sub> radicals directly to the polystyrene surface without necessarily destroying the aromaticity of the polymer. CF<sub>4</sub> plasmas appear to be intermediate in character between SF<sub>6</sub> and C<sub>2</sub>F<sub>6</sub> plasmas. (Author abstract) 7 refs.

Strobel, Mark (3M Co, St. Paul, MN, USA); Thomas, Patrick A.; Lyons, Christopher S. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3343-3348.



**083531 PREPARATION AND APPLICATION OF THE POLYMER-BOUND IODOXY FUNCTIONAL GROUP.** Poly(iodostyrene) was prepared at 90% functionalization by reaction of mercuric trifluoroacetate with 2% crosslinked polystyrene beads followed by treatment of the mercurated resin with one equivalent of iodine in refluxing THF. The iodated polymer yielded a polymeric reagent with 65% of the theoretical activity of poly(iodostyrene) upon reaction with three equivalents of peracetic acid. The activated reagent can be used for the oxidation of aromatic hydrocarbons to quinones, aromatic acetylenes to dicarbonyls, and sulfides to sulfoxides in fair to good yields. The major advantage of the polymeric reagent is that the spent reagent can be removed from the reaction medium by filtration. (Author abstract) 18 refs.

Stevenson, Thomas A. (Miami Univ, Oxford, OH, USA); Taylor, Richard T. *React Polym Ion Exch Sorbents* v 8 n 1 Feb 1988 p 7-15.

## Injection Molding

**083532 MATHEMATICAL MODELING OF THE PACKING AND COOLING STAGES FOR AN INJECTION MOLDING PROCESS.** The behavior of PS in disk and strip-shaped cavities during the packing and cooling stages for an injection molding process is studied by means of the finite difference method. Simulated results reveal that the model used in the present study for the packing stage can avoid the conflicting phenomena which appeared in T.S. Chung's model for one-dimensional flow. The results obtained by the two-stage model proposed in the present study for packing and cooling stages are better than that obtained by the unified model reported in the literature. It is also shown that the effects of shear rate and pressure on the melt viscosity during packing stage may not be neglected. (Edited author abstract) 19 refs.

Shu-Jen, Lee (Nat'l Taiwan Inst of Technology, Taipei, Taiwan); Tseng, Hsieng-Cheng. *J Chin Inst Chem Eng* v 19 n 2 Mar 1988 p 63-71.

**Latex.** See Also LATEXES—Stabilizers; POLYMERS—Adsorption.

**083533 MICROSCOPIC OBSERVATION OF ORDERED COLLOIDS IN SEDIMENTATION EQUILIBRIUM AND THE IMPORTANT ROLE OF DEBYE SCREENING LENGTH. 3. HEAVY AND MONODISPERSE POLYSTYRENE TYPE SPHERES IN AQUEOUS SOLUTION OF NEUTRAL POLYMERS.** The ordered structures are observed directly by the metallurgical microscope for the heavy (specific gravity=1.50) and monodisperse type spheres in sedimentation equilibrium and in the presence of neutral polymers, polyvinylalcohol (PVA), polyethylene glycol (PEG), polyvinylpyrrolidone (PVP), hydroxypropylcellulose (HPC), and polyacrylamide (PAA<sub>m</sub>). The intersphere distances in the ordered lattices decrease by the addition of neutral polymer in the order, PVA < PEG < PVP < HPC < PAA<sub>m</sub>. These effects of neutral polymers are reasonably well-explained by the intersphere repulsion from the electrical double layer interaction, which is influenced by the polymer adsorption on the latex surface by the hydrophobic and/or dipole-dipole interactions. (Author abstract) 43 refs.

Okubo, T. *Colloid Polym Sci* v 265 n 7 Jul 1987 p 597-603.

**083534 NONIONIC LATICES IN AQUEOUS MEDIA - PART I. PREPARATION AND CHARACTERIZATION OF POLYSTYRENE LATICES.** A series of non-ionic polystyrene latices in aqueous media containing particles with a narrow size distribution have been prepared using a nonyl phenol poly(ethylene glycol) condensate as the surfactant, methoxy poly(ethylene glycol) methacrylate as the comonomer/stabilizer, and ascorbic acid/hydrogen peroxide as the initiator system. As a control synthesis for comparison with the above latex, a charge stabilized polystyrene latex was prepared, using an anionic surfactant and potassium persulfate as the initiator. Latices employing a combination of charge plus steric stabilization mechanisms were also prepared, in

order to investigate the effect of the non-ionic surfactant and the comonomer/stabilizer. The particle size of the latices was measured by transmission electron microscopy, the surface charge density by conductimetric titration and the glass transition temperature of the polymer by differential scanning calorimetry. (Edited author abstract) 21 refs.

Ottewill, R.H. (Univ of Bristol, Bristol, Engl); Satgurunathan, R. *Colloid Polym Sci* v 265 n 9 Sep 1987 p 845-853.

**083535 POLYSTYRENE AND POLYSTYRENE-BUTADIENE LATEXES STABILIZED BY POLY(N-ISOPROPYLACRYLAMIDE).** Latexes stabilized by poly(N-isopropylacrylamide) (polyNIPAM) were presented by polymerizing NIPAM in the presence of polystyrene and polystyrene-butadiene latex or by styrene emulsion polymerization in the presence of NIPAM. In 0.01 M CaCl<sub>2</sub>, polyNIPAM stabilized latexes exhibited critical flocculation temperatures in the range 32-35°C, which is approximately equal to the lower critical solution temperature of polyNIPAM in water. Partial substitution of NIPAM with some acrylamide (AM) gave higher flocculation temperatures. Coagulation studies with cleaned latex indicated that the polyNIPAM or polyNIPAM-co-AM polymer chains were anchored to the latex particle surfaces. (Author abstract) 14 refs.

Pelton, R.H. (Pulp & Paper Research Inst of Canada, Pointe Claire, Que, Can). *J Polym Sci Part A* v 26 n 1 Jan 1988 p 9-18.

**083536 EFFECT OF pH ON EMULSION POLYMERIZATION OF STYRENE IN THE PRESENCE OF AN AMPHOTERIC EMULSIFIER.** An emulsion polymerization of styrene in the presence of an amphoteric emulsifier of the betaine type; N,N-dimethyl-N-lauryl-betaine (LNB), has been studied at various pH values. The relationships between the physicochemical properties of LNB aqueous solutions, the emulsion polymerization process and the characteristics of the synthesized latex particles were studied under various pH conditions. The polymerization rate and the particle number concentration decreased with increasing pH of LNB aqueous solution and changed in shape at both ca. pH 4 and pH 8-10. The properties of LNB aqueous solution also changed with the pH and changed in shape at the same pH as that of the emulsion polymerization. These pH values were in good agreement with the pH at which the LNB molecule changed its ionic form. The number of synthesized latex particles was proportional to the number of LNB micelles in the solution, below pH 10. The particle size of the synthesized latex particles and the molecular weight of the latex polymers also changed with the properties of LNB aqueous solutions, accompanying the change of the ionic form of LNB molecules. (Author abstract) 19 refs.

Kato, K. (Science Univ of Tokyo, Tokyo, Jpn); Kondo, H.; Takeda, M.; Esumi, K.; Meguro, K. *Colloid Polym Sci* v 265 n 11 Nov 1987 p 950-956.

**083537 REVERSIBLE AGGREGATION: PART I. REVERSIBLE FLOCCULATION MONITORED BY TURBIDITY MEASUREMENTS.** The aggregation of four separate polystyrene latices, ranging in diameter from 210 nm to ca. 1 µm, using sodium chloride and magnesium sulphate as the electrolytes, has been examined turbidimetrically. The reversibility of the aggregation was examined using a dialysis technique. It was found that for large particle size latices aggregation was reversible in sodium chloride even at concentrations up to 0.5 mol dm<sup>-3</sup>. The aggregation of smaller particles was not reversible. The aggregation of large particles in magnesium sulphate solutions was not readily reversed by dialysis. The latter result does not appear to agree with theoretical predictions. (Author abstract) 17 refs.

Jeffrey, G.C. (BP Research Cent, Sunbury-on-Thames, Engl); Ottewill, R.H. *Colloid Polym Sci* v 266 n 2 Feb 1988 p 173-179.

**083538 NARROW SIZE DISTRIBUTION POLYSTYRENE LATEXES PREPARED IN THE PRESENCE OF AMPHOTERIC SULFOBETAINE SURFACTANTS.** Polystyrene latexes with a narrow size distribution were prepared with a large range of particle sizes (from 40 to 800 nm) in the presence of various amphoteric sulfo betaine surfactants. The influence of the nature of the surfactant and of the ionic strength, the pH and solid content were studied. The results are discussed and compared with those obtained using sodium dodecyl sulfate or in the absence of surfactants. (Author abstract) 20 refs.

Essadam, H. (CNRS, Lyon-Vernaison, Fr); Pichot, C.; Guyot, A. *Colloid Polym Sci* v 266 n 5 May 1988 p 462-469.

**083539 DIFFUSIOPHORESIS OF LATEX PARTICLES IN ELECTROLYTE GRADIENTS.** Transport rates of 0.1-µm diameter polystyrene latex spheres through porous membranes separating aqueous solutions differing in electrolyte concentration were measured to determine the diffusioelectric velocities of the particles. Two types of experiments were performed. In the first the initial particle concentration was the same on both sides of the membrane; after an electrolyte concentration difference was created, the accumulation of particles on one side and the depletion on the other side were measured as a function of time. These experiments convincingly demonstrate the phenomenon of diffusioelectricity because there is no other obvious explanation for the creation of a particle gradient from a system initially uniform in particle concentration. In the second type of experiment particles were placed only on one side of the membrane, and the electrolyte gradient was established such that it augmented the particle transport rate down the particle concentration gradient. Enhancements of 50 times Brownian diffusion of the particles were observed when there was a 70% change in electrolyte concentration across the membrane. (Edited author abstract) 39 refs.

Ebel, J.P. (Carnegie Mellon Univ, Pittsburgh, PA, USA); Anderson, J.L.; Prieve, D.C. *Langmuir* v 4 n 2 Mar-Apr 1988, Mol Process at Solid Surf: Spectrosc of Intermed and Adsorbate Interact, Denver, CO, USA, Apr 6-8, 1987 p 396-406.

## Manufacture

**083540 POLYSTYRENE AND STYRENE COPOLYMERS. I. THEIR MANUFACTURE AND APPLICATION.** The manufacturing processes for polystyrene (PS) and its copolymers, including styrene-acrylonitrile (SAN), high impact polystyrene (HIPS), acrylonitrile-butadiene-styrene (ABS), styrene-butadiene latex (SBR for coatings), styrene-butadiene block copolymers (SBS), and styrene-acrylate copolymers (SMMA), are discussed and illustrated. The synthetic methods for such products are bulk, emulsion, suspension, and free radical polymerization techniques, all either in batch or in continuous operations. By comparison, it was found that continuous bulk is the most economical process among the above-mentioned polymerization methods. However, the suspension method is still the only way to make expandable polystyrene beads (EPS). (Edited author abstract) 17 refs.

Ku, Ping L. (PLK Consultant, Chester, VA, USA). *Adv Polym Technol* v 8 n 2 Summer 1988 p 177-196.

**083541 POLYSTYRENE AND STYRENE COPOLYMERS: THEIR MANUFACTURE AND APPLICATION. II.** Three decades ago, practically all polystyrene and its derived copolymers (except SBR rubber) were manufactured via suspension polymerization, due to the fact that its capital expenditure was low. In recent years, the labor costs have soared. In order to be competitive, the industry had to develop an alternative cheaper process to remain solvent. The most successful new low-cost process is bulk continuous polymerization. Therefore, most processes for manufacturing the polystyrene and its allied copolymers discussed in this study emphasized the utilization of the bulk continuous process. Some of the topics discussed include high-impact polysty-



rene manufacture, raw materials, procedures, processing conditions, and properties of polystyrene products. Acrylonitrile-butadiene-styrene terpolymer is also covered. 21 Refs.

Ku, Ping L. (PLK Consultant, Chester, VA, USA). *Adv Polym Technol* v 8 n 3 Fall 1988 p 201-223.

**Measurements** See POLYACRYLONITRILE—Mixing.

**Mechanical Properties** See POLYMERS—Blending.

**Modification** See POLYMERS—Chemical Reactions; STYRENE—Copolymerization.

## Molecular Structure

**083542 POLYSTYRENES WITH STRUCTURALLY DIFFERENT OLIGOSILOXANES AS p-SUBSTITUENTS FOR OXYGEN PERMEABLE MEMBRANE MATERIALS.** Polystyrenes with structurally different oligosiloxanes as p-substituents were synthesized and the selective oxygen permeation through the polymer film was studied. It was found that the structure of the p-oligosiloxane substituents had great effects not only on the glass transition temperature of the polymer but also on the oxygen permeation behavior through the polymer film. Trimethylsiloxy groups, especially, were shown to play an essential role in enhancing the permeability. (Author abstract) 9 refs.

Kawakami, Yuhsuke (Nagoya Univ, Nagoya, Jpn); Kamiya, Hiroki; Toda, Hiroshi; Yamashita, Yuya. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3191-3204.

**083543 APPLICATION OF AN i.r. COMPENSATION TECHNIQUE FOR STUDYING THE COMPOSITION AND STRUCTURE OF HIGH IMPACT POLYSTYRENE.** The composition and structure of high-impact polystyrene (HIPS) were studied by an i.r. compensation technique in the 500-1100/cm spectral range. The rubber type can be directly identified in HIPS commercial specimens by determining the rubber double bonds (cis, trans and vinyl). Some conclusions on the polymerization mechanism are drawn. (Author abstract) 8 refs.

Kostov, G. (Research Inst of SC 'Neftochim', Bourgas, Bulg); Bakalova, Z.; Mihailova, M.; Jordanov, B. *Eur Polym J* v 23 n 10 1987 p 753-755.

**Molecular Weight** See Also POLYMERS—Viscosity; STYRENE—Polymerization.

**083544 MULTIPLE GLASS TRANSITIONS IN BIMODAL POLYSTYRENE MIXTURES.** Monomers and oligomers are in general compatible with their polymer above the melting point of the polymer. When crystallization can be avoided, this type of mixture should produce an amorphous compatible blend with a single glass transition temperature. However, mixtures of bimodal molecular weight distribution of sufficiently high molecular weight differences may easily be thermally treated to show either a single glass transition temperature or multiple glass transition temperatures, as a consequence of non-uniform distribution of relaxation times, which may result from a separation into concentration or density domains. (Author abstract) 7 refs.

Chang, Shu-Sing (NBS, Gaithersburg, MD, USA). *Polym Commun (Guildford Engl)* v 29 n 2 Feb 1988 p 33-35.

**083545 DIMENSIONS OF ULTRAHIGH MOLECULAR WEIGHT POLYSTYRENE IN CYCLOHEXANE BELOW THE  $\Theta$  TEMPERATURE.** In this work, we investigated the temperature dependence of dimensions of a very high molecular weight ( $M_w$  to approx.  $41 \times 10^6$  g/mol) PS sample in cyclohexane below the  $\Theta$  temperature by means of laser light scattering. Experimental results show that (1) degradation of very long polymer chains occurs readily at very dilute polymer concentrations ( $C \leq 10^{-6}$  g/g) for our high molecular weight PS sample. (2) In coil-to-globule transition studies, the polydispersity effect becomes a critical issue. As it is difficult to prepare ultrahigh molecular weight PS samples

with a very narrow molecular weight distribution, the advantage of this ultrahigh molecular weight PS sample was overshadowed by its unexpectedly broad polydispersity. 16 refs.

Park, Il Hyun (State Univ of New York at Stony Brook, Stony Brook, NY, USA); Fetters, Lewis; Chu, Benjamin. *Macromolecules* v 21 n 4 Apr 1988 p 1178-1180.

**083546 MOLECULAR WEIGHT EFFECTS IN THE RELAXATION OF ORIENTATION OF POLYSTYRENE CHAINS AS REVEALED BY INFRARED DICHROISM.** The relaxation of orientation of narrow distribution polystyrenes of different molecular weights is studied over 4 decades of time by infrared dichroism and compared to the predictions of the Doi-Edwards and related models. The behavior at short times appears to be independent of the molecular weight, whereas molecular weight effects at longer time are observed, as predicted by the theory. A careful comparison between theory and experiment shows that the kinetics of the relaxation at short times are slower than predicted by the model. The experimental behavior at longer times is in good agreement, especially for the highest molecular weights, with the predictions of a self-consistent treatment including a process of equilibration across slip-links. (Author abstract) 34 refs.

Tassin, Jean Francois (Ecole Supérieure de Physique et de Chimie de Paris, Paris, Fr); Monnerie, Lucien. *Macromolecules* v 21 n 6 Jun 1988 p 1846-1854.

**Optical Properties** See PLASTICS FILMS—Optical Properties.

## Oxidation

**083547 KINETICS AND MECHANISM OF THE FORMATION AND BREAKDOWN OF THE HYDROPEROXIDE IN THE COURSE OF OXIDATION OF POLYSTYRENE.** It is shown that the effective breakdown constant  $k_{3,eff}$  of the PS hydroperoxide (ROOH) measured from the ratio of the steady rate of oxidation to  $[ROOH]_{st}$  and kinetics of accumulation of ROOH rises with increase in the oxygen pressure. Breakdown of ROOH PS in vacuo takes place as a set of two monomolecular reactions with rate constants differing by a decimal order of magnitude. The fraction of the rapidly decaying hydroperoxide rises linearly with increase in the total concentration of ROOH. The authors postulate rapid breakdown of the polyfunctional polymer ROOHs, the rate of formation of which is proportional to  $[ROOH]$ . The kinetic scheme on the basis of this assumption quantitatively describes the experimental findings. (Author abstract) 13 refs.

Gol'dberg, V.M. (USSR Acad of Sciences, USSR); Yezinin, V.N.; Zaikov, G.Ye. *Polym Sci USSR* v 28 n 8 1986 p 1819-1825.

## Phase Diagrams

**083548 THERMOREVERSIBLE GELATION OF ISOTACTIC POLYSTYRENE: THERMODYNAMICS AND PHASE DIAGRAMS.** The thermodynamics of thermoreversible gelation of isotactic polystyrene in cis-decalin, trans-decalin, and 1-chlorodecane was investigated by using differential scanning calorimetry. The gel formation and the gel melting were studied as a function of various parameters such as the cooling or heating rate and the polymer molecular weight. The temperature-concentration phase diagrams were established from both cooling and heating experiments. It is found that the shape of the phase diagram is the same in heating or in cooling, but that for cis-decalin differs from the one for trans-decalin. (Edited author abstract) 18 refs.

Guenet, Jean-Michel (CNRS, Strasborug, Fr); McKenna, Gregory B. *Macromolecules* v 21 n 6 Jun 1988 p 1752-1756.

## Physical Properties

**083549 DYNAMIC LIGHT SCATTERING MEASUREMENTS ON THE POLYSTYRENE/ETHYL ACETATE SYSTEM AT SEMI-DILUTE CONCENTRATIONS AS A FUNCTION OF TEMPERATURE.** Measurements of autocorrelation functions extending over a broad time range are reported for a sample of polystyrene in ethyl acetate as a function of temperature between  $-44^\circ\text{C}$  and  $70^\circ\text{C}$ . The corresponding spectra of decay times are obtained by two mathematical methods. The existence of three dynamic processes is shown and their temperature and angular behaviour are studied. (Edited author abstract) 20 refs.

Stepanek, Petr; Jakes, Jaromir; Konak, Cesmir; Johnsen, Robert; Brown, Wyn. *Polym Bull (Berlin)* v 18 n 2 Aug 1987 p 161-167.

**083550 DIELECTRIC AND MECHANICAL RELAXATION TIMES OF A POLYMER USING INTERMOLECULAR FORCES.** Expressions are derived for the dielectric and mechanical base relaxation times of a polymer above its glass transition temperature. Coupled oscillator theory is invoked to show that a low-frequency dielectric relaxation should have a relaxation time proportional to the degree of polymerization, N. A damped linear array is used to calculate the base mechanical relaxation time,  $\tau_p$ . The principles of intermolecular forces and dielectric energy dissipation are taken from previous work of the author in order to model the frictional drag and elastic constants required by the equation of motion of the damped linear array. (Edited author abstract) 9 refs.

Porter, D. (Dow Chemical, Terneuzen, Neth). *Polymer* v 29 n 3 Mar 1988 p 541-544.

**083551 SITE-SPECIFIC LABELING AND THE DISTRIBUTION OF FREE VOLUME IN GLASSY POLYSTYRENE.** Free volume environments at different sites along the polystyrene molecule have been evaluated by site-specific labeling with azobenzene chromophores. The sites investigated are the regions around the chain ends, the chain sides, and the chain centers along the backbone. Also investigated was the free volume of the least constrained regions between the chains by the use of free probes not attached to the polymer molecule. Trans  $\rightarrow$  cis photoisomerization kinetics of the labels and the free probe were studied at 70, 80, and  $90^\circ\text{C}$  as a function of annealing time following cooling from the melt. (Edited author abstract) 35 refs.

Yu, Wei-Ching (Univ of Connecticut, Storrs, CT, USA); Sung, Chong Sook Paik; Robertson, Richard E. *Macromolecules* v 21 n 2 Feb 1988 p 355-364.

## Polymerization

**083552 QUANTITATIVE RELATIONSHIPS OF GRAFT POLYMERIZATION OF POLYSTYRENE AND STYRENE-DIVINYLBENZENE COPOLYMER ON POLYPROPYLENE FIBERS.** The purpose of this work was to study the quantitative relationships of polystyrene grafting on polypropylene (PP) fibers, using a direct method for generation of radicals. It is shown that the direct radiation method for grafting styrene from solutions in methyl alcohol is highly effective when small amounts ( $\geq 0.1\%$ ) of divinylbenzene are introduced into the styrene. Polypropylene fibers with grafted styrene-divinylbenzene copolymer can be used for production of strongly basic and strongly acidic ion-exchange fibers having high exchange capacity and chemical stability and satisfactory mechanical properties. 10 refs.

Shunkovich, A.A.; Popova, O.P.; Belotserkovskaya, T.N.; Soldatov, V.S. *J Appl Chem USSR* v 59 n 12 pt 2 Dec 1986 p 2476-2479.

## Porosity

**083553 FISHER-TROPSCH SYNTHESIS CATALYZED BY IRON CATALYST SUPPORTED ON POROUS POLYMERS. I. SYNTHESIS OF THE SUPPORTED CATALYST AND STUDY OF THE**



**REPARTITION OF THE CATALYST IN THE POLYMERIC SUPPORT.** Macroporous styrene-divinylbenzene and 4-vinylpyridine divinylbenzene polymers were used as supports for an iron Fischer-Tropsch catalyst. The catalyst was based on iron in the zero-valent state. Two methods of preparation were tested: reduction of the catalyst after or before introduction into the polymeric support. In both cases, the dispersion of the catalytic species in the polymeric support was determined by electron probe X-ray microanalysis. It was shown that reduction of the catalyst after diffusion into the polymeric support gives a homogeneous distribution of the catalyst in the beads, whereas the diffusion of already reduced catalyst into the support leads to a heterogeneous mixture of species. (Author abstract) 19 refs.

Carlu, Jean-Claude (CNRS, Villeneuve D'Ascq, Fr); Le Maguer, Didier; Caze, Claude; Petit, Francis. *React Polym Ion Exch Sorbents* v 8 n 2 Apr 1988 p 119-128.

## Processing

**083554 ANALYSIS OF THE PRE-FOAMING AND INTERMEDIATE STORAGE STAGES IN EPS PROCESSING.** Because of their special properties, foamed plastics made from expandable polystyrene (EPS) have for a long time been successfully used for thermal insulation and as cushioning material in packaging. During processing of the raw material (polystyrene with incorporated blowing agent) into ready-to-use products, the process stages pre-foaming and intermediate storage impart to the material the specific properties of density and suitability for subsequent processing. The analysis of these process stages is intended to contribute to the realization of automated fabrication of moulded parts at the point of requirement of the products to be packaged. (Author abstract) 7 refs. In German and English.

Hahn, O.; Austermeier, M. *Kunstst Ger Plast* v 77 n 9 Sep 1987 p 9-11.

**083555 CHLOROMETHYLATION OF POLYSTYRENES AND STYRENE COPOLYMERS. APPLICATIONS.** The authors study the chloromethylation of polystyrenes and their uses. It is shown that the partially chloromethylated polystyrenes are resistant to the flow of electrons (negative resists). This property is made use of in electronic lithography for microelectronics. This material gives good resolution, nearly of the order of a micron. Sensibility and resolution increase with increasing molecular weight but decrease with increasing polydispersity, which should be between 1.05 and 1.1 for the starting polystyrene. Chloromethylated polystyrenes are also utilized in soft X-ray resist. Chloromethylated polystyrene is also a starting polymer for visible light-sensitive recording material and UV lithography. 286 refs.

Camps, Marcel (Faculte des Sciences et Techniques, St-Etienne, Fr); Chatzopoulos, Michel; Camps, Jeanne-Marie; Montheard, Jean-Pierre. *J Macromol Sci Rev Macromol Chem Phys* v C27 n 3-4 1987-1988 p 505-557.

## Production

**083556 POLYSTYRENE (PS).** Demand for polystyrene in Western Europe has increased steadily since 1981 with an average growth rate of 3 to 4%. For 1987 the increase in demand will probably be 6 to 8% following a keen upturn in the tonnage produced. Over the medium term, annual growth is expected to be 1.5 to 2% on average. The product developments of West European polystyrene manufacturers over the past few years have focussed not so much on standard ranges but more on special-purpose products. These include products with flame retardant treatment, tough and stiff, high-gloss, impact-resistant polystyrenes and grades that are resistant to stress corrosion cracking. Added to these come more recent developments such as conductive, impact-resistant polystyrene, polystyrene/polyolefin blends and polystyrene-based sealable film. In the case of multilayer film with polystyrene as the carrier material, new combinations are constantly being developed for individual applications.

Jenne, H. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 23-26.

**Pyrolysis** See POLYMERS—Pyrolysis.

## Radiation Effects

**083557 CHAIN SCISSION OF POLYSTYRENE IN SOLUTION BY UV IRRADIATION AT HIGH TEMPERATURES.** Polystyrene dissolved in five different solvents such as benzene, cyclohexane, ethylbenzene, ethylcyclohexane, and decalin was irradiated by UV for eight hours in wide ranges of temperature from 20°C to their boiling points. Changes in the molecular weight, quantity of the carbonyl group formed, and gel contents as a result of irradiation were determined. The rate of main chain scission in all the solvents studied increases with increasing temperature until 100°C. It decreases with increasing temperatures above 100°C in ethylcyclohexane and decalin. The rate of chain scission depends on the quantity of the carbonyl group formed, and the main chain scission occurring via photooxidation. (Edited author abstract) 13 refs. In Japanese.

Ikada, Eiji (Kobe Univ, Kobe, Jpn); Takeuchi, Yasunori; Ashida, Michio. *Kobunshi Ronbunshu* v 45 n 4 1988 p 357-361.

## Reaction Kinetics

**083558 KINETICS OF THE UNFOLDING OF COLLAPSED POLYSTYRENE CHAINS ABOVE THE GLASS TRANSITION TEMPERATURE.** Monodisperse polystyrenes with three molecular weights were doubly labeled with phenanthrene and anthracene and dissolved with a large excess of unlabeled polystyrene in benzene keeping the polymer concentration below the critical  $c^*$  value for chain overlap. After rapid freezing of the solution, the solvent was sublimed so that the individual chain molecules collapsed into compact globules. Pellets pressed from this material were heated above  $T_g$  and the expansion of the doubly labeled chains into the unlabeled matrix was monitored by the change in the emission spectrum due to a decreasing energy transfer from phenanthrene to anthracene with an increasing donor-acceptor separation. (Edited author abstract) 25 refs.

Liu, Chun-Yuan (Polytechnic Univ, Brooklyn, NY, USA); Morawetz, Herbert. *Macromolecules* v 21 n 2 Feb 1988 p 515-518.

## Recovery

**083559 MODEL RECOVERY PROCESS FOR SCRAP POLYSTYRENE FOAM BY MEANS OF SOLVENT SYSTEMS.** A solvent technique is studied for the recovery of polystyrene (PS) foam waste. The model process proposed ensures removal of any impurities present and comprises dissolution of the starting material, filtering, reprecipitation, thorough washing of the polymer grains obtained and drying. The solvent mixtures involved are separated by distillation for re-use, the following criteria are considered: (a) the rheological behavior of the PS solutions prepared, (b) the yield of the process of polymer of acceptable grain size and (c) sufficient solvent/non-solvent separation. On the basis of these criteria, methyl ethyl ketone/n-hexane or methanol and p-xylene/n-heptane are suggested as effective solvent/non-solvent systems. (Author abstract) 11 refs.

Kampouris, E.M. (Nat'l Technical Univ of Athens, Athens, Greece); Papaspyrides, C.D.; Lekakou, C.N. *Conserv Recycling* v 10 n 4 1987 p 315-319.

## Research

**083560 HYDRODYNAMIC RADIUS OF POLYSTYRENE IN n-BUTYL CHLORIDE.** The authors study the translational diffusion coefficients which have been determined with the extended Taylor dispersion technique for a series of polystyrene standards with peak molecular weight  $M$  from 503 to  $10^6$  g/mol in cyclohexane at the  $\Theta$  temperature of 308 K and in n-butyl chloride (a good solvent) at temperatures from 278 to 348 K. The

hydrodynamic radii  $R_h$  calculated from the measured values of translational diffusion coefficients in n-butyl chloride will be compared with those in cyclohexane at  $\Theta$  temperature to examine possible solvent effects. From the comparison of  $R_h$  values in n-butyl chloride and cyclohexane, we conclude that the excluded volume effect on  $R_h$  expected of a good solvent is not observed for polystyrene chains with molecular weights up to  $10^6$ . Higher molecular weight is required for the coil expansion due to excluded volume perturbation to be observed. 15 refs.

Maa, Y.F. (Univ of Rochester, Rochester, NY, USA); Chen, S.H. *Macromolecules* v 21 n 4 Apr 1988 p 1176-1177.

**083561 EFFECT OF COMPLEXING AGENTS ON THE RATE OF POLYMERIZATION IN SYSTEMS INVOLVING DORMANT AGGREGATED POLYMERS AND LIVING NONAGGREGATED POLYMERS.** Lithium salts of polystyrene or polydienes are aggregated in hydrocarbon solvents. The aggregates are inert and the polymerization is carried out by a minute amount of unassociated polymers which are in equilibrium with the aggregates. Various solvating agents may dissociate the aggregates by being complexed with the unassociated polymers. The resulting complexes have usually a 1:1 stoichiometry and contribute to propagation; however, their rate of growth is, on the whole, different from that of the unassociated polymers. It is found that initial addition of a complexing agent to a dimerically aggregated lithium polystyrene, or to another similarly aggregated living polymer, increases the rate of polymerization when the total concentration of polymers, in all its forms, exceeds  $(k_p/k_c) 2K_{diss}/8$  and decreases it when the inequality is reversed. 3 refs.

Fontanille, M. (CNRS, Villetaneuse, Fr); Helary, G.; Szwarc, M. *Macromolecules* v 21 n 5 May 1988 p 1532-1533.

**083562 FORCES BETWEEN SURFACES BEARING TERMINALLY-ANCHORED POLYMER CHAINS.** The forces have been measured between mica surfaces bearing terminally-anchored, non-adsorbing polymer chains in good solvents. In the first case PS was end-functionalized with a zwitterionic group. In the second case a block copolymer was used, containing a small number of polyethylene oxide monomers. Excellent quantitative agreement was found between the experimental results and the theoretical prediction for all molecular weights. This suggests that the scaling approach may indeed be a valuable tool in understanding the interactions between layers of terminally-anchored polymer chains in good solvent conditions. 7 refs.

Taunton, Hillary J. (Cavendish Lab, Cambridge, Engl); Toprakcioglu, Chris; Petters, Lewis J.; Klein, Jacob. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 151-155.

## Separation

**083563 PHASE SEPARATION OF OLIGOMERIC POLYSTYRENE-POLYBUTADIENE BLENDS AS STUDIED BY EXCIMER FLUORESCENCE.** The binodal curve and phase separation behavior of 826 MW polystyrene (PS)/2500 MW polybutadiene (PB) blends have been studied by optical density measurements and fluorescence spectroscopy, respectively. The equilibrium compositions from the binodal curve and the Gelles-Frank two-phase model, which relates the composition of phases generated during spinodal decomposition to the ratio of excimer to monomer fluorescence intensity,  $I_E/I_M$ , were used to follow the time-dependent compositions of the phases during phase separations as well as the kinetics of phase separation. For 30 wt% and 60 wt% PS blends quenched at 32°C, the change in  $I_E/I_M$  during phase separations was quite small, less than 10%, but nevertheless large enough to yield precise information. (Edited author abstract) 38 refs.

Tsai, Fu-Jya (Northwestern Univ, Evanston, IL, USA); Torkelson, John M. *Macromolecules* v 21 n 4 Apr 1988



p 1026-1033.

Solubility See Also POLYMERS—Solubility.

**083564 OZNACZANIE PARAMETRU ROZPUZCZALNOSCI POLYSTYRENU METODA POMIAROW CZASTEKOWEJ OBJETOŚCI WLASCIWEJ.** [Determination of the Solubility Parameter of Polystyrene by Partial Specific Volume Measurements]. The solubility parameter ( $\delta$ ) of polystyrene has been determined by partial specific volume ( $V_2$ ) measurements in a series of solvents and mixtures of solvent and non-solvent of varying compositions. For both series the  $V_2$  values of polystyrene have been determined by the method of Heller based on the measurements of the specific refractive index increment. The following values have been obtained for  $\delta_p$ :  $19.6 \pm 1.5$  (J/ml)<sup>1/2</sup> at 25°C;  $19.6 \pm 1.5$  (J/ml)<sup>1/2</sup> at 25°C;  $19.6 \pm 1.5$  (J/ml)<sup>1/2</sup> at 25°C. (Author abstract) In Polish. 12 refs.

Mieczkowski, Ryszard (Uniwersytet Mikolaja Kopernika, Torun, Pol); Huppenthal, Leslaw. *Polimery* v 32 n 10 Oct 1987 p 397-400.

**Solutions** See Also IONOMERS—Solutions; POLY-METHYL METHACRYLATE—Sedimentation.

**083565 RELATIONSHIP OF INTRINSIC VISCOSITY OF POLYMER SOLUTIONS TO MOLECULAR WEIGHT.** An equation derived by C.C. Han relating intrinsic viscosity to molecular weight of a polymer has been fitted to experimental data over a range of molecular weight. Excellent fits were obtained although the Mark-Houwink equation did not fit the data over the complete molecular weight range. C.C. Han's equation may be fit to intrinsic viscosity data over a moderate range of molecular weight, and is shown to then accurately predict the intrinsic viscosities for molecular weights outside this range. A method is given to compute the two parameters of this equation from the Mark-Houwink parameters of a polymer in a solvent. (Edited author abstract) 13 refs.

McCrackin, Frank L. (NBS, Washington, DC, USA). *Polymer* v 28 n 11 Oct 1987 p 1847-1850.

**083566 LIGHT SCATTERING FOR POLYSTYRENE SOLUTIONS IN CYCLOPENTANE NEAR THE UPPER AND LOWER CRITICAL SOLUTION POINTS.** Thermostats were constructed for light scattering at high temperatures up to 200°C. The intensity and line width of scattered light were measured for polystyrene solutions in cyclopentane near the lower critical solution point. The measurements for the same system near the upper critical solution point were performed for comparison. The values of critical exponents  $\gamma$  and  $\nu$  were found to be  $\gamma_U = 1.16$  and  $\gamma_L = 0.59$  for the upper side, and  $\gamma_L = 1.15$  and  $\nu_L = 0.58$  for the lower side. The dependences of line width on the temperature and wave number on the lower side were almost the same as those on the upper side. (Edited author abstract). In Japanese. 19 refs.

Gemma, Tohru (Univ of Tokyo, Tokyo, Jpn); Ogino, Kazuyoshi. *Kobunshi Ronbunshu* v 44 n 8 Aug 1987 p 621-629.

**083567 QUANTITATIVE MODEL FOR THE FORMATION OF ADSORPTION-ENTANGLEMENT LAYERS.** The formation of thick adsorption-entanglement layers at foreign surfaces during the flow of high molecular weight polymer solutions is now well documented. This paper presents a quantitative model which describes the formation of such layers in terms of the polymer molecular weight and radius of gyration, the solution concentration and the local flow velocity. The model is tested against experiments using capillary flow and atactic polystyrene solutions. The agreement between theory and experiment is very good. (Author abstract) 5 refs.

Barham, P.J. (Univ of Bristol, Bristol, Engl). *Colloid Polym Sci* v 265 n 7 Jul 1987 p 584-591.

**083568 MONTE CARLO CALCULATIONS IN**

**COMPARISON TO NEUTRON SCATTERING STUDIES: 2. GLOBAL DIMENSIONS OF 12-ARM STARS.** Light and neutron scattering studies were carried out on 12-arm star polystyrene molecules in toluene (a good solvent) and in cyclohexane (a  $\theta$ -solvent). The polymers had a molecular weight range of  $5 \times 10^4 < M_w < 1.6 \times 10^6$ . The global dimensions of all samples under  $\theta$  conditions are larger than those predicted by the existing theories. Monte Carlo simulations of 12-arm star chains as a function of chain length were performed using Flory's rotational isomeric state model. Two different types of star chains, a pure combinatorial star and a star with a specific centre were used. These aided the interpretation of the experimental results. (Author abstract) 33 refs.

Huber, Klaus (Univ of Freiburg, Freiburg, West Ger); Burchard, Walther; Bantle, Siegfried; Fetters, Lewis J. *Polymer* v 28 n 12 Nov 1987 p 1990-1996.

**083569 MONTE CARLO CALCULATIONS IN COMPARISON TO NEUTRON SCATTERING STUDIES: 3. ON THE STRUCTURE OF 12-ARM STAR MOLECULES.** The small-angle neutron scattering curves of polystyrene 12-arm star molecules exhibit deviations from the Gaussian star model according to Benoit. These deviations are comparable with those observed in the scattering curves of simulated polymethylene 12-arm star chains. They can be partially interpreted in terms of chain stiffness within the arms. If the simulated chains contain a specific star centre, their scattering curves, normalized by the radius of gyration, are in good agreement with the normalized experimental scattering curves. For very short arms the scattering curves of the simulated chains with a specific star centre approach the particle scattering factor of the rod-like star model. (Author abstract) 13 refs.

Huber, Klaus (Univ of Freiburg, Freiburg, West Ger); Burchard, Walther; Bantle, Siegfried; Fetters, Lewis J. *Polymer* v 28 n 12 Nov 1987 p 1997-2003.

**083570 HIGH-PRESSURE SOLUTION BEHAVIOR OF THE POLYSTYRENE-TOLUENE-ETHANE SYSTEM.** The effect of supercritical ethane on the high-pressure phase behavior of the polystyrene-toluene system is experimentally investigated. Adding 17.8 wt.% ethane to the polystyrene-toluene solution lowers the temperature of the lower critical solution temperature (LCST) curve by 162°C, 22.5 wt.% lowers the temperature of the curve by 231°C, and with 24.9 wt.% the curve is shifted to such low temperatures that it merges with the upper critical solution temperature curve. In practice this means that polymer solutions can be separated at lower temperatures where thermal degradation of the polymer is less. (Edited author abstract) 28 refs.

Seckner, A.J. (Johns Hopkins Univ, Baltimore, MD, USA); McClellan, A.K.; McHugh, M.A. *AIChE J* v 34 n 1 Jan 1988 p 9-16.

**083571 CROSS-OVER CONCENTRATION IN POLYDISPERSE POLYMER SOLUTIONS.** Correlation length and osmotic compressibility of blends of narrow distribution polystyrenes in benzene solutions were measured by dilute and semidilute regimes. Universal curves were obtained for correlation length and osmotic compressibility. These curves were the same as those of monodisperse polystyrenes. The cross-over concentration of polydisperse systems could be calculated. (Edited author abstract) 5 refs.

Oyama, Tomoo (Kyushu Univ, Fukuoka, Jpn); Shikawa, Kohzoh; Maeda, Kouji. *Polym J* v 19 n 11 1987 p 1279-1283.

**083572 STRUCTURE AND THERMODYNAMICS OF POLYMER SOLUTIONS NEAR THE UPPER AND LOWER CONSOLUTE TEMPERATURES.** Phase equilibrium investigations have been carried out for solutions of polystyrene in cyclohexane, and for polyoxypropylene diol in water, hexane and octane, and temperature dependences of the light scattering, optical density and viscosity of the solutions have been determined. Association of macromolecules was detected in the vicinity

of temperatures for phase separation. These association processes have been compared with the thermodynamic criteria of upper and lower consolute temperatures. (Edited author abstract) 22 refs.

Vshivkov, S. (Gorkii State Univ of the Urals, USSR). *Polym Sci USSR* v 23 n 12 Dec 1987 p 2893-2899.

**083573 DETERMINATION OF STEREOCHEMICAL COMPOSITIONS OF OLIGOSTYRENES BY <sup>13</sup>C NMR.** Solution properties such as the mean-square radius of gyration and the mean-square optical anisotropy are affected by the stereochemical composition (expressed by the fraction  $P_r$  of racemic dyads) of atactic  $\alpha$ -hydro- $\omega$ -butylpolystyrenes. In order to determine  $P_r$ , we need the assignments of <sup>13</sup>C NMR spectra of the samples. In this report, we make assignments of spectra of the pentamer with the help of calculated chemical shifts obtained by taking quantitative account of the  $\gamma$  effect on the basis of the rotational isomeric state (RIS) model. The adequacy of the calculated values is verified for the case of the tetramer for which the assignments were made. With these assignments,  $P_r$  of the tetramer and pentamer are determined from measured <sup>13</sup>C NMR spectra of these samples. 11 refs.

Konishi, Toshiaki (Kyoto Univ, Kyoto, Jpn); Yoshizaki, Takenao; Yamakawa, Hiromi. *Polym J* v 20 n 2 1988 p 175-178.

**083574 KINETICS OF ION-PAIR INTERCHANGE IN IONOMER SOLUTION.** Solutions of polystyrene in which 3.4 and 6.9 mol% of the monomer residues were sulfonated were partially neutralized with 2-(aminomethyl)naphthalene and 9-(aminomethyl)anthracene, respectively. The solutions were mixed in a stopped-flow apparatus and the interchange of the two counterions was followed by the increase in the anthracene emission intensity, when the solution was irradiated in the naphthalene absorption band, due to an increasing efficiency of nonradiative energy transfer. The kinetics of the process were studied as a function of the polymer concentration in dioxane and a 1:1 mixture of dioxane and cyclohexane, as a function of the excess of unneutralized sulfonic acid groups, and as a function of temperature. (Author abstract) 13 refs.

Morawetz, Herbert (Polytechnic Univ, Brooklyn, NY, USA); Wang, Yongcai. *Macromolecules* v 21 n 1 Jan 1988 p 107-109.

**083575 DIELECTRIC CONSTANT NEAR THE LIQUID-LIQUID CRITICAL POINT FOR POLYSTYRENE IN DIETHYL MALONATE.** We have measured the dielectric constant as a function of temperature and frequency near the liquid-liquid critical point of a mixture of polystyrene (molecular weight  $1.02 \times 10^5$ ) in diethyl malonate at the critical composition. The range of the frequency was 20 kHz to 1 MHz. For the one-phase region above the critical point, the range of the temperature was  $1.1 \times 10^{-5} < t < 7.9 \times 10^{-2}$ . The dielectric constant in the one-phase region near the critical point shows an anomalous increase of about 0.3% above the 'background' behavior far from the critical point. (Edited author abstract) 53 refs.

Tveekrem, J.L. (Univ of Maryland at College Park, College Park, MD, USA); Greer, S.C.; Jacobs, D.T. *Macromolecules* v 21 n 1 Jan 1988 p 147-153.

**083576 MOLECULAR INTERACTIONS IN POLYSTYRENE COSOLVENT SYSTEMS.** Studied are miscible binary cosolvents for polystyrene, for which polystyrene is insoluble in either of the individual solvents. Polymer-solvent interactions in solutions of atactic polystyrene in acetone/diethyl ether and in methylcyclopentane (MCP)/acetone binary cosolvents have been investigated using nuclear magnetic resonance (NMR) spectroscopy. Polystyrene <sup>13</sup>C chemical shifts were measured as a function of miscible binary solvent compositions and temperature. The NMR data were used to calculate 'association constants' as a measure of specific interac-



tions of the solvent components with all sites on the polymer. In mixtures of acetone and diethyl ether, <sup>13</sup>C-NMR indicates a weak interaction between the polystyrene phenyl ring and the diethylether solvent component. In the polystyrene/MCP/acetone system, present NMR data reveal no preferential interactions. Additional NMR measurements were performed on polystyrene in mixtures of CCl<sub>4</sub>/acetone. From these results, it is concluded that although preferential polymer-solvent interactions are present in some cosolvent systems, they are not a prerequisite for such behavior. (Author abstract) 13 refs.

Parmer, Jerome F. (Univ of Massachusetts, Amherst, MA, USA); Porter, Roger S. *J Polym Sci Part B v 26 n 5 May 1988 p 981-988.*

**083577 DILUTE SOLUTION BEHAVIOR OF ASYMMETRIC THREE-ARM AND REGULAR THREE- AND TWELVE-ARM POLYSTYRENE STARS.** The dilute solution characteristics of regular three- and twelve-arm and asymmetric three-arm polystyrene stars have been studied under  $\Theta$  conditions (cyclohexane) and in a good solvent (toluene). The parameters evaluated include the intrinsic viscosities and for the regular stars the radii of gyration and the viscometric based radii. The twelve-arm stars show the influence of high segment densities near the star core under  $\Theta$  conditions; i.e.,  $g_{\Theta}$  decreases as arm molecular weight increases and approaches the random-walk prediction only at high-arm molecular weight. Additional parameters describing the regular and asymmetric star-shaped polymers are presented and discussed. (Author abstract) 72 refs.

Khasat, Nitya (Univ of Akron, Akron, OH, USA); Pennisi, Robert W.; Hadjichristidis, Nikos; Fetters, Lewis J. *Macromolecules v 21 n 4 Apr 1988 p 1100-1106.*

**083578 LIGHT SCATTERING STUDY OF IONOMERS IN SOLUTION. 2. LOW-ANGLE SCATTERING FROM SULFONATED POLYSTYRENE IONOMERS.** Low-angle light scattering studies were conducted for partially sulfonated polystyrene ionomers in a polar and a low-polarity solvent. In the low-polarity solvent tetrahydrofuran (THF), aggregation of ionomers due to the attraction of ion pairs was seen in changes of molecular weight and interaction parameter (second virial coefficient) with ion content. At high ion content, negative interaction parameters were observed. In the polar solvent dimethylformamide (DMF), typical polyelectrolyte behavior was observed in light scattering data. Effective diameters of macroions (ionomers) were used to discuss the effect of counterion and ion content on the structural change of ionomers. (Author abstract) 40 refs.

Hara, Masanori (Rutgers Univ, Piscataway, NJ, USA); Wu, Jhi-Li. *Macromolecules v 21 n 2 Feb 1988 p 402-407.*

**083579 COMPARISON OF CORRELATION LENGTHS IN SEMIDILUTE POLYSTYRENE SOLUTIONS IN GOOD SOLVENTS BY QUASI-ELASTIC LIGHT SCATTERING AND SMALL-ANGLE NEUTRON SCATTERING.** Quasi-elastic light scattering (QELS) and small-angle neutron scattering (SANS) experiments have been made on semidilute solutions of polystyrene (PS) in methylene chloride and tetrahydrofuran. The hydrodynamic screening length ( $\zeta_H$ ) from QELS and the excluded volume screening length ( $\zeta$ ) from SANS are found to be proportional at concentrations well above the dilute-semidilute crossover. The power law  $C^{-0.68}$  applies to the static quantity whereas this asymptotic exponent value is only found for  $\zeta_H$  with PS fractions of molecular weight  $M \geq 10^6$ . The dynamic length,  $\zeta_H$ , is solvent independent while the static length is shown to be significantly shorter in methylene chloride, a result which is possibly related to differing extents of coil interpenetration in these solvents. (Edited author abstract) 37 refs.

Brown, Wyn (Univ of Uppsala, Uppsala, Sweden); Mortensen, Kell. *Macromolecules v 21 n 2 Feb 1988 p 420-425.*

**083580 SMALL-ANGLE X-RAY SCATTERING FROM SEMIDILUTE POLYMER SOLUTIONS. DEUTERATED POLYSTYRENE-DEUTERATED**

**CYCLOHEXANE SYSTEM.** Binary ( $B_1$ ) and ternary ( $B_2$ ) cluster integrals of deuterated polystyrene in deuterated cyclohexane were determined by small-angle X-ray scattering from semidilute solutions. The results were compared with those previously determined for the undeuterated polystyrene-deuterated cyclohexane system and undeuterated polystyrene-undeuterated cyclohexane system. It was found that for all cases  $B_2$  was unaltered by deuterium substitution within the experimental accuracy and had the value  $0.8 \times 10^{-51} \text{ cm}^6$  almost independently of temperature, whereas  $B_1$  had the temperature dependence of the form  $B_1 = B_{10}(1 - \theta/T)$  near the  $\theta$  temperature, where temperature independent factor  $B_{10}$  was also unaffected by deuteration; the sole deuteration effect observed was a shift of  $\theta$  temperature at which  $B_1$  vanishes. (Author abstract) 10 refs.

Ichimura, Takashi (Nihon Univ, Tokyo, Jpn); Okano, Koji; Kurita, Kimio; Wada, Eiichi. *Polym J v 20 n 4 1988 p 333-336.*

**083581 POLYMER SCIENCE SELF-DIFFUSION OF POLYSTYRENE IN SOLUTION: 1. EXPERIMENTAL RESULTS OF THE NMR PULSED FIELD GRADIENT TECHNIQUE.** We report self-diffusion measurements for polystyrene dissolved in benzene and chloroform using the NMR pulsed field gradient technique. The observed echo attenuations point to dynamic exchange processes or cluster formation in the semidilute solution. The experimental results are compared with theoretical predictions from the reptation mechanism and the 'blob' theory. There is qualitative agreement, but a more comprehensive analysis of the data and results from experiments with polymer mixtures show that polymer self diffusion in semidilute solutions cannot be explained by the reptation mechanism in its simple form. (Author abstract) 28 refs.

Fleischer, G. (Karl-Marx-Univ Leipzig, Leipzig, East Germany); Zgadzai, O.E.; Skirda, V.D.; Maklakov, A.I. *Colloid Polym Sci v 266 n 3 Mar 1988 p 201-207.*

**083582 SELF-DIFFUSION OF POLYSTYRENE IN SOLUTION: 2. DISCUSSION OF EXPERIMENTAL RESULTS ON THE BASIS OF THE REPTATION MECHANISM AND ENTANGLEMENTS.** The expressions for polymer self-diffusion in semidilute solutions, theoretically derived from the reptation mechanism, the blob concept and scaling considerations, are discussed and compared against experimental data. In the nontangled (from viscoelastic data) semidilute solution, the experimentally observed concentration and molar mass exponents are in fair agreement with those derived theoretically. However, a quantitative estimation shows that the experiments cannot be explained by reptation. Experiments with polymer mixtures also give strong evidence against reptation. It is concluded, that in the nontangled semidilute solution, the polymer self-diffusion is more complicated than simple reptation. This is also supported by recently observed long-range density fluctuations or cluster formation in this concentration region. In the entangled semidilute solution, the self-diffusion data are in accordance with the reptation mechanism. (Edited author abstract) 42 refs.

Fleischer, G. (Karl-Marx-Univ Leipzig, Leipzig, East Germany); Zgadzai, O.E. *Colloid Polym Sci v 266 n 3 Mar 1988 p 208-215.*

**083583 DISTRIBUTION OF RELAXATION TIMES FROM DYNAMIC LIGHT SCATTERING ON SEMIDILUTE SOLUTIONS: POLYSTYRENE IN ETHYL ACETATE AS A FUNCTION OF TEMPERATURE FROM GOOD TO  $\Theta$  CONDITIONS.** Intensity correlation functions have been measured over widely spaced delay times, covering 6-8 decades, for polystyrene in semidilute solutions of ethyl acetate. The solvent quality was changed systematically by varying the temperature from +70 (moderately good) to -44°C ( $\Theta$  conditions). Measurements were performed as a function of both angle and concentration. Distributions of relaxation times were extracted from the correlation functions by inverse Laplace transformation. Three relaxational modes are established in the decay time spectrum. The fast

mode corresponds to network dynamics ( $K^2$  dependent), while the following tentative assignments of the slower modes are made: (a) middle mode, insufficiently resolved for characterization, possibly contaminated by another dynamical process; (b) slow mode ( $K^2$  dependent), characterizes the concentration fluctuations associated with the motions of clusters of chains. (Edited author abstract) 52 refs.

Brown, Wyn (Univ of Uppsala, Uppsala, Sweden); Stepanek, Petr. *Macromolecules v 21 n 6 Jun 1988 p 1791-1798.*

**083584 SEMIEMPIRICAL DETERMINATION OF SOLUTION STRUCTURE IN POLYMER SOLUTION BASED ON THE CLUSTERING THEORY. 2. NONCRITICAL AND CRITICAL REGIONS.** The solution structure of the polymer solutions polystyrene (PS)-cyclohexane and PS-methylcyclohexane, in both the noncritical and critical regions, has been determined by using the experimental data of the coexistence curves by Koningsveld et al. and by T. Dobashi et al. based on the clustering function of B.H. Zimm and of J.G. Kirkwood and R. Buff. The value of  $n$  in PS-cyclohexane and PS-methylcyclohexane determined in this work is about 0.84, while  $\beta_0$  is dependent on temperature and approaches 1.0 at the critical solution temperature,  $T_c$ , for the infinite molecular weight or  $\Theta$  temperature. (Edited author abstract) 42 refs.

Saeki, S. (Fukui Univ, Fukui, Jpn); Tsubokawa, M.; Yamaguchi, T. *Macromolecules v 21 n 7 Jul 1988 p 2210-2213.*

**083585 STRESS RELAXATION OF SEMIDILUTE POLYSTYRENE SOLUTIONS. A NEW OBSERVATION WITH  $\Theta$ -SOLVENT AND WITH BLENDS CONTAINING VERY SHORT CHAINS.** The authors investigated the effects of very short chains. They also performed measurements on a solution of polystyrene of high molecular weight in a  $\theta$ -solvent since the authors expected that the deviation might be caused by an enhanced concentration fluctuation of the high  $M$  component. It is shown that the results for the monodisperse and bimodal systems in DOP (diethylhexyl phthalate) solvent agree with each other. The short chain component does not affect the shape of curve in the terminal region. In summary, weakening of the solvent power or the contamination with very short chains makes the relaxation spectrum range diffuse. 3 Refs.

Osaki, Kunihiro (Kyoto Univ, Uji, Jpn); Takatori, Eiichi; Shibasaki, Seiichi; Kurata, Michio. *Polym J v 20 n 6 1988 p 511-513.*

**083586 TEMPERATURE DEPENDENCE OF THE INTRINSIC VISCOSITY OF SOLUTIONS OF POLYSTYRENE AND POLYALKYLSTYRENES.** The experimental findings on the temperature dependence of intrinsic viscosity of solutions of PS and polyalkylstyrenes treated by the modified Flory equation gave values of the entropic parameter  $\psi_1$  concurring with the magnitudes  $\psi_1$  obtained from the molecular-mass dependence of the critical temperature of mixing. The excluded volume of the macromolecules of the polyalkylstyrenes insignificantly exceeds that for PS pointing to the closeness of their transverse dimensions, i.e. the low rigidity of the side chains of the polyalkylstyrenes. (Author abstract) 16 Refs.

Magarik, S.Ya. (USSR Acad of Sciences, USSR); Filipov, A.P.; D'Yakonova, N.V. *Polym Sci USSR v 29 n 4 1987 p 772-778.*

## Sorption

**083587 EFFECT OF ORIENTATION ON THE CO<sub>2</sub> SORPTION OF POLYSTYRENE.** The chain orientation, induced by hot drawing, decreases the sorption capacity of polystyrene due to the tighter packing of macromolecules in the oriented material. Density measurements and decay of birefringence indicate that the loss of orientation is a much more rapid phenomenon than the thermal shrinkage of the polymer. (Author abstract) 13 refs.



Carfagna, C. (Univ di Napoli, Naples, Italy); Nicodemo, L.; Nicolais, L. *Polym Eng Sci* v 27 n 17 Sep 1987 p 1334-1337.

## Specific Heat

**083588 KINETICS OF ENTHALPY RELAXATION IN GLASS TRANSITION OF FLEXIBLE-CHAIN POLYMERS.** Heat capacity has been measured between 308 and 523 K for a number of polymers: four narrow-distribution polystyrene fractions and a non-fractionated polystyrene sample; statistical copolymers of styrene with methyl methacrylate and styrene with acrylonitrile; polycarbonate and polysulfone. The samples were first cooled from the melt at different rates. Parameters in the Moynihan model of enthalpy relaxation accompanying the glass transition were determined for the studied polymers. Empirical correlations were established between a phenomenological parameter characterizing the width of spectrum of relaxation times and the polymer molecular weight and, on the other hand, the dimensionless ratio  $\Delta E/RT_g$ . (Author abstract) 20 refs.

Privalko, V.P. (UkrSSR Acad of Sciences, USSR); Demchenko, S.S.; Lipatov, Yu.S. *Polym Sci USSR* v 28 n 6 1986 p 1446-1454.

**Spectroscopic Analysis** See Also POLYMERS—Diffusion; POLYMERS—Solutions.

**083589 DETERMINATION OF BIMODAL MOLAR MASS DISTRIBUTION FUNCTIONS OF POLYSTYRENE BY PHOTON CORRELATION SPECTROSCOPY: NUMERICAL SIMULATIONS AND EXPERIMENTAL REALIZATION IN COMPARISON WITH GEL PERMEATION CHROMATOGRAPHY DATA.** The resolution of bimodal molar mass distribution functions of polymers by photon correlation spectroscopy (PCS) combined with the constrained regularization method and the estimation of the noise level of PCS measurements is presented. Molar mass distribution functions have been recalculated from the simulated autocorrelation functions. Simulation outputs show an increase of the polydispersity and a shift toward smaller molar masses with increasing statistical noise. The effective noise level of the present measurements was determined. (Edited author abstract) 25 refs.

Vancso, Gyula (Eidgenössische Technische Hochschule, Zurich, Switzerland); Tomka, Ivan; Vancso-Polacek, Klara. *Macromolecules* v 21 n 2 Feb 1988 p 415-420.

**083590 PHOTON CORRELATION SPECTROSCOPY FROM DILUTE POLYMER-POLYMER MIXTURES.** The authors examine the molecular weight, concentration, and temperature dependences of the initial decay of the light-scattering photon correlation from dilute mixtures of low molecular weight polystyrenes in poly(methylphenylsiloxane). The authors observe the  $q^2$  dependence previously reported from these mixtures. For polystyrene molecular weights substantially larger than that of the poly(methylphenylsiloxane) macromolecules, the infinite dilution limit of the diffusion coefficient extracted from the initial decay follows a molecular weight dependence close to  $M^{-0.5}$ . For the very dilute mixtures studied, the variation of the diffusion coefficient with concentration appears to be independent of temperature. The temperature dependence of the initial decay rate of the correlation deviates from an Arrhenius behavior as the coexistence curve of the mixture is approached. (Author abstract) 8 refs.

Rodrigo, Maria-Melia (Cornell Univ, Ithaca, NY, USA); Cohen, Claude. *Macromolecules* v 21 n 7 Jul 1988 p 2091-2094.

**083591 STUDIUL POLI- $\alpha$ -METILSTIRENULUI PRIN RMN-INII LARGI.** [Study of Poly- $\alpha$ -Methylstyrene by Wide Lines NMR Spectroscopy]. This work presents the study of poly- $\alpha$ -methylstyrene by means of wide-line NMR-spectroscopy. The glass transition temperatures  $T_g$ , the degree of crystallinity  $X_c$ , the correlation frequencies  $\nu_c$  and the activation energy  $E_a$  are determined for the characterization of poly- $\alpha$ -methylstyrene. These

physical parameters were correlated with the melting points and molecular weights of the analyzed polymers. (Author abstract). 5 Refs. In Romanian.

Isbacescu, Marcela Doina; Butufei, Olga; Mazare, Magdalena. *Mater Plast Elastomeri Fibre Sint* v 25 n 1 Jan-Mar 1988 p 13-15.

## Stability

**083592 EFFECT OF TRITON X-100 ON THE STABILITY OF POLYSTYRENE LATICES.** The effect of a nonionic surfactant, Triton X-100, on the stability of monodisperse polystyrene latices was investigated. It was found that at high surfactant concentration, coagulation rather than stability was induced by the presence of the surfactant. A depletion flocculation mechanism is suggested to interpret the destabilization of polystyrene latices in concentrated micellar solution of Triton X-100. (Author abstract) 15 refs.

Ma, Chiming (Peking Univ, Beijing, China). *Colloids Surf* v 28 n 1 Nov 15 1987 p 1-7.

**Structure** See Also POLYBUTADIENES—Structure.

**083593 CHANGES OF THE STRUCTURE AND PROPERTIES OF POLYSTYRENE UNDER THE INFLUENCE OF COMPLEX ACTIVATION.** In this communication the authors report data on the structure and properties of polystyrene (PST) obtained in an aqueous solution of the cationic emulsifier cetylpyridinium chloride (CPC) at room temperature under the influence of radicals produced by decomposition of the CPC-benzoyl peroxide complex. The aim of these investigations was to solve certain practical problems in relation to possible modification of the polymer under conditions of donor-acceptor interaction of components of the reaction medium. It was found that PST<sub>0</sub> has higher thermal stability than PST<sub>c</sub>; when PST<sub>0</sub> is heated for 3 h at 300 and 350°C the weight loss is 5 and 15% respectively, while in the case of PST<sub>c</sub> the corresponding losses are 15 and 45%. The authors consider on the basis of their results that the formation of nonshrinking and thermostable polystyrene under conditions of complex activation, with good dielectric properties without orientation stretching, may be regarded as a possible method of modifying polystyrene in order to extend the regions of its application as an insulating material. 4 refs.

Trubitsyna, S.N. (Abu Raikhan Beruni Polytechnic Inst, Tashkent, USSR); Lebedeva, Yu. V. *J Appl Chem USSR* v 59 n 7 pt 2 Jul 1986 p 1522-1524.

**083594 ANISOTROPIC STRUCTURE FORMED IN ATACTIC POLYSTYRENE GELS.** In order to elucidate the mode of gelation and the structure of the gels, we investigated the morphology and properties of at-Pst/CS<sub>2</sub> gels. In the course of study, it was found that not a small number of patches with an anisotropic structure are formed in the uniform gel matrix. This anisotropic patches disappear when the gel melts on heating, but survive in the dried gel. However, this anisotropic patches never appear in the solvent-cast films, indicating that the gelation is necessary for their origination. 10 refs.

Xie, Xu-Ming (Tokyo Inst of Technology, Tokyo, Jpn); Tanioka, Akihiko; Miyasaka, Keizo. *Polym J* v 20 n 1 1988 p 93-96.

**083595 LIGHT-INDUCED SPECTRAL CHANGES IN ROSE BENGAL END-CAPPED POLYSTYRENE.** Light-induced changes in the absorption spectra of Rose Bengal end-capped polystyrenes in nonpolar solvents have been observed. The spectra of the Rose Bengal polymers obtained after irradiation are clearly indicative of the photochemical conversion of Rose Bengal monomer to Rose Bengal aggregate in the nonpolar solvent. The results suggest that a photochemically induced polymer backbone conformational change driven by intramolecular dye-dye aggregation is giving rise to the observation. (Author abstract) 8 refs.

Gupta, S.N. (Bowling Green State Univ, Bowling Green,

OH, USA); Linden, S.M.; Wrzyszczyński, A.; Neckers, D.C. *Macromolecules* v 21 n 1 Jan 1988 p 51-55.

**083596 PHASE CONTRAST MATCHING IN LAMELLAR STRUCTURES COMPOSED OF MIXTURES OF LABELED AND UNLABELED BLOCK COPOLYMER FOR SMALL-ANGLE NEUTRON SCATTERING.** To extract the single-chain scattering function of polystyrene block chain in lamellar structures of styrene-2-vinylpyridine diblock copolymers, the method of 'phase contrast matching' was studied for small-angle neutron scattering from blends of the deuterium-labeled and unlabeled block copolymers. The phase contrast matching is successfully applied for the samples with the lowest molecular weights ( $3.4 \times 10^4$  for the labeled portions) but not for the samples with the higher molecular weights ( $9.2$  and  $16.2 \times 10^4$ ). It is concluded that the mismatching may be caused by concentration fluctuation in the mixture of hydrogenated and deuterated polystyrenes in domains, as well as by nonuniform distribution of deuterated species along the direction perpendicular to the lamellae due to the difference in lengths of the labeled and unlabeled blocks. (Author abstract) 24 refs.

Matsushita, Yushu (Nagoya Univ, Nagoya, Jpn); Nakao, Yasushi; Saguchi, Ryuichi; Mori, Katsuaki; Choshi, Haruhisa; Muroga, Yoshio; Noda, Ichiro; Nagasawa, Mitsuru; Chang, Taiyuan; Glinka, Charles J.; Han, Charles C. *Macromolecules* v 21 n 6 Jun 1988 p 1802-1806.

## Structures

**083597 NEW METHOD FOR QUANTITATIVE FUNCTIONALIZATION OF THE TERMINUS IN POLY(STYRENE), NAPHTHALENE FUNCTIONALIZATION.** The authors report a general functionalization method to prepare polymers labeled with fluorescent groups based on the addition reactions of polymeric carbanions to diphenylethylene derivatives. An efficient coupling reaction to synthesize polymers labeled with fluorescent aromatic groups for the functionalization of poly(styryl)lithium (PSLi) with a naphthalene (N) derivative to yield an end-labeled poly(styrene) (PS-N) is used. The number-average molecular weight and molecular weight distribution of the naphthalene end-labeled polystyrene were characterized by size-exclusion chromatography. These results show that there has been no major change either in  $M_n$  or  $M_w/M_n$ . 18 Refs.

Quirk, Roderic P. (Univ of Akron, Akron, OH, USA); Perry, Scott; Mendicutt, Francisco; Matice, Wayne L. *Macromolecules* v 21 n 7 Jul 1988 p 2294-2295.

## Surface Properties

**083598 SORPTION PROPERTIES OF POLYSTYRENE ADSORBENTS FROM ISOTHERMS OF PROPANE AND n-BUTANE.** Adsorption isotherms for propane and n-butane on two polystyrene samples of high and low specific surface areas were obtained from measurements of transmission or breakthrough curves. These isotherms were analyzed to extract the parameters that characterize the energetic heterogeneity of polystyrene. The energetic heterogeneity of the sample with low specific surface area reflects only the surface heterogeneity of polystyrene; therefore, this sample was used as a reference system to study the polystyrene sample with a high specific surface area. Analysis of the adsorption isotherm suggests that the sample with a high specific surface area possesses micropores that increase its energetic heterogeneity in comparison to that observed for the sample with low specific surface area. (Author abstract) 12 refs.

Lu, X. (Kent State Univ, Kent, OH, USA); Mader, R.; Rothstein, D.; Jaroniec, M. *Mater Chem Phys* v 19 n 3 Apr 1988 p 247-254.

**083599 SURFACE COMPOSITION OF POLYSTYRENE.** The physical and chemical properties of bulk polymers are well understood and have been measured



exhaustively for numerous systems, but the properties of polymer surfaces are quite often different from those observed in the bulk and are usually not as easily measurable. Since many polymer properties vary with molecular weight, it is of interest to determine whether or not there is any segregation in a homopolymer system based on molecular weight. In particular, does the surface of a polymer sample have the same molecular weight composition as the bulk? The current work answers this question for a polystyrene system. Through the use of secondary ion mass spectrometry and tagged polystyrene, it has been shown that surface and bulk molecular weight composition are indistinguishable within the limits of the experimental method's sensitivity. (Edited author abstract) 25 refs.

Goldblatt, Ronald D. (IBM, Yorktown Heights, NY, USA); Scilla, Gerald J.; Park, Jae M.; Johnson, Julian F.; Huang, Samuel J. *J Appl Polym Sci* v 35 n 8 Jun 1988 p 2075-2084 p 2075-2084.

**Surfaces** See Also METALS AND ALLOYS—Surfaces.

**083600 PROTEIN-REACTIVE, MOLDED POLYSTYRENE SURFACES HAVING APPLICATIONS TO IMMUNOASSAY FORMATS.** Injection-molded polystyrene surfaces were chemically modified rendering them protein reactive. The process involves chlorosulfonation of the aromatic ring, sulfonamide formation with excess di- and triamines, and reaction of the residual pendant amines with various bifunctional molecules. Surfaces possessing pendant bromoacetyl, iodoacetyl, fluorodinitrophenyl, and trimellitic anhydride were prepared and can exhibit up to ten times more protein immobilization capability compared to unfunctionalized polystyrene, where the coupling takes place presumably via hydrophobic interaction. (Author abstract) 7 refs.

Chu, Victor P. (Abbott Lab, Abbott Park, IL, USA); Tarcha, Peter J. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1917-1924.

**Suspensions**

**083601 RHEOLOGICAL INVESTIGATION OF DEPLETION FLOCCULATION OF CONCENTRATED STERICALLY STABILISED POLYSTYRENE LATEX DISPERSIONS.** The flocculation of a concentrated polystyrene latex suspension (volume fraction  $\phi = 0.3$ ), containing grafted poly(ethylene oxide) chains, by 'free' (non-adsorbing) poly(ethylene oxide) (PEO) was investigated using rheological measurements. Three techniques were used, namely steady-state shear stress-shear rate measurements, shear modulus and oscillatory measurements. From these the following rheological parameters were determined: the Bingham yield value  $\tau_B$ , the Casson yield value  $\tau_C$ , the high frequency modulus  $G_\infty$ , the complex modulus  $G^*$ , the storage modulus  $G'$  and the loss modulus  $G''$ . (Edited author abstract) 17 refs.

Prestidge, C. (Jealotts Hill Research Station, Bracknell, Engl); Tadros, Th.F. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorption, Stability and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 325-346.

**Swelling**

**083602 ANOMALOUS PENETRANT TRANSPORT IN GLASSY POLYMERS - VI. EFFECT OF TEMPERATURE ON TRANSPORT.** Transport of liquid cyclohexane through well characterized, initially glassy, crosslinked polystyrene slabs was investigated at 20, 30, 40, and 50°C. The samples used were produced by bulk polymerization of styrene and divinyl benzene (DVB) at 90°C for 48 hr using benzoyl peroxide as an initiator. Cyclohexane uptake was followed as a function of time along with dimensional changes in the thickness and area of the samples. The results of penetrant uptake as a function of time were analyzed using a simplified exponential expression and employing all the data points from the beginning of the experiment until the time of observation of the maximum in uptake. (Edited author abstract) 29 refs.

Urdahl, Kent G. (Purdue Univ, West Lafayette, IN, USA); Peppas, Nikolaos A. *Polym Eng Sci* v 28 n 2 Jan 1988 p 96-103.

**Synthesis**

**083603 RADICAL COPOLYMERIZATION OF SULPHUR DIOXIDE AND STYRENE: 4. INTRAMOLECULAR EXCIMER FORMATION IN POLY(STYRENE SULPHONE).** Intramolecular excimer formation in poly(styrene sulphone) with various compositions has been investigated on the basis of the characteristic monomer sequence distributions which were determined experimentally. The fluorescence spectra of the poly(styrene sulphone)s show two emission bands at 285 nm and 330 nm for polystyrene, corresponding to the monomer and the excimer bands, respectively. The ratio of the excimer to the monomer emission intensities ( $I_e/I_m$ ) is linearly correlated with the mole fraction of styrene. This observation is consequence of the characteristic sequence distributions in poly(styrene sulphone)s, containing a very small fraction of SMS units ( $S=SO_2$ ;  $M=$  styrene). The efficiency of excimer formation in poly(styrene sulphone)s with regular styrene sequences, e.g.  $I_e/I_m$ . It is concluded that the excimer formation in poly(styrene sulphone)s is very efficient. (Edited author abstract) 27 refs.

Bae, Hun-Jai (Tohoku Univ, Sendai, Jpn); Miyashita, Tokuji; Matsuda, Minoru. *Br Polym J* v 20 n 2 1988 p 125-129.

**083604 POLYSTYRENES WITH p-OLIGO-SILOXANE, SILANE, GERMANOSILOXANE, GERMANE, OR STANNANE AS p-SUBSTITUENTS AS MATERIALS FOR OXYGEN PERMEABLE MEMBRANES.** The title polymers were synthesized and the oxygen permeation behavior through the polymer films were studied. The oligodimethylsilane-substituted polystyrenes showed a little low  $P_O(2)$  compared with the oligodimethylsiloxane-substituted polystyrenes. The important role of trimethylsiloxy group in permeation was suggested. (Author abstract) 10 refs.

Kawakami, Yuhsuke (Nagoya Univ, Nagoya, Jpn); Hisada, Hirofumi; Yamashita, Yuya. *J Polym Sci Part A* v 26 n 5 May 1988 p 1307-1314.

**083605 PHOTOINDUCED CHARGE SEPARATION OF POLYSTYRENE-BOUND Ni(II)-4,4'-4''-TETRACARBOXYPHTHALOCYANINE.** Polystyrene with pendant Ni(II)-4,4',4'',4'''-tetracarboxyphthalocyanine (NiPtc) was synthesized by reacting NiPtc with partially chloromethylated polystyrene. Photoreduction of methylviologen by visible light was accomplished with the modified polymer. The photocatalytic activity was enhanced by bonding the NiPtc units to the polymer. The relationship between the catalytic activity and the structure of the modified polymer is discussed. (Author abstract) 10 refs.

Yamaguchi, Hidemasa (Osaka City Univ, Osaka, Jpn); Fujiwara, Ryosuke; Kusuda, Kousuke. *J Macromol Sci Chem* v 24 n 3-4 1987, Macromol-Met Complexes: Sel Pap from the US-China-Jpn Int Semin, Beijing, China, Oct 20-24 1985 p 367-374.

**Thermal Conductivity**

**083606 LOW TEMPERATURE THERMAL CONDUCTIVITY OF POLYSTYRENE.** The thermal conductivity  $\kappa$  of amorphous polystyrene has been measured in the temperature range 0.1 K-100 K as a function of molecular weight, cross-linking and annealing. We find  $\kappa$  insensitive to sample preparation and the number of type of chain ends. Crosslinking increases  $\kappa$  predominantly in the temperature range of the plateau. Our results suggest an inverse relationship between the fictive temperature and the thermal conductivity measured at temperatures below 1 K. (Author abstract) 40 refs.

Mack, J.X. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Freeman, J.J.; Anderson, A.C.; Greig, D. *J Non Cryst Solids* v 91 n 3 Jun 1 1987 p 391-401.

**Thermal Effects**

**083607 THERMAL STABILITY OF BENZOYL PEROXIDE INITIATED POLYSTYRENE.** In various studies the authors prepared polystyrene with  $^{13}C$ -labeled end groups by conducting polymerizations with benzoyl-carbonyl- $^{13}C$  peroxide as the initiator. These polymers were used to assess the thermal stability of the benzoyloxy end groups present in benzoyl peroxide initiated polystyrene and to ascertain whether they constitute 'weak links' in polystyrene. Examination of the NMR spectra of the degraded polymers showed that after only 10 min all resonances due to secondary benzoate end groups have disappeared while the primary benzoate resonances appear essentially unchanged both in appearance and relative intensity. 15 refs.

Moad, Graeme (CSIRO, Melbourne, Aust); Solomon, David H.; Willing, R. Ian. *Macromolecules* v 21 n 3 Mar 1988 p 855-857.

**Thermal Properties** See HIGHWAY SYSTEMS—Frost Effect; RAILROADS—Insulation; ROADS AND STREETS—Frost Effect.

**Thin Films** See Also ACIDS—Organic; PLASTICS FILMS—Extrusion.

**083608 MONOLAYER OF POLYSTYRENE MONOMOLECULAR PARTICLES ON A WATER SURFACE STUDIED BY LANGMUIR-TYPE FILM BALANCE AND TRANSMISSION ELECTRON MICROSCOPY.** The behavior of a monolayer of polystyrene monomolecular particles which was obtained by spreading dilute solutions in benzene on the water surface was studied by a Langmuir-type film balance and transmission electron microscopy (TEM). Since polystyrene has no hydrophilic group, the surface pressure measured by the film balance was not due to the real decrease of the surface tension but due to a mechanical force by compression, thus the  $\pi$ -A curves were apparent  $\pi$ -A curves. However, the macroscopic observation by the film balance was in good agreement with the microscopic observation by TEM, indicating the particles are stable against the compression. At the limiting area,  $A_0$ , the monomolecular particles covered 56% of the water surface, but they could not be most closely packed by further compression. Apparent  $\pi$ -A curves were measured for lower molecular weight samples, for which formation of monomolecular particles has not been confirmed. The observed small  $A_0$  indicated the particles were not formed or were unstable against the compression. (Edited author abstract) 13 refs.

Kumaki, Jiro (Research Development Corp of Japan, Tokyo, Jpn). *Macromolecules* v 21 n 3 Mar 1988 p 749-755.

**083609 POLYMERIZATION IN SUBMONOLAYERS OF STYRENE MONOMER ADSORBED FROM ITS VAPOR PHASE.** The surface coverage of porous glass ( $PD = 500$ ) by styrene adsorbed from its vapor (0.1-6 torr) was studied in a vacuum electrobalance. The adsorption isotherm of the monomer was analyzed by the BET method, and a full monolayer coverage was found to form at a relative pressure of 0.11, weighing 6 mg per gram of glass. Polymerization in submonolayers of adsorbed styrene was initiated by thermal decomposition of predeposited BPO and found to continue until all initiator decomposed, sample cooled, or vapor removed, hence allowing a controlled film thickness. The films were extracted in THF and analyzed by computerized GPC. Molecular weights were in the range 18000-69000. These were related to the rates of polymerization by the usual statistical correlations. (Author abstract) 10 Refs.

Behbahani, Houshang F. (Univ of Tokyo, Tokyo, Jpn); Inoue, H. *J Polym Sci Part B* v 26 n 7 Jul 1988 p 1519-1527.

**Viscoelasticity**

**083610 VISCOELASTIC PROPERTIES OF AQUEOUS CONCENTRATED POLYSTYRENE LATEX**



**DISPERSIONS CONTAINING GRAFTED POLY(ETHYLENE OXIDE) CHAINS.** The viscoelastic properties of aqueous concentrated polystyrene latex dispersions containing grafted poly(ethylene oxide) (PEO) chains were investigated using oscillatory and steady-state shear stress-shear rate measurements. The relative viscosity-effective volume fraction results were fitted to the Dougherty-Krieger equation for hard spheres by adjusting the value for the adsorbed layer thickness  $\Delta$ . The latter was found to decrease with an increase in volume fraction of the dispersion and near to close-packing considerable compression of the chains occurred. The results showed that the dispersion changes from being more viscous to more elastic over a narrow range of volume fraction  $\phi$  of the dispersion, i.e., when  $\phi$  is increased from 0.465 to 0.5. (Author abstract). 6 Refs.

Presidge, C. (ICI, Bracknell, Engl); Tadros, Th. F. *J Colloid Interface Sci* v 124 n 2 Aug 1988 p 660-665.

## Viscosity

**083611 COUNTERION AND SOLVENT EFFECTS ON THE DILUTE SOLUTION VISCOSITY OF POLYSTYRENE IONOMERS.** We present an analysis of data on the intrinsic viscosity  $[\eta]$  of sulfo-polystyrene ionomers in several solvents for a variety of sulfonation levels and counterions. For solvents of low dielectric constant,  $2 < \epsilon < 18$ ,  $[\eta]$  decreases from the base polymer value  $[\mu]_0$  with increasing substitution level. This behavior was attributed to intramolecular association of ionic dipoles. The ratio  $[\eta]/[\eta]_0$  was found to depend on a single reduced variable  $a_A a_{Sx}$ , where  $x$  is the fractional substitution,  $a_A$  depends only on the counterion, and  $a_S \propto \epsilon^{-1}$  depends only on the solvent. For solvents of high dielectric constant,  $36 < \epsilon < 47$ ,  $[\eta]$  increases approximately as  $x^3$ , and counterion effects are small. (Edited author abstract) 23 refs.

Agarwal, Pawan K. (Exxon Research & Engineering Co, Annandale, NJ, USA); Garner, Richard T.; Graessley, William W. *J Polym Sci Part B* v 25 n 10 Oct 1987 p 2095-2111.

## Waste Utilization

**083612 MODEL PROCESS FOR THE SOLVENT RECYCLING OF POLYSTYRENE.** A model solvent technique is presented according to which polystyrene (PS) foam scrap is recovered in the form of small grains. The process mainly comprises dissolution of the waste into benzene or toluene, filtering, dispersion of the solution into water, and subsequent distillation. The alternative solvent/non-solvent systems have been studied on the basis of solution rheology, operating conditions during the recycling procedure, and extents of recovery of PS and solvent. Eventually, the toluene/water system has been chosen for a larger scale experiment (LSE), the product of which was used for characterization work. No influence on critical properties was detected due to the solvent technique followed. (Author abstract) 17 refs.

Kampouris, E.M. (Natl Technical Univ of Athens, Athens, Greece); Papaspyrides, C.D.; Lekakou, C.N. *Polym Eng Sci* v 28 n 8 Apr 1988 p 534-537.

## Welding

**083613 POLYMER WELDING RELATIONS INVESTIGATED BY A LAP SHEAR JOINT METHOD.** A lap shear joint method was used to study strength development during welding of polystyrene surfaces. The surfaces previously had not been in contact and care was taken to insure rapid wetting of the interface. The shear stress at failure, was measured at room temperature as a function of contact time, at constant welding temperatures up to 20°C above the glass transition temperature. The polystyrene samples had molecular weights,  $M_n = 143,000$  and  $M_w = 262,000$ . The time to achieve complete healing,  $t_\infty \approx 256$  min at 118°C, was found to be of the same order of magnitude as the viscoelastic relaxation time and also with the time required for a polymer chain to diffuse a distance equal to its root mean square end-to-end vector. (Edited author abstract) 20 refs.

Kline, D.B. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Wool, R.P. *Polym Eng Sci* v 28 n 1 Mid-Jan 1988 p 52-57.

**Wetting** See ROOFS—Insulation.

**X-Ray Analysis** See Also IONOMERS—Structure.

**083614 DEUTERATION EFFECT ON THE COEXISTENCE CURVES OF SEMIDILUTE POLYMER SOLUTIONS.** Phase separation points of semidilute solutions of polystyrene in deuterated cyclohexane were measured and compared with those of polystyrene in protonated cyclohexane. Theoretical calculation of the coexistence curve by using the interaction parameters extracted from small-angle scattering of neutron and X-rays has revealed that the deuteration effect on the coexistence curve is due solely to a shift of  $\theta$  point, the temperature at which the binary cluster integral vanishes, while leaving other factors unaltered. The origin of this feature is briefly discussed. (Author abstract) 5 refs.

Ichimura, Takashi (Nihon Univ, Tokyo, Jpn); Okano, Koji; Kurita, Kimio; Wada, Eiichi. *Polym J* v 19 n 9 1987 p 1101-1103.

## POLYSULFIDES

### Doping

**083615 OPTICAL ABSORPTION AND ESR STUDIES OF POLY(p-PHENYLENE SULFIDE) DOPED WITH SULFUR TRIOXIDE.** Optical absorption and ESR spectra of  $SO_3$ -doped poly(p-phenylene sulfide) (PPS) with relatively high conductivity were measured. Two absorption bands were observed at 0.9 and 3.1 eV at the initial doping state. The intensity of these two bands increased with the rise of doping level. ESR spectra with a g-value of 2.0075 were observed for the PPS- $SO_3$  system at the same doping level as that of absorption spectra. In both cases of optical absorption and ESR spectra of  $SO_3$ -doped PPS, the spectral intensity increased slightly under UV-light irradiation, while these spectra were little affected by the near IR-light irradiation. (Edited author abstract) 17 refs.

Shimizu, Hiroshi (Research Inst for Polymers & Textiles, Tsukuba-gun, Jpn); Kanetsuna, Hisaaki; Tanabe, Yoshikazu. *Polym J* v 19 n 8 1987 p 915-922.

**Drawing and Stamping** See SYNTHETIC FIBERS—Mechanical Properties.

### Fiber Reinforcement

**083616 POLYPHENYLENE SULPHIDE (PPS).** PPS belongs to the semi-crystalline material group. It is only used with reinforcement fibres and filler for injection moulding and hence there are no transparent grades. Stretched film is crystal clear on account of the small-sized crystallites. The high melting range of around 285°C permits short-term thermal loads of up to 260°C. Polyphenylene sulphide also has excellent inherent flameproofing with its chemical structure of 70% aromatic compounds and 30% sulphur. These products have high resistance to chemicals, even under load and at high temperatures. No solvents are known that dissolve PPS at below 200°C. The low melt viscosity of PPS means that it can take up to 70% filler and/or reinforcement fibre. The new PPS generation with its linear structure brings advantages in mechanical properties and the constancy of the viscosity setting. The weak points of PPS are its low peripheral fibre elongation which results in a low level of toughness and moderate stability vis-a-vis weathering. Shell compounds for electronic components alone are expected to take three times the quantity of encapsulating compound in 1990 as in 1985. 10 refs.

Kraft, K. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 54-56.

**Physical Properties** See POLYMERS—Physical Properties.

## Pyrolysis

**083617 CHARACTERIZATION OF CURED POLYSULFIDE POLYMERS BY THERMAL DEGRADATION: PYROLYSIS-GC AND THERMOGRAVIMETRIC STUDIES.** Polymers prepared by curing thiol-terminated liquid polysulfide polymer  $[HS(RS_2)_nRSH, R = -CH_2CH_2OCH_2OCH_2CH_2-]$  with p-quinonedioxime,  $PbO_2$ , and  $MnO_2$  were studied by pyrolysis-GC and thermogravimetry. Characteristic differences were observed in the composition of the pyrolyzates under flash pyrolysis at 420 and 470°C. The concentration of the cyclic monomer, 1,3-dioxo-6,7-dithionane, in the pyrolyzates was found to vary considerably from polymer to polymer. The change in mechanism with the extent of degradation and the corresponding overall activation energies were evaluated by thermogravimetry. The pyrolysis-GC and thermogravimetric data were shown to provide partial characterization of the substrates. Mn appears to be in a coordinated complex in the  $MnO_2$ -cured polymer. (Author abstract) 12 refs.

Radhakrishnan, T.S. (Vikram Sarabhai Space Cent, Trivandrum, India); Rama Rao, M. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1985-1996.

**083618 CHARACTERIZATION OF CURED POLYSULFIDE POLYMERS BY THERMAL DEGRADATION: PYROLYSIS-GC AND THERMOGRAVIMETRIC STUDIES.** Polymers prepared by curing thiol-terminated liquid polysulfide polymer  $[HS(RS_2)_nRSH, R = -CH_2CH_2OCH_2OCH_2CH_2-]$  with p-quinonedioxime,  $PbO_2$ , and  $MnO_2$  were studied by pyrolysis-GC and thermogravimetry. Characteristic differences were observed in the composition of the pyrolyzates under flash pyrolysis at 420 and 470°C. The concentration of the cyclic monomer, 1,3-dioxo-6,7-dithionane, in the pyrolyzates was found to vary considerably from polymer to polymer. The change in mechanism with the extent of degradation and the corresponding overall activation energies were evaluated by thermogravimetry. The pyrolysis-GC and thermogravimetric data were shown to provide partial characterization of the substrates. Mn appears to be in a coordinated complex in the  $MnO_2$ -cured polymer. (Author abstract) 12 refs.

Radhakrishnan, T.S. (Vikram Sarabhai Space Cent, Trivandrum, India); Rama Rao, M. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1985-1996.

**Redox** See ELECTRIC BATTERIES.

## Sealing

**083619 COMPOUNDING POLYSULPHIDE SEALANTS FOR RESISTANCE TO BIODEGRADATION.** In the early seventies the well established use of polysulphide sealants in water-retaining structures was brought into question by the biological deterioration of a sealant in the Dunkeld Reservoir in Johannesburg. As a result, comprehensive studies were undertaken in South Africa and the UK on the mechanism of the degradation and the factors that influenced it. An accelerated biodegradation test was devised and used to determine the best combination of compounding ingredients for polysulphide sealants that are to be immersed in water. As a result of this work it is now possible to give firm guidelines for the polymer content, curative type and other ingredients to ensure the longevity of polysulphide sealants in any water environment. These recommendations are being confirmed by field trials. Nine years ago a polysulphide sealant designed according to these guidelines was installed in the same Dunkeld Reservoir in Johannesburg. A recent inspection indicated that it is still in perfect condition. (Author abstract) 2 refs.

Lee, C.P.T. (Morton Thiokol Ltd); Engelbrecht, G.W.A. *Civ Eng S Afr* v 30 n 2 Feb 1988 p 63-66.

## Solutions

**083620 KINETICS OF POLYSULFIDE SOLUTIONS: PART III, INVESTIGATION OF HOMOGENEOUS AND ELECTRODE KINETICS BY THE**



**ROTATING DISK METHOD.** The steady-state current density-overpotential relationships for cobalt and platinum rotating disk electrodes in aqueous polysulfide electrolyte (1.3M total  $S_2^{2-}$ , 1M  $S_0$ , and pH=12) were determined over a temperature range of 25–77°C. A model developed to take into account the rate of the homogeneous dissociation of  $S_4^{2-}$  to  $S_2^{2-}$  as well as a finite heterogeneous electrochemical reaction rate yielded parameters consistent with the results of previous transient experiments (in the low overpotential region). At higher overpotentials in the cathodic region a second cathodic reaction was evident. This second cathodic reaction was less prominent when the current densities were lower (as on Pt electrodes) or when the  $S_2^{2-}$  concentrations were higher (as temperature increased). (Edited author abstract) 39

Lessner, Philip (Lawrence Berkeley Lab, Berkeley, CA, USA); McLarnon, Frank R.; Winnick, Jack; Cairns, Elton J. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2669-2677.

## Spectroscopic Analysis

**083621 VIBRATIONAL SPECTRA OF SOME CYCLIC POLYSULFIDES.** Vibrational spectra and normal-coordinate analyses using a modified Urey-Bradley force field are reported for 1,2,3,5,6-pentathiepane (lenthionine), 1,3,5,7-tetrathiepane, and 1,2,3-trithiane. Characteristic Raman bands are identified for S-CH<sub>2</sub>-S and S-S-S functionalities in cyclic molecules. The observed and calculated spectra for all the molecules considered here, with the CH stretches omitted for the sake of brevity, are listed. These compounds exhibit antibiotic activity. 26 refs.

Nash, Charles P. (Univ of California, Davis, CA, USA); Musker, W. Kenneth; Lam, Ada P.-J. *Appl Spectrosc* v 42 n 3 Mar-Apr 1988 p 494-497.

## Synthesis

**083622 SYNTHESIS OF INTRAMOLECULARLY CYCLIZED POLY(PHENYLENE SULFIDE)S OF THE THIANTHRENE-TYPE.** Oligomers containing thianthrene units in the chain are synthesized by  $AlCl_3$ -catalyzed reaction of diphenylsulfide, thianthrene, poly(p-phenylene sulfide), and poly(m-phenylene sulfide) with sulfur at 80°C. The products are compared with that obtained by the reaction of diphenylsulfide with  $AlCl_3$  at 225°C. IR spectra and elemental analyses are consistent with cyclic chain structures and show a higher cyclization for  $CHCl_3$ -insoluble fractions. X-ray diffraction analysis indicates the same structure for the samples obtained with the different methods of synthesis. A possible structural model is tentatively proposed. (Author abstract) 25 refs.

Bizzarri, P. Costa (Univ de Bologna, Bologna, Italy); Casa, C. Della; Fiorini, M.; Porzio, W. *J Polym Sci Part A* v 26 n 1 Jan 1988 p 255-265.

**083623 NOVEL SYNTHESIS OF POLYSULFIDE BY PHASE TRANSFER-CATALYZED TERPOLYMERIZATION OF MALONONITRILE, CARBON DISULFIDE AND  $\alpha, \alpha'$ -DICHLORO-P-XYLENE.** In this paper, an investigation is made into a synthetic method of polysulfide by terpolymerization of malononitrile, carbon disulfide, and  $\alpha, \alpha'$ -dichloro-p-xylene. The polymerization reaction was catalyzed by benzyltriethylammonium chloride as a phase transfer catalyst. We describe the preparation of two model compounds and the terpolymerization. We have synthesized a new polysulfide having an enthalpic structure. 6 refs.

Suh, Dong Hack (Korea Research Inst of Chemical Technology, South Korea); Won, Jong Chan; Kim, Dong Kook; Jung, Jin Chul. *J Polym Sci Part C* v 16 n 2 Feb 1988 p 83-87.

**083624 CYCLOPOLYMERIZATION OF DIPROPARGYL SULFIDE BY TRANSITION METAL CATALYSTS.** During the past three decades, extensive studies on the cyclopolymerization of non-conjugated dienes have been made. It was known that group VI metal-based catalysts exhibit a high catalytic activity for the polymeri-

zation of mono- and disubstituted acetylenes. We have also found that  $WCl_6$ - and  $MoCl_5$ -based catalyst systems are very effective for the polymerization of acetylene derivatives containing aromatic heterocycles, and vinyl monomers. The present article deals with the cyclopolymerization of dipropargyl sulfide by  $WCl_6$ - and  $MoCl_5$ -based catalysts. 21 refs.

Gal, Yeong-Soon (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Choi, Sam-Kwon. *J Polym Sci Part C* v 16 n 2 Feb 1988 p 115-121.

**083625 SYNTHESIS OF POLYBUTADIENE-POLYSULPHIDE.** The anionic synthesis of polybutadiene-polysulfide polymers from butadiene, elemental sulfur, and sodium was studied in a polar solvent (THF). The polycondensation results from the combination of three reactions: initiation of the monomer by the alkali metals, anionic propagation, and deactivation of the dianionic species on elemental sulfur. From the characterization of the resulting polymers, it has been shown that the sulfur rank of the polymer can be adjusted by varying the ratio  $K=[\text{sodium}]/[\text{sulfur}]$ . The degree of polymerization of the organic chain can be controlled by changing the temperature or the monomer concentration. From the thiol content, it has been concluded that the polysulfide polymers are principally in a cyclic form. (Edited author abstract) 16 refs.

Pujol, J.M. (CRM, Strasbourg, Fr); Brossas, J.; Catala, J.M. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1575-1586.

## POLYSULFONAMIDES

### Synthesis

**083626 SYNTHESIS AND PROPERTIES OF POLYSULFONAMIDES CONTAINING THIOPHENE LINKS.** In order to study the synthesis and properties of polysulfonamides containing thiophene links, 2, 2-bis(5-chlorosulfonyl-2-thienyl)propane [BCTP], 2, 2-bis(5-chlorosulfonyl-2-thienyl)butane [BCTB], 1, 1-bis(5-chlorosulfonyl-2-thienyl)cyclohexane [BCTC], and 2,4-dichlorosulfonyl thiophene [DCST] were prepared and interfacial polycondensations with various aliphatic diamines were carried out. The resulting polymers had inherent viscosities in the range of 0.13-0.41 dL/g and showed high extent of moisture absorptions. Most of the polysulfonamides were soluble in electron-donating solvents such as pyridine, DMF, DMSO, NMP, etc. These polysulfonamides exhibited relatively good thermal stabilities. The TGA data revealed 5% weight losses at 275-405°C and residual weights at 500°C were 1-40% under nitrogen. It was also found that dithienylidissulfonyl chlorides produced more thermally stable polymers than DCST, which were comparable to common polysulfonamides from aromatic disulfonyl chlorides. (Author abstract) 15 refs.

Yi, Mi Hie (Korea Research Inst of Chemical Technology, Chungnam, South Korea); Lee, Sung Goo; Choi, Kil-Yeong; Jung, Jin Chul. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1507-1517.

**POLYSULFONES** See Also MEMBRANES—Materials; POLYMERS—Blending.

**083627 STUDIES ON THE COPOLYMER COMPOSITION OF SULPHUR DIOXIDE AND PHENYLACETYLENE.** The polysulphone copolymers synthesized from the copolymerization of liquid sulphur dioxide and phenylacetylene in the presence of tert-butyl hydroperoxide at low temperature always have an alternating structure which is independent of solvent, temperature and feed ratio. At a relatively high temperature (50°C) the phenylacetylene/ $SO_2$  system initiated by AIBN gave copolymers with a 1:1 mole ratio, whereas styrene/ $SO_2$  under the same conditions produced copolymers with 2:1 molar ratio. The free radical initiators hydrogen peroxide, m-chloroperbenzoic acid, and diphenyl peroxide were inert at low temperatures. The  $PhC\equiv CH/SO_2$  system with  $(CH_3)_3COOH$  at low temperature is more reactive than  $PhCH=CH_2/SO_2$  but with AIBN at high temperature the reactivities are reversed. These observations suggest

that different mechanisms should operate on the two systems. (Author abstract) 16 refs.

Tsonis, C.P. (Univ of Petroleum & Minerals, Dhahran, Saudi Arabia); Ali, S.A.; Hwang, J.S. *Polymer* v 28 n 12 Nov 1987 p 2139-2144.

## Applications

**083628 PLASMA-POLYMERIZED MEMBRANES AND GAS PERMEABILITY III.** Plasma-polymerized films of hexamethyldisiloxane were deposited onto various porous substrates having different pore sizes, and the gas permeability of these composite membranes was studied. In each membrane, permselectivity between oxygen and nitrogen was found, but the oxygen permeation rate was different with each substance tested. The minimum thickness of the plasma-polymerized film needed to plug all pores and show permselectivity is about five times the pore radius of the porous substrate. In cases using polysulfone hollow fibers which have high permselectivity, the composite membranes show much higher permeability ratios of oxygen-to-nitrogen than do those of the porous glass hollow fibers. (Edited author abstract) 14 refs.

Sakata, Jiro (Toyota Central Research & Development Lab Inc, Aichi, Jpn); Hirai, Masana; Yamamoto, Minoru. *J Appl Polym Sci* v 34 n 8 Dec 1987 p 2701-2711.

## Deformation

**083629 SORPTIVE DILATION OF POLYSULFONE AND POLY(ETHYLENE TEREPHTHALATE) FILMS BY HIGH-PRESSURE CARBON DIOXIDE.** Dilation of polysulfone (PSUL) and crystalline poly(ethylene terephthalate) (PET) films accompanying sorption of carbon dioxide is measured by a cathetometer under high pressures up to 50 atm over the temperature range of 35-65°C. Sorptive dilation isotherms of PSUL are concave and convex to the pressure and concentration axes, respectively, and both isotherms exhibit hysteresis. Each dilation isotherm plotted versus pressure and concentration for the  $CO_2$ -PET system shows an inflection point, i.e., a glass transition point, at which the isotherm changes from a nonlinear curve to a straight line. Dilation isotherms of PET below the glass transition point are similar to those of the  $CO_2$ -PSUL system, whereas the isotherms above the glass transition point are linear and exhibit no hysteresis. Partial molar volumes of  $CO_2$  in these polymers are determined from data of sorptive dilation. On the basis of the extended dual-mode sorption model and the current data, primitive equations for gas-sorptive dilation of glassy polymers are proposed. (Author abstract) 31 refs.

Kamiya, Yoshinori (Industrial Products Research Inst, Tsukuba, Jpn); Hirose, Takuji; Naito, Yasutoshi; Mizoguchi, Keishin. *J Polym Sci Part B* v 26 n 1 Jan 1988 p 159-177.

## Fatigue

**083630 FATIGUE BEHAVIOUR OF POROUS POLYSULPHONE SURFACE COATINGS FOR ORTHOPAEDIC APPLICATIONS.** Porous polysulphone (PPSF) has recently been selected as a candidate material for use as a prosthetic surface coating in orthopaedic applications to accommodate 'bone ingrowth' for fixation to the skeletal system. The tension-loaded fatigue behaviour of PPSF was characterized based on the interpretation of stress/life (S/N) data. Results of this investigation indicate that the fatigue life of PPSF is governed by crack propagation across the sintered necks of the porous structure. In addition, experimental data revealed that the fatigue strength-reduction factor,  $K_f$ , remains equivalent to the tensile notch strength-reduction factor for a wide range of fatigue lives. However, analytical results indicate that the material has a low notch sensitivity and that a single application of a theoretical elastic stress-concentration factor in a fatigue analysis would be inappropriate. (Author abstract) 8 refs.

Beals, N.B.; McDowell, D.L.; Spector, M. *Int J Fatigue* v 9 n 4 Oct 1987 p 211-216.



## Heat Resisting

**083631 POLYSULPHONE AND POLYETHER SULPHONE (PSU AND PES).** Thermoplastics with a high heat resistance, such as polysulphone (PSU) and polyether sulphone (PES) are gaining increasing importance. Forecasts for the growth in demand are generally optimistic. The rise in demand for high temperature resistant thermoplastics is due foremost to the trend towards miniaturisation in a large number of fields of application, particularly in electrical engineering and the electronic industry, which is going hand in hand with more stringent requirements in terms of heat distortion temperature, heat ageing behaviour and dimensional stability. These thermoplastics which can withstand high temperatures and mechanical stressing are opening up new applications, for reasons of production engineering and weight savings, and are coming to replace conventional materials such as glass, ceramics and metals in a large number of cases. 3 refs.

Kopietz, M.; Zeiner, H. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 52-53.

## Modification

**083632 MODIFICATION OF POLYSULFONE BY METALATION.** Our studies of changes in membrane characteristics brought about by various types of functional groups led to the development of this versatile modification approach in which a diverse range of substituted polymers are attainable. In this letter, the position and degree of lithiation was examined by <sup>1</sup>H-NMR spectral analysis of two simple derivatives. Polysulfone was controllably lithiated by n-butyllithium in THF at temperatures of 0°C and below. The reaction proceeded rapidly and homogeneously in high yield and required little or no excess of reagent and no catalyst. <sup>1</sup>H-NMR analysis of the methyl and deuterio derivatives indicated that the site of lithiation was at the ortho-sulfone position. Up to two lithium atoms per repeat unit were readily substituted, although lower degrees of substitution were obviously equally readily attainable. The high degree of substitution possible by direct metalation is somewhat unusual in low molecular weight systems and exceptional in polymeric systems where lower degrees of substitution and poor regiospecificity and control are typical. Lithiation is a versatile method of polysulfone modification because of the known reactivity of lithium aryls with numerous electrophiles. 15 refs.

Guiver, Michael D. (Ottawa-Carleton Inst for Research Graduate Studies in Chemistry, Ottawa, Ont, Can); Apsimon, John W.; Kutowy, O. *J Polym Sci Part C* v 16 n 2 Feb 1988 p 123-127.

## Molecular Structure

**083633 CHARACTERIZATION OF ACRYLIC ACID SULFUR DIOXIDE COPOLYMERS BY CARBON-113 NMR SPECTROSCOPY.** The synthesis and characterization of polysulfones derived from the free radical addition copolymerization of liquid sulfur dioxide with olefins or acetylenes has been the subject of several research publications. However, polysulfones made from the addition of sulfur dioxide to vinyl systems having electron-withdrawing groups directly attached to vinyl carbons are rare. A few years ago we reported the synthesis of several acrylic acid-SO<sub>2</sub> copolymers using low-temperature free-radical-addition polymerization techniques. In this note we examine systematically the structure of some of these copolymers by high field carbon-13 NMR spectroscopy. 16 Refs.

Wazeer, M.I.M. (King Fahd Univ of Petroleum & Minerals, Dhahran, Saudi Arabia); Ali, S.K. A.; Tsionis, C.P. *J Polym Sci Part B* v 26 n 7 Jul 1988 p 1539-1543.

**Performance** See AMINES—Adsorption.

## Phase Transitions

**083634 INVESTIGATION OF THE TRANSITIONS OF OLIGO-POLYSULFONES BY DSC.** The transitions of bisphenol A and phenolphthalein oligopolysulfones were investigated by DSC. It is found that both the oligomers have three transitions within the temperature range (230-550K) studied. Considering the strong dependence of the appearance of the two transitions, lower and higher than T<sub>g</sub> on the specimens' thermal history, i.e., temperature and time of heat-treatment, and their particular molecular structure, it is proposed that these two transitions are morphological in origin and are due to the disordering of relatively short range order of very small regions, and to the disordering of relatively well-ordered intra- or/and intermolecular segments, respectively. Equations for linear relationship between T<sub>g</sub> and 1/M<sup>n</sup> for both the oligomers are given in the paper. (Author abstract) 12 refs.

Dong, Lisong (Acad Sinica, Changchun, China); Zheng, Guodong; Feng, Zhiliu. *Chin J Polym Sci (Engl Ed)* v 5 n 3 1987 p 228-233.

## Photoreactivity

**083635 NOVEL THIN-FILM COMPOSITE MEMBRANES CONTAINING PHOTOREACTIVE GROUPS PART I: CHOOSING THE PHOTOREACTIVE GROUP.** Thin-film composite membranes containing photoreactive groups have been developed. The presence of these groups facilitates the subsequent photochemical conversion of the membrane to include a range of different chemical moieties. For example, a cationic or an anionic membrane can be made from the same initial composite membrane. In this paper the selection of an appropriate photolabile group is investigated. (Author abstract) 17 refs.

Chadda, S.K. (McMaster Univ, Hamilton, Ont, Can); McCarry, B.E.; Childs, R.F.; Rogerson, C.V.; Tse-Sheep, I.O.; Dickson, J.M. *J Appl Polym Sci* v 34 n 8 Dec 1987 p 2713-2732.

## Spectroscopic Analysis

**083636 INVESTIGATION OF THE COMPOSITION OF LOW MOLECULAR MASS FRACTIONS OF POLYSULFONES BY MASS SPECTROMETRY.** The consumption of low molecular mass fractions of three aromatic polysulphones has been established for the first time by the mass spectrometry of electron collisions and of field desorption. The advantages of the mass spectrometry of fields adsorption over the mass spectrometry of electron collisions in studying low volatility oligomeric compounds are indicated. It is shown that hydrolysis and cyclization reactions are of a general character in the synthesis of the polysulphones studied, and that the latter reaction is probably one of the main secondary reactions. (Author abstract) 12 refs.

Pleshkova, A.P. ('Plastmassy' Scientific Production Assoc, USSR); Matvelashvili, N.G.; Narkon, A.L.; Reiburd, L.I.; Bolotina, L.M.; Faidel, G.I. *Polym Sci USSR* v 28 n 9 1986 p 2232-2237.

## Synthesis

**083637 RHEOKINETICS OF SYNTHESIS OF POLYSULFONE IN CONCENTRATED SOLUTIONS.** The effect of temperature and solution concentration on the rheokinetics of formation of polysulphone in solutions of various concentrations is studied. For concentrations of polymer > 60 wt.% the reaction is retarded as a result of diffusional limitations. The transition into the diffusion-controlled region is described by a complex parameter, i.e. the product of the solution viscosity and the degree of polymerization. (Author abstract) 10 refs.

Malkin, A.Ya. ('Plastmassy' Scientific Production Assoc); Kulichikhin, S.G.; Kozhina, V.A.; Bolotina, L.M. *Polym Sci USSR* v 29 n 2 Feb 1987 p 469-475.

**POLYTETRAFLUOROETHYLENE** See Also FLUORINE CONTAINING POLYMERS—Coatings; FLUORINE CONTAINING POLYMERS—Reviews.

**Adhesion** See STEEL—Protective Coatings.

**Applications** See Also BEARINGS—Lubricants; ELECTROLESS PLATING—Nickel; ELECTROLESS PLATING—Solutions.

**083638 TEFLON TOUCHES GOLD.** This year is the 50th anniversary of the serendipitous discovery of poly(tetrafluoroethylene) (PTFE). The first fluorocarbon to be commercialised, PTFE is the slipperiest solid in the world, an excellent electrical insulator, displays remarkable antistick behavior, and is renowned for its chemical inertness, insolubility, weatherability and impermeability to moisture. Indispensable now in industrial, aerospace and military circles, non-stick saucepans, and fire protection is used in devices. (Edited author abstract)

Banks, R.E. (UMIST, Manchester, Engl). *Chem Br* v 24 n 5 May 1988 p 453-454.

**083639 TEFLON-WORLD'S SLIPPERIEST SUBSTANCE-WAS DISCOVERED BY ACCIDENT.** The molecular structure of 'Teflon' is a basic chain of carbon atoms, the same as all marketable fluoropolymers, in 'Teflon' this chain is completely surrounded by fluorine atoms. The bond between carbon and fluorine is very strong, and the fluorine atoms shield the vulnerable carbon chain. This unusual structure gives 'Teflon' its unique properties. In addition to its extreme slipperiness, it is inert to almost every known chemical. It has excellent electrical characteristics. It is useful over a remarkably wide temperature range, from 500°F to -400°F. 'Teflon' resin is an excellent material for piping ground water samples against contamination better than alternative materials such as PVC, glass or stainless steel. It can withstand many years of exposure to chemicals, bacteria and moisture.

Anon. *Finishing* v 12 n 6 Jun 1988 30p.

**Biocompatibility** See PROSTHETICS—Blood Vessel Prostheses.

## Blending

**083640 IONIC MISCIBILITY ENHANCEMENT IN POLY(TETRAFLUOROETHYLENE)/ POLY(ETHYLACRYLATE) BLENDS. I. DYNAMIC MECHANICAL STUDIES.** It is shown that ion-ion interactions resulting from a photon transfer induce considerable miscibility in blends of functionalized poly(tetrafluoroethylene) with ethyl acrylate copolymers containing 4-vinyl pyridine. Dynamic mechanical measurements, in conjunction with transparency of the samples, are used to evaluate miscibility. It is shown that mixing conditions exert a profound effect on the properties of the final blend. The glass transition of the blend is shown to be strong function of the blend composition, as is characteristic of highly miscible systems. (Author abstract). 41 Refs.

Murali, R. (McGill Univ, Montreal, Que, Can); Eisenberg, A. *J Polym Sci Part B* v 26 n 7 Jul 1988 p 1385-1396.

**Bonding** See FLUORINE CONTAINING POLYMERS—Bonding.

**Copolymerization** See FLUORINE CONTAINING POLYMERS—Applications.

**Corona** See PLASTICS FILMS—Corona.

## Crystal Lattices

**083641 TEMPERATURE BEHAVIOUR OF THE CRYSTALLINE LATTICE OF ORIENTED POLYTETRAFLUOROETHYLENE DURING ANNEALING.** The temperature changes of the crystalline lattice parameters a and c, and the linear coefficients of crystalline lattice expansion were determined for PTFE over the range 298-598 K from changes in angular position of equatorial (100) and meridional (0015) X-ray reflections.



By heating to 373 K the lattice expands in the direction of molecular chains, but it contracts at higher temperatures. The results obtained are discussed from the point of view of PTFE lattice dynamics. (Author abstract) 17 refs.

Shirina, N.G. (L.Ya. Karpov Physico-Chemical Research Inst, USSR); Zubov, Yu.A.; Kostromina, S.V. *Polym Sci USSR* v 28 n 6 1986 p 1454-1460.

## Crystallization

**083642 ZASTOSOWANIE METODY TERMICZNEJ ANALIZY ROZNICOWEJ W POMIARACH CIEPLA KRYSZALIZACJI POLYTETRAFLUOROETYLENU.** [DTA Measurements of Polytetrafluoroethylene Heat of Crystallization]. The applicability of DTA method for the determination of PTFE heat of crystallization during spontaneous cooling of its samples has been investigated. The values of the heat of crystallization obtained by this method for various batches of polymer were in the range from 16 to 28 kJ/kg. These results are in concordance with those obtained by the DSC method. (Author abstract) 14 refs. In Polish.

Scigala, Ryszard (Zakłady Azotowe, Tarnow, Pol); Wlochowicz, Andrzej. *Polimery* v 32 n 9 1987 p 362-364.

**Decomposition** See POLYSTYRENES—Decomposition.

## Dielectric Properties

**083643 EFFECTS OF ABSORBED BENZENE ON RELAXATION BEHAVIOR OF POLYTRIFLUOROETHYLENE.** Relaxation behavior in polytrifluoroethylene (PTFE) with varied crystallinity and swollen with benzene was investigated by mechanical and dielectric measurements. PTFE showed the  $\alpha$ ,  $\beta$ , and  $\beta'$  relaxation in decreasing order of temperature. The  $\beta$  relaxation observed around  $-20^\circ\text{C}$  at 100 Hz was considered to consist of components assigned to the amorphous and crystalline regions. The  $\beta'$  relaxation found in a lower temperature region below  $-50^\circ\text{C}$  was related to molecular motions around the defects of anomalous linkages such as head-to-head and tail-to-tail. In swollen PTFE, the  $\alpha$  relaxation due to the micro-Brownian motions of main chains shifted from  $50^\circ\text{C}$  to  $-10^\circ\text{C}$  in mechanical measurements. The  $\beta$  relaxation for swollen samples decreased in intensity or vanished. (Edited author abstract) 14 refs.

Murata, Yukinobu (Osaka Prefectural Technical Coll, Neyagawa, Jpn). *Polym J* v 20 n 3 1988 p 251-258.

## Etching

**083644 THERMAL DESORPTION MASS SPECTROMETRIC AND X-RAY PHOTOELECTRON STUDIES OF ETCHED SURFACES OF POLYTETRAFLUOROETHYLENE.** The etching of polytetrafluoroethylene (PTFE) with Na solutions is known to lead to a loss of F, a loss which is correlated with enhanced adhesion. Subsequent heating partially restores surface F with a concurrent loss of adhesion strength. The authors have combined X-ray photoelectron spectroscopy (XPS) and gas phase mass spectroscopy for in situ measurements of the processes that occur as the fluorocarbon is heated. An array of volatile products, which vary with the specific treatment, desorb from etched PTFE. XPS measurements show that etching produces a major loss of surface F and a gain of surface O. The latter probably results from the subsequent rinse steps. Heating produces a substantial recovery in surface F with only a small decrease in the surface O, and the gain in surface F is shown to occur at a higher temperature than the desorption of any species from the surface. Thus, desorption of products from the surface is decoupled, in terms of both the distribution of products and their relative temperatures, from the surface changes as monitored by XPS. This decoupling suggests that the increase in surface F results from diffusion of low molecular weight fluorocarbons from the bulk or a transition region, or from a rearrangement of the sponge-like surface region produced in the etching process. (Edited author abstract) 10 refs.

Rye, R.R. (Sandia Natl Lab, Albuquerque, NM, USA); Kelber, J.A. *Appl Surf Sci* (1985) v 29 n 4 Dec 1987 p 397-410.

**Friction** See Also LUBRICANTS—Solid Films.

**083645 INFLUENCE OF DEBRIS INCLUSION ON ABRASIVE WEAR RELATIONSHIPS OF PTFE.** This paper describes an examination of the relationship between the abrasive wear of a series of  $\gamma$ -irradiated polytetrafluoroethylene samples and some of their mechanical properties. The central theme of the paper is an examination of the correlation of the wear rate  $(\sigma\epsilon)^{-1}$ , where  $\sigma$  and  $\epsilon$  are the stress and strain to rupture in tension, respectively. In the first instance, the simple correlation is quite nonlinear and far from proportional. A major reason for the indifferent quality of the correlation is ascribed to topographical modification of the counterface by debris inclusion. An empirically based means of correcting for this process is proposed. Additional elements have also been included to account for the amount of work expended, the effective local volume deformation and the damage efficiency of the deformation work. (Edited author abstract) 23 refs.

Briscoe, B.J. (Imperial Coll, London, Engl); Evans, P.D.; Lancaster, J.K. *Wear* v 124 n 2 Jun 1 1988 p 177-194.

**Mechanical Properties** See POLYMERS—Molecular Weight.

**Medical Applications** See Also PROSTHETICS—Blood Vessel Prostheses.

**083646 IN VIVO ANTITHROMBOGENICITY OF POLY(TETRAFLUOROETHYLENE) RADIATION-GRAFT COPOLYMERIZED WITH ACRYLAMIDE.** In order to prepare an antithrombogenic material by making polymer surfaces hydrophilic, acrylamide (AAM) was radiation-graft copolymerized onto poly(tetrafluoroethylene) (PTFE) tubes by preirradiation in Ar and treatment with a monomer aqueous solution. The grafting percentage determined from the weight increment was so small that the surface grafting percentage was calculated by ESCA for the grafted tubes. The in vivo antithrombogenicity was evaluated by relative patent time in the implantation into canine peripheral veins and its relation to the contact angle of water or surface grafting percentage was discussed. From the results of ESCA measured at the photoelectron takeoff angles of  $15^\circ$  and  $90^\circ$ , the graft copolymerization was suggested to proceed into a deep layer from a surface thin layer with low grafting. (Edited author abstract) 11 refs. In Japanese.

Hayashi, Kazuko (Government Industrial Research Inst, Osaka, Jpn); Fukumura, Hiroshi; Yamamoto, Noboru; Yamashita, Iwao. *Kobunshi Ronbunshu* v 44 n 6 1987 p 429-436.

## Optical Properties

**083647 LIGHT-SCATTERING CHARACTERIZATION OF POLY(TETRAFLUOROETHYLENE).** Laser light scattering including angular dependence of absolute integrated scattered intensity and of the spectral distribution has been used successfully, for the first time, to characterize a tetrafluoroethylene polymer in oligomers of poly(chlorotrifluoroethylene) at  $340^\circ\text{C}$ . Precise measurements of the intensity-intensity time correlation function permit us to make a Laplace inversion using a variety of techniques including a multiexponential singular value decomposition (MSVD), regularized inversion of Laplace integral equation (RILE), and the CONTIN algorithm developed by S.W. Provencher. We were able to obtain an estimate of the normalized characteristic line-width distribution which could be reduced to a distribution of translation diffusion coefficient at infinite dilution, independent of the method used in the Laplace inversion. (Edited author abstract) 19 refs.

Chu, Benjamin (State Univ of New York at Stony Brook, Stony Brook, NY); Wu, Chi; Buck, Warren. *Macromolecules* v 21 n 2 Feb 1988 p 397-402.

## Order-Disorder

**083648 TEMPERATURE DEPENDENCE OF THE INTRAMOLECULAR DISORDER IN THE HIGH-TEMPERATURE PHASE OF POLY(TETRAFLUOROETHYLENE) (PHASE D).** Calculations of Fourier transforms for bundles of helices suggest that increasing the number of helix reversals should increasingly narrow the profile of the single layer line. On the basis of the reasonable assumption that the number of helix reversals increases with temperature, this narrowing of the line profile with temperature is to be expected. In order to verify this expectation, we have determined X-ray diffraction patterns for the region corresponding to the seventh and eighth layer lines over the temperature range  $20$ – $160^\circ\text{C}$ . Calculations suggest that intramolecular defects which do not involve inversions cannot account for the collapse of the two layer lines of the experimental patterns. The Fourier transform calculations indicate instead that even small variations in the number of reversals can account for dramatic changes in the experimental patterns. 11 refs.

De Rosa, C. (Univ di Napoli, Naples, Italy); Guerra, G.; Petraccone, V.; Centore, R.; Corradini, P. *Macromolecules* v 21 n 4 Apr 1988 p 1174-1176.

## Oxidation

**083649 REDUCTION IN THE ANTITHROMBOGENICITY OF POLYTETRAFLUOROETHYLENE AND POLYETHYLENE CAUSED BY RADIATION-INDUCED OXIDATION.** To examine the influence of radiation-induced oxidation on the antithrombogenicity of polymers, polytetrafluoroethylene (PTFE) and low density polyethylene (PE) tubes were irradiated with gamma-ray and then treated with water at  $50^\circ\text{C}$ , and surface characterization and evaluation of their antithrombogenicity were carried out. Irradiation was carried out mainly in argon with  $0.14$ – $0.47$  MR for PTFE and in air or water with  $0.44$ – $8$  MR for PE. Data of ESCA and zeta-potential showed the introduction of oxygen-containing groups onto the irradiated surfaces (ca.  $10$  mol% for the irradiated PE), and the contact angle of water for the PTFE and PE surfaces decreased to  $98^\circ$  and  $80^\circ$ , respectively. The relative patent time in canine peripheral veins reduced markedly with dose. The reduction in the antithrombogenicity of the irradiated surfaces is mainly due to the enhancement of platelet activation resulting from a decrease in hydrophobicity of the surfaces. (Edited author abstract) In Japanese. 28 refs.

Hayashi, Kazuko (Government Industrial Research Inst, Ikeda, Jpn); Fukumura, Hiroshi; Yoshikawa, Susumu; Yamamoto, Noboru; Sakai, Tetsuo; Yamashita, Iwao. *Kobunshi Ronbunshu* v 19 n 4 1987 p 917-924.

## Physical Properties

**083650 MELTING TEMPERATURE OF POLYTETRAFLUOROETHYLENE.** The equilibrium melting temperature of polytetrafluoroethylene (PTFE), i.e., the melting temperature of its most perfect crystals, is generally accepted to be  $327^\circ\text{C}$ . Using differential scanning calorimetry (DSC) at  $10^\circ\text{C min}^{-1}$ , the virgin (as-polymerized) PTFE exhibits a melting temperature ( $T_m$ ) of about  $342\pm 2^\circ\text{C}$ ; the corresponding  $T_m$  of a sintered PTFE (melt-crystallized) being  $328\pm 2^\circ\text{C}$ . This letter comments on the two melting temperatures of PTFE because the issue has not been addressed clearly in the literature. 5 Refs.

Khanna, Y.P. (Allied-Signal Inc, Morristown, NJ, USA). *J Mater Sci Lett* v 7 n 8 Aug 1988 p 817-818.

## Processing

**083651 OPTIMIZATION OF THE TECHNOLOGICAL PROCESS OF POLYTETRAFLUOROETHYLENE PROCESSING.** Section of the optimal technological process of processing of the polymer materials pre-determines the quality of the products and their operating characteristics. Using the method of mathematical experimental planning, the technological parameters of polytetra-



fluoroethylene processing are determined. The structure of the specimens is studied and their physicochemical properties are determined. As a result, the most optimal conditions are selected in order to obtain quality products. (Translated author abstract) In Russian. 7 refs.

Advianova, O.A.; Vionogradov, A.V.; Vol'pert, I.L.; Demidova, Yu.V. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 15 Aug 1987 p 95-100.

## Pyrolysis

**083652 DEPOLIMERYZACJA POLITETRAFLUOROETYLENU.** [Depolymerization of Polytetrafluoroethylene (PTFE)]. The results of studies on the process of PTFE pyrolysis as a method of Tarflen waste utilization are presented. (Tarflen is a Teflon-like material, produced at Nitrogen Works in Tarnow). Possible applications of reaction products are discussed. (Author abstract) In Polish. 5 refs.

Miesowicz, Halina. *Przem Chem* v 66 n 7 Jul 1987 p 333-335.

## Radiation Effects

**083653 TRANSIENT PHOTOCURRENTS ACCOMPANYING IRRADIATION OF CHARGED FILMS OF POLYTETRAFLUOROETHYLENE.** It was established experimentally that the transient photocurrents arising when PTFE films charged in a corona discharge are illuminated are reversible. It is shown that the transient current is of a thermal origin and is formed by the superposition of two oppositely directed components. The characteristics of the photocurrents are explained by the existence of internal polarization (heterocharge), arising in a strong field generated by the homocharge trapped on the surface, in the films. The existence of heterocharge in nonpolar films indicates that it is in principle possible to make stable electrets, in which the potential is maintained constant owing to slow self-consistent relaxation of the homo- and heterocharge. (Author abstract) 6 refs.

Fedosov, S.N. (M.V. Lomonosov Odessa Food Technology Inst, USSR); Sergeeva, A.E.; Motylinskaya, M.M. *Sov Phys J* v 30 n 9 Sep 1987 p 734-737.

**083654 RADIOTERMOLUMINESCENTA POLITETRAFLUORETILENEI.** [Radioluminescence of Polytetrafluoroethylene]. The radiotermoluminescence (RTL) of the polytetrafluoroethylene (PTFE) was studied in relation to the radiolytic modifications of the polymer. The nature of the traps implied in the RTL emissions, the luminescence centers and the activating energy for the molecular motions were established. A series of effects accompanying the radioinduced degradation of PTFE are presented as for instance: decrease of molecular mass, increase of density crystallinity, formation of peroxiradicals, decrease of melting point, a.s.o. (Author abstract). 44 Refs. In Romanian.

Jipa, Silviu (Inst de Cercetare Stiintifica, Bucharest, Rom); Ilie, Diana; Setnescu, Radu; Ilie, Sorin; Cazac, Constantin; Setnescu, Tanta; Radulescu, Calin; Paun, Jean; Mihalcea, Ion; Radulescu, Carmen. *Mater Plast Elastomeri Fibre Sint* v 25 n 1 Jan-Mar 1988 p 27-32.

## Reviews

**083655 PTFE: 50 YEARS OLD.** A historical review of polytetrafluoroethylene (PTFE), now known as 'Teflon,' is presented. The chemical, mechanical, and physical properties are reviewed.

Anon. *Aerosp Eng (Warrendale PA)* v 8 n 4 Apr 1988 p 31-34.

## Rheology

**083656 ELECTRO-OPTIC AND RHEOLOGICAL BEHAVIOUR OF AQUEOUS DISPERSIONS OF POLYTETRAFLUOROETHYLENE (PTFE) FIBRILS.** Electro-optic and rheological measurements were carried out on PTFE-fibrils. The crystalline fibrils had an axial

ratio of about 100 and a thickness of 200 Angstrom. The dispersions were stabilized by ionic perfluorosurfactants and could be kept for months without precipitation. The rotational diffusion constant of the fibrils was determined as a function of the volume fraction. Both electric birefringence and rheological measurements gave identical results for the orientation times. In the dilute and semidilute concentration range the rotational diffusion constant was the same and did not change at the overlap concentration. The shear modulus was found to increase in the semidilute concentration with the square of the volume fraction of the PTFE fibrils. (Edited author abstract) 21 refs.

Angel, M. (Univ Bayreuth, Bayreuth, West Ger); Hoffmann, H.; Huber, G.; Rehage, H. *Ber Bunsenges Phys Chem* v 92 n 1 Jan 1988 p 10-16.

**Surface Properties** See POWDERS—Surface Properties.

## Thermal Conductivity

**083657 THERMAL CONDUCTIVITY OF F-4 PTFE AT 5-310°K.** F-4 PTFE (polytetrafluoroethylene) belongs to the class of polymeric materials in which crystals are linked together by amorphous parts. Two phase transitions occur in F-4 PTFE: at 293 and 303°K. The thermal conductivity of PTFE has been examined with a standard system. Four specimens were examined made from a single batch of material. 3 refs.

Medvedev, V.A.; Sviridenko, V.I.; Rybkin, N.P.; Gorbunova, V.G. *Meas Tech* v 30 n 5 May 1987 p 459-460.

## Thermal Properties

**083658 THERMAL CHARACTERISTICS OF IRRADIATED POLYTETRAFLUOROETHYLENE.** This work investigates the influence of irradiation on the heat conductivity, density and linear thermal expansion coefficient  $\beta$  of PTFE to clarify the specifics of the action of such parameters as temperature of irradiation  $T_{rad}$ , the power of the absorbed dose  $P$  over a wide temperature range of measurement  $T_{meas}$  and absorbed doses and seeks to define the mechanism of the radiation changes for high radiation doses. A mechanism of the radiation changes in the properties of PTFE on the basis of analysis of the behavior of the crystalline and amorphous phases is proposed. (Edited author abstract) 16 refs.

Briskman, B.A. (Karpov Physicochemical Inst, USSR); Rozman, S.I. *Polym Sci USSR* v 28 n 6 1986 p 1388-1396.

## Thermodynamic Properties

**083659 HEAT CAPACITIES AND ENTROPIES OF LIQUID POLYFLUOROETHYLENES AND POLYCHLOROETHYLENES.** Heat capacities in the solid state for the homologous series of linear macromolecules consisting of polyethylene (PE), poly(vinyl fluoride) (PVF), poly(vinylidene fluoride) (PVF2), polytrifluoroethylene (P3FE), and polytetrafluoroethylene (PTFE), as well as poly(vinyl chloride) (PVC), poly(vinylidene chloride) (PVC2), and polychlorotrifluoroethylene (PC3FE) were recently analyzed by the authors. Prediction schemes for the heat capacity were based on the additive group vibrations and the mass-dependent  $\Theta$  temperatures of Tarasov approximations. In this research they continue this work and present data for the liquid state. Prior, extensive analyses were available only for liquid polyethylene and polytetrafluoroethylene. With heat capacities of solid and liquid states and transition parameters, it is possible to establish enthalpies, entropies, and Gibbs free energies over the whole temperature range. This establishment of thermodynamic functions is one of the main goals of ATHAS, laboratory of Advanced Thermal Analysis. 23 refs.

Loufakis, Kyriakos (Rensselaer Polytechnic Inst, Troy, NY, USA); Wunderlich, Bernhard. *J Polym Sci Part B* v 25 n 11 Nov 1987 p 2345-2354.

## Thin Films

**083660 INVESTIGATION OF PTFE TRANSFER FILMS BY INFRARED EMISSION SPECTROSCOPY AND PHASE-LOCKED ELLIPSOMETRY.** When a PTFE sheet was rubbed unidirectionally over a smooth surface of stainless steel, an essentially monomolecular transfer film was formed. By ellipsometric and emission infrared spectroscopic techniques it was shown that the film was 10 to 15 Angstrom thick and birefringent. From the intensity differences of infrared bands obtained with a polarizer passing radiation polarized in mutually perpendicular planes, it was possible to deduce transfer film orientation with the direction of rubbing. After standing in air for several weeks the transfer films apparently increased in thickness by as much as threefold. At the same time both the index of refraction and the absorption index decreased. Examination of the surfaces showed that the films had become porous and flaky. The coefficients of friction decreased with the formation of the transfer film but increased again as the film developed breaks. (Edited author abstract) 9 refs.

Lauer, James L. (Rensselaer Polytechnic Inst, Troy, NY, USA); Bunting, Bruce G.; Jones, William R. Jr. *NASA Tech Memo* 89844 1987 14p.

## Wear

**083661 MOLECULE STRUCTURE VARIATIONS IN FRICTION OF STAINLESS STEEL/PTFE AND ITS COMPOSITE.** The friction and wear characteristics of PTFE and one of its composites, JS material rubbing against stainless steel, were determined with a pin-disk tester in this study. The JS material is a multilayer composite composed of PTFE layer containing metal oxide and others, porous bronze layer, copper-plating layer and steel back. The submicroscopic features of frictional surfaces of stainless steel and JS materials were observed with an electron probe microanalyzer. The determination of JS material wear debris with electron spin resonance spectroscopy showed that polymeric radicals different in structure and stable in air existed. The authors consider that these PTFE molecule structure variations might be of benefit to the adhesion of PTFE transfer film to the rubbed stainless steel surface, which is important to improve the friction and wear performance of PTFE. (Edited author abstract) 14 refs.

Gao, Jintang (Chinese Acad of Sciences, China); Dang, Hongxin. *J Appl Polym Sci* v 36 n 1 Jun 20 1988 p 73-85.

**083662 CHANGES TO NEAR-SURFACE REGION OF PTFE DURING DRY SLIDING AGAINST STEEL.** PTFE specimens were slid against an EN24 disc. The unworn and worn surfaces as well as the wear debris were examined by X-ray diffraction. Sliding introduces shrinkage of the unit cell, enlargement of crystallites and residual stresses in the PTFE surface. No conformational changes in the 15<sub>2</sub> helix could be observed due to sliding. The wear debris was 1  $\mu$ m thick warped laminates. (Author abstract) 17 refs.

Biswas, S.K. (Indian Inst of Science, Bangalore, India); Vijayan, Kalyani. *J Mater Sci* v 23 n 5 May 1988 p 1877-1885.

**POLYURETHANES** See Also BIOMATERIALS; BRIDGES, HIGHWAY—Protective Coatings; COMPOSITE STRUCTURES; COMPOSITE STRUCTURES—Fire Resistance; ELASTOMERS—Heat Resisting; ENZYMES—Immobilization; INTERPENETRATING POLYMER NETWORKS—Curing; INTERPENETRATING POLYMER NETWORKS—Forming; PLASTICS, FOAMED—Molding; POLYIMIDES—Mechanical Properties; POLYMERIZATION—Reaction Kinetics; POLYMERS—Blending; POLYVINYL CHLORIDE; POLYVINYL CHLORIDE—Degradation; PROTECTIVE COATINGS; TEXTILE FIBERS—Synthesis; TEXTILE FIBERS—Synthetic.

**083663 EFFECT OF NETWORK CHAIN-LENGTH DISTRIBUTION, SPECIFICALLY BIMODALITY, ON STRAIN-INDUCED CRYSTALLIZATION.** Polyurethane elastomers were prepared from a series of



poly(ethylene oxide) samples by end-linking the chains into 'model' trifunctional networks. The molecular weight  $M_c$  between crosslinks in such networks is simply the number-average molecular weight  $M_n$  of the precursor polymer. End-linking samples separately gave networks with unimodal distributions of network chain lengths, whereas end-linking mixtures of two samples having very different values of  $M_n$  gave bimodal distributions with average values of  $M_c$  equal to the average value of  $M_n$  for the two samples. Stress-strain isotherms in elongation were obtained for these networks, both unswollen and swollen to various extents. Strain-induced crystallization was manifested in elastic properties that changed significantly with changes in temperature. (Edited author abstract) 24 refs.

Sun, C.-C. (Univ of Cincinnati, Cincinnati, OH, USA); Mark, J.E. *J Polym Sci Part B* v 25 n 10 Oct 1987 p 2073-2083.

**083664 HYDROFILN POLYURETAN-MOCOVINY PRO POROMERY - 1. CAST.** [Hydrophilic Polyurethane Ureas for Poromerics - 1]. The article describes the dependencies of the composition and structure of polyurethane ureas based on ethylene oxide/propylene oxide copolymers on their water vapor sorption. It is shown that the hydrophilic properties of polyurethanes to a certain degree depend on the ethylene oxide content of the copolymer, its location in the POX/EOX copolymer block, and on copolymer molecular weight. In Czech. 8 refs.

Petrik, Stanislav (Vyzkumny Ustav Gumarenske a Plastikarske Technologie, Gottwaldov, Czech); Hadobas, Frantisek; Karasek, Otakar. *Plasty Kauc* v 24 n 2 Feb 1987 p 38-41.

**083665 WATERBORNE RESINS.** The urethane chemistry to make polymers is based on the reactions of polyisocyanates with diols, in general. The advantages of the polyurethanes lie in their toughness and flexibility, and adhesion can be very good. They can be quite good in clears or pastel colors, when ambient air dried. Disadvantages may lie in their wetting of some substrates, but standard compounding (dispersant or surfactant additions) can alleviate this. ?

Athey, Robert D. Jr. (Athey Technologies, El Cerrito, CA, USA). *Met Finish* v 85 n 10 Oct 1987 p 61.

**083666 HIGH-EFFICIENCY FLAME RETARDANT FOR FLEXIBLE POLYURETHANE FOAM.** The halogenated ester, Firemaster 836, is a highly efficient flame-retardant additive for flexible polyurethane foam. Test results demonstrate its efficiency compared with other products, and the low levels required minimize adverse effects on foam physical properties. Developed specifically for flame-retarding foam for automotive interiors and furniture, it is a cost-effective alternative to flexible polyurethane foam formulations for meeting today's flammability-test requirements.

Honkomp, D. (Great Lakes Chemical, West Lafayette, IN, USA); Rose, R.; Hach, W.; Jay, T. *Plast Compd* v 11 n 1 Jan-Feb 1988 p 47-49.

**083667 FIFTY YEARS OF POLYURETHANE.** Polyurethane celebrated its 50th anniversary in November of 1987. Used extensively as a rigid foam in the construction industry, the patent issued to Bayer AG in 1937 is credited as the starting point for the development of this polymer. The article covers the history and applications of polyurethanes.

Anon. *Insul J (Rickmansworth Engl)* v 31 n 9 Dec 1987 p 22-24.

**083668 VERSATILITY OF IN-SITU POLYURETHANE FOAM.** The use of rigid, low density polyurethane foam for insulation purposes is widespread throughout the world with approximately one million tons of raw materials being sold for this purpose. The principal reasons for the continued growth of polyurethanes are insulation efficiency, ease and versatility of fabrication and long term ageing properties. The advantage of on-site

application is that it allows the insulation of non-regular surfaces as well as the facility to insulate areas where access is difficult, (particularly pipework and narrow cavities). The article highlights some of the important trends in in-situ foaming, covering both spray-applied and liquid-dispersed molecules.

Colvin, B.G. (British Urethane Form Contractors Assoc). *Insul J (Rickmansworth Engl)* v 31 n 9 Dec 1987 p 26-28.

**083669 ACTIVATION OF THE COMPLEMENT SYSTEM IN BLOOD ON THE SURFACE OF SEGMENTED POLYURETHANEUREA HAVING GOOD BLOOD COMPATIBILITY.** In this report, we employ segmented polyurethaneurea synthesized from the prepolymers whose oxyethylene-units contents are 0, 33, 62 mol% of oxytetramethylene units, as samples for the evaluation of complement activation ability in a *in vitro* complement system of human serum. The results are compared with their antithrombogenicities. These polyurethaneureas were shown to have good antithrombogenicity as well as good mechanical properties. 13 refs.

Ikeda, Yuko (Kyoto Inst of Technology, Kyoto, Jpn); Kohjiya, Shinzo; Yamashita, Shinzo; Fukumura, Hiroshi; Yoshikawa, Susumu. *Polym J* v 20 n 3 1988 p 273-276.

**Abrasion Resistance** See PIPELINES, STEEL—Lining.

## Additives

**083670 USE OF 2,6-TOLUENEDIISOCYANATE IN POLYURETHANE CAST ELASTOMERS.** A study of the use of 2,6-toluenediisocyanate (2,6-TDI) in polyurethanes was made by comparing polymers made with pure 2,6-TDI to an 80/20 isomeric blend of 2,4/2,6-TDI and to pure 2,4-TDI. Prepolymers were prepared using three different types of polyols [polybutylene adipate, polycaprolactone, and poly(oxytetramethylene glycol)] which were end-capped with the three TDI systems. In systems using the 2,6-TDI end-capped polyether, reactivity increased, but only small or insignificant changes were observed for hardness, moduli, elongation, tear resistance, and tear propagation resistance. The increases or decreases in properties due to 2,6-TDI can be attributed to the effects of the increased symmetry in the 2,6-TDI isomer compared to the 2,4-TDI. These effects may be made manifest via increased crystallinity and more efficient separation of the hard and soft segments in the polyurethane matrix. (Edited author abstract) 7 refs.

House, D.W. (Allied-Signal, Des Plaines, IL, USA); Baumann, W.M.; Scott, R.V. *J Elastomers Plast* v 19 n 4 Oct 1987 p 252-274.

**Adhesives** See Also WOOD PRODUCTS—Gluing.

**083671 POLYURETHANE-BASED SEALANTS MODIFIED BY BLENDING WITH KRAFT LIGNIN.** An investigation was conducted to establish the viability of blending Kraft lignin (L), a naturally occurring, readily available polymer resource, with polyurethane (PU) based sealants. The sealants were tested in a detailed program where lignin-sealant blends, having blend ratios varying between 0 and 20 pbw L, were prepared on substrates of aluminum, mortar, and wood, and subjected to laboratory control (C), artificial weathering (AW), and natural weathering (NW) conditions. Results of tension testing showed that generally, lignin acts as a reinforcing agent which adds rigidity to the polymeric matrix, as indicated by the increase in toughness and modulus of blended sealants with the addition of lignin. In addition, the curing mode of PU, as determined by sequence hardness testing, was modified with the addition of lignin. (Edited author abstract) 12 refs.

Feldman, D. (Concordia Univ, Montreal, Can); Lacasse, M.; Manley, R.St. J. *J Appl Polym Sci* v 35 n 1 Jan 1988 p 247-257.

**083672 WASSRIGE PUR-DISPERSIONEN.** [Aqueous PUR Dispersions]. As compared with solvent-containing polyurethane (PUR) elastomer adhesives, the use

of aqueous PUR ionomer dispersions produces a whole series of advantages. They offer a greater range of possible applications than water-soluble adhesives, since they exhibit excellent adhesive properties on a large number of substrates and they provide extremely high bond strength. PUR ionomer dispersions with improved properties may be expected in the future. (Edited author abstract). 3 Refs. In German.

Maempel, Lothar (BASF, West Ger). *Adhaesion* v 32 n 5 May 1988 p 14-18.

**Ageing** See ELASTOMERS—Mechanical Properties; ELASTOMERS—Thermodynamics.

**Applications** See Also ADHESIVES—Materials; AIR-CRAFT—Painting; ALUMINUM AND ALLOYS—Anodic Oxidation; ALUMINUM AND ALLOYS—Forming; ALUMINUM SHEET—Protective Coatings; COAL MINES AND MINING—Grouting; ELASTOMERS—Physical Properties; LEATHER—Tanning; MIRRORS—Focusing; PLASTICS, FOAMED—Painting; SCREENS AND SIEVES—Materials; SEALS—Materials.

**083673 PROGRESS IN POLYURETHANE ELASTOMERS.** Until recently a product made from a cast or injection moulded polyurethane has always been more expensive than a similar one made from a conventional rubber or plastic and hence its use was only justified by complicated long term cost-performance calculations. Whilst this remains the situation for most types of PUs, it is also now possible using the automated reaction injected molding (RIM) process to make products which are cost competitive with other rubbers and plastics and which also possess superior properties. Hence, especially in the automotive field PU usage is rapidly increasing. This review is organized into materials followed by application technology. (Edited author abstract) 44 refs.

Hepburn, Claude (Loughborough Univ of Technology, Loughborough, Engl). *Progr Rubber Plast Technol* v 3 n 3 1987 p 33-52.

**083674 EXTRACTION CAPACITY OF MACROCYCLIC POLYURETHANOURAES.** The extraction and complexing capacity of polyurethanoureas, containing macrocyclic dibenzo-18-crown-6 in the main chain, was studied. The extraction capacity of these polymers was determined, and extraction equilibrium constants were calculated. It was established that polyurethanoureas with macrocyclic ligands possess a higher complexing and extraction capacity for metal ions, in comparison with the initial dibenzo-18-crown-6. (Author abstract) 9 refs.

Veselov, V.Ya.; Zhurilo, A.A.; Grekov, A.P. *Sov Prog Chem* v 53 n 9 1987 p 103-105.

**083675 NEW DEVELOPMENTS IN ALIPHATIC POLYURETHANES.** Continued new developments have been made in the following areas of Light Stable Aliphatic Polyurethanes: (1) Film composites for optical applications, (2) Aliphatic polyurethane coatings and films, (3) Aliphatic Polyurethane adhesives for a variety of optical and non-optical applications, (4) Post curable hot-melt adhesive and film applications, (5) Novel medical applications for specialty aliphatic polyurethane elastomeric systems which have a vast potential in several medical use areas. A variety of aliphatic and pseudoaliphatic polyisocyanates have been employed to produce both coating films and elastomers having novel applications in a variety of technological areas. A variety of application methods have been explored to broaden the technological areas of elastomeric film formation for various end use applications. These areas cover a broad range of product application from preformed elastomeric film to moisture and chemically post-cured elastomers that cover the marketing potential that can be seen in each of the above technological areas. (Edited author abstract)

Gary, H.E. (K.J. Quinn & Co, Malden, MA, USA); Willwerth, L. *J Elastomers Plast* v 20 n 1 Jan 1988 p 46-53.



**083676 APPLICATIONS FOR POLYURETHANES: ADHESIVES, SEALANTS, BINDERS.** Polyurethane adhesives and sealants are used in a wide variety of applications, including shoes, laminating, moisture cure adhesives, structural bonding and hot melt urethanes. It is shown that polyurethane binding applications range from foundry binders to binders for wood, flexible urethane foam, rubber scraps, agricultural products and glass fibers. The authors indicate that as the chemistry and the materials available to the urethane industry continue to grow, new types of polymers for adhesives and sealant applications will be developed. The increase in laminates, the variety of plastics and the direction towards lighter weight structures act as a driving force for the expansion of urethane adhesives and sealants. The ability of urethanes to be molecularly engineered for specific applications and their compatibility with a great variety of polymers are major factors for the continued growth of urethane systems. 10 Refs.

Frisch, K.C. (Univ of Detroit, Detroit, MI, USA); Xiao, H.X.; Czerwinski, R.W. *Adhes Age* v 31 n 11 Oct 1988 p 27-29.

**Biocompatibility** See BIOMEDICAL EQUIPMENT—Pumps; PROSTHETICS—Blood Vessel Prostheses.

### Biodegradation

**083677 ANALYSIS OF IN VITRO ENZYMIC AND OXIDATIVE DEGRADATION OF POLYURETHANES.** In vitro biodegradation studies were performed to assess the long-term stability of poly(ether urethane) (PEU) implants. Three PEUs and one poly(ester urethane) were treated with enzymes characteristics of those released from inflammatory cells during the foreign body reaction. In addition, the effect of hydrogen peroxide was observed to examine oxidative degradation. Polymers were prepared as thin films on glass, gold, silver, and copper substrates to test the possibility of metal-catalyzed degradation. Molecular weights and polydispersities of the polymers were measured by gel permeation chromatography (GPC) before and after treatment. Changes in peak shape and location were also monitored. The results demonstrate that varying degrees of both enzymatic and oxidative degradation occurred. (Author abstract)

Ratner, B.D. (Univ of Washington, Seattle, WA, USA); Gladhill, K.W.; Horbett, T.A. *J Biomed Mater Res* v 22 n 6 Jun 1988 p 509-527.

### Blending

**083678 PREPARATION AND CHARACTERISTICS OF POLYURETHANE AND HALOGENATED POLYMER BLENDS FOR MULTI-FUNCTIONAL WETTING COAGULATING COATING.** Blends of a polyurethane elastomer and polyvinyl chloride or polyvinylidene fluoride were obtained through precipitation from DMF solvent. Studies on the compatibility of the blends were carried out using DSC, Rheovibron, infrared spectroscopy, SEM and TEM. The tensile properties and the thermal stability of these blends were investigated through the use of stress-strain curves and DAT-TG thermogram. The study also included coagulative behaviours in different coagulating conditions (temperature and composition of the coagulation bath). PU/PVC blends are compatible and can be made into porous films which possess high vapour permeability under certain conditions. However PU/PVDF blends are incompatible. (Author abstract). 11 Refs.

Zhou, Hong; Huang, Lihua. *J China Text Univ Engl Ed* v 5 n 1 Mar 1988 p 55-62.

**Casting** See Also ELASTOMERS.

**083679 ROYALCAST CASTABLE PLASTICS: A GROWTH OPPORTUNITY FOR THE POLYURETHANE CASTER.** Casting is a proven cost effective production method for satisfying certain part requirements (size, shape, quantity). Polyurethane casters generally have been limited by material and market opportunities to flexible applications. Now with the development of

castable plastics, such as Royalcast, the molder can also produce rigid parts. Thus, by utilizing existing equipment, casting expertise, and Royalcast, the polyurethane caster will be able to compete against metal and other rigid materials and enjoy new growth opportunities.

Zawacki, Chester A. (Uniroyal Chemical Co, Middlebury, CT, USA). *Elastomerics* v 120 n 4 Apr 1988 p 20-22.

### Chemical Analysis

**083680 FORMULATING POLYURETHANE ADHESIVES AND SEALANTS.** This article is the first in a series of two on polyurethane adhesives and sealants. In this segment, the authors discuss the formulation of polyurethanes. Raw materials are also covered, including isocyanates, polyols, chain extenders, catalysts, and solvents and additives. The authors also discuss one- and two-component adhesives and sealants.

Frisch, K.C. (Univ of Detroit, Detroit, MI, USA); Xiao, H.X.; Czerwinski, R.W. *Adhes Age* v 31 n 10 Sep 1988 p 8.

### Coatings

**083681 POLYURETHANE COATINGS FOR INTEGRATED OPTICS APPLICATIONS.** It is reported that optical waveguides can be fabricated using polymers based on polyurethane and the refractive index can be varied from 1.563 to 1.595 by changing the relative concentrations of various components. Coatings based on polyurethane were prepared by reacting a hydroxyl-terminated compound with an isocyanate resulting in a methane linkage. A large number of optical waveguides of various thicknesses were fabricated using these polyurethane coatings. An initial assessment of the quality of the waveguides was made by measuring the propagation losses in the films. The losses in the waveguides based on polyester were significantly higher than those based on acrylic polyol. 9 Refs.

Kapoor, S.K. (Defence Science Cent, Delhi, India); Pandey, C.D.; Joshi, J.C.; Dawar, A.L.; Tripathy, K.N.; Gupta, V.L. *Thin Solid Films* v 161 Jul 1988 P L79-L81.

### Combustion

**083682 REVIEW OF THE LITERATURE ON THE GASEOUS PRODUCTS AND TOXICITY GENERATED FROM THE PYROLYSIS AND COMBUSTION OF RIGID POLYURETHANE FOAMS.** The literature on rigid polyurethane foam has been reviewed with an emphasis on the gaseous products generated under various thermal decomposition conditions and the toxicity of those products. This review is limited to publications in English through 1984. Carbon monoxide (CO) and hydrogen cyanide (HCN) were the predominant toxicants found among more than a hundred other gaseous products. The generation of CO and HCN was found to increase with increasing combustion temperatures. Many test methods were used to assess the acute inhalation toxicity of combustion products from various rigid polyurethane foams. Lethality, incapacitation, physiological and biochemical parameters were employed as biological end points. In general, the combustion products generated from rigid polyurethane foam in the flaming mode appear to be more toxic than those produced in the non-flaming mode. (Edited author abstract) 84 refs.

Paabo, Maya (NBS, Gaithersburg, MD, USA); Levin, Barbara C. *Fire Mater* v 11 n 1 Mar 1987 p 1-29.

**Corrosion Resistance** See PROTECTIVE COATINGS—Performance.

### Crosslinking

**083683 CORRELATION OF MECHANICAL PROPERTY, CROSSLINK DENSITY AND THERMOGRAVIMETRIC BEHAVIOR OF CASTOR OIL POLYURETHANE-POLYSTYRENE DIVINYLBENZENE SIMULTANEOUS IPN NETWORKS.** Several simultaneous interpenetrating networks (IPN) of

castor oil polyurethane (COPUN) and polystyrene divinyl benzene (PSN) were synthesized under conditions where the free radical polymerization of styrene and the crosslinking reaction of castor oil and toluene diisocyanate progress at comparable rates. Comparison of the mechanical properties and crosslink density of the COPUN and COPUN/PSN-IPNs indicates a marginal increase in tensile strength and crosslink density from COPUN to 60COPUN/40 PSN IPN. IPN samples prepared with further increased PSN content show steady decrease in the above properties. This reversal of the expected trend was attributed to the possible greater molecular interpenetration achieved due to similar gelation times with resultant extension of chains and increase in free volume between crosslinks. This was further confirmed from thermogravimetric data on the initial stages of decomposition of the IPNs. (Author abstract) 17 refs.

Kumar, V.G. (Vikram Sarabhai Space Cent, Trivandrum, India); Rama Rao, M.; Guruprasad, T.R.; Rao, K.V.C. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1803-1815.

**083684 INTERPENETRATING POLYMER NETWORKS FROM CASTOR OIL-BASED-POLYURETHANES AND POLY(ETHYL ACRYLATE). VII.** Liquid prepolyurethanes were synthesized from castor oil and toluene-2,4-diisocyanate (TDI) under different experimental conditions and varying NCO/OH ratios. All these prepolyurethanes were subsequently reacted with ethyl acrylate/ethylene glycol dimethacrylate mixtures by radical polymerization using benzoyl peroxide as initiator to obtain interpenetrating polymer networks (IPNs) by transfer molding. The novel polyurethane/poly(ethyl acrylate) IPNs are found to be tough films. These IPNs are characterized in terms of their resistance to chemical reagents, thermal behavior (DSC, TGA), mechanical behavior including tensile strength, Young's modulus, and elongation. The dielectric properties, namely electrical conductivity, dielectric constant, dielectric loss, and loss tangent were computed. The mechanothermal behavior was analyzed by dynamic mechanical spectroscopy. The morphological behavior was studied by scanning electron microscopy. (Author abstract) 19 refs.

Patel, Mayur (Sardar Patel Univ, India); Suthar, Bhikhu. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 2037-2045.

**083685 EFFECTS OF CROSSLINKING ON THE DYNAMIC MECHANICAL PROPERTIES OF URETHANES.** The effects of crosslinking on a series of Solithane 113 urethane polymers was analyzed to determine how the material characteristics changed with respect to the glass transition temperature, glassy and rubbery modulus, and loss tangent. Two different sets of data were obtained. Data as a function of temperature were obtained from Polymer Laboratories DMTA and data as a function of frequency from a resonance apparatus crosslink density increases the glass transition temperature and increases the temperature of the peak loss factor density did not reduce the difference in the modulus between the glassy and rubbery regions and only a slight broadening of the loss factor curves was noted. 3 refs.

Madigosky, Walter M. (US Naval Surface Weapons Cent, Silver Spring, MD, USA). *Rubber World* v 196 n 6 Sep 1987 p 27-29.

**083686 DETERMINATION OF THE DEGREE OF CROSSLINKING IN POLYURETHANES BY REACTION ANALYSIS AND GAS CHROMATOGRAPHY.** The method for determination of the degree of crosslinking in the linear polyurethanes from TDI and oligo-(oxyethyleneoxypropylene)bisphenol-A is described. The method is based on selective reaction of imine groups contained in urethane and urea groups of polyurethane with trifluoroacetic anhydride. Resulting product reacts with aniline forming N-phenyltrifluoroacetamide. The amount of N-phenyltrifluoroacetamide is determined by gas chromatography. Basing on this, the content of secondary nitrogen atoms in polyurethane molecule is



calculated. The degree ( $\alpha$ ) of crosslinking is calculated basing on secondary nitrogen atoms content. (Edited author abstract) 6 refs.

Kusz, P.; Szweczyk, H.; Krol, P.; Latocha, Cz. *Kautsch Gummi Kunstst* v 41 n 1 Jan 1988 p 48-49.

## Curing

**083687 BI-CURING POLYURETHANES REACT WITH HEAT OR HUMIDITY.** Bi-curing polyurethane adhesives cure in the presence of heat and/or humidity. This article deals with the properties of and the processing conditions for these materials. The authors also explore applications for these products in the automotive industry. (Author abstract)

Ambrus, Zoltan (Sika Corp, Zurich, Switzerland); Zabel, Lutz. *Adhes Age* v 30 n 12 Nov 1987 p 36-37.

**083688 THREE TESTS TO IMPROVE POLYURETHANE-UREA CURING.** Unstable reactions in the cure of urethane-urea polymers can cause a fall-off in tensile strength and other properties over time. To anticipate and compensate for potential losses, the processor can test solvent absorption and viscosity and apply a new infrared (IR) analysis technique - thus improving quality and efficiency at the curing stage. Fourier transform infrared (FTIR) was used for rapid data acquisition to follow the cure of a polyurethane-urea at 110, 120, and 130°C for prolonged cure times. At the same time, identical samples were prepared and tested by chemical means to show the effects of the changing IR composition on the properties of the elastomer. A kinetic model was used to assign the majority of the more than 30 IR bands that were observed to change during cure. 6 refs.

Hergenrother, William (Firestone Tire & Rubber Co, USA); Cain, Roy. *Elastomerics* v 120 n 6 Jun 1988 p 34-37.

**Degradation** See PLASTICS, FOAMED—Thermal Effects; PROSTHETICS—Blood Vessel Prostheses.

## Dielectric Properties

**083689 ANALYSIS OF TEMPERATURE-DEPENDENT AC DIELECTRIC LOSS DATA.** The analysis of dielectric loss data is frequently complicated by the presence of ohmic conductivity, especially at lower frequencies. Two simple methods are discussed for locating transition temperatures and for determining activation energies in such cases. In the first method the permittivity derivative is used; in the second, permittivity difference spectra are used. The latter technique, however, cannot be used for activation energy determination. The theoretical basis of these methodologies and an analysis of representative experimental data are presented. The data set include measurements of pure and filled polyurethanes and of radiation-cured unsaturated polyester resins. (Edited author abstract) 14 refs.

Banhegyi, Gyorgy (Univ of Massachusetts, Amherst, MA, USA); Hedvig, Peter; Karasz, Frank E. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 679-693.

## Evaluation

**083690 DESMEARED, SLIT-SMEARED AND PROJECTED SAXS: A COMPARISON OF VARIOUS METHODS OF EVALUATION FOR SEGMENTED POLYURETHANES.** Evaluation methods for X-ray small angle scattering of segmented polyurethane elastomers are discussed using the assumption of isolated, randomly distributed hard segment domains in order to test the reliability of evaluation. Projection of the intensity distribution onto the meridian of the scattering diagram reduces the analysis to a one-dimensional problem. The projection has to be calculated in the three dimensional Fourier space either by desmeared the slit-smeared scattering intensity or by projecting it directly onto the meridian. Practically identical results are obtained by both procedures, so that the desmeared operation may be omitted in the present case. (Edited

author abstract) 15 refs.

Meyer, H. (Univ Regensburg, Regensburg, West Ger); Bonart, R. *Prog Colloid Polym Sci* v 71 1985 p 103-112.

## Extrusion

**083691 STUDY ON THE REACTIVE EXTRUSION PROCESS OF POLYURETHANE.** An engineering analysis of the reactive extrusion process of a thermoplastic polyurethane was made through numerical simulation and actual experiment. The reactants used in this system were 4,4'-diphenylmethane diisocyanate, polycaprolactone diol (M.W., 824), and 1,4-butanediol with equivalent weight ratio of 2:1:1. As a catalyst, dibutyltin dilaurate was used. The reaction kinetics and the viscosity function were obtained through experiments, and the mathematical model which includes the conservation equations of mass, momentum, energy, and chemical species was solved numerically to obtain the velocity, concentration, temperature, viscosity, and pressure profiles. The actual experiments were performed in the laboratory scale extruder to compare the experimental results with those of the numerical simulation. (Author abstract) 20 refs.

Hyun, M.E. (Korea Advanced Inst of Science & Technology, Seoul, Korea); Kim, S.C. *Polym Eng Sci* v 28 n 11 Mid-Jun 1988 p 743-757.

**Fabrication** See CELLULOSE DERIVATIVES—Manufacture.

## Fiber Reinforcement

**083692 NYLON FIBER REINFORCEMENT TO POLYURETHANE COMPOSITES.** The potential of a nylon 6 fiber was evaluated from composite applications involving rigid polyurethane systems. A study showed that the use of COMPET N, a nylon 6 based fiber surface treated to enhance wetout and adhesion, in an ISP polyurethane system results in composites with higher impact values and lower weight than those reinforced with glass fiber. A 2 percent loading of COMPET N matt increased impact values by more than 300 percent over an unreinforced control while a 3 percent loading of glass matt resulted in increases of less than 100 percent. A drop impact test showed COMPET N fabric reinforced composites to absorb twice as much energy as an unreinforced and glass reinforced composite without major damage. (Edited author abstract) 7 refs.

Cordova, C.W. (Allied Signal Corp, Petersburg, VA, USA); Young, J.A.; Rowan, H.H. *Polym Compos* v 8 n 4 Aug 1987, Pap Presented at the 1986 Annu Tech Conf of the Soc of Plast Eng, Boston, MA, USA, May 1986 p 253-255.

## Fillers

**083693 STUDIUM VLIVU PLNIV NA FYZIKALNI VLASTNOSTI POLYURETHANOVYCH SMESI.** [Investigation of the Effect of Fillers on Physical Properties of Polyurethane Compounds]. The possibilities of enhancing the service properties of polyurethane compositions used as substrate coatings are discussed. Procedures aimed at eliminating internal stresses in the polyurethane coats due to long relaxation of the polymeric material are analyzed and methods capable of improving the strength characteristics of polyurethane films are described. (Edited author abstract) In Czech. 3 refs.

Suchareva, L.A. (Lab Polymeru, Moscow, USSR); Terman, E.A. *Plasty Kauc* v 24 n 7 Jul 1987 p 193-196.

**083694 FINE COLLOIDAL SILICA AS REINFORCING FILLER IN POLYURETHANE POLYMERS.** Colloidal silica in the particle size range 1.4-10 nm was extracted into tetrahydrofuran (THF). Alkali silicate solutions with SiO<sub>2</sub>:M<sub>2</sub>O (M=Li,Na,K,Cs) ratios ranging from 3:1 to 20:1 were used as source of silica particles in the size range 1.4-4.4 nm whereas commercial silica sols were used for particles in the range 5-10 nm. Films of polyester- and polyether-based polyurethane-containing colloidal silica were prepared and their mechanical prop-

erties measured. The reinforcing effect increased with increasing silica content and showed a maximum between 1.5 and 2.5 nm for polyether-based polyurethane and between 4 and 6 nm for polyester-based polyurethane. The area under the hysteresis loops of the stress-strain curves also showed maximum in the same particle size ranges for the two types of polyurethane. Reinforcement mechanisms are discussed in terms of interactions between small particles and hard or soft segments of the polymer chains. (Author abstract) 8 refs.

Otterstedt, O.E. (Chalmers Univ of Technology, Goteborg, Sweden); Otterstedt, J.-E.A.; Ekdahl, J.; Backman, J.; Andersson, C.-H. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2575-2582.

## Flame Resistance

**083695 FLAME RETARDATION OF POLYURETHANES BY MEANS OF 1,4-BIS(DIALKOXYPHOSPHINYL)HYDROXYMETHYLBENZENE.** New phosphorus-containing homopolyurethanes were synthesized by reacting various diisocyanates such as tolylene diisocyanate, methylenebis(4-phenylisocyanate) and hexamethylene-1,6-diisocyanate with 1,4-bis(dialkoxyphosphinyl)hydroxymethylbenzene (BDAB). In addition, copolyurethanes containing approximately 3% phosphorus were prepared by copolymerization of these diisocyanates with an equimolar amount of BDAB-hydroquinone mixture. BDAB was less reactive towards diisocyanates than hydroquinone due to the electron-withdrawing inductive effect of the phosphinyl groups. The polymers synthesized were characterized by inherent viscosity measurements as well as by proton nuclear magnetic resonance (1H-NMR) and infrared (IR) spectroscopy. Differential thermal analysis (DTA) studies of polymers revealed that the incorporation of BDAB in polyurethanes altered their thermal decomposition mode by increasing the exothermicity due to pyrolysis. (Edited author abstract) 20 refs.

Mikroyannidis, John A. (Univ of Patras, Patras, Greece). *J Polym Sci Part A* v 26 n 3 Mar 1988 p 885-900.

## Flammability

**083696 COMPARTMENT TESTS OF POLYURETHANE FOAM SEATING ASSEMBLIES.** Data from compartment tests of polyurethane foam seating assemblies are reported. Results show that the behavior of such assemblies during fires is strongly dependent on the type and position of interliners and upholstery fabrics. An incidental comparison of peak rate of heat release obtained in a compartment test with a predictive model equation is made and selected data from the tests are presented. (Author abstract) 10 refs.

Zieherman, Joseph B. (IFT Technical Services Inc, Berkeley, CA, USA); Allard, Douglas L. *Fire Technol* v 24 n 2 May 1988 p 128-137.

**083697 SPOTLIGHT: THE FLAMMABILITY ISSUE.** The Flame Retardant Chemicals Assn. met last October in Monterey, Calif., to discuss progress in fire safety and developments in the flammability issue. Presentations were given on current regulations, testing technology, and new flame-retardant products. Speakers also addressed such subjects as public safety, flammability of specific products like polyurethane foam and plastic pipe, and flammability of textiles. Highlights of selected papers are presented here.

Anon. *Glass* v 11 n 2 Mar-Apr 1988 p 47-48.

## Foam

**083698 OPTIMIZED PROCESSING OF MICROCELLULAR POLYURETHANE SYSTEMS THROUGH CATALYST AND SURFACTANT TECHNOLOGY.** The paper entitled 'Novel Elastomeric Catalysts' presented at last year's SPI meeting in Reno, Nevada demonstrated substantial benefits in demold and extended cream for microcellular systems. This paper reviews the status of these catalysts and introduces additional process-



ing advantages for shoe soles identified through additives technology. The authors demonstrate how improved processing advantages can be achieved with the use of non-silicon surfactants. Several areas are investigated such as: improved flow, improved mixing and increased bonding of urethane to urethane. This paper demonstrates quality and productivity advantages through the use of fast cure catalyst in combination with an organic surfactant. (Edited author abstract)

Andrew, G.D. (Air Products & Chemicals Inc, Allentown, PA, USA); Smith, N.K. *J Elastomers Plast* v 19 n 3 Jul 1987 p 204-218.

**083699 APPLICATION OF RIGID POLYURETHANE INTEGRAL-SKIN FOAMS TO THERMAL INSULATING UNIT CASES FOR CAR AIR CONDITIONERS.** Integral-skin foams of rigid polyurethane are sandwich structures consisting of a core layer of closed cells enclosed in rigid surface layers on both sides. We examined the layer composition of integral-skin foam with the objective of maximum flexural strength, and then studied possibilities of reconciling the strength and thermal insulating properties in housings for evaporators in car air conditioners; i.e., unit cases. This examination showed that the most practical density range ( $250 \leq \rho(\text{all}) \leq 500 \text{ kg/m}^3$ ) provides vibratile resistance and thermal insulating properties. (Edited author abstract) 14 refs.

Gotoh, Masao (Hitachi Ltd, Yokohama, Jpn); Iida, Makoto; Waragai, Kenichi; Iijima, Kazumi. *Polym Eng Sci* v 27 n 17 Sep 1987 p 1323-1333.

**083700 DOWNWARD VERTICAL BURN APPARATUS - A NEW TOOL FOR EVALUATING IGNITION RESISTANT FLEXIBLE POLYURETHANE FOAM.** The Downward Vertical Burn Apparatus is an inexpensive, easily run flammability screening test for severe service foams. Simple evaluation procedures allow estimation of the effect of formulation changes on the burn properties across a broad span of fire development levels. Examination of various classes of foams have provided rankings of ignition resistance which in all cases parallels results from other standardized tests. Time required for DVBA data is approximately 1/10 required for ASTM E-906. Limited correlation data obtained from ASTM E-906 indicates that the heat release rate of foams evaluated at incrementally increased radiant flux conditions correlates with burn rate at incrementally increased oxygen levels on the DVBA. The correlation between DVBA and ASTM E-906 is insufficiently developed to calculate factors for interchanging data between the methods. 5 refs.

Parrish, D.B. (Dow Chemical Co, Freeport, TX, USA); Yorimoto, S.A.; Beal, G.E.; Chien, W.P. *J Cell Plast* v 23 n 3 May-Jun 1987 p 215-230.

**083701 POLYURETHANE FOAM IN THE NBS SMOKE CHAMBER: EFFECT OF VARIATION IN CONDITIONS AND FORMULATION.** A variety of flexible polyurethane foams were tested in the NBS Smoke Chamber over a range of incident radiant fluxes of 0.1 to 2.5  $\text{W/cm}^2$ . The effect of formulation variations on performance and the varying responses to changes in flux were determined. The determination of the dependence of the rate of smoke formation on irradiation conditions is suggested as a possible measure of smoke formation during the early stages of a developing fire. The rate of smoke development may be a more valid measure than total smoke. (Author abstract)

Stone, Herman (PMC Inc, West Hazleton, PA, USA); Poolinsky, Michael Jr.; Kapes, Mark. *J Cell Plast* v 23 n 4 Jul-Aug 1987 p 367-382.

**083702 PROMISE OF FOAMED-IN-PLACE URETHANES FOR INSULATING THE BUILDING ENVELOPE.** An assessment of foam-in-place cellular plastics has been carried out. As part of the study, current and potential uses of this type of material for insulating building envelope components was included. The paper discusses the various uses, current problem areas, and the research needs required to address these issues such that

foam-in-place materials can realize their full potential for this major application. (Author abstract) 10 refs.

Tye, R.P. (Dynatech Scientific Inc, Cambridge, MA, USA). *Plast Build Constr* v 10 n 10 1987 p 6-12.

**083703 STUDY OF THE CURING PROCESS GIVING THE RIGID POLYURETHANE FOAM BY DYNAMIC VISCOELASTIC METHOD.** Dynamic viscoelastic properties of the rigid polyurethane foam, which is used in Japan as a thermal insulator for refrigerators were studied during the curing process using the RDS-7700 Dynamic Spectrometer. The curing process, in which large volume expansion and heat evolution occurred, was easily analyzed by this method. It was found that the curing process proceeded through three stages. Curing behavior can be estimated from changes of rheological parameters during the curing. (Edited author abstract) 13 refs.

Nabata, Yoshiyuki (Wakayama Research Lab, Wakayama, Jpn); Mamada, Akira; Yamasaki, Harumasa. *J Appl Polym Sci* v 35 n 1 Jan 1988 p 155-166.

**083704 THERMOGRAVIMETRY OF POLYURETHANE-FOAMED PLASTICS.** Thermogravimetric comparison tests on foamed plastics based on polyether- and polyester-polyurethanes in two different laboratories show that thermogravimetry in combination with derivative thermogravimetry is suited for the characterization of these industrial products when values for the decomposition temperature of the main decomposition reaction (DTG-peak), the residue of thermal decomposition at 600°C and also the apparent activation energy of the main decomposition reaction are available in an exactly defined range of evaluation. In the evaluation of DTG-curves, the DTG-peaks could be correlated with specific structural characteristics of PUR-foamed plastics. (Edited author abstract) 7 refs.

Gross, H.; Knoll, G.; Sickfeld, J.; Neubert, D. *Kunstst Ger Plast* v 77 n 12 Dec 1987 p 23-26.

**083705 STRUCTURAL MODEL FOR AIR FLOW IN FLEXIBLE PUR FOAMS.** A new structural model based on the two term fluid flow equation of A.N. Gent and K.C. Rusch is described. The classical theory of flow through porous packed beds is used to relate the permeability and flow inertia coefficients to the average cell diameter, the tortuosity of the flow path and a skin friction coefficient. The model is used to predict how air flow is influenced by compression of the polyurethane (PUR) cellular matrix. Results of laboratory investigations are presented and compared with the model. For the most part good agreement is obtained for compressions up to about 60%. It is shown that the permeability is governed by cell size and the flow inertia parameter is governed by cell size, tortuosity and a roughness parameter. It is concluded from data obtained from crushed and uncrushed foams that the roughness parameter is strongly associated with cell membrane density. It is proposed that the experimental procedure can be used to quantify separately the effects of cell size and cell membranes. (Author abstract) 5 refs.

Hilyard, N.C. (Sheffield City Polytechnic, Sheffield, Engl); Collier, P. *Cell Polym* v 6 n 6 1987 p 9-26.

**083706 CARBIDE INTRODUCES NON-FLUOROCARBON FLEXIBLE URETHANE FOAM CHEMISTRY SYSTEM.** Union Carbide has introduced a new chemistry system for flexible polyurethane foam that can produce a wide variety of polyurethane foam grades without the use of chlorofluorocarbons (CFCs). The company claims it also offers improved performance in furniture, mattress, and automotive uses. The new Ultracel Intermediates are used to produce flexible foams that can be manufactured without the use of any auxiliary blowing agent such as CFCs or methylene chloride, the flexible foam industry's other key auxiliary blowing agent. Methylene chloride is under scrutiny as a suspected carcinogen. These foams also offer increased support, comfort, and durability over conventional grades of urethane foam commonly used in home furnishings.

Anon. *Rubber World* v 198 n 6 Sep 1988 p 12-13.

**Foams** See Also PLASTICS, FOAMED—Ignition.

**083707 WATER POLYURETHANE FOAMS.** The basic theory for the development of water repellent foams is related to two fundamental properties of the physical chemistry of the liquid state: the 'Wetting Law' and related contact angle; and the capillary rise or fall. Three new water repellent PU foams are surveyed, and their application fields are listed.

Kobayashi, S. (NHK Spring Co, Tokyo, Jpn); Zeegers, B. *J Cell Plast* v 24 n 1 Jan-Feb 1988 p 80-90.

**Forming**

**083708 SIDE REACTIONS IN THE FORMATION OF POLYURETHANES: MODEL REACTIONS BETWEEN PHENYLISOCYANATE AND 1-BUTANOL.** The following side reactions occurring in the formation of polyurethanes were modeled: a reaction of excess phenyl isocyanate either with 1-butanol in 1,4-dioxane and in bulk, or with n-butylphenyl urethane or water in dioxane catalyzed with dibutyltin dilaurate that leads to the formation of n-butyl- $\alpha,\gamma$ -diphenyl allophanate, N,N'-diphenylurea, and 1,3,5-triphenylbiuret. The reaction products were determined quantitatively by means of liquid chromatography. The rate and equilibrium constants were calculated at various temperatures and various initial ratios of functional groups. (Edited author abstract) 7 refs.

Spirkova, M. (Czechoslovak Acad of Sciences, Prague, Czech); Kubin, M.; Dusek, K. *J Macromol Sci Chem* v A24 n 10 Oct 1987 p 1151-1166.

**Glass Transition** See POLYURETHANES—Thermal Properties.

**Injection Molding**

**083709 EQUIPMENT FOR THE MANUFACTURE OF DENSE POLYURETHANE PRODUCTS.** Equipment has been developed, including equipment for heating raw materials, low-pressure molding equipment with an output of 0.2 to 10 kg/min for one- and two-stage fabrication of products made from polyurethane and based on polyethers and polyesters, and equipment for vulcanizing and hardening the products. The molding equipment consists of the following: units for storing the components; batching and mixing systems; units for degasification and drying; systems for thermostating and process control. The output of the molding equipment and the quality of the products very much depends on the efficiency of the processes of degasification, drying, batching, and mixing. Two types of rotary vulcanizers were developed for products of different weight. Both vulcanizers are in the form of a flat circular platform which is rotated by means of an electric motor. 3 refs.

Apanasenko, E.E. *Chem Pet Eng* v 22 n 11-12 Nov-Dec 1986 p 543-544.

**Ionic Conduction**

**083710 ION CONDUCTIVITY OF POLY(ETHYLENE OXIDE)-BASED POLYURETHANE NETWORKS CONTAINING ALKALI METAL SALTS.** Ion conductivity of poly(ethylene oxide) (PEO)-based polyurethane networks containing alkali metal salts has been investigated. Consequently, it has been revealed that the conductivity is dependent on the following parameters: lattice energy of the alkali metal salt, concentration of alkali metal salt, and the cross-linking density of the network polymer (which is a function both of the amount of cross-linking agent and the molecular weight of PEO). Under optimal conditions, the conductivity at ambient temperature corresponded to  $2.51 \times 10^{-5} \text{ Scm}^{-1}$ , which is greater than that of a typical alkali metal-PEO system by a factor of about  $10^2$  to  $10^3$ . Moreover, from the standpoint of the application to electrochromic displays (ECD), tensile bond strength between the polymer electrolytes and tungsten trioxide ( $\text{WO}_3$ ), which is the most promising electrochromic material, has been evaluated.



The bonding strength of the bond of  $WO_3$  with the present electrolyte has been found to be much larger than that of the alkali metal-PEO system. (Author abstract) 18 refs.

Tada, Hiroaki (Nippon Sheet Glass Co, Itami, Jpn); Fujino, Kozo; Kawahara, Hideo. *J Polym Sci Part A v 25 n 11 Nov 1987 p 3015-3024*.

**Manufacture** See Also FLOWMETERS—Design.

**083711 NEW NON-TOXIC REPLACEMENT FOR METHYLENE-BIS-o-CHLOROANILINE (MBOCA)-4,4'-METHYLENE-BIS-(3-CHLORO-2,6-DIETHYLANILINE)-(MCDEA).** The manufacture of polyurethanes using an aromatic diamine as a chain-extender or cross-linking agent is widely practiced. Although primary and secondary polyamines have been used, aromatic diamines and in particular 4,4'-methylene-bis-2-chloroaniline (MBOCA) are the most extensively used. With the use of MBOCA, it was possible to manufacture urethane elastomers with particularly good mechanical properties and with acceptable processing times. In general, many of the typical polyurethane elastomer formulations were tried, albeit on a small scale, but the products tended to work more or less as chain-linkers or cross-linkers for the elastomer systems. Three polymer systems were used for the comparative evaluation of these new chain extenders. 9 refs.

Voelker, Th. (Lonza Ltd, Basel, Switz); Balling, Peter. *J Elastomers Plast v 19 n 3 Jul 1987 p 219-230*.

**083712 FATE OF TDI AND MDI IN AIR, SOIL, AND WATER.** Toluene diisocyanate (TDI) and methylene diphenylene diisocyanate (MDI) are used in the production of polyurethanes. The International Isocyanate Institute, Inc. has sponsored a range of studies to determine the fate of TDI and MDI in air, soil and water. Studies of simulated atmospheric conditions indicate that TDI is destroyed predominantly by OH radicals, without the formation of toluene diamine (TDA). TDA or MDA (methylene dianiline), if generated in the atmosphere from any source, are also destroyed by OH radical attack, and no accumulation of these products is expected. In soil and water TDI and MDI are converted to polyureas, which are chemically inert, and which appear to cause no toxicological effects. (Edited author abstract) 36 refs.

Gilbert, D.S. (Int Isocyanate Inst Inc, Parsippany, NJ, USA). *J Cell Plast v 24 n 2 Mar-Apr 1988 p 178-192*.

**Mechanical Properties** See Also THERMOPLASTIC ELASTOMERS—Mechanical Properties.

**083713 DYNAMIC MECHANICAL BEHAVIOR AND STRUCTURE OF POLYURETHANEIMIDES.** Dynamic mechanical behavior and X-ray diffraction of two series of segmented polyurethaneimides (PUI) prepared either from poly(ethylene adipate) glycol (PEA), pyromellitic dianhydride (PMDA) and 4,4'-diphenylmethane diisocyanate (MDI), or from PEA, PMDA, and a mixture of 2,4- and 2,6-tolylene diisocyanate (TDI) were studied. All samples have a two-phase structure of the soft polyester (PE) phase and hard polyimide (PI) phase. PI microdomains containing MDI units are semicrystalline, whereas those with TDI are crystalline only at highest contents of TDI. The storage modulus  $E'$  increases with increasing fraction of the hard phase. The MDI-containing hard phase has a stronger effect on  $E'$  and also makes the plateau on the dependence of  $E'$  on temperature more pronounced. (Author abstract) 13 refs.

Masiulianis, B. (Czechoslovak Acad of Sciences, Prague, Czech); Hrouz, J.; Baldrian, J.; Ilavsky, M.; Dusek, K. *J Appl Polym Sci v 34 n 5 Oct 1987 p 1941-1951*.

**083714 EFFECT OF IONIC BONDING ON THE CONCENTRATION OF EFFECTIVE NETWORK CHAINS IN CROSSLINKED POLYURETHANE IONENES.** The phase separated structures of crosslinked polyurethane ionenes with different lengths of ionic segments were studied. The contributions of ionic bonds in the concentration of effective network chains,  $v_e/V$ , which were estimated from stress-strain measurements,

were separated from those of covalent bonds. A relation between the primary  $v_e/V$  and the degree of phase separation estimated from dynamic mechanical measurements was noticed. As the degree of phase separation increased, the primary  $v_e/V$  decreased in DBH series and increased in XDC series. These different trends in the primary  $v_e/V$  arise from the different sizes of ionic domains in the two series of polyurethane ionenes. (Edited author abstract) In Japanese. 6 refs.

Sasaki, Nobuyoshi (Kinki Univ, Iizuka, Jpn); Yokoyama, Tetsuo. *Kobunshi Ronbunshu v 19 n 4 1987 p 867-876*.

**083715 WPLYW WILGOCI NA WLASCIWOSCI TERMOPLASTYCZNYCH ELASTOMEROW URETANOWYCH W STANIE STOPIONYM.** [Effect of Moisture on the Properties of Thermoplastic Urethane Elastomers in Molten State]. The effect of water content on the degradation of thermoplastic urethane elastomers in molten state has been investigated. It has been found that humidity adsorbed by the granulate used in the injection molding catalytically accelerates polymer decomposition and considerably decreases its rheothermal stability, melt viscosity, molecular mass and deteriorates the mechanical properties of the product. It has been established that a safe processing of molten elastomers is possible, if water content of the granulate used for injection molding does not exceed 0.05% by weight. (Author abstract) In Polish. 18 refs.

Halasa, Eugeniusz (Politechnika Rzeszowska, Pol); Henczkowski, Maciej; Potopianek, Zygmunt. *Polimery v 32 n 10 Oct 1987 p 410-414*.

**083716 SUBSTRATE DEFORMATION STUDIES BY PHOTOELASTICITY IN SINGLE PARTICLE IMPACTS.** Dynamic photoelasticity methods have been used to study the substrate deformation in polyurethane rubber due to the impact of a 3 mm steel ball with a velocity of 50 m/s and at angles of 30° and 90°. The experimental set-up used a multiple-spark camera with an integral polariscope to visualize the dynamic stress field generated by the impact. The stress fields were photographed both in the plane of the impact as well as below it. The analysis of the data showed that the rate of propagation of the stress field was 198 m/s. A maximum strain rate of  $2.86 \times 10^3$  m/s was determined after a small time following the impact which also coincided with the time of maximum indentation. (Author abstract) 8 refs.

Naim, M. (Iowa State Univ, Ames, IA, USA); Bahadur, S. *J Elastomers Plast v 20 n 1 Jan 1988 p 10-20*.

**083717 MECHANICAL PROPERTY AND MORPHOLOGY OF POLYURETHANE-POLYACRYLONITRILE BLEND SYSTEM - A MECHANICAL MODEL INVESTIGATION.** In this paper, the mechanical property and morphology of a polyurethane-polyacrylonitrile blend system has been studied. A mechanical model with an empirical distribution function of volume fraction has been proposed. The distribution function is interpreted in terms of the blend morphology. The modulus composition relationship of the blend system can be described satisfactorily by our generalized parallel model. The interaction parameter has been calculated from the model parameters, which is well consistent with our another investigation on the PU-PAN blend system. (Author abstract). 16 Refs.

Sun, Tong; Chen, Dajun; Hanxin, Zhou. *J China Text Univ Engl Ed v 5 n 1 Mar 1988 p 1-7*.

**Medical Applications** See Also BIOMATERIALS—Plastics Applications.

**083718 POLYURETHANE MICROPOROUS MEMBRANES AS PERICARDIAL SUBSTITUTES.** Pericardial substitutes were prepared from stable and degradable segmented polyurethanes and/or polyurethane/polyhydroxybutyrate composites. Polyurethane membranes implanted as pericardial substitute in the rabbit, did not activate adhesion and epicardial reaction over 3 months. Polyurethane/polyhydroxybutyrate membranes induced minimal adhesion or epicardial reaction,

yet stimulated the growth of epithelium on the polymeric substrate and reduced the incidence of infection. (Author abstract) 25 refs.

Gogolewski, S. (Medinvent SA, Lausanne, Switz); Walpoth, B.; Rheiner, P. *Colloid Polym Sci v 265 n 11 Nov 1987 p 971-977*.

**Mixing** See ACETAL RESINS—Physical Properties.

**Modification**

**083719 EFFECT OF SMALL ADDITIONS OF AN ORGANOSILICON POLYISOCYANATE ON FORMATION AND PROPERTIES OF ESTER POLYURETHANES.** The effect of small additions (1, 3, 5%) of an organosilicon polyisocyanate on the formation process and properties of film-forming polyurethane systems based on oligoesters was investigated. It was shown that the addition of the organosilicon polyisocyanate in an amount of 1-5% leads to elasticization of polyurethanes, improvement of physicomechanical properties, and an increase in water and salt resistance of coatings, based on them. (Author abstract) 6 refs.

Kadurina, T.I.; Laskovenko, N.N. *Sov Prog Chem v 53 n 6 1987 p 108-111*.

**083720 POLYISOCYANURATE THERMOSET FOR STRUCTURAL RIM APPLICATIONS.** Polyisocyanurate modified polyurethanes have been recently used with preplaced mat reinforcement for structural RIM applications. However, some of the flow characteristics and the thermal properties of these systems resemble those of polyurethanes. ARCO Chemical has been active in developing a mat reinforced RIM system based upon a modified polyisocyanurate thermoset. This new system combines the excellent properties of thermal, chemical resistance associated with polyisocyanurates with a good balance of physical properties, low viscosities, excellent electrical properties and a good adhesion to reinforcing agents. This paper will discuss the chemistry and the properties of the system along with its application in the electronic and automotive industries and in markets currently served by epoxy resins. (Edited author abstract)

Younes, U.E. (ARCO, Newtown Square, PA, USA); Boesel, D.M. *J Cell Plast v 24 n 2 Mar-Apr 1988 p 164-177*.

**Molding**

**083721 METHODS FOR IN-MOULD COATING OF POLYURETHANE MOULDINGS FOR THE AUTOMOTIVE INDUSTRY.** The various methods of in-mould coating of polyurethane mouldings are described, and differentiated from one another according to end-use and layer thickness. Approximate specifications of painting and curing times have been arrived at from practical experience of the various manufacturing processes, and a tabular summary of their areas of application has been compiled. (Author abstract) 6 refs. In German and English.

Brix, H.; Schroeder, W. *Kunstst Ger Plast v 77 n 9 Sep 1987 p 4-7*.

**Morphology** See Also ELASTOMERS—Rheology; PLASTICS, FOAMED—Morphology.

**083722 DETERMINATION OF LAMELLAE IN SEGMENTED POLYURETHANES BY ELECTRON MICROSCOPY.** The morphology of segmented polyurethane was studied with an electron microscope. Polymers were obtained by the prepolymer method from poly(ethylene adipate), 4,4'-diphenylmethane diisocyanate and 1,4-butanediol. The unstrained sample showed spherulites with fibrillar structure. Attempts were made to enhance the contrast in order to study the fibrillar structure more thoroughly. The staining method used to study the structure of lamellae is described. (Author abstract) 44 refs.

Foks, J. (Technical Univ of Gdansk, Gdansk, Pol); Michler, G.; Nauman, I. *Polymer v 28 n 13 Dec 1987 p*



2195-2199.

**083723 MORPHOLOGY AND MECHANICAL PROPERTIES OF CROSSLINKED POLYURETHANE IONENES.** Crosslinked polyurethane ionenes with different lengths of ionene segments were prepared by using poly(oxytetramethylene) glycol ( $M_n=984$  and 2040) and 4,4'-diphenylmethane diisocyanate as starting materials. The morphology and mechanical properties were studied. The equimolar reaction of the isocyanate-terminated prepolymer with 2-dimethylaminoethanol in DMF yielded a multifunctional amino-terminated prepolymer containing isocyanurate groups as branching points. Therefore, the crosslinked polyurethane ionenes were obtained by the reaction of the amino-terminated prepolymers with dihalides: p-xylylenedichloride (XDC) and 1,6-dibromohexane (DBH). The ionene segment length was varied by adding N,N,N',N'-teramethylhexanediamine. (Edited author abstract) In Japanese. 8 refs.

Sasaki, Nobuyoshi (Kinki Univ, Iizuka, Jpn); Yokoyama, Tetsuo. *Kobunshi Ronbunshu* v 19 n 4 1987 p 857-865.

**083724 MORPHOLOGY OF BLOCK COPOLYURETHANES. III. EFFECT OF POLYETHER MOLECULAR WEIGHT ON THE MECHANICAL PROPERTIES OF SOLVENT CAST FILMS.** A homologous series of copolyether-urethane-ureas were synthesized with polypropylene glycol segments having molecular weights of approximately 200, 400, 700, 1000, 2000, and 3000. These copolymers were characterized using tensile measurements and dynamic mechanical spectroscopy. The dynamic mechanical measurements at low frequencies showed evidence of the existence of an  $\alpha$ -relaxation process. This was attributed to constrained polyether segments located at the interfacial region between the hard urea segments and the soft polypropylene glycol segments. (Edited author abstract) 10 refs.

Benson, R.S. (Univ of Utah, Salt Lake City, UT, USA); Lyman, D.J. *J Polym Sci Part A* v 26 n 5 May 1988 p 1393-1404.

## Photolysis

**083725 EFFECT OF CRYSTALLINITY AND FLEXIBILITY ON THE PHOTODEGRADATION OF POLYURETHANES.** Using fluorescence spectroscopy and gel content measurement, the photolysis of simple polyurethanes based on methylene 4,4'-diphenyl-diisocyanate (MDI) is shown to depend on both the flexibility and crystallinity of the polymer. Polyurethane films based on MDI and 1,12-dodecanediol (MDI-12) can be either annealed or quenched to yield a semicrystalline (as measured by DSC and X-ray diffraction) or amorphous film, respectively. In the case of the quenched film, photolysis yields an ortho photo-Fries product whereas the annealed film does not. Similarly, for a given photolysis time the annealed film generates a lower extent of crosslinked gel. In addition, photolysis of amorphous polyurethane films derived from MDI and ethylene oxide oligomers shows that for relatively inflexible polymers with only three ethylene oxide segments, little or no ortho photo-Fries rearrangement products are generated upon photolysis. (Edited author abstract) 18 refs.

Hoyle, Charles E. (Univ of Southern Mississippi, Hattiesburg, MS, USA); Kim, Kyu-Jun. *J Polym Sci Part A* v 25 n 10 Oct 1987 p 2631-2642.

**083726 EFFECT OF FLEXIBILITY ON THE PHOTODEGRADATION OF AROMATIC DIISOCYANATE-BASED POLYURETHANES.** The photolytic degradation of 2,4-TDI/aliphatic diol polyurethanes is directly dependent on the flexibility of the polymer backbone. The extent of photodegradation is accelerated above the glass transition temperature, indicating the role of chain flexibility and/or oxygen diffusion in the decomposition process. Photolysis of the model compound ethyl N-phenylcarbamate in neutral host polymer matrices indicates that the para photo-Fries to ortho photo-Fries product ratio experiences an accelerated increase with temperature above the glass transition of the polymer

matrix. (Edited author abstract) 23 refs.

Hoyle, Charles E. (Univ of Southern Mississippi, Hattiesburg, MS, USA); Chawla, C.P.; Kim, Kyu-Jun. *J Polym Sci Part A* v 26 n 5 May 1988 p 1295-1306.

**Physical Properties** See Also BIOPOLYMERS—Structure; ELASTOMERS—Chemistry; ELASTOMERS—Compounding; ELASTOMERS—Physical Properties; ROOFS—Protective Coatings.

**083727 WHAT POLYURETHANE? WHERE?** The chemical term polyurethane can apply to many different kinds of materials. There are the castable elastomers, which are the materials of primary importance in this discussion. There are foams, both rigid and flexible types. Rigid foams are used for applications such as insulation while flexible foams are used in upholstery and cushioning. These are each very large markets. Thermoplastic urethanes are materials which are fully reacted and processed by a melting and extrusion or injection molding procedure. Millable gums are handled in very much the same way as conventional rubber, that is, they are compounded with fillers and other ingredients, are processed on rubber machinery and are cured by vulcanization processes with peroxides or, in some cases, with sulfur. In this way the unique properties of urethanes can be achieved by the same methods used to process conventional rubbers. So what is essential, in terms of applications engineering, is to appraise each and then to select the particular polyurethane that meets the criteria of both economics and performance.

Fuest, Ronald W. (Uniroyal Chemical Co). *Rubber World* v 196 n 6 Sep 1987 p 21-22, 24-25, 50.

**083728 THERMAL AND DYNAMIC MECHANICAL PROPERTIES OF POLYURETHANEUREAS.** Measurements were made of the thermal and dynamic mechanical properties of 22 polyurethaneureas of varying diol molecular weight, type of aromatic chain extender, diol molecular weight distribution, and chain extender stoichiometry. The dynamic mechanical data, obtained as a function of temperature and frequency (in the kHz region), were used to construct master curves of shear modulus and loss factor over a wide range of reduced frequencies. Soft segment crystallization occurs at the higher diol molecular weights. Dynamic mechanical properties are well correlated with the soft segment glass transition. Diol molecular weight influences dynamic mechanical properties by affecting the degree of phase separation and hence glass transition temperature. (Edited author abstract) 15 refs.

Hartmann, Bruce (US Naval Surface Warfare Cent, Silver Spring, MD, USA); Duffy, James V.; Lee, Gilbert F.; Balizer, Edward. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1829-1852.

**083729 POLYURETHANE AND POLYISOCYANURATE RIGID BOARDSTOCK TECHNOLOGIES.** Given the global nature of urethane technology and markets, it is somewhat surprising that there exist such wide technology differences between the United States and European rigid boardstock industries. Catalyst technologies dramatically shifted as the U.S. industry incorporated aromatic polyester polyols at increasingly high levels. This paper will explore in detail, both from a marketing and technology perspective, the major factors which have contributed to this universal acceptance of these systems in the U.S. The situation in Europe is quite different; although aromatic polyester polyols are becoming more readily available, they still have not gained a significant penetration in the European market. (Edited author abstract)

Ricci, R.L. (Air Products & Chemicals Inc, Allentown, PA, USA); van der Heijden, B. *J Cell Plast* v 24 n 2 Mar-Apr 1988 p 109-119.

**083730 POLYURETHANE CATIONOMERS. I. STRUCTURE-PROPERTIES RELATIONSHIPS.** Polyurethane (PU) cationomers have been synthesized by quaternizing tertiary amine-containing linear polyurethanes using different quaternizers containing acid groups.

The effect of chemical structure of PU cationomers on the physical properties was studied. The mechanical properties of PU cationomers were improved by decreasing the molecular weight of poly(caprolactone) glycol, and increasing concentration of quaternary ammonium. Decreasing the carbon number in the alkyl group of the N-alkyl diethanol-amine chain-extenders, and using rigid symmetrical diisocyanates, improved the mechanical properties of the PU cationomers. The effects of these factors on the glass transition temperature of PU cationomers were also examined. The mechanical properties of the PU cationomers deteriorated when immersed in water and recovered after removal of the water. (Edited author abstract) 24 refs.

Al-Salah, H.A. (Univ of Detroit, Detroit, MI, USA); Xiao, H.X.; McLean, J.A. Jr.; Frisch, K.C. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1609-1620.

**083731 <sup>13</sup>C NMR OF POLYURETHANE IN THE SOLID STATE.** <sup>13</sup>C NMR spectra of bulk polyurethane samples are reported. Polyurethanes are block copolymers composed of hard and soft segments which often undergo microphase separation with the resultant formation of hard and soft domains. The hard domain component can be observed selectively by using high-power proton decoupling, cross polarization and magic angle spinning (MAS). The soft domain component can be observed selectively by using low-power proton decoupling and MAS. The <sup>13</sup>C NMR results show that one polyurethane sample has hard domains which are composed of hard segments, but the other sample does not have any hard domains. To confirm the <sup>13</sup>C NMR results, the morphology and properties of these samples were investigated by DSC, dynamic mechanical properties, stress-strain properties, pulsed NMR, WAXS, polarizing microscopy and TEM. (Edited author abstract) 10 refs. In Japanese.

Shibashi, Toru (Japan Synthetic Rubber Co, Kawasaki, Jpn); Kitazawa, Yoko; Arai, Koichi; Maekawa, Etsuji. *Kobunshi Ronbunshu* v 45 n 2 1988 p 147-153.

**Pressure Effects** See ELASTOMERS—Mechanical Properties.

## Processing

**083732 4,4'-METHYLENE-BIS(3-CHLORO-2,6-DIETHYLANILINE)-M-CDEA - A NEW CHAIN-EXTENDING AGENT FOR CAST PU-ELASTOMERS.** First developments of the use of 4,4'-Methylenebis-(3-chloro-2, 6-diethylaniline), abbreviated to M-CDEA, as a chain-extending agent were reported in October, 1986. In the current paper, the authors present a series of new findings on the relationship between the structure of this hexa-substituted methylene-bis-aniline and its effectiveness as a chain-extending agent for various cast PUR elastomers. Also discussed is information on the reactivity of M-CDEA, and on the visual, physical and in particular on dynamic properties of end products derived from M-CDEA. The presentation compares CDEA with commercially available amines used as curatives. (Author abstract) 9 refs.

Voelker, Th. (Lonza Ltd, Basel, Switz); Althaus, H.; Schmidt, A. *J Elastomers Plast* v 20 n 1 Jan 1988 p 36-45.

## Production

**083733 POLYURETHANES (PUR).** Since their discovery fifty years ago, polyurethanes have clearly demonstrated their versatility and ability to stimulate new areas of demand. Today, despite more modest growth prospects, the polyurethane industry is continuing the process of innovation both in terms of technology and markets. Following the outlook for polyurethanes by major segment, assess developments and implications in terms of polyurethane raw materials is reviewed and the structural changes which are taking place in the industry is described.

Mills, R. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 62-63.



**Reaction Injection Molding** See Also AUTOMOBILES—Bumpers; NYLON POLYMERS—Reaction Injection Molding; PLASTICS PRODUCTS—Mechanical Properties.

**083734 ADIABATIC REACTIVE VISCOMETRY FOR POLYURETHANE REACTION INJECTION MOLDING.** Adiabatic reactive rheometry involves the simultaneous measurement of viscosity and temperature changes during adiabatic polymerization. (Edited author abstract) 23 refs.

Blake, J.W. (Univ of Minnesota, Minneapolis, MN, USA); Yang, W.P.; Anderson, R.D.; Macosko, C.W. *Polym Eng Sci* v 27 n 16 Mid-Sep 1987 p 1236-1242.

**083735 AROMATIC DIOLS AS CHAIN EXTENDER IN PU REACTION MOLDING.** Polyurethane (PU) has outstanding properties, and has been applied in many fields. In general, it is prepared by the reaction of diisocyanate, polyol, chain extender, surfactant, catalyst, filler, reinforcement and blowing agent, etc. Most studies are based on the use of aliphatic chain extender such as 1,4-butanediol. The disadvantage is their low sag temperature. In this study, the aromatic diols such as bis(hydroxyethyl) terephthalate, bisphenol A and hydroquinone are used to replace aliphatic diols commonly used in the conventional PU recipe. Thus, formed products are characterized and their mechanical and thermal properties are investigated. Results show that the products have the better mechanical property and the outstanding thermal resistant property. (Edited author abstract) 6 refs.

Tong, S.N. (Industrial Technology Research Inst, Hsinchu, Taiwan); Tsai, S.R.; Lii, J.S.; Wu, P.T.K. *J Elastomers Plast* v 19 n 3 Jul 1987 p 188-203.

**083736 UNA CARROZZERIA DI POLIURETANO.** [Polyurethane Body for Cars]. Freedom of design, flexibility and productivity are the factors that mainly advocate the use of RIM and RRIM polyurethanes in the external components of the bodywork: an increase of 35% is expected by 1990. (Author abstract) In Italian.

Pontrandolfo, Pierfranco. *Mater Plast Elastomeri* n 11 Nov 1986 582-586.

**083737 POLYUREA HERALDS LATEST GENERATION OF RIM SYSTEMS.** Polyureas have been well known for years, but they are only now making their bid for recognition and acceptance as RIM (reaction injection molding) materials. Grades with a virtually limitless degree of versatility can be formulated, from soft elastomers to stiff, hard elastoplastics. Polyurea systems consist of polyether polyamines, diamine chain extenders such as DETDA, and MDI-based isocyanates. Note that polyurea RIM technology uses polyether polyamines instead of polyether polyols, and no catalysts. The implications of these two differences are discussed.

Dominguez, R.J.G. (Texaco Chemical Co, Austin, TX, USA); Rice, D.M.; Grigsby, R.A. *Plast Eng* v 43 n 11 Nov 1987 p 41-44.

**083738 RIM STRUCTURAL FOAMS IN THE EUROPEAN BUILDING INDUSTRY.** Since their introduction 18 years ago, building elements made of polyurethane RIM materials have been a great success in the European building industry. One of the main features of polyurethane reaction mixes as their excellent adhesion to a wide variety of materials like aluminum, steel, wood, and glass fiber reinforced plastics. This feature yields composite articles of two basic types. Polyurethane RIM materials are available in three basic types, with marked differences in their density and hardness. Two of the three types are reviewed in this paper.

Knipp, Ulrich (Bayer AG, Leverkusen, West Ger). *J Cell Plast* v 23 n 6 Nov-Dec 1987 p 540-554.

**083739 APPLICATION OF THERMAL METHODS IN THE CHARACTERIZATION OF POLY(URETHANE-UREA)S FORMED BY REACTION INJECTION MOULDING.** Differential scanning calorimetry (DSC) and dynamic mechanical thermal analysis

(DMTA) have been used in conjunction with tensile testing and transmission electron microscopy (TEM) to characterize novel segmented poly(urethane-urea) (PUU) network materials formed by reaction injection molding (RIM). The materials ranged from tough translucent elastomers to opaque brittle plastics depending on the chemical nature and weight fraction of the hard segments (HS). DSC and DMTA studies showed the PUU materials to be phase-separated; this was confirmed by TEM and tensile testing. (Edited author abstract) 16 refs.

Ryan, Anthony J. (UMIST, Manchester, Engl); Stanford, John L.; Still, Richard H. *Br Polym J* v 20 n 1 1988 p 77-83.

**083740 ASPECTS OF THE DESIGN OF RIM PLANTS FOR THE FUTURE.** Taking as starting point the state of the art reaction injection molding (RIM) technology and recent developments in raw materials, the development perspectives of this method of plastics processing are demonstrated - especially by comparison with injection molding. The requirements for RIM plants of the future are presented. Practical experience with the production of large surface area moldings in high precision steel molds on mold carriers with 2500 kN clamping force show that the predicted advances are actually feasible. (Edited author abstract)

Ruehmann, H.; Schaper, H. *IPE Int Ind Prod Eng* v 11 n 4 Dec 1987 p 23-24, 26, 28.

**083741 PRIM: EXPERIMENTAL STUDIES OF FLOW TRANSIENTS IN MIXHEADS.** The flow of polyol-glass fiber slurries and polymeric isocyanate reactants for polyurethane reinforced reaction injection molding (PRIM) has been studied under process conditions in high flow rate recirculation and static pre-pressurization mixheads, using a two stream computer controlled PRIM machine. Particular attention has been paid to sequence control in each mixhead and associated pressure transients at the start of the injection period. (Edited author abstract) 14 refs.

Coates, P.D. (Univ of Bradford, Bradford, Engl); Sivakumar, A.I.; Johnson, A.F. *Plast Rubber Process Appl* v 8 n 4 1987 p 203-213.

**083742 PRODUCTION, PROPERTIES, AND APPLICATION OF POLYURETHANE RRIM.** The production of automotive exterior body panels in the PUR-RRIM process is a comparatively new technology. For a better acceptance of RRIM moldings, cost reductions in the production process are necessary which, in turn, require noticeable progress in the material and process development. Due to the improvements made in the field of both raw materials and production units, the PUR-RRIM process has, in the last few years, become interesting also for high-volume production. A handicap in this connection is that the development of the RRIM process is, to a large extent, based on the practical experience of a few experts. A discussion is presented of problems relative to high-volume production. (Edited author abstract)

Braun, H.-J. (Inst for Polymer Testing & Polymer Science, Stuttgart, West Ger); Eyerer, P.; Frank, U.; Huettner, M.; Ludwig, H.-J.; Wurster, T. *Adv Polym Technol* v 8 n 1 1988 p 17-26.

**083743 IN-MOLD BONDING EXPANDS RIM'S VERSATILITY.** The ability of reaction injection molding (RIM) urethanes to exhibit high elongation and resilience, while retaining high modulus, makes them suited to a wide variety of applications. RIM's popularity is also in its rapid molding cycle, which permits high output rates to be achieved. RIM's growth has also been the recent ability to bond urethane to materials inserted in the mold such as glass, mounting plates, reinforcement members and metal parts. Recently, these new RIM urethane adhesives played an integral role in the development and success of modular, RIM-encapsulated stationary automobile windows.

Westley, Stephen A. (Lord Corp). *Rubber World* v 197 n 6 Mar 1988 p 12-13.

**083744 MOLDABILITY DIAGRAMS FOR THE REACTION INJECTION MOLDING OF A POLYURETHANE CROSSLINKING SYSTEM.** Moldability diagrams for the filling and curing stages of a RIM process are obtained based on a simplified engineering approach. The key process parameters chosen for the filling stage are initial material temperature and filling time. In the curing stage, the critical parameters are considered to be mold wall temperature and demold time. Experimental results obtained on a laboratory-scale RIM machine on a crosslinking polyurethane system are used to check the validity of the predicted molding areas. The agreement obtained is satisfactory considering the broad range of processing parameters used. (Edited author abstract) 28 refs.

Manas-Zloczower, I. (Univ of Minnesota, Minneapolis, MN, USA); Macosko, C.W. *Polym Eng Sci* v 28 n 19 MID-OCT; 1988 p 1219-1226.

**Reaction Kinetics** See POLYMERS—Reaction Kinetics.

**Rheology**

**083745 STOICHIOMETRY EFFECTS ON RHEOLOGY OF MODEL POLYURETHANES AT THE GEL POINT.** In this study the rheological behavior of PU gels with unbalanced stoichiometry is investigated. The variations of the two material parameters in eq 1, S and n, are followed over the entire range of stoichiometric ratios for which gelation can take place. The evolution of the rheological behavior at the GP as a function of the stoichiometric ratio,  $0.5 < r < 2$ , is presented. The authors emphasize that the results apply at the gel point of model cross-linking polymers at temperatures far above vitrification. The prepolymers consisted of large bifunctional molecules, however, with an initial molecular weight well below the critical mass for entanglements, and of small trifunctional cross-linker molecules. 21 refs.

Winter, H. Henning (Univ of Massachusetts, Amherst, MA, USA); Morganeli, Paul; Chambon, Francois. *Macromolecules* v 21 n 2 Feb 1988 p 532-535.

**Selection** See THERMOPLASTICS—Selection.

**Solutions** See Also NAPHTHALENE.

**083746 VISCOMETRIC AND CONDUCTIVITY STUDIES OF POLYURETHANE ANIONOMER SOLUTIONS.** Viscosity measurements of polyurethane anionomers were made in a number of solvents and mixed solvent systems at 25°C. At very low polymer concentration polyelectrolyte behavior was observed while at higher concentration ion-pair aggregation was noted in all cases. The metal ion, type of solvent and of polyol, and charge group concentration were varied to observe the effect on solution properties. These results show that the degree of dissociation of ion pairs depends on the polarity of the solvent and its solubility parameters. (Edited author abstract) 38 refs.

Al-Salah, H.A. (Univ of Detroit, Detroit, MI, USA); McLean, J.A. Jr.; Frisch, K.C.; Xiao, H.X. *J Macromol Sci Phys* v B26 n 4 Dec 1987 p 447-463.

**Spectroscopic Analysis** See Also ELASTOMERS—Spectroscopic Analysis.

**083747 SIMS AND XPS STUDIES OF POLYURETHANE SURFACES: 2. POLYURETHANES WITH FLUORINATED CHAIN EXTENDERS.** A series of fluorine-containing segmented poly(ether urethanes) and poly(ether urethane ureas), previously characterized by angular dependent x-ray photoelectron spectroscopy (XPS) have been re-examined using static secondary ion mass spectroscopy (SIMS). Comparison of the data from the two techniques has shown that the intensity of secondary ion signals which characterize the hard and soft segments can be used quantitatively for direct analysis of the molecular composition at the surface. Moreover, the SIMS sampling depth for the conditions used has been shown to be approximately 10 Å, significantly less than



the XPS sampling depth under normal conditions, and similar to the XPS sampling depth at high glancing take-off angle (with respect to the surface normal). (Author abstract) 16 refs.

Hearn, M.J. (ICI, Middlesbrough, Engl); Briggs, D.; Yoon, S.C.; Ratner, B.D. *Surf Interface Anal* v 10 n 8 Oct 1987 p 384-391.

**083748 INFRARED SPECTROSCOPY AND X-RAY STUDIES OF MODEL ALIPHATIC URETHANES.** Based on the identity of the IR spectra of crystalline aliphatic polyurethanes and low MW diurethanes, the latter were chosen as models for fragments of the polymer chain. A full X-ray structural study was made of hexamethylene-1, 6-bis-decylurethane and of hexamethylene-1, 6-bis-ethylurethane. The relationship of the bands in the IR spectra of the polyurethanes was defined more precisely. (Author abstract) 10 refs.

Atovmyan, Ye.G. (USSR Acad of Sciences, USSR); Alimova, L.L.; Filipenko, O.S. *Polym Sci USSR* v 28 n 9 1986 p 2115-2121.

**083749 QUANTITATIVE DETERMINATION OF ABSORBED WATER IN CO(POLYETHER) POLYURETHANE MEMBRANES USING FT-IR/ATR.** The authors used attenuated total reflectance FT-IR spectroscopy to quantitatively correlate absorbed water in a series of membranes with band area, following appropriate subtraction and normalization. The FT-IR data were compared with data obtained gravimetrically. The membrane series studied consisted of co(polyether) polyurethane polymers synthesized from hydrophilic polyethylene glycol (PEG) 600, 1000, or 1540 blocks and hydrophobic urethane segments. In addition to providing information about water content of membranes, the spectra also yield information which permits some conclusions to be drawn concerning the nature of the water absorbed in the polymers. 15 refs.

Hartauer, K.J. (Univ of Iowa, Iowa City, IA, USA); Matheson, L.E.; Guillery, J.K. *Appl Spectrosc* v 42 n 4 May-Jun 1988 p 699-701.

## Spectrum Analysis

**083750 INFRARED SPECTRAL STUDY ON THE HEAT CURING REACTION OF GLYCERIN-TERMINATED URETHANE PREPOLYMERS.** Glycerin, toluene diisocyanate (TDI), and polyglycol (PG) were reacted at various molar ratios to produce glycerin-terminated urethane prepolymers of different molecular weights. The prepolymers were mixed with equivalent phenol-blocked trimethylol propane-TDI-urethane triisocyanate in m-cresol to give a coating solution. The solution was coated and baked to give polyurethane crosslinked films. The changes of the functional groups during the crosslinking reaction and the mechanical properties of the polyurethane crosslinked films were studied. (Edited author abstract) 6 refs.

Yang, Chin-Ping (Tatung Inst of Technology, Taipei, Taiwan); Lee, Lung-Ta. *J Appl Polym Sci* v 35 n 2 Feb 5 1988 p 449-464.

**Stabilizers** See POLYMERS—Nitration.

**Structure** See Also BLOCK COPOLYMERS—X-Ray Analysis.

**083751 DETERMINATION OF THE STRUCTURE AND COMPOSITION OF CLINICALLY IMPORTANT POLYURETHANES BY MASS SPECTROMETRIC TECHNIQUES.** Curie-point pyrolysis mass spectrometry (Py-MS) and direct probe pyrolysis high resolution mass spectrometry (Py-HRMS) were used to identify the components and additives used in the synthesis and compounding of Biomer, Lycra Spandex, Tecoflex, and Pellethane. Two types of Biomer were identified (P and Q, our notation) which are composed of poly(tetramethylene glycol) (PTMG) capped with 4,4'-methylenebis(phenylisocyanate) (MDI) and chain-extended with ethylenediamine (EDA). Both forms contain

4,4'-butylidene-bis-(6-t-butyl-m-cresol) antioxidant, and Biomer Q also contains an additive which appears to be a quaternary ammonium chloride salt. Lycra Spandex was found to be identical to Biomer Q, with the exception that a low molecular weight polydimethylsiloxane oil is also present. Tecoflex (type SG80A) is composed of PTMG capped with 4,4'-diisocyanatodicyclohexylmethane and extended with 1,4-butanediol (BD). An industrial grade and a medical grade of Pellethane were analyzed. Both were composed of PTMG capped with MDI and extended with 1,4-butanediol. The industrial grade also contains an antioxidant, possibly butylated diphenylamine. (Edited author abstract) 18 refs.

Richards, Joseph M. (Univ of Utah, Salt Lake City, UT, USA); McClennen, William H.; Meuzelaar, Henk L.C.; Shookcor, John P.; Lattimer, Robert P. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1967-1975.

**083752 INITIATION OF MICROPHASE SEPARATION IN SEGMENTED POLYURETHANES/EMICARBAZIDES.** An investigation has been made of ionometric polyurethanes/emicarbazides containing quaternary halide (Cl, Br, I) pyridinium salts, used as chain elongators of the rigid blocks. It has been shown by use of a number of methods (low-angle X-ray diffraction, DSC etc.) that the polarity and electronegativity of the counter-ion is the predominant part in the processes of microphase separation and, consequently, in determining the properties of this series of polymers. A formula to determine the degree of heterogeneity of the segmented polyurethanes is put forward on the basis of the results obtained by differential scanning calorimetry. (Edited author abstract) 20 refs.

Vilenskii, V.A. (USSR Acad of Sciences, USSR); Kercha, Yu.Yu.; Lipatov, Yu.S.; Shtompel, V.I.; Shrubovich, V.A.; Shevchenko, V.V. *Polym Sci USSR* v 28 n 6 1986 p 1403-1411.

**083753 STRUCTURE AND MORPHOLOGY OF SEGMENTED POLYURETHANES: 4. DOMAIN STRUCTURES OF DIFFERENT SCALES AND THE COMPOSITION HETEROGENEITY OF THE POLYMERS.** The morphology of polybutadiene containing polyurethanes has been studied by using small-angle light scattering (SALS), small-angle X-ray scattering (SAXS), phase contrast microscopy and electron microscopy. Domain structures having sizes of 1000, 100 and 10 nm are observed within these samples and are explained as the results of segregation on the molecular level, subchain level and segmental level, respectively. These phenomena are related to the molecular heterogeneity in chemical composition and average hard segment length. It has been found that because of the analogy in molecular structure with SBS block copolymers, segmented polyurethanes may form microdomains of soft and hard segments with more or less uniform size and regular arrangements in space. (Author abstract) 26 refs.

Xu, M. (Univ of Massachusetts, Amherst, MA, USA); MacKnight, W.J.; Chen-Tsai, C.H.Y.; Thomas, E.L. *Polymer* v 28 n 13 Dec 1987 p 2183-2189.

**083754 STRUCTURE OF SUCCESSIVELY CURED INTERPENETRATING POLYMER NETWORKS IN RELATION TO THE CROSSLINK DENSITY OF THE PENETRATING COMPONENT.** Structural features of successively cured interpenetrating networks composed of polyurethane (PU) and of poly (methyl methacrylate) (PMMA) of varying crosslink density were studied by wide-angle and small-angle X-ray methods. It was found that the degree of phase separation of the studied network components is largely determined by the crosslink density of the penetrating component. An increase in the crosslink density of the penetrating network leads to increased incompatibility, but a sharp decrease in the mobility of the more strongly branched segments of the network structure increases the probability of entanglements between the fragments of the matrix and of the penetrating network, resulting in the persistence of a certain degree of PU and PMMA chain interpenetration in the resulting material. (Author abstract) 12 refs.

Shilov, V.V. (Acad of Sciences of the Ukrainian SSR, USSR); Lipatov, S.Yu.; Gomza, Yu.P.; Matiushov, V.F. *Polym Sci USSR* v 28 n 8 1986 p 1970-1976.

**083755 ASPECTS OF THE EFFECT OF AEROSIL ON THE STRUCTURE AND PROPERTIES OF FILLED NETWORK POLYURETHANES.** The structure and properties of network PUs based on polyoxypropylene glycol, trimethylolpropane and toluylene-2,4- or diphenylmethane-4,4'-diisocyanate cured in presence of different amounts of Aerosil have been studied. The possibility of evaluating the contribution of the two types of specific bonds to the network structure of filled PUs is demonstrated. Aerosil has a fundamentally different influence on the formation of the network structure of polymers obtained from diisocyanates of symmetrical and non-symmetrical structure, reflected in the values of the effective density of the PU cross link. (Author abstract). 18 Refs.

Lipatova, T.E. (UkrSSR Acad of Sciences, USSR); Sheinina, L.S.; Yvldimirova, L. Yu.; Maslak, Yu. V. *Polym Sci USSR* v 29 n 4 1987 p 828-834.

**Synthesis** See Also BLOCK COPOLYMERS—Synthesis; INTERPENETRATING POLYMER NETWORKS—Synthesis; IONOMERS—Synthesis.

**083756 REDUCTIVE CARBONYLATION OF NITROAROMATIC COMPOUNDS TO URETHANES CATALYZED BY [Pd(1,10-PHENANTHROLINE)<sub>2</sub>][PF<sub>6</sub>]<sub>2</sub> AND RELATED COMPLEXES.** Pd(II) complexes with 1,10-phenanthroline (phen) derivatives of general formula [Pd(chel)<sub>2</sub>][PF<sub>6</sub>]<sub>2</sub> (chel = phen, 4,7Me<sub>2</sub>-phen, 4,7Ph<sub>2</sub>-phen, 3,4,7,8Me<sub>4</sub>-phen (TMphen), 4,7(MeO)<sub>2</sub>-phen) show high activity and selectivity in the catalytic synthesis of aromatic urethanes under relatively mild reaction conditions and without any added cocatalyst. Various trends have been studied with the aim to improve the efficiency of the system and to shed light on the nature of the catalyst. (Author abstract) 31 refs.

Bontempi, A. (Univ di Trieste, Trieste, Italy); Alessio, E.; Chanos, G.; Mestroni, G. *J Mol Catal* v 42 n 1 Sep 1987 p 67-80.

**083757 EFFECTS OF DIFFERENT POLYOL-TERMINATED URETHANE PREPOLYMERS ON THE PROPERTIES OF THEIR CORRESPONDING CROSSLINKED FILMS.** Polyglycols (PG) and toluene diisocyanate (TDI) were reacted at various molar ratios to produce isocyanate-terminated polyurethanes and were then reacted with glycerine, pentaerythritol (PE), or trimethylol propane (TMP) to produce hydroxyl-terminated urethane prepolymers of different molecular weights. These prepolymers were mixed with an equivalent amount of blocked isocyanate in a mixture of m-cresol and naphtha to give the varnishes. Pretreated copper wires were coated and baked to give polyurethane coated magnet wires. The mechanical properties of the polyurethane crosslinked films, the change of functional groups during the crosslinking reaction, and the properties of magnet wires coated with polyurethane varnishes are discussed. (Author abstract) 23 refs.

Yang, Chin-Ping (Tatung Inst of Technology, Taipei, Taiwan); Lee, Lung-Ta. *J Coat Technol* v 59 n 753 Oct 1987 p 61-69.

**083758 MOLECULAR MASS DISTRIBUTION OF POLYURETHANES OBTAINED FROM OLIGOMERS, LINK OF THE FUNCTIONS OF THE MOLECULAR MASS DISTRIBUTION OF THE STARTING AND END PRODUCTS.** The paper examines the influence of the MD function of the initial hydroxyl-containing oligomers and the conditions of the process on the MD functions of linear PU obtained from oligomers and diisocyanates. The numerical functions of the MD of polyurethanes measured experimentally by the GPC method are compared with those calculated theoretically



taking into account the MD and the functionality type distribution (FTD) of the initial oligomers. (Author abstract) 8 refs.

Romanov, A.K. (USSR Acad of Sciences, USSR); Yevreinov, V.V.; Entelis, S.G. *Polym Sci USSR* v 28 n 6 1986 p 1381-1387.

**083759 LIQUID CRYSTALLINE POLYURETHANE. POLYURETHANES CONTAINING BIS-(p-OXYMETHYLPHENYL) TEREPHTHALATE.** Several polyurethanes based on bis-(p-oxy-methylphenyl) terephthalate (BOPT) were synthesized and studied with respect to some of their thermal properties. BOPT exhibits a mesomorphic phase at 252-264°C. Polymerization was carried out by equimolar reaction with hexamethylene diisocyanate (HDI), 4,4-dicyclohexylmethane diisocyanate ( $H_{12}$ MDI),  $\alpha,\alpha'$ -diisocyanate-1,3-dimethylcyclohexane ( $H_{12}$ XDI), 4,4'-diphenylmethane diisocyanate (MDI), 2,4-tolylene diisocyanate (TDI), and phenylene diisocyanate (PDI). (Edited author abstract) 3 refs.

Tanaka, Mamoru (Kobe City Technical Coll, Kobe, Jpn); Nakaya, Tadao. *J Macromol Sci Chem* v A24 n 7 1987 p 777-785.

**083760 SYNTHESIS OF POLYURETHANES CONTAINING NUCLEIC ACID BASE DERIVATIVES AS GRAFTED PENDANTS AND THEIR PRECURSOR AMINO FUNCTIONALIZED POLYURETHANE.** A new route to polyurethanes containing nucleic acid base derivatives as grafted pendants have been established. The method is based on the grafting of 2-(thymine-1-yl)propionic acid (TPA) or 2-(adenine-9-yl)propionic acid (APA), onto amino functionalized polyurethane, poly[2-amino-2-methyl-1,3-propylene methylene bis(4-phenyl carbamate)] (PU-NH<sub>2</sub>, IX) at the primary amino group by the N-hydroxy compound of active ester technique. Two novel polymer models of polynucleic acid - poly[2-(2'-(thymine-1'-yl)propionamide)-2-methyl-1,3-propylene methylene bis(4-phenyl carbamate)] (PU-NHT, X) and poly[2-(2'-(adenine-9'-yl)propionamide)-2-methyl-1,3-propylene methylene bis(4-phenyl carbamate)] (PU-NHA-40, XI) - were obtained. Prior to polymer synthesis, the amidation of APA with 3-aminoheptane or diethylamine were carried out as a model reaction study and the related monomer model compounds were prepared by the same methods. (Edited author abstract) 17 refs.

Lu, C.X. (Peking Univ, Beijing, China); Yang, Yang; Xiao, Chaodong; Ji, Aixue. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3267-3281.

**083761 POLYESTER POLYOLS FOR POLYURETHANES FROM PET WASTE: KINETICS OF POLYCONDENSATION.** The kinetics of polyesterification of the glycolized PET waste with adipic acid is reported. Glycolysis of PET waste was carried out with ethylene glycol at three different ratios of PET waste to glycol. The glycolized products could be readily polyesterified by reacting with adipic acid, to give polyester polyols with low acid number. The kinetic results of the polyesterification of glycolized PET waste are compared to the polyesterification of pur diols, namely ethylene glycol and bis(hydroxyethyl) terephthalate (BHET) with adipic acid. The reactions follow second-order kinetics at 170°C and the rate of polyesterification of the mixed diol system from PET waste lies intermediate between those of the pure diols, namely, EG and BHET. Ethylene glycol exhibited the highest reactivity. At 200°C the kinetic plots of the mixed diols from PET waste were nonlinear, and thus the reaction may not follow second-order kinetics. The nonlinearity is explained in terms of the different reactivities of the different diol species in the reaction mixture. The polyester polyols, when cured with polymeric 4,4'-diphenyl methane diisocyanates, gave polyurethane rigid foams and elastomers. (Edited author abstract) 7 refs.

Vaidya, U.R. (Nat'l Chemical Lab, Poona, India); Nadkarni, V.M. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 775-785.

**083762 INTERPENETRATING POLYMER NETWORKS BASED ON CASTOR OIL IX.** Crosslinked polyurethane were obtained when trifunctional -OH group containing castor oil was reacted with difunctional toluene-2,4-diisocyanate under different stoichiometric conditions varying NCO/OH ratio. These polyurethanes swelled in n-butyl acrylate monomer and subsequently polymerized by radical polymerization initiated with benzoyl peroxide in presence of crosslinking agent ethylene glycol dimethacrylate. A series of interpenetrating networks, PU/PnBA IPNs, were obtained as tough films by transfer molding. All these IPNs films were characterized by resistance to chemical reagents, thermal behavior (DSC, TG), and mechanical studies such as tensile strength, Young's modulus, elongation at break (%) and hardness shore A. (Edited author abstract) 31 refs.

Patel, Mayur (Sardar Patel Univ, Gujarat, India); Suthar, Bhikhu. *Polym J* v 20 n 1 1988 p 1-8.

**083763 NUCLEIC ACID BASE GRAFTED IMINO POLYURETHANE.** Preparation of two model polymers of polynucleotides with linear polyurethane backbone and 2-(thymine-1-yl)propionyl or 2-(uracil-1-yl)propionyl group as grafted pendant are described. 2-(Thymine-1-yl)propionic acid (TPA) and 2-(uracil-1-yl)propionic acid (UPA) were grafted into partial imino functionalized polyurethane, poly[ $\beta,\beta'$ -diethylene]amine methylene bis(4-phenyl carbamate)-75 (PU-NH-75), at the secondary amino group through amide bonds with 1-hydroxybenzotriazole (HOBT) using the active ester technique. Two novel polymer models of polynucleotides, poly[(N-(2-thymine-1-yl)propionyl)- $\beta,\beta'$ -diethylene]amine methylene bis(4-phenyl carbamate)-75 (PU-NU-75) and poly[(N-(2-uracil-1-yl)propionyl)- $\beta,\beta'$ -diethylene]amine methyl bis(4-phenyl carbamate)-75 (PU-NU-75) were obtained. (Edited author abstract) 5 refs.

Lu, C.X. (Peking Univ, Beijing, China); Yang, Yang; Xiao, Chaodong; Ji, Aixue. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1659-1669.

Testing See PLASTICS, FOAMED—Flexible.

Thermal Expansion See PLASTICS, REINFORCED—Glass Fiber.

Thermal Insulation

**083764 COMPARATIVE EVALUATION OF THE HEAT RESISTANCE OF POLYURETHANE COMPOUNDS.** Here we record an investigation of the thermal characteristics and heat resistance of type VILAD-13-1 and VILAD-14 polyurethane compounds and the influence of modification of VILAD-13-1 compound on the dielectric characteristics under long-term thermal aging. Types VILAD-13-1 and VILAD-14 compounds are made up of two components, a polyol (component A) and polyisocyanate (component B). At room temperatures both components are in the liquid state. The differences between one compound and another are occasioned by the utilization of different polyols. (Author abstract) 2 refs.

Kravtseva, I.I.; Silant'ev, V.A.; Yamshchikova, L.N.; Starostina, T.P.; Kornukhina, V.N.; Eroshina, E.Ya.; Bechuk, T.S. *Sov Electr Eng* v 57 n 5 1986 p 95-98.

Thermal Properties

**083765 THERMAL BEHAVIOR OF CAST POLYURETHANE ELASTOMERS.** Thermal properties like glass transition temperature, initial decomposition temperature, integral procedural decomposition temperature, and temperature at various % weight loss of a number of polyurethane systems are reported in this paper. Glass transition temperature was determined on TMA, and other thermal properties were determined by thermogravimetry. The experiments were designed to understand various factors such as length of chain extender moiety, flexibility of chain extender units by substitution of ether link in the diol chain, nature of bonds (unsaturation) in the extender unit, and nature of diisocyanates. (Edited author abstract) 14 refs.

Pandya, M.V. (Indian Inst of Technology, Bombay, India); Deshpande, D.D.; Hundiwale, D.G. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1803-1815.

Viscoelasticity

**083766 INFLUENCE OF CHEMICAL STRUCTURES OF POLYURETHANE RESINS MOLDED BY REACTION INJECTION MOLDING ON VISCOELASTIC PROPERTIES AT HIGH FREQUENCIES.** Dynamic viscoelastic properties of polyurethane resins molded by reaction injection molding (RIM) have been examined by forced oscillation method at 2 approximately 500 Hz. Polyurethane raw materials are aliphatic and aromatic polyols which have several mol numbers of PO (propylene oxide) adducts, and P-MDI (polymeric diphenyl methane diisocyanate). Increasing crosslinking density and adding benzene rings to polyols are effective ways to raise the  $T_g$  of polyurethane resins molded by RIM. Increasing crosslinking density could be obtained by decreasing mol numbers of PO adducts or by increasing functionalities of polyol. (Edited author abstract) In Japanese. 19 refs.

Gotoh, Masao (Hitachi Ltd, Yokohama, Jpn); Iida, Makoto; Miyano, Yasushi; Kunio, Takeshi. *Kobunshi Ronbunshu* v 45 n 1 1988 p 37-46.

Waste Utilization

**083767 POLYOL RECOVERY FROM ELASTOMER POLYURETHANE WASTE.** Waste and scraps, from polyurethane elastomers, mainly from the shoe sole production, can be conveniently converted by a transesterification process into polyols which can be reused in the production of rigid foams, with both economical and ecological advantages. In the transesterification process, secondary reactions leading to amine formation, can be controlled by means of the reaction conditions. In the production of rigid foam the recovered products are mixed with fresh polyol; the recovered/fresh polyol ratio must be moderate in order to obtain materials with sufficiently high dimensional properties. (Author abstract) 14 refs.

Simioni, F. (Univ di Padova, Padua, Italy); Modesti, M.; Rienzi, S.A. *Cell Polym* v 6 n 6 1987 p 27-41.

Wear

**083768 ROLE OF STRUCTURE FACTOR IN EVALUATING POLYURETHANE WEAR RESISTANCE.** We present the results of studies of the wear resistance of linear and sterically structured polyurethanes (PU) as a function of the ratio of the basic components in the synthesis stage and their chemical structure. It is established experimentally that the rigid block content in the molecule or in the interstitial fragment has significant influence on PU wear resistance. These studies permit a rational approach to regulation of the tribotechnical properties of polyurethane systems. (Author abstract) 12 refs.

Trofimovich, A.N.; Anisimov, V.N.; Kurachenkov, V.N.; Strakhov, V.V.; Letunovskii, M.P.; Egorov, S.F. *Sov J Frict Wear* v 8 n 3 1987 p 87-92.

**POLYVINYL ACETATE** See Also MONOMERS—Polymerization; POLYMERS—Blending.

Aging

**083769 PHYSICAL AGEING STUDIES ON POLY(VINYL ACETATE): ENTHALPY RELAXATION AND ITS RELATION TO VOLUME RECOVERY.** Results of recent enthalpy relaxation experiments on a standard sample of poly(vinyl acetate) at one ageing temperature ( $T_a = 303$  K) are described. By means of a recent theory relating enthalpy and volume, the volume recovery for our PVAc sample has been calculated from our enthalpy relaxation data, and comparison made with existing volume recovery data of Kovacs. (Author abstract) 7 refs.

Cowie, John M.G. (Univ of Stirling, Stirling, Scotl);



Elliott, Susan; Ferguson, Roderick; Simha, Robert. *Polym Commun (Guildford Engl)* v 28 n 11 Nov 1987 p 298-300.

**083770 DEFECT DIFFUSION MODEL FOR VOLUME AND ENTHALPY RECOVERY IN AMORPHOUS POLYMERS.** Glasses are known to undergo spontaneous densification during isothermal annealing. This volume recovery process, which is also an enthalpy recovery process, can be viewed as the collapse of highly disordered sites or 'defects'. The author has modeled this physical aging as a diffusion process in which the positive density fluctuation defects are annihilated by the corresponding negative ones. The diffusion constant depends on the concentration of defects, and each diffusion molecular jump induces hierarchically correlated molecular rearrangements which conform to a stretched exponential law. Good agreement was obtained between the theoretical and experimental volumes as well as enthalpy recovery results for poly(vinyl acetate) including the memory experiment and the variation of the effective relaxation time. (Edited author abstract) 30 refs.

Perez, J. (CNRS, Villeurbanne, Fr). *Polymer* v 29 n 3 Mar 1988 p 483-489.

## Blending

**083771 MORPHOLOGY OF POLY(ETHYLENE OXIDE)/POLY(VINYL ACETATE) BLENDS.** The morphology of poly(ethylene oxide)/poly(vinyl acetate) (PEO/PVAc) blends was examined using small angle X-ray scattering (SAXS) and optical microscopy. The morphological and structural parameters of the blends are dependent on both composition and crystallization conditions. Optical microscopy revealed that blend samples prepared by solution casting crystallized with volume-filling crystals up to a composition of 30/70 wt% PEO/PVAc; at higher PVAc content there was no evidence of crystallization in the temperature range studied. The morphological and structural properties of the PEO/PVAc blends were attributed to the presence of non-crystallizable material in both the interlamellar and interfibrillar regions. (Edited author abstract) 17 refs.

Silvestre, C. (Univ of Massachusetts, Amherst, MA, USA); Karasz, F.E.; MacKnight, W.J.; Martuscelli, E. *Eur Polym J* v 23 n 10 1987 p 745-751.

## Degradation

**083772 POLYMER PRECURSORS OF POLYACETYLENE. THERMAL DEGRADATION OF POLY(VINYL ESTERS). PART 1 - MOLECULAR WEIGHT DEPENDENCE OF THE AUTOCATALYTIC THERMAL DEGRADATION OF POLY(VINYL ACETATE) (PVAc).** This study is the first of a series on the pyrolyses of poly(vinyl esters) in which the kinetics of the isothermal degradation up to high conversions of five unfractionated heterotactic samples of poly(vinyl acetate) (PVAc) has been investigated by a static procedure in a nitrogen atmosphere over a wide temperature range. The experimental results can be explained by assuming the occurrence of a catalyzed deacetylation reaction which is first order with respect to  $\text{CH}_3 - \text{COOH}$  simultaneously with an uncatalyzed reaction. This kinetic model, based on the stripping mechanism, has been shown to be in very good agreement with the experimental data not only for low, but also for moderately high, degrees of conversion. Rate constants  $k_1$  and  $k_2$ , Arrhenius parameters  $E$  and  $A$  and  $\Delta S$  values have been determined for both the autocatalyzed and uncatalyzed elimination reactions. (Edited author abstract) 31 refs.

Barrales-Rienda, J.M. (CSIC, Madrid, Spain); Sanchez-Chaves, M.; Mazon Arechederra, J.M.; Fernandez Martin, F. *Polym Degradation Stab* v 21 n 1 1988 p 55-72.

## Diffusion

**083773 MEASUREMENTS OF MASS DIFFUSION OF DYE MOLECULES IN POLYMER MATRIX BY THE FORCED RAYLEIGH SCATTERING TECHNIQUE.** A new type of photochromic dye molecules - bis-9-anthyl methyl ether is introduced as a potential

probe for diffusion studies of small molecules in polyvinyl acetate films using the forced Rayleigh scattering technique. It is shown that this technique is very effective for measuring diffusion coefficients as low as approx.  $10^{-14} \text{ cm}^2/\text{s}$ . The temperature-dependent diffusion coefficient of the free dye molecules in this polymer matrix is measured in the temperature range from 35°C to 90°C. The normal single exponential decay and the abnormal double exponential decay are also discussed. (Author abstract) 8 refs.

Wu, Chengxun (Man-made Fiber Research Inst). *J China Text Univ Engl Ed* v 5 n 1 Mar 1988 p 87-92.

## Hydrolysis

**083774 METHODS OF INVESTIGATION. USE OF MICROCALORIMETRY FOR CALCULATION OF THE CONFORMATIONAL EFFECT IN POLYMER ANALOGOUS REACTIONS.** This paper proposes a quantitative approach to the estimation of the conformational effect in the hydrolysis of PVA using microcalorimetry. As a model hypothesis it is assumed that change in the conformation of the macromolecule due to change in the quality of the solvent or other factors may be described as an equivalent change in the conformation through pseudointramolecular crosslinking. Then to calculate the characteristics of such pseudo-crosslinked coils one may use in the known mathematical apparatus devised for intramolecular reactions. The method proposed has been used to calculate the kinetics of hydrolysis of PVA. 6 refs.

Khvan, A.M. (Lomonosov State Univ, Moscow, USSR); Noah, O.V.; Zenkov, I.D.; Shablygin, M.V.; Plate, N.A. *Polym Sci USSR* v 28 n 10 1986 p 2503-2506.

Latex See LATEXES—Viscosity.

Solutions See GELS—Concentration.

## Suspensions

**083775 OXYGEN QUENCHING STUDIES OF NONAQUEOUS DISPERSIONS OF POLY(VINYL ACETATE) LABELED WITH PHENANTHRENE GROUPS.** This paper describes experiments on nonaqueous dispersions of poly(vinyl acetate) (PVAc) particles sterically stabilized with poly(2-ethylhexyl methacrylate) (PEHMA). Particles were prepared with trace amounts of phenanthrene (Phe) groups covalently bound to either the PVAc core phase or the PEHMA stabilizer. Phe fluorescence was very similar in degassed samples of the two materials, but strong differences were noted in the presence of oxygen. Detailed oxygen fluorescence quenching studies provide information about particle morphology, about swelling of the stabilizer phase by the dispersion medium, particularly for PEHMA trapped inside the particle, and most importantly, about the PEHMA-PVAc interface. In the presence of the dispersion medium (cyclohexane), the interface is very diffuse: the presence of 7 wt% of PEHMA in the particle transforms nearly half the PVAc component into a phase swollen with cyclohexane and extremely permeable to oxygen. (Author abstract) 20 refs.

Egan, Luke S. (Univ of Toronto, Toronto, Ont, Can); Winnik, Mitchell A.; Croucher, Melvin D. *Langmuir* v 4 n 2 Mar-Apr 1988, Mol Process at Solid Surf: Spectrosc of Interm and Adsorbate Interact, Denver, CO, USA, Apr 6-8, 1987 p 438-445.

**POLYVINYL ALCOHOL** See Also COPOLYMERS—Synthesis; POLYVINYL CHLORIDE—Polymerization; SYNTHETIC FIBERS—Mechanical Properties; TEXTILE FIBERS—Synthetics.

**083776 HYDROGELS OF POLY(VINYL ALCOHOL) AND ITS COPOLYMERS.** Polyvinyl alcohol polymers form hydrogels that are used in biomedical applications. PVA gels have been used in contact lenses, artificial kidneys and as a skin substitute (Ivalon). Additionally, it has been a replacement for vocal cords and articular cartilage. Swelling systems can be used in drug release devices. 324 refs.

Peppas, Nikolaos A. (Purdue Univ, West Lafayette, IN, USA). *Hydrogels in Med and Pharm* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 v 2, p 1-48.

**083777 CONTACT ELECTRIFICATION OF CHEMICALLY MODIFIED SURFACES.** We have studied charge transfer from a variety of metals to solution-cast samples of polyvinyl-alcohol chemically treated to introduce superficial halogens (F, Cl, Br and I). Even though surface analysis shows that only a fraction of the hydroxyl groups are converted to halogen we find that the chemical treatments change the sign of the charge transfer from positive to negative; moreover, the charge transfer becomes much less dependent on metal work function as a result of the chemical treatment. Just such changes are expected if it is supposed that the Cl treatment (for example) converts the surface of the polymer from polyvinylalcohol to polyvinylchloride, and our experiments thus provide striking support for the opinion, expressed by many workers, that the contact electrification of polymers is intimately connected with their chemical composition. Chemical modification of a thin surface layer may provide a controlled means of adjusting the contact charging properties of a polymer with minimum disturbance of desirable bulk properties. (Author abstract) 18 refs.

Lowell, J. (UMIST, Manchester, Engl); Brown, A. J. *Electrostatics* v 21 n 1 Jul 1988 p 69-79.

Adsorption See Also POLYMERS—Adsorption.

**083778 EFFECT OF THE IONIC COMPOSITION OF THE SOLUTION ON THE POLYVINYL ALCOHOL ADSORPTION ON THE SURFACE OF  $\text{Al}_2\text{O}_3$ .** The adsorption of polyvinyl alcohol (PVA) from solutions of various ionic composition has been studied on alumina. In the presence of sodium dodecylsulphate (SDS) the complexes PVA-SDS are probably formed at the interface oxide-solution. The interaction between PVA and SDS at the interface leads to increase of PVA adsorption. However the presence of such complexes in the solution causes step-wise decrease of polyvinyl alcohol adsorption. The observed changes of surface charge density of alumina are in accord with the adsorption data. The estimated free energy of PVA adsorption on the surface of alumina is less than  $-9.7 \text{ kJ/mole}$ . (Author abstract) 20 refs.

Chibowski, S. (Maria Curie-Skłodowska Univ, Lublin, Pol). *Mater Chem Phys* v 20 n 1 Aug 1988 p 65-72.

## Aging

**083779 RHEOLOGICAL INVESTIGATION OF AQUEOUS SOLUTIONS OF POLY(VINYL ALCOHOL) DURING AGING - III. EFFECT OF THE THERMAL PREHISTORY OF THE POLYMER ON THE PROCESS OF AGING OF CONCENTRATED SOLUTIONS.** The paper deals with aging of concentrated poly(vinyl alcohol) solutions prepared from polymer samples which, prior to dissolution, were heated at various temperatures in an aqueous suspension or in the powder state. The effect of preheating is discussed on the basis of changes in viscosity and normal stress difference, measured during aging. (Author abstract) 6 refs.

Prokopova, E. (Czechoslovak Acad of Sciences, Prague, Czech); Stern, P.; Quadrat, O. *Colloid Polym Sci* v 265 n 10 Oct 1987 p 903-907.

Applications See EPOXY RESINS—Wear; PLASTICS FILMS—Manufacture.

## Biodegradation

**083780 BIODEGRADATION OF POLY(VINYL ALCOHOL) AND POLY(SODIUM ACRYLATE)-co-(VINYL ALCOHOL).** Biodegradation of poly(vinyl alcohol) (PVA) by microbes in the activated sludge of municipal sewage plants was studied. Two bacterial strains, *Pseudomonas* sp. M1 and *Pseudomonas putida* M2, were isolated as PVA-degrading strains. PVA was found to show excellent biodegradability. As a biodegrad-



able polyelectrolyte, poly[(sodium acrylate)-co-(vinyl alcohol)] [P(SA-VA)] which had the biodegradable vinyl alcohol units in poly(sodium acrylate) was prepared by the copolymerization of vinyl acetate with acrylic acid. It is biodegraded by the soil, and symbiotic bacterial strains of *Pseudomonas* sp. C1 and C2 were isolated and identified as P(SA-VA)-degrading strains. (Author abstract) 13 refs. In Japanese.

Matsumura, Shuichi (Keio Univ, Yokohama, Jpn); Maeda, Shuichi; Takahashi, Jun; Yoshikawa, Sadao. *Kobunshi Ronbunshu* v 45 n 4 1988 p 317-324.

**Blending** See CELLULOSE—Blending.

## Coloring

**083781 ON THE DISTRIBUTION OF DYE MOLECULES IN STRETCHED POLY(VINYL ALCOHOL).** The symmetry of the orientational distribution function of dye molecules in stretched PVA films is studied using polarized fluorescence. The different symmetries are monitored by a simple experimental technique in which angle-resolved fluorescence depolarization ratios are measured. A uniaxial distribution of rhodamine 6G molecules is obtained on stretching the film at temperatures above 60°C. In contrast, a biaxial distribution of trypanflavine molecules is found for stretch temperatures in the 50-115°C range. It is suggested that the hydrogen bonding between the PVA chains, and between the dye molecules and the PVA chains, influences the symmetry of the distribution upon stretching. (Author abstract) 28 refs.

van Gurp, M. (Physics Lab, Utrecht, Neth); van Ginkel, G.; Levine, Y.K. *J Polym Sci Part B* v 26 n 8 Aug 5 1988 p 1613-1625.

**Crosslinking** See ENZYMES—Immobilization.

**Deformation** See YARN—Deformation.

## Dyeing

**083782 EFFECT OF CONCENTRATION ON OPTICAL PROPERTIES OF DYES INCORPORATED INTO POLYVINYL ALCOHOL FILMS.** The quantum yield, lifetime and anisotropy of fluorescence emitted by molecules of neutral red dye incorporated into polyvinyl polymer films were studied as a function of dye concentration. From the data a mechanism of excitation quenching by dye monomers bound to the polymer matrix is suggested. (Author abstract) 15 refs.

Paschenko, Vladimir Z. (Moscow State Univ, Moscow, USSR); Ponomarev, Andrew N.; Yuzhakov, Victor I. *J Lumin* v 36 n 1 Oct 1987 p 57-61.

## Elasticity

**083783 PROPERTIES OF SYNDIOTACTIC-RICH POLY(VINYL ALCOHOL) THIN FILMS IN WATER. VI. ELASTIC BEHAVIOR OF UNDRAWN/ANNEALED THIN FILMS BY REPEATED ELONGATION/CONTRACTION IN WATER.** The elastic behavior of undrawn/annealed swollen thin films of syndiotactic-rich poly(vinyl alcohol), derived from vinyl trifluoroacetate, was studied by repeated elongation/contraction in water. For the films annealed at temperatures below 175°C, the characteristic of deformation was divided into low-drawn and high-drawn regions. The elastic deformation was dominant over the plastic deformation in the low-drawn region and vice versa in the high-drawn region. The effect of heat treatment on the elastic behavior of the swollen films in water was almost independent of annealing temperatures below 125°C. The elastic deformation in water at 70°C was especially remarkable in the low-drawn region for the films annealed at temperatures below 125°C and at 80°C for the films annealed at 150°C. For the films annealed at 200°C, considerable plastic deformation occurred in addition to elastic deformation from the initial drawing. (Edited author abstract) 8 refs.

Yamaura, Kazuo (Shinshu Univ, Ueda, Jpn); Hayakawa,

Akihiro; Tanigami, Tetsuya; Matsuzawa, Shuji. *J Appl Polym Sci* v 35 n 6 May 5 1988 p 1621-1629.

## Film

**083784 EXTRACTION OF ABSORPTION SPECTRA OF SOME POLYENES PRODUCED IN POLY(VINYL ALCOHOL) FILM UTILIZING PHOTODEGRADATIONS BY MONOCHROMATIC LIGHT.** Individual absorption spectra of  $-(CH=CH)_n-$  ( $n=2-5$ ) produced in heated poly(vinyl alcohol) (PVA) films can be extracted separately by selective photodegradation. Difference spectra between the two spectra obtained at various different irradiation times did not show the spectra of individual polyenes owing to overlapping of the spectra due to degraded and produced polyenes. By proper combination of irradiations, however, the other spectra could be eliminated, and each spectrum of  $n=2-5$  could be extracted. For  $n=4$  and 5, the second bands were revealed. (Author abstract) 10 refs.

Maruyama, K. (Technological Univ of Nagaoka, Nagaoka, Jpn); Kuramoto, Y.; Yagi, M.; Tanizaki, Y. *Polymer* v 29 n 1 Jan 1988 p 24-29.

**083785 STRUCTURE OF POLY(VINYL ALCOHOL)-IODINE COMPLEX IN WATER SWOLLEN FILM.** The structure of a poly(vinyl alcohol) (PVA)-iodine complex was investigated by a resonance Raman spectroscopy, wide angle X-ray diffraction, small angle X-ray scattering, NMR and IR spectroscopies. The results show that some changes in the state of hydrogen bondings are induced by complexation. The weight of the PVA film increased rapidly by iodine sorption at the first stage and then decreased. The changes of the long period and volume took place rapidly, being followed by much slower increase in Young's modulus. The ratio of the decrease in volume was much larger than that of the long period. It was assumed that the fast contraction in iodine-soaking was mainly due to the release of water out of membranes induced by iodine-sorption but not due to the complexation. (Edited author abstract) 19 refs.

Oishi, Yushi (Tokyo Inst of Technology, Tokyo, Jpn); Yamamoto, Hiroshi; Miyasaka, Keizo. *Polym J* v 19 n 11 1987 p 1261-1268.

**Grafting** See GRAFT COPOLYMERS—Chemical Analysis.

## Measurements

**083786 FORCES BETWEEN ADSORBED PVA LAYERS.** The forces between adsorbed layers of poly(vinyl alcohol) have been measured by a direct force balance technique. Not only have the equilibrium forces been measured, but also the dynamic forces have been assessed as the surfaces were rapidly moved towards each other. It was found that the dynamic forces were larger by a substantial factor than those measured at equilibrium, and this has important implications for the stability of colloidal dispersions stabilised by adsorbed polymer layers, and possibly also for electrostatically stabilised colloids. (Author abstract) 4 refs.

Lubetkin, Steven (Univ of Bristol, Bristol, Engl). *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 203-209.

## Modification

**083787 NEW MODIFICATIONS OF POLY(VINYL ALCOHOLS) AND THEIR APPLICATIONS.** Poly(vinyl alcohol) (PV-OH), prepared from poly(vinyl acetate), is used widely in many industries. Various grades have been produced, with different degree of polymerization and degree of hydrolysis. Recently, novel modified (PV-OH)s with anion, cation, silanol or hydrophobic groups have been studied and developed. They have new properties in addition to those of ordinary PV-OH and have new applications. The methods of modification and the characteristics and some applications of the modified polymers are described. (Author abstract) 28 refs.

Maruyama, Hitoshi (Kuraray Co, Okayama, Jpn); Moritani, Tohei; Akazawa, Toshiyuki; Sato, Toshiaki. *Br Polym J* v 20 n 4 1988 p 345-351.

**Molecular Weight** See GRAFT COPOLYMERS—Synthesis.

## Permeability

**083788 EFFECT OF RETORTING ON THE BARRIER PROPERTIES OF EVOH.** The effect of retort processing and storage conditions on the oxygen permeability of ethylene vinyl alcohol copolymer (EVOH) in multilayer packaging was studied. Immediately after retort processing, the oxygen permeability of EVOH increases due to plasticization by moisture. An irreversible effect of retorting on permeability is also seen though. This increase in permeability is attributed to the creation of excess free volume. Based on these experimental results, mathematical models were developed to predict EVOH oxygen permeability given the retort history and storage conditions. It is also found that incorporating desiccant in the multilayer structure overcomes the moisture effect and greatly reduces the retort path dependence. (Author abstract) 6 refs.

Tsai, Boh C. (American Natl Can Co, Barrington, IL, USA); Jenkins, Becky J. *J Plast Film Sheeting* v 4 n 1 Jan 1988 p 63-71.

**Photochromism** See SALTS—Optical Properties.

**Photovoltaic Effects** See PHOTOVOLTAIC CELLS—Materials.

## Physical Properties

**083789 PROPERTIES OF SYNDIOTACTIC-RICH POLY(VINYL ALCOHOL) THIN FILM IN WATER. V. EFFECT OF INITIAL TEMPERATURE OF HEATING ON ELONGATION.** The effect of the initial temperature of heating on the elongation of syndiotactic-rich poly(vinyl alcohol) thin films was investigated in water under a load. The elongation ratios  $E_t$  after 4 h at fixed temperatures increased roughly with an increase in the initial temperature  $T_i$  and a decrease in the annealing temperature.  $E_t$  after 4 h was the smallest at  $T_i = 45^\circ\text{C}$  for the films annealed at temperatures below  $100^\circ\text{C}$ .  $E_t$  was 6.8 at  $T_i = 60^\circ\text{C}$  for the unannealed film and 1.12 at  $T_i = 70^\circ\text{C}$  for the film annealed at  $200^\circ\text{C}$ . The elongation at break decreased and the temperature at break increased with an increase in annealing temperature, but those at the annealing temperature of  $100^\circ\text{C}$  were the smallest. The films annealed at  $200^\circ\text{C}$  did not break even at  $98^\circ\text{C}$  (boiling temperature) in water and the elongation ratio was 1.42-1.97 in the initial temperature range of  $10-70^\circ\text{C}$ . From these results, the relation between the elongation in water and the state of polymer chains in film was discussed. (Author abstract) 10 refs.

Yamaura, Kazuo (Shinshu Univ, Ueda, Jpn); Masuzawa, Tatsuaki; Tanigami, Tetsuya; Matsuzawa, Shuji. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 593-600.

**083790 PROPERTIES OF BLENDS OF SYNDIOTACTIC-RICH AND ATACTIC POLY(VINYL ALCOHOLS).** The crystallinity, solubility, degree of swelling, and hygroscopicity of the blends of syndiotactic-rich (st-PVA) and atactic poly(vinyl alcohols) (at-PVA) were studied. The crystallinity of the blends increased with increasing annealing temperature and that of the blends annealed at  $200^\circ\text{C}$  was larger than that of at-PVA. In the  $200^\circ\text{C}$  annealed blends containing st-PVA about 50%, the insoluble fraction in boiling water was larger than the fraction of st-PVA in each blend. The soluble fraction for the blend containing 75% st-PVA was 1.7%. The moisture regain of the blends was less than that of at-PVA. (Author abstract) 7 refs.

Matsuzawa, Shuji (Shinshu Univ, Ueda, Jpn); Yamaura, Kazuo; Nagura, Masanobu; Fukuta, Toyohiko. *J Appl Polym Sci* v 35 n 6 May 5 1988 p 1661-1665.



## Radiation Effects

**083791 SPECTROSCOPIC STUDIES OF PHOTO-CONVERSION IN POLYVINYL ALCOHOL UNDER THE INFLUENCE OF INFRARED AND ULTRAVIOLET RADIATION.** In the present work a comparative spectroscopic study of structural changes in polyvinyl alcohol (PVA) under the influence of IR- and UV-radiation has been carried out. The authors used PVA produced by alkaline saponification, which was first purified by double reprecipitation in acetone. Films were decanted for use in the study from 10% water solution of PVA. The thickness of the samples stood at 0.03-0.05 mm. A mean pressure mercury lamp of type PRK served as the source of radiation. It was discovered that under the action of these types of radiation there occurred a decrease in the optical density and a small  $200\text{-cm}^{-1}$  displacement in wavenumber of the electron absorption band maximum in the region of  $35,400\text{ cm}^{-1}$  (283 nm) in the UV-spectrum of PVA. 23 refs.

Kalontarov, L.I.; Marupov, R. *J Appl Spectrosc* v 47 n 2 Aug 1987 p 811-815.

Rheology See GELS—Rheology.

## Solutions

**083792 CRYSTAL GROWTH IN SYNDIOTACTIC POLY(VINYL ALCOHOL) HYDROGELS.** Aqueous solutions of syndiotacticity-rich poly(vinyl alcohol) (s-PVA) form gels easily. The optimum condition of growth of the calcium tartrate crystal formed by diffusing calcium chloride into hydrogels containing tartaric acid was studied with use of s-PVA of a syndiotacticity of 56% and a degree of polymerization of 1460. The crystal grew in the gel of the concentrations of 2% s-PVA and of 0.5 N tartaric acid at pH=4. The relation between the formation of Liesegang rings and shear modulus of a gel was studied by diffusing silver nitrate into gel containing potassium chromate. The distance between rings decreased with increasing shear modulus of a gel in the range from 670 to 7500 dyne/cm<sup>2</sup>. The Liesegang rings were not formed for the shear modulus gel for 280 and 16200 dyne/cm<sup>2</sup>. (Author abstract) 18 refs.

Matsuzawa, S. (Shinshu Univ, Ueda, Jpn); Hondo, Y.; Kawauchi, Y.; Kume, M.; Yamaura, K.; Tanigami, T.; Ogawara, K. *Colloid Polym Sci* v 265 n 9 Sep 1987 p 810-814.

**083793 GELS OF SYNDIOTACTICITY-RICH POLY(VINYL ALCOHOL) - WATER/DIMETHYL SULFOXIDE OR - WATER/ETHYLENE GLYCOL SOLUTIONS.** Gels of syndiotacticity-rich poly(vinyl alcohol) in mixed solvents of water/dimethyl sulfoxide (DMSO) or water/ethylene glycol were made by chilling at the temperatures of 0-70°C from those solutions with the polymer concentrations below 10 g/dL. The melting points of the gels were measured warming the gel from the gelling temperature at a constant heating rate. The apparent enthalpy of fusion of a junction of gel, was estimated from the relation between the apparent melting temperature and the polymer concentration. (Edited author abstract) 14 refs.

Yamaura, Kazuo (Shinshu Univ, Ueda, Jpn); Katoh, Hirohumi; Tanigami, Tetsuya; Matsuzawa, Shuji. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2347-2354.

**083794 SPECTROPHOTOMETRIC DETERMINATION OF POLY(VINYL ALCOHOL) IN CADMIUM HYDROXIDE PASTES.** A colorimetric method has been developed to spectrophotometrically determine the poly(vinyl alcohol) (PVA) content of aqueous Cd(OH)<sub>2</sub> pastes. The method, which is based upon the formation of a blue PVA-iodine-boric acid complex, can quantitatively determine PVA in aqueous solution concentrations of 2-40 mg/L corresponding to PVA levels within the paste as low as 0.02%. Solution absorbance of the complex, however, depends upon the concentration of Cd<sup>2+</sup> in solution necessitating cognizance of this level for routine quantitative analysis. (Author abstract) 11 refs.

Baumgartner, Charles E. (GE, Schenectady, NY USA). *Anal Chem* v 59 n 22 Nov 15 1987 p 2716-2718.

**083795 INVESTIGATION OF AGING AQUEOUS POLY(VINYL ALCOHOL) SOLUTIONS BY THE LIGHT SCATTERING METHOD.** Aqueous poly(vinyl alcohol) solutions of various concentrations were investigated. The aged solutions were diluted and then analyzed by the light scattering method, size exclusion chromatography, and viscometry. It was found that a relatively small quantity of supermolecular formations arise during aging; they are dispersed in the molecular solution of the predominant part of the polymeric material present. The amount of these aggregated structures and their formation rate increase with concentration of the aging solution. (Author abstract) 23 refs.

Mrkvickova, L. (Czechoslovak Acad of Sciences, Prague, Czech); Prokopova, E.; Quadrat, O. *Colloid Polym Sci* v 265 n 11 Nov 1987 p 978-981.

**083796 <sup>11</sup>B N.M.R. STUDY ON THE REACTION OF POLY(VINYL ALCOHOL) WITH BORIC ACID.** The crosslinking mechanism of an aqueous alkaline solution of poly(vinyl alcohol) (PVA) in the presence of boric acid was investigated by means of <sup>11</sup>B nuclear magnetic resonance (nmr). 2-Propanol and 2,4-pentandiol were chosen as monomeric and dimeric model samples of PVA, respectively. In the case of 2-propanol, only one strong signal was observed, which was the same as in the case without alcohol. By pentandiol and PVA. It is concluded that monohydroxyl alcohol does not react with boric acid, whereas diand polyhydroxyl alcohols having the structure of 1,3-diol do. (Edited author abstract) 16 refs.

Shibayama, Mitsuhiro (Kyoto Inst of Technology, Tokyo, Jpn); Sato, Masahiro; Kimura, Yoshiharu; Fujiwara, Hiroshi; Nomura, Shunji. *Polymer* v 29 n 2 Feb 1988 p 336-340.

**083797 THERMOREVERSIBLE GELATION OF SOLUTIONS OF POLY(VINYL ALCOHOL).** The thermoreversible gelation of solutions of poly(vinyl alcohol) in ethylene glycol was investigated by calorimetric and optical observations, X-ray scattering techniques and rheological measurements. The gelatin that occurs on cooling to room temperature results from a liquid-liquid demixing, followed by a crystallization of the polymer in the concentrated domains. As a consequence of the two-phase morphology, practically no molecular orientation is observed when the gels are stretched. Gelatin at high temperature, above the region of liquid-liquid demixing, originates from a slow crystallization from solution. (Edited author abstract) 15 Refs.

Stoks, W. (Univ Leuven, Leuven, Belg); Berghmans, H.; Moldenaers, P.; Mewis, J. *Br Polym J* v 20 n 4 1988 p 361-369.

**083798 INHIBITION PERIOD OF VINYL ACETATE MONOMER IN SUSPENSION, EMULSION AND BULK POLYMERIZATION AT 730 mm Hg AND 760 mm Hg.** A trend in the inhibition period of vinyl acetate monomer (VAM), using benzoyl peroxide (Bz<sub>2</sub>O<sub>2</sub>), azobisisobutyronitrile (AIBN) and potassium peroxy disulphate (K<sub>2</sub>S<sub>2</sub>O<sub>8</sub>), during suspension, emulsion and bulk polymerizations, with change in pressure from 730 mm Hg to 760 mm Hg is reported. From the inhibition period determinations at 730 and 760 mm Hg in suspension and emulsion polymerizations of VAM it is concluded that not only with Bz<sub>2</sub>O<sub>2</sub> (reported earlier) but with other initiators such as AIBN and K<sub>2</sub>S<sub>2</sub>O<sub>8</sub> the inhibition period of VAM increases with decrease in pressure. In bulk polymerization, with both Bz<sub>2</sub>O<sub>2</sub> and AIBN initiators, due to increase in concentration of dissolved oxygen present, the inhibition period increases with increase in pressure. (Edited author abstract) 12 Refs.

Rao, Vyakaranam K. (VAM Research Cent, Uttar Pradesh, India); Singh, Rajendra P.; Bisarya, Satish C. *Br Polym J* v 20 n 4 1988 p 371-374.

## Spectroscopic Analysis

**083799 POLARIZED SPECTRA OF A SERIES OF STILBAZOLIUM MERCOCYANINES IN POLYVINYL ALCOHOL FILMS.** Polarized absorption, fluorescence and photoacoustic spectra of a series of stilbazolium merocyanines in stretched and unstretched polyvinylalcohol films were measured. Protonated dyes and free based are present in PVA films. The degree of orientation of the dye molecules depends on the substituents present in the molecule. The bulky t-butyl causes a decrease in the degree of orientation and prevents the formation of ground state complexes. In the excited state, the steric hindrance is less important and exciplexes are formed. Only ground state complexes and exciplexes fluoresce. The excitation of monomers is followed by effective thermal deactivation. Ground state complexes and exciplexes have different geometries. Axial deformation of PVA films favours excimer formation, but causes a partial dissociation of the ground state complexes. (Author abstract) 14 refs.

Gruda, Ilona (Univ du Quebec a Trois-Rivieres, Trois-Rivieres, Que, Can); Laliberte, Stephane; Niedbalska, Malgorzata; Frackowiak, Danuta. *J Lumin* v 39 n 1 Nov 1987 p 1-10.

## Spectrum Analysis

**083800 CONCENTRATION DEPENDENCE OF SPECTRAL POLARIZATION CHARACTERISTICS OF IMPURITY FLUORESCENCE IN POLYMERS.** In the course of studies on the polarized luminescence of stretched polyvinyl alcohol (PVA) films activated by proflavin and oxadiazole derivatives, we have discovered some spectral and orientational inhomogeneity: the fluorescence anisotropy R<sub>0</sub>, which is due to molecular orientation, decreases abruptly in the long-wavelength part of the fluorescence spectrum. The elucidation of this inhomogeneity constitutes the aim of this work. 13 refs.

Gaisenk, V.A.; Gruzinskii, V.V.; Sitsko, G.N.; Afanasiadi, L.Sh. *J Appl Spectrosc* v 46 n 5 May 1987 p 457-461.

## Synthesis

**083801 STUDIES ON POLYVINYL ALCOHOL CARRIERS: III. ACTIVE AMIDES AND ESTERS DERIVED FROM POLYVINYL ALCOHOL AND THEIR APPLICATION IN AFFINITY CHROMATOGRAPHY.** Polyvinyl alcohol carriers bearing active amide and active ester groups were prepared by acetalization of granular macro-reticular water-insoluble PVA with glyoxylic acid or p-formylbenzoic acid and further activation reaction with benzotriazole or N-hydroxysuccinimide using DCCI as condensation agent. The active amides or active esters obtained were easy to react with amines such as n-butylamine or proteins under mild condition. Ovomuroid, an inhibitor of trypsin was immobilized on the above-obtained reactive PVA carrier to give effective affinity adsorbent for the separation or purification of trypsin. (Author abstract) 7 refs.

Li, Fumian (Peking Univ, Beijing, China); Wang, Lin; Feng, Xinde. *Chin J Polym Sci (Engl Ed)* v 4 n 4 Feb 1987 p 297-302.

**083802 PREPARATION OF HIGH MOLECULAR WEIGHT POLY(VINYL ALCOHOL).** Emulsion polymerizations of VAc were carried out at low temperature to obtain high molecular weight polymer. In the course of study it was found that some of them gave PVA of larger P<sub>n</sub> (average degree of polymerization) than 1×10<sup>4</sup> after hydrolysis of PVAc obtained. This method is simple and is described in this paper. 5 refs.

Yamamoto, Tohei (Himeji Inst of Technology, Himeji, Jpn); Seki, Shigetoshi; Hirota, Masayoshi; Kamachi, Mikiharu. *Polym J* v 19 n 12 1987 p 1417-1418.



**083803 SYNTHESIS OF SULFONE-MODIFIED POLY(VINYL ALCOHOL) AND ITS APPLICATION FOR PERMESELECTIVE MEMBRANE OF SULFUR DIOXIDE.** The Michael type addition reaction of poly(vinyl alcohol) (PVA) with a series of vinyl sulfones, namely methyl vinyl sulfone, ethyl vinyl sulfone, and t-butyl vinyl sulfone, was performed with NaOH as catalyst to produce 2-(alkylsulfonyl)ethyl PVA derivatives. The high permeability of sulfur dioxide against nitrogen and oxygen was achieved through these sulfone-modified PVA membranes. (Author abstract) 19 refs.

Imai, Kiyokazu (Technological Univ of Nagaoka, Nagaoka, Jpn); Shiomi, Tomoo; Tezuka, Yasuyuki; Takada, Matsunori. *J Appl Polym Sci* v 35 n 7 May 20 1988 p 1817-1828.

**Thin Films** See Also PLASTICS FILMS—Spectroscopic Analysis.

**083804 ELECTRICAL PROPERTY OF ULTRA THIN FILM OF POLYVINYLALCOHOL.** Electrical properties of ultra thin PVA films (several hundreds Å-several µm in thickness) formed by sphere bulb blowing, solution surface scooping and casting techniques are studied. The electrical conductivity of relatively thick films (> several thousands Å) is very high and is enhanced by the exposure either to high humidity of air or NH<sub>3</sub>, which can be explained in terms of the role of ionic transport. The use of PVA film as NH<sub>3</sub> sensor is also proposed. In ultra thin PVA films less than 1500 Å, two conducting states, namely, a high-conducting and a low-conducting one, are observed. The nonlinear current-voltage characteristics in the low conducting state and the switching between these two states are also confirmed. These properties are discussed in terms of electronic conduction processes. (Edited author abstract) 3 refs.

Gu, Hal Bon (Osaka Univ, Jpn); Yoshino, Katsumi; Akiya, Takeo; Yamamura, Katsumi; Matsuzawa, Shuji. *Technol Rep Osaka Univ* v 37 n 1865-1888 Mar 1987 p 105-110.

**POLYVINYL CHLORIDE** See Also BIOMEDICAL EQUIPMENT—Evaluation; ELECTRODES—Materials; PIPE, PLASTIC—Drainage; PLASTICS—Blending; PLASTICS, REINFORCED—Fracture; POLYMERIZATION; POLYURETHANES—Blending; VINYL RESINS—Crystallization.

**083805 KINETICS OF ABSORPTION OF N-ALKYL PHTHALATE PLASTICIZERS INTO PVC RESIN PARTICLES.** The kinetics of plasticizer absorption by suspension polymerized polyvinylchloride (PVC) have been investigated. The volume swelling ratios of individual PVC particles, immersed in excess plasticizer, were recorded over a period of time using an optical microscope equipped with a high-speed camera. Absorption of di-n-decylphthalate was studied in the range 70 < T < 100°C. The study shows that the uptake of plasticizer proceeds in three steps. Temperature dependency of rate of absorption in the slow initial step was fitted to an Arrhenius expression, and an activation energy for plasticizer uptake was calculated. (Edited author abstract) 5 refs.

Storey, Robson F. (Univ of Southern Mississippi, Hattiesburg, MS, USA); Mauritz, Kenneth A.; Bui, Loc Vinh. *J Vinyl Technol* v 9 n 3 Sep 1987 p 133-135.

**083806 BADANIA STOPNIA ZZELOWANIA PLASTYFIKATOW POLICHLORKU WINYLU I KOPOLIMEROW CHLORKU WINYLU Z OCETANEM WINYLU.** [Evaluation of Degree of Gelation of Plasticized PVC and Vinyl Chloride-vinyl Acetate Copolymer]. The influence of rolling temperature on the melt flow index (MFI) of plasticized polyvinyl chloride and VC-VAc copolymer has been studied. On this basis, the degree of gelation has been determined. The model of relation between the structural changes occurring in plasticized compositions during gelation and MFI has been presented. A direct correlation between the degree of gelation and the tensile strength has been established. (Edited author abstract) In Polish. 7 refs.

Zajchowski, Stanislaw; Piszczek, Kazimierz; Skraga, Jan. *Przem Chem* v 66 n 8 Aug 1987 p 383-385.

**083807 COMPATIBILITY OF PVC WITH POLYURETHANES OF DIFFERENT SOFT SEGMENTS.** Blends of PVC and polyurethanes with four different soft segments of molecular weight 1000 were prepared and studied by dynamic mechanical and DSC techniques. It was found that the compatibility of PVC with segmented polyurethanes was related to the mixing of PVC molecules and the soft segments of the polyurethanes. Polyester based polyurethanes are more compatible with PVC than polyether based polyurethanes. Solution cast blends of PVC with PCL-polyurethane (1/2/1) exhibit single and narrow glass transition, while the blends with PPO-polyurethane (1/2/1) are completely incompatible. The compatibility was found to decrease with increasing hard segment contents for all the polyurethanes used. The methods of blend preparation may change the compatibility of PVC/PU blends through their influence on the mixing or demixing of the hard and soft segments. (Author abstract) 25 refs.

Xiao, Fengfei (Acad Sinica, Beijing, China); Zhang, Xian; Hu, Shiru; Ma, Dezhu; Luo, Xiaolie; Xu, Mao. *Chin J Polym Sci (Engl Ed)* v 6 n 1 1988 p 84-96.

**083808 PVC: THE ISSUES.** Proceedings incorporates 22 papers that are arranged in four sessions dealing with: regulatory/liability issues; flammability and smoke; disposal and recycling; and leaching, diffusion, permeation and toxicity. Topics covered include: metal-oxide colors used for coloring vinyls, ceramic materials, lead stabilizers, cadmium pigments, environmental regulations, vinyl chloride monomers, water pollution, diffusion science, marketing of products made of plastic rubbish, municipal disposal of solid wastes, landfills, incineration, PVC smoke, combustibility of vinyl sidings, electrical codes requirements for telecommunication and electric cables, fire resistant materials, measurements of smoke parameters, NBS standards and measuring equipment, calorimeters, product liability, legal aspects, health hazards, combustion toxicity controversy, packaging and bottling of alcoholic beverages, and food products. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11656 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Soc of Plastics Engineers, Vinyl Div, Palisades Section, USA). *Tech Pap Reg Tech Conf Soc Plast Eng* 1987, PVC: The Issues, Atlantic City, NJ, USA, Sep 16-17 1987. Publ by Soc of Plastics Engineers, USA 224p.

**Additives** See Also PLASTICIZERS—Toxicity; PLASTICS SHEETS—Adhesion.

**083809 PROBY MODYFIKACJI OBUWNI CZEGO POLICHLORKU WINYLU PROSZKIEM GUMOWYM.** [Preliminary Experiments on the Modification of Footwear-Grade PVC with Rubber Powder]. With the aid of the method of statistical planning of experiments, the effect of the content of waste-grade silica (up to 10% by weight) and rubber powder (up to 20% by weight), as well as the degree of fineness of the powder, on the coefficient of friction of footwear-composition is evaluated on the basis of PVC of Polwiplast SBD grade. The coefficient of friction has been measured in the temperature range of 273-323 K (0-50°C) and for loads in the range of 11,300-55,000 Pa. It has been found that an addition of 5% silica (grain diameter of 0.2 µm) and 10% rubber powder (grain diameter 0.2 or 0.5 µm) has an advantageous effect on the frictional properties of the composition. (Edited author abstract) 3 refs. In Polish.

Ciesielski, Leszek (Politechnika Poznańska, Pol); Jurkowski, Boleslaw. *Polimery* v 33 n 1 Jan 1988 p 24-26.

**083810 COMPUTERIZED PVC FORMULATING FOR OPTIMIZED COST/PERFORMANCE.** A broad data base is required to capitalize on the many cost effective options posed to the PVC formulator. The Marketing Technical Service function of Exxon Chemical Co. utilizes COPPCO, Computerized Profit/Performance

Consulting, to evaluate the options. The coherent data base contains 34 different plasticizers ranging from 25 to 90 phr, and can accommodate filler effects over a range of zero to 100 phr. The functions performed by COPPCO are outlined. COPPCO utilizes SAS (Statistical Analysis System) and Telegraph graphics, combined with sophisticated mainframe programs developed specifically to provide the desired output. (Edited author abstract). 6 refs.

Brofman, C.M. (Exxon Chemical Co, Baton Rouge, LA, USA); Caillault, J.J.; Krauskopf, L.G. *J Vinyl Technol* v 10 n 3 Sep 1988 p 148-153.

## Adhesion

**083811 ADHESION MECHANISM OF POLYVINYL CHLORIDE TO SILANE PRIMED METAL SURFACES.** The interface of partially hydrolyzed organosilane primer Dow Corning Z-6020 [N-(2-aminoethyl-3-aminopropyl trimethoxy silane), which is referred to in this paper as simply AEAPS, and polyvinyl chloride (plastisol) was examined by XPS (X-ray photoelectron spectroscopy) depth profile analysis. These studies and the adhesion strength measurements under dry and wet conditions showed that the net bond strength and its resistance to moisture are determined by two factors: the extent of crosslinking of the primer and the interdiffusion of the two phases. Best adhesion is achieved as a result of the optimal balance between the above two conflicting tendencies, i.e. when the primer crosslinks after it has diffused into the polymer. (Edited author abstract) 30 refs.

Chaudhury, M.K. (Dow Corning Corp, Midland, MI, USA); Gentle, T.M.; Plueddemann, E.P. *J Adhes Sci Technol* v 1 n 1 1987 p 29-38.

**Agglomeration** See MONOMERS—Polymerization.

## Aging

**083812 GLASS TRANSITION AND PHYSICAL AGEING IN PLASTICIZED POLY(VINYL CHLORIDE).** Several samples of poly(vinyl chloride), both unplasticized and plasticized with dioctyl phthalate, have been examined by differential scanning calorimetry. It was observed that, while the glass transition temperature T<sub>g</sub> decreased as expected with increasing plasticizer content, a small portion of the sample appeared to be resistant to the plasticizer. This was manifest in the appearance of a second T<sub>g</sub> corresponding to the unplasticized sample which remained unaffected by the addition of plasticizer. The aging behavior of the samples was also examined using enthalpy relaxation measurements and it was observed that the presence of plasticizer accelerates the aging process, probably due to the fact that there is greater mobility of the chains in the plasticized samples. (Author abstract) 24 refs.

Gomez Ribelles, J.L. (Politechnical Univ of Valencia, Spain); Diaz-Calleja, R.; Ferguson, R.; Cowie, J.M.G. *Polymer* v 28 n 13 Dec 1987 p 2262-2266.

**Analysis** See POLYMERS—Analysis.

**Applications** See Also ELECTRIC CONDUITS—Materials; HOT WATER SUPPLY SYSTEMS—Piping Systems; MEMBRANES—Measurements; PACKAGING MATERIALS—Plastics; PAINT—Synthesis; PROTECTIVE COATINGS—Plastics.

**083813 NEW GENERATION, LOW TASTE AND ODOR, HIGH CLARITY, LOW BLUSH VINYL COMPOUNDS.** A new compound for vinyl bottle applications has outstanding taste and odor properties, good thermal stability and color, excellent clarity, gloss, and blush resistance, solving many of the traditional problems associated with these applications. It is shown that blush (haze developed on exposure to alcohol/water)



cannot be accelerated, but should be measured by aging at the maximum temperature at which the product is likely to be exposed. (Author abstract) 15 refs.

Wypart, Roman W. (BFGoodrich Co, Avon Lake, OH, USA); Summers, James W. *J Vinyl Technol* v 9 n 1 Mar 1987 p 22-24.

**083814 PIGMENTED AND HIGHLY TRANSPARENT IMPACT RESISTANT PVC FOR OUTDOOR APPLICATION.** A comparison of results gained over the past years with open air weathering trials of pigmented, impact resistant PVC and those of artificial ageing show that the accelerated weathering units give as good an indication to the suitability of this material for outdoor application. The suitability of a transparent, impact resistant PVC formulation for external use is being investigated at present. (Author abstract) 5 refs. In German and English.

Hepp, D. *Kunstst Ger Plast* v 77 n 11 Nov 1987 p 28-30, 1177-1179.

**083815 SHRINKAGE FORCES AND TEMPERATURE-DEPENDENT CHANGE IN LENGTH IN PLASTICIZED PVC ROOFING SHEETS.** The cause of the shrinkage forces is a plasticizer loss influenced by the sheet formulation and the method of laying. No pronounced isotropy of the forces was observed in films. A relationship with the constitution of the plasticizer could not be established. Measurement of the free elongation of the specimen strain shows that both reversible and irreversible changes in length can occur. Coated fabrics are subject to lower fluctuations than films. With coated nonwovens, the type and structure of the nonwoven are of major importance. (Author abstract) 8 refs. In German and English.

Pastuska, G.; Lehmann, V. *Kunstst Ger Plast* v 77 n 11 Nov 1987 p 30-31, 1181-1183.

**Blending** See Also POLYMERS—Blending; POLY-METHYL METHACRYLATE—Blending; RUBBER, SYNTHETIC—Blending.

**083816 EXTRUDATE MORPHOLOGY OF BLENDS OF PLASTICIZED POLY(VINYL CHLORIDE) AND THERMOPLASTIC COPOLYESTER ELASTOMER.** Properties of polymer blends are highly dependent on their morphology. During the last few years, several studies have been reported on the morphology of various polymer blends. The phenomena of segregation, stratification, and phase inversion of heterogeneous polymer blends have been reported by various researchers. Blends of copolyester thermoplastic elastomer (hytel 40 D) and plasticized PVC combine the physical properties of hytel and the excellent processing characteristics of PVC. These blends are popularly used in a variety of applications. Rheology, relationship between morphology and mechanical properties, failure behavior, compatibility, and radiation resistance of these blends have been studied. No studies have been undertaken with respect to the extrudate morphology. In this paper we report the results of our studies on the extrudate morphology of hytel-PVC blends with special reference to the effect of blend ratios and extrusion shear rates. 23 refs.

Thomas, S. (Indian Inst of Technology, Kharagpur, India); De, S.K.; Gupta, B.R. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 2053-2061.

**083817 ABS AND CPE MODIFIERS IN RIGID PVC.** A comparison of acrylonitrile butadiene styrene (ABS) and chlorinated polyethylene (CPE) as PVC modifiers showed ABS to improve processability at low concentrations. CPE is more effective at high levels. Almost all the modifiers improved impact strength dramatically at 10 parts per hundred of resin. CPE containing 36 percent chlorine was the most effective, but reduced PVC modulus and heat-deflection temperature more than ABS. (Author abstract) 16 refs.

Deanin, Rudolph D. (Univ of Lowell, Lowell, MA, USA); Chuang, Wei-Zen Lin. *J Vinyl Technol* v 9 n 2 Jun 1987 p 60-62.

**083818 STUDIES ON MORPHOLOGY, MECHANICAL PROPERTIES AND FAILURE MODE OF BLENDS OF PLASTICIZED POLY(VINYL CHLORIDE) AND THERMOPLASTIC COPOLYESTER ELASTOMER.** Morphology and mechanical properties of blends of plasticized poly(vinyl chloride) (PVC) and thermoplastic copolyester elastomer (Hytel 40D) have been studied with special reference to the effect of blend ratios. Morphology of the blends indicates that the Hytel phase is dispersed as domains in the continuous PVC phase up to 75 percent of its concentration. Dynamic mechanical analysis of the blends shows marginal level of compatibility between the two phases. The mechanical properties depend on the proportion of thermoplastic rubber in the blend. Attempts have been made to correlate the blend morphology with properties. Failure surfaces were examined by scanning electron microscope and it was found that the fractographs depend on the type of failure (tensile or tear) and on the blend composition. (Author abstract) 48 refs.

Thomas, Sabu (Indian Inst of Technology, Kharagpur, India); Gupta, B.R.; De, S.K. *J Vinyl Technol* v 9 n 2 Jun 1987 p 71-85.

**083819 COMPATIBILITY OF BLENDS OF POLY(VINYL CHLORIDE) WITH POLY(METHYL METHACRYLATE).** IR spectral shifts of carbonyl vibrational absorption for ethyl acetate, which acts analogically as the structural unit of poly(methyl methacrylate), in cyclohexane, chloroform, chlorinated paraffins, poly(vinyl chloride) and chlorinated poly(vinyl chloride) were measured. The results suggest that there are specific interactions between the carbonyl groups and the chlorinated hydrocarbons which could be responsible for the apparent compatibility of poly(vinyl chloride)-poly(methyl methacrylate) and chlorinated poly(vinyl chloride)-poly(methyl methacrylate) blends. Additionally, the effects of the preparation mode of blend films on phase separation and observed compatibility are discussed. (Author abstract) 12 Refs.

Wang, Qingguo (Nanjing Univ, Nanjing, China); Cheng, Rongshi. *Chin J Polym Sci (Engl Ed)* v 6 n 2 1988 p 186-191.

**083820 BLENDING NBR POWER WITH PVC.** The deficiencies of the conventional plasticizing systems used in polyvinyl chloride (PVC) can be improved or eliminated by the addition of nitrile rubber to the PVC compound. The introduction of a finely divided powder form of the material has brought the potential for PVC/NBR alloys to smaller compounders with conventional dry-blend mixing. Adding the nitrile powder to a PVC compound significantly reduces, and in some applications completely eliminates, the loss of plasticizer due to volatilization, migration, or extraction. Elongation retention after heat aging for 168 hours at 235°F and in extractive-fluid aging with hexane, cooking oil, and Type II fuel is 50 percent better than the all-PVC compound.

Cobb, L.A. (Goodyear Tire & Rubber Co, Akron, OH, USA); Stockdale, Michael K. *Plast Compd* v 11 n 5 Jul-Aug 1988 6p.

## Chemical Reactions

**083821 STEREOSELECTIVE SUBSTITUTION ON PVC USING PHASE TRANSFER CATALYSTS.** The nucleophilic substitution with sodium benzenethiolate in aqueous suspension in the presence of a phase-transfer catalyst has been studied for two samples of PVC of different tacticities. The kinetics show two well-defined periods: one period is very fast and involves low conversions that are greater as the isotactic content of PVC increases, while another steady period is slow and its slope seems to depend on physical features, e.g., molecular weight and crystallinity, which would affect the accessibility of nucleophile. The evolution of unreacted syndio, iso, and heteroactic triad contents with degree of substitution has been followed by <sup>13</sup>C-NMR spectroscopy. The influence of degree of substitution on both the thermal degradation rate and the evolution of UV-Visible spectra of equally degraded samples has been also studied. (Edited

author abstract) 12 refs.

Martinez, G. (CSIC, Madrid, Spain); Mijangos, C.; Terroba, P.; Millan, J. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1629-1637.

**Chlorination** See Also POLYMERS—Mixing.

**083822 CHLOROWANY POLI(CHLOREK WINYLU).** [Chlorinated Poly(vinyl Chloride)]. Mechanism and methods of chlorination of poly(vinyl chloride) physicochemical and rheological properties as well as fields of application of chlorinated product have been reviewed. (Author abstract) In Polish. 35 refs.

Ehrenfeld, Elzbieta (OBR Kauczukow i Tworzyw Winlowych, Pol); Pietkiewicz, Halina; Machina, Teresa. *Polimery* v 32 n 10 Oct 1987 p 389-392.

**083823 CONVERSION DISTRIBUTION IN DIFFUSION-GOVERNED CHLORINATION OF POLY(VINYL CHLORIDE).** Conversion distribution in particles of chlorinated poly(vinyl chloride) (CPVC) is conceptually described based on balance equations involving mass transfer and chemical reaction. In the physical sorption of chlorine in poly(vinyl chloride) (PVC) as measured by the constant volume cell method, equilibrium concentration and diffusion rate obeyed Henry's law and Fick's law. The rate process of photo chlorination of PVC, which was investigated by the gravimetric method, could be well predicted by theoretical calculation of chlorine diffusion in PVC accompanying the infinitely fast chemical reaction. (Edited author abstract) 18 refs.

Wachi, Shun (Kanegafuchi Chemical Industry Co, Hyogo, Jpn); Morikawa, Hisashi; Inoue, Hakuai. *AIChE J* v 34 n 10 Oct 1988 p 1683-1690.

## Chromatographic Analysis

**083824 STUDY ON THE GPC CONCENTRATION EFFECT OF PVC.** The GPC concentration effect has been investigated in THF at 25°C for polydispersed PVC samples. The experimental results show that the GPC elution volume is a linear function of concentration. A new simplified model theory proposed by Song for concentration dependence of GPC elution volumes agrees well with the experiments. The second virial coefficients of PVC determined from GPC concentration effect by the calibration of the polydispersed PVC samples are  $0.84 \times 10^{-3}$ ,  $1.0 \times 10^{-3}$  and  $1.32 \times 10^{-3}$ , respectively. (Edited author abstract) 9 Refs. In Chinese.

Wang, Binfang; Su, Chengwei; Xu, Zhongde; Song, Mingshi. *Huadong Huagong Xueyuan Xuebao* v 14 n 3 1988 p 393-398.

**Combustion** See Also HYDROGEN INORGANIC COMPOUNDS—Degradation.

**083825 QUICK METHOD FOR DETERMINING THE ACID GAS EVOLUTION FROM PVC FORMULATIONS.** A method has been developed for the determination of the amount of acid gas produced during the thermal decomposition of PVC formulations. A method was required to support a program to reduce acid gas generation by retention of hydrogen chloride in the char phase. The traditional method (a modified Schoeniger) produces inaccurate and irreproducible results due to uncontrolled combustion. Other methods often take an excessive amount of time to run and may need expensive and unusual equipment. The test described here is accurate, fast, reliable, reproducible, and requires equipment which is readily available in a typical chemical laboratory. The method is based on the modified Schoeniger test, but the sample is thermally decomposed by the action of a small coil of electrical resistance wire. The sample is held in a porcelain boat inside the heating coil. (Edited author abstract) 8 refs.

Smith, Gregory F. (BFGoodrich Chemical Co, Avon Lake, OH, USA). *J Vinyl Technol* v 9 n 1 Mar 1987 p 18-21.



**083826 COMBUSTION TOXICOLOGY OF POLYVINYLCHLORIDE REVISITED.** The combustion toxicology of polyvinylchloride (PVC) has been studied extensively against a background of increasing understanding of the relevance of the toxicity of combustion products in fires. Most materials have a similar toxic potency and demonstrate asphyxia and irritancy when thermally decomposed. Hydrogen chloride is a major toxicant produced by PVC, which accounts for the irritancy shown by PVC combustion products. Carbon monoxide is also produced which becomes the most significant toxicant if the hydrogen chloride levels are reduced, which can occur rapidly in fires. The toxic potency lies within the range of 300-3000 mg/l. mins, which is similar to the majority of polymeric materials whether natural or synthetic. (Edited author abstract) 40 refs.

Doe, J.E. (Imperial Chemical Industries plc, Macclesfield, Engl.). *J Fire Sci* v 5 n 4 Jul-Aug 1987 p 228-247.

**083827 HOW HAZARDOUS IS PVC?** It is commonly assumed that fires involving polyvinyl chloride (PVC) are particularly dangerous because of the toxicity of its combustion products. The author examines fire tests and statistics which prove that PVC is one of the safer synthetic materials. The combustion properties, smoke producing tendency, major combustion products of PVC are examined. 36 refs.

Hirschler, Marcelo. *Fire Prev* n 204 Nov 1987 p 19-20, 22-27.

**Compounding** See Also PLASTICS PLANTS—Computer Integrated Manufacturing.

**083828 QUALITY CONTROL IN PVC COMPOUNDING.** A review of the criteria and benefits of a successful quality control program is presented from the perspective of PVC compounders. An application of Analysis of Variance in identifying the most significant sources of inconsistencies in the manufacturing operation is illustrated. (Author abstract) 2 refs.

Wedlake, Gary Douglas (Intamix Corp, Willis, TX, USA); Banijamali, Mostafa. *J Vinyl Technol* v 9 n 1 Mar 1987 p 25-27.

**Concentration** See PLASTICS FILMS.

## Crack Propagation

**083829 FATIGUE CRACK PROPAGATION IN UNPLASTICIZED POLY(VINYL CHLORIDE): 1. EFFECT OF MEAN STRESS.** The effect of mean stress on fatigue crack growth in an unplasticized poly(vinyl chloride) (uPVC) pipe material was investigated using single-edge-notched (SEN) specimens and the results analyzed in terms of fracture mechanics. Three series of experiments were conducted. In the first the fatigue crack growth rates  $da/dN$  were collected as a function of the applied stress intensity factor range  $\Delta K (=K_{max} - K_{min})$  by keeping the stress ratio  $R (=K_{min}/K_{max})$  constant. In the second series of experiments  $da/dN$  were obtained as a function of  $\Delta K$  when the mean stress intensity factor  $K_m$  was constant; and in the third series  $\Delta K$  was maintained constant,  $da/dN$  were obtained with increasing  $K_m$ . All experimental results were obtained and processed using computerized data acquisition systems. (Edited author abstract) 34 refs.

Kim, Ho-Sung (Univ of Sydney, Sydney, Aust); Truss, Rowan W.; Mai, Yiu-Wing; Cotterell, Brian. *Polymer* v 29 n 2 Feb 1988 p 268-276.

**083830 FATIGUE CRACK PROPAGATION IN UNPLASTICIZED POLY(VINYL CHLORIDE) (uPVC): 2. NEAR-THRESHOLD FATIGUE CRACK GROWTH.** A new computer-aided test method was developed to measure near-threshold fatigue crack growth rates for a 150 mm class 12 uPVC pipe. A computer program was written to drive the fatigue testing machine and an optical microscope of 0.01 mm resolution was used to determine crack growth in the single-edge-notched

specimen. The efficiency and advantages of this new technique are discussed and compared to the current ASTM proposed method. For crack growth rates of the order of  $10^{-9}$  m cycle<sup>-1</sup> the present computerized method are approximately seven times more efficient and therefore greatly minimized the testing times required to collect near-threshold fatigue data. Using this method the effects of stress ratio and level of processing on the near-threshold fatigue crack growth were investigated. (Edited author abstract) 26 refs.

Kim, Ho-Sung (Univ of Sydney, Sydney, Aust); Mai, Yiu-Wing; Cotterell, Brian. *Polymer* v 29 n 2 Feb 1988 p 277-285.

## Crosslinking

**083831 TERMOOXIDACNI STARNUTI MEK-CENYCH SVETLEM SITOVANYCH PVC SMESI [Thermo-Oxidative Aging of Plasticized PVC Compounds Crosslinked by Light].** Changes in tensile properties of light-crosslinked plasticized PVC compounds during thermo-oxidative aging at 100° and 130°C have been examined. The changes in tensile properties are not significant enough to prevent the light-crosslinked plasticized PVC to be utilized in general-purpose products. The above compounds containing the stabilizing systems tested are not very suitable for a high-temperature usage. (Author abstract) In Czech. 9 refs.

Malac, Jiri (Vyzkumny Ustav Gumarenske a Plastikarske Technologie, Gottwaldov, Czech); Rektorikova, Libuse; Sumberova, Jirina. *Plasty Kauc* v 24 n 10 Oct 1987 p 306-311.

**083832 CROSSLINKING OF POLY(VINYL CHLORIDE).** Crosslinking of polyvinyl chloride (PVC) using a diamine such as ethylenediamine (EDA) as the crosslinking agent was studied. Studies were mostly made with unfilled compounds but the effects of fillers such as  $CaCO_3$  and  $Ca(OH)_2$  were also examined. The effects of variation of EDA content and the time of crosslinking at 170°C on the gel content (%), thermal (congo red) stability (min) and hot deformation (%) as well as curing characteristics using different proportions of EDA were also examined. Physical properties of the EDA crosslinked and those of uncrosslinked PVC were studied and compared. Activation energy of EDA-induced crosslinking was 15 kcal/mol (63 kJ/mol). Crosslinking mechanisms have been discussed. (Author abstract). 21 Refs.

Chosh, Premamoy (Calcutta Univ, Calcutta, India); Sekhar Bhattacharyya, Arabinda; Maitra, Somnath. *Indian J Technol* v 26 n 4 Apr 1988 p 183-188.

## Curing

**083833 CROSSLINKING OF POLY(VINYL CHLORIDE) WITH AROMATIC DITHIOLS.** Curing of poly(vinyl chloride) with 1,4-benzenedithiol and 4,4-diphenylsulfidedithiol has been studied. The influence of crosslinking on certain properties has been examined and the mechanism of curing discussed. (Author abstract) 7 refs.

Wejchan-Judek, M. (Politechnika Poznanska, Poznan, Pol). *Polym Degradation Stab* v 20 n 1 1988 p 59-62.

## Decomposition

**083834 TOXICITY OF THE PYROLYSIS AND COMBUSTION PRODUCTS OF POLY(VINYL CHLORIDES): A LITERATURE ASSESSMENT.** Poly(vinyl chlorides) (PVC) constitute a major class of synthetic plastics. This report reviews the literature published in English from 1969 through 1984 and endeavors to be more interpretive than comprehensive. PVC compounds, in general, are among the more fire resistant common organic polymers, natural or synthetic. The major products of thermal decomposition include hydrogen chloride, benzene and unsaturated hydrocarbons. In the presence of oxygen, carbon monoxide, carbon dioxide and water are included among the common combustion products. The main toxic products from PVC fires are

hydrogen chloride (a sensory and pulmonary irritant) and carbon monoxide (an asphyxiant). (Edited author abstract) 54 refs.

Huggett, Clayton (NBS, Gaithersburg, MD, USA); Levin, Barbara C. *Fire Mater* v 11 n 3 Sep 1987 p 131-142.

**Degradation** See Also HYDROGEN INORGANIC COMPOUNDS; IRON COMPOUNDS; POLYMERS—Antioxidants.

**083835 MECHANISMS OF ANTIOXIDANT ACTION: THE EFFECT OF SPIN TRAPS DURING THE PROCESSING AND PHOTOOXIDATION OF PVC.** It is demonstrated by the use of spin traps that during the early stages of thermal processing of PVC considerable concentrations ( $> 3 \times 10^{-6}$  mol g<sup>-1</sup>) of free radicals are produced which are primarily responsible for the initial products (hydroperoxides, unsaturation, and hydrogen chloride) previously shown to be formed in the polymer. From a semiquantitative analysis of these products, it is estimated that more than 50% of the radicals are formed from hydroperoxides and the rest by mechanoscion of the polymer chain. The spin traps are effective processing stabilizers in combination with a tin maleate HCl scavenger. One of them (2-methyl-2-nitroso propane, MNP) has also been shown to be a photoantioxidant. (Author abstract) 12 refs.

Adeniyi, J.B. (Aston Univ, Birmingham, Engl); Al-Malaika, S.; Scott, G. *J Appl Polym Sci* v 34 n 8 Dec 1987 p 2673-2679.

**083836 CATALYTIC EFFECT OF HCl ON THE DEHYDROCHLORINATION OF POLY(VINYL CHLORIDE).** Two poly(vinyl chloride) (PVC) samples with different thermal stability were degraded in both pure nitrogen and in an atmosphere containing HCl. The degradation experiments were made in a thermogravimetric system where the weight loss was measured. The polyene sequence distributions were monitored by UV-visible spectroscopy and the increase in the number of polyene sequences during degradation was measured by ozonolysis. The PVC sample with increased thermal stability showed less severe discoloration, i.e., the polyene sequences were shorter, when degraded in pure nitrogen. On the other hand when degradation was performed in an atmosphere containing HCl both the rate of dehydrochlorination and the polyene sequence length increased. (Edited author abstract) 24 refs.

Martinsson, E. (Chalmers Univ of Technology, Goteborg, Sweden); Hjertberg, T.; Soerik, E. *Macromolecules* v 21 n 1 Jan 1988 p 136-141.

**083837 INFLUENCE OF THE DEHYDROCHLORINATION RATE ON THE DEGRADATION MECHANISM OF POLY(VINYL CHLORIDE).** The degradation behavior of poly(vinyl chloride) (PVC) samples with considerably increased heat stability has been compared with that of an ordinary suspension PVC. The degradation rate was followed by measuring evolved HCl conductometrically. Structural changes in the polymer were monitored by several techniques: UV-visible spectroscopy was used to follow polyene sequences and gel permeation chromatography to detect changes in the molecular weight distribution and to determine the number of cleavages caused by ozonolysis, i.e., the number of polyene sequences. Besides decreased rate of dehydrochlorination the improved PVC samples become less discolored, i.e., the polyenes are shorter. The results obtained by ozonolysis and UV-visible spectroscopy show that this is because a lower number of HCl molecules is evolved from each initiation point. (Edited author abstract) 55 refs.

Hjertberg, T. (Chalmers Univ of Technology, Goteborg, Sweden); Martinsson, E.; Sorvik, E. *Macromolecules* v 21 n 3 Mar 1988 p 603-609.



**083838 PROBLEMS OF INTERACTION BETWEEN PLASTICISED PVC AND POLYURETHANE FOAM.** There are a number of applications of plasticized PVC where it is in contact with flexible or semiflexible polyurethane foam. In many instances the PVC has deteriorated at a faster rate than expected, the cause being the migration of plasticizers from the PVC into the PU. Of the various applications of PVC in contact with PU foam, the most technically demanding is car crashpads. The effect of PU additives on the thermal stability of PVC-based crashpad skins is the main subject of this paper. The aim of the research was to quantify the effects of different catalysts from the PU on a variety of plasticized PVC compounds under conditions of accelerated heat aging.

Wilson, A.S. (BP Chemicals Ltd); Bowley, H.J.; Gerrard, D.L. *Plast Rubber Int* v 13 n 1 Feb 1988 p 23-25.

**083839 THERMAL DEHYDROCHLORINATION AND STABILISATION OF POLY(VINYLCHLORIDE) IN SOLUTION; PART II-EFFECTS OF HCl READDITION REACTION.** The role of HCl during the thermal degradation of PVC has been investigated. It was shown that HCl catalyses the degradation as well as itself adding to the conjugated sequences in the degraded PVC. There is competition between these two reactions. At the beginning of the dehydrochlorination, the first reaction is dominant, while readdition becomes more important as double bonds are formed. Metal or organometallic chlorides may significantly influence these effects. The reverse reaction is catalysed by organotin chlorides of high Lewis acidity. These retardation effects are a pure consequence of the partial and random reversible thermal decomposition of PVC; they do not result from the configurational rearrangement by the readdition reaction nor by the internal isomerisation assisted by tin compounds. (Author abstract). 47 Refs.

Van Hoang, Tran (CNRS, Lyon-Vernaison, Fr); Guyot, A. *Polym Degradation Stab* v 21 n 2 1988 p 165-180.

**083840 SOLVATION STABILIZATION OF VINYL CHLORIDE POLYMERS TO DEGRADATION IN SOLUTION.** The rates of thermal degradation of vinyl chloride (VC) polymers in organic solvents and in the solid phase are significantly different. The kinetics of the process in the liquid phase is determined by the effects of specific and non-specific solvation interaction between the solvent and the polymer molecules. In the process of polymer degradation, solvation has different effects on the rate of random elimination of HCl from PVC with the formation of isolated C=C bonds and on the formation of poly-conjugated systems of double bonds. The rates of liquid-phase degradation of VC polymers in different classes of organic solvents are mainly determined by specific polymer-solvent solvation interaction; the overall dehydrochlorination rates of VC polymers in solution increase linearly with the basicity B (donor number  $D_N$ ) of a solvent: In addition to specific solvation, the rate of the liquid phase degradation of VC polymers in solvents is also affected by polymer-solvent non-specific interaction. The loosening of solvation interactions between polymer and solvent, resulting from addition of a non-polar hydrocarbon to the system, induces stabilization in solutions of VC polymers. (Author abstract). 8 Refs.

Minsker, K.S. (Bashkirian State Univ, Ufa, USSR); Abdullin, M.I.; Gizatullin, R.R.; Buchachenko, A.L.; Zaikov, G.E. *Polym Degradation Stab* v 21 n 3 1988 p 205-210.

**083841 THERMAL AND THERMO-OXIDATIVE DEGRADATION OF POLYVINYL CHLORIDE IN PHOSPHORUS-CONTAINING PLASTICIZERS.** The kinetics of the degradation of PVC greatly changes on introducing phosphorus-containing plasticizers into the polymer system with a significant difference in the patterns of the processes of thermal and thermo-oxidative degradation. The main reason for the acceleration of thermodegradation of PVC in a medium of phosphorus-containing plasticizers is chiefly the high nucleophilicity of the esters of o-phosphoric acid governing the

specific solvation interaction between the molecules of the plasticizer and the polymer macrochains. The rate of the thermo-oxidative degradation of PVC plasticized by o-phosphates is determined by the reactivity of the esters of o-phosphoric acid in relation to oxygen. (Edited author abstract). 9 Refs.

Ableyev, R.I. (Fortieth October Anniversary Bashkir State Univ, USSR); Abdullin, M.I.; Minsker, K.S. *Polym Sci USSR* v 29 n 4 1987 p 851-857.

**083842 USE OF LASER RAMAN SPECTROSCOPY TO STUDY THE DEGRADATION OF POLY(VINYL CHLORIDE).** The results of natural weathering tests carried out on plasticized poly(vinyl chloride) in three different locations representing cool/wet, hot/wet and hot/dry climates are detailed. The value of laser-Raman spectroscopy for determining dehydrochlorination levels of naturally weathered samples is demonstrated. The results indicate that plasticizers can play a significant role in this dehydrochlorination process. Results of studies on the effects of thermal stabilisers and amines, particularly those used as catalysts for polyurethane foam formation on the stability on poly(vinyl chloride) are also reported. (Author abstract) 30 refs.

Bowley, H.J. (BP, Sunbury-on-Thames, Engl); Gerrard, D.L.; Biggin, I.S. *Polym Degradation Stab* v 20 n 3-4 1988, Polym Addit in Stab: Perform and Mech, Birmingham, Engl, Sep 2-4 1987 p 257-269.

Dehalogenation See POLYMERS—Synthesis.

## Dielectric Properties

**083843 DIELECTRIC PROPERTIES OF POLY VINYL CHLORIDE LOCAL FILLER BLENDS.** Dielectric properties of some PVC-local filler blends were investigated. Local calcium carbonate fillers from Mosul, Falloja and Karballa were used in this work. An imported filler, namely Ommya BSH was also used for comparison purposes. Dielectric constant, loss factor and loss tangent were measured by applying the following frequencies:  $10^{12}$ ,  $10^3$ ,  $10^4$  and  $10^5$  Herz at nine temperatures in the range of 21-150°C. Local filler blends appear to have dielectric properties comparable to the imported filler. Karballa filler blend exhibited lowest loss tangent property followed by Mosul, Ommya and Falloja. The results obtained indicate the suitability of using local fillers for the electrical cable insulation industry. (Author abstract) 7 refs.

Jamil, Faiz A. (Council of Scientific Research, Baghdad, Iraq); Al-Khayat, Batool H.F. *J Pet Res* v 6 n 2 Dec 1987 p 93-104.

## Diffusion

**083844 THEORY OF THE DIFFUSION OF LARGE MOLECULES IN AMORPHOUS POLYMERS ABOVE  $T_g$ .** A general theory of diffusion of large molecules in rubbery amorphous polymers is of interest for the scientific understanding and with regard to material design and process optimization. A broadly applicable model would be useful in developing controlled transport of plasticizers and other additives through polymeric substances. A diffusion model is presented which has been developed for large molecular penetrants above the  $T_g$  of the amorphous polymer allowing for required increase in redistribution of the free volume of the polymer structure, as well as the penetrant size and shape. Applicability of the model is demonstrated by comparing theoretically developed diffusion curves for DNOP and DNDP in PVC vs. their weight fractions at 82°C and 91°C. These theoretically derived plots are compared with experimental D vs.  $w_1$  curves for these systems generated at lower temperature. (Author abstract). 6 Refs.

Mauritz, K.A. (Univ of Southern Mississippi, Hattiesburg, MS, USA); Storey, R.F. *J Vinyl Technol* v 10 n 2 Jun 1988 p 69-71.

## Dispersions

**083845 WLASCIWOSCI MICELARNE DYS-PERSJI EMULSYJNEGO PVC W PLASTYFIKATORACH.** [Micellar Behaviour of Emulsion-PVC Dispersions in Plasticizers]. The results of electrokinetic and rheological studies of emulsion-PVC dispersions in various primary plasticizers and in a composition of a primary and secondary plasticizer and a modifier have been presented. A series of factors influencing the value of  $\zeta$ -potential of a polymer particle in plastisol have been discussed, among others ionogenic impurities embedded in a PVC grain and derived from auxiliaries used in the vinyl chloride emulsion polymerization. It has been found that the particle charge increases with an increase in the solvation degree of PVC grain by plasticizer. A mechanism of the effect of a secondary plasticizer and modifier on the value of particle charge has been proposed. (Edited author abstract) 28 refs. In Polish.

Makarewicz, Edwin (Akad Techniczno-Rolnicza, Bydgoszcz, Pol). *Polimery* v 32 n 9 1987 p 364-368.

**083846 INTERACTIONS IN PVC-PLASTICIZER DISPERSIONS.** The properties of PVC plastisols depend on the interaction of the PVC particles in the plasticizer, which can be attributed to the formation of extended border layers at the particle surfaces. It is shown that this surface layer consists of a steric and an electrostatic component and its thickness can be varied within large limits. The contributions of both components are estimated, and a model of the surface layer structure is given. (Author abstract) 11 refs.

Guernitz, Eckhard (Acad of Sciences of the GDR, Teltow-Seehof, East Ger); Zecha, Helmut. *Langmuir* v 3 n 5 Sep-Oct 1987 p 738-741.

## Drawing and Stamping

**083847 ORIENTATION RELAXATION OF FLUORESCENT MOLECULES IN UNIAXIALLY DRAWN PVC-FILMS DURING ANNEALING.** PVC-films doped with fluorescent molecules of different shapes were uniaxially drawn at 65 and 80°C and subsequently annealed with free and fixed ends. The orientation behaviour of the fluorescent molecules and the polymer segments is investigated by UV-dichroism and fluorescence polarization and by birefringence respectively. The disorientation process of the fluorescent probes is shown to depend on drawing temperature and length of the probes. Longer fluorescent molecules lose their orientation more rapidly and shorter ones more slowly than the polymer segments on an average. (Author abstract) 8 refs.

Neuert, R. (Technische Univ Berlin, Berlin, West Ger); Springer, H.; Hinrichsen, G. *Prog Colloid Polym Sci* v 71 1985 p 134-139.

## Electric Properties

**083848 PHOTOEXCITABLE POLYMER MEMBRANES. PHOTOINDUCED MEMBRANE POTENTIAL ACROSS POLY(VINYL CHLORIDE) MEMBRANE DOPED WITH A PHOTOSENSITIVE CROWN ETHER HAVING LIPOPHILIC SIDE CHAIN.** Photoirradiation induced potential changes of 10-20 mv across the poly(vinyl chloride) membranes doped with a photosensitive lipophilic crown ether, p-[3,4-(1,4,7,10,13-pentaoxaatridecane-1, 13-diyl)-phenylazo]hexadecyloxybenzene was studied. The photoresponse of the membrane was highly improved, presumably due to the lipophilic nature of the crown ether. The photoresponse was explained in terms of the charge density change on the membrane surface. The electric double layer theory was applied to estimate the values of the photoinduced change of the charge density. (Author abstract) 44 refs.

Anzai, Jun-Ichi (Tohoku Univ, Sendai, Jpn); Hasebe, Yasushi; Ueno, Akihiko; Osa, Tetsuo. *J Polym Sci Part A* v 26 n 6 Jun 1988 p 1519-1529.



**Extrusion** See Also PIPE, PLASTIC—Mechanical Properties.

**083849 EVALUATION OF THE CAVITY TRANSFER MIXER FOR THE EXTRUSION OF RIGID PVC ON BOTH SINGLE AND TWIN SCREW EXTRUDERS.** PVC powder compound fed into single- and twin-screw extruders retrofitted with cavity transfer mixers improved PVC grain fusion. Consequent improvements in appearance and properties ought to reduce current tight compromises that must be made between materials costs, output rate, and quality. Impact testing was carried out using 50 mm square specimens cut from the center of the extruded strips (the edges being discarded) with a Gardner type variable height falling weight impact machine. A visual assessment was made of surface finish and general appearance, and the presence of secondary particles identified by optical microscopy using microtomed sections. (Edited author abstract) 5 refs.

Gale, G.M. (Rapra Technology Ltd, Shrewsbury, Engl). *J Vinyl Technol* v 9 n 2 Jun 1987 p 63-66.

**083850 NON-ISOTHERMAL FLOW OF RIGID PVC (POLYVINYLCHLORIDE) IN PLASTICATING EXTRUSION.** During the extrusion of rigid PVC (Polyvinylchloride) the slipping at the boundary, near the duct walls, has particular importance in avoiding the sticking of the polymer and the consequent chemical degradation. In the first part of this work a survey of the rheological characteristics of rigid PVC and the main features of the slipping effect at the wall are summarized. Afterwards the fluid dynamic behavior of the polymer in the metering zone of a single screw extruder is analyzed. The effects of viscous dissipation, of thermal boundary conditions and of slipping at the screw and barrel walls are numerically investigated using a suitable viscosity function to describe the shear-thinning behavior of the material. The influence of these parameters on the extruder characteristic curves (flow rate - back pressure gradient) is reported and the fluid dynamic regions where thermal degradation may occur are established. (Author abstract). 11 Refs.

Milano, G. (Univ Degli Studi di Genova, Genoa, Italy); Tagliafico, L. *Heat Technol* v 6 n 1-2 1988 p 131-149.

**Fiber Reinforcement** See PLASTICS, REINFORCED—Crack Propagation.

## Fillers

**083851 EFFECT OF FILLERS ON THE IMPACT PROPERTIES OF OXYTUF HIGH IMPACT PVC.** Oxytuf mass polymerized PVC (IIP) contains grafted rubber moieties which provide for excellent impact resistance. The addition of a particulate filler to this resin with preservation of impact properties can be accomplished providing the particles are submicron and can be readily dispersed in the resin. Small particle size, surface treated, precipitated  $\text{CaCO}_3$ , when added to IIP provided impact retention superior to that of a homopolymer control containing an added, non-grafted impact modifier. (Author abstract) 9 refs.

Schwartz, Willis T. (Occidental Chemical Corp, Grand Island, NY, USA). *J Vinyl Technol* v 9 n 2 Jun 1987 p 46-52.

**083852 MAKČENY PVC PLNENY ANORGANICKÝM HYDROXIDOM. [Plasticized PVC Filled with Inorganic Hydroxide].** The effect of aluminum hydroxide (alumina trihydrate) on burning characteristics, low temperature resistance, and heat stability of plasticized polyvinylchloride was investigated. The data obtained can be employed in compounding plasticized polyvinylchloride for cable sheathing. (Edited author abstract) In Slovak. 7 refs.

Liptak, Peter (Vyskumny ustav Kablov a Izolantov, Bratislava, Czech). *Plasty Kauc* v 24 n 12 1987 p 355-357.

## Film

**083853 DEVELOPMENT OF A MICRO (FTIR) SPECTROPHOTOMETRIC METHOD FOR CHARACTERIZATION OF HETEROGENEITIES IN POLYMER FILMS.** A method for characterization of heterogeneities in thin polymer films is developed. This method is based on micro (FTIR) spectrophotometry. The present paper describes the experimental procedure used to investigate the one dimension gradient of oxidation photoproducts in a poly(vinyl chloride) film (370  $\mu\text{m}$  thick) exposed to artificial accelerated weathering. (Author abstract) 6 refs.

Jouan, Xavier (CNRS, Aubiere, Fr); Gardette, Jean-Luc. *Polym Commun (Guildford Engl)* v 28 n 12 Dec 1987 p 329-331.

**083854 FLUORESCENCE METHOD FOR STUDYING SURFACE ORIENTATION OF POLYMER FILM USING VAUCCUM-DEPOSITION TECHNIQUE.** In order to establish a measurement for surface orientation of polymers, the fluorescence polarization method was applied for orientation analysis of fluorescent molecules vacuum-deposited on a polymer surface. The deposition behavior was also investigated. 1,6-Diphenyl-1,3,5-hexatriene (DPH) was deposited on the surface of poly(vinyl chloride) (PVC) films. The orientation behavior of DPH on vacuum-deposition was examined by the polarization of films, the orientation was found to be three-dimensionally random. After these fluorescent films were drawn above  $T_g$ , the surface orientation of the polymer chains was estimated by the dichroism of DPH, which was analyzed from the polarized components of fluorescence intensity. This system was compared with the DPH doped system in which DPH was distributed wholly in bulk. It was found that the orientation of DPH on the surface was slightly higher than that in the bulk. (Edited author abstract) 10 refs.

Ohmori, Satoru (Kyoto Univ, Kyoto, Jpn); Ito, Shinzaburo; Onogi, Yoshihiko; Nishijima, Yasunori. *Polym J* v 19 n 11 1987 p 1269-1278.

**083855 ID CARDS FROM PVC FILM.** The importance of the identity card has increased continuously in recent years and is expected to grow still further in the future. The majority of these cards are made of several layers of different PVC films. The construction of ID cards and their uses are described. (Author abstract) In German and English.

Bernatz, S.; Kaiser, L. *Kunstst Ger Plast* v 77 n 9 Sep 1987 p 28-29.

## Flammability

**083856 ASSESSMENT OF PVC SMOKE.** The physical problems are solved by material smoke production evaluation techniques based on apparatus, which has been developed by the National Bureau of Standards. A smoke parameter has been developed, calculated from cone calorimeter measurements, which reflects the smoke hazard of a real fire. The smoke evolution characteristics for a series of rigid thermoplastic materials have been measured using the cone calorimeter and the smoke parameter concept. The results demonstrate that due to its tendency to resist ignition and to burn very slowly, PVC would produce very little smoke in a real fire situation. Of the 15 materials tested, the expected real fire smoke performance characteristics of PVC were superior to those of all other materials except one. (Edited author abstract). 8 Refs.

Smith, Gregory F. (BF Goodrich Chemical Co, Avon Lake, OH, USA). *J Vinyl Technol* v 10 n 2 Jun 1988 p 84-89.

**083857 MODERATING THE SMOKE PRODUCED BY FLEXIBLE AND SEMI-RIGID PVC IN FIRE TESTS.** Flexible and semi-rigid PVC formulations with high oxygen indexes and low smoke densities, as measured by the NBS Smoke Test (ASTM E662-83) in both flaming and non-flaming modes have been identified. The feasibility of a significant reduction of HCl emission from PVC

compounds has been demonstrated in concept, and appears to be achievable when accompanied by increased oxygen index and/or significant reductions in rate of heat release and in smoke density, when measured in both the non-flaming and flaming modes. PVC compounds, including those incorporating the kind of improvements outlined here for experimental prototypes, may be expected to compete in the future in both performance and price compared to other plastics materials. (Author abstract). 15 Refs.

Coaker, A. William (BF Goodrich, Avon Lake, OH, USA). *J Vinyl Technol* v 10 n 2 Jun 1988 p 95-99.

**Fracture** See POLYMERS—Testing; POLYMETHYL METHACRYLATE—Fracture.

## Glass Transition

**083858 COMPOSITION DEPENDENCE OF THE GLASS TRANSITION TEMPERATURE OF POLYMER-DILUENT SYSTEMS: 1. EXPERIMENTAL EVIDENCE OF A DUAL BEHAVIOUR IN PLASTICIZED PVC.** The glass transitions of six PVC-diluent systems have been studied using differential scanning calorimetry (d.s.c.). The diluents were: di-(methyl, ethyl, n-propyl, n-butyl)-phthalate, n-butylacetate and tritolyl-phosphate. A large number of compositions have been examined over the whole concentration range, from pure polymer to pure diluent. For all systems two  $T_g$ /concentration dependencies can be identified: the fast decrease of the polymer  $T_g$  caused by plasticizer addition and the much slower increase of the diluent  $T_g$  due to the presence of the dissolved polymer molecules. (Edited author abstract) 11 refs.

Ceccorulli, G. (Centro di Studio per la Fisica delle Macromolecole, Bologna, Italy); Pizzoli, M.; Scandola, M. *Polymer* v 28 n 12 Nov 1987 p 2077-2080.

**083859 COMPOSITION DEPENDENCE OF THE GLASS TRANSITION OF POLYMER-DILUENT MIXTURES: 2. TWO CONCOMITANT GLASS TRANSITION PROCESSES AS A GENERAL FEATURE OF PLASTICIZED POLYMERS.** The available theoretical and empirical treatments concerning the glass transition temperature,  $T_g$ , of polymer-diluent mixtures do not account for the occurrence of the 'cusp' in the  $T_g$ /composition dependence or of the two concomitant glass transitions recently reported by the authors. The only treatment predicting a change of curvature in  $T_g$  vs. concentration, due to G. Braun and A.J. Kovacs, does not describe satisfactorily the behaviour of the seven polymer-diluent system is composed of two branches. It is concluded that in polymer-diluent mixtures still considered homogeneous at a macroscopic level two different mobilization phenomena occur, related to mobilization of 'hindered diluent' and 'plasticized polymer', respectively. (Edited author abstract) 24 refs.

Scandola, M. (CNR, Bologna, Italy); Ceccorulli, G.; Pizzoli, M. *Polymer* v 28 n 12 Nov 1987 p 2081-2084.

**Grafting** See POLYMERS—Grafting.

## Heat Resisting

**083860 PUTTING THE HEAT ON HOUSING DESIGN.** Vinoflex G6173, 6184 and 80616 with respective Vicat softening temperatures of 78°, 74° and 81°C have been specially formulated with all the right properties: ease of flow; enhanced performance against heat deformation; and increased impact strength, to ensure that the company can capture a large share of this growing market. Prima has fire and chemical resistance with good weatherability and stability. Plascoat LSOH (low smoke zero halogen), based on polypropylene, eliminates the problems associated with most flame-retardant thermoplastics which contain halogen. A fireproof silicone composite, FPC, demonstrates its ability to withstand temperatures of up to 1000°C applied from one side for over 1 hour - and even higher temperatures for shorter periods.

Anon. *Eng Mater Des* v 32 n 6 Jun 1988 p 32, 34.



## Heat Stabilizers

**083861 STABILISATION OF PVC WITH ORGANOTELLURIUM COMPOUNDS.** Organotellurium compounds are shown to behave similarly to organotin compounds as thermal and UV stabilisers for PVC. The most effective of these, the dialkyltellurium maleates, were, however, less effective than the corresponding tin compounds but the study points the way to further progress in the design of organometallic compounds as PVC stabilisers. (Author abstract). 23 Refs.

Sbed-Ali, S.S. (Aston Univ, Birmingham, Engl); McWhinnie, W.R.; Scott, G. *Polym Degradation Stab* v 21 n 3 1988 p 211-225.

## Heat Transfer

**083862 STUDY OF THE THERMOPHYSICAL PROPERTIES OF MODIFIED POLYVINYL CHLORIDE.** The results of study of the heat conductivity, heat capacity and density of PVC modified with polyvinylbutyral and a phenol-formaldehyde resin are discussed. It is shown that the transitional layer takes part in the determination of the thermophysical properties of the composites of the polymer-polymer type. Analyzing the results of determination of  $\lambda_{eff}$  of the transitional layer of the PVC and PVB (Polyvinylbutyral) components and also the corresponding changes in the value of their densities we see that loosening of the PVC transitional layer with increase in the PVB content hampers heat exchange in the system. 10 refs.

Lipatov, Yu.S. (Rovenskiy Manuil'skii State Pedagogic Inst, USSR); Kolupayev, B.S.; Dem'Yanyuk, B.P.; Mukha, B.I. *Polym Sci USSR* v 28 n 10 1986 p 2261-2267.

**Impurities** See PLASTICS FILMS—Radiation Effects.

## Injection Molding

**083863 INJECTION MOLDING PVC.** Injection molding rigid PVC is no longer the chore it once was. Advances in resin properties, additive systems, and molding equipment have allowed injection molders to take advantage of PVC's favorable economic, weatherability, flame retardant, and chemical resistant properties. As a result, injection molding of PVC is entering a new era. With the proper equipment and formulations, today's PVC molder is graduating from pipe fittings to ever more profitable, yet demanding, parts and applications. (Author abstract) 6 refs.

Shaw, Lane G. (Air Products & Chemicals Inc, Allentown, PA, USA). *J Vinyl Technol* v 9 n 1 Mar 1987 p 2-9.

**083864 CORRELATIONS BETWEEN EXTRUSION AND INJECTION MOLDING PROCESS VARIABLES FOR PVC DRY BLENDS.** Although thermoplastic extrusion and injection molding have been extensively studied by a large number of authors, very little is known about the correlations between the extrusion and injection molding process variables. This paper describes the various comparable process variables between extrusion and injection molding of PVC dry blends. The Brabender extruder of 19 mm diameter and 25:1 length to diameter ratio and the Szekeley reciprocating single screw injection molding machine were used. PVC dry blends of industrial importance were prepared using a high speed mixer. The four mix formulations based on a commercial grade of PVC were used. Process variables studied during the injection molding were the melt temperature near the nozzle, injection pressure, injection speed, and energy consumption. (Edited author abstract) 16 refs.

Dalal, V.F. (Polytechnic of North London, London, Engl); Palit, K. *J Vinyl Technol* v 9 n 2 Jun 1987 p 86-90.

## Lubrication

**083865 STANDARDIZATION AND CONTROL OF PETROLEUM WAXES FOR RIGID PVC.** Methods are now available to determine the chemical composition

of petroleum waxes, control of which effectively governs the functional properties. By use of the analytical and property-related techniques of gas chromatography (GC) and differential scanning calorimetry (DSC), infinitely more precise compositional definition of a wax can be given, with potentially greater control of consistency and performance on a wax-to-wax, batch-to-batch basis. The article discusses the composition/characteristics of petroleum waxes. It also describes the DSC characterization of waxes. 4 refs.

Jowett, F. (Astor Wax Corp, Harrison, NY, USA). *Plast Compd* v 11 n 2 Mar-Apr 1988 4p.

## Manufacture

**083866 POLYVINYL CHLORIDE (PVC).** The development of the PVC market over the past four years has been characterised by capacity alignments and a steady, renewed increase in demand for PVC following the low of 1981/1982. The latent structural problems of excess PVC capacity in Western Europe led to the PVC producers shutting down capacity of 450 000 t/a over the period 1982 to 1986. According to the latest scientific findings, it may be assumed that the manufacture, processing, use and disposal of PVC and the articles made from it do not carry any health risks. Above this, production of this highly versatile plastic saves on resources, since 57% of the material in PVC is common salt, which occurs in abundance in nature, and only 43% comes from crude oil or natural gas. The liberation of hydrogen chloride from PVC when incinerated has no bearing on the ecology, since refuse incineration plants are required to be fitted with a waste gas scrubbing. 48 refs.

Birkner, H.; Neundorff, U. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 13-15.

**083867 GPSS SIMULATION OF PVC MANUFACTURE.** This paper describes a discrete-event analysis of batch production of PVC (polyvinyl chloride) using the GPSS computer simulation system. A number of different equipment configurations were examined in these simulations. Specifically, the number of polymerization reactors and the number of operators were varied. The effects of these changes on equipment and manpower utilization and on plant productivity were examined. In general, increasing equipment capacity and manpower led to increased productivity, but actual benefits of such changes must be evaluated with local economic factors. (Author abstract) 10 refs.

Adebekun, Aderinola K. (Georgia Inst of Technology, Atlanta, GA, USA); Song, Zhi-Qiang; Sommerfeld, Jude T. *Polym Process Eng* v 5 n 2 1987 p 145-150.

**Mechanical Properties** See Also PLASTICS—Elastoplasticity; VINYL RESINS—Crystallization.

**083868 EFFECT OF SMALL AMOUNTS OF CALCIUM CARBONATE ON MECHANICAL PROPERTIES OF RIGID PVC.** The effect of calcium carbonate in levels of 1 to 5 phr has been studied. Two types of calcium carbonate with an average particle size of 1 and 3 microns have been tested and for each formulation a graph has been drawn with drop impact strength as a function of mechanical processing at constant melt temperature. The maximum impact strength has been read from the graph. The results show that the content of calcium carbonate has an obvious effect on impact strength and that the effect of the fine-grained filler is clearly positive and that the effect of the coarse-grained filler is slightly negative. (Edited author abstract) 3 refs.

Bystedt, Jan (Norsk Hydro Plast AB, Stenungsund, Sweden); Erlandsson, Ann-Marie; Enequist, Bengt; Josefsson, Christina. *J Vinyl Technol* v 9 n 3 Sep 1987 p 136-139.

**083869 MECHANICAL PROPERTIES OF IMPLOSI-VELY COMPACTED SUSPENSION HOMOPOLYMER S 57/116 PVC POWDER.** The response of an aggregate of commercially produced particulate polymeric material to static and shock consolidation is described.

The presence of interparticle bonding, associated with the explosive process, considerably increases the strength and hardness of the compact, as compared with static processing, and enables a high degree of densification to be attained. The final properties of the compact are influenced by the initial particle size, tap density, and the characteristics of the container. For an aggregate varying in particle size from -150 to 212  $\mu$ m, optimal conditions are reached at shock pressures of between 10 and 11 GPa. (Author abstract) 12 refs.

Abousree Hegazy, A. (Helwan Univ, Helwan, Egypt); Blazynski, T.Z. *J Mater Sci* v 22 n 9 Sep 1987 p 3321-3327.

**083870 MOLECULAR ORIENTATION AND YOUNG'S MODULUS OF PLASTICIZED AND NONPLASTICIZED POLY(VINYL CHLORIDE).** The Young's moduli of samples of poly(vinyl chloride) containing either no plasticizer or 5 phr of dioctyl sebacate were drawn uniaxially at 80°C to draw ratios,  $\lambda$ , in the range 1-3.3. The moduli, determined by a three-point bending method were found to increase monotonically with  $\lambda$  to a value of 6.3 GPa for the nonplasticized samples and to reach a maximum value of about 4.5 GPa for the plasticized samples above  $\lambda = 2.3$ , which showed voiding. The lower moduli of the plasticized samples for a given degree of orientation, as assessed from birefringence measurements, can be attributed to the diluent effect of the plasticizer on the load-bearing chains. The Raman measurements suggest that the crystallites probably orient rather like rigid rods in an affinely deforming matrix, with some relaxation. (Author abstract) 8 refs.

King, J. (Univ of Leeds, Leeds, Engl); Bower, D.I.; Maddams, W.F. *J Appl Polym Sci* v 35 n 3 Feb 20 1988 p 787-796.

**083871 CHANGE IN THE MECHANICAL PROPERTIES OF POLYVINYLCHLORIDE IN THE REGION OF THE BETA-TRANSITION.** The aim of this work is to elucidate the character of this dependence as illustrated by PVC in the region of the most considerable changes in the molecular mobility of glassy polymers - the region of the  $\beta$ -transition. It is shown that an increase in molecular mobility accompanying the  $\beta$ -transition must lead to some weakening of the intermolecular interaction. This conclusion follows from a phenomenon common to polymers as increase in the molecular mobility and fall in modulus as the temperature rises. It may be concluded that a correlation exists between the level of the molecular mobility and the elasticity modulus ion conditions of impact tests of PVC. The absence of such a correlation in the temperature dependence of the nominal elasticity modulus is explained by the fact that to fall in  $E_0$  corresponds increase in  $n$  and this mutually compensates their influence. 20 refs.

Kozlov, G.V. (Kabardino-Balkarsk State Univ, USSR); Shetov, R.A.; Mikitayev, A.K. *Polym Sci USSR* v 29 n 1 Jan 1988 p 68-74.

**083872 TENSILE, STRESS-STRAIN AND CREEP RUPTURE PROPERTIES OF POLY(VINYL CHLORIDE)/POLY(NEOPENTYL GLYCOL ADIPATE)/POLY(VINYLIDENE FLUORIDE) BLENDS.** Poly(vinyl chloride), PVC, and poly(vinylidene fluoride), PVDF, are incompatible polymers. Poly(neopentyl glycol adipate), PDPA, is miscible with both PVC and PVDF. With PDPA acting as a compatibilizer between PVC and PVDF, compatible PVC/PDPA/PVDF blends can be formed at PVDF content of about less than 50 wt percent. Above 50 wt percent PVDF the ternary blends exist in two phases exhibiting two glass transition temperatures,  $T_g$ . PVC is the main contributor to the mechanical strength while PDPA and PVDF contribute to the elastic properties of these blends. A compatible blend of 55/22.5/22.5



wt percent PVC/PDPA/PVDF exhibiting one single  $T_g$  appears to show an interesting balance of the properties of the blend components. (Author abstract). 12 Refs.

Lau, Wayne, W.Y. (Nat'l Univ of Singapore, Singapore); Swee-Hin, Teoh; Suat-Hong, Goh. *Br Polym J* v 20 n 4 1988 p 323-326.

**083873 MOLECULAR MODEL FOR TENSILE SHEAR BANDING AND THE BRITTLE-DUCTILE TRANSITION IN POLY(VINYL CHLORIDE).** Roebling's adaptation of the Ree-Eyring model to represent tensile shear banding of polymers in terms of two relaxation processes and Mansfield's model to describe alpha and beta relaxation processes in terms of polymer segment mobility are combined with the particulate structure of poly(vinyl chloride) (PVC) to give a more detailed connection between the macroscopic yielding process and the microscopic mobility of polymer segments. Mansfield's model for relaxation processes is cast in terms of intra- and inter-molecular interactions that serve to hinder orientational motions of polymer segments. The viscoelastic beta process in PVC is interpreted in terms of this model to be a hindered rotation of a segment about its main chain axis. About half of the activation energy of the beta process can be estimated from the barriers hindering rotation in simple alkyl halides. (Edited author abstract). 39 refs.

Havriliak, S. Jr. (Rohm & Haas Co, Bristol, PA, USA); Shortridge, T.J. *J Vinyl Technol* v 10 n 3 Sep 1988 p 127-147.

## Mixing

**083874 PVC GYORSKEVERO GEPEK FEJLODESE.** [Development of PVC Mixers]. As a result of efforts at material and power economy and increasing efficiency, machinery and processes for producing PVC mixtures have undergone considerable development during past years. The author describes the modernization of earlier mixing machines, and the development of novel mixers and mixing processes. (Edited author abstract) 2 refs. In Hungarian.

Baranyai, Istvan (Hungaria Muanyagfeldolgozo Vallalat, Budapest, Hung). *Muanyag Gumi* v 24 n 6 1987 p 191-192.

## Modification

**083875 STUDY OF THE POLYVINYL CHLORIDE-OLIGOETHER ACRYLATE SYSTEM BY THE PULSE NMR METHOD.** From the data on nuclear magnetic transverse relaxation the authors have derived information on change in the heterogeneity of the kinetic properties of molecules in the PVC-oligoether acrylate system at 20-175°C. Thermo-oxidative polymerization of oligoether acrylate in the polymer matrix is severely limited at a concentration of oligomer < 25 wt% proceeding much faster in the region 33-50 wt% than in the original oligomer and for a content of oligomer > 50 wt% in the same way as in the initial oligoether acrylate. Such specifics of oxidative polymerization in the absence of material initiators is predetermined by the character of the distribution of the temporary plasticizer in the system. (Author abstract) 20 refs.

Lantsov, V.M. (USSR Acad of Sciences, USSR); Kotova, A.V.; Abdrakhmanova, L.A.; Kustovskaya, L.I.; Zadontsev, B.G.; Yaroshevskii, S.A.; Derinovskii, V.S.; Abramova, Ye.I.; Chalykh, A.Ye.; Mezhevikovskii, S.M. *Polym Sci USSR* v 28 n 6 1986 p 1332-1339.

**083876 CHEMICAL MODIFICATION OF POLY(VINYL CHLORIDE).** The aim of this paper is to review the literature on chemical modification of PVC. It is shown that PVC is an inherently unstable material both under the influence of heat and chemicals. The occurrence of undesirable side reactions, mainly dehydrochlorination, has been a persistent problem in the studies on the chemical modification of PVC. In most cases it has not been possible to prevent these side reactions from occurring, though their levels may have remained within

tolerable limits. There is some evidence of reactions and reaction conditions in which it has been possible to substitute a fair amount of chlorines in PVC by other functional groups without the occurrence of any significant level of dehydrochlorination. 196 refs.

Naqvi, Mohammad Kazim (Indian Petrochemicals Corp, New Delhi, India). *J Macromol Sci Rev Macromol Chem Phys* v C27 n 3-4 1987-1988 p 559-592.

## Morphology See Also POLYMERS—Blending.

**083877 PLANIRANI EKSPERIMENT KAO OSNOVA ZA OPTIMIRANJE MORFOLOSKIH SVOJSTAVA SUSPENZIJSKOG PVC-A.** [Statistically Designed Experiment as a Basis for Optimization of Morphological Properties of Suspension Polymerized PVC]. Porosity and particle size distribution, which define the suspension PVC morphological properties, are affected, among other things, by the type and concentration of suspending agents. The paper deals with the effect of cellulose products (HPC, HEC) and sorbitan monolaurate on the morphological properties of suspension PVC. In addition, the effects on other suspension PVC physical properties (K-value, bulk density, flowability, plasticizer absorption rate) are also shown. By employing statistical design of experiments, testing time and cost has been reduced and test efficiency increased. (Edited author abstract) 26 refs. In Serbo-Croatian.

Brekalo, Marija (Jugovimil, Kastel Sucurac, Yugosl); Janovic, Zvonimir; Katalinic, Josko; Gasperic, Ivo; Ravlic, Milan. *Polimeri (Zagreb)* v 8 n 6 Jun 1987 p 170-174.

**083878 INFLUENCE OF THE MORPHOLOGICAL STRUCTURE OF THE MATRIX ON THE REGULARITIES OF IMPACT FRACTURE OF POLYVINYL CHLORIDE MATERIALS.** The influence of the morphological structure of PVC and of its compositions with elastomers on the work of fracturing has been studied over a wide range of loading rates with stretching. The relation of the specific surface of the initial polymer powder to the nature of rate dependence of the work of fracturing has been demonstrated. Some possibilities of enhancing the impact strength of PVC materials by increasing the degree of heterogeneity of their structure have been established. (Author abstract) 10 refs.

Smirnova, K.N.; Lebedev, V.P.; Monakhova, T.G.; Zavarova, T.B.; Savel'ev, A.P.; Batuyeva, L.I. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1602-1608.

## Optical Properties

**083879 OPTICAL PROPERTIES OF CONJUGATED SEGMENTS EMBEDDED IN POLYVINYLIDENE-CHLORIDE.** Oriented conjugated segments embedded in polyvinylidene-chloride (PVDC) were prepared by thermal degradation of PVDC-films under applied mechanical stress. These samples exhibit stable optical properties while stored in air in contrast to the oxidative instability of pure polyacetylene. Transmission spectra in the visible range show highly anisotropic properties even at low concentration of conjugated bonds. Distinct oscillatory behavior of the absorption of light polarized perpendicular to the stretching direction is observed and the positions of the extrema are extrapolated to infinite conjugation length assuming a simple model. A comparison with optical data for dense trans-(CH)<sub>x</sub> films yields an average conjugation length of  $n=36$  for oriented crystalline trans-(CH)<sub>x</sub>-films and  $n=11-14$  for amorphous trans-(CH)<sub>x</sub> films. (Author abstract) 12 refs.

Ankele, B. (Technical Univ Graz, Graz, Austria); Leising, G.; Kahlert, H. *Solid State Commun* v 62 n 4 Apr 1987 p 245-248.

## Oxidation

**083880 INVESTIGATION OF THE ROLE OF POLYENES SEQUENCES IN THE THERMAL OXIDATION PROCESS OF POLY(VINYL CHLORIDE).** UV-visible absorption spectrophotometry was used to

study the discoloration of thermo-oxidatively treated PVC samples at 110°C. Degraded PVC films show characteristic absorption spectra with absorption maxima at 388, 415, 441, 462 and 485 nm. The optical density of these five absorption maxima increased with time of thermal aging. Differential scanning calorimetry (DSC) was used to study the melting behaviour of polyene containing predegraded PVC samples. The melting temperature of predegraded PVC samples increased with the increase of thermal treatment. (Author abstract) 18 refs.

Al-Jarrah, Mustafa M.F. (Council of Scientific Research, Baghdad, Iraq); Saleh, Nabil A.; Apikian, Rita L. *J Pet Res* v 6 n 2 Dec 1987 p 105-116.

## Phase Diagrams

**083881 MECHANISM OF FORMATION OF THE DISPERSE PHASE STRUCTURE OF POLYMER MIXTURES DURING TRANSITION FROM TERNARY (POLYMER-POLYMER-SOLVENT) TO BINARY (POLYMER-POLYMER) SYSTEMS.** The disperse phase structure of the binary PVC-PMMA system, formed from PVC-PMMA-THF solutions, has been studied quantitatively. A phase diagram of the ternary system was obtained. It was discovered that the binary system is formed in a region of the ternary phase diagram far from the polymer-polymer equilibrium. Stabilization of the phase structure of the mixture occurs in that region of the ternary diagram where a sharp increase in the viscosity of the system occurs, due either to phase- or relaxation transitions. The observed phenomenon has a general importance for systems of limited compatibility prepared from solutions. (Author abstract) 15 refs.

Chalykh, A.Ye. (USSR Acad of Sciences, USSR); Sapozhnikova, I.N.; Medvedeva, L.L.; Gerasimov, V.K. *Polym Sci USSR* v 28 n 9 1986 p 2108-2115.

## Phase Transitions

**083882 OBSERVATION OF A SUB(gel-sol) TRANSITION IN PVC/DOP GELS.** Dynamic viscoelastic measurements on poly(vinyl chloride)/dioctyl phthalate gels have been carried out in parallel-plate shear mode. Two transitions are observed: the well-known gel-sol transition at temperature  $T_g$ , which probably corresponds to the beginning of fusion of crystallites, and a transition, at a temperature below  $T_g$ , denoted as  $T_s$  and corresponding to phase separation. The sub(gel-sol)  $T_s$  temperature is manifested as the transition from the first plateau zone to a second plateau in log  $G'$  versus temperature plots. Other techniques like polarizing microscopy and DSC measurements are not adequate for the detection of  $T_s$ . (Author abstract). 22 Refs.

Gallego, F. (Dep de Ciencia y Tecnologia de Polimeros, San Sebastian, Spain); Munoz, Ma.Ea.; Pena, J.J. *J Polym Sci Part B* v 26 n 9 Aug 20 1988 p 1871-1880.

## Photochemical Reactions

**083883 PVC COMPOUNDS FOR PHOTOCHEMICAL CROSSLINKING.** The best of all photoinitiator systems for crosslinking PVC compounds, according to tests made with a Tesla RVIM discharge tube, is the combination of chlorthioxanthone and triethanolamine. Pentaertholthriacrylate is the most effective crosslinking agent. Lead stabilizers give the best heat stability and a higher rate of a photochemical crosslinking than tin and antimony stabilizers. (Author abstract) 9 refs.

Drexler, Jiri (Research Inst for Rubber & Plastics Technology, Gottwaldov, Czech); Malac, Jiri; Rektorikova, Libuse; Simonik, Josef. *J Vinyl Technol* v 9 n 3 Sep 1987 p 95-102.

**083884 THERMAL ANALYSIS IN STUDIES OF PHOTOCHEMICAL TRANSFORMATIONS IN PVC.** The effects of photochemical processes in PVC in response to UV irradiation at 253.7 nm on its thermal stability were investigated. It was found that small



differences in the efficiency of the photochemical processes taking place in the PVC can be recorded in the thermal measurements, and that photodehydrochlorination lowers the temperature of thermal dehydrochlorination, while photooxidation and crosslinking increase the temperature of complete decomposition of this polymer. (Author abstract) 20 refs.

Kaminska, A. (N. Copernicus Univ, Torun, Pol); Kaczmarek, H. *J Therm Anal* v 32 n 6 Nov-Dec 1987 p 1791-1795.

**Physical Properties** See Also ORGANIC COMPOUNDS—Synthesis; POLYMERS—Physical Properties.

**083885 PHYSICAL GELS FROM POLY(VINYL CHLORIDE): BEHAVIOUR WITH CONCENTRATION AND TEMPERATURE OF AGGREGATES FORMED IN DILUTE SOLUTIONS.** Aggregates formed in dilute poly(vinyl chloride) (PVC) solutions (i. e. below the critical gel concentration) have been studied by static and quasielastic light scattering as well as by viscometry as a function of the polymer concentration and the temperature. From the results, it is concluded that two types of physical links exist in these aggregates: 'strong' links that persist up to 62°C and 'weak' links that progressively break up with temperature. Further, the weak links are absent in aggregates prepared at the lowest concentrations ( $C \leq 0.5 \times 10^{-2} \text{ g cm}^{-3}$ ) but appear at the highest concentrations ( $C \geq 1 \times 10^{-2} \text{ g cm}^{-3}$ ). These results are discussed and the conclusions are extrapolated to the gel state. In particular, it is suggested that the weak links are responsible for the physical ageing of PVC thermoreversible gels. (Author abstract) 17 refs.

Mutin, P.H. (CNRS, Strasbourg, Fr); Guenet, J.M.; Hirsch, E.; Candau, S.J. *Polymer* v 29 n 1 Jan 1988 p 30-36.

## Polymerization

**083886 APPLICATION OF AN EXPERT SYSTEM AND INDIRECT MODEL IN PVC INDUSTRIAL BATCH REACTOR.** PVC is one of the important materials in the modern society. The qualities of PVC depends on the constancy of the reacting temperature to a great extent. However, the polymerized process of a PVC reactor is a highly nonlinear and time-varying process. It is difficult to control the temperature of the reactor. In this paper a multistage cascade control corrected algorithm with an expert system and indirect control model is proposed. (Edited author abstract) 8 refs.

Wu, Qibin (Qingdao Inst of Chemical Engineering, China); Qi, Shufen; Liu, Chuanlai. *Modell Simul Control B* v 13 n 2 1988 p 55-63.

**083887 INFLUENCE OF POLY(VINYL ALCOHOL) SUSPENDING AGENTS ON SUSPENSION POLY(VINYL CHLORIDE) MORPHOLOGY.** After a brief review of the mechanism of PVC suspension polymerisation, the properties of polymers made using PVOH suspending agents are related to changes in the latter. The effect of variations in PVAc degree of hydrolysis and viscosity are related to changes in surface tension. Methods of achieving higher porosity by using low hydrolysis co-suspending agents are described. It is shown that higher bulk densities can be achieved by delayed addition of the PVOH. Levels of conjugated unsaturation and copolymer distributions are also shown to have important influences. (Edited author abstract). 14 Refs.

Ormondroyd, Stephen (Harlow Chemical co, Harlow, Engl). *Br Polym J* v 20 n 4 1988 p 353-359.

**Processing** See Also COPOLYMERS—Processing; PIPE, PLASTIC—Manufacture; PLASTICIZERS—Applications; WATER PIPELINES—Plastics Applications.

**083888 GEL PHENOMENA IN FLEXIBLE PVC RESIN.** The existence of fisheyes or gels in PVC final products has been a problem which the PVC industry has coped with for many years. The classical gel is a non-porous PVC particle which cannot adsorb plasticizer.

Other finished product defects which may be classified as gels by a customer are unfused particles of higher molecular weight resin or resin gels and agglomerates caused by improper mixing procedures called compound gels. Although this paper will define and cite examples of resin gels and compound gels, it will deal primarily with classical gel. Over the years, many different gel tests have been used by PVC suppliers and consumers in order to define the gel level of a particular sample of resin. The most common of these tests is the test using a two roll mill to produce a colored mill sheet which is examined and the number of gels reported. (Edited author abstract) 4 refs.

Zabrecky, Judy E. (Air Products & Chemicals Inc, Allentown, PA, USA). *J Vinyl Technol* v 9 n 1 Mar 1987 p 10-14.

**083889 PROCESSING AIDS FOR CHLORINATED POLYVINYL CHLORIDE.** Comparative studies of melt processability showed that chlorinated polyvinyl chloride (CPVC) had low melt index and high Brabender melt temperature and torque, as compared with conventional rigid polyvinyl chloride (PVC). Of 3 processing aids at 10 percent concentration, triphenyl phosphate increased melt index 30-fold, fusion rate 10-fold, melt temperature 20°C, and torque 31 percent in CPVC. Two other processing aids, an acrylic and a styrene/acrylonitrile copolymer, were less effective. Improvements in PVC were less dramatic than in CPVC. Overall, use of processing aids made CPVC processability equal or even superior to conventional rigid PVC. (Author abstract) 18 refs.

Deanin, Rudolph D. (Univ of Lowell, Lowell, MA, USA); Mast, Jonathan D. *J Vinyl Technol* v 9 n 1 Mar 1987 p 15-17.

**083890 EFFECT OF TYPE AND CONCENTRATION OF PLASTICISER ON BEHAVIOUR OF PVC. PART 2: PROCESSING.** PVC compounds containing 30, 50 and 70 phr of various plasticizers were dry blended then processed at temperatures in the range 150°C to 200°C in a Banbury mixer. Temperature profiles obtained during dry blending were interpreted in terms of physical changes in the dry blend. Rapid plasticizer uptake resulted in grain swelling which was then followed by grain attrition. Surface mattness tended to disappear at high plasticizer concentration, high Banbury processing temperatures, and when more active plasticizers were used. (Edited author abstract) 16 refs.

Patel, S.V. (Univ of Technology, Loughborough, Engl); Gilbert, M. *Plast Rubber Process Appl* v 8 n 4 1987 p 215-226.

**083891 POLY(VINYL CHLORIDE)/PLASTICIZER-MIXTURE INTERACTIONS. PART I. PHTHALATE ESTER MIXTURES.** Flory-Huggins interaction parameters,  $\chi$ , have been determined as a function of plasticizer composition for poly(vinyl chloride) in various binary mixtures of phthalate ester plasticizers using a method involving the micro-determination of the temperature at which PVC particles in excess plasticizer appear to melt. An optimum composition at which  $\chi$  goes through a minimum was found to exist for some of the systems. A good correlation between the apparent melting temperature and  $\chi$  for the neat plasticizers with PVC was also established. (Edited author abstract). 7 Refs.

Tomaselli, F. (Carlew Inc, St.-Remi, Can); Gupta, V.P.; Calderon, H.S.; Brown, G.R. *J Vinyl Technol* v 10 n 2 Jun 1988 p 72-76.

**083892 APPLICATION OF THE UNIFAC-FV GROUP CONTRIBUTION METHOD TO THE PREDICTION OF RELATIVE COMPATIBILITY OF PLASTICIZERS WITH PVC.** The applicability of a modified version of UNIFAC group contribution method, UNIFAC AC-FV, is explored for use in predicting liquid-liquid equilibrium behavior of plasticizer/PVC systems. A Fortran program for the UNIFAC-FV model has been written to calculate the activities and changes in the Gibbs free energy for multicomponent systems. By this means, the interaction parameter  $\chi$  for a polymer-solvent system is defined using the well known Flory-Huggins

equation. The concentration dependent Gibbs free energy of mixing is used as a criterion for the relative compatibility of the PVC-plasticizer system. The method indicates that, for the plasticizers examined, DOS is the least compatible and DBP is the most compatible with PVC. This confirms the results of the glass transition width measured by dynamic mechanical analysis previously reported. (Author abstract). 19 Refs.

Boo, Hwee-Khim (Univ of Connecticut, Storrs, CT, USA); Shaw, Montgomery T. *J Vinyl Technol* v 10 n 2 Jun 1988 p 77-83.

## Production

**083893 RECENT DEVELOPMENTS IN PVC POLYMERIZATION.** The report concentrates on those aspects of vinyl chloride (VCM) polymerization where recent work has provided us with a better understanding or new insight. The progress in the field made during the last few years is mainly due to the fact that new or strongly improved experimental techniques (e.g., more powerful spectroscopic methods) have become available. Besides a discussion of recent work in the field, the present contribution gives a brief, general introduction to PVC and a short description of the main polymerization processes used for PVC production. This will serve mainly as a background for those who have not been active in the field. 54 refs.

Tornell, Bertil (Univ of Lund, Lund, Swed). *Polym Plast Technol Eng* v 27 n 1 Mar 1988 p 1-36.

**Pyrolysis** See Also POLYSTYRENES—Degradation.

**083894 PRODUCTS OF NON-FLAMING COMBUSTION OF POLY(VINYL CHLORIDE).** A relatively large laboratory-scale sample of a commercial type of poly(vinyl chloride) usually used for window blinds, was decomposed by non-flaming combustion under carefully controlled conditions (823, 1023 and 1223 K, in air, in a mixture of air and nitrogen and in nitrogen) which simulated the main stages of development of a fire. Three fractions of the decomposition products, residue, gases and organic volatile-condensable products, and the influence of the decomposition conditions on their yield, were studied. The residue yield decreased with increase in the decomposition temperature and in oxygen content of the atmosphere. The organic volatile-condensable products consisted mainly of aromatic compounds many of which contained fused rings. Benzene was the dominant product in this fraction. (Edited author abstract) 24 refs.

Alajbeg, Andja (INA, Zagreb, Yugosl). *J Anal Appl Pyrolysis* v 12 n 3-4 Nov 1987 p 275-291.

## Quality Control

**083895 SQC IN PVC QUALITY CONTROL TESTING.** Quality control testing can be improved by applying statistical methods. For example, control testing of resins at different locations can identify idiosyncrasies in sites as well as in the testing itself. A program using standard and 'control' resins in round-robin testing between sites was designed to find the sources of variability and to develop procedures to reduce it. The test procedures were: inherent viscosity, bulk density, dry contamination, fisheyes, dry-blend time, particle-size distribution, and PVC resin color. Statistical quality control (SQC) charting with root-cause analysis identified mechanical, environmental, and procedural sources of variability. (Edited author abstract) 3 refs.

Hudak, Victor J. (Air Products & Chemicals Inc, Allentown, PA, USA); Hoffman, David E.; Smith, Carol J. *J Vinyl Technol* v 9 n 3 Sep 1987 p 108-113.

**Radiation Effects** See Also DOSIMETERS—Plastics Applications; MEMBRANES—Radiation Effects.

**083896 CHEMICAL CHANGES IN ELECTRON-BEAM-IRRADIATED POLYMERS.** It is shown that the unzipping mechanism could be particularly important for the initial stages of dehydrochlorina-



tion of the irradiated polymer and thus for the explanation of the double exponential decay curves. The analysis of IR spectra is not very easy and only recently has Fourier Transform Infrared (FTIR) spectroscopy with powerful facilities become available. The purpose of this work is to utilize the FTIR spectroscopy for the study of chemical changes in chlorinated polymers, mainly PVC and to correlate the results with chlorine loss curves, measured by X-ray energy dispersive analysis. 21 refs.

Vesely, D. (Brunel Univ, Uxbridge, Engl); Finch, D.S. *Ultramicroscopy* v 23 n 3-4 1987 p 329-337.

**083897 IMPROVEMENT OF PVC FLOOR TILES BY GAMMA RADIATION.** Gamma radiation presents a unique method of transforming highly plasticized PVC floor tiles, manufactured at high speed through injection moulding, into a high quality floor covering at a cost at least 30% less than similarly rated rubber tiles. A specially formulated PVC compound was developed in collaboration with a leading manufacturer of floor tiles. These tiles are gamma crosslinked in shipping cartons to form a dimensionally stable product which is highly fire resistant and inert to most chemicals and solvents. These cross-linked tiles are more flexible than the highly filled conventional PVC floor tiles, are scratch resistant and have a longer lifespan and increased colour fastness. These tiles are also less expensive to install than conventional rubber tiles. (Author abstract) 8 refs.

du Plessis, T.A. (Iso-Ster Ltd, Kempton Park, S Afr); Badenhorst, F. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 747-751.

## Recycling

**083898 RECYCLING OF WASTE PVC LEATHER AND PVC URETHANE IN THE AUTOMOBILE INDUSTRY.** Waste plastics are low in scrap value in the automobile industry and are most difficult to dispose of for reutilization. The waste plastics have been disposed of by incineration and reclamation as measures for preventing industrial pollution, but these measures involved various problems and quite a different idea could be successfully developed to effectively reutilize them. The case of reutilization is introduced here. (Author abstract)

Miyama, Seiji (Nissan Motor Co, Yokosuka, Jpn). *Conserv Recycling* v 10 n 4 1987 p 265-272.

**083899 MATERIAL AND ENERGY RECYCLING OF PVC: CASE STUDIES.** In this paper, the title subject is handled with the help of the following three cases: material recycling of post-consumer PVC bottles in France, PVC product design and material recycling and energy and raw material recycling through incineration in Germany. Subjects covered include material flow, technology, economics, raw material recycling, and others. 6 refs.

Claerbout, J. *Conserv Recycling* v 10 n 2-3 1987, Recycl of Mater, Sel Pap from the Fifth Int Recycl Congr, Berlin, West Ger, Oct 29-31 1986 p 185-190.

## Research

**083900 ROLE OF THE EMULSIFIER IN THE FORMATION OF AN ELECTRIC DOUBLE LAYER ON PARTICLES OF POLYVINYL CHLORIDE IN PLASTISOLS.** The role of an ionogenic emulsifier in the formation of an EDL on particles of polyvinyl chloride (PVC) in plastisols was determined. It was shown that the emulsifier is partially desorbed from the surface of the polymer into the plasticizer and is ionized in the plasticizer. The effect of the concentration of the emulsifier in the plasticizer on the value of the  $\zeta$  potential of the polymer particles was studied. It was found that dissociation of the emulsifier in the plasticizer determines the electrical conductivity of the dispersion medium of plastisols and consequently the thickness of the electric double layers (EDL) on the PVC particles. (Edited author abstract) 13 refs.

Berezov, L.V. (Gorky Univ, USSR); Guzev, V.V.; Golubev, A.A.; Kiryukhina, I.A.; Krupnova, M.N. *Colloid J*

*USSR* v 49 n 1 Jan-Feb 1987 p 1-6.

**083901 THEORETICAL STUDY OF PREPARATION OF PLASTICIZED PVC SAMPLES EXHIBITING LOW MATTER TRANSFERS.** A method of preparation of plasticized PVC sample exhibiting very low levels of mass transfer when contacted with a liquid was studied from an experimental and theoretical point of view. The principle of the method was as follows: The sample was soaked in the liquid for a definite short time and two matter transfers took place; the liquid entered the PVC while the plasticizer left the PVC. Then the sample was extracted and the liquid located in the PVC was evaporated. Both these transfers were found to be controlled by transient diffusion with concentration-dependent diffusivities. A model based on numerical methods with finite differences was developed and successfully tested. (Edited author abstract). 21 refs.

Khatir, Y. (Univ of St. Etienne, St. Etienne, Fr); Taverdet, J.L.; Vergnaud, J.M. *J Polym Eng* v 8 n 1-2 Jan-Jun 1988 p 111-129.

**Rheology** See Also PLASTISOLS—Physical Properties; RHEOMETERS—Applications.

**083902 RHEOLOGY OF PVC.** A brief historical review has been made of rheological instrumentation developed for measuring the flow properties of vinyl materials. During this maturation of techniques the need for more complete flow characterizations spawned the development of dynamic mechanical instruments. These instruments provided convenient and accurate means of generating complex viscosity data composed of elastic and elements. Examples have been presented illustrating how these newer techniques are able to reliably provide critical data needed to control productivity and product performance properties. Extension of these techniques to on-line rheometry has improved quality control link in the compounding operation. (Edited author abstract)

Driscoll, Stephen Burke (Univ of Lowell, Lowell, MA, USA); Grolman, Cory Peter. *J Vinyl Technol* v 9 n 2 Jun 1987 p 53-59.

**Rigid** See WATER PIPELINES—Plastics Applications.

**Sheet** See MEMBRANES.

## Stabilizers

**083903 EFFECT OF BARIUM AND CADMIUM STABILIZERS ON THE THERMAL DEHYDROCHLORINATION OF POLY(VINYL CHLORIDE): A RESONANCE RAMAN SPECTROSCOPIC STUDY.** A laser Raman spectroscopic study has been made of the effect of barium and cadmium stabilizers on the thermal dehydrochlorination of poly(vinyl chloride)(PVC). The results obtained indicate that, in terms of the total level of dehydrochlorination, cadmium stearate is not as superior to barium stearate as the visual appearance of the polymer suggests. Also, the level of dehydrochlorination produced in the presence of a mixed stabilizer is not significantly lower than that produced in the presence of barium stearate alone, while samples of the latter exhibit much stronger color. It has also been shown that cadmium stearate can reduce the length of long polyene sequences, presumably by a reaction near the center of such a sequence. (Author abstract) 8 refs.

Gerrard, D.L. (BP Research Cent, Sunbury-on-Thames, Engl); Bowley, H.J.; Biggin, I.S. *J Vinyl Technol* v 9 n 2 Jun 1987 p 43-45.

**083904 STABILIZATION OF POLY(VINYL CHLORIDE). VIII. SYNERGISMS BETWEEN EPOXY COMPOUNDS AND METAL SOAPS.** Effects of bisphenol A type epoxy compounds involving various average molecular weights on the zinc stearate/calcium stearate and the cadmium stearate/barium stearate synergistic soaps induced thermal stabilization of poly(vinyl chloride) (PVC) were investigated by colorimetry. The remarkable stabilization effects of epoxides could not be observed on the PVC films without synergistic soaps, while

the stabilization of PVC was markedly enhanced by combined use of epoxides and synergistic soaps. The appearance of excessive coloration of cool color producing metal chloride-polyene complexes which were an origin of abrupt discoloration of stabilized PVC was retarded by using epoxides together with synergistic soaps. (Edited author abstract) 18 refs.

Iida, Takeo (Osaka Inst of Technology, Osaka, Jpn); Kawato, Junji; Maruyama, Kazushige; Goto, Kunio. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2355-2365.

**083905 PVC STABILISERS.** In Western Europe, 34 companies are suppliers of PVC heat stabilisers; eighteen of these are engaged in manufacturing and development. Solid stabilisers are utilised in the processing of rigid PVC while liquid stabilisers are used for plasticised PVC and pastes. Consumption of stabilisers in Western Europe in 1987 is estimated at some 87000 t. Of this 56000 t (64%) will be for processing of rigid PVC and 31000 t (36%) for processing of plasticised PVC and pastes. The product development of PVC stabilisers must be considered in the light of the growth of PVC consumption. Although the heat stabilisation of PVC has achieved a high technical standard, innovations are still sought in areas where disproportionate growth is predicted. Toxicological reservations and environmental compatibility requirements are further reasons for increased activity in product development. Based on forecasts for PVC for the next years, it is safe to say that the stabiliser market will remain steady. There will be a shift to increased lead content. 11 refs.

Goerlich, E. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 87-88.

**083906 PROTON DONORS AS STABILIZERS FOR POLYVINYL CHLORIDE.** The chemical stabilization of PVC by proton donors such as carboxylic, hydroxyl and CH acids has been examined. The stabilizing action of these compounds was examined from the viewpoint of their interaction with active centers of PVC thermal degradation i.e. with grouping such as  $-(CO)-CH=CH-CHCl-$ . The correlations of the relation between the magnitudes of the stabilizing effect of proton donors and their activity have been established. Compounds of high acidity have a large inhibiting action of the thermal degradation of the polymer. (Author abstract) 6 refs.

Kolesov, S.V. (USSR Acad of Sciences, USSR); Steklova, A.M.; Ge, M.; Zaikov, G.Ye.; Minsker, K.S. *Polym Sci USSR* v 28 n 9 1986 p 2096-2103.

**083907 SYNERGETIC EFFECTS OF POLYACRYLATES WITH SYNERGETIC METAL SOAP ON THE STABILIZATION OF POLY(VINYL CHLORIDE).** Effects of synergistic combination of polyacrylates and zinc stearate/calcium stearate soap on the thermal stabilization of poly(vinyl chloride) (PVC) were investigated by colorimetry. Poly(sodium acrylate), poly(methyl acrylate), and poly(ethyl acrylate), and partially saponified poly(methyl acrylate) and poly(methyl methacrylate) markedly enhanced the thermal stabilization of PVC containing zinc stearate/calcium stearate soap, while poly(acrylic acid), poly(butyl acrylate), poly(2-ethylhexyl acrylate), and poly(methyl methacrylate) did not exhibit measurable enhancement of the stabilization of PVC. The synergism of polyacrylates with the synergistic metal soap was enhanced with decreasing number of carbons in the side chains, and this was due to good compatibility of the polyacrylates having shorter side chains with PVC. X-ray photoelectron spectroscopy of the polyacrylates-metal soap-PVC mixture indicated that the polyacrylates, which were effective as co-stabilizer, formed Zn-O linkages with zinc chloride. (Edited author abstract) 15 refs. In Japanese.

Iida, Takeo (Osaka Inst of Technology, Osaka, Jpn); Ikeda, Hirohisa; Kawamura, Shigeharu; Goto, Kunio. *Kobunshi Ronbunshu* v 45 n 2 1988 p 117-122.



## Strain

**083908 STUDY OF RABOTNOV'S EQUATION AND ITS APPLICATION TO POLYMER MATERIALS.** A method of independent definition of functions appearing in Rabotnov's equation is suggested; it is based on experimental isochronic curves of creep. It is shown that the equation can be applied uniformly to monotonic and nonmonotonic time variations of strain. The equation predicts an accelerated recovery, compared with the Rozovsky-Persault equation. Rabotnov's equation is shown to describe adequately the results of experiments with polyvinylchloride and polymethyl methacrylate under constant loads and when subjected to step loading. (Author abstract) 5 refs.

Bugakov, I.I.; Chepovetskii, M.A. *Leningrad Univ Mech Bull* n 1 1987 p 15-21.

**Stresses** See POLYETHYLENES—Stresses.

## Synthesis

**083909 POLYMERIZATION OF VINYL CHLORIDE AT REDUCED MONOMER ACCESSIBILITY. IV. THE EFFECT OF DIFFUSION CONTROL ON POLYMERIZATION RATE, MOLECULAR WEIGHT, AND THERMAL STABILITY.** The effect of diffusion control on the polymerization of vinyl chloride has been studied by observing the rate as well as the molecular weight and the thermal stability of the polymer formed. The polymerizations were performed at 97% of saturation pressure in a water-suspended system at 55°C, using emulsion PVC latex as seed and a water-soluble initiator. The monomer was charged as vapor from a storage vessel kept at a lower temperature. Characterization included determination of molecular weight distribution by GPC and viscometry, and thermal dehydrochlorination. The gas-liquid contact was varied by changing the speed of agitation and the design of the stirrer. With a propeller, the polymerization rate increased with the agitation up to ca. 1000 rpm, where after it became almost constant. Simultaneously, the molecular weight and the thermal stability increased. (Edited author abstract) 21 refs.

Hjertberg, Thomas (Chalmers Univ of Technology, Goteborg, Sweden). *J Appl Polym Sci* v 36 n 1 Jun 20 1988 p 129-140.

**Testing** See Also MEMBRANES—Testing.

**083910 TENSILE CREEP TESTS, INTERNAL PRESSURE TESTS, AND SCANNING ELECTRON MICROSCOPY OF ELECTRICAL CONDUITS OF POLY(VINYL CHLORIDE).** Electrical conduits prepared from a mixture of suspension and emulsion poly(vinyl chloride) (PVC) resins were subjected to internal pressure tests at 60°C, covering a wide range of pressures. Some axial tensile creep tests were also carried out at the same temperature. As expected, the ability to withstand internal pressure decreased when the amount of lubricant was increased above the level used in normal commercial production. Fracture surfaces obtained in the two test methods were investigated by scanning electron microscopy. (Edited author abstract) 6 refs.

Johansson, Lennart (Lund Inst of Technology, Lund, Sweden); Tornell, Bertil. *Polym Eng Sci* v 27 n 19 Oct 1987 p 1469-1472.

## Thermal Effects

**083911 EFFECT OF SELECTED PIGMENTS ON HEAT BUILD OF RIGID PVC SIDING.** The concept is that high-IR-reflecting pigments can be effective in reducing heat build of plastics subjected to solar exposure and that this should translate into improved physical-property retention and reduced buckling due to thermal expansion. Data are given for a high-IR black pigment in gray, pastel, and brown vinyl siding. This article will show how effective a high-IR-reflecting black pigment can be compared to other typical blacks in reducing heat build in gray, pastel, and brown rigid PVC

house siding.

Charvat, R.A. (Harshaw/Filtrol Partnership, Cleveland, OH, USA). *Plast Compd* v 10 n 7 Nov-Dec 1987 p 23-24, 26-29.

**Thermal Properties** See COPOLYMERS—Blending.

**Thermodynamic Properties** See POLYTETRAFLUOROETHYLENE—Thermodynamic Properties.

## Viscoelasticity

**083912 COMPLEX PLANE PARAMETERS FOR THE VISCOELASTIC BETA PROCESS IN POLY(VINYL CHLORIDE).** Tensile-yield studies show that the high strain rate or low temperature behavior of poly(vinyl chloride) may be determined by its beta process. In this work we made viscoelastic measurements covering the beta process over a temperature range of -140 to 20°C and a frequency range of 0.1-30 Hz. The activation energy for the beta process was found to be  $14.1 \pm 1.2$  kcal mol<sup>-1</sup> which is in excellent agreement with the value of 14 determined from tensile yield studies. The  $\alpha$  and  $\beta$  parameters for the relaxation function are discussed in terms of Mansfield's spring and dashpot model representing intra- and intermolecular interactions. (Edited author abstract) 12 refs.

Havriiik, S. Jr. (Rohm & Haas Co, Bristol, PA, USA); Shortridge, T.J. *Polymer* v 29 n 1 Jan 1988 p 70-77.

## Waste Disposal

**083913 PVC AND INCINERATION.** Among the most feared toxic chemicals known to man is 2,3,7,8-tetrachlorodibenzodioxin (TCDD). PVC is a source of chlorine in waste and therefore it has been contended that its means of disposal should not be incineration. It is argued that the chlorine content of non-PVC sources is in excess of that needed for dioxin production and therefore exclusion of PVC from municipal waste will have little effect upon harmful emissions. This investigation presents evidence substantiating this concept. (Author abstract). 19 Refs.

Carroll, William F Jr. (Vinyl Inst, Wayne, NJ, USA). *J Vinyl Technol* v 10 n 2 Jun 1988 p 90-94.

**Weathering** See Also BUILDINGS—Facings.

**083914 WEATHERABILITY OF POLYVINYL CHLORIDE.** When PVC is exposed to long-term outdoor environment, it undergoes very slow long-term photochemical degradation. It is subjected to various atmospheric effects including exposure to rain, fungus, mechanical stress pollutants and exposure to ultraviolet radiation. The ultimate result is then reflected in a marked loss of plasticizer, discoloration, embrittlement and finally loss in mechanical properties. The problem, therefore, concerns the photochemical instability even at a much lower temperature which severely restricts the use of resin in outdoors where long-term performance is of prime importance. The authors present the current trend of research in the field of photostabilization of PVC during outdoor weathering. 72 Refs.

Gupta, B.D. (ENSAM, Paris, Fr); Verdu, J. *J Polym Eng* v 8 n 1-2 Jan-Jun 1988 p 73-92.

## Welding

**083915 RELATIONSHIP OF WELDING TECHNOLOGY TO DEGREE OF PLASTICIZATION IN THE PVC FILMS.** The influence of the degree of plasticization on optimum heat-sealing or high-frequency welding conditions has been studied for plasticized PVC films with different quantities of DOP plasticizer. Two equations were obtained that relate the parameters of the welding process (time and temperature, or time and specific anodic current) with the degree of PVC film plasticization. The equations allow calculation of welding conditions needed to obtain maximum strength of welded joints. One describes the durability of lap joints; the other

of T-joints. (Author abstract) 5 refs.

Dodin, Mark (MDP Research & Testing Lab, North Reading, MA, USA). *J Vinyl Technol* v 9 n 2 Jun 1987 p 67-70.

**POLYVINYLIDENE CHLORIDES** See Also ELECTRODES—Electric Properties; VINYL RESINS—Radiation Effects.

## Blending

**083916 MORPHOLOGICAL STUDY OF PVDC/PE BLENDS.** Polyvinylidene chloride copolymers (PVDC)/polyethylene (PE) immiscible blends offer improved extrusion processing over PVDC alone while retaining the excellent oxygen and water barrier properties. The transport of permeants through these composites is related to the geometry of the dispersed phase PE. A lamella or striated type PE phase is desired as this results in a better barrier than a more spherical geometry. This morphology can originate most easily from extensional flow. Other possible mechanisms to consider are the relationship of normal and surface tension stresses, and the breakup and coalescence equilibrium of the dispersed phase. (Author abstract) 9 refs.

Kirkpatrick, Donald E. (Dow Chemical Co, Midland, MI, USA); Ranck, Dan. *J Plast Film Sheeting* v 3 n 4 Oct 1987 p 290-298.

**Bonding** See ADHESIVES—Extrusion.

**PONTOONS** See PORTS AND HARBORS—Construction.

**POPULATION STATISTICS** See Also AUTOMOBILES—Seat Belts; FISHERIES; FISHERIES—Monitoring; MOTOR TRANSPORTATION—Accidents; STATISTICAL METHODS—Statistical Tests; URBAN PLANNING—Land Use.

**083917 GENERALIZED PROBABILITY MODEL FOR ESTIMATING THE PROPORTION OF THE FEMALE POPULATION AT DIFFERENT LEVELS OF FERTILITY BASED ON CENSUS SAMPLING FROM A MIXED POPULATION.** The present exercise is an attempt to generalize a probability model referring to the waiting time distribution for conception in a mixed group of fecund females with two varying levels of fecundity, based on a census sample truncated at time  $T = t$  from the date of resumption of fecundity following an earlier conception. Estimates of the proportion of fecund females over time, viz.,  $\pi_i(t)$  ( $i = 1, 2, 3$ ) are attempted by the method of maximum likelihood on the basis of a census sample truncated at time  $T = t$  under the generalized set up. (Edited author abstract) 6 refs.

Biswas, Suddhendu (Univ of Delhi, Delhi, India); Kumar Sehgal, Vijay. *Int J Syst Sci* v 18 n 10 Oct 1987 p 1909-1917.

**083918 CHAOS AND THE DYNAMICS OF BIOLOGICAL POPULATIONS.** As first emphasized in the early 1970s, the nonlinearities that are inherent in simple models for the regulation of plant and animal populations can lead to chaotic dynamics. This review deals with a variety of instances where chaotic phenomena can arise, particularly in interactions between prey and predators (including hosts and pathogens, hosts and parasitic insects, and harvested populations). Some of the complications in disentangling deterministic chaos from environmental noise will be discussed. The combination of population biology with population genetics leads to an even richer assortment of nonlinear phenomena and to the suggestion that many genetic polymorphisms may vary cyclically or chaotically (rather than being steady, as usually is assumed implicitly). (Edited author abstract) Refs.

May, R.M. (Princeton Univ, Princeton, NJ, USA). *Proc R Soc London Ser A* v 413 n 1844 Sep 8 1987 p 27-44.



## Computation

**083919 PERIODIC STRUCTURE BEYOND A HOPF BIFURCATION.** A Hopf bifurcation where a stable fixed pointer bifurcates into a stable periodic orbit as a parameter passes through a critical value occurs frequently in nonlinear problems. Here, the Maynard Smith nonlinear map in population dynamics involving a parameter  $k$  is analysed with the help of numerical experiments in order to determine the periodic structure of the map beyond the primary Hopf bifurcation of period 6 which occurs at  $k = 1$ . The interesting result obtained is that in the parameter range from  $k = 1$  to the value for blow-up of all initial conditions, there are successive windows of periods 7, 8 and 9, the last containing a secondary Hopf bifurcation of period 4. (Author abstract) 7 refs.

Mitchell, A.R. (Univ of Dundee, Dundee, Scotl); Stein, G.; Maritz, M. *Commun Appl Numer Methods* v 4 n 2 Mar-Apr 1988 p 263-272.

**Developing Countries** See URBAN PLANNING—Land Use.

## Mathematical Models

**083920 SURVEY OF CENSUS BUREAU POPULATION PROJECTION METHODS.** Population projections methods of the US Census Bureau draw upon several different traditions of forecasting: demographic accounting, judgmental, time series, deterministic, and explanatory. This paper reviews each of the forecasting traditions in population projections, describe the US Census Bureau's current methods for national and state population projections, and proposes new hybrid approaches such as demographic-time series methods for national fertility projections and economic-demographic methods for state migration projections. Throughout the article, possible parallels with forecasting in other disciplines are noted. (Author abstract) 80 refs.

Long, John F. (US Census Bur, Washington, DC, USA); McMillen, David Byron. *Clim Change* v 11 n 1-2 Aug-Oct 1987 p 141-177.

## Research

**083921 COMPETING RISK THEORY APPROACH TO THE NATURE OF THE OUTCOME OF CONCEPTION.** An attempt has been made to obtain the probabilities of pregnancy termination by live birth, still birth and abortion, in any particular order, assuming that the termination of pregnancy is associated with three competing 'risks', i.e., live birth, still birth and abortion, which need not necessarily operate at the same point of time. A probability model has been constructed to obtain the conditional probability of live birth/still birth/abortion given that the previous pregnancy has been terminated by a particular one of the three. The correlation coefficient between the outcomes of two particular consecutive pregnancy terminations, viz., live birth and reproductive wastage has also been obtained. Given data pertaining to sample correlation coefficients between the nature of consecutive orders of the outcomes of conception from first to sixth, an exercise has been undertaken to estimate parameters relating to the 'hazard' rates of live births, still birth and abortion. (Edited author abstract) 5 refs.

Biswas, Suddhendu (Univ of Delhi, Delhi, India); Kumar Sehgal, Vijay. *Int J Syst Sci* v 18 n 10 Oct 1987 p 1899-1908.

## Sampling

**083922 RESTRICTED SIMPLE RANDOM CLUSTER SAMPLING PLAN.** A new sampling design is proposed which reduces the spread (and thus travel cost) of a simple random sample in large-scale surveys. It provides at least a partial solution to the problem of non-response. At nearly half the travel cost, the proposed design attains efficiency almost equal to that of the simple random sample mean. (Author abstract). 7 Refs.

Srivastava, O.P. (Haryana Agricultural Univ, Hisar, India); Munjal, J.N.; Goyal, K.C. *Am J Math Manage Sci* v 8 n 1-2 1988 p 165-180.

**PORCELAIN** See Also COATINGS—Wear; ELECTRIC INSULATORS—Performance; GLAZES.

**083923 ISOSTATISCHES VERDICHTEN VON TONERDEPORZELLANMASSEN.** [Isostatic Densification of Alumina Porcelain Bodies]. During the fabrication of high-voltage insulators, electro-porecelain bodies can be isostatically densified as an alternative to extrusion. Because of the obvious advantages of this so far rarely applied processing method, a number of more cost-efficient granulation processes providing compact grains are discussed as possible substitutes for the currently applied spray-drying process which is characterized by a relatively high level of energy consumption. The paper presents results concerning the isostatic densification behaviour of an industrial alumina porcelain body prepared in a granulating pan mill. (Edited author abstract) 8 refs. In German.

Hesse, A.O.F. (TU Clausthal, Clausthal-Zellerfeld, West Ger); Hennicke, H.W. *Keram Z* v 39 n 12 Dec 1987 p 868-872.

## Composition Effects

**083924 OPTIMIZATION OF THE COMPOSITION OF PORCELAIN BODIES USING A MICROCOMPUTER.** The procedures for calculating and correcting the composition of the porcelain bodies is based on the methodological recommendations that determine the order of computations with regard to three main criteria: the adsorption index, the rational composition, and the kaolin number. The authors developed and introduced an automatic system for carrying out operative (operational) calculation of the rational compositions of the raw materials and the bodies and for modelling new body composition when changing over from one raw material composition to another. The technological base of the system is an 'Elektronika-60' microcomputer present in the architecture of the 15VUMS-028-025 computer control system (complex) having an external memory in flexible magnetic disks. Programming consists of three separate problems: calculating the rational composition of the raw material, calculating the mineralogical composition of the body, and modelling the body compositions. 3 refs.

Sverdlov, L.Z. (All-Union Scientific-Research Inst of Porcelain, USSR); Krupkin, Yu.S.; Postolova, E.N. *Glass Ceram* v 44 n 5-6 May-Jun 1987 p 255-257.

**Decoration** See Also CERAMIC PRODUCTS—Decoration.

**083925 DIE FARBKONSTANZ BEIM SIEBDRUCK.** [Color Stability of Silkscreen Printing]. By comparing two body stains, which were used in a standard grain size and in an extreme degree of fineness, one was able to test the screen passage with printing going on. The results indicate that the particle size distribution changes the color shade; a narrow grain size distribution proved favorable. (Author abstract) In German.

Linke, E. (Reimbold & Strick, Cologne, West Ger). *Keram Z* v 39 n 8 Aug 1987 p 516-518.

**Dielectric Properties** See ELECTRIC INSULATING MATERIALS—Ceramic.

## Drying

**083926 INTENSITY OF ENERGY INPUT DURING RADIATION DRYING OF PORCELAIN PRODUCTS IN METALLIC MOLDS.** The application of porous metallic molds (instead of gypsum molds) in the drying and shaping units used in the production of porcelain components by plastic forming makes it possible to intensify the drying process of the components to a significant extent. An analysis of the progress of the high-temperature drying process shows that the gradients

of the potentials of heat transfer and moisture removal virtually appear right from the beginning of drying and tend to increase continuously with time. During the process of drying at 450°C, separation (detachment) of the products from the mold takes place after 40-45 sec depending on the quality of the working surface of the mold and the magnitude of the forming (shaping) stresses. The criteria of crack formation  $K_2$  and  $K_3$  can be found for any given regime. Their values are determined from the normalized thermograms and hygrograms. Figure 3 shows that the critical values of  $K_2$  increase with increasing stringency (intensity) of the thermal regime. Each regime has a specific value of  $K_{2, max}$ . 3 refs.

Bondarev, V.A. (Byelorussian Polytechnical Inst, USSR); Mikhalev, V.P.; Gubskii, G.Z. *Glass Ceram* v 43 n 7-8 Jul-Aug 1986 p 357-361.

**083927 AUTOMATIC CONTROL SYSTEM OF THE TECHNOLOGICAL PARAMETERS (ACS TP) OF DRYING AND FIRING PORCELAIN PRODUCTS.** One of the main functions of ACS TP is assembling (gathering) and processing the information entering from the control object (analog signals from the sensing devices of the technological parameters and digital signals regarding the conditions of the equipment). With reference to the drying and firing processes, these are digital (discrete) signals indicating the quality and the quantity of production of a given drying unit (and the first and the second firing units). The data are recorded in the production manual. Two methods are employed for determining the reliability of the signals of the sensing element: by comparing the current value of the signal with its technically possible limiting value or based on the rate of variation of the signal itself. The second method is based on the fact that, as a rule, the technological parameters of the thermal processes vary slowly whereas the breakdown of the sensing elements causes a rapid change in the signal. In ACS TP of firing and drying, there is a provision for feeding the initiating signals into the memory device of the computer. The initiating signals are distinguished from the signals of the common discrete sensing devices by a smaller impulse duration.

Khatamov, U.Kh. (Tashkent Polytechnic Inst, USSR). *Glass Ceram* v 44 n 5-6 May-Jun 1987 p 252-254.

**Manufacture** See Also KILNS—Design.

**083928 INVESTIGATIONS CONCERNING THE WORKABILITY AND PROPERTIES OF A HIGH-ALUMINA PORCELAIN BODY.** The properties of porcelains depend both on the body composition and on the conditions of manufacture. This report deals with the effects of various aluminas on the workability and properties of the fired body. The subject of investigation was an industrial-grade hotel porcelain body made of feldspar, kaolin and quartz. The specimens were obtained by casting. In order to avoid falsifying the effects of the alkali contents of the aluminas on the properties of the slips, no deflocculants were used. In German and English. 5 refs.

Biesen, R. (Hutschenreuther Keramag GmbH, Schwanndorf, West Ger); Geyer, G.A.; Schueller, K.-H. *CFI Ceram Forum Int Ber DKG* v 64 n 10 Oct 1987 p 376-379.

**083929 KINETICS OF SHERD (BODY) FORMATION DURING SLIP CASTING.** This paper deals with a study of the specific features of the casting process when evacuation is carried out in porous molds made from different materials and the determination of its main technological parameters. In order to reveal the effect of the physical and technological properties of the material of the molds on the process of casting porcelain products in them, we studied various materials (gypsum, phosphogypsum, and porous ceramics) having a wide range of structural characteristics. Such an approach makes it possible to evaluate the effectiveness of evacuation when using different technological flow sheets and materials. Our studies showed that the relative potential of moisture



extraction increases during evacuation with increasing pore diameter. In order to prevent entrance of the solid particles of the casting body into the pores, the average hydraulic diameter of the pores  $D_{av}$  of the material of the mold was maintained at 1.5–2  $\mu\text{m}$ . At a residual pressure of 0.08 MPa, one can expect an increase in the effectiveness of moisture extraction and a corresponding increase in the effectiveness of sinter formation by 30–60%. 2 refs.

Deich, S.M. (All-Union Scientific-Research Inst of Porcelain, USSR); Kaplan, E.D.; Strakhov, V.M.; Liburkin, V.G.; Krupnik, Yu.S. *Glass Ceram* v 44 n 5-6 May-Jun 1987 p 210-212.

**083930 INTENSIFYING THE SECOND FIRING OF FLAT PORCELAIN PRODUCTS.** The authors determined the optimum regimes of saggerless firing of flat porcelain products. The following parameters were considered to be decisive: the firing temperature of the products, the composition of the furnace atmosphere in the firing zone, the duration of holding the products during different stages of firing, the duration of firing the products, the quality of spreading the glaze, and the deformation and the whiteness of the porcelain products. The obtained results (taking the dimensions of the products and their range, the permissible temperature gradients, and the admissible heating rates into account) formed the basis of our method for calculating the length of the zones of the working channel of the thermal units intended for fast firing and establishing the firing cycle. The results of the industrial tests conducted for establishing the optimum fast second-firing regime of flat porcelain products showed that in the fast tunnel furnaces, when loading the products in the cars having shelves, it is possible to manufacture products having high quality and whiteness by maintaining a firing duration of 4–8 h. The proposed solution for intensifying the firing process of porcelain products is recommended for application at porcelain factories.

Kryzhanovskii, K.S. (Ukrainian Scientific-Research Inst of Porcelain & Pottery, USSR); Kashcheev, B.P.; Khomenko, V.A.; Nikitchen, A.S. *Glass Ceram* v 44 n 5-6 May-Jun 1987 p 249-252.

**083931 PROPERTIES AND STRUCTURE OF SPODUMENE-PORCELAIN.** Uzbekistan has reserves of numerous inorganic raw materials which can be used for the production of electrical insulators. These raw materials have not been used for the production of electrical ceramics. The aim of this work was to study the compositions and the properties of the spodumene concentrate and to develop body compositions based on it for the production of electrical ceramics. The composition of the experimental sample of the spodumene concentrate is close to that of the lithium-bearing mineral (spodumene). 3 refs.

Ismatova, R. (Tashkent Polytechnic Inst, USSR). *Glass Ceram* v 44 n 7-8 Jul-Aug 1987 p 314-316.

**083932 ZUR ANWENDUNG DER ZETA-POTENTIAL-MESSUNG BEI FEINKERAMISCHEN SUSPENSIONEN.** [Utilization of Zeta Potential Measurement in Fine Ceramic Suspensions]. The zeta potential is a parameter which shows the ratio of the electric double layer which forms round dispersely distributed solids in watery media. During sedimentation, washed china clay or other raw materials with clay mineral content - or during production and processing of whiteware casting slips - collochemical reactions are practically always involved. Therefore, the zeta potential (ZP) and its variations is connected to nearly all Fine-ceramics problems where reagents are applied. (Edited author abstract) 12 refs. In German.

Schulle, W. (Bergakademie Freiberg, Freiberg, East Ger); Plueschke, R. *Keram Z* v 39 n 8 Aug 1987 p 785-788.

**083933 SYNTHETISCHE ALKALIHALTIGE FLUSSMITTEL.** [Synthetic Alkali-Containing Fluxes]. Alkali feldspars are widely used as auxiliary flux components for producing densely sintering silicate fine ceramic mixtures. Sufficiently suitable feldspars are not available

in all countries in the necessary quantity and quality. Consequently the question of synthesizing suitable auxiliary fluxes directly from domestic raw materials given. The fundamental possibilities for making an alkali-free synthetic auxiliary flux that corresponds in its effects to feldspars are discussed. On the basis of these considerations, synthetic auxiliary fluxes made by thermal synthesis (about 1100 °C) and hydrothermal synthesis (about 200 °C and about 2 MPa) are evaluated in comparison to feldspars. In both ways it is possible to obtain suitable auxiliary fluxes. (Edited author abstract) 61 refs. In German.

Schulle, Wolfgang; Klein, Gernot. *Freiberg Forschungsh. Reihe A* n 754 1988 p 1-68.

## Mechanical Properties

**083934 MECHANICAL PROPERTIES OF ZIRCON-FELDSPAR PORCELAINS.** Replacing quartz with zircon in feldspar porcelains results in significant improvements in mechanical properties. These are dominated by fired porosity, which in turn is determined by both body composition and packing density. The effects of changing the grain size distributions of the raw materials on the mechanical properties of the body are complex and sometimes obscured by the resulting changes in the particle packing of the body. The aim of this study was to evaluate the use of zircon as the filler in porcelain. 27 refs.

Frith, V. (Univ of Cape Town, Rondebosch, S Afr); Heckroodt, R.O.; Schueller, K.-H. *CFI Ceram Forum Int Ber DKG* v 64 n 10 Oct 1987 p 379-383.

## Microstructure

**083935 MICROSTRUCTURE DEVELOPMENT IN A VITRIFIED ANORTHITE PORCELAIN.** Thermal dilatometry, differential thermal analysis, X-ray diffraction, scanning electron microscopy, and energy dispersive spectroscopy revealed the development of phases and the microstructure on firing bodies containing 40 to 50 wt percent wollastonite, 40 to 50 wt percent kaolin, and 10 wt percent nepheline syenite. Vitrified bodies contained a major glassy phase, submicrometer primary and secondary elongated anorthite crystals, and residual wollastonite. Increasing the content of  $\text{Al}_2\text{O}_3$  by increasing the clay content or by adding fine calcined alumina increased the viscosity of the glassy phase and the ratio of anorthite to wollastonite formed on firing. (Author abstract) 28 Refs.

Sletson, Lisa C. (Alfred Univ, Alfred, NY, USA); Reed, James S. *Am Ceram Soc Bull* v 67 n 8 Aug 1988 p 1403-1408.

## Moisture Determination

**083936 DETERMINING THE WATER CONDUCTIBILITY OF WHITEWARE BODIES WITH THE AID OF A PARALLEL-PLATE PLASTOMETER.** This report presents a procedure with which relatively simple means suffice to monitor the transport of water through a plastic body. The approach also makes it relatively easy to characterize different bodies and accommodate them to the given technological requirements through the use of suitable additives. In the course of testing several whiteware bodies, we noticed that the body at the center was considerably stiffer than that of the original specimen. We deduced that a mechanical pressure gradient must have caused an appreciable extent of water migration from the center of the plate towards the outer rim. In German and English. 10 refs.

Leusden, C.O. Pels (Georg-Simon-Ohm Fachhochschule, Nuremberg, West Ger). *CFI Ceram Forum Int Ber DKG* v 64 n 10 Oct 1987 p 383-389.

## Optical Properties

**083937 PORCELAIN WITH IMPROVED WHITENESS.** It is known that the whiteness of porcelain is determined by the quantity of diffuse scattered light. Taking the physical essence of the phenomenon into

account, we postulated that there is a possibility of improving its whiteness by increasing the mullite content in the phase composition of porcelain and by increasing the amount of diffuse scattered light during reflection by introducing the additives possessing a high refractive index. In this case, the difference in the refractive indices of the glassy phase of porcelain and the introduced additive must facilitate an increase in the diffuse scattering of light and, consequently, an improved degree of whiteness. The additives meeting the specifications include zinc oxide (refractive index  $n=2.004$ ). The measurements of density, water absorption, and the ultimate static bend strength make it possible to conclude that addition of 0.05–1% zinc oxide into the composition of the porcelain bodies is accompanied by lowering of the sintering temperature of the porcelain materials by 50–70°C. When 2–5% zinc oxide additive is introduced into the body, the firing temperature decreases by 30–50°C. 3 refs.

Shmeleva, V.I. (Sverdlovsk National Economy Inst, USSR). *Glass Ceram* v 44 n 5-6 May-Jun 1987 p 261-263.

Processing See SILICON CARBIDE—Mechanical Properties.

Production See Also FILTERS—Design.

**083938 OPERATION PLAN OPTIMIZATION OF PORCELAIN PRODUCTION.** The operation planning process of dining porcelain production is very complicated in respect to computation. It results from differentiated shares of single articles in assumed quality grades and from differing demand structures. The central part of this process, which is described in terms of a linear programming problem with a block structure of restrictions, is discussed in this paper. The solution algorithm based on Benders decomposition idea is presented. Application of Benders decomposition enables programming of the problem for microcomputer equipment. (Author abstract) 4 refs.

Kotowski, Jerzy (Technical Univ of Wroclaw, Wroclaw, Pol); Sygit, Maciej. *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 51-55.

## Spectroscopic Analysis

**083939 CONSTANCY IN ELEMENTAL COMPOSITION OF IDENTICAL AND SYMMETRICAL CERAMIC PAIRS.** Porcelains made in Jingdezhen, China, during the Qing dynasty (1644–1911) and the Republic period (1912–1939) have, in the rubidiumstrontium-zirconium-niobium K-lines region, a characteristic feature which is quite different in porcelains made elsewhere (whether in or outside China) and therefore could be a means of detecting modern fake reproductions. The aim of this investigation is to quantitatively study trace elements in this characteristic region in identical and symmetrical ceramic pairs from Jingdezhen. The author presents the results for the 10 ceramic pairs studied. The statistical errors at  $2\sigma$  are roughly 2% for Rb, 3% for Sr, 4% for Zr, and 8% for Y and Nb for samples exposed for 11,000 s. For all elements (Rb, Sr, Y, Zr, and Nb), the values for each pair are either identical or very close. This is particularly the case for Y, Zr, and Nb. However, ceramic pairs of different periods have distinguishing differences in their elemental compositions. 12 refs.

Yap, C.T. (Nat'l Univ of Singapore, Singapore). *Appl Spectrosc* v 41 n 8 Nov-Dec 1987 p 1446-1448.

POROSIMETERS See Also POLYMERS—Structure.

**083940 MEASUREMENT OF PORE SIZE DISTRIBUTIONS FROM CAPILLARY PRESSURE CURVES.** This note outlines a method to account for pore accessibility when calculating pore size distributions from mercury injection data. It is shown that large deviations will occur from the capillary tube predictions even for small sample sizes. 7 refs.

Mishra, B.K. (Univ of Texas, Austin, TX, USA); Sharma, M.M. *AIChE J* v 34 n 4 Apr 1988 p 684-687.



**083941 NEUTRON SCATTERING FOR POROSITY DETERMINATION.** The basic theory, instrumentation, and the response of the neutron porosity-logging tool system are described. The discussion covers epithermal neutron physics, thermal neutron physics, and multi-neutron-detector physics. Calibration and environmental corrections are briefly considered. Major parameters affecting neutron porosity response are examined. 12 refs.

Neuman, C.H. (Chevron Oil Co, New Orleans, LA, USA); Salaita, G.N.; Mahdavi, M. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 812-816.

**Computer Simulation** See OIL WELL LOGGING—Neutron.

**Errors** See MORTAR—Porosity.

**POROUS MATERIALS** See Also CONCRETE—Shrinkage; FELT—Manufacture; FLAME RESEARCH; FLOW OF FLUIDS—Multiphase; FLOW OF FLUIDS—Packed Beds; FLOW OF FLUIDS—Porous Materials; FLOW OF FLUIDS—Two Phase; FLOW OF FLUIDS—Unsteady Flow; HEAT TRANSFER—Convection; HEAT TRANSFER—Fluidized Beds; MOISTURE DETERMINATION; POROSIMETERS; SNOW AND SNOWFALL; SOLIDS—Melting; SOLIDS—Order-Disorder; SURFACE WAVES—Mathematical Models.

**083942 PROPERTIES OF POROUS NET MATERIALS.** Porous net materials (PNM) are promising for the production of structural members of high temperature systems with transpiration (porous) cooling. The hydraulic resistance of the PNM in the direction parallel to the plane of the nets is 1.3-1.6 times higher than in the perpendicular direction. The values of the coefficients of hydraulic resistance of PNM are lower than in the materials made of the particles of irregular form and similar to the values typical of the materials made of spherical particles. The strength characteristics, hydraulic resistance, heat conductivity, and the uniformity of permeability of the PNMs examined satisfy the requirements imposed on structural members. 7 refs.

Daragan, V.D.; Drozdov, V.G.; Kotov, A.Yu.; Mel'nikov, G.N.; Pustogarov, A.V. *Sov Powder Metall Met Ceram* v 26 n 3 Mar 1987 p 216-220.

**083943 ON BALANCE LAWS FOR FLUID-SATURATED POROUS MEDIA.** The space-averaging formalism of Anderson and Jackson is employed to develop a set of balance laws for a multicomponent mixture. The interactions between the mixture components appear as surface integrals in the averaged (or macroscopic) balance laws. These balance laws are used to study the motion of a porous solid; it is shown that the formulations of Herrmann and Morland are only approximate in that both of these authors neglected the effects of microinertia. The motion of an incompressible Newtonian fluid through a rigid porous matrix is considered, and the assumptions required to recover Darcy's law are discussed. Finally the averaged balance laws are used to derive a first order theory for the motion of fluid-saturated porous media; it is shown that reasonable approximations lead to the balance laws previously derived by Garg, et al. on heuristic grounds. (Author abstract) 16 refs.

Garg, Sabodh K. (S-CUBED, La Jolla, CA, USA). *Mech Mater* v 6 n 3 Sep 1987 p 219-232.

**083944 POROUS STRUCTURE OF SOLIDS AND GAS PHASE PRECIPITATION REACTIONS.** Natural and synthetic dispersed and porous materials possess individual characteristics of structure, depending on the form and structure of the primary particles and the methods of combining them or distributing the components in the original solid body and if the porous material is obtained by destructive methods. One of the main characteristics of the porous structure is the magnitude and distribution of the pore sizes. The elements of porosity in the structure can be classified according to the regimen of gas transfer into the pores. The proposed double classification divides all known types of systems into groups. 21 refs.

Andrienko, V.E. (All-Union Inst of Refractories, USSR). *Refractories* v 28 n 7-8 Jul-Aug 1987 p 434-437.

**083945 TRACER DISPERSION IN SINTERED GLASS BEADS WITH A BIDISPERSE SIZE DISTRIBUTION.** An experimental study was made of tracer dispersion in bidisperse sintered glass materials prepared from mixtures of two sizes of beads with mean diameters of 325 and 95  $\mu\text{m}$ . The equivalent dispersion coefficient increases by a factor of 30 when the porosity decreases from 30 to 12%; this variation is similar to that measured in monodisperse samples. (Author abstract) 28 refs.

Hulin, J.P. (Schlumberger Doll Research, Ridgefield, CT, USA); Charlaix, E.; Plona, T.J.; Oger, L.; Guyon, E. *AICHE J* v 34 n 4 Apr 1988 p 610-617.

**083946 POPIS VLNUTI POREZNICH MATERIALU JAKO ULOHA STEFANOVA TYPU.** [Description of Moisture Transport in Porous Materials as a Problem of the Stefan Type.] A model is derived for simulation of transport of humidity in porous materials regarding simultaneously the diffusion and convection. An analysis is performed of some input parameters of proposed model. The purpose of the analysis is determination of the velocity of convection  $v$  as well as of the coefficient of humidity and their transportability  $\chi_m$ . For convective velocity is assumed linear dependency on the location. Regarding the theory of mixtures and Vodak's model of area of discontinuity in continuum there have been derived the magnitudes of such velocity in node  $x=0$ . (Edited author abstract). 17 Refs. In Czech.

Cerny, Robert (Stavební Fakulta CVUT, Prague, Czech). *Stavebnicky Cas* v 36 n 3 Mar 1988 p 255-264.

## Adsorption

**083947 ADSORPTION FROM SOLUTION OF NONELECTROLYTES BY MICROPOROUS CRYSTALLINE SOLIDS: ETHANOL-WATER/SILICALITE SYSTEM.** A simple technique is developed which, for the first time, has enabled the experimental determination of the amount and composition of substances adsorbed from solution by microporous solids. The experimental results determined for the system [ethanol(1)-water(2)]/silicalite show considerable discrepancies with the predictions based on the available theories of adsorption from solution. The experimental determination of the (individual) adsorption isotherms enables, for the first time, the calculation of the activity coefficients and the molar excess Gibbs free energy of the adsorbed phase independent of any a priori assumption other than the existence of a distinct adsorbed phase. For the system [ethanol(1)-water(2)]/silicalite, the activity coefficients show considerable negative deviations from ideality and the molar excess Gibbs free energy is a strong function of spreading pressure as well as composition of the adsorbed phase. (Edited author abstract). 30 Refs.

Farhadpour, Farhad, A. (Univ of Surrey, Surrey, Engl); Bono, Awang. *J Colloid Interface Sci* v 124 n 1 Jul 1988 p 209-227.

**Analysis** See Also FILTERS—Porosity.

**083948 MICROGEOMETRY OF RANDOM COMPOSITES AND POROUS MEDIA.** For practical applications of variational bounds to the effective properties composite materials, the information available is often not that required by the formulae for the optimal bounds. The strategy employed in this paper differs from these earlier approaches in that the key quantities that we analyze are the parameters of the microgeometry. Our purpose is to derive some of the the microgeometry. Our purpose is to derive some of the more important relationships that exist among the geometrical parameters and the material properties. Some new bounds are presented on bulk modulus, shear modulus and electrical conductivity that improve on the Hashin-Shtrikman bounds when a measurement of another physical property has been made. For porous materials, these bounds have particularly simple analytical forms. Such cross-property bounds may prove to be quite useful when one material property is easy to

measure but the other is not. The present results are restricted to isotropic two-phase materials such as porous media with easily distinguished solid and void phases. (Edited author abstract) 29 refs.

Berryman, James G. (Lawrence Livermore Natl Lab, Livermore, CA, USA); Milton, Graeme W. *J Phys D* v 21 n 1 Jan 14 1988 p 87-94.

**Anisotropy** See FLOW OF WATER—Porous Materials.

**Applications** See BEARINGS—Mathematical Models.

## Combustion

**083949 INITIATION OF LOW-TEMPERATURE FILTRATION COMBUSTION WAVES FOR POROUS SYSTEMS.** In this work a numerical modeling method was used to study: local ignition in the central part of a porous specimen of 'infinite' (from the point of view of its excluding the effect of boundary conditions) length; initiation of a counter FC (Filtration Combustion) wave by local warm-up of the rear (in relation to the direction of gas filtration) part of the specimen; formation of an associated inverse FC wave warm-up of its frontal part. The aim of this study is to clarify the features of FC wave dynamics, the effect on it of temperature  $\Theta_p$  and width of the firing zone (warm-up)  $L_p$ ; to establish the relationship between the minimum (critical) ignition temperature  $\Theta_i$  and  $L_p$  with different regime parameters and characteristics of the physical system; to determine the ignition time  $\tau_i$  and the amount of 'flashback' of the oxidant during firing. The authors indicate possibilities for optimizing FC wave formation in technological applications. Consideration of the dependence of the energy contribution from an external source, necessary for ignition, on size of the warm-up zone, and also the dependence of integral flashback of the oxidant on the same parameter, makes it possible to draw conclusions about the economic, and in the case of a toxic oxidant, the ecological preference, for warm-up of narrow zones of material. 12 refs.

Rabinovich, O.S.; Gurevich, I.G. *Combust Explos Shock Waves* v 23 n 4 Jul-Aug 1987 p 377-384.

**Computer Aided Analysis**

**083950 PLANE PORES-SIZE DISTRIBUTION FUNCTION OF POWDER METALLURGICAL POROUS MATERIALS.** Based on the principle of the statistical analysis, the microcomputer was used to testify that porous materials' plane pores-size is in agreement with Rayleigh distributions. (Author abstract) In Chinese. 3 refs.

Yang, Tiezheng; He, Fengjia; Feng, Shuping. *Zhongnan Kuangye Xueyuan Xuebao* v 18 n 1 Feb 1988 p 67-72.

## Creep

**083951 DAMAGE EVOLUTION AND RUPTURE IN CREEPING OF POROUS MATERIALS.** The configurational evolution in time and space of two-dimensional ellipsoidal damage into an elongated flaw with preferred orientation is solved and studied. The damage is represented as a single, traction free, ellipsoidal void embedded in an infinitely large time-dependent porous-like solid. The solid creeps in a power-law fashion under static biaxial loads which induce a large-scale rotation (with volume enlargement/contraction) of the void. In the special case of unidirectional loading the free boundary of the void evolves into an expanded and elongated new shape while rotating towards a position codirectional with the principal tensile axis. The process simulation agrees well with visual observations of void expansion and rotation in a highly viscous material and with experimental measurements of the rupture ductilities of creeping materials with different strain-rate sensitivity index. Similarities and dissimilarities with existing phenomenological damage theories are discussed. (Edited author abstract). 15 Refs.

Tirosh, J. (Stanford Univ, Stanford, CA, USA); Miller, A. *Int J Solids Struct* v 24 n 6 1988 p 567-580.



## Deformation

**083952 PLASTIC DEFORMATION OF POROUS SOLIDS AT LOW POROSITY.** Plastic deformation of a porous solid under a compressive load (at a negative isostatic component of the stress tensor) brings about a decrease in its porosity, i.e., pore healing. On the other hand, plastic deformation of the matrix of a porous solid loosens its structure, i.e., results in the formation of new pores. When a solid is close to being nonporous, the two processes begin to compete with each other. In the present work, a model of a porous solid is proposed allowing for this effect, and conditions are determined under which a state of equilibrium is attained. 7 refs.

Beigel'zimer, Ya.E. (Acad of Sciences of the Ukrainian SSR, USSR). *Sov Powder Metall Met Ceram* v 26 n 3 Mar 1987 p 193-195.

**083953 PLASTIC DEFORMATION EQUATIONS FOR A STRENGTHENING MEDIUM WITH A POROUS STRUCTURE.** It has been postulated that a porous material is characterized by an ellipsoidal plasticity surface. Today preference tends to be given to a model allowing for the strengthening of the matrix of a porous medium which takes place as a result of a widening of its plasticity surface. Now with the assumption that strengthening is merely a process of isotropic widening of a flow boundary it is not possible to describe the deformation anisotropy of a plastic material. However, the strengthening process of a material may be treated in the same way as the process of displacement of its starting flow surface, and we are then dealing with translational strengthening. That such displacement does not occur is indicated by the fact that the majority of metals exhibit a Bauschinger effect. The present work was therefore undertaken with the aim of deriving determining equations of plastic deformation for a porous material whose solid phase behaves in accordance with the relationships of the theory of translational strengthening. 11 refs.

Smyslov, A.Yu. (Kuibyshev Polytechnic Inst, USSR). *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 291-294.

## Desorption

**083954 DETERMINATION OF PORE-SIZE DISTRIBUTION FROM SORPTION ISOTHERMS: APPLICATION OF PERCOLATION THEORY.** A method to analyze a desorption branch of the capillary condensation hysteresis is proposed. The pore space is treated as a lattice of voids interconnected by necks in a three-dimensional network. The method takes into account the possible overlapping of the distributions of voids and neck sizes. (Author abstract) 8 refs.

Zhdanov, V.P. (Inst of Catalysis, Novosibirsk, USSR); Fenenelov, V.B.; Efremov, D.K. *J Colloid Interface Sci* v 120 n 1 Nov 1987 p 218-223.

## Dielectric Properties See SILICA—Thick Films.

## Diffusion

**083955 PRESSURE CHANGES DURING DIFFUSION WITH CHEMICAL REACTION IN A POROUS PELLET.** A method is proposed for evaluation of the pressure change in an isothermal porous pellet within which a single chemical reaction takes place, accompanied by mass transfer by Knudsen diffusion, bulk diffusion and viscous convective flow of the reacting mixture. The dimensionless pressure is expressed as a function of two dimensionless parameters which characterize transport mechanism and mixture properties respectively. The pressure change also depends on the reaction and on the mixture composition on the pellet surface. The method requires numerical integration of an initial-value problem. A simple analytical method is also proposed for estimation of the maximum possible pressure changes in the system, both for the Knudsen diffusion control regime and for the bulk diffusion with viscous convective flow control regime. Both methods are illustrated by the computed results for a general two-molecule reaction and for the ammonia synthesis reaction. (Author abstract) 15 refs.

Burghardt, Andrzej (Polish Acad of Sciences, Gliwice, Pol); Aerts, Jerzy. *Chem Eng Process* v 23 n 2 Mar 1988 p 77-87.

**083956 EFEKTYWNY WSPOLCZYNNIK DYFUZJI SKŁADNIKA W PORACH W PROCESIE LUGOWANIA Z ZIAREN IZOMETRYCZNYCH. I. PODSTAWY TEORETYCZNE METODY OBLICZEN.** [Effective Diffusivity of Component in Pores in Solid-Liquid Extraction from Isometric Particles. I. Theoretical Basis of Calculation Method]. The method for calculating values of the effective diffusivity in porous materials based on equations of the mathematical model describing the kinetics of the batch solid-liquid extraction process experimental investigations of the kinetics of this process is presented. Mass transfer in liquid phase, adsorption of the extracted component in pores of solid phase, existence of the solid state of the extracted component in the pores and variability of the value of the effective diffusivity in the process of extraction are taken into consideration in calculations according to presented method. (Author abstract) 14 refs. In Polish.

Krauze, Ryszard (Politechnika Lodzka, Lodz, Pol). *Inz Chem Procesowa* v 8 n 4 1987 p 537-549.

**083957 ANALYSIS OF MULTICOMPONENT DIFFUSION IN PORE NETWORKS.** Diffusion flux models are developed for isobaric diffusion of a multicomponent gas mixture in pore networks of distributed pore size and length constructed by arranging pore segments around the bonds of a lattice of constant coordination number. Eigenvalue-eigenvector analysis is used to decompose the dusty-gas model equations, written for each pore segment in the network, into a set of independent single-species diffusion problems, each of which is then treated by combining the effective medium theory for resistor networks with the smooth field approximation. Results for a ternary mixture diffusing in a porous slab show that direct application of the smooth field approximation underestimates significantly the mass transport resistance. (Edited author abstract). 24 Refs.

Sotirchos, Stratis V. (Univ of Rochester, Rochester, NY, USA); Burganos, Vasilis N. *AIChE J* v 34 n 7 Jul 1988 p 1106-1118.

**Drying** See Also DRYING—Applications; WOOD—Drying.

**083958 COMPLETE MODEL OF THE DRYING CURVE FOR POROUS BODIES - EXPERIMENTAL AND THEORETICAL STUDIES.** Non-hygroscopic, capillary porous bodies, saturated with liquids were dried in an experimental device. By systematically varying the drying agent, the liquids and the differently structured samples, a wide range of drying rate curves were found experimentally and evaluated. The basic equation for the model of the constant-rate drying period refers - according to Krischer - to capillary liquid transportation only. The liquid-diffusion coefficient dependent on moisture content is calculated on the basis of the model considerations of Rumpf. For the falling-rate period the well-known receding drying front model is modified with regard to the capillary liquid movement. (Author abstract) 15 refs.

Schandler, N. (Technische Hochschule Darmstadt, West Ger); Kast, W. *Int J Heat Mass Transfer* v 30 n 10 Oct 1987 p 2031-2044.

**Elasticity** See Also MECHANICAL WAVES.

**083959 DEPENDENCE OF ELASTIC CONSTANTS OF AN ANISOTROPIC POROUS MATERIAL UPON POROSITY AND FABRIC.** The elastic properties of an anisotropic porous material can be represented as functions of the material's solid volume fraction (or porosity) and the principal diameters of the material's fabric ellipsoid. The fabric ellipsoid is a measure of the anisotropy of the microstructure of a material. The definitions and measurement techniques for fabric ellipsoids in granular materials, foams, cancellous bone, and rocks are discussed. The principal results presented in this work are algebraic expressions for the dependence of the

orthotropic elastic constants upon both solid volume fraction and the fabric ellipsoid. (Author abstract) 25 refs.

Turner, Charles H. (Tulane Univ, New Orleans, LA, USA); Cowin, Stephen C. *J Mater Sci* v 22 n 9 Sep 1987 p 3178-3184.

## Electric Conductivity

**083960 SCALING LAW FOR THE LOW-FREQUENCY A.C. CONDUCTIVITY OF FLUID-SATURATED POROUS MEDIA.** An empirical scaling law for the real part of the frequency-dependent electrical conductivity  $\sigma'(\omega)$  of brine-saturated porous materials in relation to its d.c. limit has been identified. This scaling law relates the conductivity as a function of frequency, porosity and salinity to a function of only one variable that is the ratio of the frequency to the d.c. conductivity in appropriate units. This result is very similar to what has been reported in hopping semiconducting systems. (Author abstract) 3 refs.

Ramsamugh, A. (Univ of the West Indies, Mona, Jamaica). *Phil Mag Lett* v 55 n 6 Jun 1987 p 301-304.

## Explosions

**083961 NATURE OF FAILURE AND FILTRATION PROPERTIES FOR A POROUS GAS-IMPREGNATED MATERIAL FOLLOWING CAMOUFLET EXPLOSION.** In the case of carrying out a camouflet explosion in a porous gas-impregnated material the nature of change in filtration properties depends markedly on the initial material porosity. With the aim of studying the dependence of the change in permeability caused by a camouflet explosion on the initial material porosity, laboratory experiments have been carried out with artificially prepared models of a porous collector having different porosity values. Results of experiments point to the presence of a qualitative difference in permeability factor after an explosion in materials with porosities  $m_0 > 15$  and  $< 15\%$ . A circulation model is suggested explaining this effect by change in structure of the pore space. Specific mechanisms leading to occurrence of this effect may be varied: crushing of grains, failure of intergranular cement, etc. 7 refs.

Bovt, A.N.; Vasil'ev, A.V.; Lovetskii, E.E.; Selyakov, V.I.; Sirotkin, V.K.; Shurygin, E.A. *J Appl Mech Tech Phys* v 28 n 2 Mar-Apr 1987 p 283-290.

## Failure

**083962 EFFECT OF POROSITY DISTRIBUTION ON DUCTILE FAILURE.** The effect of a nonuniform distribution of porosity on flow localization and failure in a porous material is analyzed numerically. The void density distribution and properties used to characterize the material behavior were obtained from measurements on partially consolidated and sintered iron powder. The calculations were carried out using an elastic viscoplastic constitutive relation for porous plastic solids. Local material failure is incorporated into the model through the dependence of the flow potential on void volume fraction. The results suggest a failure criterion based on a critical void volume fraction that is only weakly dependent on stress history. The critical void fraction does, however, depend on the initial void distribution and material hardening characteristics. (Author abstract) 30 refs.

Becker, R. (Brown Univ, Providence, RI, USA). *J Mech Phys Solids* v 35 n 5 1987 p 577-599.

**Fracture** See IRON AND ALLOYS—Hydrogen Embrittlement.

## Freezing

**083963 EFFECT OF MAXIMUM DENSITY OF WATER ON FREEZING OF A WATER-SATURATED HORIZONTAL POROUS LAYER.** This experiment simulates the freezing of water in a layer of earth by the use of a porous bead layer. The layer is cooled from above. The beads are 1, 5, and 11-mm-dia glass and



11-mm-dia steel. When the predominant heat transfer mode in an unfrozen layer is conduction, the freezing rate is not affected by the bead diameter. However, in natural convection the freezing rate is greatly affected by the maximum density of water at 4°C. An approximate numerical analysis which does not treat the maximum density effects predicts well the freezing rate in the range of  $0^\circ\text{C} < T_2 < 4^\circ\text{C}$  and  $26^\circ\text{C} < T_2$  ( $T_2$  = the lower plate temperature). (Author abstract) 14 refs.

Sugawara, M. (Akita Univ, Akita, Jpn); Inaba, H.; Seki, N. *J Heat Transfer Trans ASME* v 110 n 1 Feb 1988 p 155-159.

**Hardening** See SOLIDS—Cavitation.

**Heat Transfer** See Also HEAT TRANSFER—Convection; HEAT TRANSFER—Cylinders; HEAT TRANSFER—Measurements; HEAT TRANSFER—Melting; SOILS—Permafrost.

**083964 THERMAL CONVECTION IN A POROUS LAYER: EFFECTS OF ANISOTROPY AND SURFACE BOUNDARY CONDITIONS.** The theory describing the onset of convection in a homogeneous porous layer bounded above and below by isothermal surfaces is extended to consider an upper boundary which is partly permeable. Estimates of the magnitude and horizontal distribution of the vertical mass and heat fluxes at the surface, the horizontally-averaged heat flux (Nusselt number) and the fraction of the fluid which recirculates within the layer are found for slightly supercritical conditions. (Edited author abstract) 15 refs.

McKibbin, Robert (Univ of Auckland, Auckland, NZ). *Transp Porous Media* v 1 n 33 1986 p 271-292.

**083965 HEAT TRANSFER IN AN UNEVENLY HEATED POROUS LAYER.** For a uniform saturated porous layer heated from below, the dependence of the quantity of heat transferred on the distribution of the heat source is investigated. It is found, using perturbation methods and numerical techniques, that very small nonuniformities in the heat source having the same wavelength as the preferred convection mode significantly reinforce natural convection. (Author abstract) 19 refs.

O'Sullivan, M.J. (Univ of Auckland, Auckland, NZ); McKibbin, R. *Transp Porous Media* v 1 n 33 1986 p 293-312.

**083966 EFFECTIVE EQUATION GOVERNING CONVECTIVE TRANSPORT IN POROUS MEDIA.** The fine structure of disordered porous media (e.g., fully saturated randomly packed beds) causes microscopic velocity fluctuations. The effect of the spatial and temporal randomness of the interstitial velocity field on the convective transport of a scalar (heat or mass) is investigated analytically. For a uniform mean velocity profile, the effective heat transport equation is obtained as the equation governing the transport of the ensemble average of the scalar under conditions of steady or unsteady random fields (with given statistics). In both cases, it is shown that the effective transport coefficient is enhanced by a hydrodynamic dispersive component, which is an explicit function of the mean filtration velocity. The agreement with experiments is encouraging. (Edited author abstract). 18 Refs.

Georgiadis, J.G. (Univ of California, Los Angeles, CA, USA); Catton, I. *J Heat Transfer Trans ASME* v 110 n 3 Aug 1988 p 635-641.

**083967 THERMAL CONVECTION AROUND A HEAT SOURCE EMBEDDED IN A BOX CONTAINING A SATURATED POROUS MEDIUM.** A study of the thermal convection around a uniform flux cylinder embedded in a box containing a saturated porous medium is carried out experimentally and theoretically. The experimental work includes heat transfer and temperature field measurements. It is observed that for low Rayleigh numbers, the flow is two dimensional and time independent. Once a critical Rayleigh number is exceeded, the flow undergoes a Hopf bifurcation and becomes three dimensional and time dependent. The theoretical study

involves the numerical solution of the two-dimensional Darcy-Oberbeck-Boussinesq equations. The complicated geometry is conveniently handled by mapping the physical domain onto a rectangle via the use of boundary-fitted coordinates. The numerical code can easily be extended to handle diverse geometric configurations. (Edited author abstract). 17 Refs.

Himasekhar, K. (Univ of Pennsylvania, Philadelphia, PA, USA); Bau, H.H. *J Heat Transfer Trans ASME* v 110 n 3 Aug 1988 p 649-654.

**Iron Graphite** See POWDER METALLURGY—Iron Graphite.

## Manufacture

**083968 POROUS MATERIALS PREPARED BY HEATING DERIVATIVES FROM HALLOYSITE.** Halloysite clay was subjected to treatment by trimethylsilylation and hydrochloric acid. The resulting derivatives were heated below 1473 K in nitrogen or air to prepare thermally stable porous materials including larger pores than in zeolite. The trimethylsilylated halloysite resulted in a thermally stable porous material, in an amorphous state, including extremely uniform pores of 1.7 nm. Another derivative also resulted in a thermally stable porous material but consisted of very heterogeneous pores. The thermal degradation behavior of both derivatives is discussed in detail. (Author abstract) 5 refs.

Oya, Asao (Gunma Univ, Kiryu, Jpn); Kizu, Kazuhisa; Otani, Sugio. *J Mater Sci* v 22 n 12 Dec 1987 p 4541-4545.

**Mathematical Models** See Also COAL—Structure; GRANULAR MATERIALS—Porosity; MATERIALS SCIENCE—Deformation; POWDER METALLURGY—Porosity; POWDERS—Porosity.

**083969 FRACTAL DIMENSIONS OF COAL PARTICLES.** Recent work has shown that fractal geometry provides a useful description of porous surfaces by characterizing the pore size distribution over a range of pore sizes by a single number, the fractal dimension  $D$ . This paper describes measurements of the pore volume  $V_p$ , of a number of coal and char samples by mercury intrusion porosimetry. The fractal dimension was determined from the relation  $dV_p/dP \propto P^{D-4}$ , where  $P$  is the pressure. (Edited author abstract) 21 refs.

Friesen, W.I. (CANMET, Devon, Alberta, Can); Mikula, R.J. *J Colloid Interface Sci* v 120 n 1 Nov 1987 p 263-271.

**083970 AXISYMMETRIC FUNDAMENTAL SOLUTIONS FOR A COMPLETELY SATURATED POROUS ELASTIC SOLID.** This paper is concerned with the derivation of axisymmetric fundamental solutions that are required in the application of boundary integral equation method to solve complicated boundary-value problems involving poroelastic semi-infinite and infinite domains. General solutions for fully saturated poroelastic solid derived through the application of Laplace and Hankel integral transforms with respect to time and radial coordinates are utilized in the analysis. The derivation of complete fundamental solutions requires the consideration of three boundary-value problems involving unit buried ring loads acting in the vertical and radial directions and a unit buried ring flow source. These boundary-value problems are solved for both half space and full space regions. Explicit solutions for Laplace transform of displacements, tractions, pore fluid pressure and fluid flow are presented. (Edited author abstract) 30 refs.

Puswewala, U.G.A. (Univ of Manitoba, Winnipeg, Manit, Can); Rajapakse, R.K.N.D. *Int J Eng Sci* v 26 n 5 1988 p 419-436.

**Measurements** See Also ZEOLITES—Measurements.

**083971 NMR TECHNIQUE FOR THE ANALYSIS OF PORE STRUCTURE: DETERMINATION OF CONTINUOUS PORE SIZE DISTRIBUTIONS.** NMR measurements of the spin-lattice relaxation decay time for a fluid in a porous solid have been previously

demonstrated as a significant tool for pore size/structure analysis. The analysis requires the solution of a Fredholm integral equation of the first kind to extract the desired  $T_1$ , and therefore, pore size distribution from the relaxation measurements. In this work, the method of regularization is applied to extracting continuous pore volume distributions from relaxation measurements. The validity of the approach used to calculate the optimum value of the regularization smoothing parameter given an expected noise level and the data are demonstrated using 'data sets' generated from known 1 distributions. Varying levels of random noise are added to these data sets and the  $T_1$  distribution is calculated for comparison to the starting distribution. For error levels in the range of 0.001 to 0.01, agreement between the starting and the calculated distributions is good. (Edited author abstract) 11 refs.

Gallegos, David P. (Univ of New Mexico, Albuquerque, NM, USA); Smith, Douglas M. *J Colloid Interface Sci* v 122 n 1 Mar 1988 p 143-153.

**Mechanical Properties** See Also MATERIALS TESTING APPARATUS—Retrofitting; SOLIDS—Mechanical Properties.

**083972 EVALUATING THE RIGIDITY AND TENSILE STRENGTH OF HIGHLY POROUS FIBROUS MATERIALS.** A model is suggested for calculating the mechanical characteristics of sintered highly porous fibrous materials (HFM) (porosity 90%) in which the measured characteristics of the microstructure of the material are used as initial parameters: mean length and diameter of fibers, anisotropy of fiber arrangement, size of contact bridge, also mean mechanical characteristics of the fibers. It was assumed that fibers arranged along the direction of expansion has a finite length and are loaded by the bending of transverse fibers in contact with them which fulfill the role of a matrix (transfer of shear stresses). The concept is introduced of a value for the contact bridge (CB) between the fibers of the HFM. (Edited author abstract) 11 refs.

Toropov, A.I.; Nepershin, R.I. *Sov Mach Sci* n 2 1987 p 47-53.

**083973 MECHANICAL AND FRACTURE BEHAVIOUR OF POROUS MATERIALS.** The elastic moduli of porous materials represented as a combination of spherical, cylindrical or disk shaped holes or solid elements was calculated using a self consistent method. A yield criterion could be found by stating that the elastic distortion energy evaluated with these moduli was equal to a critical value. Another yield criterion could be approximated from the results of finite elements computations using the homogenization technique. These criteria possess the same homogeneity as the yield criterion of the dense material. The fracture toughness of syntactic foams could be explained by the local stress distribution in the glass spheres. In the case of ductile porous nickel the COD at initiation decreased as the fracture strain. This material exhibited a large tearing modulus whose decrease when the porosity was increased could be taken into account by the damage parameter. Fatigue crack propagation rates could also be rationalized with the use of the damage parameter and by reducing the surface of the material to be fractured. (Edited author abstract) 34 refs.

Bompard, Ph. (Ecole Centrale des Arts et Manufactures, Châtenay Malabry, Fr); Wei, Dan; Guennou, T.; Francois, D. *Eng Fract Mech* v 28 n 5-6 1987 p 627-642.

**083974 STATISTICAL ANALYSIS OF STRENGTH OF POROUS FIBROUS MATERIALS WITH NONUNIFORM STRUCTURE.** A statistical model is constructed for strength during elongation of highly porous fibrous materials containing regularly alternating region of high (grain) and low (lamella) density. The strength of the elementary structural cell, consisting of the grain and lamella, is modeled by a Weibull distribution with parameters determined from the experimental distribution of density of the lamella. The model of strength of a sample of finite dimensions was obtained according to the



statistical theory of independent parallel loaded elements in a layer of material and according to the hypothesis of a weak link for consecutively loaded layers. Using a specific material as example, the statistical strength parameters are determined. (Edited author abstract) 8 refs.

Nepershin, R.I.; Toropov, A.I. *Sov Mach Sci* n 5 1987 p 7-11.

**Microstructure** See Also FLOW OF FLUIDS—Porous Materials.

**083975 INFLUENCE OF PROCESSING ON THE MICROSTRUCTURE OF MATERIALS.** The topic described by this title is an extremely broad one. However, it will be limited mainly to the consideration of porous materials, and in particular to such materials that have a constructional engineering function. Whereas some porous materials employed in construction (or in the decoration of structures) are used in their more-or-less natural state (e.g. soil, timber, stone, natural pigments), others (such as cement, concrete, plaster, ceramics, plastics and paint) are processed during manufacture, and may even be contrived wholly artificially. Relationship between pore structure and properties, and the influence of processing on pore structure - are in fact two of the principal questions addressed at the Versailles Congress 'From materials science to construction materials engineering'.

Haynes, J.M. (Univ of Bristol, Bristol, Engl). *Mater Struct* v 21 n 122 Mar 1988 p 83-84.

#### Moisture Determination

**083976 EXPERIMENTAL DETERMINATION OF MOISTURE CHARACTERISTICS OF PERLITE AGGREGATES AND VERIFICATION OF THE VALIDITY OF THE COMPUTED K-H (OR K-0) RELATIONSHIPS THROUGH THE COMPARISON OF EXPERIMENTAL AND SIMULATED INFILTRATION.** The purpose of this paper is to investigate the validity of computational models in estimating the unsaturated hydraulic conductivity of a porous material, based on the knowledge of the experimentally obtained moisture characteristic curve and the value of the hydraulic conductivity at saturation,  $K_{\text{sat}}$ , by means of comparing the experimental and simulated process of infiltration. The comparison of the experimental cumulative infiltration versus time curve with that obtained by solving the appropriate Richard's equation numerically, under the same initial and boundary conditions shows that the computed K- $\theta$  (or K-H) relationships, where K is the hydraulic conductivity of the porous material and  $\theta$  the volumetric water content, H the matric potential, can give reliable information about the unsaturated hydraulic conductivity and can be used in water movement simulation studies. We investigate perlite, a porous material which recently gains grounds as a soil additive, as a greenhouse potting compost or as a substrate for hydrocultures. (Edited author abstract). 32 Refs.

Kerkides, P. (Agricultural Univ of Athens, Greece); Elmaloglou, S. *Modell Simul Control C* v 12 n 4 1988 p 1-22.

**Oxidation** See SEMICONDUCTING SILICON—Processing.

**Permeability, Mechanical** See Also FLOW OF FLUIDS—Porous Materials; MEMBRANES—Permeability, Mechanical; SANDSTONE—Porosity.

**083977 PERMEABILITY OF A RANDOM ARRAY OF FRACTURES OF WIDELY VARYING APERTURES.** The authors modelize a fractured rock by a random array of plane cracks of finite extent having a very broad distribution of apertures (or of hydraulic conductances). If the rock is permeable, the flow will essentially take place along a 'subnetwork' made of the less resistant cracks. Using an analogy with the treatment of variable range transport in semiconductors, the authors evaluate the homogenization length and the permeability of this disordered network. This evaluation makes use of the

notion of the critical bonds which are the weakest cracks among the good ones necessary for percolation; the remaining weaker bonds make a negligible contribution to the permeability. The method is applicable to other examples of transport in very heterogeneous macroscopic random materials. (Edited author abstract) Refs.

Charlaix, Elisabeth (CNRS, Paris, Fr); Guyon, Etienne; Roux, Stephane. *Transp Porous Media* v 2 n 1 Feb 1987 p 31-43.

**Physical Properties** See Also GELS—Physical Properties.

**083978 ACOUSTIC METHOD OF DETERMINING HYDRAULIC RESISTANCE FOR A POROUS BODY.** Determining the pneumatic and hydraulic resistances, or the permeability, of porous bodies is a common technological problem. It is solved, as a rule, by applying to the specimen being tested a pressure differential that is constant or is varying in accord with a specified law and measuring by some means the volumetric rate of flow. Drawbacks of existing methods are pointed out and modifications are suggested. 9 refs.

Mamin, V.M. *Meas Tech* v 30 n 4 Apr 1987 p 364-368.

**083979 EFFECTS OF VOIDS AND VOLUME CHANGES ON THE BEHAVIOR OF FRICTIONAL MATERIALS.** Development of constitutive models for engineering materials is often based on a framework of elasticity and plasticity theories as developed for metals. Presented here is a review of some of the basic differences in the experimentally observed behavior of metals and frictional materials. Two of the distinguishing characteristics between metals and frictional materials are the absence or presence of voids and the tendency to change or maintain constant volume during compression and shear. These differences must be recognized in order to develop reasonable constitutive models for frictional materials. (Author abstract). 22 Refs.

Lade, Poul V. (Univ of California, Los Angeles, CA, USA). *Int J Numer Anal Methods Geomech* v 12 n 4 Jul-Aug 1988 p 351-370.

#### Plasticity

**083980 INFLUENCE OF THE PORE MORPHOLOGY AND SECONDARY CAVITIES ON THE PLASTIC BEHAVIOR OF POROUS MATERIALS.** Using homogenization technique, the plastic behavior of a porous material containing two populations of cavities is constructed. The corresponding load function is given. It is shown that the interaction between the main and the secondary cavities greatly increases the relative growth rate of the porosity. This effect is more important the higher the stress triaxiality ratio or the smaller the ratio between the main and the secondary porosities. The influence of the pore morphology on the yield criterion of porous material is also studied. It is shown that the pore morphology modifies the yield criterion only for high triaxiality ratio. For small or medium ones, the main effect comes from the porosity. (Author abstract). 12 Refs.

Guenouni, T. (Ecole Centrale Paris, Chateauf-Malabry, Fr); Francois, D. *Fatigue Fract Eng Mater Struct* v 11 n 4 1988 p 267-276.

**Porosity** See Also FLOW OF FLUIDS—Porous Materials.

**083981 TRANSIENT METHOD FOR MEASUREMENT OF EFFECTIVE POROSITY.** This paper describes a new and simple method for determination of effective porosity with transient flow of gases through a porous media. The unsteady flow of gases through porous media is influenced by effective porosity. Authors have expanded numerical model and method used by Aro-nofsky and Jenkins by including the time for inlet pressure to rise in order to construct the method of measuring effective porosity of a porous media. On the basis of the numerical calculation, the timelag, required for gas flowing out to the half steady state from the time of the inlet pressure to rise to the half, was related to the characteris-

tics of gas flow such as effective porosity, permeability and so on. Present method was successfully applied to measure the three samples of porous media formed by compressing powder aluminum and powdered coal. By flowing gases uniformly through each sample, permeability, Klinsenberg's constant, effective pore-area and mean pore-radius were measured. And each effective porosity and tortuosity were determined on the measured timelag of the transient outlet flow which was generated by giving impetuous inlet pressure. (Author abstract) 14 refs. In Japanese.

Sasaki, Kyuro (Akita Univ, Jpn); Miyakoshi, Hiroshi. *Nippon Kogyo Kaishi* v 104 n 1200 Feb 1988 p 57-62.

**083982 CALCULATION OF CONTINUOUS PORE SIZE DISTRIBUTIONS FROM ADSORPTION ISOTHERMS.** The analysis of gas/vapor condensation and evaporation in a porous solid is widely applied for the determination of pore size distribution (PSD). By assuming a pore shape, the relative pressure corresponding to phase change and size are related via the Kelvin equation. However, the Kelvin radius is less than the actual pore size as a result of the presence of an adsorbed film on the pore wall. Thus, in order to extract a PSD from an adsorption/desorption isotherm, one must account for both sorption and phase change. The authors demonstrate that with the use of a more sophisticated computation scheme, additional pore structure information may be extracted from condensation/adsorption data on monodisperse silica spheres produced by sedimentation and a silica xerogel produced via the hydrolysis of tetraethyl orthosilicate. 9 Refs.

Smith, D.M. (Univ of New Mexico, Albuquerque, NM, USA); Ross, S.B.; Ciftcioglu, M. *Powder Technol* v 55 n 3 Jul 1988 p 225-228.

#### Production

**083983 POROUS SILICATE BEADS BY GELATION.** The sol-gel preparation of porous spherical beads in the system  $\text{SiO}_2\text{-ZrO}_2\text{-TiO}_2\text{-Al}_2\text{O}_3$  is described. A uniformly reacted single precursor is dispersed in an aqueous phase and the as-formed droplets are gelled by the addition of  $\text{NH}_4\text{OH}$ . After drying, the spheres are subsequently oxidized and partially densified by heat treatments in air. Physico-chemical data indicate that these materials are glassy up to about 650°C and are more resistant to chemical attack than pure silica samples. (Author abstract) 10 refs.

Gonzalez-Oliver, C.J.R. (Battelle-Europe, Geneva, Switz); Schneider, M.; Nawata, K.; Kusano, H. *J Non Cryst Solids* v 100 n 1-3 Mar 1988, Glasses and Glass Ceram from Gels, Kyoto, Jpn, Jul 13-15 1987 p 274-277.

#### Radiation Effects

**083984 MOMENTUM REDISTRIBUTION IN A BRIEFLY, INTENSELY IRRADIATED, STRUCTURAL ELEMENT.** An unsteady one-dimensional treatment is undertaken of the response of a semi-infinite porous medium (modeled as a viscoelastic material) to a very intense, brief burst of radiation. Of special interest is the redistribution of the momentum of the impulse by a stress wave, so that the momentum is shared over an appreciable thickness of the medium. A similarity solution is found to describe the Lagrangian-position displacement of the material particles for a broad class of uniform media described by a generic, nonlinear stress/rate-of-strain relation. For a specific stress/strain rate relation sensitive primarily to the porosity of the medium, numerical results are obtained to the pertinent two-point boundary-value problem. In particular, the increase in the maximum (i.e., surface particle) displacement and in the breadth of the momentum distribution is found for given magnitude of the impulse. (Edited author abstract) 1 ref.

Carrier, George F. (Harvard Univ, Cambridge, MA, USA); Fendell, Francis E.; Muirhead, Lawrence P. *AIAA J* v 25 n 11 Nov 1987 p 1490-1493.



Selection See POLYMERS—Porosity.

### Spectroscopic Analysis

**083985 NMR TECHNIQUE FOR THE ANALYSIS OF PORE STRUCTURE: APPLICATION TO MESOPORES AND MICROPORES.** In this work, we explore the extension of NMR technique to porous solids with pores in the micropore and mesopore size ranges. By comparing previously published results of the relative distribution of surface- and bulk-phase water as a function of pore size to predictions from various pore models, we have demonstrated that the 'two-fraction, fast exchange' model may be applied to relate measured  $T_1$  to pore size in the mesopore and micropore size range if the pore geometry is known (or assumed). For pore size greater than 5 nm, pore geometry is not important. Comparisons between conventional techniques, such as nitrogen sorption and mercury porosimetry, and the results of NMR spin-lattice relaxation experiments are complicated by the fact that different pore structure parameters are measured with these methods. Despite this, agreement between the methods is quite good for the five sol-gel-derived materials which we have studied. (Edited author abstract) 14 Refs.

Gallegos, David P. (Univ of New Mexico, Albuquerque, NM, USA); Smith, Douglas M.; Brinker, C. Jeffery. *J Colloid Interface Sci* v 124 n 1 Jul 1988 p 186-198.

Strengthening See CLAY MINERALS—Cracking.

Stresses See Also COAL MINES AND MINING—Hydraulic Process.

**083986 COUPLED PROBLEMS ON THE STRESSED STATE OF SATURATED POROUS MEDIA IN THE VICINITY OF NONCIRCULAR CYLINDRICAL CAVITIES.** There are a number of problems in the mechanics of saturated porous media in which the change in the stress-strain state of the medium created by filtration of liquid or gas is accounted for. Using an approximate formulation of the problem, which can often yield satisfactory results, the inverse effect of strain of a saturated medium on the filtration process is typically neglected. In this study, a method is formulated for solving the coupled problems of the stressed state of a saturated porous medium in the vicinity of noncircular cylindrical underground mine. This approach is based on the combined application of the first variant of the boundary perturbation method and the integral Laplace transformation with respect to time. 10 refs.

Nemish, Yu.N. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Isparfilov, R.M. *Sov Appl Mech* v 23 n 4 Apr 1987 p 320-327.

**083987 THEORY OF NONLINEARLY VISCOUS AND PLASTIC BEHAVIOR OF POROUS MATERIALS.** To determine macroscopic stresses using the concept of rms stresses and deformation rates, it is only necessary to know the rheological properties of the solid phase. The latter may be described by a relationship permitting an ultimate transition to a rigid-plastic model. This method has other advantages linked with the fact that it is based on the employment of principles of the thermodynamics of irreversible processes. These considerations prompted the authors to examine positions lying at the basis of the concept of root mean square parameters and formulate their premises in a general form in order to develop a model of a nonlinearly viscous porous solid enabling creep effects to be allowed for. 7 refs.

Skorokhod, V.V. (Acad of Sciences of the Ukrainian SSR, USSR); Shtern, M.B.; Martynova, I.F. *Sov Powder Metall Met Ceram* v 26 n 8 Aug 1987 p 621-626.

Structure See CARBON—Activated.

Sublimation See HEAT TRANSFER—Porous Materials.

Surfaces See Also POWDERS—Surface Measurement.

**083988 STRUCTURAL AND HYDRAULIC CHARACTERISTICS OF POROUS FILTERING MATERIALS.**

**ALS AFTER SHOTBLASTING THEIR SURFACE.** Experimental data on the effect of plastic deformation of the surface of porous materials with silica sand and electrocorundum has shown that this type of treatment makes it possible to produce a two-layer material but leads to contamination of the surface and clogging with fragments of broken particles. This reduces the permeability and filtering properties of the materials. This work examined the effect of plastic deformation on structural and hydraulic characteristics in treatment of the surface with nickel shot. 9 refs.

Belov, S.V. (Moscow Higher Technical Sch, USSR); Ksenofontov, A.V.; Kallas, P.K. *Sov Powder Metall Met Ceram* v 26 n 3 Mar 1987 p 224-227.

Testing See SOILS—Deformation.

Theory See AIR FILTERS—Permeability, Mechanical.

### Thermal Conductivity

**083989 INVERSION METHOD FOR DETERMINING EFFECTIVE THERMAL CONDUCTIVITIES OF POROUS MATERIALS.** An inversion method for determining the effective thermal conductivities of porous materials from observed mean effective thermal conductivities is presented. Its validity is confirmed by numerical simulations. The effective thermal conductivities of glass beads are determined by the proposed method successfully used to predict the temperature profiles within the glass beads. (Author abstract) 1 ref.

Kamiuto, K. (Ohita Univ, Ohita, Jpn); Iwamoto, M. *J Heat Transfer Trans ASME* v 109 n 4 Nov 1987 p 831-834.

Transport Properties See Also GLASS—Surfaces; HEAT TRANSFER—Porous Materials.

**083990 MACROSCOPIC MODELLING OF TRANSPORT PHENOMENA IN POROUS MEDIA. 1: THE CONTINUUM APPROACH.** This paper presents a systematic development of a continuum model of a porous medium and of transport processes occurring in it. The concept of a Representative Elementary Volume (REV) as opposed to any arbitrary volume of averaging quantities at the micro-scale, is quantified. A universal criterion for selecting the size of an REV as a function of measurable characteristics of a porous medium and selected tolerance levels of estimation errors, is developed. The rules of spatial averaging are extended by including the effects of both the configuration of the solid matrix and of interphase transfer phenomena within an REV. (Edited author abstract) 18 refs.

Bachmat, Yehuda (Hydrological Service, Jerusalem, Isr). *Trans Porous Media* v 1 n 33 1986 p 213-240.

**083991 MACROSCOPIC MODELLING OF TRANSPORT PHENOMENA IN POROUS MEDIA. 2: APPLICATIONS TO MASS, MOMENTUM AND ENERGY TRANSPORT.** In this paper, the averaging rules are employed in order to develop a general macroscopic balance equation and particular equations for mass, mass of a component, momentum and energy, all of a phase in a porous medium domain. These balance equations involve averaged fluxes. Then macroscopic equations are developed for advective, dispersive and diffusive fluxes, all in terms of averaged state variables of the system. These are combined with the macroscopic balance equations to yield field equations that serve as the core of the mathematical models that describe the transport of extensive quantities in a porous medium domain. (Edited author abstract) 10 refs.

Bear, Jacob (Technion-Israel Inst of Technology, Haifa, Isr); Bachmat, Yehuda. *Trans Porous Media* v 1 n 33 1986 p 241-269.

**083992 CLOSED TUBE METHOD FOR MEASURING GAS DIFFUSION COEFFICIENTS.** A transient, closed tube method for measuring both ordinary gas diffusivities and porous media effective diffusivities is

presented. The current method is suitable for measuring gas diffusivities in air-dry systems over a range of temperatures. Gas concentrations are continuously monitored in a well-stirred volume of a single end chamber, which is connected to a closed sample chamber during experiments. An analytic solution for this diffusion process is available in which, after a sufficient time, the diffusivity of the sample is obtained from the slope of the logarithm of dimensionless concentration excess versus time. The method was checked by comparing measurements of  $N_2-O_2$  gas diffusivities at 0, 30, and 60°C to various previously reported values in the literature. (Edited author abstract) 29 refs.

Tokunaga, T.K. (Lawrence Berkeley Lab, Berkeley, CA, USA); Waldron, L.J.; Nemson, J. *Soil Sci Soc Am J* v 52 n 1 Jan-Feb 1988 p 17-23.

**083993 SCALE-DEPENDENT EQUATION FOR SOLUTE TRANSPORT IN POROUS MEDIA.** The governing equation describing solute transport in porous media is reformulated using standard volume averaging techniques. The alternative formulation is based on a modified definition of the deviation, which allows for variation of macroscopic velocity across the REV. The new equation contains additional scale-dependent terms which are functions of the size of the averaging volume (REV). This result indicates that the scale-dependent nature of the dispersion phenomenon is inherent even at the scale of the REV. (Author abstract) 12 refs.

Berkowitz, Brian (Ministry of Agriculture, Jerusalem, Isr); Bachmat, Yehuda. *Trans Porous Media* v 3 n 2 Apr 1988 p 199-205.

### Vaporization

**083994 INTERNAL VAPORIZATION IN POROUS MATERIALS UNDER LASER IRRADIATION.** Under laser irradiation, a porous material may vaporize within its pores as well as at the surface. The effect of this phenomenon is examined for pores with a high degree of connectivity and for a pore tree model. It is shown that in the former case, the internal vaporization of material is bounded by the rate at which vapor can escape from inside the porous substance. This rate is sufficiently large so that significant modification of the internal temperature profile may result. For the pore tree model, the buildup of vapor pressure in the pores suppresses the internal vaporization. An upper bound on the mass flow rate from the pore tree is derived when the back pressure is self-consistently included. For pore trees of interest, this bound is small enough so that significant modification of the internal temperature profile will not result; however, material damage may occur due to the high internal pressures. (Author abstract) 9 refs.

Hastings, D.E. (Physical Sciences Inc, Andover, MA, USA); Rigos, A.A. *AIAA J* v 26 n 5 May 1988 p 561-565.

### Wave Effects

**083995 PRESSURE WAVES IN A POROUS MEDIUM SATURATED WITH A GASSY FLUID.** Experimental data on the evolution of pressure waves in a consolidated porous medium saturated with a gassy fluid are obtained. These data are generalized on the basis of a theoretical analysis. (Author abstract) 11 refs.

Dontsov, V.E.; Kuznetsov, V.V.; Nakoryakov, V.E. *Fluid Dyn* v 22 n 4 Jul-Aug 1987 p 564-570.

### Waves

**083996 SPATIAL DIFFRACTION PROBLEM ON A RIGID AND OPAQUE WEDGE IN A BIOT MEDIUM.** We solve a three-dimensional problem of wave diffraction on an opaque wedge inserted without friction into an infinite two-component porous medium. 4 refs.

Takhirov, Sh.M. *Moscow Univ Mech Bull* v 42 n 6 1987 p 25-27.



**X-Ray Analysis** See CEMENT—Porosity; FOAMS—Moisture Determination.

**PORT STRUCTURES** See Also OCEANOGRAPHY—Currents.

**083997 LE BANCHINE REALIZZATE CON PARATIE DI PALI DI GRANDE DIAMETRO TIRANTI PRESOLLECITATI E PALI DI ANCORAGGIO.** [Realization of a Wharf with Large Diameter Piles, Prestressed Tension Bars and Grousers]. The behavior of a wharf built with streamflow diverters consisting of large diameter piles and prestressed tension bars and grousers is outlined. Problems of theoretical modeling and the importance of experiments carried out at the site are also discussed. Investigation of the interaction between the piles and the soil due to seismic forces is assessed. Instruments to be incorporated into the piles during tests for the determination of the Kr module are also described. (Edited author abstract) In Italian. 10 refs.

Bentivoglio, Cesare (Genio Civile Opere Marittime di Roma, Italy). *G Genio Civ* v 125 n 1-2-3 Jan-Feb-Mar 1987 p 17-22.

## Bulkheads

**083998 PREDICTION OF LATERAL DISPLACEMENT OF ANCHORED BULKHEADS INDUCED BY SEISMIC LIQUEFACTION.** Numerical analysis was carried out on earthquake-induced displacement of anchored bulkheads. The permanent displacement of several meters experienced in liquefied areas during the Niigata earthquake was large enough to damage the functions of nearby structures. Since the conventional methods of predicting seismically-induced displacement could not deal with thin sheet-pile walls subject to liquefaction, they were modified and improved. The new method analyzes the limit equilibrium of a backfill soil wedge under the action of pseudostatic seismic force, and calculates the critical acceleration of an earthquake which is required for the sliding mechanism to be activated. By following Newmark's sliding block theory, the seismic acceleration in excess of the critical value is integrated twice with time so that permanent displacement may be obtained. Effects of pore water pressure development is taken into account by allowing the variation of critical acceleration with time. (Edited author abstract) 16 refs.

Towhata, Ikuro (Asian Inst of Technology, Bangkok, Thailand); Islam, Md. Shafiqul. *Soils Found* v 27 n 4 Dec 1987 p 137-147.

**Construction** See Also BREAKWATERS—Performance.

**083999 QUICKLY ERECTED PORT BUILDINGS PROVE LONGTERM INVESTMENT.** To cope with changing trade patterns, a port needs flexibility in its storage buildings. Traditional-built structures have high cost/long wait disadvantages, while units once regarded as 'temporary' accommodation are now accepted as permanent solutions but retain their relocatable superiority. (Edited author abstract)

Anon. *Port Constr Ocean Technol* v 4 n 2 Mar-Apr 1987 p 43-44.

**084000 STEEL SHEET PILES AS PREFABRICATED ELEMENTS IN HARBOUR CONSTRUCTION.** Installation of sheet piling utilizes pre-fabricated components. Its main features combine immediate construction start-up, simple and overseeable equipment placement, low personal requirement, rapid construction progress and relative weather independence. Sheet Pile Structures are economically adaptable to existing conditions. Extensions, changes or strengthening of old structures to accommodate present demands are possible without difficulties and represent typical areas of applications for sheet piling. Examples for such measures are: redriving of sheet piling to deeper penetrations even after decades; reinforcing sheet piling; strengthening of anchoring systems; installation of additional anchor rods; and splicing to existing piling (e.g. in area of ground subsi-

dence). This is valid both for inland harbors and sea ports, and is applicable also for sheet piling as double or treble piling; armor-plated sheet piling; heavy, wave-shaped sections; combined (mixed) sheet pile structures; flat web sheet piling; and dolphins. (Edited author abstract) 11 refs.

Roth, Siegfried (Hoesch Stahl AG, Dortmund, West Ger). *Bull Perm Int Assoc Navig Congr* n 59 Oct-Dec 1987 p 101-117.

## Corrosion

**084001 KORROSION UND ZERSTÖRUNGSFREIE PRÜFUNG IN DER MEERESTECHNIK.** [Corrosion and Non-Destructive Testing in Marine Technology]. The available methods for underwater inspection and supervision are presented. For each case of underwater inspection, the demands concerning accuracy and reliability have to be specified beforehand, so that a suitable method may be selected. The divers involved have to be supervised in some adequate manner, because mere descriptions of even trained divers are not sufficient. (Edited author abstract) In German. 11 refs.

Richter, B. (Germanischer Lloyd, Hamburg, West Ger). *Tech Mess TM* v 55 n 4 1988 p 139-143.

## Design

**084002 CONSTRUCTION OF NEW PRODUCTS-BERTH FOR 80,000-DWT VESSELS.** A new products-berth was designed to accommodate vessels up to 80,000 DWT, thus providing cost savings in ocean freight charges. In Chiba Works the design of the new products-berth was an absolute necessity, in order to utilize the cargo handling equipment and techniques more effectively and economically. The berth is a quay-type wharf structure supported on steel pipe piles. A structure 300-m long and 41-m wide was designed, with a dredge depth of -15.5 m. In this project, each work of dredging and pile installation was completed by using measuring systems. For example, it was necessary to monitor potential movement of the existing concrete-caisson sea wall. This project has three innovative technological features: the KST cantilevered pile driving system for marine structures, polyethylene film coated steel pipe piles, and pile driving control using the wave equation. (Author abstract) 3 refs.

Kenmochi, Satoru (Kawasaki Steel Corp, Jpn); Kimura, Tamotsu; Okumura, Ichiro. *Kawasaki Steel Tech Rep* n 17 Oct 1987 p 98-103.

**084003 FINGER-TYPE FITTING-OUT JETTY, CALCUTTA.** The paper describes the scheme and salient features of a finger-type fitting-out jetty constructed for Garden Reach Shipbuilders and Engineers Ltd., Calcutta, which is a leading public-sector shipbuilding firm in India. The jetty is located within the complex of Netaji Subhas (NS) Dock of Calcutta Port Trust, and it is used to carry out sophisticated and intricate technological works required for specialized types of vessels. The paper describes briefly the various structural components of the jetty which were innovatively designed so that a construction technique could be adopted for maximum economy, reliability and quality control, considering the existing conditions at site and its geotechnical aspects. (Author abstract) 10 refs.

Guha, Sukumar (Government of India, India). *Indian Constr J* v 61 n 11 Nov 1987 p 297-300, 306.

**Dolphins** See MARINE PLATFORMS—Concrete Construction.

**Earthquake Resistance** See PORT TERMINALS—Structural Design.

## Fenders

**084004 FOCUS ON FENDERS.** Six leading fender designers and manufacturers - Andre, Burleigh Marine, Kommerling, Pirelli, Rubber Millers and Seward - who between them can offer systems to suit every application,

outline the benefits of their products. Recent developments and current installations are discussed.

Anon. *Dock Harbour Auth* v 63 n 799 Mar 1988 p 271-273.

## Poland

**084005 PORT STRUCTURES AND EQUIPMENT.** A brief survey is presented of the historic development of port constructions and equipment in Poland, a country for centuries connected with the sea. Special attention has been paid to the port structures and equipment introduced in the period of reconstruction and development of ports in the estuarine area of the Odra river, e.g. those of Szczecin and Swinoujscie. The author tries to demonstrate that, if the port complex Szczecin-Swinoujscie has attained the actual level of development and become one of the most important merchant ports on the Baltic sea, it is only thanks to having been regained and included within the borders of the Polish state. (Edited author abstract) In English and French. 13 refs.

Mazurkiewicz, Boleslaw (Technical Univ of Gdansk, Pol). *Bull Perm Int Assoc Navig Congr* n 60 Jan-Mar 1988 p 34-45.

## Portable

**084006 DEVELOPMENT OF DEPLOYABLE PORTS MAY PROVE VITAL TO U.S. NAVY.** The deployable port represents a radical departure from current port construction techniques. The port facilities are preconstructed on large (100×300 foot) floating barges. The barge modules are connected and anchored to form a port complex. Construction of the modules can be carried out in shipyards without tying up vital port operation areas. Once constructed, the modules can be installed in a matter of three to four weeks to replace or augment existing stateside port facilities. This article discusses how providing a less expensive, highly mobile alternative to permanent port facilities can achieve greater political and operational flexibility.

Bretz, Glenwood (US Naval Civil Engineering Lab, USA). *Sea Technol* v 29 n 9 Sep 1988 5p.

## Quay Walls

**084007 DATA REPORT OF TWO DYNAMIC CENTRIFUGE MODEL TESTS ON FREE CANTILEVER RETAINING WALLS.** With aims to investigate the effects of earthquakes on free sheet pile type of quay wall, two centrifuge model tests were carried out on free cantilever wall model using the Cambridge University Geotechnical Centrifuge. Among the two tests, one had a dry sand backfill and the other had a saturated sand backfill. This data report contains all the data recorded in these tests. 3 refs.

Zeng, X (Cambridge Univ, Engl); Steedman, R.S. *Cambridge Univ Eng Dep Tech Rep CUED/D-Soils* TR 202 1987 46p.

## Wave Effects

**084008 WATERLINE OSCILLATION AND RIPRAP MOVEMENT.** Eight test runs using a 1:3 glued gravel slope with an impermeable base were conducted in a wave tank to evaluate and calibrate the numerical model developed previously. For each run with the specified incident wave train generated in a burst, measurements were made of the free surface oscillation at the toe of the slope, the waterline oscillation on the slope, the temporal variation of dynamic pressure on the base of the slope, and the displacements of loose gravel units placed on the glued gravel slope. First, the friction factor associated with the rough slope is calibrated within a relatively narrow range using the measured waterline oscillation. Second, the coefficient for the lift force acting on a sliding gravel unit is calibrated in the range 0.18-0.4 by comparing the measured and predicted displacements of loose gravel units on the 1:3 glued gravel slope. (Edited author abstract) 9 refs.



Kobavashi, Nobuhisa (Univ of Delaware, Newark, DE, USA); Greenwald, Jeffrey H. *J Waterw Port Coastal Ocean Eng* v 114 n 2 May 1988 p 281-296.

**PORT TERMINALS** See Also COAL HANDLING—Control Systems; TELEPHONE EXCHANGES, MOBILE—Applications.

## Belgium

**084009 ZEEBRUGGE LNG TERMINAL.** The Distrigas Zeebrugge project is the largest LNG terminal in Europe and currently second largest in the world. Total storage capacity is 260,000 cu m with a peak send out capability of 7 billion cu m of natural gas per year. Developed at a cost of £90 million, the terminal will also be the receiving point for Statoil's Zeepipe. This will transport Norwegian gas from Troll and Sleipner and place Zeebrugge for the future expansion of European gas distribution.

Anon. *Pet Times* v 91 n 2216 Nov 1987 p 18-19.

## Chile

**084010 OPEN-SEA TERMINAL IN HOSTILE ENVIRONMENT.** A shiploading terminal near Punta Arenas, the southernmost city of the world (lat. 53°-10'S, long. 70°-54'W) is described. Strong winds, choppy seas, frequent gales, rain, and snow make it difficult to load ships at an offshore berth in this area. Detailed site investigations supplied sufficient information for the analysis of operating conditions. The results showed that a bulk loading terminal at this location is feasible, provided the design takes into consideration the specific problems of the site. Results of wind recording, statistical analysis of wind and wave data, operating criteria, and berth availability analysis are included in the paper. (Edited author abstract) 11 refs.

Koman, Bela (Soros Associates, New York, NY, USA). *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt A 1986 p 2117-2121.

**Construction** See PORTS AND HARBORS—Great Britain; PORTS AND HARBORS—Northern Ireland.

## Electric Lighting

**084011 SEEING IT IN A DIFFERENT LIGHT.** Today, a terminal has to offer the ability for around-the-clock working. This means good floodlighting, as no shipper is going to be attracted to facilities that cannot continue after the hours of darkness. The competitive market situation ensures a continuing striving for further efficiency in lighting design as ports themselves achieve long-term experience in night-time illumination.

Anon. *Port Constr Ocean Technol* v 4 n 3 May-Jun 1987 p 31-33.

**Equipment** See CRANES—Supports; MATERIALS HANDLING—Equipment.

**Federal Republic of Germany** See PORTS AND HARBORS—Federal Republic of Germany.

**Finland** See PORTS AND HARBORS—Construction.

**Planning** See DECISION THEORY AND ANALYSIS.

**Portable** See PORT STRUCTURES—Portable.

**Retrofitting** See PORTS AND HARBORS—Oakland, California.

## Structural Design

**084012 DESIGNING TO A FAULT.** A 30 dollars million expansion at one of the Port of Los Angeles' busiest terminals took the fast track over the Palos Verdes Fault. The seismicity of California is well known; however, setting seismic design criteria for a marine shipping facility is a major issue that is still not specifically addressed by local building codes. The design team began

by performing a probabilistic evaluation of the seismic activity expected at the facility site during an earthquake, considering all seismic sources in the Los Angeles basin. This paper describes the soil evaluation, settlement calculations and selection of pile system under horizontal seismic loads.

Erickson, Bradley P. (CH2M Hill, USA); Anderson, Donald G.; Wittkop, Richard C. *Civ Eng (New York)* v 58 n 8 Aug 1988 p 58-60.

**Transportation** See PORTS AND HARBORS—Canada.

**PORTS AND HARBORS** See Also CARGO HANDLING; COAL HANDLING; HYDROGRAPHIC SURVEYING; NOISE POLLUTION—Simulation; SHIPS—Constructing and Outfitting; WATER WAVES—Mathematical Models.

## Australia

**084013 PORT SAFETY DOWN UNDER.** The Australian waterfront industry shows many positive safety measures and procedures, but safety questions cannot be divorced from the broader problems of industrial relations. Statistics collected and published every six months by the training and accident prevention division of the Association of Employers of Waterside Labour (AEWL) show that in the 12 months to June 1986 a total of 4617 treatment and suspected personal injury accidents were recorded, a 10 per cent drop in two years. The AEWL also acts as secretariat to the influential Federal Advisory Committee on Waterfront Accident Prevention and Occupational Health (FAC). The general safety code to which all the ports work was compiled and issued in 1975 with FAC approval and is now in the last stages of revision. Specific guidance notes on the handling of monazite sand and uranium oxide have also been published by the FAC, as well as advice on respiratory and associated equipment for use on the waterfront. This article discusses safety training, legal position, terminal operations, and other aspects of the subject.

Compton, Mike. *Cargo Syst Int* v 15 n 2 Feb 1988 p 78-79, 81.

## Canada

**084014 PORT OF VANCOUVER: CANADA'S GATEWAY TO THE PACIFIC RIM.** The 120-year old Port of Vancouver lies in the heart of a sprawling urban area, the City of Vancouver. Today, city and port move people, traffic, and ships in a setting geared to economic growth and a cosmopolitan life style. Serving the numerous and highly varied port activities presents many ongoing challenges, not the least of which is access. Although new entrance roadways have been recently completed, access to port facilities remains an issue. Over 80% of traffic is in major bulk commodities, primarily coal, grain, forest products, sulphur, mining products, and petrochemicals. Critical to this shipping is the port's intermodal infrastructure of on-dock rail service and truck transport arteries. More than 20 specialized terminals, lining both sides of the inner harbor, are fully equipped to handle all types of bulk, general, and containerized cargo. This article surveys the port facilities in Vancouver, British Columbia, and related operational problems.

MacNaughton, Francis J. *ITE J* v 58 n 4 Apr 1988 p 21-24.

**084015 SHIP-HANDLING IN THE PORT OF CHURCHILL—THE B%EAR ESSENTIALS.** This paper describes an in-depth study performed by the authors' company to properly determine the shiphandling requirements in the Port of Churchill, on Canada's Hudson Bay, and the subsequent design and construction of the 3000-hp tugboat, H.M. Wilson. This tug is unusual primarily because of the unique and remote location of the port in which it operates, and by the limitations which this remote site placed upon its design and construction. (Author abstract). 3 Refs.

Allan, Robert G. (Robert Allan Ltd, Vancouver, BC, CAN); Woodward, Peter. *Mar Technol* v 25 n 3 Jul 1988

p 190-204.

## Cleaning

**084016 SCOURING THE HARBOR.** For a harbor to be maintained at a depth sufficient for handling high-tonnage ships, it must be kept clear of river silt. The traditional method of accomplishing this is periodic dredging. But dredging is an expensive operation; berths must be temporarily closed, which leads to scheduling problems with incoming vessels and to lost revenues when the terminal cannot accommodate them. Instead of dredging, a West Coast port uses a hydraulic scourjet system to wash silt away before it can settle. A digital data acquisition and control system is in charge of the operation. (Edited author abstract)

Jessen, Kenneth (Hewlett-Packard Co, Loveland, CO, USA). *Mech Eng* v 109 n 10 Oct 1987 p 46-48.

## Concrete Construction

**084017 CONCRETE IN CONSTRUCTION: LEARNING THE HARD WAY.** For many years, the north pier at the UK east coast port of Bridlington has provided a shelter for the fish quay. This regularly takes a pounding from the sea. When the authors were there, a definite swell was running against the pier, even though it was a pleasant day. It is understood that waves often break completely over the pier and the shelter: this occurrence is crucial to what happened. At a time when both paradoxically the uses of concrete are expanding whilst its limitations are being redefined, this report of one port's recent experience might prove a salutary lesson to others.

Anon. *Port Constr Ocean Technol* v 4 n 3 May-Jun 1987 p 26, 28.

## Construction

**084018 CHANNEL PORTS: STILL FIGHTING THE FIXED LINK.** Construction starts soon in earnest of the fixed link under the Channel between the UK and France. Not to be outdone, ports on both sides continue to invest heavily in development. Dover Harbor Board, set to lose most, are currently investing £1.5 million a month on civil engineering improvements. This month, construction was completed on a new number one and number three berths, and both have been designed for provide different types of facility.

Anon. *Port Constr Ocean Technol* v 4 n 5 Sep-Oct 1987 p 32, 34-36.

**084019 MINIPORT CONCEPT CUTS TIME AND COST.** The Miniport concept is basically the use of floating pontoons as quay frontage with various types of connections to shore. Several companies are offering systems that offer the advantage of considerably reducing port construction time and capital costs. (Author abstract)

Anon. *Port Constr Ocean Technol* v 4 n 2 Mar-Apr 1987 p 33-34, 36.

**084020 GO-AHEAD FINNS PLAN MAJOR PROJECTS.** With port construction currently in a very dynamic state worldwide, there is no lack of developments and ideas - some unusual - taking place. This article looks at Finland, where several construction projects are under way. (Edited author abstract)

Anon. *Port Constr Ocean Technol* v 4 n 3 May-Jun 1987 p 24-25.

**084021 AUST CONSULTANT DESIGNS TONGAN HARBOR.** Riedel & Byrne Consulting Engineers Pty Ltd is designing a new harbor for the island of 'Eua in the kingdom of Tonga. The harbor features an unusual breakwater to be constructed on top of a reef with a new vertical face. The Australian Government is providing funds for the design and supervision of construction as



part of its aid program to Tonga. The harbor works will include a new wharf, a ramp for landing barges and other craft, provision of small boat pull-out facilities, harbor excavation, breakwaters and an area of reclamation. Experimental results showed that a 2-part breakwater constructed of locally quarried 2.5 t to 3 t armor rock provided the most cost-effective solution. The breakwaters on either side of the entrance channel near the reef edge will consist of a pair of precast concrete walls grouted and bolted into the reef and infilled with armor rocks.

Dixon, Susette. *J Inst Eng Aust* v 59 n 22 Nov 13 1987 p 33.

**084022 SELF-UNLOADERS SUGGESTED AS SOLUTION TO PORT DEVELOPMENT COSTS.** A Canadian firm is marketing a bulk commodity self-unloading system which can dramatically reduce port construction costs. Construction of new bulk receiving ports can cost in the range of \$100 million, and require three to five years of lead time. Stevedoring and annual maintenance contribute further to this cost. The self-unloading system is described in the article and the advantages of the system are discussed.

Anon. *World Dredging Mar Constr* v 23 n 9 Sep 1987 p 34-35.

## Design

**084023 KALLIN HARBOUR - DESIGN AND CONSTRUCTION.** This paper describes the design and construction of a new fishing harbor which was excavated out of the rocky coastline of the Hebridean Island of Grimsay. The harbor is 25 meters wide and 32 meters long with a six meter wide slipway. The works involved the excavation of 11,000 cubic meters of rock; the formation of 1000 square meters of vertical rockface by specialized blasting techniques; the construction of 90 meters of reinforced concrete wall, eight meters high, anchored to the vertical rockfaces by resin anchors; the construction of a 35 meter long slipway; and the formation of 1600 square meters of car park and storage areas. 2 refs.

Robson, A.M. (Western Isles Islands Council, Scotl). *Munic Eng (Inst Civ Eng)* v 4 n 5 Oct 1987 p 243-255.

**084024 PORT & HARBOR DESIGN SIMULATOR FOR PORT & HARBOR RESEARCH INSTITUTE, MINISTRY OF TRANSPORT.** The article reports on a system manufactured for the purpose of studying the relationship between the plan of a port and ship maneuvering by integrating all IHI technologies related to ship maneuvering simulators. The system simulates the movement of its own ship and target ships based on a port design displayed graphically. The system was completed in February 1984 and is in use at present.

Matsuura, Yoshitsugu (IHI, Tokyo, Jpn); Ushio, Takao. *IHI Eng Rev (Engl Ed)* v 19 n 2 Apr 1986 p 96-98.

**084025 CARDIFF BAY BARRAGE - REMODELING FOR REGENERATION.** Cardiff Bay Development Corporation's ambitious plan to transform Cardiff into an international maritime city, hinges on the construction of a barrage across the mouth of the Bay. Stretching from Penarth Head in the west to a point adjacent to Queen Alexandra Dock in the east, the 1.2 km barrage is expected to carry high and low level sluices, locks, and probably a service road and walkways. At full tide, the barrage will create a 250 ha inland lake.

Anon. *Civ Eng (London)* Jan-Feb 1988 p 22-23.

**084026 WAVE GROUPING AND HARBOUR DESIGN.** Residual disturbances in harbors, associated with wave grouping, are discussed. The main source of energy is identified as set-down beneath wave groups, and data are provided which show the existence of set-down in the real sea; the implications for wave generation in physical models are considered. A self-consistent statistical description for responses at wave group periods is presented. This starts with a random sea in which the ordinary waves are assumed to consist of a superposition of wave components with random phases. Wave groups occur

naturally along with the associated set-down, but in physical models, compensation for set-down at the wave-maker is needed to avoid the generation of spurious long waves. Expressions for the magnitude of set-down are derived and verified experimentally in random wave flume tests. Results from a random wave physical model investigation of a proposed new harbour are used to illustrate the importance of wave grouping effects in harbour design. (Author abstract). 10 Refs.

Bowers, E.C. (Hydraulics Research Ltd, Wallingford, Engl). *Proc Inst Civ Eng (London)* v 85 n Pt 2 Jun 1988 p 237-258.

**Dredging** See Also DREDGING; DREDGING—Costs.

**084027 DUTRA/MORRISON-KNUDSEN CONTINUE WORK ON \$12.5 MILLION MONTEZUMA SLOUGH PROJECT.** A massive control structure designed to protect the water quality of the largest brackish water marsh in the United States is being built in California by a joint venture of Dutra Construction Company and Morrison-Knudsen Company. The ambitious project involves constructing and placing a three-component gate and lock structure in the Montezuma Slough, at the upper end of the Suisun Marsh in California's Sacramento River Delta. Based upon the complex engineering and fabrication work involved in the project, it is a marine construction project with few rivals on the West Coast. The project is truly unique since the three specially designed components of the control structure were built on barges in Stockton, California, moved more than 50 miles to the Montezuma Slough, floated off the barges, and sank at the final in-service point. The Montezuma Slough project is described in detail in the article. The three major parts of the project namely dredging, concrete work and sinking are presented in detail.

Anon. *World Dredging Mar Constr* v 23 n 10 Oct 1987 p 6-11.

**084028 SAN FRANCISCO BAY DEVELOPMENT.** Author describes three navigation projects, namely Oakland Inner and Outer Harbors deepening, Richmond Harbor deepening and Sacramento Deepwater Ship Channel deepening. Disposal problems and the user fees are discussed.

Kelly, Patrick J. (US Army Corp of Engineers, USA). *World Dredging Mar Constr* v 23 n 8 Aug 1987 p 9-12.

**084029 BENEFICIAL USES OF DREDGED MATERIAL: THE WORD IS OUT.** The Corps of Engineers oversees the operation and maintenance of more than 400 U.S. ports and harbors, and 250,000 miles of inland waterways. Some 300 million cubic yards of material is dredged from these waters annually. Public Law 91-611 enacted by Congress in 1972, directed the Corps to conduct a national environmental research program on dredged material: the Dredged Material Research Program (DMRP). The five year, \$33 million program showed conclusively that 95 percent of the material dredged was uncontaminated. Today, the total amount spent by the Corps on studying the effects of dredged material disposal has reached \$100 million. Given that the vast majority of material dredged has been found not to be contaminated, dredged material can be looked upon as a valuable resource to the ecologies and economies of coastal regions. Author describes the beneficial uses of dredged material such as habitat development, beach nourishment, aquaculture, strip mine reclamation and solid waste landfill.

Anon. *World Dredging Mar Constr* v 23 n 8 Aug 1987 p 14-17.

**084030 U.S. ARMY CORPS OF ENGINEERS STEPPED UP DREDGING PROGRAM.** The waterways system is vital to the flow of the domestic and foreign commerce because it offers the cheapest and most energy efficient transport mode for such bulk cargoes as coal, grain, petroleum products, chemicals, iron and steel. In addition, the waterway system has proved to be of great

importance to our defense efforts in the past and is an essential element of our current mobilization readiness posture. The dredging program is also very important to the regional and national economies. The author describes the importance of dredging operations and the part played by US Army Corps of Engineers in the dredging program.

Murden, William R. (US Army Corps of Engineers, USA). *World Dredging Mar Constr* v 23 n 12 Dec 1987 p 6-13.

**084031 'COLUMBUS' PERFORMS MAINTENANCE JOB: B+B COMPLETES FIRST CONTRACT IN NEW YORK.** The author describes the dredge which was recently converted from a trailing suction hopper barge. This is designed for maintenance dredging as well as for aggregate dredging and beach nourishment.

Anon. *World Dredging Mar Constr* v 23 n 12 Dec 1987 p 17-18.

**084032 DREDGING PROPOSAL INTERESTS THE CORPS AND INDUSTRY.** To preclude the potential for bid unbalancing, South Atlantic Division (SAD) eliminated the allowable overdepth provision from its bid documents for maintenance dredging in June 1985. The Corps' Washington office, which currently operates with bid document regulations specifying that required dredging must be at least 50 percent of advertised quantities, approved SAD's move to more stringently control allowable overdepths, and plans to include this option in its new regulation. The South Atlantic Division hopes to show substantial cost savings through sharper competition on a fixed scope of work. The change being used by the South Atlantic Division is a logical departure from past practices. The article discusses several important issues that are brought into focus as a result of the change.

Bradley, James H. *Mil Eng* v 80 n 522 Jul 1988 p 380-381.

**084033 OCEAN ENGINEERING: PROCEEDINGS OF THE NINETEENTH DREDGING SEMINAR (HELD IN CONJUNCTION WITH WESTERN DREDGING ASSOCIATION ANNUAL MEETING).** The proceedings contain 16 papers. Some of the main topics are dredged sediment disposal, dredging legislation, cost sharing simulation techniques for engineering design, thin layer disposal, and harbor channel dredging. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11634 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Herbich, John B. (Compiler) (Texas A&M Univ, College Station, TX, USA). *Tex A&M Univ Sea Grant Coll Program Rep TAMU-SG* n 293 1987, Ocean Eng: Proc of the Nineteenth Dredging Seminar, Baltimore, MD, USA, Oct 15 1986. Publ by Texas A&M Univ, College Station, TX, USA, 1987 186p.

**Electric Lighting** See PORT TERMINALS—Electric Lighting.

**Emden, Federal Republic of Germany**

**084034 DOLLART-DOCK PROJECT EMS BYPASS AND A NEW ACCESS TO THE PORT OF EMDEN.** The increase in costs for maintenance dredging in the Port of Emden and in the seaward access, on the one hand, and the desire to improve the fairway situation, on the other hand, were decisive for the Dollart-Dock-Project (DDP). Since the middle of the sixties, the Port of Emden planning staff has developed a port extension plan. It is foreseen to bypass the river Ems through the Dollart-bay and to block up the Emden-fairway on downstream and upstream sides. The new access to the Port of Emden will be 10 km seawards the old sea lock, nearby Knock-landmark. Nearly 67 mill. m<sup>3</sup> of different kinds of soil is to be dredged in the bypass and to be used or setting up a new sea dyke. The rest is to be deposited on a disposal areas in the estuary. A new sea lock for ocean-going vessels up to 150,000 dwt and an inland navigation lock are to be built. (Author abstract) 3 refs.



Carsiens, Roelf (Lower Saxonian Authority for the Port of Emden, West Ger); Wurpts, Rewert. *Bull Perm Int Assoc Navig Congr* v 59 Oct-Dec 1987 p 56-82.

## Federal Republic of Germany

**084035 STANDORT HAMBURG-SERVICE IM BE-REICH DES SEEVERKEHRS.** [Maritime-Transport-Related Service Based in Hamburg]. Hamburg, the largest seaport of the Federal Republic of Germany is not only an important place of transshipment for West German imports and exports but, due to its geographical location, one of the most important European transit ports. Approx. 15,000 ships call at Hamburg each year. Over 40 PERCENT of the total maritime-transport-related cargo transshipment volume (approx. 140 million tons) of the Federal Republic of Germany is handled via Hamburg. In German.

Hoffmann, Hans-Joachim (Blohm & Voss AG, Hamburg, West Ger). *Thyssen Tech Ber* v 20 n 1 1988 p 69-73.

## Fire Protection

**084036 FRESH LOOK AT SHIP AND PORT FIRE-FIGHTING.** The article is a resume of a study report on the title subject. The original report was written by Michael Charles, of Trinidad and Tobago, following a visit to the United Kingdom and to whom a Commonwealth and Overseas Fire Services Association (COFSA) scholarship was awarded. Subjects covered include ships types and materials, warning systems, fire-fighting planning, fire-fighting equipment, at-sea and in-port fire-fighting, and others. 6 Refs.

Charles, Michael. *Fire Int* v 12 n 111 Jun 7 1988 p 58-59.

France See CLAY—Consolidation.

Goderich, Ontario See PIERS—Repair.

## Great Britain

**084037 MULTI-MILLION POUND INVESTMENTS IN UK SOUTH COAST PORTS.** From Newhaven to Falmouth the ports on England's south coast are investing vast sums in a bid to remain competitive, avoid stagnation and capture a greater share of available trade. This article reports on individual developments. (Edited author abstract).

Stevens, Barrie. *Dock Harbour Auth* v 68 n 800 Apr 1988 p 299-301.

## Hong Kong

**084038 TOLO HARBOUR - THE CASE FOR INTEGRATED WATER QUALITY MANAGEMENT IN A COASTAL ENVIRONMENT.** Tolo Harbour (Hong Kong) is a marine inlet which is under severe development pressure. Degradation of the environment has caused visual nuisance, adverse ecological changes, economic losses, and health risks. The increasing occurrence of damaging and potentially dangerous red tides is closely correlated with the increase in nutrient pollution loading. This comes mainly from two sewage treatment works, even though they are performing in accordance with their design. The Hong Kong Government's response involves a co-ordinated sequence of conventional pollution control activities. The problems which are now being faced would not be so severe if earlier planning and given adequate recognition to the ecological consequences of all the aspects of development in combination. (Author abstract) 13 refs.

Holmes, Paul R. (Environmental Protection Dep, Hong Kong). *J Int Water Environ Manage* v 2 n 2 Apr 1988 p 171-179.

## Inspection

**084039 COMPUTERISING UNDERWATER INSPECTION.** It is now possible for ports to go one step further and adopt the most up-to-date method of maintenance control by investing in a micro-based computer system for running all phases of subsea inspection and maintenance work. This is the aim of Transcon, London-based consultants specializing in detailed planning and management of underwater inspection programs using a unique program called SIMMS. The 'Structural Inspection and Maintenance Management System' can be tailored to individual needs, is menu driven, has ready access to historical data and is transportable for immediate on-site control.

Anon. *Port Constr Ocean Technol* v 4 n 5 Sep-Oct 1987 p 20-21.

## Japan

**084040 LOOKING TO THE FUTURE WITH LAND FROM THE SEA.** Port projects in Japan are so huge that even though they are no longer just about ports, but about a full range of civic functions, they still involve a massive increase in cargo handling capacity. Kobe's 'Renaissance' project has three aspects, all due for completion by 1995. The centrepiece of Yokohama's development is the Minato Mirai 21 (MM21) project, meaning future port for the 21st century, due for completion in 2000. The three aspects form the subject of this article.

Champion, Vincent. *Cargo Syst Int* v 14 n 8 Aug 1987 p 28-29.

## London, England

**084041 REORGANISATION AT THE PORT OF LONDON.** Organizational changes designed to improve the Port of London's efficacy and competitiveness became fully operational in 1987. The management of London's main activities has been devolved into separate operational units so that performance in individual sections can be measured. This is the first time that business units within the Port of London Authority (PLA) have been able to identify and develop their own commercial ventures. The author evaluates the effectiveness of the organizational changes in relation to the performance of the various areas of operation.

Stevens, Barrie. *Dock Harbour Auth* v 68 n 798 Feb 1988 p 239-242.

Maintenance See DREDGING.

## Management

**084042 STRATEGIES FOR SUCCESS.** Small ports can be divided into two basic categories: Those which cater for a single commodity or handle traffic for a single user; and those operated as general cargo and common user facilities. The ownership of the port will have a significant bearing on the type of facility provided but irrespective of ownership, effective planning and management are essential to the successful operation of any small port. The small port has to base future strategies on sound research which will then be used to determine how the port facilities could be developed to maximize returns. The various factors which will influence future strategies include: Commodities and anticipated parcel size; Commodities and anticipated parcel size; determination of the port's hinterland and an examination of the inland transport system; physical limitations on vessels using the port; an analysis of total transport costs to the shipper/-consignee; and available finance. These and other aspects of the subject are discussed.

Anon (Ocean Mackenzie Ltd, Woking, Engl). *Cargo Syst Int* v 14 n 10 Oct 1987 p 87, 89.

## Mathematical Models

**084043 CORPUS CHRISTI INNER HARBOR SHOALING INVESTIGATION.** A combination of numerical models was used to test alternatives for shoaling prevention in Corpus Christi Harbor, Texas. The vertically averaged model system, TABS-2, was used to simulate contributions of sediments by bay waters to the sediment load. The laterally averaged estuarine model,

LAEMSED, was used to simulate density currents in the channel and sedimentation that occurs at the harbor entrance. Applications of the models testing advance maintenance, removal of industrial discharges and withdrawals, advance maintenance in conjunction with a sill, and movement of the disposal areas showed a 20 percent decrease in shoaling as a result of industrial activity removal, a 75 percent decrease in sediments entering the bay channel due to disposal area relocation, and practically no effect on shoaling rates resulting from advance maintenance. (Edited author abstract) 20 refs.

Smith, Tamsen M. (US Army Corps of Engineers, Vicksburg, MS, USA); McAnally, William H. Jr.; Teeter, Allen M. *Tech Rep US Army Eng Waterw Exp Stn HL-87-13* Sep 1987 var pagings.

New Zealand See Also WATER POLLUTION—Analysis.

**084044 PORT SAFETY THE NEW ZEALAND WAY.** Waterside workers are administered by the Waterfront Industry Commission (WIC). Employers belong to the New Zealand Association of Waterfront Employers (NZAW). Safety is inextricably linked with each of these various strands and an important element is the Waterfront Training Organization (WTO). Founded in 1968 as a separately funded division of the NZAW, the WTO is recognized as one of the nation's Industry Training Boards. This article discusses legal considerations, compensation, safety organization, applications, and other aspects of the subject.

Compton, Mike. *Cargo Syst Int* v 15 n 1 Jan 1988 p 64-65, 67.

## Northern Ireland

**084045 MAIL QUAY DEVELOPMENT AT LARNE HARBOUR.** In September 1985, the Board of Larne Harbour Ltd, recognizing that the existing Mail Quay, equipped with an aged narrow single deck vehicle ramp (which had steep operating gradients and a maximum safe working load of 32 t) was too short and shallow for modern ro/ro vessels, decided to upgrade the structure. Work began in 1986 and the quay was commissioned in October 1987. A brief description of the work involved in the upgrading of Larne's Mail Quay is presented. (Edited author abstract)

Anon. *Dock Harbour Auth* v 68 n 798 Feb 1988 p 244-245.

## Oakland, California

**084046 RECENT DEVELOPMENTS AT THE PORT OF OAKLAND.** The attitude of the Oakland Port Authority is that ports must be even more competitive than shipping companies as clients have the choice of taking their shipping elsewhere. Accordingly, Oakland is taking energetic steps to upgrade its terminals and intermodal facilities within the port area, enter into joint-venture programs with rail and ocean carriers in order to improve bridge and tunnel access hundreds of kilometres from the port, and to market its advantages aggressively to those who make the real decisions. This article reviews some of the projects that the Port of Oakland is undertaking.

Anon. *Dock Harbour Auth* v 69 n 801 May 1988 p 5-7.

Planning See COASTAL ZONES—Sedimentation.

## Poland

**084047 SMALL HARBOURS AT THE WESTERN POMERANIA SEA COAST AND IN THE ODRA RIVER ESTUARY.** Small harbors are playing a role in local and regional economy in Western Pomerania. Here is presented an analysis of existing and potential possibilities of their development. Small harbors' future is correlated with the development of fishery, transport of passengers, tourism, recreation and yachting. Cargo transportation and industrial functions are related with selected



harbors. (Author abstract) In English and French.

Lesniewski, Gabriel; Zaremba, Peter Jr. *Bull Perm Int Assoc Navig Congr* n 60 Jan-Mar 1988 p 21-27.

**084048 SZCZECIN-SWINOUJSCIE PORT COMPLEX AND PROSPECTS FOR ITS DEVELOPMENT.** The article presents the development of the Szczecin-Swinoujscie ports in the period from the end of World War II till the year 1987, as well as possibilities and views for their further development. Special attention has been paid to present the difficult period of reconstruction of ports after the war destructions and to a proper determination of directions of their further development. The article also presents an offer to the possible transit partners, i.e. Czechoslovakia, Hungary, Austria, GDR - for whom availability of services in the ports of Szczecin-Swinoujscie is an optimum link in the whole transport chain. (Author abstract) In English and French.

Wielaw, Jan (Szczecin-Swinoujscie Harbour Complex, Pol). *Bull Perm Int Assoc Navig Congr* n 60 Jan-Mar 1988 p 28-33.

**Protection** See SONAR—Military Applications.

**Sedimentation** See BREAKWATERS—Design.

**Sweden**

**084049 PICKING PRIORITIES.** Sweden's ports provide diverse answers to diverse cargo handling requirements and are constantly trying to widen their cargo base. The Port of Goteburg, Scandinavia's leading ro-ro and container port, exemplifies this approach. One of its key projects is known as 'SKT 90', meaning 1990 as the deadline for commissioning all new handling traffic management systems at the Skandiahamnen container/ro-ro terminal. To date most attention has focused on the equipment aspects, in particular new quayside and yard cranes and the phased introduction of straddle carriers. The decision to introduce straddle carriers was based on the assessment that modern straddles are efficient transporters as well as lifters. Given Goteburg's established consultancy work in different parts of the world, it could well be of major long-term significance to manufacturers in this sector. This and other Swedish ports, cargo handling equipment, and management are discussed.

Champion, Vincent. *Cargo Syst Int* v 15 n 2 Feb 1988 P 45, 47.

**084050 PROFITABLE LINKS?** The explosion in ferry and ro-ro capacity in Sweden's ports creates important new opportunities for landbridge operations, yet may not have such negative consequences for lo-lo handling as is commonly supposed. Shipping line executives have been surprised by the apparent enthusiasm with which Swedish ports have chased new ferry links with Denmark, East and West Germany and other Baltic areas. Flexi and fixed links as well, may bring new opportunities to expand their total traffic base. Already Stockholm has witnessed a 50 per cent increase in throughput at the Baltic Ferry Terminal, opened only last year. This article discusses market conditions, management, and other factors related to the development of ferry links among Swedish shippers.

Champion, Vincent. *Cargo Syst Int* v 15 n 2 Feb 1988 P 49, 51.

**United Arab Emirates**

**084051 PORT WORKS AT FUJAIRAH, UNITED ARAB EMIRATES.** Construction of a new deepwater port at Fujairah on the east coast of the United Arab Emirates on the Gulf of Oman commenced in 1979; the port began operating in 1983. The paper discusses the considerations in choosing a suitable site and the investigations and planning for an artificial harbor within two major breakwaters extending 1 1/2 km. offshore into natural water depths of 15 meters, allowing for final provision of ten deepwater and two shallow water berths. It describes the design and construction of the port works

in the initial phase of development including the rock-filled concrete-dolosse-armored breakwaters, two deepwater container berths in mass concrete slice work with extensive areas of pre-cast blockwork paving for general cargo and container handling and storage, and ancillary facilities. (Edited author abstract) 3 refs.

Taylor, J.R. (Wilton & Bell Pty Ltd); Sivaloganathan, K. *Hong Kong Eng* v 14 n 7 Aug 1986 p 17-26.

**Wales**

**084052 WELSH WIZARD.** A small yet ambitious multi-purpose port project is gradually taking shape in Pembroke Dock, West Wales. The main quay will offer a depth alongside of 10.8 m below chart datum at any state of the tide, and the facilities will be open round the clock. The development is being both executed and managed by the Govan Davies Group (GDG). There are 150 acres available for warehousing, open storage or offshore gear fabrication either within the dock perimeter or immediately adjacent to it. This includes two former Sunderland Flying Boat hangars, located behind the main quay, each offering 3750 m<sup>2</sup> of storage and a clear working height of 18 m, with full opening 13.5 m x 49 m doors. Even more land is available for stockholding or other port-related duties within a five mile radius of the dock area. The new deep water port, scheduled for completion towards the end of this year, will provide almost 400 m of continuous quay frontage.

Champion, Vincent. *Cargo Syst Int* v 15 n 2 Feb 1988 P 63.

**Wave Effects**

**084053 NUMERICAL MODELLING OF HARBOUR WAVE DISTURBANCE IN COMPARISON WITH PHYSICAL MODELLING AND FIELD MEASUREMENTS.** This paper describes the results of numerical modeling of wave disturbance in the harbor of Ronne, Denmark, using the hydrodynamic modeling System 21 of the Danish Hydraulic Institute. The name of the system indicates that it can be applied to unsteady 2-dimensional flow in 1 layer. It includes the so-called 'Boussinesq' terms, which account for the deviation from hydrostatic pressure distribution caused by the vertical accelerations. It can simulate the phenomena of diffraction, refraction, reflection, and shoaling of natural irregular waves in a harbor of arbitrary shape and bathymetry. Comparisons have been made between the disturbance coefficients of numerical modelling and those of physical modeling and also between the former and those of field measuring data. The results indicate that there is in general a good agreement between them. (Author abstract) 5 refs.

Yu, Kuang-ming (Nanjing Hydraulic Research Inst, Nanjing, China); Rugbjerg, Morten; Kej, Asger. *China Ocean Eng* v 1 n 2 May 1987 p 40-47.

**Wilmington, Delaware**

**084054 OVERVIEW OF WILMINGTON HARBOR SOUTH PROJECT.** A 2440-m long dredged material disposal area containment embankment averaging 3.65 m in height is being constructed at Wilmington, Delaware. The construction is accomplished using high strength geotextiles as tensile reinforcement over a foundation consisting of soft, weak silts and clays forming the tidal flats and shallows of the Delaware River at the site. Vertical strip drains are used to speed the consolidation of the upper 7.3 m of the foundation soils to allow completion of the second stage of the embankment construction within a reasonable (12 to 18 month) time period. The embankment fill is hydraulically placed and the two stage construction is required to complete the embankment to its full height without risking failure of the foundation materials. Design features and construction methods, along with problems encountered to date are addressed. (Author abstract). 5 Refs.

Uibel, Bruce L. (US Army Corp of Engineers, Philadelphia, PA, USA). *Geotext Geomembr* v 6 n 1-3 1987 p 233-246.

**POSISTORS**

**Materials**

**084055 TRENDS IN PTC RESISTOR TECHNOLOGY.** Positive temperature coefficient (PTC) resistors have been in widespread use since 1965 in automotive, home appliance, telecommunication and industrial applications. They are used as self-regulating heaters, current limiters, overcurrent protectors, and sensors. Recent progress in PTC resistor technology includes the development of materials with transition temperatures exceeding 300C, improved microstructures with greater resistance to degradation, new device shapes useful in heater applications and a better understanding of the PTC mechanism. Piezoresistive properties have been more fully characterized. New ceramic materials have been explored. Polymer composite PTC resistors have been introduced for heater and current overload protection applications. These developments are reviewed. The stability of both types of resistor is compared, and the advantages of each are discussed. (Edited author abstract) 39 refs.

Kulwicki, Bernard M. (Texas Instruments Inc, Attleboro, MA, USA). *SAMPE J* v 23 n 6 Nov-Dec 1987 p 34-38.

**POST OFFICES** See Also MAIL HANDLING—Computer Simulation.

**Automation**

**084056 MAN-MACHINE SYSTEM PARAMETERS EXAMINATION IN THE AUTOMATED PARCEL TREATING PROCESS.** The results of a man-machine system parameters examination are presented. This system has been implemented in a parcel handling technological process. The system parameters and some manners of their calculation have been considered. The mathematical model for an operator activity optimization has been presented. The results can be used for mailing technology development. (Author abstract). 2 Refs.

Mroz, Dariusz (Technical Univ of Opole, Pol). *Modell Simul Control C* v 13 n 2 1988 p 35-42.

**Operations Research** See MAIL HANDLING—Optimization.

**Prefabrication**

**084057 NEW POST OFFICE AND TELECOMMUNICATIONS HEADQUARTERS IN DUESSELDORF.** The new building, rising in the center of the town, houses one of the most important telecommunications plants. The formal aspect can be envisaged as a compact parallelepiped volume, 6 floors in height and rectangular, 57 m x 74 m, in plan. The load-bearing structure is in situ cast reinforced concrete and is formed by a central core with columns and beams at the perimeters. The floor structures consist of joists at 55 cm centers topped with a concrete slab. The facades are entirely prefabricated using various types of concrete units which can be subdivided into three different groups according to their dimensions and finish characteristics. All the exposed surfaces are characterized by the red granite Odenwalder aggregate employed. (Author abstract) In Italian and English.

Tiballi, Massimo (Hentrich-Petschnigg & Associates). *Ind Ital Cem* v 57 n 7-8 Jul-Aug 1987 p 486-497.

**POTASH**

**Agricultural Applications**

**084058 REVIEW OF AGRICULTURAL DEVELOPMENTS IN POTASH USE.** Efforts to develop potash use in agricultural production were begun in the US 50 years ago. Early growth was rapid and continued well into the 1960s. Many soils were inherently low in K, so crop responses to fertilization were often dramatic. Deficiency symptoms were common. Per-acre use has continued to increase in recent years, but annual growth rates have slowed. Soil buildup has occurred in some



areas. Poor economics in the 1980s have been difficult to overcome. Efforts are now under way to develop potential markets around the world. (Edited author abstract) 9 refs.

Darst, B.C. (Potash & Phosphate Inst., Atlanta, GA, USA). *Trans Am Inst Min Metall Pet Eng Soc Min Eng AIME* v 280 pt A 1986 p 2075-1079.

Fracture See ROCK—Deformation.

## POTASH DEPOSITS

Saskatchewan, Canada

**084059 SASKATCHEWAN POTASH: NEAR-TERM PROBLEMS, LONG-TERM OPTIMISM.** Canadian Potash Export Ltd. (Canpotex) was created in 1970 as the offshore marketing organization for Canadian producers. Canpotex is owned by Saskatchewan producers and is their exclusive marketing organization for offshore business. The Saskatchewan industry has an ore body of a size and consistency unmatched anywhere in the world. Large efficient mines have production costs that costs that compare favorably with other producing countries. On the minus side, Saskatchewan is remote from most major markets. It therefore needs the efficiencies that stem from one organization that coordinates all offshore shipments and minimizes distribution costs.

Heath, R.J. (Canpotex Ltd, Saskatoon, Sask, Can); Ekedahl, E.C. *Min Eng (Littleton Colo)* v 39 n 12 Dec 1987 p 1071-1072.

## POTASH MINES AND MINING

Costs See POTASH DEPOSITS—Saskatchewan, Canada.

Drills See ROCK DRILLS—Diamond.

Dust Control

**084060 IONIC AIR COMPOSITION AT THE INDUSTRIAL SITE AND IN DEEP POTASSIUM MINES.** Potassium mine air ionization is the result of dust and chemical aerosol pollution. Ionic air composition changes are assessed. Hygienic evaluation of ion content in the air of industrial sites is included and analyzed. Atmospheric dust contamination in deep potassium mines may be controlled and industrial hygienic conditions may be enhanced. In Russian. 13 refs.

Ashelrod, A.A.; Kosyachenko, G.E.; Bogdanovich, A.S.; Zyatikov, E.S. *Gig Tr Prof Zabol* n 7 Jul 1987 p 48-50.

**084061 FREE RADICAL LIPID OXIDATION AND ACTIVITY OF SOME ENZYMES IN BLOOD SERUM OF THOSE WORKING AT POTASSIUM MINES.** The data were obtained on the dust effect of polymineral potassium ore on the processes of free radical lipid oxidation in blood serum and on the functional state of the liver in practically healthy workers engaged in mining of polymineral potassium ore. It was established that dust of polymineral potassium ore affected all the studied parameters. The amount of variations and their character specified intensity of dust effect and represented the body back reaction. The obtained variations preceded the development of the pathologic process. (Author abstract) In Russian. 8 refs.

Berezhnitsky, M.N.; Strutinsky, G.M.; Savitskaya, L.G.; Maschakevich, I.I. *Gig Tr Prof Zabol* n 4 Apr 1988 p 27-29.

Flooding

**084062 ALBERTA'S GEOTECHNOLOGY: OIL KNOWHOW HELPS THE POTASH AND HARD-ROCK MINERS.** The Rocanville study was performed to plot overlying areas of potentially hazardous brine solutions. This followed PCS Rocanville's successful handling of the underground flood which occurred between November 11, 1984 and January 24, 1985. Consultants used oil technology seismic reflection geophysics;

work was also done using a radar survey of the salt back. The new pulseEKKO III ground penetrating radar technology is the electromagnetic analog of the seismic reflection method.

Hopkins, John L. *Can Min J* v 108 n 9 Sep 1987 p 23-27.

Grouting

**084063 ERGEBNISSE INGENIEUR-GEOLOGISCHER KLÜFTUNTERSUCHUNGEN IM SALINAR FUER ABDICHTUNGSINJEKTIONEN VON ZUFLUESSEN IM KALIBERGBAU DER DDR.** [Results of Engineering-Geological Studies of Fractures in the Salt Body for Grouting of Inflows in GDR Potash Mining by Injections]. A sound knowledge of the structural-geological conditions of the salt body is an important prerequisite to successful grouting of water and brine inflows in salt mining by injections. In this paper, a primarily rock-dependent jointing of sulfate and carbonate layers of the Upper Permian is proven and quantified. The influence of the depth, the development of tectonic stress and other influence factors on the formation and intensity of the jointing in the Upper Permian salt body are discussed. The jointing models established by engineering-geological methods are the basis for a decision aimed at obtaining an efficient and economically favorable control of inflows by injections. (Edited author abstract) 50 refs. In German.

Staubert, Axel. *Freiberg Forschungsreihe A* n 753 1988 p 1-59.

Management

**084064 BOULBY POTASH MINE.** Beleaguered by problems in its early days, Cleveland Potash Ltd's Boulby mine has overcome earlier setbacks and is now running at a profit. The development plan called for the sinking of two shafts; the construction of a totally enclosed finished product silo; and onsite process plant with two stacks. Owing to the situation of the site - 3 km within the boundaries of a national park - Boulby was one of the first mines to conform to 'modern' planning requirements. For instance, the site was to occupy an area of old iron ore workings, and transport by rail direct to Teeside was specified for some 75% of the potash, on 9 km of reinstated railway track, previously closed by British Rail in 1958.

Anon. *Mine Quarry* v 16 n 11 Nov 1987 p 14-16.

Planning See MINE SHAFTS—Lining.

Productivity

**084065 AUX MINES DE POTASSE D'ALSACE, COMMENT ENCORE PROGRESSER APRES LES AMELIORATIONS DE PRODUCTIVITE DES DIX DERNIERES ANNEES? [How to Make Further Progress at the Potash Mines of Alsace After the Productivity Advances of the Past Ten Years].** During the last ten years, the productivity progress of the potash mines of Alsace originated substantially, on the one hand, from the modernization and the adaptation of the long-wall faces with full-face shearing to all heights of the seam, and, on the other hand, from the concentration of the production in two establishments. In two areas (full-face shearing and haulage), programmable automation or systems with microprocessors have been installed. The improvement of the performances of the next few years will come from the development of these systems. (Edited author abstract) In French.

Streckdenfinger, Michel (Mines de Potasse d'Alsace, Mulhouse, Fr). *Ind Miner Mines Carrieres* v 69 Oct 1987 p 501-506.

Rock Bursts

**084066 MULTIDIMENSIONAL STATISTICAL MODEL FOR THE REGIONAL PREDICTION OF DISCHARGE HAZARD OF POTASH ROCK.** The discharge-hazard factor currently determines, to a considerable extent, the technical principles and organizational

and economic aspects of the working of potash deposits. This factor must be taken into account in designing potash mines, in proceeding to the development of new levels, and in the operation of working sections. Information on the discharge hazard of potash rock provides the economic basis for the construction of potash mines, taking account of the use of counterejection measures. 4 refs.

Kovalev, O.V. (UralVNIIG, Perm, USSR); Andreiko, S.S. *Sov Min Sci* v 23 n 3 May-Jun 1987 p 262-266.

Waste Disposal

**084067 MODELLING OF FLOW THROUGH POTASH TAILINGS PILES.** Modelling the flow of brine through potash tailings requires that the saturated and unsaturated hydraulic properties of the tailings be established; in particular, the relationships of fluid content and permeability to matrix suction are required. The in situ and laboratory testing techniques used for determining these properties are described and the results are presented. Numerical modelling techniques for the flow of brine through potash tailings are demonstrated by performing a computer simulation of an open-trench infiltration test. The responses of the field instrumentation during the infiltration test were compared with the results of the simulation. The simulation utilizes the measured fluid content versus suction curves and the calculated permeability versus suction curves as input parameters. The effects of varying the hydraulic properties of the tailings are examined to arrive at a better understanding of the flow mechanism involved. (Edited author abstract). 23 Refs.

Wong, D.K.H. (Univ of Saskatchewan, Saskatoon, Sask, Can); Barbour S.L.; Fredlund, D.G. *Can Geotech J* v 25 n 2 May 1988 p 292-306.

## POTASH ORE TREATMENT

Decomposition

**084068 UNDERGROUND DISSOLUTION OF SYLVINITE. SEARCHING FOR AN EFFECTIVE METHOD OF TREATING THE PRODUCTION SOLUTIONS.** It is shown that the solution of the problem of more rapid mastery of the method of underground liquefaction of sylvinites depends decisively on finding an effective method of treating the extracted brines. One of the interesting proposals for treating sylvinites brines is a method based on successive precipitation of sodium and potassium bicarbonates by carbonization of sylvinites brine in the presence of organic analogs of ammonia (amines and imines), in particular, hexamethylenimine or hexamethylenediamine. Because of some problems with this method, the authors propose a method of simultaneous precipitation of sodium and potassium bicarbonates by carbonization in the presence of hexamethylenimine. In Russian. 6 refs.

Avens, V.Zh.; Remopov, B.V.; Barybin, V.N.; Vinogradov, D.L. *Khim Prom* n 4 1987 p 213-216.

**POTASSIUM AND ALLOYS** See Also CRYSTALS—Physical Properties; GLASS—Structure; GRAPHITE—Spectroscopic Analysis; HARMONIC GENERATION.

**084069 DE-INTERCALATION AND SECOND INTERCALATION OF POTASSIUM INTO A HIGHLY ORIENTED PYROLYTIC GRAPHITE.** Staging has been studied during intercalation and de-intercalation of potassium vapor into HOPG (Highly Oriented Pyrolytic Graphite). Kinetics, (001) peak broadening and apparent mosaic spread of the HOPG crystal have been studied. As intercalation/de-intercalation cycles occur, mosaic spread markedly increases while stage purity of graphite interca-



lation compounds improves. A mosaic spread minimum is observed close to the 3rd stage. (Edited author abstract) 7 refs.

Touzain, Ph. (Ecole Natl Supérieure d'Electrochimie et d'Electrometallurgie de Grenoble, St.-Martin d'Heres, Fr); Hamwi, A. *Synth Met* v 23 n 1-4 Mar 1988, Graphite Intercalation Compd, Proc of the Fourth Int Symp, Jerusalem, Isr, May 24-29 1987 p 127-132.

**Adsorption** See SILICA—Defects; TUNGSTEN AND ALLOYS—Surfaces.

**Concentration** See ISOTOPES.

## Condensation

**084070 EXPERIMENTAL STUDY ON POTASSIUM CONDENSATION.** The objective of the present study is to clarify the characteristics of metal condensation. In the present study, highly accurate measurements of condensation rate, condenser surface temperature and vapour pressure are rendered possible. In addition to the techniques for these measurements, the vacuum distillation method is adapted to ensure that the results are not affected by the presence of non-condensable gases. The conformity in the vapour flow field of the present apparatus to previous analyses is also assured. Measurements are made by using potassium for a vapour temperature range from 553 K to 633 K. It is found that the present result is in agreement with the analysis of Labuntsov and Kryukov and the condensation coefficient is very close to unity. It is also concluded that Schrage's theory predicts higher condensation rates than those in actual cases. (Author abstract) In Japanese. 14 refs.

Ishiguro, Ryoji; Sugiyama, Kenichiro. *Nippon Kikai Gakkai Ronbunshu* v 54 n 500 Apr 1988 p 967-973.

## Electric Properties

**084071 PYROELECTRIC PROPERTIES OF POTASSIUM AND RUBIDIUM ACID PHTHALATES.** Results on measurements of temperature dependences of pyroelectric coefficients for potassium and rubidium acid phthalates are presented for temperatures ranging from 4.2 to 350 K. Based on the achieved results, the Debye and Einstein temperatures for those crystals were estimated along with the wave number of phonons contributing to the pyroelectric effect. (Author abstract) 15 refs.

Poprawski, R. (Technical Univ of Wrocław, Wrocław, Pol); Matyjasik, S.; Shaldin, Yu. *Solid State Commun* v 62 n 4 Apr 1987 p 257-259.

**Heat Transfer** See HEAT TRANSFER—Liquid Metals.

## High Pressure Effects

**084072 POTASSIUM AT HIGH PRESSURE: ANOMALY IN THE 500 KBAR-REGIME.** Scalar relativistic augmented-spherical-wave (ASW) bandstructure calculations are presented for K which predict a strong equation-of-state anomaly due to  $4sp \rightarrow 3d$  electron reordering in the 500 kbar-regime. Consequences for the phase diagram are outlined using the Lindemann melting law. The relation to other work is discussed, including experimental results. (Author abstract) 17 refs.

Zittel, W. (Max-Planck-Institut fuer Quantenoptik, Garching, West Ger); Meyer-ter-Vehn, J.; Kubler, J. *Solid State Commun* v 62 n 2 Apr 1987 p 97-100.

**Ionization** See LASERS, CHEMICAL—Ionization.

## Isotopes

**084073 AUTOMATED PRODUCTION OF POTASSIUM-38 FOR THE STUDY OF MYOCARDIAL PERFUSION USING POSITRON EMISSION TOMOGRAPHY.** The  $^{35}\text{Cl}(\alpha,n)$  reaction on sodium chloride has been selected for the rapid and reproducible production of  $^{38}\text{K}$  for repeated heart studies by means of positron emission tomography. A simple automated ra-

diochemical system has been developed and tested which makes routinely available 10-12 mCi batches of  $^{38}\text{K}$  ready to be injected at successive intervals of time of 40 min. The number of i.v. injections is only limited by the acceptable total absorbed dose to the patient. This limitation could be substantially reduced by using more recent multislice positron cameras which show better detection efficiency and resolution. 30 refs.

Guillaume, M. (Univ de Liege, Liege, Belg); De Landsheere, C.; Rigo, P.; Czichosz, R. *Appl Radiat Isot* v 39 n 2 1988 p 97-107.

**Molten** See Also COAL—Alkylation.

**084074 SOLUBILITY OF OXYGEN IN LIQUID POTASSIUM.** The solubility of oxygen in liquid potassium has been determined in the temperature range of 343 to 675 K. Equilibration experiments were carried out in a nickel-lined stainless steel solubility vessel with samples being withdrawn through a nickel filter of porosity 5  $\mu\text{m}$ . The oxygen content of the filtered sample was determined by the vacuum distillation method. A least-squares fit of the solubility data yielded the following equation:  $\log C (\text{ppm}) = 3.9702 - 420.4/T(\text{K})$ . The heat of solution derived from this expression is  $8047 \text{ J mol}^{-1}$ . The new solubility equation has been utilized to calculate oxygen potentials in liquid potassium and threshold oxygen levels for the formation of  $\text{KCrO}_2$  on a stainless-steel surface exposed to liquid potassium at high temperatures. (Author abstract) 10 refs.

Krishnamurthy, D. (Indira Gandhi Cent for Atomic Research, Kalpakkam, India); Thiruvengadasami, A.; Bhat, N.P.; Mathews, C.K. *J Less Common Met* v 135 n 2 Nov 1987 p 285-292.

## Phase Diagrams

**084075 ON THE SLOPES OF PHASE BOUNDARIES.** Several simple equations are derived which can be used to check binary phase diagrams for thermodynamic consistency. In many cases, the only thermodynamic data required are the entropies of fusion. (Author abstract). 10 Refs.

Pelton, Arthur D. (Ecole Polytechnique de Montreal, Montreal, Que, Can). *Metall Trans A* v 19A n 7 Jul 1988 p 1819-1825.

**084076 CRITICAL ASSESSMENT OF THERMODYNAMIC PROPERTIES AND PHASE-DIAGRAM CALCULATIONS OF K-KCl AND K-KBr SYSTEMS.** All the available thermodynamic information on the K-KCl and K-KBr systems has been collected and used, through an optimisation procedure, to check the thermodynamic consistency of those experimental thermodynamic data. Optimized sets of parameters for the excess Gibbs energy of mixing of the K-KX liquid solutions have been obtained; the liquid phase was modelled as a simple mixture of K and KX, exactly equivalent to a 'sublattice' type model, the excess Gibbs energies being represented by Redlich-Kister polynomials. Agreement between calculated and experimental phase diagrams and thermodynamic functions is within the experimental uncertainties. (Author abstract). 23 Refs.

Rand, M. (AERE Harwell, Oxfordshire, Engl); Gaune-Escard, M.; Gaune, P.; Bros, J.P. *Ber Bunsenges Phys Chem* v 92 n 8 Aug 1988 p 877-880.

**Physical Properties** See GRAPHITE—Physical Properties.

**Radioactivity** See BIOLOGICAL MATERIALS—Radioactivity.

## Structure

**084077 ELECTRONIC STRUCTURE OF POTASSIUM AND METAL HALIDE GICs STUDIED BY ANGLE-RESOLVED X-RAY EMISSION SPECTROSCOPY.** Angle-resolved C K-emission bands of the donor-GICs  $\text{C}_8\text{K}$  and  $\text{C}_{24}\text{K}$ , of acceptor compounds intercalated with  $\text{AlCl}_3$ ,  $\text{FeCl}_3$ ,  $\text{SbF}_3$ ,  $\text{SbCl}_5$ ,  $\text{BiCl}_3$ ,  $\text{InCl}_3$

and of different species of pure graphite have been measured using synchrotron radiation for excitation. Decomposition of the emission bands into the  $\pi$ - and  $\sigma$ -subbands provides insight into the modification of the  $\pi$  and  $\sigma$  electron density of states of graphite by intercalation. The  $\pi$ - and  $\sigma$ -band of the potassium-GICs are considerably changed. In the  $\pi$ -band new states arise near the Fermi energy  $E_F$ . For the metal halide-GICs the observed changes which we relate to charge transfer are smaller and restricted to the high energy part of the  $\pi$ -band. (Author abstract) 10 refs.

Eisberg, R. (Univ Muenchen, Munich, West Ger); Wiech, G. *Synth Met* v 23 n 1-4 Mar 1988, Graphite Intercalation Compd, Proc of the Fourth Int Symp, Jerusalem, Isr, May 24-29 1987 p 183-189.

**Vaporization** See TURBOMACHINERY—Seals.

**POTASSIUM COMPOUNDS** See Also ALKALI METAL COMPOUNDS—Synthesis; AMMONIA; COPOLYMERS—Degradation; ELECTRIC CONTACTS, POINT—Electronic Properties; FLUID DYNAMICS; GRAPHITE; HYDROGEN PEROXIDE—Decomposition; IONS—Mathematical Models; LEAD SMELTING—Physical Chemistry; LIGHT—Coherent; METALLIC COMPOUNDS; MONOMERS—Polymerization; OLIGOMERS—Synthesis; PHOTOGRAPHIC EMULSIONS—Sensitivity; POLYCARBONATES—Synthesis; POLYMERS—Synthesis; SOILS—Sampling; STYRENE—Polymerization; SULFUR—Reduction; TITANIUM AND ALLOYS—Analysis; TITANIUM ORE TREATMENT—Reduction; YTTRIUM COMPOUNDS—Surface Properties.

**084078 CRYSTAL STRUCTURE OF POTASSIUM DIMOLYBDATE HYDRATE.**  $\text{K}_2\text{Mo}_2\text{O}_7 \cdot \text{H}_2\text{O}$  crystallizes in the triclinic system. The structure was solved by Patterson and Fourier methods. Of the 2361 unique reflections measured by counter techniques, 2229 with  $I \geq 3\sigma(I)$  were used in the least-squares refinement of the model to a conventional R of 0.032 ( $R_2 = 0.036$ ). The structure of  $\text{K}_2\text{Mo}_2\text{O}_7 \cdot \text{H}_2\text{O}$  consists of infinite chains of edge-shared  $\text{MoO}_6$  octahedra and  $\text{MoO}_3$  trigonal bipyramids parallel to the crystallographic a axis. The chains are separated by potassium ions and water molecules. (Edited author abstract) 22 refs.

Gatehouse, B.M. (Monash Univ, Clayton, Aust); Jozsa, A.J. *J Solid State Chem* v 71 n 1 Nov 1987 p 34-39.

**084079 PREPARATION OF POTASSIUM NITRATE USING CATION EXCHANGE RESIN.** A method has been developed for the preparation of potassium nitrate from limestone, nitric acid, and potassium chloride using a cation exchange resin. Effect of flow rate and concentration of calcium nitrate on the breakthrough capacity of the resin was studied. Based on these results, potassium nitrate was prepared on a bigger scale using 15 litres of a cation exchange resin filled in a PVC column. Regeneration of the exhausted bed was carried out efficiently and excess regenerant was recovered. (Author abstract) 7 refs.

Tipnis, Usha K. (Central Salt & Marine Chemicals Research Inst, Bhavnagar, India); Mandalia, B.T. *Res Ind* v 32 n 2 Jun 1987 p 82-84.

**084080 EINE 'MISSLUNGENE' SYNTHESE: UEBER  $\text{K}_4\text{Li}[\text{IO}_6]$  UND  $\text{K}_3\text{I}_2[\text{AuO}_2]$ .** ['Unsuccessful' Synthesis:  $\text{K}_4\text{Li}[\text{IO}_6]$  and  $\text{K}_3\text{I}_2[\text{AuO}_2]$ ]. Attempting to synthesize hitherto unknown  $\text{K}_4\text{Li}[\text{IO}_6]$  by heating mixtures of  $\text{K}_2\text{O}$  and  $\text{LiIO}_3$  we obtained (formed by disproportion) colorless transparent single crystals of the new periodate  $\text{K}_4\text{Li}[\text{IO}_6]$  and also transparent green single crystals of  $\text{K}_3\text{I}_2[\text{AuO}_2]$ , a new type of iodide aurate(I). Stacked layers of  $\text{KLiO}_6$  are characteristic, connected along [001] by further  $\text{K}^+$ . (Edited author abstract) In German. 19 refs.

Hoppe, R. (Justus-Liebig-Univ-Giessen, West Ger); Schneider, J. *J Less Common Met* v 137 Feb 1 1988 p 85-103.



**084081 ORIENTATION DEPENDENCE OF THE CARBON K-EDGE IN THE ELECTRON ENERGY LOSS SPECTRA OF A POTASSIUM-BENZENE-GRAPHITE INTERCALATION COMPOUND.** Electron energy loss spectra of the carbon K-edge region in graphite and the first-stage potassium-benzene-graphite intercalation compound (GIC) have been measured as a function of the crystal orientation defined by the angle between the crystal c-axis and the incident electron beam direction. The intensity of the carbon  $1s \rightarrow \eta^*$  transition peak strongly depends on the crystal orientation. The dependence for potassium-benzene-GIC differs from that for graphite. By analyzing the orientation dependence of the  $1s \rightarrow \eta^*$  transition intensity observed in potassium-benzene-GIC, it is found that the molecular plane of benzene intercalating between the graphite layers is tilted relative to the crystal c-axis. (Author abstract) 18 refs.

Kurata, H. (Kyoto Univ, Uji, Jpn); Ishizuka, K.; Kobayashi, T.; Uyeda, N. *Synth Met* v 22 n 4 Feb 1988 p 337-348.

**084082 OBSERVATION OF A PRESSURE INDUCED REVERSE PEIERLS INSTABILITY IN THE QUASI-ONE-DIMENSIONAL MIXED VALENCE SOLID  $K_4 [Pt_2(P_2O_5H_2)_4Br] \cdot 3H_2O$ .** The pressure dependence of the resonance Raman and UV-visible absorption spectra of the quasi-one-dimensional mixed valence solid  $K_4 [Pt_2(P_2O_5H_2)_4Br] \cdot 3H_2O$  has been observed. The band maximum of intervalence-charge-transfer (IVCT) transition red shifts from 620 to 740 nm as pressure is increased from 0.0 to 4.0 GPa and then levels off. Resonance Raman spectra obtained with excitation into the IVCT band show a continuous decrease in the scattering intensity of the Pt-Br symmetric stretch and one of the Pt-Ft stretches as pressure is increased and neither mode can be observed above 4.0 GPa. These results are attributed to a structural change where the Br ion moves toward a central position between neighboring Pt<sub>2</sub> moieties along the chain axis, as is consistent with a reverse Peierls transition. (Author abstract) 18 refs.

Swanson, B.I. (Los Alamos Natl Lab, Los Alamos, NM, USA); Stroud, M.A.; Conradson, S.D.; Zietlow, M.H. *Solid State Commun* v 65 n 11 Mar 1988 p 1405-1409.

**084083 KINETICS OF INTERACTION OF GLASERITE WITH CALCIUM NITRATE SOLUTION.** The authors report a study of the kinetics of interaction of glaserite of mono- and polydisperse composition with calcium nitrate solution at 25-80°. It is shown that the process includes formation of an intermediate product, syngenite, which passes into gypsum at 80°. It is also shown that difficultly soluble reaction products crystallize both in the bulk solution and on the surface of the glaserite particles, where they form a gradually thickening crust whose porosity varies with time and which hinders free diffusion of the reactants. The thickness of this crust as a function of temperature was calculated theoretically and measured experimentally. 6 refs.

Sokolov, I.D. (All-Union Scientific-Research & Design Inst of Halurgy, USSR); Stepanova, N.N.; Murav'ev, A.V. *J Appl Chem USSR* v 60 n 7 pt 1 Jul 1987 p 1373-1376.

**084084 LIQUIDUS SURFACES OF THE  $KF-B_2O_3-Li_2WO_4$ ,  $KF-B_2O_3-Na_2WO_4$  AND  $KF-B_2O_3-K_2WO_4$  SYSTEMS.** In order to search for a fused salt that can be used for the smooth electrodeposition of tungsten by fused salt electrolysis, the liquidus surfaces of the  $KF-B_2O_3-Li_2WO_4$ ,  $KF-B_2O_3-Na_2WO_4$ , and  $KF-B_2O_3-K_2WO_4$  systems were determined by the hot thermocouple method. These systems have compositional regions with low melting points around 80mol. percent  $KF$ -10mol. percent  $B_2O_3$ -10mol. percent  $Li_2WO_4$ , 80mol. percent  $KF$ -10mol. percent  $B_2O_3$ -10mol. percent  $Na_2WO_4$  and 70mol. percent  $KF$ -15mol. percent  $B_2O_3$ -15mol. percent  $K_2WO_4$ ; melting points of these regions are 910 - 925 K, 940 - 950 K and 990 - 1000 K respectively. (Author abstract) 8 refs.

Koyama, Koichiro (Himeji Inst of Technology, Himeji, Jpn); Hashimoto, Yasukiho. *J Less Common Met* v 141

n 1 Jul 1988 p 55-58.

**084085 STAGE DEPENDENCE OF ELECTRONIC STATES IN POTASSIUM GIC BY X-RAY ABSORPTION NEAR EDGE POLARIZATION-DEPENDENT STRUCTURE (XANEPS) MEASUREMENTS.** The x-ray absorption, near edge polarization-dependent structure measurements have been carried out for several stages of potassium intercalation compounds of graphite. The dependence of the structure on polarization has been interpreted using the calculated band structure and the symmetry of the wave-functions at potassium site. Based on the dependence of the location of absorption edge on stage as well as the case of fully ionized potassium, it is concluded that the charge transfer in  $KC_8$  is nearly total. (Author abstract) 7 refs.

Loupas, G. (UPMC, Paris, Fr); Chomilier, J.; Tarbes, J.; Rabii, S.; Tatar, R.; Guerard, D. *Synth Met* v 23 n 1-4 Mar 1988, Graphite Intercalation Compd, Proc of the Fourth Int Symp, Jerusalem, Isr, May 24-29 1987 p 205-210.

**Agricultural Applications** See SOILS—Composition Effects.

**Analysis** See BENTONITE—Analysis.

**Applications** See GASOLINE—Additives; MAGNETO-HYDRODYNAMIC CONVERTERS—Analysis.

**Chemical Analysis** See NUCLEAR REACTORS, WATER COOLED—Cooling.

**Chemical Reactions** See BLAST FURNACE PRACTICE—Physical Chemistry.

**Concentration** See THALLIUM AND ALLOYS—Electrodeposition; WATER—Electrolysis.

**Crystal Lattices**

**084086 USE OF SIMILARITY OPERATORS FOR LATTICE-SUPERLATTICE RELATIONS: I. APPLICATIONS TO MONOCLINIC AND ORTHORHOMBIC FLUORITE-RELATED STRUCTURES.** Similarity operators are shown to relate the lattice vectors and origins of the structure and the superstructure, the symmetry operators of the space group  $G$  of the structure to those of the subgroup  $H$  of  $G$  of the superstructure, and finally those atomic positions which are conserved in the superstructure. In the monoclinic and orthorhombic fluorite-related structures of composition  $K_{0.5-x}Ln_{0.5+x}F_{2+2x}$  ( $Ln = \text{lanthanide and Y}$ ) considered here we find that the cation sublattice is conserved. The origin of the superstructure does not necessarily coincide with the origin of the structure, but is a point of high site symmetry. (Author abstract) 7 refs.

Bertaut, E.F. (CNRS, Grenoble, Fr); Le Fur, Y.; Aleonard, S. *J Solid State Chem* v 73 n 2 Apr 1988 p 556-562.

**Crystallization**

**084087 CRYSTALLIZATION KINETICS OF POTASSIUM CHLORIDE FROM BRINE AND SCALE-UP CRITERION.** In this paper a three-year study on the kinetics of potassium chloride crystallization from brine is reported. This work was done in two analogous mixed-suspension, mixed-product-removal (MSMPR) crystallizers, one of 2.5 dm<sup>3</sup> volume and the other of 25 cm<sup>3</sup>. The constant tip speed TIPS was found to be the scale-up criterion, and the hydrodynamic conditions can be defined by a group  $M_T(\text{TIPS})^3$ . The nucleation rate and growth rate correlated well with this group in a general kinetic equation. 143 tests were made to obtain satisfactory standard deviations of all power indexes and the coefficient in the general kinetic equation. (Edited author abstract) 19 refs.

Qian, Ru-ying (Shanghai Research Inst of Chemical Industry, Shanghai, China); Chen, Zu-De; Ni, He-Gen; Fan, Zhang-Zhang; Cai, Fu-Di. *AIChE J* v 33 n 10 Oct 1987 p 1690-1697.

**084088 CRYSTALLIZATION OF POTASSIUM TITANATE FROM THE AMORPHOUS PHASE.** By using amorphous potassium titanates as the starting materials, a sintered body of  $K_2Ti_4O_9$  or  $K_2Ti_6O_{13}$  with porous and fibrous textures was prepared.  $K_2Ti_2O_5$  and a new phase,  $K_6Ti_4O_{11}$ , were synthesized by the thermal reaction of  $KNO_3$  with  $TiO_2$  at 1000°C for 10 to 20 h. On leaching in water to expel excess potassium ions, both phases became amorphous. After mixing and moulding these materials in the desired proportion, a sintered body containing fibrous crystals of  $K_2Ti_4O_9$  was fabricated by heating at 1000°C for 12 h. When 5 wt%  $B_2O_3$  was added, single phase  $K_2Ti_6O_{13}$  with a fibrous texture grew on heating at 1000°C for 12 h. Addition of PVA polymer to the amorphous phases was responsible for controlling the porosity of the sintered body, about 52% theoretical density at 20 wt% PVA polymer. The optimum conditions for preparing the amorphous phases were examined and the effect of the chemical reaction environments such as different crucible materials on the calcination of  $KNO_3$  and  $TiO_2$  is discussed. (Author abstract) 8 refs.

Endo, Tadashi (Tohoku Univ, Sendai, Jpn); Nagayama, Hiroyuki; Sato, Tsugio; Shimada, Masahiko. *J Mater Sci* v 23 n 2 Feb 1988 p 694-698.

**Decomposition** See POLYMERIZATION.

**Defects** See Also GRAPHITE—Defects.

**084089 EVOLUTION OF A DISLOCATION STRUCTURE IN THE SURFACE LAYERS OF SINGLE CRYSTALS DURING HIGH-TEMPERATURE ANNEALING.** The dislocation structure of KCl crystals annealed in a forevacuum has been shown to display a nonmonotonic variation of the density of dislocations in the direction from the surface. Our experiments and estimates showed that the observed redistribution of dislocations near the surface is due to the diffusion of impurities from the atmosphere and the generation of dislocations in the diffusion zone. (Author abstract) 9 refs.

Kononenko, V.G. (A.M. Gorki State Univ, Kharkov, USSR); Nazarenko, V.G.; Shcherbina, K.G. *Sov Phys J* v 30 n 9 Sep 1987 p 763-767.

**Deformation**

**084090 ELECTROPLASTIC EFFECT IN  $Ca^{2+}$ -DOPED KCl SINGLE CRYSTALS.** The application of electric fields up to 6 MV m<sup>-1</sup> reduces the flow stress during constant-strain-rate deformation of KCl containing 90 mol.p.p.m.  $Ca^{2+}$ . These stress drops have been measured for various magnitudes and directions of electric field. It was found that the amount of stress drop is dependent on the component of electric field along the direction of Burgers vector. These effects are quantitatively interpreted by the charge-dislocation model which was first proposed by Whitworth in 1976 and which is modified in this paper. The charge values estimated in this model are  $2.8 \times 10^{-1}$  for a rapidly cooled crystal and  $1.9 \times 10^{-10} \text{Cm}^{-1}$  for a slowly cooled crystal. (Author abstract) 22 refs.

Yamada, Tomoharu (Osaka Univ, Suita, Jpn); Ozaki, Junji; Kataoka, Toshihiko. *Philos Mag A* v 58 n 2 Aug 1988 p 385-395.

**Dielectric Properties**

**084091 IONIC THERMOCURRENTS DUE TO Z-CENTRES IN  $KCl:Gd^{2+}$ .** The technique of ionic thermocurrents (ITC) was used to study the field-induced reorientation of electric dipoles in crystals of  $KCl:Gd^{2+}$ . Besides the peak at 240 K due to impurity-vacancy (I-V) dipoles, a new peak is observed at 213 K which can be attributed to  $Z_1$ -centers. This supports a model involving an F-center coupled to an I-V dipole. No new ITC peak was observed in crystals containing  $Z_2$ -centers. (Author abstract) 16 refs.

Vijayan, C. (Indian Inst of Technology, Madras, India); Murti, Y.V.G.S. *Phys Status Solidi A* v 105 n 2 Feb 1988 p 397-402.



**084092 ON THE ANALYSIS OF THE IONIC THERMOCURRENT SPECTRUM.** Dielectric relaxation parameters are usually evaluated from the ionic thermocurrent (ITC) spectrum following the method suggested by C. Bucci et al. However, the BFG method becomes ineffective in the cases where either the background current is not estimated correctly or multiple relaxation processes are present. In the latter case, the method suggested by the author can be followed which utilizes the heating rate dependence of the peak and the position of the ITC maximum. Although this method is theoretically sound, it fails to give satisfactory results when applied to actual experimental systems. A modification is proposed to meet this inability. 5 Refs.

Prakash, J. (Univ of Gorakhpur, Gorakhpur, India); Nishad, A.K. *Phys Status Solidi A* v 106 n 2 Apr 1988 p k177-k179.

**Diffusion** See ZINC COMPOUNDS—Diffusion.

**Dissociation** See SODIUM COMPOUNDS—Dissociation.

**Doping**

**084093 O-TRAPPED HOLES IN ACCEPTOR DOPED  $\text{KNbO}_3$ .** Under illumination with visible and near uv light, Ti doped  $\text{KNbO}_3$  shows ESR of O-trapped holes as well as a corresponding optical absorption band with maximum at approximately 2 eV. In the most likely model the hole wavefunction extends over two neighboring oxygen ions next to  $\text{Ti}^{4+}$  substituting for  $\text{Nb}^{5+}$ . (Author abstract) 12 refs.

Possnerriede, E. (Univ of Osnabrueck, Osnabrueck, West Ger); Hellermann, B.; Schirmer, O.F. *Solid State Commun* v 65 n 1 Jan 1988 p 31-33.

**Electric Conductivity** See Also SUPERCONDUCTING MATERIALS—Synthesis.

**084094 CONDUCTIVITIES OF MOLTEN MIXTURES OF POTASSIUM FLUORIDE OR CHLORIDE WITH HAFNIUM TETRAFLUORIDE.** The authors describe results obtained when studying the conductivity of molten  $\text{KF-HfF}_4$  and  $\text{KCl-HfF}_4$  mixtures. It is shown that when hafnium tetrafluoride is added to melts of potassium fluoride or chloride the self-complexation present in these melts is disrupted and new complex forms based on the hafnium ion arise which have a rather higher ionic moment and larger polarizing power. The hafnium ion coordinates the fluoride and chloride ions, and the potassium ions are crowded out to the second coordination sphere. In melts of the  $\text{KF-HfF}_4$  system containing insignificant charge transport are elemental potassium ions of the second coordination, complex potassium ions, and the complex hafnium ions  $\text{HfF}_7^{3-}$  and  $\text{HfF}_6^{2-}$ . 4 refs.

Darienko, S.E. (S.M. Kirov Urals Polytechnic Inst, Sverdlovsk, USSR); Raspopin, S.P.; Chervinskii, Yu.F. *Sov Electrochem* v 23 n 2 Feb 1987 p 242-244.

**084095 SLIDING CHARGE DENSITY WAVES WITHOUT DAMPING: POSSIBLE FROHLICH SUPERCONDUCTIVITY IN BLUE BRONZE.** We observed zero differential resistance in  $\text{K}_{0.3}\text{MoO}_3$  in the temperature range of 4.2-40 K. It appears above a contact dependent barrier voltage. At 4.2 K the current can be increased from 50 nA to 1A without observable change in voltage. By measuring narrow band noise spectra at different current levels we show that the phenomenon arises from undamped sliding of charge density waves. (Author abstract) 15 refs.

Mihaly, G. (CNRS, Grenoble, Fr); Beauchene, P. *Solid State Commun* v 63 n 10 Sep 1987 p 911-914.

**084096 CHARGE-DENSITY WAVE CONDUCTION WITH EXTREMELY LOW DIFFERENTIAL RESISTANCE IN  $\text{K}_{0.3}\text{MoO}_3$ : CURRENT OSCILLATIONS.** We have studied the real time current oscillations in the low temperature zero differential resistance state of blue bronze ( $\rho_{\text{diff}} < 10^{-4} \Omega\text{cm}$ ), where the current

increases more than seven orders of magnitude without observable change in the voltage. The linear relation between the oscillation frequency and the current as well as the pulse duration memory effect observed demonstrate that the electronic transport is due to the charge-density waves (CDW). The drift velocity of the condensate reaches values as large as a few hundred cm/sec, leading to a metallic conductivity in an 'insulating' medium at  $T=4.2$  K. The drop of the CDW damping reflects the qualitative change in the conduction mechanism as normal carriers freeze out. (Edited author abstract) 25 refs.

Mihaly, G. (CNRS, Grenoble, Fr); Beauchene, P.; Marcus, J. *Solid State Commun* v 66 n 2 Apr 1988 p 149-152.

**Electric Field Effects**

**084097 PHOTOLUMINESCENCE OF  $\text{KTaO}_3$  UNDER ELECTRIC FIELD.** The photoluminescence in undoped  $\text{KTaO}_3$  crystal has been measured under static electric fields at 49 K. When a voltage is applied to the crystal, the intensity of the blue emission band decreases, and the emission spectrum becomes a yellow emission band. It is shown that these effects are caused by an increase of the temperature in  $\text{KTaO}_3$  as a result of Joule heating. (Author abstract) 23 refs.

Yamaichi, Eiji (Waseda Univ, Tokyo, Jpn); Ohno, Shunichi; Oh, Kikuo. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 583-586.

**Electric Properties** See Also SODIUM COMPOUNDS—Electric Properties.

**084098 JOULE HEATING AND BREAKDOWN EFFECTS IN  $\text{KNO}_3$  THIN LAYERS.** The current-voltage (I-V) characteristics of  $\text{KNO}_3$  single crystal thin layers of the thickness range 35 to 145  $\mu\text{m}$  have been studied and the critical voltage  $V_c$  and breakdown voltage  $V_b$  determined. Experimental evidence for the existence of Joule heating has been found. A semi-theoretical approach to the data involving a law of cooling has enabled the activation energy associated with the current increase to be estimated and found to be  $\phi = 0.05$  eV. The effect of externally heating the layer indicates a change in the layer current at  $T_c = 130^\circ\text{C}$ . This suggests phase changes and is supported by differential thermal analysis. It is concluded that the I-V characteristics are influenced by Joule heating which causes changes in the  $\text{KNO}_3$  phase. A discussion is given on which type and mechanism of electrical breakdown is present. (Edited Author abstract) 23 refs.

El-Kabbany, F. (Cairo Univ, Cairo, Egypt); Badawy, W.; Tahr, N.H.; El-Khwass, E.H. *J Mater Sci* v 23 n 2 Feb 1988 p 583-587.

**Electrolysis** See CATHODES—Activation.

**Electronic Properties** See Also SODIUM COMPOUNDS—Electronic Properties.

**084099 EVIDENCE FOR ALKALI-METAL - CARBON HYBRIDIZATION IN  $\text{KC}_8$ .** The partial p-like electron densities of states at potassium sites in the graphite intercalation compound  $\text{KC}_8$  has been investigated by means of soft x-ray emission spectroscopy. It is demonstrated that hybridization between the potassium and graphitic valence states occurs over the 0-10 eV binding energy region. The p-like charge at the intercalated potassium sites is equivalent to 0.6 electrons per potassium atom, i.e. double the value for elemental potassium. (Author abstract). 30 Refs.

Hague, C.F. (CNRS, Paris, Fr); Mariot, J.M.; Indlekofer, G.; Oelhafen, P.; Guntherodt, H.J. *Solid State Commun* v 66 n 11 Jun 1988 p 1131-1134.

**Encapsulation**

**084100 MEASUREMENT OF LIPOSOME-RELEASED FERROCYANIDE BY A DUAL-FUNCTION POLYMER MODIFIED ELECTRODE.** Potassium ferrocyanide is encapsulated in the aqueous cavity of spherical phospholipid bilayer vesicles (liposomes) at

concentrations of approximately  $10^4$  molecules/liposome. Physical parameters and stability of these structures are determined by electrochemical and spectroscopic methods. The electroactive marker ions (ferrocyanide) are released from within the liposome by either the addition of surfactant or the complement lysis of the membrane. This work is pertinent to specific drug delivery systems. (Edited author abstract) 23 refs.

Kannuck, Rosanne M. (Univ of Maryland, College Park, MD, USA); Bellama, Jon M.; Durst, Richard A. *Anal Chem* v 60 n 2 Jan 15 1988 p 142-147.

**Extraction** See SOILS—Testing; STRONTIUM COMPOUNDS—Extraction.

**Granulation**

**084101 STUDY OF GRANULATION OF POTASSIUM SALTS WITH THE AID OF ROLLS WITH A RIFFLED SURFACE.** The dependence of the density of powdered materials on the average normal stress determines their compactability. It is possible with the aid of diagrams for compaction of powders to estimate the influence of the physical and mechanical properties of the original salt and to determine the compactability coefficients and the specific work of pressing of materials to a specified final density. Compactability diagrams of fine-grained potassium chloride were obtained with the aid of a PMM-125 hydraulic press and a cylindrical mold 36 mm in diameter. Curves for variation of the density of flotation potassium chloride with the load at final pressures from 40 to 200 MPa are given. The diagram can be used for determining the specific work of compression of the powder to a specified final density, which is needed for calculation of the power consumption of roll-press drives. The authors devise a method for calculating, with adequate accuracy for practical purposes, the output rate and the power consumption of presses with riffled rolls; this is of considerable interest for development of new high-capacity roll presses for granulation of mineral salts and fertilizers. 6 refs.

Oganeyan, K.L. (All-Union Scientific-Research & Design Inst of Halurgy, USSR); Seballo, V.A.; Kazarinov, S.N.; Sarnovskii, D.I. *J Appl Chem USSR* v 60 n 2 pt 2 Feb 1987 p 393-396.

**Heat Transfer**

**084102 RADIATIVE HEAT TRANSFER IN MOLTEN POTASSIUM NITRATE AND GLASSY MELTS OF BORIC OXIDE.** A model for radiative-convective heat transfer at high temperatures in molten potassium nitrate and boric oxide is proposed which takes into account recent experimental determination of the absolute values of absorption coefficients in the infrared. Corrections for radiative heat transfer in the thermal conductivity data reported by several authors are suggested and, it is shown that the great uncertainty in the thermal conductivity data is partly due to underestimation of the radiative transfer. For molten potassium nitrate the conclusions is that its thermal conductivity is independent of temperature. In contrast, the temperature coefficient of thermal conductivity of boric oxide is positive. (Edited author abstract) 13 refs.

Ping, Tan He (CNRS, Poitiers, Fr); Lallemand, Michel. *High Temp High Pressures* v 19 n 4 1987 p 417-424.

**High Pressure Effects** See Also FERROELECTRIC MATERIALS—Phase Transitions.

**084103 THEORETICAL STUDIES ON THE EPR OF  $\text{K}_3\text{Co(CN)}_6\text{Cr}^{3+}$ .** The high order perturbation formulae of the EPR parameters possessing  $C_2$  symmetry for the  $d^3$  ion in the ground state are derived and applied to the study of the high pressure effect on  $\text{K}_3\text{Co(CN)}_6\text{Cr}^{3+}$ . The calculated results agree well with the experimental findings. It is hoped that the equations for  $V - P$  and  $\phi - P$  will be tested by further X-ray diffraction experiments. (Author abstract) 10 refs.

Xiao-Peng, He (Sichuan Normal Univ, Chengdu, China); Mao-Lu, Du. *J Phys Chem Solids* v 49 n 4 1988 p



339-341.

## Hydration

**084104 ADSORPTION AND STRUCTURAL STUDIES OF WATER IN THE LAYERED COMPOUNDS  $K_3Sb_3M_2O_{14}$ ,  $xH_2O$  ( $M = P, As$ ).** The layered compounds  $K_3Sb_3M_2O_{14}$ ,  $xH_2O$  ( $M = P, As$ ) crystallize in a rhombohedral system. They are isomorphous. Their hydration-dehydration process has been studied using various techniques: adsorption isotherms, thermogravimetric analysis, and thermodiffraction; it occurs between 30 and 180°C and is completely reversible. At 20°C and for almost the whole range of relative humidity the formulas are  $K_3Sb_3P_2O_{14}$ ,  $5H_2O$  and  $K_3Sb_3As_2O_{14}$ ,  $4.3H_2O$ . The crystal structure of  $K_3Sb_3P_2O_{14}$ ,  $xH_2O$  previously described as that of an anhydrous compound has been reexamined and the oxygen atoms of the water molecules located, thus leading to the true composition of the crystal,  $K_3Sb_3P_2O_{14}$ ,  $1.32(6)H_2O$ . (Edited author abstract) 3 refs.

Lachgar, A. (CNRS, Nantes, Fr); Deniard-Courant, S.; Piffard, Y. *J Solid State Chem* v 73 n 2 Apr 1988 p 572-576.

## Impurities

**084105 X-RAY INDUCED RELAXATION BAND DUE TO HIGHER AGGREGATES IN KCl:Pb.** Although aggregation of impurity centers in doped alkali halides upon X-irradiation is proposed earlier, direct evidence of such centers having dipole moment is reported here for the first time by the method of ionic thermocurrents (ITC). The normal dipolar relaxation band in KCl:Pb is located around 224 K, while sometimes a small band at about 160 K is found in the ITC spectrum of heavily doped systems. Exposure to X-rays increases this band around 160 K at the cost of the 224 K dipolar band. Optical absorption in the A-band of KCl:Pb, along with ITC measurements indicates that higher aggregates of I-V dipoles are easily formed in heavily doped systems. Formation and growth of the 160 K ITC band upon X-ray irradiation are explained. (Edited author abstract) 7 refs.

Mukherjee, M.L. (Univ of Parma, Parma, Italy); Capelletti, R. *Phys Status Solidi B* v 142 n 2 Aug 1987 p 361-366.

**084106 PHYSICO-CHEMICAL PROPERTIES OF  $Dy^{3+}$  IN SINGLE  $KY(MoO_4)_2$  CRYSTAL (ELECTRON ABSORPTION, EMISSION, IR, RAMAN, AND MAGNETIC DATA).** Electron absorption, luminescence, vibrational, and magnetic properties of  $KDy_xY_{1-x}(MoO_4)_2$  crystals are examined over the entire concentration region  $x = 0$  to  $x = 1$  and a temperature range 13-293 K. The crystal field scheme of the  $^6H$ ,  $^6F$ ,  $^4F$ ,  $^4I$  manifolds and their Stark components are established. The  $\tau_\lambda$  Judd-Ofelt parameters are determined by the numerical method and related to the concentration effect. The temperature dependence of the lifetime of luminescence is discussed and a quenching mechanism is proposed. (Author abstract) 21 refs.

Hanuzza, J. (Polish Acad of Sciences, Wroclaw, Pol); Macalik, L.; Ryba-Romanowski, W.; Mugenski, E.; Cywinski, R.; Witke, K.; Piltz, W.; Reich, P. *J Solid State Chem* v 73 n 2 Apr 1988 p 488-501.

**084107 OBSERVATION OF ABSORPTION AND SUBSEQUENT LUMINESCENCE FROM THE RELAXED EXCITED STATE OF  $Sn^{2+}$  IN KI.** By pump-probe experiments, an absorption from an excited state of the  $Sn^{2+}$  impurities in KI and subsequent luminescence at 445 nm was found. Time-resolved, phase sensitive measurements showed that this absorption took place from the relaxed excited state, related to the  $A_1$ -luminescence, to a short-living ( $\tau < 15$  ns) energy level from which radiative decay at 445 nm occurred. This luminescence could not be reproduced by one photon irradiation in any of the A, B and C absorption bands of isolated  $sn^{2+}$  impurities in KI. The intensity and the decay time of the luminescence can be accounted for by the temperature dependence of the lifetime of the relaxed

excited state. (Edited author abstract). 7 Refs.

De Kinder, J. (Univ of Antwerp (U.I.A.), Antwerp, Belg); Goovaerts, E.; Schoemaker, D. *Solid State Commun* v 66 n 11 Jun 1988 p 1145-1148.

## Ionic Conduction

**084108 IONIC CONDUCTIVITY IN KBr IRRADIATED AT ROOM TEMPERATURE.** There are different points of view to explain the effect of radiation on the ionic conductivity. A new model has been proposed by J. Vignolo and J.L. Alvarez Rivas to explain the effect of radiation on the ionic conductivity in KCl crystals irradiated at room temperature. These authors found that some radiation-induced damage partly inhibits the dipole dissociation. A step to gain support for this model is to determine whether or not the phenomenology of the radiation-induced ionic conductivity in KBr crystals also fits into the model. This is the purpose of this work. In this letter a study of radiation-induced effect on the ionic conductivity of pure KBr crystal and its thermal stability is presented. 9 refs.

Mariani, D.F. (Pontificia Univ Catolica de Chile, Santiago, Chile); Vignolo, J. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 993-995.

**084109 INTERCONNECTION OF INDIVIDUAL VACANCY FORMATION AND PINNING THERMODYNAMIC PARAMETERS IN KCl.** Over the past few decades, attention has been drawn to the role of electrical charge on dislocations in ionic crystals in determining mechanical properties. J.L. Tallon et al. have recently measured the individual thermodynamic parameters for cation vacancy and anion vacancy formation in KCl. Furthermore M. Tamabayashi and J.L. Tallon have reported the thermodynamic parameters of pinning in KCl. We show that the parameters of the above three processes are interconnected through well known properties of the bulk crystal. 15 refs.

Varotsos, C. (Univ of Athens, Athens, Greece); Hadjiconis, V.; Eftaxias, K. *Solid State Ionics* v 26 n 1 Jan 1988 p 11-13.

**084110 STATIC MODELLING OF THE FAST ION CONDUCTORS  $\beta$ -KBiF<sub>4</sub> AND  $\gamma$ -RbBiF<sub>4</sub>.** A modeling of the cubic variety of the fast ion conductors KBiF<sub>4</sub> ( $\beta$ -KBiF<sub>4</sub>) and RbBiF<sub>4</sub> ( $\gamma$ -RbBiF<sub>4</sub>) is undertaken using elaborate computer codes. An explicit account of the cationic sublattice is given based on the Fd3m space group. The structure obtained after minimization of the energy is stable and results in K-F and Rb-F bond distances larger than the Bi-F ones and in different environments of the cations. (Author abstract) 23 refs.

Matar, S.F. (CNRS, Talence, Fr); Reau, J.M.; Laborde, P.; Rhandour, A. *J Phys Chem Solids* v 49 n 3 1988 p 285-288.

**084111 XANES AND EXAFS STUDIES ON K-SHELL ABSORPTION IN  $K_{1-x}Na_xCl$  SOLID SOLUTIONS.** X-ray absorption measurements were made for Na K-edge on  $K_{1-x}Na_xCl$  solid solutions at room and at low temperatures using synchrotron radiation. The prominent peak can be assigned as the exciton associated with intra-ionic transition of  $Na^+$  ion. The small structure appearing in the edge is assigned as the exciton associated with the dipole-forbidden s-s transition. From the analysis of EXAFS (extended absorption fine structure) spectra, it was concluded that the first shell distance around the sodium ion in the solid solution holds the value of the pure NaCl, and is insensitive to the concentration of NaCl in KCl. (Edited author abstract) 12 refs.

Murata, T. (Kyoto Univ of Education, Kyoto, Jpn); Matsukawa, T.; Naoe, S. *Solid State Commun* v 66 n 8 May 1988 p 787-790.

## Magnetic Properties See Also MAGNETIC MATERIALS—Antiferromagnetism.

**084112 COMPARATIVE STUDY OF THE MAGNETIC AND ELECTRICAL PROPERTIES OF PE-**

**ROVSKITE OXIDES AND THE CORRESPONDING TWO-DIMENSIONAL OXIDES OF  $K_2NiF_4$  STRUCTURE.** Experimental results show that (i) Perovskite oxides which are ferromagnetic in three dimensions do not show long-range ferromagnetic ordering in the corresponding two-dimensional oxides. This behavior is observed in both itinerant and insulating oxide systems. (ii) The magnetic susceptibility behavior of these oxides in the high-temperature region is not affected by changing the dimensionality. The observed changes in paramagnetic Curie temperature is consistent with the reduction of the number of nearest neighbors. (iii) Oxides which are metallic in three dimensions with a resistivity less than that corresponding to the 'minimum metallic conductivity' ( $2 \times 10^{-3}$  ohm cm) show a negative TCR in two dimensions with a resistivity always higher than  $10^{-2}$  ohm cm. 25 refs.

Rao, C.N.R. (Indian Inst of Science, Bangalore, India); Ganguly, P.; Singh, K.K.; Mohan Ram, R.A. *J Solid State Chem* v 72 n 1 Jan 1988 p 14-23.

## Manufacture See Also CHLORINE—Manufacture.

**084113 PREPARATION OF HIGH PURITY POTASSIUM SILICATE.** High-purity potassium silicate finds extensive use as an adhesive of phosphors in television receiver screens. Ammonium silicate is prepared from sodium silicate with the help of cation-exchange resin in ammonium form. Effect of concentration of sodium silicate on the breakthrough capacity of the resin is studied. Exhausted resin was efficiently regenerated with 2.0 N solution of ammonium salt. Silica was precipitated from ammonium silicate with concentrated solution of ammonium salt. (Edited author abstract) 18 refs.

Tipnis, U.K. (Central Salt & Marine Chemicals Research Inst, Bhavnagar, India); Mandalia, B.T. *Res Ind* v 31 n 4 Dec 1987 p 266-269.

## Microscopic Examination

**084114  $K_5Nb_9W_2O_{31}$ : A NEW TETRAGONAL-TUNGSTEN-BRONZE-RELATED STRUCTURE, DEDUCED FROM HREM IMAGES.** High resolution electron microscopy (HREM) and X-ray powder-diffraction studies of samples in the K-Nb-W-O system revealed a new type of tetragonal-tungsten-bronze (TTB) related structure of the general composition  $A_xM_{11}O_{31}$ . The parent TTB has the unit cell content  $K_{6-x}W_{10}O_{30}$ , with potassium occupying four- and five-sided tunnels. In the present structure,  $K_5Nb_9W_2O_{31}$ , as in many of its relatives, some of the five-sided tunnels are filled with strings of -M-O-M-O- ( $M = Nb, W$ ) and have thereby been transformed into pentagonal columns (PCs). The PCs are mutually diamond-linked to form slabs. (Edited author abstract) 15 refs.

Sundberg, Margareta (Univ of Stockholm, Stockholm, Swed); Lundberg, Monica. *Chem Scr* v 28 n 1 Mar 1988, Adv in Prep and Prop Character of Cryst Inorg Mater, St. Leonard des Bois, Fr, Sep 26-28 1987 p 77-80.

## Microstructure

**084115 SYNTHESIS OF NEW PHASES,  $K_2MXO_4$  ( $MX = BeSi, MgGe, CaSi, CdGe$  AND  $ZnSi$ ).** Within the families of stuffed silica structures, there exist several phases which are face centered cubic and appear to be stuffed cristobalite phases. The structures are presumed to be three-dimensional frameworks built of corner-sharing tetrahedra, with the alkali ions occupying large interstitial sites within the framework. This letter reports the synthesis and preliminary characterization of other new phases which appear also to be stuffed cristobalite-like phases. These are listed, together with their refined unit cell parameters and melting behavior. Indexed X-ray powder diffraction patterns are also given. 8 refs.

Torres, Leticia M. (Univ of Aberdeen, Aberdeen, Scotl); Torres-Martinez, M.; West, A.R. *J Mater Sci Lett* v 7 n 8 Aug 1988 p 821-822.



## Optical Properties

**084116 GROWTH AND EVALUATION OF LARGE KDP SINGLE CRYSTALS FOR HIGH-POWER HARMONIC GENERATION BY TEMPERATURE DECREASE METHOD.** In the growth of KDP single crystals by the temperature decrease method, the dimensions of equipment for the growth of the crystal whose dimensions are desired for type I and type II phase matching of SHG are discussed, where the (001) plate and (101) plate are used as seed crystals, respectively. It is shown that the equipment has the smallest dimensions in the growth of the crystals for type II with the seeds of the (101) plate. Then the large crystals are grown with the seeds of the (101) plate and their optical characteristics are described. (Author abstract) 5 refs.

Shimomura, Osamu (Yamanashi Univ, Kofu, Jpn). *Electron Commun Jpn Part 2* v 71 n 1 Jan 1988 p 91-101.

**084117 ACCURATE VALUES FOR THE INDEX OF REFRACTION AND THE OPTIMUM PHASE MATCH PARAMETERS IN A FLUX GROWN KTiOPO<sub>4</sub> CRYSTAL.** Precise values of refractive indices, measured by the auto-collimation method, are presented in this paper. The phase match parameters of a KTP crystal at 1.064  $\mu\text{m}$  were calculated, and from these were obtained the optimum phase match parameters,  $\theta = 90^\circ$ ,  $\Phi = 23.6^\circ$ , with an effective non-linear coefficient  $1.75 \times 10^{-8}$  esu. This is the best agreement with an experimental result ever reported. (Author abstract) 6 refs.

Liao, Hong (Acad Sinica, Fuzhou, China); Shen, Hongyuan; Sheng, Zhendong; Lian, Tianquan; Zhou, Yuping; Huang, Chenghui; Zeng, Ruirong; Yu, Guifang. *Opt Laser Technol* v 20 n 2 Apr 1988 p 103-104.

**084118 VIBRATIONAL PROPERTIES OF THE Ga<sup>0</sup> AND In<sup>0</sup> CENTERS OF THE Ti<sup>0</sup> (I) STRUCTURE AS STUDIED BY RESONANT RAMAN SCATTERING.** The Raman scattering spectra of M<sup>0</sup>(I) centers (M = Ga, In, and Ti) in KCl, which possess the laser-active type structure, have been resonantly excited in their third optical transitions (OT<sub>3</sub>). The low frequency resonances at 59, 45, and 30  $\text{cm}^{-1}$ , respectively, are attributed to the totally symmetric motion of the impurity atom along the fourfold axis in the C<sub>4v</sub> point group of the defects. The spectral distribution of the defect-induced first order phonon spectrum is remarkably similar for the three centers, showing that it essentially reflects the motion of the surrounding ions. The Raman spectrum of In<sup>0</sup>(I) in NaCl almost exclusively consists of the fundamental vibration of In<sup>0</sup> and its overtones. A correspondence is indicated between this discrete character of the Raman spectrum and the electronic properties of the M<sup>0</sup>(I) defects in the NaCl host lattice. (Edited author abstract) 18 refs.

Joosen, W. (Univ of Antwerp, Wilrijk, Belg); Sierens, C.; Schoemaker, D. *Solid State Commun* v 63 n 1 Jul 1987 p 69-72.

**084119 ON THE SKEWNESS OF THERMALLY STIMULATED LUMINESCENCE PEAKS.** The skewness of numerically computed thermally stimulated luminescence (TSL) peaks with various values of order of kinetics (b),  $0.8 \leq b \leq 2.2$ , were investigated for a particular value of b the skewness is a function of  $E/kT_m$ . First-order (b = 1) TSL peaks are characterized by negative skewness, whereas second-order (b = 2) ones show positive skewness. These results are utilised to determine the order of kinetics of some typical first-order (b = 1) and second-order (b = 2) TSL peaks from their skewness. The experimental measurements were performed on X-irradiated Ca doped KCl. (Edited author abstract) 7 refs.

Hakeem, S.A. (Manipal Univ, Imphal, India); Gartia, R.K. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 635-640.

**084120 CROSS LUMINESCENCE OF KF AND RELATED COMPOUNDS.** The luminescence of KF, KMgF<sub>3</sub>, KCaF<sub>3</sub>, and solid solutions KF-RbF was studied under excitation with 6 keV electron pulses. Electronic

transitions from the F<sup>-</sup> 2p valence band to the K<sup>+</sup> 3p core band result in a specific 'crossluminescence' in the 6-9 eV region with decay time <2 ns. In the KF-RbF solid solutions the transitions from the F<sup>-</sup> 2p valence band to the Rb<sup>+</sup> 4p localized states or to the corresponding impurity band gives rise to luminescence bands at 5.4 and 6.1 eV as in pure RbF. (Author abstract) 18 refs.

Jansons, J.L. (Latvian State Univ, Riga, USSR); Krumins, V.J.; Rachko, Z.A.; Valbis, J.A. *Solid State Commun* v 67 n 2 Jul 1988 p 183-185.

**084121 DECREASE OF THE TL GLOW PEAK TEMPERATURE BY PARTIAL CLEANING.** An interesting phenomenon is observed for a thermoluminescence (TL) glow peak of an additively colored and X-irradiated KCl:Cu, Cs single crystal. The peak temperature decreases by performing the partial cleaning. This is out of our common sense, because it is expected that a lower temperature TL peak should decay earlier than higher ones when they are overlapping. As the result, the composite peak should shift to the higher temperature side. A tentative calculation is performed to explain the effect assuming the transfer of electrons from one type of traps to the other during the TL. (Author abstract) 4 refs.

Nakagawa, Y. (Kanazawa Univ, Kanazawa, Jpn); Nakamura, S.; Takeuchi, N. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 463-468.

**084122 OPTICAL ABSORPTION AND EMISSION FROM Ho<sup>3+</sup> IONS IN KCaF<sub>3</sub> CRYSTALS.** The optical absorption, emission, and excitation spectra are reported for KCaF<sub>3</sub>:Ho<sup>3+</sup> crystals. The Ho<sup>3+</sup> ions evidently occupy only one site in this lattice. The measured oscillator strengths for several transitions are compared with values calculated from Judd-Ofelt theory and the calculated radiative rates are also tabulated. The temperature dependence of the lifetimes suggests that energy transfer occurs between Ho<sup>3+</sup> ions at concentration levels of 1.3 at. percent. (Author abstract) 35 refs.

Mondragon, M.A. (Oklahoma State Univ, Stillwater, OK, USA); Garcia M., J.; Sibley, W.A.; Hunt, C.A. *J Solid State Chem* v 76 n 2 Oct 1988 p 368-374.

**Order-Disorder** See ELECTROLYTES, SOLID—Physical Chemistry.

**Oxidation** See Also MASS TRANSFER—Packed Beds.

**084123 XPS STUDY OF THE KCl SURFACE OXIDATION IN OXYGEN GLOW DISCHARGE.** The reaction between the surface of KCl and oxygen in a glow discharge has been studied by X-ray photoemission spectroscopy (XPS). Oxygen glow discharge treatment resulted in the formation of a superoxide, which decomposed under vacuum at room temperature to KO<sub>2</sub> and finally to K<sub>2</sub>O. No evidence of KClO<sub>3</sub> or KClO<sub>4</sub> formation has been found. Binding energies of some oxygen species in potassium oxides were determined. The possible role of potassium in K-doped silver catalysts of ethylene epoxidation is discussed. (Author abstract) 25 refs.

Stoch, J. (Polish Acad of Sciences, Cracow, Pol); Ladecka, M. *Appl Surf Sci* (1985) v 31 n 4 May 1988 p 426-436.

**Phase Diagrams** See POTASSIUM AND ALLOYS—Phase Diagrams.

## Phase Transitions

**084124 BRILLOUIN, RAMAN AND LIGHT DIFFRACTION STUDY OF PHASE TRANSITIONS IN KLiSO<sub>4</sub> UNDER A UNIAxIAL STRESS.** The phase transitions between 150 and 300 K in KLiSO<sub>4</sub> are studied under an applied stress through the simultaneous observation of Raman and Brillouin spectra and of the diffraction of light by the domain walls. Three distinct phases are identified; it is proved that between 190 and 265 K the sample can consist of the mixing of two phases; the ferroelastic behavior of the low-temperature phase (T < 190 K) is confirmed and the orientations of the

related domain walls are defined. (Author abstract) 27 refs.

Ganot, F. (CNRS, Villetaneuse, Fr); Kihal, B.; Dugautier, C.; Farhi, R.; Moch, P. *J Phys C Solid State Phys* v 20 n 28 Oct 10 1987 p 4491-4503.

**084125 OPTICAL STUDIES ON THE ORTHORHOMBIC-CUBIC TRANSITIONS FOR KClO<sub>4</sub>, RbClO<sub>4</sub> AND CsClO<sub>4</sub>.** An optical investigation of the high-temperature structural transitions in gel-grown single crystals of KClO<sub>4</sub>, RbClO<sub>4</sub> and CsClO<sub>4</sub> is reported. These crystals undergo transitions from the room-temperature Pnma phase to a cubic Fm3m phase at T<sub>c</sub> values of 306°C, 281°C and 222°C, respectively. The birefringence  $\Delta n$  falls abruptly to zero at T<sub>c</sub>, as is expected in a first-order transition. The phase transition was also studied by measuring the intensity of light transmitted by the sample placed between crossed Nicol prisms. The results do not suggest the coexistence of phases above T<sub>c</sub>. Microscopy examination of the samples at transition reveals that on cooling from the high-temperature phase the crystals have a tendency to form multidomains, with differing orientations, in the orthorhombic phase. (Edited author abstract) 14 refs.

Raghurama, G. (Indian Inst of Technology, Bangalore, India); Al-Dhahir, T.A.; Bhat, H.L. *J Phys C Solid State Phys* v 20 n 28 Oct 10 1987 p 4505-4511.

**084126 PREMARTENSITIC PHASE IN KAlF<sub>4</sub>: NEUTRON AND X-RAY SCATTERING EVIDENCES.** From elastic neutron scattering experiments, it is shown that the anomalies which have been recently observed in the high temperature phase of KAlF<sub>4</sub> by the x-ray mono-Laue technique can be attributed to embryonic domains of a premartensitic phase which coherently coexists with the high temperature phase. The arrangement of the domains and the lattice parameters of the premartensitic phase are determined. On the basis of geometrical considerations and with regard to the two-dimensional character of this layered compound we propose a possible structure for the premartensitic phase. The coexistence of the two phases can be interpreted by means of edge dislocations which are presumably formed during the crystal growth procedure. The role played by the premartensitic phase on the onset of the KAlF<sub>4</sub> martensitic transformation is discussed. (Author abstract) 28 refs.

Gibaud, A. (Univ du Maine, Le Mans, Fr); Bulou, A.; Le Bail, A.; Nouet, J.; Zeyen, C.M.E. *J Phys (Paris)* v 48 n 9 Sep 1987 p 1521-1532.

**084127 CRYSTAL OPTICAL STUDIES OF THE PHASE TRANSITIONS IN KLiSO<sub>4</sub>.** The sequence of phases and transition temperature of KLiSO<sub>4</sub> - hexagonal I (948 K) orthorhombic II (711 K) hexagonal III (205 K) trigonal IV (185 K) monoclinic V (83 K) VI (65 K) VII (38 K) VIII - was investigated using microscopically resolved measurements of linear birefringence (LB), refractive indices and optical activity (OA). Principal results are: (i) orthorhombic stripe domains intersecting under  $\pm 120^\circ$  in the C plane characterize phase II; (ii) vanishing LB and residual OA hint at merohedrally twinned 3m symmetry in phase IV; (iii) none of the phases V thru VIII is axial; (iv) observation of three pairs of twin domains refute orthorhombicity of phase V. (Author abstract) 17 refs.

Kleemann, W. (Univ Duisburg, Duisburg, West Ger); Schaefer, F.J.; Chaves, A.S. *Solid State Commun* v 64 n 7 Nov 1987 p 1001-1004.

**Photochemical Reactions** See POLYMERS—Photosensitivity.

**Physical Properties** See Also CRYSTALS—Physical Properties; MAGNETIC MATERIALS—Paramagnetism.

**084128 ENERGY TRANSFER IN MONOCRYSTALLINE KCl DOPED WITH EUROPIUM AND MANGANESE.** Fluorescence intensity and lifetime measurements of the Eu<sup>2+</sup> and Mn<sup>2+</sup> emissions have been carried out in single crystals of KCl doped with europium and manganese ions. The data obtained indicate



that sensitized luminescence with the europium ions as sensitizers and the manganese ions as activators occurs between  $\text{Eu}^{2+}$ - $\text{Mn}^{2+}$  pairs which are formed in this material. The number of these pairs are, however, smaller than those which are formed in the lattice of NaCl. The calculations based on the Forster-Dexter model of energy transfer indicate that the observed fast rise time of the manganese fluorescence after pulse excitation of  $\text{Eu}^{2+}$  can only be explained if a short range interaction mechanism such as electric dipole-quadrupole or exchange in nature is active. (Edited author abstract) 10 refs.

Rubio O., J. (Univ Autonoma Metropolitana, Mexico City, Mex); Munoz F. A.; Zaldo, C.; Murrieta S., H. *Solid State Commun* v 65 n 4 Jan 1988 p 251-255.

## Production

**084129 PREPARATION OF POTASSIUM TETRAFLUOROBORATE ENRICHED WITH BORON-10 OR BORON-11 ISOTOPES.** A new method is proposed in this study for the preparation of potassium tetrafluoroborate by the conversion of boron trifluoride into potassium tetrafluoroborate which includes the reaction of boron trifluoride with an aqueous solution of potassium fluoride. The theoretical yield of the potassium tetrafluoroborate according to the above scheme does not exceed 94% (without accounting for the losses with the mother liquor), excluding the participation of the hydrofluoric acid which is formed in one reaction. In another reaction where fluoroboric acid is formed, as expected in such a case, part of the boric acid does not take part in any further reactions and remains unconverted into the fluoroboric acid, reducing the yield of the potassium tetrafluoroborate. The synthesis conditions described in this work enable one to obtain potassium tetrafluoroborate of 99.0% purity and in 98.0% yield. 7 refs.

Gutyskov, V.V. (Scientific-Research Inst of Stable Isotopes, USSR); Bashkatova, N.F.; Oganezov, K.A.; Pavlenko, A.M.; Chitaladze, M.A. *J Appl Chem of USSR* v 59 n 12 pt 1 Dec 1986 p 2414-2417.

**Radiation Effects** See Also CRYSTALS—Defects; HARMONIC GENERATION—Spectrum Analysis.

**084130 ESR STUDY OF X-IRRADIATED  $\text{KNO}_3$ .** Single crystals of  $\text{KNO}_3$  were irradiated with X-rays at room temperature, and ESR measurements were performed over the temperature range from 85 K to 400 K. The g and hyperfine tensors of some paramagnetic centers were determined, and it was concluded that  $\text{F}$ ,  $\text{O}_2^-$ ,  $\text{O}_3^-$  and  $\text{NO}_2$  centers were produced. The sites and orientations of  $\text{O}_2^-$ ,  $\text{O}_3^-$  and  $\text{NO}_2$  molecules in a  $\text{KNO}_3$  crystal were also determined. The superhyperfine interactions of F and  $\text{O}_2^-$  centers with adjacent  $^{14}\text{N}$  and  $^{39}\text{K}$  nuclei were investigated, and the superhyperfine components were determined. Further, isothermal annealing measurements were performed for the F and  $\text{O}_3^-$  centers. (Author abstract) 15 refs.

Tagaya, Kimihito (Univ of Osaka Prefecture, Sakai, Jpn). *Jpn J Appl Phys Part 1* v 26 n 10 Oct 1987 p 1745-1748.

**084131 IDENTIFICATION OF A PARAMAGNETIC  $\text{Bi}^{0+}$  CENTER IN X-IRRADIATED  $\text{KCl}:\text{Bi}$  CRYSTALS.** Crystals of KCl doped with bismuth exhibit after X-irradiation at room temperature the presence of a paramagnetic defect with tetragonal  $<100>$  symmetry. Based on the analysis of the ESR spectra a structural model based on a  $\text{Bi}^{0+}$  atom center is proposed. The strong axial crystal field is due to the presence of a vacancy in the first neighborhood and/or a static Jahn-Teller distortion of  $\text{E}_g$  character. (Author abstract) 16 refs.

Nistor, S.V. (Central Inst of Physics, Bucharest, Rom). *Solid State Commun* v 66 n 9 Jun 1988 p 995-997.

**084132 LUMINESCENT PROPERTIES OF  $\gamma$ -IRRADIATED KCl AT ROOM TEMPERATURE.** Gamma-irradiated KCl shows afterglow at room temperature. The luminescent behaviour of  $\gamma$ -irradiated KCl is studied at room temperature, and results are presented to understand the correlation of known types of colour

centres with luminescence. The results are compared with the previous results for NaCl. (Author abstract). 17 refs.

Deshpande, Aparna V. (Univ of Bombay, Bombay, India). *J Lumin* v 42 n 3 Sep 1988 p 137-142.

## Reaction Kinetics

**084133 KINETIC STUDY OF ELECTROCHEMICAL INTERCALATION OF POTASSIUM SOLVATED BY TETRAHYDROFURAN INTO GRAPHITE.** The formation of ternary graphite intercalation compounds  $\text{K}(\text{THF})_x$  approximately 2 C approximately  $20\text{H}$  has been followed by neutron diffractometry during cathodic intercalation of  $\text{K}^+$  ( $\text{THF}$ )<sub>y</sub> into a HOPG electrode. The pure first stage appears only after the formation of transient phases from about 4th stage towards the second. All the phases are constituted with organic molecules 'standing up' between graphene layers. For the first time in the study of ternary compounds, a new phase of stage 4/3 has been observed for cation concentrations ranging from the second stage stoichiometry to the first one. It corresponds to highly ordered stacking domains consisting of 66% stage 1 and 33% stage 2. (Author abstract) 9 refs.

Marcus, B. (Ecole Natl Supérieure d'Electrochimie et d'Electrometallurgie de Grenoble, St.-Martin-d'Heres, Fr); Touzain, Ph. *Synth Met* v 23 n 1-4 Mar 1988, Graphite Intercalation Compd, Proc of the Fourth Int Symp, Jerusalem, Isr, May 24-29 1987 p 13-17.

## Recovery

**084134 POSSIBILITIES OF RECOVERING POTASSIUM SALTS FROM BITTERN BY METHANOL PRECIPITATION.** Bittern is treated with methanol in order to study the possibility of selective crystallization of a potassium salt by the salting out effect. It is shown that at low methanol concentrations the only solid phase obtained is NaCl. At moderate methanol concentrations sodium potassium sulfate and sodium magnesium sulfate double salts crystallize together with NaCl. When the methanol to bittern volume ratio is higher than one, solid phases are composed of sodium sulfate, potassium sulfate and NaCl. Sodium sulfate percentage in the solid phases is always dominant. Potassium salts in bittern are materials of interest to Turkey since there is no known potash ore reserve. Potassium salts are used mostly as fertilizer and are totally imported. (Edited author abstract) 5 refs.

Nusret Bulutcu, A. (Istanbul Technical Univ, Istanbul, Turk); Tolun, Rasit. *Bull Tech Univ Istanbul* v 38 n 3 1985 p 313-324.

## Reduction

**084135 KINETICS AND MACROKINETICS OF THE HIGH-TEMPERATURE REDUCTION OF POTASSIUM SULFATE BY HYDROGEN. III. REDUCTION BY A MIXING OF STEAM AND HYDROGEN.** A study was carried out on the reduction of solid potassium sulfate ( $d \approx 50 \mu\text{m}$ ) by a mixture of hydrogen and water vapor at 1073 K initial temperature and atmospheric pressure. An increase in  $\text{H}_2\text{O}$  at 35 kPa leads to an increase in the liberation and integral yield of  $\text{H}_2\text{S}$  as well as the conversion of  $\text{K}_2\text{SO}_4$  to  $\text{KOH}$ . A drop in the yield of  $\text{H}_2\text{S}$  and extent of reduction is found at higher  $\text{P}_{\text{H}_2\text{O}}$ . The proposed model for the reduction of  $\text{K}_2\text{SO}_4$  by hydrogen was extended to the case of the hydrogen-steam mixture and the nonisothermal nature of this process was considered. The calculated differential and integral curves for the liberation of hydrogen sulfide were in satisfactory accord with the experimental data for the  $\text{P}_{\text{H}_2\text{O}}$  range studied (from 0 to 46.7 kPa). (Author abstract) 5 refs.

Zyryanov, S.I. (Acad of Sciences of the USSR, Moscow, USSR); Ibragimov, V.A.; Rozovskii, A.Ya.; Mostinskii, I.L. *Kinet Catal* v 28 n 5 pt 1 Sep-Oct 1987 p 930-935.

## Research

**084136 SOLVENT EFFECTS ON THE REDOX POTENTIALS OF POTASSIUM 12-TUNGSTOSILICATE AND 18-TUNGSTODIPHOSPHATE.** To our knowledge, hexacyanoferrate (III) and hexacyanomanganate (III) are the best representative cases for the study of solvent effects on redox potentials of anions. To enlarge examples in this field, it is shown here that two heteropolyacid potassium salts,  $\alpha\text{SiW}_{12}\text{O}_{40}\text{K}_4$  and  $\alpha\text{P}_2\text{W}_{18}\text{O}_{62}\text{K}_6$ , as studied by slow sweep rate cyclic voltammetry, undergo reversible or quasi-reversible reduction in several solvents. The specific interactions between solvents and the nitrogen atoms of the hexacyano complexes are replaced by interactions with oxygen atoms. The redox potentials, in the present cases, are also found to be functions of the acceptor number of the solvents. (Author abstract) 14 refs.

Keita, B. (CNRS, Nancy, Fr); Bouaziz, D.; Nadja, L. *J Electrochem Soc* v 135 n 1 Jan 1988 p 87-91.

**Solubility** See Also PHOSPHORIC ACID.

**084137 SOLUBILITY IN THE SYSTEM  $\text{K}_2\text{SO}_4\text{-H}_2\text{SO}_4\text{-H}_2\text{O}$ .** The purpose of this work was to study equilibrium in the system  $\text{K}_2\text{SO}_4\text{-H}_2\text{SO}_4\text{-H}_2\text{O}$  at temperatures of 75 and 90°C. Study of solubility in this system in relation to conversion of potassium chloride with sulfuric acid in aqueous solution is linked with the fact that the system  $\text{KCl-H}_2\text{SO}_4\text{-H}_2\text{O}$  becomes a nonequilibrium system at sulfuric acid concentrations above 50 mass % and temperatures above 75°. Solubility in the system  $\text{K}_2\text{SO}_4\text{-H}_2\text{SO}_4\text{-H}_2\text{O}$  at 75 and 90° was studied, and the presence of the following solid phases was established:  $\text{K}_2\text{SO}_4$ ,  $\text{K}_3\text{H}(\text{SO}_4)_2$ ,  $5\text{K}_2\text{SO}_4\text{-3H}_2\text{SO}_4\text{-2H}_2\text{O}$ , and  $\text{KHSO}_4$ . The existence of the double acid sulfate  $5\text{K}_2\text{SO}_4\text{-3H}_2\text{SO}_4\text{-2H}_2\text{O}$  at 75 and 90° between tripotassium hydrogen bis(sulfate) and potassium hydrogensulfate was demonstrated. Points lying in the region of the molten hydrate  $\text{K}_2\text{SO}_4\text{-3H}_2\text{SO}_4\text{-H}_2\text{O}$  were found on the 90° isotherm; potassium hydrogensulfate is present in the solid phase in equilibrium with the melt. 11 refs.

Buksha, S.V.; Sokolov, I.D.; Kopylev, B.A.; Buksha, Yu.V. *J Appl Chem USSR* v 59 n 10 pt 1 Oct 1986 p 2072-2076.

**084138 CHANGE OF SOLUBILITY OF POTASSIUM SULFATE IN WATER CAUSED BY TRACES OF CHROMIUM(III).** The solubility of potassium sulfate in water is shown to be decreased by a trace (up to 150 ppm) of chromium(III) added as green sulfate ( $\text{Cr}_2(\text{SO}_4)_3\text{-4H}_2\text{O}$ ). The proposed mechanism for the impurity action is that an adsorbed layer of chromium(III) on the surface of the dissolving potassium sulfate crystals stops their dissolution and prevents the solution concentration from reaching the true equilibrium value. The measured solubility in the presence of chromium(III), therefore, is only an apparent solubility and is always lower than the true equilibrium solubility. Its actual value is probably determined by two competing rate processes: adsorption of chromium(III) and dissolution of potassium sulfate crystals. This mechanism offers a reasonable explanation of the experimental results on the 'solubility'. (Edited author abstract) 6 refs.

Kubota, Noriaki (Iwate Univ, Morioka, Jpn); Uchiyama, Isao; Nakai, Kyoichi; Shimizu, Kenji; Mullin, John W. *Ind Eng Chem Res* v 27 n 6 Jun 1988 p 930-934.

**Solutions** See Also ALUMINUM MOLYBDENUM ALLOYS—Corrosion; CADMIUM NICKEL ALLOYS—Anodic Oxidation; CALCIUM COMPOUNDS—Reaction Kinetics; CATALYSTS—Vanadium Compounds; ELECTRODES—Nickel Compounds; FIBERS, NONTEXTILE—Testing; GLYCOLS; IRON AND ALLOYS—Dissolution; MEMBRANES—Structure; TITANIUM COMPOUNDS—Oxidation; TUNGSTEN AND ALLOYS—Dissolution.



**084139 STANDARD pH VALUES FOR POTASSIUM HYDROGENPHthalate REFERENCE BUFFER SOLUTIONS IN ACETONITRILE-WATER MIXTURES UP TO 70 WT% AT VARIOUS TEMPERATURES.** Reference value standards, pHs, for 0.05 mol kg<sup>-1</sup> potassium hydrogenphthalate (KHPH) reference buffer solutions in 30, 50 and 70 wt% acetonitrile-water mixed solvents at temperatures from 288.15 to 308.15 K have been determined from emf measurements of the reversible cell Pt|Ag|AgCl|KHPH+KCl|Quinhydrone|Pt, in which the H<sup>+</sup>-reversible quinhydrone electrode replaces the ill-behaving hydrogen electrode. Values of the first ionization constant of the o-phthalic acid (H<sub>2</sub>Ph; benzene-1,2 dicarboxylic acid) in these mixed solvents have also been determined from analogous measurements. The consistency of the present results with the previously determined pHs values in 5, 15 and 30 wt% acetonitrile-water mixtures is analysed by multilinear regression of pHs as a function of both solution composition and temperature. (Edited author abstract) 14 refs.

Rondinini, Sandra (Dep of Physical Chemistry & Electrochemistry, Milan, Italy); Nese, Anna. *Electrochim Acta* v 32 n 10 Oct 1987 p 1499-1505.

**084140 CONDUCTOMETRIC STUDY OF ION-PAIR FORMATION IN AQUEOUS SOLUTIONS OF POTASSIUM AND AMMONIUM THIOSULPHATES.** The thermodynamic association constants (K<sub>A</sub>) for K<sub>2</sub>O<sub>3</sub><sup>-</sup> and NH<sub>4</sub>S<sub>2</sub>O<sub>3</sub><sup>-</sup> ions have been estimated at 25°C and 35°C by the method of E.C. Righelatto and C.W. Davies with slight modification. The limiting mobilities of thiosulfate ion at 25°C and 35°C have also been evaluated independently. The thermodynamic parameters for the process of ion pair formation have been determined and are discussed. (Edited author abstract) 8 refs.

Manaiiah, V. (Osmania Univ, Hyderabad, India); Sethuram, B.; Navaneeth Rao, T. *Trans SAEST* v 22 n 4 Oct-Dec 1987 p 243-246.

**084141 THERMODYNAMIC STUDY OF WATER AND VAPOR SOLUTIONS OF K<sub>2</sub>CO<sub>3</sub> UNDER CONDITIONS OF PHASE EQUILIBRIUM IN A WIDE RANGE OF TEMPERATURES AND CONCENTRATIONS.** The authors present the results of an experimental study of p-p-t-ω properties of the system H<sub>2</sub>O-K<sub>2</sub>CO<sub>3</sub> under conditions of the vapor-liquid phase equilibrium in the temperature range up to 400°C and concentration of the liquid phase ω up to 50 mass %. The work was performed using the method of γ-transillumination for determining the densities of the vapor and liquid phases. The measurement error equaled ±0.5°C for the temperature, to ±0.005-0.025 MPa for the pressure for values up to 10 MPa and ±0.1 MPa for higher values, ±5 kg/m<sup>3</sup> for the density of the liquid phase, and ±2 kg/m<sup>3</sup> for the vapor phase. 10 refs.

Novikov, B.E. (G.M. Krzhizhanovskii Energy Inst, USSR); Korzhavina, N.A. *High Temp* v 25 n 3 May-Jun 1987 p 350-354.

**084142 INFLUENCE OF BACTERIA IN A POTASSIUM DIHYDROGEN PHOSPHATE SOLUTION ON THE GROWTH HABIT OF CRYSTALS.** We found that bacteria present in a potassium dihydrogen phosphate (KDP) solution affect the growth habit of the KDP crystals. Hillocks appeared only on the tapered prismatic surfaces of the crystals grown in solution containing the bacteria. One possible mechanism of this hillock formation is a biochemical between the live bacteria and the KDP crystal. (Author abstract) 6 refs.

Sasaki, Takatomo (Osaka Univ, Suita, Jpn); Yokotani, Atsushi; Fujioaka, Kana; Nishida, Yasunori; Yamanaka, Tatuhiro; Yamanaka, Chiyoee. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1767-1769.

**084143 VISCOSITY, DENSITY, AND ELECTRICAL CONDUCTIVITY OF K<sub>4</sub>P<sub>2</sub>O<sub>7</sub> SOLUTIONS.** The density, viscosity, and electrical conductivity at 293-363 K of solutions having X<sub>4</sub>P<sub>2</sub>O<sub>7</sub> concentrations of 0.007-0.91 kmole/m<sup>3</sup> were studied using water thermo-

statting to an accuracy of ±0.1. It is found that the decrease in the activation energy of viscous flow for 10<sup>-3</sup>-10<sup>-2</sup> mole/kg of water may be associated with the destructive action of the ions, while for higher concentrations and with a decrease in the size of the charge on the ions due to the formation of anions of the type P<sub>2</sub>O<sub>7</sub><sup>4-</sup> and a weakening of their electrostatic interaction it may be associated with the ionic atmospheres and the neighboring water molecules. The decrease in the activation energy of viscous flow with an increase in temperature and the change in the values of η<sub>sp</sub> is explained. 5 refs.

Baldynova, F.P.; Maksimova, I.N. *J Appl Chem USSR* v 60 n 6 pt 2 Jun 1987 p 1325-1328.

### Spectroscopic Analysis

**084144 LOW TEMPERATURE RAMAN SPECTRA OF KLiSO<sub>4</sub>.** Raman experiments have been performed on KLiSO<sub>4</sub> below room temperature. In the intermediate temperature range (190 K < T < 265 K), the spectra are better understood on the basis of the C<sub>3</sub> rather than C<sub>6</sub> point group, but a lower symmetry cannot be rejected. In the low temperature region (T < 190 K) the occurrence of three ferroelastic domains should be taken into account to explain the corresponding Raman spectra. (Author Abstract) 14 refs.

Kihal, B. (CNRS, Villetaneuse, Fr); Dugautier, C.; Farhi, R. *Solid State Commun* v 62 n 5 May 1987 p 373-377.

**084145 VIBRATIONAL SPECTRA OF THE LAYERED COMPOUNDS K<sub>3</sub>Sb<sub>2</sub>M<sub>2</sub>O<sub>14</sub>·xH<sub>2</sub>O (M = P, As): NORMAL COORDINATE ANALYSIS OF K<sub>3</sub>Sb<sub>3</sub>P<sub>2</sub>O<sub>14</sub>·xH<sub>2</sub>O.** Infrared and Raman spectra on powder samples of K<sub>3</sub>Sb<sub>3</sub>P<sub>2</sub>O<sub>14</sub>·xH<sub>2</sub>O and K<sub>3</sub>Sb<sub>3</sub>As<sub>2</sub>O<sub>14</sub>·xH<sub>2</sub>O and polarized Raman spectra on a single crystal of K<sub>3</sub>Sb<sub>3</sub>P<sub>2</sub>O<sub>14</sub>·xH<sub>2</sub>O have been recorded. A normal coordinate analysis using a generalized valence force field has been performed. All the normal modes of vibration are described in terms of potential energy distribution. The validity of the force field and the values of the force constants are discussed. (Author abstract) 14 refs.

Husson, E. (CNRS, Chateau-Malabry, Fr); Lachgar, A.; Piffard, Y. *J Solid State Chem* v 74 n 1 May 1988 p 138-146.

**084146 STRUCTURE IN THE TEMPERATURE DEPENDENCE OF THE LIFETIME OF THE EXCITED F-CENTER IN KCl.** Evidence of a temperature-dependent structure in the lifetime of excited F-centers in KCl is reported. The sharp features are revealed when the temperature control of the sample is better than a few hundredth of a degree. For less accurate temperature control, as currently used in lifetime measurements, sharp variations of the lifetime with temperature are averaged, and the structure is not detectable. A theoretical explanation is suggested. (Author abstract) 9 refs.

Da Silva, L. (Univ Tecnica Federico Santa Maria, Valparaiso, Chile); Agüero, G.; Lagos, M.; Cáceres, E. *J Lumin* v 37 n 1 Apr 1987 p 51-56.

**084147 EMISSION AND EXCITATION SPECTRA FROM DIVALENT Ge IONS IN KCl SINGLE CRYSTALS.** The emission from KCl:Ge<sup>2+</sup> excited in the A-absorption band was studied as a function of temperature. The A-band excitation produces complex emission from KCl:Ge<sup>2+</sup>, compared with ones from Ti<sup>3+</sup>-like ions with the s<sup>2</sup> electronic configuration. The A-band emissions from KCl:Ge<sup>0</sup> and KCl:Ge<sup>4+</sup> were also measured at low temperature. The analysis of these spectra indicates that the two low-energy emission bands of KCl:Ge<sup>2+</sup> which peaked at 515 and 675 nm, respectively, are to be attributed to divalent Ge ions. The definitive assignment of the two bands is presented in terms of the adiabatic potential energy surface (APES). (Author abstract).

Kang, J.G. (Chungnam Natl Univ, Daejeon, South Korea); Ju, S.K.; Gill, Y.H.; Shim, I.K.; Chang, C.K. *J Phys Chem Solids* v 49 n 7 1988 p 813-818.

**084148 MAGNETIC PROPERTIES OF THE SYNTHETIC LANGBEINITE KBaCr (PO<sub>4</sub>)<sub>3</sub>.** The crystal

and magnetic structures of the synthetic langbeinite KBaCr<sub>2</sub>(PO<sub>4</sub>)<sub>3</sub> at 1.8 K have been determined from neutron powder diffraction data. The two crystallographically distinct Cr<sup>3+</sup> sublattices in the cubic structure are antiferromagnetically coupled with an ordered magnetic moment of 2.4(2) μ<sub>B</sub> per Cr<sup>3+</sup>. Mossbauer spectroscopy has been used to determine the Neel temperature of an <sup>57</sup>Fe-doped sample at 12 K. The effective magnetic moment in the paramagnetic phase has been determined to be 3.84 μ<sub>B</sub> per Cr<sup>3+</sup> ion. (Edited author abstract). 13 Refs.

Battle, P.D. (Univ of Leeds, Leeds, Engl); Gibb, T.C.; Nixon, S.; Harrison, W.T.A. *J Solid State Chem* v 75 n 1 Jul 1988 p 21-29.

**084149 U.P.S. AND X.P.S. STUDIES OF ALKALI-GRAPHITE INTERCALATION COMPOUNDS.** K, Rb and Cs graphite intercalation compounds have been studied by photoelectron spectroscopy both in U.P.S. and in X.P.S. The study in high vacuo purity conditions and on well characterized samples ensures the experimental results to be relative to clean and not deteriorated surfaces. This certainty has been verified by comparison with spectra obtained on the same surfaces after a well-controlled oxidation. Core and valence spectra of carbon and alkaline species obtained at three different energies (1253.6, 21.2 and 40.8 eV) at room and at low temperature are analyzed in terms of stoichiometry and surface cleanliness. (Edited author abstract) 14 refs.

Estrade-Szwarckopf, H. (CNRS, Orleans, Fr); Rousseau, B. *Synth Met* v 23 n 1-4 Mar 1988, Graphite Intercalation Compd, Proc of the Fourth Int Symp, Jerusalem, Isr, May 24-29 1987 p 191-198.

**084150 FINE STRUCTURE IN LUMINESCENCE SPECTRA OF KCl-KF CRYSTALS DOPED WITH Eu<sup>++</sup> IONS.** It has been found that luminescence and ESR spectra of KCl-Eu crystals are strongly influenced by F<sup>-</sup> impurity ions. New zero-phonon lines with resolved phonon sideband were found in F<sup>-</sup> doped crystals. Models of emissive centers are discussed. (Author abstract) 4 refs.

Bryukvin, Victor (Irkutsk State Univ, Irkutsk, USSR); Parfianovich, Iosif; Niznikov, Vyacheslav; Pencina, Emiliya. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 353-354.

**084151 LUMINESCENCE OF Z<sub>4</sub> CENTERS.** New infrared excitation and absorption bands were found in alkali halides containing a Z<sub>4</sub> center. IR absorption bands exhibit a zero-phonon line with resolved phonon sideband at 4.2 K. It is concluded that the Z<sub>4</sub> center is an analogue of the F<sub>3</sub> center in undoped crystals. (Author abstract) 4 refs.

Sobolev, Leonid (Irkutsk State Univ, Irkutsk, USSR); Pencina, Emiliya; Makushev, Konstantin. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 355-356.

**084152 SITE SELECTIVE LASER SPECTROSCOPY OF THE DYNAMICS OF DEFECT AGGREGATION IN ALKALI HALIDES.** The individual sites in KCl:Sm<sup>2+</sup> are followed by site selective spectroscopy as aggregation occurs after quenching from high temperatures. The mechanism for aggregation is found to be dimer formation. (Author abstract) 3 refs.

Ramponi, A.J. (Univ of Wisconsin, Madison, WI, USA); Wright, J.C. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 387-388.

**084153 DECAY PROCESSES IN RELAXED TRIPLET STATES OF SELF-TRAPPED EXCITONS IN POTASSIUM HALIDES.** The temperature dependence of lifetimes of the π emission in KCl, KBr and KI has been studied in detail to clarify the spin-lattice relaxation mechanism among zero-field-split triplet sublevels of the



self-trapped excitons. It was concluded that the two-phonon process is very important in KCl and KBr instead of the one-phonon direct process which is dominant in KI. (Author abstract) 8 refs.

Mukai, Takuya (Kyoto Univ, Kyoto, Jpn); Arimoto, Osamu; Kan'no, Ken-ichi; Nakai, Yoshio. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 447-448.

**084154 POLARON THEORY OF CONCENTRATION QUENCHING OF F CENTER LUMINESCENCE IN KCl.** Electron transfer rates from excited F centers to nearby F centers via bound polarons are calculated using a semicontinuum model in a two-mode coupling. Averaging over the  $F^{\pm}$ -F pair separations for a random F center distribution, a concentration dependence is derived of the intrinsic F center photoluminescent efficiency in KCl. It agrees reasonably well with experimental data. (Author abstract) 5 refs.

Georgiev, Mladen (Bulgarian Acad of Sciences, Sofia, Bulg); Staikova, Mima. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 461-462.

**084155 HOT LUMINESCENCE IN F CENTER UNDER ONE- AND TWO-PHOTON EXCITATIONS.** The spectra of hot luminescence from F center in KCl excited by one and two photons are theoretically investigated on the basis of a vibronic model. The depolarization spectra as well as the total emission intensity are calculated, and compared with experiments in good agreement. It is also shown that the non-Markov effect plays very important roles in the vibrational relaxation. (Author abstract) 3 refs.

Muramatsu, S. (Utsunomiya Univ, Utsunomiya, Jpn); Nasu, K.; Aihara, M. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 603-604.

**084156 LUMINESCENCE SPECTRUM OF THE VIBRONIC LASER  $KZn_{1-x}Co_xF_3:NI$ .** The luminescence spectrum of the vibronic laser material  $KZn_{1-x}Co_xF_3:NI$  with  $x < 0.15$  has been studied by Fourier transform spectroscopy under argon laser photoexcitation using both conventional and double modulation signal processing. The effects on the luminescence spectrum and lifetime of the Co concentration, the Ni impurity level, the sample temperature (8-300K), the pump laser power, and its wavelength (457.9-514.5 nm) indicate that temperatures below 20K, pump wavelengths near 514.5 nm, and some Ni impurity lead to enhanced laser operation. (Author abstract) 7 refs.

Rowell, N.L. (Nat'l Research Council, Ottawa, Ont, Can); Lockwood, D.J. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 629-630.

**084157 STUDY OF THERMAL GLOW CURVES OF KCl:Ba EXPOSED TO DIFFERENT RADIATIONS.** Polycrystals of KCl:Ba of  $10^{-2}$  m.f. Ba concentration were studied in as received condition from solution and after rapid quenching from 700°C. They were exposed to either alpha, beta, or gamma radiations and the resulting glow curves were recorded with linear heating rate strip chart recorder. Examination sheds adequate light on the nature of the associated thermoluminescence centres. (Edited author abstract) 1 ref.

Akolekar, M.S. (MS Univ of Baroda, Baroda, India); Joshi, T.R.; Joshi, R.V.; Prasad, L.H.H.; Dhake, K.P. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 852-853.

**Spectrum Analysis** See Also CRYSTALS—Lattice Defects.

**084158 STRUCTURE OF LOW-TEMPERATURE IR ABSORPTION SPECTRA OF KCl AND KBr**

**CRYSTALS WITH  $NO_2^-$  AND  $NO_3^-$  ANION IMPURITIES.** The structure of the IR absorption of KCl and KBr crystals doped with the MA  $NO_2^-$  and  $NO_3^-$ , both additionally doped and not doped with  $Ca^{2+}$  and  $Ba^{2+}$  cations, were studied. The complicated structure of the spectra, which is most distinct at low (4.2-77K) temperatures, was interpreted; it was found that complexes of the impurity MA  $NO_2^-$  and  $NO_3^-$  with  $Ca^{2+}$  and  $Ba^{2+}$  cations form. The structure of the complexes formed and the local symmetry of the MA in such complexes are discussed. 12 refs.

Boiko, V.V.; Kushnirenko, I.Ya.; Shinkarenko, V.K.; Shcherbatskii, V.P. *J Appl Spectrosc* v 46 n 5 May 1987 p 462-466.

**084159 ENDOR STUDY OF  $Ni^{2+}$  IN  $KMgF_3$ .** An ENDOR study of cubic  $Ni^{2+}$  ions in  $KMgF_3$  is presented. The superhyperfine (SHF) interaction with second shell fluorine ions is found to have axial symmetry, the values of the isotropic and anisotropic interaction constants being  $a = 0.36 \pm 0.03$  MHz and  $b = 1.02 \pm 0.03$  MHz. A calculation of these SHF parameters has been performed assuming that the lattice is undistorted around  $Ni^{2+}$  and using a simple overlap model. The calculated values agree within 15% with the experimental ones. (Author abstract) 11 refs.

Zorita, E. (CSIC, Zaragoza, Spain); Alonso, P.J.; Alcalá, R.; Spaeth, J.M.; Soethe, H. *Solid State Commun* v 66 n 7 May 1988 p 773-775.

## Stresses

**084160 TEMPERATURE DEPENDENCE OF THE EFFECTIVE STRESS FOR KCl SINGLE CRYSTALS.** The authors have proposed a method which is based on the Blaha effect which is the phenomenon that the flow stress decreases by superposition of an ultrasonic oscillatory stress during plastic deformation. Using the new method they separated the effective stress from the applied one for KCl crystals. The ratio of the effective stress to the applied one at 77 K is larger than that at higher temperatures. This leads to a difference between the temperature dependences of  $m^*$  and  $m$ . The value of  $m$  at room temperature is so large that the error becomes very large if I. Gupta and J.C.M. Li's method is applied. This is the reason why the authors failed to obtain a reasonable value of  $m^*$  at room temperature in a previous paper. 9 refs.

Ohgaku, T. (Kanazawa Univ, Kanazawa, Jpn); Takeuchi, N. *Phys Status Solidi A* v 106 n 1 Mar 1988 p K19-K21.

**Structure** See Also CRYSTALS—Growth; CRYSTALS—Growth; RUBIDIUM COMPOUNDS—Structure.

**084161  $[As(V)As(III)O_6]^{4-}$ : AN UNCOMMON ANION GROUP IN THE CRYSTAL STRUCTURE OF  $K_2Cu_3(As_2O_6)_2$ .** The crystal structure of  $K_2Cu_3(As_2O_6)_2$  was determined from single-crystal X-ray data by a direct method strategy and Fourier summations. The structure consists of  $As(V)O_4$  tetrahedra and  $As(III)O_3$  pyramids linked by a common O corner atom to  $[As(V)As(III)O_6]^{4-}$  groups with symmetry  $m$ . The  $As_2O_6$  groups and the Cu coordination polyhedra are linked to sheets parallel to (001). These sheets are connected by the K atoms. Single crystals of  $K_2Cu_3(As_2O_6)_2$  suitable for X-ray work were synthesized under hydrothermal conditions. (Edited author abstract) 21 refs.

Effenberg, H. (Univ Wien, Vienna, Aust); Pertlik, F. *J Solid State Chem* v 70 n 2 Oct 1987 p 219-224.

**084162 CRYSTAL STRUCTURE AND ELECTRICAL PROPERTIES OF  $K_3Bi_2(VO_4)_3$ , A NEW POTASSIUM BISMUTH VANADATE.** The crystal structure was determined from single-crystal intensity data obtained by means of an automated four-circle diffractometer and refined to the conventional values  $R = 0.050$  and  $R_w = 0.059$  for 1498 observed reflections. The structure is characterized by a three-dimensional network of  $Bi_2O_{10}$  units and  $VO_4$  tetrahedra. A  $Bi_2O_{10}$  unit is formed by two  $BiO_6$  octahedra sharing an edge.  $K^+$  ions occupy three

different crystallographic sites. One of them has a high thermal vibration which could reflect ionic mobility. The ionic conductivity highly increases at 790 K. DSC measurements show a reversible transition at this temperature. One K atom, and only one, can be substituted by one Na atom to give  $NaK_2Bi_2(VO_4)_3$ ; this substitution improves the conductivity. (Edited author abstract) 9 refs.

Debreuille-Gresse, M.F. (CNRS, Villeneuve d'Ascq, Fr); Abraham, F. *CHEMTECH* v 17 n 8 Aug 1987 p 466-471.

**084163 NEW METAL OXIDES OF THE FAMILY  $A_m(VO)_q$ :  $ALiMn_3O_4$  AND  $ALiZn_3O_4$  ( $A = K, Rb$ ).** Like in  $KLiZnO_2$  and  $KLiMnO_2$ , the similarity between the zinc and manganese oxides is striking. In the case of other oxides of the type  $ANA_mO_4$  (with  $A = K, Rb, Cs$  and  $M = Mn, Zn$ ) we find principally the same structural features, but in every case there is an unsolved superstructure observed. Other members of this family are the tetragonal oxides  $NaLi_3SiO_4$  and  $NaLi_3GeO_4$ , the trichloride compounds  $KLi_3MO_4$  ( $M = Si, Ge, Ti$ ) and  $CsNa_3PbO_4$ , and surprisingly  $KLi_3PbO_4$ . 20 refs.

Hoppe, R. (Justus Liebig-Univ, Giessen, West Ger); Seipp, E.; Baier, R. *J Solid State Chem* v 72 n 1 Jan 1988 p 52-57.

**084164 POTASSIUM MONOPHOSPHATE TUNGSTEN BRONZES WITH HEXAGONAL TUNNELS,  $K_x(PO_3)_4(WO_3)_{2m}$ : X-RAY DIFFRACTION AND NREM STUDY.** The series  $K_x(PO_3)_4(WO_3)_{2m}$  has been investigated by X-ray diffraction and electron microscopy. Five compositions have been isolated as pure phases for  $x = 2$  and  $m = 4, 6, 7, 8$ , and 10. These bronzes are built up from  $WO_3$  slabs connected through  $PO_4$  groups forming hexagonal tunnels. High-resolution lattice images allow a correlation between the image contrast and the structure to be established. Three groups of defects are observed in the crystals which deal with (i) the distribution of the phosphate planes with respect to the  $ReO_3$ -type slabs, (ii) the distribution of the  $K^+$  ions in the tunnels, and (iii) the uneven arrangements of the phosphate planes. (Edited author abstract) 23 refs.

Domenges, B. (Laboratoire de Cristallographie et Sciences des Matériaux, Caen, Fr); Hervieu, M.; Raveau, B.; O'Keeffe, M. *J Solid State Chem* v 72 n 2 Feb 1988 p 155-172.

**084165 SUBSTRUCTURES DE TYPE FLUORINE OBSERVÉS DANS LES SYSTÈMES  $KF-LnF_3$  ( $Ln = Pr...Er$ ). [Observed Fluorine Structures in the Systems  $KF-LnF_3$  ( $Ln = Pr...Er$ ).** Phases having fluoride-related superstructures are determined in the system  $K_{0.5-x}Ln_{0.5+x}F_{2+2x}$ . The composition range in which they are observed has been studied by X-ray and electron diffraction at high resolution. An incommensurate modulated structure appears, with a wave vector  $q = yb_0^*$ . This incommensurate structure is limited by two commensurate phases. (Edited author abstract) In French. 4 refs.

Le Fur, Y. (CNRS, Grenoble, Fr); Aleonard, S.; Perroux, M.; Gorius, M.F.; Roux, M.T. *J Solid State Chem* v 72 n 2 Feb 1988 p 173-180.

**084166 COPPER (III) PERIODATE PEROXO COMPLEX:  $K_4H_4Cu(IO_6)_2O_2 \cdot 6H_2O$ .** The chemical preparation and crystal structure of the trivalent copper salt  $K_4H_4Cu(IO_6)_2O_2 \cdot 6H_2O$  are described. Crystals are monoclinic. The structure is refined until  $R = 0.038$  for 2223 reflections. Isolated  $Cu(IO_6)_2^{7-}$  units and  $O_2^{2-}$  superoxide groups occur. In the  $Cu(IO_6)_2^{7-}$  unit, the trivalent copper ion is surrounded by four oxygen atoms in a rectangular configuration. (Edited author abstract) 13 refs.

Masse, R. (CNRS, Grenoble, Fr); Durif, A. *J Solid State Chem* v 73 n 1 Mar 1988 p 206-210.

**084167 PHONON DISPERSION RELATIONS FOR POTASSIUM THIOCYANATE.** Measurements of some low frequency phonon dispersion curves in potassium thiocyanate have been made using inelastic neutron



scattering techniques. The measured phonon frequencies are presented along with ones calculated from a simple model comprising axially-symmetric force constants between nearest neighbour atoms. The applicability of such a model in describing the lattice dynamics of this crystal structure is discussed. (Author abstract) 12 refs.

Cookson, D.J. (Monash Univ, Clayton, Aust); Finlayson, T.R.; Elcombe, M.M. *Solid State Commun* v 64 n 3 Oct 1987 p 357-359.

**084168 PHASE AND STRUCTURE ANALYSIS OF THE  $\text{KbO}_3\text{-Nb}_2\text{O}_5\text{-NbO}_2\text{F}$  SYSTEM BY X-RAY POWDER DIFFRACTION AND HIGH-RESOLUTION ELECTRON MICROSCOPY.** The structures of specimens in the  $\text{KbO}_3\text{-Nb}_2\text{O}_5\text{-NbO}_2\text{F}$  system have been studied with combination of X-ray powder diffraction and high-resolution electron microscopy methods. Seven different tetragonal-tungsten-bronze (TTB) related phases have been observed. Their structures can be described as built from three different structure elements, namely  $\text{MX}_6$  octahedra,  $\text{MX}_9$  tri-capped trigonal prisms and pentagonal columns (built up of  $\text{MX}_7$  pentagonal bipyramids equatorially linked by edge sharing with five  $\text{MX}_6$  octahedra. Various types of defects, twinning and intergrowth between the TTB-related phases are discussed. (Edited author abstract)

Lundberg, Monica (Univ of Stockholm, Stockholm, Sweden); Sundberg, Margareta. *Chem Scr* v 28 n 1 Mar 1988, Adv in Prep and Prop Charact of Cryst Inorg Mater, St. Leonard des Bois, Fr, Sep 26-28 1987 p 81-87.

Surfaces See CRYSTALS—Failure.

## Synthesis

**084169 SYNTHESIS AND CRYSTAL STRUCTURE OF  $\text{KMn}_2\text{O}(\text{PO}_4)(\text{HPO}_4)$ .**  $\text{KMn}_2\text{O}(\text{PO}_4)(\text{HPO}_4)$  crystallizes in the monoclinic space group  $\text{P2}_1/\text{m}$ , with  $a = 6.226(1)$ ,  $b = 6.890(2)$ ,  $c = 8.809(1)$  Angstrom, and  $\beta = 107.67(1)^\circ$ . For  $Z = 2$  the calculated density is  $3.282 \text{ g cm}^{-3}$ . Crystals were obtained hydrothermally, from a mixture of  $\text{Mn}_2\text{O}_3$ ,  $\text{KH}_2\text{PO}_4$ , and  $\text{H}_2\text{O}$ , by slow cooling from 673 K under an external nitrogen pressure of 3 kbar. The structure is composed of zigzag chains of edge sharing  $\text{MnO}_6$  octahedra linked together by  $\text{PO}_4$  tetrahedra to form sheets parallel to the  $bc$  plane. These sheets are linked to adjacent ones via additional  $\text{PO}_4$  tetrahedra and hydrogen bonds. The resulting framework encloses channels running parallel to the  $[011]$  direction in which the potassium resides. (Edited author abstract) 12 refs.

Lightfoot, Philip (Univ of Oxford, Oxford, Engl); Cheetham, Anthony K.; Sleight, Arthur W. *J Solid State Chem* v 73 n 2 Apr 1988 p 325-329.

**084170 SYNTHESSES, ETUDE STRUCTURALE PAR DIFFRACTION X, SPECTROSCOPIES INFRAROUGE ET MOESSBAUER DE  $\text{K}_2\text{SeO}_4 \cdot \text{SbF}_3 \cdot \frac{1}{2} \text{H}_2\text{O}$ .** [Synthesis, Structural Study by X-Ray Diffraction, Infrared and Mossbauer Spectroscopy of  $\text{K}_2\text{SeO}_4 \cdot \text{SbF}_3 \cdot \frac{1}{2} \text{H}_2\text{O}$ ]. The X-ray crystal structure of  $\text{K}_2\text{SeO}_4 \cdot \text{SbF}_3 \cdot \frac{1}{2} \text{H}_2\text{O}$  is reported. It crystallizes in the orthorhombic space group  $\text{Pnma}$  with  $a = 10.560(5)$ ,  $b = 12.803(4)$ ,  $c = 11.806(4)$  Angstrom,  $Z = 8$ , and a final  $R = 0.034$ . The antimony environment is that of a distorted dodecahedron  $\text{SbF}_3\text{O}_4\text{E}$  where E represents the nonbonding electron pair of  $\text{Sb}^{III}$ . For  $\text{K}_2\text{SeO}_4 \cdot \text{SbF}_3 \cdot \frac{1}{2} \text{H}_2\text{O}$ , infrared and antimony-121 Mossbauer spectra have been recorded; the data of the title compound and of other complexes are interpreted in terms of  $\text{SbX}_3\text{E}$  and  $\text{SbFX}_6\text{E}$  distorted environments. In all case the nonbonding electron pair is stereochemically active. (Author abstract). 18 refs. In French.

Mascherpa-Corral, D. (Univ des Sciences et Techniques du Languedoc, Montpellier, Fr); Ducourant, B.; Alberola, S. *J Solid State Chem* v 76 n 2 Oct 1988 p 276-283.

## Testing

**084171 SYSTEM  $\text{K}_2\text{SO}_4\text{-(NH}_4)_2\text{SO}_4\text{-DMF-H}_2\text{O}$  AT  $20^\circ$ .** Studies are now in progress for finding new salting-out

agents for the production of chlorine-free sulfate-containing salts with potassium chloride. We tested dimethylformamide (DMF) for this purpose in conversion of potassium chloride and ammonium sulfate. For scientific validation of the possibility of using DMF in conversion of  $\text{KCl}$  and  $(\text{NH}_4)_2\text{SO}_4$  we studied salt solubilities in the systems  $\text{K}_2\text{SO}_4\text{-(NH}_4)_2\text{SO}_4\text{-H}_2\text{O}$  and  $\text{K}_2\text{SO}_4\text{-(NH}_4)_2\text{SO}_4\text{-DMF-H}_2\text{O}$  at  $20^\circ$ , which corresponds to the optimal conditions for this reaction. There is no information in the literature on the solubilities of these salts at  $20^\circ$  in presence of DMF. Experimental evidence shows that the solubility isotherms of potassium and ammonium sulfates are represented by a single solubility curve, corresponding to formation of continuous solid solutions of the  $(\text{K}, \text{NH}_4)_2\text{SO}_4$  type. In the system  $\text{K}_2\text{SO}_4\text{-(NH}_4)_2\text{SO}_4\text{-DMF-H}_2\text{O}$  containing 20% DMF the solid-solution field increases while the field of unsaturated solutions decreases, indicating salting-out of solid solutions from the liquid phase by DMF. 6 refs.

Goncharik, I.I. (Acad of Sciences of the Belorussian SSR, USSR); Orlova, V.T.; Aleksandrovich, Kh.M.; Lepeshkov, I.N. *J Appl Chem USSR* v 60 n 7 pt 1 Jul 1987 p 1367-1369.

## Thermal Effects

**084172 TEMPERATURE OF THE TETRAFLUOROALUMINATES  $\text{K}_{1-x}\text{Rb}_x\text{AlF}_6$  EVOLUTION OF THE SHEAR STRUCTURAL PHASE TRANSITION.** By DSC, X-ray diffraction and neutron powder diffraction the temperature behavior of the  $\text{K}_{1-x}\text{Rb}_x\text{AlF}_6$  compounds is investigated in the concentration range  $x = 0$  to  $x = 0.10$ . For large crystals it is shown that if  $x$  is greater than 0.02 the shear transformation of pure  $\text{KAlF}_6$  splits into two structural phase transitions. The structures are determined by neutron powder profile refinement and the space groups  $\text{P4}/\text{mbm}$ ,  $\text{P2}_1/\text{m}$  and  $\text{P2}_1/\text{m}$  are attributed to the three successive phases. The high and low temperature phases are the same as in pure  $\text{KAlF}_6$ . It is shown that the temperature of the transition leading to the low temperature phase is sample size dependent. (Edited author abstract) 11 refs.

Launay, C. (Univ du Maine, Le Mans, Fr); Bulou, A.; Nouet, J. *Solid State Commun* v 61 n 9 Mar 1987 p 539-541.

Thermodynamics See LEAD COMPOUNDS—Thermodynamics.

## Thin Films

**084173 NOISE AND SHAPIRO STEP INTERFERENCE IN THE CHARGE-DENSITY-WAVE CONDUCTOR  $\text{K}_{0.3}\text{MoO}_3$ .** Extremely thin (transverse dimensions about  $0.2 \mu\text{m}$ ) samples of the charge density wave (CDW) conductor  $\text{K}_{0.3}\text{MoO}_3$  are found to display unusually coherent narrow-band noise spectra and well defined Shapiro step interference structure. The results suggest an intrinsic pinning potential with periodicity equal to the CDW wavelength. The Shapiro step interference appears to arise from a coupling of the external electric field to the low frequency dielectric relaxation mode rather than to the high frequency pinned phason mode. (Author abstract) 24 refs.

Hundley, M.F. (Univ of California at Berkeley, Berkeley, CA, USA); Zettl, A. *Solid State Commun* v 66 n 3 Apr 1988 p 253-256.

## Vaporization

**084174 MECHANISM AND THERMODYNAMICS OF THE VAPORIZATION OF  $\text{K}_2\text{CrO}_4$ .** The vacuum vaporization behavior of  $\text{K}_2\text{CrO}_4$  was studied over the range 1075-1240 K, which is just below the melting point of the material. Both molecular vaporization of  $\text{K}_2\text{CrO}_4$  and decomposition to  $\text{K(g)}$ ,  $\text{O}_2(\text{g})$ , and  $\text{Cr}_2\text{O}_3(\text{s})$  contribute to the total vaporization flux. Vapor composition and sublimation thermodynamics were studied by Knudsen cell mass spectrometry, while total vapor pressure and vapor molecular weight were determined by the torsion-effusion method. Composition data inferred

from the mass spectrum, the vapor molecular weight data, and comparison of calculated decomposition pressure with measured total pressure are all in close accord in showing the molecular chromate  $\text{K}_2\text{CrO}_4$  to account for 83% of the total sublimation pressure. (Edited author abstract) 26 refs.

Brittain, R.D. (SRI Int, Menlo Park, CA, USA); Lau, K.H.; Hildenbrand, D.L. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2900-2904.

## Viscosity

**084175 VISCOSITY OF POTASSIUM NITRATE + SILVER NITRATE MELT MIXTURES.** The viscosity of  $\text{KNO}_3 + \text{AgNO}_3$  melt mixtures has been determined in the range  $0.25 \leq x(\text{AgNO}_3) \leq 1.460$  K to 610 K. The viscosity of pure  $\text{KNO}_3$  was measured over the temperature span 620 K to 720 K. An oscillating-cylinder viscometer was used. This method is absolute and requires no calibration against reference liquids. The viscosities in units of MPa s conform to the expanded Arrhenius type equation with 0.04 to 0.31% standard deviations in the fit. (Edited author abstract) 14 refs.

Schardey, A. (RWTH Aachen, West Ger); Richter, J.; Oye, H.A. *Ber Bunsenges Phys Chem* v 92 n 1 Jan 1988 p 64-68.

X-ray Analysis See Also CEMENT—Alumina.

**084176 TEMPERATURE VARIATION OF DEBYE-WALLER FACTOR OF  $\text{KNO}_3$ .** In the present work measurements of X-ray diffracted intensities at various temperatures were carried out with the object of extracting the overall X-ray Debye-Waller factor (B) for  $\text{KNO}_3$ , in order to study the variation of the overall Debye-Waller factor of  $\text{KNO}_3$  below and above the phase transitions. It is clear from the values of  $\theta_M$  that it remains practically constant. On the other hand, the Debye-Waller factor increases with increasing temperature below the phase transition and decreases above the phase transition. This is not surprising because the phase change is associated with appreciable variations in the atomic parameters and electron distributions and these, in turn, have significant effect on the mean atomic displacements. 11 refs.

Somashekar, R. (Univ of Mysore, Mysore, India); Prahlad, U.D.; Madhava, M.S. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1103-1104.

**084177 ON THE DISTORTION WAVE VECTOR IN THE BLUE BRONZES.** We present X-ray measurements of the distortion wave numbers and their temperature evolution in the blue bronzes  $\text{K}_{0.3}\text{MoO}_3$  and  $\text{K}_{0.28}\text{MoO}_3$ , the stoichiometry  $\text{K}/\text{Mo}$  of which has been established using structural refinements as well as an electron probe microanalysis. The results show an independence of the wave number upon the alkaline concentration. We find that both samples have the same wave vector  $Q \approx (0, 0.75, 1/2)$  at low temperature, whereas in the quasi-one-dimensional band filling consideration and a Peierls scenario, the wave vector, for a  $\text{K}_{0.28}\text{MoO}_3$  stoichiometry, is expected to be  $Q = (0, 0.70, 1/2)$ . The results are discussed in terms of either an additional non-stoichiometry or possible warped Fermi surface and bare phonon dispersion effects. (Author abstract) 13 refs.

Girault, S. (CNRS, Orsay, Fr); Moudou, A.H.; Collin, G.; Pouget, J.P.; Comes, R. *Solid State Commun* v 63 n 1 Jul 1987 p 17-20.

## POTASSIUM RUBIDIUM ALLOYS

### Electric Conductivity

**084178 VERY-LOW-TEMPERATURE RESISTIVITY ANOMALY OBSERVED FOR POTASSIUM-RUBIDIUM ALLOYS: EFFECT OF A SHORT ELECTRON MEAN FREE PATH.** The anomalous very-low-temperature resistivity data reported recently for concentrated potassium rubidium alloys have been explained by applying the Pippard ineffectiveness condition



to inelastic electron-impurity scattering, thus taking into account the fact that the electron mean free path is finite. A discussion is presented of the Pippard condition, its successes and limitations, and further experiments are suggested for clarifying the role of the Pippard condition in modifying the low-temperature resistivity of concentrated crystalline alloys. (Author abstract) 21 refs.

Wiser, Nathan (Bar-Ilan Univ, Ramat-Gan, Isr). *Philos Mag B* v 56 n 6 Dec 1987, Second Bar-Ilan Conf on the Phys of Disordered Syst, Ramat-Gan, Isr, Jan 5-7 1987 p 1009-1013.

#### POTENTIOMETERS See Also INTEGRATED CIRCUIT MANUFACTURE—Performance.

**Applications** See Also ELECTRIC MEASUREMENTS—Resistance; HALL EFFECT—Measurements.

**084179 DIGITAL POTENTIOMETER BRINGS  $\mu$ P-BASED CONTROL TO AUDIO SYSTEMS.** From rotary volume and tone controls to the sliders on an equalizer, the control of most audio systems is still primarily mechanical. But this situation is changing as  $\mu$ P-based systems employing digitally controlled potentiometers find increasing use in audio designs. (Author abstract) 6 refs.

Randall, Jeff (Xicor Inc). *EDN* v 32 n 20 Oct 1 1987 p 177-182, 184, 186.

#### Automatic Testing

**084180 AUTOMATIC TEST INSTRUMENT FOR PRECISE WIRE-WOUND POTENTIOMETER.** Linearity, function conformance, and short circuits between turns have direct effect on the applications of the potentiometer used in automatic control and instrument systems. So the parameters of potentiometers should be precisely measured in production processing. But in traditional method, the accuracy and efficiency are not high. At the same time, some parameters, as specified in IEC standard, can not be tested. According to the specification of IEC, some mathematical models are applied to the linearity of potentiometers in this paper, in which the principles and applied methods of an automatic test equipment for potentiometers are described. (Author abstract) 2 Refs.

Du, Jiwu (Beijing Aviation Instrument Factory, Beijing, China); Yang, Jingzeng. *Instrumentation in China* Instrumentation in China, Technical Papers. English Language Edition of Selected Articles Originally Published in the Chinese Journal of Scientific Instrument 1987. Publ by ISA, Research Triangle Pk, NC, USA, 1987 p 129-141.

#### Plastics Applications

**084181 GUETEMERKMALE VON LEITPLASTIK-POTENTIOMETERN: 1. TEIL.** [Quality Characteristics of Plastic Potentiometers: Part 1]. The fast growth of microprocessor technology for control and regulation applications in the machine and automobile industries has increased drastically the need of sensors for measurement of angles and mileage. This led to the development of plastic potentiometers. Some basic definitions and standards as well as quality criteria are suggested. In German.

Gass, Ernst. *Elektronik* v 36 n 16 Aug 7 1987 p 94-100.

**POWDER METAL PRODUCTS** See Also ELECTRODES—Fabrication; FERROMAGNETIC METALS; HEAT TRANSFER—Porous Materials; MAGNETIC MATERIALS; METALS AND ALLOYS—Reviews; POROUS MATERIALS; POWDER METALLURGY; POWDER METALLURGY—Applications; POWDER METALLURGY—Cobalt; POWDER METALLURGY—Copper; POWDER METALLURGY—Iron; POWDER METALLURGY—Iron Nickel Alloys; POWDER METALLURGY—Iron Tin Copper Alloys; POWDER METALLURGY—Sintering; POWDER METALLURGY—Stainless Steel; POWDER METALLURGY—Steel; PROTECTIVE COATINGS—Wear; STEEL—Wear.

**084182 PRODUCTION AND APPLICATION OF GAS-ATOMIZED CLEAN METAL POWDERS:**

**THERMAL-SPRAY POWDERS AND MAGNETIC POWDERS FOR POWDER CLUTCHES.** Vacuum-melted, Ar-gas-atomized powders produced by Kobe Steel are spherical in shape with highly clean surfaces. Powders of Ni-Cr-Al-Y, Ni-Cr, Ni-Al, and Fe-Cr alloys produced by this method allow higher formation rates of plasma-spray coatings than conventional atomized powders. Excellent fluidity of iron-base-alloy magnetic powders improves responsiveness of powder clutches and ensures smooth operation without vibration. (Author abstract) 7 refs.

Satoh, Yoshitomo; Yoshikawa, Kazuo; Seki, Yoshikazu; Namba, Yoshio. *Kobelco Technol Rev* n 3 Feb 1988 p 11-14.

**Alumina** See Also ALUMINA—Sintering.

**084183 NOVEL COMBUSTION PROCESS FOR THE SYNTHESIS OF FINE PARTICLE  $\alpha$ -ALUMINA AND RELATED OXIDE MATERIALS.** Synthesis of fine particle  $\alpha$ -alumina and related oxide materials such as  $MgAl_2O_4$ ,  $CaAl_2O_4$ ,  $Y_3Al_5O_{12}$  (YAG),  $t-ZrO_2/Al_2O_3$ ,  $\beta'$ -alumina,  $LaAlO_3$  and ruby powder ( $Cr^{3+}/Al_2O_3$ ) has been achieved at low temperatures (500°C) by the combustion of corresponding metal nitrate-urea mixtures. Solid combustion products have been identified by their characteristic X-ray diffraction patterns. The fine particle nature of  $\beta$ -alumina and related oxide materials has been investigated using SEM, TEM, particle size analysis and surface area measurements. (Author abstract). 23 Refs.

Kingsley, J.J. (Indian Inst of Technology, Bangalore, India); Patil, K.C. *Mater Lett* v 6 n 11-12 Jul 1988 p 427-432.

**Aluminum** See POWDER METALLURGY—Aluminum.

**Amorphous** See Also POWDER METALLURGY—Iron.

**084184 AMORPHOUS MAGNETIC POWDERS - SOME SPECIAL PECULIARITIES.** The amorphous powders prepared by a high-rate borohydride reduction process propose the possibility for some principal conclusions concerning the occurrence of closest packing of the monodomain magnetic globules. The simultaneous nitrogeneration, pressing and determination of the thermal effects of crystallization provided for both kinds of probes -  $Fe_xCo_yB_{1-(x+y)}$  (compositionally equal), obtained with or without a magnetic field show differences in the structure and energy of the interglobular voids. Therefore, the differences between the predominating amount of tetrahedral or octahedral voids determine some special peculiarities of this material. (Author abstract) 7 refs.

Dragieva, Iovka (Higher Inst of Mechanical & Electrical Engineering, Sofia, Bul); Buchkov, Dimitir; Mehandjiev, Dimitir; Slavecheva, Mina. *J Magn Magn Mater* v 72 n 1 Mar 1988 p 109-113.

**084185 PREPARATION AND COMPACTION OF MECHANICALLY ALLOYED AMORPHOUS MATERIALS.** The article examines the use of mechanical alloying to produce amorphous materials with constituents and compositions which cannot be prepared by rapid solidification. The thermodynamic properties of these materials are similar to those of rapidly solidified ribbons. The compaction of these materials to form bodies with amorphous or microcrystalline structures was also studied using hot and cold pressing techniques. The best results were obtained using hot isostatic pressing. The systems studied were Hf-Ni, Hf-Cu, Ti-Cu, Ti-Pd and Fe-Ni-B. 15 refs.

Krauss, W. (Kernforschungszentrum Karlsruhe GmbH, Karlsruhe, West Ger); Politis, C.; Weimar, P. *Met Powder Rep* v 43 n 4 Apr 1988 p 231-232, 234-236, 238.

**Applications** See Also AUTOMOBILE MATERIALS—Powder Metals; POWDER METALLURGY—Iron; POWDER METALLURGY—Lead; POWDER METALLURGY—Processing.

**084186 P/M PARTS FOR AUTOMOTIVE APPLICATIONS.** The trend to production of near net shape

components in the automotive industry and the crusade for cost reduction has brought powder metallurgy technology to the foreground. Savings of material, energy, manufacturing cost and the avoidance of capital expenditure are some of the principal benefits of this process. This paper describes P/M components in the automobile. It includes a new family of sensors used in conjunction with electronics and microcomputers. In addition, progress made in recent years in P/M technology is summarized. (Edited author abstract) 17 refs.

Mocarski, Stanley (Ford Motor Co, Detroit, MI, USA); Hall, D. William. *Int J Powder Metall (Princeton NJ)* v 23 n 2 Apr 1987 p 109-110, 112-116, 118-125.

**084187 APPLICATIONS AND PROPERTIES OF CONTROLLED POROSITY PM PARTS.** For several years, controlled porosity PM parts have proven themselves in a variety of non-filtration applications. Areas as diverse as communications equipment, writing instruments, and military ammunition are taking advantage of the unique characteristics of porous metals. The review illustrates examples of applications and mathematical and statistical concepts which are of value in optimizing product properties. 6 refs.

Mossner, W.R. (SSI Technologies Inc, Janesville, WI, USA). *Met Powder Rep* v 43 n 1 Jan 1988 p 43-45.

**084188 TRENDS IN POROUS PM PARTS AND FILTERS.** The two most commonly used metal powders for porous parts - 10% tin bronze and Type 316L stainless steel - have seen little change in the past twenty years. As design engineers become more familiar with the characteristics of porous PM parts, they call out for new requirements in the areas of improved corrosion resistance, heat resistance, and filtration performance. This has led to an increasing use of parts made from powder of the Hastelloys, Inconel, and other nickel-base materials as well as metals now available as powders such as titanium, zirconium, niobium, and tantalum.

Johnson, W.R. (Newmet Krebsoge, Terryville, CT, USA); Eisenmann, M. *Met Powder Rep* v 43 n 1 Jan 1988 p 46-47.

**084189 AWARD-WINNING PARTS SHOW BROAD SPECTRUM OF P/M APPLICATIONS.** Winners of the 1988 Powder Metallurgy (P/M) Part of the Year Design Competition show the growing international diversity of P/M applications. Markets for the parts include computers, automobiles, high-security locks, firearms, chemical processing and bio-medical prostheses. The competition is sponsored by the Metal Powder Industries Federation. The article describes the winning entries.

Johnson, Peter K. (American Powder Metallurgy Inst, Princeton, NJ, USA). *Int J Powder Metall (Princeton NJ)* v 24 n 3 Jul 1988 p 251-257.

**084190 APPLICAZIONE DEI COMPONENTI SINTERIZZATI NELL'AUTOMOBILE.** [Application of Sintered Components in the Car Industry]. Powder metallurgy is a technology which has a wide application potential for its low energetic content properties and almost complete utilization of material. Its success is due to the research activities carried out by all major metal powder manufacturers in view of supplying metal powders suitable for making high mechanical strength products and to the development of new production processes such as isostatic pressing, high temperature and/or vacuum sintering, and dual pressing techniques. In general, the automotive industry represents the major user of sintered component products worldwide with a market share of about 65% of the total. (Edited author abstract). In Italian.

Costa, A. (Fiat Auto, Turin, Italy); Rigoni, S. *Metall Ital* v 80 n 4 Apr 1988 p 297-302.



**Bonding** See POWDER METALLURGY—Iron.

**Brazing** See POWDER METALLURGY—Iron.

**Chemical Vapor Deposition** See MATERIALS WITH MEMORY—Thin Films.

**Compaction** See Also POWDER METALLURGY—Copper; POWDER METALLURGY—Densification.

**084191 EFFECT OF SHOCK AND ELASTIC WAVES ON DYNAMIC COMPACTION PROCESS OF TWO-LAYER POWDER MEDIA.** The dynamic compaction processes of copper powder which was filled in two layers into a die and subjected to solid punch impact were investigated experimentally in order to assess the effect of different initial density distributions of the powder on the compaction process. The compaction experiments were performed for two situations for layer arrangement: in the first situation the upper layer had a lower uniform initial density distribution than the lower layer and in the second this order was reversed. The processes were photographed for the two situations of layer arrangement using a high speed camera in order to analyze the movement of powder medium and punch, the propagation of shock and elastic waves in the powder medium and density distributions. The pressure on the plug supporting the medium in the die was also measured so that the analysis of the photograph would be facilitated. (Edited author abstract) 13 refs.

Miyagi, K. (Univ of the Ryukyus, Okinawa, Jpn); Sano, Y. *J Eng Mater Technol Trans ASME* v 109 n 4 Oct 1987 p 266-271.

**084192 EXPERIMENTAL VERIFICATION OF THE SIMILARITY OF DYNAMIC COMPACTION PROCESSES OF A COPPER POWDER MEDIUM IN DIES OF ELEMENTARY SHAPES.** The similarity of dynamic compaction processes was investigated theoretically and predicted in our previous report, where powder media in a die were assumed to be of a simple type, and the punch and plug to be rigid bodies. The predictions were based on a set of one-dimensional equations and a set of nondimensionalized one-dimensional equations. The objective of this study is to examine the similarity experimentally and to present the results of compaction experiments in order to verify the existence predicted. The experiments were carried out on a copper powder medium in dies having inner cross-section in elementary shapes such as circle, square and triangle. The pressure of the medium at a point contacting the end of the plug, the density distribution and mean density of the green compacts were measured in the experiment. (Edited author abstract) 7 refs.

Miyagi, Kiyohiro (Univ of Ryukyus, Okinawa, Jpn); Sano, Yukio; Hayashi, Takuo. *J Eng Mater Technol Trans ASME* v 109 n 4 Oct 1987 p 306-313.

**084193 ANALYSIS METHOD FOR THE DYNAMIC COMPACTION PROCESSES OF POWER MEDIA WITHIN A DIE.** A method of analysis for the multishock compaction process of die-contained power media with a plug at one end and an impacting punch at the other end is presented. In the method assumptions are made that the media are of a simple rigid-plastic type, and compressed only at the fronts of the shock waves passing through, and furthermore the punch and plug are rigid bodies. Based on the assumptions, particle velocities of elements between the punch surface and a shock wave front are the same and equal to the punch velocity, while velocities of elements between the front and the plug surface are equal to a velocity of the plug surface, i.e., zero. Therefore, it is possible to use jump conditions at the front and equations of motion for the punch and medium moving with the same velocity as it, instead of partial differential equations, i.e., conservation equations which were used in other methods. (Edited author abstract) 12 refs.

Sano, Yukio (Kobe Univ of Mercantile Marine, Kobe, Jpn). *J Eng Mater Technol Trans ASME* v 110 n 1 Jan 1988 p 28-34.

**Computer Integrated Manufacturing** See Also PRESSES—Automation.

**084194 CALCULATION OF PM TOOLS FOR PRESSING AND SIZING.** PM moulding tools are calculated by using two parameters. The first is based on the assumption that the elastic swelling from the dimensions of a rigid dies is horizontally isotropic. The second is the pressure on the die which causes its deformation. M.A. Eudier of Alliage Frittes Metafram, in Paris, France, Describes in this paper the development of a computer program which takes into consideration these calculations in the design of PM moulding tools. For the sizing tools the principles are identical but new parameters are added. They are the positive or negative clearances, between the part and the die and between the part and the core-rod. Interesting results have especially been obtained for gears. It has been possible to show that the calculation is roughly ten times more precise than that produced practically. (Author abstract) 1 ref.

Eudier, M.A. (Alliage Frittes Metafram, Paris, Fr). *Met Powder Rep* v 42 n 9 Sep 1987 p 623, 625, 627-628.

**Copper Chromium Alloys** See ELECTRIC CIRCUIT BREAKERS—Contacts.

**Corrosion** See POWDER METALLURGY—Stainless Steel.

**Costs** See Also POWDER METALLURGY—Quality Assurance; POWDER METALLURGY—Titanium.

**084195 COST ESTIMATING OF PM PARTS BY COMPUTER.** The many variables involved in the PM manufacturing process has made the traditional job of preparing PM part quotations lengthy and highly complex. A computer program developed by Vertech Computer Services of Basalt, Colorado reduces the preparation of quotes to a matter of minutes. The article describes some of the program's features. (Edited author abstract)

Williams, Bernard. *Met Powder Rep* v 42 n 11 Nov 1987 p 774, 766-778, 780.

**Deformation** See Also POWDER METALLURGY—Aluminum Silicon Nickel Alloys.

**084196 VARIATION OF THE DEFORMATION CHARACTERISTICS OF POROUS BLANKS FROM TITANIUM, COPPER, AND ALUMINUM POWDERS.** Experiments were carried out under isothermal conditions on sintered and unsintered blanks with relative densities of 70-100% pressed from the following powders PTES-1 (titanium), PTEK-1 (titanium), screened TG-TV sponge titanium, PMS-1 (copper), and PA-2 (aluminum). The study was based on compressive testing which was performed under standard forging presses at various speeds. The variations of Poisson's ratio and modulus of elasticity with density were determined at various temperatures from 400-100°C. The method of testing in compression in a stressed and strained mode corresponds to the first stage (upsetting) of forging and extrusion processes. It enables stable test results to be obtained in the whole density range and characterizes the properties of metals under conditions of densification. 1 ref.

Pavlov, V.A. (Zaporozhe Machine Construction Inst, USSR); Nosenko, M.I.; Popov, B.V.; Yakunin, S.N. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 704-708.

**Density** See POWDER METALLURGY—Compacting; POWDER METALLURGY—Copper; POWDER METALLURGY—Iron.

## Density Measurement

**084197 ANWENDUNG DER DICHTMESSUNG ZUR POROSITAETSCHARAKTERISIERUNG PULVERMETALLURGISCHE HERGESTELLTER TEILE.** [Application of Density Measurement for Characterization of Porosity of Powder Metal Products]. This paper is concerned with problems involved in density measurements with a view to porosity characterization. Due to the rapid increase of the measurement error with the decrease

of specimen volumes, a minimum specimen volume of approx. 0.5 cm<sup>3</sup> has to be strictly observed. This in turn strongly hampers the application of density measurement in order to characterize local density differences in powder-metal products. A procedure which allows a safe definition of such density differences is described. (Edited author abstract) In German. 6 refs.

Seidel, Martin (Ingenieurhochschule Swickau, Xwickau, East Ger); Nocke, Guenter; Schuessler, Reiner. *Neue Huette* v 32 n 9 Sep 1987 p 351-353.

**Electric Conductivity** See Also POWDER METALLURGY—Copper.

**084198 CONDUCTIVITY OF P/M MATERIALS WITH DIFFUSIONAL INTERACTION OF PHASES.** In this work a rigorous analytical derivation has been carried out of an expression for the conductivity of a randomly inhomogeneous P/M material with diffusional interaction of phases. An explicit and full calculation is given. It is based on the assumption that the variation in conductivity with concentration is a parabolic function which enables numerical calculations to be made of elastic properties. 8 refs.

Babushkin, G.A. (Acad of Sciences of the USSR, USSR). *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 537-542.

**084199 FREQUENCY RELATIONSHIP OF THE ELECTRICAL RESISTANCE OF CERMET FILMS BASED ON THE HEXABORIDES OF RARE-EARTH ELEMENTS.** In this work an investigation was made of the conductivity of cermet films with an alternating current in the 100 kHz-300 MHz range. The conductivity of the film depends on the configuration of the specimens and on the structure and composition of the films. The relationship of conductivity to specimen configuration may be explained by the influence of the distributed capacitances between the electrodes and near-electrode areas of the resistive layer. A new interpretation of the experimental data is proposed. In high-resistance films, breaks in the conducting chains are shunted at high frequencies by intergranular capacitances which leads to an increase in conductivity. The theoretical frequency relationship of conductivity calculated with the use of the theory of percolation agrees with the experimental data. 6 refs.

Islamagaliev, R.K. (Acad of Sciences of the Ukrainian SSR, USSR); Zyrin, A.V.; Shulishova, O.I.; Shcherbak, I.A. *Sov Powder Metall Met Ceram* v 26 n 8 Aug 1987 p 664-667.

**Erosion** See METALS AND ALLOYS—Erosion.

**Extruding** See Also POWDER METALLURGY—Injection Molding; POWDER METALLURGY—Iron Silicon Aluminum Alloys; POWDER METALLURGY—Steel.

**084200 SOME FEATURES OF INVESTIGATION OF LARGE PLASTIC STRAINS IN THE EXTRUSION OF SINTERED MATERIALS BY THE FINITE-ELEMENTS METHOD.** In powder metallurgy, extrusion of sintered blanks is employed as a means of obtaining materials possessing good physicochemical characteristics. At the large plastic strains characteristic of extrusion processes it is necessary to determine the distribution of the pressing and find zones of porosities and sites of nonporous structure and cracks. To check the results of theoretical investigations of extrusion through a flat and a conical die, hardness tests were carried out on deformed porous specimens of Pzh4M2 fine reduced iron powder. 5 refs.

Petrosyan, G.L. (Erevan Polytechnic Inst, USSR); Musaelyan, G.V.; Petrosyan, Kh.L. *Sov Powder Metall Met Ceram* v 26 n 3 Mar 1987 p 200-202.



**084201 THEORETICAL INVESTIGATION OF THE PROCESS OF COLD EXTRUSION OF RODS FROM UNPLASTICIZED METAL POWDERS. I. DISTRIBUTION OF POROSITY AND STRESSES IN THE CONICAL SEAT OF PLASTIC DEFORMATION.** Existing theoretical solutions of the extrusion problem are applicable mainly to sintered porous metals. The stressed-strained state, variation of porosity in the conical seat of deformation, and the energy and force parameters of the process of cold extrusion of unplasticized powders were investigated. Methods of solution based on continual representations of a compressible powder medium were used. 12 refs.

Stepanenko, A.V. (Byelorussian Polytechnic Inst, USSR); Isaevich, L.A.; Veremeichik, A.A.; Medvedeva, T.A. *Sov Powder Metall Met Ceram* v 26 n 5 May 1987 p 353-356.

**084202 THEORETICAL INVESTIGATION OF THE PROCESS OF COLD EXTRUSION OF RODS FROM UNPLASTICIZED METAL POWDERS - III. EXTRUSION PRESSURE.** Rod extrusion pressure determinations were made by solving simultaneously problems on the extrusion of a powder through a conical die and single-ended pressing in its container. An axisymmetric problem is considered on the single-ended pressing of the powder in the container preceding the extrusion stage. The stressed and strained state was determined. The proposed method of calculation makes it possible to determine the extrusion pressure of P/M rods and geometric tool parameters necessary for the production of parts with a given porosity. 9 refs.

Stepanenko, A.V. (Byelorussian Polytechnic Inst, USSR); Isaevich, L.A.; Veremeichik, A.A.; Medvedeva, T.A. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 519-523.

## Fabrication

**084203 P/M PLANT AUTOMATION.** The role and importance of plant automation in the production of P/M structural parts are considered, and several examples of implementation in Japan are cited. Six approaches are discussed by which automation can achieve lower production costs: the grouping of P/M parts, making the production system flexible, practicing quality control within the production process, decreasing the idle time of production units, use of work systems in which operators perform multiple tasks, and making automation a function of parts quantity and complexity. With a move toward a greater number of part shapes/sizes and smaller part runs in a given plant, flexibility is necessary in the design of automated production systems. It is also likely that each parts producing plant will have to develop its own automated equipment to fit specific requirements. (Author abstract)

Furukawa, Nobuo (Sumitomo Electric Industries Ltd, Itami, Jpn). *Int J Powder Metall (Princeton NJ)* v 23 n 3 Jul 1987 p 179-187.

**084204 CERMETS OF THE  $Y_1Ba_2Cu_3O_{7-\delta}$  SUPERCONDUCTORS.** Conventional powder processing methods have been used to fabricate superconducting cermets, using non-noble metals. Two distinct classes of superconducting cermets have been made. The first expels magnetic fields at liquid  $N_2$  temperatures. The second exhibits zero resistivity on a macroscopic scale. Authors report preliminary success in the fabrication of these cermets. (Author abstract) 5 refs.

Goyal, A. (Univ of Rochester, Rochester, NY, USA); Funkenbusch, P.D.; Chang, G.C.S.; Burns, S.J. *Mater Lett* v 6 n 8-9 May 1988 p 257-260.

**Fatigue** See Also BEARINGS—Powder Metal.

**084205 FESTIGKEIT UND ERMUEDUNG MAS-SIV UMGEFORMTER SINTERMETALLE-EIN UEBERBLICK. [Strength and Fatigue of Solid Transformed Sinter Metals - An Overview].** The strength and fatigue behaviour of sintered metal materials after plastic deformation is characterized with respect to an appropriate combination of powder metallurgy with metal forming

techniques. The manufacturing process of P/M parts and additional strength enhancing measures are described. As an example some results of investigations on the effect of forward rod extrusion using sintered preforms on the static and dynamic properties are reported. A comparison is made for the cyclic deformation behaviour of both P/M and I/M (ingot metallurgy) materials to obtain information on fatigue behavior. (Edited author abstract) 16 refs. In German.

Hager, B. (Univ Stuttgart, Stuttgart, West Ger). *Metall* v 42 n 4 Apr 1988 p 351-355.

**Fiber Reinforcement** See ALUMINUM COPPER ALLOYS—Fiber Reinforcement; METALS AND ALLOYS—Metallic Matrix Composites.

## Finishing

**084206 SURFACE TREATMENT OF SINTERED METAL COMPONENTS.** This article deals with the final stages of producing P/M parts - surface treatment and finishing. The following operations are covered: cleaning and deburring; treatment for wear resistance; corrosion protection; and decorative finishing.

Braddick, D.M. (Rigby Metal Components Ltd, Cleckheaton, Engl). *Metallurgia* v 54 n 11 Nov 1987 p S30-S31.

**Forging** See Also POWDER METALLURGY—Aluminum Silicon; POWDER METALLURGY—Densification; POWDER METALLURGY—Iron.

**084207 COMPUTER AIDED DESIGN OF PRE-FORMS FOR POWDER METAL FORGING.** A study funded by the National Science Foundation investigated the feasibility of computer aided preform design for powder forging. The project melded a CAD description of part geometry, artificial intelligence programming techniques (AI), and numerical methods of metal working plasticity analysis. Contributions from AI included new methods of internal representation of part geometry and properties, a knowledge base which captured the design logic, and a decision technique that implemented the design logic. In addition to application of AI methods, a major accomplishment was interfacing of a module for mathematical modeling of the deformation pressures required in each region of the part. This module was accessed to aid in decision making during the design phase. This article summarizes the results of the study.

Ferguson, B. Lynn (Deformation Control Technology Inc, Cleveland, OH, USA); Kuhn, Howard A.; Trasorras, Juan. *Carbide Tool J* v 20 n 1 Jan-Feb 1988 p 16-21.

## Friction

**084208 FRICTION MECHANISMS OF ANTI-FRICTION PRODUCTS.** Friction materials made from mixtures of metal and ceramic powders are used in applications where the friction coefficient must be very high, for example in aircraft brakes, brakes on high speed TGV trains and on trains operating in mountain regions. This paper describes work done to study the mechanisms which influence the friction properties of copper-base products containing metallic glasses. The mechanisms proposed are specific to the applications which have been made. There are other ways to transform mechanical energy into heat but SSD and viscous films are among the most simple ones. 3 refs.

Eudier, M. (Alliages Frites Metafram, Paris, Fr); Youssef, H. *Met Powder Rep* v 43 n 1 Jan 1988 p 15, 17-18, 20.

**Heat Transfer** See HEAT TRANSFER—Radiation.

**Heat Treatment** See Also POWDER METALLURGY—Iron Graphite; POWDER METALLURGY—Steel; POWDER METALLURGY—Superalloys; STEEL HEAT TREATMENT—Carburizing.

**084209 DEVELOPMENTS IN SINTERING INJECTION MOULDED PM PARTS.** Injection moulding of metal powders holds considerable promise for the development of a new range of highly complex PM compo-

nents. However, one of the drawbacks of the process is that it takes many hours and even days to remove the binder used to assist moulding of parts, thereby adding to production costs. A new, one-step binder removal and sinter process has been developed based upon vacuum techniques. Both laboratory size and production size equipment has been developed in parallel. The result is a much shorter single cycle processing time for a range of parts, as well as good control of carbon levels. As the process, materials and equipment are further developed, a much wider range of cost-effective parts can be expected to appear in the marketplace.

Kennedy, Sheldon W. (Vacuum Industries Inc, Somerville, MA, USA). *Met Powder Rep* v 42 n 9 Sep 1987 p 609-611.

**084210 PREDICTING CASE DEPTHS FOR VACUUM CARBURIZING.** Curves for estimating effective case depth relative to processing variables and part density simplify procedure. Surface-hardening steel powder-metal (PM) parts has long posed problems because the sintered parts are generally porous and, therefore, not homogeneous. Carbon potential, the driving force in conventional atmosphere carburizing, depends on balancing atmosphere constituents under non-equilibrium conditions. If the constituents - carbon monoxide, carbon dioxide, hydrogen, nitrogen, water vapor, oxygen, and, if carbonitriding, ammonia - are not properly controlled, carburizing/decarburizing and reducing/oxidizing reactions can slow the rate of carbon absorption. Care is also required to minimize surface dealloying.

Vaccari, John A. (American Machinist & Automated Manufacturing, New York, NY, USA). *Am Mach Autom Manuf* v 131 n 9 Sep 1987 p 160-161.

**084211 ION NITRIDING REDUCES DISTORTION, IMPARTS DISTINCT CASE DEPTHS.** Having major advantages over conventional methods, ion nitriding may be adopted by a major user of PM parts. Rapidly emerging as an effective treatment for altering the surface characteristics of many materials, ion nitriding may soon find a home at Pitney Bowes (Stamford, Conn), long a major producer and user of PM parts. Because of its advantages over conventional carbonitriding and vacuum carbonitriding, it is being considered for surface-hardening cams, gears, pulleys, and other steel PM parts as well as for punching and stamping dies.

Anon. *Am Mach Autom Manuf* v 131 n 9 Sep 1987 p 161-162.

**084212 HEAT TREATMENT OF SINTERED STEELS MADE FROM A PARTIALLY PREALLOYED IRON POWDER.** Compacts of steels containing 1.75% nickel, 1.5% copper, 0.5% molybdenum and 0%, 0.3% or 0.6% carbon with about 6% or 15% porosity were sintered at 1150°C for 1 h. Subsequently they were austenitized at 850°C for 0.5 h, quenched in either oil or water and tempered at temperatures in the range 200°C...700°C for 1 h. The carbon-containing steels responded to the heat treatments in a similar manner to wrought steels, and developed tensile properties that were markedly superior to those of the same steels that were in the sintered and fairly slowly cooled condition. The strengths of the steels that had been tempered at temperatures up to about 500°C decreased only slowly with increase in tempering temperature, possibly owing to the effect of the copper in the steels. Carbon-free steels responded to the heat treatment in a different manner, undergoing precipitation hardening in the temperature range 400 to about 550°C, brought about by the precipitation of a copper-rich phase. Optimum strengthening occurred on tempering at about 500°C. (Edited author abstract) 8 refs.

Khaleghi, M. (Ministry of Heavy Industry, Tehran, Iran); Haynes, R. *Powder Metall Int* v 20 n 1 Feb 1988 p 9-12.

## Heating

**084213 MODELING THE TEMPERATURE FIELD IN A POWDER MATERIAL SUBJECTED TO DI-**



**RECT ELECTRIC HEATING.** In order to reveal the effect of the temperature gradient in the sintering zone, a study was made of the process of self-propagating high temperature synthesis (SHS) of a powder mixture initiated by direct electric heating. Modeling the temperature field in the SHS or sintering of a powder mixture by the direct passage of a current makes it possible to determine optimum conditions of production of hard-metal materials. These processes are characterized by a multifactorial dependence on starting conditions and design features of the set-up. 5 refs.

Pilipchenko, A.V. (Ivano-Frankovsk Inst of Petroleum & Gas, USSR); Belousov, V.Ya.; Tsitrin, A.I.; Khomchenko, A.N. *Sov Powder Metall Met Ceram* v 26 n 3 Mar 1987 p 208-210.

**Impregnation** See Also CASTINGS—Quality Assurance; POWDER METALLURGY—Tungsten.

**084214 VACUUM IMPREGNATION: THE BASICS.** Impregnation, by improving final quality, allows manufacturers to utilize casting and powdered metallurgy techniques. Distinct benefits of impregnation include elimination of 'leakers' to provide pressure tight castings and enhanced ability to plate or anodize the impregnated parts. Casting impregnation can be performed successfully using several different methods that employ a variety of sealant materials. This paper discusses basic methods of impregnation, including dry vacuum/pressure, wet vacuum/pressure, wet vacuum, and internal pressure. 1 ref.

Stevenson, Milton Jr (Anoplate Corp, Syracuse, NY, USA); Stevenson, James. *Met Finish* v 86 n 6 Jun 1988 p 93-95.

**Injection Molding** See Also POWDER METALLURGY; POWDER METALLURGY—Compacting; POWDER METALLURGY—Nickel.

**084215 PRESENT STATUS OF PM INJECTION MOULDING (MIM) - AN OVERVIEW.** The current technologies for metal injection moulding (MIM), including Wiech, Rivers, and others are reviewed. The factors affecting the growth of the industry are summarized and compared with the impeding factors. This leads to estimates of the cost of making MIM parts, how they compare with investment castings, and a forecast for future market growth. The present markets, shipments, tooling, technology, and history of the 29 active MIM producers in North America and Europe are reviewed by company. A table contains mechanical property data for MIM materials. Work under way at various research institutions and efforts at standardization are described. 51 refs.

Pease, Leander F. III (Powder-Tech Associates Inc, North Andover, MA, USA). *Met Powder Rep* v 43 n 4 Apr 1988 p 242-243, 245-247, 249-254.

**084216 PRODUCTION AND EVALUATION OF PM INJECTION MOULDING FEEDSTOCKS.** The authors investigated several types of polymer/stainless steel powder feedstocks for powder injection moulding with respect to preparation and evaluation techniques. Categories of polymer binders examined include waxes, plastics and wax/plastic combinations. Oil smear tests were performed to determine the maximum powder loading. Preparation techniques for each system varied with the type of binder. Waxes could be easily melted and the powder added directly, whereas with plastics or wax/plastic combinations a solvent was used to dissolve the binder before adding the powder. Evaluation of the feedstock density was performed to determine the reproducibility of the composition of the blend. Specific gravity was determined. 8 refs.

Libb, R.S. (Univ of Alabama, Birmingham, AL, USA); Patterson, B.R.; Heflin, H.A. *Met Powder Rep* v 43 n 4 Apr 1988 p 255-258.

**084217 ADVANCED POWDER PROCESSING RESEARCH FOCUSES ON INJECTION MOULDING.** An industrially sponsored research programme entitled 'Advanced Powder Processing' has been initiated at

Rensselaer Polytechnic Institute in Troy, New York. The research focus is on powder injection moulding. The article reviews some of the research aspects of the programme and its objectives in producing components with complex geometries, close tolerances, unique microstructures and improved properties.

Anon. *Met Powder Rep* v 43 n 4 Apr 1988 p 262-263.

**084218 METAL INJECTION MOULDING, A NEW FABRICATION TECHNIQUE FOR SINTERED PARTS OF INTRICATE GEOMETRY.** Powder metallurgical (PM) injection molding is a new net-shape forming process for small parts of intricate geometry, to be fabricated in large production runs. It is similar to plastic injection molding, using a plastic coated metal powder as feedstock. Removing the plastic after injection molding and subsequent sintering the parts to high density results in a family of new PM-products. This article describes in detail the process, presents examples illustrating the potential of this technique in various industrial sectors, and discusses its economy.

Lange, E.; Poniatowski, M. *ATB Metall* v 27 n 2-3 1987, Powder Metall, Brussels, Belg, May 13-14 1987 p 103-108.

## Lubricants

**084219 NEW METHOD OF DETERMINATION OF THE OIL CONTENT IN POROUS POWDER METALLURGY PARTS.** The authors have developed a method of determination of the quantity of oil in porous powder metallurgy parts. The basis is the phenomenon of thermal destruction of the molecules of a lubricant material. As the result of the action of high temperature the molecules of a chain-type oil decompose into shorter portions. As the result of their shorter length and lower molecular weight they acquire in vacuum an increased volatility and are almost completely removed from the pores of the powder metallurgy part. 4 refs.

Zozulya, V.D. (Acad of Sciences of the Ukrainian SSR, USSR); Prikhod'ko, V.G. *Sov Powder Metall Met Ceram* v 26 n 8 Aug 1987 p 675-677.

**Machining** See Also POWDER METALLURGY—Densification; POWDER METALLURGY—Iron; POWDER METALLURGY—Steel.

**084220 MACHINABILITY OF POWDER METALLURGY MATERIALS.** This paper reviews the prior research performed on the machinability of powder metallurgy (P/M) materials and describes recent related studies by the authors. Most of the P/M machining literature has been focused on the influence of additives on machinability. Little effort has been expended on studying the effects of porosity, machining parameters, cutting tool parameters and processing variables on the machinability of P/M parts and materials. This paper describes these effects based on tests using 304L stainless steel P/M materials. The poor machinability of these materials is related to the presence of porosity which affects their mechanical and physical properties. (Author abstract) 44 refs.

Agapiou, John S. (GM Technical Cent, Warren, MI, USA); DeVries, Marvin F. *Int J Powder Metall (Princeton NJ)* v 24 n 1 Jan 1988 p 47-57.

**084221 DRILLED HOLE QUALITY ASSESSMENT IN FERROUS PM COMPONENTS USING SURFACE INTEGRITY TECHNIQUES.** It is suggested that undue emphasis has been placed on tool wear and that the effects of machining on component integrity have not been fully appreciated. Surface integrity can be a more reliable means of assessing the geometric, topographical, and metallurgical characteristics of the machined component and of the machining operation as a whole. The mechanisms involved in drilling a PM product are discussed and it is suggested that hole quality can be linked to other forces generated while cutting and to the vibration that attends machining. Recommendations are made as to the best approach in alleviating these problems with regard to control over sintering conditions and drill shape/geometry. The powders used were Hoganas

ASC100.29 atomised powder (straight iron), Hoganas SNC100.24 sponge iron powder (sulphurised) and Mannesman Demag Fe-Ni-Mo atomised prealloyed powder. (Edited author abstract). 9 Refs.

Smith, G.T. (Inst of Higher Education, Southampton, Engl). *Powder Metall* v 31 n 2 1988 p 117-125.

**Magnetic Properties** See POWDER METALLURGY—Iron Silicon.

**Manufacture** See Also POWDER METALLURGY; POWDER METALLURGY—Federal Republic of Germany; POWDER METALLURGY—Iron; POWDER METALLURGY—Japan.

**084222 TOWER-BUFFER: A NEW CONCEPT TO INCREASE PRODUCTIVITY IN P/M PARTS MANUFACTURING.** A description is given of a tower buffer system for the automatic accumulation of output from compacting presses, automatic loading and retrieval from sintering furnaces, sizing and calibration, cleaning/washing, and packing and shipping. Experience with the concept in Europe suggests that improved productivity can be achieved through automation in handling. This results in improved plant integration, operational flexibility, and increased utilization of equipment. (Edited author abstract)

Miller, Jerry H. (North American Automation, Glen Ellyn, IL, USA). *Int J Powder Metall (Princeton NJ)* v 23 n 2 Apr 1987 p 127-128, 130-131.

**084223 P/M COMPONENT PRODUCTION - EXTENDING SHAPE CAPABILITY.** Inherent limitations of the traditional P/M route have tended to restrict certain types of product applications, but a wide range of developments outlined in this article are addressing and solving the problems. The various developments are categorized as follows: those involving manipulations (often minor) to what remains essentially the standard P/M route; those involving the use of isostatic pressure rather than axial compaction; those involving injection techniques; and those involving standard metal forming operations applied to preforms produced by conventional P/M compaction and sintering.

Whittaker, D. (GKN Technology Ltd, Wolverhampton, Engl). *Metallurgia* v 54 n 11 Nov 1987 p S1-S2, S4.

**084224 P/M INJECTION MOULDING EXTENDS PROCESS VERSATILITY.** One recognized disadvantage of P/M manufacture has been the restriction of design geometries mainly due to limitations inherent in the compaction/pressing stage. This article describes a new 'near-net-shape' forming method for sintered parts with intricate geometry. This process combines the advantages of P/M with those of plastic injection molding (offering great possibilities of design). An additional advantage lies in improved microstructural properties of MIM parts due to various process particularities which increase the total benefit that MIM-parts provide.

Poniatowski (Degussa AG, Hanau, West Ger); Will, G. *Metallurgia* v 54 n 11 Nov 1987 p S18-S19.

**084225 METAL INJECTION MOULDING BOOSTS P/M'S RANGE.** Metal injection molding is an emerging powder metallurgy technique which is applicable to the manufacture of small complex components. This technique, as outlined in this article, has proved to be cost-effective for the production of components which would otherwise have to be made by lost wax casting, machining or fabrication of more than one part. The technology's development has also included the successful manufacture of ceramic components. (Edited author abstract)

Case, L.W.J. (Rigby Metal Components Ltd, Cleckheaton, Engl). *Metallurgia* v 54 n 11 Nov 1987 p S20.

**084226 SHEEPBRIDGE PRODUCES A UNIQUE RANGE OF PM PRODUCTS.** Sheepbridge Sintered Products Ltd, part of the GKN PowderMet Division, is



one of the longest established PM companies in the UK. The friction materials manufactured by Sheepbridge Sintered Products are marketed under the tradenames 'Durasint' and 'Supasint'. Its expertise in this area has made it one of the UK's leading manufacturers of friction materials.

Weaver, Amanda (Metal Powder Report, Shrewsbury, Engl). *Met Powder Rep* v 43 n 1 Jan 1988 5p between p 7 and 14.

**084227 NATIONAL FORGE EUROPE—A LEADER IN HIGH PRESSURE TECHNOLOGY.** National Forge Europe, a subsidiary of the National Forge Company in the USA, has been building cold and hot isostatic presses at its St. Nikolaas facility in Belgium for over 20 years, and the company has in this period established itself as one of the leaders in this field. (Edited author abstract)

Williams, Bernard. *Met Powder Rep* v 43 n 2 Feb 1988 p 114-118.

**Measurements** See FLOWMETERS—Control; POWDER METALLURGY—Stainless Steel.

**Mechanical Properties** See PLASTICS—Injection Molding; POWDER METALLURGY—Aluminum Copper; POWDER METALLURGY—Aluminum Iron; POWDER METALLURGY—Aluminum Iron Alloys; POWDER METALLURGY—Aluminum Lithium; POWDER METALLURGY—Chromium; POWDER METALLURGY—Chromium Compounds; POWDER METALLURGY—Compacting; POWDER METALLURGY—Copper; POWDER METALLURGY—Copper Zinc Alloys; POWDER METALLURGY—Densification; POWDER METALLURGY—Injection Molding; POWDER METALLURGY—Iron; POWDER METALLURGY—Nickel; POWDER METALLURGY—Stainless Steel; POWDER METALLURGY—Steel; POWDER METALLURGY—Titanium; POWDER METALLURGY—Titanium Aluminum Vanadium; POWDER METALLURGY—Titanium Chromium; POWDER METALLURGY—Titanium Cobalt Alloys; POWDER METALLURGY—Tungsten; POWDER METALLURGY—Tungsten Nickel Iron Alloys; POWDER METALLURGY—Tungsten Rhenium Alloys; POWDER METALLURGY—Zirconium; REFRACTORY MATERIALS—Zirconia.

## Melting

**084228 MELTING POWDER PARTICLES IN A LOW-PRESSURE PLASMA JET.** A numerical model has been developed to predict the temperature history of metal particles injected in a low-pressure (supersonic) d-c plasma jet. The temperature and velocity fields of the plasmajet are predicted by solving the parabolized compressible Navier-Stokes equations using a spatial marching scheme. Particle trajectories and heat transfer characteristics are calculated using the predicted plasma jet temperature and velocity fields. Correction factors have been introduced to take into account the noncontinuum effects encountered in the low-pressure environment. The plasma jet profiles as well as the particle/plasma interactions under different jet pressure ratios (from underexpanded to overexpanded cases) have been investigated. (Author abstract) 27 refs.

Wei, D.Y.C. (Drexel Univ, Philadelphia, PA, USA); Farouk, B.; Apelian, D. *J Heat Transfer Trans ASME* v 109 n 4 Nov 1987 p 971-976.

**Microstructure** See POWDER METALLURGY—Reviews.

**Models** See POWDERS—Forging.

**Nickel** See PROTECTIVE COATINGS—Powder.

**Nondestructive Examination** See Also CARBON STEEL—Nondestructive Examination.

**084229 MAGNETIC INSPECTION PARAMETERS OF CERMET PLATES CONTAINING COBALT.** The possibility of nondestructive inspection is discussed for the faces of cermet plates made from type TSK10 alloy according to the normal component of the residual field that is produced by magnetizing an object with an electromagnet that has a rod-type core. There is shown to be a relationship between the residual field and the magnetic characteristics of the material. (Author abstract)

10 refs.

Tabachnik, V.P. (Acad of Sciences of the USSR, USSR); Chernova, G.S.; Fedorishcheva, E.E.; Turetskii, Ya.Sh. *Sov J Nondestr Test* v 23 n 7 Jul 1987 p 463-467.

**Optical Properties** See FILMS—Dielectric.

**Oxidation** See Also POWDER METALLURGY—Titanium Compounds.

**084230 EFFECT OF 5-20 WT.-% CHROMIUM ADDITION ON THE OXIDATION BEHAVIOUR OF NICKEL-COBALT-THORIUM OXIDE COMPOSITES AND STUDY OF THE OXIDE SCALES.** Ni-Co-ThO<sub>2</sub> composites prepared by a coprecipitation method have been studied under air oxidation conditions between 800 and 1000°C. Thermogravimetry showed slight but continuous oxidation of the material. The effect of 5-20% chromium powder additions to the base powder mixture was studied. The results demonstrated significant decreases in oxidation rate, starting from 10 wt.-% chromium addition while efficient protection was obtained from 15 wt.-% by formation of a Cr<sub>2</sub>O<sub>3</sub> scale. Polarized light microscopy studies, as well as scanning electron microscopy, coupled with x-ray emission microanalysis and x-ray diffraction, enabled qualitative analysis of the different zones distinguished inside the oxide scale. This led to the establishment of an oxidation mechanism related to the chromium content. (Author abstract) 15 refs.

Ghods, M. (Univ Libre de Bruxelles, Brussels, Belg); Beatse, T.; Geuens, C. *React Solids* v 4 n 1-2 Oct 1987 p 41-51.

**084231 HIGH TEMPERATURE OXIDATION AND CRYSTALLOCHEMICAL INTERACTION OF THE Kh18Ni10-SiC-SiO<sub>2</sub>-Al<sub>2</sub>O<sub>3</sub> SYSTEM DURING HEAT TREATMENT.** Methods of structural (x-ray diffraction and electron diffraction), petrography, and x-ray spectrum microanalysis and metallographic examination were used to study the products of interaction in sintering powder mixtures of Kh18Ni10 corrosion-resisting steel, quartz, carborundum and alumina in oxidizing media (air, vacuum 0.013 Pa) in a wide temperature range (1100-1500°C) and holding times (up to 50 h). It is shown that in addition to oxidation of the component of the mixture as a result of diffusion and crystallochemical interaction, spinel phases also form; these phases protect the metallic component of the mixture against complete oxidation, and the method of production of the cermet (cold compacting or hot extrusion) and the form and dimensions of the specimens (cylindrical or flat, thin or thick) exert a strong effect on the phase composition of the final product. (Author abstract) 20 refs.

Kovneristiy, Yu.K.; Kornilova, Z.I.; Lazareva, I.Yu.; Lazarev, E.M. *Phys Chem Mater Treat* v 21 n 5 Sep-Oct 1987 p 518-523.

**Performance** See POWDER METALLURGY—Dispersion Hardening.

**Physical Properties** See POWDER METALLURGY—Stainless Steel.

**Plasticity** See POWDER METALLURGY—Copper Niobium Alloys.

**Porosity** See Also POWDER METALLURGY—Iron; POWDER METALLURGY—Sintering; POWDER METALLURGY—Titanium.

**084232 POROUS STRUCTURE PARAMETERS OF PERMEABLE POWDER MATERIALS.** For the control and optimization of the technological parameters for the manufacture of porous powder materials and products as well as forecasting their performance characteristics, various methods for the determination of their porous structure parameters are used. One of the most objective properties which characterize porous materials is the pore size distribution. In the model constructed by considering the liquid displacement kinetics, the relationship of molar viscosity to porosity of the material and the

pore blocking effect permits one to increase the reliability and accuracy of determination of the parameters in powder materials. 8 refs.

Kryuchkov, Yu.N. (Ukrainian Scientific-Research Inst of the Porcelain & Earthenware Industry, USSR). *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 594-599.

## Processing

**084233 THEORY OF THERMAL DEBINDING.** The process of removing a binder from a powder compact using heat is modeled for diffusion control, permeation control, and fluid wicking. The time for binder removal is minimized by using large particle sizes, thin compact sections, high compact porosity, high temperatures and large pressure gradients. The models are assessed by calculations for water as an ideal binder. (Edited author abstract) 23 refs.

German, Randall M. (Rensselaer Polytechnic Inst, Troy, NY, USA). *Int J Powder Metall (Princeton NJ)* v 23 n 4 Oct 1987 p 237-245.

**084234 DEVELOPMENT ACTIVITIES CONCERNING HIGH-SPEED HIP.** The following article describes the development of a high-speed hot isostatic pressing system which allows a full pressure cycle in as little as 5 minutes and with loads changing using a 'liquid load modular furnace' taking less than 30 seconds. The system uses a specially constructed liquid argon Dewar located above the modular furnace and rapid pressurization is attained by applying power to the electrical heaters in the Dewar. (Edited author abstract) 2 refs.

Conaway, Robert M. (Conaway Inc, Dublin, OH, USA). *Met Powder Rep* v 43 n 2 Feb 1988 p 119-122.

**084235 NEW ATOMIZATION PROCESS AND THE PROPERTIES OF THE POWDER.** Newly, powders of controlled shape from irregular to spherical with low oxygen content can be produced by a new atomization process utilized mineral oil for atomizing medium. Characteristics of this oil atomized powders are as follows: low alloy steel powders have high compressibility and sintered low alloy steels have high tensile strength and toughness owing to low oxygen content; high alloy steel powders have finer and uniform microstructure by high cooling rate at atomization. Microstructure of high speed steel shows small and uniformly distributed carbide particle, and the high speed steel have high tensile strength and toughness, while keeping the level of hardness. (Author abstract) 17 refs.

Yoshinaga, Hisashi; Nakanishi, Mutsuo; Kubo, Toshihiko; Fukuda, Tadashi; Hamazaki, Atsushi. *Sumitomo Met* v 40 n 1 Jan 1988 p 61-70.

**Production** See POWDER METALLURGY—Iron.

**Purification** See POWDER METALLURGY—Purification.

## Quality Assurance

**084236 COST OF QUALITY.** Over the past decade there has been an increasing emphasis on total quality assurance programs in the U.S. The impetus for this emphasis on quality originated with the automotive industry's response to increased competition from Japanese manufacturers. The Japanese competitive edge was based almost solely on quality. In the early and mid 1980's the push for quality in the powder metal industry came from customers in the form of mandated statistical process control (SPC) programs. The intent of this article is to stress the measuring of quality costs as a tool for evaluating the SPC program. A simple definition of quality costs is all costs relating to or resulting from making defective products. In reality, these are costs of not having quality.

Meek, Gary E. (Univ of Akron, Akron, OH, USA); Dunning, Kenneth A. *Carbide Tool J* v 20 n 4 Jul-Aug 1988 p 20-22.



Reliability See AIRCRAFT MATERIALS—Light Metals.

Solidification See Also POWDER METALLURGY—Aluminum.

**084237 DYNAMIC CONSOLIDATION OF RAPIDLY SOLIDIFIED POWDERS.** Rapid solidification processing (RSP) holds promise for producing engineering alloys with refined microstructures, improved chemical homogeneity, extended solute solubility, and possible retention of metastable phases. Dynamic consolidation can be an attractive alternative to conventional methods for temperature-sensitive materials. Some potential advantages are relatively low bulk temperatures; nearly random crystallographic texture in the product; near-neighbor retention during densification, which may allow forming of composites or dispersion-strengthened materials from powders; shock hardening, which may be useful for wear-resistant applications; and the possibility of deformation-induced phase transformations. The article briefly reports on work with Type 304 stainless steel. 2 refs.

Wright, R.N. (EG&G Idaho, Idaho Falls, ID, USA); Korth, G.E.; Flinn, J.E. *Adv Mater Processes* v 132 n 4 Oct 1987 p 56-59.

## Stresses

**084238 SINTERING STRESS OF HOMOGENEOUS AND HETEROGENEOUS POWDER COMPOSITES.** The thermodynamic meaning of the sintering stress is considered for some simple 2-dimensional porous bodies. The sintering stress acts as an effective mean grain boundary stress and can thus be combined with applied stresses. The sintering stress cannot be described in rigorous thermodynamic terms, especially for heterogeneous composites. Simplifications allow one to assess the effects of some microstructural heterogeneities, including the presence of large pores or dispersed second phases on the sintering stress. (Author abstract) 17 refs.

De Jonghe, L.C. (Lawrence Berkeley Lab, Berkeley, CA, USA); Rahaman, M.N. *Acta Metall* v 36 n 1 Jan 1988 p 223-229.

Superalloys See POWDER METALLURGY—Federal Republic of Germany.

Testing See POROUS MATERIALS—Computer Aided Analysis.

## Thermal Conductivity

**084239 HEAT CONDUCTIVITY AND THERMAL DIFFUSIVITY OF HARD ALLOYS OF THE TK TYPE AT ELEVATED TEMPERATURES.** Alloys of the tungsten carbide-titanium carbide-cobalt system (TK alloys) are used in production of tools for metalworking. The aim of this work was to determine the thermal diffusivity of T15KX (mass content of cobalt X = 1.5, 6, 10, 15%) and T20KX (X = 4, 6, 12, 15, 20%) alloys with various amounts of the binding phase. Thermal diffusivity was measured in the temperature range 800-1500°K. The differences in the heat conductivity values determined by experiments and calculated on the basis of the measured heat conductivities of the phase components are caused mainly by differences in the composition of the Co phase and the (Ti, W)C phase of real alloys in relation to the model used for the calculations. 7 refs.

Emel'yanov, A.N. (Acad of Sciences of the USSR, USSR); Tumanov, V.I. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 749-754.

## Wear

**084240 WEAR-RESISTANT POWDER MATERIALS WITH INTERMETALLIC PRECIPITATION HARDENING. II. WEAR-RESISTANT POROUS MATERIALS.** The authors obtained an analytical expression determining the dependence of hardness on the porosity and chemical composition for alloys subjected to precipitation hardening and containing various amounts of alloying elements. They investigated the wear resistance

of the alloys under conditions of dry friction ( $P = 150$  N,  $v = 1$  m/sec). With increasing porosity wear increase parabolically, and with increasing content of AE it decreases parabolically. Aging effects were also studied. 8 refs.

Karapetyan, G.Kh. (Erevan Polytechnic Inst, USSR); Akopov, N.L.; Karapetyan, F.Kh.; Manukyan, N.N. *Sov Powder Metall Met Ceram* v 26 n 5 May 1987 p 421-424.

**084241 WEAR RESISTANCE OF PM Fe-Cu-C MATERIALS CONTAINING STEEL-TiC PARTICLES.** Composite materials with an Fe-Cu-C matrix including steel-TiC particles were made by sintering mixtures containing Fe, Cu and graphite powder and steel-TiC particles between 125 and 1000 microns and infiltrating with copper. The abrasion resistance of these composites was studied using the ASTM B611 method. The results show that the addition of steel-TiC particles does not always improve the wear resistance of the Fe-Cu-C matrix and that the maximum improvement in wear resistance was about 25%. The results are compared to results obtained elsewhere on the abrasion resistance of composites made of a PM steel matrix containing WC-Co cermet particles. 3 refs.

Chagnon, F. (Quebec Metal Powders Ltd, Tracy, Que, Can); Angers, R.; Fiset, M. *Int J Refract Hard Met* v 7 n 1 Mar 1988 p 29-33.

Welding See WELDING, GAS—Superalloys.

## Wetting

**084242 DETERMINATION OF THE PORE SIZES OF PERMEABLE METALLIC MATERIALS BY THE LIQUID DISPLACEMENT METHOD.** Contact angles were determined by the sessile drop method and capillary rise method. Contact angle determinations by the capillary rise method were made, on porous specimens from BrOF10-1 bronze, titanium, and Kh18N15 corrosion-resistant steel powders. Measurements made by the sessile drop method established that iron, nickel, the corrosion-resistant steel, copper, bronze, and titanium were wetted completely by acetone, gasoline, and ethanol and partially by distilled water. This result is linked mainly with the free surface energy of the liquids investigated. It is therefore possible to employ these data in pore size determinations by the Barus-Beghold method. Thus, for ethanol with alcohol content not less than 96.2 wt. % and density  $0.807 \text{ g/cm}^3$  at  $t = 20^\circ\text{C}$  and  $P = 0.1 \text{ MPa}$  the surface tension is  $22.8 \text{ mJ/m}^2$ . 14 refs.

Lunin, L.E. (Acad of Sciences of the Ukrainian SSR, USSR); Kostornov, A.G.; Glushchenko, A.S.; Kolesnikchenko, G.A. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 721-724.

X-Ray Analysis See NICKEL AND ALLOYS—Amorphous.

**POWDER METALLURGY** See Also ALUMINUM ZINC MAGNESIUM ALLOYS—Corrosion; CERAMIC MATERIALS—Hot Pressing; COMPOSITE MATERIALS—Wear; EVAPORATION—Laser Applications; FURNACES, ELECTRIC; INTERMETALLICS; IRON TITANIUM ALLOYS—Physical Properties; METALS AND ALLOYS—Injection Molding; METALS AND ALLOYS—Metallic Matrix Composites; PAINTING; PLASMAS—Mathematical Models; POWDER METAL PRODUCTS—Manufacture; PROTECTIVE COATINGS—Wear; SOLDERING—Materials; TUNGSTEN CARBIDE—Processing.

**084243 MICROSTRUCTURE AND MECHANICAL PROPERTIES OF THE DISPERSION-HARDENED P/M Al-10% Mn AND Al-10% Mn-2.5% Si ALLOYS.** On two dispersion-hardened P/M Al-alloys, Al-10 wt.% Mn and Al-10 wt.% Mn-2.5 wt.% Si, tensile tests, fatigue tests and fatigue crack propagation tests were performed. The yield stress is mainly controlled by the spacing of the dispersoids, while the true fracture strain is dominated by a certain fraction of the powder particles, in which large precipitates have developed leading to early crack nucleation. When testing in air at  $200^\circ\text{C}$ , a significant ductility reduction in the ternary alloy was observed due to environmental effects. Compared to ingot alloys a good

high-cycle fatigue strength was found. (Edited author abstract) 11 refs.

Terlinde, Gregor (GKSS-Forschungszentrum, Geesthacht, West Ger); Peters, Manfred; Luetjering, Gerd; Williams, James C. *Z Metallkd* v 78 n 8 Aug 1987 p 607-612.

**084244 RHEOLOGICAL CHARACTERISTICS OF SPHERICAL NICKEL AND STAINLESS STEEL POWDERS.** Published information on the internal and external friction characteristics of spherical metal powders is scant. It was therefore considered of interest to study these characteristics and their variation with fractional composition, using, as examples, atomized nickel (PSN) and 18% Cr-9% Ni stainless steel (PRKh18N9) powders. The method of determining rheological characteristics consists in calculating the force necessary to disintegrate a specimen of a free-flowing material by sliding on a surface, with the simultaneous measurement of the normal compressing load. In this work internal friction testing was preceded by the assembly of the shear unit of the apparatus. A comparative analysis of our results for the various powders from the point of view particle size and morphology indicates that it is the latter factor that exerts a dominant influence on the internal friction of such powders. 6 refs.

Andrievskii, R.A. (Acad of Sciences of the Kirgiz SSR, USSR); Levin, V.P. *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 299-302.

**084245 FRICTION IN METAL POWDERS.** A technique for measuring interparticle friction has been developed. It employs the concept of sliding a powder monolayer of nearly equal size particles against a flat surface of finite surface roughness and measuring both the normal and shear forces. This paper describes the technique, test equipment, and a novel method for measuring the total number of contact points at the sliding interface. Data measured by this technique show a dependence of the coefficient of friction on both the particle size and normal load and predicts a Hertzian elastic contact at the sliding interface. The data also show that the coefficient of friction of coated powder monolayers depends on lubricant film thickness in a manner similar to that of coated bulk surfaces. (Author abstract) 20 refs.

Amin, Kamal E. (Norton Co, Northboro, MA, USA). *Int J Powder Metall (Princeton NJ)* v 23 n 2 Apr 1987 p 83-93.

**084246 POWDER METALLURGY AT THE TURN OF THE NEW CENTURY.** The author examines the powder metallurgy industry in the 21st century. According to this forecasting, by the year 2000 the American P/M parts industry will probably consist of less than its present number of companies. Consolidation will be the key to survival; however, those remaining will be turning over more than double the dollar volume they are today. About 10% of American P/M companies will be foreign-owned or controlled.

Roll, Kempton H. (Metal Powder Industries Federation, Princeton, NJ, USA). *Int J Powder Metall (Princeton NJ)* v 23 n 4 Oct 1987 p 271-276.

**084247 DEVELOPMENTS IN GAS ATOMISATION AND SPRAY DEPOSITION.** The extensive development work on gas atomisation and spray deposition done at MIT and in other laboratories has made possible the production of rapidly solidified powders and compacts of selected sizes for a broad range of alloys, with improved structures and properties. There are however issues that remain to be addressed, such as the fluid dynamics and heat transfer mechanisms during atomisation and deposition, the extent of oxide contamination during deposition and the optimisation of the numerous process parameters in order to get the best material properties at maximal economic efficiency. The present



report summarises the progress made in investigating the above mentioned processing issues over the past years, based on studies undertaken mostly at MIT. 52 refs.

Lavernia, E.J. (MIT, Cambridge, MA, USA); Baram, J.C.; Grant, N.J. *Met Powder Rep* v 42 n 10 Oct 1987 p 688, 690-692, 694-695.

**084248 PULVERMETALLURGIE HOCHSCHMELZENDER METALLE - WERKSTOFFBEISPIELE AUS DER ELEKTROTECHNIK.** [Powder Metallurgy of High-Melting Metals - Examples from Electrical Engineering]. The importance of powder metallurgy as a manufacturing method for special materials on the basis of high-smelting metals used in electrical engineering is discussed. Attention is focused on powder metallurgical methods of producing materials on the basis of molybdenum and tungsten, as well as on the basis of chromium, molybdenum, and tungsten. In German. 8 refs.

Kalning, Ilgwar (Akad der Wissenschaften der DDR, Dresden, East Ger). *Neue Huette* v 32 n 9 Sep 1987 p 334-339.

**084249 POWDER CASTING AND METAL INJECTION MOLDING.** Metal injection molding is used to make small, highly configured, high density parts from extremely fine metal powders. Powder casting a newly developed process that overcomes the size limitation problem of the technique. The author outlines the development of the process and its potential in the production of large, complex shapes. (Edited author abstract) 5 refs.

Sjoberg, Goran (ASEA Metallurgy, Vasteras, Swed). *Met Powder Rep* v 42 n 11 Nov 1987 p 787, 789, 791.

**084250 MPR UPGRADES COMPUTER PROGRAM FOR PM MATERIALS SELECTION.** In March 1986 MPR launched the first version of its 'PM Ferrous PM Materials Selector', a computer program based on expert systems which allowed users to find a suitable iron-base PM material to meet their particular specification. The updated version of the 'MPR Structural PM Materials Selector' contains over 400 sets of data on individual PM materials produced in Europe, North America and Japan, including the chemical composition of each material and remarks concerning applications. Also included are heat treated properties. The expanded range of PM materials in the system covers Fe, Fe-C, Fe-Cu-C, Fe-P, Fe-Cu-P, Fe-Cu-Ni, Fe-Ni, Fe-Ni-Mo-Cu, Fe-Mn-Cr, high alloy steels, infiltrated steels, stainless steels, powder forged steels, injection molded PM materials, brass, bronze, nickel silver, and aluminum alloys. (Edited author abstract)

Anon. *Met Powder Rep* v 42 n 11 Nov 1987 p 805-806.

**084251 NEW NUMBER BASED EXPRESSION AND VARIOUS MEAN PARTICLE DIAMETERS FOR ROSIN-RAMMLER DISTRIBUTION.** The Rosin-Rammler distribution is used as a particle size distribution function for its good applicability. The results are summarized as follows: New number based approximate equation is at least ten times more accurate for the expression of the modified Rosin-Rammler distribution. The equations for the calculation of the various mean particle diameters of the distributions are tabled in Table 3. The various mean particle diameters can be also calculated in the cases of classification and blending of the powders, having the distributions. The present results are also applicable to other distributions such as grain, pore sizes, etc. (Author abstract) In Japanese. 8 refs.

Itoh, Takashi (Nagoya Univ, Nagoya, Jpn); Wanibe, Yoshimoto; Sakao, Hiroshi. *Nippon Kinzoku Gakkaishi* v 51 n 10 Oct 1987 p 956-964.

**084252 'HEALING' OF AN ISOLATED PORE SURROUNDED BY A LOCALIZED STRESS GRADIENT FIELD.** This article presents the results of experiments carried out with the aim of observing the influence exerted by a stress gradient on the healing kinetics of an isolated pore. A stress gradient was set up in cylindrical capillaries made of an iron-nickel alloy (hypodermic syringe needles). The experiments were

conducted at 1000-1200°C. Using the results of experiments conducted at various temperatures, the authors found that the activation energy for the process is about  $1.2 \cdot 10^{-19}$  J. 6 refs.

Boiko, Yu.I. (Kharkov Univ, USSR); Geguzin, Ya.E.; Kupina, I.N. *Sov Powder Metall Met Ceram* v 26 n 5 May 1987 p 363-366.

**084253 METAL INJECTION MOLDING EXPERIENCE AT P/M PLANT.** Metal Injection Molding (M.I.M.) is a newly emerging metal working technique which should be especially applicable to small, highly configured, complex metal parts. The process uses very fine, spherical metal particles which are mixed with organic binders and the fluid mixture injected into molds. After setting up in the molds, the part is removed, the binders removed, usually by thermal decomposition, and the resulting metal part is then sintered at high temperature to bond the particles and shrink the structure to near full density. The advantage of the process is its ability to make more complex shapes with the third axis capability than conventional P/M and probably will find its greatest initial market competing with investment castings. The techniques, the properties and microstructures obtained are described.

Anon (Handy & Harman Co, USA). *Ind Heat* v 55 n 1 Jan 1988 p 18, 20.

**084254 MECHANISM OF DEFORMATION AND DISINTEGRATION OF A MOVING DROP.** Now the disintegration of a moving drop in a stationary medium (a liquid) is preceded by its deformation, first into an ellipsoid and then a disk, which finally breaks up in a miniature explosion into smaller droplets. The deformation is accompanied by oscillations about the center of gravity of the drop. The mechanism of disruption is studied numerically. The most probable cause of the explosive character of the break-up of a drop are its resonant vibrations. 15 refs.

Sosnin, V.P. (Chelvabinsk Scientific-Research Inst of Metallurgy, USSR); Kopyrin, I.A.; Filimonov, S.G. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 515-518.

**084255 LA METALLURGIE DES POUDRES ET SON ROLE DANS LE DEVELOPPEMENT DE NOUVEAUX MATERIAUX.** [Powder Metallurgy and Its Role in the Development of New Materials]. The first part of the article describes briefly the different processes of the powder metallurgy. Subsequently, the contribution of the powder metallurgy on the development of new materials is illustrated by several examples of materials recently brought into use. These examples are taken from the domains of magnetic, electric and composite materials, materials reinforced by dispersion, alloys produced by rapid solidification and biomaterials. (Translated author abstract) In French. 12 refs.

Angers, Roch (Univ Laval, Ste-Foy, Que, Can). *New Metall Mater and New Fabr Processes* Publ by Natl Research Council Canada, Ottawa, Ont, Can p 6.0-6.32.

**084256 COMPOSITE ENGINEERING BY HOT ISOSTATIC PRESSING.** During the last five years H.I.P. Ltd has recruited a development team to extend the application of HIP processing. Responding to a continued interest in the use of HIP for powder densification and dissimilar material bonding, a separate sister company Infutec Ltd. was formed in April 1987. The current range of activities for both companies are broad but three specific areas of development have emerged and are described.

Anon. *Met Powder Rep* v 43 n 4 Apr 1988 p 270.

**084257 CERAON PROCESS READY TO SHAPE THE FUTURE.** The term 'Ceracon' is an acronym for 'ceramic granular consolidation' and is essentially a quasi-isostatic method of consolidation which has been developed by Ceracon Inc. in Sacramento, Calif. The secret of the process is the pressure transmitting medium (PTM) which transfers the force of the press to the preformed part. The PTM, a graphite or ceramic grain or

a mixture of both, is heated until it glows red at which temperature it exhibits properties similar to those of gases used in a hot isostatic press. By burying the preform or containerised powder in the PTM and applying high pressure at temperature in a conventional hydraulic press, the consolidation cycle at temperature is reduced to only 0.5 to 30 seconds as compared to many hours in HIP and the process allows a predictable shape control over the finished components for the production of near-net shapes. The process can be used to fabricate ceramic superconductors.

Anon. *Met Powder Rep* v 43 n 4 Apr 1988 p 272-273.

**084258 METAL INJECTION MOLDING: THE INCUBATION IS OVER.** Metal injection molding (MIM) was introduced to the P/M community nearly twenty years ago. Since that time, there has been a relatively slow growth in terms of application to parts making. In this article, the author examines the underlying reasons for this disappointing record and cites emerging factors that are expected to turn MIM into a viable component of the P/M industry within five years. (Edited author abstract)

Pease, Leander F. III (Powder-Tech Associates Inc, North Andover, MA, USA). *Int J Powder Metall (Princeton NJ)* v 24 n 2 Apr 1988 p 123-127.

**084259 POWDER METALLURGY INDUSTRY CHALLENGES AND OPPORTUNITIES IN THERMAL PROCESSING AND APPLICATIONS.** The utility of powder metallurgy and needs for thermal processing and production of quality parts for many applications are described. These products comprise different metals formed by different techniques, such as compacting and sintering, hot isostatic pressing, cold isostatic pressing, metal injection molding, spray forming, extrusion, direct powder rolling and consolidation by atmospheric pressure. Technology developments in the automotive industry, a forming and sintering are described. It is shown how P/M parts are replacing conventional metals. Continued growth for the P/M industry is forecast.

Johnson, Peter K. (Powder Metallurgy Equipment Assoc, Princeton, NJ, USA). *Ind Heat* v 55 n 5 May 1988 p 12-13.

**084260 MATERIALS & TECHNOLOGY FOR THE P/M INDUSTRY.** The company Jorn Sandberg Ronne ApS in cooperation with Riso and the Technological Institute Metallurgy has developed a kiln for controlled expulsion of organic additives from ceramic objects. The kiln allows firing in a controlled atmosphere such as atmospheric air, O<sub>2</sub>, and vacuum or expulsion in an inert atmosphere such as argon and N<sub>2</sub>. It is possible to establish a vacuum down to  $-10^{-4}$  bars.

Vago, F. (Teknologisk Inst, Den). *Powder Metall Int* v 20 n 3 May 1988 p 51-52.

**084261 COMPLEX COMPONENTS VIA 'NEW' TECHNIQUES.** Powder metallurgy is not a new process. It owes its origins to the invention, in the early 1900s, of tungsten lamp filaments. But recently there has been a growth in the versatility of the process as a result of new ways of compacting the powder forms. Several of the methods are adaptations of techniques in use with other manufacturing processes. This article outlines some of them.

Kellock, Brian. *Mach Prod Eng* v 146 n 3737 Apr 20 1988 5p.

**084262 VERFAHREN ZUR HERSTELLUNG MIKROKRISTALLINER ODER AMORPHER METALLPULVER.** [Methods of Producing Microcrystalline or Amorphous Metal Powders]. Metal alloys of microcrystalline or amorphous structure are produced by rapid cool-down from the melt. Atomization of metal melts with a high-energy inert gas jet is one of the most economical methods of producing high-quality powders. Using helium as process gas in powder particles of approximately 20 microns in diameter, the microstructure is similar to



that of strip and foil produced on water-cooled copper substrates. Due to their unsuitable shapes, materials produced by melt spinning or melt extraction have to be comminuted to fine metal powder with a uniform particle shape before these materials can be compacted to larger size blanks. The fluidized-bed counterflow jet mill enables brittle, rapidly chilled metal alloys to be optimally processed to a powder with narrow particle size distribution and high purity. (Author abstract) In German. 24 refs.

Joensson, S. (Leybold AG, Hanau, West Ger); Hohmann, M. *Metal* v 42 n 5 May 1988 p 475-480.

**084263 EXAMINATION OF PREGREEN SPECIMEN PROCESS.** The isostatic powder process used at present is based on a procedure in which an elastic (reusable) or a plastic (disposable) mould is filled with powder, possibly with a few per cent of binder and/or lubricant added. The mould is closed and its contents pressed isostatically into green specimens. The pregreen specimen process combines the core making process used in the foundry industry with the conventional isostatic powder process. Powder specimens are produced in a pregreen specimen mould (core box). Experiments were carried out to determine the most suitable binder for the pregreen specimen process. The following were included: phenolic resin + polyisocyanate + triethylamine (cold box); sodium silicate +  $\text{CO}_2$  wax; and water (ice).

Huusmann, O. (Technological Inst of Copenhagen, Copenhagen, Den). *Powder Metall* v 31 n 2 1988 p 90-93.

**084264 ECONOMIC EVALUATION OF PREGREEN SPECIMEN PROCESS.** The pregreen specimen process has the potential to replace casting in certain instances and could also be useful in new areas of production. An economic comparison with the sand mould casting process is presented. Economically the process is comparable with sand casting. The cost considerations were based on production of pulleys in gray iron.

Kraemer, O. (Technological Inst of Copenhagen, Copenhagen, Den). *Powder Metall* v 31 n 2 1988 p 93-95.

**084265 POWDER METALLURGY.** This conference proceedings contains 13 papers covering the following topics: high performance materials made by powder metallurgy; tungsten carbide-cobalt powders recycled by the zinc process; recent developments in new ceramic materials; production of water- and gas-atomized powders; purification of metal powders; ultrasonic gas atomization; use of tin and cobalt as alloying elements in powder metallurgy; metal injection molding; fabrication of sintered parts of intricate geometry; aluminum powder metallurgy; superconducting materials from niobium-titanium powders; and current lead powder applications. All papers are abstracted and indexed separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10639 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Benelux Metallurgie). *ATB Metall* v 27 n 2-3 1987. *Powder Metall*, Brussels, Belg, May 13-14 1987 p 42-121.

**084266 ON SOME PROPERTIES OF WC-Co POWDERS RECYCLED BY THE ZINC PROCESS.** This article discusses experimental results of work in progress on the properties of cemented carbides sintered from powders recycled by the zinc process. It is shown that the use of large amounts of powders recycled by the zinc process in the preparation of sintered material do not affect the mechanical properties (bending and compressive strength) at all for a 50% recycled/50% virgin blend material, and has small effects in the case of 100% recycled parts. On the other hand, the recycled containing samples have a better wear-shock resistance in simulated mining drill conditions. The differences in properties are due to structural effects such as porosities present and mean grain size of the carbides. 3 refs.

Totolids, D. (CRM, Liege, Belg); Diderrich, E.; Magnee, A.; Trachte, J.P.; Boisot, P. *ATB Metall* v 27 n 2-3 1987. *Powder Metall*, Brussels, Belg, May 13-14 1987 p 61-67.

**084267 PRODUCTION OF WATER AND GAS ATOMIZED POWDERS.** A metal powder can be produced in a large number of different ways. For alloys, the choice is mainly between gas and water atomization. The manufacturer must find out how to produce the powder in the most economical way. Depending on alloy composition, required cleanliness with respect to various elements and inclusions, particle shape, sieve fraction and production volume he can select the proper raw materials, melting procedures, atomizing process and handling methods. The paper gives a comparison of costs for different powder processing routes. (Edited author abstract)

L'Estrade, Leif (Hoganas AB, Hoganas, Swed); Hallen, Hans. *ATB Metall* v 27 n 2-3 1987. *Powder Metall*, Brussels, Belg, May 13-14 1987 p 77-80.

**084268 PROS AND CONS OF ULTRASONIC GAS ATOMIZATION.** Various types of nozzle systems have been developed for the inert gas atomization technique in order to reduce the gas consumption and to increase the yield of fine powder. This report compares the results obtained with a conventional confined nozzle design and an ultrasonic designed nozzle system. Trials with cobalt base and aluminum base alloys, carried out with an optimized conventional Leybold-Heraeus nozzle, are discussed with published results of ultrasonic gas atomized powders. Experiments showed that the production of fine powder with a particle size below 50  $\mu\text{m}$  and optimal particle shape is possible with both techniques. (Edited author abstract) 7 refs.

Hohmann, M. (Leybold-Heraeus GmbH, Hanau, West Ger); Joensson, S. *ATB Metall* v 27 n 2-3 1987. *Powder Metall*, Brussels, Belg, May 13-14 1987 p 85-87.

**084269 1986 ANNUAL POWDER METALLURGY CONFERENCE PROCEEDINGS.** This conference proceedings contains 58 papers. Some of the subjects covered are intermetallics, metal matrix composites, liquid dynamic compaction, injection molding, controlled porosity, reducing atmospheres, sintering, mechanical properties, lubricants, infiltration, rapid solidification, embrittlement, wear resistant coatings, statistical process control, plasma processing, gas atomization, spray deposition, applications and marketing. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10967 in the Ei Engineering Meetings (TM) (database produced by Engineering Information, Inc).

Carlson, Earl A. (Compiler); Gaines, Gary (Compiler). *Prog Powder Metall* v 42, 1986 Annu Powder Metall Conf Proc, Boston, MA, USA, May 18-21 1986. Publ by Metal Powder Industries Federation, Princeton, NJ, USA, 1986 807p.

**Alumina** See Also ALUMINA—Coatings.

**084270 SOME PROPERTIES OF  $\text{Al}_2\text{O}_3$ -SiC SINTERED COMPACT.** The microstructure, density, transverse rupture strength of  $\text{Al}_2\text{O}_3$ -SiC ceramics prepared by hot-pressing at 2123 K have been studied. The particle size of starting powders were varied in the range of 0.3-3.0  $\mu\text{m}$ . Strength affected by microstructural defects acting as fracture sources. The  $\text{Al}_2\text{O}_3$ -(25-30) vol percent SiC ceramics, when the required microstructure was obtained by a suitable combination of particle size showed TRS as high as about 1 GPa or more. The strengthening mechanism is discussed in detail. (Edited author abstract). 4 Refs. In Japanese.

Katsumura, Yuji; Kobayashi, Masaki; Kobori, Keichi; Suzuki, Hisashi. *J Jpn Soc Powder Powder Metall* v 35 n 3 Apr 1988 p 137-141.

**Aluminum** See Also ALUMINUM AND ALLOYS—Dispersion Hardening; ALUMINUM AND ALLOYS—Fiber Reinforcement; ALUMINUM AND ALLOYS—Internal Friction; ALUMINUM AND ALLOYS—Solidification; CERAMIC MATERIALS—Surfaces; POWDERS—Production.

**084271 MICROSTRUCTURE AND BONDING OF**

**DYNAMICALLY CONSOLIDATED ALUMINUM AND Al-1.4Co POWDERS.** The mechanism of interparticle bonding and the extent of thermal modification of the microstructure are examined for aluminum and Al-1.4Co powders (where the composition is in approximate weight percent) consolidated at ambient temperatures and  $-50^\circ\text{C}$  using explosives. Dynamically consolidated material with substantial tensile strength is obtained without significantly altering the fine-precipitate microstructure in the Al-1.4Co. The primary bonding mechanism is localized interparticle melting associated with regions of particle extrusion and extensive plastic flow. Defect substructures show extensive recovery in the as-consolidated material resulting directly from the consolidation process rather than from post-consolidation annealing from heat retained in the fixtures. (Author abstract) 21 refs.

Wright, R.N. (Idaho Natl Engineering Lab, Idaho Falls, ID, USA); Doyle, T.E.; Flinn, J.E.; Korth, G.E. *Mater Sci Eng* v 94 Oct 1987 p 225-231.

**084272 COLD FORGING OF METAL POWDER PREFORMS.** This paper reviews the state of the art of cold forming porous preforms into net or near-net shapes for structural applications. Materials discussed include ferrous and aluminum powders. Processes include both bulk and localized cold forming. Analysis of densification and deformation for cold forming of axisymmetric cup shapes, hubs and flanges is presented. Empirically based relationships concerning proper preform design are extended to more complex shapes. (Author abstract) 8 refs.

Ferguson, B. Lynn (Deformation Control Technology Inc, Cleveland, OH, USA). *Met Powder Rep* v 42 n 9 Sep 1987 p 583-586.

**084273 WELDABLE RAPIDLY SOLIDIFIED ALUMINUM ALLOY FOR MARINE APPLICATIONS.** A program was initiated to develop weldable rapidly solidified aluminum alloys and associated fusion and solid state joining methods for marine applications. A set of goal properties for this program was developed. Emphasis was placed on identifying alloy compositions and welding techniques which have high potential to meet the desired strength, ductility, and weldability goals. This paper details the results for a promising RSP Mg-Cr aluminum alloy. (Author abstract) 8 refs.

Leimkuhler, Angela M. (David Taylor Naval Ship R&D Cent, Annapolis, MD, USA); Lukens, William E.; Palko, William A. *Int J Powder Metall (Princeton NJ)* v 23 n 1 Jan 1987 p 39-42.

**084274 RAPIDLY SOLIDIFIED ALUMINUM ALLOYS: A MARKET ASSESSMENT.** A survey of the markets for rapidly solidified, high strength aluminum alloys has been made on the basis of currently available technologies. This survey includes an assessment of potentially new developments. Advanced powder metallurgy technologies possess a visible market potential primarily in applications requiring high-strength, heat-treatable alloys of modified 7075 composition (currently alloys 7090 and 7091) and lithium bearing 2XXX series. (Author abstract) 12 refs.

Lavernia, Enrique J. (MIT, Cambridge, MA, USA); Poggiali, Barbara; Servi, Italo S.; Clark, Joel P.; Katrak, Firoze E.; Grant, Nicholas J. *Int J Powder Metall (Princeton NJ)* v 23 n 1 Jan 1987 p 55-60.

**084275 HIGH STRENGTH ALUMINUM-LITHIUM-SILICON CARBIDE P/M COMPOSITES - A REVIEW.** In the present study, various investigations of the aluminum-based P/M composites containing silicon carbide as dispersoids have been examined. Because of the decrease in density produced by lithium addition in aluminum Al-Li alloy development is receiving considerable attention as possible aerospace material. Various studies on the properties and fabrication of Al-Li alloys by P/M techniques have been reviewed. Development of P/M composites based on Al-Li alloys as matrix and SiC



as second phase particles is a promising area of research for high strength and high temperature applications. In the future, these composites may replace some of the superalloys in less demanding applications. The development of Al-Li-SiC composites may lead to the consideration of other dispersoids and P/M fabrication procedures like resistance sintering. (Author abstract) 42 refs

Hamiuddin, M. (Aligarh Muslim Univ, Aligarh, India). *Powder Metall Int* v 19 n 5 Oct 1987 p 28-30.

**084276 OSPREY BREAKS NEW GROUND IN SPRAY DEPOSITION TECHNOLOGY.** The spray deposition process developed by Osprey Metals Ltd involves depositing gas atomized hot metal droplets onto a collector or mandrel where the droplets coalesce to form highly dense preforms having extremely uniform, fine grain size microstructure, which are macrosegregation free and very low in oxygen content. This gives the as-deposited preforms mechanical properties which are normally similar to those of wrought materials of similar compositions. However, because of the fine microstructure and the absence of macrosegregation, the preforms can be hot worked more easily than many conventional wrought materials, and properties of hot worked preforms are generally superior to those of conventional wrought alloys.

Williams, Bernard. *Met Powder Rep* v 42 n 10 Oct 1987 p 712, 714-716.

**084277 ADVANCED P/M ALUMINIUM ALLOY: RAPIDLY QUENCHED STRUCTURE AND DECOMPOSITION BEHAVIOUR DURING ANNEALING.** An Al-Fe-Cr-Zr alloy is currently being developed for elevated temperature service utilizing rapid solidification technology. The inert gas atomized powder has been assessed microstructurally and the solidification behavior interpreted as a function of particle size. It was significant that both fine and coarse powders exhibited structures created by solute trapping during the initial stages of solidification. An unidentified phase (or possibly phases) was detected by X-ray and electron diffraction and shown to form at cell boundaries. Zirconium was retained in solid solution during solidification of all powder structures and subsequently precipitated as fine particles of the metastable  $Al_3Zr$  phase during heat treatment. This precipitation was extremely fine and deemed suitable for elevated temperature strengthening. (Edited author abstract) 14 refs.

Marshall, G.J. (Imperial Coll, London, Engl). *J Mater Sci* v 22 n 10 Oct 1987 p 3581-3588.

**084278 PRODUCTION OF FINE ALUMINIUM POWDERS BY GAS BUBBLING ATOMIZATION PROCESS.** In this process, the bubbles produced by the ejection of Ar gas into molten metal atomize it to fine liquid particles which reach an upper rotating disk cooled with liquid  $N_2$  and are crushed into finer solid particles. The obtained powders were polycrystalline and their shapes were irregular. The size of particles was distributed at values between 0.5 and 10  $\mu m$ . Mean particle size decreased with lower atomization temperature and increasing discharge of Ar gas and rotational speed. (Edited author abstract) In Japanese. 4 refs.

Ochiai, Shouchi (Technological Univ of Nagaoka, Nagaoka, Jpn); Ueno, Manabu; Kojima, Yo; Takashima, Kazuki; Kanazashi, Hisayoshi. *Keikinzoku* v 37 n 10 Oct 1987 p 665-669.

**084279 PILOT PRODUCTION OF RAPIDLY SOLIDIFIED ALUMINIUM ALLOY POWDERS BY GAS ATOMIZATION.** The development of the pilot plant at Eckart-Werke was sponsored by the German Federal Department of Research and Technology for the production of AlCuMg, AlZnMgCu, AlFe(Ce,Y), Al-FeNi (Mg,Zr,Ti,Mo,Cr, Cu), AlSi(Fe,Ni,Mn,Ti) by gas atomization. The maximum melt size of the plant is 60 kg. Different spray jets and several kinds of gas (argon, nitrogen, helium, gas-mixtures and air) can be used to vary the produced powder. The cooling rate of an Al 2024 was estimated for particles of different sizes and particles

atomized with different kinds of gas. For this estimation the secondary dendrite arm spacing was measured and compared with a calibration line of secondary dendrite arm spacings obtained by known cooling rates. 3 refs.

Gerstner, R.J. (Eckart-Werke, Fuerth, West Ger); Reif, G. *Met Powder Rep* v 43 n 1 Jan 1988 p 35-36.

**084280 THERMAL CONSIDERATIONS ON THE RECALESCENCE OF ALLOY POWDERS.** The principles involved in the solidification of supercooled binary alloy droplets are discussed with particular emphasis on solute redistribution. The effects of alloying elements on the parameters of the thermal history of recalescing aluminum droplets are studied with the aid of enthalpy-temperature relationships. Thermal considerations indicate that the critical supercoolings to achieve partitionless solidification change modestly. The rate of calescence after nucleation is likely to be slowed down by the addition of solute. A Newtonian model for solidification of nonideal binary alloys with morphologically stable interfaces is used to study the thermal history and solute redistribution during recalescence. (Edited author abstract) 32 refs.

Levi, Carlos G. (Univ of California, Santa Barbara, CA, USA). *Metall Trans A* v 19A n 3 Mar 1988 p 687-697.

**084281 EVOLUTION OF MICROCRYSTALLINE STRUCTURES IN SUPERCOOLED METAL POWDERS.** A numerical model has been developed to study the relative effects of nucleation and growth kinetics on the evolution of ultrafine grain structures observed in some supercooled metal powders. The thermal history during solidification is analyzed using a Newtonian heat transfer formulation coupled to classical models for homogeneous nucleation and continuous growth with a diffuse interface. The results indicate that decreasing particle size increases both the supercooling prior to solidification and the thermal excursion beyond the nucleation temperature. There is a range of particle size in which the achievable supercooling are high enough to produce massive nucleation before any significant growth - and the ensuing recalescence - can take place. The probability of multiple nucleation may be evaluated, from a dimensionless parameter combining the characteristic frequencies of the nucleation, growth, and heat transfer processes at the moment of nucleation. Calculations for Al and Ni model systems confirm the experimental observation that the latter has a stronger tendency to supercool and develop microcrystalline structures. (Edited author abstract) 36 refs.

Levi, Carlos G. (Univ of California, Santa Barbara, CA, USA). *Metall Trans A* v 19A n 3 Mar 1988 p 699-708.

**084282 RECENT R&D OF ALUMINIUM ALLOYS FOR AIRCRAFT APPLICATIONS: PART 3. POWDER METALLURGY ALLOYS.** Because rapid solidification and mechanical alloying can extensively control the microstructure of aluminium alloys, combination of one of these powder production processes and powder metallurgy (P/M) process leads to the development of unique alloy systems with high performance. High strength alloys including 7 XXX, 2 XXX and 5 XXX alloys, low density and high modulus alloys, dispersion-strengthened alloys with high strength at elevated temperature, and wear-resistant alloys are being developed. They offer great advantages over conventional ingot metallurgy alloys. Most of them have the potential to meet the demands for enhancing the properties of aluminium alloys in the field of aircraft industries. Thus, much effort is being continued in order to apply these alloys to aircraft. This paper reviews recent trends of P/M aluminium alloys with the main focus on aircraft applications. (Author abstract) In Japanese. 61 refs.

Yamauchi, Shigenori. *Sumitomo Keikinzoku Giho* v 29 n 1 Jan 1988 p 69-81.

**084283 RAPID SOLIDIFICATION AND POWDER METALLURGY AT ALLIED-SIGNAL INC.** Allied-Signal's activity in rapid solidification and powder metallurgy (RS/PM) is broad based in research, develop-

ment and applications. The activities include process development, alloy development, powder production, consolidation and fabrication and evaluation of prototype parts. This profile elaborates on current RS/PM activities in aluminum and magnesium-based alloys. (Author abstract)

Das, Santosh K. (Allied-Signal Inc, Morristown, NJ, USA). *Int J Powder Metall (Princeton NJ)* v 24 n 2 Apr 1988 p 175-183.

**084284 ADVANCED ALUMINUM ALLOYS FOR HIGH TEMPERATURE STRUCTURAL APPLICATIONS.** Advanced aluminum alloys for elevated structural applications have been developed in recent years via the powder metallurgy techniques including rapid solidification (atomization and melt spinning), mechanical alloying and metal matrix compositing. The most promising of all appear at present to be rapidly solidified Al-Fe base powder alloys. Studies conducted several years ago for a variety of potential aircraft applications have identified that substantial weight and cost savings would be obtained if these alloys were used successfully at service temperatures between 120°C and 350°C (248°F and 662°F). When compared with competitive high strength materials such as steel and titanium alloys for elevated temperature (120-350°C) applications, the relatively low machining costs and density of these aluminum alloys are very attractive. The prospect of achieving the same strength/density properties as Ti-6Al-4V at temperatures in excess of 300°C (572°F) is good. 5 refs.

Kim, Young-Won (Metcut Materials Research Group, Wright Patterson AFB, OH, USA). *Ind Heat* v 55 n 5 May 1988 p 31, 33-34.

**084285 DEPENDENCE OF ROLLING RESISTANCE ON STRAIN IN COMPACTING ALUMINIUM POWDER MATERIALS.** The authors examined the variation of the properties of porous sheet blanks and force characteristics of the deformation process in compacting by rolling. It is shown that a large reduction of the pressure in rolling the rapidly solidified powder materials can be utilized in selecting the technological regimes of producing sheets of composite materials with limited force characteristics of deformation, and also of components from such materials, by this type. 8 refs.

Yuditskii, S.A.; Popov, E.A. *Phys Chem Mater Treat* v 22 n 1 Jan-Feb 1988 p 100-103.

**084286 POWDER METALLURGY. A WAY FOR IMPROVING THE PERFORMANCES OF ALUMINIUM ALLOYS.** P/M of Al alloys appears thus as a very effective way for improving many engineering properties of Al alloys and is a chance for this still young metal to find applications in new areas and markets. Of particular importance are the improvements possible in terms of surface properties, temperature stability, specific strength and stiffness of Al alloys. The main challenge now is to upscale the process and bring it at an industrial scale; at this point, both technical and economical parameters are of paramount importance and emerging routes like the Spray Deposition Approach may be of interest. 7 refs.

Faure, J.F. (Cent de Recherches de Voreppe, Voreppe, Fr). *ATB Metall* v 27 n 2-3 1987, Powder Metall, Brussels, Belg, May 13-14 1987 p 109-114.

**084287 EFFECT OF PROCESSING VARIABLES ON PARTICLE SIZE IN GAS ATOMIZATION OF RAPIDLY SOLIDIFIED ALUMINIUM POWDERS.** The performance of a 'confined' type atomizing nozzle was investigated using nitrogen, argon, and helium gases at different pressures and AA 2014 metal at varying superheats and flow rates. Helium produced the finest powders with median diameters between 14.6 and 18.5  $\mu m$ . Nitrogen powders showed an intermediate size while those made in argon were the coarsest (21-37  $\mu m$ ). Metal temperatures above 825°C led to only a small decrease in particle size which could be explained on the basis of lowered surface tension and viscosity of the melt. At lower



temperatures (775°C), possible interference from pre-mature solidification was noted. Operation at 1.56 MPa pressure offered the optimum conditions (nitrogen). There was a wastage of gas at higher pressures (2.12 MPa) and flake formation interfered at lower pressures (1.05 MPa). Powder median diameter increased in proportion to the square root of the metal flow rate and in all cases the size distribution could be satisfactorily represented by the log-normal law. The spread of the sizes, as measured by geometric standard deviation, increased at high metal flows indicating that relatively higher proportions of large particles were present in such powders. (Author abstract) 30 refs.

Unal, A. (Imperial Coll of Science & Technology, Engl). *Mater Sci Technol* v 3 n 12 Dec 1987 p 1029-1039.

## Aluminum Chromium

**084288 PREPARATION OF SOME ALUMINUM ALLOYS BY MECHANICAL ALLOYING AND THEIR MECHANICAL PROPERTIES.** The mechanical alloying process is a method for producing alloys with controlled structure. Al-Cr and Al-Cr-C alloys were prepared by mechanical alloying and powder hot extrusion. Tensile strength, hardness and microstructure were investigated. The fine particles of oxides and carbides gave a high hardness and tensile strength. The alloys kept their high hardness after heating about 400°C. Tensile strength at high temperature decreased linearly up to 400°C. (Edited author abstract) In Japanese. 16 refs.

Morooka, Toshimasa (Musashi Inst of Technology, Tokyo, Jpn); Yuasa, Eiji. *Keikinzoku* v 37 n 10 Oct 1987 p 683-689.

## Aluminum Copper

**084289 EFFECT OF POROSITY ON THE VOLUME CHANGES EXPERIENCED BY Al-Cu COMPOUNDS DURING LIQUID-PHASE SINTERING.** In the Al-Cu system a linear relationship between the end and starting porosities exists only at porosities exceeding 20%. At a smaller pore content the linearity is disturbed by the presence of an irreducible oxide phase on the aluminum particles. Decreasing the starting compact porosity results in greater growth in the first stage of sintering and smaller shrinkage in the second. The extent of the compact growth preceding the shrinkage may exceed that due to atom diffusion under conditions of uniform reaction of the liquid phase on surfaces of the particles. The anomalously large compact growth in the first stage is due to a negative regrouping of particles resulting from uneven Kirkendall flow of material inside the particles. 17 refs.

Savitskii, A.P. (Acad of Sciences of the USSR, USSR); Romanov, G.N. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 532-536.

**084290 P/M MATERIALS FROM SPLAT QUENCHED FLAKES OF 2024 ALUMINUM ALLOY CONTAINING TRANSITION METALS.** Improvement of conventional 2024 aluminum alloy was experimentally studied by the addition of transition metals and rapid solidification. Alloying additions were 1 to 4 wt% Fe, 2 to 6 wt%Mn and 2 to 6 wt%Ni. Rapidly solidified flakes were produced by atomizing the melt and subsequent splat quenching onto a water cooled copper roll. Consolidation was done by cold pressing, degassing and hot extrusion. Microhardness increased with the addition of transition metals due to fine particles of their eutectic compounds. P/M materials from these flakes also contained fine dispersions of eutectic compounds and showed higher hardness after annealing at high temperatures. Mn bearing material showed the highest strength and Ni bearing the lowest. However, addition of these elements reduced the age hardening of 2024 alloy. The alloys with large addition of transition metals showed higher fatigue strength than conventional 2024 alloy in high cycle fatigue. (Edited author abstract) In Japanese. 6 refs.

Lim, Su-gun (Nihon Univ, Narashino, Jpn); Sugamata,

Makoto; Kaneko, Junichi. *Keikinzoku* v 37 n 10 Oct 1987 p 690-697.

**084291 DEVELOPMENT AND EVALUATION OF BEARING CHARACTERISTICS OF MECHANICALLY ALLOYED Al-4.5% Cu-GRAPHITE COMPOSITES.** Dispersion of graphite by MA in Al-4.5% Cu improves its bearing performance and wear resistance without any decrease in its K-factor value. For the same level of improvement in the bearing performance of Al-4.5% Cu, the amount of graphite addition decreases if it is added by MA. About 3 wt.% of graphite addition to the Al-4.5% Cu by MA is sufficient to improve its performance. 18 refs.

Sharma, A. (Malaviya Regional Engineering Coll, Jaipur, India); Soni, P.R.; Rajan, T.V. *Met Powder Rep* v 43 n 1 Jan 1988 p 37-38.

**084292 EFFECT OF SINTERING CONDITIONS ON THE STRUCTURE AND MECHANICAL PROPERTIES OF P/M ALUMINUM BASE ALLOYS.** Specimens of Al-4.4% Cu and Al-4.4% Cu-0.5% Mg were studied. A magnesium addition promotes densification of Al-Cu specimens sintered for short periods of time in the range 595-635°C. Longer sintering at 615 and 635°C results in porosity. At a temperature above 595°C Al-Cu alloys experience coarsening. Alloying with magnesium does not significantly affect the structure. A magnesium addition improves the mechanical properties of Al-Cu alloy. The extent to which magnesium alters the mechanical characteristics of heat treated Al-Cu alloys depends on sintering conditions. The highest strength - 340 MPa and  $\delta = 6\%$  - is exhibited by specimens sintered for 45 min at 595°C. 21 refs.

Al'tman, A.B. (All-Union Scientific-Research Inst of Electromechanics, USSR); Brodov, V.A.; Zhil'tsov, A.V.; Melashenko, I.P. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 713-717.

## Aluminum Iron

**084293 RELATIONSHIP BETWEEN STRUCTURE AND MECHANICAL PROPERTIES OF Al-Fe POWDER METALLURGY ALLOYS.** The relationship between structure and mechanical properties of extruded Al-2-10%Fe powder metallurgy alloys was investigated. The yield strength is related to the volume fraction of dispersoids ( $V_p$ ) and the average dispersoid radius ( $r$ ). This relationship suggests that higher  $V_p$  and smaller  $r$  result in higher strength. Increase of Fe content raises the strength because of the increase of volume fraction of dispersoids. Annealing above 400°C lowers the strength of Al-8%Fe alloy because of coarsening of dispersoids. (Edited author abstract) In Japanese. 11 refs.

Shibue, Kazuhisa (Sumitomo Light Metal Industries Ltd, Nagoya, Jpn); Sano, Hideo; Yamauchi, Shigenori. *Keikinzoku* v 37 n 10 Oct 1987 p 698-703.

**084294 DEVELOPMENT OF ELEVATED TEMPERATURE P/M ALUMINUM ALLOY BY RAPID SOLIDIFICATION PROCESSING.** Al-Fe system alloys were investigated from the viewpoints of solid solubility, diffusion coefficient, temperature of liquidus and material cost. The mechanical properties at room and elevated temperature were evaluated in various Al-Fe system alloys. Al-8%Fe-2%V-2%Mo-1%Zr alloy was superior to the conventional 2618 alloy in room and elevated temperature tensile strength, thermal stability of hardness, and fatigue and creep properties. The properties were due to Al-Fe-V-Mo, Al-Fe and Al-Zr system dispersoids. (Edited author abstract) In Japanese. 20 refs.

Yamauchi, Shigenori (Sumitomo Light Metal Industries Ltd, Nagoya, Jpn); Shibue, Kazuhisa; Sano, Hideo; Ito, Kiyofumi; Inumaru, Susumu. *Keikinzoku* v 37 n 10 Oct 1987 p 704-709.

**084295 RAPIDLY SOLIDIFIED Al-Fe ALLOY FLAKES BY ATOMIZATION-ROLLING PROCESS.** Al-2,4,6,8 and 10%Fe alloys were rapidly solidified by means of atomization-rolling which is a combined process

of gas atomization using a single roller. Microstructure of the flake was finer than that of atomized powder. From the cell spacing of the flake, the cooling rate is estimated at  $10^5$ - $10^7$ °C/sec. The lattice constant decreased with Fe content and reached a constant value beyond 4% Fe content. The solubility of Fe was estimated at 1.4% in the flake containing more than 4%. Hardness increased with Fe content. It was higher than that of gas atomized powder. In Japanese. 14 refs.

Shibue, Kazuhisa (Sumitomo Light Metal Industries Ltd, Jpn); Sano, Hideo; Yamauchi, Shigenori; Inumaru, Susumu. *Sumitomo Keikinzoku Gihō* v 28 n 4 Oct 1987 p 181-186.

**084296 MECHANICAL PROPERTIES OF THE RAPIDLY SOLIDIFIED Al-Fe BINARY ALLOYS BY ATOMIZATION-ROLLING PROCESS.** In this work, Al-Fe alloy flakes solidified at a cooling rate of  $10^5$ - $10^7$ °C/sec were consolidated and the mechanical properties and microstructures were evaluated in comparison with alloys made by gas atomization. Al-2-10wt%Fe alloys had higher strength at room temperature. Al-8wt%Fe had higher elevated temperature strength up to 350°C. Al-8wt%Fe had finer dispersoids of  $Al_3Fe$  or  $Al_6Fe$ . Higher strength is attributed to the fine dispersion of Al-Fe intermetallic compounds due to a higher cooling rate. (Edited author abstract) In Japanese. 5 refs.

Sano, Hideo (Sumitomo Light Metal Industries Ltd, Jpn); Shibue, Kazuhisa; Yamauchi, Shigenori; Inumaru, Susumu. *Sumitomo Keikinzoku Gihō* v 28 n 4 Oct 1987 p 187-192.

**084297 ELEVATED-TEMPERATURE Al ALLOYS FOR AIRCRAFT STRUCTURE.** To improve the performance characteristics of advanced aerospace vehicles, lower-density, stronger, stiffer and higher-temperature materials are being studied. Elevated-temperature powder metallurgy (P/M) aluminum alloys are being developed to replace titanium aircraft structure materials for operation in the 300-600°F temperature range. Typical mechanical properties of P/M Al-Fe-Ce and Al-Fe-V-Si alloys are superior to those of conventional materials. Cost savings of fifty to seventy percent have been projected for these alloys which can be fabricated and processed using methods similar to those used in the production of conventional aluminum. (Edited author abstract) 5 refs.

Rainen, Richard A. (Lockheed Aeronautical Systems Co); Ekvall, John C. *J Met* v 40 n 5 May 1988 p 16-18.

## Aluminum Iron Alloys

**084298 CHARACTERISTICS OF RAPIDLY SOLIDIFIED Al-8wt%Fe POWDERS PRODUCTION BY FLAME SPRAYING METHOD.** Al powders containing 8wt%Fe were solidified rapidly by collision onto a stainless steel vessel cooled by ice water. Characterizations of these powders were carried out by X-ray diffraction analysis, electron microscopic observations and electron probe X-ray microanalysis. The main phases formed by flame spraying were composed of  $\alpha$ -Al, stable  $Al_3Fe$  and metastable  $Al_mFe$  phases. A metastable  $Al_6Fe$  phase was observed to form at relatively low cooling rates. (Edited author abstract) In Japanese. 36 refs.

Yokota, Masaru; Ueda, Taiji; Asakura, Tadashi; Shoji, Keichiro. *J Jpn Soc Powder Powder Metall* v 34 n 6 Aug 1987 p 248-253.

**084299 INFLUENCE OF ANNEALING ON MECHANICAL PROPERTIES OF FLAME SPRAYED AND RAPIDLY SOLIDIFIED Al-8wt%Fe ALLOY POWDER EXTRUDED MATERIALS.** Mechanical properties of as-extruded materials were tensile strength 37 kgf/mm<sup>2</sup>, elongation 9.5%, proof strength (0.2%) 27 kgf/mm<sup>2</sup> and hardness 100 kgf/mm<sup>2</sup>. These properties at room temperature were maintained up to 773 K of annealing for 1 hour. Beyond that, except for elongation, the other mechanical properties decreased with annealing temperature. At 773 K, hardness decreased with anneal-



ing time. The same tendency against annealing time was observed in the X-ray diffraction experiment. The mechanism of strengthening is thought to be dispersion hardening. (Edited author abstract) In Japanese. 25 refs.

Yokota, Masaru; Ueda, Taiji; Kuroda, Hayao; Shoji, Keiichiro. *J Jpn Soc Powder Metall* v 34 n 6 Aug 1987 p 254-258.

**084300 MECHANICAL ALLOYING AND CONSOLIDATION OF ALUMINUM-IRON SYSTEM.** Pure aluminum and iron powders were processed by mechanical alloying and consolidated by strained powder rolling (SPR). Iron particles are dispersed finely in the aluminum powders after long mechanical alloying time. Their number increases with increasing iron content. The composite powders processed less than 172 ks are well consolidated by the SPR method. In the case of specimens powder processed for 130 ks and consolidated at 673 K by the SPR method, tensile strength increases almost linearly but elongation decreases little with iron content up to 8%. The tensile strength is about 550 MPa and elongation is about 1.6%. (Edited author abstract) 13 refs.

Bin, Huang (Kyoto Univ, Kyoto, Jpn); Kobayashi, Kojiro F.; Shingu, Hideo P. *Keikinzoku* v 38 n 3 Mar 1988 p 165-171.

**084301 DEVELOPMENT OF Al-Re P/M ALLOY BY ATOMIZATION-ROLLING PROCESS.** Ultra-rapid solidification is required instead of gas atomization in order to modify the properties of P/M alloys, especially dispersion-strengthened Al-Fe alloys. In the present work, various Al-Fe alloys were rapidly solidified by means of atomization-rolling and consolidated by hot extrusion. Microstructure and tensile properties were evaluated in comparison with gas atomization. The cooling rate of atomization-rolling was  $10^5$ - $10^7$ °C/sec which was higher than gas atomization. Extruded alloys had higher strength at room and elevated temperature due to finer dispersion of intermetallic compounds. Al-8 percent Fe-2 percent V-2 percent Mo-1 percent Zr alloy had high strength at elevated temperature. (Edited author abstract). 7 Refs. In Japanese.

Yamauchi, Shigenori; Shibue, Kazuhisa; Sano, Hideo; Ohkubo, Yoshimasa. *J Jpn Soc Powder Metall* v 35 n 3 Apr 1988 p 87-90.

**084302 RELATIONSHIP BETWEEN MICROSTRUCTURE AND MECHANICAL PROPERTIES OF Al-Fe POWDER METALLURGY ALLOYS.** The relationship between microstructure and mechanical properties of extruded Al-2-10%Fe P/M alloys was investigated. The results obtained were as follows: Yield strength ( $\sigma_{0.2}$ ) is related to volume fraction of dispersoids ( $V_d$ ) and average dispersoid radius ( $r$ ):  $\sigma_{0.2} \propto V_d^{1/2} \cdot r^{-1}$ . This relationship suggests that higher  $V_d$  or smaller  $r$  results in higher strength. Increase of Fe content raises the strength of Al-Fe alloy because of the increase of volume fraction of dispersoids. Annealing at the temperature above 400°C lowers the strength of Al-8%Fe alloy according to coarsening of dispersoids. (Author abstract). 12 Refs. In Japanese.

Shibue, Kazuhisa; Sano, Hideo; Yamauchi, Shigenori. *Sumitomo Keikinzoku Gihō* v 29 n 2 Apr 1988 p 14-21.

**084303 PROPERTIES OF GAS ATOMIZED Al-Fe POWDERS AND ITS VARIATION BY ANNEALING.** Properties of Ar gas atomized powders of Al-8 mass percent Fe alloy and its variation by annealing have been examined by means of scanning electron microscopy, transmission electron microscopy and hardness measurement. A cell structure having metastable phase  $Al_3Fe$  at its boundaries forms in particles in the size smaller than 105  $\mu m$ , besides a primary crystallized intermetallic compound  $Al_3Fe$  predominantly exists in the particles larger than 105  $\mu m$ . The hardness of powders increases with decreasing particle diameter due to the refinement of cell structure. The annealing at temperature above 400°C accelerates the decomposition of cell structure and the formation of granular intermetallic compound, both of which result in the notable softening in the small size

particles.  $Al_3Fe$  which has been at cell boundaries transforms to  $Al_3Fe$  by the annealing above 450°C. Even after high temperature annealing, large particles show only a slight decrease in hardness keeping low values due to small change in the coarse structure. (Author abstract). 16 Refs. In Japanese.

Asami, Shigenori (Furukawa Aluminum Co, Nikko, Jpn); Asada, Kiyuki; Togami, Yoshiro. *Keikinzoku* v 38 n 6 Jun 1988 p 345-351.

#### Aluminum Iron Nickel Alloys

**084304 PROPERTIES OF CONTINUOUSLY EXTRUDED Al-Fe-Ni-Cu-Mg ALLOY POWDERS.** Alloys of Al-2.2 percent Cu-1.5 percent Mg with equal amounts of Fe and Ni addition up to 7 percent each were argon gas-atomized to fine powders, and continuously extruded by a Conform machine. The extrudates showed superior strength, heat resistance and high modulus of elasticity and also exhibited low thermal expansion coefficients and good wear resistance. The extrudates from rapidly solidified alloy powders were dispersion hardened by fine dispersoids of  $Al_3FeNi$  and age hardened by Al-Cu-Mg precipitates. High volume fraction of  $Al_3FeNi$  phase also caused high modulus, low thermal expansion and good wear resistance. (Author abstract). 5 Refs. In Japanese.

Kobayashi, Yasuo (Mitsubishi Aluminum Co, Susono, Jpn); Yoda, Michioh; Suzuki, Yoshiya. *Keikinzoku* v 38 n 6 Jun 1988 p 338-344.

#### Aluminum Lithium

**084305 ALUMINUM-LITHIUM POWDER METALLURGY ALLOYS WITH IMPROVED TOUGHNESS.** A technique has been developed for increasing the toughness of Al-Li products made by powder metallurgy. The technique which involved forming a duplex structure by the addition of unalloyed aluminum powder to Al-Li powder before compaction was evaluated with Al-Li-Cu-Mg-Zr alloys (A18090). The strength, ductility, toughness, and short transverse stress corrosion resistance were determined. The addition of 15 pct aluminum to A18090 aged at 422 K for 40 hours produced an increase in impact toughness of 215 pct at the expense of a drop in yield strength of 11 pct. The alloys with a duplex structure had superior longitudinal strength-toughness combinations to ingot materials of similar composition processed identically. (Edited author abstract) 22 refs.

Webster, D. (Kaiser Aluminum & Chemical Corp, Pleasanton, CA, USA). *Metal Trans A* v 19A n 3 Mar 1988 p 603-615.

**084306 EFFECT OF SILICON, MAGNESIUM, COBALT AND IRON ADDITIONS ON THE MICROSTRUCTURE OF Al-Li CENTRIFUGALLY ATOMIZED POWDERS.** The effect of the addition of silicon (up to 4 wt%), magnesium (up to 7.25 wt%), cobalt (up to 0.8 wt%) and iron (up to 1.5 wt%) on the microstructure of as-solidified Al-3 wt% Li powders produced by centrifugal atomization in a helium atmosphere has been studied by optical, scanning electron and transmission electron microscopy. The microstructure changes from dendritic in the case of Al-Li and Al-Li-Mg alloys to a eutectic (Al + AlLiSi) mixture in the Al-Li-Si alloy to a cellular structure for the Al-Li-Co alloy and results in the direct nucleation of coarse intermetallic  $Al_6Fe$  from the melt followed by subsequent growth in the case of Al-Li-Fe alloy. (Author abstract) 7 refs.

Samuel, Fawzy H. (Central Metallurgical Research & Development Inst, Cairo, Egypt); Champier, G. *J Mater Sci* v 23 n 2 Feb 1988 p 541-546.

#### Aluminum Magnesium See ALUMINUM MAGNESIUM ALLOYS—Dispersion Hardening.

#### Aluminum Magnesium Alloys

**084307 INCO UNVEILS NEW PRODUCTION FACILITY FOR MECHANICALLY ALLOYED ALU-**

**MINIUM PRODUCTS.** IncoMAP, a division of Inco Alloys International, has started production of mechanically alloyed aluminum at a new plant in Pittsboro, North Carolina. The article describes the manufacturing facilities used at Pittsboro and the properties of the mechanically alloyed aluminum which are either in commercial production or still undergoing development and testing. The alloys described are AL-905 XL, AL-9052 and composites based on the latter.

Schelleng, D. *Met Powder Rep* v 43 n 4 Apr 1988 p 239-241.

#### Aluminum Magnesium Iron Alloys

**084308 STRUCTURAL INHOMOGENEITY DURING PRODUCTION AND PROCESSING OF RAPIDLY SOLIDIFIED Al-6Mg-5Fe ALLOY.** Considerable microstructural differences have been noted from among different powder particles and from within the same particles. Three typical microstructures were observed; small particles exhibited a microcellular structure, medium-sized particles a dual morphology of microcellular and cellular structure, whilst in the large particles coarse intermetallics were formed, acting as nucleation sites for a cellular structure. Apart from Al3other phases were detected  $Fe_4Al_{13}$ , (Fe, Mn) $Al_6$  and an unidentified phase termed 'F'. The formation of both spheres and needle particles was promoted at high temperatures irrespective of the type of phase ( $Fe_4Al_{13}$  or (Fe, Mn) $Al_6$ ). The heterogeneity of the microstructural features was maintained during subsequent consolidation via extrusion. The influence of heating and deformation modifies the microstructures but was insufficient to produce a uniform microstructure. The decomposition behavior has been examined. The heterogeneities in the extrudate could be related to the microstructure and solidification behavior during atomization. (Edited author abstract) 18 refs.

Ioannidis, E.K. (Imperial Coll, London, Engl); Marshall, G.J.; Sheppard, T. *J Mater Sci* v 23 n 4 Apr 1988 p 1486-1495.

#### Aluminum Manganese Chromium Alloys

**084309 MASS AND HEAT TRANSFER DURING ULTRASONIC GAS ATOMIZATION.** Fluid flow behavior during ultrasonic gas atomization was studied. Gas velocity was measured by pilot tube experiments and Schlieren photography. Powder particle velocities were calculated. The gas velocity reaches 1700 m/s (Mach 1.7) in the supersonic flow region for helium gas at a backing pressure of 6.9 MPa. A 15  $\mu m$  diameter Al-5mass% Mn-2.5mass% Cr powder particle is accelerated to a maximum velocity of 1200 m/s while for a 150  $\mu m$  diameter particle, the maximum particle velocity is about 400 m/s. Solidification studies were carried out by collecting powder particles at different flight distances from the atomization nozzle. A comparison between a theoretical solidification model and the experimental result shows good agreement. (Author abstract) 22 refs.

Liu, J. (Swedish Inst for Metals Research, Stockholm, Swed); Arnberg, L.; Backstrom, N.; Klang, H.; Savage, S. *Powder Metall Int* v 20 n 2 Apr 1988 p 17-22.

#### Aluminum Silicon

**084310 PROPERTIES OF Al-Si-X P/M ALLOYS USING RAPIDLY SOLIDIFIED POWDERS.** The P/M alloys were based on a hypereutectic Al-Si system to which transition elements (Fe, Ni, Mn) were added up to 10 wt.% as well as 3 wt.%Cu and 1 wt.%Mg in order to improve the strength at elevated and room temperature, respectively. Addition of a transition element caused an intermetallic compound to be formed. Extruded P/M alloys had fine and homogeneous structures which are not obtainable from ingot metallurgy alloys. The Al-Si P/M alloys were higher in tensile I/M alloys of the same composition. An addition of transition element improved strength and thermal stability at elevated temperature. Addition of Si and SiC particles improved seizure and wear properties. The alloys containing more than 20



wt% Si and a transition element had a low thermal expansion coefficient. (Edited author abstract) In Japanese. 8 refs.

Hirano, Tadao (Showa Denko KK, Chichibu, Jpn); Fujita, Tatsuo. *Keikinzoku* v 37 n 10 Oct 1987 p 670-676.

**084311 PRODUCTION AND WEAR CHARACTERISTICS OF SI-DISPERSED ALUMINUM COMPOSITE PREPARED BY POWDER EXTRUSION.** Al-Si-X composites containing dispersed Si particles were prepared by powder extrusion. Wear characteristics were investigated by a pin-drum type wear testing machine under lubrication of compressor oil. The wear resistance of the composites is higher than that of the base material because of its large Si particles. In the case of Si-dispersed composites, wear resistance increases with increasing hardness of the composites. (Edited author abstract) In Japanese. 7 refs.

Fujita, Tatsuo (Riken Corp, Kashiwazaki, Jpn); Kiyota, Fumio; Hirano, Tadao; Kojima, Yo. *Keikinzoku* v 37 n 10 Oct 1987 p 677-682.

**084312 EFFECTS OF TEMPERATURE AND STRAIN RATE ON DUCTILITY AND FLOW STRESS OF A RAPIDLY SOLIDIFIED HYPEREUTECTIC AL-SI P/M ALLOY.** A hypereutectic Al-Si P/M alloy can be produced in which fine silicon particles with a size on the order of a few micrometres are uniformly dispersed. Hot forging in the temperature range 400-500°C is recommended for plastic working because the improvement in ductility and the decrease in flow stress are accelerated with the increase in temperature. The required working pressure can be determined from a nomogram. 5 refs.

Hirai, Yukio (Government Industrial Research Inst, Nagoya, Jpn); Kanayama, Kouzou; Nakamura, Mamoru; Sano, Hideo; Kubo, Katsushi. *J Mater Sci Lett* v 7 n 5 May 1988 p 517-519.

## Aluminum Silicon Alloys

**084313 EFFECTS OF DEFORMATION TEMPERATURE AND STRAIN-RATE ON WORKABILITY OF A RAPIDLY SOLIDIFIED HYPEREUTECTIC AL-SI/P/M ALLOYS.** The flow stress and ductility of an aluminum P/M alloy prepared by hot extrusion from rapidly solidified powders of an Al-20Si-5Fe-2Cu-1Mg-1Mn alloy were investigated by compression and tensile tests to clarify its workability. Flow stress decreases and critical amount of strain for deformation without cracking increases with deformation temperature. The increase in strain rates increases flow stress at a higher temperature than 180°C.  $\sigma$  and strain rate  $\epsilon$  is described as  $\sigma = K\epsilon^m$ . The strain sensitivity exponent increases with deformation temperature and becomes about 0.3 at 480°C. A nomogram to predict the flow stress at a certain ram speed and temperature has been drawn. (Author abstract) 7 refs.

Hirai, Yukio (Government Industrial Research Inst, Nagoya, Jpn); Kanayama, Kouzou; Nakamura, Mamoru; Sano, Hideo; Kubo, Katsushi. *Keikinzoku* v 38 n 3 Mar 1988 p 153-158.

**084314 CONSOLIDATION OF RAPIDLY SOLIDIFIED AL-SI POWDERS BY THE STRAINED POWDER ROLLING METHOD.** Rapidly solidified Al-Si ribbons prepared by the single roller method were pulverized by a vibration mill. The milled powders were consolidated at different temperatures by the strained powder rolling method. P/M alloys have a density more than 95% of that of metal mold cast alloys. Hypereutectic P/M alloys have a uniform distribution of fine Si particles in the structure. P/M alloys harden with increasing Si content and soften at higher rolling temperatures. Tensile strength and elongation are higher than those of cast alloys containing Si 20 at% or more. A 30 at% Si P/M alloy has a tensile strength of about 33 kg/mm<sup>2</sup> and elongation of about 5%. (Edited author abstract) 15 refs. In Japanese.

Gohchi, Hidenobu (Kyoto Univ, Kyoto, Jpn); Kobayashi, Kojiro F.; Shingu, Paul H. *Keikinzoku* v 38 n 4 Apr 1988

p 222-227.

**084315 FRICTIONAL CHARACTERISTICS IN WARM AND HOT UPSETTING OF HYPEREUTECTIC AL-SI P/M ALLOY.** In this study, suitable lubrication conditions for warm and hot upsetting of Al-20Si-5Fe-2Cu-1Mg-1Mn P/M alloy were investigated using commercially available lubricants. Coefficients of friction were measured by the ring compression tests in temperatures up to 560°C. The effect of lubrication on deformation behavior such as barreling, folding, and surface roughness was also examined. (Edited author abstract). 7 Refs. In Japanese.

Hirai, Yukio (Government Industrial Research Inst, Nagoya, Jpn); Kanayama, Kouzou; Nakamura, Mamoru; Sano, Hideo; Kubo, Katsushi. *Keikinzoku* v 38 n 5 May 1988 p 281-286.

## Aluminum Silicon Nickel Alloys

**084316 MICROPLASTIC DEFORMATION IN POWDER METALLURGY SILUMINS AND ITS INFLUENCE ON DIMENSIONAL STABILITY.** After pressing, powder metallurgy silumin SASI-50 is in a strongly stressed state. The change in dimensions of parts occurs as the result of the action of oriented stresses causing the development of microplastic deformation changing into macroplastic deformation. High temperature thermal cycling treatment of the alloy increases its relaxation resistance by 20-40%. 13 refs.

Bellavin, A.D.; Smagorinskii, M.E.; Monin, V.I.; Chelnokov, V.A. *Met Sci Heat Treat* v 29 n 3-4 Mar-Apr 1987 p 283-290.

## Aluminum Zinc Alloys

**084317 USE OF ION SCATTERING IN CHARACTERIZING THE SURFACE OXIDE OF P/M ALUMINUM ALLOY 7091.** Ion scattering techniques can be used effectively in analyzing the composition and spacial distribution of various elements present in rapidly solidified aluminum powder alloys. Oxygen and hydrogen were detected and the hydrogen concentration decreased after detuned degassing procedures. Degassing 7091 aluminum powder compacts for four hours at 520°C at a pressure of 30  $\mu$  of Hg reduced the hydrogen concentration by approximately a factor of three. 13 refs.

Pronko, P.P. (Universal Energy Systems, Dayton, OH, USA); Bhattacharya, R.S.; Kleek, J.J.; Froese, F.H. *Metal Trans A* v 19 n 5 May 1988 p 1372-1374.

## Aluminum Zinc Nickel Zirconium Alloys

**084318 DEFORMATION AND MECHANICAL PROPERTIES OF A RAPIDLY SOLIDIFIED 7075-TYPE ALLOY.** An experimental modified 7075-type aluminum alloy containing 1% Ni plus 0.8% Zr was prepared using inert gas atomization. The alloy was hot consolidated by a blank (1:1) upset. The upset material was then extruded at an area reduction ratio of 13:1. A re-extrusion of the material at 16:1 was performed to yield a net reduction of 200:1. The alloy showed a fine microstructure with a grain size of approximately 2  $\mu$ m. Very high strength and improved fatigue performance were achieved when compared with the ingot metallurgy 7075 alloy. Further working by extrusion or hot forging redistributed deleterious oxide stringers but did not significantly change mechanical properties. The deformation-mechanical property relationship is discussed. (Author abstract). 10 Refs.

Ting, Edmund Y. (Grumman Corp Research Cent, Bethpage, NY, USA); Grant, Nicholas J. *Int J Powder Metall (Princeton NJ)* v 24 n 3 Jul 1988 p 225-232.

## Amorphous

**084319 GLASS FORMATION IN MECHANICALLY ALLOYED TRANSITION METAL-TITANIUM ALLOYS.** The formation of amorphous powders by mechanical alloying of crystalline elemental powders is

investigated for a series of transition metal-titanium alloys. Completely amorphous powders are received in the Ni-Ti, Co-Ti and Cu-Ti systems. Partial amorphization is possible in the Fe-Ti, Mn-Ti and Cr-Ti systems whereas, for V-Ti, mechanical alloying results in a crystalline solid solution. The alloying and amorphization process is monitored by X-ray diffraction, magnetization measurements and thermal analysis. The experimental results are compared with calculated free enthalpy diagrams. It is shown that the amorphization depends strongly on a large negative heat of mixing. (Author abstract) 14 refs.

Hellstern, E. (Siemens AG, Erlangen, West Ger); Schultz, J. *Mater Sci Eng* v 93 Sep 1987 p 213-216.

**Applications** See Also POLYIMIDES—Physical Properties.

**084320 NEAR NET SHAPE FORMS SAVINGS.** This paper discusses the near net shape processes of cold forming and powder metallurgy which offer the ability to reduce cost and assembly time by combining the functions of what otherwise would be two or more parts into one, and at the same time greatly reduce material waste as compared to machined or stamped parts. Cold forming is a forging process using a die or a succession of dies, to displace the metal in a length of rod or wire, to form a diameter or shape different from the original. The metal is forced to flow around and into shape-forming dies. The powder metal process also uses dies, but the material is very fine particles (2 to 8 mils diameter) of metal. These particles are blended to form the desired alloy and mixed with a lubricant.

Schwartz, Walter H. (Assembly Engineering, Wheaton, IL, USA). *Assem Eng* v 31 n 7 Jul 1988 p 34-35.

## Beryllium

**084321 HIP BERYLLIUM ACHIEVES FULL COMMERCIAL STATUS.** This paper describes the experience in producing beryllium components by two basic processes. The first of these is direct HIPing of powder in a container. The alternate approach is containerless HIPing, where the parts are cold pressed (die or isopressed), vacuum sintered, and then HIPed. The relative economics of conventional versus HIP processing of several production parts is compared. (Edited author abstract) 5 refs.

Hanes, H.D. (Brush Wellman Inc, Elmore, OH, USA); Stonehouse, A.J. *Met Powder Rep* v 42 n 10 Oct 1987 p 708-711.

## Boron Compounds

**084322 AMBIENT PRETREATMENT EFFECT ON HIGH PRESSURE SINTERING OF c-BN USING h-BN AS A STARTING POWDER.** Single phase sintered compact of c-BN was prepared by high pressure and temperature treatment (7 GPa, 1700°C, 30 min) of h-BN powder mixed with 30 wt percent c-BN powder. An induced transformation from h-BN to c-BN was affected by ambient pretreatment in a hydrogen and nitrogen stream. The c-BN sintered compact showed an homogeneous microstructure composed of directly bonded grains of 0.5-1.0  $\mu$ m in particle size. Density and microhardness were 3.41 g/cm<sup>3</sup> and 5100 kg/mm<sup>2</sup>, respectively. The dielectric constant of the c-BN compact decreased monotonously with increase in frequency and showed a constant value of 10.0 above a frequency of 1 MHz. (Edited author abstract). 3 Refs. In Japanese.

Itoh, Hideaki; Matsudaira, Tsuneaki; Asano, Hideki; Inoue, Katsuya; Naka, Shigeharu. *J Jpn Soc Powder Powder Metall* v 35 n 3 Apr 1988 p 125-127.

## Bronze

**084323 INVESTIGATION ON P/M POROUS MATERIALS USED FOR FOUNDRY TOOLS AND DEVICES.** A rudimentary experiment was tried on the P/M bronze filtering components used for cold box tools by investigating the technologies of triethylamine air spray



cold boxes. It has been found that production costs can be decreased and casting qualities can be improved by using P/M bronze filtering components as venting units. This is a trial to extend the application range for these porous materials. (Author abstract) 1 ref. In Chinese.

Chang, Zhongmin. *Fenmo Yejin Jishu* v 5 n 2 May 1987 p 93-96.

**084324 INFLUENCE OF THE PARTICLE SIZE COMPOSITION OF 6-63 BRONZE POWDER BY GAS ATOMIZATION UPON APPARENT DENSITY AND COMPRESSIBILITY.** The present paper has concisely discussed the influence of particle size upon the apparent density, flow rate and compressibility of gas-atomized 6-63 bronze powder. The more fine particles ( $-320+400$  mesh size), the greater is the apparent density. The more coarse particles, the greater is the flow rate. When the composition of the fine powder is about 70%, the density of the compressed unit reaches its maximum. (Edited author abstract) In Chinese. 2 refs.

Wang, Shoushi (Shanghai Instrumental Powder Metallurgy Factory, China); Zhang, Hui. *Fenmo Yejin Jishu* v 6 n 1 Feb 1988 p 43-46.

## Carbon Steel

**084325 HIGH-STRENGTH CARBON STEELS WITH HEREDITARY FINE CRYSTAL STRUCTURE. IV. SOME TRAITS OF THE STRUCTURE FORMING PROCESS IN THE HEAT TREATMENT OF POWDERED CARBON STEELS.** The present work deals with the characteristic structures of carbon steels (0.95% C), the fracture surface of specimens (fractographic investigations), and on the basis of that the authors determine the essence of the strengthening of the alloy, ways of improving further the mechanical properties and their stability. The induced structural states of the grain boundaries endow the material with greater strength than the grain boundaries. In some cases there is intergranular failure, in other cases there is brittle failure. Ductile intergranular failure is preferable because with the optimal ratio of the dimension, density of segregates, and width of the depleted zone material with high strength and fracture toughness may be obtained whereas brittle intergranular failure cannot ensure high values of these characteristics. Consequently, revealing the peculiarities of the processes of strength formation of a high-strength alloy and investigation of the fracture surfaces make it possible to shed light on the essence of the strengthening of a material, and also to determine ways of further increasing the load bearing capacity of the steel. 4 refs.

Radomysel'skii, I.D. (Acad of Sciences of the Ukrainian SSR, USSR); Dzyubenko, A.I.; Lyapunov, A.P.; Drachinskii, A.S.; Podrezov, Yu.N.; Ponomarev, S.S. *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 339-345.

**Chromium** See Also CHROMIUM COMPOUNDS—Heat Treatment.

**084326 TENSILE DEFORMATION BEHAVIOR OF SINTERED CHROMIUM.** Tensile properties of sintered powder chromium produced by a cold isostatic press (CIP) and a hot isostatic press (HIP) were examined to find conditions favorable to plastic working of the sintered chromium. Specimens A and B<sub>1</sub> taken from a sintered ingot A and half of an ingot B were annealed at 1823 K, higher than the 1473 K encountered in the HIP. Specimen B<sub>2</sub> from the remainder of ingot B was not heat treated. Transition from ductile to brittle fracture occurred in a small range of temperature and at the higher temperature in testing at the higher speed of deformation. Ductile-to-brittle transition temperature of specimen B<sub>1</sub> was lower than that of specimen B<sub>2</sub> suggesting that the annealing at 1823 K is effective in lowering the transition temperature. A small plastic tensile prestrain given to a specimen at a temperature slightly beyond its transition temperature reduced brittleness. This prestraining effect comes from free dislocations generated in the prestrained specimen. At temperatures between 700 K to 1023 K, flow stress never changed even when the strain rate was increased from  $1.7 \times 10^{-4} \text{ s}^{-1}$  to  $1.7 \times 10^{-1} \text{ s}^{-1}$ . The

decrease in stress with increasing temperature was small. (Edited author abstract) 28 refs. In Japanese.

Ohmori, Masanobu (Hiroshima Univ, Higashi-Hiroshima, Jpn); Kaya, Akira; Harada, Yasunori; Yoshida, Fusahito; Itoh, Misao. *Nippon Kinzoku Gakkaishi* v 52 n 2 Feb 1988 p 223-228.

## Chromium Compounds

**084327 SINTERING OF CHROMIUM BORIDE BASE MATERIALS.** A study was made of conditions of production of chromium boride base materials with iron and nickel base binders. Sintering was performed for 0.5-2.0 h in the temperature range 1000-1700°C. The chromium boride-iron-nickel alloys had a multiphase structure consisting of grains of the chromium boride CrB, the iron boride FeB with a microhardness of about 11,000 MPa, and the binary boride  $(\text{Cr}_2\text{Ni})_x\text{B}_y$  with a microhardness of 18,500 MPa. The chromium boride base material with the nickel-chromium alloy binder as had a multiphase structure consisting of grains of the chromium boride CrB with a microhardness of 11,000-12,900 MPa and the binary boride  $(\text{Cr}_2\text{Ni})_x\text{B}_y$  with a microhardness of 19,000 MPa. 5 refs.

Barshchevskaya, L.F. (Acad of Sciences of the Ukrainian SSR, USSR); Maslyuk, V.A.; Klimenko, V.N.; Mamonova, A.A. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 717-720.

## Cobalt

**084328 ON THE SINTERING PROCESS OF COBALT AND DIAMOND MIXED POWDER COMPOUNDS.** The sintering process of Co and diamond mixed powder compacts in normal sintering and hot pressing was investigated by dilatometric and microscopic examinations. In the case of normal sintering, the shrinkage of Co powder compact started at 500°C and finished at about 1200°C. The shrinkage behavior of Co and diamond mixed powder compact was similar to that of the Co powder compact. In the case of hot pressing, shrinkage started at about 200°C and finished at 900°C. The Co and diamond mixed powder compact was denser than normally sintered compacts. (Edited author abstract). 5 Refs. In Japanese.

Shibata, Jiro; Tanabe, Shigenori; Kuno, Masaaki; Akiyama, Hisanori; Amitani, Tadao. *J Jpn Soc Powder Powder Metall* v 35 n 3 Apr 1988 p 109-113.

**084329 COBALT IN POWDER METALLURGY.** After situating the cobalt powder production in the total cobalt consumption, this article comments on different industrially available cobalt powders. It then illustrates the use of these powders by examples from the main P/M applications: heat resisting alloys, magnets, hardfacing alloys, and carbide and nitride production. (Edited author abstract)

Du Bois, Ivan (Metallurgie Hoboken-Overpelt, Hoboken, Belg). *ATB Metall* v 27 n 2-3 1987, Powder Metall, Brussels, Belg, May 13-14 1987 p 95-101.

**Compacting** See Also METAL FORMING—Pressing; NICKEL TITANIUM ALLOYS—Phase Transitions; POWDER METAL PRODUCTS—Amorphous; POWDERS—Compaction; POWDERS—Magnetic Field Effects.

**084330 POWDER METALLURGY: A TECHNOLOGY FOR ALL INDUSTRIES.** In the future the specialist materials such as the carbide producers will meet increasing competition from alternatives. The technology which will dictate the development of this position is undoubtedly that of surface coating. Once the final performance is determined to a larger extent by its surface only, the use of alternative substrates becomes competitive where such alternatives may be used to reduce costs. Finally, whilst the development of magnetic materials was precluded by space from all but superficial mention, a speculation for the future may perhaps be permitted. Very rapid strides in the performance of both soft and permanent magnets have been achieved by powder methods. The pace of development continues to be very significant. There are indications that major developments are well

along the road. Imagine therefore the impact of a magnet with the best performance available currently, but only a third of present size. This development will surely be apparent within the next ten years.

Brown, Gordon T. (GKN Technology Ltd). *Steel Times* v 215 n 10 Oct 1987.

**084331 COMPARATIVE EVALUATION OF LUBRICANTS FOR FERROUS STRUCTURAL ALLOYS.** Lubricants are used in Powder metallurgy for minimizing die wear and aiding powder handling. In this study a performance evaluation was conducted using a statistical experimental design with three premixed lubricants (Acrawax C at 0.75 wt%, Glycolube PM-100 at 0.50 and 0.75 wt%, and Lubrazinc W zinc stearate at 0.75 wt%). These combinations were selected based on earlier testing involving several lubricants at concentrations ranging from 0.25 to 1.00 wt%. The lubricants were applied to a conventional ferrous alloy (FC-0208) of 2 wt% Cu and 0.8 wt% C using a water atomized iron powder. (Edited author abstract) 24 refs.

German, R.M. (Rensselaer Polytechnic Inst, Troy, NY, USA); Christian, K.D.J.; Sacher, R.S.; Hall, L.; Reinert, J. *Met Powder Rep* v 42 n 11 Nov 1987 p 781-784, 786.

**084332 APPLICATIONS OF HUANG PEIYUN'S DOUBLE LOGARITHMIC EQUATION OF POWDER COMPACTING.** In this paper the extended applications of Huang Peiyun's double logarithmic equation of powder compacting are introduced on the basis of isostatically pressing practice. The equation can be turned into a non-logarithmic form by mathematical treatment. Experimental data on 11 kinds of powder isostatically pressed show that the equation has high accuracy and is practical. The equation is indicative of expression of a pressure - green density curve. (Edited author abstract) 5 refs. In Chinese.

Hu, Jiuzhi (Central-South Univ of Industry, China). *Fenmo Yejin Jishu* v 5 n 3 Aug 1987 p 137-146.

**084333 COMPACTIBILITY AND STRENGTH OF ROLLED STRIP FROM POWDERS (REVIEW).** By compactibility is meant the ability of a compact to retain its shape in a given porosity range. The compactibility of a powder depends on its porosity in the loosely poured state, physical condition, particle size distribution, particle shape and the presence of surface oxides. The review covers research published in the USSR and elsewhere. 42 refs.

Radchenko, A.K. (Acad of Sciences of the Ukrainian SSR, USSR); Katus, O.A. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 523-529.

**084334 POWDER FLOW DURING DYNAMIC AND QUASISTATIC COMPACTION.** An experimental study has been made of the flow of metal powders in an axisymmetric die incorporating a shoulder marking an abrupt reduction of diameter in the direction of compaction. A comparison has been made between powder flow in quasistatic and dynamic (shock wave) compaction when both methods produce a compact of the same average density. With the commercial grades of aluminum, iron, and copper powders studied, higher peak pressures were necessary during dynamic compaction to produce compacts with the same average density as those made quasistatically. Compacts made using dynamic compaction had a more uniform density distribution and were denser and harder near the die walls below the shoulder. With the powders that more strongly work hardened, closed shear surfaces were formed near the shoulder when compacted dynamically. (Edited author abstract) 10 refs.

Page, N.W. (Univ of Queensland, Brisbane, Aust); Killen, P.D. *Powder Metall* v 30 n 4 1987 p 233-239.

**084335 DEVELOPMENT OF NEW MODEL FOR COMPACTION OF POWDERS.** A theoretical model for compaction of powders has been proposed based on



the contribution of two different types of mechanisms. The first type is the rearrangement of powder particles which essentially acts at low compacting pressures. The second includes plastic deformation, fragmentation, or a combination of the two processes. The equations derived have been applied to the load-displacement curve obtained by pressing the powders in a die on a mechanical testing machine and recording the ram travel and the transmitted load. Tests on different kinds of materials (organic compounds, magnesium oxide, flint clays, metallic powders) showed that the proposed theoretical model gives a good description of the compaction process. The constants in the derived equations have been combined to obtain reliable parameters (maximum density attainable, compaction ratio). (Author abstract) 9 refs.

Cytermann, R. (IMI Inst for Research & Development, Haifa, Isr); Geva, R. *Powder Metall* v 30 n 4 1987 p 256-260.

**084336 INFLUENCE OF SMALL DIE WIDTH ON FILLING AND COMPACTING DENSITIES.** Experiments conducted to establish the influence of small die openings on actual filling density are reported. A special apparatus consisting of rectangular dies of various widths has been utilized with copper and mixed elemental bronze powders. The results show that filling densities decrease with decreasing die opening. The angle between sense of motion in filling and main die axis also influences the filling density through rebounds during powder fall; these rebounds play a positive role. The changing quantity of powder entering various dies can be explained by assuming that a boundary layer is present on the die surfaces. A simple theory, including a hydraulic radius of 'compacting' area, has been proposed and the corresponding formulae for different die geometries derived. The theoretical lines are in good agreement with the results of experimental tests. (Edited author abstract) 3 refs.

Bocchini, G.F. (Hoganas Italia srl, Como, Italy). *Powder Metall* v 30 n 4 1987 p 261-266.

**084337 DIE WALL LUBRICATION FOR POWDER COMPACTION: A FEASIBLE SOLUTION?** The development of an automatic die wall lubrication system for use during powder compaction of ferrous based materials is described. The technique, employing EP oil fed to the die wall interface under slight air pressure and augmented by the action of the toolset, appears to work well. Following laboratory scale development of the technique, involving lubricant selection, satisfactory works trials have been implemented. Five thousand simple preforms for subsequent powder forging and 2000 green compacts for a commercial sintered component of some geometric complexity have been produced in a modified production toolset. (Author abstract) 12 refs.

James, B.A. (GKN Technology Ltd, Wolverhampton, Engl). *Powder Metall* v 30 n 4 1987 p 273-280.

**084338 DENSITY-ENERGY RELATIONSHIPS IN EXPLOSIVE COMPACTION OF METAL POWDERS.** Powders of copper, iron, APK1 superalloy, and RSR aluminum alloy have been compacted in steel tubes of varying wall thickness using Trimonite explosive. In compaction tests, the energy required to compact the powder was determined by subtracting the tube deformation energy from the total initial kinetic energy of the tube. The results show that relationships exist between the specific kinetic energy applied to the powder and the compacted density achieved. These relationships are similar to relationships established between applied pressure and compacted density in isostatic and die compaction. (Edited author abstract) 15 refs.

Baird, K.S. (Queen's Univ of Belfast, North Irel); Williams, J.D. *Powder Metall* v 30 n 4 1987 p 281-285.

**084339 HOT COMPACTION EQUATIONS FOR METAL POWDERS AND POROUS PREFORMS.** Theoretical compaction equations for preheated metal powders and porous preforms are formulated from a micromechanical (hollow sphere) model with a temperature dependent strain hardening law. These equations

provide a useful means to predict the pressure-relative density relation during hot compaction at various preheating temperatures. One of these hot compaction equations gives the pressure-relative density relation of Shapero and Kolthoff and of Konopicky. Theoretical predictions are compared with experimental data for copper and beryllia powder. (Edited author abstract) 34 refs.

Kim, Katae (Pohang Inst of Science & Technology, Pohang, South Korea). *Int J Powder Metall (Princeton NJ)* v 24 n 1 Jan 1988 p 31-37.

**084340 OPTIMISATION OF THE COMPACTING PROCESS OF P/M PRODUCTS.** A lot of parameters have to be taken into consideration when planning the compacting device of a P/M production. This is shown in the following contribution. Economic aspects are dealt with first, followed by a detailed analysis of the shaping process with regard to the compaction processes. There, the correct quality of the powder is of great importance, which is described separately. Furthermore, the two basic types of press design - mechanically or hydraulically driven - are discussed thoroughly. Depending on the production goal, both can display certain advantages. (Author abstract)

Fischer, E. (Dorst Maschinen- und Anlagenbau, Kochel, West Ger). *Powder Metall Int* v 20 n 1 Feb 1988 p 32-34.

**084341 HIGH-SPEED COMPUTER CONTROLLED ROBOTIC LOADING SYSTEM.** Robotic loading or pick and place systems have become an important part of modern automation in recent years. The high speed systems have been designed for the powder compacting industry to load parts from a press or feeding machine one at a time or a row at a time at up to 60 parts or rows of parts per minute. Speeds of up to 100 parts or rows of parts are possible for special applications. The article describes the equipment and its operation.

Wheeler, Frederick S. (PTX Pentronix, Lincoln Park, MI, USA). *Carbide Tool J* v 20 n 1 Jan-Feb 1988 p 29-30.

**084342 THEORETICAL STUDY ON THE IMPACT COMPACTION OF METAL POWDERS.** A theoretical investigation was made on the impact compaction of metal powders based on dynamics and rheology. The stress, displacement and acting time exerted on the powder by a drop hammer were measured by using dynamics electrometry controlled by a single-board microcomputer. The results obtained are as follows: a) The maximum stress produced by a dropping hammer with a certain kinetic energy and the acting time depend on the hammer weight, the filling weight of the powder in the die and the degree of deformation of the powder. The green density depends on the maximum impact stress and acting time, but it does not correspond to the impact kinetic energy. b) The relationship between stress and strain on impact compaction may be described by the nonlinear visco-elastic model derived by Professor Huang Peiyun. The rheologic parameters of Fe, Cu, Sn and Mo powders are calculated by a computer. The calculation shows that theoretical and experimental data are in satisfactory agreement. (Edited author abstract) 9 refs.

Chen, Zhenhua (Powder Metallurgy Research Inst, China); Huang, Peiyun. *Zhongnan Kuangye Xueyuan Xuebao* v 18 n 4 Aug 1987 p 452-458.

**084343 THEORETICAL STUDY ON THE COMPACTION OF METAL POWDERS UNDER A CONSTANT APPLIED PRESSURE.** A theoretical study on the compaction of metal powders under a constant applied pressure in terms of rheology is presented. The relationship between the stress and strain is described by using a nonlinear visco-elastic equation. The rheologic parameters of Sn, Cu, Fe and Mo powders are calculated by an electronic computer. The calculation result shows that theoretical and experimental data are in satisfactory agreement. (Edited author abstract) In Chinese. 8 refs.

Chen, Zhenhua; Huang, Peiyun. *Zhongnan Kuangye Xueyuan Xuebao* v 18 n 1 Feb 1988 p 60-66.

**084344 OPTIMISATION OF THE COMPACTING**

**PROCESS OF P/M PRODUCTS.** The author considers parameters for the compaction process and the compact. Filling conditions and the compaction process of press and tool must be well reproducible in large quantity production runs. It is for this reason that there is a trend in press engineering - particularly for components of intricate shape - towards controlled movements. Recently this has resulted in presses with up to 7 axes of movements, including the controlled filling movement.

Fischer, E. (Dorst Maschinen & Anlagenbau, Kochel a See, West Ger). *Powder Metall Int* v 20 n 2 Apr 1988 p 27-30.

**084345 IMPROVED METHOD FOR SHOCK CONSOLIDATION OF POWDERS.** This technique uses a potential geometry with two co-axial tubes. The powder is contained in the internal tube. The external tube is surrounded by the explosive charge which is detonated at one end. This tube acts as a layer tube, impacting the internal tube. This technique generates pressures in the powder that can be several times higher than generated by the single-tube technique. The lower reaction velocity explosives minimize cracking of compacts. Improvements in compact quality were obtained in nickel-base superalloys, titanium alloys and aluminium-lithium alloys. (Edited author abstract) 25 refs.

Meyers, M.A. (New Mexico Inst of Mining & Technology, Socorro, NM, USA); Wang, S.L. *Acta Metall* v 36 n 4 Apr 1988 p 925-936.

**084346 1985 POWDER METALLURGY GROUP MEETING: THE PRODUCTION, CHARACTERISATION AND HANDLING OF METAL POWDERS - PREPRINT.** This conference proceedings contains 22 papers arranged in six sections. Topics presented includes production methods of metal powders; powder mixing and handling; rapidly solidified powders; general aspects of the production and properties of metal powders; powder classification and production and properties of atomized powder. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10635 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Inst of Metals, CRC Unit, London, Engl). *1985 Powder Metall Group Meet: The Prod, Character and Handl of Metal Powders - Prepr, Eastbourne, Engl, Oct 21-23 1985* Publ by Inst of Metals, London, Engl, 1985 var pagings.

**Compaction** See Also THERMAL INSULATION—Optimization.

**084347 ADVANCES IN COMPACTING PRESS TECHNOLOGY.** The Stokes Summit series compacting press has been designed to give the PM industry the capability of producing optimum parts, while at the same time reducing scrap and down-time. Especially with today's emphasis on just-in-time manufacturing and documentation through statistical process control, the 'Summit' press can meet the demanding standards required by customers. Edward F. Adolf of Pennwalt Corporation's Sharples-Stokes Division, in Warminster, PA, outlines in the following article some of the advances his company has made in powder compacting technology. Today's parts producers have a marked advantage over their predecessors of as recently as five to ten years ago, with the application of electronics and microprocessor technology to the art of pressing. Advances in automation, monitoring, and control have kept the powder metal compacting process a viable, economical alternative to other forming technologies. In order to remain competitive, the parts fabricators must take advantage of these advances in press design by investing for tomorrow.

Adolf, Edward F. (Pennwalt Corp, Warminster, PA, USA). *Met Powder Rep* v 42 n 9 Sep 1987 p 629-631.



**084348 VACUUM ASSISTED COMPACTING.** Juan A. Bas and Cesar Molins of Ames SA, Barcelona, Spain, describe a newly developed and patented process 'Vacuum Assisted Compacting', which provides a considerable increase in productivity in the compacting of PM parts. The process is said to be particularly suitable for the production of thin-walled components. After the tests performed, the 'Vacuum Assisted Compacting' (VAC) system is a technique of interest for PM, making it possible to increase the compacting speed and also the compacting of thin walled parts, and it facilitates the filling of chambers with poor flowing powders. 2 refs.

Bas, Juan A. (Ames SA, Barcelona, Spain); Molins, Cesar. *Met Powder Rep* v 42 n 9 Sep 1987 p 632-633.

**084349 POWDER TRANSFER SYSTEMS IN PM COMPACTING.** Powder transfer is the controlled movement of metal powder from the fill position onto a transferred position which is relative to its final structural shape, and this movement of powder must be performed prior to any precompaction of the material taking place. John Reid of High Wycombe, Bucks, describes in detail the way in which powder transfer systems can be applied using four complex PM components as example. This article will describe in detail the way in which powder transfer systems should be applied, using four components shown in Figs 1 to 4, which are a fair representation of the PM parts normally requiring effective powder transfer. For those experienced engineers who require assistance in the manufacture of specific components which their companies are currently producing, or about to start the manufacture of, then further information is available having first agreed the terms of disclosure.

Reid, John (PM Industry, High Wycombe, Engl). *Met Powder Rep* v 42 n 9 Sep 1987 p 634-637.

**084350 SYSTEM FOR MEASUREMENT AND CONTROL OF PRESSING PARAMETERS.** This paper by R. Jansson and P. Samuelson of AB Sandvik Hard Materials, Stockholm, Sweden, describes a system for supervising and controlling the essential pressing parameters of mechanical powder compacting presses. The system is designed for monitoring the entire cycle of the pressing forces and correcting the compact weight to its target values. The adjustment of weights is optimized for the specific press tool and powder by means of an automatic pressure-weight calibration routine. The paper concludes with some ideas on how the information received by this system can be used for trouble-shooting purposes. A Sandvik system for the measurement of compaction forces and control of compacts weight has been described. Compared with a manual system, the automatic control system reduces the variations of compact weight by 20-50%. It also provides for a tool for trouble-shooting and tuning purposes. The highly automated operations allow non-specialists to operate the system. 3 refs.

Jansson, R. (AB Sandvik Hard Materials, Stockholm, Sweden); Samuelson, P. *Met Powder Rep* v 42 n 9 Sep 1987 p 638-639.

## Computer Aided Analysis

**084351 OPERATOR-FREE POWDER COMPACTING.** The majority of all PM products today are produced by the so-called conventional die compaction process, and it is expected that this will continue in the immediate future. However, powder press utilization is often poor, and Ove Wigren of Convey Technik AB, in Harnosand, Sweden, describes the development of an operator-free 'Result' hydraulic press system where all the main functions are controlled by a combination of robotic devices and microprocessors. The above combination makes it possible to make powder compacts operator-free during part of a shift or a complete shift. The built-in flexibility means that the press changes the depth of fill for each stroke or after a desired number of compacts in order to stay inside the preset tolerances. Because the press station does not need the operator it is possible to increase the utilization up to 75-80% and reduce the number of operators by at least 50%.

Wigren, Ove (Convey Technik AB, Harnosand, Swed). *Met Powder Rep* v 42 n 9 Sep 1987 p 640-641.

**Computer Applications** See IRON AND STEEL PLANTS—Automation; POWDER METAL PRODUCTS—Costs.

**Copper** See Also ATOMIZERS—Design; COPPER CHROMIUM ALLOYS—Solidification; PARTICLE SIZE ANALYSIS.

**084352 MECHANISM OF THE CATHODIC PROCESS IN THE FORMATION OF A POWDER COPPER DEPOSIT.** As a result of earlier studies of the process of copper powder deposition in a microcell, conclusions have been drawn concerning the character of the electrocrystallization of dendritic deposits. The present work was undertaken with the aim of investigating the differences in copper electrocrystallization conditions at different cathode heights. A study was made of the variation of copper (II) ion and sulfuric acid concentrations inside the powder deposit over the rod cathode height. Experiments were conducted in a box-type electrolysis cell. 2 refs.

Smirnov, B.N. (Ural Scientific-Research & Design Inst of the Copper Industry, USSR); Popova, L.I.; Artem'ev, A.D.; Galieva, L.M. *Sov Powder Metall Met Ceram* v 26 n 3 Mar 1987 p 185-187.

**084353 EFFECT OF PRESSING AND SINTERING CONDITIONS ON ANISOTROPIC SWELLING OF ELECTROLYTIC COPPER POWDER COMPACT.** The swelling of cylindrical compacts was measured after pressing at 2-8 t/cm<sup>2</sup> (196-784 MPa), after dewaxing at 500°C (773 K) for 30 min, and after sintering at 900°C (1173 K) for 5-180 Min. Compacts pressed under higher pressures (588-784 MPa) swelled during sintering, while those pressed under lower pressures (196-392 MPa) shrank. Both the swelling and the shrinkage of compacts pressed with die wall lubrication and sintered in cracked ammonia gas were larger than those of compacts pressed with powder lubrication or sintered in argon gas. The sintering time for the swelling of electrolytic powder compacts in argon gas was longer than that of compacts sintered in cracked ammonia gas or of compacts made from atomized powder. (Edited author abstract) In Japanese. 11 refs.

Kuroki, Hidenori. *J Jpn Soc Powder Powder Metall* v 34 n 5 Jul 1987 p 198-204.

**084354 INFLUENCE OF ADDITIONAL Al<sub>2</sub>O<sub>3</sub> POWDER ON SINTERING BEHAVIOR OF CU ULTRAFINE POWDER.** The relative density and average Cu grain size of a sintered compact prepared from Cu ultrafine powder and Al<sub>2</sub>O<sub>3</sub> powders were investigated in relation to density and the amount and particle size of Al<sub>2</sub>O<sub>3</sub> powder. The compacts were sintered at 1273 K for 3.6 ks in hydrogen. Density increased with increasing amount of Al<sub>2</sub>O<sub>3</sub> powder. When the amount of Al<sub>2</sub>O<sub>3</sub> was larger than a limiting value, the sintered compact became porous. The grain growth of the Cu matrix became more suppressed as the Al<sub>2</sub>O<sub>3</sub> powder became larger in amount and finer in size. (Edited author abstract) In Japanese. 7 refs.

Hayashi, Koji; Itabashi, Masao; Kihara, Hiroshi. *J Jpn Soc Powder Powder Metall* v 34 n 6 Aug 1987 p 259-263.

**084355 PREPARATION AND PROPERTIES OF DISPERSION STRENGTHENED Cu-Al<sub>2</sub>O<sub>3</sub> POWDER USING Al-ALOXIDE.** Cu-Al<sub>2</sub>O<sub>3</sub> powders were prepared by a process where electrolytic fine copper powders were mechanically alloyed with Al propoxide in air or argon then heated in hydrogen. The properties of the powders obtained were studied. The mass transfer of copper to the surface of each powder particle occurred at about 873 K. By this phenomenon, sinterability was improved. The powder processed in air was superior in sinterability and mechanical properties. (Edited author abstract) In Japanese. 10 refs.

Arami, Yoshiro; Korekawa, Hiroshi; Iwatsu, Osamu. *J Jpn Soc Powder Powder Metall* v 34 n 6 Aug 1987 p

264-268.

**084356 PRODUCTION OF COPPER-GRAPHITE COMPOSITES FROM METALLIZED POWDERS.** The methods of differential-thermal and thermogravimetric analysis were used to examine the special features of oxidation-regression processes which take place in heating in air in compacts made by pressing copper-graphite powder compositions produced in various conditions and by various methods. The nature and temperature zones of occurrence of these processes were established. (Author abstract) 4 refs.

PASTUKHOV, V.P.; Kuz'mina, I.V.; Frishberg, I.V. *Phys Chem Mater Treat* v 21 n 3 May-Jun 1987 p 277-279.

**084357 MECHANICAL AND ELECTRICAL PROPERTIES OF PM BRASS.** Non-ferrous copper-base powders have been used for structural part applications for many years. Brasses and other prealloyed copper-base alloy powders are normally compacted within the 30 to 40 ton per square inch range resulting in the attainment of densities adequate for medium strength and hardness applications. The article discusses the production and properties that can be achieved with sintered brass. 2 refs.

Anon. *Met Powder Rep* v 43 n 1 Jan 1988 p 31-32.

**084358 RESEARCH OF P/M Cu-Al<sub>2</sub>O<sub>3</sub> ALLOY WORK-HARDENING BEHAVIOUR.** This paper deals with the work-hardening behaviour of a Cu-Al<sub>2</sub>O<sub>3</sub> alloy rod in the cold-worked and annealed states. The P-ΔL curve obtained on an electrical tension test device was reported. The work-hardening exponent was measured by using the first work-hardening curve and it was compared with the deformation resistance method. Results show that as the strain rate increases, the work-hardening degree and yield strength become larger, and both properties are affected by the chemical composition. (Edited author abstract) 6 refs. In Chinese.

Zhang, Yinqiu; Lei, Changming. *Zhongnan Kuangye Xueyuan Xuebao* v 18 n 3 Jun 1987 p 281-287.

**084359 RELATION BETWEEN SINTERABILITY AND INITIAL PACKING DENSITY IN LOOSELY SINTERED COPPER SPHERE COMPACTS.** Spherical copper powders with various initial packing densities were pressureless formed and sintered. Sintered properties, shrinkage, electrical resistivity, and breaking strength were measured and examined on the basis of simple geometrical model. These properties were dependent on the initial packing density of the green compact. Sintering shrinkage and breaking strength increased with increasing initial packing density whereas electrical resistivity decreased. The activation energy of the sintering process was 172.6 kJ mol<sup>-1</sup> and volume diffusion from the grain boundaries appeared to be the most plausible mechanism for sintering. (Edited author abstract) 8 refs.

Moon, In-Hyung (Hanyang Univ, Seoul, South Korea); Lee, Jeong-Keun. *Powder Metall* v 30 n 4 1987 p 249-254.

**084360 COMPLETE DENSIFICATION OF COPPER SINTERED COMPACT BY THE ADDITION OF IRON POWDER.** The relative density (D<sub>r</sub>) of the sintered compact from water-atomized Cu powder was investigated in relation to the relative density (D<sub>g</sub>) of the green compact with the additions of iron powder. The green compact was sintered in flowing H<sub>2</sub> gas at 773-1253 K for 3.6-72 ks. D<sub>r</sub> tended to show a maximum of 93-96% and did not become 100% irrespective of the value of D<sub>g</sub> and sintering conditions. This finding is due to H<sub>2</sub>O gas produced by the reaction of a minute amount of retained copper oxide or dissolved oxygen. (Edited author abstract) In Japanese. 5 refs.

Hayashi, Koji (Univ of Tokyo, Tokyo, Jpn); Lim, Dai-Wan; Itabashi, Masao. *Nippon Kinzoku Gakkaishi* v 52 n 1 Jan 1988 p 121-125.



**084361 ELECTROCHEMICAL DISSOLUTION OF COPPER-IRON SULFIDES IN SULFATE AND SULFATE-CHLORIDE ELECTROLYTES.** The electrolysis of copper-iron mattes makes it possible, in one operation, to obtain copper powder meeting the requirements for PM powder. The problem discussed is determining an expedient ratio of copper and iron in mattes and optimizing the electrolyte concentration. It is most expedient to subject copper-iron mattes containing 30-40% copper to electrochemical dissolution. The optimum electrolyte acidity for obtaining copper powder is 30 g/liter  $H_2SO_4$  with a chloride ion content of 40 g/liter (for mattes with a copper content of 40-43%, the content should be 50-60 g/liter). 5 refs.

Sabauri, G.N. (USSR Acad of Sciences, USSR); Subbotina, E.A.; Reznichenko, V.A.; Bryukvin, V.A. *Prot Met* v 23 n 3 May-Jun 1987 p 339-342.

**084362 REVIEW OF RECENT DEVELOPMENTS IN POWDER METALLURGY OF COPPER ALLOYS.** Research aimed at improving the density and electrical conductivity, and the uniformity of these properties, in a relatively thick pressed and sintered pure copper parts for electrical applications is first described. Improved high-strength, high-conductivity copper alloys by rapid solidification powder metallurgy (RS P/M) processing has been an active area of investigation. Results from several studies are reviewed and discussed. The results of one investigation of spray forming as an RS P/M technique is reviewed. Powder metallurgy copper alloys that combine precipitation hardening and oxide dispersion strengthening have shown promise for applications where high temperature properties are important. Certain copper alloys incorporating oxide dispersoids have shown particular promise in maintaining mechanical properties and showing very low swelling after exposure to substantial neutron irradiation. (Edited author abstract) 15 refs.

Peters, D.T. (Int Copper Research Assoc Inc). *ATB Metall* v 27 n 4 1987 p 143-154.

**084363 THERMOMECHANICAL ANALYSIS OF WELDED POWER METALLURGY JOINTS.** The results of the present investigations on welded porous/solid couples can be broadly classified into two categories: (a) samples which show measurable shrinkage at elevated temperature but retain their original length upon cooling (or a marginal increase in a few cases); (b) samples which show constant dimensions at elevated temperatures but show a net increase in length upon cooling. 5 refs.

Badarinarayana, H.S. (Indian Inst of Technology, Kharagpur, India); Godkhindi, M.M. *J Mater Sci Lett* v 7 n 2 Feb 1988 p 97-101.

**084364 EFFECT OF PRESSING PRESSURE AND SINTERING TEMPERATURE ON THE ELECTRICAL CONDUCTIVITY AND LINEAR ELONGATION OF COPPER POWDER SINTERED COMPOSITES.** The relationship between the electrical resistance and linear elongation and the parameters of pressing and sintering of copper powder materials is presented. From comparison of the changes in resistivity and the dilatometric curves it follows that three stages occur in the process of sintering. The value of electrical resistance shows a drop only for certain value of pressing pressure and sintering temperature. The specimens pressed under a pressure of over 190 MPa and sintered above 700°C show an increase in resistance and a decrease in conductivity. (Edited author abstract) 19 refs.

Piszczyk, T. (Inst of Nonferrous Metals, Gliwice, Pol); Stolarz, S. *Sci Sintering* v 19 n 3 Sep 1987 p 143-149.

**084365 FORMING AND DENSIFICATION OF SINTERED POWDER MATERIALS.** A yield criterion for sintered powder materials is proposed. The stress-strain curve and Poisson's ratio are determined from simple uniaxial compression tests of sintered copper. The methods of engineering and slipline are applied to analyses of strain compression and axial symmetry deformation. The experimental results are compared with the theoretical solutions. (Author abstract) 37 refs.

Zhao, Zhong-zhi (Wuhan Inst of Technology, Wuhan, China); Hual, Lin; Wang, Hua-chang. *Sci Sintering* v 19 n 2 May 1987 p 65-80.

**084366 KINETICS AND THERMODYNAMICS OF COPPER POWDER PELLETS RECOVERY.** The process of dislocation generation during copper powder pressing has been investigated as well as annihilation when exposed to heating. Measurements of the energy of elastic deformation liberated in the course of annealing have been performed. The results prove that a maximal energy is liberated from samples obtained under the pressure of 200 MPa. The activation energies and rate constants of the recovery process have been determined. (Edited author abstract) 5 refs.

Maricic, A. (Technological Faculty, Cacak, Yugosl); Susic, M. *Sci Sintering* v 19 n 2 May 1987 p 89-94.

**084367 CHANGES IN THE LONGITUDINAL FLOW AND APPARENT PLASTIC POISSON'S RATIO OF A POROUS METAL STRIP DURING HOT DENSIFICATION ROLLING.** Analytical relationships between the longitudinal flow and the thickness deformation and between the apparent plastic Poisson's ratio and the relative density of a porous metal strip during hot rolling have been derived from geometrical considerations. Experimental data obtained from the hot rolling of porous copper strips of relative density of 0.4 agree well with the results predicted from analytical relationships. Changes in the longitudinal flow and the apparent plastic Poisson's ratio take place in three stages of densification. Stage I, densification up to the relative density of 0.70, involves densification by decreasing the pore channel widths without closing them. Stage II, densification from the relative density from 0.70 to that of 0.95, is associated with the patching of pore channels at some points, the number of which increases as the thickness deformation given to the strip increases. Stage III, densification of the strip from the relative density of 0.95 and onward, involves elimination of the newly formed closed porosity by shearing. (Edited author abstract) 8 refs.

Bhargava, S. (Indian Inst of Technology, Kanpur, India); Dube, R.K. *Metall Trans A* v 19 n 5 May 1988 p 1205-1211.

**084368 EVALUATION OF ACTIVATION ENERGY IN SINTERED SAMPLES.** The neck curvature obtained in sintering two spherical copper particles is related to the neck radius of the contact area and the radius of the particles. The radius of the neck curvature, when expressed in terms of the fractional shrinkage, leads to method of evaluating the activation energy corresponding to the operating mechanism at different stages of sintering. The calculated values of activation energy confirm the diffusion mechanisms operative at different temperatures and different sintering durations. (Author abstract) 8 refs.

Achari, K.M.R. (Loyola Acad, Andhra Pradesh, India); Reddy, M.B.; Ramachander, R.B. *J Mater Sci* v 23 n 5 May 1988 p 1673-1676.

**084369 NOVEL PROCESS DEVELOPED FOR ULTRA-FINE METAL POWDERS.** A new technique which offers simple continuous production of submicronic metal powders has been developed by L'Air Liquide of France. The process involves melting the metal to be converted into powder in a superheated bath under a pressure greater than 1,000 Pa. This superheated metal is then covered with a cryogenic liquid and fumes are emitted which consist of spherical metal particles generated by condensation of metallic vapours in the gas film separating the cryogenic liquid from the molten metal. The particles are then carried away by the flow resulting from the liquid film vapourisation. To date L'Air Liquide has produced powders of copper, silver, zinc and magnesium.

Anon. *Met Powder Rep* v 43 n 6 Jun 1988 P434.

## Copper Graphite

**084370 INFLUENCE OF POROSITY AND SLIDING RATE ON THE TRIBOTECHNICAL PROPERTIES AND FEATURES OF DEFORMATION ON THE SURFACE LAYERS OF COPPER-GRAPHITE MATERIALS DURING FRICTION WITHOUT LUBRICATION.** The relationship of the intensity of wear of a copper-graphite material containing 10% graphite to porosity has an extreme character. The optimum antifriction properties are obtained with a porosity of 6-12%. In this interval of porosities the minimum degree of deformation of the surface layer in friction is observed. The minimum values of the intensity of wear and the coefficient of friction are observed in the 2.6-22 m/sec range of sliding rates, at which solid films of secondary structures distinguished by low roughness are formed on the surface. 11 refs.

Paderno, V.N. (Acad of Sciences of the Ukrainian SSR, USSR); Baranov, N.G.; Dyachenko, L.I.; Pilyankevich, A.N.; Ageeva, V.S.; Il'nikskaya, A.I. *Sov Powder Metall Met Ceram* v 26 n 8 Aug 1987 p 671-674.

## Copper Iron Alloys

**084371 EFFECT OF SINTERING TEMPERATURE AND PRESSURE ON SINTERED AND FRICTION PROPERTIES OF A Cu BASE FRICTION MATERIAL.** A powder mixture of 71 Cu-12Fe-10C-4SiO<sub>2</sub>-2Pb-0.5MoS<sub>2</sub> (in mass%) has been compacted into disks. The pellets and steel backing plates have been diffusion bonded and sintered at various temperatures (700 to 965°C) and pressures (1.5 to 3 MPa). Under constant pressure, porosity decreases and sintered hardness increases with increasing sintering temperature. A change in porosity and hardness is observed by raising the temperature from 950 to 985°C. A gradual increase of sintered density and hardness with sintering pressure has been observed. As sintered hardness increases, friction coefficient and wear rate decreases slightly. (Edited author abstract) 10 refs.

Kim, J.W. (Korea Advanced Inst of Science and Technology, Seoul, South Korea); Kang, B.S.; Kang, S.S.; Kang, S.-J.L. *Powder Metall Int* v 20 n 3 May 1988 p 32-34.

## Copper Nickel

**084372 PM WROUGHT CuNiSn STRIP FINDS APPLICATION IN THE ELECTRONICS INDUSTRY.** Cu-Ni-Sn alloys made by powder rolling and sintering are attractive materials for use in the electronics industry, particularly when high spring strength, good formability, electrical conductivity and corrosion resistance are required. Pfinodal alloy strip is a product of Pfizer's patented wrought PM technology. In this process strip is made by cold compaction of fully homogenized high purity powder which has been produced by melting and atomizing high purity copper, nickel and tin. The molten alloy stream is broken into fine homogeneous particles by high pressure water jets. The atomized powder is then fed between horizontal rolls and friction between the powder and the roll surface draws the powder into the roll gap where the roll pressure produces a mechanical bond between the powder particles. After compaction the green strip is sintered, coiled and passed through a series of high temperature anneals and cold rolling steps to produce 100% density.

Anon. *Met Powder Rep* v 43 n 1 Jan 1988 p 33-34.

## Copper Nickel Tin

**084373 SMALL ANGLE X-RAY SCATTERING STUDY OF THE DECOMPOSITION PROCESS OF THE POWDER METALLURGY ALLOY Cu-15wt%Ni-8wt%Sn.** The authors studied an alloy named Pfinodal using SAS. Whereas fluctuations of the tin composition are present at the very beginning of the decomposition process, such fluctuations are not in agreement with the SAS measurements. The anomalous effect considers that scattered entities having the composition (Cu<sub>0.75</sub>Ni<sub>0.25</sub>)<sub>3</sub>Sn are responsible for the opposite



intensity variations near both Ni and Cu K-edges. This technique of anomalous small angle X-ray scattering is a concrete example in a ternary alloy for differentiating between different models which can fit the classical data. 11 refs.

Goudeau, Ph. (CNRS, Orsay, Fr); Naudon, A.; Welter, J.M. *Scr Metall* v 22 n 7 Jul 1988 p 1019-1022.

#### Copper Nickel Tin Alloys See COPPER NICKEL TIN ALLOYS—Mechanical Properties.

#### Copper Niobium

**084374 THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE PROCESS OF PLASTIC DEFORMATION OF SINTERED COMPOSITE MATERIALS. II. EFFECT OF SHAPE OF HARD INCLUSIONS ON THE DEVELOPMENT OF SIMULTANEOUS DEFORMATION OF THE PHASES OF A COMPOSITE MATERIAL.** When the strength characteristics of the soft and hard phase materials of a given composite material and certain parameters are known, it is possible to determine minimum values of the parameter  $t/d$  (shape factor) at which simultaneous deformation of the two phases of the material will commence under any given conditions of deformation. To verify the findings of a theoretical investigation, experiments were carried out in which a composite material of the copper-40% niobium system was rolled. As hard inclusions chopped lengths of niobium wire with  $t/d$  ratios of 2, 5, and 10 were used, the reduction in each stage of deformation being 15%. The results show the variation of the degree of deformation of the inclusions with deformation. 5 refs.

Kiparisov, S.S. (Moscow Inst of Fine Chemical Technology, USSR); Kiyanskii, I.A.; Perel'man, V.E. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 697-701.

**084375 USE OF THE ROTATING-ELECTRODE PROCESS IN THE FABRICATION OF Cu-Nb COMPOSITES.** Extremely fine niobium dendrites can be attained by rapid solidification of Cu-Nb alloys. The rotating electrode process (REP) is a powder atomization technique with cooling rates on the order of  $10^3$  to  $10^4$  °C sec<sup>-1</sup>. These cooling rates are predicted to yield niobium dendrites of diameter 1.4 to 3.0 μm. In addition, the REP uses no crucible and the melting is done in an inert environment which makes it an attractive process for reactive metals like niobium. The powders did not exhibit increased tensile strength upon deformation due to the non-uniform microstructure. 14 refs.

Trybus, C.L. (Iowa State Univ, Ames, IA, USA); Verhoveen, J.D.; Schmidt, F.A.; Spitzig, W.A. *J Mater Sci Lett* v 7 n 5 May 1988 p 532-534.

#### Copper Niobium Alloys

**084376 THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE PROCESS OF PLASTIC DEFORMATION OF SINTERED COMPOSITE MATERIALS. I. ANALYSIS OF THE CONDITIONS OF SIMULTANEOUS DEFORMATION OF THE DIFFERENT PHASES OF A COMPOSITE MATERIAL.** The article presents the results of an investigation into the dependence of the shear strength of composite materials on the magnitude of the compressive stress. Experiments were carried out on nonporous composite materials from powders of ductile metals (copper and aluminum) and a hard filler (niobium and alumina) and on porous blanks (compacts) pressed from the powders. The filler content varied from 10 to 70% and the porosity of the compacts, from 60 to 10%. Curves of shear strength vs compressive stress (plasticity function of the materials) are shown for porous compacts and for dense composite materials of the copper-niobium system. It was found that the plasticity function of a composite material (like that of a porous powder medium) depends on the first invariant of the stress tensor. The intensity of this dependence, assessed by the internal friction angle, is determined by the magnitude of the difference in strength properties between the components of the composite material, the area of the property discontinuity surfaces in unit volume of the

composite, and the relative orientation of the property discontinuity and slip surfaces. 6 refs.

Kiparisov, S.S. (Moscow Inst of Fine Chemical Technology, USSR); Kiyanskii, I.A.; Perel'man, V.E. *Sov Powder Metall Met Ceram* v 26 n 8 Aug 1987 p 615-620.

#### Copper Tin

**084377 INVESTIGATION OF PORE SIZE DISTRIBUTION IN POROUS POWDER MATERIALS BY DIFFERENT METHODS.** The interest in methods of investigating specific properties of porous power materials (PPM) is due to their application in filters, catalysts, flame barriers, mixers, capillary structures of heat pipes, etc. An important characteristic of PPM determining their operational properties is the power size distribution. Most widely used are three methods of investigating pore size distribution: mercury porosimetry, substitution of liquid in pores by gas and metallography. The article compares these methods in measurements on bronze powder. 8 refs.

Kaptsevich, V.M. (Bryansk Scientific & Production Assoc of Power Metallurgy, USSR); Sheleg, V.K.; Sorokina, A.N.; Savich, V.V.; Mazyuk, V.V.; Anishchik, T.A. *Sov Powder Metall Met Ceram* v 26 n 3 Mar 1987 p 234-236.

**084378 DENSIFICATION KINETICS OF A COPPER-TIN POWDER COMPOSITE DURING ELECTRIC-DISCHARGE SINTERING.** The density of specimens produced by electric discharge sintering depends to a large extent on the mechanical and electrical parameters of the process. In the electric discharge sintering of a copper-tin composite, raising the prepressing pressure from 4.17 to 12.5 MPa decreased the extent and rate of shrinkage by more than half. To attain the same hardness on passing from a low (4.17 MPa) to a higher prepressing pressure (12.5 MPa), it was necessary to increase the current density by 100 A/cm<sup>2</sup> (from 595 to 695 A/cm<sup>2</sup>). 4 refs.

Sukhov, O.V. (Acad of Sciences of the Ukrainian SSR, USSR); Baidenko, A.A.; Istomina, T.I.; Raichenko, A.I.; Popov, V.P.; Svehkov, A.V.; Gol'dberg, M.Sh. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 530-532.

**084379 HYDROMETALLURGICAL PROCESS FOR PREPARING COMPOSITE Cu-Sn POWDER.** The present work has tried successfully to cement the copper-tin composite powders from sulfate solutions of Cu and Sn at pH 0.12 to 1.2%. The composite powders with copper compositions of 91.2% and 79.9% were obtained, respectively, for the theoretical corresponding compositions of 90% and 80%. Thus cemented higher copper content powders are of cubic shape, while increasing contents of tin tends to distort the cubic shape. The rate of copper cementation is enhanced by the increasing pH values of the initial solution. (Author abstract) 6 refs.

Lin, K.-L. (Nat'l Cheng Kung Univ, Tainan, Taiwan); Shu, Y.-M. *Powder Metall Int* v 19 n 6 Nov 1987 p 28-30.

**084380 DYNAMICS OF INTERPARTICLE REACTIONS IN SPHERICAL METAL POWDERS DURING ELECTRIC SINTERING.** A study was made of atomized powder particles of BrOf-10-1 tin bronze. The dynamic characteristics of interparticle neck formation depend not only on current density (raising the current density by 1.7 times increases interaction rates by an order) but also on the positions of the particles relative to the direction of passage of current (particles lying in a plane parallel to the direction of passage of current interact 3.4-5 times more rapidly than particles lying in a plane perpendicular to this direction). The kinetics of powder particle sintering by an electric current is due to the most intense sintering mechanisms such as viscous flow, transport through the gaseous phase, and spreading of liquid metal over the solid surfaces of particles. The strongest influence on the kinetics of mutual particle sintering is exerted by a transport mechanism. 7 refs.

Burenkov, G.L. (Acad of Sciences of the Ukrainian SSR, USSR); Raichenko, A.I.; Surava, A.M. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 709-712.

#### Copper Zinc Alloys

**084381 DEVELOPMENT OF P/M BRASS COMPONENTS FROM METAL CUTTING CHIPS.** Procedures for the processing of powder from brass chips are described. Powders were evaluated in terms of compaction response and in comparison to atomized brass powder. Properties measured included green density, bend and compressive strength, hardness and shatter resistance and surface finish. It is shown that the proposed P/M technology represents an economically viable alternative to that using conventional brass powder. (Author abstract) 10 refs.

Basheen Kutty, Y. (Indian Inst of Technology, Madras, India); Pullavalili, K. Philip. *Int J Powder Metall (Princeton NJ)* v 24 n 1 Jan 1988 p 65-71.

#### Costs See Also COMPOSITE MATERIALS—Mechanical Properties; INDUSTRIAL ECONOMICS.

**084382 COST MODELING RS POWDERS PRODUCED BY INERT GAS ATOMIZATION.** In order to understand the major factors affecting the manufacturing costs of rapidly solidified powder metals (RSPM), economic models have been developed taking into consideration industrial processes and RSPM research. The gas atomization model used in this study was developed to be user-interactive. It was created on a Lotus 123 spreadsheet which allows it to be run on IBM PC's or compatibles. The model is divided into three sections: inputs, cost calculations by unit operation, and results. Using these components, the model allows the user to review the effects of one or several process variables on the overall costs. 15 refs.

Jacob, J.E. (MIT, Cambridge, MA, USA); Schoenung, J.M.; Lavernia, E.J.; Clark, J.P.; Grant, N.J. *J Met* v 39 n 10 Oct 1987 p 19-21.

#### Densification See Also CERAMIC MATERIALS—Hot Pressing.

**084383 DETERMINATION OF THE GRUNHEISEN COEFFICIENT AND THE SHOCK PARAMETERS OF A POROUS BODY IN AN INCOMPLETE COMPRESSION DOMAIN.** Processes of shaping powders by shockwaves with a pressure of approximately 2 GPa at the front are used in powder metallurgy practice. Results presented in the literature for investigations of shock compression of porous materials refer, as a rule, to bodies having a comparatively low porosity and, moreover, a durable baked skeleton. Theoretical and experimental data are compared for powder materials with different structural and physical characteristics. The static compressibility of a number of powders was investigated on the INSTRON testing machine. 5 refs.

Gorobtsov, V.G.; Mirilenko, A.P.; Pikus, I.M. *Combust Explos Shock Waves* v 23 n 1 Jan-Feb 1987 p 48-50.

**084384 DENSIFICATION BEHAVIOR OF METAL POWDERS DURING PRESSING.** This work was undertaken with the aim of making a comprehensive study of the densification process in the pressing of metal powders under conditions close to real. In addition to plotting a metal powder compressibility curve, an investigation was carried out into the dependence of the elastic aftereffect of compacts after the removal of pressing pressure and their mechanical strength before and after sintering. Specimens for investigation were produced by double-ended single pressing. The starting materials were a water atomized PZh4M2 fine reduced iron powder. 7 refs.

Fedorchenko, I.M. (Acad of Sciences of the Ukrainian SSR, USSR); Kushchevskii, A.E.; Mozol', T.F.; Chudovskii, V.F. *Sov Powder Metall Met Ceram* v 26 n 3 Mar 1987 p 196-199.



**084385 CONSOLIDATION BY ATMOSPHERIC PRESSURE IN GLASS MOULDS GIVES HIGH DENSITY PREFORMS.** Atomized powder is loaded into glass molds which are evacuated and the resulting mold/compact is sintered at atmospheric pressure. Resulting preforms are said to be 98-99% of theoretical density. Cytemp Specialty Steel Division, Cyclops Corporation, has developed an alternative PM consolidation process, Consolidation by Atmospheric Pressure (CAP), which is said to combine all of the inherent advantages of PM with several others, including increased cleanliness, greater flexibility, easier fabricating and machining characteristics, and improved hot working and heat treating characteristics. US Patent No 4,227,927 uses standard melting and atomization methods to make powder. After being screened to customer-specified mesh size, the powder is loaded into a blender/drier, where it is mixed and chemically treated with an additive in a carrier solution such as methanol. The chemical additive, which promotes diffusion bonding during subsequent consolidation, varies with different types of specialty steels, but is a normal constituent of the alloy. During the vacuum drying cycle, the methanol evaporates, leaving a minute coating of the chemical additive on all powder particle surfaces.

Anon (Cytemp Specialty Steel Div, Bridgeville, PA, USA). *Steel Times* v 215 n 10 Oct 1987 p 516.

**084386 ISOSTATIC PRESSING EXTENDS POWDER METALLURGY PERFORMANCE.** Isostatic pressing of powder metallurgy components removes the inherent problem of density gradients which are unavoidable with conventional press tools. In the case of hot isostatic pressing densities of up to 100% can be reached. The IMT Division of National Forge specializes in applying HIP technology to modern materials. More than 15 HIP units located in the USA and in Belgium can offer industry the service it needs, particularly in the fields of tool steel, stainless steel, powder metallurgy, casting densification, diffusion bonding, and HIP processing of ceramic materials. National Forge has been building HIP units for the PM and ceramic industry since the early development of the process. Units ranging from 90mm diameter for laboratory units to 1500mm for production units operating at temperatures up to 2200°C and pressures to 4000 bar are built for many specific applications.

Anon (Natl Forge Europe, Sint-Niklass, Belg). *Steel Times* v 215 n 10 Oct 1987 p 518.

**084387 PRODUCTION OF SOME METAL POWDERS BY THE ROTATING ELECTRODE PROCESS.** The Rotating Electrode Process is a method for producing spherical metal powder particles by melting the end of the metal rod which is rotated at high speed about its longitudinal axis. Molten droplets are centrifugally ejected and chilled into solid form in an inert gas atmosphere or in a vacuum. The characteristics of Rotating Electrode Process powder are a spherical shape with very few irregular particles by a ceramic free process, the maximum yield of powder within a very narrow size range by rotational speed control and ideal consistent and reproducible flow rate and apparent density for pressing and sintering process. (Edited author abstract) 8 refs.

Akamatsu, Katsuya (Kansai Univ, Osaka, Jpn); Nakao, Kazuyoshi; Kanaoka, Junji; Kamei, Kiyoshi. *Technol Rep Kansai Univ* n 29 Mar 1987 p 41-46.

**084388 NUMERICAL SIMULATION OF HIP PROCESS.** A numerical simulation method based on viscoplastic theory is introduced to simulate the densification behavior of metal powder during the hot isostatic pressing process. The dependence of flow stress on temperature, strain rate and relative density of the material was taken into consideration. Uniaxial compression tests were carried out to determine the parameters of the constitutive equations. Experimental results for a turbine disk confirmed the accuracy of this simulation technique. (Author abstract) In Japanese. 3 refs.

Shinke, Tohru; Soh, Tadashi; Nakagawa, Tomokazu; Nohara, Akira. *R&D Res Dev Kobe Steel Ltd* v 37 n 4 Oct 1987 p 29-32.

**084389 ON DENSIFICATION AND SHAPE CHANGE DURING HOT ISOSTATIC PRESSING.** When the temperature of a powder compact is raised, heat diffuses inwards from the surface. If the compact is under pressure (as it is during HIPing), the surface layers start to densify, increasing the local thermal conductivity. Under certain conditions a densification front propagates into the powder, and this leads to changes of shape of the compact which is no longer identical to the preform shape. The conditions which lead to non-uniform densification are analyzed and the consequences are compared with experiments on copper, alumina and tool steel. (Edited author abstract) 12 refs.

Li, W.-B. (Univ of Lulea, Lulea, Swed); Ashby, F.; Easterling, K.E. *Acta Metall* v 35 n 12 Dec 1987 p 2831-2842.

**084390 COMPUTER MODEL FOR PREDICTING DENSIFICATION IN POWDER FORGING.** One method of obtaining the information required concerning the deformation behaviour of aluminium alloys during forging is to use modelling techniques. The Centre de Mise en Forme des Matériaux of the Ecole des Mines in Paris has developed a computer program which permits modelling of the hot forging process approached through a yield criterion adapted to porous material plastic deformation. The program describes both densification and plastic flow by relating the equivalent stress supported by the material to the stress deviator and stress tensor functions through rheological parameter functions of relative density and temperature. The forming process simulation is based on a finite element calculation.

Anon. *Met Powder Rep* v 43 n 6 Jun 1988 P432.

**084391 MODELLING SHAPE CHANGE OF PARTS PRODUCED BY HOT ISOSTATIC PRESSING OF POWDERS.** Models for analysing shape changes during the HIPping of powder compacts enclosed in preshaped containers are presented. Two limiting mechanisms are considered: homogeneous densification and the motion of a sharply defined densification front through the compact as HIPping proceeds. The shape changes and shrinkages occurring in a number of simple one, two, and three dimensional shapes are analysed and illustrated. Although some of the assumptions implicit in the model are at variance with the conditions found in practice, it is concluded that useful insights are provided into the shape changes occurring during HIPping. (Author abstract). 3 Refs.

Aren, B. (Lulea Univ of Technology, Lulea, Swed); Navara, E. *Powder Metall* v 31 n 2 1988 p 101-105.

**084392 UNTERSUCHUNGEN EINER VIBRATIONSDOSIEREINRICHTUNG ZUM VERDICHTEN DES EINSATZGUTES IN WALZENPRESSEN.** [Investigations of a Vibratory Dosing Device for the Compaction of the Charging Material in Roll Presses]. In order to reach the desired degree of densification of a fine-grained substance in a roller press, a continuous and even feeding of the material between the rollers of the press is necessary. This article discusses the design of a vibration feed regulation installation and determination of the optimum outline for the profile of the die sets of the regulation system using a mathematical model. For the installation tested, optimal operation parameters for compacting fine-grained copper concentrates were established. (Edited author abstract). 11 Refs.

Drzymala, Von Zygmunt (Inst fuer Huttenmaschinen, Cracow, Pol). *Radex Rundsch* n 2 pt 3 Jul 1988 p 616-623.

## Diffusion

**084393 INFLUENCE OF POROSITY ON MUTUAL DIFFUSION IN POWDER MATERIALS.** If the method of obtaining the material is such that the length of the diffusion zones are greater than the size of the pores and the distance between them, as experiments on the diffusion pairs showed, then the effective coefficient of mutual diffusion depends both upon the total porosity and

upon the size of the pores. If the diffusion zones are on the order of or less than the distance between the pores, as occurred in the homogenization tests, then only the defectiveness of the crystalline lattice but not the porosity of the material may influence the effective coefficient of mutual diffusion. To verify this conclusion an investigation was made of the mutual diffusion in the Fe-Ni, Fe-Cr, and Cr-Ni diffusion pairs prepared by pressing of powders and by the method of drying of a suspension, which provides a higher porosity and larger pores in them than in parts obtained by pressing. 6 refs.

Antsiferov, V.N. (Perm Polytechnic Inst, USSR); Eremina, E.Yu.; Peshcherenko, S.N.; Rabinovich, A.I.; Khramtsov, V.D. *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 306-309.

**Dispersion Hardening** See Also CERAMIC MATERIALS—Toughening.

**084394 ODS ALLOYS: HIGH PERFORMANCE MATERIALS MADE BY P/M.** This article reviews very briefly the state of development of ODS (Oxide Dispersion Strengthened) alloys. The interest in ODS alloys can be traced back to the beginning of the fifties when the mechanisms of strengthening by second phase particles began to receive some explanation. The model which, even now, best describes the increase in strength has been developed 40 years ago by Orowan. Then, the various methods used presently for preparing these alloys are reviewed and examples of commercial fabrication and utilization are given. 21 refs.

Cohere, L. (CEN, Mol, Belg). *ATB Metall* v 27 n 2-3 1987, Powder Metall, Brussels, Belg, May 13-14 1987 p 53-60.

## Economics

**084395 ASPEKTE DER PULVERMETALLURGIE HOCHFESTER LEICHTMETALLEGIERUNGEN AUF ALUMINIUM- UND TITANBASIS.** [Aspects of the Powder Metallurgy of High-Strength Light-Metal Alloys Based on Aluminum and Titanium]. Attempts have been made over a ten-year period to apply the advantages expected from powder metallurgy - cost reduction, improvement of properties and development of new alloys not producible by conventional ingot metallurgy - to high-strength lightweight alloys. State of the art and problems still to be solved are reviewed with respect to the particular objectives, and future trends of development are pointed out. For aluminum alloys, the main objective is the improvement of properties, e.g., higher elevated-temperature strength by rapid solidification and mechanical alloying, whereas in the case of titanium alloys emphasis is on the lowering of production costs. Meanwhile, improved properties could be achieved by rapid solidification for titanium alloys as well. But, the improvement of profitability still remains an important task to be solved for both types of alloys. (Edited author abstract) In German. 23 refs.

Wirth, G. *Z Werkstofftech* v 18 n 8 Aug 1987 p 241-250.

**084396 EKONOMICZNE ASPEKTY METALURGII PROSZKOW.** [Economic Aspects of Powder Metallurgy]. On the basis of literature data the production volume of sintered articles in the world has been determined. Main applications are mentioned. Some factors significant for production costs have been given. The application possibilities of this technology with the regard to energy and raw material economy are discussed. (Author abstract) 23 refs. In Polish.

Pieczonka, T. (Acad Gornicz-Hutnicza, Cracow, Pol); Cias, A.; Frydrych, J. *Hutnik* v 54 n 9 Sep 1987 p 250-254.

## Electrodeposition

**084397 CONTACT DEPOSITION OF METALS IN DISPERSED FORM.** The cementation of cadmium with zinc chloride-containing solutions, in comparison with sulfuric acid solutions, ensures the deposition of a more



dispersed powder with a lower pouring weight. During contact deposition of tin, the cementing metal zinc, in comparison with aluminum, ensures the deposition of a more dispersed and dendritic powder. The physical properties of a cementation metal powder and the rate of its deposition depend on the nature of the cementing metal and the solution being cemented. In Russian. 6 refs.

Artamonov, V.P.; Baikenova, T.T. *Izv Vyssh Uchebn Zaved Tsvetn Metall* n 3 1987 p 38-41.

## Equipment

**084398 SOME IMPROVEMENT IN APPARATUS FOR BLAINE AIR PERMEABILITY METHOD.** In this paper two improvements of apparatus for Blaine air permeability method have been described. One is improving the position fixer to keep the constant volume of the sample. Another is increasing the pressure of the manometer to decrease the measuring time. (Edited author abstract) 2 refs. In Chinese.

Huang, Yongshu (Acad Sinica, China). *Fenmo Yejin Jishu* v 5 n 3 Aug 1987 p 160-163.

**084399 LEYBOLD IN FOREFRONT OF METAL POWDER PRODUCTION TECHNOLOGY.** The Vacuum Process Engineering Division of Leybold AG in Hanau, Germany, has been designing and manufacturing special metallurgical plants for metal powder production for more than 20 years. Over this period the company has developed sophisticated inert gas atomization systems, centrifugal atomization processes for ceramic-free metal powders, and complete powder handling and treatment systems. The article reports current activities.

Williams, Bernard. *Met Powder Rep* v 43 n 6 Jun 1988 p 405-408.

**084400 ATOMIZATION PLANT FOR ALL APPLICATIONS FROM DAVY MCKEE.** Davy McKee, part of the Davy Corporation, is an international organization offering an engineering, contracting and construction service to the world's metals industries. The powder metallurgy section of the company specializes in the design and engineering of systems for the production of metal powders using water and gas atomization techniques. Plant supplied by the company ranges in size from a completely automated production facility capable of producing 10,000 tons of powder a year down to laboratory scale atomizers with a melt capacity of 5 kg. The article describes company operations and equipment.

Weaver, Amanda. *Met Powder Rep* v 43 n 6 Jun 1988 p 413-416.

## Federal Republic of Germany

**084401 KRUPP PULVERMETALL UNVEILS PM PLANT FOR THE FUTURE.** Krupp Pulvermetall GmbH, which was founded in Essen, Germany, in July 1987, has embarked on ambitious plans to commercialize the production of a 'new generation' of powder metallurgy components. Included in the company's recently established production facilities is a futuristic powder production plant capable of producing titanium, superalloy, high-speed steel and other powders. (Edited author abstract)

Williams, Bernard. *Met Powder Rep* v 43 n 2 Feb 1988 p 78-80, 82-83, 85-86.

**084402 KREBSOEGE - PORTRAIT OF A P/M MANUFACTURER.** This article profiles the history, present organization, equipment and activities of the Krebssoege group of companies. The Krebssoege group deals exclusively with metal powder products. Its technology has been licensed worldwide for many years. Since September 1986, 74% of the Krebssoege shares have been held by the Swiss MAAG group, a manufacturer of high precision gears and gear machining equipment. (Edited author abstract) 10 refs.

Arnhold, Volker (Sintermetallwerk Krebssoege GmbH, Radevormwald, West Ger); Beiss, Paul. *Int J Powder*

*Metall (Princeton NJ)* v 24 n 1 Jan 1988 p 77-84.

**084403 PROGRESS OF POWDER METALLURGY IN THE FEDERAL REPUBLIC OF GERMANY.** The P/M industry in West Germany is pushing the state-of-the-art of powder metallurgy with research help from the government. Government funding in 1987 exceeded \$35 million. Conventional parts makers are emphasizing higher strength parts and more sophisticated sintering atmosphere control. P/M forged synchronizing rings are used in truck gear boxes. Materials development is the subject of R&D at a number of research institutes. (Author abstract)

Kayser, Wolfgang A. (Max-Planck-Inst fuer Metallforschung, Stuttgart, West Ger); Petzow, Guenter E. *Int J Powder Metall (Princeton NJ)* v 24 n 2 Apr 1988 p 167-172.

## Finland

**084404 FINLAND.** In spite of a small population, Finland has strong ferrous and non-ferrous metallurgical and mechanical working industries. The industrial activities in the powder-metallurgical field have been limited to the production of fine cobalt powder and cemented carbide parts. A substantial amount of fundamental and applied research has been carried out in the P/M field during the last 20 years, mainly at Finnish technical universities and research institutes. The research efforts related to powder metallurgy have been enhanced during 1987 due to the start of an extensive research program. These projects are oriented towards the development of P/M process technologies and powder metallurgical materials. New applications for powder metallurgical techniques are also being studied.

Grinder, N. Olle (P/M Technology AB, Nynashamn, Sweden); Sirkkola, Erkki M. *Int J Powder Metall (Princeton NJ)* v 24 n 2 Apr 1988 p 135-138.

Graphite Compounds See ELECTRIC CONTACTS—Manufacture.

## India

**084405 POWDER METALLURGY IN INDIA.** The status of the P/M industry in India is assessed. There has been recent growth in the areas of ferrous powder production, hard metals, and structural P/M parts. The latter area is illustrated by reference to the automotive industry and the sales of two, three and four-wheel vehicles. Current R&D activities are highlighted and a brief review is given of P/M education and professional society activities. (Author abstract).

Upadhyaya, Gopal S. (Indian Inst of Technology, Kanpur, India). *Int J Powder Metall (Princeton NJ)* v 24 n 3 Jul 1988 p 259-262.

## Injection Molding

**084406 RHEOLOGY OF METAL INJECTION MOLDING FEEDSTOCK.** In this paper the features of the MIM process in general are reviewed and the rheological characteristics of the plastic binder will be examined. The rheological characteristics will also be interpreted to qualitatively predict the flow behavior in injection molding. This paper represents the initial studies in a long term project aimed at optimizing the metal injection molding process. 12 refs.

Shah, J. (Univ of Lowell, Lowell, MA, USA); Nunn, R.E. *Powder Metall Int* v 19 n 6 Nov 1987 p 38-40.

**084407 PRESENT STATUS OF P/M INJECTION MOLDING (MIM) - AN OVERVIEW.** The current technologies for metal injection molding (MIM) are reviewed. The factors affecting the growth of the industry are summarized and compared. This leads to estimates of the cost of making MIM parts, how they compare with investment castings, and a forecast for future market growth. The present markets, shipments, tooling, technology, and history of the 29 active MIM procedures in

North America and Europe are reviewed by company. A table contains mechanical property data for MIM materials. Work under way at research institutions and efforts at standardization are described. (Edited author abstract)

Pease, Leander F. III (Powder-Tech Associates Inc, North Andover, MA, USA). *Carbide Tool J* v 20 n 1 Jan-Feb 1988 p 4-15.

**084408 DEVELOPMENTS IN SINTERING INJECTION-MOLDED P/M PARTS.** Small metal parts of intricate shape can be made by injection molding. Metal powders are mixed with plastic binder materials. Following molding, the binder is removed from the matrix and the powder is sintered to form the final article. Excellent repeatability hence close mechanical tolerances are practical. This technique for manufacturing has been proved to be cost effective for the production of a wide range of parts which otherwise would need to be made by more expensive lost wax casting, machining, or assembly of a number of small pieces. However, the utility of the process has been limited and a reduction in both the material cost and the processing cost is desirable. The injectavac furnaces are one of the developments which lower the cost of this process.

Kennedy, S.W. (Vacuum Industries Inc, Somerville, MA, USA). *Carbide Tool J* v 20 n 1 Jan-Feb 1988 p 22-24.

**084409 PULVERMETALLURGISCHE SPRITZGIESSEN - EIN NEUES FORMGEBUNGSAUSFAHREN FUER SINTERTEILE KOMPLIZIERTER GESTALT.** [Powered Metal Injection Molding - New Forming Techniques for Sintered Complex Shapes]. An overview of the current manufacturing technology that combines powder metallurgy and plastic molding methods for complex parts is given. The advantages of powder metallurgy over other manufacturing methods are pointed out. 6 refs. In German.

Lange, E.; Poniatowski, M. *Konstruktion (Berlin)* v 40 n 6 Jun 1988 p 233-238.

**084410 INJECTION MOULDING OF POWDERS.** Different types of iron powder possessing a range of particle characteristics and a standard grade of hardmetal powder have been mixed with low molecular weight thermoplastics and wax formulations to produce plastisols suitable for injection moulding. Mixing of up to 70 vol.-percent loading of powder with waxes and low density polyethylene formulations has produced acceptable rheological requirements for the production of sound mouldings. Test shapes have been moulded on a conventional injection moulder and modified pressure die casting machine with multicavity moulds. Measured green densities were found to correspond to theoretical values. Debinding studies have been evaluated by thermogravimetric analysis and sintering profiles applied to produce relatively high densities in the test shapes. Final density levels were influenced by particle characteristics, mixing conditions, and debinding and sintering profiles. (Edited author abstract). 12 Refs.

Martyn, M.T. (Univ of Technology, Loughborough, Engl); Issitt, D.A.; Haworth, B.; James, P.J. *Powder Metall* v 31 n 2 1988 p 106-112.

IRON See Also BEARINGS—Powder Metal; FRICTION MATERIALS—Mechanical Properties; IRON POWDER—Injection Molding; IRON POWDER—Production; MILLING.

**084411 PRODUCTION OF IRON POWDER FROM IRON SULFOHEPTAHYDRATE.** In methods of producing iron powder from iron sulfoheptahydrate are proposed which differ substantially from each other in their parameters of drying and decomposition of the starting material and of reduction of the resultant ferric oxide. The present work was therefore undertaken with the aim of determining the optimum temperature conditions of these stages of the process of production of iron powder from recrystallized iron sulfoheptahydrate - a conversion product of cold-rolled sheet pickling solutions.



By reducing the ferric oxide in a hydrogen atmosphere at a temperature of 950°C, an iron powder was obtained corresponding in chemical composition and physicochemical to PZh4M3 fine reduced powder. 5 refs.

Zalazinskii, G.G. (Acad of Sciences of the USSR, USSR); Shchennikova, T.L.; Ugol'nikova, T.A. *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 284-286.

**084412 COMPOSITION AND MAGNETIC PROPERTIES OF FINE IRON POWDERS TREATED WITH ORGANIC COMPOUNDS.** In this article are presented the results of an investigation into the composition and magnetic properties of iron VFPs modified with an organosilicon polymer (OSP) and also data yielded by an analysis, carried out by conversion Mossbauer spectroscopy (CMS), of the surface layers of particles with different coatings to depths of up to 0.1  $\mu\text{m}$ . The phase compositions of VFPs were analyzed by the absorption and conversion Mossbauer spectroscopy techniques and by x-ray diffraction (construction of diffractograms). CMS spectra were recorded at room temperature, using a flow-type proportional counter with a helium-methane filler. Electrons were registered having a kinetic energy corresponding to depths of layers investigated of up to 0.1  $\mu\text{m}$ . When, as in this case, specimens are studied in the form of powders whose particle size substantially exceeds the maximum departure depth of conversion electrons, relative areas under different CMS lines cannot provide unique information on the relative amounts of the corresponding iron-containing compounds represented in spectra. In such a case CMS spectra afforded information only on the qualitative composition of the surface of a specimen. In absorption spectra such a correspondence is observed. In our work the latter were processed on the computer to determine the relative amounts of the  $\alpha\text{-Fe}$  phase and various oxides. 7 refs.

Zhelibo, E.P. (Acad of Sciences of the Ukrainian SSR, USSR); Pol'shin, E.V.; Ivoilov, N.G.; Ishchuk, V.L.; Romanov, E.S.; Lapshuk, P.V.; Nepomnyashchii, V.V. *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 286-290.

**084413 EFFECTS OF MO AND CR CONTENTS ON THE PROPERTIES AND PHASE FORMATION OF IRON MOLYBDENUM BORIDE BASE HARD ALLOYS.** Fe-5B-xMo-yCr alloys with five levels of Mo contents which correspond to Mo/B atomic ratios ranging from 0.7 to 1.1 and three levels of Cr contents, namely 0.5 and 10 mass%, were prepared in order to investigate the effects of Mo and Cr contents on the mechanical properties and the phase formation in  $\text{Mo}_2\text{FeB}_2$  type complex boride base hard alloys. The best mechanical properties were obtained for the Fe-5B-xMo alloys when Mo was added to match the Mo/B atomic ratio of the alloys with that of  $\text{Mo}_2\text{FeB}_2$ . Similar results were noted for the Fe-5B-xMo-yCr alloys with optimum Mo/B ratios somewhat lower than unity. Metallographic studies revealed formation of third phases, such as  $\chi(\text{Fe}_3\text{CrMo})$ ,  $\text{M}_6\text{C}$ ,  $\text{Fe}_2\text{B}$  and  $\text{Cr}_2\text{B}$ , at compositions off the optimum Mo/B values. (Author abstract) 13 refs.

Takagi, K.; Komai, M.; Ide, T.; Watanabe, T.; Kondo, Y. *Powder Metall Int* v 19 n 5 Oct 1987 p 30-33.

**084414 JOINING OF IRON POWDER COMPACTS BY AN INFILTRATION METHOD.** Joining of iron powder compacts by an infiltration method was attempted. The joining strength of the compacts was investigated with respect to variations in roughness of the surface, applied pressure, relative density of preforms, infiltration temperature and the time. The joining strength was found to be almost equal to those of monobloc compacts by conventional infiltration when the joining was done under the optimum conditions. Joining of the iron powder compact and wrought steel samples such as S10C and S55C was also carried out and high strength could be obtained by this method. Samples with complicated shapes or with holes in the parts could be easily made with the infiltration technique proposed. (Author abstract) 8 refs.

Okimoto, Kunio (Government Industrial Research Inst,

Tosu, Jpn); Satoh, Tomio. *Int J Powder Metall (Princeton NJ)* v 23 n 3 Jul 1987 p 163-169.

**084415 ROTARY FORGING OF METAL POWDERS.** This paper outlines the principles of operation of a nutation spin rotary forging machine and describes initial experiences of its application to the consolidation of metal powders. Seven different ferrous and non-ferrous powders were studied, including two aluminium alloys made by rapid solidification methods. Relative densities > 96% have been obtained with all materials. The forces required consist of two components. An initial, uniaxial compaction phase to densities of approximately 80-90% requires ordinary compaction forces. Final densification during a second, nutation, phase requires additional forces which are only 5-10% of the initial compaction force. Microstructures and hardness surveys on sections of compacts are presented and used as a basis to discuss possible mechanisms of densification and material deformation brought about by the process. (Author abstract) 5 refs.

Moon, J.R. (Univ of Nottingham, Engl); Standing, P.M. *Powder Metall* v 30 n 3 1987 p 153-163.

**084416 CLOSE-COUPLED GAS ATOMISATION OF METAL ALLOYS.** A nozzle design that closely couples the atomising gas jet to the melt stream has been developed. Close-coupling allows more efficient use of the gas energy to create fine powder than do conventional designs. Yields of -37 micrometer powder of high surface tension alloys in excess of 75 wt.% have been attained at moderate gas consumption. Because of the relationship between reduced particle size and increased cooling rate, and the high yield of fine powder which is attainable with the nozzle, the close-coupled nozzle is an attractive method for producing rapidly solidified powder. Finally, high-speed photographic studies of the atomisation process show that melt stream disruption occurs right at the nozzle tip. The observed break-up process is not the same as that reported in the literature for conventional atomisation nozzle designs. 12 refs.

Miller, Stephen A. (GE, Schenectady, NY, USA). *Met Powder Rep* v 42 n 10 Oct 1987 p 702-703.

**084417 COMPACTIBILITY OF PARTIALLY DIFFUSION-ALLOYING IRON-BASED POWDERS AND THEIR HOMOGENEITY AFTER SINTERING.** Compactibility, homogeneity and mechanical properties, etc. of sintered specimens made from partially diffusion-alloying powders of Fe-1.5 Cu-2 Ni, Fe-7 MC and Fe-2 Cu-0.6 P (mixed with carbon respectively) have been studied. It demonstrates that partially diffusion-alloying powders possess superior compactibility as well as sintering homogeneity. After sintering distribution of copper, molybdenum and phosphorus etc. elements were very homogeneous. The strength of above three sintered materials is 500-600 and 700N/mm<sup>2</sup> respectively. (Edited author abstract) 5 refs. In Chinese.

Yang, Zongpo (Northeast Inst of Technology, China); Han, Xueyi; Han, Jingui. *Fenmo Yejin Jishu* v 5 n 2 May 1987 p 65-72.

**084418 PRODUCTION AND ALLOYING OF FERROUS POWDERS.** To avoid using very high compacting pressures which can lead to tool wear or tool breakage, it is important that the iron powder has a good compressibility. By carefully selecting the raw materials, by using modern steel refining techniques and by optimizing the powder annealing process it has been possible for the powder manufacturers to continuously increase the compressibility of both sponge and atomized iron powders while maintaining good green strength properties after compacting. By adhesive or diffusion bonding of the alloying elements, problems with segregation or dusting can be eliminated. Large scale production trials have shown that dimensional tolerances can be greatly improved using both these techniques. Finally the powder manufacturers can contribute in several ways to the joint effort to introduce PM parts into more highly stressed applications.

Lindskog, Per (Hoganas AB, Swed); Wastenson, Goran. *Steel Times* v 215 n 10 Oct 1987 p 508, 511.

**084419 DEVELOPMENT OF THE PRODUCTION TECHNOLOGY FOR THE FERROUS SINTERED STRUCTURAL PARTS IN JAPAN.** This report explains the history of the development of ferrous sintered structural parts by illustrating the progress of their technology in Japan. The production technology includes the production equipment and the iron powders in addition to compacting and sintering. The production of ferrous sintered structural parts started with the introduction of foreign technology but since 1965, domestic technology has been fostered and the 1970s have seen expansion of the sintered parts market through the developments of Japanese technology. In the 1980s Japanese production technology of sintered parts reached a leading position in the world. (Edited author abstract) In Japanese. 6 refs.

Furukawa, Nobuo. *J Jpn Soc Powder Powder Metall* v 34 n 7 Sep 1987 p 283-290.

**084420 ASSEMBLED CAMSHAFT FOR I.C. ENGINES WITH FORGED POWDER METAL CAMS.** An element in the automotive industry's efforts to improve fuel economy and engine performance is the introduction of roller tappets to reduce friction in valve trains. As a result, contact stresses in excess of 200,000 psi may be experienced at the roller and cam (shaft) interface. Conventional cast iron camshafts cannot effectively carry this stress level. After studying several alternatives, the authors have developed a camshaft with powder forged cam lobes. (Edited author abstract) 10 refs.

Lugosi, Robert (Torrington/Fahnir Co, Torrington, CT, USA); Brauer, Michael; Cook, John. *Met Powder Rep* v 42 n 11 Nov 1987 p 792-793, 795-797.

**084421 PM CYLINDERS LINERS FOR LARGE DIESEL ENGINES BY CIP.** This article describes recent developments in the production of diesel engine cylinder liners by dry bag cold isostatic pressing, sintering and sizing. The properties of PM cylinder liners are compared with cast iron liners. Special attention has been paid to dimensional tolerances both in the as-sintered and as-sized condition. (Edited author abstract) 12 refs.

Tengzelius, J. (Cold Isostatic Pressing Systems KB, Swed); Wirgarth, E. *Met Powder Rep* v 42 n 11 Nov 1987 p 801-804.

**084422 THERMOGRAPHIC STUDY OF THE OXIDATION PROCESS OF ULTRADISPERSED ELECTROLYTIC IRON POWDERS.** This report presents the results of investigation of the oxidation process of iron powders of two types: highly dispersed electrolytic powder designated PZhVE and PZh4K powder produced by reduction of scale and grinding in a planetary mill. Oxidation is accompanied by liberation of a significant quantity of heat as the result of the oxidation reaction. This leads to transformation of the metal powder into the oxide phase, sintering of the basic material, slowing of oxidation, and an increase in the effective activation energy of this process. 13 refs.

Zhigotskii, A.G. (Acad of Sciences of the Ukrainian SSR, USSR); Radoshinskaya, S.I.; Shvets, T.M. *Sov Powder Metall Met Ceram* v 26 n 5 May 1987 p 415-419.

**084423 PREPARATION OF Fe-, Co, AND Ni-BASED AMORPHOUS ALLOY POWDERS BY HIGH-PRESSURE GAS ATOMIZATION AND THEIR STRUCTURAL RELAXATION BEHAVIOR.** By using newly constructed high-pressure gas atomization equipment, the effect of atomizing gas (Ar, N<sub>2</sub>, or He) on the formation tendency of amorphous alloy powders and their Curie temperature ( $T_c$ ), structural relaxation, glass transition ( $T_g$ ), and crystallization ( $T_x$ ) was examined for Fe-P-C, Fe-Si-B, Fe-Cr-Mo-P-C, Co-Si-B, Ni-Si-B, Ni-Pd-P, and Cu-Zr alloys with easy glass forming capacity. Amorphous powders are formed in all the alloy



systems and the critical diameter for the formation of amorphous powders is 25 to 44  $\mu\text{m}$  for Ar and 44 to 100  $\mu\text{m}$  for He. The average particle size is smaller for He than for Ar and  $\text{N}_2$ . No appreciable differences in  $T_C$ ,  $T_B$ , and  $T_X$  of  $\text{Fe}_{77}\text{P}_{13}\text{C}_{10}$  amorphous powders with the kind of atomizing gas are seen and these values are the same as those of the amorphous ribbon with 20  $\mu\text{m}$  thickness. He atomized  $\text{Fe}_{77}\text{P}_{13}\text{C}_{10}$  powders exhibit a lower onset temperature of relaxation and larger heats of relaxation and crystallization as compared with the Ar- and  $\text{N}_2$ -atomized powders and the values of the He-atomized powders are comparable to those of the ribbon sample, indicating that He-gas atomization has a higher cooling capacity and results in the formation of a more disordered amorphous structure. This difference agrees with the tendency estimated under the assumption that heat removal from atomized droplets occurs by Newtonian cooling caused only by the convective heat transfer. Accordingly, the greater heat removal capacity of He gas is a dominant factor for the formation of amorphous alloy powders with more unrelaxed atomic configurations. (Edited author abstract) 18 refs.

Inoue, A. (Tohoku Univ, Sendai, Jpn); Masumoto, T.; Ekimoto, T.; Furukawa, S.; Kuroda, Y.; Chen, H.S. *Metall Trans A* v 19A n 2 Feb 1988 p 235-242.

**084424 CONTROLLED THERMAL EXPANSION METAL-CERAMIC COMPOSITES BY CO-SINTERING.** A two phase metal-ceramic composite composed of iron and cordierite was formed from powders using die compaction and sintering. Boron was added to induce co-sintering of the two phases. Thermal expansion was measured versus composition up to 80 vol.% cordierite. As the cordierite content increased, the thermal expansion decreased, with a dramatic decrease when the cordierite became a continuous phase. The thermal expansivities were compared with predictions from published models, but no model was found that adequately predicts the results over all compositions. The difficulty with modeling originates with the simplifications made in treating the connectivity of the two phases. The material may be used as a semiconductor substrate. (Edited author abstract) 22 refs.

Klein, Lori J. Shaw (Bausch & Lomb, Rochester, NY, USA); German, Randall M. *Int J Powder Metall (Princeton NJ)* v 24 n 1 Jan 1988 p 39-46.

**084425 EFFECT OF ZINC STEARATE ON THE PROPERTIES OF SINTERED PRODUCTS.** The authors studied  $\text{ZnGr}_0.8\text{D}_2\text{N}_1$  based on powdered iron marke PZh2M3. When a large amount of plasticizer is mixed with a metal powder, the plasticizer envelops the surface of the particles with a thick layer and clogs the open intraparticle pores. This impedes degassing of the charge in molding and thereby promotes the formation of closed pores filled with gas under high pressure and with the plasticizer itself. In the production of structural products from powder metallurgy materials, the optimal content of zinc stearate in the charge is 0.5-0.7%. A further increase (from 0.7 to 1.5%) increases total and open porosity and reduces closed porosity. Such a content of zinc stearate in the charge may be recommended for the production of bearings. 7 refs.

Gaidarov, V.A. (Production Assoc 'Bakkonditioner', USSR); Mamedov, A.T. *Sov Powder Metall Met Ceram* v 26 n 8 Aug 1987 p 636-640.

**084426 SINTERING MECHANISMS AND MECHANICAL PROPERTIES OF  $\text{Fe}_2\text{B}$  BASE HARD ALLOYS.** By utilizing the excellent properties of boride, a new type of sintered hard alloy has been developed. The sintering phenomena of  $\text{Fe}$ -(4-8) wt%  $\text{B}$ -(0-30) wt%  $\text{Cr}$ -0.3 wt%  $\text{C}$  alloys were studied by TG-DTA, dilatometric measurements and x-ray diffractometry. The mechanical properties of the sintered alloys are discussed. The alloy comprises an  $\text{Fe}_2\text{B}$  type boride as a hard phase and a ferrous binder phase containing Cr and C. When the hard alloy contains more than 10 wt% Cr, both  $\text{Fe}_2\text{B}$  and  $\text{Cr}_2\text{B}$  type borides coexist. The liquid phase sintering is attained by two liquid forming reactions, namely,  $\gamma\text{-Fe} + \text{Fe}_3(\text{B,C}) + \text{M}_{23}(\text{B,C})_6 \rightarrow \text{L}_1$  and  $\gamma\text{-Fe} + \text{Fe}_2\text{B} \rightarrow \text{L}_2$ , the

latter reaction occurring in a higher temperature range. (Edited author abstract) In Japanese. 11 refs.

Ide, Tsuneyuki; Nakano, Kazunori; Takagi, Kenichi; Watanabe, Tadao. *J Jpn Soc Powder Powder Metall* v 35 n 1 Jan 1988 p 33-39.

**084427 MECHANISMS OF ADHESION AND DIFFUSION BONDING OF POWDERED ALLOY SHEET.** A powdered alloy sheet process which provides the required minimum wear resistant layer was developed. This layer was obtained by bonding a flexible sheet formed with wear resistant alloy powder using a polymer as the binder. After tests on alkyl resin, urethane polymer, vinyl acetate and acrylic resin, acrylic resin was selected for the binder due to superior properties for bonding. The sheeted powder of mixed SUS-410 and OS-23 with adding acrylic resin of 2-4 wt% was soft enough to bond to the curved parts by sintering after preheating. Cam shafts rocker arms and the swing arms were made by this process. (Edited author abstract) 3 refs. In Japanese.

Morishita, Tsuyoshi; Ohsaki, Shigemi; Kamei, Kiyohiro. *J Jpn Soc Powder Powder Metall* v 35 n 2 Feb 1988 p 53-57.

**084428 DENSIFICATION AND GRAIN GROWTH OF IRON ULTRAFINE POWDER DURING PRESSURE-SINTERING.** A green compact was pressure sintered under 100 and 200 MPa at 673-973 K for 1.8 ks in flowing hydrogen. The nearly full densification temperatures under 100 and 200 MPa were lower by about 150 K and above 300 K respectively than that (970 K) in pressureless sintering. The minimum value of the average grain size in the dense pressure sintered compact was about 0.15  $\mu\text{m}$  which was smaller than 1.2  $\mu\text{m}$  of the pressureless sintered compact. The hardness of the pressure-sintered compact was as high as about 385 H<sub>v</sub>, compared with about 85 H<sub>v</sub> of the coarse grained metal. The Hall-Petch linear relationship between H<sub>v</sub> and the square root of the grain size was confirmed to hold also for the grain size range larger than about 0.15  $\mu\text{m}$ . (Edited author abstract) 20 refs.

Hayashi, Koji (Univ of Tokyo, Tokyo, Jpn); Kihara, Hiroshi. *Nippon Kinzoku Gakkaishi* v 52 n 3 Mar 1988 p 343-347.

**084429 SOME OBSERVATIONS ON HOT-FORGING CHARACTERISTICS OF IRON-POWDER PREFORMS.** Forging of powder preforms is a technique that closes the gap between normally produced powder metallurgy parts and high quality forgings. The present paper outlines the basic hot forging characteristics of iron powder preforms. Preforms made of hydrogen reduced iron powder were sintered and then hot-forged at various temperatures in the range of 800°C to 1100°C. The highest hardness and density were observed on specimens hot forged in the ferritic range. (Author abstract) 9 refs.

Chakraborty, S.P.; Chaudhury, S.K.; De, P.K.; Dubey, R.K. *NML Tech J* v 28 n 1-4 Feb-Nov 1986 p 26-29.

**084430 CORROSION RESISTANCE OF AMORPHOUS  $\text{Fe}_{75}\text{Cr}_{13}\text{C}_7$  POWDER.** Amorphous  $\text{Fe}_{75}\text{Cr}_{13}\text{C}_7$  alloy powder was prepared using an internal gyrate solution method. The powder is irregular and easy to shape. Tests in acid and neutral environments show that the corrosion resistance is excellent. (Edited author abstract) In Chinese.

Sun, Zhongzi (Tianjin Univ, China); Wang, Jingyin. *Chin Shu Hsueh Pao* v 24 n 1 Feb 1988 p B68-B70.

**084431 ANTIMICROBIAL EFFECT OF FINELY DIVIDED IRON.** The antimicrobial properties of finely divided iron in a compound with an antibiotic and without it were studied. It is shown that an applied constant magnetic field intensifies the antimicrobial effect. The results obtained permit the assumption that compounds of finely divided iron and various antibiotics can find use in clinical practice, particularly in the treatment of purulent-necrotic formations. (Author abstract) 5 refs.

Shvets, T.M.; Mel'nichenko, Z.M.; Zemlyak, N.A.; Gor-

shevikova, E.V. *Sov Surf Eng Appl Electrochem* n 3 1987 p 124-127.

**084432 IRON POWDERS SPEARHEAD GROWTH FOR PM INDUSTRY.** Iron powders continue to represent the largest tonnage of raw materials used in the production of PM parts and remarkable progress is being made by iron powder producers to improve their products and to introduce new grades thereby enabling the PM industry to broaden its fields of application. The author reviews the worldwide powder production arena, and this is followed by a number of articles from individual iron powder producers on their own developments. (Author abstract)

Williams, Bernard. *Met Powder Rep* v 43 n 5 May 1988 p 296-298, 300.

**084433 DOMFER INCREASES PRODUCT RANGE WITH MACHINABLE PM GRADE POWDER.** Domfer Metal Powders Ltd in Ville, LaSalle, Quebec, Canada, has maintained its important position among North America's major iron powder producers through a continuing program of product development and production of consistently high quality powders. The company's most recent innovation is a new high strength PM iron grade with improved machinability. (Author abstract)

Anon. *Met Powder Rep* v 43 n 5 May 1988 p 316-317.

**084434 QMP - PREPARING FOR THE FUTURE.** QMP is preparing for the future by utilizing the unique natural resources of its parent company, QIT-Fer et Titane Inc. with modern steel and powder manufacturing technology. Initial experience suggests significant benefits from enhanced purity and proprietary manufacturing techniques. QMP has developed a successful SPC program which has resulted in improved consistency for a number of powder properties. QMP expects both programs to contribute to an improved competitive position for the PM process.

Edgar, Robert L. (Quebec Metal Powders Ltd, Sorel, Que, Can); Poirier, Joel P.; Trudel, Yves. *Met Powder Rep* v 43 n 5 May 1988 p 3.

**084435 NEW DEVELOPMENTS IN POWDER METALLURGY AT HOEGANAES CORP.** The North American iron powder industry continued its upward swing with 6.6% growth recorded in 1987. This article reports on some recent developments in iron powders for PM applications and the establishment of a new facility in Milton, Penna., for large-scale blending of iron-base premixes. (Edited author abstract) 3 refs.

Michael, William H. (Hoeganaes Corp, Riverton, NJ, USA). *Met Powder Rep* v 43 n 5 May 1988 p 304-306.

**084436 MANNESMANN'S METAL POWDER TECHNIQUE IS WIDELY ACCEPTED.** Mannesmann DEMAG Huettentechnik is one of the pioneers of the atomization process to produce iron and steel powders, and in addition to its own large powder production facility in Moenchengladbach, Germany, the company has licensed its technology to other countries in Eastern Europe, China, Iran and Brazil. The author describes his company's iron powder production technology with particular reference to its licensees around the world. (Author abstract)

Findeisen, Gerhard (Mannesmann DEMAG Huettentechnik). *Met Powder Rep* v 43 n 5 May 1988 p 2.

**084437 EFFECT OF SHOCK DURATION TIME ON MAGNETIC PROPERTIES OF DYNAMICALLY COMPACTED AMORPHOUS POWDER.** Dynamic compaction of amorphous  $\text{Fe}_{80}\text{P}_{16}\text{C}_4$  powder produced by rapid quenching water atomization was performed using a gun accelerator. The effect of shock duration time on magnetic properties has been investigated by means of X-ray diffraction analysis, microhardness tests, optical microscopy, scanning electron microscopy and magnetic



measurements. The results indicate that the magnetic properties can be described by a change in the atomic short-range order which is caused by shock pressure and temperature. (Edited author abstract). 7 Refs. In Japanese.

Sato, Takashi; Taniguchi, Takashi; Kondo, Ken-ichi; Sawaoaka, Akira. *J Jpn Soc Powder Powder Metall* v 35 n 3 Apr 1988 p 96-100.

**084438 HIGH DENSITY FERROUS PM PARTS OPEN NEW MARKETS FOR SOFT MAGNETS.** The applications for soft magnets have multiplied rapidly in recent years with major users including the data processing, telecommunications, automotive industries, as well as numerous domestic applications. The principal technologies used in the fabrication of sintered soft magnets can be split into normal and high density technologies. Sintering temperature is a particularly important parameter and the normal density technologies can be divided into three groups: those with sintering temperatures of (a) less than 1150°C, (b) between 1150°C and 1250°C, and (c) in excess of 1300°C. The range of materials which can be fabricated by the normal density method and the properties which can be obtained are shown.

Anon. *Met Powder Rep* v 43 n 6 Jun 1988 P435.

**084439 THEORETICAL ASPECTS OF COMPACTION OF DIELECTROMAGNETIC POWDER METALLURGY MATERIALS.** Dielectromagnetic and magnetodielectric are terms referring to materials consisting of a magnetic material (predominantly iron powder) and a dielectric. In dielectromagnetics magnetic features prevail over dielectric ones, whereas the opposite applies in magnetodielectrics. Particular features of the compaction of dielectromagnetic materials and factors affecting the attainment of required density are described and discussed. The dependence of density on compaction pressure is approximated by an exponential curve. Models are presented illustrating the effects of compaction on magnetodielectrics with various dielectric/pore volume ratios as well as changes in particle shape, cold work, and internal stresses. The possibility of improving magnetic properties of dielectromagnetics by recrystallisation annealing is considered. (Edited author abstract). 2 Refs.

Kordecki, A. (Technical Univ of Wrocław, Wrocław, Pol); Wegliński, B. *Powder Metall* v 31 n 2 1988 p 113-116.

**084440 HARDNESS AND WEAR OF HOT-PRESSED Fe-Cr-Mo-C-Si AMORPHOUS ALLOY POWDERS.** Powder of amorphous Fe-16Cr-8Mo-18C-4Si having a size below 25 µm has been produced by ultrasonic helium atomization. A fully dense material with finely and homogeneously mixed structure of B + M<sub>7</sub>C<sub>3</sub> + M<sub>6</sub>C phases can be obtained by hot pressing at 1300 to 1350 K. The packing fraction is about 100% and the particle size and the interparticle distance of the carbides are 0.6 - 1.0 µm and 1.2 - 1.9 µm, respectively. The alloy has high hardness, e.g., 965 DPN at room temperature and 400 DPN at 1 073 K as well as good wear resistance which is comparable to the highest value of commercial wear resistant high alloy steel. 19 refs.

Inoue, Akihisa (Tohoku Univ, Sendai, Jpn); Arnberg, L.; Oguchi, Masahiro; Backmark, U.; Backstrom, N.; Masumoto, Tsuyoshi. *Trans Iron Steel Inst Jpn* v 28 n 1 1988 p 7-15.

## Iron Boron Molybdenum Alloys

**084441 EFFECTS OF Mo CONTENT AND SINTERING TEMPERATURE ON THE STRENGTH, HARDNESS AND DENSITY OF Fe-6 MASS% B-x MASS% Mo ALLOYS.** The ternary Fe-6 mass% B-x mass% Mo alloys have a composite microstructure consisting mainly of a complex boride Mo<sub>2</sub>FeB<sub>2</sub> as a hard phase and a ferritic binder. Both hardness and strength are improved by Mo addition due to formation of the high strength phase Mo<sub>2</sub>FeB<sub>2</sub>. The hardness increases monotonically with increasing Mo content. Alloy density also increases with Mo content. The highest strength was obtained for an Fe-6 mass% B-48 mass% Mo alloy in

which a small amount of brittle Fe<sub>2</sub>B formed as a result of a reaction in the compact. The composition Fe-6 mass% B-53 mass% Mo at which Fe<sub>2</sub>B is expected to be eliminated was found to lead to a reduced strength owing to a high sintering temperature required for complete densification. Decreasing of the Mo content below 48 mass% results in the excessive formation of Fe<sub>2</sub>B and leads to degraded strengths. (Edited author abstract) 17 refs.

Ide, T. (Toyo Kohan Co, Kudamatsu, Jpn); Nakano, K.; Ando, T. *Powder Metall Int* v 20 n 3 May 1988 p 21-24.

## Iron Chromium

**084442 INFLUENCE OF DISPERSION AND SUPERFICIAL APPLICATION OF RARE EARTH OXIDES ON THE HIGH TEMPERATURE OXIDATION OF Fe-20Cr SINTERED ALLOY.** The effects of dispersion and superficial application of rare earth oxides (Y<sub>2</sub>O<sub>3</sub>, La<sub>2</sub>O<sub>3</sub>, CeO<sub>2</sub>, Eu<sub>2</sub>O<sub>3</sub>, Gd<sub>2</sub>O<sub>3</sub>) on the isothermal oxidation of Fe-20Cr sintered alloy have been studied at 1373 K in air. The dispersion of these rare earth oxides reduced the oxidation rate but the effect was dependent on the kind of dispersoid. The dispersion of La<sub>2</sub>O<sub>3</sub>, Y<sub>2</sub>O<sub>3</sub> and Gd<sub>2</sub>O<sub>3</sub> reduced the oxidation rate, while the effect of Eu<sub>2</sub>O<sub>3</sub> dispersion was less than that of the other oxides. The dispersion of rare earth oxides except Gd<sub>2</sub>O<sub>3</sub> had a negligible effect on the oxidation rate. The results suggest that the rare earth oxides suppressed outward migration of Fe ions through the Cr<sub>2</sub>O<sub>3</sub> scale. (Edited author abstract) In Japanese. 7 refs.

Nagai, Hiroshi; Sawayama, Tetsuya; Shoji, Keiichi. *J Jpn Soc Powder Powder Metall* v 34 n 5 Jul 1987 p 222-228.

## Iron Chromium Aluminum Alloys

**084443 EXPLOSIVE COMPACTION OF Fe-25Cr-5Al HEAT RESISTING ALLOY POWDERS.** An optimum E/M ratio was determined to be between 3.5 and 4.0, where no cracks were formed in the compacts. The specific density ratio of the compact reached 98%. Although the tensile strength of as-compacted material was 12 kgf/mm<sup>2</sup>, strength was increased to 80 kgf/mm<sup>2</sup> by post sintering treatment. Oxidation behavior of the explosively compacted material was comparable to melted and forged material and superior to conventionally sintered and hot pressed materials. Hardness of the explosively compacted material in the temperature range from 400°C to 1,000°C represented a higher value than that of the melted and forged material. This result and the high tensile strength mentioned suggest that the powder boundaries were strengthened by dispersed oxides from the initial powder surface during explosive compaction. (Edited author abstract) 22 refs. In Japanese.

Takashima, Kazuki (Kumamoto Univ, Kumamoto, Jpn); Tonda, Hideki; Ueno, Manabu; Toraiishi, Tatsuo; Miyano, Masaharu. *Tetsu To Hagane* v 73 n 16 Dec 1987 p 2219-2226.

## Iron Copper

**084444 INFLUENCE OF THE MIXING METHOD ON THE MICROSTRUCTURE OF SINTERED IRON WITH 8 WT% Cu.** The efficiency of the cementation of copper on iron sponge as a mixing method to achieve a homogeneous distribution of both metals before compacting and sintering in powder metallurgy parts production is demonstrated by means of scanning electron microscopy of polished surfaces and fracture surfaces. Through this mixing process a complete contrast between iron and copper is produced, so that even during short sintering times solid solution formation is complete, thus achieving more uniform mechanical properties, compared with those attained by mechanical mixing. Cemented powders may be suitable for solid phase sintering (without copper melting), thus avoiding undesired dimensional changes. In English and German. 14 refs.

Pardo, A. (Univ Complutense, Madrid, Spain); Otero, E.; Merino, C.; Laguna, M. *Prakt Metallogr* v 24 n 7 Jul 1987 p 313-322.

**084445 CORROSION KINETICS STUDY OF SINTERED Fe/8% wt Cu BY MEANS OF ELECTRO-CHEMICAL METHODS.** The corrosion resistance of Fe/8wtCu sintered products in simulated atmospheres contaminated with SO<sub>2</sub> was studied. The importance of the mixing procedure during the preparation of the sintered products is stressed with special emphasis on the effectiveness of the cementation of the copper on the iron sponge in order to obtain products with a greater degree of corrosion resistance. In addition, the influence of sintering temperature, time and heat treatment on the kinetics of corrosion is analyzed thus establishing the optimum conditions of preparation. (Edited author abstract) 16 refs.

Otero, E. (Univ Complutense, Madrid, Spain); Pardo, A.; Merino, M.C.; Laguna, M.; Cifuentes, M.J. *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 2, p 1693-1701.

## Iron Graphite

**084446 OXIDATION OF CHROMIZED IRON-GRAPHITE MATERIALS.** We have investigated the oxidation process in air at 1140°K of iron-based porous materials subjected to diffusion chromizing. The specimens in the forms of cylinders were pressed from PZ4M3-iron powder with additions of GK-3 graphite (1.0, 1.5, and 2.0 wt.%) and zinc stearate (1 wt.%) with a pressure of 200 MPa. The metallographic investigations were made on a Neophot-2 microscope and the etchant was Grossbeck's reagent. The data of metallographic and quantitative micro-x-ray spectral analyses showed that diffusion chromizing leads to the formation of a diffusion layer. On the basis of the results obtained it is concluded that it is undesirable to use chromized porous iron-base materials as heat resistant ones at high temperatures in air. However, these materials may reveal high protective properties in weakly oxidizing gaseous media. An analysis of the kinetics of oxidation shows that materials with the minimum carbon content and the least porosity and given long diffusion impregnation are distinguished by the greatest heat resistance. 3 refs.

Yurkov, I.I. (Plant Higher Technical School at Likhachev Automobile Plant, Moscow, USSR); Vasil'eva, E.V.; Ishkineev, I.I.; Mel'nichuk, G.A. *Sov Mater Sci* v 23 n 1 Jan-Feb 1987 p 38-40.

**084447 CATALYTIC EFFECT OF CARBONATES IN IRON-GRAPHITE COMPACTS.** Additions of certain alkali metal carbonates to iron-graphite compacts cause the generation of a carburizing gas atmosphere within the pores during sintering, and carbon alloying takes place efficiently and homogeneously at temperatures as low as 850°C if sintering is conducted in an inert gas furnace atmosphere. The process is believed to invoke the same catalytic cycle of reactions as that which is involved in pack carburizing. However, in the sintering case only those carbonates which react with carbon to produce alkali metal are effective, and then only if the vapour pressure of the alkali metal is high at the sintering temperature. Both sodium and potassium carbonate are efficient catalysts at 850-950°C. It is necessary to add more carbonate than will theoretically sustain the catalytic cycle within the pores. The excess is required to ensure that there is a net flow of reaction products from the pores, so that furnace gases cannot enter and dilute the carburising pore gases before all the graphite in the compact has reacted. (Author abstract) 5 refs.

Tanaka, Yoshiaki (Komatsu Ltd, Hirakata, Jpn); Lund, J.A. *Powder Metall* v 31 n 1 1988 p 45-51.

## Iron Nickel

**084448 PRODUCTION AND PROPERTIES OF POWDER ALLOYS FOR THERMOSTAT METALS.** This article presents technical features of production and the basic properties of powder metallurgy alloys with the minimum and high temperature coefficients of linear expansion for the passive and active constituents of thermocouple alloys. Powder metallurgy alloys with the minimum temperature coefficient of linear expansion were



produced based on Invar compositions including binary and those alloyed with cobalt (3.5%) and copper (up to 0.8%). For the constituent of the thermocouple alloy with the high temperature coefficient of linear expansion a low nickel alloy containing 27% Ni was alloyed with molybdenum in a quantity of 6.5%. The mechanism and kinetics of the synthesis process were studied on a  $(\text{Fe}_2\text{3-NiO-CoO-CuO}) + 4\% \text{NH}_4\text{Cl}$  system by thermogravimetric and differential thermal analyses. 4 refs.

Sarkisyan, L.E. (Erevan Polytechnic Inst, USSR); Samvelyan, R.G. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 572-575.

## Iron Nickel Alloys

**084449 MECHANICAL PROPERTIES OF SINTERED Fe-Ni-P ALLOYS PREPARED WITH PLATED POWDER.** Mechanical properties of alloys sintered by using atomized iron powder which was electroless plated with nickel-phosphorus alloy were studied. The sintered alloys with plated powder showed higher tensile strength and larger elongation than sintered alloys with mixed powders. The microstructure of the sintered alloys showed a composite structure consisting of two regions. One is the intergranular region containing smaller iron particles where nickel content is higher. The other is the inside region of larger iron particles where iron remains low alloyed after sintering. This composite structure gives high tensile strength and large ductility of alloys sintered with plated powder. The relationship between the tensile strength and the content of nickel and phosphorus is represented by an equation. (Edited author abstract) In Japanese. 11 refs.

Kohara, Shiro; Tatsuzawa, Kiyohiko. *J Jpn Soc Powder Powder Metall* v 35 n 1 Jan 1988 p 6-11.

## Iron Silicon

**084450 MAGNETIC PROPERTIES AND STRUCTURE OF Fe-3 MASS%Si SINTERED ALLOY.** Magnetic hysteresis, induction at 800 AT/m ( $B_0$ ), maximum permeability ( $\mu_m$ ) and coercive force ( $H_c$ ) were measured using a recording fluxmeter and core loss ( $W_{50}$ ) was measured at 50 Hz and maximum induction of 0.5 T. The sintered alloy shows a hysteresis loop suitable for block magnetic cores at the sintering temperature range between 1473 and 1673 K. At this temperature range,  $B_0$  increases from 1.22 to 1.41 T and  $\mu_m$  increases from  $9 \times 10^{-3}$  H/m to  $1.5 \times 10^{-2}$  H/m linearly with density. On the other hand,  $H_c$  decreases from 84 AT/m to 48 AT/m linearly with density.  $W_{50}$  is improved at sintering temperatures higher than 1473 K and is almost constant (25.0 W/kg) at sintering temperatures up to 1673 K. Grain growth does not affect the coercive force since intermetallic inclusions are formed. (Edited author abstract) In Japanese. 5 refs.

Sakai, Takeaki (Fujitsu Lab Ltd, Atsugi, Jpn); Sato, Takehiko; Henmi, Zenzo. *Nippon Kinzoku Gakkaishi* v 52 n 4 Apr 1988 p 434-439.

## Iron Silicon Aluminum Alloys

**084451 HOT EXTRUSION PROCESS FOR FE-SI-AL ALLOY POWDER.** An alloy of 85 percent Fe-9.6 percent Si-5.4 percent Al exhibits high permeability and low hysteresis loss. Its use for magnetic applications has been limited because of poor workability. A new practice has been developed to form the alloy to full density from gas atomized powder. With this process, the alloy shows good workability at a high strain rate. The extruded material has good magnetic properties and improved mechanical properties compared with the conventional cast alloy.

Anon. *Trans Iron Steel Inst Jpn* v 28 n 5 1988 P416.

## Iron Tin Copper Alloys

**084452 INCREASE IN SINTERING ABILITY AT LOWER TEMPERATURE OF IRON-TIN-COPPER COMPACTS.** Studies are in progress concerning reduc-

tion of sintering costs for iron-base sintered products. It was found that the iron-tin-copper compact made from iron-base mixed powders with tin and copper additive powders showed better mechanical properties when sintered at about 900°C than the conventional iron-copper compacts sintered at about 1150°C. An attempt was also made to investigate the lower-temperature sintering of a new iron-tin-copper compact made from mixed iron-base powders, of which a little of an powder was admixed to iron-copper prealloyed powder. The resulting compact could be obtained when sintering at only 700°C and had superior mechanical properties. (Edited author abstract) 7 refs.

Watanabe, Teruhisa; Kim, Youn Chai; Yamane, Masayuki; Iwatsu, Osamu. *Rep Cast Res Lab Waseda Univ* n 38 Jan 1988 p 27-32.

## Iron Titanium

**084453 HYDRIDING CHARACTERISTICS AND CYCLIC LIFE OF Fe-Ti-O ALLOYS.** The effects of powder size, environment and time on the hydriding process of  $\text{FeTi}_{1.15}\text{O}_{0.014}$ ,  $\text{FeTi}_{1.14}\text{O}_{0.023}$  and  $\text{FeTi}_{1.15}\text{O}_{0.024}$  were investigated by means of a volumetric method and differential scanning calorimetry. The change in the amount of hydrogen storage during hydriding-dehydriding cycles was also investigated by pressure-composition isotherms and X-ray analysis. It is concluded that a mechanism of hydrogen penetration through the phase boundaries plays an important role. The difficulty of  $\gamma$  hydride formation with increasing hydriding-dehydriding cycles can be explained in terms of hardening due to the high density of dislocations generated during the cycles. (Edited author abstract) 18 refs. In Japanese.

Amano, Muneyuki (Nat'l Research Inst for Metals, Tokyo, Jpn); Shibata, Michio; Sasaki, Yasuo. *Nippon Kinzoku Gakkaishi* v 51 n 9 Sep 1987 p 871-878.

## Israel

**084454 ISRAEL.** The P/M-based industry in Israel is oriented mainly towards the production and development of high performance parts and materials. The sales of P/M oriented industries were about \$150 million in 1986 and these have been growing at about 10-20% a year during the last several years. More than 60% of the products produced by P/M methods are exported. More than 90% (in sales) of P/M products are full density high performance parts and components. The research activities in universities and other research institutions are primarily in the field of high performance P/M materials, rapid solidification, consolidation of powders to full density, design of high performance materials, investigation of microstructure, and properties of high performance materials produced by modern P/M methods.

Gutmanas, Elazar Y. (Technion, Haifa, Isr). *Int J Powder Metall (Princeton NJ)* v 24 n 2 Apr 1988 p 139-141.

## Italy

**084455 ITALY.** During the last ten years the growth of P/M has been considerable and generally faster than the evolution of mechanical mass production. From this standpoint, Italy does not differ from the main industrialized countries. Because statistical surveys and reports concerning market situations in Italy are not available, the trends and data presented are based on estimates made by people involved in the P/M industries. 5 refs.

Bocchini, Gian F. (Hoganas Italia srl, Como, Italy). *Int J Powder Metall (Princeton NJ)* v 24 n 2 Apr 1988 p 143-151.

**084456 VANZETTI - ITALY'S PIONEERING CARBIDE PRODUCER.** Metalloceramica Vanzetti of Milan is one of Italy's leading producers of cemented carbide indexable inserts and was the first to pioneer carbide production in that country in 1942. The present owners have decided to concentrate on carbide insert tooling. From the current production of 45 tonnes or 5 million pieces per year, around 80% comprises indexable inserts

for metal removal, the remainder being mainly wear parts and other types of cutting tools. This article is based on a plant visit.

Brookes, Kenneth J.A. (Int Carbide Data). *Met Powder Rep* v 43 n 7-8 Jul-Aug 1988 3p.

## Japan See Also METALS AND ALLOYS—Solidification.

**084457 PRESENT STATUS OF POWDER METALLURGY IN JAPAN.** In this article the industrial developments, production equipment, products, new trends, application distribution of structural parts and self-lubricating bearings, and standards of Japanese P/M industry are described and reviewed. (Author abstract) 4 refs. In Chinese.

Han, Fenglin (Beijing Powder Metallurgy Co, China). *Fenmo Yejin Jishu* v 5 n 2 May 1987 p 103-111.

**084458 PRODUCTION, COMPACTION AND APPLICATION OF METAL POWDERS.** Kobe Steel Ltd of Kobe, Japan, produces both water and gas atomized metal powders for the PM industry. They have recently developed a range of new powders for use in applications such as injection molding, gas turbines, and magnetic clutches. The article describes some of Kobe Steel's recent developments in materials and powder production technology. 2 refs.

Kawai, N.; Honma, K.; Takigawa, H.; Iwai, K.; Hirano, M.; Yoshikawa, K.; Inoue, H. *Met Powder Rep* v 43 n 1 Jan 1988 p 21-22, 24-25.

**084459 JAPAN.** The export demand for Japanese industrial products decreased due to the rise of the Japanese yen in the foreign exchange market from September 1985. On the other hand, the domestic demand for these products has expanded because of the increase in personal consumption resulting from price stability and the lowering of interest rates. The total production of Japanese P/M products continued to increase in spite of the international oil crisis of 1975. These amounted to 153,671 tons in 1986, registering an increase of about 2% over the previous year. This is because production increases are being maintained in the automobile industry and the electric and electronic equipment industries, which are the main users of P/M products. 2 refs.

Watanabe, Teruhisa (Waseda Univ, Tokyo, Jpn); Sakurai, Tohru. *Int J Powder Metall (Princeton NJ)* v 24 n 2 Apr 1988 p 154-158.

**084460 PRESENT STATUS OF POWDER METALLURGY IN JAPAN.** This paper covers the present status of powder metallurgy. Discussed are the present outlook, raw materials, production equipment, powder metallurgy products and new developments in powder metallurgy. 13 refs.

Watanabe, Teruhisa (Waseda Univ, Tokyo, Jpn). *Rep Cast Res Lab Waseda Univ* n 37 Jan 1987 p 9-16.

## Lead

**084461 SURVEY ON CURRENT LEAD POWDER APPLICATIONS.** The various applications for lead in powder form, either as single element or as an alloy, are discussed in the light of its specific characteristics. It is indicated that health hazard created by dust could generally be reduced by the use of lead alloy powders or of lead pastes. Because of its versatile properties no economical replacement is found for many important applications. (Author abstract)

Bolze, G.A. (SPMS Poudmet). *ATB Metall* v 27 n 2-3 1987, Powder Metall, Brussels, Belg, May 13-14 1987 p 119-121.

## Light Metals

**084462 ADVANCED LIGHTWEIGHT METALS USING RAPID SOLIDIFICATION.** The use of rapid solidification (RS) to improve the mechanical and physical properties of alloys based on the lightweight metals



aluminum, titanium, and magnesium are discussed. The alloying strategies used in the three alloy systems will be presented, and it will be shown how the attributes of RS have been utilized in designing alloys. The paper also demonstrates how RS has led to improved high strength/corrosion resistant, elevation temperature and low density aluminum alloys. In the titanium system emphasis to date has been on elevated temperature terminal and intermetallic alloys, and recent results will be presented. It will also be shown how RS of magnesium alloys has allowed circumvention of the low strength, low ductility and rapid corrosion rate typical of cast product. Consideration will be given to applications of these improved alloys, and some projections will be made on future developments. (Author abstract) 111 refs.

Froes, F.H. (Air Force Wright Aeronautical Lab, Wright-Patterson AFB, OH, USA); Quist, W.E.; Das, S.K. *Met Powder Rep* v 43 n 6 Jun 1988 p 392, 394, 396-403.

**Molybdenum** See Also MOLYBDENUM AND ALLOYS—Welding.

**084463 HIGH-ENERGY, HIGH-RATE MATERIALS PROCESSING.** The availability of pulsed power, high-energy kinetic energy storage devices offers an opportunity to perform a wide range of experiments. The power density/interaction time plot gives the regimes where the processing has the most potential. Processing approaches can be divided between direct and indirect techniques. HEHR processing is a potentially useful approach to powder consolidation for two reasons. The first is that the speed associated with the processing offers the opportunity to maintain the fine microstructure associated with the original powders in the consolidated material. This fine structure could be either a non-equilibrium microstructure or a fine grain or subgrain structure. The second is that the heating is concentrated at the interfaces of the conducting particles. 9 refs.

Marcus, H.L. (Univ of Texas at Austin, TX, USA); Bourell, D.L.; Eliezer, Z.; Persad, C.; Weldon, W. *J Met* v 39 n 12 Dec 1987 p 6-10.

#### Molybdenum Iron Boron Alloys

**084464 EFFECTS OF CARBON CONTENT ON SINTERING MECHANISMS OF  $\text{Mo}_2\text{FeB}_2$  BASE HARD ALLOYS.** The liquid phase sintering of Fe-6wt. percent B-48wt. percent Mo-(0.01-0.55)wt. percent C alloys was studied by DTA, dilatometric measurements and microstructural observations. The liquid phase sintering accomplished by the formation of two liquid phases produced by  $\text{L}_1$  and  $\text{L}_2$  reactions, that is  $\gamma\text{-Fe} + \text{Fe}_3\text{B} \rightarrow \text{L}_1$  and  $\gamma\text{-Fe} + \text{Mo}_2\text{FeB}_2 \rightarrow \text{L}_2$ , when carbon content in the sintered alloy is low. As carbon content increases, another liquid phase reaction,  $\gamma\text{-Fe} + \text{Fe}_3\text{C} \rightarrow \text{L}_3$ , adds to  $\text{L}_1$  and  $\text{L}_2$ , which lies slightly below the temperature range in which the  $\text{L}_1$  reaction occurs. In proportion to the increase of carbon content, the temperature ranges of  $\text{L}_3$ , the  $\text{L}_1$  and  $\text{L}_2$  shift to lower temperature. When carbon content is in the range 0.01-0.55wt.%, the optimum sintering temperature lies slightly above the temperature at which the  $\text{L}_2$  reaction occurs. (Edited author abstract). 5 Refs. In Japanese.

Ide, Tsuneyuki; Nakano, Kazunori. *J Jpn Soc Powder Metall* v 35 n 3 Apr 1988 p 131-134.

**Nickel** See Also AIRCRAFT MATERIALS—Powder Metals; NICKEL CHROMIUM COBALT ALUMINUM ALLOYS—Mechanical Properties; NICKEL TUNGSTEN COBALT CHROMIUM ALLOYS—Superplasticity.

**084465 PRODUCTION OF DEFORMED BLANKS FROM POWDERS OF COMPLEXLY ALLOYED CREEP-RESISTING ALLOYS.** In this investigation, centrifugal spraying of a rotating blank was used to produce powders of three creep-resisting alloys denoted PZhS, PDZh-1, and PDZh-2. The PDZh-1 and PDZh-2 alloys contained 4% W-8% Co-4% Mo and 8% W-10% Co-2% Mo. The chromium content of all the alloys was 10%, the hafnium content was 0.5-1%. The alloys were subjected to mechanical tests combined with structural

analysis to obtain information on the strength and ductility properties and the degree of preparation of the structure of subsequent deformation. The alloys show superplastic behavior in the temperature ranges examined but the rates at which this effect operates are low. 2 refs.

Popova, L.E.; Dudkin, A.S.; Surikova, M.A.; Shvarts, V.I.; Kotov, V.F.; Suslov, M.A. *Sov Powder Metall Met Ceram* v 26 n 3 Mar 1987 p 221-223.

**084466 INJECTION MOULDED PM NICKEL-STEEL MANUFACTURED USING THE RIVERS PROCESS.** In the Rivers process the wax based binder is replaced by an organic mixture consisting of methylcellulose in water. Using this system the lengthy binder removal step is rendered obsolete on many occasions with the heat up part of the sintering cycle being sufficient, providing the parts have first been oven dried. An additional advantage of this novel process is that the difficulty in dewaxing thick section parts experienced when using a thermoplastic binder is eliminated.

Anon. *Met Powder Rep* v 42 n 9 Sep 1987 p 646-647.

**084467 EFFECT OF Ni ON THE MECHANICAL PROPERTIES OF Fe, Mo BORIDE HARD ALLOYS.** The effect of Ni content on the mechanical properties of iron molybdenum boride base hard alloys was studied by adding six levels of Ni to Fe-5 B-44.4 Mo which has the stoichiometric ratio of  $\text{Mo}_2\text{FeB}_2$ . The iron base binder phase varied from ferrite to martensite to austenite with increasing Ni content. A martensitic binder phase at 2.5%Ni gave the highest observed transverse rupture strength of 2.24 GPa, and a hardness of 86.9  $\text{R}_A$ . (Author abstract) 8 refs.

Takagi, Kenichi (Toyo Kohan Co, Higashitoyoi, Jpn); Komai, Masao; Ide, Tsuneyuki; Watanabe, Tadao; Kondo, Yoshikazu. *Int J Powder Metall (Princeton NJ)* v 23 n 3 Jul 1987 p 157-161.

**084468 ON THE SINTERED Ni-BASE SUPERALLOY. (VII) - LIQUID PHASE SINTERING AND MICROSTRUCTURAL CHANGES OF MERL 76 POWDER.** DTA during the sintering and solidification processes of Merl 76 powder detected five endothermic and five exothermic reactions, respectively. Although the phase reactions during both processes occurred in approximately the same temperature range, microstructural observations and EPMA analyses revealed that the phase reactions during sintering were not the reverse of those during solidification. Rapid densification occurred in the temperature range of the first reaction, which corresponded to incipient melting. The microstructure consisted of a fine dendritic structure. The liquid phase appeared in the regions between the dendrite arms and the amount of the liquid phase increased, changing its composition with increasing holding time. (Edited author abstract) In Japanese. 12 refs.

Morishita, Masao; Nagai, Hiroshi; Shoji, Keiichi. *J Jpn Soc Powder Metall* v 34 n 7 Sep 1987 p 296-301.

**084469 STUDY OF NICKEL BASE BRAZING POWDER AND ITS APPLICATIONS.** The paper has described the melting operation of nickel brazing powder and its atomizing process. The focus is on the composition of alloys and their various properties. (Edited author abstract) In Chinese. 2 refs.

Zhou Yulin (Hunan Metallurgy Material Research Inst, China); Zhang Chunyou. *Fenmo Yeyin Jishu* v 5 n 4 Nov 1987 p 210-214.

**084470 SINTERING OF NICKEL-CONTAINING METALLIC OXIDE CERMETS.** It is possible to sinter nickel-containing cermets in a hydrogen-containing atmosphere when water vapor is present in that atmosphere and titanium oxide is present in the charge in an amount exceeding the equilibrium concentration of the  $\text{Ti}_2\text{O}_3$  solid solution in corundum. During calcining the titanium oxide is reduced, with the formation of a solid solution of  $\text{Ti}_2\text{O}_3$  in corundum and other phases, in particular  $\text{AlTi}_2\text{O}_5$ . This plays an important part in the densification of the material. Sintering can be improved by employing a fine

metallic nickel powder as the nickel-containing component. 6 refs.

Fedotov, A.V.; Zhukov, S.T.; Shkirov, V.S. *Sov Powder Metall Met Ceram* v 26 n 5 May 1987 p 360-363.

**084471 INFLUENCE OF THE PHYSICAL CHARACTERISTICS OF HIGH NICKEL IRON ALLOY POWDER ON MAGNETIC PROPERTIES OF THE POWDER CORE.** The Powder body is a major factor affecting the preparation of the magnetic powder core. The relationship between magnetic properties of the powder core and physical characteristics of the powder body such as powder shape, particle size and size distribution and thickness has been studied in this paper. (Edited author abstract) 4 refs. In Chinese.

Deng, Hongcai; Li, Jingshun; Xu, Zhenming. *Zhongnan Kuangye Xueyuan Xuebao* v 18 n 3 Jun 1987 p 289-293.

**084472 HIGH-TEMPERATURE ALLOYS FROM POWDERS.** It is the objective in this paper to give a brief history of the development of high-temperature alloys indicating when and where powder metallurgy has been considered. It also outlines the processes employed for manufacture of the powder materials and the reasons for their use. The authors comment on the present status of powder high-temperature alloys and prospects for the future. The review covers wrought and cast alloys for the period 1940-1980. 70 refs.

Tracey, V.A.; Cutler, C.P. *Sel of Mater for Serv Environ (Source Book Series)* Publ by ASM Int, Metals Park, OH, USA, 1987 p 237-245.

**084473 PERFORMANCE OF NICKEL ALLOYS IN NITROGEN BASED ATMOSPHERES FOR SINTERING.** Nickel and iron base alloys were subject to nitrogen and hydrogen containing atmospheres over the temperature range 700°C (1292°F) to 1204°C (2200°F) to characterize the long term high temperature corrosion resistance of candidate alloys for P/M sintering furnace components, such as muffles and wire mesh belts. In addition, tests were also run in dry and wet ammonia atmospheres. Very low levels of oxygen in the atmosphere will retard nitridation by preferential oxide formation. Cyclic exposure with its concomitant air exposure is generally less severely nitriding than isothermal exposure. For the alloys of this study, the two most benign environments were nitrogen-cracked methanol and nitrogen-1% hydrogen both with added water vapor. In general, the higher the nickel content of the alloy, the more nitridation resistance of the alloy. Best overall performance was exhibited by Inconel alloy 600, which has the highest nickel and lowest chromium content among the alloys tested. 3 refs.

Rosa, Ed (Inco Alloys Int Inc, Huntington, WV, USA); Smith, Gaylord D. *Ind Heat* v 55 n 5 May 1988 p 15-17.

**084474 POTENTIAL OF POWDER INJECTION MOLDING AND HOT ISOSTATIC PRESSING OF NICKEL ALUMINIDE MATRIX COMPOSITES.** Intermetallic compounds are emerging as the next generation of high temperature, oxidation resistant materials applicable to turbines. Nickel aluminide is the initial choice as the matrix material. For injection molding a low density polyethylene wax with a softening temperature of 90°C was mixed with chopped alumina fiber and prealloyed nickel aluminide powder. The injection molding process and its difficulties are described. Proper mixing, slumping after debinding and presintering, reactive isostatic pressing and debinding of injection molded composites is discussed. It is concluded that debinding of coarse spherical powder is not possible without adequate support. The support is ideally in the form of a wicking material. With the wicking, the binder can be removed quickly (within 4 to 5 hours). The top surface slumps as soon as the binder liquifies, resulting in a depression on that surface. This is remedied by adding fibers, which increases the friction of the mixture. 7 refs.

Bose, A. (Rensselaer Polytechnic Inst, Troy, NY, USA); German, R.M. *Ind Heat* v 55 n 5 May 1988 p 38-41.



**Nickel Aluminum** See NICKEL ALUMINUM BORON ALLOYS—Solidification.

**Nickel Chromium Cobalt** See NICKEL CHROMIUM COBALT ALLOYS—High Temperature Properties.

### Nickel Chromium Cobalt Alloys

**084475 LOW COBALT POWDER METALLURGY SUPERALLOY.** With appropriate chemistry modifications, ZH56-K (Ni-11Cr-4.5Co-5W-5Al-3.5Mo-3Ti-0.15C-0.02B, weight %) has potential as a prospective low cobalt turbine disc material and was selected for investigation. The ZH56-K alloy composition was modified by increasing cobalt (from 4.5 to 5.5 wt%) and chromium (from 11 to 11.5 wt%) and adding 1.5 wt% niobium to increase strength. The powder was prepared by argon atomization and hot isostatically pressed at different temperatures to study the effects of consolidation temperature on microstructure and mechanical properties. The heat treatment, 1080°C/8h, rapid air cool + 650°C/24h, air cool + 760°C/16h, air cool, offered the best combination of tensile and stress rupture properties due to finely distributed carbide precipitates, coarse  $\gamma'$  precipitates at the grain boundaries and a bimodal distribution of intragranular  $\gamma'$  particles. Another heat treatment, 1220°C/2h, rapid air cool + 1050°C/8h, air cool + 850°C/16h, air cool, resulted in the formation of a continuous carbide network at grain boundaries and a high volume fraction of fine  $\gamma'$  particles with a raft-like morphology. This heat treatment resulted in reduced strength at high temperatures. (Edited author abstract) 19 refs.

Sharma, Krishan Kumar (Defense Metallurgical Research Lab, Hyderabad, India); Tewari, Surender Nath. *Int J Powder Metall (Princeton NJ)* v 24 n 1 Jan 1988 p 13-26, 28-29.

### Nickel Chromium Iron Alloys

**084476 WARM SHOCK CONSOLIDATION OF IN 718 POWDER.** Explosive consolidation of the rapidly-solidified nickel-base superalloy powder IN 718 was accomplished. The effects of explosive type, explosive-to-powder mass ratio, powder container material and thickness, type of confinement, shielding material and preheating temperature were investigated. Conditions for satisfactory consolidation with good mechanical properties and low microcrack density were established. The best consolidation was achieved by using a double-tube design in which a flyer tube was explosively accelerated, impacting the powder container. The powder was pre-heated at 525°C and the initial consolidation pressure was calculated to be 18 GPa, resulting in approximately 20% apparent interparticle melting. The quality of the consolidates was evaluated by optical and electron microscopy and by tensile testing. (Author abstract) 27 refs.

Wang, S.L. (New Mexico Inst of Mining & Technology, Socorro, NM, USA); Meyers, M.A.; Szecket, A. *J Mater Sci* v 23 n 5 May 1988 p 1786-1804.

### Nickel Chromium Molybdenum Alloys

**084477 PRODUCTION OF WATER AND GAS ATOMIZED POWDERS.** A metal powder can be produced in a large number of different ways. For alloys the choice is mainly between gas and water atomization and the manufacturer must find out how to produce the powder in the most economical way. Depending on alloy composition, required cleanliness with respect to various elements and inclusions, particle shape, sieve fraction and production volume, he can select the proper raw materials, melting procedures, atomizing process and handling methods. This article presents a comparison of costs for different powder process routes. The alloy chosen in this article is nickel with 30 weight-% chromium and 10 weight-% molybdenum.

L'Estrade, L.; Hallen, H. *Metallurgia* v 54 n 11 Nov 1987 p S6, S8.

### Nickel Iron Tungsten Alloys

**084478 DEFORMATION BEHAVIOR OF TUNGSTEN COMPOSITES.** Particle composites are a group of materials which include possibilities for developing new types of composites by powder metallurgy. Liquid phase sintered tungsten composites containing W/Ni/Fe and sometimes an addition of Co have spherical single crystals of tungsten (BCC) in a ductile matrix of around 52Ni/26Fe/22W (FCC). Compared to pure tungsten, the composite has good ductility (25-30% elongation to fracture). The deformation properties and its temperature dependence are the same as that for tungsten single crystals. The aim of this investigation was to find a relation between the total deformation of a particle composite and the local deformation of the particles and the matrix. The intention was also to investigate different test methods, especially the computerized image analysis method. 8 refs.

Ekbom, Lars (Natl Defence Research Inst, Stockholm, Sweden). *Scand J Metall* v 17 n 2 1988 p 84-89.

**Nickel Niobium Alloys** See GLASS, METALLIC—Thermal Properties.

**Nickel Tungsten Cobalt Chromium** See NICKEL TUNGSTEN COBALT CHROMIUM ALLOYS—High Temperature Properties.

**Niobium** See Also NIOBIUM AND ALLOYS—Solidification.

**084479 PARTICLE MORPHOLOGY AND PROCESSING PROPERTIES OF NIOBIUM POWDERS.** The main methods of producing niobium powders are the sodium thermic and carbothermic techniques, atomization of molten metal with compressed gases, and hydrogenation-dehydrogenation. In order to perform various powder metallurgy operations in the manufacture of parts with predetermined properties, it is necessary to carry out experimental investigations of the particle shape, particle size distribution, mechanical characteristics (microhardness), and compressibility of the powder to be used. In this connection, a study was made of niobium powders produced by hydrogenation-dehydrogenation under laboratory conditions by the same method but with additional roll-burnishing, by atomization with compressed gas and by an experimental process. The sizes and shapes of particles and their surface topography were investigated. 7 refs.

Flis, A.A. (Acad of Sciences of the Ukrainian, USSR, USSR); Gol'dberg, M.Sh.; Valentinov, V.D.; Verkhovodov, P.A. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 690-692.

**084480 PRODUCTION OF NbTi SUPERCONDUCTING MATERIALS BY USING NbTi POWDERS AND SUBSEQUENT ARC MELTING.** NbTi alloys for superconducting purposes are produced on an industrial scale by vacuum arc remelting or electron beam melting of ingots made of electron-beam melted semi-products of the pure metals niobium and titanium. Due to the high vapor pressure of titanium at the melting point of niobium, mainly titanium vaporizes, so that the concentration of titanium can vary considerably in the ingot. Furthermore, due to the wide solidification range in the Nb-Ti phase diagram, strong segregations can occur in the material. In order to achieve a high homogeneity, the ingots are often formed into rods, bundled and remelted. To simplify this relatively costly method of production, investigations were carried out as to which extent NbTi ingots with high homogeneity can be produced with powder metallurgical intermediary steps. This paper reports on the results obtained. (Edited author abstract) 4 refs.

Haehn, Reinhard (Gesellschaft fuer Elektrometallurgie, Nuremberg, West Ger). *ATB Metall* v 27 n 2-3 1987, Powder Metall, Brussels, Belg, May 13-14 1987 p 115-118.

**084481 PREPARATION OF DUCTILE Nb-Al POWDERS FOR THE FABRICATION OF Nb<sub>3</sub>Al SUPERCONDUCTORS.** The influence of rapid quench-

ing and hydrogenation on the structure and phase composition of niobium-rich Nb-Al alloys was investigated. Starting ingots were prepared by conventional arc melting of compacted powder mixtures. The phase diagram for Nb-Al, presented by Jorda et al., was confirmed in the examined concentration range up to about 30 at.% aluminium. Specimens were quenched with cooling rates not less than  $10^4$  K s<sup>-1</sup>, both from the solid and liquid state. A metastable extension of the niobium solid solution up to 27 at.% aluminium was obtained after quenching small droplets from temperatures  $T \geq 2200$  °C. Ductile Nb-Al powders of an average composition 'Nb<sub>3</sub>Al' were prepared with a combined hydriding-dehydriding process. (Edited author abstract) 28 refs.

Schulze, K. (Max-Planck-Inst fuer Metallforschung, Stuttgart, West Ger); Mueller, G.; Petzow, G. *J Less Common Met* v 139 n 1 Apr 1988, Pap Presented at the TMS Symp on Niobium and Niobium Alloys in Supercond Appl, Feb 24-27 1987 p 97-106.

**Niobium Tin Alloys** See NIOBIUM COMPOUNDS—Manufacture.

### Nitration

**084482 NITRIDIERUNG VON AL-PULVERN NAHE AN DER SCHMELZTEMPERATUR DES METALLS.** [Nitridation of Al-Powders Near by the Melting Temperature of the Metal]. Apart from the carbothermal reaction method, the production of sinterable AlN-powder is based on direct nitridation of Al-powder in a stream of nitrogen. This report deals with an investigation of the nitriding reaction in the 525-660°C temperature range by way of differential thermal analysis (DTA). The findings are reproduced by treating small batches in a tube furnace. The products are characterized by X-ray diffraction and scanning electron microscopy and tested for sinterability. (Edited author abstract) 4 refs. In German and English.

Belau, A. (TH Darmstadt, Darmstadt, West Ger); Mueller, G. *CFI Ceram Forum Int Ber DKG* v 65 n 5 May 1988 p 122-124.

### Peoples Republic of China

**084483 POWDER METALLURGY AT THE CENTRAL-SOUTH UNIVERSITY OF TECHNOLOGY, PRC.** The powder metallurgy program at the Central-South University of Technology was started in the early 1950's. The Powder Metallurgy Research Institute within CSUT was founded in 1960 and was the first of its kind in the People's Republic of China (PRC). This profile gives an outline of the Institute, its history, faculty, facilities, academic programs, research activities and future prospects. It also reviews some of the previous research work performed at the Institute. (Edited author abstract)

Wang, Lingsen (Central-South Univ of Technology, Changsha, China); Lu, Haibo. *Int J Powder Metall (Princeton NJ)* v 23 n 4 Oct 1987 p 285-291.

**084484 DEVELOPMENTS AND PRESENT STATUS OF P/M INDUSTRY IN JIANGSU PROVINCE.** This paper highlights the present status and the developmental features of the P/M industry in Jiangsu province. It outlines the problems and offers suggestions on solving them. (Edited author abstract) In Chinese.

Zhou Zuoping (Hefei Polytechnic Univ, China). *Fenmo Yejin Jishu* v 5 n 4 Nov 1987 p 229-232.

**Porosity** See Also POWDER METAL PRODUCTS—Density Measurement.

**084485 PREDICTION OF MECHANICAL PROPERTIES OF POROUS MATERIALS AND CERMETS - A CRITICAL ANALYSIS.** In the present study, the correlation between elastic moduli and porosity or dispersoids in porous materials or cermets has been reviewed and various equations developed so far have been examined with respect to their validity. Model equations for fracture toughness and strength have been discussed and



analyzed for their usefulness as design criteria. The validity of the composition between porous materials and cermets for predicting the various mechanical properties has been questioned and critically examined. (Author abstract) 25 refs.

Hamiuddin, M. (Aligarh Muslim Univ, Aligarh, India). *Powder Metall Int* v 19 n 6 Nov 1987 p 25-27.

**Processing** See Also METALS AND ALLOYS—Solidification.

**084486 BETTER PROCESSING WITH POWDER METALS.** Powder metallurgy technology - both in materials and processing methods - has developed significantly in the past few years. PM is becoming an increasingly attractive alternative to conventionally formed metal parts, and the developing area of metal injection molding promises to recapture some metal markets lost to plastics. Rapid solidification technology, high temperature sintering, hot-forging, hot-isostatic pressing, and new materials - such as nickel aluminides - also continue to develop. The article discusses developments in the field.

East, William R. (Materials Engineering, Cleveland, OH, USA). *Mater Eng (Cleveland)* v 104 n 11 Nov 1987 p 21-23.

## Purification

**084487 PURIFICATION OF METAL POWDER.** For manufacturing high grade metal components like turbine disks, tools and other high stressed parts, it is significant to process only metal alloy powder with a very low impurity content. The high purity of these powders can be achieved by superclean processing during melting, disintegration and the subsequent handling of the material. Another way is the application of cleaning processes before compacting the metal powder. There are two main sources for detrimental impurities, namely, ceramic liner material which is to be used during melting, and adsorbed gases which will be picked up during powder production and handling. Many different methods have been developed in order to clean the metal powder immediately before the final compaction. Some of these methods are described in this paper. 3 refs.

Joensson, S. (Leybold-Heraeus GmbH, Hanau, West Ger); Haeussermann, M.; Hohmann, M. *ATB Metall* v 27 n 2-3 1987, Powder Metall, Brussels, Belg, May 13-14 1987 p 81-84.

## Quality Assurance

**084488 LIGHT AND SHADOW ALONG THE POWDER METALLURGICAL ROUTE.** This paper discusses the cost and the quality aspects of PM parts for structural applications. The cost considerations include a shorter processing path, the production of near-net-shape components, the most efficient use of raw materials and energy, the fabrication of complex shapes with close tolerances and assembling which is possible before sintering. The quality considerations are the homogeneous structures with (almost) no segregation, the fine microstructure, the controlled density and porosity, the good surface finish, the possibility of obtaining non-equilibrium structures, and the fabrication of metal-matrix composites. 6 refs.

Aernoudt, E. (Katholieke Univ Leuven, Louvain, Belg); Froyen, L. *ATB Metall* v 27 n 2-3 1987, Powder Metall, Brussels, Belg, May 13-14 1987 p 45-51.

**Quality Control** See EARTHMOVING MACHINERY—Excavators.

**Reduction** See SAMARIUM COBALT ALLOYS—Synthesis.

**Research** See POWDER METAL PRODUCTS—Injection Molding.

## Reviews

**084489 INTELLIGENT PARTICULATE PROCESSING, NET SHAPE MANUFACTURING AND THE PRODUCTION OF NOVEL P/M MICROSTRUCTURES.** The melt prior to atomization is considered and the different refining, degassing and filtering methods are addressed. The detrimental role of inclusions, particularly in components to be utilized in low cycle fatigue applications, is discussed. The role of sensors, on-line feedback control, and the intelligent processing controls needed to ensure a given size powder distribution are considered. The processing methodologies which have emerged to produce composites and gradient microstructures, such as plasma processing, are reviewed. (Edited author abstract) 8 refs.

Apelian, Diran (Drexel Univ, Philadelphia, PA, USA). *Int J Powder Metall (Princeton NJ)* v 23 n 4 Oct 1987 p 249-259.

**084490 1988 P/M TECHNOLOGY REVIEW.** In the second annual P/M technology review, the author highlights advances and trends in 1987 and conjectures on what lies ahead. The review focuses on developments in materials and equipment, new products, and the metal injection molding process. It is based on a survey response among companies who are members of the Metal Powder Industries Federation. (Edited author abstract)

Johnson, Peter K. (Metal Powder Industries Federation, Princeton, NJ, USA). *Int J Powder Metall (Princeton NJ)* v 24 n 2 Apr 1988 p 129-133.

## Silicon

**084491 FLUIDIZED BED JET MILLING - KEY TO HIGH PURITY, FINE Si, Si<sub>3</sub>N<sub>4</sub> POWDERS.** Engineering ceramics are becoming increasingly important for a host of applications requiring high wear resistance. The article describes the use of the fluidized bed jet milling process developed by Alpine American Corp. for the production of fine, high purity silicon and silicon nitride powders. Applications for these products are found in advanced ceramics, electronic components, specialty chemicals, silicones, aluminum and other areas.

Kaiser, Robert (Elkem Metals Co, Niagara Falls, NY, USA). *Met Powder Rep* v 42 n 12 Dec 1987 p 850, 852.

**Silicon Compounds** See Also CERAMIC MATERIALS—Silicon Nitride; SILICON CARBIDE—Microstructure; SILICON NITRIDE—Manufacture.

**084492 RECENT TRENDS IN COLD AND WARM ISOSTATIC PRESSING EQUIPMENT.** Cold isostatic pressing (CIP) technology has seen rapid diversification in Japan in recent years, with high pressure equipment now available to process new materials such as Si<sub>3</sub>N<sub>4</sub>, SiC, rapidly solidified metal powders, hardmetals, plastics etc. T. Nishimoto, Y. Kishi and T. Naoi of Kobe Steel Ltd. in Chuo-ku, Kobe, Japan, describe their company's recent developments in wet-bag and dry-bag CIP equipment, and also the introduction of a warm isostatic press. In the Japanese material producing industry, the intention to commercialize higher value-added materials has become very strong. Isostatic pressing technology is recognized as one of the most promising technologies to break through the technological barrier against the actual production of the above materials. There is demand for advanced CIP systems suitable for diversified specific purposes. In this paper, some of the newly developed CIP systems were described. Kobe Steel intends to contribute to the future progress of CIP technology through its advanced CIP system, which are based upon much experience with high pressure technology.

Nishimoto, T. (Kobe Steel Ltd, Kobe, Jpn); Kishi, Y.; Naoi, T. *Met Powder Rep* v 42 n 9 Sep 1987 p 614, 616, 618.

## Silver Nickel

**084493 EFFECT OF THE COMPOSITION OF THE CERMET COMPOSITE SILVER-NICKEL-GRAPHITE ON THE OPERATIONAL CHARACTERISTICS OF CONTACT MATERIAL.** The authors studied cermet silver-containing contact material for automatic circuit breakers for a nominal current of 25 A. The percent content of the separate components was determined by the method of planning experiments. According to the criteria chosen, the optimal composition is 45% Ag-50% Ni-5% C. The lower contact resistance when the new contact material is used. 2 refs.

Dolinskii, Yu.M. (Kharkov Polytechnic Inst, USSR); Zinov'ev, V.V.; Novichenko, A.N. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 550-553.

**Sintering** See Also BORIDES—Mechanical Properties; BORON COMPOUNDS—Phase Transitions; BRONZE—Synthesis; CERAMIC MATERIALS—Microstructure; CRYSTALS—Dislocations; DIAMONDS—Synthetic; ETCHING; FRICTION MATERIALS; FURNACES; HEATING; IRON BORON MOLYBDENUM ALLOYS—Differential Thermal Analysis; IRON COPPER ALLOYS—Corrosion Resistance; IRON MOLYBDENUM BORON ALLOYS—Mechanical Properties; IRON POWDER; MAGNETS—Ferrite Applications; MAGNETS—Powder Metall; METALS AND ALLOYS—Solidification; MOLYBDENUM AND ALLOYS—Processing; NICKEL AND ALLOYS—Measurements; NICKEL AND ALLOYS—Mechanical Properties; POLYMERS—Processing; POWDER METAL PRODUCTS—Fatigue; POWDER METAL PRODUCTS—Injection Molding; REFRACTORY MATERIALS—Zirconia; SILICON NITRIDE—Crack Propagation; SILVER AND ALLOYS—Thick Films; SOLAR CELLS—Cadmium Sulfide; SOLID SOLUTIONS—Electric Properties; TITANIUM IRON ALLOYS—Mechanical Properties; TUNGSTEN CARBIDE—Processing.

**084494 SINTERING WITH ADDITIVES.** The addition of Ni to the refractory metals W and Mo is used to describe the three stages of solid state sintering as well as postdensification by hot isostatic pressing. It is shown that densification phenomena are changed by the presence of additives via a simultaneous increase in grain boundary diffusivity and surface diffusivity. From experiments with W-Ni, Mo-Ni and Fe-Cu it is concluded that in the presence of liquid additives, the densification phenomena, rearrangement and center to center approach occur by particle disintegration, coarsening and directional grain growth. The influence of driving forces provided by a chemical reaction on the kinetics of mass transfer is discussed for diffusion-induced grain boundary migration and liquid film migration. These types of interface migration were caused by interdiffusion of the additives with the host metal. Liquid film migration is thought to be of importance for the homogenization of Fe-Cu and Fe-Cu-C alloys during liquid phase sintering. (Edited author abstract) 38 refs.

Petzow, Guenter (Max-Planck-Inst fuer Metallforschung, Stuttgart, West Ger). *J Jpn Soc Powder Powder Metall* v 34 n 6 Aug 1987 p 235-247.

**084495 INTERACTION OF CHROMIUM CARBIDE (Cr<sub>3</sub>C<sub>2</sub>) WITH IRON MATRIX IN THE PRESENCE OF PHOSPHORUS DURING SINTERING.** In this work the effect of phosphorus on the dissolution process of the chromium carbide (Cr<sub>3</sub>C<sub>2</sub>) particles in an iron matrix was investigated with the aim of discovering the structure formation mechanism of the wear resistant alloy of the type CrCFe of chrome steels synthesized from a mixtures of the carbide with iron powders. It follows from the above that the reaction of the carbide Cr<sub>3</sub>C<sub>2</sub> with the iron matrix containing phosphorus has specific characteristics which distinguish it from the carbide diffusion mechanisms in pure iron or nickel which contains phosphorus. Actually, recrystallization of the Cr<sub>3</sub>C<sub>2</sub> carbide into the carbide M<sub>7</sub>C<sub>3</sub> appears as if it was retarded in the temperature range of 1100-1280°K in comparison with the development of this process in the Cr<sub>3</sub>C<sub>2</sub>-Fe system. Besides this, as a result of dissolving of the carbide particle in the iron matrix at a temperature of 1350-1380°K a crater



with a relatively smooth wall is formed in its place, whereas in the iron-phosphorus matrix a carbide eutectic crystallizes in that place. 6 refs.

Vlasyuk, R.Z. (Acad of Sciences of the Ukrainian SSR, USSR); Smirnov, V.P.; Sotnik, A.A. *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 303-306.

**084496 MICROWAVE SINTERING OF SOME OXIDE MATERIALS USING SINTERING AIDS.** The present work investigates several sintering aid systems. Hardness as a function of sintering aid and sintering time for  $Y_2O_3$  and densification as a function of time for  $Y_2O_3$  with 10 wt% ZON is shown. In conclusion, authors have shown that additions of small amounts of second-phase materials to common oxide materials enhance or accelerate the densification process with microwave sintering. Nitrates are shown to be very effective sintering aids for microwave sintering. 2 refs.

Meek, T.T. (Univ of Tennessee at Knoxville, Knoxville, TN, USA); Holcombe, C.E.; Dykes, N. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1060-1062.

**084497 DENSIFICATION KINETICS DURING SINTERING OF MATERIALS BY A FLOW MECHANISM.** In this letter particular attention is paid to consideration of the sintering of amorphous materials during a viscous flow mechanism, and to the possibilities of correlation of these results with a diffusion-dislocation flow of crystalline materials. The dependence of the pore reduction rate during sintering in a sample obtained by pressing an amorphous powder is defined. A new equation describing the sintering kinetics of real powder pellets has been derived and on the basis of that equation the physical significance of characteristic coefficients of a kinetic equation established by Ivensen has been more thoroughly defined. 7 refs.

Ristic, Momcilo M. (Serbian Acad of the Sciences & Art, Belgrade, Yugoslavia); Dragojevic-Nesic, Miroslava J. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1091-1092.

**084498 RECENT DEVELOPMENTS IN AUTOMATED VACUUM SINTERING.** New developments in the fields of batch vacuum furnaces for automatic sintering processes are reviewed. Vacuum equipment for sintering hard metals and other products sensitive to reactions with the environment are described which allow to increase sintering capacity, to reduce capital investment and running costs, and to improve quality. (Author abstract)

Bauer, R. *Powder Metall Int* v 19 n 5 Oct 1987 p 13-17.

**084499 ON THE IMBIBITION OF METAL MELTS BY SINTERED CARBIDES.** The interaction of Co and Ni melts and WC-Co and WC-Ni sintered carbides has been studied. At temperatures above the binding metal melting point, chemically equilibrated metal melts are imbibed by poreless sintered carbide bodies. The motivating forces underlying this phenomenon have been clarified and the concurrent liquid phase mass transfer through imbibition and components diffusion mechanisms have been studied. (Author abstract) 9 refs

Lisovsky, A.F. (Ukrainian Acad of Sciences, Kiev, USSR). *Powder Metall Int* v 19 n 5 Oct 1987 p 18-21.

**084500 NEUERE ANSCHAUUNGEN ZUM FESTPHASENSINTERING.** [Recent Views on Solid Phase Sintering]. Solid phase sintering of technical objects is fundamentally a high-temperature deformation process. In analogy to compact materials, this process can be understood as high-temperature creep. Depending on the powder particle size, the compaction in the stage of intensive shrinkage is caused either by diffusional creep, or by dislocation creep. (Edited author abstract) In German. 18 refs.

Schatt, Werner (Technische Univ Dresden, Dresden, East Ger). *Neue Huette* v 32 n 9 Sep 1987 p 325-329.

**084501 TRENDS AND DEVELOPMENTS IN MESH-BELT CONVEYOR SINTERING FURNACE DESIGN.** The mesh-belt conveyor furnace is the most

universally accepted furnace for sintering in the ferrous powder metal industry. The simplicity of the furnace design, outlined in this article, allows the furnace operator to maintain constant control over process conditions, thereby allowing constant product quality to be achieved. (Edited author abstract)

Smith, D.E. (Camlaw Ltd, Tamworth, Engl). *Metallurgia* v 54 n 11 Nov 1987 p S22.

**084502 VACUUM SINTERING FURNACES BOOST EFFICIENCY, RELIABILITY AND PRODUCTIVITY.** USA company Vacuum Industries Inc. has gained a world-wide reputation for the high performance characteristics of its vacuum sintering furnaces. This article outlines some of the current state-of-the-art models, together with some recent specific developments. (Edited author abstract)

Anon. *Metallurgia* v 54 n 11 Nov 1987 p S24.

**084503 OPTIMISED SINTERING IN NITROGEN-BASED ATMOSPHERES - THE NITRAZONE APPROACH.** Historically, the most common atmospheres used in the sintering of powder metal components have been endothermic gas, cracked ammonia and exothermic gas. Of these, endothermic gas found most general use, with exothermic gas and cracked ammonia being used for more specialized applications, e.g., sintering stainless steel in cracked ammonia. This article describes a system developed by BOC Ltd. (Edited author abstract)

Morris, J. (BOC Ltd, Shipley, Engl). *Metallurgia* v 54 n 11 Nov 1987 p S26, S28.

**084504 INVESTIGATION OF SINTERING OF WC-Co CEMENTED CARBIDE SYSTEMS IN A MAGNETIC FIELD.** The sintering of cemented carbide in a homogeneous and strong magnetic field is a new powder metallurgy technique. Experimental results demonstrate that the method efficiently improves the quality and structure of cemented carbides. A WC-(10-6)%Co alloy sintered in a magnetic field has a bending strength ( $\sigma_{bb}$ ) 20% higher, ratio of oriented WC crystals three items higher, and the  $\beta$ -Co (f. c.c.) content ten times higher than in alloys sintered without the use of the magnetic field. Its porosity is <0.02% (vol.). Substantial changes are observed both in its macro- and microstructure. (Edited author abstract) In Chinese. 8 refs.

Zhang, Daming (Central South Univ of Technology, China); Zhou, Luosan. *Zhongnan Kuangye Xueyuan Xuebao* v 18 n 2 Apr 1987 p 163-170.

**084505 ABNORMAL GRAIN GROWTH IN SINTERING POWDER COMPACTS.** The objectives of this paper are (i) to discuss the existing qualitative model for the initiation of discontinuous grain growth and (ii) to propose possible reasons for interpreting the development of faceted abnormal grains. The phenomenon of abnormal grain growth in sintering powder compacts in quite complicated. The presence of abnormal large grains or pore-boundary separation is not the primary reason for the initiation of discontinuous grain growth, but the correlation of the anisotropic grain growth, the purity level, the degree of agglomeration, and temperature should be considered. The faceting of grains is associated with the liquid phases. 17 refs.

Fang, Tsang-Tse (Nat'l Cheng Kung Univ, Tainan, Taiwan). *Scr Metall* v 22 n 1 Jan 1988 p 9-11.

**084506 COMPUTER SIMULATION CODE FOR PARTICLE GROWTH IN LIQUID PHASE SINTERING.** The purpose of the present work is a more realistic prediction of the microstructural evolution of a liquid phase sintering (LPS) material by Ostwald ripening. The computer model does not consider a size distribution of particles but describes the real material using a finite, as large as possible, number of close packed particles. Each particle is defined by a set of surface points. Each point evolves according to its local environment. In the present paper, the growth is assumed to be limited by interface reaction, which is the simplest mechanism. 10 refs.

Chaix, J.M. (CNRS, St. Martin d'Heres, Fr); Guyon, M.; Rodriguez, J.; Allibert, C.H. *Scr Metall* v 22 n 1 Jan 1988 p 71-76.

**084507 PRODUCTION PLANTS FOR DEWAXING, VACUUM SINTERING, AND PRESSURE SINTERING IN A COMBINED PROCESS.** To eliminate porosity and thereby improve product quality of cemented carbides, hot isostatic pressing (HIP) with pressures = 1000 bar (Ar) was introduced in production in USA and Sweden during the year 1967. Moreover, besides a sintering furnace, also a separate high pressure HIP plant is also required. Just at the beginning of this decade, the realization took place that the 'defect healing of pores' can also be done in suitable equipment at lower pressures up to 100 bars isothermally in connection with the vacuum sintering procedure. With this method, equivalent good results were achieved at lower costs and at an improved grade of automation. 6 refs.

Hofmann, G. (Arthur Pfeiffer Vakuumtechnik Wetzlar GmbH, Asslar, West Ger); Hack, R.; Ermel, D.; Polhede, W. *Powder Metall Int* v 19 n 6 Nov 1987 p 35-37.

**084508 DIFFUSION HOMOGENIZATION OF POWDERED MATERIALS OF THE Fe-Ni-Cr-Mo SYSTEM.** A statistical approach is proposed for studying homogenization in powdered materials during sintering expressions are obtained which describe the homogenization process in the 4-component Fe-Ni-Cr-Mo powdered system containing up to 20% chromium and nickel and up to 5% molybdenum. The distribution of the concentrations of alloying elements is asymptotically log-normal. The calculated diffusion activation energies agree with data obtained on diffusion couples; in this case the maximum energy occurs in the range of heat-resistant chromium-nickel steels. 11 refs. In Russian.

Antsiferov, V.N.; Peshcherenko, S.N.; Shatsov, A.A. *Izv Vyssh Uchebn Zaved Chern Metall* n 9 1987 p 65-68.

**084509 MAGNETIC STUDY OF SINTERING OF ULTRAFINE PARTICLES.** Sintering of Ni ultrafine particles and Cu ultrafine particles was studied by measuring the ferromagnetism of Ni. It was found that diffusion started at about 100°C and accelerated above 250°C. In a reducing atmosphere of  $H_2$ , the diffusion started at a lower temperature than in a He atmosphere. (Author abstract) 6 refs.

Okamoto, Yoichi (Univ of Tsukuba, Jpn); Koyano, Tamotsu; Tasaki, Akira. *Jpn J Appl Phys Part 1* v 26 n 11 Nov 1987 p 1943-1944.

**084510 HOMOGENIZATION AND PORE FORMATION DURING SINTERING WITH TRANSIENT LIQUID PHASE.** Sintering with transient liquid phase can greatly enhance homogenization of P/M alloys produced from elemental starting powders. It is shown that homogenization strongly depends on the type of system, being promoted by rapid formation of liquid phase as e.g. in peritectic systems, while slow formation of liquid phase by interdiffusion, as in eutectic systems, may result in insufficient homogeneity, in practice necessitating more intense sintering. (Author abstract) 41 refs.

Danninger, H. (Technische Univ Wien, Vienna, Austria). *Powder Metall Int* v 20 n 1 Feb 1988 p 21-25.

**084511 IZVEDBA PRILAGODLJIVIH AVTOMATIZIRANIH CELIC ZA PROIZVODNJO IZDELKOV IZ PRAHASTIH MATERIALOV S POU-DARKOM NA POSTOPKU SINTRANJA.** [Flexible Automated Cells for the Manufacturing of Products from Powder Materials with a Special Emphasis on Sintering]. The paper discusses the steps which have to be taken for the automation of manufacturing powder material products following the principle of process flexibility. The realization of the automation is based on knowledge already confirmed in practice in the field of flexible manufacturing cells. This knowledge contributed to a



better design of the cell and to the selection of the most suitable equipment. (Author abstract) In Serbo-Croatian. 2 refs.

Ausman, Herbert. *Stroj Vest* v 33 n 10-12 Oct-Dec 1987 p 205-210.

**084512 CURRENT VIEWS ON THE PROCESSES OF SINTERING IN THE PRESENCE OF A LIQUID PHASE.** In recent years advances have been made in investigations into the physical processes taking place during liquid phase sintering, particularly in the elucidation of the nature and laws governing changes occurring during the sintering of powder mixtures of interacting components. This article is a brief summary of some of these studies. The review covers driving forces, regrouping of particles, particle growth and dissolution, and solution-precipitation. 20 refs.

Savitskii, A.P. (Acad of Sciences of the USSR, USSR). *Sov Powder Metall Met Ceram* v 26 n 8 Aug 1987 p 631-636.

**084513 EVOLUTION OF SOME IDEAS IN SCIENCE OF SINTERING.** Historical studies dealing with the history of sintering are few. The purpose of this paper is to consider the evolution of views and conceptions in the last 5-6 decades. The theories of Russian and Yugoslavian scientists are emphasized. (Edited author abstract)

Plotkin, S.Ya. (Acad of Sciences of the USSR, Moscow, USSR). *Sci Sintering* v 19 n 3 Sep 1987 p 123-131.

**084514 SINTERING KINETICS AND MECHANISM OF POLYMETHYL METHACRYLATE.** A simultaneous investigation of sintering of a particles system (pellets) and that of a two-sphere model of polymethyl methacrylate has been carried out. It was established that the sintering process of a sphere model is performed at two stages and that the initial stage corresponds to the initial stage of sintering of two spheres. The results concerning activation energy prove that viscous flow is the responsible mechanism of this process. 8 refs.

Cvetkovic, N.R. (Serbian Acad of Sciences & Arts, Belgrade, Yugosl). *Sci Sintering* v 19 n 3 Sep 1987 p 151-155.

**084515 HIP SINTERING OF  $\text{Si}_3\text{N}_4$  WITHOUT ADDITIVES AND PROPERTIES OF SINTERED COMPACTS.** Four kinds of  $\text{Si}_3\text{N}_4$  powders were hot-isostatically pressed to dense compacts using a glass encapsulation technique without additives. The investigation into the compacts revealed the following facts. (1) Fabrication of almost fully dense  $\text{Si}_3\text{N}_4$  compacts without additives is possible by the present method. (2) The microstructure of the compacts is characterized by equiaxed grains and a very small amount of secondary glassy phase along the grain boundary. (3) Flexural strength at 1400°C is excellent (735MPa) compared with ordinary  $\text{Si}_3\text{N}_4$  ceramic materials. This work was supported by MITI's Project for Basic Technology for Future Industries. (Author abstract) 8 refs.

Fujikawa, Takao (Kobelco Research Inst Inc, Jpn); Inoue, Yasuhiko; Homma, Katsuhiko; Kondo, Nobuo; Tatsuno, Tsuneo; Okada, Hiroshi. *Kobelco Technol Rev* n 3 Feb 1988 p 1-5.

**084516 COLD FORGING OF SINTERED IRON POWDER PREFORMS.** Recently, sintered powder preform forging has been developed as a method for producing products of high density and with good mechanical properties. This paper reports on an investigation into the various aspects of cold forging of iron powder preforms which have been compacted and sintered from atomized iron powder. The influence of powder particle size, compacting pressure, sintering temperature and forging parameters on relative density of the preform was investigated. Considering the process of the forging of metal powder preforms under axisymmetric condition, the problems of pressure distribution at the die-work piece interface and the load have been analysed. The correctness of the yield criterion and interfacial friction law used during the analysis have also been verified experimentally.

Measurements were made on the development of barreling and strain variations at the free surface of the preform. The results so obtained are discussed critically to illustrate the interaction of various parameters involved and are presented graphically. (Author abstract) 24 refs.

Jha, A.K. (Heavy Engineering Corp, Ranchi, India); Kumar, S. *J Inst Eng India Part MM* v 68 pt 2 Mar 1988 p 110-118.

**084517 RING-COMPRESSION TESTS ON SINTERED IRON PREFORMS.** Standard ring-compression tests have been carried out on sintered iron preforms of different initial densities. The values of the apparent strength coefficient and the strain hardening exponent have been estimated to identify which conditions of the preform result in mechanical properties closest to those of the equivalent wrought part. The coefficient of friction has also been estimated for compacts as well as for wrought parts, so that near identical frictional conditions could be employed for comparison purposes, in computations of their respective force requirements. Compacts of different length-to-diameter ratios have been prepared for different compacting pressures and the optimal conditions of the billet geometry for the least non-uniform densification along the length of the compact have been established. The main aim of this fundamental work was to prepare, and explore the properties of, sintered preforms of different initial densities and of a greater length-to-diameter ratio so that future cold Hooker studies on these compacts would be possible. (Edited author abstract) 4 refs.

Venugopal, P. (IIT, Madras, India); Venkatraman, S.; Vasudevan, R.; Padmanabhan, K.A. *J Mech Work Technol* v 16 n 1 Feb 1988 p 51-64.

**084518 DEFORMATION CHARACTERISTICS AND FRACTURING OF SINTERED COPPER POWDER STRIPS DURING COLD FORGING.** The industrial processing of sintered powder preforms has recently been developed for manufacturing various engineering components. The present investigation has been undertaken with a view to studying the deformation characteristics and fracture mechanism during the cold forging of sintered copper powder strips. The influence of compacting pressure, sintering temperature and forging parameters on the relative density of the copper powder strip is explored. Experiments have been conducted and measurements made on the development of barreling and strain variations at the free surface. Crack formation at the free surface has also been examined. The theoretical and experimental results are analysed and discussed critically to explain the deformation characteristics and the fracturing of sintered copper powder strips during cold forging. Results are presented graphically. (Author abstract) 22 refs.

Jha, A.K. (Heavy Engineering Corp, Ranchi, India); Kumar, S. *J Mech Work Technol* v 16 n 2 Apr 1988 p 145-164.

**084519 SOME FAILURE STUDIES IN THE HOOKER EXTRUSION OF SINTERED IRON POWDER METALLURGICAL PREFORMS.** This paper highlights some typical circumferential and longitudinal cracking encountered during the Hooker extrusion of sintered iron preforms. Studies carried out indicate that the preform shape, the preform sintered density, the die included angle and the extrusion reduction (deformation ratio) have a strong influence in the arresting of such cracks. (Author abstract) 4 refs.

Venugopal, P. (IIT, Madras, India); Venkatraman, S.; Vasudevan, R.; Padmanabhan, K.A. *J Mech Work Technol* v 16 n 2 Apr 1988 p 165-174.

**084520 PRODUCTION OF THIN TUBES AND TAPERED CUPS BY THE SPINNING OF SINTERED POWDER PREFORMS.** As an attempt to facilitate the small-batch production of axisymmetric parts such as thin tubes and tapered cups, a powder metallurgy technique has been employed in combination with a shear-spinning process. Electrolytic copper powder

is used as the starting material instead of a tube or a sheet and the powder is compacted within a simple device using a polyurethane cylinder as the pressure medium. The green compact is sintered in vacuum and then the sintered preform is spun to decrease its porosity and to improve its dimensional accuracy. The product obtained is annealed to diminish the brittleness arising from work-hardening in the multi-pass spinning. Finally, as an additional process to remove feed marks generated on the surface, the product is polished with sandpaper or a wiper roller. The relative density achieved by this process is about 0.98 and the dimensional accuracy, ductility and surface finish are also adequate for practical use. (Author abstract) 5 refs.

Yamaguchi, K. (Kyoto Inst of Technology, Kyoto, Jpn); Takakura, N.; Fukuda, M. *J Mech Work Technol* v 16 n 2 Apr 1988 p 203-213.

**084521 ANALYSIS OF SINTERING IN  $\alpha$  AND  $\gamma$  PHASES OF IRON BASED ALLOY USING WIRE MODEL.** A study of sintering in  $\alpha$  and  $\gamma$  phases of iron based mixed powder compacts has been made using specimens prepared by winding 200  $\mu\text{m}$  dia iron-molybdenum alloy wires around the same alloy spools. Changes in the size of the necks between wires were observed as a function of sintering time and temperature. By the 'exponential method', both the rate and the mechanism of sintering can be investigated. The neck growth rate was remarkably larger in  $\alpha$  phase than in  $\gamma$  phase, although the difference between the two phases was not clear in the mixed powder compacts. The sintering occurred mainly by lattice diffusion in both  $\alpha$  and  $\gamma$  phases, and additionally by surface diffusion in  $\gamma$  phase at lower temperature. (Author abstract) 13 refs.

Tanabe, Shigenori; Shibata, Jiro; Asakura, Kenji. *Bull Univ Osaka Prefect Ser A* v 36 n 1 1987 p 21-28.

**084522 SINTERED HIGH SPEED STEEL AND ITS APPLICATIONS.** The sintering densification process is one way to manufacture P/M tool steel products. By using this process, nearly-densified P/M tool steel with superior performance can be obtained. The present paper briefly describes the basic technology of sintered high speed steel products and their properties. Preliminary trials have shown bright prospects for making cutting tools, dies and wear-resistant parts. (Edited author abstract) In Chinese. 8 refs.

Dai, Xinyi (Shanghai Research Inst of Materials, China); Yian, Jiansu; Zhong, Shouliang; Liu, Yunmei. *Fenmo Yejin Jishu* v 6 n 1 Feb 1988 p 7.

**084523 DRUCKSINTERN VON  $\text{AlN}$  MIT  $\text{Y}$ -HALTIGEN ZUSATZSTOFFEN.** [Pressure Sintering of  $\text{AlN}$  with Y-Containing Additives]. It is well known that  $\text{Y}_2\text{O}_3$  can serve as an effective sintering agent for  $\text{AlN}$  ceramics (1). Its influence derives from the formation of a liquid phase at sintering temperature, i.e., roughly 1800°C. During cooling, Y-Al-garnet (YAG),  $\text{Y}_3\text{Al}_5\text{O}_{12}$ , crystallizes out of the liquid phase. This report deals with the phase and microstructural development of Y-containing  $\text{AlN}$  ceramics as functions of the type and quantity of the Y-containing additives, the atmosphere and the temperature/time program of the sintering process. In English and German. 5 refs.

Toepfer, U. (Technische Hochschule Darmstadt, Darmstadt, West Ger); Mueller, G. *CFT Ceram Forum Int Ber DKG* v 65 n 3-4 Mar-Apr 1988 p 70-74.

**084524 ON PHENOMENA APPEARING DURING SINTERING PROCESS OF THE IRON-TIN MIXED POWDERS COMPACTS.** Phenomena appearing during sintering process of an iron-1.0 wt% tin mixed powders compact were investigated in comparison with those of the iron powder compact. When the iron-tin mixed powders compact is being heated, tin powder particles become liquid at the melting-point of tin, 505 K (232°C). The tin-liquid penetrates into capillaries between iron powder particles above about 673 K (400°C) and with the rising of temperature up to about 1173 K (900°C), the tin-liquid



forms various tin-iron intermetallic compounds. When the temperature is above about 1273 K (1000°C), however, all the intermetallic compounds become  $\alpha$  phase iron-tin solid-solution having higher self-diffusion coefficient than the  $\gamma$  phase. The above phenomena make the compact have a higher strength as well as more shrinkage in comparison with those of iron powder compact at the sintering temperature of about 1423 K (1150°C). (Edited author abstract) 10 refs.

Watanabe, Teruhisa (Waseda Univ, Tokyo, Jpn); Kim, Youn Chai. *Rep Cast Res Lab Waseda Univ* n 37 Jan 1987 p 1-7.

**084525 ROLE OF SAMSONOV'S STABLE ELECTRON CONFIGURATION MODEL IN SINTERING OF REAL SYSTEMS.** Previous studies have analysed the density and volume change in porous green compacts of crystalline materials depending on pressure, temperature and sintering period and how these changes are influenced by the powder characters. G.V. Samsonov's fundamental unified model on the formation of stable electronic configurations in condensed matters is discussed in this work. In the review, an attempt has been made to apply the model in sintering of alloys, metal-ceramic composites and special ceramics. Specific examples from aluminium bronze, brass, ferrous alloys containing phosphorus, heavy alloys, Al-refractory carbide composites, WC based cemented carbides, refractory carbides and covalent bonded solids have been included. (Edited author abstract). 27 Refs.

Upadhyaya, G.S. (Indian Inst of Technology, Kanpur, India). *Sci Sintering* v 20 n 1 Jan 1988 p 23-29.

**084526 ALLOY PHASE STABILITY IN LIQUID PHASE SINTERING.** The criteria for identification of successful liquid phase sintering systems are reviewed to establish common phase diagram characteristics. These phase diagram characteristics are related to the thermodynamic interaction between the components that constitute the sintering system. The desired phase stability relations for liquid phase sintering are represented by the interaction parameters. In turn, the phase stability is related to the electronic structure of the components. These concepts provide a basis for analyzing the sintering behavior of various transition metals. (Author abstract). 21 Refs.

Kipphut, C.M. (Rensselaer Polytechnic Inst, Troy, NY, USA); German, R.M. *Sci Sintering* v 20 n 1 Jan 1988 p 31-40.

**084527 EPR SPECTROSCOPY IN SOLUTION TO SOME PROBLEMS OF PHYSICS OF SINTERING.** EPR spectroscopy can be useful in the investigation of numerous processes in powder technology. As the investigative source in a paramagnetic probe, one can use study paramagnetic impurities previously introduced into the investigated object, paramagnetic centres that are formed during the study of technological processes and non-paramagnetic impurities that can be transformed into paramagnetic states by physical and chemical procedures. In this paper, the possibilities of application of the method for investigation of the sintering and consolidation process have been studied. (Edited author abstract). 37 Refs.

Trefilov, V.I. (Inst for the Problems of Material Science of AS Ukr, Kiev, USSR); Vlasova, M.V.; Kakazei, N.G.; Minakov, V.N.; Ristich, M.M. *Sci Sintering* v 20 n 1 Jan 1988 p 41-60.

**084528 ON THE PROPERTIES AND ECONOMICS OF SINTERED IRON POWDER METALLURGICAL EXTRUDES.** Cold Hooker extruded iron compacts have been evaluated for density, mechanical and metallurgical properties, in the as-extruded, annealed and re-sintered conditions and the results compared with those for an equivalent wrought composition. The extent of densification occurring due to cold deformation of the P/M compacts has also been examined. The commercial viability of the process of cold extruding a P/M preform has been analysed by considering the manufacture of a suitable component by the above process and comparing it with manufacture by the existing conventional process.

This evaluation gives an indication of the economics of the Hooker extrusion process of P/M preforms for the manufacture of a similar family of products. (Author abstract). 3 Refs.

Venugopal, P. (IIT, Madras, India); Venkatraman, S.; Vasudevan, R.; Padmanabhan, K.A. *J Mech Work Technol* v 16 n 3 Jun 1988 p 231-242.

**084529 PRESSURE ASSISTED SINTERING OF METAL ALLOYS AND CERAMICS.** The development of the pressure assisted sintering (PAS) process came about as a result of a two-year study of containerless hot isostatic press (HIP) treatment of pressed and sintered alloys. This work was started at the Gorham Advanced Materials Institute (GAMI) in 1977, and led to the patented PAS process. Shortly after the completion of this initial work, a study of the effects of HIPing on sintered rare earth cobalt magnets was undertaken. This article reviews the results of these early experimental programs, and shows how the results of these programs led logically to the invention of the PAS process for pressed, injection molded, gravity presintered and slip cast parts. The article also covers in detail the application of PAS to injection molded and die pressed P/M parts, the use of hot isostatic processing to densify intermetallic magnets, and the use of continuous sinter/HIPing of ceramics using pressures in the range of 200 to 30,000 psi.

Andersen, I. Fred (Thermal Technology Inc); Nyce, Andrew C. *Carbide Tool J* v 20 n 3 May-Jun 1988 p 7-12.

**084530 FRITTAGE PAR MICRO-ONDES DE MATERIAUX DIELECTRIQUES POUR CONDENSATEURS: ORIGINE DES INTERACTIONS MICRO-ONDES/MATIERE DANS LES PEROVSKITES DIELECTRIQUES.** [Microwave sintering of perovskite type materials for capacitors]. Sintering of perovskite type  $ABO_3$  compounds has been studied using microwave heating. The behavior observed at low temperatures are analyzed in terms of polarization and ionic conduction losses. At higher temperature, a band model based on the super-exchange between the titanium 3d orbitals and the  $p\pi$  orbital of the oxygen allows the different behavior between titanium and niobium to be explained. (Author abstract). 6 refs. In French.

Desgardin, Gilbert (Univ de Caen, Caen, Fr); Aliouat, Mohammed; Mazo, Louis; Raveau, Bernard. *RGE Rev Gen Electr* n 5 May 1988 p 33-37.

**084531 GUIDE TO ATMOSPHERE CONTROL FOR SINTERING.** Metal-atmosphere reactions during sintering may involve oxidizing, reducing and carburizing conditions. This article, based on an outline of information presented by the author at the Sintering Seminar, sponsored by Metal Powder Industries Federation and held in Pittsburgh, in October 1987, concisely explains reactions involved in sintering and the measuring instruments involved in their control.

McGeever, J.O. (Liquid Air Corp, Countryside, IL, USA). *Ind Heat* v 55 n 10 Oct 1988 p 36-37.

**Solidification** See Also ALUMINUM AND ALLOYS —Wear Resisting; POWDER METAL PRODUCTS—Processing.

**084532 COST MODELING RS POWDERS PRODUCED BY THE GAS ATOMIZATION.** Major factors affecting the cost of rapidly solidified powders produced by inert gas atomization have been identified by economic modeling. Case studies are presented for atomized aluminum and nickel-base alloy products. Input factors (e.g., materials, capital, labor, energy) and process costs (e.g., melting, atomization, collection, classification, handling, packaging) are compared for the two alloy systems. Raw materials constitute a major portion of the direct costs, and economy of scale can be achieved in both systems. The results are applied to aluminum and nickel powder. (Author abstract). 14 Refs.

Jacob, Jeffrey E. (Univ of Arizona, Tucson, AZ, USA); Schoenung, Julie M.; Laverna, Enrique J.; Clark, Joel P.; Grant, Nicholas J. *Int J Powder Metall* (Princeton NJ)

v 24 n 3 Jul 1988 p 233-238.

**Stainless Steel** See Also HEAT TRANSFER—Porous Materials; POWDER METAL PRODUCTS—Injection Molding; POWDER METAL PRODUCTS—Machining; POWDER METAL PRODUCTS—Solidification.

**084533 STRUCTURAL FEATURES AND THE MECHANISM OF WEAR OF DETONATION COATINGS OF TUNGSTEN-FREE COMPOSITE POWDERS.** Selection of the components in detonation coating causing minimization of triboactivation must take into consideration the combination of the properties of the materials and medium causing the stable appearance of structural adaptability during friction. Powders of type PKh20N80 Nichrome and type PKh23N15 austenitic stainless steel were used as the original material of the tungsten-free composite coatings. The tribotechnical characteristics were investigated for the purpose of obtaining equivalent replacements of tungsten-containing hard alloys. The antifriction properties of the sprayed coatings were provided as the result of the change in chemical composition of the original powder materials by additional alloying by diffusion with boron and aluminum. 5 refs.

Nosovskii, I.G. (Kiev Higher Military Aviation Engineering Sch, USSR); Shchepetov, V.V.; Kadyrov, V.Kh. *Sov Powder Metall Met Ceram* v 26 n 3 Mar 1987 p 265-269.

**084534 AISI STAINLESS STEEL PIPES PRODUCED BY POWDER EXTRUSION.** A new process has been developed for the production of stainless steel pipes by powder extrusion and sintering. Authors investigation was variously aimed at the industrial production of PM pipe which is free from any restriction of length by the extrusion method. Various properties of PM pipe by this new method were confirmed in comparison with those by the ordinary press-compaction from a viewpoint of filter uses. 3 refs.

Hisada, T. (Daido Steel Co, Nagoya, Jpn); Kusaka, K.; Hayashi, K. *Met Powder Rep* v 42 n 9 Sep 1987 p 588-590.

**084535 SURFACE REACTIONS DURING ATOMIZATION AND CONSOLIDATION OF STAINLESS STEEL POWDER.** Mechanical properties of P/M-produced metals are influenced by the reaction products which form on the surface of the metal powder during the P/M process. To improve the understanding of the surface reactions, chemical characterization of the powder surfaces and interfaces of P/M ferritic and martensitic stainless steels has been carried out. During gas atomization of the steels, 10-15 nm thick particles of Mn- and Cr-oxides form on the powder surface at high temperatures. A 3 nm thick layer of Fe-oxide is formed at lower temperatures during cooling and handling of the powder. In the case of ferritic steel, 50 nm thick particles of Cr-carbonitride are also formed. Unlike gas atomization, atomization using the Rotating Electrode Process (REP) results in significant formation of Si-oxide on the powder surface. Si-oxide appears as a 2 nm thick layer and covers about 60% of the surface. The remainder of the surface is covered by Cr-oxide particles (6 nm) and a 3 nm thick Fe-oxide. The overall rate of oxidation at high temperatures is determined by the transfer of oxygen gas to the metal particle surface. The oxidation of the alloying elements is controlled by their availabilities and oxygen affinities. The reactions which take place on the prior particle boundaries (PPBs) during Hot Isostatic Pressing (HIPing) of martensitic stainless steel are strongly influenced by temperature. (Edited author abstract) 50 refs.

Nyborg, Lars (Chalmers Univ of Technology, Goteborg, Sweden). *Chalmers Tek Högsk Doktorsavh* 629 1987 45p.

**084536 ADVANCED PM TECHNOLOGY FROM ASEA POWDERMET.** Asea Powdermet, Surahammar, Sweden, has developed new technology for the industrial-scale production of stainless and heat-resistant steels as well as certain superalloys. The process is based on



powder metallurgy and hot isostatic pressing. The review describes the development of new PM materials for engineering applications. (Edited author abstract)

Bathheim, Bjorn. *Met Powder Rep* v 42 n 11 Nov 1987 p 763, 765-767.

**084537 METHOD OF MEASUREMENT OF THE LOCAL PERMEABILITY OF POROUS POWDER MATERIALS WITH THE USE OF A HOT-WIRE ANEMOMETER.** Investigations of porous powder materials in the form of 5 mm thick sheets produced by pressing Kh18N15 stainless steel powder with a particle size of  $-0.315+0.2$  mm in a metal mold and sintering were made in the unit developed. The results are presented in the form of a histogram of the distribution of local flows. The proposed method of measurement may be used not only in research work but also in production inspection since the method is simple, possesses sufficient accuracy, is easily automated, and makes it possible to inspect finished parts of different forms. 13 refs.

Kaptsievich, V.M. (Belorussian Scientific & Production Unit for Powder Metallurgy, USSR); Sheleg, V.K.; Pilinevich, L.P.; Savich, V.V.; Sorokina, A.N.; Georgiev, V.P. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 567-569.

**084538 MOLD POWDER TECHNOLOGY FOR CONTINUOUS CASTING OF TITANIUM-STABILIZED STAINLESS STEEL.** Skin inclusions, a type of defect that detracts from the surface conditioning yield of continuously cast blooms of titanium-stabilized stainless steel, were presumed to result from high-melting point  $\text{CaTiO}_3$  that is formed when titanium in the molten steel is absorbed by the mold powder. The change in the properties of the mold powder after the absorption of titanium was investigated. When the basicity ( $\text{CaO}/\text{SiO}_2$ ) of the powder is above 1,  $\text{CaTiO}_3$  is formed and the powder increases in viscosity, but when the basicity is below 1,  $\text{CaTiO}_3$  is not formed and the powder decreases in viscosity. (Edited author abstract) 6 refs.

Kishi, Tadao (Nippon Steel Corp, Jpn); Takeuchi, Hidemaro; Yamamiya, Masao; Tsuboi, Harumi; Nakano, Taketo; Ando, Teiichi. *Nippon Steel Tech Rep* n 34 Jul 1987 p 11-20.

**084539 PRODUCTION OF STAINLESS STEEL POWDERS AT PACIFIC METALS.** Pacific Metals Co. Ltd. is one of Japan's largest producers of stainless steels with a capacity of 10,000 t/month at its Hachinohe Works in Aomori, Japan. The company has also added water atomization facilities to produce a range of stainless steel and special alloy powders. The article describes the range of powders produced and the company's pilot plant for metal injection moulding.

Kimura, Akira; Kato, Yoshiyuki. *Met Powder Rep* v 43 n 3 Mar 1988 p 148-150, 153-154.

**084540 ANPAB GEARS UP FOR HIGH QUALITY, HIGH ALLOY POWDER PRODUCTION.** Anval Nyby Powder AB (ANPAB) of Torshalle, Sweden, has established itself as the world's largest producer of gas atomized stainless steel powders which are used predominantly for hot extruded seamless tubes, HIPed products and plasma sprayed coatings. ANPAB, which is now a wholly owned subsidiary of the French company Vallourec SA, recently completed an expansion programme which has increased its annual capacity for gas atomized powders to around 10,000 t. The article outlines the production technology used and the trend towards high quality, inclusion-free powders of fine particle sizes.

Anon. *Met Powder Rep* v 43 n 3 Mar 1988 p 155, 158-159.

**084541 STAINLESS STEEL POWDERS AT SCM METAL PRODUCTS.** SCM Metal Products, Inc. is a major US producer of copper, premixed bronze and high alloy steel powders for the powder metallurgy industry. Since the early 1960's the company has been producing stainless steel powders by water atomization. These powders are characterized by irregular particle shape

which provides sufficient green strength for cold compaction and sintering into net shape structural parts. The article provides a brief description of stainless steel powder production, properties, and applications. The processing requirements for good corrosion resistance are highlighted. 4 refs.

Klar, Erhard (SCM Metal Products Inc, Cleveland, OH, USA). *Met Powder Rep* v 43 n 3 Mar 1988 p 160, 162-163, 165.

**084542 PRODUCTION OF STAINLESS STEEL POWDERS AT BSA.** Recent advances in water atomization techniques have allowed greater flexibility in the control of alloy composition and particle characteristics in the production of various grades of stainless steel powders at BSA Metal Powders Ltd., Birmingham, UK. The selection of refractories and deoxidation techniques is of importance to ensure a clean product free from contaminant particles. The high degree of chemical purity and irregular particle shape helps provide the compressibility and high green strength properties essential to the manufacture of stainless steel PM products. The article briefly describes production and quality control. A formula may be used for predicting the average particle size of a given powder such as 316L stainless steel. 1 ref.

Anon. *Met Powder Rep* v 43 n 3 Mar 1988 p 166, 168.

**084543 STAINLESS STEEL PM PARTS: A GROWING BUSINESS AT RIGBY METAL COMPONENTS.** Rigby Metal Components Ltd is a UK producer of powder metallurgy components for a diverse range of industries. Although the majority of these parts are manufactured from iron-based alloys, components made from 316L sintered austenitic stainless steel now constitute a growing proportion of the company's production. The article reports on new developments at the company, particularly its approach to automation and statistical process control.

Weaver, Amanda (Metal Powder Report, Elmont, NY, USA). *Met Powder Rep* v 43 n 3 Mar 1988 p 170, 172-173, 175.

**084544 SUBMICRON DEFECTS IN RAPIDLY SOLIDIFIED TYPE 304 STAINLESS STEEL POWDERS CONTAINING NOBLE GASES.** The purpose of this work is to examine the defect microstructure of 304 SS powders processed by different atomization methods. The powders examined were processed by centrifugal atomization (CA) and vacuum gas atomization (VGA). In the CA process the molten droplets exiting from the spinning cup were convectively cooled with flowing helium. The VGA process involves pressurizing and mechanical mixing of the melt with argon. The entrapped argon in the melt as well as the carrier argon associated with the melt stream produces the molten droplets. Optical microscopy was performed on screened particle sizes to resolve the morphological features such as porosity and solidification microstructure. 18 refs.

Bae, Jung Chan (Univ of Wisconsin-Madison, Madison, WI, USA); Kelly, Thomas F.; Flinn, John E.; Wright, Richard N. *Scr Metall* v 22 n 5 May 1988 p 691-696.

**084545 INFLUENCE OF POWDER SURFACE OXIDATION ON SOME PROPERTIES OF A HIPED MARTENSITIC CHROMIUM STEEL.** A martensitic chromium steel, SS 2317 (12% Cr, 1% Mo, 0.6% Ni, 0.03% V, 0.24 C by weight) was nitrogen atomized and the powder oxidized by controlled heating in air to three oxygen concentrations: 150, 200 and 250 ppm. The powders were consolidated by hot isostatic pressing. The tensile properties and impact strength were investigated and compared with the properties of a reference material produced from unoxidized powder with an oxygen concentration of 100 ppm. The yield strength and tensile strength do not change significantly with surface oxidation but ductility, and particularly the impact properties are significantly affected, even at the lowest oxidation level of 150 ppm. (Author abstract) 6 refs.

Arnberg, Lars (Swedish Inst for Metals Research, Stockholm, Swed); Karlsson, Anita. *Int J Powder Metall*

(Princeton NJ) v 24 n 2 Apr 1988 p 107-112.

**084546 EFFECT OF COPPER AND BRONZE ADDITION ON THE SINTERED PROPERTIES OF 316L AUSTENITIC STAINLESS STEEL AND ITS COMPOSITES CONTAINING 4 VOL.%  $\text{Y}_2\text{O}_3$ .** Copper and bronze additions up to 3 mass% were made to 316L austenitic stainless steel and to mixtures of the steel and 4 vol.%  $\text{Y}_2\text{O}_3$ . Green compacts were subsequently sintered at 1300°C for one hour in dry hydrogen ( $-32^\circ\text{C}$ ). Linear shrinkage, radial shrinkage, densification parameter, sintered density and sintered porosity were measured. Corrosion resistance against  $\text{H}_2\text{SO}_4$  and mechanical properties were also evaluated. Improvements in the corrosion resistance were observed due to the addition of either copper or bronze. Bronze addition showed a comparatively better improvement. Optimum tensile strength and elongation were observed when 1 mass% copper or bronze were added to either straight SS or its 4 vol.%  $\text{Y}_2\text{O}_3$  containing composites. Hardness values are also higher for bronze additions. (Edited author abstract) 12 refs.

Lal, S. (Indian Inst of Technology, Kanpur, India); Upadhyaya, G.S. *Powder Metall Int* v 20 n 3 May 1988 p 35-38.

**084547 STUDY OF THIN-WALL POROUS TUBES PRODUCED BY COLD ROLLING OF STAINLESS STEEL POWDER.** The present paper studies processes for producing porous stainless steel tubes by rolling stainless steel powder, followed by sintering, winding, welding, etc. The gas-atomized stainless-steel shots having a particle size over 5 mm were crushed into powders of  $-100+250$  mesh by an Eddy rotary mill. The thickness of the stainless steel tube was 0.8-1.2 mm. The average diameter of the pores of porous stainless steel tubes was 6 to 15  $\mu\text{m}$ . The relative permeability of the porous stainless steel tube for nitrogen was (3 approx.  $7$ )  $\times 10^{-3} \text{ L} \cdot \text{N}/\text{cm}^2 \cdot \text{min} \cdot \text{mmHg}$ . (Edited author abstract) In Chinese. 5 refs.

Guo Dong (Central Steel & Iron Research Inst, China); Li, Dequan; Wang, Enke. *Fenmo Yejin Jishu* v 6 n 1 Feb 1988 p 32-36.

**084548 CORROSION BEHAVIOUR OF SINTERED AUSTENITIC STAINLESS STEEL FILTERS IN SULPHURIC ACID SOLUTIONS.** The corrosion behaviour of porous sintered 316L stainless steel in sulphuric acid media has been compared to that of a wrought material. Potentiodynamic polarisation studies and the variation of open circuit electrode potential with time have been used to evaluate the corrosion behaviour. The effect of porosity on corrosion has been examined. Compared to wrought material, the limiting current in the cathodic region is lower for sintered steels and the critical current in the anodic region is higher. The open circuit electrode potential of the sintered samples decreased continuously from 0 to -280 mV(SCE) after 40 h of exposure, then remained constant; for the wrought material, it increased from 0 to +150 mV(SCE), becoming steady after 25 h. SEM observations and XPS studies on the surface film revealed penetration of sulphuric acid into the specimen during corrosion. The overall trend in corrosion behaviour remained the same with changing electrolyte concentration. It is suggested that the inferior corrosion resistance of sintered samples is due to the formation of hydrogen ion concentration cells following entrapment of electrolyte in the pores. (Edited author abstract) 27 refs.

Raghu, T. (Naval Chemical & Metallurgical Lab, Bombay, India); Malhotra, S.N.; Ramakrishnan, P. *Br Corros J* v 23 n 2 1988 p 109-116.

**084549 INFLUENCE OF SLAG PARTICLES ON THE MECHANICAL PROPERTIES AND CORROSION RESISTANCE OF A P/M AUSTENITIC STAINLESS STEEL.** A series of type 316 L stainless steels have been produced by hot extrusion of nitrogen atomized powders. High concentrations of non-metallic



inclusions have been introduced by atomizing a melt with a high sulfur content, by controlled powder surface oxidation or by mixing the powder with slag particles prior to extrusion. The slag levels influence both the impact strength and the tensile properties. The fatigue strength decreases with additions of large (500 µm) exogenous particles. The pitting corrosion resistance is also affected by additions of large exogenous slags and the corrosion resistance measured by the Huey test decreases when some of the slags are present. (Edited author abstract). 11 refs.

Arnberg, Lars (Swedish Inst for Metals Research, Stockholm, Sweden); Karlsson, Anita; Brandrup-Wognsen, Helene. *Int J Powder Metall (Princeton NJ)* v 24 n 3 Jul 1988 7p.

**084550 RECENT RESEARCH INTO THE USE OF TIN IN FERROUS AND NON-FERROUS POWDER METALLURGY.** This paper describes the sintering and aging properties of binary alloys in the composition range Cu/10-40%Sn and the ternary alloys Cu/1-20%Sn/1-20%Ni. The benefits of using prealloyed powder and temperature-programmed sintering regimes have been demonstrated. Aging of the ternary alloys by spinodal decomposition, which is a valuable property in the wrought materials, was observed in the powder metal samples. The use of tin in ferrous powder metallurgy has been more restricted but the advantages of making tin additions to stainless steel powders have now been clearly demonstrated. This paper summarizes the benefits to corrosion resistance of adding 1-2%Sn to AISI 304L stainless steel powder and indicates the probable mechanism. (Edited author abstract) 9 refs.

Warwick, M.E. (Int Tin Research Inst); Chatterjee, S.K. *ATB Metall* v 27 n 2-3 1987, Powder Metall, Brussels, Belg, May 13-14 1987 p 89-93.

**Steel** See Also CUTTING TOOLS—Materials; GRAPHITE—Grinding; IRON POWDER—Production; POWDER METAL PRODUCTS—Wear; ROLLING MILL PRACTICE—Powder Metals; STEEL—Continuous Casting; STEEL—Protective Coatings; STEEL HEAT TREATMENT—Nitriding; TOOL STEEL—Grinding; TOOL STEEL—Mechanical Properties; TOOL STEEL—Production; TOOL STEEL—Solidification.

**084551 EFFECT OF METHOD OF MANUFACTURING OF HIGH-SPEED STEEL POWDERS ON THEIR COOLING RATE (REVIEW).** Investigations have shown that high rates of cooling of materials may lead, depending on their nature, to qualitative changes in the structural state of melts, such as substantial decrease in grain size, the formation of new metastable phases, and also the preservation of an amorphous state, which in turn can improve the properties of existing alloys and enable new materials to be created that cannot be produced by orthodox techniques. The effects are particularly pronounced when cooling is performed at ultrahigh rates. The results of a study of MI high-speed steel produced at cooling rates of  $10^6$  deg C/sec and higher are reported. On the basis of x-ray structural and electron microscopical examinations it is concluded that at ultrahigh cooling rates austenite formation is impeded, and a  $\delta$ -ferrite structure is preserved in the solidified state down to room temperature. Investigations of the carbide inclusions and structure in such materials have shown that a common property of high-speed steels produced at ultrahigh cooling rates is their greater solid-state homogeneity, due to inhibited formation and growth of second-phase particles during rapid solidification. 36 refs.

Kulak, L.D. (Acad of Sciences of the Ukrainian SSR, USSR); Pikozy, A.P.; Dorogoi, A.A. *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 277-281.

**084552 NEW ERA FOR IRON & STEEL POWDERS AT QUEBEC METAL POWDERS LIMITED.** For many years, Quebec Metal Powders has been North America's second largest producer of ferrous powders. With the advent of clean, high-purity steel from a new steel mill, QMP is entering the market for high-performance steel powders with the completion of a 37,000 metric ton/year expansion. Concurrently, QMP's tradi-

tional iron powder manufacturing operations are being updated with the introduction of statistical process control. (Edited author abstract) 4 refs.

Capus, Joseph M. (Quebec Metal Powders Ltd, Sorel, Que, Can). *Int J Powder Metall (Princeton NJ)* v 23 n 1 Jan 1987 p 61-66.

**084553 SPC IN STEEL POWER MANUFACTURING.** Experiences gained in implementing statistical process control (SPC) in the Hoeganaes manufacturing operations for the production of water atomized powder and sponge iron are described. The impact of implementing SPC is illustrated by reference to the production of water-atomized low alloy steel powder. The process control program was designed to minimize inclusion content in powder forging grade materials. Process characterization, sampling, and the control charts appropriate to powder production are discussed. (Edited author abstract)

Gummeson, P. Ulf (Hoeganaes, Riverton, NJ, USA); Kasputis, David J. *Int J Powder Metall (Princeton NJ)* v 23 n 4 Oct 1987 p 261-266.

**084554 EFFECTS OF CARBON, COBALT, AND POWDER ANNEALING ON SINTERING CHARACTERISTICS OF BM2 TYPE HIGH SPEED STEEL.** Formation of grain boundary film and excessive grain growth restrict the upper useful sintering temperature for BM2 grade of high speed steel. Since cobalt bearing grades of steel, e.g. BM35, BM42, appear to have superior sintering characteristics, densification of cobalt enriched BM2 grades of HSS has been carried out - by vacuum sintering of cold compacted water atomized annealed powder. Cobalt additions of 2, 4, and 8%, however, did not lower the sintering temperature. A small decrease observed in the BM2 + 4% cobalt alloy, to 1245-1260°C from 1250-1260°C for the other compositions, was interpreted as a slight carbon enrichment of the particular powder batch, since the addition of elemental carbon was found to lower the sintering temperature. The effect of powder annealing conditions on the sintering behaviour was also studied. Vacuum annealing at 950°C was superior to hydrogen annealing at the same temperature which in turn showed better sintering response than hydrogen annealing at 900°C. In the sintered alloys the primary carbides were  $M_6C$  and  $MC$ . Additionally,  $M_3C$  type carbide was observed in BM2 + 8% Co and in the carbon enriched alloys. (Author abstract) 14 refs.

Maulik, P. (Univ of Bradford, Engl); Price, W.J.C. *Powder Metall* v 30 n 3 1987 p 165-174.

**084555 DYNAMIC PROPERTIES OF SINTERED STEEL.** Two sintered steels of identical composition (1.75 Ni-0.5 Mo-0.5C) were studied: one, with a coarse, pearlitic microstructure, produced from chemically homogeneous (water atomized) powder, and one, with a microstructure of ferrite, pearlite, and martensite, produced from chemically inhomogeneous (diffusion alloyed) powder. Four densities ranging from 6.6 Mg m<sup>-3</sup> to full density were included. The mechanical properties were investigated by tensile testing (monotonic and cyclic), impact testing, fatigue crack propagation, and fracture toughness testing. The results of the different testing modes are in qualitative agreement with the character of the corresponding fracture surfaces. It was found that the chemically homogeneous alloy has in general slightly better mechanical properties. (Author abstract) 26 refs.

Bertilsson, I. (Chalmers Univ of Technology, Goteborg, Sweden); Karlsson, B. *Powder Metall* v 30 n 3 1987 p 183-188.

**084556 BATTELLE PLAN COMMERCIALIZATION OF TWO-STAGE SPINNING CUP ATOMISATION PROCESS.** Battelle's Columbus Division in Columbus, Ohio, has developed a new two-stage rapid spinning cup (RSC) atomisation process which is expected to fulfill market requirements for fine metal powders used in a variety of applications. The capabilities of the RSC process, as demonstrated in Battelle's laboratory unit, are described in this article. This article briefly describes the

basic spinning cup atomisation process and its latest two-stage version. Some experimental results demonstrating the ability to produce fine powders and to control particle shape, size and size distribution are presented. An example of the level of impurity pick up in fine powder associated with the process is provided and the status of plans to develop the process to pilot- and eventually commercial-scale capacity is discussed. 3 refs.

Erich, Donald L.; Patel, Aspi N. *Met Powder Rep* v 42 n 10 Oct 1987 p 698-700.

**084557 FATIGUE PROPERTIES OF P/M HIGH STRENGTH SINTERED STEEL.** The fatigue characteristics of sintered materials have been investigated by determining the S-N curve, the fatigue crack propagation rate da/dN and fatigue threshold  $\Delta K_{th}$  of N-110 sintered steel by rotating bending fatigue testing machine. The explanation of the influence of porosity on various fatigue properties and the relations between heat treatment and fatigue properties have been discussed. (Author abstract) 4 refs. In Chinese.

Liu, Jianxin (Xian Communications Univ, China); Wu, Rongwei. *Fenmo Yejin Jishu* v 5 n 2 May 1987 p 73-77.

**084558 GAS ATOMISED POWDERS ARE RAW MATERIAL FOR EXTRUDED BARS AND TUBES.** Within the Swedish Avesta Group is a leading manufacturer of steel powders and components. Avesta Nyby specializes in the production of extruded and HIP bar and tube. The powder production unit consists of two 6t induction furnaces and a vertical tower with recirculation of the gas. The unit has a maximum production capacity of 10,000t/year of powder. Avesta Nyby powders have a spherical shape which gives excellent free flowing properties, which is important in all thermal spraying and surfacing techniques. A further use for gas atomized superfine stainless steel powders is for the injection molding process, where the product offers a higher density feedstock and less shrinkage than water atomized or blended powders. 1 ref.

Anon. *Steel Times* v 215 n 10 Oct 1987 p 512.

**084559 POWDREX HIGH SPEED STEEL BILLET PROCESS.** A new process for the production of powder metallurgical quality high speed steel bar and billet has been developed. The quality aspects depend partly on the ability of the process to produce a sintered ingot which is less than fully dense but which is sufficiently strong to withstand the stresses of forging. Material has been produced in different compositions and forged by a variety of methods and an understanding has been gained of the optimum ingot quality and forging method. (Author abstract) 3 refs.

Brewin, P.R. (Powdrex Ltd, Tonbridge, Engl); Nurthen, P.D.; Toloui, B. *Steel Times* v 215 n 10 Oct 1987 p 520-521.

**084560 HEAT TREATMENT OF POWDER METALLURGY CONSTRUCTIONAL STEEL (REVIEW).** This review of powder metallurgy steels covers the period 1960 to date. Some general conclusions are drawn. While following the general rules, the transformations in heating and cooling of a sintered steel have their own specific features caused by the presence of porosity, structural inhomogeneity, and inhomogeneity of the solid solution. The porosity and increased microdefect content have an influence on the position of the critical points, the austenitization process, and the transformations of supercooled austenite. The inhomogeneity of the solid solution formed in sintering alloy cement steels also changes the position of the critical points therefore in selection of the heat treat cycles, it is necessary to determine the critical points in each individual case. 50 refs.

Moskvina, T.P. (I.P. Bardin Central Scientific-Research Inst for Ferrous Metallurgy, USSR); Sidorova, O.D. *Met Sci Heat Treat* v 29 n 3-4 Mar-Apr 1987 p 270-282.



**084561 FRACTURE TOUGHNESS OF AN EXTRUDED POWDER BEARING STEEL.** Powder steels with low porosity (less than 2%) may already be regarded as dense so that their fracture toughness can be evaluated using the same methods as in the conventional materials. The aim of this work was to examine the relationship between fracture toughness, fractographic characteristics, and the austenitizing conditions of a powder steel produced by extrusion with special reference to using this steel for bearings. 10 refs.

Sinka, Viliam (VST Univ, Kosice, Czech); Veles, Pavol; Sladik, Stefan. *Met Mater (Cambridge Engl)* v 25 n 3 May-Jun 1987 p 130-134.

**084562 TECHNOLOGICAL EXPERTISE EXTENDED IN HIGH ALLOY STEEL POWDER METALLURGY.** The production of high-speed steel by a powder metallurgical route developed by Powdrex Ltd. is shown to result in reduced manufacturing costs, uniform grain characteristics, excellent performance, and an ability to cope exactly with the most complicated shapes. Powdrex sintering technology has been applied, for example, to the production of rocker arm tips, push rod tips and cam rings, oil pump rotor vanes.

Anon. *Metallurgia* v 54 n 11 Nov 1987 p S10.

**084563 INFLUENCE OF SURFACE ROLL STRENGTHENING ON FATIGUE STRENGTH OF P/M SINTERED STEEL.** The process is an efficient way to improve the fatigue strength by surface strengthening. The paper describes the results of fatigue experiments on N-110 high strength sintered steel strengthened by surface roll strengthening. The fatigue strength was improved. (Edited author abstract) In Chinese. 4 refs.

Wu Rongwei (Beijing Research Inst of Powder Metallurgy, China); Liu Jianxin. *Fenmo Yejin Jishu* v 5 n 4 Nov 1987 p 207-209.

**084564 COMPARISON BETWEEN HOT ISOSTATIC PRESSING AND ROTARY FORGING FOR TOOL STEEL PRODUCTION.** Several properties of PM cold work tool steel D7 have been determined as a function of different hot consolidation methods. Gas atomized powder was processed by HIP and/or forging and investigated. Toughness, tensile strength, density and microstructure were examined. For certain dimensions there was no influence due to the method of consolidation. A hot forming operation after HIP or rotary forging further improved the mechanical properties of the PM material.

Stamberger, J.; Hribernik, B.; Jaeger, H. *Steel Times* v 215 n 11 Nov 1987 p 575.

**084565 HEAT TREATMENT OF HOT-WORKED P/M MEDIUM-MANGANESE STEELS.** The properties of P/M constructional materials produced under optimum processing conditions can in general be improved by reducing their porosity and at the same time ensuring that the distribution, shape, and size of the remaining pores are the least harmful. Suitable alloying and heat treatment is also necessary. In this connection, work was undertaken with the aim of improving the properties of hot-worked P/M medium-manganese steels by quenching directly after high temperature thermomechanical processing and by additional heat treatment. The hot working was performed by hot compression in a closed die and by hot extrusion. 4 refs.

Ananyan, K.E. (Novocherkassk Polytechnic Inst, USSR); Dorofeev, V.Yu.; Chumakov, V.I. *Sov Powder Metall Met Ceram* v 26 n 5 May 1987 p 372-375.

**084566 EFFECT OF POROSITY ON THE RELIABILITY OF MAGNETIC QUALITY CONTROL OF THE HEAT TREATMENT OF SINTERED STEELS.** Measurements were carried out on specimens of sintered steel 30NM. Variations in porosity cause large changes of hardness and imperceptible changes of the coercive force after hardening and tempering. That impairs the reliability of magnetic hardness control of heat treated products. To improve the quality of finished products, it is advisable to

use articles with known porosity for heat treatment. The porosity of products after sintering can be determined from the measurement of saturation magnetization and coercive force. 5 refs.

Ul'yanov, A.I. (Acad of Sciences of the USSR, USSR); Korobeinikova, V.S.; Sterkhov, G.V.; Sidorov, N.A. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 553-556.

**084567 SPECIAL FEATURES OF FAILURE OF R6M5 AND 10R6M5-MP HIGH-SPEED TOOL STEELS IN SUPERPLASTIC DEFORMATION.** The aim of this work was to examine the special features of failure of multiphase materials both in the SPD conditions and at different temperature-rate conditions of deformation. The investigations were conducted on R6M5 tungsten-molybdenum high speed tool steel with carbide hardening. For comparison, 10R6M5-MP high speed tool steel was examined. Deformation of both steels in the optimum temperature-rate conditions makes it possible to achieve high strains without the risk of failure even in the presence of an unfavorable (hard) stress state with mainly tensile stresses which open the pores. 13 refs.

Chernyshova, T.A. (Tula Polytechnic Inst, USSR); Gvozdev, A.E.; Bazyk, A.S. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 576-580.

**084568 EFFECT OF CARBON ADDITIONS ON SINTERING CHARACTERISTICS AND MICROSTRUCTURE OF BT42 HIGH SPEED STEEL.** The isochronal vacuum sintering behavior of BT42 after cold compaction of annealed water atomized powder is reported. Densities on the order of 99% theoretical were achieved. For the as-received powder the sintering temperature range was 1245-1260°C. The effect of adding nominal 0.01% elemental carbon was negligible. For 0.1% carbon densification commenced at a lower temperature and the sintering range was reduced to 1230-1250°C. The addition of carbon had no deleterious effect on the microstructure. The primary carbides present in the microstructure (compositions, excluding carbon, in weight percent) were 9% $M_6C$  (4Co-4Cr-28Fe-14Mo-3V-47W), 13% $MC$  (1Co-4Cr-4Fe-15Mo-41V-35W), and  $M_3C$  (cementite). When the specimens were oversintered by 20 K, grain boundary eutectic carbides (4Co-14Cr-40Fe-20Mo-6V-16W) were also detected. (Edited author abstract) 35 refs.

Maulik, P. (Univ of Bradford, Engl); Price, W.J.C. *Powder Metall* v 30 n 4 1987 p 240-248.

**084569 CYCLIC DEFORMATION BEHAVIOUR AND LOW CYCLE FATIGUE OF SINTERED STEEL.** Two P/M steels with the compositions 1.75Ni, 0.5Mo, 0.5C and 0.8P, 0.3C have been investigated. The Ni-Mo steels were produced in two different ways: by a diffusion-alloying technique leading to a chemically and microstructurally inhomogeneous material and by atomizing producing a homogeneous state. The P-steel was produced from a powder mixture. The cyclic deformation behavior as well as the low cycle fatigue properties were determined from uniaxial cyclic testing in strain-control. The Ni-Mo steels cyclically soften at low strains and harden at higher strains, while the P-steel hardens at all but the smallest plastic strains. A decreasing porosity generally improves the low cycle fatigue properties. The microstructural influence on these properties decreases at increasing porosity. At higher strain amplitudes the inhomogeneous Ni-Mo steel exhibits the largest and the P-steel the lowest fatigue life. Toward the endurance limit the materials behave in the reverse order. (Edited author abstract) 13 refs.

Bertilsson, I. (Volvo Flygmotor AB, Trollhattan, Swed); Karlsson, B. *Powder Metall Int* v 20 n 1 Feb 1988 p 13-18.

**084570 FATIGUE PROPERTIES OF P/M HIGH SPEED STEELS.** On cylindrical samples of hot forged, heat treated, quenched and tempered P/M ASP 30 and cast M2 high speed steels fatigue testing experiments were performed. Fatigue life was much lower in M2 than in ASP 30, due to finer and more homogeneous microstruc-

ture of ASP 30. Specimens with polished surfaces had a much longer fatigue life than samples with ground surfaces, indicating fracture to initiate at the surface of the specimen. (Author abstract) 5 refs.

Brandrup-Wognsen, H. (Swedish Inst for Metals Research, Swed); Engstrom, J.; Grinder, O. *Powder Metall Int* v 20 n 1 Feb 1988 p 18-20.

**084571 SEPARATE DETERMINATION OF  $M_6C$  AND  $MC$  IN POWDER HIGH-SPEED STEELS.** To determine  $M_6C$  and  $MC$  in high speed steels separately, an etching quantitative phase analysis method without a standard sample has been developed. Coexistent phases  $M_{23}C_6$  and  $M_7C_3$  do not interfere with the determination. Fast phase identification of  $M_6C$ ,  $MC$  and  $M_{23}C_6$  in the high speed steels can also be carried out by this method. (Author abstract) In Chinese.

Ma, Xiang (Central Iron & Steel Research Inst, Beijing, China); Luo, Sujuan; Zhao, Han. *Chin Shu Hsueh Pao* v 23 n 6 Dec 1987 p B311-B317.

**084572 DETERMINATION OF THE STRUCTURAL MORPHOLOGY OF EUTECTIC COATINGS FROM TECHNOLOGICAL FACTORS.** Specimens of 45 steel with a powder mixture consisting of gray iron, ferromanganese, a fluxing agent, and an activator applied to their face surface were placed in a furnace previously heated at 1280°C which provided heating at a rate of 10°K/sec (heating time to 1280°C 2 min), and were then cooled at different rates (0.5-150°K/sec). The structure of the coatings obtained was investigated with microscope and the phase composition was determined by x-ray analysis. The formation of coatings with hypoeutectic and eutectic structures on carbon and alloy steels is possible with a change in composition and thickness of the powder mixture, the temperature-time conditions of the process, and the cooling rate of coatings with a hypereutectic structure only with a change in the concentration of the components of the mixture. 9 refs.

Golubets, V.M. (Acad of Sciences of the Ukrainian SSR, Lvov, USSR); Pashechko, M.I. *Met Sci Heat Treat* v 29 n 7-8 July-Aug 1987 p 541-546.

**084573 HIP, HIP, HOORAY - FOR A SWEDISH FIRST.** With the world's largest hot isostatic pressing (HIPping) facility at its disposal, ASEA Powdermet in Sweden is claiming to have pushed powder metallurgy into new fields - for the alloys that can be made and the types of components produced. As far as alloying is concerned, ASEA Powdermet claims that HIPping opens the way for new families of materials, based on combining powders or combining powder with a conventionally-manufactured alloy. By these means it is possible to produce a component having layers of materials with different properties - a composite/compound.

Astrop, Arthur. *Mach Prod Eng* v 146 n 3729 Jan 1988 p 21.

**084574 EFFECT OF METHOD OF PROCESSING ON THE PHYSICO-CHEMICAL AND TECHNOLOGICAL PROPERTIES OF POWDER FROM SkKh15 STEEL SWARF.** In the course of investigations into mechanical comminution as a means of producing powder from SkKh15 steel swarf the problem arose of defining the boundaries of the ranges of physicochemical characteristics of powder particles ensuring that such powder possesses the necessary processing properties for its use in industry. A study was made of morphological characteristics and the effect of hardness and particle size analysis of the powder. Analysis of histograms reveals that, although each fraction contained a certain amount of elongated particles, the bulk of the particles were characterized by form factors of 0.74-0.82. With such a particle shape, satisfactory compactibility and flowability can be achieved. Lowering the carbon content of the powder improved its compressibility. At a carbon content of less than 0.2%, a level of compressibility was reached comparable with that of iron powders produced by the reduction



and atomization methods. In industrial production, annealing should be performed under carburizing conditions. 3 refs.

Kislov, V.G. (Scientific-Research Inst of Tractor & Agricultural Machine Construction, USSR); Stepnov, S.A.; Arabi, B.G.; Esikman, V.L. *Sov Powder Metall Met Ceram* v 26 n 8 Aug 1987 p 608-611.

**084575 SPECIAL FEATURES OF THE PRODUCTION OF LOW-ALLOY POWDER STEEL FOR STRUCTURAL AND ANTIFRICTION PURPOSES.** The objective of the work was optimization of the technological parameters of producing rollers from powder charge  $ZhGrO$ , 8D2N1 by a single compacting-sintering with subsequent hardening and tempering such that the rollers have the required structural strength and wear resistance. Another was study of the structure formation and properties. The material was a mixture with weight content of 0.8% graphite, 2% copper, 1% nickel, the remainder iron. The weight content of zinc stearate in the charge was varied in the range 0-1.5%. The use of a minimal amount of plasticizer (not more than 0.5%) in the compacted charge and molds with additional drainage made it possible with a single compaction and sintering to obtain highly dense powder products -  $(7.2-7.3) \cdot 10^3$  kg/m<sup>3</sup> - with a compacting pressure of 1000 MPa. Sintering for 3.6 ksec is accompanied by decompaction in consequence of degassing. Extending the sintering time to 10.8 ksec reduces the porosity and improves the mechanical properties. 6 refs.

Dorofeev, Yu. G. (Novocherkassk Polytechnic Inst, USSR); Geidarov, V.A.; Mamedov, A.T. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 725-728.

**084576 SOME SPECIAL FEATURES OF THE TEMPERING OF POWDER STEELS.** The investigations were carried out on steels ZhGr1.3 and ZhGr1G1 which were annealed, compacted and sintered. The results show the dependences of hardness, tensile strength, and impact toughness on tempering temperature. More homogeneous steel has greater hardness both after hardening and after tempering in all regimes. The speed of martensite disintegration increases with increasing porosity. 6 refs.

Antsiferov, V.N. (Perm Polytechnic Inst, USSR); Grevnov, L.M. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 729-732.

**084577 SINTERING MECHANISMS IN VACUUM SINTERED M2 AND T15 HIGH SPEED STEEL POWDERS.** Significant differences are observed in the sintering response of high speed steel water-atomized powders between molybdenum (M) and tungsten (T) grades. This paper reports the results of a study of phase distributions in M2 and T15 grades during sintering with and without the presence of a liquid phase. Data from differential thermal analysis, optical and scanning electron microscopy (using EDS) are presented to illustrate the mechanisms operating for a variety of temperatures and times around the empirically-derived optimum conditions. The presence of a small volume fraction of liquid is necessary to achieve high densities. It is observed by hot stage scanning electron microscopy that small diameter powders are the first to melt because of their higher dissolved carbon content and high relative surface energy. 12 refs.

Bee, J.V. (Univ of Adelaide, Aust); Brewin, P.R.; Nurthen, P.D.; Wood, J.V. *Met Powder Rep* v 43 n 3 Mar 1988 p 177-180, 182-184.

**084578 POWDREX TECHNOLOGY FOR PM HIGH ALLOY STEELS.** This article describes the developments made by Powdrex Ltd of Tonbridge, England, in the field of high alloy steel powders. While Powdrex technology was originally developed for the production of tools for metal cutting, it is being extended to a range of hard wearing components. One of the recent developments is the introduction of tool steel powders which can be sintered in conventional mesh belt gas atmosphere furnaces and used to produce hard wearing components for demanding applications. Water atomised

high alloy steel powders have been used in two different consolidation processes: one for the production of near net shape components or 'preforms' and the second for the production of high speed steel sintered billets suitable for forging and rolling into bar or rod.

Brewin, P.R.; Nurthen, P.D.; Toloui, B. *Met Powder Rep* v 43 n 3 Mar 1988 p 186-187.

**084579 MANUFACTURE AND APPLICATIONS OF SINTERED HIGH-SPEED STEEL PREFORMS.** The production of near net shape PM high-speed steel components for wear parts and cutting tool applications is described. Powder particles which are mainly produced by atomization of a melt can be compared to micro ingots. Every segregation that occurs is limited to the size of the powder particles. When compared to conventional HSS, PM high-speed steels are more homogeneous products with improved mechanical properties. The paper also discusses the properties of some PM high speed steel material and provides examples of applications. 5 refs.

Wachling, R. (Sintermetallwerk Krebssoe GmbH, Radevormwald, West Ger); Arnhold, V. *Met Powder Rep* v 43 n 3 Mar 1988 p 188, 190-192.

**084580 NOVEL APPROACH TO PRODUCTION OF PM HIGH-SPEED STEELS WITH DISPERSION OF FINE ALUMINA.** There is a novel development underway at Kalumetals Inc. of Latrobe, Penna involving the production of PM high-speed steels containing a small percentage of dispersed aluminum oxide. Grinding swarf containing alumina particles can be reclaimed and used as a raw material for PM high-speed steels sintered to full theoretical density. The grinding swarf, which is available from finishing wrought high-speed steels, is mainly based on Mo and W-Mo grades such as M1, M2 or M7. Results are also given of bend test and hardness measurements on the alumina-dispersed steels. Bend rupture values for the 0.72, 0.82, and 0.87% carbon alloys are similar with average values in the 260-270 ksi (1800-1850 MPa) range. Hardness ranged from 63.5 Rc for the 0.72% C alloy to 65 Rc for the 0.87% carbon alloy. Results for triple tempered samples are also shown.

Anon. *Met Powder Rep* v 43 n 3 Mar 1988 p 193-194.

**084581 PROCESSING VARIABLES AND CUTTING PROPERTIES OF VACUUM SINTERED M2 AND T15 STEEL TOOLS.** Full density sintered T15 high-speed inserts tested in this research proved to be about three times more resistant to cutting tests than a conventional wrought material. The simultaneous control over carbon additions, sintering temperature and sintering time can produce, after sintering to about 96% of the theoretical density, fine and uniform carbide distributions which are maintained during HIPing to full density. A fine distribution of carbides as obtained by HIPing undersintered T15 to full density appears to be deleterious to the cutting properties of the material yielding higher values of flank wear than the full density sintered tool steel. 4 refs.

Oliveira, M.M. (LNETI, Lisbon, Port); Martins, I.M.; Mesquita, R.M.D.; Marques, M.B.; Carvalhinhos, H. *Met Powder Rep* v 43 n 3 Mar 1988 p 196-197.

**084582 NOVEL ROUTE TO PM HIGH-SPEED STEELS/TOOL STEELS.** The Worl-Tech Metals Corp. of Carnegie, Penna., has commercialised a novel production route capable of producing powder metallurgy high speed steel billets weighing up to 2 tons which are then reduced by hot working and/or hot rolling down to the desired diameter before being cut into appropriate sections for use as tools. The company also has the capability to produce composite billets. Because of the rapid solidification process employed, the PM billets produced have an improved microstructure compared with conventional wrought high speed steel.

Anon. *Met Powder Rep* v 43 n 3 Mar 1988 p 199-200.

**084583 TiC-TOOL STEEL COMPOSITE WITH IMPROVED WEAR AT HIGH TEMPERATURES.** Research work by B.K. Lograsso and R.M. German at the Rensselaer Polytechnic Institute in Troy, New York, has

shown that the properties of ferro-tic materials can be improved at 650°C and higher. A composition based on a mix of elemental powders including 0.85 C, 8.6 Mo, 2 V, 5 Ni, 5 Cr, 0.1 B, 25 vol % TiC and balance iron produced a TiC-tool steel composite which gives good high temperature hardness, corrosion resistance and a compressive strength at 677°C of 848 MPa. The addition of 0.1% B aided the precipitation of carbides - VC, Cr<sub>23</sub>C<sub>6</sub>, Mo<sub>6</sub> C-type. Vanadium, which forms hard and stable carbides, accounts for the improved elevated temperature properties.

Lograsso, B.K. (Rensselaer Polytechnic Inst, Troy, NY, USA); German, R.M. *Met Powder Rep* v 43 n 3 Mar 1988 p 202.

**084584 TRANSFORMATION, DURING TEMPERING, OF ATOMISED POWDERS OF HIGH SPEED STEELS CONTAINING MOLYBDENUM, VANADIUM, AND COBALT.** The authors describe a study of the kinetics of retained decomposition and carbide formation during tempering of atomized Mo-V and Mo-V-Co steel powders in the range 100-750°C. The high speed steel powders were produced by nitrogen atomization of liquid metal. Alloying of 6%Mo steel powders with 8%Co alters the kinetics of austenite transformation and carbide formation during tempering. The various types of carbides precipitated are discussed and their effects on hardness are detailed. (Edited author abstract) 8 refs.

Popandopulo, A.N. (Leningrad Polytechnic Inst, USSR); Efimov, Yu.I. *Steel USSR* v 17 n 6 Jun 1987 p 281-283.

**084585 PM-WARMARBEITSWERKSTOFFE.** [Powder Metallurgy Hot Work Materials]. The article gives information about the powder metallurgy of hot work tool steel. The manufacturing method is hot isostatic pressing. The report reviews recent research and development work. In German.

Seilstorfer, H. (Seilstorfer GmbH, Haag-Winden, West Ger). *Metall* v 42 n 2 Feb 1988 p 146-152.

**084586 SURFACE ANALYSIS OF REP-ATOMIZED MARTENSITIC STEEL POWDER.** Martensitic stainless steel powders (Fe12Cr) were produced utilizing the rotating electrode process (REP). Four different alloys were produced. The sulphur and phosphorus contents were 0.01 mass% and 0.1 mass%. The surface composition of the powders was determined by ESCA (electron spectroscopy for chemical analysis) and AES (auger electron spectroscopy). Prior to the analysis the powders were handled in argon atmosphere. The cooling rate during atomization is  $5 \cdot 10^3$  K/s. SiO<sub>2</sub> and Cr<sub>2</sub>O<sub>3</sub> are formed as particles on the surface at high temperatures during atomization. At lower temperatures a thin continuous film of Fe<sub>2</sub>O<sub>4</sub> is formed. The average oxide thickness of the powders is in the range of 4 nm - 6 nm. With high sulphur content, Cr- and Mn-sulphides form on the surface of the powder. The coverage and the thickness of the sulphides are 8% and 50 nm, respectively. Even at the highest phosphorus level, no surface segregation of phosphorus or formation of phosphorus compounds were observed. (Author abstract) 16 refs.

Nyborg, L. (Chalmers Univ of Technology, Goteborg, Swed); Olefjord, I. *Powder Metall Int* v 20 n 2 Apr 1988 p 11-16.

**084587 SURFACE ANALYSIS OF PM MARTENSITIC STEEL BEFORE AND AFTER CONSOLIDATION: PART 1. SURFACE ANALYSIS OF POWDER.** Surface analysis of Fe12Cr martensitic steel powder was performed using electron spectroscopy for chemical analysis and Auger electron spectroscopy. The composition and thickness of the surface oxides are independent of powder particle size in spite of the difference in cooling rate between large and small metal particles. The liquid metal droplets solidify at or below 1400°C. Most of the oxide is formed during solidification. It is suggested that a mixed oxide (MnCr<sub>2</sub>O<sub>4</sub>) is produced. Above 1400°C no metallic oxide is formed due to the oxidation of carbon to carbon



monoxide. At very high temperatures manganese evaporates. During cooling the manganese gas is condensed and oxidised on the surface. (Edited author abstract) 12 refs.

Nyborg, L. (Chalmers Univ of Technology, Goteborg, Sweden); Olefjord, I. *Powder Metall* v 31 n 1 1988 p 33-39.

**084588 SURFACE ANALYSIS OF PM MARTENSITIC STEEL BEFORE AND AFTER CONSOLIDATION; PART 2. SURFACE ANALYSIS OF COMPACTED MATERIAL.** Martensitic steel powder (Fe12Cr) was consolidated using hot isostatic pressing (hipping) at three combinations of temperature, pressure, and time: 770°C/150 MPa/8 h; 1000°C/50 MPa/2 h; 1150°C/150 MPa/2 h. The two lower hipping temperatures were chosen to obtain fracture along the prior particle boundaries (PPBs). Thereby, it was possible to study the reaction products formed on the PPBs during consolidation using Auger electron spectroscopy. During consolidation at 770°C the manganese and chromium oxides formed on the surface of the powder during atomisation are coarsened. At 770 and 1000°C silicon, vanadium, and nitrogen diffuse to the PPBs and form compounds. After compaction at 1000°C no MnO was detected on the fracture surface, which indicates that MnO is reduced at higher temperatures. Raising the hipping temperature to 1150°C enhances densification, thus no PPB failure is observed. (Author abstract) 5 refs.

Nyborg, L. (Chalmers Univ of Technology, Goteborg, Sweden); Olefjord, I. *Powder Metall* v 31 n 1 1988 p 40-44.

**084589 NIOBIUM-ALLOYED HIGH SPEED STEEL BY POWDER METALLURGY.** A philosophy for the use of strong carbide formers like niobium in high speed steels is described. It follows the concept of independently optimizing the compositions of the matrix (for maximum secondary hardening potential) and the volume fraction of the blocky carbides (for protection against abrasive wear). Atomization and powder metallurgical processing is described. In this way, a steel has been produced whose matrix composition is similar to that of AISI M2, and whose primary carbides are all of NbC type. Its composition is 1.3C, 2W, 3Mo, 1.6V, 3.2Nb (wt%). Because of its high stability, NbC is a much more effective obstacle to grain growth than the normal high speed steel carbides, and this allows substantially higher austenitization temperatures to be used. Despite its leaner composition, the Nb-alloyed steel matches the cutting performance of AISI M2, and its secondary hardening seems to be more persistent at high temperatures. (Edited author abstract) 39 refs.

Karagoz, S. (Yildiz Univ, Istanbul, Turk); Fischmeister, H.F. *Metall Trans A* v 19A n 6 Jun 1988 p 1395-1401.

**084590 DEVELOPMENT OF TOOL STEEL POWDERS FOR SINTERING PRESSED PARTS IN GAS ATMOSPHERES.** A range of powders directed towards smaller PM components in hard wearing applications of all types have been developed by Powdrex Ltd., Kent, England. The powders, based on molybdenum tool steels, bridge the gap between the diffusion alloyed nickel-molybdenum high carbon iron powders, and the 'super grade' powders normally sintered to full density and used for metal cutting. Depending on the grade, compositions are in the following ranges: Mo 1.5/5.0; W 1.5/6.0; V 1.0/3.0; Cr 2.0/4.0; C 0.6/0.9. These alloys contain high carbon to achieve high hardnesses, and compounds including carbides of vanadium, tungsten and molybdenum, which impart exceptional abrasion resistance.

Henry, Richard J. (Powdrex Ltd, Kent, Engl). *Ind Heat* v 55 n 5 May 1988 p 14.

**084591 CARBIDE DECOMPOSITION IN BT42 HIGH SPEED STEEL.** The carbides present in conventional and powder metallurgical BT42 steels are MC and M<sub>6</sub>C. Depending upon the cooling condition, M<sub>3</sub>C and M<sub>23</sub>C<sub>6</sub> may also occur. An intermediate cooling rate of 15°C min<sup>-1</sup> from the sintering temperature of 1250°C produces M<sub>3</sub>C, while prolonged heating at 700°C causes precipitation of M<sub>23</sub>C<sub>6</sub> and dissolution of M<sub>3</sub>C. This communication describes the carbides observed in powder

metallurgical BT42 oversintered by 40°C (resulting in total fusion) and the effect of subsequent heating on the decomposition of the carbide. 4 refs.

Maulik, P. (Univ of Bradford, Bradford, Engl). *Scr Metall* v 22 n 4 Apr 1988 p 441-444.

**084592 STRIP FABRICATION FROM POWDER METAL USING HIP/PEELING TECHNIQUES.** Fabricating an experimental 13% chromium, 2% aluminum alloy steel into strip first requires compacting gas atomized metal powder into a ring by hot isostatic pressing. Thin strip then is produced by peeling - a technique of machining a wide chip off of the outside diameter of the ring. This process and subsequent annealing are described with reference to surface finish and microstructures. Fabrication of strip by hot isostatic pressing gas atomized powder into large rings and peeling into strip can be a flexible and efficient method of producing strip up to 160mm. (6.2 in.) wide and 200 microns thick, provided: (1) the alloy is readily machinable; (2) microstructures are well controlled; and (3) the material is free of voids and non-metallic inclusions. The advantage of using gas atomized/hot isostatically pressed material is that it can produce thin strip that is free of macrosegregation and consistent in properties. 12 refs.

Brown, Robert L. (Gillette Co, Boston, MA, USA). *Ind Heat* v 55 n 6 Jun 1988 p 18-20.

**084593 RECENT PROGRESS IN KOBE ATOMIZED STEEL POWDERS.** Kobe Steel Ltd Kobe, Japan, has been producing water atomized iron and steel powders in Japan for 18 years, and during 1987 shipped around 42,000 tons (metric) of powder mainly for use in the PM industry. The author describes some recent developments in powder grades at Kobe Steel and also the construction of a new 24,000 tons/month steel powder plant in Seymour, Indiana, USA, which is scheduled to start production in 1989. (Author abstract)

Manto, Hiromune (Kobe Steel Ltd, Kobe, Jpn). *Met Powder Rep* v 43 n 5 May 1988 p 322-323.

**084594 KAWASAKI'S NEW ALLOYED STEEL POWDERS.** Kawasaki Steel Ltd of Chiba, Japan, is one of Japan's leading iron and steel powder producers, and to meet the increasing need for high density, high strength PM steel the company has developed and introduced a number of new prealloyed powders having high compressibility. The article presents a brief review of these new developments. (Author abstract)

Anon. *Met Powder Rep* v 43 n 5 May 1988 p 326-327.

**084595 TOOL AND DIE MATERIALS FROM RAPIDLY SOLIDIFIED POWDERS.** A number of tool steel compositions are being produced from rapidly solidified prealloyed powders. New tool and die materials are currently being developed which utilize rapid solidification to produce alloys not producible by ingot metallurgy techniques. The potential for producing near-net shapes of PM tool and die alloys will also be discussed. The current status of these materials will be presented. (Edited author abstract)

Staski, W. (Crucible Materials Corp, Pittsburgh, PA, USA); Chandhok, V.K.; Pinnow, K.E. *Met Powder Rep* v 43 n 6 Jun 1988 p 409-412.

**084596 NEW HIGH STRENGTH PM STEEL FOR CLOSE TOLERANCE PARTS.** Because of the requirement for narrow dimensional tolerances, particularly close control of the chemical composition must be maintained. In the production of Distalloy AG Hoegaes employs two methods for bonding alloying elements to the iron particles: diffusion bonding and bonding with organic binders. Diffusion annealing minimises segregation by creating a bond between the iron powder and the alloying powder particles by hating the powder mix in a reducing atmosphere - resulting in partial prealloying therefore permitting the utilisation of much finer particles than those in plain mixes. An additional method of overcoming the problem with dusting and segregation is using mixes prepared using the Hoegaes STARMIX technology, a

technique of adding certain binders in combination with a mixing treatment which permits fine particles to be bonded to the iron powder particles.

Anon. *Met Powder Rep* v 43 n 6 Jun 1988 p 433.

**084597 P/M PISTON ROD ENDS MACHINING, FORGING COSTS.** Automotive piston rods, customarily forged and then machined, are prime candidates for conversion to near-net processes. Engineers at Sumitomo Metal Industries Ltd. are using a high-strength steel alloy powder to replace forged rods. The as-sintered automotive component avoids costs of forging and needs only secondary machining.

Anon. *Mod Met* v 44 n 4 May 1988 p 76, 78.

**084598 INVESTIGATION OF PHASE COMPOSITION AND STRUCTURE IN PG-S1 HIGH CHROMIUM ALLOY.** The authors studied structure and hardness in wear resistant layers formed by different methods on a steel 45 base metal. The methods used comprised pouring steel 45 into a mould containing an insert layer of PG-S1 alloy made by the powder route, induction weld deposition of the wear proof layer, and rolling of a casting of steel 45 with an attached layer of PG-S1. Maximum hardness and abrasion layer adhesion were obtained with PG-S1 alloy prepared by the powder metallurgy route. (Author abstract). 3 Refs.

Osadchii, V.A. (Moscow Steel and Alloys Inst, USSR); Zhadan, V.T.; Titis, M. Yu.; Rummyantsev, A.V.; Mikhailov, A.I. *Steel USSR* v 17 n 9 Sep 1987 p 431-432.

**084599 SINTERING PHENOMENA AND HEAT-TREATED PROPERTIES OF CARBIDES AND BORIDES PRECIPITATED P/M ALLOYS MADE OF H.S.S. POWDER.** Sintering of mixtures of high speed steel powder and boron containing ferrous alloy powders were studied to obtain carbide and boride precipitated wear resisting P/M alloys. The properties after heat treatment were examined. AISI M7 and carbon reduced M7 (0.5 percent C) powders were selected and Fe-B and Fe-Cr-B powders were used as additive powders. Fe-B powder was better than Fe-Cr-B powder as the boron-containing additive powder. In order to get good mechanical properties, boron content of the mixture was determined as (Mo at percent + W at percent)/B at percent = 1.0. (Edited author abstract). 27 Refs. In Japanese.

Fujiki, Akira; Maki, Yoshihiro; Kanou, Makoto; Tanimoto, Ichiro. *J Jpn Soc Powder Metall* v 35 n 3 Apr 1988 p 118-124.

**084600 PROPERTIES OF HIGH COMPRESSIBILITY COMPOSITE-TYPE ALLOY STEEL POWDERS, 'KIP SIGMALOY'.** Composite-type alloy steel powders, KIP SIGMALOY, have been developed for the production of high density and heavy duty structural parts. The powders are characterized by metallurgically bonding fine particles of alloying elements on the surfaces of soft iron particles, and satisfy both compressibility at compaction and alloy diffusivity during sintering. SIGMALOY Cu powders, which contain 2 to 20 PERCENT Cu as an alloying element, suppress "copper growth" during sintering and hence improve sintered strength by 10 PERCENT and dimensional accuracy by 30 PERCENT, when compared with conventional powder mixes. SIGMALOY 215, 315 and 415 powders with compositions 2 to 4 PERCENT Ni-1.5 PERCENT Cu-0.3 to 0.5 PERCENT Mo attain compressibility equal to or higher than that of pure iron powders and improve the homogeneity of sintered specimens, resulting in over 10 PERCENT higher strength and toughness than those of sintered powder mixes. (Author abstract). 9 Refs.

Ogura, Kuniaki (High-Technology Research Lab, Jpn); Abe, Teruyoshi; Makiishi, Yukio; Takajo, Shigeaki; Minegishi, Toshiyuki; Hatsugai, Eiji. *Kawasaki Steel Tech Rep* n 18 May 1988 p 66-72.



**084601 TOOL AND DIE MATERIALS FROM RAPIDLY SOLIDIFIED POWDERS.** A number of tool steel compositions are being produced from rapidly solidified prealloyed powders. The microstructural and property characteristics of these materials are reviewed. The potential for producing near-net shapes of PM tool and die alloys is also discussed. The current status of these materials is discussed. 8 Refs.

Staski, W. (Cruible Materials Corp, Pittsburgh, PA, USA); Chandhok, V.K.; Pinnow, K.E. *Met Powder Rep* v 43 n 6 Jun 1988 p 409-412.

**084602 NEW HIGH STRENGTH PM STEEL FOR CLOSE TOLERANCE PARTS.** The objective in developing designated Distaloy AG was to reach high strength and hardness in combination with high density and sufficient elongation by using a single pressing/single sintering route without any post-treatments. In order to produce a material with sufficiently high density, shrinkage of about 0.8% occurs during sintering; however, this shrinkage can be controlled in such a way that the dimensional precision is similar to that of more conventional PM steels. Distaloy AG is based on iron powder with additions of 8% Ni and 1% Mo.

Anon. *Met Powder Rep* v 43 n 6 Jun 1988 P433.

**084603 INFLUENCE OF SLAG PARTICLES ON THE MECHANICAL PROPERTIES OF A P/M HIGH SPEED STEEL.** A series of high speed steels based on the commercial composition ASP 23 has been produced by nitrogen atomization and hot isostatic pressing. Controlled amounts of slag particles have been introduced by atomizing melts with high concentrations of sulfur and nitrogen, by surface oxidizing the powder or by mixing the powder with exogenous slag particles prior to HIP. The influence of the slags on the microstructure, impact and bend fracture strength, fatigue properties and cutting performance has been investigated. The steel is sensitive to slag inclusions and mechanical properties and cutting performance are strongly influenced. The decrease in impact and bend fracture strength depends mainly on the inclusion size. Subsequent forging of the HIPed materials improves mechanical properties. (Edited author abstract). 11 Refs.

Arnberg, Lars (Swedish Inst for Metals Research, Stockholm, Sweden); Karlsson, Anita. *Int J Powder Metall (Princeton NJ)* v 24 n 3 Jul 1988 9p.

**084604 DEVELOPMENT OF AS-SINTERED P/M CONNECTING RODS FOR AUTOMOBILES.** The P/M forged connecting rod is in commercial use. However, this mode of manufacturing is at a disadvantage with respect to cost. As-sintered connecting rods for automobiles were developed via a combination of high strength powder and the optimization of rod shape. The latter was evaluated by the finite element method. A rectangular hollow beam was suitable for the powder material. Oil atomized 4100s low alloy steel powder was used because of its high strength and compressibility. It was mixed with graphite, compacted, sintered and machined. This processing sequence resulted in acceptable fatigue strength in the as-sintered condition. (Edited author abstract). 7 Refs.

Suzuki, Shigeru (Sumitomo Metal Industries Inc, Osaka, Jpn); Toyama, Kazuo; Konda, Noboru. *Int J Powder Metall (Princeton NJ)* v 24 n 3 Jul 1988 p 243-250.

**Superalloys** See Also AIRCRAFT ENGINE MANUFACTURE; SUPERALLOYS—Mechanical Properties.

**084605 IMPHY ADVANCES TECHNOLOGY FOR PM SUPERALLOYS.** Imphy SA of Imphy, France, has devoted a considerable amount of effort in recent years to improving its powder production processes in order to achieve the cleanliness levels now required for PM superalloy components used in rotating parts subject to high stresses and temperatures in aero engines. The author has visited Imphy and reports on advances that have been made particularly with regard to powder cleanliness. (Author abstract)

Dowson, Gordon (Metal Powder Report, Shrewsbury,

Engl). *Met Powder Rep* v 42 n 10 Oct 1987 p 718-721.

**084606 SUPERPLASTIC BEHAVIOUR AND OPTIMUM WORK PROCESSING OF POWDER-CONSOLIDATED AND EXTRUDED NI-BASE SUPER-ALLOY.** Powder of nickel-base superalloy Mod. IN-100 was consolidated by hot isostatic pressing and recrystallized under the conditions of an extrusion ratio of 72% at 1,373 K and subsequent annealing at 1,343 K  $\times$  1 h. The superplastic behavior was investigated in the temperature range 1,223-1,423 K and range of strain rates from  $2.5 \times 10^{-4}$  to  $10^{-1} \text{ s}^{-1}$ . The conditions obtaining in the maximum strain rate sensitivity index,  $m$ , changed from the constant strain rate of  $10^{-2} \text{ s}^{-1}$  at temperatures above 1,303 K to the constant flow stress of 150 MPa below 1,303 K. It was desirable to decrease the temperature continuously for the purpose of keeping the maximum  $m$  during superplastic deformation in tensile test. (Edited author abstract) In Japanese. 10 refs.

Torisaka, Yasunori (Agency of Industrial Science & Technology, Tsukuba, Jpn); Miyagawa, Matsuo. *Tetsu To Hagane* v 74 n 1 Jan 1988 p 115-122.

**084607 EFFECT OF CONSOLIDATION TEMPERATURE AND BORON ADDITION ON MICROSTRUCTURE AND MECHANICAL PROPERTIES OF HOT ISOSTATICALLY PRESSED PM SUPER-ALLOY BASED ON Zr56-K.** The chemistry of a high performance cast superalloy, Zr56-K (Ni-10Cr-5Co-5W-5Al-3.5Mo-3Ti-0.2C-0.02B), was modified by slight reductions in carbon, titanium, and aluminium content and minor additions of niobium and hafnium. It was observed that, unlike carbon, an increase in boron content did not promote the formation of continuous precipitates at the prior powder particle boundaries. Increased boron content narrowed down the consolidation temperature range and changed the morphology of  $\gamma'$  particles from cuboidal to dendritic. Precipitation of an eutectic  $\gamma + \gamma'$  structure and formation of continuous boride films at the grain boundaries severely degraded the mechanical properties of the high boron PM superalloy that was consolidated at a temperature marginally above the  $\gamma'$  solvus. An optimum consolidation schedule was determined for the high boron alloy, which after a suitable heat treatment produced significant property improvement in stress rupture and tensile properties. (Edited author abstract) 19 refs.

Sharma, K.K. (Defence Metallurgical Research Lab, Hyderabad, India); Tewari, S.N.; Birla, N.C.; Misra, P.S. *Powder Metall* v 31 n 1 1988 p 52-62.

## Sweden

**084608 POWDER METALLURGY IN SWEDEN.** Sweden's major P/M industries are described in terms of processing capabilities, materials, product lines, plant modernization, acquisitions and turnover. A worldwide position has been established in ferrous powders, full-density P/M processing, cemented carbides, and the equipment sector of the industry. About 4 percent of turnover is invested annually in research and development. A broad range of P/M research is on-going at several technical universities and research institutes. (Edited author abstract).

Olle Grönder, N. (P/M Technology AB, Nynashamn, Sweden). *Int J Powder Metall (Princeton NJ)* v 24 n 3 Jul 1988 p 263-268.

## Tantalum

**084609 PRODUCTION AND APPLICATIONS OF TANTALUM POWDER.** More than 50% of total sales of the refractory metal tantalum are for capacitor applications in the electronics industry. The author reviews the advances that have been made in improving the properties of tantalum powder for electronic applications, and how these advances will affect future consumption of the metal. (Edited author abstract)

Jones, Andrew (Tantalum-Niobium Int Study Cent, Brussels, Belg). *Int J Refract Hard Met* v 6 n 3 Sep 1987

p 119-121.

**084610 VERY-FINE-GRAINED HARDMETALS.** In an investigation of the effect of (Ta, Nb) C, Cr<sub>3</sub>C<sub>2</sub>, and VC additions on a range of very-fine grain-size hardmetals, methods for determining the sizes of very-fine powders have been devised; measurements have been made of grain-size distributions, compressive properties, fracture toughness, Palmqvist toughness, edge toughness and of resistance to abrasive wear, creep, oxidation, and corrosion. It was concluded that for the compositions examined, there were no major differences in the effectiveness of the various additions on properties or variability, but there may be considerable advantages in developing hardmetals with grain-sizes less than 0.1  $\mu\text{m}$ . (Author abstract) 19 refs.

Almond, E.A. (NPL, Teddington, Engl); Roebuck, B. *Int J Refract Hard Met* v 6 n 3 Sep 1987 p 137-144.

## Terbium

**084611 Tb-Fe-B AND Lu-Fe-B TERNARY SYSTEMS.** Until now the Tb-Fe-B and Lu-Fe-B ternary systems have been investigated only for the formation of compounds of individual structural types. The borides detected are listed. The purpose of this work is a study of the interaction of terbium (or lutetium) with iron and boron in the complete concentration range. The samples were annealed at 1070°K for not less than 800 h and were hardened in cold water. The x-ray diffraction patterns were recorded and the lattice parameters were determined. 16 refs.

Dub, O.M. (Lvov Univ, USSR); Kuz'ma, Yu.B.; David, M.I. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 563-566.

**Titanium** See Also POWDER METAL PRODUCTS—Deformation; TITANIUM AND ALLOYS—Melting; TITANIUM CARBIDE—Manufacture; TITANIUM COMPOUNDS—Physical Chemistry.

**084612 EFFECT OF EUTECTOID  $\beta$  STABILIZING ELEMENTS ON THE DENSIFICATION AND TENSILE PROPERTIES OF TITANIUM POWDER COMPACTS.** The effect of Cr, Mn, Fe, Ni, Cu, and Si on sintering characteristics and tensile properties was investigated and compared with the case of Co addition. Fe and Ni had a good effect on densification. In the case of Si addition, a high sintered density ratio of 99% was obtained for the 2 wt% Si specimen. The other specimens of Ti-X (X=Cr, Mn, Cu) showed decreasing sintered density ratios with increasing amount of additional elements. Ti-2%Fe specimen showed the highest tensile strength. Though the elongation value of 8% obtained for the (a+ $\beta$ )-quenched Ti-2%Fe specimen was lower than the 14% of the (a+ $\beta$ )-quenched Ti-2%Co specimen, it could possibly be improved by heat treatment in the (a+ $\beta$ )-region. (Edited author abstract) In Japanese. 11 refs.

Majima, Kazuhiko; Yoshimura, Yoshihito; Shoji, Keiichi. *J Jpn Soc Powder Powder Metall* v 34 n 5 Jul 1987 p 205-210.

**084613 EFFECT OF TECHNOLOGICAL FACTORS ON THE PROPERTIES OF HIGH-DENSITY TITANIUM SPONGE COMPACTS.** It is important to choose judiciously the thermomechanical conditions of compact re-pressing, heating, and forging and to study their effect on the properties of sponge titanium. It has been established that the sponge processing method developed enables titanium to be obtained which is comparable in physicochemical properties and melting sponge titanium. The solid titanium obtained contained the following impurities: 0.04 Fe, 0.02 C, 0.01 Si, 0.025 N, 0.08 O<sub>2</sub>, and 0.006% H<sub>2</sub>. These figures meet the purity requirements for VT1-00 technical titanium produced by the generally adopted method. The new process has been



employed for making titanium blanks and forged valves and other components for industrial applications. 6 refs.

Obodovskii, E.S. (Kramatorsk Industrial Inst, USSR); Laptev, A.M. *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 295-299.

**084614 PREALLOYED TITANIUM POWDER METALLURGY - BARRIERS TO USE.** The technology of prealloyed titanium P/M has matured to the point where it is ready to be used as a bill of materials in high integrity applications, in particular the aerospace industry. Mechanical properties of powder parts are at least equivalent to those of the counterpart conventional ingot metallurgy products. In this commentary, the several generic technical and economic factors which determine the viability of a process and/or product are examined. These factors are considered in the specific case of prealloyed titanium P/M aerospace components. Actions that must occur if the cost-effective prealloyed approach is to be accepted are analyzed. (Edited author abstract) 9 refs.

Froes, F.H. (US Air Force Wright Aeronautical Lab, Wright-Patterson AFB, OH, USA). *Int J Powder Metall (Princeton NJ)* v 23 n 4 Oct 1987 p 267-269.

**084615 EVALUATION AND APPLICATION OF PREALLOYED TITANIUM P/M PARTS FOR AIRFRAME STRUCTURES.** Titanium powder metallurgy parts in the form of engine mount supports (EMS) were evaluated for use on the U.S. Navy's F/A-18A fighter aircraft. The parts were made to near-net shape by hot isostatic pressing (HIP) of pre-alloyed Ti-6Al-4V powder by the ceramic mold process. The powder was made by the plasma rotating electrode process (PREP), which produces powder that is free of contaminant particles. The evaluations included microstructural examination, hydrogen and oxygen analyses, dimensional inspection, radiographic inspection, residual stress measurement, and mechanical property testing. The latter included tests of tensile, compressive, shear, and bearing strengths; impact resistance, fracture toughness; stress corrosion cracking resistance; fatigue crack growth; and smooth S-N, notched S-N, strain-life, and spectrum fatigue behavior. The properties of the P/M EMS were equivalent to those of wrought material currently used to fabricate the EMS. (Author abstract) 2 refs.

Sheinker, Abraham A. (Northrop Corp, Hawthorne, CA, USA); Chanani, Govind R.; Bohlen, James W. *Int J Powder Metall (Princeton NJ)* v 23 n 3 Jul 1987 p 171-176.

**084616 TITANIUM POWDER METALLURGY-PRODUCTS AND APPLICATIONS.** The three facets of titanium PM, blended elemental, prealloyed, and rapid solidification, are reviewed in the following paper by F.H. Froes, D. Eylon and R.G. Rowe. The blended elemental approach has already been used for production runs of a number of components and introduction of a low cost chloride-free powder should greatly increase use. The prealloyed method exhibits mechanical properties at least equivalent to conventional ingot metallurgy product and appears to be very cost competitive especially for complex shapes which conventionally require extensive machining. However, acceptance is slow perhaps due to the conservation of the aerospace industry. It is suggested that the prealloyed approach will gain acceptance with the use of rapidly solidified alloys which can only be produced via PM, development of design data, lower cost powder, and introduction into new systems. (Author abstract) 65 refs.

Froes, F.H. (US Air Force Materials Lab, Wright-Patterson AFB, OH, USA); Eylon, D.; Rowe, R.G. *Met Powder Rep* v 42 n 10 Oct 1987 p 676, 678, 681-682, 684-686.

**084617 BLENDED ELEMENTAL POWDER TITANIUM FOR AUTOMOTIVE APPLICATIONS.** A fully dense, blended elemental titanium powder metallurgy process (MR-9) was used to demonstrate a 70% weight savings over a conventional steel valve retainer cap. The same technology offers similar weight savings for connecting rods. This paper describes how retainer cap

was optimized for material properties and how parts were fabricated and tested. (Edited author abstract)

Brosius, E. (Clevite Industries Inc, Cleveland, OH, USA); Malek, J.C.; Petek, N.K.; Trzcinski, M.J. *Met Powder Rep* v 42 n 11 Nov 1987 p 768, 770, 773.

**084618 FUTURE OF TITANIUM POWDER METALLURGY.** Near-net-shape parts can be produced economically from elemental powders for numerous applications. In this paper the author discusses the current state-of-the-art of titanium powder metallurgy, then the current and potential markets for titanium powder metallurgy and near net-shape production; third, potential markets, and, last, some specific attributes of elemental powder. The author sees titanium powder metallurgy as being a viable partner to the wrought and cast titanium industry if the learning curves are followed intelligently in P/M parts manufacture and if pricing of titanium powders is such that the development of new and expanded markets can continue. 7 refs.

Fry, Robert K. (Micron Metals Inc.). *Light Met Age* v 45 n 3-4 Apr 1987 p 13-14, 16.

**084619 EFFECTS OF PURITY OF TITANIUM POWDER AND POROSITY ON STATIC TENSILE PROPERTIES OF SINTERED TITANIUM SPECIMENS.** Using two different kinds of titanium powders, some properties of P/M titanium specimens were investigated in relation to porosity. Hunter process sponge fines showed a better compressibility than Kroll process HDH titanium powders but the sintered density ratio of the former became nearly the same as that of the latter due to poorer shrinkage during sintering. Both tensile strength and elongation of the sintered HDH powder specimen increased nearly in proportion to the increased sintered density ratio. In the sintered Hunter process sponge fines specimen, there existed a flat region where the static tensile properties were nearly constant independently of sintered density ratio. In the fracture surface of the sintered Hunter process sponge fines specimen there were non-metallic inclusions identified as NaCl. (Edited author abstract) In Japanese. 10 refs.

Majima, Kazuhiko (Osaka Univ, Suita, Jpn); Hirata, Takehiko; Shouji, Keiichiro. *Nippon Kinzoku Gakkaishi* v 51 n 12 1987 p 1194-1200.

**084620 EXPLOSIVE CONSOLIDATION OF TITANIUM POWDER WITH A PRESSURE MEDIUM.** This paper reports a new explosive consolidation procedure of metal powder that employs a pressure medium in order to induce the homogeneous transfer of shock waves. The trial manufacture of a complex form compact is also made by taking advantage of the proposed method. It can be deduced that the shock wave transfers isostatically to the innermost tube wall through the pressure medium in spite of the concentric configuration of the explosive. All experimental results presented here demonstrate the advantage of using a pressure medium for explosive consolidation of metal powders. 6 refs.

Chiba, A. (Kumamoto Univ, Kumamoto, Jpn); Nishida, M.; Yamaguchi, T.; Tosaka, J. *Scr Metall* v 22 n 2 Feb 1988 p 213-217.

**084621 P/M TITANIUM TECHNOLOGY FOR HIGH PERFORMANCE USES.** A powder metallurgy process for titanium has been developed for high performance applications including aircraft engine and airframe components. The process utilizes high quality prealloyed powder produced by gas atomization or the PREP process. These powders have been consolidated into a variety of near-net shapes using the ceramic mold process and hot isostatic pressing. The resulting material is fully dense and exhibits mechanical properties which equal or exceed those of castings, forgings and plate. The process has been successfully applied to conventional and advanced titanium alloys, including the titanium aluminides. 13 refs.

Moll, J.H. (Crucible Materials Corp, Pittsburgh, PA, USA); Yoltan, C.F.; Chandhok, V.K. *Ind Heat* v 55 n 5 May 1988 p 24-27, 30.

**084622 DENSIFICATION OF TITANIUM POWDER DURING HOT ISOSTATIC PRESSING.** The densification of spherical and angular titanium powder during hot isostatic pressing (HIP) at 700°C has been studied. The angular powder densifies in a manner similar to the spherical powder despite its low initial packing density. Good agreement is found between a model for the HIP of monosize spheres and the experimental data for both spherical and angular powder provided that the transition between the initial stage of densification (contacts between individual particles) and the final stage (compact is a homogeneous solid with isolated pores) occurs at a density of roughly 95 pct of theoretical. This is consistent with observations of the pore microstructure as a function of density. (Author abstract). 20 Refs.

Lograsso, B.K. (Michigan Technological Univ, Houghton, MI, USA); Koss, D.A. *Metall Trans A* v 19A n 7 Jul 1988 p 1767-1773.

**Titanium Aluminum** See Also TITANIUM ALUMINUM BORON ALLOYS—Solidification.

**084623 POWDER METALLURGY OF TITANIUM ALUMINIDES.** Recent advances in prealloyed titanium aluminide powder metallurgy have now made it possible to produce fully-dense compacts with mechanical properties at least equivalent to those found in wrought material. Through powder metallurgy, it is possible to enhance functional properties by manufacturing bimetallic components that would be extremely complicated to make by conventional methods. The paper describes microstructure/property relationships in Ti<sub>3</sub>Al (alpha), TiAl (gamma), and bimetallic Ti<sub>3</sub>Al/Ti-6Al-4V hot isostatic pressed powders. Heat treat conditions, diffusion, and room temperature tensile properties were established. (Edited author abstract) 3 refs.

Moxson, V.S. (Precision Cast Part Corp, Cleveland, OH, USA); Friedman, G.I. *Met Powder Rep* v 43 n 2 Feb 1988 p 88-91.

**Titanium Aluminum Vanadium**

**084624 CHARACTERISTIC PROPERTIES OF HOT ISOSTATICALLY PRESSED Ti-6Al-4V ALLOYS.** Static tensile properties of HIP Ti-6Al-4V alloys after sintering at 1473 K for 3.6 ks by blended elemental powder metallurgy process were studied and compared with those of HIP compacts made by the rotating electrode process (REP). The tensile strength and ductility after sintering using hydride-dehydride Kroll process sponge fines as the titanium source were nearly the same as those of the REP alloy. On the other hand, ductility degradation was observed in the case of using Hunter process sponge fines as the titanium source. This behavior is related to NaCl in the sintered compacts. (Edited author abstract) In Japanese. 7 refs.

Majima, Kazuhiko; Hirata, Takehiko; Yamamoto, Mitsumasa; Shoji, Keiichiro. *J Jpn Soc Powder Powder Metall* v 34 n 5 Jul 1987 p 211-216.

**Titanium Aluminum Vanadium Alloys**

**084625 MANUFACTURE OF A NOVEL POROUS METAL.** A patented method of producing a novel type of porous metal is described, using as the matrix material the titanium alloy Ti-6Al-4V. Produced by consolidation of alloy powder in the presence of argon, the low density porous metal is generated by subsequent heat treatment. In the as-consolidated condition the material is close to theoretical density and can be hot worked to give primary sections such as plate, sheet or bar. During heat treatment kinetically controlled pore growth occurs to develop the required porosity level. Limited work has shown that porosity levels of close to 40% can be achieved. Although the work reported concerns Ti-6Al-4V, the technique is applicable to other titanium alloys as well as to other materials. (Edited author abstract)

Kearns, Michael W. (IMI Titanium Ltd, Birmingham, Eng); Blenkinsop, Paul A.; Barber, Antony C.; Farthing, Thomas W. *Int J Powder Metall (Princeton NJ)* v 24 n



1 Jan 1988 p 59-64.

## Titanium Carbide

**084626 EFFECT OF PARTICLE SIZE OF TITANIUM CARBIDE POWDER ON ITS HOT PRESSING UNDER HIGH PRESSURE.** A study was made of the hot pressing of titanium carbide powders of various particle sizes under pressures of 2.5-7.0 GPa at temperatures of up to 1800°C. Prior comminution has no significant activating effect on the sintering process, but leads to contamination by grain boundary impurities which adversely affects the strength of intergranular bonds. Specimens may fail as a result of nonuniform residual elastic strains during cooling under pressure and the fact that pressing in high pressure apparatus does not take place under hydrostatic conditions. The microhardness of titanium carbide grows with a rise in pressing temperature and pressure as a consequence of work hardening. 6 refs.

Stasyuk, L.F. (Acad of Sciences of the Ukrainian SSR, USSR); Neshpor, V.S. *Sov Powder Metall Met Ceram* v 26 n 8 Aug 1987 p 627-630.

## Titanium Chromium

**084627 INFLUENCE OF CHROMIUM CONTENT ON THE TRIBOTECHNICAL PROPERTIES OF TITANIUM-CHROMIUM ALLOYS.** The purpose of this work was a study of the mechanical properties and wear resistance of titanium-chromium alloys containing 10-35%. Specimens prepared by pressing and subsequent sintering were investigated. Improvement in mechanical properties is accompanied by an increase in wear resistance. For alloys containing more than 20% Cr an increase in wear resistance is accompanied by a drop in mechanical properties. Such behavior is explained by the increase in content and structure of the TiCr<sub>2</sub> intermetallic formed. 8 refs.

Petrova, A.M. (Acad of Sciences of the Ukrainian SSR, USSR); Polotai, V.V. *Sov Powder Metall Met Ceram* v 26 n 5 May 1987 p 392-396.

## Titanium Cobalt Alloys

**084628 EFFECT OF TITANIUM POWDER ON THE CHARACTERISTIC PROPERTIES OF HOT ISOSTATICALLY PRESSED Ti-Co ALLOYS.** Static tensile properties of HIP Ti-Co binary alloys containing 2 wt% or 4 wt% Co were studied. Metallographic and fractographic observations were carried out by scanning electron microscope and X-ray energy dispersion analysis. Despite the low level of oxygen content, the specimen using Hunter process sponge fines as a titanium source showed poorer ductility properties than the specimen using hydride-dehydride Kroll process sponge fines of high oxygen content. The ductility degradation was related to the NaCl in the specimen using Hunter process sponge fines. Brittle fracture was due to the NaCl. (Edited author abstract) In Japanese. 9 refs.

Majima, Kazuhiko; Hirata, Takehiko; Maeda, Shuhei; Shoji, Keiichi. *J Jpn Soc Powder Powder Metall* v 35 n 1 Jan 1988 p 1-5.

## Titanium Compounds

**084629 HIGH-TEMPERATURE OXIDATION OF COMPOSITE MATERIALS BASED ON TITANIUM DIBORIDE.** Composite materials based on titanium diboride and a mechanical mixture of titanium diboride and carbide with Fe-Cr and Fe-Ni metallic binders are used for coating components working in conditions with abrasive wear and in corrosive media. This work examined high temperature oxidation of powders of composite materials with these binders (20% by mass) and corresponding dense specimens with a porosity of 2-3% in air at temperatures of up to 1770K by nonisothermal thermogravimetry and differential thermal analysis. The data on the stage mechanism of oxidation are in agreement with thermodynamic calculations in which the reactions taking place with the formation of boron and titanium oxide are the most preferred reactions. 4 refs.

Lavrenko, V.A. (Acad of Sciences of the Ukrainian, SSR, Kiev, USSR); Chuprov, S.S.; Umanski, A.P.; Protchenko, T.G.; Lugovskaya, E.S. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 761-762.

## Titanium Iron

**084630 INTERACTION OF THE COMPONENTS IN Ti-Fe, Ti-Fe-Ni, AND Ti-Fe-Mn POWDER MIXTURES BY THE METHOD OF HOT MICROSCOPY.** Formation of the intermetallic TiFe in compacts of a mixture of titanium and iron powders occurs after sintering at 900-1000°C. Intermetallics are formed more actively under conditions of liquid phase sintering at temperatures exceeding the temperature of the first eutectic (1085°C). The existence of intermetallics in compacts being sintered before reaching of the eutectic temperature is an indication of solid phase interaction at the points of contact of the powder particles. The character of this interaction, which leads to the formation of eutectic concentrations containing 70 wt.% iron, was investigated. The microstructure during heating was studied in a vacuum with a pressure of  $12 \cdot 10^{-4}$  Pa. The phases were identified on the basis of high temperature x-ray diffraction analysis and chemical analysis. 5 refs.

Vlasyuk, R.Z. (Acad of Sciences of the Ukrainian SSR, USSR); Kivalo, L.I.; Skorokhod, V.V. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 746-749.

## Titanium Molybdenum Alloys

**084631 EFFECTS OF MIXING AND SINTERING CONDITIONS ON SOME PROPERTIES OF SINTERED TITANIUM-MOLYBDENUM ALLOY.** A fluidizing type mixer may be useful in mixing titanium and other metal powders because it causes less contamination of oxygen, carbon and iron. Mixing by the fluidizing type mixer and sintering in a non-carbonizing atmosphere in a vacuum improve the elongation and strength of Ti-30Mo sintered alloy. Corrosion resistance against non-oxidizing acids is better than that of titanium and is not influenced by oxygen, carbon and iron which are contaminated in the mixing and sintering process. (Edited author abstract) 10 refs. In Japanese.

Sakaguchi, Shigeo. *J Jpn Soc Powder Powder Metall* v 35 n 2 Feb 1988 p 58-62.

## Titanium Nickel Copper Tin

**084632 STRUCTURE AND PHASE COMPOSITION OF ALLOYS Ti-Ni-Cu-Sn.** Sintering of powdered mixtures of Ti-Ni-Cu-Sn is accompanied by the formation of biphasic and triphasic alloys that are rich in intermetallic phases. The bending strength of this alloy is 106-9.8-10 Pa, its impact toughness is  $0.31 \cdot 9.8 \cdot 10^4$  Pa and hardness is 62 HRA. The sintered alloys are characterized by high strength and ductile properties, low sintering temperature, and satisfactory adhesion to diamonds. 4 refs.

Chepeleva, V.P. (Acad of Sciences of the Ukrainian SSR, USSR). *Sov Powder Metall Met Ceram* v 26 n 3 Mar 1987 p 242-247.

## Titanium Oxide

**084633 FRACTOGRAPHIC STUDY OF SINTERED NANOPHASE TiO<sub>2</sub>.** Fractography of sintered nanophase and commercial coarser TiO<sub>2</sub> powders was carried out using scanning electron microscopy. Compared with material sintered from commercial TiO<sub>2</sub> powder, nanophase TiO<sub>2</sub> sintered at 1400°C contains smaller voids and the sintering temperature for completely transgranular fracture is 200°C lower. The cracking of nanophase samples during sintering is also discussed. (Author abstract) 9 refs.

Li, Zongquan (Argonne Natl Lab, Argonne, IL, USA); Ramasamy, S.; Hahn, H.; Siegel, R.W. *Mater Lett* v 6 n 7 Apr 1988 p 195-201.

## Tools, Jigs and Fixtures

**084634 TOOLS AND DIES - A KEY ELEMENT IN P/M PRODUCTION.** Careful attention to detail is an absolute must when specifying tool and die materials and design configurations for P/M part production. This article presents some of the background and current state-of-the-art in the field from a specialist tool and die company's point of view. Examples from the wide range of other tools including a synchro die, damper punches, gear punches, formed core rods etc. are given.

Harrison, D.G.G. *Metallurgia* v 54 n 11 Nov 1987 p S14, S16.

**Tungsten** See Also POWDERS—Testing; TUNGSTEN AND ALLOYS—High Temperature Properties; TUNGSTEN COMPOUNDS—Morphology; TUNGSTEN COMPOUNDS—Reduction; TUNGSTEN NICKEL IRON ALLOYS—Mechanical Properties.

**084635 ADDITION OF MOLYBDENUM PRODUCES HIGH STRENGTH HEAVY ALLOYS.** The article describes the development of a high strength tungsten-base heavy alloy with hardness greater than HRC 44 and which could find potential applications in armour penetrator ammunition. The authors stated that it was evident from the binary phase diagrams of Mo-Ni and Mo-Fe that Mo has a fair amount of solubility at the liquid phase sintering temperature used for heavy alloys, and that W and Mo exhibit complete solid solubility in each other over the whole range of compositions.

Anon. *Int J Refract Hard Met* v 6 n 3 Sep 1987 p 125.

**084636 EINFLUSS VON ALUMINIUM AUF DIE REDUKTION VON WOLFRAMOXID ZU WOLFRAM.** [Influence of Aluminum on the Reduction of Tungsten Oxide to Tungsten Powder]. The action of aluminum traces on tungsten reduction by hydrogen is examined. A detailed description of the morphological changes which occur during the reduction of the tungsten oxide to metal powder is given. The effect of Al on the nucleation and growth of the tungsten particle is discussed. (Author abstract) 13 refs.

Haubner, R. (Technische Univ Wien, Vienna, Austria); Schubert, W.D.; Lassner, E. *Int J Refract Hard Met* v 6 n 3 Sep 1987 p 161-167.

**084637 STRUCTURE OF SINTERED ALLOYS OF TUNGSTEN WITH RHENIUM, Y<sub>2</sub>O<sub>3</sub> AND HfC AFTER LONG TERM TREATMENT OF POWERS IN AN ATTRITOR.** Investigations were conducted into the effect of long-term treatment of powders in a high-energy mill (attritor) on the structure of sintered alloys of tungsten with rhenium, Y<sub>2</sub>O<sub>3</sub> and HfC. The results show that intensification of mixing the powder tungsten alloys prevents formation of large inclusions (conglomerates) of hardening phases. Cold working often leads to cracking of pressings. Satisfactory dispersion of the particles of the hardening phases and uniform distribution of the alloying elements in the sintered alloys were already obtained after the first two hours of treatment in the attritor. (Author abstract) 5 refs.

Povarov, K.B.; Zavarzina, E.K.; Makarov, P.V.; Gachev, V.I.; Ol'shanskii, A.B.; Kolesnikov, A.A.; Korol', V.A. *Phys Chem Mater Treat* v 21 n 3 May-Jun 1987 p 297-300.

**084638 STUDY ON SOME PHYSICAL PROPERTIES OF TUNGSTEN POWDER USED FOR Ba-W CATHODES.** Some physical properties of tungsten powder have been analyzed by an electronic probe scanning microscope and a light emission particle size measuring instrument. The relations between fracture morphology, surface character and the current density of the cathode



has been tested. The physical theory of a particle surface has been used to illustrate the relationships. (Edited author abstract) In Chinese.

Li Jinyao (Central-South Univ of Technology, China); Li Hanguang. *Fenmo Yejin Jishu* v 5 n 4 Nov 1987 p 193-199.

**084639 ELECTRON-OPTICAL INVESTIGATION OF THE SINTERING KINETICS OF TUNGSTEN POWDERS OF SPHERICAL PARTICLE SHAPE. I. EXPERIMENTAL INVESTIGATIONS OF THE SINTERING OF TUNGSTEN POWDERS.** A study was made of the kinetics of contact formation and densification in the sintering of porous bodies from atomized spherical tungsten powders of mean particle sizes 4 and 10  $\mu\text{m}$ . Sintering was performed in hydrogen in the temperature range 1800-2000°C. Isoporous disks were produced by pressing with an addition of paraffin wax which was subsequently removed by slow heating to 800°C in hydrogen. To increase the strength of compacts used for pore size determinations by the Barus-Bechgold method, they were annealed for 0.5 h at 1400°C. A good correlation was found between pore sizes determined by the Barus-Bechgold method and those calculated with  $L=4/3 R_0/N-1(1-V/V_0^{2/3}-V)$ . 2 refs.

Skorokhod, V.V. (Acad of Sciences of the Ukrainian SSR, USSR); Veremenko, L.A.; Get'man, O.I.; Karpikov, I.I.; Rikitin, S.P. *Sov Powder Metall Met Ceram* v 26 n 5 May 1987 p 357-360.

**084640 LIQUID PHASE SINTERING OF TUNGSTEN HEAVY ALLOYS IN VACUUM.** Research on tungsten heavy alloys has shown that mechanical property improvement might be obtained by sintering in vacuum. A treatment for heavy alloys is described which incorporated the use of vacuum during part of the liquid phase sintering cycle. The tensile properties of the alloys are superior to those of similar alloys sintered in dry hydrogen and are compared to the maximum values reported in the literature. 18 refs.

Bose, A. (Rensselaer Polytechnic Inst, Troy, NY, USA); Rabin, B.H.; German, R.M. *Met Powder Rep* v 42 n 12 Dec 1987 p 834, 836, 838-839.

**084641 NEW GAS SPARGING PROCESS PROMISES CHEAPER TUNGSTEN CARBIDE POWDER.** Following the development at the US Bureau of Mines Reno Laboratories in Nevada of a new two-step technique for the preparation of tungsten monocarbide (WC) directly from one concentrate, the patented process has been licensed to International Carbide of Canada in Vancouver, British Columbia. The company has now successfully scaled up the process. The author reports on some of the tungsten carbide powders being produced in the pilot plant and how these powders are expected to compete against powders made by more conventional routes.

Williams, Bernard. *Met Powder Rep* v 42 n 12 Dec 1987 p 853-855.

**084642 REFRACTORY METAL POWDER PRODUCTION AT MUREX.** Murex Ltd of Rainham, Essex, UK, has been involved in the production of tungsten powders for almost 80 years, having been formed in 1909 to exploit a magnetic process for the separation of metallic ferrous ores. Today, Murex is a major producer not only of tungsten powders, but also tungsten carbide powder molybdenum powder and products, chromium metal and ferroalloys. The article describes production processes for tungsten and molybdenum powder.

Weaver, Amanda (Refractory & Hard Metals, Bellstone, Engl). *Int J Refract Hard Met* v 6 n 4 Dec 1987 p 175, 177-178.

**084643 STUDY OF CARBURIZATION OF COARSE TUNGSTEN POWDER.** The carburization of W powder is a reaction diffusion process. The carburization proceeds from the outside to the inside of the polycrystalline W particles or the sintered agglomerates of W which function as reaction units. The coarser the W particles, the higher the temperature required for complete

carburization and the longer the time required. The authors studied the various conditions for carburization of coarse W powder and ways of eliminating  $W_2C$  in WC. (Edited author abstract)

Tao, Zhengji (Zhuzhou Cemented Carbide Industrial Co, Zhuzhou, China). *Int J Refract Hard Met* v 6 n 4 Dec 1987 p 221-225.

**084644 ELECTRICAL RESISTIVITY OF THE ACTIVATED SINTERED W-PRODUCT.** The electrical resistivity was measured for a Ni-activated sintered W-product compact after the pertinent elements had completed the alloying reactions. The relation between electrical resistivity and porosity of the sintered product was also examined with geometrical models to determine the electrical resistivity of the fully densified poreless product. The electrical resistivity of the 0.2% Ni-doped W-sintered product ranged from  $0.85 \times 10^{-5} \omega\text{-cm}$  to  $1.15 \times 10^{-5} \omega\text{-cm}$ , depending on the particle size of the W powder. This value is higher than that of pure W by a factor of two. (Edited author abstract) 12 refs.

Moon, I.H. (Han Yang Univ, Seoul, South Korea); Suh, Y.H.; Choi, J. *Int J Refract Hard Met* v 6 n 4 Dec 1987 p 226-230.

**084645 RESULTS FROM THE MELTING OF TUNGSTEN COMPOSITES UNDER MICROGRAVITY IN SPACE (TEXUS 10 FLIGHT).** If a composite of low tungsten content is melted in space, the tungsten particles can grow freely floating in the molten matrix. The influence of surface energy, crystallographic anisotropy and attraction between the particles can be studied. After solidification the mechanical behaviour as a function of the amount of particles can be evaluated. The plastic deformation of the matrix compared to that of the particles is of principal interest. A primary test of the tungsten composite was undertaken in space using the Texus 10 module. During this test samples of two different compositions were melted. The results are given. 4 refs.

Ekbohm, Lars B. (Natl Defence Research Inst, Stockholm, Swed). *Int J Refract Hard Met* v 6 n 4 Dec 1987 p 231-232.

**084646 BOARD HORIZONS FOR P/M TECHNOLOGY.** (P/M) technology can form parts of tungsten and other difficult-to-melt metals at temperatures well below tungsten's 3000°F melting point. P/M parts can be designed so that after sintering (baking to weld the metal particles together), they arrive at net dimensions. In large runs (10,000 or more), P/M technology is often the least expensive way to produce parts. P/M also produces less waste and is more energy-efficient than many alternatives. Advances in impregnation have succeeded in preventing leakage, easing the use of plating and improving the machinability of P/M parts. Cadmium or zinc plating now may be applied to P/M parts. Machining P/M parts is notoriously difficult by filling the porosity with resin, machinability is vastly improved.

Rhodes, O. Thompson. *Des News (Boston)* v 43 n 12 Jun 22 1987 p 48-51.

**084647 EFFECT OF HEATING ON THE STRUCTURE OF ULTRAFINE TUNGSTEN POWDERS.** A study was made of the physicochemical properties and structure of ultrafine tungsten powders (UTPs) during heating to 1100°C. They were studied in the starting condition and after 30-min annealing in hydrogen at 300-1100°C. Determinations were made of changes in the specific surface of the powders and weight losses experienced during heating in hydrogen. The morphology and structure were investigated by transmission electron microscopy. 6 refs.

Skorokhod, V.V. (Acad of Sciences of the Ukrainian SSR, USSR); Panichkina, V.V.; Oleinik, G.S.; Novikov, V.I. *Sov Powder Metall Met Ceram* v 26 n 8 Aug 1987 p 611-614.

**084648 STRUCTURES OF SINTERED TUNGSTEN BARS AS EFFECT OF PRESSING LOAD.** The differences in structures of sintered W-AKS (doped

tungsten) which are dependent on pressing load at cold pressing the tungsten powder were analysed. High loads result in more closed pores and make the diffusion of doped elements to the surface difficult. Differences were found in the amount and distribution of pores as well as in the structure of the bars depending on the pressing load. (Author abstract) 8 refs.

Kolczynski, Z. (Warsaw Technical Univ, Warsaw, Pol); Rutkowski, W.; Swierczynska, M.B.; Trzaska, M. *Powder Metall Int* v 20 n 2 Apr 1988 p 22-26.

**084649 MECHANICAL PROPERTIES OF SINTERED TUNGSTEN BASE COMPOSITES.** This report describes the density, strength, toughness and ductility variations of tungsten base composites. Composites with additional nickel and iron (91.3 approximately 95.5%W/5.8 approximately 3.0% Ni/2.9 approximately 1.5% Fe) were fabricated by liquid phase sintering in a hydrogen atmosphere. In order to investigate deformation and fracture behavior, metallographic and fractographic examinations were performed in terms of a tension test,  $K_{Ic}$  test and Charpy impact test. The tensile strength, hardness and toughness are increased with increase in W content and swagging rate. The elongation is decreased with increasing W content and swagging rate. The mechanical properties are governed by the binding energy between the tungsten-matrix phases. The weaker this binding energy, the lower the ductility to failure. (Edited author abstract) 6 refs. In Japanese.

Kaneko, Takeshi. *J Jpn Soc Powder Powder Metall* v 35 n 2 Feb 1988 p 63-71.

**084650 STUDY OF POROUS COMPONENTS MADE OF TUNGSTEN POWDER PRODUCED BY THE SINGLE REDUCTION PROCESS OF HYDROGEN.** Sintering characteristics of tungsten powder with a mean particle size of 6.5 to 7.5  $\mu\text{m}$  singly reduced by hydrogen have been investigated. It is concluded that the relative density of porous tungsten components varies with the sintering temperature and time, particle size and green density. The parameters for producing porous tungsten products with relative density in a range of 78-81% and open porosity over 95% are outlined as follows: relative density of compacts, 60-65%; sintering temperature, 2100-2250°C; and sintering time, 4-8 hours. (Edited author abstract) In Chinese. 2 refs.

Sun, Baishun (Shanghai Research Inst of Materials, China). *Fenmo Yejin Jishu* v 6 n 1 Feb 1988 p 37-42.

## Tungsten Compounds

**084651 PREPARATION OF TUNGSTEN BORIDE SINTERED COMPACT BY HOT-PRESSING.** WB and  $W_2B_5$  powders containing 10 mol percent excess amorphous boron which was compensated by the addition of tungsten powder to keep the respective stoichiometries were hot-pressed at 20 MPa and 1900°C for 30 min. Microhardness of WB and  $W_2B_5$  sintered compacts was 2600 and 2700 kg/mm<sup>2</sup> and transverse strength was 57 and 43 kg/mm<sup>2</sup>, respectively. Coefficient of linear thermal expansion of WB and  $W_2B_5$  compacts was  $5.3 \times 10^{-6}$  and  $4.7 \times 10^{-6} \text{ deg}^{-1}$  at room temperature and  $7.3 \times 10^{-6}$  and  $6.8 \times 10^{-6} \text{ deg}^{-1}$  at temperatures above 400°C, respectively. (Edited author abstract). 5 Refs. In Japanese.

Hamamoto, Hiroshi; Obayashi, Mikio; Matsudaira, Tsuneki; Itoh, Hideaki; Naka, Shigeharu. *J Jpn Soc Powder Metall* v 35 n 3 Apr 1988 p 128-130.

## Tungsten Copper

**084652 STEREOLOGICAL INVESTIGATION OF TUNGSTEN-COPPER PSEUDOALLOYS - II. EFFECT OF THE PRODUCTION METHOD AND OF THE PARTICLE-SIZE DISTRIBUTION OF THE INITIAL TUNGSTEN POWDER ON CHANGES OF THE MICROSTRUCTURE OF MATERIALS.** The communication submits the results of study of the size and shape of initial tungsten particles and of the effect of the method of producing them and of their particle size distribution on the evolution of the formation of the grain



structure in the process of producing the materials. The authors studied tungsten powders produced by the plants 'Pobedit' and the Uzbek Combine of High Melting and Heat Resistant Metals (UzKTZhM) in different modifications (PVN and PVT). 3 refs.

Paderno, V.N. (Acad of Sciences of the Ukrainian SSR, USSR); Pilyankevich, A.N.; Martynenko, A.N.; Pilipovskii, Yu.L.; Fal'kovich, L.D. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 543-546.

## Tungsten Nickel Iron Alloys

**084653 SINTERING TEMPERATURE EFFECTS ON A TUNGSTEN HEAVY ALLOY.** A 93 wt.% tungsten heavy alloy (W-Ni-Fe) was sintered from three different lots of commercial powder at five sintering temperatures. After sintering, two different heat treatments were employed. Variations in microstructures and tensile properties were measured to assess the effects of these three test parameters. The evaluation included density, hardness, tensile strength, elongation to failure, grain size, contiguity and volume fraction of matrix phase. The results show little significant lot-to-lot variation with respect to tensile properties. With higher sintering temperatures the elongation increases and the strength decreases. These changes result from microstructural coarsening at the higher sintering temperatures. The difference between the two post-sintering heat treatments is small and dependent on the sintering temperature. (Author abstract) 22 refs.

Bourguignon, Laura L. (Leach & Garner Co, Attleboro, MA, USA); German, Randall M. *Int J Powder Metall (Princeton NJ)* v 24 n 2 Apr 1988 p 115-118, 120-121.

**084654 INVESTIGATION OF THE PROPERTIES OF COMMERCIAL TUNGSTEN HEAVY METALS.** The development of tungsten heavy metals during the last decades has been intensive. One reason for this is the use of this type of alloy in armour piercing projectiles. To check the quality of commercial alloys an investigation of composition, microstructure, and different mechanical properties of such alloys was undertaken. The mechanical testing also involved different high strain rate tests. The investigation shows that the quality of commercial heavy metals has been improved during the last decade but that problems in production still exist. Among the alloys tested the best quality was found for a French alloy. 16 Refs.

Ekblom, Lars B. (Natl Defence Research Establishment, Stockholm, Sweden); Oestensson, Mikael; Hellner, Lars. *Met Powder Rep* v 43 n 7-8 Jul-Aug 1988 5p.

## Tungsten Rhenium

**084655 ANISOTROPY OF THE STRUCTURE AND MECHANICAL PROPERTIES OF LOW-ALLOY TUNGSTEN.** This work examined the relationship of the structure and mechanical properties of alloys of tungsten with rhenium produced by sintering powders. The theory of microalloying the case and recrystallized bcc metals may also be used for rolled powder materials. In this case, the addition of elements which increase the ductility of the body of the grain improves the properties of rolled stock in the longitudinal and transverse directions, whereas the addition of oxide particles reduce the delamination susceptibility of the material. 10 refs.

Podrezov, Yu.N. (Acad of Sciences of the Ukrainian SSR, USSR); Radchenko, O.G.; Danilenko, N.G.; Skorokhod, V.V.; Panichkina, V.V.; Firstov, S.A. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 584-588.

## Tungsten Rhenium Alloys

**084656 MECHANICAL PROPERTIES AND STRUCTURE OF TUNGSTEN-RHENIUM POWDER METALLURGY DEFORMED ALLOYS.** In this work mechanical properties of tungsten alloys containing up to 2% rhenium were investigated. For this investigation the alloys were obtained by sintering of compacts of dispersed powders, which provided the formation of a tungsten-rhenium solid solution at relatively low sintering

temperatures. The blanks were deformed by rolling into sheet with a degree of deformation of 80%. For comparison three similarly treated alloys were investigated in parallel: (1) an alloy of tungsten with 2% rhenium; (2) an alloy of tungsten with dispersed additions of yttrium and hafnium oxides; and (3) commercially pure tungsten. The properties determined were the ductile-to-brittle transition temperature, bend strength, bend yield strength and crack resistance. 6 refs.

Podrezov, Yu.N. (Acad of Sciences of the Ukrainian SSR, USSR); Radchenko, O.G.; Danilenko, N.G.; Panichkina, V.V.; Gachegov, V.I.; Ol'shanskii, A.B. *Sov Powder Metall Met Ceram* v 26 n 8 Aug 1987 p 677-680.

## United Kingdom

**084657 UNITED KINGDOM.** Since the last International Powder Metallurgy Conference in North America, the UK industry has seen a considerable change both in fortunes and in outlook. In 1984, at that time of the meeting, the worst of the recession was at an end, but at that time the industry was still attempting to see a way forward. Today, there is an atmosphere of optimism and a new drive is apparent. Within the UK, the industry has shed manpower, improved productivity and increased profitability. In this report each sector in turn is looked at and the results are reported. The intention is to concentrate on the main stream business and to comment on the present and future outlook. 2 refs.

Brown, Gordon T. (GKN Technology Ltd, Wolverhampton, Engl); Pulling, David H. *Int J Powder Metall (Princeton NJ)* v 24 n 2 Apr 1988 p 161-165.

## USSR

**084658 PLANT FOR THE PRODUCTION OF METAL POWDERS BY A CENTRIFUGAL HYDRAULIC METHOD.** At the Moscow Engineering and Physical Institute a pilot plant has been developed and undergone tests for the production of powders of nonferrous metals and alloys with melting points of up to 1273°K by centrifugal hydraulic atomization of melts. In the production of powder, metal is charged into a crucible and the column of the plant is sealed, evacuated to a working pressure, and filled with an inert gas to a pressure slightly exceeding atmospheric. Next, voltage is applied to the heating elements, and the metal is melted and heated to a temperature 2-5% higher than its melting point. 2 refs.

Sheikhaliev, Sh.M. (Moscow Engineering & Physical Inst, USSR); Kuz'min, V.V.; Luzin, E.V. *Sov Powder Metall Met Ceram* v 26 n 8 Aug 1987 p 601-602.

## Vanadium

**084659 POWDER METALLURGY OF VANADIUM AND ITS ALLOYS (REVIEW).** The review covers various methods of producing powdered vanadium. The metallurgy of alloying is briefly discussed. The main findings of sintering experiments are summarized. Studies of various properties are identified. 40 refs.

Radomysel'skii, I.D. (Acad of Sciences of the Ukrainian SSR, USSR); Solntsev, V.P.; Evtushenko, O.V. *Sov Powder Metall Met Ceram* v 26 n 5 May 1987 p 367-372.

## Yugoslavia

**084660 SINTAL - YUGOSLAVIA'S GO-GETTING PM PRODUCER - PART 1.** Sintal was founded as a cooperative in 1946 under the name Masovmetal. The article is the first part of a review covering the production of hardmetal tools at Sintal's plant in Zagreb. Part 2, to be published in January 1988, will cover the production of sintered filters at the company's new plant in Oklaj.

Brookes, Kenneth J.A. (Int Carbide Data). *Met Powder Rep* v 42 n 12 Dec 1987 p 856-857, 860-862.

**084661 SINTAL - YUGOSLAVIA'S GOGETTING PM PRODUCER: PART 2.** Sintal is a member of UNIS, one of Yugoslavia's largest companies involved in the metals industry, Part 1 of this company profile was

published in the December 1987 issue of Metal Powder Report and described the company's activities in the production of hardmetal powders and cutting tools in Zagreb. Part 2 covers Sintal's recently established production facility for new PM products such as filters, hardfacing rods and contacts.

Brookes, Kenneth J.A. (Int Carbide Data). *Met Powder Rep* v 43 n 7-8 Jul-Aug 1988 3p.

## Zinc Aluminum Alloys

**084662 FABRICATION OF A MAGNETIC COMPOSITE MATERIAL FROM Zn-22Al SUPERPLASTIC POWDER.** Air atomized Zn-22Al superplastic powder and ferromagnetic barium ferrite powder were mixed with various mixing ratios and compacted in a closed die at room temperature or 250°C. The compacts were magnetized in a strong magnetic field and converted into a permanent magnet. Magnetic characteristics of the composite material were almost equal to those of conventional plastic magnets. The magnetic composite material, as opposed to the conventional plastic magnets, provides essentially metallic functions such as good electric conductivity and re-formability. (Author abstract) 6 refs. In Japanese.

Okimoto, Kunio; Satoh, Tomio; Horishi, Nanao. *J Jpn Soc Powder Powder Metall* v 35 n 2 Feb 1988 p 47-52.

**084663 IMPROVEMENT OF SUPERPLASTICITY OF Zn-22Al PRE-ALLOY POWDER BY THE USE OF RAPID SOLIDIFICATION TECHNIQUE AND HEAT-TREATMENT METHOD.** Zn-22Al pre-alloy powders were fabricated by air-atomized, argon-atomized and rapidly solidified methods. The rapidly solidified powder was fabricated by centrifugal atomization. To improve the superplasticity of the air-atomized and argon-atomized powders, rapid cooling after heating at 380°C for half an hour was attempted. Microstructures of the rapidly solidified and heat-treated powders were observed by an optical microscope, SEM and TEM. Compactibility of the rapidly solidified powder was inferior to that made from the air-atomized and argon-atomized powders because the shape was nearly spherical. However, the refinement and homogenization of the rapidly solidified powder was similar to that of the heat-treated powders and elongation reached about 1000 percent. (Edited author abstract). 10 Refs. In Japanese.

Satoh, Tomio; Okimoto, Kunio; Nishida, Minoru; Imamura, Kihachiro; Chiba, Akira. *J Jpn Soc Powder Powder Metall* v 35 n 3 Apr 1988 p 91-95.

## Zinc Compounds

**084664 PROMOTION OF ZnAl<sub>2</sub>O<sub>4</sub> FORMATION BY LiF: PART 1. EFFECT OF ALUMINA AND COMPACTION PRESSURE ON ZINC ALUMINATE FORMATION IN THE PRESENCE OF LITHIUM FLUORIDE.** The formation of ZnAl<sub>2</sub>O<sub>4</sub> in the presence of LiF was affected by the various states of Al<sub>2</sub>O<sub>3</sub> and by the compaction pressure. The rate curves showed a typical sigmoid form and were analysed by the Hancock and Sharp method. The results indicated a main process controlled by nucleation which is followed by a diffusion-controlled process. The effects of the aggregation or agglomeration state of Al<sub>2</sub>O<sub>3</sub> powder were examined with compaction pressures of up to 60 MPa. The amount of ZnAl<sub>2</sub>O<sub>4</sub> decreased with an increase in the degree of agglomeration or aggregation when the firing temperature was around 600°C but no effect was observed at higher temperatures. Similar effects were also observed for the compaction pressures. These effects are the result of the degree of formation of a liquid intermediate phase. (Edited Author abstract) 23 refs.

Hashiba, M. (Gifu Univ, Gifu, Jpn); Nurishi, Y.; Hibino, T. *J Mater Sci* v 23 n 2 Feb 1988 p 565-569.



**084665 PROMOTION OF  $ZnAl_2O_4$  FORMATION BY  $AlF_3$ .** Details of the formation of  $ZnAl_2O_4$  in the presence of  $AlF_3$  were studied for the purpose of elucidating the effect of fluoride anion on the reaction. In the  $ZnO-AlF_3$  binary system, sublimation of  $AlF_3$  and successive reaction of  $ZnO$  with  $AlF_3$  vapour were the first route of  $ZnAl_2O_4$  formation.  $ZnAl_2O_4$  formation with  $AlF_3$  was initiated at the  $ZnO-AlF_3$  interface as well as that of the  $ZnO-AlF_3$  binary system. This reaction was used to predict the formation of unstable zinc fluoride or zinc oxyfluoride. When the fluoride anions bound with zinc cations were transported to the surface of an  $Al_2O_3$  particle, the intermediate phase was formed at the site. In addition, the vapour transport of  $AlF_3$  to the  $ZnO-Al_2O_3$  interface was expected to form an intermediate phase containing fluoride anions such as  $Zn_xAl_yO_zF_y$  phase. The  $ZnAl_2O_4$  formation was promoted by the material transport through the intermediate phase around  $Al_2O_3$  particles. (Author abstract) 26 refs.

Hashiba, M. (Gifu Univ, Gifu, Jpn); Nurishi, Y.; Hibino, T. *J Mater Sci* v 23 n 2 Feb 1988 p 570-576.

**084666 CONTRIBUTION TO STUDYING MICROSTRUCTURAL CHANGE DURING SINTERING IN THE SYSTEM  $ZnO-B_2O_3$  USING QUANTITATIVE MICROSCOPIC METHOD.** Using a quantitative microscopic method, the effect of  $B_2O_3$  additive on the sintering of  $ZnO$  in the presence of a liquid phase was studied. The inhibitory action of  $B_2O_3$  on grain growth during isothermal sintering at  $1150^\circ C$  was established. Changes in the grain size and distribution during sintering are discussed. (Edited author abstract) 8 refs.

Vulicevic, Lj. (Faculty of Pedagogical-Technical Engineering, Cacak, Yugoslavia); Jordovic, B.; Andjelic, B.; Petrovic, V. *Sci Sintering* v 19 n 3 Sep 1987 p 161-165.

## Zirconium

**084667 EVALUATION OF PM PROCESSED ZIRCONIUM-2.5% NIOBIUM ALLOY.** Zirconium-2.5% niobium is an alloy commonly used in nuclear reactors and more recently chemical plants because of its corrosion resistance. As an alternative manufacturing method for producing certain irregular shapes more efficiently, the author has developed several different PM fabrication methods. Angular powder was prepared by the hydride-dehydride process. Spherical powder was manufactured by an electron beam atomization process. Microstructural and compositional variations were compared with conventional wrought processed material. Mechanical properties, corrosion behavior and weldability were also compared. 4 refs.

Wojcik, C.C. (Teledyne Wah Chang Albany, Albany, OR, USA). *Met Powder Rep* v 43 n 1 Jan 1988 p 39-40.

## Zirconium Compounds

**084668 NEUTRON DIFFRACTION ANALYSIS OF ULTRADISPERSE POWDERS OF ZIRCONIUM NITRIDE.** The article gives data on the specific surface of the powders as determined by thermal desorption of argon and data on the mean size of the particles of each nitride. The chemical formulae of the mixtures determined on the basis of the results of chemical and activation analyses and calculations are presented. These data show that the presence of the  $ZrO_2$  fraction confirms the value of the relative concentration of the nitrogen atoms in the nitride determined by chemical analysis. At the same time, the oxygen content of the dioxide is lower than its total content determined in activation analysis. On the basis of this result it may be assumed that parts of the oxygen atoms are distributed in the nitride. Several variants of the probable distribution of these atoms in the lattice were examined. 12 refs.

Petrinin, V.F. (Moscow Engineering & Physical Inst, USSR); Andreev, Yu.G.; Miller, T.N.; Grabis, Ya.P. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 767-772.

**POWDERS** See Also ALUMINA; BIOLOGICAL MATERIALS—Adsorption; CEMENT—Ultrasonic Applications; CERAMIC MATERIALS—Sintering; CHEMICAL EQUIPMENT—Fluidized Beds; CONVEYORS—Pneumatic; CRUSHING AND GRINDING; ELASTIC WAVES—Propagation; FLUIDS—Solutions; GASES—Suspensions; GRANULAR MATERIALS; GRANULAR MATERIALS—Consolidation; HYDROGEN—Storage; LIQUIDS—Bubble Formation; LITHIUM COMPOUNDS—Structure; NICKEL ZIRCONIUM ALLOYS—Amorphous; ORE TREATMENT—Crushing and Grinding; PARTICLE SIZE ANALYSIS; PHOSPHATES; POWDER METALLURGY—Copper; PROTECTIVE COATINGS—Electrostatic; PROTECTIVE COATINGS—Plasma Spraying; REFRACTORY MATERIALS—Zirconia; SEMICONDUCTING INDIUM COMPOUNDS—Amorphous; STEEL—Continuous Casting; SURFACES—Wear Resisting; ZIRCONIUM COMPOUNDS.

**084669 HODNOCENI FINALNI UPRAVY PRAS-KOVYCH MATERIALU - MERENI PRASIVOSTI.** [Evaluation of Finishing of Powdered Substances and Dustiness Measurement]. Methods applicable in the development of dust-free forms and low-dusting formulations of powdered chemical products are reviewed. A new method and equipment for objective dustiness measurement of powdered substances is described. (Edited author abstract) In Czech. 15 refs.

Docekal, Petr. *Chem Prum* v 37 n 8 Aug 1987 p 414-416.

**084670 THEORETICAL PREDICTIONS OF OPTICAL BEAM ATTENUATIONS IN POWDER PIPE FLOW.** A theoretical model was constructed to model the interaction of single powder particle with an optical beam. From the transmitted waveform as a function of time, information about particle size, location and velocity can be obtained. Two theoretical models for the time-averaged transmitted fraction of an optical beam are the equivalent particle model and Monte Carlo simulations. Good agreement was obtained between the predicted results of the two models. With information on channel width, optical beam size and particle size, particle density can be obtained. 9 refs.

Wan, Pak T. (McMaster Univ, Hamilton, Ont, Can); Chang, Jen-Shih. *Powder Technol* v 53 n 2 Dec 1 1987 p 121-126.

**084671 ON THE SEGREGATION MECHANISM OF PERCOLATING FINES IN COARSE-PARTICLE FLUIDIZED BEDS.** The effect of a percolation phenomenon on segregation of fines in fluidized beds was studied using experiments on representative fine/coarse model mixtures. The capability of a coarse particle bed to contain defined amounts of flotsam fines within its interparticle voids is demonstrated. Relationships between fine particle concentration, particle characteristics and fluidization velocity are discussed. (Author abstract) 12 refs.

Donsi, G. (Univ di Salerno, Salerno, Italy); Ferrari, G.; Formisani, B. *Powder Technol* v 55 n 2 Jun 1988 p 153-158.

**084672 DERIVATION OF NUMBER BASED SIZE DISTRIBUTION FROM MODIFIED MASS BASED ROSIN-RAMMLER DISTRIBUTION AND ESTIMATION OF THE VARIOUS MEAN PARTICLE DIAMETERS OF POWDER.** A new number based approximate equation is at least ten times more accurate for the expression of the modified Rosin-Rammler distribution than a previous equation. The equations for the calculation of the various mean particle diameters of the distributions have been derived. The various mean particle diameters can be also calculated in the cases of classification and blending of the powders. The present results are also applicable for other distributions such as grain and pore sizes. (Edited author abstract). 8 Refs.

Itoh, Takashi (Nagoya Univ, Nagoya, Jpn); Wanibe, Yoshimoto. *Trans Jpn Inst Met* v 29 n 8 Aug 1988 p 671-684.

**Additives** See POWDER METALLURGY—Iron.

**Agglomeration** See Also BARIUM TITANATE—Additives.

**084673 LOW FLOW RATE LABORATORY FEEDERS FOR AGGLOMERATIVE PARTICLES.** This communication has described the performance of a fluidization feeder and an entrainment feeder with  $Ca(OH)_2$ . The former has the advantage of higher solids concentration and lower carrier gas flow rates than the latter, but suffers the disadvantages of excessive noise from the vibrators and substantial particle agglomeration. In a system that can handle 2 to 3 l/min of carrier gas without an adverse impact upon the reactor environment, the entrainment feeder supplies a particle size distribution with little apparent sorbent agglomeration albeit at a lower, time-variant solids concentration. 3 refs.

Gullett, B.K. (US EPA, Research Triangle Park, NC, USA); Gillis, G.R. *Powder Technol* v 52 n 3 Oct 1987 p 257-260.

**084674 SEGREGATION AND AGGLOMERATION OF TYPE C POWDERS FROM HOMOGENEOUSLY AERATED TYPE A-C POWDER MIXTURES DURING FLUIDIZATION.** Impressive segregation and agglomeration of fine powders (Type C powders) were found during fluidization. Agglomerates precipitated from a homogeneous emulsion phase of Type A-C powder mixtures. These phenomena provide insights concerning the mixing mechanism of fine powders in aerated conditions in relation to the powder packing structure. (Edited author abstract) 10 refs.

Kono, H.O. (West Virginia Univ, Morgantown, WV, USA); Huang, C.C.; Morimoto, E.; Nakayama, T.; Hikosaka, T. *Powder Technol* v 53 n 3 Dec 15 1987 p 163-168.

**084675 EFFECT OF A STERICALLY STABILIZING SURFACTANT ON THE NUCLEATION, GROWTH AND AGGLOMERATION OF MONOSIZED CERAMIC POWDERS.** Hydroxypropyl cellulose (HPC) has been shown to provide steric stabilization during the precipitation of  $TiO_2$  from alcohol solution, allowing the precipitation of high solids loading of monosized particles by preventing agglomeration. The adsorption isotherm for HPC on  $TiO_2$  in ethanol was determined to account for the effect of HPC on the nucleation, growth and agglomeration of particles during the hydrolysis of titanium tetraethoxide in ethanol. Agglomeration is essentially prevented by HPC. (Author abstract) 21 refs.

Jean, J.H. (MIT, Cambridge, MA, USA); Ring, T.A. *Colloids Surf* v 29 n 3 Feb 15 1988 p 273-291.

**084676 STICKING AND AGGLOMERATION OF HYGROSCOPIC, AMORPHOUS CARBOHYDRATE AND FOOD POWDERS.** Sticking temperatures as a function of moisture content have been measured for various hygroscopic powders by use of a closed and agitated vessel held in a temperature bath. Earlier results reported by Downton, et al., for a mixture of sucrose and fructose have been extended to cover coffee extract and a mixture of maltodextrin, sucrose, and fructose. Results for these various substances are interpreted in terms of the Frenkel model and approximation, which postulate that these phenomena occur by a coalescence process, driven by surface energy and accomplished through viscous flow. The size of the interparticle bridge required for sticking is an important parameter in the analysis, and has been measured through use of scanning electron microscopy. (Author abstract) 23 refs.

Wallack, David A. (Univ of California, Berkeley, CA, USA); King, C. Judson. *Biotechnol Prog* v 4 n 1 Mar 1988 p 31-35.

**084677 SELECTION OF TEXTILE AUXILIARIES FOR REDUCING THE AGGLOMERATION OF CELLULOSE POWDER.** The authors describe the effect of TA (Textile Auxiliaries) which have been introduced in



the stage of hydrolysis of fiber waste on looseness of the powder. As a result of these studies, it was found that addition of the investigated TA during the hydrolysis of fiber waste reduces the bulk density of CP by 5-33% and essentially does not affect the sorption of water vapor by the powder. Oksamin L-15 and diethanolamine, introduced in the amount of 3% during the hydrolysis of the fiber waste, are effective additives. 2 refs.

Agafonova, L.L.; Glavochevskaya, R.A.; Egorova, R.V. *Fibre Chem v 19 n 3 May-Jun 1987 p 198-200.*

## Amorphous

**084678 NEW APPROACH FOR THE DESCRIPTION OF THE INITIAL-STAGE KINETICS DURING AMORPHOUS MATERIALS SINTERING.** The sintering process, considered from a rheological point of view has proved to be a characteristic example of a relaxation process, development of which is conditioned by the tendency of a dispersion system to reach an equilibrium state. Consequently, macrorheology is of particular importance for the sintering process of amorphous materials, as this process results from local deformation and material flow. On the basis of the general principles of rheological theory and Frenkel's law for viscous flow, an equation is derived which describes the initial sintering stages of amorphous materials by a viscous flow mechanism. 6 refs.

Ristic, M.M. (Serbian Acad of Sciences & Arts, Belgrade, Yugoslavia); Dragojevic-Nesic, M.J. *Powder Technol v 49 n 2 Jan 1987 p 189-190.*

**084679 PRODUCTION AND CONSOLIDATION OF AMORPHOUS Ni<sub>63.7</sub>Zr<sub>36.3</sub> POWDER AND AMORPHOUS Cu<sub>60</sub>Zr<sub>40</sub> RIBBON.** Cu<sub>60</sub>Zr<sub>40</sub> amorphous powder of 210µm in diameter and Ni<sub>63.7</sub>Zr<sub>36.3</sub> amorphous powder less than 38µm in diameter as well as Ni<sub>36.5</sub>Zr<sub>63.5</sub> amorphous powder less than 10µm in diameter can be prepared by a special Ar gas-water atomization device. As long as the temperature of a warm pressed die is lower than the glass temperature of the amorphous powder or ribbon, an amorphous billet with a density of more than 99 percent can be obtained. The density of a Ni<sub>63.7</sub>Zr<sub>36.3</sub> amorphous billet increases with increasing temperature and pressure of the warm pressed die. (Edited author abstract). 7 Refs. In Chinese.

Xing, Zhao-Jie (General Research Inst for Non-Ferrous Metals, Beijing, China); Murphy, R.J. *Xiyou Jinshu v 7 n 1 Feb 1988 p 70-74.*

## Analysis

**084680 MICROANALYSIS OF SOLID SAMPLES BY TOTAL-REFLECTION X-RAY FLUORESCENCE SPECTROMETRY.** Microgram quantities of different solid powders and smears of alloys were analyzed with total-reflection X-ray fluorescence spectrometry, a special variant of energy-dispersive X-ray fluorescence spectrometry. The samples were analyzed directly without chemical pretreatment. The method works simultaneously for about 20 elements. Quantitative analysis with internal standardization was executed with 10-50 mg of sample mass, but only microgram quantities were necessary for the determination. Results for standard reference materials such as coal fly ash, bovine liver, tomato leaves, and electrical furnace dust are reported. (Edited author abstract) 17 refs.

von Bohlen, Alex (Inst fuer Spektrochemie und Angewandte Spektroskopie, Dortmund, West Ger); Eller, Rudolf; Klockenkamp, Reinhold; Toelg, Guenther. *Anal Chem v 59 n 21 Nov 1 1987 p 2551-2555.*

**084681 ON THE DETERMINATION OF THE SURFACE FRACTAL DIMENSION OF POWDERS BY GRANULOMETRIC ANALYSIS.** We investigate the physical meaning of the exponent derived from the particle size (R) dependence of the surface area (S) of a solid powder, in cases where a power law S approximately R<sup>α</sup> is observed. In general, when the surface area is measured at constant apparent volume, α = D<sub>s</sub> - 3. D<sub>s</sub> is

the surface or textural fractal dimension of the particles, at least in the dimension range spanned by the particle size. On the other hand, when S is measured at constant mass, α = D<sub>s</sub> - D<sub>m</sub>, where D<sub>m</sub> is the mass fractal dimension of the particles, and the knowledge of D<sub>m</sub> is required in order to determine D<sub>s</sub>. D<sub>m</sub> is 3 either for compact or, on the opposite, for very porous particles in which the 'external' surface area is negligible with respect to the 'internal' surface area. In all the other cases, where the internal morphology of the particles is unknown, D<sub>m</sub> can be measured from the particle size dependence of the apparent density of the powder, ρ<sub>a</sub>, which scales as R<sup>D<sub>m</sub>-3</sup>. (Edited author abstract) 33 refs.

Van Damme, H. (Cent de Recherche sur les Solides a Organisation Cristalline Imparfait, Orleans, Fr); Levitz, P.; Gatineau, L.; Alcover, J.F.; Fripiat, J.J. *J Colloid Interface Sci v 122 n 1 Mar 1988 p 1-8.*

**Chemical Analysis** See CERAMIC MATERIALS—X-Ray Analysis.

## Classification

**084682 ON THE MINIMUM BUBBLING VOIDAGE AND THE GELDART CLASSIFICATION FOR GAS-FLUIDISED BEDS.** Reported experimental findings for the effect of systematic variation of all the relevant variables on the bubbling point of gas-fluidized beds are shown to be in agreement with the predictions of a general fluid dynamic stability criterion for fluidization. The criterion is also applied to the evaluation of the stabilizing effect of fines addition and, somewhat speculatively, to the prediction of the boundary between the Geldart Group A and Group C powders. (Author abstract). 33 Refs.

Gibilaro, L.G. (Univ Coll London, London, Engl); Di Felice, R.; Foscolo, P.U. *Powder Technol v 56 n 1 Sep 1988 p 21-29.*

## Coagulation

**084683 EFFECT OF COAGULATION ON STEADY-STATE BROWNIAN DIFFUSION FOR PARTICLES WITH A FRACTAL STRUCTURE.** The treatment of Simons concerning the effect of particle coagulation on steady-state Brownian diffusion in a fluid, is extended to cover the case of particles with a fractal structure. It is shown that if a particular dimensionless parameter E lies within certain limits then the spatial variation of φ, the volume fraction of particulate material, exhibits a maximum, while if E exceeds the upper limit no steady state can be set up. It is suggested that measurements of φ could be used for the experimental determination of the fractal dimensionality of coagulating clusters. (Author abstract) 5 refs.

Simons, S. (Queen Mary Coll, London, Engl). *J Phys D v 20 n 9 Sep 14 1987 p 1197-1199.*

**Compaction** See Also ACCELERATORS—Targets; AMMONIUM COMPOUNDS—Chemical Reactions; CERAMIC PRODUCTS—Manufacture; CERAMIC PRODUCTS—Performance; COMPOSITE MATERIALS—Mechanical Properties; DIAMONDS; FLOW OF FLUIDS—Granular Materials; POWDER METALLURGY; POWDER METALLURGY—Beryllium; POWDER METALLURGY—Computer Aided Analysis; REFRACTORY MATERIALS—Synthesis; SILICON NITRIDE—Compaction.

**084684 FEATURES OF THE THERMAL EXPANSION OF WATER IN PORES OF POWDERED AEROSIL.** Measurements of the thermal expansion of water in pores between particles of powdered Aerosil with a mean pore diameter of about 50 Angstrom have been described. A special version of Ur'ev's method for the vibratory compacting of powders was employed in order to eliminate the formation of aggregates of the particles. The results prove that the boundary layers of water at an oleophilic surface have a structure differing from the bulk structure. (Author abstract) 5 refs.

Deryagin, B.V. (Acad of Sciences of the USSR, Moscow, USSR); Karasev, V.V.; Chernomaz, V.E.; Ur'ev, N.B. *Colloid J USSR v 49 n 1 Jan-Feb 1987 p 11-13.*

**084685 COMPACTING POWDERED MIXTURES: A METHOD FOR INTENSIFYING CHEMICAL ENGINEERING PROCESSES.** The authors have devised and tested under laboratory conditions a method for compacting mixtures of fines of phosphorite, quartzite, and coke in a ratio providing for economically rational operating conditions for the electric furnaces used in phosphorous production. In this work, the manufacture of fiber glass and glass provide examples of the advantages of this compaction method. As a result of the analysis of the data obtained, three phases of consolidation were established: 1) consolidation due to elastic deformation of the framework of the powdered batch; 2) structural deformation of the components of the batch; and 3) destruction of the individual particles and the flow of components into the interior of the pressed material. It was established that there is a limiting pressure above which is observed the massive destruction of the particles of the batch, which leads to a rapid increase in energy expended for an insignificant increase in the density of the batch. 17 refs.

Chekhov, O.S. (Moscow Inst of Chemical Engineering, USSR); Kalygin, V.G.; Nazarov, V.I.; Shcherbin, N.V. *J Appl Chem USSR v 59 n 9 pt 1 Sep 1986 p 1838-1843.*

**084686 AUTOMATION TO THE FORE IN POWDER COMPACTING.** PTX-Pentronix of Lincoln Park, Mich., has introduced a new fully automatic hydraulic press system for powder compacting applications. The presses, which stem from Japan, are available from 20 to 1000 tons and can be custom modified to meet the user's specific needs. They are said to feature the latest advances in PC logic and also provide automatic part weight monitoring. This leads to decreased operator error with a consequent reduction of scrap to near zero and the manufacture of higher quality parts. Standard features of the system include: solid state controls; one-piece welded steel frame; withdrawal type die-set tooling; precision powder dispenser and safety devices (that meet or exceed OSHA standards). Optional features include: automatic robotic parts removal systems, quick die-set systems and an automatic weight monitoring and feedback system.

Anon. *Met Powder Rep v 42 n 9 Sep 1987 p 650.*

**084687 USE OF CUMULATIVE PORE VOLUME DIFFERENCE IN THE STUDY OF PORE CHANGES OCCURRING DURING COMPACTION OR SINTERING.** The feasibility of using differences in the cumulative pore volume distribution curves to monitor changes in the open pore size distribution as a result of the compaction of granules or the sintering of compacts has been studied. The cumulative pore volume difference distribution curve is obtained from the difference of two cumulative pore size distribution curves and illustrates clearly the pore volume difference at each pore size range. MnZn ferrite granules were used as an example. Increase and decrease of pore volume in larger and smaller pore size ranges respectively in sintering process and the opposite changes in compaction process were clearly recognized. The effect of the strength of granules in these processes was also studied. (Author abstract) 8 refs.

Kuno, H. (Keio Univ, Yokohama, Jpn); Tsuchiya, M. *Powder Technol v 52 n 3 Oct 1987 p 187-192.*

**084688 LE MAGNETOCOMPACTION DE POUDES: OBTENIR DES MATERIAUX INEDITS. [Electromagnetic Powder Compaction: Obtaining New Materials].** We present an experimental study on electromagnetic powder compaction. The classical method has been improved to give hybrid technique using both electromagnetic and impact phenomena. This technique is used to produce particulate composite materials. We have fabricated tubular aluminum-base compacts with dispersions of lead and indium up to 40% wt. Non-metallic phases like graphite, MoS<sub>2</sub> or PTFE have also been alloyed to metal matrices. In the same way we have made compacts including hard carbide particles in a cobalt or nickel matrix. These materials are interesting for their



tribological properties and we intend to use them for bearing applications. (Edited author abstract) 4 refs. In French.

Baccino, Regis (CEA, Fr); Parayre, Claude; David, Rene. *RGE Rev Gen Electr* n 9 Oct 1987 p 58-61.

**084689 AGGLOMERATE STRENGTH.** The bending strength of compacted powder samples was measured and compared with Rumpf's theory of agglomerate cohesion. It was discovered that the results could not be described by Rumpf's argument, which failed to account for the mechanism of failure, the pronounced effect of cracks, the problem of scatter in the strength determinations, the diameter dependence, and the volume fraction influence on strength. A new theory based on fracture mechanics analysis of an assembly of smooth adhesive elastic spheres gave a better fit to the data on titania and alumina powders. It is demonstrated that a perfect assemblage of particles should show a remarkably high strength. However, real assemblies are imperfect and weak because they contain small agglomerates which act as defects. Breakdown of these small agglomerates increases the strength of powder compacts substantially. (Author abstract) 23 refs.

Kendall, K. (ICI, Runcorn, Engl). *Powder Metall* v 31 n 1 1988 p 28-31.

**084690 OPTIMIERUNG DER FORMGEBUNG FÜR PULVERGEPRESSTE ERZEUGNISSE. II. PRESSENKONSTRUKTION UND WERKZEUGE.** [Optimization of the Compacting of Pressed-Powder Products]. The investments for the compacting process in the pressed-powder production depend on many factors. In the second part of a two part study, machine concepts are handled explaining the advantages and disadvantages of mechanic and hydraulic presses which make the decision on investments easier. Finally the pressing tools are discussed. (Edited author abstract) In German.

Fischer, E. (Dorst Maschinen- und Anlagenbau, Kochel am See, West Ger). *Keram Z* v 40 n 3 Mar 1988 p 165-168.

**Compressibility** See FOOD PRODUCTS—Analysis.

## Contamination

**084691 DETECTION OF METAL CONTAMINATION IN BULK POWDERS AND GRANULES.** Inspection of free-flowing bulk solids using high-performance metal detectors is an excellent method of eliminating metallic contaminants. A system may be installed where the product is falling freely by gravity, in existing pipework, or beneath a feed hopper. Machinery protection and improvement to product quality are metal detectors' prime benefits, but they also offer a supplement to consumer protection on finished-pack inspection. The article discusses the design and operating principles of vertical fall metal detectors. (Author abstract)

Lock, Andrew P. (AM Lock Inc). *Powder Bulk Eng* v 1 n 11 Nov 1987 p 11-13.

**Crushing and Grinding** See CERAMIC MATERIALS—Processing.

**Cryogenic Treatment** See CRUSHING AND GRINDING.

**Densification** See ALUMINA—Doping; CERAMIC MATERIALS—Sintering.

## Density

**084692 PARTICLE DENSITY DISTRIBUTION IN THE FREEBOARD OF A FLUIDIZED BED.** An experimental apparatus to measure the particle density distribution in the freeboard near the surface of a fluidized bed was developed. Experiments were carried out on a scale model of an atmospheric fluidized bed combustor. The magnitude and duration of gas jets at the bed surface were also measured. The density was found to decrease exponentially with height; the rate of decrease was higher at smaller values of  $U/U_{mf}$ . The mean size of the particles

in the freeboard did not change for heights up to 36 cm. The variation with density followed the variation in heat transfer to horizontal tubes in the freeboard. A particle trajectory model was developed using the in-bed particle size distribution for particles ejected into the freeboard under the action of the gas jet. The predicted rate of change of particle density with height agreed within 20% of the experimental value when the mean values of the measured jet velocity and duration were used in the model. The model was sensitive to the jet characteristics. (Author abstract) 12 refs.

Glicksman, L.R. (MIT, Cambridge, MA, USA); Piper, G.A. III. *Powder Technol* v 53 n 3 Dec 15 1987 p 179-186.

**Density Measurement** See CERAMIC MATERIALS—Sintering; REFRACTORY MATERIALS—Zirconia.

**Diffusion** See DIAMONDS—Oxidation.

**Drying** See DRYERS—Microwaves; REFRACTORY MATERIALS—Firing.

**Electric Properties** See GRANULAR MATERIALS—Electric Properties; SUPERCONDUCTING MATERIALS—Synthesis.

## Electrodeposition

**084693 ELECTRODEPOSITION OF CATALYTICALLY ACTIVE NICKEL POWDERS FROM ELECTROLYTES OF VARIOUS ANIONIC COMPOSITIONS.** The electrodeposition of nickel powders from different baths containing the same chemical constituents except for the anion was studied. The baths were based mainly on aqueous dilute solutions of nickel sulfate, chloride, iodide, nitrate and acetate. A detailed study was carried out to investigate the influence of these anions on the cathodic polarization curves, current efficiency, growth morphology and catalytic activity of the electrodeposited nickel powders. The characteristics tested were affected to different extents by the nature of the anion employed. (Edited author abstract) 23 refs.

Khalil, R.M. (King Abdulaziz Univ, Jeddah, Saudi Arabia). *J Appl Electrochem* v 18 n 2 Mar 1988 p 292-297.

**Encapsulation** See Also MONOMERS—Polymerization.

**084694 UNIFORM ENCAPSULATION OF FINE INORGANIC POWDER WITH SOAPLESS EMULSION POLYMERIZATION.** The encapsulation of inorganic powder of submicron sizes was attempted with soapless emulsion polymerization of methyl methacrylate in water in the presence of the powder. The powders used were barium sulfate and calcium carbonate. The polymerizations were initiated by potassium persulfate and by sodium bisulfite-oxygen redox reaction. The encapsulation state of the powder with the polymer formed varied considerably with the initiators used. With potassium persulfate initiator the powder surface was partially or totally covered by polymer particles, while with redox initiator under air atmosphere the powder surface was well encapsulated with a film-like polymer layer. From the differences in the encapsulation states, an encapsulation mechanism is suggested for each initiator system. Based upon this mechanism, a new encapsulation process capable of covering uniformly fine powders with a film polymer is proposed. (Edited author abstract) 14 refs.

Hasegawa, Masahiro (Tohoku Univ, Sendai, Jpn); Arai, Kunio; Saito, Shozaburo. *J Polym Sci Part A* v 25 n 11 Nov 1987 p 3117-3125.

**084695 EFFECT OF SURFACTANT ADSORBED ON ENCAPSULATION OF FINE INORGANIC POWDER WITH SOAPLESS EMULSION POLYMERIZATION.** The encapsulation of fine inorganic powder was carried out with the soapless emulsion polymerization of methyl methacrylate in water in the presence of the powder, a layer of surfactant being

adsorbed. The powder used was titanium dioxide. Surfactants added prior to the polymerization were sodium dodecyl sulfate, dodecyltrimethyl ammonium bromide, and polyoxyethylene sorbitan mono-oleate. The encapsulation state of the powder with polymer was closely related to the amount of surfactant adsorbed on the powder; and an amount of adsorption above a certain value was necessary for uniform encapsulation. (Edited author abstract) 15 refs.

Hasegawa, Masahiro (Tohoku Univ, Sendai, Jpn); Arai, Kunio; Saito, Shozaburo. *J Polym Sci Part A* v 25 n 12 Dec 1987 p 3231-3239.

## Evaluation

**084696 EVALUATION OF THE POLISHING POWER OF MICROPOWDERS FROM THE SURFACE ROUGHNESS AS DETERMINED OPTICALLY.** The polishing powers of micro- and submicro diamond and Cubonite powders of grain size 2/1 and 5/3 in machining AK6 aluminum alloy and MO6 copper are compared, using the roughness of the polished surface as determined from scattering of a light flux as a starting point. The practical results obtained provide a basis for recommending this optical method of determining surface roughness for evaluating the polishing power of the micro- and submicro powders. (Author abstract) 2 refs.

Orap, A.A.; Koshkin, A.M.; Sokhan, S.V.; Stakhniv, N.E.; Shchelchikov, S.N. *Sov J Superhard Mater* v 9 n 5 1987 p 43-46.

## Explosions

**084697 IGNITABILITY AND EXPLOSIBILITY OF POLYESTER/EPOXY RESINS FOR ELECTROSTATIC POWDER COATING.** A comprehensive investigation of ignitability and explosibility properties of 11 polyester/epoxy resin powders used in electrostatic powder coating has been carried out. The powders differed with respect to the ratio of polyester to epoxy, pigment type, pigment content, density and particle size distribution. The powders were tested in the closed Hartmann bomb for establishing the maximum explosion pressure and the maximum rate of pressure rise, in the open Hartmann tube fitted with the CMI electric spark generator for measurement of the minimum ignition energy, and in the 'Nordtest Fire 011' apparatus for determination of the minimum explosible dust concentration. All the powders gave approximately the same maximum explosion pressures in the Hartmann bomb, whereas the maximum rate of pressure rise decreased with increasing pigment content and particle size. Clouds in air of all the resins had quite low minimum ignition energies. (Edited author abstract) 17 Refs.

Eckhoff, Rolf K. (Chr. Michelsen Inst, Bergen, Norw); Pedersen, Geir H.; Arvidsson, Tommy. *J Hazard Mater* v 19 n 1 Jul 1988 p 1-16.

## Fabrication

**084698 REACTION OF ACTIVE URANIUM AND THORIUM WITH AROMATIC CARBONYLS AND PINACOLS IN HYDROCARBON SOLVENTS.** Highly reactive uranium and thorium metal powders have been prepared by reduction of the anhydrous metal(IV) chlorides in hydrocarbon solvents. The reduction employs the crystalline hydrocarbon-soluble reducing agent [(TMEDA)Li]<sub>2</sub>[Nap]. The resulting active metal powders have been shown to be extremely reactive with oxygen-containing compounds and have been used in the reductive coupling of aromatic ketones giving tetra-arylethenes. Reactions with pinacols have given some mechanistic insight into the ketone coupling reaction. These finely divided metal powders activate very weakly acidic C-H bonds forming metal hydrides, which can be transferred to organic substrates. (Edited author abstract) 95 refs.

Kahn, Bruce E. (Univ of Nebraska-Lincoln, Lincoln, NE, USA); Rieke, Reuben D. *Organometallics* v 7 n 2 Feb 1988 p 463-469.



**Flocculation** See CERAMIC MATERIALS—Suspensions.

**Fluidization** See Also CHEMICAL EQUIPMENT—Fluidized Beds; CHEMICAL OPERATIONS—Fluidization; HEAT TRANSFER—Fluidized Beds.

**084699 GAS-SOLIDS CONTACT EFFICIENCY IN A HIGH-VELOCITY FLUIDISED BED.** The efficiency of contact between gas and solid phases in a high-velocity fluidised bed of fluidised catalytic cracking (FCC) catalyst has been measured. The technique involves the use of heated gas as a reacting tracer and detection of this hot gas by a rapid-response thermocouple. The resulting measurement indicates how much gas emerges at the outlet from the bed without having come into contact with any solid particles. This type of information has significant implications for the design and operation of commercial high-velocity systems. A simple model is used to estimate the ratio of effective to actual particle surface area in the bed, and this defines a surface efficiency. (Edited author abstract) 18 refs.

Dry, R.J. (Monash Univ, Clayton, Aust); Christensen, I.N.; White, C.C. *Powder Technol* v 52 n 3 Oct 1987 p 243-250.

**084700 BEHAVIOUR OF LARGE JETSAM PARTICLES IN FLUIDISED BEDS.** The behaviour of segregated jetsam particles and their effect on gas flow is not well understood. This note reports observations made in large two-dimensional and rectangular beds of the effect of a significant quantity of jetsam material. The results show that piles of large jetsam particles present a gas path of lower resistance than the sand bed. This is clearly the reason for the gas maldistribution caused by the jetsam: gas flows preferentially through the parts of the distributor covered by jetsam, to form a local spout or bubble track above each jetsam pile. 8 refs.

Carter, B. (Univ of Surrey, Guildford, Engl); Ghadiri, M.; Clift, R.; Jury, A.W. *Powder Technol* v 52 n 3 Oct 1987 p 263-266.

**084701 MIXING AND SEGREGATION KINETICS IN A STRONGLY SEGREGATED GAS-FLUIDIZED BED.** The rate of approach to steady state of a gas-fluidized bed composed of a mixture of iron and glass particles was determined, starting from both initially fully mixed and initially completely segregated conditions. The data were interpreted using a model based on a pure jetsam stratum underlying a uniform stratum of mixed composition. The model allowed calculation of the average upward velocity of jetsam particles across the interface between the strata, and of the average downward velocity of jetsam particles in the upper stratum. With some exceptions, values of two parameters calculated using the two types of runs agreed well. The mean upward jetsam velocity at the interface and the jetsam descent velocity in the upper stratum were both found to be strongly increasing functions of the excess fluidization velocity. (Author abstract) 11 refs.

Beekmans, J.M. (Univ of Western Ontario, London, Ont, Can); Stahl, B. *Powder Technol* v 53 n 1 Nov 1987 p 31-38.

**084702 HIGH-PRESSURE PARTICULATE EXPANSION AND MINIMUM BUBBLING OF FINE CARBON POWDERS.** Particulate expansion and minimum bubbling parameters are measured for fine carbon powders fluidized with synthesis gas at pressures within the range  $2,070 < P < 12,420$  kPa in an industrial, pilot-scale fluidized bed. Deviations between minimum bubbling and minimum fluidization conditions increase with increasing pressure,  $P$ . The expansion index,  $n$ , decreases with increasing  $P$  and always exceeds values recommended by J.F. Richardson and W.N. Zaki for solid/liquid systems. (Edited author abstract) 42 refs.

Jacob, K.V. (Dow Chemical USA, Midland, MI, USA); Weimer, A.W. *AIChE J* v 33 n 10 Oct 1987 p 1698-1706.

**084703 MODEL FOR THE CIRCULATING FLUIDIZED BED.** A model for the hydrodynamics of

circulating fluidized beds is proposed. The model combines existing entrainment and bed expansion correlations with a system pressure balance. Starting from a knowledge of the powder size distribution, particle density, gas velocity, equipment geometry and solids inventory, the variation of voltage within the riser is predicted together with distribution of solids between the riser and supply hopper (or 'slow' bed). Qualitative trends with gas velocity and solid circulation flux show good agreement with experiment but better quantitative agreement must await the development of an improved correlation for entrainment. (Author abstract) 17 refs.

Rhodes, M.J. (Univ of Bradford, Bradford, Engl); Geldart, D. *Powder Technol* v 53 n 3 Dec 1987 p 155-162.

**084704 STUDY OF FINE PARTICLES RESIDENCE TIME IN A JETTING FLUIDIZED BED.** Experiments were carried out to study the residence time of fine particles in a 30-cm dia. laboratory fluidized bed. Fines -170 +230 mesh with an average size of 75  $\mu$ m were injected both radially and coaxially to simulate different fines recycle possibilities in an operating unit at two different bed heights and three different bed operating conditions. It was found that the transitory time of fines from the bed surface to the collecting cyclone dipleg and filter dominated the characteristic particle collection times. The true residence time in the bed is on the order of 10 to 20 s. (Edited author abstract) 8 refs.

Yang, Wen-Ching (Westinghouse Electric Corp, Pittsburgh, PA, USA); Keairns, D.L. *Powder Technol* v 53 n 3 Dec 1987 p 169-178.

**084705 EFFECT OF PRESSURE ON BUBBLE PARAMETERS IN GAS-FLUIDIZED BEDS.** The effect of system pressure on bubble parameters (bubble frequency, velocity and size) was determined in a 15-in dia. fluidized bed. System pressures were varied over a range of 5 to 450 psig. The effects of particle size, particle density, gas velocity and bed height on the bubble characteristics were also determined. Bubble size decreased with pressure while bubble frequency increased with pressure. (Author abstract) 18 refs.

Chan, I.H. (Inst of Gas Technology, Chicago, IL, USA); Sishla, C.; Knowlton, T.M. *Powder Technol* v 53 n 3 Dec 1987 p 217-235.

**084706 FLUIDIZATION STATE OF ULTRAFINE POWDERS.** The fluidity of submicron powders was studied in a small-scale transparent column. Powders of Ni, Si<sub>3</sub>N<sub>4</sub>, SiC, Al<sub>2</sub>O<sub>3</sub> and TiO<sub>2</sub> were smoothly fluidized when gas velocity exceeded the apparent minimum fluidization velocity. The electrical conductivity of the particles did not affect the fluidizing quality in the range of the present experiments. All the tested submicron particles formed agglomerates during fluidization. The agglomerate size and the apparent minimum fluidization velocity were dependent on species of particles and fluidizing gas. The equilibrium size of agglomerates calculated from the apparent minimum fluidization velocity and the sedimentation velocity was in the range of 70-700  $\mu$ m. However, the agglomerates of CaCO<sub>3</sub> and ZrO<sub>2</sub> were very cohesive and could not be evaluated. The primary particle size was not a proper measure for the classification of the particles. (Author abstract) 16 refs.

Morooka, Shigeharu (Kyushu Univ, Fukuoka, Jpn); Kusakabe, Katsuki; Kobata, Atsuo; Kato, Yasuo. *J Chem Eng Jpn* v 21 n 1 Feb 1988 p 41-46.

**084707 FLUIDIZATION BEHAVIOUR OF FINE POWDERS AND THE CRITERION OF CLASSIFICATION OF GROUP C POWDERS.** Based on the experimental curves of  $\Delta P_B - U$  of various kinds of fine powders (FCC, AN catalyst, Al<sub>2</sub>O<sub>3</sub>, alum and limestone powders) belonging to the C group of Geldart's classification, the effect of cohesive forces between the particles on fluidization behavior has been investigated. It was found that the intersection point of  $\Delta P_{B, \max}$  VS  $\text{avg } d_p$  line and  $\Delta P_B$  VS  $d_p$  line gives more precisely the boundary value of  $\text{avg } d_p$  between A group and C group particle regions, and thus the present criterion can be used for classification

of C group particles. (Edited author abstract) In Chinese. 8 refs.

Wang, Zhangmou (Zhejiang Univ, China); Chen, Wei; Chen, Gantang; Zhang, Bing; Yan, Huiqing. *Huaxue Fanying Gongcheng yu Gongyi* v 4 n 1 Mar 1988 p 89-92.

**084708 NORMAL BUBBLING OF FINE CARBON POWDERS IN HIGH-PRESSURE FLUIDIZED BEDS.** Normal bubbling velocity, and normal bubbling voidage, are determined from analyses of bed expansion measurements carried out at higher  $u_0$ . Measurements of relative localized fluctuations in bed density are also reported. All measurements were made by means of a nonintrusive rapid-response nuclear radiation density gauge. 5 Refs.

Jacob, Karl V. (Dow Chemical USA, Midland, MI, USA); Weimer, Alan W. *AIChE J* v 34 n 8 Aug 1988 p 1395-1397.

**Forging** See Also POWDER METALLURGY—Aluminum.

**084709 COMPUTER MODEL FOR PREDICTING DENSIFICATION IN POWDER FORGING.** Of the many forming processes involved in powder metallurgy (PM), hot forging is particularly effective in permitting the rapid transformation of powder compacts into full density parts. The program has been used to calculate values for the grain aspect ratio of the connecting rod which were then compared with those values measured on the actual part. Maximum deformation was predicted to occur in the shank and although only two dimensions rather than three are taken into account CEMEF believes that the shank should have good mechanical properties with well broken up oxide layers.

Anon. *Met Powder Rep* v 43 n 6 Jun 1988 p 432.

**Freezing**

**084710 DETERMINING THE THERMOPHYSICAL PARAMETERS OF MEDIA THAT FREEZE.** There are changes in the phase state of pore water in a powder medium in the region of the phase-transition temperature, and this can affect all the physicochemical properties, including the thermophysical ones. In many heat-engineering calculations, one requires the values for the thermophysical parameters and the heats of phase transitions, which are used separately. The article shows how to determine the temperature dependence of the conductivity for a moist powder medium in the phase-transition region with allowance for the latent heat of the transition in the form of heat sinks in an equation having nonlinear coefficients. 5 refs.

Stepanov, A.V.; Timofeev, A.M.; Filippov, P.I. *Meas Tech* v 30 n 5 May 1987 p 461-464.

**Friction** See POWDER METALLURGY.

**Fuels** See FUEL BURNERS—Design.

**Granulation**

**084711 GRANULATION OF AN INSOLUBLE POWDER IN A SPOUTED BED.** Granulation of a finely ground phosphatic rock in a spouted bed has been carried out. Granule size distribution, sphericity and crushing strength have been measured against granulation time for temperatures between 80 and 140°C and concentrations of corn starch (retention agent) between 0 and 1.8 wt.%. The granule growth rate increased with increasing starch content and was not sensitive to temperature. Particle crushing strength increased with granulation time and starch content. The sphericity of the granules increased with granulation time. The elutriation rate decreased with starch content. Granule size increased exponentially with granulation time. (Edited author abstract) 7 refs.

Pavarini, P.J. (UFSCar, Sao Carlos, Brazil); Coury, J.R. *Powder Technol* v 53 n 2 Dec 1 1987 p 97-103.



**084712 PRECONDITIONING PROCESS POWDERS WITH DRY GRANULATION.** Dry granulation offers powder processors the advantages of controlled particle size, hardness, and density. It also improves dust control and material flow characteristics and aids product solubility and dispersability. This article describes the dry granulation process and discusses its benefits in contrast with conventional preconditioning techniques. (Author abstract)

Johnson, Calvin E. (Fitzpatrick Co). *Powder Bulk Eng* v 1 n 12 Dec 1987 p 14-17.

**084713 GRANULATION OF PARTIALLY PREWETTED ALUMINA POWDERS - A NEW CONCEPT IN COALESCENCE MECHANISM.** The proposed granulation mechanism elucidates the significance of the structure heterogeneity of the granulation feed on granule growth by coalescence. The structure heterogeneity of the fine alumina powders at various water-powder ratios was investigated by moisture distribution and tensile strength measurements. The granulation characteristics were also observed in a spouted fluidized bed granulator. Experimental data support the proposed mechanism. (Edited author abstract) 30 refs.

Huang, Ching-Chung (West Virginia Univ, Morgantown, WV, USA); Kono, H.O. *Powder Technol* v 55 n 1 May 1988 p 19-34.

**084714 MATHEMATICAL COALESCENCE MODEL IN THE BATCH FLUIDIZED BED GRANULATOR.** The granule porosity and voidage saturation (the volume percentage of the voidage filled with liquid in a granule) are two factors to determine the surface moisture of colliding granules necessary for granule growth by coalescence. The structure heterogeneity of the granulation feed is able to induce a porosity reduction by colliding granules. As a result, surface moisture is formed between the colliding granules. In this study, the coalescence mechanism model for heterogeneous granulation feed was applied. A coalescence probability function and a non-dimensional model predicting granule growth rate were obtained. Employing experimental correlations, dimensional model predictions can be obtained and are in agreement with reported data. (Edited author abstract) 33 refs.

Huang, Ching-Chung (West Virginia Univ, Morgantown, WV, USA); Kono, H.O. *Powder Technol* v 55 n 1 May 1988 p 35-49.

**Grinding** See Also ZINC COMPOUNDS—Spectroscopic Analysis.

**084715 FUNDAMENTAL STUDY OF DRY AND WET GRINDING FROM THE VIEWPOINT OF BREAKING STRENGTH.** The preparation of fine powders by grinding may be accomplished by either a dry or a wet process and the differences between these have been discussed. In this paper, bending tests were carried out on glass material in order to investigate the difference between dry and wet grinding. The quantitative effects of water on bending strength, and of crack propagation on glass surface, and the relationship between the bending strength and the number of cracks were studied fundamentally. As a result, it was found that the wet strength is less than the dry, the crack length in water is larger than that in air and a wet grinding process is useful from the point of view of strength of solids. (Edited author abstract) 24 Refs.

Kanda, Y. (Yamagata Univ, Yonezawa, Jpn); Abe, Y.; Yamaguchi, M.; Endo, C. *Powder Technol* v 56 n 1 Sep 1988 p 57-62.

**Heating** See Also ZIRCONIUM COMPOUNDS—Heat Treatment.

**084716 HEATING OF POWDERS IN AN R.F. INDUCTIVELY COUPLED PLASMA UNDER DENSE LOADING CONDITIONS.** A study was carried out of the heating of powders in an r.f. inductively coupled plasma under dense loading conditions. The results obtained using a mathematical model taking into

account plasma-particle interaction effects reveal an important cooling of the plasma caused by the presence of the particles. This, in turn, gave rise to a corresponding drop of the efficiency of the melting of the particles in the plasma. The effect is shown to depend strongly on the thermodynamic properties of the material of the powder. (Author abstract) 25 refs.

Proulx, Pierre (Univ de Sherbrooke, Sherbrooke, Que, Can); Mostaghimi, Javad; Boulos, Maher I. *Plasma Chem Plasma Process* v 7 n 1 Mar 1987 p 29-52.

**Hot Pressing** See POWDER METALLURGY—Titanium; SUPERCONDUCTING MATERIALS—Density.

**Injection Molding** See POWDER METAL PRODUCTION—Heat Treatment.

**Iron** See POWDER METALLURGY—Sintering.

## Magnetic Field Effects

**084717 EFFECT OF UNIFORM MAGNETIC FIELD ON PACKING OF MAGNETIZABLE GRANULAR MEDIA.** The packing of magnetizable powders is strongly influenced by uniform magnetic fields. At a superficial magnetic flux density of 50 Gauss, the apparent and tapped densities of some powders (in the 50-100  $\mu$ m size range) are decreased by approx. 10 percent and approx. 20 percent, respectively. This magnetic-field-coupled packing, strongly influenced by particle size and shape, is hysteretic, in that the final packing density depends on when the magnetic field is applied during the tapping. The results suggest that a magnetic field can influence powder flows in two ways: an anisotropic inter-particle force (which directly influences cohesion) and a decrease in packing (which influences shear flow). (Edited author abstract) 21 Refs.

Jones, T.B. (Univ of Rochester, Rochester, NY, USA). *Powder Technol* v 56 n 1 Sep 1988 p 31-39.

**Magnetic Properties** See Also MAGNETIC MATERIALS—Reviews.

**084718 PREPARATION AND APPLICATION OF  $Fe_3O_4$  COLLOIDAL SOLUTIONS SUITABLE FOR THE COLLOID-SEM METHOD (A METHOD FOR OBSERVING FINE MAGNETIC DOMAINS).** Magnetite ( $Fe_3O_4$ ) colloidal solutions suitable for the colloid-SEM method for observing fine magnetic domains have been prepared.  $Fe_3O_4$  powders were co-precipitated from  $FeSO_4$ ,  $FeCl_3$  and NaOH solutions in a magnetic field of about 200 kA/m. Examples of domain patterns using some of these solutions are shown for a  $Sm(Co_{0.64}Fe_{0.28}Cu_{0.06}Hf_{0.02})_{7.1}$  sintered magnet and small  $SmCo_5$  particles. (Edited author abstract) In Japanese. 17 refs.

Sakurai, Tomoaki (Tohoku Univ, Sendai, Jpn); Goto, Kimiyoshi; Inoue, Tetsuo. *Nippon Kinzoku Gakkaishi* v 51 n 8 Aug 1987 p 774-777.

**084719 MECHANICS OF MAGNETIC POWDERS.** The focus of this paper is magnetic tumbling. The authors used a flow visualization cell to study the phenomenology of magnetic tumbling and metering. An experiment is described which uses the flow cell to measure magnetic tumbling on a sleeve. Quantitative analysis of the data provides guidance in formulation of a surface effect hypothesis that seems to be consistent with the observed behavior. A theoretical model for the electromechanics of a layer of magnetic particles situated over a rotating cylindrical harmonic magnet is formulated and its predictions are compared with experimental results. 15 refs.

Jones, T.B. (Xerox Corp, Webster, NY, USA); Whittaker, G.L.; Sulenski, T.J. *Powder Technol* v 49 n 2 Jan 1987 p 149-164.

**Manufacture** See Also COBALT ORE TREATMENT—Reduction; POWDER METALLURGY; POWDER METALLURGY—Densification; POWDER METALLURGY—Nickel Chromium Molybdenum Alloys; POWDER METALLURGY—Steel.

**084720 NONEQUILIBRIUM PLASMA IN POWDER TREATMENT PROCESSES.** A feature of the physicochemical powder treatment processes investigated by the authors is that energy is 'pumped' from the outside into a prepared gas mixture which is at a low pressure. Such systems are characterized by a high level of energy of electrons and a high concentration of excited and charged particles at a low temperature of a neutral gas. By combining such conditions, it is possible to perform some unique process of synthesis of various inorganic substances. A difficulty arising with nonequilibrium plasma-chemical processes is their optimization, for which it is necessary both to determine the internal parameters of plasma and to calculate the kinetics of physicochemical processes. Devices employing nonequilibrium plasma excited at reduced pressures can be successfully used for the production and treatment of powders of various chemical compositions. 10 refs.

Folmanis, G.E. (Acad of Sciences of the USSR, USSR); Shorshorov, M.Kh. *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 282-284.

**084721 CARTRIDGE FILTER COLLECTORS HANDLE HAZARDOUS DUSTS - SAFELY.** An aluminum powder manufacturer has combined its cyclones with filter collectors to create a dust collection system that ensures employee safety and meets customers' product fineness requirements. The filter collector's split-housing design eliminates safety problems. The top section, including filter elements, can be lifted to a remote outdoor area where maintenance can be done in the open.

Anon. *Powder Bulk Eng* v 1 n 12 Dec 1987 p 18-21.

## Mass Transfer

**084722 AUTOMATED POWDER MASS FLOW MONITORING AND CONTROL SYSTEM.** Much of the industry's effort has been directed toward regulatory systems based on the weight loss of the powder feeder. The technology described in this paper presents the alternative of measuring powder mass flow independent of the powder feeder. This paper presents both means of powder mass flow measurement with an emphasis on the latter system's operating principles and characteristics, and the results of benchmark tests using various types of powder feeders and powders. The results are summarized and supported with data and graphs depicting accuracy and precision of the powder mass flow monitors as well as illustrations of the powder feeder closed-loop control enhancements. (Edited author abstract) 3 refs.

Saenz, J.A. (Garrett Corp, Phoenix, AZ, USA). *Surf Coat Technol* v 34 n 1 Jan 1988, Pap Presented at NTSC87, The Natl Therm Spray Conf and Expo, Orlando, FL, USA, Sep 14-17 1987 p 89-99.

**Materials** See Also ELECTRODES—Coatings.

**084723 COLOR CHARACTERISTICS OF SYNTHETIC DIAMOND GRINDING POWDERS.** The results of measuring the color characteristics of synthetic diamonds are given. It is shown that the color tones of crystals obtained in different growth systems differ insignificantly and that the brightness depends markedly on the presence of a darkening film and the surface microtopography, while the purity of tone is higher with the more perfect diamonds, and can serve for indirect determination of their quality. The color parameters of the diamonds studied are compared with their physicochemical characteristics. (Author abstract) 4 refs.

Bogatyeva, G.P.; Gatilova, E.G.; Bazalii, G.A. *Sov J Superhard Mater* v 9 n 4 1987 p 46-49.

**084724 HIGH TEMPERATURE OXIDATION OF ULTRAFINE TITANIUM NITRIDE POWDERS.** The high temperature oxidation of titanium nitride powders of particle size 1-2 and about 10  $\mu$ m is studied. It is concluded that the degree of dispersion of the titanium nitride powders has a marked effect on the nature of their



interaction with atmospheric oxygen and on corrosion resistance. The interaction of atmospheric oxygen with titanium nitride having a particle size of about 10  $\mu\text{m}$  the contribution of its surface to the free energy is small. Because of this the oxide (in its less stable form) does not arise at low temperatures. (Edited author abstract) 8 refs.

Lavrenko, V.A.; Alekseev, A.F.; Neshpor, V.S.; Bogdanov, V.S.; Kondrashev, Yu.D.; Zhidkova, T.G. *Sov J Superhard Mater* v 9 n 4 1987 p 50-54.

**084725 PROBABILITY-STATISTICAL EVALUATION OF THE STRENGTH PROPERTIES OF DIAMOND POWDERS.** A method is proposed in this paper for predicting the conditions required for increasing the strength of diamond powders with rejection of weak grains. The method is based on a mathematical relation connecting the diamond strength distribution factors in the original and treated batches with its limiting values  $P_{li}$ , i.e., the minimum permissible strength of grains in the treated batches. In obtaining the relations it was assumed that in the original (general) totality of diamonds the static strength of the crystals is normally distributed, while the mean arithmetic value of the strength  $P_0$  and its mean square deviation  $\sigma_0$  are known. 3 refs.

Tkhagapsoev, Kh.G.; Yakhutlov, M.M.; Oshkhunov, M.M.; Goov, A.A.; Khazhiev, V.Sh. *Sov J Superhard Mater* v 9 n 4 1987 p 55-59.

**084726 PREPARATION AND CHARACTERIZATION OF MgO POWDERS HAVING  $\text{Ca}^{2+}$  OR  $\text{Ba}^{2+}$  AS SURFACE DOPANTS.** This paper presents results of experiments aimed at: (i) preparation of powdered MgO materials having monolayer amounts of CaO or BaO segregated upon their surfaces; and (ii) testing whether such monolayer-doped  $\text{Ca}^{2+}/\text{MgO}$  and  $\text{Ba}^{2+}/\text{MgO}$  materials exhibit physical and/or chemical properties indicative of the 'rumpling' favoured by computations. Chemical comparisons made between surface reactivities of  $\text{Ca}^{2+}/\text{MgO}$  and  $\text{Ba}^{2+}/\text{MgO}$  versus the pure MgO support include: liability of surface oxide ions, as manifested in ease of heterophase oxygen isotope exchange at 623-873 K, and relative activities for oxidative coupling of methane at 923-958 K. (Edited author abstract) 18 refs.

Cunningham, Joseph (Univ Coll, Cork, Irel); Healy, Con; McNamara, David; O'Brien, Sarah. *Catal Today* v 2 n 5 Apr 1988, New Methods of Catal Prep and Character, Proc of the Surf React and Catal Meet, Uxbridge, Engl, Sep 14-16 1987 p 557-567.

**Measurements** See Also PARTICLE SIZE ANALYSIS.

**084727 ACCURACY EVALUATION FOR METHODS OF DISPENSING POWDERS BY WEIGHT.** Batch dispensing by weight is a major operation in many technological processes; the various methods have been described but the accuracy aspects have not been fully examined. In batch dispensing, the set batch of mass is produced by feeding the material from a bunker to a weighing device (WD) set up on an automatic balance. When the mass in the WD agrees with some set value, a command is issued to halt the supply (switch off the feed), and the batch is considered as dispensed. An attempt was made to estimate the accuracy of weighed batches of powders. 2 refs.

Gal'Chenko, V.D.; Polunov, Yu.D.; Fufaev, Yu.N. *Meas Tech* v 30 n 2 Feb 1987 p 137-139.

**084728 SIMPLE LIGHT-PROBE METHOD FOR QUANTITATIVE MEASUREMENTS OF PARTICLE VOLUME-FRACTIONS IN FLUIDIZED BEDS.** An improved light probe system in conjunction with an IBM PC interfacing system and two proposed calibration techniques provides an efficient and inexpensive method for measuring the volume fraction distribution and its statistical fluctuation (standard deviation) in fluidized beds. The results suggest that traditional mechanical recorders can give misleading information for acquiring data output from a light probe. This is mainly due to the fast fluctuating character of the fluidizing system and the slow response time of many traditional recorders. 7 refs.

Yang, J.-S. (Liu, Y.A.); Squires, A.M. *Powder Technol* v 49 n 2 Jan 1987 p 177-187.

**Mechanical Properties** See Also COMPOSITE MATERIALS—Wear; SILICA.

**084729 MECHANICAL BEHAVIOUR OF GRAPHITE POWDER.** The wear particles appearing between two solids in dry friction are thought to have a great influence on the running of a contact. To study the mechanical properties of such particles usually called a third body, cyclic shear tests were performed on precompact graphite powder with both a three-dimensional pressing machine and a direct shear box. The results provided by the two types of apparatus and their comparison with classical friction measurements are discussed with the aim of improving the understanding of dry friction mechanisms in the sense of the third body theory. (Author abstract) 6 refs.

Bouvard, D. (Inst Mecanique de Grenoble, St.-Martin d'Heres, Fr); Lanier, J.; Stutz, P. *Powder Technol* v 54 n 3 Mar 1988 p 175-181.

**084730 MEASUREMENT OF POWDER COHESIVE STRENGTH WITH A PENETRATION TEST.** An assessment was made of the utility of a cone penetrometer technique for measurement of the cohesive caking strength of a powder. Results from a shear cell are compared with those from a penetrometer using five different types of powder. Comparison of shear cell and penetrometer data showed that there was a reasonable correlation between the two techniques. The powders used were detergent, sodium perborate, sodium triphosphate and sodium aluminosilicate. (Edited author abstract) 5 refs.

Knight, P.C. (Unilever Research, Wirral, Engl); Johnson, S.H. *Powder Technol* v 54 n 4 Apr 1988 p 279-283.

**Melting** See METAL MELTING—Plasma Arc.

**Microstructure** See METALLOGRAPHY—Microstructures.

**Mixing** See Also CERAMIC MATERIALS—Granulation; CERAMIC MATERIALS—Processing; COMPOSITE MATERIALS—Fabrication; MIXTURES—Design; POWDER METALLURGY.

**084731 MIXING OF FINELY DISPERSED MATERIALS IN REACTORS WITH A PULSED NONUNIFORM PSEUDOFUIDIZED BED.** A physical model has been developed, along with a mathematical description of the process of mixing of two and more loose components, charged in layers, with the aim of determining the parameters of air supply ( $G$ ,  $f_p$ ,  $\psi$ ), and the time of mixing required to obtain a mixture of the required quality. It has been established experimentally that mixing of finely dispersed materials in an inhomogeneous pulsed pseudofluidized layer occurs as the result of circulatory movement of the material which encompasses the entire volume of the layer and which is created by the formation and passage of gas bubbles through the layer. The physical model and the mathematical description of the process establish the correlation between the parameters that characterize the regime of inhomogeneous pseudofluidization and the kinetic mixing of the components. 6 refs.

Aleksandrov, M.V. (Lensovet Leningrad Technological Inst, USSR); Mikhalev, M.F.; Puchkin, I.A.; Tsyba, S.I. *J Appl Chem USSR* v 60 n 6 pt 1 Jun 1987 p 1230-1234.

**084732 CONTINUOUS MEASUREMENT OF DEGREE OF MIXING IN POWDER MIXER BY AN OPTICAL METHOD.** A new system has been developed to measure continuously the flow characteristics of solid particles and the degree of mixing in powder mixers. Modulated light from a light-emitting-diode is conducted onto a mixture of colored particles through a probe consisting of a pair of optical fibers, and the intensity of the reflected light from the surface of the mixture is measured continuously by a high-sensitive photometer. Five sets of the probes are installed in separate positions of a mixer vessel. The signal from the five photometers are

processed by an analog-to-digital converter and a microcomputer system. The concentration of the key component in the mixture and the degree of mixing at every moment are calculated and displayed on the video screen of the computer system. (Author abstract) 8 refs.

Satoh, Munetake; Miyayami, Kei. *Bull Univ Osaka Prefect Ser A* v 36 n 2 1987 p 141-148.

## Morphology

**084733 EVALUATION OF THE 'BLANKET' ALGORITHM FOR RUGGEDNESS ASSESSMENT.** A Richardson plot of an arbitrarily rugged line can be constructed by 'coating' it with a 'blanket' of increasing thickness and calculating its length from the blanket's area divided by its thickness. This algorithm was applied to lines constructed with constant and variable random frequency and random amplitude within a predetermined range. Since lines could be generated using the same parameters but different random features, the method could be tested for reproducibility and sensitivity. The method satisfies both conditions. (Edited author abstract) 7 refs.

Normand, M.D. (Univ of Massachusetts, Amherst, MA, USA); Peleg, M. *Powder Technol* v 54 n 4 Apr 1988 p 255-259.

**084734 PARTICLE SAMPLE SHAPE DESCRIPTION WITH AN AUTOMATED CASCADOGRAPH PARTICLE ANALYZER.** The Cascadograph particle analyzer is an instrument which characterizes the particle shape distribution in particles by measuring the rate at which they pass through a stack of identical sieves. Recently automated, the Cascadograph particle analyzer monitors particle passing rate using an optical counter interfaced with a computer. The automated instrument can distinguish between different particle samples and can reproduce the characteristic signature for a sample. (Edited author abstract) 25 refs.

Clark, N.N. (West Virginia Univ, Morgantown, WV, USA); Meloy, T.P. *Powder Technol* v 54 n 4 Apr 1988 p 271-277.

**Optical Properties** See Also CERIUM COMPOUNDS—Optical Properties.

**084735 REFINED STATISTICAL MODEL OF DIFFUSE REFLECTANCE OF POWDERED SOLIDS.** Equations are derived relating the diffuse reflectance of a powdered sample to the optical constants and the diameter of the powder particles. Contrary to previous models, the mutual irradiation of the particles in the elementary layers is self-consistently taken into account. The model has been tested using reflectance data of a powdered glass. (Author abstract) 22 refs.

Gade, Reinhold (Friedrich-Schiller-Univ Jena, Jena, East Ger). *Opt Acta* v 35 n 7 Jul 1988 p 1187-1200.

## Oxygen Determination

**084736 BRIEF INTRODUCTION OF DETERMINATION OF OXYGEN CONTENTS IN METAL POWDERS AND NATIONAL STANDARD GB4164-84.** Several conventional and international methods for determining oxygen contents in metal powders the values obtained by these methods and their effects on technology have been described. A detail comparison has been made between the national standard GB 4164-84 'Determination of Reducible Oxygen Contents by Hydrogen in Metal Powders' and the current international and corresponding standards in various countries. GB4164-84 has the advantages of eliminating interference from carbon, wide range of applications, good efficiency of purification of hydrogen gas and rapid determination. (Author abstract) In Chinese.

Bo, Yaxian (Beijing Research Inst of Powder Metallurgy, China). *Fenmo Yejin Jishu* v 5 n 2 May 1987 p 97-102.



## Packaging

**084737 STROEMUNGSTECHNISCHE OPTIMIERUNG EINER PNEUMATISCHEN FUELLMACHINE UND VERBESSERUNG DES WAGE-SYSTEMS.** [Optimizing the Flow Conditions in a Pneumatic Filling Machine and Improving the Weighing System]. Knowledge derived from previous basic experimental research was translated into actual practice with the design of the HSP high-speed sack packer. The results of the two-dimensional model tests were verified in two prototypes. The measurements substantially confirmed the results of the model tests. For example, for PVC powder it proved possible to double the hourly sack filling performance with the prototype HSP, while moreover the filling time, air consumption and current consumption were reduced to half the values for the type 60 FF machine. The special design of the aerating bottom enables the filling machine to be optimally adapted to whatever material it has to deal with. (Edited author abstract) In German.

Spieß, Von J. *ZKG Int* v 40 n 4 Apr 1987 p 187-189.

## Pelletizing See Also FURNACES, METALLURGICAL

**084738 DEGREES OF CRYSTALLINITY AND POLYMERIZATION OF MODIFIED CELLULOSE POWDERS FOR DIRECT TABLETING.** Modified celluloses are probably the best regarded pharmaceutical excipients for direct tableting. The degrees of crystallinity and of polymerization of 21 celluloses used in direct tableting were determined, using X-ray diffraction and viscosimetry respectively. The crystallinity of the microcrystalline celluloses varied widely from one product to another. Average degrees of polymerization were less than the usually accepted value of the 'level-off degree of polymerization'. Degrees of crystallinity of powdered celluloses were generally lower than those of microcrystalline celluloses, although some were as high as those of certain hydrolyzed samples. Degrees of polymerization of powdered celluloses did not differ as much as those of microcrystalline celluloses. The observed ranges for both parameters were wider than previously reported; the differences could be explained by structural considerations. (Edited author abstract) 38 refs.

Doelker, E. (Univ de Geneva, Geneva, Switz); Gurny, R.; Schurz, J.; Janosi, A.; Martin, N. *Powder Technol* v 52 n 3 Oct 1987 p 207-213.

## Permeability

**084739 VIBRATIONAL DOSING (METERING) OF HIGHLY DISPERSED POWDERS.** The process of vibrational dosing of highly dispersed powders was studied. In order to improve the effectiveness of this process, it is necessary to control the rheological properties of the powders. During the process, there are five periods of variation of the productivity of the vibrational metering device depending on the level of the powder in its receiving bunker. Clay, feldspar and talc were used as model powders. 19 refs.

Klimenko, V.P. (Acad of Sciences of the USSR, USSR); Ur'ev, N.B. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 29-33.

## Permeability, Mechanical

**084740 ADVANCES IN GAS PERMEABILITY MEASUREMENTS.** The Carman-Arnell equation relates the rate of flow of a fluid through a packed bed to the pressure drop across the bed. This equation is the basis for surface area determination by permeametry. It is found that the surface area measured at sub-atmospheric pressure varies with the bed porosity, so a porosity was selected where the rate of change was at a minimum. The study suggests that, at reduced pressures, the gas flow rate is a linear function of the mean pressure. (Author abstract) 13 refs.

Igwe, Godwin J.I. (Univ of Bradford, Bradford, Engl); Allen, Terence. *Chem Eng Technol* v 10 n 2 Apr 1987 p 86-92.

## Photolysis See SILVER COMPOUNDS—Photolysis.

Physical Properties See EUROPIUM COMPOUNDS—Optical Properties; MAGNESIA—Calcination.

## Polishing

**084741 MOTION OF A FERROMAGNETIC POWDER DURING MAGNETOABRASIVE POLISHING.** An experimental investigation has been carried out into the distribution of a magneto-abrasive powder in the working zones of a machine with annularly arranged MAP zones. It has been established that in the working zone of the magnetic gap the minimum density region is located at a distance of one-third of the working gap length from the point of entry into the gap. Qualitative expressions have been obtained reflecting the character of the variation of the velocity components of ferroabrasive particles moving in the course of MAP. Experimental and calculated data are in agreement. 9 refs.

Maiboroda, V.S. (Kiev Polytechnic Inst, USSR); Shlyuko, V.Ya. *Sov Powder Metall Met Ceram* v 26 n 8 Aug 1987 p 603-607.

## Polymerization

**084742 POLYMERIZATION AND CRYSTALLIZATION BEHAVIOR OF A LARC-TPI POWDER.** The crystallization and polymerization behavior of a crystalline LARC-TPI powder at elevated temperatures have been studied. The characterization methods include differential scanning calorimetry and the measurements of inherent viscosity,  $\eta_{inh}$ , and viscoelastic properties of the fully imidized samples. The as-received material possesses an initial crystal melting peak temperature of 272°C. For the material annealed at temperatures below 320°C, a semicrystalline polymer can be obtained. On the other hand, a purely amorphous structure is realized in the samples annealed at temperatures above 320°C. (Edited author abstract) 12 refs.

Hou, T.H. (NASA, Hampton, VA, USA); Bai, J.M.; St. Clair, T.L. *J Appl Polym Sci* v 36 n 2 Jul 5 1988 p 321-333.

Porosity See Also PARTICLE SIZE ANALYSIS; PARTICLE SIZE ANALYSIS—Measurements.

**084743 POROSITY CALCULATIONS OF MULTI-COMPONENT MIXTURES OF SPHERICAL PARTICLES.** It is shown that the relative maximum void contraction and the corresponding relative fractional solid volume are only the functions of size-ratio for binary mixtures, which can be determined experimentally. A linear analytical model, directly based on the experimental results of binary mixtures, is developed. The results show that the calculated porosities for ternary mixtures are within 8% relative error of measurements. Good agreement between the theoretical and experimental results was also obtained for Gaussian and log-normal size distributions. It is concluded that the porosity of multi-component mixtures of particles may be confidently predicted from the results of binary mixtures. (Author abstract) 23 refs.

Yu, A.B. (Univ of Wollongong, Wollongong, Aust); Standish, N. *Powder Technol* v 52 n 3 Oct 1987 p 233-241.

**084744 MERCURY POROSIMETRY IN RANDOM SPHERE PACKINGS: BREAKTHROUGH PRESSURE AND PORE STRUCTURE DETERMINATION.** By using a model which accounts for the filling of all four throats connecting the central pore cavity in a random packing of spheres, good agreement between theoretical and experimentally measured pore size distributions in random packings of spheres has been obtained. Even after a central pore cavity has been filled through the largest throat in the face of a tetrahedron, some of the total pore volume in the tetrahedron, some of the total pore volume in the tetrahedron will not be filled until higher pressures associated with the smaller throats are reached. Approximately 11% of the total pore volume is observed

as this throat filling process. The error associated with the use of the independent domain theory appears in terms of a broader calculated pore size distribution in the region of central cavity filling. 18 refs.

Smith, D.M. (Univ of New Mexico, Albuquerque, NM, USA); Gallegos, D.P.; Stermer, D.L. *Powder Technol* v 53 n 1 Nov 1987 p 11-22.

**084745 LIMITATION OF THE SIMPLEX-CENTROID DESIGN FOR THE POROSITY CALCULATION OF TERNARY MIXTURES.** In our recent paper we used the simplex-centroid design which gave the calculated porosities within 2% relative error of measurements for the ternary mixtures used. However, further study has shown that the porosities calculated by the above design may, under some conditions, be quite different from the measurements. The limiting conditions of the design and a method of overcoming them are given in this note. 5 refs.

Standish, N. (Univ of Wollongong, Wollongong, Aust); Yu, A.B. *Powder Technol* v 53 n 1 Nov 1987 p 69-72.

**084746 MERCURY POROSIMETRY OF ORDERED SPHERE COMPACTS: INVESTIGATION OF INTRUSION AND EXTRUSION PORE SIZE DISTRIBUTIONS.** In this work, the possible use of both intrusion and extrusion for pore structure characterization has been investigated. Submicron monosize spherical particles of silica and yttrium hydroxycarbonate were synthesized and ordered compacts of these powders have been prepared. Mercury porosimetry tests on the high-density compacts (typically 68-70% of sphere density) have shown the presence of two pore peaks for intrusion and extrusion with the exception of one compact. Comparisons of intrusion pore sizes with the theoretical sizes of the constrictions for ordered sphere packings have shown reasonable agreement. Similar comparisons between the sizes of cavities in sphere packings and the extrusion pore sizes did not show the same agreement. Results for one sample did not show a distinct extrusion pore size even at large pore sizes, most probably due to the domination of mercury extrusion by few large pores in the sample. For all other samples, the extrusion pore sizes were close to the actual sphere size and the extrusion was probably dominated by a few vacant sphere sites in the ordered structures. The results have shown that the possibility of using extrusion data for pore body size distribution determination is in doubt. The presence of few larger pores in the porous body may dominate the extrusion process and can cause inaccurate pore size information. (Edited author abstract) 25 Refs.

Ciftcioglu, M. (Univ of New Mexico, Albuquerque, NM, USA); Smith, D.M.; Ross, S.B. *Powder Technol* v 55 n 3 Jul 1988 p 193-205.

Precipitation See CHEMICAL EQUIPMENT—Cyclones; PIEZOELECTRIC MATERIALS—Synthesis.

## Preparation

**084747 INFLUENCE OF POWDER PREPARATION AND COMPACTING PRESSURE ON THE STRUCTURE OF LITHIUM SILICATE PELLETS.** This contribution reports on lithium meta- and orthosilicates as potential breeder materials for fusion reactors. The preparation of the powder by the spray-dry technique and the selection of the compacting pressure were important influences on the structure of the 'green pellets'. (Author abstract) 5 refs.

Mickeleit, Michael (Kernforschungszentrum, Karlsruhe, West Ger). *J Am Ceram Soc* v 70 n 12 Dec 1987 p C387-C388.

Pressing See CERAMIC MATERIALS—Manufacture; IRON COMPOUNDS—Reduction; POWDER METALLURGY—Iron.

Processing See Also BARIUM TITANATE—Fabrication; COBALT NICKEL THALLIUM ALLOYS—Electrodeposition; FERRITES—Fabrication; POWDER METALLURGY—Steel; SCREENS AND SIEVES.



**084748 EFFECT OF TEXTILE AUXILIARIES ON THE FREE-FLOWING CELLULOSE POWDER.** The effect of textile auxiliaries on the bulk density and water vapor sorption of cellulose powder prepared from fiber waste from viscose manufacturing is studied. It is shown that treatment of the cellulose powder with textile auxiliaries leads to an increase in its free-flowing properties and to a considerable improvement in the quality of the product obtained. A composition based on S-9 mineral oil and an added emulsifier, which reduces the bulk density of the cellulose powder by 46-57%, is the most effective agent. 4 refs.

Agafnova, L.L.; Glavochevskaya, R.A.; Panova, L.N.; Egorova, R.V.; Dmitriev, V.A. *Fibre Chem* v 19 n 2 Mar-Apr 1987 p 111-113.

**084749 AGITATION IN DRY MATERIAL FEEDING.** Keeping dry materials flowing from metering devices into processing systems has long been a problem. Dry materials tend to be sticky, to bridge over the metering screw, or to pack in the hopper. This can cause discrepancies in feeding accuracy, consistency, and uniformity. The gentle massaging action of flexible wall feeders is a solution to the problems generally associated with other agitation mechanisms.

Anon. *Powder Bulk Eng* v 1 n 12 Dec 1987 p 28-31.

**084750 GRAINS OF HOPE.** One aim of the present Science and Engineering Research Council (SERC) Specially Promoted Programme (SPP) in particulate technology is to bring academic scientists and industrial engineers together. To this end, the SPP has directed the resources at its disposal towards three main areas of investigation: particle formation, solid-liquid phenomena and dry solids handling. It aims to 'radically improve our processing ability' through a proper understanding and utilization of process control parameters such as particulate characteristics. The flow behavior of a powder, be it dry, wet or suspended, when subjected to external stresses, is a predictive problem of immense complexity. We can identify three distinct levels of characterization which, if successfully researched and described, could in principle lead to a complete prediction of powder flow behavior for engineering design.

Woodcock, Les. *Process Eng (London)* v 68 n 10 Oct 1987 p 41-43.

**084751 HYDROCHEMICAL PREPARATION OF FINE PRECIOUS METAL POWDERS.** The importance of fine precious metal powders for electronic material applications has spurred development of precipitation methods from aqueous and organic media. Three systems in particular are of interest: the in-situ precipitation of gold crystals from a loaded organic phase via an intramolecular redox reaction mechanism; the precipitation of palladium from loaded organic solvents by direct hydrogen reduction; and the precipitation of platinum and palladium powders from aqueous chloride solutions by hydrogen reduction. The particle size and powder morphology of the precipitates are related to the nucleation mechanism (homogeneous or heterogeneous) and the particle-particle and particle-solvent interaction. (Author abstract) 30 refs.

Demopoulos, G.P. (McGill Univ, Montreal, Que, Can); Pouskoulleli, G. *J Met* v 40 n 6 Jun 1988 p 46-50.

**084752 MATHEMATICAL ANALYSIS OF THE MILLING OF MINERAL FERTILIZER POWDERS.** A fundamental problem in the theory and practice of compressing mineral fertilizer powders is the development of methods of calculating the density of the cake formed and the milling power parameters under specific conditions and roller operation programs. The authors have investigated a two-dimensional Maxwell viscoelastic equation in a section  $\Omega$  of the compression zone. The authors also set up an algorithm for solving this equation by successive approximations in which a linear system of equations is solved at each step. For the first approximation, they developed a program of 300 commands in FORTRAN that solves an elliptical equation for  $u$  by the

method of finite elements and permits the calculation of the stress on the roller and the overall characteristics of the process: the densification coefficient, the force on the roller, and the power consumed in driving the press. The starting data needed to make a mathematical analysis of the process are given.

Generalov, M.B.; Oganessian, K.L. *Chem Pet Eng* v 23 n 7-8 Jul-Aug 1987 p 384-387.

**Production** See Also ALUMINA—Hydrated; METALLIC COMPOUNDS—Production; POWDER METALLURGY—Compacting; POWDER METALLURGY—Iron; SILICON CARBIDE—Synthesis.

**084753 STRUCTURE OF METAL POWDERS PRODUCED BY ELECTROEROSION DISINTEGRATION IN GRANULATORS.** It is demonstrated that electroerosion (EE) disintegration is a process enabling metal powders to be obtained composed of spherical particles ranging in size from about 0.01 to about 100  $\mu\text{m}$ . During EE disintegration metal experiences local melting by electrical discharges in a dielectric liquid; as its boiling point is reached, a spray of macroscopic molten metal droplets is produced in an explosive manner, which are rapidly cooled in the surrounding liquid. In the production of a metal powder by the EE disintegration of a metal in a granulator all the conditions are spontaneously created necessary for obtaining an ultrafine-grained crystal structure in the material of the powder, so that it is not necessary to introduce special nucleating inoculant additions into the metal. 13 refs.

Fominskii, L.P. (Tulacherm Scientific Production Assoc, USSR); Levchuk, M.V.; Tarabrina, V.P. *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 273-277.

**084754 FORMATION AND GROWTH MECHANISM OF POROUS, AMORPHOUS, AND FINE PARTICLES PREPARED BY CHEMICAL VAPOR DEPOSITION. TITANIA FROM TITANIUM TETRAISOPROXIDE.** The formation and growth mechanism of porous, amorphous, and fine particles were investigated.  $\text{TiO}_2$  particles were produced in a tubular flow reactor by a chemical vapor deposition technique using titanium tetraisopropoxide as a starting material at low temperatures (573-973 K) and atmospheric pressure. Prepared particles were of submicron size and had large surface area (as large as  $270 \times 10^3 \text{ m}^2/\text{kg}$ ). According to the proposed mechanism, reactions begin on the reactor wall and then the primary particles form in the gas phase by chemical reactions. The primary particles collide, coalesce with each other and grow. However, significant experimental deviations from the Brownian collision and coalescence theory imply that other processes, such as the surface reactions on the particle, play an important role in the growth, in addition to coalescence. Intraparticle reactions decreased the surface area by filling the pores. (Author abstract) 19 refs.

Kirkbir, Fikret (Univ of Tokyo, Tokyo, Jpn); Komiya, Hiroshi. *Can J Chem Eng* v 65 n 5 Oct 1987 p 759-766.

**084755 MAKING POWDERS.** As end use demands on powder (for example, microelectronic and superconductivity applications) become more pressing, the demands for understanding precipitation mechanics become more pressing. The paper demonstrates the current state of the powder precipitation. The nature of powders depends on nucleation and growth. Both nucleation and growth share supersaturation as a common driving force. Sometimes applying steam to a solution causes precipitation. Adding a component in which the solute is insoluble also causes supersaturation. The author reviews heterogeneous and secondary nucleation, particle growth and structure, and, finally, network growth of the powder precipitates. 6 refs.

Ring, Terry A. *CHEMTECH* v 18 n 1 Jan 1988 p 60-64.

**084756 LEYBOLD IN FOREFRONT OF METAL POWDER PRODUCTION TECHNOLOGY.** The Vacuum Process Engineering Division of Leybold AG in Hanau, Germany, has been designing and manufacturing special metallurgical plants for metal powder production

for more than 20 years. Over this period the company has developed sophisticated inert gas atomization systems, centrifugal atomization processes for ceramic-free metal powders, and complete powder handling and treatment systems. (Author abstract)

Williams, Bernard. *Met Powder Rep* v 43 n 6 Jun 1988 p 405-408.

**084757 PRODUCTION OF METAL POWER FROM RAPIDLY SOLIDIFIED DUCTILE RIBBONS.** Ductile metallic ribbons have been reduced into small particles by a blade cutter mill designed to cut and slash the ribbons. The resulting powders are suitable for subsequent P/M processing. This batch process and the results obtained with a Zn-20.5Al-0.7Cu alloy are described. (Author abstract) 5 refs.

Gelinas, C. (Laval Univ, Ste.-Foy, Que, Can); Angers, R.; Pelletier, S. *Mater Lett* v 6 n 10 Jun 1988 p 359-361.

**084758 EVALUATION AND CONTROL OF PARTICLE PROPERTIES IN AEROSOL REACTORS.** The production of powders by aerosol routes spans a wide range of operating temperatures depending on the type of aerosol reactors used. The dominant mechanism of particle growth and evolution depends highly on the rate at which the reactions producing the condensable species are carried out. Numerical solutions of the discrete-sectional aerosol general dynamic equation that accounts for the interactions of the discrete clusters were obtained for conditions representative of the different types of aerosol reactors used for powder production today. Simplified reaction and coagulation equations that give fast and useful prediction of the evolution of aerosols associated with chemical reactions were derived, and a simple reaction-coagulation model was developed. The effects of reaction rate, initial vapor concentration, residence time, seed particles, and temperature profile on the properties of fine particles produced by gas-phase chemical reactions were evaluated using both models. Results show good agreement between the two. (Author abstract) 18 refs.

Wu, Jwang Jin (California Inst of Technology, Pasadena, CA, USA); Nguyen, Hung V.; Flagan, Richard C.; Okuyama, Kikuo; Kousaka, Yasuo. *AIChE J* v 34 n 8 Aug 1988 p 1249-1256.

**084759 PROPERTIES OF  $\text{ZrO}_2\text{-Al}_2\text{O}_3$  COMPOSITE POWDERS PREPARED FROM Zr-Al METALLO-ORGANIC COMPOUNDS.** Zr-Al metallo-organic compounds (zirconaluminates), having  $(\text{CH}_2)_4\text{COOH}$ ,  $(\text{CH}_2)_6\text{CH}_3$  and  $(\text{CH}_2)_7\text{NH}_2$  as the organofunctional groups, were treated preliminarily by: (1) spray-drying, (2) gelation of addition of 10%  $\text{NH}_4\text{OH}$  aqueous solution followed by spray-drying, and (3) rotary evaporation under a reduced pressure. After the treatment, they were heated in air to prepare  $\text{ZrO}_2\text{-Al}_2\text{O}_3$  composite powders. The IR and DTA profiles for the treated compounds indicated that the procedures modified the structures for the zirconaluminates. The stability of tetragonal  $\text{ZrO}_2$  for the  $\text{ZrO}_2\text{-Al}_2\text{O}_3$  composite powder was dependent on the modification in the structure for the zirconaluminates. (Edited author abstract) 8 refs.

Yoshimatsu, Hideyuki (Industrial Technology Cent of Okayama Prefecture, Okayama, Jpn); Yabuki, Tatsumi; Kawasaki, Hitoshi. *J Non Cryst Solids* v 100 n 1-3 Mar 1988, Glasses and Glass Ceram from Gels, Kyoto, Jpn, Jul 13-15 1987 p 413-417.

**Purification** See SUPERCONDUCTING MATERIALS—Synthesis.

## Pyrolysis

**084760 ESTIMATION OF FORMATION MECHANISM OF SPHERICAL FINE  $\text{ZrO}_2\text{-SiO}_2$  PARTICLES BY ULTRASONIC SPRAY PYROLYSIS.** Spherical fine  $\text{ZrO}_2\text{-SiO}_2$  (1:1) particles were synthesized from a hydrolyzed solution of  $\text{Si}(\text{OC}_2\text{H}_5)_4$  and  $\text{ZrOCl}_2 \cdot 8\text{H}_2\text{O}$  by ultrasonic spray pyrolysis. The formation mechanism of the particles is discussed. All of the particles identified as t- $\text{ZrO}_2$  and amorphous  $\text{SiO}_2$  with an atomic



order dispersion were spherical and mainly of diameter 0.8 to 1.0  $\mu\text{m}$ . It is estimated that the three-dimensional ladder siloxane chains containing an equimolar  $\text{Zr}^{4+}$  homogeneously dispersed were formed by hydrolysis. An atomized droplet converted into an isolated  $\text{ZrO}_2\text{-SiO}_2$  (1:1) particle without aggregation. (Edited author abstract). 22 Refs.

Kanno, Yoshinori (Yamanashi Univ, Kofu, Jpn); Suzuki, Tadashi. *J Mater Sci* v 23 n 9 Sep 1988 p 3067-3072.

**Recovery** See PROTECTIVE COATINGS—Powder.

**Reduction** See CHEMICAL EQUIPMENT—Fluidized Beds; COPPER COMPOUNDS—Reduction.

**Research** See SILICON CARBIDE—Research.

**Rheology** See Also PLASTICS—Rheology; POWDER METALLURGY; POWDER METALLURGY—Compacting.

**084761 RHEOLOGY OF AQUEOUS DISPERSIONS OF ALUMINA, TITANIA AND MIXTURE OF ALUMINA AND TITANIA POWDERS.** The electrophoretic mobility and rheology of alumina, titania and alumina/titania powder mixtures (ratio of alumina:titania 1:2 and 2:1) were investigated in aqueous suspensions in the pH range 3 - 10. The results suggest that the electrophoretic mobility of the individual powders is independent of the particle concentration, but the electrokinetic behavior of the powder mixture depends upon the concentration of the individual constituents. The rheology of all the suspensions is charge related and while alumina and alumina/titania (ratio 2:1) flocculate at pH 9.0 both titania and alumina/titania (ratio 1:2) form low viscous dispersions. (Edited author abstract) 17 refs.

Rao, A. Srinivasa (Rutgers Univ, Piscataway, NJ, USA). *J Dispersion Sci Technol* v 8 n 5-6 1987 p 457-476.

**Sampling**

**084762 DEMONSTRATING THE SAMPLING OF HETEROGENEOUS, FREE-FLOWING, SEGREGATING POWDERS.** Experiments with common powder laboratory apparatus are used to illustrate the problems of sampling a poor mixed quantity of glass ballottini. The use of known and easily sieved mixtures permits the quantitative analysis of the results to show how bias in samples may be detected. (Author abstract). 11 Refs.

Hawkins, Arthur E. (Univ of Bradford, Engl). *Part Part Syst Charact* v 5 n 1 Mar 1988 p 23-28.

**Sedimentation** See Also ALUMINA—Suspensions.

**084763 EXPLICIT RELATIONSHIP TO PREDICT SPHERICAL PARTICLE TERMINAL VELOCITY.** The communication presents a new explicit correlation for the dimensionless terminal velocity  $U_t$  in terms of the dimensionless particle diameter  $d_n$ . It is shown that this correlation is more accurate over the range of reported experimental data than the correlation due to Zigrang and Sylvester. Extension to the case of an assemblage of particles is also provided. 8 refs.

Turton, R. (West Virginia Univ, Morgantown, WV, USA); Clark, N.N. *Powder Technol* v 53 n 2 Dec 1 1987 p 127-129.

**084764 CAT SCAN CHARACTERIZATION OF SEDIMENTATION AND FLOCCS.** A CAT scan is a special kind of X-ray instrument that can produce three-dimensional pictures of an object. Although the CAT scan is designed for medical purposes, we have successfully applied it in the engineering field, such as in the 3-D visualization of oil recovery from porous media. In this note, we report the application of this technique to sedimentation and flocculation systems. 6 refs.

Somasundaran, P. (Columbia Univ, New York, NY, USA); Huang, Y.B.; Gryte, C.C. *Powder Technol* v 53 n 1 Nov 1987 p 73-77.

**084765 ON THE DIVERGENCE PROBLEM IN**

**CALCULATING PARTICLE VELOCITIES IN DILUTE DISPERSIONS OF IDENTICAL SPHERES: II. EFFECT OF A PLANE WALL.** The authors consider a dilute random dispersion of identical spheres sedimenting slowly in a viscous fluid toward a horizontal plane wall. This wall imposes the return flow and yields the usual result for the effect of long-range interactions on mean velocity. Since the usual method of imposing return flow leads to the divergence of the variance of velocity, they used this method to calculate the covariance matrix. Lengthy but straightforward analytical integration and algebraic manipulation yield a diagonal matrix whose entries are finite when the test sphere is a finite distance  $z$  from the plane. The trace of this matrix is the variance of velocity. This vanishes as the solids fraction approaches zero, confirming a postulate of the Pickard-Tory model for sedimentation. However, its linear dependence on  $z$  seems unphysical and additional terms should be derived. Additional boundaries may also be necessary. (Edited author abstract) 23 refs.

Tory, E.M. (Mount Allison Univ, Sackville, NB, Can); Kamel, M.T. *Powder Technol* v 55 n 1 May 1988 p 51-59.

**Sintering** See Also CERAMIC MATERIALS—Injection Molding.

**084766 EFFECT OF RIGID INCLUSIONS ON THE SINTERING OF GLASS POWDER COMPACTS.** The effect of rigid inclusions on the sintering of glass powder compacts has been investigated at 600°C. The densification rates show good agreement with the rule of mixtures for inclusion volume fractions of  $\leq 0.1$ . The transient stresses generated during sintering by the presence of the inclusions were evaluated from the sintering data. Below inclusion volume fractions of approximately 0.12, the results are in excellent agreement with Scherer's theory for viscous sintering with rigid inclusions. At higher inclusion volume fractions, interactions between the inclusion particles lead to large deviations from theoretical predictions. (Author abstract) 13 refs.

Rahaman, M.N. (Lawrence Berkeley Lab, Berkeley, CA, USA); De Jonghe, L.C. *J Am Ceram Soc* v 70 n 12 Dec 1987 p C348-C351.

**Size Determination**

**084767 ACCURACY OF DUAL PARAMETRIC DISTRIBUTION FUNCTIONS USED FOR THE DESCRIPTION OF PARTICLE SIZE DISTRIBUTIONS.** The determination of particle size distribution of powders is generally carried out by sieve analysis in which the particles are separated into six or ten fractions regarding their sizes. The analysis itself is often laborious, time consuming and therefore gratuitous. Efforts were made to lessen the number of fractions without a significant decrease of accuracy and reproducibility of particle size distribution values. The application of dual parametric distribution functions was investigated both theoretically and practically, the latter by using experimentally determined data. As a result, the selection and number of fractions are recommended and the application of multi-stage cyclone instruments is proposed. (Author abstract) 9 refs.

Petroll, J. (Technische Hochschule 'Carl Schorlemmer' Leuna-Merseburg, Merseburg, West Ger); Teske, M.; De Jonge, J. *Hung J Ind Chem* v 15 n 4 1987 p 389-401.

**Spectroscopic Analysis** See Also EUROPIUM COMPOUNDS; POTASSIUM COMPOUNDS—Spectroscopic Analysis; SILICON NITRIDE—Composition Effects; TITANIUM COMPOUNDS—Spectroscopic Analysis; ZINC COMPOUNDS—Morphology.

**084768 MOLECULAR MOTIONS FROM TWO-DIMENSIONAL NMR OF POWDERS: COMPARISON OF ROTATIONAL JUMPS AND DIFFUSIVE REORIENTATIONS.** With the two-dimensional (2D) exchange NMR experiment on polycrystalline or amorphous solids it is possible to study reorientations in the slow motion limit. Anisotropic interactions lead to 2D powder spectra exhibiting characteristic singularities ('ridges'). From such a powder spectrum the relative

orientations of a coupling tensor at the beginning and at the end of the mixing time can be measured without reference to any model of reorientation. The method is demonstrated for hexamethylbenzene and linear polystyrene. (Author abstract) 32 refs.

Schmidt, C. (Max-Planck-Institut fuer Polymerforschung, Mainz, West Ger); Blumrich, B.; Wefing, S.; Kaufmann, S.; Spiess, H.W. *Ber Bunsenges Phys Chem* v 91 n 11 Nov 1987 p 1141-1145.

**084769 MATHEMATICAL JUSTIFICATION OF THE USE OF IR TRANSMISSION SPECTROSCOPY FOR THE QUANTITATIVE ANALYSIS OF SURFACE-TREATED POWDERS.** Measuring the IR transmission through a loosely packed powder layer offers a cheap and experimentally simple method for the quantitative and qualitative analysis of surface-treated powders. It is, however, practically impossible to obtain a perfectly smooth and even powder layer - a fact that introduces large errors in the quantitative determination. To cope with this problem, one derives an equation, by means of which it is possible to carry out the determination irrespective of the layer-thickness variations. The equation is based on the use of an 'internal thickness standard.' The theory is illustrated with, and supported by, a series of determinations of a silane coupling agent on a phlogopite powder. (Edited author abstract) 11 refs.

Hanning, Anders (Univ of Abo Akad, Abo, Finl). *Appl Spectrosc* v 42 n 1 Jan 1988 p 90-95.

**084770 ANALYSIS OF INORGANIC POWDERS BY TIME-WAVELENGTH RESOLVED LUMINESCENCE SPECTROSCOPY.** A spectrometer for measuring time-wavelength resolved luminescence spectra was constructed. A gated integrator was used for time resolution. Solid samples of  $\text{CaWO}_4$ ,  $\text{CaMoO}_4$ ,  $\text{SrWO}_4$ , and  $\text{SrMoO}_4$  were excited at room temperature by an excimer laser at 193 and 248 nm. The substances examined showed first order decay kinetics and the spectra were broad, featureless Gaussian bands. The luminescence spectral envelope was described by the parameters lifetime, peak maxima, peak half-width, and intensity factor. Data reduction was carried out by using a linear algebra construct and simplex optimization. The algorithm was evaluated with synthetic data. (Edited author abstract) 17 refs.

Paski, Edgar F. (Univ of British Columbia, Vancouver, BC, Can); Blades, M.W. *Anal Chem* v 60 n 11 Jun 1 1988 p 1224-1230.

**084771 DETERMINATION OF PARTICLE SIZE IN POWER BY SCATTER CORRECTION IN DIFFUSE NEAR-INFRARED REFLECTANCE.** Diffuse near-infrared reflectance spectroscopy has traditionally been an analytical technique for determining chemical compositions in a sample. The authors focus on light scattering effects and their ability to determine the mean particle sizes of powders. The reflectance data of NaCl, broken glass, and sorbitol powders are linearized and submitted to the Multiplicative Scatter Correction (MSC), and the ensuing parameters are used in subsequent multivariate calibrations. The results indicate that particle size can, to a large degree, be determined from NIR reflectance data for a given type of powder. Up to 99 percent of the partial size variance was explained by the regression. (Edited author abstract). 19 Refs.

Ilari, J.L. (Enitaa, Nantes, Fr); Martens, H.; Isaksson, T. *Appl Spectrosc* v 42 n 5 Jul 1988 p 722-728.

**Storage** See Also CONTAINERS—Pressure Effects.

**084772 CHOOSING SUITABLE STORAGE EQUIPMENT.** A main concern of the bulk powder user is the proper integration of the various pieces of equipment used to comprise a complete storage system. Broadly speaking, a storage system can be divided into: (a) transport of the powder from the supplier to the consumer, (b) acceptance of the material and its storage; and (c) transfer of material from storage to process. This article discusses factors to consider when choosing equip-



ment for the second part of the system-material acceptance and its storage. (Edited author abstract)

Dry, Jim F. (J.T. Sootney Ltd). *Powder Bulk Eng* v 1 n 11 Nov 1987 p 30-34.

## Stresses

**084773 SHEAR PROPERTIES OF UNIAXIALY PRE-CONSOLIDATED POWDER BED - NON-UNI-FORMITY OF THE SHEAR STRESS ACTING ON THE SHEAR PLANE.** Failure properties of a powder bed have been widely obtained by the shear tests on the basis of Jenike's method. A special feature of Jenike's method is that a powder bed has been sheared in pre-consolidating before the shear test (pre-shearing). Therefore, it is presumed that the failure properties of the shear-consolidated bed pre-sheared on the basis of his method differ from the properties of the uniaxially consolidated bed. Although a uniaxially consolidated bed is often handled in powder operation, the failure properties of the bed have been scarcely discussed since the experimental results lack reliability. In this paper, a new experimental method is presented to obtain the exact failure properties for a uniaxially consolidated powder bed. Further, the results obtained by Jenike's tester are compared with those by our tester. (Author abstract) 13 refs.

Hirota, M. (Himeji Inst of Technology, Himeji, Jpn); Oshima, T. *Powder Technol* v 53 n 1 Nov 1987 p 49-54.

## Structure

**084774 NEUTRON DIFFRACTION AND <sup>1</sup>H RIGID LATTICE WIDE-LINE NMR STUDIES OF POWDER (K, Bi<sup>III</sup>, Bi<sup>V</sup>) PYROCHLORES.** The structure of an A cation-deficient pyrochlore (K, Bi)<sub>2</sub>1.5Bi<sub>2</sub>O<sub>6</sub>(H<sub>2</sub>O)<sub>1</sub> has been investigated by powder neutron diffraction using a deuterated sample. Main results of previous X-ray work are confirmed: 25% of A sites are empty; only a small amount of oxygen is found in 8(b) positions, a greater proportion being located in 32(e) positions which are displaced toward the A vacancy. The latter oxygen atoms belongs to a heavy water molecule, the deuterium atoms of which are distributed near 96(g) positions. Proton wide-line nuclear magnetic resonance experiments were performed at 4 K using an undeuterated sample. (Edited author abstract) 32 refs.

Trehoux, Jacques (CNRS, Villeneuve d'Ascq, Fr); Abraham, Francis; Thomas, Daniel; Doremieux-Morin, Claudine; Arribart, Herve. *J Solid State Chem* v 73 n 1 Mar 1988 p 80-91.

## Surface Measurement

**084775 RAPID SURFACE AREA DETERMINATION VIA NMR SPIN-LATTICE RELAXATION MEASUREMENTS.** In this work, a theoretical and experimental approach has been developed for measuring the surface area of both solid powders and porous solids. Spin-lattice relaxation measurements were made of adsorbed water at 20 MHz and 303 K. Materials studied included three Cab-O-Sil fumed silica powders and three controlled pore glasses with various water contents. The variation of the observed spin-lattice relaxation decay time was found to be linear with both the solids concentration and specific surface area, as predicted by the theory. (Edited author abstract) 19 refs.

Davis, P.J. (Univ of New Mexico, Albuquerque, NM, USA); Gallegos, D.P.; Smith, D.M. *Powder Technol* v 53 n 1 Nov 1987 p 39-47.

## Surface Properties

See Also NITROGEN—Adsorption.

**084776 SURFACE FREE ENERGY DETERMINATIONS ON POWDERS.** A comparison has been made between surface free energy determinations on polytetrafluoroethylene and poly(methylmethacrylate) in powder and sheet form. Surface free energies were calculated from contact angle data using a series of liquid pairs. Good

agreement was observed between contact angles measured on the materials in the two forms. Surface energy determinations were more reliable for the higher energy solid and when liquids with widely differing surface tensions were used. (Edited author abstract) 10 refs.

Luangtana-anan, M. (Univ of Manchester, Manchester, Engl); Fell, J.T. *Powder Technol* v 52 n 3 Oct 1987 p 215-218.

## Surfaces

See Also FLOW OF FLUIDS—Packed Beds; SURFACE ACTIVE AGENTS—Adsorption.

**084777 SURFACE AREA DETERMINATION VIA NMR: FLUID AND FREQUENCY EFFECTS.** The use of NMR spin lattice relaxation measurements has been proposed as a tool for the determination of specific surface area. The use of this approach was demonstrated using relaxation measurements of water at 20 MHz for two materials with similar surface chemistry. In principle, the surface-enhanced spin lattice relaxation rate is a function of proton frequency, fluid, temperature and surface chemistry. This paper, describes relaxation measurements at 303 K using a range of fluids (water, methanol, ethanol, cyclohexane) at two proton frequencies (20 and 300 MHz) for samples with different surface areas from three different porous solid groups (controlled pore glass, mixed ester cellulose membranes and carbon blacks). Surface areas studied were in the range of 4.4 to 179.0 m<sup>2</sup>/g. A three-fold increase in the sensitivity of the surface area determination is noted when the frequency is decreased from 300 to 20 MHz. In general, surface area sensitivity increases with fluid type as (cyclohexane < water < methanol < ethanol). (Edited author abstract) 11 refs.

Glaves, G.L. (Univ of New Mexico, Albuquerque, NM, USA); Davis, P.J.; Smith, D.M. *Powder Technol* v 54 n 4 Apr 1988 p 261-269.

**084778 GEOMETRY FOR CHARACTERIZING FRACTURED PARTICLE SHAPE.** In the physical model of particle formation by the catastrophic failure of a brittle solid, it is postulated that cracks sequentially form the surfaces of the fragments and that the resulting particles may be characterized by faces, edges and points. Using this simple model and several apoditic observations, three equations are derived that relate the number of points on a particle to the number of edges and faces on that particle surface. It was found that the number of points on the surface of a particle is always even, there are 50 percent more edges than points and the number of faces is 2 plus half the number of points. Unusual or forbidden shapes were found that are both rare and tend to disappear on further size reduction, and, moreover, are characterized by pairs of multiply connected points. Moreover, because a fragment is one of a very large number of particles, it will have traces (faces) of other particles on its surface, and its shape will be complex. Finally, using a point counting system, a particular characterization system for angular particles is proposed. (Author abstract) 9 refs.

Meloy, T.P. (West Virginia Univ, Morgantown, WV, USA). *Powder Technol* v 55 n 4 Aug 1988 p 285-291.

## Synthesis

See Also GLASS—Synthesis.

**084779 PLASMASYNTHESSE KERAMISCHER SINTERPULVER FUER HOCHLEISTUNG-SKERAMIK.** [Plasma Synthesis of Ceramic Sinter Powders]. Increasing research efforts are being made towards studying reactions in the gas phase for synthesizing carbide and nitride-base sinter powders. With the aid of these processes it is possible to directly produce optimum powders of high purity in the submicron range. Plasma reactors are used for these purposes because such reactions require high temperatures. Plasma properties, plasma installations and the properties of the sinter powder thus produced compared with powders synthesized by other processes are dealt with in this paper. (Author abstract) In German. 6 refs.

Schulz, O. (Technische Univ Berlin, West Ger); Hausner, H. *Elektrowarme Int Ed B* v 45 n 3-4 Jun-Aug 1987 p 174-178.

**084780 SYNTHESIS OF HYDROUS SnO<sub>2</sub> AND SnO<sub>2</sub>-COATED TiO<sub>2</sub> POWDERS BY THE HOMOGENEOUS PRECIPITATION METHOD AND THEIR CHARACTERIZATION.** The article concerns a new method to prepare fine ceramic powders coated with other kinds of substances. These powders are useful because it is possible to make a new class of powder with two different properties. For example, SnO<sub>2</sub>-coated TiO<sub>2</sub> powder has the shielding power and UV absorption of TiO<sub>2</sub> and the electrical conductivity of SnO<sub>2</sub> and is of practical interest as a filler for plastic films. The homogeneous precipitation method is one of the best methods to control the pH and to form pure and dense precipitates, because it produces a precipitant slowly in the solution. This paper deals with the synthesis of SnO<sub>2</sub>-coated TiO<sub>2</sub> powders using the homogeneous precipitation method as a coating process. The powders have been characterized with scanning electron microscopy (SEM), thermogravimetry, differential thermal analysis (TG-DTA) and X-ray diffractometry (XRD). Electrical conductivities were also measured. 12 refs.

Kim, Byung-Kwan (Univ of Tokyo, Tokyo, Jpn); Yasui, Itaru. *J Mater Sci* v 23 n 2 Feb 1988 p 637-642.

## Testing

**084781 TESTING OF REFRACTORY METAL POWDERS.** Engineering components and other products made from metal, ceramic and plastic powders can be defined by specific parameters, but the powders from which they are fabricated cannot be so easily defined. In the case of metals it is particularly relevant, and a range of physical and chemical properties have to be tested for and equated to determine the properties of the ultimate powder metallurgy processed end products. This review of testing procedures covers powder metallurgy products which are predominantly based on refractory metals. The greatest tonnage of these are derived from tungsten and molybdenum, but reference is also made to tantalum and hard metals.

Marshall, Ronald P. *Met Powder Rep* v 43 n 7-8 Jul-Aug 1988 4p.

## Thermal Effects

See HELIUM—Fluid Dynamics; SILICON NITRIDE—Composition Effects.

## Thermodynamic Properties

**084782 THERMODYNAMIC CHARACTERISATION OF MICROCRYSTALLINE AND MICRO-FINE CELLULOSE POWDERS.** Cellulose produced by different processes (Spray dried and comminuted) have been characterized by low temperature (77K) nitrogen adsorption to determine the specific surface areas, micro- and meso-porosities together with the thermodynamic properties of the Polanyi surface potential and heat (enthalpy) of adsorption. These physico-chemical and thermodynamic parameters are then correlated with the physico-mechanical properties of compactability to indicate the bonding strengths of microcrystalline and micro-fine celluloses. (Author abstract) 11 refs.

Stanley-Wood, Nayland (Univ of Bradford, Bradford, Engl). *Part Charact* v 4 n 3 Sep 1987 p 106-111.

## Transport Properties

**084783 INTRINSIC-TRANSPORT MODEL FOR SOLID-SOLID REACTIONS INVOLVING A GASEOUS INTERMEDIATE.** A model has been developed for solid state reactions between powders in pellets or beds of reacting mixtures where the rate-limiting step is diffusion of a gaseous intermediate within the pore space (called intrinsic transport). The basis of the model is a network of expanding reaction cells, each centered on a particle of the reactant which gives rise to the gaseous intermediate. The partial pressure of the intermediate decreases from the equilibrium value at the surface of the central particle to zero at the reaction front of the cell due to reaction with the other solid reactant within the cell volume. The rate constant for an intrinsic transport controlled reaction is related to physical properties of



the system. A partial pressure of the intermediate on the order of  $10^{-4}$  to  $10^{-10}$  atm is sufficient to sustain solid state reactions at commonly observed rates. (Edited author abstract) 17 refs.

Wynnycky, J.R. (Univ of Waterloo, Waterloo, Ont, Can); Ruskin, W.J. *Mettall Trans B* v 19B n 1 Feb 1988 p 73-81.

## Transportation

**084784 TRANSPORTATION OF POWDERS USING A LINEAR MOTOR DEVICE.** The theory of linear motors has been formulated for both magnetic and non-magnetic reaction plates and criteria established to assess their performance. The predominant mechanism involved in the transportation of ferromagnetic powders cannot be the same as that in a motor device, because basic calculations show that the induced currents in the particles at 50 Hz are small. Instead, the ferromagnetic particles seem to follow the movement of the travelling magnetic field itself. This paper illustrates the motion of the particles along a linear motor device and also reviews the experimental work done previously, especially that associated with powder cleaning devices. Areas of future research work to be followed are discussed and possible new industrial applications mentioned. (Edited author abstract) 13 refs.

Gupta, D.K. (Univ of Technology, Loughborough, Engl); Hobson, L.; Lloyd, P.J. *Appl Energy* v 28 n 2 1987 p 107-122.

## Wear

**084785 REVIEW OF ATTRITION AND ATTRITION TEST METHODS.** The sources of attrition during the use of particulate materials are described and the mechanisms which cause breakdown are discussed. Techniques for testing the susceptibility of particles to attrition aim either to characterize and compare attrition of different materials or to predict particle behavior during powder use. The majority involve some form of mechanical means for inducing attrition under standard if undefined conditions. The mechanical tests fall into two categories, namely single particle and multi-particle. The multi-particle tests more closely relate to powder use but they are primarily empirical in nature whereas the single particle tests enhance the understanding of particle breakage but are difficult to compare with attrition observed in practice. The use of tests for predictive purposes currently presents difficulties, especially under diverse conditions of application. (Edited author abstract) 103 refs.

Bemrose, C.R. (Univ of Birmingham, Birmingham, Engl); Bridgwater, J. *Powder Technol* v 49 n 2 Jan 1987 p 97-126.

## Wear Resisting

**084786 WEAR-RESISTANT POWDER MATERIALS WITH INTERMETALLIC HARDENING. I. NONPOROUS MATERIALS FOR ANTIFRICTION PURPOSES.** The authors suggest the following principles of designing wear resistant materials: ensuring a homogeneous and balanced structure consisting of three phases where the base (the matrix) is the elastoplastic phase, then there are wear-resistant inclusions uniformly distributed throughout the bulk of the grains and inclusions having a laminated structure uniformly distributed along the grain boundaries; the material of the abradant is single-phase material with greater microhardness than the matrix; the structure of the material does not change in the process of friction. The results of the investigations confirm the possibility of predicting the structure and properties of wear-resistant powder materials with intermetallic hardening, and also of correcting the chemical composition in dependence on the operating conditions of the material. 13 refs.

Karapetyan, G.Kh. (Erevan Polytechnic Inst, USSR); Akopov, N.L.; Karapetyan, F.Kh.; Manukyan, N.N. *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 334-338.

**X-Ray Analysis** See SILICON NITRIDE—Oxygen Determination.

**POWER GENERATION** See Also FUEL CELLS—Design; NUCLEAR POWER PLANTS; PLASMA—Flow.

**084787 SMALL SCALE COMBINED HEAT AND POWER SYSTEMS. PART 1: TECHNICAL ASPECTS AND GOVERNING REGULATIONS.** The Lambeth Small Scale Combined Heat and Power 3-Year Demonstration Project is being undertaken by the Centre for Energy Studies which is part of the Polytechnic of the South Bank, London. The primary objective of the project is to show that where a demand exists for both heat and electric be maximized and consequently fuel costs to be reduced. The search for a suitable location for the demonstration project involved the analysis of heat and electricity consumption in a wide range of buildings throughout the London Borough of Lambeth. For this particular project it was necessary to find a location which offered accommodation for demonstration and seminar purposes, as well as having a suitable annual energy profile. The British Home and Hospital at Streatham met all these requirements and this paper has been produced to provide an introduction to the technology and application of micro CHP in a selected location.

Rufford, George (Energy & Business Management Consultancy, Woodbridge, Engl). *H&V Eng* v 59 n 675 p 10-13.

**084788 PHOTOVOLTAIC POWER GENERATION TECHNOLOGY IN FUTURE URBAN LIFE.** A photovoltaic power generation system can be recommended as a leading member for the dispersed power system because of its nature, e.g., simple system, clean energy, easy handling, maintenance free, etc. It cannot be forgotten for the urban construction of the future. The author explains about present status and activity of photovoltaic power generation in accordance with such a viewpoint. Further contents are the statistics of solar cell production and its cost, and the technology flow regarding cell production processes and applications, future aspects of conversion efficiency improvement of various kinds of solar cells, a principle system configuration diagram, system classification, etc. Trends in the commercialization toward the introduction to a future city and problems on electric power network at the introduction are also mentioned. (Edited author abstract) In Japanese. 15 refs.

Kurokawa, Kosuke (Electrotechnical Lab, Jpn). *Nenryo Kyokai Shi* v 66 n 11 1987 p 939-947.

**084789 FULL-SCALE TESTING OF THE LENIN-GRAD METAL WORKING PLANT 1200 KtsS-1 CONDENSER OF THE 1200 MW POWER-GENERATING UNIT AT KOSTROMA CENTRAL POWER STATION.** Thermal tests were conducted on the LMZ 1200 KtsS-1 condenser to determine its actual performance characteristics and to check operational efficiency of the tube bundles. The LMZ-1200 KtsS-1 sectional condenser group is designed to condense exhaust steam from the LMZ K-1200-240 turbine and it consists of four condensers connected with respect to cooling water in two parallel groups in each of which the two condensers have the cooling water connected in series via an intermediate water box. The full-scale thermal testing of the LMZ 1200 KtsS-1 condenser confirmed the high design characteristics at design cooling water temperature ( $12^{\circ}\text{C}$ ) and above. At c.w. temperatures below  $12^{\circ}\text{C}$  the actual characteristics were found to be inferior to the design ones but not to the characteristics of other types of Soviet condensers. 2 refs.

Ivanov, A.V. (Uraltekhenergo); Kopylov, N.F. *Therm Eng* v 33 n 12 Dec 1986 p 657-660.

**084790 NEUER WÄRMEEKRAFTPROZESS FÜR DIE NUTZUNG VON NIEDERTEMPÉRATURWÄRME.** [New Thermal Power Process for the Utilization of Low-temperature Heat]. The working principle and the motion equation of the expansion and compression strokes of a new thermal power process, which is similar to the Stirling one, are described in this

paper. The calculated motion operation is shown in a p,V-diagram. In this double-acting thermal power process, an isothermal operating process is realized with good approximation. The thermal energy is transferred to a working gas by means of a working liquid during the expansion stroke. The cooling during the compression of the working gas is effected by a counterstroke to the expansion in a second working cylinder in the same way by means of a working liquid. Both gas chambers are separated by a movable liquid column. With the aid of the operating process this liquid is set into oscillation. The oscillation can be converted into electric energy. The non-operational pressure of the working gas can be varied within a wide range of boundaries. The sealing of the gas is problem-free. For operating the engine, low-temperature heat - either from solar collectors or from waste process heat - is also particularly suited. (Edited author abstract) In German.

Fette, P. *Brennst Waerme Kraft* v 39 n 11 Nov 1987 p 496-500.

**084791 MAIN STAGES IN THE DEVELOPMENT OF THE POWER INDUSTRY OF KAZAKHSTAN DURING THE LAST 70 YEARS.** Industry was very little developed in Kazakhstan in the prerevolutionary period. The capacity of all the power stations in prerevolutionary Kazakhstan was no more than 2.5 MW, with annual generation of power of 1,300,000 kWh, which was 2 to 3 times less than the requirement today for one mechanised state farm. Significant development of the power industry in the republic began in 1928 when, in accord with Lenin's GOELRO plan, the first large hydro station was built and put into service; this was the Khariuzovsk Hydro Station with a capacity of 3 MW, which is still operational today. At the start of the first five-year plan overall capacity of the Kazakhstan power stations had reached 9.0 MW, some 7,000,000 kWh being generated. In prewar 1940 capacity of the Kazakhstan power stations was already 224 MW and the power generated 630,000,000 kWh. The paper provides a historical perspective of the development of the power generation facilities in Kazakhstan.

Kazachkov, V.T. (Minister of Power, Kazakh, USSR). *Therm Eng* v 34 n 11 Nov 1987 p 593-596.

**Computer Simulation** See ELECTRIC POWER PLANTS—Optimization.

## Control

**084792 AUTOMATIC GENERATION CONTROL FOR HYDRO SYSTEMS.** The authors present the decision of an automatic generation control (AGC) system implemented with digital computers that periodically sample tie-line real power flows, line frequency, and generator power outputs. These analog signals are measured at 2-5 intervals and combined with desired interchange to obtain the area control error (ACE). The ACE digital quantity is allocated to regulating hydro turbines and transmitted via telemetry to the remote terminal units (RTU). The RTUs convert the raise/lower megawatts (MW) into timed relay contact closures to the governor which result in wicket gate open/close movement to change the generator output power. The output power of each generator is monitored by the digital AGC, which closes a feedback loop around the governor-turbine-generator to assure that the desired power level is attained. The feedback loop design, which is essentially a sampled-data control, is described. Additional feedback loops due to the ACE and load regulation are also analyzed. A method for allocating water usage between reservoirs on a generator command-time basis is presented. The theoretical designs are verified by online measurements. 6 refs.

Kusic, G.L. (Advanced Control Systems Inc, Atlanta, GA, USA); Sutterfield, J.A.; Caprez, A.R.; Haneline, J.L.; Bergman, B.R. *IEEE Trans Energy Convers* v 3 n 1 Mar 1988 p 33-39.



**Economics** See WATER WAVES—Wave Energy Conversion.

**Energy Resources** See TIDAL POWER—India.

**Equipment** See BUILDINGS—Heating.

**Magnetohydrodynamic** See Also MATHEMATICAL TECHNIQUES—Boundary Element Method.

**084793 STUDY OF SMALL MAGNETOHYDRODYNAMIC PERTURBATIONS OF COLLISIONLESS PLASMA.** The authors consider small perturbation of collisionless plasma in a strong magnetic field, abandoning Chu-Goldberger-Low hypothesis that the energy of the flows parallel to the magnetic field of a random longitudinal motion and random transverse motion is equal to zero. A system of magnetohydrodynamic equations is obtained from Vlasov's equation for the ion distribution function, and from Maxwell's equations. (Edited author abstract) 4 refs.

Barkhudarov, M.R.; Zakharov, V.Yu. *Moscow Univ Mech Bull* v 42 n 4 1987 p 20-24.

**Pumps** See Also ELECTRIC POWER PLANTS—Thermoelectric.

**084794 APPLICATION OF CENTRIFUGAL PUMPS FOR POWER GENERATION.** The fact that centrifugal pumps can be used as turbines has been known for over half a century, but only limited use has been made of this knowledge. In most cases this has been due to ignorance. Although water turbines for plant power recovery situations are generally uneconomical, it would at times be viable to use pump turbines. Characteristics of pumps are freely available from pump manufacturers, but their characteristics as pump turbines are not. This article provides some basic ground rules and examples of possible applications. (Edited author abstract) 9 refs.

Wong, W. (Bechtel Ltd, London, Engl). *World Pumps* n 12 Dec 1987 p 381-384.

**Solar Energy** See Also PHOTOVOLTAIC CELLS—Applications; SOLAR CELLS—Arrays; SOLAR POWER PLANTS—Design; SOLAR RADIATION—Collectors.

**084795 MODIFIED REFRIGERANT COMPRESSOR AS A RECIPROCATING ENGINE FOR SOLAR THERMAL POWER GENERATION.** The prime mover of a small solar thermal power generation system can be either a turbine or a reciprocating engine. In this paper a case is made for the use of a reciprocating engine instead of a turbine. A new design of valves is described which results in an extremely simple reciprocating engine. It is argued that the efficiency of such an engine would be at least as good as that of a comparable turbine. A one-ton refrigerant compressor was modified to incorporate the valves proposed in order to run it as an engine. The engine was run on compressed air and the pressure-time diagram of this engine has been analyzed to evaluate the performance of the new valves. The present engine is compared with a similar engine developed by the Thermo Electron Corporation, U.S.A. (Author abstract) 4 refs.

Singh, R. (Indian Inst of Technology, Kanpur, India); Srinivasan, J. *Int J Energy Res* v 12 n 1 Jan-Mar 1988 p 69-74.

**084796 EARLY EXPERIENCE WITH SOLAR ELECTRIC GENERATING STATION 1 AT DAGGETT, CALIFORNIA.** The solar field comprised of 71,680 square meters of Luz parabolic trough line-focus solar collectors, supplies thermal energy at about 307°C (585°F) to the thermal storage tank. This energy is then used to generate saturated steam at 3.79 MPa and 247°C (550 psia and 477°F), which passes through an independent natural gas-fired superheater and is brought to 416°C (780°F) superheat. The SEGS I solar electric plant is performing well in its startup year of operation. Placed in service on schedule in 1984, the plant is producing electricity with a high degree of reliability.

Kearney, D.W. (Luz Engineering Corp, Westwood, CA,

USA). *Prog in Sol Eng*. Publ by Hemisphere Publ Co, Washington, DC, USA and Springer-Verlag, Berlin, West Ger and New York, NY, USA p 37-42.

**Thermodynamics** See REFRIGERANTS—Thermodynamics.

## USSR

**084797 POWER INDUSTRY IN THE 12TH FIVE-YEAR PERIOD.** In the decisions of the 27th Congress of the CPSU it was noted that in the 11th five-year period a new large step was taken in raising the standard of living of the Soviet people and in development of all branches of the economy. National income increased by 17% and the increase in industrial production was 20%. This paper describes the plans for development of the power industry in 1986-1990 which envisage the provision of reliable power supply for the national economy based on more effective procedures, extensive introduction of new, progressive technology and on modernizing and re-equipping existing plants.

Troitskii, A.A. (USSR State Planning Committee, USSR). *Therm Eng* v 33 n 12 Dec 1986 p 645-648.

**084798 USSR POWER INDUSTRY.** Power generated in the USSR in 1986 reached 1599 milliard kWh, comprising 59 percent of the level in the USA. Power generated in the USSR exceeds the total produced in the developed capitalist countries of Europe. The paper describes some of the hydroelectric stations and nuclear power plants of the Soviet Union.

Zheimerin, D.G. (All-Union Scientific Research & Design Inst of the Power Industry, USSR); Lavrenko, D.D. *Therm Eng* v 34 n 11 Nov 1987 p 585-588.

**084799 ESTONIAN SHALE-BASED POWER INDUSTRY-EXPERIENCE OF OPERATION AND THE PROSPECTS OF FUTURE DEVELOPMENT.** The experience of use of shales in the power industry based on the Estonian power system is of considerable importance for the power industry of the country as a whole, above all due to the fact that in the fairly near future in connection with the limited reserves of fossil fuel of high calorific value all the power stations of the country working on solid fossil fuel will have to change over to fuels of medium and low calorific value. The total installed capacity of the stations of the Estonian power system at the end of 1986 was 3311.3 MW, of which 3104 MW is generated by burning shale. The paper provides the performance characteristics of the Estonian power system working at base load and under conditions of load control in 1979-1986.

Semenov, A.N.; Arkhipov, Yu.N. *Therm Eng* v 34 n 11 Nov 1987 p 597-599.

**POWER METALLURGY** See ELECTRIC CONTACTS.

**POWER PLANTS** See Also CATALYSTS; COGENERATION PLANTS; FLOW OF FLUIDS—Films; GEOTHERMAL ENERGY; POWER GENERATION; POWER GENERATION—USSR; STEAM TURBINES—Design; TURBOGENERATORS; WATER TREATMENT.

**084800 COMBINED SYSTEM OF A SOLAR CONCENTRATOR AND WIND-POWERED GENERATOR FOR SPACE HEATING AND HOT-WATER SUPPLY.** It is shown that a station with total power of 10 kW can provide for the operation of a space-heating and hot-water supply system for 2/3 of the year. (Author abstract) 5 refs.

Avaliani, D.I.; Gabuniya, Z.T. *Appl Sol Energy* v 23 n 5 1987 p 80-83.

**084801 INTEGRATION OF SYNTHESIS AND OPTIMIZATION FOR CONCEPTUAL DESIGNS OF ENERGY SYSTEMS.** The evolutionary process of system synthesis and the mathematical process of system optimization are integrated in one do-it-yourself software. A large number of flowsheet arrangements can be con-

niently evaluated and optimized. The interactions among dissipations and dissipators can be monitored and analyzed to establish leading indicators to optimal configuration. The software is briefly described. An example problem demonstrates the integration of synthesis and optimization. The distribution of dissipations of the considered solutions to the problem are discussed. (Author abstract). 11 Refs.

El-Sayed, Y.M.; Gaggioli, R.A. *J Energy Resour Technol Trans ASME* v 110 n 2 Jun 1988 p 109-113.

**084802 SECOND LAW EFFICIENCY AND COSTING ANALYSIS OF A COMBINED POWER AND DESALINATION PLANT.** Flow diagrams for exergy have been made for Unit 2 at the Umm Al Nar West power plant in Abu Dhabi. This unit is one of six in a combined power and desalination facility, each delivering 60 MW of electricity and 18000 metric tons per day of freshwater at design conditions. The diagrams show the rates of exergy flow between all of the components in the facility as well as the consumption in each. For the desalination facility, diagrams were developed for both summer and winter operation, at design conditions. The steam generation and power plant diagrams were made for full and three-quarter electrical loads, and full-load delivery of steam to the desalination plant. Furthermore, detailed exergy costing diagrams have been constructed for the steam/power facility, at both full and three-quarter electrical load conditions. Conclusions are drawn regarding means for improving the existing plant and future designs. (Author abstract). 14 Refs.

Gaggioli, R.A. (Univ of Lowell, Lowell, MA, USA); El-Sayed, Y.M.; El-Nashar, A.M.; Kamaluddin, B. *J Energy Resour Technol Trans ASME* v 110 n 2 Jun 1988 p 114-118.

**084803 POWER BEHIND COMPETITIVE INDUSTRIES (PRESENTED AT THE 1987 INDUSTRIAL POWER CONFERENCE).** This conference contains 27 papers. The topics included are: newest generation of fluid bed boilers, small steam systems, cogeneration, controls and instrumentation, environmental technology, waste fuels, package boilers, landfill gas fueled power plants, and nondestructive testing techniques for package boilers. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10546 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Greenwald, R.F. (Ed.). (Donovan Engineering & Construction Co). *ASME Power Div Publ PWR* v 2, Power Behind Compet Ind, Atlanta, GA, USA, Oct 25-28 1987. Publ by ASME, New York, NY, USA, 1987 181p.

**Boilers** See Also WATER SUPPLY—Water Quality; WATER TREATMENT PLANTS—Process Control.

**084804 STUDY OF TRAJECTORIES AND COMBUSTION OF FUEL-OIL DROPLETS IN THE COMBUSTION CHAMBER OF A POWER-PLANT BOILER WITH THE USE OF A MATHEMATICAL MODEL.** A mathematical model is developed to permit study of the behavior of fuel-oil droplets in a combustion chamber, and results are presented from a computer calculation performed for the 300-MW model TGMP-314P boiler of a power plant. (Author abstract) 14 refs.

Enyakin, Yu.P. (F.E. Dzerzhinskii All-Union Scientific-Research Inst of Heat & Power Engineering, Moscow, USSR); Usman, Yu.M. *J Eng Phys* v 53 n 3 Sep 1987 p 1064-1071.

**084805 CREEP CRACK GROWTH BEHAVIOR IN POWER PLANT BOILER AND STEAM PIPE STEELS.** One of the important ingredients in remaining creep crack growth life assessment of elevated temperature power plant components is the material creep crack growth rate data. This report summarizes the currently available data on Cr-Mo and Cr-Mo-V steels most



commonly used in steam pipes and boilers. All data are correlated with the crack-tip parameter,  $C_t$ . The accompanying creep deformation data and tensile properties are also included. The influence of in-service degradation, test temperature and the welding parameters such as impurity level and post-weld heat treatment (PWHT) on the creep crack growth behavior were examined. It was shown that the influence of nominal material chemistry, service degradation and test temperature can be normalized into a single  $da/dt$  versus  $C_t$  trend for the base materials. It was also shown that the level of impurities and the PWHT can significantly influence the  $da/dt$  versus  $C_t$  behavior in weldments. (Author abstract) 22 refs.

Saxena, A. (Georgia Inst of Technology, Atlanta, GA, USA); Han, J.; Banerji, K. *J Pressure Vessel Technol Trans ASME* v 110 n 2 May 1988 p 137-146.

**084806 HEAT ABSORPTION OF FURNACES WITH WATER LANCING BY DEEPLY-EXTENDING UNITS.** The main difficulty encountered in operating power stations working on low-cost solid fuels with a complex composition of the mineral matter is the intensive fouling of heating surfaces by ash and slag deposits. The results of this study are: 1. Cleaning the furnace waterwalls of steam boilers with water with the deeply-penetrating apparatus ensures a high thermal efficiency of the waterwalls when operating boilers both with dry and wet bottom ash removal. 2. The water lancing system enables a boiler to be operated for a virtually unlimited time with the same high thermal efficiency of the waterwalls. 3. Change in thermal efficiency of furnace waterwalls in the period between two cycles of cleaning takes place at a uniform rate. 7 Refs.

Ots, A.A. (Tallinn Polytechnic Inst, USSR); Tallermo, Kh.I.; Sirde, A.E.; Ingermann, K.I. *Therm Eng* v 34 n 11 Nov 1987 p 605-609.

## Calculations

**084807 ENERGY CHARACTERISTICS OF ELECTROCHEMICAL POWER PLANTS WITH METHANE FEED AND HIGH-TEMPERATURE CELLS.** The paper describes a procedure for calculating the parameters of an electrochemical power plant (EPP) based on high-temperature cells. Methane serves as the raw fuel. The scheme involves a prior conversion of the methane with the water vapor and carbon dioxide which are the anodic reaction products of the high-temperature fuel cell (HTFC) with solid electrolyte. The mixture of hydrogen and carbon monoxide obtained as a result of the conversion is used as the reducing agent in the HTFC. The calculations show that the efficiency of such a power plant will be between 50 and 60%, depending on different parameters. (Edited author abstract) 5 refs.

Korovin, N.V. (Moscow Power Engineering Inst, USSR); Voloshchenko, G.N.; Vagin, V.F. *Sov Electrochem* v 23 n 4 Apr 1987 p 425-431.

**Components** See NUCLEAR POWER PLANTS—Design; STEEL—Aging; TUBES—Welding.

## Computer Aided Design

**084808 SMART CAD BUILDS LARGE PLANTS.** The use of symbolic processing techniques in CAD systems is considered to be an effective way to automate design of large, complex products. It also promised to speed repetitive design tasks and reduce costs. It is shown how knowledge base, definition-driven systems dramatically speed power plant design. Using design definitions, constraints, and rules these systems determine the characteristics and attributes of parts as well as their relationship to assemblies. Object-oriented programming and symbolic processing techniques are used to compile these definitions into a knowledge base. Then, information is extracted from the knowledge base to create drawings, parts lists, bills of materials, process plans, and other documents. An example of definition-driven mechanical design systems from ICAD Inc., Cambridge, MA is introduced that reduced the design time of large, complex boiler parts for power plants by two-thirds, and lowered

operating expenses by making designers more efficient and have significantly reduced product lead times.

Santalla, Richard W. (Combustion Engineering Inc, Windsor, CT, USA). *CAE Comput Aided Eng* v 7 n 6 Jun 1988 p 85-86, 89.

**Computer Aided Engineering** See ELECTRIC POWER PLANTS—Computer Aided Design.

## Computer Applications

**084809 ARCHITECTURAL DEVELOPMENTS IN ON-LINE COMPUTER SYSTEMS FOR POWER STATIONS.** On-line computer systems for monitoring and controlling fossil-fuel and nuclear power stations were implemented in the 1970s. Developments in the technology of communications and chips have taken place in the 1980s, and two systems making use of such facilities are described, including current developments in prospect. These are monitoring systems for a fossil-fuelled station at Rihand in Uttar Pradesh, India, and for the new AGR at Torness in Scotland. Rihand is a coal-fired power station with two units each rated at 500 Mw (electric). Each unit has its own dual-redundant OLCs. Torness is an AGR station with two reactor/boiler/turbine units each rated at 660 Mw (electric). There is an OLCs for each unit in addition to auxiliary monitoring systems. 1 ref.

Humphries, Frank. *Power Eng J* v 2 n 2 Mar 1988 p 115-119.

## Computer Interfaces

**084810 POWER PLANT PRODUCTIVITY AND RELIABILITY INFORMATION SYSTEM.** An information system for handling equipment failure information of fossil fuel plants is described. This system produces 33 different reports, which contain failure statistics, plant availability, unavailability classified by cause, plant reliability indices, and maintenance productivity indices. Some of the innovations introduced by this system are: (1) event partition into any number of subevents for accurate description of event evolution, (2) separation of equipment and event cause for easy reporting, and (3) failure-mode information for better event description.

Pazos, Rodolfo (Inst de Investigaciones Electricas, Mex); Lizarraga, Ezequiel. *IEEE Comput Appl Power* v 1 n 2 Apr 1988 p 25-29.

**Computer Simulation** See Also ELECTRIC POWER PLANTS—Geothermal Energy.

**084811 COMPACT, HIGH-FIDELITY SIMULATOR FOR POWER PLANTS.** Aging of existing plants, the high cost of constructing new ones, the need for cyclic operation, and pressures from regulatory agencies have forced the fossil-power industry to undertake plant-life extension and modernization programs. These programs require dynamic simulation codes to help engineers understand the behavior of plant equipment and processes and to predict the impact of proposed changes. In addition, plant operators need training simulators to help them become familiar with new equipment and to increase their expertise in areas such as plant heat rate. A description is given of the Compact Analyzer, which is an interactive program accessed through a PC, to help engineers devise and refine control strategies and make decisions on upgrading and cycling.

Khadem, Mostafa (Systems Control Inc, Palo Alto, CA, USA); Ipakchi, Ali. *Mech Eng* v 110 n 8 Aug 1988 p 58-61.

## Construction

**084812 CONCRETE POWER PLANT.** What may be one of the world's largest power plants with a superstructure essentially of reinforced concrete instead of conventional steel is now in operation in South Africa. The six boiler houses of the Lethabo coal-powered plant near Vereeniging, South Africa, were constructed of reinforced concrete to speed completion and reduce maintenance costs. Despite the tight construction schedule, the plant

was finished and in operation almost one year ahead of contractual commitments. This paper describes construction method and materials used.

Anon. *Concr Int* v 10 n 7 Jul 1988 p 27.

**Control** See ELECTRIC POWER SYSTEMS—Load Management.

## Cooling

**084813 EFFECT OF SUBCOOLING OF DISPERSED LIQUID ON CRITICAL HEAT FLUX WITH COOLING OF A PLANE SURFACE.** To ensure prescribed thermal state of elements of power plant extensive use is made of the method of cooling surfaces by dispersed liquid with different levels of subcooling. At the same time, information on critical heat fluxes with this means of cooling is very limited, and the applicability of relations derived for critical conditions with subcooled boiling of liquid in tubes and in channels is open to question. The paper describes a heat flux meter for determining parameters corresponding to critical heat transfer which was designed to carry out local measurements in the region of the space under the spray. The experiments showed that when a surface is cooled by a dispersed subcooled liquid, the critical heat flux density increases with the increase in subcooling and spraying density. 8 refs.

Bratuta, E.F. (Kharkov Polytechnic Inst, USSR); Kravtsov, S.F. *Therm Eng* v 33 n 12 Dec 1986 p 674-676.

## Cooling Water

**084814 TIDAL MODEL TEST OF SALINE SEDIMENT-LADEN FLOW IN A TRENCH ON MUD FLAT.** An experimental method for the tidal model of a trench dredged on a mud flat to pump cooling water for a power station is proposed in this paper. Saline water at low concentration was used in the model, in which prototype sediment was employed as model sediment. The purpose of the model test is to estimate the silting rate of the tidal flow of saline sediment-laden water in the dredged trench before and after dykes have been built on both sides. Conditions for siltation similarity and erosion similarity are discussed. Under the conditions of lacking local siltation data for model verification, comparisons are made of the data on the silting rates of tidal flows in dredged trenches and analogous projects in nearby regions for the purpose of validation. (Edited author abstract) 10 refs.

Fan, Jiahua (Inst of Water Conservancy & Hydroelectric Power Research, Beijing, China). *Sci Sin Ser A* v 30 n 11 Nov 1987 p 1203-1214.

**Costs** See Also ELECTRIC POWER PLANTS—Gas and Steam Turbine Combined; ELECTRIC UTILITIES—Economics; NUCLEAR POWER PLANTS—Construction.

**084815 WHAT MAKES A COAL-FIRED PLANT SO COSTLY?** The cost of constructing coal-fired power plants has increased twice as fast as inflation over the past two decades. Among the reasons are unusually high interest rates and the necessity of installing scrubbers. The paper describes other reasons for these cost increases and considers future costs.

Tessmer, Raymond G. Jr. (TVA, Chattanooga, TN, USA); Sauls, Timothy R. *Mech Eng* v 110 n 8 Aug 1988 p 62-66.

**Design** See Also SHIP PROPULSION—Selection.

**084816 INVESTIGATION OF THE p-v-T-DEPENDENCE OF THE  $\text{NaCl} + \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}$  SYSTEM AT HIGH TEMPERATURES AND PRESSURES.** Design and development of present-day thermal power plants and chemical-technological processes are not possible without knowledge of the thermodynamic properties of working media and coolants. Aqueous solutions of salts are extensively used in the thermal power industry, the oil refining and chemical industries and many other branches of the national economy. This paper is devoted to an



experimental investigation of the p-v-T-dependence of aqueous solutions of NaCl + Na<sub>2</sub>SO<sub>4</sub> and is a continuation of the authors' previous work. A piezometric constant volume method<sup>2</sup> was used to determine the p-v-T-dependence of these systems within a wide range of change in parameters of state. This method enables experiments to be conducted in the liquid, two-phase, vapour and near-critical regions within a wide range of change in parameters of state. 6 refs.

Mamedov, R.K.; Abdullaev, K.M.; Mamedov, F.I.; Muradov, Sh.Ya. *Therm Eng* v 34 n 12 Dec 1987 p 691-693.

**Economics** See Also ELECTRIC POWER PLANTS—Gas and Steam Turbine Combined.

**084817 WIRTSCHAFTLICHKEITSANALYSE DER REDUZIERUNG VON SCHADSTOFFEMISSIONEN EINES HEIZKRAFTWERKES.** [Economic Analysis of the Reduction of Emission of Pollutants from a Heating Power Plant]. The emission of pollutants from a heating power plant with 150 MW thermal output should be reduced by modifications to the most cost-effective extent possible. In this respect different variants in relation to cost and economics are compared. The special ratios for smaller plants for flue gas washing are discussed. From the flue gas desulfurization processes taken into consideration (spray absorption, wet washing with limestone suspension, the Wellman-Lord process, adsorption on active coal), the spray absorption process proved to be the most favorable. Primary measures should be sufficient for NO<sub>x</sub> reduction, but if necessary the SCR process can be used. Since electric power is also required at the same time by the heat consumer concerned, a check should also be made whether there would be economic advantages in combining district heat production and electricity generation. This proceeds from the limiting condition that on average as much electricity should be generated as is consumed. (Author abstract) In German. 30 refs.

Leithner, R. (Technische Univ Braunschweig, Braunschweig, West Ger.); Mueller, H.; Menke, Ch. *VGB Kraftwerkstechnik* v 67 n 9 Sep 1987 p 883-892.

**Efficiency** See COGENERATION PLANTS.

**Effluents** See WATER POLLUTION—Waste Heat Effects.

**Electric Equipment** See HYDROELECTRIC POWER PLANTS—Pumps.

**Emissions** See Also AIR POLLUTION—Computer Simulation; AIR POLLUTION—Reviews; NITROGEN COMPOUNDS—Adsorption; SCRUBBERS—Foundations.

**084818 ENERGIAINTUOTANNON PAASTOJEN MITTAAMINEN: HUIKASTEN SAHKOINEN LUOKITTELIJA JA SEN SOVELLUKSLIA.** [Measuring Energy Production Emissions: Electrostatic Particle Classifier and Its Applications]. The purpose of this study is to present a method of measuring the particle size distribution in the 0.01-1.0 µm diameter size range. The size distribution is measured by the Differential Mobility Particle Sizer (DMPS), in which the submicrometer particles are classified according to their electrical mobility. Electrical mobility is a function of the particle diameter and the number of elementary charges on the particle. The DMPS system uses a condensation nucleus counter (CNC) as the number concentration detector. A microcomputer performs the data inversion to obtain the particle concentration as a function of diameter. The volume (mass) distribution and the surface distribution are obtained by assuming spherical particles and a particle density of 1 g/cm<sup>3</sup>. In this study the size distributions of liquid DOP particles and solid NaCl particles were measured for particles generated by an atomizer. The electrostatic classification method provides a convenient source of monodisperse aerosol for instrument calibration. (Edited author abstract) In Finnish. 29 refs.

Heiskanen, Merja (Technical Research Cent of Finland, Espoo, Finl); Kauppinen, Esko; Hakkala, Matti. *Valt Tek Tutkimuskeskus Tutkimuksia* 512 Dec 1987 61p.

**Energy Management** See HEATING—District.

**Environmental Impact**

**084819 COMPENSATORY MECHANISMS IN FISH POPULATIONS: AN EPRI RESEARCH PLAN.** Using existing information, utility planners cannot accurately estimate the compensation by fish populations for power plant-induced mortalities. This plan maps a research effort to develop methods of quantifying this natural mitigation that would produce more-accurate assessments of utility impacts and help utilities make cost-effective decisions about power plant siting and design. The plan proposes two parallel, interactive research efforts - a key species program and a fellowship program - to develop a quantitative model for predicting the direction and magnitude of fish population response to site-specification impacts. Both are empirical programs: the first emphasizes the generation of data sets tailored to the needs of a modeling framework; the second tests and expands the concepts on which the models are based. As proposed, the research plan would last 9-11 years, with a funding requirement of approximately \$12 million.

Anon. *Electr Power Res Inst Rep EPRI EA 5404 Sep 1987 80p.*

**084820 UMWELTAUSWIRKUNGEN DER ENERGIEGEWINNUNG.** [Environmental Consequences of Winning Energy]. In the dispute on questions on our future energy supply it is now more vital than ever to rationally consider the advantages and disadvantages of the various methods for energy generation. A special, although not solitary role, is played by environmental effects which occur with any type of energy generation. Any assessment of the environmental risks must include not only those relating to the operation, but all consequences starting with the procurement of the energy raw materials right through to the ultimate removal of the energy generation plant. (Author abstract) In German.

Seidel, Ernst R. (Grundsatzfragen der Kernenergie im Bayer, Munich, West Ger). *At Strom* v 33 n 4-5 Jul-Oct 1987 p 123-126.

**Equipment**

**084821 IDENTIFICATION AND CONTROL OF SCALING IN RECIRCULATING ASH DISPOSAL SYSTEMS.** The scaling problems encountered in the recirculating ash disposal systems of three Canadian Thermal Generating Stations are studied in terms of the nature and types of scale that have deposited. These stations, the Nanticoke, Poplar River, and Keppells Generating Stations are unique in Canada, in that they burn significant quantities of low sulfur or lignite coal, and either currently employ, or have had previous experience in, the use of a wet recirculating system for transport of fly ash and bottom ash. Operating data obtained from these stations have been analyzed through the use of saturation indices developed for the major scaling species of concern, particularly calcium carbonate. (Edited author abstract) 54 refs.

Tonelli, F.A. (Zenon Environmental Inc, Burlington, Ont, Can); Nicolaides, G.M.; Silbert, M.D. *Res Rep Can Electr Assoc* 408 U 450 Jan 1986 2 vol, 141p.

**084822 POWER PLANT'S MAINTENANCE DEPARTMENT GETS FIRED UP ABOUT COUPLING.** Lubricated drive couplings are being eliminated wherever possible at the Tennessee Valley Authority's Colbert Steam Plant. Colbert, located in Tusculumbia, Ala., contains more than 1,000 pieces of rotating equipment, 700 of which have couplings between the driving and the driven components. Nonlubricated couplings not only require less time to replace than lubricated ones, they also reduce the vibration transferred from one piece of equipment to another, improving equipment performance.

Anon. *Powder Bulk Eng* v 2 n 3 Mar 1988 p 24-27.

**084823 LA CENTRALE A BOIS DE DEGRAD DES CANNES.** [Wood Power-Plant of Degrad des Cannes].

After a summary about gasification and combustion, the paper deals with the characteristics of the wood power-plant of Degrad des Cannes (Guyane): storage and shredding of wood, storage and drying, and wood gasification and gas purification are discussed. The characteristics of the 18 PC 2.5 DFC engine are then described and results of experiments done in Canada with the 8 PA 4-200 engine are presented. To conclude some economic data are presented as well as the advantages and the drawbacks of this type of power plant. (Edited author abstract) In French. 6 refs.

Boillot, M. (Electricite de France, Chatou, Fr); Migeot, J.L. *Entropie* v 23 n 134 1987 p 11-18.

**Evaluation** See COGENERATION PLANTS—Efficiency.

**Failure** See ELECTRIC POWER PLANTS—Gas and Steam Turbine Combined.

**Fluid Dynamics** See FLOW OF FLUIDS—Turbulent.

**Fuels**

**084824 ANALYSIS OF A WOOD-FUELED TRIM-BURNER SYSTEM FOR USE IN A COMBINED-CYCLE, WOOD-FIRED POWER PLANT.** This paper investigates the use of wood to fuel a trimburner incorporated in a combined-cycle, wood-fired power plant. The trimburner is designed to boost the temperature of the air stream entering the gas turbine. Wood conversion processes capable of producing a clean synthetic fuel were investigated since direct wood combustion products are too 'dirty' to be allowed to pass through the turbine blading. Of the three wood conversion processes considered (pyrolysis, gasification, methanol production), gasification was selected as the most applicable process for the trimburner concept. Three wood-fired trimburner systems employing an updraft gasifier design were developed and simulated. These subsystems differ in the way the producer gas, formed in the gasifier, was compressed to the trimburner operating pressure. (Edited author abstract) 8 refs.

Stephenson, J.D. (Oregon State Univ, Corvallis, OR, USA); Reistad, G.M. *J Sol Energy Eng Trans ASME* v 110 n 2 May 1988 p 82-89.

**Gas and Steam Turbine Combined** See Also COAL GASIFICATION—Testing; COGENERATION PLANTS; STEAM TURBINES—Design.

**084825 GAS TURBINE-STEAM TURBINE COMBINED-CYCLE SYSTEMS.** A combined-cycle system consists of two or more cycles operating at different temperatures. Heat rejected by the higher temperature cycle is used to drive the lower temperature cycle to produce additional power and operate at a higher overall efficiency than either cycle by itself could achieve. Combined cycle plant is a promising mode of energy recovery and conservation and is an economically interesting proposition where inexpensive low-ash fuel is available for the gas turbine and consequently the majority of these plants will be located where natural gas is available for driving the gas turbine and also for supplementary heating in the waste-heat boiler. 6 refs.

Singal, R.K. (Bombay Univ, India). *Electr India* v 27 n 14 Jul 31 1987 p 11-16.

**084826 LATEST ADVANCES OVERCOME WASTE HEAT SHORTFALL.** A combination of gas and steam turbine drives for auxiliary power generation - both exploiting exhaust gas waste heat - has attracted interest from operators of comparatively high powered vessels. Systems are projected or already in service in large containerships and VLCCs.

Anon. *Mar Eng Rev* Oct 1987 p 18-19.



**084827 HOW OPERATING CONDITIONS AFFECT PERFORMANCE OF HYBRID STEAM/GAS TURBINE PLANTS (PGU).** Design data and ratings for hybrid steam turbine and gas turbine plants (PGU) have been commonly cited in the scientific and technical literature, but actual PGU performance data arrived at empirically under on-stream conditions are often at sharp variance with the design data and ratings. Even in cases where steam parameters for hybrid steam/gas turbine plants (PGU) and steam-only plants (PSU) are identical, the heightened thermal performance of the former will make itself felt only when there is adequate and efficient gas turbine topping action over the steam portion of the cycle, i.e., when the efficiency of the initial uncombined gas turbine plant operating in an autonomous cycle is high. The advantages offered by PGU hybrids with a lowered air excess ratio in the off-gases improve as the required depth of load dump (in terms of percentage capacity) under operating conditions increases. 18 refs.

Prutkovskii, E.N.; Safonov, L.P.; Varvarkii, V.S.; Drobot, V.P.; Tarasov, E.A. *Sov Energy Technol* n 5 1987 p 1-11.

**Geothermal Energy** See Also TURBOMACHINERY.

**084828 FRACTURING OF A PILOT PLANT FOR BOREHOLE HEAT STORAGE IN ROCK.** This paper describes research on a pilot plant in Lulea, Sweden. The plant consists of 19 boreholes, 52 mm in diameter, for heat supply and extraction; and 10 boreholes for temperature monitoring. All the boreholes are 21 m deep. The report describes in detail the performance and results of rock mass permeability and borehole permeability tests. It also discusses hydraulic fracturing and explosive fracturing in the boreholes. A simulation model of water flow in the test plant is described. The paper includes conclusions from the test results. (Edited author abstract) 18 refs.

Nordell, Bo (Lulea Univ of Technology, Lulea, Swed); Bjarnolt, Gert; Stephansson, Ove; Torikka, Arne. *Tunnelling Underground Space Technol* v 1 n 2 1986 p 195-208.

**India** See FOSSIL FUEL POWER PLANTS—Design.

**Maintenance** See Also ARTIFICIAL INTELLIGENCE—Expert Systems; MAINTENANCE—Scheduling.

**084829 COMPUTERIZED MAINTENANCE MANAGEMENT...HELPING A WESTERN POWER PLANT STAY ON THE LEADING EDGE OF TECHNOLOGY.** Intermountain Power Service Corp. located in Delta, Utah, decided to operate the plant with state of the art maintenance technology. The company operates two 800-MW coal-fired units, a DC converter station, and a railcar service center that is located about 90 miles away. The facility has a fully integrated computer control system and virtually everyone in the plant has access to a computer terminal.

Anon. *Pract Lubr Maint* v 10 n 4 Dec 1987 p 25-26.

**Management**

**084830 OPERATIONAL PROCEDURES TO EVALUATE DECISIONS WITH MULTIPLE OBJECTIVES.** Many decisions facing utilities involve more than one objective, such as minimizing cost while maximizing environmental protection. In the work described here, actual electric utility applications illustrate operational techniques that can help utilities with multiobjective decision making. Presented in a workbook format, the report provides procedures and checklists for assigning values to potential outcomes of multiobjective decisions in a four-step process: In the first step, an analyst specifies distinct objectives. The second step requires associating attributes with each objective. For situations involving difficult-to-define attributes, such as minimizing environmental impact, the workbook discusses and demonstrates the construction of artificial scales and the use of proxy attributes. The third step requires quantifying relative values of the attributes. For the fourth step, an analyst uses the assigned values developed in the first three steps

to evaluate alternative scenarios.

Anon. *Electr Power Res Inst Rep EPRI EA* 5433 Sep 1987 164p.

**Mathematical Models** See ELECTRIC POWER PLANTS—Geothermal Energy.

**Monitoring**

**084831 MAXIMUM SALT CONTENT OF COOLANT AND CHOICE OF INTEGRAL MONITORING POINT WHEN STARTING SUPERCRITICAL POWER-GENERATING UNITS.** The blading of turbines of supercritical power-generating units is considerably more sensitive to deposits of salts and corrosion products than the steam-generating heating surfaces. A particularly important part of deposits, impairing operational reliability of turbines, is that of the corrosive compounds. Possessing fairly high solubility in the medium at supercritical pressure, these compounds pass through the circuit of a boiler at any of the concentrations in feedwater which are possible in practice, and then precipitate onto surfaces in the turbine flow section. In this work an analysis was made of practicability of standardizing characteristics and the practical advisability of standardizing. Measurements were made during the time of starting 300 MW supercritical generating units with TGMP-114 boilers and LMZ K-300-240 turbines at Syrdar' Central Power Station, where neutral/oxidant water treatment is practiced. 3 refs.

Rossikhin, L.Ya. (Sredaztekhnenergo-Syrdar' Central Power Station, USSR); Polevoi, E.N.; Smirnova, T.N. *Therm Eng* v 33 n 12 Dec 1986 p 683-685.

**Noise Abatement**

**084832 DECREASE OF NOISE LEVEL WHEN PASSING THROUGH A CONICAL UNION OF TWO PIPES.** The problem of the passage of sound waves through a conical diffuser connecting two pipes is considered. Expressions are obtained for the coefficients of sound passage  $\sigma$  and sound insulation  $R_0$ . The results obtained for a conical diffuser are compared with the data for an exponential diffuser. (Translated author abstract) 2 refs. In Russian.

Borovskii, B.I.; Chucherov, A.I.; Khitrik, V.L. *Izv Vyssh Uchebn Zaved Mashinostr* 2 1987 p 38-41.

**Optimization** See CHEMICAL PLANTS—Power Supply; GEOTHERMAL ENERGY.

**Outages** See FOSSIL FUEL POWER PLANTS—Maintenance; NUCLEAR POWER PLANTS—Retrofitting.

**Pipelines** See HEATING—District; STEAM PIPELINES—Bends.

**Piping Systems**

**084833 DEVELOPMENT OF MEASURES TO IMPROVE THE RELIABILITY OF THE FLANGED JOINTS OF HIGH-PRESSURE HEATERS OF 800 MW POWER GENERATING UNITS.** Reliable operation of the flanged joint ring seals of high-pressure heaters has been achieved as a result of developing and putting into operation a system of functional group control for the heaters. This ensures optimal heating conditions when starting and optimal cooling when shutting off heaters. It also provides monitoring of operation of the automatic level controllers.

Nosul'ko, D.R. (Zaporozhe Central Power Station, USSR); Bugasov, A.V. *Therm Eng* v 31 n 11 Nov 1987 p 635-637.

**Planning** See Also COGENERATION PLANTS—Gas Engines.

**084834 KRAETWERKSAUSBAUPLANUNG MIT MEHRZIELOPTIMIERUNG.** [Power Plant Extension Planning with Multiple Goal Optimization]. The authors present a mathematical model for multi-goal optimization

in system extension planning. This is an investment model which considers the overall system to optimize extension requirements of an existing power system with account being taken of a minimization of the present value of capital and operating cost versus an evaluation of environmental aspects. The method used is Dynamic Programming. Results are plotted as a multi-goal diagram for interpretation. (Author abstract) In German. 14 refs.

Kalliauer, A.; Leopold, G.; Schiller, G. *OZE Oesterr Z Elektrizitaetswirtschaft* v 40 n 12 Dec 1987 p 670-677.

**Pumps**

**084835 MICROPROCESSOR CONTROLLED OIL-HYDRAULIC MECHANICAL ACTUATOR FOR VARIABLE PITCH SEMI-AXIAL PROPELLER PUMPS IN POWER PLANTS.** Large cooling water pumps whose flow rates are regulated by variable pitch propeller blades require powerful actuators. An oil-hydraulic mechanical actuator for a force of 600 kN and controlled by a microprocessor is described. Oil-hydraulic and mechanical elements are an integral part of the pump while the microprocessor is typically installed in the pump motor control cabinet. The software and hardware and the flexibility of programmable pump operation of the microprocessor-based system are provided. (Author abstract)

Handwerker, Th. (KSB, West Ger); Kuch, J.; Richter, H. *KSB Tech Ber* n 22e Sep 1988 p 39-45.

**Reliability** See WATER TREATMENT—Optimization.

**Service Life**

**084836 ANALYSIS OF THE RESIDUAL LIFE OF HIGH-TEMPERATURE SYSTEMS.** Thermal power plants are high temperature systems. At high temperature under load, materials deteriorate continuously by diffusional processes like creep microstructural changes or oxidation. After a certain period, the residual life of a component can thus be defined as the time left till design life is reached. Simulation studies can help reach general conclusions about damage evaluation. For instance, that the simulation of service conditions by pure isothermal heat treatment does not give reliable results. For future simulation, the systematic integration of physical parameters, e.g., the cavity formation rate, particle coarsening or oxidation behavior in the extrapolation procedure should be considered. 30 refs.

Schepp, P. (Sulzer Brothers Ltd, Wintherthur, Switz); Walser, B.; Rosselet, A. *Met Mater (Cambridge Engl)* v 25 n 5 Sep-Oct 1987 p 331-338.

**Shutdown**

**084837 LIFE-CYCLE COST COMPARISON OF ALTERNATIVE MATERIALS FOR FLUE GAS DESULFURIZATION COMPONENTS.** Life-cycle cost analyses of the use of stainless steels (SSs) and other corrosion-resistant alloys were compared with those of lined carbon steel in the construction of flue gas desulfurization components. The life-cycle cost analysis included all of the cost components that are affected by the materials of construction and was based on standard costing procedures followed by the utility industry. Although the capital costs for SS and corrosion-resistant alloys are generally higher than those of the lined carbon steel components, the life-cycle costs are less in most cases. Additional benefits include improved reliability and reduced downtime. Savings can be further increased by optimizing the selection of materials for individual components by matching the operating environment of the component and mechanical characteristics of the materials. Extensive field experience confirms the favorable conclusions of the study. (Author abstract) 3 refs.

Shah, Y.M. (PEI Associates Inc, Cincinnati, OH, USA); Redmond, J.D. *Mater Perform* v 26 n 10 Oct 1987 p 50-55.



**South Africa** See ELECTRIC POWER PLANTS—Site Selection.

**Steam Turbines** See FEEDWATER HEATERS—Heat Transfer.

## Stresses

**084838** UEBERWACHUNG DER INSTATIONÄREN WÄRMEBEANSPRUCHUNG IN DICKWANDIGEN BAUTEILEN VON KRAFTWERKS-BOECKEN. [Control of Instationary Thermal Stress in Thick-walled Parts of Power Station Units]. On starting and switching off as well as load changes of steam generators, thermal stresses occur in parts which come into contact with steam and lead to a reduced service life due to metal fatigue. To ensure operational procedures adjusted to the stresses and economically optimized, the instationary thermal stresses in steam generator parts have to be determined during operation. In the following part of the paper, a new method has been developed for the determination of instationary temperature fields and thermal stresses by using two or more temperature measuring points in the wall, respectively. (Author abstract) In German. 20 refs.

Taler, Jan. *Brennst Waerme Kraft* v 39 n 11 Nov 1987 p 484-489.

## Structural Analysis

**084839** UNTERSUCHUNG VON EIGENSCHWINGUNGEN VON BUEHNEN UND GERUESTEN IN EINEM KRAFTWERK. [Investigation into Natural Oscillations in Floors and Supporting Structures in a Power Plant]. The calculation by computer of natural frequencies in a supporting structure require, as a rule, elaborate numerical analysis. In the case in question, an experimental procedure is offered, since the structural components to be studied have already been manufactured. Economies of time, low costs and realistic results make the oscillation measurements described in detail in the paper a rewarding alternative. (Author abstract) In German.

Menner, W. (Rheinisch-Westfaelischer Technischer Ueberwachungs-Verein eV, Essen, West Ger); Ruenz, G. *VGB Kraftwerkstech* v 67 n 9 Sep 1987 p 917-920.

## Structural Design

**084840** PROGRESSIVE CONSTRUCTION MATERIALS IN POWER MACHINE BUILDING. The continuous progress in power machine building is characterized by an increase in unit power of thermal, nuclear, and hydroelectric power plant units and imposes a number of requirements on the structural steels and alloys in use. The problems of using progressive structural steels and alloys, the development of new materials and the requirements on them for the power equipment developed in the period 1987-2000 were taken up at a meeting of the Scientific and Technical Council of the Ministry of Power Machinery in April 1987. In the reports and presentations of specialists from institutes, plants, special design offices, it was noted that structural steels and alloys used in the nuclear machine building in the production of steam boilers, steam and hydraulic turbines are at the levels of the better foreign materials for similar purposes in terms of calculated characteristics and technological properties, and satisfy the requirements imposed during design and manufacture of power equipment parts and components.

Trusov, L.P. *Sov Energy Technol* n 9 1987 p 79-81.

**Testing** See Also ELECTRIC POWER PLANTS—Geothermal Energy; HEATING—District.

**084841** HOW TO SELECT ANTICORROSION LOW-FREEZING FLUIDS FOR HYDRAULIC TESTS ON POWER MACHINERY PRODUCTS. Plants manufacturing power equipment and power machinery have been furnishing outside packages ready for operation to high-rated conventional and nuclear electric power-generating stations in recent years. Techniques for

mechanical removal of water currently in use at power equipment plants (blowdown with compressed air, vacuum and non-vacuum flashing of water, gravity-aided draining) run into serious problems in terms of equipment requirements, power drain, and cost, and at that without guaranteeing complete removal of water present. A crucial deficiency of these techniques is lack of objective quality control of the water remaining within the system. The Physical Chemistry Institute of the USSR Academy of Sciences (IFKh AN SSSR) has recommended several nitrobenzoate amines combined with sodium and potassium bichromates, silicates, and phosphates as corrosion inhibitors for salt anti-freezes. The Institute of Inorganic Chemistry of the Academy of Sciences of the Latvian SSR has recommended complexes of boric acid with polyhydroxy carboxylic acids (concentrations to 1%) as inhibitor additives. 10 refs.

Sizova, N.I.; Nagina, A.Ya.; Nechesova, E.I.; Zeitman, G.I. *Sov Energy Technol* n 12 1987 p 65-67.

## Thermal Effects

**084842** ADS SUBSYSTEM FOR SOLVING PROBLEMS OF NONSTATIONARY HEAT CONDUCTIVITY AND THERMAL STRENGTH. This article considers effective algorithms for numerical solution of problems in calculating thermomechanical states of parts; the group of programs developed based on the method of finite elements, for solution of the direct and inverse problems of heat conductivity, thermoelasticity, thermoplasticity, and heat creep for the two-dimensional (plane or axisymmetry) region; preparation of data and analysis of results during performance of calculations using modern computer technology and methods of information processing. The subsystem for solving the problems of nonstationary heat conductivity and thermal strength consists of two main components: the calculation and system components in which the algorithms for solving the above indicated problems based on the method of finite elements are implemented; dialog methods, processing of the input graphic information and partial graphic accompaniment of the calculation, means to control the calculation process. 7 refs.

Malyshev, N.G.; Suvorov, A.V.; Svintsitskii, F.B.; Sheshtakov, A.V. *Sov Energy Technol* n 9 1987 p 72-78.

**Thermodynamics** See Also ELECTRIC POWER PLANTS—Gas and Steam Turbine Combined.

**084843** THEORY OF HEAT TRANSFER-IRREVERSIBLE POWER PLANTS. The observed degree of thermodynamic imperfection of existing power plants is explained based on a steady-state power plant model the irreversibility of which is due to three sources: the hot-end heat exchanger, the cold-end heat exchanger and the heat leaking through the plant to the ambient. While maximizing the instantaneous power output, it is shown that in addition to Curzon and Aihorn's optimum temperature ratio there exists also an optimum balance between the sizes of the hot- and cold-end heat exchangers. A graphic construction for pinpointing the optimum location of the power plant on the absolute temperature scale is presented. (Edited author abstract). 13 Refs.

Bejan, Adrian (Duke Univ, Durham, NC, USA). *Int J Heat Mass Transfer* v 31 n 6 Jun 1988 p 1211-1219.

**Waste Disposal** See WATER POLLUTION—Underground.

## Waste Heat Utilization

**084844** ANWENDUNG DER BRENNWERTECHNIK BEI KRAFTERZEUGUNGSANLAGEN FUER ABWAERMENUTZUNG. [Application of Useful Heat Engineering in Power Generating Plants for the Utilization of Waste Heat]. Acidproof coatings for heating surfaces of economizers enable the utilization of the flue gas energy in the temperature range below the dew point of sulfuric acid. Apart from a simplification of the circuitry from the technical point of view, an increase in process efficiency is achieved, too. This paper deals with

the fundamental principles of useful heat engineering and its application in plants which utilize waste heat for power generation. (Author abstract) In German. 13 refs.

Kotzerke, C. *Brennst Waerme Kraft* v 39 n 6 Jun 1987 p 292-295.

**Water Supply** See Also FISHERIES—Protection; OSMOSIS, REVERSE—Evaluation; RIVERS—Discharge; WATER TREATMENT.

**084845** STATUS AND FUTURE DEVELOPMENT OF WORK ON AUTOMATIC OPERATIONAL MONITORING OF THE WATER-CHEMISTRY CONDITIONS OF POWER STATIONS. As a result of the work which has been carried out, including investigation of the water-steam circuits of generating units of power stations as systems for chemical control with different water-chemistry conditions and methods of water preparation used to maintain them, and also the methods used at present in the USSR and abroad for physico-chemical analysis of microimpurities in water and steam, several problems have been solved. To improve further the effectiveness of chemical monitoring systems it is necessary to introduce new types of automatic analysers with still better metrological characteristics, among which are the multirange electrochemical oxygen meter with a separating membrane, a conductivity meter for ultra-pure water, and also a unit for calibrating and checking analysers under operational conditions. 10 refs.

Zhivilova, L.M. (All-Union Heat Engineering Inst, USSR). *Therm Eng* v 33 n 6 Jun 1986 p 317-323.

**084846** SORPTION OF SILICIC ACID BY ANION EXCHANGE RESINS. The presence of silicic acid in natural waters, mainly in the form of orthosilicic acid ( $H_2SiO_4$ ), has been confirmed many times by various methods: by cryoscopic methods by spectral analysis, by electrical conductivity in concentrated alkaline solutions and other methods. In conformity with the Nichols equation the effectiveness of removing silica from water by strongly basic anion exchange resins depends on silica content of the resin. 17 refs.

Braudo, M.M. *Therm Eng* v 34 n 12 Dec 1987 p 664-668.

**POWER TRANSMISSION** See Also BEARINGS—Roller; BEARINGS—Vibrations; GEARS—GEARS—Design; GEARS—Performance; GEARS—Selection.

**084847** OBTAINING OPTIMUM POWER OUTPUT FROM AN ENGINE TRANSMISSION UNIT WITH A TRANSMISSIVE TORQUE CONVERTER. It is generally recognized that the use of a torque converter (TC) in an engine transmission power unit (ETPU) improves the performance of the unit, and particular increases its ability to cope with sharp random changes in external loads. The authors cover the question of matching the TC with the engine and adjusting it to the external load, to form a unified power system, and obtain optimum potential power from the system. By optimum potential power is meant the maximum power which the unit can develop when operating in a given loading mode. Optimum matching of the engine and TC does not depend on the distribution of the random load, if the latter is expressed by a single-modulus curve. The power of the ETPU is practically independent of the form of the loading characteristic and the transmissiveness of the TC. 5 refs.

Raevskii, A.N. *Sov Eng Res* v 7 n 7 Jul 1987 p 22-25.

**084848** GRAPHIC MODELLING OF THE DYNAMIC PERFORMANCE OF MULTI-STAGE GEAR TRANSMISSIONS. For the mathematical modelling of dynamic processes, methods based on the use of equivalent circuits and graphs are available, permitting equations of motion to be derived automatically. The proposed method was used in writing a program for computer-aided calculation of dynamic loads in gear engagements and bearings of multi-stage transmissions with up to 20 elastic



links. The calculation is made for a system with distributed parameters, determined from the dimensions of sections of stepped shafts; these dimensions are entered when it is required to run the calculation. The program takes into account the stiffness and damping coefficients of the joints (key, spline, etc.) and the elastically connected masses and inertia moments. 6 refs.

Podzharov, E.I. *Sov Eng Res* v 7 n 7 Jul 1987 p 34-36.

**084849 ANALYSIS OF DYNAMICS BEHAVIOR FOR A POWER TRANSMISSION MECHANISM USING LINEAR GRAPH THEORY (IN THE CASE OF CONSIDERATION OF MOTOR, SUPPORT AND GEAR).** The importance of system design in the field of mechanical engineering has been increasingly recognized recently. But suitable and useful methods for machine design are not yet established. So we must derive easy and useful designing methods for each machine element. In the previous report, we derived a new designing method by linear graph theory and analyzed the results of the dynamic behavior of a power transmission mechanism as an example. In the report, we understand that the mechanisms which are subject to restrictions of high accuracy and high performance must be designed by considering the characteristic of each machine element. This report deals with a more general power transmission mechanism containing a motor, bearing, support and so on, and analyzes the results of dynamic behavior. Provided that the analytical model and system graph as in this report are prepared for the mechanism, the performance of the mechanism is easily grasped by this method. (Author abstract) In Japanese. 6 refs.

Watanuki, Keiichi; Otaki, Hideyuki; Ishikawa, Yoshio. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 494 Oct 1987 p 2135-2142.

**084850 REVERSING SYSTEM FOR GAS TURBINES AND HIGH-SPEED ENGINES.** A particularly interesting transmission system is being installed in a large and fast fleet replenishment ship now under construction for the US Navy by NASSCO (National Steel and Shipbuilding Co) of San Diego. Two General Electric LM2500 gas turbines will be driven through Cincinnati double-reduction locked-train combining and reduction gears, incorporating SSS-Tosi reversing systems. The gear arrangement will be conventional, with each gas turbine input pinion driving two parallel secondary shafts, and all four secondary pinions engaging with the main gearwheel. An auxiliary gearbox fitted to the far end of each turbine drive train contains the reversing mechanism components. A second subject concerns how, with the adoption of a torsional elastic damper, severe vibration problems with a large slow-speed engine were successfully solved.

Anon. *Mar Eng Rev* Jun 1988 p 25-27.

**084851 LINEAR-MOTION ADVANCES: PATHWAYS TO GLORY.** The development of linear motion devices is surveyed. Most linear motion devices can be teamed with like or unlike devices into systems of two or more axes of linear motion. Linear actuation devices for single-axis motion include: various complex linkages such as walking beams or rod-and-crank mechanisms; cam drives with fixed-axis followers; gear rack and pinion sets; transmission chain drives in the linear part of chain travel, with or without special attachments; belt drives in the linear part of belt travel, with or without special attachments; plastic drive tapes; sliding-action leadscrews, with nuts; ball-bearing leadscrews, with nuts (ballscrews); skewed rollers on a rotating cylindrical rod (threadless rod; traction motion); fluid-power cylinders, with direct-driving rod, rodless cylinders, and cable cylinders; electric solenoids; electric linear motors. Some linear motion systems are reversible and capable of back-driving.

Hughes, Tom. *Power Transm Des* v 30 n 8 Aug 1988 p 15-16, 25-26.

**Automation** See AUTOMOBILE TRANSMISSIONS—Hydraulic Drive.

## Calculations

**084852 PROBABILISTIC ASSESSMENT OF THE KINEMATIC ERROR CALCULATION OF A PLANETARY TRANSMISSION.** Special constructional-design measures must be used for uniform distribution of the load over parallel branches in planetary transmissions. The theoretical calculation of the kinematic error of a planetary transmission described by Korotkov and Gusakova takes into account its reduction owing to an increase in the number of satellites and variation in the engagement factor for different transmission ratios. A more accurate relation was developed for the calculation of the kinematic error of a planetary transmission based on an experimental investigation. 6 refs.

Popov, P.K. *Sov Eng Res* v 7 n 4 Apr 1987 p 20-22.

**Components** See MECHANICAL DRIVE—Design.

## Computer Aided Analysis

**084853 COMPUTER ANALYSIS OF CONTINUOUSLY VARIABLE TRANSMISSIONS USING NON-CIRCULAR GEARS.** A mathematical model of the theoretical continuously variable transmissions (CVT's) using non-circular gears (NCG's) was analyzed. Based on torque, efficiency and speed characteristics, generalized conclusions were drawn. (Author abstract) 10 refs.

Cleghorn, W.L. (Univ of Manitoba, Winnipeg, Manit, Can); Shaw, E.C. *Trans Can Soc Mech Eng* v 11 n 2 1987 p 113-120.

**Design** See GEARS—Computer Aided Design; LUBRICANTS—Synthetic Products.

**Efficiency** See MECHANICAL DRIVE—Design; MECHANICAL DRIVE—Friction.

## Equipment

**084854 PODSTAWU DOBORU FILTROW W UKLADACH HYDRAULIKI SILOWEJ.** [Principles of Selecting Filters in Fluid Power Transmission Systems]. Causes of failures of fluid systems are considered, along with primary and secondary impurities of oil. Factors allowing a numerical determination of the goodness of filtration are presented. Techniques of reaction of particles of different size on the individual elements of a fluid system are discussed. The dependence of the life of a filter on the area of the filtering cartridge is outlined. (Edited author abstract). In Polish.

Anon. *Przegl Mech* v 47 pt 2 n 2 Jan 1988 p 29-31.

**Mathematical Models** See GEARS—Theory.

**Service Life** See GEARS—Lubrication.

## Testing

**084855 CHARACTERISTIC TEST OF STATIC POWER TRANSMISSION ON THE FACE-TYPE PERMANENT MAGNET TORQUE COUPLING.** A characteristic test of the face-type magnetic coupling static power transmission system was performed to obtain basic data on a permanent-magnet torque coupling. It was found that facing poles and adjacent poles have to be unlike for maximum transmission torque.

Tsurumoto, K. (Tohoku Gakuin Univ, Tagajo, Jpn). *IEEE Trans J Magn Jpn* v TJMJ-2 n 6 Jun 1987, Contrib from the Ninth Annu Conf on Magn in Jpn, Nov 26-29 1985 p 551-552.

**084856 CHARACTERISTIC TEST OF DYNAMIC POWER TRANSMISSION ON A FACE-TYPE PERMANENT MAGNET TORQUE COUPLING.** A dynamic power transmission characteristic test was performed on a face-type magnetic coupling static power transmission system to obtain basic data on the dynamic torque of permanent magnet fragments. The test showed that coercive force was high, but careful arrangement of the magnetic poles resulted in a high transmission torque.

Maximum transmission torque was obtained at the point when the magnetic shear force and magnetic repulsion force were greatest. 1 ref.

Tsurumoto, K. (Tohoku Gakuin Univ, Tagajo, Jpn). *IEEE Trans J Magn Jpn* v TJMJ-2 n 6 Jun 1987, Contrib from the Ninth Annu Conf on Magn in Jpn, Nov 26-29 1985 p 553-555.

**Variable Speed** See Also MECHANICAL DRIVE—Design; VEHICLES—Transmission.

**084857 CALCULATION OF THE CRITICAL SPEEDS OF A DRIVE WITH HARMONIC GEAR TRANSMISSION.** When investigating the dynamic stability of drives incorporating harmonic gear transmissions (HGT), we have to take into account the transverse vibrations of HGT elements. Determination of the natural frequencies of these vibrations is of the greatest interest, its purpose being to eliminate resonance phenomena where the kinematic error and non-uniformity of rotation reaches their maximum values. 6 refs.

Popov, P.K. *Sov Eng Res* v 7 n 3 Mar 1987 p 17-18.

**084858 CONTINUOUSLY-VARIABLE TRANSAXLE FOR FRONT WHEEL DRIVE VEHICLES.** A major problem has been in transmitting the power from the engine to the driving axles. Many attempts have been made to simplify manual gear changing and to eliminate it, as witnessed by the progression through synchromesh and epicyclic gearboxes to automatic drives operating electrically or hydraulically. One of the major problems has been the loss of power through the transmission, with consequent lack of economy on fuel. This article describes a continuously-variable transaxle designed specially for smaller front-wheel-drive vehicles on which the fuel consumption is approximately the same as for manual gearboxes, with the advantage of smooth gear changing comparable to a gearbox with no less than six speeds. (Edited author abstract)

Anon (Ford Motor Co). *Power Int* v 33 n 389 1987 p 174-176.

**084859 IDEAL CHARACTERISTICS OF A VARIABLE RATIO BELT DRIVE.** A fundamental theory concerning the theoretical power-torque envelopes over the speed ratio range of a general variable ratio belt drive is presented, to the best of the author's knowledge, for the first time. This theory applies to both V and flat belt drives, and is independent of the detailed designs. The analysis is based on two limiting factors, namely the maximum tension and the tendency of the belt to slip bodily on one or both pulleys assuming that the centre distance and the belt length are constant. These above factors determine the power and torque envelopes. The most suitable envelopes for the design purpose of the variable ratio belt drive are those of compact size, maximum belt tension and relatively high transmitted power. (Author abstract)

Bekircan, S. (Eaton Ltd, Manchester, Engl). *Proc Inst Mech Eng Part D* v 202 n 1 1988 p 45-49.

**Vibration** See GEARS—Mechanical Drive.

**PRASEODYMIUM AND ALLOYS** See Also BORIDES; GADOLINIUM COMPOUNDS—Impurities; GLASS—Optical Properties; ION SOURCES—Performance; LASERS, SOLID STATE—Materials.

**084860 ENRICHMENT OF PRASEODYMIUM IN BINARY MIXTURES OF NEODYMIUM AND PRASEODYMIUM.** Data on enrichment of praseodymium in a binary mixture of neodymium and praseodymium (4:1) are presented.  $\geq 40$  percent enrichment in praseodymium was achieved by hydrolysis of binary chloride solutions by airborne ammonia, and by decomposition of EDTA



complex solution of neodymium and praseodymium binary mixture on Amberlystic-15 resin. (Author abstract) 11 refs.

Phatak, G.M. (BARC, Bombay, India); Gangadharan, K.; Rao, G.S. *Res Ind* v 32 n 2 Jun 1987 p 124-126.

**084861 OPTOGALVANIC SPECTROSCOPY AND HYPERFINE STRUCTURE STUDIES IN PRASEODYMIUM.** The atomic spectra of praseodymium have been recorded using laser optogalvanic spectroscopy in a hollow cathode discharge over an extended range for the first time. About 78 atomic transitions of Pr I and 43 transitions of Pr II have been identified and their visual estimates of relative intensities are tabulated in the spectral range 5760-6250 Å. The laser optogalvanic spectroscopy is also used to record the hyperfine structure of the 6055.13, 5874.72, 5821.36 and 5779.28 Å transitions in Pr I. The large hyperfine splittings of the levels involved enabled us to resolve the hyperfine components even in the Doppler limited experiments and to obtain the hyperfine constants for the lower and upper levels involved. (Author abstract) 10 refs.

Reddy, M.N. (Indian Inst of Technology, Kanpur, India); Rao, G.N. *Physica B & C* v 150 n 3 Jun 1988 p 457-464.

## Electronic Properties

**084862 SELF-CONSISTENT BAND STRUCTURE OF PRASEODYMIUM UNDER PRESSURE.** Praseodymium (Pr) like cerium (Ce) has a number of phase transitions under pressure. In this work, we present a fully self-consistent band structure of Pr at four different pressures, using the linearized augmented plane wave method. For this purpose a potential of the muffin-tin form has been assumed. The exchange and correlation parts of the potential have been calculated by the local density formalism. The results show that between Pr III and Pr IV a band broadening occurs that looks similar to the band broadening between the  $\gamma$  and  $\alpha$  phases of Ce, in the sense of similar f-band widths. From the band-structure results, the density of states, coefficient of linear specific heat and superconducting transition temperature are calculated and are compared with experimental data wherever possible. (Author abstract) 32 refs.

De, S.K. (Indian Assoc for the Cultivation of Science, Calcutta, India); Chatterjee, S. *J Phys F Met Phys* v 17 n 10 Oct 1987 p 2057-2066.

**Laser Applications** See CALCIUM COMPOUNDS—Spectroscopic Analysis.

**Magnetic Properties** See RARE EARTH COMPOUNDS—Magnetic Properties.

**Phase Transitions** See RARE EARTH COMPOUNDS—Phase Transitions.

## Purification

**084863 ALTERATION OF SOME PROPERTIES OF PRASEODYMIUM METAL BY ELECTRON BEAM MELTING.** A commercial Pr rod with a purity of 3N(REO) was melted in an electron beam furnace under a pressure of  $10^{-5}$  approx.  $10^{-6}$  mmHg. The content of hydrogen decreased from 76 ppm to 4 ppm and the Vickers hardness number dropped from 58 to 32. The melted metal showed a higher oxidation resistivity, while the starting rod was easily cracked and oxidized. (Author abstract) 4 refs.

Hasegawa, Ryosuke (Nat'l Research Inst for Metals, Tokyo, Jpn); Kamihira, Kazushige; Suzuki, Shunichi; Yoshimatsu, Shiro. *Chem Express* v 2 n 11 Nov 1987 p 671-674.

## Radiation Effects

**084864 STRUCTURAL TRANSFORMATION AND CHEMICAL REDUCTION OF  $\text{Pr}_2\text{O}_3$  INDUCED BY THE ELECTRON BEAM DURING MICROSCOPICAL EXAMINATION.** The effects of electron beam irradiation on  $\text{Pr}_2\text{O}_3$  were followed at high

resolution in a JEM-4000EX electron microscope. Two categories of electron beam effects are reported. In one image sequence, the orientational transformation of  $\text{Pr}_2\text{O}_3$  from the [100] to the [313] direction was observed to occur. In another sequence, reduction of  $\text{Pr}_2\text{O}_3$  to  $\text{Pr}_2\text{O}_2$  resulted from intense beam irradiation. Electron diffraction patterns showed the further reduction of the specimen to  $\text{Pr}_2\text{O}_2$  and finally to  $\text{Pr}_2\text{O}_3$ . (Author abstract) 11 refs.

Schweda, E. (Arizona State Univ, Tempe, AZ, USA); Eyring, L.; Smith, David J. *Ultramicroscopy* v 23 n 3-4 1987 p 443-451.

**Solvent Extraction** See Also ORE TREATMENT—Solvent Extraction.

**084865 SYNERGISTIC SOLVENT EXTRACTION OF LANTHANIDES WITH MIXTURE OF 1-PHENYL-3-METHYL-4-BENZOYL-PYRAZOL-5-ONE AND TRI-N-OCTYLAMINE.** The synergistic solvent extraction of Pr, Gd and Yb with mixtures of 1-phenyl-3-methyl-4-benzoyl-pyrazol-5-one and tri-n-octylamine in  $\text{CCl}_4$ ,  $\text{C}_6\text{H}_6$  and  $\text{CHCl}_3$  is studied. The composition of the extracted species has been determined as  $\text{LnP}^+ \cdot 4\text{TOAH}$  ( $\text{Ln} = \text{Pr, Gd, Yb}$  and  $\text{P}^-$  and  $\text{TOAH}^+$  are the chelating extractant anion and the amine salt cation respectively). The values of the equilibrium constants are calculated. The extraction mechanism is discussed. (Edited author abstract). 17 Refs.

Dukov, I.L. (Higher Inst of Chemical Technology, Sofia, Bulg); Genov, L. Ch. *Solvent Extr Ion Exch* v 6 n 3 1988 p 447-459.

## Spectroscopic Analysis

**084866  $4f5d-4f^2$  RADIATIVE TRANSITION PROBABILITIES OF  $\text{Pr}^{3+}$  IN  $\text{PrP}_2\text{O}_{14}$  CRYSTALS.** The spectra of excitation and fluorescence were measured in  $\text{PrP}_2\text{O}_{14}$  crystals. The d-f radiative transition probabilities of  $\text{Pr}^{3+}$  ion were calculated. The excitation spectral peaks are at 238 nm and 298 nm. They were measured at room temperature on a Hitachi MPF-4 spectrophotometer. 5 refs.

Zhang, Siyuan (Acad Sinica, Changchun, China). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 159-160.

**084867 ON THE BROAD BAND EMISSION OF  $\text{Pr}^{3+}$  IN  $\text{LnOX}$  ( $\text{Ln} = \text{La, Gd OR Y}$ ;  $\text{X} = \text{Cl, Br OR I}$ ).** Of the nine hosts studied only  $\text{LaOI}$ ,  $\text{YOCI}$ ,  $\text{YOBr}$  and  $\text{YOI}$  show a broadband emission of  $\text{Pr}^{3+}$ . By comparing with codoped samples, the mutual influences on luminescence between  $\text{Pr}^{3+}$  and other Ln's were studied. Samples were prepared by a flux method. Excitation and emission spectra were taken with a Hitachi MPF-4 at room temperature. 6 refs.

Li, Youmo (Acad Sinica, Changchun, China). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 161-162.

**084868 STARK ENERGY LEVELS OF GROUND STATES OF  $\text{Pr}^{3+}$  ION IN  $\text{PrP}_2\text{O}_{14}$ .** In present paper the polarized fluorescence spectra and infrared absorption spectra of single crystal of  $\text{PrP}_2\text{O}_{14}$  were measured at 77K, most of the observed transitions were identified, and the energy level of the ground states was defined. The crystal field calculation was performed for  $\text{C}_{4v}$  symmetry and gave a respectable to fit for the observed stark splitting of the ground states. 5 refs.

Bai, Yubai (Jilin Univ, Changchun, China); Kan, Qiubin; Zhao, Yongnian; Li, Tiejin. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 702-703.

**Vibrations** See CRYSTALS—Spectrum Analysis.

## PRASEODYMIUM ANTIMONY ALLOYS

### Phase Diagrams

**084869 PHASE DIAGRAM OF THE Pr-Sb SYSTEM.** This study contains a phase diagram of the Pr-Sb system which was built up using high temperature differential, x-ray phase and microstructural analyses. Praseodymium, containing 99.84% of the basic metal, and antimony of superhigh purity were used for the investigation. The preliminary synthesis of the alloys was carried out in evacuated (up to  $10^{-4}$  mmHg) molybdenum ampoules at 500°C. The X-ray phase analysis was performed on powders using a Tu-62M diffractometer and a HZG-3 goniometer with Cu K radiation. The microstructural analysis was carried out with an MIM-8 microscope. The phase with the highest melting point is the praseodymium monoantimonide which melts congruently at 2170°C. At 1950°C it undergoes a reversible polymorphic transformation. Microstructural analysis revealed that the samples close to equiatomic composition always contain a second phase. 11 Refs.

Abdusalyamova, M.N. (Acad of Sciences, Dushanbe, USSR); Rahmatov, O.I.; Faslyeva, N.D.; Tchuiko, A.G. *J Less Common Met* v 141 n 2 Aug 1988 p L23-L26.

## PRASEODYMIUM IRON BORON ALLOYS

### Amorphous

**084870 MAGNETIC PROPERTIES OF MELT-SPUN (Pr, Dy)-(Fe, Co)-B SYSTEM ALLOYS AND THEIR BONDED MAGNETS.** In melt-spun ribbon of (Pr,Dy)-(Fe,Co)-B alloys prepared by the single roller method, the effects of composition and substrate surface velocity on the magnetic properties were studied. Bonded magnets were made of  $\text{Pr}_{15}\text{Fe}_{77}\text{B}_8$ ,  $\text{Pr}_{15}(\text{Fe}_{0.9}\text{Co}_{0.1})_{77}\text{B}_8$ , and  $(\text{Pr}_{0.95}\text{Dy}_{0.05})_{15}(\text{Fe}_{0.9}\text{Co}_{0.1})_{77}$ . Values of a maximum energy product in  $\text{Pr}_{15}\text{Fe}_{77}\text{B}_8$ ,  $\text{Pr}_{15}(\text{Fe}_{0.9}\text{Co}_{0.1})_{77}\text{B}_8$  and  $(\text{Pr}_{0.95}\text{Dy}_{0.05})_{15}(\text{Fe}_{0.9}\text{Co}_{0.1})_{77}$  prepared at a substrate surface velocity of 11.8 m/s were 98.3 kJ/m<sup>3</sup>, 97.4 kJ/m<sup>3</sup> and 97.8 kJ/m<sup>3</sup> respectively. The best magnetic property obtained was  $(\text{BH})_{\text{max}} = 64.8 \text{ kJ/m}^3$  in  $\text{Pr}_{15}\text{Fe}_{77}\text{B}_8$ . The temperature coefficients of  $B_r$  and  $H_{CB}$  were improved by Co substitution for Fe and Dy for Pr. (Edited author abstract). 12 Refs. In Japanese.

Yamamoto, Hiroshi; Nagakura, Mitsuru; Hori, Kunihiko; Ozawa, Yoshiaki. *J Jpn Soc Powder Powder Metall* v 35 n 3 Apr 1988 p 101-105.

### Structure

**084871 STUDY OF THE ONE-DIMENSIONAL COMPOSITION-INCOMMENSURATE STRUCTURE OF  $\text{Pr}_{1+x}\text{Fe}_4\text{B}_4$ .** The crystal structure of the B-rich phase  $\text{Pr}_{1+x}\text{Fe}_4\text{B}_4$  was studied by means of X-ray powder diffraction and electron diffraction methods. One-dimensional composition-incommensurate structure along the c-direction is found. The structure is composed of Fe-B substructure and Pr substructure. Both substructures have tetragonal symmetry with the same lattice parameter a, but there is no lowest common multiple relation between  $c_{\text{Fe-B}}$  and  $c_{\text{Pr}}$  parameters. The lattice parameter at room temperature of  $\text{Pr}_{1+x}\text{Fe}_4\text{B}_4$  is a = 0.7144,  $c_{\text{Fe-B}} = 0.3900$ ,  $c_{\text{Pr}} = 0.3485$  nm and after quenched from 950°C a = 0.7138 nm,  $c_{\text{Fe-B}} = 0.3881$  nm and  $c_{\text{Pr}} = 0.3618$  nm. The space groups of substructures of Fe-B and Pr are  $\text{P4}_2/\text{ncm}$  and  $\text{I4}/\text{mmm}$ , respectively. (Edited author abstract). 5 Refs.

Tian, Jinghua (Chinese Acad of Sciences, Beijing, China); Jingkui, Liang; Dayu, Yang; Hanjie, Fan; Fanghua, Li. *Phys Status Solidi A* v 107 n 1 May 1988 p 45-53.



## PRASEODYMIUM IRON COBALT CHROMIUM ALLOYS

## Magnetic Properties

**084872 MAGNETIC PROPERTIES OF  $\text{Pr}_2\text{Fe}_{14-x}\text{Co}_x\text{Cr}_y\text{B}$  COMPOUNDS.** The replacement of iron by cobalt leads to an increase in Curie temperatures but decreases the anisotropy field. Studies of  $\text{Nd}_2\text{Fe}_{14-x}\text{Cr}_x\text{B}$  compounds have shown that replacement of Fe by Cr results in an increase of the uniaxial anisotropy for  $0 \leq x \leq 1$ . The present note represents an extension to corresponding compounds with praseodymium. Magnetic measurements were performed at 77 to 800 K in fields up to 26 KOe. The values of the saturation moment,  $M_S$ , were obtained from Honda ( $M$  versus  $1/H$ ) plots. 12 refs.

Kowalczyk, A. (Polish Acad of Sciences, Poznan, Pol); Stefanski, P.; Wrzeczono, A. *Phys Status Solidi A* v 107 n 1 May 1988 pK61-K64.

## PRASEODYMIUM YTTRIUM COBALT BORON ALLOYS See MAGNETIC MATERIALS—Thermal Effects.

**PRECISION ENGINEERING** See Also BORING—Control Systems; INSTRUMENTS—Lubricating Oils; MEASUREMENT ERRORS; MECHANICAL VARIABLES MEASUREMENT—Reliability; METAL FINISHING; SAWS—Manufacture; SPEED REDUCERS—Selection; STEEL—Forming; SURFACES—Grinding.

**084873 NANOTECHNOLOGY.** Nanotechnology is concerned with manufacturing to dimensions or tolerances in the range 0.1-100 nm. It plays a key role in many areas including materials processing, mechanical engineering, optics and electronics. The author discusses technologies for manipulating materials at or near the molecular level are coming increasingly into use. (Edited author abstract) 87 refs.

Franks, A. (NPL, Teddington, Engl). *J Phys E* v 20 n 12 Dec 1987 p 1442-1451.

**084874 KINEMATIC COUPLINGS FOR PRECISION FIXTURING - PART I: FORMULATION OF DESIGN PARAMETERS.** A closed form analysis for the design of a three-groove kinematic coupling is developed and used to design a 356 mm (14 in) diameter kinematic coupling with 28.6mm (1.1/8 in) diameter balls and 45 kN (10,000 lbf) preload. When the coupling is subjected to cutting loads in the order of 75 N (17 lbf), the resulting wall thickness errors in a 254 mm (10 in) diameter hemispherical part are: (1) a  $0.36\mu\text{m}$  ( $14\mu\text{in}$ ) error from the cutting force, and (2) a  $0.89\mu\text{m}$  ( $35\mu\text{in}$ ) error with a 2% preload error. If ceramic balls and grooves are used, fretting corrosion of the coupling interface can be avoided and the coupling can operate in a corrosive environment. The kinematic design is unaffected by film contamination and does not require an extensive wear-in period. Preliminary experiments show the coupling to be repeatable to  $\pm 0.25\mu\text{m}$  ( $\pm 10\mu\text{in}$ ). (Author abstract) 8 refs.

Slocum, A.H. (MIT, Cambridge, MA, USA). *Precis Eng* v 10 n 2 Apr 1988 p 85-91.

**Automation** See ROBOTS, INDUSTRIAL—Manipulators.

## Bonding

**084875 KLEBEN IN DER FEINWERKTECHNIK. ERGEBNISSE EINER UMFANGE, TEIL II.** [Bonding in Precision Engineering. Results of a Survey. Part II]. Part I already reported on joints in use, joint types, joint functions, materials to be joined and the employed methods of joining. Part II takes a special look at the use of bonding in precision mechanics, including electrical engineering and electronics. (Author abstract) In German.

Marwinsky, Beate; Rasche, Manfred. *F&M Feinwerktech Messtech* v 95 n 6 Sep-Oct 1987 p 401-403.

## Mathematical Models

**084876 COMPUTER AIDED DIMENSIONAL PLANNING.** A mathematical model, incorporating a matrix-tree chain method for generating a tolerance chart and the method of tracing has been established based on the tolerance chart technique. A mathematical method for performing calculations of working dimensions and specification of tolerances in manufacturing processes is proposed. An interactive computer aided dimensional planning system (CADP) is presented. (Author abstract) 5 refs.

Tang Xiaoping (Beijing Inst of Aeronautics & Astronautics, China); Davies, B.J. *Int J Prod Res* v 26 n 2 Feb 1988 p 283-297.

**Measurements** See MECHANICAL VARIABLES MEASUREMENT—Angles.

## Technology Transfer

**084877 ENGINEERING TO NANOMETRE ACCURACIES.** Nanotechnology is the technology associated with the manufacture and measurement of components to accuracies between 1 nm and  $1\mu\text{m}$  ( $10^{-9}$  to  $10^{-6}$  m). To those who work in the electronics industry where individual structures on a semiconductor chip are fabricated to nanometre tolerances, nanotechnology has been familiar for years but for many others the concept of mechanical engineering to these levels of precision is unheard of and unnecessary. However, the ability to mechanically engineer to nanometre precision has already created, in just a few years, world markets of many billions of pounds in products with which all of us are familiar.

Raven, Tony (Scientific Generics). *Eng Mater Des* v 32 n 3 Mar 1988 p 19-20.

**PRESSES** See Also ELECTRIC SWITCHGEAR—Manufacture; FORGING MACHINES; METAL FORMING—Cold Working; PLASTICS LAMINATES—Manufacture; POWDER METALLURGY—Compacting; SOLIDS—Granulation; STEEL—Drawing.

**084878 OPTIMAL DESIGN OF THE MULTIBAR MECHANISM OF A DOUBLE-ACTION MECHANICAL PRESS.** The development of a mathematical model and the choice of optimal methods are presented in this paper on the optimal design of a blankholder mechanism in the double-action press. Besides, as an example a comparison is made of this optimum with computed results of the Verson Co. This research effort has been undertaken in an effort to incorporate technology imported into China as a result of cooperation with the Verson Co. In Chinese. 3 refs.

Liang, Chuntang (Shaan Xi Mechanical Engineering Inst, China); Yang, Chaoyun. *Chi Hsieh Kung Ch'eng Hsueh Pao* v 23 n 3 Sep 1987 p 77-86.

**084879 COMPARISON OF ELECTRICAL VERSUS MECHANICAL FEEDS FOR TRANSFER PRESSES.** This article deals with the different methods of driving machines for press feeding. While neither the mechanical or electrical transfer feeds have had significant cumulative experience on large presses at high production rates, some general conclusions can be drawn from field experience. The two drive mechanisms are compared in terms of reliability, accuracy, production rate and synchronization.

Chaytor, Alan (Unico Inc). *Sheet Met Ind* v 65 n 9 Sep 1988 5p.

**Applications** See PAPERMAKING—Drying.

**Automation** See Also GLASS MANUFACTURE—Pressing.

**084880 AUTOMATING THE POWDER COMPACTING PRESS.** Cincinnati Inc. of Cincinnati, Ohio, has introduced a PM part manipulator, designated Model 523, which can be fitted to any of its powder presses up to 220 tons, and which incorporates a weighing station for

quality control or statistical process control. Cincinnati has also introduced a 'fast set up' module for these presses which allows for greatly improved productivity and flexibility. The '523 Parts Manipulator' is an electromechanical transfer unit. It is capable of picking a part off the die, transferring it to a scale, weighing the part and then transferring the part to a handling station. This parts manipulator can be mounted on any 66, 110 or 220 ton Cincinnati compacting press that is microprocessor controlled and has a motorised feeder. The manipulator is a two axis microprocessor controlled, programmable system. There are two axes: the vertical motion of the Y-axis and the horizontal motion of the X-axis. Both axes are electrical servo controlled and independently programmed by the operator.

Anon. *Met Powder Rep* v 42 n 9 Sep 1987 p 642-644.

## Computer Aided Analysis

**084881 COMPUTER AIDED ANALYSIS OF SCREW PRESS DYNAMICS.** Dynamic mechanical and mathematical models for screw press and plastic-working processes of die forging and coining were developed, verified with experimental observations and used for analysis of screw press dynamics. Some results helped to optimize nut design elements of a screw-working mechanism. (Edited author abstract) 19 refs.

Bocharov, Y.A. (Bauman Inst of Technology, Moscow, USSR); Vlasov, A.V. *Int J Mach Tools Manuf* v 27 n 2 1987 p 143-154.

## Control

**084882 COMPACT PRESS CONTROLLER FOR SHEET METALWORKING.** The necessity to improve the economics of sheet metalworking has also spread to power presses, bringing with it greater automatic control and greater stroke rates. Nowadays, presses capable of producing 2000 items per minute are no longer a rarity. Implementation details are reported. (Edited author abstract)

Fehr, Manfred (Siemens AG, Geraetewerk Erlangen, West Ger); Mosburger, Jakob; Rissmann, Gerhard. *Energy Autom* v 9 n 2 Mar-Apr 1987 p 24-27.

**084883 COMPACT AND MODULAR CONTROLS FOR PRESSES.** Rapid set-up for new parts and operator prompting in the event of faults have been provided as standard and at an acceptable cost for a number of years in press lines and progressive presses. This user-friendliness is now also available in singly operated, small and medium-sized presses in the form of the WS510P compact control. (Author abstract)

Klose, Guenter (Siemens AG, Nuremberg, West Ger). *Energy Autom* v 9 Oct 1987 p 62-65.

**084884 FLEXIBEL GESTEUERTE STANZSTRABEN FUR TEILEFAMILIEN.** [Flexibly Controlled Stamping Lines for Component Families]. Decreasing batch sizes and growing type variety in sheet metal working generally results in the requirement for more flexibility in set-up changing for given component families. The consequence of this in turn is a demand for stamping lines permitting programmed set-up changing either within strip profiling and forming facilities or in press lines made up of conventional presses. This is a report on this trend with an example from refrigerator production. (Author abstract). In German.

Salinas, Ramirez, Felix. *Werkstatt Betr* v 121 n 6 Jun 1988 p 517-521.

**084885 INTERNATIONAL PUNCHING.** A joint venture between Bruderer of Switzerland and Siemens of West Germany has resulted in a flexible punching cell. The aims of the project were to combine a material storage, tool storage and punching into one machine simplifying the transport of coil and dies and reducing set up times from 40 minutes plus to 4 minutes. The crucial feature of



the cell is, of course, its performance, governed by the Siemens control system, which consists of a Simatic central controller with 20Mb of data storage, including all material and tool, storage data, and four satellite controllers for different parts of the process.

Anon. *Prod Eng (London)* v 67 n 9 Oct 1988 p 34.

## Control Systems

**084886 SAFETY START SWITCH FOR PRESS CONTROL.** The safety starting device for press control is recommended for use at enterprises which produce and use forging and press machinery with two-handed control. The proposed device prevents accidental actuation of the press, as well as the possibility of operating with one button when the contacts of the other button are closed, thus improving the reliability and safety of press operation. Since the introduction of the safety starting device at the Dimitrovgrad Automotive Component Plant, no accidental press actuations have occurred.

Fomakin, A.N. *Sov Forg Sheet Met Stamping Technol* n 2 1987 p 110-111.

## Corrosion Resistance

**084887 PROPERTIES AND MANUFACTURE OF THE CORROSION-RESISTING PLATE AND FRAME PRESS.** The acid/alkali resistance and manufacture of the corrosion-resisting plate and frame press made of rubber and poly-propylene are discussed. The structures and characteristics of various types of plate and frame often used are contrasted. The failures which often happen in production are analysed and preventing methods are presented. (Author abstract) 9 refs. In Chinese.

Zhang, Zhiying (Shijiazhuang No 1 Rubber Plant, Hebei, China). *Huagong Jixie* v 14 n 6 1987 p 444-448.

**Design** See Also POWDER METAL PRODUCTS—Manufacture; POWDER METALLURGY—Compaction.

**084888 DIMENSIONING OF AN EXTRUSION PRESS.** In connection with investigations on a so called ram or piston feed lock for introducing solids into, or discharging solids from, pressurized spaces, which operates on exactly the same principle as an extrusion press, the question as to the relationship between the piston pressure to be applied and the length to be adopted for the die channel has to be considered. The criterion is that a particular compaction pressure must not be exceeded. A consistent distinction is drawn between the compaction phase and the extrusion (or conveying) phase. On the basis of theoretical considerations relating to bulk materials and correspondingly different formulations for the pressure conditions established, it is possible to obtain a differential equation whose solution yields an unambiguous relationship between compaction pressure and required channel length. A dimensionless representation of the results based on this approach offers a simple method of determining the dimensions of extrusion presses taking due account of the compaction phase and the extrusion phase. (Edited author abstract). 16 Refs.

Horrighs, W. (Univ of Essen, West Ger). *Powder Technol* v 56 n 1 Sep 1988 p 13-20.

**Energy Utilization** See STEEL SHEET—Forming.

## Feeding

**084889 MECHANIZED SYSTEM FOR STRIP FEEDING IN PRESSES.** A system has been developed for handling the strips left over after cutting large sheets in the main production shops. These strips are fed to the press section which produces consumer goods. The system consists of receiving and discharging tables, a modernized roll-feed device (type VP35A), two guide rollers, and thrust units. The system is connected to the KD-2330 press. The incoming strip is placed on the receiving table and inserted between the push rolls of the feed device. The guide rollers are intended for locating the straight edge of the strip, preventing transverse movement, and guiding

the strip onto the top surface of the die. The flat spring of the thrust unit keeps the strip pressed against the faces of the guide rollers. At the exit of the die zone the strip is engaged by the pull rolls of the feed device and is removed from the press. The used strip falls on the discharging table and is thrown in a waste container.

Titov, Yu.S.; Kuz'min, G.G. *Chem Pet Eng* v 22 n 7-8 Jul-Aug 1986 p 407-408.

**High Pressure Effects** See DIAMONDS—High Pressure Effects.

**Hydraulic** See Also DIES—Design; FORGING MACHINES; FORGINGS—Superplasticity; METAL DRAWING—Deep; POWDERS—Compaction; STEEL—Forging.

**084890 FLEXIBLE MANUFACTURE OF WHITE GOODS.** A company with long experience in the design and manufacture of press lines for the white goods industry is Soenen. The company has designed press lines for various manufacturers and recently supplied equipment to Creda. Soenen's emphasis is currently on flexibility of operation and its flexible manufacturing press line comprises the following: a blank destacker with transfer and feeding unit to a prepositioning table, double blank control and oiling device; four hydraulic deep drawing presses; eight flexible feeding arms for input and output between the press tools; three transfer units with turn over facilities between the presses; and electrical and electronic controls.

Anon. *Sheet Met Ind* v 65 n 2 Feb 1988 p 66, 68.

**084891 ACCELERATION OF HYDRAULIC PRESS PARTS.** This article presents a method of determining the maximum accelerations of a press cross-arm based on the wave theory. Another result is the derivation of fairly simple formulas, which give the dependences in explicit form, and which make it possible not only to estimate the maximum acceleration, but also to determine the influence of the main design parameters on the maximum acceleration. 4 refs.

Tarko, L.M. *Sov Forg Sheet Met Stamping Technol* n 2 1987 p 99-102.

**084892 HEAT LOSS ANALYSIS OF TIRE CURING PRESS.** At the development stage of a new hydraulically operated tire press, the KOBELCO 'SUPER CUREX,' the design conception of optimal energy savings was adopted to realize a specific target value of heat loss from the press body. This paper describes the numerical calculation method with a personal computer to evaluate the heat loss from the press in operation, and presents a comparison between the results of numerical calculation and actually measured data. (Author abstract) In Japanese.

Amano, Itaru; Shibata, Masaharu. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 39-41.

**084893 HOT PLATEN PRESS IS A COMPUTER SUCCESS.** This article details the operating characteristics of a special hot platen press destined for work in the US aerospace industry. It has an advanced level of computerized control which enables the critical parameters involved in forming superplastic light-alloy materials to be programmed and continuously varied in-cycle, if required.

Astrop, Arthur. *Mach Prod Eng* v 146 n 3738 May 6 1988 p 45.

**Load Control** See LIMESTONE—Crushing and Grinding.

**Optimization** See POWDER METALLURGY—Compaction.

## Performance

**084894 DYNAMIC ACCURACY OF MECHANICAL PRESS - MEASUREMENT OF DYNAMIC CHARACTERISTICS BY A SIMULTANEOUS MULTI-MEASURING DEVICE.** In order to investigate

the dynamic characteristics of mechanical presses, precise measurement of dynamic accuracy is attempted by a simultaneous multi-measuring device. This device has one load cell, and six noncontact sensors used to detect the slide displacement in x, y and z directions relative to the bolster. The blanking operation is carried out by using a straight-side press. Steel plates (SPCC, 1 mm in thickness) are blanked varying the stroke number per minute. The results obtained are as follows: (1) Immediately after break-through, the vibration of the lower surface of slide relative to bolster becomes larger, and the inclination between the slide and the bolster is also bigger than that before break-through. (2) As the stroke number per minute increases, a) the position of lower dead point of the slide becomes lower, b) the vibration of slide inclination becomes larger even before break-through, c) the lower surface of the slide is given a violent distortion and the maximum amplitude of inclination increases immediately after break-through. (Edited author abstract) In Japanese. 8 refs.

Hatsukano, Kan-ichi; Sano, Toshio; Matsuno, Ken-ichi. *Kikai Gijutsu Kenkyusho Shoho* v 42 n 1 Jan 1988 p 27-37.

**Processing** See VENEER—Drying.

## Productivity

**084895 FEEDING HUNGRY PRESSES.** Just-in-time demands have wrought big changes for the stamping industry. Short runs, fast change-overs, and tremendous cost-squeezing competitive pressures have forced a lot of reluctant stampers to take a bold leap into the brave new world of automated press feeding to get the productivity they need to compete. Although few can afford the investment in large press lines recently made by General Motors and other large automotive companies, advances in transfer automation are helping a lot of stampers retrofit existing presses with automated transfer equipment and get significant productivity increases. The effects are already measurable. A recent study of Michigan's stamping industry revealed autobody production rates two to three times faster than were typical just a few years ago, uptimes have nearly doubled from 40 to 50 percent to 70 and 80 percent, and rejection rates dropped from 3 to 5 percent to fractions of a percent.

Sprow, Eugene E. *Tool Prod* v 54 n 7 Oct 1988 p 62-66, 71-72.

**Tools** See DIES—Control.

**Vacuum Applications** See PRINTED CIRCUITS—Manufacture.

**PRESSURE CONTROL** See Also COMPRESSORS—Computer Applications; NUCLEAR REACTORS—Containment Vessels; PRESSES—Design; THERMOPLASTICS—Injection Molding.

**084896 CUT-OUTS FOR KEEPS.** E. Norfolk explains the ins and outs of setting up high and low pressure controls for temperature regulation in display cases - particularly the important cut-out point. (Author abstract)

Norfolk, E. *Aust Refrig Air Cond Heat* v 41 n 5 May 1987 p 32.

**Analysis** See OPTICAL FIBERS—Fabrication.

**PRESSURE EFFECTS** See AERODYNAMICS—Drag; ALUMINUM CASTINGS—Porosity; ALUMINUM MAGNESIUM ALLOYS—Fiber Reinforcement; ALUMINUM ZINC ALLOYS—Mechanical Properties; BIOLOGICAL MATERIALS—Blood Vessels; CERIUM COMPOUNDS—Magnetic Properties; CHROMIUM COMPOUNDS—Magnetic Properties; CLAY MINERALS—Dehydration; COAL COMBUSTION—Fluidized Beds; COPPER ZINC ALLOYS—Diffusion; CYLINDERS—Composite; CYLINDERS—Explosions; CYLINDERS—Mathematical Models; CYLINDERS—Structural Analysis; DISKS—Stresses; DOMES AND SHELLS—Buckling; DOMES AND SHELLS—Stability; ELECTRIC CABLES—Sheathing; FARM BUILDINGS—Ventilation; FLOW OF FLUIDS; FLOW OF FLUIDS—Turbulent; FLOW OF FLUIDS—Two Phase; FLOW OF



FLUIDS—Viscous; FLOW OF WATER—Open Channels; GLASS—Drilling; GLASS—Elasticity; IRON AND ALLOYS—Electric Conductivity; MANGANESE AND ALLOYS—Magnetic Properties; MANGANESE COMPOUNDS—Thermal Expansion; MATERIALS SCIENCE; MECHANISMS—Hydraulic Drive; OIL WELL PRODUCTION—Enhanced Recovery; PETROLEUM, CRUDE—Vaporization; POLYESTERS—Curing; POLYMERS—Spectroscopic Analysis; POWDER METALLURGY—Copper Tin; POWDER METALLURGY—Titanium Carbide; POWDERS—Fluidization; REFRACTORY MATERIALS—Zirconia; SAND AND GRAVEL—Consolidation; SEMICONDUCTING SAMARIUM COMPOUNDS—Phase Transitions; SOILS—Pressure Measurement; SOILS—Testing; TIN LEAD ALLOYS—Creep; WOOD PRODUCTS—Manufacture; ZINC AND ALLOYS—Internal Friction; ICE—Mechanical Properties; SILOS—Unloading; PLATES—Deformation; CYLINDERS—Stability; AGRICULTURAL MACHINERY—Implements; PIPELINES—Pressure Effects; PLASTICS, REINFORCED—Transfer Molding; ATMOSPHERIC PRESSURE AND DENSITY—Oscillations; SOILS—Testing.

**PRESSURE MEASUREMENT** See Also AERODYNAMICS—Boundary Layer; AERODYNAMICS—Wings and Airfoils; AEROSOLS—Analysis; BEARINGS—Journal; BIOLOGICAL MATERIALS—Cartilage; BIOMECHANICS—Joints; BOILERS—Failure; CHEMICAL REACTIONS—Monitoring; COMPRESSORS—Blades; DAMS, ARCH—Structural Analysis; DIESEL ENGINES; DIESEL ENGINES—Combustion; FLOW OF FLUIDS—Jets; FLOW OF FLUIDS—Nozzles; FLOW OF FLUIDS—Spheres; FLOW OF FLUIDS—Subsonic; FLOW OF FLUIDS—Suspensions; FLOW OF FLUIDS—Tubes; FLOW OF FLUIDS—Two Phase; FLOW OF FLUIDS—Vortex Flow; GAS TURBINES—Blades; HYDROELECTRIC POWER PLANTS—Vibrations; ICE—Pressure Effects; INTERFEROMETERS; MATERIALS HANDLING—Pneumatic Measurement Errors; MECHANICAL VARIABLES MEASUREMENT—Forces; NATURAL GAS WELLS—Flow; OIL WELLS—Fracturing; PAPER—Testing; PETROLEUM RESERVOIR ENGINEERING; PISTONS—High Pressure Effects; PLASTICS MACHINERY—Extruders; PRESSURE TRANSDUCERS—Switching; PUMPS—Vanes; SENSORS; SILOS—Measurements; VACUUM PUMPS—Noise, Spurious Signal; WATER—Shock Waves; WIND EFFECTS—Measurements; WIND TUNNELS—Wall Interference.

**084897 EFFECTS OF AEROSOL SCATTERING ON REMOTE PRESSURE MEASUREMENT VIA OXYGEN A-BAND ABSORPTION.** The technique recently proposed by I.J. Barton and J.C. Scott to monitor surface pressure using absorption of reflected sunlight in the oxygen A-band is subject to errors due to aerosol scattering. Errors arising from specified uncertainties in the aerosol optical depth are evaluated. Zones of feasibility are presented for typical surface conditions and aerosol parameters. This shows that the region within which an accuracy of 2 mbar is obtained is so small as to render the technique operationally unviable, even if monitoring of the aerosol optical depth to  $\pm 0.02$  was available. (Edited author abstract) 13 refs.

Mitchell, R.M. (CSIRO, Spendale, Aust). *Int J Remote Sens* v 8 n 8 Aug 1987 p 1175-1188.

**084898 MEASURING PROCESS PRESSURE - A USERS GUIDE.** The object of this paper is to consider aspects of pressure measurement as applied to process plant from the point of view of a typical user. An extremely basic approach will be made to the subject and some initial consideration of the fundamental measuring principles of pressure sensors will be discussed. Criteria that should be considered when selecting a sensor will be outlined and a simplified set of pre-selection guidelines will be proposed. It is not the objective of this paper to discuss specific applications in any detail, as these would be too diverse and numerous, although pressure sensing will be considered in general.

Challoner, Tony (Warren Spring Lab, Stevenage, Engl). *Meas Control* v 20 n 8 Oct 1987 p 19-23.

**084899 INTERMEDIATE RANGE PRESSURE MEASUREMENT.** This article deals with a variety of techniques and applications in the measurement of the intermediate range of pressures centered about atmospheric pressure, with emphasis on the use of silicon sensor technology and high accuracy systems, using the vibrating cylinder transducer. The extension of the use of the silicon sensor is described through a series of application areas leading to their use in precision pressure calibration instruments. The use of the vibrating cylinder

transducer in these instruments to meet the highest accuracy requirements is also described. 1 ref.

Bertioli, Michael (Druck Ltd, Groby, Engl). *Meas Control* v 20 n 8 Oct 1987 p 33-36.

**084900 MEASURING THE PRESSURE IN A GAS THERMOMETER.** The All-Union Technical Physics and Electronics Research Institute has completed research on a precision gas thermometer for this range and has derived new numerical values for the thermodynamic temperatures of the main reference points on IPTS-68 and correspondingly the deviations from the thermodynamic scale. This constant-density gas thermometer uses a system without a harmful volume. The main readout instrument is an interference manometer especially built for the purpose. The manometer design features have been described. Here the authors consider the error sources in pressure measurement, together with the corrections made and the performance of the instrument as a whole. 17 refs.

Zakharov, A.A.; Astrov, D.N.; Belyanskii, L.B.; Dedikov, Yu.A.; Polunin, S.P. *Meas Tech* v 30 n 3 May 1987 p 242-247.

**084901 FLOW EFFECTS ON DYNAMIC PRESSURE MEASUREMENTS.** The measurement of dynamic pressure signals in wind tunnels is often required when it is impractical to locate a pressure transducer at the source. In this case, signals may be transmitted to a transducer through tubing that serves as a transmission line. The dynamic characteristics of fluid transmission lines used to transmit these dynamic pressure signals need to be known if accurate measurements are to be obtained. The response of transmission lines and the effects of flow in the line and across the line inlet are described. (Author abstract) 26 refs.

Frank, M.E. (US Air Force Inst of Technology, USA); Chretien, W.P. *ISA Trans* v 26 n 4 1987 p 19-23.

**084902 PRESSURE MEASUREMENT IN HAZARDOUS AREAS.** Initially developed for use in aerospace and defence applications, the sputtered thin film strain gauge sensor has exhibited excellent performance, particularly in terms of long term stability. Maintenance-free operation over extended periods without the need for periodic recalibration is one of the consequences. Features of the basic sensor are described together with some of the changes which have been introduced in order to provide the desired safety features.

Clare, P.M. (Transamerica Instruments, Basingstoke, Engl). *Meas Control* v 20 n 9 Nov 1987 p 45-48.

**084903 ADVANCED DESIGN CONCEPTS FOR FUSED QUARTZ PRESSURE TRANSDUCERS.** The author discusses the engineering design considerations applied in the development of a laboratory grade pressure standard utilising a fused quartz Bourdon tube transducer. Its adaptation to uses in field services and process control industries is described. The applications for generating accurate pressures are of equal importance than just measuring pressure accurately. The sensor has the ingredients needed for a pressure controller when a servovalve is added to the system.

Worden, Ray D. (Ruska Instrument Corp, Houston, TX, USA). *Meas Control* v 20 n 9 Nov 1987 p 51-55.

**084904 GENERATION OF STABLE HYDRAULIC PRESSURES IN CALIBRATION SYSTEMS.** The availability and use of higher accuracy pressure standards and more sensitive pressure transducers means that special consideration must be given to the calibration systems. In addition to ensuring that the environmental conditions under which such equipment is used are appropriate, care must be taken in the selection of a suitable pressure regulation and control system. Using motorised means for pressure generation reduces operator fatigue and gives more reliable and repeatable results compared to manual systems.

Shorroock, R.S. (Oxford Pressure Systems Ltd, Oxford, Engl); Atherton, E.J. *Meas Control* v 20 n 9 Nov 1987

p 63-65.

**084905 OPTICALLY EXCITED RESONANT BEAM PRESSURE SENSOR.** Micromechanical silicon beams fabricated by anisotropic etching techniques are coated with a thin layer of chromium. An intensity-modulated laser beam focused on the beam generates transverse vibrations which are detected interferometrically. We report how the vibration frequency changes with temperature and pressure applied to the beam. (Edited author abstract) 7 refs.

Uttamchandani, D. (Univ of Strathclyde, Glasgow, Scotl); Thornton, K.E.B.; Culshaw, B. *Electron Lett* v 23 n 25 Dec 3 1987 p 1333-1334.

**084906 KAPAZITIVS DIGITALDRUCKMEßGERÄT UND SEINE ANWENDUNG. [Capacitive Digital Pressure Gage and Its Application].** A digital pressure gauge working according to a capacitive principle and having ranges from 0 to  $\pm 99.9$  Pa and 0 to  $\pm 999$  Pa has been developed and tested. Its maximum error is in the order of magnitude of 1 percent. Owing to its very good dynamic properties the unit may be used for measuring both static and dynamic pressures up to a limit frequency of 25 Hz. Efforts are continued to optimize the pressure pickup in the interest of improving its temperature error, long-time stability and limit frequency. (Author abstract) 5 refs. In German.

Matter, G. (VEB, East Ger); Hoffrichter, H.; Gellrich, P.; Riegel, K.; Reimann, J. *Luft Kältetechnik* v 24 n 1 1988 p 42-45.

**084907 PRESSURE MEASUREMENT IMPROVES, BUT CALIBRATION IS STILL NEEDED.** There have not been many new methods for measuring pressure introduced in the recent past, at least not as many as there have been for other process variables like flow and temperature, but the advances in electronic manufacturing technologies and the addition of communications capabilities have had an effect on pressure sensors and transmitters. New materials, improvements in manufacturing, and advancing electronic technologies are providing both low cost and high cost types of pressure measurement.

Blickley, George J. (Control Engineering, USA). *Control Eng* v 35 n 5 May 1988 p 87-89.

**084908 CHARACTERIZATION OF CONTROLLED CLEARANCE PISTON GAUGE USING DIFFERENT WORKING FLUIDS UP TO 5 MPa.** A systematic study carried out to characterize the controlled clearance piston gauge in the pneumatic pressure region up to 5.09 MPa full-scale pressure using different working fluids such as argon, nitrogen, helium and hydrogen is described. The characterization was conducted/carried out by measuring the fall rate of the piston as a function of the jacket pressure ( $P_j$ ) in order to determine the stall jacket pressure ( $P_{zj}$ ) corresponding to the zero clearance between the piston and cylinder. A comparatively greater reproducibility in the  $P_{zj}$  value is obtained for helium and hydrogen as compared to that of argon and nitrogen. The effects of the temperature of the operation on the fall rate in this piston gauge using gaseous nitrogen as the working fluid are also reported. (Edited author abstract). 12 Refs.

Sharma, J.K.N. (Nat'l Physical Lab, New Delhi, India); Jain, Kamlesh K.; Bandyopadhyay, A.K. *Jpn J Appl Phys Part 1* v 27 n 5 May 1988 p 843-848.

**084909 PRESSURE-HOLE ERRORS-AN ALTERNATIVE APPROACH.** A new analysis of the pressure-hole problem, which avoids some of the problems of the Higashitani-Pritchard (HP) analysis, is presented. The results are the same as those of the HP analysis for any fluid where the viscosity and the normal stress functions are multiples of one another. The relation of this result to experiments and computations is discussed. (Author abstract). 10 Refs.

Tanner, R.I. (Univ of Sydney, Sydney, Aust). *J Non Newtonian Fluid Mech* v 28 n 3 Jul 1988 p 309-318.



**Analysis** See PRESSURE TRANSDUCERS—Pistons; WATER, UNDERGROUND—Monitoring.

## Automation

**084910 DEVELOPMENT OF SENSING SYSTEM OF PIEZOELECTRIC CERAMICS MEASURING CONTACT PRESSURE DISTRIBUTIONS.** In this paper, an automatic sensing system measuring contact pressure distributions is proposed. The sensing material is made of piezoelectric ceramics. To measure electric charge in the material produced by contact pressures, a special electric circuit is designed by using a peak hold circuit. A micro computer (NEC PC-9801) and a multiplexer controller are used to automatically measure the contact pressure distributions. By using the ceramic sensor for  $5 \times 5$  measuring points, the pressure distributions for several contact problems are measured. The obtained total forces and the pressure distributions are compared with the corresponding acting forces and the theoretical values. From the results, it is recognized that the proposed sensing system is excellent in reliability and durability. (Author abstract) 10 refs. In Japanese.

Oda, Juhachi; Shinada, Tomohiro; Inoue, Jirou; Hanamoto, Kouji. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 498 Feb 1988 p 399-404.

**Calibration** See AIRCRAFT INSTRUMENTS; HIGH PRESSURE ENGINEERING.

**Computer Applications** See PRESSURE TRANSDUCERS—Performance.

**Equipment** See Also GAGES—Calibration; PRESSURE TRANSDUCERS—Performance.

**084911 PRESSURE SCANNING: ROTARY VS ELECTRONIC.** This article describes the choices available for today's pressure scanning applications. Typical examples include: wind tunnels, flight test, turbine engine test, process control, and laboratory/bench test. (Edited author abstract)

Pemberton, Addison (Scanivalve Corp, San Diego, CA, USA). *InTech* v 35 n 1 Jan 1988 p 47-51.

**Instruments** See Also CLAY—Stresses; CLAY—Testing; ICE—Creep; PRESSURE TRANSDUCERS—Selection; SOILS—Pressure Measurement.

**084912 PRESSURE SENSORS: THE ADVANTAGES OF GOING DIGITAL.** There are several analog devices that convert process pressure into an electrical signal. Traditionally, each device has been selected for application in a particular instrument because of its performance characteristics, physical attributes, and cost. This article deals with the advantages of using frequency-based pressure sensors and digital counting circuits for pressure measurement. It covers digital sensors as they are applied in a range of pressure-based measurements such as flow, differential pressure, hydrostatic tank gaging, and applications requiring direct pressure readings.

Gray, James O. Jr. (Foxboro Co, Foxboro, MA, USA). *Chilton's I&CS* v 61 n 2 Feb 1988 p 37-39.

**084913 INSTRUMENT FOR MEASURING PRESSURE IN SOLIDS-LADEN FLOWS.** The efficiency, reliability and safe operation of boiler plants depend to a great extent on the accuracy and reliability of monitoring pressure of solids-laden gas flows, for example air/pulverised coal flows, air which has been regeneratively preheated, drying agent, flue gases, etc. The Pitot or Stanton tubes used for this purpose are insufficiently reliable and precise due to obstruction by solids of the pressure receivers and impulse lines. This article considers an instrument of improved reliability in measuring static pressure of solids-laden gas flows. It can be used also for measuring pressure drops, in Venturi tubes. 3 refs.

Etkin, V.B. (All-Union Heat Engineering Inst, USSR); Motro, M.Ya. *Therm Eng* v 34 n 10 Oct 1987 p 560-562.

**084914 MODELING RATE EFFECTS AND CYCLIC LOADS WITH THE PRESSUREMETER.** A

relatively new tool, the cone pressuremeter (CPMT), was used in order to evaluate its usefulness in predicting the effects on solids due to various rates of loading and to repetitive loading. Field tests were conducted in two phases. The first phase included 24 CPMT tests, at the Texas A&M University research annex, which were designed to show 1) if the CPMT could be used to predict the effects on the soil due to both rate effects and repetitive loads; and 2) if the CPMT should be inserted into a prebored hole to the desired test depth or if the CPMT should be driven to the desired test depth. The soils at the research annex were a clay and a sand. It was concluded that a single CPMT test could be used to model both rate effects and cyclic effects on the soil modulus and that the most consistent method of inserting the probe was to place it in a prebored hole. It was also concluded that a linear relationship exists between the exponents  $n$  in both modeling equations and the normalized CPMT stress level. (Edited author abstract). 10 Refs.

Cosentino, P.J. (Texas Tech Univ, Lubbock, TX, USA); Briaud, J.-L.; Terry, T.A. *J Energy Resour Technol Trans ASME* v 110 n 3 Sep 1988 p 196-202.

**084915 DEVELOPMENT OF A HIGH PRESSURE SECONDARY GAUGE USING AUCR SPIN-GLASS SYSTEM.** The metrological behavior of an Au + 6.4 at%-Cr pressure gauge under the influence of external parameters, at standard range of temperatures and for pressures up to 600 MPa is explained. This is based on pressure and temperature effects on indirect RKKY and direct d-d exchange interactions between the spins associated with magnetic Cr impurities in spin-glass alloys such as AuCr. Special attention is paid to interpretation of the positive resistance-pressure coefficient, also known as an 'abnormal' effect. Other metrological properties (i.e., perfect linearity, lack of hysteresis, and temperature stability under low and high pressure) of pressure gauges made from AuCr spin-glass alloy are discussed. Suggestions for future improvements are included, along with measurements of low temperature (77 K) effects in AuCr pressure gauges. An approach to understanding these effects in terms of magnetic properties of the alloy is presented. 9 refs.

Bock, Wojtek J. (Univ of Quebec, Hull, Que, Can); Grochowski, Lucjan; Zaremba, Marek B. *IEEE Trans Instrum Meas* v IM-36 n 4 Dec 1987, IMTC/1987: The Fourth IEEE Instrum and Meas Technol Conf, Boston, MA, USA, Apr 27-29 1987 p 945-949.

**Mathematical Models** See Also ENCAPSULATION—Pressure Effects.

**084916 DYNAMIC MODELLING OF DIFFERENTIAL PRESSURE TRANSMITTERS.** The paper describes the dynamic modeling of two force-balance differential-pressure transmitters, one pneumatic and one electronic. In both cases an experimental transmitter transfer function is found from frequency response tests. This is then compared with a theoretical transfer function calculated from the differential equations describing the principles of transmitter operation. (Edited author abstract) 13 refs.

Cartledge, Jane (Marton Sixth Form Coll, Middlesbrough, Engl); Bentley, J.P. *Trans Inst Meas Control* v 8 n 5 Oct-Dec 1986 p 256-272.

**Sensors** See Also OPTICAL FIBERS—Sensors.

**084917 SIMPLE MULTIMODE FIBRE INTERFEROMETRIC SENSOR FOR PRESSURE-RELATED MEASUREMENTS.** A multimode optical fiber sensor is described, based on phase change information due to interference between light reflected from the fiber end and from a flexible membrane. The experimental version made is tested to be used for gas and liquid pressure measurements in medical and industrial applications. The mode of operation is described in terms of the combined effects of the mode transformations in the passive fiber components and at the reflections. It is shown that the uniform mode transformation properties, as found in the splitters and couplers made in the

Fused-Head-End method, are indispensable. Applying the Fused-Head-End directly, without a single fiber connected, the device can operate simultaneously as an intensity-based proximity sensor. (Author abstract). 14 Refs.

Severin, P.J. (Philips Research Lab, Eindhoven, Neth); Bardool, W.H. *Philips J Res* v 43 n 2 1988 p 137-151.

**Standards** See Also VACUUM TECHNOLOGY—Gases; VACUUM TECHNOLOGY—Measurements; VACUUM TECHNOLOGY—Standards.

**084918 STANDARDS FOR THE MEASUREMENT OF PRESSURE.** This paper will concentrate on standards for the measurement of static 'absolute' pressures (referred to absolute vacuum), static 'gauge' pressures (referred to ambient pressure) and static differential pressures (superimposed on a defined bias or line pressure). The problem of measuring dynamic pressures is one of growing importance but it is unfortunately very difficult to provide a comprehensive set of dynamic measurement standards because of the wide range of amplitudes, frequencies, waveforms and static bias pressures occurring in practice. 21 refs.

Stuart, P.R. (NPL, Teddington, Engl). *Meas Control* v 20 n 8 Oct 1987 p 7-11.

**084919 METHOD OF CONSTRUCTING SECONDARY STANDARDS FOR ABSOLUTE PRESSURE ON THE BASIS OF FIXED POINTS FOR PHASE TRANSITIONS IN PURE SUBSTANCES.** Mercury and piston standards give the highest accuracy in measuring absolute pressures, but the equipment is complicated and not capable of being transported, so it is impossible to compare stationary standards directly, and thus to evaluate the unification in absolute-pressure measurement. Interest attaches to devices based on the triple point or a continuous part of the first-order transition curve for a pure gas to provide simple and transportable secondary standards giving the necessary stability and reproducibility on comparison with the initial ones. This will give a theoretical and experimental evaluation of the scope for making such a standard with fixed pressure points. 7 refs.

Afanas'ev, S.N.; Stepanov, A.Yu.; Suprunyuk, V.V. *Meas Tech* v 30 n 6 Jun 1987 p 532-535.

**084920 INTERNATIONAL COMPARISONS OF PRESSURE STANDARDS: A STATUS REPORT.** In 1979 four working groups were established to organize comparisons between the pressure standards of the different national standards laboratories. These comparisons cover the range  $10^{-6}$  to  $10^8$  Pa. This report describes the progress of the different comparisons and summarizes the results where available. (Author abstract). 4 Refs.

Tilford, Charles R. (NBS, Gaithersburg, MD, USA). *J Res Natl Bur Stand (US)* v 93 n 4 Jul-Aug 1988 p 545-549.

**PRESSURE REGULATORS** See Also GAS PIPELINES—Pressure Regulation.

**084921 PRESSURE REGULATORS.** A description is given of pressure regulators which combine the three main components of a control loop into a single device which is simple, dependable, rugged and inexpensive. The self-contained regulator has no adjustments in terms of capacity (reduced valve trim) or of stability (proportional band and reset adjustments). It has a fixed proportional band of about 5%, or a gain of about 20. Descriptions are provided of the most common designs along with their inherent advantages and disadvantages. Factors such as droop or offset, stability and safety, sizing and rangeability, noise and cavitation are discussed. Various types of regulator designs are outlined along with an analysis of the pilot-operated regulator which is a two stage device. Finally, since many applications in pressure control can be handled by either a regulator or a control valve, the author provides an analysis designed to make selection easier. Regulator applications are also given. 14 refs.

Liptak, Bela G. (Bela G. Liptak Associates). *Chem Eng*



(New York) v 94 n 5 Apr 13 1987 p 69-76.

**084922 ELECTRICAL SIGNALS SET AIR REGULATOR'S PRESSURES.** A new type of multi-pressure, electropneumatic regulator has been developed for the precise electronic control of air operated industrial and process equipment. A special strain gage in a closed-loop regulator design gives important operating and reliability advantages. This design precisely controls air pressures, that are either proportional to applied analog voltages and currents or are defined by applied digital signals. It also produces analog and TTL (Transistor-to-Transistor Logic) output signals for continuous pressure monitoring. The regulator operates in any orientation and exhibits high resistance to moisture, vibration, mechanical shock and internal and external contamination. Command signals can be supplied by simple circuitry using potentiometers, rotary switch controller resistor networks or other discrete control devices.

Stefanides, E.J. (Design News, Newton, MA, USA). *Des News (Boston)* v 43 n 12 Jun 22 1987 p 86-88.

**084923 AVAILABILITY OF A PRESSURE REGULATING INSTALLATION ON A CITY MAINS.** Detection of the cause of a Pressure Regulating Installation (PRI) breakdown or fault is done via analytical approach, using the Failure Mode and Effect Analysis, and by looking back over the available records of maintenance operations. To see how far some causes of failure might give rise to dangerous situations, use was made of logical diagrams such as the Incidental Sequences Diagrams and Fault Trees. The availability investigation of a PRI has brought out the difficulty of making a quantitative assessment owing to the scarcity of trustworthy reliability data. This study, in fact, has underscored the extreme individuality of gas distribution plants and the need for a sector data bank operating in such a way as to ensure the constant updating of its reliability data. Qualitative development of the Fault Trees and the consequent analysis of criticality have in any case revealed the existence of second-order minimal cut sets. (Author abstract) 8 refs.

Reliability (Piccinini, N.); Politecnico di Torino, Turin, Italy; Scarrone, M.; Malinverni, E.; Rosti, P. *Reliab Eng Syst Saf* v 20 n 4 1988 p 303-321.

**084924 DYNAMICS OF GAS PRESSURE REGULATOR WITH ATTACHED PIPES.** Dynamics of a pressure regulator with attached pipes has been the subject of numerous studies. In this study, the authors construct a mathematical model of a regulator that takes into account the distribution of the gas parameters with respect to the pipe length. On the basis of this model, an analytic relation for dividing the 'input pipe length-output pipe length' plane into a region of stability 'in the small' and the region of instability is derived. 3 refs.

Latyshev, V.I.; Maliovanov, M.V.; Petrov, R.A. *Sov Aeronaut* v 30 n 3 1987 p 110-113.

**Automation** See VALVES AND VALVE GEAR—Applications.

**Fire Resistance** See GAS METERS—Fire Resistance.

**Pneumatic Drive**

**084925 MOTORIZED PRESSURE CONTROL.** Pressure regulators maintain a constant output pressure in a system, regardless of changes in flow or inlet pressure. They are used in nearly all industrial air systems, in process industries, petrochemical plants, paper mills, and where the pneumatic signal must be accurately controlled. Regulators can be set manually, with close-coupled or remote pneumatic signals, or with electrical or electronic signals. The latter offer some unique advantages, particularly in remote control or automated applications. A description is given of regulator considerations. The paper highlights the use of computer control in pressure regulates and explains how these advanced electronic controls provide fast and precise control of air pressures.

Askew, Andy (Fairchild Industrial Products Co, Winston-Salem, NC, USA). *Mach Des* v 58 n 28 Nov 20 1986 p 161-163.

**PRESSURE TRANSDUCERS** See Also CHEMICAL EQUIPMENT—Fluidized Beds; CONTROL EQUIPMENT. PNEUMATIC—Design; MECHANICAL VARIABLES MEASUREMENT—Level; PRESSURE MEASUREMENT; PRESSURE MEASUREMENT—Instruments; PROCESS CONTROL; SENSORS—Applications; SOILS—Stresses; STRAIN—Sensors; TRANSDUCERS—Applications; WATER METERS—Automation.

**084926 NONLINEARITY OF A PRESSURE CONVERTER CONTAINING A MECHANICAL STRESS CONCENTRATOR.** The following is demonstrated from the measurements: (1) nonlinearity in the characteristics of the individual gauges in these devices is determined in the main by nonlinearity in the piezoresistance effect. The piezoresistance coefficients to the second and third degrees of the stress are given for diffusion layers in p-type silicon in the [110] direction. 6 refs.

Vaganov, V.I.; Sluchak, I.I. *Meas Tech* v 30 n 7 Jul 1987 p 664-667.

**084927 NEW TYPE OF DIMENSION MEASURING AND CONTROLLING INSTRUMENT. PNEUMATIC INSTRUMENT WITH PIEZORESISTIVE PRESSURE TRANSDUCER.** In this paper, a kind of precision dimension measuring and controlling instrument, the GLQ type pneumatic instrument with piezoresistive pressure transducer, is introduced. It is small in size, stable, reliable and has wide linear range, large adjustable range in gain and good dynamic characteristic, as well as the advantages of an electropneumatic instrument. All these raise the adaptability of the instrument. The experiments showed that measurement accuracy of the instrument is superior to 2 percent FS. The error of stability of the indication is 1 percent FS. Stable time of transient response is 0.1-0.2 sec, which is 3-5 times smaller than present pneumatic instrument with membrane and bellows. A new type of pneumatic instrument has been provided for precision dimension measuring and controlling. This paper refers to the construction of the instrument, considering problems in design and compensation method of temperature drift of transducer, and gives testing data of static and dynamic characteristics of the instrument. (Author abstract). 4 Refs.

Che, Rensheng (Harbin Inst of Technology, Harbin, China); Xu, Fuge. *Instrumentation in China* Instrumentation in China, Technical Papers. English Language Edition of Selected Articles Originally Published in the Chinese Journal of Scientific Instrument 1987. Publ by ISA, Research Triangle Pk, NC, USA, 1987 p 101-107.

**Applications** See WATER WAVES—Measurements.

**Calibration**

**084928 DEVELOPMENT OF A PORTABLE PRESSURE SOURCE FOR THE STATIC AND DYNAMIC CALIBRATION OF PRESSURE TRANSDUCERS.** The development by the National Building Research Institute (NBRI) of a portable pressure source, with applications in both wind-tunnel and in full-scale environments, is described. The instrument, which is equally suited to the static or dynamic calibration of pressure transducers, contains an electronic controller using a pneumatic signal generator as the actuator. The overall operation of the pressure source is controlled by a built-in microprocessor. An approach to overcome the obstacles normally facing the occasional user of microprocessors as instrument controllers is described, and the versatility of the instrument is demonstrated by a number of applications. (Edited author abstract) 4 refs.

Waldeck, J.L. (CSIR, Pretoria, South Afr). *J Wind Eng Ind Aerodyn* v 26 n 2 Oct 1987 p 213-230.

**Coatings**

**084929 GOLD PLATING OF PUSH RODS OF PRESSURE TRANSDUCERS - AN EXAMPLE OF**

**COATING FOR JOINING METALS.** A popular type of pressure transducer employs a stainless steel membrane as a pressure sensing element. The pressure is transferred as a load by a push rod which is brazed to the diaphragm. The authors describe the use of composite coating of 2  $\mu$ m Ni+5  $\mu$ m gold as a filler for brazing instead of the conventional 25  $\mu$ m gold coating. Details of the jig used for this plating are also described. The process described has the twin advantages of saving of gold and being more economical than the conventional process. (Edited author abstract). 10 Refs.

Rajagopal, Indira (Nat'l Aeronautical Lab, Bangalore, India); Rajam, K.S.; Rajagopalan, S.R. *Indian J Technol* v 26 n 1 Jan 1988 p 32-34.

**Components** See ROBOTS, INDUSTRIAL—Sensors.

**Design**

**084930 CATHETER-MOUNTED PRESSURE TRANSDUCER USING A FIBER LOOP.** A catheter-mounted fiber optic pressure sensor is described. The sensor consists of a looped fiber; light is coupled into one leg and detected at the other. When the loop bends, microbending in the neck of the loop couples light out of the fiber, resulting in a detectable signal. The catheter was placed in a closed-circuit pumping station in parallel with a strain gauge pressure transducer; the fiber sensor simulated the transducer's output with good fidelity. Aging tests indicate remarkably good reproducibility and stability. (Author abstract) 9 refs.

Auerbach, A. (BOC Group Inc, New Providence, NJ, USA); Doersam, D. *Sens Actuators* v 13 n 2 Feb 1988 p 195-199.

**Fabrication**

**084931 POLYSILICON-DIAPHRAGM-BASED PRESSURE SENSOR TECHNOLOGY.** The fabrication of capacitive pressure sensors, using silicon integrated circuit processes is described. Polysilicon diaphragms are laid down using the conventional LPCVD technique. A cavity between the polysilicon layer and silicon substrate is created by etching away an intermediate oxide layer. The subsequently sealed cavity with deformable polysilicon membrane decreases in volume with a positive differential pressure between outside and inside. Capacitance changes between an electrode on the membrane and the silicon substrate allow pressure changes to be measured. The batch fabrication technology for microminiature device manufacture is described and electrical characteristics of the device presented. (Author abstract) 2 refs.

Farooqui, M.M. (Univ of Southampton, Southampton, Engl); Evans, A.G.R. *J Phys E* v 20 n 12 Dec 1987 p 1469-1471.

**084932 SILICON DIAPHRAGM PRESSURE SENSORS FABRICATED BY ANODIC OXIDATION ETCH-STOP.** Silicon diaphragm pressure sensors have been fabricated by anodic oxidation etch-stop to reduce the pressure sensitivity variation. The diaphragm thickness is precisely controlled by automatic etch-stop in hydrazine-water solution. p-Type piezoresistive elements are fabricated by boron ion implantation on a (100) orientation n-type epitaxial layer. A 5 v positive voltage is applied to the n-type layer of an n/p epitaxial silicon wafer. The thick p-type substrate is then etched off, etching stopped and a thin n-type diaphragm is left. (Edited author abstract) 10 refs.

Hirata, Masaki (NEC, Kawasaki, Jpn); Suzuki, Kenichi; Tanigawa, Hiroshi. *Sens Actuators* v 13 n 1 Jan 1988 p 63-70.

**Magnetic Field Effects**

**084933 MAGNETIC SENSITIVITY AND MAGNETICALLY INSENSITIVE DESIGN OF TRANSVERSE VOLTAGE PRESSURE VOLTAGE.** As the geometry of a transverse-voltage pressure sensor is similar to that of a Hall element, it is susceptible to the



interference of the magnetic field. From the Boltzmann transport equation in a weak field, the expression of Hall voltage for an inhomogeneously doped layer has been derived. The calculated results for a practical device agree with the experimental data. A method to eliminate the interference of the magnetic field is described. The results are satisfactory. (Edited author abstract). 5 Refs. In Chinese.

Qi, Weijia (Fudan Univ, Shanghai, China); Bao, Minhang; Yu, Lianzhong. *Bandaoti Xuebao* v 9 n 4 Jul 1988 p 439-442.

**Manufacture** See AIR FILTERS.

## Materials

**084934 PIEZOELECTRIC POLYMER PRESSURE SENSORS.** The use of the piezoelectric material polyvinylidene fluoride (PVdF) in sensors to measure underwater shock wave pressures is described. Its advantages and disadvantages as a sensor material are compared to those of conventional tourmaline sensors. Preliminary results from sensors using this material are shown to compare well with results from tourmaline sensors. Some irregularities are, however, found in the PVdF sensor output, but it is anticipated that these can be eliminated by improved sensor design. (Author abstract) 9 refs.

Leaver, P. (Univ of Manchester, Manchester, Engl); Cunningham, M.J.; Jones, B.E. *Sens Actuators* v 12 n 3 Oct 1987 p 225-233.

**Mathematical Models** See STRAIN GAGES—Mathematical Models.

**Medical Applications** See Also BIOMEDICAL ENGINEERING—Gynecology; BIOMEDICAL EQUIPMENT—Calibration; BIOSENSORS—Evaluation.

**084935 MONOLITHIC PRESSURE-FLOW SENSOR.** A novel silicon-based monolithic pressure-flow sensor has been developed. Its operation is based on the piezoresistive effect for pressure sensing and heat transfer for flow sensing. The sensor chip has a thermal isolation structure that is made of an oxidized porous silicon membrane. This structure thermally isolates the heating element located on the membrane from the rim of the chip. The sensor, in which the chip was mounted on a wall of an acrylate plastic pipe, was designed for biomedical applications. Measurements were made at pressures of 0-300 mmHg, water flow rates of 0-7 l/min, and fluid temperatures of 25-45°C. Results are presented. 11 refs.

Tabata, Osamu (Toyota Central Research & Development Lab Inc, Jpn); Inagaki, Hazime; Igarashi, Iseimi. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2456-2462.

## Performance

**084936 AUTOMATIC MEASUREMENT OF HIGH PRESSURES.** A manganin pressure transducer has been calibrated for use with a computer-controlled data gathering system. A single polynomial for  $R(p,t)$  reproduces the measurements of pressures up to 350 MPa and temperatures from 0 to 40°C. The repeatability obtained in the initial calibration of  $R(p,t)$  was 12 ppm. An uncertainty of 0.1 K would result in a variability in  $R(p,t)$  of, at most, 3 ppm, but over most of the temperature span it would be much smaller because of the favorable temperature characteristic of manganin. Pressure measurements are accurate to 0.1 MPa, and probably repeatable to better than this. This corresponds to an uncertainty of less than 2.5 ppm in  $R(p,t)$ . (Edited author abstract) 12 refs.

Noreldin, O. (Trinity Coll, Dublin, Irel); Scaife, W.G. *J Phys E* v 20 n 10 Oct 1987 p 1212-1214.

**084937 DEVELOPMENT LINES FOR AUTOMATIC PRESSURE SENSORS.** Simple and reliable loaded-piston manometers represented the basic means of transmitting the pressure unit in the range 0.1-1000 MPa in the 1940s to 1960s, and these always included devices

for setting up the pressure and connecting test instruments, i.e., they were not simply standard instrument but instead test systems. However, they had one major disadvantage: they were laborious to use, and considerable physical stress was required at pressures above 10 MPa on account of the handling of heavy loads and the manual compression involved. At the end of the 1950s, large-scale gauge production was initiated, and it became desirable to mechanize the main manual operations. An automatic pressure sensor was developed in the USSR. These sensors were made in batches of 16 and used in production. The sensor was an automated loaded-piston gauge giving the range 0.25-30 MPa for test manometers of accuracy class 0.2%. For each standard range, it provided three pressure steps, not including zero. More recent developments in Russia and in the United States are reported. 6 refs.

Kipnis, A.M. *Meas Tech* v 30 n 4 Apr 1987 p 359-361.

**084938 METHODS OF DETERMINING THE DYNAMIC CHARACTERISTICS OF PRESSURE TRANSDUCERS.** Variable-pressure transducers VPT are used in monitoring these processes, which are usually of special and narrowly defined purpose. In most cases, the errors are determined only under static conditions, since there are no standard methods of estimating dynamic characteristics. This means that there may be deviations from unified measurements, so it is important to devise methods for determining these dynamic characteristics. The proposed technique is based on an adaptive method of determining the complete dynamic characteristics of means of measurement which enables one to use standard test signals to derive analytic expressions for the transfer function and for the pulse, transient, and amplitude-frequency characteristics. The basic method consists in using the response of the test instrument to a standard signal to find the optimum structure for the transfer function. A multistep adaptive procedure is used, which includes surveying transfer functions of increasing complexity from step to step and deriving the optimal coefficients in the transfer function at each step. 5 refs.

Ostrovskii, E.S.; Solomonik, V.A. *Meas Tech* v 29 n 2 Feb 1986 p 172-174.

**084939 CERAMIC DIFFERENTIAL-PRESSURE TRANSDUCER.** The differential-pressure transducer is made completely of alumina, and is therefore resistant to practically all corrosive fluids used in process engineering. The transducer has a single liquid-filled chamber, isolated by two diaphragms from the fluids whose differential pressure is to be measured. The deflections of these diaphragms are measured by a capacitive method. Four electrodes, applied to the two diaphragms and on opposite sides of a central plate, form two capacitors. The measured differential pressure is proportional to the difference of the reciprocals of their capacitances. This difference is affected, however, by the temperature of the liquid in the transducer. The effect is compensated by using the sum of the reciprocals of the capacitances, which is proportional to the temperature. The linear temperature compensation is produced by an electronic circuit that includes operational amplifiers and a feedback loop. This circuit and the ceramic transducer are incorporated in the differential-pressure transmitter, which is now on the market in six models with different measuring ranges. Experimental versions are now ready of a differential-pressure transducer for laboratory use, in which nonlinear temperature effects can also be compensated. A method is being studied for transmitting the results of measurements along optical fibers. (Edited author abstract) 5 refs.

Graeger, V. (Philips GmbH, Hamburg, West Ger); Kobs, R.; Liehr, M. *Philips Tech Rev* v 43 n 4 Feb 1987 p 86-93.

**084940 EIN SENSOR FUER DRUCK UND TEMPERATUR. HOHE GENAUIGKEIT DURCH DIGITALE MESSWERTVERARBEITUNG.** [Single Sensor for Pressure and Temperature. High Accuracy by Digital Processing of Measured Data]. It is reported how it is possible to replace two separate sensors for sensing pressure and temperature, respectively, by a single unit. A microcomputer is used for processing the measurement signals. A built-in linearization algorithm allows a high

precision to be obtained. 3 refs. In German.

Anon. *Elektronik* v 36 n 16 Aug 7 1987 p 74-77.

**084941 PIEZORESISTIVE ELEMENTS OF POLYCRYSTALLINE SEMICONDUCTOR THIN FILMS.** Polycrystalline Si and Ge films have been prepared by the CVD method and have been used as sensing elements of pressure sensors that have a semiconductor/insulator/stainless steel structure. Values of the gage factor were 20 and 30 for polycrystalline Si and Ge films, respectively. Hysteresis and deviation from linearity were less than 0.6%. (Author abstract) 4 refs.

Onuma, Yoshiharu (Shinsyu Univ, Nagano, Jpn); Kamimura, Kiichi; Homma, Y. *Sens Actuators* v 13 n 1 Jan 1988 p 71-77.

**084942 NOVEL OPTICALLY EXCITED RESONANT PRESSURE SENSOR.** A novel pressure sensitive microresonator structure has been fabricated by anisotropic etching of silicon. An intensity modulated laser beam is focused onto the resonator and generates transverse vibrations, which are detected using optical heterodyne interferometric techniques. The pressure and temperature dependence of the resonant frequency of this structure is reported. (Author abstract) 4 refs.

Thornton, K.E.B. (Strathclyde Univ, Glasgow, Scotl); Uttamchandani, D.; Culshaw, B. *Electron Lett* v 24 n 10 May 12 1988 p 573-574.

## Pistons

**084943 EFFECTS ON THE PARAMETERS OF A PISTON PRESSURE GAUGE FROM THE PRESSURE DISTRIBUTION IN THE PISTON PAIR.** The pressure distribution influences the effective area of a noncylindrical piston pair (all piston pairs are noncylindrical), and pertinent theoretical and experimental studies have been made, which enables one to reduce the deformation error in high-pressure piston gauges by more than two orders of magnitude, namely to thousandths of a percent. No study has been made of the effects of the pressure distribution on other parameters of these gauges. An attempt is made to fill this gap. 5 refs.

Borovkov, V.M. *Meas Tech* v 30 n 4 Apr 1987 p 361-364.

## Selection

**084944 PICKING THE PERFECT PRESSURE TRANSDUCER.** Innovations in pressure transducer technology have resulted in improved designs and reduction of the cost of pressure measurements. These advances, coupled with the trend toward factory automation and computer control of plant systems, have generated many new applications for pressure transducers, some of which are discussed. (Edited author abstract).

Loth, Steven A. (Imo Delaval Inc, Pasadena, CA, USA). *InTech* v 35 n 7 Jul 1988 p 37-40.

## Stability

**084945 ZERO STABILITY OF DISPOSABLE AND REUSABLE PRESSURE TRANSDUCERS.** Zero stability tests were performed on contrasting, commercially available, blood pressure-transducer systems. One system was based on a brand of disposable transducer. The others employed one brand of reusable transducer with and without samples of two different brands of compatible disposable domes. Drift was measured at atmospheric pressure over 3-hr periods. Drifts with the disposable transducers and with the bare reusable transducers were small, ranging from -2 to +2 mm Hg over 3 hr. However, the drifts of the reusable transducers with domes were significantly greater, ranging from -11 mm to +5 mm Hg. The disposable transducers did not drift significantly after the first half hour, although the reusable transducers with domes continued to drift. In addition, one brand of disposable dome produced inaccurate calibrations with the reusable transducer. The methodology of drift measurement and analysis should be practical and useful in other settings and with other brands of transduc-



ers. In general, the results indicate that periodic zeroing is still a clinically important procedure, and it is a worthwhile effort prior to treatment decisions based on pressure readings. (Author abstract) 5 refs.

Gordon, Virginia L. (Massachusetts General Hospital, Boston, MA, USA); Welch, James P.; Carley, David; Teplick, Richard; Newbower, Ronald S. *Med Instrum v* 21 n 2 Apr 1987 p 87-91.

## Switching

**084946 PRESSURE SWITCHES - AN INTRODUCTION.** Pressure switches are used in a variety of applications. For example, a gage sensor can be used to indicate the presence of a work piece on a vacuum check or holder, or in a multiple switch point system to maintain a constant tank pressure. The use of pressure switches is widespread and virtually unlimited. This article gives some basic switch configurations and the design details for low cost, reliable, semiconductor sensor pressure switches.

Morton, Gary (Hi-Tek Electronics); Tandeske, Duane. *Electron Technol (London) v* 21 n 9 Oct 1987 p 177-178.

Vacuum See VACUUM TECHNOLOGY—Sensors.

**PRESSURE VESSELS** See Also CONVEYORS—Pneumatic; ELECTRON TUBES—Computer Aided Design; VALVES AND VALVE GEAR—Remote Control.

**084947 PRESSURE VESSEL AND PIPING TECHNOLOGY: TWO DECADES OF PROGRESS AND FUTURE CHALLENGES.** The organizational and technological advances of the last two decades in the U.S. Pressure Vessel and Piping (PVP) Technology are first traced. Highlights of growth in the major organizations supporting PVP technology: ASME Boiler and Pressure Vessel Code, Pressure Vessel Research Committee, and the ASME Pressure Vessels and Piping Division, are given, along with highlights in the technological advances in Design Analysis, Materials and Fabrication. Future challenges in key technological areas for PVP engineers are discussed, including the role of the PVP engineer in developing technologies such as BIOTECHNOLOGY, SUPERCONDUCTIVITY, MICRO-ELECTRONICS, ENERGY, ENVIRONMENTAL ENGINEERING, and ADVANCED MATERIALS. This paper concludes with a discussion of two major institutional challenges of our time: winning public acceptance of technology; competitiveness and foreign trade. (Author abstract) 7 refs.

Pai, D.H. *J Pressure Vessel Technol Trans ASME v* 109 n 4 Nov 1987 p 363-367.

**084948 COMPUTER AIDED DESIGN OF SADDLE SUPPORTS FOR HORIZONTAL PRESSURE VESSELS.** Computer aided design of saddle supports for chemical process equipment has been presented. Though apparently looks simple in construction, the design of saddle supports involves a large number of tedious trial and error computations. Various combinations of the design parameters such as the included angle of the saddle (TETA), saddle width (B), location of the saddle from vessel end (AS), the stiffener requirement and the required area of ring stiffener (AR), the width (W) and thickness (TI) of reinforcing backing plate (if required) between the saddle and the vessel shell, require to be tried to propose an optimum choice for final design. A consolidated CAD program as discussed in this paper shall therefore be of advantage for determining an optimum combination of the above-mentioned parameters. The CAD flow-sheet has been prepared in a versatile and flexible manner and it has been checked and verified on EC-1045 computer. (Author abstract) 3 Refs.

Narayanan, C.M. (Regional Engineering Coll, Durgapur, India); Bhattacharya, B.C. *J Inst Eng India Part CH v* 68 n 3 Jun 1988 p 101-104.

## Acoustic Emission Testing

**084949 INSPECTION OF SMALL VESSELS BY ACOUSTIC EMISSION ANALYSIS WITHOUT**

**FAULT LOCATING.** Investigation in acoustic emission testing of small vessels are surveyed. Results suggest that fault location may be obviated in certain future applications. (Author abstract) 20 refs.

Morgner, W. (Otto von Guericke Technical Univ of Magdeburg, Magdeburg, East Ger). *Mater Eval v* 46 n 2 Feb 1988 p 210-214.

**084950 EVALUATING THE RESULTS OF ACOUSTIC EMISSION TESTS APPLIED TO INDUSTRIAL EQUIPMENT.** Acoustic emission testing of different industrial equipment over a period of 18 months yielded results reported in five case histories and induced the value of the technique for such application. Complementary nondestructive tests support the value of the method. (Author abstract) 5 refs.

Feres, P. Jr. (KORCO/Brasitest SA, Sao Paulo, Braz). *Mater Eval v* 46 n 2 Feb 1988 p 215-219.

**084951 ZB2-TESTS - DESCRIPTION OF THE INTERMEDIATE SIZE VESSEL AND AE RESULTS.** To demonstrate and to extend the performance of acoustic emission testing as a method of detecting and classifying flaws, six institutes conducted acoustic emission measurements in the course of various loading tests on a medium-sized, thickwalled vessel (model of a reactor pressure vessel) containing natural flaws. This paper will present an outline of the working program of the Stuttgart Materials Testing Institute (MPA) within the framework of this project. (Edited author abstract) 5 refs.

Knoch, P. (Univ Stuttgart, Stuttgart, West Ger); Gertkemper, H.; Maier, H.-J. *Nucl Eng Des v* 106 n 3 Mar 1988 p 315-325.

**084952 RESULTS OF ACOUSTIC EMISSION DURING MECHANICAL AND THERMAL LOADINGS OF VESSEL COMPONENTS AND THEIR FRACTURE MECHANICAL INTERPRETATION.** AE measurements are presented which were performed at pressure vessel components during different loadings: thermal shocking hydrotest, cyclic loading. The tests were executed with the IZP AE system. With this it is possible to locate the AE sources and to identify two source mechanisms: crack growth and crack flank friction. The AE results are discussed and compared with the results of calculations about the residual stress in a clad vessel wall: AE signals originating from crack growth process are detected very sensitively. During thermal shock a lot of crack border friction occurs in consequence of compressive stresses on the crack flanks. However, during the hydrotests no crack border friction appears, because the crack flanks are mainly under tensile stresses. (Author abstract) 6 refs.

Gries, H. (Univ, Saarbruecken, West Ger); Waschki, E. *Nucl Eng Des v* 106 n 3 Mar 1988 p 399-403.

Codes See Also CYLINDERS—Fabrication.

**084953 SAFE AND COST-EFFECTIVE DESIGN OF PRESSURE VESSELS.** This paper discusses the design of new pressure vessels. The discussions conclude that: 1. The contemporary design method can be strenuous, and the as-built thickness(es) (less CA) may be uneconomically distant from the optimum. Computerization does not necessarily bring them closer to the optimum. 2. More realistic thinning rates and ratios would significantly improve future vessel maintenance costs. 3. The employment of the ECS Boundary Curves can give optimum thickness for a given vessel/nozzle junction. 4. Since the boundary curves remain unchanged for an intended service-life, the S/H-N graph complements the U-1A form. This graph can be the "birth certificate" for the vessel on which the owner of the vessel could chart his actual thinning as years of service pass.

Grosshandler, S. *Process Eng (London) v* 68 n 10 Oct 1987 p 51, 53.

## Computer Aided Design

**084954 PROGRAM FINDS VESSEL TOWER'S FIRST NATURAL PERIOD OF VIBRATION.** Determination of the natural period of vibration for tall, small-diameter pressure vessels is very important when designing the vessel to withstand both wind and earthquake forces. A program, suitable for use on personal computers, has been developed that will calculate the first natural period of vibration of these complicated vessel shapes. The program makes use of the Rayleigh method of approximation using the conjugate beam method for numerical integration. 6 refs.

Yarbrough, Ray (Fluor Daniel, Sugar Land, TX, USA). *Oil Gas J v* 85 n 42 Oct 19 1987 p 50-53.

**084955 COMPUTER AIDED DESIGN OF VERTICAL SUPPORTS FOR CHEMICAL PROCESS EQUIPMENT.** In the present paper, computer aided design of two types of popular supports used for chemical process equipment such as skirt and lug supports has been discussed. The CAD flow-sheets prepared are quite flexible that can be easily applied to different design situations by adjusting the initial values and the specification files. The CAD programs have been tested and verified on EC-1045 computer. (Edited author abstract) 6 Refs.

Narayanan, C.M. (Regional Engineering Coll, Durgapur, India); Bhattacharya, B.C. *J Inst Eng India Part CH v* 68 n 3 Jun 1988 p 96-100.

## Concrete

**084956 BEHAVIOUR OF PRESTRESSED CONCRETE CONTAINMENT STRUCTURE UNDER EXTREMELY LOW TEMPERATURE.** Prestressed concrete has been recognized as an excellent containment structure for storages of low temperature liquid such as LNG (-164°C). The study was conducted to evaluate mechanical properties of prestressed materials. Emphasis was laid on the evaluation of material and structural behavior in terms of ductility and liquid tightness. The experimental research was divided into five phases. Phase 1 tested and evaluated the notch sensitivity of prestressing wire, while Phase 2 examined the ductility of anchorage materials. In Phase 3, full size prestressing tendon systems of 12T 15.2 were subjected to static and cyclic loading under low temperature conforming to the FIP recommendation. Phase 4 examined the structural behavior of prestressed concrete beams under the impact loading at low temperature. Phase 5 tests the response of prestressed concrete beams subjected to various axial stresses and temperature gradient. Prestressed concrete and its steel materials have shown superior mechanical properties for cryogenic storage structure. (Edited author abstract) 13 Refs. In Japanese.

Rai, Chimoto; Kitamura, Hachirou; Ukaji, Kenichi. *Doboku Gakkai Rombun Hokokushu n* 396 V-9 Aug 1988 p 99-108.

## Cooling

**084957 THERMALLY STRESSED STATE OF HIGH PRESSURE VESSELS UNDER CHILLING AND SUPERCHARGING CONDITIONS: COMMUNICATION 4. COMBINED CHILLING CONDITIONS.** Three variants for conditions of combined chilling (preliminary purging of the vessel with a gaseous and its subsequent filling with a liquid coolant - nitrogen) of thick-walled HP vessel are calculated. Results of the calculation are presented. General regularities of the change in nonstationary heat and thermoelastic stressed states in the process of chilling during a long period of time as dependent on conditions of thermal and force loading are established. Rational conditions of the vessel chilling are determined which provide the required rate of the vessel chilling within the time range of 0 < t < 6 h and mild conditions of the thermal and force loading. (Edited author abstract) In Russian. 4 refs.

Tsybenko, A.S.; Kuranov, B.A.; Chepurnoi, A.D.; Sha-



poshnikov, A.A.; Krishchuk, N.G. *Probl Prochn* n 10 Oct 1987 p 85-89.

**Corrosion** See STEEL CORROSION—Stress Corrosion Cracking.

## Crack Propagation

**084958 STRESS INTENSITY FACTORS FOR A PRESSURIZED THICK-WALLED CYLINDER WITH RADIAL CRACKS OF UNEQUAL LENGTH.** The loading capacity of many industrial pressure vessels is often impaired by the gradual degradation of their internal surfaces under the combined action of high pressure pulses and environmental factors. As a rule, this degradation leads to microcracking, thereby creating potential sources of macroscopic fracture due to fatigue mechanisms. Furthermore, these cracks tend to grow unevenly as a result of the stochastic nature of the material's matrix and the varying environmental conditions. In order to evaluate the influence of crack length variance on the stress intensity factors  $K_I$ , for large arrays of radial cracks emanating from the bore of the cylindrical vessel, a 'two crack length level model' is applied. In this model the array of radial cracks is assumed to consist of two subarrays each of which comprises cracks of constant depth, though the two subarrays themselves may bear different crack lengths. All cracks are evenly spaced while crack length alternates. A few sets of calculations were performed. 4 refs.

Arone, R. (Technion, Haifa, Isr); Perl, M. *Int J Fract* v 34 n 4 Aug 1987 p R75-R78.

**084959 THREE-DIMENSIONAL RUPTURE ANALYSIS OF STEEL LINERS ANCHORED TO CONCRETE PRESSURE AND CONTAINMENT VESSELS.** Steel liners or plates are anchored to concrete pressure and containment vessels for nuclear and offshore facilities. Due to extreme loading conditions a liner may buckle due to the pull-out or shearing of anchors from the base metal and concrete. Under certain conditions attributed to loadings, liner metal deterioration and cracking of concrete behind the liner, the liner may fail by rupture. This paper presents a three-dimensional analysis of steel-concrete elements, using finite element in which a provision is made for liner instability, anchor strength and stiffness, concrete cracking and finally liner rupture. The analysis is tested first on an octagonal slab with and without an anchored steel liner. It is then extended to concrete pressure and containment vessels. The analytical results obtained are compared well with those available from the experimental tests and other sources. (Author abstract) 37 refs.

Bangash, Y. (Middlesex Polytechnic, Enfield, Engl). *Eng Fract Mech* v 28 n 2 1987 p 157-185.

## Cracking

**084960 THERMAL, IRRADIATION AND CYCLIC LOADING ANALYSIS FOR STRESS FATIGUE CRACK IN REACTOR VESSELS.** The thermal, irradiation and cyclic loading analysis for stress fatigue crack (SFC) of the base and weld materials of LMFBR (liquid metal fast breeder reactor) and LWR (light water reactor) pressure vessels is theoretically carried out based on experimental data. The power function and exponential function crack (rate) laws and the SFC theory are introduced and postulated for the stress intensity factor,  $K_I$ , or the effective stress intensity factor versus the fatigue crack growth rate in the vessel materials. Experimental data of austenitic stainless steels 304 and 316, nickel alloy Inconel 600, and low-carbon alloy steels A516 and A533 of the LMFBR and LWR pressure vessels were respectively computedly measured, examined and analyzed, and then plotted for either power function crack rate and/or exponential function crack law. (Edited author abstract) 24 refs.

Ma, Benjamin M. (Iowa State Univ, Ames, IA, USA). *Int J Pressure Vessels Piping* v 31 n 2 1988 p 83-104.

## Cutting

**084961 UNITARY TORCH FOR UNDERWATER DISMANTLING OF NUCLEAR REACTOR VESSELS.** A combined arc gouging and flame cutting torch was developed for dismantling commercial nuclear reactor components and was used in underwater cutting trials on mild steel clad with stainless steel. The torch combines arc gouging and flame cutting torches in a single unit. Procedures and results obtained are detailed. (Author abstract) 2 refs.

Hamasaki, Masanobu (Toyama Industrial Technology Cent, Jpn). *Met Constr* v 19 n 11 Nov 1987 p 641-642.

## Deformation

**084962 INVESTIGATION OF DEFORMATIONS AND FATIGUE RESISTANCE OF CYLINDRICAL PRESSURE VESSELS.** It is shown that distribution of tangential strains under cyclic loading of pressure vessels produced by 30KhGSA steel is heterogeneous in length. Fatigue resistance in vessels is determined by the sites with the highest values of accumulated strains along the perimeter of a cylindrical part. The fatigue curves are obtained for the experimental vessel and for vessels with the length differing from the experimental one. (Author abstract) In Russian. 4 refs.

Babitsky, M.S. *Probl Prochn* n 9 1987 p 55-57.

**Design** See Also NUCLEAR REACTORS, BREEDER —Pressure Vessels; STRESSES—Analysis.

**084963 RATIONAL DESIGN OF THIN-WALLED PRESSURE VESSEL ENDS.** Optimal contours for heads of cylindrical pressure vessels are discussed. As opposed to the common method of preventing buckling in pressure vessel ends by means of increased wall thickness or local reinforcements, this paper proposes a design for 'buckle-free' shapes in which the contour is established/adjusted so as to ensure stable behavior. A previous analysis by the authors, in which compressive stresses were eliminated, is extended so as to take into account the actual flexural rigidity of the wall. The shapes obtained from such buckle-free designs appear to be similar to standard ellipsoidal and torispherical ends and should be acceptable from various design and aesthetic viewpoints. (Author abstract) 14 refs.

Szyszkowski, W. (Univ of Calgary, Calgary, Alberta, Can); Glockner, P.G. *J Pressure Vessel Technol Trans ASME* v 109 n 4 Nov 1987 p 368-373.

**084964 ZEITLICHER DRUCKVERLAUF BEI EXPLOSIONEN ALS GRUNDLAGE ZUR AUSLEGUNG VON BEHAELTERN UND APPARATEN.** [Time-Dependent Behavior of Pressure in Cases of Explosions: A Basis for Design of Pressure Vessels and Apparatus]. Knowledge of the maximum explosion pressure is important for design of pressure vessels subject to danger of explosion. For non-spherical geometries or plant-internal pressure relief, the maximum explosion pressure has to be calculated from the time-dependent pressure caused by a chemical reaction in the vessel. Therefore, a set of ordinary differential equations was solved numerically by means of the method of differences. Examples are drawn from known experimental studies. Turbulence effects are also considered. As a result, an analytical relationship is derived which gives the necessary pressure relief area. Finally the results are compared with those of available formulas. Deviations are explained in detail. (Edited author abstract) 22 refs. In German.

Gruber, Udo (Univ Hannover, Hannover, West Ger); Puppich, Peter; Noll, Ewald; Mewes, Dieter. *Chem Ing Tech* v 59 n 12 Dec 1987 p 917-926.

**084965 OPTIMIZED PRESSURE VESSEL DESIGN WITH SPECIAL RESPECT TO OPERATING CONDITIONS.** Stress calculations for pressure vessels must be performed to demonstrate that at least minimum requirements of the relevant technical code are met. With stress analysis it is demonstrated that component fatigue

life can be influenced to a considerable extent by design and manufacture. Practical examples are provided to show the influence of stress concentrations and expansion constraints as well as the importance of using the proper weld seam and the influence of manufacture-based stress concentrations such as undercuts, edge displacements and surface influences. It is shown that in many cases tremendous improvements in component performance and component life can be gained at low expense if simple design principles are observed. (Edited author abstract)

Gerlach, H.D. (Rheinisch-West-Faelischer Technischer Ueberwachungs-Verein eV, Essen, West Ger). *Int J Pressure Vessels Piping* v 31 n 4 1988 p 285-293.

**084966 PROBLEM OF DESIGNING DOUBLE-CHAMBER GAS PRESSURE VESSELS.** The use of reaction gases under pressure offers new possibilities for hot isostatic processing: the manufacturing of articles with new or enhanced properties, shorter process time, and improved process productivity. However the processing pressure vessel must be protected against the reaction gases. One approach is to have a two-chamber gas pressure vessel, the outer chamber of which contains the thermal insulating hood and the heating element, and the inner chamber of which contains the workpiece and the reaction working medium. There are two fundamentally different designs for the inner chamber: the first type must be removable from the pressure vessel to allow loading of workpieces; the second type can be placed directly in the working space of the pressure vessel. 6 refs.

Zverev, A.D.; Krivonos, G.A.; Snop, V.I.; Orlova, E.V. *Sov Forg Sheet Met Stamping Technol* n 2 1987 p 89-93.

**084967 DISRUPTIVE FAILURE OF PRESSURE VESSELS: PRELIMINARY DESIGN GUIDELINES FOR FRAGMENT VELOCITY AND THE EXTENT OF THE HAZARD ZONE.** In the event of an accident, an industrial plant must be capable of being shut down in a safe, controlled manner. Thus, when a plant containing high-pressure fluids is being designed, the potential damage to essential shut-down equipment resulting from rupture of the pressure envelope must be assessed and, where necessary, protection provided. For example, pressure vessel rupture may generate missiles; i.e., sections of the pressure envelope become detached and are accelerated to significant velocities by the expanding fluid contents. An assessment of the consequences of pressure vessel rupture must therefore include estimates of the likely extent of the missile impact zone and the potential damage to equipment within that zone, which are both functions of the missile velocity. This paper describes preliminary guidelines for defining the velocity of the various types of missile which can be generated by pressure vessel failure. (Edited author abstract) 15 refs.

Baum, M.R. (CEGB, Berkeley, Engl). *J Pressure Vessel Technol Trans ASME* v 110 n 2 May 1988 p 168-176.

**084968 OPTIMAL SOLUTIONS DECISION OF EQUIVALENT STRESS FUNCTION WITH RESPECT TO TWO VARIABLES FOR THE AUTO-FRETTAGED VESSEL.** The formulae of equivalent stress were constructed in other papers. Some methods of optimization also were proposed. To obtain the optimal solution of equivalent is the key in the engineering design of autofrettaged vessel of high pressure. Therefore, this paper investigates some properties of optimal solutions and the existence of optimal solutions for the equivalent stress function with respect to two variables by the theory of convex function analysis and multiple objective programming. (Edited author abstract) 4 refs.

Huiming, Xing (So China Inst of Technology, Guangzhou, China); Xingren, Huang. *Modell Simul Control B* v 15 n 1 1988 p 1-7.

## Elastoplasticity

**084969 ELASTIC-PLASTIC ANALYSIS OF HYDRIDE BLISTERS IN ZIRCALLOY-2 PRESSURE TUBES.** The possibility that stresses might be produced as a consequence of expansion resulting from the transfor-



mation of zirconium to zirconium hydride in the form of blisters was investigated. Parametric elastic-plastic finite element analyses were performed because the physical properties near the blister were not clearly defined. Results show that significant stresses can arise from the volume expansion of hydride blisters, being largely compressive within the blister, tensile outside. (Author abstract). 7 Refs.

Kim, Y.J. (Sung Kyun Univ, Suwon, South Korea); Vanderlas, M.L. *J Pressure Vessel Technol Trans ASME* v 110 n 3 Aug 1988 p 276-282.

**Environmental Testing** See STEEL TESTING—Fatigue.

## Evaluation

**084970 EVALUATION OF REACTOR VESSEL BELTLINE INTEGRITY FOLLOWING UNANTICIPATED OPERATING EVENTS.** Using these simplified ASME code guidelines, a utility can determine within hours whether it can safely return a reactor vessel to service after a transient has caused operation beyond the specified pressure-temperature limits. The guidelines, endorsed by NRC, include criteria both for quick screening and for more-detailed evaluation of pressure vessel integrity. Low-temperature overpressure (LTOP) and pressurized thermal transient (PTT) events sometimes cause reactors to operate beyond those limits. The study produced screening criteria for quickly assessing the integrity of the reactor vessel after a LTOP or PTT event. In addition, it yielded a fracture mechanics evaluation procedure and acceptance criteria for a more detailed assessment. (Edited author abstract)

Anon. *Electr Power Res Inst Rep EPRI NP 5151 Apr 1987 52p.*

**Failure** See Also FRACTURE MECHANICS—Applications; NUCLEAR REACTORS, PRESSURIZED WATER—Containment Vessels.

**084971 CREEP RELAXATION IN MULTILAYER WRAPPED VESSELS.** One of the common methods of construction of vessels for high to ultra-high pressure applications is the wrapping technique. In this method, relatively thin plates (normally in the range of 6 mm) are rolled to proper curvature, wrapped around the core or the preceding layers and then welded. In this fashion, a prestress is gradually built in the cylinder wall which would compensate and moderate the extreme stresses due to internal pressure. Relying on such prestress, however, should be done only with careful consideration of stress relaxation that will take place while the vessel is in service, especially in high temperature services. In this paper, the initial stresses due to wrapping are obtained. These stresses are due to shrinkage of the weld as well as the plate affected by the heat of welding. The power function stress-creep strain rate is employed to predict the relaxation of interface pressure between any two adjacent layers. (Edited author abstract) 11 refs.

Dalton, M. (GE, Erie, PA, USA); Sabbaghian, M. *J Pressure Vessel Technol Trans ASME* v 109 n 4 Nov 1987 p 464-468.

**084972 STATISTICS OF PRESSURE VESSEL AND PIPING FAILURES.** This paper attempts to present a broad overview of failure statistics for both pressure vessels and piping. The pressure vessel case is more straightforward because each vessel is a discrete component. With piping the situation is much more difficult. Piping systems consist of a number of components varying markedly from system to system. While there is a large body of fairly well-defined statistics for pressure vessels in Germany, the United Kingdom and the United States, the same cannot be said for piping. As a result, piping statistics in this section are limited to nuclear systems with the assumption that they are extrapolatable to non-nuclear systems. 17 Refs.

Bush, S.H. (Pacific Northwest Lab, Richland, WA, USA). *J Pressure Vessel Technol Trans ASME* v 110 n 3 Aug 1988 p 225-233.

**Fatigue** See Also STEEL—Crack Propagation.

**084973 PROBLEMS OF INCREASING LOW CYCLE FATIGUE RESISTANCE OF HIGH PRESSURE VESSEL STUDS.** A new variant of engineering estimation of elastic stress concentration coefficients in the threads of 10,200 mm diameter studs in a pair with compressive nuts is suggested taking account of standard geometrical parameters of the threads. It is shown that the pitch is a key parameter of the thread geometry in the stud-nut joint. Results studies of low-cycle fatigue (LCF) of M12 threads with different thread geometry are presented. It is shown that a decrease in the thread pitch of M12 studs considerably increases the nut joint life. The scale factor and thread geometry are studied for their effect on LCF of 38KhN3MFA steel nut studs. Results of the study are presented. It is established that the effect of the thread geometry on LCF of large-diameter studs is less noticeable than on the small diameter ones. (Edited author abstract) In Russian. Refs.

Gorynin, V.I. *Probl Prochn* n 10 Oct 1987 p 40-44.

**Fracture** See Also NUCLEAR REACTORS, PRESSURIZED WATER—Materials; STEEL—Fracture.

**084974 LATE-EVENT VISCOPLASTICITY IN WIDE-PLATE CRACK-ARREST TESTS.** A primary objective of the crack-arrest studies being conducted by the Heavy-Section Steel Technology (HSST) program is to understand pressure vessel conditions that would initiate growth of an existing crack and conditions that would lead to arrest of a moving crack. In meeting this objective, the HSST program is generating crack-arrest data over an expanded temperature range through tests involving large cylinders, pressure vessels and wide-plate specimens. This paper describes the portion of those studies that relate to the installation of two viscoplastic constitutive models and several proposed fracture criteria into the ADINA finite element program. (Edited author abstract) 35 refs.

Bass, B.R. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Pugh, C.E.; Keeney-Walker, J.; Schwartz, C.W. *Int J Pressure Vessels Piping* v 31 n 5 1988 p 325-348.

**084975 BRITTLE FRACTURE RESISTANCE OF WELDED HIGH PRESSURE VESSELS.** This paper summarizes experimental data on the fracture toughness of heat resistant pressure-vessel steels and welded joints for power equipment, and also on the effect of different process and experimental factors upon this property. Suggestions for refining standard relationships and for their use in the evaluation of high pressure vessel strength are given. (Author abstract). 18 refs.

Gorynin, I.V. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Ignatov, V.A.; Zvezdin, Y.I.; Timofeev, B.T. *Int J Pressure Vessels Piping* v 33 n 4 1988 p 317-327.

**Heat Transfer** See Also LIQUIDS—Bubble Formation.

**084976 MATHEMATICAL MODEL FOR DETERMINING THE THERMOHYDRAULIC PARAMETERS OF BOILING COOLANT WITH LOSS-OF-COOLANT FROM A VESSEL.** The investigations of thermodynamic processes in emergency situations at nuclear power stations should there be loss-of-coolant accidents have led to the formulation of a number of programs describing these processes. There is particular interest in studying the effects of separation of coolant with small leakages, when residual heat release has a considerable effect on characteristics of the process of escape of boiling liquid. To describe this effect a mathematical model was developed and a calculation program written which enabled allowance to be made for residual heat release with escape of two-phase mixture from a vessel. 7 refs.

Dement'ev, B.A. (Moscow Power Inst, USSR); Kevkhishvili, N.A.; Gemega, B.V. *Therm Eng* v 34 n 2 Feb 1987 p 93-96.

## High Pressure Effects

**084977 SIMPLE DESIGN OF WINDOW FOR A PRESSURE VESSEL.** A sealed window of diameter 20 mm for use in high-pressure vessels (up to 50 MPa) has been made. It is fitted with a deformable ring. (Edited author abstract) 1 ref.

Azarkh, M.Z. (Rubber Industry Research Inst, Moscow, USSR); Kaporovskii, B.M.; Prokhorenko, O.A.; Yurtsev, N.N. *Instrum Exp Tech* v 30 n 3 pt 2 May-Jun 1987 p 739.

## Human Factors

**084978 VESSELS WITH A VIEW.** Pressure vessels are used when it is necessary to subject human beings to higher than atmospheric pressures, as in the case of divers undergoing decompression or recompression. These pressure vessels designed for human occupancy may be made from aluminum, titanium, and fiber-reinforced plastic composites.

Stachiw, Jerry D. (US Naval Ocean Systems Cent, San Diego, CA, USA). *Mech Eng* v 109 n 2 Feb 1987 p 80-81.

**Inspection** See Also NUCLEAR REACTORS, PRESSURIZED WATER—Pressure Vessels.

**084979 VAARALLISTEN AINEIDEN JA PAINEASTOIDEN TARKASTUS - MUUTTUUKO KÄYTTÄNTÖKÄ. [Inspection System of the Pressure Vessels and Dangerous Substances: Shall the System be Changed in Finland].** The important regulations concerning technical safety are based on the following laws: the Poison Act, the Act on Explosive Substances and the Act on Pressure Vessels. These laws cover not only the administration of licensing, inspection and surveillance, but also the various regulations governing the construction, arrangement and use of facilities. It is obvious that in the future the present legal requirements for licensing and inspection will have to be considerably improved. Technological advances and the increasing size of production facilities will require more detailed inspection of safety arrangements and also, in certain cases, the use of safety analysis procedures as a precondition for awarding licences. 4 refs. In Finnish.

Tuominen, Seppo. *Kem Kem* v 15 n 4 1988 p 366-368.

**Joints** See RINGS—Stresses.

**Manufacture** See Also NONDESTRUCTIVE EXAMINATION—Ultrasonic Applications.

**084980 ASSESSMENT OF ALTERNATE STEELS FOR WELDED PRESSURE VESSELS.** The objective of this project was to identify alternate steels to the standard SA 516Gr70 steel for pressure vessel fabrication. The Welding Institute of Canada (WIC) Rigid Restraint Cracking Test (RRC) was modified to cope with steels thicker than 50mm and used to establish minimum preheat/heat input conditions necessary to avoid heat-affect zone (HAZ) cracking in the high restraint conditions of the WIC test. After a world-wide survey of steelmaking technologies and a listing of available steels by Chinook Fuels of Calgary, eight steels are assessed in the original contract. No individual steel better than a particular SA 516Gr70 was found. Further testing at the University of Alberta was carried out on five more steels. Four of the new contract steels showed better cracking resistance than the standard SA 516Gr70 after preliminary testing. Continued testing revealed that a normalizing heat treatment on several original contract steels improved their resistance to HAZ-cracking. (Edited author abstract) 6 refs.

Patchett, B.M. (Univ of Alberta, Edmonton, Alberta, Can). *Res Rep Can Electr Assoc* v 109G276 Dec 1987 52p.



**084981 NEW MANUFACTURING TECHNIQUES OF LARGE FORGED SHELL RINGS FOR PRESSURE VESSELS.** A 250 ton hollow ingot was made for experimental purposes so that the properties of a large-sized hollow ingot could be simulated. The investigation results indicated that this ingot was suitable for forged shell rings of nuclear reactor pressure vessels (RPV). They were used in the manufacture of forged shell rings for an RPV of a 1300 MW type PWR and for an RPV of an 1100 MW type BWR using basic oxygen furnace, RH degassing, hollow ingot-making process. These shell rings had less segregation and clean inner surfaces which are attributed to the homogeneity of the hollow ingot. (Author abstract) 6 refs.

Saito, K. (Kawasaki Steel Corp, Jpn); Namba, A.; Aso, K.; Abe, N.; Nagai, J.; Ejima, A. *J Mater Shaping Technol* v 5 n 1 1987 p 9-15.

**Materials** See Also NICKEL AND ALLOYS—Mechanical Properties; NUCLEAR REACTORS, PRESSURIZED WATER—Pressure Vessels; STEEL TESTING—Fracture.

**084982 PLASTIC DEFORMATION AND FRACTURE BEHAVIOUR OF 2 1/4 Cr-1 Mo PRESSURE-VESEL STEEL WITH BAINITIC AND BAINITIC-FERRITIC MICROSTRUCTURE.** During the heat treatment of steel plates and forgings with large thicknesses, microstructures with various volume fraction of ferrite can appear. Plastic properties and fracture behavior of these mixed microstructures are a function of ferrite content. The influence of ferrite content in the range from 0% to 54% in the bainitic-ferritic microstructure on mechanical properties and fracture behavior of 2 1/4Cr-1 Mo steel was examined. The yield stress was found to decrease linearly with the volume fraction of ferrite. The tensile strength was independent of ferrite content up to 25 percent, after which the tensile strength decreased as well. By the Charpy test it has been found that there exists the critical ferrite content - 25 percent - in a mixed microstructure, at which the propagation and initiation transition temperature attain the highest values. The fracture toughness tests pointed out the same results. (Edited author abstract). 28 Refs.

Holzmann, Miloslav (CSAV, Brno, Czech); Vlach, Bohumil; Man, Jiri. *Acta Tech CSAV* v 33 n 1 1988 p 37-58.

## Nondestructive Examination

**084983 COMPUTER-ASSISTED ULTRASONIC DETECTION AND MEASUREMENT OF CRACKS IN PRESSURE VESSELS.** This imaging system uses both straight and shear-wave ultrasonic beams to construct a three-dimensional crack profile on the hot surface (up to 400°F) of an operating digester. (Author abstract)

Anliker, Dennis M. (Champion Int Corp, West Nyack, NY, USA); Cilauro, Santo A. *Tappi J* v 71 n 3 Mar 1988 p 41-45.

**084984 BETRIEBSNAHE SCHADENSERKENNUNG MIT HILFE DER HOLOGRAFISCHEN INTERFEROMETRIE UND EINES DOPPELIMPULSLASERS.** [Holographic Investigation on Failure Mechanisms in Homogeneous Materials]. There is a relation between defects occurring in the wall material of pressurized equipment and deformation of the wall surface under load. If the deformation at the surface exceeds 35 nm, it is possible to use holographic interferometry for detection. The method is applicable to pressure vessels if the holographic fringe pattern is related quantitatively to the size of a failure. This report presents experimental results which give the relation between the perturbation of the holographic fringes and the size of different kinds of failures. The size of the smallest detectable failure is smaller than the critical size of a flaw in the material. (Edited author abstract) 5 refs. In German.

Hajduk, M.; Mewes, D. *Materialwiss Werkstofftech* v 19 n 5 May 1988 p 152-156.

**Nozzles** See Also CYLINDERS—Nozzles; PLATES—Strain; WELDING—Standards.

**084985 NOZZLES IN PRESSURE VESSEL HEADS - A COMPARISON OF PAD AND INTEGRAL REINFORCEMENTS.** A thin shell analysis is presented to investigate the stress distribution of welded-pad reinforced nozzles in ellipsoidal pressure vessel heads when an internal pressure loading is considered. A comparison of the structural behavior of such a nozzle to an integrally reinforced nozzle shows a thirty-nine percent higher stress is present in a typical nozzle-vessel geometry. A comprehensive comparison of the stress concentration and radial flexibility at these two types of reinforced nozzles is presented for both hemispherical and ASME 2:1 ellipsoidal vessel heads. (Author abstract) 11 refs.

Chao, Y.J. (Univ of South Carolina, Columbia, SC, USA). *Res Mech* v 22 n 2 1987 p 151-170.

**084986 USING AE MONITORING FOR ON-LINE CRACK DETECTION.** On-line acoustic emissions (AE) monitoring of a feed nozzle on a heat cracking tower and butt weld seams between the piping and flanges in the high pressure reforming process of an ammonia plant was conducted with a two-channel waveform recorder and an AE analyzer. To avoid degradation of the PZT sensors from high temperature, two sensors were separately attached to the cold top-surfaces of two wave guides through which the feed nozzle and the butt weld seam were monitored for cracking and leaking under operating conditions. Inspection and X-ray examination, after shut down, proved that on-line AE monitoring was effective.

Zhang, B.Q. (Daqing Petroleum Coll, Anda, China). *Hydrocarbon Process* v 67 n 1 Jan 1988 p 35-37.

## Pressure Effects

**084987 PREDICTION OF BURST PRESSURE OF PRESSURE VESSELS.** A general predicting expression is derived for the burst pressure of pressure vessels. Based on the theory of ideal plastic materials, the results of the prediction have good agreement with those of experiments. It can be concluded that the expression for the burst pressure of pressure vessels is applicable to single-layer, multi-layer and flat steel ribbon vessels. (Edited author abstract) In Chinese. 10 refs.

Li, Shengchang (Fujian Petrochemical Designing Inst, Fuzhou, China). *Huagong Jixie* v 14 n 2 1987 p 120-126.

## Production

**084988 PRODUCTION EQUIPMENT FOR SPIRALLY WOUND LAYERED VESSEL.** Spirally wound layered vessels are a type of multi-layered vessel used as high pressure vessels in chemical plants, etc., and consist of an internal shell around which hoop steel is wound spirally in layers. Stable, automatic winding and high-speed welding of hoop steel are major considerations to ensure efficient production of high-quality spirally wound layered vessels. For these purposes, the hoop steel must be wound with a uniform gap between the hoop steel and minimum clearances between the layers. In order to develop winding equipment which will meet these requirements, tests were carried out to determine which parameters should be controlled and by what method. As a result, it was found that if hoop steel is controlled at a proper angle, both the gap between the hoop steel and the clearances between the layers will be within the target values and the ASME requirements. (Author abstract) In Japanese. 2 refs.

Iwasaki, Yasuhiro; Ooe, Tsutomu; Yuzaki, Yoshinori. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 494 Oct 1987 p 2167-2171.

## Radiation Damage

**084989 RADIATION-INDUCED EMBRITTLEMENT IN LIGHT WATER REACTOR PRESSURE VESSELS.** In operating light water reactor (LWR) commercial power plants, neutron radiation induces

embrittlement of the pressure vessel (PV) and its support structures. As a consequence, LWR-PV integrity is a primary safety consideration. Recent LWR-PV benchmark experiments are analyzed in this paper. On this basis, it is established that an exponential representation accurately describes the spatial dependence of neutron exposure in LWR-PV. Implications produced by this simple exponential behavior are explained and trend-curve models for the prediction of PV embrittlement are derived. These derivations provide for a clearer understanding and assessment of the assumptions underlying these trend-curve models. It is demonstrated that LWR-PV embrittlement possesses significant material dependence. (Edited author abstract) 25 refs.

Gold, Raymond (Westinghouse Hanford Co, Richland, WA, USA); McElroy, William N. *Nucl Eng Des* v 104 n 2 Oct 2 1987 p 155-174.

## Safety Codes

**084990 PREDICTIVE MAINTENANCE OF PRESSURE VESSELS.** In-service corrosion/erosion data can be computer-analyzed to prove Code-compliance and predict the remnant life of vessels. Measurement of thickness(es) for vessels in service is therefore to be strongly encouraged. API 510 makes valuable recommendations in this respect. Thickness measurements can now be made by ultrasonics without interfering with your production process. But that's just the beginning. Subsequently, the measured wall thicknesses must be used in an engineering evaluation to provide answers to: 1. Is the vessel Code-compliant or non-compliant today? 2. How soon should the next set of measurements be taken? 3. How much thickness is left for safe continued use? The author divides the discussion into several parts: how the evaluation of in-service vessels is performed at present; how it could be improved by using the concept of 'minimum thickness' and by computerisation; and finally the practicalities of setting up a predictive maintenance programme.

Grosshandler, S. *Process Eng (London)* v 68 n 8 Aug 1987 p 27-29, 31.

**084991 EMERGENCY RELIEF SYSTEM DESIGN FOR REACTIVE AND NON-REACTIVE SYSTEMS: EXTENSION OF THE DIERS METHODOLOGY.** Simple mechanistic models for reactive and non-reactive chemicals are summarized. The DIERS methodology has been extended as well as simplified to account for vapor disengagement and frictional effects including laminar flow conditions-both principal objectives of the DIERS program. Gassy systems involving non-flashing two-phase flow are also discussed including a simple procedure for assessing the vent size without requiring specific knowledge about tempering conditions. Non-reactive systems involving fire exposure are discussed including atmospheric as well as high pressure systems. A possible preventive measure for boiling liquid expanding vapor explosions (BLEVE) is suggested. (Edited author abstract). 29 Refs.

Fauske, Hans (Fauske & Associates Inc, Burr Ridge, IL, USA). *Plant Oper Prog* v 7 n 3 Jul 1988 p 153-158.

**Steel** See Also NUCLEAR REACTORS—Pressure Vessels; PETROLEUM REFINERIES—Port Harcourt, Nigeria; PLATES—Steel; STEEL STRUCTURES—Deformation; STEEL TESTING—Fracture.

**084992 LIFE ASSESSMENT TECHNIQUES APPLIED TO A 1% Cr-0.5%Mo PRESSURE VESSEL AFTER 95,000 HOURS SERVICE.** A 1% Cr-0.5% Mo primary superheater outlet header failed through cracking of the central girth weld after 94 835 hours of service. The header was replaced and made available for study as it was thought that a residual life analysis may provide an indication of the life that could be expected from similar headers in the remaining boilers of this power station. The life of this header was firstly assessed using the boiler operating history in conjunction with the Life Fraction



Rule. It was then assessed using accelerated creep rupture testing. Problems with each method are discussed. Stub-tube hole ovality is described as an 'in situ' method of life assessment; however, although results indicate that the header has sustained some creep, these results cannot be interpreted in a quantitative manner. A microstructurally based method for determining average operating temperature of components is also mentioned. (Edited author abstract) 9 refs.

Coade, R.W. (State Electricity Commission of Victoria, Aust.). *Mech Eng Trans Inst Eng Aust V ME 11 n 2 Jul 1986 p 104-111.*

**084993 DIAMETRAL STRAIN RESPONSE AND MICROSTRUCTURAL YIELDING MECHANISMS OF A BAINITIC PRESSURE VESSEL STEEL.** Unexpected trends of diametral strain range response have been recorded for annealed bainitic Cr-Mo-V pressure vessel steel at room temperature and moderate strain amplitudes. Stress and diametral strain response were also recorded for three harder heat treatment variants, but they behaved as expected. The alloy is strengthened by a carbide dispersion and a dislocation network, both of variable density. The unexpected diametral strain response is suggested to be associated with yet unknown macroscopic effects of particular observed microscopic mechanisms of slip. These mechanisms of slip can be analyzed with a model for dispersion strengthening which expresses the connection between nominal dislocation activity and the plastic and elastic components of elongation. Additional aspects of the subject are discussed. (Edited author abstract) 17 refs.

Rahka, K.A. (Technical Research Cent of Finland, Espoo, Finl); Solin, J.P.; Kemppainen, M.J. *J Test Eval v 16 n 1 Jan 1988 p 44-58.*

**084994 DISCUSSION OF THE DESIGN FATIGUE CURVES OF PRESSURE VESSEL STEELS.** Modification and correction have been made to the present fatigue curves for the short service life zone based on Langer's principle, and to the results of low-cycle fatigue tests conducted on BHW35 boiler drum steel and its electroslag welding materials as well as on 19Mn5 steel. The effect of mean stress correction on fatigue curve is also discussed. (Author abstract) In Chinese.

Li, Yi-Ming; Wang, Jing-Rui. *Dongli Gongchen n 2 Apr 15 1987 p 43-48.*

**084995 PLASTIC DEFORMATION AND FRACTURE BEHAVIOUR OF 2 1/4 Cr-1 Mo PRESSURE VESSEL STEEL WITH BAINITIC AND BAINITIC-FERRITIC MICROSTRUCTURE.** During the heat treatment of steel plates and forgings with large thicknesses, microstructures with various volume fraction of ferrite can appear. Plastic properties and fracture behavior of these mixed microstructures are a function of ferrite content. The influence of ferrite content in the range from 0% to 54% in the bainitic-ferritic microstructure on mechanical properties and fracture behavior of 2 1/4 Cr-1 Mo steel was examined. The yield stress was found to decrease linearly with the volume fraction of ferrite. The tensile strength was independent of ferrite content up to 25%, after which the tensile strength decreased as well. By the Charpy test it has been found that there exists the critical ferrite content - 25% - in a mixed microstructure, at which the propagation and initiation transition temperatures attain the highest values. The fracture toughness tests pointed out the same results. Increasing the volume fraction of ferrite, the cleavage fracture toughness versus temperature curves were shifted to higher temperatures. Simultaneously, the ductile-brittle fracture toughness transition temperature was raised reaching the highest value for the critical ferrite content. (Edited author abstract) 28 refs.

Holzmann, Miloslav; Vlach, Bohumil; Man, Jiri. *Acta Tech CSAV v 33 n 1 1988 p 37-58.*

**084996 STATUS OF RESEARCH ON ENVIRONMENTALLY ASSISTED CRACKING IN LWR PRESSURE VESSEL STEELS.** This paper reviews collabora-

tive work that has the objective of defining, from first principles, the environmentally assisted crack growth rates in the Type A533B or A508 low-alloy steel/water system at 288°C under static and cyclic loading conditions. These theoretical rates are then used to assess the validity of the current ASME XI life evaluation code. The investigations, which were conducted by members of the International Cyclic Crack Growth Rate Group, have centered around (a) defining a working hypothesis for environmentally assisted cracking, (b) determining the nature and magnitude of crack tip environments and reaction rates that are pertinent to the crack advance hypothesis, (c) quantitatively validating a hypothesis by comparing observed and theoretical values, and (d) using the qualified mechanism to evaluate the validity of current life-evaluation codes for environmentally assisted crack propagation. It is concluded that, on the basis of the bulk of present data, the slip dissolution (film rupture) model seems to be quantitatively the most valid crack advance mechanism for this system at 288°C. (Edited author abstract) 104 refs.

Ford, F.P. (GE Corporate Research & Development Cent, Schenectady, NY, USA). *J Pressure Vessel Technol Trans ASME v 110 n 2 May 1988 p 113-128.*

**084997 DETERMINATION OF CRACK ARREST TOUGHNESS AT HIGH TEMPERATURES USING COMPACT SPECIMENS.** In order to determine the influence of the test temperature on the crack arrest toughness, investigations were carried out on pressure vessel steels of various strength and toughness up to the upper-shelf of the Charpy V-notch impact energy ( $C_V$ -energy). The tests were conducted on the basis of the proposed ASTM test method for ferritic steels with modified wedge-loaded compact specimens. The thickness ranged from 0.75-6.69 in. (19-170 mm), the in-plane dimensions from 3.94-15.75 in. (100-400 mm). The comparison with the reference curves of the American and German guidelines showed significant discrepancies at high temperatures. (Author abstract) 12 refs.

Kussmaul, K. (Univ of Stuttgart, West Ger); Gillot, R. *J Pressure Vessel Technol Trans ASME v 110 n 2 May 1988 p 129-136.*

**084998 MEASUREMENTS OF THERMAL CONTACT RESISTANCE FOR STEEL LAYERED VESSELS.** An experimental procedure for measuring the thermal contact resistance of layered specimen under normal stress is described. Results for as-rolled SA-516-70 steel layered are used to establish a functional relationship between contact resistance and stress. The relationship is employed in a finite element formulation in order to predict transient temperature distributions. Agreement between the finite element results and the experimentally determined temperature profiles is good. (Author abstract) 11 refs.

Tauchert, T.R. (Univ of Kentucky, Lexington, KY, USA); Leigh, D.C.; Tracy, M.A. *J Pressure Vessel Technol Trans ASME v 110 n 3 Aug 1988 p 335-337.*

**084999 FRACTURE TOUGHNESS AND CRACK GROWTH RESISTANCE OF PRESSURE VESSEL PLATE AND WELD METAL STEELS.** Compact tension specimens were used to measure the initiation fracture toughness and crack growth resistance of pressure vessel steel plates and submerged arc weld metal. Plate test specimens were manufactured from four different casts of steel comprising: aluminum killed C-Mn-Mo-Cu and C-Mn steel and two silicon killed C-Mn steels. Weld metal test specimens were extracted from five weld joints of Unionmet No. 2 weld metal. The welds were of double V butt geometry having either the C-Mn-Mo-Cu steel (three weld joints) or one particular silicon killed C-Mn steel (two weld joints) as parent plate. On the upper shelf, a multiple specimen test technique was used to obtain crack growth data which were analyzed by simple linear regression to determine the crack growth resistance lines and to derive the initiation fracture toughness values for each test temperature. These regression lines were highly scattered with respect to temperature and it was very difficult to determine precisely the temperature depen-

dence of the initiation fracture toughness and crack growth resistance. (Edited author abstract). 8 Refs.

Moskovic, R. (CEGB, Gravesend, Engl). *Eng Fract Mech v 30 n 6 1988 p 839-861.*

**085000 OBSERVATIONS OF HYDROGEN DAMAGE IN A FAILED PRESSURE VESSEL.** An amine absorber tower used to strip  $H_2S$  from propane fractured adjacent to a repair weld made to replace a section of the vessel damaged by hydrogen blisters and delaminations. Hydrogen stress cracks developed during operation of the vessel at the inside surface in martensite formed during repair welding. These cracks propagated by hydrogen pressure cracking in a zigzag path through the vessel wall. Catastrophic rupture initiated at an 800 mm long crack at a low stress level because hydrogen embrittlement reduced the fracture toughness of the steel by more than half. Observations of five types of hydrogen damage are discussed. (Author abstract) 12 refs.

McHenry, H.I. (NBS, Boulder, CO, USA); Purtscher, P.T.; Shives, T.R. *Corros Sci v 27 n 10-11 1987, Hydrogen Sulphide Induced Environ Sensitive Fract of Steels, Sel Proc from the Int Conf, Amsterdam, Neth, Sep 10-12 1986 p 1041-1057.*

**Stresses** See Also CYLINDERS—Elastoplasticity; HEAT EXCHANGERS—Fracture.

**085001 THERMALLY STRESSED STATE OF HIGH PRESSURE VESSELS SUBJECTED TO CHILLING AND SUPERCHARGING. COMMUNICATION 2. CHILLING OF VESSEL WITH LIQUID COOLANT.** Liquid nitrogen chilling of HP vessel is calculated. Calculation results are presented. Nonstationary heat and thermoelastoplastic stress-strained state of the vessel is analyzed for the case when nonlinear temperature dependences of mechanical and physical parameters are taken into account. Local regions of inelastic strain of the vessel material are detected and values of residual stresses are determined. (Author abstract). In Russian. 5 refs.

Tsybenko, A.S.; Kuranov, B.A.; Chepurnoi, A.D.; Shaposhnikov, A.A.; Kpishchuk, N.G.; Malashkin, G.Yu. *Probl Prochn n 8 1987 p 75-80.*

**085002 THERMALLY STRESSED STATE OF HIGH PRESSURE VESSELS DURING CHILLING AND SUPERCHARGING. COMMUNICATION 3. CHILLING OF VESSEL WITH GASEOUS REFRIGERANT.** Results of calculations of the thermostressed state of a thick-walled HP vessel for three possible structural-technological conditions of chilling with gaseous nitrogen are presented. General regularities in variation of heat exchange parameters, nonstationary nonlinear heat and thermoelastic stressed states in the process of chilling over a long-term time interval are established. (Author abstract) In Russian. 8 refs.

Tsybenko, A.S.; Kuranov, B.A.; Chepurnoi, A.D.; Shaposhnikov, A.A.; Krishchuk, N.G. *Probl Prochn n 9 1987 p 99-104.*

**085003 INFLUENTA PARAMETRILOR GEOMETRICI AI SECTIUNII ASUPRA STARII DE TENSIUNE DIN INVELISURILE CILINDRICE OVALIZATE SOLICITATE CU PRESIUNE INTERIOARA.** [Influence of Geometrical Parameters of the Section on the Stresses in Ovalised Cylindrical Tubes Under Internal Pressure]. The calculation relations obtained by means of a simplified model are transcribed via dimensionless parameters with a view to using them in the study of stresses produced by the internal pressure in ovalised cylindrical tubes. The conclusions derived from the application of these relations to shells having different diameters, wall thickness and ovalizations led to the



elaboration of a simple methodology for the calculation of stresses generated by this particular form of the cross section. (Author abstract) In Romanian. 3 refs.

Gheorghiu, H. (Inst Politehnic Bucuresti, Rom). *Bul Inst Politeh Bucuresti Ser Mec* v 48 1986 p 75-80.

**085004 STRESS ANALYSIS OF PRESSURE VESSELS WITH UNIFORMLY SPACED LUGS.** Stresses and displacements in circular cylindrical shells having square and rectangular lugs have been studied in this paper. The analysis presented here is based on finite element technique using 17-node doubly curved shell elements. Numerical computations have been performed for the case of longitudinal moments applied at discrete points around the circumference of the vessel. Four identical lugs uniformly spaced around a parallel have been considered. Results have been generated for several cases with different lug sizes and  $t/a$  ratios. (Author abstract) 11 refs.

Mirza, S. (Univ of Ottawa, Ottawa, Can); Guggupoglu, K. *J Pressure Vessel Technol Trans ASME* v 110 n 1 Feb 1988 p 70-75.

**085005 PRESSURE VESSEL RESEARCH COMMITTEE: WRC - 50 YEARS OF PROGRESS THROUGH COOPERATIVE RESEARCH.** The Welding Research Council (WRC) Bulletin No. 107 and Bulletin No. 297 are two of the most important design guides ever published for the design of pressure vessels. Widely used in the design of attachments and nozzle connections, they have become indispensable tools in recent years. WRC-107 and WRC-297 are invaluable due to their combined consideration of theory, experimental data, and engineering judgment. In some instances the theoretical values have been adjusted several hundred percent upward to match the available experimental results. They are reliable tools without which the so-called 'Design by Analysis' approach would have been impractical. Unfortunately many designers have misapplied the data presented, thus resulting in inconsistent designs. This article describes the data available in these two bulletins and explains the nature of inconsistency incurred in some designs. A supplemental formula is then developed for calculating the combined maximum stress intensity to be used in designs. 4 refs.

Peng, L.-C. (Peng Engineering, Houston, TX, USA). *J Pressure Vessel Technol Trans ASME* v 110 n 1 Feb 1988 p 106-109.

**085006 DERIVATION OF THE STRESSES IN A PRESSURIZED PIPE OR CYLINDRICAL VESSEL WITH INITIAL GEOMETRIC IMPERFECTIONS.** Several analytical methods are outlined to deal with the title problem when the vessel is free of external constraints. In essence these correspond to the Haigh equation, which provides a nonlinear relationship between the induced circumferential stress and the applied internal pressure. To make use of these analyses a survey of the cross sectional profile is required. The approach using an internal swinging arm has been found most useful. The extent to which an improved Haigh equation is valid is examined with reference to the pneumatic loading of a twin saddle supported horizontal vessel which contains imperfections and restraints at the supports. (Author abstract) 10 refs.

Tooth, Alwyn S. (Univ of Strathclyde, Glasgow, Scotl); Ong, Lin-Seng. *Strain* v 24 n 1 Feb 1988 p 7-14.

**085007 NONHYDROSTATIC STRESS IN FIXED-PRESSURE VESSELS AT LOW TEMPERATURES.** The anisotropic stresses are determined that can be produced in specimens located in hydrostatic-pressure vessels with a kerosene-oil or pentane-oil medium with cooling to the liquid-helium temperature. For specimens situated crosswise to the vessel channel, the compressive stress reaches 60-70 MPa for a pressure of 0.1-0.2 GPa and then is unchanged with pressure. The compressive stress is lower by one order of magnitude for similar but shorter specimens and practically nonexistent for specimens situated along the channel. (Author abstract) 9 refs.

Keptya, V.F. (Moscow State Univ, USSR); Lavrenyuk, M.Yu.; Minina, N.Ya. *Instrum Exp Tech* v 30 n 5 pt 2 Sep-Oct 1987 p 1210-1213.

**085008 EFFECTS OF STRESS RELIEF ON THE PROPERTIES OF C AND C-Mn PRESSURE-VESSEL PLATE STEELS.** The effect of post-weld heat-treatment on the mechanical properties of C and C-Mn pressure-vessel plate steels is presented in this work. To take account of the possible ranges of times, temperatures, heating and cooling rates, a time-temperature parameter has been used. It is concluded that reduction of as much as 10 percent of U.T.S. and Y.S. and 30°C increase of Charpy impact transition temperature for a typical post-weld heat treatment have been observed. (Author abstract) 5 refs.

Shaikh, Nazimuddin (Mehran Univ of Engineering & Technology, Jamshoro, Pak). *Mehran Univ Res J Eng Technol* v 7 n 1 Jan 1988 p 25-28.

**085009 EFFECT OF IMPERFECT CONTACT BETWEEN ADJACENT LAYERS ON THE INTEGRITY OF WRAPPED VESSELS.** Multilayer vessels are the designer's solution to the inefficiency involved in operating monoblock vessels at pressures above 50 MPa. Multilayer wrapped vessels are commonly employed in high-pressure applications of up to 550 MPa. They are advantageous to monoblock cylindrical construction in several aspects, one of which is the prestressing of the layers in order to more efficiently distribute the stresses developed due to the inside pressure. Calculation of prestress in each layer, due to shrinkage of the weld, has been reported before. Nearly all such reports are based on the assumption that layers are in perfect contact with one another. In practice, however, occasions may arise, where due to imperfect rolling and/or variations in the thickness of a plate, there remains an isolated local gap between adjacent layers. In this investigation, the size of a gap is defined in terms of its circumferential arc length and maximum radial height. (Edited author abstract). 9 refs.

Rasty, J. (Texas Tech Univ, Lubbock, TX, USA); Sabaghian, M. *J Pressure Vessel Technol Trans ASME* v 110 n 3 Aug 1988 p 247-254.

## Structural Analysis

**085010 STRESS ANALYSIS OF RECTANGULAR PRESSURE VESSELS HAVING THIN-WALLED REINFORCING MEMBERS.** A modified formula is presented for rectangular pressure vessels having thin-walled reinforcing members. The formula is derived from the compatibility that relates to shear deformation of the corner. Experimental results on full-size vessels are reported. The results obtained from the authors' formula are compared with those obtained from the ASME Code and by the finite element method, which indicate that the modified formula gives better accuracy. (Author abstract) 9 refs.

Zeng, Zhao-jing (Nanjing Inst of Chemical Technology, Nanjing, China); Gao, Jia-ju; Gu, Qi-shou. *Int J Pressure Vessels Piping* v 30 n 3 1987 p 193-204.

**085011 INSTALLATION OF REINFORCING RINGS FOR HORIZONTAL VESSELS.** Analysis shows that the heating forces vary according to the different installations of reinforcing rings (including cylinders) and saddles, and the distributed proportion of rotational inertia  $I_0$  is given in the case of installing some reinforcing rings near saddles. (Edited author abstract) In Chinese. 5 refs.

Li, Zhian; Song, Mingchen. *Huagong Jixie* v 14 n 3 1987 p 200-205.

**085012 LINEAR VERSUS NON-LINEAR ANALYSIS OF IMPERFECT SPHERICAL PRESSURE VESSELS.** A pressurized thin spherical shell with deviations in shape is analyzed using a geometrically linear and a non-linear version of a finite element formulation. A local geometric imperfection, described as a cosine function, is assumed, and the influence of different parameters on the

non-linear behavior is considered. The results show the importance of the non-linear terms in the analysis of slender shells, and that a linear analysis can be highly conservative, depending on the geometric parameters which define the problem. (Edited author abstract). 10 refs.

Flores, Fernando G. (Univ Nacional de Cordoba, Cordoba, Argent); Godoy, Luis A. *Int J Pressure Vessels Piping* v 33 n 2 1988 p 95-109.

## Structural Design

**085013 CAST IRON FOR PRESTRESSED HIGH PRESSURE VESSELS.** Tests were run on assembly design of a physical model of a high pressure vessel and its components or innards, inner cavity diameter 400 mm and height 750 mm, designed to take 35 MPa (350 atmospheres) pressure. Dimensions of model and testing characteristics were selected with account taken of experience in testing similar prestressed reinforced concrete models. Predicted breaking load was 60 MPa (600 atmospheres). A basic prerequisite for successful design of prestressed reinforced concrete high pressure vessels is inadmissibility of any cracks appearing on the inner surface of the vessel, which means absence of any tensile stresses. In the case of a prestressed pressure vessel assembled from cast iron elements, this constraint is retained in full force, so that the design is arrived at on a basis of recognizing inadmissibility of any butt joints opening up, i.e., again no tensile stresses on the inner surface of the pressure vessel. 3 refs.

Aleksandrov, N.N.; Kovalevich, E.V.; Kulikov, V.I.; Belyakov, A.I.; Mirenkov, A.F. *Sov Energy Technol* n 5 1987 p 67-73.

**085014 ADVANCES IN DESIGN AND ANALYSIS IN PRESSURE VESSEL TECHNOLOGY (PRESENTED AT THE WINTER ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS).** This conference proceedings contains eleven papers covering various facets of fracture mechanics, plasticity, and microcomputer application to structural design analysis. Part 1 of this publication contains six papers covering a range of recent developments on fracture mechanics and plasticity in pressure vessel technology. Part 2 deals with recent advances in microcomputer application to engineering design analysis. In just one decade microcomputers have emerged as a major engineering tool having proliferated to the extent where most engineers have access to one, if not their own personal machine. Software developers have taken advantage of this popular mode of computing and have written both specific purpose and general purpose of software to serve the needs of engineers in the pressure vessel and piping industry. This publication provides an overview of some of this software with the specific purpose of encouraging its use and development. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10850 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Chung, Howard (Ed.) (Argonne Natl Lab, IL, USA); Ayyaswamy, P.S. (Ed.); Nicholson, D.W. (Ed.); Woodward, W.S. (Ed.). *ASME Pressure Vessels Piping Div Publ PVP* v 130, Adv in Des and Anal in Pressure Vessel Technol (NE v 2), Boston, MA, USA, Dec 13-18 1987. Publ by ASME, New York, NY, USA, 1987 99p.

## Surfaces

**085015 J-INTEGRAL AND STRESSES AT AN INNER SURFACE FLAW IN A PRESSURE VESSEL.** This paper presents the results of elastic-plastic finite element analyses of a pressurized cylinder containing an inner surface flaw under three different load boundary conditions. The applicability of the Newman-Raju formula for calculating the stress intensity factor is extended to the calculation of the elastic-plastic J-integral up to the collapse pressure of the structure. The stress results are compared with a corresponding analysis of a compact specimen of the same material showing that the stress state



in the latter is a more severe one and, hence, will yield conservative estimates for crack initiation of the surface flaw. The phenomenon of the 'canoe' shape which has been examined for stable crack growth of surface flaws is discussed on the background of the triaxiality of the stress state. (Edited author abstract) 27 refs.

Brocks, W. (Bundesanstalt fuer Materialforschung und-pruefung, Berlin, West Ger); Noack, H.D. *Int J Pressure Vessels Piping* v 31 n 3 1988 p 187-203.

**Testing** See Also GAS CYLINDERS—Stability; STEEL—Fatigue.

**085016 BEWERTUNG VON BERTSTVERSUCHEN NACH KONZEPTEN DER BRUCHMECHANIK UND DES PLASTISCHEN VERSAGENS.** [Evaluation of Burst Tests on the Basis of Fracture-Mechanics and Plastic-Failure Concepts]. In pressure vessels with artificial surface cracks of various sizes failure at ambient temperature and  $-20^{\circ}\text{C}$  was due to ductile fracture. The fracture surface exhibits dimples without cleavage. The onset of crack extension and instability occurred in the elastoplastic regime. When applying the fracture toughness  $K_{IC}$  in accordance with the equations of linear elastic fracture mechanics (LEFM) the stresses at the onset of crack extension derived from the potential drop measurements will, on average, be overestimated by 12%, even with a 7% correction according to Irwin. The onset of crack extension may also be determined by using the two-criteria approach and the failure assessment diagram. The failure assessment diagram and an EPRI (Electric Power Research Institute) approach assuming surface cracks to be of infinite lengths clearly underestimate the stresses to failure by 31% and 51%, respectively. Quirk's method was applied at the same time that the fracture mechanics approaches were used and was transferred to surface cracks by equating the crack surface areas or the failure stresses (according to LEFM and plastic collapse) respectively. With this, the prediction of the failure stress, being, on average, 9% or 2%, is slightly conservative. (Edited author abstract) In German. 17 refs.

Keller, H.P.; Morsi, M.; Junker, G. *Materialpruefung* v 29 n 6 Jun 1987 p 153-161.

**085017 PREVENTION OF CATASTROPHIC FAILURE OF PRESSURE VESSELS AND PIPING: RESULTS OF PRESSURE TEST WITH A LARGE VESSEL (HCI-TEST).** Within the Nordic countries a four-year research program in the area of elastoplastic fracture mechanics was initiated in 1985. This program aims to assess the leak-before-break (LBB) criterion for pressure vessels and piping. The major experimental effort of the program is the pressurization until rupture of large pressure vessels having dimensions resembling those of a nuclear reactor pressure vessel. The vessels tested had been in operation for 20 years in a Finnish oil refinery plant. Artificial flaws were made on the inner walls of the vessels. The flaw dimensions were defined by calculations so that the LBB condition was not anticipated during the tests. The first pressure test was performed at  $+60^{\circ}\text{C}$ , which was the lowest acceptable temperature for the hydrotest. The instrumentation used in the test included strain gauges on the inner and outer vessel walls, crack opening displacement measurement with clip gauges, potential drop measurements and acoustic emission tests. (Edited author abstract)

Rintama, Rauno (Technical Research Cent of Finland, Espoo, Fin); Torronen, Kari; Keinänen, Heikki; Sarkimo, Matti; Sundell, Henrik; Talja, Heli; Ikonen, Kari. *Valt Tek Tutkimuskeskus Tutkimuksia* n 515 Jan 1988 52p.

**Vacuum Applications** See TOKAMAK DEVICES—Pressure Vessels.

**Valves** See CONVEYORS—Pneumatic.

**Welding** See Also NUCLEAR REACTORS—Pressure Vessels; WELDS—Mechanical Properties.

**085018 POSUDENIE OPRAVY ZVAROV HRUBOSTENNYCH TLAKOVYCH NADOB Z OCELE 15**

**121.5 BEZ NASLEDNEHO ZIHANIA.** [Evaluation of Weld Repair in Thick-Walled Pressure Vessels Made from Type 15 121.5 Steel Without Subsequent Annealing]. The fracture toughness of a repaired welded joint in a 14 Cr 1 Mo 0.5 steel 90 mm in thickness without subsequent stress relief annealing is examined. The brittle fracture resistance of the repaired weld with regard to the effect of residual stresses is evaluated. The critical crack length in welded joints of pressure vessels is calculated. (Translated author abstract) In Slovak. 9 refs.

Muncner, Ladislav (Vyskumny ustav Zvaracsky Bratislava, Czech); Adamickova, Maria. *Zvaranie* 35 n 5 May 1986 p 130-134.

**085019 SHAPE WELDING. THE CURRENT STATE OF THE ART IN THE FEDERAL REPUBLIC OF GERMANY.** The author reports a research carried out in the Federal Republic of Germany since 1970 on the manufacture of large size components by welding. Advantages of the method and examination of the installations used are reported. A special advantage of this procedure is short-term delivery, which ultimately affects the price. Other advantages are: almost unlimited size; great flexibility with regard to shape; little machining required; simple heat treatment; low fabrication risk because of NDT parallel to fabrication and batch testing; greater flexibility in adjusting the composition; smaller composition tolerance; and fewer longitudinal and circumferential welds. 10 refs.

Gnirss, G. (Rheinisch-Westfaelischer Technischer ueberwachungs-Verein eV, West Ger). *Weld World Soudage Monde* v 25 n 7-8 1987 p 132-139.

**PRINTED CIRCUITS** See Also AUTOMATIC TESTING; COMPUTER NETWORKS—Protocols; ELECTRIC CONNECTORS; ELECTRIC RELAYS—Electronics Packaging; ELECTRONIC EQUIPMENT MANUFACTURE; ELECTRONICS PACKAGING; ELECTRONICS PACKAGING—Scheduling; INTEGRATED CIRCUIT MANUFACTURE—Automation; INTEGRATED CIRCUITS; INTEGRATED CIRCUITS—Electronics Packaging; RADAR CIRCUITS; SERVOMECHANISMS—Hydraulic; SOLDERING; SOLDERING—Inspection; SUBSTRATES—Dielectric Properties.

**085020 CHOICES IN STANDARD AND CUSTOM BUSING FOR MULTILAYER BACKPLANES.** This paper discusses multilayer backplane design, bus performance levels, power quality on the backplane, nonstandard users and custom backplanes.

Steranko, Jim (Augat Inc, Attleboro, MA, USA). *Electronics* v 32 n 13 Dec 1986 p 50-53.

**085021 HIT ON TARGET.** The partitioning of complex surface mount printed circuit boards into more easily manageable sub-assemblies is the basic feature of the Hierarchical Interconnection Technology (HIT) system. Partitioning and connectors are discussed.

Buckley, David. *Electron Prod (London)* v 16 n 11 Nov-Dec 1987 p 12-13, 15.

**085022 DISPENSING WITH SCREEN PRINTING.** Screen printing has become an accepted methodology for low to medium volume assemblers of surface mount boards, since it enables the adhesive or the solder cream to be applied to the PCB in one step. But simple though it might be in concept, when it comes down to applying materials with viscosities ranging to 500,000 centipoise, as is the case with many solder creams, there are problems. Modern dispensing equipment offers advantages over screen printing when applying such materials as solder creams and adhesives.

Turner, C.C. *Electron Prod (London)* v 16 n 11 Nov-Dec 1987 p 27, 29.

**085023 PRINTED CIRCUITS BECOME COMPONENTS.** In this article past, present, and future of printed circuit technology are told by the editor of Printed Circuits Handbook. The main topics are the second generation, the present generation, and technology evolution.

Coombs, Clyde F. Jr. (Hewlett Packard, Santa Clara, CA, USA). *Electron Packag Prod* v 28 n 1 Jan 1988 p 64-65.

**085024 TESTER WRINGS OUT BOARDS BY FAKING FINAL SYSTEM.** Ironman automatic testers are introduced that include a capability called System Emulation Testing (SET) that addresses the problem of functionally testing extra-complex printed-circuit boards which are accessible only from their edge connectors. The SET environment replicates the board's intended operating system. That is, a board plugged into a SET tester sees no difference between the tester and its final system when it comes to interfacing and data exchange.

McLeod, Jonah. *Electronics* v 61 n 1 Jan 7 1988 p 115-116.

**085025 SURVEY OF PWB TRACE ROUTING TECHNOLOGIES - PART 1.** This is the first part of a three-part article discussing automatic PWB routing techniques and algorithm implementation. This part addresses various router types. Among them heuristic routers, line probe routers and maze routers.

Anastasi, Robert (Cadnetix Corp, Boulder, CO, USA). *Electronics* v 33 n 12 Aug 1987 p 21-23.

**085026 RELIABILITY, THERMAL AND THERMO-MECHANICAL CHARACTERISTICS OF POLYMER-ON-METAL MULTILAYER BOARDS.** Wiring requirements and thermomechanical factors related to the design and fabrication of Polymer-on-metal constraining core PWBs are discussed. The necessity of small plated-through-holes for high-density surface mount design is shown. Typical MLB constructions are shown with techniques for increasing wiring density. A design methodology for the POM construction is defined. The thermomechanical properties of copper-Invar-copper and the interactions of the MLB are described. The reliability of small PTHs is measured over a wide range of module constructions. (Edited author abstract) 13 refs.

Gray, F. (Texas Instruments Inc, Austin, TX, USA); Elkins, M. *Circuit World* v 14 n 3 Mar 1988 p 12-21.

**085027 APPLICATIONS OF POLYMER THICK FILM INKS IN SURFACE MOUNT TECHNOLOGY.** The properties and constituents of PTF inks are outlined. Surface resistivity in relation to PTF inks is defined. Applications of PTF inks are discussed with emphasis on potential design and cost benefits for SMT applications, including crossovers, polymer multilayer, printing through holes, printed resistors, carbon key pads, moulded and three-dimensional circuits. (Author abstract) 8 refs.

Fearn, D.J. (Coates Electrographics Ltd, Midsomer Norton, Engl). *Circuit World* v 14 n 3 Mar 1988 p 27-30.

**085028 CURE ANALYSIS OF PRINTED WIRING BOARDS CONTAINING REACTIVE ADHESIVE LAYERS.** This paper presents a method for analyzing the cure of multilayer circuit boards containing chemically reactive adhesive interlayers. The cure kinetics of the adhesive are first quantified by differential scanning calorimetry, using the method of Freeman and Carroll to obtain the numerical kinetic parameters. These parameters are then used in a finite-element model of the circuit board which solves the heat and species transfer equations simultaneously. It is then possible to predict the temperature and extent of reaction at any time and position within the laminate, enabling the curing program to be optimized. (Author abstract) 19 refs.

Fullerton, Rhonda (MIT, Cambridge, MA, USA); Roylance, David; Allred, Ronald; Acton, Adra. *Polym Eng Sci* v 28 n 6 Mar 1988 p 372-376.

**085029 DISPENSING VERSUS SCREEN PRINTING.** Responding to a recent article which advocated dispensing as the better method of applying solder cream to SM boards, the author takes issue with many of the



previous author's claims. In particular, he challenges assumptions about printing problems caused by the viscosity of solder cream.

Hobby, Alan (DEK Printing Machines Ltd, Weymouth, Engl). *Electron Prod (London)* v 17 n 4 Apr 1988 p 29.

**085030 ALIGNMENT-LIMITED YIELD.** As the drive to smaller linewidths, more layers and larger board areas continues, PWB makers must find better ways to understand and quantify their processes. This greater complexity has led to a marked decrease in both innerlayer and final PWB yield. The result is a much more expensive final product. The fall in yield can be attributed to both random defects and alignment-related causes. Borrowing from the semiconductor industry, the authors present a model for quantifying these alignment effects and their contribution to final yield. They show how several imaging approaches affect yield. Direct imaging, which minimizes lithography steps, posts the highest yields with shrinkage line widths. 4 refs.

Allison, Robert W. Jr. (R.A. Services); De Mott, Richard W.; Shaw, M. Alex; Powell, Michael W. *Circuits Manuf* v 28 n 3 Mar 1988 p 49.

**085031 FINE SOLDER PRINTS.** Standard solder deposition during the past decade has been at 50-mil pitch. However, 25-mil and finer pitched screen printing is becoming increasingly common as the newer fine-pitch components become more available and affordable. Fine-pitch printing puts greater demands on materials and screen printers. And current materials, rather than equipment, place practical limits on printing fineness. Today's fine-pitch solder deposition demands that screen printer operators achieve an optimum balance between the materials used in printing and the setup parameters on the screen printer. The author discusses pads tinning, screen printer flexibility and automatic alignment.

Freeman, Gary (MPM Corp, Medfield, MA, USA). *Circuits Manuf* v 28 n 3 Mar 1988 p 59.

**085032 CERAMIC-ORGANIC BRIDGE.** The author reports on a process which is designed to close the gap between ceramic and plastic printed circuit boards and in known as multilayer hybrid (MLH). He describes current and proposed techniques undertaken by a number of manufacturers.

Murray, Jerry (Circuits Manufacturing, San Francisco, CA, USA). *Circuits Manuf* v 28 n 7 Jul 1988 p 30-33.

**085033 PROFILES IN REWORK.** Rapid increases in component size, population density, and board size and thickness have recently outpaced rework station technology. To address the rework needs of SMT on both large and small boards, for large and small devices, requires process repeatability through precise control of all process parameters. These are temperature, time, heat transfer rate through control of air flow and distance to the device, and heating configuration (for uniformity). It is also necessary to establish individual time temperature profiles for each part on each board to be reworked by using an accurate temperature feedback device, such as a probe, so that results may be duplicated. Finally, and especially with massive boards, a rework system should offer optimization of a temperature ramp/soak profile to overcome a board's heat sink characteristics so that a part may be reworked without board damage.

Martel, Michael L. (Conceptronic, Gonic, NH, USA). *Circuits Manuf* v 28 n 7 Jul 1988 p 47, 49-50.

**085034 SURFACE MOUNT PCBS-MAKERS MEET USERS.** The author reports on the topics discussed at a joint SMART Group/PCA seminar on surface mount PCBs. He covers essential requirements for surface mount CAD systems; specifications; materials and finishes; registration and tolerance; and communication between manufacturer and specifier. (Edited author abstract).

Garnett, Chris. *Electron Prod (London)* v 17 n 6 Jun 1988 p 59.

**085035 PROCEEDINGS OF THE TECHNICAL PROGRAM - NEPCON WEST '87: NATIONAL ELECTRONIC PACKAGING AND PRODUCTION CONFERENCE.** This conference contains 108 papers five of which are in abstract form only. They deal with a wide variety of developments in the field of printed wiring board technology. Among the areas covered are: Surface mount technology; Productivity increase; High performance interconnect technology; Static management issues; Polymer tack films; 'JUST IN TIME' DESIGN Reflow Soldering; Total quality control; Automated assembly; Solder joint inspection; Printed wiring assembly cleaning; and Failure mechanisms and modeling. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10918 in the Ei Engineering Meeting (TM) database produced by Engineering Information, Inc.

Anon. *Proc Tech Program Natl Electron Packag Prod Conf* 1987, Anaheim, CA, USA, Feb 24-26 1987. Publ by Cahners Exposition Group, Des Plaines, IL, USA, 1987 2 vol, 1050p.

## Accident Prevention

**085036 CYANIDES IN PLATING SOLUTIONS.** In all plating shops, including those in the printed circuit industry, solutions containing cyanide are commonplace. Because of their special properties, they are found not only in plating solutions, particularly gold plating solutions, but also in cyanide cleaners. Cyanides are known poisons and are subject to mandatory governmental regulations. Because they are known by the public, it is essential to keep supplies locked up and only available for issue by responsible personnel. Similarly, and because they are also valuable, gold cyanide solutions should be kept under lock and key: it is often necessary to protect the gold solutions by placing a thief proof cage over the plating tank when it is not in use. Toxic hazards of cyanides are discussed, along with treatment of a casualty from hydrogen cyanide gas.

Tucker, Eric. *Electron Prod (London)* v 15 n 11 Nov-Dec 1986 p 15, 17.

## Adhesion See Also ADHESIVES—Selection.

**085037 FROZEN ADHESIVE ADVANTAGES IN ELECTRONIC MANUFACTURING.** This paper describes a relatively new methodology which helps eliminate the problem of utilizing the wrong epoxies, silicones, polysulfides, or polyurethanes, and their accompanying catalysts and additives, for specific applications. It also offers the advantage of providing a cleaner operation, consistent formulation, and a reduction of waste that is an inevitable by-product of self-mixing ingredients. It involves the pre-blending of resins and hardeners in a laboratory, having them packaged in appropriately marked containers, freezing them, and then storing them in a freezer at -40°F. Once out of the freezer, the compound is ready for use in a minute or two. By tracking the effectiveness of a given frozen compound, chemists are able to recommend modifications where the performance or handling characteristics have not met expectations. The degree of control obtained through frozen mixtures assures consistency that takes out the guesswork and possible messiness of mixing at the work station.

Rocheleau, Hal (Poly-Freeze Inc, Van Nuys, CA, USA). *Electron Manuf* v 34 n 7 Jul 1988 p 18-19.

**085038 AN OVERVIEW OF ADHESIVES USED IN ELECTRONIC MANUFACTURING.** This paper presents a description of the various types of adhesives often used in electronic applications. These types include cyanoacrylates, anaerobics, acrylics, urethanes, silicones, epoxies, hot melts, solvent cements and ultraviolet curing systems. Application systems are also discussed.

Lilly, Ron (Loctite Corp, Newington, CT, USA). *Electron Manuf* v 34 n 7 Jul 1988 p 23-25.

## Analysis

**085039 HOW TOLERABLE ARE BOARD TOLERANCES?** The effect of line widths and dielectric thicknesses of printed circuit boards (PCB) on their electric properties are considered. The control of physical tolerances is discussed, with special attention to the controlled impedance, critical tolerances, structural effects, etchout and burial depth. 5 refs.

Doyle, Greg J. (Control Data Corp, Minneapolis, MN, USA); Sheehan, Bernard J. *Circuits Manuf* v 27 n 12 Dec 1987 p 42-43, 45-46.

## Applications See Also INTEGRATED CIRCUIT MANUFACTURE; SUBSTRATES.

**085040 ONE PC CARD CAN SIMULATE MIL-STD-1553B SYSTEM.** Time-division-multiplexed serial data buses that meet the 1553B specification are now in place in most military aircraft and are planned for more advanced military aircraft. As the complex digital circuitry of the 1553B bus is difficult to test or simulate, a new tester and simulator is introduced that consists of a plug-in card for IBM Personal Computers and compatibles, plus appropriate software.

Lyman, Jerry. *Electronics* v 60 n 14 Jul 9 1987 p 92-93.

## Assembly See Also BAR CODES—Applications; COMPUTER INTEGRATED MANUFACTURING; ELECTRONICS PACKAGING—Soldering; INTEGRATED CIRCUIT MANUFACTURE—Soldering; PROCESS CONTROL—Quality Assurance.

**085041 HOW TO EVALUATE HANDLING EQUIPMENT FOR PWB ASSEMBLY APPLICATIONS - PART 1.** This is part one of a two-part article on handling and conveying equipment for PWB production. Part one discusses handling and conveying systems, CIM, and cost justification. (Edited author abstract)

Moosmann, Kari (Electri-onics, Libertyville, IL, USA); Bartos, Sara. *Electronics* v 33 n 1 Jan 1987 p 44-46.

**085042 HOW TO EVALUATE HANDLING EQUIPMENT FOR PWB ASSEMBLY APPLICATIONS - PART 2.** This is part two of a two-part article about handling and conveying equipment for PWB production. Part two discusses flexibility, changes, costs, and system specification. (Edited author abstract)

Moosmann, Karl (Electri-onics, Libertyville, IL, USA); Bartos, Sara. *Electronics* v 33 n 3 Feb 1987 p 25-26.

**085043 CFM SOLVES A WORST CASE.** Manufacturing mixed-technology assemblies (surface mount and through-hole components) efficiently in the flexible environment of a contract manufacturer is a challenge. To produce high volumes of mixed-technology assemblies and stay flexible, a continuous flow manufacturing (CFM) method is used. CFM reduces waste and increases quality by continuously monitoring all elements of operation. Products are processed one unit at a time. This differs from common manufacturing procedures where products are handled in batches. Three requirements for achieving CFM are given: in-process controls, preventive maintenance and process verification. Each is necessary to efficiently produce a quality product.

Arnold, Dan (EMD Associates Inc, Winona, MN, USA). *Circuits Manuf* v 28 n 1 Jan 1988 p 61-62.

**085044 ROBOTIC WORKCELLS FOR PCB ASSEMBLY.** Light assembly robots have been successfully used in printed circuit board assembly for several years now. Having grown in sophistication during this time, they perform an increased share of the total work required to successfully assemble PCBs. A modern robotic assem-



bly system is a fully integrated workcell, providing manufacturers with a flexible and dependable tool for producing quality products.

Schnedler, Dave (Intellex Inc, Corvallis, OR, USA). *Electron Packag Prod* v 27 n 2 Feb 1987 p 108-110.

**085045 FLEXIBILITY, SPC LOOM LARGE IN CAPTIVE SMT ASSEMBLY.** Two leading manufacturers have each establish consolidated surface-mounting operations to make varied products for their different business units. This article discusses how Allen-Bradley partitioned SMT assembly into four lines and how John Fluke Manufacturing Co. linked SMT processes within on flexible line.

Pound, Ronald (Electronic Packaging & Production, Newton, MA, USA). *Electron Packag Prod* v 28 n 1 Jan 1988 p 42-45.

**085046 SMT AND JIT: THE DYNAMIC DUO.** The installation of a modular assembly line based on surface mount technology (SMT) is considered to increase production, yet reduce production floor space. The manufacturing is changed to a just-in-time (JIT) manufacturing system along with a zero-defect attitude. While not yet in full operation, this system is already slashing costs and maximizing product quality.

Metcalfe, Henry (Foxboro Co, Foxboro, MA, USA); Jacques, Joe. *Circuits Manuf* v 27 n 12 Dec 1987 p 67, 69-71.

**085047 TURN THE KEY AND GO?** Turnkey production lines for the assembly of single mount technology (SMT) components on printed circuit boards (PCB) are considered. Buying an SMT line from a single source appeals to companies with a limited engineering staff—small- to medium-sized firms making everything from fish finders to wiring devices to push-button units for door entry. Some well-known makers in the computer industry have taken this route as well. Wang Laboratories and Control Data Corp. have recently installed single-sourced SMT lines.

Tuck, John (Circuits Manufacturing, San Francisco, CA, USA). *Circuits Manuf* v 28 n 2 Feb 1988 p 67-68, 70, 72.

**085048 ORGANISING HIGH DENSITY PCB ASSEMBLY.** Techniques used in the assembly of high density printed circuit boards (PCB) are considered that are used with surface mount (SM) and conventional components. The surface mount technology (SMT) enables the necessary density to be achieved, with conventional components being used where lack of availability or other reasons have precluded the use of SM components. The soldering of surface mount devices (SMD) on the board is also described.

Upton, Roger (Radamec Microsystems Ltd, Crowthorne, Engl). *Electron Prod (London)* v 17 n 2 Feb 1988 p 22-23.

**Automatic Testing** See Also ELECTRONICS ENGINEERING—Computer Aided Engineering.

**085049 HOW TO USE PWB FAULT PREVENTION TO IMPROVE MANUFACTURING YIELDS.** Printed wiring board manufacturers traditionally have used automatic test equipment (ATE) for detecting board faults. In an attempt to be as efficient as possible, they used testing as a screening device to prevent defective products from leaving the factory and moving into subsequent production steps. Many manufacturers have introduced the bare board testing step into their fabrication processes. This paper discusses several reasons for the growing acceptance of bare board testing. Other subjects include: testing parameters, defect prevention testing and cost considerations.

Hroudas, George (Trace Instruments, Canoga Park, CA, USA). *Electronics* v 33 n 1 Jan 1987 p 55-58.

**085050 PRUEFSTRATEGIE UND WIRTSCHAFTLICHKEIT BEIM AUTOMATISCHEN LEITERPLATTENTEST.** [Testing Strategy and Cost Effective-

ness with Automatic Testing of PC Boards]. The economical production of reliable electronic flat subassemblies requires an adapted and individual testing strategy. This article presents various test conceptions and explains the essential factors of determination. (Author abstract) In German.

Erfurth, Michael. *F&M Feinwerktech Messtech* v 95 n 5 Jul-Aug 1987 p 325-328.

**085051 USING COMPUTER AIDED TESTING FOR PRINTED WIRING BOARD APPLICATIONS.** Faced with new and more stringent PWB design requirements, automatic test equipment (ATE) manufacturers are striving to meet the objective of supplying solutions to problems while keeping costs within reach. The need for affordable, flexible, reliable equipment is accentuated by the trends toward use of surface mount devices, application specific integrated circuits (ASIC) and very large scale integration (VLSI). This paper discusses the subjects of time and cost saving in PWB production, custom-designed equipment and flexibility of test equipment. Improving communication is one way that ATE manufacturers are trying to keep pace with changing PWB test needs, and to integrate testing into the total manufacturing process.

O'Loughlin, Michael (Electri-onics, Libertyville, IL, USA); Bartos, Sara. *Electronics* v 33 n 3 Feb 1987 p 39-42.

**085052 FAST SOLUTION TO INTERMITTENT FAILURES.** The GenRad Functional and Stress Testing (GR FaST) System is a comprehensive diagnostic environment which combines the functional electrical testing commonly used at military repair depots with the vibration stress screening used during the design and production cycle by suppliers of advanced electronic equipment. By testing boards for electrical functioning while they are subjected to the simulated stress of their real-world operating environment, the system identifies not only hard failures but also those intermittent flaws which normally escape detection in the quiescent state. In essence, it provides military repair depots with test methods which are equal to the complexity of the products being tested.

Grafton, William (GenRad Inc, Milpitas, CA, USA); Wagner, Robert. *Eval Eng* v 27 n 1 Jan 1988 6p between p 36 and 45.

**085053 AUTOMATISCHER ABGLEICH BEIM LEITERPLATTENTEST.** [Automatic Adjustment Associated with Testing of Printed Circuit Boards]. Advantages of automatic adjustment are enumerated. These include: high precision and accuracy; simpler service so that less quantification is necessary; shorter training period; and computer aids that are applicable for complex and frequently changing tasks. The incorporated trimming screws and control equipment are based on the Robotrim system. In German.

Muehlbauer, H. *Elektron Prod Prueftech* n 9 Oct 1987 p 18, 23-24.

**085054 SECOND-GENERATION PCB SELF-LEARN.** Manufacturing defect analysers generally incorporate some form of self-learn capability, allowing board tests to be developed in as short a time as possible without the need for skilled programmers. Existing methods generally meet these two objectives but lack both fault coverage and component level diagnostics. Following a brief introduction to the use of manufacturing defect analysers, this paper describes a new self-learn technique which allows a board test to be generated incorporating individual tests on each component. This provides diagnostics close to those of manually developed programs. (Author abstract)

Matheson, Robert (Marconi Instruments Ltd). *Comput Aided Eng J* v 4 n 5 Oct 1987 p 209-212.

**085055 BARE-BOARD ATE/EMBEDDED COMPONENT TEST. FIRST THINGS FIRST.** Embedded components, multilayers and several thousand pads have forced production managers to demand that all boards be tested prior to placing the first component on them.

Guidelines are providing for buying bare-board testers which are available in a variety of styles and sizes for just about any board configuration. The problems particular to boards with embedded components are discussed.

Anon. *Eval Eng* v 27 n 3 Mar 1988 p 40, 42, 45.

**085056 FUNCTIONAL BOARD TEST HYBRID DIAGNOSTICS. THE EVOLUTION AND ADVENT OF ANALOG SIGNATURE ANALYSIS.** The concept and application of signature analysis are discussed. The various techniques involved in network verification. There are two modes of digital network verification and six modes of analog network verification. However, any of the analog network verification modes can be applied to a period square wave function.

Reiss, Alan (Schlumberger ATE, Latham, NY, USA). *Eval Eng* v 27 n 3 Mar 1988 p 106-107.

**085057 TOWARDS A NEW APPROACH TO FAULT LOCATION ON PCBs.** There is an urgent need to provide a more integrated and effective approach to the test requirements of board manufacturers. There is a widespread acceptance in the ATE industry, which has traditionally produced sophisticated test hardware, of the need for research into the application of scientific techniques to fault diagnosis. This need has resulted in a joint research program, known as Project FLAIR, between Factron Schlumberger and the Department of Electrical Engineering, Imperial College. The technical aim of the research is the development of diagnostic algorithms which locate faults on electronic printed circuit boards.

Rae, Bill (Imperial Coll). *New Electron* v 20 n 16 Aug 11 1987 p 20, 22.

**085058 USING IN-CIRCUIT ATE FOR DEPOT REPAIRS.** NCR's Worldwide Service Parts Center (WSPC) has been using in-circuit ATE to test and repair field failures for more than three years. The repair process is a fast and economic approach in repairing defective PC boards. In-circuit ATE can be a very effective standalone depot repair test system with test comprehension levels in excess of 95 percent. Every test program is verified by repairing and system-testing a minimum of 50 defective PC boards. When at least 95 percent of the repaired PC boards pass the system test, the program is made available to repair field returns. After the program is verified, the system test no longer is required.

Christopher, J.R. (NCR Corp, Peachtree City, GA, USA); Quattlebaum, Edward W. *Eval Eng* v 27 n 8 Aug 1988 p 136-139.

**085059 SYSTEM FOR PCB AUTOMATED INSPECTION USING FLUORESCENT LIGHT.** Research was performed on the detection of faults such as shorts, cuts, and nicks in a printed circuit board pattern. The possibility was investigated of detecting a pattern by illuminating a printed circuit board with violet or ultraviolet rays and detecting the pattern using the (yellow or other) fluorescent light emitted by the base material consisting of glass-epoxy or glass-polyimide, etc. It was found that the pattern could be detected clearly by selecting an optical fiber that would separate the emitted fluorescent light from the illumination and using a detector consisting of a high-sensitivity TV camera that produces a silhouette image in which the base material is bright and the pattern is dark. A printed-circuit-board pattern inspector using this approach was developed. Test operation of the inspector in a plant demonstrated that it performs consistently good pattern inspections. 9 refs.

Hara, Yasuhiko (Hitachi Ltd, Yokohama, Jpn); Doi, Hideaki; Karasaki, Koichi; Iida, Tadashi. *IEEE Trans Pattern Anal Mach Intell* v 10 n 1 Jan 1988 p 69-78.

**085060 PROCEEDINGS - ATE EAST.** This conference contains 43 articles on developments in the field of automatic test equipment. Among the areas covered are: Test modeling and testing technology; ATE productivity improvement; Functional board testing; Testability con-



siderations; In-circuit testing; ATE networking technology; Fault isolation methodology; Surface mount technology; Environmental stress screening; and Computer aided engineering in automatic testing programs. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10327 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Electronics Test Magazine). *Proc - ATE East, Boston, MA, USA, Jun 23-26 1986* Publ by MG Expositions Group, Boston, MA, USA, 1986 var pagings.

## Bonding

**085061 PALIDELIGHEDSUNDERSOGELSE AF TAB-TEKNOLOGIEN. UDFORT I SAMARBEJDE MED A/S MODULEX OG GN DANAVOX A/S.** [Tape Automated Bondings]. The present report is a reliability investigation of five Tape Automated bonded variants and two wirebonded variants. Four TAB-variants were delivered from A/S MODULEX, and one TAB-variant and one TAB-film wirebonded variant were delivered from GN DANAVOX A/S. All variants were visually inspected, electrically tested (as a 'go/no go test'), and the terminals were pull-tested before and after some environmental exposures as humidity, dry heat, industrial atmosphere, salt mist, vibration, and acceleration. The results of the investigation showed that none of the variants failed during and after the environmental exposure, and that the weakest part of the TABN-variants were the terminals, which easily could be damaged during mounting and handling. In Danish. 9 refs.

Jorgensen, Tom (Elektronikcentralen, Horsholm, Den). *Elektronikcentralen Rep ECR* 211 Jan 1988 60p.

**085062 ELASTOPLASTIC ANALYSIS OF SURFACE-MOUNT SOLDER JOINTS.** Thermal strain in surface-mount chip resistor assemblies is studied by the finite-element method using two-dimensional and three-dimensional models. Emphasis is placed on the effects of interconnection geometry on solder-joint fatigue. Nine different solder-joint geometries are considered. 47 refs.

Lau, John H. (Hewlett Packard Co, Palo Alto, CA, USA); Rice, Donald W.; Avery, Phil A. *IEEE Trans Compon Hybrids Manuf Technol* v CHMT-10 n 3 Sep 1987, Second Int Electron Manuf Technol (IEMT) Symp, San Francisco, CA, USA, Sep 15-17 1986 p 346-357.

## Chemical Deposition

**085063 ANALYTICAL TECHNIQUES TO MONITOR AND CONTROL PRINTED CIRCUIT PLATING.** This paper discusses application of ion chromatography for the separation, identification, and control of key plating bath species in printed circuit board fabrication solutions. Closer monitoring, fingerprinting, and subsequent control of key parameters can lead to decreased bath solution losses and a better understanding of the plating process.

Heberling, S.S. (Dionex Corp, Sunnyvale, CA, USA); Haak, K.; Carson, S.; Doyle, M. *Electron Manuf* v 34 n 6 Jun 1988 p 27-30.

## Classification See BAR CODES: BAR CODES—Design.

## Cleaning See Also ELECTRON DEVICE MANUFACTURE.

**085064 SMT FLUX CLEANING.** Complete removal of harmful flux residues under SMCs is hindered by the difficulty in forcing solvent through extremely narrow clearances between components and the board, and by the inability of current nondestructive testing methods to detect remaining residues. Long immersion times, liquid sprays directed at the liquid surface of the cleaning bath and/or ultrasonic agitation are the methods commonly used to promote penetration of solvents. The studies reported here evaluated the effectiveness of spraying high-pressure fluorosolvent directly onto the com-

ponent/board interface. 5 refs.

Lermond, David S. (DuPont, Wilmington, DE, USA). *Circuits Manuf* v 27 n 9 Sep 1987 4p between p 86 and 92.

**085065 EXAMINATION OF SOLVENT CLEANING FOR PRINTED WIRING BOARD APPLICATIONS.** Performance factors for efficient cleaning of through hole, surface mount, and mixed technology printed wiring board assemblies are similar in nature. Surface mount assemblies require solvents with the highest possible solvency and may require revised cleaning techniques and equipment. Flux type, soldering techniques, solvent blend, cleaning equipment, and cleaning cycle are other factors which must be considered to achieve proper assembly cleaning. Improper board assembly cleaning leaves harmful flux residues consisting of both ionic and organic (non-ionic) flux components. Ionic levels can be characterized by present test methods. However, quantitative methods only recently have been introduced for determining levels of organic (rosin) residues. This paper discusses various factors to consider when selecting a solvent cleaner including solvent temperature, substrate wetting solvency and constant boiling blends. Safety considerations are also discussed.

Archer, Wesley L. (Dow Chemical Co, Midland, MI, USA). *Electronics* v 33 n 7 May 1987 p 11-14.

**085066 ASSESSMENT OF SOLVENT CLEANING PERFORMANCE AND SAFETY.** When choosing a cleaning material and method, through hole assemblers should select one that is compatible with the construction materials of both the components and printed wiring board (PWB), it is important that the cleaning process not leave residues that are cosmetically unacceptable, or that interfere with proper conformal coating adhesion or automatic test equipment. The performance index provides a method of generating a two or three digit number that characterizes a flux/solder/deflux system. For through hole technology, moderate pressure (30-50 psig) vapor/spray, inline, fluorosolvent defluxers are efficient and capable of meeting basic requirements for reliability after soldering and cleaning. Compared to through hole, surface mount (SMT) and mixed technology have performance factors that are more complex and subtle, which affect the choice of a cleaning agent and method. The paper discusses advantages and trade-offs of solvent cleaners, evaluating solvent safety and management liability for PWB manufacturers.

Kenyon, W.G. (DuPont, Wilmington, DE, USA). *Electronics* v 33 n 7 May 1987 p 16-18.

**085067 PLASMA-DESMEARING VON MULTI-LAYER-LEITERPLATTEN.** [Plasma Desmearing of Multilayer Printed Circuit Boards]. The significance attributed to the cleaning of multilayer printed circuit boards is illustrated by the number of publications on this subject. This article reports on the present state of development of plasma desmearing etchback plants, on some aspects to be taken into account with rigid-flexible circuits, and contains some remarks on the removal of hydrogen fluoride and ozone from the waste gases. (Edited author abstract) In German. 4 refs.

Kegel, Bert; Naversnik, Rudolf. *Metalloberflaeche* v 41 n 11 Nov 1987 p 521-525.

**085068 MODERNE ASPEKTE ZUR LOCHWANDREINIGUNG MIT PERMANGANATHALTIGEN LOESUNGEN.** [Cleaning Punched-Hole Walls with Permanganate-Containing Solutions]. Since 1965, the year in which industrial production of multilayer circuits supposedly started, it has been necessary to look for a smear removal process which would be technically efficient, advantageous from the processing engineering viewpoint and economically justified. It was decided therefore, to switch over to an alkaline permanganate-containing medium, since this was the only way to avoid wicking and the red-ringing phenomenon. (Edited author abstract) In German. 3 refs.

Ehrich, Hans-Juergen. *Metalloberflaeche* v 41 n 11 Nov

1987 p 531-536.

**085069 EVALUATION OF PWB CLEANING ISSUES - PART 2.** This is the second part of a two-part article about issues in PWB cleaning. Part two covers PWB cleaning safety and environmental concerns. (Edited author abstract)

Clark, Jerry (Gram Corp, Hancock, NH, USA). *Electronics* v 33 n 9 Jun 1987 p 38.

**085070 SPECIFICATION GUIDE FOR AQUEOUS AND SOLVENT PCB CLEANING CHEMICALS AND EQUIPMENT.** In Electronic Manufacturing's specification guide for aqueous and solvent PCB cleaning chemicals and equipment, contributing companies have listed solvents aqueous detergents, equipment, and accessories used for cleaning printed circuit boards. These include hydrocarbons, chlorinated hydrocarbons, fluorinated or fluorinated chlorinated, and azeotropic types, as well as saponifiers. It also includes automated, semi-automated, solvent, and aqueous equipment. Details are provided for each chemical section. Various types of equipment are listed, along with a variety of accessories.

Anon. *Electron Manuf* v 34 n 3 Mar 1988 p 12-15, 18-23.

**085071 RESTRICTIONS ON THE USE OF CHLOROFLUOROCARBONS FOR CLEANING SOLDERED PCBs.** The flux residues on almost all soldered printed circuit boards are removed using the chlorofluorocarbon (CFC) 113. In just one year's time production of this solvent will almost certainly be curtailed, on a scale agreed internationally. This is a major issue that needs to be addressed by the electronics assembly industry worldwide. This paper presents (i) the background that has led to the restrictions being placed on production and consumption of solvent 113, (ii) the international agreement and timetable for the implementation of the restrictions and (iii) the perceived opportunities that are available to the industry to meet this challenge. (Edited author abstract). 27 Refs.

Lea, C. (NPL, Teddington, Engl). *Circuit World* v 14 n 4 Jul 1988 p 4-12.

**085072 CLEANING ALTERNATIVES FOR THE 1990S.** In August 1987, the EPA held a conference in Washington DC with consultants and users from the electronics industry to determine the feasibility of practical cleaning alternatives to reduce emissions of chlorofluorocarbon solvents which are considered to be a major contributor to the ozone problem in the stratosphere the world over. This paper presents a resume of these goals and how they will affect cleaning in the electronics industry. Electronic design and packaging are the first steps in the soldering and cleaning. Selection of components compatible with alternative cleaning methods as well as process changes to permit low solids fluxes in some cases where cleaning can be eliminated are discussed. 'High containment' in-line solvent cleaning systems which reduce emissions are likely to become the new standard for the industry. Machines will become longer in order to include internal drying stages, instead of allowing a board with residual solvent trapped under components to evaporate after it leaves the machine prior to electronic test. Alternative solvents will become available. Designers of components and assemblies will respect their designs to permit water cleaning, even for surface mount assemblies. (Edited author abstract). 14 Refs.

Elliott, D.A. (Electrovert Ltd, Laprairie, Que, Can). *Circuit World* v 14 n 4 Jul 1988 p 44-48.

**085073 DESIGN CONSIDERATIONS TO FACILITATE EASE OF CLEANING PRINTED WIRING ASSEMBLIES.** There are many factors to consider when designing a printed wiring assembly to facilitate ease of cleaning, some of which have been briefly addressed in this article. They include choice of solder process, device termination, board complexity, space considerations and use of adhesives. But the major fact is the need for a team



approach to design and produce an economically manufacturable and testable board or assembly. Achieving this means that boards and assemblies can be cleaned with little or no problem at all.

Kenyon, W.G. (DuPont, Wilmington, DE, USA). *Electron Manuf* v 34 n 8 Aug 1988 p 26-28.

## Coatings

**085074 CONFORMAL COATINGS SEAL OUT ADVERSE ENVIRONMENTS.** Conformal coatings are liquid resin formulations used in protecting assembled printed circuit boards from the environment. Being initially liquid, they conform to the topography of the board and components, then cure to provide a thin, protective film. Depending upon the coating application process, number of coats applied and the type of resin used, the film thickness can range from less than one mil on up to 20 mils or more. Greater thicknesses approach the realm of potting, thereby defeating the purpose of a conformal coating - which is to provide protection from the environment without excessive resin shrinkage and component stress, offer repairability and minimize the weight penalty.

Markstein, Howard W. (Electronic Packaging & Production, Newton, MA, USA). *Electron Packag Prod* v 27 n 3 Mar 1987 p 82-84.

**085075 CONSIDERATIONS FOR SELECTING, APPLYING PWB CONFORMAL COATINGS.** The use of conformal coatings in electronics has grown out of the need to improve device performance and to protect devices from environmental conditions that may cause premature failure. Failure may be caused by moisture, contamination, and fungus growth. To show how different requirements influence the final decision, three common applications are examined. The first is a high volume, lower cost consumer-oriented circuit card assembly that needs protection from elements encountered in every day use. The second example focuses on devices used in industrial applications. There are more demanding applications, such as protecting assemblies that have to meet stringent military and aerospace industry requirements. Parylene is mentioned as particularly attractive coating in most of these applications.

Stewart, Jeffrey (Para Tech Coating Co, Laguna Hills, CA, USA). *Electronics* v 33 n 12 Aug 1987 p 11-12.

**Components** See Also ADHESIVES—Selection; ASSEMBLY MACHINES—United States; ELECTRIC CONNECTORS—Contacts; INFRARED RADIATION—Soldering; INTEGRATED CIRCUITS—Cleaning; LOGIC DEVICES—Testing; ROBOTIC ASSEMBLY—Computer Interfaces; SEMICONDUCTOR DEVICE TESTING—Computer Interfaces; SEMICONDUCTOR DEVICES—Microwaves; SOLDERING—Defects; SUBSTRATES—Performance.

**085076 SMART CARDS YIELD HIGH MEMORY CAPACITIES FOR MASS-STORAGE AND DATA-SECURITY USES.** Thanks to advances in IC fabrication and packaging technologies, you can now obtain high-capacity memories or complete  $\mu$ P-driven systems in credit-card-sized packages. These memory cassettes, or so-called smart cards (they really do not have any intelligence), suit an extremely wide variety of applications, ranging from the customization of terminals and other peripherals, to data logging, and to mass storage for computers that must run in hostile environments. The cards also have varying memory capacities.

Terry, Chris (EDN, Newton, MA, USA). *EDN* v 32 n 20 Oct 1 1987 p 61, 63-64, 67.

**085077 ELECTROMECHANICAL RELAYS FIND A NICHE ON THE CIRCUIT BOARD.** Tiny new electromechanical relays may be a better choice than solid-state components for some straightforward switching jobs. Solid-state switches have entirely replaced relays in logic circuitry. But for straightforward switching tasks, relays cost less and often do the job better. Manufacturers, moreover, have cut relay size and improved reliability. Electromechanical relays also have become widely avail-

able in PCB-mount packages that are suitable for automated soldering. (Edited author abstract)

Carlisle, Ben H. (Machine Design, Cleveland, OH, USA). *Mach Des* v 59 n 18 Aug 6 1987 p 64-68.

**085078 FINISH FIRST.** In the elimination of solder joint defects in surface mounted technology (SMT) opinions differ about the merits of solder-dipped finishes versus electro-plated finishes. Proponents of solder dipping content that electroplated finishes are porous, allowing oxidation of the base metal that can lead to dewetting during the solder process. Modern, automated plating systems have overcome these problems by exerting excellent control over process parameters. Fine-grain finishes low in codeposited organics with very low thickness variability from lead to lead and unit to unit are now possible with electroplated leads. 10 refs.

Bowlby, Reed (Motorola Inc, Phoenix, AZ, USA). *Circuits Manuf* v 27 n 11 Nov 1987 p 76-77, 79, 85-86.

**085079 AUTOMATISCHES JUSTIEREN VON LEITERPLATTENRELAIS.** [Automatic Adjustment of Relays for Printed Circuit Boards]. The adjustment of relays requires a definite plastic deformation of the springs of the relay and of the armature in order to guarantee the required electrical function of the relay. The solution of technological, product-specific, and instrumental tasks connected with that is presented. (Author abstract) 3 refs. In German.

Meissner, M. (Technische Hochschule Ilmenau, East Ger); Noennig, R.; Schorch, H.-J.; Weiss, M. *Feingeraetetechnik* v 36 n 6 1987 p 247-249.

**085080 OVERVIEW OF 3-D MOLDED INTERCONNECTION PROCESSES AND MARKETS.** Three-dimensional molded interconnections will not replace traditional laminates, standard connectors, or sockets in the near term for most applications. They will, however, open new engineering opportunities previously unavailable to end users. The specific advantages and trade-offs of using molded interconnections are discussed. Other subjects include imaging, additive plating techniques, dry additive processing, high volume requirements and optimizing production.

O'Loughlin, Michael (Electronic Manufacturing, Libertyville, IL, USA); Duensing, Susan. *Electron Manuf* v 33 n 18 Dec 1987 p 22-25.

## Computer Aided Analysis

**085081 INTEGRATED ANALYSIS FOR PCBs.** The author reports on an integrated electrical and mechanical design system to perform a full range of mechanical analysis techniques on printed circuit boards. The system automatically generates a solid model from printed circuit board (PCB) layout data. Because mechanical properties are included in component libraries, the design model can be used without modification for solid, surface, and wire frame modeling as well as for drafting.

Barton, Brian (CAD/CAM, Ann Arbor, MI, USA). *CAE Comput Aided Eng* v 7 n 5 May 1988 p 78, 80.

**Computer Aided Design** See Also COMPUTER AIDED ENGINEERING; COMPUTER SOFTWARE—Quality Assurance; INTEGRATED CIRCUIT MANUFACTURE—Computer Applications; INTEGRATED CIRCUITS—Computer Aided Design.

**085082 CHECK LIST HELPS YOU CHOOSE A PC-BOARD AUTOROUTER.** An automatic printed circuit (PC) board-routing program can save a lot of time, provided that it is used as a design aid and it is not expected to solve all routing problems. Before you can choose the right pc-board autorouter for your needs, you need to understand how these programs work and how their features affect your project's entire design cycle. This article explains the functions of eight types of autorouters and provides a check list of 26 key features that will help you compare and select routers.

Roth, John (Aptos Systems Corp). *EDN* v 32 n 18 Sep

3 1987 p 191-196, 198.

**085083 MAJOR ROLE FOR PCs IN PCB DESIGN.** Many recent PC hardware performance improvements, taken in conjunction with a number of developments that will affect application software costs, will result in personal computers playing a more significant role in PCB CAD and may very well take market share away from engineering workstations. The article discusses the capabilities of available personal computers applied for printed circuit board design.

Marsh, H.G. (CAD Software). *New Electron* v 20 n 15 Jul 21 1987 p 29-31.

**085084 PHOTOPLOTTERS: CREATING THE CRITICAL SHADOWS.** This article addresses many of the questions facing those who must evaluate, recommend or purchase photoplotting systems. Several of the basic issues leading up to the decision to buy a photoplotting system are discussed. These issues have changed considerably in the past several years, as both plotting technologies and PWB design rules have evolved. A comparison matrix, showing the published specifications of most of the photoplotters on the market as of this writing are presented.

Henningsgard, Robert C. *Printed Circuit Des* v 4 n 9 Sep 1987 p 8-15.

**085085 CONSIDERATIONS FOR CHOOSING AN IN-HOUSE PHOTOPLOTTER.** Taking the process of board design and production to its next logical step, the newer issue of the decade has become that of affordable photoplotting. The photoplotter, once a gigantic, complicated, slow, and expensive piece of equipment, has finally evolved to become a small, simple-to-use, fast, low cost solution for service bureaus and end users, some of which are discussed.

Peddie, Cynthia. *Printed Circuit Des* v 4 n 9 Sep 1987 p 17-21.

**085086 LASER PHOTOPLOTTING TECHNOLOGY.** This article gives some of the basic facts about laser photoplotters. We review the different technologies that are available and explain the positive and negative characteristics of each. We explore the problem of determining which solution best meets your needs. We do this by providing several key criteria that can help you decide what is best for your organization.

Hill, Jerry. *Printed Circuit Des* v 4 n 9 Sep 1987 p 22-23.

**085087 PLOT YOUR ARTWORK WITHOUT PHOTOPLOTTING.** The original intent of photoplotters was to meet the needs for producing errorless and accurate 1:1 artwork for intricate IC masks. The resulting equipment is overkill for most densities of hybrid and PCB designs. If a company has a need for all kinds of circuits and densities, then a photoplotter can certainly meet all their artwork demands. If a company is more limited as to the circuits it produces, then a photoplotter may be a larger bite than that company should have to chew. This article provides an alternative for those companies who need the advantages of CAD but cannot justify purchasing a photoplotter.

Langley, Bill. *Printed Circuit Des* v 4 n 9 Sep 1987 p 24 and 32.

**085088 DESIGNING ON THE MAC.** Two software products for the Macintosh personal computer are reported. Both of these packages are for the same purpose: to enable the user to draw printed circuit boards on a Mac screen, and to take the resulting output file and: print it out, to ImageWriter (dot matrix) printer, LaserWriter (laser printer 300 dots per inch), or LinoType machine (1200 dots per inch) (LinoTypes are to be found at the new desktop publishing places that have appeared lately



around the Mac). Laser printer or LinoType quality is probably adequate for PCB photo artwork. Some operational details are included.

Lizard, A. *Printed Circuit Des* v 4 n 9 Sep 1987 p 33-36.

**085089 PCB ARTWORK FROM A PLOTTER.** The author works for a company that manufactures high density surface mount RF PC boards which are incorporated into their product. They were faced with the problem of our CAD system not being able to easily handle this type of PCB and so switched over to an Apple Macintosh computer with a PCB layout software package. They found it necessary to overcome the obstacles present in pen plotting PCB artwork, because they had an early release of the software that would not output to a photoplotter. Some of the problems that can be encountered and how they can be rectified are explained.

Newman, Glenn P. *Printed Circuit Des* v 4 n 9 Sep 1987 p 40, 42.

**085090 CAD CONSIDERATIONS FOR SMT BOARDS.** The general steps for using a CAD system to design SMT boards are basically the same as designing regular multilayer PCBs. We should be aware, however, of the similarities and differences which relate to designing both through hole and SMT PCBs. The first-time user of CAD for the design of an SMT board can be intimidated by the visibility issues relating to seeing both sides on the board at the same time. Automatic tools can go a long way toward minimizing errors but only if the basic system has SMT capabilities first.

Nedbal, Richard A. *Printed Circuit Des* v 4 n 10 Oct 1987 p 10, 14-16, 18.

**085091 SMT MANUAL DESIGN SYSTEM.** The SMT artwork design system is well suited for multilayer as well as double-sided boards. Using the specially designed 30 lines/inch grid along with a pin registration bar and pre-punched polyester film, the designer is assured of achieving accurate registration of all layers. Symbols such as sequential reference designators, targets, board delineation marks, etc., in addition to precision slit tape and any required through hole DIP patterns, can be used to complete the artwork.

Kem, Fred H. *Printed Circuit Des* v 4 n 10 Oct 1987 p 31-34, 36.

**085092 CONSIDERATIONS FOR SELECTING COMPUTER AIDED DESIGN SYSTEMS FOR PRINTED WIRING BOARDS.** As the speed, density, and overall complexity of printed wiring boards increase, so does the time required for their design. In a marketplace that demands prompt delivery, inefficiency and delays cannot be tolerated. Computer aided design (CAD) hardware and software manufacturers have introduced and modified products to accommodate both complex designs and changing requirements for efficiency and prompt turnaround. The paper discusses many factors which must be considered when selecting CAD hardware (also called a platform) and/or software.

Bartos, Sara (Electronics, Libertyville, IL, USA); O'Loughlin, Michael. *Electronics* v 33 n 3 Feb 1987 p 19-22.

**085093 CONTOUR PROGRAM SMOOTHES 'STRIP' DISCONTINUITIES.** Discontinuities in microstrip transmission lines result in actual circuit operating parameters that are different from the theoretically designed values. Exact design of these discontinuities - either the step- or open-end types - requires the correct discontinuity equivalent circuit. Designers often use only one of the two discontinuity equivalent circuit components - the capacitive or the inductive component. However, a software-based technique ensures use of the correct equivalent circuit. This technique also reduces circuit complexity, provides more reliable circuits, and generates printed-circuit artwork. The technique is applicable to discontinuity steps of any size and is easily incorporated into existing circuit artwork plotting facilities. 11 refs.

Hutchings, J.L. (CSIR, Pretoria, S Afr); Nortier, J.R.; Lambert, D.A.T. *Microwaves RF* v 26 n 12 Nov 1987 p 129-130, 132-134, 138-139.

**085094 DESIGNER'S LOOK AT AUTOROUTING.** About seven years ago in the engineering lab, it was decided that About seven years ago in the engineering lab, it was decided that the only way to layout the next generation of large (8 inch  $\times$  10 inch), high density (1.0 sq. inch per IC) printed circuit boards (PCBs) was to use a CAD system with an automatic router. A list of some of the requirements the router must be capable of is presented.

Anon. *Printed Circuit Des* v 4 n 11 Nov 1987 p 15-18.

**085095 CAD FOR PC DESIGN: A SOFTWARE SURVEY.** Comments are presented which accompanied a table of answers to 150 questions by 30 suppliers of PCB software. All suppliers reviewed the table in June 1987. This covers virtually all of the low cost layout packages and some of the popular higher cost systems. The comments also document experiences of 50+ users of PCB CAD in the Pacific Northwest. The software grouping is: IBM compatible only, AutoCAD add-on, workstation, Atari and Amiga, Macintosh, then schematic capture.

Lahore, Henry. *Printed Circuit Des* v 4 n 11 Nov 1987 p 19-23.

**085096 RELATIONSHIP BETWEEN DESIGN RULES AND ROUTABILITY.** The successful use of automatic routers requires a firm grasp of the mathematics of router algorithms. An attempt is made to re-examine some of the basic rules of layout as they apply to the use of automatic tools for board routing.

Tasker, Shiv; Wines, Lisa. *Printed Circuit Des* v 4 n 11 Nov 1987 p 30, 34-37.

**085097 SELECTION CRITERIA FOR SURFACE MOUNT DESIGN SYSTEMS - PART 1.** Although surface mounting is not a new technology, it is one that has presented new and unusual problems. As surface mount technology evolved, many problems occurred because people tried to design surface mount on systems that were never intended for it. The article centers on the limitations of traditional systems and human interface with the design system.

Arana, Phil (Calma Co, Milpitas, CA, USA). *Surf Mount Technol* v 1 n 3 Jun 1987 p 22-23.

**085098 EINFACHE ERMITTLUNG VON SUBSTRATDATEN IM GHz-BEREICH.** [Simple Determination of Substrate Data in the GHz Region]. A method is described which makes it possible to determine in a simple manner the substrate data of materials for printed circuit boards in the GHz region. For this purpose use is made of the hf CAD program 'Supercompact'. It is thus possible to realize cost effectiveness of the P/C-board material. In German. 4 refs.

Dirks, Christian. *Elektronik* v 36 n 19 Sep 18 1987 p 149-152.

**085099 EXTENDED LAYERING ALGORITHM FOR MULTILAYER PRINTED WIRING BOARDS.** Layering problem of multilayer printed wiring boards in the single-row routing approach is considered. For use in high density printed wiring boards, an extended layering algorithm is proposed for the case of street capacity  $K > 2$ , while all conventional algorithms are for  $K = 2$ . (Author abstract) 5 refs.

Ghameshlu, Mohsen (Hiroshima Univ, Higashi-Hiroshima, Jpn); Yoshida, Noriyoshi. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 10 Oct 1987 p 906-908.

**085100 DESIGNING CIRCUITS WITH PCs.** Laying out a printed circuit board (PCB) is a perfect application for a computer. Dedicated PCB workstations have performed the task for some time. A few years ago, personal

computer (PC) software vendors began offering CAD packages. The early CAD packages helped the design process but had many deficiencies. The number of components and circuit layers they could work with was fairly limited. And few of the early packages offered autorouting of the circuit traces. Today, packages are available that can handle up to 1,000 components, and most offer autorouting. Though the circuit completion rate for these routers is still less than that of a workstation, it is high enough - typically around 90% - to drastically reduce the designers task. The author describes the printed circuit CAD packages.

Bahniuk, Douglas (Machine Design, Cleveland, OH, USA). *Mach Des* v 59 n 18 Aug 6 1987 p 91-95.

**085101 SOLVING THE INSOLUBLE: PCB PLACEMENT.** The article focusses on the complexity of the placement problem, describes the placement tools within the Board Station PCB Layout system and demonstrates how advanced design automation techniques can be applied to assist and complement the effort of the pcb designer. The authors seek to set the foundation for the artificial intelligence approach in solving the placement problem.

Kohkani, Kanti; Rogoyski, Eric; Chou, Anna; Lin, Juno. *Electron Prod Des* v 8 n 4 Apr 1987 p 53-56.

**085102 MULTILEVEL ELECTRONIC DESIGN ENVIRONMENTS.** The article reviews the place of printed board design systems in the larger networks which are now being configured. A new analog simulation package, SABER, which is outlined, offers better convergence and performance improvements of 10-15 times in comparison to SPICE. The advantage of NFS in a distributed CAE/CAB/CAM environment is stressed.

Turner, Nigel. *Electron Prod Des* v 8 n 4 Apr 1987 p 59-61.

**085103 PCB DESIGN - IMPLICATIONS FOR MANUFACTURING.** The paper centers on the implications of PCB CAD for manufacturing. The author argues that the design quality and integrity are as important to manufacturing as they are to engineering. In order to customize links to special process equipment, manufacturing needs to have access to all design data and system outputs.

Farrant, David. *Electron Prod Des* v 8 n 4 Apr 1987 p 65-66.

**085104 EXPANDING CAPABILITIES IN 'BUDGET' CAD.** The article traces the progress in developing PC CAD systems. A number of software products are outlined, including EE Designer and Executive CAD, which run on an IBM AT, XT or compatible PC. The difficulties in selecting the most cost-effective system from those offered by today's market are mentioned.

Hewer, Johnathon. *Electron Prod Des* v 8 n 4 Apr 1987 p 83-84.

**085105 PWB DESIGN AND THE CADDS DESIGNER.** The intent of this article is to give the reader some insight into some of the processes involved with the fabrication of PWBs, along with some helpful design tips, and to stress the importance of being able to incorporate this knowledge into the design of their boards. Some problems associated with computer-aided design/drafting systems (CADDS) are discussed.

DeSantis, John A. *Printed Circuit Des* v 5 n 1 Jan 1988 p 16-21.

**085106 CHANGING OF PCB CAD.** The demarcation between logic design and PCB design was once clearly defined by the technology available to perform each task. Logic design, even of complex boards, was accomplished with colored pencils and paper, while physical board design used large mainframe computers. Computational power was more easily applied to the tangible design than



the abstract. It is argued that integration of board design tasks into CAE tools will redefine the nature of the board designer's job.

Smith, Lee D. *Printed Circuit Des* v 5 n 1 Jan 1988 p 22, 26-27, 29.

**085107 COMPUTER-AIDED DESIGN ANALYSIS TO IMPROVE PCB RELIABILITY.** Various types of circuit element adjacencies in a high density printed circuit board are described. A methodology for using CAD tools to analyze printed circuits and enumerate the circuit adjacencies is outlined. Two examples are cited where utilizing the methodology induced the technology engineer to make design changes that increased the product reliability with no loss in circuit performance. 3 refs.

Shaul, Roy F.; Haining, Frank W. *Printed Circuit Des* v 5 n 1 Jan 1988 p 30, 32-34, 38.

**085108 CALAY AIMS TO USE CAD DATA TO BUILD AND LOAD BOARDS.** The use of computer-aided design (CAD) data in the computer-aided manufacturing (CAM) workstations of printed circuit (PC) boards is presented. The ECAM (Electronic Computer-Aided Manufacturing) work station is presented, a system that takes a giant step toward full automation. ECAM brings single-keystroke commands to the CAM world; it expands the repertoire of translators that convert CAD data for use in pc-board manufacturing, include translators that convert CAD data for use in board stuffing. The ECAM system provides 'neutral' data-base conversion, that is, it can quickly convert design data into equipment-specific file formats. For example, a manufacturing engineer might create a file for an n/c drill machine that breaks down halfway through a run. With a few keystrokes, he can create a new file for an entirely different machine and resume the production run. On other systems, he would have had to manually change the file over to the new n/c machine.

McLeod, Jonah (Electronics, New York, NY, USA). *Electronics* v 60 n 22 Oct 29 1987 p 61-63.

**085109 DEVELOPING A PRINTED CIRCUIT BOARD DESIGN SYSTEM.** In 1982 Hewlett-Packard addressed the computer-aided printed circuit board layout problem with HP EGS (HP's Engineering Graphics System), a product that provides design capture (via an electrical schematic) and general physical design capabilities. In 1986 HP introduced its first fully automated printed circuit board layout product as a member of the HP DesignCenter family. This HP Printed Circuit Design System (HP PCDS) is a fully functional computer-aided design application that couples printed circuit board layout to electrical engineering design, manufacturing, and testing. This article provides an overview of the product and the environment in which it runs, and includes a discussion of HP PCDS' Design Module. 1 ref.

Regelson, Elaine C. *Hewlett Packard J* v 39 n 1 Feb 1988 p 65-67.

**085110 AUTOMATING THE PRINTED CIRCUIT BOARD DESIGN PROCESS.** The author describes the placement method used in the HP Printed Circuit Design System (HP PCDS). He then discusses placement improvement methods. He finally describes the autorouter, its parameters and its method of operation. 1 ref.

Jackoway, Gary. *Hewlett Packard J* v 39 n 1 Feb 1988 p 68-71.

**085111 MANAGING HP PCDS WITH THE DESIGN SYSTEM MANAGER.** A description is given of the Design System Management (DSM) part of the HP Printed Circuit Design System. The discussion covers: design history and version control; DSM architecture; DSM networks; file structure; interface; design access; file security; the spooler system; and customization and usability.

Reese, Paul S.; Mayotte, Mark E. *Hewlett Packard J* v 39 n 1 Feb 1988 p 71-76.

**085112 MULTIDEVICE SPOOLER FOR TECHNICAL APPLICATIONS.** The HP Printed Circuit Design System (HP PCDS) produces output that goes to a wide variety of physical devices. The DSM (Design System Manager) spooler system provides a method for accessing each of the peripherals and the Autorouter Module through a common user interface. This lets HP PCDS users concentrate on designing printed circuit boards instead of interacting with each device individually. The DSM spooler can be easily customized. This allows customer sites to configure the systems to that it works with their peripherals and manufacturing processes. Because the spooler is integrated within DSM, the user does not need to specify information that is already known by DSM, such as the names and locations of files. In addition, DSM can be used to transfer job files and status information across the network.

Lienhart, Deborah H. *Hewlett Packard J* v 39 n 1 Feb 1988 p 77-80.

**085113 INTEGRATING APPLICATIONS IN A DESIGN MANAGEMENT SYSTEM.** The author describes the Design System Manager, which was developed in conjunction with the HP Printed Circuit Design System (HP PCDS) to allow an organization to control the access to and the distribution of their CAD data. The basic functions of a design manager are to provide the file management tasks of versioning, access control, archival storage, and reporting. The discussion focuses on the environment initialization, automatic execution, and the DSM query facility.

Mayotte, Mark E. *Hewlett Packard J* v 39 n 1 Feb 1988 p 80-83.

**085114 IPC-D-350: ONE STANDARD FOR PC DESIGN.** Over the years, IPC members have spent a great deal of effort in the development of a printed board standard language. The IPC-D-350, 'Printed Board Description in Numeric Form,' was initially released in 1972, approved for use by the U.S. Department of Defense (required by MIL-STD-275) and continues today to be a viable language. In addition, the D-350 computer format for boards was supplemented in 1985 with companion languages for drawings (IPC-D-351) and electronic data base descriptions (IPC-D-352). Both of these standards were also adopted by the DoD. Work is now in progress for library descriptions and test vectors.

Bergman, Dieter. *Printed Circuit Des* v 4 n 12 Dec 1987 p 17-18.

**085115 USING EDIF FOR PCB DESIGN.** The Electronic Design Interchange Format (EDIF) is emerging as the most advanced means of exchanging design data between CAE system vendors. EDIF can describe many different aspects of an electronic system, including netlists, schematics, PCB layout, IC layout, simulation, and documentation. The EDIF standard is new and evolving. Its use in the printed circuit board industry is still experimental. This article describes some of the open issues that must be resolved in order to allow the commercial use of EDIF for PCB design and layout. It will help you to set realistic expectations and schedules as you plan for changes in your CAE/CAD systems.

Clawson, Harvey. *Printed Circuit Des* v 4 n 12 Dec 1987 8p between p 19 and 32.

**085116 REAL-WORLD CONSTRAINTS ON PRINTED CIRCUIT CAD PERFORMANCE.** The design rules imposed on PCB auto-routers and placement programs reflect the state of manufacturing process capabilities of PCB fabrication and assembly operations. They can often be very restrictive, as can the tough layout design rules arising from the need to manage transmission-line behavior in high-speed circuits. 2 refs.

Keeler, Robert (Electronic Packaging & Production, Newton, MA, USA). *Electron Packag Prod* v 27 n 2 Feb 1987 p 88-90.

**085117 EFFECTS OF INTEGRATED CAE/CAD ON THE DESIGN CYCLE.** This article explain how and

why the PCB designer's day-to-day activities will change due to integrated CAE/CAD, and discusses general CAE concepts pertinent to the PCB designer using an integrated CAE/CAD system.

Munich, Steve. *Printed Circuit Des* v 5 n 2 Feb 1988 p 9-12, 15-18, 22-23.

**085118 AUTOPLACEMENT: THE LONELIEST SOFTWARE IN TOWN.** From an engineering and design standpoint most autoplacement software does not work well. The problems are complex. One autoplacement program cannot possibly incorporate the intricate engineering and design criteria for all PCB applications. Digital, analog, SMT, ECL, TAB, and two-sided component placement are a few of the challenges. Autoplacement advancements are driven by the knowledgeable consumer. It is argued that the evaluation of and emphasis on competent placement will demonstrate which CAD vendors are dedicated to the advancement of PCB design tools.

Rygiel, James. *Printed Circuit Des* v 5 n 3 Mar 1988 p 5-6, 10-12.

**085119 OVERVIEW OF PLACEMENT ALGORITHMS.** While printed circuit board routing appears to be more difficult, it is a complete placement algorithm that continues to evade CAD developers. Commercial 100% routers are commonplace, but placement still requires manual intervention. In many cases a board may be completely placed by a designer. Due to this fact, the selection and use of a proper placement tool can save many man-hours of design. Placement algorithms can be divided into two sub-classes by their usage. Constructive placement algorithms start from an empty or partially placed board and produce a placed arrangement. Iterative improvement algorithms are those which begin with a placement and optimize its arrangement according to some cost function. An attempt is made to examine cost functions.

Meyers, Ben; Elmer, Diane. *Printed Circuit Des* v 5 n 3 Mar 1988 p 13-14, 16.

**085120 PROS AND CONS OF AUTOMATIC COMPONENT PLACEMENT.** Many electronic design automation (EDA) systems available today provide automatic placement tools. These tools, although readily available on most platforms and in all price ranges, are seldom or never used by engineers or designers. Automatic placement tools often do not meet the user's expectation, so the tools are left idle while the designer places the components either manually or interactively. The placement problem is discussed, and guidelines for eliminating the problem are indicated.

Bracha, Gabriel; Harvel, Jerry; Dvir, Assaf. *Printed Circuit Des* v 5 n 3 Mar 1988 p 17-20.

**085121 BRIDGING THE GAP: PRODUCT DESIGN GROUPS VS. COMPUTER-AIDED DESIGN.** The design of printed wiring boards and flex harnesses for electronic, electromechanical, and electrooptical systems is of prime importance to Martin Marietta. Most of our products - missiles, projectiles and communications systems - contain active electronic equipment that is unique in its application and which must be packaged on printed wiring boards and interconnected with flex or rigid-flex harnesses with specific form factors. The author reports the gradual development of modern technology, starting with the 1960's. Presently used methods are described.

McEachnie, William E. *Printed Circuit Des* v 5 n 3 Mar 1988 8p between p 23 and 35.

**085122 LAYOUT INCLUDING PARASITICS FOR PRINTED CIRCUIT BOARDS.** An automatic layout system is developed for optimal simultaneous placement of elements and equipotential nodes and routing interconnection paths that can be applied to multilayer analogue printed circuit boards (PCBs) including parasitic couplings. The objective is to minimize the influence of



parasitic capacitance and inductance couplings of printed paths on performance of analogue circuits as an electrical criterion. A force model has been used to determine optimal placement where the sensitivities of network function on parasitic capacitances and inductances are the sets of weighted coefficients between forces of attractions and repulsions. The routing algorithm is a combination of topographic simulation method with minimum length connection path. Placement and routing algorithms have been developed, programmed and compared with conventional force algorithm and the Lee algorithm. Practical results of frequency characteristics of printed circuit boards of a wide-band HF amplifier have been obtained and presented. (Edited author abstract) 14 refs.

Wawryn, Krzysztof (Technical Univ of Koszalin, Koszalin, Pol). *Int J Circuit Theory Appl* v 16 n 2 Apr 1988 p 107-128.

**085123 CAD REVIEW: APTOS SYSTEMS.** In a previous issue, a checklist for comparing CAD systems and software was printed within these pages. That guide, adapted from a publication created by Aptos Systems (Scotts Valley, CA), raised questions that should be asked when evaluating any PC-based CAD system. From the comments of Printed Circuit Design's readership, a standardized questionnaire evolved that is to be used for future reviews of CAD bundled systems or software packages. These reviews should allow quick, consistent and unbiased comparisons regardless of the review date. This initial review is directed toward Aptos. Aptos Systems offers designers two paths from conception to artwork-ready design. One path is Rgraph, Aptos' front-to-back schematic capture and board layout system. A less expensive path is provided by Aptos' Criterion I and Criterion II.

Balingit, Bill. *Printed Circuit Des* v 5 n 4 Apr 1988 p 23-26, 30-33.

**085124 IGES: TRANSFERRING DESIGN DATA.** One exchange format for transfers from any CAD system to any other make of CAD system is called IGES. Initial Graphics Exchange Specification. Product Data Exchange Specification refers to a current project, which is also known as PDES. Sometimes IGES refers to a document and sometimes to the organization (now more correctly called IGES/PDES) of people who created and maintain that document. This article focuses on IGES, with brief mentions of three other exchange vehicles.

O'Connell, Larry. *Printed Circuit Des* v 5 n 4 Apr 1988 p 34-36, 40-42, 44.

**085125 BLIND BURIED VIAS.** A three-dimensional computer-aided design (CAD) capability permits the blind buried via (BBV) application in the production of surface mount technology (SMT) printed circuit boards (PCB) in order to obtain compact interconnects. The CAD system auto-routes to terminal pads, interconnects selected layers, and generally looks at a board as the three-dimensional thing that it is. A new data structure handles components on both the top and bottom of the board, auto-routes around vias, and brings a layer to a surface for making contact.

Murray, Jerry (Circuits Manufacturing, San Francisco, CA, USA). *Circuits Manuf* v 28 n 4 Apr 1988 p 62-64.

**085126 CASE STUDY: REDESIGN WITH A PERSONAL COMPUTER.** The use of personal computers in printed circuit design is considered. Experience with the PC is reported. A unique redesign problem is discussed, along with computer graphics aid component placement. The importance of cost effectiveness is pointed out.

Bange, Brian D. (Precision Printed Circuit, Houston, TX, USA). *Printed Circuit Des* v 5 n 5 May 1988 p 36-39.

**085127 DESIGNER'S VIEWPOINT.** Current design and layout techniques associated with printed-circuit boards are discussed. It is being argued that the fact that we have abandoned the central CPU approach for the workstation is the best thing that could have happened.

Jodoin, Claude J. (United Technologies Automotive Group, Dearborn, MI, USA). *Printed Circuit Des* v 5 n 5 May 1988 p 41-42.

**085128 DESIGN OF A ROBOTIC WORKSTATION FOR COMPONENT INSERTION.** The characteristics of electronics manufacture have changed: instead of high volumes of the same product, the trend is toward much smaller volumes of many varieties of similar products. In this environment, the ideal assembly machine would be capable of virtually limitless adaptability. Using robotic technology, AT&T at Merrimack Valley has undertaken a project to design such a machine for printed-wiring-board assembly. This paper describes the configuration of the resulting workstation for component insertion on the automated in-line manufacturing system. (Author abstract) 1 ref.

Decelle, Linda S. (AT&T Merrimack Valley Works, North Andover, MA, USA). *AT&T Tech J* v 67 n 2 Mar-Apr 1988 p 15-22.

**085129 COMMON DESIGN ERRORS DECREASE MULTILAYER YIELDS.** A list of common design errors likely to compound the fabrication challenge is drawn up. This list provides a set of guidelines to pass on, in capsule form, to internal or external customers. And that, in turn, may help to achieve the goal of truly fabrication-driven design.

Nap, Kimbel A. (Automated Systems Inc, Brookfield, WI, USA). *Electron Manuf* v 34 n 5 May 1988 p 10-12.

**085130 OVERVIEW OF TRENDS IN COMPUTER AIDED DESIGN.** For the last five years, some of the biggest CAD breakthroughs have taken place in the area of PCB routing. The introduction of special purpose accelerators made significant reduction in routing time about two to ten times faster. Accelerators, because they were so fast, permitted designers to tweak their designs and make them more manufacturable - fewer vias, fewer layers, etc. They also permitted true multilayer routing of large dense boards. User interface has become important to the value of a CAD system. Other trends include changes in library creation, automation of PCB component placement and application of artificial intelligence.

Anastasi, Robert (Cadnetix Corp, Boulder, CO, USA). *Electron Manuf* v 34 n 3 Mar 1988 p 26-28.

**085131 PC CAD SOFTWARE GAINING ON WORKSTATION PROGRAMS.** An interesting shift in the computer-aided-design (CAD) market will be seen in 1988 as more engineers buy software that runs on personal computers (PCs). Lower priced PC software products will be able to do what more expensive workstation software traditionally accomplished, and cost differences will no longer be justified. The paper describes four areas of new product opportunity in the CAD arena: concept design, design verification, manufacturing tools and PCB layout area.

Collison, Rick (Personal CAD Systems Inc, San Jose, CA, USA). *Electron Manuf* v 34 n 3 Mar 1988 p 29-30.

**085132 CHOOSING A MONITOR FOR PC-BASED CAD/CAE.** Resolution is at the top of the list of criteria for choosing monitors. Other features PCB designers should look for are the highest levels of brightness, contrast, and bandwidth rate.

Gonor, Kevin L. (Monitronix Corp, Westerville, OH, USA). *Electron Manuf* v 34 n 3 Mar 1988 p 31-32.

**085133 USING A CAD/CAE SYSTEM FOR FLEXIBLE CIRCUIT DESIGN.** While working on an internal productivity project geared to develop computer aided flexible circuit design capabilities, a breakthrough in project management, project design communication, design documentation, and automated flexible circuit design and fabrication emerged. These capabilities have been realized by taking the basic hierarchical design structure of a certain CAD/CAE schematic capture system and expanding it beyond the scope for which it was originally intended.

Lacy, Steve (Power, Distribution & Telemetry Systems Design, Pomona, CA, USA). *Electron Manuf* v 34 n 3 Mar 1988 p 35-36.

**085134 TECHNIK UND ABLAUF BEI CAE/CAD-LEITERPLATTENENTWICKLUNGEN.** [Engineering and Procedure in CAE/CAD Printed-Circuit Board Developments]. The computer-assisted development of PCBs displays functional and constructional design phases. Systematic use of CAE/CAD design systems results in time savings as well as production documentation of greater precision. Several variations exist for employing computer processes, their effective application being conditional on a smooth cooperation between user and manufacturer. (Author abstract) In German. 6 refs.

Ammon, P.; Guth, F. *F&M Feinwerktech Messtech* v 96 n 5 May 1988 p 215-219.

**085135 HIDDEN DOLLARS IN YOUR COST.** With CAD data being available with artwork films, PWB manufacturers can make PWBs faster, better and cheaper. CAD data allows reduced tooling and production costs. PWB quality improves with better matching of tooling to the manufacturer's process. Tooling preparation requires fewer steps, with these steps being automated, and thus takes less time and shortens delivery lead time. Independent PWB manufacturers have cultivated business with PWB buyers willing to release CAD data with their film artwork. These PWB manufacturers achieve quality, yield and cost improvements that have made them better suppliers and more effective competitors. They have taken on more complex multilayer work profitably, with their cost savings paying back their investment in CAD/CAM equipment.

Juha, Mike (Excellon Photonics Div, Costa Mesa, CA, USA). *Circuits Manuf* v 28 n 3 Mar 1988 p 3.

**085136 INTERFACING WITH A SERVICE BUREAU.** An attempt is made to explain how one can provide information to the service bureau in a way that both will be able to understand what is expected of each other and the finished result will be exactly what was needed, if not better than what was expected. These steps will also enable control to be maintained while not slowing up the progress of the design. The use of CAD (computer aided design) as a design tool is considered. Economic aspects are discussed.

Umina, John (Product Development Co, Newton, MA, USA). *Printed Circuit Des* v 5 n 7 Jul 1988 p 27-33, 35.

**085137 AUTOROUTER SOFTWARE.** This article is concerned with writing automatic router software for good printed circuit board design and the practical goals which should be aimed for. PCB routing is but one facet of the design process. Schematic design, or data entry and part placement precede the problem of routing the board. If the placement has not been properly studied in order to minimize the interconnection problem, no router, human or computer, will produce a good board design. Designing good router software for experienced layout designers is not an easy task. The design of a software tool which is of practical use to a professional requires a thorough understanding of the way in which a professional layout designer manually routes a board. Some useful guidelines are presented.

Maton, John (Academi Systems, Livermore, CA, USA). *Printed Circuit Des* v 5 n 10 Oct 1988 p 27-30, 34-35.

**085138 EVALUATING PERSONAL COMPUTER AUTOROUTERS.** Features like automatic placement, gate and pin swapping, design rule checking, CAE-to-PCB integration, and surface mounted design support are now available from personal CAD vendors at total system prices ranging from 3,000 dollars to 20,000 dollars. Today's personal computer CAD tools meet the need of their users in practically every aspect of PCB design. A good autorouter can save you a lot of work and



reduce your design time by 50 percent. A bad one or one not suited to your design needs will be worthless. The right router will depend on your design requirements because different routers will be effective on different boards. This article has been written to enable a user with limited time to evaluate autorouters quickly to find one that will work well with this layout rules and design technology.

Marsh, Michael (Router Solutions, Littleton, MA, USA). *Printed Circuit Des* v 5 n 10 Oct 1988 6p.

**085139 MINIMIZATION OF THE NUMBER OF LAYERS FOR SINGLE ROW ROUTING WITH FIXED STREET CAPACITY.** A set of three algorithms is presented for solving single-row routing problems with a fixed street capacity using the least number of layers. The main difference among these algorithms is in the strategy used to search for an optimal solution, which greatly affects the performance. At the extreme points of the strategy are algorithms Q and S. The worst-case time complexity is linear for algorithm Q and exponential for algorithm S. The best-case time complexity of all the algorithms is linear. The main disadvantage of algorithm Q is that the constant associated with its time complexity bounds is large. On the other hand, the constant associated with the best-case time complexity bound for algorithm S is small. An experimental evaluation of the performance of the algorithms is presented. 9 refs.

Gonzalez, Teofilo F. (Univ of California, Santa Barbara, CA, USA); Kurki-Gowdara, Shashishekar. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 3 Mar 1988 p 420-424.

**085140 GRAPHICS FUNDAMENTALS FOR A PCB-CAD PC SYSTEM.** Research has been initiated to develop a low-cost PCB-CAD system on a personal computer. This paper describes the approach to build device dependent and device independent common parts as also interactive graphics fundamentals to which a whole PCB-CAD package can be linked. The paper also describes tools that were used during the development of the workstation package for PCB design. (Edited author abstract) 6 refs.

Berce, Jaro (Iskra-Avtomatika Research & Development Inst, Ljubljana, Yugosl). *Microprocess Microprogram* v 23 n 1-5 Mar 1988, Short Notes - Euromicro '87. Microcomput: Usage, Methods and Struct, 1987 p 359-364.

## Computer Aided Engineering

**085141 HOW TO EVALUATE CAE EQUIPMENT FOR PWB LAYOUT - PART 1.** This is the first part of a two-part article discussing CAE equipment evaluation. Part one covers linking schematic capture to layout, and part placement. (Author abstract)

Miller, Timothy C. (Daisy Systems Corp, Mountain View, CA, USA). *Electronics* v 33 n 12 Aug 1987 p 25.

**085142 HOW TO EVALUATE CAE EQUIPMENT FOR PWB LAYOUT - PART 2.** This is the second part of a two-part article discussing CAE equipment evaluation. This part covers routing functions. (Edited author abstract)

Miller, Timothy C. (Daisy Systems Corp, Mountain View, CA, USA). *Electronics* v 33 n 14 Sep 1987 p 51.

## Computer Aided Manufacturing See Also ELECTRONICS PACKAGING—Modular Construction.

**085143 ACCURATE PLACEMENT OF SMDs: VISION MEETS THE CHALLENGE.** Assembling printed circuit boards populated with surface mount devices (SMD) is a problem manufacturing engineers have been struggling with for several years. In some cases, where the volume is high and the variety of boards is low, hard automation has provided an answer. For those producing low volumes of a broad mix of boards, robots guided by machine vision and CAD/CAM systems have proven most successful. As the number of leads on SMDs

increases and distance between the leads decreases, the problem grows in complexity, making the role of vision guidance and inspection more critical. This article describes some techniques for using vision to inspect leaded SMDs, and provides inputs to a robot for their placement on printed circuit boards. Leaded parts are more difficult to inspect and place than parts such as leadless chip carriers (LCC), but many of the same techniques apply to both.

Chapman, Kenneth W. (Intellex, Corvallis, OR, USA). *Rob World* v 5 n 11 Oct 1987 p 27-30.

**085144 FEATURES TO COMPARE WHEN EVALUATING PWB COMPUTER AIDED MANUFACTURING SYSTEMS.** Because the main benefit of an advanced system derived from the comprehensive array of features, these benefits can be demonstrated only in a general way by way of example. This paper discusses the following example of advanced features: scanning, design rule checking (DRC), creation of special solder masks, drill and route tape preparation, elimination of nonfunctional pads, merging of positive and negative layers, and communication interfaces.

McDonald, Roy K. (Optrotech Inc, Billerica, MA, USA). *Electronics* v 33 n 7 May 1987 p 30-32.

**085145 TAPPING CAD DATA FOR PC BOARD PANELIZATION.** A workstation 'panel editor' can bridge the CAE/CAD database to CAM and provide the ability to create manufacturable printed circuit panel artwork from one or more single copies of a PCB. The data available from the panel editor that are crucial to the various islands of automation within CAM are accessed through a data query language facility and through a host of direct machine interfaces. The panel editor places the solutions to manufacturing problems in the manufacturing environment. Manufacturers can create and modify their own panel artwork without having to rely on the CAE/CAD groups. Similarly, the database and tools for configuring and programming fabrication, assembly and test equipment are available in the workstation.

White, Lisa D. (Cadnetix Corp, Boulder, CO, USA). *Electron Packag Prod* v 27 n 3 Mar 1987 p 51-52.

**085146 OVERVIEW OF PWB PANELIZATION STATIONS, PLOTTERS.** The two main components of a CAM phototooling system are the panelization station (front end) and plotting device (output). Although many front end systems have been introduced recently, there have been few changes in plotters, which may cost between 60-70 percent of the total system. This paper stresses on selecting a phototooling system. Photoplotter should be selected based on its speed, accuracy and resolution.

Herzka, Dani (Scitex America Corp, Bedford, MA, USA). *Electron Manuf* v 33 n 18 Dec 1987 p 15-16.

**085147 PAPERLESS TRAIL TO ZERO DEFECTS.** The author reports on a paperless-rework and data collection system for surface mount technology printed circuit testing based on a manufacturing database system. The assembly area consists of two functionally identical SMT lines and one through-hole technology line connected by conveyors. Total placing capacity is 20,000 discrete/hr and 7200 ICs/hr. Running 152 hr, the factory produces 25,000 boards/week. All of the boards are single-sided mixed technology with only a small percentage of through-hole components. The boards are all for the personal computer industry and consist of disk controllers or communications boards for distribution to original equipment manufacturers (OEMs), value-added distributors (VADs) or value-added retailers (VARs). Data is collected at five stages for work-in-process (WIP) tracking and yield information purposes.

Arp, Rudy (Western Digital Corp, Irvine, CA, USA). *Circuits Manuf* v 28 n 3 Mar 1988 3p.

**085148 NEW MACHINES FOR OLD.** The implementation of a phased CIM strategy at a printed-circuit-board (PCB) manufacturing site in England is re-

ported. This site produces 95% of the company PCB's for all its product lines, and the range of boards covers over 600 types, varying from simple double-sided boards to complex multilayer boards with up to 18 logic layers. On average 10,000 assembled and tested boards are produced each week, although at peak periods this figure can rise to over 30,000 a week. The manufacturing process begins with laminate and components entering the factory, and ends with tested PCBs leaving to be fitted into products at assembly plants or stored for field spares.

Banister, Ray (ICL Mainframe Systems). *IEE Rev* v 34 n 7 Jul 14 1988 p 283-287.

**085149 KNOWLEDGE-BASED CAP SYSTEM IN PCB PRODUCTION.** The introduction of computer-aided planning in printed circuit board (PCB) production was the basis of a project designed to increase planning quality and shorten response times for new planning or for tenders. To achieve this aim, the knowledge of the methods engineer has to be modelled in an EDP system. In such cases, the result is called a knowledge-based system. Implementation is based on an interpretive decision table technique which was preferred to the more complex expert systems. Implementation of the first planning logic took 4 months and it has since been used in production with great success since April 1987. (Edited author abstract). 6 Refs.

Gmuer, E. (Hasler Ltd, Bern, Switz). *Hasler Rev* v 21 n 2 1988 p 13-17.

## Computer Integrated Manufacturing See Also MATERIALS HANDLING—Computer Aided Design.

**085150 HOW ONE COMPANY IS APPROACHING JIT.** At Calcomp's Display Products Division in Hudson, N.H., a different approach produced gains just as big, with little or no capital investment. One sentence sums up what JIT means to Calcomp - 'The philosophy calls for the production of only the minimum necessary units in the smallest possible quantities at the latest possible time.' With that overall guideline, Calcomp personnel accomplished the following: a 30% reduction in floor space required; a 70% reduction in work-in-process (WIP); an increase in quality that brought preshipment audit yields from 82% up to more than 96%, and a decrease in production cycle time from 12 weeks to less than 5. That list does not even include intangibles such as higher employee morale and better rapport between manufacturing engineers and designers. Furthermore, the floor space that was opened up gave Calcomp room to expand their business to include contract manufacturing of printed circuit boards.

Krepchin, Ira P. *Mod Mater Handl* v 43 n 1 Jan 1988 p 101-104.

**085151 SOFTWARE INTEGRATION EXPEDITES ANALYSIS.** Mechanical considerations such as packaging, thermal deformation, stress and vibration can frequently be as important as electronic properties in printed circuit board design. Yet conventional CAD/CAM systems usually make such analysis intolerably expensive. In order to perform a mechanical analysis, geometric, thermal and other properties of the PCB's components must be tediously entered one by one in an environment different from the one where the PCB was originally laid out. To eliminate this problem, an electronic design system, Bravo3, offers fully integrated mechanical and electronic computer-aided engineering.

Barton, Brian (Applicon, Ann Arbor, MI, USA). *Electron Packag Prod* v 28 n 1 Jan 1988 p 87-89.

**085152 IMPLEMENTING A CIM SYSTEM FOR MULTILAYER PWB FABRICATION.** A flexible computer integrated manufacturing (CIM) system is the key to efficient management of a dynamic, custom-built printed wiring board manufacturing facility. The PWB often is the last component designed for a particular application, but usually is the first component assembled,



changed, or modified during revision. This paper describes a CIM program in place at AT&T Technology Systems' Richmond, Va. facility which permits a PWB design to be put into production in less than one day, and cuts overall lead time in half. The system is used to provide various benefits, including real-time data for sequencing jobs and setting up equipment, and monitoring output, quality, and shipping. Although the system has unique features, the approach that AT&T has taken is one that many multilayer board fabrication facilities can apply.

Sage, Donald L. (AT&T Engineering & Computer Systems Development, Berkeley Heights, NJ, USA). *Electronics* v 33 n 11 Jul 1987 p 31-33.

**085153 TEKTRONIX INTEGRATES PCB MANUFACTURING.** Designed to hold sophisticated microprocessors and other complex devices, bare circuit boards must be built to proper wiring connections and signal routing. To make things more difficult, components are moving to higher levels of integration and designers continue to pack more functions into less space. Board manufacturers are striving to keep up. Some, however, are not only keeping up but in fact have gained a significant edge through computer-integrated manufacturing. The authors describe customer benefits testing, improvements in automating manufacturing and methods for better process planning.

Christensen, Jay (Tektronix, Beaverton, OR, USA); Hill-Tanquist, Sheri. *CAE Comput Aided Eng* v 7 n 5 May 1988 p 97-98, 101.

**085154 CIM-PRAXIS IN DER LEITERPLATTEN-FERTIGUNG EINES COMPUTERHERSTELLERS.** [CIM in Practice in a Computer Maker's Printed-Circuit Board Production.]. A description is given of a computer-integrated production and quality assurance system for the assembly and inspection of the large multilayer PCBs. Equal light will be thrown on the manufacturing sequence, inspection steps, data flow and material flow. Positive experiences with the system are reflected in drastic reductions of throughput times, high changeover flexibility, improved product quality, and transparent and up-to-date data on all levels. (Author abstract). 1 Ref. In German.

Meyer, Rolf (IBM Deutschland GmbH, Hanover, West Ger). *F&M Feinwerktech Messtech* v 96 n 7-8 Jul-Aug 1988 p 313-318.

**Computer Interfaces** See COMPUTERS, MICROCOMPUTER—Components.

## Computer Simulation

**085155 3-D ELECTROMAGNETIC ANALYSIS OF PRINTED BOARDS BY A NOVEL BOUNDARY ELEMENT METHOD.** Computer simulations of devices, circuits and systems are a major benefit to the electronics industry because they can remove the need for very costly design iterations in hardware. However such simulation can only be useful if it provides a sufficiently accurate prediction of the actual hardware performance. An example is the modification to the performance of a circuit implemented on a printed circuit board (PCB). This is due to the parasitic electrical behavior of the board itself. Problems that arise vary from common or differential mode coupling to crosstalk and feedback. It is therefore clear that accurate simulation of such circuits requires a mathematical model of the PCB. A unique description of the electrical behavior of the board is an  $N \times N$  admittance (or impedance) matrix, where  $N$  is the number of pads. This must be found at each frequency of interest. All the problems would be accounted for in a circuit analysis that are included this model. The broad outline of a method for finding the matrix is described here together with comparison between simulation and measurement. 5 refs.

Milsom, R.F.; Scott, K.J. *Annu Rev Philips Res Lab* 1986 p 73-76.

**Construction** See SUBSTRATES—Materials.

## Contacts

**085156 OVERVIEW OF BARRIER TERMINAL STRIPS.** Barrier terminal strips are one of the most widely used devices to terminate wires because of their versatility - they are available in various top and bottom termination styles - and cost effectiveness, both initial and installed cost. The devices provide increased insulation to stop creepage and arcing, eliminate time-consuming splicing, and provide a simple and convenient method for field wiring - only a screwdriver is necessary. Usually, high density circuitry can be attained with barrier terminal strips, which saves panel or PCB space. The result is a professional-looking termination rather than a jumble of wires. Barrier terminal strips also permit convenient circuit changes made by rearranging wires, and provide a good test point for trouble-shooting. In addition, circuit tracing is simplified when strips are imprinted with circuit designations. This paper discusses the benefits of using less expensive thermoplastic terminal strips, market trends in this field and barrier strip characteristics.

Twombly, Daryl (Vernitron Corp, Laconia, NH, USA). *Electron Manuf* v 34 n 5 May 1988 p 38-41.

**085157 MACHINE DESIGNED TO CLEAN CONTACTS TO IMPROVE PCB CONNECTOR RELIABILITY.** This paper describes a contact cleaner for PCB used by a leading computer manufacturer. The company's failure rate for insertions was 47 percent; almost half of the PCBs inserted into ZIF (zero insertion force) type connectors had to be removed, cleaned, and reinserted. Moreover, the faults resulting from poor contacts were often of an intermittent nature. After including the extra step of cleaning all contacts with the contact cleaner before inserting the boards, the manufacturer reported a failure rate of less than 3 percent, a significant improvement. Among the lessons learned is that contact cleanliness cannot be determined visually. Almost microscopic particles can interfere with proper contact between the board and connector. Finger prints, masking adhesives, fatty oils, and rosin flux are readily removed by the combination of solvent and mechanical scrubbing, but none of the gold is removed and lint, formerly a problem, is eliminated.

Larrabee, Bryce B. (Harvard Products Inc, Harvard, MA, USA). *Electron Manuf* v 34 n 8 Aug 1988 p 14-15.

## Cooling

**085158 COOLING DEVICES TAKE THE HEAT FROM SMDs.** Shrinking board size has changed the rules for thermal design: A surface-mount assembly that occupies only 40% of the space of its through-hole counterpart can nevertheless dissipate as much power. Achieving adequate reliability requires that one understands and applies the new rules. Products ranging from CAD tools to heat sink help develop and implement a strategy to limit semiconductor junction temperatures to a level that delivers the desired reliability. A CAD software package is presented that allows one to impose thermal as well as electrical constraints when determining where to place components on a circuit board.

Strassberg, Dan (EDN, Newton, MA, USA). *EDN* v 32 n 25 Dec 10 1987 p 96-102, 104, 106.

**085159 TAKING THE HEAT OFF.** Because of the lack of space in tightly-packed sealed electronic assemblies used in military/aerospace equipment, the removal of unwanted heat is achieved by means of conduction cooling. Appropriately designed heat sinks, or thermal planes, transfer the heat to the 'cold wall'. But too many designers leave heat dissipation considerations until the last minute. Enco's computer-aided thermal analysis system is used to establish the thermal problems associated with each printed circuit board (PCB) assembly. Factors taken into account by the analysis include heat generated on the board, heat transferred from other boards, thermal characteristics of the enclosure system, and any convection or radiation cooling that may be

available.

Buckley, David (ENCO Industries Ltd, Scott). *Electron Prod (London)* v 16 n 11 Nov-Dec 1987 p 33.

**085160 VERBESSERUNG DES AEUSSEREN WAERMEUEBERGANGS BEI DER KUEHLUNG ELEKTRONISCHER BAUELEMENTE UND LEITERPLATTEN.** [Improving the External Heat Transfer during the Cooling of Electronic Components and Printed Circuit Boards]. Proceeding from the relations between heat conduction and convective heat transfer in the region near a wall, a number of possibilities for intensifying the heat transfer are cited and discussed. In this connection, the heat transfer on electronic components and printed circuit boards in longitudinal or vertical flows are described on the basis of models and experimental results. (Translated author abstract) 16 refs. In German.

Hanel, B. (Technische Univ Dresden, Dresden, East Ger); Hoepfner, G.; Richter, E.; Neumann, K. *Feingerneteknik* v 37 n 3 1988 p 122-125.

**Costs** See Also COMPUTERS, MICROCOMPUTER—Performance.

**085161 PCB COST CONSIDERATIONS.** Printed circuit boards are the one common factor in all electronic assemblies. Every aspect of their design, manufacture and use has become so familiar that the purchase of PCBs seems routine. Now surface mounting raises new issues, whilst highlighting some old ones, and often the first symptom of things going astray comes with a surprise at the quotation stage; and abnormally high price. With surface mounting promising new economies this can certainly come as a shock but it either indicates over-specification in an area that was thought to be trivial or it brings to attention the true worth of some aspects of PCB capabilities that, once appreciated has acceptable value. This article compares through-hole assembly and surface mounting and examines the actual cost features of PCB.

Topham, David (Cambridge Interconnection Technology). *New Electron* v 20 n 14 Jul 7 1987 p 18-19.

## Cutting

**085162 EXAMINATION OF WATERJET CUTTING SYSTEMS FOR PWB PANEL SEPARATION.** Waterjet cutting is a method of depaneling PWB's which not only has advantages such as clean, smooth cuts, and the ability to accurately make contour cuts, but it lends itself to work with automated systems. Surface mount devices, a variety of substrates, and line automation, will contribute to a strong future for waterjet cutting in the PWB industry. Enhancements on the waterjet method include the abrasive jet system. The system uses an abrasive intensifier pump, which is a high pressure water system with inexpensive abrasives introduced into the stream. The enhancement expands the use of waterjet-type methods into cutting other materials, including glass, ceramics, and metallic substrates.

Jones, Ed (Flow Systems Inc, Kent, WA, USA). *Electronics* v 33 n 1 Jan 1987 p 23-24.

## Decontamination

**085163 FLUXES AND PCB CLEANING.** Comments are made on recent articles published on the use of 'No Clean' fluxes and on the alternative methods of cleaning PCB assemblies.

Fenner, Mike (Dage GB Ltd). *Electron Prod (London)* v 16 n 10 Oct 1987 p 53.

**085164 DETECTION OF IONIC CONTAMINATION UNDER SM COMPONENTS.** In view of the uncertainty of the applicability of traditional ionic contamination measurement to surface mount assemblies, a mathematical study was made of the phenomena involved. A model was derived, showing that under-component



contamination behaves differently from ordinary surface contamination. By breaking down a curve obtained under practical conditions into its components, it is possible to derive separate figures for surface and under-component ionic contamination, ignoring the influence of spurious noise signals. A new software, using these techniques, has been written for this application. Comparative tests between non-destructive testing, using this software, and tests on similar circuits with the components torn off, show that there is a close correlation between the results from these two techniques, even though the under-component contamination is only partially dissolved with the former method. (Edited author abstract). 7 Refs.

Ellis, B.N. (Protonique SA, Romanel-sur-Lausanne, Switz). *Circuit World* v 14 n 4 Jul 1988 p 59-61.

## Defects

**085165 MANUFACTURING DEFECT ANALYZERS: THE MDA NICHE WIDENS.** During the years 1983 through 1993, the world market for PC board automatic test equipment is expected to experience a compound annual growth of 9.3 percent, as represented by revenues. Manufacturing defect analyzers [MDAs] are expected to show the greatest amount of revenue growth, with an estimated compound annual growth rate of 24 percent. In many areas, the distinction between MDAs and in-circuit testers (ICTs) has become blurred, so much so that manufacturers have different views as to where the MDA coverage ends and the ICT begins.

Anon. *Eval Eng* v 27 n 8 Aug 1988 3p.

**Design** See Also AMPLIFIERS—Design; CAPACITORS, CERAMIC—Applications; ELECTRONIC CIRCUITS—Computer Aided Design; ELECTRONICS PACKAGING; SIGNAL INTERFERENCE—Crosstalk.

**085166 COST-EFFECTIVE MULTILAYER DESIGN.** Designers should consider the constraints they may impose on the printed circuit manufacturer since these can greatly affect the final cost and quality of the printed circuit board. A flow chart shows the major processes in manufacturing multilayer printed circuit boards. The processes which are common to both plated-through hole (PTH) and multilayer boards are customer input, material selection, tooling, imaging, etching, bonding, drilling, electroplating, soldering and other finishes.

Anon. *Electron Prod (London)* v 16 n 9 Sep 1987 p 35-36, 38-39, 41.

**085167 PCB FILL FACTOR CONSIDERATIONS.** The author points out that the best and least expensive way to produce a workable component placement is to do it at the drafting board. Some design and implementation details are presented.

Adams, Ira. *Printed Circuit Des* v 4 n 9 Sep 1987 p 37-39.

**085168 TERMINATE BUS LINES TO AVOID OVERSHOOT AND RINGING.** At high frequencies, the traces on a pc board act as transmission lines, so one may need to terminate them to avoid signal distortion caused by impedance mismatches. The five termination techniques presented are particularly suitable for use with high-speed CMOS logic, but can be adapted to suit other logic families as well. (Edited author abstract)

Pace, Charles (Fairchild Semiconductor Corp). *EDN* v 32 n 19 Sep 17 1987 p 227-232, 234.

**085169 COMPARISON OF PCB ROUTING METHODS.** The process of choosing a PCB router and layout system has become confusing as more types of systems are introduced. This confusion is worsened by claims made by each manufacturer. These claims usually emphasize the best features of the system being advertised rather than the features that might do the best job of designing a particular set of PCBs. This article examines the PCB design problem in order to develop a set of requirements to use in selecting a router. The features of the various routing methods are examined and compared

to these requirements.

Ritchey, Lee W. *Printed Circuit Des* v 4 n 11 Nov 1987 p 9-11, 14.

**085170 WORST-CASE TIMING ANALYSIS ENSURES BOARD RELIABILITY.** As printed circuit board designers continue pushing the limits of circuit performance, they face an increasingly critical and demanding chore: verifying the timing of new designs. Indeed, the potential for timing problems that can devastate product-development timetables multiplies when designing a complex VLSI board, where custom and semicustom ICs interact with standard off-the-shelf components in a dense, high-speed environment. The main topics are structural and functional timing, modeling functional timing, worst-case timing analysis, dealing with glitches, and weighing costs and benefits.

Rizzatti, Lauro (Teradyne, Boston, MA, USA); Wasilewski, Mary. *Comput Des* v 26 n 21 Nov 15 1987 p 90-94, 96.

**085171 COAXING TOP BIPOLAR SPEEDS FROM PROTOTYPING BOARDS.** The circuit designer working on high-speed applications like graphics or signal processing must push TTL and ECL logic chips close to their theoretical limits. Extensive computer modeling helps, of course, but the computer model just cannot predict the final effect of all the power delivery path variables. The designer accordingly turns to physical prototyping. Often that means using wire-wrappable boards, which allow device locations to be changed quickly. These boards vary in complexity from a simple two-layer board with a voltage plane on one side and a ground plane on the other to high-performance multilayer boards. Besides prototyping, they can also be used for short-run production.

Visco, P. Anthony (Mupac Corp, Brockton, MA, USA). *Electron Prod (Garden City NY)* v 30 n 7 Sep 1 1987 p 55-56, 58.

**085172 DESIGN STANDARDS FOR SMT.** Within a new technology such as SMT, we have seen a lot of excitement and confusion. Much of this has been centered around standards both for packages and for designing. In 1985 the IPC formed an SMT Land Pattern Task Group to generate a guideline for the SMT industry users. In April 1987 a document was released called IPC-SM-782. This addressed package standards and land patterns for them as well as information on design rules, fabrication and testing. Some pertinent details are outlined.

Blankenhorn, James C. *Printed Circuit Des* v 4 n 12 Dec 1987 p 33.

**085173 PACKLAYER - ALTERNATIVE TO CONVENTIONAL PRINTED CIRCUIT BOARDS.** The printed circuit board version, 'packlayer', represents an alternative to printed circuit boards with conventional solder mask systems which is not yet widely known. This alternative type does, however, offer some considerable advantages in comparison with printed circuit boards with solder resist, with the result that the higher cost involved is thoroughly acceptable. Through the development of a new system called 'Low-Cost-Packlayer', bearing the special name McSoMask, a variant has emerged within the packlayer sector. This special version combines the advantages of the packlayer with the costs of a conventional solder resist system and therefore presents a genuine alternative to the normal printed circuit board. (Author abstract)

Weiss, D.G. (Melchert Elektronik, Cologne, West Ger). *Circuit World* v 14 n 2 Jan 1988 p 42-45.

**085174 DESIGNING SMT CIRCUIT BOARDS.** Designing SMT printed circuit boards requires greater expertise than designing through-hole, leaded-component boards. Surface-mount-technology boards are typically 1.5 to 2 times more dense, are mostly of multilayer design, often have line widths of from 5 to 8 mils, can have components on both sides, and may use blind and buried vias for maximizing density. This article discusses how

standardized SMT pad sizes, spacings, and geometries ensure reliable assembly.

Markstein, Howard W. (Electronic Packaging & Production, Newton, MA, USA). *Electron Packag Prod* v 28 n 1 Jan 1988 p 52-54.

**085175 FORGING LINKS BETWEEN BOARD DESIGN AND TEST.** PC board testing generally breaks down into three categories: continuity testing, in-circuit testing, and functional testing. Requirements and features of each category are discussed. It is pointed out that connecting the board designer's data base to ATE systems is shaping up as a Herculean task, yet the potential rewards are equally great.

Milne, Bob. *Electron Des* v 33 n 7 Mar 20 1986 p 94-98, 100-101.

**085176 COMPONENT CHOICE AND PCB DESIGN FOR AUTOMATION.** Techniques, procedures and concepts which produce a PCB that has manufacturability as part of its design cycle are outlined.

Noble, Peter. *New Electron* v 21 n 2 Feb 1988 p 47-48, 51-52.

**085177 COST-EFFECTIVE PCB DESIGN.** With increasing power densities on printed circuit boards (PCBs), the dissipation of heat has become a problem. One solution is to utilise thermal planes to conduct heat away from the components to a cold wall. Thermal planes, often called heat sinks, can be used in three ways. They can be bonded to the component side of the PCB before the board is populated or they can be laminated within a circuit board to form a metal-core board. They can also be used to support areas of a flexible circuit. For the majority of circuits using leaded components, bonding to the surface of the printed circuit board is the most thermally efficient and cost-effective solution.

Haken, Brian (Printed Circuit Assoc, Fleet, Engl); Hamilton, Sheila; Hardie, Jim; Law, Ken; Willson, Ian; Wilcockson, Eric; Avery, David; Horning, Paul; Brumfield, Geoffrey; Greaves, Barry; Rayment, Terry. *Electron Prod (London)* v 17 n 4 Apr 1988 p 12-14, 16.

**085178 LASER PLOTS ON NEW EMULSION.** The installation of a new laser plotter together with the use of new high-definition films at British Telecom's Research Laboratories at Martlesham Heath has led to higher standards of productivity. It has been installed to eradicate one of the most irritating bottlenecks known to PCB designers: producing phototooling from PCB layout data. The DISC LPS720 laser plotter produces a plot in a few minutes. The control computer switches the laser beam's shutter on and off as it scans the film, building up the image as it goes. The plotting time is virtually independent of circuit complexity. The harnessing of an He-Ne laser which peaks at 630nm has necessitated the use of a new emulsion from Agfa-Gevaert. This is a dimensionally-stable red-sensitive film which accommodates the output from He-Ne lasers and which was designed specially for the printed circuit industry.

Anon. *Electron Prod (London)* v 17 n 4 Apr 1988 p 19.

**085179 FLEXIBLE PRINTED CIRCUITS: A DESIGN PRIMER.** Flexible circuits consist of conductive strips in a sandwich of insulating or dielectric material. They resist moisture and contamination and are insulated from external shorts, with holes or contact surfaces for interconnection. The mechanical and electrical characteristics of flexible circuits determine what type should be used. Total installed cost, including inspection, interconnection, fixturing and testing, must be weighed against the advantages of each. There are two general areas of application that may take the designer down different paths. The first is a circuit that will be bent or formed into



a rigid package during assembly. The second is where the circuit will be flexed continuously or intermittently during operations.

Keirstead, Chris D. (Jannock Ltd). *Assem Eng* v 31 n 5 May 1988 p 32-36.

**085180 MULTILAYER RIGID-FLEX DESIGN CONSIDERATIONS.** Rigid-flex printed wiring board (PWB) designs require careful material selection and properly specified features to produce reliable hardware. Varying material properties cause processing difficulties and thermal-stress related defects such as lifted lands, plated through hole (PTH) barrel cracks, foil cracks, foil separation, meandering, and misregistration. This article identifies design considerations for MIL-P-50884C-Type 4 multilayer rigid and flexible material combinations with plated through holes (PTH) that help produce a reliable design at a reasonable cost. Military specifications governing rigid-flex printed wiring boards are MIL-STD-2118 for design requirements and MIL-P-50884C for manufacturing requirements. 8 Refs.

Nicewarner, Earl (Fairchild Space Co, Germantown, MD, USA). *Printed Circuit Des* v 5 n 8 Aug 1988 p 16-27.

**085181 FLEX CIRCUITRY: DESIGNING FOR MANUFACTURABILITY.** A properly designed flex circuit will often be the difference between a cost-effective and a cost-prohibitive electronic interconnect. Reliability is also maximized through proper design selection. Although unique product solutions are often required for individual applications, three generic rules are appropriate for providing high reliability at minimum cost. These are discussed. An attempt is made to introduce the reader to some basic information that will aid electronic equipment manufacturers in incorporating flexible printed circuits into their product.

Becker, David (Sheldahl Inc, Northfield, MN, USA). *Printed Circuit Des* v 5 n 8 Aug 1988 p 54-57.

**085182 TO GRID OR NOT TO GRID.** Most printed circuit trace routers today use a rigid grid for trace layout. Now, since a few gridless routers are available, even more questions are added to the selection process for printed circuit design systems. This article addresses the differences between gridded and gridless routers, how they work, and where each is most applicable. While it is not always the case, the gridless router is usually best suited for handling boards with many off-grid components or with aggressive design rules. However, because of data-handling complexities inside such a router, it will usually be slower and/or less determined in its routing strategies than its gridded counterpart.

Simon, Charles J. *Printed Circuit Des* v 5 n 10 Oct 1988 p 10-14, 16.

**085183 IMPORTANCE OF SHOVE ROUTING.** Pick up a set of printed circuit board artwork and show it to some printed circuit designers. Ask them if it was routed by a manual designer or by an autorouter. Chances are that they will know immediately and be right every time. It is pointed out that with today's powerful workstations and PCs, it is now possible to obtain excellent autorouting that works with designers, not against them. With interactive shove capabilities, you no longer have to pick between quality routing and autorouting.

Wadland, Kenneth R. (Engineering Software Inc, Grafton, MA, USA). *Printed Circuit Des* v 5 n 10 Oct 1988 p 20, 22-25.

**Drilling** See Also MICROELECTRONICS—Laser Applications.

**085184 CHOOSING BACKUP MATERIALS FOR PWB DRILLING OPERATIONS.** Backup panels are flat sheets of material which serve as termination materials during the drilling of printed wiring boards (PWB's). Panels were originally used to protect expensive drilling machine tables from damage. Expensive subtooling is preserved by backup in a similar manner. Applications

have slowly evolved so that the most advanced backup materials serve as a medium through which drill bits can be cooled. This paper discusses the origins of backup materials, their effect on hole quality temperature problems, and application of air vented aluminum as backup material.

Berlin, Alvin J. *Electronics* v 32 n 12 Nov 1986 p 29-30.

**085185 GENAUGKEIT VON LEITERPLATTEN-BOHRMASCHINEN.** [Accuracy of Printed Circuit Board Drilling Machines]. The future development of the printed-circuit board is tending toward an increase in the integration of components. The results are narrower printed wiring conductors and ever smaller drill holes. When drilling PC boards, the consequence is that the demand on accuracy of the drill hole location is constantly mounting. This report defines all influencing variables, establishes their admissible tolerances and describes the effects on drilling accuracy. In addition, a procedure for testing drilling accuracy is outlined. (Edited author abstract) In German. 13 refs.

Gerlach, Burghart. *Metallverarbeitung* v 41 n 11 Nov 1987 p 539-543.

**085186 SMALL HOLE DRILLING: THE JAPANESE WAY.** Drilling techniques and philosophies are described that have made Hitachi successful in producing advanced multilayer boards (MLB). Holes from 4 to 16 mil with aspect ratios of 8:1 or more are addressed. Drilling machine functions, and variations in drill bit geometry are also included.

Kanaya, Yasuhiko (Hitachi Seiko Ltd, Tokyo, Jpn); Arai, Kunio. *Circuits Manuf* v 27 n 12 Dec 1987 p 33, 35-36, 38.

**085187 TUNE-UP FOR MICRODRILLING.** The author gives advice to those PCB producers who work with their older machines how to increase productivity in PCB microdrilling and reduce drill bit breakage. One of the methods is progressive, or peck, drilling which offers improved ability for drilling small high-aspect ratio holes, especially in hard-to-drill substrates. The practice not only allows the production of previously impossible holes, but can produce these holes without excessive bit breakage and without significantly increasing WIP time in the drilling room. The main rule in peck drilling is to drill as deeply as possible on the first peck then proceed as quickly as possible from there. Other improvements include using higher spindle speed as microdrill diameters go down checking machine stability, its squareness and collect run-out. Suggested modifications include doubling up of the spindles adding a camera to the drilling machine for better drill alignment and using a larger tool-change cassette.

Hendrik, Ed (Advanced Controls, Irvine, CA, USA). *Circuits Manuf* v 28 n 8 Aug 1988 p 63-64, 65.

**085188 SMALL HOLE DRILLING PRODUCTIVITY.** Even though significant production gains can be achieved using standard drill bit configurations with a dynamically stable machine, the realization of full productivity potential awaits major innovations in drill bit design. The author suggests using higher drilling speeds. The benefits of high-speed drilling with conventional bits in machines of high dynamics stability are: increased bit life, low cutting temperatures, absence of fiber crushing and good hole wall quality. The factors which can improve the drill bit performance are discussed. They include material chip removing ability, penetration force and self-centering. Also discussed are the factors on which drill wear depends, the four most predominant being: distance the cutting edge travels, load on the cutting edge, abrasiveness of the workpiece material, and cutting temperature.

Kosmoski, Wojciech (Dynamotion, Santa Ana, CA, USA). *Circuits Manuf* v 28 n 8 Aug 1988 p 4.

## Electric Field Effects

**085189 ELECTROSTATIC DISCHARGE: AN EXAMINATION OF CONCERNS, ISSUES, AND SOLUTIONS - PART 1.** This is the first part of a two-part article about issues related to controlling electrostatic discharge (ESD) damage in PWB assembly environments. Part one discusses appropriate amounts of ESD damage protection, tips for preventing ESD, and education. (Edited author abstract)

Bartos, Sara (ELECTRI-ONICS, Libertyville, IL, USA). *Electronics* v 33 n 11 Jul 1987 p 27-30.

**Electric Power** See ELECTRIC POWER SUPPLIES TO APPARATUS—Switching.

## Electric Wiring

**085190 CHARACTERIZATION OF VIA CONNECTIONS IN SILICON CIRCUIT BOARDS.** Conducting vias, isolated by silicon dioxide from a bulk silicon wafer and used to interconnect stripline transmission lines on opposite surfaces of the wafer, are analyzed. The net VSWR (virtual standing wave ratio) and insertion loss for a single via and the crosstalk or coupling between two nearby vias are determined as a function of geometry, frequency, and silicon resistivity. For small via dimensions and frequencies up to 1 GHz, the analysis predicts low VSWR and low insertion loss, provided the silicon resistivity is greater than about 100  $\Omega$ -cm. It is shown that crosstalk can be small, and is mostly due to inductive coupling. 6 refs.

Quine, John P. (GE, Schenectady, NY, USA); Webster, Harold F.; Glascock, Homer H.; Carlson, Richard O. *IEEE Trans Microwave Theory Tech* v 36 n 1 Jan 1988 p 21-27.

**085191 ON TWO-DIMENSIONAL VIA ASSIGNMENT FOR SINGLE-ROW ROUTING.** The authors study the via assignment problem when vias are allowed to appear rowwise as well as columnwise. Previously they proved that the problem belongs to the class of NP-hard problems and therefore it is unlikely that polynomial-time algorithms exist for solving the problem. Two heuristics (HEU1 and HEU2) to solve the problem were proposed. HEU1 splits the nets before any routing is done while HEU2 assigns the nets alternately to via rows and via columns. Here they modify HEU2 so that the side of the board to which the nets are assigned first for connection is selected according to a desired ratio of board width to height. 13 refs.

Du, H.C. (Univ of Minnesota, Minneapolis, MN, USA); Ibarra, Oscar H.; Naveda, J. Fernando. *IEEE Trans Comput* v 37 n 6 Jun 1988 p 721-727.

**Electronics Packaging** See Also ELECTRIC CONNECTORS; ELECTRONIC EQUIPMENT MANUFACTURE—Equipment.

**085192 OBLIQUE ROUTING SYSTEM FOR FACOM M-780 SSC.** This paper describes an automatic routing system called the oblique routing system, which is used for large-scale, high-density printed wiring boards (PWBs). In addition to the conventional X and Y directions, several oblique directions are provided for the routing axes in this system. This multidirectional routing technique reduces the required wiring length and minimized the number of routing fail wires when compared with conventional methods. As a result, the propagation delay related to the interconnections of modules mounted on PWBs is reduced to enable increased package densities to be used on PWBs. This system was used to support the development of the FACOM M-780 PWBs, for which the CPU can now be mounted on a single board. (Author abstract) 3 refs.

Oda, Masahiro; Hamaguchi, Tatsuo. *Fujitsu Sci Tech J* v 23 n 4 Dec 1987 p 236-242.



**085193 DEVELOPMENT OF PACKAGING TECHNOLOGY.** Printed board assembly technology has developed rapidly since the end of the 1970's. The main driving factor has been the drastic increase in the functional content and speed of the semiconductor components. Now not only hermetically encapsulated components but also plastic packages are acceptable for demanding applications. Ericsson Telecom will employ several different types of packaging technique. Surface mounting is becoming an important method for many products although through hole mounting will still be used for long time. The author describes the development of printed board assemblies emphasizing the adaptation of packages for large VLSI circuits, and also the development of packages and its background. (Author abstract) 6 refs.

Liljestrand, Lars-Gunnar (Ericsson Telecom AB). *Ericsson Rev (Engl Ed)* v 64 n 4 1987 p 189-197.

**085194 ENTWICKLUNG VON SMD-LEITERPLATTEN-REINIGUNGSVERFAHREN FÜR ZEITGEMÄSSE ANSPRÜCHE.** [Development of SMT-Printed-Circuit Cleaning Techniques for Timely Requirements]. Problems associated with cleaning of printed circuits based on surface mounted technology are considered. These circuits incorporating surface mounted devices have a high packing density and therefore all separations between components have to be reduced considerably as compared with conventional circuitry. The use of ultrasonics as a means of cleaning is pointed out. 9 refs. In German.

Connon, H.A.; Wolff, M.C. *Elektron Prod Prueftech* n 8 Sep 1987 p 50-54.

**085195 PACKAGING PRINTED CIRCUITS.** The need for integration between mechanical and electronic design systems is particularly evident in the design of printed-circuit boards and their packages. Layout tools often require 2D geometric outlines of a board based upon constraints from the electronic package. Equally important, thermal analysis conducted during electronic package design often has a significant impact on the placement of components during board layout. This level of interaction requires numerous data transfers from one type of design automation system to another. However, due to the parallel way these systems have evolved, such transfers have been difficult at best. The solution is a design automation environment that automatically provides for data transfer between design, layout, and electronic packaging. One such environment is the Mentor Graphics IDEA Series of engineering workstations which supports not only electronic packaging and thermal analysis, but also PCB design, analysis, and layout.

Wolfson, Marv (Mentor Graphics, Beaverton, OR, USA). *CAE Comput Aided Eng* v 7 n 5 May 1988 p 72, 76.

**085196 DESIGNING ELECTRONICS FOR AUTOMATED INSPECTION.** Electronic packaging technologies, such as pin grid arrays, increasingly small pitch surface mount, and double-sided assemblies are aimed towards the highest possible product density, with improved performance. The gap between inspection effectiveness and advances made in packaging technologies is becoming larger. As efforts proceed, to learn more about critical factors influencing reliability of solder joints, it is prudent to ensure that printed wiring assembly (PWA) design rules evolve to permit the broadest range of anticipated automated inspection requirements. The automated inspection technologies can be made more effective through careful design of electronics for inspection. Significant opportunities lie in both PWA layout and design, as well as electronic component design, tolerancing, and standardisation. Many inspection issues are shared, but with increased recognition of digital radiography's unique capabilities. This discussion emphasises X-ray inspection issues. (Edited author abstract). 22 Refs.

Thompson, D. (IRT Corp, San Diego, CA, USA); Stroebel, T. *Circuit World* v 14 n 4 Jul 1988 p 13-20.

**085197 AUTOROUTING TODAY'S HIGH DENSITY PCBs.** Autorouting a printed circuit board with

mixed component types immediately raises the problem of setting an effective routing grid. Use of a uniform grid diminishes routability to PGA components while a non-uniform fine line grid usually works poorly for SMDs. Our solution to this problem is a 'combination grid' capability that allows the user to specify different grids that are combined to form an overall grid for autorouting. Using the combined grid, the autorouter is able to work effectively to satisfy the requirements of PCBs with mixed component technologies. We describe how the 'evolutionary' strategy is implemented using an iterative rip-up and retry router combined with a squeeze-through and shove-aside router. This implementation has shown itself in practice to achieve a high completion rate while improving the overall quality of the routing with a balanced distribution of wires over the board and among the layers.

Cooper, John (Mentor Graphics Corp, Beaverton, OR, USA); Chyan, David. *Printed Circuit Des* v 5 n 10 Oct 1988 7p.

## Electroplating

**085198 AUTOMATING PLATING SYSTEMS FOR PWB FABRICATION - PART 2.** This is part two of a two-part article that discusses automating plating systems for printed wiring board fabrication. This part covers training, improving capabilities, and advances and developments. (Edited author abstract)

Moosmann, Kari (Electronics, Libertyville, IL, USA). *Electronics* v 33 n 1 Jan 1987 p 47-48.

**085199 CIRCUIT FABRICATION TECHNIQUES FOR SMT BOARDS.** Changes in circuit board design and characteristics are considered. With surface attachments eliminating the need for insertion of leads in through holes, surface mount device (SMD) designs include chip carriers, flat pads on external surfaces, and smaller holes (vias) that allow for more interconnections in the steadily increasing board logic capacity. An examination of the US trends exhibited in board design and fabrication through the 1980s shows a notable evolution prompted by the increasing use of surface mount technology (SMT) and multilayer board (MLB) usage. New plating techniques of the boards are described that are based on electro-deposited copper for through-hole connection. 5 refs.

Nargi, Kathy (Enthone Inc, New Haven, CT, USA). *Circuits Manuf* v 27 n 12 Dec 1987 5p between p 59 and 66.

**085200 EFFECT OF SURFACE TREATMENT ON THE ELECTROPLATED COPPER/CARBON INTERFACE.** Conventional copper electroplating of the through holes of a printed circuit board is based upon the adsorption of a tin/noble metal complex, as the catalyst for the electroless copper deposition, followed by electrolytic copper plating. This paper will describe briefly a radically different technology, based on carbon particle adsorption, as the precursor to electroplating through the hole. In both cases, the printed circuit boards undergo surface treatments. The manner in which these treatments affect the adsorption phenomena and locus of failure of electroplated model surfaces will be discussed. Adsorption studies and surface energy analyses were used to monitor surface treatment effects. XPS and SEM were used to define and image the locus of failure of electroplated model surfaces in peel and lap shear tests. The correlation of these data with advancing and receding contact angles and surface energy will also be discussed.

Pendleton, Phillip (Olin Hunt Specialty Products Inc, Palisades Park, NJ, USA). *Surf Interface Anal* v 11 n 6 Apr 1988, Proc of the 9th Symp on Appl Surf Anal, Dayton, OH, USA, Jun 3-5 1987 p 400.

## Equipment

**085201 DRILLING ROUTING, AND CUTTING TOOLS, EQUIPMENT, AND ACCESSORIES SPECIFICATION GUIDE.** This guide includes features and

specifications of equipment used to drill, separate, and profile printed wiring boards. It also includes information to facilitate selection of drill and router bits. Also included is a section containing accessories, kits, tools, equipment, and services offered by manufacturers and distributors.

Anon. *Electronics* v 33 n 4 Mar 1987 p 22-25.

## Etching See Also COPPER AND ALLOYS—Etching.

**085202 SULFURIC/PEROXIDE ETCHANT - A NOVEL REGENERATION METHOD.** Two methods of recycling sulfuric-peroxide have been described and the merits (and demerits) of each pointed out. With the increased emphasis on environmental control and the liabilities associated with landfill disposal methods, the practice of recycling chemicals is becoming more attractive. In the case of the machines described, there is the possibility of recovering some of the operating cost through the sale of the by-product, either as copper or copper sulfate. 5 refs.

Stupar, Max (QMS Circuits Inc, Walton Beach, FL, USA). *Met Finish* v 86 n 2 Feb 1988 p 95-99.

## Fabrication See Also INTEGRATED CIRCUITS; INTEGRATED CIRCUITS, VLSI—Components.

**085203 FABRICATION OF A TWO-SIDED SURFACE MOUNT PRINTED CIRCUIT BOARD.** Surface mount technology (SMT) is a method of attaching leadless, short leaded, or bare chips to various substrate materials. This technology is not new, but has caught on as a method of assembling printed circuit boards and is considered the wave of the future, since it permits the packaging of a large amount of circuitry in a very small area. SMT, which may be regarded as a marriage between conventional hybrid assembly and printed circuit boards, has been used for over 30 years in the hybrid industry. This article discusses how the technologies developed by the hybrid industry were applied to a computer graphics controller consisting of a two-sided surface mount assembly printed circuit board. 2 refs.

Danner, Paul A. (Pacific Hybrid Microelectronics Inc, Portland, OR, USA); Bruce, Robert A. *Solid State Technol* v 30 n 9 Sep 1987 p 51-52.

**085204 POLYMER CIRCUIT AND COMPONENT BOARD.** [Polymer Circuit and Component Board]. The report deals with conditions, results, experience, and conclusions from the work a-s elbau has accomplished in connection with the examination of the possibilities and limitations of the polymer thickfilm technology. The report begins with a main report which gives the decision-makers an insight into the technic and economic aspects of the PTF-technology. This is followed by 4 part projects that all together represent the practical implementation of the PCB project. 14 refs. In Danish.

Wuertz Nielsen, Claus (Elektronikcentralen, Horsholm, Den). *Elektronikcentralen Rep ECR* 202 Jan 1987 145p.

**085205 CHARACTERIZATION OF SURFACES AND INTERFACES DURING CIRCUIT BOARD MANUFACTURE.** This paper describes surface and interface analysis studies done on manufacturing-line parts as a function of the processing steps in order to establish the reasons for failures in the processing and to rectify them. They were supplemented by laboratory-scale simulations of some of the processes. The analytical techniques used involved the usual sophisticated surface analyses, XPS and SAM, but were also supplemented by simpler methods such as SEM, ultraviolet microscopy and ink tracing. (Edited author abstract)

Brundell, C.R. (IBM, San Jose, CA, USA); Miller, D.C.; Auerbach, D.J. *Surf Interface Anal* v 11 n 6 Apr 1988, Proc of the 9th Symp on Appl Surf Anal, Dayton, OH, USA, Jun 3-5 1987 p 400.

## Heat Sinks

**085206 DEVELOPMENTS IN PASSIVE THERMAL MANAGEMENT SYSTEMS FOR ELECTRON-**



ICS. Increasing power densities within electronic equipment have led to a rise in the number of heat related problems being experienced. This paper describes the use of computerized thermal analysis techniques to optimise the design of passive thermal management systems for electronic equipment. (Author abstract)

Hamilton, S. (Enco Industries Ltd, Howwood, Scotl). *Circuit World* v 14 n 1 Oct 1987 p 22-25.

**085207 HOW TO SELECT ADHESIVE FILM FOR HEAT SINK ATTACHMENT TO PWB'S.** The main selection requirements for a material used to attach a heat sink to a PWB are good thermal conductivity, adequate bond strength, and sufficient resilience to offset assembly warpage and prevent stress transfer to delicate components or circuitry on the PWB. Such warpage and stresses occur as a result of the different thermal expansion coefficients of the PWB and heat sink. This paper discusses the subjects of choosing adhesive materials, film selection, common bonding problems and film application.

Dominic, Chris (Ablestik Lab, Gardena, CA, USA). *Electronics* v 33 n 4 Mar 1987 p 48-49.

## Heat Transfer

**085208 HEAT TRANSFER ANALYSIS OF DIGITAL TRANSMISSION EQUIPMENT WITH HORIZONTALLY ARRANGED PRINTED CIRCUIT BOARDS.** Printed circuit boards (PCBs) may be arranged horizontally in many situations, as for example in some digital transmission equipment being used in Brazil. Such pieces of equipment, known as slim racks, have a high aspect ratio (height/width) and are assembled side by side and back to back. The present work deals with the steady-state thermal dissipation in the so-called thermal unit of the slim rack made of the PCB, the magnetic shield above it and the bounding walls constituting an enclosure. The heat transfer in each thermal unit was investigated by assuming isothermal enclosure surfaces with uniform radiosities. Once the thermal paths are identified, an electric circuit analogy is employed to obtain the overall thermal resistance network. Most of the thermal resistances are temperature-dependent, so the associated nonlinear algebraic equations can be solved only by an iterative method. An experimental investigation was carried out in a module of the slim rack with simplified boundary conditions in order to verify the theoretical model. There was good agreement between the theoretical and experimental temperature fields. (Author abstract). 17 Refs.

Carvalho, R.D.M. (Univ Estadual de Campinas, Sao Paulo, Brazil); Goldstein, L.; Milanez, L.F. *Heat Transfer Eng* v 9 n 3 1988 p 44-53.

## Impedance Matching

**085209 CONTROLLED IMPEDANCE INTERCONNECTIONS: THEORIES, PROBLEMS, AND APPLICATIONS - PART 2.** This is the second of a two part article discussing changes in the interconnection and packaging of electronic components. This part addresses controlled impedance design and crosstalk. Few solutions to the problems of designing controlled impedance interconnection systems have been provided here. However, this article is intended to increase awareness to the problem, and give some background in electromagnetic waves, which may lead to a better understanding of how to cope with increasingly stringent design, processing, and fabrication requirements. (Edited author abstract)

Fujitsu, W.S. (Hughes Aircraft Co, Irvine, CA, USA). *Electronics* v 32 n 13 Dec 1986 p 55-56.

**Inspection** See Also ELECTRONIC EQUIPMENT MANUFACTURE—Robotic Assembly.

**085210 SYSTEM FOR INSPECTING CIRCUIT BOARDS.** A printed circuit board made of translucent material and having circuit paths deposited on both sides is presented. Inspection of the circuit board for flaws is

accomplished by projecting light from a source onto one side of the board, e.g., the back side of the board, to back light and silhouette the circuit paths on the front side of the board. The light passing through the translucent board is diffused so that the back circuit paths are not silhouetted on the front side of the board. However, if a silhouette of paths does appear, it will be a substantially attenuated representation thereof in comparison to the dark silhouette of the front circuit paths. The inspection of the board is described.

Wyatt, K.L. *Tech Dig AT&T Technol* n 78 Jul 1986 p 31-32.

**085211 INSPECTING BARE BOARDS.** The Inspection/Testing of PCBs was covered previously. The author deals with the philosophy behind the test methods, an understanding of which helps in the assessment of the results. 2 refs.

Manfield, Henry G. *Electron Prod (London)* v 16 n 10 Oct 1987 p 46-48, 50.

**085212 AUTOMATED INSPECTION - ARE WE SOLVING THE RIGHT PROBLEM? - PART 2.** While inspection is the most frequent operation in circuit board assembly, it has not been widely automated because of serious shortcomings in existing inspection systems. These systems have been unable to address important classes of defects, relied on inadequate camera-based imaging, and have focused on identifying defects rather than shippable products. To achieve acceptance, inspection systems for circuit board assembly must perform like inspection personnel, only faster and more accurately. The article shows how inspection systems can improve their performance using high resolution 3-D vision and multiple quality models. 4 refs.

Juha, Mika (Photonic Automation Inc, Santa Ana, CA, USA). *Surf Mount Technol* v 1 n 3 Jun 1987 p 13-15.

**085213 LASER INSPECTION SYSTEM PROVIDES PROCESS CONTROL DATA.** Purchased to reduce the cost of detecting PCB solder-joint defects, Laser/INSPECT equipment from Vanzetti Systems Inc. was instrumental in diagnosing the cause of repeated PCB solder-joint defect patterns in circuit boards used for computer-based gasoline dispensing systems. The inspection system eliminated the cause of major PCB defects, bringing the board reject rate down to 0.7 percent from an excessively high figure while eliminating 9,000 hours of inspection and rework annually.

Roeger, Bill (Tokheim Corp, Albion, IN, USA); Morrison, Ron. *Electron Packag Prod* v 27 n 2 Feb 1987 p 128-129.

**085214 TRACKING THE EVOLUTION OF AOI.** The technology applied to automated optical inspection (AOI) of bare printed wiring board panels and artwork is evolving at a rapid and sustained pace. Systems currently in use have addressed a critical need by providing basic inspection of fine line products that could no longer be checked by manual methods. The new generation of equipment goes far beyond this, providing vastly improved throughput, versatility, and detection accuracy. The new technology uses image acquisition techniques that are unaffected by the surface condition of the metal, so inspection at the oxide stage is no longer a problem. These image acquisition units also allow detection of 1 mil shorts (measured at the base) in normal operation; while reflected light technology typically allows detection of shorts only down to 2.5 mils.

McDonald, Roy (Optrotech Inc, Billerica, MA, USA). *Electronics* v 33 n 9 Jun 1987 p 12-13.

**085215 RESOLVING PWB INSPECTION PROBLEMS WITH AOI - PART 1.** This is the first part of a two-part article comparing features of automatic optical inspection equipment. This part describes imaging systems, resolution, and speed considerations. (Author abstract)

Bunze, Victor F. (Visionetics, Brookfield Center, CT,

USA). *Electronics* v 33 n 9 Jun 1987 p 15-16.

**085216 ADVANCES IN AOI EQUIPMENT ADDRESS NEEDS, INCREASE THROUGHPUT.** From the beginning, commercially available AOI systems' scan rates were equated with throughput rates. Scan rate, however, is only one factor in the overall throughput equation. Yet many system suppliers tout their product's scan rate and virtually ignore other important elements of throughput. This paper discusses various subjects relating to throughput increase for AOI systems, including setup time, false defects, evaluation and repair.

Domres, Douglass M. (AOI Systems Inc, Westlake Village, CA, USA). *Electronics* v 33 n 9 Jun 1987 p 21-22.

**085217 HOW TO SELECT AN AOI SYSTEM - PART 1.** This is part one of a three-part article that describes factors to consider when purchasing an automatic optical inspection (AOI) system. This part discusses why AOI should be used, how to define needs, technical tradeoffs, and features. (Edited author abstract)

Benron, Hai (Orbot Inc, Woburn, MA, USA). *Electronics* v 33 n 9 Jun 1987 p 23-26.

**085218 CONSIDERATIONS FOR USING PWB VISUAL INSPECTION - PART 1.** This is the first part of a two-part article about visual inspection of printed wiring boards. Part one includes information about applications and capabilities of visual inspection. (Edited author abstract)

Kempf, Paul S. (Metron Optics Inc, Solana Beach, CA, USA). *Electronics* v 33 n 9 Jun 1987 p 35-36.

**085219 INSPECTING SURFACE MOUNTED PCBs WITH 3-D LASER SCANNERS.** Compared with 2-D imaging, the 3-D scanning method separates component and background as a function of height and shape, providing reliable inspection data. The 3-D laser scanner analyzes gray scale patterns as well as height measurements so that such variations as color, texture or the effects of ambient lighting do not influence its performance.

Trail, David K. (Synthetic Vision Systems, Ann Arbor, MI, USA); Jakimcius, Andrew. *Surf Mount Technol* v 2 n 2 Apr 1988 p 19-21.

**085220 OVERVIEW OF PWB INSPECTION/REWORK METHODS.** PWB inspection/rework capabilities can be found either on the assemble equipment in the form of component verifiers, or off the system as test rework stations. Often, off-line test units are either manual rework stations working in conjunction with automated test equipment (ATE) or automated optical inspection (AOI)/repair cells. This paper discusses both manual repair/rework stations and AOI systems. It is concluded that whichever inspection/repair method is used, manual or automated, it is vital that this step of the assembly process be closely investigated before any dollars are investigated.

Horne, Dennis (Universal Instruments Corp, Binghamton, NY, USA). *Electronics* v 33 n 11 Jul 1987 p 23-24.

**085221 RESOLVING PWB INSPECTION PROBLEMS WITH AOI - PART 2.** This is the second part of a two-part article comparing features of AOI equipment. This part covers data storage and referencing. (Edited author abstract)

Bunze, Victor F. (Visionetics, Brookfield Center, CT, USA). *Electronics* v 33 n 11 Jul 1987 p 35-36.

**085222 CONSIDERATIONS FOR USING PWB VISUAL INSPECTION - PART 2.** This is the second part of a two-part article about visual inspection of printed



wiring boards. Part two discusses optical comparators, microscopes for solder joint inspection, and 3-D scanners. (Edited author abstract)

Kempf, Paul S. (Metron Optics Inc, Solana Beach, CA, USA). *Electronics* v 33 n 11 Jul 1987 p 37-38.

**085223 HOW TO SELECT AN AOI SYSTEM - PART 2.** This is part two of a three-part article that describes factors to consider when purchasing an automatic optical inspection (AOI) system. Part two covers the setup, operational tradeoffs, ease of operation, and throughput. (Edited author abstract)

Benron, Hai (Orbot Inc, Woburn, MA, USA). *Electronics* v 33 n 11 Jul 1987 p 39-42.

**085224 AUTOMATED VISUAL INSPECTION FOR PRINTED CIRCUIT BOARDS.** This paper describes newly developed inspection technologies for intermediate products of PCBs such as photomask patterns, inner layer copper patterns, plated through holes of multilayer boards, and mounted components. New techniques were developed in such areas as sensing optics and inspection algorithms. (Edited author abstract) 4 refs.

Ando, Moritoshi (Fujitsu Lab, Atsugi, Jpn); Nakashima, Masato; Inagaki, Takefumi. *Fujitsu Sci Tech J* v 24 n 1 Mar 1988 p 1-23.

**085225 INFRAROT-LEITERPLATTEN-PRUEFUNG.** [Infrared Inspection of Printed-Circuit Boards]. Using the system under review it is possible to conduct computer-aided evaluation of the infrared heat images of assembled printed-circuit boards in the operating state and compare these actual images with desired images. Wide-ranging analysis for quality assurance purposes is thus possible. (Author abstract). In German.

Wendeler, V. *F&M Feinwerktech Messtech* v 96 n 6 Jun 1988 p 263-264.

**085226 AUTOMATIC SOLDER JOINT INSPECTION.** The task of automating the visual inspection of pin-in-hole solder joints is addressed. Two approaches are explored: statistical pattern recognition and expert systems. An objective dimensionality-reduction method is used to enhance the performance of traditional statistical pattern recognition approaches by decorrelating feature data, generating feature weights, and reducing run-time computations. The expert system uses features in a manner more analogous to the visual cues that a human inspector would rely on for classification. Rules using these cues are developed, and a voting scheme is implemented to incrementally accumulate classification evidence. Both methods compared favorably with human inspector performance. 32 refs.

Bartlett, Sandra L. (Univ of Michigan, Ann Arbor, MI, USA); Besl, Paul J.; Cole, Charles L.; Jain, Ramesh; Mukherjee, Debashish; Skifstad, Kurt D. *IEEE Trans Pattern Anal Mach Intell* v 10 n 1 Jan 1988 p 31-43.

**Labeling** See Also BAR CODES—Applications.

**085227 HOW AND WHY TO MARK ELECTRONIC COMPONENTS, BOARDS, AND PACKAGES.** This paper discusses marking methods for electronic components and the purpose and benefits of various marking methods: direct printing, dry offset, rotary dry offset, laser printing and pad printing. Methods to produce pressure sensitive labels are compared.

Nelson, Benjamin A. (Markem Corp, Keene, NH, USA). *Electron Manuf* v 34 n 6 Jun 1988 p 8-9.

**085228 MATCHING APPLICATION REQUIREMENTS AND MATERIALS USED FOR LABELS.** Electronic industry places high demands on labels used in its manufacturing processes and environments. Because of these demands, many specialized label substrate materials, coatings, adhesives, and carriers have been developed. The specifying engineer in production or quality control (QC) is faced with decisions about labelling that can impact the bottom line significantly - positively or negatively. The

type, quality, and printing techniques used for a label can mean the difference between a smoothly running production line, or one that is plagued with downtime. This paper discusses printing methods used for labels, bar coding label construction, labels for integrated circuits, aluminum labels, labels for PCB's and the ways to specify wires and cables.

Lyon, Marty (EPC Identification Systems, Rohnert Park, CA, USA). *Electron Manuf* v 34 n 6 Jun 1988 p 23-26.

**085229 HOW TO SELECT BAR CODE LABEL MATERIALS FOR PCB IDENTIFICATION.** This paper explains how to match label characteristics with conditions PCB's undergo during manufacture, and selection criteria for a variety of label materials. The paper provides the guidelines to select bar code labels for PCB's and explains the structure of a bar code label.

Williams, James R. (Imtec Inc, Bellow Falls, VT, USA). *Electron Manuf* v 34 n 6 Jun 1988 p 38-40.

## Laser Applications

**085230 HOW LASER PHOTOPLOTTING ASSISTS COMPUTER AIDED DESIGN GROUPS.** Recently, there has been increasing interest in using the capabilities available on laser plotting systems from both captive and independent computer aided design (CAD) groups. This trend may be attributed to the increasing availability of laser plotting systems, the introduction of new capabilities by laser plotter manufacturers, and increased awareness of these capabilities by people in CAD organizations. It is beneficial to the designer that laser plotters can handle large plot files, so that the designer no longer needs to limit designs because of photoplotting costs. However, it is important for other reasons that circuit designers do not unnecessarily increase the size of their image files. This article contains suggestions that may be implemented in order to reduce the amount of image data in new designs.

Klages, Scott (Excellon Phototonics, Costa Mesa, CA, USA). *Electronics* v 33 n 16 Oct 1987 p 19-21.

**Machining** See MACHINE TOOLS—Control.

## Maintenance

**085231 REPAIR OF PRINTED CIRCUIT BOARDS CARRYING SURFACE MOUNT COMPONENTS.** Removal and replacement instructions for surface mounted components are given, as well as certain precautionary measures and examples. Some of the figures have already been published in service manuals. A distinction is made between methods for replacing one or a few components, several components and many components. It is indicated which method can be applied, which equipment is available and what must be considered. (Author abstract) 4 refs.

Verguld, M.M.F. (Nederlandse Philips Bedrijven BV, Eindhoven, Neth); Leenaerts, M.H.W. *Circuit World* v 14 n 2 Jan 1988 p 11-15.

**Manufacture** See Also ADHESIVES—Applicators; BAR CODES—Laser Applications; CAPACITORS—Failure; COMPUTER AIDED MANUFACTURING; COMPUTER AIDED MANUFACTURING—Costs; COPPER PLATING—Additives; DRILLS—Bits and Holders; ELECTRON DEVICE MANUFACTURE—Assembly; ELECTRONIC CIRCUITS—Assembly; ELECTRONICS PACKAGING; ELECTROSTATICS—Electric Charge; INTEGRATED CIRCUIT MANUFACTURE; INTEGRATED CIRCUIT MANUFACTURE—Design; INTEGRATED CIRCUIT MANUFACTURE—Microwave; INTEGRATED CIRCUIT MANUFACTURE—Modular Construction; INTEGRATED CIRCUIT MANUFACTURE—Performance; INTEGRATED CIRCUIT MANUFACTURE—Soldering; INTEGRATED CIRCUIT TESTING—Contamination; INTEGRATED CIRCUITS—Masks; INTEGRATED CIRCUITS, LSI—Design; PHOTO-RESISTS—Performance; RADIOGRAPHY—Automation; ROBOTIC ASSEMBLY; ROBOTS, INDUSTRIAL—Grippers; SCHEDULING—Mathematical Models; WASTE-WATER—Treatment.

**085232 METALIZING THROUGH-HOLE INTERCONNECTIONS.** Plated through-hole processing has experienced the introduction of new processes, new

chemistries, and new technologies at an unrestrained rate. The impact of surface-mount technology and the special electrical requirements of high-speed packaging has hit interconnection techniques. A look at some improvements on the standard plated through hole process, changing production methods, and plating chemistry is taken as part of the special series on printed circuit manufacture. 10 refs.

Smith-Vargo, Linda (Electronics Packaging & Production, Newton, MA, USA). *Electron Packag Prod* v 27 n 9 Sep 1987 p 56-59.

**085233 LOW-WASTE TECHNOLOGY FOR FINAL PCB ETCHING.** The article gives recommendations on how to implement low-waste technology for final PCB etching operations. Specific types of etchants are presented and off-the-shelf waste treatment and metal-recovery systems are listed. 3 refs.

Smith-Vargo, Linda (Electronic Packaging & Production, Newton, MA, USA). *Electron Packag Prod* v 27 n 10 Oct 1987 p 52-53.

**085234 AUTOMATING A PRINTED CIRCUIT CARD LINE.** In the early 1980s, IBM's Charlotte facility decided to automate its production line for the IBM Proprietary electronic card assembly. Unique features of the Charlotte line include the presence of automatic laser marking and work-holder loading, a common magazine containing various PC card part numbers, random delivery of magazines to insertion equipment throughout the process center, and computer control of all aspects of the assembly process. In addition, a mix of auto-insertion equipment and robotics is present, as is automatic vision inspection - an integral part of the process - and automatic robotic loading of PC cards into solder equipment from the work holder.

Cooper, Stuart (IBM, Charlotte, NC, USA). *Electron Packag Prod* v 27 n 10 Oct 1987 p 88-90.

**085235 EXAMINATION OF FACTORS INFLUENCING ADDITIVE/SUBTRACTIVE CIRCUIT FABRICATION - PART 1.** One of the most controversial topics in electronic manufacturing is the fabrication of circuit traces to produce printed wiring boards. The difficult problems associated with producing increasingly dense boards are exacerbated by worker safety and environmental issues, government regulation, and an increasing amount of offshore competition. This article examines some of the critical issues, problems, and trends associated with fabricating boards using additive and subtractive techniques. The first part of the article begins with an examination of the materials on which much of the attention is focused: the prepreg and laminate.

Bartos, Sara (Electri-onics, Libertyville, IL, USA); Davenport, Bill. *Electronics* v 32 n 12 Nov 1986 p 19-22.

**085236 EXAMINATION OF FACTORS INFLUENCING ADDITIVE/SUBTRACTIVE CIRCUIT FABRICATION - PART 3.** This article is the third part of a three-part examination of the issues, problems, and trends associated with fabricating PWB's using additive and subtractive techniques. This part begins with a discussion of three dimensional molded board technology. (Author abstract)

Bartos, Sara (Electri-onics, Libertyville, IL, USA); O'Loughlin, Michael; Davenport, Bill. *Electronics* v 33 n 1 Jan 1987 p 19-21.

**085237 SELECTING AND USING ROUTING EQUIPMENT FOR PANEL SEPARATION.** Cutting and dpaneling has become more complex because of the trends toward increased density and unusual PWB configurations. Routing equipment has evolved from routing bare boards to also routing loaded and surface mounted boards. With changes in boards and components, routing equipment can be adapted or refined to fulfill the PWB fabricator's requirements. This paper discusses various factors to consider when selecting routing equipment.



These factors include tool bit specifications, component heights, and electrostatic discharge (ESD). Several ways in which a board may be routed are described. Routing equipment will experience increasing integration into automated systems in the next two to three years, requiring minimal operator intervention, and improving productivity and manufacturing yields.

Stewart, Tom (Easterline Co, Torrance, CA, USA). *Electronics* v 33 n 1 Jan 1987 p 37-39.

**085238 PWB WASTEWATER PROBLEMS.** Manufacturers of printed circuits have to meet wastewater disposal regulations. The article reviews some basic wastewater concerns in which problems can arise. Some of these are pH control, heavy metals, total toxic organics, cyanides and dumping.

Frizzell, Michael A. *Prod Finish (Cincinnati)* v 51 n 12 Sep 1987 p 90-96.

**085239 ONE-WAY ETCH: THE SCIENTIFIC APPROACH TO ADVANCING THE STATE OF PCB ART.** The etching of rectangular lines on printed circuit boards by means of nitric acid is described. Copper foils of a special variety of crystallographic texture [III] has to be used for best results. The research problems, the system approach adopted, and the technical aspects of the process are briefly described.

Murray, Jerry (Circuits Manufacturing, San Francisco, CA, USA). *Circuits Manuf* v 27 n 8 Aug 1987 p 23-25.

**085240 FORCEFUL PLATING: AN AUTOMATED ALTERNATIVE TO PROGRAMMABLE HOIST PLATING SYSTEMS.** In 1981, Hewlett-Packard Co. began PCB manufacturing operations in a new facility in Boise, ID. After five years of production operation, H-P's conveyorized impingement-agitated plating system can be declared a success. The processes are segregated into the develop-and-plate line and the strip-and-etch line. The plating processes are bright acid copper, Watts nickel and bright acid tin. The etching is a conventional proprietary alkaline process. All plating operations are conventional in that the panels are submerged in the tanks, but they are unconventional in. Several respects which are described. 8 refs.

Davidson, D. Paul (Hewlett-Packard Co, Boise, ID, USA). *Circuits Manuf* v 27 n 8 Aug 1987 p 36, 38-40, 42.

**085241 NEW COPPER SURFACE TREATMENT FOR POLYIMIDE MULTILAYER PRINTED WIRING BOARDS.** A new treatment method for the copper innerlayers of polyimide multilayer printed wiring boards has been developed. Conventional oxide coatings experience acid penetration through the bonding interface during through-hole plating pretreatment. This problem was eliminated by substitution of metallic copper for the surface oxide. Promotion of the copper innerlayer adhesion to the prepreg by the oxide coating was based upon a mechanical interlocking effect caused by the minute roughness of the oxide crystals. Reduction treatment of the surface oxide layer was found to give a metallic copper surface with no changes in its morphology. Adhesion strength of polyimide prepregs to copper foils after the reduction treatment was equivalent to that of the original brown oxide coating. Acid resistance was enhanced by elimination of the oxide layer from the bonding interface. (Edited author abstract) 6 refs.

Akahoshi, H. (Hitachi Ltd, Hitachi, Jpn); Kogawa, K.; Suzuki, Y.; Wajima, M. *Circuit World* v 14 n 1 Oct 1987 p 18-21.

**085242 CRITICAL ASPECTS OF MULTILAYER MANUFACTURE.** The key to the production of high quality multilayer PWBs lies in a clear understanding of the many interactions between the chemical and mechanical processing involved. This describes some of these interactions, namely those between oxide treatment, lamination and drilling and the subsequent chemical processing steps, up to, and including, copper electroplating. Choice of oxide treatment has consequences that are not limited to the lamination and drilling operations. Process

problems, such as 'pink ring (haloing)' are discussed in the context of their sensitivity to particular stages in the manufacturing process. (Author abstract) 9 refs.

Bayes, M. (Enthone Inc, West Haven, CT, USA); Chiba, K.; Kurokawa, Y. *Circuit World* v 14 n 1 Oct 1987 p 26-28.

**085243 PHOTOTOOLS FOR PRINTED CIRCUIT BOARD PRODUCTION - PART 2.** Photographic films and glass plates are widely used as phototools for PCB production. In this two-part paper photographic and physical characteristics of the products are discussed as well as their differences and specific features. Terms such as contrast, density, speed, processing, etc. are explained and dimensional stability is discussed in depth. Suggestions are made for proper handling of the photographic materials. (Author abstract)

Junginger, H. (Kodak AG, Stuttgart, West Ger); Werner, W. *Circuit World* v 14 n 1 Oct 1987 p 32-35.

**085244 DEVELOPMENTS IN PCB PLATING AND CHEMICAL SYSTEMS.** Much has happened in the last few years to make it cost effective for both large and small R&D establishments to become self sufficient in the production of prototype and small batch pcbs, labels and front panels. Experiences by several British manufacturers are reported.

Walton, J. Page. *Electron Prod (London)* v 15 n 11 Nov-Dec 1986 4p between p 29 and 35.

**085245 OXIDE SELECTION TIPS FOR MULTILAYER PWB FABRICATION.** The primary reason a black, brown, or red copper oxide is used is to passivate the copper board surface, i.e., prevent the copper from oxidizing in an uncontrolled manner. If a surface is unpassivated and nonuniform oxidation occurs, water can form on the copper surface when heat and pressure are applied during lamination. Oxides also are used to increase surface area, and consequently strengthen layer to layer lamination. An important factor in choosing an oxide is the type of substrate material to be treated. Other criteria for oxide selection include cosmetic appearance, peel strength, cost and ease of operation.

Nargi, Kathy (Enthone Inc, New Haven, CT, USA). *Electronics* v 33 n 4 Mar 1987 p 19-20.

**085246 EXOTIC PCBs FOR HOT SMDs.** This article reports on three alternative configurations of PCB (printed circuit board) for use at high temperatures with surface mounted components. All three designs have been developed independently to overcome problems of thermal mismatch between conventional PCBs and ceramic SMDs, and the resulting breaks in soldered contacts. With components mounted directly onto the board, even small variations in the dimensional changes of the board and component, as the temperature fluctuated, could lead to cracks in the soldered joints.

Rogerson, Steve. *Eng Mater Des* v 31 n 10 Oct 1987 p 35-36.

**085247 TYPE SRM-01 SPECIALIZED WORKPLACE FOR ASSEMBLY OF PRINTED CIRCUIT BOARDS.** The type SRM-01 specialized workplace described here is intended for mechanical installation of radioelectronic components (REC) on a printed circuit board in accordance with a prescribed program determined by the technical documentation. The SRM-01 workplace consists of three units: light-indication unit (LIU); component supply unit (CSU); and control and power unit (CPU). The SRM-01 specialized printed-circuit board assembly workplace is simple in design and simple to operate, not requiring a highly skilled worker. Its cost of manufacture is about 2000 rubles.

Permovskii, O.S.; Sagal'skii, V.S.; Bugaev, V.G. *Sov Electr Eng* v 57 n 6 1986 p 116-117.

**085248 FERTIGEN VON MULTILAYERPLATTEN MIT SIMULIERTER PIN-LAMINIERTECHNIK IM MASS-LAM-VERFAHREN.** [Production of

Multilayer Boards by a Simulated Pin-Laminating Technique according to the MASS-LAM Method]. When producing multilayer PC boards by the MASS-LAM method, accurate alignment of the various layers with regard to each other poses a problem. It was found that optical alignment methods do not provide the desired accurate congruence. Systems for lateral mating are equally subject to tolerance losses. With the so-called pin technique, alignment is obtained by inserting pins in the fitting holes of core layers, which would not be possible by the MASS-LAM method. A new, patented method now simulates this pin technique during the pressing and thus provides the advantages of a highly precise alignment by means of fitting holes, but without using fitting pins. (Edited author abstract) In German.

Limberg, Kurt. *Metalloberflaeche* v 41 n 9 Sep 1987 p 432-436.

**085249 STOCK BONDING PROBLEM: A MACRO INVESTIGATION OF MICRO FLAWS IN MIL-SPEC BOARDS.** Current manufacturing technology used to fabricate polyimide PCBs has evolved from processes used to make epoxy boards. These processes have been found to give variable bond quality between innerlayer traces/planes and the polyimide B-stage material. Results of studying standard oxidizing and several novel surface treatments demonstrated that several areas dramatically affected the quality of the copper/polyimide bond. These include strict materials control prior to laminating, incorporating an aggressive chemical copper etching, use of a minimum thickness copper oxide film to promote adhesion, and a laminating press cycle optimized for polyimide. The overall results indicate that this copper/polyimide bond could be improved to the point of structural failure rather than interfacial failure. This may be accomplished within the existing materials and technology or with new surface treatments. 3 refs.

Grannells, R.T. (Hamilton Standard, Windsor Locks, CT, USA); Winiarski, H.C.; Lamm, F.P. *Circuits Manuf* v 27 n 9 Sep 1987 p 28, 31-32.

**085250 JAPAN RESPONDS TO THE COST-DRIVEN MARKET.** The article reviews printed wiring board (PWB) production methods used by the Japanese electronics industry. Sequential multilayer board production and the alternative methods, among them SES and ED processes, are outlined.

Nakahara, Hayao (PCK Technology, Melville, NY, USA). *Electron Packag Prod* v 27 n 12 Dec 1987 p 34-37.

**085251 IMPROVEMENTS IN SOLDERING TECHNOLOGY FOR SEMICONDUCTOR COMPONENTS.** In recent years, there has been much emphasis on the soldering performance of electronic component leads. Improvements toward the goal of zero-defect solderability performance have been made. Some of these are discussed in this paper as they pertain to both dual-in-line components for through-hole mounting and the newer surface-mount devices, small outline integrated circuits and plastic leaded chip carriers.

Asher, Reginald K.; Endicott, Duane W. *Plat Surf Finish* v 75 n 1 Jan 1988 p 34-37.

**085252 STATISTICAL METHODS FOR CONTROLLING THE BROWN OXIDE PROCESS IN MULTILAYER BOARD PROCESSING.** The sodium hydroxide concentration in brown oxide baths for multilayer printed circuit boards determines the crystal structure and color of the coating. The formation of sodium carbonate in these baths limits the accuracy of the existing procedure for chemical control of the sodium hydroxide concentration. Multiple regression models have been developed to compensate for such limitations in the existing analytical method. (Author abstract) 6 refs.

Amadi, S.I. *Plat Surf Finish* v 75 n 1 Jan 1988 p 56-60.



**085253 SCHREIBEN LEITFAEHIGER SUBSTANZEN ALS ALTERNATIVE IN DER LEITERPLATTENFERTIGUNG.** [Drawing of Conductive Substances As an Alternative in Printed Circuit Board Manufacture]. A procedure for drawing conductive bonding agents with canules is considered for application of surface-mounted devices in printed circuit board manufacture. Practical experience in the elimination of flatness variations of the substrate are reviewed, test equipment for verifying functional capacity of the contacts is described, and the results of tests of the most important parameters of the contacts are discussed. In German. 7 refs.

Hoesel, M. (Ingenieurhochschule Mittweida, West Ger). *Feingeraetetechnik* v 36 n 8 Aug 1987 p 346-347.

**085254 DEVELOPING A CLEANER-CONDITIONER FOR ELECTROLESS COPPER.** Three performance criteria had to be attained in order to develop this new cleaner-conditioner: copper cleaning, good rinsability, and glass fiber conditioning. When all three criteria were met the process system interactions between cleaner-conditioner, microetch, catalyst and electroless copper were attained. In order to establish a basis for comparison, backlighting evaluations were performed.

Lynch, Robert W. (M&T Chemicals Inc, Rahway, NJ, USA). *Met Finish* v 86 n 1 Jan 1988 p 31-32.

**085255 CONTROL MATERIAL HANDLING & WATCH ELECTRONICS PRODUCTION SOAR.** The Military Avionics Div., Honeywell Inc., in St. Louis Park, Minnesota, is one of four related facilities which form a material requirements planning (MRP) system for the production of military avionics. Printed wiring assemblies are manufactured here for use in military flight control systems, target systems, and microwave systems. Two single-aisle material handling units are installed at right angles to each other in an L-shaped configuration for progressive assembly of the assemblies.

Anon. *Automation (Cleveland)* v 35 n 1 Jan 1988 p 60-62.

**085256 VIDEO TECHNIQUES AID MACHINE DEVELOPMENT.** Competitive automatic component insertion needs to be at least 99.9% reliable. To achieve this figure, individual parts or mechanisms must be even more reliable, something like 99.9%. As machines become more reliable, errors become rarer and engineers have to wait longer and longer to see examples of what is going wrong. High-speed video captures errors on film so they can be analyzed over and over again using slow motion techniques. Because the human eye is not quick enough to spot high speed errors, Ambotech Ltd used a special video camera to develop its 'Robin' component insertion machine. The first problem which came to light was asymmetric bending of axial components leads. As it lies beneath the PCB, the bending mechanism is difficult to view so the insertion head was filmed instead. Contrary to prior speculation, this revealed that the asymmetric bending was due to faulty insertion and not to faulty bending.

Noble, Peter (Ambotech Ltd). *Electron Prod (London)* v 16 n 11 Nov-Dec 1987 p 25.

**085257 NEW MATERIALS FOR SMT.** Potentially, 55% silicon density may be attainable with advanced surface mount technology (SMT). This approach has been used to replace traditional one-sided boards with PCBs densely populated on both sides with devices soldered directly to surface conductor pads. By eliminating the need to insert component leads into holes, automated assembly is expedited, board real estate is conserved, and the PCBs are simplified and less costly to make.

Shumay, William C. Jr. (Advanced Materials & Processes, Metals Park, OH, USA). *Adv Mater Processes* v 133 n 2 Feb 1988 p 37-40.

**085258 AUTOMATED EDGE CONNECTOR PLATING EQUIPMENT FOR PRINTED CIRCUIT BOARDS.** This paper describes the development of a new generation automated edge connector plating system specifically concerned with the even distribution of pre-

cious metal on the connector surfaces. Other aspects include the minimization of process chemical contamination through the development of special interstage sealing methodology, and the introduction of high speed process chemical technology. (Author abstract) 3 refs.

Hemsley, J.D.C. (OMI Int (GB) Ltd, Woking, Engl). *Circuit World* v 14 n 2 Jan 1988 p 39-41.

**085259 NEW PROCESS TECHNOLOGY FOR HIGH TOLERANCE CIRCUIT BOARDS.** The design of PCBs is highly influenced by the components being mounted on them. Holes with diameters as small as, for example, 0.008 in. and aspect ratios of 10:1 will become standard. More complicated PCBs of higher value need enhanced security and uniformity in processing. An answer to these requirements is provided by UNIPLATE, a horizontal processor developed by Schering Electroplating. To secure hole wall treatment, this system uses floodbars for forcing the solution through the holes. Together with chemicals, tuned to this very application, very high quality PCBs can be accomplished. (Author abstract)

Kreisel, R. (Schering AG, Berlin, West Ger). *Circuit World* v 14 n 2 Jan 1988 p 68-72.

**085260 LASER-DRILLED BLIND VIAS INCREASE PCB REAL ESTATE.** Printed circuit board density and circuit performance have been increased by the use of double-sided surface-mount packages, fine-line widths and spaces down to 3 mils, more impedance-controlled layers, small drilled through-holes, and buried and blind holes (vias). Laser-drilled blind holes increase device area coverage by more than 25 percent at a drilling cost less than that of mechanically drilled blind vias.

Korf, Dana W. (Interconnect Technology Inc, Beaverton, OR, USA). *Electron Packag Prod* v 27 n 2 Feb 1987 p 56-57.

**085261 VACUUM FILLS THE VOIDS IN LAMINATION.** Vacuum-assisted lamination is rapidly becoming the preferred method for fabricating high-density multilayer printed circuit boards. Laminating multilayer printed circuit boards under simultaneous heat, pressure and vacuum results in a void-free, dimensionally stable product.

Markstein, Howard W. (Electronic Packaging & Production, Newton, MA, USA). *Electron Packag Prod* v 27 n 2 Feb 1987 p 62-65.

**085262 COMPLEX MULTILAYER BOARDS VIE FOR SPACE IN JAPANESE COMPUTERS.** Chased by its developing neighbors in the low end of electronic products and strained by the recent upward re-evaluation of its currency against the U.S. and other currencies, Japan is accelerating toward the goal of becoming a major supplier of knowledge-intensive, high-tech products in the world market. VLSI, telecommunications and computers are the most important strategic areas of technology where the Japanese are concentrating their efforts. Multilayer printed circuit boards are fabricated in Japan with electroplated, 2.36-mil-wide conductors and 21:1 aspect ratios for plated through holes - 50-layer boards are planned for the next generation of mainframe computers. 28 refs.

Nakahara, Hayao (Electronic Packaging & Production, Newton, MA, USA). *Electron Packag Prod* v 27 n 2 Feb 1987 p 70-75.

**085263 FINE LINES: TWEAKING THE PROCESS OR A QUANTUM LEAP?** Tweaking may be good enough to 5-mil patterns, but it takes more than that for finer line geometries in production volume with high yield. The main topics are process overview, board preparation, lamination, exposure, on wet processing techniques.

Spitz, S. Leonard (Electronic Packaging & Production, Newton, MA, USA). *Electron Packag Prod* v 28 n 1 Jan 1988 p 58-60.

**085264 LAMINIEREN VON MULTILAYERN:**

**VERARBEITUNG AUF HYDRAULISCHEN VAKUUM-PRESSEN UND VAKUUM-PRESSANLAGEN.** [Lamination of Multilayers: Treatment in Hydraulic Vacuum Presses and Vacuum Pressing Plants]. The number of multilayer PC boards produced had constantly increased over the last few years and now amounts to about 25 percent of the overall PC board production. This multilayer technique can be handled by almost every manufacturer of PC boards, since the mass-lam technique is presently offered by manufacturers of basic materials. This report discusses both the mass-lam and the so-called pin-lam production of multilayers. (Edited author abstract) In German.

Holtgrewe, Franz. *Metalloberflaeche* v 41 n 11 Nov 1987 p 511-517.

**085265 AUTOMATING SURFACE-MOUNT ASSEMBLY IN A EUROPEAN PLANT.** N.V. Philips Industries, located in Leuven, Belgium is discussed. The facility produces a wide range of electronic products, including hi-fi audio systems, hybrid customized electronic systems, and general consumer electronics goods. The automation program at Leuven is discussed.

Maes, M. (N.V. Philips Industrie, Louvain, Belg). *Electron Packag Prod* v 27 n 3 Mar 1987 p 30-33.

**085266 AUTOMATIC GUIDED VEHICLES MOVE PCBs BETWEEN ASSEMBLY STATIONS.** Electronic manufacturers have for years been automating their printed circuit assembly operations. These automated operations, however, were individual assembly and test areas, or 'islands of automation'. It is the materials handling field that provides methods of physically tying these islands of automation together in the factory. One means of doing this today is with wire-guided vehicle systems. A wire-guided vehicle works in a test area carrying printed circuit boards to conveyors positioned for pick up and delivery and the test equipment.

Daebl, Donald H. (SEMCOR, Huntsville, AL, USA). *Electron Packag Prod* v 27 n 3 Mar 1987 p 42-44.

**085267 IMPACT OF PCB PROCESSING ON SURFACE-MOUNT ASSEMBLY.** Surface-mount technology (SMT), in today's context, refers specifically to the attachment and electrical connection of electronic components to interconnecting substrates (including printed circuit boards) at a planar interface. The SMT attachment process, called placement, is distinguished from the more common method of attachment by component leads through holes, called insertion or through-hole mounting. Quality in the SMT assembly process is largely dependent upon the accuracy with which component leads or contact surfaces are placed on the actual pads of the printed circuit board (PCB).

Amick, Christopher G. (Micro Component Technology, St. Paul, MN, USA). *Electron Packag Prod* v 27 n 3 Mar 1987 p 104-105.

**085268 CUTTING PCB'S WITH PCD.** In the production of printed circuit boards (PCBs), the cutting of large boards to specified dimensions is a process which is frequently automated today. Correct choice of cutting tool material is essential to ensure economic operation. (Author abstract)

Anon. *Ind Diamond Rev* v 47 n 523 1987 p 265.

**085269 FORMTEILAEZTEN IM KLEINFERTIGUNGSZENTRUM FUER LEITERPLATTEN.** [Form Etching in the Small-Scale Series Production Center for Printed Circuit Boards]. The manufacturing of metallic forms in the small-scale series production center for printed circuit boards has required slight adaptations in the wet process section and modification of the software of the CAD work station. These changes were made in order to realize forms with a maximum thickness of 1 to 1.5 mm (depending on the material) and structures up to



0.15 mm or to produce front panels with an outline and with lettering. (Edited author abstract) In German. 2 refs.

Beining, R. (Akad der Wissenschaften der DDR, East Ger); Gerstaeker, F. *Fingeraetetechnik* v 36 n 12 1987 p 531-533.

**085270 LAMINATING FLEXIBLE AND FLEXI-RIGID CIRCUIT BOARDS IN THE ISO-STATIC GAS-PRESSURE VACUUM PRESS.** The manufacture of flexible and flexi-rigid circuits represents a particular area of process technology concerned with the production of printed circuit boards in which material and equipment selection, and its application based upon experience, requires special care. Description is given of the vacuum press process with comparisons made between the isostatic gas pressure and hydraulic press technologies; advantages of the former; materials for flexible and flexi-rigid circuit production in the vacuum press.

Stein, W. (Robert Buerkle GmbH, Freudenstadt, West Ger). *Circuit World* v 14 n 3 Mar 1988 p 45-48.

**085271 NEW PRODUCTION TECHNOLOGIES FOR PCBs IN THE 90'S.** Due to stringent market demands, the methods of interconnecting electronic components will be in the next decade considerably different from the ones today. The paper takes a look at the following issues of the problem: forecast printed board technological refinements, changes in operational methods in manufacturing, and alternate technologies to meet new packaging requirements. (Author abstract)

Messner, George (Kollmorgen Corp, Melville, NY, USA). *Alta Freq* v 57 n 1 Jan 1988 p 3-14.

**085272 CONTROLLING INDIVIDUAL TIME/TEMPERATURE PROFILES IS KEY TO SURFACE MOUNT REWORK.** The ability to differentially heat components and boards is essential to the safe and effective rework of high mass surface mounted components and densely populated multilayer boards. The need for this capability has precipitated the development of a new generation of rework systems. It is argued that this will continue to spark new research and development of intelligent rework systems in what has been a technologically neglected step in SMT manufacturing and process equipment engineering.

Martel, Michael L. (Conceptronic, Gonic, NH, USA). *Surf Mount Technol* v 2 n 2 Apr 1988 p 37-40.

**085273 CIRCUPOSIT 3000 PROCESS SOLVES CIRCUIT BOARD BLOW-HOLE PROBLEMS.** Since the emergence of the printed wiring board industry, the plated-through-hole process has remained a cornerstone of the manufacturing sequence. The essential feature of the PTH process is the deposition of a conductive film, normally copper, onto all hole wall surfaces.

Anon. *Finishing* v 12 n 2 Feb 1988 p 31-32.

**085274 BETTER PLATING FOR PCBs.** A New electroless or autocatalytic method of copper plating is proving advantageous to electroplating in manufacturing printed circuit boards. Fully additive (which means that it can be used effectively to deposit thick plates instead of just thin preplates), the method provides more uniform plate distribution over large surface areas as well as along the wall of the multitude of small holes that the boards often contain. Moreover, the plate is stronger and more ductile than that deposited by a previous fully additive electroless copper system and is resistant to thermal stresses induced by the application of solder. The plating solution, designated the 570, is being licensed by Kollmorgen's PCK Technology Div (Melville, NY).

Vaccari, John A. (American Machinist & Automated Manufacturing, Cleveland, OH, USA). *Am Mach Autom Manuf* v 132 n 2 Feb 1988 p 65-66.

**085275 SURVEY OF PWB TRACE ROUTING TECHNOLOGIES - PART 2.** This is the second part of a three-part article describing automatic PWB routing techniques and algorithm implementation. This part

features automatic router implementation and discusses the subjects of copper sharing, routing by net, multilayer routing, hardware implementation and design rule checking. (Edited author abstract)

Anastasi, Robert (Cadnetix Corp, Boulder, CO, USA). *Electronics* v 33 n 14 Sep 1987 p 42-44.

**085276 ADDITIVE LEITERPLATTENHERSTELLUNG. [Manufacturing Printed Circuit Boards by the Additive Process].** The starting point for manufacturing printed circuit boards by the additive process are base materials coated with bonding agents, e.g., phenol resin paper laminates, epoxy resin paper laminates and glass-fiber-reinforced epoxy resin laminates. They are similar to those used for the subtractive system, except that the laminates are not coated with copper but with a bonding agent. Details of the process are explained by drawing comparison with the semiadditive system. (Edited author abstract) 5 refs. In German.

Steffen, H. (RWTH, Aachen, West Ger). *Metalloberflache* v 42 n 3 Mar 1988 p 131-133.

**085277 OVERVIEW OF PWB PHOTOTOOL PREPARATION - PART 1.** This is the first of a two-part article discussing many of the problems associated with creating a printed wiring board phototool. This part focuses on handling touch-up, and preparing a production master.

Anon. *Electronics* v 33 n 16 Oct 1987 p 23-24.

**085278 SURVEY OF PWB TRACE ROUTING TECHNOLOGIES - PART 3.** This is the third part of a three-part article describing automatic PWB routing techniques and algorithm implementation. This part includes advanced routing technologies and future trends. Discussed are the subjects of pin grid arrays (PGA), gridless routing and flexible field routing.

Anastasi, Robert (Cadnetix Corp, Boulder, CO, USA). *Electronics* v 33 n 16 Oct 1987 p 26-28.

**085279 USING SUBSTRUCTIVE METHODS FOR MULTILAYER BOARD FABRICATION.** The manufacturing processes involved in fabricating multilayer printed wiring boards (PWBs) are complex. With each step in the process, time and cost are added to the board. Process control throughout the manufacturing sequence, therefore, is paramount in ensuring successful fabrication. To better address PWB fabricator's questions and needs, suppliers have carefully studied the manufacturing process. Each manufacturing operation is evaluated to determine critical control parameters. Among these methods this paper discusses inner layer manufacturing, innerlayer cleaning and etching, copper oxide process, desmear and etchback and electroless copper processing.

Nargi, Kathleen (Enthone Inc, New Haven, CT, USA). *Electron Manuf* v 33 n 17 Nov 1987 p 9-11.

**085280 AUTOMATING PWB CROSS-SECTIONAL ANALYSIS TO MEET MILITARY REQUIREMENTS.** Printed wiring board manufacturers and users constantly strive to maintain realistic quality standards that permit high production yields and low scrap rates. Cross-sectional analysis is one way that both high and low volume board manufacturers can maintain a cost-effective operation; by monitoring various stages of the manufacturing process, serious and costly process deviations may be avoided. In connection with this the paper discusses the subjects of coupon preparation, system implementation and post-curing steps.

Nelson, James A. (Buehler Ltd, Lake Bluff, IL, USA). *Electron Manuf* v 33 n 17 Nov 1987 p 14-15.

**085281 PROCESSING METHOD FOR IMPROVING THROUGHPUT, QUALITY OF PWB PRODUCTION MASTERS.** Size reductions of 5:1 or greater are permitting PWB manufacturers to produce smaller, less expensive products and increase the functionality of a product within the same package area. Manufacturers are turning to sophisticated 84-pin devices in place of 64-lead

dual in-line packages (DIP's). The resulting shorter signal paths cause fewer capacitance problems. These innovations have posed new challenges in the generation of production masters, however. Four-mil lines have been achieved, and manufacturers are striving to produce lines as thin as 1 or 2 mils. To meet the needs of automated positioning equipment, these masters must conform to higher standards of precision than ever before. This paper discusses the films and processing methods corresponding to these higher standards.

McCaleb, Wick L. (Eastman Kodak Co, Rochester, NY, USA). *Electron Manuf* v 33 n 17 Nov 1987 p 25-26.

**085282 OVERVIEW OF PWB PHOTOTOOL PREPARATION - PART 2.** This is the second of a two-part article discussing many of the problems associated with creating a printed wiring board phototool. This part discusses AOI, mishandling, and phototool preparation.

Anon. *Electron Manuf* v 33 n 17 Nov 1987 p 49-50.

**085283 LEAD TRIMMING MODIFICATIONS SOLVE PWB ASSEMBLY PROBLEMS.** Although component lead trimming is just one step in the total printed wiring board assembly process, inefficient lead trimming can hinder assembly and cause board defects. Common problems include excessive wear on the blade used for trimming; material buildup on the blade; and damage caused by blade heat. Operator error may result in poor cutting, and scrap leads also may accumulate and damage a PWB. This paper describes some modifications which solve these problems. The modifications include changing blade angle and installation of cleaning pad for blades and a cooling system to lower the blade temperature.

Sengbusch, Egon (SLI Avionic Systems Corp, Florham Park, NJ, USA); Lorenzo, Joe. *Electron Manuf* v 33 n 17 Nov 1987 p 51-52.

**085284 IMAGING TECHNOLOGY TRENDS IN ELECTRONIC MANUFACTURING PROCESSES.** This paper discusses the trends in photoimaging of PCB's, the making of screens and stencils, direct etching of circuits, and imaging fine line ceramics. Other subjects include CAD/CAM systems, phototooling, IC packaging and interconnects, display technology and manufacturing environment.

Cundy, Alan S. (Dover Electronic Manufacturing, Binghamton, NY, USA). *Electron Manuf* v 34 n 6 Jun 1988 p 14-18.

**085285 HOW TO EVALUATE PCB LASER PHOTOPLOTTERS.** To produce today's fine circuit traces on PCB's, phototools need sharp edges with minimal roughness to permit the best possible resist-coated copper exposure. Sharpness and edge roughness are difficult to quantify and vary from shop to shop, although 5 to 10 percent line width is typical for roughness. These qualities are associated with photomasters' aesthetic characteristics. Three factors in designing laser plotters - resolution, spot size, and beam profile - affect plot aesthetics. As to the PCB production, it is influenced by plot quality, throughput and reliability, and this paper discusses the subjects.

Rittichier, Jeffrey (Gerber Scientific Instrument Co, South Windsor, CT, USA). *Electron Manuf* v 34 n 5 May 1988 p 8-9.

**085286 PRINTED CIRCUIT MULTILAYER PROCESSES AND MATERIALS REVIEW.** Multilayer circuits consist of layers of circuitry that are carefully registered and then laminated (pressed) together. Interconnections to the various circuitry layers are made through plated through holes. This paper gives an



explanation of the construction of multilayer boards. The various stages of production and construction materials necessary are described.

Dominici, Peter A. (Electrotek, Oak Creek, WI, USA); Kinsey, Steve. *Electron Manuf* v 34 n 5 May 1988 p 14-16.

**085287 HOW TO AVOID WET PROCESSING.** Two recently developed dry additive technologies avoid the waste handling, wet process control problems and fine-line limits imposed by today's subtractive method of board processing. The first dry process writes circuit lines directly onto a substrate from a CAD/CAM database. There is no need for artwork and its inherent limitations. The second technology, directed towards higher volume production, takes advantage of fundamental principles well understood in the photocopying field: electrostatic force transfer conductive particles from a master pattern to a substrate. Performance improvements include lower overall costs, higher circuit density and lower environmental impacts. 6 refs.

Soszek, Peter (Somich Technology Inc, Winnipeg, Manit, Can). *Circuits Manuf* v 28 n 5 May 1988 p 21-2, 24-25.

**085288 PANELS IN, PCBs OUT.** Liquid photoimaging will provide the most cost-effective and productive process for manufacturing high-density circuit boards - the continuous coating line. In this process, a plate copper panel is placed at the start of the line's conveyor system, and the entire manufacturing process takes place as the panel moves down the line. Inline AOI would be incorporated in the computer controlled process. The Microfine coating system is a unique adaptation of the slot-coating process. Unlike the coating techniques mentioned earlier, Microfine is a closed system in which the coating fluid is isolated from the environment before coating, preventing evaporation losses and contamination. The system does not depend on viscosity to determine coating thickness. Instead it accurately meters the photoresist fluid through a precision slot and deposits a uniform liquid layer onto the copper panel moving steadily past the coating slot.

Choinski, Ed (Epicor Technology, Inc, Wayland, MA, USA). *Circuits Manuf* v 28 n 5 May 1988 p 27-28, 30-31.

**085289 DER WICHTIGE BLICK UEBER DEN ZAUN - AUCH IN DER LEITERPLATTENTECHNOLOGIE.** [Looking Over the Fence Is Important in Printed-Circuit Board Technology Too]. PCB technology breaks down traditionally into separate manufacturing stages: mechanical working and electroplating, assembly and soldering, and testing. The works divisions or component supplier companies involved are accordingly varied. For an optimal product to result, it is particularly important, therefore, for the participating specialists to acquaint themselves with operations in the other fields too. (Author abstract) In German.

Todt, Hansjuergen (AEG, Ulm, West Ger). *F&M Feinwerktech Messtech* v 96 n 5 May 1988 p 185.

**085290 LEITERPLATTEN HERSTELLEN, BESTUECKEN UND TESTEN IM ZULIEFER-VERBUND.** [Manufacturing, Assembling and Testing Printed-Circuit Boards by Subcontractor Teamwork]. Quality inspections between value-adding production stages help cut costs. The practical application of this maxim is demonstrated by the example of a PCB module for an electronic test instrument. Subcontractor services are utilized on the one hand for manufacturing and testing the PCB and on the other hand for assembling, soldering and testing. (Author abstract) In German.

Frank, Manfred. *F&M Feinwerktech Messtech* v 96 n 5 May 1988 p 211-213.

**085291 DISPATCHER COMPLEMENTS MATERIAL HANDLING SYSTEM.** An automated material handling system is described used in a printed circuit board (PCB) assembly and test area of an electronic industrial plant. An expert system in a central dispatch and storage area efficiently tracks printed circuit boards and allocates work on them through 115 workstations.

Gorman, Hugh (Manufacturing Systems, Pittsburgh, PA, USA). *Manuf Syst* v 6 n 5 May 1988 p 30-31.

**085292 DER WICHTIGE BLICK UEBER DEN ZAUN - AUCH IN DER LEITERPLATTENTECHNOLOGIE.** [Looking over the Fence Is Important in Printed-Circuit Board Technology Too]. PCB technology breaks down traditionally into separate manufacturing stages: mechanical working and electroplating; assembly and soldering; and testing. The works divisions or component supplier companies involved are accordingly varied. For an optimal product to result, it is particularly important, therefore, for the participating specialists to acquaint themselves with operations in the other fields, too. (Author abstract) In German.

Todt, Hansjuergen. *Metalloberflaeche* v 42 n 5 May 1988 p 223-224.

**085293 NETWORKING PC BOARD ASSEMBLY.** Electronics assemblers are realizing that it takes more than just highspeed equipment to meet today's production requirements. High speed printed circuit board (pc board) assembly machines require specific production data for each board type they produce. To address these problems, many are implementing manufacturing cell controllers. This article presents a few of the key points to consider when evaluating a manufacturing cell controller.

Marra, Ed (Universal Instruments Corp); Kane, Jim. *Assem Eng* v 31 n 5 May 1988 p 26-28.

**085294 INTELLIGENT CONTROLLER FOR PRODUCTION USING 'DYNAMIC SCHEDULING'.** For companies which undertake the electrodeposition of copper and tin/lead in the production of printed circuit boards (PCBs) and have complex production problems caused by the number of different PCBs and the variety of different processing needs, Dynamic Scheduling may be the answer. This article presents a review of the dynamic scheduling method.

Rickwood, Frank (Process Plant & Chemicals Ltd, Slough, Engl). *Prod Finish (London)* v 41 n 4 Apr 1988 p 22-23.

**085295 MATTER OF LIFE AND DEATH.** A brief description is given on the impact of surface mount technology (SMT) on circuit board manufacturers. The major benefit offered by SMT is in cost. The benefits are many but so are the problems. For SMT, high quality results are much more difficult and pose greater risks for investment. AB Electronics is a specialist in the field of SMT. Its facility at Rogerstone offers an almost noiseless environment. AB operates a zero defect policy. Quality auditors stalk each production line and have the power to stop the line at any time. A major part of functional testing is dynamic burn-in - accelerated life testing. AB operates a continuous flow manufacturing policy, what the company calls JIT.

Carrie, Ron (Rogerstone). *Prod Eng (London)* v 67 n 6 Jun 1988 p 18-19, 22.

**085296 HERE, JIT AND MRP II WORK IN HARMONY.** The computer industry is a logical place to find exemplary use of manufacturing software. The plant in Rancho Santa Margarita, Calif., where Unisys assembles printed circuit boards and computers is not all high technology. Instead, a combination of computers, automated and manual materials handling techniques, and just-in-time (JIT) principles helps the plant turn out its products. Central to success, are Manufacturing Resource Planning (MRP II) software and a focused factory approach.

Krepchin, Ira P. *Mod Mater Handl* v 43 n 7 Jun 1988 p 87-89.

**085297 TALK TO ME.** The industry has not yet adopted a communication protocol for automating PCB manufacturing and assembly. But, in the mean time, some large manufacturers have developed their own proprietary standards or customized systems to meet current needs. Of the several communication protocols available to the

PCB industry, one candidate is the Semi Equipment Communications Standard (SECS). The protocol and messages in SECS are directed toward equipment activities at the shop-floor level. Most of the basic documentation and initial implementation have been done in the semiconductor industry. Commercial channels can readily supply low-cost RS 232 hardware to support SECS projects. The author describes an assembly example using SECS. 2 refs.

Secrest, Jerry. *Circuits Manuf* v 28 n 6 Jun 1988 p 65, 68-69.

**085298 PADS ONLY, PLEASE.** The pads-only concept of PCB fabrication offers cost, quality and manufacturing advantages over assemblies that contain external foil paths protected by a solder mask. By eliminating defects that need rework and inspection, pads-only fabrication enhances assembly, solderability, module test and engineering changes. Thus, systems test receives boards virtually defect-free and product cost is reduced considerably. Technically, the pads-only concept completely eliminates all exposed circuit traces/foils and solder masking from the overlayers of the finished PCBs. In actual practice, however, some line traces are intentionally left on the PCB to connect circuit mounting pads to vias on the overlayers. This maintains testability, improves manufacturing ability and facilitates engineering change orders (ECOs).

Jain, Ravi K. (Control Data Corp, Arden Hills, MN, USA); Kennedy, Jeff K. *Circuits Manuf* v 28 n 6 Jun 1988 p 71-73.

**085299 HOHERE PACKUNGSDICHTEN BEI MULTILAYERSCHALTUNGEN DURCH EINSATZ ULTRADUNNER KUPFERFOLIEN.** [Higher Packing Densities for Multilayer Circuits by Using Ultrathin Copper Foils]. Some 10 percent of the entire output of epoxy glass fiber base material is offered as thin foil laminate with the designation 'UTC'. To satisfy the demand in microconductor engineering and to enable designers to build printed-circuit boards with three conductors between the holes in the module spacing, the manufacturers of printed-circuit boards have pushed the development of a laminate with ultrathin copper foil. The copper foil producers and a number of base material manufacturers have responded to the demand. (Edited author abstract). In German.

Niklassowski, Gerd. *Metalloberflaeche* v 42 n 6 Jun 1988 p 307-309.

**085300 INFRARED REFLOW FOR SMT.** In this concluding half of their investigation into thermal and yield considerations for infrared reflow, the authors question the importance of 'shadowing' and consider atmospheres for IR processing. They discuss the three-step profile; the atmosphere inside the infrared equipment; forming gas; and yield data. (Edited author abstract). 7 Refs.

Arslanacan, Ahmet N. (Radiant Technology Corp); Flatery, David K. *Electron Prod (London)* v 17 n 6 Jun 1988 p 27,29-30.

**085301 NEW METHODS OF SURFACE AREA MEASUREMENT AND CURRENT DENSITY CONTROL IN PCB MANUFACTURE.** New methods of surface area measurement by electrolytic means have been introduced by a British company. Two instruments, known as the DIM and MIM systems respectively, are available. The instruments differ in their method of measurement and applications, but both measure the conductive surface area of photo-resisted boards to a high degree of accuracy and can convert this area measurement via an interface unit to a rectifier current output, thereby controlling plating current density. (Edited author abstract).

Menzies, G.D.M. (PMD Chemicals Ltd, Coventry, Engl). *Circuit World* v 14 n 4 Jul 1988 p 27-28.



**085302 ANALYSIS OF MASS TRANSPORT AND OHMIC LIMITATIONS IN THROUGH-HOLE PLATING.** Fluid flow, mass transfer, and ohmic resistance are analyzed in through-hole plating of multilayer printed circuit boards. The analysis indicates that in holes in high aspect ratios plated under practical conditions, the ohmic rather than the mass transport resistance imposes the critical limitation on the current density at which through-holes may be uniformly plated. An ohmically limited current density is quantitatively identified as a function of the hole dimensions, the conductivity, and the deposition kinetics. It is shown that the ohmic limitation is highly sensitive to the hole dimensions, especially its length. The maximum current density which provides deposits of acceptable uniformity can be increased by increasing the electrolyte conductivity, the electrode polarization, or by modifying the hole geometry. (Author abstract). 14 refs.

Lanzi, Oscar (Case Western Reserve Univ, Cleveland, OH, USA); Lannaud, Uziel. *J Electrochem Soc* v 135 n 8 Aug 1988 p 1922-1930.

**085303 BENCHMARK TECHNIQUE FOR MICRODRILLING.** The authors discuss the primary factors associated with microdrilling performance which are drilled hole precision, productivity, quality and cost. These four factors are trade-offs within the drilling process, and management can intelligently balance their interaction by specifying, understanding and controlling microdrilling via the benchmarking process.

Beetlestone, Rogers (Excellon Automation, Torrance, CA, USA); Candell, Russell. *Circuits Manuf* v 28 n 8 Aug 1988 4p.

**085304 DESIGNING FOR ZERO-DEFECT SOLDERING.** Printed circuit board designers are not generally involved in the soldering phase of PCB manufacture. Now, however, with the move to high technology PCBs, and to surface mounted devices, design changes are necessary to ensure high first-pass yields in soldering. Printed circuit board designers must, therefore, learn to understand the basics of cost effective assembly, soldering and testing. This article discusses different aspects of the problem and the changes required to achieve highest possible first-pass yields at the lowest possible soldering cost.

Weinhold, Michael (Dupont Int S.A., Geneva, Switz). *Printed Circuit Des* v 5 n 8 Aug 1988 9p.

**085305 ONE FABRICATOR'S EXPERIENCE WITH PRINTED CIRCUIT BOARD DIRECT IMAGING.** This paper reports the initial results of using a direct laser imaging system by a PCB manufacturer. The benefits of direct laser imaging are described, the results of the testing of new films for use with the visible argon laser systems are reported and recommendations for the future are discussed.

Feltham, Steve (Automata Inc, Sterling, VA, USA); Jean, Louis. *Electron Manuf* v 34 n 8 Aug 1988 p 16-19.

**085306 PRINTED CIRCUIT BOARDS FOR INDUSTRY.** The article describes the various steps in producing boards with plated through holes. In recent years, the demands for increasing packaging density of PCBs has led to the widespread use of surface-mounted devices, whereby both active and passive components can be attached to a substrate without the use of leads or their corresponding holes. The small size of such components, together with the fact that they can be soldered to both sides of a board, enables a greater number of components to be accommodated per unit area. Tin-lead or solder plays an important part in the production of PCBs, where it is able to carry out several functions with high reliability. The review concludes with profiles of several PCB manufacturers in the UK.

Karpel, S. *Prod Finish (London)* v 41 n 7 Jul 1988 p 6-8, 16.

**085307 FACTORS WHICH AFFECT OUTGASING AND HOLE-WALL ADHESION IN**

**THROUGH-HOLE PLATING.** This article examines what takes place inside the hole at various stages of manufacture of PCB's by the subtractive method using electroplated tin-lead as a metallic etch resist which is subsequently fused. The topics considered are the following: 1) The quality of laminate used, with regard to: (a) the adhesion between glass and resin; (b) the amount of air encapsulated in the resin at the pressing stage; and (c) the degree of polymerization of the resin and dimensional stability of the laminate. 2) The drilling parameters, e.g. penetration rate, rotation speed. 3) The significance of the electroless copper process used. Hole-wall pull-away and resin recession treated in the same section on general hole-wall adhesion since these phenomena are related. 2 refs.

Favini, Carlo; Whitlaw, Keith. *Prod Finish (London)* v 41 n 7 Jul 1988 p 11-15.

**Marketing See ELECTRONICS INDUSTRY—France.**

**Materials See Also COMPOSITE MATERIALS—Applications; CONTAINERS—Dispensers; ELECTRONIC CIRCUITS—Materials; ELECTRONICS PACKAGING; PACKAGING MATERIALS—Classification; PHENOLIC RESINS—Mechanical Properties.**

**085308 IMPACT OF MICROWAVE THEORY ON MLBs FOR HIGH-SPEED DIGITAL APPLICATIONS - DESIGN, PRODUCTION QUALIFICATION.** Multilayer boards for high-speed digital applications are no longer solely substrates for the electrical interconnections needed but play an active role regarding the overall performance of electronic assemblies. In the general part of this paper all the important parameters regarding achievable impedances and their tolerances are discussed in detail. The second part is concerned with the practical realization of Microwave Theory on a selected example of a high-speed MLB. (Author abstract) 6 refs.

Angstenberger, A.L.M. (LEITRON Leiterplatten-Electronic GmbH, Gmuend, West Ger). *Circuit World* v 14 n 1 Oct 1987 p 39-43.

**085309 MOLDED CIRCUITS REQUIRE ATTENTION TO NEW DESIGN TECHNIQUES.** Molded circuit boards offer designers creative opportunities that lead to new electronic products. But before you can take advantage of these molded circuits, you must consider new and demanding design guidelines. Fortunately, one can handle these additional considerations in a straightforward manner. It is shown that by carefully using surface-mount-technology (SMT) components can reduce the number of holes and thus the number of weld lines in the assembly can be reduced to strengthen the board. (Edited author abstract)

Williams, John (ICI Electronics, USA). *EDN* v 33 n 2 Jan 21 1988 p 161-164, 166.

**085310 GIVE NEW STRENGTH TO MULTILAYER BONDING.** The process is an immersion-tin process, now being evaluated as a substitute for the familiar black-, red- or brown-oxide processes. Both types of processes promote the inner-layer adhesion of multilayer assemblies, but attention should be given first to the advances that the familiar oxide process is undergoing. Both approaches are discussed. 5 refs.

Smith-Vargo, Linda (Electronic Packaging & Production, Newton, MA, USA). *Electron Packag Prod* v 27 n 2 Feb 1987 p 52-55.

**085311 USING FLUOROPOLYMER SUBSTRATES FOR HIGH SPEED, DIGITAL CIRCUITS.** A circuit material R02800 was designed to meet the electrical and mechanical requirements of high speed, high density, digital PWB's. This material was developed as part of a program which include production of circuit materials, flexible circuits, multilayer PWB's a high performance connector system, and a resistive foil for terminating resistors. The proprietary material is a highly filled, fluoropolymer composite designed for high performance multilayer boards. The key electrical properties are a dielectric constant of 2.9 and a dissipation factor of

0.0012 at frequencies as high as 10 GHz. These properties are stable over wide variations in temperature, frequency, and humidity.

Lockard, Steven C. (Rogers Corp, Chandler, AZ, USA). *Electronics* v 33 n 9 Jun 1987 p 28-30.

## Measurements

**085312 AUTOMATISCHES MESSEN DES LAGENVERSATZES IN MEHRLAGENSCHALTUNGEN.** [Automatic Measuring of Layer Offset in Multilayer Circuits]. Knowledge of the inner layer offset in the production of multilayer circuits is of central importance for quality assurance. The article presents a test system which enables nondestructive inspection by means of radiography and subsequent image processing. Automatic measurement of the layer offset on the production line permits early intervention in the process and thus minimizes rejects of the expensive multilayer circuits. (Author abstract) In German. 2 refs.

Kellner, Rolf. *F&M Feinwerktech Messtech* v 96 n 5 May 1988 p 193-196.

## Nondestructive Examination

**085313 REAL-TIME RADIOGRAPHY FOR ELECTRONICS RELIABILITY ASSESSMENT.** X-radiography is commonly used for nondestructive evaluation (NDE) of microelectronic circuits and components. With the development of real-time microfocus systems, however, radiography becomes a much more rapid and efficient - and in some cases the only - means of assuring reliability. Two simultaneous capabilities have been joined - a real-time ability so that the part can be viewed while it is remotely manipulated and the microfocus x-ray tube, which can provide very sharp and magnified images, virtually without distortion. The combination of these two mutually complementary capabilities permits rapid and exact visualization of details in many types of electronic hardware and assemblies. The Technology Support Division of Hughes Aircraft Co. currently employs a Magnaflux Realtime Microfocus X-Ray System in the reliability and failure analysis of electronic components, assemblies, and related hardware. Some specific examples of this are presented. Examples of analyses relating to printed wiring board (PWB) assemblies will include identification of improperly formed solder joints, location of a potential open trace in an encapsulated assembly, and imaging of incompletely plated throughholes. (Edited author abstract)

Buechler, D.W. (Hughes Aircraft Co, El Segundo, CA, USA). *Mater Eval* v 45 n 11 Nov 1987 p 1326-1329.

**085314 X-RAY INSPECTION MEETS INCREASED PWB THROUGHPUT, DENSITY CHALLENGE - PART 1.** This is the first part of a two-part article discussing X-ray inspection equipment. This part describes the capabilities of X-ray technology and other inspection methods.

Soron, Edward W. (IRT Corp, San Diego, CA, USA). *Electronics* v 33 n 16 Oct 1987 p 36-37.

**085315 AUTOMATISCHES MESSEN DES LAGENVERSATZES IN MEHRLAGENSCHALTUNGEN.** [Automatic Measuring of Layer Offset in Multilayer Circuits]. Knowledge of the inner layer offset in the production of multilayer circuits is of central importance for quality assurance. The article presents a test system which permits non-destructive inspection by means of radiography and subsequent image processing. Automatic measurement of the layer offset on the production line permits early intervention in the process and thus minimizes rejects of the expensive multilayer circuits. (Author abstract) 2 refs. In German.

Keller, Rolf. *Metalloberflaeche* v 42 n 5 May 1988 p 229-232.



**Optimization** See ELECTRONIC CIRCUITS—Electromagnetic Shielding.

**Performance** See COMPUTERS, MICROCOMPUTER—Military Applications.

**Photography** See PHOTOGRAPHIC FILMS AND PLATES—Performance.

**Plastics Applications** See Also EPOXY RESINS—Curing.

**085316 SUPERIOR RESIN GRADES SPARK E/E MARKET GROWTH.** Today's applications of high-tech electrical/electronic parts and systems are making accelerated property demands on plastics. Resins aimed at these markets must be able to maintain exceptional stability at the high assembly and use temperatures to which these components are being subjected. Many plastics suppliers have responded to the challenge by introducing new grades that address particular developments: high-density surface-mount technology, molded printed circuit boards, and other design objectives.

Wigotsky, Victor (Plastics Engineering, Brookfield Center, CT, USA). *Plast Eng* v 43 n 11 Nov 1987 p 21-28.

**085317 MOLDED CIRCUIT INTERCONNECTS.** A new class of selectively metallized injection-molded thermoplastic substrates is reported. They are called molded circuit interconnects that provide creative applications and solutions for the most complex electronic packaging requirements. Through the selective metallization of injection-molded thermoplastic substrates, they combine the functions of printed circuit boards, connectors, chip carriers, spacers, clips, and other functional components.

Mihelcic, Jean M. *Printed Circuit Des* v 5 n 2 Feb 1988 p 41-42, 44, 47.

## Printing

**085318 LIQUID INK JET PRINTING WITH MOD INKS FOR HYBRID MICROCIRCUITS.** Application of the computer-controlled impulse ink jet with liquid metallo-organic decomposition (MOD) inks is demonstrated to be feasible in printing hybrid microcircuits. The advantages of ink-jet printing over conventional screen printing are discussed. The hardware and software of the ink-jet printing system have been developed. A theoretical model has been derived relating the ink jet flow rate to the primary spray control parameters. The MOD ink system suitable for the ink jet was studied and printing experiments with the ink jet were conducted. The ink jet system with silver neodecanoate MOD ink has been applied to metallize the grid pattern of silicon solar cells. 7 refs.

Teng, K.F. (Purdue Univ, West Lafayette, IN, USA); Vest, Robert W. *IEEE Trans Compon Hybrids Manuf Technol* v CHMT-10 n 4 Dec 1987, Contrib from the 37th Electr Compon Conf, Boston, MA, USA, May 1987 p 545-549.

## Process Control

**085319 MICROSECTIONING OF PCB'S AS A PROCESS CONTROL TOOL.** Microsectioning of printed circuit boards (PCB's), including rigid, flexible, and rigid-flex combinations, has long been widely recognized as an important quality assurance tool. MIL-P-55110D, with Interim Amendment 2, the current military specification for rigid PCB's, and MIL-P-50884C, the current military specification for flexible and rigid-flex printed circuits, require that test coupons on every multilayer panel be microsectioned in the 'as produced' condition and after thermal stress (solder float) conditioning. These microsections are then evaluated to determine compliance with various dimensional and physical requirements. These inspections form one of the bases for acceptance of the actual production boards on the panel. Many commercial, aerospace, computer, and communication equipment corporations have specifications with similar requirements. Many PCB manufacturers use microsectioning for in-process inspection to increase yields and avoid costly rejection of product at final inspection.

This paper discusses microsectioning procedures, encapsulation, grinding of specimens, post-cure grinding, polishing compounds and etching of specimens.

McCrory, Brian (Delsen Testing Lab Inc, Glendale, CA, USA). *Electron Manuf* v 34 n 7 Jul 1988 p 14-17.

**Processing** See Also IMAGING TECHNIQUES—Automation; SOLDERING—Defects.

**085320 PAINFUL PROCESSING: ANAESTHETIC SOLDER MASKS?** Problems in processing of printed circuit boards (PCB), like troubles with adhesion, bleeding, bubbling, slipping and post solder residue in screening solder masks are considered. High solid content, low cure time solder masks are sought to obtain better definition on today's denser and more complex boards.

Murray, Jerry (Circuits Manufacturing, San Francisco, CA, USA). *Circuits Manuf* v 27 n 12 Dec 1987 p 26, 28.

**085321 AUTOMATED WET PROCESSING.** The most complex operation in making a circuit board is wet processing. Etching, electroplating, stripping, developing and electroless plating combine to involve a myriad of chemistries, all of which must be kept at concentration. Simultaneously, immersion times, temperatures, current densities and rinses must all be controlled, and these parameters vary throughout the millions of different boards now being made. Then, at the end of the line, waste treatment waits to be automated. Wet processing automation at various circuit board manufacturing plants is described.

Murray, Jerry (Circuits Manufacturing, San Francisco, CA, USA). *Circuits Manuf* v 28 n 2 Feb 1988 p 48-50, 52.

**Production** See Also BAR CODES; COMPUTER AIDED MANUFACTURING—Automation.

**085322 AUTOMATION AND SOLDER PASTE PRINTING GUIDELINES FOR SMCs.** Printed circuit boards (PCBs) containing surface mount components (SMCs) exclusively or a combination of both SMCs and insertion mounted components (IMCs) are becoming more common in the electronics industry. The increased use of high density boards with SMCs and IMCs is creating new challenges. They include establishing effective printing guidelines, and utilizing equipment that can reliably produce completed boards, both from a printing and an assembly/solder standpoint. With automation comes the need for standardization of the entire process. The equipment will vary, but there must be a common factor: total process control. This only can be achieved if manufacturers adhere to printing guidelines such as those discussed in this article.

Horne, Dennis (Universal Instruments Corp, Binghamton, NY, USA); Cundy, Alan. *Surf Mount Technol* v 1 n 1 Feb 1987 p 19-24.

**085323 LEITERPLATTEN-HERSTELLUNG UND BEGLEITENDE QUALITAETSSICHERUNG.** [Printed-Circuit Board Production and Accompanying Quality Assurance]. In this article readers learn about PCB production at the Italian Zincoelcere company, a member of the Teknecomp Group (Olivetti) and one of Europe's leading firms in terms of invoiced sales and production technology. At the centre of attention are the main phases of the overall mechanical working cycle, notably the lamination of semifinished stock, etching and board finishing. The necessary inspection and test operations are also considered. (Author abstract) In German.

Mazzolini, Sergio. *Metalloberflaeche* v 42 n 5 May 1988 p 225-228.

**085324 LAGEBERICHT ZUR LEITERPLATTEN-FERTIGUNG: BEARBEITEN VON LEITERPLATTEN.** [Situational Report on Printed-Circuit Board Production: Mechanical Working of Printed-Circuit Boards. Applications in Practice - Manufacturers' Experiences - Machine Systems - Tool Developments]. The purpose of this situational report is to spotlight the state of the art and a trend over the next few years of the mechanical

working of PCBs. So as to be able to sketch a complete picture, interviews were conducted with a representative selection of users, tool makers and machine builders. The sometimes critical comments are the outcome of the interviewees conflicting view-points and our own critical assessment of the situation. Rather than being regarded at individual levels, such views are intended as helpful observations. (Author abstract) In German.

Wiendl, Josef; Marka, Rudolf. *Metalloberflaeche* v 42 n 5 May 1988 17p.

**085325 MODULAR CLEANROOM DESIGN.** Printed circuit board (PCB) and hybrid microelectronic assembly (HMA) photoplotting operations have long been plagued by microscopic airborne dust that causes minute pinholes in the production film used. Opaquing time required to eliminate these pinholes is costly. To combat these problems, we have installed an interconnected, 600 sq. ft Class 100, multi-cleanroom complex in our film-production facility. This facility houses our laser photoplotter, which produces 24 in. x 36 in. film in 15 min and a vector photoplotter, which produces 48 in. x 60 in. film. Also included in this cleanroom complex is a 300-Megabyte digital design system. A computer autoroute system permits us to generate PCB and HMA circuitry from a customer's schematic. Both the design system and the autorouter produce the input tapes for the photoplotters.

Ramirez, Jose B. (Computer Circuit Inc, Cardena, CA, USA). *Printed Circuit Des* v 5 n 8 Aug 1988 p 36-38.

**085326 AUTOMATION AIDS PCB PRODUCTION.** It is reported that Teli, the industrial division of the Ministry of Telecommunications in Sweden, recently made the decision to commence production of its own printed circuit boards in a factory designed to be one of the most advanced of its kind in Europe. Now commissioned and in operation, the processing equipment comprises two plating lines - one electroless and one electrolytic. The electroless plating line - incorporates MLB permanganate desmear and plated-through hole (PTH) electroless copper stages. A special feature is 45° mechanical agitation which improves the turbulence inside small holes. The electrolytic line, equipped with two 'A' shaped transporters, includes electrolytic copper and tin/lead processing.

Anon. *Electron Prod (London)* v 17 n 8 Aug 1988 p 20-21.

**Protective Coatings** See Also TINNING.

**085327 TIPS FOR SALVAGING PARYLENE-COATED PWB's.** High performance printed wiring boards that require conformal coating for moisture and mechanical protection are generally expensive to produce; manufacturers hesitate to discard them if they malfunction. Therefore, it is important that the coating material selected be removable for component testing and replacement. Parylene vacuum-deposited conformal coating is used for various military and commercial board protection applications. The advantages of this coating include high dielectric strength in very thin layers (as much as 5kV/mil); complete conformity of the coating on flat surfaces, around corners, on sharp edges, and other components; and high resistance to solvents and moisture. This paper discusses vacuum deposition of parylene and the methods of its removal by local heating, air abrasive method or mechanical removal.

Olson, Roger (Nova Tran Corp, Clear Lake, WI, USA). *Electronics* v 32 n 9 Aug 1986 p 23-25.

**085328 JAPAN'S SMOBC OPTION: COAXING THE UTMOST OUT OF A CHEMICAL REACTION.** Because of their many benefits, all-copper SMOBC boards with plated through-holes are increasingly prevalent. The elimination of solder slivers and improved solder mask adhesion are not the least of their benefits. The current prevailing methods for fabricating this type of board are



relatively cumbersome and costly, and are not conducive to high yields. Manufacturers often express a desire to have a simple dip that would act as an etch resist and eliminate steps in these processes for making SMOBC boards. Such an alternative is now available.

Siegmund, Jerry (Siegmund Inc, Hamden, CT, USA). *Circuits Manuf* v 27 n 9 Sep 1987 p 24, 27.

**Quality Assurance** See Also INTEGRATED CIRCUIT MANUFACTURE—Process Control.

**085329 LEITERPLATTEN-HERSTELLUNG UND BEGLEITENDE QUALITAETSSICHERUNG.** [Printed-Circuit Board Production and Accompanying Quality Assurance]. In this article readers learn about PCB production at the Italian Zincocelere company, a member of the Teknecomp Group (Olivetti) and one of Europe's leading firms in terms of invoiced sales and production technology. At the center of attention are the main phases of the overall mechanical working cycle, notably the lamination of semifinished stock, etching and board finishing. The necessary inspection and test operations are also considered. (Author abstract) In German.

Mazzolini, Sergio. *F&M Feinwerktech Messtech* v 96 n 5 May 1988 p 187-190.

**085330 PROZESSSICHERUNG BEI DER MULTI-LAYER-HERSTELLUNG.** [Process Assurance in Multilayer Production]. The concept of process assurance is becoming more and more important. Active process assurance is an effective quality assurance measure. Good possibilities of describing process assurance by means of a practical example are afforded by the control of a production chain with numerous greatly differing individual processes, such as is called for in the production of multilayers. (Author abstract) In German.

Winkelmann, Robert. *F&M Feinwerktech Messtech* v 96 n 5 May 1988 p 191-192.

**Quality Control**

**085331 QUALITY CONTROL METHODS FOR ANTICIPATING PROBLEMS ON PRINTED CIRCUIT BOARD PLATING LINES.** This paper presents a case history on the implementation of touchscreens for improved monitoring and control of a PCB plating line. Touchscreens, new measuring methods, and the use of real-time statistical control have resulted in a significant increase in board quality. The touchscreens have given line operators new understanding of the process leading to increased motivation and participation.

Watson, Rick (Texas Instruments, Austin, TX, USA). *Electron Manuf* v 34 n 6 Jun 1988 p 35-37.

**Reliability** See LOGIC DEVICES—Reliability.

**Repair** See Also INTEGRATED CIRCUIT TESTING.

**085332 STICKY SOLUTION.** Use of the proper processes, equipment and materials optimizes results and ensures process repeatability of surface mount rework and repair. But once the optimum processes and equipment have been chosen, the proper selection of materials, i.e., flux, solder paste, epoxies, solvents, etc., becomes tantamount to a successful rework operation. Using the proper materials is crucial because the rework process often pushes materials outside the range of operating parameters for which they were originally formulated. This is most apparent with flux. The following establishes flux as an essential in the rework process and examines the viability of paste flux. Paste flux, a relative newcomer to SMT, appears to eliminate many of the problems associated with traditional liquid flux formulations in the harsh world of rework and repair.

Martel, Michael L. (Conceptronic US Ltd, Gonic, NH, USA). *Circuits Manuf* v 28 n 2 Feb 1988 p 73, 75-76.

**085333 BOARD REPAIR - THE ECONOMIC ANSWER.** The electronics industry is now expanding at a considerable rate, but not so the board geometry. Track

sizes are generally still at 0.010 in. but even this size puts considerable strain on the repair operations. The move to surface mount technology also has the effect of reducing track sizes. The quality of repair which may be produced by conventional methods can not rival the visual quality which may be obtained by parallel gap welding. This paper examines in a practical way the process and methods which can be employed to save valuable material. (Author abstract)

Willis, R. (Dimension 2 Technology plc, Reading, Engl). *Circuit World* v 14 n 3 Mar 1988 p 74-75.

**085334 TOOLS AND TECHNIQUES FOR REWORK STATION SET-UP AND REPAIR.** Many manufacturers realize that printed wiring board (PWB) rework and repair, engineering changes, and damaged board scrapping cost organizations thousands of dollars each year. As board assembly technology advances, however, assemblers' ability to perform non-destructive rework and repair diminishes. Three major influences contribute to this trend: designers often do not incorporate repairability factors into board designs; manufacturing processes do not permit repairability; and the skills, knowledge, tools, and equipment are inadequate to perform a job correctly. Many PWB assemblies are 10, 20, or 30 times smaller than their counterparts of a decade ago. Components, circuit configurations, and packaging are sophisticated to such an extent that they only can be handled by people trained in rework techniques, using tools designed especially for a task. The paper shows how rework stations equipped with the proper supplies and a skilled staff can facilitate repairs on PWB, specifically component removal and conformal coating removal.

Bausell, James (Pace Inc, Laurel, MD, USA). *Electronics* v 33 n 11 Jul 1987 p 12-14.

**085335 REDUCING WASTE WITH PROPER PWB REWORK/REPAIR STATION SETUP.** The paper discusses the operations which take place at PWB rework/repair stations including testing, desoldering, faulty component removal and cleaning. Methods of waste reducing are mentioned. It is stressed that testing components and boards before and during assembly ensures product integrity, and provides the key to reducing rework and repair expenditures, and avoiding backups and delays. Rework and repair are facts of life in electronic production. They can, however, be managed efficiently and cost effectively through testing, process implementation, and proper equipment use.

Logee, Curtis (EPE Technology, Manchester, NH, USA). *Electronics* v 33 n 11 Jul 1987 p 19-20.

**085336 SERVICING SOLID-STATE CIRCUIT BOARDS.** Rapid changes in electrical/electronic technology have taken place since solid-state equipment has been installed. For such items as DC drives and similar equipment, it is not uncommon to find that replacement printed circuit boards for the units either are no longer available, need to be custom produced, or are long-delivery items. Thus, it is increasingly the plant electrician's job to repair this type of equipment to keep it running. The author describes a servicing procedure which has been developed for circuit board repair. The servicing program includes the logging of information on the various types of drives and cross referencing the solid-state devices. This information is drawn upon when testing transistors and diodes, replacing parts, and repairing the circuit boards. Obtaining information on the various types of drives is the basis of the servicing procedure.

Huseman, John M. (Purdue Univ). *ECM Electr Constr Maint* v 86 n 2 Feb 1987 p 66-68.

**Robot Applications**

**085337 ROBOT EXCELS AT HIGH-MIX PRODUCTION.** Demand for higher board densities drove the Government Systems Div., Control Data Corp., Minneapolis, to search for an automatic process for implementing new types of surface-mount technology. Manufacturing faced an investment decision: buy either fixed automation

(dedicated machines) or flexible automation (robotic workcells) to populate printed wire boards. Because flexibility was paramount, Control Data installed a robotic workcell from Adept Technologies, San Jose, Calif. This article discusses various aspects of the application.

Oquist, Michael R. (Control Data Corp, Minneapolis, MN, USA). *Automation (Cleveland)* v 34 n 11 Nov 1987 p 68-70.

**Robotic Assembly**

**085338 OVERVIEW OF ROBOTICS FOR PRINTED WIRING BOARD ASSEMBLY.** The use of robotics in printed wiring board assembly is expanding in two ways. First, virtually every process on a board assembly line can be automated, thus facilitating automated, integrated production. Second, off-line programming via downloaded design data makes low volume production feasible. This paper discusses selection criteria, assembly control, accuracy and repeatability of robotics in PWB assembly.

Dudley, John (Seiko Instruments, Torrance, CA, USA). *Electronics* v 33 n 1 Jan 1987 p 40-41.

**085339 VIEWING THE ROBOTIC WORKCELL AS A SYSTEM.** Once an electronics manufacturer decides to automate a printed circuit board assembly line, it soon becomes apparent that what is needed is not merely a robot but rather a complete robotic workcell. The key to successful automation is to look at the entire system, reviewing and analyzing the whole manufacturing process. The goal is not superb robotics, but rather the attainment of an efficient, flexible production system, which adapts easily to future needs and component changes.

Michaels, Robert H. (Heller Industries Inc, Florham Park, NJ, USA); De Angelo, Don. *Electron Packag Prod* v 27 n 11 Nov 1987 p 46-47.

**085340 ELECTRONIC PARTS PRESENTATION USING VIBRATORY BOWL FEEDERS.** This paper presents the results of experiments using custom tooled vibratory bowls for presenting non-standard electronic parts to a robot for insertion on printed circuit boards. (Author abstract) 19 refs.

Schroer, Bernard J. (Univ of Alabama at Huntsville, Huntsville, AL, USA). *Robotics* v 3 n 3-4 Sep-Dec 1987 p 409-419.

**085341 THRU-HOLE SYSTEM ACHIEVES QUALITY AND FLEXIBILITY.** Thru-hole insertion is being used by every major electronics manufacturer building printed circuit boards. This requires that reliability, flexibility and quality be included when getting the pegs (component leads) into the holes of the circuit board. Product mix, shorter production runs, engineering changes to the product, faster delivery requirements, CAD/CAM, Just-In-Time manufacturing strategies and CIM lines all require high degrees of reliability and flexibility. Quality assures longterm reliability in the operation.

Holcomb, Gregory W. (Chad Industries, Orange, CA, USA). *Rob World* v 6 n 5 Jun 1988 p 38-40.

**Soldering** See Also COPPER ZINC ALLOYS—Protective Coatings; ELECTRONICS PACKAGING—Materials; INTEGRATED CIRCUIT MANUFACTURE—Decontamination; INTEGRATED CIRCUITS—Electronics Packaging; INTEGRATED CIRCUITS, VLSI—Electronics Packaging; INTEGRATED CIRCUITS, VLSI—Manufacture; SOLDERING—Reliability; SOLDER—Mechanical Properties.

**085342 COPPER SURFACE FINISH PROMOTES SOLDERABILITY.** Benzotriazole prevents surface tarnishing and oxide formation, and promotes surface wetting and solderability of copper surfaces. A copper benzotriazole process consists of four main steps: cleaning, benzotriazole application, water rinsing and air dry.



Benzotriazole application methods, and the wave-soldering criteria on the copper benzotriazole boards are discussed. 8 refs.

Ho, Man Kei (Digital Equipment Corp, Kanata, Can). *Electron Packag Prod* v 27 n 10 Oct 1987 p 39-41.

**085343 APPLICATION OF DRY FILM SOLDER MASK RESISTS.** Since their development in the mid-1970's, dry film solder mask resists have offered an efficient, versatile alternative to more traditional liquid screen solder masks in the production of printed wiring boards. As printed wiring boards start to use combinations of surface mount and leaded through hole components with high densities, manufacturers are using dry film solder masks even more. Dry film solder masks can accurately register and reproduce phototools and tent via holes with films. In addition, it is successfully being used with automation. The compatibility of dry films with denser boards and improvements in production economics are keeping the growth of dry film solder masks ahead of the PWB production growth. This paper discusses the types of dry film solder masks, their advantages, their comparison with liquid solder masks and cost saving results.

Cassady, Kim (DuPont, Wilmington, DE, USA). *Electronics* v 32 n 10 Sep 1986 p 28-30.

**085344 METHOD TO IMPROVE WAVESOLDERING QUALITY.** Instead of continually trying to control all process variables, a soldering process was developed which is far less sensitive to most variables and requires only a few PWB design considerations. It is more effective to design a process which reduces the variables and their influences than it is to control them. The process begins with the PWB design. Lead-to-hole clearances are maintained at 10-18 thousandths to optimize solder wicking of plated through holes, while limiting the possibility of voids. Pad sizes and configurations are designed to limit heat sinking and bridging effects. Solder masks are used on all double-sided boards, and single-sided boards with dense circuitry patterns. These design considerations, when combined with proper lead forming, are sufficient to control most defects resulting from design parameters. This soldering process has resulted in substantially improved solder joint quality. Printed wiring boards once considered difficult to solder now routinely exceed specification.

Sholley, Craig B. (Oven Industries Inc, Mechanicsburg, PA, USA). *Electronics* v 32 n 10 Sep 1986 p 32-33.

**085345 COMMON QUESTIONS ABOUT SOLDER MASKING.** Solder masks have evolved to meet the increasingly stringent demands of the printed wiring board industry. As a result, PWB manufacturers are faced with an increasing number of complex choices in materials and application technologies. Despite the proliferation of products and application methods, the PWB manufacturer's job can be simplified when the correct material and application method for a particular job is determined. Making that determination is not easy and involves many considerations. This article answers some of the frequently asked questions about materials and process technologies available to meet PWB design requirements.

Denkler, John D. (M&T Chemicals Inc, Rahway, NJ, USA). *Electronics* v 32 n 10 Sep 1986 p 36-40.

**085346 SOLVING PWB SOLDERING PROBLEMS TO IMPROVE QUALITY.** The increasing demand for reduction of solder joint defects and for 100 percent solderability requires a careful examination of the soldering process. The author notes that with all the repair and rework stations available, there are very few solderability testers being introduced. Repair and rework are unnecessary if boards and components are solderable. Touchup and rework can be reduced significantly and in some cases eliminated, providing a tremendous improvement in product reliability and an equally impressive cost reduction. This improved reliability will not be achieved by installing new soldering machines nor by using more active fluxes. In addition, this program is not difficult or expensive to

initiate. An understanding of the soldering process and its importance is required to implement this program; also required are carefully developed process controls. The program requires the backing of an educated management, and above all, the determination to do the job right the first time.

Woodgate, Ralph (WoodCorp Inc, Brewster, NY, USA). *Electronics* v 33 n 3 Feb 1987 p 29-30.

**085347 DOD-STD-2000: THE ALL-IN-ONE SOLDERING STANDARD, PART 1.** DOD-2000 is the first tri-service (Army, Navy, Air Force, DLA) agreement as to what the DOD needs in products from manufacturers. It is a mandatory minimum requirement for soldering/wiring practices. By incorporating 33 different federal, military and industry specifications and standards into one DOD-2000 should improve MIL spec system efficiency. In its entirety, DOD-STD-2000 addresses the spectrum of solder and wire connections normally defined as standard and miniature. It was written as a guideline defining the technical criteria essential to electrical connections and wiring within equipment fabricated by or for the Dept. of Defense. Other requirements not directly addressed, such as those for micro-miniature soldering of thin/thick film microelectronic assemblies, will be imposed by reference to other standards (for example, MIL-M-38510).

Roy, Roland (Royer Manufacturing, Chelmsford, MA, USA); Grinovich, Ed; Worthington, Shari. *Circuits Manuf* v 27 n 8 Aug 1987 p 46-48, 50.

**085348 BATCH VS IN-LINE VAPOUR PHASE SOLDERING.** In the early days of surface mounting when the batch vapour phase solder reflow process was adopted as a fabrication technique by hybrid producers, there were no objections to the throughput capabilities of systems since hybrid manufacture centered on batch techniques: standard batch tanks could more than cope with production requirements. However, with surface mounting now being applied to printed circuit assemblies, where large board sizes and high production rates are required, the question of batch system throughput has become a subject of discussion. Pertinent production guidelines are considered.

Booth, Richard (IV Products Ltd). *Electron Prod (London)* v 15 n 11 Nov-Dec 1986 p 21-23.

**085349 SOLVING PROBLEMS IN HOT AIR SOLDER LEVELING.** The process of solder coating and hot air solder leveling (HASL) has been regarded with both interest and aversion by printed wiring board (PWB) fabricators since its introduction. As the process and suppliers matured, several points became obvious: system simplicity was preferable; a large solder pot had greater thermal stability than a small pot; and vertical processing, no matter how advanced, had drawbacks inherent in the way the board was handled. A compact horizontal system has been introduced recently, making the equipment advantages available to the average size facility. The compact design provides greater reliability and ease of maintenance than standard units. By combining this equipment with conveyorized pre-cleaning and post-cleaning units, a total process system for hot air leveling can be realized.

White, Butch (Gyrex Corp, Santa Barbara, CA, USA). *Electronics* v 33 n 6 Apr 1987 p 20.

**085350 COMMON PROBLEMS WITH HOT AIR SOLDER LEVELING - PART 1.** This is the first part of a two-part feature about common problems encountered during hot air solder leveling and recommended solutions. Part one describes problems and solutions associated with solder appearance and solderability as well as solder leveling problems. (Edited author abstract)

Fischer, Ivo Jr. (Voss Electronic Inc, Sant Ana, CA, USA). *Electronics* v 33 n 6 Apr 1987 p 22-23.

**085351 HOW TO EVALUATE HOT AIR SOLDER LEVELLING SERVICES.** This paper helps a PWB fabricator to determine whether a hot air leveling system

should be purchased. In addition to the basic equipment price, other factors which should be considered when buying HASL equipment include: operating costs, overhead, equipment depreciation, interest, and floor area. Often overlooked, but equally important are maintenance costs and the cost of rejects. It is important to understand what all the costs are, and not just the purchase price.

Fishfeld, Albert (Summatek Group, Trenton, NJ, USA). *Electronics* v 33 n 6 Apr 1987 p 24.

**085352 OVERVIEW OF HOT AIR SOLDER LEVELING.** Hot air solder leveling is a method of ensuring and preserving the solderability of a PWB. In hot air solder leveling, a clean, fluxed PWB is dipped vertically into a bath of hot liquid solder. Next, both sides of the board are exposed to hot air jets while the board is withdrawn from the solder. Solder leveling equipment clears all holes of solder, removes excess solder from conductor surfaces, and uniformly levels the solder to a predetermined thickness (within the limitations of this somewhat geometry dependent process). Operating parameters can be controlled accurately to achieve consistent results. This paper discusses selection criteria for hot air solder leveling equipment and some changes influencing the process.

Anon. *Electronics* v 33 n 6 Apr 1987 p 27.

**085353 HOW TO PREVENT THERMAL SHOCK USING TEMPERATURE SOLDERING.** Thermal shock during soldering can be a major threat to ceramic devices, particularly chip capacitors and resistors. A device is said to be shocked when temperature increases or decreases too rapidly, and/or when temperature gradients ( $\Delta t$ ) are too great. To reduce the chance of thermal shock in wavesoldering, two thermal limits were defined. The first specifies that the rate of preheating should not exceed approximately 2°C per second, meaning that the chip - as measured by a thermocouple imbedded in the capacitor or resistor - should not experience a rise of more than 2°C per second. The second thermal limit states that the difference in temperature between the preheated component and the solder wave it encounters initially (in dual-wave systems) must not exceed approximately 100°C.

Burley, James (Hollis Automation Inc, Nashua, NH, USA). *Electronics* v 33 n 6 Apr 1987 p 23-33.

**085354 HOW TO ELIMINATE WAVESOLDERING DEFECTS.** The relationship between time and temperature in soldering ensures proper wetting and complete capillary rise in all plated through holes. However, the effect of time/temperature relationships on the creation and/or elimination of soldering defects is less understood. This paper discusses this problem and concludes that process-related solder defects can be eliminated and should not be accepted. The time/temperature relationship can be used as a tool for improving first pass yields through the wavesoldering system.

Down, William H. (Electrovert USA Corp, Arlington, TX, USA). *Electronics* v 33 n 6 Apr 1987 p 35-36.

**085355 FLUX SELECTION FOR PWB WAVESOLDERING.** The selection of a flux for wavesoldering is dependent upon the type of board, its use, economics, and whether or not cleaning is required (and if so, to what degree). Ideally, the least aggressive flux and solder at the highest possible speed should be used. Specific gravity of the flux must be maintained at prescribed levels. For foaming fluxes, the compressed air introduced must have a minimum moisture content. For spray fluxing applications, the solvent blend must be adjusted carefully and controlled to prevent clogging. Wavefluxing, another alternative to foam fluxing, is used primarily for high solids content applications, particularly for optimum through hole penetration. Soldering should take place at the lowest possible temperature consistent with flux activity and conveyor speed.

Anon. *Electronics* v 33 n 6 Apr 1987 p 37.



**085356 PROBLEM OF RESIDUAL FLUX.** Improper or inadequate cleaning of electronic assemblies leaves harmful flux residues containing both ionic and organic (non-ionic) material. To ensure that the results of all tests performed to find residual flux after soldering would be applicable to the widest possible range of solvents and fluxes, it was decided that rosin left on printed circuit boards (PC boards) would be measured after cleaning in a fluorocarbon-113/methanol blend, a 1,1, 1-trichloroethane/alcohol blend or a fluorocarbon-113 solvent. This procedure allows for accurate comparisons to be made concerning the flux/defluxer combination and aids in the accurate determination of amount of rosin residue so that the optimum cleaning cycle can be observed.

Archer, Wesley L. (Dow Chemical Co); Nalazek, Jeffrey J. *Assem Eng* v 30 n 12 Dec 1987 p 20-23.

**085357 DOD-STD-2000: THE ROAD TO COMPLIANCE, PART 2.** DOD-STD-2000 is an attempt to efficiently pull together the current soldering specifications of the Navy, Air Force, Army and Defense Logistics Agency into a simpler, more comprehensive standard. In this article, we will show how strict enforcement of DOD-2000 will constrain military suppliers of PCB assemblies. Specifically, we will discuss the standard's impact on machine soldering and what manufacturers can do to meet the standard's criteria.

Roy, Roland (Royer Manufacturing, Chelmsford, MA, USA); Grinovich, Ed; Worthington, Shari. *Circuits Manuf* v 27 n 9 Sep 1987 p 50, 53, 55-56.

**085358 NEW PHASE IN VAPOR PHASE.** Significant improvements in vapor phase soldering (VPS) equipment have affected both the cost and the viability of this assembly method. The past several years have seen reduced system and operating costs, higher production throughput, simplified operation and greater reliability. In response to increased competition, manufacturers have improved equipment designs and reduced prices accelerating the rate of VPS development. Today, inline VPS units come with belt widths up to 42 in. and can process at rates of 5 to 10 ft/min. Equipment manufacturers now offer a variety of VPS system designs, including small tabletop prototyping units, batch units for low volumes and inline systems for large production runs. Evolution of the VPS process and 15 years of field experience have produced VPS systems that more closely meet user needs.

Pignato, John (3M, St. Paul, MN, USA). *Circuits Manuf* v 27 n 9 Sep 1987 p 71-72, 74, 76.

**085359 TI SOLVES WICKING PROBLEM.** Soldering wicking can cause open solder joints when J-leaded devices are processed in a vapor-phase system. This article describes a quantitative method for analyzing the wicking problem and a new solder paste. The new paste achieves the delayed mobility by taking into advantage the alloying properties of tin and lead. The degree of reflow delay is also affected by prebaking the assemblies prior to reflow. 9 refs.

McLellan, R. Neil (Texas Instruments, Dallas, TX, USA); Schroen, Walter H. *Circuits Manuf* v 27 n 9 Sep 1987 p 78 and 85.

**085360 COMMON PROBLEMS WITH HOT AIR SOLDER LEVELING - PART 2.** This is the second part of a two-part article about common problems encountered during hot air solder leveling and recommended solutions. Part two describes problems caused during solder leveling. The following problems may be caused either during solder leveling or during other fabrication processes: short circuits or wicks (tails) on the PWB, bridging, grainy solder on PWB, solder mask peeling, delamination, scratches or tape residue on PWB, solder on gold tips and gold peeling from gold tips.

Fischer, Ivo Jr. (Voss Electronic Inc, Santa Ana, CA, USA). *Electronics* v 33 n 7 May 1987 p 22.

**085361 WAVE SOLDERING SMDs.** Although surface mounted devices were never designed to be wave

soldered, many users are successfully using this method of attachment. The component joint areas must be solder wettable. If they are not, the user will encounter failures for which the soldering process cannot be blamed. The author examines the behavior of liquid wave solder as it meets the SMD. Joint formation and the prevention of solder bridging are also examined. 1 ref.

Schouten, Gert. *Electron Prod (London)* v 16 n 11 Nov-Dec 1987 p 21, 23.

**085362 SOLDERING WITHOUT CLEANING.** The steady advance of Surface Mount Technology (SMT) has spurred development of fluxes that leave minimum residues after soldering. A range of synthetic-based soldering products is presented whose soldering residues can be regarded as safe to ISO and other specified requirements. These are already widely used internationally. Although they are not yet recognized as fully acceptable for US military requirements, moves are afoot to have them seriously considered for US defense contract work. Meanwhile, they are used extensively in consumer and professional electronics production. Various types of fluxes, resin, organic and inorganic, are reviewed, clarified by ingredients, and flux form (liquid, solid, paste) and their typical properties are listed.

Rubin, Wallace (Multicore Solders Ltd, Engl). *Circuits Manuf* v 28 n 1 Jan 1988 p 21-22, 24.

**085363 SURFACE PREPARATION ENSURES UV SOLDER MASK ADHESION.** Since their introduction in the early 1970s, UV-curable solder masks have shown major growth in replacing conventional, thermally cured solder masks. While conventional solder masks, such as the two-part epoxy, still enjoy considerable popularity among today's board manufacturers, UV-curable masks have been gaining acceptance, especially from the high-volume board shops. About one-third of the commercial solder masks used today are believed to be UV-curable systems, and continued future growth is expected. The success of UV-curable solder-mask adhesion is dependent upon consistently good surface preparation.

Wang, Alan E. (London Chemical Co, Bensenville, IL, USA). *Electron Packag Prod* v 27 n 2 Feb 1987 p 123-124.

**085364 HOT TINNING AND SOLDERABILITY.** Tinning, or hot tinning as it is sometimes known, has been the mainstay of the assembly house when poor solderability of component leads causes defective solder joints on the shop floor. Some aggressive flux, a solder pot, and hands to dip the parts and later clean them, are the only tools required. In the last few years the process has moved to the manufacturing side of the industry, and tinning is slowly becoming the preferred method for assuring solderability when the parts are made and for securing a long solderable life.

Woodgate, Ralph (Wood Corp, Brewster, NY, USA). *Electron Packag Prod* v 28 n 1 Jan 1988 p 109-110.

**085365 ANALYTICAL MODEL FOR LASER REFLOW SOLDERING OF AN ELECTRONIC COMPONENT.** An analytical model for laser reflow soldering of a thick-film ignition module is presented in this paper. The analytical model is used to better understand the effect of process variables on soldering. The process variables investigated include beam power, beam ontime, beam spot diameter, preheat temperature, and specimen materials and configurations. Conclusions drawn from the model analysis are compared against experimental results for verification. The model was found useful in understanding the process and developing an optimum soldering schedule for manufacturing. (Author abstract) 14 refs.

Chang, D.U. (Lasertech Inc, Windermere, FL, USA). *Weld J (Miami Fla)* v 66 n 11 Nov 1987 p 323.s-331.s.

**085366 CHOOSING A SOLDER MASK FOR HIGH DENSITY PWB'S.** Screen printing will continue to be the method selected for masking large lot, low- to moder-

ate-density panels because of its costs advantages compared to photoimageable systems. However, photoimageable solder masks will account for an increasing share of the solder mask market because of increasing circuit and hole densities; surface mount technology (SMT) penetration; and use of just in time (JIT) inventory and supply programs; and increasing emphasis on quality aesthetics. This paper discusses the subjects of PWB density versus process latitude, SMT and yield improvement, JIT inventory and supply programs, board quality and aesthetics.

Halter, Mark A. (W.R. Grace & Co, Lexington, MA, USA). *Electronics* v 33 n 14 Sep 1987 p 15-17.

**085367 HOW TO HANDLE, APPLY DRY FILM SOLDER MASKS.** This paper describes the handling methods and application of dry film solder mask in Automata Inc., Reston, VA. The subjects of discussion include: shelf life, panel processing (cleaning, drying, laminating, etc.) - critical handling and process control.

O'Loughlin, Michael (ELECTRONICS, Libertyville, IL, USA). *Electronics* v 33 n 14 Sep 1987 p 21-23.

**085368 PRINTED CIRCUIT BOARDS FOR INDUSTRY.** This paper gives an outline of modern printed circuit board (PCB) production, introduces some production facilities in UK and describes various applications of tin and tin-lead in PCB production.

Karpel, S. *Tin Its Uses* n 155 1988 p 5-8.

**085369 HOW TO IMPROVE PWB WAVESOLDERING.** High speed printed wiring board wavesoldering operations require careful consideration of four basic elements: base metals, solder alloys, heating profiles, and fluxes. This paper discusses the ways to optimize these elements in order to improve the soldering performance of a board.

Harris, Aaron (Litton Systems Inc, Des Plaines, IL, USA). *Electron Manuf* v 33 n 18 Dec 1987 p 19-21.

**085370 LAMP IR SOLDERING.** The T3 lamp used for solder fusing has a low-mass tungsten filament element sealed within a quartz envelope filled with inert gas. The lamps are designed to work for 5000 hr at 2500°K. In SMT applications, lamp life is usually 20,000 hr at temperatures of 1500°K. The T3 radiant emitter provides fast and efficient product heating. A rapid-response capability is the lamp's greatest advantage. Within 1 sec of a voltage change, the lamp is at 90% of its new equilibrium temperature. This rapid response makes the lamp system ideally suited for closed-loop temperature control. Another benefit of the lamp system is its ability to change profile temperatures rapidly.

Cox, Norman R. (Research Inc, Minneapolis, MN, USA). *Circuits Manuf* v 28 n 5 May 1988 p 43-44.

**085371 PANEL/CONVECTION IR REFLOW.** Convection/IR is a system specifically developed for reflow of SMT board assemblies. Heating of the assembly can be done in a controlled and uniform manner, regardless of size, color or density of the work, and without the added expense of an inert atmosphere. In light of the inherent characteristics of lamp versus convection/IR and the application at hand, careful consideration should be given to the IR technology used. Board composition in terms of overall mass, size, component density and makeup, solder and substrate material may or may not interact with the type of IR employed with regard to wave length, absorptivity, and presence or lack of convection heating. Machines should be considered and compared from a hands-on standpoint, and their results should be assessed in terms of uniformity of heating, control of heat rate, throughput, ease of setup, facilities required and repeatability.

Zarrow, Phil (Vitronics Corp, Newmarket, NH, USA). *Circuits Manuf* v 28 n 5 May 1988 p 47, 49.



**085372 FORCED CONVECTION IR REFLOW.** The various types of reflow are described. Two major problems with conventional panel systems are examined. It is shown that forced air improves IR reflow system performance in two distinct ways. The technology minimizes temperature gradients between components of differing thermal mass by blowing fresh air at precisely controlled temperatures across the board during ramp-up stage. By setting air temperatures just below the hottest spot on the board, the cool regions of the board can be heated without overheating the hotter regions. This air flow continues to moderate temperature gradients during reflow where maintaining equilibrium is critical. The second advantage of forced-air convection radiant heating is the minimization of across-panel temperature gradients under high throughput conditions.

DeAngelo, Don (Heller Industries, Inc, Florham Park, NJ, USA). *Circuits Manuf* v 28 n 5 May 1988 p 51, 53.

**085373 SMT-LEITERPLATTEN-BAUGRUPPEN. ENTWURF - BESTUECKEN - LOETTECHNIKEN - LOESTOPMASKEN.** [SMD Printed-Circuit Board Modules. Design - Assembly - Soldering Systems - Solder Resist Masks]. This article is intended to help the PCB designer and artist create the type of PCB design which makes the production of the PCBs as simple as the circumstances allow, enables assembly and soldering with high ultimate efficiency, allows the PCBs to be inspected and, in the event of defective components, permits simple repair of the module. (Author abstract) In German.

Weinhold, M. *F&M Feinwerktech Messtech* v 96 n 5 May 1988 p 197-200.

**085374 PRAXIS DER DAMPFPHASEN-REFLOW-LOETTECHNIK.** [Vapour-Phase Reflow Soldering in Practice]. The special geometries of SMD components and their temperature sensitivity have resulted in both the modification of existing soldering systems and the introduction of new reflow soldering techniques. This article deals with vapour-phase soldering and focuses on a selection of systems in practical application. (Author abstract) In German.

Panzer, Birger. *F&M Feinwerktech Messtech* v 96 n 5 May 1988 p 201-204.

**085375 WELLENLOETEN VON SMDs.** [Wavesoldering of SMDs]. Use of SMDs (surface-mounted devices) entails applying the solder as paste prior to soldering before the component is mounted. The connection is then made by reflow soldering. SMDs are now also being bonded on the bottom side of PCBs and soldered in a solderwave. Basically speaking, SMDs are not especially suited for wavesoldering, so it is necessary to apply the measures described in the article in order to improve the soldering. (Author abstract) In German. 2 refs.

Schouten, G. *F&M Feinwerktech Messtech* v 96 n 5 May 1988 p 205-207.

**085376 STATISTICAL VARIATIONS IN SM COMPONENT SOLDERABILITY TESTING.** The reduced size of many military and consumer electronic systems has brought surface mount technology to the forefront of electronic packaging. SMT demands superior joint quality to ensure adequate reliability, but unfortunately, SMT solder joints are prone to low cycle fatigue failures caused by substrate and component thermal coefficient of expansion (TCE) differences. Because of this, component and substrate solderability must be tested by both the vendor and component user to achieve the goal of high reliability. Agreement on test conditions and test results is essential. This study quantitatively assesses the impact of varying certain test conditions on the solderability test results of surface mount components (SMCs). The variables include flux activity level, steam aging chamber design, and steam aging time. These particular variables were chosen because they often are sources of conflict between component vendors and users when solderability test results do not agree. 7 refs.

Evans, John W. (Unisys Corp, Greenbelt, MD, USA). *Surf Mount Technol* v 1 n 5 Oct 1987 p 21-24.

**085377 HOW PRETINNING, TESTING HELP IMPROVE SOLDERABILITY OF SURFACE MOUNT COMPONENTS.** The purpose of pretinning parts prior to use is to improve solderability. In order to achieve the best results, parts should be pretinned prior to storage. This will increase shelf life and improve solderability by providing a fused layer of tin/lead coating. It is even more beneficial to perform solderability testing prior to acceptance and pretinning. Without this additional step, vendor-related problems may be masked or otherwise go unnoticed if a strong flux is used for pretinning.

Tiehl, Rena E. (TRW Operations & Support Group, Redondo Beach, CA, USA). *Surf Mount Technol* v 1 n 5 Oct 1987 p 31-36.

**085378 HOW A DEFLUXING SOLVENT HELPED INCREASE PRODUCT EFFICIENCY.** Finding the right combination of production parameters and defluxing solvent has increased PCB production efficiency noticeably. However, additional benefits are being realized as higher quality boards and computers are delivered to the market. On the assembly floor, the new defluxing solvent has eliminated the buildup of contaminants on the heating elements of the defluxing unit and in the still. Cleaning is now determined by the amount of rosin suspended in solution instead of the fear of caked rosin buildup on the heating elements. The improved solvent stability over previous solvents also has resulted in a lower volume of waste requiring disposal - generation of waste has been reduced from about 55 gallons per month to 10.

Humphrey, Joe (Harris Corp, Ft. Lauderdale, FL, USA). *Electron Manuf* v 34 n 7 Jul 1988 p 8-9.

**085379 UNDERSTANDING AND CONTROLS NECESSARY FOR WAVE SOLDERING RELIABILITY - PART 1.** Whether soldering by hand with a soldering iron and flux-cored wire solder, or with automated soldering machines, there are four important considerations requiring thorough understanding and tight control: 1.) Solderability, 2.) Flux, 3.) Solder, and 4.) Heat. Every soldering application involves these four factors, all equally important in the process of completing reliably soldered assemblies. Circuit board metal surfaces, the type of plating, protective coatings, and layout should be selected with soldering in mind. Component lead solderability and placement on the PCB in a solderable configuration also determine the reliability of the soldered assembly. The choice of soldering flux is related directly to the solderability of the metal surfaces. The solder alloy selected and the level of purity determine the speed of soldering. This paper discusses the subjects of solderability, soldering flux and flux removal. Metal solderability chart and flux selection guide are included.

Bernier, Dennis F. (Litton Systems Inc, Des Plaines, IL, USA). *Electron Manuf* v 34 n 7 Jul 1988 p 10-13.

**085380 VAPOR PHASE SOLDERING BASICS.** Vapor phase mass reflow soldering (VPS) is a non-contact soldering process that takes place in a vapor-filled zone. This thermal transfer vapor is formed by heating a perfluorinated electronic liquid that boils at a temperature higher than the solder reflow temperature. The VPS technique uses condensation heating - the transfer of the latent heat of vaporization of the saturated vapor to circuit assemblies as the vapor condenses on these cooler surfaces. The VPS process has potential in certain cases for significant increases in circuit production over alternate soldering methods. It offers a high level of solder joint uniformity and reliability, even for densely packed, complex, high mass assemblies and odd geometries. These benefits are due to the characteristics of perfluorocarbon liquids and the efficiency of heat transfer obtained from a condensing vapor.

Ruffing, John (3M, St. Paul, MN, USA). *Electron Manuf* v 34 n 7 Jul 1988 p 20-21.

**085381 SOLDERABILITY AND SURFACE MOUNTING.** In the last decade through-hole mounting to printed wiring boards has matured and people now have the tools to diagnose and correct any solderability

problems which might arise. Such is not the case with surface mount soldering technology. In surface mount the connections are smaller and are often hidden from view. Therefore when a solderability problem occurs it may never be known until the assembly fails. The solution to the situation is to understand the nature of the problems and provide assurance that they will not occur during assembly soldering. This paper details the types of solderability problems unique to surface mounting. Examples of these problems are shown and discussed with reference to solder joint life. The second part of the paper discusses the solderability testing of surface mount devices and printed wiring boards intended for surface mounting. This discussion concentrates on the new quantitative solderability test methods being developed for leadless devices and printed wiring boards. New solderability criteria have been defined which reflect the unique problems associated with surface mounting. (Edited author abstract). 7 refs.

DeVore, J.A. (GE, Syracuse, NY, USA). *Circuit World* v 14 n 4 Jul 1988 p 37-41.

**085382 KNOW THY PROCESS.** The author shows how automated process information systems can play a big role in moving the wave soldering process out of the realm of black magic and into the domain of methodical, scientific management. Such systems can provide a comprehensive view, in useful terms of what is really going on in this complex process. By watching what is happening in the wave soldering process, you can act on problems before they become serious, while continually improving performance. These systems allow a manufacturer to run each board type according to a unique, optimized soldering recipe to track down the resource of problems, to improve soldering results based on experience, to improve new product introductions, to increase operator involvement and to apply statistical process control techniques to soldering operations. Elements of a process information system are discussed.

Picker, Dennis (Fidelis Group Inc, Newton, MA, USA). *Circuits Manuf* v 28 n 8 Aug 1988 p 4p.

**085383 SURFACE MOUNT PRODUCIBILITY AND RELIABILITY.** A design perspective on common SMT assembly concerns is presented. It is pointed out that as in the case of printed circuitry, components must be specified for reliable applications concerning SMT. Emphasis in this paper is on solderability. Component and printed circuit solderability, in conjunction with the solder medium and process, is all there is to a solder joint; if one of these elements is questionable, so is the solder joint itself.

Moon, Earl (Proof of Design, San Jose, CA, USA). *Printed Circuit Des* v 5 n 8 Aug 1988 p 30-35.

**085384 PRINTED CIRCUIT BOARD CLEANING AGENTS AND SOLDERING FLUXES: CFC ALTERNATIVES.** The selection of a flux for printed circuit soldering and a possible cleaning material or method traditionally have been dependent on a number of factors. However, selection considerations increasingly are being influenced by concerns over depletion of the earth's ozone layer by chlorofluorocarbons (CFC's). In electronic manufacturing, CFC's are widely used for solvent cleaning to remove soldering flux residues for components and PCB's after wave soldering. Research efforts already are underway to find alternatives to soldering with rosin flux and cleaning with CFC-based solvents. This paper explains what is a CFC and discusses the concerns about the ozone, the conservation measures and CFC alternatives, among them chlorinated solvents, alkaline saponifiers, emulsifiers and water soluble fluxes.

Bernier, Dennis (Litton Systems Inc, Des Plaines, IL, USA). *Electron Manuf* v 34 n 8 Aug 1988 p 29-31.



**085385 UNDERSTANDING THE CONTROLS NECESSARY FOR WAVE SOLDERING RELIABILITY - PART 2.** Soldering is the most economical way to make reliable electrical connections. However, failure of electronic equipment may result in defective solder joints. To combat solder joint problems, the user of soldering material should become familiar with the basic requirements for producing the necessary skills in using the proper solder, flux, and solder equipment. There are four important considerations to take into account for proper soldering techniques: 1) solderability, 2) flux, 3) solder, and 4) heat. Part 2 of this feature will discuss solder alloys and impurities, heat, and computer controls.

Bernier, Dennis F. (Litton Systems Inc, Des Plaines, IL, USA). *Electron Manuf* v 34 n 8 Aug 1988 p 35-36.

**085386 AUTOMATION OF SOLDER JOINT INSPECTION PROCEDURES UTILIZING LASER INDUCED INFRARED.** Automation of solder-joint inspection by means of laser-induced infrared radiation is investigated. A focused laser beam is used to apply an intense, short-duration heat pulse to the surface of the solder joint to be evaluated. This heat flows freely into the metallic interior of the joint by conduction while the surface of the joint emits radiation. The temperature rise on the surface of the joint is monitored by an infrared detection system, which also monitors the cooling process following the laser pulse. This infrared signature is used to detect defective joints. The capabilities of the system and the advantages of automated inspection are discussed. 2 refs.

Fugate, Gary W. (Texas Instruments Inc, Dallas, TX, USA); Felty, Joe R. *IEEE Trans Compon Hybrids Manuf Technol* v CHMT-10 n 3 Sep 1987, Second Int Electron Manuf Technol (IEMT) Symp, San Francisco, CA, USA, Sep 15-17 1986 p 374-378.

## Standards

**085387 MIL-P-13949 G AND ITS CONSEQUENCES FOR THE PCB INDUSTRY.** The new military specification for PCB base material was published on February 11th, 1987. This 'G' version is not merely an amendment of the 'F' version, but basically a new specification with far reaching consequences for both the base material manufacturers and the printed circuit board manufacturers. In this paper the major changes and also the latest introductions are discussed. (Author abstract)

Huschka, M. (Norplex/Oak Europa GmbH, Wipperfurth, West Ger). *Circuit World* v 14 n 2 Jan 1988 p 26-29.

## Stresses

**085388 STRESS AND DEFLECTION ANALYSIS OF PARTIALLY ROUTED PANELS FOR DEPA-NELIZATION.** Analytic studies of deflection and stress in partially routed panels using the finite-element method are discussed. Emphasis is placed on the effects of partial routing on the assembly processes for surface-mount printed circuit boards. To test the validity of the finite-element results, the overall deflection profile of a partially routed panel was measured. The calculated deflection profile agreed with the experimental results. Two different tab configurations have been designed, and four connecting tab widths have been analyzed for each design. The results indicate that panels dimensions could be partially routed without causing material failure or compromising solder-joint quality. 20 refs.

Lau, John H. (Hewlett Packard Co, Palo Alto, CA, USA); Barrett, George E. *IEEE Trans Compon Hybrids Manuf Technol* v CHMT-10 n 3 Sep 1987, Second Int Electron Manuf Technol (IEMT) Symp, San Francisco, CA, USA, Sep 15-17 1986 p 411-419.

**Substrates** See Also ELECTRONIC CIRCUITS, COU-PLER—Design.

**085389 LIMITATIONS OF HIGH SPEED HIGH DENSITY PWB SUBSTRATES.** This paper looks at the implications of increases in system speed and density for

the interconnection system, noting particularly the increased requirements placed on the substrate and tracking system. It reviews the properties required of substrates and the limitations derived from the materials used and the processes needed to put tracks on them. Those areas where these requirements are in conflict are highlighted, including such low technology problems as the limited size availability of substrate prepreps which may limit the tracking density achievable on the newer, more advanced low dielectric materials. Some limitations and trade-offs are identified. (Author abstract) 20 refs.

Curtis, J.C. (Plessey Research (Caswell) Ltd, Towcester, Engl); Lodge, K.J.; Pedder, D.J. *Circuit World* v 14 n 3 Mar 1988 p 4-11.

**Testing** See Also AUTOMATIC TESTING; INTEGRATED CIRCUIT TESTING; INTEGRATED CIRCUITS, VLSI—Testing; TELECOMMUNICATION EQUIPMENT—Testing.

**085390 ROLE OF INTERFACE BUSES IN PRINTED WIRING BOARD TESTING.** Printed wiring board testing has become increasingly complex as the number of instruments required in the test environment has increased, and costs of both hardware and software have changed over time. Adding to this complexity is concern about networking, that is, ensuring that all the instruments in the test environment are communicating with each other. The interface bus and associated hardware and software products are fundamental to this communication. A combination of hardware and software may be used to provide the required interfaces for a particular board testing application. This paper discusses various interface solutions and the concept of a 'virtual instrument' (VI) to create test equipment in software or to control real test equipment. A VI is similar in function to a physical instrument. However, it is created out of software, and may be made up of other virtual or real instruments. Virtual instruments are designed to take the place of dedicated hardware by tailoring general purpose hardware into specialized test functions.

Bartos, Sara (Electronics, Libertyville, IL, USA). *Electronics* v 33 n 3 Feb 1987 p 55-57.

**085391 HOW TO SELECT SPRING PROBES FOR TESTING PWB'S - PART 2.** This is the second part of a two-part feature about selection criteria for high density spring probes and testability guidelines for designing a high density board. Part two includes electrical performance, probe cost and testability guidelines. (Edited author abstract)

Robison, Ronald L. (Everett/Charles Contact Products Inc, Pomona, CA, USA). *Electronics* v 33 n 6 Apr 1987 p 16-17.

**085392 FIXTURING METHODS FOR TESTING HIGH DENSITY PWB'S - PART 2.** This is the second part of a two-part article on different techniques for testing PWB's that are difficult to access. Part two discusses how to design PWB's for test access, whether to build or buy fixtures, and CIM's impact on fixturing. (Edited author abstract)

Jones, Kris (Hewlett-Packard, Loveland, CO, USA); Ormsby, Jim. *Electronics* v 33 n 6 Apr 1987 p 28-29.

**085393 HOW TO SELECT SPRING PROBES FOR TESTING PWB'S - PART 1.** This is the first part of a two-part feature about selection criteria for high density spring probes and testability guidelines for designing a high density board. Part one discusses various selection criteria such as pointing accuracy, plunger travel, and tip selection. (Edited author abstract)

Robison, Ronald L. (Everett/Charles Contact Products Inc, Pomona, CA, USA). *Electronics* v 33 n 4 Mar 1987 p 39-40.

**085394 FIXTURING METHODS FOR TESTING HIGH DENSITY PWB'S - PART 1.** This is the first part of a two-part article on different techniques for testing PWB's that are difficult to access. Part one covers the problems of limited access, the types of specialized

mixturing available, and the combinational test fixturing technique. (Edited author abstract)

Jones, Kris (Hewlett-Packard, Loveland, CO, USA); Ormsby, Jim. *Electronics* v 33 n 4 Mar 1987 p 41-43.

**085395 OVERVIEW OF BURN-IN TESTING.** This paper discusses advantages of PWB burn-in testing and the measures to protect valuable workloads during burn-in testing.

Scheppe, William (General Signal, Blue Island, IL, USA); Miller, Russel F. *Electronics* v 33 n 7 May 1987 p 59.

**085396 COMBINATIONAL BOARD TEST SYSTEM.** The HP 3065AT is a combinational tester in the sense that it supports both in-circuit and functional testing methods. It provides a completely integrated set of resources for testing analog, hybrid, and digital circuits incorporating surface mounted devices, application specific ICs, and VLSI circuits. 1 ref.

Gravitz, Michael E. *Hewlett Packard J* v 38 n 11 Dec 1987 p 53-64.

**085397 ANWENDUNG LEITFAEHIGER ELASTOMERE ZUR PRUEFSIGNALGEWINNUNG.** [Use of Conductive Elastomers for the Detection of Test Signals]. Test signal detection with the aid of conductive elastomers constitutes a low-cost alternative to signal scanning with conventional needle adapters and is suitable for the testing of high-precision printed circuit boards. In particular, it is shown that these elastomers may be successfully used as tappet connectors for the scanning of unmounted printed circuit boards. In German. 8 refs.

Schulze, M. (Technische Univ Karl-Marx-Stadt, East Ger). *Feingeraetetechnik* v 36 n 10 1987 p 466-468.

**085398 LOW VOLTAGE INSULATION RESISTANCE MEASUREMENT OF PRINTED CIRCUITS AND ITS IMPLICATIONS.** The use of surface insulation resistance testing has been restricted to QC laboratory applications. The extension of this technique to modern electronics and, in particular, to contamination control of SMAs has forced the development of new methods of SIR measurement. These have revealed that existing standards are rapidly becoming obsolete because the premises on which they are founded are no longer valid. Even more alarming, it is revealed that we are rapidly reaching, not only the limit of our knowledge in the field, but also the technical limits of existing standard materials used in industry today. This paper is a warning against too much complacency, as the risk of running into real problems, at all process stages, will become very pertinent within a few years. The technical content of this paper is based on about three years' study of the subject resulting in the measurement of SIR at about 10 v, as opposed to the traditional values of 100 and 500 V, which have been proved to be of little value with conductor spacings such as are usual on SMAs. (Author abstract) 15 refs.

Ellis, B.N. (Protonique SA, Romanel-sur-Lausanne, Switz). *Circuit World* v 14 n 2 Jan 1988 p 21-25.

**085399 FOR HIGHER YIELD: TEST OR INSPECT BARE PCB'S?** Test and inspection systems are more complementary than competitive. While there is some performance overlap, both have unique benefits. Electrical test is swift and has a favorable price/performance ratio; AOI provides real-time process control and detects flaws, invisible to test, that affect reliability.

Spitz, Leonard (Electronic Packaging & Production, Newton, MA, USA). *Electron Packag Prod* v 27 n 2 Feb 1987 p 96-98.

**085400 ESD FAILURES OF BOARD-MOUNTED DEVICES.** Electrostatic discharge (ESD) plagues the modern microelectronics industry and poses unique reliability problems due to failures on the production line, in the inspection department, at the stockroom, while in



transit or in the hands of customers. Such ESD threats are supposedly experienced only in isolated devices; that is, in devices which are not mounted on a printed circuit board (PCB). This presumption is incorrect. It is a myth that an ESD-sensitive component cannot be damaged once installed on a circuit board. Analysis and simulated experiment indicate that mounted devices are more vulnerable to ESD than are unmounted devices. 12 refs.

Neelakantaswamy, Perambur S. (RIT Research Corp, Rochester, NY, USA); Turkman, Rennen I. *Electron Packag Prod* v 27 n 2 Feb 1987 p 132-134.

**085401 SOLUTIONS BEGIN TO SURFACE FOR LINKING BOARD DESIGN AND TEST.** Although many tools have been developed to automate the efforts of design engineers and test engineers, little has been done to make design tools and test tools compatible. And until recently, there hasn't been a big push to force design and test to communicate and make use of each other's efforts. This is somewhat understandable, since the design engineering department and the test engineering department are separate entities in most companies. This article shows how many companies are finding ways to link design and test tools, including recruiting the services of third-party vendors. The main topics are linking CAE to ATE, compatibility of test and design, how third-party links assist test, and CEA/ATE standardization.

DeSena, Art (ADS Associates, USA). *Comput Des* v 27 n 5 Mar 1 1988 p 34-39.

**085402 FLEXIBLE PCB TEST WORK-CELL.** Flexible robotic-based work-cells are considered that design and implement flexible PCB test systems to reduce human handling and thereby improve the yield of assemblies. In addition to improving quality, the PCB test work-cell is justified by increasingly complex test procedures that can best be driven and monitored through software integrated with the work-cell. The robot can also service multiple test sets, thereby eliminating idle labor time and increasing productivity.

Pearce, Bill (Intellex Inc, Corvallis, OR, USA). *Circuits Manuf* v 28 n 2 Feb 1988 p 37-38.

**085403 NEW STRATEGIES FOR BUS-STRUCTURED PCB TESTING.** Bus timing emulation is widely used for the production testing of bus-structured printed circuit boards. However, with the ongoing advance of bus-structured technology, continued successful use of the technique will require new facilities for, and approaches to, test hardware, fixturing and design for testability. The bus timing emulation technique continues to be used successfully for testing state-of-the-art bus-structured boards. The BTE test hardware has evolved rapidly to keep pace with advancing bus-structured technology. In order to achieve maximum test efficiency it is necessary for careful consideration to be given to fixturing and PCB design for testability. (Edited author abstract)

Hay, Malcolm J. (Zehntel Performance Systems). *Comput Aided Eng J* v 5 n 1 Feb 1988 p 29-32.

**085404 FIXTURING FOR ATE. SHIFTING INTO HIGH GEAR FOR SMT.** The advent of mount technology (SMT), drastically has changed ATE fixturing. Probing point accuracy, repeatability and 50-mil centers must be addressed by everyone involved with fixture design. Selection of the probe is one of the first considerations facing the fixture designer. High-density boards require probes with excellent pointing accuracies. Design for testability (DFT), functional testing and probing accuracy are discussed.

Anon. *Eval Eng* v 27 n 4 Apr 1988 8p.

**085405 FUNCTIONAL BOARD TEST HYBRID DIAGNOSTICS. THE EVOLUTION AND ADVENT OF ANALOG SIGNATURE ANALYSIS. PART 2.** Hybrid functional testing is composed of two distinct processes. Hybrid go, no-go testing means that the functional ATE provides a cycle of mixed-signal stimulus and predicted response. If at least one significant deviation from either the predicted (simulated) or learned response

set is detected, then the functional ATE proceeds to enter the second board test process, hybrid diagnostics the fault isolation phase. For descriptive purposes, the hardware and software implementation solution for analog functional hybrid diagnostics is presented using the Schlumberger ATE (FACTRON) Series 700 tester line.

Reiss, Alan (Schlumberger ATE, Latham, NY, USA). *Eval Eng* v 27 n 4 Apr 1988 p 108-111.

**085406 BARE BOARD TEST METHODS FOR HIGH DENSITY BOARD DESIGNS - PART 1.** This is the first of a two-part article describing bare board testing alternatives. The first part discusses the bed-of-nails method, high density fixturing problems, universal grid systems, and the moving probe method. (Edited author abstract)

Conti, Joseph (Kollmorgen Corp, Melville, NY, USA). *Electronics* v 33 n 14 Sep 1987 p 31-32.

**085407 BARE BOARD TEST METHODS FOR HIGH DENSITY BOARD DESIGNS - PART 2.** This is the second part of a two-part feature about bare board testing. This part describes use of the moving probe method, fixtures vs. probes, and the future of bare board testing.

Conti, Joseph (Kollmorgen Corp, Melville, NY, USA). *Electronics* v 33 n 16 Oct 1987 p 39.

**085408 USING PERFLUORINATED ELECTRONIC LIQUIDS FOR COMPONENT TESTING.** Perfluorinated electronic liquids - high dielectric fluids with unusual physical characteristics - are used for several distinctly different applications in the electronic industry. This class of liquids is chemically inert, colorless, non-toxic, nonflammable, and compatible with printed wiring board and component materials. As a replacement for air in electronic testing, perfluorinated electronic liquids improve the ability to control individual device temperatures and can reduce the time required for testing procedures. This paper gives examples of testing procedures that make use of these liquids. Among these procedures there are ceramic crack test, thermal shock test, liquid burn-in testing and environmental testing.

Seldinger, Kurt (3M, Industrial Chemical Products Div, St. Paul, MN, USA). *Electron Manuf* v 33 n 17 Nov 1987 p 16-18.

**085409 HOW TO TEST FLEXURAL FATIGUE, ENDURANCE, DUCTILITY OF FLEXIBLE PWB'S.** Various test methods are used to test the physical and mechanical characteristics of flexible printed wiring boards during fabrication. The choice of test method used should be based upon the substrate type and the particular characteristic to be tested. This article examines the substrate materials used and details several flexural endurance and fatigue tests recommended by the Institute for Interconnecting and Packaging Electronic Circuits (IPC), Lincolnwood, Ill.

Moosman, Kari (Electronic Manufacturing, Libertyville, IL, USA). *Electron Manuf* v 33 n 18 Dec 1987 p 13-14.

**085410 OPTIMIZING THE IN-CIRCUIT TEST PROCESS.** This paper describes a mathematical model of the in-circuit test process and the effects of the following 3 parameters: 1) Yield (from assembly): percentage of boards that pass the first time that they are tested; 2) Test time: average test time per board; and 3) Efficiency (shift): percentage of total shift time actually available for testing boards. Fractors that influence the parameters are also discussed. These are: assembly process design, test process design, physical PCB design, electrical PCB design and test design.

Curtis, Steve (Telex Corp, Raleigh, NC, USA); Douglas, Phil. *Electron Manuf* v 34 n 6 Jun 1988 p 11-13.

**085411 TESTING PHILOSOPHY FOR ZERO DEFECTS.** A philosophy for improving the yield problem is to verify the part is correct and properly oriented for installation. A complete test is not necessary because the

part has been through receiving inspection. This philosophy redefines the function of test. Instead of identifying or detecting faults after the manufacturing process, the emphasis is on preventing defects from entering the process. The philosophy is then based on eliminating defects rather than detection and rework to produce quality finished goods. With in-process test and automation, the concept of zero-defects becomes truly practical. Benefits of zero-defect approach are discussed.

Shemeta, E.H. (Boeing Electronics Co, Seattle, WA, USA). *Electron Manuf* v 34 n 5 May 1988 p 20-24.

**085412 TEST STRATEGY DEVELOPMENT: A BROAD APPROACH.** Current manufacturing industry trends significantly impact new product test strategies, and today's business environment requires a broad selection perspective. The paper discusses types of test systems, forces affecting test strategy, general test philosophies and product test strategy selection.

Martin, Mike (Tektronix Inc, Vancouver, WA, USA). *Electron Manuf* v 34 n 5 May 1988 p 25-28.

**085413 FEATURES TO CONSIDER WHEN CHOOSING A BURN-IN TEST OVEN.** When considering the purchase of a chamber for burn-in test applications, the two most important factors to weigh are the value of the workload and the value of the oven. It is not unusual for a workload to be worth \$250,000 or more. Thus, the cost of the workload may far exceed the combined cost of the burn-in chamber and the necessary interior fixturing. In fact, the chamber itself often is the least expensive element in a burn-in test system. Accordingly, only a first quality chamber should be considered, because in burn-in testing, a quality chamber is a safe chamber. This paper discusses the following subjects: burn-in test procedures, adjusting heat levels over-temperature protection of test chamber and oven design.

Scheppe, William (General Signal, Blue Island, IL, USA.). *Electron Manuf* v 34 n 3 Mar 1988 p 37-38.

**085414 COMPUTER INTEGRATED PC BOARD TEST & REPAIR.** Printed circuit board test and rework is an area which, like design, machine insertion, flexible assembly, wave solder, and the other processes involved in the production of pc boards, must be incorporated under the umbrella of computer integrated manufacturing (CIM) to reduce costs and improve quality and productivity. This article discusses how printed circuit board production test and repair can effectively be made part of an overall computer integrated manufacturing system.

Saunders, Glenn (CIMM Inc). *Assem Eng* v 31 n 5 May 1988 p 42-46.

**085415 QUEST FOR TEST.** The author reports on one development in bare board surface mount technology testing - a double-sided universal grid tester. She also discusses the importance of fixturing in the testing of increasingly dense circuitry on SMT boards and the use of CAD data download capability for designing fixtures and creating test programs.

Abrams, Alice C. (Circuits Manufacturing, San Francisco, CA, USA). *Circuits Manuf* v 28 n 3 Mar 1988 4p.

**085416 INTERFACE BRINGS STANDARDIZED DFT CLOSER TO REALITY.** A specification for a four-wire serial interface to incorporate boundary-scan cells for standard ICs and application-specific ICs is being finalized by the Joint Test Action Group (JTAG), an international ad hoc group of companies promoting standardization of design-for-testability techniques. The interface will enhance testability of printed circuit board assemblies and can virtually eliminate the need for bed-of-nails fixtures, especially critical when boards are designed using surface-mount components. A key feature of the JTAG 2.0 standard is a four-pin implementation with a clock, a single-mode input and serial I/O lines. It also has a small state machine to decode the mode input and generate control and clock signals, and it includes



serial path shifts for instructions or data. Multiple parallel data paths are available, including a bypass path and a boundary-scan path.

DeSena, Art (ADS Associates). *Comput Des* v 27 n 10 May 15 1988 p 104-105.

**085417 IDENTIFYING ISOLATION SHORTS DURING BARE-BOARD TESTING.** Isolation shorts are defects in the etched circuit traces or board composite or merely surface contaminants that become evident only when relatively high voltage is applied between traces. This article discusses the types of isolation shorts prevalent in PC board manufacture and specific steps recommended to test and identify these defects. The main topics are oxide whiskers, voltage arc-over and under etching, surface contamination, surface moisture, inner ionic contamination plus moisture, and recommended testing procedures. 3 refs.

Leech, Bill (Program Data Inc, Irvine, CA, USA). *Eval Eng* v 27 n 6 Jun 1988 p 136, 138.

**085418 BRINGING TEST ON BOARD.** Nodal access has become the most critical issue in testing surface mount boards. To overcome this potential problem, Texas Instruments uses a test strategy that provides in-circuit testing for surface mount boards with a 100-mil gap between components and 50-mil gap between components and 50 mil between component pad centers. This strategy involves an innovative land pattern design and a tightly controlled board manufacturing process. Manufacturing faults form the largest class of loaded board faults. Catching these faults is the main feature of in-circuit test because it isolates them less expensively than other test methods, such as functional or systems test. In-circuit test provides quick feedback to correct process faults before factory yields drop too low.

Keagy, R.A. (Texas Instruments, Dallas, TX, USA). *Circuits Manuf* v 28 n 6 Jun 1988 p 85-89.

**085419 LEITERPLATTEN-PRUEFUNG MIT MULTI-MODE-TESTER.** [Printed-Circuit Board Inspection with a Multimode Tester]. For many companies quality is the topmost priority. In order to be able to maintain the desired quality level for VME bus boards in large batches as well, the manufacturer Eltec decided at the end of 1986 in favor of using a multimode tester. The arguments in support of the company's decision are explained. (Edited author abstract). In German.

Fischer, Petra (SPEA GmbH, Buseck, West Ger). *F&M Feinwerktech Messtech* v 96 n 7-8 Jul-Aug 1988 p 326-328.

**085420 CONTROLLED ELECTROMIGRATION FOR FIELD FAILURE ACCELERATION.** A simple test for stressing specific areas of an assembly has been developed, using threshold values for the parameters studied that are based on understanding of the electromigration failure mechanism. This test can be applied to a functional system or component, and a life expectancy can be predicted. Incompatible components can be eliminated from the system or their surfaces prepared in such a manner as to prevent premature demise. This type of testing is well-suited to printed-circuit-board platings, component platings, and final assembly cleaning. With controlled electromigration the best possible process can be determined for coating the exposed metal surfaces so that maximum reliability is achieved. 8 refs.

Juskey, Frank (Motorola Inc, Ft. Lauderdale, FL, USA). *IEEE Trans Compon Hybrids Manuf Technol* v CHMT-10 n 3 Sep 1987, Second Int Electron Manuf Technol (IEMT) Symp, San Francisco, CA, USA, Sep 15-17 1986 p 370-373.

**Thermal Effects** See Also INTEGRATED CIRCUITS, VLSI—Electronics Packaging; INTERFEROMETRY, HOLOGRAPHIC; PLASTICS LAMINATES—Materials.

**085421 PCB THERMAL ANALYSIS PROBLEM.** It is seldom necessary to justify the need for an accurate assessment of the temperature of electronic components

and printed circuit boards (PCBs). Design engineers understand that the operational characteristics of circuits are temperature-dependent and also that the lifetime of electronic components is adversely affected by excessive temperatures. Reliability analysts use the junction temperature of active devices as a parameter in their mean-time-to-failure equations. This article provides a brief discussion from a thermal analyst's point of view. 15 refs.

Ellison, Gordon N. *Printed Circuit Des* v 4 n 10 Oct 1987 p 27-30.

**085422 THERMAL ANALYSIS EXPLORES PCB BEHAVIOR.** The article reviews different thermal analysis techniques available for multilayer boards thermal behavior testing. Among these techniques are differential scanning calorimetry, thermomechanical analysis, dynamic mechanical analysis, thermogravimetric analysis, and differential photocalorimetry. 5 refs.

Smith-Vargo, Linda (Electronic Packaging & Production, Newton, MA, USA). *Electron Packag Prod* v 27 n 12 Dec 1987 p 30-33.

## Thermal Expansion

**085423 T300 GRAPHITE CORE PRINTED WIRING BOARD: PREDICTING THE COEFFICIENT OF THERMAL EXPANSION.** Materials with low thermal expansion rates are being used in printed wiring boards (PWBs) to obtain a thermal expansion factor compatible with that of surface mounted leadless ceramic chip carriers (LCCCs), thus improving solder joint survivability and reliability. Boeing Electronics Company (BEC) selected T300 graphite, a constraining core material, as its baseline in establishing methodology for predicting and then measuring coefficient of thermal expansion (CTE). Predicted results from the Interactive Composite Analysis Program (INCAP) were compared with CTE measurements derived from a relatively new strain gage technique. (Author abstract)

Williams, R.L. (Boeing Electronics Co, Seattle, WA, USA); Hauch, R.J.; Noblett, A.W. *Circuit World* v 14 n 2 Jan 1988 p 46-48.

## Thermoanalysis

**085424 EXAMINATION OF THERMAL ANALYSIS FOR PWB, ELECTRONIC BASE MATERIALS TESTING - PART 1.** This is part one of a two-part article which describes four types of computer controlled thermal analysis methods for PWB and electronic applications. This part is an overview of the methods as used with laminates and preregs. (Edited author abstract)

Thomas, Leonard C. (DuPont, Wilmington, DE, USA). *Electronics* v 32 n 12 Nov 1986 p 35-39.

**085425 EXAMINATION OF THERMAL ANALYSIS FOR PWB, ELECTRONIC BASE MATERIALS TESTING - PART 2.** This is part two of a two-part article which describes four types of computer controlled thermal analysis methods for PWB and electronic applications. This part discusses the use of thermal analysis for electronic applications and how to justify the equipment expense. (Edited author abstract) 2 refs.

Thomas, Leonard C. (DuPont, Wilmington, DE, USA). *Electronics* v 32 n 13 Dec 1986 p 37-39.

## Waste Disposal

**085426 SOLVING WASTE DISPOSAL PROBLEMS ASSOCIATED WITH PRINTED WIRING BOARD FABRICATION - PART 2.** Because of increasingly stringent regulations concerning proper handling and disposal of hazardous wastes, PWB manufacturers are faced with having to select process chemicals which not only can be used effectively in PWB fabrication, but can be disposed of efficiently as well. This is the second part of a two-part article describing chemicals which may be used in the solder plating process, including suggestions for facilitating compliance with waste guidelines. (Author

abstract)

Carano, Michael (Electrochemicals, Youngstown, OH, USA). *Electronics* v 33 n 6 Apr 1987 p 30-31.

## Wastes

**085427 SOLVING WASTE DISPOSAL PROBLEMS ASSOCIATED WITH PRINTED WIRING BOARD FABRICATION - PART 1.** Because of increasingly stringent regulations concerning proper handling and disposal of hazardous wastes, PWB manufacturers are faced with having to select process chemicals which not only can be used effectively in PWB fabrication, but can be disposed of efficiently as well. Part 1 of this two-part article describes how various chemicals may be used for PWB surface preparation and etching, and highlights waste treatment procedures. (Author abstract)

Carano, Michael (Electrochemicals, Youngstown, OH, USA). *Electronics* v 33 n 4 Mar 1987 p 50-51.

**PRINTING** See Also CARBIDES—Thin Films; CERAMIC MATERIALS—Applications; FLOW OF FLUIDS—Jets; PATTERN RECOGNITION—Analysis; PHOTORESISTS—Applications; PRINTED CIRCUITS—Production; SEMICONDUCTOR DIODES, LIGHT EMITTING—Applications; VISION.

**085428 ADVANCES IN HIGH-SPEED PHOSPHOR PRINTING.** The development of the optical character reading machine for high-speed codemarking and sortation of letter mail has led to the need for a high-speed method of printing the phosphorescent code-marks used by the mechanized letter sorting machine. This article considers the requirements for the printing system, the method adopted and the results achieved. (Edited author abstract) 6 refs.

Evans, D. (British Post Office); Spicer, C.J. *Br Telecommun Eng* v 6 pt 3 Oct 1987 p 186-191.

**085429 MAGNETIC PRINTER FOR NEWSPAPER CTS.** This paper describes a magnetic printer which was developed as a proofing printer for newspaper CTS (computerized type-setting system). In order to produce a number of copies of the proof efficiently, this printer is intended to have copying function. In recording latent image, the recording drum is rotated at high speed of 4,000 r.p.m. A newly devised multiple-channel head is employed in the printer. The track width of the preceding channels are wider than those of the succeeding channels. The latent images recorded by the preceding channels are sequentially overlapped by the succeeding channels. The recording resolution of 454 dots per inch was achieved. In this paper the overview of the printer structure and operation is described, and the detail of the multiple channel head is discussed. (Edited author abstract) 3 refs.

Kokaji, Norio (Iwatsu Electric Co, Hachioji, Jpn). *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2889-2891.

**085430 MAGNETICALLY BIASED DEVELOPMENT OF MAGNETOGRAPHIC IMAGES.** The effect of magnetic bias fields on magnetographic development is studied. An analytical model of image field and associated force on toner particles is modified to incorporate bias fields of either direct or reverse polarity with respect to the dots magnetization. Using simple series expansions derived from the model, the main mechanisms of biased development are first identified. Based on the full model, 3-D computer simulations of the particles equilibrium on the imaged media, while exposed to bias fields of various intensity and polarity, are then provided and shown to reproduce quite reliably the real observed behavior. (Author abstract) 5 refs.

Eltgen, Jean-Jacques P. (Bull Peripheriques, Belfort, Fr). *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2892-2894.



**085431 VERY HIGH SPEED 450 PAGES-PER-MINUTE EXPERIMENTAL MAGNETIC PRINTER.** Starting from the MP magnetographic technology an experimental research program has been conducted to assess the potential of the technology for extension to much higher speeds. The magnetic shunt of the MP drum media was found to be the most limiting factor to significant speed increase. Characterization of various experimental media, in terms of write time constant, permitted a new 'fast' drum structure. As a result, a full function 8½ inch-wide, experimental magnetic printer was built and tested up to speeds of 450 pages per minute. (Author abstract) 3 refs.

Elitgen, Jean-Jacques P. (Bull Peripheriques, Belfort, Fr); Magnenet, Jean; Bresson, Jean-Pierre. *IEEE Trans Magn v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2895-2897.*

**Color** See Also CERAMIC PRODUCTS—Decoration; COMPUTER PERIPHERAL EQUIPMENT—Plotters; COMPUTER PERIPHERAL EQUIPMENT—Printers; GLASS—Decoration; MECHANICAL VARIABLES MEASUREMENT—Volumes.

**085432 COLOR PRINTING A BALANCING ACT AMONG PRICE, PERFORMANCE, AND PRINT QUALITY.** Six basic color-printing technologies are: pen and electrostatic plotters, thermal-transfer, ink-jet, serial dot-matrix, and electrophotographic (color laser) printers. The vector-oriented pen plotters are by far the most popular, largely because they are flexible. They 'write' with varied-color pens on various media and have a large base of existing software. However, raster-based competitive technologies are gaining ground by offering faster print speeds, superior text printing, and compatibility with the emerging world of digital imaging. Generating and mixing colors, including dye sublimation and dithering, are also discussed.

Luft, Naomi M. (Datek Information Services, Newtonville, MA, USA). *Byte v 12 n 10 Sep 1987 7p between p 163 and 175.*

**085433 NEW MODEL OF DOT GAIN AND ITS APPLICATION TO A MULTILAYER COLOR PROOF.** The phenomenon of dot gain, whether physical or optical, has been studied greatly with regard to printed inks. Off-press proofs must reasonably simulate printing gain in order to be predictive. Since the halftone colors of many off-press proofs are in multiple layers, optical gain will be much different from printed inks. This paper develops a new approach to the phenomenon of optical dot gain and examines the effect of multiple layers on gain, including the effect of screen resolution. (Author abstract) 9 refs.

Huntsman, James R. (3M, St. Paul, MN, USA). *J Imaging Technol v 13 n 5 Oct 1987 p 136-145.*

**085434 EFFECT OF PICTORIAL CONTENT ON PREFERRED GRAY BALANCE IN FOUR-COLOR HALFTONE PROOFS.** The objective of this study was to measure the influence of pictorial content on preferred gray balance in four-color, halftone, off-press proofs. The effect was studied by preparing single-sheet Matchprint proofs of three pictorial images in which the exposures of yellow, magenta and cyan were varied to produce dot gains which were  $\pm 3\%$  from a center point value. These nine color variations of each image were visually examined by 20 observers using the method of paired comparisons. The visual preferences were compared with colorimetric measurements of typical areas in each sample. Dot gain differences of 3% from a neutral center point proof produced CIELAB Delta E values of 2-4 which were usually apparent in all eight samples of each subject. (Edited author abstract) 4 refs.

Colestock, R.O. (3M, St. Paul, MN, USA). *J Imaging Technol v 13 n 5 Oct 1987 p 150-157.*

**085435 COLOUR-DISTANCE JUDGEMENT AND THE INFLUENCE OF THE BACKGROUND IN COLOUR REPRODUCTION.** The influence of the background in colour reproduction can be described in

colorimetric terms by the use of corrections to the colorimetric scaling factors. This leads to transformation formulae that describe the change of chromatic adaptation. The method leads to an improved reconciliation between the specification of colour-rendering properties in both colour photography and multicolour printing and the visual evaluation. (Edited author abstract) 16 refs.

Schultz, Ursula (Deutsche Forschungsgesellschaft fuer Druck- und Reproduktionstechnik eV, Munich, West Ger). *Color Res Appl v 13 n 2 Apr 1988 p 99-105.*

**085436 B350 VIDEO-PROCESSING UNIT FOR COLOR PRINTERS.** While the Centronics interface is useful for printing images in a single color, there is still no widely used standard for expressing multicolor-image data. With the development of multicolor thermal printers, this has become an important issue: multicolor printing via a Centronics interface requires that each application program have a special-purpose color-printer driver. In fact, very few such driver programs have been written, limiting the utility of existing color-printer technology. (Author abstract)

Kitamura, Shozo; Takakuwa, Kiyoshi. *Mitsubishi Electr Adv v 42 Mar 1988 p 15-17.*

**085437 HIGH-SPEED THERMAL-CONTROL TECHNOLOGY FOR THERMAL COLOR PRINTERS.** Mitsubishi Electric has been studying the effect of the heating elements on each other in order to devise methods to limit temperatures by reducing the duration of the current pulses applied to those elements during printing and by modifying the structures, thermal capacities, and thermal-transfer efficiencies of the head.

Onishi, Masaru. *Mitsubishi Electr Adv v 42 Mar 1988 p 30-31.*

**085438 CONTINUOUS-TONE COLOR HARD COPY.** Color scanners capture images at far higher quality levels than today's color hard-copy systems can reproduce. As a result, hard copies do not adequately support high-performance color image processing, and their support of computer graphics and computer-aided design (CAD) systems is limited. But industry is responding to this challenge with new approaches. Foremost among these is continuous-tone hard copy, in which each pixel can be varied in density and hue. Several continuous-tone hard-copy technologies are available, each offering distinct strengths and weaknesses. It is not yet clear which technology will dominate, but users and system integrators will soon have access to high-performance continuous-tone hard-copy systems.

Seldon, Denise (Honeywell Test Instruments, Denver, CO, USA). *Inf Disp v 4 n 10 Oct 1988 p 14-16.*

**085439 BICMOS THERMAL HEAD INTELLIGENT DRIVER WITH DENSITY CONTROLLERS FOR FULL-TONE RENDITION PRINTERS.** A 3- $\mu$ m BiCMOS thermal head driver using pulsewidth modulation dealing with eight-bit density input data (256 gray levels) is described. Circuits composed of 64  $\times$  8-bit complex counters, which function as eight-line parallel 64-bit shift registers (shift mode) and as 64 counters which have eight bits (count mode) by alteration of their mutual connections according to the mode signals, have been developed. The complex counter controls the output pulse width according to the binary data and the clock intervals (minimum 100 ns). The shift registers can operate using a 20-MHz clock. The driver consists of about 4500 CMOS gates and 128 bipolar transistors in a 2.8-mm  $\times$  8.8-mm chip size. The breakdown voltage of the bipolar transistor  $BV_{cb0}$  is more than 35 V. The driver is especially suited for full-tone rendition printers. Applications of the driver include use in thermal print heads, LED print heads, and LCD print heads. 4 refs.

Tsumura, Makoto (Hitachi Ltd, Hitachi, Jpn); Takeuchi, Ryozi; Shimizu, Isao. *IEEE J Solid State Circuits v 23 n 2 Apr 1988 p 437-441.*

## Computer Aided Design

**085440 HUMAN FACTORS DESIGN INVESTIGATION OF A COMPUTERIZED LAYOUT SYSTEM OF TEXT-GRAPHIC TECHNICAL MATERIALS.** In converting task listings into multiple pages of documentation for job aids or training, the two major problems are deciding how much material should go on each page and how text and graphics should be laid out on the page. A questionnaire study was used to collect input from 14 human factors personnel in order to design algorithms for page splitting and page layout. From the rules or heuristics used for page splitting, an algorithm was devised that closely matched human page-splitting results. Layout of individual pages was automated with an algorithm based on the (significant) consensus among the subjects on questions of graphics positioning and label ordering. The two algorithms have been combined in a computer-aided design procedure that automatically pages task lists and lays out individual pages. (Author abstract). 7 Refs.

Sylla, Cheickna (Drexel Univ, Philadelphia, PA, USA); Drury, Colin G.; Babu, A.J.G. *Hum Factors v 30 n 3 Jun 1988 p 347-358.*

## Computer Applications

**085441 INK JET PRINTING PAYS OFF FIVE WAYS.** Computerized carton coding with an ink jet printing system has paid off handsomely in expected benefits as well as some unanticipated bonuses for the Water Systems Division of Goulds Pumps, Inc., Seneca Falls, N.Y. The system at Goulds Pumps reduces label stocks, selects proper coding data, saves on labor, cross-checks carton usage, and adapts easily to marking new products and special orders.

Feare, Tom. *Mod Mater Handl v 43 n 8 Jul 1988 p 74-75.*

## Control Systems

**085442 TECHNOLOGISCHE BEDINGUNGEN FÜR DIE BEDIENARME PRODUKTION IN DER POLYGRAFISCHEN INDUSTRIE DURCH FLEXIBLE VERKETTUNG.** [Technological Conditions for Untended Manufacturing in the Printing Industry by Flexible Linking]. Technological conditions for untended production in the metal working and printing industries are different. Before deciding on a possible linking of machines, it is necessary to check to specific coupling criteria. It is necessary to state the fundamental relations for the calculation of the required speeds and storage quantities for a loose linkage as well as indications as to the further work tasks. (Translated author abstract) In German. 5 refs.

Ruder, Rudolf. *Wiss Z Tech Univ Karl Marx Stadt v 29 n 3 1987 p 412-418.*

## Density

**085443 OPTIMUM DENSITY LEVELS FOR MULTILEVEL HALFTONE PRINTING.** New dot matrix printing technologies are offering the possibility of printing more than one density level at any picture element location. The selection of optimum intermediate density levels depends on the optimization criteria and halftoning algorithm. We have used a minimax graininess criterion in conjunction with an error diffusion (Floyd-Steinberg) halftoning algorithm. Under some practical simplifying assumptions, there is a known relationship between the standard deviation of the density fluctuations, the granularity, and the average density. (Edited author abstract) 7 refs.

Engel drum, Peter G. (Imcotek Inc, Bloomfield, CT, USA). *J Imaging Sci v 31 n 5 Sep-Oct 1987 p 220-222.*

**Electrostatic** See Also OFFICE EQUIPMENT; POWERS—Magnetic Properties.

**085444 ION FLOW CONTROL CHARACTERISTICS FOR HIGH QUALITY CONTINUOUS-TONE**



**PRINTING.** Ion flow control is investigated theoretically and experimentally in order to achieve a high quality continuous-tone electrostatic printing process. The behavior of ion flux controlled by a pair of aperture electrodes is clarified by an analysis using computer simulation of ion trajectories, paying particular attention to the diameter of the ion flux. An electric charge image is formed experimentally by controlling ion projection time and analyzed by SEM observation and by measurement of surface potential, revealing its change with ion projection time. Gray-scale printing characteristics are then clarified by measuring the optical densities of the image developed with toner; 64 levels of gray-scale image are obtained with resolutions of 8 dots  $\text{mm}^{-1}$  and 12 dots  $\text{mm}^{-1}$ , demonstrating the feasibility of this method for continuous-tone printing. (Author abstract) 9 refs.

Omodani, Makoto (NTT, Yokosuka, Jpn); Tanaka, Tomoaki; Hoshino, Yasushi. *J Phys D* v 20 n 10 Oct 14 1987 p 1224-1229.

**Equipment** See Also PHOTOGRAPHIC REPRODUCTION; PHOTOGRAPHIC REPRODUCTION—Analysis; PHOTOGRAPHIC REPRODUCTION—Electrostatic; PRINTING PLATES—Evaluation.

**085445 MATRIX-LINE PRINTING.** In matrix-line technology, 24 print hammers are arrayed horizontally on an 8-inch shuttle (wide-carriage designs use more print hammers and a wider shuttle). The hammers fire simultaneously, printing an entire horizontal line of dots with a single 1/3-inch sweep of the shuttle assembly. A simplified drawing shows the design's major components. The advantage of the hammer-bank design are discussed.

Hohnaker, Mark (Printronix Inc, Irvine, CA, USA). *Byte* v 12 n 10 Sep 1987 p 215-216.

## Health Hazards

**085446 PROBLEMS OF PREVENTION OF OCCUPATIONAL DISEASES IN THE PRINTING INDUSTRY.** Lead-induced intoxications are regarded as the major cause of occupational diseases in the printing industry. The second place is occupied by skin diseases, primarily of allergic origin, which are followed by stress-associated disorders of the neuromuscular system of hands. Regular registration of occupational diseases confirms the necessity of implementing a set of preventive recommendations aimed at the improvement of technological equipment and labor conditions in the printing industry along with the introduction of scientifically proved work and recreation regimens. (Author abstract) In Russian. 4 refs.

Anan'ev, B.V. *Gig Tr Prof Zabol* n 5 May 1988 p 33-36.

## Heat Transfer

**085447 THERMAL-TRANSFER TECHNOLOGY COMES OF AGE.** Thermal-transfer printing can be described as a non-impact printing technology that uses thermal energy to transfer ink from an inked coated substrate to a receptor sheet. The ink transfer is caused not by the impact of the printing element to the ribbon, but by the heating up of elements on the print head to melt the ink on to the paper. Of the many different thermal-transfer printing devices that have been released or are under development, almost all require a unique ink formulation. Highly specialized ink making, coating, and slitting equipment is necessary to produce consistently high-quality monochrome and multicolored ribbons. Various considerations dictate the thickness of ribbon chosen for a particular application: (1) energy requirements to transfer the ink; (2) a preference for a particular length of ribbon; and (3) cost considerations.

O'Leary, John W. (Int Imaging Materials Inc, Tonawanda, NY, USA). *Inf Disp* v 3 n 5 May 1987 p 23-25.

**Laser Applications** See Also COMPUTER PERIPHERAL EQUIPMENT—Printers.

**085448 OPTICAL SCANNER DESIGN LEADS TO COMMERCIAL LASER PRINTER SUCCESS.** The

scanning optical systems in recent laser-printer models follow a common set of principles. A combination of one or two lenses (known as f $\theta$ -DEC) provides an f $\theta$  characteristic combined with deflection error compensation (DEC). Key elements of the scanning systems include a polygonal mirror scanner and a toric lens. To compensate deflection errors the authors developed a system of the so-called conjugate type, which has a high compensation ability. 4 refs.

Minami, Setsuo (Canon Research Cent, Atsugi, Jpn); Minoura, Kazuo; Yamamoto, Hironori. *Laser Focus* (Littleton Mass) v 23 n 10 Oct 1987 5p between p 98 and 106.

## Materials

**085449 HARD COPY OUTPUT TECHNOLOGIES.** This conference proceedings contains 17 papers. The main subjects are electronic printing and hardcopy output technologies, thermal writing, thermal transfer printing, ink jet printing, continuous binary ink jets, magnetographic printing, recording and printing media, hardcopy graphics, business presentation graphics, high resolution printing and recording systems, and application of internal drum film recorder architecture. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 1151 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Herzog, Donald G. (Ed.) (RCA Corp). *Proc SPIE Int Soc Opt Eng* v 759, Hard Copy Output Technol, Los Angeles, CA, USA, Jan 13-14 1987. Publ by SPIE, Bellingham, WA, USA, 1987 117p.

**Offset** See Also PAPER—Printing Properties; PHOTOGRAPHIC REPRODUCTION—Color.

**085450 IMPACT OF ORTHONAPHTHOQUINONE DIASIDE PHOTOLYSIS ON COPYISTS' HEALTH STATUS.** Deviation from the standard prothrombin time was detected in copyists. Correlation of the blood coagulation system variations with photolysis products' impact was experimentally confirmed on laboratory animals. It was found that photolysis products did not cause skin allergic diseases and had no effect on workers' immunologic reactivity and peripheral blood indices. It was recommended to examine the state of copyists' coagulation system when carrying out preventive medical check-ups. (Author abstract) 2 refs. In Russian.

Andrianov, A.P. *Gig Tr Prof Zabol* n 9 1987 p 38-40.

**085451 INFLUENCE OF INSTRUMENT GEOMETRY AND FILTER CHOICE ON DENSITY AND DOT AREA MEASUREMENT.** This research project was intended to shed light on the factors which account for different color density and dot area readings being produced by various densitometers applied to the same print sample. The experiments showed that interchanging illumination and detection has no effect, but that even small deviations from the 0°/45° position can give a false reading in the case of measurement without polarization. No systematic deviations were observed when the aperture angle or the size of the measurement patch were adjusted. Major discrepancies were found when different filters were used. (Edited author abstract) 4 refs.

Wardel, H. (Deutsche Forschungsgesellschaft fuer Druck-und Reproduktionstechnik eV, Munich, West Ger); Dolezalek, F. *J Imaging Technol* v 13 n 5 Oct 1987 p 145-150.

**Photocomposition** See PHOTOGRAPHIC REPRODUCTION—Equipment.

## Quality Assurance

**085452 PRINT QUALITY: THE FACTORS INFLUENCING PRINT QUALITY AND WAYS TO MEASURE IT.** A set of objective definitions for print quality is sought. A measurement system that is also developed rates a print sample over a wide range of performance values relating to print quality. The ultimate goal is to rate

printer technologies, as well as commercial printers, on the basis of print quality without relying on subjective, variable human judgements. The readability of dots, lines and arcs, the blank area factor minimization, property of symbols, grid design, dot size, and shape, character shape, position deviations, edges and grey level variance are considered.

Jansson, Lars (Facit, AB, Sundbyberg, Swed). *Byte* v 12 n 10 Sep 1987 7p between p 199 and 207.

**Screen** See Also INK; INTEGRATED CIRCUIT MANUFACTURE—Performance; POLYIMIDES—Applications; SOLDER—Selection; TEXTILES—Printing.

**085453 COMMENTS ON: 'THE FUNCTION AND PERFORMANCE OF THE STAINLESS STEEL SCREEN DURING THE SCREEN-PRINT INK TRANSFER PROCESS' (ISHM VOL. 10/2, 1-8, 1987).** The screen printing model proposed in the stated paper by D.E. Riemer appears conceptually sound but is found to be deficient in its analysis. Not all modeling assumptions are stated. Some of the stated assumptions are unwarranted while others require a closer scrutiny. The unstated assumptions are discussed in this paper. It is found that these assumptions restrict the generality of the analysis presented, with the result that misleading calculations are performed. Mistakes detected in the main derivations of the article cast doubt on many of the article's conclusions. Alternate derivations are made, along with suggestions for the general improvement of the model. (Edited author abstract) 23 refs.

Huner, Burke (Louisiana State Univ, Baton Rouge, LA, USA). *Int J Hybrid Microelectron* v 10 n 4 1987 p 6-13.

## Thermal Effects

**085454 COLOR THERMAL-TRANSFER PRINTING.** The thermal-transfer process is simple in principle, but its implementation for high-quality printing is quite complex. Some of the engineering challenges are described and it is shown how CalComp solved them in designing a series of color printers. By repeating the process three times using combinations of inks of the three primary subtractive colors (yellow, magenta, and cyan), colors can be produced across the full spectrum.

Guardado, Julio (CalComp, Anaheim, CA, USA). *Byte* v 12 n 10 Sep 1987 p 221-222.

## PRINTING MACHINERY

### Computer Aided Design

**085455 TAMING THE HOT HEADS.** The high temperature of a dot-matrix impact (DMI) print head during operation often reduces throughput because the printer must slow the printing rate at various times during printing to let the head cool off. This inefficiency was reduced through new head design that permits the head to run cool. The plan of action involved considerable mathematical work, CAD, and optimization using prototype models. A summary of the process by which they maximized the efficiency of a DMI print-head design is presented.

Davenport, Keith B. (Newbury Data Recording Ltd, Staines, Eng). *Byte* v 12 n 10 Sep 1987 p 209-212.

**Control** See Also COMPUTER PERIPHERAL EQUIPMENT—Printers.

**085456 DESIGNING A HIGH-SPEED PAGE PRINTER CONTROLLER.** In a desktop page printer, the engine outperforms the controller. The engines are capable of printing at a rate of six or more pages per minute, while the controllers often feed the printer data at less than one page per minute. The controller bottleneck is a serious problem in forms processing, where the printer must turn out many different form sets every day. Placing the printer controller in the computer lets the computer's microprocessor handle memory-intensive page makeup and processing operations. The controller writes the byte stream to the print engine. This approach eliminates



duplicating parts of the computer system, such as chassis, memory, and power supply.

Ellison, Phil (Electronic Form Systems, Carrollton, TX, USA). *Byte* v 12 n 10 Sep 1987 p 225-226.

## Performance

**085457 LESS WASTE WITH ROTOGRAVURE PRINTING MACHINES.** In the printing industry, control technology has to keep pace with continuous mechanical developments. There is no other way of achieving high printing speeds, less waste, faster and easier reel changing during operation and high availability of the system as a whole. Features and capabilities of this machinery are reported. (Author abstract)

Raum, Helmut (Siemens AG, Erlangen, West Ger). *Energy Autom* v 9 n 4 Jul-Aug 1987 p 20-24.

## Thermal Effects

**085458 GRUBOWARSTOWE GLOWICE TERMOPISZACE.** [Thick-Film Thermal Print Heads]. This paper presents the analysis of the employed thermal print heads considering their development methods especially thick-film technology. The main technological problems and methods of that solution are presented. The selection of materials, screens and masking methods are considered. The practical realization of the two-line alpha-numeric thermal print head is considered. (Edited author abstract) In Polish. 11 refs.

Kieras, Marian (Politechniki Rzeszowskiej, Rzeszow, Pol); Potencki, Jerzy. *Elektronika* v 28 n 1 1987 p 20-22.

## PRINTING PLATES

Drilling See DRILLS—Carbide.

## Evaluation

**085459 RESOLUTION AS AN EXPOSURE DETERMINANT FOR NEGATIVE-ACTING PRESENSITIZED PRINTING PLATES.** This work was performed to test the practicality of using resolution to determine the proper printing exposure for several US available graphic arts presensitized negative-acting printing plates. Standard techniques employed by UGRA and FOGRA of West Europe for determining the optimum printing exposure of positive-acting presensitized plates were employed. Additional data was gained on the resultant photographic images produced. A comparison of these results versus results obtained using the plate manufacturer's recommendations is also included. Results indicate that this technique is not fully applicable to all the negative-acting presensitized plates available in the US. (Author abstract) 8 refs.

Fisch, R.S. (3M, St. Paul, MN, USA); Cavin, R.D. *J Imaging Technol* v 13 n 5 Oct 1987 p 158-163.

Photolysis See PRINTING—Offset.

## Plastic

**085460 STRESS-STRAIN STATE OF SCREEN PHOTOPOLYMER PLATES.** Photopolymer printing plates are widely used for the production of various forms of publications. A method of numerical investigation of the stress-strain state of the screen elements of Tselfot-2 (type B) illustration photopolymer plates is presented. It was established that the strains in the photopolymer material are less under the action of the drying oil than in air. The proposed method of a numerical experiment makes it possible to investigate the strains of the material of a printing plate taking into consideration the change in its mechanical characteristics under production conditions. 7 refs.

Ogirko, I.V. (Ukrainian Scientific-Research Inst for the Printing Industry, Lvov, USSR); Zapotochnyi, V.I. *Sov Mater Sci* v 22 n 6 Nov-Dec 1986 p 640-643.

## PRINTING PRESSES See Also LITHOGRAPHY—Materials.

## Computer Applications

**085461 TRENDS IN WEB PRINTING.** The move toward central-impression (CI) cylinders on flexographic web presses, which provide improved speed, clarity, and resolution over stack presses, has been a major trend. The main advantage of a central-impression press is that the web stays on the CI cylinder instead of traveling from one impression cylinder to another, as on a stack press. Also, with its print units directly geared to a single drive gear, a CI press can better provide tight, crisp registration from one color to the next. Microprocessor controllers that permit fast thumbwheel setup of printing stations and push-button precision print positioning have resulted in quicker flexo job changeover and higher speeds for shops with many short runs. Also, more and more video scanners are being used for off-press web viewing and monitoring.

Warren, Lilli Manolis (Plastics Technology, New York, NY, USA). *Plast Technol* v 34 n 3 Mar 1988 p 54-59.

## PRISMS See Also OPTICAL SYSTEMS; OPTICAL SYSTEMS—Control; SOLAR RADIATION—Concentrators.

**085462 FIXED DERIVATION SPECTRO-SYSTEM OF 'VARIABLE BEAM PRISM PAIRS'.** This paper reports a new type of prism spectro-system, which is comparable to the grating. The angular dispersion amplification of VBP (Variable Beam Prisms) is applied to this spectro-system, so that its dispersion and resolution are greater than that of a normal prism spectro-system by  $10^{10}$  times. When the VBP is pair-wise set into a spectro-system, the derivation between the incident and exit beams is always fixed in operation. In Chinese. 4 refs.

Zhang, Guowei (Beijing Inst of Technology, China). *Guangxue Xuebao* v 7 n 9 Sep 1987 p 858-863.

Applications See ACOUSTOOPTICAL DEVICES; LASERS, DYE—Accessories; SPECTROSCOPY—Equipment.

Manufacture See LENSES—Manufacture.

Stresses See MATHEMATICAL TECHNIQUES—Boundary Value Problems.

**PROBABILITY** See Also ACCIDENTS—Analysis; ADSORPTION—Mathematical Models; AIRCRAFT—Take-off; ALUMINUM AND ALLOYS—Crack Propagation; ARTIFICIAL INTELLIGENCE; ARTIFICIAL INTELLIGENCE—Expert Systems; ARTIFICIAL INTELLIGENCE—Research; CHARGED PARTICLES—Emission; CHARGED PARTICLES—Scattering; CLUTCHES—Friction; CODES, SYMBOLIC; CODES, SYMBOLIC—Decoding; CODES, SYMBOLIC—Encoding; COMPUTER METATHEORY—Formal Logic; COMPUTER METATHEORY—Programming Theory; COMPUTER NETWORKS—Analysis; COMPUTER NETWORKS—Local Networks; COMPUTER PROGRAMMING—Algorithms; COMPUTER SOFTWARE—Reliability; COMPUTER SYSTEMS, DIGITAL—Fault Tolerant Capability; COMPUTER SYSTEMS, DIGITAL—Multiprocessing; COMPUTERS, DIGITAL—Data Communication Systems; CONTROL SYSTEMS—Identification; CONTROL SYSTEMS—Observability; CONTROL SYSTEMS, OPTIMAL—Theory; CONTROL SYSTEMS, STOCHASTIC; DATA PROCESSING—Data Reduction and Analysis; DATA TRANSMISSION—Mathematical Models; DECISION THEORY AND ANALYSIS; DIFFUSION—Mathematical Models; DIGITAL COMMUNICATION SYSTEMS; DIGITAL COMMUNICATION SYSTEMS—Noise, Spurious Signal; DIGITAL COMMUNICATION SYSTEMS—Voice/Data Integrated Services; DIGITAL DEVICES—Testing; ECONOMICS—Management; EDUCATION—Teaching; ELECTRIC CORONA—Analysis; ELECTRIC MEASUREMENTS—Noise, Spurious Signal; ELECTRIC MEASURING INSTRUMENTS—Synthesis; ELECTRIC POWER SYSTEMS—Interconnection; ELECTRIC POWER SYSTEMS—Load Flow Analysis; ELECTRIC POWER SYSTEMS—Loss of Load Probability; ELECTRIC POWER SYSTEMS—Mathematical Models; ELECTRIC POWER SYSTEMS—Reactive Power; ELECTRIC POWER SYSTEMS—Reliability; ELECTROMAGNETIC WAVES—Scattering; ENGINEERING—Economics; ENGINEERING EDUCATION—Reliability; FAILURE ANALYSIS; FIRE PROTECTION; FLOODS—Estimation; FLOW OF FLUIDS—Boundary Layer; FRACTURE MECHANICS—Elastoplasticity; GEOLOGY—Subaqueous; HIGHWAY TRAFFIC CONTROL—Mathematical Models; IMAGE PROCESSING—Enhancement; INFORMATION RE-

TRIEVAL SYSTEMS; INFORMATION THEORY; INFORMATION THEORY—Channel Capacity; INFORMATION THEORY—Communication Channels; INFORMATION THEORY—Data Compression; INVENTORY CONTROL—Mathematical Models; IRRIGATION; LIQUIDS—Fluid Dynamics; MATERIALS TESTING—Failure; MATHEMATICAL STATISTICS; MATHEMATICAL TECHNIQUES—Algorithms; MATHEMATICAL TECHNIQUES—Estimation; MATHEMATICAL TECHNIQUES—Fuzzy Sets; MATHEMATICAL TECHNIQUES—Heuristic; MATHEMATICAL TECHNIQUES—Matrix Algebra; MATHEMATICAL TECHNIQUES—Sensitivity Analysis; MATHEMATICAL TECHNIQUES—State Space Methods; MATHEMATICAL TECHNIQUES—Trees; MEASUREMENT THEORY; MECHANISMS—Design; MINERAL EXPLORATION; NUCLEAR POWER PLANTS—Accident Prevention; NUCLEAR POWER PLANTS—Earthquake Resistance; NUCLEAR REACTORS—Core Meltdown; OIL FIELDS—Reserves to Production Ratio; OPERATIONS RESEARCH; OPTIMIZATION; ORE TREATMENT—Crushing and Grinding; PARTICLE DETECTORS; PATTERN RECOGNITION; PAVEMENTS—Management; PHASE MODULATION—Phase Shift Keying; PIEZOELECTRIC TRANSDUCERS—Reliability; PLASMAS—Beam-Plasma Interactions; POPULATION STATISTICS; PUMPS, CENTRIFUGAL—Performance; QUALITY CONTROL; QUALITY CONTROL—Sampling; RADAR SYSTEMS; RADIO SYSTEMS, MOBILE—Cellular Technology; RADIO SYSTEMS, MOBILE—Reliability; RADIO TRANSMISSION—Noise; RADIO TRANSMISSION—Scattering; RADIO TRANSMISSION—Spread Spectrum; RADIOACTIVE WASTES—Geological Repositories; RAIN AND RAINFALL—Analysis; RELIABILITY; RELIABILITY—Evaluation; RELIABILITY—Mathematical Models; RELIABILITY THEORY; RELIABILITY THEORY—Estimation; RISK STUDIES; Statistical Models; RUNOFF—Estimation; SCINTILLATION COUNTERS—Efficiency; SENSORS—Theory; SEPARATORS—Design; SIGNAL FILTERING AND PREDICTION—Estimation; SIGNAL GENERATORS—Oscillations; SIGNAL PROCESSING; SIGNAL PROCESSING—Estimation; SIGNAL THEORY; SOIL MECHANICS—Design; SOLID SOLUTIONS—Diffusion; SOLIDS—Electric Conductivity; SOLIDS—Mathematical Models; SOLIDS—Order-Disorder; SPEECH—Recognition; STATISTICAL METHODS; STATISTICAL METHODS—Statistical Tests; STRENGTH OF MATERIALS; STRENGTH OF MATERIALS—Evaluation; STRUCTURAL ANALYSIS; STRUCTURAL ANALYSIS—Dynamic Response; STRUCTURAL ANALYSIS—Vibrations; STRUCTURAL DESIGN; SURFACES—Electronic Properties; SWITCHING SYSTEMS—Redundancy; SYSTEMS SCIENCE AND CYBERNETICS; SYSTEMS SCIENCE AND CYBERNETICS—Hierarchical Systems; SYSTEMS SCIENCE AND CYBERNETICS—Learning Systems; SYSTEMS SCIENCE AND CYBERNETICS—Noise, Spurious Signal; SYSTEMS SCIENCE AND CYBERNETICS—Reliability; TELECOMMUNICATION SYSTEMS—Analysis; TELECOMMUNICATION SYSTEMS—Mathematical Models; TELECOMMUNICATION SYSTEMS—Performance; VACUUM PUMPS—Calculations; VACUUM PUMPS—Theory; VEHICLES—Spectrum Analysis; VIBRATIONS—Mathematical Models; VIBRATIONS—Theory; WATER DISTRIBUTION SYSTEMS—Reliability; WATER SUPPLY—Mathematical Models; WATER WAVES—Mathematical Models; WIND EFFECTS—Estimation; WIND POWER.

**085463 PROBABILISTIC VERSUS FUZZY REASONING.** This paper shows how to solve problems using probability theory that the fuzzy approaches claim probability cannot solve. By using the view that probabilities are a measure of belief in a proposition in a particular context, limitations imposed by the frequency interpretations of probability are avoided. The various fuzzy approaches (fuzzy sets, fuzzy logic, possibility theory and higher order generalizations) seem to fill the gap caused by the restricted frequency interpretation. Close examination shows that the fuzzy approaches have exactly the same representation as the corresponding probabilistic approach and include similar calculi. The probabilistic approach assumes less information when the calculi differ. (Author abstract) 18 refs.

Cheeseman, Peter (NASA, Moffett Field, CA, USA). *Mach Intell Pattern Recognit* v 4. Publ by North-Holland, Amsterdam and New York, NY, USA, 1986 p 85-102.

**085464 RELATIVE ENTROPY, PROBABILISTIC INFERENCE, AND AI.** For probability distributions  $q$  and  $p$ , the relative entropy is an information-theoretic measure of the dissimilarity between  $q = q_1, \dots, q_n$  and  $p = p_1, \dots, p_n$ . I review some basic properties of relative entropy as well as its role in probabilistic inference. I also



mention briefly a few existing and potential applications of relative entropy to artificial intelligence. (Edited author abstract) 22 refs.

Shore, John E. (US Naval Research Lab, Washington, DC, USA). *Mach Intell Pattern Recognit* v 4. Publ by North-Holland, Amsterdam and New York, NY, USA, 1986 p 211-215.

**085465 APPLICATION OF ALGORITHMIC PROBABILITY TO PROBLEMS IN ARTIFICIAL INTELLIGENCE.** The author discusses algorithmic probability: the motivation for defining it, how it overcomes difficulties in other formulations of probability, some of its characteristic properties, and successful applications. He applies it to problems in artificial intelligence, where it promises to give near optimum search procedures for two very broad classes of problems. 17 refs.

Solomonoff, Ray (Oxbridge Research, Cambridge, MA, USA). *Mach Intell Pattern Recognit* v 4. Publ by North-Holland, Amsterdam and New York, NY, USA, 1986 p 473-491.

**085466 NOTE ON MAXIMIZED LIKELIHOOD SETS.** An important tool for decision making is in many cases Bayesian statistical inference. But sometimes the prior information needed for applying this method is only partially known. This note shows that the posterior measure under a partial prior information, which is constructed on the maximized likelihood function, is compatible with the Bayesian properties of the likelihood sets. (Edited author abstract) 7 refs.

Cano Sanchez, J.A. (Univ of Granada, Spain); Hernandez Bastida, A.; Moreno Bas, E. *Eur J Oper Res* v 32 n 2 Nov 1987 p 291-293.

**085467 CONFIDENCE COEFFICIENT OF APPROXIMATE TWO-SIDED CONFIDENCE INTERVALS FOR THE BINOMIAL PROBABILITY.** The confidence coefficient of a two-sided confidence interval for the binomial parameter  $p$  is the infimum of the coverage probability of the interval as  $p$  ranges between 0 and 1. The confidence coefficients for five different approximate confidence intervals are computed and compared to the confidence coefficient for the two-sided C.J. Clopper-E.S. Pearson confidence interval. J.W. Pratt's approximation method yields virtually the same confidence coefficients as the Clopper-Pearson interval, and is easily computed without resorting to iterative methods. (Author abstract) 12 refs.

Angus, John E. (Hughes Aircraft Co, Fullerton, CA, USA). *Nav Res Logist* v 34 n 6 Dec 1987 p 845-851.

**085468 LOWER BOUND ON MAXIMA OF GAUSSIAN PROCESSES.** This paper presents an alternative lower bound on  $P(\chi_7)$ . The bound is based on the discretization of the time parameter and a theorem that provides a bound on the absolute value of the differences between the largest value distribution of the serial approximation and of a stationary independent series having the same marginal distribution response. It can be optimized relative to the number of samples and one other parameter. 7 refs.

Grigoriu, Mircea (Cornell Univ, Ithaca, NY, USA). *J Eng Mech* v 113 n 12 Dec 1987 p 1961-1967.

**085469 GENERAL THEORY OF FUZZY PLAUSIBILITY MEASURES.** The purpose of this paper is to present a fuzzification of probability theory, or more precisely to give a fuzzification of plausibility measures first introduced by Shafer in 1976. Although plausibility measures include probability measures as well as possibility measures, it is a typical result of this theory that only a fuzzification of possibility measures is attainable, while a fuzzification of probability measures seems to be impossible. Moreover with regard to fuzzy plausibility measures we specify a concept of mean values and entropies, which can be considered as a direct generalization of the classical notions of mean value and entropy based upon probability measures. (Author abstract) 21 refs.

Hoehle, Ulrich (Univ Wuppertal, Wuppertal, West Ger). *J Math Anal Appl* v 127 n 2 Nov 1 1987 p 346-364.

**085470 FURTHER RESULTS ON DISCRIMINATION WITH AUTOCORRELATED OBSERVATIONS.** This paper considers the estimation of the actual error rates of Fisher's linear discriminant function formed from training data which are serially correlated. The asymptotic bias of the so-called plug-in error rate is given for multivariate training data following a first order autoregressive model. The authors' earlier work on the performance of Fisher's linear discriminant function relative to its version using maximum likelihood estimates obtained under the appropriate correlation model, is reconsidered. A correction is noted to their results on the differences in the individual error rates of these two linear discriminant functions. (Edited author abstract) 14 refs.

Lawoko, C.R.O. (Univ of Queensland, St. Lucia, Aust); McLachlan, G.J. *Pattern Recognit* v 21 n 1 1988 p 69-72.

**085471 RECURRENT COMPETITIVE BIDDING.** In this review the approaches will be considered under four headings; basic probabilistic approaches, game theoretic approaches, probabilistic strategy approaches and non-price approaches. In the next sections the review concentrates on models that have been applied to the suppliers' problem of selecting a bid price from the cost estimate that they have calculated. This problem is virtually identical to that of a customer who is competing against other customers to purchase some desirable object from a sole supplier who invites bids for the object. The best known example of this is a government auction of drilling rights on tracts of land or sea to oil companies. 35 refs.

King, Malcolm (Loughborough Univ of Technology, Loughborough, Engl); Mercer, Alan. *Eur J Oper Res* v 33 n 1 Jan 1988 p 2-16.

**085472 ON SOME MULTIVARIATE NORMAL PROBABILITY INEQUALITIES.** With the aid of the vanishing Jacobian theory some multivariate normal probability inequalities are derived. Some inequalities derived in the literature for convex symmetric regions about the origin are shown to hold for nonsymmetric regions. Alternative proofs of some existing inequalities are obtained. (Author abstract) 7 refs.

Kabe, D.G. (Bowling Green State Univ, Bowling Green, OH, USA). *Ind Math* v 37 pt 1 1987 p 53-63.

**085473 POOLING EXPERT OPINIONS ON PROBABILITY DISTRIBUTIONS.** When several probability distributions are to be synthesized into one, there are certain consistency requirements that generally should be satisfied. They include symmetry, continuity, conservation of form, Bayesian coherence, and application consistency. A vector space formulation of Bayes' theorem is used to derive a convenient restatement of Bayesian coherence. It is shown that a logarithmic pooling formula satisfies the requirements of Bayesian coherence, symmetry, and continuity. It is possible to satisfy the requirements of application consistency in some specific contexts; this is illustrated by an example drawn from highway bridge loads. (Author abstract) Refs.

Lind, Niels C. (Univ of Waterloo, Waterloo, Ont, Can); Nowak, Andrzej S. *J Eng Mech* v 114 n Feb 1988 p 328-341.

**085474 DETERMINATION DU TAUX DE COMPTAGE EN AMONT D'UN TEMPS MORT GENERALISE.** [Determination of the Count Rate after a Generalized Dead Time]. The Takacs formula, which gives the output count rate for a Poisson process after a generalized dead time, is reversed analytically: the same series yields the two possible input count rates. An application is made to the numerical determination of the input count rates by an iterative method. (Author abstract) 8 refs. In French.

Libert, Jacques (Univ de Mons-Hainaut, Mons, Belg). *Nucl Instrum Methods Phys Res Sect A* v A265 n Mar 15 1988 p 537-540.

**085475 ESTIMATION OF PERCENTILE RESIDUAL LIFE.** We initiate a nonparametric, large sample estimation theory for the percentile residual lifetime. We introduce the empirical percentile residual life process and determine its asymptotic distribution, resulting in asymptotically distribution-free confidence intervals and confidence bands for the percentile residual lifetime. We illustrate the methods using strike duration data from the work of D. C. Schmittlein and D. G. Morrison. (Author abstract) 17 refs.

Csorgo, Miklos (Carleton Univ, Ottawa, Can); Csorgo, Sandor. *Oper Res* v 35 n 4 Jul-Aug 1987 p 598-606.

**085476 NOTE ON THE AVERAGE-CASE BEHAVIOR OF A SIMPLE DIFFERENCING METHOD FOR PARTITIONING.** Given  $n$  positive values we wish to partition them into two subsets such that the difference between the sums of the subsets is minimized. Karp and Karmarkar have shown that a fairly complicated linear-time differencing algorithm achieves, a certain difference for a broad class of probability distributions. Their work left open the question of how two simple and more natural implementations of the algorithm behaved. In this paper, under the assumption that the input values are uniformly distributed, we show that one of these algorithms is not nearly so effective, confirming empirical observations of Karp. (Edited author abstract) 7 refs.

Lueker, George S. (Univ of California, Irvine, CA, USA). *Oper Res Lett* v 6 n 6 Dec 1987 p 285-287.

**085477  $\beta$ -INFORMATIONAL SUFFICIENT PARTITION.** This paper deals with the construction of a  $\beta$ -sufficient partition of the sample space, in the sense that the relative loss of information induced by the partition, is considered. A necessary and sufficient condition for a partition to be sufficient has been derived. Several illustrative examples are given, together with a comparative study of the relative loss of information when three different information measures are used. (Author abstract) 4 refs.

Awad, Adnan M. (Univ of Jordan, Amman, Jordan). *IMA J Math Control Inf* v 5 n 1 1988 p 1-10.

**085478 ESTIMATION OF PROBABILITY TAILS BASED ON GENERALIZED EXTREME VALUE DISTRIBUTIONS.** For high reliability devices or structures it is not uncommon that the probabilities to be estimated are lower than  $10^{-6}$ . In such cases the standard methods of the empirical fit approach and the counting approach may become impractical. In this paper the estimation problem is handled by extrapolation methods which give an approximate expression of an entire probability tail on the basis of the classical and generalized Extreme Value Theory. Comparative performance of these methods, with respect to the classical ones, are drawn by means of a simulation study, which has taken into account the effect of the sample size, the population being investigated and the estimation method. (Author abstract) 11 refs.

Guida, Maurizio (Natl Research Council, Naples, Italy); Longo, Maurizio. *Reliab Eng Syst Saf* v 20 n 3 1988 p 219-242.

**085479 BOOLE-BONFERRONI INEQUALITIES AND LINEAR PROGRAMMING.** We present a method to obtain sharp lower and upper bounds for the probability that at least one out of a number of events in an arbitrary probability space will occur. The input data are some of the binomial moments of the occurrences, such as the sum of the probabilities of the individual events, or the sum of the joint probabilities of all pairs of events. We develop a special, very simple linear programming algorithm to obtain these bounds. The method allows us to compute good bounds in an optimal way, utilizing only the first few terms in the inclusion-exclusion formula. In a numerical example we approximate the



probability that a Gaussian process runs below a given level in a number of consecutive epochs. (Edited author abstract) 25 refs.

Prekopa, Andras (Rutgers Univ, New Brunswick, NJ, USA). *Oper Res* v 36 n 1 Jan-Feb 1988 p 145-162.

**085480 PROBABILITY OF CORRECT DIAGNOSIS OF OPERATION DAMAGE SUSCEPTIBILITY OF GTE DESIGN COMPONENTS.** The probability of a diagnostic error (as a measure of the probability that a diagnostic system will determine properly the condition of the diagnostic object) is a basic diagnostic indicator as defined by the All-Union State Standard [GOST] 23564-79. With respect to functional and nonfunctional technical condition of elements of a GTE design, the authors discuss the probability of correct diagnosis.

Borovskii, S.M. *Sov Aeronaut* v 30 n 3 1987 p 95-97.

**085481 NOTE ON MULTIVARIATE DISTRIBUTIONS WITH SPECIFIED MARGINALS.** Johnson and Tenebein describe a procedure for generating random values from a bivariate distribution with specified marginal forms an any required correlation between the two variables. This note shows that the approach can be extended to produce values from general multivariate distributions in a straightforward manner. This work, provides a fast and simple procedure for generating an n dimensional distribution, with any required marginals and specified correlations, which can be used in simulation models. 3 refs.

Butterworth, Nicholas J. (Bank of England, London, Engl). *J Oper Res Soc* v 39 n 5 May 1988 p 477-479.

**085482 RESAMPLING-TYPE ERROR RATE ESTIMATION FOR LINEAR DISCRIMINANT FUNCTIONS. PEARSON VII DISTRIBUTIONS.** This paper extends the work of a previous paper on error rate estimation for linear discriminant functions by considering additional non-Gaussian distributions from the Pearson VII family. The Pearson VII family is an elliptically contoured family of probability densities with a parameter  $m$  that controls the tail length of the distribution. For  $m > 2$  (i.e. reasonably light tails) the estimators perform similarly to previous Gaussian case studies and previous simulated exponential and uniform distributions. For  $m \leq 1.6$  (i.e. heavy tails) results similar to previous Cauchy cases are obtained. The 0.632 estimator generally performed best for large  $m$ , but it does not perform as well as the  $e_0$  and convex bootstrap when the tails are heavy. The positive bias of  $e_0$  no longer pertains when the tails are heavy. (Author abstract). 10 refs.

Chernick, M.R. (Aerospace Corp, Los Angeles, CA, USA); Nealy, C.D.; Murthy, V.K. *Comput Math Appl* v 15 n 11 1988 p 897-902.

**085483 HYBRID APPROACH TO DEDUCTIVE UNCERTAIN INFERENCE.** Deductive uncertain inference has been one of the most important ways of handling uncertainty. We report the development of a hybrid approach to such an inference. This approach has been implemented in a system which is based on INFERNO but integrates the strength of probabilistic logic and Dempster's rule. (Edited author abstract). 26 refs.

Liu, X. (Heriot-Watt Univ, Edinburgh, Scotl); Gammerman, A. *Int J Man Mach Stud* v 28 n 6 Jun 1988 p 671-681.

**085484 COMMENT ON 'AN ALGORITHM FOR EXACT FAULT-TREE PROBABILITIES WITHOUT CUT SETS' BY L. B. PAGE, ET AL.** A direct evaluation algorithm was presented by L. B. Page and J. E. Perry (1986) that is based on a bottom-up modularization of the fault tree and a top-down recursive probability calculation. The point is made here that direct evaluation techniques that do not use cut sets have not been taken seriously in the past and that one reason for this is that recursion is not permitted in Fortran, which is the language used by most engineers. Several additional computer codes that evaluate a fault tree directly are described. One of the codes is written in PL/1, and uses techniques of pat-

tern-recognition and list-processing to evaluate fault-tree probabilities. Two other codes illustrate the use of Lisp and Prolog to implement recursive algorithms for the direct evaluation of fault trees. 7 refs.

Patterson-Hine, F.A. (Univ of Texas, Austin, TX, USA); Koen, B.V. *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 640-641.

## Analysis

**085485 PWM SOLUTIONS TO NORMAL, LOG-NORMAL AND PEARSON-III DISTRIBUTIONS.** It has been considered that a new statistical parameter estimation method using probability weighted moments (PWM) is difficult to be applied for the distributions that cannot be expressed in an inverse form. The authors show in this paper that it has been successfully applied and that the analytical PWM solutions were obtained for the representative distributions of non-inverse type, that is, Normal, 3-parameter Lognormal and 3-parameter Pearson-III distributions. The PWM estimate of the standard deviation of the Normal distribution turned out to be unbiased and having a form of a linear combination of samples (Author abstract) In Japanese. 17 refs.

Takeuchi, Kuniyoshi; Tsuchiya, Kazuhito. *Doboku Gak-kai Rombun-Hokokushu* v 9 n 5 May 1988 p 95-102.

**Applications** See ELECTRIC LINES; MATERIALS—Creep.

**Calculations** See INFORMATION THEORY—Optimization.

## Computation

**085486 POISSONIAN BINOMIAL MODEL WITH CONSTRAINED PARAMETERS.** The article examines ways of computing cumulative probabilities for a constrained Poissonian binomial distribution arising from a model of a weapon defense system. (Author abstract) 7 refs.

Kemp, A.W. (Univ of St. Andrews, Fife, Scotl). *Nav Res Logist* v 34 n 6 Dec 1987 p 853-858.

**085487 FORTRAN FUNCTION FOR THE BIVARIATE NORMAL INTEGRAL.** This paper describes a program for microcomputers as well as mainframes, written in FORTRAN 77, which calculates a bivariate normal probability. (Author abstract). 10 refs.

Baughman, Andrew L. (US Dep of Health & Human Services, Atlanta, GA, USA). *Comput Methods Prog Biomed* v 27 n 2 Sep-Oct 1988 p 169-174.

## Computer Aided Analysis

**085488 FORTRAN ROUTINE FOR THE COMPUTATION OF GAMMA PERCENTILES.** A simple FORTRAN routine, employing a combination of third-order Schroder iteration and the Newton-Raphson method, is given for computing gamma percentiles. (Author abstract). 19 Refs.

Huynh, Ngoc Phien (Asian Inst of Technology, Bangkok, Thail). *Adv Eng Software* v 10 n 3 Jul 1988 p 159-164.

**Computer Applications** See INFORMATION RETRIEVAL SYSTEMS—Performance.

**Design** See BREAKWATERS—Design.

## Estimation

**085489 ON RELATIVE ACCURACY OF PWM ESTIMATES OF NORMAL AND 3-PARAMETER LOGNORMAL DISTRIBUTIONS.** Following the successful derivation of PWM solutions for Normal and 3-parameter Lognormal distributions by the authors, this paper presents their relative accuracy in comparison with other parameter estimation procedures such as Moment, Maximum-likelihood, Quantile and Sextile methods

through Monte Carlo simulation experiments. Simulation results revealed that PWM estimates of quantiles are unbiased for Normal distribution and less biased than those of Moment method for Lognormal distribution with a large coefficient of skewness. It was also revealed that rmse of PWM estimates of quantiles is as small as that of Moment method for Normal distribution but larger for Lognormal distribution. (Author abstract) In Japanese. 13 refs.

Takeuchi, Kuniyoshi; Tsuchiya, Kazuhito. *Doboku Gak-kai Rombun-Hokokushu* v 9 n 5 May 1988 p 103-112.

**Evaluation** See HYDROLOGY—Mathematical Models.

**Failure** See RELIABILITY THEORY—Mathematical Models.

**Game Theory** See Also ARTIFICIAL INTELLIGENCE; CONTROL SYSTEMS—Mathematical Models; CONTROL SYSTEMS, ADAPTIVE—Theory; CONTROL SYSTEMS, OPTIMAL—Design; CONTROL SYSTEMS, OPTIMAL—Theory; DECISION THEORY AND ANALYSIS; ECONOMICS—Mathematical Models; ELECTRIC POWER DISTRIBUTION—Optimization; INFORMATION THEORY—Channel Capacity; MATHEMATICAL TECHNIQUES—Chebyshev Approximation; MATHEMATICAL TECHNIQUES—Matrix Algebra; MATHEMATICAL TECHNIQUES—Trees; ROCKETS AND MISSILES—Guidance; SIGNAL FILTERING AND PREDICTION—Optimization.

**085490 MONOTONE STOPPING GAMES.** We consider the extension of optimal stopping problems to non-zero-sum strategic settings called stopping games. By imposing a monotone structure on the pay-offs of the game we establish the existence of a Nash equilibrium in non-randomized stopping times. As a corollary, we identify a class of games for which there are Nash equilibria in myopic stopping times. These games satisfy the strategic equivalent of the classical 'monotone case' assumptions of the optimal stopping problem. The results are relevant to economics and management science. (Edited author abstract) 11 refs.

Mamer, John W. (Univ of California, Los Angeles, CA, USA). *J Appl Probab* v 24 n 2 Jun 1987 p 386-401.

**085491 PARALLEL SEARCHES OF GAME TREES.** A two-person perfect-information game is represented by a minimax game tree and, by solving the tree, we can obtain the result of the game when both players choose perfect moves at all the positions. To this end, various search procedures have been proposed. In this paper, these procedures are modified to implement them on a parallel computer consisting of  $m$  processors, and variations of the computation time are investigated with  $m$  being a parameter. As a theoretical result, we point out that the speedup ratio of the computation time of solving a game tree by  $m$  processors to that by 1 processor may become larger than  $m$  (acceleration anomaly) or smaller than 1 (detrimental anomaly) in general. (Edited author abstract) 17 refs.

Usui, Hiromoto (Seiko Epson Corp, Shiojiri, Jpn); Yamashita, Masafumi; Imai, Masaharu; Ibaraki, Toshihide. *Syst Comput Jpn* v 18 n 8 1987 p 97-109.

**085492 POSITIONAL PURSUIT PROBLEM IN MANY-PURSUER DIFFERENTIAL GAME.** The article solves a differential game of team pursuit. It was previously assumed that all pursuers know the evader control function at every time during the entire period of the game up to a given time, i.e., the pursuers are informed about the previous history of the evader control. However, such a formalization of the conflict process is not always realistic, because to know an opponent's control is to understand his choices, and only very rarely is that ever possible, as, eg., when a tracker is used. It is more realistic to assume knowledge of the phase state of the game, and so the objective of the present article is to develop a certain modification of the above-described method for the solution of many-pursuer differential games to allow the pursuers to formulate their control on the basis of the position (status) of the game at the given time. This is



accomplished by the introduction of a certain fictitious scout system, whose motion is utilized by the pursuers at certain fixed times to correct their own paths. 9 refs.

Shishkina, N.B. *Cybernetics* v 23 n 1 Jan-Feb 1987 p 58-63.

**085493 ANALYTIC METHOD FOR THE SOLUTION OF THE APPROACH-DEVIATION PROBLEM IN A LINEAR DIFFERENTIAL GAME WITH TERMINAL PAYOFF FUNCTION.** We consider some questions regarding the solving of approach-deviation problems in linear differential games with terminal payoff function, which depends on the end of the trajectory and estimates the outcome of the game. The construction of the strategies of the players has in general a nonconstructive character and, therefore, the problem of the creation of methods, allowing to construct in a simple manner the controls of the players for definite classes of games, is important. In this paper, making use of the concept of an H-convex set, we succeed to describe a sufficiently large class of games in which the players may use the so-called stroboscopic strategies. (Edited author abstract)

Ostapenko, V.V.; Kalimoldava, S.N. *Cybernetics* v 23 n 1 Jan-Feb 1987 p 123-127.

**085494 PRESENT AND FUTURE OF METAGAME ANALYSIS.** The author gives a general, accessible account of the present state of the art and consider possible directions for future research. A discussion of the following areas is presented. The topics covered are: the option-analysis method; metagame theory; application of metagames; the breakdown of rationality; the function of emotion, irrationality, preference change, deceit, and rational arguments; computer programs; metagame theory and individual psychology; the theory of exploitation; and, the theory of organizational games. 32 refs.

Howard, Nigel. *Eur J Oper Res* v 32 n 1 Oct 1987 p 1-25.

**085495 MAPS, GAMES AND THINGS IN-BETWEEN: MODELLING ACCOUNTS OF CONFLICT.** This paper describes a way of combining hypergame problem-structuring with the use of cognitive maps to elicit and use information about perceptions in conflicts. In bringing these two forms of analysis together, a new form of model is introduced, based on the notion of a 'decision arena'. The approach is illustrated by reference to a project carried out in a local government setting, and some general conclusions drawn as to its potential advantages. (Author abstract) 24 refs.

Bennett, P.G. (Univ of Sussex, Brighton, Engl); Cropper, S.A. *Eur J Oper Res* v 32 n 1 Oct 1987 p 33-46.

**085496 PURSUIT-EVASION DIFFERENTIAL GAMES WITH UNCERTAINTIES IN DYNAMICS.** Pursuit-evasion differential games with bounded uncertainties in dynamics are considered. As one may expect, the classical concepts of optimality, of the value of a game and of the saddle point do not apply to such games. The 'value' become dependent on the (unknown) uncertainties and is located somewhere between certain bounds which can be determined as solutions (if they exist) of a pair of antisymmetric Isaacs equations. A new method employing V-functions is then proposed for determining the strategies assuring the capture for any realization of uncertainties. The ideas are illustrated by examples. (Author abstract) 28 refs.

Galperin, E.A. (Univ du Quebec a Montreal, Montreal, Que, Can); Skowronski, J.M. *Comput Math Appl* v 13 n 1-3 1987 p 13-35.

**085497 BARRIER IN A PURSUIT-EVASION GAME WITH TWO TARGETS.** We consider the problem of determining the barrier in a pursuit-evasion game involving two objectives in which the evader seeks to reach his own safety zone before capture by the pursuer, and the pursuer seeks capture while avoiding the evader's safety zone. The boundaries of the two winning regions are determined and are shown to be semi-barriers for the players using the Liapunov method. The intersection of the semi-barriers is shown to be non-empty and is the

barrier for the problem. The concept of Isaac's barrier is thus extended to the game which involves two targets associated with two objectives for each player. (Edited author abstract) 5 refs.

Skowronski, J.M. (Univ of Queensland, St. Lucia, Aust); Stonier, R.J. *Comput Math Appl* v 13 n 1-3 1987 p 37-45.

**085498 GEOMETRIC APPROACH TO THE CONSTRUCTION OF THE BARRIER SURFACE IN DIFFERENTIAL GAMES.** In the present work we examine Isaacs' geometric method for the construction of the barrier surface in differential games. We are thus led, in a natural way, to a new (geometric) second-order necessary condition that a valid barrier surface must satisfy. This helps us, on the one hand, to clarify the appearance of a previously discovered qualitatively new type of barrier surface when the problem parameters enter a certain region of the parameter space, and, on the other hand, our systematic analysis also helps us to identify new interesting regions in parameter space where the barrier surface qualitatively differs from previously observed patterns. (Author abstract) 9 refs.

Pachter, M. (CSIR, Pretoria, S Afr); Miloh, T. *Comput Math Appl* v 13 n 1-3 1987 p 47-67.

**085499 SIMPLE-MOTION PURSUIT-EVASION IN THE HALF PLANE.** We consider a pursuit-evasion differential game in the half plane in which the players, i.e. the pursuer and the evader, have simple motion and thus are 'pedestrians' a la Isaacs. In the present paper we present a complete analysis of this state-constrained pursuit-evasion differential game for the case where the pursuer is faster than the evader. (Author abstract) 3 refs.

Pachter, M. (CSIR, Pretoria, S Afr). *Comput Math Appl* v 13 n 1-3 1987 p 69-82.

**085500 SIMPLE LINEAR PURSUIT-EVASION GAMES.** We approach the qualitative games of pursuit-evasion using differential game with terminal cost. The terminal time is then used as a parameter to test capture and avoidance. Evasion problems previously introduced without complete solutions, are shown to satisfy the present conditions for evasion. (Author abstract) 5 refs.

Gutman, S. (Technion-Israel Inst of Technology, Haifa, Isr); Esh, M.; Gefen, M. *Comput Math Appl* v 13 n 1-3 1987 p 83-95.

**085501 APPROACH TO THREE-DIMENSIONAL AIRCRAFT PURSUIT-EVASION.** An algorithm for obtaining a state-feedback control law for near-optimal aircraft pursuit-evasion in three dimensions is outlined. Key features of the approach are the use of singular-perturbation ideas to decouple the dynamics of each of the two players and the use of a reference frame that decouples the slow subsystem extremals of one player from those of the other. The resulting subproblems are then tractable for closed-loop solution, and the solutions may be combined to give a control law feasible for real-time implementation. Compared with past analyses of pursuit-evasion games, our dynamic model is higher order and more realistic; therefore, our results should be of practical value for aircraft control. And because we use fewer time-scales than were used in past analyses of flight dynamic problems by singular-perturbation methods, our algorithm should be more accurate. (Author abstract) 37 refs.

Ardema, M.D. (Santa Clara Univ, Santa Clara, CA, USA); Rajan, N. *Comput Math Appl* v 13 n 1-3 1987 p 97-110.

**085502 AIRCRAFT PURSUIT-EVASION PROBLEMS WITH VARIABLE SPEEDS.** Aircraft pursuit-evasion encounters in a plane with variable speeds are analyzed as a differential game. An engagement-dependent coordinate system confers open-loop optimality on the game. Each aircraft's optimal motion can be represented by extremal trajectory maps which are independent of role, adversary and capture radius. These maps are used in two different ways to construct the feedback solution. Some examples are given to illustrate these features. The paper draws on earlier results and surveys several existing

papers on the subject. (Author abstract) 28 refs.

Prasad, U.R. (Indian Inst of Science, Bangalore, India); Rajan, N. *Comput Math Appl* v 13 n 1-3 1987 p 111-121.

**085503 TWO-TARGET GAME ANALYSIS IN LINE-OF-SIGHT COORDINATES.** The engagement between two aggressively operating similar aircraft armed with boresight limited 'all-aspect' missiles is modeled as a two target differential game between 'two identical cars'. By using a line-of-sight coordinate system the symmetry of the problem can be exploited leading to a reduced complexity in the game of kind analysis. The barrier trajectories are obtained in a closed form allowing us to generate closed barrier surfaces with a reasonable computational effort. These barrier surfaces enclose the 'winning zone' of each player and the 'region of mutual kill'. The analysis reveals several new features not encountered in previous studies. (Author abstract) 16 refs.

Shinar, J. (Technion-Israel Inst of Technology, Haifa, Isr); Davidovitz, A. *Comput Math Appl* v 13 n 1-3 1987 p 123-140.

**085504 STOCHASTIC TWO-TARGET PURSUIT-EVASION DIFFERENTIAL GAME WITH THREE PLAYERS MOVING IN A PLANE.** A stochastic version of a two-target homicidal chauffeur pursuit-evasion differential game between a player P on one side and players  $Q_1$  and  $Q_2$  on the other side is considered. This is used to model a dogfight between two very agile players,  $Q_1$  and  $Q_2$ , and a much less maneuverable player P. Sufficient conditions on optimal strategies are derived. These conditions require the existence of a properly smooth solution to a nonlinear partial differential equation on a generalized torus in  $R^4$ . By applying a finite-difference method, the equation is solved numerically, and optimal strategies are computed. (Author abstract) 22 refs.

Yavin, Y. (CSIR, Pretoria, S Afr). *Comput Math Appl* v 13 n 1-3 1987 p 141-149.

**085505 STOCHASTIC GUIDANCE LAWS IN SATELLITE PURSUIT-EVASION.** The presence of noise in the driving equations and in the data makes the stochastic version of two-player pursuit-evasion differential games difficult to define unequivocally, even for very low-order dynamic models. The analysis of specific problems of this type often do not include trajectories as determined by using the guidance algorithms in the equations of motion. More often, the problems are studied analytically to determine certain functions which are necessary or relevant to a solution. In the present study, a guidance algorithm is described and derived before being applied to a specific two-spacecraft encounter. Numerical results are presented graphically for a specific set of independent parameters and input variables. 2 refs.

Merz, A.W. (Lockheed Palo Alto Research Cent, Palo Alto, CA). *Comput Math Appl* v 13 n 1-3 1987 p 151-156.

**085506 ON CLOSED-LOOP CONTROLS IN PURSUIT-EVASION.** A hybrid algorithm is introduced in order to generate optimal closed-loop controls in a pursuit-evasion problem. The algorithm is composed of a differential dynamic programming method and a singular perturbation technique. The first mentioned method is used in those parts where the latter is weak. The method so created has an open-loop character. By having the open-loop solution updated as often as possible when new measures of the states have been estimated, the method will be near-optimal closed-loop. The game problem is discussed in terms of optimistic or pessimistic strategies, based on assumptions of the evader's strategy. In practice, the evader he may not do his best. The demonstrative example is in the horizontal plane, formulated as a game of degree. The pursuer uses a variable speed model with throttle and turn controls. The computer requirements



can be kept to a reasonable level, and the new algorithm can be implemented on an airborne computer. (Author abstract) 23 refs.

Jaemark, B. (SAAB-SCANIA AB, Linköping, Swed). *Comput Math Appl* v 13 n 1-3 1987 p 157-166.

**085507 PURSUIT-EVASION IN MEDIUM-RANGE AIR-COMBAT SCENARIOS.** A procedure for developing strategies for unmanned combat is presented that consists of modeling the air combat scenario as a differential game problem - or a series of such problems and applying differential game theory. Full order modeling of 1 vs 1 engagements with medium range missiles is discussed, including constraints in dynamic pressure, radar visibility and load factors. As an example the open-loop solution of a characteristic pursuit-evasion problem is presented and compared to a simulation result using a typical air combat simulation computer program. (Edited author abstract) 8 refs.

Moritz, K. (DFVLR, Munich, West Ger); Polis, R.; Well, K.H. *Comput Math Appl* v 13 n 1-3 1987 p 167-180.

**085508 PARTIALLY OBSERVABLE LINEAR-QUADRATIC STOCHASTIC PURSUIT-EVASION GAMES.** A linear-quadratic differential game in which the system is affected by additive as well as multiplicative disturbances and both players have access to the same noisy measurements is solved. Using the concept of projection estimates, the problem is reduced to a completely observable one and the optimal linear nonanticipative strategy is found via a deterministic Hamilton-Jacobi-Bellman-Isaacs theory. (Author abstract) 8 refs.

Chan, W.L. (Chinese Univ of Hong Kong, Hong Kong); Ng, S.K. *Comput Math Appl* v 13 n 1-3 1987 p 181-189.

**085509 PURSUIT-EVASION DIFFERENTIAL GAMES WITH DECEPTION OR INTERRUPTED OBSERVATION.** Three stochastic pursuit-evasion differential games involving two players, E (the evader) and P (the pursuer), moving in the plane are considered. In the first game, the case where E induces errors in P's measurements of the bearing  $\beta$  of E from P and controls the size and direction of these errors, is considered. In the second game, the case where P receives readings of two false targets, which are seen within the same range of P, but with different bearing angles, is considered. In the third game, the case where P observes the range  $r$  of E from P, but has interrupted observation of  $\beta$ , is considered. Results are derived for all three cases. A procedure is suggested for computing weak suboptimal pursuit strategies, and these are computed for a variety of cases. (Edited author abstract) 13 refs.

Yavin, Y. (CSIR, Pretoria, S Afr). *Comput Math Appl* v 13 n 1-3 1987 p 191-203.

**085510 RABBIT AND HUNTER GAME: TWO DISCRETE STOCHASTIC FORMULATIONS.** We study stationary and non-stationary versions of the same game with different information structures. In a discrete set up, we find algorithms to calculate value and saddle-point. (Author abstract) 1 ref.

Bernhard, P. (INRIA, Valbonne, Fr); Colomb, A.-L.; Papavassilopoulos, G.P. *Comput Math Appl* v 13 n 1-3 1987 p 205-225.

**085511 n-PERSON NONCOOPERATIVE DISCOUNTED VECTOR VALUED DYNAMIC GAME WITH A STOPPED SET.** The optimization problem of an n-person noncooperative discounted vector valued dynamic game with a stopped set is investigated. A D-convex equilibrium point as the optimization criterion in the game is defined under a domination structure of a convex cone D. We show that there exists such a D-convex equilibrium point in the game system. A modified game system of the original game is formulated which is weighted by a vector factor so that an equilibrium point of the modified game system is still a D-convex equilibrium point of the original game system. Conversely, under some additional conditions a D-convex equilibrium point

will become an equilibrium point of the modified game system. Further, a relation of D-convex equilibrium point and the super-gradient is discussed. (Author abstract) 13 refs.

Lai, H.-C. (Nat'l Tsing Hua Univ, Taiwan); Tanaka, K. *Comput Math Appl* v 13 n 1-3 1987 p 227-237.

**085512 ON WORST CASE DESIGN STRATEGIES.** For sequential decision processes, we consider the problem of obtaining the min-max strategy which minimizes the worst case performance. This is a game against nature, where the controller attempts to minimize a specified cost criterion, while nature attempts to maximize it. It is apparently a folk theorem that such a min-max strategy can be obtained by means of a dynamic programming like recursion, even though we have not seen any general proof of this, applicable to stochastic systems, which does not rely on the existence of a saddle point. We prove this theorem, and also examine the precise roles of the strategy sets allowed to the minimizer and the maximizer in determining the upper value of the game. Improvements in the results for the case of deterministic systems, and generalizations to continuous time systems are indicated. (Author abstract) 4 refs.

Basar, T. (Univ of Illinois, Urbana, IL, USA); Kumar, P.R. *Comput Math Appl* v 13 n 1-3 1987 p 239-245.

**085513 LINEAR-QUADRATIC STOCHASTIC DIFFERENTIAL GAMES FOR DISTRIBUTED PARAMETER SYSTEMS.** A linear-quadratic differential game with infinite dimensional state space is considered. The system state is affected by disturbance and both players have access to different measurements. Optimal linear strategies for the pursuer and the evader, when they exist, are explicitly determined. (Author abstract) 7 refs.

Aihara, S.-I. (Twente Univ of Technology, Enschede, Neth); Bagchi, A. *Comput Math Appl* v 13 n 1-3 1987 p 247-259.

**085514 ARTIFICIAL INTELLIGENCE IN AIR COMBAT GAMES.** A general framework for the utilization of large numbers of optimal pursuit-evasion algorithms, as applied to air combat, is described. The framework is based upon and is driven by artificial intelligence concepts. The method involves the valuation of alternative tactical strategies and maneuvers through a goal system and pilot-derived expert databases. The system is designed to display the most promising strategies to the pilot for a final decision. Two aspects are described: the general framework and a specific implementation for a synthetic method of flight and fire control system optimization. (Edited author abstract) 7 refs.

Rodin, E.Y. (Washington Univ in St. Louis, St. Louis, MO, USA); Lirov, Y.; Mitnik, S.; McElhaney, B.G.; Wilbur, L. *Comput Math Appl* v 13 n 1-3 1987 p 261-274.

**085515 PURSUIT-EVASION BIBLIOGRAPHY - VERSION 1.** The manner in which the bibliography was compiled is described. The limitations of the bibliography and the reasons for them are discussed. Refs.

Rodin, E.Y. (Washington Univ, St. Louis, MO, USA). *Comput Math Appl* v 13 n 1-3 1987 p 275-340.

**085516 SIMPLE GAME, VOTING REPRESENTATION AND ORDINAL POWER EQUIVALENCE.** The paper gives an analysis to the question of whether the Shapley-Shubik (SS) and Banzhaf-Coleman (BC) power indices have the same ordering of power values for members in a simple game. To this ordinal power equivalence problem, the following results are obtained: The two power indices are always ordinally equivalent in weighted majority games, which are defined as simple games with a voting representation. They are not always ordinally equivalent in six- or more-member simple games which have no voting representation. Through the analysis, we get the noticeable difference between the two power indices. It is that the ordering of the BC power values for members in a simple game is always the same as it in its veto-holder extension game, but the ordering of the SS power values is not always the same. (Author abstract) 5

refs.

Tomiya, Yoshinori (Univ of Tsukuba, Jpn). *Int J Policy Inf* v 11 n 1 Jun 15 1987 p 67-75.

**085517 PRICING PROBLEMS WITH A CONTINUUM OF CUSTOMERS AS STOCHASTIC STACKELBERG GAMES.** The pricing problem where a company sells a certain kind of product to a continuum of customers is considered. It is formulated as a stochastic Stackelberg game with nonnested information structure. The inducible region concept, recently developed for deterministic Stackelberg games, is extended to treat the stochastic pricing problem. Necessary and sufficient conditions for a pricing scheme to be optimal are derived, and the pricing problem is solved by first delineating its inducible region, and then solving a constrained optimal control problem. (Author abstract) 10 refs.

Luh, P.B. (Univ of Connecticut, Storrs, CT, USA); Chang, T.S.; Ning, T. *J Optim Theory Appl* v 55 n 1 Oct 1987 p 119-131.

**085518 IDENTIFICATION OF CLASSES OF DIFFERENTIAL GAMES FOR WHICH THE OPEN LOOP IS A DEGENERATE FEEDBACK NASH EQUILIBRIUM.** In general, it is clear that open-loop Nash equilibrium and feedback Nash equilibrium do not coincide. In this paper, we study the structure of differential games and develop a technique using which we can identify classes of games for which the open-loop Nash equilibrium is a degenerate feedback equilibrium. This technique clarifies the relationship between the assumptions made on the structure of the game and the resultant equilibrium. (Author abstract) 15 refs.

Fershtman, C. (Hebrew Univ, Jerusalem, Isr). *J Optim Theory Appl* v 55 n 2 Nov 1987 p 217-231.

**085519 DIFFERENTIAL GAME OF APPROACH WITH TWO PURSUERS AND ONE EVADER.** A differential game of approach with one evader and two pursuers with a nonconvex payoff function is considered. The duration of the game is fixed. The payoff functional is the distance between the object being pursued and the pursuer closest to it when the game terminates. An explicit form of the game value is found for all possible game positions. (Author abstract) 12 refs.

Pashkov, A.G. (Acad of Sciences of the USSR, Moscow, USSR); Terekhov, S.D. *J Optim Theory Appl* v 55 n 2 Nov 1987 p 303-311.

**085520 NOTE ON CLEMHOUT AND WAN'S DYNAMIC GAMES OF COMMON PROPERTY RESOURCES.** Recently, S. Clemhout and H.Y. Wan provided solutions to a class of Stochastic differential game models concerning common property resources. However, they only established closed-loop strategies for the infinite-horizon problem using the Kushner test. In this paper, we provide closed-loop feedback solutions to their game in a finite-time horizon with deterministic evolution dynamics. (Author abstract) 6 refs.

Plourde, C. (York Univ, Ont, Can); Yeung, D. *J Optim Theory Appl* v 55 n 2 Nov 1987 p 327-331.

**085521 COMPARISON OF THE SOLUTIONS OF LINEAR AND NON-LINEAR POSITIONAL DIFFERENTIAL GAMES OF ENCOUNTER.** A positional differential game of encounter of a non-linear, conflict-controlled system with a given target set is considered. Sufficient conditions for a successful encounter of the initial system with the target set are given. The differential game problem of encounter between two objects with restricted manoeuvrability is solved. The equations of motion of the objects and the constraints imposed on the controls are given using the same relations as those in the differential game known as the two-car game. It is assumed that both objects have restricted manoeuvrability and the game takes place over a fixed time interval. A positional strategy is constructed for the pursuer guaran-



teering that it arrives at a previously specified distance from the pursued at the instant of game termination. (Edited author abstract) 15 refs.

Pashkov, A.G. *Appl Math Mech* v 50 n 4 1986 p 421-428.

**085522 ON AN ALTERNATIVE FOR PURSUIT-EVASION GAMES IN AN INFINITE TIME INTERVAL.** The structure of phase of differential pursuit-evasion games is studied for the case when the evader is subjected to information discrimination with an advance by  $\delta > 0$ ,  $\delta = \text{const}$ . The method of transfinite iteration of the pshechichnyi operator is used to establish an alternative for differential pursuit-evasion games in an infinite time interval. (Author abstract) 12 refs.

Azamov, A.A. *Appl Math Mech* v 50 n 4 1986 p 428-432.

**085523 ON DISCRETE LOWER  $\Pi$ -STRATEGIES.** Two-person zero-sum differential games of survival are investigated. It is assumed that player I, as well as player  $\Pi$ , can employ during the course of the game any lower  $\Pi$ -strategy,  $\Pi(t_i)$  being a finite partition of  $[t_0, \infty)$ . The concept of a discrete lower  $\Pi$ -strategy is introduced and it is shown that if player I ( $\Pi$ ) confines himself to the space of discrete lower  $\Pi$ -strategies, being a subset of the space of lower  $\Pi$ -strategies, then he will be able to force the same lower (upper) value as if he could employ any lower  $\Pi$ -strategy. Since we do not use any deep facts about differential games, the results contained here might be extended to continuous games. (Author abstract) 8 refs.

Zaremba, Leszek S. (Agricultural & Pedagogical Univ, Siedlce, Pol). *Syst Control Lett* v 9 n 4 Oct 1987 p 355-359.

**085524 THREE-LEVEL INCENTIVE SCHEMES USING FOLLOWER'S STRATEGIES IN DIFFERENTIAL GAMES.** We deal with three-level incentive differential games in which first and second leaders have access not only to state information but also to information on follower's strategies. We derive sufficient conditions for three-level incentive schemes using information on follower's strategies in both linear and nonlinear differential games, and show that three-level incentive schemes using information on follower's strategies depend on an initial state value. (Author abstract) 5 refs.

Ishida, Tsutomu (Univ of the Ryukyus, Nishihara, Jpn). *Int J Control* v 46 n 5 Nov 1987 p 1739-1750.

**085525 EXPERIMENTAL STUDY OF A DIFFERENTIAL GAME SYSTEM FOR DYNAMIC OBJECT CONTROL.** An experimental model of a differential game system controlling the relative motions of dynamic objects is described. Simulation data are presented. (Author abstract) 2 refs.

Tsurkan, Yu.V. *Cybern Comput Technol* n 3 1986 p 84-88.

**085526 ON SYNTHESIS IN A DIFFERENTIAL GAME.** The control problem is considered with minimization of the guaranteed result for a system described by an ordinary differential equation in the presence of uncontrolled noise. It is shown that, when forming the optimal extremal shift at the accompanying point can be reduced to extremal shift against the gradient of the appropriate function. This explains the connection between the programmed stochastic synthesis and the generalized Hamilton-Jacobi equation in the theory of differential games. (Edited author abstract) 6 refs.

Krasovskii, N.N. *Appl Math Mech* v 50 n 6 1986 p 696-700.

**085527 GAME-THEORETIC VERSION OF THE MAXIMUM PRINCIPLE WITH DISCRETE PARTIALLY ORDERED TIME.** In addition to traditional game-theoretic problems related to developing optimality principles, establishing their realizability and finding solutions, it is of considerable interest to discover relationships between the separate optimal functioning of components (units) of a system and the functioning of their system as a whole. We refer to assertions which reduce the

optimality of operation of a system as a whole to the optimal operation of its units (components) as a game-theoretic version of the maximum principle. It is this problem which is the subject of the paper. Adopting the traditional terminology of games theory, we refer to individual representatives of interests or points of view, or sometimes the interests or points of view themselves, as players. 6 refs.

Vorob'yev, N.N. *Sov J Comput Syst Sci* v 25 n 3 May-Jun 1987 p 99-104.

**085528 VERY SIMPLE DIFFERENTIAL GAME WITH CHOICE OF THE TIME IN MIXED STRATEGIES.** A program differential game on a straight line is considered in which the pursuer P minimizes and the evader E maximizes the probability of evading the r rendezvous at the instant at which the game is stopped. The pursuer controls the duration of the game, whereas the evader controls the speed variation. The optimal mixed strategies of the players are determined, as well as the payoff of the game. (Author abstract) 9 refs.

Zheleznev, V.S. (Kryakovskii, B.S.); Maslov, E.P. *Autom Remote Control* v 48 n 8 pt 1 Aug 1987 p 1010-1017.

**085529 THEORIES OF PURSUIT AND EVASION.** We give three elementary definitions of a game of pursuit and evasion in a large class of metric spaces. Our definitions are independent of the theory of differential games. We prove that the three definitions yield the same value of the game, and we study this value as a function of the initial positions of the players and their velocities. Several open problems are stated. (Author abstract) 15 refs.

Mycielski, J. (Univ of Colorado, Boulder, CO, USA). *J Optim Theory Appl* v 56 n 2 Feb 1988 p 217-284.

**085530 NONLINEAR DIFFERENTIAL ENCOUNTER-EVASION GAMES WITH DELAY.** The author investigates the problem of avoiding encounter from a specified initial point (encounter-evasion problem) as described by a differential equation with delay in the state vector and its derivative. He departs from previous treatments in the assignment of different conditions for the possibility of evasion. We find a guaranteed lower bound for the distance from the phase point to the endset. 8 refs.

Konovalov, A.P. *Cybernetics* v 23 n 3 May-Jun 1987 p 418-425.

**085531 INTERPOLATION OF STRATEGIES OF DIFFERENTIAL GAMES UNDER UNCERTAINTY.** The following types of differential pursuit-evasion games are considered: A differential game with inequality constraints on the controls of the players, and differential games with integral payoffs in the case of a fixed or a non-fixed time of termination of the game. A pursuer strategy is constructed that takes into account the incompleteness of information about the control possibilities of the opponent and possible changes in the nature of the game (i.e., going over from antagonistic games to cooperative or stochastic games). These techniques can be extended to a special method of investigation of more complex systems, i.e., multidimensional and nonlinear systems. (Edited author abstract) 8 refs.

Fomenko, A.V. *Autom Remote Control* v 48 n 9 pt 1 Sep 1987 p 1157-1161.

**085532 CLOSED-LOOP STRATEGIES IN CONTINUOUS DYNAMIC GAME WITH MULTI-LEVEL OF HIERARCHY.** The derivation is given of the closed-loop Stackelberg strategy for a class of continuous three-player non-zero-sum differential games using the idea of the team-optimal Stackelberg strategy. The game systems are described by linear state dynamics and quadratic objective functions. A definition of the three-player hierarchical equilibrium is given; then a general theorem which was developed by Basar (1981) is examined and applied to the game under consideration to deduce some sufficient conditions for the solution of the game to exist. A simple example is given. (Edited author abstract) 4 refs.

Jiong, Jiang (Zhejiang Univ, Hangzhou, China). *Int J Control* v 47 n 3 Mar 1988 p 905-913.

**085533 STOCHASTIC TWO-TARGET PURSUIT-EVASION DIFFERENTIAL GAMES IN THREE DIMENSIONS.** Stochastic versions of a three-dimensional two-target 'game of two cars' and a three-dimensional two-target 'homicidal chauffeur' game are considered. These are used to model a dogfight, in the  $(x, y, z)$  space, between a very agile player Q and a less maneuverable player P. A numerical study is conducted, by numerically solving a non-linear partial differential equation, to investigate the role of the parameters of maneuverability, speed and the performance of the 'weapon systems' in the encounter. (Author abstract) 11 refs.

Yavin, Y. (CSIR, Pretoria, S Afr); Miloh, T. *Optim Control Appl Methods* v 8 n 4 Oct-Dec 1987 p 311-325.

**085534 PURSUIT OF A GROUP OF EVADERS BY A SINGLE CONTROLLED OBJECT.** A quasidifferential pursuit-and-evasion game is considered in which a single controlled object pursues several evaders. Sufficient conditions for the termination of pursuit are established in the class of stroboscopic strategies with memory (SSM). The case of simple motion of the pursuer and the evaders is studied in more detail. In this case, the SSM coincides with parallel pursuit strategy. 13 refs.

Chikrii, A.A.; Kalashnikova, S.F. *Cybernetics* v 23 n 4 Jul-Aug 1987 p 437-445.

**085535 LINEAR DIFFERENTIAL EVASION GAMES WITH LAG AND INTEGRAL CONSTRAINTS.** Starting from previous investigation of linear differential evasion games with integral constraints, the author considers linear differential evasion games from a given initial point (the deviation problem) with lag in the state and velocity vectors under the same constraints. He gives sufficient conditions for the possibility of a deviation from a fixed initial point of the phase space and indicates a method for the computation of the evasion control, as well as a lower estimate from a phase point to the terminal set. 6 refs.

Konovalov, A.P. *Cybernetics* v 23 n 4 Jul-Aug 1987 p 485-491.

**085536 TYPE OF LINEAR GAME WITH MIXED CONSTRAINTS ON THE CONTROLS.** A differential game in which the first person's control is subject to a geometric and an integral constraint. The second person can choose a control, subject to the geometric constraint. The game ends at a given instant. The sets of controls values and the terminal set are of the same type. The conditions are found for the game to the end from a given initial position. The player's controls are constructed, and an example is given. (Edited author abstract) 8 refs.

Ukhobotov, V.I. *Appl Math Mech* v 51 n 2 1987 p 139-144.

**085537 SECOND PLAYER'S STRATEGY IN A LINEAR DIFFERENTIAL GAME.** A linear antagonistic two-person differential game with fixed instant of termination and convex pay-off function is considered. A numerical method is described for constructing the second (maximizing) player's strategy, which guarantees a close-to-optimal result. A computer-checked example is given. (Edited author abstract) 12 refs.

Zarkh, M.A.; Patsko, V.S. *Appl Math Mech* v 51 n 2 1987 p 150-155.

**085538 PROBLEM OF THE NASH EQUILIBRIUM SITUATION IN A POSITIONAL N-PERSON GAME WITH A MEMORY.** The approach of a pencil of trajectories to the terminal set, when the control side uses positional strategies with a memory and is ignorant of the discrete parameter on which both the dynamic system and the terminal set depend, is considered. The set of initial positions for which the problem is solvable is



constructed. It is shown that this set can be constructed by solving several standard problems on approach in positional strategies without a memory and without undetermined parameters. It is also shown that the set has in a certain sense the bridge property which is typical for the solution of positional approach problems with undetermined parameters. (Edited author abstract) 3 refs.

Chistyakov, Yu.E. *Appl Math Mech* v 51 n 2 1987 p 156-161.

**085539 NASH, PARETO, AND STACKELBERG SOLUTIONS IN NON-ANTAGONISTIC TWO-PERSON GAMES.** Nonantagonistic differential games are formalized on the basis of the formal theory of positional antagonistic differential games. All three types of solution are considered in a unified approach. Our concept of a Pareto solution differs from the usual one in allowing for the individual scope of each player. A single structure of strategies for all types of solutions of different types are established. It is shown that the set of solutions of each type is characterized by the solutions of appropriate non-standard (optimal) control problems. The results are illustrated by the example of the plane motion of a material particle subject to the total action of control forces generated by the different players. (Edited author abstract) 10 refs.

Kleimenov, A.F. *Appl Math Mech* v 51 n 2 1987 p 162-166.

**085540 ON A COMPUTATIONAL ALGORITHM FOR SOLVING GAME CONTROL PROBLEMS.** Positional differential game of approach to a target is considered. The construction of the set of positional adsorption (SPA) is studied. Relations are given, on the basis of which an algorithm of approximate computation of the SPA for controlled systems in the plane is developed. (Author abstract) 11 refs.

Taras'yev, A.M.; Ushakov, V.N.; Khripunov, A.P. *Appl Math Mech* v 51 n 2 1987 p 167-171.

**085541 STRUCTURAL CHOICES OF 2 VERSUS 1 PURSUIT-EVASION DIFFERENTIAL GAMES.** Problems particular to N versus 1 differential games are investigated based on a 2 versus 1 game. A differential game arises between two sonar (or radar) systems and a target. The target uses a mixed strategy by adding white noise into its controller to hamper the tracking of the sonars. The two structures studied, a centralized and a decentralized structure that correspond to a 1 versus 1 or a 2 versus 1 game formulation, are shown to yield different results. Nash-optimality of each structure is shown to depend on the dynamics of the evader. The study provides insight into the solution of difficult problems specific to N versus 1 games. To illustrate further N versus 1 game problems, a nonoptimal scalar case is presented in which the decentralized structure is proven superior. (Edited author abstract) 10 refs.

Bugnon, F.J. (Oregon State Univ, Corvallis, OR, USA); Mohler, R.R. *J Dyn Syst Meas Control Trans ASME* v 110 n 2 Jun 1988 p 160-167.

**085542 STOCHASTIC TWO-TARGET PURSUIT-EVASION DIFFERENTIAL GAMES IN THE PLANE.** A stochastic version of a two-target homicidal chauffeur, pursuit-evasion differential game (using polar coordinates) is considered. This is used to model a dogfight between a very agile player Q and a less maneuverable player P. First, the case where both players have complete observation of the state of the game is considered. A numerical study is conducted, by solving numerically a nonlinear partial differential equation on a torus in  $R^2$ , to investigate the role of the parameters of speed, maneuverability, and performance of the weapon systems, in the encounter. Second, the model is extended to include the case where player P is jamming player Q's measurements of  $\beta$ , where  $\beta$  denotes the bearing of Q from P. A numerical study is conducted, by solving numerically a nonlinear partial differential equation on a generalized torus in  $R^2$ , to investigate the role of the jamming parameter on the outcome of the combat. (Author

abstract) 13 refs.

Yavin, Y. (CSIR, Pretoria, S Afr). *J Optim Theory Appl* v 56 n 3 Mar 1988 p 325-343.

**085543 STOCHASTIC PURSUIT-EVASION DIFFERENTIAL GAMES IN 3D.** A stochastic version of Isaacs's homicidal chauffeur game in the  $(x, y, z)$ -space is considered. This is used to solve a pursuit-evasion problem in the  $(x, y, z)$ -space in which the pursuer has incomplete information on the evader motion. Optimal feedback strategies for the game, and optimal feedback guidance laws for the pursuer, which uses only the measurements available to the pursuer, are computed. A simple suboptimal guidance law for the pursuer is suggested. (Author abstract) 10 refs.

Yavin, Y. (CSIR, Pretoria, S Afr); De Villiers, R. *J Optim Theory Appl* v 56 n 3 Mar 1988 p 345-357.

**085544 RECURSIVE SOLUTION OF LINEAR-QUADRATIC NASH GAMES FOR WEAKLY INTERCONNECTED SYSTEMS.** A recursive method is developed for the solution of coupled algebraic Riccati equations and corresponding linear Nash strategies of weakly interconnected systems. It is shown that the given algorithm converges to the exact solution with the rate of convergence of  $O(\epsilon^2)$ , where  $\epsilon$  is a small coupling parameter. In addition, only low-order systems are involved in algebraic computations; the amount of computations required does not grow per iteration and no analyticity assumption is imposed on the system coefficients. (Author abstract) 19 refs.

Petrovic, B. (Univ of Belgrade, Belgrade, Yugosl); Gajic, Z. *J Optim Theory Appl* v 56 n 3 Mar 1988 p 463-477.

**085545 PERFORMANCE VERSUS INFORMATIVENESS IN LINEAR-QUADRATIC GAUSSIAN NONCOOPERATIVE GAMES.** We study the impact of informativeness on the performance of linear quadratic Gaussian Nash and Stackelberg games. We first show that, in two-person static Nash games, if one of the players acquires more information, then this extra information is beneficial to him, provided that it is orthogonal to both players' information. A special case is that when one of the players is informationally stronger than the other, then any new information is beneficial to him. We then show that a similar result holds for dynamic Nash games. In the dynamic games, the players use strategies that are linear functions of the current estimates of the state, generated by two Kalman filters. The same properties are proved to hold in static and feedback Stackelberg games as well. (Author abstract) 20 refs.

Tu, M. (Bell Communications Research, Red Bank, NJ, USA); Papavasiliopoulos, G.P. *J Optim Theory Appl* v 57 n 1 Apr 1988 p 161-187.

**085546 DETERMINATION OF PREFERENCES ON THE BASIS OF POST-GAME ANALYSIS OF EVENTS.** A new approach to the investigation of conflicts is proposed. A conflicting interaction of participants shows up in the form of a sequence of events. The game-theoretic interpretation is assigned to the event sequence; that is, the different events are regarded as moves in a game. With such a representation of a conflict, there arises the problem of reconstruction of systems of preferences of the participants on the basis of analysis of the event sequence as a problem of analysis of the structure of the conflict. A method based on modeling the rational behavior of the participants in a game with nonzero sum is proposed for solving the problem. Since a unique solution of the problem cannot be guaranteed, one uses Bayes' formula in making a comparative estimate of the likelihood of different hypotheses. (Author abstract). 10 Refs.

Akimov, V.P.; Sergeev, V.M. *Sov J Comput Syst Sci* v 26 n 1 Jan-Feb 1988 p 156-162.

**085547 DYNAMIC PROGRAMMING EQUATIONS FOR STOCHASTIC GAMES WITH DISCRETE ACTIONS.** We consider the quasi-variational inequalities associated with a stochastic game with dis-

crete actions and switching costs. We obtain an analytical uniqueness result, and, for a particular case, a regularity estimate. (Author abstract). 18 Refs.

Belbas, S.A. (Univ of Alabama, University, AL, USA). *Syst Control Lett* v 11 n 3 Sep 1988 p 235-242.

**085548 SADDLE POINT CONDITIONS FOR A CLASS OF STOCHASTIC DYNAMICAL GAMES WITH IMPERFECT INFORMATION.** Nonlinear dynamical games are considered in which one player has full (causal) information on the state and the opponent's measurements and control, while the other one only has partial, possibly noise-corrupted, state information. A dynamic-programming-like algorithm in an extended space is given that, when successful, yields, a saddle point, usually in mixed strategies. This result is used to provide an equilibrium in safe strategies for the case in which both players are restricted to imperfect state information. 12 refs.

Bernhard, Pierre (Inst Natl de Recherche en Informatique et en Automatique, Valbonne, F); Colomb, Annie-Laure. *IEEE Trans Autom Control* v 33 n 1 Jan 1988 p 98-101.

**085549 SOCIAL IMPLICATIONS OF NON-ZERO-SUM GAMES.** It is argued that a reorientation of the theory and application of non-zero-sum (NZS) games is needed in order for that discipline to have a beneficial impact on societal problems such as war. Accordingly, a general strategy of cooperation with minimum sanctions (CMS) is developed and applied to prisoner's dilemma (PD) and dollar auction games. It is shown that tit-for-tat-like strategies are appropriate for all PD games, not just iterated PD, and that, contrary to previous consensus, it is rational to cooperate in the single-shot PD. In evaluating NZS strategies in human or computerized tournaments, special NZS scoring rules should be used. A water-division bargaining example is included to illustrate the superiority of the maximum-welfare approach to the Nash bargaining solution. 12 refs.

Rabow, Gerald. *IEEE Technol Soc Mag* v 7 n 1 Mar 1988 p 12-18.

**Mathematical Models** See Also HURRICANES—Mathematical Models.

**085550 SOME REMARKS ON THE HAZARD FUNCTIONS OF THE INVERTED DISTRIBUTIONS.** The probability models of reciprocals of normal, Gamma and Weibull variates are called inverted normal, inverted Gamma and inverted Weibull distributions, respectively. These distributions arise naturally in the study of certain stochastic processes causing wearout failures of mechanical systems. Characteristic features of the hazard functions based on this inverted class of distributions are discussed and their possible uses are explored. Hazard functions and mean residual life of inverted normal, inverted Gamma and inverted Weibull are compared with the normal, Gamma and Weibull hazards. (Edited author abstract) 9 refs.

Sheikh, Anwar Khalil (King Fahd Univ of Petroleum & Minerals, Dhahran, Saudi Arabia); Ahmad, Munir; Ali, Zulfiqar. *Reliab Eng* v 19 n 4 1987 p 255-261.

## Optimization

**085551 IMPROVING ON BOLD PLAY AT CRAPS.** We derive heuristically a strategy we believe to be nearly optimal at craps (in the sense of maximizing the probability of reaching a specified goal). We then prove rigorously (with the aid of a computer) that this strategy is superior to bold play on 'don't pass,' regardless of the ratio of one's initial fortune to one's goal. It is emphasized that the analysis assumes infinitely divisible capital and no betting limits. Of course, a gambler cannot bet what he does not have. (Edited author abstract)

Ethier, S.N. (Univ of Utah, Salt Lake City, UT, USA). *Oper Res* v 35 n 6 Nov-Dec 1987 p 814-819.



**Queueing** See COMPUTER NETWORKS—Mathematical Models.

**Queueing Theory** See Also COMPUTER NETWORKS; COMPUTER NETWORKS—Analysis; COMPUTER NETWORKS—Calculations; COMPUTER NETWORKS—Local Networks; COMPUTER NETWORKS—Mathematical Models; COMPUTER NETWORKS—Performance; COMPUTER NETWORKS—Protocols; COMPUTER SIMULATION LANGUAGES; COMPUTER SIMULATION LANGUAGES—Performance; COMPUTER SYSTEMS, DIGITAL; COMPUTER SYSTEMS, DIGITAL—Analysis; COMPUTER SYSTEMS, DIGITAL—Distributed; COMPUTER SYSTEMS, DIGITAL—Fault Tolerant Capability; COMPUTER SYSTEMS, DIGITAL—Interactive Operation; COMPUTER SYSTEMS, DIGITAL—Mathematical Models; COMPUTER SYSTEMS, DIGITAL—Multiprocessing; COMPUTER SYSTEMS, DIGITAL—Parallel Processing; COMPUTER SYSTEMS, DIGITAL—Performance; COMPUTER SYSTEMS, DIGITAL—Real Time Operation; COMPUTER SYSTEMS, DIGITAL—Scheduling; COMPUTER SYSTEMS, DIGITAL—Scheduling; COMPUTER SYSTEMS, PROGRAMMING—Multiprogramming; CONTROL SYSTEMS—Estimation; CONTROL SYSTEMS, OPTIMAL; CONTROL SYSTEMS, OPTIMAL—Mathematical Models; DATA TRANSMISSION—Packet Switching; DATABASE SYSTEMS; DATABASE SYSTEMS—Analysis; DATABASE SYSTEMS—Control; DIGITAL COMMUNICATION SYSTEMS; DIGITAL COMMUNICATION SYSTEMS—Analysis; DIGITAL COMMUNICATION SYSTEMS—Voice/Data Integrated Services; EARTHMOVING MACHINERY; FLOW OF FLUIDS; INDUSTRIAL PLANTS—Flexible Manufacturing Systems; INDUSTRIAL PLANTS—Location; INVENTORY CONTROL; INVENTORY CONTROL—Computer Simulation; INVENTORY CONTROL—Mathematical Models; LOGIC CIRCUITS—Testing; MAINTENANCE—Mathematical Models; MAINTENANCE—Optimization; MATHEMATICAL STATISTICS; MATHEMATICAL TECHNIQUES—Sensitivity Analysis; PRODUCTION CONTROL—Scheduling; PRODUCTION ENGINEERING—Analysis; RAILROAD TRANSPORTATION—Scheduling; RAPID TRANSIT—Operations Research; RELIABILITY THEORY; SCHEDULING—Mathematical Models; SEMICONDUCTOR DEVICE MANUFACTURE—Mathematical Models; SWITCHING SYSTEMS—Theory; SYSTEM STABILITY—Mathematical Models; SYSTEMS ANALYSIS—Mathematical Models; SYSTEMS SCIENCE AND CYBERNETICS—Large Scale Systems; SYSTEMS SCIENCE AND CYBERNETICS—Models; TELECOMMUNICATION SYSTEMS—Analysis; TELECOMMUNICATION SYSTEMS—Mathematical Models; TELECOMMUNICATION SYSTEMS—Performance; TELEPHONE SYSTEMS—Traffic Analysis; TRANSPORTATION—Scheduling; TRANSPORTATION—Traffic Control.

**085552 UPPER BOUND ON THE PERFORMANCE OF QUEUES WITH RETURNING CUSTOMERS.** Multiple channel queues with Poisson arrivals, exponential service distributions, and finite capacity are studied. A customer who finds the system at capacity either leaves the system forever or may return to try again after an exponentially distributed time. Steady state probabilities are approximated by assuming that the returning customers see time averages. The approximation is shown to result in an upper bound on system performance. (Author abstract) 9 refs.

Greenberg, Betsy S. (Univ of Texas at Austin, Austin, TX, USA); Wolff, Ronald W. *J Appl Probab* v 24 n 2 Jun 1987 p 466-475.

**085553 BUSY-PERIOD ANALYSIS OF A CORRELATED QUEUE WITH EXPONENTIAL DEMAND AND SERVICE.** In this paper we investigate the server's busy period in a single-server queueing situation in which the interarrival  $T$  preceding the arrival of a customer and his service time  $S$  are assumed correlated. A closed-form expression is obtained for the Laplace transform  $b_n(z)$  of the joint probability and probability density function of the busy period duration and the number of customers served in it. Some numerical values are given showing the effect of correlation between  $T$  and  $S$ . (Author abstract) 10 refs.

Langaris, Christos (Univ of Ioannina, Ioannina, Greece). *J Appl Probab* v 24 n 2 Jun 1987 p 476-485.

**085554 EXPLICIT FORMULAS FOR THE CHARACTERISTICS OF THE M/M/2/2 QUEUE WITH REPEATED ATTEMPTS.** In this paper we study the M/M/2/2 queue with repeated attempts. It is shown that the partial generating functions of the steady-state probabilities can be expressed in terms of generalized hypergeometric functions. (Author abstract) 11 refs.

Hanschke, Thomas (Johannes Gutenberg-Univ Mainz,

Mainz, West Ger). *J Appl Probab* v 24 n 2 Jun 1987 p 486-494.

**085555 ON SOJOURN TIME IN JACKSON NETWORKS OF QUEUES.** This paper is about representations for equilibrium sojourn time distributions in Jackson networks of queues. For a network with  $N$  single-server nodes let  $b_i$  be the Laplace transform of the residual system sojourn time for a customer 'arriving' to node  $i$ , 'arrival' meaning external input or internal transfer. The transforms  $\{b_i; i=1, \dots, N\}$  are shown to satisfy a system of equations we call the network flow equations. These equations lead to a general recursive representation for the higher moments of the sojourn time variables  $\{T_i; i=1, \dots, N\}$ . This recursion is discussed and then, by way of illustration, applied to the single-server Markovian queue with feedback. (Author abstract) 14 refs.

Lemoine, Austin J. (Ford Aerospace & Communication Corp, Palo Alto, CA, USA). *J Appl Probab* v 24 n 2 Jun 1987 p 495-510.

**085556 SOJOURN TIMES IN QUEUEING NETWORKS WITH MULTISERVER MODES.** This paper generalizes previous results for sojourn-time distribution along so-called overtake-free routes in product-form networks of queues. (Author abstract) 25 refs.

Schassberger, R. (Technische Univ Berlin, Berlin, West Ger); Daduna, H. *J Appl Probab* v 24 n 2 Jun 1987 p 511-521.

**085557 NOTE ON WAITING TIMES IN SYSTEMS WITH QUEUES IN PARALLEL.** Numerical data are presented concerning the mean and the standard deviation of the waiting-time distribution for multiserver systems with queues in parallel, in which customers choose one of the shortest queues upon arrival. Moreover, a new numerical method is outlined for calculating state probabilities and moments of queue-length distributions. This method is based on power series expansions and recursion. It is applicable to many systems with more than one waiting line. (Author abstract) 2 refs.

Blanc, J.P.C. (Delft Univ of Technology, Neth). *J Appl Probab* v 24 n 2 Jun 1987 p 540-546.

**085558 REDUCING THE CONGESTION IN A CLASS OF JOB SHOPS.** Consider a job shop that is modeled as an open queueing network of the J.R. Jackson type. All work stations in the shop have the same number of parallel servers. Two problems are studied: the loading of stations and the assignment of servers, which are represented by loading and assignment vectors, respectively. Majorization and arrangement orderings are established to order, respectively, the loading and the assignment vectors. It is shown that reducing the loading vector under majorization or increasing the assignment vector under arrangement ordering will reduce the congestion in the shop in terms of reducing the total number of jobs. The results can be used to support production planning in certain job shops, and to aid the design of storage capacity. (Edited author abstract) 14 refs.

Yao, David D. (Harvard Univ, Cambridge, MA, USA); Kim, S.C. *Manage Sci* v 33 n 9 Sep 1987 p 1165-1172.

**085559 OPTIMAL SERVER ALLOCATION IN A SYSTEM OF MULTI-SERVER STATIONS.** Consider a closed queueing network with a set of stations. The service rate at each station is an increasing concave function of the number of jobs at that station. Suppose there also exists a station that has  $c$  ( $\geq 1$ ) parallel servers, each of which has a fixed service rate. We show that the throughput of this network is an increasing concave function with respect to  $c$ . This result is then applied to solve the optimal server allocation problem in a system of multi-server stations with a fixed buffer capacity (for the total number of jobs) at each station. For a single-station system, the simultaneous optimal allocation of both servers and buffer capacity is also studied. (Edited author abstract) 10 refs.

Shanthikumar, J. George (Univ of California, Berkeley, CA, USA); Yao, David D. *Manage Sci* v 33 n 9 Sep 1987

p 1173-1180.

**085560 SIMULATING GI/G/k QUEUES IN HEAVY TRAFFIC.** This paper proposes a new consistent estimator for the expected waiting time in queue in the simulation of a multiserver queueing system. This estimator is called the 'error estimator' because it estimates only the error involved in the use of Kingman's heavy traffic approximation. Not only does this estimator retain all the advantages of the regenerative method, but it also reduces the variance of the estimator substantially when the traffic becomes heavy. (Author abstract) 10 refs.

Minh, Do Le (California State Univ, Fullerton, CA, USA). *Manage Sci* v 33 n 9 Sep 1987 p 1192-1199.

**085561 SOJOURN TIME DISTRIBUTIONS FOR THE M/M/1 QUEUE IN A MARKOVIAN ENVIRONMENT.** The author a single server queue in which both the arrival rate and service rate depend on the state of an external Markov Process (called the environment) with a finite state space. Given that the environment is in state  $j$ , the mean arrival and service rates are  $\lambda_j$  and  $\mu_j$  respectively. For such a queue, the queue length distribution is known to be matrix geometric. In this paper, we characterize the Laplace-Stieltjes transform of the sojourn time distribution under four disciplines - last come first served preemptive resume, last come first served, processor sharing and round robin. We also discuss a potential application of this queue in the area of data communication. (Edited author abstract) 11 refs.

Sengupta, Bhaskar (AT&T Bell Lab, Holmdel, NJ, USA). *Eur J Oper Res* v 32 n 1 Oct 1987 p 140-149.

**085562  $\Sigma \text{GI}[X_i]/M/S/K$  QUEUES WITH MIXED BATCH RENEWAL INPUTS.** This paper presents the analysis for the finite capacity queueing model with two independent mixed batch renewal inputs. The analysis is presented for the steady-state distribution at an arbitrary time and the steady-state distribution immediately before the arrival for each type of customers. The results can be applied to the models of various kinds of strategies such as delay-delay, delay-loss and loss-loss. Several examples are presented in order to discuss the effects of the interarrival distribution and the batch-size distribution on the individual blocking probabilities. (Edited author abstract) 17 refs.

Machihara, Fumiaki (NTT, Musashino, Jpn). *Electron Commun Jpn Part 1* v 70 n 9 Sep 1987 p 78-86.

**085563 DISCRETE PRIORITY QUEUEING SYSTEMS.** The author considers a single-service queueing system (QUS) with an infinite queue. It is assumed that any changes in the QUS take place at equidistant isolated instants of time  $t_j - 0$ ,  $t_j - t_{j-1} = t$ . The random variables  $(RV) \eta$  which is the interval between the instants of arrival of calls in the QUS, and  $\mu$  which is the service time of calls, have mesh distributions. In the case of simultaneous arrival of a bundle of calls in the QUS, it is assumed that all sorts of orders of service of the calls of the bundle are equally likely. Results show that input flow is a discrete counterpart of a very simple flow. Polaczek-Khinchin formulas for such systems are found to be similar to the formulas for the corresponding continuous systems. (Edited author abstract) 6 refs.

Ivanovskii, V.B. *Autom Remote Control* v 48 n 4 pt 1 Apr 1987 p 452-458.

**085564 QUEUEING NETWORKS WITH SYMMETRIC STANDBY CHANNELS.** A necessary and sufficient condition for representability of the equations of equilibrium in the product form is proven for open Markov queueing networks with two symmetric standby channels at the nodes. A stationary distribution of the probabilities of the states is found for analogous closed networks. The characteristics of the flows issuing from the network are investigated. (Author abstract) 12 refs.

Malinkovskiy, Yu.V. *Sov J Comput Syst Sci* v 25 n 2 Mar-Apr 1987 p 1-9.



**085565 EXACT ANALYSIS OF ROUND-ROBIN SCHEDULING OF SERVICES.** A multi-queue, cyclic-service model with a single-message buffer is considered. Each message consists of a number of characters, and one character is served at the server's each visit. Exact and explicit expressions are derived for performance measures, such as mean cycle time, mean message response time, and mean response time conditioned on the message length. (Edited author abstract) 14 refs.

Takagi, Hideaki. *IBM J Res Dev* v 31 n 4 Jul 1987 p 484-488.

**085566 THROUGHPUT RATE OF THREE-STATION PRODUCTION LINES: A UNIFYING SOLUTION.** A three-station production line with a Laplace transformable distribution of service time of the middle station and phase-type distribution of service times of the two outside stations is treated. A general formula for the throughput rate is derived. In this formula a system of linear equations with the number of equations equal to the number of stages of the service time of the last station needs to be solved. For some special cases, this formula reduces to simple expressions. (Author abstract) 12 refs.

Muth, Eginhard J. (Univ of Florida, Gainesville, FL, USA); Alkaff, Abdullah. *Int J Prod Res* v 25 n 10 Oct 1987 p 1405-1413.

**085567 EFFECTS OF SKEWNESS AND KURTOSIS OF PROCESSING TIMES IN UNPAID LINES.** Numerous empirical studies have shown that, in unpaid lines, the stations' processing times have a variety of shapes (i.e., skewness and kurtosis). This paper investigates how the line's utilization factor is affected by these skewness and kurtosis measures. We found that positive skewness has a significant negative effect on utilization, and that the magnitude of this effect is greater if the line has more stations or less buffer capacity, or if the processing-times' cv is larger. Kurtosis also affects utilization significantly, but the effect may be negative or positive, depending upon the processing-times' skewness and the number of stations in the line. (Edited author abstract) 23 refs.

Lau, Hon-Shiang (Oklahoma State Univ, Stillwater, OK, USA); Martin, G.E. *Int J Prod Res* v 25 n 10 Oct 1987 p 1483-1492.

**085568 SOFTWARE PACKAGE FOR THE QUEUEING SYSTEM  $M^x / G / 1$ .** A user-friendly software package, which should be found useful by researchers, practitioners and students alike, for the bulk-arrival single-server queueing system  $M^x / G / 1$  is discussed. It finds numerically the steady-state probabilities and moments for the number in the system at each of the three time epochs (pre-arrival, post-departure and random). It also finds the moments for waiting time in queue and busy and idle periods. (Author abstract) 2 refs.

Chaudhry, M.L. (Royal Military Coll of Canada, Kingston, Ont, Can); Hasham, Alnoor. *Oper Res Lett* v 6 n 4 Sep 1987 p 195-196.

**085569 ON THE  $\langle m, n(M^-/M^-) \rangle$  PRIORITY QUEUES AND THEIR APPLICATIONS.** We deal with a heterogeneous double finite-source priority model under the assumption that the priority group has preemptive priority over the ordinary one. In each source the units are characterized by exponentially distributed random variables with multiple parameters. The units are served by a single server according to first-in, first-out (FIFO), preemptive resume (PR) and priority processor sharing (PPS) service disciplines. The aim of the present paper is to give the main steady-state characteristics of the system, such as server's utilization, expected busy period length, mean sojourn and delay times, average number of customers staying at the service facility. As an application we consider the machine interference problem and show how this model can be used for the mathematical description of multiprogrammed computer systems. (Edited author abstract) 9 refs.

Posafalvi, A.; Sztrik, J. *Probl Control Inf Theory* v 16 n 3 1987 p 169-186.

**085570 ANALYSIS OF THE QUEUE LENGTH AND THE OUTPUT FLOW IN SINGLE SERVER WITH FINITE WAITING ROOM AND PHASE TYPE DISTRIBUTIONS.** A single server queueing system with a buffer of finite capacity is considered. The interarrival times of customers and their service times are distributions of phase type (PH-distributions). The relations for binomial moments of stationary queue length distribution at the arbitrary instants of time as well as at the instants of customer arrival and service completion are obtained. The Laplace-Stieltjes transforms of waiting time distribution for the discipline FIFO and interdeparture times distribution are determined. (Author abstract) 11 refs.

Bocharov, P.P. *Probl Control Inf Theory* v 16 n 3 1987 p 211-222.

**085571 NON-PREEMPTIVE PRIORITY QUEUE WITH SERVER'S WALKING PROCESS.** This paper considers the non-preemptive priority queue with the server's walking process. The state probability of the queue at the arrival of the server is derived from the generating function for the joint probability of the numbers of jobs with various priorities. Then the jobs are partitioned into two classes. The generating function for the number of jobs with higher priority is derived from which the queue waiting time is determined as one of the important evaluation measures of the queue system. The results in this paper can be applied to the performance evaluation of the simplified model for the data transmission system, TSS system and LAN. 8 refs.

Fukagawa, Yukinori (Nishinippon Inst of Technology, Fukuoka, Jpn); Yanaru, Torao; Yoshida, Sho. *Electron Commun Jpn Part 1* v 70 n 11 Nov 1987 p 49-57.

**085572 QUEUEING SYSTEM WITH SERVER'S WALKING-TIME AND SERIAL SERVICE.** This paper considers two queueing systems with the server's walking process, where the service of the job is composed of more than one serial process. The first system is the scheme where the server arriving at the station serves in the last service stage for a job. The second system is the scheme where the server arriving at the station can serve more than one service-stage from the last to the first stage in the reverse order. When a job goes through a service at a certain stage, either it proceeds to the next service stage or leaves the system, following a specified probability. For both systems, the case of three serial stages in the stationary state is considered where the service time and the walking time follow general distributions. (Edited author abstract) 12 refs.

Fukagawa, Yukinori (Nishinippon Inst of Technology, Fukuoka, Jpn); Yanaru, Torao; Yoshida, Sho. *Electron Commun Jpn Part 1* v 70 n 11 Nov 1987 p 58-67.

**085573 INFINITE CHANNEL QUEUEING SYSTEM WITH CONTROLLED INPUT.** The authors study a queueing model with a nonrecurrent input. The intensity of the input stream is regulated at epochs of successive starts of customers moving from the source to the system, and it is dependent on the number of busy channels. We consider three groups of channels. Such a division is connected with different expenditures of servicing within each of the groups. It is worthwhile to control the input rates in order to minimize the long-run average cost. The basic process is the number of busy channels. We derive its limiting distribution explicitly by introducing an auxiliary two-dimensional Markov process and treating the corresponding Kolmogorov system of differential equations. We also use some properties of semiregenerative processes. This limiting distributions are used to solve an optimization problem. (Edited author abstract) 8 refs.

Dshalalov, Jewgeni (Florida Inst of Technology, USA). *Math Oper Res* v 12 n 4 Nov 1987 p 665-677.

**085574 NOTE ON THE BEST ORDER FOR QUEUES IN SERIES.** The authors have been working on the problem of developing approximate solutions to the distribution function of waiting time in complex network queues, particularly under stationary conditions. Some

remarks are made on the best order for queues in series in the light of these investigations. 8 refs.

Ghosal, A. (CSIR Complex, New Delhi, India); Gujaria, S.C. *Int J Syst Sci* v 18 n 10 Oct 1987 p 1995-1999.

**085575 GENERALIZED EXPANSION METHOD FOR OPEN FINITE QUEUEING NETWORKS.** Blocking makes the exact analytical analysis of open queueing networks with finite capacities intractable except for very small networks, therefore, approximation approaches are needed to analyze these types of networks. For exponential open finite queueing networks, some methods have been proposed but little has been done so far on nonexponential open finite queueing networks. This paper introduces a new approximation technique for the analysis of general open finite queueing networks. Extensive numerical examples are performed for different network topologies and the results are compared with simulation. (Author abstract) 37 refs.

Kerbache, Laoucine (Univ of Massachusetts, Amherst, MA, USA); MacGregor Smith, J. *Eur J Oper Res* v 32 n 3 Dec 1987 p 448-461.

**085576 MULTIQUEUE SYSTEM WITH NON-EXHAUSTIVE CYCLIC SERVICE MODELED AS A LINEAR-PROGRAMMING PROBLEM.** This paper shows how one important parameter can be estimated quickly, namely the cycle-time distribution. This is the distribution of times taken for the cyclic server to perform one complete cycle in its continuous scan of a number of queues. The method of solution is to identify various constraints which will determine the cycle-time distribution, formulate them as linear inequality and equality constraints and, by determining an appropriate objective function, apply the simplex method to find upper and lower bounds on the values taken by the cycle-time distribution itself. A great strength of this technique is its overall simplicity, which enables it to be used to obtain important results very quickly and cheaply. (Edited author abstract) 4 refs.

McCron, David A. (Standard Telephones & Cables plc, London, Engl). *J Oper Res Soc* v 38 n 11 Nov 1987 p 1067-1072.

**085577 STRONG CONVEXITY RESULTS FOR QUEUEING SYSTEMS.** We prove a strong (and seemingly odd) result about the  $M/M/c$  queue: the reciprocal of the average sojourn time is a concave function of the traffic intensity. We use this result to show that the average itself is jointly convex in arrival and service rates. The standard deviation has the same properties. Also, we determine conditions under which these properties are exhibited by a standard approximation for the  $M/G/c$  queue. These results are useful in design studies for telecommunications and production systems. (Author abstract) 21 refs.

Harel, Arie (Rutgers Univ, Newark, NJ, USA); Zipkin, Paul H. *Oper Res* v 35 n 3 May-Jun 1987 p 405-418.

**085578 APPROXIMATING THE MEAN TIME IN SYSTEM IN A MULTIPLE-SERVER QUEUE THAT USES THRESHOLD SCHEDULING.** We consider a queueing system consisting of a single queue with multiple exponential servers with different servicing rates. We assume that arrivals to the queue come from a Poisson source and are scheduled according to a threshold policy. Since determining the exact mean time in system appears to be difficult, we present an approximation that yields results very close to those obtained from simulation. (Edited author abstract) 7 refs.

Nelson, Randolph (IBM, Yorktown Heights, NY, USA); Towsley, Don. *Oper Res* v 35 n 3 May-Jun 1987 p 419-427.

**085579 ALGORITHM FOR COMPUTING THE CONVOLUTION OF POISSON NEGATIVE BINOMIAL AND GEOMETRIC DISTRIBUTIONS.** We present a simple algorithm that computes the convolution



of Poisson, negative binomial, and geometric distributions. We show that a certain infinite-server queue in a random facility repair environment has a steady-state distribution that involves such convolutions. The algorithm arises from the steady-state equations of this process. (Author abstract) 4 refs.

O'Connell, Colm Art (Univ of Arkansas, Fayetteville, AR, USA); Schneider, Helmut. *Oper Res* v 35 n 3 May-Jun 1987 p 445-449.

**085580 ANALYSIS OF MODELS REDUCIBLE TO A CLASS OF DIFFUSION PROCESSES IN THE POSITIVE QUARTER PLANE.** This paper is concerned with the two-dimensional generalization of the single server queue 'diffusion approximation'. This single queue approximation is based on a continuous representation of the discrete process of the number of jobs in the system, but differs by the type of boundary condition which is used. The state space of this continuous model is the positive real axis and the boundary is the zero of the real axis. The boundary condition consists here of an absorption and a sojourn on the boundary, followed by a jump back into  $R^+$ . This model describes within the same framework such phenomena as coupling of processors or simultaneous arrivals of jobs which do not preserve the classical 'product form' solutions. First we exhibit a pathwise construction of the process which leads to the existence, the uniqueness and the Markov property. From this, we derive a functional equation for the Laplace transform of the steady state distribution. The solution of this functional equation is obtained by reduction to a boundary value problem on the right branch of a hyperbola. Accordingly, these Laplace transforms are given as Cauchy type integrals since the conformal mapping of the infinite domain inside this right branch onto a disc is known in closed form. Finally, we propose a method for establishing the conditions ensuring the existence of the steady state distribution. (Edited author abstract) 14 refs.

Baccelli, Francois (Inst Natl de Recherche en Informatique et en Automatique, Le Chesnay, Fr); Fayolle, Guy. *SIAM J Appl Math* v 47 n 6 Dec 1987 p 1367-1385.

**085581 STATIONARY DETERMINISTIC FLOWS: II. THE SINGLE-SERVER QUEUE.** The goal of this paper is to establish fundamental properties of queueing systems. A single-server queue is considered in which the usual probabilistic assumptions are not assumed to hold. Only the existence of long-term averages of inter-arrival times and service times is assumed. Based on the minimal assumptions, stability conditions are established. The asymptotic behavior of the unstable queue is determined. In addition, an investigation of the stable queue is undertaken. Topics include queues with failures and asymptotic birth-and-death equations. (Author abstract) 6 refs.

Gelenbe, Erol (Univ de Paris Sud, Orsay, Fr); Finkel, David. *Theor Comput Sci* v 52 n 3 1987 p 269-280.

**085582 MULTISERVER QUEUES WITH SYNCHRONOUS FLUCTUATION OF TRAFFIC INTENSITY.** A study is presented on the generalization of the M/M/1 model with synchronous fluctuation of traffic intensity for the case of more than one server. The parameters of the queueing system fluctuate between two phases and the phase process is assumed to make changes according to an irreducible Markov chain. Phase changes may occur only when a customer arrives to the queue; his service time is also determined at his arrival instant, we compare our results to that of the asynchronous one and the comparison shows that we can approximate the performance of the asynchronous model by that of the synchronous one and vice-versa. However, we point out that to extend the M/M/K (M/M/ $\infty$ ) model with fluctuating parameters to the case of general inter-arrival, service, or sojourn time distribution, is easier in the synchronous model than in the case of the asynchronous one since the latter introduces considerable analytic complications. Two models, the M/M/K and M/M/ $\infty$ , with synchronous fluctuation of parameters are analyzed. Explicit results for the expected queue length are dis-

cussed. (Edited author abstract) 10 refs.

Sotelo, Walter (Shizuoka Univ, Hamamatsu, Jpn); Fukuda, Akira. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 10 Oct 1987 p 951-959.

**085583 STOCHASTIC INEQUALITIES FOR AN OVERFLOW MODEL.** A general method to obtain insensitive upper and lower bounds for the stationary distribution of queueing networks is sketched. It is applied to an overflow model. The bounds are shown to be valid for service distributions with decreasing failure rate. A characterization of phase-type distributions with decreasing failure rate is given. An approximation method is proposed. The methods are illustrated with numerical results. (Author abstract) 21 refs.

Hordijk, Arie (Univ of Leiden, Leiden, Neth); Ridder, Ad. *J Appl Probab* v 24 n 3 Sep 1987 p 696-708.

**085584 IMPACT OF THE COMPOSITION OF THE CUSTOMER BASE IN GENERAL QUEUEING MODELS.** We consider general queueing models dealing with multiple classes of customers and address the question under what conditions and in what (stochastic) sense the marginal increase in various performance measures, resulting from the addition of a new class of customers to an existing system, is larger than if the same class were added to a system dealing with only a subset of its current customer base. Our results enhance our understanding of the dependence of various performance measures with respect to the composition of the customer base. In addition they translate readily into convexity results in an (appropriately defined) arrival rate. (Author abstract) 25 refs.

Federgruen, A. (Columbia Univ, New York, NY, USA); Groenevelt, H. *J Appl Probab* v 24 n 3 Sep 1987 p 709-724.

**085585 CONVEXITY OF A GENERAL PERFORMANCE MEASURE FOR MULTISERVER QUEUES.** This paper examines a general performance measure for queueing systems. This criterion reflects both the mean and the variance of sojourn times; the standard deviation is a special case. The measure plays a key role in certain production models, and it should be useful in a variety of other applications. We focus here on convexity properties of an approximation of the measure for the M/G/c queue. For  $c \geq 2$  we show that this quantity is convex in the arrival rate. Assuming the service rate acts as a scale factor in the service-time distribution, the measure is convex in the service rate also. (Author abstract) 13 refs.

Harel, Arie (Rutgers Univ, Newark, NJ, USA); Zipkin, Paul. *J Appl Probab* v 24 n 3 Sep 1987 p 725-736.

**085586 CONVEX ORDERING OF SOJOURN TIMES IN SINGLE-SERVER QUEUES: EXTREMAL PROPERTIES OF FIFO AND LIFO SERVICE DISCIPLINES.** The extremal properties of the ergodic sojourn times in G/G/1 queues under various service disciplines are studied in terms of the convex ordering. It is shown that among work-conserving non preemptive service disciplines that are service time independent, the FIFO and the LIFO service disciplines provide the minima and the maxima, respectively, of the ergodic sojourn times for any G/G/1 queue. For G/M/1 queues, this class of work-conserving service disciplines is extended to include preemptive/resume disciplines. (Author abstract) 7 refs.

Shanthikumar, J. George (Univ of California, Berkeley, CA, USA); Sumita, Ushio. *J Appl Probab* v 24 n 3 Sep 1987 p 737-748.

**085587 BOUNDS ON THE EXPECTED WAITING TIME IN A GI/G/L QUEUE: UPGRADING FOR LOW TRAFFIC INTENSITY.** For a GI/G/1 queue we derive new lower and upper bounds on the expected stationary waiting time which are a function of more than the first two moments of the inter-arrival and service times. When the probability for a delay is low, the bounds tend to be better than other bounds. This is illustrated in

an example of a Uniform/Uniform/1 queue. (Author abstract) 10 refs.

Rosberg, Zvi (IBM, Yorktown Heights, NY, USA). *J Appl Probab* v 24 n 3 Sep 1987 p 749-757.

**085588 SINGLE-SERVER QUEUE WITH SERVICE DEPENDING ON QUEUE SIZE AND WITH THE PREEMPTIVE-RESUME LAST-COME-FIRST-SERVED QUEUE DISCIPLINE.** This paper studies the GI/G/1 queueing system assuming that customers have service times depending on the queue size and also that they are served in accordance with the preemptive-resume last-come-first-served queue discipline. Expressions are given for the limiting distribution of the queue size and the remaining duration of the corresponding services, when the system is considered at arrival epochs, at departure epochs and continuously in time. Also these results are applied to some particular cases of the above queueing system. (Author abstract) 7 refs.

Fakinos, D. (Aristotle Univ of Thessaloniki, Thessaloniki, Greece). *J Appl Probab* v 24 n 3 Sep 1987 p 758-767.

**085589 STUDY OF A TIME DEPENDENT QUEUEING SYSTEM WITH TWO PARALLEL CHANNELS.** A time dependent queueing system is studied by obtaining the probabilities of the exact number of arrivals and departures by a given time. The service is accomplished through two parallel channels, each channel having a different service rate. The marginal probability of exactly  $i$  arrivals and the mean number of  $i$  arrivals are obtained. (Author abstract) 2 refs.

Sharda (Kurukshetra Univ, Kurukshetra, India); Garg, Prem Chand. *Microelectron Reliab* v 28 n 1 1988 p 7-9.

**085590 ANALYTICAL APPROXIMATION TO THE QUEUEING MODEL:  $(HE_3/HE_3/1): (GD/\infty/\infty)$  FOR MAINTAINABILITY.** A queueing model,  $(HE_3/HE_3/1): (GD/\infty/\infty)$ , justified from a machine maintenance problem is investigated. This model defines both the interarrival times and service times as the hyperexponential distributions with three branches. This non-Poisson queueing model is considered as an alternate queueing system consisting of three separate stages, each of which is a Poisson queue. Therefore, the conventional analytical approach to a Poisson queueing model can be applied. Accomplishments of this study include constructing the flow rate diagram, setting up the state balance equations for acquiring queueing statistics, and employing the Gauss-Siedel numerical approach to obtain an analytical solution. (Author abstract) 4 refs.

Kuo, Way (Iowa State Univ, Ames, IA, USA); Zhang, Weixing. *Microelectron Reliab* v 28 n 1 1988 p 59-73.

**085591 CHARACTERIZATIONS OF EQUILIBRIUM QUEUE LENGTH DISTRIBUTIONS IN M/GI/1 QUEUES.** In certain multiqueue systems, a resourceful server may decide on which queue to attend to next based on critical that may include the equilibrium queue lengths of some or all queues. The server's decision will be unaffected by queue length only when the distribution of queue length is uniform. In studying this problem, we present first the simple case of the M/GI/1 queue to determine conditions under which equilibrium queue lengths can either be uniformly distributed, or have components that are uniform, and also present a method for designing such a queueing process. It is shown that there is an inherent connection between probability distributions  $\{k_j\}$  of the number of arriving customers during a service that are geometric, and equilibrium queue length distributions  $\{p_j\}$  that are geometric. In particular, we present a simple probabilistic proof via a recurrence equation that says that the M/M/1 queue is the only M/GI/1 queue with both  $\{k_j\}$  and  $\{p_j\}$  geometric. (Author abstract) 7 refs.

Rego, Vernon (Purdue Univ, West Lafayette, IN, USA). *Comput Oper Res* v 15 n 1 1988 p 7-17.



**085592 ANALYSIS OF QUEUEING SYSTEMS WITH RANDOMLY CHANGING POPULATION STATES.** The queueing system, in which the property of the population is changing randomly, frequently is observed in various problems, and it is important to know its property. However, the analysis of the characteristics of such a system in general is difficult. From such a viewpoint, this paper considers the simplest example of the M/M/1 system, where the inter-arrival-time distribution or service-time distribution changes following a two-stage Markov chain. A strict solution is derived for the behavior of the system. Using the state-transition rate diagram of the system, the system equation for the steady-state is derived. Then the z-transform of the steady-state probability distribution and the Laplace transform of the waiting time distribution are obtained. (Edited author abstract) 4 refs.

Fukuda, Akira (Shizuoka Univ, Hamamatsu, Jpn). *Electron Commun Jpn Part 1* v 71 n 1 Jan 1988 p 1-10.

**085593 ON A GENERALIZED DISCRETE QUEUEING SYSTEM WITH INFINITELY MANY SERVERS.** This note follows the authors' previous paper on queueing systems with infinitely many servers. Here, however, we consider the most common case in practice of modern automatic processing, where the system is discretized when data are input into the computer. Such discrete queueing systems with infinitely many servers are used successfully as mathematical models when solving applied problems of various kinds. The objective of this note is to determine the joint distribution of the busy period, the idle period, and the number of demands served per busy period. 10 refs.

Dvurechenskiy, A. (Ososkov, G.A.). *Sov J Comput Syst Sci* v 25 n 3 May-Jun 1987 p 42-46.

**085594 SINGLE-LINE SYSTEM WITH GROUP SERVING UNDER HEAVY LOAD CONDITIONS.** The limiting distribution of the number of orders in a group in a stationary regime for a single-line queueing system with group service under heavy load is found. This makes it possible to estimate the minimum volume of computer memory which is used in operation in a group regime under heavy load conditions, since it is proportional to the size of the group in a stationary regime. 4 refs.

D'Yakonova, Ye.Ye.; Solov'yev, A.D. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 74-79.

**085595 NUMBER OF ORDERS IN A SINGLE-CHANNEL SYSTEM UNDER HEAVY LOAD FOR SCHRAGE DISCIPLINES.** A  $G|G|1$  system in which orders are served according to Schrage's discipline or two related service disciplines is studied. The case of heavy load is investigated. It is assumed that the distribution function of the service time of a single order,  $F(x)$ , satisfies the following conditions:  $F(x) < 1$  for  $x \geq 0$  and  $F'(x) = 1 - F(x)$  decreases as  $x$  approaches  $\infty$  faster than any negative power of  $x$ . It is proved that the limiting distribution of the normalized number of orders in the system in a stationary regime will be exponential. The explicit form of the normalization parameter is given. (Author abstract) 11 refs.

Pavlov, A.V. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 90-98.

**085596 FLOW OF LOST ORDERS IN SYSTEMS WITH FINITE QUEUE.** A complete description of the flow of lost orders in a  $G|M|r|n-r$  queueing system is given, and a condition under which this flow converges to a Poisson flow is found. The results also have application in reliability theory. (Edited author abstract) 7 refs.

Shakhbazov, A.A. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 104-110.

**085597 JOINT DISTRIBUTION OF QUEUES IN SOME TWO-PHASE SYSTEMS WITH NONORDINARY FLOW.** A two-phase queueing system with a composite Poisson flow at the input, an arbitrary load of each of the devices, and no limitations on the lengths of the queues in front of them, is considered. An algorithm

for determining the joint stationary distribution of the queues in this system is developed. The basic steps of this algorithm are the solution of a Fredholm equation of the second kind and the calculation of a generalized Cauchy integral. (Author abstract) 7 refs.

Yakushev, Yu.F. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 111-117.

**085598 NEW PROOF OF ERLANG'S FORMULA FOR A LOSSY MULTICHANNEL QUEUEING SYSTEM.** A new proof of the insensitivity of Erlang's formula for an  $M|G|n|0$  queueing system to the form of the distribution function of service time is presented. (Author abstract) 10 refs.

Pechinkin, A.V. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 165-168.

**085599 CONTROL OF SYSTEMS WITH CYCLIC INSTANTS OF START OF SERVICE.** Control which consists of compression during the expansion of the intervals between adjacent instants of start of service is introduced for systems with cyclic instants of start of service. A class of queueing systems for which it is expedient to introduce such a control is described, and the explicit form of the optimal function which minimizes the mean time of waiting for the start service is found. (Author abstract) 6 refs.

Gadzhiev, A.G. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 174-177.

**085600 NONPARAMETRIC ESTIMATION OF THE DISTRIBUTION FUNCTIONS OF THE SERVICE TIMES IN MULTICHANNEL SYSTEMS.** A method for studying the asymptotic properties of nonparametric estimates of distribution functions obtained from incomplete data was proposed elsewhere. The same approach is applied in this paper to the estimation of the distributions of the service times in multichannel systems with some constraints on the service discipline. (Author abstract) 6 refs.

Chistyakova, N.V. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 178-181.

**085601 ESTIMATES OF THE STABILITY OF QUEUEING PROCESSES.** This paper is devoted to estimates of the ability of the distributions of discontinuous functionals of queueing processes under disturbances of the distribution functions of the input data. The estimates are made under some assumptions which ensure continuity of these functionals with probability 1 with respect to the undisturbed distribution of the input. (Author abstract) 3 refs.

Logunov, P.L. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 182-184.

**085602 TWO-PHASE QUEUEING SYSTEM WITH MULTIPLICATIVE DISTRIBUTION OF THE STATIONARY PROBABILITIES.** The solution for a stationary distribution of the state probabilities in multiplicative form is obtained for a two-phase queueing system with supplementary flow into the second phase and with a dependence of the service in the first phase on service in the second. The system is subject to Poisson input flows and exponential service laws. (Author abstract) 4 refs.

Gromov, A.I. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 184-186.

**085603 DISTRIBUTION OF THE SUPREMUM OF THE QUEUE LENGTH IN QUEUEING SYSTEMS WITH POISSON INPUT FLOW.** A single-server queueing system with a nonordinary Poisson input flow is examined. The durations of orders service are independent but not necessarily identically distributed. The distribution of the supremum of the queue length is obtained. (Author abstract) 8 refs.

Abramov, V.M. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 189-193.

**085604 APPROXIMATION OF KNOWN ACCU-**

**RACY FOR SINGLE SERVER QUEUES WITH INHOMOGENEOUS ARRIVAL RATE AND CONTINUOUS SERVICE TIME DISTRIBUTION.** A practical method for obtaining approximate results for single server queues with inhomogeneous queues and continuous service time distribution is presented. The method is based on a discrete approximation to the continuous service time distribution. Exact results can be obtained for the corresponding queueing system with discrete service time distribution. These results are then corrected, and the likely accuracy of the corrected results is estimated. Four measures of performance are considered, idleness probability, mean and variance of number of customers in the system and virtual waiting time. (Author abstract) 7 refs.

Ömosigbo, S.E. (Univ of Lancaster, Lancaster, Engl); Worthington, D.J. *Eur J Oper Res* v 33 n 3 Feb 1988 p 304-313.

**085605 MEAN VALUE ANALYSIS OF CLOSED QUEUEING NETWORKS WITH ERLANG SERVICE TIME DISTRIBUTIONS.** The classical mean value analysis approach is extended to single class closed queueing networks containing Erlang service time distribution and FCFS scheduling disciplines. A new formula for the mean residence time of jobs is derived. Each iteration provides self-checks for validity, and is repeated whenever invalid results are detected. On the average, the solutions obtained vary by less than five percent from their respective simulation results. (Author abstract) 24 refs.

Akyildiz, I.F. *Computing (Vienna/New York)* v 39 n 3 1987 p 219-232.

**085606 PERTURBATION ANALYSIS GIVES STRONGLY CONSISTENT SENSITIVITY ESTIMATES FOR THE M/G/1 QUEUE.** This paper considers, for an M/G/1 queueing system, the sensitivity of mean system time of a customer to a parameter of the arrival or service distribution. It shows analytically that (i) the steady state value of the perturbation analysis estimate of this sensitivity is unbiased, and (ii) a perturbation analysis algorithm implemented on a single sample path of the system gives asymptotically unbiased and strongly consistent estimates of this sensitivity. Numerical extensions to G/G/1 queues, and applications to optimization problems, are also illustrated. (Edited author abstract) 31 refs.

Suri, Rajan (Univ of Wisconsin, Madison, WI, USA); Zazanis, Michael A. *Manage Sci* v 34 n 1 Jan 1988 p 39-64.

**085607 MULTIPRODUCT QUEUEING NETWORKS WITH DETERMINISTIC ROUTING: DECOMPOSITION APPROACH AND THE NOTION OF INTERFERENCE.** In this paper, we consider open queueing networks with multiple product classes, deterministic routings and general arrival and service distributions. We examine the decomposition method for such systems and show that it provides estimates of key parameters with an accuracy that is not acceptable in many practical settings. Recognizing this weakness, we enrich the approach by modeling a phenomenon previously ignored. We consider interference among products and describe its effect on the variance of the departure streams. The recognition of this effect significantly improves performance of this methodology. We provide extensive experimental results based on the data of a manufacturer of semiconductor devices. (Edited author abstract) 43 refs.

Bitran, Gabriel R. (MIT, Cambridge, MA, USA); Tirupati, Devanath. *Manage Sci* v 34 n 1 Jan 1988 p 75-100.

**085608 VERTEX-ALLOCATION THEOREM FOR RESOURCES IN QUEUEING NETWORKS.** A product-form queueing network with multiple open and closed chains is considered. Some of the closed chains, which have a single customer each, require allocation of resources in the network so as to maximize a weighted



throughput performance criterion. Chains with more than one customer can be decomposed into many chains of one customer each. It is proved that an optimal allocation of resources lies on a vertex (extreme points) of the set of feasible allocations. This considerably reduces the search space for an optimal allocation. Applications of this result in distributed computing are discussed. (Author abstract) 15 refs.

Tripathi, Satish K. (Univ of Maryland, College Park, MD, USA); Woodside, C. Murray. *J Assoc Comput Mach* v 35 n 1 Jan 1988 p 221-230.

**085609 PERFORMANCE EVALUATION OF A FINITE QUEUE WITH RANDOM ROUTING.** In previous papers, the steady-state behavior of a finite queue which accepts batch Poisson inputs and receives service operating in the synchronous mode was studied. Analysis was successfully completed via the application of the Residue theorem in complex variables. This paper extends the work to include the effect of routing. Two types of random routing are considered in this paper. Results obtained include state-transition probability, blocking probability, delay, and throughput. The validity of analysis has been verified by computer simulation. (Author abstract) 6 refs.

Chang, Chung-Ju (Directorate General of Telecommunication, Chungli, Taiwan); Chang, Jin-Fu. *Chung kuo Kung Ch'eng Hsueh K'an* v 10 n 6 Nov 1987 p 671-680.

**085610 FINITE-DIMENSIONAL DISTRIBUTIONS OF QUEUE LENGTHS IN PRIORITY SYSTEMS.** For systems  $M_1 | G_1 | 1 | \infty$  with relative and absolute priorities, finite-dimensional distributions are defined for the length vector of the queues of unequal-priority requests. (Author abstract) 2 refs.

Belokurov, D.V. *Moscow Univ Comput Math Cybern* n 4 1987 p 45-50.

**085611 OPTIMAL ARRANGEMENTS FOR SYSTEMS WITH AN OPTIMAL SERVICE DISCIPLINE.** A queueing system of  $n$  stations arranged on a plane is studied. The stations serve requests arriving from their respective influence zones. The first to be served is the shortest-remaining-processing-time request, but no service interruptions are allowed. The problem of optimization of the arrangement of service stations is solved with the criterion of mean stationary waiting time. (Author abstract) 3 refs.

Zakharova, T.V. *Moscow Univ Comput Math Cybern* n 4 1987 p 78-81.

**085612 DYNAMICS OF THE M/G/1 VACATION MODEL.** An M/G/1 processor schedule attends to auxiliary vacation tasks iteratively. We describe the influence of these tasks on the dynamic behavior of the system and obtain, for several cases of interest, the relaxation time of the vacation system required to validate steady-state approximation. Finally, we find the distribution of the duration of the primary busy period, the vacation busy period, and an associated cycle time. (Author abstract) 31 refs.

Keilson, J. (Univ of Rochester, Rochester, NY, USA); Servi, L.D. *Oper Res* v 35 n 4 Jul-Aug 1987 p 575-582.

**085613 STOCHASTIC MONOTONICITY OF THE QUEUE LENGTHS IN CLOSED QUEUEING NETWORKS.** We study a Gordon-Newell type of closed queueing network that frequently arises in modeling manufacturing and computer systems. We are concerned with the transient and equilibrium behavior of the joint and individual queue lengths in the network when the job population increases. We show that increasing the job population will stochastically increase the queue-length vector process, provided that all stations have nondecreasing service rates. Single and multivariate likelihood ratio orderings are also established for the joint queue lengths in equilibrium. Our results extend the applicability of previously known results in the literature. (Author abstract) 15 refs.

Shanthikumar, J. George (Univ of California, Berkeley, CA, USA); Yao, David D. *Oper Res* v 35 n 4 Jul-Aug 1987 p 583-588.

**085614 SIMPLE INEQUALITIES FOR THE D/G/1 QUEUE.** We present a new method for obtaining bounds for the stationary D/G/1 queue. The basic idea is to translate crude bounds on the probability that the system is empty at time  $t$  into sharp bounds for the expected waiting time. The crudest possible bounds on the probability that the system is empty at time  $t$  reproduce the Kingman upper bound and the Marshall lower bound, and show that the Marshall lower bound is tight for the D/G/1 queue and is attained if and only if the service times are integer (random) multiples of the interarrival time. (Edited author abstract) 23 refs.

Ott, Teunis J. (Bell Communications Research, Morristown, NJ, USA). *Oper Res* v 35 n 4 Jul-Aug 1987 p 589-597.

**085615 QUEUE LENGTH IN A  $M_2 | G_2 | 1 | \infty$  SYSTEM WITH A SINGLE SERVICE MODALITY WITHOUT INTERRUPTION.** A queueing system  $M_2 | G_2 | 1 | \infty$  with a special type of service discipline without interruptions is considered. Equations are given describing the state of the queue in the system. (Author abstract)

Akbulatov, N.A. *Moscow Univ Comput Math Cybern* n 3 1987 p 59-62.

**085616 FINITE-SOURCE QUEUEING MODEL FOR SOME MANUFACTURING PROCESSES.** The paper is concerned with a finite-source queueing model which can be applied in the field of manufacturing economics. Different types of highly reliable machines are supervised by a single robot which supplies them with raw materials in random order. The production time of machine  $i$  is supposed to be an arbitrarily distributed random variable having density function  $f_i(x)$ ,  $i = 1, \dots, n$ , while the service times are assumed to be identically and exponentially distributed random variables. This paper gives the main steady-state operational characteristics of the system, such as utilizations, average number of idle machines, and mean waiting times of the machines. A cost function is considered which measures the total loss of the system per unit time. (Edited author abstract) 15 refs.

Sztrik, J. *Probl Control Inf Theory* v 16 n 6 1987 p 449-457.

**085617 HEAVY TRAFFIC LIMIT OF A CLASS OF MARKOVIAN QUEUEING MODELS.** Reflected Brownian motion is obtained as the heavy traffic limit of the level component of a class of bivariate Markov chains incorporating those having a matrix-geometric stationary distribution. Approximations for both transient and ergodic behavior are obtained as a corollary and illustrated for the Markov-modulated queue. The result is stated and proven. Once this has been established, approximations for a number of relevant characteristics then come out as corollaries. (Edited author abstract) 14 refs.

Asmussen, Soren (Aalborg Univ, Aalborg, Den). *Oper Res Lett* v 6 n 6 Dec 1987 p 301-306.

**085618 INCLUSION OF STORAGE IN A QUEUEING SYSTEM.** Service operations involving an intermediate store are modelled using an extended definition of the system state which is a conventional definition of state supplemented with an indicator of the live capacity in the store. Additional to the parameters of mean service rate and mean arrival rate, a mean discharge rate of the store is introduced and the steady state probabilities are calculated in terms of these three quantities. Both finite source and infinite source cases are considered under the assumption of exponential distributions. The models permit production comparisons for systems with and for systems without storage devices. (Author abstract) 5 refs.

Carmichael, D.G. (Univ of Western Australia, Nedlands, Aust). *Z Oper Res Ser B* v 30 n 6 1986 p 127-134.

**085619 ON MULTISERVER QUEUES WITH**

**m-PHASE SYNCHRONOUS FLUCTUATION OF TRAFFIC INTENSITY.**  $M^{(m)}/M/K$  and  $M^{(m)}/M/\infty$  models with synchronous fluctuation of traffic intensity are considered. The phase process is assumed to make changes according to an irreducible m-phase Markov chain. In contrast to the model with asynchronous fluctuation of parameters, phase changes may occur in synchronization with an arrival or beginning of a customer's service. We study mainly the steady-state regime of our models, and observe that, in general, closed form solutions for the limiting probabilities are difficult to obtain but their numerical computation straightforward. We give a necessary and sufficient condition for the steady-state to be attained. For the model  $M^{(d)}$  considered which measures  $m/M/K$ , it is shown that, for the case where the traffic intensity of one phase is greater than one, the average queue length approaches infinity as the fluctuations among phases gets more sluggish. However, for the case where the traffic intensity for all phases is less than one, the queue length is moderate and not dependent as much on the rate of fluctuation among phases. Numerical examples are given and discussed. We point out that our models may be more tractable than the asynchronous ones, when we try to generalize them to the case of general inter-arrival, service, or sojourn time distribution. (Edited author abstract) 14 refs.

Sotelo, Walter (Shizuoka Univ, Hamamatsu, Jpn); Mukumoto, Kaiji; Fukuda, Akira. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 12 Dec 1987 p 1187-1194.

**085620 QUEUEING ANALYSIS METHODS FOR MIXED LOSS AND DELAY SYSTEMS: EXACT AND DIFFUSION APPROXIMATION RESULTS.** This paper presents queueing analysis methods for mixed loss and delay systems. The queueing models considered are an extension of previously analyzed models and are applicable to the Facsimile Intelligent Communication System (FICS). Assuming compound Poisson arrivals and a single server, an exact result for performance measures of the model is obtained by the supplementary variable technique. Assuming general batch arrivals and many servers, a diffusion process approximation with the elementary return boundary is developed. A new recursive scheme for the steady-state distribution of the number of customers in the system is derived. Numerical examples are provided and compared with exact and simulated results, which demonstrate the accuracy of the approximation. (Edited author abstract) 29 refs.

Takahashi, Yoshitaka (NTT, Musashino, Jpn). *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 12 Dec 1987 p 1195-1202.

**085621 OPTIMIZING NUMBER OF CALLING UNITS USING QUEUEING THEORY.** Many of the operations related to construction, including the selection and use of equipment, can be analyzed by operations research methods such as queueing theory, simulation, and linear programming. This article applies the theory of queues to a dual-cycle system to select the most economical number of calling units by means of a computer program. The computer program presented can assist contractors in selecting equipment and methods that will reduce cost of construction to a minimum.

Tavakoli, Amir. *Cost Eng (Morgantown WV)* v 30 n 3 Mar 1988 p 21-23.

**085622 ARRANGEMENT OF SERVERS IN AN ORDERED-ENTRY SYSTEM.** We consider a service system whose servers may work at different rates (systems with 'heterogeneous servers'). Jobs arriving at the system access the servers in accordance with an 'entry order' that relates to the arrangement of the servers. When all servers are occupied, arriving jobs are blocked and lost. This model has applications in the study of the conveyors and other circulation systems. We wish to compare various server arrangements in such systems. We represent the arrangement of servers by a permutation vector of their service rates, and develop a partial order on these vectors.



By moving in the direction pointed out by this partial order, one can reduce blocked traffic, thereby improving system performance. (Edited author abstract) 14 refs.

Yao, David D. (Harvard Univ, Cambridge, MA, USA). *Oper Res* v 35 n 5 Sep-Oct 1987 p 759-763.

**085623 STOPPED BIRTH-AND-DEATH PROCESSES.** Birth-and-death processes are analyzed that stop at an instant at which the process reaches a certain nonzero level. The integral probabilities that the process is in different states are obtained, as well as other characteristics of the process. An example of operation of a self-repair system is analyzed. (Author abstract) 2 refs.

Volkovskii, M.I.; Filin, A.V. *Autom Remote Control* v 48 n 9 pt 1 Sep 1987 p 1170-1174.

**085624 MAXIMUM ENTROPY ANALYSIS OF THE G/G/1 QUEUE AT EQUILIBRIUM.** The principle of maximum entropy is used to analyze a G/G/1 queue at equilibrium when the constraints involve only the first two moments of the interarrival-time and service-time distributions. Robust recursive relations for the queue-length distribution are determined, and a probability density function analog is characterized. Furthermore, connections with classical queueing theory and operational analysis are established, and an overall approximation, based on the concept of 'global' maximum entropy, is introduced. Numerical examples provide useful information on how critically system behavior is affected by the distributional form of the interarrival and service times, and favorable comparisons are made with diffusion and other approximations. (Edited author abstract) 38 refs.

Kouvatsos, Demetres D. (Univ of Bradford, Engl). *J Oper Res Soc* v 39 n 2 Feb 1988 p 183-200.

**085625 <G/M/r/FIFO> MACHINE-INTERFERENCE MODEL WITH STATE-DEPENDENT SPEEDS.** This article treats a version of the multiple machine-interference problem with  $r$  operatives under FIFO repair discipline. The running times of machine  $i$  are supposed to be identically and arbitrarily distributed random variables with a given density function. The repair times of all machines are assumed to be identically and exponentially distributed random variables with mean  $1/\mu$ . The paper provides the main steady-state operational characteristics of the system when the running and repair speeds are dependent on the number of machines in working order. (Edited author abstract) 24 refs.

Sztrik, J. (Univ of Debrecen, Hung). *J Oper Res Soc* v 39 n 2 Feb 1988 p 201-207.

**085626 APPLICATION OF LITTLE'S RESULT TO THE G/G/1 (LCFS/P) QUEUE.** This paper considers a quite general single-server queueing system, under a last-come-first-served queue discipline, with pre-emption and arbitrary restarting policy. Expressions are given for the queue-size limiting distribution when the system is considered at arrival (or departure) epochs and in continuous time, by using very simple arguments. The service system is such that customers arrive at a service station at certain epochs in accordance with a stationary point process of rate. There is a single server and waiting facility for infinitely many customers. The service times of the successive arriving customers form a stationary process. Hence, these are identically distributed but not necessarily independent random variables, with a mean by which is assumed to be finite. The arrival process and the service times are stochastically independent. (Edited author abstract) 9 refs.

Fakinos, D. (Univ of Thessaloniki, Greece). *J Oper Res Soc* v 39 n 2 Feb 1988 p 209-213.

**085627 DESIGNING OF OPTIMUM QUEUES.** Recently the concept of  $\alpha$ -power—has been introduced into the flow control of computer communications networks. We have clarified the conception from the point of view of electrical network designs. Originally the word  $\alpha$ -power—was derived from a category of electrical circuit theory. There are three criteria for electrical network design: maximum voltage (voltage oriented)

technique, maximum current (current oriented) technique, and the maximum power (power oriented) technique. The last technique is more useful for design of audio amplifiers, transmission lines, and antennas. With such apparatus, there are two elements of power, i.e. power loss due to inner impedance and working power due to the effective resistance of the connection to the external world. Customers of a queueing system are forced to wait. This waiting is an disadvantage, and thus a loss. We regard the queueing system as being equivalent to an electrical circuit and have applied electrical circuit design techniques to queueing system design. All the power of the system, that is, the supplied power, the loss power and the working power has been automatically derived from the correspondence between a queueing system and an electrical circuit. (Edited author abstract) 10 refs.

Yoshioka, Yosio (Iwate Univ, Morioka, Jpn). *Technol Rep Iwate Univ* v 21 1987 p 1-15.

**085628 ANALYSIS OF THE GROUP ARRIVAL QUEUE FOR A DATA FLOW MACHINE.** A data flow machine processes a program using an iterative algorithm which is designed to generate new packets from the resultant packets of functional units (FU's), to transmit the generated packets into the idle FU's, and to process the packets at the FU's. This paper suggests a queueing model with a group arrival for the algorithm. The queue length and the waiting time are solved. We discuss the comparison between our queueing system model and the M/G/1 queueing model. (Edited author abstract) 1 ref.

Yoshioka, Yoshio (Iwate Univ, Morioka, Jpn). *Technol Rep Iwate Univ* v 21 1987 p 16-23.

**085629 THREE SIMPLE ALGORITHMS FOR THE N/I/F PROBLEM.** Various techniques such as divide and conquer, greedy, and dynamic programming are used to solve the N/I/F problem that arises in connection with database access. The algorithms are presented and proven theoretically. They are also tested with an example. Complexity analysis is then performed. (Edited author abstract) 8 refs.

Sharma, Ravi S. (St. Francis Xavier Univ, NS, Can). *Perform Eval Rev* v 15 n 3-4 Feb 1988 p 29-32.

**085630 TWO-QUEUE SYSTEM WITH ALTERNATING SERVICE.** We analyze a queueing system with two types of customers, one server, exponentially distributed service time, and Poisson inputs, whose parameters (customer arrival and service rates) depend on the current queue length. Efficient recursive methods are proposed for calculating nonembedded stationary state probabilities, stationary probabilities at the arrival moments, and the moments of the distribution functions of the sojourn time in the system. The results may be applied to estimate the efficiency of some MIS operating in an interactive multi-user mode. (Author abstract) 14 refs.

Logunov, M.G.; Signaevskii, V.A. *Autom Remote Control* v 48 n 9 Sep 1987 p 1260-1268.

**085631 ASYMPTOTIC BEHAVIOR OF THE EXPANSION METHOD FOR OPEN FINITE QUEUEING NETWORKS.** In previous papers, we have reported on the use of the expansion method for estimating sojourn times in finite network topologies. In this paper, we focus on comparing the expansion method with P.C. Bell's consistency conditions where subject to unbalanced service rates at tandem queues, other decomposition approaches yield impossible throughput results. We compare numerical results of the expansion method with the other approaches in light of these conditions. (Author abstract) 28 refs.

Kerbache, Laoucine (Univ of Massachusetts, Amherst, MA, USA); Smith, J. MacGregor. *Comput Oper Res* v 15 n 2 1988 p 157-169.

**085632 APPROXIMATE ANALYSIS OF PRODUCT-FORM TYPE QUEUEING NETWORKS WITH BLOCKING AND DEADLOCK.** A numerical procedure for analyzing exactly closed exponential queueing networks with finite queues is presented first. Due to the

finiteness of these queues, blocking and deadlock may occur. Deadlocks are assumed to be detected and resolved instantaneously. The numerical procedure is then incorporated in an approximation algorithm for analyzing closed exponential queueing networks of the product-form type, in which some of the queues are finite. These finite queues are assumed to be linked together to form a single subnetwork. The approximation algorithm is based on a variant of Norton's theorem. Comparisons between the approximate results and exact numerical results were carried out and the relative error was observed to be small. (Author abstract) 20 refs.

Perros, Harry G. (North Carolina State Univ, Raleigh, NC, USA); Nilsson, A.A.; Liu, Y.C. *Perform Eval* v 8 n 1 Feb 1988 p 19-39.

**085633 ALLOCATION OF SPACE BETWEEN SERVICE AND WAITING AREAS IN A SERVICE SYSTEM.** Service systems are concerned with provision of some form of treatment or accommodation to customers or to something belonging to the customers. Typically, service systems are comprised of two physically distinct areas, one dedicated to the service itself, the other used for customers waiting for service. A limited amount of space is available for the two purposes. This paper addresses a related problem of concern to designers and managing operators of service systems, namely how to divide a total available area among service units and waiting spaces. Under Poisson arrivals and exponentially distributed service times we develop an algorithm for choosing the number of service units and the number of waiting spaces so as to minimize the expected total costs per unit time. (Author abstract) 5 refs.

Silver, Edward A. (Univ of Calgary, Calgary, Alberta, Can); Rahnama, Mina Rasty. *INFOR* v 26 n 1 Feb 1988 p 63-76.

**085634 TANDEM QUEUE WITH FINITE INTERMEDIATE WAITING ROOM AND BLOCKING IN HEAVY TRAFFIC.** A two-stage exponential network with an unlimited first-state queue and a finite waiting room in the second stage are investigated. When the waiting room is full, the first-stage server is blocked and ceases to offer service. A request served by the second-stage server may return to the first-stage queue with a positive probability or leave the network. A limiting distribution of the steady-state queue lengths in heavy traffic is obtained explicitly. The queues are shown to be asymptotically independent. The first-stage queue behaves as an M/G/1 queue in heavy traffic, and the second-stage queue as an M/M/1/m queue. (Author abstract) 5 refs.

Kogan, Ya.A.; Pukhalsky, A.A. *Probl Control Inf Theory* v 17 n 1 1988 p 3-13.

**085635 INFINITESIMAL PERTURBATION ANALYSIS OF A BIRTH AND DEATH PROCESS.** Using a birth and death process as an illustrative example, we introduce the notion of alternative representations of stochastic processes. We discuss its importance for infinitesimal perturbation analysis derivative estimation. Through a different choice of representation, we are led to an infinitesimal perturbation analysis (IPA) algorithm for a birth and death process better than one discussed by other authors. (Edited author abstract) 9 refs.

Glasserman, Paul (Harvard Univ, Cambridge, MA, USA). *Oper Res Lett* v 7 n 1 Feb 1988 p 43-49.

**085636 ON THE RELATIONSHIP BETWEEN WORK LOAD AND WAITING TIME IN SINGLE SERVER QUEUES WITH BATCH INPUTS.** The relationship between work load and waiting time in single server queues with batch input is discussed under a work-conserving service discipline. Based on a result of Brumelle, the relationship is newly presented especially



under the preemptive-resume discipline. This relationship is applied to analyze batch Poisson input models. (Author abstract) 19 refs.

Takahashi, Yoshitaka (NTT Lab, Musashino, Jpn). *Oper Res Lett* v 7 n 1 Feb 1988 p 51-56.

**085637 PERSPECTIVES ON QUEUES: SOCIAL JUSTICE AND THE PSYCHOLOGY OF QUEUEING.** Queueing environment and feedback regarding the likely magnitude of the delay can also influence customer attitudes and ultimately, in many instances, a firm's market share. Even if we focus on the wait itself, the 'outcome' of the queueing experience may vary nonlinearly with the delay, thus reducing the importance of average time in queue, the traditional measure of queueing performance. This speculative paper uses personal experiences, published and unpublished cases, and occasionally 'the literature' to begin to organize our thoughts on the important attributes of queueing. (Edited author abstract) 46 refs.

Larson, Richard C. (MIT, Cambridge, MA, USA). *Oper Res* v 35 n 6 Nov-Dec 1987 p 895-905.

**085638 PERSPECTIVES ON QUEUES: COMBINING QUEUES IS NOT ALWAYS BENEFICIAL.** There are significant reasons for believing that combining queues may at times not be a good thing to do. These reasons include customer reaction, elimination of jockeying, increased service times and costs for combined queues, and the absence of published before-and-after studies. It is hoped that when operations researchers think about and analyze service systems, they will pay attention to the concerns raised. In addition, it is hoped that some of these concerns will inspire new research on queueing questions and will encourage publication of careful reports of experience in combining queues in counter service systems. 21 refs.

Rothkopf, Michael H. (Univ of California, Berkeley, CA, USA); Rech, Paul. *Oper Res* v 35 n 6 Nov-Dec 1987 p 906-909.

**085639 MEAN VALUE ANALYSIS APPROXIMATION FOR MULTIPLE SERVER QUEUEING NETWORKS.** An approximation of mean value analysis is presented for queueing networks containing multiple server stations. The approximation is based on the estimation of the conditional marginal probabilities used by the mean residence time formula in mean value analysis. A comparison against classical mean value analysis allows us to determine the accuracy of our algorithm. In all investigated network models, the approximate results vary from the exact results by less than four percent on the average. This approximation method has the advantages of classical mean value analysis; specifically, it is easy to implement and has a short run time. (Edited author abstract) 21 refs.

Akyildiz, Ian F. (Georgia Inst of Technology, Atlanta, GA, USA); Bolch, Gunter. *Perform Eval* v 8 n 2 Apr 1988 p 77-91.

**085640 ANALYSIS OF SYMMETRIC POLLING SYSTEMS WITH TWO PRIORITY CLASSES.** A cyclic multiqueue system consists of several stations in which messages are enqueued for transmission, and which are served sequentially in cyclic order by a single server. The arrivals at each queue are independent Poisson processes, and the transmission times are generally distributed. There is a nonzero switchover time from one station to the next, which is also generally distributed. Messages can be at either of two priority levels: priority 1 (low) or priority 2 (high), and polling occurs either at low priority, in which case both priority 1 and priority 2 messages can be transmitted, or at high priority, in which case only priority 2 messages are transmitted. The service disciplines considered are the exhaustive service discipline and the gated service discipline. In both cases the performance, as measured by the expected delay for high- and for low-priority messages, is evaluated. Part of the analysis is approximate. (Edited author abstract) 20 refs.

Gianini, Jacqueline (Univ of Ottawa, Ottawa, Ont, Can);

Manfield, David R. *Perform Eval* v 8 n 2 Apr 1988 p 93-115.

**085641 SIMPLE BOUNDS FOR QUEUEING SYSTEMS WITH BREAKDOWNS.** Computationally attractive and intuitively obvious simple bounds are proposed for finite service systems which are subject to random breakdowns. The services are assumed to be exponential. The up and down periods are allowed to be generally distributed. The bounds are based on product-form modifications and depend only on means. A formal proof is presented. This proof is of interest in itself. Numerical support indicates a potential usefulness for quick engineering and performance evaluation purposes. (Author abstract) 28 refs.

Van Dijk, Nico M. (Technical Univ of Twente, Enschede, Neth). *Perform Eval* v 8 n 2 Apr 1988 p 117-128.

**085642 TWO-STAGE SERVICE SYSTEM.** This paper deals with a two-stage tandem queueing system with no waiting room between stages, where we have one server at each stage. The service system has been designed explicitly with Poisson arrivals and exponential service processes. A general formula for the waiting time involving correlated or uncorrelated service in both stages has been found when unlimited waiting space is available before the first stage. (Author abstract) 7 refs.

Assimakopoulos, Nikitas (Univ of London, London, Engl). *Ind Manag* v 37 pt 2 1987 p 171-193.

**085643 COMPUTATIONAL ANALYSIS OF SINGLE-SERVER BULK-ARRIVAL QUEUES  $M^X/G/1$ .** This paper studies numerically the bulk-arrival queueing model  $M^X/G/1$ . For a specified service-time distribution, an algorithm for the limiting distribution of the number in the system at random epoch is developed. This is also used to find the limiting distribution of the number in the system at pre-arrival and post-departure epochs. The mean and standard deviation of these distributions are also computed. Four cases of the service-time distribution are discussed: hyperexponential, deterministic, uniform and Erland. (Author abstract) 6 refs.

Briere, G. (Royal Military Coll of Canada, Kingston, Ont, Que); Chaudhry, M.L. *Comput Oper Res* v 15 n 3 1988 p 283-292.

**085644 NUMERICAL SOLUTION FOR THE DEPARTURE PROCESS FROM THE  $GI/G/1$  QUEUE.** The performance measures of a queue is depend on its input process. Hence, if the input process of a queue in the output process of another, this output process becomes important. For similar reasons, output processes are important in queueing networks. The purpose of this note is to present a numerical solution for the interdeparture-time distribution of the  $GI/G/1$  queueing system. We present efficient numerical procedures to determine the idle-time distribution of a  $GI/G/1$  queue. (Edited author abstract) 10 refs.

Jain, Joti L. (Univ of Delhi, Delhi, India); Grassmann, Winfried K. *Comput Oper Res* v 15 n 3 1988 p 293-296.

**085645 SIMPLE APPROXIMATIONS FOR THE  $GI/G/C$  QUEUE - I: THE STEADY-STATE PROBABILITIES.** Viewing the  $GI/G/c$  queue as a service system alternating between two basic states - that of a loaded (non-empty)  $GI/G/1$  queue and that of a  $GI/G/\infty$  queue (dependent, respectively, on whether all servers in the  $GI/G/c$  queue are busy or otherwise) - approximations for the components of the mixture distribution of the steady-state probabilities are derived. The  $M/G/c$  queue is separately treated. Two imposed prerequisites, that only minimal prior information about the queue will be required and that no numeric method be needed other than a root-finding algorithm, are strictly adhered to. The accuracy attained is generally satisfactory, while remarkable algebraic simplicity is preserved. (Author abstract) 20 refs.

Shore, Haim (Tel Aviv Univ, Isr). *J Oper Res Soc* v 39 n 3 Mar 1988 p 279-284.

**085646 EXTREME VALUES OF QUEUE LENGTHS IN  $M/G/1$  AND  $GI/M/1$  SYSTEMS.** We study the limiting behavior of maximum queue lengths in the  $M/G/1$  and  $GI/M/1$  service systems. When the systems are positive recurrent, the distributions of their maximum queue lengths, under standard linear normalizations, either do not converge or they converge to degenerate limits. Consequently, one cannot use classical extreme value theory to characterize their limiting behavior. We show, however, that by varying the system parameters in a certain way as the time interval grows, these maxima do indeed have three possible limit distributions. Two of them are classical extreme value distributions and the third one is a new distribution. The latter distribution is the best one for practical approximations. (Author abstract) 9 refs.

Serfozo, Richard F. (Univ of North Carolina at Chapel Hill, USA). *Math Oper Res* v 13 n 2 May 1988 p 349-357.

**085647 APPROXIMATION METHOD FOR TANDEM QUEUES WITH BLOCKING.** Our approach relies on the use of marginal probability distributions ('state equivalence') coupled with an approximate evaluation of the conditional probabilities introduced through the equivalence. The method iterates over consecutive pairs of servers using the solution of a two-queue system as a building block. It produces performance measures for individual servers as well as an approximation to joint queue-length probability distributions for pairs of neighboring stations. Experience indicates that the number of iterations required for the method grows moderately with the number of nodes in the network. We give examples to demonstrate the accuracy and the convergence properties of the proposed approximation. (Edited author abstract) 20 refs.

Brandwajn, Alexandre (Univ of California, Santa Cruz, CA, USA); Jow, Yung-Li Lily. *Oper Res* v 36 n 1 Jan-Feb 1988 p 73-83.

**085648 SAMPLE PERFORMANCE FUNCTION OF CLOSED JACKSON QUEUEING NETWORKS.** We study a sample performance function of a closed Jackson queueing network; specifically, the time required by a server to serve a finite number of customers. We show that this sample performance function is a continuous, piecewise linear function of the mean service time. We prove that the average of derivatives of this sample performance function with a given initial state does converge, with probability one, to the derivative of the conditional mean value, given the same initial state. The result shows that the estimate of the derivative of a server's mean throughput in a finite time period with respect to the mean service time obtained by infinitesimal perturbation analysis is strongly consistent. (Edited author abstract) 14 refs.

Cao, Xi-Ren (Harvard Univ, Cambridge, MA, USA). *Oper Res* v 36 n 1 Jan-Feb 1988 p 128-136.

**085649 SIMPLE APPROXIMATIONS FOR THE  $GI/G/C$  QUEUE - II: THE MOMENTS, THE INVERSE DISTRIBUTION FUNCTION AND THE LOSS FUNCTION OF THE NUMBER IN THE SYSTEM AND OF THE QUEUE DELAY.** Based on the results obtained in part I of this paper, approximations for the first four moments of the number in the system are developed and thence used to approximate the inverse distribution function (IDF) and the loss functions (LF), employing Shore's general approximations. Existing approximations for the first two moments of queueing time in a  $GI/G/1$  queue serve to approximate the IDF and the LF of queueing time in the corresponding  $GI/G/c$  queue. The accuracy attained is generally satisfactory, while a remarkable algebraic simplicity is preserved. A numerical example demonstrates the applicability of some of the new approximations to solve optimization problems. (Author abstract) 15 refs.

Shore, Haim (Tel Aviv Univ, Isr). *J Oper Res Soc* v 39 n 4 Apr 1988 p 381-391.



**085650 ANALYSIS AND DESIGN OF AN INTEGRATED MATERIAL HANDLING SYSTEM.** An open queueing network model is developed to analyze the effects of the loading, the material handling, the storage, and the processing operations on the asymptotic performance of the system. A methodology for controlling the congestion along the material handling system is suggested. Numerical results are also provided and the approximations results are compared against those from a simulation study. (Edited author abstract) 16 refs.

Pourbabai, Behnam (New York Univ, New York, NY, USA). *Int J Prod Res* v 26 n 7 Jul 1988 p 1225-1236.

**085651 SOME THOUGHTS ON AN  $O(N^3)$ -ALGORITHM FOR THE OPTIMAL CONTROL OF ARRIVALS IN A GI/M/1/N QUEUE.** A formerly presented  $O(N^3)$ -algorithm for the optimal control of arrivals in a GI/M/1/N queue is extended for solving the problems with the average reward criterion and with a general action space. Details of the model are described where specific problems are formulated. This section considers a version of the control problem where the average reward per transition in the long run is to be maximized by choosing an appropriate customer acceptance/rejection rule. 3 refs.

Mizuno, Norihiro (New York Univ, New York, NY, USA). *Oper Res Lett* v 7 n 2 Apr 1988 p 81-84.

**085652 BLOCK CUTPOINT DECOMPOSITION FOR MARKOVIAN QUEUEING SYSTEMS.** Steady-state probabilities of Markov Processes are computed by enumerating subgraphs of the transition diagram of the process. The presence of cutpoints in the transition diagram allows for decomposition of the problem into smaller components. Examples from queueing theory are presented. Matrix representations for these structures are also discussed. (Author abstract) 12 refs.

Fox, Dale R. (Univ of Tennessee, Knoxville, TN, USA). *Appl Stochastic Models Data Anal* v 4 n 2 Jun 1988 p 101-114.

**085653 QUEUEING SYSTEM WITH PARALLEL SERVICE OF GROUP CALLS.** A queueing system of group calls is considered which have a Poisson input flow and a parallel discipline of service of individual groups. The author discusses stationary conditions, the probability of absence of queue in a buffer, and the utilization factor of the server unit. 2 refs.

Ivanov, N.N. *Autom Remote Control* v 48 n 10 pt 1 Oct 1987 p 1330-1334.

**085654 ESTIMATING THE SERVICE CHARACTERISTICS OF A SINGLE-SERVER DISCRETE SYSTEM ON THE BASIS OF EMPIRICAL DATA.** A method of estimation, based on empirical data, is proposed for the characteristics of a discrete queueing system, and their properties are studied. An equivalent queueing system can be designed whose characteristics are related to the characteristics of the original system in accordance with stochastic ranking. Examples are also presented. (Author abstract) 15 refs.

Ivanovskii, V.B. *Autom Remote Control* v 48 n 10 pt 1 Oct 1987 p 1335-1341.

**085655 MINISUM LOCATION OF A TRAVELING SALESMAN.** We deal with the problem of locating on a network a service unit that must visit all the calls that are registered in a service list. Each node can generate a call with a given probability and the service list contains the first  $b$  calls that have arrived  $b \leq n$  ( $n$  is the number of nodes). In our problem the optimal location minimizes the expected length of a traveling salesman tour (TST) traveled. For the problem which requires  $2^n$  calculations of probabilities, we develop an  $O(n)$  algorithm when  $b = n$ , for a tree, and study the sensitivity of this optimal solution when  $b < n$ . (Edited author abstract) 10 refs.

Berman, O. (Univ of Calgary, Calgary, Alberta, Can); Simchi, Levi D. *Networks* v 16 n 3 Fall 1986 p 239-254.

**085656 SOLVING STOCHASTIC PROGRAMS WITH NETWORK RECOURSE.** We provide computational procedures for solving stochastic programs with network recourse. Attention is paid to the feasibility problem and we show how to solve the recourse or second stage problem. This problem is how to solve a large number of networks where the only differences are the amounts supplied and demanded at the nodes. For this purpose we have developed the Schur complement for networks. Computational results are given. We show how preprocessing based upon facet generation can simplify the rest of the procedures. (Edited author abstract) 30 refs.

Wallace, Stein W. (Chr. Michelsen Inst, Bergen, Norw). *Networks* v 16 n 3 Fall 1986 p 295-317.

**085657 APPROXIMATE PRODUCT FORM FOR A CLASS OF DEGRADABLE QUEUEING NETWORKS.** An approximate product form for a class of degradable queueing networks (DQNs) is presented. DQNs emerge from a synthesis of separable queueing networks (BCMP networks) and the classical machine-repair-man mode. Under the assumption that failure and repair events which change the level of performance are less frequent compared with the service completions of tasks moving through the network, the presented product form approximates the exact probability distribution very closely. Because DQNs are near-completely decomposable, the error of approximation depends on the degree of coupling between the different modes of degraded performance. In accordance with the theory of near-complete decomposability, a numerical example shows that the approximation error is proportional to the degree of coupling. (Edited author abstract) 22 refs.

Mueller-Clostermann, Bruno (Univ of Dortmund, Dortmund, West Ger). *Perform Eval* v 8 n 3 Jun 1988 p 165-172.

**085658 AMVA PRIORITY APPROXIMATION.** Most computer systems contain one or more system resources whose usage is controlled on the basis of workload priorities. Unfortunately, the exact analysis of queueing network models incorporating priority scheduling disciplines is usually infeasible. The MVA Priority Approximation has been proposed as a comparatively inexpensive, and yet reasonably accurate, approximation technique for queueing networks with priority scheduled service centers. Even this algorithm, however, is too expensive to apply to large networks with many classes of customers. We show how the MVA Priority Approximation can be modified so that it utilizes approximate rather than exact Mean Value Analysis (MVA), without significant loss of accuracy. Numerical experiments are performed to further assess the accuracy of the modified algorithm, termed the AMVA Priority Approximation. These experiments utilize the parameter space mapping technique for studying 'local' queueing network approximations. (Edited author abstract) 20 refs.

Eager, Derek L. (Univ of Saskatchewan, Saskatoon, Sask, Can); Lipscomb, John N. *Perform Eval* v 8 n 3 Jun 1988 p 173-193.

**085659 NEW MVA-BASED APPROXIMATION FOR CLOSED QUEUEING NETWORKS WITH A PREEMPTIVE PRIORITY SERVER.** We propose a new MVA-based noniterative algorithm for solving closed queueing network models of computer systems with a preemptive priority server. The algorithm attempts to capture synchronization error, delay error and the effect of preemption on the interarrival time variability of lower priority jobs at FCFS servers, but also at other servers in the system. Numerical results indicate that the algorithm predicts the performance measures of low priority jobs more accurately than previously developed MVA-based algorithms. (Author abstract) 25 refs.

Bondi, Andre B. (Univ of California, Santa Barbara, CA, USA); Chuang, Yie-Min. *Perform Eval* v 8 n 3 Jun 1988 p 195-221.

**085660 ON SERVER ALLOCATION IN MULTIPLE CENT MANUFACTURING SYSTEMS.** The

problem is formulated as a nonlinear integer program of allocating servers in a closed queueing network to maximize throughput. We show that the throughput of the closed queueing network has a monotonicity property, such that any optimal allocation must give more servers to stations with a higher workload. The number of allocations that satisfy this property is much smaller than the total number of feasible allocations. This property and a bounding technique for the throughput of the closed queueing network are combined to develop a search algorithm to obtain an optimal allocation of servers. A greedy heuristic is also developed, and its optimality proven in the special case of a two-center system. (Edited author abstract) 19 refs.

Shanthikumar, George J. (Univ of California, Berkeley, CA, USA); Yao, David D. *Oper Res* v 36 n 2 Mar-Apr 1988 p 333-342.

**085661 BUFFER SPACE ALLOCATION IN AUTOMATED ASSEMBLY LINES.** Automated assembly lines are modeled as finite open queueing networks and a heuristic for buffer space allocation within these lines is presented. The Expansion Method, an analytical technique for modeling finite open queueing networks and Powell's unconstrained optimization procedure are integrated in a design methodology, which evaluates alternative line topologies, system throughputs, and their optimal buffer sizes. The resulting design methodology is demonstrated for series, merging and splitting topologies of automated assembly lines with balanced and unbalanced service rates. (Author abstract) 46 refs.

Smith, J. MacGregor (Univ of Massachusetts, Amherst, MA, USA); Daskalaki, Sophia. *Oper Res* v 36 n 2 Mar-Apr 1988 p 343-358.

**085662 SYSTEMS WITH HIDDEN SERVICING UNDER CONDITIONS OF A HEAVY LOAD. I.** A study is made of a queueing system consisting of a single device that receives a flow of orders, each of which leaves the system at the end of some random interval that is independent of the servicing process and that began at the instant of arrival of the order. This interval is called the lifetime of the order. The servicing device moves along a queue, allotting for each order a random time - a servicing quantum. The situation of a heavy load is investigated; that is, it is assumed that the lifetime is much greater than the duration of a service quantum and the average interval between arrivals in the system. Three types of motion of the device are examined: forward motion, from the beginning to the end of the queue, inverse motion, from the end to the beginning, and shuttle motion, from the beginning to the end of the queue and back. Limiting distributions are obtained for the number of times orders appearing in the system are serviced in a stationary regime. (Author abstract) 2 refs.

Afanasyev, B.A. *Sov J Comput Syst Sci* v 26 n 1 Jan-Feb 1988 p 78-86.

**085663 PROCEDURE FOR ESTIMATING THE PROBABILITIES OF PROCESSING TIME-SENSITIVE REQUESTS IN A QUEUEING SYSTEM WITH COST-DYNAMIC RESOURCE CONTROL.** An examination is made of the processing of different kinds of time-sensitive requests in a queueing system in the case of cost-dynamic control, which takes into account the age, value, duration of service, and the constraints on the processing delay of orders. A procedure for calculation of the stationary probabilities of processing is included. (Author abstract) 1 Ref.

Bukchin, A.M. (Acad of Sciences, USSR). *Sov J Autom Inf Sci* v 20 n 4 Jul-Aug 1987 p 91-93.

**085664 OPTIMAL PREDICTION OF TIMES AND QUEUE LENGTHS IN THE M/G/1 QUEUE.** This paper concerns the optimal mean-square prediction of future queue lengths, system times and waiting times based on measured queue-length data in the stationary M/G/1 queue. In particular, conditional expectation



predictors are derived for the number in the queue, time in the queue, and the waiting time, with a previous number in the queue as the basis for the prediction. The relationships between the predictors are derived, and the basic properties are illustrated with examples. (Edited author abstract). 9 Refs.

Pagurek, Bernard (Concordia Univ, Montreal, Que, Can); Stanford, David A.; Woodside, C. Murray. *J Oper Res Soc* v 39 n 6 Jun 1988 p 585-593.

**085665 TRANSIENT SOLUTIONS FOR SOME EXHAUSTIVE M/G/1 QUEUES WITH GENERALIZED INDEPENDENT VACATIONS.** Some exhaustive single server queueing systems in which the servers can be unavailable for occasional intervals of time, independently with the arrival and service processes, can be treated as exceptional queueing systems in which the customers who initiate the busy periods have to wait for a random time. This paper illustrates the idea and shows that transient and stationary results already available for the latter can be easily adapted for the former. (Author abstract). 11 Refs.

Minh, Do Le (California State Univ, Fullerton, CA, USA). *Eur J Oper Res* v 36 n 2 Aug 1988 p 197-201.

**085666 OPTIMAL DESIGN OF MULTISERVER QUEUEING SYSTEMS WITH DIFFERENT WAITING COSTS FOR TIME IN QUEUE AND TIME IN SERVICE.** The optimal number of servers and service rate are characterized for multiserver systems in which waiting times in service and in queue have different costs. It is shown that the optimal choice of the service rate and the number of servers depends on the ratio of the in-service waiting cost coefficient to the in-queue waiting cost coefficient. For M/M/c systems, a single server is optimal if the cost-coefficient ratio exceeds a threshold value of one-half. For GI/M/c and M/G/c systems, the threshold ratio increases as the variation of the interarrival or service time increases. (Author abstract). 12 Refs.

Jo, Kyung Y. (Systems & Network Analysis Directorate, Reston, VA, USA). *IEEE Trans* v 20 n 2 Jun 1988 p 235-239.

**085667 ASYMPTOTIC ANALYSIS OF G/G/K QUEUEING-LOSS SYSTEM WITH RETRIALS AND HETEROGENEOUS SERVERS.** The asymptotic performance of a G/G/K queueing-loss system with a stationary-counting arrival process, generally-distributed service times, K parallel heterogeneous servers, no waiting room, and retrials, is analyzed by a recursive technique. In queueing-loss systems with retrials, the units which find all processors busy are not lost: these units try again to be processed by merging with the incoming arrival units at the system. Furthermore, numerical results are provided and the approximation outcomes are compared against those from a simulation study. (Author abstract). 8 Refs.

Pourbabai, Behnam (New York Univ, New York, NY, USA). *Int J Syst Sci* v 19 n 6 Jun 1988 p 1047-1052.

**085668 QUEUEING ANALYSIS OF POLLING MODELS.** A polling model is a system of multiple queues accessed by a single server in cyclic order. Polling models provide performance evaluation criteria for a variety of demand-based, multiple-access schemes in computer and communication systems. This paper presents an overview of the state of the art of polling model analysis, as well as an extensive list of references. Single-buffer systems and infinite-buffer systems with exhaustive, gated, and limited service disciplines are treated. Systems with a noncyclic order of service and systems with priority are discussed. Applications to computer networks are illustrated, and future research topics are suggested. (Edited author abstract). 224 Refs.

Takagi, Hideaki (Tokyo Research Lab, Tokyo, Jpn). *Comput Surv* v 20 n 1 Mar 1988 p 5-28.

**085669 TRANSIENT BEHAVIOR OF THE M/E<sub>K</sub>/2 QUEUE AND STEADY-STATE SIMULATION.** The probabilistic structure for the transient M/E<sub>K</sub>/2 queue is derived in discrete time, where K<sub>k</sub> denotes a

k-Erlang distribution. This queue has a two-dimensional state-space. Expressions for the expected delay in queue are formulated in terms of transition probabilities. Results are numerically evaluated for a few cases. The convergence behavior is similar to that seen in previous work on queues with one-dimensional state spaces. The implications for initialization of steady-state simulations are discussed. (Author abstract). 16 Refs.

Murray, Joseph R. (Univ of Michigan, Ann Arbor, MI, USA); Kelton, W. David. *Comput Oper Res* v 15 n 4 1988 p 357-367.

**085670 COMPUTERIZED CLOSE QUEUEING NETWORK MODELS OF FLEXIBLE MANUFACTURING SYSTEMS: A COMPARATIVE EVALUATION.** Advanced closed queueing network models are available for stochastic performance evaluation of Flexible Manufacturing Systems (FMS). These models are useful during the planning and design phases of FMS, since they can be applied to study gross tradeoffs between principal design parameters. This paper analyzes several computerized models for evaluating complex FMS facilities with respect to the desired allocation of the following key resources: manufacturing centers, transporters, pallets and tools. It focuses on such issues as the structure of the mathematical system models, the variety of performance measures (model outputs), model inputs, accuracy of results and computational effort. Original alternatives to overcome part of the common limitations of the models are developed and tested empirically. (Edited author abstract). 32 Refs.

Seidmann, Abraham (Univ of Rochester, Rochester, NY, USA); Schweitzer, Paul J.; Shalev-Oren, Sarit. *Large Scale Syst* v 12 n 2 1987 p 91-107.

**085671 ON EXTENDING THE SCOPE OF BOUNDING TECHNIQUES FOR CLOSE QUEUEING NETWORKS.** Queueing network models are widely used to analyze the performance of automated manufacturing facilities and computer systems. These models aid the designers/operators of the system in evaluating the impact of various alternate configurations on the performance of these systems. In many instances, however, the exact analysis of these networks for performance measures may not be necessary; some bounds on the performance measures may be adequate. This has motivated research on obtaining bounds on performance measures, and a number of techniques have recently been developed. These techniques have generally obtained bounds on the throughput for networks with a single class of customers, where each node is either a single server fixed-rate type or is a delay (infinite server) type. We extend the scope of these techniques to networks where non-delay nodes are allowed to have some service rates which depend on the number of jobs present at the nodes. Efficient means are developed for calculating bounds on the mean queue lengths forming at the nodes in these networks. (Edited author abstract). 21 Refs.

Srinivasan, M.M. (Univ of Michigan, Ann Arbor, MI, USA). *Large Scale Syst* v 12 n 2 1987 p 125-142.

**085672 SINGLE SERVER QUEUEING-LOCATION MODELS WITH REJECTION.** Calls from a node can either all be accepted or all be rejected by the service system. Two models are considered: a call can be rejected independently of the state of the system when the call arrives; an arriving call can be rejected only if it finds the server busy. The queueing systems are analyzed for both models. A greedy heuristic is developed which, parametrically in the arrival rate of calls, determines the location of the server and the rejection strategies at nodes. Extreme case analysis with respect to the arrival rate is investigated. Our major observation is that the rejection strategies for calls are dependent on the arrival rate and the choice of model. (Edited author abstract). 12 Refs.

Batta, Rajan (State Univ of New York at Buffalo, Buffalo, NY, USA). *Transp Sci* v 22 n 3 Aug 1988 p 209-216.

**085673 INTERPOLATION APPROXIMATION FOR QUEUEING SYSTEMS WITH POISSON IN-**

PUT. Heavy traffic limit theorems yield expressions for normalized quantities of interest. In light traffic, we can obtain, in addition to limits, more sensitive information by calculating what are effectively derivatives (of the quantity of interest) with respect to the arrival rate. We can then combine the light and heavy traffic results to yield a polynomial (in the arrival rate) as an approximation to the normalized quantity of interest. We present the details of the above approximation, focusing, via several examples, on applications of the method. We compare the results of the approximation, for the examples considered, with exact and simulation results. We compare our results to some related approximations. For the examples considered, the approximation works extremely well. (Edited author abstract). 10 Refs.

Reiman, Martin I. (AT&T, Murray Hill, NJ, USA); Simon, Burton. *Oper Res* v 36 n 3 May-Jun 1988 p 454-469.

**085674 SIMPLE BOUNDS FOR FINITE SINGLE-SERVER EXPONENTIAL TANDEM QUEUES.** A new bounding methodology for nonproduct form systems is applied to the finite single-server exponential tandem queues. The methodology is based on modifying the original system into product form systems that provide bounds for some performance measure of interest. The product form modifications given for this finite tandem queue propose a computationally attractive and intuitively obvious lower and upper bound for the call congestion and throughput. Numerical results indicate that the bounds are reasonable indicators of the order of magnitude. This can be useful for quick engineering purposes as will be illustrated by an optimal design example. A formal proof of the bounds is given. (Edited author abstract). 32 Refs.

Van Dijk, Nico M. (Vrije Univ, Amsterdam, Neth); Lamond, Bernard F. *Oper Res* v 36 n 3 May-Jun 1988 p 470-477.

**085675 FURTHER REMARKS ON QUEUEING NETWORK THEORY.** Most attributions date the start of queueing network theory to a 1957 paper of J.R. Jackson entitled, 'Networks of waiting lines'. This paper has formed the basis of a considerable amount of work that has occurred since. This is reviewed so as to introduce the important idea of a Jackson network. The paper also considers three problem areas that seem to be those considered most often in current queueing network theory. The areas are: traffic processes; sojourn times; and queue lengths.

Kiessler, Peter C. (Virginia Commonwealth Univ, Richmond, VA, USA); Disney, Ralph L. *Eur J Oper Res* v 36 n 3 Sep 1988 p 285-296.

**085676 REALIZATION PROBABILITY IN MULTI-CLASS CLOSED QUEUEING NETWORKS.** Perturbation analysis results of single-class queueing networks are extended to the multi-class case. The realization probability is defined and used to calculate the limiting value of the sample derivative of the system throughput with respect to mean service times in a multi-class closed queueing network with exponentially distributed service times. A necessary condition for this value to be an asymptotically unbiased estimate of the derivative of the steady-state throughput is given. (Author abstract). 9 Refs.

Cao, Xi-Ren (Digital Equipment Corp, Marlboro, MA, USA). *Eur J Oper Res* v 36 n 3 Sep 1988 p 393-401.

**085677 ON THE OVERFLOW PROCESSES FROM THE PH<sub>1</sub> + PH<sub>2</sub>/M/S/K QUEUE WITH TWO INDEPENDENT PH-RENEWAL INPUTS.** This paper presents an analysis of overflow processes from a PH<sub>1</sub> + PH<sub>2</sub>/M/S/K queue having two independent phase type renewal input streams. Both the superposed overflow process and individual overflow processes for the PH<sub>1</sub>- and PH<sub>2</sub>-streams are analyzed using first passage time distributions for the number of customers in the system. Each



overflow process is characterized as a Markov renewal process. The  $n$ th moment of the number of customers in an infinite server group to which these overflows have been offered is derived using a theory for the  $MR/M/\infty$  queue with a Markov renewal input. The numerical examples for means and variance-to-mean ratios (peakednesses) of the individual overflow streams are given for an  $H_2+H_2/M/S/S$  queue with interrupted Poisson inputs, which is a vital model for telephone network planning. Overflow traffic characteristics are discussed by using these examples. (Edited author abstract). 21 Refs.

Machihara, Fumiaki (NTT, Musashino, Jpn). *Perform Eval* v 8 n 4 Aug 1988 p 243-253.

**085678 ACCURACY, SPEED, AND CONVERGENCE OF APPROXIMATE MEAN VALUE ANALYSIS.** Approximate Mean Value Analysis (AMVA) is an approach to analyzing queueing network performance models because of the combination of efficiency, accuracy, and versatility that it affords. We present a new modification, termed the Aggregate Queue Length (AQL) algorithm, of the basic AMVA scheme for load-independent separable networks. AQL is more efficient than, and yet has apparently similar accuracy as, the most accurate of the AMVA algorithms previously known. We examine the question of convergence of AMVA techniques, and demonstrate that there are networks for which convergence occurs only extremely slowly. We propose a new stopping criterion that detects these cases, and an extrapolation technique for them that allows accurate solutions to be obtained quickly. (Edited author abstract). 22 Refs.

Zahorjan, John (Univ of Washington, Seattle, WA, USA); Eager, Derek L.; Sweilam, Hisham M. *Perform Eval* v 8 n 4 Aug 1988 p 255-270.

**085679 M/G/ $\infty$  WITH BATCH ARRIVALS.** Let  $p_{\infty}(n)$  the distribution of the number  $N(\infty)$  in the system at ergodicity for systems with an infinite number of servers, batch arrivals with general batch size distribution and general holding times. This distribution is of importance to a variety of studies in congestion theory and storage systems. To obtain this distribution, a more general problem is addressed. In this problem, each epoch of a Poisson process gives rise to an independent stochastic function on the lattice of integers, which may be viewed as stochastic impulse response. A continuum analogue to the lattice process is also provided. (Author abstract). 6 refs.

Keilson, J. (GTE, Cambridge, MA, USA); Seidmann, A. *Oper Res Lett* v 7 n 5 Oct 1988 p 219-222.

**085680 DISTRIBUTIONAL FORM OF LITTLE'S LAW.** For many system contexts for which Little's Law is valid a distributional form of the law is also valid. This paper establishes the prevalence of such system contexts. It also makes clear the value of the distributional form. (Edited author abstract). 20 refs.

Keilson, J. (GTE, Cambridge, MA, USA); Servi, L.D. *Oper Res Lett* v 7 n 5 Oct 1988 p 223-227.

**085681 CONDITIONAL PASTA.** Let  $Y$  be a stochastic process representing the state of a system and  $N$  a doubly stochastic Poisson process whose intensity varies with the state of a random environment represented by a stochastic process  $X$ . In this context a generalization of 'PASTA' (Poisson Arrivals See Time Averages) is shown to be valid. Various applications of the result are given. (Author abstract). 8 refs.

van Doorn, Erik A. (Univ of Twente, Enschede, Neth); Regterschot, G.J.K. *Oper Res Lett* v 7 n 5 Oct 1988 p 229-232.

**085682 ON JACKSON'S PRODUCT FORM WITH 'JUMP-OVER' BLOCKING.** This note aims to provide a simple and straightforward proof for the 'jumping-over' protocol to retain Jackson's product form. To highlight the essential feature of 'jump-over' blocking, the presentation is restricted to the standard closed and exponential Jackson network formulation. The extension to open, non-exponential and more complex product form situa-

tions is immediate as is briefly argued. 12 refs.

van Dijk, Nico M. (Free Univ, Amsterdam, Neth). *Oper Res Lett* v 7 n 5 Oct 1988 p 233-235.

**085683 TWO PARALLEL M/G/1 QUEUES WHERE ARRIVALS JOIN THE SYSTEM WITH THE SMALLER BUFFER CONTENT.** Two parallel, infinite-capacity M/G/1 queues characterized by  $(U_1(t), U_2(t))$ , with  $U_i(t)$  denoting the unfinished work (buffer content) in queue  $i$  are considered. An arrival is assigned to the queue with the smaller buffer content. Asymptotic approximations to the joint stationary distribution of the Markov process  $(U_1(t), U_2(t))$  are constructed, treating separately the asymptotic limits of heavy traffic, light traffic, and large buffer contents. In heavy traffic, the stochastic processes  $U_1(t) + U_2(t)$  and  $U_2(t) - U_1(t)$  become independent; the distribution of  $U_1(t) + U_2(t)$  is identical to the heavy traffic waiting time distribution in the standard M/G/2 queue, and the distribution of  $U_2(t) - U_1(t)$  is closely related to the tail of the service-time density. In light traffic, a formal expansion of the stationary distribution in powers of the arrival rate is obtained. 12 refs.

Knessl, Charles (Northwestern Univ, Evanston, IL, USA); Matkowsky, Bernard J.; Schuss, Zeev; Tier, Charles. *IEEE Trans Commun* v COM-35 n 11 Nov 1987 p 1153-1158.

**085684 OPTIMAL CONTROL OF PREMATURE QUEUEING.** Given an M/G/1 queue, a special customer, and an exponential random variable  $M$  that is independent of the queueing process, if the special customer reaches the front of the queue before the time specified by  $M$ , it cannot be processed and must re-enter the queue at the back. While waiting in the queue, the available decisions for the special customer are either to keep its position in the queue or to leave its position to join the back of the queue. The author's goal is to find a strategy that minimizes the expected delay until the special customer starts being processed. The move-along policy is to always stay in the queue until the front of the queue is reached, and if it cannot be served, to join the back of the queue. The basic result is that if the queue is stable, the move-along policy is optimal. 7 refs.

Li, Shuo-Yen Robert (Bell Communications Research, Morristown, NJ, USA). *IEEE Trans Autom Control* v 33 n 4 Apr 1988 p 386-389.

**085685 MULTISERVER QUEUE WITH NARROW- AND WIDE-BAND CUSTOMERS AND WIDE-BAND RESTRICTED ACCESS.** A multiserver queueing system with two classes of customers is considered: a type-1 (narrowband, NB) customer requires a single server, while each type-2 (wideband, WB) customer requests  $n$  of the  $m$  servers ( $n$  is not random). Servers allocated to a type-2 customer are seized and released simultaneously. Service times are exponentially distributed with mean  $1/\mu_i$  for type  $i$  customers ( $i = 1, 2$ ). Blocked type-1 customers are cleared while blocked type-2 customers may be delayed in an infinite waiting room. A type-1 customer enters service immediately upon arrival if at least one server is free, irrespective of the status of the type-2 queue. WB customers have restricted access to the service facility; a cutoff parameter specifies the maximum number of type-2 customers that can be in service at the same time. Two approaches, moment-generating functions and matrix-geometric techniques, are considered for the computation of the system performance, that is, the mean waiting time in queue and the probability of delay (i.e., nonzero waiting time) for type-2 customers, as well as the probability of blocking for type-1 customers. 34 refs.

De Serres, Yves (INRS Telecommunications, Verdun, Que, Can); Mason, Lorne G. *IEEE Trans Commun* v 36 n 6 Jun 1988 p 675-684.

**085686 RESEQUENCING DELAY FOR A QUEUEING SYSTEM WITH TWO HETEROGENEOUS SERVERS UNDER A THRESHOLD-TYPE SCHEDULING.** In service centers with multiple-parallel servers,

jobs may complete their service in a different order from the one in which they enter the center. In order to reestablish the original order resequencing protocols need to be implemented. It is shown that under a threshold-type policy, the resequencing delay depends on the strategy by which customers are selected and dispatched to the servers. Two selection strategies are developed, and the delay characteristics corresponding to the two strategies are studied. Existing methods for finding the sequencing delay are extended to cover the threshold-type policy. Closed-form solutions for the resequencing delay distributions under both selection policies are derived. To characterize the performance of the system under the two policies, two optimization criteria are introduced, namely, the fraction of customers that experience resequencing delay and the mean resequencing delay. These quantities are calculated explicitly, and their comparison reveals that the optimal decision is independent of the load on the system. The selection of the optimal policy under the first criterion depends only on the service rates, whereas for the second criterion the optimal selection depends on the threshold value and the ratio of the service rates. 10 refs.

Iliadis, Ilias (Columbia Univ, New York, NY, USA); Lien, Luke Y.-C. *IEEE Trans Commun* v 36 n 6 Jun 1988 p 692-702.

**085687 TRANSIENT M/M/1 QUEUE VARIANCE COMPUTATION USING GENERALIZED Q FUNCTIONS.** A generalized  $Q$  function representation for the transient M/M/1 queue variance is developed. The expression is highly accurate and computationally efficient, and an upper bound on the error is easily calculated. For a  $Q$  function relative error of  $2 \times 10^{-12}$  using Parl's method, the relative error of the variance is generally less than  $10^{-9}$ . Average execution time is on the order of 70 ms per point on a VAX 11/750, but faster execution times can be obtained by using larger  $Q$  function relative errors. 13 refs.

Cantrell, Pierce E. (Texas A&M Univ, College Station, TX, USA); Beall, Gary R. *IEEE Trans Commun* v 36 n 6 Jun 1988 p 756-758.

**085688 APPROXIMATE ANALYSIS OF FORK-/JOIN SYNCHRONIZATION IN PARALLEL QUEUES.** An approximation technique, called scaling approximation, is introduced and applied to the analysis of homogeneous fork/join queueing systems consisting of  $K \geq 2$  servers. The development of the scaling approximation technique is guided by both experimental and theoretical considerations. The approximation is based on the observation that there exist upper and lower bounds on the mean response time that grow at the same rate as a function of  $K$ . Simple, closed-form approximate expressions for the mean response time are derived and compared to simulation results. The relative error in the approximation is less than 5% for  $K \leq 32$ . 8 refs.

Nelson, R. (IBM, Yorktown Heights, NY, USA); Tantawi, A.N. *IEEE Trans Comput* v 37 n 6 Jun 1988 p 739-743.

**085689 ON A NUMERICAL METHOD FOR CALCULATING STATE PROBABILITIES FOR QUEUEING SYSTEMS WITH MORE THAN ONE WAITING LINE.** M.S. Keane et al. have proposed a new numerical method for calculating state probabilities for queueing systems with more than one waiting line in parallel. The method is based on power series expansions of state probabilities as functions of the traffic intensity of a system. The coefficients of these power series can be recursively calculated. The coefficients of the power series expansions of moments of queue length distributions can be derived from those of the state probabilities in a straightforward manner. The above method is discussed for a rather general class of exponential queueing systems. The asymptotic behavior of moments in heavy traffic is used to obtain extrapolations of the coefficients of their



power series expansions at the origin. The calculation of moments is strongly improved by means of these extrapolations. (Author abstract) 7 refs.

Blanc, J.P.C. (Delft Univ of Technology, Delft, Neth.). *J Comput Appl Math* v 20 Nov 1987, Proc of the 2nd Int Conf on Comput and Appl Math, Louvain, Belg, Jul 21-26 1986 p 119-125.

**085690 APPROXIMATE DISAGGREGATION AND PERFORMANCE BOUNDS FOR QUEUEING NETWORKS WITH MULTIPLE-SERVER STATIONS.** We introduce the concept of approximate disaggregation which enables us to replace a station by a subnetwork, i.e. a set of stations, such that the performance of the derived network is close to the performance of the initial network. We use this concept to disaggregate any multiple-server station into a set single-server stations. Using two different disaggregations, we are able to bound the performance of the initial network by the performance of a 'lower' and an 'upper' network each consisting of single-server stations, whose performance can in turn be bounded by the Balanced Job Bounds (or other known bounds). Several examples show the useful information provided by these bounds at a very low cost: for K stations and N customers, the computational complexity here is  $O(K)$  which is significantly less than the  $O(KN^2)$  operations required for exact solution. Indeed, despite the multiple server stations, the computational complexity of our bounds is the same as that of Balanced Job Bounds. (Author abstract) 24 refs.

Dallery, Yves (Harvard Univ, Cambridge, MA, USA); Suri, Rajan. *Perform Eval Rev* v 14 n 1 May 1986, Perform '86 and ACM SIGMETRICS 1986: Jt Conf on Comput Perform Modell, Meas and Eval, Raleigh, NC, USA, May, 28-30 1986 p 111-128.

**085691 ANALYSIS OF A CONVEYOR QUEUE IN A FLEXIBLE MANUFACTURING SYSTEM.** In a flexible manufacturing system stations are arranged along a common conveyor that brings items for processing to the stations and also carries away the processed items. At each station specialized robots automatically load and unload items on and off the conveyor. We examine here a single station in such a system. A new kind of queueing problem arises, with input-output dependencies that result because the same conveyor transports items both to and from the station. The paper analyzes two models of a station. Model 1 has one robot that cannot return a processed item to the conveyor while unloading a new item for processing. Model 2 has two robots to allow simultaneous loading and unloading of the conveyor. A principal goal of the analysis is the proper choice of the distance separating the two points at which items leave and rejoin the conveyor. (Author abstract) 5 refs.

Coffman, E.G. Jr. (AT&T Bell Lab, Murray Hill, NJ, USA); Gelenbe, E.; Gilbert, E.N. *Perform Eval Rev* v 14 n 1 May 1986, Perform '86 and ACM SIGMETRICS 1986: Jt Conf on Comput Perform Modell, Meas and Eval, Raleigh, NC, USA, May, 28-30 1986 p 204-223.

**085692 MAXIMUM ENTROPY QUEUE LENGTH DISTRIBUTION FOR A G/G/1 FINITE CAPACITY QUEUE.** A new 'hybrid' analytic framework, based on the principle of maximum entropy, is used to approximate the queue length distribution of a G/G/1 finite buffer queue. Robust recursive relations are derived and asymptotic connections to the infinite capacity queue are established. Furthermore, 'equivalence' principles are applied to analyse two-stage cyclic queues with general service times and favourable comparisons with global balance solutions are made. Numerical examples provide useful information on how critically system behaviour is affected by the distributional form of interarrival and service patterns. It is shown that the maximum entropy solution predicts the bottleneck 'anomaly' and also it defines bounds on system performance. Comments on the implication of the work to the analysis and aggregation of computer systems are included. (Author abstract) 28 refs.

Kouvatso, Demetres D. (Univ of Bradford, Bradford, Engl). *Perform Eval Rev* v 14 n 1 May 1986, Perform '86

and ACM SIGMETRICS 1986: Jt Conf on Comput Perform Modell, Meas and Eval, Raleigh, NC, USA, May, 28-30 1986 p 224-236.

## Random Number Generation

**085693 VARIATE GENERATION FOR ACCELERATED LIFE AND PROPORTIONAL HAZARDS MODELS.** In reliability, covariates such as the turning speed of a machine tool or the stress applied to a component affect the lifetime of an item. Two models are often used to incorporate the effect of these covariates on lifetimes: accelerated life and proportional hazards models. We use accelerated life and proportional hazards lifetime models to account for the effects of covariates on a random lifetime. We find that variate generation algorithms for Monte Carlo simulation in both the renewal and nonhomogeneous Poisson process cases are a simple extension of the inverse cumulative distribution function (cdf) technique. (Edited author abstract) 8 refs.

Leemis, Lawrence M. (Univ of Oklahoma, Norman, OK, USA). *Oper Res* v 35 n 6 Nov-Dec 1987 p 892-894.

**Random Processes** See Also AUTOMATA THEORY; AUTOMATIC TESTING; BIOMEDICAL ENGINEERING—Mathematical Models; BUILDINGS—Earthquake Resistance; CODES, SYMBOLIC; COMPUTER NETWORKS; COMPUTER NETWORKS—Local Networks; COMPUTER NETWORKS—Performance; COMPUTER NETWORKS—Protocols; COMPUTER PROGRAMMING—Algorithms; COMPUTER SIMULATION—Applications; COMPUTER SYSTEMS, DIGITAL—Multiprocessing; CONTROL SYSTEMS—Analysis; CONTROL SYSTEMS—Identification; CONTROL SYSTEMS, ADAPTIVE—Stability; CONTROL SYSTEMS, DISCRETE TIME—Computer Aided Design; CONTROL SYSTEMS, LINEAR—Controllability; CONTROL SYSTEMS, NONLINEAR—Estimation; CONTROL SYSTEMS, OPTIMAL—Estimation; CONTROL SYSTEMS, STOCHASTIC; CONTROL SYSTEMS, STOCHASTIC—Mathematical Models; CRYPTOGRAPHY—Analysis; CRYSTALS—Phase Transitions; DAMS—Control; DATA CONVERSION, ANALOG TO DIGITAL—Optimization; DATA PROCESSING—Data Structures; DATABASE SYSTEMS—Performance; DECISION THEORY AND ANALYSIS; DIGITAL COMMUNICATION SYSTEMS—Multiplexing; DIGITAL COMMUNICATION SYSTEMS—Performance; DIGITAL COMMUNICATION SYSTEMS—Voice/Data Integrated Services; DYNAMICS—Theory; ECONOMICS—Operations Research; ELECTRIC EQUIPMENT—Thermal Effects; ELECTRIC POWER DISTRIBUTION—Reliability; ELECTRIC POWER SYSTEMS—Load Flow Analysis; ELECTROMAGNETIC FIELD THEORY; ELECTROMAGNETIC FIELDS; ELECTROMAGNETIC WAVES—Propagation in Ionosphere; EQUALIZERS; FLOW OF FLUIDS—Mathematical Models; FLOW OF FLUIDS—Porous Materials; HEAT TRANSFER—Convection; HIGHWAY ACCIDENTS—Mathematical Models; IMAGE PROCESSING—Image Analysis; INFORMATION THEORY; INFORMATION THEORY—Channel Capacity; INFORMATION THEORY—Correlation Theory; INVENTORY CONTROL—Management; INVENTORY CONTROL—Mathematical Models; MATERIALS—Order-Disorder; MATHEMATICAL MODELS; MATHEMATICAL PROGRAMMING, LINEAR; MATHEMATICAL TECHNIQUES—Differential Equations; MATHEMATICAL TECHNIQUES—Estimation; MATHEMATICAL TECHNIQUES—Graph Theory; MATHEMATICAL TECHNIQUES—Integral Equations; MATHEMATICAL TECHNIQUES—Matrix Algebra; MATHEMATICAL TECHNIQUES—Nonlinear Equations; MATHEMATICAL TECHNIQUES—Perturbation Techniques; MATHEMATICAL TECHNIQUES—Vectors; MEASUREMENT THEORY; MINES AND MINING—Mathematical Models; OPERATIONS RESEARCH; OPTIMIZATION; OSCILLATORS, MICROWAVE; POPULATION STATISTICS—Sampling; RADAR—Measurement Application, RADIO TRANSMISSION—Propagation in Ionosphere; RAIN AND RAINFALL—Classification; RAIN AND RAINFALL—Mathematical Models; RELIABILITY THEORY; RELIABILITY THEORY—Costs; RISK STUDIES; ROBOTS, INDUSTRIAL—Reliability; SAMPLING; SEMICONDUCTOR MATERIALS—Charge Carriers; SHOCK WAVES—Mathematical Models; SIGNAL DETECTION; SIGNAL DETECTION—Analysis; SIGNAL FILTERING AND PREDICTION; SIGNAL INTERFERENCE—Calculations; SIGNAL PROCESSING; SIGNAL PROCESSING—Digital Techniques; SIGNAL PROCESSING—Sampling; SIGNAL PROCESSING—Theory; SIGNAL THEORY; SILOS—Pressure Effects; SOLAR ENERGY—Storage; SPECTRUM ANALYSIS; STATISTICAL METHODS—Time Series Analysis; STRESSES—Mathematical Models; STRUCTURAL ANALYSIS; STRUCTURAL DESIGN—Loads; STRUCTURAL DESIGN—Reliability; SWITCHING SYSTEMS—Theory; SYSTEMS ANALYSIS; SYSTEMS ENGINEERING; SYSTEMS SCIENCE AND CYBERNETICS—Identification; SYSTEMS SCIENCE AND CYBERNETICS—Learning Systems; SYSTEMS SCIENCE AND CYBERNETICS—Neural Nets; SYSTEMS SCIENCE AND CYBERNETICS—Theory; TELECOMMUNICATION SYSTEMS—Mathematical Models; TELECOMMUNICATION SYSTEMS—Multiplexing; VIBRATIONS—Auto-

matic Testing.

**085694 CONDITIONS FOR THE NON-ERGODICITY OF MARKOV CHAINS WITH APPLICATION TO A COMMUNICATION SYSTEM.** We obtain a sufficient condition for the transience of a Markov chain, and sufficient condition for its null recurrence. These are applied to characterize the stability of a multiple-access communication system. Performance bounds for the system are also obtained. (Author abstract) 9 refs.

Sennott, Linn I. (Illinois State Univ, Normal, IL, USA). *J Appl Probab* v 24 n 2 Jun 1987 p 339-346.

**085695 CRITERIA FOR THE NON-ERGODICITY OF STOCHASTIC PROCESSES: APPLICATION TO THE EXPONENTIAL BACK-OFF PROTOCOL.** In this paper, we present some simple new criteria for the non-ergodicity of a stochastic process  $(Y_n)$ ,  $n \geq 0$  in discrete time, when either the upward or downward jumps are majorized by i.i.d. random variables. This situation is encountered in many practical situations, where the  $(Y_n)$  are functionals of some Markov chain with countable state space. An application to the exponential back-off protocol is described. (Author abstract) 9 refs.

Fayolle, Guy (INRIA, Le Chesnay, Fr); Iasnogorodski, Rudolph. *J Appl Probab* v 24 n 2 Jun 1987 p 347-354.

**085696 ON THE PROBABILITY DENSITIES OF AN ORNSTEIN-UHLENBECK PROCESS WITH A REFLECTING BOUNDARY.** We show that the transition p.d.f. of the Ornstein-Uhlenbeck process with a reflection condition at an assigned state S is related by integral-type equations to the free transition p.d.f., to the transition p.d.f. in the presence of an absorption condition at S, to the first-passage-time p. d.f. to S and to the probability current. Such equations, which are also useful for computational purposes, yield as an immediate consequence all known closed-form results for Wiener and Ornstein-Uhlenbeck processes. The results are relevant to one-dimensional diffusion processes (Edited author abstract) 21 refs.

Ricciardi, L.M. (Univ of Naples, Naples, Italy); Sacerdote, L. *J Appl Probab* v 24 n 2 Jun 1987 p 355-369.

**085697 JOINT DISTRIBUTION OF SUCCESSIVE ZERO CROSSING DISTANCES FOR STATIONARY GAUSSIAN PROCESSES.** It has been shown that in a stationary Gaussian process the length of the successive zero-crossing intervals cannot be independent, except for the degenerate case of a pure cosine process. However, no closed-form expression of the distribution of these quantities is known at present. In this paper we present an accurate explicit approximative formula, derived by replacing the Slepian model process by its regression curve. (Edited author abstract) 6 refs.

Rychlik, Igor (Univ of Lund, Lund, Swed). *J Appl Probab* v 24 n 2 Jun 1987 p 378-385.

**085698 FIRST PASSAGE TIME INTERVALS OF GAUSSIAN PROCESSES.** The first passage time problem of a stationary Gaussian process is theoretically and experimentally studied. Renewal functions are derived for a time-dependent boundary and numerically calculated for a Gaussian process having a seventh-order Butterworth spectrum. The results show a multiplex property not only for the constant boundary but also for a linearly increasing boundary. The first passage time distribution densities were experimentally determined for a constant boundary. The renewal functions were shown to be a fairly good approximation to the distribution density over a limited range. (Author abstract) 8 refs.

Perez, Hector (Univ of Electro-Communications, Chofu, Jpn); Kawabata Tsutomu; Mimaki, Tadashi. *Jpn J Appl Phys Part 1* v 26 n 8 Aug 1987 p 1378-1383.



**085699 ON USING DETERMINISTIC FUNCTIONS TO REDUCE RANDOMNESS IN PROBABILISTIC ALGORITHMS.** We show the existence of nonuniform schemes for the following sampling problem: Given a sample space with  $n$  points, an unknown set of size  $n/2$ , and  $s$  random points, it is possible to generate deterministically from them  $s + k$  points such that the probability of not hitting the unknown set is exponentially smaller in  $k$  than  $2^{-s}$ . Tight bounds are given for the quality of such schemes. Explicit, uniform versions of these schemes could be used for efficiently reducing the error probability of randomized algorithms. A survey of known constructions is included. (Edited author abstract) 17 refs.

Santha, Miklos (Univ of California, Berkeley, CA, USA). *Inf Comput* v 74 n 3 Sep 1987 p 241-249.

**085700 SOME PROPERTIES OF SIMULATION INTERVAL ESTIMATORS UNDER DEPENDENCE INDUCTION.** Variance reduction techniques (VRTs) represent a choice between a crude experiment and a more statistically efficient experiment for estimating the parameters of a stochastic process. The most widely used VRTs change the joint distribution of the simulation output random variables upon which the point estimators are based. When this change is achieved by inducing dependence among input random variables we call them dependence induction (DI) VRTs. Some basic, but surprising properties of confidence intervals formed under antithetic-variables and common-random-numbers (VRT) are derived. It is shown that improved point estimator performance, the primary goal of variance reduction techniques, does not necessarily imply improved interval estimator performance. 18 refs.

Nelson, Barry L. (Ohio State Univ, Columbus, OH, USA). *Oper Res Lett* v 6 n 4 Sep 1987 p 169-176.

**085701 PROBABILISTIC ANALYSIS OF THE NEXT FIT DECREASING ALGORITHM FOR BIN-PACKING.** Given a list of  $n$  items, the bin-packing problem is to find the smallest number of bins in which these items can be packed, subject to the constraint that the total size of the items packed in any bin cannot exceed 1. This problem is NP-hard, so researchers have turned to the analysis of simple heuristics. We are concerned with the Next Fit Decreasing (NFD) method. We use a simple deterministic inequality to simplify and strengthen previous results on the probabilistic analysis of Next Fit Decreasing for Bin-Packing. 4 refs.

Rhee, WanSoo T. (Ohio State Univ, Columbus, OH, USA). *Oper Res Lett* v 6 n 4 Sep 1987 p 189-191.

**085702 ESTIMATION OF THE MEAN FROM RANDOMLY CENSORED DATA.** Let random variables  $Y_1, \dots, Y_N$  be i.i.d. according to continuous distribution function  $F$ , with finite mean  $\mu$ . Their measurements are censored from the right by the realizations of random variables  $V_1, \dots, V_N$ , independent mutually and of  $Y_i$ 's, too. We construct the estimator  $\mu_N = \sum T_i \cdot \Delta F_N(T_i) \cdot I_i / T_i$ , where  $T_i = \min(Y_i, V_i)$ ,  $F_N$  is the product limit estimator of  $F$ ,  $A_N \rightarrow \infty$  is a real sequence, conveniently chosen. The conditions are derived for strong consistency of  $\mu_N$  as well as for its asymptotic normality, and the rate of convergence is studied. Trimmed mean estimator is considered, too. (Author abstract) 5 refs.

Volf, P. *Probl Control Inf Theory* v 16 n 3 1987 p 233-241.

**085703 ONE PROPERTY OF A SAMPLE AUTOCOVARIANCE OF PURELY RANDOM SEQUENCES AND ITS APPLICATION.** One odd property of the purely random sequences introduced: In the sample autocovariance of the purely random sequence the squared magnitude at the origin tends to the sum of the squared magnitudes except at the origin irrespective of the type of its probability distribution function. Further expressing the above property in the frequency domain we give the different approach to prove the known fact that the power spectrum of the purely random sequence is always different from its periodogram even if the number

of sample points tend to infinity. Finally, as an application we show that the noise periodogram can be estimated from the image degraded by the additive noise. (Author abstract) 17 refs.

Kondo, Hiroshi (Kyushu Inst of Technology, Kitakyusyu, Jpn). *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 9 Sep 1987 p 823-834.

**085704 OPTIMAL SEARCH FOR ONE OF MANY OBJECTS HIDDEN IN TWO BOXES.** A discrete search model for one of many objects hidden in two boxes is studied. The number of objects is assumed to be a random variable with a known prior distribution. When the box is searched, a cost is paid and the conditional probability of finding a specific object given it was hidden there is given. We are interested in determining a search which finds at least one object with minimum expected cost. Zones of the state space for which Blackwell's rule is optimal are characterized. Based on these results an algorithm for constructing an optimal search sequence is suggested and demonstrated in the case where the number of hidden objects has a geometric distribution. (Edited author abstract) 14 refs.

Sharlin, Ariela (Hebrew Univ of Jerusalem, Isr). *Eur J Oper Res* v 32 n 2 Nov 1987 p 251-259.

**085705 MULTIOBJECTIVE MODELS IN IDENTIFICATION OF RANDOM FIELDS.** Two basic classes of random fields are presented and their applicability to real-life problems is emphasized. The problem of optimal identification of the random field is developed by means of kriging theory. Several multiobjective cases are considered and possible procedures for aiding the decision making identification process of random fields are discussed. Some remarks related to the application as well as to possible extension of presented methods are included. (Edited author abstract) 13 refs.

Wiecek, Malgorzata (Univ of Mining & Metallurgy, Cracow, Pol). *Eur J Oper Res* v 32 n 2 Nov 1987 p 267-275.

**085706 MULTIPLE WIENER INTEGRALS AND NONLINEAR FUNCTIONALS OF A NUCLEAR SPACE VALUED WIENER PROCESS.** In this work we develop techniques for the study of nonlinear functionals of a  $\Phi$ -valued Wiener process  $W_t$ , where  $\Phi$  is the dual of a countably Hilbert nuclear space. We construct stochastic integrals and multiple Wiener integrals of operator-valued processes with respect to  $W_t$ . The Wiener decomposition of the space of  $\Phi$ -valued nonlinear functionals of  $W_t$  is established. We also obtain multiple stochastic integral expansions and representations of  $\Phi$ -valued nonlinear functionals of  $W_t$  as operator-valued stochastic integrals of Ito type. (Author abstract) 21 refs.

Perez-Abreu, Victor (IIMAS Univ Nacional Autonoma de Mexico, Mexico City, Mex). *Appl Math Optim* v 16 n 3 Nov 1987 p 227-245.

**085707 ON THE FEYNMAN-KAC FORMULA AND ITS APPLICATIONS TO FILTERING THEORY.** In this article the Feynman-Kac formula is obtained for a Markov process  $(X_t)$  whose transition probability function is not stationary. A converse to the Feynman-Kac formula is also obtained. This is used to prove the uniqueness of the solution to a measure-valued equation satisfied by the optimal filter in the white-noise approach to nonlinear filtering theory. (Author abstract) 5 refs.

Karandikar, Rajeeva L. (Univ of North Carolina, Chapel Hill, NC, USA). *Appl Math Optim* v 16 n 3 Nov 1987 p 263-276.

**085708 IMPROVED POISSON LIMIT THEOREM FOR SUMS OF DISSOCIATED RANDOM VARIABLES.** A Poisson limit theorem for sums of dissociated 0-1 random variables is refined by deriving the first terms in an asymptotic expansion. The most natural refinement does not remove all the first-order error in a number of applications to tests of clustering, and a further approximation is derived which gives excellent results in practice.

(Author abstract) 11 refs.

Barbour, A.D. (Univ Zuerich, Zurich, Switz); Eagleson, G.K. *J Appl Probab* v 24 n 3 Sep 1987 p 586-599.

**085709 MONOTONE AND ASSOCIATED MARKOV CHAINS, WITH APPLICATIONS TO RELIABILITY THEORY.** We study monotone and associated Markov chains on finite partially ordered state spaces. Both discrete and continuous time, and both time-homogeneous and time-inhomogeneous chains are considered. The results are applied to binary and multistate reliability theory. (Author abstract) 26 refs.

Lindqvist, Bo Henry (Norwegian Inst of Technology, Trondheim, Norw). *J Appl Probab* v 24 n 3 Sep 1987 p 679-695.

**085710 IDENTIFICATION OF THE TREND OF A RANDOM PROCESS BY MEANS OF FIRST-ORDER SPLINES.** The problem of approximating the trend of a time-varying random process by means of first-order splines is analyzed. The parameters of the spline are estimated in real time by the method of least squares and by modifications of this method: a sliding least-squares method and a least-squares method involving combinations into groups. Statistical characteristics of the estimates are found. The algorithms have been optimized. (Author abstract) 3 refs.

Livshits, K.I. *Optoelectron Instrum Data Process* n 3 1987 p 30-37.

**085711 OPTIMAL ESTIMATES OF THE NUMBER OF RANDOM PULSE DISTURBANCES AFFECTING A DYNAMIC SYSTEM.** Optimal estimates of the number of pulse disturbances affecting a continuous dynamic system is examined. A closed system of equations is given for a one-dimensional, a posteriori characteristic function of the number of disturbances. For the case of a nonuniform Poisson flow of disturbances, an algorithm for computing an optimal in the mean-squared sense estimate of the number of pulse disturbances occurring during the observation period is presented. An example of making an optimal estimate of the number of discontinuities in a simple, two-state dynamic system is presented. (Author abstract) 15 refs.

Mal'tsev, A.A.; Silaev, A.M. *Autom Remote Control* v 48 n 5 pt 2 May 1987 p 654-661.

**085712 NUMERICAL TRANSIENT ANALYSIS OF MARKOV MODELS.** We consider the numerical evaluation of Markov model transient behavior. Our research is motivated primarily by computer system dependability modeling. Other application areas include finite-capacity queueing models, closed queueing networks, and inventory models. We focus our attention on the general problem of finding the state probability vector of a large, continuous-time, discrete-state Markov chain. Two computational approaches are examined in detail: uniformization and numerical linear multistep methods for ordinary differential equation solution. In general, uniformization provides greater accuracy but deals poorly with stiffness. A special stable ordinary differential equation solver deals well with stiffness, but it provides increased accuracy only at much greater cost. Examples are presented to illustrate the behavior of the techniques discussed as a function of model size, model stiffness, increased accuracy requirements, and mission time. (Author abstract) 26 refs.

Reibman, Andrew (Duke Univ, Durham, NC, USA); Trivedi, Kishor. *Comput Oper Res* v 15 n 1 1988 p 19-36.

**085713 EMPIRICAL STATIONARY DISTRIBUTION FUNCTION OF MARKOVIAN CORRELATED RANDOM SEQUENCES.** Considering a homogeneous recurrent  $(k+1)$ -node Markov chain with stationary d.f.  $F(x)$  it is shown that a so-called 'F(x)-equivalent' 2-node Markov chain can be associated to any point  $x$  and that thereupon the Bayes-Laplace-statistics for 2-node chains can be used to evaluate the correlated  $x$ -sequence generated by the  $(k+1)$ -node chain



yielding under large sample conditions simple posterior statements about its empirical stationary  $d_f F_n(x)$ , the associated relative error  $d_f(x)$  and also about a mean correlation coefficient  $\rho^-(x)$ . This statistical procedure can be generally applied not only discrete but also to continuous stationary processes with unknown properties; this is demonstrated in case of the heavily correlated delay time of queueing system M/M1. (Author abstract) 18 refs.

Schreiber, Friedrich (Technische Hochschule, Aachen, West Ger). *AEU Arch Elektron Uebertrag Electron Commun* v 41 n 5 Sep-Oct 1987 p 257-263.

**085714 EFFECT OF PARAMETER CHANGE OF THE HOLDING TIME DISTRIBUTION ON INTERVAL TRANSITION PROBABILITIES.** This paper discusses the role of the parameters change of the holding time distribution and its impact on the limiting distribution of the interval transition probabilities of the semi-Markov process. A numerical example is used to illustrate its potential application in the marketing field of the car rental industry. (Author abstract) 5 refs.

Jain, R.K. (Memorial Univ of Newfoundland, St. John's, Newfoundl, Can). *Ind Math* v 37 pt 1 1987 p 77-81.

**085715 OPTIMAL DETECTION OF CHANGING PROPERTIES OF RANDOM SEQUENCES. I. NONSEQUENTIAL DETECTION.** The nonsequential detection of a 'failure' of random sequences is considered. The author constructs an optimal Bayesian nonsequential algorithm of detection of a failure of a stochastic process observed at discrete instants of time. He finds recursion formulas for the averaged likelihood ratio and the a posteriori probability of a failure, both of them being sufficient statistics. In the case of independent observations these statistics are proved to be nonhomogeneous Markov functions. Examples are also presented. (Edited author abstract) 12 refs.

Tartakovskii, A.G. *Autom Remote Control* v 48 n 7 pt 2 Jul 1987 p 918-925.

**085716 LIMIT THEOREM FOR THE JOINT DISTRIBUTION OF A RANDOM SUM AND THE NUMBER OF SUMMANDS AND SOME OF ITS APPLICATIONS.** A limit theorem is proved for the joint distribution of the sum of a random number of random variables and their number itself. Examples of its application in the investigation of the characteristics of queueing systems are presented. (Author abstract) 9 refs.

Azlarov, T.A.; Aripov, Kh.M.; Dzhamirzayev, A.A. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 99-103.

**085717 MODIFICATION OF DEMAND DISTRIBUTIONS ON THE BASIS OF AGGREGATE INFORMATION.** This paper addresses the situation where information is known about the sum of a number of random variables as opposed to their individual values. For cases of normal and Poisson demand, results are developed for the conditional distribution or one of the variables given that we know i) the exact value of the sum or ii) that the sum is less than some value. Two modelling applications from the production/inventory field are discussed and an additional numerical example is presented. (Author abstract) 7 refs.

Jonsson, Henrik (Linköping Inst of Technology, Linköping, Swed); Silver, Edward A. *IIE Trans* v 19 n 4 Dec 1987 p 379-384.

**085718 FAST AND FLEXIBLE FAMILY OF DISTRIBUTIONS FOR SIMULATION STUDIES.** This paper describes a fast and flexible family of probability distributions which are suitable for approximating unimodal, Pearson type distributions in simulation exercises. We examine the criteria such a family should satisfy and compare the new curves with other proposed families. A fitting method is described to satisfy various 'goodness of fit' criteria. (Author abstract) 17 refs.

Butterworth, N.J. (Cambridge Univ, Cambridge, Engl). *IIE Trans* v 19 n 4 Dec 1987 p 439-444.

**085719 CONTINUOUS AND DISCRETE SEARCH FOR ONE OF MANY OBJECTS.** By an easy observation we show that the basic result of Blackwell according to which the most inviting strategy is optimal in a discrete search for one object, is also true when the number of objects is random provided the search is made in continuous time. This result does not hold in the discrete search model even when only two boxes are present (contrary to a conjecture of Smith and Kimeldorf). For the case of two boxes, a convenient sufficient condition on the distribution of the number of objects is provided which ensures optimality of the most inviting strategy. As a result, this strategy is shown to be optimal for several important distributions. (Edited author abstract) 9 refs.

Assaf, David (Hebrew Univ of Jerusalem, Jerusalem, Isr); Zamir, Shmuel. *Oper Res Lett* v 6 n 5 Nov 1987 p 205-209.

**085720 GENERALIZED VARIANCE FUNCTION OF RANDOM DISTURBANCES AND MULTIPLE ESTIMATES OF THE VALUES OF THE NOISE.** A new characteristic of stationary random processes is introduced: a generalized variance function. A study is made of its properties. Estimates of the intervals of approximate values of the mathematical expectation are obtained by Chebyshev's inequality. A definition is given of a stationary intermediate process based on analogous multiple estimates. (Author abstract) 8 refs.

Lychak, M.M. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR). *Sov J Autom Inf Sci* v 20 n 1 Jan-Feb 1987 p 28-33.

**085721 DETERMINATION OF THE CHARACTERISTICS OF A RANDOM PROCESS AT THE OUTPUT OF A DIVIDER.** The probability characteristics of a random process  $\eta(t)$ , the quotient resulting from division of Gaussian random processes  $\xi_1(t)$ ,  $\xi_2(t)$  that are stationary in the broad sense have been considered. We shall consider a method for determining the probability characteristics of  $\eta(t)$  under the requirement that  $\xi(t)$  arrive at one of the divider inputs through a delay line with delay time  $\tau_d$  not exceeding the correction time  $\tau_k$  and that  $P_1(\xi)$  be described by a Rayleigh law. The method considered makes it possible to determine the probability characteristics of a random process at the output of a divider for various forms of random processes input. 4 refs.

Zyuz'ko, A.K. *Radioelectron Commun Syst* v 30 n 7 1987 p 70-71.

**085722 STATIONARY MARKOV RENEWAL PROCESS ON THE WHOLE TIME AXIS.** Markov renewal process (MRP) is widely used in communication theory, OR, physics and so on. This paper is concerned with the mathematically rigorous construction of the stationary MRP with finite states on the whole time axis. A joint (forward and backward) invariant probability exists uniquely for an irreducible MRP. A stationary MRP on the whole time axis is defined by setting the joint invariant probability at the point of origin and by forming the MRP in the positive direction and the reverse MRP in the negative direction. An elementary proof of the stationarity of the defined process is given by showing directly that any finite-dimensional distribution is invariant under the shift of time. The proof of the existence and uniqueness of the joint invariant probability is also presented. Once the stationarity of the defined MRP is established, various stochastic processes generated by it can be shown to be stationary as well. (Edited author abstract) 8 refs.

Sugiyama, Hiroshi (NTT, Musashino, Jpn). *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 12 Dec 1987 p 1208-1213.

**085723 SYMMETRY PROPERTIES OF HIGH-ORDER SPECTRAL DENSITIES OF STATIONARY AND PERIODIC-NONSTATIONARY STOCHASTIC PROCESSES.** In this study, we consider the high-order spectral densities of a periodic-nonstationary stochastic process. The main focus is on the symmetry

properties of spectral densities of orders  $v=3, 6$ . In parallel we describe the symmetry properties of the high-order spectral densities of discrete- and continuous-time stationary stochastic processes. The symmetry properties of the high-order spectral densities obtained in this study reduce the computational work necessary for their estimation. 8 refs.

Alekseev, V.G. *Probl Inf Transm* v 23 n 3 Jul-Sep 1987 p 210-215.

**085724 ADAPTIVE PREDICTION FOR ARMA PROCESSES WITH MARKOV SWITCHING PARAMETERS.** The problem of prediction for ARMA processes with switching parameters modelled as a finite-state Markov chain is considered. The Markov transition probability matrix is assumed to be unknown but constant and can take values only from a finite collection which contains the true transition matrix. A multiple-model prediction method is presented. The digital simulation shows a good performance of the proposed predictor. (Author abstract) 15 refs.

Qi, Xiao-Jiang (ETH, Lausanne, Switz). *Int J Control* v 47 n 3 Mar 1988 p 895-904.

**085725 FILTERING ALGORITHM FOR ONE CLASS OF DISCRETE-CONTINUOUS MARKOV PROCESSES.** In utilization of filtering algorithms for discrete-continuous Markov processes (DCMP) there is a typical situation in which the parameters of the mixture received may be described by two vector Markov processes  $\beta$ ,  $\lambda$  with different minimum correlation time for the respective components. A DCMP filtering algorithm has been obtained by the author previously for constant  $\beta$ . Here the results are extended to the case of variable  $\beta$ , also including the parameters of the random delay in subelements of the signal. A new algorithm has been obtained that is optimal in Gauss approximation for DCMP filtering that generalizes the approximate algorithms obtained elsewhere that use feedback with respect to a discrete parameter (ADFPB) and with overassignment of continuous parameters (AOCP). 3 refs.

Chesnokov, M.N. *Radioelectron Commun Syst* v 30 n 9 1987 p 79-81.

**085726 PREDICTION IN ZERO-ONE RANDOM SEQUENCES.** A method for prediction in sequences of random variables which assume only two values (say zero and one) is derived. The method is based on the application of the higher order Markovian model with pair interactions and it suits well in case of rather short sequence of observed data and long range of dependence. The obtained result is formulated in a way which is easy to be implemented and a numerical example with simulated data is included. (Author abstract) 5 refs.

Janzura, M. *Probl Control Inf Theory* v 17 n 1 1988 p 15-22.

**085727 IMPROVED ALGORITHM TO APPROXIMATE THE BEHAVIOR OF FLOW LINES.** An approximation method is given for the analysis of flow lines with a continuous product flow. The algorithm is an improvement of an earlier developed method. It is applied here to lines in which the machines are unreliable with exponentially distributed life and repair times. All intermediate buffers have finite capacity. The algorithm consists of repeated decomposition and aggregation steps, in which two-stage lines are approximated by a single machine. The method appears to be fast and performs well for lines which are not too long. (Edited author abstract) 14 refs.

De Koster, M.B.M. (Eindhoven Univ of Technology, Eindhoven, Neth). *Int J Prod Res* v 26 n 4 Apr 1988 p 691-700.

**085728 NEW RESULTS ON THE ENUMERATION OF NON-INTERSECTING RANDOM WALKS.** Many attempts have been made to obtain approximations and closed forms for the generating function enumerating



non-intersecting (self-avoiding) walks on a periodic lattice. In this paper we introduce an approach based on the Mayer cluster theory of imperfect gases and liquids and apply it to a continuum model and to a lattice model. The combinatorics are appreciably simpler than it is to a continuum model and to a lattice model. The combinatorics are appreciably simpler than for the Mayer problem. We have not yet solved any such problems analytically, but a combination of analytical work and a series expansion enables us to approach the exact generating functions as closely as we please. The starting point is an approximation very similar to the Percus-Yevick approximation for liquids and this can be progressively improved upon. (Author abstract) 10 refs.

Temperley, H.N.V. *Discrete Appl Math* v 19 n 3 Mar 1988 p 367-379.

**085729 FIRST PASSAGE APPROXIMATION FOR NORMAL STATIONARY RANDOM PROCESSES.** A new approximate solution for the first passage probability of a stationary Gaussian random process is presented which is based on the estimation of the mean clump size. A simple expression for the mean clump size is derived in terms of the cumulative normal distribution function, which avoids the lengthy numerical integrations which are required by similar existing techniques. The method is applied to a linear oscillator and an ideal bandpass process and good agreement with published results is obtained. By making a slight modification to an existing analysis it is shown that a widely used empirical result for the asymptotic form of the first passage probability can be deduced theoretically. (Author abstract) 27 refs.

Langley, R.S. (Cranfield Inst of Technology, Cranfield, Engl). *J Sound Vib* v 122 n 2 Apr 22 1988 p 261-275.

**085730 EFFICIENT SOLUTION PROCEDURE FOR TRANSIENT MARKOV PROCESSES.** We present a procedure for computing transient solutions to discrete state space, continuous time Markov processes. This procedure, based on the Laplace transform, computes transient state probabilities. The technique is applied to a Markov process model of a two-unit cold standby system for illustrative purposes. The main advantage of the procedure is that the time value has no effect on the time needed to compute the state probabilities. (Author abstract) 4 refs.

Eddaifi, D. (Ecole Natl Supérieure d'Informatique et d'Analyse des Systèmes, Agdal Rabat, Morocco). *Microelectron Reliab* v 28 n 2 1988 p 235-241.

**085731 ON ENTROPY OF RANDOM SETS AND POSSIBILITY DISTRIBUTIONS.** The concept of entropy of stochastic systems, as a measure of uncertainty, is examined for the case of random sets. Motivated by the connection between possibility theory and random sets, the principle of maximum entropy is discussed as a selection criterion for choosing random set representations. (Author abstract) 18 refs.

Nguyen, Hung T. *Anal of Fuzzy Inf* Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 145-156.

**085732 APPROXIMATION FOR OPTIMAL STOPPING OF A PIECEWISE-DETERMINISTIC PROCESS.** This paper deals with approximation techniques for the optimal stopping of a piecewise-deterministic Markov process (P.D.P.). Such processes consist of a mixture of deterministic motion and random jumps. We study the optimal stopping problem with lower semianalytic gain function; our main result is the construction of  $\epsilon$ -optimal stopping times. We consider a P.D.P. satisfying some smoothness conditions, and for  $N$  integer we construct a discretized P.D.P. which retains the main characteristics of the original process. By iterations of the single jump operator from  $R^N$  to  $R^N$ , each iteration consisting of  $N$  one-dimensional minimizations, we can calculate the payoff function of the discretized process. We demonstrate the convergence of the payoff functions, and for the case when the state space is compact we construct  $\epsilon$ -optimal stopping times for the original problem using the payoff function of the discretized problem. A numerical

example is presented. (Edited author abstract) 24 refs.

Costa, O.L.V. (Imperial Coll, London, Engl); Davis, M.H.A. *Math Control Signals Syst* v 1 n 2 1988 p 123-146.

**085733 EMPTY ENVELOPE EXCURSIONS IN STATIONARY GAUSSIAN PROCESSES.** The probability of the adverse event of upcrossing, within a given time interval, of some critical level by some structural random vibration response quantity is usually evaluated on the conservative side in terms of the mean upcrossing rate. Due to clumping of the upcrossings the evaluation may become overly conservative. This is remedied by only counting the non-empty excursions above the level of a suitable envelope of the response. Some excursions can be 'empty' in the sense that no upcrossings of the response occur during the excursion of the envelope. The long run fraction of empty excursions of the Cramer-Leadbetter envelope is evaluated for a stationary and ergodic Gaussian process by use of the regression method. The formula obtained is an approximation that improves earlier assessments due to Vanmarcke. (Edited author abstract) 7 refs.

Ditlevsen, O. (Technical Univ of Denmark, Lyngby, Den); Lindgren, G. *J Sound Vib* v 122 n 3 May 8 1988 p 571-587.

**085734 SIMPLE AND EFFICIENT ALGORITHM TO COMPUTE TAIL PROBABILITIES FROM TRANSFORMS.** We present an algorithm to approximately compute the 'tail' probability that a random variable exceeds a specified number, given only an expression for its transform. We also show that the problem is #P-hard (more difficult than NP-hard), suggesting that no efficient procedure can solve it exactly. Our method consists essentially of summing a power series, and thus is easy to perform and requires little memory. Furthermore, its computational effort is nearly linear in the reciprocal of a prescribed worst-case error bound. (Author abstract) 6 refs.

Platzman, Loren K. (Georgia Inst of Technology, Atlanta, GA, USA); Ammons, Jane C.; Bartholdi, John J. III. *Oper Res* v 36 n 1 Jan-Feb 1988 p 137-144.

**085735 DISTRIBUTION OF THE VALUES OF A RECURSIVE PULSED PROCESS.** The fact is now firmly established that processes whose properties are very similar to those of random processes can arise in strictly deterministic dynamic systems without any 'contaminating' noise. Radio-electronic devices occupy a special place among systems capable of stochastic behavior. A deterministic process in the form of a sequence of uniformly spaced pulses with recursively related amplitudes is considered. The distribution function of the process is derived by time averaging, and its properties are studied. The conditions under which this distribution approaches a normal distribution are investigated. (Edited author abstract) 11 refs.

Gukov, G.B. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 119-125.

**085736 REDUCTION OF PERTURBED MARKOV GENERATORS: AN ALGORITHM EXPOSING THE ROLE OF TRANSIENT STATES.** A new algorithm for the hierarchical aggregation of singularity perturbed finite-state Markov process is derived. The approach taken bridges the gap between conceptually simple results for a relatively restricted class of processes and the significantly more complex results for the general case. The critical role played by (almost) transient states is exposed, resulting in a straightforward algorithm for the construction of a sequence of aggregate generators associated with various time scales. These generators together provide a uniform asymptotic approximation of the original probability transition function. (Author abstract) 21 refs.

Rohlicek, Jan Robin (Bolt, Beranek & Newman Lab Inc, Cambridge, MA, USA); Willsky, Alan S. *J Assoc Comput Mach* v 35 n 3 Jul 1988 p 675-696.

**085737 VARIANCE CALCULATIONS FOR**

**TWO-DIMENSIONAL ARMA PROCESSES.** This note describes a method for computing the exact numerical value of the variance of a two-dimensional (2-D) ARMA process. Such calculations are useful in connection with current work on 2-D smoothers and predictors. Comparison is made of various methods of variance calculation using both 1-D and 2-D models. (Edited author abstract) 1 Ref.

Zarrop, M.B. (UMIST, Manchester, Engl). *Int J Control* v 48 n 1 Jul 1988 p 29-32.

**085738 SOME ELEMENTARY PROOFS OF THE NORMALITY OF  $X_Y/(X^2 + Y^2)^{1/2}$  WHEN X AND Y ARE NORMAL.** We give three elementary and short proofs of the following statement: if  $X$  and  $Y$  are independent, normally distributed random variables with zero means and variances  $\sigma^2 > 0$  and  $\tau^2 > 0$ , respectively, then the random variable  $XY/(X^2 + Y^2)^{1/2}$  is also normal with mean zero and standard deviation  $\sigma\tau/(\sigma + \tau)$ . No knowledge of the theory of stable laws is needed. (Author abstract) 3 Refs.

Baringhaus, L. (Univ Hannover, Hanover, West Ger); Henze, N.; Morgenstern, D. *Comput Math Appl* v 15 n 11 1988 p 943-944.

**085739 SOLUTION OF THE NONLINEAR STOCHASTIC REALIZATION PROBLEM.** In a recent paper we have constructed a solution of the nonlinear stochastic realization problem. The purpose of this paper is to announce the result to system theorists, as well as to motivate the approach by considering in detail some simple examples. (Author abstract) 15 Refs.

Taylor, T.J. (Arizona State Univ, Tempe, AZ, USA); Pavon, M. *Syst Control Lett* v 11 n 2 Aug 1988 p 117-121.

**085740 DIRECT PROOF OF THE EXPONENTIAL LIMIT LAW FOR ONE DIMENSIONAL SMALL NOISE DIFFUSION PROCESSES.** In a recent paper C. Kipnis and C.M. Newman introduced a simple mathematical model of a Markov process that illustrates in a nontrivial way the phenomenon of metastability. Starting with this model the author gives a direct proof of a limit theorem for the renormalized escape time of the process. This problem has direct application to the performance of the slotted ALOHA protocol. 5 Refs.

Rosenkrantz, Walter A. (Univ of Massachusetts, Amherst, MA, USA). *J Math Anal Appl* v 133 n 2 Aug 1 1988 p 359-365.

**085741 MODEL ORDER ESTIMATION FOR PARTIALLY OBSERVED MARKOV CHAINS.** Model order estimation for the partially observed Markov chain (POMC), also called the hidden Markov model, is addressed. Model order is defined as the number of independent model parameters. Simulation is used to investigate the small sample performance of a number of model order criteria, as applied to POMC models with low state dimension and binary observations. Consistency of these criteria in the context of POMC models with discrete state and observation space is also investigated. A criterion due to Akaike is shown not to be consistent. Simulation results indicate that Akaike's criterion can provide more accurate estimation in the small sample case. (Author abstract) 18 Refs.

Whiting, R.G. (Univ of Toronto, Toronto, Ont, Can); Pickett, E.E. *Aeronautics* v 24 n 4 Jul 1988 p 569-572.

**085742 STOCHASTICALLY MINIMIZING TOTAL PENALTY COSTS IN THE TWO-MACHINE FLOW SHOP WITH RANDOM PROCESSING TIMES.** A set of  $n$  jobs is to be processed on two machines in series. The job processing times are independent random variables. We first develop a sufficient condition on the processing time distributions to reduce stochastically a total penalty cost function. We then establish, for exponential job processing times, a set of sufficient and transitive conditions for stochastically



minimizing a total penalty cost function. Two examples are given to illustrate the results. (Author abstract). 11 refs.

Forst, Frank G. (Loyola Univ of Chicago, Chicago, IL, USA). *Am J Math Manage Sci* v 8 n 1-2 1988 p 121-133.

**085743 MULTIVARIATE STOCHASTIC DOMINANCE WITH FIXED DEPENDENCE STRUCTURE.** Stochastic dominance conditions for multivariate prospects are provided under the assumption of equal dependence structure for the prospects. These conditions are easily testable since they involve only the marginal distribution functions. This note proves that the crucial assumption is not independence, but rather the fact that the two random vectors have the same dependence structure, in a sense that will be specified. Therefore, whenever two random vectors have the same dependence structure, then multivariate stochastic dominance conditions may be provided simply by examining the marginal distribution functions of each of the components of the random vectors. (Edited author abstract). 19 refs.

Scarsini, Marco (Univ 'La Sapienza', Rome, Italy). *Oper Res Lett* v 7 n 5 Oct 1988 p 237-240.

**085744 IMAGING BLACK BOXES WITH MULTIPLE STOCHASTIC OUTPUT.** A black box is modeled by decomposition into an unknown but finite number of independent noise sources and of independent signal sources. Signal sources carry signals in strict relation to an input signal vector. Output signal vectors are transformable into a system-state vector by means of stochastic properties of an assembly of independent noise sources. By proper scaling such system-state vectors are measurable. The internal organization structure can be imaged by the correlation of components of the state vector. This correlation reflects overlap of so-called activity profiles which are defined by the fraction of signal sources and of noise sources used in the formation of a response. In accordance with the two kinds of sources, there are two complementary images, for overlap of noise sources and for overlap of signal sources, respectively. 6 refs.

Eijkman, Eg G. *IEEE Trans Syst Man Cybern* v SMC-17 n 5 1987 p 828-833.

**085745 ON THE DISTRIBUTION OF POSITIVE-DEFINITE GAUSSIAN QUADRATIC FORMS.** To describe the performance of quadratic signal processing used in detection and estimation of random signals, the probability distribution, of the output of the processor is needed. Positive-definite Gaussian quadratic forms are considered here. The quadratic form is diagonalized in terms of independent Gaussian variables and its mean, moment-generating function, and cumulants are computed. Conditions are given for the quadratic form to be  $\chi^2$  distributed and distributed like a sum of independent random variables having a Gamma distribution. A method is proposed to approximate its probability distribution using an expansion in Laguerre polynomials for the central case and in generalized  $\chi^2$  distributions in the noncentral case. The series coefficients and bounds on truncation error are evaluated. Some applications in average power and power spectrum estimation and in detection illustrate the method. 32 refs.

Tziritas, Georgios G. (CNRS, St. Martin d'Heres, Fr). *IEEE Trans Inf Theory* v IT-33 n 6 p 895-906.

**085746 NUMBER OF DEGREES OF FREEDOM, CORRELATION TIMES, AND EQUIVALENT BANDWIDTHS OF A RANDOM PROCESS.** New definitions for the number of degrees of freedom (NDF) of a stationary process are proposed and their general form derived for Gaussian processes. Correlation times and equivalent bandwidths, which have been important in random processes and some fields in physics, are deduced from the first-order and second-order NDF and studied. 9 refs.

Kikkawa, Sho (Tokyo Women's Medical Coll, Jpn); Ishida, Masayuki. *IEEE Trans Inf Theory* v 34 n 1 Jan 1988 p 151-155.

**085747 REPRESENTATIONS FOR MULTIVARIATE RECIPROCAL GAUSSIAN PROCESSES.** Multivariate reciprocal Gaussian processes are represented as a sum of two independent processes: a piecewise Markov process, which is also represented in terms of a Wiener-type process, and a time-dependent linear transformation of a normally distributed random vector. This result is then applied to the first-passage time problem. 19 refs.

Carmichael, Jean-Pierre (Univ of Laval, Que, Can); Masse, Jean-Claude; Theodorescu, Radu. *IEEE Trans Inf Theory* v 34 n 1 Jan 1988 p 155-157.

**085748 NONSTATIONARY NOISE EFFECTS IN THE ABEL INVERSION.** A method for calculating the autocorrelation function of the output noise resulting from the Abel inversion of a wide-sense stationary random process is presented. An internal formula that expresses the autocorrelation in terms of the power spectral density of the input noise and explicitly as a function of radial position is derived. Asymptotic approximations for the variance are found for the case of bandlimited white input noise. 16 refs.

Smith, L. Montgomery (Univ of Tennessee Space Inst, Tullahoma, TN, USA). *IEEE Trans Inf Theory* v 34 n 1 Jan 1988 p 158-161.

**085749 ESTIMATION IN A RANDOM CENSORING MODEL WITH INCOMPLETE INFORMATION: EXPONENTIAL LIFETIME DISTRIBUTION.** Analysis of methods and simulation results for estimating the exponential mean lifetime in a random-censoring model with incomplete information are presented. The instant of an item's failure is observed if it occurs before a randomly chosen inspection time and the failure is signaled. Otherwise, the experiment is terminated at the instant of inspection during which the true state of the item is discovered. The maximum-likelihood method (MLM) is used to obtain point and interval estimates for item mean lifetime, for the exponential model. It is demonstrated, using Monte Carlo simulation, that the MLM provides positively biased estimates for the mean lifetime and that the large-sample approximation to the log-likelihood ratio produces accurate confidence intervals. The quality of the estimates is slightly influenced by the value of the probability of failure to signal. Properties of the Fisher information in the censored sample are investigated theoretically and numerically. 5 refs.

Elperin, Tov I. (Ben-Gurion Univ of the Negev, Beer Sheva, Isr); Gertsbak, Ilya B. *IEEE Trans Reliab* v 37 n 2 Jun 1988 p 223-229.

**Safety Codes See STRUCTURAL DESIGN—Reliability.**

**Theory See Also COMPUTER SYSTEMS, DIGITAL—Fault Tolerant Capability; HEAT TRANSFER—Radiation; MATHEMATICAL TECHNIQUES—Error Analysis; MATHEMATICAL TECHNIQUES—Fuzzy Sets; RELIABILITY THEORY; SOLAR ENERGY—Storage; STRUCTURAL DESIGN—Reliability.**

**085750 PROBABILITE ET DECISION.** [Probability and Decision]. The decision theory proposes to establish a rational base for action in uncertainty. It is a normative theory as it elaborates the rules according to which a system of rational decision (human or technical) will have to act. It is also a descriptive theory which searches to discover and to formalize algorithms utilized by other humans in presence of uncertainty. 4 refs. In French.

Belis, Marianne. *Cybernetica* v 30 n 1 1987 p 57-74.

**085751 COMPUTING THE PHASE-TYPE RENEWAL AND RELATED FUNCTIONS.** This article presents a procedure for computing the renewal function, the renewal density, the integral of the renewal function, and the variance function of phase-type renewal processes. The procedure hinges on the computation of the state probability vector of a continuous-time Markov chain. This is accomplished by using a randomization approach that is simple, efficient, and numerically stable and does not require numerical integration. The author discusses approximating arbitrary interrenewal distributions by

phase-type distributions so that the procedure can be used to approximate renewal and related functions. (Edited author abstract) 24 refs.

Kao, Edward P.C. (Univ of Houston, Houston, TX, USA). *Technometrics* v 30 n 1 Feb 1988 p 87-93.

**085752 ON THE CORRELATION BETWEEN INTER-ARRIVAL DELAYS OF SHOCKS.** An attempt has been made to obtain the correlation between the waiting times between the (i-1)th to ith and the (j-1)th to jth shocks ( $j > i$ ) ( $i, j = 0, 1, 2, \dots$ ) which a component has received. The arrival rate of a shock is taken to be Poisson, which is assumed to vary from component to component following a gamma distribution leading to a dependent process. A simple method of estimating the parameters of the process has been illustrated. The application of the result and a device to remove the effect of the correlation coefficient in developing shock models is discussed. (Edited author abstract) 5 refs.

Biswas, Suddhendu (Univ of Delhi, Delhi, India); Kumar Sehgal, Vijay. *Microelectron Reliab* v 28 n 2 1988 p 189-192.

**085753 PROBABILITY DENSITIES FOR CONDITIONAL STATISTICS IN THE CUBIC SENSOR PROBLEM.** This paper applies the techniques of Malliavin's stochastic calculus of variations to Zakai's equation for the one-dimensional cubic sensor problem in order to study the existence of densities of conditional statistics. Let  $\{X_t\}$  be a Brownian motion observed by a cubic sensor corrupted by white noise, and let  $\phi$  denote the unnormalized conditional estimate of  $\phi(X_t)$ . If  $\phi_1, \dots, \phi_n$  are linearly independent, and if  $\Phi = (\phi_1, \dots, \phi_n)$ , it is shown that the probability distribution of  $\Phi$  admits a density with respect to Lebesgue measure for any  $n$ . This implies that, at any fixed time, the unnormalized conditional density cannot be characterized by a finite set of sufficient statistics. (Author abstract) 13 refs.

Ocone, Daniel (Rutgers Univ, New Brunswick, NJ, USA). *Math Control Signals Syst* v 1 n 2 1988 p 183-202.

**085754 FIRST- AND SECOND-ORDER BOUNDS ON TERMINAL RELIABILITY.** We show that existing network algorithms solve the terminal reliability bound problem under limited information about the probabilities of operation of the components. Tightening of the bounds is achieved by introducing bounds on the probabilities that pairs of network components fail. A heuristic algorithm is developed to determine a tighter lower bound. The problem of the upper bound is addressed. Our approach discards the traditional assumption of statistical independence of components failures. (Edited author abstract) 14 refs.

Yael Assous, J. (AT&T, Holmdel, NJ, USA). *Networks* v 16 n 3 Fall 1986 p 319-329.

**PROBES See Also AEROSOLS—Physical Properties; AGRICULTURAL WASTES—Rheology; CHEMICAL OPERATIONS—Fluidization; COKE MANUFACTURE—Temperature Measurement; COMBUSTION—Fluidized Beds; ELECTRONIC CIRCUITS, DIFFERENTIATING—Computer Aided Design; FLOW OF FLUIDS—Two Phase; GELS—Spectroscopic Analysis; GOLD DEPOSITS—Japan; MANOMETERS—Performance; MOLECULES—Diffusion; PLASMAS—Measurements; POLYMERS—Solutions; POLYPROPYLENE—Spectroscopic Analysis; SHIPS—Instruments; SPECTROMETERS—Components; STEELMAKING—Physical Chemistry; STEELMAKING—Sensors.**

**085755 RESPONSE OF PLANAR POTENTIOMETRIC PROBES TO CHANGES IN POLARIZATION CONDITIONS OF THE COPPER ELECTRODE.** The concentrations of species having an intermediate oxidation state (SIOS) generally are measured with indicator electrodes. It is the aim of this work to describe a potentiometric indicator electrode which can be used for measuring the concentration changes of SIOS under transient conditions. It is found that the concentration changes which occur in the solution layer next to the electrode when a cathodic current is turned on in a  $\text{Cu}^{2+}$



-ion-containing solution consist of an accumulation and consumption of Cu+ SIOS. The data reported also show that planar indicator electrodes can be useful in solving electrochemical problems, since universal information can be obtained; they can be used when studying the transient changes in the concentrations of SIOS at electrodes in real hydrodynamic situations. The concentration changes in the layer next to the electrode can be estimated from the current of SIOS oxidation when planar platinum indicator electrodes are used. 14 refs.

Yarkhunov, V.L. (S.M. Kirov Chemical Engineering Inst, Kazan, USSR); Gudim, N.V.; Gil'manshin, G.G.; Andreev, I.N. *Sov Electrochem* v 22 n 9 Sep 1986 p 1168-1170.

**085756 INVESTIGATION OF BUBBLE DYNAMICS IN POOL BOILING IN HIGH HEAT FLUX REGION.** It has been hypothesized that the pool boiling at high heat flux is characterized by the formation of a liquid layer known as macrolayer which is trapped between the heating surface and the vapor mass. The thickness of the macrolayer and the initiation, growth and departure cycle periods of the vapor mass have been found to be the critical parameters that determine heat flow rate from heated surface. The theory of electric probe method to determine bubble emission frequency and initial thickness of the liquid macrolayer has been described in this paper. The experimental procedure has been found to give results which conform to the findings of previous investigators. This simple though indirect method could be used for detailed investigations of bubble dynamics at high heat fluxes. (Author abstract) 8 refs.

Bhat, A.M. (Regional Engineering Coll, Srinagar, India); Saini, J.S.; Prakash, R. *J Inst Eng India Part ME* v 68 pt 3 Nov 1987 p 52-56.

**085757 TECHNIQUE FOR MEASUREMENT OF JET PENETRATION IN HOT FLUIDIZED BEDS WITH A MODIFIED PITOT-TUBE PROBE.** A miniature probe with a modified Pitot-tube design was developed to measure the local momentum flux in a fluidized bed. With this probe, and with an isolated jet in the grid zone of a high-temperature fluidized bed, an experimental technique to locate a jet and measure the jet penetration was developed. At the measured jet height, dynamically, the jet phase becomes homogeneous with the surrounding emulsion phase; visually, this corresponds to the height where the bubble detaches from the jet. With this technique, invisible jets at the interior of the bed can be located and their penetration heights measured. A semiempirical procedure is suggested to measure the width of the dynamic core of the jet with this probe. (Edited author abstract) 15 refs.

Raghuathan, K. (West Virginia Univ, Morgantown, WV, USA); Mori, Hideki; Whiting, Wallace B. *Ind Eng Chem Res* v 27 n 6 Jun 1988 p 1011-1016.

**085758 VORONOI POLYHEDRA AS STRUCTURE PROBES IN LARGE MOLECULAR SYSTEMS - VII. CHANNEL IDENTIFICATION.** The use of Voronoi polyhedra as a tool in identifying channels and crypts in atomic assemblies is presented and discussed. It is clear that Voronoi polyhedra's volumes and adjacencies allow an artificial assessment of the possibility of a channel existing in a cluster based solely on the instantaneous coordinates of all the centers in the system. (Edited author abstract) 5 refs.

David, Carl W. (Univ of Connecticut, Storrs, CT, USA). *Comput Chem* v 12 n 3 1988 p 207-208.

**085759 KOORDINATENMESSUNG MIT EINEM LASER TRIANGULATIONSTASTER.** [Coordinate Measurement With a Laser Triangulation Probe]. The contactless-measuring laser triangulation probe with turn-and-swivel fixture for precision column-type measuring instruments solves problems in plastic parts and vehicle body measuring systems where tactile sensors fail. After presenting a brief outline of the complete system, the article describes the principles of laser triangulation, the structure of the probe head, its methods of measurement

and applications. (Author abstract). In German.

Koch, Klaus P.; Peter, Ralf; Weisig, Sigurd. *F&M Feinwerktech Messtech* v 96 n 6 Jun 1988 p 253-257.

**Applications** See Also CHEMICAL EQUIPMENT—Fluidized Beds; ELECTRIC MEASUREMENTS—Resistance; MACHINE TOOLS—Automation; MICROANALYSIS—Equipment; PLASMAS—Diagnostics; STEEL—Continuous Casting; SUPERCONDUCTING MATERIALS; SUPERCONDUCTING MATERIALS—Microanalysis.

**085760 PARTICLE VELOCITY MEASUREMENTS THROUGH ELECTROSTATIC FIELD FLUCTUATIONS USING EXTERNAL PROBES.** Two probes for measuring particle velocity and flowrate based on the electrostatic field nature of a pneumatic transport system are introduced. The first probe is based on the current of charged particles inducing a current in a coil placed perpendicular to the flow. The magnitude of the current induced appears to be related to the amount of charged particles passing through the coil and the velocity of the particles. The second probe utilizes fluctuations in the electrostatic field which are picked up by two probes placed a fixed distance along the axis of the flow. The signals from these two probes are identical in waveform but offset in time, therefore, particle velocity can be obtained by cross-correlation techniques. (Edited author abstract) 6 refs.

Klinzing, George E. (Univ of Pittsburgh, Pittsburgh, PA, USA); Zaltash, Abdolreza; Myler, Craig A. *Part Sci Technol* v 5 n 1 1987 p 95-104.

**Automation** See ELECTRIC MOTORS, LINEAR—Reliability.

## Calibration

**085761 FREQUENCY RESPONSE OF A CONSTANT-TEMPERATURE HOT-WIRE TO TEMPERATURE FLUCTUATIONS.** A temperature-sensitive hot-wire under constant-temperature operation is analyzed to predict its frequency response to temperature fluctuations of the fluid. Effects of the finite Wollaston length, the over-heat ratio and the transconductance of the amplifier are taken into account, and a precise expression for the transfer function is derived. Various probes with different geometries are dynamically calibrated using the new developed procedure, in which a linear temperature distribution or a thermal wake just behind parallel line-sources is utilized to generate prescribed temperature fluctuations over a wider range of frequencies. Good agreement is obtained between the predictions and the experimental results on the gain of the sensitivity. (Edited author abstract) In Japanese. 4 refs.

Maekawa, Hiroshi; Kobayashi, Mutsuo; Yashiro, Kazuo. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 492 Aug 1987 p 2560-2566.

**085762 RIG FOR THE STATIC CALIBRATION OF CONSTANT-TEMPERATURE HOT WIRES AT VERY LOW VELOCITIES.** A rig for the calibration of hot-wire anemometer probes at velocities below 1 m/s that uses a stepping motor to drive the probe at controlled velocities down the center of an enclosed channel is described. A typical calibration curve (over the range 0.02-1 m/s) displays the usual characteristics of a hotwire probe under combined natural and forced convection. A reasonable degree of fit with an equation of the form proposed by Van der Hegge Zijnen is demonstrated. Repeated calibrations confirm the very high accuracy of the rig, which demonstrates its suitability for detailed study of this interesting flow regime as well as for straightforward calibration. (Author abstract) 6 refs.

Heikal, M. (Brighton Polytechnic, Brighton, Engl); Antoniou, A.; Cowell, T.A. *Exper Therm Fluid Sci* v 1 n 2 Apr 1988 p 221-223.

## Components

**085763 SPIN POLARIZATION ANALYZER ATTACHMENT TO A SCANNING AUGER MICRO-PROBE.** A new, compact electron spin polarization

analyzer attachment to a scanning Auger microprobe has been described. Its operation and present performance have been demonstrated using the SEMPA technique to image the surface magnetic microstructure of three different types of magnetic samples. The unique advantages of SEMPA have been identified previously; those that were illustrated in these applications are: (1) the technique is surface sensitive; (2) the magnetic structure is imaged independently of the surface topography; (3) the contrast and signal are large; and (4) all three components of the polarization can be determined and therefore the surface magnetic vector can be mapped. Additionally, high spatial resolution can be achieved. (Author abstract). 11 refs.

Welkie, David G. (Perkin-Elmer Corp, Prairie, MN, USA). *Surf Interface Anal* v 11 n 12 Sep 1988 p 605-610.

**Computer Interfaces** See LOGIC CIRCUITS—Analysis.

**Design** See Also BLAST FURNACE PRACTICE—Fuels.

**085764 DIRECT COUPLING OF OPEN-TUBULAR LIQUID CHROMATOGRAPHY WITH MASS SPECTROMETRY.** The design and performance of a probe that allows direct liquid introduction of the total effluent of an open-tubular liquid chromatography (OTLC) column into a mass spectrometer are described. No modification of the mass spectrometer source is required, and the probe is introduced through the direct insertion probe inlet. Because flow rates are less than 0.1  $\mu\text{L}/\text{min}$ , this system can be used under both conventional electron impact and chemical ionization mass spectrometric conditions. (Edited author abstract) 20 refs.

de Wit, Jos S.M. (Nat'l Inst of Environmental Health Sciences, Research Triangle Park, NC, USA); Parker, Carol E.; Tomer, Kenneth B.; Jorgenson, James W. *Anal Chem* v 59 n 19 Oct 1 1987 p 2400-2404.

**085765 DESIGN AND CALIBRATION OF A GAMMA RAY TRANSMISSION DENSITY PROBE.** A dual probe gamma ray transmission gage has been designed in LNETI for the measurement of soil porosities and bulk densities. The gage makes use of a 4 cm GM counter and of a  $^{137}\text{Cs}$  source, and can be operated at a source-detector distance of either 20 or 30 cm. The gage performance and main parameters were studied experimentally as well as by means of a computer simulation. The experiments were carried out both in the laboratory and on the field. Monte Carlo simulations were performed for both Cs and Co sources and the two source-detector distances. Reported here are calibration curves for sensitivity, relative statistical errors and resolution. Good agreement has been found between simulated and experimental data. (Author abstract) 4 refs.

Oliveira, Carlos (Lab Nacional de Engenharia e Tecnologia Industrial, Sacavem, Port); Salgado, Jose. *Nucl Instrum Methods Phys Res Sect A* v A260 n 1 Oct 1 1987 p 276-279.

**Evaluation** See TEXTILE FIBERS—Measurements.

## Fabrication

**085766 FABRICATION AND CHARACTERIZATION OF A FIBER-OPTIC-BASED SPECTROELECTROCHEMICAL PROBE.** Probes were constructed from fused silica optical fibers embedded in electrically conductive graphite/epoxy material with the optical end face and the working electrode active surface in a coplanar arrangement. The electrochemical properties and spectroelectrochemical response of the microprobe were characterized in solutions and in gels containing UV-absorbing oxidizable compounds. The concept of electrochemical modulation of spectral signals for fiber-optic-assisted spectroscopy was demonstrated by using the ascorbate/dopamine gel model. (Edited author abstract). 15 refs.

Van Dyke, David A. (Smith Kline & French Lab, Philadelphia, PA, USA); Cheng, Hung-Yuan. *Anal Chem* v 60 n 13 Jul 1 1988 p 1256-1260.



**085767 FABRICATION OF AN INTEGRATED MICROPROBING HEAD FOR FAULT ANALYSIS OF MOS INTEGRATED CIRCUITS.** The fabrication of an integrated microprobing head for fault analysis of MOS ICs is described. The microprobe is etched out from a silicon wafer to a tip size of about 10  $\mu\text{m}$  and it has an NMOS impedance transformer integrated very close to the tip. The input capacitance of this device is smaller than 0.1 pF and the delay time (at 50% of the final value) is lower than 100 ns at a 100 k $\Omega$  signal source resistance. This is a significant improvement on the response time of a conventional microprobe. (Author abstract) 4 refs.

Shoji, Shuichi (Tohoku Univ, Sendai, Jpn); Esashi, Masayoshi; Matsuo, Tadayuki. *Sens Actuators* v 14 n 2 Jun 1988, Pap Presented at the 2nd Int Meet on Chem Sens, Bordeaux, Fr, Jul 7-10 1986 p 125-132.

**hydraulic Drive** See SOILS—Sampling.

**Microwaves** See Also MICROSTRIP DEVICES—Standards.

**085768 PROBING TECHNIQUES BECOME CRUCIAL ABOVE 500 MHz.** As circuit and oscilloscope bandwidths increase, getting distortion-free signals to the scope is an increasing challenge. Probe effects that are bothersome at 100 MHz become devastating at 1 GHz. By understanding how probes interact with high-frequency circuits, one can improve the chances of making accurate measurements. (Edited author abstract)

Walters, Eldon (Tektronix Inc); Kaveckis, Stan. *EDN* v 32 n 21 Oct 15 1987 p 165-170, 172, 174.

**Optimization** See Also ELECTRON BEAMS.

**085769 OPTIMIZATION OF SMALL ELECTRON PROBES.** The size of an electron probe is determined by many different factors including diffraction, lens aberrations, space charge and defocus. In many applications it is desirable to optimize the probe to achieve the smallest size (or, equivalently, the best resolution). This is particularly difficult to do when the effect of diffraction is significant. We have noted that many of the published approaches to this problem are based upon false premises and give erroneous results. In this paper we attempt to correct at least some of these errors, although it is undoubtedly true that some remain. (Author abstract) 8 refs.

Crews, Albert V. (Univ of Chicago, Chicago, IL, USA). *Ultramicroscopy* v 23 n 2 1987 p 159-167.

**Performance**

**085770 PERFORMANCE OF A LOW-VOLTAGE HIGH-CURRENT-DENSITY ELECTRON PROBE.** A low-voltage high-current-density electron probe has been constructed. Electrons are extracted at 7 kV from a zirconiated tungsten thermal field emission source, pass through a two-lens collimated optical system, and are decelerated by a retarding field at the sample. A focused probe is obtained at 1-keV landing energy with 40-nm diameter and 320-nA current. The corresponding peak current density is  $1.3 \times 10^4 \text{ A/cm}^2$ . This result shows that space-charge beam broadening is much better controlled in these retarding field probes than in conventional low-voltage column designs where the extraction and landing energies are equal. 17 refs.

Wolfe, John C. (Univ of Houston, TX, USA). *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2435-2438.

**Selection** See PRINTED CIRCUITS—Testing.

**Surfaces**

**085771 ANALYSIS OF THE SURFACE-PROBE EQUATION.** An integrating surface-probe is a tool for the determination of local fluxes from surface-integrated measurements. For an axisymmetric system, the data

analysis involves the numerical solution of a severely ill-conditioned Volterra integral equation of the first kind. This study establishes the existence of a unique solution under certain conditions and considers solution techniques based on product integration and also the evaluation of the inversion integral. The methods are tested for convergence against exact input data, and the performance of the best methods against simulated experimental data is studied. (Author abstract) 24 refs.

Swathi, P.S. (Arizona State Univ, Tempe, AZ, USA); Cremers, C.J. *Exper Therm Fluid Sci* v 1 n 4 Oct 1988 p 385-394.

**Temperature Measurement**

**085772 NOVEL TEMPERATURE PROBE FOR MIDDLE ATMOSPHERIC AND METEOROLOGICAL APPLICATIONS.** A new type of temperature probe employing a novel feedback technique and making use of the temperature-dependent property of a commercial silicon 2N 2222 n-p-n transistor has been developed and successfully flight tested in meteorological balloons. The feedback technique employed not only overcomes the problems of DC drift but also enables handling of large signals. Its ability to measure absolute temperature and fast response (approx. 0.3 s) make this probe suitable for atmospheric studies and meteorological applications. (Author abstract) 2 refs.

Sridharan, R. (Physical Research Lab, Ahmedabad, India); Das, S.R.; Raghavarao, R. *J Phys E* v 20 n 10 Oct 1987 p 1199-1201.

**Testing** See MANOMETERS—Performance.

**PROCESS CONTROL** See Also ARTIFICIAL INTELLIGENCE; ARTIFICIAL INTELLIGENCE—Expert Systems; CEMENT PLANTS—Control Systems; CEMENT PLANTS—Optimization; CHEMICAL ENGINEERING—Education; CHEMICAL PLANTS—Accident Prevention; CHEMICAL PLANTS—Automation; CHEMICAL PLANTS—Control Systems; COMPUTER PROGRAMMING—Algorithms; COMPUTERS, MICROCOMPUTER—Industrial Applications; COMPUTERS, PERSONAL—Applications; CONTROL SYSTEMS; CONTROL SYSTEMS—Estimation; CONTROL SYSTEMS—Retrofitting; CONTROL SYSTEMS—Theory; CONTROL SYSTEMS, DISTRIBUTED PARAMETER—Modular Construction; CONTROL SYSTEMS, DISTRIBUTED PARAMETER—Performance; CONTROL SYSTEMS, NONLINEAR; CRYSTALS—Growing; CUTTING TOOLS—Manufacture; DATA TRANSMISSION; DATABASE SYSTEMS—Management; DISPLAY DEVICES—Liquid Crystal; DISTILLATION—Control; ELECTRIC BATTERIES, SECONDARY—Manufacture; ELECTRIC POWER PLANTS—Malaysia; ELECTRONIC EQUIPMENT MANUFACTURE; FASTENERS—Manufacture; FIBER OPTICS—Applications; FIBER OPTICS—Industrial Applications; GOLD PLATING—Solutions; HEAT TREATMENT—Process Control; INDUSTRIAL PLANTS—Accident Prevention; INDUSTRIAL PLANTS—Maintenance; INSTRUMENTS—Applications; INTEGRATED CIRCUIT MANUFACTURE—Production Control; INVENTORY CONTROL—Management; IRON AND STEEL PLANTS—Computer Integrated Manufacturing; IRON ORE TREATMENT—Crushing and Grinding; JOB ANALYSIS; LATHES—Control Systems; LITHOGRAPHY—Inspection; MATHEMATICAL STATISTICS; MEASUREMENT ERRORS; NUCLEAR FUELS—Quality Assurance; PACKAGING—Efficiency; PARTICLE SIZE ANALYSIS; PETROLEUM REFINERIES—Computer Applications; PETROLEUM REFINING—Fractionation; PHOTORESISTS—Photochemical Reactions; PLASTICS—Coloring; PLASTICS MACHINERY—Molding Machines; POWDER METAL PRODUCTS—Quality Assurance; PRINTED CIRCUITS—Assembly; PULP MANUFACTURE—Sulfite Process; PUMPS—Control Systems; QUALITY ASSURANCE; QUALITY CONTROL; QUALITY CONTROL—Management; ROLLING MILL PRACTICE—Plate; ROLLING MILL PRACTICE—Quality Control; SCALES AND WEIGHING—Control; SEALS—Manufacture; SEWAGE TREATMENT PLANTS—Computer Applications; SEWAGE TREATMENT PLANTS—Federal Republic of Germany; STEEL—Continuous Casting; STEEL—Refining; SYSTEMS SCIENCE AND CYBERNETICS—Cognitive Systems; VALVES AND VALVE GEAR—Selection; WASTEWATER—Biological Treatment; WELDING—Clad Metals.

**085773 ADAPTIVE OPTIMAL CONTROL OF DYNAMIC DISTRIBUTED OBJECTS.** The design of mathematical software for automatic technological process control systems requires the development of simple and effective control algorithms with feedback. The control problem becomes more complex if the parameters

of the model of the object are unknown and must be corrected in the course of operation of the closed system. Control algorithms can be significantly simplified using nonterminal (local) optimality criteria and sufficiently effective adaptive identification algorithm. The method of synthesis of adaptive control algorithms with identification, developed for lumped systems, is extended here to certain classes of distributed dynamic systems. 12 refs.

Ruban, A.I. *Cybernetics* v 23 n 1 Jan-Feb 1987 p 99-106.

**085774 MODELLGESTUETZTE PROZESSLEIT-TECHNIK IN DER VERFAHRENSTECHNISCHEN PRODUKTION.** [Model-Based Process Control Engineering in Chemical Engineering Production]. Modern process control engineering nowadays provides almost ideal tools for the implementation of even highly sophisticated control concepts. The very reluctant acceptance of these tools is due to the following bottlenecks: insufficient understanding of chemical engineering control processes; limitations in the acquisition of sensorial primary information; and insufficient performance of control engineering concepts. This article considers how these bottlenecks can be overcome. (Edited author abstract) In German. 30 refs.

Gilles, Ernst Dieter (Univ Stuttgart, Stuttgart, West Ger). *Chem Ing Tech* v 59 n 9 Sep 1987 p 715-726.

**085775 INDUSTRIAL PROCESS CONTROL STRATEGIES.** The age of the 'super' controller - the 'expert' system which employs artificial intelligence to supervise the control electronics in a process plant - is only a short step away. The author traces the development of process control from the turn-of-the-century meters and hand valves to today's expert systems. (Edited author abstract)

Ingrey, Andy. *Electron Power* v 33 n 9 Sep 1987 p 567-569.

**085776 FUTURE TRENDS IN PROCESS CONTROL.** Process control has advanced, over the past few decades, in a succession of large strides, the most significant single influence being digital-electronics technology. The author explains how artificial intelligence will shape the future of process control. (Edited author abstract)

Simmonds, W.H. *Electron Power* v 33 n 9 Sep 1987 p 570-572.

**085777 EFFECT OF DISTURBANCE DIRECTIONS ON CLOSED-LOOP PERFORMANCE.** The effectiveness of disturbance suppression in a multivariable control system can depend strongly on the direction of the disturbance. The 'disturbance condition number' is introduced to quantify the effect of disturbance direction on closed-loop performance. As an example a two-point composition control system for a distillation column is analyzed for various disturbance and set-point changes. (Author abstract) 9 refs.

Skogestad, Sigurd (California Inst of Technology, Pasadena, CA, USA); Morari, Manfred. *Ind Eng Chem Res* v 26 n 10 Oct 1987 p 2029-2035.

**085778 PROCESS CAPABILITY: ONE ELEMENT OF ZERO INVENTORIES.** The process capability study addresses whether the process is in control and whether the process is stable. It should be noted that the application of process capability analysis does not yield benefits in zero inventories environments alone; any manufacturing environment can gain significant improvement through its application. Further, this technology has an indirect impact on planning and scheduling; after all, if process yield can be predicted and controlled, disruption from manufacturing fallout will be lessened, and schedules can be more effectively stabilized. The application of this theory requires in-depth understanding and working



knowledge of the principles and techniques of statistical inference and prediction and their application to data samples and quality assurance. 7 refs.

Krupp, James A.G. (Sealectro Corp, Trumbull, CT, USA). *Prod Invent Manage* v 28 n 3 3rd Quarter 1987 p 17-21.

**085779 BILINEAR MODEL PREDICTIVE CONTROL.** Bilinear model predictive control is defined for single-input-single-output systems. Offset compensation is provided to correct for the effects of unmeasured disturbances and model inaccuracies. Controller tuning is accomplished through the adjustment of a single parameter. The control algorithm is explicit, which allows implementation without requiring large computer memory or rapid computational speed. A filter with a single parameter is used to correct for the effects of an incorrect model. (Author abstract) 26 refs.

Yeo, Yeong K. (Auburn Univ, Auburn, AL, USA); Williams, Dennis C. *Ind Eng Chem Res* v 26 n 11 Nov 1987 p 2267-2274.

**085780 VERALLGEMEINERTE PRAEDIKTOR-REGELUNG FÜR TOTZEITSYSTEME MIT APERIODISCHEM EINSCHWINGERHALTEN - ANFORDERUNGEN AN DIE PROZESSMODELLIERUNG.** [Generalized Predictor Feedback Control for Dead-Time Systems with Aperiodic Response - Requirements for Process Modeling]. For systems containing essential dead-times the author presents a feedback control based upon the principle of the prediction by an internal model, suited for stable process with aperiodic response, being robust against model errors and having no hard requirements as to the structure and linearity of the process. The risk of instability due to model errors is eliminated by introducing an insensitivity depending on the situation. (Author abstract) In German. 7 refs.

Uhlig, J. (TU Dresden, East Ger). *MSR Mes Steuern Regeln* v 30 n 8 Aug 1987 p 341-343.

**085781 STATISTICAL PROCESS CONTROL... THE OTHER SIDE OF THE QUALITY COIN.** Traditional quality control techniques are being challenged today by statistical process control (SPC) - a quality control alternative that reduces piece-part variability, concentrates process variables around a target, increases productivity, and ultimately results in more economic production. Developed in this country more than 50 years ago, its value has only recently been recognized in the U.S. This article explains what SPC is, details the benefits it provides, and discusses how it is best applied. The article concludes with a look at how SPC was successfully applied at Kavlico in the production of capacitive thick film pressure transducers.

Constantinou, Tat A. (Kavlico Corp, Moorpark, CA, USA). *Chilton's I&CS* v 60 n 11 Nov 1987 p 45-47.

**085782 PRODUCTION CONTROL ON THE BASIS OF FUZZY MODELS.** The efficiency of modern control systems for controlling production - of integrated automatic systems for continuous processes and flexible systems for discrete processes - is largely determined by the quality of models and algorithms for solving functional tasks corresponding to the level of control hierarchy. Experience shows that in control systems uncertainty of qualitative character is easily taken into consideration by applying the body of mathematics of fuzzy set theory. (Edited author abstract) 11 refs.

Aliev, Rafik A. (Baku Polytechnic Inst, Baku, USSR). *Fuzzy Sets Syst* v 22 n 1-2 Apr 1987 p 43-56.

**085783 HUMAN MODELING OF THE OPERATOR PROCESS INTERFACE.** The paper reviews some of the major approaches for modeling the human operator in process control systems. Approaches considered include theories of estimation, control and fuzzy sets. These approaches offer a wide variety of mathematical and logical tools that are useful for analyzing the operator-process interaction. (Author abstract) 34 refs.

Simcox, William (Consulting Statisticians Inc); Kreifeldt, John. *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul* Publ by TAPPI Press, Atlanta, GA, USA, 1985 p 145-153.

**085784 TECHNIQUES FOR DISPLAYING MULTIVARIATE DATA.** A major concern in the process industry is how to convey the myriad of process parameters to an operator in a way that is easily apprehended. The purpose of this paper is to present some of the graphical techniques that may allow effective presentation of this multivariate data. The techniques presented are integrated displays and include gray-scale tables, linear profiles, star charts, n-fold circular displays, and faces. (Author abstract) 4 refs.

Simcox, William (Consulting Statisticians Inc). *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul* Publ by TAPPI Press, Atlanta, GA, USA, 1985 p 155-159.

**085785 STATE OF CHEMICAL PROCESS CONTROL: AN INDUSTRIALIST'S VIEW.** The author traces advances in process control over the last 25 years and assesses the current state of the technology. Areas for future development are outlined. The author argues that while chemical process control has made very significant advances in the last 25 years it has really only scratched the surface of its potential. By ensuring that the processes meet the target there are enormous benefits to be achieved in reducing capital and revenue costs.

Benson, R.S. (ICI plc, Billingham, Engl). *Chem Eng Res Des* v 65 n 6 Nov 1987 p 451-452.

**085786 ROBUST PROCESS CONTROL.** Model uncertainty is one of the major problems facing control system designers in practice. In this paper a general approach is outlined for the assessment of the effects of model uncertainty on control system performance. Also discussed are methods for the design of controllers which meet given performance specifications despite model uncertainty. The power of the new techniques as well as the failure of the traditional ones is illustrated on two examples widely studied in the process control literature: The design of Smith predictor controllers and the design of 2-point composition controllers for high purity distillation columns. (Author abstract) 42 refs.

Morari, M. (California Inst of Technology, Pasadena, CA, USA). *Chem Eng Res Des* v 65 n 6 Nov 1987 p 462-479.

**085787 ADAPTIVE PROCESS CONTROL.** This paper reviews some recent developments in the area of adaptive control. It is pointed out that global stability in the root mean square sense is not necessarily indicative of good steady state and transient performance. This problem is in part due to slow parameter drift and the lack of process excitation. The inclusion of leakage and/or a deadzone function can help solving this particular problem. A linear programming formulation of the finite receding horizon control problem allows for the inclusion of process constraints. (Author abstract) 58 refs.

Ydstie, B.E. (Univ of Massachusetts at Amherst, Amherst, MA, USA). *Chem Eng Res Des* v 65 n 6 Nov 1987 p 480-489.

**085788 CONTROLLING PROCESSES WITH INVERSE RESPONSE AND DEAD TIME.** Model based control such as a Smith Predictor or a dynamic reconciliator has been applied successfully in control of systems with a major dead time. Some processes, however, show an inverse response and major dead time as well. This paper proposes a technique for the compensation of both these effects. The technique has been successfully applied to temperature difference control of a chemical reactor. 5 refs.

Roffel, B. (Polysar Ltd, Sarnia, Ont, Can); Chin, R.A. *Hydrocarbon Process* v 66 n 12 Dec 1987 p 40-42.

**085789 TOTAL MANUFACTURING PROCESS CONTROL - THE HIGH ROAD TO PRODUCT CONTROL.** Total manufacturing process control in-

volves: getting a clear definition of what is required of the product; understanding the production process; improving the process so that an acceptable product is manufactured; controlling and monitoring the process itself; searching out new quality improvement opportunities. Different tools must be used, depending on the activity's complexity and whether one is dealing with variables, attributes, or some combination thereof. These steps are applicable to any manufacturing operation, and if properly followed, will lead to the required quality level in an expeditious and cost-effective manner. The steps should be continuously repeated to bring about better and better quality at lower and lower cost. 11 refs.

Tunmer, Joseph R. *Qual Prog* v 20 n 10 Oct 1987 p 43-50.

**085790 COMMON-SENSE APPROACH TO SPC.** A common sense platform is offered to combat the confusion concerning the statistical process control widespread in the USA. It is argued that: production employees need only a working knowledge of SPC; one should generate only the quantity of data that one's organization can digest; one should concentrate on the areas with the greatest cost effect first; one should realize that statistics is a tool; that statistics is not corrective action; one should work for continuous improvement. 1 ref.

Leppelmeier, John W. *Qual Prog* v 20 n 10 Oct 1987 p 62-64.

**085791 STATISTICS FOR THE SMALL-LOT JOB SHOP.** Statistical process control (SPC) has not been easy for many companies in the United States because it is thought that the technique is only applicable to high volume shops. This article describes methods which are suitable for small volume shops. The methods are gage repeatability and reproducibility, part family, minicapability and process evaluation studies.

Dovich, Robert A. (American Technologies Inc, Marshall, MI, USA). *Mach Tool Blue Book* v 83 n 1 Jan 1988 p 10, 12.

**085792 WHAT IS STATISTICAL PROCESS CONTROL?** The SPC approach to quality assurance can be defined as prevention of errors and producing products that come off the production line perfect the first time and every time. SPC is also a form of stressing quality throughout the entire company including sales and administrative personnel. With SPC each position within the company has a documented list of requirements to be fulfilled by the person holding the position. In addition, there are precise measurements to evaluate how well the requirements are carried out. Each employee must be aware of how his or her contribution affects the quality of the final product. Statistical process control is meant to control just the normal variations of a manufacturing process. There are several types of monitoring systems used in statistical process control. Control charts give a very complete picture of the quality of a product with a minimum amount of testing.

Anon. *Fastener Age* v 2 n 1 Jan-Feb 1988 p 23-24.

**085793 ROBUST POLE-PLACEMENT SELF-TUNING CONTROLLER FOR CHEMICAL PROCESS CONTROL: THEORETICAL STUDIES AND SIMULATION.** A single variable pole-placement self-tuning controller (PPSTC) is used to simulate examples typical of chemical processes; i.e., open-loop stable, unstable, and unstable non-minimum phase systems with unknown varying process dead time. The PPSTC is shown to be effective in each case. Set-point tracking and rejection of randomly occurring deterministic disturbances for all three types of processes are achieved. Simultaneous estimation of process parameters and process time delay is realized by using a recursive extended least squares method. (Author abstract) 13 refs.

Rohani, Sohrab (Univ of Saskatchewan, Saskatoon, Sask, Can); Quail, Douglas W. *Chem Eng Technol* v 11 n 1 Feb 1988 p 57-62.



**085794 USING STATISTICAL PROCESS CONTROL WITH ROBOTIC TESTING IMPROVES QUALITY LEVEL.** The proper application of statistical process control (SPC) in conjunction with 100% robotic testing can yield a very high reduction in parts per million defect (PPM) levels. SPC can eliminate the variability and identify process problems, while 100% robotic testing can detect and extract defective components caused by chance occurrences. The article presents a case study wherein a company utilizes the bakayoke (the Japanese term for devices that automatically check for abnormalities in a process). The bakayoke was to sort out defective product, and if an increased amount of product was rejected, would effectively flag when the process may be working incorrectly. The result was a substantial reduction in PPM defect levels and a corresponding cost savings.

BenDaniel, Elisabeth (Haemonetics). *Ind Eng (Norcross GA)* v 20 n 2 Feb 1988 p 26-29, 31.

**085795 ATTENDING TO ANCILLARIES.** The highly interactive nature of modern processes means that it is becoming increasingly necessary to specify in terms of 'criticality' a whole range of ancillary systems. Any failure in these systems may result in a costly and possibly dangerous breakdown of the entire process. One important ancillary which increasingly displays this criticality to the ultimate degree is heating, ventilating and air-conditioning (HeVAC) plant. As an example, the article briefly discusses the design of the HeVAC systems at Heysham power station.

Hodgson, Trevor. *Process Eng (London)* v 68 n 9 Sep 1987 p 55-57.

**085796 SPC: A MANAGEMENT TOOL TOWARDS PRODUCTIVITY IMPROVEMENTS.** Statistical Process Control is becoming more important than ever in the industries for better quality and high productivity. The author wants to emphasize the importance of SPC as an important tool, giving new dimensions to the industries. Various steps involved in implementing the program are also discussed with a detailed process analysis flow chart. SPC success depends on the support at all levels. The implementation of the program is not an overnight process and once the problem is solved, continuous monitoring of the process is necessary. Different steps of continual quality improvement are also discussed in the article. (Author abstract) 3 refs.

Singh, Durgesh K. (Klinger Electric Corp, Jackson, MS, USA). *Adv Manuf Processes* v 2 n 3-4 1987 p 259-266.

**085797 ADAPTIVE INFERENCE CONTROL FOR CHEMICAL PROCESSES WITH PERFECT MEASUREMENTS.** A single-input/single-output (SISO) adaptive inferential control system is proposed to deal effectively with real process control problems characterized by unmeasured disturbances, nonlinearities, and/or time-varying process parameters. The basic structure of an inferential (internal model) control system is coupled with an on-line parameter estimation method for estimation of the process model parameters and adjustment of the controller. To obtain a stable approximation to the inverse of the process model for use as the controller, the use of adaptive inverse modeling based on discrete convolution model is examined. (Edited author abstract) 18 refs.

Shen, Gwo-Chyau (Ohio State Univ, Columbus, OH, USA); Lee, Won-Kyoo. *Ind Eng Chem Res* v 27 n 1 Jan 1988 p 71-81.

**085798 MEASUREMENT EFFICIENCY IN A CONTROL SYSTEM.** The author considers the construction of a local sensor criterion consistent with the efficiency criterion of the entire control system. This criterion is applied to select a sensor for an optimal stabilization system of a stochastic delayed plant. It is shown that when constructing a consistent local criterion of the sensor, it is necessary and sufficient to identify its kernel with the global criterion kernel and to select its hull allowing for the properties of the global criterion hull and the desired properties of the local criterion. Two methods

have been proposed in order to isolate the global criterion kernel: the method of successive stripping of hulls and the method of reconstructing the kernel from its partial derivatives. For the mean-square optimal stabilization system of a stochastic delayed plant, we have obtained a consistent local sensor criterion having the properties of uncertainty function, which is more convenient in analysis and application than the global criterion. (Edited author abstract) 15 refs.

Klovov, Yu.L. *Autom Remote Control* v 48 n 9 Sep 1987 p 1251-1259.

**085799 RESPONSE OF INDUSTRIAL DISTRIBUTED DATA ACQUISITION AND CONTROL SYSTEMS UNDER UPSET CONDITIONS.** Of major concern in distributed control situations is the ability of the communication system to respond adequately in the face of major plant upsets. Characteristics of process control applications and distributed control systems important to upset response are defined and used as the basis for the application specifications and the analysis of performance. A method of estimating time to clear an upset is presented, which is particularly helpful in both configuring given systems and comparing different types of distributed control systems. (Author abstract) 5 refs.

Schoeffler, James D. (Cleveland State Univ, USA). *ISA Trans* v 27 n 2 1988 p 13-23.

**085800 IMPROVED MULTILoop SINGLE-INPUT/SINGLE-OUTPUT (SISO) CONTROLLERS FOR MULTIVARIABLE PROCESSES.** Three methods are proposed for improving the performance of multiloop single-input/single-output (SISO) controllers which have been tuned by an approach illustrated in an earlier paper. In that paper, multiloop PI controllers were designed by detuning the controllers equally from SISO Ziegler-Nichols settings until a multivariable stability criterion was satisfied. In the present paper, several methods are described for adding derivative action to the PI controllers. An empirical procedure is developed for weighting the detuning of the loops by the predicted final ITE of the process after load and set-point disturbances. (Edited author abstract) 10 refs.

Monica, Thomas J. (Lehigh Univ, Bethlehem, PA, USA); Yu, Cheng-Ching; Luyben, William L. *Ind Eng Chem Res* v 27 n 6 Jun 1988 p 969-973.

**085801 TUNING TECHNOLOGY FOR TRANSMITTERS.** Smart transmitters are a combination of good sensing and microprocessor technology. They offer the potential to make better measurements, to add options, such as internal square root signal conditioning, and also permit remote reranging, remote diagnostics and bidirectional digital communication. The development of the smart transmitter has been constrained by low power technology. Manufacturers have dealt with the power problem by selection of low power CMOS microprocessors and by reducing the clock speed of the digital circuits to hold the power down.

Gray, James (Foxboro Co). *Control Instrum* v 20 n 5 May 1988 p 103, 105.

**085802 IMPLEMENTING STATISTICAL PROCESS CONTROL: TWO CASE HISTORIES.** This paper describes a successful and an unsuccessful application of statistical process control techniques in manufacturing industry. The case histories show that the reasons for both success and failure lie with the senior management. The factors contributing to the successful implementation of the techniques and the benefits obtainable from using appropriate techniques are summarised. (Author abstract) 5 refs.

Sohal, A.S. (Univ of Bradford, Engl). *Qual Assur* v 14 n 2 Jun 1988 p 64-68.

**085803 HUMAN SIDE OF PROCESS CONTROL.** The Key Minimum-Maximum Standards Process Control System (KMS) promotes harmony by blending its many meanings in a way that motivates people and process control to respond to each other's basic needs for benefits

they share and also at a price they must share. The KMS system was originated to provide safeguards that prevent people and process control from maltreating each other when they work together. Managements that have best utilized the system have achieved excellent control and teamwork. An example concerns casting defects.

Smith, Kenneth M. *Mod Cast* v 78 n 6 Jun 1988 p 32-33.

**085804 NEW TOOLS PUT SPC IN HAND.** Many of America's top manufacturers will soon require statistical process control (SPC) and statistical quality control (SQC) data in a computerized and printed form from their suppliers. SPC/SQC reporting is an essential part of the more productive changes going on in inventory control (just-in-time delivery, particularly) and the trend towards closer relationships between manufacturers and their ever-smaller pools of suppliers. And the benefits, which will accrue mostly to the customers in the beginning, eventually will be felt by the job shops, screw-machine facilities and contract stamping plants that supply them. The statistical reports, such as X-bar and R charts, histograms, as well as sigma, and standard deviation are explained. An example is given where an SPC has been started in a small stamping plant.

Freyberg, Dale (MIT Corp, Paramus, NJ, USA). *Mod Mach Shop* v 60 n 12 May 1988 p 50-57.

**085805 SPC: A SEARCH FOR ZERO DEFECTS.** The basic theory behind the statistical process control (SPC) in particular the usefulness of the frequency distribution curve (the bell-shaped curve), is explained and exemplified by its application to the control of the manufacturer of 2-inch-long widgets. The successful SPC program introduced by the EIS Brake Parts, Middleton, Connecticut, is described.

Milton, Ray. *Mod Mach Shop* v 60 n 12 May 1988 p 60-67.

**085806 STARTUP OF A CATALYTIC REACTOR BY FUZZY CONTROLLER.** It is difficult to control the start-up of a packed-bed catalytic reactor with exothermic reaction by conventional controller. In this paper, a controller based on the fuzzy set theory is applied to such a system. The controller treats heuristic rules by fuzzy interpretation, and it is also equipped with adaptive scaling factors. The performance of the controller is experimentally examined with a reactor for the catalytic oxidation of hydrogen. (Author abstract). 7 Refs.

Yamashita, Yoshiyuki (Tohoku Univ, Jpn); Matsumoto, Shigeru; Suzuki, Mutsumi. *J Chem Eng Jpn* v 21 n 3 Jun 1988 p 277-282.

**085807 MOVE TOWARDS DISTRIBUTED CONTROL.** Changes in methods of controlling process plants take place slowly and therefore the trends which will be important in the market-place in the 1990s can already be discerned. The in-words will be microsensors, optical sensors, fibre-optics, digital communications, radio communication, bus architectures, distributed intelligence, distributed control, modelling, model building and expert systems because these are the in-words now in the universities and in the R&D departments. None of these advances can take place without standardisation of the communication methods and protocols. Users will insist that they retain the ability to mix and match transducers and control systems from different suppliers at least as easily as they can at present with a 4-20 mA standard.

Johnston, J.S. (Rosemount Ltd, Bognor Regis, Engl). *Meas Control* v 21 n 6 Jul-Aug 1988 p 175-176.

**085808 TOWARDS DIGITAL INFORMATION CONTROL.** The coming decade will see the end of the analogue era in process control. From the simple plant sensor to the terminal on the Managing Director's desk, the process control business will become completely digital. This trend will continue through the 1990s with digital components supplying economic solutions for signal processing and communication in all final field



devices such as sensors, valves and relays. The 1990s may well be characterised as the decade when 'Process control becomes fully based on digital information control'. Given these tools and technologies, users will increasingly apply them to operation of flexible plants and factories. In many applications, 'lights out' automatic operation may become common practice for overnight shifts.

Wood, G.G. (Foxboro Co, Redhill, Engl). *Meas Control* v 21 n 6 Jul-Aug 1988 p 179-180.

**085809 STATISTICAL PROCESS CONTROL: THE LESSONS TO BE LEARNED.** The authors, from their training and research activities, have identified a number of practicalities and pitfalls relating to the introduction and application of statistical process control (SPC) in the automotive supplier community. These include: senior management not taking their obligations for quality improvement seriously; insufficient thought being given to the role of the SPC facilitator; people who are not directly responsible for control of a process, collecting and plotting data on control charts; control charts being displayed away from the work area; an over-reliance being placed on SPC computerized packages; confusion over the type of control chart to use in a particular situation; a lack of action on the data collected and presented on control charts; and a lack of confidence to experiment with the use of SPC. This paper articulates these difficulties and speculates on the reasons for them. (Author abstract).

Dale, B.G. (UMIST, Manchester, Engl); Shaw, P. *Int J Veh Des* v 9 n 3 1988 p 276-286.

**085810 ADVANCES IN PROCESS CONTROL.** The proceedings includes 15 papers dealing with advances in process control in a variety of industries: mining, chemical, water treatment, steelmaking, and cement. Fluid processes identification, batch process control, Petri nets in batch sequence control, safety in advanced control systems, self-tuning process controllers, and expert systems and their relation to process control are the main topics of the conference. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10879 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Inst of Chemical Engineers, Yorkshire Branch, Bradford, Engl). *Adv in Process Control, Bradford, Engl, Sep 17-18 1985* Publ by Inst of Chemical Engineers, Rugby, Engl var pagings.

**085811 QUALITY: DESIGN, PLANNING AND CONTROL (PRESENTED AT THE WINTER ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS).** This conference proceedings contains 21 papers. The papers contributed deal with a wide range of issues including quality design of products and processes, statistical process control, measurement and error analysis, and on-line process control. The papers are a blend of new theoretical developments, new concepts and methods related to implementation strategy, and application experiences. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10999 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

DeVor, R.E. (Ed.) (Univ of Illinois at Urbana-Champaign, Champaign, IL, USA); Kapoor, S.G. (Ed.). *ASME Prod Eng Div Publ PED* v 27, Qal: Des, Plan and Control, Boston, MA, USA, Dec 13-18 1987. Publ by ASME, New York, NY, USA, 1987 229p.

**085812 PAPERS FROM THE MARINE SCIENCES DIVISION: THE DAWN OF NEW TECHNOLOGY, PROCEEDINGS OF THE 1987 SPRING CONFERENCE AND EXHIBIT.** Proceedings incorporates 20 papers, of which one is presented in the form of an abstract only. The material is subdivided into six sessions that deal with: marine applications, communications, instrument design, special strategies for process control, retrofit of plant controls by microprocessor-based instruments as well as personal computers and programmable logic control-

lers (PLC) in process control. Topics considered include: computer hardware and software, versatile PC-based gaging system for remote tank management, compressor control, distributed control systems, petroleum refineries, chemical plants, data storage and compression, optimum controller tuning, multilayer microprocessors, use of logic in continuous process control, load shedding and management, enthalpy control of air washers in textile fibers, thermowell standardization, cost effectiveness of computerization, temperature sensors, and SCADA (Supervisory Control and Data Acquisition) systems. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10948 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (ISA, Chemical & Petroleum Industries Div, Research Triangle Park, NC, USA). *Instrum Chem Pet Ind* v 19, Pap from the Mar Sci Div: The Dawn of New Technol, Proc of the 1987 Spring Conf and Exhibit, New Orleans, LA, USA, May 27-29 1987. Publ by ISA, Research Triangle Park, NC, USA, 1987 155p.

**085813 CHEMICAL PROCESS CONTROL - CPCIII, PROCEEDINGS OF THE THIRD INTERNATIONAL CONFERENCE.** This volume contains 24 papers on the current state of process control. The papers focus on advances that have taken place over the last five years. In particular, developments in control system robustness, process operability, adaptive control, and model predictive control are highlighted. In addition new results on on-line identification and optimization, reactor control, and actual industrial applications of advanced control are presented. Lastly, the potential impact of artificial intelligence and expert systems is assessed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11523 in the Ei Engineering Meeting (TM) database produced by Engineering Information, Inc.

Morari, Manfred (Ed.) (California Inst of Technology, Pasadena, CA, USA); McAvoy, Thomas J. (Ed.). *Chem Process Control - CPCIII, Proc of the Third Int Conf, Asilomar, CA, USA, Jan 12-17 1986* Publ by Elsevier Science Publ, Amsterdam, Neth & New York, NY, USA, 1986 932p.

## Alarm Systems

**085814 ALARM MESSAGES IN PROCESS CONTROL.** The process control industry is upgrading from hardwired alarm systems to computer generated alphanumeric messages displayed on CRT's. Unfortunately, the choice of message content, format and dynamics are typically left to the programmer. This article outlines work done on both alarm message content and format. Tests showed that more familiar portions of the message should appear in a 'postfix' position. Testing the dynamics requires situations close to reality. Thus, a series of low fidelity experiments is proposed that allows testing under reasonable circumstances. (Author abstract) ?

Danchak, Michael M. (Hartford Graduate Cent, Hartford, CT, USA). *InTech* v 35 n 5 May 1988 p 43-47.

**Analysis** See CONTROL SYSTEMS, MULTIVARIABLE—Design.

**Applications** See Also PAPER AND PULP MILLS—Machinery; WIRE PRODUCTS—Manufacture.

**085815 PROCESS INSTRUMENTATION AND CONTROL TODAY - DEVELOPMENT AND APPLICATIONS.** The turbulent development of large-scale integrated electronic components - LSI chips - in the form of microprocessors and memory chips has given a vital impulse to the formulation of new and more powerful automation structures. Improved microcomputers can now solve data processing problems which were previously only handled in large computer centers. This article takes stock of the state of process instrumentation and control (I&C) today, with some remarks about further developments in this field. An outline is given of some of the I&C applications. (Edited author abstract) 12 refs.

Schneider, Ernst (Siemens AG, Karlsruhe, West Ger); Urbach, Walter. *S Afr Mech Eng* v 38 n 4 Apr 1988 10p.

**Automation** See Also CEMENT PLANTS—Automation; COAL PREPARATION—Flotation; COMPUTER SOFTWARE—Process Control; CONTROL SYSTEMS, PROGRAMMED; DATABASE SYSTEMS—Management; ELECTRIC POWER PLANT EQUIPMENT—Construction.

**085816 DISTRIBUTED CONTROL SYSTEMS.** Distributed control systems for industrial automation have been available since the mid-1970s, and originally programmable electronics was used to realize the functions previously done with relays or hard-wired electronics. Newer systems use more efficient programming methods, and greater emphasis is laid on user friendliness and flexibility. A modern, integrated automation system combining instrumentation and PLC functions, as well as supervisory functions of the SCADA system is described.

Pauly, Thomas. *Electron Power* v 33 n 9 Sep 1987 p 573-576.

**085817 ARCHITECTURE FOR FACTORY CONTROL AUTOMATION.** The automation of manufacturing functions can be usefully categorized as physical, control, and information automation. Because control and information automation are functionally dedicated to processing data, they are founded in computing and data communications technology. But they characteristically differ in important ways, such as response-time requirements, variability of functionality, and volume and volatility of associated data. Thus, different computing architectures are appropriate for these automation arenas. This paper outlines the functional and performance requirements typical in control automation. It also suggests an architectural approach to the automation of factory control functions. (Author abstract)

Campbell, Richard L. (AT&T, Princeton, NJ, USA). *AT&T Tech J* v 66 n 5 Sep-Oct 1987 p 77-85.

**085818 PC GRAPHICS ARE KEY TO LOW COST AUTOMATION.** One of the areas in industry that is currently undergoing fastest change, potentially affecting everything from small scale process control, through the range of SCADA users, to piece part production, is computer graphics at (and beyond) the man-process interface. It is the graphics control systems that are now set to make one of the greatest impacts. This article will look at systems based on the IBM PC and its compatibles, aimed at providing: first, run time monitoring of intelligent instrumentation and programmable controllers; second, direct digital control via distributed I/O; and third, sophisticated off-line plant analyses.

Tinham, Brian. *Control Instrum* v 20 n 2 Feb 1988 p 63, 67-68, 70.

**Calculations** See DISTILLATION EQUIPMENT—Performance.

**Computer Aided Analysis** See COMPUTER INTEGRATED MANUFACTURING.

**Computer Aided Design** See Also IRON AND STEEL PLANTS—Control Systems.

**085819 COMPUTER AIDED DESIGN FOR INDUSTRIAL CONTROL SYSTEMS.** This chapter presents a review of particular techniques that many be employed for the modelling and analysis of industrial processes and for the design of control systems to regulate those processes. These techniques have been integrated into a package of computer hardware and software that is now being marketed by Vuman Ltd. VUMAN stands for the 'Victoria University of Manchester' and the company is wholly owned by Manchester University. The package is termed the 'Plant Analysis System' or PAS for short. It has been successfully applied to a number of processes in a variety of industries. 6 refs.

Sandoz, D.J. *Ind Digital Control Syst* Publ by Peter Peregrinus Ltd (IEE Control Eng Ser 29), London, Engl, 1986 p 221-241.



**085820 EXPERT PROCESS PLANNING SYSTEM WITH SOLID MODEL INTERFACE.** This paper presents an integrated hierarchical framework of a process planning system with a Computer Aided Design (CAD) interface. The objective of the project is to integrate design with process planning using artificial intelligence (AI) techniques. The development of a CAD interface is discussed with respect to automated feature recognition, determination of tool approach direction, and deciding the precedence relationship between the features. Sample results from the CAD interface are presented. The expert system for the process planning module is discussed with the part representation and knowledge base, and the plan generation procedure. The module uses hierarchically organized frames for both part representation and the knowledge base. Some initial results are presented from the process planner to demonstrate the current capability of the system. (Edited author abstract) 40 refs.

Joshi, Sanjay (Purdue Univ, West Lafayette, IN, USA); Vissa, Narendra Nath; Chang, Tien-Chien. *Int J Prod Res* v 26 n 5 May 1988 p 863-885.

## Computer Aided Engineering

**085821 CAE IN DER PROZESSLEITTECHNIK.** [CAE in Process Control Engineering]. The design and operation of chemical engineering plants involves collaboration of various specialist departments over a long period in an interactive sequence of steps. Any change in data in any of the necessary iterative steps can generate expensive errors. The aim of computer application and computerized development is thus basically to improve the integration of the various applications. Technical data processing, especially the use of CAD/CAE systems, therefore provides a framework for a whole group of measures intended to provide tools for medium-term automatic handling of data and re-use of partial solutions in memory. (Author abstract) 3 refs. In German.

Geibig, Karl-Friedrich (Hoechst Aktiengesellschaft, Frankfurt am Main, West Ger). *Chem Ing Tech* v 60 n 4 Apr 1988 p 237-242.

**Computer Applications.** See Also ADHESIVES—Applications; ARTIFICIAL INTELLIGENCE—Applications; ARTIFICIAL INTELLIGENCE—Expert Systems; BREWERIES—Automation; CHEMICAL INDUSTRY—Process Control; CHEMICAL OPERATIONS—Computer Simulation; CHEMICAL OPERATIONS—Optimization; CHEMICAL PLANTS—Computer Aided Design; COMPUTER ARCHITECTURE; COMPUTER ARCHITECTURE—Applications; COMPUTER NETWORKS—Industrial Applications; COMPUTER NETWORKS—Local Networks; COMPUTER SOFTWARE—Software Engineering; COMPUTERS—Grounding; COMPUTERS, MICROCOMPUTER—Applications; CONTROL SYSTEMS, DIGITAL—Industrial Applications; DRUG PRODUCTS—Computer Aided Manufacturing; ETHYLENE—Processing; EXTRACTION—Mathematical Models; GLASS FURNACES—Energy Conservation; INTEGRATED CIRCUITS, VLSI—Computer Aided Manufacturing; INTEGRATED CIRCUITS, VLSI—Fabrication; IRON FOUNDRY PRACTICE—Process Control; LUBRICATING GREASES—Manufacture; ORE TREATMENT—Computer Applications; PLASTICS MACHINERY—Control; PRECISION ENGINEERING—Mathematical Models; ROLLING MILLS—Control; ROLLING MILLS—Japan; SEWAGE TREATMENT PLANTS—Personnel Training; SUGAR FACTORIES—Process Control; TEXTILE MACHINERY—Spinning Machines; WELDING, ELECTRIC ARC—Flash; WIRE—Manufacture; YEAST—Fermentation.

**085822 SOME ALGORITHMS FOR TREATMENT OF INFORMATION IN AUTOMATIC CONTROL SYSTEMS FOR TECHNOLOGICAL PROCESSES.** Questions in the selection of optimum algorithms for filtration, extrapolation, and interpolation in an ACS TP have been examined. Procedures have been proposed for estimating optimum values for the sampling period and filter parameters from measured signal values. Results of this work have been introduced into the ACS TP for viscose tire cord manufacture at the Svetlogorodsk 'Khimvolokno' PO. 8 refs.

Suris, T.G.; Koval'chuk, A.V.; Zhuravlev, L.V. *Fibre Chem* v 19 n 1 Jan-Feb 1987 p 30-34.

**085823 APPLICATION OF EXPERT SYSTEMS TO MANUFACTURING PROCESS CONTROL.** In

recent years the control of the manufacturing process has received prime focus of manufacturers throughout the world. Expert systems technology allows for the implementation of sophisticated and efficient process control systems. This paper provides a framework for the application of expert systems to manufacturing process control. It details the unique features of such a system and explains the constitution of the knowledge base. (Author abstract) 47 refs.

Alexander, S.M. (Univ of Louisville, Louisville, KY, USA). *Comput Ind Eng* v 12 n 4 1987 p 307-314.

**085824 NEW DEVELOPMENTS IN COMPUTER CONTROL SYSTEMS.** Recent technological developments in both electronics and computing have led to a simplification and a dramatic cost reduction in computer control systems. The author describes the configuration of a new distributed system based on powerful microcomputers. (Edited author abstract)

Miller, R.L. *Electron Power* v 33 n 9 Sep 1987 p 577-579.

**085825 CONTROL OF CONSTRAINED MULTIVARIABLE NONLINEAR PROCESS USING A TWO-PHASE APPROACH.** A computer-based algorithm is presented for the control of complex process units which are characterized by difficult features such as nonlinear input/output relationships, multivariable nature, operational constraints, imprecise models, and inadequate measurements. A two-phase algorithm is proposed to deal with these difficult features in a direct manner. The algorithm makes use of approximate process models which take into account significant physical and chemical events in the process. The first phase of this algorithm consists of identifying unmeasured disturbances and the parameters and states of the approximate model using measurements from the immediate past. (Edited author abstract) 15 refs.

Jang, Shi-Shang (Washington Univ, St. Louis, MO, USA); Joseph, Babu; Mukai, Hiro. *Ind Eng Chem Res* v 26 n 10 Oct 1987 p 2106-2114.

**085826 STATISTICAL PROCESS CONTROL FOR TOMORROW.** The author takes a look at statistical process control and demonstrates several ways that a distributed computing system can be used in conjunction with the ideas behind SPC. (Author abstract)

Rice, George F. (Foxboro Co). *PIMA Mag* v 69 n 9 Sep 1987 p 36-39.

**085827 PHILOSOPHY OF REAL-TIME COMPUTING.** Responding to external events as they occur, real-time computing systems efficiently monitor and control the operations of remote devices while seemingly simultaneously executing other significant processing functions. In the context of the GIMIX system, two applications are briefly mentioned. One is computer control of the heating system of a refining furnace. Another is a study of the effect of oxygen on the recovery and dissolution of ferroalloys in steelmaking. 5 refs.

Argyropoulos, Stavros A. (Univ of Toronto, Can); Albaharna, Osama T. *J Met* v 39 n 10 Oct 1987 p 10-13.

**085828 PROCESSING PRODUCTION'S VITAL STATISTICS.** After a two-year examination of comparative statistical process control (SPC) systems, the quality engineers at Clayton Dewandre of Leeds opted to install the Precom system at their Hailwood & Ackroyd plant at Morley. The first of six networked SPC installations was initially for the small-valve product group; subsequently, it was extended throughout all manufacturing sections. Obtaining on-the-job feedback from all types of inspection and gauging functions appears to be a prerequisite for the successful implementation of statistical process control systems. The author probes the market for SPC-friendly gauging equipment.

Hartopp, Harold. *Metalwork Prod* v 131 n 11 Nov 1987 7p between p 94 and 110.

**085829 TRULY DISTRIBUTED PROCESS CON-**

**TROL SYSTEM WITH ON-LINE CONFIGURATION AND EXPANSION CAPABILITIES.** The process control system described in this paper, is a very flexible system equipped with a range of computer-aided configuration tools. These are tools for the configuration and reconfiguration of control loops, computing blocks, logic control modules, i/o connections or graphics, and presentation elements such as reports, trend curves, flowsheets, free graphical pictures etc., while the system is operational and in control. Documentation of system topology, system parametrization and the i/o configuration/connection etc., can be extracted from the system at any time. The system can also be configured for training and simulation applications as well as for process control. (Edited author abstract) 1 ref.

Saelid, Steinar (Kongsberg Albatross A/S, Kongsberg, Norw). *Model Ident Control* v 8 n 4 Oct 1987 p 201-222.

**085830 STRATEGIES FOR BATCH CONTROL.** Batch master is a software utility that, hierarchically speaking, sits on top of the sequences. At its simplest level it can be realized by means of another sequence. The functions of a batch master are various but, essentially, it is in overall control of the sequencing operations. The four attributes of recipes which contain specific information and are used in conjunction with sequences during batch production are given. Sequential, parallel and common modes of batch operations are discussed.

Love, Jonathan. *Chem Eng (London)* n 440 Sep 1987 p 29-31.

**085831 PORAZDELJENI IN DECENTRALIZIRANI RACUNALNISKI SISTEM LANA ZA VODENJE PROCESOV.** [Distributed and Decentralized LANA Computer System for the Process Control]. The paper briefly defines the model of a distributed LANA processor from the point of view of systems for the process control. The model allows the construction of actually decentralized and distributed systems for the process control with a possibility of an economic optimization of performances of fault tolerance and for failure safety, gradual degradation capability, expansion and configuration adaptivity. (Edited author abstract) In Slovenian. 13 refs.

Panic, Nikola. *Elektroteh Vestn* v 54 n 4 Aug-Oct 1987 p 249-254.

**085832 TOPOLOGICAL DESIGN OF DISTRIBUTED CONTROL SYSTEMS USING THE PROLOG PROGRAMMING LANGUAGE.** The features of the logical programming language PROLOG are discussed with special reference to the topological design of distributed control systems. Applications are illustrated by a distributed system for control of an industrial process with a hierarchical structure. Topological problems are solved to determine the locations of computer units, the types of computer equipment installed at them, and the structure of the data transmission network. Since, in distributed control systems, computer facilities are located within a short range from one another, such systems can be interpreted as local area computer networks. (Edited author abstract) 5 refs.

Kozhevnikov, G.K. *Autom Control Comput Sci* v 21 n 3 1987 p 1-3.

**085833 ON THE LEADING EDGE OF PROCESS I & C.** Reducing operating costs and improving product quality were once the sole reasons for acquiring process technology. Advances in microelectronics, computer technology and mathematical models, however, have expanded the applications potential of process I & C systems dramatically. These and other new technologies, now allow automation specialists to plan plant safety and environmental protection into the process optimization strategy. (Edited author abstract)

Schneider, Ernst (Siemens AG, Karlsruhe, West Ger); Urbach, Walter. *Siemens Rev* v 55 n 1 Jan-Feb 1988 p 25-30.



**085834 BATCH CONTROL: A COST-EFFECTIVE FAULT TOLERANT SOLUTION.** State of the art fault tolerant control systems employing triple modular redundant (TMR) architecture are now available for use in the process industry. They are proven; the question is, are they cost-effective? In order to demonstrate that TMR systems are less expensive compared to conventional main/hot-standby systems - and under certain circumstances can be compared favorably in terms of cost with a simplex solution - both project and operational costs must be considered. The cost benefits of using a TMR system can be particularly demonstrative in the control of a batch plant.

Mulligan, Tony. *Process Eng (London)* v 68 n 9 Sep 1987 p 39, 41, 43.

**085835 FIELD BUS COMMUNICATION STANDARD - A WINDOW OF OPPORTUNITY.** The quest for plant-wide communication standards to interconnect automation systems has tended to focus on the requirements of the higher level computing devices. The use of standard communication protocols at the lowest automation level of field mounted devices has been the missing piece in the hierarchy. But this situation is rapidly changing. Since international field bus standards work started in 1985, the number of commercially available intelligent field instruments has increased and four bus contenders have become prominent. The author reviews the world-wide engineering design activities aimed at development of a common protocol for linking low-level industrial control elements.

Kent, David W. *New Electron* v 21 n 1 Jan 1988 p 53-54, 56.

**085836 INCREASING THE EFFICIENCY OF USE OF CONTROL COMPUTER TECHNOLOGY.** Problems that exist in introducing automatic control systems for process operations are discussed. The goals of the 12th five year plan are outlined. Steps that will be taken to solve these problems are stated.

Domashevskii, B.N.; Frolov, V.A. *Sov Energy Technol* n 2 1987 p 67-68.

**085837 SICHERHEIT GARANTIERT: FEHLER-KONTROLLE BEI STEUERUNGSEINHEITEN.** [Safety Guaranteed: Error Control in Control Units]. A supervision method for control systems, subject to high safety requirements, is described. A microprocessor is added to the basic process computer so that a trajectory control of the process is implemented, suitable to temporal response. The computer and accompanying control unit supervise each other and thus reduce possible errors. 3 refs. In German.

Wratil, Peter. *Elektronik* v 37 n 6 Mar 19 1988 p 84-86.

**085838 PROGRAMMABLE MOTION CONTROL PENETRATES PROCESS INDUSTRIES.** In order to implement computer integrated manufacturing (CIM), process industries are finding it necessary to integrate programmable intelligent motion control into traditional process operations. A variety of devices can be used to provide programmable motion control. This article explains some of these motion control devices and offers criteria for selecting and implementing them into process applications such as pulp and paper, rubber processing and steel production. (Author abstract)

Amato, Gary (Allen-Bradley Co, Cleveland, OH, USA). *InTech* v 35 n 4 Apr 1988 p 43-47.

**085839 INDUSTRIAL COMPUTERIZED PROCESS MONITORING AND CONTROL.** The INDUSTAR MASTER SYSTEM is an industrial control software product designed to run on networked (Token Ring or Arcnet) IBM Industrial computers 7531/7532 or 7552, IBM PC-AT's, P/S 2's, or true compatibles. Communication with the process is handled by intelligent co-processor boards (IBM's RIC/ARTIC or Toptools CCU/MPST). The software was developed by Toptools, a subsidiary of the large French multinational group: Societe des Ciments Francais. Industar gives the user the features and perfor-

mance of a large distributed control system at the price level and ease of implementation of PC-based systems.

Caro, Richard; Merritt, Richard; Rowland, Ernest. *Cim Beton Plantes Chaux* n 5(768) 1987 p 281-282.

**085840 CHOOSING DISTRIBUTED CONTROL SYSTEMS.** The problem of selecting a right control equipment for distributed control purposes is addressed. The authors assert that the best systems for plant control can be selected using a benchmarking approach. Guidelines on the selection are given.

Alcock, Phil (KBC Process Automation); Ogden-Swift, Andrew. *Control Instrum* v 20 n 5 May 1988 p 79-81.

**085841 LOW COST MICROS AID DISTRIBUTION.** Traditional process control and industrial automation architectures based on a centralized computer system are steadily being replaced by the distributed system concept. The major stimulus for this change is the availability of inexpensive, but capable single loop controllers, programmable controllers and intelligent measurement/control interface stations, the majority of which are designed around the ubiquitous microprocessor. The author compares trade-offs between centralized and distributed control and reviews some distributed control equipment and communication interfaces available.

Readman, Geoff (DI-AN Micro Systems). *Control Instrum* v 20 n 5 May 1988 p 83-85.

**085842 SIMPLIFIED TESTING OF NETWORK CONTROL SYSTEMS.** Components of network control systems, particularly of the process computer system, must be tested before delivery and commissioning. Such systems are complex, and the test equipment and methods must be equally sophisticated. The PROSIM process simulator provides the data necessary for testing - in the form of messages having the same structural and dynamic response as in the actual system. (Edited author abstract) 2 refs.

Gerlach, Reinhard (Siemens AG, Erlangen, West Ger); Jansen, Juergen. *Energy Autom* v 10 n 2 Mar-Apr 1988 p 22-23.

**085843 CONTROL SYSTEMS FOR PROCESS INDUSTRIES.** Process industries are going through a stage that their counterparts, the discrete metal-bending and assembly manufacturers, went through 15 years ago. They are realizing they can rely on commercially packaged software to manage their businesses and no longer can hide behind the excuse that their businesses are 'unique'. It is reported that there are more than 200 MRP software vendors, and many manufacturers have outgrown their first systems and subsequently implemented newer replacement systems. Material requirements planning (MRP) software vendors, and many manufacturers have outgrown their first systems and subsequently implemented newer replacement systems. It is argued that because different rules govern the functions within process firms, the controlling software must fit the task and not be a variation of MRP for discrete manufacturers.

Cokins, Gary M. (Deloitte Haskins & Sells, Detroit, MI, USA). *Manuf Syst* v 6 n 5 May 1988 p 79-80, 83.

**085844 DIGITALIS KOMPAKT FOLYAMTIRANYITO EGYSEGEK ES AZ EZEK-BOL FELEPITHETO HALOZATOK.** [Digital Compact Progress Control Units and Networks]. Due to the quick spreading of modern semiconductor units small-size intelligent process control devices have been designed for the optimal autark control of partial technological processes. The special features of these devices and their applicational possibilities are mentioned. Manufacturers in highly developed industrial countries designed compact unit families for various control functions. The individual compatible units can be turned into hierarchic process control network systems by series data transmission lines. There is a personal computer on the upper level. These systems become rapidly popular for their manifold applicational possibilities and low investment cost. (Author abstract). 16 Refs. In Hungarian.

Tamas, Harkay (Kandoo Kalman Villamosipari Muszaki Foiskola, Budapest, Hung). *Meres Autom* v 36 n 5 1988 p 153-158.

**085845 PCS EXPAND ROLE IN PROCESS CONTROL.** The role of the personal computer has grown rapidly from a household amusement to a practical - and, in some cases nearly indispensable - industrial fixture. The personal computer (PC) can be found in engineering offices, on the plant floor, in control rooms, in executive suites, and in a variety of administrative, financial and supervisory areas. It is flexing its newly-found muscles in control applications that were not even dreamed of 10 short years ago. (Edited author abstract).

Waterbury, Robert C. (InTech, Research Triangle Park, NC, USA). *InTech* v 35 n 7 Jul 1988 p 27-31.

**085846 MODULAR PROCESS CONTROL SOFTWARE OF THE MULTI-LOOP DIGITAL CONTROLLER.** The modularization of process control software provides a method of software design. This method possesses some outstanding advantages: it is simple to design and convenient to extend to new functions. The software designed with this method is flexible in application and is easy to use in forming various control systems for users. This paper deals mainly with the fundamental principle and designing method of the modular software of a multi-loop controller, the construction of the module and its connecting program. Some examples are given to illustrate the feasibility of this method. (Author abstract). 2 Refs.

Xiang, Wancheng (Tianjin Univ, China); Zhang, Yuanliang. *Instrumentation in China Instrumentation in China, Technical Papers, English Language Edition of Selected Articles Originally Published in the Chinese Journal of Scientific Instrument 1987. Publ by ISA, Research Triangle Pk, NC, USA, 1987 p 13-20.*

**085847 PROPAGATION OF FAULTS IN PROCESS PLANTS-5. FAULT TREE SYNTHESIS FOR A BUTANE VAPORISER SYSTEM.** An interactive, computer-based facility, FAULTFINDER, has been developed for fault tree synthesis. The modelling of fault propagation, fault tree synthesis, the interactive facility and its application to a pump changeover sequence have been described in four earlier papers. This paper describes the application of FAULTFINDER to the construction of a fault tree for a butane vaporising system. The results are compared with those achieved by the manual digraph method of fault tree construction. It is shown that FAULTFINDER is capable of generating logically consistent and structured trees for a process system comprising control and trip loops. (Author abstract). 7 Refs.

Mullis, J.S. (Loughborough Univ of Technology, Loughborough, Engl); Ang, M.L.; Lees, F.P.; Andrews, J.D. *Reliab Eng Syst Saf* v 23 n 1 1988 p 31-49.

**085848 PROCESS-MONITORING RAISES PRODUCTION, IMPROVES QUALITY.** Automation at Georgetown Steel in the form of computerized process-monitoring has produced these benefits: a substantial reduction in time for vital verification of the content of molten steel; reduced downtime throughout the plant; improved quality of products and higher 'hit rates'; better information on true product costs, and improvements in yield. The installed system includes the Concept/32/27 with two megabytes of memory, two terminals in a lab; a terminal in the control room of each furnace, various tape and disk drives, communications including 3780 emulation and I/O hardware and the necessary languages, diagnostics and utilities. A superminicomputer is used in the metallurgy lab, heat sample readings are analyzed via computers and each furnace has a microcomputer installed in it.

Coudal, Edgar F. (Coudal & Associates Ltd, Prospect Heights, IL, USA). *Manuf Syst* v 6 n 9 Sep 1988 p 24-28.



**085849 SIMULATE A DIGITAL INDUSTRIAL PROCESS.** A BASIC programmable simulator was developed in order to aid the exhaustive testing of the industrial programmable controllers. It runs on a personal computer, extended with a parallel digital I/O board. The simulator reads the outputs issued by the programmable controller and feeds its inputs interpreting a BASIC program. Both normal and abnormal behaviors of the process can be simulated in this manner. The start-up of a steam boiler is an application example solved with the aid of this simulator. (Author abstract). 7 Refs.

Constantinescu, Cristian (Polytechnic Inst of Bucharest, Bucharest, Rom). *Comput Ind v 10 n 4 Aug 1988 p 241-245.*

**Computer Interfaces** See Also CONTROL SYSTEMS, PROGRAMMED—Industrial Applications; INDUSTRIAL PLANTS—Planning.

**085850 FAULT TOLERANCE IN PROCESS CONTROL: AN OVERVIEW AND EXAMPLES OF EUROPEAN PRODUCTS.** The behavior of plants disturbed by the failure of the control computer due to malfunction is examined. The role of plant tolerance and the concepts of availability and safety are discussed. The different types of dependable computers are classified, and redundancy types are considered. Approaches to providing integrity and persistency, both separately and together, are presented. 21 refs.

Kirmann, Hubert D. (Brown Boveri & Co, Baden, Switz). *IEEE Micro v 7 n 5 Oct 1987 p 27-50.*

**Computer Simulation** See Also MECHANICAL ENGINEERING—Education; PETROLEUM INDUSTRY—Employee Training; PULP MANUFACTURE—Sulfonation.

**085851 PROCESS STYLE PACKAGES FOR DISCRETE EVENT MODELLING: DEMOS: A PROCESS BASED SIMULATION PACKAGE.** This is the fourth paper in a series dealing with discrete event simulation modeling. We illustrate modelling in Demos by emphasizing its process synchronisation mechanisms. These include resource allocation based on the mutual exclusion and the producer/consumer paradigms, inter-process cooperation via the master/slave synchronisation, waits until, and process cancellation and interruption. The simpler synchronisation method are illustrated by small examples. In the final portion of the paper, we illustrate program development in Demos with a fairly substantial model of steel mill operations. The model brings nearly all of the features of Demos into play. (Edited author abstract) 21 refs.

Birtwistle, Graham (Univ of Calgary, Calgary, Alberta, Can); Lomow, Greg; Unger, Brian; Luker, Paul. *Trans Soc Comput Simul v 3 n 4 Oct 1986 p 279-318.*

**085852 ON-LINE PROCESS SIMULATION TECHNIQUES IN INDUSTRIAL CONTROL: INCLUDING PARAMETER IDENTIFICATION AND ESTIMATION TECHNIQUES, PROCEEDINGS OF THE ELEVENTH ANNUAL ADVANCED CONTROL CONFERENCE.** This conference proceedings contains 14 papers. Topics covered include: recursive techniques for identifying dynamic systems; model-based controller tuning; nonlinear inferential control; TUNES—a tool for estimating dynamic parameters via nonlinear regression; simulation in manufacturing; putting more productivity into metal cutting; block diagram as a mathematical model and a computer language; interactive solutions to complex control problems; process modeling and simulation with ONSPEC control software; using dynamic simulation for control system development; simulation as a design tool; cold reduction mill modeling; simulation of large-scale control systems; and, computer-aided engineering of large-scale process control systems. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 09832 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *On-Line Process Simul Tech in Ind Control: Ind Param Identif and Estim Techniques, Proc of the Eleventh*

*Annu Adv Control Conf, West Lafayette, IN, USA, Sep 30-Oct 2 1985 Publ by Control Engineering, 1985 117p.*

**Control Systems** See Also GLASS MANUFACTURE—Control Systems.

**085853 DESIGN OF A MONITORING SYSTEM FOR THE AUTOMATIC PROCESS CONTROL SYSTEM OF POWER MACHINE BUILDING PLANTS.** The software of automated systems is divided into applied software (ASW) and system software (SSW). Applied software represents the program implementation of traditional methods of design operation and procedures and is the designing component of any automatic process control system (APCS). A group of ASW components forms the subset of objectively oriented APCS subsystems. Recently the concept APCS software has been connected only with ASW, i.e., in essence groups of applied programs are treated as an APCS. A similar approach is now fairly widespread, especially for the APCS of construction objects. It is now clear that there is a need to isolate certain objectively independent (invariant) subsystems of APCS software which carry out specific system functions. The group of indicated invariant subsystems forms the APCS system software. 1 ref.

Gakh, V.Ya. *Sov Energy Technol n 10 1987 p 75-80.*

**085854 SINGLE LOOP SIMPLIFIED MODEL PREDICTIVE CONTROL.** Performance and implementation of a recently developed advanced control algorithm are analyzed for single-input single-output systems. Some of the topics covered include open-loop characteristics, reset problem, controller tuning, robustness of algorithm, dead time compensation, closed loop dynamics, and comparison of performance of different control systems. (Edited author abstract). 23 Refs.

Vaidya, C.M. (Univ of Louisville, Louisville, KY, USA); Deshpande, P.B. *Hydrocarbon Process v 67 n 6 Jun 1988 p 53-57.*

**085855 APPLICATION OF GENERALIZED PREDICTIVE CONTROL TO INDUSTRIAL PROCESSES.** A novel algorithm called generalized predictive control (GPC) is shown to be particularly effective for the self-tuning control of industrial processes. The method uses long-range predictive control ideas with a carefully chosen controlled autoregressive and integrated moving-average (CARMA) plant model and various horizons that allow for a rich variety of control objectives. The procedure can adapt to process dead time and model order, and a multivariable version gives tight control of complex plants without prior knowledge of the interactor matrix. Applications of GPC to a cement mill, a spray-drying tower, and a compliant robot arm give performance better than that of fully tuned proportional-integral-derivative regulators. 14 refs.

Clarke, David W. (Oxford Univ, Engl). *IEEE Control Syst Mag v 8 n 2 Apr 1988 p 49-55.*

**085856 PROCEEDINGS OF THE SIXTH ANNUAL CONTROL ENGINEERING CONFERENCE.** This conference proceedings contains 91 papers. Topics include: commercially poorer advanced control techniques; induction motor servos; control systems for batch processes; shop floor computing standards and work cell controllers; interfacing the plant floor with the outside world; manufacturing automation protocol; management information systems; operator interfaces in integrated manufacturing systems; control computer programming; vision systems for inspection applications; statistical process control; safety systems in process plants; flexible manipulation with programmable motion controllers; personal computers in control systems; software for manufacturing plant control; analytical instruments in control applications; programmable logic-controllers and complex control applications; control retrofitting and modernization; local area networks; process computers in generating stations; discrete simulation in control systems design; personal computer to programmable controller interfaces; artificial intelligence and expert systems in plant floor applications; planning and management for

computer integrated manufacturing, and self-tuning controllers. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11289 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Control Engineering, Barrington, IL, USA). *Proc Annu Control Eng Conf 6th, Rosemont, IL, USA, May 19-21 1987. Publ by Control Engineering, Barrington, IL, USA, 1987 703p.*

**085857 PROCEEDINGS OF THE ISA/87 INTERNATIONAL CONFERENCE AND EXHIBIT.** This proceedings contains 169 papers by various authors, dealing with advances in instrumentation. Major topics covered are: process control strategies, integrated plant management systems, pipeline pumps/compressor control, tank gauging and storage monitoring; food/pharmaceutical instrumentation control systems; control systems for power plants, pulp and paper industry, waste disposal; water production/distribution automation; computer applications for water/wastewater control; electrochemical analysis, process gas chromatography/IR spectroscopy; modern control technology applications; discrete/batch control and process management; smart field devices; manufacturing automation protocol (MAP); adaptive control applications; control concepts; PC's in manufacturing; computer integrated manufacturing (CIM); programmable logic controller (PLC); database/software integration; human interfaces; fiber optic data communications; artificial intelligence; reason technology; optical analyzer techniques; start-up management; project management; biotechnology instrumentation control; modeling/simulating manufacturing systems; batch control applications; microsoftware environments, broadband networked systems, space telemetry communications, training program development. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11460 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (ISA, Research Triangle Park, NC, USA). *Adv Instrum v 42 pt 1-3, Proc of the ISA/87 Int Conf and Exhib, Anaheim, CA, USA, 1987. Publ by ISA, Research Triangle Park, NC, USA, 1987 1721p.*

## Costs

**085858 SPC: HOW IT WORKS, WHAT IT IS MEANT TO ACCOMPLISH AND SOME COMMON MISCONCEPTIONS.** SPC (Statistical Process Control) is a tool which, when used correctly and with a sufficient understanding of the concepts, allows one to see a process with a degree of resolution otherwise unattainable. In the mad rush to institute SPC, however, misassumptions and misunderstandings will hamper or even completely short circuit any meaningful change.

Liberatore, Ralph L. (A. Blount Inc). *Abrasive Eng Soc Mag v 27 n 1 Mar-Apr 1988 p 8-14.*

**Design** See Also CHEMICAL EQUIPMENT—Reactors; CHEMICAL PLANTS—Control Systems; CONTROL SYSTEMS, DIGITAL—Design; CONTROL SYSTEMS, MULTIVARIABLE—Computer Aided Design.

**085859 DESIGN OF SET POINT REGULATORS FOR PROCESSES INVOLVING TIME DELAY.** An efficient frequency domain methodology for the design of set point regulators for high-order process models involving relatively large pure time delay is presented. The unique advantage of the methodology is that it enables the designer to rapidly visualize the structure of the required controller as soon as the time and frequency domain specifications are stipulated for the closed-loop system. Optimizing the parameters of an appropriate structure improves the robustness of the controller. The method



does not require order reduction of the original model, and time delay is handled directly. Also, only output feedback is utilized. (Author abstract) 27 refs.

Sanathanan, C.K. (Univ of Illinois, Chicago, IL, USA); Quinn, S.B. Jr. *AIChE J* v 33 n 11 Nov 1987 p 1873-1881.

**085860 PROCESS CONTROL USING IR SENSORS AND SCANNERS.** Temperature and thermal behavior of materials and fabricated parts in process are the most critical factors in the manufacturing process. For this reason, temperature is by far the most measured quantity in industrial process monitoring and control. Conventional methods using thermometers and thermocouples are commonly used for the majority of applications. Noncontact temperature measurement using infrared sensors has become an increasingly desirable alternative to conventional methods as IR sensors have become less expensive, more reliable and electrically interchangeable with conventional thermistors and thermocouples. Now, with the introduction of innovative computer hardware and software, full-image thermal control of products and processes is being made possible.

Kaplan, Herbert. *Photonics Spectra* v 21 n 12 Dec 1987 p 92-95.

**085861 PREDICTIVE CONTROLLER DESIGN FOR SINGLE-INPUT/SINGLE-OUTPUT (SISO) SYSTEMS.** This paper presents a fundamental analysis of the stability of single-input/single-output (SISO) closed-loop systems with predictive controllers. The analysis can be used to calculate allowable modeling errors for a given system and controller. Design parameter selection guidelines for prediction controllers in SISO systems have been developed by considering performance, robustness, and ease of tuning. The performance and robustness of the resulting controllers are demonstrated in four numerical examples and compared to controllers designed using other parameter choices. (Author abstract) 14 refs.

Maurath, Paul R. (Univ of California, Santa Barbara, Santa Barbara, CA, USA); Mellichamp, Duncan A.; Seborg, Dale E. *Ind Eng Chem Res* v 27 n 6 Jun 1988 p 956-963.

## Economics

**085862 1988 CONTROL INDUSTRY OUTLOOK: BEGIN WITH THE BASICS.** Every new year promises new challenges to engineers in process control industries. Usually, the challenges are clear: improve quality, increase productivity, reduce scrap, improve the profit margin by 15%, cut the leadtime for new product introductions, or conserve energy. In 1988, all of the above, and more, still apply. Yet, the real challenges facing instrument/control engineers and managers are not so easily explained. Rather, they have become clouded because they are so intimately intertwined. An attempt is made to clarify the confusion and point out some pertinent guidelines.

Maczka, Walter J. (InTech, Research Triangle Park, NC, USA). *InTech* v 35 n 1 Jan 1988 p 9-12.

**Education** See ARTIFICIAL INTELLIGENCE—Expert Systems.

**Electronic Equipment** See COAL MINES AND MINING—Process Control.

**Equipment** See Also CONTROL EQUIPMENT—Design; CONTROL SYSTEMS, SELF ADJUSTING; GAS PURIFICATION; MEASUREMENTS—Equipment; OPTICAL FIBERS—Applications; PRINTED CIRCUITS—Assembly.

**085863 AVOIDING THE PITFALLS OF SPECIFYING SYSTEMS.** A new control system requires a review of the existing process to anticipate potential problem areas and to take account of the increasing proportion of the cost which today is attributable to new instruments, valves, actuators and related equipment. It is argued that a feasibility study should address not only the control system hardware and software requirements, but also the process hardware needed to reduce operator intervention.

Pym, David. *Control Instrum* v 19 n 12 Dec 1987 p 53,

55.

**085864 INTERFACING SENSORS TO PROGRAMMABLE CONTROLS.** Process control applications are claiming an increasing total of the programmable control marketplace. As a result, there is the need to ensure proper interfacing between programmable controllers and sensors - both digital and analog - and input/output (I/O) devices. (Author abstract)

Infelise, Nick (Omron Electronics Inc, Schaumburg, IL, USA). *InTech* v 35 n 1 Jan 1988 p 63-66.

**085865 MIKROCONTROLLER FUER PROZESSSTEUERUNGEN.** [Microcontroller for Process Control Equipment]. A digital control device is described. It incorporates a 10-bit analog-digital converter and a 16-bit pulse-width modulated digital-analog converter. Additional components are discussed, such as integrated peripheral circuitry, including a special computer counter and a watchdog circuit. 2 Refs. In German.

Timm, Volker. *Elektronik* v 37 n 11 May 27 1988 p 117-122.

## Fermentation

**085866 CONSIDERATIONS IN CONTROL SCHEME DEVELOPMENT FOR FERMENTATION PROCESS CONTROL.** It is shown that more effective use of those measurements that are already available can provide an improvement in fermentation process control, which has been commonly viewed as almost insurmountable due to inherent measurement difficulties. Fermentation process problems that are significant in control system design are highlighted. Two industrial examples are given, showing how operation can be improved using currently available technology. One is a penicillin fermentation process, and the other is commercial mycelial fermentation. 12 refs.

Montague, Gary A. (Univ of Newcastle-upon-Tyne, Engl); Morris, A. Julian; Bush, John R. *IEEE Control Syst Mag* v 8 n 2 Apr 1988 p 44-48.

## Final Control Devices See ACTUATORS.

**Identification** See Also CONTROL SYSTEMS, ADAPTIVE—Design.

**085867 ACTIVE IDENTIFICATION OF THE PARAMETERS OF A LINEAR STATIC PLANT (A GAME PROBLEM OF EXPERIMENTAL DESIGN).** The design is considered of algorithms of active multiple identification of the parameter vector of a linear static plant. It is assumed that this vector belongs to a preassigned convex polyhedron, and that the disturbances are bounded. Properties of optimal active identification are studied that make it possible to reduce the diameter of the a posteriori region of uncertainty of the parameter vector. A recursive suboptimal algorithm of active identification is proposed, its convergence is proved, and bounds are obtained for the convergence rate. The results of numerical simulation are also presented. (Edited author abstract) 8 refs.

Kuntsevich, V.M.; Lychak, M.M.; Nikitenko, A.S. *Autom Remote Control* v 48 n 9 pt 1 Sep 1987 p 1174-1181.

## Imaging Techniques

**085868 DETECTING MATERIAL DEFECTS IN REAL TIME.** A variety of sophisticated imaging techniques are improving in-process quality control of materials. NDE, emerging as a useful tool for online process control, is no longer limited to final or in-service inspection. Sophisticated imaging techniques are being developed to meet the demands of this new role for NDE. Increasingly, research is gearing to improve imaging of material defects with systems that can be applied during raw-materials production. Likewise, equipment manufacturers are continually improving their systems for online, real-time process control. 2 refs.

Sheppard, Laurel M. (Advanced Materials & Processes,

Metal Park, OH, USA). *Adv Mater Processes* v 132 n 5 Nov 1987 p 53-60.

## India

**085869 DISTRIBUTED CONTROL SYSTEM FOR TRADITIONAL PROCESS INDUSTRIES IN INDIA.** Due to tremendous advances in the last few years, distributed control systems offer attractive cost benefit ratio even for traditional process industries. This paper analyses the state of distributed control systems today and discusses how they can help in traditional process industries. Some ideas on how to successfully retrofit a distributed control system into a running process plant have been given, citing concrete examples of Sugar, Glass and Cement industries. (Author abstract)

Rastogi, V.K. (UPTRON India Ltd, Lucknow, India); Gupta, Sudhir. *IETE Tech Rev* v 4 n 5 May 1987, 18th Mid-term Symp of IETE: Electron in Soc Dev, Lucknow, India, Oct 4-5 1986 p 206-214.

**Industrial Applications** See Also CONTROL SYSTEMS, DIGITAL—Industrial Applications; CONTROL SYSTEMS, TIME VARYING—Theory.

**085870 DIGITAL SOLUTIONS FOR INDUSTRY, SCIENCE AND TECHNOLOGY (PRESENTED AT: DIGITECH '85 NORTHEASTERN CONFERENCE AND EXHIBIT ON INDUSTRIAL INSTRUMENTATION AND CONTROL).** This conference proceedings contains twenty three papers. Topics covered includes the Plant Automation, Distributed Control Systems, Man-Machine Interfaces. Programmable controls, Fiber optic Systems and Sensors, Laser Applications, Software for Digital Systems, Process Measurement Theory and Application. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10764 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Herbst, Keith S. (Ed.) (Moore Products Co). *Digital Solutions for Ind, Sci and Technol*, Boston, MA, USA, May 14-16 1985 Publ by ISA, Research Triangle Park, NC, USA, 1985 215p.

**Instruments** See Also CHEMICAL PLANTS—Process Control; DATA CONVERSION, ANALOG TO DIGITAL—Equipment; MEASUREMENTS—Automation; VISCOMETERS—Process Control.

**085871 INTRODUCING DIGITALLY INTEGRATED MEASUREMENT.** Plant managers, process engineers and plant operators for decades have decried the gap between control and measurement technology. More than one system designer or control engineer has lamented that many of his best ideas for more effective control required a level of measurement performance that he could not find on the market. Among the most frequently cited deficiencies are: insufficient accuracy, too much shift or drift, limited rangeability, uncertainty about the validity of transmitted data, and high support and maintenance costs. Ways to mitigate such deficiencies are considered. (Edited author abstract).

Dallimonti, Renzo (Honeywell Inc, Fort Washington, PA, USA). *InTech* v 35 n 7 Jul 1988 p 41-43.

## Laser Applications See WELDS—Defects.

## Management See Also STATISTICAL METHODS.

**085872 STRATEGIC CONTROL OF FACTORY AUTOMATION.** This article identifies strategic control as an unexpected difficulty in implementing the 'factory of the future' and as a major stumbling block to firms in their automation efforts. The concept of strategic control is discussed and an example is given. The results of a study in this area are then described and used to explain how managers have unknowingly relinquished control of the manufacturing operation. The article concludes with advice for managers in setting up strategic control systems in their firms that will facilitate rather than hinder the progress of factory automation. (Author abstract) 12 refs.



Meredith, Jack R. (Univ of Cincinnati, OH, USA). *Long Range Plann* v 20 n 6 Dec 1987 p 106-112.

**085873 MANAGEMENT OF PROCESS INNOVATION - THE CASE OF FMS: A SYSTEMS APPROACH.** The objective of our research is the development of management methods for the effective introduction of new production processes into companies. To support this a descriptive model of process innovation has to be developed. In this paper we will present the framework of such a model and discuss the theoretical and practical implications in the light of data collected in case-studies of the introduction of Flexible Manufacturing systems into Dutch and British firms. (Author abstract) 17 refs.

Boer, Harry (Univ of Twente, Enschede, Neth); During, Willem E. *Int J Prod Res* v 25 n 11 Nov 1987 p 1671-1682.

**085874 PROCESS CONTROL MANAGEMENT PAYS OFF FOR CORNING.** Process control management (PCM) is a technique which directs attention of quality control and engineering personnel only to machines and processes that present difficulties. With PCM, the burden of continuous checking is placed on the operator. As soon as the data are obtained from a specified number of operations, they are fed into the system and tabulated to produce a new picture of the area. The new picture is available to production, quality control, and engineering for analysis and reevaluation. PCM was implemented successfully in the late 1970s in four of six Corning Glass Works electronics plants - two in the U.S., one in France, and one in England. Annual savings of more than \$200,000 in direct labor and \$300,000 in selection (yield) improvement were realized. 2 refs.

Denissioff, Basile A. (Corning Glass Works, Raleigh, NC, USA). *Glass Ind* v 68 n 11 Oct 1987 p 14-16, 32.

**Mathematical Models** See Also CONTROL SYSTEMS, OPTIMAL—Estimation; CONTROL SYSTEMS, PREDICTIVE; INTEGRATED CIRCUITS, VLSI—Computer Aided Manufacturing; MACHINERY—Automation; MEASUREMENT ERRORS—Control.

**085875 DETERMINATION OF THE EXPECTED ECONOMIC EFFECT OF AUTOMATED PROCESS CONTROL SYSTEMS BY STRUCTURAL-STATISTICAL MODELING.** The authors have developed and tested a modeling procedure for a number of automated process control systems in ferrous metallurgical industry which links the target indicators characterizing the technological effectiveness of the control system with indicators representing the economic effectiveness of these systems. A specific feature of their methodology is the introduction of latent production indicators which characterize the major operating conditions of the automated process. The proposed approach makes it possible to determine the magnitude of the economic effect also in cases with complex dependence between the improved technological indicators and the resulting economic production indicators. 3 refs.

Galitskii, E.B.; Levin, M.I.; Rubinchik, M.V. *Autom Remote Control* v 48 n 4 pt 2 Apr 1987 p 523-529.

**085876 PRINCIPLES AND ENGINEERING OF PROCESS CONTROL WITH PETRI NETS.** Event-related control is considered in which process and related process control can be described by states and transitions that can be represented concisely by a Petri net (PN). Both process and related process control systems are event-related, causal, and concurrent and define a special type of PN using a few primitives that are assembled to form a net for which structural and dynamic invariants apply. The PNs can be used for a general approach to event-related process control in simulating, checking, debugging, and stating the quantitative deviations from the ideal solution for any given process control system. The technique can be applied to continuous or discrete processes, and provides formal checks at all development stages. It allows for components with nonideal behavior and yields numerical performance criteria. The invariants allow the PN to be structured in such a way

that even complex process control systems become manageable. Examples are presented for the control tasks in an electrical substation. 11 refs.

Brand, Klaus-Peter (Brown Boveri & Co, Baden, Switz); Kopainsky, Jurgen. *IEEE Trans Autom Control* v 33 n 2 Feb 1988 p 138-149.

**085877 STATISTICAL CONTROL OF VLSI FABRICATION PROCESSES - I: A FRAMEWORK.** A general framework for statistical control of VLSI (very large-scale integration) fabrication processes is given along with the architectural description of a software system that can be used for monitoring, diagnosis, and quality/quantity control of computer-aided integrated circuit (IC) manufacture. The task of process control is formulated as one of profit maximization, and the associated objective function and the constraints are developed for a number of manufacturing scenarios. The IC fabrication process is modeled as a stochastic system and the necessary conditions for efficient statistical control of VLSI fabrication processes are described. 16 refs.

Mozumder, Purnendu K. (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Shyamsundar, C.R.; Strojwas, Andrzej J. *IEEE Trans Semicond Manuf* v 1 n 2 May 1988 p 62-71.

**Monitoring** See Also INDUSTRIAL PLANTS—Production Control; WASHING MACHINES—Sensors.

**085878 BIOSENSORS BRING NEW LIFE TO PROCESS CONTROL.** Biotechnology is breaking new ground for monitoring any process that is compatible with biological activity. Biosensors will be used to monitor these processes, with industry growth mainly for the production of food, pharmaceuticals and beverages, as well as waste water treatment. Biosensors provide specificity and sensitivity of measurement at high speed and low cost, unachievable with other techniques. (Edited author abstract)

Reeve, Alan. *Control Instrum* v 20 n 2 Feb 1988 p 78-79.

**Optimization** See Also ELECTRONICS PACKAGING—Quality Control.

**085879 PROCESS FLOWSHEET OPTIMIZATION STRATEGIES: RECENT RESULTS AND FUTURE DIRECTIONS.** Here we review earlier optimization strategies and emphasize more recent strategies based on successive quadratic programming (SQP). This report describes the process optimization problem with a simple flowsheeting model and briefly discusses the infeasible path approach, which permits simultaneous recycle convergence and optimization with SQP. Several improvements to the infeasible path algorithm are then outlined that include better gradient calculation and scaling strategies, a more efficient line search function and more reliable performance through intermediate recycle convergence. These concepts are applied to a large-scale process problem and resulting improvements are demonstrated. Finally, we present a brief discussion of open research questions and directions for future research. (Edited author abstract) 34 refs.

Biegler, L.T. (Carnegie-Mellon Univ, Pittsburgh, PA, USA). *Appl Numer Math* v 3 n 5 Oct 1987 p 393-408.

**085880 ECONOMIC DESIGN OF SAMPLING CONTROL STRATEGIES FOR A CLASS OF INDUSTRIAL PROCESS.** Many authors have proposed models for the optimal design of control charts for the control of the defect rate for industrial processes. If it were, the obvious optimal strategy would be to rebuild the process, possibly without samplings, after each batch or unit produced. This paper considers the determination of the optimal sample size and sample interval for the case where the process does not have to be rebuilt, but rather may be simply adjusted at a nominal cost after each sample. A model, which assumes a continuum of process fraction defectives, is developed and then used to explore the effect of fixed and variable sampling cost, specification limits and measurement errors on the optimal sampling policy and costs. (Edited author abstract) 23 refs.

McDowell, Edward D. (Oregon State Univ, Corvallis, OR, USA). *IIE Trans* v 19 n 3 Sep 1987 p 289-295.

**085881 CHARACTERIZING AND OPTIMIZING MULTI-RESPONSE PROCESSES BY THE TAGUCHI METHOD.** We demonstrate the ability of the Taguchi technique accurately to characterize and successfully to optimize complicated multi-response processes with the minimum of experiments, provided one uses simple statistical techniques which can ensure valid and definitive results. We point out the usefulness of suitable data-transformations, and we suggest a systematic procedure for establishing the optimal operating conditions and for carrying out confirmatory experiments. For the particular case detailed in this paper (which is typical of multi-response processes) the Taguchi technique achieved an improvement in uniformity of a factor of 2, together with optimized process control. (Edited author abstract) 14 refs.

Logothetis, N. (GEC plc, Wembley, Engl); Haigh, A. *Qual Reliab Eng Int* v 4 n 2 Apr-Jun 1988 p 159-169.

**085882 INTEGRATED COST MODEL FOR THE JOINT OPTIMIZATION OF PROCESS CONTROL AND MAINTENANCE.** Statistical process control and preventive maintenance have been treated separately by past research. This study presents an economic model that incorporates both process control and maintenance procedures, and simultaneously optimizes their design parameters. It is shown how a pure process-control policy and a pure preventive-maintenance policy constitute special cases of the general model. Numerical examples illustrate the application of the method and suggest that, under the Markovian deterioration assumption, in many cases a pure policy is economically justifiable. (Author abstract) 7 refs.

Tagaras, George (Univ of Pennsylvania, USA). *J Oper Res Soc* v 39 n 8 Aug 1988 p 757-766.

**Performance** See Also CONTROL SYSTEMS—Performance.

**085883 PROCESS CONTROL STRATEGY WIDENS.** Statistical process control is implemented in many of today's distributed control systems, with this tighter control showing up as increased quality at the end of the day. Taylor MOD systems provide statistical calculations as standard within the system software. Statistical calculations are part of the standard library of configurable control functions, a menu-driven application software package for control and data acquisition. Some specific applications are reported. It is argued that statistical control techniques provide another means of tightening the process and improving final product quality.

Opie, Roy. *Control Instrum* v 20 n 4 Apr 1988 p 67, 69.

**Planning** See Also COMPUTER AIDED MANUFACTURING—Scheduling.

**085884 KNOWLEDGE-BASED APPROACH FOR AUTOMATED PROCESS PLANNING.** Automated process planning (APP) is a critical interface to both design and manufacturing. Several evolving systems have employed artificial intelligence (AI) procedures to capture the basic logic used by a process planner. However, no effort has been directed to systemize the knowledge in the field of process planning. In this paper process planning knowledge extraction and formalization are discussed. A framework for the development of intelligent APP systems capable of learning through user interaction is also presented. (Author abstract) 20 refs.

Wang, Hsu-Pin (State Univ of New York at Buffalo, Buffalo, NY, USA); Wysk, Richard A. *Int J Prod Res* v 26 n 6 Jun 1988 p 999-1014.

**Quality Assurance** See Also QUALITY CONTROL—Management.

**085885 STOP IN THE NAME OF QUALITY.** This article details a dynamic process control system in a circuit card assembly shop that monitors quality at the



source during the assembly process. Using this procedure, defects are identified at the earliest possible stage in the manufacturing cycle. When tied in with a single-card transfer manufacturing process, basic problems can be discovered quickly and permanent solutions implemented with minimal rework.

Gaston, Howard (AT&T, Little Rock, AR, USA); Young, James. *Circuits Manuf* v 28 n 2 Feb 1988 p 54-56.

## Quality Control

**085886 STATISTICAL PROCESS CONTROL - ITS IMPLICATIONS FOR THE METALS INDUSTRY.** Ford's operating philosophy of never ending improvement has resulted in a change of emphasis from defect detection to defect prevention through the application of Statistical Process Control (SPC), employee involvement and training. This approach will lead to improvements in both quality and productivity that will be of mutual benefit to suppliers and Ford. (Author abstract)

Cordwell, T.C. (Iveco Ford Truck Ltd.). *Int J Mater Prod Technol* v 2 n 2 1987 p 149-155.

**085887 GAUGE R&R - THE ORPHAN OF SPC.** For statistical process control (SPC), often little attention has been paid to the accuracy of numbers. This involves the gage producing the numbers, the person using the gage, the environment, the method, and anything else that could affect the repeatability and reproducibility of the measurements. All of this has been reduced to a new technique, and a new buzzword: Gage R&R, which stands for Gage Repeatability & Reproducibility. According to the General Motors General Quality Standard for Purchased Material, there are five elements involved in determining Gage R&R: accuracy, repeatability, reproducibility, stability, and linearity.

Crosby, David C. (Crosby Co.). *Rubber World* v 198 n 3 Jun 1988 p 12-13.

## Reliability

**085888 CUMULATIVE SUM CONTROL SCHEME FOR TRUNCATED EXPONENTIAL DISTRIBUTION WITH GROUPED OBSERVATIONS.** The Cumulative Sum (CUSUM) control scheme for testing the mean of a doubly truncated exponential distribution is constructed by considering group of observations at each state of inspection. Emphasis is given on the effect of group size and truncation intervals on the parameters of the V-mask of the CUSUM chart and the average run length. It is seen that the grouping procedure enables one to have an early detection of the shift in process mean. (Author abstract) 6 refs.

Kakoty, S.; Chakravorty, A.B. *QR J* v 14 n 2 May 1987 p 51-55.

## Research

**085889 CLOSED-LOOP TUNING OF PROCESS CONTROL SYSTEMS.** A technique for tuning PID controllers, involving a single dynamic test (such as a step or pulse change in set point) implemented during closed-loop operation, is proposed. The resulting transient data are used to predict the frequency response of the open-loop process which in turn is used to compute the optimum controller settings. Simulation results reveal that this technique provides reliable tuning constants even when such practical problems as process noise and unanticipated load upsets arise during implementation. A comparison with the recently proposed tuning alternative confirms that in general the suggested procedure, apart from being more flexible, yields also relatively better results. (Edited author abstract) 10 refs.

Krishnaswamy, P.R. (Natl Univ of Singapore, Singapore); Chan, B.E. Mary; Rangaiha, G.P. *Chem Eng Sci* v 42 n 9 1987 p 2173-2182.

## Reviews

**085890 CONTROL OF PROCESSES WITH TIME DELAYS.** The need to control processes with time delays can be found in many aspects of the metals industry from refining to rolling mills. When the time delay becomes long compared with the system time constant, or when the time delay varies, then control of the process becomes difficult using classical control methods. Yet, with the increasing demand to have tighter control of the processes, methods must be developed to achieve high-quality control despite the time-delay problem. Three controllers are evaluated for their applicability to this problem: the classic proportional-integral (P-I), the Smith linear predictor, and the Clarke-Gawthrop self-tuning controller. Each of the controllers is implemented on an example process which is first-order with a long time delay. Implementation details, like selection of tuning parameters, are discussed. What type of performance can be expected from the classic P-I controller is quantified in terms of time delay and time constant. All three control strategies are evaluated for their response to step reference changes, step load disturbances, and variations in the process time delay. No one control strategy has the perfect solution, so the advantages and limitations of each strategy are presented and discussed. 7 refs.

Schneider, Donna M. (Alcoa, Alcoa Center, PA, USA). *IEEE Trans Ind Appl* v 24 n 2 1988 p 186-191.

## Robot Applications

**085891 PREP OF HIGH-DENSITY COMPONENTS.** A CAD data-driven SMD placement system is presented. The system accurately places a wide range of components including chip capacitors, electrolytic capacitors and large quad packs with 0.025-in. lead spacing. To control processes involved in lead forming, tinning, inspection and kitting these very expensive high-density quad packs, a robot is used. All tooling control, vision system application and data logging is performed by software running on the robot controller. Variables governing flux and solder processes are stored in decoupled databases that define component geometries and feeder inventories. Kits are built from the same CAD databases used by the placement workcell.

Stover, Jeff (Gelzer Systems Co, Westerville, OH, USA). *Circuits Manuf* v 28 n 2 Feb 1988 p 28, 30.

**085892 LAYOUT PLANNING AND SIMULATION FOR APPLICATION OF ROBOTS.** In the case where robots are introduced into a production line, if the operation scenario of the robots is known beforehand in the planning stage, it is possible to save time from robot introduction to production line start-up. This paper gives an outline of an actual engineering technique application with the aid of computer technology. For example, 'ROSET' is a CAD system for robots application engineering developed by KHI. This system is useful for the layout planning of robots, the precheck of the operation motion and the generation of the teaching data, when it is planned to introduce robots into a production line. This paper gives a concept concerning the planning and the simulation for application of the robots. (Edited author abstract).

Mitsuhashi, Kanji (Kawasaki Heavy Industries Ltd, Akashi, Jpn); Yamato, Kunitada. *Adv Rob* v 2 n 1 1987 p 87-98.

## Robustness See COMPUTER SOFTWARE—Reliability.

## Stability See Also CONTROL SYSTEMS, NONLINEAR—Design.

**085893 PROCEDURE FOR COMPUTING OPTIMAL STABILITY PROPORTIONAL CONTROLS. PART I.** Among process control systems, astatic proportional-integral (PI) and proportional-integral-derivative (PID) controls hold an important place. This is because the controls manufactured in quantity by the instruments making industry produce just these controlling actions. The creation of effective and fairly simple procedures for

analyzing these systems is a factor in expanding the possibilities and improving the quality of PI and PID systems. Optimal stability solutions were found in a previous work for the problems in designing the linear control systems. However, the form in which these optimal solutions are given does not lend itself to analyzing optimal systems or to understanding their physical meaning. Results of a previous work are used for designing optimal PI and PID systems into a form more convenient to understanding and practical use. Special cases of computing PI control systems are examined. 2 refs.

Shubladze, A.M. *Autom Remote Control* v 48 n 4 pt 1 Apr 1987 p 435-442.

## Structure

**085894 CONCEPT OF 'EIGENSTRUCTURE' IN PROCESS CONTROL.** Much of the work in multivariable process control has been directed at finding control structures that minimize interaction among loops and decouple the system. This paper claims that this approach is flawed. What is really important in the vast majority of chemical and petroleum processes is a structure that does the best job in rejecting load disturbances. This inherent or intrinsic 'eigenstructure' (choice of controlled and manipulated variables and their pairing) is that configuration which yields a system that is naturally self-regulating for load disturbances and self-optimizing. Eigenstructure is a unifying concept that links several previously published approaches to the process control problem. (Author abstract) 8 refs.

Luyben, William L. (Lehigh Univ, Bethlehem, PA, USA). *Ind Eng Chem Res* v 27 n 1 Jan 1988 p 206-208.

## Technology Transfer

**085895 TRANSFERRING TECHNOLOGY TO DEVELOPING NATIONS.** This paper reviews the principles of technology transfer and four examples that illustrate pitfalls in undertaking technology transfer programs without a thorough understanding of the process. The nature of the commitment required is emphasized and then it is noted that frequently long-term commitment cannot be maintained. The concept of mini-technology transfer as a solution to continuing efforts in periods of depressed economic activity is presented. Mini-technology transfer involves the use of mentors, tutors and tapes. Mentors help with the decision process and teamwork. Tutors and tapes help to upgrade technology applications. (Edited author abstract) 1 ref.

Ekholm, E.L. *Eng Manage Int* v 5 n 1 Apr 1988 p 45-52.

## Telemetering See Also NATURAL GAS PIPELINES—Control Systems.

**085896 TURNING TELEMETRY TO PROCESS CONTROL.** As distributed control in the process industries has become more in vogue as a concept, aided and abetted by ever cheaper, smaller and more ruggedized remote process units, plus more reliable and faster dual redundant data highways of one sort or another, the most advanced hardware in this field has begun to resemble ever more closely its telemetry counterparts. The author examines what telemetry and process control have in common and outlines current supervisory and data acquisition (SCADA) projects.

Tinham, Brian. *Control Instrum* v 19 n 11 Nov 1987 p 43, 45, 47.

## Temperature Control See Also STEEL HEAT TREATMENT—Temperature Control.

**085897 CONTROLLER TUNING FOR A SLOW NONLINEAR PROCESS.** Determining the tuning constants of a classical PID (proportional-integral-derivative) controller for a slow nonlinear process, such as the temperature loops on a heat-treat or annealing furnace, can be a laborious task. Several tuning methods were considered to identify a method that could be applied easily in the field with limited resources. The Zie-



gler-Nichols method proved to be easy and effective. Results obtained by using the Ziegler-Nichols open-loop method to determine the tuning constants for a classical PID temperature controller for a heat-treat furnace are described. The process being controlled is described, and open-loop test data are presented. 6 refs.

Dreinhofer, Louis H. (Aluminum Co of America, Pittsburgh, PA, USA). *IEEE Control Syst Mag* v 8 n 2 Apr 1988 p 56-60.

**Theory** See ARTIFICIAL INTELLIGENCE—Expert Systems; CONTROL SYSTEMS—Theory; CONTROL SYSTEMS, ADAPTIVE—Theory; CONTROL SYSTEMS, DIGITAL—Applications; CONTROL SYSTEMS, DIGITAL—Theory; CONTROL SYSTEMS, PREDICTIVE—Theory.

**Valves** See VALVES AND VALVE GEAR—Testing.

**PRODUCT DESIGN** See Also ASSEMBLY MACHINES; AUTOMOBILES—Springs and Suspensions; BEARINGS—Journal; DIE CASTING; DOMESTIC APPLIANCES—Materials; ENGINEERING—Project Management; GEARS—Bevel; INDUSTRIAL MANAGEMENT—Planning; METAL EXTRUSION; PACKAGING—Tampers; TAMPERS—Production Engineering; PRODUCTION ENGINEERING—Design Aids; PRODUCTION ENGINEERING—Management; PRODUCTION ENGINEERING—Planning; PUMPS—Impellers; QUALITY ASSURANCE.

**085898 HEURISTIC APPROACH TO PRODUCT DESIGN.** A dynamic-programming heuristic is described to find approximate solutions to the problem of identifying a new, multi-attribute product profile associated with the highest share-of-choices in a competitive market. The input data consist of idiosyncratic multi-attribute preference functions estimated using conjoint or hybrid-conjoint analysis. An individual is assumed to choose a new product profile if he/she associates a higher utility with it than with a status-quo alternative. Importance weights are assigned to individuals to account for differences in their purchase and/or usage rates and the performance of a new product profile is evaluated after taking into account its cannibalization of a seller's existing brands. (Edited author abstract) 17 refs.

Kohli, Rajeev (Univ of Pittsburgh, Pittsburgh, PA, USA); Krishnamurti, Ramesh. *Manage Sci* v 33 n 12 Dec 1987 p 1523-1533.

**085899 IMPROVING PRODUCT DEVELOPMENT USING ORGANIZATIONAL ANALYSIS.** This article proposes an organizational analysis matrix to help companies establish an R&D program that provides better new products faster and less expensively. The author discusses staff management and marketing; R&D department planning, structure and controls; R&D department innovation and creativity; and manufacturing, quality and finance operations. (Author abstract)

Gerace, Michael J. (ASTER Inc, Yellow Springs, OH, USA). *Adhes Age* v 31 n 1 Jan 1988 p 28-30.

**085900 NEW APPROACH TO PRODUCT DEVELOPMENT.** In contrast to the traditional serial approach to product development which does not maximize quality or minimize time to market, the parallel approach combines a wider range of talent and disciplines and results in innovative ideas enabling a company to become or remain competitive. Having the whole development group - from marketing to manufacturing - work on the project together as well as make several passes through the development cycle, allows mistakes to be made early and enables the group to consider a wide range of possible designs before choosing the best.

Kelley, D. *Eng Dig (Toronto)* v 33 n 3 Mar 1987 p 15-16.

**085901 ROLE OF EXPERIMENTAL VIBRATION ANALYSIS IN PRODUCT DEVELOPMENT AND MACHINE DIAGNOSTICS.** Since the advent of the mini-computer in the mid-sixties experimental vibration analysis has had a tremendous increase in scope and application. This paper discusses the role of experimental prototype of the techniques involved and contains case studies concerning the development of prototypes of an

agricultural aircraft, a washing machine and a commercial vehicle suspension, as well as a diagnostic case study of ship vibrations. (Author abstract) 7 refs.

de Cock, Simon G.J. (DSIR, Auckland, NZ). *Trans Inst Prof Eng NZ Electr Mech Chem Eng Sect* v 14 n 3 Nov 1987 p 152-162.

**085902 MAKING IT SIMPLE: DESIGN FOR ASSEMBLY.** Design-for-assembly procedures are now followed widely throughout industry and are providing benefits beyond reductions in assembly costs. In fact, simplified designs resulting from the use of DFA techniques often lead to reductions in the cost of parts significantly greater than reductions in the cost of assembly. Other benefits, more difficult to quantify, include reductions in inventory and record keeping and improvements in material and production flow. Design for assembly involves reducing the number of separate parts to a minimum and making the remaining parts as easy as possible to assemble. The paper evaluates by means of examples various alternative designs and compares the end product costs by changing the design.

Boothroyd, Geoffrey (Univ of Rhode Island, Kingston, RI, USA). *Mech Eng* v 110 n 2 Feb 1988 p 28-31.

**085903 EXPERT APPROACH TO DESIGN.** The importance of good design to business success is recognized by a growing number of UK companies. This article discusses three successful products in which help from an independent design consultant was provided. A reduction in manufacturing costs, leading to an increase in sales volumes of a Heparin injector, was the challenge put to Cambridge Consultants (CCL) by Princess Risborough-based manufacturer Edwin Burgess. Cost reduction was the major factor when Havant-based manufacturer of louvered ventilators, Colt International, invited PE Consulting Group to carry out a feasibility study. When Permutit decided that its water deionisers needed redesigning, the Design Council put the company in touch with Moggridge Associates, a London-based design consultancy.

Anon. *Engineering (London)* v 228 n 2 Feb 1988 p 84-85.

**085904 DESIGN ISSUES IN MECHANICAL TOLERANCE ANALYSIS.** Tolerance analysis is a valuable tool for reducing manufacturing costs by improving producibility. Several useful methods of selecting design tolerances are presented with examples. The common and more advanced tolerance analysis methods are also reviewed and evaluated. A simple new tolerance analysis model suitable for designers is described as an alternative to the advanced methods. It is much more flexible than the common engineering methods. For example, it can mix statistical and worst-case components in the same assembly. Also, it includes a critical manufacturing variable that is often overlooked: 'nominal shifts' or biased distributions. (Author abstract) 11 refs.

Chase, K.W. (Brigham Young Univ, Provo, UT, USA); Greenwood, W.H. *Manuf Rev* v 1 n 1 Mar 1988 p 50-59.

**085905 USE OF  $2^k-P$  DESIGNS IN PARAMETER DESIGN.** The article shows that a single  $2^k-P$  fractional factorial design matrix and the traditional data analysis techniques associated with this design can be used effectively to achieve the goal of parameter design while reducing the total number of experiments required. A real example is used to compare Taguchi's two-part design and S/N analysis to a  $2^k-P$  design and its associated analysis. Also, a flow diagram is presented to guide a practitioner through the parameter design process using a  $2^k-P$  design. This flow diagram provides an annotated guide to the literature on  $2^k-P$  decision and shows the design processes leading to proper choice of design and appropriate data analysis techniques. (Author abstract) 12 refs.

Song, Jae; Lawson, John. *Qual Reliab Eng Int* v 4 n 2 Apr-Jun 1988 p 151-158.

**085906 DESIGNING FOR MANUFACTURABILITY.** Manufacturability is the measure of a design's ability to consistently satisfy product goals while being profit-

able. Product goals can be broken down into several categories: technical performance, quality, reliability, availability, and cost. Traditionally, design engineers have focused on the technical performance of products and not on other manufacturability considerations. The use of design guidelines for manufacturability can change this focus and permit significant product improvements. This article discusses how the best manufacturers address potential problems before they occur. Subjects covered include defect levels and quality, reliability, availability and cost.

Heidenreich, Paul (Manufacturing Technique). *Qual Prog* v 21 n 5 May 1988 p 41-44.

**085907 RATIONALISATION RESULTS IN ASSEMBLY-ORIENTATED DESIGN.** Assembly-orientated product design means that the products should be designed in such a way that expenditure on assembly and production costs are reduced to a minimum. The design process is divided into four stages: planning; rough design; drafting; and detailed design, and the needs for assembly-orientated product design will vary with different design activities. The assembly-orientated design process shows that among the large number of applicable aids the most important are the systematically applied design rules and the evaluation of the suitability for assembly. Design rules represent a set of known and well-tried solutions for certain design tasks and can be conveniently summarised in catalogues. 7 refs.

Baessler, R. (Fraunhofer-Inst for Manufacturing Engineering & Automation (IPA), Stuttgart, West Ger). *Assem Autom* v 8 n 2 May 1988 p 82-86.

## Accident Prevention

**085908 VIEWING SAFETY FROM A POSITIVE PERSPECTIVE.** Recent, highly publicized failures of engineered systems and facilities make it important to put the issue of safety in engineering into perspective. Given a burgeoning population and a vast increase in the quantity, scope, and complexity of engineering work worldwide, the level of safety we have achieved is incredibly high. The failures that have occurred - tragic though they are - involve only a tiny fraction of total engineering activity. It would seem that the public and the press do not always take this fact into account.

Allen, William F. (Stone & Webster Inc, New York, NY, USA). *Mech Eng* v 110 n 7 Jul 1988 p 78-81.

## Assembly

**085909 DESIGN FOR ASSEMBLY.** DFA procedures have traditionally relied on the use of a few general guidelines to aid the designer in the product assembly construction and component feeding and orientating. While Design for Assembly (DFA) is a relatively new field, the increasing realization that it is the crucial factor in automating assembly and handling processes has meant that there is strong reader-interest in this topic. (Edited author abstract).

Miles, B. (Lucas Engineering Systems); Swift, K.G. *Automot Eng (London)* v 13 n 3 Jun 7 1988 p 38-40.

**Bonding** See ASSEMBLY MACHINES—Automation.

## Computer Aided Analysis

**085910 VENTURE EVALUATION AND REVIEW TECHNIQUE EMPLOYED IN PLAN EVALUATION.** This paper illustrates the application of Venture Evaluation and Review Technique (VERT-3), the up-to-date network technique used for treating many decision parameters simultaneously. This technique is employed to simulate the whole engineering of designing and producing a new complex product in F company, getting the risky statistical data of the expended time, expense and product performance of engineering, and providing the decision basis for a company. (Edited author abstract) 4 refs. In Chinese.

Lin, Xihe. *Zhongnan Kuangye Xueyuan Xuebao* n 5 Oct



1986 p 90-96.

**Computer Aided Design** See Also BEARINGS—Marketing; BICYCLES—Design; COMPUTER AIDED DESIGN—Economics.

**085911 RATIONALISED APPROACH TO THE APPLICATION OF CAD WITHIN MECHANICAL PRODUCT DESIGN.** This paper reviews the nature of the product design process by focusing on the types of design that arise throughout the life cycle of an engineering product. It is proposed that considerations of 'design by evolution' and 'design by innovation' should be carefully assessed as fundamental criteria when formulating decisions on the adoption and implementation of CAD within mechanical product design. It is further suggested that, within the conceptual boundaries of product design, the application of CAD techniques may accelerate a product's progression from the state of innovative design towards the evolutionary design condition. (Author abstract) 9 refs.

Black, I. (Heriot-Watt Univ); Linton, H.C. *Comput Aided Eng J* v 4 n 5 Oct 1987 p 213-216.

**085912 PART-FEATURE RECOGNITION SYSTEM FOR ROTATIONAL PARTS.** A part-feature recognition system for the conversion of a CAD language to a CAM language is developed. The parts of interest are rotational without deviation. The recognized part information is posted into a part-definition data structure, which many manufacturing functions such as computer-aided process planning, group technology coding, NC program generation, and inspection can access to. A part-feature recognition algorithm, the 'intelligence' of the system, is discussed in great detail. Finally, an example is evaluated to demonstrate the success of the system. (Edited author abstract). 13 Refs.

Rong-Kwei, Li (Nat'l Chiao Tung Univ, Taiwan). *Int J Prod Res* v 26 n 9 Sep 1988 p 1451-1475.

## Computer Applications

**085913 PRODUCT DESIGN AND INTRODUCTION SUPPORT SYSTEMS.** Design decisions made early in the product realization cycle can have a dramatic effect on the manufacturability, quality, and ultimate marketplace success of a product. The features of CAE/CAD systems must ensure that, as designs progress, they adhere to design rules that codify manufacturability and quality. But that is only the start. For successful introduction of a product into the factory, computer-aided systems must be integrated with the design aids to augment the design information with all the factory-specific information needed to reach the state where the product is ready to manufacture. All this information must be put under change, version, and configuration control so that the factory is assured of accurate and consistent information. Finally, the data must be made available to the ordering systems to ensure that the product is manufactured to specification. This article describes the AT&T computer aids that satisfy these needs. (Author abstract) 2 refs.

Burling, William A. (AT&T Bell Lab); Bartels Lax, Barbara J.; O'Neill, Lawrence A.; Pennino, Thomas P. *AT&T Tech J* v 66 n 5 Sep-Oct 1987 p 21-38.

**085914 KNOWLEDGE-BASED SOLUTION TO THE DESIGN-FOR-ASSEMBLY PROBLEM.** A knowledge-based system to assist engineers in the process of designing products for easier assembly is presented. Contrary to other methods, the emphasis in this work is on the conceptual design stage where the structure of the product as a whole is considered. Upon completion of the analysis and design of the product structure, the system then considers the individual parts. The general methodology and architecture of the design-for-assembly system is described, followed by an example. The system was implemented in Turbo-PROLOG on an IBM-XT. (Author abstract). 5 Refs.

Kroll, E. (Technion, Haifa, Isr); Lenz, E.; Wolberg, J.R. *Manuf Rev* v 1 n 2 Jun 1988 p 104-108.

**Costs** See Also PRODUCTION ENGINEERING—Design Aids.

**085915 REMANUFACTURING BY DESIGN, THE MISSING LINK.** This overview of the industry proposes greater consideration of remanufacturing when designing new products for market. The time has come for American industry to expand its notion of the product life cycle to include remanufacturing. Instead of simply offering the consumer a process that goes from raw material to product to user to scrap, the concept should include the remanufacture of the product as an alternative to disposal when it becomes inoperable beyond simple repair. The remanufacturers could be the original equipment manufacturer (OEM) or an independent competitor. Regardless of who performs the function, however, its existence should be 'by design'. 13 refs.

Haynsworth, H.C. (Winthrop Coll, Rock Hill, SC, USA); Lyons, R. Tim. *Prod Invent Manage* v 28 n 2 Second Quarter 1987 p 24-29.

**085916 PROFIT THROUGH DESIGN - MANAGING MID-LIFE CRISIS.** This article looks at a technique which has been used successfully to prolong product viability until the replacement can be brought to the market place. The authors have worked with a lot of companies to identify and address whatever potential exists for reduction of product costs at a late stage in product's life. The technique is a simple, four-step framework but the way in which it is used depends very much on the constraints and requirements of the particular products and markets. (Edited author abstract)

Slade, Michael J.F. (Manufacturing Services, Manchester, Engl); Thomson-Bell, Ian. *CME Chart Mech Eng* v 34 n 9 Sep 1987 p 51-52.

**085917 DESIGN-TO-COST TEAM APPROACH.** The aerospace industry needs to be cost effective in its design while improving ways to design for manufacturability. The design-to-cost (DTC) approach establishes an interdisciplinary team composed of people from industrial engineering, manufacturing engineering, test operations, procurement and logistics support. The main function of the team is to provide cost analysis data from contract inception, conduct producibility reviews and develop cost tradeoffs for the various designers. The team is also responsible for predicting, reporting and tracking the recurring unit production costs and nonrecurring tools costs.

Schehr, Leonard (Westinghouse Electric Corp, Baltimore, MD, USA). *Manuf Syst* v 5 n 12 Dec 1987 p 24-28.

**085918 DESIGN FOR ASSEMBLY: FORD'S BETTER IDEA TO IMPROVE PRODUCTS.** Three major corporate objectives at Ford Motor Co. are presented. The first objective is to improve the quality of the product. The second is to reduce the time it takes to design, develop, produce and introduce a new vehicle. The third corporate objective is to reduce costs. That runs the full gamut of reducing work-in-process, reducing raw material costs, increasing capacity usage, increasing labor utilization, and reducing warranty costs. A design and manufacturing methodology is discussed.

Miller, Frederick W. (Manufacturing Systems, Wheaton, IL, USA). *Manuf Syst* v 6 n 3 Mar 1988 p 22-24.

## Economics

**085919 PRODUCT DEVELOPMENT PROBLEMS IN 1987 - A DIAGNOSIS.** A set of 'rules' is suggested to cover the present limitations imposed on product development in public companies by the requirement of institutional investors for regularly increasing profits. (Author abstract) 5 refs.

Ashton, E.W.S. (Dunlop Ltd, Coventry, Engl). *Proc Inst Mech Eng Part B* v 201 n B3 1987 p 191-196.

## Evaluation

**085920 STATISTICAL TOOLS FOR IMPROVING DESIGNS.** The author believes statistically controlled experiments serve as a catalyst to design. These methods help engineers to build good quality into products, which should reduce the need to inspect bad quality out of them. This paper investigates statistical experimental design which includes factorial designs, fractional designs, and response surface methods. Analysis by G. Taguchi applicable to quality engineering is described. (Edited author abstract) 14 refs.

Box, George (Univ of Wisconsin, Madison, WI, USA); Bisgaard, Soren. *Mech Eng* v 110 n 1 Jan 1988 p 32-40.

**Industrial Applications** See PRODUCTION ENGINEERING—Technology Transfer.

## Legislation

**085921 DEFENSIVE DESIGNING: ON GUARD AGAINST THE BIZARRE.** Fourteen years ago, product liability cases were being filed in federal courts at the rate of 1579 a year; by 1985, the number had risen to 13,554. The implications of such figures - a 758 percent increase in 11 years - are dramatic, throwing a shadow over the engineering profession and provoking serious questions about product safety. The paper emphasizes that if product liability lawsuits continue to mount, engineers may feel constrained to design exactly by the book and to stifle their innovative ideas.

Cortes-Comerer, Nhora (Mechanical Engineering, New York, NY, USA). *Mech Eng* v 110 n 8 Aug 1988 p 40-42.

## Management

**085922 ENGINEERING DESIGN '86 CONGRESS: DES 86, DESIGN MATTERS (CAD-PRESENT AND FUTURE, SEMINAR 1A-01; CAD SYSTEMS EVALUATION, SELECTION, IMPLEMENTATION, SEMINAR 1A-03; CAD AND PEOPLE, SEMINAR 1A-04; SELECTION OF SURFACE TREATMENTS, SEMINAR 2A-01; IMPACT OF ADHESIVES ON DESIGN, SEMINAR 2A-02; DESIGN AND THE TOTAL BUSINESS, SEMINAR 3A-01; INFLUENCE OF MICRO-PROCESSOR BASED SYSTEMS ON DESIGN, SEMINAR 3A-03; DESIGN FOR THE MARKET-PLACE, SEMINAR 5B-01; CAD - THE IMPORTANCE OF DATABASE DEVELOPMENT AND MAINTENANCE, SEMINAR 5B-02; DESIGNING WITH NEW MATERIALS - AN OVERVIEW, SEMINAR 6B-01; DESIGN AND INFORMATION EXCHANGE FOR MANUFACTURING, SEMINAR 7B-01; LEARNING DESIGN, SEMINAR 7B-02; WHAT'S NEW IN GEARING FOR THE DESIGNER, SEMINAR 8B-02; QUALITY AND RELIABILITY BY DESIGN, SEMINAR 8B-03; ROAD TRANSPORT FORUM, SEMINAR 4A-03/5B-03; ROLE OF DESIGN IN BUSINESS STRATEGY, SEMINAR 6B-03).** This conference proceedings contains 65 papers. The subject matter concerns the engineering design of various products, particularly machinery and vehicles. Associated topics include road transportation, business strategy, marketing, CAD/CAM systems evaluation, human engineering, surface coatings, adhesives and database systems. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11300 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Inst of Mechanical Engineers, London, Engl). *Eng Des '86 Congr: DES 86, Des Matters, Engl, 1986*. Publ by Inst of Mechanical Engineers, London, Engl, 1986 var pagings.

## Mathematical Models

**085923 GENERAL MODEL OF DESIGN: FORMALIZATION AND CONSEQUENCES.** The design process may be modeled as a sequence of transitions, from an initial knowledge base to the final state which includes the desired result. In mathematical logic, this process may



be described as an initial set of axioms which are transformed into a final set of statements through a transformation process. Formalization should clarify the nature of the design process and has implications for design automation. The utility of the formal model is illustrated by interpreting it in the context of discovery in design. This is followed by a discussion of the limits to such discovery. By incorporating this model in a knowledge-based system, it may also serve as the basis for an automated designer. (Edited author abstract). 30 Refs.

Kim, Steven H. (MIT, Cambridge, MA, USA). *Manuf Rev* v 1 n 2 Jun 1988 p 109-116.

**Models** See MATERIALS TESTING—Models.

**Optimization** See Also CONSUMER PRODUCTS—Optimization; ELECTRIC MOTORS, INDUCTION—Design; MECHANISMS—Design; QUALITY CONTROL; WIND TURBINES—Design.

**085924 DESIGNING FOR THE LIFE CYCLE.** The entire life of a product, as well as that of the manufacturing process and of the service system, should be considered in the original design. The life cycle of a product or system begins with the identification of a need and extends through conceptual/preliminary design, detailed design, production and/or construction, installation, customer use, support, and finally, decline and disposal. This paper reviews the actions affecting life-cycle cost.

Fabrycky, Wolter J. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA). *Mech Eng* v 109 n 1 Jan 1987 p 72-74.

**085925 QUALITY IN DESIGN.** This paper attempts to define a quality engineering role in the product design process. The product design process is also placed within the modern quality system. Methods of experimentation and modelling in design are emphasized and an example is described. (Author abstract) 9 refs.

Ganter, William A. (Production Automation Inc, Boulder, CO, USA). *Qual Reliab Eng Int* v 4 n 1 Jan-Mar 1988 p 4-6.

**085926 OPTIMAL DEVELOPMENT PLAN FOR NEW PRODUCTS: A CONTROL THEORETIC APPROACH.** Product quality affects a manufacturer's profitability since better quality results in a bigger market share and greater revenue. Product quality can be improved by product development which costs money. Hence to maximize total profit the development plan must be selected optimally. This paper develops a dynamic model to optimally select the development rate and timing of release to maximize discounted expected profit. (Author abstract) 4 refs.

Murthy, D.N.P. (Univ of Queensland, St. Lucia, Aust); Nguyen, D.G. *Optim Control Appl Methods* v 9 n 2 Apr-Jun 1988 p 201-207.

## Planning

**085927 STRATEGIES FOR PLANNING EXPERIMENTS USING ORTHOGONAL ARRAYS AND CONFOUNDING TABLES.** Taguchi's success in getting engineers to use experimental design techniques is due, at least in large part, to his use of tools and techniques that simplify the experiment planning process. Recognizing the advantages of this approach, this paper proposes a new set of tools, confounding tables, which offer more guidance to experimenters. Confounding tables provide a clear and systematic representation of confounding relationships. They are simple and useful tools for constructing experiment plans, and they enable users to easily evaluate the confounding patterns of a completed plan. We show how confounding tables provide more information than Taguchi's linear graphs, and are useful for a large class of experimental plans. (Edited author abstract) 13 refs.

Tsui, Kwok-Leung (AT&T Bell Lab, Holmdel, NJ, USA). *Qual Reliab Eng Int* v 4 n 2 Apr-Jun 1988 p 113-122.

**Quality Control** See Also PRODUCTION CONTROL—Management.

**085928 ESTIMATING THE ERROR OF AN EFFECT IN UNREPLICATED 2-LEVEL FRACTIONAL FACTORIAL DESIGNS.** This note develops an estimator of the experimental error based on the hypothesis that not all factor effects will be non-zero. A joint Bayesian prior distribution is presented for the experimental error variance of an effect,  $\sigma^2$ , and the probability that each effect is non-zero. From this prior distribution a posterior marginal distribution for  $\sigma^2$  is derived along with a direct estimate of  $\sigma^2$ . This method is compared with the traditional methods of estimating  $\sigma^2$  in unreplicated designs through a numerical example. (Edited author abstract) 5 refs.

Wang, Wenhao (Tianjin Normal Univ, Tianjin, China); Lawson, John. *Qual Reliab Eng Int* v 4 n 2 Apr-Jun 1988 p 189-192.

**Reliability** See Also ENGINEERING—Design; QUALITY CONTROL.

**085929 OFF-LINE QUALITY CONTROL AND ILL-DESIGNED DATA.** 'Bad' data resulting from ill-designed experiments or in-production/after-production monitoring require a careful use of proper statistical techniques for their analysis. Prior exploration of the available data is of paramount importance especially if we wish to apply off-line quality control techniques such as the Taguchi method. A stepwise approach is proposed involving data analysis and straightforward significance tests, which can ensure statistically valid and useful conclusions. (Author abstract) 15 refs.

Logothetis, N. (GEC Research Ltd, Wembley, Engl). *Qual Reliab Eng Int* v 3 n 4 Oct-Dec 1987 p 227-238.

**085930 METHODOLOGY FOR PLANNING EXPERIMENTS IN ROBUST PRODUCT AND PROCESS DESIGN.** This paper presents a methodology for the problem formulation and experiment planning steps. We give practical guidelines for making key decisions in these two steps, including choice of response characteristics, and specification of interactions and test levels for variables. We describe how orthogonal arrays and interaction graphs can be used to simplify the process of planning an experiment. We also compare the experiment planning strategies we are recommending to those of Taguchi and to more traditional approaches. (Edited author abstract) 22 refs.

Shoemaker, Anne C. (AT&T Bell Lab, Holmdel, NJ, USA); Kacker, Raghu N. *Qual Reliab Eng Int* v 4 n 2 Apr-Jun 1988 p 95-103.

**085931 OPTIMIZATION OF PRODUCT AND PROCESS DESIGN FOR QUALITY AND COST.** Robust product and process design involves making the product's function much less sensitive to various sources of noise such as manufacturing variation, environmental variation and deterioration. This is a problem in optimization involving minimization of the mean square loss resulting from the deviation of the product's function from its target. Here we show that the optimization can be carried out in two steps: first maximize a quantity called signal-to-noise ratio (S/N) and then bring the performance on target by special adjustment parameters. The two-step procedure works for a wide variety of product functions and makes the optimization process more efficient and practical compared to the direct minimization of the quadratic loss function. (Edited author abstract) 7 refs.

Phadke, M.S. (AT&T Bell Lab, Holmdel, NJ, USA); Dehnad, K. *Qual Reliab Eng Int* v 4 n 2 Apr-Jun 1988 p 105-112.

**085932 WORST CASE PRODUCT PERFORMANCE VERIFICATION WITH ELECTROMAGNETIC INTERFERENCE TEST APPLICATIONS.** When many variables are prevalent, it is difficult systematically to identify the optimum configuration for product certification. This need can occur in areas such as testing

performance of closed-loop servo systems and testing products for electromagnetic interference (EMI). This paper proposes a test strategy to identify a 'determined worst case expected' product configuration and a criterion for pass/fail. The process was developed originally for EMI test applications; however, it can also be useful for other product performance specifications. (Author abstract) 4 refs.

Breyfogle, Forrest W. (IBM, Austin, TX, USA); Davis, Jim H. *Qual Reliab Eng Int* v 4 n 2 Apr-Jun 1988 p 183-187.

**085933 FOCUSING PRODUCT RELIABILITY PROGRAMS FOR RESULTS.** High product reliability is the consequence of good product design, high quality manufacturing, and an on-going process of problem elimination. All the elements must be present and well managed for a company to achieve a reputation for product and service excellence. Methods of measurement of product reliability are discussed. 2 refs

Potts, George W. (Occam Research Corp, Wellesley, MA, USA). *Manuf Syst* v 6 n 6 Jun 1988 p 28-30, 32-35.

**085934 LOAD-STRENGTH SIMULATION OF PLASTIC MOULDINGS.** The basic idea behind the load-strength theory is that a component or a system will fail exactly at the moment the load exceeds the strength. Load and strength are both modelled by distribution curves (probability density functions). The load-strength theory is used to simulate the relations between the reliability, the safety factors used in the mechanical design and the different material conditions caused by batch variations in raw material, the injection moulding process and the mould design. (Edited author abstract). 9 Refs.

Loll, Valter (TERMA Elektronik AS, Lystrup, Den). *Qual Reliab Eng Int* v 4 n 3 Jul-Sep 1988 p 223-226.

**Standards** See TRAFFIC SIGNS, SIGNALS AND MARKINGS—Equipment.

**Testing** See Also PACKAGING—Shock Problems.

**085935 MORE SHIPPING ENVIRONMENT KNOWLEDGE MAKES THE ELECTROHYDRAULIC VIBRATOR AN INDUSTRIAL STANDARD.** Given that transporting a product from the manufacturer to the end user causes the most severe stresses during the product's life cycle, there has been greater emphasis on measuring the shipping environment. In parallel with the development of ASTM test methods, electrohydraulic (EH) vibration test systems have evolved to meet test requirements. Electrohydraulic vibration systems have become an industrial standard because they meet the needs of this field so well. In so doing they have helped to: 1) improve product reliability due to reduction of shipping damage; 2) reduce packaging costs by reducing the incidence of overpackaging where it is unnecessary; and 3) bring new products to market faster by eliminating the need for trial shipment of pilot production runs. 6 refs.

Bresk, Frank C. (Lansmont Corp, Pacific Grove, CA, USA). *Test (Oakland CA)* v 48 n 3 Jun-Jul 1986 p 16-19.

**Weight Control** See BOTTLES—Glass.

**PRODUCT LIABILITY** See Also BIOMEDICAL ENGINEERING—Computer Applications.

**085936 PRODUCT LIABILITY - THE ROLE OF PRODUCTION MANAGERS.** Author describes the new laws, which become operative in October (Part II) and January 1988. No production manager reading this article will doubt the necessity to involve a wide range of management functions - from procurement to sales - in steps to improve safety and liability management in his or her organisation. One of the key successes an industrial or technical manager might have to achieve in adapting to the new legal regime is to convince colleagues in other departments - especially in the areas of contracts, procurement, marketing, sales, service and record keeping - of the essential roles which these must perform.



Mackmurdo, Robert. *Prod Eng (London)* v 66 n 8 Sep 1987 p 14-15.

**085937 BETTER SAFE THAN SORRY.** New legislation making producers strictly liable for any damage caused by defective products will be introduced this year in the U.K. This article explains the implications for design managers and outlines a strategy for dealing with this new responsibility. Subjects covered include risk management, design reviews, and others.

Abbott, Howard (Product Safety, Kingston Upon Thames, Engl). *Engineering (London)* v 228 n 2 Feb 1988 p 65-69.

**085938 MANAGING PRODUCT LIABILITY RISKS.** The author discusses a strategy to minimize risk. The first stage in carrying out a risk management plan is to decide what product liability risks exist, assess how product hazards are created and what the consequences of such hazards are. The assessment of risks can be carried out in a variety of ways and will be largely dependent on the product and the industry involved. A set of guidelines is given.

Farnsworth, Norman (Leyland DAF, Engl). *Prod Eng (London)* v 67 n 2 Feb 1988 p 28-30.

**085939 PRODUCT LIABILITY.** This paper starts by going over the present position with regard to civil liability for loss and damage caused by a defective product. It then describes the object of Part 1 of the Consumer Protection Act, 1987, following which its looks at that part of the Act in some detail. The paper concludes by looking at some practical matters which have been of interest to various groups.

Paton, A.J. (Pinsent & Co). *Br J Non Destr Test* v 30 n 3 May 1988 p 191-195.

**085940 PRODUCT LIABILITY: EUROPE'S QUALITY CHALLENGE.** Recent product liability developments in the European Economic Community may affect U.S. exporters as well as U.S. legislation. In an attempt to introduce uniformity and stability into the law of product liability, the U.S. Department of Commerce published the Model Uniform Product Liability Act in 1979. It was offered for voluntary use by the states, with limited success. A number of product liability reform bills have also been introduced in Congress, but these have made little progress. This article presents product liability issues from a European standpoint, with an emphasis on quality control. 10 refs.

Roche, John G. (Univ Coll, Galway, Irel). *Qual Prog* v 21 n 6 Jun 1988 p 61-63.

**085941 LITIGATING TOXIC SHOCK SYNDROME: LESSONS TO BE LEARNED.** An analysis of West versus Johnson & Johnson Products, Inc., an important case involving toxic shock syndrome, was performed in order to determine if any lessons could be learned that would be applicable to toxic tort litigation in general. A detailed analysis of the facts of the case as well as background on toxic shock syndrome is presented. A number of important conclusions were drawn, concerning (1) manufacturer liability arising out of a design effect theory involving a product which is, by itself, relatively sterile and chemically inert, (2) defective warning (as distinct from failure to warn), and (3) punitive damage liability arising from inadequate testing. These conclusions should assist certain manufacturers to minimize their exposure in toxic tort litigation, particularly to punitive damages. The failure to introduce proper defense theories during trial is also discussed. (Author abstract). 7 Refs.

Cole, Marc Steven (Kern & Wooley, Los Angeles, CA, USA). *J Hazard Mater* v 18 n 3 Jun 1988 p 285-294.

## Economics

**085942 ON PRODUCT LIABILITY AND QUALITY CONTROL.** Product liability is one of the most costly and confusing problems facing manufacturing today. Models of the economic impact of both final

acceptance sampling and process control on liability risk due to a manufacturing defect are presented. A numerical example reveals that selection of cost-effective quality control methods depends on assumed disposition of rejected lots. (Author abstract) 22 refs.

Maruchek, Ann S. (Univ of North Carolina, Chapel Hill, NC, USA). *IIE Trans* v 19 n 3 Sep 1987 p 355-360.

## Legislation

**085943 MOTORCYCLE HELMETS: ESTABLISHING PRODUCT LIABILITY.** Even if a helmet complies with governmental standards, evaluation of its shock-absorbing characteristics may show that it is defective. Various considerations are explained that provide a basis for establishing product liability in cases where severe head injuries have resulted from the use of an unduly hard liner. For this purpose it must be established that the subject liner would exhibit a relatively small compressive distance under the conditions of the standardized test; the severity of the impact in the subject case is not significantly greater than in the standardized test.

Ryder, Frederick L. (New York Univ, New York, NY, USA). *J Prod Liability* v 11 n 2 1988 p 69-71.

**085944 COLLOQUIUM ON LIVING WITH THE EEC DIRECTIVE ON PRODUCT LIABILITY: MANAGEMENT, DESIGN AND MANUFACTURING ISSUES.** This colloquium proceedings contains 5 articles, one in abstract form only, on the EEC directive on product liability. Subjects include: practical implications for the practicing engineer; consumer viewpoint on product liability; product liability and contract research/development; management/design/manufacturing issues; and product safety in appliances. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11334 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Management & Design Div, London, Engl). *IEE Colloq Dig* n 1987/19, Colloq on Living with the EEC Dir on Prod Liability: Manage, Des and Manuf Issues, London, Engl Feb 3 1987. Publ by IEE, London, Engl, 1987 var pagings.

## United Kingdom

**085945 QUALITY MANAGEMENT - THE IMPACT ON PROFIT AND PRODUCT SAFETY.** Manufacturers are recognizing that quality is critical to success in today's complex and competitive international market place. In the UK the Consumer Protection Act 1987 comes into effect from March this year. It and similar laws throughout the EEC strengthen existing legislation to make it easier to claim liability from a producer or supplier of a defective product that causes death or injury or damage in the home. Absence of negligence will no longer be a defence; a producer will have to demonstrate that the product was not defective at the time of its sale or that it has been manufactured according to specification. To do so, modern quality management methods must be used, allied to recording of the design, production and distribution processes.

Leegood, Steve (Logica Energy & Industry Systems, Engl). *Prod Eng (London)* v 67 n 2 Feb 1988 p 36-37.

**PRODUCTION CONTROL** See Also CEMENT PLANTS; CHEMICAL OPERATIONS—Scheduling; DECISION THEORY AND ANALYSIS—Control; ELECTRONIC EQUIPMENT TESTING—Optimization; INDUSTRIAL MANAGEMENT; INDUSTRIAL MANAGEMENT—Quality Control; INDUSTRIAL PLANTS—Flexible Manufacturing Systems; INDUSTRIAL PLANTS—Production Control; INVENTORY CONTROL; IRON AND STEEL PLANTS—Computer Integrated Manufacturing; IRON AND STEEL PLANTS—Optimization; MACHINE SHOPS—Flexible Manufacturing Systems; MANAGEMENT SCIENCE; MARKETING; MATERIALS HANDLING—Computer Simulation; NONDESTRUCTIVE EXAMINATION; PROBABILITY—Queueing Theory; PROCESS CONTROL; PRODUCTION ENGINEERING; PRODUCTION ENGINEERING—Database Systems; PRODUCTION ENGINEERING—Planning; ROBOTS,

INDUSTRIAL—Japan; SCHEDULING; SPRINGS—Manufacture; STEEL FOUNDRY PRACTICE—Computer Applications.

**085946 SIMULTANEOUS DETERMINATION OF PRODUCTION CYCLE AND INSPECTION SCHEDULES IN A PRODUCTION SYSTEM.** This paper addresses the problem of joint control of production cycles or manufacturing quantities and maintenance by inspection. A simple relationship has been developed to determine the effectiveness of maintenance by inspection. Furthermore, when maintenance by inspection is adopted, it is shown that the optimal inspection intervals are equally-spaced. The problem of simultaneous determination of EMQ (Economic Manufacturing Quantity) and the inspection schedules is solved by using an approximation to the cost function. The resulting EMQ is found to be an adjustment to the classical EMQ. Finally, the relationships between different parameter values and the magnitudes of the cost penalty for using the classical EMQ are examined. 22 refs.

Lee, Han L. (Stanford Univ, Stanford, CA, USA); Rosenblatt, Meir J. *Manage Sci* v 33 n 9 Sep 1987 p 1125-1136.

**085947 FREEZING THE MASTER PRODUCTION SCHEDULE UNDER ROLLING PLANNING HORIZONS.** The stability of the Master Production Schedule (MPS) is a critical issue in managing production operations with a Material Requirements Planning System. This paper examines three decision variables in freezing the MPS: the freezing method, the freeze interval length, and the planning horizon length. Simulation experiment results are reported which suggest that freezing up to 50% of the planning horizon has a marginal effect on production and inventory cost under a wide range of operating conditions. These results also suggest that an order based freezing method produces superior results in comparison with a period based method. (Edited author abstract) 21 refs.

Sridharan, V. (Clemson Univ, Clemson, SC, USA); Berry, William L.; Udayabhanu, V. *Manage Sci* v 33 n 9 Sep 1987 p 1137-1149.

**085948 STUDY OF GRAPHICAL AND TABULAR DISPLAYS AND THEIR INTERACTION WITH ENVIRONMENTAL COMPLEXITY.** Since most interactive systems use either graphical or tabular displays, this experiment contrasts the effectiveness of the two displays in making the production scheduling decision in low and intermediate levels of environmental complexity. The study concludes that tabular aids outperform the graphical aids in environments with low complexity, replicating an earlier study. In intermediate complexity environments, the graphical aids outperform the tabular aids. These findings may resolve many conflicts in the literature on data displays. (Author abstract) 25 refs.

Remus, William (Univ of Hawaii, Honolulu, HI, USA). *Manage Sci* v 33 n 9 Sep 1987 p 1200-1204.

**085949 PULL VERSUS PUSH STRATEGY FOR AUTOMATED GUIDED VEHICLE LOAD MOVEMENT IN A BATCH MANUFACTURING SYSTEM.** Most automated guided vehicle (AGV) dispatching rules reported in literature to date are based on the attributes of the vehicles and the workcenters from where the loads originate. An algorithm that assigns load movement priority based on the demand states of the load destinations is presented. When applied to the material flow of an illustrative shop, analysis indicates that the algorithm performs competitively with some of the best source driven rules currently reported. It also provides a material flow and workcenter priority assignment flexibility not matched by any source-based rules. (Edited author abstract) 11 refs.

Egbelu, Pius J. (Pennsylvania State Univ, University Park, PA, USA). *J Manuf Syst* v 6 n 3 1987 p 209-221.



**085950 DESIGN AND OPERATION OF A MULTICOMMODITY PRODUCTION/DISTRIBUTION SYSTEM USING PRIMAL GOAL DECOMPOSITION.** An optimization-based decision support system has been developed and used by NABISCO to manage complex problems involving facility selection, equipment location and utilization and manufacture and distribution of products. Excellent quality solutions for problems with more than 40,000 variables (including several hundred binary variables with fixed charges) and in excess of 20,000 constraints require only 0.6 megabytes region and less than one compute minute on a time-shared IBM 3033 computer; average problems (with fewer binary variables) require only a second or two. (Edited author abstract) 8 refs.

Brown, Gerald G. (US Naval Postgraduate Sch., Monterey, CA, USA); Graves, Glenn W.; Honeczarenko, Maria D. *Manage Sci* v 33 n 1 Nov 1987 p 1469-1480.

**085951 TIME-OPTIMAL PRODUCTION CONTROL IN A MANUFACTURING SYSTEM.** This study demonstrates the use of control engineering techniques to regulate the product inventory levels of a workshop in a manufacturing system by manipulating the number of machines and the labor time employed during production. The production policy that minimizes the production time is obtained by time-optimal control techniques. (Author abstract) 8 refs.

Yurtseven, M.K. (Pennsylvania State Univ at Harrisburg, Middletown, PA, USA); Bak, T. *Int J Syst Sci* v 18 n 11 Nov 1987 p 2175-2182.

**085952 PRODUCT REALIZATION SYSTEMS.** The product realization process is the way in which AT&T moves from technology in the laboratories to products in the hands of customers. The goal of the process is customer satisfaction. Important features of this process include: (a) high productivity, enabling the company to meet its financial targets; (b) short intervals, to match the needs of the market; and (c) high quality levels, to meet or exceed customer expectations. (Author abstract) 6 refs.

Boza, Luis B. (AT&T Bell Lab, Holmdel, NJ, USA); Powers, Tom L. *AT&T Tech J* v 66 n 5 Sep-Oct 1987 p 3-4.

**085953 MAP IS REAL BUT...** Proponents have hailed the Manufacturing Automation Protocols (MAP) as the key to automation for years now. But actual installations are still few. MAP is probably the answer for some applications, but there are alternatives as well.

Krepchin, Ira P. *Mod Mater Handl* v 42 n 14 Dec 1987 p 101, 103-104.

**085954 CMMs CUT COSTS AND STREAMLINE QC.** Coordinate measuring machines (CMMs) first emerged during the 1960s in response to demand for three-dimensional accuracy, gaging flexibility, faster turn-around time, and less production downtime during inspection. CMMs work by passing a probe over a part's feature and finding the displacement along each of three measurement axes. The machine transmits these measurements to a central processing unit which compares the values to programmed specifications.

Deller, Hans (Numerex Corp.). *Mach Tool Blue Book* v 83 n 1 Jan 1988 p 48-50.

**085955 COORDINATE MACHINES CHECK QUALITY DRIFT.** Coordinate measuring machines are becoming necessary in enabling the production shop to comply with stringent quality specifications. As manufacturing industry approaches the 1990s the CMM is acquiring a new significance. It is no longer just the question of how fast one can measure a component, how quickly one can process the data or how soon statistical process control (SPC) can display a trend. The CMM is becoming an essential instrument in the qualification of tooling and fixturing to maintain higher accuracies for automation systems and satisfy the requirements of national and international quality assurance standards.

Page, Mike. *Metalwork Prod* v 132 n 1 Jan 1988 5p between p 46 and 53.

**085956 ON UPPER BOUNDS OF SEQUENTIAL STOCHASTIC PRODUCTION PLANNING PROBLEMS.** Consider a class of problems that determine production, inventory and work force levels for a firm in order to meet fluctuating demand requirements. A production planning problem arises because of the need to match, at the firm level, supply and demand efficiently. In practice, the two common approaches to counter demand uncertainties are (i) carrying a constant safety stock from period to period, and (ii) planning with a rolling horizon. We derive two a priori upper bounds on the costs for a class of production planning problems under the rolling horizon strategy. These upper bounds are derived by establishing correspondences. We propose refinements to the non-Lagrangian bounds and present limited computational results. (Edited author abstract) 9 refs.

Bitran, G.R. (MIT, Cambridge, MA, USA); Sarkar, D. *Eur J Oper Res* v 34 n 2 Mar 1988 p 191-207.

**085957 ANFORDERUNGEN AN DIE BEREITSTELLUNGSPLANUNG VON WERKZEUGEN IN EINER FERTIGUNGSSTEUERUNG.** [Requirements Imposed on Availability Planning of Tools in a Production Control System]. Rapid changes in market requirements have in the recent years also brought about distinct changes in weighing the objectives of production control, with the aims of just-in-time production and short production runs being in the foreground today. This is why many production control systems fail to give full satisfaction in spite of high investments. The major reasons for this are to be found in treating production control as an isolated solution, in a deterministic instead of stochastic view taken of the production process, and in the nonexistence of appropriate parameters and approaches for exerting a direct influence on production run times and inventories. (Edited author abstract) In German. 8 refs.

Wiendahl, H.-P.; Ullmann, W. *Werkstatt Betr* v 121 n 2 Feb 1988 p 133-136.

**085958 TRANSPORTATION TYPE AGGREGATE PRODUCTION MODEL WITH BOUNDS ON INVENTORY AND BACKORDERING.** We consider a certain T period aggregate production planning model, where the two sources of production are regular and overtime. The model allows for time varying production, holding and backordering costs and includes bounds on inventory and backorders. We show that the problem has a rather interesting network structure and exploit this structure to develop a greedy algorithm to solve the problem. The procedure is easy to implement and has a computational complexity of  $O(T^2)$ . We report computational experience with the greedy procedure and demonstrate its superiority to a well known network simplex code, GNET, implemented on the classical network formulation of the problem. (Author abstract) 14 refs.

Erenguc, S. Selcuk (Univ of Florida, Gainesville, FL, USA); Tufekci, Suleyman. *Eur J Oper Res* v 35 n 3 Jun 1988 p 414-425.

**085959 COMPONENT COMMONALITY WITH SERVICE LEVEL REQUIREMENTS.** A model is formulated for an arbitrary number of products with general joint demand distribution. The results obtained are not all intuitive. While utilizing commonality is beneficial, nothing general can be said about the resulting change in the components' stock levels. When the cost structure is of a particular simple form, though, some interesting general patterns do emerge. We also discuss the case of using a service-level measure where rationing of common components might be required, and characterize the implied rationing rule. (Edited author abstract) 11 refs.

Gerschak, Yigal (Univ of Waterloo, Waterloo, Ont, Can); Magazine, Michael J.; Gamble, Bruce A. *Manage Sci* v 34 n 6 Jun 1988 p 753-760.

**085960 PRODUCTION CONTROL OF A MANUFACTURING SYSTEM WITH MULTIPLE MACHINE STATES.** The production control of a single-product manufacturing system with arbitrary number of machine states (failure modes) is discussed. The objective is to find a production policy that would meet the demand for the product with minimum average inventory or backlog cost. The optimal production policy has a special structure and is called a hedging-point policy. If the hedging points are known, the optimal production rate is readily specified. Assuming a set of tentative hedging points, the simple structure of the optimal policy is utilized to find the steady-state probability distribution of the surplus (inventory or backlog). Once this function is determined, the average surplus cost is easily calculated in terms of the values of the hedging points. This average cost is then minimized to find the optimum hedging points. 5 refs.

Sharifnia, Ali (Boston Univ, Boston, MA, USA). *IEEE Trans Autom Control* v 33 n 7 Jul 1988 p 620-625.

**085961 ON THE DEVELOPMENT OF PRODUCTION AND MATERIAL CONTROL SYSTEMS IN A CORPORATION ORGANIZED INTO PROFIT CENTERS.** The present paper deals with the problems involved in the development of control systems for production and material management and the solutions we have adopted, as well as some, as yet, unsolved problems. The subject of this report is an electronics corporation, formed by a Finnish and a Swedish company, which is organized into relatively independent profit centers, each with its own products and factories. The goal was set to develop control systems by which one would achieve the following: a low level of current assets from the corporation as a whole; the flexible use of production resources; the advantage of largeness in purchasing operations; the benefits of rationalization in administrative functions. The nature of our analysis and solution model is more practical than theoretical. (Author abstract) 3 refs.

Kuutti, Jorma (Salora OY, Salo, Finl). *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 123-130.

**085962 PRODUCTION CONTROL IN A CONSUMER ELECTRONICS FACTORY.** This paper deals with production control in a consumer electronics factory. A short description of the situation and of the actual way of control (Material Requirements Planning) is given. Most attention is paid to modularity. The concept of marketing modularity is introduced to be able to analyze in the advantages of product modularity increasing external flexibility by generating component stocks. (Author abstract) 8 refs.

Wijnjaard, J. (Eindhoven Univ of Technology, Eindhoven, Neth). *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 165-173.

**Automation** See Also ARTIFICIAL INTELLIGENCE—Expert Systems; MATERIALS HANDLING—Costs; ROBOTS, INDUSTRIAL—Vision Systems.

**085963 AUTOMATED SYSTEM FOR CONTROLLING THE PRODUCTION PROCESS OF WIRING BY TWISTING.** The central computer of this computer-aided manufacturing system is a Elektronika-60M microcomputer with additional devices. The computer-aided manufacturing system includes two subsystems: twisting-device control and monitoring of finished wiring. The twisting control object is a type MPA-2 device, which in simplicity of design approaches is similar to those used for manual twisting, but is devoid of the inherent drawbacks. The type U322 wiring monitoring automatic unit provides for registration and printout of all wiring errors of the 'break' or 'unnecessary link' types; automatic printout of table of links; detection of contacts coupled with specified contact (at operator's request). The com-



puter-aided manufacturing system developed permits simultaneous control of five MPA-2 devices and one U322 automatic unit.

Beletskii, A.F.; Chesnokov, A.N. *Sov Electr Eng* v 57 n 8 1986 p 107.

**085964 PRODUCAM CONTROL SYSTEM FOR AUTOMATED AND NON-AUTOMATED PRODUCTION PROCESSES.** With PRODUCAM, Brown Boveri offer a turnkey production control system whose modularity suits it for both conventionally operated, semi-automated and automated plants. System features allow planning and implementation of 'transit' times previously thought unattainable. PRODUCAM's system components - computers, networks, peripherals and industrial software - are proven in the field. (Author abstract)

Beier, H.H. (Brown Boveri, Mannheim, West Ger). *Brown Boveri Rev* v 74 n 12 Dec 1987 p 671-678.

**Computer Aided Analysis** See QUARRIES AND QUARRYING—Control Systems.

**Computer Applications** See Also ARTIFICIAL INTELLIGENCE—Expert Systems; CONCRETE MIXERS AND MIXING—Quality Control; INDUSTRIAL PLANTS—Flexible Manufacturing Systems; INDUSTRIAL PLANTS—Production Control; IRON AND STEEL PLANTS—USSR; PRODUCTION ENGINEERING—Computer Applications; QUARRIES AND QUARRYING—Control Systems.

**085965 KNOWLEDGE BASED ROUTING AND SEQUENCING FOR DISCRETE PART PRODUCTION.** This paper describes an experimental knowledge based routing system, named KBRS, for computer aided manufacturing and assembly facilities. The knowledge based system is composed of five parts: a static database, a dynamic database, behavioral knowledge, procedural knowledge, and a simulation driver. A second level of knowledge observes the system and tunes it according to known observed behavioral evidence. The KBRS is simulated and compared with six static routing policies and an interactive human scheduler. The KBRS outperforms the other routing policies. (Author abstract) 19 refs.

Ben-Arieh, D. (Ben-Gurion Univ, Beer-Sheva, Isr); Moudie, C.L. *J Manuf Syst* v 6 n 4 1987 p 287-297.

**085966 PRODUCTION CONTROL AID FOR MANAGERS OF MANUFACTURING PLANTS.** An interactive computer model in a scheduling and modeling package being developed for small and medium-sized manufacturing plants is described. There are four main uses of the model. First, the model can simulate in detail the running of a given schedule to verify that assumptions made by the scheduler are valid. The scheduler and the model will interact to arrive at a feasible schedule. Secondly, the plant manager can run through tomorrow's schedule on the model and identify potential trouble spots. Thirdly, in actually executing today's schedule, the manager can use the model to respond to machine breakdowns and other unscheduled occurrences. Finally, the model can be used to evaluate 'what-if' type situations, where the impact of different facility layouts, manpower levels, number of shifts used, etc., can be investigated. (Author abstract) 7 refs.

Graefe, P.W. Udo (Nat'l Research Council of Canada, Ottawa, Ont, Can); Chan, A.W.; Levi, M. *Int Trends Manuf Technol Simul Appl in Manuf* Publ by IFS Publ Ltd, Bedford, Engl and Springer-Verlag, Berlin, West Ger and New York, NY, USA, 1986 p 213-223.

**085967 ENGINEERING CHANGE CONTROL SYSTEMS-THEIR TIME HAS COME.** The elements of an engineering changes (EC) control system includes: on-line entry of any request for engineering change activity; status reporting to help assure that an EC coordinator and engineer are assigned; ability to easily assign departmental reviewers to a project request; status reports to alert the reviewing departments of the need to review; on-line retrieval of project descriptive data with the ability to log the name of the reviewer, data and time reviewed, code indicating approval/disapproval to pro-

ceed, and the reviewer's comments regarding the EC. Engineering change requests (ECRs) are descriptions of the proposed solutions and are defined for each major section of the proposed project. There are some other facilities that should help data synchronization and improve communications along all affected departments and customers.

Glaza, Tom (GMD, Atlanta, GA, USA). *Manuf Syst* v 6 n 9 Sep 1988 p 66, 68.

## Computer Integrated Manufacturing

**085968 DATA COLLECTION-TAKING AIM AT THE I OF CIM.** The results of a recent survey on factory data collection and management systems, conducted by Automation Research Corp. (ARC) of Medfield, MA, show several trends in data collection and application. For example, bar codes are the preferred technology for automated identification, but newer technologies such as radio frequency identification and voice recognition are becoming more common on the factory floor. While standardized data collection software packages are increasingly available, many users are looking to plantwide collection systems and networked equipment requiring significant vendor/user interaction in the development stages. Finally, the ubiquitous personal computer and its siblings are becoming a factor in the factory as terminal controller, data host, network server or terminal emulator. The preferred operating system for the microcomputer is Unix, particularly on the Digital Equipment Micro-VAX and IBM's 80386-based PS/2 systems.

Inglesby, Tom (Manufacturing Systems, Wheaton, IL, USA). *Manuf Syst* v 6 n 10 Oct 1988 3p.

**Computer Simulation** See Also ARTIFICIAL INTELLIGENCE—Expert Systems.

**085969 COMPUTER MODEL FOR ASSEMBLY LINE BALANCING.** This paper discusses a computer model for assembly line balancing COMSOAL, an acronym for a computer method of sequencing operations for assembly lines, is a method of balancing large complex machine-paced assembly lines. Though the computer program for this algorithm is available in western countries, an attempt has been made to develop the same with modification, since this is not readily available in India. (Author abstract) 3 refs.

Rajendran, N. (Hindustan Motors Ltd, Bangalore, India). *J Inst Eng India Part PR* v 68 pt 3 Mar 1988 p 65-67.

**085970 USE OF A QUEUEING SIMULATOR IN DESIGN OF A BATCH CHEMICAL PRODUCTION SYSTEM.** A queueing simulator can help identify whether a production has the planned capacity and whether delays within the system are acceptable (for example, excessive demurrage charges, high WIP, inadequate customer service). It can identify production bottlenecks or system components of greater capacity (cost) than necessary. It can suggest more effective configurations of components and allow for testing of alternative scheduling rules. 13 Refs.

Bales, William J. (Occidental Chemical Co, White Springs, FL, USA); Johnson, Jerry R.; Sommerfeld, Jude T. *Prod Invent Manage J* v 29 n 2 1988 p 36-41.

## Control Systems

**085971 MOVING TOWARDS MORE EXPERT PROCESS MANAGEMENT.** Whereas ICI's Keystone represents, in some ways, the state-of-the-art so far as PC-based computerized production management is concerned, researchers at Sira are making plans for a new generation of production management tools, based on powerful second-generation expert system software running on personal computers. Like ICI, Sira preferred a subtle change of name not long ago. It used to be SIRA, the partly-Government funded Scientific Instrument Research Association, but is now a private sector company, Sira Ltd. Sira's expert system club activities are now well known.

Taylor, Clive. *Process Eng (London)* v 69 n 4 Apr 1988 p 63-64, 66.

**Costs** See Also COST ACCOUNTING—Management; FITS AND TOLERANCES—Optimization; INVENTORY CONTROL—Management; INVENTORY CONTROL—Mathematical Models; INVENTORY CONTROL—Optimization; IRON AND STEEL PLANTS—Production Control; JOB ANALYSIS; MACHINERY—Repair; MAINTENANCE—Management; PRODUCTION ENGINEERING—Economics; QUALITY CONTROL—Inspection; QUALITY CONTROL—Management; QUALITY CONTROL—Sampling.

**085972 DESIGN-TO-COST APPROACH IN SELECTING PRODUCTION SYSTEMS.** This analysis provides a framework for selection of major production systems or facilities based on system life-cycle cost, which includes acquisition and ownership costs. The basic steps for estimating the life-cycle cost are presented and can be used to evaluate different systems. This model can also be used with other selection decision models, combining several subjective and objective factors. 5 Refs.

Ahmed, Nazim U. (Ball State Univ, Muncie, IN). *Prod Invent Manage J* v 29 n 2 1988 p 52-56.

**085973 COSTS OF PRODUCTION IN THE SHENZHEN SPECIAL ECONOMIC ZONE OF CHINA.** This paper analyzes the costs of production in and around the Shenzhen special economic zone and compares them to those of producing the same products in Hong Kong. This is done through two case studies involving the production of a doll and a digital watch. Results indicate that while production costs are much lower in Shenzhen, problems can arise in dealing with the local Chinese authorities. The general work attitudes in socialist China often make it difficult to select and retain workers. (Author abstract). 9 Refs.

Chan, J.C.M. (Univ of Hong Kong, Hong Kong); Sculli, D.; Wong, S.K. *Eng Costs Prod Econ* v 14 n 3 Sep 1988 p 199-209.

**Economics** See Also QUALITY CONTROL—Costs; SCHEDULING—Mathematical Models.

**085974 ECONOMIC DESIGN AND CONTROL OF MONITORING MECHANISMS IN AUTOMATED PRODUCTION SYSTEMS.** Inspection as well as restoration capabilities are necessary to provide early detection and correction of shifts in the production process. This paper considers the costs of different policies for providing these detection and restoration capabilities. These policies amount to periodic or continuous inspection of the production process with perfect information, and continuous or periodic availability of maintenance facilities. The optimal operation of each policy is studied. Comparative analyses are conducted with different specifications of key parameters such as the rate of shift of the process and the cost of producing defective items. These analyses enable the derivation of the optimal policy when only ranges of the values of these parameters are known. (Edited author abstract). 32 Refs.

Lee, Hau L. (Stanford Univ, Stanford, CA, USA); Rosenblatt, Meir J. *IIE Trans* v 20 n 2 Jun 1988 p 201-209.

**Inspection** See Also QUALITY CONTROL—Sampling; STEAM GENERATORS—Reliability.

**085975 SHOPFLOOR METROLOGY PRACTICE CUTS DELAY AND BOOSTS PROFIT.** A surface texture analysis system designed by Rank Taylor Hobson, of Leicester, is being used to great effect in the measurement of cylinder bores, by a leading British combustion engine manufacturer. With the new cylinder block surface, texture measuring system, random blocks are diverted from the main production line into a lay-by station where bore inspection procedures are quickly carried out, after which the cylinder block is simply fed back into the main production line as required. The measuring head of the system incorporates two vertically mounted pick-ups in a cylindrical section plug which is manually inserted into the cylinder bore. Spring-loaded rollers, mounted diagonally,



nally oppose each pickup, ensure conformity of pressure against the bore wall. The design and construction of the plug allows the measurement of a number of different bore diameters to be accommodated.

Anon. *Ind Lubr Tribol* v 40 n 1 Jan-Feb 1988 p 16-17.

**085976 CASE FOR CMMs.** The author cites some factors which make the question of whether or not to purchase a coordinate measuring machine (CMM) not one of justification but one of survival. It is shown that the use of a CMM makes it possible to achieve very tangible savings while meeting the more exacting requirements of customers. In addition, a CMM improves inspection accuracy by minimizing human influence. CMM prices have been relatively stable for the past few years, while accuracy and speed have improved significantly, especially in the moderate- and high-accuracy machines. Intense competition and aggressive technical development have made today's CMM a better value than ever before.

Bosch, John (Sheffield Measurement, Dayton, OH, USA). *Tool Prod* v 54 n 7 Oct 1988 4p.

**Inventory Control** See **MARKETING—Management; PLASTICS PLANTS—Quality Control; PROBABILITY—Random Processes; QUALITY CONTROL—Management; QUALITY CONTROL—Sampling; SCHEDULING—Mathematical Models.**

### Laser Applications

**085977 ZASTOSOWANIE TECHNIKI LASEROWEJ DO KONTROLI CECH GEOMETRYCZNYCH FORM PRODUKCYJNYCH I PREFABRYKATOW.** [Application of the Laser Technique to the Control of Geometrical Features of Production Forms and Prefabricated Products]. The laser instruments PL-1 and PL-2 were designed for the control of geometrical features of production forms and prefabricated products. The results of the investigations concern control of thickness and shape of the prefabricated products and control of flatness of the bases of the production forms. They include the measuring stands, calculation of deviations, interpretation of results, and graphic presentation of the geometrical features. (Author abstract) 2 refs. In Polish.

Przewlocki, Stefan (Lodz Technical Univ, Pol); Pawlowski, Wieslaw. *Zesz Nauk Politech Lodz Budownictwo* n 38 1987 p 45-66.

**Management** See Also **ELECTRONIC EQUIPMENT MANUFACTURE—Quality Control; INDUSTRIAL PLANTS—Automation; INVENTORY CONTROL—Computer Simulation; INVENTORY CONTROL—Mathematical Models; INVENTORY CONTROL—Scheduling; IRON MINES AND MINING—Planning; MACHINERY—Reliability; PRODUCT DESIGN—Costs; PRODUCTION ENGINEERING—Education; QUALITY CONTROL—Inspection; SCHEDULING—Computer Applications; SCHEDULING—Mathematical Models; SYSTEMS ANALYSIS—Mathematical Models; WAREHOUSES—Scheduling.**

**085978 POLITICS OF CHANGE IN MANUFACTURING.** We can now set forth the specifics of applying political science to the management of a change process within manufacturing. The psychology and politics of effectively relating with seniors, peers, and subordinates must be combined with the dynamics of a change process spanning the entire manufacturing system. Each issue area must be thought through in terms of the specific needs for administrative support and leadership, enabling decisions, technical know-how, cooperation, convincing, credit sharing, security, involvement, and expert operating knowledge. (Author abstract) 13 refs.

Bell, Robert R. (Tennessee Technological Univ, Cookeville, TN, USA); Burnham, John M. *Prod Invent Manage* v 28 n 2 Second Quarter 1987 p 71-78.

**085979 CHANGES WORTH MAKING - MANAGING THE MUNDANE.** This is an example of how managers can improve productivity, quality, service, and inventory turns by what appear to be ordinary procedures. Working on this project has been refreshing because it has confirmed that managing the uncommonly ordinary - the mundane - yields good returns. The day-to-day stuff -

sharing individual expectations; meeting to develop joint understandings; setting work unit and interdepartment targets; scheduling regular follow-up reviews work unit and interdepartment targets; scheduling regular follow-up reviews to discuss progress on the plan; and making gradual change - will improve productivity. The answer to business problems lies in the subtle process of getting business men and women to implement these practices.

Marek, E. William (Brigham Young Univ, Provo, UT, USA). *Prod Invent Manage* v 28 n 2 Second Quarter 1987 p 104-109.

**085980 PRODUCTION AND OPERATIONS MANAGEMENT TECHNIQUES IN MANUFACTURING: COMPARING THE UNITED KINGDOM AND THE UNITED STATES.** The survey upon which this work was based sought to establish production managers' areas of responsibility, the use pattern of several techniques, and the reasons why some techniques are used rarely. Thirty-five widely promulgated techniques were grouped into eight categories for the purpose of the survey. The questionnaire used in this work was designed (1) to establish main areas of responsibility of the production managers in the manufacturing industry, (2) to discover use patterns of several proven production management techniques, and (3) to investigate the reasons for no or low usage. Only those techniques that were shown from previous studies to be most likely to be used were included in the survey. They were divided into two groups. 35 refs.

Oakland, John S. (Univ of Bradford Management Cent, Bradford, Engl); Sohal, Amrik. *Prod Invent Manage* v 28 n 3 3rd Quarter 1987 p 12-16.

**085981 USE OF OPERATIONS RESEARCH IN PRODUCTION MANAGEMENT.** The results of a survey of large U.S. industrial firms indicates high use of operations research techniques in the application areas of scheduling, forecasting, and advertising sales research. The heavily used techniques are regression analysis, linear programming, and simulation. Several techniques declined in use over the last ten years, including project planning/control and inventory analysis control. 6 refs.

Ford, F. Nelson (Auburn Univ, Auburn, AL, USA); Bradbard, David A.; Ledetter, William n.; Cox, James F. III. *Prod Invent Manage* v 28 n 3 3rd Quarter 1987 p 59-63.

**085982 DYNAMIC PLANNING TECHNIQUE FOR CONTINUOUS ACTIVITIES UNDER MULTIPLE RESOURCE CONSTRAINTS.** The solution technique developed integrates the simplex search algorithm into the recursive calculations of dynamic programming in order to mitigate the 'curse-of-dimensionality.' Since differentiation is not required as a means of optimization procedure, it is expected that this technique will have an important impact on planning problems, such as the multiple resource allocation problems which involve nondifferentiable and/or highly nonlinear performance functions. Applications of the technique to very complex problems seem to confirm the anticipated polynomial average performance. (Edited author abstract) Refs.

Ozden, Mufit (Miami Univ, Oxford, OH, USA). *Manage Sci* v 33 n 10 Oct 1987 p 1333-1347.

**085983 CREATING A MANUFACTURING STRATEGY TO SUIT YOUR BUSINESS.** The development of manufacturing strategy requires approaches and techniques different from those used in the past. To play its proper role in establishing competitive advantage, the contribution of manufacturing must be recognized explicitly and exploited in conjunction with marketing, design and purchasing. Strategy and implementation are inseparable, and are a vital force in overcoming resistance to change. (Author abstract) 4 refs.

Pendlebury, A. John (Coopers & Lybrand Associates Europe). *Long Range Plann* v 20 n 6 Dec 1987 p 35-44.

**085984 MANAGERIAL FOCAL POINTS IN MANUFACTURING STRATEGY.** Data were collected by mailed questionnaires as a part of a large research project-

'Manufacturing Futures'. The responses to a list of 35 specific current action programmes in manufacturing were reduced through a principal component analysis to eight factors. We have labelled the factors as action flexibility, changing role of workforce, quality, information systems, upkeep of existing systems, re-sizing the structure, automation, and product-process adjustments. We interpret them as the dimensions which reflect the focal points of attention of management as judged from implemented manufacturing strategies. On the basis of this analysis, we recommend explicit management attention to eight questions while formulating a manufacturing strategy. (Edited author abstract) 22 refs.

De Meyer, Arnoud (INSEAD, Fontainebleau, Fr); Ferdows, Kasra. *Int J Prod Res* v 25 n 11 Nov 1987 p 1551-1562.

**085985 FMS AS INDICATOR OF THE STRATEGIC ROLE OF MANUFACTURING.** Statistical analysis of questionnaire data from 163 large European manufacturers show that those who put high emphasis on the development of flexible manufacturing systems (FMS) also pay more attention to many other elements in the management of their production systems. The authors hypothesize that FMS is management of their production systems. The authors hypothesize that FMS is being used, apart from its technological benefits, as a managerial tool for pushing new modes of thinking and performance in production, with the underlying objective of upgrading the strategic role of manufacturing in the company. (Author abstract) 14 refs.

Ferdows, Kasra (INSEAD European Inst of Business Administration, Fontainebleau, Fr); Lindberg, Per. *Int J Prod Res* v 25 n 11 Nov 1987 p 1563-1571.

**085986 MANUFACTURING STRATEGIES IN SWEDEN.** A survey of 125 Swedish manufacturing companies has shown that they tend to follow a product oriented strategy expressed by a high emphasis on the development of new products and a high level of innovation. The business units primarily compete with high quality, high performance products, and dependable deliveries. Altogether this puts high demands on the manufacturing processes utilized. The relationship between the production processes and the degree of product standardization is relatively low, and manufacturing concerns are to some extent grouped around these matters. Companies facing these concerns tend to emphasize programs dealing with worker motivation, focusing factories and efforts concerning improvement of process quality. (Author abstract) 15 refs.

Horte, S.A. (Inst for Management of Innovation & Technology, Goteborg, Swed); Lindberg, P.; Tunalyv, C. *Int J Prod Res* v 25 n 11 Nov 1987 p 1573-1586.

**085987 GENERIC BILLS OF MATERIALS IN ASSEMBLE-TO-ORDER MANUFACTURING.** For every customer order, the functional specifications which define a product that suits the customer's needs have to be determined. In order to define a bill-of-material (BOM) for every new customer order, these functional specifications have to be related to the engineering characteristics. This requires considerable knowledge about the product and its potential specifications. To support this error-prone task a generic BOM describes a range of products implicitly instead of enumerating the products individually. The importance of the use of a generic BOM is illustrated. The essence of the generic BOM is explained briefly and some of the problem in determining the suitability of a generic BOM are discussed. (Edited author abstract) 7 refs.

Van Veen, E.A. (Eindhoven Univ of Technology, Eindhoven, Neth); Wortmann, J.C. *Int J Prod Res* v 25 n 11 Nov 1987 p 1645-1658.

**085988 MANAGING PRODUCTION FOR CUSTOMER SERVICE AND PLANT EFFICIENCY.** The primary target of production management has been



capacity utilization, and many companies have incentives, reporting and accounting which focus on capacity efficiency as a primary measure of performance. The author believes that customer service should be the primary objective of production management efforts. This belief is based on two studies: a questionnaire based analysis of production situations at the beginning of this decade (117 plants) and a recent case study based deep analysis (10 case plants and 20 reference plants) in medium-to-small-size industries. Because of the modest size of the samples, the conclusions made should be generalized with caution. 4 refs.

Eloranta, Eero (Helsinki Univ of Technology). *Ind Eng (Norcross GA)* v 20 n 3 Mar 1988 p 36-38, 40.

**085989 THAT'S A GOOD IDEA, BUT...** The article examines how it is to get a group of workers involved in a new system. The method starts with determining goals in an unconstrained environment (described). From this point, the participants address organizational strengths and limitations on a personal basis, and finally move toward steps that can actually be taken in the short term.

Ettkin, Lawrence P. (Univ of Tennessee/Chattanooga, Chattanooga, TN, USA). *Prod Invent Manage J* v 28 n 4 1987 p 48-49.

**085990 HOW STUDENTS PERCEIVE THE BENEFITS OF STUDYING PRODUCTION AND OPERATIONS MANAGEMENT.** The study polled both graduate and undergraduate college students. They were also asked to list the benefits they had expected to gain, and felt they had gained, from taking such courses. The reasons ranged from exposure to technology, learning decision skills, and familiarity with terminology, to enhancing career opportunities, increasing intracompany cooperation, and reestablishing the United States' international industrial status.

Ala, Mohammad (California State Univ, Los Angeles, CA, USA). *Prod Invent Manage J* v 28 n 4 1987 p 71-74.

**085991 FAILURES CAN'T BE ELIMINATED, BUT MAINTENANCE COSTS CAN BE MINIMIZED.** This is the second in a two-part installment on how to improve production economics with plant engineering decisions. The author emphasizes that failures cannot be eliminated but maintenance costs can be minimized. He explains this through a discussion of engineering costs; labor overhead; relating costs to benefits; and system implementation.

Brown, Edward (Halcyon Corp). *PIMA Mag* v 70 n 3 Mar 1988 p 31-33.

**085992 APPROACH TO COMPUTER INTEGRATED PRODUCTION MANAGEMENT.** Computer integrated manufacturing (CIM) can never be constructed just by combining the automated devices available at present, such as CAD, CAM, CAPP and MRP systems. To realize successful CIM, the automation of friendly communication between experts is required, which plays a most important role in the integration of the various functions of production management. This points to the importance of computer integrated production management. In order to confirm the validity of the paradigm proposed in this paper, a prototype in process planning has been developed which aims at integration with CAD. (Edited author abstract) 7 refs.

Ando, K. (Inst of Technology, Ohmiya, Jpn); Takeshige, A.; Yoshikawa, H. *Int J Prod Res* v 26 n 3 Mar 1988 p 333-350.

**085993 PRODUCTION IN THE FACTORY OF THE FUTURE.** There is much discussion of the general decline of smokestack industries worldwide with some notable exceptions. These exceptions sought manufacturing efficiency improvements in order of magnitude higher than previously achieved. It is now clear that the future belongs to the factory with computer technology at its core. Production in a computer supported factory is very different. The support functions and the factory itself operate like a well-oiled machine. This paper shows where

manufacturing is headed and the changes needed in management practices to make automated, computerized manufacturing possible. (Edited author abstract)

Plossl, Keith R. (George Plossl Educational Services, Marietta, GA, USA). *Int J Prod Res* v 26 n 3 Mar 1988 p 501-506.

**085994 FLEXIBLE DESIGN OF PRODUCTION PLANNING SYSTEMS.** The paper discusses future production systems with emphasis on new production management concepts. Planning problems are identified. Computer applications in the fields are briefly explained. The main part of the paper discusses basic operations in production management. These are operations invariant to different applications and will thus serve as truly modular building blocks in a computer based production management system. The data structures involved are discussed and a list of operations proposed. (Author abstract) 6 refs.

Rolstadas, Asbjorn. *Int J Prod Res* v 26 n 3 Mar 1988 p 507-520.

**085995 OBJECT ORIENTED PROGRAMMING IN PRODUCTION MANAGEMENT - TWO PILOT SYSTEMS.** This paper discusses artificial intelligence (AI)-oriented production management systems using object oriented programming. The two pilot systems described here are both implemented using the Smalltalk-80 programming environment. One of the systems concerns production flow analysis. The merits of object oriented programming in the design of the user interfaces are emphasised. The flexibility of the object oriented approach for stepwise development has been observed. Simulation method as a communication tool is used in both systems and the applicability of Smalltalk in simulation is demonstrated. (Edited author abstract) 9 refs.

Alasuvanto, Jari (Helsinki Univ of Technology, Finl); Eloranta, Eero; Fuyuki, Masahiko; Kida, Tomoyuki; Inoue, Ichiro. *Int J Prod Res* v 26 n 5 May 1988 p 765-776.

**085996 PRODUCTION AND INVENTORY MANAGEMENT AND STRATEGY FIELDS - A CASE FOR MORE DIALOG.** The author makes a case for more communication between production and inventory managers and strategists. In particular, he suggests that a full assessment of the competitive forces that underlie a company's industry and a knowledge of its own and its competitors' basic strategies should be important considerations in demand management, resource planning, and production planning. Industry analysis should be at the front end of the manufacturing resources planning (MRP-II) flow chart. 13 refs.

Leavy, Brian (Dublin Business Sch, Dublin, Irel). *Prod Invent Manage J* v 29 n 1 1988 p 61-64.

**085997 INTEGRATED PRODUCTION-INVENTORY MODEL WITH REPROCESSING AND INSPECTION.** Cost and quality levels of production systems are addressed via a model that synthesizes several potential features of production systems: production processes, quality control procedures, in-process inventory and reprocessing. For any specified inspection configuration the model can be used, for serial production systems, to obtain closed-form expressions for two important decision variables: optimal lot size and reprocessing batch size, which minimize the total system costs. A numerical example highlights the interdependencies and the role of various system features in determining the values of the decision variables and hence in reducing the total costs. The paper also discusses the managerial implications of the model. (Edited author abstract). 14 Refs.

Tayi, Giri Kumar (State Univ of New York at Albany, Albany, NY, USA); Ballou, Donald P. *Int J Prod Res* v 26 n 8 Aug 1988 p 1299-1315.

**085998 STRATEGIC ANALYSIS OF INTEGRATED PRODUCTION-DISTRIBUTION SYSTEMS: MODELS AND METHODS.** This paper pres-

ents a comprehensive model framework for linking decisions and performance throughout the material-production-distribution supply chain. The purpose of the model is to support analysis of alternative manufacturing material/ service strategies. A series of linked, approximate submodels and an heuristic optimization procedure are introduced. A prototype software implementation is also discussed. (Author abstract). 28 Refs.

Cohen, Morris A. (Univ of Pennsylvania, Philadelphia, PA, USA); Lee, Hau L. *Oper Res* v 36 n 2 Mar-Apr 1988 p 216-228.

**085999 AMERICAN PRODUCTION & INVENTORY CONTROL SOCIETY, INC. TWENTY-NINTH ANNUAL INTERNATIONAL CONFERENCE PROCEEDINGS.** This conference proceedings contains 188 papers, two of which are in abstract form only. Some of the topics covered are: Production and Inventory Control Management; Computer Integrated Manufacturing; Manufacturing Resource Planning/MRP; Just-In-Time/JIT; Master Planning; Demand Management; Capacity Management; Operations Management; Functional Interfaces; Professional Development; and, Executive Management Issues. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11014 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (APICS, Falls Church, VA, USA). *Annu Int Conf Proc Am Prod Inventory Control Soc* 29th, St. Louis, MO, USA, Oct 20-24 1986. Publ by APICS, Falls Church, VA, USA, 1986 707p.

**Mathematical Models** See Also INDUSTRIAL PLANTS—Layout; IRON AND STEEL PLANTS—Quality Control; MACHINE SHOPS—Flexible Manufacturing Systems; MATERIALS HANDLING—Synchronization; MATHEMATICAL TECHNIQUES—Algorithms; QUALITY CONTROL—Management; SCHEDULING—Optimization.

**086000 COMPUTATION OF THE MAKESPAN IN A TRANSFER LINE WITH STATION BREAKDOWNS USING STOCHASTIC PETRI NETS.** The authors developed a Petri net model of a transfer line, whose machines are subject to failure, considering both blocking and rerouting of workpieces when a machine fails. The introduction in the net of the marked token is shown to allow the computation of the makespan of the system. The authors describe how to model production processes by stochastic Petri nets. It is shown how stochastic Petri Nets (SPN) can be modified introducing a 'marked token' in order to compute the makespan: details of the marked token method are given and worked out in a simple example. A model of a transfer line is presented, in which service, failure and repair times are assumed to be exponential; for this problem the mean value of the makespan under different control policies of a workpiece is computed, using the marked token technique. (Edited author abstract) 12 refs.

Archetti, F. (Univ of Milan, Milan, Italy); Fagioli, E.; Sciomachen, A. *Comput Oper Res* v 14 n 5 1987 p 409-414.

**086001 LEAST-COST RATIONS AND OPTIMAL LIVESTOCK FEEDING POLICY.** In evaluating feeding policy in livestock production, it is generally assumed that an optimal feeding policy will involve using least-cost rations throughout the production process. It is demonstrated that this assumption may not be valid when the supply of some of the feedstuffs used for livestock feeding is limited. A method for testing the validity of this assumption is presented for a linear programming model of an integrated crop and intensive beef production enterprise in which some of the crops may be used for livestock feeding, and an iterative solution procedure is proposed for cases where this assumption is not valid. (Author abstract) 7 refs.

Glen, J.J. (Univ of Edinburgh, Scotl). *J Oper Res Soc* v 38 n 9 Sep 1987 p 847-851.



**086002 DETERMINISTISCHES MODELL ZUR BESTIMMUNG OPTIMALER PRODUKTIONS- UND INSTANDHALTUNGSZYKLEN.** [Deterministic Model for Determining Optimal Production and Maintenance Cycles]. Means of production with gradually decreasing efficiency have to be put out of operation periodically to remove the cause of this decrease, such as wear and tear, and formation of crusts. This leads to downtimes which in turn result in loss in production. Hence determination of cycles of maintenance and cleaning is an optimization problem. A general mathematical model is presented, and a practical approach of optimization is demonstrated by the example of a chemical plant. (Edited author abstract) In German. 4 refs.

Renger, Klaus (Technische Hochschule 'Carl Schorlemmer', Leuna-Merseburg, East Ger). *Chem Tech (Leipzig)* v 39 n 9 Sep 1987 p 367-370.

**086003 STRATEGIC SUBCONTRACTING FOR EFFICIENT DISAGGREGATE MANUFACTURING.** A new method is presented for using a subcontracting strategy to induce manufacturing efficiency by re-organizing the existing parts and machines into disaggregated cells. Two efficient algorithms are developed which identify the minimal number or minimal total cost of subcontractable parts while achieving disaggregation. The method has the flexibility of letting the designer control the number of cells and cell size thus generating a variety of cellular manufacturing system designs to choose from. (Author abstract) 13 refs.

Ravi Kumar, K. (Univ of Southern California, Los Angeles, CA, USA); Vannelli, A. *Int J Prod Res* v 25 n 12 Dec 1987 p 1715-1728.

**086004 VARIATIONS OF QUOTAS IN A PRODUCTION SYSTEM WITH FIXED PRICES.** Conditions for increasing the net system product are derived in the framework of an abstract production model. The use of these conditions essentially simplifies the proof and provides a generalization of some known results of Braverman's model with nonequilibrium prices. It is shown that in some cases the potential for increased output cannot be realized by small variations of quotas. Conditions are proposed when variation of output quotas of the system elements is free from this difficulty. (Author abstract) 10 refs.

Polterovich, V.M.; Spivak, V.A. *Autom Remote Control* v 48 n 9 Sep 1987 p 1228-1235.

**086005 EVENT-DRIVEN MODEL OF UNRELIABLE PRODUCTION LINES WITH STORAGE.** Using this algorithm a production line, with an arbitrary number of machines each processing items at different rates and with buffers by any size, can be modelled efficiently. The algorithm is based on computing the time to the next event for each buffer and machine, where the events are: a buffer becomes full, a buffer becomes empty, a machine fails, and a machine is repaired. By collapsing the production line to exclude empty buffers that stay empty and full buffers that stay full, piece-by-piece computation is avoided. Computation time is reduced further by updating a buffer only when the input or output rate of that buffer changes or when the state of that buffer changes. (Edited author abstract) 14 refs.

D'Angelo, Henry (Boston Univ, Boston, MA, USA); Caramanis, Michael; Finger, Susan; Mavretic, Anton; Phillis, Yannis A.; Ramsden, Edward. *Int J Prod Res* v 26 n 7 Jul 1988 p 1173-1182.

**086006 PRODUCTION CONTROL IN MULTI-STAGE SYSTEMS WITH VARIABLE YIELD LOSSES.** We develop a procedure to determine optimal input quantities at each stage of a serial production system in which process yields at each stage of production may be stochastic. The procedure is applied to an example in the manufacture of a light-emitting diode (LED) display using actual yield data. We also provide a brief analysis of the quantifiable savings obtained by reducing the variability of the yield at one production stage. (Edited author abstract). 10 refs.

Lee, Hau L. (Stanford Univ, Stanford, CA, USA); Yano, Candace Arai. *Oper Res* v 36 n 2 Mar-Apr 1988 p 269-278.

**086007 DAILY PRODUCTION PLANNING IN FISH PROCESSING FIRMS.** Production planning in fish processing firms is analyzed. A linear programming model maximizing the firms' profit over a five days' horizon is presented, and the experience of real life testing is discussed. Our ultimate goal is to develop an easy to use decision support system, which could be used daily by production managers in fish processing firms. The optimization model is seen as an important step toward this end. (Edited author abstract). 8 refs.

Jensson, Pall (Univ of Iceland, Reykjavik, Icel). *Eur J Oper Res* v 36 n 3 Sep 1988 p 410-415.

**Mechanical Drive** See ELECTRIC MOTORS, LINEAR.—Analysis.

**Operations Research** See Also INVENTORY CONTROL—Mathematical Models; SCHEDULING—Optimization.

**086008 FORECASTING OF JOB ORDER PRODUCTS BY OPTIMIZING ERRORS.** The present work uses a nonconventional technique of specifying the job order product. In forecasting, error minimizing technique was also used, which was superimposed on the original forecasting model. Effectiveness of models was judged statistically and confirmed by the future product demand. (Author abstract) 5 refs.

De, Amitosh (Indian Sch of Mines, Dhanbad, India). *J Inst Eng India Part PR* v 68 pt 2 Nov 1987 p 35-40.

**Optimization** See Also INVENTORY CONTROL—Mathematical Models.

**086009 OPTIMAL CONTROL OF PRODUCTION AND MARKETING SYSTEMS WITH DISTRIBUTED TIME LAGS.** This paper deals with the problem of production and advertising policy for a decaying item whose gradual loss of potential or utility is associated with the passage of time, such as grain, photographic film or electronic components. The delay effects of the advertisement on the sales rate are also considered in the equations. The objective is to use optimal control theory to determine the production and advertising rates of the decay item which maximize the current value of net profit stream. For the model developed we present a computational procedure of finding the optimal policy and then carry out sensitivity analysis through an example problem. The properties of the optimal solution are discussed for the case of constant rate of delay effect. (Author abstract) 18 refs.

Choi, Sung-Bin (Korea Inst for Defense Analyses, Seoul, South Korea); Hwang, Hark. *Optim Control Appl Methods* v 8 n 4 Oct-Dec 1987 p 351-364.

**086010 OUTPUT-MAXIMAL CONTROL POLICIES FOR CASCADED PRODUCTION-INVENTORY SYSTEMS WITH CONTROL AND STATE CONSTRAINTS.** Optimal control policies are derived for cascaded production-inventory systems. As objectives, output maximization and the minimum time to produce a fixed output are considered. An example consisting of three subsystems is detailed to illustrate the proposed theory. (Author abstract). 6 refs.

Warschat, J. (Fraunhofer Inst for Industrial Engineering, Stuttgart, West Ger); Wunderlich, H.J. *Int J Syst Sci* v 19 n 6 Jun 1988 p 1011-1020.

## Performance

**086011 REGENERATIVE PULL (KANBAN) PRODUCTION CONTROL POLICIES.** Two novel tractable and optimal regenerative pull ('Kanban') control policies are formulated: one policy minimizes the weighted starvation penalty, while the other maximizes the weighted throughput per unit time. Following these regenerative policies the production schedules are re-evaluated at each

decision epoch to mitigate the effects of processing time variability. Several important properties regarding the inherent interaction between the structure of the optimal policy, the performance of the system and the desired allocation of productive capabilities among the manufacturing resources are exemplified. (Edited author abstract) 44 refs.

Seidmann, Abraham (Univ of Rochester, Rochester, NY, USA). *Eur J Oper Res* v 35 n 3 Jun 1988 p 401-413.

**Personnel Training** See Also QUALITY CONTROL—Management.

**086012 EDUCATIONAL AND SYSTEM REQUIREMENTS FOR PRODUCTION CONTROL.** This study of production control personnel in industry is intended to determine current industry requirements which may be converted to educational prerequisites. It also identifies the educational backgrounds and current duties of production control personnel. The findings should aid educators in both university and industry settings in inductively developing programs to meet these requirements. 5 refs.

White, Charles R. (Auburn Univ, Auburn, AL, USA); Adams, Jeff; Donehow, Kathryn; Hofacker, Scott. *Prod Invent Manage J* v 29 n 2 1988 p 10-12.

**Planning** See Also COMPUTER AIDED MANUFACTURING; INVENTORY CONTROL—Management; PORTFOLIO—Production; SCHEDULING—Management.

**086013 EFFECTS OF MANUFACTURING PROGRESS FUNCTIONS ON MACHINE REQUIREMENTS AND AGGREGATE PLANNING PROBLEMS.** The existing models for machine requirements planning are based on the assumption of a constant production rate per machine throughout the planning horizon. This assumption is not valid in many production environments where the manufacturing productivity increases because of factors like: product and process redesign, more efficient maintenance and setup procedures, direct-labor learning, reduction of scrap losses, etc. This paper presents the effects of improving manufacturing productivity on machine requirements planning. An integral model which combines the aggregate production planning and machine requirements planning problems is discussed under the effects of manufacturing progress function. (Edited author abstract) 19 refs.

Behnezhad, Ali R. (California State Univ Northridge, Northridge, CA, USA); Khoshnevis, Behrokh. *Int J Prod Res* v 26 n 2 Feb 1988 p 309-326.

**086014 DISAGGREGATION UNDER UNCERTAINTY IN HIERARCHICAL PRODUCTION PLANNING.** This study deals with a hierarchical planning system that is used for planning of a single-stage manufacturing system. We consider two decision levels, aggregate and detailed planning, and formulate a model for evaluation of aggregate plans and optimal disaggregation in case of independent stochastic demand. It is shown how the optimal solution can be obtained with the aid of a dynamic programming algorithm. Furthermore, we give conditions that will guarantee optimality of a simple intuitive disaggregation rule. (Author abstract) 8 refs.

Ari, E. Aysen (Lulea Univ of Technology, Lulea, Sweden); Axsater, Sven. *Eur J Oper Res* v 35 n 2 May 1988 p 182-186.

**086015 MANUFACTURING PLANNING AND CONTROL IN KOREA.** A number of Korean manufacturers were surveyed to determine the production planning and control systems being used. In general, the systems resemble those used by U.S. firms and typically employ some form of material requirements planning (MRP) software. Japanese just-in-time approaches are



used to a lesser extent. A shift from high-volume repetitive manufacturing to job-lot manufacturing (Dapoomjong Soryang) is also discussed. 10 refs.

Morris, John S. (Univ of Idaho, Moscow, ID, USA); Kim, Wae-Jung. *Prod Invent Manage J* v 29 n 1 1988 p 39-43.

**Process Control** See Also INVENTORY CONTROL—Management.

**086016 PROCESS CONTROL AND PEOPLE AT GENERAL MOTORS' DELTA ENGINE PLANT.** At General Motors' Delta Engine Plant near Lansing, MI, teams of employees have implemented a highly innovative process control system, with quality as its driving force, for the production of the Quad 4 engine. What remains to be done now is to continue accelerating production without compromising quality. The key tools and techniques can be categorized as 'process control and people.' This article explains the details and reasoning behind this approach.

Blache, Klaus M. (GM, Lansing, MI, USA); Steward, Kenneth C.; Zimmerman, Robert L.; Shaul, James E.; Benner, Raymond D.; Humphrey, Gary P. *Ind Eng (Norcross GA)* v 20 n 3 Mar 1988 p 24-30.

**Quality Control** See Also INDUSTRIAL ENGINEERING—Safety Codes; INTEGRATED CIRCUIT MANUFACTURE—Management; PROCESS CONTROL; PRODUCT DESIGN—Reliability; SPACE SHUTTLES—Manufacture.

**086017 GAS SPRING ASSEMBLER RUNS BY 'YELLOW BOOK'.** The yellow book was a well-planned part of Gas Spring's rapid growth from a small, 18-person assembly operation in 15,000 square feet of leased space in 1983 into a new 100,000-square foot facility with more than 150 people in June 1985. The 'whole concept and environment' of modern material handling, just-in-time manufacturing, process management and process control in a basic, straight-line batch assembly operation were designed into the plant. But there was another important ingredient: people. The company was fortunate in getting excellent people who had good industrial experience. This helped in handling all the problems of getting started.

Miller, Frederick W. (Manufacturing Systems, Wheaton, IL, USA). *Manuf Syst* v 6 n 1 Jan 1988 p 47-49.

**086018 SIGNIFICANT IMPROVEMENTS TO THE QUALITY OF DURACELL SPECIALTY BATTERY PRODUCTS MANUFACTURED BY GATWICK ROAD ASSEMBLY DIVISION.** This paper describes the programme which successfully achieved increased efficiency in product design, manufacturing systems and quality control procedures, enabling Duracell to make significant improvements in the quality of its specialty products, assembled in Crawley. After a brief outline of the product and the specialty cell market, the principles of the programme are described, and the changes detailed, including the reduction of leakage and the introduction of computer-based systems. The substantial improvements are quantified in cost and performance terms. (Author abstract)

Kilshaw, J.A. (Duracell Batteries Ltd, Crawley, Engl); Parmenter, G.; Carpenter, G. *Qual Assur* v 13 n 4 Dec 1987, Ed Versions of Pap Presented to the 26th Int Qual Assur Conf, Entitled: 'Bus Improv by Qual Methods', Oxford, Engl, Sep 1987 p 101-107.

**Research** See INVENTORY CONTROL.

**Robot Applications** See Also ROBOTIC ASSEMBLY—Productivity.

**086019 MACHINE-TENDING ROBOT RAISES PRODUCTION CAPACITY.** Sales growth at the Commercial Cam Division of Emerson Electric Co. (CAMCO), Wheeling, Ill., has necessitated doubling of production throughput. These goals are being accomplished through the creation of Group Technology (GT) workcells. GT workcells typically may consist of various CNC or conventional turning, milling and grinding machines, loading/unloading robots, related gaging and

tooling, and material handling equipment such as conveyors or storage trays.

Anon. *Rob World* v 5 n 10 Sep 1987 p 30-31.

**Scheduling** See Also DECISION THEORY AND ANALYSIS; ELECTRONIC EQUIPMENT MANUFACTURE—Quality Control; INVENTORY CONTROL—Costs; INVENTORY CONTROL—Economics; INVENTORY CONTROL—Management; INVENTORY CONTROL—Mathematical Models; JOB ANALYSIS—Computer Aided Analysis; MACHINE SHOPS—Inventory Control; MACHINE SHOPS—Process Control; MATERIALS HANDLING—Design; MATHEMATICAL PROGRAMMING, LINEAR; PROBABILITY—Queueing Theory; QUALITY CONTROL—Management; SCHEDULING—Mathematical Models; SEMICONDUCTOR DEVICE MANUFACTURE—Computer Simulation.

**086020 POTENTIAL BENEFITS OF JUST-IN-TIME PURCHASING FOR U.S. MANUFACTURING.** This article provides the results of a study done among U.S. firms to explore the potential benefits of just-in-time purchasing and the degree to which these benefits could be important to U.S. manufacturers. The results of the survey indicate that implementing JIT purchasing produces substantial benefits representing drastic economic improvements for companies that had formerly used traditional U.S. purchasing practices. In terms of intangible benefits from JIT, the survey confirms that the greatest degree of improvement appears in product quality, productivity, and success in encouraging suppliers to meet quality requirements. 15 refs.

Ansari, A. (Seattle Univ, Seattle, WA, USA); Modarress, Batoul. *Prod Invent Manage* v 28 n 2 Second Quarter 1987 p 30-36.

**086021 SHOP FLOOR CONTROL AND PRIORITY SCHEDULING.** The advent of just-in-time programs makes it necessary to look at the two subjects in the title of this article. For those companies which still have queue times much longer than actual work times, some resolution between operational back dating and critical ratio scheduling may be necessary. Where queue times are reduced so that the first pieces have moved downstream before the last pieces are completed, adjustments may be made for overlapping. Input-output control and master production scheduling are critical to planning and successful execution.

Putnam, Arnold O. (Rath & Strong Inc, Lexington, MA, USA). *Prod Invent Manage* v 28 n 2 Second Quarter 1987 p 50-58.

**086022 SINGLE MACHINE SEQUENCING TECHNIQUES WITH BOTH TARDINESS AND FLOW-TIME CRITERIA.** The performances of the best efficient sequence, contingent critical ratio (CCR), shortest processing time (SPT), earliest due date (EDD), and critical ratio sequences (CR) are compared. The processes are found to function in that order of success. Criteria considered here, the rule performs at least as well as SPT and EDD in the cases examined and was superior to EDD when due dates were narrowly distributed and superior to SPT when the due dates had a wide range. The implications are: (1) never use the conventional CR procedure, and (2) the best efficient sequences is better than any other rule. CCR performs robustly and better over a wide range of problems than do SPT or EDD. 16 refs.

Litteral, Lewis A. (Univ of Richmond, VA, USA). *Prod Invent Manage* v 28 n 2 Second Quarter 1987 p 59-64.

**086023 LINKING LEVEL REQUIREMENTS IN PRODUCTION PLANNING AND SCHEDULING.** Hierarchical planning and scheduling models force management to explicitly consider the links between different levels in an organization involved in the planning and scheduling process. This, alone, justifies their consideration as a planning tool. Additionally, this type of planning provides the flexibility necessary for realistically addressing actual problems. One is not restricted to a particular mathematical formulation or to particular assumptions, which in the past have limited the applications of planning and scheduling models. Their flexibility and usefulness is well demonstrated by the two applica-

tions. 8 refs.

Burch, E. Earl (Clemson Univ, Clemson, SC, USA); Oliff, Michael D.; Sumichrast, Robert T. *Prod Invent Manage* v 28 n 2 Second Quarter 1987 p 123-131.

**086024 PRE-JIT/TQC AUDIT: FIRST STEP OF THE JOURNEY.** Preparing for and taking a just-in-time (JIT) journey involves a complex set of activities whose progress needs to be monitored as it unfolds. Performing a pre-JIT/total quality control (TQC) audit with an interdisciplinary team provides a means to develop these baselines and to partially prepare the team to act as guides (and perhaps missionaries) for the journey. Both global and decomposed inventory turnover ratios and cycle times are easily understood measurement tools and are reasonably easy to develop. These measures, coupled with the others suggested in this article, can not only define the journey's starting point, but give some good hints for the most promising directions to take. 27 refs.

Hendrick, Thomas E. (Arizona State Univ, Tempe, AZ, USA). *Prod Invent Manage* v 28 n 2 Second Quarter 1987 p 132-143.

**086025 NEW FORMULATION OF OPERATION ALLOCATION PROBLEM IN FLEXIBLE MANUFACTURING SYSTEMS: MATHEMATICAL MODELLING AND COMPUTATIONAL EXPERIENCE.** This paper extends the formulation of the operation allocation problem to include the important planning aspects of refixturing and limited tool availability. A 0-1 integer programming formulation is proposed with two objective functions and a set of realistic constraints. The computational behavior of the solution is discussed and a number of observations prompted by the solution methodology have been made. (Author abstract) 10 refs.

Lashkari, R.S. (Univ of Windsor, Windsor, Ont, Can); Dutta, S.P.; Padhye, A.M. *Int J Prod Res* v 25 n 9 Sep 1987 p 1267-1283.

**086026 COMPARATIVE ANALYSIS OF THE COVERT JOB SEQUENCING RULE USING VARIOUS SHOP PERFORMANCE MEASURES.** The COVERT rule is examined in detail relative to its applicability, its sensitivity to various operating parameters and performance measures, and its performance compared to several other sequencing rules including truncated shortest processing time (SPT) rules, dynamic slack rules and modified due-date rules. The performance of COVERT is examined for a variety of tardiness measures. The examination is conducted within the context of a simulation model of a machine-constrained job shop with serial jobs and random routings. The results indicate that COVERT performs well as a sequencing rule and in most instances was superior to the other sequencing rules tested both directly and across varying degrees of due-date tightness. (Edited author abstract) 19 refs.

Russell, R.S. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Dar-El, E.M.; Taylor, B.W. III. *Int J Prod Res* v 25 n 10 Oct 1987 p 1523-1540.

**086027 PRODUCTION BATCH SIZES IN A REPETITIVE FLEXIBLE ASSEMBLY SYSTEM.** The approach used in this study accounts for variations of part requirements, setup times, part costs, process times, and available capacity, and supports just-in-time (JIT) concepts. The joint production batch size procedure is illustrated using data from the taillight flexible assembly systems (FAS) center at the Ford fabrication plant in Sandusky, OH. Based upon monthly demand schedules, production batch sizes are estimated and scheduled. Since setup time and available uptime influence overall performance, we demonstrate how this approach assists in sensitivity analysis of the FAS's capabilities to support



manufacturing's mission of achieving low costs, low inventories, good equipment utilization, and minimum part shortages. 8 refs.

Mabert, Vincent A. (Indiana Univ, Bloomington, IN, USA); Pinto, Peter A. *Prod Invent Manage* v 28 n 3 3rd Quarter 1987 p 34-38.

**086028 PLANNED LEADTIMES FOR SERIAL PRODUCTION SYSTEMS.** We investigate the problem of setting planned leadtimes in serial production systems when the actual leadtimes are stochastic. The objective is to minimize the sum of inventory holding costs, rescheduling costs arising from tardiness at intermediate stages of production, and tardiness of delivery to the customer. A single-pass algorithm is developed which finds optimal solutions. The analytical models underlying the algorithm and extensive computational experience indicate that it is never optimal to have planned leadtimes of zero when there are rescheduling costs at intermediate stages of production. This also implies that unconditional immediate dispatching is not optimal under these conditions. (Author abstract) 11 refs.

Yano, Candace Arai (Univ of Michigan, Ann Arbor, MI, USA). *IIE Trans* v 19 n 3 Sep 1987 p 300-307.

**086029 PRIORITY ASSIGNMENT PROCEDURES IN MULTI-LEVEL ASSEMBLY JOB SHOPS.** This paper explores the means by which the structural complexity of jobs can be incorporated explicitly into priority rules to reduce job lead times. The job lead time is viewed as consisting of two components: flow time and job staging delays. The primary focus of the paper is on the development of a class of priority rules that is aimed at reducing the staging delay. The class of priority rules that is developed is then used in combination with rules that are effective for the flow time component. The combined rule results in the improvement of the lead time performance. The paper also includes experimental results on sets of jobs of varying degrees of complexity. (Edited author abstract) 13 refs.

Adam, Nabil R. (Rutgers State Univ, New Brunswick, NJ, USA); Bertrand, J. Will M.; Surkis, Julius. *IIE Trans* v 19 n 3 Sep 1987 p 317-328.

**086030 PERFORMANCE OF A MANUFACTURING CELL WITH INCREASED PRODUCT MIX.** We investigate the impact of increasing the number of items made in a cell on its performance. The optimal lot sizes of production and queuing delays are both shown to increase with increased product mix. However, these adverse effects diminish as more items are assigned to the cell. We also examine a strategy of sequencing which attempts to minimize the number of setups by looking ahead in the queue and processing all items for which the machine is already setup. In the case of similar items, it is found that this sequencing policy results in little savings in setup time. (Author abstract) 16 refs.

Kekre, Sunder (Carnegie-Mellon Univ, Pittsburgh, PA, USA). *IIE Trans* v 19 n 3 Sep 1987 p 329-339.

**086031 IMPLEMENTATION OF AN EXPERT SYSTEM FOR PRODUCTION SCHEDULING.** An attempt was made to capture the local knowledge and informal heuristics used by the experienced human production scheduler and to reduce these to a set of rules which would operate on a relational database representing current shop floor status and projected future loading; the objective was for the system to produce schedules similar to those of the human. Some background information is given on the scheduling environment in the company concerned, followed by a general description of the Expert System itself. Some experiences and lessons learned from the experimental implementation are discussed. (Edited author abstract) 11 refs.

Kerr, R.M. (Univ of New South Wales, Kensington, Aust); Ebsary, R.V. *Eur J Oper Res* v 33 n 1 Jan 1988 p 17-29.

**086032 SINGLE FACILITY SCHEDULING WITH MULTIPLE JOB CLASSES.** This paper considers a

static single facility scheduling problem where jobs are divided into several mutually exclusive classes. The jobs in a given class need not be processed together. In addition to a known processing time for each job, there is a switching time involved which depends on the class of the job immediately preceding a job. A heuristic algorithm is proposed to find a minimum mean flow time schedule. The effectiveness of the proposed heuristic algorithm is empirically evaluated and found to indicate that the solutions obtained from this heuristic algorithm are often close to optimal. (Author abstract) 6 refs.

Gupta, Jatinder N.D. (Ball State Univ, Muncie, IN, USA). *Eur J Oper Res* v 33 n 1 Jan 1988 p 42-45.

**086033 ALTERNATIVE APPROACHES TO SCHEDULE INSTABILITY: A COMPARATIVE ANALYSIS.** While there are many potential sources of schedule nervousness, we focus on two which appear to be most pervasive: the effect of forecast errors and the use of a rolling horizon. The alternatives examined are: freezing the schedules over the planning horizon; lot-for-lot ordering after the final product; buffer stocks; forecasting beyond the planning horizon; and, the change product; buffer stocks; forecasting beyond the planning horizon; and, the change cost produce. The effectiveness of these procedures was examined through a series of simulation experiments where the length of the planning horizon, the lot-sizing method, cost parameters, forecast error, and product structure were varied. (Edited author abstract) 14 refs.

Blackburn, Joseph D. (Vanderbilt Univ, USA); Kropp, Dean H.; Millen, Robert A. *Int J Prod Res* v 25 n 12 Dec 1987 p 1739-1749.

**086034 HEURISTIC METHODS FOR FLEXIBLE FLOW LINE SCHEDULING.** Heuristic methods are presented for scheduling a flexible flow line. Two problems are considered: entry point sequencing, that is, deciding the order in which to present the jobs to the system, and dispatching, that is, deciding at each machine which job to start next. The results of these methods on test and realistic problems are described. The approach takes into account various line phenomena, such as setups, finite buffers, blocking and starvation, machine downtimes, and the current and subsequent states (at rescheduling intervals) of the line. Various optimization techniques are investigated including myopic and local search methods. (Edited author abstract) 15 refs.

Kochhar, Sandeep (Harvard Univ, Cambridge, MA, USA); Morris, Robert J.T. *J Manuf Syst* v 6 n 4 1987 p 299-314.

**086035 SIMULATING THE ECONOMIC LOT SCHEDULING PROBLEM: I. MODEL DESCRIPTION.** This simulation model for the economic lot scheduling problem was created to evaluate scheduling policies, safety stock requirements, and customer service levels for facilities using this methodology. It includes the environment and evolution of the model and the implementation results. A simulation model is an attractive approach to controlling the investment in safety stock and the resulting service levels. 5 refs.

Galvin, Thomas M. (Northern Illinois Univ, DeKalb, IL, USA). *Prod Invent Manage J* v 28 n 4 1987 p 32-38.

**086036 PRODUCTIVITY GAINS AT SOUTHWEST TUBE.** Analysis of manufacturing systems focuses attention on how to best utilize people and equipment. At Southwest Tube, all four of the basic manufacturing systems were developed or enhanced for significant gains in productivity. Four key systems are needed to enhance manufacturing information flow to improve productivity: methods and labor standards; manufacturing supervision; measurement and reporting; and manpower scheduling. One of the interesting aspects of this productivity improvement program is the organizational environment in which it occurred. 7 refs.

Shirley, James M. (Webb & Shirley Tulsa, OK, USA); Box, Thomas M. *Prod Invent Manage J* v 28 n 4 1987 p 57-60.

**086037 PRODUCTION ACTIVITY CONTROL - A KEY ASPECT OF PRODUCTION CONTROL.** This paper reviews the role of Production Activity Control (PAC) in modern production and inventory management systems. It argues that the PAC system is fundamental to the realization of computer integrated manufacturing (CIM) at the operational or shop floor level. It presents an architecture for PAC and suggests that to date research has overemphasized one element of PAC, namely the scheduling function, and further has considered scheduling as an isolated problem without reference to the overall PAC system requirement. This, along with the tendency to consider scheduling as a combinatorial problem to be solved using mathematically elegant techniques accounts for the 'theory-practice gap' in scheduling. The paper concludes with some suggestions for further research effort in the PAC area. (Author abstract) 17 refs.

Browne, J. (Univ Coll Galway, Ire). *Int J Prod Res* v 26 n 3 Mar 1988 p 415-427.

**086038 OPERATION SCHEDULING WITH GT AND PBC.** Generations of managers in industry and of academics in universities, have been intrigued by the problem of how to plan, and more recently how to automate the scheduling of the operations needed to make parts, on the machines and other work centres in a factory. The usual solution is: 'Tell the foreman to do the best he can'. This paper submits that the introduction of group technology (GT), coupled with period batch control (PBC), so simplifies the problem, that with minor analytical assistance the GT group foremen can do their own operation scheduling, more reliably and cheaply than it can be done by the computer. (Edited author abstract)

Burbidge, John L. (Cranfield Inst of Technology, Engl). *Int J Prod Res* v 26 n 3 Mar 1988 p 429-442.

**086039 CYCLIC SCHEDULING FOR IMPROVEMENT.** Enormous improvements are possible by synchronizing manufacturing tasks sequentially within a short lead time and by creating cycle times by which many different kinds of work can be fitted together like clockwork. Actually achieving close synchronization requires utmost effort to improve every aspect of a manufacturing organization. A concept central to the improvement is the creation and use of cyclic schedules. The paper discusses how and why these relationships exist. (Author abstract)

Hall, Robert W. (Indiana Univ Sch of Business, Indianapolis, IN, USA). *Int J Prod Res* v 26 n 3 Mar 1988 p 457-472.

**086040 MODELLING AND SCHEDULING A BATCH-TYPE PRODUCTION ON IDENTICAL MACHINES.** A new formulation and a near-optimal algorithm are presented for some variation of an NP-hard parallel scheduling problem with forest-type constraints and a  $C_{max}$  optimality criterion where multiple performing of each operation is required. The problem is formulated using a state space approach. In the algorithm the priority in which the assignment of operations to machines is made is based on the level of operation in the graph of precedence constraints. The worst-case performance bound of the algorithm is given, and the average performance is illustrated with computational examples. (Author abstract) 8 refs.

Sawik, T.J. (Univ of Mining & Metallurgy, Cracow, Pol). *Eur J Oper Res* v 35 n 3 Jun 1988 p 393-400.

**086041 MASTER PRODUCTION SCHEDULING, CUSTOMER SERVICE AND MANUFACTURING FLEXIBILITY IN AN ASSEMBLE-TO-ORDER ENVIRONMENT.** This paper reports the results of a simulation experiment that compares alternative master production scheduling (MPS) procedures in an assemble-to-order environment. The results of the simulation experiment strongly support the use of the superbill techniques over the covering set technique. Moreover, of the experimental factors that influence delivery time



performance, the choice of master production scheduling technique has the largest effect. Demand variability has the next greatest effect on delivery time performance. The safety stock level has the third greatest effect and product commonality was fourth. (Edited author abstract) 4 refs.

King, Barry E. (Marquette Univ., Milwaukee, WI, USA); Benton, W.C. *Int J Prod Res* v 26 n 6 Jun 1988 p 1015-1036.

**086042 DYNAMIC KANBAN SYSTEM CASE STUDY.** This production control system was designed for a batch flow shop producing a woven product, but the same approach could be applied with very little modification to other multi-machine, multiproduct production cells with similar characteristics like plastics molding, metal pressing, die casting, bar stock turning, and extrusion. It has operated successfully for two years. This 'dynamic' kanban system differs from the standard kanban in accounting for seasonality of demand, the availability of forecasts, the fact that material identity cannot be maintained throughout the process, and the high variability of demand. This is a 'disassembly' process with independent demand. 7 refs.

Groenevelt, Harry (Univ of Rochester, Rochester, NY, USA); Karmarkar, Uday S. *Prod Invent Manage J* v 29 n 2 1988 p 46-51.

**086043 ESSENTIALS OF DELIVERY ANALYSIS.** In quantitative terms, delivery involves the design, approval, and purchase of equipment, tooling, and parts; plus the manufacturing, inspection, and shipping time periods - all evaluated against an agreed-upon date. This target date should be evaluated in two terms: deviation from target date, and delivery time. Delivery dates can be analyzed to compare different firms' delivery on similar items to evaluate each one as a potential supplier. The results of actual evaluations performed on three companies that make high-speed steel tooling are given. Control charts are shown for the individual delivery times expressed in terms of deviation from target date, and the moving ranges of delivery times. The control limits are calculated based on the average of moving ranges of successive points.

Collins, Ronald D. (Borg-Warner Automotive Inc., Muncie, IN, USA). *Qual Prog* v 21 n 8 Aug 1988 p 55-57.

**086044 PARALLEL COMPUTING FOR PRODUCTION SCHEDULING.** Manufacturing operations managers daily face complex scheduling decisions when, in what quantities, and on what machines to manufacture a broad range of components, subassemblies, intermediate products and finished goods. To perform these tasks, managers need a true decision support system and the combination of mathematical modeling and parallel processing provides the key. By distributing submodels to multiple processors and integrating the results on other, concurrently running processors, a parallel approach can produce optimal answers in close to real time. Once implemented, the final schedules can produce significant cost savings.

Snyders, Jan (Manufacturing Systems, Wheaton, IL, USA). *Manuf Syst* v 6 n 10 Oct 1988 5p.

## Theory

**086045 CONTROL OF MULTISTAGE, MULTIPRODUCTION FACILITY MANUFACTURING SYSTEMS USING PIECEWISE-CONSTANT CONTROL POLICIES.** A mathematical model is developed for a class of multistage manufacturing systems in which each manufacturing subsystem comprises one or several production facilities. It is shown that when the manufacturing subsystems are connected in cascade, singular perturbation methods can be used to synthesize fast-sampling error-actuated production control policies that ensure the closed-loop behavior of such manufacturing systems becomes increasingly noninteracting as the length of the sampling interval is reduced. The theory is illustrated by computer simulation studies showing typical transient and steady-state response characteristics of a

controlled manufacturing system consisting of three manufacturing subsystems. (Edited author abstract) 14 refs.

Mak, K.L. (Univ of Hong Kong, Hong Kong). *Cybern Syst* v 18 n 5 1987 p 355-379.

**X-Ray Analysis** See Also CEMENT—Raw Materials.

**086046 DEGREE ASSESSMENT OF RADIATION SAFETY DURING THE OPERATION OF RADIOISOTOPIC AND PULSE X-RAY FLAW DETECTOR.** Highlighted are the problems of radiation safety during the operation of modern gamma and X-ray flaw detectors. Spatially angular distribution of exposition dose rate is presented for radiography of various products aimed at model operation in case of emergency and establishment of the line of demarcation for the personnel. Under the frontal and panoramic radiography of products by means of various types of flaw detectors, hazardous zones are determined. The analysis of individual radiation doses has been carried out for the personnel involved in the operation of flaw detectors and modelling of emergency. (Author abstract) In Russian.

Korenkov, I.P.; Voronin, K.V.; Karklinskaya, O.N.; Gladikh, N.N. *Gig Tr Prof Zabol* n 2 Feb 1988 p 5-8.

**PRODUCTION ENGINEERING** See Also AIRCRAFT ENGINES; JET AND TURBINE—Manufacture; ARTIFICIAL INTELLIGENCE—Industrial Applications; AUTOMOBILE MANUFACTURE; AUTOMOBILE MANUFACTURE—Management; BRAZING—Applications; CASTINGS—Manufacture; CHEMICALS—Manufacture; COMPUTER AIDED DESIGN; COMPUTER AIDED MANUFACTURING; CONTROL SYSTEMS—Design; DATABASE SYSTEMS—Applications; ECONOMICS—Models; ELECTRIC CABLES—Manufacture; ELECTRONIC EQUIPMENT MANUFACTURE; ELECTRONIC EQUIPMENT MANUFACTURE—Scheduling; FASTENERS; FLUIDIC DEVICES—Computer Aided Manufacturing; GAGES—Block; GEAR MANUFACTURE—Automation; HAZARDOUS MATERIALS—Wastes; INDUSTRIAL ECONOMICS; INDUSTRIAL MANAGEMENT; INDUSTRIAL MANAGEMENT—Analysis; INDUSTRIAL PLANTS—Automation; INDUSTRIAL PLANTS—Flexible Manufacturing Systems; INVENTORY CONTROL; MACHINE SHOP PRACTICE—Operations Research; MACHINE SHOP PRACTICE—Production Control; MACHINE SHOPS—Flexible Manufacturing Systems; MACHINE TOOLS; MACHINE TOOLS—Automation; MACHINE TOOLS—Machining Centers; METAL FINISHING; MINES AND MINING—Open Pit; PATTERN RECOGNITION SYSTEMS—Automation; PRESSES—Feeding; PRINTED CIRCUITS—Robot Applications; PRODUCT DESIGN; PRODUCTIVITY—Productivity—Analysis; PRODUCTIVITY—Economics; QUALITY CONTROL; REFRIGERATORS—Computer Aided Manufacturing; ROBOTICS—Evaluation; ROBOTS; INDUSTRIAL—Materials Handling Applications; ROCKET ENGINES—Manufacture; SAWS; SENSORS—Applications; TELECOMMUNICATION SYSTEMS—Maintenance; TIRES—Manufacture; VISION—Artificial.

**086047 CONTROL IN THE OPT ENVIRONMENT.** Optimized Production Technology (OPT) is attracting attention from manufacturing organizations in the UK and USA. The OPT system considers production bottlenecks as the basis for scheduling and capacity planning. Flow is considered the driving force so that resources must be divided into bottleneck and non-bottleneck areas. Bottleneck resources are scheduled for maximum effect and non-bottlenecks are scheduled to serve these bottlenecks.

McManus, John J. (GE, USA). *Prod Eng (London)* v 66 n 7 Jul-Aug 1987 p 20-21.

**086048 CAPACITY ANALYSIS OF A MANUFACTURING CELL.** Traditional capacity analysis in manufacturing assumes that capacity is adequate if average utilization is under 100%. In practice, high utilization levels result in the formation of large queues, which in turn cause high production lead times and work-in-process inventories. Queuing models of manufacturing cells have been successfully used to analyze the relationships between utilization and queues. However, these models do not consider the impact of operational policy on the performance characteristics of the facility; this impact can be substantial. Here we describe the capacity analysis of a cell in which alternative overtime and shift policies, equipment choice and batching policy are considered. It is seen that in an integrated cell configuration, excess

equipment capacity may be economically preferable to multiple shifts. (Author abstract) 20 refs.

Karmarkar, Uday S. (Univ of Rochester, Rochester, NY, USA); Kekre, Sham; Kekre, Sunder. *J Manuf Syst* v 6 n 3 1987 p 165-175.

**086049 PROBLEM OF PRODUCTION PROCESS ARRANGEMENT (OPTIMIZATION METHOD FOR ARRANGEMENT ANALYSIS).** The problem of plant and process layout is one of the most significant and involved engineering problems. The digital computer is generally employed to optimize the arrangement order for the products. This paper describes a new method for solving the layout problem. We use cofactors of graph theory and incident matrix to solve the problem efficiently. The last section of this paper deals with several examples of layout problems. (Author abstract) In Japanese. 8 refs.

Sakano, Susumu. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 493 Sep 1987 p 2060-2065.

**086050 FORECAST HORIZONS FOR THE DISCOUNTED DYNAMIC LOT-SIZE PROBLEM ALLOWING SPECULATIVE MOTIVE.** This article considers the dynamic lot-size problem under discounting, allowing speculative motive for holding inventory. A variable rolling-horizon procedure is presented, which, under certain regularity conditions, is guaranteed to generate an infinite-horizon optimal-production plan. We also discuss a fixed rolling-horizon procedure which provides a production plan that achieves an infinite-horizon cost within a user-specified tolerance  $\epsilon$  of optimality. The fixed-horizon length  $T_\epsilon$  needed in this procedure is given in terms of a closed-form formula that is independent of specific forecasted demands. We also present computational results for problems with a range of cost parameters and demand characteristics. (Author abstract) 15 refs.

Bean, James C. (Univ of Michigan, Ann Arbor, MI, USA); Smith, Robert L.; Yano, Candace A. *Nav Res Logist* v 34 n 6 Dec 1987 p 761-774.

**086051 LOT SIZING IN A PRACTICAL MANUFACTURING SYSTEM.** The determination of lot sizes is important to the effective operation of a manufacturing system. Previous approaches for determining lot sizes usually have some major problems associated with their use in a practical manufacturing system. This paper presents a methodology for setting lot sizes in a practical manufacturing system that is both simple and powerful in operation. This methodology is based on dividing the products into product families with each family having a lot size factor associated with it. The lot size factors can be tested by simulating the manufacturing system and a particular set of lot size factors chosen on the basis of good overall system performance. (Edited author abstract) 28 refs.

O'Grady, P.J. (North Carolina State Univ., Raleigh, NC, USA); Byrne, M.D. *Eag Costs Prod Econ* v 13 n 1 Nov 1987 p 13-26.

**086052 IMPLEMENTING JUST-IN-TIME CONCEPTS INTO EUROPEAN COMPANIES.** JIT is the ultimate in employing simple concepts to the avoidance of waste and improving employee morale and dignity. Several JIT principles are reviewed in this paper which contradict traditional approaches. Nonetheless, these thought provoking ideas should be considered by those wishing to remain competitive in the domestic and world markets. Research into models which simulate various manufacturing environments must be encouraged. The growth of microcomputers, computer knowledge and computer software is permitting giant strides in the ability



to test some of the controversial aspects of JIT, especially those involving economics. (Edited author abstract) 20 refs.

Wildemann, Horst (Passau Univ, Passau, West Ger); Carlson, John G. *Eng Costs Prod Econ* v 13 n 1 Nov 1987 p 27-37.

**086053 DEVELOPMENT OF A COMPLEX MIXED PRODUCTION SYSTEM FOR PLAIN PAPER COPIER MACHINES.** Manufacturers now face the challenges of increased product variety, the need for small-to-medium-quantity production, shortened product life cycles, and reduced costs due to changes in customer demand. Total factory automation, including the automation of assembly as well as indirect (overhead) functions, must be realized for these challenges to be met. Ricoh's factory for the production of the Plain Paper Copier (PPC) has developed a new production system employing hardware, software and 'humanware'. This system has an automated production support system (RINKS), assembly system, and physical distribution system. It is a network composed of computer and terminals. This article discusses the development and implementation of Ricoh's system. (Author abstract)

Kanamoto, Haruo (Ricoch Co, Atsugi, Jpn); Endo, Koichi. *Rob Comput Integr Manuf* v 3 n 4 1987 p 409-416.

**086054 MACHINE VISION IN PRACTICE.** Automation is the key to the competitive position and, ultimate survival of any manufacturing organization. Machine vision is identified as the key enabling technology in automated manufacture. Machine vision allow increased productivity by ensuring the rapid and consistent execution of complex tasks. It will improve quality control by achieving inspection of partly made and finished products throughout all phases of production, reduce scrap and cut costs through accurate dimensioning and measurement and improve working conditions by freeing workers from the need to perform tedious, repetitive and dangerous tasks.

Adaway, Bill (Computer Recognition Systems). *Prod Eng (London)* v 66 n 11 Dec 1987 p 20-21.

**086055 EASING THE PAIN OF PRODUCT CHANGE.** Change is a fact of life in engineering. Whether the change involves a necessary alteration in design to make a product safer, or a discretionary redesign to improve product quality, it can cause severe disruptions that can allow costs to get out of hand. To avoid such crises, a comprehensive change-control policy is needed to keep track of what is changed, how, and why. The paper presents a sensible change-control policy as one of the keys to running the engineering department in a cost-effective manner. The different types of changes needed are described.

Cavasin, John (Coulter Electronics Inc, Hialeah, FL, USA). *Mach Des* v 58 n 7 Apr 1986 p 105-108.

**086056 PRODUKTLEBENSZYKLUS-CONTROL LING ALS TEIL EINER DATEN- UND METHODENBANK FÜR DAS RECHNUNGSWESEN.** [Product Life Cycle Controlling as Part of an Accounting Data and Methods Base]. Traditional cost accounting concepts are not tailored for products with a relatively short life cycle. Their product management has to be supported by a comprehensive view, which takes into account all costs and revenues from product development to obligations for guarantee and service. This paper proposes an adequate structuring of cost and revenue data and also describes two selected methods as examples for life cycle cost applications. They are embedded in a prototype version of a data base and methods storage bank information system for internal accounting purposes. The conclusion refers to prerequisites and problem inherent with the realization of the concept in practical application. (Author abstract) In German. 10 refs.

Back-Hock, Andrea (Friedrich-Alexander-Univ Erlangen-Nuernberg, Erlangen, West Ger). *Angew Inf Appl Inf* v 29 n 12 Dec 1987 p 518-526.

**086057 SERIELLE FERTIGUNGSSYSTEME MIT ZWISCHENSPEICHERN.** [Serial Manufacturing Systems with Intermediate Stores]. The author presents a reduction method allowing one to calculate the stationary flow of a serial system consisting of  $n$  working elements with stores placed between them. The working element flows may be different one from the other. The method is suited to localization and dimensioning of intermediate stores and can be applied both in the design stage and in calculating the possible increase of flow in existing systems. (Author abstract) In German. 16 refs.

Petigk, J. *MSR Mes Steuern Regeln* v 30 n 9 Sep 1987 p 402-405.

**086058 SIMULTANEOUS ENGINEERING.** Pioneers of the automobile industry practiced what is now called simultaneous engineering. They did not limit themselves simply to designing products; they were product and process engineers who designed both cars and the factories that built them. In fact, many of the early inventors in other American industries were also craftsmen, who knew how to build the products they invented. The paper emphasizes the importance of designing the process at the same time that a product is designed. To achieve this design for a manufacturability system called simultaneous engineering the companies may have to make a special effort to knock down departmental barriers, real or imagined, that have developed over the years.

Evans, Bill (Mechanical Engineering, New York, NY, USA). *Mech Eng* v 110 n 2 Feb 1988 p 38-39.

**086059 PRECISION SERVO SYSTEMS: A VEHICLE TOWARDS HIGHER-VALUE-ADDED MANUFACTURE.** The technology involved in manufacturing mainly involves product design and manufacturing engineering. In the latter field, the two main thrusts for improving output are: automation - through the use of computer integrated, flexible manufacturing to increase the efficiency of production; precision manufacturing - to produce components of high precision on which a wide range of higher-value-added products are dependent. The paper outlines precision processes which are thought to be relevant to Hong Kong and the techniques involved in controlling machines to very high degree of accuracy. (Edited author abstract) 13 refs.

Yung, K.L. (Hong Kong Polytechnic, Hong Kong). *Hong Kong Eng* v 16 n 1 Jan 1988 p 35-42.

**086060 MONITORING CONTROLLING AND FORCE.** The article discusses how force sensors can reveal details about production processes that cannot be obtained in any other way, and production applications for force sensors. Subjects covered include force sensor types, signal conditioning, sensor operating environment, and sensor calibration.

Brendel, Albert E. (Sensor Developments Inc, Lake Orion, MI, USA). *Automation (Cleveland)* v 35 n 3 Mar 1988 p 34-36, 38.

**086061 ANALYTICKY POHLED NA VYROBNÍ PROCES.** [Analytical View of the Manufacturing Process]. The importance of simulation and object-oriented programming for system analysis in manufacturing conditions is illustrated by the examples of processes in a warehouse. Simulation imitates the behavior of processes in time; however, a simulation program has to be formulated independently of time, so that those components which are essential for the simulated process must be determined. Object-oriented programming in this case makes it possible to define these components independently of the situation examined and of the quantitative properties of the processes in question. (Translated author abstract) In Czech. 16 refs.

Kindler, Evzen (Univ Karlovy, Prague, Czech); Brejcha, Milan. *Automatizace* v 30 n 11 Nov 1987 p 288-290.

**086062 PRINCIPLES OF DESIGNING FAP STORAGE SYSTEM FROM THE POINT OF VIEW OF ITS UNIVERSALITY.** The role of storage system in the

structure of FAP is shown. The main routes of unifying technological solutions in FAP storage system are determined. Two ways of unification are examined - finding optimal characteristics of the system and making up the control system. Analytical model of storage system and principles of its operation are given. The principles of creating universal control system, consisting of information, control and executive subsystems are formulated. (Author abstract) In Russian.

Ivashenko, S.A.; Malikov, O.V.; Filipchuk, S.F.; Sergeev, A.F. *Tr Leningradskii Politekh Inst im M I Kalinina* n 419 1986 p 49-55.

**086063 MANUMARK AIDS AVON OPT ENVIRONMENT.** A small British engineering company is practising a management technique normally associated only with major industrial firms. More an attitude than a precise strategy, the adoption of OPT (optimised production technology) claims improved profitability for those companies implementing it. Ampep plc is one of the UK exponents of OPT. Based in Clevedon, Avon, it produces components for almost every modern jet and passenger plane, Formula One racing car and helicopter. Ampep bearings also feature in a variety of oil/gas pipelines, earthmoving equipment and forklift trucks. The OPT philosophy is based on attaining the shortest time between receiving an order and being paid for the final sale.

Anon. *Prod Eng (London)* v 67 n 3 Mar 1988 p 23-24.

**086064 ACCUMULATING CONVEYORS AID ASSEMBLY OF KENWOOD'S PRODUCT MIX.** A production line based on the use of accumulating pallet conveyors has enabled Kenwood Ltd to bring about a number of improvements in the assembly of some of its food processors. The improvements will initially become evident in increased quality and productivity. While the majority of the assembly operations are manual at present, the design of the conveyor system also provides opportunities for the gradual introduction of automated assembly where this is appropriate.

Anon. *Prod Eng (London)* v 67 n 3 Mar 1988 p 40-41.

**086065 INCREASING PARTS FEEDER PRODUCTIVITY.** The article covers feeder basics, performance evaluations, component adjustments, and related topics. Feeder manufacturers are becoming increasingly aware that the majority of small-parts feeding devices currently in service are operating below par. Instead of taking feeders out of service for repairs and adjustments that could greatly improve productivity and longevity, many companies are merely purchasing new feeders. This may be one way of improving productivity; however, there are several other less costly methods that can make substantial improvements in present equipment.

Ruhl, Ronald J. (Automation Devices Inc, Fairview, PA, USA). *Automation (Cleveland)* v 35 n 4 Apr 1988 p 18-20.

**086066 STATISTICS OF HIGH-YIELD MANUFACTURING PROCESSES.** This paper reviews the basis and application of the '6 8' process design criterion in the context of the process capability index for high-yield production operations. The approach assumes that product features can be described by a Gaussian (normal) distribution function. When the number of components and subordinate processes is large, and if the process mean varies from its intended centered position, the work of each process element must be accomplished at very low defect rates for acceptable yields of finished products. The 6 8 criterion establishes a 3.4 parts per million (ppm) defect rate as a target value for each process element. A quality budget procedure is suggested as an effective means for planning and managing defect rates of each process element and for indicating where efforts can best



be placed for continuing process improvements. Finally, the paper recommends, a design space based on the shifted process capability index. (Author abstract) 3 refs.

Francis, Philip H. (Motorola Inc, Schaumburg, IL, USA). *Manuf Rev* v 1 n 1 Mar 1988 p 6-13.

**086067 COMPLEXITY, RELIABILITY, AND DESIGN: MANUFACTURING IMPLICATIONS.** This paper presents some interesting and new ideas about the nature of the forces driving the worldwide trend toward flexible automation. It suggests, in brief, that the demand for computer-integrated manufacturing (CIM) arises from what Nathan Rosenberg has termed a 'mismatch,' that is, a problem that was created, in effect, by technological progress itself. In this case the 'problem' is that defects in manufacturing have become intolerable. The paper explores four related hypotheses, as follows: That the human 'error rate' is inherently large and cannot be reduced to (or nearly to) zero even under the most favorable conditions. That 'high performance' in a product tends to require a high degree of precision and complexity in the design and manufacturing process. This tendency can be seen most clearly over time. That defects can be thought of as lost information (just as errors in accounts or messages) and that error-detection and error-correction techniques from communications theory may be appropriate tools for management. That defects can best be eliminated in manufacturing by adopting the 'monolithic' concept that has been so successful in electronics. (Edited author abstract) 27 refs.

Ayres, Robert U. (Carnegie-Mellon Univ, Pittsburgh, PA, USA). *Manuf Rev* v 1 n 1 Mar 1988 p 26-35.

**086068 STUDY ON PRODUCTION LOT-SIZING IN MRP SYSTEM (1ST REPORT, SINGLE-ITEM, UNCAPACITATED LOT-SIZING).** This paper considers a single-item, uncapacitated lot-sizing problem in MRP system, and new heuristic approaches, called Forward-Forward (FF) method and Forward-Backward (FB) method are proposed. These methods are based on Silver-Meal (SM) method. For the initial production plan obtained by SM method, a cost minimum procedure for successive two lot-sizing periods is repeated forward from the first period or backward from the last period, which results the decrease of total cost for whole planning horizon. And to evaluate the performance of FF and FB methods, four heuristic approaches (FF, FB, SM, Part-Period-Balancing) are compared in fixed horizon and rolling horizon environments. By testing each method for various coefficients of cost (set-up, holding) and demand variance, the cost deviation from the minimum cost by Wagner-Whitin (WW) method is analyzed. The result has shown that FF, FB methods may outperform the other heuristics and even WW method for rolling horizon. (Author abstract) 4 refs. In Japanese.

Honiden, Terushige; Nishiyama, Noriyuki. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 496 Dec 1987 p 2692-2698.

**086069 INTEGRATION OF NETWORK ANALYSIS SYSTEMS WITH MRP IN A MAKE-TO-ORDER MANUFACTURING ENVIRONMENT.** Material Requirements Planning (MRP) is capable of handling manufacturing tasks in great detail, but it is not designed to accommodate non-material related tasks. Network Analysis, also known as Critical Path, can handle activities of any nature. The paper examines these issues in detail and describes an integrated MRP/Network Analysis system for use in a make-to-order manufacturing environment by demonstrating potential benefits on purchasing and manufacturing orders generated by a combined MRP/Network Analysis system compared to ones generated by traditional MRP systems. A computer program is being developed to implement the above issues. This paper contains portions of the program. (Edited author abstract) 10 refs.

Harhalakis, G. (Univ of Maryland, College Park, MD, USA); Yang, S.S. *Eng Costs Prod Econ* v 14 n 1 May 1988 p 47-59.

**086070 ENERGY DISSIPATION, OPERATION TIME, AND PRODUCTION SPEED.** This paper aims at reconciling the neoclassical theory of production and some fundamental physical laws underlying production processes. In particular, the phenomenon of energy dissipation is modelled. The relation between energy consumption and operation time is established. (Author abstract) 30 refs.

Van Den Heuvel, Paul (De Nederlandsche Bank NV, Amsterdam, Neth). *Resour Energy* v 10 n 1 Mar 1988 p 31-54.

**086071 BECOMING A JUST-IN-TIME VENDOR.** A company implementing just-in-time manufacturing must develop its suppliers into just-in-time vendors. This article discusses the experiences of Westinghouse Corporation, who found that it is not an easy task.

Kapoor, Vinod (Challenger Electrical Equipment Corp, USA). *Qual Prog* v 21 n 6 Jun 1988 p 56-59.

**086072 LA QUALITE TOTALE OU L'ENTREPRISE DESENCLAVEE.** [Total Quality, Or the Decentralized Firm]. The article discusses the Total Quality concept. The basic principles are to be more concerned about markets than machines, to consider each company department to be a client of other departments, to improve production from the start and to draw up reliability agreements with subcontractors and suppliers and to prevent rather than control. These concepts involve the evolution of production systems. In French.

Serieyx, Herve. *Ann Mines* n 4 Apr 1988 p 32-34.

**086073 HIDDEN POTENTIAL TRANSFER PHENOMENA.** Suggested ways of improving the competitiveness of US industry range from changes in federal fiscal policy and industrial management practices, through the establishment of educational programs, to the increased use of computers and robotics. The paper indicates how most industrial processes and the equipment associated with them have remained essentially unchanged since they were introduced. Improving their efficiency will require a much better knowledge of the basic phenomena on which they depend. Transport phenomena, important in many industrial processes, are an example of a field in which study has been motivated by the discovery of practical applications. As a result, it can be expected that many new problems and areas of research will be identified, leading to the revitalization and generalization of the discipline.

Ostrach, Simon (Case Western Reserve Univ, Cleveland, OH, USA). *Mech Eng* v 110 n 7 Jul 1988 p 83-85.

**086074 DIVISION OF APPLIED KINEMATICS, PRODUCTION ENGINEERING DEPARTMENT, KOBE UNIVERSITY, KOBE, JAPAN.** The major research works carried out in the research group of Applied Kinematics are classified into the following three fields: (1) Manufacturing technology: high speed ultra-precision machining, analysis of cutting processes, etc. (2) Manufacturing systems: accuracy, thermal deformation and dynamics of machine tools, intelligent control of machine tools, sensor technology, etc. (3) Ergonomics: motion analysis of the human body, etc. Some parts of the research are carried out in cooperation with the research group of Production Engineering. This paper explains briefly the research activities in the past and present related to ergonomics.

Moriwaki, Toshimichi. *Adv Rob* v 2 n 3 1987 p 311-313.

**086075 CERTAIN PROBLEMS OF ANALYSIS OF FMS FOR MACHINING OPERATIONS.** The general approach to the analysis of flexible manufacturing systems (FMS) is presented in a number of papers. FMS analysis includes calculations of productivity, economic effectiveness, reliability and flexibility. This article considers certain problems of structural analysis of FMS for machining operations. The objective of the analysis of structural diagrams of FMS is to determine the conditions for their effective functioning. 5 Refs.

Arkhipenko, N.A. *Sov Eng Res* v 7 n 8 Aug 1987 p 36-39.

**086076 INCREASING THE SENSITIVITY OF PARTS CLASSIFICATION SYSTEM.** This paper demonstrates the application of fuzzy set theory to increase the sensitivity of group technology (GT), the most popular parts classification system in use today. It is shown that subjective descriptors of part shape can be quantified with a reasonable degree of reliability and, in reduced form, provide that portion of the part code which describes the part geometry. The proposed procedure is not only objective, it is more sensitive than the existing method of assigning codes for part geometry. Moreover, it can lead to superior sequencing of parts when such sequencing is based on similarity of geometrical shapes. (Author abstract). 3 Refs.

Mital, Anil (Univ of Cincinnati, Cincinnati, OH, USA); Kromodihardjo, Sudiyono; Channaveeraiah, Chetan. *Fuzzy Sets Syst* v 28 n 1 Oct 1988 p 1-13.

**086077 CIRP ANNALS: MANUFACTURING TECHNOLOGY.** These conference proceedings contain 18 papers discussing advances in Manufacturing Technology. Knowledge-based systems in production engineering, including numerous applications of expert systems and artificial intelligence for the solution of many of the problems of manufacturing, automation-related joining processes, and current trends in non-conventional material removal processes are topics presented. New technologies of metal forming, belt grinding techniques, as well as, changes in the role of production management in the Computer Integrated Manufacturing (CIM) era are also presented. Also considered are metallurgical aspects in machining, and analysis of material handling functions. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10584 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (CIRP, Paris, Fr). *CIRP Ann* v 35 n 2 1986, Manuf Technol, Jerusalem and Haifa, Iss, Aug 17-22 1986. Publ by Technische Rundschau, Berne, Switz, 1986 160p.

**086078 PRODUCTION-ECONOMIC ASPECTS ON SETUP EFFICIENCY.** In recent years, the reduction of set-up times has been given increasing attention as a fundamental prerequisite for efficient and flexible production. In this paper, some theoretical and practical production-economic aspects on set-up efficiency are presented. The relationship between set-up efficiency and lot sizing is investigated for different planning situations and production systems. Furthermore, practical aspects on these relationships are discussed based on set-up efficiency practice in six Japanese companies, as well as on case studies from two Swedish manufacturing firms. 10 refs.

Edstrom, Anders (Alfakonsult AB, Goteborg, Swed); Olhager, Jan. *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 99-106.

**086079 JUST-IN-TIME FROM A BUSINESS LOGISTICS PERSPECTIVE.** Just-In-Time (JIT) administration based on the Japanese model is being used by an increasing number of companies in Scandinavia. The objective is to eliminate unnecessary stock and increase the quality standard for both manufacturing and assembly processes. In a present research project at Linkoping Institute of Technology, Sweden, Just-In-Time is treated from a business logistics perspective with emphasis on effects for the external transportations. The main objective is to identify the changed demands, from the transport point of view. The results of the study show that every specific transport arrangement is studied thoroughly by the transport buying company. Adjustment is then made



to the total transport flow in the appropriate zone. The clearest effect on the transporters is a more difficult time control. (Edited author abstract) 1 ref.

Storhagen, Nils G. (Linköping Inst of Technology, Linköping, Swed); Hellberg, Roland. *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 117-121.

**086080 INFORMATION SYSTEMS FOR ASSEMBLY-TO-ORDER PRODUCTION: AN APPLICATION.** In many production systems, the procurement of materials from suppliers has to be determined long before actual customer orders are available. In such systems, the material orders are generated either from forecasts or from a master production schedule. Actual customer orders should be evaluated with respect to the time-phased availability of the components to be assembled. This paper describes a number of requirements and solutions with respect to information systems in order to support this control structure. Special attention is given to the bill-of-material module. (Author abstract) 9 refs.

Wortmann, J.C. (Eindhoven Univ of Technology, Eindhoven, Neth). *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 187-196.

**086081 ADVANCED TOPICS IN MANUFACTURING TECHNOLOGY: PRODUCT DESIGN, BIOENGINEERING, AND SPACE COMMERCIALIZATION (PRESENTED AT THE WINTER ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS).** This conference proceedings contains 14 papers, two of which are represented by extended abstracts only. The papers are organized into the following groups: Product design; Bioengineering; and Space Commercialization. Some of the subjects covered are designed for manufacturing; control of robotics by gestures, voice and eye tracking; space welding; remote sensing and microgravity processing. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10873 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Francis, P.H. (Ed.) (Motorola Inc). *Adv Top in Manuf Technol: Prod Des, Bioeng, and Space Commer*, Boston, MA, USA, Dec 13-18 1987 Publ by ASME, New York, NY, USA, 1987 102p.

**086082 SAFETY AND RELIABILITY SOCIETY SYMPOSIUM 1985: ACHIEVEMENT OF RELIABILITY IN OPERATING PLANT.** This conference proceedings contains 6 papers discussing the activities of various companies in the field of Reliability and Safety Engineering. The papers present probabilistic quantifications of reliability and employ statistical procedures for their manipulation. The statistical approach to design is discussed in one presentation. Developments in the process plant area covering aspects of instrumentation, microprocessor control and human factors technology are also presented. A comparison of approaches is provided for the estimation of production from a sub-sea cluster of wells in a hostile environment and in another paper, reliability analysis is used to compare protection systems for pipelines. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10650 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Safety & Reliability Soc). *Saf & Reliab Soc Symp 1985: Achiev of Reliab in Oper Plant*, Southport, Engl, Sep 26 1985 Publ by Safety & Reliab Soc, 1985 var pagings.

**086083 MANAGING ADVANCED MANUFACTURING TECHNOLOGY, PROCEEDINGS OF THE UK OPERATIONS MANAGEMENT ASSOCIATION CONFERENCE.** This conference proceedings contains 30 papers discussing different aspects related to the use and implementation of advanced manufacturing technology (AMT). Various sessions are presented covering:

Strategic overview, Flexible manufacturing Systems (FMS) implementation, case studies, evaluation and costing, user-vendor issues, performance measures, modeling and planning, and human factors. The main theme of the conference was the total process of managing advanced manufacturing technology. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11399 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Voss, C.A. (Ed.) (Univ of Warwick, Coventry, Engl). *Managing Adv Manuf Technol, Proc of the UK Oper Manage Assoc Conf*, Coventry, Engl, Jan 2-3 1986 Publ by IFS (Publ) Ltd, Kempston, Engl, 1986 430p.

**086084 PROCEEDINGS OF MANUFACTURING INTERNATIONAL '88 (V 1, SYMPOSIUM ON PRODUCT AND PROCESS DESIGN; V 2, SYMPOSIUM ON MANAGEMENT AND ECONOMICS; V 3, SYMPOSIUM ON MANUFACTURING SYSTEMS; V 4, MANUFACTURING SCIENCE OF COMPOSITES).** This conference proceedings contains 115 papers addressing a wide range of issues in manufacturing. These issues include product and process design; process control; forming processes; management and economics; strategic planning; manufacturing systems design, integration, and control; robotics; flexible fixturing; computer integrated manufacturing; flexible manufacturing systems; and manufacturing science of polymer matrix composites. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11477 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Chryssolouris, George (Ed.) (MIT, Cambridge, MA, USA); Komanduri, R. (Ed.); Jaikumar, R. (Ed.); Von Turkovich, B. (Ed.); Francis, P. (Ed.); Gutowski, T.G. (Ed.). *Proc of Manuf Int '88, Atlanta, GA, USA, Apr 17-20 1988* Publ by ASME, New York, NY, USA, 1988 4 v, 937p.

**Accident Prevention** See ROBOTS, INDUSTRIAL—Applications.

#### Analysis

**086085 SNAPSHOT OF THE PROFILE OF A QUALITY CIRCLE PROGRAMME AT THE EIGHTEENTH MONTH STAGE.** The paper outlines the findings of a case study carried out in a printed-circuit board manufacturer, as part of a development project on quality circles. At the time of study, the circle program had been operational for around 18 months, which is recognised as a critical phase for circles. The strengths and weaknesses of the circle program are discussed. Among the main findings are that circles were introduced to develop the communication and problem solving skills of employees; these objectives have been achieved, however, the trivial nature of many circle projects has caused some circle members, nonmembers and managers to question the benefits. Most of the circles are facing problems due to the movement of people between departments, and the company has adopted a 'classical' circle concept and is pursuing it in an almost evangelical fashion which is strangling the development of some circles. (Edited author abstract) 4 refs.

Dale, B.G. (Univ of Manchester, Inst of Science of Technology, Manchester, Engl); Lees, J. *IEE Proc Part A* v 134 n 9 Nov 1987 p 747-751.

**086086 SURVEY OF QUEUEING NETWORK PACKAGES FOR THE ANALYSIS OF MANUFACTURING SYSTEMS.** Successful design and installation of a complex manufacturing system can depend on the proper utilization of a mathematical model during the initial design and planning phases. Because the number of decision variables and potential configurations are large, analysis typically requires a computational tool. This paper surveys the most widely used queueing network packages for practical manufacturing system design. Contrasts are drawn among the particular underlying mathematical models and their corresponding assump-

tions and network properties, and the computational environment for the implementation of these tools is described. (Author abstract) 49 refs.

Snowdon, Jane L. (Georgia Inst of Technology, Atlanta, GA, USA); Ammons, Jane C. *Manuf Rev* v 1 n 1 Mar 1988 p 14-25.

**086087 CAPACITY ANALYSIS OF TWO-STAGE PRODUCTION LINES WITH MANY PRODUCTS.** We consider two-stage production lines with an intermediate buffer. A buffer is needed when fluctuations occur. For single-product production lines fluctuations in capacity availability may be caused by random processing times, failures and random repair times. For multi-product production lines fluctuations are also caused by different processing time ratios for different products and by set up times. We examine whether it is possible to use the results developed for single-product flow lines, where the production units have exponentially distributed life- and repair times, for the multi-product case. As an example the case of a consumer electronics factory is studied. (Author abstract) 8 refs.

de Koster, M.B.M. (Eindhoven Univ of Technology, Eindhoven, Neth). *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 175-186.

**Assembly** See Also ELECTRONIC EQUIPMENT MANUFACTURE—Assembly; SOLDERING; TOOLS, HAND.

**086088 WHAT'S TOMORROW'S MOST CRITICAL ASSEMBLY TECHNOLOGY?** Information, not automation, is where most gains promised by new technology can be found. Information associated with assembly can be split into physical processing (including robotics, AGVs, etc.) and information processing. An assembly operation can be broken further into a series of tasks that must be completed to assemble a product. Each task then can be reduced to the physical actions necessary and the associated information. What has yet to be perfected are the ways to process sensor information and feed it back to the physical processors. Current systems are incapable of translating deviations into the proper physical actions needed to assemble a part. Addressing this shortcoming will produce many of assembly's future advancements.

Coleman, John R. (Assembly Engineering, Wheaton, IL, USA). *Assem Eng* v 31 n 1 Jan 1988 p 22-25.

**086089 ASSEMBLY HALL OF FAME.** Through most of history assembly technology has been primitive at best. Products were made of individually produced and assembled components, hand fitted, even when a quantity was desired. The concept of mass production of interchangeable parts is a comparatively recent one. This article presents a historical review of assembly in manufacturing operations from the mid-18th century to the present. Subjects covered include work design, automation, adhesives, electronics assembly, and others.

Schwartz, Walter H. (Assembly Engineering, Wheaton, IL, USA). *Assem Eng* v 31 n 1 Jan 1988 p 30-32.

**086090 EVOLUTION OF AUTOMATIC ASSEMBLY.** The 30 years of Assembly Engineering have seen rapid evolution in automatic assembly. New technologies have matured providing tools for an even broader range of application possibilities. The most significant include robots, programmable controllers, ultrasonic welding, orbital riveting, lasers, and machine-vision systems. Development and implementation of these tools have been advanced or retarded by economic conditions and management's perceptions at the time. The article presents a historical review of the title subject in terms of assembly machinery, military ordnance requirements, computer integrated manufacturing, machine vision, and others.

Riley, Frank J. (Bodine Corp). *Assem Eng* v 31 n 1 Jan 1988 p 36-38.



**086091 LASERS LIGHT UP ASSEMBLY.** Laser welding is rapidly replacing many conventional welding and fastening processes. The benefits vis-a-vis conventional welding and fastening techniques include: no contact with the workpiece, no pressure applied on material, no thermal distortion, and no electrode wear; the beam produces uniform weld penetration, resulting in excellent weld integrity; minimum heat affected zone (HAZ), microcracking and melting, and others. Because of these advantages, laser welding is increasingly the process of choice for fabricating precision electronic components and assemblies, medical implant devices, diaphragms, bellows, pressure sensors, and auto components. High melting point materials such as tungsten, molybdenum, zirconium, and tantalum were welded with good results by using cover gases. High reflectivity materials (95% for Nd:Yag) such as gold and silver also can be welded. These and other aspects of the subject are discussed, along with laser soldering.

Coleman, John R. (Assembly Engineering, Wheaton, IL, USA). *Assem Eng* v 31 n 3 Mar 1988 p 33-34.

**086092 TORQUING TUTORIAL.** Demand for better product quality is leading to widespread application of torque transducers and instrumentation for monitoring and controlling fastener installation. Such systems precisely control fastener torque. They also record performance and quality trends, thus providing a basis for statistically controlling assembly. This article discusses strain gage-based torque transducers. Subjects covered include type and operation of the transducers, instrument readings, torque monitoring applications, angle monitoring applications, and others.

Munn, Harold (GSE Inc, Farmington Hills, MI, USA). *Assem Eng* v 31 n 3 Mar 1988 p 38-41.

**086093 ASSEMBLY WORKTRACKING.** Some of the technologies in use are optical character recognition, bar coding, magnetic strip, touch screen, radio frequency identification and radio frequency data communication. Most of these are simply identification systems and of these bar coding is by far most common and by now familiar. Radio Frequency (RF) systems recently have been developed to a point where intriguing data transfer applications are possible. Work tracking, while itself computer based, is not necessarily part of an automated assembly system. As valuable as the information collected in a manual operation is, bar codes or other automatic identification and data collection techniques come into their own only on the automated assembly line. RF identification systems comprise a miniature transmitter/receiver, a transceiver or transponder with memory (usually mobile) and a sensor or reader unit that is stationary or perhaps portable. These and other aspects of the subject are discussed.

Schwartz, Walter H. (Assembly Engineering, Wheaton, IL, USA). *Assem Eng* v 31 n 4 Apr 1988 p 32-34.

**086094 MECHANICAL ASSEMBLY: MACHINES, SYSTEMS, CONTROLS & ACCESSORIES.** During the early '80s, the words assembly system replaced assembly machine. Systems usually have more inspection and functional testing stations, and include data highway capability. They also have greater flexibility for future model changes. But, with these exceptions, there is little difference in the mechanisms of various assembly processes. This article presents the opinions of various manufacturers on assembly machines and systems, assembly automation, quality control, and other aspects of the subject.

Coleman, John R. (Assembly Engineering, Wheaton, IL, USA). *Assem Eng* v 31 n 9 Sep 1988 p 22,26-28.

**086095 ADHESIVES, SEALANTS, PASTES & DISPENSERS.** Adhesive vendors focusing on products that lower labor content, facilitate speed of assembly, increase ease of process automation, improve assembly/component quality, and meet specific user requirements. They will provide more assistance to facilitate a manufacturer's adhesive selection and process development procedures.

The article discusses new materials, automation, preapplication, the effect of just-in-time production on automated dispensing, and other aspects of the subject.

Coleman, John R. (Assembly Engineering, Wheaton, IL, USA). *Assem Eng* v 31 n 9 Sep 1988 p 83-85.

**Automation** See Also ARTIFICIAL INTELLIGENCE—Expert Systems; COMPOSITE MATERIALS—Processing; COMPUTER INTEGRATED MANUFACTURING; COMPUTER NETWORKS—Local Networks; DATABASE SYSTEMS—Design; INDUSTRIAL MANAGEMENT; INDUSTRIAL PLANTS—Flexible Manufacturing Systems; LATHES—Design; MACHINE SHOPS—Flexible Manufacturing Systems; MAINTENANCE; PIPE, CONCRETE—Manufacture; PRINTED CIRCUITS—Production; PROBABILITY—Queueing Theory; ROBOTIC ASSEMBLY; SCHEDULING.

**086096 MAP AND GEC.** This paper opens with the origins of MAP, the Manufacturing Automation Protocol, covering the technical and economic reasons for its adoption. An outline of the current MAP specification, based on the OSI seven-layer model is supplemented by a description of TOP, the Technical Office Protocol, and methods of linking MAP and TOP. GEC involvement in MAP is described in terms of products and services on offer to the MAP user. The paper looks forward to MAP developments in the next two years. (Edited author abstract)

Platt, E. (GEC Electrical Projects Ltd). *GEC Rev* v 3 n 2 1987 p 107-114.

**086097 ANALYSIS OF A LOOP FLOW TYPE OF AUTOMATED MANUFACTURING SYSTEM.** This paper deals with an automated manufacturing system which consists of same machines located along a loop type of conveyor with a loading-unloading station. The system is described by a Markov chain model and the production rate is analytically derived. The relation between the production rate and the arrival rate of parts and the average processing time of the machines is studied by the numerical results. Furthermore, the optimal control problem of dispatch of parts into the system is formulated as a Markov decision process. The properties of optimal control are considered and the production rate under the optimal control is compared with that under noncontrol. (Author abstract) In Japanese. 10 refs.

Shiroyama, Tadayoshi; Kise, Hiroshi. *Nippon Kikai Gak-kai Ronbunshu C Hen* v 53 n 493 Sep 1987 p 2048-2053.

**086098 AUTOMATING THE MANUFACTURE OF ONE-OFFS WITH MOULD MAKING AS AN EXAMPLE.** Any future automation of one-off manufacture - one-offs being a characteristic of mold making - is not to be expected in the area of machine components. There is indeed a considerable reluctance to employ automated machines and flexible manufacturing systems on a broader front than hitherto. On the other hand, development and utilization of information technology as components in the manufacturing sequence are likely to advance apace. Quite apart from the improved performance of electronic control systems, computer aided design (CAD) and manufacturing (CAM) are likely to achieve more widespread and rapid acceptance, in particular by way of linking different technologies. (Author abstract) 4 refs.

Specht, G.; Kollatz, C.; Zoergel, W. *IPE Int Ind Prod Eng* v 11 n 3 Oct 1987 p 16, 25-26.

**086099 DIAGNOSTISCHE TESTS IN AUTOMATISIERUNGSANLAGEN.** [Diagnostic Tests in Automation Systems]. The author describes a method for realizing diagnostic tests in automation systems in order to detect and localize errors. The tests used are characterized, requirements for a diagnosis software are formulated, methods for realizing the tests in the individual diagnosis phases are presented and explained by means of an example. (Author abstract) In German.

Koscielny, J.M. *MSR Mes Steuern Regeln* v 30 n 11 1987 p 493-496.

**086100 ZUM EINFLUSS DER KUENSTLICHEN INTELLIGENZ AUF THEORIE UND PRAXIS DER**

**PROZESSAUTOMATISIERUNG.** [Influence of Artificial Intelligence on Theory and Practice of Process Automation]. Due to the use of artificial intelligence the fields of computer science, automation, manufacturing process engineering are more and more influencing each other. Methods of AI will be coupled with algebraic automation algorithms, the subject of automation theory being essentially extended. Problems weakly structured will be solvable in future. The statements are supported by means of examples. (Author abstract) In German. 11 refs.

Balzer, D.; Boehme, B. *MSR Mes Steuern Regeln* v 30 n 12 Dec 1987 p 530-534.

**086101 FUNCTIONAL COMPLETENESS OF FAP.** The necessity of combining within (Flexible Automatic Productions (FAP) of both flexibility, smaller maintenance staff and integration of designing with production is shown. To meet the requirements of single- and small-scale production FAPs must be made functionally complete. The study of structure of FAP intended for unknown nomenclature of products was carried out. A number of special requirements for functional completeness which ensure wide reproduction of unified FAPs is determined. (Author abstract) 4 refs. In Russian.

Kolosov, V.G. *Tr Leningradskii Politekh Inst im M I Kalinina* n 419 1986 p 3-6.

**086102 MODULAR SOFTWARE DESIGNING FOR THE LOWER LEVEL OF FAP.** The principles of decomposing software design of the lower level of FAP are presented. Programming modules for solving some problems of controlling technological and auxiliary FAP equipment, which depend on the parameters of the controlled object, are given. A method for software development is suggested, which includes the choice, adjustment and combining the program modules. (Author abstract) 6 refs. In Russian.

Korolev, V.S.; Nurulin, Yu.R.; Sergeev, A.F.; Tretyakov, V.A. *Tr Leningradskii Politekh Inst im M I Kalinina* n 419 1986 p 13-18.

**086103 TURING MACHINES AND GUTENBERG TECHNOLOGIES: THE POSTINDUSTRIAL MARRIAGE.** This paper examines the managerial and economic implications of the new forms of automation based on microprocessor control, for use in piece part manufacturing. The important technological characteristics of the new forms of automation are identified, and compared with those of the premicroprocessor era. The new technologies combine the characteristics of Gutenberg technologies and Turing machines, and provide the potential for a high level of versatility and the ability to integrate information fully with material processing. This is in marked contrast to the previous technologies which resulted in systems with fixed production sequences, where information was manually processed, and which were predominantly used for long production runs and low product variety. (Edited author abstract) 29 refs.

Shirley, Gordon V. (Univ of California, Los Angeles, CA, USA); Jaikumar, Ramchandran. *Manuf Rev* v 1 n 1 Mar 1988 p 36-43.

**086104 INTELLIGENT INSTRUMENT: ITS ROLE IN FACTORY AUTOMATION.** The technologies associated with manufacturing have undergone several changes in the past decades; the primary business objective forcing these changes has been the need to increase profitability by improving products and raising productivity. Current management thinking, in order to achieve these objectives, centres on the concept of an automated factory incorporating computer integrated manufacture (CIM), which brings together the design, production, marketing, commercial and financial functions. It is



argued that cost-effective implementation of CIM systems depends crucially on the effectiveness of sensors and instruments acquiring plant-level data.

Bhattacharya, S. (BICC Research & Engineering Ltd, London, Engl). *IEE Rev* v 34 m 5 May 12 1988 p 203-206.

**086105 MOVING SMALL PARTS AND ELECTRONICS—SYSTEMS AND SUPPLIERS.** Automated storage and retrieval systems, conveyors and automated guided vehicles make up the 'skeleton' that can move products and components from fabricating to shipping. It is argued that selecting the right systems and suppliers is crucial to success in the move toward automation. (Edited author abstract)

Buiten, Roger (Jervis B. Webb Co, Ann Arbor, MI, USA). *Manuf Syst* v 6 n 5 May 1988 p 18-23.

**086106 CONCEPT ENGINEERING: FACTORY AUTOMATION'S MISSING FRONT END.** Factory automation or computer-integrated manufacturing (CIM) can help strengthen America's competitive position. By automating the production and manufacturing of products, CIM allows products to be taken to market faster and more efficiently. Yet, if CIM is to live up to its full potential, it must focus not only on product manufacturing but also on the design and quality of these products. This is the missing front end of CIM. Some appropriate guidelines are outlined. It is pointed out that with the advent of powerful desktop computers and sophisticated software, mechanical engineers can reduce development times by using such systems for concept design and testing.

Miller, Richard (Aries Technology Inc, Lowell, MA, USA). *Manuf Syst* v 6 n 5 May 1988 p 44-46.

**086107 PRINCIPLES FOR PART SETUP AND WORKHOLDING IN AUTOMATED MANUFACTURING.** The future automation of small batch manufacturing will depend on part fixturing. Fixturing involves the workholding components and the associated planning that must be done to properly position and finally clamp a part. In the past, part setup and clamping problems have been dealt with as a craft: human expert machinists, after an accumulation of many years of experience, derive part process planning strategies in a reasonable amount of time. This paper describes work that aims to create a science base for clamping: distinct patterns have been discovered that characterize how expert machinists plan setups and clamp parts. A core set of tradeoffs employed by the experts to clamp and machine parts has been established, and these tradeoffs are parameterized by models based on first principles of mechanical engineering and experimental results. Knowledge based planning methods of template matching, feature interaction guide selection, and attribute value approximation have been identified. (Edited author abstract). 20 Refs.

Englert, Paul J. (AT&T Bell Lab, Whippany, NJ, USA); Wright, Paul K. *J Manuf Syst* v 7 n 2 1988 p 147-161.

**086108 PRODUCTION ENGINEERING TECHNOLOGY. PRINCIPLES UNDERLYING CONSTRUCTION OF INTEGRATED MACHINE BUILDING SYSTEMS FOR EXPERIMENTAL MANUFACTURE.** Considering the effectiveness of automation in the production of new technology components, the need for a substantial reduction in the production time, and the need to solve production problems with available labour resources, the Kurchatov Atomic Energy Institute, jointly with the Keldysh Applied Mathematics Institute, is developing an integrated machine building system (KAPRI). The KAPRI system consists of the following subsystems which are interrelated as regards their information aspects: design automation, technology planning, organizational-economic control of experimental manufacture, operational-scheduling control, control of technological processes. The basic aims and applications of the KAPRI system are discussed. 12 Refs.

Adamov, E.O.; Dukarskii, S.M. *Sov Eng Res* v 7 n 8 Aug 1987 p 29-35.

**Computer Aided Design** See Also ENGINEERING EDUCATION; PAPER AND PULP INDUSTRY—Computer Simulation; PRODUCTION CONTROL—Management.

**086109 TECHNIQUES FOR DESIGNING PRODUCTION SYSTEMS.** While individual production technologies are developing rapidly to meet modern manufacturing objectives, emphasis now needs to be directed towards finding ways of maximising their effectiveness when the various components are combined into systems. In supporting the optimal designs of complex systems like FMS, new tools are required that not only follow a systems approach but also attempt to prescribe a system design. This paper provides some background to FMS design, briefly reviews several supporting design techniques, and highlights the need for new tools that will lead to more effective systems. (Author abstract) 4 refs.

Dooner, Mike (Open Univ, Engl). *Comput Aided Eng J* v 4 n 4 Aug 1987 p 157-159.

**086110 COMPUTATIONAL TASKS IN ROBOTICS AND FACTORY AUTOMATION.** The design of Manufacturing Planning and Control Systems (MPCSs) that negotiate with customers and suppliers to exchange products in return for money in order to generate profit is discussed. The computational tasks of MPCS components are specified as a starting point for the development of computational engines, such as computer systems and programs, that execute the specified computation. Key issues are the overwhelming complexity and frequently changing application of MPCSs. (Edited author abstract). 57 Refs.

Beimans, Frank P. (Philips Lab, Briarcliff Manor, NY, USA); Vissers, Chris A. *Comput Ind* v 10 n 2 Jul 1988 p 95-112.

**Computer Aided Manufacturing** See DISPLAY DEVICES—Applications.

**Computer Applications** See Also ARTIFICIAL INTELLIGENCE—Expert Systems; AUTOMOBILE MANUFACTURE—Automation; AUTOMOBILES; COMPUTER GRAPHICS—Applications; COMPUTER INTEGRATED MANUFACTURING; COMPUTER NETWORKS; DATA PROCESSING—Manufacturing Applications; ENGINEERING—Computer Applications; FITS AND TOLERANCES—Computer Applications; INDUSTRIAL ENGINEERING—Computer Applications; INDUSTRIAL ENGINEERING—Production Control; INDUSTRIAL PLANTS—Computer Applications; INDUSTRIAL PLANTS—Control; INDUSTRIAL PLANTS—Control Systems; INDUSTRIAL PLANTS—Flexible Manufacturing Systems; MACHINE SHOPS—Flexible Manufacturing Systems.

**086111 ATTITUDES TO THE USE OF COMPUTERISED INFORMATION SYSTEMS FOR PRODUCTION MANAGEMENT IN MANUFACTURING INDUSTRY: A SURVEY.** The application of computers in production management is receiving considerable attention as is that it can help the production manager make complex decisions about sequencing and timing production activities to satisfy competing priorities. This report consists of the presentation of findings gleaned from a survey of 107 companies in manufacturing, together with case studies of two companies who have recently ventured into the application of 'computerized information systems for production management' (CISPMs). The overall aim of the survey was to obtain as objective an assessment as possible of the level of CISPM applications in UK manufacturing and the attitudes of production managers to their use. The body of the report is in three parts. Firstly, an account is given of the principal findings from the main survey of 63 companies. This is subdivided into three sections, namely: an analysis of the results by company and by site; an analysis by site and by type of computer system; an assessment of overall adequacy by type of computer system. This constitutes the core of the report. Secondly, two case studies of companies' experiences of operating a CISPM are presented, based on the detailed follow-up interviews conducted with them. Finally, the report is concluded with a statement of the general findings from the main survey and the case studies. (Edited author abstract) 16 refs.

Gillingwater, D. (Loughborough Univ of Technology,

Engl). *Loughborough Univ Technol Dep Transp Technol TT Rep* 8706 Aug 1987 54p.

**086112 LEARNING FROM THE SYSTEMS HOUSES.** Talking to systems and engineering houses can be quite an education. These systems houses have been faced with bringing in the whole spectrum of programmable monitoring and control equipment, from intelligent instrumentation and PLCs, through graphics systems and on to computer-based systems, some of which have superseded their earlier output, while others have served to augment it. This in turn has meant undertaking overall system design, and a massive investment in software at all levels, as well as a substantial burden both in terms of acquiring appropriate development and documentation systems and in assessing the various manufacturers' hardware prior to promoting its implementation. Pertinent experience is reported.

Tinham, Brian. *Control Instrum* v 19 n 10 Oct 1987 p 57, 59, 61.

**086113 PRODUCT INFORMATION DATABASES.** Product information is one of the primary needs of architects and engineers. Microfilm-based products have been around for some time to record pictures, drawings, and text of product catalogs. Only recently, however, has optical disk technology allowed vast quantities of graphic and text data to be stored on small disks, distributed at a reasonable cost, and then searched with microcomputer-based equipment. This technology, along with existing computer systems and database, will revolutionize how architects and engineers practice their professions. 5 refs.

Ballast, David Kent. *Constr Specifier* v 40 n 8 Aug 1987 p 44-47, 49-50.

**086114 BEYOND MRP II.** Many companies have been using materials requirements planning systems (MRP) or manufacturing resource planning systems (MRP II) for over two decades. In this time there has been little enhancement other than the adoption of on-line data processing which has speeded up the flow of information. In this article the author introduces a strategy for the development of finite scheduling systems to create computer-based intelligent systems.

Burgoine, John. *Prod Eng (London)* v 67 n 1 Jan 1988 p 31-33.

**086115 HOW DO WE OPTIMISE PRODUCTION ON THIS SITE?** Planning is the allocation of resources (process plant, materials, labor, etc) to meet a given production requirement. Scheduling is the organization over time of these resource allocations. In practice, planning and scheduling are usually performed as one integrated activity. A PC-based expert system is being developed to advise process plant managers how they might use their production resources to best effect.

Taylor, Clive. *Process Eng (London)* v 68 n 9 Sep 1987 p 35, 37.

**086116 SOFTWARE ARCHITECTURE OF INTEGRATED COMPUTER AIDED DESIGN AND MANUFACTURING SYSTEMS.** Fujitsu has developed an open architecture CAD/CAM system called Integrated Computer Aided Design and manufacturing system (ICAD). In addition to having several broadly applicable easy-to-use functions, ICAD can be used instantly after installation, and can be customized to meet each user's specific requirements. ICAD can also be integrated with other systems in order to extend the scope of applications for automatic design and manufacturing. This paper discusses the basis structure of ICAD, with particular attention being given to its open architecture. Also discussed are problems of system implementation and the method used to achieve such. This paper evaluates ICAD's use in the field, and provides commentaries on future plans. (Edited author abstract) 11 refs.

Kanatani, Yoshiharu; Choshi, Toshiki; Hotoge, Keichi. *Fujitsu Sci Tech J* v 23 n 4 Dec 1987 p 341-352.



**086117 COMMUNICATIONS PROCESSOR FACILITATES OPERATOR-PROCESS COMMUNICATION AND PROCESS VISUALIZATION.** Production processes require human supervision and intervention, thus making the quality of the tools available for operator-process communication and process visualization essential for the quality of an automation system. The scope of the operator-process communication and process visualization facilities in the SIMATIC S5 automation system has now been extended to include the new configuration level 2 of the CP526 communications processor, thus providing capabilities for additional important graphic renditions of process variables. (Edited author abstract) 2 refs.

Geil, Thomas (Siemens AG, Karlsruhe, West Ger); Hennessen, Monika. *Energy Autom* v 10 n 1 Jan-Feb 1988 p 14-17.

**086118 TOOL FOR CONSTRUCTING PRODUCTION SYSTEMS ON THE DEDUCTIVE DATABASE SYSTEM ADBIS.** The authors have designed and implemented a tool for constructing production systems on the deductive database system Adbis that is a relational database management system with inference functions based on Horn set refutation procedures. Characteristics of the production systems developed by using this tool users can handle large factual data as well as production rules since they are linked with a relational database through the Horn set refuter; users are able to easily perform a backward reasoning because the left-hand side and right-hand side of production rules rules are syntactically symmetrical; inference functions based on Horn set refutation procedures can be used for checking the applicability of production rules to data accessed by the production rules, and for expressing and checking the integrity constraints which the data satisfies; the performance of the production systems are expected to be improved by using the results of much research in Horn set refuters and Prolog. (Edited author abstract) 20 refs.

Takagi, T. (Kyushu Univ, Fukuoka, Jpn); Ushijima, K.; Matsuo, F.; Futamura, S. *Eng Costs Prod Econ* v 14 n 1 May 1988 p 77-84.

**086119 OPERATOR/COMPUTER INTERFACE: ENSURING A GOOD WORKING RELATIONSHIP.** In recent years, the trend in machine control has been away from custom-built dedicated logic circuits to flexible programmable systems. With the introduction of the microprocessor came the ability to produce small, compact, relatively cheap computers, greatly increasing the range of projects to which they could be applied. It is pointed out that without the support and understanding of operators and engineers, the full benefits to be gained from investing in computer-controlled equipment may never be realised.

Bradford, Mike (Lucas Engineering & Systems Ltd, UK). *IEE Rev* v 34 n 4 Apr 21 1988 p 161-164.

**086120 UTILIZATION OF MICROCOMPUTERS IN PRODUCTION AND INVENTORY CONTROL.** The aim of this paper is to describe the use of microcomputers in production and inventory control from several points of view. However, it is not intended to be a complete survey of the field. The main reasons for the increased interest in microcomputers are the development of microelectronics and the modern manufacturing philosophy. Microcomputers may be utilized as single units, as networks of micros or as a part of the whole computer system including a main frame. The available technology is reviewed according to typology of microcomputers, data transmission and programming tools. Finally, examples of available software are represented. (Author abstract)

Lehtimäki, Allan (Tampere Univ of Technology, Tampere, Finl). *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 131-135.

**086121 INTELLIGENT CONTROL (PRESENTED AT THE WINTER ANNUAL MEETING OF THE**

**AMERICAN SOCIETY OF MECHANICAL ENGINEERS).** This conference proceedings contains five papers. The subjects covered include computer aided engineering, automated assembly, robotic path planning, tool wear estimation and intelligent machining. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11000 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Shoureshi, R. (Ed.) (Purdue Univ, Lafayette, IN, USA). *ASME Dyn Syst Control Div Publ DSC* v 5, Intell Control, Boston, MA, USA, Dec 13-18 1987. Publ by ASME, New York, NY, USA 1987 43p.

## Computer Integrated Manufacturing

**086122 DYNAMIC SCHEDULING IN CELLULAR MANUFACTURING SYSTEMS: A FRAMEWORK FOR NETWORKED DECISION MAKING.** This paper describes a dynamic scheduling method for cellular manufacturing systems. Essentially an artificial intelligence based approach for the networking environment, the method is adaptive to the changes in the manufacturing environment and can take into account such information as loading factor, unexpected breakdowns, and new job arrivals. The major features of the method are a distributed task assignment mechanism executed through the communication network for intercell scheduling and a knowledge based system for cell level scheduling. A main advantage of such a method is that the scheduling on both levels can be dynamically executed in real time. (Author abstract). 25 Refs.

Shaw, Michael J. (Univ of Illinois at Urbana-Champaign, Champaign, IL, USA). *J Manuf Syst* v 7 n 2 1988 p 83-94.

**086123 CIM, DATA AND STANDARDIZATION WITHIN THE NBS AMRF.** Computer-Integrated Manufacturing (CIM) is key to the factory of the future, shared data is key to integration, and interface standards are key to data-sharing. Within its Automated Manufacturing Research Facility (AMRF), the U.S. National Bureau of Standards is addressing issues of standardized interfaces in the four principal data activities of the automated factory: data preparation, data administration, data communication, and data-driven control. By means of such interface standards, the flexibly automated, robotics-based, computer-integrated factory of the future can be realized in a modular, easily integratable, multi-vendor form. (Author abstract). 19 Refs.

Swyt, Dennis A. (NBS, Gaithersburg, MD, USA). *Robotics* v 4 n 2 Jun 1988 p 193-199.

## Computer Simulation See Also COMPUTER SIMULATION.

**086124 ON-LINE SIMULATION OPTIMIZES FLEXIBLE MANUFACTURING SYSTEMS.** Smaller batch sizes, shorter product life and the need to react more quickly to changing markets call for more use of flexible manufacturing systems. It is pointed out how optimization of these systems is achieved by simulation. (Edited author abstract) 2 refs.

Neupert, Heinrich (Siemens AG, Erlangen, West Ger). *Energy Autom* v 9 n 2 Mar-Apr 1987 p 18-20.

**086125 REDUCE MANUFACTURING RISK WITH SIMULATION.** Simulation is an analytical technique that allows complex manufacturing or material handling systems to be evaluated numerically over a period of time with the help of a computer. This analytical technique has been around for some time but has only recently met with acceptance in manufacturing. In addition to offering visual capability, some new simulation systems allow design parameters of a working concept to be changed and models built without writing any simulation code. Simulation significantly reduces the technical risk of implementing production changes by allowing the effects upon a system to be seen and by providing performance measures such as work-in-process, percent utilization, and throughput. This article discusses simulation basics and other

aspects of the subject.

Vester, John (Litton Industrial Automation Systems); Muller, Dan. *Automation (Cleveland)* v 34 n 11 Nov 1987 p 42-44.

**086126 SELECTION OF A MANUFACTURING SIMULATION TOOL.** Over the past five years, the options available for individuals attempting to select a simulation tool have risen. This discussion describes one approach to categorising and selecting simulation software tools. It follows eighteen months of research into the requirements of production engineers involved in process design within a large electronics factory in the UK.

Chrystall, C.N. (Portsmouth Polytechnic, Engl). *Prod Eng (London)* v 66 n 11 Dec 1987 p 24-28.

**086127 EQUIPMENT MODEL UNIFICATION FOR CONTROL AND EFFICIENT PLANNING OF SINGLE-SCALE PRODUCTION.** The use of simulation for designing, technological preparation and organization of FAP is discussed. Algorithm for efficient planning for FAP is suggested. The scheme of utilization of unified machining FAP technological equipment models is given. (Author abstract) 3 refs. In Russian.

Redko, S.G.; Tukkel', I.L. *Tr Leningradskii Politekh Inst im M I Kalinina* n 419 1986 p 107-111.

**086128 PROCEEDINGS OF THE 2ND INTERNATIONAL CONFERENCE ON SIMULATION IN MANUFACTURING: SIM-2.** This conference proceedings contains 24 papers. The main topics discussed are: new technologies in simulation; simulation role in design; simulation in control systems; simulation on the shop-floor; simulation in decision support for management; process evaluation using simulation. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11034 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Lenz, J.E. (Ed.). *Proc of the 2nd Int Conf on Simul in Manuf: SIM-2*, Chicago, IL, USA, Jun 24-26 1986 Publ by IFS (Conferences) Ltd, Kempston, Engl, 1986 256p.

## Control Systems See Also CONTROL SYSTEMS, NUMERICAL—Applications.

**086129 UNIFICATION OF FAP TERMINAL CONTROL SYSTEMS.** The main requirements for FAP terminal systems and ensuing computer architectural characteristics are discussed. A unified control system is developed based on a single-board microcomputer with the interface of the unibus 'Elektronika 60' type. A new flexible programmed device - module of active memory - is used as an expander of micro-computer functional capacities. (Author abstract) 4 refs. In Russian.

Alekseev, V.N.; Goryachev, S.V.; Melekhin, V.F.; Shelonin, Yu.V. *Tr Leningradskii Politekh Inst im M I Kalinina* n 419 1986 p 55-62.

**086130 OPTIMIZATION OF FAP CONTROL HIERARCHY.** The task of synthesizing optimal structure of control in two-level FAP is set forth. For analysis of the system the efficiency criterion is offered, envisaging a possibly extreme situation. A comparison of structural solutions by discrete programming and use of heuristic algorithms was performed. The results of computer experiments are presented. (Author abstract) 9 refs. In Russian.

Kononov, A.M.; Sergeev, V.A.; Taldikin, V.V. *Tr Leningradskii Politekh Inst im M I Kalinina* n 419 1986 p 62-69.

**086131 UNIFICATION OF INTERFACES WITH AN OBJECT IN FAP TERMINAL CONTROL SYSTEM.** As a result of study of machining equipment the main requirements for the modules of interfaces of terminal control system have been worked out. The



smallest number of modules which enable to ensure optimal parameters of terminal control system for each particular case is given. (Author abstract) 2 refs. In Russian.

Vorzhev, V.G.; Afanasev, E.G. *Tr Leningradskii Politekh Inst im M I Kalinina* n 419 1986 p 74-80.

**Costs** See Also AIRCRAFT, MILITARY—Airframes; COMPUTER AIDED MANUFACTURING; ECONOMICS—Mathematical Models.

**086132 TECHNIQUES FOR COST ESTIMATING IN EARLY PROGRAM PHASES.** This paper describes the process of eliciting cost estimates and modifying cost assumptions which enable cost prediction of not well defined systems. It describes what kinds of cost models are acceptable and usable and how the data may be efficiently obtained. The choice of the right experts (generalists, people with perception), the proper interviewing techniques (written versus oral, delphi, argumentative, etc.), the important role of the interviewer or moderator (reinforcing behavior versus objective criticism), and the transformation of question responses into cost model inputs are discussed. The paper reveals the thought process and includes several examples of actually performed, early concept phase cost estimates and contains a list of several do's and don'ts the author experienced in arriving at these early cost predictions. (Edited author abstract) 10 Refs.

Meisl, Claus (Rockwell Int, Canoga Park, CA, USA). *Eng Costs Prod Econ* v 14 n 2 Jul 1988 p 95-106.

## Database Systems

**086133 SYSTEMS APPROACH TO PLANT MONITORING.** A systematic approach to the collection and evaluation of data is required to ensure that timely, reliable and concise information is available upon which plant management decisions can be made. The data must be analysed to yield parameters which define the state of the object being monitored. The most striking characteristic of diagnostic monitoring within discrete parts manufacturing as opposed to continuous process plant is that the machinery is changing its operating state second by second. Speeds, feeds, tools, workpiece material and geometry are all variables. Any monitoring system must be able to cope with this non-stationary environment. The DAAS therefore incorporates facilities to enable it to communicate with the CNC or PLC on the machine and follow the execution of the part program line by line making it aware of the machine's operating conditions. Data acquisition and analysis are synchronised accordingly to provide real time status information.

Ephraim, Piet. *Prod Eng (London)* v 67 n 4 Apr 1988 p 50-52.

**Design** See PRODUCT DESIGN; QUALITY CONTROL—Management.

## Design Aids

**086134 DESIGN FOR MANUFACTURE.** Design for manufacture (DFM) represents a new awareness of the importance of design as the first manufacturing step. It recognizes that a company cannot meet quality and cost objectives with isolated design and manufacturing engineering operations. To be competitive in today's marketplace requires a single engineering effort from concept to production. The essence of the DFM approach is, therefore, the integration of product design and process planning into one common activity. The objectives of the design for manufacture approach are to identify product concepts that are inherently easy to manufacture, to focus on component design for ease of manufacture and assembly, and to integrate manufacturing process design and product design to ensure the best matching of needs and requirements.

Stoll, Henry W. (Industrial Technology Inst). *Manuf Eng* v 100 n 1 Jan 1988 p 67-73.

**086135 TOWARDS SOCIO-TECHNICAL PROTO-**

**TYPING OF WORK SYSTEMS.** Although prototyping is a technique widely used in manufacturing industry during the design development and manufacture of a new or updated project, the technique is rarely used to test out options during the design of a manufacturing system. The work organization action simulation was developed in response to a need identified in the training of engineers. Such an approach can be used to prototype socio-technical systems and explore technical options in association with the organizational structure. (Author abstract) 13 refs.

Kember, Paul (Cranfield Inst of Technology, Bedford, Engl); Murray, Hugh. *Int J Prod Res* v 26 n 1 Jan 1988 p 133-142.

**086136 DESIGN ANALYSIS THROUGH TECHNIQUES OF PARAMETRIC COST ESTIMATION.** This paper focuses on the parametric model as a tool for design engineering analysis. The technique is made relevant to routine, everyday living. It proceeds to the engineering design function with a case study of over 4000 instances where the parametric model provided estimates closer to actual costs than the traditional 'bottom-ups' means to cost estimation in an aerospace industrial application. (Edited author abstract) 4 Refs.

Daschbach, J.M. (Univ of Toledo, Toledo, OH, USA); Aggar, Henry. *Eng Costs Prod Econ* v 14 n 2 Jul 1988 p 87-93.

**Economics** See Also ARTIFICIAL INTELLIGENCE—Expert Systems; BUDGET CONTROL—Optimization; ENERGY RESOURCES; NUCLEAR POWER PLANTS—Economics; PRODUCTION CONTROL—Mathematical Models; QUALITY CONTROL—Computer Applications.

**086137 EVALUATION OF OUTLOOK FOR PRODUCT SPECIALIZATION IN POWER MACHINE BUILDING.** The unit and small-series character of production and the uniqueness of the products impose special requirements on increasing the technical production level (TPL) of power machine building enterprises, since the production turnaround time, increase in quality and increase in production efficiency all depend on its condition and further development. The development of engineering and technology, their improvement and progress largely govern not only the TPL, but also the structure and form of the production facilities of enterprises, the organizational and economic levels of the plant and the level of product specialization. The authors have proposed a procedural approach which enables us to switch from the coefficient of unification between designs to the coefficient of specialization, defined in the form of a relative quantity that enables us to compare perspective and existing levels (to evaluate perspective solutions) and establishes the volumes of centralized production of unified components and parts in a cost expression. 1 ref.

Tsitalovskii, E.A.; Mozhaikii, A.M.; Grigorev, A.S. *Sov Energy Technol* n 6 1987 p 80-84.

**086138 PRODUCT COST-ESTIMATION BY THE DESIGNER.** Shorter through-put times demand flexibility in production. Along with this, the need arises to speed the production-planning and cost-estimating activities. The designer does not have the estimator's time however, nor his skill and experience. Therefore new tools have to be developed - tools that give the designer a quick and accurate estimate of the financial consequences of his design-decisions. The article gives a survey of possible cost estimation techniques and current research efforts. For the future, an integration of Computer Aided Design, production-planning programs and cost-estimation programs using Expert Systems, is predicted. (Edited author abstract) 41 refs.

Wierda, Leo S. (Univ of Technology, Delft, Neth). *Eng Costs Prod Econ* v 13 n 3 Mar 1988 p 189-198.

**086139 TAKE FULL ADVANTAGE OF COMPUTER-AIDED COST ESTIMATING.** The benefits of advanced PC-based computer-aided cost estimating - (CACE) - accuracy, speed, consistency and flexibility - are proven and significant. The detailed information contained in a CACE printout, derived from the extensive

data on tooling, materials and labor standards accumulated in the software, could be utilized by a number of other departments. When Remmele Engineering, Inc. purchased a CACE system, in June of 1987, management was already planning which areas would benefit. Information from estimates is now used for tasks such as process planning, production control, NC programming and JIT (just-in-time) planning.

Herzog, John (Remmele Engineering Inc, St. Paul, MN, USA). *Mod Mach Shop* v 61 n 4 Sep 1988 p 92-98.

**086140 PROCEEDINGS OF THE FOURTH INTERNATIONAL WORKING SEMINAR ON PRODUCTION ECONOMICS.** The proceedings comprise 48 papers divided into 10 themes: theoretical approaches, production control, production control in a consumer electronics factory, investment and financial planning, strategic planning for production systems, inventory control, production innovation management, production information systems, transportation, product pricing and costing. The theoretical approaches section contains articles on: a multivariate utility function approach to stochastic capacity planning; comparison of the discrete and continuous-time stochastic selling models; the feasible approach to the optimization of exploitation of tree stems; dimensioning of bus driver buffers subject to variations in the traffic load; decomposition principles applied to the dynamic production and work-force scheduling problem; operation plan optimization of porcelain production; the firm's investment policy rules a concave adjustment cost function; similarities between lot sizing and clustering; and an analysis of heuristic trim-loss algorithms. Abstracts of all articles are indexed separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10537 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Grubbstrom, Robert W. (Ed.). (Linköping Inst of Technology, Dep of Production Economics, Linköping, Swed); Hinterhuber, Hans H. (Ed.); Lundquist, Janerik (Ed.). *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 409p.

**Education** See Also PRODUCTION CONTROL—Personnel Training.

**086141 UNDERGRADUATE CURRICULUM FOR PRODUCTION AND OPERATIONS MANAGEMENT.** The article clarifies some of the program development issues associated with the curriculum design for production and operations management (POM). The recent developments and trends taking place in the field are discussed. An advanced course incorporating these developments is proposed. 2 refs.

Satir, Ahmet (Concordia Univ, Montreal, Que, Can); Goyal, Suresh. *Prod Invent Manage* v 28 n 2 Second Quarter 1987 p 10-14.

**086142 DESIGN OF A MICROCOMPUTER BASED SIMULATOR FOR PRODUCTION MANAGEMENT TRAINING.** The proliferation of independent computer based systems in some manufacturing companies has more than often led to islands of automation. The effective integration of such systems has become imperative for the complete realization of the advantages of computer based systems in the manufacturing environment. The teaching of the fundamental principles of production management and control to engineering students is suffering from the same lack of integration and a need for more effective training methods has been identified. The purpose of this paper is to demonstrate that the computerized training simulator, CIMSIM, might fulfill this need. (Author abstract) 11 refs.

Lindeque, Pieter (Univ of Pretoria, Pretoria, S Afr); Kruger, Paul S. *Comput Ind Eng* v 14 n 1 1988 p 53-62.



**086143 DISTANCE LEARNING.** Today's courses incorporate multi-media techniques including audio and video material and innovatively designed text matter. They are designed to be flexible in terms of start date, completion time and method of study and are intended for use either by an individual or as part of a company's training scheme. The course components, video and text are totally integrated to provide a method of study which is not only informative, but is easy to use and appealing to the student. The course materials are structured to use the workplace as a key source of example and exercise. In this way, direct benefits can be achieved for the individual and the company. An example, the Production Management Course, is described.

Sellers, Sheila (Henley Distance Learning Ltd). *Prod Eng (London)* v 67 n 7 Jul-Aug 1988 p 30-31.

**Efficiency** See Also TOOLS, JIGS AND FIXTURES.

**086144 COUNTERS CUT PRODUCTIVITY PLUNGE.** A 24-hour-a-day operation can be the ultimate in plant and equipment use, but with it comes the problem of maintaining consistent productivity throughout all three shifts even when supervision is at a minimum. While the application reported takes place at a manufacturer of plastic parts, the techniques used are generally applicable to any process manufacturer. (Edited author abstract)

Anon. *InTech* v 35 n 4 Apr 1988 p 49-50.

**086145 MANAGING CHANGE BY INTEGRATING MANUFACTURING AND ENGINEERING.** It is printed out that the use of a large-scale mainframe computer is often overlooked as a method of integrating a company's many data requirements. It is reported that a given company's customers have found that improving the product introduction cycle has enhanced their ability to respond to change. Reducing design times and speeding the transition from engineering to manufacturing can make possible broader product line-ups, products with more features, lower cost responses to market changes, and an ability to react quickly to technological advancements.

Bryan, G.E. (Los Angeles Development Cent, Los Angeles, CA, USA); Williams, C.H. *Manuf Syst* v 6 n 5 May 1988 p 74-76.

**086146 SINGLE MACHINE SETUP-DEPENDENT SEQUENCING USING A SETUP COMPLEXITY RANKING SCHEME.** This paper presents a group technology-based heuristic for the single machine setup-dependent sequencing problem. An earlier approach of multiple classification analysis used the 'nearest neighbor' approach for solving the traditional 'traveling salesman' structure of this problem. The new heuristic uses the clustered traveling salesman analogy for the problem to incorporate a one-dimensional clustering algorithm. Intrafamily and interfamilial sequencing of parts is achieved by using an absolute measure of setup complexity assuming a bare machine before setup. This measure requires that significant setup attributes be ranked in the order of decreasing complexity. The inspection approach to the selection of similar parts is eliminated in this approach. An optimal solution is not guaranteed by this method. It yields a dominant set of schedules which can be evaluated with time studies. Two examples from the literature are solved using this method. Extensions of the method to the rationalization of machine tool design are proposed. (Edited author abstract). 19 Refs.

Irani, Shahrugh Adi (Pennsylvania State Univ, University Park, PA, USA); Gunasena, Udaya; Davachi, Ali; Enscore, E. Emory. *J Manuf Syst* v 7 n 1 1988 p 11-23.

**086147 MINIMAX METHOD OF MEASURING PRODUCTIVE EFFICIENCY.** A class of minimax methods for measuring productive efficiency is proposed here and compared with two other methods currently available in the literature. Some advantages of the minimax methods such as robustness and probability maximization are analyzed both theoretically and empirically. The empirical results show some aspects of superiority of

the class of minimax methods proposed here. (Author abstract). 8 Refs.

Sengupta, Jati K. (Univ of California, Santa Barbara, CA, USA); Sfeir, Raymond E. *Int J Syst Sci* v 19 n 6 Jun 1988 p 889-904.

## Energy Conservation

**086148 NOTWENDIGKEITEN UND MOEGLICHKEITEN DER STOFF- UND ENERGIEEINSPARUNG IN DER PRODUKTION.** [Necessities and Possibilities of Material and Energy Savings in Production Processes]. Energy and material flows are to be used optimally in industry, which is of business-management as well as national-economy interest. This means for the production of goods that the losses of energy and raw materials should be kept at the lowest possible level. For achieving this aim, the author suggests an approach in which the production process is taken as an irreversible thermodynamic process, and in which the objective of the production is geared towards the minimization of the entropy increase. The paper describes the strategy of applying the energy and the raw material, the evaluation factors of a production process, the possibilities of recovering the energy and raw material. Finally, two examples are given to show clearly, how this new approach improved the conventional processes. (Author abstract) 5 refs. In German.

Scharmer, K. *Brennst Waerme Kraft* v 39 n 12 Dec 1987 p 535-538.

**Industrial Applications** See VEHICLES—Industrial Applications.

## Management

**086149 POTENTIAL OF RECONSTRUCTABILITY ANALYSIS FOR PRODUCTION RESEARCH.** Reconstructability analysis is a package of methodological tools for dealing with the relationship between wholes and parts in the context of computer-aided system modeling. The applicability of reconstructability analysis in industrial engineering and production research is the primary purpose of this paper. It is illustrated by simple examples based upon data obtained from psychophysiological and ergonomic experiments under real working conditions. (Edited author abstract) 34 refs.

Kliir, G.J. (State Univ of New York, Binghamton, NY, USA); Mariano, M.; Pittarelli, M.; Kornwachs, K. *Int J Prod Res* v 26 n 4 Apr 1988 p 629-645.

**086150 BOTTLENECK GENERALIZED ASSIGNMENT PROBLEMS.** We discuss bottleneck (or minimax) versions of the generalized assignment problem. The basic problem involves the assignment of a number of jobs to a number of agents such that each job is performed by a unique agent, and capacity limitations on the agents are not exceeded. Two versions of the bottleneck generalized assignment problem (BGAP) are defined. The first of these is called the Task BGAP and has as its objective the minimization of the maximum of the costs of the assignments that are made. The second version is referred to as the Agent BGAP and has as its objective the minimization of the maximum of the total costs assigned to each agent. Both problems are formulated, and applications are discussed. Procedures for solving the Task BGAP are presented, and one of the procedures is illustrated in an example. (Author abstract) 22 refs.

Mazzola, J.B. (Duke Univ, Durham, NC, USA); Neebe, A.W. *Eng Costs Prod Econ* v 14 n 1 May 1988 p 61-65.

**086151 SCHEDULING IN LARGE SCALE PRODUCTION SYSTEMS: A MEDIUM TERM PRODUCTION MANAGEMENT MODEL.** This paper describes a medium term production management model, where the system is partitioned into production subsystems and part families. The goal of this research is to evaluate the production rate, which minimizes the cumulative inventory cost over a given planning horizon. (Author abstract) 5 refs.

Meier, Klaus (INRIA, Vandoeuvre Les Nancy, Fr); Proth, Jean-Marie. *Eng Costs Prod Econ* v 14 n 1 May 1988 p 67-74.

**086152 LONG RANGE PROCESS DESIGN AND COMPATIBILITY AMONG OPERATIONS.** This paper presents an efficient algorithm with computational results for identifying all feasible designs based on compatibility considerations. The implementation issues, both computational and organizational, are discussed as integral parts of a framework for process design efforts. This framework combines the advantages of both the traditional and morphological approaches and mitigates their disadvantages. It also facilitates interaction between the expert's judgment and the programmed model. (Edited author abstract). 13 refs.

Singhal, Jaya (Univ of Baltimore, Baltimore, MD, USA); Singhal, Kalyan; Weeks, James K. *Manage Sci* v 34 n 5 May 1988 p 619-632.

**086153 CREATING A COMPETITIVE MANUFACTURING STRATEGY.** To ensure a systems approach to business redesign, a 5-step approach is needed. This includes: data collection on markets, product volume, factory processes; engineering analysis to define volume-variety groups, Pareto structures, product/component categorization; define business architecture with the business unit divided into units (manufacturing and service); dynamic design by identifying potential change sources; definition of information flow requirements/paperwork systems. Manufacturing strategy has to be underpinned by the five step design process and be seen to be an equal partner with the other segments of strategy, Sales and Marketing strategy - Product Engineering strategy - Manufacturing Systems Engineering strategy - Business systems Engineering strategy. These must all be detailed and integrated into a total business strategy by an input-output matching approach. 8 Refs.

Parnaby, John. *Prod Eng (London)* v 67 n 7 Jul-Aug 1988 p 24-28.

**Marketing** See MARKETING—Management.

## Materials

**086154 ZUZYCIE MATERIALOW W PRZEDSIEBIORSTWIE.** [Consumption of Materials in an Enterprise]. Problems associated with the effective use of materials in enterprises are discussed. Factors influencing the effectiveness of use of materials are considered. An appraisal of material losses occurring in the production process is presented. The application of the analysis results in practice is described. (Edited author abstract). 2 Refs. In Polish.

Polak, Andrzej. *Przegl Mech* v 47 pt 1 n 5 Mar 1988 p 14-16.

**Mathematical Models** See Also INDUSTRIAL ENGINEERING—Mathematical Models; INDUSTRIAL PLANTS—Research; LOGGING—Production.

**086155 PRODUCTION MODEL UNDER THE CONDITIONS OF VARIABLE INTENSITY OF OUTPUT OF MATERIAL RESOURCES.** A nonlinear model of industrial branch-production planning is proposed in which the variables are the volume of production outputs and the norms of material expenditures. Under a quadratic criterion conditions are obtained which guarantee unextremality of the problems solved for this model. An efficient algorithm scheme for determining a global optimum is considered. (Author abstract). 5 Refs.

Zak, Ye.I.; Rikun, A.D. *Sov J Comput Syst Sci* v 26 n 2 Mar-Apr 1988 p 58-62.

**Measurements** See ELECTRIC MOTORS, STEPPING TYPE—Applications.

## Monitoring

**086156 TYPIZATION OF OPERATIONAL STRUCTURE OF FAP MONITOR CONTROL.** Oper-



ational structure of FAP monitor control is presented. Some factors effecting the algorithms of certain modules are shown. The apparatus of cyclic algebra is introduced and synthesis of module of optimal transport route is made on its basis. (Author abstract) 2 refs. In Russian.

Dronov, V.V. *Tr Leningradskii Politekh Inst im M I Kalinina* n 419 1986 p 121-123.

## Operations Research

**086157 SENSITIVITY ANALYSIS AND OPTIMIZATION OF THROUGHPUT IN A PRODUCTION LINE WITH BLOCKING.** It is pointed out that production lines with limited storage capacities can be modeled as cyclic queueing networks with finite buffers and general service times. A technique called perturbation analysis of discrete-event dynamic systems is applied to these queueing networks. An estimate of the gradient of the system throughput is obtained by perturbation analysis, based on only one sample trajectory of the system. It is shown that the estimate is strongly consistent. Using this perturbation analysis estimate of gradient, it is possible to apply the Robbins-Monro stochastic procedure in optimizing the system throughput. Compared to the conventional Kiefer-Wolfowitz optimization procedure, this approach saves a large amount of computation. For a real system, the gradient estimate can be obtained without changing any parameters in the system. The results also hold for systems with general routing but in which no server can block more than one other server simultaneously. 19 refs.

Cao, Xi-Ren (Harvard Univ, Cambridge, MA, USA); Ho, Yu-Chi. *IEEE Trans Autom Control* v AC-32 n 11 Nov 1987 p 959-967.

**Optimization** See Also ELECTROPLATING—Productivity; INDUSTRIAL PLANTS—Flexible Manufacturing Systems.

**086158 OPTIMAL PRODUCTION RUN FOR A PROCESS HAVING MULTILEVEL TOOL WEAR.** This paper considers the problem of selecting the most economical production run for a continuous process having multi-tool machines. Each tool may have different but similar wear characteristics. The process produces a certain type of product having two measurable quality control characteristics which jointly determine the effectiveness of the product. Simultaneous gradual changes in process means and process variances are experienced as the time passes due to tools wearing out. An expected total cost per unit is developed which consists of the cost of resetting the tools, the cost of defective items, the loss of production cost due to shutdown, and the sampling cost. An optimal production run is determined by employing a one-dimensional Fibonacci search technique on the expected total cost function. A graphical method is also provided to determine the optimal production run. Numerical examples are provided to demonstrate the applications of the model. (Edited author abstract) 7 refs.

Rahim, M.A. (Univ of New Brunswick, Fredericton, NB, Can); Raouf, A. *Int J Syst Sci* v 19 n 1 Jan 1988 p 139-149.

**086159 FIXED STRUCTURE PRODUCTION OPTIMIZATION AT LIMITED ENERGY SUPPLY.** The paper presents a procedure for finding a suboptimal strategy of production objects switch-off when the energy supply is periodically limited. The problem is considered for production of a fixed final products structure. Taken into account are the production objects, work in process stores, the relation between them, materials flow and wastes. (Edited author abstract) 2 refs.

Bien, A. (Technical Univ of Mining & Metallurgy, Cracow, Pol); Jodowski, W.; Khafagy, A.Z.; Wolczko, P. *Modell Simul Control C* v 12 n 2 1988 p 13-19.

**086160 MINIMUM CONCAVE COST PRODUCTION SYSTEM: A FURTHER GENERALIZATION OF MULTI-ECHOLON MODEL.** We consider a concave minimization problem associated with a series production system in which raw material is processed in  $m$  consecutive facilities. The products at some facility are either sent to the next facility or stocked in the warehouse.

The amount of demand for the final products during period  $i$ ,  $i = 1, \dots, n$ , are known in advance. Our problem is to minimize the sum of processing, holding and backlogging cost, all of which are assumed to be concave. The origin of this model is the classical economic lot size problem of M.H. Wagner and T.M. Whitin. The purpose of this paper is to extend the model further to the situation in which time lag is associated with processing at each facility. We propose an efficient  $O(n^4 m)$  algorithm for this class of problems. (Edited author abstract). 11 Refs.

Konno, Hiroshi (Tokyo Inst of Technology, Tokyo, Jpn). *Math Program* v 41 n 2 Jul 1988 p 185-193.

**Performance** See MATERIALS HANDLING—Automation.

**Planning** See Also COMPUTER AIDED MANUFACTURING—Planning; INDUSTRIAL MANAGEMENT—Planning; INDUSTRIAL PLANTS—Flexible Manufacturing Systems; MATHEMATICAL PROGRAMMING; PRINTED CIRCUITS—Computer Aided Manufacturing.

**086161 OPTIMAL STOCHASTIC PRODUCTION PLANNING PROBLEM WITH RANDOMLY FLUCTUATING DEMAND.** This paper considers an infinite horizon stochastic production planning problem with demand assumed to be a continuous-time Markov chain. The problems with control (production) and state (inventory) constraints are treated. It is shown that a unique optimal feedback solution exists, after first showing that convex viscosity solutions to the associated dynamic programming equation are continuously differentiable. (Author abstract) 14 refs.

Fleming, W.H. (Brown Univ, Providence, RI, USA); Seth, S.P.; Soner, H.M. *SIAM J Control Optim* v 25 n 6 Nov 1987 p 1494-1502.

**086162 VARIANCE OF THE NUMBER OF UNITS PRODUCED ON A TRANSFER LINE WITH BUFFER INVENTORIES DURING A PERIOD OF LENGTH T.** The transfer-line models in the literature are planning models rather than operational models. The performance measure used in these models is the efficiency of the line A. The expected number of units produced during a period of length T cycles is AT. In this article a procedure is presented for calculating the variance of the number of units produced by the transfer line during a period of length T cycles. These two performance measures can be used to construct an interval estimate for, say, the number of units produced during a shift. (Edited author abstract) 9 refs.

Miltenburg, G.J. (McMaster Univ, Hamilton, Ont, Can). *Nav Res Logist* v 34 n 6 Dec 1987 p 811-822.

**086163 PROCESS PLANNING PERFECTS PRODUCTION.** The process plan is a set of sequential work instructions for making a particular product. It specifies the essentials such as materials, processes and routings. But different planners may take different routes, including different manufacturing operations and sequences, in arriving at the production of any given product. Subjects covered include group technology, classification methods, computer-aided processes planning, and others.

Waterbury, Robert C. (Assembly Engineering, Wheaton, IL, USA). *Assem Eng* v 30 n 11 Nov 1987 p 34-36.

**086164 BUSINESS RESOURCES PLANNING SYSTEM.** Concepts of business resources planning are cornerstones of the AT&T project that has become known as BRPS (Business Resources Planning System). Under the BRPS project umbrella is a family of integrated initiatives that address the manufacture and distribution of AT&T products in a market-focused environment. Elements of the BRPS project specify the functional architecture, the management processes, policies, procedures, and accountabilities necessary to mold the functions of business planning and execution into a total closed-loop control system. The scope of the BRPS project spans a gamut of manufacturing planning and execution functions, from interfaces with sales and marketing to interfaces with material suppliers. Included

within the purview of the BRPS system model are modules for planning, control, and performance measurement for demand management, distribution network operations, and material acquisition and facility management. Through a hierarchically defined specification of the processes and data needed for a total business system, BRPS provides criteria for identifying software solutions and procedural solutions. (Author abstract)

Gray, James C. (AT&T, Short Hills, NJ, USA); Ehlers, Merle L. *AT&T Tech J* v 66 n 5 Sep-Oct 1987 p 49-60.

**086165 SEMI-GENERATIVE APPROACH TO COMPUTER-AIDED PROCESS PLANNING USING GROUP TECHNOLOGY.** Computer-Aided Process Planning (CAPP) has a key role in Computer-Integrated Manufacturing (CIM) as an interface between design and manufacturing. This paper reports on a research effort that had as a major thrust the demonstration that a correctly designed Group Technology (GT) part coding scheme can assist in generating the sequence of machine operations for making the part. To exemplify the approach, a 14-digit chain-structured GT code was designed to capture the part features for the most common rotational/gear part shapes using DCLASS information processing trees. The GT code was then processed to generate process plans using a semi-generative CAPP approach that integrates sets of machining operations for part basic shapes and form features. The results have shown promising perspectives of GT application in CAPP. (Author abstract) 14 refs.

Lin, Li (Arizona State Univ, Tempe, AZ, USA); Bedworth, David D. *Comput Ind Eng* v 14 n 2 1988 p 127-137.

**086166 HEURISTIC PROCEDURE FOR A SINGLE-ITEM DYNAMIC LOT SIZING PROBLEM.** An  $O(T)$  heuristic procedure for a single-item dynamic lot sizing problem is introduced in this paper. The algorithm tries to establish the regeneration points of the problem when either the production or the beginning inventory must be equal to zero. The proposed algorithm is very easy to implement and compares very favourably with the existing heuristic procedures. (Author abstract) 24 refs.

Benli, O.S. (Bilkent Univ, Ankara, Turk); Sabuncuoglu, I.; Tufekci, S. *Comput Ind Eng* v 14 n 2 1988 p 181-192.

**086167 LAYERED ARCHITECTURE FOR MANUFACTURING OPERATION PLANNING.** Machining operation planning involves the selection and sequencing of machining operations for fabricating a workpiece. It is the first step in the process of generating a detailed process plan for a workpiece. The main focus of this paper is on a layered architecture for manufacturing knowledge representation and automated reasoning for operation planning. This is addressed through a discussion of both the knowledge representation structure and the inference mechanism. The proposed layered architecture has been implemented on a microcomputer using PROLOG. The results are satisfactory. (Edited author abstract) 10 refs.

Wang, Hsu-Pin (State Univ of New York at Buffalo, Buffalo, NY, USA). *Comput Ind Eng* v 14 n 2 1988 p 201-210.

**086168 IMPROVING PRODUCTION PLANNING AT AN INDUSTRIAL ENTERPRISE.** The organization of the production planning system is validated using a plan to supply customers with product, allowance being made for the transportation resources allocated. (Author abstract)

Belous, N.P.; Boguslavskii, E.I.; Ponomarenko, V.S. *Sov Electr Eng* v 58 n 10 1987 p 71-73.

**086169 METODO PRIMAL DUAL PARA MODELOS DE PLANIFICACION CON COSTES CONCAVOS Y LIMITACIONES DE CAPACIDAD.** [Primal-Dual Approach to the Capacitated Production Planning Problem with Concave Costs]. This paper studies the production planning problem represented by a concave



model subject to capacity constraints. The linear relaxation of the model is analyzed using a primal-dual approach. Solutions to the dual are obtained solving one product uncapacitated models penalizing the capacity restrictions. The restricted primals correspond to feasibility tests of the dual implied solution. The restricted dual informs on the recommended new penalties for the capacity restrictions. The paper concludes with a proposed algorithm to select the increasing penalties to guarantee monotone improvements toward the optimal solution. (Author abstract) 7 refs. In Spanish.

Onieva, L. (Univ de Sevilla, Sevilla, Spain); Lozano, S.; Larraneta, J.; Ruiz Usano, R. *Questio* v 11 n 2 1987 p 117-133.

**086170 HIERARCHICAL APPROACH TO THE PROCESS PLANNING PROBLEM.** A hierarchical approach to the process planning problem in manufacturing systems is presented. The model developed consists of the following three subproblems: (1) the tool path selection, (2) the tool path sequencing and (3) the process selection. These problems lead to three distinct combinatorial optimization problems which are characterized and for which solution procedures are discussed. (Author abstract) 12 refs.

Kusiak, Andrew (Univ of Manitoba, Winnipeg, Manit, Can); Finke, Gerd. *Discrete Appl Math* v 18 n 2 Nov 1987, Rio Conf on Comb Optim, Rio de Janeiro, Braz, Jul 8-19 1985 p 175-184.

**086171 ON SIMILARITIES BETWEEN LOT SIZING AND CLUSTERING.** The focus of this paper is on connections between lot sizing and cluster analysis. The similarities between integer programming formulations for minimizing the total within-clusters sum of squares in cluster analysis, and the single item uncapacitated lot sizing problem, are discussed. The development of heuristics in cluster and analysis is expected to benefit from this comparison. (Author abstract) 18 refs.

Weeda, Piet J. (Univ of Twente, Enschede, Neth). *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 65-69.

**086172 ANALYSIS OF HEURISTIC TRIM-LOSS ALGORITHMS.** In industry, a wide variety of materials, such as steel, glass or paper has to be cut into smaller pieces to fulfill production requirements or to satisfy customers' needs. This study concentrates on low order polynomial algorithms to get near optimal solutions for such problems. Four of these algorithms were presented in papers by Coffman et al. and Sleanor in 1980. Additionally two improved algorithms for the two-dimensional trim-loss problem are developed. In an extensive computational analysis it is shown that one of the improved heuristics yields solutions better than or equal to the others in more than 90% of all analyzed problems. (Author abstract) 2 refs.

Rode, Mathias (Univ of Paderborn, Paderborn, West Ger); Rosenberg, Otto. *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 71-78.

**086173 SURPLUS OR DISPOSAL QUANTITIES IN OPTIMAL PROGRAM PLANNING IN JOINT PRODUCTION.** For an optimal design of a production program in joint production (multi-product output from one raw material) one has to take into account that partial quantities of production have to be included which can neither be used within the production process nor marketed. These quantities are called surplus or disposal quantities. The paper is concerned with the question to what extent the optimal design of a production program in joint production is affected by variable disposal costs and maximum disposal quantities, while all the other data remain constant. For this purpose we start from a generalized formulation approach based on a linear programming model with parametrically variable disposal costs and maximum disposal quantities. The results show that deliberately allowing for surplus quantities under

profit aspects is still advantageous, even if comparatively high disposal costs have to be taken into account. (Edited author abstract) 13 refs.

Fandel, Guenter (Fernuniversitaet Hagen, Hagen, West Ger). *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 143-158.

**Project Management** See Also INDUSTRIAL PLANTS—Modernization; PAPER AND PULP MILLS —Process Control; QUALITY ASSURANCE—Management; QUALITY CONTROL—Management; SCHEDULING—Mathematical Models.

**086174 SEEKING CLARITY IN INDUSTRIAL ORGANIZATIONAL PROJECTS.** Many industrial firms have undertaken large internal projects aimed at boosting productivity and competitiveness. They include major changes in the existing product programme, in the production system, and in the organization. Many divisions, sections and employees are to be involved. Such projects differ from traditional productivity improvement projects and from projects on designing and erecting engineered facilities. The paper characterizes such large internal, industrial projects. It is argued that seeking clarity is a countermeasure in the complex and fuzzy world in which many industrial projects are imbedded. Four methods for increasing clarity in complex organizational projects are proposed and discussed. (Edited author abstract) 5 refs.

Riis, Jens Ove (Technical Univ of Denmark, Lyngby, Den). *Proj Manage in Prog: Tools and Strategies for the 90s, Int Resour on the Appl of Ideas, Knowl and Exper Concern Proj and Proj Manage* Publ by North-Holland, Amsterdam, Neth and New York, NY, USA p 77-83.

## Quality Assurance

**086175 OPTIMAL DEVELOPMENT TESTING POLICIES FOR PRODUCTS SOLD WITH WARRANTY.** This paper deals with product development to improve product quality. It examines two stochastic models incorporating development testing and derives the optimal testing plans to minimize expected costs for products sold with warranty. (Author abstract) 8 refs.

Murthy, D.N.P. (Univ of Queensland, St. Lucia, Aust); Nguyen, D.G. *Reliab Eng* v 19 n 2 1987 p 113-123.

## Quality Control

**086176 LE CONTROLE DE LA QUALITE DES FABRICATIONS. [Manufacturing Quality Control].** Non-destructive testing is widely used during manufacture and assembly of power plant components, in order to assess the quality of the finished parts. Selection of the appropriate technique and interpretation of the results often require complete knowledge of the manufacturing process, and the most likely types of potential defect. Controllability is strongly dependent on material selection and component design. Standardization of practices and specification of acceptance criteria must be based on extended field experience. Testing reliability can be improved by automatic systems and data processing. (Author abstract) In French.

Colot, Yves (EDF, Evry, Fr); Donati, Jean-Roger. *Epure* n 16 Oct 1987 p 15-23.

**086177 WITHOUT MUDA, MURI, MURA.** The author discusses how construction companies in Japan are using quality control techniques to produce a high quality product at a reasonable cost, quickly and safely. Seven quality control techniques are used: Pareto diagrams, histograms, cause-and-effect diagrams, checkup sheets, scatter diagrams, control charts and time-series diagrams, and stratifications. Quantitative quality control is achieved by statistical methods.

Shoji, Mikio (Kajima Corp, Jpn). *Mech Eng* v 110 n 1 Jan 1988 p 41.

**086178 GAINING SUPPORT IN THE QUALITY BATTLE: A FORD SUPPLIER SPEAKS OUT.** It is

argued that the trend toward higher quality products is no longer a trend, but a fact of life. If one cannot produce a top quality product backed by a quality program, the customers may just take their business elsewhere. Examples are cited from the automotive industry.

Parrish, Rod (Manufacturing Systems, Pleasant Lake, IN, USA). *Manuf Syst* v 6 n 5 May 1988 p 77-78.

**086179 SAE QUALITY AND PRODUCTIVITY CONFERENCE PROCEEDINGS.** This conference proceedings contains 7 papers discussing quality considerations in production engineering. The advantages of the use of robots in areas such as assembly, welding, sealing, parts handling, and painting are illustrated. Quality considerations starting from the design process are discussed. One paper discusses the use of Computer Integrated Manufacturing techniques combined with the Manufacturing Automation Protocol (MAP) to achieve better quality products. The major elements of the Total Quality of Performance (TQP) are evaluated, and aspects are discussed of world competition issues. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10759 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (SAE, Warrendale, PA, USA). *Proc Soc Automot Eng* P-166, SAE Qual and Prod Conf Proc, Dearborn, MI, USA, Sep 24-25 1985. Publ by SAE, Warrendale, PA, USA, 1985 64p.

## Reliability

**086180 COMPLEX APPROACH TOWARDS FAP RELIABILITY.** Measures for ensuring reliability of FAP and its subsystems at various stages of designing, implementation and service are described. Special attention is drawn to majority redundancy of terminal control systems of technological modules. A complex program is shown to be a necessary means of FAP reliability. (Author abstract) 3 refs. In Russian.

Vereikin, V.V.; Morozov, Yu.M.; Nekrasov, S.P.; Cherkasov, G.N. *Tr Leningradskii Politekh Inst im M I Kalinina* n 419 1986 p 18-21.

**086181 SYSTEMS RELIABILITY AND THE AMTA PROJECT.** The promise of advanced manufacturing technology (AMT) is one of high productivity, high quality, lower labor costs, minimum work in progress, all this in return for higher capital investment. To achieve these goals high utilization is a primary requirement. This is a situation which exists in the power generation and process industries where availability and reliability are considered as basic design parameters. A pilot project concerned with integrated manufacturing systems, but also including conventional machines was carried out in conjunction with the Production Engineering Research Association (PERA) and a number of leading firms with the support of the Department of Trade and Industry (DTI). This focused on failure data collections and analysis because this was what most of the firms felt that they needed primarily and because the NCSR Data Bank had as then insufficient specific data to meet the firm's needs. This project enabled NCSR to develop the methods already in use more widely for reliability data collection and analysis to suit this particular requirement and take advantage of high-tech developments in computerized data bases which were concurrent.

Anon. *Prod Eng (London)* v 67 n 5 May 1988 p 49-50.

## Research See Also MARKETING—Management

**086182 PREDICTION OF THE SYSTEM EFFICIENCY OF BALANCED AUTOMATIC TRANSFER LINES.** This paper presents a simulation study of the system efficiency, in terms of production rate, of automatic transfer lines. A particular type of system, referred to as balanced automatic transfer lines, is considered in the study. In such a balanced automatic transfer lines, the situations are considered identical in terms of availability and the buffers are uniformly allocated, and only four



system design parameters are involved, namely the number of situations, the identical failure and repair rates, and the uniform buffer capacity. Based upon simulation results, an empirical production rate equation is established by using available optimization techniques for fitting non-linear functions. (Edited author abstract) 31 refs.

Ma, X. (Univ of Bradford, Engl); Kochhar, A.K. *Proc Inst Mech Eng Part B* v 202 n B1 1988 p 51-59.

## Reviews

**086183 EPISTEMOLOGICAL ANALYSIS OF PRODUCTION ENGINEERING.** This paper outlines the perspectives of production engineering in terms of post-industrial conditions and aggregated informations in the forms of knowledge. This outline will be used to extrapolate what the desired life style of most members of 'Post-industrial Society' will be, along with the associated productivity demands. Finally the definition of Producting Engineering is given. (Edited author abstract)

Bhattacharyya, Amitabha (Jadavpur Univ, Calcutta, India). *J Inst Eng India Part PR* v 68 pt PR 3 Mar 1988 p 61-64.

**Robot Applications** See ROBOTS, INDUSTRIAL—Selection.

**Safety Codes** See INDUSTRIAL MANAGEMENT—Accident Prevention.

**Scheduling** See Also PRINTED CIRCUITS—Manufacture; SCHEDULING—Computer Applications.

**086184 SCHEDULING TO A COMMON DUE DATE ON PARALLEL UNIFORM PROCESSORS.** We consider scheduling a set of jobs on parallel processors, when all jobs have a common due date and earliness and lateness are penalized at different cost rates. For identical processors, the secondary criteria of minimizing makespan and machine occupancy are addressed. The extension to different, uniform processors is also solved. (Author abstract) 4 refs.

Emmons, Hamilton (Case Western Reserve Univ, Cleveland, OH, USA). *Nav Res Logist* v 34 n 6 Dec 1987 p 803-810.

**086185 EVALUATION OF STATIC FLOWSHOP SCHEDULING HEURISTICS IN DYNAMIC FLOWSHOP MODELS VIA A COMPUTER SIMULATION.** This paper provides an evaluation of static flowshop scheduling heuristics for minimizing makespan as an objective function in the dynamic flowshop model. A total of 16 scheduling heuristics including several revisions and combinations of previously reported methods are summarized. The scheduling rules are evaluated via computer using a SLAM discrete event simulation model. The results for the simulation are analyzed using statistical methods. The results from the study suggest which of the popular scheduling heuristics hold promise for application to practical dynamic flowshop problems. (Author abstract) 17 refs.

Park, Yang Byung. *Comput Ind Eng* v 14 n 2 1988 p 103-112.

**086186 PRODUCTION SCHEDULING ON PARALLEL MACHINES SUBJECT TO STAIRCASE DEMANDS.** Given is a set of  $m$  unrelated machines working in parallel and a set of  $n$  independent products which have to be produced on these machines using  $p$  additional resources. A machine cannot work on more than one product at a time but a product can simultaneously be produced on different machines. For each triple (machine, product, resource) productivity per time unit is given. The objective is to minimize the total penalty following from deviations above and below production plans. The sum of machine setup costs is considered as a secondary performance measure. The problem is solved by an extension of the two phase method, Phase 1 consists in solving an LP problem and Phase 2 is the construction of the schedule which reduces to a sequence of compatible flow problems.

(Edited author abstract) 7 refs.

Slowinski, Roman (Technical Univ of Poznan, Poznan, Pol). *Eng Costs Prod Econ* v 14 n 1 May 1988 p 11-17.

**086187 MULTICRITERIA SCHEDULING OF DYNAMIC PRODUCTION ACTIVITIES.** In this paper we study multicriteria production scheduling problems in which  $n$  parallel activities must be performed using continuous, renewable resources of  $s$  types. Each activity is characterized by a continuous function relating its performing speed to the amounts of resources allotted at every moment, and by the demand for the product resulting from its performance. The goal is to find optimal (in a vector sense) amounts of resources and the schedule length or the maximum lateness. We show how to reduce the scheduling problems to non-linear vector-optimization problems for given classes of activity models. (Author abstract) 7 refs.

Weglarz, Jan (Technical Univ of Poznan, Poznan, Pol). *Eng Costs Prod Econ* v 14 n 1 May 1988 p 19-24.

**086188 LOCAL SEARCH APPROACH TO FLEXIBLE FLOW LINE SCHEDULING.** Local search methods are presented for scheduling a flexible flow line. The authors consider the problem of entry point sequencing, that is, deciding the order in which to present the jobs to the system. Results on test and realistic problems are described. The strength of the approach lies in its ability to take into account various line phenomena, such as setups, finite buffers, blocking and starvation, machine breakdowns and downtimes, and the current and subsequent states (at rescheduling intervals) of the line. The technique developed uses local perturbation to successively obtain improved schedules. In test cases where the optimal schedule is obtainable, solutions are produced within a few percent of the optimal. A new method is described for choosing starting sequences for local search methods which is based on the use of sphere partitions. (Edited author abstract) 14 refs.

Kochhar, Sandeep (Harvard Univ, Cambridge, MA, USA); Morris, Robert J.T.; Wong, Wing S. *Eng Costs Prod Econ* v 14 n 1 May 1988 p 25-37.

**086189 SCHEDULING SYSTEM FOR HIGH TECHNOLOGY PRODUCTS.** A production scheduling for high technology products is extremely cumbersome due to the high uncertainty and complexity associated with the production process. A real time scheduling system was developed at a large scale, electronics plant to deal with this problem. The conceptual design and the methodologies used will be discussed. Some findings as a result of implementing the pilot system will be presented. (Author abstract). 6 Refs.

Tonegawa, Koichi (Nagoya Univ, Jpn). *Int J Policy Inf* v 12 n 1 Jun 15 1988 p 117-126.

**086190 DECOMPOSITION PRINCIPLES APPLIED TO THE DYNAMIC PRODUCTION AND WORK-FORCE SCHEDULING PROBLEM.** One of the most important problems in the production and inventory planning field is the scheduling of production and work force in a dynamic environment. Although this problem can be formulated as a linear program, it is often quite difficult to solve directly, due to its large scale. Instead, it might be fruitful to use a decomposition approach. Decomposition, in general, means decomposing a difficult problem into several easier, or a sequence of easier problems which are later coordinated to reconstruct the original problem. In this report we discuss several possibilities of applying the most common decomposition principles, namely Benders (primal) and Dantzig-Wolfe (dual), as well as a relatively new decomposition method, called cross decomposition, to the dynamic, multiproduct production and employment planning problem. A number of special cases are also presented. (Author abstract) 16 refs.

Aardal, Karen (Linköping Inst of Technology, Linköping, Swed); Ari, Aysen. *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 39-49.

## Simulation

**086191 SIMULATION VON FERTIGUNGSABLAUFEN - BERECHNUNG DES MITTLEREN BESTANDES UND DER MITTLEREN DURCHLAUFZEIT MIT NEUEN WARTESCHLANGENMODELLEN.** [Simulation of Production Processes - Calculation of the Average Inventory and of the Average Processing Time on the Basis of New Queueing Models]. The simulation of production processes gains increasing importance for the planning and control of production plants. Methods have been used exclusively up to now which simulate the observed events stepwise in the form of a deterministic simulation model. An alternative is the reproduction of the same process on the basis of the queueing model, which may be called stochastic simulation. Queueing models, however, have so far not been successful in practice for this type of application as they are too inaccurate. This paper explains the reasons for this lack of accuracy and introduces two new queueing models for the calculation of the average inventory and of average processing time specifically for workshop manufacturing. A comparison with measured operational data and deterministic simulation results show that the model is suitable for practical conditions. (Edited author abstract) In German. 7 refs.

Wiendahl, Hans-Peter; Lorenz, Wolfram. *VDI Z* v 129 n 12 Dec 1987 p 38-45.

**South Africa** See METAL FORMING—Efficiency.

**Space Applications** See SATELLITES—Marketing.

## Technology Transfer

**086192 POWER OF TAGUCHI METHODS TO IMPACT CHANGE IN U.S. COMPANIES.** New quality technology based on Taguchi Methods was first introduced to the U.S. automotive industry in March 1982. What evolved are fundamental changes in US engineering and quality control methods which greatly changed in the operating aspects of US companies. These operational changes will drive further improvement in the competitive position of all US industries. The ultimate benefit of Taguchi Methods education, training, and application will be to significantly shorten the product development cycle, improve quality, and reduce cost. As a result, many US industries will become more competitive in world markets.

Sullivan, Lawrence P. (American Supplier Inst, Dearborn, MI, USA). *Spring* v 26 n 2 Oct 1987 p 67-73.

**Testing** See PRINTED CIRCUITS—Testing.

**Textbooks** See QUALITY CONTROL—Education.

## Theory

**086193 MANUFACTURING ENGINEERING: THE BIRTH AND GROWTH OF A NEW SCIENCE.** The Hungarian Academy of Sciences officially uses the term 'technical sciences', this term encompasses manufacturing engineering as well as other scientific fields. The author is one among those who do consider the term 'technical sciences' to be legitimate; in his opinion this term must embrace manufacturing science. Manufacturing science consists of knowledge of the manufacturing processes, tools, equipment and systems on the one hand, and the methodology or theory of their planning, design, analysis and synthesis on the other. 4 refs.

Horvath, Matyas (Budapest Technical Univ, Hung). *Rob Comput Integr Manuf* v 4 n 1-2 1988, Manuf Sci, Technol and Syst of the Future, Ljubljana, Yugosl, Sep 12-14 1985 p 285-292.

**United Kingdom** See COMPUTER INTEGRATED MANUFACTURING—Research.



USSR See LOCOMOTIVES, ELECTRIC—Computer Aided Design.

Viscoplasticity See SHEET AND STRIP METAL—Piercing.

## Yugoslavia

**086194 GROUP TECHNOLOGY IN YUGOSLAVIA.** The author describes experience in 'production flow analysis' (PFA) to plan the 'groups' and 'families' for the machine tool factory of the Majejica Co in B Palanka, Vojvodina. This company makes a range of grinding machines and accessories. The groups in the Majejica machine tool factory have now been installed and running for several years. Since then GT has been planned for eight other factories. 4 refs.

Burbidge, John L. *Prod Eng (London)* v 66 n 11 Dec 1987 p 11-13.

**PRODUCTION PLATFORMS** See Also OCEAN ENGINEERING—Economics; PETROLEUM PROSPECTING—Offshore; PIPELINES, SUBMARINE—Structural Analysis; WIRE ROPE—Corrosion Protection.

**086195 SELECTION OF OPTIMAL PLATFORM LOCATIONS.** A new method for finding the optimal platform and best well locations in offshore oil fields is presented to minimize the total drilling cost while the productive potential is maximized. The general mathematical model is defined as a nonlinear mixed-integer programming problem in three-dimensional (3D) space that is solved in a two-dimensional (2D) plane. Graph-theory approach and an alternate-location/allocation algorithm were used sequentially for the solution of this problem. The model has been tested on several actual offshore fields. Some computational results are given for both limited and unlimited platform capacity cases. (Author abstract) 18 refs.

Dogru, Sevgi (Core Lab Inc). *SPE Drill Eng* v 2 n 4 Dec 1987 SPE 10754, p 382-386.

**086196 CUTTING DOWN THE PAPER FOR OFFSHORE PLATFORMS.** If an offshore oil or gas platform is considered as a simple upstream production plant, built on custom designed real estate and operating in a harsh environment, then it is possible to trace the way use of computers on these platforms has developed and separated from the parallel developments of computer usage onshore. In this paper a discussion is given of the use of computers, the advantages and disadvantages that have been learnt to date, and some trends for future development. (Edited author abstract)

Anon. *Pet Times* v 91 n 2217 Dec 1987 p 6, 8.

**086197 FLOATERS GAIN EXPERIENCE AND FAVOUR.** Floating production systems (FPS) have experienced a lack of confidence among oil companies in the past with mistrust towards riser and subsea systems. However, the oil price fall of 1985/86 and significant progress in the design and technical maturity of the FPS have led to it being accepted as a viable alternative to fixed platforms. (Author abstract)

Anon. *Mar Eng Rev* May 1988 p 31.

## Accident Prevention

**086198 LIFTING THE PLATFORMS IN THE EKOFISK FIELD.** The recent events taking place about 300 km of the Norwegian coast were followed with great interest by offshore experts. Six platforms operated by the Norwegian Phillips Petroleum Company in the Ekofisk field situated in this region, had to be lifted 6 m, because of sea bed subsidence. The 6 platforms total a weight of approximately 40,000 t, and 5 of them had to be lifted simultaneously in one operation, because they are connected by various supply conduits and bridges. This successfully completed lifting project is described in this article.

Van Dijk, Janwybe (Hydraudyne Systems & Engineering); Kloeters, Walter. *Erdoel Kohle Erdgas Petrochem*

v 40 n 10 Oct 1987 p 415-418.

## Accidents

**086199 PIPER IN PERSPECTIVE: CAUSES AND REACTIONS.** Over two months after the most devastating disaster ever to strike the offshore industry, several major questions about the incident and its effects remain unanswered. As this is being written, the precise cause of the explosions and fire that destroyed Piper A platform 120 miles NE of Aberdeen has not been officially determined. However, the Piper A disaster has revealed deficiencies in safety practices aboard North Sea platforms involving both design and enforcement. Remedying these deficiencies is a principal goal of inquiries now being conducted by government agencies and Occidental.

Anon. *Ocean Ind* v 23 n 10 Oct 1988 p 35-37.

Assembly See SEMISUBMERSIBLES—Design.

## Cathodic Protection

**086200 USE OF INITIAL CURRENT DENSITY IN CATHODIC PROTECTION DESIGN.** The cathodic protection systems of two platforms installed by Conoco Netherlands in the southern North Sea were based on accepted design criteria. The use of elongated anodes resulted in high initial current densities (CDs) that polarized the structures well beyond the minimum protective potential. The results of surveys conducted a few months and one year after installation are presented. An initial CD on the order of 30 mA/ft<sup>2</sup> (320 mA/m<sup>2</sup>) polarized the structures to -0.95 V with respect to silver-silver chloride reference electrode. It is shown that this initially high CD allows for lowering the maintenance CD. Cost effectiveness will be reflected in a reduced anode weight requirement and added insurance to obviate any need for premature retrofit. (Edited author abstract) 15 refs.

Evans, Sheldon (Conoco Inc, Houston, TX, USA). *Mater Perform* v 27 n 2 Feb 1988 p 9-11.

## Computer Aided Analysis

**086201 SOECO'S COMPUTER PROGRAMS AND SYSTEMS FOR OFFSHORE ENGINEERING.** This paper introduces the offshore engineering computer programs worked out independently by SOECO (Shanghai Offshore Engineering Corporation). These computer programs can be used for static and dynamic analysis of a jacket platform. They can also be adopted for other offshore structural calculations, e.g. jack-ups and semi-submersibles. This enables SOECO to offer a better service for offshore development both at home and abroad. (Edited author abstract)

Lian Gan (Shanghai Offshore Engineering Corp, Shanghai, China). *China Ocean Eng* v 1 n 1 Feb 1987 p 41-50.

## Concrete Construction

**086202 CONCRETE - THE COST EFFECTIVE ALTERNATIVE FOR FLOATING PLATFORM CONSTRUCTION?** A determined bid to convince oil companies that floating platforms with concrete hulls will be cheaper to build and operate than all-steel units is currently being mounted in Norway. Backed by 15 years of construction experience with fixed production installations in concrete, this drive has already evoked a positive response from several operators in Norwegian waters. This article reviews the utilization of concrete as a material for constructing offshore platforms.

Anon. *Mar Eng Rev* Oct 1987 p 32-34.

Construction See Also OIL WELL PRODUCTION—Offshore; SHIPYARDS—Productivity.

**086203 FIRST JACK-UP SIMULATOR WILL TRAIN RIG CREWS.** Jacking accidents have caused total loss of some rigs and major damage to others. To help prevent accidents of this sort, a Houston company

has developed a simulator that will be used to train jack-up crews in proper jacking procedures and emergency responses. Key components of new industry training tool include ability to simulate problems with leg punch-through and leg extraction that can result in serious accidents during critical jacking operations.

Stewart, Bil (Stewart Technology Associates, Houston, TX, USA). *Ocean Ind* v 23 n 5 May 1988 p 44-45, 47-48.

## Control

**086204 CONTROL SYSTEM FOR FLOATING PRODUCTION VESSELS.** Integrated Control systems can play a major part in reducing costs and easing operations of a floating production system. Costs can be reduced during design, construction, commissioning and operations, and savings can also be realized on system configuration and modernization. The main control system for the Balmoral floating production vessel combines distributed digital control with a supervisory computer to provide great design flexibility and plant-wide integration. 2 refs.

Munro, P.A.D. (Honeywell Aerospace & Defense Ltd); Daniel, C.J. *Ocean Ind* v 23 n 5 May 1988 p 30-33.

Corrosion See Also OIL WELL DRILLING—Rigs.

**086205 IMPROVED MONITORING OF BACTERIALLY MEDIATED CORROSION RISKS IN OFFSHORE SYSTEMS.** The major problem encountered by the petroleum microbiologist working in the North Sea oilfields is that of convincing the oilfield engineer that bacterial corrosion is a subject worthy of serious attention. Although many bacteria play a role in bacterial corrosion, the chief culprits are the sulfate-reducing bacteria (SRB). The SRB constitute a diverse group of bacteria which are characterized by two major factors in their metabolism. Firstly, they grow only under strictly anaerobic conditions; i.e. in the complete absence of molecular oxygen. Secondly, their growth is always associated with the production of sulfide; either as hydrogen sulfide, or as precipitated iron sulfide. The production of sulfide is due to the reduction of sulfate during the metabolic processes essential for growth. In this study the problem addressed was that of the potential for sulfide mediated corrosion processes to proceed in specific areas during offshore operations in the North Sea. 21 refs.

Maxwell, Stephen (Corrosion Specialists (North Sea) Ltd, Aberdeen, Scotl). *Q J Tech Pap Inst Pet* Jul-Sep 1986 p 1-25.

## Corrosion Protection

**086206 PROTECTION STEEL LEGS.** When the gas platforms were being designed for Morecambe Bay it was realized that conditions would be more demanding even than those in the North Sea. To obtain an economic life the steel legs of the platforms had to be protected from corrosion, abrasion and biofouling caused by the sea. This article discusses the techniques employed.

Anon. *Mar Eng Rev* Apr 1987 p 20-21.

Design See Also OFFSHORE STRUCTURES—Design; OIL WELL PRODUCTION—Offshore; OIL WELL PRODUCTION—Sub-sea Production System.

**086207 DESIGN OF PRODUCTION FACILITIES FOR FLOATING OFFSHORE PLATFORMS.** The authors shed some light on current progress and experience gained in the design of floating production facilities. Operators are moving towards subsea completion, with specially designed wellheads installed on the sea bed, and floating production facilities (FPFs) to help improve the economics of new field development. An FPF may be a barge, a tanker, a semi-submersible or a tension leg platform. The most common technical and economic considerations which favour FPFs, apart from possible lower initial capital costs are: the shorter schedule for overall project completion which improves cash flow by



advancing the start of production; improvement of field appraisal by extended production testing from initial wells; use on small fields with short production life, even in shallow waters. The various types of floating facilities, such as tankers which have been converted, semi-submersibles, and the tension leg platform are discussed. Process facilities on the fixed platform are also detailed. Oil production process design and riser systems are also discussed.

Head, John (John Brown Engineers & Constructors Ltd, London, Engl); Rumley, Jim. *Chem Eng (London)* n 432 Jan 1987 p 17-21.

**086208 SEMI-SUBMERSIBLE FLOATING PRODUCTION VESSEL FOR ICE INFESTED WATERS.** At the present time there is considerable interest in Floating Production Systems and many new designs are emerging. Many of these new designs tackle the problems of deep water and small accumulations. This paper describes a semi-submersible production vessel designed by Floatech and Submarine Engineering for use in an icy environment, an alternative 'way forward' for Floating Production Systems. Two versions of the SSPV design have been produced, one equipped for drilling and the other without. This paper is concerned with the non-drilling version and describes the special features of the design which enable it to be used in the harsh environment such as that found off the Newfoundland Grand Banks.

Jordan, P.A. (Floating Technology Co); Haavie, T.O. *Q J Tech Pap Inst Pet* Jan-Mar 1986 p 19-35.

**086209 PRODUCTION DESIGN FOR FLOATING PLATFORMS.** The anticipated motion of a floating production facility (FPF) has considerable impact on the design of motion-sensitive process equipment. The FPF design contractor normally defines that motion under 'design sea conditions', and it is important that such data are made available early in the design program because some items of motion-sensitive equipment may be on long delivery schedules. A discussion is presented of the effects of motion on equipment performance such as separators, oil treaters, tray columns, liquid knock-out drums and instrumentation. Design layout considerations are addressed along with environmental limitations.

Head, John (John Brown Engineers & Constructors Ltd, London, Engl); Rumley, Jim. *Chem Eng (London)* n 438 Jul 1987 p 17-22.

**086210 DESIGN AND ITS TECHNICAL ASPECTS FOR FLOATING PRODUCTION AND TESTING SYSTEM (PTS).** The PTS (Production and Testing System) was conceptually developed by K/S Petrojarl I A/S, Norway as the prototype of its kind, and was designed in detail and constructed by Nippon Kokan K.K. It is a ship type floating production unit, adopting the turret mooring system. Due to the motion and moored condition of the floating hull, the production systems and facilities are susceptible to certain limitations of each function. This report presents measures to lessen the hull's motion and upgrade mooring, position keeping and other functions so that each system and facility are effectively and economically operated in safety under the environmental offshore conditions. (Author abstract) 3 refs.

Jibiki, Yoshimichi (Nippon Kokan K.K., Jpn); Watanabe, Toshihiro; Sato, Shoichi; Yamauchi, Hachiro; Komiya, Haruhiko; Ishida, Sho. *Nippon Kokan Tech Rep Overseas* v 50 Sept 1987 p 62-73.

**086211 UNIQUE PLATFORM DESIGN STUDIED FOR 2,000-FT WATER.** Doris Engineering of France has designed a hybrid compliant tower/fixed jacket platform called the Delta Tower, which might be used to develop ultra-deep water oil and gas fields in the U.S. Gulf of Mexico. Recently, 10 oil companies joined with Doris in a joint industry project to further investigate the potential of the idea. The project involves a compliant tower attached to the top of a fixed jacket. The tower can move with the waves, pivoting on top of the jacket and effectively filtering-out most of the dynamic wave loading. The fixed jacket transmits the remaining loads to the

foundation. This article describes the preliminary design of the structures for a payload of 15,000 tons in water depths to 2,000 ft for Gulf of Mexico environmental conditions.

Anon. *Ocean Ind* v 23 n 4 Apr 1988 p 58-59.

**086212 NEW PLATFORM DESIGNS MAKING GULF OF MEXICO ENTRANCE.** Oil and gas operators in the Gulf of Mexico, as well as the rest of the world, have shifted their focus to reducing costs of bringing oil and gas reserves on stream and development and use of better technology. Smaller fields in deeper waters located farther from consuming areas require greater efficiency. Most oil and gas companies see the subsea-based production system and the tension-leg platform as the two best-developed methods now available to the industry for very deep water. Each has its advantages, and both systems likely will be applied in the Gulf of Mexico many times. Several state-of-the-art production systems have recently been installed or are planned in the next several years in the Gulf of Mexico. Placid installed the first floating production system in 1540-foot waters in the Gulf of Mexico's Green Canyon area in late 1987/early 1988; it is the first system to be developed for permanent use with survivability in 100-year hurricane conditions. Bullwinkle, the world's tallest fixed steel production platform, made out of prefabricated components, was scheduled to be installed in May 1988 in 1353-foot waters in the Green Canyon area offshore Louisiana. Another new type of oil production platform being marketed for the Gulf of Mexico is the French design Roseau tower, a compliant structure.

Pagano, Susanne S. (Sea Technology, Arlington, VA, USA). *Sea Technol* v 29 n 4 Apr 1988 p 15-17.

**086213 INNOVATIVE TLWP IS KEY TO DEVELOPMENT OF DEEP WATER FIELD.** Since Conoco first announced plans early last year for the first tension-leg well platform (TLWP) for the Gulf of Mexico, this single project has created significant interest within oil and gas industry circles. The Du Pont Company subsidiary captured the limelight in the oil and well platform, a shallow-water tie-back platform to handle production, pipelines, and the drilling of wells. This is the largest domestic offshore project in Conoco's history and the U.S. debut for tension-leg technology, which will substantially reduce the exorbitant cost of deep water oil development.

Pagano, Susanne S. (Sea Technology, Arlington, VA, USA). *Sea Technol* v 29 n 4 Apr 1988 p 19-20.

**086214 TLP DESIGN ENGINEERED FOR CAREFUL COST CONTROL.** Tension leg platform (TLP) technology has developed rapidly and diversified over the last 4 years as operators seek systems for deepwater production needs. GVA has presented a TLP design to U.S. Gulf Coast operators which aims to refine and optimize TEP technology. In its main outlines, GVA's TLP concept resembles its semi-submersibles and the floating production vessel built for Sun Oil's Balmoral field. Structural innovations in the TLP concept include a new type of open deck, an all-welded design for column-/pontoon nodes and close consideration of cost-effective fabrication techniques. They have been developed to provide an efficient, strong, lightweight structure suitable for low-cost construction methods. 4 refs.

Anon. *Ocean Ind* v 23 n 6 Jun 1988 p 31-34.

**086215 UNIQUE DESIGN, STRICT OPERATING RULES MARK ZUIDWAL FIELD.** Some 18 years after discovery, and after 14 years of negotiations to obtain a production permit, a gas field in the environmentally sensitive Waddenzee along the Dutch coast is scheduled to go onstream this fall. Zuidwal field will begin producing October 1 from an unusual platform, and under strict operating rules. For instance, there can only be a single unmanned drilling platform, designed to blend into the surroundings. Processing on the platform is restricted to simple dehydration. No solids or liquids are allowed into the waters; all liquids, including rain water, are collected

in containers and taken ashore by barge. Flaring at night is forbidden and the platform does not have the myriad lights that festoon platforms in the North Sea. In addition, there are strict limitations on noise. All visits are by boat, since helicopters are banned except in emergencies and hovercraft are forbidden.

Anon. *Oil Gas J* v 86 n 33 Aug 15 1988 p 44-46.

**Economics** See OFFSHORE STRUCTURES—Design.

**Equipment** See OPTICAL FIBERS—Applications.

**Fabrication** See OFFSHORE STRUCTURES—Construction.

**Inspection**

**086216 MODU MARINE SAFETY: STRUCTURAL INSPECTION AND READINESS SURVEYS.** Several years ago, Exxon instituted a survey of mobile offshore drilling units (MODU's) under contract to the corporation to evaluate structural integrity and readiness to respond properly to marine emergencies. This paper briefly describes results of the inspections and our on-going marine safety program. Industry activity is also highlighted. (Author abstract) 2 refs.

Cole, M.W. (Exxon Co Int); Marucci, T.F.; Taft, D.G. *JPT J Pet Technol* v 39 n 11 Nov 1987 p 1437-1440.

**Maintenance**

**086217 MAINTENANCE OF RIGS IN LAY-UP.** The collapse in crude oil prices has resulted in many rigs being laid-up awaiting further work. Each representing an investment of as much as \$100M, these rigs must be preserved in good working order. This article explains how.

Thomas, J.W. (BP Shipping's Lay-Up Services Branch). *Mar Eng Rev* Apr 1987 p 17-18, 21.

**Materials**

**086218 DEVELOPMENT OF ULTRA-HIGH-GRADE STEELS FOR MOSSGAS.** In South Africa, Iscor will be producing approximately 60 000 tons of steel for the production platform and 84km-long dual pipeline of the Mossel Bay liquid fuel from gas project after having been accepted as supplier of the ultra-high grade steels required for the offshore development. Most of the steel will be a special version of BS 4360 grade 50E. About 1 800 tons of a lower strength grade will be required, as well as a small tonnage of seamless tubes. The article describes the development of the special steels.

van Wyk, Willem (Iscor). *S Afr Mech Eng* v 37 n 10 Oct 1987 p 509, 511, 513.

**086219 HIGH PERFORMANCE MATERIALS.** For the extraction of oil or gas from the sea bed, as in few other industries, material selection and design require greater attention in order to achieve a predictable life expectancy through correct choice of material and its correct installation. There are a number of critical areas on a platform involving materials resistance to elevated temperatures and corrosion. This paper seeks to evaluate the choice of high-performance materials for various applications and present some guidelines for selection, with special reference to the reliability of the various options in available fabrication and welding processes. Attention is drawn to the use of titanium alloys, nickel alloys and austenitic high molybdenum alloys, duplex steels and copper base alloys. (Author abstract). 6 Refs.

Taylor, M.D. (VDM Technology). *FWP J* v 28 n 5 May 1988 9p.

**Mooring**

**086220 STUDY LOOKS AT SYNTHETIC FIBER ROPE FOR DEEP WATER RIG MOORING.** Omega Marine Services International (OMSI) of Houston, Texas, has organized a team to conduct a Joint Industry Project



to assess the readiness of synthetic-fiber rope for use in deep water moorings. Several synthetic fibers hold potential for application to deep water moorings. A good start has been made toward qualifying the aramid fiber Kevlar for such an application. It has been tried unsuccessfully as the mooring line material for a derrick vessel during the insulation of Exxon's Lena guyed tower, but subsequent mooring system tests have been successful. OMSI will perform a testing program designed to provide statistically meaningful results. A minimum of three test specimens will be used in each test to provide a statistical confidence level. The focus of the testing will be on the wet breaking strength, wet cyclic load testing, and wet fatigue life (durability) of the rope.

Hervey, Don (Omega Marine Services Int). *Sea Technol* v 29 n 7 Jul 1988 p 10-14,16.

#### North Sea See Also OFFSHORE STRUCTURES—Earthquake Resistance.

**086221 ELEVATION OF EKOFISK.** In the North Sea, six of the nine platforms on the Ekofisk Complex have been elevated some 20 feet to compensate for an increase in water depth caused by subsidence of the ocean floor. Since production began in 1971, subsidence is estimated to be about 12 feet. This article briefly describes the major steps in the elevation project.

Anon. *Pet Rev* v 41 n 488 Sep 1987 p 4-7.

#### Painting See OFFSHORE STRUCTURES—Protective Coatings.

#### Removal See Also OFFSHORE STRUCTURES—Removal.

**086222 REMOVAL AND ABANDONMENT OF OFFSHORE PLATFORM TOPSIDES.** In European waters there are approximately 215 fixed steel platform installations, many of which are small and weigh only hundreds of tonnes. There are also 18 concrete platforms. At some time in the future these installations will have to be removed partially or totally. The first part of this paper reviews the extent of work necessary to remove the 'topsides' of such platforms. The paper also considers the possibility of demolishing steel platforms at their installed site by toppling them to the sea bed, where water depth permits this kind of operation. The final part gives an indication of the costs. (Edited author abstract)

Boyd, Norman (Taylor Woodrow Offshore Ltd). *Q J Tech Pap Inst Pet* Jul-Sep 1987 p 43-45.

**086223 NEW CONNECTOR PROMISES EASY PLATFORM REMOVAL.** Houston-based Offshore Technologists Ltd. is developing a simple, positive, permanent pile connector with a releasable mechanism that will eliminate the need for grouting in main and skirt pilings. The releasable feature will greatly facilitate removal of future offshore platforms. The connection will be particularly economical for applications where grouting would involve significant use of costly offshore construction equipment.

Anon. *Ocean Ind* v 23 n 6 Jun 1988 p 39.

**086224 FIRST PLATFORM REMOVAL FROM DUTCH SHELF.** Pennzoil Nederlands Co., faced with the prospect of removing an obsolete platform from a depleted field in the Dutch North Sea, recently opted to remove the six-pile satellite platform from its Block K/13-D gas field in 85-ft water. The platform removal, successfully undertaken by Heerema, is the first oil and gas installation to be removed from the Dutch Shelf and only the second such undertaking in the North Sea. The removal sequence selected by Heerema engineers called for the entire structure to be removed in three separate lifts using the company's semi-submersible crane barge (SSCV) Balder.

Anon. *Ocean Ind* v 23 n 6 Jun 1988 p 42.

#### Repair See Also OFFSHORE STRUCTURES—Repair.

**086225 TEMPORARY PIPELINE PLUG SAVES TIME AND MONEY.** Phillips Petroleum Co. used a unique temporary plug to block a 36-in. gas line during its recent Ekofisk field repair that involved jacking up seven steel platforms and all associated equipment and piping to compensate for subsidence. The HydroTech Sub Sea Systems Ltd. dual module HydroPlug prevented blow-down of some 90 mi of pipeline to atmospheric pressure between Ekofisk and the nearest pumping station which was also the closest shut-in point on the pipeline. Use of the plug saved significant time, a huge waste of gas and much expense, and allowed the jack-up program to begin with a minimum constraint on lead time.

Thomson, Brian (HydroTech Sub Sea Systems Ltd, Aberdeen, Scotl). *Ocean Ind* v 23 n 4 Apr 1988 p 148.

#### Reviews

**086226 HUTTON TLP MARINE OPERATIONS.** This paper reviews the planning and execution of the marine operations for the Hutton tension leg platform (TLP), including well template installation, site preparation, foundation installation, temporary anchorages, mating, major tows, and TLP installation. Planning the work to meet project objectives resulted in the use of a number of new techniques and advanced equipment applications. These included underwater pile hammers and special acoustic equipment to provide positioning information during underwater operations. However, the detailed planning that preceded each operation enhanced the effectiveness of the equipment significantly. Further, it contributed materially to the attainment of first oil only 22 days after TLP installation. (Author abstract) 6 refs.

Hart, H.J. (Conoco (UK) Ltd); White, G.J.; von Fisher, E.L. *JPT J Pet Technol* v 39 n 11 Nov 1987 p 1426-1436.

#### Service Life See OFFSHORE STRUCTURES—Service Life.

#### Testing

**086227 AUTOMATIC STRESSES ACQUISITION AT HOT SPOT OF TUBULAR JOINTS IN THE OFFSHORE DRILLING PLATFORMS.** A new technique which combines photoelastic testing with digital image processing (DIP) technique is described in this paper, from which photoelastic data are acquired, processed and analyzed automatically. The technique has been employed to analyze the hot spot stresses of tubular K and T joints in offshore drilling platforms, and the results are satisfactory. (Edited author abstract) 6 refs.

Wei, Yanan (Shanghai Jiao Tong Univ, Shanghai, China); Qi, Feihu; Wang, Xiangdi; Zhang, Liying; Hu, Cuixian. *China Ocean Eng* v 1 n 2 May 1987 p 33-39.

#### Transportation

**086228 ARTICULATING BARGE CUTS DEEPWATER PLATFORM COSTS.** The ability to tow out and launch platform jackets using conventional barges would seem to be approaching economically feasible limits with Shell Offshore Inc.'s Bullwinkle project. This 1,368-ft structure weighing 50,000 tons required Heerema's newly built 850-ft launch barge, the world's largest, which Bullwinkle nevertheless overhung some 400 ft at the top end. It is likely that another conventional jacket structure or compliant tower even larger than Bullwinkle will be proposed for deepwater production in the Gulf, creating demand for greater launch barge capabilities. If that happens, one of the candidates for consideration will be McDermott International's articulated launch barge concept which the company is now marketing. McDermott claims the articulated barge could provide a launch capability for a 1,600-ft jacket or compliant tower superior to that of a 1,000-ft conventional barge, and at a lower cost.

Anon. *Ocean Ind* v 23 n 6 Jun 1988 p 40-41.

#### Wave Effects

**086229 APPROXIMATE METHOD TO COMPUTE THE DRIFT FORCE ON AN ARRAY OF VERTICAL CYLINDERS.** An approximate method to compute the drift forces on semisubmersible platforms is presented. The platform is supposed to have vertical, circular columns. It is assumed that the drift forces are governed by the scattering of waves from vertical columns only. The interaction between the columns is treated in a simplified manner; only the effects of phase shifts in the wave are included. Under these assumptions the drift forces may be estimated without use of general programs based on diffraction theory. The method is suited for estimating the drift forces on floating platforms at an early design stage before more advanced numerical tools are applied. The drift forces as computed by this simplified approach are compared with the drift forces obtained by use of a panel method approach. For the two platforms used in the comparison the agreement between the two methods is satisfactory. (Edited author abstract) 18 refs.

Nielsen, Finn Gunnar (Norsk Hydro Research Cent, Bergen, Norw). *Appl Ocean Res* v 10 n 1 Jan 1988 p 35-42.

#### Welding

**086230 TRANSFER OF WELDING TECHNOLOGY FOR THE OFFSHORE INDUSTRY.** The Moss-gas project will place demands on material technology and welding engineering for the construction of the fixed offshore platforms. The grade to be used for primary structural components for the project is BS 4360-50E, now locally produced by Iscor in South Africa. In addition other materials for associated pipework will be required covering a range from carbon manganese to duplex stainless steels. The article covers the mechanical properties required for the welds.

Kaljee, Jan (Afrox/Transarc Welding Consumables). *S Afr Mech Eng* v 37 n 10 Oct 1987 p 504-507.

**PRODUCTIVITY** See Also ADHESIVES—Hot Melt; ADHESIVES—Manufacture; BLAST FURNACE PRACTICE—Fuel Injection; BLAST FURNACE PRACTICE—Fuels; BLAST FURNACE PRACTICE—Physical Chemistry; BLAST FURNACES—Stoves; COAL MINES AND MINING—Continuous Miners; CONSTRUCTION INDUSTRY—Nigeria; COPPER MINES AND MINING—Manitoba; EARTHMOVING MACHINERY—Selection; ELECTRIC CABLES—Manufacture; ELECTRIC DRIVE; ELECTRIC POWER PLANTS—Retrofitting; FORESTRY—Equipment; FOUNDRY PRACTICE—Cleaning; FOUNDRY PRACTICE—Investment Casting; GLASS FURNACES—Performance; GLASS MANUFACTURE; GRINDING WHEELS—Bonds; INDUSTRIAL MANAGEMENT; INDUSTRIAL PLANTS—Electric Power; INDUSTRIAL PLANTS—Flexible Manufacturing Systems; IRON AND STEEL PLANTS—Energy Conservation; IRON ORE TREATMENT—Sintering; LATHES, TURRET; MATERIALS HANDLING—Loading; METAL FORMING—Stamping; METAL MELTING—Electroslag Remelting; MINE SHAFTS—Design; PLASMA ARC CUTTING—Automation; POWDER METAL PRODUCTS—Manufacture; PROCESS CONTROL; PRODUCTION ENGINEERING; ROLLING MILL PRACTICE; ROLLING MILLS—Modernization; STEEL—Protective Coatings; STEEL FOUNDRY PRACTICE—Gating and Feeding; TECHNOLOGY—Economic and Sociological Effects; WELDING; WELDING, ELECTRIC ARC—Electrodes; WELDING, ELECTRIC ARC—Submerged Arc; WIRE MILLS—Automation.

**086231 STRATEGY FOR PRODUCTIVITY IMPROVEMENT.** In the strategy described, productivity improvement is not a one-time cost reduction exercise but a continuous ongoing operation. A continuous program can improve the utilization of existing resources at comparatively low cost. The perpetual search for improvement requires innovation and involvement on the part of all concerned, widens the scope of investigation and poses questions not normally considered as opportunity potential.

Worrall, R.G. *Prod Eng (London)* v 66 n 7 Jul-Aug 1987 p 32-33.



**086232 PRODUCTIVITY IMPROVEMENTS THROUGH COMPUTER GRAPHICS: A CASE STUDY.** The Graphic Arts Department of Oak Ridge National Laboratory (ORNL) has used computer graphics for production work since 1979. From the beginning the computer graphics project has been subjected to cost/benefit analysis. As the system has evolved and the work has gotten more complex, the methods used to measure productivity have changed. This paper discusses what productivity enhancements have been gained, how productivity is measured in this changing environment, and what the present trends in productivity indicate for the future. (Author abstract) 17 refs.

Riley, Betsy A.; Slabbekorn, Morris H. *Tech Commun* v 34 n 4 Nov 1987 p 257-263.

**086233 PRODUCTIVITY IMPROVEMENT SYSTEMS FOR MANUFACTURING.** Managing information accurately and efficiently is a key function that allows AT&T to reduce manufacturing costs and improve product quality. Productivity Improvement Systems for Manufacturing (PRISM) is a family of computerized information systems supporting manufacturing execution functions for AT&T's factories. Manufacturing execution includes all factory functions involved from the receipt of materials to the making of final products, including deriving the engineering information guiding these functions. (Author abstract) 2 refs.

Franks, Richard L. (AT&T Bell Lab, Holmdel, NJ, USA); Holtman, James P.; Hsu, John L.C.; Raymer, L. Gary; Snyder, Bernard E. *AT&T Tech J* v 66 n 5 Sep-Oct 1987 p 61-76.

## Analysis

**086234 ROLE OF THE SERVICE SECTOR.** As the economies of the western world swing more and more towards service activity, and those working in production industries contribute service activities within their organizations, measuring output and productivity becomes a vital concern. In this paper an economist studies the issues from a national viewpoint. Many of the ideas are directly relevant at the level of the firm or corporation. (Edited author abstract)

Nankivell, O. *Trans Inst Meas Control* v 9 n 3 Jul-Sep 1987 p 152-164.

**086235 PLANT PRODUCTIVITY MEASURE FOR 'HIGH-TECH' MANUFACTURING.** A total productivity measure was developed as part of an action research productivity analysis project of a manufacturer of computer peripheral devices. The productivity measure had to be appropriate for a broad range of automation levels, yet resolve the long-standing methodological problems of index construction in a manner intuitive to management. The difficulties encountered in attempting to institutionalize the measure point to the need for a compromise with cost accounting. (Author abstract) 20 refs.

Adler, Paul S. (Stanford Univ, Stanford, CA, USA). *Interfaces (Providence RI)* v 17 n 6 Nov-Dec 1987 p 75-85.

**086236 FRAMEWORK FOR PRODUCTIVITY ANALYSIS AT THE ORGANISATIONAL LEVEL: METHOD AND AN APPLIED CASE.** This paper outlines a framework for productivity analysis which enables both partial and total input productivities to be identified in terms of money values and their real (volume) and unit value (terms-of-trade) components. Attention is given to the specification of the production relationship, index number issues and aggregation problems. The framework is applied to a British manufacturing company, some further methodology issues being considered and the results presented. (Author abstract) 12 refs.

Bennett, A. (Univ of Aston in Birmingham, Birmingham, Engl); Hui, J.; Silver, M.S. *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 401-411.

**Computer Applications** See ARTIFICIAL INTELLIGENCE—Expert Systems.

**Control** See CONSTRUCTION INDUSTRY—Costs.

## Economics

**086237 ECONOMIC MEASURE OF PRODUCTIVITY, QUALITY AND FLEXIBILITY IN ADVANCED MANUFACTURING SYSTEMS.** Productivity, quality and flexibility are critical measures of manufacturing performance for justifying the investment in integrated manufacturing and production systems. The objective of this research is to define, quantify and incorporate these three measures. The conventional productivity measure was improved so that it could be used in integrated manufacturing production systems. Quality and flexibility measures were newly defined and quantified. These three measures were integrated for the evaluation of a manufacturing system as a whole. (Author abstract) 24 refs.

Young Kyu, Son (Auburn Univ, Auburn, AL, USA); Park, Chan S. *J Manuf Syst* v 6 n 3 1987 p 193-207.

## Efficiency

**086238 JUST-IN-TIME OVER THE LONG HAUL.** The concept of just-in-time (JIT) used in American industry is discussed, along with its importance in productivity. It is defined as a combination of many elements or objectives to minimize inventories, lower unit manufacturing costs, eliminate waste and inefficiencies, and obtain 'absolute' quality. The JIT philosophy is based on maintaining a smooth and uniform flow of material in manufacturing and distribution - not just into the manufacturing plant, but out to the customer as well. This can be accomplished only when the transportation linkages among the manufacturer vendors and customers are controlled.

Emrich, Mary (Manufacturing Systems, Wheaton, IL, USA). *Manuf Syst* v 6 n 5 May 1988 p 24-25, 28-29.

**England** See COAL MINES AND MINING—England; COAL MINES AND MINING—United Kingdom.

**Evaluation** See INDUSTRIAL PLANTS—Performance.

**German Democratic Republic** See LIGNITE MINES AND MINING—German Democratic Republic.

**Japan** See IRON ORE TREATMENT—Sintering; ROLLING MILLS—Japan.

**Management** See Also MATERIALS HANDLING—Mathematical Models.

**086239 INTERNATIONAL PACIFIC RIM PRODUCTIVITY CONFERENCE.** This conference proceedings contains 32 papers. The main topics discussed are: a review of national productivity programs; productivity measurements of white collar, knowledge intensive staff; objectives matrix/extensions applications; productivity movement/measurement/improvement in Taiwan and Japan; productivity audits; integrated manufacturing and socio-technology approaches; information integration technology; productivity strategy development; goal setting and behavioral approaches; electronic design productivity improvement; comparison of east-west strategies/approaches to productivity enhancement; managerial engineering applications; university role in technology transfer; productivity accounting; industry-academic co-operation; automated storage/retrieval system in Taiwan; total productive maintenance; effects of corporate culture, management style, organization structure on productivity; industrial cooperation; productivity improvement in sales/distribution; relationship between productivity improvement and economic performance. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11216 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Inst of Industrial Engineers, Norcross, GA, USA). *Int Pac Rim Prod Conf, Maui, HI, USA, Feb 12-14 1986*

Publ by Inst of Industrial Engineers, Norcross, GA, USA, 1986 var pagings.

**Mathematical Models** See AGRICULTURAL MACHINERY—Harvesters.

**Measurements** See Also ARTIFICIAL INTELLIGENCE—Expert Systems; COMPUTER AIDED MANUFACTURING—Evaluation.

**086240 PRODUCTIVITY MEASUREMENT IN MULTI-PRODUCT MANUFACTURING FIRMS.** In this paper, a systematic procedure has been described for developing a productwise productivity measurement model in a complex and dynamic multi-product multi-stage manufacturing firm. As the interdependency among various stages of production in a manufacturing firm is to be taken care of for effective monitoring and controlling various 'input' factors, a 'stagewise' productivity measurement is possible and is developed. A hypothetical manufacturing firm has been considered for illustrating the proposed model. Also highlighted are benefits of the resulting model, along with some limitations, with particular reference to conditions prevalent in India. (Author abstract) 9 refs.

Ray, Pradip K. (Indian Inst of Technology, Kharagpur, India); Sahu, S. *Eng Costs Prod Econ* v 13 n 1 Nov 1987 p 39-54.

**086241 METHOD TO MEASURE PRODUCTIVITY: JPL'S PRODUCT INVENTORY SYSTEM.** What is productivity and how is it measured? What does productivity mean to a technical documentation department? Is productivity relevant at all in a technical documentation production environment where all projects are 'special,' demand varying levels of effort, and consume different amounts of time? JPL's Documentation Section 648 measures productivity with its Product Inventory System, which is described in detail here. (Author abstract) 4 refs.

Corbett, John R. (JPL, Pasadena, CA, USA). *Tech Commun* v 34 n 4 Nov 1987 p 225-235.

**086242 DEVELOPING FLEXIBLE PRODUCTIVITY MEASUREMENT MODELS USING SPREADSHEET SOFTWARE.** This paper discusses the development of a series of interactive computer models for measuring productivity. By using LOTUS 123, a series of flexible models were developed which can easily be modified to fit the productivity measurement system used by most companies. Rather than force the company's productivity measurement system to fit an available computer model, a company can now tailor the computer model to exactly fit its productivity measurement system. (Author abstract) 9 refs.

Oden, Howard W. (Worcester Polytechnic Inst, Worcester, MA, USA). *Comput Ind Eng* v 14 n 2 1988 p 161-170.

**Monitoring** See ENGINEERING—Project Management.

**Peoples Republic of China** See IRON AND STEEL INDUSTRY—Peoples Republic of China.

**Planning** See CEMENT PLANTS—Computer Aided Manufacturing.

## Taiwan

**086243 PRODUCTIVITY MOVEMENT AND MEASUREMENT IN TAIWAN: A CASE STUDY.** The paper reviews the history of the productivity movement in Taiwan, including methods to increase productivity. Also a framework of productivity measurement in an integrated steel making corporation is presented. (Author abstract) 7 refs.

Tsong Ming Lin (Nat'l Taiwan Inst, Taiwan); Wann Yih Wu. *Eng Costs Prod Econ* v 13 n 2 Jan 1988 p 97-109.



Testing See COMPUTER AIDED DESIGN—Productivity.

United States See COAL MINES AND MINING—Productivity.

Wales See COAL MINES AND MINING—Wales.

## PROMETHIUM

**086244 ABSORPTION SPECTROPHOTOMETRIC AND X-RAY DIFFRACTION STUDIES OF THE TRIHALIDES OF PROMETHIUM IN THE SOLID STATE.** The anhydrous trihalides of promethium ( $Z=61$ ) were examined by absorption spectrophotometry and X-ray powder diffraction. Room temperature lattice parameters for  $\text{PmF}_3$ ,  $\text{PmCl}_3$  and  $\text{PmBr}_3$  were in agreement with those obtained by F. Weigel and V. Scherer. Two previously unreported crystallographic modifications of  $\text{PmI}_3$  were found. Each compound has been characterized on the basis of its solid state absorption spectrum, in addition to characterization by X-ray powder diffraction analysis. (Edited author abstract). 10 Refs.

Wilmarth, W.R. (Univ of Tennessee, Knoxville, TN, USA); Haire, R.G.; Young, J.P.; Ramey, D.W.; Peterson, J.R. *J Less Common Met* v 141 n 2 Aug 1988 p 275-284.

## Chemical Analysis

**086245 IMPROVED METHOD FOR THE ANALYSIS OF PROMETHIUM-147.** Promethium is co-precipitated with other lanthanide elements using an inactive neodymium carrier. It is then separated from other lanthanides and actinides by cation exchange chromatography in an  $\alpha$ -hydroxy-isobutyric acid ( $\alpha$ -HIBA) medium. The remaining actinides are removed an anion exchange chromatography in a thiocyanate medium. Promethium is then co-precipitated with neodymium and determined by liquid scintillation counting. The method can be applied directly to aqueous samples and to solid samples after an initial dissolution step with a detection limit of about 0.01 Bq per aliquot. (Edited author abstract) 15 refs.

Jerome, S.M. (CEGB, Gravesend, Engl). *Sci Total Environ* v 70 Mar 1988, Environ Radiochem Anal, Proc of the Fifth Symp, Harwell, Engl, Oct 1-3 1986 p 275-298.

PROPANE See Also PLASMAS—Composition Effects.

Adsorption See GASES—Adsorption.

## Applications

**086246 USE OF PROPANE AS COMPLEMENTARY FEED IN A TURBULENCE CHAMBER ENGINE.** The present work describes an experiment during which propane has been injected in the inlet nozzle of a monocylinder Ricardo E-6 type diesel engine (four strokes and turbulence chamber). The influence of propane/fuel ratio (for different loads and rotation speeds) on the power the fuel consumption, the pressure and the exhaust: fumes, nitrogen, dioxides, hydrocarbons and carbon monoxide, has been studied by comparison with operating conditions with fuel only. The study shows that for operating conditions above 60% of the full load, there is a decrease of the specific consumption and a decrease of the exhaust gases temperature as well as a pressure increase and a large decrease of fumes exhaust. The analysis of gaseous pollutants levels shows that they depend on the load conditions and on the mixture ratio of the components, but in every case the difference with respect to the Diesel fuel only operation is small. (Author abstract) 10 refs.

Kouremenos, D.A. (Univ Natl Technique d'Athens, Athens, Greece); Rakopoulos, C.D.; Kotsiopoulos, P. *Entropie* v 24 n 139 1988 p 59-63.

Combustion See Also COMBUSTION; FLAME RESEARCH; FLOW OF FLUIDS—Jets.

**086247 CONTRIBUTION OF THE GAS PHASE REACTION TO THE CATALYTIC COMBUSTION OF PROPANE.** Catalytic combustion is controlled not only by surface reactions but also by gas phase reactions.

When propane is used as the fuel, the contribution of the gas phase reaction becomes significant, and fundamental information about gas phase reactions become important. In the previous study, the significance of gas phase reactions in the catalytic combustion of propane was shown, and rate constants of three step gas phase reactions which can well predict the temperature and concentration profile were proposed. In this study, the contribution of the gas phase reaction to the catalytic combustion of propane was examined quantitatively, and the role of each gas phase reaction was made clear. (Author abstract) In Japanese. 5 refs.

Fuketa, Toyoshi; Miyauchi, Toshio. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 492 Aug 1987 p 2590-2595.

**086248 STUDY ON SOOT FORMATION IN PREMIXED CONSTANT VOLUME COMBUSTION.** The effects of pressure and temperature on soot formation in premixed propane-oxygen-inert gas combustion are investigated over the pressure range of 0.4 to 5.8 MPa and the temperature range of 1000 to 1800 K by using a concentration in the chamber constant volume combustion bomb. The soot concentration in the chamber center during the final stage of combustion at the highest pressure is measured by the in situ laser extinction method. It is found that the soot yield in lower temperatures rises sharply with increasing pressure, but the dependence of pressure gets weaker with higher temperatures, and that the pressure and temperature during the soot formation mainly influence the soot yield. (Author abstract) In Japanese. 19 refs.

Bae, Myung-hoan; Kamimoto, Takeyuki; Kobayashi, Haruki. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 493 Sep 1987 p 2884-2889.

**086249 CHEMISTRY OF PREMIXED HYDROCARBON/AIR COMBUSTION IN A FLUIDIZED BED.** Propane premixed with air in stoichiometric proportions was burned at various bed temperatures in a bench-scale (76 mm i.d.) fluidized bed. An in-bed probe was used to measure the steady-state concentration profiles of the stable chemical species. In-bed burning (bed temperature = 850°C) of the mixture was shown to be a gradual process rather than the sudden, explosive conversion measured during overbed ignition (bed temperature = 750°C). Ironically, the rapid overbed conversion which resulted in the latter case may improve the overall amount of heat captured by the bed due to the more efficient freeboard-to-bed heat transfer nearer the bed surface. (Author abstract) 9 refs.

Van Der Vaart, D.R. (Univ of Cambridge, Cambridge, Engl). *Combust Flame* v 71 n 1 Jan 1988 p 35-39.

Cracking See Also ETHANE—Cracking.

**086250 EFFECTS OF UV LIGHT IRRADIATION ON PROPANE IN AN ARGON PLASMA.** It has been shown that propane conversion into acetylene, by propane cracking in an argon plasma, is increased when the reaction site is irradiated with UV light in the range 220-400 nm. The reactions were carried out between 4500 and 6400 K. A model is outlined following which the propane conversion increase at 6400 K (40%) is tied up to energy absorption by acetylene in the lower wavelengths range (220-250 nm). Also, a combined adsorption-photochemical process, related to precursors and submicron carbon particles, could be responsible for the yield increase observed at 5400 K (45%), around 365.0 nm. (Author abstract) 13 refs.

Meubus, P. (Univ du Quebec a Chicoutimi, Chicoutimi, Que, Can). *Plasma Chem Plasma Process* v 6 n 2 Jun 1986 p 143-157.

## Explosions

**086251 BLEVE: THE PROPANE CYLINDER.** Over the past two decades, there has been a dramatic increase in the use of small, portable cylinders of liquefied petroleum gases at home and at the workplace. These 20-pound cylinders—generally propane or butane—are used

for cooking, home repair torches, lighting, and heating. There also has been a dramatic increase in the number of firefighters killed and injured by explosions of small, portable propane cylinders. This report describes proper handling methods of propane cylinders during fires and BLEVE (boiling-liquid, expanding-vapor explosion).

Dunn, Vincent (New York Fire Dep, Manhattan, NY, USA). *Fire Eng* v 141 n 8 Aug 1988 p 63-65,67-70.

## Ignition

**086252 PROPANE OVER-FILLING FIRES.** The classic propane over-filling fire occurs in cold weather when a container is filled, then brought into a warmer environment. The container may be portable, used to supply heating fuel inside a building under construction, or it may be permanently attached to a recreational vehicle that is brought inside a heated garage to be serviced or parked. After the container has been in the warmer environment for some time, the high-pressure safety relief valve on the propane container opens, venting a large amount of propane which finds a convenient ignition source and ignites. The article examines how over-filling fires start. Tips are given to prevent over-fill fires. The article strongly suggests the need for following proper procedures for filling propane.

De Nevers, Noel (Univ of Utah, Salt Lake City, UT, USA). *Fire J (Boston)* v 81 n 5 Sep-Oct 1987 p 80-82, 124.

Oxidation See HYDROCARBONS—Oxidation.

Phase Equilibria See CARBON DIOXIDE—Phase Equilibria; MIXTURES—Phase Equilibria.

## Photochemical Reactions

**086253 ARYL CYCLOPROPANE PHOTOCHEMISTRY. UNUSUAL AROMATIC SUBSTITUENT EFFECTS ON THE PHOTOCHEMICAL REARRANGEMENT OF (2-ARYLCYCLOPROPYL)-METHYL ACETATES TO 1-ARYLHOMOALLYL ACETATES.** Irradiation of trans(2-arylcyclopropyl)-methyl acetates a 4-butenyl-1-arylacetate (7a,b,d-h) via an ionic mechanism from the singlet state. Similar rearrangements occurred with exo-(1,1a,6,6a-tetrahydrocyclopropyl)inden-1-yl)methyl acetate and the 4-cyano derivative. Excited state reaction rate constants were determined from reactant fluorescence lifetimes and product quantum yields. It is concluded that the rate-determining step involves conversion of the initially formed aromatic excited state to a reactive cyclopropane excited state and that cyclopropane to aromatic ring charge transfer enhances this process. (Edited author abstract) 26 refs.

Hixson, Stephen S. (Univ of Massachusetts, Amherst, MA, USA); Franke, Lothar A.; Gere, Jeffrey A.; Xing, Yi-de. *J Am Chem Soc* v 110 n 11 May 25 1988 p 3601-3610.

## Processing

**086254 ROLE OF GALLIUM SPECIES ON THE DEHYDROCYCLODIMERIZATION OF PROPANE ON ZSM5 CATALYSTS.** The transformation of propane was carried out in a flow reactor. The conversion of propane on HZSM5 (0.2 g) is twice as high as on gallium oxide (0.2 g). It is slightly higher on the equal-mass mixture of HZSM5 and gallium oxide (0.4 g) than on HZSM5 (0.2 g). On gallium oxide, the products of propane transformation are essentially composed of propene (70 wt.%) and of an equimolar mixture of  $C_2$ , mostly olefinic (> 90%), and of  $C_1$ . The results obtained with the mixture of  $\text{Ga}_2\text{O}_3$  and HZSM5 show the transformation of propane on  $\text{GaHZSM5}$  is a reaction of bifunctional catalysis as is the hydroisomerization and hydrocracking of alkanes on Pt zeolites r the dehydrocyclodimerization of propane on  $\text{PtHZSM5}$  or on  $\text{PtAl}_2\text{O}_3$ . 12 refs.

Gnep, N.S. (CNRS, Poitiers, Fr); Doyemet, J.Y.; Guisnet, M. *J Mol Catal* v 45 n 3 May 30 1988 p 281-284.



## Production

**086255 DETERMINATION OF OPTIMAL CONDITIONS FOR OBTAINING 1, 3-DIMETHOXY-1-PHENYLPROPANE BY ADDITION OF METHYLAL TO STYRENE.** In this work the reaction of styrene with methylal was investigated in order to gain insight into the reaction and determine the conditions for obtaining acceptable yields of 1, 3-dimethoxy-1-phenylpropane. In a previous work boron trifluoride was recommended as catalyst of the reaction. However the necessity of working at low temperatures or under pressure makes this catalyst inconvenient for quantitative syntheses. Investigation of the influence of the styrene:methylal ratio at fixed styrene concentration of 0.8 and catalyst concentration of 0.2 mole/liter showed that with increase of the ratio from 1:2 to 1:10 conversion of styrene decreases from 95 to 54% in 1 h, while the selectivity of the reaction increases from 80 to 95.5%. A styrene:methylal ratio of 1:5 can be considered as close to optimal. The study of the influence of catalyst concentration on reaction of methylal with styrene showed that with change of catalyst concentration from 0.2 to 0.8 mole/liter the ratio rate significantly increases. Investigation also indicates that boron trifluoride etherate catalysts are the most effective of all those investigated. 11 refs.

Brudnik, I.M. (Ufimsk Petroleum Inst, USSR); Akhmatdinov, R.T.; Kantor, E.A.; Rakhmankulov, D.L. *J Appl Chem USSR* v 60 n 8 pt 2 Aug 1987 p 1697-1701.

**Pyrolysis** See Also CARBON—Microstructure; HYDROCARBONS—Pyrolysis.

**086256 SURFACE EFFECTS DURING THE PROPANE PYROLYSIS.** With equipment specially designed and assembled for studying coke deposition in pyrolysis of hydrocarbons, the surface effects on the product distribution and on the tendency for coke formation during propane pyrolysis were studied. Experiments were carried out in which (a) the material of the reactor tube was kept unchanged and the formation of coke was measured on small cylinders pretreated by different methods and (b) the material of the reactor tube was varied or treated by different methods and coke formation was measured on a small cylinder of the same material. The rate of coke deposition or even the property of the coke formed on the surface can be changed significantly depending on the material of the reactor and pretreatment of the surface. The physical and chemical properties of the reactor surface not only influence the coke deposition but also remarkably affect the gas phase product distribution. (Edited author abstract) In Chinese. 9 refs.

Lou Qiangkun (Hebei Inst of Technology, China); Liu Huicai; Niu Fenghui; Zou Renjun. *Shiyou Xuebao Shiyou Huagong* v 3 n 1 Mar 1987 p 34-41.

**086257 KINETIC STUDY OF COKE DEPOSITION DURING PROPANE PYROLYSIS.** On the equipment designed and assembled by the authors, the mechanism and kinetics of the coke deposition during propane pyrolysis were studied under the temperature of 800 approximately 900°C and residence time of 0.1 approximately 1.5 s. The experiment results showed that both the initial and asymptotic rate of coke deposition increased with the temperature and residence time in the range of the said conditions. Since high temperature and long residence time result in more coke precursor formation and high surface rate, more coke is formed. According to the results obtained, a mechanism of coke deposition was proposed. (Edited author abstract) In Chinese. 10 refs.

Liu, Huicai (Hebei Inst of Technology, China); Lou, Qiangkun; Zou, Renjun. *Shiyou Xuebao Shiyou Huagong* v 3 n 2 Jun 1987 p 21-28.

**086258 STUDY OF KINETIC MODELS FOR THE PYROLYSIS REACTION OF PROPANE.** The pyrolysis reaction of propane was studied using a pulsed micro-reactor system with on-line chromatography, at 700-825°C and atmospheric pressure with chromatographically pure propane and high-purity nitrogen as reactant and diluent respectively, at propane: nitrogen

dilution ratios of 0.49, 0.9 and 1.9. A simplified kinetic model is presented. Marquardt's algorithm was used to estimate all the kinetic parameters in the model. The concentration of each species in the reaction system calculated using the model are close to the experimental values. (Author abstract) 13 refs.

Zou, Renjun (Hebei Inst of Technology, Tianjin, China); Lou, Qiangkun; Liu, Zhiyong. *J Anal Appl Pyrolysis* v 13 n 3 Apr 1988 183-190.

**Recovery** See Also GAS CONDENSATE—Processing; NATURAL GAS, LIQUEFIED.

**086259 PROPANE RECOVERY: THE RYAN/HOLMES PROCESS.** The Alford South Unit of Mitchell Energy Company is the first gas plant utilizing the Ryan Holmes process to recover propane and higher hydrocarbons from the gas production of a CO<sub>2</sub> flood enhanced Oil Recovery project. The plant produces a CO<sub>2</sub> product suitable for reinjection into area reservoirs and recovers both natural gas liquids and gas for sales or use as fuel. Plant construction was approved on May 25, 1985 and was mechanically completed on January 31, 1986. The plant was not brought on line until March 10, 1986 due to an insufficient volume of fuel gas for startup. 6 refs.

McCann, Pat (Mitchell Energy Corp, Bridgeport, TX, USA); Ryan, James M.; O'Brien, John V. *Energy Prog* v 7 n 4 Dec 1987 p 230-240.

## Removal

**086260 PROPANE REMOVAL FROM PROPANE-AIR MIXTURES BY SOIL BEDS.** Dilute concentrations of hydrocarbons are difficult and expensive to remove from air by conventional scrubbing methods. Propane removal from propane-air mixtures by soil beds were measured in laboratory experiments and in an industrial application. In closed containers in the laboratory, the time to reduce the initial 1-3 percent propane concentration by half was 5 to 20 hours for soils at pH 6-8, moderate moisture contents, and temperatures  $\geq 15^\circ\text{C}$ . The propane removal rate was slower when the soil was air dry at 2°C temperature, or was pH 5.3. A test soil bed continuously removed 92-98 percent of the propane from an input air stream containing 0.6-1 percent propane. (Author abstract) 13 refs.

Ebinger, Michael H. (Univ of Arizona, Tucson, AZ, USA); Bohn, Hinrich L.; Puls, Robert W. *JAPCA* v 37 n 12 Dec 1987 p 1486-1489.

## Solubility

**086261 SOLUBILIZATION OF PROPANE BY MIXED MICELLES COMPOSED OF SODIUM ALKYL SULFATES.** This paper examines the role played by mixed micelles in gas solubilization and reports results obtained from a series of experiments in which the solubility of one gas, propane, is determined in aqueous solutions containing sodium dodecyl sulfate (SDS) mixed with either sodium octyl sulfate (SOS) or sodium hexyl sulfate (SHS) in various fixed proportions. High concentrations of sodium chloride are maintained in these solutions in order to suppress the critical micelle concentration (CMC) values for the various surfactant mixtures, thus allowing the onset of gas solubilization to be observed at lower surfactant concentrations. 7 refs.

Nugara, N. (Univ of Georgia, Athens, GA, USA); Prapaitrakul, W.; King, A.D. Jr. *J Colloid Interface Sci* v 120 n 1 Nov 1987 p 118-124.

**Structure** See MOLECULES—Structure.

**Transportation** See PIPELINES—Welding.

**PROPELLANTS** See Also POLYMERS—Synthesis; ROCKET ENGINES—Design.

**086262 HARMONIC ANALYSIS OF PISTON AND PYROTECHNIC PULSERS FOR T-BURNERS.** The purpose of this paper is to compare a local version of a

pyrotechnic pulser with a piston pulser manufactured at Weapons Systems Research Laboratory and based on the design given by Lovine. The results of frequency analyses are presented to show the pulse harmonic contents. All tests were carried out in a T-burner under "cold" conditions, i.e., without propellant samples; "hot" tests during actual T-burner firings are planned for the future. 9 refs.

Beck, W.H. (Dep of Defence, Adelaide, Aust); Jolley, W.H. *J Propul Power* v 4 n 3 May-Jun 1988 p 283-285.

**Additives** See ORGANIC COMPOUNDS—Synthesis.

**Combustion** See Also AMMONIUM COMPOUNDS—Combustion; METHANE—Ignition; ROCKET ENGINES—Stability.

**086263 COMBUSTION OF A NON-MOVING DROPLET: NUMERICAL STUDY OF THE INFLUENCE OF THE ASSUMPTIONS LEADING TO THE 'D<sup>2</sup> LAW'.** In most reactive flow calculations requiring a droplet combustion model, a quasi-steady analytical model is used leading to the D<sup>2</sup> law. This model is based on assumptions that are sometimes open to doubt, in particular when the pressure is high. In this paper, a numerical model of the combustion of a nonmoving droplet is presented which is free of the assumptions of the D<sup>2</sup> law. This model, based on the numerical solution of unsteady balance equations, uses an entirely implicit method of finite volumes. Each of the assumptions of the D<sup>2</sup> law has been studied successively, using the numerical model and comparing it with the quasi-steady model, in order to evaluate their influence. Among other things, it was found that the D<sup>2</sup> law becomes erroneous when the combustible droplet decomposes before reacting with the oxidizer; what is more, unsteady effects prove to be substantial at high pressure. (Edited author abstract) 7 refs.

Scherrer, D. (ONERA). *Rech Aerosp (Engl Ed)* n 5 1985 p 25-37.

**086264 AEROTHERMOCHEMICAL STUDIES OF ENERGETIC LIQUID MATERIALS: 1. COMBUSTION OF HAN-BASED LIQUID GUN PROPELLANTS UNDER ATMOSPHERIC PRESSURE.** The gasification and microexplosion characteristics of droplet of liquid gun propellants under atmospheric pressure have been experimentally investigated. Results show that the propellant explosion temperature is around 200°C and is substantially in excess of previously reported values. The droplet surface regression rate prior to the onset of microexplosion is found to be close to that of water and therefore is insensitive to the water content in the propellant as well as the oxygen concentration in the hot environment; these results demonstrate the dominance of water in the gasification process. It has also been determined that the propellant density attains a critical value of about 1.5 g/cm<sup>3</sup> at the state of microexplosion. (Author abstract) 6 refs.

Zhu, D.L. (Univ of California, Davis, CA, USA); Law, C.K. *Combust Flame* v 70 n 3 Dec 1987 p 333-342.

**086265 IGNITION AND COMBUSTION OF PROPELLANT IN A RADIATING GAS FLOW.** In an opaque fuel, in which heat transfer occurs only by heat conduction, the radiant component can be taken into account by the introduction of an effective heat exchange factor. The effects noted are investigated theoretically in an example of the ignition of a gasified double-base propellant. The problem is examined within the framework of a model combining the representations of the thermal theory of ignition and the phenomenological theory of nonstationary combustion under irradiation. 12 refs.

Assovskii, I.G.; Zakirov, Z.G.; Leipunskii, O.I. *Combust Explos Shock Waves* v 22 n 6 Nov-Dec 1986 p 658-664.



**086266 MECHANISM OF COMBUSTION OF CATALYZED DOUBLE BASE PROPELLANTS.** Existing combustion models, namely, photo chemical theory, chelate and  $\pi$ -complex theory, and free radical mechanism and carbon/carbonaceous matter formation theory, for catalyzed double base propellants have been evaluated in the light of the experimental findings of the present study. Results obtained suggest that carbon formation and its availability to catalyze the reactions in foam and fizz zones are the probable cause of catalysis and platonization. It seems that both these phenomena (catalysis/platonization) are dependent on the C/NO ratio. So long as this ratio is above unity, the catalytic effect is observed, followed by the plateau effect, where this ratio is changed to unity. Ultimately, when the C/NO ratio is reduced to less than one, the burning rate falls and the postplateau effect is obtained. (Author abstract) 32 refs.

Singh, Haridwar (Explosive Research & Development Lab, Poona, India); Rao, K.R.K. *Combust Flame* v 71 n 2 Feb 1988 p 205-213.

**086267 APPLICATION OF THE DIFFUSIONAL COMBUSTION MODEL TO THE CALCULATION OF SUPERSONIC TURBULENT REACTING JETS.** In the present work, the influence of turbulence on the occurrence of chemical reactions is calculated using a modification of the method of the probability-density functional: the method of a conservative scalar quantity. The same approach was used in investigating the subsonic reacting jets in a covaleting flow and in a channel and supersonic flows in a channel. 12 refs.

Baranovskii, S.I.; Perminov, V.A. *Combust Explos Shock Waves* v 23 n 3 May-Jun 1987 p 324-326.

**086268 FORMULATION EFFECTS ON THE BURNING RATE OF ALUMINIZED SOLID PROPELLANTS.** Porous ammonium perchlorate was prepared by a fluidization process at 230°C, the product of which was used as a partial substitute for crystalline ammonium perchlorate in composite solid propellants. Fourteen aluminumized propellants were divided into five groups containing various promoters (modifiers) having different burning rates in order to compare the effects of aluminum powder particle size on the burning rates of the propellants. Aluminum powders having three particle sizes (6-9, 16-19, and 60µm) were used. The burning rate was measured in a strand burner at 30, 50, 70, 100, and 150 atm of nitrogen pressure. The burning rates of propellants containing catocene or n-butylferrocene as a promoter increased with decreasing aluminum particle size. When copper chromite and/or ferric oxide was used as a promoter, the particle size of aluminum had no effect on the burning rate of the propellant. Therefore, the effect of aluminum particle size on the burning rate depends on the burning rate modifier in the propellant. (Author abstract) 8 refs.

Leu, An-Lu (Chung Cheng Inst of Technology, Tachi, Taiwan); Wu, Ru-Jau. *J Propul Power* v 4 n 1 Jan-Feb 1988 p 22-26.

**086269 DC ARC DISCHARGE IGNITION AND COMBUSTION CONTROL OF SOLID PROPELLANTS.** The feasibility of ignition and combustion control of solid propellants by dc arc discharge was empirically examined. In this experiment Al/Teflon composite propellants and a conventional HTPB/AP/Al composite propellant were studied. It was shown that the dc arc discharge coupled with a high-frequency-discharge arc initiator works as an efficient ignition method for solid propellants; that, for Al/Teflon propellants with appropriate O/F ratios, repeated ignitions and extinctions are possible by applying and interrupting the arc discharge; and that, for all the propellants tested, burning rates can be varied with the discharge intensity, although there exists a threshold current below which no effect on the burning rate is observed. (Edited author abstract) 10 refs.

Tachibana, Takeshi (Kyushu Inst of Technology, Kitakyushu, Jpn); Kimura, Itsuro. *J Propul Power* v 4 n 1 Jan-Feb 1988 p 41-46.

**086270 COMBUSTION OF MAGNESIUM/POLYTETRAFLUOROETHYLENE.** The combustion of magnesium (Mg) with polytetrafluoroethylene (TF) is a complex oxidation reaction accomplished by physical changes from solid to liquid and to gas. The burning rate characteristics were determined with Mg/TF propellant pellets made of various-sized Mg particles and different mixture ratios of Mg/TF. The adiabatic flame temperature of Mg/TF propellants is the maximum when the weight fraction of Mg particles ( $\xi$ ) is 0.33. However, the experimental results indicate that the burning rate increases with increasing  $\xi$  for the propellants tested ( $\xi=0.2-0.7$ ), which shows that the burning rate does not depend on the final flame temperature. (Edited author abstract) 2 refs.

Kubota, N. (Japan Defense Agency, Tokyo, Jpn); Serizawa, C. *J Propul Power* v 3 n 4 Jul-Aug 1987 p 303-307.

**086271 THEORETICAL INVESTIGATION IN STEADY STATE AND EROSION BURNING OF SOLID COMPOSITE PROPELLANTS.** The BDP steady burning model is revised in this paper and the revised BDP model is used in the prediction of steady burning rates of composite propellants. Based on the revised BDP model and turbulent flow theory a model for erosive burning is proposed. When the propellant compositions, chamber pressure and gas-dynamic conditions are given, these models can be used in the prediction of steady state and erosive burning rates. (Author abstract) 7 refs. In Chinese.

Pei, Ming; Wang, Shoufan. *Bingong Xuebao* n 2 May 1988 p 24-30.

**086272 COMBUSTION OF HAN-BASED LIQUID MONOPROPELLANTS NEAR THE THERMODYNAMIC CRITICAL POINT.** The high-pressure combustion properties of liquid monopropellants involving mixtures of hydroxyl ammonium nitrate (HAN), triethanol ammonium nitrate (TEAN), and water are considered theoretically. Liquid surface properties and the critical combustion pressure (the pressure required for the propellant surface to exceed its thermodynamic critical point) were found allowing for real-gas phenomena and the presence of dissolved combustion product gases in the liquid. Critical combustion pressures for the HAN-based monopropellants were found to be unusually high, ca. 2500 atm, with an estimated uncertainty of 50 percent. Predictions were unusually sensitive to the critical temperature of TEAN and the binary interaction parameter between TEAN and water. (Edited author abstract). 32 Refs.

Kounalakis, M.E. (Univ of Michigan, Ann Arbor, MI, USA); Faeth, G.M. *Combust Flame* v 74 n 2 Nov 1988 p 179-192.

**Cryogenic Treatment** See SPACECRAFT—Propellants.

**Detonation** See PROPULSION—Laser Applications.

**Diffusion**

**086273 NON-FICKIAN DIFFUSION OF DETERENTS INTO A NITROCELLULOSE-BASED PROPELLANT.** The diffusion of solutions of ethyl centralite (EC), dibutylphthalate (DBP), and dinitrotoluene (DNT) into a nitrocellulose (NC) propellant is investigated. DBP and EC penetrate the propellant in a way consistent with Case II diffusion. The diffusion of DNT solutions is Fickian. The apparent activation energy for Case II diffusion is 62 kJ/mol for DBP and 66 kJ/mol for EC. Changes to coating solvent polarity have little effect on DNT and DBP penetration and merely alter the rate, not the mechanism, of EC diffusion into the propellant. (Author abstract) 20 refs.

Winkler, David A. (Dep of Defence, Adelaide, Aust); Starks, Alan. *J Appl Polym Sci* v 35 n 1 Jan 1988 p 51-62.

**Extrusion**

**086274 EXTRUSION STRESSES, DIE SWELL, AND VISCOUS HEATING EFFECTS IN DOUBLE-BASE PROPELLANTS.** A capillary extrusion rheometer was used to evaluate the flow behavior of mixtures of nitrocellulose (12.2% nitrogen) and nitroglycerine when processed using solvent blends of different strengths. The aim of the work was to quantify the effects on flow behavior of 'gelatinization,' that is, the degree of breakdown of the fibrous structure of the nitrocellulose. The flow behavior was measured over a range of extrusion temperatures. The results indicate that the materials behave as Herschel-Bulkley fluids, that the shear stress decreases as gelatinization increases, and that viscous heating is more apparent in poorly gelatinized doughs. Surface temperatures of the extrudate determined experimentally are compared with computer-modelled values. Die swell measurements decreased with decreasing degree of gelatinization and with increasing extrusion temperature. (Author abstract) 15 refs.

Carter, R.E. (Research & Development Cent, Waltham Abbey, Engl); Warren, R.C. *J Rheol* v 31 n 2 Feb 1987 p 151-173.

**Heat Transfer**

**086275 MODELING OF HOT FRAGMENT CONDUCTIVE IGNITION OF SOLID PROPELLANTS WITH APPLICATIONS TO MELTING AND EVAPORATION OF SOLIDS.** A comprehensive theoretical model has been formulated for studying the degree of vulnerability of various solid propellants being heated by hot spall fragments. The model simulates the hot fragment conductive ignition (HFCI) processes caused by direct contact of hot inert particles with solid propellant samples. The model describes the heat transfer and displacement of the hot particle, the generation of the melt (or foam) layer caused by the liquefaction, pyrolysis, and decomposition of the propellant, and the regression of the propellant as well as the time variation of its temperature distributions. To validate partially the theoretical model in the absence of the necessary chemical kinetic data, an ice melting and evaporation experiment was designed and conducted. (Edited author abstract). 31 Refs.

Kuo, K.K. (Pennsylvania State Univ, University Park, PA, USA); Hsieh, W.H.; Hsieh, K.C.; Miller, M.S. *J Heat Transfer Trans ASME* v 110 n 3 Aug 1988 p 670-679.

**Liquid** See Also MATERIALS—Decomposition; ROCKET ENGINES; ROCKET ENGINES—Propellants; ROCKET ENGINES—Reliability; STAINLESS STEEL—Corrosion.

**086276 LIQUID PROPELLANTS FOR ADVANCED GUN AMMUNITIONS.** With constant improvements, the conventional solid propellants for guns have almost reached their limit in performance. Liquid gun propellants are promising new comers capable of surpassing these performance limits and have numerous advantages over solid propellants. A method has been worked out to predict the internal ballistics of a liquid propellant gun and illustrated in a typical application. (Author abstract) 5 refs.

Rao, K.P. (Explosives Research & Development Lab, Pune, India); Bartakke, A.S.; Nair, R.G.K. *Def Sci J* v 37 n 1 Jan 1987 p 45-50.

**086277 STUDIES ON SOME ASPECTS OF PROPELLANTS FOR IMPROVING THE PERFORMANCE OF TANK GUNS.** The main criterion, in the design of propellant charge for a tank gun, is to achieve the highest possible muzzle velocity for fin stabilized armor piercing discarding sabot (FSAPDS) projectiles. This ensures penetration through the toughest armor plates by the kinetic energy of the projectile. One of the solutions, is to increase the force constant of the propellant. Higher force constants from conventional double and triple base propellant compositions lead to prohibitive



linear rates of burning coefficients. ERDL has developed a high energy propellant based on RDX, with very high force constant and low linear rate of burning coefficient. The objective of the present paper is to discuss various aspects of the interior ballistics of the three types of propellants in question in 105 mm tank gun with FSAPDS ammunition. The study shows that only the solution with RDX base propellant is feasible for an increase of three per cent in muzzle velocity. (Author abstract) 6 refs.

Rao, K.P. (Explosives Research & Development Lab, Pune, India); Umrani, P.K.; Nair, R.G.K.; Venkatesan, K. *Def Sci J* v 37 n 1 Jan 1987 p 51-57.

**086278 INVESTIGATION OF THE COMBUSTION OF LIQUID GUN PROPELLANTS IN CLOSED CHAMBERS.** Closed-chamber tests on hydroxylammonium nitrate (HAN) based liquid monopropellants were performed on loading densities of about 0.2 g/cm<sup>3</sup>. The objective of the studies was to investigate the composition of the HAN-based liquid propellants under various conditions. Pressure and temperatures were measured for both neat and intentionally contaminated monopropellants. Contaminants tested were iron, copper, aluminum, and nickel at concentrations of about 100 ppm. The temperatures were determined using both thermocouples and specially designed temperature (emission) gages. The data illustrate the behavior of the liquid propellants during the decomposition phase. (Edited author abstract) 13 refs.

Klingenberg, G. (Fraunhofer Inst fuer Kurzzeitdynamik, Weil am Rhein, West Ger); Knapton, J.D.; Watson, C. *Propellants Explos Pyrotech* v 12 n 4 Aug 1987 p 133-136.

**086279 STUDIES ON HYPERGOLICITY OF SEVERAL LIQUID FUELS WITH FUMING NITRIC ACIDS AS OXIDIZERS.** Hypergolic or self-ignition delays of unsymmetrical dimethylhydrazine (UDMH) and several amine fuels, mixed with three fuming nitric acid oxidizers, have been determined, at room temperature, in a highly sensitive 'cup test' apparatus. Ignition delay (ID) variations have been studied as a function of the chemical structure of the fuel, oxidizer composition, and oxidizer-to-fuel ratio. Probable pre-ignition reactions and structure-hypergolicity correlations have been suggested. Some nonhypergolic hydrocarbons and petroleum fractions have been hypergolized by addition of UDMH, and ID variations have been studied with respect to UDMH content in fuel and catalytic additives (ammonium metavanadate, ammonium dichromate, and cuprous oxide) in a red fuming nitric acid oxidizer (RFNA). Increasing UDMH content improves the hypergolicity of fuels toward RFNA. (Edited author abstract) 20 refs.

Durgapal, U.C. (Inst of Armament Technology, Poona, India); Dutta, P.K.; Pant, G.C.; Ingalkar, M.B.; Oka, V.Y.; Umap, B.B. *Propellants Explos Pyrotech* v 12 n 5 Oct 1987 p 149-153.

**086280 EVALUATION OF METALLIZED PROPELLANTS BASED ON VEHICLE PERFORMANCE.** An analytical study was conducted to determine the improvements in vehicle performance possible by burning metals with conventional liquid bipropellants. These metallized propellants theoretically offer higher specific impulse, increased propellant density, and improved vehicle performance compared with conventional liquid bipropellants. Metals considered were beryllium, lithium, aluminum and iron. Liquid bipropellants were H<sub>2</sub>/O<sub>2</sub>, N<sub>2</sub>H<sub>4</sub>/N<sub>2</sub>O<sub>4</sub>, RP-1/O<sub>2</sub> and H<sub>2</sub>/F<sub>2</sub>. The results of thermochemical calculations and mission analysis calculations for liquid bipropellants metallized with beryllium, lithium, aluminum and iron are presented. Technology issues pertinent to metallized propellants are discussed. (Edited author abstract)

Zurawski, Robert L. (NASA, Lewis Research Cent, Cleveland, OH, USA); Green, James M. *NASA Tech Memo* 100104 1987 25p.

## Manufacture

**086281 NEW PURPOSE-BUILT CONTINUOUS PROCESSING FACILITY FOR ENERGETIC MATERIALS.** Based on a study of the rheological properties of triple-base gun propellants during processing, a flexible research plant has been designed and installed to define the processing parameters necessary to make gun propellants by a continuous process based upon a twin-screw extruder. The major rheological phenomena which influenced the selection of equipment are discussed in detail, followed by a discussion of the plant design, and of raw material and extrudate handling considerations. (Edited author abstract) 8 refs.

Carter, R.E. (Royal Ordnance plc, Essex, Engl). *Propellants Explos Pyrotech* v 13 n 3 Jun 1988 p 80-86.

## Materials

**086282 PYROLYSIS STUDIES OF POLYMERIC MATERIALS USED AS BINDERS IN COMPOSITE PROPELLANTS: A REVIEW.** A review is presented of pyrolysis studies of polymeric materials (with the emphasis on polybutadiene-type polymers) which are used as binders in composite propellants. Where possible, the polymer pyrolysis characteristics are discussed in terms of their relevance to combustion studies of propellants containing these (or similar) polymers as binders. It is shown that binders should receive more attention in any study on composite propellant combustion - both physical and chemical properties may be important, although there is no way as yet to decide beforehand which one plays the larger role. (Edited author abstract) 37 refs.

Beck, Walter H. (Dep of Defence, Adelaide, Aust). *Combust Flame* v 70 n 2 Nov 1987 p 171-190.

## Measurements

**086283 IMPACT AND FRICTION SENSITIVITIES OF COMPOSITE MODIFIED DOUBLE BASE (CMDB) PROPELLANTS.** The impact and friction sensitivities of CMDB propellant ingredients, ingredient combinations and propellants both in the form of slurry and cured propellants have been measured. Among the ingredient combinations, desensitized nitroglycerine (DNG) and ammonium perchlorate (AP) gave the height of 50% explosion of 18.5 cm, followed by spheroidal nitrocellulose (SNC) and casting liquid (desensitized NG). Like SNC and DNG combinations, CMDB propellant slurry also gave a height of 50% explosion of 23 cm. As compared to double base (DB) and composite propellants (CP), CMDB propellants containing AP were found to be more impact sensitive. Among the various combinations, the mixtures of SNC and AP and that of SNC, AP and Al were highly friction sensitive (6.4-8.4 kg). (Author abstract) 10 refs.

Choudhri, M.K. (Explosives Research & Development Lab, Poona, India); Vaidya, M.V.; Deshmukh, M.Y.; Singh, Haridwar. *Indian J Technol* v 25 n 9 Sep 1987 p 390-392.

Performance See EXPLOSIVES—Combustion.

## Pyrolysis

**086284 STUDIES ON THE PYROLYSIS OF COMPOSITE SOLID PROPELLANTS LEADING TO IGNITION.** Studies on pyrolysis leading to the ignition of polystyrene (PS)/ammonium perchlorate (AP), polyvinyl chloride (PVC)/AP and polyphenol formaldehyde (PPF)/AP propellants revealed that the activation energy for the ignition strongly depends upon the binder. Double base propellants exhibit an empirical relationship between the ignition delay ( $\tau$ ) and the oxidizer concentration; when the same solution is applied to composite solid propellants, the plot of  $\ln \tau$  vs  $\ln C$  ( $C$ =concentration, %) yields a straight line with a knee corresponding to 65-70 per cent AP, above which the dependence on  $\tau$  becomes less sensitive. (Edited author abstract) 6 refs.

Kishore, K. (Indian Inst of Science, Bangalore, India);

Sankaralingam, S. *Def Sci J* v 37 n 3 Jul 1987 p 333-338.

Solid See Also HEAT INSULATING MATERIALS—Degradation; POLYMERS—Strain; PROPULSION—Electric Energy; ROCKET ENGINES—Mathematical Models.

**086285 COMBUSTION WAVE STRUCTURE OF AP COMPOSITE PROPELLANTS.** The combustion mechanism of ammonium perchlorate (AP) composite propellants was studied. The oxidizer-rich propellants tested were made with excess concentrations of AP particles. The pressure deflagration limit of the propellant decreases with an increase in the binder concentration. The combustion wave consists of two reaction regions, I and II: region I is the zone of the AP monopropellant flame, while region II is the zone of the diffusion flame. The heat flux feedback from the gas phase to the burning surface increases as the pressure increases, and the heat flux is responsible for the burning rate characteristics. (Edited author abstract) 7 refs.

Yano, Y. (Japan Defense Agency, Tokyo, Jpn); Miyata, K.; Kubota, N.; Sakamoto, S. *Propellants Explos Pyrotech* v 12 n 4 Aug 1987 p 137-140.

**086286 ORGANIC FILLERS FOR SMOKELESS INSULATIONS OF DOUBLE-BASE PROPELLANTS.** The number of organic fillers for smokeless polyurethane insulations hitherto known is rather small. In this paper, two general formulas expanding the range of organic fillers are described. The first formula describes molecules with linear structures, while the second one describes those with cyclic structures. A common feature of the above-mentioned fillers is their high (N+O)/C ratio. (Edited author abstract) 9 refs.

Proebster, M. (Bayern-Chemie GmbH, Aschau, West Ger). *Propellants Explos Pyrotech* v 12 n 4 Aug 1987 p 141-142.

**086287 COMBUSTION PROCESS OF Mg/TF PYROTECHNICS.** The combustion process of pyrotechnics was studied in order to obtain information concerning the burning rate control parameters. The pyrotechnics tested were made of magnesium (Mg) and tetrafluoroethylene (TF). The burning rate measurements revealed that the burning rate of the Mg/TF propellants (pellet-shaped) increases with increasing weight fraction ( $\xi$ ) of Mg in the range of  $\xi > 0.33$ . Although the adiabatic flame temperature reaches a maximum at  $\xi = 0.33$ , the burning rate increases with decreasing flame temperature. The total burning surface area of the Mg particles embedded in the propellant mass plays an important role in the oxidation process in the gas phase just above the propellant burning surface. The heat flux feedback from the gas phase to the propellant burning surface increases with increasing  $\xi$ . Therefore, the burning rate increases as  $\xi$  increases. (Edited author abstract) 4 refs.

Kubota, N. (Japan Defense Agency, Tachikawa, Jpn); Serizawa, C. *Propellants Explos Pyrotech* v 12 n 5 Oct 1987 p 145-148.

**086288 DETERMINATION OF DERIVATIVES OF DIPHENYLAMINE IN AUSTRALIAN GUN PROPELLANTS BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY.** A new high-performance liquid chromatography (HPLC) method has been developed for the quantitative analysis of diphenylamine and its N-nitroso- and C-nitro derivatives found in single-base gun propellants. Of the potential derivatives, only 2- and 4-nitrodiphenylamine, 2,2', 2,4'- and 4,4'-dinitrodiphenylamine, 2,2',4,4'-trinitro-diphenylamine, 2,2'-tetranitrodiphenylamine, N-nitrosodiphenylamine and 4-nitro-N-nitrosodiphenylamine were found in major amounts. Minor derivatives noted were: 2,4-dinitrodiphenylamine, 2-nitro-N-nitrosodiphenylamine, 2,4'- and 4,4'-dinitro-N-nitrosodiphenylamine. This HPLC method can be used to quantify all the major derivatives in a single chromatogram and importantly, can be used even in the presence of propellant additives dinitrotoluene, di(ethylhexyl) phthalate and dibutyl phthalate. This procedure



provides the most effective analysis of stabilizer in single-base propellants yet published. (Edited author abstract) 14 refs.

Curtis, N.J. (Dep of Defence, Adelaide, Aust); Rogasch, P.E. *Propellants Explos Pyrotech* v 12 n 5 Oct 1987 p 158-163.

**086289 EROSION BURNING MODEL FOR COMPOSITE-PROPELLANT ROCKET MOTORS WITH LARGE LENGTH-TO-DIAMETER RATIOS.** An improved phenomenological heat transfer model is presented to describe erosive burning flow processes in composite solid-propellant rocket motors having propellant grains of large length-to-diameter ratios. This model is based on the concept of enhanced propellant burning due to cross-flow-increased convective heat transfer from the flame and core flow to the propellant surface, with individual chemical reactions included implicitly in this macroscopic (or lumped-parameter) approach. The new equations governing the erosive burning rate are in general not only free of experimental coefficients derived from rocket motor firing data, in contrast to most past phenomenological models, but also include all important effects on the burning rate from previous models (e.g., local flame and core-flow properties, local grain port diameter, Reynolds number, initial propellant temperature, propellant surface temperature, propellant surface roughness, and turbulent heat transfer coefficient). (Edited author abstract) 38 refs.

Greatrix, D.R. (Univ of Toronto, Ont, Can); Gottlieb, J.J. *Can Aeronaut Space J* v 33 n 3 Sep 1987 p 133-142.

**086290 EXPERIMENTAL METHOD FOR  $J_{IC}$  COMPUTATION ON FRACTURE OF SOLID PROPELLANTS UNDER DYNAMIC LOADING CONDITIONS.** An experimental method is proposed for fracture characterization of solid propellants. Regarding nonlinear behavior of such material, investigation is restricted to high loading rate conditions and  $J_{IC}$  fracture criterion is computed. A tensile split Hopkinson bar device was set up and fitted to experiments up to strain rate of  $300 \text{ s}^{-1}$ . Axisymmetric samples of various crack length was tested allowing  $J_{IC}$  computation using J.A. Begley-J.D. Landes method. Results are then analyzed and special attention is given to validity of L.E.F.M. assumptions in this case. (Author abstract) 17 refs.

Abdelaziz, M. Nait; Nevire, R.; Pluvinaige, G. *Eng Fract Mech* v 28 n 4 1987 p 425-434.

**086291 TEMPERATURE SENSITIVITY OF BURNING RATE OF AMMONIUM PERCHLORATE PROPELLANTS.** The temperature sensitivity of the burning rate of ammonium perchlorate (AP) composite propellants was studied as a function of the AP particle size and a burning rate catalyst. A simplified temperature sensitivity model is presented in order to distinguish between the effects of the gas-phase and solid-phase reactions on the initial propellant temperature ( $T_0$ ). The temperature sensitivity is decreased by the addition of small-sized AP particles and/or 2,2-bis(ethylferrocenyl)propane. This is caused by the insensitivity of the burning surface temperature to  $T_0$ . Thus, the gas-phase reaction rate depends only slightly on  $T_0$ , and the temperature sensitivity decreases. (Edited author abstract) 10 refs.

Kubota, N. (Japan Defense Agency, Tachikawa, Jpn); Miyazaki, S. *Propellants Explos Pyrotech* v 12 n 6 Dec 1987 p 183-187.

**086292 COMBUSTION MECHANISM OF DOUBLE-BASE PROPELLANTS WITH LEAD BURNING RATE CATALYSTS.** On the basis of relevant experimental phenomena and results, which also include the results of nonpropellant combustion, basic reactions caused by lead burning rate catalysts in the combustion process and their approximate reaction temperatures are described. Owing to the presence of carbon on the burning surface, part of the NO is reduced to  $N_2$  after six reaction stages occurring with carbon instead of the reaction between NO and CO. As a result of changing the reduction sequence for NO, the burning rate increases as a result of an increase in the temperature gradient in the

fizz zone of the burning surface. The reactions between PbO and C and between PbO and CO prevent the burning rate from increasing by consuming carbon on the burning surface and ejecting carbon particles from this surface. The super-rate, plateau and mesa effects are perfectly explained with these reactions and the fundamentals of heat transfer. 35 refs.

Cai, Youfang (Beijing Inst of Technology, Beijing, China). *Propellants Explos Pyrotech* v 12 n 6 Dec 1987 p 209-214.

**086293 PROPAGATION OF CONVECTIVE COMBUSTION IN TWO-PHASE SYSTEMS WITH LONGITUDINAL POROSITY AND TRANSITION INTO THE UNDERDRIVEN DETONATION REGIME.** In this paper a theoretical model is proposed for the nonstationary propagation of a convective flame front in porous solid fuel and in fuel with longitudinal channels, and the conditions for the appearance of convective combustion and the emergence of the process into a regime exhibiting the characteristics of pseudounderdriven (weak) detonation are studied. 19 refs.

Smirnov, N.N. *Combust Explos Shock Waves* v 23 n 3 May-Jun 1987 p 300-309.

**086294 EFFECT OF OXIDIZER-PARTICLE SIZE ON THE UNSTEADY-STATE COMBUSTION TIME OF A COMPOSITE SOLID FUEL DURING A PRESSURE DROP.** A rapid variation of pressure during the combustion of a composite solid fuel alters considerably the composition and temperature of the combustion products during the unsteady-state-combustion period. The time required to reach a new steady-state combustion regime following a sharp rise in pressure is proportional to the burnup time of a grain of oxidizer. We considered the dependence of the duration of the transition regime of combustion on the size of PCA crystals during a pressure drop. The results indicate that the time required to achieve steady-state combustion regime is proportional to the burnup time of a grain of oxidizer. 2 refs.

Ilyukhin, V.S.; Margolin, A.D.; Valeev, I.N.; Lebedev, A.A. *Combust Explos Shock Waves* v 23 n 3 May-Jun 1987 p 332-333.

**086295 APPLICATION OF XPS AND SIMS TO THE STUDY OF COMBUSTION THEORY OF SOLID PROPELLANT.** In this paper the surface property of combustion catalyst (chromic oxide) is studied by XPS and SIMS, and its effect on the catalysis of AP is measured. It is evident that calcined chromic oxide enhances the combustion catalysis due to the change of surface property. 2 refs.

Ma, Qingyun; Yang, Ronjie. *Bingong Xuebao* n 4 Nov 1987 p 50-55.

**086296 THEORETICAL AND NUMERICAL STUDY OF RADIATIVE IGNITION AND DERADIATIVE EXTINCTION IN SOLID PROPELLANTS.** Time-dependent processes of solid propellant deflagration are modeled, and a numerical simulation of ignition and extinction is undertaken. Since the analytic theory of ignition is well developed, the authors rely on it to verify the ability of the numerical algorithm to track stiff, time-dependent features of an ignition event. The verification of their numerical method provides a degree of confidence for the subsequent study of deradiation, which is less well understood. An activation energy asymptotic theory for deradiation is developed, which predicts that an influx of radiation on the order of the steady heat release of the exothermic reaction will, at near term, extinguish the propellant. Beyond this, conduction processes inherited from the thermal profile at the instant of deradiation may, or may not, cause resumption of pyrolysis, and, presumably, the deflagration as a whole. The analytic theory ignores the subsequent impact of a possible gas-phase flame that is detached many conductive-diffusive lengths away from the gas/solid surface. (Edited author abstract) 12 refs.

Armstrong, Robert C. (Sandia Natl Lab, Livermore, CA, USA); Koszykowski, M.L. *Combust Flame* v 72 n 1 Apr 1988 p 13-26.

**086297 KINETIC MECHANISM ON THERMAL DEGRADATION OF A NITRATE ESTER PROPELLANT.** The thermal degradation of a double-base propellant has been studied to elucidate the rate-determining steps and the kinetic mechanism in a wide range of temperatures (60 to 200°C) using a modified Taliani test, thermogravimetry (TG), and a temperature-varied Abel (TVA) test. The results indicate that the degradation process consists of two major reactions, homolysis and autocatalysis, depending on temperature and total pressure due to evolved gases. The activation energy for homolysis was found to be 35-37 kcal/mol from the Taliani and TVA tests, which falls in the range of the bond dissociation energy of the weakest RO-NO<sub>2</sub> bonds. The activation energy for autocatalysis was determined to be 46-49 kcal/mol from Taliani and TG methods. These values observed for the two key reactions are totally opposite to the values reported in the earlier literature. The temperature dependence of the reaction rates obtained in this study implies that homolysis is the rate-determining step in the lower temperature range, while autocatalysis is rate-determining in the higher temperature range. (Edited author abstract) 20 refs.

Kimura, J. (Japan Defense Agency, Tachikawa, Jpn). *Propellants Explos Pyrotech* v 13 n 1 Feb 1988 p 8-12.

**086298 PROPERTIES OF 1,3,3,5,7,7-HEXANITRO-1,5-DIAZACYCLOOCTANE (HCO) AND ITS APPLICATION IN PROPELLANTS.** The properties of HCO and its application as a monopropellant are described. In comparison with MHX, it is also a high-energy explosive with high thermal stability and can be used as an oxidizer in solid rocket propellants. The theoretical specific impulse of HCO double base propellant systems was calculated and the burning rates and thermal stability of the propellants were experimentally determined. The propellants were prepared by a spray-casting process. As an oxidizer in solid rocket propellant, HCO shows better characteristics under certain circumstances compared with HMx. (Edited author abstract) 5 refs.

Xu Li-hua (Beijing Inst of Technology, Beijing, China); Wang Ming-xuan; Wang En-pu; Tan Hui-min; Chen Bo-ren. *Propellants Explos Pyrotech* v 13 n 1 Feb 1988 p 21-24.

**086299 EXPERIMENTAL INVESTIGATION OF EROSION BURNING SOLID PROPELLANTS.** This paper presents experimental measurements of the erosive burning rate of composite solid-propellant grains having a star perforation. The erosive burning rate data were obtained using web burnout detectors on the outer surface of the propellant grain. These experimental results were compared with the predictions from the design procedure using the Lenoir and Robillard theory supported by numerical analysis. 11 refs.

Kawamoto, Aparecida M. (Space Activity Inst, Sao Jose dos Campos, Braz); Filho, Gordiano F.A. *J Propul Power* v 3 n 4 Jul-Aug 1987 p 375-377.

**086300 ACTIVE CONTROL OF SOLID PROPELLANT CONSUMPTION RATE BY FORCED CONE BURNING.** Cone-shaped burning surfaces are known to form around areas of enhanced burning rate in solid propellant. A concept for actively controlling solid propellant charge consumption rate is presented that utilizes these areas of enhanced burning rate. Active control of mass flow rate is obtained that can be independent of other ballistic requirements such as specific impulse. A geometric time-dependent model is used to analyze the transition between quasi-steady-state conical burning surfaces in an end-burning configuration. Some means of controlling the areas of enhanced burning rate are discussed. Experiments using single-core negative exponent charges verified the model. (Author abstract) 22 refs.

Winch, P.C. (Defence Science & Technology Organisation, Salisbury, Aust); Irvine, R.D. *J Propul Power* v 4 n 2 Mar-Apr 1988 p 104-110.



**086301 SELECTION OF AN IGNITER SYSTEM FOR MAGNESIUM-BASED SOLID FUEL RICH PROPELLANT.** The suitability of a number of metal-based igniter compositions has been studied for magnesium-based fuel-rich propellants. Igniter compositions have been tested in closed vessels for evaluation of ignition pressure output and impetus. Heat energy values were determined calorimetrically in a closed bomb. A vented vessel study was carried out in a test motor to assess relative behavior and to select a suitable composition. Compositions containing magnesium powder and potassium nitrate were found to give satisfactory ignition of the propellants. (Edited author abstract) 4 refs.

Singh, Harihar (Explosives Research & Development Lab (Cell), Hyderabad, India); Somayajulu, M.R.; Bhaskar Rao, R. *Propellants Explos Pyrotech* v 13 n 2 Apr 1988 p 52-54.

**086302 CONTINUOUS AUTOMATED PRODUCTION FACILITY FOR THE MANUFACTURE OF SINGLE-BASE PROPELLANT POWDERS.** The design features of the first continuous single-base propellant powder plant in the Western Hemisphere are summarized in this report. The plant is distinguished by low investment costs. Unmanned automated operations assure improved product quality, lower operating cost, and better safety conditions. As a result of an advanced design the plant is simple, easy to operate, very versatile, and capable of accommodating changes. (Edited author abstract)

Helle, C.J. v. (Companhia Brasileira de Cartuchos, Sao Paulo, Brazil). *Propellants Explos Pyrotech* v 13 n 2 Apr 1988 p 55-57.

**086303 EFFECT OF ACCELERATION ON THE BURNING RATE OF HTPB COMPOSITE ALUMINIZED SOLID PROPELLANTS.** The objectives of this paper are twofold. First, it describes briefly the analytic and experimental results on the combustion of HTPB composite aluminumized solid propellants in acceleration fields. The test were conducted in the jet propulsion laboratory of Beijing Institute of Technology. The facility used is a centrifuge mounted rocket motor. The second objective is to discuss the problem of modelling in detail. The paper presents a model in the form of an exponential function which correlates the combustion process, properties of the propellant and the burning rate acceleration sensitivity of composite propellants. The calculated results are in good agreement with the experimental data for HTPB propellants at acceleration levels from 75g to 107g. It is thus seen that such models can be utilized for the prediction of solid rocket motor performance. (Author abstract) 6 refs. In Chinese.

Zhang, Ruzhou; Li, Baojiang; Zheng, Xiaoping. *Bing-gong Xuebao* n 2 May 1988 p 17-23.

**086304 VELOCITY-COUPLED RESPONSE FUNCTION OF COMPOSITE SOLID PROPELLANT.** An analytical method is presented which permits one to predict velocity-coupled response function of composite solid propellants. The present analytical method is characterized by consideration of the phase advance of the oscillating component of the flow within the flame zone with respect to that of external flow outside the boundary layer. According to the theory of laminar boundary layer in oscillating flow, when the external flow oscillates in its magnitude of velocity at small amplitude, a very thin layer of order of  $\sqrt{\nu/\omega}$  exists near the wall, which is usually called as 'viscous wave penetrating thickness.' In this layer the phase of the oscillating component will be different from that of external flow, because for the most of composite solid propellants, their flames are within this layer, the phase shift must be taken into consideration in the calculation of velocity-coupled response function. A numerical example shows that the phase shift between the flow in the flame zone and the main stream is almost of the same order as that induced in solid. It increases the imaginary part of velocity response function  $R_v^{(0)}$  to positive value in a wide range of frequency where it would be negative without considering this phase advance, resulting in an increased wave

growth constant. (Author abstract). 12 Refs.

Liu, Ni-shing (Univ of Tokyo, Tokyo, Jpn); Kimura, Itsuro. *J Fac Eng Univ Tokyo Ser B* v 39 n 3 Mar 1988 p 297-309.

**086305 DECOMPOSITION CHEMISTRY OF TAGN.** Triaminoguanidine nitrate (TAGN) is a unique energetic material which produces relatively low molecular weight combustion products. TAGN is characterized by the oxidizer fragment "HNO<sub>3</sub>" that an ionic bond in the molecular structure. In this study, various types of experiments were conducted in order to elucidate the physicochemical decomposition process of TAGN. The exothermic rapid reaction observed at the early stage of the decomposition is the process representing the nature of energetics of TAGN. This exothermic reaction occurs immediately after the endothermic phase change from solid to liquid. Since the weakest chemical bond existing in the TAGN molecule is the N-N bond (159 kJ/mol), the initial bond breakage should be that of the amino groups and the NH<sub>2</sub> radicals split off. The energy released by the dissociation of the NH<sub>2</sub> radicals (104.3 kJ/mol) is the heat produced at the early stage decomposition of TAGN. Thus, the burning rate of TAGN is considered to be dominated by the dissociation of the NH<sub>2</sub> radicals. (Edited author abstract). 2 Refs.

Kubota, Naminosuke (Japan Defense Agency, Tachikawa, Jpn); Hirata, Norimasa; Sakamoto, Satoshi. *Propellants Explos Pyrotech* v 13 n 3 Jun 1988 p 65-68.

**086306 DEVELOPMENT OF SOLID PROPELLANT TECHNOLOGY IN INDIA.** High energy composite solid propellants have been developed, characterized and produced at the Vikram Sarabhai Space Center and at the Sriharikota Center in India. Exotic fuel binders such as HEF-20, Polyol and HTPB for these propellants were also developed in ISRO as part of the indigenization program. The Satellite Launch Vehicle-3 (SLV-3) conceived in the early seventies, was fitted with four stage motors filled with solid propellants. These facilities, including critical process equipment, have come up as a result of indigenization efforts. The SHAR Plant known as SPROB has been further augmented to produce large propellant grains to meet the needs of the Polar Satellite Launch Vehicle (PSLV). (Edited author abstract).

Kurup, M.R. (Indian Space Research Organisation, Sriharikota, India); Krishnamoorthy, V.N.; Uttam, M.C. *Sadhana* v 12 n 3 Mar 1988 p 229-234.

**086307 SMOKELESS PROPELLANTS (PAPERS PRESENTED AT THE PROPELLATION AND ENERGETICS PANEL 66TH (A) SPECIALIST'S MEETING).** This conference proceedings contains 11 papers. Topics include: smokeless propellants; stability of nitro-cellulose propellants; particle behavior in solid propellant combustion; measurements of distributed combustion; and elastomer modified cast double base propellants. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11501 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (AGARD, Neuilly-Sur-Seine, Fr). *AGARD Conf Proc* n 391, Smokeless Propellants, Sep 12-13 1985, Florence, Italy. Publ by AGARD, Neuilly-Sur-Seine, Fr, 1986 var pagings.

## Solids

**086308 RHEOLOGICAL ANALYSIS ON THE EXTRUSION PROCESS OF DB PROPELLANT GRAINS WITH EMBEDDED CONTINUOUS WIRES.** Various factors affecting the quality of DB propellant grains with embedded continuous wires processed in a screw extruder are analysed through rheological and mechanical analyses of matrices and wires during the process. Based on the analyses, an improved method for die design is suggested. With the improved die, DB propellant grains with embedded continuous coated wires have been produced in the screw extruder, and are found to be of good quality, meeting all the demands of

performance tests. (Edited author abstract) 3 refs. In Chinese.

Xie, Yuli; Wang, Xiyou. *Bing-gong Xuebao* v 2 n 3 Aug 1987 p 76-80.

## Stabilizers

**086309 LC/MS STUDIES OF ETHYL CENTRALITE STABILIZED PROPELLANTS.** Extracts of the stabilizer ethyl centralite and its derivatives in a series of aged gun and mortar propellants were investigated by combined high-performance liquid chromatography/mass spectrometry (LC/MS). The HPLC retention times and the chemical ionization mass spectra obtained allowed positive identification of several products and made it possible to construct concentration profiles as a function of aging time. These results are useful for implementation of modern methods into stability surveillance programs for gun and mortar propellants. (Author abstract). 9 Refs.

Druet, L. (Defence Research Establishment Valcartier, Courcellette, Que, Can); Angers, J. *Propellants Explos Pyrotech* v 13 n 3 Jun 1988 p 87-94.

## Testing

**086310 CROSS-LINKED SLURRY CAST COMPOSITE MODIFIED DOUBLE BASE PROPELLANTS: MECHANICAL PROPERTIES.** Cross-linking of NC by TDI in slurry cast CMDB propellant enhanced TS by about 100 per cent. Coated AP with resorcinol, phloroglucinol, hexanetriol or silicone oil etc. along with cross-linking of NC raised TS from 18 - 30 kg/cm<sup>2</sup>. Inclusion of phloroglucinol and silicone oil gave increased burning rates. The probable mechanism of action of cross-linking and improvement of mechanical properties by coating of AP has been discussed. (Author abstract) 10 refs.

Bhat, V.K. (Explosives Research & Development Lab, Pune, India); Singh, Haridwar. *Def Sci J* v 37 n 1 Jan 1987 p 39-44.

## Thermodynamics

**086311 ENERGETICS OF PROPELLANTS, FUELS AND EXPLOSIVES; A CHEMICAL VALENCE APPROACH.** A simple approach involving the chemical valences of the fuel and the oxidizer elements present in a combustible mixture is described to evaluate the energetics-related parameters of propellants, fuels and explosives. It simplifies the stoichiometric balancing of complex combustion equations, and provides an easy method of calculating the elemental stoichiometric coefficient. The method correctly predicts whether a mixture is fuel-lean, fuel-rich or stoichiometrically balanced combustible systems has been shown to be linearly dependent upon their total oxidizing (or reducing) valences. This relationship has been used successfully to evaluate the calorific value of fossil fuels. For fuel-rich explosives, a new valence-dependent parameter has been derived which is found to be related to properties such as detonation velocity, heat of explosion and impact sensitivity. (Edited author abstract) 22 refs.

Jain, S.R. (Indian Inst of Science, Bangalore, India). *Propellants Explos Pyrotech* v 12 n 6 Dec 1987 p 188-195.

## PROPELLERS

### Acoustic Wave Effects

**086312 ACOUSTIC INTERFERENCE OF COUNTER-ROTATION PROPELLERS.** The noise fields from the rotors of counter-rotating propellers having the same number of blades and angular frequency tend to cancel or reinforce each other depending on the relative phase of the two fields at the point of observation. Because of this, the total noise field at the blade passage frequency or harmonics forms a characteristic standing wave pattern. A general investigation of this acoustic interference phenomenon is carried out. Unlike previous works, the present analysis allows the front and the rear



rotor to have different blade geometry and loading. Further, the effect of forward flight is included. Numerical results indicate that at high subsonic cruise Mach number the acoustic interference pattern differs substantially from that at static condition. (Author abstract). 11 refs.

Tam, C.K.W. (Florida State Univ., Tallahassee, FL, USA); Salikuddin, M.; Hanson, D.B. *J Sound Vib* v 124 n 2 Jul 22 1988 p 357-366.

## Aerodynamics

**086313 WIND TUNNEL PERFORMANCE RESULTS OF AN AEROELASTICALLY SCALED 2/9 MODEL OF THE PTA FLIGHT TEST PROP-FAN.** High-speed wind tunnel aerodynamic performance tests of the SR-7A advanced Prop-Fan have been completed at the NASA Lewis Research Center in support of the Prop-Fan Test Assessment (PTA) flight test program. The 62.23 cm (24.5 in.) diameter adjustable-pitch aeroelastic model was tested at Mach numbers typical of climb and cruise (i.e., from 0.45 to 0.90) in the NASA Lewis 8- by 6-Foot Wind Tunnel. The SR-7A model was aeroelastically scaled to have the same structural characteristics as the 2.743 m (9 ft) diameter PTA flight test Prop-Fan. This Prop-Fan has eight blades and a cruise design operating condition of 0.80 Mach number, 10.66 km (35 000 ft) I.S.A. altitude, 243.8 m/s (800 ft/sec) tip speed and a high power loading of 256.85 kW/m<sup>2</sup> (32.0 shp/ft<sup>2</sup>). At the cruise design condition, the SR-7A Prop-Fan had a high measured net efficiency of 79.3 percent. Further, it showed good aerodynamic performance over a wide range of Mach numbers. (Edited author abstract) 8 refs.

Stefko, George L. (NASA, Lewis Research Cent., Cleveland, OH, USA); Rose, Gayle E.; Podboy, Gary G. *NASA Tech Memo* 89917 1987 48p.

**086314 NUMERICAL SIMULATION OF TRANSONIC PROPELLER FLOW USING A THREE-DIMENSIONAL SMALL DISTURBANCE CODE EMPLOYING NOVEL HELICAL COORDINATES.** This paper discusses the numerical simulation of three-dimensional transonic flow about propeller blades. The equations for the unsteady potential flow about propellers is given for an arbitrary coordinate system. From this the small disturbance form of the equation is derived for a new helical coordinate system. The new coordinate system is suited to propeller flow and allows cascade boundary conditions to be straightforwardly applied. A numerical scheme is employed which solves the steady flow as an asymptotic limit of unsteady flow. Solutions are presented for subsonic and transonic flow about a 5 percent thick bicircular arc blade of an eight-bladed cascade. (Edited author abstract) 8 refs.

Snyder, Aaron (NASA, Cleveland, OH, USA). *NASA Tech Memo* 89826 1987 20p.

**086315 NUMERICAL NAVIER-STOKES SOLUTIONS OF HIGH-SPEED PROPELLER FLOWS.** The search for improved fuel economy for subsonic aircraft has led to a renewed interest in propeller aerodynamics. The goal of this work has been to extend detailed viscous analysis of propeller flows into the high-speed regime. The calculations were made with a finite-difference solution of the compressible, axisymmetric (with swirl), Reynolds-averaged, turbulent Navier-Stokes equations. (Edited author abstract).

Yoon, S.J. (Virginia Polytechnic Inst., Blacksburg, VA, USA); Schetz, J.A. *J Propul Power* v 4 n 4 Jul-Aug 1988 p 291-292.

## Cavitation

**086316 ON THE MECHANISMS OF PROPELLER CAVITATION NOISE.** This thesis deals with generation mechanisms and scaling of the propeller cavitation noise, i.e., the noise generated at the implosion of the vapour-filled cavities, which usually appear in the water around an operating marine propeller. The governing equations for generation of noise by the collapse of a single spherical cavity are reviewed, and the approximations

later used for derivation of similarity principles and scaling relations are clearly related to the theory of inviscid compressible flow. To obtain information about the way in which violent collapses develop for the non-spherical cavities occurring at propellers, experiments were carried out with propellers as well as oscillating foils. By synchronizing recordings of noise signals with high speed filming the mechanisms governing the noise generation could be identified. Finally, investigations of the experimental technique for model testing in cavitation tunnels are discussed with respect to hydrodynamics, acoustics and signal processing, and a comparison of model and full-scale noise data is also presented. (Edited author abstract) 21 refs.

Bark, Goran. *Chalmers Tek Hogsk Doktorsavh* n 652 1988 32p.

## Design See Also SHIPS—Rudders.

**086317 HYDRODYNAMIC DESIGN OF PROPELLERS WITH UNCONVENTIONAL GEOMETRY.** The paper defines tip fin propellers as propellers with large degrees of rake and skew in the tip region. To examine whether such propellers of unconventional geometry are more efficient than normal propellers, lifting line theory is applied with a curved lifting line. Criteria for maximum efficiency are established, by Blade Element Theory and by Munk's Displacement Theory, and calculations indicate that an increase in efficiency can be obtained for most propeller loadings. By a series of calculations, guidelines for design of tip fin propellers are presented. (Author abstract) 25 refs.

Vogt Andersen, Svend (Technical Univ of Denmark, Lyngby, Den); Andersen, Poul. *R Inst Nav Archit Suppl Pap* v 129 Jul 1987 p 201-221.

**086318 COUNTER-ROTATING PROPELLER-THRUSTER SYSTEM.** In recent years, high fuel prices have brought increased efforts to improve the efficiency of ship propulsion machinery. This article proposes a new concept in counter-rotating propellers which is claimed to improve efficiency for nominal extra capital expenditure.

Bjorheden, O. (KaMeWa); Larberg, L. *Nav Archit* May 1988 p 155, 157, 159.

## Fatigue

**086319 RELIABILITY ANALYSIS OF PROPELLER BLADE FATIGUE FAILURE.** Fatigue strength of Ni-Al bronze, which is normally used as large size propeller material, was discussed both experimentally and analytically. P-S-N diagram of Ni-Al bronze was proposed from S-N curve and the same stress level fatigue test results of thirty specimens. By applying modified Miner's rule to P-S-N diagram and the alternating blade stress frequency distribution model, the fatigue strength of propeller blade at various non-failure probability was estimated. It was concluded that the blade stress of high speed ships in operation was a little higher than estimated fatigue strength at stress cycles of 10<sup>9</sup>. Furthermore the fatigue strength of notched specimens were examined experimentally and analytically. And the fatigue crack propagation probability was also discussed by Monte Carlo simulation under postulation of distribution functions for crack size, number of cracks, material constants and applied alternating blade stress. (Author abstract) In Japanese. 19 refs.

Takai, Motohiro. *Pap Ship Res Inst (Tokyo)* v 24 n 4 Jul 1987 p 1-16.

## Fluid Dynamics

**086320 PHASE SAMPLING IN THE ANALYSIS OF A PROPELLER WAKE.** A phase sampling procedure is used for the analysis of the non-steady, periodic flow field in the near wake of a marine propeller. This method allows to obtain a true ensemble averaging of the experimental measurements. The average is made over a large number of repeated experiments each of which is taken during a complete revolution of the propeller. The

measurements are carried out in a recirculating water tunnel with a two-channel laser Doppler velocimeter. The computer-aided evaluation of the experimental results visualizes the following characteristic features of the wake: (1) the vortex sheet developing from the trailing edge; (2) a sudden increase of the axial velocity in the core of the tip vortex; (3) a boundary layer effect near the shaft of the propeller. From the analysis of the direction of vortex rotation along the radial direction of the blade, it is possible to derive information on the working conditions of the propeller. (Author abstract) 4 refs.

Cenedese, A. (Univ degli Studi di Roma 'La Sapienza', Rome, Italy); Accardo, L.; Milone, R. *Exp Fluids* v 6 n 1 1988 p 55-60.

**086321 EXPERIMENTAL AND NUMERICAL INVESTIGATION OF A PROPELLER WITH THREE-DIMENSIONAL INFLOW.** The goal is to study the three-dimensional (3-D) flow produced by a propeller operating in a 3-D approach flow representative of pusher-prop arrangements on aircraft or underwater vehicles. The research involves both numerical predictions and wind-tunnel experiments. The specific nonuniform inflow studied is generated by a varying mesh screen disk of one large-diameter mesh, one smaller-diameter mesh, and a 30-deg mesh wedge aligned with the tip of the wedge and the centers of the two circular screens matching. This inflow is similar to the wake behind a slender axisymmetric body with a slender planar appendage. The propeller has three blades, and is 'self-propelled' with respect to the drag of the screen disk. The testing is divided into two main parts. The first deals with propeller performance and the condition needed to reach a self-propelled mode. The second part is the measurement of the mean and turbulent flow downstream of the propeller for two axial locations,  $x/D = 0.025$  and 0.5. (Edited author abstract). 14 refs.

Schetz, Joseph A. (Virginia Polytechnic Inst & State Univ., Blacksburg, VA, USA); Pelletier, Dominique; Mallory, David A. *J Propul Power* v 4 n 4 Jul-Aug 1988 p 341-349.

## Ice Problems

**086322 ANALYTICAL DETERMINATION OF PROPELLER PERFORMANCE DEGRADATION DUE TO ICE ACCRETION.** A computer code capable of computing the propeller performance for clean, glaze, or rime ice propeller configurations to determine the performance degradation resulting from a given icing encounter has been developed. The inviscid, incompressible flowfield at each specified propeller radial location is first computed using the Theodorsen method. A droplet trajectory computation then calculates the droplet impingement points and airfoil collection efficiency for each radial location. User-selectable empirical correlations are available for determining the aerodynamic penalties due to ice accretion. Propeller performance is finally computed using strip analysis for either the clean or iced propeller. In the iced mode, the thrust and torque coefficient equations are modified by the drag and lift coefficient increments due to obtain the appropriate iced values. Comparison with available experimental propeller icing data shows generally good agreement. (Edited author abstract) 11 refs.

Miller, T.L. (Sverdrup Technology Inc., Cleveland, OH, USA); Korkan, K.D.; Shaw, R.J. *J Aircr* v 24 n 11 Nov 1987 p 768-775.

## Mathematical Models See Also SHIPS—Propellers.

**086323 NUMERICAL PREDICTION OF PROPELLER PERFORMANCE BY VORTEX LATTICE METHOD.** The vortex lattice methods of lifting line, and lifting surface with one and two layers of vortex elements have been developed to analyze the performance of propellers. Comparison of the predicted thrust and power coefficients for NACA 109622, NACA 6623-A, NACA 6623-D straight blade propellers and NACA 4-(4) (06)-057-45A swept blade propeller gives close prediction with the experimental results by using the appropriate vortex lattice method. Two dimensional airfoil drag data has been included in the deviation of the equations of



thrust and power coefficients. However, only a small improvement of the predicted results is observed. (Edited author abstract) 21 refs.

Cheung, Richard Shiu Wing. *UTIAS Tech Note* n 265 Nov 1987 116p.

**Noise, Acoustic** See Also AIRCRAFT—Propellers; AIRCRAFT ENGINES, JET AND TURBINE—Turboprop.

**086324 ADVANCED TURBOPROP NOISE PREDICTION BASED ON RECENT THEORETICAL RESULTS.** This paper is about the development of a high speed propeller noise prediction code at Langley Research Center. The code utilizes two recent acoustic formulations in the time domain for subsonic and supersonic sources. The selection of appropriate formulation is automatic in the code. The structure and capabilities of the code are discussed. Grid size study for accuracy and speed of execution on a computer is also presented. The code is tested against an earlier Langley code. Considerable increase in accuracy and speed of execution are observed. Some examples of noise prediction of a high speed propeller of which acoustic test data are available are given. A brisk evaluation of formulations used is given in Appendix 1. (Author abstract)

Farassat, F. (NASA, Hampton, VA, USA). *J Sound Vib* v 119 n 1 Nov 22 1987 p 53-79.

**086325 CRUISE NOISE OF THE 2/9TH SCALE MODEL OF THE LARGE-SCALE ADVANCED PROPPAN (LAP) PROPELLER, SR-7A.** Noise data on the Large-scale Advanced Propan (LAP) propeller model SR-7A were taken in the NASA Lewis Research Center 8- by 6-Foot Wind Tunnel. The maximum blade passing tone noise first rises with increasing helical tip Mach number to a peak level, then remains the same or decreases from its peak level when going to higher helical tip Mach numbers. This trend was observed for operation at both constant advance ratio and approximately equal thrust. This noise reduction or, leveling out at high helical tip mach numbers, points to the use of higher propeller tip speeds as a possible method to limit airplane cabin noise while maintaining high flight speed and efficiency. (Edited author abstract) 13 refs.

Dittmar, James H. (NASA, Cleveland, OH, USA); Stang, David B. *NASA Tech Memo* 100175 Sep 1987 51p.

**086326 NOISE OF A MODEL COUNTERROTATION PROPELLER WITH REDUCED AFT ROTOR DIAMETER AND SIMULATED TAKEOFF/APPROACH CONDITIONS (F7/A3).** A model high-speed advanced counterrotation propeller, F7/A3, was tested in the NASA Lewis Research Center's 9- by 15-Foot Anechoic Wind Tunnel at simulated takeoff/approach conditions of 0.2 Mach number. Acoustic measurements were taken with an axially translating microphone probe, and with a 'polar' microphone probe which was fixed to the propeller nacelle and could take both sideline and circumferential acoustic surveys. Aerodynamic measurements were also made to establish propeller operating conditions. (Edited author abstract) 10 refs.

Woodward, Richard P. (NASA, Cleveland, OH, USA); Gordon, Elliott B. *NASA Tech Memo* 100254 1988 29p.

**086327 EXTENSION OF KIRCHHOFF'S FORMULA TO RADIATION FROM MOVING SURFACES.** Kirchhoff's formula for radiation from a closed surface has been used recently for prediction of the noise of high speed rotors and propellers. Because the closed surface on which the boundary data are prescribed in these cases is in motion, an extension of Kirchhoff's formula to this condition is required. In this paper such a formula, obtained originally by Morgans for the interior problem, is derived for regions exterior to surfaces moving at speeds below the wave propagation speed, by making use of some results of generalized function theory. It is shown that the usual Kirchhoff formula is a special case of the main result of the paper. The general result applies to a deformable surface. However, the special form it assumes for a rigid surface in motion is also noted. Some possible areas of

application of the formula to problems of current interest in aeroacoustics are discussed. (Author abstract). 14 Refs.

Farassat, F. (NASA, Hampton, VA, USA); Myers, M.K. *J Sound Vib* v 123 n 3 Jun 22 1988 p 451-460.

**Reviews** See SHIPS—Propellers.

## Selection

**086328 HYDRODYNAMIC FEATURES OF THE NEW QE2 PROPULSION SYSTEM.** Ever since the completion in 1969, the QE2 has sailed the seas with two fixed pitch propellers each driven by John Brown-Pamet-rada steam turbines. These six bladed propellers were designed to operate with maximum efficiency at 60 mW (total) and 28.5 knots. Now a new propulsion package is installed which utilizes the most up-to-date hydrodynamic standards. With the additional installation of Grim Wheels, the total configuration is far ahead of its time.

van Beek, T. *Nav Archit* Jun 1987 p 219-222.

**Testing** See AIRCRAFT, TRANSPORT—Propellers.

**Theory** See FLOW OF FLUIDS—Vortex Flow.

**Vibrations** See FISHING VESSELS—Propellers; SHIPS—Propellers; SHIPS—Vibrations.

**PROPORTIONAL COUNTERS** See Also BIOLOGICAL MATERIALS—Imaging Techniques; CALORIMETERS; CAMERAS; CAMERAS—Medical Applications; CARBON—Radioactivity; CERENKOV COUNTERS; IMAGE PROCESSING—Enhancement; NUCLEAR INSTRUMENTATION—Performance; OIL WELL LOGGING—Neutron; SCINTILLATION COUNTERS; TRITIUM—Radioactivity.

**086329 GAS GAIN IN XENON + 2,3 DIMETHYL-2-BUTENE FILLED PROPORTIONAL COUNTERS.** The gas gain in xenon-filled proportional counters can be greatly increased by the addition of a small quantity of 2,3 dimethyl-2-butene (DMB). We have found that a broad peak in gas gain appears when the concentration of additive is between approx. 0.4% and approx. 0.75% and the molecular number density of the gas filling is about  $2.7 \times 10^{25} \text{ m}^{-3}$  (approx. 1 atm). When the gas density is reduced to about  $1.4 \times 10^{25} \text{ m}^{-3}$  (approx. 0.5 atm) the peak becomes much sharper and better defined and reaches its maximum when the concentration of additive is approx. 0.43%. Lowering the density to approximately  $7.0 \times 10^{24} \text{ m}^{-3}$  (approx. 0.26 atm) results in a very sharp, well defined peak centered on an additive concentration of approx. 0.23%. The gas gains used to define these peaks were of the order of  $10^5$ , whilst in pure xenon at identical anode potentials the gas gain was of the order of 10. (Author abstract) 10 refs.

White, K.G. (Univ of Tasmania, Hobart, Aust); Fenton, A.G.; Fenton, K.B. *Nucl Instrum Methods Phys Res Sect A* v A260 n 2-3 Oct 15 1987 p 443-446.

**086330 EXTENDED PARAMETRIZATION OF GAS AMPLIFICATION IN PROPORTIONAL WIRE CHAMBERS.** It is normally assumed that the gas amplification in proportional chambers is a function of Townsend's first ionization coefficient,  $\alpha$ , and that  $\alpha$  is a function of the anode surface electric field only. Experimental measurements are presented demonstrating the breakdown of the latter assumption for electric fields,  $X$ , greater than about 150 V/cm/Torr on the anode wire surface for a gas mixture of 80/20 argon/methane. For larger values of  $X$ , the parametrization of the proportional gas gain data requires an additional term related to the gradient of the electric field near the wire. This extended gain parametrization remains valid until the onset of nonproportional contributions such as positive ion space charge saturation effects. Furthermore, deviations of the data from this parametrization are used to measure the onset of these space charge effects. A simple scaling dependence of the gain data on the product of pressure and wire radius over the whole proportional range is also demonstrated. (Author abstract) 6 refs.

Beingsner, Sean P. (Carleton Univ, Ottawa, Ont, Can);

Carnegie, R.K.; Hargrove, C.K. *Nucl Instrum Methods Phys Res Sect A* v A260 n 1 Oct 1 1987 p 210-220.

**086331 STACK OF TWO-DIMENSIONAL MULTI-WIRE PROPORTIONAL CHAMBERS AS PART OF AN ELECTROMAGNETIC CALORIMETER.** A set of four multiwire proportional chambers with analog readout were inserted in the calorimeter of the R704 experiment at the CERN ISR. In this experiment, charmonium ( $\psi$ ) resonances were directly formed through  $p\bar{p}$  annihilation. Owing to the high hadronic background, only electromagnetic final states ( $e^+e^-$  and  $\gamma\gamma$ ) were detected. Located near the maximum of the electromagnetic shower development, the stack of four chambers had as its main purpose a fine spatial localization, together with a good electron-hadron discrimination and multi-shower rejection in the critical few GeV region. (Author abstract) 7 refs.

Mouellic, B. (CERN, Geneva, Switz); Santiard, J.C.; Pia, M.G.; Chermarin, M.; Fay, J.; Larsen, B.; Brom, J.M.; Escoubes, B. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 269-283.

**086332 OPERATION OF HELIUM-FILLED PROPORTIONAL COUNTER AT LOW TEMPERATURES (4.2-295 K).** Following the previous work by our group, the operation of the helium-filled counter has been studied more in detail at liquid-helium (approx. 5 K), liquid-nitrogen (77 K) and room (295 K) temperatures. (Edited author abstract) 23 refs.

Kishimoto, Shunji (Kyoto Univ, Kyoto, Jpn); Isozumi, Yasuhito; Katano, Rintaro; Takekoshi, Hidekuni. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 413-418.

**086333 STUDY OF PROPORTIONAL COUNTER READOUT IN URANIUM CALORIMETERS.** Gain saturations of proportional counters are determined by a comparison of the signals for electron and hadron induced showers in uranium calorimeters with proportional chamber readout. This includes a detailed comparison of predictions from the GHEISHA shower code with experimental data. The competition of increasing pulse heights caused by decreasing gain saturations on the one hand and elastic neutron scattering on the other hand in hydrogen containing vapours is discussed. A comparison between gaseous and liquid argon readout as well as between i-butane and organic scintillator readout will be performed. (Author abstract) 23 refs.

Fesefeldt, Harm (Technische Hochschule, Aachen, Aachen, West Ger). *Nucl Instrum Methods Phys Res Sect A* v A267 n 2-3 May 1 1988 p 367-385.

**086334 MULTIELEMENT POSITION SENSITIVE PROPORTIONAL COUNTER FOR MEASUREMENT OF TRITIUM LABELED GAS MOVEMENT.** A multielement position sensitive proportional counter was developed for the measurement of  $^3\text{H}$  labeled gas movement in a pipe by internal counting. The counter consists of an outer cylindrical pipe with an inner diameter of 40 mm, seven resistive stainless steel anode wires with a diameter of 22  $\mu\text{m}$ , and 24 cathode wires with a diameter of 120  $\mu\text{m}$ . These wires divide the radial cross section of the pipe into seven regions. Since each region independently works as a position sensitive proportional counter and the seven resistive anode wires are connected in series through lump resistors, the region and the axial position where a  $\beta$ -decay event occurred can be known by a simple operation upon the charge signals obtained from two preamplifiers. (Edited author abstract) 20 refs.

Mori, Chizuo (Nagoya Univ, Nagoya, Jpn); Uritani, Akira; Watanabe, Tamaki. *J Nucl Sci Technol* v 25 n 4 Apr 1988 p 341-349.

**086335 BACKGROUND REDUCTION BY PULSE SHAPE DISCRIMINATION IN A MULTI-WIRE PLUTONIUM LUNG MONITOR.** Investigations have been made on the reduction of background count rate by



pulse shape discrimination, in a xenon multiwire proportional chamber designed as a monitor for plutonium lung contamination. A simple discrimination system was employed in which waveform crossover time was employed as a measure of anode charge rise time. An estimate was made for the minimum detectable activity, for a 40 min count, of 45 nCi (1.7 kBq). This figure compares favorably with that of the phoswich monitor currently employed. (Author abstract) 15 refs.

Leake, J.W. (Univ of Leicester, Leicester, Engl); Mathieson, E.; Ratcliff, P.R.; Turner, M.J. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 305-311.

**086336 TWO-DIMENSIONAL BEAM IMAGE MONITOR.** In this letter we describe a device useful in obtaining two-dimensional information from low intensity beams of ionizing radiation. It consists of an anode wire plane (to provide charge amplification), a gating plane (to control the flow of charge through the chamber), and a cathode plane for collecting charge. With a prototype chamber we have obtained 1 mm × 1 mm resolution with 48 × 48 pixels, and a sensitivity to single 6 keV X-ray events. (Author abstract) 1 refs.

Morris, C.L. (Los Alamos Natl Lab, Los Alamos, NM, USA); Atencio, L.G.; Idzorek, G.C.; Morris, S.L. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 333-334.

**086337 GAS AMPLIFICATION FACTOR IN NEON-NITROGEN FILLED PROPORTIONAL COUNTERS.** The gas amplification factor in a cylindrical proportional counter filled with Ne-N<sub>2</sub> Penning mixtures has been measured (over the range  $1 < A < 6.4 \times 10^3$ ) to verify the validity of the gas gain formulae of Rose and Korff, Khristov, Williams and Sara, Diethorn and Zastawny. This factor has been found to obey Zastawny's formula over the range of variables studied. The formula of Diethorn can be fitted only for small nitrogen concentrations (below  $5 \times 10^{-4}$ ). Constants appropriate to the Zastawny and Diethorn formulae have been determined over a wide range of N<sub>2</sub> concentrations from spectroscopically pure Ne up to 11.1% N<sub>2</sub>. (Author abstract) 18 Refs.

Othman, A. (Assiut Univ, Assiut, Egypt). *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 492-497.

**086338 CHARGE DIVISION IN A SMALL PROPORTIONAL CHAMBER CONSTRUCTED WITH ALUMINIZED MYLAR TUBES.** A tracking detector composed of aluminumized mylar drift tubes is under development for the Fermilab experiment 760. A prototype chamber has been constructed. Results on the longitudinal coordinate determined by charge division are given. Spatial resolution values below 2 mm (rms) were found, corresponding to <1 percent of the chamber length. Results on chamber ageing are also discussed. (Author abstract) 13 Refs.

Biino, C. (Istituto Nazionale di Fisica Nucleare, Turin, Italy); Mussa, R.; Palestini, S.; Pastrone, N.; Pesando, L. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 417-422.

**086339 ENERGY RESPONSE OF BONNER SPHERES TO NEUTRONS IN PARALLEL BEAM AND POINT SOURCE GEOMETRIES.** The energy response of the multisphere system equipped with a <sup>3</sup>H proportional counter was calculated by means of the adjoint flux technique. Calculations were performed using the one-dimensional, discrete ordinate neutron transport code ANISN and the DLC47 cross section library. The effect of the angular distribution of the impinging neutrons in the so-called 'point source' geometry was studied. In current correction procedures, this effect is expressed only as a function of the ratio of the sphere radius and source-to-sphere distance. This study shows additional pronounced dependences on both neutron energy and sphere size. (Author abstract) 13 Refs.

Vylet, Vaclav (Cite Univ, Lausanne, Switz); Kumar, Anil. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep

1988 p 607-610.

**086340 HIGH VOLTAGE CONTROL AND MONITORING SYSTEM FOR PROPORTIONAL CHAMBERS.** A description is given of a system that has been built and operated for distributing high voltage to 2000 channels of proportional chambers in the gas calorimeters of the CDF detector. The system consists of CAMAC-based controllers and distribution modules in the Rabbit hardware standard developed at Fermilab. Current monitoring to 1 nA and remote disconnect are available on each channel. 3 refs.

Saarloos, J. (Lawrence Berkeley Lab, Berkeley, CA, USA); Olson, S.; Carithers, W.; Haber, C.; Orme, C.; Siegrist, J. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 191-192.

**086341 CAPACITIVE CHARGE DIVISION IN CENTROID FINDING CATHODE READOUTS IN MWPCS.** A technique is described in which the centroid of induced charge on cathode strips in a proportional chamber can be determined with reduced differential and integral nonlinearity, without increasing the number of readout channels. It is based on capacitive charge division from intermediate cathode strips to adjacent readout strips. It can be applied both to amplifier-per-channel systems and to global-position readout. Both types of readouts have been studied using this approach, which is easy to implement and does not require modification of the existing readout electronics. 11 refs.

Smith, G.C. (Brookhaven Natl Lab, Upton, NY, USA); Fischer, J.; Radeka, V. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 409-413.

**086342 RICH MWPC PAD READOUT BY USING CUSTOM MICROPLEX I.C.** The use of custom microplex integrated circuits to read out directly 10,800 of a multiwire proportional chamber based on a ring imaging Cerenkov (RICH) photon detector is described. Analog pedestal subtraction for every pad, digitization, sparsification, and hit list are done on the fly while serial analog data is being read from the microplex chips. The overall system uses less than 100 cables. Cost per channel for electronics and pads are \$4.00 and \$1.07, respectively. 6 refs.

Dhawan, S.K. (Yale Univ, New Haven, CT, USA); Grudberg, P.; Venkateramanian, H.; Woods, C. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 436-440.

**086343 WIRE CHAMBER AGING WITH CF<sub>4</sub>/ISOBUTANE AND ARGON/ETHANE MIXTURES.** The aging characteristics of CF<sub>4</sub>/isobutane (80:20) and argon/ethane (50:50) in identical test cells have been investigated. The gas gain and gas flow rate were varied and the measurements extended beyond 6 C/cm of wire. Study of a third gas mixture Ar/Eth/CF<sub>4</sub> (48:48:4) is at an early stage. The Ar/Eth mixture has shown a variety of problems including cathode foil etching, anode deposits, dark currents, and pulse-height degradation. In contrast the CF<sub>4</sub>/Iso mixture produced some cathode etching for low flow velocities and only very minor anode deposits. With very little pulse-height degradation or dark current this mixture is an considered excellent candidate for a high-rate chamber. A small-area multiwire proportional chamber using this mixture has been evaluated in a pion beam with particle fluxes up to  $3 \times 10^7$  particles/cm<sup>2</sup>-s. 5 refs.

Henderson, R. (TRIUMF, Vancouver, BC, Can); Openshaw, R.; Faszler, W.; Salomon, M.; Salomons, G.; Sheffer, G. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 477-482.

**086344 CONSTRUCTION AND INITIAL OPERATION OF A PROPORTIONAL WIRE DETECTOR FOR USE IN A CERENKOV RING IMAGING SYSTEM.** The final version of the multiwire single-electron

detector for the Cerenkov ring imaging device of the Stanford Linear Collider Detector is described. Recent research-and-development efforts to define the design parameters are reported. These were concerned with computer simulations necessary for the detector design; wire aging and its solution; surface resistivity and voltage breakdown of G-10 in a TMAE environment; corona studies for various gases; wire breaking in the spark; measured mechanical characteristics of 7-μm carbon wires; wire-stretching technique for 7-μm carbon wires; and wire tension measuring for the final detector. The details of the geometry of the detector and experimental tests with the detector itself are discussed. 22 refs.

Va'vra, J. (Stanford Univ, CA, USA); Bienz, T.; Bird, F.; Gaillard, M.; Hallewell, G.; Kwon, Y.J.; Leith, D.; Ratcliff, B.; Rensing, P.; Schultz, D.; Shapiro, S.; Toge, N.; Cavalli-Sforza, M.; Coyle, P.; Coyne, D.; Williams, D. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 487-492.

**086345 APPLICATION OF PULSE-SHAPE DISCRIMINATION TO IMPROVE THE PRECISION OF THE CARBON-14 GAS-PROPORTIONAL-COUNTING METHOD.** The utilization of the pulse-shape-discrimination technique is demonstrated to improve the precision and accuracy of radiocarbon measurements by conventional-size carbon dioxide gas-proportional counters. Up to now, the maximum measurable age of a sample has been increased from 51,000 to 57,000 y B.P. (Author abstract) 9 refs.

Mantynen, P. (Geological Survey of Finland, Espoo, Finl); Aikaa, O.; Kankainen, T.; Kaihola, L. *Appl Radiat Isot* v 38 n 10 1987, Tech in Radionuclide Metrol, Proc of an ICRM Semin, Rome, Italy, Jun 15-16 1987 p 869-873.

**086346 3-D PET WITH MWPCs: PRELIMINARY TESTS WITH THE HISPET PROTOTYPE.** We describe the current status of the HISPET project. The project is a High Spatial Positron Emission Tomograph with fully 3-D imaging capabilities, based on the use of gas MWPCs coupled to lead glass drift space converters. (Edited author abstract) 9 refs.

Del Guerra, A. (Univ di Pisa, Pisa, Italy); Bandettini, A.; Conti, M.; De Pascalis, G.; Maiano, P.; Rizzo, C.; Perez Mendez, V. *Nucl Instrum Methods Phys Res Sect A* v A269 n 2 Jun 10 1988, Proc of the Int Symp on the Use of Wire Chambers in Med Imaging, Corsendonk, Belg, Jun 28-30 1987 p 425-429.

## Analysis

**086347 CATHODE CHARGE DISTRIBUTIONS IN MULTIWIRED CHAMBERS: 4. EMPIRICAL FORMULA FOR SMALL ANODE-CATHODE SEPARATION.** Single parameter values for the Gatti empirical formula describing cathode charge distribution in a symmetrical MWPC are presented, graphically, for small values of anode-cathode separation. The simple empirical formula can only represent an average behavior since it does not recognise any angular localisation of the avalanche. (Edited author abstract) 6 Refs.

Mathieson, E. (Univ Leicester, Leicester, Engl). *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 602-603.

## Applications

**086348 APPLICATIONS OF MULTIWIRED PROPORTIONAL CHAMBERS TO TIME RESOLVED X-RAY STUDIES ON MUSCLE.** Multiwire proportional chambers have been used for making time resolved X-ray diffraction measurements from skeletal muscle. The most useful properties are low noise, high efficiency and fast readout. A number of applications from measurements on skeletal muscle are described. (Author abstract) 18 refs.

Faruqi, A.R. (MRC Lab of Molecular Biology, Cambridge, Engl). *Nucl Instrum Methods Phys Res Sect A* v



A269 n 2 Jun 10 1988, Proc of the Int Symp on the Use of Wire Chambers in Med Imaging, Corsendonk, Belg, Jun 28-30 1987 p 362-368.

## Imaging Techniques

**086349 SOME APPLICATIONS OF THE IMAGING PROPORTIONAL CHAMBER.** Photons emitted by avalanches in gases can be detected with an image intensifier coupled to a solid-state camera. Some vapors enhance the emission at wavelengths close to the visible. Progress made in using this technique to image charged particles and Cerenkov photons is described. Results are presented for various gas mixtures containing TEA and TMAE. 15 refs.

Chapka, G. (CERN, Geneva, Switz); Dominik, W.; Fabre, J.P.; Gaudaen, J.; Peskov, V.; Sauli, F.; Suzuki, M.; Breskin, A.; Chechik, R.; Sauvage, D. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 483-486.

## Materials

**086350 STUDY OF THE EFFECT OF METHANE AND CARBON DIOXIDE CONCENTRATION ON GAS AMPLIFICATION IN ARGON BASED GAS MIXTURES.** Proportional counter gas amplification has been studied for argon based gas mixtures with methane and carbon dioxide as the quenching agent. Measurements of gas gain have been made using coaxial proportional tubes with different wire radii over a wide range of chamber voltages and pressures. The reduced gain function was found to be dependent on the reduced field  $E_0/P$ , and the fraction of the quenching minority gas, and approximately independent of the choice of quencher in most of the proportional region. The full data sample for the ten different gas mixtures can be described by a function with only nine parameters. (Edited author abstract). 8 Refs.

Armitage, J.C. (Carleton Univ, Ottawa, Ont, Can); Beingessner, Sean P.; Carnegie, R.K.; Ritchie, E.F.; Waterhouse, John. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 588-596.

**086351 APPLICATION OF CONDUCTING-POLYMER THIN FILM FOR SOURCE MOUNT IN  $4\pi\beta$  COUNTING.** This film ( $\leq 30 \mu\text{g cm}^{-2}$ ) electrically-conducting polypyrrole polymer is shown to be a practical backing material for radioactive source intended for  $4\pi\beta$  proportional counting. In all essential respects the polypyrrole behaves similarly to VYNS but needs no metallizing to yield counting results of the sample accuracy as realized with conventional methods. There are some difficulties with shrinkage during drying and the resistance of the films increases with age but it remains sufficiently low for at least one year. 12 refs.

Miyahara, Hiroshi (Nagoya Univ, Nagoya, Jpn); Suzuki, Manji; Watanabe, Tamaki. *Appl Radiat Isot* v 38 n 10 1987, Tech in Radionuclide Metrol, Proc of an ICRM Semin, Rome, Italy, Jun 15-16 1987 p 887-890.

## Medical Applications

**086352 MWPC DEVELOPMENTS AT RUTHERFORD APPLETON LABORATORY FOR MEDICAL IMAGING.** We report the work in progress at the Rutherford Appleton Laboratory in the development of various MWPC-based systems for biomedical applications. These various developments are described in the context of the particular applications to which they are relevant: X-ray imaging for X-ray microscopy, coherent scatter radiography, autoradiography for DNA sequencing and positron emission tomography (PET) using MWPCs. 17 refs.

Bateman, J.E. (Rutherford Appleton Lab, Didcot, Engl); Stephenson, R.; Connolly, J.F. *Nucl Instrum Methods Phys Res Sect A* v A269 n 2 Jun 10 1988, Proc of the Int Symp on the Use of Wire Chambers in Med Imaging, Corsendonk, Belg, Jun 28-30 1987 p 415-424.

**086353 DIGITAL IMAGING WITH ADVANCED GASEOUS DETECTORS DEVELOPED AT PISA UNIVERSITY.** Several biomedical applications of MWPC and other advanced gaseous detectors currently developed at Pisa University are discussed. Results of MWPC digital autoradiography and bone densitometry are presented together with preliminary results of X- and  $\beta$ -ray imaging with parallel plate counters. (Author abstract) 7 refs.

Angelini, F. (Univ di Pisa, Pisa, Italy); Bellazzini, R.; Brez, A.; Massai, M.M.; Torquati, M.R. *Nucl Instrum Methods Phys Res Sect A* v A269 n 2 Jun 10 1988, Proc of the Int Symp on the Use of Wire Chambers in Med Imaging, Corsendonk, Belg, Jun 28-30 1987 p 430-435.

## Noise, Spurious Signal

**086354 APPLICATION OF THE PARTITION NOISE THEORY.** The operation of the wedge and strip position sensing element in three different types of detector (multichannel plate device, parallel plate proportional counter and multiwire proportional counter) is examined. It is shown that, unlike the two other detector types, the position resolution of a multiwire proportional counter cannot be affected by partition noise because its wedge and strip works from induced charge rather than collected charge. (Author abstract) 8 refs.

Thornton, John (Univ of Surrey, Guildford, Engl). *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 523-525.

## Performance

**086355 NON-LINEARITY IN POSITION SENSING WITH CATHODE STRIPS OF A SINGLE WIRE PROPORTIONAL COUNTER.** The nonlinearity in the position readout from cathode strips has been investigated by a single-wire proportional counter using the charge-division method. The measured nonlinearities depended on the width of the cathode strip. This dependence agrees very well with theoretical predictions based on the formulae of E. Gatti et al. and J.S. Gordon and E. Mathieson. Obtainable position resolutions are independent of the strip width. (Author abstract) 12 refs.

Ohgaki, Hideaki (Kyushu Univ, Kasuga, Jpn); Kondo, Shingo; Uehara, Seiji; Fujiki, Toshihiro; Ijiri, Hidenobu; Matoba, Masaru; Sakae, Takeji; Koori, Norihiko. *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 302-306.

**086356 4.5-m<sup>2</sup> PROPORTIONAL CHAMBER FOR X-RAY DETECTORS.** A multiwire proportional chamber with an area of 4.5 m<sup>2</sup> is described. The energy resolution (total half-width) for registration of gamma quanta with an energy of 5.9 keV is not worse than 20% over the entire area of the chamber. The spread of the gas amplification factor is not over 20% for the wires of one section and not over 2% along the wires. (Author abstract) 4 refs.

Avundzhyan, A.T.; Bagdasaryan, A.A.; Bagdasaryan, L.S.; Balayan, Z.K.; Vinnitskii, O.M.; Kankanyan, S.A.; Oganessian, A.G.; Tamanyan, A.G. *Instrum Exp Tech* v 30 n 5 Pt 1 Sep-Oct 1987 p 1074-1076.

## PROPULSION See Also AIRCRAFT ENGINES, JET AND TURBINE; CARS; FUEL CELLS—Research; ROCKETS AND MISSILES.

**086357 BOUNDARY-ELEMENT ANALYSIS OF FLAGELLAR PROPULSION.** The swimming of a flagellar micro-organism by the propagation of helical waves along its flagellum is analyzed by a boundary-element method. With regard to the flagellum, it is concluded that the optimum helical wave (amplitude  $\alpha$  and wave-number  $k$ ) has  $\alpha k \approx 1$  (pitch angle of 45°) and that for the optimum flagellar length  $L/\lambda = 10$  ( $L$  being the flagellar length,  $\lambda$  being the radius of the assumed spherical cell body) the optimum number of wavelengths  $N_\lambda$  is about 1.5. Furthermore there appears to be no optimal value for the flagellar radius  $a$ , with the thinner flagella being favored. These conclusions show excellent quantitative

agreement with those of slender-body theory. For the case of an ellipsoidal cell body, the optimum aspect ratios  $B/\lambda$  and  $C/\lambda$  of the ellipsoid are about 0.7 and 0.3 respectively;  $A$ ,  $B$  and  $C$  are the principal radii of the ellipsoid. (Edited author abstract) 20 refs.

Phan-Thien, N. (Sydney Univ, Aust); Tran-Cong, T.; Ramia, M. *J Fluid Mech* v 184 Nov 1987 p 533-549.

**086358 ALTERNATIVE PROPULSION CONCEPTS USING HIGH-ENERGY BATTERIES AND HYDROGEN.** The role of electricity and hydrogen in vehicle propulsion, whether in a purely solar energy system or in a mixed nuclear/solar system, but at any rate in an extremely low pollution energy economy, could be outlined as follows. Advanced systems such as the sodium-sulphur battery offer the possibility of providing urban and short range transport (up to a range of 200 km). Larger distances of 200-500 km would have to be covered by using liquid hydrogen fuelled cars with internal combustion engines.

Braess, Hans-Hermann (BMW AG, Bonn, West Ger). *Electr Veh Dev* v 7 n 3 Jul 1988 p 94-95.

**Aerospace Applications** See Also AEROSPACE VEHICLES—Design; AIRCRAFT ENGINES; AIRCRAFT ENGINES, JET AND TURBINE—Nozzles; AIRCRAFT, VTOL/STOL—Control; ROCKET ENGINES—Combustion Chambers; ROCKET ENGINES—Costs; ROCKET ENGINES—Performance; SPACECRAFT—Orbital Transfer; SPACECRAFT—Orbits and Trajectories; SPACECRAFT—Structural Analysis.

**086359 HYDROGEN SCRAMJET WITH SIDE WALL INJECTION.** This paper presents the results of some preliminary experiments on a wall injection scramjet performed in the free piston shock tunnel at the Australian National University. Several interesting features of this engine configuration were observed. Firstly, there is a region of cooled flow near the wall which cannot sustain combustion. This leads to a significant drop in performance compared to injectors mounted away from the wall. Secondly, a marked drop in the surface heat transfer rates was observed due to the film cooling effect of the cold fuel, and this might help to alleviate thermal protection problems on a flight vehicle. (Author abstract) 6 refs.

Morgan, R.G.; Paull, A.; Morris, N.A.; Stalker, R.J. *Trans Inst Eng Aust Multi Discip Eng* v Gell n 1 Apr 1987 p 45-51.

**086360 QUELQUES REMARQUES SUR LES SYSTEMES DE PROPULSION MULTIFONCTIONS OU 'COMBINES'.** [Remarks on Multifunction, or 'Combined' Propulsion Systems]. Much work is currently, devoted to complex systems for powering aircraft to hypervelocities, or even orbital aircraft. These are made of components insuring various functions and used (together or separately) at their optimal performance in each flight phase. The choice among variety of proposed solutions is difficult because of the various constraints of the mission. The studies made in the past and recent published results suggested some remarks concerning the classification of combined propulsion systems, their performance, and their choice. (Edited author abstract) In French.

Barrere, M. (Office Natl d'Etudes & de Recherches Aérospatiales, Chatillon, Fr). *Acta Astronaut* v 15 n 11 Nov 1987 p 931-935.

**086361 THRUSTER REQUIREMENTS AND CONCERNS FOR BI-PROPELLANT BLOWDOWN SYSTEMS.** Bi-propellant blowdown applications can involve a wide range of operating conditions and requirements for thrusters in the system. These requirements are determined by studies and analyses plus computer simulations of propulsion system operation. These studies, in conjunction with associated thruster testing, have resulted in the identification of significant areas of concern that should be addressed, including performance effects, chamber life, ignition spikes, and combustion stability. There are also potential duty cycle sensitivities, and successful operation in the steady-state mode does not guarantee acceptable



thermal control during pulsing modes. Testing should be conducted using realistic inlet conditions and duty cycles, and caution should be exercised in attempting to extrapolate into regions that have not been covered by actual testing. (Author abstract) 10 refs.

Hearn, H.C. (Lockheed Missiles & Space Co, Huntsville, AL, USA). *J Propul Power* v 4 n 1 Jan-Feb 1988 p 47-52.

**086362 GENERALIZED THEORY OF ROCKET PROPULSION FOR FUTURE SPACE TRAVEL.** This paper introduces a generalized theory of classical rocket propulsion for reusable space vehicles wherein the propellant is atmospheric gas and the propulsive decelerating or accelerating thrust is generated by, respectively, ingesting or expelling atmospheric gas at high velocities. The working fluid expelled during accelerating propulsive maneuvers is automatically replenished during decelerating propulsive maneuvers. The refueling retrothrust is generated by a large-diameter hypervelocity gas inlet diffuser mounted at the front of the vehicle, which ingests gas while traversing through the tenuous upper regions of a planet's atmosphere. (Edited author abstract) 18 refs.

Minovitch, Michael A. (Phaser Telepropulsion Inc, Los Angeles, CA, USA). *J Propul Power* v 3 n 4 Jul-Aug 1987 p 320-328.

**086363 LIFE-CYCLE-COST METHODOLOGY FOR THE SPACE STATION PROPULSION SYSTEM.** A life cycle cost (LCC) model was developed for the space station propulsion system, to support requirement and configuration trade studies. The model was conceived to be flexible in its structure in order to handle the large variations in propulsion concepts with regard to propellants, hardware, space station characteristics, and operational support schemes. The model categorizes LCC into four cost segments: development, production, transportation, and operational support. The methodology is described with regard to the model structure, assumptions and ground rules, types of cost estimating relationships used, validation, and input/output features. (Edited author abstract) 7 refs.

Meisl, Claus J. (Rockwell Int, Canoga Park, CA, USA). *J Propul Power* v 4 n 2 Mar-Apr 1988 p 111-117.

**086364 ELECTROTHERMAL PROPULSION OF SPACECRAFT WITH MILLIMETER AND SUBMILLIMETER ELECTROMAGNETIC ENERGY.** The concept of millimeter and submillimeter wave electrothermal propulsion is considered. State-of-the-art radiation sources from 30-1000 GHz are examined to determine their applicability to electrothermal propulsion systems. The problem of energy conversion and power conditioning in this frequency range is also addressed. The potential advantage of utilizing power beaming with millimeter and submillimeter systems is examined. Finally, areas of future research and development are indicated. (Author abstract) 69 refs.

Frasch, L.L. (Michigan State Univ, East Lansing, MI, USA); Frutz, R.; Asmussen, J. *J Propul Power* v 4 n 4 Jul-Aug 1988 p 334-340.

**Components** See DIESEL ELECTRIC TRACTION—Federal Republic of Germany.

**Control** See HELICOPTERS—Flight Dynamics.

## Electric

**086365 WATER-PROPELLANT RESISTOJETS FOR MAN-TENDED PLATFORMS.** Space platforms are planned for the early 1990's which can be serviced by the Shuttle Orbiter, and at a later date, via the Space Station. Man-tended platforms are smaller than the manned Space Station and have significantly lower requirements for propulsion total impulse. Nonetheless, the basic requirements of integration with the Space Transportation System, altitude maintenance, reboost, attitude control, and collision avoidance must be met. The selection of a propulsion system for the man-tended platform has been influenced by the planned use of

resistojets for drag make-up on the manned Space Station. For this application, a resistojets has been designed that is capable of operation with a wide variety of propellants, including water. This paper discusses the reasons for selection of water as the propellant and the performance of resistojets using water, and describes the man-tended platform and its mission requirements. (Edited author abstract) 15 refs.

Louviere, Allen J. (Space Industries Inc, Webster, TX, USA); Jones, Robert E.; Morren, W. Earl; Sovey, James S. *NASA Tech Memo* 100110 1987 15p.

**Electric Energy** See Also ELECTRIC MOTORS, LIN-EAR—Reviews; LOCOMOTIVES, DIESEL—Electric Power Supplies; ROCKET ENGINES—Design; ROCKET ENGINES—Electric Propulsion; SPACE RESEARCH; SPACECRAFT—Guidance; VEHICLES—Magnetic Levitation.

**086366 PRELIMINARY PERFORMANCE CHARACTERIZATIONS OF AN ENGINEERING MODEL MULTIPROPELLANT RESISTOJET FOR SPACE STATION APPLICATION.** This paper presents the results of a program to describe the operational characteristics of an engineering model multipropellant resistojets for application as an auxiliary propulsion system for a space station. Performance was measured on hydrogen, helium, methane, water (steam), nitrogen, air, argon, and carbon dioxide. Thrust levels ranged from 109 to 355 mN, power levels ranged from 167 to 506 W, and specific impulse values ranged from 93 to 385 sec, depending upon the propellant, chamber pressure, and heater current level selected. Detailed thermal maps of the heater and heat exchanger were also obtained for operation with carbon dioxide. (Author abstract) 16 refs.

Morren, W. Earl (NASA, Cleveland, OH, USA); Hay, Stuart S.; Haag, Thomas W.; Sovey, James S. *NASA Tech Memo* 100113 1987 22p.

**086367 NASA/USAF ARCJET RESEARCH AND TECHNOLOGY PROGRAM.** Direct-current arcjets have the potential to provide specific impulses > 500 sec with storable propellants, and > 1000 sec with hydrogen. This level of performance can provide significant benefits for such applications as orbit transfer, stationkeeping, orbit change, and maneuvering. The simplicity of the arcjet system and its elements of commonality with state-of-the-art resistojets systems offer a relatively low risk transition to these enhanced levels of performance for low power (0.5 to 1.5 kW) stationkeeping applications. Arcjets at power levels of 10 to 30 kW are potentially applicable to orbit transfer missions. Furthermore, with the anticipated development of space nuclear power systems, arcjets at greater than 100 kW may become attractive. This paper describes the ongoing NASA/USAF program and describes major recent accomplishments. (Author abstract) 40 refs.

Stone, James R. (NASA, Cleveland, OH, USA); Huston, Edward S. *NASA Tech Memo* 100112 1987 19p.

**086368 UN MODELLO ELETTRODINAMICO PER L'ANALISI DEI PROPULSORI A CAMPO ELETTRO.** [Electrodynamic Model to Analyze Field Emission Thrusters]. After a short description of the principle of working of the field emission thrusters, a surface emission electrodynamic model capable of describing the required propulsive effects is shown. The model, developed according to cylindrical geometry, provides one-dimensional differential relations, and therefore an easy method of integration. Characteristic curves obtained are shown; a comparison with experimental data confirms the validity of the proposed model. (Edited author abstract) In Italian. 21 refs.

Cardelli, Ermano (Univ di Pisa, Italy); Del Zoppo, Romano; Venturini, Giuliano. *Energ Elettr* v 64 n 12 Dec 1987 p 477-484.

**086369 REVIEW OF EUROPEAN ELECTRIC PROPULSION DEVELOPMENTS.** This paper presents the major activities carried out in Europe in the field of Electric Propulsion. Several lines of development, the

majority of which are sponsored by ESA, are being pursued. Three different models of the RIT family of radio-frequency ion thruster are being developed in Germany. In the United Kingdom, development was re-started in 1985 on a 10 cm diameter Kaufman thruster (UK10), derived directly from the former T5 thruster. In 1986 development of a scaled up version was initiated with a diameter of 25 cm (UK25). These engines, with thrust ranges of 10 and 200 mN respectively, have been extensively tested with Xenon propellant and are now undergoing further optimization for possible applications in secondary and primary propulsion. Tests and experiments on the Field Emission Electric Propulsion (FEPP) system are continuing, with attention now focused on a pulsed mode of operation which may open new applications for ultra-fine pointing and positioning of spacecraft. (Edited author abstract) 51 refs.

Bartoli, C. (ESA, Noordwijk, Neth); Berry, W. *J Br Interplanet Soc* v 41 n 4-5 Apr-May 1988 p 147-165.

**086370 UK LARGE DIAMETER ION THRUSTER FOR PRIMARY PROPULSION.** Previous work on electric propulsion systems within the UK has been concerned only with ion thrusters with thrust levels of a few tens of millinewtons, even though early planning assigned an orbit-raising function to the thruster. Recently, however, there has been renewed interest in the UK in the use of ion thrusters for orbit-raising of low Earth platforms, drag compensation of large spacecraft and general control and positioning tasks for future space systems. Also in Europe, there is increasing interest in high energy science missions. All these applications require thrust levels of a few hundred millinewtons. It was decided, therefore, to develop a 25 centimetre diameter Kaufman-type ion thruster, with a nominal thrust of 200 mN operating with xenon as propellant, for this class of application. The present paper describes the thruster design and initial test results. (Author abstract) 20 refs.

Martin, A.R. (UKAEA Culham Lab, Abingdon, Engl); Bond, A.; Lavender, K.E.; Harvey, M.S.; Latham, P.M. *J Br Interplanet Soc* v 41 n 4-5 Apr-May 1988 p 167-173.

**086371 USE OF ELECTRIC PROPULSION ON LOW EARTH ORBIT SPACECRAFT.** This paper has considered the use of electric propulsion on low Earth orbit space platforms and in particular the application of such propulsion systems to the different elements of the NASA/International Space Station Program. Although the detailed definition and specification of the Space Station Elements is still in progress, it was possible to choose spacecraft which were thought to be sufficiently representative of each particular element for study and evaluation. 14 refs.

Martin, A.R. (UKAEA Culham Lab, Abingdon, Engl); Cresdee, M.T. *J Br Interplanet Soc* v 41 n 4-5 Apr-May 1988 p 175-182.

**086372 PERFORMANCE ASSESSMENT OF A UK RARE GAS ION THRUSTER.** During the years from 1967-77 the UK had a very successful programme of development for a 10 centimetre beam diameter mercury ion thruster. This work was discontinued in 1978, but as the market opportunities for such devices have improved since that date the development was restarted in 1985. Rare gas propellants rather than mercury are being used to avoid any spacecraft surface contamination problems. The performance of the UK thruster system in xenon has been found to be entirely satisfactory, and the operation appears to suffer no adverse effects from the propellant change. Performance has been mapped, both at the nominal 10 mN thrust level and at higher levels. The maximum thrust level achieved was 34.4 mN with a total power input of 930 W. This limit was set by the capability of the power supplies used to run the thruster itself. (Author abstract) 7 refs.

Martin, A.R. (UKAEA Culham Lab, Abingdon, Engl); Harvey, M.S.; Latham, P.M. *J Br Interplanet Soc* v 41 n 4-5 Apr-May 1988 p 183-192.



**086373 PLANS FOR AN IN-ORBIT TEST OF A UK RARE GAS ION THRUSTER.** As part of the development work on a UK rare gas ion thruster an exercise has been carried out to provide an initial assessment of the integration of such a thruster into a technology demonstrator satellite. The aim of the mission is to provide an in-orbit flight test of the thruster system, and to evaluate the effect of the thruster ion beam upon the spacecraft and upon the surrounding space plasma. Any interactions with communications links will also be assessed, to check that thruster operation and associated noise levels do not have any unacceptable effect upon the communications. (Author abstract) 6 refs.

Martin, A.R. (UKAEA Culham Lab, Abingdon, Engl); Bond, A.; Lavender, K.E. *J Br Interplanet Soc* v 41 n 4-5 Apr-May 1988 p 193-198.

**086374 FACTORS INFLUENCING THE INTEGRATION OF THE UK-10 ION THRUSTER SYSTEM WITH A SPACECRAFT.** The UK-10 ion thruster system is based closely on the 10 cm diameter T5 Kaufman-type thruster and its power conditioning and control system, which were developed during the 1970s for the North-South station-keeping application. The T5 device was designed to produce a thrust of 10 mN using mercury propellant. However, in the current work, mercury has been replaced by xenon to avoid any possibility of adverse chemical reactions with materials used in constructing spacecraft. In the previous phase of the programme, it was shown that the system was fully suitable for its intended mission and that its integration into a spacecraft should present no difficulties. This paper re-examines that conclusion, bearing in mind the different physical characteristics of the new propellant. It is confirmed that the UK-10 system, using xenon, is compatible with the requirements of a wide range of applications. (Author abstract) 31 refs.

Fearn, D.G. (Royal Aircraft Establishment, Farnborough, Engl). *J Br Interplanet Soc* v 41 n 4-5 Apr-May 1988 p 199-207.

**086375 RIT 35 RF-ION THRUSTER - DESIGN AND PERFORMANCE.** Within the basic research work on rf-ion thrusters, scaled-up versions of the standard RIT 10 engine, namely the RIT 15, RIT 20 and RIT 35 have been studied starting 1972. The tests on the RIT 35 have been carried out in 1986 until January 1987 with mercury as the propellant, demonstrating excellent operation data. Thus, a mass efficiency up to 89% and an electrical efficiency up to 84% could be proved. The minimum power-to-thrust ratio was 21.5 W/mN. Presently, the RIT 35 motor has been modified for inert gas operation using a new discharge vessel and a mass flow controller. The tests with xenon started in May 1987 using the flat grid system of the mercury tests which will be replaced by a dished grid system which has been manufactured by MBB, Munich. Then, the xenon performance data of the RIT 35 can be mapped completely. (Edited author abstract) 11 refs.

Groh, K.H. (Giessen Univ, Giessen, West Ger); Loeb, H.W.; Mueller, J.; Schmidt, W.; Schuetz, B. *J Br Interplanet Soc* v 41 n 4-5 Apr-May 1988 p 209-214.

**086376 CATHODE PHENOMENA IN PLASMA THRUSTERS.** Processes at the arc cathode attachment decisively determine the entire discharge behavior of almost all arc devices and therefore also of MPD and/or arc jet thrusters. One well known process occurring on spotty arc attachments in a transverse magnetic field is the fact that the cathode spots move or jump in the direction opposite to the Lorentzian rule. In pulsed thruster devices with cold cathodes and very likely also in continuously running thrusters with so-called thermionic, seemingly diffuse attachments of hot surfaces, the arc attachment consists of many high current density spots. These spots can stick or spread upstream and thereby overheat the insulating material of the backplate of the thruster. In this paper an explanation of the phenomena of spot motion is presented. (Author abstract) 20 refs.

Schrade, H.O. (Univ Stuttgart, Stuttgart, West Ger);

Auwater-Kurtz, M.; Kurtz, H.L. *J Br Interplanet Soc* v 41 n 4-5 Apr-May 1988 p 215-222.

**086377 EXPERIMENTAL MPD THRUSTER INVESTIGATIONS.** The experimental results presented are part of a greater effort to understand MPD propulsion and the related phenomena, which include theoretical investigations, both of the midstream flow field and electrodes and of erosion. The goal of the experiments is twofold: first to give a basis of data for the theories and second to come up with better and more efficient thruster designs, since the performances of self-field MPD thrusters, at least in the investigated power field < 500 kW, are quite modest. 19 refs.

Kurtz, H.L. (Univ Stuttgart, Stuttgart, West Ger); Auwater-Kurtz, M.; Merke, W.; Schrade, H.O. *J Br Interplanet Soc* v 41 n 4-5 Apr-May 1988 p 223-232.

**086378 COAXIAL NON-STEADY SOLID PROPELLANT MPD THRUSTER EXPERIMENTAL ANALYSIS.** A parametric experimental analysis of a coaxial non-steady solid propellant thruster has been carried out by varying the thruster geometry and the energy per shot. Their influence on the main working parameters and performance parameters has been determined. Thruster functioning is strongly affected by the ablation process. This process depends on the energy density which exists in the space adjacent to the ablation surface and, therefore, on coupling between the discharge and this surface. A field of -operating regularity- is defined by high values of the angle between the propellant surface and the normal surface to the thruster axis, by short cathodes, medium anodes, medium anode-to-cathode radius ratio and medium to high current. The current only depends weakly on the geometry. By increasing the energy per shot the current linearly increases and the performance parameters-impulse bit and thrust efficiency increase too. (Edited author abstract) 13 refs.

Paccani, G. (Univ degli Studi di Roma 'La Sapienza', Rome, Italy). *J Br Interplanet Soc* v 41 n 4-5 Apr-May 1988 p 233-240.

**086379 10kW STEADY-STATE MPD THRUSTER.** An experimental study on a 10 kW steady-state, direct-current MPD thruster has been made. A permanent magnet was used to supply an external field thereby reducing the thruster weight increase and eliminating the power requirements of a solenoidal coil. Magnet design was performed by numerical calculation with the intention of obtaining a field pattern similar to that produced by a solenoidal coil. Stable arc operation was obtained with the permanent magnet. This thruster delivered a specific impulse of 7700 sec and thrust efficiency of 25 percent with hydrogen propellant. Diagnostic measurements have clarified certain aspects of the plasma acceleration mechanism. It was found that the electromagnetic force related to the applied magnetic field is dominant for hydrogen propellant. The thrust production of this component was proved to be closely related to the current distribution in the plasma. (Author abstract). 19 Refs.

Sasoh, Akihiro (Dep of Aeronautics, Jpn); Solem, Anders E.; Arakawa, Yoshihiro. *J Fac Eng Univ Tokyo Ser B* v 39 n 3 Mar 1988 p 275-296.

**Equipment** See LOCOMOTIVES, ELECTRIC.

**Ion Energy** See Also ROCKET ENGINES—Ion Propulsion.

**086380 ANALISI DI PROPULSORI DI TIPO FEED MEDIANTE PROVE SPERIMENTALI.** [Analysis of FEED Thrusters by Means of Experimental Tests]. The experimental measurements achieved with an ionic thruster of the FEED type fed by liquid cesium and kept in a vacuum chamber are presented. The testing system is adopted to investigate in particular the onset of the phenomenon, the ionic beam production and its propulsive characteristics. The emission is divided into three different phases, depending on the level of ionic current produced, and for each of them the main characteristics are described and commented upon. (Edited author

abstract) In Italian. 6 refs.

Cardelli, Ermanno (Univ di Pisa, Italy); Del Zoppo, Romano; Venturini, Giuliano. *Energia Elett* v 64 n 12 Dec 1987 p 485-490.

**086381 FIELD EMISSION ELECTRIC PROPULSION: EMISSION SITE DISTRIBUTION OF SLIT EMITTERS.** Research work on a slit-type field ion thruster for electric space propulsion is reported and discussed. Liquid-metal ion sources are used. A slit emitter with a closed propellant supply system was fired in any optional direction, requiring in principle no gravitational forces. Quantitative data relating the constituents of the residual gas atmosphere to the wetting behavior of the liquid-metal propellant and the emission-site distribution were obtained. A homogeneous distribution of equally spaced emission sites was observed; the measured spacing is in good agreement with a simple hydrostatic model of wavelike instabilities on electrically stressed surfaces of fluids. 13 refs.

Mitterauer, J. (Technical Univ Wien, Austria). *IEEE Trans Plasma Sci* v PS-15 n 5 Oct 1987, XIIth Int Symp on Discharges and Electr Insul in Vac, Shosh, Isr, Sep 22-25 1986 p 593-598.

**Land Vehicle Applications** See Also MILITARY VEHICLES—Tanks.

**086382 CHOICE OF HYBRID PROPULSION SYSTEMS - WHEELED CITY AND URBAN VEHICLE - TRACKED ALL-TERRAIN VEHICLE (PART I).** The major effort of the author's research and development work reaches the highest level of the design and construction of experimental proof-of-concept hybrid electromechanical VAP (very advanced propulsion) systems for civilian wheeled and tracked ATVs (all-terrain vehicles) with extremely high mobility. These systems are being developed using VAP technology improvements to reach a level of performance considerably better than the present state-of-the-art hybrid electromechanical or fluidomechanical AP (advanced propulsion) systems. The use of these hybrid electromechanical VAP systems for civilian wheeled and tracked ATVs with extremely high mobility opens up wide possibilities for improving fuel economy. (Author abstract) 12 refs.

Fijalkowski, B.J. (Cracow Polytechnical Univ, Thaddeus Kosciuszko Memorial, Pol). *Electr Veh Dev* v 6 n 4 Oct 1987 p 113-117, 142.

**Laser Applications**

**086383 STRONG SHOCK WAVE SUPPORTED BY THE ABSORPTION OF LASER.** Basically, laser propulsion can be achieved either by a laser-supported combustion wave or by a laser-supported detonation wave as a mechanism for a propellant gas to absorb laser radiation. In this paper the structure of a laser-supported detonation wave is shown by solving one-dimensional gasdynamic equations, taking account of inverse bremsstrahlung absorption of the laser energy incident on the front shock wave. The structure of the detonation consists of (i) a shock wave heating the low-temperature nonabsorbing propellant gas up to a very high temperature, enabling it to absorb laser radiation, (ii) followed by a thick absorption region where the subsonic flow is accelerated by exothermicity to the sonic velocity. Virtually all the laser energy is utilized to raise the temperature of this region until an equilibrium state is established between the radiation at incident laser wavelength and the bremsstrahlung radiation emission from the heated gas. (Edited author abstract) 5 refs.

Fujiwara, Toshi (Dep of Aeronautical Engineering, Jpn); Nishiwaki, Takashi. *Mem Fac Eng Nagoya Univ* v 39 n 1 1987 p 163-179.

**Nozzles** See AERODYNAMICS—Nozzles.



Optimization See AIRCRAFT, VTOL/STOL—Design.

**Space Applications** See Also ROCKET ENGINES; ROCKET ENGINES—Electric Propulsion; ROCKET ENGINES—Electromagnetic Propulsion; ROCKET ENGINES—Exhausts; ROCKET ENGINES—Nuclear Energy; ROCKET ENGINES—Testing.

#### 086384 SPACE STATION PROPULSION SYSTEM TECHNOLOGY.

Two propulsion systems have been selected for the space station: O/H rockets for high thrust applications and the multipropellant resistojets for low thrust needs. These thruster systems integrate very well with the fluid systems on the station. Both thrusters will utilize waste fluids as their source of propellant. The O/H rocket will be fueled by electrolyzed water and the resistojets will use stored waste gases from the environmental control system and the various laboratories. This paper presents the results of experimental efforts with O/H and resistojets thrusters to determine their performance and life capability. (Author abstract) 18 refs.

Jones, Robert E. (NASA, Cleveland, OH, USA); Meng, Phillip R.; Schneider, Steven J.; Sovey, James S.; Tacina, Robert R. *Acta Astronaut* v 15 n 9 Sep 1987 p 673-683.

## PROPYLENE

### Chemical Reactions

**086385 KINETICS OF THE  $\gamma$ -RADIATION-INITIATED REACTION OF 2-PROPANOL WITH TRI- AND HEXAFLUOROPROPYLENE.** The object of this work was to study the reactivity of trifluoropropylene (TFP) and hexafluoropropylene (HFP) with 2-propanol (IPA). From the experimental results it is evident that the rate constant for the addition of the  $\alpha$ -hydroxyisopropyl radical increases by a factor of  $2.6 \cdot 10^3$  when the hydrogen in propylene is completely replaced by fluorine. This is explained by a reduction of the electron density on the  $\beta$ -carbon atoms (relative to the  $\text{CF}_3$  group) as a result of the electron acceptor effect of the fluorine atoms. For this reason, and also because of the steric hindrance due to the  $\text{CF}_3$  group, the  $\alpha$ -hydroxyisopropyl radical, which has a nucleophilic character, adds to the  $\beta$ -carbon atom of trifluoropropylene. 5 refs.

Zamyslov, R.A. (D.I. Mendeleev Moscow Chemical Engineering Inst, USSR); Shostenko, A.G.; Dobrov, I.V.; Tarasova, N.P. *Kinet Catal* v 28 n 4 pt 2 Jul-Aug 1987 p 858-860.

### Oxidation

**086386 ROLE OF ZINC COMPLEXES AT THE ELEMENTARY STEPS OF THE RADICAL CHAIN CATALYTIC REACTION OF ISOPROPYLENE OXIDATION.** The authors studied the oxidizability of cumene (isopropylbenzene) in presence of monophenanthrolinezinc (II) pyrazolonate and monophenanthrolinezinc (II) acetate, which are catalysts found to have the highest activity in the oxidation reaction. The results of this study are presented in this communication. The oxidizability of cumene was estimated from the rate of initiated oxidation in a gasometric apparatus using azobisisobutyronitrile (AIBN) as the initiator. It was shown in special experiments that the rate of initiated oxidation of cumene at oxygen partial pressures of 400 GPa and higher is independent of the oxygen concentration in the system and on the frequency of shaking the reaction mass. Therefore chain termination occurs only upon recombination of peroxy radicals. Data on oxidizability of cumene in presence of the catalysts studied are given. Since zinc phenanthroline monoadducts do not influence the initiation step either, it can be said with certainty that the role of the catalytic systems studied lies in their active influence on degenerate branching.

Kozlov, S.K. (All-Union Scientific-Research Inst of Petrochemical Processes, USSR); Potekhin, V.M. *J Appl Chem USSR* v 59 n 7 pt 2 Jul 1986 p 1519-1521.

#### 086387 THEORETICAL AB INITIO STUDY OF THE VINYL CARBENE-CuO COMPLEX: APPLICATION TO LAST STEP OF THE PROPYLENE PARTIAL OXIDATION MECHANISM ON $\text{Cu}_2\text{O}$ .

Using non-empirical pseudopotentials, we have performed a theoretical study on the last step of the propylene partial oxidation mechanism, the acrolein desorption from the catalyst surface. To represent the catalyst we have used a simplified model of a catalyst active site. We have studied the  $\text{C}_3\text{H}_4\text{CuO}$  complex, analyzing the dissociation process of the oxygenated complex from a metallic center. The results indicate that this complex dissociates into cis- and trans-acrolein and a metal site, in a process without energetic barrier. (Author abstract) 46 refs.

Gonzalez-Luque, R. (Univ de Valencia, Valencia, Spain); Nebot-Gil, I.; Montanana, R.; Sanchez-Marín, J. *J Mol Catal* v 44 n 3 Mar 21 1988 p 323-336.

**086388 KINETICS OF THE OXIDATION OF PROPYLENE OVER A BISMUTH MOLYBDATE CATALYST.** Using statistical design procedures an initial-rate study of the oxidation of propylene over a silica-supported bismuth molybdate catalyst was carried out using a differential-bed reactor over the following range of conditions: temperatures from 350 to 390°C, oxygen and propylene concentrations from 1.0 to 8.0 mmol/L. Among the models considered a Redox Steady-State Model (with half-order oxygen concentration) involving oxygen adsorption and reaction with propylene from the gas phase was found to provide the best fit to the data. (Author abstract). 22 Refs.

Tan, H.S. (Queen's Univ, Kingston, Ont, Can); Downie, J.; Bacon, D.W. *Can J Chem Eng* v 66 n 4 Aug 1988 p 611-618.

**Polymerization** See Also ETHYLENE—Polymerization; POLYMERIZATION—Catalysts.

**086389 MAGNESIUM CHLORIDE SUPPORTED HIGH-MILEAGE CATALYSTS FOR OLEFIN POLYMERIZATION. XVII. EFFECT OF LEWIS BASE ON PROPYLENE POLYMERIZATION.** A systematic study has been made on the functions of external Lewis base ( $\text{B}_2$ , methyl-p-toluate, MPT) and internal Lewis base ( $\text{B}_1$ , ethyl benzoate, EB) for the CW-catalyst system  $\text{MgCl}_2/\text{EB}/\text{PC}/\text{AlEt}_3/\text{TiCl}_4\text{-AlEt}_3/\text{MPT}$  (PC, p-resol).  $\text{B}_1$  is a nonstereoselective modifier. It increases the active site concentrations and rate constants of propagation of both the isospecific and nonspecific sites, and thus the productivities of the stereoregular and irregular polypropylenes by five- to tenfold. It seems that  $\text{B}_1$  complexes with the  $\text{MgCl}_2$  support to lower the electronegativity of the surface Mg atoms. It also acts to lower the rate constant of chain transfer to aluminum alkyl by two- to fourfold. The action of  $\text{B}_2$  is highly stereospecific. The isotacticity index of polypropylene is  $\geq 95\%$  in the presence of  $\text{B}_2$  but  $\leq 68\%$  without it. (Edited author abstract) 26 refs.

Chien, James C.W. (Univ of Massachusetts, Amherst, MA, USA); Hu, Youliang. *J Polym Sci Part A* v 25 n 10 Oct 1987 p 2847-2870.

**086390 CATALYST FRAGMENTATION DURING PROPYLENE POLYMERIZATION: PART I. THE EFFECTS OF GRAIN SIZE AND STRUCTURE.** Fragmentation of support/catalyst particles during propylene polymerization in the gas phase is analyzed via a mathematical model including energy and mass transfer with chemical reaction processes. The rupture phenomenon is considered specifically by the model, and evaluated as it proceeds in time. Two different regions are recognized in the polymerizing particle at fragmentation time: an inner core resembling the original solid support/catalyst structure, and an external set of layers where most of the polymerization occurs. Model predictions concerning the effects of fragmentation on polymerization are discussed. (Edited author abstract) 21 refs.

Ferrero, Monica A. (CONICET, Santa Fe, Argent); Chiovetta, Mario G. *Polym Eng Sci* v 27 n 19 Oct 1987 p 1436-1447.

#### 086391 CATALYST FRAGMENTATION DURING PROPYLENE POLYMERIZATION: PART II. MI-

**CROPARTICLE DIFFUSION AND REACTION EFFECTS.** A mathematical model is used to predict the behavior of the support/catalyst/polymer macroparticle during the gas phase polymerization of propylene. The problem is focused on the micrograin level of the macroparticle, and the emphasis placed on the combined reaction and diffusion processes taking place in the macroparticle. Particular attention is given to the effect of the main geometry parameter, the size of the catalytic nucleus, on polymerization variables. Fragmentation rate, monomer concentration, and temperature are studied in terms of their dependence on the geometry-related dimensionless numbers typical of the process. The model suggests criteria for predicting 'a priori' the combination of reaction parameters that will produce a diffusion-limited reaction regime in the macroparticle. (Edited author abstract) 12 refs.

Ferrero, Monica A. (CONICET, Santa Fe, Argent); Chiovetta, Mario G. *Polym Eng Sci* v 27 n 19 Oct 1987 p 1448-1460.

**086392 PROPENE OLIGOMERIZATION OVER SYNTHETIC MICA-MONTMORILLONITE (SMM) AND SMM INCORPORATING NICKEL, ZINC AND COBALT.** The activity and selectivity for propene oligomerization of pure synthetic mica-montmorillonite, SMM, as well as SMM incorporating various transition metals, was studied. The effect of incorporating nickel into the matrix as well as ion-exchanging (IX) nickel, zinc and cobalt into the interlayer spaces was investigated. Matrix nickel removed the long induction period characteristic of SMM and ion-exchanged SMM. Reducing the ion-exchanged nickel removed the induction period in the oligomerization reaction. Removal of the reduced nickel by carbon monoxide leaching caused an increase in activity. Water drastically decreased the catalyst lifetime. Zn(IX)SMM had a greater activity than Ni(IX)SMM, and Co(IX)SMM was initially more active than either but deactivated rapidly. Oligomerization selectivity was fairly constant throughout this study and the products were predominantly trimers and tetramers. (Edited author abstract). 14 Refs.

O'Connor, C.T. (Univ of Cape Town, Cape Town, S Afr); Jacobs, L.L.; Kojima, M. *Appl Catal* v 40 n 1-2 Jun 15 1988 p 277-290.

### Processing

**086393 SELECTIVITY STUDIES ON THE HYDROFORMYLATION OF PROPYLENE CATALYZED BY THE CLUSTER ANION  $[\text{HB Ru}_3(\text{CO})_11]^-$ .** The chemo- and regioselectivity of the hydroformylation of propylene catalyzed by  $[\text{NET}_4][\text{HRu}_3(\text{CO})_11]$  was studied as a function of solvent, temperature and pressure. The catalyst was found to be chemospecific, independent of the reaction conditions; exclusively aldehydes were formed, and no alcohols were detected in the mixture. The regioselectivity can be optimized by variation of the reaction conditions: In the best case, the n/i ratio of the butanals formed was a high as 98.6:1.4. In every case the catalyst remained unchanged in the solution. (Author abstract) 10 refs.

Suess-Fink, Georg (Univ Bayreuth, Bayreuth, West Ger); Schmidt, Gerhard F. *J Mol Catal* v 42 n 3 Nov 2 1987 p 361-366.

**086394 STUDY OF THE HYDROFORMYLATION OF PROPYLENE TRIMERS.** The authors previously studied the effect of solvent, olefin concentration, and temperature on the rate and selectivity of propylene trimer hydroformylation (oxo reaction). In this communication we report on the continuing investigation of the kinetic characteristics of this reaction. It is shown that the kinetic characteristics of olefin hydroformylation in the presence of the catalytic system cobalt carbonyls + Lewis bases are essentially identical to those obtained with the classical catalyst  $\text{HCo}(\text{CO})_4$ . However, in the present case two characteristic features were observed: a) a higher alcohol



yield (20-25% higher than obtained with the classical catalyst) and b) a significantly lower yield of high-boiling side products [4-6 vs 16-25% for  $\text{HCo}(\text{CO})_4$ ]. 8 refs.

Vigranenko, Yu.T.; Rybakov, V.A.; Khokhlova, M.V.; Fedorov, V.S. *J Appl Chem USSR* v 60 n 7 pt 2 Jul 1987 p 1490-1493.

## Pyrolysis

**086395 PYROLYSIS OF PROPYLENE OVER CARBON ACTIVE SITES II. PYROLYSIS PRODUCTS.** The pyrolysis of propylene over Graphon, a graphitized carbon black, was studied in the temperature range 873 to 1073 K at a starting pressure of 1.6 Pa. Using this substrate, the effect of the carbon active surface area (ASA) on the type, distribution, and mode of formation of the reaction products was investigated. On a clean surface, propylene instantly chemisorbed on some active sites at the beginning of each pyrolysis run and ultimately formed a more unsaturated hydrocarbon complex on the surface. Regardless of the cleanliness of the surface, a carbon deposit was formed on the surface. In the range 873 to 973 K, the major gas phase products consisted of methane, ethylene, and  $\text{H}_2$ . A model is proposed to explain the origin of all the pyrolysis products. (Edited author abstract). 29 Refs.

Hoffman, W.P. (Pennsylvania State Univ, University Park, PA, USA); Vastola, F.J.; Walker, P.L. Jr. *Carbon* v 26 n 4 1988 p 485-499.

**PROSTHETICS** See Also BIOMATERIALS—Plastics Applications; BIOMATERIALS—Testing; BIOMECHANICS—Musculoskeletal Systems; BIOMEDICAL ENGINEERING—Hemodynamics; BIOMEDICAL ENGINEERING—Orthopedics; ELECTRIC BATTERIES, PRIMARY—Performance; ELECTRIC MOTORS, LINEAR; HUMAN REHABILITATION ENGINEERING—Electric Equipment; ROBOTICS—Sensors; ROBOTS, INDUSTRIAL—Anthropomorphic; STAINLESS STEEL—Corrosion; STAINLESS STEEL—Protective Coatings.

**086396 TWENTY YEARS OF NEUROLOGICAL PROSTHESIS-MAKING.** The UK Medical Research Council's Neurological Prosthesis Unit was formed on 1 October 1968. In this review, the author, who has been with the unit from the beginning, reflects on what seem to him to be the most important contributions to implant technology from the unit, and suggests some possible developments for the future. (Edited author abstract) 9 refs.

Donaldson, P.E.K. (MRC, London, Engl). *J Biomed Eng* v 9 n 4 Oct 1987 p 291-298.

**086397 EXTRACORPOREAL CIRCULATORY ASSIST DEVICES.** Extracorporeal circulatory assist devices have salvaged patients who could not be weaned from cardiopulmonary bypass, and most of these patients have returned to a useful and productive life. A variety of cannulation techniques and devices have been developed. Right or left ventricular assistance was provided with a centrifugal pump, and percutaneous veno-venous bypass was instituted with a centrifugal pump and a semiporous membrane oxygenator for patients with postoperative respiratory failure. The success of this system encouraged the authors to use veno-arterial bypass for either biventricular failure or a combination of cardiac and respiratory failure. This paper reports experiences with circulatory assist devices. Extracorporeal circulatory support provided a period for recovery from potentially reversible injury. It was found that single ventricular support produced the best chance of survival; veno-arterial bypass may provide short-term support until another system can be instituted. 15 refs.

Birnbaum, Peter L. (Toronto General Hospital, Toronto, Ont, Can); Henderson, Mark J.; Weisel, Richard D.; Benak, Arnold M.; Madonik, M. Mindy; Mickleborough, Lynda L.; Williams, William G.; Scully, Hugh E.; Goldman, Bernard S.; Baird, Ronald J. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 190-193.

**086398 INFECTIOUS COMPLICATIONS ASSOCIATED WITH VENTRICULAR ASSIST DEVICE**

**SUPPORT.** Mechanical circulatory support of patients in refractory cardiogenic shock has become commonplace since Spencer's initial success in 1965. The majority of devices are inserted as either bridges to cardiac transplantation or as interim circulatory support until myocardial recovery occurs. A significant number of patients die of related septic complications despite maintenance of adequate hemodynamics. This study was designed to determine the incidence and influence of septic complications on survival in patients supported with mechanical circulatory assist devices. 7 refs.

McBride, Lawrence R. (St. Louis Univ Medical Cent, St. Louis, MO, USA); Ruzevich, Shelly A.; Pennington, D. Glenn; Kennedy, Donald J.; Kanter, Kirk R.; Miller, Leslie W.; Swartz, Marc T.; Termuhlen, David F. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 201-202.

**086399 NEW RIGHT VENTRICULAR ASSIST DEVICE: THE EXTRACORPOREAL PULSATILE ASSIST DEVICE (EPAD).** This paper reports on a study to evaluate the short-term effectiveness of a low-cost, readily manufactured extracorporeal pulsatile assist device (EPAD) as a temporary right ventricular assist pump during acute pulmonary artery hypertension. The EPAD is designed to permit rapid open-chest cannulation of the PA to obtain vascular access, and no device components remain implanted following discontinuation of circulatory support. The EPAD was designed specifically as a temporary device. The EPAD was designed as a valveless device, a configuration that permits a simple, cost-effective pump design and does not require surgeons currently performing open-heart surgery to have specialized training to implant it. 17 refs.

Whalen, R.L. (Harvard Medical Sch, Boston, MA, USA); Hurford, W.E.; Skoskiewicz, M.; Wonders, T.R.; Zapal, W.M. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 222-226.

**086400 RENAL FAILURE IN PATIENTS WITH VENTRICULAR ASSIST DEVICES.** In view of a lethal association of renal failure in patients undergoing cardiopulmonary bypass, the authors reviewed their experience with patients requiring the use of a Pierce-Donachy pneumatic ventricular assist device to determine if renal failure is a predictor of mortality. It is concluded that the appearance of renal failure in a patient supported with a pulsatile ventricular assist device or under consideration for placement of such a device portends a poor prognosis and thought must be given to alternative methods of treatment. 4 refs.

Kanter, Kirk R. (St. Louis Medical Cent, St. Louis, MO, USA); Swartz, Marc T.; Pennington, D. Glenn; Ruzevich, Shelly A.; Madden, Michael; McBride, Lawrence R.; Termuhlen, David F. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 426-428.

**086401 AUTOSTATIC ENDOURETHRAL PROSTHESIS FOR LONG-TERM MODELING-REPLACEMENT OF THE MALE URETHRA.** The device is an 'en bloc' molded silicone tube, 20 centimeters in length and of variable diameters from 18 to 22 F. Lateral orifices are situated at the upper part to ensure optimal urinary drainage. To prevent migration downward and upward, barbs are implanted laterally. The distal part is free of barbs and can be divided to adjust the prosthesis to individual urethral lengths. The device is an endoluminal tube, is expected to allow urethral modeling, and is autostatic, disposable, and interchangeable. The paper reports results of applying the prosthesis in 14 patients. 5 refs.

Chopin, D. (CNRS, Fr); Abbou, C.; Theodon, P.L.; Leandri, J.; Rey, P. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 480-481.

**086402 PIN TRACT INFECTIONS: A CANINE MODEL.** The purpose of this study was to examine three issues: the relationship between the length of time of skeletal pin insertion and bacterial infection, the connection between skin organisms and the intramedullary infecting agent, and the length of time necessary for the medullary canal to sterilize itself after pin removal.

Skeletal pins were inserted in a group of dogs, and a direct correlation was found between the duration of time that the pins remained in the bone and positive intramedullary cultures. The infecting agent in 88% of the medullary cultures was also cultured from the skin. In a second group of dogs, the pins remained in place for 1, 2, 3, or 4 weeks, respectively. The pins were removed, and the pin tracts were permitted to heal for varying periods of time. The medullary canals were then cultured. Study results are discussed. (Edited author abstract) 4 refs.

Respet, Patrick J. (Nassau County Medical Cent, East Meadow, NY, USA); Kleinman, Paul G.; Meinhard, Bruce P. *J Orthop Res* v 5 n 4 Dec 1987 p 600-603.

**086403 RESEARCH AND DEVELOPMENT OF ADVANCED BIO-COMPOSITE MATERIALS AND APPLICATION TO THE ARTIFICIAL HIP JOINT.** The object of the experiments was to discover the static and dynamic load-carrying capacity of a prosthetic system consisting of a Ti alloy stem, zirconia ceramic ball head and ultra-high molecular weight polyethylene socket molded in the ceramic shell, the latter two both 22 mm in diameter. The components of the artificial hip joint were placed in a vertical position and load was applied, alternating between 0 and 10kN and then 12kN with a frequency of 30Hz under Ringer's solution up to  $10^7$  cycles respectively. After  $2 \times 10^7$  cycles there was no sign of damage to be observed among the system tested using the joint simulator. This seems to be a very high safety factor compared with loads occurring in vivo. 2 refs.

Tateishi, T. (Mechanical Engineering Lab, Sakura-mura, Jpn); Yunoki, H. *Bull Mech Eng Lab (Sakura-mura)* n 45 1987 9p.

**Artificial Limbs** See Also BIOMECHANICS—Gait Analysis; ORTHOTICS—Functional Electric Stimulation.

**086404 EXTENT OF ARTIFICIAL LIMB USE FOLLOWING REHABILITATION.** The extent of prosthesis use is reported for 104 lower limb amputees from the onset of gait training up to 2 years later. Unilateral trans-tibial (UTT) amputees progressed more quickly during the inpatient gait training program than did unilateral trans-femoral (UTF) subjects. UTT subjects also walked more than UTF subjects just prior to discharge during the first year after discharge and during the second year after discharge. Similarly, younger patients progressed more quickly in gait training and walked more than older subjects throughout the study period. There were no significant interactions between age and amputation. At the time of discharge from the inpatient gait training program, older unilateral amputees and trans-femoral amputees were not able to walk the 600 steps a day necessary to manage with a moderate level of support in a one-level apartment or home. The declining number of steps taken in the follow-up period indicated that the UTF subjects might benefit from some special attention paid to their community support needs. Additional study results are discussed. (Edited author abstract) 14 refs.

Holden, Jean M. (Univ of Toronto, Can); Fernie, Geoffrey R. *J Orthop Res* v 5 n 4 Dec 1987 p 562-568.

**086405 DIGITAL ELECTRONIC CONTROLLER FOR ABOVE KNEE LEG PROSTHESES.** A digital electronic controller scheme has been proposed to control the angle at knee and ankle joints in above knee (A/K) lower extremity prostheses during locomotion. The control strategy is based on close scrutiny of locomotion in normal human beings. Laboratory testing of the proposed sequential network confirmed the uniqueness of the controller in providing signals to get desired state of prostheses at every stage during swing phase of walking. The use of such a controller would relieve handicapped subjects of awkwardness during walking and there will not be unnecessary stress on the remaining part of an amputated limb. If successful in field testing such a



controller can be mass-produced and would offer advantages of compactness, lightness and high efficiency. Apart from prosthetic devices the controller may find applications in robot arm movements. (Author abstract) 4 refs.

Chitore, D.S. (Univ of Technology, Baghdad, Iraq); Rahmatallah, S.F.; Albakry, K.S. *Int J Electron* v 64 n 4 Apr 1988 p 649-656.

**086406 DESIGN OF A SLEWER FOR WRIST PRONATION AND SUPINATION IN A MYOELECTRIC ARM PROsthESIS.** This paper presents a type of slewer used for the pronation and supination of the wrist in an electronic prosthesis, a miniature slewing ring composed of ball bearings. A method of calculation and design of the miniature slewing ring is proposed, and a practical example of a design of a prosthesis with myoelectric control of three degrees of freedom is illustrated. (Edited author abstract) 2 refs. In Chinese.

Zhang, Zong-ming (Shanghai Jiao Tong Univ, China); Liu, Wen-ying. *Zhongguo Shengwu Yixue Gongcheng Xuebao* v 6 n 4 Dec 1987 p 209-213.

**086407 VOLUME CHANGES OCCURRING IN POSTOPERATIVE BELOW-KNEE RESIDUAL LIMBS.** Comparative maturation rates of 36 below-knee postoperative, healed amputation residual limbs were observed. Measured were the limb volumes and circumferences. Three methods of residual limb stabilization were employed: 1) elastic wrap; 2) plaster cast and pylon; and, 3) plastic laminate socket and pylon. The limbs receiving the plastic laminate showed the most rapid stabilization, while the elastic wrap did not stabilize. Considerable variance existed in relations between variables. Correlation between limb circumference and volume was poor. However, in general, the rates of change, i.e., the relations between volume and time, and circumference and time, were statistically significant ( $p < .05$ ). (Author abstract) 7 refs.

Golbranson, Frank L. (Veterans Administration Medical Cent, San Diego, CA, USA); Wirta, Roy W.; Kuncir, Eric J.; Lieber, Richard L.; Oishi, Calvin. *J Rehabil Res Dev* v 25 n 2 Spring 1988 p 11-18.

**086408 INTELLIGENT CONTROL OF THE UPPER ARM PROsthESIS.** The upper arm prosthesis system is a complex man-machine system. In this paper the special features of the upper arm prosthesis and its control are discussed. The authors propose an intelligent control system, which consists of three levels: servo level, coordination level and organization level. The results of simulation and experiments with the actual system show that the system implements the expected function and the mental burden of the amputee is minimized. (Edited author abstract). 5 Refs. In Chinese.

Yuankun, Feng (Tsinghua Univ, China); Jihong, Du; Zhengshun, Sun; Renjie, Teng. *Ching Hua Ta Hsueh Hsueh Pao* v 26 n 4 1986 p 19-28.

**086409 CONCEPTUAL FRAMEWORK FOR TACTUALLY GUIDED EXPLORATION AND SHAPE PERCEPTION.** A conceptual framework for tactually guided exploration and shape perception using a robotic medium is provided. The conceptual framework identifies the needed sensory information, the spatial and temporal transformations of this information, the control mechanism, both feedforward and feedback, for performing the missions and the perception machinery. These attributes, in turn, sharpen the focus on the major building blocks needed in design of artificial skins, tactile sensing, and processing systems of the future. These building blocks are identification of central nervous system (CNS) machinery in living systems that perform the required computations, mappings, processors for extraction of the needed manipulation and recognition parameters, processing of outputs of populations of natural tactile sensors, and finally, understanding the dynamics of sensor-imbedded skin and artificial skin in fixed, gliding, and rolling contact with known and unknown objects and surfaces. 48 refs.

Hemami, Hooshang (Ohio State Univ, Columbus, OH, USA); Bay, John S.; Goddard, Ralph E. *IEEE Trans*

*Biomed Eng* v 35 n 2 Feb 1988 p 99-109.

**Artificial Organs** See Also BIOLOGICAL MATERIALS—Pressure Measurement; BIOMEDICAL ENGINEERING—Cardiovascular Surgery; BIOMEDICAL ENGINEERING—Hemodynamics; ELECTRIC MOTORS, LINEAR—Medical Applications.

**086410 HEMODYNAMIC AND FUNCTIONAL CONSIDERATIONS OF THE JARVIK TOTAL ARTIFICIAL HEART (TAH).** The Jarvik TAH has been used as a bridge to cardiac transplantation in 14 patients between October 1985 and April 1987. Transplantation was accomplished in 13 of 14 patients, and 8 of those are alive and doing well at home. Early experience indicates that the 100 CC device was used whenever the size of the patient permitted (three of the first four cases), because of its availability and the presumed hemodynamic advantage of the larger device. Because the 70 CC device was found to be considerably easier to implant and presented less risk of fit associated occlusion of the vena cavae and pulmonary veins, the subsequent 10 patients have had the smaller device implanted regardless of their size (56 kg to 104 kg). The purpose of this report is to describe and compare the hemodynamic and functional performance of the two devices. 4 refs.

Herlan, D.B. (Univ of Pittsburgh Sch of Medicine, Pittsburgh, PA, USA); Kormos, R.L.; Wei, L.; Borovetz, H.S.; Hardesty, R.L.; Griffith, B.P. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 147-150.

**086411 NEW CONNECTOR SYSTEM FOR TOTAL ARTIFICIAL HEARTS: PRELIMINARY RESULTS.** The atrial cuff and vascular graft connector junctions and the valve mounting junctions have been identified as two major predilection sites for thrombus formation in the valve containing portion of the quick connector system. To reduce thrombus formation in these areas, a high precision screw type connector system (CS-I and CS-II) has been designed. In addition, a new technique has been used to seat commercially available valves into a mounting ring and seal them before incorporation into the total artificial heart. 6 refs.

Holfert, John W. (Univ of Utah, Salt Lake City, UT, USA); Riebmman, Jerome B.; Dew, Pamela A.; De Paulis, Ruggero; Burns, Gregory L.; Olsen, Don B. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 151-156.

**086412 LONG-TERM SURVIVAL WITH A PNEUMATIC ARTIFICIAL HEART.** Pneumatic total artificial hearts (pTAHs) have been under development for nearly three decades. Survival in experimental animals has gradually increased from several hours in the initial experiments to nearly a year in more recent reports. Recently, temporary implantation of pTAHs as a bridge to heart transplantation has been reported by several groups. This report presents recent clinical and experimental experience with the Penn State University pneumatic total artificial heart (PSU-pTAH). Study materials, animals, methods and results are discussed. 8 refs.

Aufiero, Thomas X. (Pennsylvania State Univ, Hershey, PA, USA); Magovern, James A.; Rosenberg, Gerson; Pae, Walter E.; Donachy, James H.; Pierce, William S. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 157-161.

**086413 REGISTRY AND TABULATIONS OF ORTHOTOPIC TOTAL ARTIFICIAL HEARTS IN HUMANS.** The pneumatically powered artificial hearts have been used as a bridge to cardiac transplantation with increasing frequency since 1985. Pneumatically powered, orthotopically placed total artificial hearts (TAHs) have been used in 68 patients through March 31, 1987. Five of these patients were designated as nontransplantable candidates. Sixty-three TAH recipients were bona fide cardiac transplantation candidates. The Symbion (Jarvik series) device was implanted in 51 patients: 41 were transplanted with 26 patients alive, 51% of those patients receiving a TAH. Of those patients who received transplants, 63% were alive with good to excellent outcomes. All of the users of the Symbion devices have had an extensive training program that contributes to this success. Additional aspects of the subject and data gathered are

discussed. 20 refs.

Olsen, Don B. (Univ of Utah, Salt Lake City, UT, USA); Riebmman, Jerome B.; De Paulis, Ruggero; Durrant, Gary; Nielsen, Steve D. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 182-189.

**086414 MODE COMPARISON STUDY FOR A COMPLETELY IMPLANTABLE TAH (CITAH) SYSTEM.** The long-range objective of the work reported has been the development of a control algorithm to meet the following requirements: 1) simple and reliable; 2) smallest physical package to meet anatomic constraints; and 3) adequate responses to all possible hemodynamic demands. If the alternate beating mode could maintain the recipient for extended periods and also have meaningful flow responses to demand, the overall volume and complexity of a CITAH would be reduced significantly. Some comparison studies with PP TAH systems have been published, a few aspects still remained to be investigated: 1) long-term effects of the alternate beating mode; 2) how to protect the lung circulation against any possible sudden hemodynamic changes, and 3) the possible requirements for built-in stroke volume differences between two ventricles. This study was designed and performed to answer these questions. 11 refs.

Ishikawa, Mikio (Cleveland Clinic Foundation, Cleveland, OH, USA); Jacobs, Gordon B.; Uchida, Naoki; Nasu, Michihiro; Oku, Takahiko; Emoto, Hideto; Watanabe, Takashi; Smith, William A.; Kiraly, Raymond J.; Harasaki, Hiroaki; Nose, Yukihiro. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 194-200.

**086415 TOWARD A COMPLETELY IMPLANTABLE TAH: A LEFT-RIGHT SIMULTANEOUSLY EJECTING MOTOR-DRIVEN TAH SYSTEM.** As shown in recent total artificial heart studies, even with the alternate ejection system an auxiliary compliance chamber is required to compensate for the left-right flow differences and differences in ejection and filling times between the two ventricles. In addition, alternate ejection is unphysiologic in comparison to the simultaneous ejection of the natural heart. The design of the left-right simultaneously ejecting system was previously proposed. This paper describes the left-right simultaneously ejecting motor driven total artificial heart using a single electromechanical actuator, and presents in vitro evaluation. Study materials, methods and results are discussed. 8 refs.

Takatani, S. (Nat'l Cardiovascular Cent, Suita, Jpn); Takano, H.; Taenaka, Y.; Nakatani, T.; Noda, H.; Kinoshita, M.; Fukuda, S.; Akutsu, T. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 235-239.

**086416 AUGMENTATION OF CO<sub>2</sub> TRANSFER IN MEMBRANE LUNGS BY THE INFUSION OF A METABOLIZABLE ORGANIC ACID.** Clinical observation suggested that the continuous acidification of the blood entering the membrane lung with small amounts of a strong organic metabolizable acid such as L-lactic acid might significantly augment the CO<sub>2</sub> transfer of membrane lungs, yet be cleared by metabolism and avoid a progressive metabolic acidosis. In this paper the authors present theoretical calculations, in vitro testing of an aqueous sodium bicarbonate perfusate equilibrated with CO<sub>2</sub>, and in vivo perfusions in awake sheep demonstrating that short-term increases of 120-170% in CO<sub>2</sub> transfer rate can be obtained by membrane lung inlet acidification with 2 to 8 mEq/min of L-lactic acid. 25 refs.

Snider, Michael T. (Pennsylvania State Univ Coll of Medicine, Hershey, PA, USA); Chaudhari, Sunita N.; Richard, Russell B.; Whitcomb, Donna R.; Russell, Garfield B. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 345-351.

**086417 MICROENCAPSULATION OF PARATHYROID CELLS AS A BIOARTIFICIAL PARATHYROID.** Encouraged by successful allografts and xenografts of encapsulated islets of Langerhans in diabetic animals, the authors undertook an investigation of the



potential use of encapsulated parathyroid cells as bioartificial organs. An alginate polylysine membrane with dispersed cells from either rat or bovine parathyroids was used, and in a preliminary in vitro study the functional viability of the cells after microencapsulation was assessed as well as the membrane permeability to parathyroid hormone. 17 refs.

Darquy, Sylviane (Univ of Toronto, Toronto, Ont, Can); Sun, Anthony M. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 356-358.

**086418 NEW HYBRID ARTIFICIAL LIVER USING A COMBINATION OF HEPATOCYTES AND BIOMATRIX.** To supplement deficient functions of mechanical artificial livers, the combined use of biologic artificial livers utilizing viable hepatocytes becomes necessary. Survival efficiencies and retention of metabolic function of hepatocytes are especially important. M. Rojkind et al. reported that liver extracellular matrix (biomatrix) is extremely useful as a culture substrate for long-term maintenance of functional cultured hepatocytes. In this paper, as one step toward their application to biologic artificial livers, isolated hepatocytes and biomatrix were simultaneously administered intraperitoneally to rats with d-galactosamine induced hepatic failure, and the effect on the survival rate was studied. 9 refs.

Saito, Shinya (Okayama Univ Medical Sch, Okayama, Jpn); Sakagami, Kenichi; Orita, Kunzo. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 459-462.

**086419 TOWARD AN IMPLANTABLE IMPELLER TOTAL HEART.** Since 1985, a 3-year project supported by the Chinese Academy of Sciences has been carried out at the Shanghai Second Medical University. This initial goal was to develop a left ventricular assist impeller pump. After solving the main problems of any centrifugal pump i.e., hemolysis, bearing and sealing, and generation of pulsatile flow, the authors have gone on to develop both non-pulsatile and pulsatile pumps which produce minimal amounts of hemolysis. On the basis of this progress a prototype design of a total impeller heart was developed. 17 refs.

Qian, K.X. (Shanghai Second Medical Univ, China); Pi, K.D.; Wang, Y.P.; Zhao, M.J. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 704-707.

**086420 EXPLANT ANALYSIS OF THIRTY-THREE BRIDGE TO TRANSPLANT  $\beta$  TOTAL ARTIFICIAL HEART DEVICES.** From August 1985 to January 1987, 33 Symbion- $\beta$  TAH's were implanted for varying durations. Routine post mortem examination of these devices, conducted by Symbion Inc., entailed external and internal surface macroscopic evaluation, scanning electron microscopy (SEM) analysis, histopathologic analysis of suspect material surfaces and foreign deposits, and material integrity testing on devices implanted for significant durations. This paper discusses the general findings of the 33 TAH devices in terms of thrombus deposition scoring results, prominent areas and types of cellular deposition, and the items that appear to affect red cell and/or thrombus deposition in these devices. 7 refs.

Taylor, Kevin D. (Symbion Inc, Salt Lake City, UT, USA); Gaykowski, Rick; Keate, Kelly S.; Winters, Suzanne; Price, Ralph R.; Topaz, Stephen R. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 738-743.

**086421 PHYSIOLOGICAL PROFILE DURING VENOVENOUS PERFUSION IN DOGS USING A POLYPROPYLENE MEMBRANE LUNG WITH SECONDARY FLOWS.** Venovenous perfusion has been conducted in 12 healthy dogs to examine carbon dioxide ( $\text{CO}_2$ ) transfer and haemocompatibility over 9 h during total extracorporeal  $\text{CO}_2$  removal using a microporous polypropylene membrane lung with secondary flows in the blood channel. The anesthetized animals were maintained normocapnic by including  $\text{CO}_2$  in the inspired gases. The  $\text{CO}_2$  removal was achieved using  $0.631 \text{ mm}^2$  of active membrane, at a pulsatile Reynolds number of 50, and a  $\text{CO}_2$  extraction from blood of  $17.8 \text{ ml (STP) dl}^{-1}$ .

. Gas exchange remained constant during the perfusions. Several aspects of our results suggest that the haemocompatibility of a system of the kind used here is at least as favorable as that of a steady flow device using a continuous silicone rubber membrane of equivalent gas transfer capability. (Author abstract) 40 refs.

Gardaz, J.P. (Hopital Cantonal Univ, Geneva, Switz); Dorrington, K.L.; Py, P.; Schweizer, A. *J Biomed Eng* v 10 n 1 Jan 1988 p 74-81.

**086422 ANALYSIS OF ULTRAFILTRATION AND MASS TRANSFER IN A BIOARTIFICIAL PANCREAS.** A bioartificial pancreas is an implantable device which contains insulin secreting cells (Langerhans islets), separated from the circulating blood by a semi-permeable membrane to avoid rejection. This paper describes the operation of such a device and evaluates the respective contributions of diffusion and ultrafiltration to the glucose and insulin mass transfer. It is shown that the pressure drop along the blood channel produces across the first half of the channel an ultrafiltration flux toward the islet compartment followed in the second half by an equal flux in reverse direction from islets to blood. The mass transfer analysis is carried out for an optimal geometry in which a U-shaped blood channel surrounds closely a very thin islet compartment formed by a folded flat membrane. A complete model of insulin release by this device is developed and is compared with in vitro data obtained with rats islets. (Edited author abstract) 6 refs.

Jaffrin, M.Y. (Univ de Technologie de Compiègne, Compiègne, Fr); Reach, G.; Notelet, D. *J Biomech Eng Trans ASME* v 110 n 1 Feb 1988 p 1-10.

**086423 TIME OPTIMAL POLICY FOR PATIENT ARTIFICIAL KIDNEY SYSTEMS.** A multicompartiment model of human body coupled to an artificial kidney is discussed in this paper. A method has been developed to find out the time optimal policy for obtaining a comfortable and minimum time dialysis therapy. Developed policy maintains the cerebro-spinal fluid (CSF) pressure transients within desired limits. Treatment time is reduced by 45% as compared to the uncontrolled process. (Author abstract) 7 refs.

Kumar, Vinod (Univ of Roorkee, Roorkee, India); Sharma, J.D.; Mukhopadhyay, P.; Saxena, S.C. *J Inst Eng India Part IDP* v 68 Feb 1988 p 21-25.

**086424 ARTIFICIAL HEART IMPLANTATION.** Since 1975 experiments have been being conducted at the Scientific-Research Institute of Transplantation and Artificial Organs on the POISK model of an ellipsoidal artificial heart, which was developed at this institute. A modification of the model of a diaphragm type made from polyurethane has been used in recent years. At present the average survival of calves with an implanted heart is more than 55 days with a maximum survival of more than 3 months. The high implantability of the ellipsoidal artificial heart permits implanting it in calves with a weight from 60 kg, whereas animals with a weight from 85 to 95 kg are usually used. The stroke volume of the artificial ventricles of the POISK model is from 90 to 100 ml, which makes it possible to achieve an output of 12-13 liters/min. As our experience shows, the use of an ellipsoidal heart of the POISK type with a semirigid housing does not lead to thrombosis within the blood chamber (excluding the inlet valve) in those cases when an adequate anticoagulation regime was maintained. 13 refs.

Shumakov, V.I. (USSR Ministry of Health, Moscow, USSR); Zimin, N.K. *Biomed Eng (New York)* v 21 n 5 Sep-Oct 1987 p 159-163.

**086425 DEVELOPMENT OF THE LEFT VENTRICULAR BYPASS PUMPS FOR ADULTS AND CHILDREN.** In animal experiments with goats and dogs, and also by clinical applications for adults and children the small Left Ventricular Bypass Pumps with the stroke volume of 30-35 ml and 10-15 ml respectively are desirable. We have developed two prototype pumps to meet with such requirements. The in vitro and in vivo experiments have shown that these pumps with the

advantages of the simplified production, the possibility of the reuse of the pump components and less thrombosis can sufficiently assist the circulation of experimental animals. (Author abstract) In Chinese. 2 refs.

Qian, K.X. (Shanghai Second Medical Coll, China); Wang, H.S. *Zhongguo Shengwue Yixue Gongcheng Xuebao* v 6 n 2 Jun 1987 p 91-94.

**086426 STUDY ON SYSTEMIC CIRCULATORY SIMULATOR.** A systemic circulatory simulator was devised for study of left ventricular assistance. The device consisted of four parts: two systemic arterial chambers, a systemic venous chamber, a resistor, and a blood pump. The systemic circulatory system was simulated in compliance with sealed air chambers, i.e., double for arterial and single for venous system, while the peripheral vascular resistance was simulated with a special resistor consisting of bellows, a cone valve, and a spring. Arterial pressure waves were recorded, and showed a sharp rise in the ascending part and a marked dirotic wave in descending part, similar to the aortic pressure wave of human body with the systemic flow (P-Q) curve similar to that of the normal subject. (Edited author abstract) In Chinese. 19 refs.

Zhang, Yong-fu (Chinese Acad of Medical Sciences, China); Xu, Kai-yun; Yang, Cheng-min. *Zhongguo Shengwue Yixue Gongcheng Xuebao* v 6 n 3 Sep 1987 p 161-167.

**Blood Vessel Prostheses** See Also BIOLOGICAL MATERIALS—Blood; BIOLOGICAL MATERIALS—Blood Vessels.

**086427 BLOOD HEMOLYSIS BY PTFE AND POLYURETHANE VASCULAR PROSTHESES IN AN IN VITRO CIRCUIT.** In order to improve understanding of the appearance of bright yellow stains in vivo (consecutive to the absorption of bilirubin) on a novel microporous, hydrophilic polyetherurethaneurea vascular prosthesis, the in vitro hemolytic activity of the material was compared with expanded polytetrafluoroethylene and silicone rubber. The results show that the tendency of the polyetherurethaneurea to produce free hemoglobin is low, so that the yellow staining observed is likely to be a result of the contact between the polymer and thrombi. Bilirubin is produced because of hemoglobin degradation in the thrombi rather than an active hemolysis on the surface of the prosthesis itself. (Author abstract) 18 refs.

Martz, Hugues (Laval Univ, Quebec, Que, Can); Paynter, Royston; Losier, Michel; Dumorado, Dominique; Forest, Jean-Claude; Guidoin, Robert. *J Biomed Mater Res* v 21 n 10 Oct 1987 p 1187-1196.

**086428 EFFECTIVENESS OF A COUNTERPULSATION DEVICE IMPLANTED ON THE ASCENDING AORTA.** The abdominal aortic counterpulsation device (AACD) has proved more effective than the intraaortic balloon pump, and the effectiveness of this device along with its biocompatibility make it a promising device for chronic mechanical assistance. On the other hand, the closer to the aortic valve a counterpulsation device is implanted, the more effective it is. This paper reports on an evaluation of the hemodynamic effects of a valveless counterpulsation device implanted on the ascending aorta in a left ventricular heart failure model. 12 refs.

Nanas, John N. (Univ of Athens, Athens, Greece); Nanas, Serafim N.; Charitos, Chris E.; Poyiadjis, Anastasios D.; Kontoyannis, Dimitrios; Melkaoui, Abed; Kokolis, Gerasimos; Mouloupoulos, Spyridon D. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 203-206.

**086429 COMPARATIVE ANALYSIS OF THROMBOGENICITY AND CLINICAL PATENCY BETWEEN WOVEN AND KNITTED AORTO-ILIAC AND AORTO-FEMORAL PROSTHESES.** A special bifurcated graft consisting of one woven limb and one knitted limb was implanted into 158 patients. They were then followed for 4 years and 3 months. The patients were



diagnosed as having either occlusive arteriosclerotic disease of the abdominal aorta or an abdominal aortic aneurysm. The role of platelet deposition in relation to thrombus formation was also considered. To test the relative thrombogenicity of the different graft materials, 20 patients with autologous platelets labeled with <sup>111</sup>Indium were studied. The 20 patients were divided into three groups - those 2 weeks, 1 year, and 2 years after implant - and scans were obtained to demonstrate a difference in platelet aggregation between the two grafts. Study results are discussed. 14 refs.

Burtoft, John N. (Charlotte Memorial Hospital & Medical Cent, Charlotte, NC, USA); Robicsek, Francis; Daugherty, Harry K.; Cook, Joseph C.; Selle, Jay G.; Hess, Philip J.; Lawhorn, Robert. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 207-211.

**086430 LOW DENSITY LIPOPROTEIN ACCUMULATION BY PTFE GRAFTS IN THE RABBIT AORTA: AUTORADIOGRAPHIC-MORPHOLOGIC CORRELATIONS.** In earlier studies, the authors showed that healing arteries in rabbits and atherosclerotic arteries in humans sequestered radiolabeled low density lipoproteins (LDL), the major cholesterol-carrying proteins of human plasma. The focal accumulation of radiolabeled LDL permitted external imaging of the affected arteries. Since arterial grafts provoke a healing response analogous in many respects to native arterial intimal repair, the authors tested the possibility that healing prosthetic vascular grafts might also accumulate radiolabeled LDL. This paper reports preliminary studies of the sequestration of LDL by arterial grafts in the rabbit and the potential significance of the finding for monitoring graft function and predicting graft failure. 13 refs.

Miller, Arnold (New England Deaconess Hospital, MA, USA); Schoen, Frederick J.; Lees, Ann M.; Fallon, John T.; Strauss, H. William; Lees, Robert S. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 489-493.

**086431 HUMAN ENDOTHELIAL CELL ATTACHMENT RECEPTORS.** The present study evaluates the efficacy of 15 lectins to identify the presence of cell surface glycoconjugates in human umbilical vein endothelial cells (HUVEC) and the further use of these lectins as specific attachment receptors for HUVEC. The results of these studies demonstrate that  $\alpha$ -L-fucose binding lectin (Ulex I) is a specific and fast attaching substrate for HUVEC isolated by the collagenase procedure. Lectin binding intensity to HUVEC glycoconjugates does not parallel the HUVEC attachment profile of these lectins. RCA and WGA demonstrate the highest binding intensity to HUVEC, whereas Ulex I results in superior cell attachment. Additional study results are discussed. 27 refs.

Parhizgar, Azin (Brown Univ, Providence, RI, USA); Galletti, Pierre M.; Jauregui, Hugo O. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 494-500.

**086432 ENDOTHELIAL CELL SEEDING OF ULTI CARBON-COATED SMALL-DIAMETER PTFE VASCULAR GRAFTS.** The relative nonthrombogenicity of ultralow temperature, isotropically (ULTI) carbon-coated, small-diameter vascular prostheses, compared with polytetrafluoroethylene (PTFE) grafts of the same size, has been reported. The authors speculated that in addition to their inherent property of biocompatibility, carbon-coated graft surfaces might provide an excellent substrate for attachment of seeded endothelial cells. Therefore, in the canine carotid artery model the authors evaluated the efficacy of endothelial cell seeded and nonseeded 4 mm ID PTFE vascular prostheses that had been coated with ULTI carbon. 17 refs.

Boyd, Kevin L. (Univ of Akron, Akron, OH, USA); Schmidt, Steven P.; Pippert, Todd R.; Sharp, William V. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 631-635.

**086433 POLYURETHANE VASCULAR PROSTHESES IN PIGS.** Microporous, compliant vascular prostheses made from segmented polyurethanes of various molecular stability, have been implanted in the infrarenal aorta of young pigs. Prosthesis prepared from a hydrolyti-

cally stable polyetherurethane showed a limited patency up to 1 month. Composite prosthesis with the wall made from a hydrolytically stable polyurethane and the lumen side prepared from a degradable polyurethane, were patent up to one year. A degradable layer of this composite prosthesis induced the growth of a neo-artery. Prosthesis prepared from a degradable polyurethane alone, were substituted within 4 months with a functional neo-artery. (Author abstract) 17 refs.

Gogolewski, S. (Medinvent SA, Lausanne, Switz); Galletti, G.; Ussia, G. *Colloid Polym Sci* v 265 n 9 Sep 1987 p 774-778.

**086434 CHARACTERIZATION OF THE TISSUE PROLIFERATED AT THE BLOOD INTERFACE OF CARBON/CERAMIC COMPOSITES.** The reconstruction of a normal arterial wall in human surgery remains an unfulfilled dream. To ensure long-term graft patency it would be necessary to achieve complete healing of the prosthetic wall, i.e., an endothelialized surface. The ideal vascular substitute must be linked by tissues and cells that possess morphological and functional characteristics of the normal vascular elements. The present study focuses on cell adhesion/differentiation and material stability of surfaces of the three carbon/ceramic composites implanted in intra-atrial position in dogs for 1 year. Before implantation their surface was characterized by scanning electron microscopy. After harvesting, the tissue proliferated on the blood interface was examined by histology, scanning, and transmission electron microscopy, wavelength dispersive and x-ray spectrometry, electrophoretic and enzymatic characterization of glycosaminoglycans (GAGs) which were compared to endocardial tissue as control samples. (Edited author abstract) 23 refs.

Chignier, Elza (INSERM, Bron, Fr); Guidollet, Jeanine; Dureau, Georges; Grousson, Brigitte; Buttazzoni, Bernard; Louisset, Pierre; Elloy, Rosy. *J Biomed Mater Res* v 21 n 12 Dec 1987 p 1415-1433.

**086435 HYDROPHILIC MICROPOROUS POLYURETHANE VERSUS EXPANDED PTFE GRAFTS AS SUBSTITUTES IN THE CAROTID ARTERIES OF DOGS. A LIMITED STUDY.** A novel, microporous, hydrophilic polyether urethane-urea (PEUU) vascular graft was compared with expanded PTFE in the canine carotid artery. At implantation times ranging from 4 h to 6 months, all the PEUU grafts were found to be occluded while of the PTFE grafts, only those implanted for 1 week and 6 months were blocked. Histopathological analysis of the explanted grafts and their capsules revealed an ongoing inflammatory reaction at the anastomotic sites of the PEUU grafts. (Author abstract) 12 refs.

Maritz, Hugues (St. Francois d'Assise Hospital, Quebec City, Que, Can); Paynter, Royston; Slimane, Saidi Ben; Beaudoin, Gilles; Guidoin, Robert; Borzone, Juan; Simhon, Haim Ben; Satin, Richard; Sheiner, Nathan. *J Biomed Mater Res* v 22 n 1 Jan 1988 p 63-69.

**086436 EFFECTS OF PORE SIZE AND ENDOTHELIAL CELL SEEDING UPON THE PERFORMANCE OF SMALL-DIAMETER e-PTFE VASCULAR GRAFTS UNDER CONTROLLED FLOW CONDITIONS.** The purpose of this study was to determine the effects of endothelial cell seeding and graft internal distance upon the performance of 4-mm-ID e-PTFE grafts during acute reduced blood flow conditions. PTFE grafts especially manufactured with three different mean internal distances (28, 40, and 52  $\mu$ m) were evaluated. Fifteen dogs underwent bilateral carotid artery replacements. In each dog one graft was seeded with enzymatically derived endothelial cells; the contralateral graft was nonseeded. All grafts were evaluated 5 weeks postoperatively. Endothelial cell seeding improved patency and thrombus-free surface areas in grafts of all pore sizes. (Edited author abstract) 19 refs.

Boyd, Kevin L. (Akron City Hospital, Akron, OH, USA); Schmidt, Steven; Pippert, Todd R.; Hite, Scott A.; Sharp, William V. *J Biomed Mater Res* v 22 n 3 Mar 1988 p 163-177.

**086437 VASCULAR PROSTHESES: PRESENT STATUS AND FUTURE DEVELOPMENT.** Advances in small vessel reconstruction include the use of autogenous veins for small diameter and coronary artery lesions and microvascular repair of digital and cerebral vessels. Future developments in graft design will enable prosthetic repair of 2 to 4 mm arteries and reconstruction of veins. 98 refs.

White, Rodney A. *Blood Compat* v 2. Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 47-61.

**086438 COMPLIANT SMALL-DIAMETER ARTERIAL PROSTHESES.** A synthetic artery graft is manufactured from polyetherurethane fibers (Biomer). It is sufficiently porous to allow ingrowth of collagenous scar tissue. Biomer has good enzyme resistance, good blood compatibility, and confers compliance to the prosthesis in both circumferential and axial directions. 16 refs.

Annis, D.; Fisher, A.C.; How, T.V. *Blood Compat* v 2. Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 63-78.

**086439 EFFECT OF POROSITY AND BIOMATERIAL ON THE HEALING AND LONG-TERM MECHANICAL PROPERTIES OF VASCULAR PROSTHESES.** Continuing efforts in vascular prosthetic design are focused on understanding the characteristics required for function of small internal diameter and low-flow prostheses. The pioneers of vascular surgery developed large diameter textile prostheses for successful reconstruction of the aortiliac vessels, but fabric grafts function poorly in diameters less than six millimeters. Major advances in small vessel reconstruction include the use of autogenous vessels for coronary artery lesions and microvascular surgery of digital and cerebral vessels. The author believes that future advances in graft design will enable prosthetic repair of two to four millimeter arteries and reconstruction of veins. This manuscript discusses the development of improved synthetic blood-compatible surfaces with detailed consideration of prosthetic design factors such as pore size, biomaterial mechanical properties and thrombogenicity of the blood flow surface. (Author abstract) 25 refs.

White, Rodney A. (Harbor-UCLA Medical Cent, Torrance, CA, USA). *ASAIO Trans* v 34 n 2 Apr-Jun 1988 p 95-100.

**086440 STABILITY OF PERFORMANCES OF VASCULAR PROSTHESES RETROSPECTIVE STUDY OF 22 CASES OF HUMAN IMPLANTED PROSTHESES.** Twenty-two cases of vascular graft failures (thrombosis, pseudoaneurysm, dilation, infection) were investigated by means of physicochemical, histological, and ultrastructural studies. A general decrease of mechanical resistance to stress of the prostheses was observed. Its magnitude ranged from 2 to 75% of the values of identical virgin prostheses and there was no relation with the duration of implantation. In addition to the breakage of yarn filaments (SEM), migration of fiber debris (histology) was observed in 7 cases. The structure of the polyester molecule had evolved after implantation. A decrease of crystallinity (x-ray diffraction and differential scanning calorimetry) was noted. These observations raise the question of the established stability of vascular prostheses and emphasize the need for further investigations in human graft retrieval programs. (Author abstract) 32 refs.

Vinard, Elisabeth (INSERM, Bron, Fr); Eloy, Rosy; Descotes, Jacques; Brudon, Jean Robert; Guidicelli, Henri; Magne, Jean Luc; Patra, Philippe; Berruet, Regis; Huc, Alain; Chauchard, Jacques. *J Biomed Mater Res* v 22 n 7 Jul 1988 p 633-648.

**086441 HYDROLYTIC STABILITY OF MITRATHANE (A POLYURETHANE UREA)-AN X-RAY PHOTOELECTRON SPECTROSCOPY STUDY.** The hydrolytic stability of the microporous Mitrathane polyetherurethane urea vascular prostheses has been



evaluated at pH 7 and pH 9, at 37°, 60°, and 80°C for time periods of up to 968 days. Mechanical strength was evaluated using a hydrodynamic burst test and surface chemical changes by x-ray photoelectron spectroscopy. The samples held at 80°C showed the greatest mechanical strength loss which corresponded to the hydrolysis of the urethane groups. It was concluded that the gross in vivo surface degradation of Mitrathane prostheses, observed after six months, could not have been caused by simple chemical hydrolysis alone, as the polymer was found to be stable at 37°C for at least 11 months. (Author abstract). 25 Refs.

Paynter, R.W. (Univ Laval, Que, Can); Askill, I.N.; Glick, S.H.; Guidoin, R. *J Biomed Mater Res* v 22 n 8 Aug 1988 p 687-698.

**086442 BLOOD COMPATIBILITY OF SURFACES MODIFIED BY PLASMA POLYMERIZATION.** Tubular blood-contacting polymeric materials were modified by plasma polymerization and evaluated in the baboon with respect to their capacity to introduce both acute and chronic arterial thrombosis. Polymer surface composition was determined by electron spectroscopy for chemical analysis. Steady-state arterial thromboembolism was initiated by introducing tubular segments into chronic arteriovenous shunts. Rates of platelet destruction induced by the test materials were calculated from  $^{111}\text{In}$ -platelet survival measurements. Nine plasma polymers based on tetrafluoroethylene, hexafluoroethane, hexafluoroethane/ $\text{H}_2$ , and methane, when deposited on silicone rubber, consumed platelets at rates from  $1.1\text{--}5.6 \times 10^8$  platelets/ $\text{cm}^2\text{-day}$ . These low values were considered relatively nonthrombogenic. Acute thrombus formation was initiated by inserting expanded Teflon (Gore-Tex PTFE) vascular grafts into the shunt system. (Edited author abstract). 25 Refs.

Yeh, Y.-S. (Univ of Missouri-Rolla, Rolla, MO, USA); Iriyama, Y.; Matsuzawa, Y.; Hanson, S.R.; Yasuda, H. *J Biomed Mater Res* v 22 n 9 Sep 1988 p 795-818.

**086443 PARTNERSHIP SUCCESS.** Vascutek is a British company which manufactures vascular grafts (artificial arteries made out of Dacron). The purpose of this paper is to present a short case report on the conception of the company and its development to the present stage. Subjects covered include materials development, production considerations, marketing, and others.

Maini, Roshan (Vascutek Ltd, Inchinnan, Engl). *J Med Eng Technol* v 11 n 5 Sep-Oct 1987, Technol Transfer - The Br Health Serv and Ind Proc of a Conf, Uxbridge, Engl, May 27-28 1987 p 267.

## Computer Aided Design

**086444 IMPACT OF ADVANCED MANUFACTURING TECHNOLOGY ON PROSTHETIC AND ORTHOTIC PRACTICE.** Radical changes in the technology applied to prosthetics and orthotics are being proposed. This paper attempts to define the scope and character of advanced manufacturing technology and examines the rehabilitation problems which are or could be tackled. Lower-limb prosthetics has been the major area under investigation so far, but orthopaedic footwear, spinal orthotics and custom seating for the disabled have also been investigated using similar technological approaches. The whole process of patient measurement, device design, and component manufacture is conceived as an integrated system relying upon shape of tissue property sensing, computer based device design and computer-numerically-controlled or robot manufacturing processes. The aim is to retain flexibility for custom design which is necessary to provide for individual patients, and yet improve the rapidity and precision of overall device manufacture and service delivery. (Author abstract) 12 refs.

Jones, D. (Univ of Strathclyde, Glasgow, Scotl). *J Biomed Eng* v 10 n 2 Apr 1988, Pap Presented at the 27th Annu Sci Meet of the Biol Eng Soc, Oxford, Engl, Sep 2-4 1987 p 179-183.

## Control

**086445 LIMB-FUNCTION DISCRIMINATION METHOD USING EMG SIGNALS FOR THE CONTROL OF MULTIFUNCTIONAL POWERED PROSTHESES.** This paper describes a method to estimate the motion intended by an amputee from his EMG symbols. This is one of the important abilities to be provided by the amputee-prosthesis interface within the multifunctional powered prosthesis. To make the interface easy for the amputee to use, the measurement of EMG should be simplified as much as possible. Up to now, function discrimination by the surface EMG has been employed in which a particular muscle must be specified for the EMG electrode. This imposes a restriction in the electrode placement, and restricts the function discrimination ability. The present study aims at the development of a discrimination method in which the electrode locations are made flexible by utilizing the cross-information among the electrodes as well as the amplitude and frequency characteristics of the EMG. The method proposed is a combination of the multidimensional AR model and the discriminant function. It is shown by experiment that the method can discriminate, with accuracy above 93%, 6 motions of forearm and hands using 4 pairs of electrodes and EMG for 100 ms after motion generation. Thus the method can simplify the electrode placement and realize a high discriminating ability. (Edited author abstract) 14 refs.

Tsuji, Toshio (Hiroshima Univ, Higashi-Hiroshima, Jpn); Ito, Koji; Nagamachi, Mitsuo. *Syst Comput Jpn* v 18 n 12 Dec 1987 p 42-53.

**Electric Power Supplies** See Also ORTHOTICS—Functional Neural Stimulation.

**086446 ELECTRICALLY DRIVEN IMPLANTABLE PROSTHESES.** Electrically and electronically driven devices available in chemical practice or research stages include devices in the following areas: heart pacing, bone growth and repair, hearing aids, chemical dosing, drug infusion and dispensing, defibrillation, heart assist, nerve stimulation, gut stimulation, artificial larynx, pain suppression, implanted sensors, scoliosis treatment, artificial vision, and artificial heart. This article lists the desired implant instruments, briefly describes the electronic circuit technology and concentrates on some devices, such as the heart pacing systems, cardiac pacing leads, the automatic implantable defibrillator, bone growth and repair stimulators, and developments in the areas of pain control, central nervous system stimulation, implanted drug dispensers, telemetering devices, hearing aids, health assist sensors, and mentions some major manufacturers of implanted heart pacemakers and batteries. 72 refs.

Salkind, Alvin J. (UMDNJ-Rutgers Medical Sch, Piscataway, NJ, USA); Spontitz, Alan J.; Berkovits, V.; Owens, Boone B.; Stokes, B.; Bilitch, Michael. *Batteries for Implantable Biomed Devices* Publ by Plenum Press, New York, NY, USA, 1986 p 1-36.

## Electrodes

**086447 CURRENT DENSITY PROFILES OF SURFACE MOUNTED AND RECESSED ELECTRODES FOR NEURAL PROSTHESES.** A Green's function approach has been used to solve Laplace's equation for the quasistatic fields of a recessed, disk electrode. The resulting integral equation was solved numerically using the moment method. An analysis of the error in the approximate solution shows that it must be less than 7% for the cases studied. The calculations indicate that a recessed electrode has a more uniform current density profile than a surface mounted electrode, both at the electrode surface and at the electrode carrier-tissue junction. The significance of this finding is discussed as its application to electrochemical, histopathological, and physiological studies of neural prostheses. The clinical use of recessed electrodes in cochlear implants is recommended. 52 refs.

Rubinstein, Jay T. (Univ of Washington, Seattle, WA, USA); Spelman, Francis A.; Soma, Mani; Suesserman,

Michael F. *IEEE Trans Biomed Eng* v BME-34 n 11 Nov 1987 p 864-875.

**086448 REDUCTION OF ELECTRICAL INTERACTION IN AUDITORY PROSTHESES.** A method based on the thresholds of multiple electrode stimuli was developed to calculate accurately, in multichannel implants, the mapping from electrode current levels to excitation levels at each neural site. For the implant subjects tested, this technique accurately predicted thresholds for arbitrary patterns of stimulation. Inverting this mapping matrix produced patterns of stimulation that selectively stimulated only one neural site with minimum of interaction, while satisfying current limit constraints. These sharpened stimuli exhibited lower interaction and were pitch ranked with greater consistency than either monopolar or bipolar stimuli. 9 refs.

Townshend, Brent (Stanford Univ, CA, USA); White, Robert L. *IEEE Trans Biomed Eng* v BME-34 n 11 Nov 1987 p 891-897.

## Failure

**086449 FAILURE ANALYSES OF ORTHOPEDIC ARTIFICIAL PROSTHESES.** Three cases of failures of different kinds of artificial prostheses which were implanted in human bodies and were made of various materials have been investigated in this paper. According to metallographic and fractographic examinations and mechanical analyses, the authors have concluded that the failures were caused by fatigue cracking and corrosion fatigue cracking of implanted materials, and that the designs of prostheses were inadequate for real loads. In order to improve the qualities and reliabilities of biomaterials the authors have suggested that a series of tests of fatigue, stress corrosion and corrosion fatigue in simulated in vivo conditions is necessary. The authors have also suggested that the designs of artificial prostheses should be based on sufficient biomechanical experiments and calculations. (Edited author abstract) In Chinese. 13 refs.

Xu, Pei-yuan (Shanghai Jiaotong Univ, China); Zeng, Shen-peng; Lu, Jian-min; Wang, Wen-hua. *Zhongguo Shengwue Yixue Gongcheng Xuebao* v 6 n 2 Jun 1987 p 68-74.

**Grafts** See Also BIOMEDICAL ENGINEERING—Patient Treatment; BIOMEDICAL ENGINEERING—Surgical Implants.

**086450 COMPLETELY NEW POLY(ETHER-URETHANE) GRAFT IDEAL FOR HEMODIALYSIS BLOOD ACCESS.** Expanded polytetrafluoroethylene (E-PTFE) grafts have been used frequently to establish blood access for patients having no suitable arteries and veins to create arteriovenous fistulas. These grafts have several advantages over saphenous vein or bovine arterial grafts, but they could not be called ideal for blood access. A completely new synthetic vascular graft has been fabricated from poly(ether-urethane) with the use of an innovative casting method. In this report basic studies and animal experiments are introduced along with preliminary clinical applications. 5 refs.

Ota, Kazuo (Tokyo Women's Medical Coll, Tokyo, Jpn); Sasaki, Yuri; Nakagawa, Yoshihiko; Teraoka, Satoshi. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 129-135.

**086451 NEW GRAFT MATERIALS AND CURRENT APPROACHES TO AN ACCEPTABLE SMALL DIAMETER VASCULAR GRAFT.** Prosthetic graft material has not been successful for small artery bypass. Mechanical, cellular, and humoral factors have all been implicated as a cause of failure. In vitro, ex vivo, and in vivo methods have been developed to assess platelet and fibrinogen deposition, measure compliance, and study other factors theorized to relate to graft failure. Cell culture techniques have been used to determine the role of cellular mitogens. The goal of an arterial substitute that can maintain patency in a 3-4 mm diameter low-flow configuration and that is not associated with the develop-



ment of anastomotic hyperplasia has yet to be reached. A variety of solutions are being researched. New nonthrombogenic polymers are being tested as are new coatings for standard materials. Endothelial cell seeding has been accomplished in animals and is being tried in human clinical studies. (Edited author abstract) 112 refs.

Yeager, Anson (Tufts Univ, Boston, MA, USA); Callow, Allan D. *ASAIO Trans* v 34 n 2 Apr-Jun 1988 p 88-94.

**086452 RECONSTRUCTION OF THE DIGITAL PULLEY IN THE MONKEY USING BIOLOGIC AND NONBIOLOGIC MATERIALS.** A-2 pulleys were replaced in the hand of the nonhuman primate; on the long/little fingers the pulleys were reconstructed with a woven nylon fabric (Nitec), and on the ring/index fingers the pulleys were reconstructed with fascia lata. The opposite unoperated hand served as a control. At 2, 3, and 6 months postoperative, the animals were killed to compare the function of the reconstructed pulleys with the control pulleys of the opposite digit. Using a tensile testing machine, two parameters, work of flexion and tendon excursion, showed that both pulley reconstructions permitted minimal tendon bow-stringing and had excellent gliding function. Both materials increased in strength over time to become stronger than the control pulley. The Nitec pulley compared favorably with the fascia pulley biomechanically and histologically; both reconstructed pulleys functioned well compared with normal pulleys. (Edited author abstract).

Kain, Christopher C. (Washington Univ Sch of Medicine, St. Louis, MO, USA); Manks, Paul R.; Reinsel, Tom E.; Rouse, Andrew M.; Peterson, William W. *J Orthop Res* v 6 n 6 Nov 1988 p 871-877.

**Heart Valves** See Also BIOLOGICAL MATERIALS—Mechanical Properties; BIOMEDICAL ENGINEERING—Cardiology; BIOMEDICAL ENGINEERING—Surgical Implants.

**086453 PERICARDIAL HETEROGRAFT VALVES: AN ASSESSMENT OF LEAFLET STRESSES AND THEIR IMPLICATIONS FOR HEART VALVE DESIGN.** This study uses experimental results obtained from cyclic uniaxial load tests to predict the type and magnitude of operational stresses which occur in pericardial heterograft leaflets. Both Young's modulus and Poisson's ratio varied with uniaxial loading in pericardium, chemically modified free of tension. Leaflet stresses were analyzed by using effective incremental representations of these parameters. In leaflets with unrestricted rotation at the point of attachment to the stent, the mid-plane tensions always exceeded the bending stresses, and no zones of leaflet compression were predicted. In contrast, with totally restricted leaflet rotation induced by clamping (possibly between a male and a female frame) the bending stresses were greater than the mid-plane tensions at the hinge line and significant compressive stresses were predicted at this site. Glutaraldehyde fixation of the pericardium under load produced a stiffer material. These and other study results are discussed. (Edited author abstract) 17 refs.

Trowbridge, E.A. (Univ of Sheffield, Sheffield, Engl); Crofts, C.E. *J Biomed Eng* v 9 n 4 Oct 1987 p 345-355.

**086454 CHOICE OF HEART VALVES.** Although there have been a number of heart valve prostheses that have been adaptations of the types described, there are currently five basic types of prosthetic valves. In order to make the discussion workable, this paper presents each type of valve as it relates to hemodynamics, thromboembolism, durability, and cost. Hemolysis, previously a factor in prosthetic valves, now occurs at such an insignificant rate as to not be a factor in valve selection. It uses an example only one valve of each type. For the caged ball: Starr-Edwards; tilting disc: Hall-Medtronic; bileaflet: St. Jude; bioprosthesis: Hancock porcine bioprosthesis; and homografts: CryoLife. 26 refs.

Magilligan, Donald J. Jr. (Henry Ford Hospital, Detroit, MI, USA). *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 90-95.

**086455 INHIBITION OF BIOPROSTHETIC**

**HEART VALVE CALCIFICATION WITH COVALENTLY BOUND AMINOPROPANEHYDROXYDIPHOSPHONATE.** Aminodiphosphonate pretreatment of bioprosthetic heart valves (BPHV) has been shown in a very limited study to effectively inhibit calcification of bioprosthetic heart valve tissue in the rat subdermal model without adverse effects. Therefore, the purposes of this study were to determine, at physiologic pH, the optimal duration of incubation in aminopropanehydroxydiphosphonate (APDP) at which profound inhibition of tissue calcification would occur. Secondly, the amount of bound APDP that significantly inhibited calcification was determined. Finally, the question of adverse side effects caused by APDP on calcium metabolism and growth was addressed. 12 refs.

Webb, Catherine L. (Univ of Michigan Medical Cent, Ann Arbor, MI, USA); Benedict, James J.; Schoen, Frederick J.; Linden, Judith A.; Levy, Robert J. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 592-595.

**086456 TURBULENCE DOWNSTREAM FROM THE IONESCU-SHILEY BIOPROSTHESIS IN STEADY AND PULSATILE FLOW.** The Ionescu-Shiley (IS) bioprosthesis has become increasingly popular as an aortic valve replacement since being released in 1976 for general use in the United States. The turbulence generated downstream from an aortic Ionescu-Shiley bioprosthesis has been investigated in vitro with both steady and pulsatile flow. Instantaneous point velocities were measured using laser-Doppler anemometry (LDA) at numerous preselected locations in the flow. The mean and RS velocities from these data at each location were then used to estimate the laminar and turbulent shear in the bulk flow as a function of radial position on a cross-section of the flow system downstream from the mounted prosthesis. Estimated total shear stresses were found in the bulk flow of sufficient magnitude to possibly cause hemolysis and initiate platelet chemical-release reactions. (Edited author abstract) 30 refs.

Hanle, D.D. (California Inst of Technology, Pasadena, CA, USA); Harrison, E.C.; Yoganathan, A.P.; Corcoran, W.H. *Med Biol Eng Comput* v 25 n 6 Nov 1987 p 645-649.

**086457 DEVELOPMENT OF ARTIFICIAL LEAFLETS FOR HEART VALVE PROSTHESES.** For the fabrication of leaflets for a heart valve prosthesis a number of polyurethane elastomers based on poly(tetramethylene)glycol. MDI and ethylenediamine were prepared and tested for their elastic and viscoelastic properties. The results indicated that the molecular weight of the polyether has a strong effect on these properties at low strain levels. (Edited author abstract) 16 refs.

Wouters, L.H.G. (Eindhoven Univ of Technology, Eindhoven, Neth); Rousseau, E.P.M.; van Steenhoven, A.A.; German, A.L. *Plast Rubber Process Appl* v 8 n 4 1987 p 197-202.

**086458 IN VITRO ULTRASONIC IMAGING OF FLOW THROUGH PROSTHETIC HEART VALVES.** A rapid, inexpensive, portable technique has been developed for the qualitative and semiquantitative evaluation of in vitro flow characteristics through prosthetic heart valves. The technique combines a cardiac pulse duplicator and any diagnostic, linear sequential array, ultrasonic imaging system. The pulse duplicator has been modified to include an acoustically transparent aortic section which contains the prosthetic valve to be evaluated. The acoustically transparent section is fabricated from Rho-c rubber and enables direct flow-imaging for several centimeters on both sides of the prosthesis. Aerated tap water is used as a contrast medium. Forward and reverse flow, laminar flow complex eddy patterns, regurgitation, and jets are easily observed in real time over a wide field of view. Time-exposure photography of sequential images and subsequent off-line calculations enable point-by-point determinations of flow velocities. (Edited author abstract) 12 refs.

Gels, Gerald C. (FDA, Rockville, MD, USA); Stewart, Harold F.; Smith, Stephen W. *Med Instrum* v 21 n 2 Apr

1987 p 66-74.

**086459 HEART, ITS VALVES AND THEIR REPLACEMENT.** Stages in the development of various types of prosthetic heart valves are described. Data on survival rates indicates that large numbers of patients remain trouble-free. Attention should be paid to thromboembolic complications, mechanical valve hemolysis, and bioprosthetic valve durability. 62 refs.

Williams, D.F. *Blood Compat* v 2. Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 107-130.

**086460 PROSTHETIC VALVE DYSFUNCTION: MATERIAL AND COMPONENT FAILURE IN PROSTHETIC HEART VALVES.** The long-term durability of valve prostheses will play an increasing role as the limiting factor in device function. Retrieval and evaluation programs should be developed to investigate modes and mechanisms of prosthesis failure. Recipients should have more knowledge of aspects of valve prostheses. 94 refs.

Anderson, James M.; Ferraro, Robert; Ankeney, Jay L.; Hiltner, Anne. *Blood Compat* v 2. Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 131-147.

**086461 IN VITRO STRESS MEASUREMENTS IN THE VICINITY OF SIX MECHANICAL AORTIC VALVES USING HOT-FILM ANEMOMETRY IN STEADY FLOW.** Based on hot-film anemometry, point velocity measurements in the total cross sectional area 1 and 2 diameters downstream of Bjork-Shiley Standard, Convex-Concave and Monostut, Hall-Kaster (Medtronic-Hall), St. Jude Medical and Starr-Edwards Silastic Ball aortic valves were made. The spatial distribution of Reynolds Normal Stresses (RNS) was visualized three-dimensionally in order to point out where and to what extent the highest RNS were found. The measurements were made in steady flowing glycerol mixture at flow rates 10, 20 and 30 l. min<sup>-1</sup> corresponding to mean velocities of 27, 54 and 81 cm s<sup>-1</sup>. The highest maximum RNS values were around 250 Nm<sup>-2</sup> and were found downstream of the Bjork-Shiley Monostrut and Starr-Edwards Ball valves. (Edited author abstract) 33 refs.

Hasenkam, J.M. (Aarhus Kommunehospital, Aarhus, Den); Westphal, D.; Nygaard, H.; Reul, H.; Giersiepen, M.; Stodkilde-Jorgensen, H. *J Biomech* v 21 n 3 1988 p 235-247.

**086462 HEMODYNAMIC CHARACTERISTICS OF THE 'EMIKS' DISK ARTIFICIAL HEART VALVES.** Artificial replacement of the mitral valve is an effective method of correcting disturbed intracardiac hemodynamics in patients with mitral defect of the heart. The results of this operation in many respects are determined by the hemodynamic characteristics of the artificial heart valves (AHVs) being implanted. Low-profile disk AHVs with a flap closing element of the 'EMIKS' type were introduced into clinical practice in the USSR in 1983. The purpose of the present article is to analyze the hemodynamic characteristics of the 'EMIKS' valves after isolated artificial replacement of the mitral valve. 12 refs.

Semenovskii, M.L. (USSR Ministry of Health, Moscow, USSR); Manukyan, V.E.; Chestukhin, V.V. *Biomed Eng (New York)* v 21 n 5 Sep-Oct 1987 p 163-164.

**086463 METHOD OF DETERMINING THE KINEMATIC PARAMETERS OF DISK ARTIFICIAL HEART VALVES.** Operations on artificial replacement of heart valves have become prevalent in the USSR and abroad. Several thousands of them are performed every year just in our country. Improvement of existing designs and development of new designs of artificial heart valves (AHVs) are continuing. Some of their most important characteristics are the opening and closing time, as well as the rate of movement of the closing elements. These characteristics determine the speed of AHVs and the force loads on its elements. The small disk valves of the foreign



companies Bjork-Shiley, Medtronic-Hall, Omniscience, Sorin, the Soviet-made EMIKS and LIKS artificial valves, and also the two-disk valve made by St. Jude Medical are among the most frequently used ones. A method is proposed in this work for determining the kinematic parameters of disk AHVs under bench conditions. 2 refs.

Zaretskii, Yu.V. (Acad of Medical Sciences of the USSR, Moscow, USSR). *Biomed Eng (New York)* v 21 n 5 Sep-Oct 1987 p 165-158.

**086464 INFLUENCE OF CARDIAC FLOW RATE ON TURBULENT SHEAR STRESS FROM A PROSTHETIC HEART VALVE.** Two-component, simultaneous, correlated laser velocimeter measurements were recorded at four different axial locations and three different flow rates in a straight tube model of the aorta. All velocity data were ensemble averaged within a 15 ms time window located at approximately peak systolic flow over more than 300 cycles. Shear stresses as high as 992 dynes/cm<sup>2</sup> were found 0.92 tube diameters downstream of the monostrut, disk valve. The maximum turbulent shear stress was found to scale with flow rate to the 0.72 power. A repeatable starting vortex was shed from the disk at the beginning of each cycle. (Edited author abstract) 14 refs.

Schwarz, A.C. (Purdue Univ, West Lafayette, IN, USA); Tiederman, W.G.; Phillips, W.M. *J Biomech Eng Trans ASME* v 110 n 2 May 1988 p 123-128.

**086465 RESPONSE TO UNIAXIAL LOAD OF CHEMICALLY MODIFIED BOVINE PERICARDIUM AT DIFFERENT TEMPERATURES.** Non-destructive uniaxial load tests were performed on glutaraldehyde-fixed pericardium at two different temperatures. Samples were tested first at room temperature. Mean response curves to load were constructed. The temperature of the saline test medium was raised to body temperature at 37°C. Analysis of variance demonstrated no statistically significant difference in the response to load of the tissue at the two temperatures. Hence, it appears that the temperature is not an important parameter in the mechanical and accelerated fatigue tests of pericardial heart valve substitutes. (Edited author abstract) 14 refs.

Crofts, C.E. (Univ of Sheffield, Sheffield, Engl); Trowbridge, E.A. *J Mater Sci* v 23 n 4 Apr 1988 p 1510-1513.

**086466 SELECTION OF A PROSTHESIS FOR HEART VALVE REPLACEMENT ANALYSIS AND FUTURE DEVELOPMENT.** Currently, there are two main categories of cardiac valve replacements: mechanical models, or bioprostheses. Although all available models provide comparable hemodynamic benefits in vivo, none is perfect. Replacement valves must be selected on an individual basis, taking into account the patient's heart size and severity of valve damage; age; medical history; activity level and lifestyle; and postoperative quality of life. Bioprostheses are in general superior to mechanical substitutes. They close more rapidly, have central flow, are quieter, and are less prone to thromboembolic complications. Their durability, however, remains a significant concern. Reliability of tissue valves will likely be enhanced through superior engineering study and analysis of the effects of various tissue treatments and preservation; intensive research in the field of polymer science to develop a sufficiently strong man-made leaflet membrane; and development of new geometrical valve configurations which minimize mechanical stress. (Author abstract). 24 refs.

Haggag, Yosr A.M. (King Saud Univ, Riyadh, Saudi Arabia). *J Clin Eng* v 13 n 3 May-Jun 1988 p 217-223.

**086467 MECHANICAL ANALYSIS OF THE CLOSED HANCOCK HEART VALVE PROSTHESES.** In order to obtain mechanical specifications for the design of an artificial leaflet valve prosthesis, a geometrically nonlinear numerical model is developed of a closed Hancock leaflet valve prosthesis. In this model, the fiber reinforcement of the leaflet and the viscoelastic properties of frame and leaflets are incorporated. The calculations are primarily restricted to 1/6 part of the valve and a time

varying pressure load is applied. The calculations are verified experimentally by measuring the commissure displacements and leaflet centre displacement of a Hancock valve. The numerically obtained commissure displacements are found to be linearly dependent on the pressure load, and the slope of the curves is hardly dependent on loading type and loading velocity. Experimentally a difference is found between the three commissure displacements, which is also predicted numerically using a simplified asymmetric total valve model. (Edited author abstract). 32 Refs.

Rousseau, E.P.M. (Eindhoven Univ of Technology, Neth); Van Steenhoven, A.A.; Janssen, J.D.; Huysmans, H.A. *J Biomech* v 21 n 7 1988 p 545-562.

**086468 DYNAMIC ANALYSIS OF FLUTTER IN DISK TYPE MECHANICAL HEART VALVE PROSTHESES.** Parametric study of the low frequency oscillations occasionally observed in certain types of disc type prosthetic heart valves (PHV) are carried out using a finite element technique. The analysis is performed to determine the frequencies of the dynamic fluttering with the help of the 'ANSYS' computer program. The results show that the frequencies of the dynamic fluttering for both the circular occluders and the semicircular occluders are at least two orders of magnitude higher than that observed in vivo. It is thus concluded that the clinically observed leaflet oscillations should not be a dynamic flutter phenomenon. Rather, the vortex shedding has been assumed to be the cause of these oscillations. (Author abstract). 13 Refs.

Prabhu, Annapa A. (Univ of Houston, Houston, TX, USA); Hwang, Ned H.C. *J Biomech* v 21 n 7 1988 p 585-590.

**086469 TURBULENT STRESS MEASUREMENTS DOWNSTREAM OF SIX MECHANICAL AORTIC VALVES IN A PULSATILE FLOW MODEL.** In a pulsatile flow model aortic Bjork-Shiley Standard, Convex-Concave and Monostrut valves were investigated together with the Hall-Kaster (Medtronic-Hall), St. Jude Medical and Starr-Edwards Silastic Ball valve using hot-film anemometry. Three-dimensional visualization of average systolic Reynolds normal stresses (RNS) reflected the design of the valves. Mean average RNS were used for comparison of the fluid dynamic performance along with Velocity Energy Ratio (VER<sub>100</sub>) and Turbulence Energy Ratio (TER) as a relative turbulence intensity for pulsatile flow. Mean average RNS ranged from 13.2 to 37.6 N m<sup>-2</sup> for all the valves with the highest levels for the Bjork-Shiley Standard and Starr-Edwards Ball valve and lowest values for the St. Jude Medical valve and with the Hall-Kaster (Medtronic-Hall), Bjork-Shiley Convex-Concave and Monostrut valves in between. (Author abstract). 37 Refs.

Hasenkam, J.M. (Aarhus Kommunehospital, Aarhus, Den); Nygaard, H.; Giersiepen, M.; Reul, H.; Stodkilde-Jorgensen, H. *J Biomech* v 21 n 8 1988 p 631-645.

**086470 THREE-DIMENSIONAL VISUALIZATION OF VELOCITY FIELDS DOWNSTREAM OF SIX MECHANICAL AORTIC VALVES IN A PULSATILE FLOW MODEL.** Velocity fields downstream of 27 mm Bjork-Shiley Standard, Bjork-Shiley Convex-Concave, Bjork-Shiley Monostrut, Hall-Kaster (Medtronic-Hall), St. Jude Medical and Starr-Edwards Silastic Ball aortic valves were studied in a pulsatile mock circulation. Stroke volume was 70 cm<sup>3</sup> and frequency 71 min<sup>-1</sup> and 88 min<sup>-1</sup>. Fluid velocity was measured by a catheter mounted hot-film anemometer probe in a glycerol water mixture one and two diameters downstream of the aortic valve. Velocity fields were dynamically visualized by a three-dimensional technique and revealed qualitative independence of frequency. The differences between the three investigated Bjork-Shiley valves were remarkable. The St. Jude Medical valve generated velocity peaks downstream of the two major orifices and the central slit, and lower velocities in the hinge areas. A rather flat profile with central hollowing was seen downstream of the Starr-Edwards Ball valve. All velocity profiles were more or less dampened two diameters downstream. (Edited

author abstract). 32 Refs.

Hasenkam, J.M. (Aarhus Kommunehospital, Aarhus, Den); Giersiepen, M.; Reul, H. *J Biomech* v 21 n 8 1988 p 647-661.

**086471 EFFECT OF DELAY BETWEEN TISSUE HARVEST AND GLUTARALDEHYDE PRETREATMENT ON MINERALIZATION OF BOVINE PERICARDIUM USED IN BIOPROSTHETIC HEART VALVES.** There is concern that delayed glutaraldehyde treatment of bioprosthetic tissue could potentiate calcification by autolytic generation of mineralization nuclei. This study investigated the effects on mineralization of variable delays between harvest of bovine pericardium and initial glutaraldehyde treatment, using tissue implanted subcutaneously in rats for 21 days. Susceptibility to mineralization increased statistically but only modestly with delays to 34 h. This suggests that mineralization will not be significantly inhibited by rapid treatment of otherwise properly handled tissue and that clinically important prevention of calcification will require more dramatic means. (Author abstract). 8 Refs.

Maranto, Anthony R. (Brigham and Women's Hospital and Harvard Medical Sch, Boston, MA, USA); Schoen, Frederick J. *J Biomed Mater Res* v 22 n 9 Sep 1988 p 819-825.

**086472 DYNAMIC RESPONSE OF CLOSED BIOPROSTHETIC VALVE LEAFLETS.** The dynamic response of the leaflets of a closed bioprosthetic valve was determined using triangular shell elements. The damping ratio of the system was estimated using a one-dimensional springmass system and was found to be 0.02. This damping ratio was used in estimating the transient response of the three-dimensional leaflets that occurs due to the normal pressure gradient during diastole. The maximal deflection with a Young's modulus of 600 kPa was 3.71 mm. Stiffening of the leaflet was shown to reduce the maximal deflection. A perforation in one of the leaflets (20 percent area of a single leaflet) did not change the response appreciably. (Author abstract). 21 refs.

Hamid, Mohamed S. (Henry Ford Heart & Vascular Inst, Detroit, MI, USA); Sabbah, Hani N.; Stein, Paul D. *Comput Struct* v 29 n 5 1988 p 807-813.

**086473 in vitro EXPERIMENTAL COMPARISON OF EDWARDS-DUROMEDICS AND ST. JUDE BI-LEAFLET HEART VALVE PROSTHESES.** An in vitro comparison of the hydrodynamic characteristics of the Edwards - Duromedics (DM) and St Jude (SJ) bi-leaflet aortic valve prostheses is presented. Aortic valves 27 mm in diameter were mounted in a pulse duplicator simulating physiological pulsatile flow using a glycerol solution as the blood analogue fluid. Mean trans-valvular pressure difference (TPD) in systole, the percent regurgitation (PCR) and the projected valve orifice area (VOA) were compared at a range of flow rates and heart rates to reflect the functioning of the valve under resting as well as exercise conditions. Study results are discussed. (Edited author abstract). 11 Refs.

Chandran, Krishnan B. (Univ of Iowa, Iowa City, IA, USA); Schoephoerster, Richard; Fatemi, Reza; Dove, Edwin L. *Clin Phys Physiol Meas* v 9 n 3 Aug 1988 p 233-241.

**086474 STUDY OF PROSTHETIC HEART VALVE SOUNDS.** A mechanism is proposed for the generation of phonocardiogram (PCG) sounds from implanted mechanical prosthetic heart valves. The structures in the chest, the heart, its partitions, and its major vessels, constitute a frequency-selective system excited by the rapidly decelerating valve occluder. It is shown that the rapidly decelerating valve produces a wide and flat power spectrum and hence is an impulsive excitation that couples energy to the resonance modes specified by the structures in the chest. Consequently, the PCG signal is composed of decaying sinusoids. The parameters of the decaying sinusoids are estimated, and it is observed that the power spectra of the



PCG signals have two dominant peaks in the frequency band of 200-500 Hz. The energy coupled to these two modes depends on the state of the valve. With thrombus, the decelerating occluder slows down and becomes a broader pulse concentrating the energy to the lower resonance mode. This is verified by experiments on 30 postoperative patients. 21 refs.

Koymen, Hayrettin (Middle East Technical Univ, Ankara, Turk); Altay, Bulent K.; Ider, Y. Ziya. *IEEE Trans Biomed Eng* v BME-34 n 11 Nov 1987 p 853-863.

**086475 HEART VALVE ENGINEERING, PAPERS PRESENTED AT A SEMINAR.** This seminar proceedings consists of fifteen papers. Some of the subject covered are: Laboratory testing of prosthetic valves; pulsatile flow testing of prosthetic conduits; fluid forces on pivoted disc prosthetic valves; hydrodynamic advantages of mechanical bileaflet valves; and clinical aspects - an overview. Other topics are: the use of ceramics; mechanical properties of bovine pericardium; pericardial heterografts; and quality control of heart valves. Long term assessment of heart valve substitutes; modes of failure observed in explanted valves; and quality assurance of valves by in vitro testing are also presented. All of the papers are abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11224 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Inst of Mechanical Engineers, Engineering in Medicine Group, London, Engl). *Heart Valve Eng. Pap Presented at a Semin, London, Engl, Dec 4-5 1986* Publ by Mechanical Engineering Publ Ltd, Bury St. Edmunds, Engl, 1986 107p.

**Hip Prostheses** See Also ADHESIVES—Bone Cement; BIOMECHANICS—Gait Analysis; BIOMEDICAL ENGINEERING—Orthopedics.

**086476 CAUSES OF FEMORAL HEAD ROUGHENING IN EXPLANTED CHARNLEY HIP PROSTHESES.** The effect of particles of first, acrylic bone cement containing either barium sulphate or zirconium dioxide as X-ray contrast media, and second, particles of fresh cortical bone, on a surgical grade stainless steel surface against which polyethylene was rubbing, has been investigated. It was found that under physiological loads, particles of acrylic cement which have been embedded in the polyethylene bearing surface caused severe scratching of the stainless steel. Additional study results are discussed. 14 refs.

Isaac, G.H. (Univ of Leeds, Engl); Atkinson, J.R.; Dowson, D.; Kennedy, P.D.; Smith, M.R. *Eng Med* v 16 n 3 Jul 1987 p 167-173.

**086477 CONTACT FINITE ELEMENT STRESS ANALYSIS OF POROUS INGROWTH ACETABULAR CUP IMPLANTATION, INGROWTH, AND LOOSENING.** Two-dimensional linear and contact finite element analyses were conducted of total hip arthroplasty using metal-backed, porous ingrowth acetabular components. The results indicated that when a conventional metal-backed component (without a flange) is initially implanted and subjected to normal loading, these components may experience distraction between the component and the surrounding bone at inferior sites. Compressive stresses in the superior dome cancellous bone, however, will be substantial. If complete porous ingrowth is achieved, the superior dome compressive stresses will be reduced and substantial shear stresses created. If bone ingrowth is achieved only in specific locations, stress transmission will be dictated by those locations and may differ markedly from the case of complete bone ingrowth. In the event that no porous ingrowth is achieved and a fibrous layer forms around the component, the interface stresses will be similar to those calculated for the natural hip. Additional study results are discussed. (Edited author abstract) 32 refs.

Rapperport, D.J. (Veterans Administration RR&D Cent, Palo Alto, CA, USA); Carter, D.R.; Schurman, D.J. *J Orthop Res* v 5 n 4 Dec 1987 p 548-561.

**086478 WEAR, CREEP, AND FRICTIONAL HEAT OF FEMORAL IMPLANT ARTICULATING SURFACES AND THE EFFECT ON LONG-TERM PERFORMANCE - PART I, A REVIEW.** Creep and wear of articulating reconstructed joints is a complex process, resulting in adverse tissue response, decreased range of motion, and eventual revision. As improvements are made in the design and surgical techniques of reconstructed joints, the long-term performance of the articulating system and materials becomes more important, particularly for younger, heavier, and more active patients. One aspect previously ignored in the long-term performance of articulating systems is the tendency for these systems to generate heat during articulation, particularly for extended periods of relatively strenuous activity. The present study reviews the various aspects of joint lubrication, friction, wear, and overall system performance. Local heating can increase the creep, wear, and oxidation degradation of UHMWPE, thus, specific attention is given to the effect that heat generation can have on long-term performance of these systems. (Edited author abstract). 101 refs.

Davidson, J.A. (Richards Medical Co, Memphis, TN, USA); Schwartz, G. *J Biomed Mater Res* v 21 n 3 Suppl Dec 1987 p 261-285.

**086479 ROLE OF STEM DESIGN AND MATERIAL ON STRESS DISTRIBUTIONS IN CEMENTED TOTAL HIP REPLACEMENT.** The risk of fatigue fractures of the femoral stem in a cemented total hip arthroplasty can be minimized by either increasing the stem cross-section and/or using a very high strength alloy. This study compares important mechanical characteristics of five selected stem designs, differing in configuration and materials (stainless steel, cast chrome cobalt alloy, nickel based alloy and titanium alloy). The strain pattern on the stem was analyzed in a 3-point-bending jig and also after cementing it into cadaver femurs. Regardless of stem type or test method, the typical tensile stress distribution on the lateral stem was a bell shaped curve. For the cobalt-chrome and stainless steel stems, the larger the stem, the lower the stem stresses and stress gradient, and the higher the factor of safety. However, the factor of safety was increased even further by the use of super alloys (MP35N and Ti<sub>6</sub>Al<sub>4</sub>V). (Edited author abstract) 28 refs.

Christel, P.S. (CNRS, Paris, F); Meunier, A.; Blanquaert, D.; Witvoet, J.; Sedel, L. *J Biomed Eng* v 10 n 1 Jan 1988 p 57-63.

**086480 FATIGUE AND CORROSION FATIGUE TESTING OF HIP JOINT ENDOPROSTHESES IN AIR AND IN NaCl-SOLUTION.** To assure the quality of hip joint endoprosthesis stems, comparative investigations are made for the first time on marketable prostheses of different producers to determine fatigue and corrosion fatigue strength under long time service conditions. The results show that even for these remarkable corrosion resistant materials (cast CoCrMo- and wrought Co-NiCrMo-alloys) under test conditions which are relevant for practice there exists no real fatigue strength, but only a corrosion fatigue loadability for finite life time. The fatigue loadability obtained in air will be reduced remarkably by the simultaneous effect of the physiological NaCl-solution. Recommendations for an effective system of quality assurance are given. (Author abstract) 9 refs.

Kunze, E. (TUEV Rheinland eV, Cologne, West Ger). *Werkst Korros* v 38 n 12 Dec 1987 p 757-762.

**086481 GLOBAL MECHANICAL CONSEQUENCES OF REDUCED CEMENT/BONE COUPLING RIGIDITY IN PROXIMAL FEMORAL ARTHROPLASTY: A THREE-DIMENSIONAL FINITE ELEMENT ANALYSIS.** Component loosening in total hip arthroplasty is often accompanied by substantial bony remodelling, associated initially with reduced stiffness of the cancellous bone bordering the cement, and eventually with the formation and proliferation of a compliant fibrous membrane at the bone/cement interface. An anatomically based three-dimensional finite element model has been developed to explore the salient stress changes occurring with progressive degradation of the

stiffness of the cancellous bone in a thin zone bordering the cement. This border zone, modelled as a distinct linearly elastic and isotropic material layer, assumed a geometry and a range of mechanical properties inferred from eventual membrane thickness apparent in recent animal studies of component loosening. The major variables considered were: stiffness (elastic modulus) and compressibility (Poisson ratio) of the border zone, stiffness changes in the outlying cancellous bone, resultant hip contact force, and trochanteric muscle loadings. The results for the limiting case of a non-degraded border zone compared reasonably with previous studies of femoral reconstructions having rigid bone-to-cement attachment. (Edited author abstract) 26 refs.

Brown, Thomas D. (Univ of Iowa, Iowa City, IA, USA); Pedersen, Douglas R.; Radin, Eric L.; Rose, Robert M. *J Biomech* v 21 n 2 1988 p 115-129.

**086482 MULTICHANNEL STRAIN GAUGE TELEMETRY FOR ORTHOPAEDIC IMPLANTS.** In vivo measurements of the loads and deformations occurring in orthopaedic implants will allow future improvements to be made. This paper describes an extremely small telemetry for long term measurements with three strain gauges and methods for an absolutely safe implant design. Developed for measuring the load at hip prostheses, the telemetry can also be used for other implants. Its size makes feasible the instrumentation of devices with only slight mechanical modifications. In addition to the description of our own measuring system, the paper gives a survey on the problems of telemetrized implants, on methods for measuring spatial loads, and on the investigations of other authors. Future publications will present in vivo measurements with this telemetry, among others on hip endoprostheses. (Author abstract) 18 refs.

Bergmann, G. (Free Univ, Berlin, West Ger); Graichen, F.; Siraky, J.; Jendrynski, H.; Rohmann, A. *J Biomech* v 21 n 2 1988 p 169-176.

**086483 EFFECT OF FEMORAL COMPONENT SECTION MODULUS ON THE STRESS DISTRIBUTION IN THE PROXIMAL HUMAN FEMUR.** The study tested the hypothesis that femoral prostheses having a reduced section modulus will provide a distribution of stress in the proximal femur that better matches the stress field present in the normal intact femur. Four embalmed femora from adult human cadavers were instrumented with bonded-foil strain gauges and the states of strain present in the proximal-medial cortex after implantation of three different femoral components were compared with the strain present before implantation. In all cases, low modulus stems showed higher strains than the standard prosthesis. Strains as high as 74 percent of intact were found at the calcar region. Our results suggest that, while lower stiffness stems provide better retention of stress levels, other factors including proximal stem geometry, changes in bending moment after implantation of the prosthesis and cortical bone thickness also played an important role in the strain distribution in bone. (Edited author abstract) 9 refs.

Engelhardt, J.A. (Louisiana State Univ Medical Cent, Shreveport, LA, USA); Saha, S. *Med Biol Eng Comput* v 26 n 1 Jan 1988 p 38-45.

**086484 RADIOGRAPHIC DETERMINATION OF THE ANGLE OF VERSION OF THE FEMORAL COMPONENT IN TOTAL HIP REPLACEMENT.** This paper describes a simple method to determine stem orientation after total hip replacement: It is based on standard antero-posterior radiographs and computes the angle between prosthesis and film plane from the shortening of predefined distances in the projection. The error of the method is less than 5 per cent for the stem orientation and less than 10 per cent for the neck orientation. The



method allows accurate control of stem orientation by means of standard equipment in orthopaedic practice. (Author abstract) 3 refs.

Schmotzer, Hans (Univ of Cape Town); Learmonth, Ian D. *Eng Med* v 17 n 1 Jan 1988 p 7-9.

**086485 VERGLEICHENDE UNTERSUCHUNGEN ZUM LANGZEIT-ERMUEDUNGSVERHALTEN VON HUEFTGELENKPROTHESEN AN LUFT UND IN NaCl-LOESUNG.** [Fatigue and Corrosion Fatigue Testing of Hip Joint Endoprostheses in Air and in NaCl Solution]. To assure the quality of hip joint endoprostheses stems, comparative investigations were made on prostheses of different producers to determine fatigue and corrosion fatigue strength under long time service conditions. The results show that for these corrosion resistant materials (cast CoCrMo and wrought CoNiCrMo alloys) under test conditions which are relevant for practice there exists no real fatigue strength, but only a corrosion fatigue loadability for a finite life time. The fatigue loadability obtained in air reduced by the simultaneous effect of the physiological NaCl solution. Under comparable conditions wrought CoNiCrMo, TiAlV and TiAlFe stems perform better than cast CoCrMo stems. The lowest loadability was determined in a wrought stem produced from stainless steel 316L. Recommendations for an effective system of quality assurance are given. (Edited author abstract) 11 refs. In German.

Kunze, E. (TUV Rheinland, Cologne, West Ger). *Metall* v 42 n 2 Feb 1988 p 140-145.

**086486 NONLINEAR FINITE ELEMENT ANALYSIS OF INTERFACE CONDITIONS IN POROUS COATED HIP ENDOPROTHESES.** We used a geometrically simplified finite element model to investigate load transfer between a porous coated hip endoprosthesis and a femur. Assuming both rigidly bonded and nonlinear interfaces, we analyzed fully and partially coated stems that had coatings of different elastic moduli. Our results indicate that maximum values for relative motion in the interface between bone and implant occur for implants with the same elastic modulus as compact bone. By comparison, interface motion is reduced by about half for Co-Cr-Mo alloy stems. We also showed that the elastic modulus of the porous coating had only a small influence on bone stresses. (Author abstract). 17 Refs.

Rohlmann, A. (Free Univ Berlin, Berlin, West Ger); Cheal, E.J.; Hayes, W.C.; Bergmann, G. *J Biomech* v 21 n 7 1988 p 605-611.

**086487 FRICTIONAL PROPERTIES OF ARTIFICIAL HIP JOINTS.** A new generation of hip replacements has been designed incorporating compliant layers to promote fluid film lubrication when the joints are implanted in patients. Tests in the Durham hip function simulator show that the friction in these joints is up to an order of magnitude lower than in currently used prostheses, and because this is due to complete separation of the rubbing surfaces, wear ought to be vastly reduced. Experiments have shown that the best results are achieved with compliant surfaces of hardness between 4 and 8 N/mm<sup>2</sup>. Such surfaces produce coefficients of friction of the order of  $5 \times 10^{-3}$ . (Author abstract). 9 Refs.

Unsworth, A. (Univ of Durham, Engl); Pearchy, M.J.; White, E.F.T.; White, G. *Eng Med* v 17 n 3 Jul 1988 p 101-104.

**086488 DESIGN AND DEVELOPMENT OF A VERSATILE HIP JOINT SIMULATOR AND A PRELIMINARY ASSESSMENT OF WEAR AND CREEP IN CHARNLEY TOTAL REPLACEMENT HIP JOINTS.** Although wear testing of bulk materials provides valuable background data, and may lead to an understanding of the various wear mechanisms and the effects of surface topography, a more rigorous and complete simulation of physiological conditions is necessary for the laboratory evaluation of complete prostheses. This can best be provided by the use of a joint simulator. This paper describes the design of a new 3-station hip joint simulator and briefly discusses early results. 5 Refs.

Dowson, D. (Univ of Leeds, Engl); Jobbins, B. *Eng Med* v 17 n 3 Jul 1988 p 111-117.

**086489 PROSTHETIC HIP FAILURE: PRELIMINARY FINDINGS OF RETROSPECTIVE RADIOGRAPH IMAGE ANALYSIS.** The paper presents the results of a retrospective study based on radiographs of 75 successful total hip replacements, and 103 which involved failure of the femoral component of the prosthesis. Measurements were made on radiographs which had been obtained immediately post-operatively, so that the features measured would depend on surgical procedure rather than on any subsequent biological response. Computer image analysis has been used to make precisely defined, reproducible measurements of 58 parameters characterizing the insertion of the femoral component of a standard Charnley prosthesis. These parameters include geometry of insertion, distribution of cement, surrounding bone thickness, and so on. Clinical findings, including patient weight, were also recorded with the measurements on computer disc. Preliminary statistical comparisons indicate that several of the measured parameters are of predictive value for determining the long-term success or failure of total hip replacements. (Edited author abstract). 18 Refs.

Jones, P.R. (Univ of Manchester, Engl); Taylor, C.J.; Hukins, D.W.L.; Hardinge, K.; Porter, M.L. *Eng Med* v 17 n 3 Jul 1988 p 119-125.

**086490 ROTATIONAL MOVEMENT OF FEMORAL COMPONENTS OF TOTAL HIP REPLACEMENTS IN RESPONSE TO AN ANTERIORLY APPLIED LOAD.** Mechanical testing has been performed on total hip replacements implanted in sections of cadaveric femora. A purpose built transducer has been used to measure the rotation of the implant in the bone under loads applied in the anterior-posterior direction. This has been used to assess the effect of cement and also of retaining more of the femoral neck. The retention of the femoral neck improved stability, as did the bone cement, and in the case of the uncemented prosthesis, longitudinal ridges increased the stability of the prosthesis. (Author abstract). 7 Refs.

Tanner, K.E. (Univ of London, London, Engl); Bonfield, W.; Nunn, D.; Freeman, M.A.R. *Eng Med* v 17 n 3 Jul 1988 p 127-129.

**Joint Prostheses** See Also BIOMATERIALS—Reviews; BIOMECHANICS—Joints; BIOMECHANICS—Musculoskeletal Systems.

**086491 LONG-TERM EXPERIENCE WITH TOTAL JOINT PROSTHETIC REPLACEMENT FOR THE ARTHRITIC GREAT TOE.** A report on the use of 13 double-stemmed flexible hinge silicone elastomer implants as total joint replacements for the metatarsophalangeal (MTP) joint of the great toe in 98 patients since 1971. In the 57 patients with osteoarthritis, 81 joints were replaced; in the 30 patients with rheumatoid arthritis, 37 joints were replaced. The results were graded excellent, good, fair, or poor based on relief of pain and cosmesis. The overall results were good. On the basis of these findings, the author concludes that there is a place for total joint prosthetic replacement with this device in the surgical reconstruction of the painful, destroyed MTP joint of the great toe. (Edited author abstract) 29 refs.

Kampner, Stanley L. (Univ of California Medical Cent, San Francisco, CA, USA). *Bull Hosp Jt Dis Orthop Inst* v 47 n 2 1987 p 153-177.

**086492 ADAPTIVE BONE-REMODELING THEORY APPLIED TO PROSTHETIC-DESIGN ANALYSIS.** The subject of this article is the development and application of computer-simulation methods to predict stress-related adaptive bone remodeling, in accordance with 'Wolff's Law'. These models are based on the Finite Element Method (FEM) in combination with numerical formulations of adaptive bone-remodeling theories. In the adaptive remodeling models presented, the Strain Energy Density (SED) is used as a feed-back control variable to determine shape or bone density adaptations to alternative

functional requirements, whereby homeostatic SED distribution is assumed as the remodeling objective. These models are applied to investigate the relation between 'stress shielding' and bone resorption in the femoral cortex around intramedullary prostheses, such as used in Total Hip Arthroplasty (THA). It is shown that the amount of bone resorption depends mainly on the rigidity and the bonding characteristics of the implant. (Edited author abstract) 50 refs.

Huiskes, R. (Univ of Nijmegen, Nijmegen, Neth); Weinans, H.; Grootenboer, H.J.; Dalstra, M.; Fudala, B.; Slooff, T.J. *J Biomech* v 20 n 11-12 1987 p 1135-1150.

**086493 STRESS COMPATIBLE FINITE ELEMENT FOR IMPLANT/CEMENT INTERFACE ANALYSES.** A new finite element has been developed to enforce normal and shear stress continuity at bimaterial interface points in order to alleviate the problem of high stress discontinuity predictions by the conventional displacement finite element method. The proposed element is based on a five node isoparametric quadrilateral element where the fifth node is located at the interface boundary of the element. A series of validation tests have been carried out to assess the correctness of the stress distribution obtained by the new element at interfaces of highly dissimilar materials. The results of the tests are compared to analytical solutions and to results from convergence studies performed by the conventional finite element method (SAP-IV). Overall, the proposed element has been demonstrated to have a very satisfactory degree of reliability. (Edited author abstract) 21 refs.

Angelides, M. (McGill Univ, Montreal, Que, Can); Shirazi-Adl, A.; Shrivastava, S.C.; Ahmed, A.M. *J Biomech Eng Trans ASME* v 110 n 1 Feb 1988 p 42-49.

**086494 WEAR, CREEP, AND FRICTIONAL HEATING OF FEMORAL IMPLANT ARTICULATING SURFACES AND THE EFFECT ON LONG-TERM PERFORMANCE - PART II, FRICTION, HEATING, AND TORQUE.** The present study was performed to examine closely the propensity to generate heat during articulation in a hip joint simulator. The systems investigated were polished Co-Cr-Mo alloy articulating against UHMWPE, polished alumina ceramic against UHMWPE, and polished alumina against itself. Frictional torque was also evaluated for each system at various levels of applied loads. A walking load history was used in both the frictional heating and torque tests. The majority of tests were performed with 5 mL of water lubricant. However, the effect of various concentrations of hyaluronic acid was also evaluated. Results showed frictional heating to occur in all three systems, reaching an equilibrium after roughly 30 min articulation time. Additional study results are discussed. (Edited author abstract) 21 refs.

Davidson, J.A. (Richards Medical Co, Memphis, TN, USA); Schwartz, G.; Lynch, G. *J Biomed Mater Res* v 22 n A1 Suppl Apr 1988 p 69-91.

**086495 SILICONE RUBBER TEMPOROMANDIBULAR JOINT (TMJ) MENISCAL REPLACEMENTS: POSTIMPLANT HISTOPATHOLOGY AND MATERIAL EVALUATION.** Medical grade silicone rubber has long been considered a suitable meniscal replacement, but there has been increasing concern about migration of this material into adjacent tissues. The objectives of this study were to determine the definitive composition of tissue-incorporated material which is presumed by light microscopy to be silicone and to identify long term histopathologic sequelae of meniscal replacement. Adult female patients underwent meniscectomy and replacement with silicone rubber (Silastic) implants. After 12 to 18 months, recurrence of symptoms in 8% of these cases led to implant removal with excision of peri-implant fibrous pseudocapsules. Excised tissues, including one preauricular lymph node and implants were submitted for light microscopy, SEM, and energy dispersive X-ray microanalysis (EDX) for the identification of elemental composition, critical surface tension measure-



ment, and internal reflection-infrared spectroscopy. EDX revealed prominent peaks for silicon in both pseudocapsular and nodal tissues. Morphological findings surrounding the long-term implants included foreign body reaction synovitis, dystrophic calcification, fibrocartilaginous metaplasia, hyalinization, and scarring. (Edited author abstract) 11 refs.

Hartman, Laurie C. (State Univ of New York at Buffalo, Buffalo, NY, USA); Bessette, Russell W.; Baier, Robert E.; Mayer, Anne E.; Wirth, John. *J Biomed Mater Res* v 22 n 6 Jun 1988 p 475-484.

**086496 COMPONENT WEAR OF TOTAL KNEE PROSTHESES USING Ti-6Al-4V, TITANIUM NITRIDE COATED Ti-6Al-4V, AND COBALT-CHROMIUM-MOLYBDENUM FEMORAL COMPONENTS.** A knee simulator was used to study the wear of carbon fiber reinforced UHMWPE (Poly Two) tibial and patellar components against Ti-6Al-4V, titanium nitride (TiN)-coated Ti-6Al-4V, and cobalt-chromium-molybdenum femoral components. The prostheses tested were regular sized Miller-Galante total knees mounted on 316L stainless steel fixtures using bone cement. The wear mechanisms found on the tibial components were scratching, carbon-fiber associated damage, surface deformation, pitting, minor abrasion, and delamination. Three forms of carbon fiber associated damage were identified; fibers pulled from the surface, broken fibers, and UHMWPE removed from the surface fibers. The SEM evaluation revealed a pit forming mechanism. Additional study results are discussed. (Edited author abstract). 24 Refs.

Peterson, C.D. (Purdue Univ, West Lafayette, IN, USA); Hillberry, B.M.; Heck, D.A. *J Biomed Mater Res* v 22 n 10 Oct 1988 p 887-903.

**086497 WEAR AND CONTACT STRESS STUDIES OF THE MINNS MENISCAL KNEE PROSTHESES.** This paper describes the results of wear testing and contact area studies of a R.J. Minns meniscal knee prosthesis and compares the results of previous work on wear and contact stress studies of other knee prosthesis designs. Although stresses that arise at the surface of the polyethylene meniscus components are large, after repetitive loading the contact area rises, as a consequence of plastic flow and creep, and they reduce to a fifth of the initial stress after 1 million cycles. Contact area studies show that asymmetrical loading of the meniscus give proportionally high stresses on the higher loaded meniscus and, at large values of flexion, have similar values to a more conforming but fixed polyethylene tibial component design of knee prosthesis. A. 4 Refs.

Minns, R.J. (Dryburn Hospital, Durham, Engl). *Eng Med* v 17 n 3 Jul 1988 p 135-138.

**086498 EFFECTS OF POLYMETHYLMETHACRYLATE EXPOSURE UPON MACROPHAGES.** The effects of polymethylmethacrylate (PMMA) exposure upon macrophage viability and function were studied in an attempt to determine what role these cells play in the loosening of cemented arthroplasties. P388D1 murine macrophage cell line was exposed to PMMA and polystyrene particles of similar size and concentration. DNA synthesis following exposure to PMMA or polystyrene was studied by [<sup>3</sup>H]thymidine incorporation. Macrophage function was studied by analyzing the ability of activated macrophages to kill mast cell targets following particle exposure. Our results demonstrate that exposure of macrophages to PMMA particles in vitro inhibits DNA synthesis and impairs their cytotoxic ability. Histologic examination revealed that macrophages phagocytose both PMMA and styrene particles, but the former eventually lyse these cells. Our studies suggest that the histologic appearance of macrophages and foreign body giant cells at the bone-cement interface may be secondary to a repetitive cycle of PMMA particle phagocytosis and cell death, similar to that found in a foreign body granulomatous response. (Author abstract). 34 refs.

Horowitz, Stephen M. (Johns Hopkins Hospital, Baltimore, MD, USA); Frondoza, Carmelita G.; Lennox, Dennis W. *J Orthop Res* v 6 n 6 Nov 1988 p 827-832.

**086499 GEOMETRY OF THE FIRST METATARSOPHALANGEAL JOINT.** This study aimed to define the articular geometry of the metatarsophalangeal (MTP) joint of the great toe. Embedded in resin blocks, five pairs of cadaveric first MTP joints (all from men) were sequentially cut in the sagittal plane with a milling machine, removing 0.5 mm of bone in each cut. The photographed cartilaginous outline of each cut was digitized against reference markers, which enabled a computer system to superimpose each outline in three dimensions. The intersesamoid ridge was found to be parallel to the lateral shaft. The peak of the ridge was just lateral to the midline of the MT head. The articular outline, through the ridge of each sample, was circular. The sample size is too small for the sizing of prostheses but it is adequate to study the geometry of the MTP joint. More data are needed for the accurate replication of a resurfacing prosthesis and understanding of joint kinematics. (Edited author abstract). 12 refs.

Yoshioka, Yuki (Queen's Univ, Kingston, Ont); Can, Siu, David W.; Derek, T.; Cooke, T. Derek V.; Bryant, J.T.; Wyss, Urs. *J Orthop Res* v 6 n 6 Nov 1988 p 878-885.

**086500 GEOMETRY OF THE HUMEROULNAR JOINT.** Clinical results with elbow prostheses have been disappointing. A detailed knowledge of elbow joint geometry and mechanics is necessary to improve prosthetic design. In this study, the humeroulnar articulation of four human cadaver elbows was examined using surface analytic methods. In this article, the location of the transverse axis of elbow flexion-extension is suggested in relation to well-defined landmarks, the medial and lateral epicondyles, and subsequently to the line connecting their most lateral points - the transepicondylar line. The geometry of the structures responsible for the carrying angle is discussed, as is the extent of cartilage-covered bearing areas of the lower humerus and upper ulna. Implications pertaining to prosthetic design and surgical technique resulting from this study are discussed. (Author abstract). 22 refs.

Shiba, Ryoichi (Kobe Univ, Kobe, Jpn); Sorbie, Charles; Shi, David W.; Bryant, J. Timothy; Cooke, T. Derek V.; Wevers, Hendrik W. *J Orthop Res* v 6 n 6 Nov 1988 p 897-906.

**Materials** See ELASTOMERS—Biocompatibility.

## Mathematical Models

**086501 STRUCTURAL MODEL FOR MOLDED THERMOPLASTIC ANKLE-FOOT ORTHOSES.** The structural response of a posterior leaf spring, ankle-foot orthosis (AFO) was studied both experimentally and with a simple theoretical model. The theoretical model, which was compared with other analytical solutions and experimental data, predicted the bending and twisting of the AFO due to unit loads. The simple theoretical model utilized beam equations and small deflection theory. Excellent agreement between test and predicted values was achieved, indicating that the simple theoretical model, which was relatively easy to implement computationally, could serve as the major component of a computer-aided design program. (Author abstract) 9 refs.

Leone, D.J. (Univ of Hartford, West Hartford, CT, USA). *J Biomech Eng Trans ASME* v 109 n 4 Nov 1987 p 305-310.

## Measurements

**086502 OPTO/COMPUTER METHODS APPLIED TO THE EVALUATION OF A RANGE OF ACETABULAR CUPS.** Non-contact optical measurements have been made for acetabular cups of both the Charnley (worn in vivo) and Stanmore (simulator worn) types. The measurements employ optical contouring as the technique for deriving point coordinates. Optical contouring consists of creating or projecting fringes of known spacing onto an object. Points lying on a line (fringe edge) are then known to be of the same height/depth from a particular reference). This paper shows the problems and solutions

of applying this technique to both knee and hip prostheses. 4 Refs.

Atkinson, J.T. (Liverpool Polytechnic, Engl); Burton, D.R.; Lator, M.J.; O'Donovan, P.C. *Eng Med* v 17 n 3 Jul 1988 p 105-110.

**Monitoring** See BIOMEDICAL ENGINEERING—Fracture Fixation.

## Myoelectric Control

**086503 MICROPROCESSOR BASED TRAINER FOR BOTH SINGLE-SITE AND TWO-SITE MYOELECTRIC PROSTHESES.** Electronic training aids are essential in preparing an amputee for the use of a myoelectric prosthesis, but are often complicated in use and never flexible enough to handle a wide variety of possible myoelectric control strategies. The Bio-Engineering Institute of the University of New Brunswick has designed a 'high-tech' training device, which overcomes these drawbacks. The new trainer interacts with a therapist via a 2x40 character liquid crystal display and two key switches. It is completely menu driven. By using low power circuitry throughout the design, the instrument can be run continually for up to 8 h off a set of five standard D-type cells. In addition, the instrument can be easily adapted to any new control strategy by an update to read-only-memory based software. (Edited author abstract) 7 refs.

Lovely, D.F. (Univ of New Brunswick, Fredericton, NB, Can); Hruszkowski, T.W.; Scott, R.N. *J Microcomput Appl* v 11 n 1 Jan 1988 p 31-45.

**086504 MYOELECTRIC PROSTHESES: STATE OF THE ART.** A brief introduction to powered prosthetics and myoelectric control is presented. This paper reviews the present availability and clinical impact of myoelectric prostheses. A significant observation is that these systems have reached a sufficient degree of maturity that they are accepted by many health-care funding agencies as reasonable and cost-effective components of the rehabilitation process. The limitations of both the mechanical systems and the myoelectric controls are discussed in some detail, from the viewpoint of the potential user. Finally, an overview is given of current research in this field with comments on probable directions of development. (Edited author abstract). 10 refs.

Scott, R.N. (Univ of New Brunswick, Fredericton, NB, Can); Parker, P.A. *J Med Eng Technol* v 12 n 4 Jul-Aug 1988 p 143-151.

**Pacemakers** See Also BIOMEDICAL ENGINEERING—Electromagnetic Field Effects; ELECTRIC BATTERIES—Medical Applications; ELECTRODES—Platinum.

**086505 PROSPECTS FOR DEVELOPMENT OF PROGRAMMED PACEMAKERS AND MONITORING DEVICES.** The paper presents an analysis of experience gained in the West and the USSR in the field of pacemaker design in four principal directions: an increase in the quantity of information obtained from the pacemaker; introduction of new work schedules; physiological nature of modern pacemakers; improvement of the electrodes.

Mikhailov, V.A. (Ministry of Health of the USSR, Moscow, USSR); Khvostov, L.Ya. *Biomed Eng (New York)* v 21 n 2 Mar-Apr 1987 p 83-85.

**086506 KEY EVENTS IN THE EVOLUTION OF IMPLANTABLE PACEMAKER BATTERIES.** The successful development of implantable cardiac pacemakers has been facilitated by the merging of the relevant technologies in electronics and power sources. The mercury/zinc oxide battery was a key component in the initial development of implantable pulse generators and that battery system is closely associated with the name of Dr. Samuel Ruben. Subsequently, the lithium/iodine battery was developed for hermetically sealed, longer-lived pulse



generators, and this development has been closely associated with the name of Dr. Wilson Greatbatch. These inventors were able to assess the existing technology and make improvements and innovation as required to achieve a product that satisfied the need. The present chapter records interviews that occurred in January 1983; the purpose was to explore these individuals' thoughts on the subject of creativity in general and their experiences in being so innovative in the area of power sources. 8 refs.

Owens, Boone B. (Univ of Minnesota, Minneapolis, MN, USA); Salkind, Alvin J. *Batteries for Implantable Biomed Devices* Publ by Plenum Press, New York, NY, USA, 1986 p 37-49.

**086507 PHRENIC PACEMAKER: SUBSTITUTION OF PARALYZED FUNCTIONS IN TETRAPLEGIA.** Electrophrenic respiration - the control of respiration by proper stimulation of phrenic nerves - was first discussed in a publication by S.J. Sarnoff in 1948. Unlike the cardiac pacemaker, however, the respiratory pacemaker has had no significant success in recent years. Perhaps the only modest progress in this field has been a result of the electrically induced fatigue of the nerve-muscle complex. The aims of this study are concerned with the modern rehabilitation of patients with quadriplegia and respiratory insufficiency who have been implanted with the authors' respiratory pacemaker. Subjects covered include preclinical stage studies. Stability of impedance and threshold, clinical experience, and others. 11 refs.

Thoma, H. (Univ of Vienna, Vienna, Austria); Gerner, H.; Holle, J.; Kluger, P.; Mayr, W.; Meister, B.; Schwanda, G.; Stoehr, H. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 472-479.

**086508 CHOOSING AN ELECTRONIC CARDIAC PACEMAKER: A DECISION ANALYSIS.** Cardiac pacemaker malfunctions are of continuous concern to the medical profession as well as to the electronics industry. This paper employs a decision analytic framework to help cardiologists choose among several pacemaker models. Failure data were obtained from the literature and a utility function over failure outcomes was elicited from a cardiologist. The paper presents a 'Batch Reliability Comparison' method for utility assessment which might also be attractive in other reliability settings. Three specific pacemaker models were evaluated. The expected utility approach yielded a different ranking than the conventional expected life approach. (Edited author abstract) 4 refs.

Pliskin, Joseph S. (Ben Gurion Univ of the Negev, Beer Sheva, Israel); Ronen, Boaz; Feldman, Shlomo. *Eur J Oper Res* v 32 n 3 Dec 1987 p 333-339.

**086509 ANALYSIS OF THE CURRENT-DENSITY DISTRIBUTION FROM A TAPERED, GELLED-PAD EXTERNAL CARDIAC PACING ELECTRODE.** We have designed a high-temperature (5000  $\Omega$ -cm), tapered, gelled-pad, external cardiac pacing electrode that limits the migration of charges to the perimeter of a circular electrode and produces a more uniform current-density distribution than external cardiac pacing electrodes in clinical use. A computer simulation was developed that uses cylindrical coordinates to analyze the current-density distribution at the interface between the electrode and human tissue. Our computer simulation analyzed 32 different electrodes, and the results showed that the gelled-pad thickness, the gelled-pad taper, and the radius of the conducting disk were not significant parameters in determining the current-density distributions for low-resistivity electrodes. Those parameters were, however, significant for high-resistivity electrodes. The peak current density of the tapered, gelled-pad electrode was 50% lower than that of the clinically available electrodes, while delivering 58% more current to the human tissue. (Edited author abstract) 11 refs.

Williams, Christopher R. (Purdue Univ, West Lafayette, IN, USA); Geddes, Leslie A.; Bourland, Joe D.; Furgason, Eric S. *Med Instrum* v 21 n 6 Dec 1987 p 329-334.

**086510 FUNCTIONAL TESTING OF EXTERNAL**

**CARDIAC PACEMAKERS.** In common with all other biomedical equipment, cardiac pacemakers should be routinely tested and serviced. Experience has shown that although they are generally very reliable, some faults have occurred that might have been detected by regular testing. A testing protocol is suggested that has two levels, routine tests that check the essential functions of the pacemakers and supplementary tests that check those parameters which are less likely to be of immediate clinical significance. The measurement details and rationale of the tests are described in some detail. Finally, a preliminary evaluation of a test instrument which has been developed specifically for these procedures shows that it is rapid and easy to use and allows a more rigorous standard of testing to be achieved. (Author abstract) 8 refs.

Watts, M.P. (West of Scotland Health Boards, Glasgow, Scotland); Evans, A.L. *Clin Phys Physiol Meas* v 9 n 2 May 1988 p 113-121.

**086511 FREQUENCY SPECTRA OF VENTRICULAR TACHYCARDIA AND SINUS RHYTHM IN HUMAN INTRACARDIAC ELECTROGRAMS - APPLICATION TO TACHYCARDIA DETECTION FOR CARDIAC PACEMAKERS.** Presently available antitachycardia pacemakers detect ventricular tachycardia (VT) by measurement of the period of the intracardiac electrogram (EGM). The resulting inability to differentiate between VT and rapid normal sinus rhythm (NSR) can cause inappropriate pacemaker output, possibly initiating an arrhythmia where none existed previously. It is reported that FFT analysis of matched-pair NSR-VT EGM recordings from 33 patients revealed a mean ( $\pm$ S.D.) NSR-VT difference in the peak amplitude point of  $8 (\pm 7)$  Hz and a difference of  $18 (\pm 18)$  Hz in the  $-3$  dB point. NSR-VT amplitude differences could be significantly increased by filtering over the range of greatest spectral differences. Variable-passband programmable filters could enhance VT detection in antitachycardia pacemakers. 16 refs.

Pannizzo, Frank (Columbia Univ, New York, NY, USA); Furman, Seymour. *IEEE Trans Biomed Eng* v 35 n 6 Jun 1988 p 421-425.

## Plastics Applications

**086512 POLYMERS ON THE PITCH.** The author outlines three kinds of ligament replacements: permanent - implanted prostheses, which stay in the body; inductive - these allow collagen to grow in and around them and act as a scaffold for a new ligament or tendon (a neoligament); resorbable - these act as a temporary scaffold, eventually biodegraded by the body. Among the replacement materials discussed by the author are carbon fiber, polyesters and PTFE. Also presented are the properties of the ideal prosthetic material.

Nelson, Sally. *Chem Br* v 23 n 12 Dec 1987 p 1152-1153.

**Transplantation** See Also BIOMEDICAL EQUIPMENT; COMPUTER SOFTWARE—Medical Applications.

**086513 BRIDGE TO HEART AND LUNG TRANSPLANTATION: PA TO LA SHUNTING WITH AN INTERPOSED RECIRCULATION CIRCUIT FOR OXYGENATION.** The authors have designed a system that allows for pulmonary artery (PA) to left atrium (LA) shunting with an interposed recirculation circuit for oxygenation as a bridge to heart-lung transplantation. PA to LA shunting can effectively reduce the PA pressure and relieve the pressure load of the right ventricle in conditions of primary or secondary pulmonary artery hypertension. This study succeeded in doing total PA to LA shunting with oxygenation for 13 hours. Although this procedure is more invasive than ordinary ECMO, it may be useful as a temporary assistance device in those candidates awaiting heart-lung transplants. 3 refs.

Kawamura, Tsuyoshi (Univ of California at San Diego, CA, USA); Fukui, Yasuhiro. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 433-435.

**086514 RIGHT HEART ASSIST FOR ACUTE**

**RIGHT VENTRICULAR FAILURE AFTER ORTHOTOPIC HEART TRANSPLANTATION.** Fixed high pulmonary vascular resistance (PVR) is a major contraindication to orthotopic heart transplantation, and patients with this condition are usually excluded during preoperative evaluation. Nevertheless, those with normal or slightly elevated PVR can develop acute right ventricular failure as a result of right ventricular afterload mismatching caused by a spastic reaction of the pulmonary vasculature. Right ventricular dysfunction may be fatal if functional improvement and/or decrease of resistance is not achieved. This report concerns such a patient, in whom right heart bypass (RHB) was used to maintain the systemic circulation. The patient was eventually weaned successfully but died 2 weeks later of septicemia and multiple organ failure. The paper concludes that when acute right ventricular failure follows orthotopic heart transplantation and the patient does not respond to medical therapy, RHB may be useful for overcoming transient right heart dysfunction caused by temporarily elevated afterload. 10 refs.

Nakatani, Takeshi (Texas Heart Inst, Houston, TX, USA); Radovancevic, Branislav; Frazier, O.H. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 695-698.

**086515 EPIPHYSEAL REPLACEMENT USING DEVELOPING TISSUE DONORS IN A MURINE MODEL: A COMBINED HISTOLOGIC AND RADIOGRAPHIC STUDY.** The purpose of this experiment was to develop such a model of epiphyseal transplantation in the mouse. Developing CD1 mouse or Lewis rat limb tissue was used to replace the knee tissue that had been resected from CD1 postnatal mouse hosts. Donor tissue ranged from 14-day embryonic mouse to 9-day postnatal mouse or 18- and 19-day fetal rat, which has a gestation similar to the mouse. The murine tissue is known to be avascular prior to the sixth postnatal day. The limbs were analyzed radiographically and histologically. The results show that epiphyseal replacement could be studied using developing tissue donors in a murine model. The results suggest that donor tissue prior to vascularization and tissue combinations with the least developmental time mismatch (the least heterochronicity) produced relatively the best, although still abnormal epiphyses. (Edited author abstract) 20 refs.

Zaleske, David J. (Massachusetts General Hospital, Boston, MA, USA); Floyd, Waldo E. III; Hallett, Joseph; Kushner, David; Jupiter, Jesse; Trahan, Carol; Ehrlich, Michael G.; Mankin, Henry J. *J Orthop Res* v 6 n 2 Mar 1988 p 155-165.

**PROTECTIVE ATMOSPHERES** See POWDER METALLURGY—Sintering; POWDER METALLURGY—Nickel.

**PROTECTIVE COATINGS** See Also AUTOMOBILES—Painting; BEARINGS—Wear; BRIDGES, STEEL—Corrosion Protection; CHEMICAL PLANTS—Painting; CONCRETE CONSTRUCTION—Precast; ELECTRIC CABLES—Fire Protection; ELECTROPLATING—Reviews; FLOORS—Concrete; GAS INDUSTRY—Equipment; GAS TURBINES—Blades; IRON CHROMIUM ALLOYS—Corrosion Protection; METAL FINISHING; METAL FINISHING—Reviews; METALS AND ALLOYS—Corrosion; METALS AND ALLOYS—Hardening; METALS AND ALLOYS—Heat Treatment; METALS AND ALLOYS—Oxidation; NICKEL AND ALLOYS—Heat Resisting; NICKEL CHROMIUM COBALT MOLYBDENUM ALLOYS—Hydrogen Embrittlement; NIOBIUM AND ALLOYS—Creep; NIOBIUM AND ALLOYS—Oxidation; OIL FIELD EQUIPMENT—Corrosion; SHIPS—Hulls; SILICON STEEL—Oxidation; SILVER PLATING—Friction; STEAM TURBINES—Erosion; STEEL—Painting; TERBIUM IRON ALLOYS—Magnetic Properties; TITANIUM ALUMINUM ZIRCONIUM TIN ALLOYS—Oxidation; TITANIUM AND ALLOYS—Plating.

**086516 PROTECTIVE CAPACITY OF ZINC SILICATE COATINGS IN DAMAGE OF THEM.** In anticorrosion protection of hydraulic structures and also of ship hulls in service under complex Arctic conditions mechanical damage of coatings and wear of them until uncovering of large areas of metal are possible. Silikat-sink-2 (STs-2), Silikat-sink-01 (STs-01), and Silikat-sink-02



(STs-02) coatings, the zinc content in which is 80, 75, and 60%, respectively, were investigated. The specimens were shot-blasted plates of 08 steel. The coating thickness was 80  $\mu\text{m}$ . The corrosive medium was sea water. Despite cleaning until uncovering of the surface of the base, it is not possible to completely eliminate the zinc. Particles of it remain in the depressions of the surface occurring in shot-blasting. The zinc deposited in the depressions provides protection for 210 days and traces of corrosion are not observed. 4 refs.

Knyazeva, V.V. (Acad of Sciences of the Ukrainian SSR, Lvov, USSR); Stepanok, N.A.; Orlov, V.A. *Sov Mater Sci v 22 n 6 Nov-Dec 1986 p 629-630.*

**086517 POLYAMIDE COATINGS OBTAINED BY ELECTRODEPOSITION ON A CATHODE.** The studies resulted in the discovery of a stable aqueous dispersion of polyamide stabilized by an amine-bearing acryl copolymer and cation-active surfactant. This makes it possible to use the method of electrodeposition on a cathode to obtain 60-70 mm thick coatings based on powdered polymers. These coatings have good physicochemical properties and high alkali resistance. 11 refs.

Pankina, L.D. ('Lakokrasopkrytie' Scientific-Industrial Assoc, USSR); Klimenkova, V.M.; Utkina, I.F.; Krylova, I.A. *Prot Met v 23 n 1 Jan-Feb 1987 p 96-98.*

**086518 DISTRIBUTION OF TEMPERATURE AND HEAT FLUX AT THE CONTACT OF THE SUBSTRATE WITH A SUBLAYER DURING ELECTRIC-ARC DEPOSITION OF PROTECTIVE COATINGS.** Results of mathematical modeling of the temperature state of a substrate-sublayer system during deposition of protective coatings by the electric-arc method are presented. The thermal effect of the coating particles on the free surface of the sublayer is assumed to be equivalent to heating of this surface by a heat flux of a given power. The authors will assume that the substrate and sublayer have the same initial temperature and that the thickness of the substrate considerably exceeds the thickness of the sublayer. 1 ref.

Mrochek, Zh.A.; Antonenko, A.B.; Vershina, A.K. *Sov Surf Eng Appl Electrochem n 1 1987 p 28-31.*

**086519 INTENSIFICATION OF THE ELECTROSPARK ALLOYING PROCESS IN A MEDIUM OF LOW-MELTING SURFACE-ACTIVE METALS.** The effect of low-melting surface-active metals (SAMs) on the technological characteristics of electrospray alloying (ESA) was investigated. It is shown that, depending on the treatment conditions and absorption activity of the SAMs, both plasticizing and embrittling effects are observed, which can be used for controlling the process of transport and erosion of the metal during ESA. It was established that the main cause of limitation of the thickness of the alloyed layer is its limiting energy saturation, which can be reduced by the plasticizing effect of SAMs. Modification of the substrate by surface-active melts makes it possible to increase by 2-2.5 times the rate of metal transport with an increase of the transport coefficient by 20-35%. (Edited author abstract) 8 refs.

Meshcheryakov, N.G.; Charugin, N.V. *Sov Surf Eng Appl Electrochem n 1 1987 p 42-50.*

**086520 WEAR AND CORROSION-RESISTANT COMPOSITE LEAD COATINGS.** The present article gives the results of research to develop electrochemical composite coatings with a lead matrix for centrifugal pumps and chemical plant equipment. The research was undertaken because little information on such coatings has been published, and because electrolytes currently used for this purpose do not give the requisite proportion of metal particles and do not prevent agglomeration. 6 refs.

Abdullin, I.A. *Sov Eng Res v 7 n 2 Feb 1987 p 31-33.*

**086521 EXOTHERMIC REACTION OF Ni-AL DURING SPRAYING.** According to observations during Ni-Al spraying, the phase structures of coatings and the results of differential thermal analysis, the reaction

process of Ni-Al during spraying was studied. The heat release and the synergistic enhancement temperature during spraying were calculated. The heat releases were in conformity with calculated results within the range of conventional Ni-Al compositions. (Edited author abstract) 7 refs. In Chinese.

Chu, Jianxin (General Research Inst of Nonferrous Metals, Beijing, China). *Fenmo Yejin Jishu v 5 n 3 Aug 1987 p 147-151, 136.*

**086522 LARGE-TYPE ION PLATING EQUIPMENT FOR TAIYO SEISAKUSHO.** Ion-plating is a technique of forming a thin film on the surface of the work to be processed with the aim of improving wear resistance and corrosion resistance, thereby giving lubrication to the work. Heretofore, the ion-plating process was generally applied by a small-sized unit to surface hardening of small works such as cutting tools, but in recent years, it has come to be applied to larger-sized works, and larger sized ion-plating equipment is being required. The ion-plating equipment which IHI has recently completed on the order of Taiyo Seisakusho forms hardened films mainly consisting of TiN and TiC, and will also form ceramics films in the future. This article describes the features of this plant.

Okabe, Syuichi (IHI, Jpn); Nakajima, Shinobu; Nebashi, Kiyoshi. *IHI Eng Rev (Engl Ed) v 20 n 4 Oct 1987 p 154-156.*

**086523 COATINGS FOR PERFORMANCE RETENTION.** This article reviews both progress and challenges in three areas: wear-resistant coatings, erosion-resistant coatings and coatings for seal systems. For many years, wear-resistant coatings have been used in fans and compressors to minimize wear from impact, fretting, or galling. Airfoil and blade tip coatings have been used to combat erosion problems in the fan and compressor as well as erosion problems resulting from combustor deterioration, but considerable room for improvement remains. In the area of seal systems also, while significant improvements have been made in materials for compressors, labyrinth seals, and turbine gas path seals, there remains much to be done. (Edited author abstract) 3 refs.

Hillery, Robert V. (Coating & Seal Systems). *Leading Edge (Evendale OH) Spring 1987 p 36-41.*

**086524 LES REVETEMENTS CERAMIQUES: OUTILS DE DEVELOPPEMENT TECHNOLOGIQUE.** [Ceramic Coatings: Tools of Technological Development]. Ceramic coatings, whose role is less apparent than that of the metallic coatings, have played an important part in the technological development. The principal coating processes that are described in the article have made it possible to overcome considerable technological barriers in the field of optics, electronics, wear, and high temperatures. Introduction of new technologies or putting new materials into service can necessitate adaptation of some current procedures or resorting to procedures that have not yet found wide application. (Translated author abstract) In French. 43 refs.

Dallaier, Serge (Conseil Natl de Recherches du Canada, Boucherville, Que, Can). *New Metall Mater and New Fabr Processes Publ by Natl Research Council Canada, Ottawa, Ont, Can p 10.0-10.26.*

**086525 MECHANISM OF STRUCTURE FORMATION IN ELECTROLYTIC COATINGS.** The article analyzes the dependence of the average size of zones of X-ray coherent dissipation which in many investigations is accepted as the main characteristics of the fine structure of electrolytic coatings on the difference  $\Delta T$  of the melting temperature and electrodeposition temperature of the coating. On the basis of literature data the authors established and experimentally confirmed that there is a general mechanism of formation of fine crystalline structure for all electrolytic coatings. The supercooling level in electrocrystallization of metals is the main factor defining the fine structure of the coatings. 25 refs.

Girin, O.B.; Vorob'ev, G.M. *Russ Metall Met n 4 1987 p 148-152.*

**086526 NEW WORLD OF FINISHING. URETHANES - PART II.** The basic chemical ingredient of the urethane enamels and coating materials covered in Part I last month emphasized the environmental problems associated with the isocyanates. A second environmental problem with the urethanes is the solvents required to be used with them. Research is centering on a number of ways to produce single part urethanes which offer properties as good as their solvent counterparts. The article lists the important properties needed for a coating for a typical urethane which could be used over an epoxy primer, a lacquer primer or by itself on a metal substrate. 1 ref.

Groshart, Earl. *Met Finish v 86 n 3 Mar 1988 p 33-34.*

**086527 SPECIAL EQUIPMENT REQUIREMENTS FOR SPRAY FINISHING WITH COMPLIANCE COATINGS.** The trend toward greater use of compliance coatings has affected both suppliers and end users of all types of coatings. As industrial finishers have been faced with more stringent EPA guidelines for low VOC (volatile organic compound) emissions, they have turned to their paint suppliers for new formulations which will meet these requirements. The result has been development and formulation of various new liquid compliance coatings such as high solids coatings, waterborne coating and coatings formulation which utilize compliant solvents. The change to higher levels of solids and the wide range of solvents and formulation bases (e.g. waterbornes) have highlighted the need for special equipment to effectively apply these new materials.

Bain, R. Clark (Graco Inc, Minneapolis, MN, USA); Muir, Glen. *Met Finish v 86 n 3 Mar 1988 p 55-57.*

**086528 KORROSIONSSCHUTZ DURCH CHEMISCH ABGESCHIEDENE NICKELUEBERZUEGE.** [Corrosion Resistance by Chemically Deposited Nickel Coatings]. An investigation of the chemical resistance of chemical nickel coatings with more than 10 per cent of phosphorus shows that they are resistant in a range of media, including among others, the various materials employed in the food industry. Their application depends, however, on the corrosion resistance of the system as well as the chemical resistance. The corrosion resistance depends, apart from the chemical resistance, on the basis material, the pre-treatment, the coating technology, the coating thickness, and various other factors. Guidelines are given for the use of chemical nickel for corrosion protection. (Author abstract) 15 refs. In German.

Roubal, Jiri. *Galvanotechnik v 79 n 3 Mar 1988 p 736-742.*

**086529 UMWELTFREUNDLICHE BESCHICHTUNGSSSTOFFE FUER WIRTSCHAFTLICHEN KORROSIONSSCHUTZ.** [Low-Pollution Coating Materials for Economical Corrosion-Protection]. Suitable combinations of modern binders, fillers and pigments have been developed which not only have little pollution effect, but are also highly economical. (Author abstract) In German.

Anon. *Stahlbau Rundsch n 70 Apr 1988 p 18.*

**086530 ECONOTECHNICAL ANALYSIS OF CLEAR COATINGS - VALUE IN USE.** The selection of UV/EB technology as a clear coating is no longer limited to situations determined by external environmental and mechanical considerations. There are now applications where coating selection is made on the basis of the cost/performance analysis of the coating itself. There are 'real' advantages and UV/EB systems are leveraged. In order to sustain the growth that radiation-cured clear coatings have enjoyed, we will have to look to other areas for that growth. The time is coming soon when a change to UV/EB coatings will no longer be required, but will have to be earned on a competitive basis.

Melber, George E. (Pierce & Stevens Corp). *Radiat Curing v 15 n 2 May 1988 p 10-12.*



**086531 PAPERS PRESENTED AT THE 14TH INTERNATIONAL CONFERENCE ON METALLURGICAL COATINGS.** This conference proceedings is distributed between two journals: 'Surface and Coating Technology' and 'Thin Solid Films'. The two volumes of 'Surface and Coating Technology' contain 73 papers on metallurgical coatings, three of which appear as extended abstracts. The first of these volumes covers the conference sessions devoted to: corrosion resistant coatings and materials development; clearance control and high temperature applications; and thermal barrier coatings. The main topics of the second volume include: hard coatings; tribological coatings and surface modifications; industrial coating equipment and applications; and surface modification using direct ion beams. The second part of the conference proceedings is packaged under Code No. 10820. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10819 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Krutenat, R.C. (Ed.). *Surf Coat Technol* v 32 Nov and v 33 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat, San Diego, CA, USA, Mar 23-27 1987 2 vol, 918p.

#### Acoustic Emission Testing

**086532 ACOUSTIC EMISSION MEASUREMENTS TO EVALUATE THE DEGRADATION OF COATING FILMS.** Two types of acoustic emission (AE) have been observed during cathodic degradation of coating films. Under a cathodic polarization of very low overpotential at which no hydrogen gas evolved, intermittent AE signals with long intervals were observed. This type of AE measured should be responsible for a chemical and/or physical breaking of the bond between the metal and the film. Therefore, early stage evaluation of films will be performed by this type of experiment. The second type of AE was measured under higher overpotential. The formation of hydrogen gas bubbles caused this type of AE. Thus, it is possible to detect the existence of water layers or small blisters under the film by a cathodic polarization of coated steels and simultaneous AE measurement. (Edited author abstract) 11 refs.

Tsuru, T.; Sagara, A.; Haruyama, S. *Corrosion (Houston)* v 43 n 11 Nov 1987 p 703-707.

**Adhesion** See ALUMINUM AND ALLOYS—Painting; COATINGS—Performance; SURFACES—Activation; WOOD—Painting.

**Aging** See COATINGS—Magnetic Properties.

#### Analysis

**086533 PHASE COMPOSITION OF DETONATION COPPER-MOLYBDENUM DISULFIDE COATINGS.** The present work involves the investigation of the phase composition of coatings made from different mechanical mixtures of copper with molybdenum disulfide and sprayed on with different compositions of the detonating gas mixture. Radiographic analysis of the distribution of molybdenum disulfide over the surface of flat specimens showed that here the molybdenum disulfide is distributed nonuniformly. As had been assumed, in a number of specimens its largest amount is found in the central part of the surface of the specimen corresponding to the core of the spraying spot, and in some specimens the maximum lies in the peripheral part of the spraying spot, i.e., in the zone with the minimal thickness of the coating. This circumstance has to be taken into account in the spray-coating of extended surfaces and in matching the feed of the coated surface to the spraying spot. 5 refs.

Temkin, V.M.; Vlasenko, V.V.; Podol'skii, B.A.; Baldina, T.P.; Gruzlov, V.V. *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 331-334.

**086534 FROM DIAMOND-LIKE CARBON TO DIAMOND COATINGS.** Coatings which have a high degree of sp<sup>3</sup> bonding generally have properties, especially hardness, close to those of single-crystal diamond and are

often referred to as diamond-like carbon. Recently, large grain size diamond crystals and continuous diamond coatings have been prepared by plasma chemical vapor deposition methods. Although such materials are different from the diamond-like carbon class of materials, there is clearly a continuum of materials which is expected to lead to vagueness and confusion in nomenclature. In this paper, such issues are dealt with and a working definition of 'diamond' coatings is offered. (Edited author abstract) 39 refs.

Messier, R. (Pennsylvania State Univ, University Park, PA, USA); Badzian, A.R.; Badzian, T.; Spear, K.E.; Bachmann, P.; Roy, R. *Thin Solid Films* v 153 Oct 26 1987, Pap Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 1-9.

**Applications** See Also COATINGS—Reviews; STEAM TURBINES—Blades; TEXTILE MACHINERY—Protective Coatings.

**086535 COATINGS COMPATIBLE WITH MOIST, OILY, RUSTY SURFACES.** Although the ultimate performance of most coatings will depend to a large extent on the surface preparation of the substrate, there are many instances in maintenance painting, especially in the oil and process industries, where high standards of surface preparation by abrasive blasting are not possible. New resin and coating technology has been developed by scientists from the British Petroleum Research Center in response to an even greater need for more surface-tolerant coatings. The coating can be applied over marginal surfaces without abrasive blasting, even though surfaces are contaminated with oil. The author describes these coatings which are compatible with moist, oily and rusty surfaces.

Masciale, Michael (Valspar Corp). *J Prot Coat Linings* v 5 n 5 May 1988 p 9, 11-13.

**086536 APPLICATION AND QUALITY CONTROL OF FUSION BONDED EPOXY COATINGS.** The performance of mill-applied fusion bonded epoxy coatings in pipe service is dependent upon surface preparation and application procedures. The author focuses on measures to control the quality of application. FEB coating is widely used on oil and gas pipelines where high quality corrosion protection is a priority. FEB coatings provide superior performance, and when coated to the requirements of published standards, provide a high quality coating that is compatible with the cathodic protection system required on these pipelines. 13 refs.

McConkey, S.E. (Shaw Pipe Protection Ltd). *J Prot Coat Linings* v 5 n 5 May 1988 p 26-31.

**086537 MANAGING PROTECTIVE COATINGS PROJECTS.** Protective coatings are necessary in any large chemical complex. Otherwise, the chemicals used in processes and the atmosphere around the plant will corrode and/or erode the structural steel, tanks, pumps, motors, and other equipment to the point where replacement is required in a very short time. But the coatings themselves do not solve corrosion problems. Sound engineering judgment and practices are required to assure that the proper materials are selected, that well written specifications appropriately govern the conduct of the work, that competent contractors are selected to apply the coatings, and that the work is conducted efficiently and professionally. This article focuses on the management of painting projects, with the aim of describing sound practice in all of the activities necessary to a successful painting project. 5 refs.

Nockengost, Robert F. (Allied Fibers). *J Prot Coat Linings* v 5 n 5 May 1988 p 41-47.

**Bituminous** See PIPELINES—Protection.

**Borides** See Also MOLYBDENUM AND ALLOYS—Protective Coatings; TANTALUM AND ALLOYS—Coatings.

**086538 ELEKTROCHEMISCHE KORROSION-UNTERSUCHUNGEN AN BORHALTIGEN HARTSTOFFSCHICHTEN.** [Electrochemical Studies of the Corrosion Behavior of Refractory Boride Layers]. Pure

and alloyed with a transition element (titanium, chromium, nickel, cobalt) iron boride layers have been produced by means of a CVD process. The corrosion behavior of these compositions was compared by recording the current density - potential curves. It was found that the compositions containing titanium, chromium and nickel demonstrate a better corrosion behavior than the unalloyed iron boride layers. No improvement could be determined for the composition containing cobalt. (Translated author abstract) 16 refs. In German.

Treffer, Gerd; Bochmann, Gerd; Pläntitz, Hermann; Lehmann, Christa; Wagner, Wolfgang. *Wiss Z Tech Univ Karl Marx Stadt* v 29 n 2 1987 p 327-332.

#### Brazing

**086539 CHARACTERISTICS AND APPLICATION OF BRAZED METAL COATINGS.** This article deals with the characteristics of brazed metal coatings, with specific reference to their hardness, wearing properties and the arrangement of layers of carbide in the matrix. A number of possible applications are also mentioned. It will be seen that by reducing the proportion of brazing solder and using coarse carbide splinters, it is even possible to produce rough surface layers for abrasive tools. (Author abstract) 6 refs. In English and German.

Muerrle, Ulrich; Szulczyk, Andreas; Schachinger, Helmut. *Schweissen Schneiden* v 38 n 3 Mar 1986 p E44-E45, 124-127.

#### Cavitation Corrosion

**086540 EFFECTS OF PLATING ON CAVITATION EROSION.** To study the cavitation erosion behavior of interfaces and base metals used for plating, magnetostrictive erosion tests were carried out in a 3% NaCl solution using a structural carbon steel specimen plated thinly with zinc, tin, chromium or nickel. When erosive attack extends to the interface between the plating and the base metal, forms a rough surface because of the large difference in hardness and electrochemical corrosion between the plating and the base metal, even though it shows high erosion resistance in itself. Thus the protective effects of a thin and hard plating are lost immediately. However, a zinc plating or a thin plating which is underplated with copper becomes effective because of the electrochemical reactions of the plating layer that remains on the surface outside the eroded region. (Author abstract) 7 refs.

Okada, T. (Fukui Univ, Fukui, Jpn); Iwai, Y.; Awazu, K. *Wear* v 124 n 1 May 16 1988 p 21-31.

#### Ceramic

**086541 MICROSTRUCTURE OF PLASMA-SPRAYED WC-Co COATINGS.** The microstructure of low-pressure-plasma-sprayed and air-plasma-sprayed WC-Co coatings was studied by means of physical experiments, including X-ray diffraction, SEM, TEM, metallograph, etc. The densification mechanism was also discussed. (Edited author abstract) In Chinese. 11 refs.

Zhou, Xuke (Acad Sinica, China); Wen, Lishi; Guan, Kan. *Fenmo Yejin Jishu* v 6 n 1 Feb 1988 p 25-31.

**Ceramics** See Also BRACHES—Protective Coatings; COMPOSITE MATERIALS—Protective Coatings; CUTTING TOOLS—Protective Coatings; DIESEL ENGINES—Components; FASTENERS—Corrosion Resistance; METALS AND ALLOYS—Protective Coatings; NICKEL AND ALLOYS—Protective Coatings; REFRACTORY MATERIALS—Protective Coatings; STEEL—Protective Coatings.

**086542 DAS TD-VERFAHREN: EIN NEUES VERFAHREN ZUR CARBIDBESCHICHTUNG, SEINE DURCHFUEHRUNG UND PRAKTIISCHE ANWENDUNG.** [TD-Process: A New Carbide Coating Method, its Implementation and Practical Application]. In recent years three new processes for depositing thin carbide or nitride films have been developed, namely, the PVD (Physical Vapor Deposition) process, the CVD (Chemical



Vapor Deposition) process, and the TD-process. The latter, developed in 1971 by the Toyota Central Research and Development Laboratories, Inc., is a special carbide coating process characterized by simple operation, which is similar to the conventional treatment of steel in salt solutions. The facilities necessary for this process are also very simple and correspond to those used in salt solution processes. (Translated author abstract) In German. 11 refs.

Arai, Tohru. *TZ Metallbearb* v 80 n 3 Mar 1986 p 27-32.

**086543 CHARACTERIZATION OF PLASMA-SPRAYED ALUMINA-ZIRCONIA COATINGS.** Microstructures of two  $\text{Al}_2\text{O}_3$ -12 mol% $\text{ZrO}_2$  composite powders prepared by blending and fusing, respectively, were investigated by means of X-ray diffraction and laser-Raman spectroscopy before and after plasma spraying. The results obtained were as follows: The structural behavior of the B-coating was almost the same as that of a single alumina or zirconia coating prepared by plasma spraying. The T- $\text{ZrO}_2$  phase was predominant in the B-coating and was a metastable phase as the result of plasma spraying. The laser-Raman microprobe measurement indicated that the transformation behavior in the B-coating caused by a Vickers indentation was observed in the central area and around cracks of an indent due to stress concentration. In the F-coating the  $\alpha$ - $\text{Al}_2\text{O}_3$  phase was mostly retained after plasma spraying, while a large amount of the m- $\text{ZrO}_2$  phase was formed. These results indicate that the microstructure of the alumina-zirconia coatings are dependent on the state of the starting ceramic powders. (Edited author abstract) In Japanese. 19 refs.

Iwamoto, Nobuya (Osaka Univ, Ibaraki, Jpn); Umesaki, Norimasa; Endo, Shigeki. *Nippon Kinzoku Gakkaishi* v 51 n 10 Oct 1987 p 971-978.

**086544 UNLUBRICATED SLIDING WEAR OF CERAMIC MATERIALS.** The potential use of thermal insulating ceramic coatings on the cylinder walls of diesel engines at elevated temperatures requires that an understanding of the operative friction and wear mechanisms be gained. An investigation was carried out to determine the unlubricated sliding wear behavior of a thermal insulating oxide coating in combination with a number of carbide, boride, and mixed oxide coatings at room and elevated temperatures to 730°C. The coatings were applied up to several hundred micrometers thick by plasma spray and chemical vapor deposition (CVD) processes. It was found that the binder metal in sprayed metal-carbide composites had a dominant influence on the wear, more so than the composition of the carbide. Different wear surface morphologies and attendant wear rates occurred at each of the test temperatures. The shape of the deposited grains in the CVD coatings had a major effect on the wear rates; rounded grains being better than angular grains of the same material. (Edited author abstract) 1 ref.

Levy, Alan V. (Lawrence Berkeley Lab, Berkeley, CA, USA); Jee, Nancy. *Wear* v 121 n 3 Feb 1 1988 p 363-380.

**086545 EIGENSCHANNUNGEN, HAFTFESTIGKEIT UND VERSCHLEISSEIGENSCHAFEN VON GESPUTTERTEN, AMORPHEN ALUMINIUMOXIDSCHICHTEN.** [Internal Stresses, Adhesion and Wear Behavior of Sputtered Amorphous Alumina Coatings]. Thin alumina coatings have been produced by means of reactive RF magnetron sputtering. The layers, deposited on metallic substrates, show an amorphous crystallographic structure, which may be due to the low deposition temperatures below about 250°C. Measurement of internal stress was performed by using the bending-beam method. The experiments show that there is not only a dependence on the film thickness but even pressure and sputtering power have a strong influence on the internal stresses of the alumina coatings. Some correlations between internal stress and adhesion of the coatings are evident. Besides scratch-test measurements, the layer removal behavior of the bending-specimen gave information about the adhesion of the coatings. The results of the two methods are in good agreement. Some of the alumina coatings were tested with regard to their tribological behavior by means of a model testing apparatus. The coatings show excellent

wear behavior even under severe tribological conditions. (Edited author abstract) In German. 9 refs.

Roth, Th.; Broszeit, E.; Kloos, K.H. *Z Werkstofftech* v 18 n 11 Nov 1987 p 375-380.

**086546 ELECTROCHEMICAL METHOD TO EVALUATE THE CONNECTED POROSITY IN CERAMIC COATINGS.** The electrochemical behavior of plasma-sprayed SS41 steels with the  $\text{Al}_2\text{O}_3$ - $\text{TiO}_2$  system,  $\text{Cr}_2\text{O}_3$  and  $\text{ZrO}_2$  stabilized by  $\text{Y}_2\text{O}_3$  ceramics was studied using a potentiostat by measuring their natural potential and anodic polarization curves in 3.5% NaCl aqueous solution. The natural potential of ceramic-sprayed SS41 steels is the same as that of the substrate. The anodic polarization behavior of ceramic-sprayed SS41 steels is also dominated by the substrate through connected porosity. The strong relation between the connected porosity and the porosity of cross-sections of the ceramic coatings, shown using micrographs, was recognized. By measuring electrochemically the connected porosity in coatings obtained under various spraying conditions, it would be possible to select the optimum spraying conditions to spray coatings which have less porosity. (Edited author abstract) 4 refs.

Arata, Yoshiaki (Osaka Univ, Osaka, Jpn); Ohmori, Akira; Li, Chang-Jiu. *Thin Solid Films* v 156 n 2 Jan 30 1988 p 315-325.

**086547 THERMODYNAMIC AND EXPERIMENTAL STUDY OF CVD OF NON-STOICHIOMETRIC TITANIUM NITRIDE FROM  $\text{TiCl}_4$ - $\text{N}_2$ - $\text{H}_2$  MIXTURES.** Using the polynomial description of the Gibbs free energy of formation of titanium nitride against its composition, thermodynamic deposition diagrams were determined at 1900 K. Deposition rates and composition of the film were studied. The cold wall reactor is associated with a dew point evaporator. At 1900 K, on a molybdenum substrate, experiments carried out as a function of input nitrogen, temperature and pressure, confirmed the theoretical trends. The different deposition mechanisms in relation to total pressure are thermodynamically related with a progressive reduction of the halide to solid titanium under one atmosphere instead of a major formation of gaseous titanium under  $6.6 \times 10^{-3}$  atm. The lowest N/Ti value obtained in the deposits is 0.63. (Edited author abstract) 21 refs.

Teyssandier, F. (CNRS, Perpignan, Fr); Bernard, C.; Ducarroir, M. *J Mater Sci* v 23 n 1 Jan 1988 p 135-140.

**086548 CHARACTERISTICS OF METAL ELECTROPLATING TO PLASMA SPRAYED CERAMIC COATINGS.** The characteristics of electroplating a metal onto  $\text{Al}_2\text{O}_3$  and  $\text{ZrO}_2$  coatings themselves sprayed by plasma onto mild steel, were investigated. It was recognized that copper plating along the porosities connected to the substrate started from the interface between the ceramic coating and the substrate. The microphotographs show that the nonbonded area between flattened ceramic particles in the coating can be filled up with copper. The plating of copper into coatings depends greatly on the shape and the size of the porosities in the coating, which are determined by the ceramic type and spraying conditions. Moreover, they are affected greatly by electroplating conditions such as current density. It is possible to obtain composite coatings of metals and ceramics by the composite processing of both thermal spraying and electroplating, which can improve the coating properties and suppress completely corrosion of the substrate. (Edited author abstract) 7 refs.

Arata, Yoshiaki (Osaka Univ, Jpn); Ohmori, Akira; Li, Chang-Jiu. *Trans JWRI* v 16 n 2 Dec 1987 p 31-37.

**086549 SVILUPPI ED APPLICAZIONI DEI DEPOSITI CERAMICI PRODOTTI COL METODO CVD.** [Developments and Applications of CVD Ceramic Coatings]. The Chemical Vapour Deposition (CVD) technique is increasingly used to produce layers of ceramic compounds to modify the surface properties of metal, ceramic or polymeric components for specialised conditions or in severe conditions of use. Carbides, nitrides,

oxides, silicides, borides, etc., have been deposited in the most varied supports to solve problems of high temperatures, erosion, corrosion, diffusion and conductivity or electrical resistance. CVD is quite versatile and allows a great variety of deposits. It is characterised by great penetrating power and can cover uniformly pieces with complicated shapes, with cavities and porosities. It allows deposits which are firmly anchored and with controlled purity. (Edited author abstract). 39 Refs. In Italian.

Brossa, F. (Commissione delle Comunità Europee, Ispra, Italy). *Ceramurgia* v 18 n 1 Jan-Feb 1988 p 28-33.

**086550 SINTERING STUDIES OF PLASMA-SPRAYED ZIRCONIA.** Several studies have shown the benefits of plasma-sprayed ceramic coatings of zirconia in producing enhanced performance or extended life capabilities in gas turbine engines. This study examines the rate and magnitude of sintering in plasma-sprayed zirconia vs. time (1-24 h), temperature exposure (1038-1510°C) and silica impurity level (0.2%-4.0%). Mechanical property changes (up to 3.5 times the original strength and four times the original modulus) are shown to be associated with sintering. Significant effects of sintering on the mechanical properties of the sprayed material are seen at temperatures as low as 1100°C. The discussion includes effects of impurity level, microstructural morphology and stabilizer concentration. 13 refs.

Eaton, H.E. (United Technologies Research Cent, East Hartford, CT, USA); Novak, R.C. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 227-236.

**086551 HIGH TEMPERATURE EROSION BEHAVIOR OF TUNGSTEN- AND CHROMIUM-CARBIDE-BASED COATINGS.** This study was undertaken to obtain a better understanding of the erosion mechanisms occurring in currently used materials to serve as a baseline for development of coatings with improved erosion resistance. Coatings made using a mechanical mixture of chromium carbide and nichrome were compared with tungsten-carbide-base materials made with pre-alloyed nickel and cobalt metal matrices. Erosion data were obtained at temperatures up to 1400°F at angles of impact of 30° and 90° with an alumina erodent carried in a heated gas stream. Erosion scars were studied using a scanning electron microscope and evaluated in the light of optical metallography of the coating's structure. An attempt was made to interpret the data in the light of existing erosion theory. (Edited author abstract) 5 refs.

Sue, J.A. (Union Carbide Corp, Indianapolis, IN, USA); Tucker, R.C. Jr. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 237-248.

**086552 FRICTION AND WEAR BEHAVIOR OF CHROMIUM CARBIDE COATINGS.** Chromium carbides, tungsten carbide and chromium oxide have been tested and evaluated as coatings to protect high temperature gas-cooled reactor (HTGR) steam generator and other HTGR components from adhesion, galling associated with sliding wear or from fretting. Several types of chromium carbide coatings including  $\text{Cr}_3\text{C}_2$ ,  $\text{Cr}_7\text{C}_3$  and  $\text{Cr}_{23}\text{C}_6$  were tested for wear resistance and resistance to long-term spalling. Tungsten carbide and chromium oxide coatings were tested in sliding wear tests.  $\text{Cr}_{23}\text{C}_6$ -NiCr coatings showed the best performance (from 400 to 816°C) whether they were applied by detonation gun or plasma gun spraying methods. (Edited author abstract) 13 refs.

Lindgren, J.R. (GA Technologies Inc, San Diego, CA, USA); Johnson, W.R. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 249-260.

**086553 CHARACTERIZATION AND THERMAL SHOCK TESTING OF YTTRIA-STABILIZED ZIRCONIA COATINGS.** Industrially manufactured partially stabilized zirconia thermal barrier coatings were



characterized and tested. Optical microscopy tests were employed for qualitative and quantitative characterization of the coating structures as sprayed and after testing. Particular emphasis was given to the porosity of the ceramic coatings with regard to the size, shape and distribution of the pores by use of an interactive image processing system. In addition, the nature and quantity of phases in the ceramic coatings were determined using X-ray diffraction analysis. Thermal shock resistance was detected by burner rig tests. (Author abstract) 5 refs.

Steffens, H.-D. (Univ of Dortmund, West Ger); Fischer, U. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 327-338.

**086554 DEGRADATION MECHANISMS OF THERMAL BARRIER COATINGS IN BENDING TESTS.** The strain tolerance of thermal barrier coating (TBC) systems is limited by the properties of the ceramic coating. In this paper a bending test combined with acoustic emission measurements is described. The results show the ability of the method to investigate the degradation mechanisms of the ceramic TBC that result from mechanical loading. In addition, the possibility of conditioning the coating system by heat treatment is discussed. (Edited author abstract) 7 refs.

Cohrt, H. (Univ of Karlsruhe, Karlsruhe, West Ger); Thummmler, F. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 339-348.

**086555 HOT CORROSION STUDIES OF ZIRCONIA CERAMICS.** The corrosion of stabilized zirconia ceramics by vanadic salts at 700-900°C was investigated to elucidate the mechanisms of attack, and to determine the effects of the chemical reactivity of the stabilizing oxide ( $\text{CeO}_2$ ,  $\text{Y}_2\text{O}_3$ ) and of the physical structure of the zirconia (sintered, rapidly solidified (RS), single crystal (SC)). The SC and RS zirconias were less degraded in molten  $\text{NaVO}_3$  than was sintered zirconia. The results are discussed in terms of understanding ceramic molten salt corrosion, and the development of corrosion-resistant stabilized zirconias. Stabilized zirconia ceramics are being developed for use as blade coatings in gas turbines. 10 refs.

Jones, R.L. (US Naval Research Lab, Washington, DC, USA); Williams, C.E. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 349-358.

**086556 PHILOSOPHY FOR THERMAL BARRIER COATING DESIGN AND ITS CORROBORATION BY 10,000 h SERVICE EXPERIENCE ON RB211 NOZZLE GUIDE VANES.** In considering the use of thermal barrier coatings (TBCs) in aero gas turbine engines, several potential design philosophies can be considered. Rolls-Royce has used ceramic thermal barrier coatings (TBCs) in jet engine combustors for well over a decade and on turbine nozzle guide vane platforms (RB211-535E4) and aerofoils (RB162) for several years. Much work has been done to characterize and improve TBC systems for use in more aggressive engine applications. The philosophy and some of the studies performed are reviewed in this paper to understand better the failure mechanisms which govern coating life in service. Findings are correlated with relatively simple laboratory rig test evaluations and with a rainbow service trial involving over ten thermal barrier systems. Some of these systems have been inspected after close to 10,000 flying hours (5000 cycles) and found to be in near-perfect condition. 20 refs.

Bennett, A. (Rolls-Royce plc, Derby, Engl); Toriz, F.C.; Thakker, A.B. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 359-375.

**086557 THERMIONICALLY ASSISTED PLASMA ASSISTED PHYSICAL VAPOUR DEPOSITION OF STABILIZED ZIRCONIA THERMAL BARRIER COATINGS.** Since the mid 1970s, ceramic thermal barrier coatings (TBCs) have been used in the turbine combustors and afterburners of several commercial

aero-engines. In this work, yttria partially stabilized zirconia has been deposited under a range of process conditions, by both electron beam physical vapor deposition (EBPVD) and radio-frequency plasma assisted (PA) PVD. The addition of thermionic assistance to the above techniques was also investigated. The effects of plasma assistance, thermionic assistance, pressure, surface finish and source-to-substrate distance on structure, phase, uniformity and adhesion are reported. PAPVD alone was found to improve adhesion and permit control of coating structure and densification over more conventional EBPVD coatings. The addition of thermionic emission for both PAPVD and EBPVD results in further improvements in adhesion and coating densification. 10 refs.

James, A.S. (Univ of Hull, Hull, Engl); Fancey, K.S.; Matthews, A. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 377-387.

**086558 CERAMIC THERMAL BARRIER COATINGS WITH IMPROVED CORROSION RESISTANCE.** Ceramic thermal barrier coatings (TBCs) are increasingly being applied to aircraft gas turbine combustors and afterburners. A method for limiting the ingress of corrosive species into physical vapor deposited zirconia thermal barrier coatings by inserting dense ceramic sealing layers into the usual columnar (segmented) ceramic microstructure has been examined. The concept was evaluated by sputtering a series of  $\text{ZrO}_2\text{-}20\text{Y}_2\text{O}_3$  deposits onto In792 substrates coated with a  $\text{CoCrAlY}$  bondlayer. In each coating the majority of the ceramic layer was deposited with a porous columnar (segmented) microstructure. This microstructure provided the ceramic with excellent tolerance to thermal cycling. The use of intermediate sealing layers has been shown to block the infiltration of deleterious species, such as  $\text{Na}_2\text{SO}_4$ ; however, methods for significantly slowing the diffusion of oxygen were not identified. 11 refs.

Prater, J.T. (Pacific Northwest Lab, Richland, WA, USA); Courtright, E.L. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 389-397.

**086559 FRACTURE TOUGHNESS OF PLASMA-SPRAYED ZIRCONIA COATINGS.** Plasma-sprayed ceramic coatings are formed by introducing a powder into a plasma jet to produce a stream of molten particles which then impact, spread and rapidly solidify onto a substrate to form a lamellar microstructure. The cohesive and adhesive fracture toughness of zirconia coatings, fully or partially stabilized with  $\text{Y}_2\text{O}_3$  or  $\text{CeO}_2$ , plasma sprayed onto steel, have been determined using the double cantilever beam (DCB) technique. The results show that cohesive fracture toughness is greater than adhesive toughness and that tetragonal coatings have significantly higher toughness than fully stabilized (cubic) zirconia coatings. The highest toughness was achieved with  $\text{ZrO}_2\text{-CeO}_2$  coatings which contained a significant proportion of transformable tetragonal phase. The results are interpreted in terms of the influence of grain size and composition on the tetragonal-to-monoclinic phase transformation. (Author abstract) 9 refs.

Heintze, G.N. (Monash Univ, Clayton, Aust); McPherson, R. *Surf Coat Technol* v 34 n 1 Jan 1988, Pap Presented at NTSC87, The Natl Therm Spray Conf and Expo, Orlando, FL, USA, Sep 14-17 1987 p 15-23.

**086560 RESIDUAL STRESSES IN  $\text{ZrO}_2\text{-}8\% \text{Y}_2\text{O}_3$  PLASMA-SPRAYED THERMAL BARRIER COATINGS.** The successful application of zirconia as thermal barrier coatings in the combustion chamber of diesel engines is dependent on their achieving adequate thermal shock resistance and resistance to attack by combustion gases. Of particular importance is the control of residual stresses in the ceramic coatings if useful lifetimes are to be achieved. An experimental technique for the determination of residual stresses is described, and the effect of varying spraying parameters such as deposition rate and air cooling, and the presence of a bondcoat, are discussed. (Author abstract) 11 refs.

Hobbs, M.K. (Univ of Bath, Bath, Engl); Reiter, H. *Surf Coat Technol* v 34 n 1 Jan 1988, Pap Presented at NTSC87, The Natl Therm Spray Conf and Expo, Orlando, FL, USA, Sep 14-17 1987 p 33-42.

**086561 NiCrAl BENTONITE THERMAL SPRAY POWDER FOR HIGH TEMPERATURE ABRADABLE SEALS.** The function and basic requirements of turbine engine clearance control abrasible seals are reviewed. For the specific case of an abrasible seal operating in the temperature range 650 - 850°C the use of a thermal-sprayed deposit of an alloy composite powder consisting of a bentonite core particle coated with an alloy layer of NiCrAl is described. A series of tests was carried out to arrive at an optimum combination of abrasibility, erosion resistance and oxidation resistance in the thermal-sprayed deposit. The selected composite powder consists of a closely sized bentonite core in the range 75 - 150  $\mu\text{m}$ , coated with an alloy consisting of Ni-5% Cr-3% Al, such that the alloy coating-to-core ratio is 80:20 by weight. When flame sprayed by standard practice this powder was found to produce an abrasible seal with the optimum combination of desired properties. (Author abstract) 9 refs.

Clegg, M.A. (Sherritt Gordon Mines Ltd, Fort Saskatchewan, Alberta, Can); Mehta, M.H. *Surf Coat Technol* v 34 n 1 Jan 1988, Pap Presented at NTSC87, The Natl Therm Spray Conf and Expo, Orlando, FL, USA, Sep 14-17 1987 p 69-77.

**Chemical Vapor Deposition See PLATES—Protective Coatings; TOOL STEEL—Protective Coatings.**

**Chromate See ALUMINUM AND ALLOYS—Protective Coatings; METALS AND ALLOYS—Plating; SURFACES—Cleaning; ZINC AND ALLOYS—Corrosion; ZINC AND ALLOYS—Protective Coatings.**

## Combustion

**086562 PROTECTION OF ALUMINUM OVERCAST CONSTRUCTIONS AGAINST FIRE.** A test program was undertaken by the U.S. Mine Safety and Health Administration to evaluate various materials for protecting aluminum overcast constructions against fire. Selected coatings and one covering were tested under large-scale, simulated mine fire conditions to determine their effectiveness as a fire barrier for protection of aluminum. Coatings consisting of expanded vermiculite, limestone, and portland cement; mineral wool fibers in hydraulic setting, inorganic binders; cellulose mixed with liquid sodium silicate; and a fiberglass-reinforced surface-bonding mortar were particularly effective in protecting the aluminum structures against the heat of the simulated mine fire. Three inches of a ceramic-fiber blanket and a four-inch coating of phenolic spray foam also proved to be relatively effective barriers for fire protection under the conditions of the test. (Author abstract) 3 refs.

Luzik, Steven J. (US Mine Safety & Health Administration, Pittsburgh, PA, USA). *Fire Technol* v 24 n 3 Aug 1988 p 227-244.

**Computer Aided Analysis See COATINGS—Defects.**

**Corrosion See Also ALUMINUM AND ALLOYS—Anodic Oxidation; CADMIUM PLATING—Solutions; ELECTROLESS PLATING—Nickel; GALVANIZED METAL—Painting; GAS TURBINES—Protective Coatings; METAL CLEANING; METALS AND ALLOYS—Protective Coatings; NICKEL CHROMIUM COBALT ALLOYS—Protective Coatings; NICKEL CHROMIUM MOLYBDENUM COBALT ALLOYS—Protective Coatings; NICKEL COBALT CHROMIUM ALUMINUM ALLOYS—Oxidation; STEEL—Protective Coatings; WIRE—Protective Coatings; ZINC AND ALLOYS—Corrosion; ZINC PLATING—Solutions.**

**086563 CORROSION PROCESS OF Zn-Co, Zn-Fe AND Zn-Ni ALLOY ELECTROPLATINGS.** The corrosion behavior of Zn-Co, Zn-Fe and Zn-Ni alloys containing about 10% alloying elements in pH 6 solutions was



investigated. At the beginning of immersion, corrosion rate of the alloy plating was larger than that of pure Zn plating because the alloying elements (Co, Fe and Ni) promoted a cathodic reaction. As corrosion proceeded, corrosion potential shifted to noble potential in a complex manner. The development of corrosion induces a corrosion groove reaching the underlying steel and an increase of relative content of the alloying elements in the corrosion products and/or on the alloy plating layers. The galvanic protection of the plating decreases, leading to corrosion of the underlying steel. When the solution contains NaCl, a compound  $ZnCl_2 \cdot 4Zn(OH)_2$  is formed as a corrosion product. (Edited author abstract) In Japanese. 14 refs.

Hagi, Hideki (Kyushu Univ, Fukuoka, Jpn); Inokuchi, Kohsuke; Hayashi, Yasunori; Higashi, Kei. *Tetsu To Hagane* v 73 n 14 Oct 1987 p 1730-1737.

**086564 SODIUM VANADATE INDUCED CORROSION OF MCrAlY COATINGS - BURNER RIG STUDIES.** The corrosion of several MCrAlY-coatings (M=Ni, Fe and Ni+Co) has been studied in a high velocity burner rig at 650, 800 and 950°C. The fuel used was diesel oil with additions of 3% sulfur, 200 ppm vanadium and 100 ppm sodium. The deposits formed on the specimens mainly consisted of sodium vanadates which were molten at the test temperature. Sodium sulfate was only found at and below 650°C. The corrosion mechanism involved was vanadate-induced hot corrosion. This corrosion mechanism is characterized by the formation of an oxide layer adjacent to the metal, the dissolution of oxide in the outer surface of the deposit. The continuous deposition of fresh vanadate on the surface served to maintain high corrosion rates of extended exposures. (Author abstract) 24 refs.

Seiersten, M. (Cent for Industrial Research, Oslo, Norw); Rætzner-Scheibe, H.-J.; Kofstad, P. *Werkst Korros* v 38 n 9 Sep 1987 p 532-540.

**086565 DETERMINATION OF CORROSION PRODUCTS OF THE COATING OF THE TIN-BISMUTH ALLOY BY THE MOESSBAUER SPECTROSCOPY METHOD.** It is known that the Moessbauer parameters (isomeric displacement, quadrupolar splitting) of the tin-bismuth alloy and tin oxide greatly differ. Consequently, the process of oxidation of the tin-bismuth alloy coating may be examined using Moessbauer spectroscopy. This work shows that this method can be used to determine the composition and growth of corrosion products. The investigations were carried out on specimens of brass electroplated with a tin-bismuth alloy. The bismuth content was 2%. 5 refs.

Petkov, V. (Kliment Ochridskii Univ, Sofia, Bulg); Nanova, L.; Rusanov, V. *Prot Met* v 23 n 3 May-Jun 1987 p 386-388.

**086566 FIVE-YEAR OUTDOOR EXPOSURE CORROSION COMPARISON.** In this study, the outdoor corrosion resistance of both electroplated and mechanically plated zinc and cadmium coatings was observed at four outdoor exposure sites over a period of five years to determine relative corrosion resistance in terms of different deposit thicknesses. In addition, mixed mechanically deposited coatings of tin/cadmium, tin/zinc and cadmium/zinc were studied to compare their relative corrosion resistance. In all, seven different coatings of various thicknesses in the asplated, clear chromated and yellow chromated conditions were evaluated. The pure zinc coatings outperformed cadmium coatings of equal thicknesses in all environments, except the marine environment. The pure cadmium coatings outperformed the zinc coatings in the marine environment.

Holford, Raymond N. Jr (MacDermid Inc, Waterbury, CT, USA). *Met Finish* v 86 n 7 Jul 1988 p 17-18.

**086567 ATMOSPHERIC TESTING OF METALLIC COATINGS.** Metallic coatings have been used for centuries either for decoration or corrosion protection. Zinc coatings on steel have been used for their atmospheric corrosion resistance since the mid-18th century, and users and producers have accurately defined the

corrosion characteristics of the material in a wide variety of environments. Environmental and alloying effects are discussed. The performance of newer metallic coatings are covered in relation to their relative comparative behavior with respect to galvanized steel. Long term testing has been carried out over the last 45 years during which a significant change in atmospheric conditions has occurred worldwide due to pollution effects. The effect of this change on the corrosion of metallic coatings will be illustrated by empirical data obtained by annual exposures of standard materials. (Author abstract)

Lawson, Herbert H. (Armco Inc, Middletown, OH, USA). *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 1, p 147-165.

## Corrosion Protection

**086568 CHARACTERIZATION OF CORROSION INHIBITORS FOR ZINC COATINGS.** Chromate conversion coatings are widely used in the automobile and other industries to enhance environmental corrosion resistance of the zinc layers on zinc plated steel. A technique utilizing photo-excitation of charge carriers as a measure of the effectiveness of chromate conversion coatings as corrosion inhibitors has been developed. The technique involves irradiating the zinc oxide surface with pulsed UV radiation and observing the photo-response as a function of applied voltage using lock-in signal detection and amplification. Initial analysis of the data shows a linear relationship between the photo-response of the ZnO layer and applied bias voltage across the sample up to 3.2 V. (Edited author abstract) 5 refs.

Christafferson, J.A. (Univ of Akron, Akron, OH, USA); Mallik, R.R.; Henriksen, P.N.; Chu, H.T.; Savinell, R.F. *Surf Interface Anal* v 11 n 6 Apr 1988, Proc of the 9th Symp on Appl Surf Anal, Dayton, OH, USA, Jun 3-5 1987 p 399.

**Corrosion Resistance** See STAINLESS STEEL—Applications; STEEL HEAT TREATMENT—Nitriding.

**Costs** See NATURAL GAS PIPELINES—Cathodic Protection; PIPELINES—Cathodic Protection.

**Crack Propagation** See Also ROOFS—Coverings.

**086569 STUDY OF CRACK INITIATION AND PROPAGATION IN Ni-Cr THERMALLY SPRAYED COATINGS USING ACOUSTIC EMISSION TECHNIQUES.** Many metallurgical coatings applied by thermal spraying tend to exfoliate or spall through the growth of cracks, presumably initiated at the metal-coating interface or at the substrate. The present study was undertaken to determine whether such cracks are at the substrate-coating interface or within the coating or the substrate themselves. An AISI 1045 steel overlaid with a nickel-chrome alloy was used and the samples were subjected to a positive stress and fatigued using sinusoidal oscillations. In order to obtain a continuous record of crack initiation and propagation, acoustic emission equipment was used. It was found that the cracks initiated in the coating near the interface and not at the substrate or interface as suggested elsewhere. The conditions promoting crack initiation were also determined. (Edited author abstract) 9 refs.

Mora-Marquez, J.G. (Simon Bolivar Univ, Caracas, Venez); Lira-Olivares, J. *Thin Solid Films* v 153 Oct 26 1987, Pap Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 243-252.

**Defects** See COATINGS—Spraying; MARAGING STEEL—Coatings.

**Degradation** See COATINGS—Organic; METALS AND ALLOYS—Protective Coatings.

**Diffusion** See PIPE—Heat Treatment.

## Discoloration

**086570 DETERMINATION OF THE SPECIFIC RATE CONSTANT FOR THE LOSS OF A YELLOW INTERMEDIATE DURING THE FADING OF ALIZARIN LAKE.** In the course of photochemically-induced fading, alizarin lake mixed with a photochemically-inert titanium white in a poly(vinylacetate) vehicle apparently passes through a yellow intermediate stage. A simple graphical method is described which permitted calculation of the specific rate constant for the first-order rate of fading of the yellow intermediate. (Author abstract) 4 refs.

Feller, Robert L. (Carnegie Mellon Univ, Pittsburgh, PA, USA); Johnston-Feller, Ruth M.; Bailie, Catherine. *J Coat Technol* v 59 n 751 Aug 1987 p 93-96.

**Drying** See Also COATINGS—Drying.

**086571 MODELLING OF DRYING OF COATINGS: EFFECT OF THE THICKNESS, TEMPERATURE AND CONCENTRATION OF SOLVENT.** Various factors are relevant in the drying of coatings in motionless air, e.g. the temperature at which the process is performed, the thickness of the coating and the concentration of solvent in the coating when the latter is deposited. A model, based on a numerical method with finite differences, has been constructed in order to describe the drying process under various conditions. The kinetics of drying have been shown as being controlled by the diffusion of the solvent through the paint and by the evaporation of the solvent from the coating surface. The diffusivity was concentration-dependent, the rate of evaporation and diffusivity varying with the temperature and following a relationship similar to the Clausius-Clapeyron law. (Author abstract) 7 refs.

Blandin, H.P. (Dr. P. Michelon Univ of St. Etienne, St. Etienne, Fr); David, J.C.; Vergnaud, J.M.; Illien, J.P.; Malzewicz, M. *Prog Org Coatings* v 15 n 2 1987 p 163-172.

**Efficiency** See STEEL CORROSION.

**Electrodeposition** See Also COATINGS—Organic.

**086572 GALVANISCH AUFGEBRACHTE SCHUTZSCHICHTEN AUS PARTIKEL- UND FASER-VERBUNDWERKSTOFFEN: DISPERSIONSSCHICHTEN.** [Electrodeposited Protective Coatings from Particle and Fibre Composite Materials: (Dispersion Coatings)]. By the incorporation of nonmetallic solid particles in the electrolytically produced metallic matrix, composite materials are obtained whose properties are better than those of the particle-free coating metal. The incorporation of fibre material is also possible electrolytically, so that the inconveniences of producing such metal composites by the casting and powder coating procedures conventionally employed are avoided. (Edited author abstract) 17 refs. In German.

Ehrhardt, J.; Gruenthaler, K.H. *Galvanotechnik* v 78 n 10 Oct 1987 p 2806-2810.

**086573 TEMPERATURE FIELD OF AN INHOMOGENEOUS SUBSTRATE OF FINITE THICKNESS IN PROCESSES OF ELECTRIC ARC DEPOSITION OF PROTECTIVE COATINGS.** The results are given of mathematical modeling of the temperature state of a substrate-sublayer system during deposition of protective coatings by the electric arc method under the condition that the components of the given system are comparable in thickness. The thermal effect of the coating particles on the free surface of the sublayer is assumed equivalent to heating of this surface by a heat flux of a given density. (Author abstract) 3 refs.

Mrochek, Zh.A.; Antonenko, A.B.; Vershina, A.K. *Sov Surf Eng Appl Electrochem* n 6 1987 p 19-22.



**086574 CHARACTERISTICS OF Ni-Al<sub>2</sub>O<sub>3</sub> ELECTRODEPOSITED COMPOSITES.** Electro-deposited composites are gaining importance for their advantages including low cost, ease and simplicity of operation to produce tailor made coatings for tribological applications. Generally composites containing oxide inclusions are preferred for high temperature oxidation resistance along with increased hardness and wear resistance compared to pure nickel. In this paper the authors discuss some of the properties of nickel-alumina composites especially after heat treatment. Their wear resistance, oxidation resistance and corrosion resistance are presented. (Author abstract) 10 refs.

Pushpavanam, Malathy (Central Electrochemical Research Inst, Karaikudi, India); Balakrishnan, K.; Sharma, L.R. *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 2, p 1343-1354.

**Electrophoretic** See Also COMPOSITE MATERIALS—Electrodeposition.

**086575 EFFECT OF THE HEAT-TREATMENT PARAMETERS AND OF THE COMPOSITION OF ELECTROPHORETIC COATINGS ON THE MICROSTRUCTURE AND THE NATURE OF FAILURE OF CARBIDE-CHROMIUM MATERIALS. I. SUBSTRATE OF CARBIDE-CHROMIUM ALLOY WITH NICKEL BOND.** The object of the present work is study of the special features of the structure formation of the transition layer which originates between the substrate made of variously heat-treated carbide-chromium alloys and the coatings with various compositions applied by electrophoretic deposition, and also the nature of failure of these materials. By varying the parameters of the preliminary and of the subsequent heat treatments, and also the compositions of the electrophoretic coatings, the authors substantially change the composition and structure of the surface layer of carbide-chromium alloy KKhN, i.e., and can control the properties and the obtained materials, and consequently, their operational potentialities. 10 refs.

Paderno, V.N. (Acad of Sciences of the Ukrainian SSR, USSR); Martynenko, A.N.; Tashlyk, B.N.; Furman, V.V. *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 322-327.

**Electroplating** See ELECTRIC CONTACTS—Protective Coatings.

**Electrostatic** See Also ELECTRIC MOTORS—Insulation.

**086576 POVRCHOVE UPRAVY POVLAHY Z PRASKU.** [Surface Treatments by Powder Coatings]. Anticorrosion surface treatments involving electrostatic coating with thermosets are described. The principal advantages and disadvantages of this method including fields of application are reviewed. The characteristics of the powder coating process and grades and properties of the coating powders are presented. Also, powder selection criteria and curing conditions are reviewed. In conclusion manufacturing processes, types of production equipment, and pre-treatment methods are described. (Edited author abstract) In Czech. 14 refs.

Bares, Richard A. *Plasty Kauc* v 24 n 4 Apr 1987 p 97-104.

**Equipment** See METALS AND ALLOYS—Painting.

**Erosion** See Also SUPERALLOYS—Protective Coatings.

**086577 EFFECT OF CRYSTALLOGRAPHIC ORIENTATION ON EROSION CHARACTERISTICS OF ARC EVAPORATION TITANIUM NITRIDE COATING.** Recent development of TiN coatings specifically for erosion protection has focused on better process control as well as crystallographic orientation. The erosion behavior of TiN coatings, which were produced by the arc evaporation process, was evaluated using 27  $\mu$ m angular alumina particles at a velocity of 91 m s<sup>-1</sup>. The eroded

surfaces were examined in a scanning electron microscope, and erosion mechanisms in response to the oblique and normal impacts were characterized. The erosion characteristics of various TiN coatings are presented. The variation of surface morphology, microstructure, hardness and erosion characteristics of the coating with crystallographic orientation is also discussed. (Author abstract) 58 refs.

Sue, J.A. (Union Carbide Corp, Indianapolis, IN, USA); Troue, H.H. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 169-181.

**086578 EFFECT OF PROCESSING PARAMETERS ON THE MICROSTRUCTURE AND EROSION RESISTANCE OF NiCr<sub>3</sub>C<sub>2</sub> COATINGS.** NiCr<sub>3</sub>C<sub>2</sub> coatings have been applied to Ti-6Al-4V and Inconel 718 substrates using direct current magnetron sputtering. The substrate surface finish, bias voltage, percentage bias and deposition rates were varied systematically. The effect of changing sputtering parameters on the resultant microstructure was characterized using scanning electron microscopy and microhardness measurements. The erosion resistance of the coatings to an Al<sub>2</sub>O<sub>3</sub> abrasive stream was determined at 30° and 90° impingement angles and related to the process parameters. The dominant erosion mechanisms at the two impingement angles were determined using scanning electron microscopy. (Author abstract) 20 refs.

Wert, James J. (Vanderbilt Univ, Nashville, TN, USA); Baker, D.M.; McKechnie, T.M. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 245-265.

**Evaluation** See Also COATINGS—Water Borne; IRON CHROMIUM NICKEL ALLOYS—Electrodeposition.

**086579 EVALUATION OF RUST-TOLERANT COATINGS FOR SEVERE ENVIRONMENTS.** There are more than 100 commercially available coatings that are made specifically to perform on rusty and contaminated steel. Fourteen of these were selected for a laboratory and field evaluation program. Twelve of the coatings were selected based on historical data, purported corrosion prevention mechanisms, and suitability for contaminated rust. In addition, two control coatings, a red lead alkyd and a tar mastic, were included. After two years in the field, all four rust-tolerant coatings and the red lead alkyd control had failed, while the tar mastic control exhibited incipient rusting portending the beginning of failure. The present evidence suggests that on inadequately prepared steel in severe environments, a low-cost, easily applied conventional system for which there should be modest expectations is the best strategy. 21 refs.

Frondestou-Yannas, S. (Management & Technology Associated Inc). *J Prot Coat Linings* v 3 n 8 Aug 1986 p 26-35.

**Failure** See Also AIRCRAFT ENGINES, JET AND TURBINE—Protective Coatings; COATINGS—Degradation; STEEL—Protective Coatings.

**086580 EXAMINATION OF COATING FAILURE ON WING PIVOT FITTINGS OF F111 AIRCRAFT.** Examination of fuel and moisture resistance of a range of possible coatings has been undertaken against those currently in use on the wing pivot fittings in integral wing fuel tanks of F111 aircraft. The results suggest that coatings based on epoxy polyamide resins are sensitive to glycol ether compounds employed as fuel system icing inhibitors in aviation turbine fuels. A more resistant epoxy polyurethane paint coating has therefore been proposed for use on the inspection area of the fittings. It is also recommended that respraying over existing coatings inside the wing fuel tanks and of the fittings away from the inspection areas, a practice that has led to a series of intercoat adhesion failures following overhaul, be discontinued. (Edited author abstract) 17 refs.

Wake, L.V. *Rep Mater Res Lab Aust* 1060 May 1987 31p.

**Fire Resistance** See MILITARY EQUIPMENT—Fire Protection.

**Flame Spraying** See Also COATINGS—Flame Spraying; GLASS—Coatings; NAVAL VESSELS—Maintenance.

**086581 DETERMINATION OF THE EXPENDITURE OF COATING MATERIALS IN SPRAY-COATING SMALL SOLIDS OF REVOLUTION.** On the basis of the author's investigations it may be concluded that for the purpose of the rational distribution of the material resources of sprayed-on coatings it is indispensable to take into account the geometric structure (nomenclature) of the treated components. The obtained formulas for determining the coefficients of utilization of coating materials with a view to the geometry of the products help to a considerable extent in solving the problem of the scientific substantiation of the standards of expenditure of sprayed-on power and wire materials. 4 refs.

Lelyukh, I.M. (Acad of Sciences of the Ukrainian SSR, USSR). *Sov Powder Metall Met Ceram* v 26 n 4 Apr 1987 p 328-331.

**086582 MODIFYING FLAME SPRAYED COATINGS BY LASER RADIATION.** Results are presented of experimental investigations into the modification of a number of flame sprayed coatings on steel and aluminum alloys with the radiation of a pulsed YAG laser and a continuous CO<sub>2</sub> laser. These investigations were carried out on coatings of powders of a self-fluxing alloy of NiCrBSi type, ZrO<sub>2</sub> oxide ceramics, and titanium. Advantages are shown of complex application of the processes of flame spraying of coatings and laser treatment for solving the problems of improving their service characteristics and producing refractory protective coatings on low-melting substrates with the simultaneous increase of the strength of bonding of the coating with the substrate. (Edited author abstract) 4 refs.

Uglov, A.A.; Fomin, A.D.; Naumkin, A.O.; Pekshev, P.Yu.; Smurov, I.Yu.; Ignat'ev, M.B. *Phys Chem Mater Treat* v 21 n 4 Jul-Aug 1987 p 368-371.

**086583 PROBLEMLÖSUNGEN DURCH THERMISCH GESPRITZTE METALLSCHICHTEN.** [Solving Problems with Thermally Sprayed Metal Coatings]. The possibilities afforded by thermal spraying are too diverse to be fully covered in a single feature article. The purpose of this publication, therefore, is to familiarize the active specialist with a number of implemented problem solutions, to inspire him to invest more of his time with this technology, and to encourage him to open up new fields of application through his own ideas and experiments. (Edited author abstract). 14 Refs. In German.

Leuze, Gerhart. *Metalloberflaeche* v 42 n 7 Jul 1988 p 340-344.

## Forming

**086584 INFLUENCE OF THE OPERATING CONDITIONS OF A BARREL ELECTROLYZER ON THE UNIFORMITY OF ELECTROLYTIC ZINC COATINGS.** The purpose of the work was to study the distribution of coating thicknesses on the components during zinc plating in a barrel in ammonia-urotropin (AUE) and zincate electrolyte with addition of NBTs additive. Experimental data indicate that the values of K (coefficient characterizing electrolyte composition) depend strongly on the load factor of the barrel, and are appreciably sensitive to variations of current density at low and high load factors. The optimal load factor with respect to the resistance of the influence of current density is about 40%. At this load the average value of K is 0.63 min<sup>0.5</sup> in AUE, and 0.68 min<sup>0.5</sup> in ZE. A certain decrease of the variance of the thickness of the zinc layers on simultaneously coated components with increase of current density can probably be attributed to increasing depth of penetration of current into the load. 7 refs.

Andreev, I.N. (S.M. Kirov Inst of Chemical Technology, Kazan, USSR); Kaidrikov, R.A.; Semenova, I.A.; Valeev,



N.N. *J Appl Chem USSR* v 59 n 11 pt 2 Nov 1986 p 2357-2360.

**086585 EXAMINATION OF THE PROCESS OF FORMATION OF THE TRANSITION LAYER IN DEPOSITING COATINGS BY CONDENSATION OF THE ION FLUX.** The authors substantiate a physical model describing the process of formation of the transition layer in formation of coatings using ion beams. The mass transfer equation is derived and solved. The calculated results are compared with experimental profiles of distribution of the elements at the interface of carbon films with substrates made of aluminum, titanium and iron (obtained by x-ray photoelectron spectroscopy combined with etching with argon ions). (Author abstract) 8 refs.

Aleshin, V.G.; Gorokhovskii, V.I.; Dunae, V.V.; Zhiglin-skii, A.G.; Kuchinskii, V.V.; Smekhov, A.A.; Uryukov, B.A.; Shekin, E.G. *Phys Chem Mater Treat* v 21 n 6 Nov-Dec 1987 p 596-600.

**Fracture** See CORROSION PROTECTION: STAINLESS STEEL—Protective Coatings.

**Friction** See NICKEL COPPER ALLOYS—Friction.

## Hardening

**086586 SOLID SOLUTION HARDENING IN HIGH RATE REACTIVELY SPUTTERED (HF, Ti)N COATINGS.** Coatings of (HF, Ti)N were deposited by a high rate reactive sputtering process using a dual-cathode configuration. The coatings were analyzed to determine the effect of film composition on microhardness. Solid solution hardening was observed and was dependent on the partial pressure of the reactive gas ( $N_2$ ). At the pressure where hardening was observed, the maximum hardness (3760 HV at 100 gf) occurred at a Ti:(Ti+HF) ratio of approximately 50%. (Author abstract) 11 refs.

Fenske, G.R. (Argonne Natl Lab, Argonne, IL, USA); Kaufherr, N.; Sproul, W.D. *Thin Solid Films* v 153 Oct 26 1987, Pap Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 159-168.

## Health Hazards

**086587 RESPIRATORY PROTECTION IN THE PROTECTIVE COATINGS INDUSTRY.** Recently, the issue of worker respiratory protection in the protective coatings industry has received increased attention from both outside observers and members of the industry. Particular attention has been focused on the appropriateness of using silica sand in blasting, given its known link to the development of silicosis and other delayed lung disorders. Attention has also been given to the harmful effects that arise when abrasive blasters remove lead-based paints from bridges and breathe the respirable-sized lead dust created in the blasting process. This article focuses on ways to provide workers with respiratory protection from some of the hazards of the protective coatings industry. The regulations affecting an employer's responsibility for providing respiratory protection to workers who require it are reviewed as well as the sources of exposure and contamination. 9 refs.

Miller, Richard C. (ED Bullard Co). *J Prot Coat Linings* v 5 n 4 Apr 1988 p 36-41.

**086588 PROVIDING SAFE PRESPIRATORY PROTECTION IN THE PROTECTIVE COATINGS INDUSTRY.** Complying with OSHA standards and providing a safe respiratory protection program in the abrasive blasting and protective coating industries require investigation of the advantages and limitations of available respirator equipment in relation to site conditions. The principal objective is worker protection in the midst of a wide range of respiratory hazards. The article discusses the types of equipment and considerations such as compressed air contamination by carbon monoxide, water, oil and particulates, and breathing air purification. 12 Refs.

Woodruff, Sheri L. (Deltech Engineering). *J Prot Coat*

*Linings* v 5 n 8 Aug 1988 p 54-59.

**Heat Resisting** See Also COBALT CHROMIUM ALUMINUM ALLOYS—Oxidation; GAS TURBINES—Corrosion Protection; GLASS—Coatings; METALLIZING—Plasma Spraying; METALS AND ALLOYS—Protective Coatings; SUPERALLOYS—Protective Coatings.

**086589 COMPARATIVE EVALUATION OF HIGH TEMPERATURE COATINGS FOR CORROSION PROTECTION OF FUEL INJECTOR TIPS.** Fuel injector tips fabricated from Hastelloy X and Haynes 188 alloys were coated with the electron beam-physical vapor deposition (EB-PVD) MCrAlY overlay coating ATD 63 (Temescal), the platinum aluminide diffusion coatings RT-22A (Chromalloy Research and Technology) and PS 138 (Turbine Metals Technology), an EB-PVD NiCoCrAlY-YSZ overlay coating (Chromalloy Research and Technology) and SN-5A, a vitreous phase ceramic coating (Solar Turbines Incorporated). The coatings were subjected to cyclic oxidation testing at 1149°C and cyclic corrosion testing with 95%Na<sub>2</sub>SO<sub>4</sub>-5%NaCl deposits at 982°C. Microstructural examination showed a correlation between oxidation protection and high platinum and aluminum levels for the platinum aluminide diffusion coatings. The NiCoCrAlY-YSZ overlay coating demonstrated poor adherence and spallation in oxidation testing. Debonding of this coating occurred through cracking of the oxidized surface (Al<sub>2</sub>O<sub>3</sub>) of the bond coat. SN-5A exhibited morphological changes in the coating matrix following oxidation-corrosion testing. (Edited author abstract) 11 refs.

Van Roode, Mark (Solar Turbines Inc, San Diego, CA, USA); Hsu, Lulu. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 153-167.

**086590 ON DELETERIOUS EFFECTS OF OXIDE PARTICLES PROXIMATE TO FREE SURFACES.** Diffusion of oxygen through columnar grain boundaries formed during processing of coatings can lead to internal oxidation and the formation of oxide inclusions in close proximity to a free surface. Since oxidation is accompanied by an increase in volume, large misfit strains are generated at the inclusions. These stresses have been determined exactly for a cylindrical inclusion using linear elasticity theory and stresses for a spherical inclusion have been estimated using these exact solutions. These stresses seem to be significant in that they could lead to fracture or prismatic dislocation punching in a coating. In addition, it is shown that these hydrostatic stresses can accelerate kinetics of diffusion of the damaging species and lead to rapid deterioration of the coating. Furthermore, the stresses can induce the formation of pits at the coating surface which can grow into cracks and lead to failure of the coating. (Author abstract) 8 refs.

Louat, N. (US Naval Research Lab, Washington, DC, USA); Sadananda, K. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 169-179.

**086591 THERMAL BARRIER COATING LIFE PREDICTION MODEL.** The objectives of this research were to determine the predominant modes of degradation of a plasma-sprayed thermal barrier coating (TBC) system and then to develop and verify life prediction models accounting for these degradation modes. The TBC system consists of a low pressure plasma-sprayed bond coat layer of Ni-22Cr-10Al-0.3Y and an air plasma-sprayed yttria partially stabilized zirconia (ZrO<sub>2</sub>-8Y<sub>2</sub>O<sub>3</sub>) top coat on a conventionally cast Rene'80 (nickel-base) substrate. Thermal cycle testing of TBCs was employed to evaluate the effect of coating edges, bond coat oxidation, bond coat creep, top coat thickness and bond coat thickness. A time-dependent, non-linear finite element model was developed to predict the stresses-strains present in the TBC system. The model predicts failure in the TBC owing to imposed strains on the basis of the foregoing considerations; hence, changes in substrate and bond coat material, in geometry, in thickness and the effect of oxidation can be accommodated by this model. (Edited author abstract) 1 ref.

Pilsner, B. (GE Aircraft Engine Business Group, Cincinnati, OH, USA); Hillery, R.; McKnight, R.; Cook, T.; Hartle, M. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 305-306.

## Heat Treatment

**086592 CHANGE IN CERTAIN PROPERTIES OF ELECTROLYTIC DEPOSITS OF ZINC AND LEAD DURING ANNEALING.** Natural aging or heat treatment of galvanic coatings leads to ordering of the crystalline structure of the deposits and an improvement in service properties. The authors investigated the changes in structure and properties (internal stresses, corrosion resistance, electrical resistance) of zinc and lead galvanic coatings in natural aging and low-temperature annealing. The electroplating of the zinc was done from a sulfate solution; that of the lead from a nitrate electrolyte. Natural aging of the deposits for a day did not lead to a significant change in lattice parameters. The corrosion resistance and electrical resistance of the deposits and the internal compressive stresses also remain unchanged. After low temperature annealing the corrosion rate of the zinc deposits decreases by 8.5% and that of the lead by 5.3%. There is a drop in electrical resistance (by 10-14%) and lattice parameters with a simultaneous relief in internal stresses. 7 refs.

Kovenski, I.M. (Lenin Komsomol Tyumen Industrial Inst, USSR); Povetkin, V.V. *Prot Met* v 23 n 4 Jul-Aug 1987 p 501-503.

**High Temperature Effects** See STEEL—Protective Coatings.

**Inspection** See Also NUCLEAR REACTORS, BOILING WATER—Protective Coatings.

**086593 UNDERWATER INSPECTION AND REPAIR OF LININGS IN IMMERSION AREAS.** This paper presents a system of underwater cleaning, inspection, and repair of immersed lining systems. Underwater inspection and repair is accomplished in contaminated liquids ranging from chemicals to radiologically contaminated water. The paper also discusses completed projects, project safety, scheduling, client support, documentation, and costs. 1 ref.

Stuart, Charles O. Jr. (S.G. Pinney & Associates Inc, Port St. Lucie, FL, USA); Vallance, Charles. *Mater Perform* v 27 n 6 Jun 1988 p 44-47.

**Ion Implantation** See Also TITANIUM COMPOUNDS—Thin Films.

**086594 EFFECT OF NITROGEN ION IMPLANTATION ON THE PROPERTIES OF COATINGS.** Ion implantation modifies the surface composition and properties of material by bombardment with high energy ions. The low temperature of the technique ensures the avoidance of distortion or surface degradation of components. Wear resistance can be improved by up to four times and the surface hardness of hard chromium and cobalt/tungsten alloys can be increased by up to 40% when an optimum dose of nitrogen is implanted. These effects are explained in terms of the formation of nitrides which improve the load bearing capacity of the surface and its abrasion resistance. (Edited author abstract) 22 refs.

Onate, J.I. (Aston Univ, Engl); Dennis, J.K.; Hamilton, S. *Trans Inst Met Finish* v 65 pt 3 Aug 1987 p 99-104.

**Ionization** See FILMS—Metallic.

**Laser Applications** See Also COATINGS—Sprayed.

**086595 CERAMIC COATING OF TITANIUM BY PULSED YAG LASER.** With the object of improving erosion and wear resistance of titanium (Ti), the feasibility of the formation of hard ceramics such as carbides, borides and nitrides on its surface was investigated by irradiating powder-predeposited Ti sheet with a pulsed YAG laser under argon (Ar) or nitrogen (N<sub>2</sub>) atmosphere. As a



result, a flat surface of laser-melted zone was formed depending on a proper amount of powders under appropriate laser irradiation conditions, and the fusion zone generally exhibited a dendritic microstructure. The analyses of X-ray diffractometer results confirmed that carbides, borides and nitrides were formed in addition to alpha-Ti phase in the vicinity of the surface, and probably constituted the dendrites in the fusion zone. Vickers surface hardnesses of fusion zones measured under 100 g load were increased and varied in the range of about 500 to 1200 kg/mm<sup>2</sup> in Ar atmosphere and about 1000 to 1700 kg/mm<sup>2</sup> in N<sub>2</sub> environment. (Edited author abstract) 10 refs.

Wehr, Muryel; Katayama, Seiji; Matsunawa, Akira. *Trans JWRI* v 16 n 1 Jun 1987 p 43-49.

**Legislation** See Also SHIPS—Hulls.

**086596 COATINGS - THE CHALLENGE OF THE 1990s.** The author summarizes the yearly cost of metallic corrosion in the U.S. and the amount spent for protective coatings and services. The coatings industry has been responsive to enacted and proposed legislation limiting the use of potentially harmful or toxic raw materials or surface preparation and/or application techniques. As a result of this positive industry reaction, the legislators as a whole have been pragmatic in their laws. Some examples are given. New surface preparation techniques are needed to comply with legislation, particularly that connected with disposal of lead-containing removed from bridges.

Tator, Kenneth B. (KTA-TATOR Inc). *Mater Perform* v 26 n 11 Nov 1987 p 9-10.

**Maintenance** See OFFSHORE STRUCTURES—Protective Coatings.

**Materials** See Also ELECTRODES—Fabrication; ENAMELING—Corrosion Resistance; OFFSHORE STRUCTURES—Protective Coatings; REFRIGERATING MACHINERY—Evaporators; TITANIUM CARBIDE—Thin Films.

**086597 ZINC COATING WITH THE AID OF AN EXTERNAL ELECTRODE AT HIGH CURRENT DENSITIES.** In this investigation the authors determined the optimal parameters of zinc deposition on carbon steels with the aid of an external electrode. It is shown that deposition of zinc is accompanied by increase of the acidity of the electrolyte. The current efficiency rises with increase of the electrolyte pH, reaching 99% at pH = 4. It follows from these data that the electrolyte pH should be kept in the range 3-4. The energy consumption is influenced by the thickness of the layer of absorbent material and by the temperature of the electrolyte. 5 refs.

Vdovenko, I.D. (Acad of Sciences of the Ukrainian SSR, USSR); Lisogor, A.I.; Litovchenko, V.D.; Volokh, E.A. *J Appl Chem USSR* v 59 n 11 pt 2 Nov 1986 p 2361-2363.

**086598 COMPARISON OF PHOTOSTABILIZATION IN ACRYLIC/URETHANE AND ACRYLIC/MELAMINE COATINGS CONTAINING HINDERED AMINES AND ULTRAVIOLET ABSORBERS.** The photostabilization chemistry of a two-package acrylic/urethane coating containing a benzotriazole UV absorber and/or a hindered amine light stabilizer has been studied by using FTIR and ESR. FTIR has been used to follow the rate of chemical change on exposure of the coatings to UV light and humidity. The coatings are found to undergo photooxidation and loss of urethane cross-links during exposure. In contrast to melamine cross-linked coatings, humidity plays only a minor role in the degradation of the urethane coating. The addition of a benzotriazole UV absorber reduces the rate of degradation by reducing the rate of formation of free radicals. The addition of hindered amine greatly reduces the rate of oxidation and urethane loss. (Edited author abstract) 13 refs.

Bauer, David R. (Ford Motor Co, Dearborn, MI, USA); Dean, Mary J.; Gerlock, John L. *Ind Eng Chem Res* v 27 n 1 Jan 1988 p 65-70.

**086599 CORROSION EVALUATION OF VERY RAPID HIGH-CURRENT VACUUM ARC COATINGS.** The corrosion resistance of Al alloy, Ni, and stainless steel coatings deposited on 1010 steel sample anodes using pulsed high-current vacuum arcs was investigated as a function of the arc parameters. Coating thicknesses of up to 30 µm were obtained from a sequence of six 70-ms pulses, indicating effective coating rates of up to 72 µm/s. The thicker coatings and the best corrosion protection were obtained at higher currents (600-900 A) and short gaps (3 mm). The coatings were generally well bonded to the substrate. The composition of the coatings was approximately that of the source electrode. With optimal arc parameters, all three coating materials gave full corrosion protection during a 5-h salt-spray test, and Al and Ni coatings showed no signs of corrosion after a 48-h test. 5 refs.

Bababeggy, S. (Tadiran Electronics Industry, Rehovoth, Isr); Boxman, R.L.; Goldsmith, S. *IEEE Trans Plasma Sci* v PS-15 n 5 Oct 1987, XIIth Int Symp on Discharges and Electr Insul in Vac, Shores, Isr, Sep 22-25 1986 p 599-602.

## Measurements

**086600 MICROHARDNESS MEASUREMENTS ON BORON COATINGS.** Boron has been considered as a promising candidate coating material for the first wall and the limiter of the Tokamak-type controlled thermonuclear reactor. Efforts have been made to develop these coatings for reducing plasma power loss. The microhardness of boron coatings as one of their important characteristics is reported here. 4 refs.

George, V.C. (BARC, Bombay, India); Dua, A.K.; Agarwala, R.P. *Thin Solid Films* v 152 n 3 Sep 28 1987 p L131-L133.

**086601 REVIEW OF HAND HELD COATING THICKNESS GAUGES.** When in 1947 Elcometer launched the 101 it was the first hand held coating thickness gauge. This article reviews instrumentation for the measurement of thickness of paint and organic coatings on metal, especially steel. Paint on steel is the sector commanding the highest volume of instrument sales.

Davies, Mike. *Anti Corros Methods Mater* v 34 n 12 Dec 1987 p 14-18.

**Mechanical Properties** See Also ALUMINUM ZINC MAGNESIUM ALLOYS—Anodic Oxidation; TUNGSTEN RHENIUM ALLOYS.

**086602 RELATIONS BETWEEN COATING CONDITIONS AND PROPERTIES OF TiC LAYERS FORMED BY THE METHOD OF ION-PLATING.** Relation between the coating conditions and properties of the TiC layer formed on SUS304 stainless steels by activated reactive evaporation (ARE) was studied at electron beam (EB) emission currents ranging from 0.15 to 0.25 A, and acetylene gas pressures ranging from  $5 \times 10^{-4}$  to  $1 \times 10^{-3}$  Torr. Other parameters were fixed: ionization current = 1 A, substrate bias = -2 kV, and substrate temperature = 400°C. Measurement of composition by EPMA, lattice constant by X ray diffraction and micro-vickers hardness of the TiC layer showed that the lowest possible EB emission current and highest possible acetylene pressure were preferable. The conditions for obtaining the best TiC coating layer were found to lie within a limited range. In this experiment, the optimum conditions were found to be 0.17 A for the EB emission current and  $8.5 \times 10^{-4}$  Torr for the acetylene pressure. (Edited author abstract) 7 refs.

Takei, Atsushi; Ishida, Akira. *Trans Natl Res Inst Met (Tokyo)* v 29 n 4 Dec 1987 p 10-16.

**086603 (Ti,Al)N-SCHICHTEN - EIN BEISPIEL FUER 'TERNAERE' NITRID-HARTSTOFFSCHICHTEN. [(Ti,Al)N Coatings - An Example of 'Ternary' Nitride Hard Coatings].** Transition metal compounds find increasing use as hard materials for tool and work piece coatings for wear reduction, decorative pur-

poses and applications in microelectronics and other technical fields. Besides binary nitrides and carbides multicomponent compounds and multilayers are the focus of research activities. The paper summarizes the results of investigations on (Ti<sub>x</sub>Al<sub>1-x</sub>)N<sub>x</sub> coatings. Following a review of deposition processes (PVD) and deposition rates, the morphology and lattice structure are discussed as well as mechanical properties and wear test results. Results on the coating/substrate interface composition and oxidation behaviour are also reported. (Edited author abstract). 30 Refs. In German.

Jehn, H. (Max-Planck-Inst fuer Metallforschung, Stuttgart, West Ger); Hofmann, S.; Muenz, W.-D. *Metall* v 42 n 7 Jul 1988 p 658-669.

## Microanalysis

**086604 THIN FILM CHARACTERIZATION USING A MECHANICAL PROPERTIES MICRO-PROBE.** A new ultra-low load microindentation system has been acquired in the Metals and Ceramics Division of Oak Ridge National Laboratory. The system's spatial resolution and its data acquisition capabilities allow the determination of several mechanical properties from volumes of material with submicron dimension - hence the term mechanical properties microprobe (MPM). Research with the MPM at Oak Ridge has led to improved techniques for determining the plastic and elastic properties of materials using microindentation experiments. The techniques have been applied to thin films created by ion implanting metals and ceramics, radiation damaged materials and thin hard coatings of TiN. Changes in the strength (hardness) and modulus have been measured in films as thin as 200 nm. (Author abstract) 29 refs.

Oliver, W.C. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); McHargue, C.J.; Zinkle, S.J. *Thin Solid Films* v 153 Oct 26 1987, Pap Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 185-196.

**Microscopic Examination** See Also STEEL HEAT TREATMENT—Nitriding.

**086605 METALLOGRAPHIC AND ELECTRON-BEAM METALLOGRAPHIC INVESTIGATIONS OF THERMALLY-SPRAYED COATINGS.** In addition to the usual problems of edge preparation, metallographic investigation of thermally sprayed coatings is hampered by the presence of pores, which give rise to contamination of the sections during etching. By using scanning electron microscopy and imaging with backscattered electrons, the coatings can be depicted with good contrast and sharpness without the need for etching. In German and English. 6 refs.

Burchard, W.-G. (RWTH, Aachen, West Ger); Knotek, O.; Heintz, H.-R. *Prakt Metallogr* v 24 n 6 Jun 1987 p 249-256.

**086606 CROSS-SECTIONAL TRANSMISSION ELECTRON MICROSCOPY CHARACTERIZATION OF THE INTERFACE BETWEEN PLASMA-SPRAYED TiC AND INCONEL.** Transmission electron microscopy was used to study the very first layer of TiC deposited by plasma spraying over Inconel. Various techniques to prepare cross-sectional specimens have been reviewed and adapted to suit plasma-sprayed material. The main aspects considered were the relatively large thickness of the coatings, the irregularity of the interface and the different sputtering yields of the two materials. The results show that the TiC at the interface can have either a very fine unidirectional solidification or a coarser structure. These observations are discussed in terms of thermal contact with the substrate. We have not observed a structural link between the TiC and the substrate; the structure and the composition change



abruptly at the interface. Hence it is believed plasma-sprayed coatings is mainly mechanical. (Author abstract) 10 refs.

Veilleux, G. (Inst Natl de la Recherche Scientifique, Varennes, Que, Can); Saint-Jacques, R.G.; Dallaire, S. *Thin Solid Films* v 154 n 1-2 Nov 12 1987, Pap Presented at the Int Conf on Metall Coat - Part II, San Diego, CA, USA, Mar 23-27 1987 p 91-100.

#### Microstructure

**086607 MICROSTRUCTURAL ASPECTS OF WEAR-RESISTANT STELLITE AND COLMONOY COATINGS BY LASER PROCESSING.** Two coatings were produced, using a high power CO<sub>2</sub> laser of 15 kw maximum power as a heat source to melt and bind Stellite and Colmonoy powders on to a substrate of AISI 304 stainless steel. The processing parameters were optimized in order to obtain homogeneous and uniform surface layers up to 1.5 mm thick. Morphological and microanalytical analyses were performed using Auger electron spectroscopy-scanning Auger microprobe and scanning electron microscopy techniques both on the coating and into the bonding region. The coating showed a homogeneous dendritic structure with some differences in grain size and shape. The intermediate precipitates were analyzed both in the coating and after extraction, by checking the chemical composition, structure and morphology. (Edited author abstract) 6 refs.

Corchia, M. (ENEA, Rome, Italy); Delogu, P.; Nenci, F.; Belmonto, A.; Corcoruto, S.; Stabielli, W. *Wear* v 119 n 2 Sep 15 1987 p 137-152.

#### Modification See PIGMENTS—Testing.

#### Nondestructive Examination See Also STEEL—Protective Coatings.

**086608 ZERSTÖRUNGSFREIE PRÜFUNG VON BESCHÜTTUNGEN BEI ABNAHME UND IM BETRIEB.** [Non-Destructive Testing of Coatings During Acceptance and in Service]. The non-destructive testing of organic, inorganic and metal coatings is described. The testing extends the measurement of the coating thickness, the adherence to the metal and the density. Special problems to be considered at a building location are explained. (Author abstract) In German. 1 refs.

Schaper, H. (Schadenverhuetung und Sicherheitstechnik GmbH, Cologne, West Ger); Priess, F. *Tech Mess TM* v 55 n 4 1988 p 157-159.

#### Organic See Also METALS AND ALLOYS—Corrosion Protection; PRINTED CIRCUITS—Protective Coatings.

**086609 SURFACE CHARACTERIZATION OF IRON AND STEEL PRIOR TO COATING.** This report presents the latest knowledge on surface properties by which the mechanism and intensity of the adhesion of organic coatings can be influenced on iron materials. On the basis of experimental results it is concluded that greater attention should be paid to the hydroxyl group-containing primary oxides being formed spontaneously on steel surfaces following the mechanical or chemical pretreatment during contact with air, when coating materials and techniques are selected. If such a continuous, homogeneous primary oxide layer exists, its amphoteric surface hydroxyl groups can be utilized for the chemical adhesion of suitable organic film-formers. On steels whose surface is heterogeneous due to the island-shaped distribution of primary oxides, non-metallic deposits and pollutants, homogenization can be achieved by producing a conversion layer. Usually, phosphate and oxide layers have amphoteric surface hydroxyl groups, too, whose isoelectric point (IEPS) varies with the composition, so that it is possible to select thermodynamically favorable conditions for the chemical adhesion of organic coatings. (Edited author abstract) 134 refs.

Reinhard, G. (Dresden Univ of Technology, Dresden, East Ger). *Prog Org Coatings* v 15 n 2 Jun 26 1987 p 125-148.

**086610 DOW SHRINKS THE VOC IN ITS 1,1,1-TRICHLOROETHANE.** The Dow Chemical Co. has introduced a 1,1,1-trichloroethane for California coatings use that contains only 0.75% volatile organic compound (VOC) inhibitors by weight. In states where 1,1,1-trichloroethane is exempt as a coatings solvent, VOC additives in the solvent must be factored into compliance formulas. The new product, Proact, is expected to help industrial finishers in California's South Coast Air Quality Management District (SCAQMD) meet super-tough VOC compliance regs. The new product is particularly important to paint formulations that require only a marginal reduction in VOC to achieve compliance. Some resin systems require less thinning than others; some achieve application viscosities at well below the VOC limit. However, for those coating systems that are near or over the limit after thinning or formulating the final coating, Proact can play an important role.

Spencer, David R. (Dow Chemical Co, Walnut Creek, CA, USA). *Ind Finish (Wheaton Ill)* v 63 n 10 Oct 1987 p 20, 22.

**086611 ADHESION AND INHIBITOR PROPERTIES OF ORGANIC COATINGS INVESTIGATED WITH VERY THIN POLYMER FILMS ON NOBLE METAL ELECTRODES.** The electrochemical impedance and the rate of faradaic reactions were measured on platinum electrodes coated with very thin ( $\approx 10^{-3}$  cm) acrylonitrile glow-discharge polymer films. The desorption of the organic matrix from the metal surface after immersion into aqueous 1 M H<sub>2</sub>SO<sub>4</sub> was determined quantitatively. The rate of electrocatalytic charge transfer reactions is directly proportional to the number of unblocked metal surface atoms as determined from the hydrogen adsorption capacitance. The relevance of such measurements for protective coatings is pointed out. (Edited author abstract) 21 refs.

Dobhofer, Karl (Max-Planck-Gesellschaft, Berlin, West Ger); Eisel, Irmgard. *Corros Sci* v 27 n 9 1987 p 947-956.

**086612 CORROSION PROTECTIVE PROPERTY OF FERRITE PAINT FILMS.** The corrosion protective property and the effective pigment concentration of the paint of various mixture ratios prepared from ferrite pigments (MO-Fe<sub>2</sub>O<sub>3</sub>, M=Mg, Ca, Sr, Ba, Fe, Zn) and linseed oil were investigated by the various electrochemical measurements. From these results, the value of tan  $\delta$  of Mg ferrite paint of 4:1 (a mixture ratio of linseed oil and ferrite pigment), and of Fe ferrite paints of 4:2 and 4:3 was about 0.5. Both the resistance of their paint film (R<sub>p</sub>) and the charge transfer resistance (R<sub>ct</sub>) were larger than 10<sup>5</sup>  $\Omega$ . Consequently, it was found that the good corrosion protective property of Mg ferrite paint is seen in low pigment concentration and of Fe ferrite paint is seen in high pigment concentration. From the impedance measurement of SS 41 steel in the extracted aqueous solution of the paints, the value of R<sub>ct</sub> became large with time. Therefore, it was supposed that the corrosion protective property of the extracted aqueous solution is ascribed to the passivation of the decomposition components of linseed oil and ferrite pigments. (Edited author abstract) In Japanese. 11 refs.

Sekine, Isao (Science Univ of Tokyo, Noda, Jpn); Kato, Takeshi; Suda, Hideaki. *Boshoku Gijutsu* v 36 n 8 1987 p 487-491.

**086613 POSITRON IMPLANTATION AND ANNIHILATION IN PROTECTIVE ORGANIC COATINGS.** Positron implantation and annihilation were studied in two polymeric coatings, one pigmented and the other unpigmented, deposited on steel substrates. Positron lifetime spectra recorded on the coatings exhibited three components and closely resembled characteristic lifetime spectra of bulk polymers, but they were strongly dependent on the coating thickness. It was shown that the lifetime spectra could well be described as a sum of two contributions: spectra of the coating and the steel substrate. Differences between the measured and simulated lifetimes and intensities at low thickness values were associated with an inhomogeneous size and depth distribution of open volumes in the coatings. (Edited author

abstract)

Szeles, Cs. (Eotvos Univ, Budapest, Hung); Suvegh, K.; Vertes, A. *J Coat Technol* v 60 n 758 Mar 1988 p 47-52.

#### Painting See PAINT SPRAYING—Planning.

#### Performance See Also ENAMEL—Manufacture; PIPELINES—Protective Coatings; TANKS—Cathodic Protection.

**086614 CONTAMINATION AND DECONTAMINATION EXPERIENCE WITH PROTECTIVE COATINGS AT TMI-2.** The extraordinarily high costs of protective coatings in nuclear power plants, coupled with concern about their effectiveness in facilitating decontamination, prompted questions about their use in this application. TMI-2, the only U.S. nuclear power plant subjected to the full spectrum of conditions resulting from a major reactor accident, provided valuable coating performance data. Coating systems are not likely to experience widespread physical degradation (peeling) or failure as the result of a severe core damage accident. Coatings and near-surface concrete will absorb fission products and be penetrated by water-soluble contaminants. Therefore, it is necessary to remove such coatings in order to effect decontamination. Given the high cost of coatings and related maintenance work, a program of coating improvement or replacement might offer substantial benefits. (Edited author abstract)

Anon. *Electr Power Res Inst Rep EPRI NP 5206* May 1987 76p.

**086615 INFLUENCE OF UNDERSIDE MOISTURE ON FLOOR SCREEDS AND COATINGS: CAUSAL RESEARCH AND DAMAGE PREVENTATION.** Structural components made from concrete or floor screeds with coatings are frequently exposed on the underside to the action of precipitation, soil and ground moisture, seepage water or also groundwater. This action by water on the underside of the coating has in the last twenty years frequently resulted in damage to coated concrete components. The following influences have been discussed as possible causes of damage: vapour pressure; water pressure (hydrostatic pressure); saponification of the coating; swelling of the coating; condensation at the underside of the coating; osmosis; reaction and application temperature; action of solvents; differences in the coefficient of thermal expansion; high relative humidity at the time of application; low concrete temperature; reaction of the paint coatings with the air or the concrete; low concrete strength and concrete surface properties.

Rieche, R.; Fischer, E. *Kunstst Ger Plast* v 78 n 2 Feb 1988 p 30-32.

**086616 100 PERCENT SOLIDS PLURAL COMPONENT URETHANE COATINGS.** Because various kinds of urethane coatings can be formulated to have valuable performance properties, such as color and gloss retention, abrasion resistance, and moisture and chemical resistance, they are useful as anti-corrosion coatings in a variety of industrial settings. Solvent-free 100 percent solids urethanes have the additional advantage of compliance with the most rigorous air pollution regulations on solvent emissions (VOC's); and they can be formulated for fast curing, extremely high build, and strong adhesion. These characteristics make them useful for a range of special applications. This paper describes the chemical and performance characteristics of 100 percent solids urethanes, and some measures that can be taken to assure the successful application of the coating. 6 refs.

Roebuck, Al H. (Truesdail Lab); Foster, Roger W. *J Prot Coat Linings* v 5 n 2 Feb 1988 p 22-27.

**086617 PROTECTING CONCRETE FROM EXPOSURE TO AGGRESSIVE CHEMICALS.** There are four major factors that dictate product selection: chemical exposure; compatibility with the substrate; application conditions; and type of exposure. This article will high-



light each of these factors and describe the advantages and limitations of the most commonly used materials for chemical exposures.

Stavinoha, Ray (Sentry Polymers). *J Prot Coat Linings* v 5 n 2 Feb 1988 p 28-32.

**Phosphate** See Also GALVANIZED METAL—Corrosion Resisting; GALVANIZED METAL—Protective Coatings; METAL CLEANING—Equipment; METALS AND ALLOYS—Painting; MOTOR BUSES—Finishing; PAINT—Adhesion; STEEL—Protective Coatings.

**086618 STATIONARY ZINC PHOSPHATE/ELECTROCOAT SYSTEM.** An unusual stationary zinc phosphate and electrocoating system requires less than half the floor space and 70 pct less processing solution than conventional systems, according to the manufacturer. Developed for use in automotive body paint preparation operations, the patented system also can be used for coating a variety of parts for other industries, including appliance and furniture.

Anon. *Prod Finish (Cincinnati)* v 52 n 2 Nov 1987 p 90-91.

**086619 METAMORPHOSIS OF THE COMMON SLUG.** The article discusses phosphating as an aid to cold drawing. Cold drawn parts are formed from blanks or slugs of metal and are often shaped progressively in several stages. A phosphate coating will form a crystalline layer that will hold the drawing lubricant in place yet allow it to flow as the base metal flows, thus improving the flow and extending die life.

Rickwood, Frank (Process Plant & Chemicals Ltd, Engl). *Prod Finish (London)* v 40 n 11 Nov 1987 p 20, 22.

**086620 MANGANESE PHOSPHATE COATING KINETICS.** A phosphate coating as produced from a stock manganese phosphating bath was studied. An addition of manganese citrate, tartrate or gluconate was made. Processing was accomplished in an autoclave at temperatures above 212°F with steam pressure to determine the composition of the coating and the reactions associated with their formation. 8 refs.

Talaat El-Mallah, A. (Nat'l Research Cent, Giza, Egypt); Farid Shaffei, M.; Hassib Abbas, M. *Met Finish* v 86 n 1 Jan 1988 p 66-69.

**086621 ASPECTS OF THE ADHESION AND CORROSION RESISTANCE OF POLYELECTROLYTE-CHEMISORBED ZINC PHOSPHATE CONVERSION COATINGS.** The ability of polyelectrolyte macromolecules to suppress the crystal growth of zinc phosphate (Zn · Ph) conversion coatings depends primarily on the functional pendant groups. The extent of segmental chemisorption of macromolecules having carboxylic and sulphonic acid groups on the embryonic crystal faces was found to be considerably higher than that of macromolecules containing amine groups. The reaction products formed by intermolecular reactions between amide groups in polyurethane coatings and carboxylic acid groups on the outermost surface of polyelectrolyte-modified Zn · Ph in Zn · Ph-to-polymer adhesive joint systems played an essential role in developing interfacial adhesive forces. A highly dense precipitation of Zn · Ph derived from a zinc orthophosphate dihydrate-based phosphating solution contributed significantly to reducing the corrosion rate of cold-rolled steel. It also was determined that the presence of an internally diffused polyelectrolyte in the Zn · Ph layers further enhances the resistance to corrosion of Zn · Ph itself. (Author abstract) 7 refs.

Sugama, T. (Brookhaven Nat'l Lab, Upton, NY, USA); Kukačka, L.E.; Carciello, N.; Warren, J.B. *J Mater Sci* v 23 n 1 Jan 1988 p 101-110.

**086622 LE TRAITEMENT PAR PHOSPHATATION AU ZINC DES PIÈCES EN ACIER DESTINÉES A LA MISE EN FORME A FROID.** [Zinc Phosphating Process of Steel Parts to be Cold Forged]. The main objective of the use of phosphate coatings in metal forming process is to reduce the friction forces

occurring at the tool-material interfaces. It is shown that the efficiency and the regularity of the coatings depend on the surface chemical composition of the steel parts, nucleation sites occurrence, treatment duration, bath temperature and spraying. Phosphate coatings give the most attractive properties when the local increase of temperature at the interface is moderate: lower hardness compared to those of steel parts, low porosity and high adhesion. 6 refs. In French.

Cabezon, Jose (Vallourec Industries, Fr); Oudin, Jerome; Ravalard, Yves; Rigaut, Jean Michel. *Cah Inf Tech Rev Metall* v 85 n 2 Feb 1988 p 175-182.

**086623 MANGANMODIFIZIERTE ZINKPHOSPHATUBERZUG ALS HAFTGRUND FÜR MODERNE LACKIERUNGEN.** [Manganese-Modified Zinc Phosphate Coatings as Primers for Modern Painting Processes]. The use of manganese ions in addition to zinc and nickel ions demonstrably improves corrosion protection in low-zinc phosphating processes, especially when employing surface-treated sheets. Incorporating manganese into the zinc-phosphate coatings results in smaller crystals of greater compactness and with higher alkali stability. Not only is the operating range of phosphating baths increased simultaneously, but aluminium can also be phosphated in combination with steel and galvanized steel to form a layer, with the generally attained quality standard guaranteed. (Edited author abstract). 13 Refs. In German.

Roland, Wolf A. (G. Collardin GmbH, Cologne, West Ger); Gottwald, K.H. *Metallberfläche* v 42 n 6 Jun 1988 p 301-305.

**Physical Chemistry** See CARBON STEEL—Corrosion Protection.

**Physical Properties** See Also ELECTROPLATING—Efficiency; METALS AND ALLOYS—Electrodeposition; PLATINUM COBALT ALLOYS—Electrodeposition; STEEL HEAT TREATMENT—Boriding.

**086624 EFFECTS OF CHROMIC-ACID CONCENTRATION ON THE STRUCTURE AND PROPERTIES OF CHROMIUM COATINGS.** The structure and physicochemical properties of the chromium coatings obtained from dilute chromic-acid electrolytes are rather poorly known. This work aims at closing this gap. The results obtained show that a decrease in chromic-acid concentration from 2.5 to 0.2 M influences the structure and properties of the chromium coatings in the same direction as increasing sulfate and silicofluoride concentration viz., the grain size in the deposits decreases, and the tendency of the deposits to undergo microcracking, their brightness, hardness, hydrogenation, and internal stresses increase. The data reported show that bichromate ions have no effects on the rate of chromium deposition and on chromium structure when they are present at constant relative concentration with respect to the sulfate ions. 7 refs.

Solodkova, L.N. (Acad of Sciences of the USSR, Moscow, USSR); Solov'eva, Z.A.; Monev, M.; Nikolova, S.; Rashkov, S.; Dobrev, Ts. *Sov Electrochem* v 23 n 4 Apr 1987 p 503-506.

**086625 MICROSTRUCTURE AND PHYSICAL PROPERTIES OF POLYCRYSTALLINE METASTABLE  $Ti_{0.5}Al_{0.5}N$  ALLOYS GROWN BY D.C. MAGNETRON SPUTTER DEPOSITION.** Metastable single-phase polycrystalline  $Ti_{0.5}Al_{0.5}N$  alloy films, approximately 3  $\mu$ m thick, have been grown on stainless steel substrates by d.c. magnetron sputter deposition from a TiAl target in mixed Ar- $N_2$  discharges. The deposition temperature was between 400 and 500°C and the applied negative substrate bias  $V_s$  was varied from 0 to 250 V. Electron microprobe analyses, using pure elemental standards, showed that the film composition was independent of  $V_s$  to within the experimental accuracy,  $\pm 3$  at.%. All films were found, based upon X-ray diffraction (XRD) and transmission electron microscopy (TEM), to have a B1 NaCl structure (AlN crystallizes in the wurtzite structure) with a (111) preferred orientation. The lattice parameter  $a_0$  of films grown at  $V_s < 80$  V was 0.4176 nm

and cross-sectional TEM showed that such films had a columnar structure exhibiting a high intercolumn, as well as intragrain, porosity. (Edited author abstract) 17 refs.

Hakansson, G. (Linköping Univ, Linköping, Swed); Sundgren, J.-E.; McIntyre, D.; Greene, J.E.; Munz, W.-D. *Thin Solid Films* v 153 Oct 26 1987, Pap Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 55-65.

**Plasma Spraying** See Also COATINGS—Bonding; COATINGS—Ceramics; COATINGS—Composite Materials; COATINGS—Sprayed; FLUORINE CONTAINING POLYMERS—Films; METAL FINISHING—Blast; NICKEL AND ALLOYS—Protective Coatings; PLASMA DEVICES—Guns; PLASMAS—Diagnostics; POWDER METALLURGY—Equipment; PROTECTIVE COATINGS—Microscopic Examination; REFRACTORY MATERIALS—Zirconia; STEEL—Coatings; THERMAL CONDUCTIVITY.

**086626 GERAETE UND EINRICHTUNGEN ZUR BESCHICHTUNG VON TECHNISCHEN OBERFLÄCHEN DURCH PLASMASPRITZEN.** [Equipment and Installations for Deposition of Coatings on Technical Surfaces by Plasma Spraying]. Plasma spraying has been established on an industrial scale in the early sixties. Since then the process has become remarkably more flexible and has gained significance in almost all industries. Recent developments in the processes, equipment and deposition materials are attributable to increasing demands on quality, new applications and the need for better operating characteristics and results. The authors present an overview of equipment and facilities for a process which has proved its merits and cost-effectiveness even in the present economic situation. (Author abstract) In German. 24 refs.

Steffens, H.-D. (Univ Dortmund, West Ger); Busse, K.-H. *Elektrowärme Int Ed B* v 45 n 3-4 Jun-Aug 1987 p 183-189.

**086627 STAND UND ENTWICKLUNGSTENDENZEN BEIM PLASMASPRITZEN.** [State of and Development Trends in Plasma Spraying]. Equipment and process developments in plasma spraying have focused on improving torch performance and increasing gas flow rates, the design of manipulators and robots for special applications and part geometries, short and long-run production and multiple-powder systems for simultaneous and graded coating. Optimization and development of powder coatings aimed at fully exploiting the advantages offered by plasma deposition will gain increasing importance and open up further applications. A wide variety of materials amenable to the process is available. Both low-melting plastics as well as high-melting refractory metals can be deposited by plasma spraying. The use of the process has already extended far beyond the deposition of corrosion and wear-resistant coatings. Thermal coatings are not only being applied for repair work; they are also used in production to impart specific surface properties. Since the combination of substrate and coating can largely be selected at random, the process offers enormous potential for use. (Edited author abstract) In German. 11 refs.

Lugscheider, E. (RWTH, West Ger); Weber, Th. *Elektrowärme Int Ed B* v 45 n 3-4 Jun-Aug 1987 p 190-195.

**086628 EFFECT OF LASER TREATMENT ON THE STRUCTURE, COMPOSITION AND MICROHARDNESS OF PLASMA COATINGS OF THE Fe-Cr-V SYSTEM.** The effect of treatment by continuous  $CO_2$  laser according to different modes of the capacity introduced on the structure, composition and microhardness of plasma-sprayed coatings of the Fe-Cr-V system is investigated. Variations of the chemical and phase compositions of coatings, compared with the initial sprayed ones, as a result of their alloying with substrate elements, are established. Differences in the formation of the strengthening wear-resistant phases, depending on treatment conditions, are noted. Laser treatments of plasma-sprayed coatings makes it possible to increase considerably their adhesion and, when combined with



high-rate cooling, offers a possibility to control the processes of structure formation, dispersion and phase formation. (Translated author abstract) In Russian. 5 refs.

Larionov, V.P.; Bolotina, N.P.; Argunova, T.V. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 11 1987 p 106-109.

**086629 APPLICATION DE LA PROJECTION A CHAUD AU PLASMA AUX BARRIERES THERMIQUES.** [Application of Hot Plasma Spraying to Thermal Barriers]. Thermal barriers produced by hot plasma spraying make use essentially of partially or totally stabilized zirconias. The characteristics of the ceramic coating depend on the composition and structure of the powder employed and on the spraying conditions. The results of thermal-shock and hot-corrosion testing of a newly developed plasma-sprayed stabilized zirconia coating are presented. In French. 6 refs.

Dehaut, P. (CENG, Grenoble, Fr). *Mec Mater Electr* n 422 Sep-Oct 1987 p 8-12.

**086630 CALCULATIONS OF THE PROCESS OF FORMATION OF HOT SPRAYED COATINGS.** To calculate the formation of gas-thermal coatings from the flow of the sprayed material, the authors derived an equation for the thickness of coatings using the concept of 'the flow density' and 'the surface flow density'. Examples of calculating cylindrical and conical flows are presented. (Author abstract) 2 refs.

Kulagin, I.D.; Sarbuichev, S.N. *Phys Chem Mater Treat* v 21 n 3 May-Jun 1987 p 247-249.

**086631 MECHANISM OF FORMATION OF INTERNAL STRESSES IN TIN VACUUM PLASMA CONDENSATES.** X ray tensometry was used to examine the internal stresses in vacuum-plasma condensates of TiN produced by the condensation of plasma flows in vacuum with ion bombardment on Kh12 and 5KhNM steels. Probable mechanisms of formation of these stresses are discussed. (Author abstract) 6 refs.

Boiko, Yu.F.; Belova, E.K.; Alekseeva, O.A. *Phys Chem Mater Treat* v 21 n 3 May-Jun 1987 p 270-272.

**086632 DEPOSIT CHARACTERISTICS OF SPRAYED POWDER BY GAS TUNNEL TYPE PLASMA SPRAYING APPARATUS.** The deposit characteristics of alumina powder which was sprayed on a substrate by the gas tunnel-type plasma spraying apparatus were studied. The shape, the weight, and the state of deposit of the powder on the substrate were observed. The relations between these deposit characteristics and the torch condition, such as the input to the torch and the spraying distance, were clarified. The alumina coating on stainless steel was examined in terms of hardness, and porosity and, as a result, it was proved that the quality of the coating was influenced by these conditions. (Edited author abstract) 6 refs.

Arata, Yoshiaki; Habara, Yasuhiro; Kobayashi, Akira. *Trans JWRI* v 16 n 1 Jun 1987 p 31-36.

**086633 PROPRIETES ELECTRIQUES DU SILICIUM ELABORE PAR A TORCHE PLASMA.** [Electrical Properties of Silicon Coatings Deposited Using a Plasma Torch]. We have applied the plasma torch process to the preparation of polycrystal Si deposits of the n and p types on various substrates and we have examined the influence of the operating conditions on the growth rate and electrical properties. The origin of the impurities such as Fe, Ni and Al is evidenced and a growth rate of 0.6 cm<sup>3</sup>/min is obtained. Resistivity can range from 100 down to less than 0.1  $\Omega$ cm. The influence of heat treatment of the deposits on density, electrical, and photoelectrical properties has been studied. (Edited author abstract) In French.

Suryanarayanan, R. (CNRS, Meudon, Fr); Akani, M.; Brun, G. *Soudage Tech Connexes* v 41 n 9-10 Sep-Oct 1987 p 505-509.

**086634 PHYSICO-CHEMICAL PROPERTIES OF**

**PLASMA COATINGS.** In many parameters plasma sprayed coatings differ radically from normal compact materials. Unfortunately until now systematic experimental investigations of the whole combination of properties of plasma coatings have not been undertaken, as the result of which the optimum methods and appropriate equipment are lacking. Therefore selection of the objects of observation and methods of investigation acquire the greatest importance. Plasma coatings by materials so widely used in production as titanium, nickel, copper, tungsten, molybdenum, and alsilfer alloy obtained with certain variations of the spraying methods were used as the object of this investigation. 6 refs.

Lyasnikov, V.N. *Sov Mater Sci* v 23 n 2 Mar-Apr 1987 p 208-211.

**086635 CHARACTERISTICS OF GAS-TUNNEL PLASMA-SPRAYED COATINGS.** The quality of Al<sub>2</sub>O<sub>3</sub> coatings formed by gas-tunnel plasma-spraying apparatus has been evaluated with respect to hardness and porosity under various spraying conditions. The deposit characteristics of Al<sub>2</sub>O<sub>3</sub> powder sprayed onto a substrate by this type of plasma spraying were also studied and the relation between the deposit characteristics and the spraying distance was investigated. Estimation of the deposit characteristics was found to be a very effective method for determining the proper spraying conditions under which a good quality coating can be obtained. (Author abstract) 7 refs.

Arata, Y.; Kobayashi, A.; Habara, Y. *High Temp Technol* v 6 n 1 Feb 1988 p 9-15.

**086636 SPOJENI PLASMATICEHO NASTRIKU SE ZAKLADNIM MATERIALEM.** [Bond of Plasma-Sprayed Coating with the Substrate]. The article examines the possibilities of improving the cohesion strength between corrosion- and oxidation-resistant coatings and the substrate. An analysis is made of experimental tests of plasma-sprayed coatings under high-temperature corrosion conditions. (Translated author abstract) In Czech. 14 refs.

Pilous, Vaclav (CSAV, Plzen, Czech); Musil, Jan. *Zvaranie* v 37 n 1 Jan 1988 p 2-6.

**086637 EFFECT OF MODULATION OF THE PLASMA ARC ON THE STRUCTURE OF COATINGS.** It is shown that the extent of dispersion of sprayed particles and the structure of coatings vary in relation to the parameters of modulation of the plasma arc. The effect of shock waves removes the oxide film from the surface of particles and caused partial degassing. Consequently, the amount of the nonmetallic oxide component in the coating decreases by a factor of 3-4. These processes reduce the gas permeability of the coatings by an order of magnitude. (Author abstract) 5 refs.

Shorshorov, M.Kh.; Volkova, R.M.; Bozhenov, V.A.; Gutman, B.E. *Phys Chem Mater Treat* v 21 n 6 Nov-Dec 1987 p 593-595.

**086638 EFFECT OF THE COLLISION SPEED ON THE THERMAL CYCLE IN CONTACT BETWEEN THE MOLTEN PARTICLE AND THE SOLID SURFACE.** The author describes a method of calculating the contact temperature between the molten particle and the surface of the solid which takes into account the rate of their collision. The difference in the thermal cycles of the points of contact of the particle with the surface positioned at various distances from the centre of the impact is shown. (Author abstract) 11 refs.

Kharlamov, Yu.A. *Phys Chem Mater Treat* v 21 n 6 Nov-Dec 1987 p 606-610.

**086639 PARTICLE MELTING AND DROPLET CONSOLIDATION DURING LOW PRESSURE PLASMA DEPOSITION.** A d.c. plasma jet was used as a heat source to melt and accelerate powder particles which subsequently impinged and solidified on a glass substrate. Ni-based alloys with different melting ranges (i.e. T<sub>L</sub>-T<sub>H</sub>) were fed to a low enthalpy high velocity and a high enthalpy low velocity jet. Improvement in the

degree of particle melting was found when the gun to substrate distance was increased from 200 to 400 mm and when the higher enthalpy jet was used. Alloys with large melting ranges had higher deposit densities. (Author abstract) 6 refs.

Apelian, D. (Drexel Univ, Philadelphia, PA, USA); Smith, R.W.; Wei, D. *Powder Metall Int* v 20 n 2 Apr 1988 p 7-10.

**086640 STRUKTUR DER AL<sub>2</sub>O<sub>3</sub> SCHICHTEN NACH DEM GAS TUNNEL PLASMA-SPRITZGERAT.** [Structure of Al<sub>2</sub>O<sub>3</sub> Layers Produced by Gas Tunnel Plasma Spraying Device]. Compared with the presently used plasma spraying apparatus, the gas tunnel type plasma spraying device can produce layers with good hardness and porosity qualities because it can discharge the sprayed particles at a very high temperature and at a high velocity. The structure of alumina layers produced by such a plasma spray jet torch was investigated. On the surface of Al<sub>2</sub>O<sub>3</sub> layers produced by a gas tunnel-type spray jet torch there are layers whose hardness is high. The structural analysis of the hardening layers of Al<sub>2</sub>O<sub>3</sub> was carried out by the X-ray diffraction method. (Translated author abstract) In German. 7 refs.

Arata, Yoshiaki; Habara, Yasuhiro; Kurihara, Setsu; Kobayashi, Akira. *Trans JWRI* v 16 n 2 Dec 1987 p 27-30.

**086641 PARTICULATE EROSION OF ZIRCONIA-ALUMINA PLASMA SPRAYED COATINGS I: CERAMIC COATING EROSION MECHANISM.** A series of plasma sprayed ceramic coatings were produced from mixtures of zirconia and alumina powders. The morphology and thermal expansion coefficients of the coatings were determined. Experiments were conducted to evaluate the resistance of these coatings to particulate erosion as a function of erodent particle impact angle, particle size, particle velocity and sample temperature. The results are discussed in the context of published experimental information on the erosion of bulk ceramics and metals and plasma sprayed metallic coatings. (Edited author abstract) 26 refs.

Murphy, J.G. (Technical Univ of Nova Scotia, Halifax, NS, Can); King, H.W.; Taylor, M.L. *J Can Ceram Soc* v 60 n 4 Dec 1987 p 26-32.

**086642 RESISTANCE TO ABRASION AND THERMAL SHOCK IN TRANSFORMATION-TOUGHENED ALUMINA II - COMPARATIVE PERFORMANCE OF VARIOUS POWDERS.** Studies were undertaken cost-effectiveness being a consideration, of the shrinkage, hardness, grain size, resistance to abrasion, resistance to thermal shock, and fracture toughness, of sintered specimens of various aluminas and alumina-zirconia composites. In general the purer, more expensive, aluminas had the least porosity after sintering, and exhibited the greatest hardness and resistance to abrasion. The highest fracture toughness was obtained using a less pure, less expensive alumina with 5% zirconia added. (Edited author abstract) 6 refs.

Kazi, A. (Nova Scotia Research Foundation, Dartmouth, NS, Can); Marple, B.; Whiteway, S.G. *J Can Ceram Soc* v 60 n 4 Dec 1987 p 33-38.

**086643 PHYSICO-CHEMICAL INTERACTION BETWEEN SPRAYED PARTICLES AND A POWDER BASE.** Within the framework of the theory of thermal activation of the process of formation of a strong bond between sprayed coatings, an analysis is made of the physico-chemical processes taking place in the contact between a particle and its powder base. Theoretical calculations of the kinetics of the development of a topochemical reaction at the interface are compared with original experimental data on the effect of the magnitude of the average porosity P of the sintered iron powder based on the strength of the bond with it of sprayed nickel particles. The conclusion is drawn that the effect of the porous structure of the zone adjacent to the surface of the



substrate on the generation and growth of seizure centers is decisive. The range of the P values within which maximum development of physico-chemical interaction is possible is established. (Translated author abstract) 8 refs. In Russian.

Shmakov, A.M.; Antsiferov, V.N. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 4 Feb 1988 p 96-101.

**086644 INDENTATION TOUGHNESS TESTING OF PLASMA SPRAYED COATINGS.** The sharp indentation technique for determining material toughness was applied to selected plasma sprayed coatings and for comparison, annealed glass. Three distinct types of crack pattern are observed in the ceramic coatings at all loads within the working range. Little correlation between indentation-derived fracture data and that from double cantilever beam methods could be found. This is attributed to the non-ideal behaviour of the porous stressed coatings during indentation loading. It appears that the relationship between indenter stress field and coating microstructure may provide information on coating toughness as indentation-derived  $G_c$  data was found to fit a Weibull distribution. This suggests characterizing coatings in terms of their Weibull modulus and characteristic strength, an approach which may prove useful in both toughness and quality control applications. Indentation tests were performed on plasma sprayed coatings of commercially pure  $Al_2O_3$ ,  $Al_2O_3$ -2.5wt percent  $TiO_2$ , and Ni-20wt percent Al. (Author abstract) 36 Refs.

Ostojic, P. (Monash Univ, Clayton, Aust); McPherson, R. *Mater Forum* v 10 n 4 1987 p 247-255.

**086645 FUNDAMENTAL IRRADIATION PROCESSES RELEVANT TO PLASMA-SURFACE TECHNOLOGY.** Plasma-surface technology is becoming increasingly widely used for both controlled growth and erosion of solids. The interactions between the plasma and a surface include irradiation of the latter with a range of projectiles including atoms, ions, electrons and photons. This review examines the important fundamental processes which occur during irradiation with these species separately and in synergism. (Author abstract) 48 Refs.

Carter, G. (Univ of Salford, Salford, Engl); Nobes, M.J.; Katardjiev, I.V. *Vacuum* v 38 n 6 1988 p 479-486.

**086646 LOW LOAD ABRASIVE WEAR BEHAVIOUR OF PLASMA SPRAY AND LASER-MELTED PLASMA COATINGS.** Low-load abrasive wear characteristics of plasma-spray and laser-melted plasma coatings have been determined using the block-on-cylinder test configuration. Marked differences observed between the wear behaviors of the plasma coating and the melted layer were attributed to the removal of the faults inherent in the plasma spray coating and significant changes in the composition due to the laser melting. The structure of the layer is prone to rapid wear by a delamination mechanism. Plasma coat melting by laser removes the flaws, generating an adherent wear-resistant layer exhibiting a wear behavior similar to that of hardened wrought steels. (Edited author abstract) 24 Refs.

Boas, M. (Technion-Israel Inst of Technology, Haifa, Isr); Bamberger, M. *Wear* v 126 n 2 Sep 1 1988 p 197-210.

**086647 PHASE TRANSFORMATION IN PLASMA-SPRAYED IRON OXIDE COATINGS.** Pure and silicon-, indium- and magnesium-doped  $\alpha-Fe_2O_3$  powders have been plasma sprayed on titanium substrates. The resulting coatings were analyzed by electron and optical microscopy, thermogravimetry and x-ray diffraction. The results show that  $Fe_3O_4$  is present in all coatings and comes from the reduction of  $Fe_2O_3$ . The latter phase is also obtained in most of the coatings and its presence is explained on the basis of a mechanism of re-oxidation of  $Fe_3O_4$ . This mechanism is affected by the spraying distance and also by the presence of dopants. These plasma-sprayed coatings have semiconductive properties which can find applications in photoelectrochemical or photocatalytic systems. (Author abstract) 18 refs.

Parent, L. (INRS-ENERGIE, Que, Can); Dodelet, J.P.;

Dallaire, S. *Thin Solid Films* v 154 n 1-2 Nov 12 1987, Pap Presented at the Int Conf on Metall Coat - Part II, San Diego, CA, USA, Mar 23-27 1987 p 57-64.

**086648 INTERRELATIONSHIP BETWEEN INTERNAL STRESS, PROCESSING PARAMETERS AND MICROSTRUCTURE OF PHYSICALLY VAPOUR DEPOSITED AND THERMALLY SPRAYED COATINGS.** For plasma-sprayed coatings in particular a heat transfer model is described which predicts the variation in residual stress distribution as a function of coating thickness and deposition rate and the results are compared with experimental observations. The level of residual stress in plasma-sprayed tungsten have been measured by x-ray and mechanical slitting methods and explanations as to why these methods yield different results given. For PVD tungsten coatings the most important systems parameter is substrate bias since this allows some stress relaxation to occur via its influence on porosity levels in the coating and the consequences this has on residual stress levels is discussed. In PVD tungsten coatings the internal stress was completely relaxed on dissolution of the substrate, accompanied by a decrease in the lattice parameter of the film. (Author abstract) 62 refs.

Rickerby, D.S. (UKAEA, Engl); Eckold, G.; Scott, K.T.; Buckley-Golder, I.M. *Thin Solid Films* v 154 n 1-2 Nov 12 1987, Pap Presented at the Int Conf on Metall Coat - Part II, San Diego, CA, USA, Mar 23-27 1987 p 125-141.

**086649 PLASMA DIAGNOSTIC STUDIES OF THE ACTIVATED REACTIVE EVAPORATION PROCESS.** Plasma volume reactions play an important role in the deposition of films by plasma-assisted processes. We have applied several techniques to the analysis of the plasma volume in the activated reactive evaporation process. Neutral mass spectrometry, plasma mass spectrometry and optical emission spectroscopy (OES) were used to examine the nature and relative concentrations of neutral, excited neutral and ionized species present in the process. Initial experiments involved evaporating titanium in the presence of  $CH_4$  and  $C_2H_2$  gases. Results of plasma mass spectrometry and OES indicate several differences between the species observed depending on the reactive gas used and the evaporation rate used. These results have been used to explain possible reaction paths for TiC compound formation as well as to correlate the dependence of film properties on the deposition conditions. (Author abstract) 15 refs.

Deshpandey, C.V. (Univ of California, Los Angeles, CA, USA); O'Brien, B.P.; Doerr, H.J.; Bunshah, R.F.; Hofmann, D. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 1-16.

**086650 SOME FUNDAMENTAL ASPECTS OF GLOW DISCHARGES IN PLASMA-ASSISTED PROCESSES.** The applicability of some theoretical models for ionization-assisted processes are discussed using data obtained by the authors and other researchers in the field. Information derived from argon discharges is used as a basis, and provides a convenient foundation from which to compare different system layouts, such as the direct current diode, and various triode systems. Detailed information is given on the estimation of the cathode fall distance. Other important parameters are also discussed, such as ionization efficiency, as well as the effect of additional species within the discharge. (Edited author abstract) 25 refs.

Fancey, K.S. (Univ of Hull, Hull, Engl); Matthews, A. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 17-29.

**086651 PRINCIPLES OF PLASMA-ACTIVATED CHEMICAL VAPOUR DEPOSITION.** Over the past decade the non-equilibrium low pressure plasmas have been developed and introduced into a variety of deposition techniques. A short introduction to the definition and characterization of the plasma state is given. Principal reactions in the plasma are reviewed with an emphasis on the plasma bulk processes and on the plasma-surface

coupling. To conclude, a correlation between the main experimental variables, plasma properties and the properties of the deposit is discussed and illustrated by selected examples of nitride and carbide coatings in electrodeless tubular reactors. (Edited author abstract) 139 refs.

Inspektor-Koren, Aharon (NRC Negev, Beer-Sheva, Isr). *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 31-48.

**086652 ZIRCONIUM NITRIDE FILMS PREPARED BY CATHODIC ARC PLASMA DEPOSITION PROCESS.** Zirconium nitride has been reactively deposited using the cathodic arc plasma deposition process. Deposited films have been analyzed for their surface morphology, crystal structure, microhardness and composition. Performance of the films was evaluated by conventional wear testing methods and the potential for decorative applications by reflectivity measurements. Wear test results indicated that ZrN is marginally superior to titanium nitride in conventional metal cutting applications, but outperforms TiN by a factor of two when cutting titanium alloys. Reflectance measurements indicate that ZrN-doped films are very similar to gold films. (Author abstract) 11 refs.

Johnson, P.C. (Vac-Tec Systems Inc, Boulder, CO, USA); Randhawa, H. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 53-62.

**086653 PLASMA-SPRAYED TiC PROTECTIVE COATINGS FOR FUSION DEVICES: COATING FABRICATION CRITERIA.** Titanium carbide is of interest for limiters in tokamak-type fusion devices subjected to high pulsed heat loads because of its low physical and chemical sputtering yield under ion bombardment. This study was carried out to outline the fabrication criteria needed to obtain thick TiC coatings which can withstand severe thermal shocks. TiC coatings with different microstructures (porosities) and thicknesses, plasma-sprayed under atmospheric and inert atmosphere conditions, were exposed to pulsed electron beam thermal shocks. The results obtained after thermal exposure indicate that the thermal shock resistance decreases as the TiC coating porosity increases. They also indicate that coatings obtained by spraying a narrow band powder into an inert gas enclosure contain some porosity that could help them to withstand spallation. 12 refs.

Dallaire, S. (Natl Research Council Canada, Boucherville, Que, Can); Saint-Jacques, R.G. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 319-326.

**086654 OPTIMIZED VACUUM PLASMA-SPRAYED TITANIUM COATINGS.** With vacuum plasma-spraying, there is now a process which can produce dense adhesive coatings of the reactive titanium, and this may expand its range of application. The quality of vacuum plasma-sprayed (VPS) coatings is largely dependent on the proper optimization of spraying parameters. This paper shows that, by two-level factorial analysis, a drastic reduction of porosity is achieved, which is the primary requirement for corrosion protection. The mechanical properties of optimized plasma-sprayed coatings were investigated. Low gas contents in the layers and a proper pretreatment of the substrates including sputtering and preheating gave highly ductile and adhesive coatings. The dependence of both properties on either the powder grain size or its oxygen content was tested. The adhesion strength was determined for different substrate materials such as austenitic steel, carbon steel and titanium alloy, where an average value of  $75 \text{ N mm}^{-2}$  was measured. (Edited author abstract) 5 refs.

Lugscheider, E. (RWTH Aachen, West Ger); Lu, P.; Haeuser, B.; Jaeger, D. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 215-226.



**086655 PAPERS PRESENTED AT NTSC87, THE NATIONAL THERMAL SPRAY CONFERENCE AND EXPOSITION.** This issue contains 11 papers presented at NTSC 87, the National Thermal Spray Conference and Exposition. Topics presented include plasma spraying; thermal spraying; fracture toughness of ceramic coatings; strength of thermally sprayed coatings; cavitation erosion of alloy coatings; low pressure plasma spray process; coatings adhesion and current industrial practices. Technical and professional papers from this conference are indexed and abstracted with the conference code No. 11199 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (ASM, Thermal Spray Div, Metals Park, OH, USA). *Surf Coat Technol* v 34 n 1 Jan 1988, Pap Presented at NTSC87, The Natl Therm Spray Conf and Expo, Orlando, FL, USA, Sep 14-17 1987 108p.

**086656 FUNDAMENTAL STUDIES ASSOCIATED WITH THE PLASMA SPRAY PROCESS.** More than 25 years ago, plasma spraying was established as a commercial process, but only recently have serious attempts been reported to establish a solid scientific base for this technology. The first part of this paper refers to the basic processes involved in plasma spraying, including plasma generation, plasma jet formation, particle injection, particle heat and momentum transfer, and particle deposition. In the second part, recent results obtained in this laboratory are summarized. These results are mainly concerned with the effects of vortex flow on particle motion and on air entrainment during atmospheric spraying. (Author abstract)

Pfender, E. (Univ of Minnesota, Minneapolis, MN, USA). *Surf Coat Technol* v 34 n 1 Jan 1988, Pap Presented at NTSC87, The Natl Therm Spray Conf and Expo, Orlando, FL, USA, Sep 14-17 1987 p 1-14.

**086657 EFFECT OF CHAMBER PRESSURE ON PARTICLE VELOCITIES IN LOW PRESSURE PLASMA SPRAY DEPOSITION.** A laser velocimeter has been used to measure spray particle velocities in a low pressure plasma spray system at chamber pressures ranging from 6.7 to 80 kPa (50 to 600 Torr). For  $Al_2O_3$  spray powder with a mean diameter of 44  $\mu m$ , peak particle velocities were of the order of 200 - 400  $m s^{-1}$ . The measured velocity distributions were strongly dependent upon spray chamber pressure, with the highest particle velocities at intermediate pressures of about 40 kPa (300 Torr). Particle velocities predicted with a simple analytical model are in reasonable agreement with experimental results close to the spray gun, where drag due to chamber gases can be neglected. This simple model also correctly predicts a particle velocity maximum at 45 kPa (340 Torr). (Author abstract) 4 refs.

Smith, Mark F. (Sandia Natl Labs, Albuquerque, NM, USA); Dykhuizen, Ronald C. *Surf Coat Technol* v 34 n 1 Jan 1988, Pap Presented at NTSC87, The Natl Therm Spray Conf and Expo, Orlando, FL, USA, Sep 14-17 1987 p 25-31.

**Plastics** See Also ALUMINUM AND ALLOYS—Painting; AUTOMOBILES—Coatings; CERAMIC MATERIALS—Fibers; CHEMICAL PLANTS—Corrosion; COATINGS—Curing; COATINGS—Synthesis; COMPOSITE MATERIALS—Mechanical Properties; CONCRETE—Painting; EPOXY RESINS—Applications; HEAT EXCHANGERS—Plastics Applications; LEATHER—Protective Coatings; MACHINE COMPONENTS—Protective Coatings; METALS AND ALLOYS—Protective Coatings; OLIGOMERS—Permeability; OPTICAL FIBERS—Protective Coatings; PIPE, STEEL—Protective Coatings; PIPELINES—Protective Coatings; PIPELINES, STEEL—Protective Coatings; SHIPS—Ballast Tanks; SILOS—Protective Coatings; STEEL—Painting; STEEL—Protective Coatings; STEEL SHEET—Protective Coatings; WATER DISTRIBUTION SYSTEMS—Protective Coatings.

**086658 PERFORMANCE OF PIGMENTS IN BARRIER COATINGS.** This paper has attempted to demonstrate that the corrosion protection obtained through the use of high build, aluminum epoxy mastics is considerably greater than expected based on several known mechanisms of coatings performance. It has been demonstrated that reduction in oxygen permeation is not the limiting

factor. The data strongly suggest that the enhanced performance with aluminum pigmentation exceeds that which would be expected based merely on the barrier effect of high build epoxies plus the anticipated improvement due to reduction in moisture vapor transmission rates. The frequently observed, and readily reproduced, enhanced performance over hand-cleaned rusty steel substrates as opposed to clean steel has not been explained. 12 refs.

Montle, John F. (Carboline Co). *J Prot Coat Linings* v 4 n 6 Jun 1987 p 38-45.

**086659 CHEMISTRY OF FILM-FORMING RESINS.** Frequently, the generic name of a resin is not a useful clue to its structure and function. For example, a mixture of an epoxy resin and other materials may undergo a manufacturing process that produces a material having little resemblance to conventional epoxy resins, but this product may be marketed as an 'epoxy' because of the favorable connotations of that name. One of the goals of this article is to teach the reader that, for example, an 'epoxy' resin is not always an epoxy resin. Liquid coatings are converted to dry films by one of five distinct mechanisms. The properties of the film are determined primarily by the process by which it is formed. For each process, this article discusses the mechanism, gives generic examples of film-forming resins that are used as binders for corrosion control, and explains how the film-forming mechanism influences the properties of the dry film. The mechanisms are discussed in the order of their importance in modern coatings for controlling corrosion. 3 refs.

Brady, Robert F. Jr. (US Naval Research Lab, USA). *J Prot Coat Linings* v 4 n 7 Jul 1987 p 42-51.

**086660 CROSSLINK DENSITY OF HIGH SOLIDS MF-CURED COATINGS.** Dynamic mechanical analysis (DMA) and solvent induced swelling were used to determine the crosslink density (XLD) of cured films. Films were prepared from polyester or acrylic polyols crosslinked with etherified melamine formaldehyde (MF) resins. Cure conditions were found for which co-condensation of the polyol with the MF resin was complete and self-condensation of the MF resin was avoided. Under these conditions, excellent agreement was found between experimental XLD values and XLD values calculated from structure using rubber elasticity theory and swelling theory. New insights concerning network formation in high solids films became apparent. It was found that all of the methoxymethyl groups in MF resins can react during cure. (Edited author abstract) 30 refs.

Hill, L.W. (Monsanto Chemical Co, Springfield, MA, USA); Kozlowski, K. *J Coat Technol* v 59 n 751 Aug 1987 p 63-71.

**086661 EFFECT OF WATER CONTAMINATION ON THE PERFORMANCE OF URETHANE ACRYLATE COATINGS.** The protection of delicate components from damaging environmental effects is a primary advantage of radiation curable coatings. These liquid coatings can rapidly be transformed into highly cross-linked polymers, yet the process is inoffensive to heat sensitive substrates. The effects of contamination of the uncured coating are first examined. Viscosity, shelf life, tensile properties of the film, and glass transition temperatures of the cured polymer are discussed. Next, the effect of humidity and water on the tensile properties of the cured urethane acrylate are analyzed. Finally, methods for determining the presence of water contamination are discussed. 5 refs.

Kallendorf, Camille J. (Borden Chemical); Woodruff, Rex T. *Radiat Curing* v 14 n 3 Aug 1987 p 12-18.

**086662 AIR-DRY PLASTIC - AN EVOLVING COATING MATERIAL.** Air-dry plastic is a blend of polyvinyl chloride (PVC), solvents and plasticizers. For many years, air-dry plastic has been used for repair of damaged areas on thermally-cured vinyl (plastisol) coatings at the tips of plating racks and for masking applications. Among its newer applications are repair of polypropylene tanks, nonslip flooring and impact protec-

tion. Air-dry plastisols are highly resistant to the acids and salts used in the metal finishing shop, withstanding continuous immersion in common electroplating solutions and most acid pickles. ?

Stanziale, E.A. (Advanced Materials, Peachtree City, GA, USA). *Met Finish* v 85 n 10 Oct 1987 p 37-39.

**086663 THERMAL OXIDATION AND ADHESION TO STEEL OF STABILIZED POLYETHYLENE COATINGS.** The effect of the nature and concentration of antioxidants on the oxidation of polyethylene coatings of thickness 200-500  $\mu m$  on steel in air at 423-453 K is studied. (Edited author abstract) 13 refs.

Yegorenkov, N.I. (Gomelsk State Univ, USSR); Kuzavkov, A.I.; Doktorova, V.A. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1698-1705.

**086664 IMPROVEMENT OF THE PROPERTIES OF POLYMER COATINGS.** Sample plates of type 45 steel with a thickness of 2mm were utilized for an investigation into the principal operational properties of anticorrosion polymer coatings; polymer coatings 0.5mm thick were applied to the plates. Coatings were cured in an h.f.c. generator. The adhesion strength in the presence of shear of the polymer coatings made of filled epoxy compositions, cured by h.f.c. is much higher than that of the same compositions, cured by the normal method.

Shturman, A.A.; Cherkashina, A.N. *Sov Eng Res* v 7 n 3 Mar 1987 p 29-31.

**086665 HIGH SOLIDS EPOXY COATINGS FOR STRUCTURAL STEEL.** Increasing raw materials costs and tightening environmental regulations are major driving forces for change in the coatings industry and have resulted in a tremendous increase in the amount of research in the area of higher solids coatings. Making coatings that conform with the increasingly stringent air quality regulations and that are at the same time high in quality, strong in performance, and appealing to the eye is a challenge facing the coatings industry. 20 refs.

Hill, D.A. (Dow Chemical Co, USA); Massingill, J.L. *J Prot Coat Linings* v 3 n 10 Oct 1986 p 47-51.

**086666 FUNCTIONAL COATING EXTENDS PHOTOCOPIER LIFE.** Orion Industries, Ltd., Chicago, Illinois, a custom coating applicator, has helped copier roller suppliers increase sales and production. This is due to a special fluoropolymer coating that Orion applies to copier rollers. It has helped reduce photocopier failures from ten to under one per while nearly eliminating problems with premature wear.

Anon. *Prod Finish (Cincinnati)* v 52 n 3 Dec 1987 p 80-82.

**086667 POLYMERIC COATINGS.** The use of polymeric coatings to prevent or retard corrosion is examined. The characteristics properties of polymer materials which make them suitable for protective coatings are outlined. The various polymeric coatings which are presently in use are described and methods for coating application are reviewed. The use of polymeric coatings at relatively moderate temperatures and under cyclic loading such as in corrosion-fatigue is also presented. (Author abstract) 28 refs.

Bassim, M.N. (Univ of Manitoba, Winnipeg, Manit, Can); Yannacopoulos, S.; Chaturvedi, M.C. *New Metall Mater and New Fabr Processes* Publ by Natl Research Council Canada, Ottawa, Ont, Can p 11.0-11.18.

**086668 NEW WORLD OF FINISHING.** The article is the first of a series. The basic chemistry of epoxy resins is briefly reviewed. Mention is made of resistance to abrasion, bacteria, fungi, chemicals, solvents, water, humidity, temperature and weather.

Groshart, Earl. *Met Finish* v 86 n 4 Apr 1988 p 34-35.



**086669 METHODENKOMBINATION ZUR UNTERSUCHUNG DER KORROSIONSSCHUTZWIRKUNG VON ANSTRICHEN.** [Combination of Methods to Study the Corrosion Protection Properties of Coatings]. The authors describe a procedure consisting of a combination of impedance and resistance methods which enables the inhibitor and barrier effects of organic coatings to be determined separately. The procedure involves measuring corrosion losses by means of resistance measurement on steel foils. The barrier effect is characterized by the frequency-related conductivity,  $(\omega \cdot R_p)^{-1}$ , while the inhibitor effect is characterized by the start of corrosion and the slope of the function  $K=f(t)$ . The efficiency of the method is demonstrated by investigations on chlorinated rubber coatings. (Edited author abstract). 12 Refs. In German.

Pietch, Sigunde (Untersuchung Organischer Schutzschichten); Woelker, Gerald. *Farbe Lack* v 94 n 7 Jul 1988 p 524-526.

**086670 FLUOROPOLYMERS AS COATING MATERIAL.** The durability of fluoropolymers has been discussed with focus on FEVE (Fluoroethylene/Vinyl Ether Copolymer) and the coatings made from it. The limited use of a weather-proof coatings system which is due to the rather poor processability of thermoplastic fluoropolymers is almost completely solved by the use of the thermocurable fluoropolymers, FEVE, which are sufficiently soluble in organic solvents and curable over a wide temperature range. Furthermore, the scope of the application of fluoropolymers to coatings should expand into various fields not only because of the superior weather-ability, but also because of special features such as low friction, abrasion, oil and water repellency, non-adhesiveness and antifouling. These features are primarily caused by the unique nature of the C-F bond in the polymers. 14 Refs.

Munekata, Seiji (Asahi Glass Co, Yokohama, Jpn). *Prog Org Coatings* v 16 n 2 Aug 1 1988 p 113-134.

Urbana, Illinois, recently saw a problem developing in the number of bumpers rejected for finish defects, it called on the expertise of its suppliers to help find a solution. As many as half of the company's rear step and hitch truck bumpers were being rejected daily because gel particles were forming during powder coating application. Complete analysis of powder coating system led to improvements that have bettered quality and cut rejects.

Roberts, James. *Prod Finish (Cincinnati)* v 52 n 1 Oct 1987 p 80-84.

**086673 PC FOR PC.** Many companies are striving to be more cost effective in order to meet foreign competition. One way is to buy manufacturing equipment that operates by itself (as much as possible), doesn't make mistakes and, if programmed properly, will produce perfect parts consistently. Programmable controllers (PC) are not the answer to everything, but they can keep track of what occurs on the finishing line and assure that the finishing processes are performed as accurately as the previous manufacturing steps. Programmable controllers can decrease down time and rejects on a powder coating line.

Lehr, W.D. (Finishing Systems Consultants, Prior Lake, MN, USA). *Prod Finish (Cincinnati)* v 52 n 2 Nov 1987 p 82-85.

**086674 POWDER COATING - A VERSATILE FINISH FOR VEHICLE AND COMPONENT MANUFACTURERS.** Powder coating is one of the fastest growing sectors of the world coatings market. In the competitive business of vehicle manufacture, importance is placed on the performance of coatings and their ability to cope with harsh environmental conditions. This has led to the evolution of a range of powder coating chemistries which covers a variety of applications throughout the transportation industry.

Davis, Tim (Int Paint plc). *Corros Prev Control* v 34 n 5 Oct 1987 p 117-120.

**086675 SPECIALITY POWDER COATINGS GIVE AN UNMATCHED RANGE OF FINISHES.** The use of powder coatings has grown over the last fifteen years at the expense of traditional solvent based industrial finishes. One of the reasons for this growth has been the development of speciality powder finishes such as textures, structures, antiques and hammers. Speciality powders give finishes similar to those obtained with wet paints but are easier to apply. Novel finishes which are easy to use and have a unique appearance unobtainable with wet paints have also been developed. An example of these is the antique finish.

Howell, David (BASF Coating & Inks). *Prod Finish (London)* v 40 n 8 Aug 1987 p 11-12.

**086676 POWDER COATINGS FOR THE BUILDING SECTOR.** High ultimate film performance, application versatility and economics make powder finishing an ideal choice for architects, specifiers and construction and component suppliers to the building sector. Powder coatings are used, for example, to protect steel pipelines in both land and sub-sea oil and gas operations in conditions ranging from the heat of the Middle East to the cold of the Canadian arctic. It is under such hostile conditions that fusion bonded epoxy (FBE) powders best demonstrate their unique combination of excellent corrosion protection, toughness and flexibility.

Higgins, Richard J. (Int Paint plc, Gateshead, Engl). *Prod Finish (London)* v 40 n 8 Aug 1987 p 17-18, 20.

**086677 PROTECTING AND DECORATING METAL SURFACES BY FLUID BED POWDER COATING.** The article discusses the Rilsan Nylon 11 fluidised bed coating. It is simple in its approach, requires less costly plant than normal powder coating and is ideal for producing thick coatings (up to .025 in) on a variety of substrates of varying mass. Rilsan Nylon 11, known for its ease of processing by injection molding and extrusion, has proved of most interest as a protective and decorative coating on metals.

Hornsby, Peter (Atochem, UK). *Prod Finish (London)* v 40 n 8 Aug 1987 p 6-7, 12.

**086678 PRETREATMENT FOR POWDER COATING.** During the past ten years, pretreatment technology for steel and zinc prior to powder coating has progressed at a relatively modest pace compared with requirements for aluminium. Demand for powder coated aluminium components has risen for window frames, double glazing extrusions and similar architectural features. For steel, zinc coated steel and aluminium, the reason for pretreatment is to convert the metallic surface to a condition that will ensure the long-term adhesion of a cured powder film and promote its corrosion protection.

Lund, P.J. (Pyrene Chemical Services Ltd). *Prod Finish (London)* v 40 n 9 Sep 1987 p 16, 19.

**086679 GROWTH OF POWDER COATINGS TECHNOLOGY FOR FINISHING OF BUILDING COMPONENTS.** The type of powder chemistry used in the finishing of aluminum building extrusions varies around the world, but in Europe, architectural-grade TGIC/polyester powders are the most common. Architectural aluminum finishing is handled largely by specialist coaters who are equipped to carry out the required ten or eleven-stage chromate pretreatment of the aluminum profiles or cladding panels. The article describes the Interpon range of architectural polyester powders.

Higgins, Richard (Int Paint Powder Coatings). *Finishing* v 12 n 2 Feb 1988 p 36, 38.

**086680 CHARACTERISATION OF POWDERS FOR THERMAL SPRAYING.** The properties that fully characterise a powder for thermal spraying are listed. Control of one or all of these is necessary to maintain reliable reproducibility in the properties of thermally sprayed coatings. They include chemical composition, microstructure, particle morphology (shape, size, size distribution), type (related to method of manufacture) and physical properties.

Kilp, F. (VALCO Werkstoff-Technologie GmbH, Dueseldorf, West Ger). *Met Constr* v 20 n 4 Apr 1988 p 169-170.

**086681 DESIGNING A COMBINATION ELECTRODEPOSITION/POWDER COATING SYSTEM.** Both electrodeposition and powder coatings exhibit characteristics that are very nearly ideal for compliance with environmental protection standards. Given the increase in finish durability (especially salt spray resistance), minimal additional equipment requirements, high operating efficiency and low labor and maintenance costs, a combination electrocoat/powder coating system may prove a desirable solution to finishing problems, especially in shops serving the appliance and automotive industries. Following the design guidelines outlined will ensure successful installation and operation of such a system in most manufacturing and/or custom coating shops.

Marino, Frank P. (DPP Systems Inc, Norwalk, CT, USA). *Met Finish* v 86 n 5 May 1988 p 23-25.

**086682 PRETREATMENT FOR POWDER COATING.** The highest quality powder coating can provide excellent results if the pretreatment is done correctly and the overall system is maintained up to its potential. The article defines a clean surface as opposed to poor cleaning. There is a brief discussion of conversion coatings. Iron phosphate and zinc phosphate pretreatments are covered.

Gruss, Brad B. (Fremont Industries Inc, Shakopee, MN, USA). *Met Finish* v 86 n 5 May 1988 p 29-31.

**086683 COMPLIANCE COATINGS - AN OVERVIEW.** Emission regulations regarding VOC and energy conservation accelerated the creativity of the coatings industry and its scientists to develop and improve new technologies which would perform as well as or better than conventional solvent systems. Working with equipment manufacturers and users of coatings, several suppli-

## Plastics Applications

**086671 FEATURES OF THE ELECTROCHEMICAL STAGES OF FORMATION OF PROTECTIVE POLYMER COATINGS.** Polymer coatings applied to metal articles by electroprecipitation have elevated physical and mechanical properties and are superior to coatings prepared by traditional methods with respect to their protective properties. The high degree of organization of the supermolecular structure and uniformity of the polymer film, which is in turn due to and determined by the features of the electrochemical stages of the process, is one of the determining factors of the effect of the electroprecipitation parameters on the properties of coatings. The mechanism of the electrode reactions which take place in electrolysis of solutions of polymers was established in this study. Results indicate that the adhesion of the film to the metal increases and corrosion under the film is inhibited due to the surface activity of the pyridine ring. Addition of such modifying agents as dibutyl phthalate and butyl acrylate to the polymer system positively affects the elasticity and adhesion of the coatings to a copper base, which increases the time in service of the protected articles. The physical and mechanical properties of the electroprecipitated coatings are reported. 6 refs.

Barabanov, V.P. (S.M. Kirov Kazan Chemical Technology Inst, Kazan, USSR); Vyaseleva, G.Ya.; Torushev, D.M.; Konopleva, A.A. *J Appl Chem USSR* v 60 n 4 pt 2 Apr 1987 p 844-848.

**Porosity** See ELECTROPLATING; METALS AND ALLOYS—Protective Coatings.

**Powder** See Also ALUMINUM AND ALLOYS—Protective Coatings; AUTOMOBILE MANUFACTURE—Finishing; CARBON STEEL—Protective Coatings; METAL FINISHING; NYLON POLYMERS—Applications; OVENS, INDUSTRIAL—Convection; SPRAY GUNS; STEEL—Protective Coatings.

**086672 BUMPER COATING BACK ON TRACK.** When the management of Flex-N-Gate Corporation,



ers developed compliance coatings which are now used worldwide. The article briefly describes recent commercializations and developments and end-use applications, how the technology responded to the needs of a customer and what performance benefits each brought to the user.

Bolek, Bernice (Glidden Co, Cleveland, OH, USA). *Met Finish* v 86 n 5 May 1988 p 33-35.

**086684 HEALTH AND SAFETY CONSIDERATIONS FOR POWDER COATINGS.** According to the author, powder coatings are safer than solvent-based liquid paint coatings. The hazards which may be involved in the application of coating powders come under the general headings of toxicity and health hazards; fire and explosion hazards; and electrical hazards and electrical shock; and hazards in handling. Each of these topics is discussed.

Ruzicka, F.C.J. *Corros Prev Control* v 35 n 2 Apr 1988 p 31-35.

**086685 SATURATED POLYESTERS USED IN POWDER COATING.** Mixtures of carboxylated polyester and epoxy resins as hardener are largely used for domestic appliances, heating and air-conditioning units, computers, car accessories, etc, where outdoor resistance is not the dominant factor. Exterior PU powders have been replaced by mixtures of carboxylated polyesters and a special epoxide containing compound. This system does not give any volatile by-product during baking and has excellent outdoor resistance confirmed by more than 10 years outdoor exposure. The article gives market size and growth projections to 1990. 9 refs.

Merck, Yves (UCB (Chem) Ltd). *Corros Prev Control* v 35 n 2 Apr 1988 p 36-40.

**086686 PULVERLACK: EINFLUSS VON BINDEMITELEN UND PIGMENTEN AUF DEN KORROSIONSSCHUTZ.** [Powder Coatings. Effect of Binders and Pigments on Corrosion Protection.]. Rather than focus on the general processes of corrosion, which are sufficiently familiar from coating chemistry, this article takes a look at the recipe composition of powdered corrosion protection systems. The latter differ greatly from 'wet' compositions, as special influences can be exerted when processing electrostatic powder coats. (Edited author abstract). In German.

Weigel, Kurt. *Metalloberflaeche* v 42 n 7 Jul 1988 p 333-339.

**086687 LOWER TEMPERATURE CURE POWDER COATINGS.** Current state of the art in lower temperature cure powder coatings technology offers products with functional performance characteristics and aesthetic properties consistent with standard cure materials. Most functional and aesthetic requirements can be met or exceeded with low temperature cure powders. A number of factors dictating the use of low temperature cure powders are cited, including energy conservation.

Sandor, Timothy L. (Pratt & Lambert, Buffalo, NY, USA); St. John, James J. *Met Finish* v 86 n 8 Aug 1988 p 38-39.

**086688 POWDER COATINGS AND THEIR USES.** Today, powder coatings can be utilized for almost any application where steel, galvanized steel or aluminum is the substrate. Present-day thermoset powder coatings technology is rivaling all but the most specialized industrial liquid applications. Thermoset powder coatings are classified into five basic chemical groups: epoxy, epoxy-polyester (commonly referred to as hybrid), polyester-urethane, TGIC-polyester, and acrylic. The specific uses for each chemistry are varied, and often 'cross-over' depending on customer specifications and performance criteria.

Gill, Debra E. (O'Brien Corp, Houston, TX, USA). *Met Finish* v 86 n 8 Aug 1988 p 41-42.

**086689 NEW FLAVEL LEISURE COMPONENT FINISHING PLANT EXCEEDS EXPECTATION.**

Major plant modifications involving refurbishment and re-equipment of the product finishing facilities were completed during the two weeks annual shut-down at Flavel-Leisure manufacturing in Royal Leamington Spa. This necessitated stripping out old pre-treatment and finishing equipment including ovens, booths and conveyors and the laying down of new production flow lines and the installation of the latest design of powder coating equipment. The Company's products include gas and electric stoves.

Anon. *Prod Finish (London)* v 41 n 8 Aug 1988 3p.

**086690 THIN FILM POWDER COATING.** The increasing worldwide demand for powder coatings is due mainly to the continuous development of products which meet more stringent environmental legislation, give greater chemical and corrosion resistance and yet show cost benefits when compared with other surface coatings. This paper deals with one aspect of product development - thin film powder coatings. The topics covered are formulation, manufacture, application and reclamation.

Ingleston, R. (Ferro Drynamels Ltd, Engl). *Prod Finish (London)* v 41 n 8 Aug 1988 p 15-16.

**086691 MANAGEMENT OF POWDER RECOVERY.** Powder coating is the fastest growing and is becoming the most technically advanced of paint finishing technologies. It is estimated that 93,000 tonnes of powder will be used in Europe in 1988 - a market of £230m, and this will increase £400m at today's prices by 1995. The largest percentage growth will take place in the UK where the tonnage will increase from 13,000 this year to 26,000 tonnes in 1995. A crucial factor in the operation of large powder coating plants is to recover oversprayed powder efficiently and reuse it. The article discusses transfer efficiency, correct jigging, computer control and cyclone separation.

Craine, Ken (Itep (UK) Ltd, Croydon, Engl). *Prod Finish (London)* v 41 n 8 Aug 1988 p 18-20, 30.

**086692 TECHNICAL NOTE: IMPROVED UNIVERSAL POWDER MASS FLOW CONTROL FOR THERMAL SPRAY APPLICATIONS.** In thermal spray, a major cause of inconsistent coating quality is the inability of the typical powder feeder to deliver powder at a constant rate. A higher degree of consistency has been achieved by monitoring powder mass flow while making adjustments via closed-loop analog control. Screw and meter-wheel powder feeders were used at powder mass flow rates from 2 to 10 lb h<sup>-1</sup> (15 to 76 g min<sup>-1</sup>). Experiments were conducted with powders having various particle size distributions, densities and morphologies. The results of the data obtained are reported using standard deviation calculations. (Edited author abstract)

Crawmer, D.E. (Battelle Columbus Div, Columbus, OH, USA); Bartoe, R.L.; Kramer, J. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 353-365.

**086693 NEW TYPE OF ATOMIZED COATING POWDER FOR PROTECTION AGAINST WEAR AND CORROSION.** This paper discusses a new type of nickel-base alloy, the properties of which are governed by the presence of a complex ternary boride. This boride has a face-centered cubic structure and a composition range of Ni<sub>20-21</sub>M<sub>2-3</sub>B<sub>6</sub>, where M is a group IV-Va metal used as a stabilizer. Optimized alloys were chosen for powder production via vacuum melting and inert gas atomization. Finally, high quality powders ready for industrial application in various spraying techniques were made available. The paper discusses the properties of the alloys with regard to wear resistance, oxidation behavior and corrosion. (Edited author abstract) 9 refs.

Lugscheider, E. (RWTH Aachen, Aachen, West Ger); Krautwald, A.; Eschnauer, H.; Wilden, J.; Meinhardt, H. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 273-284.

## Production

**086694 THERMAL SPRAYING FROM ART TO SCIENCE.** Thermal spray coatings have been in use for over eighty years, and this paper traces the growth of the process. The author discusses various systems of thermal spraying, including flame spraying, arc spraying, plasma spraying, flame shock spraying and spraying with condenser energy. The author also reviews three versions of combustion metal powder spraying.

Haywood, David M. (UTP Welding Materials). *FWP J* v 27 n 12 Dec 1987 7p between p 21 and 32.

Pulverization See WEAR OF MATERIALS—Protection.

Quality Assurance See COPPER PLATING—Power Supply.

Quality Control See Also ALUMINUM AND ALLOYS—Anodic Oxidation; ELECTROLESS PLATING—Nickel; PAINT—Manufacture; WIRE—Enameling.

**086695 NEW, PORTABLE ORANGE PEEL METER FOR PAINT COATINGS.** A simple and easy-to-operate instrument has been developed to measure the degree of distortion of a reflected image related to orange peel. The orange peel meter has the following features: the reproducibility is within  $\pm 2\%$ ; the correlation factor between the physical and visual evaluation is 0.98; and the measuring time is 0.1 sec. The meter measures  $10.5 \times 20.5 \times 31$  cm, and weighs 3.3 kg. (Author abstract) 3 refs.

Matsuta, Morihiro (Toyota Central R&D Lab Inc, Jpn). *J Coat Technol* v 59 n 754 Nov 1987 p 61-64.

**086696 ZERSTÖRUNGSFREIE MESSUNGEN UND UNTERSUCHUNGEN AN LACKSCHICHTEN.** [Nondestructive Measurements and Inspections of Paint Coatings]. This article presents some equipment, devices and procedures used for measuring the thickness of paint coatings and for detecting pore formation. It is shown that the coating thickness can be reliably measured by the magnetic adhesion force method, the magnetic induction method and the eddy current method, while pores can be detected with the aid of a high-voltage testing device. In German.

Nix, Hans F. *Metallberflaeche* v 41 n 12 Dec 1987 p 580-582.

Radiation Effects See POLYMERS—Radiation Damage.

## Refractory Materials

**086697 CONTRIBUTION TO THE INVESTIGATION OF TITANIUM NITRIDE LAYERS: (PVD TECHNIQUE).** The most important criteria for maintaining the quality of physical vapor deposited TiN coatings on cutting tools are discussed, and it is demonstrated how and with which methods of metallographic and electron-microscopic investigation it is possible to check and assess them. Using a number of examples taken from actual service, it is shown how these methods of investigation complement one another and, in particular, how useful scanning electron microscopy can be for the evaluation of the quality of such coatings and the analysis of defectively coated components. In German and English. 3 refs.

Schwarz, Helmut (Daimler-Benz AG, Stuttgart, West Ger). *Prakt Metallogr* v 24 n 6 Jun 1987 p 257-267.

**086698 EROSION OF HARD MATERIAL COATING SYSTEMS.** The use of coating systems to protect structural metal surfaces from elevated-temperature, small-solid-particle erosion and erosion-corrosion can extend component life and permit operation in more severe environments. The room and elevated-temperature erosion behavior of several hard material coating systems, i.e., carbides, borides and nitrides, were determined over



a range of test conditions. Particle velocities from 70 to 150 m s<sup>-1</sup> and test temperatures from 25 to 540°C were used. Mechanisms of erosion were established and related to erosion rates in a manner that defined the requirements of composition, morphology and defect levels of coating systems for long-term performance. It was determined that small grain size, low porosity and absence of cracks were the microstructural features that enhanced erosion resistance. Hardness levels and the composition and distribution of second-phase, hard particles had less effect on coating performance. (Edited author abstract) 7 refs.

Levy, Alan V. (Lawrence Berkeley Lab, Berkeley, CA, USA); Wang, Buqian. *Wear* v 121 n 3 Feb 1 1988 p 325-346.

**Reliability** See COATINGS—Chromate.

**Reviews** See Also SHIPS—Protective Coatings.

**086699 STATUS OF PROTECTIVE COATING AND LINING IN THE INDUSTRY IN INDIA - AN OVERVIEW.** The authors describe various advancements in India in the field of protective coatings and linings through development of organic materials and how they have been adopted by Indian industries. The article refers specifically to epoxy resin-hardener systems and bitumen-filled and unfilled rubber and brick. (Edited author abstract)

Gupta, V.S. (Projects & Development India Ltd, India); Ghosh, P.K.; Guhasarkar, D.K. *Key Eng Mat* v 20-28 pt 1-4 1988, 10th Int Congr on Met Corros, Madras, India, Nov 7-11 1987 pt 2, p 1035-1044.

**Selection** See Also BRIDGES, HIGHWAY—Protective Coatings; MARBLE—Protection; PAINT—Selection.

**086700 MATCHING COATINGS WITH ENVIRONMENT.** Successful coating specifications are founded on a basic understanding of coatings technology. Three major categories of exposures - light, moderate, and severe - have been identified as predominant in plant environments, and a selected group of coatings have been found most suitable for these exposures. The coatings most frequently used in these environments include water-based acrylic, alkyd, silicone alkyd, chlorinated rubber, epoxy, coal tar epoxy, polyurethane, vinyl, and zinc rich. The article discusses characteristics of these coatings and factors to consider in applying them in the various environments.

Riders, Zig (Sherwin-Williams Co, Cleveland, OH, USA). *Plant Eng (Barrington Ill)* v 41 n 21 Nov 12 1987 p 92-94.

**086701 SELECTION AND USE OF PROTECTIVE COATINGS FOR WATER STORAGE AND WASTE TREATMENT FACILITIES.** A good protective coating job in a water or wastewater treatment plant requires the teamwork of several people: the engineer, the applicator, the coatings manufacturer, and the inspector. A good specification means better bidding, better job timing, and compatibility of shop coatings and field paints. Although water and wastewater plants are alike in many ways, they are quite different in their effect on a coating system. The wastewater plant is generally far more difficult to protect with a paint system. Generally speaking, any coating system that will give good service in a wastewater treatment plant will, in a similar exposure, give good service in a water treatment plant. But the reverse is not always true, because certain gases, acids, oils, greases, and soaps are present in the sewage works exposure that are not normally present in the water works.

Delany, Thomas P. (Valspar Corp). *J Prot Coat Linings* v 3 n 5 May 1986 p 22-29.

**086702 PROPRIETES PRISES EN COMPTE POUR LE CHOIX D'UN REVETEMENT. PERFORMANCES ET LIMITATIONS DES PRINCIPALES METHODES INDUSTRIELLES DE DEPOT.** [Properties Taken into Account for the Selection of a Coating. Performance and Limitation of Industrial Deposition Methods]. The following properties normally taken into

consideration are: structural properties (composition texture, porosity, adherence), geometric properties and mechanical properties. Phase vapor deposition and chemical vapor deposition and other electrochemical and chemi-cotautocatalytic methods are considered. In French.

Dore, R. (CERES, Romainville, Fr). *Vide Couches Minces* v 41 n 230 Jan-Feb 1986, C R des Journ d'Etude sur les Depots Ioniques, Limoges, Fr, Sep 25-26 1985 p 109.

## Silicones

**086703 PROPERTIES OF HIGH TEMPERATURE SILICONE COATINGS.** For purposes of this article, high temperature service is defined as 200 F to 1200 F. Within this extremely broad range, 12 general categories of coatings effectively meet high temperature needs and most employ silicone resins in some form. Silicone resins for high temperature coatings are usually a mixture of organic groups attached to silicone atoms. While there are many factors that can contribute to a coating's resistance to high temperatures, the primary reason why silicone atoms are effective in this service is their excellent bond energy, or energy required to break down their chemical bonds. Silicon-oxygen bonds, for example, are far superior in strength than carbon-carbon bonds, so therefore they stand up to heat and ultraviolet light for a much longer period of time before disintegrating.

Finzel, William A. (Dow Corning Corp). *J Prot Coat Linings* v 4 n 8 Aug 1987 p 38-43.

**Spectroscopic Analysis** See Also METALS AND ALLOYS—Protective Coatings; WIRE—Coatings.

**086704 AUGER ELECTRON SPECTROSCOPY AND RUTHERFORD BACKSCATTERING SPECTROSCOPY STUDIES OF TIN AND TIC COATINGS PREPARED BY THE ACTIVATED REACTIVE EVAPORATION PROCESS.** TiN<sub>x</sub> and TiC<sub>x</sub> films were deposited by the activated reactive evaporation process under different process conditions. The films were studied by Auger electron spectroscopy and Rutherford backscattering spectroscopy (RBS); standards were used for both techniques. The RBS techniques showed low sensitivity to carbon and nitrogen when 1.8 MeV He<sup>+</sup> ions were used. The sensitivity was enhanced by using 1.5 MeV H<sup>+</sup> ions, but the resulting non-Rutherford scattering necessitated the use of standards although RBS is potentially a standardless method. A correlation was found between the chemical composition of TiN<sub>x</sub> and TiC<sub>x</sub> films and the partial pressures of N<sub>2</sub> and C<sub>2</sub>H<sub>2</sub> respectively. (Author abstract) 16 refs.

Kaufherr, N. (Argonne Natl Lab, Argonne, IL, USA); Fenske, G.R.; Busch, D.E.; Lin, P.; Deshpande, C.; Bunshah, R.F. *Thin Solid Films* v 153 Oct 26 1987, Paper Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 149-157.

**086705 CATHODIC DELAMINATION OF EPOXY/POLYAMIDE COATINGS FROM STEEL.** X-ray photoelectron spectroscopy (XPS) has been used to determine the mechanisms responsible for the debonding of epoxy/polyamide coatings from steel during cathodic delamination in 3.5% aqueous NaCl solutions. Failure always occurred near the interface between the coating and the oxide. The nitrogen content of the free surface of the as-prepared coating was about 10%. However, the nitrogen content of the free surface dropped to only 5% after exposure to 1N NaOH for four weeks and that of the coating failure surface after cathodic delamination was only about 2%, implying that the failure involved degradation of the polyamide curing agent by hydroxide ions formed at the steel surface by the reduction of oxygen. (Edited author abstract)

Horner, M.R. (Univ of Cincinnati, Cincinnati, OH, USA); Boerio, F.J. *Surf Interface Anal* v 11 n 6 Apr 1988, Proc of the 9th Symp on Appl Surf Anal, Dayton, OH, USA, Jun 3-5 1987 p 403.

**Sputtering** See Also BEARINGS—Design; LUBRICANTS—Solid Films; TITANIUM COMPOUNDS—Thin Films.

**086706 FUNDAMENTALS OF THE FORMATION OF PROTECTIVE AND REPAIR COATINGS BY ELECTRIC ARC SPRAYING OF POWDER WIRES.** An investigation was made of certain general aspects of application on steel of repair and protective coatings of powder wires by electric arc spraying. Basic principles of selection of the composition of mixtures for powder wires and of formation of coatings are outlined. The influencing of fineness of the original powders of the mixture on particle size distribution of the coating, and the condition of formation of the metal-air stream are discussed. The properties of coatings applied from powder wires are described. 7 refs.

Pokhmurskii, V.I. (Acad of Sciences of the Ukrainian SSR, Lvov, USSR); Student, M.M.; Pikh, V.S. *Sov Mater Sci* v 22 n 6 Nov-Dec 1986 p 548-553.

**086707 MODIFICATION OF SURFACE MORPHOLOGY OF SOLIDS BY ION-BEAM SPUTTERING.** It is the purpose of this letter to present and discuss the main questions concerning this problem, i.e. to give a relatively full picture of what author calls the modification of surface morphology of solids by ion-beam sputtering. It seems that the problem of ion-bombardment modification of surface morphology of solids with its various aspects is very interesting and important from the theoretical point of view, as well as very promising from the practical applications point of view. Therefore further studies in this field are necessary. 10 refs.

Kowalski, Zbigniew W. (Technical Univ of Wroclaw, Wroclaw, Pol). *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1083-1085.

**086708 EIGENSCHAFTEN AUFGESTAUBTER SCHICHTEN AUS ALUMINIUMLEGIERUNGEN, TEIL 1.** [Properties of Sputtered Aluminum Alloy Coatings]. With the aid of high-frequency magnetrons aluminum alloys with or without organic additives can be sputtered onto any desired substrate surface at rates up to 20 nm/sec. In this paper, a summary is given of studies carried out to establish whether these coatings, from the standpoint of their friction behavior and their corrosion protection efficiency, can be used for the surface treatment of screws. In German.

Schils, H.W.; Raub, Ch. J.; Gmund, Schwabisch; Frey, H. *Metallberflaeche* v 42 n 6 Jun 1988 p 289-292.

**086709 RF OSCILLATIONS IN dc PLANAR SPUTTERING MAGNETRONS.** Many types of oscillations are possible in magnetized plasmas. Two frequencies were observed corresponding to waves travelling along and across the magnetic field lines. Measurements of these frequencies gave a value for the electron density of  $2 \times 10^{15}$  m<sup>-3</sup>. The waves travelling along the field lines only occurred with low magnetic field strengths and high magnetron currents. Low magnetic field strengths should be avoided when designing magnetrons for use at high currents. (Edited author abstract). 4 Refs.

Spencer, A.G. (Loughborough Univ of Technology, Loughborough, Engl); Howson, R.P. *Vacuum* v 38 n 6 1988 p 497-498.

**086710 HIGH RATE REACTIVE SPUTTERING PROCESS CONTROL.** Reactive sputtering is usually a slow process because the reactive gas interacts with the target, and in this poisoned state the deposition rate drops off. Pulsing the reactive gas led to improvements in the reactive deposition rate. At fast pulsing rates (0.2 s on, 0.2 s off), the reactive deposition rate for TiN is almost the same as that for metallic titanium, but control of the process is difficult. Implementation of closed-loop feedback control systems using the nitrogen peak height (partial pressure) from a mass spectrometer as the control



signal to the reactive gas mass flow controller brought the process under control and also removed the need for pulsing. (Edited author abstract) 19 refs.

Sproul, William D. (Borg-Warner Research Cent, Des Plaines, IL, USA). *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 73-81.

**086711 REACTIVE MAGNETRON SPUTTERING OF TIN: ANALYSIS OF THE DEPOSITION PROCESS.** The pumping speed of the vacuum system and the location of the gas inlet are two parameters which play a prominent part in the production of titanium nitride by reactive magnetron sputtering. In general it is observed that as the nitrogen flow is progressively introduced into the plasma there is an abrupt increase in the total system pressure. This disturbing, albeit slowly reversible, phenomenon, which corresponds to the rapid formation of nitride on the entire target surface, has to be minimized in order to obtain easier control of the coating process. In this transition zone it is possible to obtain a more progressive variation of the total pressure by locating the nitrogen inlet next to the pumping device and/or by increasing the pumping speed. In this way, the nitriding process appears to be rapidly reversible, and the resulting nitride composition undergoes very slow variation with an increasing nitrogen flow rate. (Edited author abstract) 6 refs.

Danroc, J. (CEA, Grenoble, Fr); Aubert, A.; Gillet, R. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 83-90.

**086712 TECHNICAL NOTE: CRYOGENIC VACUUM PUMP CHARACTERISTICS IN REACTIVE MAGNETRON SPUTTERING PROCESSES.** The purpose of this study is to investigate the effect of pumping system characteristics using a standard CVI TM150 size cryogenic pump on the profile of the cathode discharge with respect to  $O_2$  percentage.  $TiO_x$  films were deposited reactively at discharge power levels of 1.0 kw, 2.0 kw and 4.0 kw respectively for  $P_{tot}$  levels of 1.0 mTorr and 2.0 mTorr. A direct comparison with oil diffusion pumping was obtained by replacing the cryogenic pump with a Varian VHS6 oil diffusion pump and repeating the test depositions at the previously stated discharge power levels. (Edited author abstract) 5 refs.

Taylor, K.A. (CVI Inc, Hilliard, OH, USA); Wan, C.T.; Susi, G.T.; Chambers, D.L. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 379-391.

**086713 TECHNICAL NOTE: DESIGN AND PERFORMANCE OF A MOVABLE POST-CATHODE MAGNETRON SPUTTERING SYSTEM FOR MAKING PBFA II ACCELERATOR ION SOURCES.** This paper primarily addresses the design of a post-cathode sputter deposition system designed specifically to deposit films for the PBFA II ion diode source. A post-cathode magnetron sputter deposition system is described for depositing one-, two- or three-layer coatings with uniform thickness and film properties on the inside of a cylindrical substrate. The system uses a unique movable post-cathode which allows the substrate to remain stationary during the deposition process. Film stress is controlled by cycling the sputtering pressure during the sputter deposition process. 22 refs.

Mattox, D.M. (Sandia Natl Lab, Albuquerque, NM, USA); Cuthrell, R.E.; Peeples, C.R.; Dreike, P.L. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 425-432.

**Standards** See METAL FINISHING—Quality Control.

**Stresses** See Also CYLINDERS—Stresses; GAS TURBINES—Blades; METALS AND ALLOYS—Protective Coatings.

**086714 METHOD AND RESULTS OF CHECKING THE STRESSED STATE OF SURFACE LAYERS**

**WITH COATINGS.** On the basis of a mechanical method, highly efficient means are developed for determining residual stresses in surface layers with coatings during the continuous etching of coating and substrate. Results are given for an investigation into the dynamics of residual stresses in a coating and substrate during the surface preparation process and detonation depositing of tungsten carbide onto a titanium alloy. (Author abstract) 6 refs.

Karasev, B.E.; Merkulova, N.S. *Sov Mach Sci* n 2 1987 p 99-101.

**Stripping** See Also GALVANIZED METAL—Corrosion.

**086715 PLASTIC BLAST MEDIA. AN ALTERNATIVE TO CHEMICAL STRIPPING.** Of the estimated 300 million-plus tons of hazardous waste produced annually in the United States, a notable portion derives from the chemical stripping agents methylene chloride and phenol compounds, widely used by both military and commercial operations. Together, they generate one-billion gallons of wastewater and 30-million gallons of hazardous solid wastes. Some industries have been searching for non-chemical alternatives since the mid-1970's. Lasers, carbon dioxide pellets and flash lamps were explored for their possibilities as substitutes, along with the more common methods of hand and power disc sanding. To varying degrees, each method proved either overly costly, ineffective, or damaging to the substrate. Abrasive blast cleaning seemed to hold the most promise.

Duhnkrack, George B. *Pollut Eng* v 19 n 12 Dec 1987 p 54-57.

**Structure**

**086716 MONTE CARLO SIMULATION OF THE LAMELLAR STRUCTURE OF THERMALLY SPRAYED COATINGS.** The structure of thermally sprayed coatings is principally characterized by its lamellar nature and more or less high porosity. This structure is created by impacting molten or highly plastic particles on the substrate surface or existing partial coating. The process by which discrete molten particles impact at random points within a surface area can be simulated using the Monte Carlo method. An appropriate computation model is presented. Structural parameters such as the size of the lamellae, their orientation with respect to the substrate surface and the variation in lamellar orientation over the coating cross-section are determined using simulated coating structures. The impact energies of the spray particles at the moment of impact serve as input data to the model. The results of simulation can be used to interpret phenomena observed in real plasma-sprayed coatings such as substrate-near crack propagation in adhesive strength tests and energy-dependent adhesive strength test values. (Author abstract) 15 refs.

Knotek, O. (RWTH Aachen, Aachen, West Ger); Elsing, R. *Surf Coat Technol* v 32 Dec 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 1, San Diego, CA, USA, Mar 23-27 1987 p 261-271.

**Surfaces**

**086717 APPLICATION DES DEPOTS IONIQUES A LA PROTECTION DES OUTILS DE COUPE.** [Application of Ionic Deposits for Protection of Cutting Tools]. Ion plating and its tribologic applications require the preparation of surfaces. The complexity of problems connected with specification is described and an example of protection coatings for cutting tools is considered. In French.

Bergmann, E. (Balzers, Liechtenstein); Vogel, J. *Vide Couches Minces* v 41 n 230 Jan-Feb 1986, C R des Journ d'Etude sur les Depots Ioniques, Limoges, Fr, Sep 25-26 1985 p 111-116.

**Synthesis**

**086718 HYDROCARBON SOLVENTS IN HIGH SOLIDS COATINGS.** In this paper, alkyd and polyester

high solids coatings formulated with a combination of aromatic hydrocarbon and oxygenated solvents are compared to the same coatings formulated only with oxygenated solvents. The properties investigated were solubility, volatile organic compound (VOC) content, viscosity, rheology, sprayability, and final film properties. It was found that substituting hydrocarbon solvent for some of the oxygenated solvent reduced the viscosity and volatile organic compound content of the high solids coatings without compromising performance. The substitution also substantially reduces cost; aromatic solvents cost about \$2.00 per gallon less than the oxygenated solvents they replace. (Edited author abstract) 3 refs.

Albaugh, E.W. (Chevron Research Co, Richmond, CA, USA); Chiozza, R.F.; Pecoraro, J.M. *J Coat Technol* v 59 n 754 Nov 1987 p 75-85.

**Testing** See Also COATINGS—Degradation; COATINGS—Organic; ELECTRIC CONTACTS—Electroplating; GLASS—Coatings; GOLD PLATING—Reliability; PETROLEUM PIPELINES—Corrosion Protection.

**086719 ESTABLISHING A USER'S LABORATORY FOR EVALUATING PROTECTIVE COATINGS.** This article is intended, first, to identify the major reasons for maintaining a coatings user laboratory; second, to describe how to establish a laboratory; and finally, to review the testing functions that can be carried out. A number of strategies must be employed to protect the assets of structures and coatings systems, such as assuring quality of workmanship, which can be accomplished by having good job specifications, by careful prequalification of contractors, and by rigorous inspection of work in progress. Assuring the performance capabilities and the quality of paint materials is the principal function of a coatings laboratory. 1 ref.

Hendry, C. Malcolm. *J Prot Coat Linings* v 4 n 7 Jul 1987 p 34-40.

**086720 STOSSBEANSPRUCHUNG BEI DUEN-NEN BESCHICHTUNGEN.** [Impact Testing of Thin Coatings]. Impact tests with steel balls with a diameter of 4.3 mm on various automotive coatings have been carried out using an apparatus constructed at the German Federal Institute for Materials Testing. The influence of various test parameters, especially the coating thickness and the temperature, on the size of the flaked area was investigated, with allowance for the glass transition of the coatings and also the influence of the support. The influence of the impact velocity is also demonstrated by means of SEM photos. (Edited author abstract) 5 refs. In German.

Sickfeld, Juergen; Raabe, Hans-Joachim. *Materialpruefung* v 29 n 7-8 Jul-Aug 1987 p 203-209.

**086721 COMPARATIVE ANALYSIS OF METHODS OF DETERMINING THE SEPARATING STRENGTH BETWEEN SPRAYED-ON COATINGS AND THE SUBSTRATE.** The separating strength between a sprayed-on coating and the substrate is one of the basic indices determining the durability of coated parts under real conditions. When the adhesive strength is determined by the method of the annular layer, the stress concentration is smaller than in tests using the pin method or an annular pin. The maximal stresses in the coating arise in the layers that are farthest from the base layer of the material. In order to prevent the sprayed-on material from getting into the gap between the ring and the substrate, the taper angle has to be kept within the limits 30-60°. 7 refs.

Puzryakov, A.F. (Moscow Technical Univ, USSR); Eremichev, A.N.; Garanov, V.A. *Sov Powder Metall Met Ceram* v 26 n 5 May 1987 p 425-429.

**086722 UNLUBRICATED SLIDING WEAR BEHAVIOUR OF NICKEL DIFFUSION-COATED Ti-6Al-4V.** Electroless Ni-P alloy was deposited onto a commercial Ti-6Al-4V substrate and diffusion-treated at 1123 K for 7 h. Unlubricated sliding wear tests were



performed in air using upper and lower disk-shaped specimens both rotating in the counter-clockwise direction with a relative sliding velocity of  $0.6 \text{ m s}^{-1}$  and loads of 2.5 - 5 kgf. Coated and uncoated specimens were tested against a counterface made out of heat-treated 52100 steel. The wear rate of the coated specimens was significantly lower than that of the uncoated specimens. Examination of the wear tracks, wear debris and subsurface structure indicated that these two materials wear by entirely different mechanisms. (Edited author abstract) 13 refs.

Lu, Guang-Xi (Jilin Inst of Engineering, Changchun, China); Liu, Jing-Rong. *Wear* v 121 n 3 Feb 1 1988 p 259-269.

**086723 WEAR AND FRICTION OF POLYVINYL CHLORIDE COATINGS UNDER FRETTING CONDITIONS.** The purpose of this study was to investigate the effects and interactions of load, frequency and amplitude of slip, humidity, and film thickness on the coating life and coefficient of friction of a 52100 steel ball oscillating on polyvinyl chloride coated 1045 steel disks. A two-level, five-factor experiment with two replicates per condition was performed. An analysis of variance of the film life indicated that 26 main effects and interactions were significant at the 99 percent level. Humidity was the most significant factor; at low humidity the mean film life was 15 times that at high humidity. Load and the interaction of load and humidity were the next most significant effects. The initial and final coefficients of friction were most significantly affected by the film thickness. (Author abstract) 19 refs.

Rorner, R.A.L. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Mabie, H.H.; Eiss, N.S. Jr.; Furey, M.J. *Tribol Trans* v 31 n 1 Jan 1988 p 98-104.

**086724 IS THIS YOUR PROBLEM?** With the introduction of BS 5750 and its widespread acceptance in the industry there is a greater awareness of the need for maintaining quality standards. While much of the emphasis of 5750 is on record keeping and traceability of goods and materials, there is still a need for regular checking of the quality of plated and painted deposits. The article briefly reviews methods of testing thickness and deposit quality.

Brown, Lawrie. *Finishing* v 12 n 4 Apr 1988 p 16.

**Thermal Effects** See Also ELECTRIC CONDUCTORS, WIRE—Soldering.

**086725 EFFECT OF THE RADII OF CURVATURE OF PARTS AND THE THICKNESS OF VITREOUS-ENAMEL COATINGS ON THERMAL STABILITY.** An analysis of failures of enameled chemical units showed that they often break down because of thermal stresses. Thermal fractures appear as a result of sharp heating or cooling of the walls of the enameled unit during use. An equation is derived which can be used to determine the value of the permissible pressure drop of the enameled equipment for a preassigned number of thermal-loading cycles (not less than 100) to fracture of the unit. Test results show that an increase of the thickness of the UES-300 coating from 0.9 to 2.5 mm with a temperature drop of 120-140°C does not significantly affect the decrease of the thermal stability. This effect is more significant at 160-200°C. The curves for determination of thermal stability of the coatings make it possible to estimate the permissible temperature drop of the wall of actual units. The thermal stability of UES-300 and UES-200 coatings at 100 thermal-loading cycles corresponds roughly to the value of the permissible temperature drop of walls of actual units included in technical specifications for enameled equipment. The results were used to develop standard STP 0181-118-82. 3 refs.

Kozlov, Yu.F.; Suchkov, V.I.; Nikitaeva, A.I.; Shapko, A.N. *Chem Pet Eng* v 22 n 11-12 Nov-Dec 1986 p 609-611.

**086726 TRANSIENT THERMAL LOAD EFFECTS ON COATINGS BONDED TO CYLINDRICAL SUBSTRATES AND CONTAINING CIRCUMFERENCE**

**TIAL CRACKS.** The effect of a transient thermal load on a coating which is bonded to a cylindrical substrate is analyzed using fracture mechanics by considering the presence of a circumferential edge crack normal to the inner boundary of the coating. The solution is obtained using the finite element method and is compared to the exact solution of the problem. The analysis is then used to show that smaller heat transfer rates at the boundary result in smaller stress intensity factors. For three different materials combinations, including two ceramic coatings on metal, the nondimensional stress intensity factor has a similar magnitude for short crack lengths, but varies appreciably as the crack length becomes longer. It is also determined that inner coatings result in smaller or comparable stress intensity factors than thicker ones. (Author abstract) 13 refs.

Kokini, K. (Purdue Univ, West Lafayette, IN, USA); Hornack, T.R. *J Eng Mater Technol Trans ASME* v 110 n 1 Jan 1988 p 35-40.

**086727 ELEVATED TEMPERATURE EROSION OF SELECTED THERMALLY APPLIED COATINGS.** Thermally applied coatings have exciting possibilities for reducing erosion, particularly under conditions of elevated temperature. This is the finding of the authors after a series of tests on selected thermally applied coatings. It should be considered that only a limited number of coatings were evaluated and that further work will be required to optimize the structure, property and processing of these palliatives. (Edited author abstract) 3 refs.

Wright, Graham (CSIR, S Afr); Haywood, Dave. *S Afr Mech Eng* v 38 n 3 Mar 1988 p 6.

#### Thermal Properties

**086728 PARTING COATING WITH SPECIAL PROPERTIES.** The strength of molding sand in the cold and heated states according to the results of standard tests is not identical to the strength of real molds and cores. The latter depends on the degree of compaction and the properties of the antipickup coatings. Resin mixtures at low heat stability of the binder have a tendency toward cracking, which leads to the formation of notching. It follows from the cited data that during operation of the mold under extreme conditions the strength of modern molding sands is inadequate and there is a need to strengthen them with a parting paint or by impregnation. On standard specimens the authors investigated the effect of parting paint (composition, parts by weight: binder 40, filler 58 and stabilizer 2) on the strength of resin (furan) and liquid glass mixtures for 24 hours and during prolonged storage. 1 ref.

Gulyaeva, T.B.; Velikanov, G.F.; Brechko, A.A. *Sov Energy Technol* n 1 1987 p 47-50.

#### Thermoanalysis

**086729 CALCULATING THE TEMPERATURE FIELD IN MULTILAYER PROTECTIVE COATINGS OF COMPOSITE MATERIALS IN DRY SLIDING FRICTION.** We pose and solve in general form the problem of the temperature field distribution in multilayer protective coatings of composite materials in dry sliding friction in the moderately loaded regime of operation. Numerical realization of the obtained model on a computer (with account for the experimental dependence of the composite material friction coefficient on the temperature) for a steel 45 versus composite bimetallic part confirmed the assumption on the oscillatory nature of the variation of the average surface temperature of the composite. Quantitative estimates of this process are given. (Edited author abstract) 6 refs.

Tsitin, A.I.; Belousov, V.Ya. *Sov J Frict Wear* v 8 n 3 1987 p 104-111.

**Thickness Measurement** See ALUMINUM AND ALLOYS—Anodic Oxidation; ALUMINUM AND ALLOYS—Protective Coatings.

**Thin Films** See Also SEMICONDUCTING SILICON—Protective Coatings.

**086730 CARACTERISATION DES SURFACES ET DES DEPOTS EN COUCHES MINCES PAR SPECTROMETRIE INFRAROUGE.** [Characterization of Surfaces and Coatings of Thin Films by Infrared Spectrometry]. We describe some applications of infrared vibrational spectroscopy to the study of coatings, thin deposits and surfaces, obtained by ion plating, plasma spray or chemical vapor deposition. We discuss more particularly by absorption the infrared determination of alpha alumina in plasma sprayed gamma alumina which is correlated with the parameters of the spraying process and with the mechanical properties, and used for electronic circuits and electrical insulation; by reflection the degree of orientation of the hexagonal sprayed polycrystalline chromium oxide used as low friction coefficient deposits, and thin films of ion plated indium oxide used as high quality transparent and conducting films; by Attenuated Total Reflectance the surfaces damages of polytetrafluoroethylene, sputter cleaned to achieve good adhesion properties with copper films. As a final step we point out the advantages offered by powders of high specific surface area: infrared spectroscopy can provide unique information concerning surface structure, adsorption sites and catalytic properties. (Author abstract) 34 refs. In French.

Quintard, P. (CNRS, Limoges, Fr); Gerbier, M.M.; Baraton, M.I. *Vide Couches Minces* v 41 n 230 Jan-Feb 1986, C R des Journ d'Etude sur les Depots Ioniques, Limoges, Fr, Sep 25-26 1985 p 91-96.

#### Vacuum Application

**086731 MANAGEMENT OF WATER VAPOR IN HIGH VACUUM SYSTEMS.** Water is the primary component of the atmosphere in almost all vacuum systems. Because of its negative effect on attainable pressure and its interference in process chemistry, it is crucial to understand the different sources of water in vacuum systems and the difficulty of removing it. In most applications, the limiting source is water adsorbed on vacuum chamber walls which clings tenaciously and evolves slowly. If atmospheric water vapor can condense and form puddles, this source may control attainable pressure and the water removal rate. In all cases, the use of high vacuum pumps with high net realized water vapor speed in the chamber is essential to improvements in both throughput and yield. 2 Refs.

Harvell, John (CTI Cryogenics Inc, Waltham, MA, USA); Lessard, Phillip. *Met Finish* v 86 n 7 Jul 1988 p 33-35.

**Vapor Deposition** See Also CERAMIC MATERIALS—Processing; CUTTING TOOLS—Woodworking; ELECTROPLATING; FILMS—Mechanical Properties; PLASMAS—Thin Films.

**086732 DUENNE BESCHICHTUNGEN ZUR FUNKTIONALEN GESTALTUNG TECHNISCHER OBERFLAECHE.** [Thin Coatings for Functional Formation of Technical Surfaces]. The technology of Physical Vapor Deposition (PVD) of wear- and corrosion-resistant coatings stands at the beginning of a promising future. Tool industry is the main area of industrial application for wear protecting PVD-coatings. Based on these experiences a number of new applications are in development. (Edited author abstract) In German. 14 refs.

Leyendecker, T. (CEMECOAT GmbH, Aachen, West Ger). *Sprechsaal* v 120 n 8 Aug 1987 p 668-672.

**086733 ON THE PROPERTIES OF PHYSICALLY VAPOUR-DEPOSITED Ti-AL-V-N COATINGS.** Since coatings of the Ti-Al-V-N system crystallize in an f.c.c. TiN structure, the alloying agents aluminium and vanadium have a significant influence on their physical and chemical properties. Microstructural, X-ray diffraction, microprobe and micrographic analyses confirm the importance of the aluminium and vanadium content of the multicomponent hard coating. In addition, wear tests with



coated tools show the effect of the alloying agents on the wear resistance of the coating. (Edited author abstract) 14 refs.

Knotek, O. (RWTH, Aachen, West Ger); Leyendecker, T.; Jungblut, F. *Thin Solid Films* v 153 Oct 26 1987, Pap Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 83-90.

**086734 TECHNICAL NOTE: OPTICAL PROPERTIES OF REACTIVELY EVAPORATED  $\text{SiO}_2$  FILMS.** In an industrial plant engineered for coating substrates  $1.8 \times 2.2$  m in size, we have evaporated  $\text{SiO}_2$  to produce interference layers and protective coatings. The distance between evaporator and substrate is 85 cm. In the residual gas the water vapor dominates as a reactive gas. Compared with arrangements with a shorter distance between evaporator and substrate, and oxygen as a reactive gas, these conditions brought about distinct variations in refractive index, ultraviolet transmission and absorption measured at a wavelength of about  $10 \mu\text{m}$  as far as their dependence on the impact ratio is concerned. These differences are attributed to chemisorption of the reactive gas component during the formation of the film. (Edited author abstract) 15 refs.

Schiller, S. (Forschungsinstitut Manfred von Ardenne, Dresden, East Ger); Beister, G. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 367-377.

**086735 OBTENTION ET CARACTERISATION DE DEPOTS REALISES DAN LE TERNAIRE Cr-C-N PAR PVD.** [Fabrication and Characterization of Depositions Realized in Ternary Cr-C-N by Means of PVD]. Coating in the Cr-C-N ternary system are deposited by reactive vapor deposition using an arc discharge. The structures of the films are closely related to the experimental parameters. (Author abstract) 17 refs. In French.

Cholv, G. (Etablissement Technique Central de l'Armement, Arcueil, Fr); Derep, J.L.; Michel, H.; Gantois, M. *Vide Couches Minces* v 41 n 230 Jan-Feb 1986, C R des Journ d'Etude sur les Depots Ioniques, Limoges, Fr, Sep 25-26 1985 p 71-75.

**086736 CARACTERISATION METALLURGIQUE ET TRIBOLOGIQUE DES REVETEMENTS ANTI-USURE DANS LE SYSTEME Ti-N OBTENUS PAR PVD IONIQUE.** [Metallurgical and Tribological Characterization of Protective Coatings in Ti-N Systems Obtained by Ionic PVD]. The thin film ceramic coatings are used more frequently to increase the protection resistance and to improve abrasion properties of metallic materials. Different aspects of metallurgical and tribological characterization of hard coatings in the Ti-N binary system elaborated by various PVD processes are presented. (Edited author abstract) 9 refs. In French.

Farges, G. (Etablissement Technique Central de l'Armement, Arcueil, Fr). *Vide Couches Minces* v 41 n 230 Jan-Feb 1986, C R des Journ d'Etude sur les Depots Ioniques, Limoges, Fr, Sep 25-26 1985 p 97-101.

**Water Borne** See Also COATINGS—Plastics; PAINTING—Robot Applications; SHIPS—Hulls.

**086737 WATER-BORNE COATINGS FOR INDUSTRIAL MAINTENANCE: PART I. REVIEW OF GOVERNMENT AND INDUSTRY EVALUATIONS.** Use of water-borne coatings is one of the major approaches for complying with increasing restrictions on the use of volatile organic compounds. Water-borne coatings offer definite advantages for light to moderate duty maintenance, and show some potential for eventual use in heavy-duty maintenance application. Water-borne coatings will probably never completely afford all the advantages in terms of application and formulation latitude of solvent-borne coatings. In the last five to ten years, however, there have been enormous strides made in the application and performance properties of these systems. Similar improvements are expected in the next decade. 11 refs.

Appleman, Bernard R. (Journal of Protective Coatings & Linings, Pittsburgh, PA, USA). *J Prot Coat Linings* v 3 n 10 Oct 1986 p 36-41.

**086738 WATER-BORNE COATINGS FOR INDUSTRIAL MAINTENANCE: PART II. RECENT EXPERIENCE WITH ACRYLIC MAINTENANCE FINISHES.** In a climate of regulatory pressures, the overall balance of properties that is available from water-borne finishes is receiving much attention. Based on positive statements from end users, commercial water-borne products are a viable option to consider when specifying coatings for the protection of steel structures. While experience has demonstrated that water-borne coatings can be effective for protection of steel in mild environments, this paper presents cases suggesting that recently developed water-borne coating materials may be suitable for more aggressive environments, such as chemical exposure in industrial plants. More information is needed, of course, to verify the promise suggested in these cases, but they call attention to the need for additional assessment of the range of capability to be found in current proprietary formulations. 2 refs.

Flynn, Roy W. (Rohm & Haas Co). *J Prot Coat Linings* v 3 n 10 Oct 1986 p 42-46.

**086739 WATERBORNE ADDITIVES: MAKING WATERBORNE COATINGS USER FRIENDLY.** This article is the concluding part of a series on water borne coatings. The author summarizes the technical factors on use of the coatings. Tables show the properties expected, classes of colloidal stabilizers and classes of rheology modifiers.

Athey, Robert D. Jr. (Athey Technologies, El Cerrito, CA, USA). *Met Finish* v 86 n 1 Jan 1988 p 35-37.

**086740 TWO BREAKTHROUGHS IN WATER-BORNE EMI/RFI COATINGS.** A breakthrough in the efficiency of waterborne conductive coatings has been reported for electromagnetic interference/radio frequency interference (EMI/RFI) applications. The innovation improves shielding at low coating thickness. The key to the breakthrough is in new proprietary ways to disperse fine powders containing nickel and other conductive materials. The high conductivity permits effective shielding with 2 mils of coating (dry film thickness). Conductivity of the coating is in the range of 0.02 to 0.9 ohm per square. Also discussed is a 'new generation' coating for EMI/RFI shielding of plastic housings containing electronic equipment.

Anon. *Ind Finish (Wheaton Ill)* v 64 n 6 Jun 1988 p 28.

**Wear** See Also COPPER AND ALLOYS—Friction; ELECTROLESS PLATING—Nickel; NICKEL AND ALLOYS—Chemical Vapor Deposition; POLYMERS—Wear; POWDER METALLURGY—Stainless Steel.

**086741 WEAR CHARACTERISTICS OF EUTECTIC-ALLOY GASOTHERMAL COATINGS.** We present the results of a study of the structure, phase composition, and antifriction properties of gasothermal coatings consisting of iron-base eutectic-alloy powders alloyed with aluminum and titanium. We note the hereditary nature of the morphology of the eutectic colonies of the powder and coating structure. It is shown that a characteristic feature of the failure of the eutectic-alloy gasothermal coatings in boundary friction is increase of the surface porosity, the value of which is determined by the degree of heterogeneity of the structure. (Author abstract) 12 refs.

Polishchuk, I.E.; Oliker, V.E.; Voitovich, V.B.; Goshtovt, I.V. *Sov J Frict Wear* v 8 n 3 1987 p 65-69.

**086742 COATING WEAR IN ELASTIC JUNCTIONS WITH VARIABLE CONTACT AREA.** We study theoretically the wear of a thin elastic coating with variable contact area and examine the cases of a foundation in the form of an elastic halfplane and a circular cutout in an elastic plane (sliding bearing). We identify the existence of a steady-state wear regime, when the pressure pattern takes a very definite form. On the basis of numerical analysis we substantiate the model with a rigid

shaft and bushing. (Author abstract) 7 refs.

Soldatenkov, I.A. *Sov J Frict Wear* v 8 n 2 1987 p 8-13.

**086743 WEAR RESISTANCE OF TWO-LAYER COATINGS IN LUBRICATED FRICTION.** We present the results of studies of the wear resistance and the friction coefficients of two-layer coatings with low melting Sn, Cd, Zn sublayers at varying temperatures and loads under lubricated friction conditions. The comparative studies show that thanks to the damping capability of the low-melting sublayer increase of the wear resistance of the outer coating layer (OCL) by 20-40% is possible. This makes it possible to recommend the two-layer coatings with low-melting sublayers for wide industrial use. (Author abstract) 6 refs.

Kupriyanov, I.L.; Genin, E.P.; Azizov, R.O. *Sov J Frict Wear* v 8 n 2 1987 p 129-132.

**086744 COATINGS APPLIED BY THERMAL SPRAYING AND THEIR WEARING BEHAVIOUR.** Coating applied by thermal spraying are of great practical importance. Their varied uses as a protection against wear suggests that a closer quantitative and qualitative investigation of wearing behaviour might be rewarding. This will be the subject of this report, taking examples of sliding and abrasive wear as illustrations. These comprise: a bronze/ $\text{Al}_2\text{O}_3$  model system with systematically varied proportions of hard material, molybdenum and tungsten carbide/cobalt standard coatings, and self-spreading nickel-chromium-boron-silicon coatings. (Author abstract) 15 refs. In German and English.

Sandt, Axel. *Schweissen Schneiden* v 38 n 4 Apr 1986 p E52-E54.

**086745 EVALUATION OF WEAR RESISTANCE AND ANTIFRICTION PROPERTIES OF  $\text{Pn85Yu15}$  POWDER MATERIAL PLASMA COATING IN FRICTION AGAINST A GALVANIC CHROMIUM COATING.** We present the results of experimental determination on specimens of the wear resistance and antifriction properties of  $\text{Pn85Yu15}$  powder-material plasma coating during operation in a friction pair with a galvanic chromium coating. The results are compared with a baseline friction pair variant: phosphated iron surface versus galvanic chromium coating. (Author abstract) 2 refs.

Gladyuk, N.V.; Gel'tman, I.S.; Oguenko, V.N.; Pron'kina, T.M.; Yarovenko, V.S.; Bagrova, T.P.; Lobachev, N.N. *Sov J Frict Wear* v 8 n 4 1987 p 106-108.

**086746 APPLYING WEAR RESISTANT COATINGS BY NEW TECHNIQUES.** To apply these coatings, a typical cross hatch pattern that might be used on the target area of a shute or on a bucket lip has been taken as an example for this discussion. Prices given are current examples for the UK market at the time of going to press. To sum up the cost of the deposit is four times greater using the traditional method and, in addition, does not have the abrasion resistant properties of the cored wire. 3 refs.

Jackson, Howard (Eutectic Co, Middlesex, Engl). *World Cem* v 19 n 4 Apr 1988 p 134-135.

**086747 EFFECT OF PROTECTIVE COATINGS UNDER THE EFFECT OF A GAS-ABRASIVE MEDIUM.** The paper discusses the results of studies of plasma coatings M1, M2,  $\text{PN55T45}$ ,  $\text{PN65T35}$  subjected to wear under the effect of a gas-abrasive medium. Wear regularities are established for coatings under varying angle of attack of the gas-abrasive flow of particles. The wear mechanism of porous coatings is compared with that of carbon steel 45. The relation between the wear rate of gas-thermal coatings and the level of their cohesion



strength is found. Recommendations are given on application of the investigated coatings subjected to the effects of gas-abrasive media. (Author abstract). In Russian.

Tushinskii, L.I.; Bataev, A.A.; Bataev, V.A.; Gel'tman, A.I.S. *Probl Prochn* n 5 May 1988 p 108-110.

**086748 WEAR-RESISTANT PROPERTIES OF PROTECTIVE LAYERS APPLIED TO THIN FILM METALLIC MEDIA.** Wear-resistant properties of inorganic protective layers applied to thin film metallic media are determined for several combinations of protective layer and sliding head materials. When a fluid lubricant is applied, medium durability tends to improve with increasing hardness of the protective layer material. Durability also depends on the slider material. (Author abstract) 2 refs.

Saito, S. (Hitachi Ltd, Kokubunji, Jpn); Futamoto, M.; Honda, Y.; Nishimura, T.; Yoshida, K. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2398-2400.

**Wear Resisting** See Also IRON AND ALLOYS—Protective Coatings; NICKEL PLATING; STEEL—Protective Coatings; TOOL STEEL—Protective Coatings.

**086749 OPTICAL INTERFERENCE EFFECT IN THE LASER CHEMICAL VAPOR DEPOSITION OF SiC.** Because it is an attractive material for use in selected area deposition of hard and wear-resistant coatings, SiC was chosen as a model for the investigation of compound growth via laser chemical vapor deposition (LCVD). In these experiments, the reactants consisted of SiH<sub>4</sub> plus CH<sub>4</sub> mixtures with various silicon-to-carbon ratios and the substrate was made of hot-pressed SiC. A continuous wave (c.w.) line-tunable CO<sub>2</sub> laser operating at 9.27 μm (single-mode, TEM 00) provided a beam of the desired characteristics for this particular deposition system. The initial stage of the macroscopic growth is generally accompanied by the formation of some isolated droplet-shaped islands across the irradiated site. Interacting with the incident beam, these surface features generate a surface electromagnetic wave (SEW). A coupling between this SEW and the primary beam results in an interference effect. A periodic substructure appears on top of the deposited films as the growth continues. This substructure upgrades the frictional characteristics of these wear-resistant coatings. (Edited author abstract) 3 refs.

Shapur, F. (Univ of Southern California, Los Angeles, CA, USA); Allen, S.D. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 49-51.

**086750 HARD COATINGS OF TiN, (TiHf)N AND (TiNb)N DEPOSITED BY RANDOM AND STEERED ARC EVAPORATION.** The conventional arc evaporation process with a random moving cathode spot was modified to minimize the ejection of solid particles from the cathode spot using steered arc evaporation. The TiN tool coatings (6-7 μm thick) deposited by in this manner showed about 42% lower flank and crater wear than did TiN coatings (6-7 μm thick) deposited random arc evaporation, and comparable flank and crater wear with TiC-TiN coatings (10 μm thick) deposited by chemical vapor deposition (CVD). Using steered arc evaporation, further improvements were obtained by depositing ternary coatings. (Edited author abstract) 8 refs.

Boelens, S. (Hauzer Techno Coating Europe BV, Venlo, Neth); Veltrop, H. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 63-71.

**086751 DEPOSITION AND PROPERTIES OF MULTICOMPONENT HARD COATINGS.** A systematic investigation of the properties of ternary nitrides and carbonitrides is presented. Alloys of titanium, zirconium, hafnium, vanadium, niobium, chromium and aluminum were selected for the preparation of targets. Coatings of ternary nitrides and carbonitrides, deposited by magnetron sputtering are examined. It was found by X-ray diffraction analysis that most of the deposits have cubic structures with a solid-solution distribution of the metal

atoms. Very hard coatings were obtained in the Hf-Ti-N and V-Ti-N systems. Zr-Ti-N coatings showed good resistance and performance in cutting tests. The results of the investigations show that coatings of this class of compounds exhibit properties well suited to providing cutting tools with better protection against wear. (Edited author abstract) 12 refs.

Koenig, U. (Krupp WIDIA GmbH, Essen, West Ger). *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 91-103.

**086752 KNOWLEDGE-BASED EXPERT SYSTEMS IN SURFACE COATING AND TREATMENT SELECTION FOR WEAR REDUCTION.** Most engineering failures occur because of surface initiated effects such as wear, corrosion and fatigue. Surface coatings and treatments specified at the design stage thus offer considerable potential to prevent failure and reduce costs. However, few design engineers possess the comprehensive knowledge needed to specify optimum surface coatings and there is no recognized procedure for selection which can be universally adopted. With the advent of computer systems which can manipulate and store large amounts of data at low cost, a solution to this problem is now at hand. We report the development of a knowledge-based computer system to aid the designer in this crucial area. The paper presents the methodology behind the coating/treatment selection process, and outlines the knowledge used at the various solution stages, emphasizing wear reduction. The main selection criteria are presented and the industrial application of the system is discussed. (Author abstract) 13 refs.

Syan, C.S. (Univ of Hull, Hull, Engl); Matthews, A.; Swift, K.G. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 105-115.

**086753 PERFORMANCE OF TIN-COATED TOOLS IN WOOD CUTTING.** The possibility of using titanium nitride (TiN) as a wear-resistant coating in wood cutting was investigated. Three types of TiN-coated tungsten carbide tipped circular saws were compared by sawing under normal production conditions. The thickness of the coatings varied from 0.7 to 1.0 μm. The sawn materials were hardboard, polyvinylchloride coated particleboard, waste paper based paperboard and plywood. Coated high speed steel (HSS) cutter heads were also tested in the cutting of spruce. All coatings were deposited by reactive triode ion plating. The coating reduced the wear on the rake face about 50% when sawing hardboard. (Edited author abstract) 6 refs.

Osenius, S. (Helsinki Univ of Technology, Espoo, Finl); Korhonen, A.S.; Sulonen, M.S. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 141-151.

**086754 CATHODE-SPOT ARC COATINGS: PHYSICS, DEPOSITION AND HEATING RATES, AND SOME EXAMPLES.** Cathodic arc coatings have found their way into industrial applications, particularly in using a titanium cathode in a low pressure nitrogen background gas to produce hard TiN coatings, which give superior wear protection to cutting tools. This paper reviews the basic physics of the cathode-spot arc, and applies the information available to frame simple models from which the deposition rate and energy flux can be estimated. The paper concentrates on the vacuum arc for which more extensive data are available. A preliminary rough model for the less researched case of a cathode-spot arc in a low pressure background gas is also presented. The models are illustrated with reference to laboratory cathode-arc coating experiments. 34 refs.

Boxman, R.L. (Tel Aviv Univ, Tel Aviv, Isr); Goldsmith, S. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 153-167.

**086755 FRICTION AND WEAR BEHAVIOUR OF**

**THERMALLY SPRAYED NICHROME-WC COATINGS.** Four types of nichrome-WC sprayed coatings (85%, 55%, 15% and 5% WC) were studied by means of Falex dry friction and wear tests. Significant sudden drops in the friction force were recorded; from the morphological study of the worn surfaces it was determined that these friction force variations correspond to the removal of WC particles. This interpretation was substantiated using a reliability model to estimate the mean lifetime of a WC particle and its surrounding media as a function of the experimentally determined frequency of the friction force drops, width of the wear scar and the diameter and density of WC particles. (Author abstract) 10 refs.

Lira Olivares, J. (Simon Bolivar Univ, Caracas, Venez); Grigorescu, I.C. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 183-190.

**086756 WEAR AND EROSION RESISTANCE OF HARD PVD COATINGS.** The abrasive and erosive wear behavior of titanium nitride coatings prepared using physical vapor deposition has been studied and the mechanism(s) by which the coatings fail identified and contrasted with those of uncoated material similarly treated. For abrasive wear it is not sufficient to consider only hardness as a guide to coating selection; it is also important to consider the load-bearing capacity of the coating/substrate system. Under erosion conditions it is found that thick coatings are more resistant to angular particle erosion while thin coatings have longer lifetimes when exposed to blunt erodents. (Edited author abstract) 37 refs.

Rickerby, D.S. (Harwell Lab, Didcot, Engl); Burnett, P.J. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 191-211.

**086757 MECHANICAL STRENGTH AND TRIBOLOGICAL BEHAVIOR OF ION-BEAM-DEPOSITED BORON NITRIDE FILMS ON NON-METALLIC SUBSTRATES.** An investigation was conducted to examine the mechanical strength and tribological properties of boron nitride (BN) films ion-beam-deposited on silicon, fused silica (SiO<sub>2</sub>), gallium arsenide (GaAs) and indium phosphide (InP) substrates in sliding contact with a diamond pin under a load. The results of the investigation indicate that BN films on non-metallic substrates, like metal films on metallic substrates, deform elastically and plastically in the interfacial region when in contact with a diamond pin. However, unlike metal films and substrates, BN films on non-metallic substrates can fracture when they are critically loaded. Not only does the yield pressure (hardness) of silicon and SiO<sub>2</sub> substrates increase by a factor of two in the presence of a BN film, but the critical load needed to fracture also increases. The presence of films on the brittle substrates can arrest crack formation. The BN film reduces adhesion and friction in the sliding contact. BN adheres to silicon and SiO<sub>2</sub> and forms a good quality film, but it adheres poorly to GaAs and InP. (Author abstract) 21 refs.

Miyoshi, Kazuhisa (Lewis Research Cent, Cleveland, OH, USA); Buckley, Donald H.; Pouch, John J.; Alterovitz, Samuel A.; Sliney, Harold E. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 221-233.

**086758 COATINGS FOR FRICTION AND WEAR CONTROL AT HIGH TEMPERATURES.** One way to achieve both the wear resistance of hard coat materials and low friction is to develop coating materials that are composites of hard materials for wear control and solid lubricants for friction control. Using this approach, a series of composite coatings (the PS200 series) was developed at NASA Lewis Research Center. The compositions contain chromium carbide for wear control, calcium fluoride-barium fluoride eutectic and silver for friction control, and nickel alloy binder. The optimized



coatings in this series are lubricative from room temperature (or lower) to 900°C in oxidizing or reducing atmospheres. (Edited author abstract) 4 refs.

Sloney, Harold E. (NASA Lewis Research Cent, Cleveland, OH, USA). *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 243-244.

**086759 CAVITATION-EROSION RESISTANCE OF ION PLATED Cr-TiN MULTILAYER COATING.** Ion plated Cr-TiN multilayer coatings showed good cavitation-erosion resistance. To determine the reason for this improved behavior, a detailed study of the deposition conditions was carried out. It was shown that the coating conditions for desired cavitation-erosion resistance depended on the surface roughness of the substrate, deposition temperature and substrate bias voltage. Strong adhesive force at the bonded layer, high compressive residual stress in the coating, and small grain size and proper preferred orientation of the coating were found to contribute to cavitation-erosion resistance. (Author abstract) 9 refs.

Odohira, T. (Mitsubishi Heavy Industries Ltd, Hiroshima, Jpn); Wada, T.; Ebara, R.; Kobayashi, T. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 301-308.

**086760 TECHNICAL NOTE: A GYRO SPIN AXIS BEARING PERFORMANCE USING TITANIUM CARBIDE COATED BALLS.** In the gyroscope bearings investigated the primary failure mode was lubricant thickening and hardening through an oxidation-polymerization process. Some of the intermediate compounds are ferro-organic, the iron being provided by the bearing balls and races from normal asperity wear. The bearing balls were replaced with balls having a titanium carbide coating applied by a chemical vapor deposition process as a means of preventing metallic wear by virtue of the high surface hardness and insolubility of TiC in iron. This scheme succeeded and wear was completely arrested thus interrupting the supply of free iron to the lubricant. Upon examination after operation for 5600 h there was no degradation of the lubricant found. (Author abstract) 3 refs.

Brown McKee, F. (Litton Industries Inc, Woodland Hills, CA, USA). *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 401-404.

**086761 COMPOSITION, STRUCTURE AND WEAR RESISTANCE OF Ti-6Al-4V IMPLANTED WITH CARBON OR BORON TO HIGH DOSES.** High-dose ion implantation of carbon or boron into Ti-6Al-4V alloy produced flat-topped concentration profiles indicating considerable solute redistribution. Carbon implantation produced precipitates of TiC, which became a continuous layer at the highest doses. This layer showed very high abrasion resistance, at least 70 times that of the substrate. Boron implantations generated increasingly dense layers of TiB<sub>2</sub> dispersed in amorphous titanium. Boron and lower-dose carbon provided appreciable increases in wear resistance (by about ten times). Wear of these ultra-adherent but thin layers (less than 300 nm) was not uniform. (Author abstract) 31 refs.

Bolster, R.N. (US Naval Research Lab, Washington, DC, USA); Singer, I.L.; Vardiman, R.G. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 469-477.

**086762 TRIBOLOGICAL BEHAVIOUR OF SOME ALLOYS AFTER SURFACE MODIFICATION USING ION BEAM TECHNIQUES.** Two types of ion beam surface modifications have been performed. (i) Superficial amorphization has been induced in an industrial NiTi shape memory alloy by direct ion implantation. A remarkable increase in the wear resistance and exceptional reduction in the friction coefficient has been observed for an implantation of  $3 \times 10^{17} \text{ N}^+ \text{ cm}^{-2}$ . (ii)

An FeAl coating 1  $\mu\text{m}$  thick on steel has been obtained by iron and aluminum evaporation simultaneously with argon ion irradiation. This coating significantly improves the tribological behavior of this steel and presents an exceptional adherence to the substrate, which is not so if the coating is performed without ion assistance. (Author abstract) 9 refs.

Moine, P. (Faculte des Sciences, Poitiers, Fr); Popoola, O.; Villain, J.P.; Junqua, N.; Pimbert, S.; Delafond, J.; Grilhe, J. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 479-486.

**086763 EFFECTS OF ION IMPLANTATION IN CEMENTED CARBIDES AND COBALT ALLOYS.** WC-Co cemented carbides and Co-W-C cobalt alloys were implanted with nitrogen. No significant change in microhardness and only a small decrease in transverse rupture strength were observed. An investigation with a transmission electron microscope revealed a high level of radiation damage. X-ray diffraction studies of implantation in Co-W-C show that the modified subsurface zone is thicker than the penetration depth of implanted nitrogen. Finally, the wear behavior of some implanted cemented carbide tools is presented. (Author abstract) 14 refs.

Koenig, U. (Krupp WIDIA GmbH, Essen, West Ger); Wolf, G.K. *Surf Coat Technol* v 33 Nov 1987, Pap Presented at the 14th Int Conf on Metall Coat - Part 2, San Diego, CA, USA, Mar 23-27 1987 p 501-509.

**Weathering** See Also COATINGS—Testing; CONCRETE—Protective Coatings.

**086764 NEW DEVELOPMENTS IN WEATHER RESISTANT POWDER COATINGS.** The flow of thermoset powder coatings depends on a number of factors, including the selection of suitable pigments and fillers, pigment concentration, additives such as flow agents, bake schedule, reactivity and structure of the resinous components, melt viscosity, and the viscosity profile during crosslinking. This paper reports about recently developed carboxyl terminated triglycidyl isocyanurate (TGIC) cured polyesters which result in powder coatings with remarkably improved flow properties due to the polyester's molecular structure and functionality and the viscosity profile during the curing process. These improvements have been reached without any prolongation of the gel time and without compromising the weathering resistance of the film. Such new powder coatings completely crosslink at 160°C within 15 minutes yielding films with excellent mechanical properties. (Author abstract). 5 Refs.

Hoppe, Manfred (EMS-Chemie AG). *J Coat Technol* v 60 n 763 Aug 1988 p 53-59.

**PROTEINS** See Also AGRICULTURAL WASTES; AGRICULTURAL WASTES—Applications; BIOLOGICAL MATERIALS—Blood; BIOLOGICAL MATERIALS—Cells; BIOMEDICAL ENGINEERING—Hemodynamics; BIOPOLYMERS; BIOSENSORS—Design; BIOTECHNOLOGY—Fermentation; CELL CULTURE; CHEMICAL REACTIONS—Fermentation; COMPUTER PROGRAMMING—Algorithms; COTTON—Magnetic Field Effects; CRYSTALS—Growing; ENERGY RESOURCES; GENETIC ENGINEERING; IMMUNOLOGY—Sensors; MAGNETISM—Paramagnetism; MEMBRANES; ORGANIC COMPOUNDS—Thin Films; POLYMERS—Physical Properties.

**086765 ROLE OF PROTEIN STRUCTURE IN CHROMATOGRAPHIC BEHAVIOR.** Chromatographic retention is determined by a relatively small number of amino acids located in a chromatographic contact region on the surface of a polypeptide. The contact area may be as small as a few hundred square angstroms in bioaffinity chromatography. In contrast, the contact region in nonbioaffinity separation modes is much broader, ranging from one side to the whole external surface of a polypeptide. Furthermore, structural changes that alter the chromatographic contact region will alter chromatographic properties. Thus, although immunosorbents can be very useful in purifying proteins of similar primary structure, they will be ineffective in discriminating between small, random variations within a

structure. Nonbioaffinity columns complement affinity columns in probing a much larger portion of solute surface and being able to discriminate between protein variants. (Edited author abstract) 38 refs.

Regnier, Fred E. (Purdue Univ, West Lafayette, IN, USA). *Science* v 238 n 4825 Oct 16 1987 p 319-323.

**086766 STUDIES ON APPLICATION OF THE AVIDIN-BIOTIN HIGH AFFINITY SYSTEM.** The affinity of an egg white protein (avidin) and biotin (vitamin H) is characterized by a large value of the association constant ( $10^{15} \text{ M}^{-1}$ ). The application of this high affinity system to enzyme immobilization was investigated. Urease was immobilized on the beams of polyvinyl alcohol (Toyopearl: TPL) by means of avidin-biotin coupling. The immobilization procedure included four steps as follows: preparation of biotinyl-TPL; binding of avidin to biotinyl-TPL; preparation of biotinyl-urease; and binding of biotinyl-urease to avidin-coupled biotinyl-TPL. Immobilized urease retained enzymatic activities. (Edited author abstract) In Japanese. 3 refs.

Nozawa, Taihei (Univ of Tokyo, Jpn); Furusaki, Shintaro. *J Fac Eng Univ Tokyo Ser A* n 24 1986 p 56-57.

**086767 THEORETICAL CALCULATION OF RELATIVE AFFINITIES IN PROTEIN-SUBSTRATE BINDING.** Determination of the three-dimensional structures of several binding proteins from Gram-negative bacteria has been carried out. These proteins, which are located in the periplasmic space, serve as essential components of osmotic shock-sensitive active transport systems for a large variety of carbohydrates, amino acids and ions. Several of the sugar-binding proteins also act as initial receptors for chemotaxis. With the highly refined structure of L-arabinose-binding protein (ABP) and experimental values of free energies of binding for L-arabinose and various deoxyarabinoses, an attempt is made to compute the difference in the relative free energy change for binding of different substrates using the thermodynamic cycle-perturbation method. By this technique, it becomes possible to quantitatively assess the contribution of individual hydroxyl-protein interactions to the overall binding energy of the sugar substrate.

Luecke, Hartmut (Rice Univ, Houston, TX, USA). *Modell Simul Control C* v 8 n 4 1987 p 21-23.

**086768 ARIADNE: PATTERN-DIRECTED INFERENCE AND HIERARCHICAL ABSTRACTION IN PROTEIN STRUCTURE RECOGNITION.** ARIADNE was developed as a hierarchical pattern-directed inference system for the ill-structured problem area of protein structure analysis. The system (ARIADNE) identifies the optimal match between a given complex pattern descriptor and genetic (protein) sequences annotated with various inferred properties, by abstracting intermediate levels of structural organization. Inference is grounded solely in knowledge derivable from the primary sequence, and exploits such weakly inferred properties as secondary structure predictions and hydrophobicity. The proposed aminoacyl-tRNA synthetase alignment and functional domain identification is new and was found using this system with a hypothesized descriptor. 50 refs.

Lathrop, Richard H.; Webster, Teresa A.; Smith, Temple F. *Commun ACM* v 30 n 11 Nov 1987 p 909-921.

**086769 METHOD FOR THE RADIOHALOGENATION OF PROTEINS RESULTING IN DECREASED THYROID UPTAKE OF RADIOIODINE.** A procedure is described for the radioiodination of proteins using an iodinated derivative of N-succinimidyl 3-(tri-n-butylstannyl) benzoate (ATE). Adequate removal of unreacted ATE from [<sup>125</sup>I]ATE was necessary for optimal protein radioiodination. Labeling efficiencies of greater than 60% could be obtained after a 20 min incubation of goat IgG with [<sup>125</sup>I]ATE at 4°C. Paired-label experiments with goat IgG labeled with [<sup>125</sup>I] using ATE and [<sup>131</sup>I] using Iodogen



demonstrated that use of the ATE reagent for protein labeling significantly reduced ( $P < 0.005$ ) the thyroid uptake of radiiodine. (Author abstract) 16 refs.

Zalutsky, Michael R. (Duke Univ Medical Cent, Durham, NC, USA); Narula, Acharan S. *Appl Radiat Isot* v 38 n 12 1987 p 1051-1055.

**086770 RAPID AND EFFICIENT PHYSIOLOGIC CHEMICAL METHOD OF LABELING PLASMA PROTEINS WITH INDIUM-111.** A rapid physiologic chemical method had been developed for labeling plasma proteins with  $^{111}\text{In}$ . Human serum albumin, IgG, fibrinogen, transferrin, lactoferrin and the enzyme bovine thrombin had been successfully labeled with exceptionally high labeling yields of greater than 98%. In vitro bioassays confirmed that  $^{111}\text{In}$ -fibrinogen and  $^{111}\text{In}$ -thrombin retained 96-99% of their biochemical activities after labeling with the radionuclide. All radiolabeled proteins were stable at 2-8°C in excess of 3 week periods without elution of the 'label' or any significant loss of biological activity. (Author abstract) 16 refs.

Wong, Dennis W. (King/Drew Medical Cent UCLA, Los Angeles, CA, USA). *Appl Radiat Isot* v 38 n 12 1987 p 1067-1072.

**086771 LONG-RANGE ELECTRON TRANSFER IN PROTEINS: A PERCOLATION MECHANISM.** None of current theories fully account for all the dynamical characteristics of proteins, especially their conformational changes. A percolation mechanism that could explain, in certain cases, long-range electron-transfer reactions in proteins is proposed on the basis of conformational kinetics. 17 refs.

Jay-Gerin, J.-P. (Univ de Sherbrooke, Sherbrooke, Que, Can); Ferradini, C.; Houe-Levin, C.; Lopez-Castillo, J.-M.; Faraggi, M. *Radiat Phys Chem* v 30 n 4 1987 p 309-310.

**086772 MODELS FOR STRONG INTERACTIONS IN PROTEINS AND ENZYMES: 1. ENHANCED ACIDITIES OF PRINCIPAL BIOLOGICAL HYDROGEN DONORS.** The acid dissociation energies of several key biological hydrogen donors are found to fall into a narrow range,  $\Delta H^\circ_{\text{acid}} = 352\text{-}355$  kcal/mol. The strong acidities of these donor groups enhance the hydrogen bond strengths involved in the protein  $\alpha$ -helix, imidazole enzyme centers and DNA. Specifically, the peptide link is modeled by the dipeptide analogue  $\text{CH}_3\text{CO-Ala-OCH}_3$ . Its acidity is strengthened, i.e.,  $\Delta H^\circ_{\text{acid}}$  is decreased by 8 kcal/mol compared with other amides, due to electrostatic stabilization by the second carbonyl in the peptide  $-\text{CON}-\text{CH}(\text{CH}_3)\text{CO}-$  grouping. The acidity of imidazole is also strengthened by 8 kcal/mol compared with that of the parent molecule, pyrrole, primarily due to resonance stabilization of the ion. (Edited author abstract) 23 refs.

Meot-Ner, Michael (NBS, Gaithersburg, MD, USA). *J Am Chem Soc* v 110 n 10 May 11 1988 p 3071-3075.

**086773 MODELS FOR STRONG INTERACTIONS IN PROTEINS AND ENZYMES: 2. INTERACTIONS OF IONS WITH THE PEPTIDE LINK AND WITH IMIDAZOLE.** Cluster ions provide an experimental measure of ionic interaction energies in proteins. Peptide links, modeled by the alanine derivative  $\text{CH}_3\text{CO-Ala-OCH}_3$ , are strong hydrogen donors and bond by 30 kcal/mol to anions such as  $\text{RCOO}^-$  and  $\text{Cl}^-$ . The protein environment as modeled by two peptide amide groups stabilizes an anion by about 45 kcal/mol and a cation by about 50 kcal/mol. Therefore, in general, a protein backbone can stabilize a charge-separated ion pair by 90-110 kcal/mol. Applying clustering results to a specific biological system, anionic centers in the active site of serine proteases are examined. The model suggests that the aspartate carboxyl of the enzyme is solvated by four hydrogen bonds by about 65 kcal/mol, and the tetrahedral oxyanion intermediate is stabilized by hydrogen bonds to two peptide links by about 30 kcal/mol. (Edited author abstract) 18 refs.

Meot-Ner, Michael (NBS, Gaithersburg, MD, USA). *J*

*Am Chem Soc* v 110 n 10 May 11 1988 p 3075-3080.

**086774 NMR OF SILK FIBROIN. 8.  $^{13}\text{C}$  NMR ANALYSIS OF THE CONFORMATION AND THE CONFORMATIONAL TRANSITION OF PHILOSAMIA CYNTHIA RICINI SILK FIBROIN PROTEIN ON THE BASIS OF BIXON-SCHERAGA-LIFSON THEORY.** The helicity of each residue for the sequence of the alanine residues in Philosamia cynthia ricini silk fibroin protein, where the number of the alanine residues were determined as 22, was calculated by using the Bixon-Scheraga-Lifson theory for the helix-coil transition of poly(L-alanine) including the hydrophobic side-chain interactions. The NMR line shape of the carbonyl carbon of the alanine residue observed in aqueous solution was simulated on the basis of the helicity of the alanine sequence determined here. In addition, the change in the NMR spectra of the alanine carbonyl region due to the temperature-induced helix-coil transition was also interpreted in terms of the change in the statistical weight parameter  $w$ , where  $w$  is related to the formation of an intramolecular hydrogen bond. From this theoretical analysis and CD observations, the structure of P.c. ricini silk fibroin in aqueous solution was clarified. (Author abstract) 16 refs.

Asakura, Tetsuo (Tokyo Univ of Agriculture & Technology, Koganei, Jpn); Kashiwa, Hitoshi; Yoshimizu, Hiroaki. *Macromolecules* v 21 n 3 Mar 1988 p 644-648.

**086775 METHOD FOR CLUSTERING PROTEINS BY USE OF ALL POSSIBLE PAIRS OF AMINO ACIDS AS STRUCTURAL DESCRIPTORS.** Proteins were represented as vectors, of which components were all possible pairs of amino acids. From a distance matrix between any pairs of proteins thus represented, several clusters corresponding to connected components were generated. Application of this method to three different sets of proteins showed that it was suitable for clustering closely related proteins with respect to the sequential similarity defined by M.O. Dayhoff. (Author abstract) 7 refs.

Nakayama, Shun-ichi (Univ of Library & Information Science, Tsukuba, Jpn); Shigezumi, Satoko; Yoshida, Masayuki. *J Chem Inf Comput Sci* v 28 n 2 May 1988 p 72-78.

## Absorption

**086776 PROTEIN ADSORPTION TO HYDROGELS.** Protein adsorption is thought to be one of the more important initial events which occurs upon exposure of solid surfaces to the biological environment. Many different types of observations have contributed to this conclusion, but it derives most fundamentally from the fact that the rapid formation of a relatively tightly held layer of protein prevents direct contact of cellular elements with the surface. Thus, all of the situations in which solid surfaces interact with biological systems actually involve interactions between the adsorbed protein layer present at the interface and the various other biological elements. As will be seen, measurements of adsorption isotherms, competitive adsorption studies from simple protein mixtures, studies of the types and amounts of protein adsorbed from blood plasma, and characterization of the desorption/exchange reactions all reveal significant differences between hydrogels and nonhydrogels. 68 refs.

Horbett, Thomas A. (Univ of Washington, Seattle, WA, USA). *Hydrogels in Med and Pharm* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 v 1, p 127-172.

**Adsorption** See Also BIOLOGICAL MATERIALS—Blood; BIOMATERIALS—Chemical Reactions; BIOPOLYMERS—Alkylation; DAIRY PRODUCTS—Casein; EMULSIONS—Coagulation; POLYPEPTIDES—Adsorption.

**086777 ADSORPTION OF PROTEINS AND HYDRODYNAMIC FLOW OF SOLUTIONS IN THIN CAPILLARIES.** The hydrodynamic rate of flow of a liquid in a flat slot or a cylindrical capillary has been calculated for a two-layer model of flow, in which one layer determines the hydrodynamics of the flow in an

adsorbed protein layer, and the outer layer determines the hydrodynamics in the solution. The resistance created by segments of adsorbed macromolecules can cause a decrease in the flow rate of a liquid through a capillary in comparison to the classical Poiseuille formula in a number of situations. Such a decrease in the experimental flow rate may be interpreted as an apparent increase in viscosity, and thus the main relationships obtained in this work make it possible to explain the Copley-Scott-Blair effect and to propose a quantitative description for it. (Author abstract) 16 refs.

Sigal, V.L. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR). *Colloid J USSR* v 49 n 1 Jan-Feb 1987 p 49-53.

**086778 ADSORPTION OF LIPASE AND OTHER GLOBULAR PROTEINS ON A HYDROPHOBIC SURFACE.** A comparative analysis of the isotherms of adsorption of pancreatic lipase and other globular proteins on a hydrophobic surface was conducted. The adsorption isotherms of  $\alpha$ -chymotrypsin, bovine serum albumin, and lipase are described by the Langmuir equation. It is shown that there are no significant differences in the kinetics of adsorption of the proteins, but the adsorption activity of lipase is higher than for the other proteins. (Edited author abstract) 10 refs.

Elenskii, A.V. (Moscow Univ, USSR); Yampol'skaya, G.P.; Izmailova, V.N. *Colloid J USSR* v 49 n 1 Jan-Feb 1987 p 119-121.

**086779 PROTEIN ADSORPTION AND MATERIALS BIOCOMPATIBILITY: A TUTORIAL REVIEW AND SUGGESTED HYPOTHESES.** A comprehensive review of protein adsorption at solid-liquid interfaces is presented, including a brief review of protein structure and the principles of protein adsorption. Adsorption-based biocompatibility hypotheses and correlations are discussed, including surface charge, interface energetics, passivation, protein-resistant surfaces, and the role of adsorbed immunoglobulins and complement. New methods for the study of protein adsorption are discussed, including total internal reflection techniques (absorbance, fluorescence, and raman) and ellipsometry. Qualitative 'rules of thumb' of protein adsorption are also presented. (Author abstract) 193 refs.

Andrade, J.D. (Univ of Utah, Salt Lake City, UT, USA); Hlady, V. *Adv Polym Sci* 79. Publ by Springer-Verlag, Berlin, West Ger and New York, NY, USA, 1987 p 1-63.

**086780 ADSORPTION DISPLACEMENT OF PROTEINS BY SURFACTANTS IN OIL-IN-WATER EMULSIONS.** The adsorption displacement of  $\beta$ -lactoglobulin and  $\beta$ -casein by water- and oil-soluble surfactants in 50% oil-in-water emulsions was studied with the depletion method. Not only the surface concentration of the protein was measured, but also that of the surfactant. The surfactants may partly or even completely displace the protein from the droplet surface, depending on surfactant concentration and type. This phenomenon is independent of protein type and the way in which the surfactant is added to the system (before or after emulsification) and only slightly depends on the type of oil. Displacement occurs by water-soluble as well as by oil-soluble surfactants. (Edited author abstract) 33 refs.

De Feijter, J.A. (Unilever Research Lab Vlaardingen, Vlaardingen, Neth); Benjamins, J.; Tamboer, M. *Colloids Surf* v 27 n 1-3 Oct 1987 p 243-266.

**086781 REMOVAL OF BETA-2-MICROGLOBULIN BY DIRECT HEMOPERFUSION WITH A NEWLY DEVELOPED ADSORBENT.** Although high-flux membrane dialyzers may prove to be of value as part of a therapy for elimination of  $\beta_2\text{M}$ , none of those yet developed has a  $\beta_2\text{M}$  removal capability sufficient for therapy unaided by some other means of  $\beta_2\text{M}$  removal. Direct hemoperfusion (DHP) with an effective  $\beta_2\text{M}$  adsorbent may be considered as an alternative therapeutic method. In the study reported, the authors attempted the



development of such an absorbent, and conducted in vitro and clinical studies to evaluate its  $\beta_2$ M adsorption capabilities and blood compatibility. 12 refs.

Akizawa, T. (Showa Univ, Yokohama, Jpn); Kinugasa, E.; Kitaoka, T.; Koshikawa, S.; Nakabayashi, N.; Watanabe, H.; Yamawaki, N.; Kuroda, Y. *ASAIO Trans* v 33 n 3 Jul-Sep 1987 p 532-537.

**086782 COUPLING BETWEEN INTERFACIAL PROTEIN ADSORPTION AND BULK DIFFUSION. A NUMERICAL STUDY.** A set of differential equations for describing the kinetics of adsorption of globular proteins diffusion to the interface is presented. A modification of the usual boundary condition is proposed:  $dC_s/dt = D(\delta C(x,t)/\delta x)_{x=0}$ , where  $C_s$  is the surface concentration,  $C(x,t)$  is the bulk concentration,  $D$  is the solute diffusion coefficient and  $x$  is the distance to the interface. Some numerical results help to illustrate the complex physical processes involved. 22 refs.

Schaaf, P. (CNRS, Strasbourg, Fr); Dejardin, Ph. *Colloids Surf* v 24 n 2-3 May 15 1987 p 239-247.

**086783 PROTEIN ADSORPTION ON FUNCTIONALIZED AND ESCA-CHARACTERIZED POLYMER FILMS STUDIED BY ELLIPSOMETRY.** In a recent ESCA study of protein adsorption we found very low adsorption of bovine serum albumin (BSA) on photopolymerized monoacrylated polyethylene oxide (PEO) films as compared to films of charged hydrophilic films or hydrophobic PVC films. This indicates the importance of both polar/ionic and hydrophobic interactions in protein adsorption. In this paper we have used ellipsometry to investigate the adsorption of BSA,  $\gamma$ -globulin (IgG), fibrinogen, and poly-L-lysine (PLL) to silicon wafers, which were surface modified by attaching PVC, a methacrylic acid/methacrylate copolymer (PMA), or PEO films all of which were characterized by ESCA. 45 refs.

Golander, Carl-Gustaf (Inst for Surface Chemistry, Stockholm, Sweden); Kiss, Eva. *J Colloid Interface Sci* v 121 n 1 Jan 1988 p 240-253.

**086784 PROTEIN ADSORPTION ON THE SURFACE OF A THIN-FILM POLYMER INTEGRATED OPTICAL WAVEGUIDE.** Protein adsorption (fluorescein labeled gamma globulin, FITC-IgG) on the surface of poly(styrene) thin-film optical waveguides was fluorescently detected. The time course of adsorption, the FITC-IgG fluorescence spectra, and the surface concentration estimates are presented. The results demonstrate the potential use of polymer optical waveguides as integrated optic evanescent sensors. (Author abstract) 12 refs.

Ives, J.T. (Univ of Utah, Salt Lake City, UT, USA); Reichert, W.M. *Appl Spectrosc* v 42 n 1 Jan 1988 p 68-72.

**086785 MOLECULAR AND SUPRAMOLECULAR STRUCTURE OF ADSORBED FIBRINOGEN AND ADSORPTION ISOTHERMS OF FIBRINOGEN AT QUARTZ SURFACES.** The process of protein adsorption to solid surfaces is an important step in the physiological function of plasma proteins in surface induced thrombosis. Fibrinogen adsorbed at solid surfaces has been shown to promote platelet adhesion. The adsorption of fibrinogen to quartz surfaces was measured by ellipsometry, ELISA, and electron microscopy. The initial adsorption at low concentrations was diffusion rate limited as determined by the ELISA and by counting the number of adsorbed molecules at electron micrographs. At a hydrophilic quartz surface a plateau level of the adsorption isotherm was found at a surface concentration of  $0.1 \text{ pmol/cm}^2$  where adsorbed molecules had a mean intermolecular distance of  $10 \pm 5 \text{ nm}$ . At higher surface concentrations the molecules were densely packed and formed a layer where single molecules could not be identified. Adsorbed fibrinogen showed different structure at hydrophobic and hydrophilic quartz surfaces. (Edited author abstract) 20 refs.

Nygren, Hakan (Univ of Goteborg, Sweden); Stenberg, Manne. *J Biomed Mater Res* v 22 n 1 Jan 1988 p 1-11.

**086786 USE OF AN ENZYME LINKED IMMUNOSORBENT ASSAY (ELISA) FOR QUANTIFICATION OF PROTEINS ON THE SURFACE OF MATERIALS.** This study demonstrates the usefulness of an enzyme linked immunosorbent assay (ELISA) for detection and quantification of protein on the surface of materials. Bovine serum albumin (BSA) and bovine gamma globulin (BGG) were the proteins used. Titanium and stainless steel were the materials tested. The proteins were detected with the use of rabbit antiserum specific for BSA and for BGG. This reaction was quantitated by the use of horseradish peroxidase conjugated goat anti-rabbit gamma globulin. The technique is described in detail. The technique was demonstrated to be suitable for quantitation of protein from  $0.01 \text{ mg/mL}$  to  $0.1 \text{ mg/mL}$  on the surface of  $3 \text{ mm} \times 10 \text{ mm}$  materials. The technique was also demonstrated to be suitable for determining the surface area of solid materials. It is a simple technique and suitable for most biomaterials laboratories. (Author abstract) 10 refs.

Merritt, Katharine (Case Western Reserve Univ, Cleveland, OH, USA); Edwards, Christopher R.; Brown, Stanley A. *J Biomed Mater Res* v 22 n 2 Feb 1988 p 99-109.

**086787 ADSORPTION OF  $\alpha$ -LACTALBUMIN AND  $\beta$ -LACTOGLOBULIN ON METAL SURFACES VERSUS TEMPERATURE.** The heating of biological fluids in the food industry often causes deposition (fouling) on the processing equipment. This study is part of a research program directed toward a better understanding of fouling associated with the heat treatment of milk. The adsorption of  $\alpha$ -lactalbumin and  $\beta$ -lactoglobulin on a hydrophilic chromium surface was followed in situ, using ellipsometry. The experiments were performed at temperatures up to and exceeding (in the case of  $\alpha$ -lactalbumin) the thermal denaturation temperatures of the proteins. The two proteins exhibit quite different properties, which makes it interesting to compare their behavior at the solid/liquid interface. 21 refs.

Arnebrant, Thomas (Univ of Lund, Lund, Sweden); Barton, Kathleen; Nylander, Tommy. *J Colloid Interface Sci* v 119 n 2 Oct 1987 p 383-390.

**086788 ADSORPTION KINETICS OF PROTEINS ONTO SOLID SURFACES IN THE LIMIT OF THE INTERFACIAL INTERACTION CONTROL.** We have developed an experimental set-up using radiolabeled proteins for the continuous measurement, as a function of time, of the excess concentration of superficial protein at a solid/liquid interface. The experimental conditions were designed in order to minimize the coupling of the interfacial interaction with bulk diffusion, and therefore to work within the limit of the interfacial interaction control. Chemical kinetics were assumed to follow a Langmuir equation. The adsorption ( $K_a$ ) and desorption ( $K_d$ ) rate constants have been evaluated in the case of fibrinogen and albumin adsorption, onto glass beads and synthetic hydroxyapatite powder, respectively. (Edited author abstract) 38 refs.

Aptel, J.D. (Inserm, Strasbourg, Fr); Voegel, J.C.; Schmitt, A. *Colloids Surf* v 29 n 4 Feb 1988 p 359-371.

**086789 ADSORPTION OF INSULIN ON METAL SURFACES IN RELATION TO ASSOCIATION BEHAVIOR.** The adsorption of insulin on metal surfaces from aqueous solutions was monitored by in situ ellipsometry. Clean (hydrophilic) chromium and titanium surfaces as well as chromium surfaces treated to be hydrophobic were used. The adsorbed amount was found to be higher on the hydrophilic than on the hydrophobic surfaces. The presence of the divalent metal ions zinc and calcium increased the adsorbed amount and also the fraction desorbable upon rinsing. This was related to the behavior in the bulk solution, where zinc and calcium increase the association. The increase in adsorbed amount was observed also when zinc was added to an adsorbed layer of Zn-free insulin in contact with insulin solution. Addition of citrate to an adsorbed layer of insulin from a solution containing four zinc ions per hexamer had an effect similar to that of rinsing, indicating a removal of

zinc in both cases. The effect of the pH was investigated in the range from pH 7 to pH 8. (Author abstract) 40 refs.

Arnebrant, Thomas (Univ of Lund, Lund, Sweden); Nylander, Tommy. *J Colloid Interface Sci* v 122 n 2 Apr 1988 p 557-566.

**086790 EFFECT OF SURFACE CHARGE ON ADSORPTION OF BOVINE SERUM ALBUMIN: 2. INTERACTION OF PROTEIN MOLECULES WITH AN ANIONIC MONOLAYER, AS STUDIED BY ELLIPSOMETRY, RADIOTRACER AND SURFACE TENSION MEASUREMENTS.** The adsorption of bovine serum albumin (BSA) onto an anionic monolayer of sodium dodecylsulfate (SDoS) spread at the air/water interface was studied by ellipsometry. The adsorption behavior of BSA was estimated from the observed changes in phase differences and in the ratio of reflection coefficients. The dynamic process of BSA adsorption was measured after the injection of BSA solution into the aqueous substrate of SDoS monolayer. The gentle stirring of the substrate solution for 10 min was found to be enough to make the solution homogeneous without damaging the monolayer. The adsorption characteristics of BSA onto a negatively charged surface was compared with that onto a positively charged surface previously reported. The amount of adsorption depended on time and showed a maximum with an initial rapid rise, followed by gradual decrease toward the ultimate equilibrium value. The amount and time of the maximum adsorption depended on the concentration of BSA added to the aqueous substrate. Separate radiotracer measurement, using  $^{35}\text{S}$ -labeled SDoS monolayer, which is insoluble by itself, revealed that SDoS is solubilized into the bulk solution when BSA is added to the aqueous substrate. (Author abstract) 29 refs.

Watanabe, N. (Toyo Ink Mfg Co, Tokyo, Jpn); Shirakawa, T.; Iwahashi, M.; Seimiya, T. *Colloid Polym Sci* v 266 n 3 Mar 1988 p 254-260.

**086791 FLUORESCENCE EMISSION FORM ADSORBED BOVINE SERUM ALBUMIN AND ALBUMIN-BOUND 1-ANILINONAPHTHALENE-8-SULFONATE STUDIED BY TIRF.** Total internal reflection fluorescence (TIRF) spectroscopy was used to analyse the conformational changes of bovine serum albumin (BSA) upon adsorption to silica surfaces. The intrinsic fluorescence emitted by BSA tryptophans and the fluorescence of BSA-bound ligand 1-anilino-naphthalene-8-sulfonate (ANS) were analysed prior to and after the removal of nonadsorbed protein. It was found that the irreversibly adsorbed BSA emits a blue-shifted intrinsic fluorescence (11 nm) and that the surface-adsorbed BSA-bound ANS fluorescence emission is red-shifted (12 nm). It was concluded that the conformational change in adsorbed BSA involves the whole BSA molecule: tryptophans become exposed to a less polar environment while the binding site polarity is increased. (Edited author abstract) 25 refs.

Hlady, V. (Inst Ruder Boskovic, Zagreb, Yugoslavia); Andrade, J.D. *Colloids Surf* v 32 n 3 pt 4 Jul 1988 p 359-369.

**086792 STUDY OF THE ADSORPTION OF ALBUMIN ON A PLATINUM ROTATING DISK ELECTRODE USING IMPEDANCE MEASUREMENTS.** The study of the adsorption of albumin on a platinum rotating disk electrode was performed using impedance measurements. The kinetics of the adsorption was investigated by recording, during 15 min after protein addition, the variation with time of the electrochemical double layer capacitance,  $C_d$ . The resulting curve was computed and a model of two consecutive reactions occurring at the interface was proposed to describe the adsorption reaction. The corresponding theoretical equation used to fit the data showed five parameters: three capacitances (of the bare surface, of the surface covered with the reversibly



adsorbed proteins, and of the surface covered with the irreversibly adsorbed proteins) and two time constants. (Edited author abstract). 33 Refs.

Bernabeu, P. (Hopital Broussais, Paris, Fr); Tamisier, L.; de Cesare, A.; Caprani, A. *Electrochim Acta* v 33 n 8 Aug 1988 p 1129-1136.

**086793 PHYSICO-CHEMICAL AND BIOCHEMICAL ASPECTS OF FIBRINOGEN ADSORPTION FROM PLASMA AND BINARY PROTEIN SOLUTIONS ONTO POLYETHYLENE AND GLASS.** The adsorption of fibrinogen to polyethylene and glass from plasma and binary protein solutions was measured using baboon fibrinogen radiolabeled with  $^3\text{H}$ . The effects of plasma dilution, shear rate contact time, and plasma fibrinogen concentration were examined. Fibrinogen adsorption to polyethylene passed through a maximum at times dependent upon the plasma dilution, shifting from 1 h to 10 s as the plasma concentration varied from 0.01 to 100%. Fibrinogen adsorption to glass from solutions containing either albumin or hemoglobin was maximal at intermediate mixture concentrations. The maximum shifted to smaller concentrations as the ratio of competing protein to fibrinogen increased. The effect is similar to that caused by plasma dilution and suggests that the observed fibrinogen displacement phenomenon occurring with plasma results from numerous proteins expressing their stronger affinity for a finite number of adsorption sites. (Edited author abstract). 45 Refs.

Slack, Steven M. (Univ of Washington, Seattle, WA, USA); Horbett, Thomas A. *J Colloid Interface Sci* v 124 n 2 Aug 1988 p 535-551.

**086794 IMMOBILIZATION OF PROTEINS ON ORGANIC POLYMER BEADS.** A new method is described for the immobilization of biologically active proteins onto several types of organic polymer beads. First, the soluble protein is modified by reaction with an excess of a hydrophobic imidoester. Excess imidoester and side products resulting from imidoester hydrolysis are separated from the hydrophobic protein derivative by exclusion chromatography or dialysis. A suspension of polymer beads (e.g. Amberlite XAD-7) is then added to a solution of the modified protein at room temperature or below and stirred gently for 1-2 h. The polymer beads are allowed to settle, separate from the solution by decantation or filtration, washed, and resuspended in an appropriate buffer. Quantitative adsorption of protein to the polymer beads is observed under such conditions. The synthesis of seven hydrophobic imidoesters and their use for the immobilization of trypsin onto several types of porous polymer beads is described. (Edited author abstract). 38 Refs.

Ampon, Kamaruzaman (Ohio State Univ, Columbus, OH, USA); Means, Gary E. *Biotechnol Bioeng* v 32 n 5 Aug 20 1988 p 689-697.

**086795 PROTEIN ADSORPTION ON POLYMERIC BIOMATERIALS I. ADSORPTION ISOTHERMS.** The equilibrium adsorption of seven purified human proteins to four different biomaterials was studied at different protein concentrations under in vitro conditions. The proteins studied were albumin, transferrin, three monoclonal antibodies of different net charge, fibrinogen, and  $\alpha_2$ -macroglobulin. The biomaterials used in the adsorption studies included a polyether urethane urea, polyethylene, silicone rubber, and plasticized polyvinyl chloride. The equilibrium adsorption data for these protein-biomaterial combinations could be fit by a protein adsorption model assuming two or more adsorbed protein layers. The monolayer concentrations of adsorbed protein agreed closely with the theoretical monolayer concentrations based on the macromolecular dimensions of the proteins. From these studies, it is apparent that the magnitude of the binding forces at the liquid-polymer interface is a function of both the biomaterial composition and the individual protein. (Edited author abstract). 37 Refs.

Young, B.R. (Upjohn Co, Kalamazoo, MI, USA); Pitt, W.G.; Cooper, S.L. *J Colloid Interface Sci* v 124 n 1 Jul

1988 p 28-43.

**Analysis** See Also GEOCHEMISTRY—Natural Waters.

**086796 KINETIC ANALYSIS OF PROTON TRANSPORT IN BACTERIORHODOPSIN-LIPIDOMES BASED ON BILATERAL pH DETERMINATIONS.** Simultaneous changes of pH in the inner and outer liquids of proteoliposomes, the membrane of which consisted of asolectin and bacteriorhodopsin (BR), were determined during transient states after a shift from the light to the dark and the reverse. Some mathematical equations of a model characterizing the mechanism of the proton transport through the proteoliposome membrane were developed by considering the proton pump of BR, light-dependent and light-independent proton leaks from the liposomes, and buffering capacities of the intra- and extra-vesicular liquids. The model equations (equations 8(A) and 8(B)) could assess the effect of concurrent change of the bilateral proton concentrations on the rate of proton transport and could simulate well the dynamic aspect of pH changes within the internal and external liquid of the proteoliposomes. 22 refs.

Yabe, Isamu (Univ of Tokyo, Tokyo, Jpn); Toda, Kiyoshi; Matsuoka, Hiroshi. *J Chem Eng Jpn* v 20 n 4 Aug 1987 p 392-398.

**Applications** See Also EMULSIONS—Stability.

**086797 PROTEINS AND CARBOHYDRATES AS ALTERNATIVE SURFACTANTS FOR THE PREPARATION OF STABLE MAGNETIC FLUIDS.** A one-stage preparation of table aqueous magnetic fluids is reported, whereby colloidal  $\text{Fe}_3\text{O}_4$  particles are dispersed using naturally occurring polymers and their derivatives (e.g. gelatine, polygalacturonic acid, carboxymethyl-cellulose and succinylated gelatine) as surfactant materials. Low-toxicity materials have been used to permit possible medical use of the fluids. Using a variety of surfactant concentrations at the time of particle formation, control of particle size has been achieved, and particles as small as 3.0 nm in diameter obtained. Stable fluids with up to 6%  $\text{Fe}_3\text{O}_4$  content can be produced, having magnetizations of 2  $\text{JT}^{-1}\text{Kg}^{-1}$  (20 Gauss). Fluids diluted 30-fold remain stable colloids. 13 refs.

Wooding, A. (Univ of Durham, Engl); Kilner, M.; Lambick, D.B. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1650-1652.

**Biosynthesis** See Also CELL CULTURE—Animal.

**086798 EFFECT OF SUGARS ON  $\beta$ -LACTAMASE AGGREGATION IN ESCHERICHIA COLI.** Overproduction of the secreted protein  $\beta$ -lactamase was inhibited when non-metabolizable sugars, such as sucrose and raffinose, were added into the growth medium. A four-fold increase in the amount of soluble protein was obtained under optimal conditions. The mechanism for the inhibition of protein aggregation was investigated. Addition of 0.3M sucrose decreased the rate of processing of the  $\beta$ -lactamase precursor, causing its transient accumulation within the cell. (Author abstract). 16 Refs.

Bowden, Gregory A. (Univ of Texas at Austin, Austin, TX, USA); Georgiou, George. *Biotechnol Prog* v 4 n 2 Jun 1988 p 97-101.

**Centrifugation**

**086799 SIMPLIFIED MODEL FOR PROTEIN INCLUSION IN REVERSE MICELLES SANS MEASUREMENTS AS A CONTROL TEST.** A thermodynamic, first approximation model for the uptake of globular protein by reverse micelles is discussed and tested using the experimental SANS spectra reported in the literature. The agreement is very good for cytochrome c 40M, but is less so when the concentration of the protein is increased. The reasons for these discrepancies are discussed. 11 Refs.

Caselli, M. (Univ di Bari, Bari, Italy); Maestro, M.;

Morea, G. *Biotechnol Prog* v 4 n 2 Jun 1988 p 102-106.

**Chemical Reactions** See Also POLYMERS—Chemical Reactions; POLYSTYRENES—Surfaces.

**086800 LIGHT- OR OXIDANT-INDUCED GENERATION OF FREE RADICALS IN HEMOPROTEINS.** Upon reactions with oxidants, hemoproteins retain their oxidizing equivalents not only in the heme iron, but also in the porphyrin or amino acid residues. HRP has a protein structure that stabilizes the porphyrin  $\pi$ -cation radical, which can easily be formed through various reactions. CCP reacts with  $\text{H}_2\text{O}_2$  to form free radicals in amino acid residues as a catalytic intermediate species, which is stable in the absence of added electron donor. Ferric myoglobin apparently behaves as CCP, but its amino acid free radicals are unstable. These properties seem to be reflected on photooxidation of these hemoproteins. (Author abstract). 27 Refs.

Miki, Hideho (Hokkaido Univ, Hokkaido, Jpn); Harada, Kazuo; Yamazaki, Isao. *Radiat Phys Chem* v 32 n 3 1988 p 375-378.

**Chemistry**

**086801 PROSOFT: A GENERAL PURPOSE SOFTWARE IN PROTEIN CHEMISTRY.** Applesoft and 6502 Assembler software was designed to quickly perform operations commonly encountered in protein chemistry. It was not designed for a specific application but can be conveniently used to speed up the determination of protein primary structure. (Author abstract) 14 refs.

Petrilli, P. (Univ di Napoli, Naples, Italy). *Comput Appl Biosci* v 4 n 2 Apr 1988 p 265-270.

**Chromatographic Analysis** See Also AMINO ACIDS—Chromatographic Analysis; BIOLOGICAL MATERIALS—Chromatographic Analysis; ETHANOL; ORGANIC COMPOUNDS—Chromatographic Analysis; POLYMERS—Chemical Reactions.

**086802 SYNTHESIS AND CHARACTERIZATION OF 2- $\mu\text{m}$  WIDE-PORE SILICA MICROSPHERES AS COLUMN PACKINGS FOR THE REVERSED-PHASE LIQUID CHROMATOGRAPHY OF PEPTIDES AND PROTEINS.** Silica microspheres have been prepared with wide (200 Å) pores for the high-speed separation of biomacromolecules. These 1-2- $\mu\text{m}$  particles are synthesized in a narrow particle-size distribution at relatively high yield by significantly modifying the coacervation reaction used to produce Zorbax (Du Pont) chromatography packings. Reversed-phase columns prepared from 2- $\mu\text{m}$  particles exhibited > 130,000 plates/m with good permeability and peak symmetry. Separations of the multicomponent peptide and protein mixtures were performed in less than a minute with good recoveries of such solutes. (Author abstract) 23 refs.

Danielson, Neil D. (DuPont, Wilmington, DE, USA); Kirkland, J.J. *Anal Chem* v 59 n 20 Oct 15 1987 p 2501-2506.

**086803 FAST AFFINITY CHROMATOGRAPHY USING SMALL PARTICLE SILICA-BASED PACKING MATERIALS.** Affinity chromatography is one of the most powerful techniques for the purification of biologically active proteins available. The ability of this method to purify proteins is based on highly specific, selective or characteristic interactions with immobilized ligands. The criteria for developing a general, derivatizable, high performance support for high performance affinity chromatography are discussed. The step-by-step examination of these criteria and experimental evidence for determining parameters such as ligand density, non-specific adsorption and column lifetime for such a system are described. Chromatographic results are shown



for preparative separations of (i) receptor proteins, (ii) antibodies and (iii) active enzymes. (Edited author abstract) 12 refs.

Hollis, Donald F. (Smith Kline & French Lab, Philadelphia, PA, USA); Ralston, Steven; Suen, Eric; Cooke, Nelson; Shorr, Robert G.L. *J Liq Chromatogr* v 10 n 11 1987 p 2349-2368.

**086804 HIGH-PERFORMANCE AQUEOUS SIZE-EXCLUSION CHROMATOGRAPHY USING DIOL-BONDED POROUS GLASS PACKING MATERIALS. RETENTION BEHAVIOR OF SOME PROTEINS.** This paper is concerned with the observation of the effects of the concentration, the type and pH of buffer solutions used as the mobile phase and the concentration of added neutral electrolytes on the retention volume. Elucidation of the various contributions from non-size-exclusion effects to the retention volume of proteins was attempted. It is shown that potassium thiocyanate showed a different action for retention of proteins compared to other neutral electrolytes and acted like sodium dodecyl sulphonate. (Edited author abstract) 8 refs.

Mori, Sadao (Mie Univ, Tsu, Jpn); Kato, Masatoshi. *J Liq Chromatogr* v 10 n 14 1987 p 3113-3126.

**086805 DIRECT COMBINATION OF A HIGH PERFORMANCE LIQUID CHROMATOGRAPH AND A CIRCULAR DICHROISM SPECTROMETER FOR SEPARATION AND STRUCTURAL ANALYSIS OF PROTEINS.** Basic studies of the combined system of a high performance liquid chromatograph (HPLC) and a circular dichroism (CD) spectrometer for separation and analysis of proteins are described. The HPLC-CD measurement of standard protein mixture was easily carried out by using a micro flow-cell device with a beam condenser and with a thin cell of a 1 mm-optical path. The effluent was firstly monitored at 280 nm by using an UV detector and subsequently monitored at 220 nm by using a CD spectrometer. The CD spectrum at each chromatographic peak by CD was measured in the wavelength region of 250-195 nm by a stopped flow method. (Author abstract) 16 refs.

Takakuwa, Takashi (Japan Spectroscopic Co, Tokyo, Jpn); Kurosu, Yasuyuki; Sakayanagi, Nobuyuki; Kaneuchi, Fumiko; Takeuchi, Norimasa; Wada, Akio; Senda, Masaaki. *J Liq Chromatogr* v 10 n 12 1987, Seventh Annu Res Triangle Park Liq Chromatogr Symp, Research Triangle Park, NC, USA, Oct 15 1987 p 2759-2769.

**086806 LINEAR MULTIDIMENSIONAL LIQUID CHROMATOGRAPHY IN PROTEIN SEPARATION.** The objective of this article is to define, discuss and illustrate the concept of on-line multidimensional liquid chromatography (MDLC) in protein separation. In particular the emphasis of this paper is centered on a special form of on-line MDLC that will be referred to as linear MDLC. Examples of this technique, which involves the coupling of two or more chromatographic columns each employing a different separation mechanism, in both the analytical and preparative mode, are given in order to demonstrate its utility. (Author abstract) 28 refs.

Berkowitz, Steven A. (J.T. Baker Chemical Co, Phillipsburg, NJ, USA). *J Liq Chromatogr* v 10 n 12 1987, Seventh Annu Res Triangle Park Liq Chromatogr Symp, Research Triangle Park, NC, USA, Oct 15 1987 p 2771-2787.

## Coagulation

**086807 CASEIN MICELLES: STRUCTURE, PROPERTIES AND ENZYMIC COAGULATION.** It is necessary to understand the effects of micelle size, chemical and physical structure and the electrostatic, hydrophobic and steric forces acting between micelles if realistic explanations of the coagulation process are to be developed. This paper reviews the developments in the literature that contribute to such an understanding. The literature suggests that prediction of coagulation should be possible once the forces that impact micelle coagulation

are understood. (Edited author abstract) 84 refs.

Ruettimann, K.W. (Purdue Univ, West Lafayette, IN, USA); Ladisch, M.R. *Enzyme Microb Technol* v 9 n 10 Oct 1987 p 578-589.

**Computer Aided Analysis** See Also COMPUTER SOFTWARE; NUCLEIC ACIDS—Computer Aided Analysis.

**086808 COMPUTER PROGRAM FOR THE DESIGN OF OPTIMAL SYNTHETIC OLIGONUCLEOTIDE PROBES FOR PROTEIN CODING GENES.** A computer program has been written in FORTRAN 77 to locate on a protein sequence a region with optimum length and limited degeneracy in order to design artificial oligonucleotide probes for use in molecular cloning. In addition the program checks for regions of homology between this probe and any other base sequence found in nucleotide sequence data banks. There are options in the program to eliminate rare codons or to make preferential choices of bases in order to minimize the degeneracy of probes. (Author abstract) 13 refs.

Danckaert, Anne (Univ Paris 7, Paris, Fr); Mugnier, Claude; Dessen Philippe; Cohen-Solal, Michel. *Comput Appl Biosci* v 3 n 4 Nov 1987 p 303-307.

**086809 PROGRAM FOR TEMPLATE MATCHING OF PROTEIN SEQUENCES.** The matching of a template to a protein sequence is simplified by treating it as a special case of sequence alignment. Restriction of the distances between motifs in the template controls against spurious matches within very long sequences. The program using this algorithm is fast enough to be used in scanning large databases for sequences matching a complex template. (Author abstract). 6 Refs.

Boswell, D. Ross (Christchurch Sch of Medicine, NZ). *Comput Appl Biosci* v 4 n 3 Aug 1988 p 345-350.

**086810 ANTHEPROT: A PACKAGE FOR PROTEIN SEQUENCE ANALYSIS USING A MICROCOMPUTER.** A simple microcomputer package is described to make the theoretical analysis of protein sequences. Several methods designed to compare two sequences, to model proteolytic reactions and to predict the secondary structure, the hydrophobic/hydrophilic regions and the potential antigenic sites of proteins have been included in an Apple II microcomputer software. The package comprises 21 programs as well as the secondary structure database of W. Kabsch and C. Sander. (Author abstract). 25 Refs.

Deleage, Gilbert (CNRS, Villeurbanne, Fr); Clerc, Francois F.; Roux, Bernard; Gautheron, Daniele C. *Comput Appl Biosci* v 4 n 3 Aug 1988 p 351-356.

**086811 SIMPLE METHOD FOR PREDICTING THE SECONDARY STRUCTURE OF GLOBULAR PROTEINS: IMPLICATIONS AND ACCURACY.** A method is presented for predicting the secondary structure of globular proteins from their amino acid sequence. It is based on a rigorous statistical exploitation of the well-known biological fact that the amino acid compositions of each secondary structure are different. Also proposed is an evaluation process that allows us to estimate the capacity of a method to predict the secondary structure of a new protein which does not have any homologous proteins whose structure is already known. This evaluation process shows that the method has a prediction accuracy of 58.7 percent over three states for the 62 proteins of the W. Kabsch and C. Sander (1983a) data bank. This result is better than that obtained by the most widely used methods. A simple Pascal implementation of the method prediction algorithm is given. (Edited author abstract). 23 Refs.

Gascuel, O. (INSERM, Paris, Fr); Golmard, J.L. *Comput Appl Biosci* v 4 n 3 Aug 1988 p 357-365.

**086812 USE OF VARIOUS PROPERTIES OF AMINO ACIDS IN COLOR AND MONOCHROME DOT-MATRIX ANALYSES FOR PROTEIN HOMOLOGIES.** Software has been developed to allow the

use of a number of parameters in the comparative representation of proteins in color and monochrome dot matrices. The problem of scoring matched identities is addressed. The PAMs matrix has been incorporated in such a way to allow the user to stipulate various PAM's values or estimated percentage difference between two peptide sequences, and converting to log odds values. In addition, the similarity ring developed by R. Swanson and the matrix proposed by D.J. Bacon and W.F. Anderson have been adapted for use in the program. Color indices have been utilized to give a 'third dimension' to the projections, allowing the user to judge the degree of similarity of different regions which are represented. (Edited author abstract). 8 Refs.

Reisner, A.H. (CSIRO, North Ryde, Aust); Bucholtz, C.A. *Comput Appl Biosci* v 4 n 3 Aug 1988 p 395-402.

**086813 SIGSEQX: A COMPUTER PROGRAM FOR PREDICTING SIGNAL SEQUENCE CLEAVAGE SITES.** In the Signal hypothesis a signal sequence is that sequence of a protein which initiates the export of a growing protein chain across a membrane. Subsequently the signal sequence is cleaved from the mature protein. There has been significant correlation of cleavage site with molecular structure. A computer program to predict the signal sequence cleavage site, based on the G. von Heijne's method, has been implemented in the C language. The program is run interactively with options specified in the program run command line or entered at program prompts for information. Typical processing times are in the order of a few tenths of a second of CPU time. 6 Refs.

Popowicz, A.M. (Rockefeller Univ, New York, NY, USA); Dash, P.F. *Comput Appl Biosci* v 4 n 3 Aug 1988 p 405-406.

**Concentration** See Also BIOLOGICAL MATERIALS—Measurements; ENZYMES—Enzyme Kinetics.

**086814 MEMBRANE ELECTROCHEMICAL CONCENTRATION OF PROTEIN.** The possibility of the selective membrane electrochemical concentration of protein from aqueous solutions has been demonstrated. The concentration of the protein was carried out under the conditions of natural convection and the forced supply of the solution to the electrochemical membrane cell. The electrical power consumption for the isolation of 1 kg of protein did not exceed 4 kW·h. (Author abstract) 6 res.

Verbich, S.V. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Ponomarev, M.I.; Grebenyuk, V.D. *Colloid J USSR* v 49 n 4 Jul-Aug 1987 p 656-658.

## Condensation

**086815 NOVEL CONDENSATION SYSTEM FOR AQUEOUS SOLUTIONS OF PROTEINS. FACILITATED PERMEATION OF PROTEINS THROUGH A POROUS MEMBRANE PREPARED FROM A BLOCK COPOLYMER CONSISTING OF HYDROPHILIC POLYAMIDE AND POLYOXYETHYLENE SEGMENTS.** A new porous membrane was prepared from a block copolymer consisting of hydrophilic polyamide as outer segments and polyoxyethylene as an inner segment by casting a mixture of the block copolymer with polyoxyethylene glycol and drying it at room temperature, followed by immersion and rinsing in water. In the solute rejection test for some proteins, the concentration of the permeate was found to be much higher than that in the feed. This peculiar condensation was highly dependent not only on the casting conditions for the porous membrane, but also on the permeation conditions, such as the pressure difference, mechanical stirring, and the initial concentration of the protein solutions. The present transport system is presumed to result from a delicate combination of the rapid adsorption of proteins onto the porous membrane and their transport driven by the lower pressure. (Edited author abstract) 16 refs.

Hashimoto, Kazuhiko (Nagoya Univ, Nagoya, Jpn); Sumitomo, Hiroshi; Yamamori, Hiroo. *Polym J* v 19 n 10 1987 p 1139-1145.



## Cooling

**086816 STABILIZATION OF LABILE BIOCHEMICALS BY UNDERCOOLING.** The problems relating to the stabilization of isolated biochemicals are discussed, with special emphasis on proteins. A novel process for the preparation of products with long shelf-lives is described. It relies on undercooling, as distinct from freezing, and does not require the use of protectant additives. Isolated proteins can be formulated to any desired concentration and can be stored in a freezer ( $-12$  or  $-20^{\circ}\text{C}$ ) for extended periods without loss of activity. (Author abstract) 26 refs.

Hatley, Ross H.M. (Pafra Ltd, Cambridge, Engl); Franks, Felix; Mathias, Sheila F. *Process Biochem* v 22 n 6 Dec 1987 p 169-172.

## Degradation

**086817 BARLEY PROTEIN DEGRADATION: MECHANISM OF PROTEIN SOLUBILIZATION DURING BARLEY MASHING WITH NEUTRAL PROTEINASE.** Kinetics of protein solubilization during barley mashing with neutral proteinase were studied. By plotting the kinetics data in Foster-Niemann coordinates for barley concentration range of 10-30% linear relationships with high correlation coefficients ( $r \geq 0.999$ ) were obtained. The slopes of straight lines were very close to corresponding reciprocal initial insoluble nitrogen concentrations. Barley proteolytic inhibitors affected the ordinate intercept; by their addition the values of ordinate intercept decreased. The data suggest that the modified Foster-Niemann equation can be proposed to interpret kinetics of insoluble barley protein degradation. The proteolytic activity decay was studied as well. The enzyme decay was faster in buffer solution than during barley mashing, but in both cases first-order kinetics can be applied. A mathematical model describing protein solubilization and enzyme decay kinetics were developed. The results of computer simulation were in good agreement with experimental data. (Author abstract) 35 refs.

Markovic, Ivan (PLIVA, Pharmaceutical, Chemical, Food & Cosmetic Industry, Zagreb, Yugosl); Topolovec, Velimir; Maric, Vladimir; Johanides, Vera. *Biotechnol Bioeng* v 32 n 1 Jun 1988 p 18-27.

## Desorption

**086818 DESORPTION OF SPREAD MONOLAYERS OF  $[^{14}\text{C}]$  METHYLATED AND COLD BSA FROM THE AIR-AQUEOUS INTERFACE.** Compression-expansion cycles on spread monolayers of BSA (Bovine Serum Albumen) and  $[^{14}\text{C}]$  methylated BSA at the air/phosphate buffer interface at  $20^{\circ}\text{C}$  showed that irreversible losses in area occurred after films were held at surface pressure greater than  $18 \text{ mN m}^{-1}$ , although the compressibility was unchanged. The rates of desorption of BSA and of a 2:1 mixture with radiolabelled BSA were similar at  $\Pi = 21, 24$  and  $30 \text{ mN m}^{-1}$ , and increased with increasing surface pressure. The surface concentration of protein obtained after successive cycling, from the activity of the labelled monolayer transferred onto plates by the Langmuir-Blodgett technique, was constant within experimental error, indicating that area losses were caused by desorption. (Edited author abstract). 15 Refs.

Herrington, T.M. (Univ of Reading, Reading, Engl); Sahi, S.S. *Colloids Surf* v 32 n 3 pt 4 Jul 1988 p 289-295.

## Differential Thermal Analysis

**086819 THERMOANALYTICAL INVESTIGATIONS OF EXTENDED AND ANNEALED KERATINS.** DSC (differential scanning calorimetry) investigations have been used to characterize the microfibril-matrix complex of wool and hair keratins consisting of helical low-sulfur microfibrils in a nonhelical high-sulfur matrix. The corresponding DSC curves display one or two endothermic peaks in the temperature range  $230^{\circ}$ - $255^{\circ}\text{C}$ . The first peak is a microfibrillar peak and the second one a matrix peak (cystine decomposition peak). DSC investigations of extended keratins have shown that the microfibrillar peak is a helix peak. DSC investigations of annealed keratins confirm an earlier assumption that the helix peak is an irreversible helix unfolding, superimposed by various decomposition reactions. The matrix peak is less reproducible than the corresponding helix peak and cannot be used for further characterization studies of keratins. (Author abstract) 11 refs.

Spei, M. (RWTH Aachen, Aachen, West Ger); Holzem, R. *Colloid Polym Sci* v 265 n 11 Nov 1987 p 965-970.

## Drying See Also DRYING.

**086820 CENTRIFUGAL DEWATERING OF ACID CASEIN CURD: EFFECT OF CASEIN MANUFACTURING AND CENTRIFUGATION VARIABLES ON CURD COMPRESSION IN A LABORATORY CENTRIFUGE.** Data relevant to curd compression in a horizontal, solid bowl decanter centrifuge have been obtained by studying the dewatering of acid casein curd in a batch laboratory centrifuge. Analysis of curd compression under centrifuge force predicts a moisture content gradient in the dewatered curd from a maximum at the curd-liquid interface to a minimum at the centrifuge bowl wall. This moisture content gradient was also measured experimentally, and its practical implications are discussed. (Edited author abstract). 15 Refs.

Munro, P.A. (Massey Univ, Palmerston North, NZ); Van Til, H.J. *Biotechnol Bioeng* v 32 n 9 Oct 20 1988 p 1153-1157.

## Electric Conductivity

**086821 DOUBLE-ELECTRODE BEHAVIOR OF THE BILAYER LIPID MEMBRANE IN ELECTROLYTIC SOLUTION.** The electrical conductivity across the bilayer lipid membrane of oxidized cholesterol in the presence of different electrolytes in aqueous solution is a function of the standard electrode potential of the ions of the electrolytes. The same correlation follows in the presence of these electrolytic solutions containing iodine although the conductivity value increases manifold. The results can be satisfactorily explained in the light of electronic conduction through the bilayer membrane which acts as a double electrode. (Author abstract) 15 refs.

Bhowmik, Benoy B. (Jadavpur Univ, Calcutta, India); Dutta, Ruma; Nandy, Papiya. *J Colloid Interface Sci* v 122 n 2 Apr 1988 p 450-455.

## Extraction See Also WOOL—Cleaning.

**086822 PROTEIN EXTRACTIONS WITH HOLLOW FIBERS.** Differential protein extractions were measured with two types of extractants: inverted micelles and two-phase aqueous systems. The results show that hollow-fiber extractions are substantially faster than those possible in conventional equipment. The extractions are not compromised by loading or flooding because the flows of extractant and raffinate are almost completely independent. Mass transfer coefficients inferred from the measurements both support and extend design equations for these contactors. (Author abstract) 25 refs.

Dahuron, Lise (Univ of Minnesota, Minneapolis, MN, USA); Cussler, E.L. *AIChE J* v 34 n 1 Jan 1988 p 130-136.

**086823 EXTRACTION OF  $\beta$ -GALACTOSIDASE FUSED PROTEIN A IN AQUEOUS TWO-PHASE SYSTEMS.** A method for the purification of proteins hybridized with  $\beta$ -galactosidase and produced in *Escherichia coli* is suggested. The method is based on the dominating properties of the  $\beta$ -galactosidase part of the molecule that are utilized for extraction in a poly(ethylene glycol) 4000/potassium phosphate aqueous two-phase system. The purification of the hybrid protein *Staphylococcal* protein A-*Escherichia coli*- $\beta$ -galactosidase (SpA- $\beta$ gal) produced in *Escherichia coli* is described. The partitioning of the cell debris and SpA- $\beta$ gal depended on the distance to the critical point, i.e., the length of the tie line. A poly(ethylene glycol) top phase and an interface

free from cell debris were obtained for a composition close to the binodal with a relatively short tie line. At this composition no SpA- $\beta$ gal was caught by the interface. The partitioning of SpA- $\beta$ gal to the top phase was also affected by the salts present during the extraction. The utilization of SpA- $\beta$ gal for affinity extraction has been investigated. Experiments with SpA- $\beta$ gal and fluorescence-labeled human IgG(higG-F) in a poly(ethylene glycol) 4000/potassium phosphate aqueous two-phase system showed that the complex SpA- $\beta$ gal-higG-F was partitioned to the interface, probably as a precipitate. (Author abstract) 32 refs.

Veide, Andres (Royal Inst of Technology, Stockholm, Sweden); Strandberg, Lars; Enfors, Sven-Olof. *Enzyme Microb Technol* v 9 n 12 Dec 1987 p 730-738.

**086824 LIQUID-LIQUID EXTRACTION OF LOW MOLECULAR-WEIGHT PROTEINS BY SELECTIVE SOLUBILIZATION IN REVERSED MICELLES.** The effects of pH and salt concentration on the solubilization of ribonuclease-a, cytochrome-c and lysozyme in Aerosol OT/isooctane reversed micelle solutions have been studied to explore the potential for employing this solvent system in the large-scale recovery and concentration of proteins using liquid extraction. For pH values below the isoelectric point, pI, of the protein, solubilization was high, probably owing to strong electrostatic interactions between the positively charged proteins and the anionic surfactant heads forming the inner micelle wall. (Edited author abstract) 18 refs.

Goklen, Kent E. (MIT, Cambridge, MA, USA); Hatton, T. Alan. *Sep Sci Technol* v 22 n 2-3 Feb-Mar 1987, Fourth Symp on Sep Sci and Tec for Energy Appl, Knoxville, TN, USA, Oct 20-24 1985 p 831-841.

## Filtration See Also BIOLOGICAL MATERIALS—Blood.

**086825 POLARIZATION AND ADSORPTION EFFECTS ON SIEVING IN MEMBRANE PROTEIN FILTRATION.** The authors have developed a theoretic model to predict both the measured sieving coefficient and the ultrafiltrate flux in an unstirred batch filtration cell. Model predictions are in good agreement with experimental data, providing quantitative evidence for the effects of protein polarization on flux and sieving. In addition, results indicate that protein adsorption plays an important role in membrane filtration. The model for the unstirred cell permits very accurate evaluation of intrinsic membrane sieving coefficients for highly rejected proteins. These results are critical in the design and analysis of selective protein filtration devices, e.g., cascade filtration for separation of albumin from immunoglobulins. 10 refs.

Robertson, Bruce C. (Univ of Delaware, Newark, DE, USA); Zydney, Andrew L. *ASAIOTrans* v 33 n 3 Jul-Sep 1987 p 118-122.

**086826 MICROFILTRATION OF PROTEIN SOLUTIONS: EFFECT OF FOULING ON REJECTION.** In cross-flow microfiltration of proteins both flux and protein transmission decline over time as proteins adsorb onto the membrane. It was found that protein-membrane interaction is a consequence of charge effects in the double-layer of the membrane and the charged ion. Whey protein solutions of different pH in the presence of salt and without salt were filtered to investigate this interaction. Addition of 100 mM NaCl to water which has been pretreated by reverse osmosis increased the water flow. (Author abstract) 7 refs.

Heinemann, P. (Univ of Bath, Bath, Engl); Howell, J.A.; Bryant, R.A. *Desalination* v 68 n 2-3 Mar 1988, Proc of the 5th Symp on Synth Membr in Sci and Ind, Tuebingen, West Ger, Sep 2-5 1986 p 243-250.

## Fractionation

**086827 CONTINUOUS FRACTIONATION OF HUMAN PLASMA PROTEINS BY PRECIPITATION FROM THE SUSPENSION OF THE RECYCLING STREAM.** The conventional cold-ethanol batch fractionation method of human plasma is converted to an



automatically controlled continuous fractionation process. The selected protein fractions are precipitated by mixing in the recycled product stream of the suspension. Compared to the batch process, the continuous fractionation process generates less coprecipitation and less spontaneous nucleation, allowing efficient centrifugation of precipitates, and the yield and purity of albumin in the final fraction is significantly increased. (Author abstract) 12 refs.

Chang, Chong E. (Alpha Therapeutic Corp, Los Angeles, CA, USA). *Biotechnol Bioeng* v 31 n 8 May 20 1988 p 841-846.

**Hydrolysis** See Also ALGAE—Industrial Applications; AMINO ACIDS—Production.

**086828 SPECIFIC LIMITED HYDROLYSIS AND PHOSPHORYLATION OF FOOD PROTEINS FOR IMPROVEMENT OF FUNCTIONAL AND NUTRITIONAL PROPERTIES.** Limited specific hydrolysis of casein by *Staphylococcus aureus* V8 protease was used to produce 2% and 6.7% hydrolysates (2 and 6.7% of the peptide bonds hydrolyzed), each containing five polypeptides (by gel filtration) ranging in size from approximately 16,000 to approximately 1,000 daltons. The mixtures of polypeptides had substantially increased solubilities at pH 4.0-4.5, near the isoelectric point of casein. Phosphorylation of zein markedly increased the water solubility of zein above and below pH 4. All the modified zeins had improved emulsifying activity indices. (Edited author abstract) 50 refs.

Chobert, Jean-Marc (Univ of California, Davis, CA, USA); Sitohy, Mahmoud; Whitaker, John R. *JAOCs J Am Oil Chem Soc* v 64 n 12 Dec 1987 p 1704-1711.

**086829 ENZYME HYDROLYSIS OF PLASMA PROTEINS IN A CSTR ULTRAFILTRATION REACTOR: PERFORMANCES AND MODELING.** By investigating the effects of four operating variables - volume (V), ultrafiltration flux (J), enzyme concentration (E), and substrate concentration (S) - on capacity (K) and conversion rate ( $\epsilon$ ) of a hollow fiber CSTR, the performances of the CSTR and the kinetic constants of the reaction were determined. A model which takes into account the course of fractional conversion (X) according to the modified space-time parameter,  $\tau$  (integrated form of V, J, S, and E), was devised by employing the relationship to integrate the equation for the reaction rate of the CSTR and the expression of the modified space time. Correlation of this model and the experimentally obtained results demonstrates that the characteristics for an ultrafiltration membrane reactor for enzymatic hydrolysis by alcalase of plasma proteins are close to those of an ideal CSTR. Optimal scaling up, however, remains dependent on the compromise which may be obtained between capacity and the conversion rate. (Author abstract) 29 refs.

Bressollier, Ph. (Lab de Biochimie UFR des Sciences, Limoges, Fr); Petit, J.M.; Julien, R. *Biotechnol Bioeng* v 31 n 7 May 1988 p 650-658.

**086830 APPLICATION OF ULTRAFILTRATION TO THE PREPARATION OF DEFINED HYDROLYSATES OF BOVINE HAEMOGLOBIN.** Many uses of protein hydrolysates have been developed and applied to areas such as nutritional therapy, culture media, and the isolation of biologically active peptides. All these applications need carefully controlled and characterized hydrolysates. In order to produce such a type of hydrolysate, it is possible to use haemoglobin which is a very well defined and constant protein source. Enzymic hydrolysis of haemoglobin by pepsin was carried out at pilot-plant scale in an ultrafiltration reactor with mineral membranes. The object was to obtain a reproducible, decolorized, salt-free enzymic hydrolysate. Two types of membranes were tested having 10,000 dalton (M5 type) and 20,000 dalton (M4 type) cut-offs. Little significant difference was observed in the final products when both types of membranes were used. Reproducibility of hydrolysates was verified by amino acid analysis and gel filtration chromatography. The haemoglobin hydrolysates produced contained more than 90 percent protein and are especially

suitable for fine applications. (Author abstract) 14 Refs.

Piot, Jean-Marie (Lab de Technologie des Substances Naturelles, Villeneuve d'Ascq, Fr); Guillochon, Didier; Leconte, Danielle; Thomas, Daniel. *J Chem Technol Biotechnol* v 42 n 2 1988 p 147-156.

**Manufacture** See Also GENETIC ENGINEERING—Applications.

**086831 TOXICOLOGIC AND HYGIENIC APPRAISAL OF YEAST-LIKE FUNGI AS INDUSTRIAL PRODUCERS OF FODDER PROTEIN.** Yeast-like protein-producing fungi are nontoxic, have low toxicogenicity and weak virulence. Sensitizing activity of yeast-like fungi is a major factor contributing to their negative body effect. When introducing microorganisms as fodder protein producers into the manufacture process it is necessary to take account not only of their virulent but also allergic nature. Yeast strain for DA<sub>50</sub> less than 10<sup>3</sup> cells per animal under intracutaneous administration should not be allowed to be used in the manufacture process. Taking into account the obtained sensitizing characteristics the analyzed strains are attributed to the second risk class. Maximum allowable concentration of yeast-like fungi for the work zone air should be set at 460 cells per 1 m<sup>3</sup>. (Author abstract) 2 refs. In Russian.

Bodienkova, G.M. *Gig Tr Prof Zabol* n 9 1987 p 43-45.

**086832 EFFECT OF THE GLUCOSIDASE INHIBITOR 1-DEOXYNOJIRIMYCIN ON PROTEIN SECRETION FROM SACCHAROMYCES CEREVISIAE.** 1-Deoxynojirimycin (dNM), an inhibitor of the trimming enzymes glucosidase I and II, increased secretion of a cloned human peptide hormone, somatomedin C, about fourfold. The stimulation was reversible and directly dependent on dNM concentration. The effect was observed with cells grown in batch or with immobilized steady-state cultures. Most likely, dNM affected processing of N-linked glycans, since it reduced the catalytic activity of external yeast invertase even in low concentrations. This could be attributed to preventing the outer chain glycosylation of the surface exposed glycans. (Author abstract) 38 refs.

Greber, Urs F. (ETH Hoenggerberg, Zurich, Switz); Sode, Koji; Meussdoerffer, Franz. *Enzyme Microb Technol* v 10 n 4 Apr 1988 p 246-251.

## Measurements

**086833 LOW COST NUCLEAR TECHNIQUE FOR THE RAPID DETERMINATION OF THE PROTEIN CONTENT OF RICE.** An attempt has been made to use the 10.82 MeV  $\gamma$  rays emitted in the prompt <sup>14</sup>N (n,  $\gamma$ ) reaction to investigate the feasibility of determining the content of nitrogen in bulk samples of rice using a <sup>252</sup>Cf source. Gamma ray spectra of samples of urea (H<sub>2</sub>NCONH<sub>2</sub>) irradiated with thermal neutrons from a <sup>252</sup>Cf source with a yield of  $3.0 \times 10^5$  neutrons/s clearly showed the full energy peak and escape peaks due to  $\gamma$ -rays from neutron capture in nitrogen. A  $3 \times 3$  in. NaI(Tl) crystal was used as the detector and the neutrons were thermalized in paraffin before their capture. The 10.82 MeV  $\gamma$ -rays from neutron irradiated rice have been detected using the weak neutron source. It appears that the method should be useful for rapid determination of the nitrogen content in rice if a stronger californium source were employed. This should enable a rapid determination of the protein content, as this is correlated with the amount of nitrogen in the rice. (Author abstract) 6 refs.

Hussain, M. (Univ of Dhaka, Bangladesh); Hoque, M. *Appl Radiat Isot* v 39 n 4 1988 p 358-359.

**Medical Applications** See ELECTROTHERAPEUTICS—Electroacupuncture.

## Microstructure

**086834 NEW GRAPHIC REPRESENTATION OF STRUCTURAL PARAMETERS OF PROTEINS.** A computer program is described that is designed to make the visual inspection of classical plots of protein properties

(e.g. hydrophobicity, volume, etc.) as a function of sequence easier. An algorithm written in BASIC language has been used in order to generate a pseudo-tridimensional representation of the desired protein property. The data utilized by the program are arithmetic averages of the selected parameter obtained by using a five-residue window as a shuttle along the given amino acid sequence. (Author abstract) 7 refs.

Facchiano, Francesco (First Faculty of Medicine, Naples, Italy); Facchiano, Antonio; Facchiano, Angelo; Ragone, Raffaele; Colonna, Giovanni. *Comput Appl Biosci* v 4 n 2 Apr 1988 p 303-305.

**Modification** See Also WOOL FIBERS—Crimping.

**086835 CHEMICAL AND PHYSICAL LIPOPHILIZATION OF PROTEINS.** With a view to enhance the amphipathic nature of food proteins, chemical and physical modification were carried out. Soy glycinin and  $\alpha_{s1}$ -casein were lipophilized by chemically attaching naturally occurring fatty acids to them. The covalent attachment of fatty acyl residues to these proteins caused an increase in their emulsification activity. Soy proteins and the maize protein, zein, were associated with soy lecithin and phosphatidate, respectively, by sonication. The emulsification activity of phospholipid-protein complexes was greatly increased after they were treated with 50% ethanol or enzyme digestion. (Author abstract) 13 refs.

Kito, Makoto (Kyoto Univ, Uji, Jpn). *JAOCs J Am Oil Chem Soc* v 64 n 12 Dec 1987 p 1676-1681.

**086836 CHEMICAL INACTIVATION OF SOY-BEAN TRYPSIN INHIBITORS.** Sodium metabisulfite and glutaraldehyde were used alone and in combination to inactivate Kunitz trypsin inhibitor (TI) in model systems and TI in lyophilized alkaline soy meal extract. Reaction of glutaraldehyde (0.1 to 3.0%, based on total volume of the reaction mixture) with Kunitz TI (3 mg/ml buffer) at 25 C resulted in 60-75% reduction in activity. Treatment of soy meal extract containing 0.08 mg TI/mg at a concentration of 10 mg sample/ml buffer under similar reaction conditions reduced TI activity only 40%, however. A reaction temperature of 75 C had little additional effect on TI inactivation. (Edited author abstract) 29 refs.

Sessa, D.J. (USDA, Peoria, IL, USA); Ghantous, P.E. *JAOCs J Am Oil Chem Soc* v 64 n 12 Dec 1987 p 1682-1687.

**086837 COMPARATIVE NUTRITIONAL VALUE FOR AMINO ACIDS, OLIGOPEPTIDES AND SOY-BEAN PROTEIN.** It has been hypothesized that partial protein hydrolysates or oligopeptide mixtures are nutritionally superior to corresponding amino acid mixtures. With this consideration for a background, the authors developed a sophisticated technique of protease-catalyzed modification of soy protein to produce enzymatically modified proteins (EMP) having different levels of covalently attached methionine. Discussions stress the importance of applying such a technique to production of an oligopeptide rather than a free amino acid nitrogen source as a foodstuff for therapeutic use. (Edited author abstract) 25 refs.

Arai, Soichi (Univ of Tokyo, Tokyo, Jpn); Kimura, Hiroko. *JAOCs J Am Oil Chem Soc* v 64 n 12 Dec 1987 p 1692-1696.

**086838 EFFECTS OF LIMITED PROTEOLYSIS ON FUNCTIONAL PROPERTIES OF OVALBUMIN.** The authors examined the limited proteolysis of ovalbumin by pepsin and its effect on the functional properties of the ovalbumin. Pepsin hydrolyzed only the single peptide bond of ovalbumin between His-22 and Ala-23. This provided a large intermediate (MW 42,500), P-ovalbumin. A P-ovalbumin solution gave a transparent gel when heated. Under the same conditions, an ovalbumin solution gave a turbid gel. The authors studied the



physicochemical properties of P-ovalbumin and the formation of the transparent gel. (Edited author abstract) 14 refs.

Doi, Etsushiro (Kyoto Univ, Uji, Jpn); Koseki, Taihei; Kitabatake, Naofumi. *JAOCs J Am Oil Chem Soc* v 64 n 12 Dec 1987 p 1697-1703.

**086839 FUNCTIONAL PROPERTIES OF CHEMICALLY MODIFIED EGG WHITE PROTEINS.** Functional properties of egg white proteins can be altered through selected chemical reactions. Acylations with acid anhydrides have received the greatest amount of attention. Oleic acid and sodium dodecyl sulfate (SDS) have also been used to affect function of egg white proteins. The altered ionic properties have been shown to affect the optical properties of protein sols, heat stability, foaming, performance in angel cakes, initiation of gelation, ultimate strength and freeze-thaw stability of heat-set gels. (Edited author abstract) 33 refs.

Ball, Hershell R. Jr. (North Carolina State Univ, Raleigh, NC, USA). *JAOCs J Am Oil Chem Soc* v 64 n 12 Dec 1987 p 1718-1725.

**086840 FUNCTIONAL PROPERTIES OF OAT PROTEINS MODIFIED BY ACYLATION, TRYPSIN HYDROLYSIS OR LINOLEATE TREATMENT.** Proteins extracted from defatted oats were chemically modified by acylation (succinylation and acetylation), potassium linoleate treatment or partial hydrolysis with trypsin. Total essential amino acid content was slightly lowered by acetylation, but unaffected by succinylation. Gel filtration chromatography showed some dissociation of oat polypeptides by succinylation, while trypsin hydrolysis caused considerable breakdown of the protein. When compared to the unmodified oat protein, succinylation led to an improvement in performance in an emulsified meat system. (Edited author abstract) 17 refs.

Ma, C.-Y. (Agriculture Canada, Ottawa, Ont, Can); Wood, D.F. *JAOCs J Am Oil Chem Soc* v 64 n 12 Dec 1987 p 1726-1731.

**086841 MODIFICATION OF ARACHIN - EFFECT OF CITRATE IONS - STRUCTURAL IMPLICATIONS.** The effect of the anion citrate on the subunit structure of arachin has been monitored by velocity sedimentation, viscosity and circular dichroism techniques. The results indicate that as the concentration of citrate ion increases from 25 mM to 150 mM, arachin dissociates progressively to the low molecular weight 2S component. This dissociation is not accompanied by any conformational changes or denaturation as revealed by the far ultraviolet circular dichroic spectra and viscosity results, respectively. The results are explained by direct anion binding and changes in the solvent structure. (Author abstract) 17 refs.

Prakash, V. (Central Food Technological Research Inst, Mysore, India); Appu Rao, A.G.; Rajagopal Rao, D. *JAOCs J Am Oil Chem Soc* v 64 n 12 Dec 1987 p 1732-1735.

**086842 GENETIC MODIFICATION OF FOOD PROTEINS.** Directed alterations in the genome of food-producing organisms by deletion or addition of selected nucleic acid bases can lead to changes in the primary sequences of individual food proteins. Resulting modifications in the physico-chemical properties or enzymatic susceptibility of the altered gene product are superimposed on the endogenous normal proteins. If sufficient quantities of the novel protein are synthesized and become admixed with the basal levels of protein in the food, the functional properties of the food system (emulsification, foaming, gelling, etc.) may become enhanced. Alternatively, the modified protein might be isolated for use separately as a food ingredient. Thus genetic engineering techniques may provide the basis for production of higher quality and novel food products. (Author abstract) 19 refs.

Creamer, Lawrence K. (New Zealand Dairy Research Inst, Palmerston North, NZ); Jimenez-Flores, Rafael; Richardson, Tom. *Trends Biotechnol* v 6 n 7 Jul 1988 p

163-169.

## Molecular Structure

**086843 STRUCTURE OF CASEIN MICELLES II.  $\alpha_{s1}$ -CASEIN.** Static and dynamic light scattering measurements were performed in a concentration range from 0.5 to 6.0 mg/ml at  $T=35^\circ\text{C}$ . A constant apparent molecular weight of  $3.4 \times 10^6$  daltons was found over the whole range. The apparent radii of gyration and the diffusion coefficients also show no detectable concentration dependence. The ratio of the two radii  $\rho \equiv R_g/R_H = 2.78 \pm 0.21$  is characteristic of extended rigid structures.  $R_g$  is the radius of gyration and  $R_H$  the hydrodynamic radius extended via the Stokes-Einstein relationship from the translational diffusion coefficient. This is in agreement with the analysis of the pronounced angular dependence of the scattered light, which leads to the conclusion that  $\alpha_{s1}$ -casein forms very long worm-like micelles. The contour length of one cylinder was found to be  $L \approx 1600$  nm and the chains appear to be composed of about 12 Kuhn segments. (Edited author abstract) 9 refs.

Thurn, A. (Univ of Freiburg, West Ger); Buchard, W.; Niki, R. *Colloid Polym Sci* v 265 n 10 Oct 1987 p 897-902.

**Permeability, Mechanical** See ULTRAFILTRATION—Equipment.

**Physical Chemistry** See Also MARINE BIOLOGY.

**086844 PROTEIN STRUCTURE DETERMINATION BY NMR.** For soluble proteins below about 10 kDa, nuclear magnetic resonance (NMR) now offers a route to obtaining a 3-D structure. The method is illustrated with work on human epidermal growth factor. The significance for biotechnology is that for the first time there is now an alternative to X-ray crystallography. Once a structure is solved by NMR methods, a relatively rapid examination of minor variants produced by recombinant DNA methods then becomes possible. (Author abstract) 26 refs.

Campbell, Iain D. (Univ of Oxford, Oxford, Engl); Sheard, Brian. *Trends Biotechnol* v 5 n 11 Nov 1987 p 302-306.

**086845 SPIN EXCHANGE BROADENING AS A MEASURE OF SOLUBILIZATION OF PHOSPHATIDYLCHOLINE BILAYER WITH OCTYL GLUCOSIDE.** One of the spin label methods, using the spin exchange broadening, was applied for the investigation of the solubilization of egg phosphatidylcholine (PC) bilayer with octyl glucoside (OG) and for the study of the structure of OG/PC mixed micelle. This technique had never been employed for the study of dissolution of lipid bilayer by surfactants and was revealed to be a promising method. 19 refs.

Yoshioka, Hisashi (Shizuoka Coll of Pharmacy, Shizuoka, Jpn). *J Colloid Interface Sci* v 119 n 2 Oct 1987 p 371-377.

## Physical Properties

**086846 INTERFACIAL INTERACTIONS BETWEEN PROTEINS AND MAMMALIAN LIPASES.** The effects of proteins, both endogenous and exogenous, on the activity of lipases against water soluble and water insoluble substrates have been reviewed. The enzymes considered are pancreatic and gastric lipases, and lipoprotein, bile-salt-stimulated human milk and pancreatic carboxyl ester lipases. This discussion gives consideration to association of the proteins with the enzyme or the interface and to whether the interactions with specific binding sites or interfacial inactivation are responsible for the observations. However, the effect of proteins on lipases acting against water soluble substrates varies from protein to protein. (Edited author abstract) 131 refs.

O'Connor, J. (Univ of Auckland, Auckland, NZ); Sutton, Bridget M. *Adv Colloid Interface Sci* v 28 n 1 Nov 1987 p 1-34.

**Precipitation** See Also DRUG PRODUCTS—Chromatographic Analysis.

**086847 POLYMER DOSAGE CONSIDERATIONS IN POLYELECTROLYTE PRECIPITATION OF PROTEIN.** The properties of aggregates formed by the precipitation of egg white proteins by carboxymethyl cellulose (CMC) were examined. Both the final level and the number of incremental additions of the polyelectrolyte were varied. The protein and lysozyme recoveries, particle zeta potential, and protein composition of the precipitate were found to vary with only the final CMC level. Particle size and size distributions were dependent on both the polymer dosage and manner of addition. Overdosed systems, or systems in which the CMC dosage exceeded that required for optimal total protein removal, produced the smallest particles, with size increasing as the number of incremental polymer additions increased. Optimally dosed systems produced the largest particles. (Author abstract) 31 refs.

Clark, K.M. (Iowa State Univ, Ames, IA, USA); Glatz, C.E. *Biotechnol Prog* v 3 n 4 Dec 1987 p 241-247.

**086848 PROTEIN PRECIPITATE RECOVERY USING MICROPOROUS MEMBRANES.** The use of microporous membranes has been examined for the recovery of precipitated protein suspensions and related soluble protein. Membrane flux rates and soluble protein transmissions are reported for unstirred batch-cell studies and cross-flow experiments. The unstirred batch-cell gave soluble protein transmissions in the range 80-100% for feeds containing either soluble protein or a mix of soluble and isoelectrically precipitated protein. In all cases a sharp decline in flux was observed which was, for example, considerably greater for soluble protein at its isoelectric point, pH 4.6, than at pH 8.8. The presence of precipitated protein led to a further decrease in flux rate. In cross-flow studies, flux decline was eventually accompanied by a significant decline in soluble protein transmission. The flux protein-transmission characteristics of microporous membranes are discussed in terms of the interaction of the soluble and precipitated protein with the membrane. (Author abstract) 22 refs.

Bentham, A.C. (Univ Coll London, London, Engl); Ireton, M.J.; Hoare, M.; Dunnill, P. *Biotechnol Bioeng* v 31 n 9 Jun 5 1988 p 984-994.

**Processing** See MEMBRANES.

**Production** See Also SUGAR BEETS—Fermentation.

**086849 REPEATED FED BATCH FERMENTATION FOR SINGLE CELL PROTEIN PRODUCTION FROM PREHYDROLYSATE OF A PULP MILL.** The prehydrolytate liquor generated from a rayon pulp mill (after prehydrolysis of wood) was used for the production of single cell protein using yeast and mold cultures by repeated fed batch fermentation in a laboratory fermenter. The results are compared with those of simple batch fermentation. The repeated fed batch fermentation gave up to 75% higher biomass productivity and the sugars utilization was also improved. (Author abstract) 8 refs.

Bajpai, Pratima (Thapar Corp Research & Development Cent, Patiala, India); Bajpai, Pramod K. *Enzyme Microb Technol* v 10 n 5 May 1988 p 280-283.

**086850 PRODUCTION OF PROTEIN BY THERMOPHILIC FUNGI FROM SUGAR-BEET PULP IN SOLID-STATE FERMENTATION.** Conversion of lignocellulosic plant materials into protein by microorganisms is a process of increasing importance for the future. The organic biomass produced by photosynthesis is estimated at  $163 \times 10^9$  tons annually, and over half of this is in the form of cellulose and hemicelluloses. Management of these raw materials is difficult, however, because of the seasonal variation in plant vegetation and its territorial dispersion. For these reasons, waste materials from agriculture and forestry are attractive, such as cereal



straw, bagasse, sugar-beet pulp, residual plant materials, and wastepaper. Sugar-beet pulp was chosen as a cellulosic substrate as its physicochemical structure was considered suitable for the SSF process. The widespread production of sugar beets in some countries and the current high level of stock in the sugar industry suggest the possibility of real industrial applications. 5 refs.

Grajek, W. (Acad of Agriculture, Poznan, Pol). *Biotechnol Bioeng* v 32 n 2 Jul 5 1988 p 225-260.

**086851 PRODUCTION OF MICROBIAL BIOMASS PROTEIN FROM AUTOTROPHIC FERMENTATION OF HYDROGEN SULFIDE.** K.L. Sublette and N.O. Sylvester have proposed a process for the removal of  $H_2S$  from natural gas based on the microbial oxidation of  $H_2S$  by *T. denitrificans*. The feasibility of producing a high-quality microbial biomass protein as a saleable by-product of this process or as a main product has been investigated and is reported here. 6 Refs.

Sublette, Kerry L. (Univ of Tulsa, Tulsa, OK, USA). *Biotechnol Bioeng* v 32 n 3 Jul 20 1988 p 408-409.

**086852 OPTIMIZING THE PRODUCTION OF RECOMBINANT PROTEINS IN MICROORGANISMS.** To optimize the production of recombinant proteins, the special characteristics and physiology of genetically-engineered cells must be taken into account in the design of optimal bioreactors. The scale-up of processes involving recombinant organisms is currently one of the central problems in biochemical engineering. Related research is being conducted in cellular physiology, fermentations, reactor design, mathematical modelling, instrumentation, and product recovery. 162 Refs.

Gergiou, George (Univ of Texas, Austin, TX, USA). *AIChE J* v 34 n 8 Aug 1988 p 1233-1248.

**Purification** See Also ADSORBENTS—Porosity; ANTIBODIES—Production; ENZYMES—Immobilization; ENZYMES—Purification.

**086853 PURIFICATION OF PROTEINS BY AQUEOUS TWO-PHASE PARTITION IN NOVEL ACRYLIC CO-POLYMER SYSTEM.** Polyampholytic acrylic co-polymers have been shown to form two-phase systems with polyvinyl alcohol under appropriate conditions of pH, ionic strength and temperature. These novel systems have been used for the purification of a number of proteins from crude extracts. The partition behavior of proteins appeared to be influenced predominantly by electrostatic interactions and could be manipulated by including electrolytes in the systems. Human serum albumin could be purified to apparent homogeneity (2.2-fold) in a single extraction step from plasma while partial purifications of trypsin (3.4-fold) and carboxypeptidase G2 (3.5-fold) were also obtained. In contrast to conventional PEG/dextran two-phase systems, quantitative protein recovery from liquid phases containing polyampholytes could be achieved simply by iso-electric precipitation of the polymer. (Author abstract) 19 refs.

Hughes, Peter (Univ of Cambridge, Cambridge, Engl); Lowe, Christopher R. *Enzyme Microb Technol* v 10 n 2 Feb 1988 p 115-122.

**086854 REMOVAL OF NUCLEIC ACID CONTAMINANTS USING NUCLEASE ENZYMES DURING PROTEIN ISOLATION.** An immunogenic subunit of the Plasmodium falciparum circumsporozoite protein confers immunity against the sporozoite stage of malaria. This antigen has a molecular weight (MW) of 17,254 and is composed of 163 amino acids, including 32 randomly repeated tetrapeptides fused to a 32 amino acid sequence derived from the tetracycline resistance region (tet32) of pBR322. The tet32 gene fragment is read out of frame, yielding an amino acid sequence containing 12 arginines and 6 histidines at the C-terminus. This highly cationic tet32 tail results in a theoretical pI for the antigen of 12.8. Conventional isolation techniques initially failed to yield a product substantially free from nucleic acids. This communication presents evidence for the formation of a nucleic-acid-antigen complex to account for the copurification of these two species during isolation and describes

a process to degrade this complex enzymatically using commercially available phosphodiesterases. 9 refs.

Zabriskie, D.W. (Smith Kline & French Lab, Swedeland, PA, USA); DiPaolo, M. *Biotechnol Bioeng* v 32 n 1 Jun 1988 p 100-104.

**086855 LARGE-SCALE ELECTROPHORESIS FOR PROTEIN PURIFICATION: EXPLOITING ISOELECTRICITY.** Preparative electrophoresis methods (including isoelectric focusing in immobilized pH gradients) in gel phases are characterized by low loading (barely a few mg protein per ml matrix), low recoveries (rarely exceeding 70%), and heavy contamination from neurotoxic gel materials (the unreacted gel monomers and ungrafted oligomers). These drawbacks can be minimized by a version of isoelectric focusing in which the need for protein of interest to pass the gel is eliminated: only the contaminants traverse the gel. This is achieved by circulating a liquid sample between two gels held at controlled pHs. The method can provide: (1) high rate of sample processing (up to 1 g h<sup>-1</sup>); (2) high purification (in general to charge homogeneity) and (3) high recoveries (>95%). A large-scale membrane apparatus has been built, with a cross-sectional diameter of 9 cm. Large Pt electrode disks provide even current flow. In this electrolyser, 10 g of Eglin C (produced by recombinant DNA technology) have been purified to homogeneity in around 10 h from 1 l of a partially enriched preparation. (Author abstract) 18 refs.

Righetti, Pier Giorgio (Univ of Milan, Milan, Italy); Barzaghi, Barbara; Faupel, Michel. *Trends Biotechnol* v 6 n 6 Jun 1988 p 121-125.

**086856 DUAL-FUNCTIONAL AFFINITY PROTEIN PURIFICATION.** A rapid, single stage purification scheme for the enzyme pyruvate kinase (PK), overproduced by a genetically altered strain of *Saccharomyces cerevisiae*, is presented. A single affinity adsorption, washing and elution stage using a novel dual-functional polyacrylamide affinity gel produces 60 percent recovery of PK and purification to near homogeneity within a few hours. A second elution step increases the recovery to 77 percent, but does not enhance purification. The novel dual-functional polyacrylamide affinity gel is a crosslinked matrix containing both Cibacron Blue F3G-A and carboxylic acid groups, resulting in a higher fraction of accessible Cibacron Blue F3G-A groups than Blue Sepharose CL-6B. The significant purification achieved in a single stage is due in part to the large initial PK concentration in the recombinant yeast. However, the unique dual-functional interaction between PK and the support surface greatly facilitates the one-step purification. PK interacts with the pseudo-affinity ligand, Cibacron Blue F3G-A, as well as the carboxylic acid groups on the gel support. This dual functional binding increases the strength of the PK-gel binding and the selectivity for PK when binding is carried out below the pI of PK. Elution is accomplished under mild conditions, by raising the pH above the isoelectric pH of PK, making the interaction between PK and the carboxylic acid groups repulsive.

Ruaan, R.C. (West Virginia Univ, Morgantown, WV, USA); Blair, J.B.; Shaeiwitz, J.A. *Biotechnol Prog* v 4 n 2 Jun 1988 p 107-112.

**Pyrolysis** See ORGANIC COMPOUNDS—Chromatographic Analysis.

**Radiation Effects** See AMINO ACIDS—Radiation Effects; SEWAGE TREATMENT—Activated Sludge.

**Radioactivity**

**086857 ASTATINATION OF PROTEINS USING AN N-SUCCINIMIDYL TRI-N-BUTYLSTANNYL BENZOATE INTERMEDIATE.** A method is described for labeling proteins with 7.2 h half-life <sup>211</sup>At. The  $\alpha$  particle-emitting nuclide was coupled to goat IgG using an N-succinimidyl 3-(tri-n-butylstannyl) benzoate intermediate. The reaction and purification sequence requires about 2 h to produce <sup>211</sup>At-labeled IgG in 25-40% radiochemical yield. Comparative blood clearance mea-

surements in mice suggest that the <sup>211</sup>At-labeled IgG conjugate is stable in vivo. (Author abstract) 27 refs.

Zalutsky, Michael R. (Duke Univ Medical Cent, Durham, NC, USA); Narula, Acharan S. *Appl Radiat Isot* v 39 n 3 1988 p 227-232.

**Recovery** See YEAST—Processing.

**Reduction**

**086858 KINETICS OF PEROXIDASE REDUCTION AT MODIFIED ELECTRODES.** The electrochemical reduction of horse radish peroxidase was studied at gold electrodes modified with methyl, benzyl, and aminoethyl viologens. The heterogeneous rate constants of the enzyme's redox reaction at the equilibrium potential of the active site are  $(8.4 \pm 0.2) \cdot 10^{-4}$  and  $(1.3 \pm 0.8) \cdot 10^{-5}$  cm/sec, the transfer coefficients  $0.31 \pm 0.06$  and  $0.71 \pm 0.14$  at electrodes modified with benzyl viologen and methyl viologen, respectively. Lactoperoxidase is not reduced at viologen-modified gold electrodes. (Author abstract) 26 refs.

Razumas, V. (Acad of Sciences of the Lithuanian SSR, Vilnius, USSR); Gudavicius, A.; Kulyas, J. *Sov Electrochem* v 23 n 1 Jan 1987 p 121-126.

**Research** See Also ENZYMES.

**086859 EFFECT OF LOCAL CONDITIONS ON HETEROGENEOUS REACTIONS IN THE BACTERIORHODOPSIN MEMBRANE: AN ELECTROCHEMICAL VIEW.** This paper analyzes the problem from an electrochemical point of view: the proton translocation across the membrane is treated as two coupled interfacial proton transfer reactions in a three-phase system (one membrane phase and two aqueous phases). In view of the existence of two exposed surfaces of bacteriorhodopsin, the concept of 'local reaction conditions' is proposed to emphasize the unique situation of the two coupled heterogeneous reactions that are subject to different reaction conditions at the two membrane surfaces. (Edited author abstract) 69 refs.

Hong, Felix T. (Wayne State Univ, Detroit, MI, USA). *J Electrochem Soc* v 134 n 12 Dec 1987 p 3044-3052.

**086860 DEOXYMYOGLOBIN MODEL WITH A STERICALLY UNHINDERED AXIAL IMIDAZOLE.** With use of an  $\alpha, \alpha, \alpha, \alpha$ -tetra-*o*-amido functionalized tetraphenylporphyrin having trans-dipivalamido pickets and a trans-NH-C(O)-(CH<sub>2</sub>)<sub>6</sub>-C(O)-NH- strap, a single-face hindered porphyrin is produced. Its iron(II) complex attains only five-coordination with the unhindered axial ligand 1-methylimidazole. The product has been isolated as a toluene solvate and characterized by magnetic susceptibility. Mossbauer spectroscopy and single-crystal X-ray structure analysis as a five-coordinate high-spin iron(II) complex. The structure is compared to other five-coordinate imidazole-ligated metalloporphyrin species reported in the literature. Of greatest interest is the comparison with previously characterized five-coordinate 2-methylimidazole-ligated iron(II) complexes where the 2-methyl substituent on imidazole is the means used to attain five-coordination. (Edited author abstract) 57 refs.

Momenteau, Michel (Centre Univ Orsay, Fr); Scheidt, W. Robert; Eigenbrot, C.W.; Reed, Christopher A. *J Am Chem Soc* v 110 n 4 Feb 1988 p 1207-1215.

**086861 PHARMACEUTICAL PROTEINS.** Of the more than 200 pharmaceutical proteins which have been investigated to date, more than half are undergoing research and development, about 100 are in clinical trials, and a dozen or so have already been marketed. The most important indications for them are cardiovascular disorders, tumors, autoimmune diseases, and infections. Genetically engineered proteins can be used as active substances, which are chemically and biologically exactly defined, for new drug products and in research to acquire new information on therapeutic use, based on the concept of



therapy with endogenous proteins. Very recent developments have shown that proteins, either in their natural form or modified, are becoming of increasing importance for research into active substances. (Edited author abstract) 222 refs.

Blohm, Dietmar (BASF AG, Ludwigshafen, West Ger); Bollschweiler, Claus; Hillen, Heinz. *Angew Chem (Int Ed Engl)* v 27 n 2 Feb 1988 p 207-225.

**086862 ELECTROSTATIC INTERACTIONS IN PROTEIN STRUCTURES: THE INFLUENCE OF WATER ON ENZYME FLUCTUATIONS.** A discussion is presented of the close relationships that exist between protein-water interactions, protein structural fluctuations and enzyme activity. This discussion is based on a review of the various X-ray crystallographic, dielectric and NMR investigations that have addressed the problem of the nature and extent of protein hydration. (Author abstract). 49 Refs.

Bone, S. (Univ Coll of North Wales, Bangor, Wales). *J Electrostatics* v 21 n 2-3 Sep 1988 p 245-256.

**086863 RESEARCH REPORT ON PROTEINS IN REVERSE MICELLES. STRUCTURAL ASPECTS AND ENZYMOLOGY.** In this research report we present various aspects of our basic investigations on proteins solubilized in AOT reverse micelles. In a first section, we present data on the rate of formation of water pool of reverse micelles: the time course of water solubilization is biphasic and it is often accelerated by the presence of proteins. In another section, kinetic studies of trypsin in reverse micelles are presented with the aim of a comparison with  $\alpha$ -chymotrypsin. In contrast to the latter protease, trypsin solubilized in AOT/isooctane did not show 'superactivity' at the pH optimum of the reaction. Finally, preliminary solubilization studies with lecithin as the surfactant in organic solvents are presented. (Edited author abstract) 44 refs.

Magid, Linda (Univ of Tennessee, Knoxville, TN, USA); Walde, Peter; Zampieri, Gianni; Battistel, Ezio; Peng, Qiaolian; Trotta, Edoardo; Maestro, Marco; Luisi, Pier Luigi. *Colloids Surf* v 30 n 1-2 Mar 1988, Biosurfactants, Sel Pap from a Symp Held at the Am Chem Soc Natl Meet, Apr 5-10 1987 p 193-207.

## Rheology

**086864 THERMOTROPIC GELATION OF OVALBUMIN 1. VISCOELASTIC PROPERTIES OF GELS AS A FUNCTION OF HEATING CONDITIONS AND PROTEIN CONCENTRATION AT VARIOUS pH VALUES.** The present paper deals with the influence of pH on formation and viscoelastic properties of ovalbumin thermotropic gels. By a systematic approach, using the shear modulus as indicator of the degree of conversion during gelation, optimal gelation conditions were determined, i.e. temperature and heating time, for each pH value. Relaxation properties of thermotropic gels at various pH, obtained under optimal conditions, have also been compared. 20 refs.

Grinberg, N.V. (USSR Acad of Sciences, Moscow, USSR); Bibkov, T.M.; Grinberg, V.Ya.; Tolstoguzov, V.B. *Colloid Polym Sci* v 266 n 1 Jan 1988 p 52-59.

**Separation** See Also BIOLOGICAL MATERIALS—Chromatographic Analysis; MEMBRANES—Research; POLYMERS—Porosity.

**086865 SORPTION PROPERTIES OF A COMPOSITE SORBENT BASED ON AN ALUMINOSILICATE MATRIX.** The purpose of this work is to study the acid-base and sorption characteristics of KAS-1M sorbent. Serum albumin and proteins from milk serum were used as sorbates. The sorption characteristics of vermiculite itself with respect to the same protein macromolecules were studied for comparison. The results of potentiometric titration of KAS-1M sorbent without preliminary acid treatment, and of vermiculite, which is the aluminosilicate matrix for production of the carbonized sorbent, are given. By using solutions of serum albumin,  $\alpha$ -lactalbumin, and  $\beta$ -lactoglobulin, it is possible to study the sorption

relationships of proteins differing in molecular weight on KAS-1M sorbent. The results of this work show that carbonization of an organic component in the aluminosilicate structure is a significant factor for increasing the sorption capacity and raising the selectivity of native materials for protein macromolecules. 13 refs.

Konovola, N.G. (Acad of Sciences of the USSR, USSR); Shataeva, L.K.; Zosin, A.P. *J Appl Chem USSR* v 59 n 12 pt 2 Dec 1986 p 2509-2511.

**086866 ISOLATION OF PROTEINS FROM WHEY WITH A NEW STRONGLY ACIDIC SILICA-BASED ION EXCHANGER.** A new type of strongly acidic ion exchanger based on macroporous silica coated with a thin layer of hydrophilic copolymer with sulphonic acid groups has been evaluated. The coating is crosslinked and covalently linked to the silica surface via diol groups. The performance for isolation of proteins from whey of the new ion exchanger and Spherosil S were compared using both batchwise adsorption and column operations with reconstituted whey. Higher breakthrough capacities were observed for the new ion exchanger than for Spherosil S. Excellent column operational lifetimes were found for the new product. (Edited author abstract) 17 refs.

Schuttyer, Jan A.J. (Akzo Corp Research Dep, Arnhem, Neth); Buser, Tonny J.W.; van Olden, David; Overem, Ton. *J Liq Chromatogr* v 10 n 10 Aug 1987 p 2151-2175.

**086867 PARAMETRIC EVALUATION OF FLUX DECLINE DURING ULTRAFILTRATION OF PROTEIN SOLUTIONS.** The authors investigated the application of ultrafiltration for the concentration and separation of protein solutions. Flux decline, varying both initial fluid properties and operating conditions, was experimentally studied using cellulose acetate hollow fiber modules. In addition, some methods for reducing flux decline, including backwash, backflush and chemical cleaning have been tested. Results indicate that flux decline is mainly due to macrolutes from the feed. However, moderate ultrafiltration pressure may lead to a slow flux decline in spite of low initial permeation rates. The use of chemical cleaning agents, especially sodium hypochlorite, proved to be highly effective in increasing the permeation rate to almost initial levels. Process design and scaling-up conditions are discussed. (Edited author abstract) 10 refs.

Abulnour, A.G. (Natl Research Cent, Cairo, Egypt); Talaat, H.A.; Sorour, M.H.; Tewfik, S.R. *Desalination* v 68 n 1 Jan 1988 p 35-44.

**086868 CORRELATION OF AQUEOUS TWO-PHASE PARTITIONING OF PROTEINS WITH CHANGES IN FREE VOLUME.** Phase separation and protein partitioning in polymer-salt aqueous two-phase systems have been correlated with changes in free volume. Both solute partitioning and phase stability are proposed to be related to those changes in liquid structure that can be described by measurements of the free volume of the mixture upon phase splitting. (Author abstract) 18 refs.

Grossman, Paul D. (Univ of Virginia, Charlottesville, VA, USA); Gainer, John L. *Biotechnol Prog* v 4 n 1 Mar 1988 p 6-11.

**086869 RESTRICTED DIFFUSION EFFECT ON THE BINDING OF PROTEINS TO POROUS POLYMER RESINS AS STUDIED BY REPETITIVE INJECTION METHOD.** A solution of bovine serum albumin (BSA) is repeatedly injected into a column packed with highly porous and hydrophobic polymer resins at appropriate intervals. The injected BSA is thoroughly retained in the column for 10 injections and, afterwards, starts to be eluted from the column gradually. Taking into consideration the restricting effect of already bound BSA upon the diffusion of newly injected BSA into the pores of the polymer resins, we can interpret the BSA elution profile from columns packed with polymer resin of various pore sizes and porosities. The effects of the binding rate constant and BSA concentration upon the elution profiles of BSA are also analyzed. Formyl groups are introduced into the polymers as a binding site with proteins, and the elution profiles of BSA from the column

packed with the formylated resin are also analyzed. (Author abstract) 19 refs.

Kitano, Hiromi (Kyoto Univ, Kyoto, Jpn); Nakamura, Katsunori; Hirai, Youhei; Kaku, Takashi; Ise, Norio. *Biotechnol Bioeng* v 31 n 6 Apr 20 1988 p 547-552.

**086870 RETENTION OF INSULIN IN ALGINATE GEL BEADS.** Insulin is entrapped in zinc alginate and zinc-calcium alginate gels. It is thought that the insulin molecule has strong and weak zinc binding sites. The zinc ions may form a bridge between the protein molecules and the alginate matrix. Insulin can be eluted with glycine buffer. 11 refs.

Gray, C.J. (Univ of Birmingham, Birmingham, Engl); Dowsett, J. *Biotechnol Bioeng* v 31 n 6 Apr 20 1988 p 607-612.

**086871 LEAKAGE STABILITY OF LIGAND-SUPPORT CONJUGATES UNDER OPERATIONAL CONDITIONS.** Leakage of ligands bound either monovalently or polyvalently to Eupergit C and macroporous glass was followed spectrophotometrically in a recirculation reactor up to 2 months under continuous operation. The data revealed a very stable fraction of bound protein desorbing only slowly from saturable noncovalent binding sites. Once this fraction was removed (which takes at least 3 days of continuous washing) conjugates with practically unlimited leakage stability were obtained. (Author abstract) 10 refs.

Lasch, J. (Martin-Luther-Univ, Halle, East Ger); Janowski, F. *Enzyme Microb Technol* v 10 n 5 May 1988 p 312-314.

**086872 CONTINUOUS SEPARATION OF PROTEIN FROM COLLOIDAL SOLUTION CONTAINING SEVERAL KINDS OF PROTEINS WITH ISOELECTRIC FOCUSING.** The continuous separation of each protein from a colloidal solution containing several kinds of proteins was investigated by isoelectric focusing. A separation device comprising three separation cells divided by semipermeable Teflon membranes and two electrode compartments was used in this experiment. A colloidal solution containing bovine serum albumin and bovine hemoglobins was used as a sample and ampholytes were used as a buffer reagent. The costly ampholytes were recovered from effluent by ultrafiltration for reuse as buffer solution. The equation for separation efficiency was analyzed semi-theoretically and the adaptability of the equation was examined experimentally. A separation efficiency of over 95 percent was obtained. (Author abstract). 6 Refs.

Yukawa, Hiroshi (Gunma Univ, Jpn); Hoshino, Teruhiko; Kasakoshi, Toshiyuki; Hakoda, Masaru. *J Chem Eng Jpn* v 21 n 3 Jun 1988 p 262-266.

**086873 LIQUID-LIQUID EXTRACTION FOR PROTEIN SEPARATIONS.** The liquid-liquid extraction of proteins directly from fermentation media or cell homogenates is an attractive primary purification process and can be used both to remove cell debris and to provide some initial purification and concentration of the desired products. Suitable solvents for this extraction process are the two-phase polymer systems and reversed micellar organic phases, both of which offer moderate to high selectivities and capacities for the proteins to be recovered. Protein partitioning to the extractants can be controlled in a number of ways, including the changing of pH conditions, varying the ionic strength and salt type, and changing polymer or surfactant concentrations. Affinity partitioning has also been found to be effective in enhancing the selectivity of the extraction for specific proteins. 38 refs.

Abbott, Nicholas L. (MIT, Cambridge, MA, USA); Hatton, T. Alan. *Chem Eng Prog* v 84 n 8 Aug 1988 p 31-41.



**086874 ANALYTICAL AND PROCESS CHROMATOGRAPHY IN PHARMACEUTICAL PROTEIN PRODUCTION.** Liquid chromatography can be used to separate proteins in the production of drug products. Some of the topics discussed include the protein structure of recombinant DNA-derived plasminogen activator; purification techniques; and product quality control. 7 refs.

Builder, Stuart E. (Genentech Inc, South San Francisco, CA, USA); Hancock, William S. *Chem Eng Prog* v 84 n 8 Aug 1988 p 42-46.

**086875 SEPARATION OF PROTEIN MIXTURES BY BIORAN POROUS GLASS MEMBRANES.** Glass as a membrane material has interesting features which contrast with the properties of the polymers employed conventionally, for example its rigid structure and its resistivity to aggressive media. Such membranes have been developed in the form of capillaries for the ultrafiltration of protein solutions. Possible applications include membrane plasmapheresis for medical purposes and fractionation in downstream processing of fermentation reactors. The physical, chemical and mechanical properties of glass membranes, and demonstration of their use in separation experiments of protein mixtures are described. Cut-off behaviour, influence of various process parameters and fouling problems as well as cleaning procedures and steam sterilization treatment is discussed. (Edited author abstract) 5 refs.

Schnabel, R. (Schott Glaswerke, Mainz, West Ger); Langer, P.; Breitenbach, S. *J Membr Sci* v 36 Mar 1988, Fifth Int Symp on Synth Membr in Sci and Ind, Sel Pap, Tuebingen, West Ger, Sep 2-5 1986 p 55-66.

**Solubility** See Also GRAIN—Surfaces.

**086876 REDUCTION OF PHYTIC ACID CONCENTRATION IN PROTEIN ISOLATES BY ACYLATION TECHNIQUES.** The interaction of phytic acid (PA) with proteins is dependent on the charges and conformation of the proteins and the ionic strength of the solution. Hence, changes in these parameters brought about by acylation could change the extractability, precipitation and interactions of PA with protein and minerals and consequently the PA concentration of protein isolates from phytate-containing foods. This paper summarizes studies in rapeseed and navy bean flours which demonstrate that a high degree of succinylation or acetylation can be used to separate the proteins from the PA and to prepare low phytate protein isolates of good functional properties. (Edited author abstract) 27 refs.

Thompson, Lilian U. (Univ of Toronto, Toronto, Ont, Can). *JAOCs J Am Oil Chem Soc* v 64 n 12 Dec 1987 p 1712-1717.

**Solutions** See Also SURFACE ACTIVE AGENTS.

**086877 INTERACTION BETWEEN SERUM ALBUMIN AND WATER AT DIFFERENT CONCENTRATIONS OF HYDROGEN IONS BASED ON DATA FROM RAYLEIGH SCATTERING.** Diluted solutions of serum albumin in water are studied at different values of the total surface charge in protein using a Rayleigh light scattering method. It is shown that the effective electron polarizability, the second virial coefficient, the degree of depolarization, and the parameters of the tensor of polarizability of the macromolecules of the protein are a nonlinear function of the pH of the solution and have an extremum at the isoelectric point. (Author abstract) 7 refs.

Petrova, G.P.; Petrushevich, Yu.M.; Shirkova, I.I.; Revokator, O.P. *Moscow Univ Phys Bull* v 42 n 2 1987 p 71-75.

**086878 NATURE OF THE LAYERS ADJACENT TO THE SURFACE OF A BALL OF FAT AND THE CHANGES IN THEM DURING ITS MOTION.** As a ball of fat moves, a cone containing layers forms in front of it. The formation of the layers occurs as a result of a redistribution of the components of the solution (proteins, phospholipids) close to the surface of the fat ball. It is

proposed that the redistribution is due to the oscillation generated by the surface of the fat ball as the liquid impinges against its surface. (Author abstract) 13 refs.

Strakulenko, I.I. (Uglic Scientific & Industrial Assoc, USSR); Zhernosekova, S.D. *Colloid J USSR* v 49 n 2 Mar-Apr 1987 p 333-335.

**086879 SURFACE PRESSURE, SURFACE POTENTIAL AND ELLIPSOMETRIC STUDY OF CYTOCHROME C BINDING TO DIOLEOYLPHOSPHATIDYLCHOLINE MONOLAYER AT THE AIR-WATER INTERFACE.** The binding of soluble cytochrome c to an insoluble monolayer of dioleoylphosphatidylcholine was studied. Surface pressure, surface potential and ellipsometric isotherms show that (i) cytochrome c is not adsorbed on a phosphatidylcholine monolayer compressed at 20 mN m<sup>-1</sup>, (ii) gradual incorporation of cytochrome c takes place as surface pressure decreases, and (iii) on recompression, the adsorbed protein is desorbed from the monolayer. In order to determine if the results can be explained by intrinsic interfacial properties of phosphatidylcholine and cytochrome c taken separately, we measured surface pressure, surface potential and ellipsometric-area isotherms of pure cytochrome c which had been (i) deposited from crystals, (ii) deposited from ethanol:H<sub>2</sub>O solution (2:1, v/v), and (iii) adsorbed at the air-water interface after injection into the subphase. (Edited author abstract) 25 refs.

Lamarche, F. (Univ du Quebec a Trois-Rivieres, Trois-Rivieres, Que, Can); Aghion, J.; Leblanc, R.M.; Tegy, F. *Colloids Surf* v 30 n 1-2 Mar 1988, Biosurfactants, Sel Pap from a Symp Held at the Am Chem Soc Natl Meet, Apr 5-10 1987 p 209-222.

**Spectroscopic Analysis** See Also BIOCHEMISTRY; BIOPOLYMERS—Structure; DRUG PRODUCTS—Interactions.

**086880 MYOTOXIN  $\alpha$ -PHOSPHOLIPID INTERACTIONS, AN ATTEMPT BY INTRINSIC FLUORESCENCE TO DEFINE A POSSIBLE MODE OF ACTION FOR THE TOXIN ON MEMBRANES.** Intrinsic fluorescence of myotoxin  $\alpha$  from *Crotalus viridis* viridis has been proved to be due to tryptophan residues, and this knowledge allows one to detect, for the first time, an interaction of the toxin with phospholipids. The formation of lipid-protein species is followed by a blue shift of about 8 nm and a quenching of up to 50% of the emission of tryptophans. These changes could result from the positioning of Trp 32,34 residues at the lipid interface and/or a local conformational change of the toxin. In the  $\mu$ M range, complexes are formed only with charged lipids; charge complementarity of two partners is needed regardless of the physical state of the lipids. (Edited author abstract) 34 refs.

Dufourco, Jean (CNRS, Talence, Fr); Dousseau, Francoise; Faucon, Jean-Francois; Tu, Anthony T. *Appl Spectrosc* v 41 n 8 Nov-Dec 1987 p 1410-1417.

**086881 SPECTROSCOPIC STUDY OF THE CONFORMATIONAL PROPERTIES OF FOAMED BOVINE SERUM ALBUMIN.** The conformational properties of resolubilized foamed protein are investigated using intrinsic protein fluorescence and circular dichroism. It is clear that this approach will only allow the observation of irreversible conformational changes that occur as a result of foaming and persist after resolubilization, but it has allowed a more thorough study of the nature of these irreversible changes by fluorescence quenching techniques. 25 refs.

Clark, David C. (Inst for Food Research, Norwich, Engl); Smith, Linda J.; Wilson, David R. *J Colloid Interface Sci* v 121 n 1 Jan 1988 p 136-147.

**086882 SPECTROSCOPIC QUANTITATIVE ANALYSIS OF STRONGLY INTERACTING SYSTEMS: HUMAN PLASMA PROTEIN MIXTURES.** Blood plasma protein infrared spectra, while qualitatively similar, display differences in the frequencies and intensities of absorption bands. These differences are sufficient to permit an accurate quantitative analysis of mixtures of

these proteins. The authors examine the performance of some alternative methods of spectroscopic quantitative analysis in determining the concentrations of proteins in aqueous solutions. The widely-used K matrix method, using sloping baselines and intercept functions, was found to be inadequate for these determinations. In contrast, a method based on the Q matrix approach, augmented by a robust equation solver, yielded results with a sufficient degree of accuracy to make it a viable tool for use in the study of proteins at solid interfaces and for more general applications in the field of protein chemistry. (Edited author abstract) 14 refs.

Nyden, Marc R. (NBS, Gaithersburg, MD, USA); Forney, Glenn P.; Chittur, Krishnan. *Appl Spectrosc* v 42 n 4 May-Jun 1988 p 588-594.

**086883 MASS SPECTROMETRY OF NATURAL AND RECOMBINANT PROTEINS AND GLYCOPROTEINS.** Most modern protein sequence analysis is carried out using classical, wet-chemical Edman degradation technology. However, an increasing number of studies on both natural and recombinant genetically engineered proteins demands the use of new technologies capable of assigning structural features such as glycosylation, which cannot be assigned by Edman sequence analysis. The most important alternative and complementary procedure at present is the use of high-mass mass spectrometry. This brief article introduces some of the principles and applications of the technique. Protein research laboratories, both academic and industrial, will make increasing use of these techniques to complement classical gas phase sequencing, and to identify post-translational modifications including glycosylation, phosphorylation, S-S bridge assignment and processing events, including the formation of 'ragged ends'. (Author abstract) 34 refs.

Morris, Howard R. (Imperial Coll, London, Engl); Greer, Fiona M. *Trends Biotechnol* v 6 n 7 Jul 1988 p 140-147.

**086884 NMR OF SILK FIBROIN. 9. SEQUENCE AND CONFORMATION ANALYSIS OF THE SILK FIBROINS FROM BOMBYX MOTI AND PHILOSAMIA CYNTHIA RICINI BY <sup>15</sup>N NMR SPECTROSCOPY.** <sup>15</sup>N NMR spectra of the silk fibroin proteins from Bombyx mori and Philosamia cynthia ricini are reported. The silk fibroins were labeled biosynthetically with [<sup>15</sup>N]glycine or [<sup>15</sup>N]alanine. In the glycine resonance region, there are roughly three peaks for B. mori silk fibroin and four peaks for P. c. ricini silk fibroin. These peak splittings reflect the amino acid sequences in the main chain. There are two peaks in the alanine resonance region of the P. c. ricini silk fibroin spectrum. The higher field peak is assigned to the sequence of only alanine residues, where fast interconversion between  $\alpha$ -helix and random coil forms occurs, and the lower field peak to the random coil form. (Edited author abstract) 21 refs.

Asakura, Tetsuo (Tokyo Univ of Agriculture & Technology, Tokyo, Jpn); Yoshimizu, Hiroaki; Yoshizawa, Fumihiko. *Macromolecules* v 21 n 7 Jul 1988 p 2038-2041.

**086885 FOURIER DECONVOLUTION OF THE AMIDE I RAMAN BAND OF PROTEINS AS RELATED TO CONFORMATION.** Fourier deconvolution has been employed to enhance the resolution of the amide I Raman band of nine proteins found in milk and/or other foods. The broad band was resolved into several components. The overall shape of the amide I Raman band of proteins was found to be nearly Gaussian or to be composed of components. A Gaussian function was therefore used for deconvolution. The results obtained were more detailed than those obtained with the Lorentzian approximation usually employed. The resolved band components were assigned to specific conformations. The frequencies and assignments are in good agreement with previous Raman work based on entirely different procedures. The band areas of the resolved components appear to reflect the fraction of any given conformation in a protein. Semiquantitative estimations of protein confor-



mation are in reasonable agreement with data obtained by x-ray diffraction and by infrared methods. (Author abstract). 22 Refs.

Susi, Heino (USDA, Philadelphia, PA, USA); Byler, Michael. *Appl Spectrosc* v 42 n 5 Jul 1988 p 819-826.

**086886 TIME RESOLUTION OF A SHORT-WAVELENGTH CHLOROPLAST FLUORESCENCE COMPONENT AT LOW TEMPERATURE.** The chloroplast is the basic structural unit of photosynthetic activity in green plants. It contains light-harvesting chlorophyll (LHC), photosystem I (PSI), and photosystem II (PSII). LHC is the system 'antenna' which absorbs light and transfers the excitation energy to the photosystems, where the primary photochemistry occurs. Using a streak camera and interference filters we observe a 676-nm 9-ps chloroplast emission band. It is attributed to light harvesting chlorophyll proteins. 5 refs.

Lin, Su (Univ of Rochester, Rochester, NY, USA); Knox, Robert S. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 209-210.

**086887 VIBRATIONAL ENERGY RELAXATION PROCESSES IN HEME PROTEINS.** Vibrational energy relaxation pathways from optically excited heme proteins are studied using a transient thermal phase grating technique which monitors the solvent lattice temperature. Vibrational energy transfer from the porphyrin ring to the protein backbone leads to extensive delocalization of the energy in the protein helix which is efficiently transferred to the water interface in less than 20 psec. A slower relaxation process on the nanosecond time scale is also observed. The slow relaxation component is attributed to slow conformational relaxation processes of high potential energy states of the heme proteins accessed during the high internal energy conditions of the optically excited molecule. (Author abstract) 2 refs.

Genberg, L. (Univ of Rochester, Rochester, NY, USA); Heisel, F.; McLendon, G.; Miller, R.J. Dwayne. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 571-572.

**086888 CHEMILUMINESCENCE FROM THE REACTION OF HEMOPROTEINS WITH INORGANIC PEROXIDES.** Chemiluminescence from hemoproteins oxidation are composed of two components: the dimol emission of the singlet oxygen and the excited carbonyls, accompanied by the destruction of porphyrin rings. We found that when hemin and hemoproteins react with inorganic peroxides (sodium perborate or  $H_2O_2$ ) in alkaline solution, low-level chemiluminescences could be detected. (Edited author abstract) 5 refs.

Liu, Yaning (Xidiayutai Hospital, Beijing, China); Zhao, Xinhua. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 840-841.

## Spectrum Analysis

**086889 DIRECT AND HYDRODYNAMIC INTERACTIONS BETWEEN  $\alpha$ -CRYSTALLIN PROTEINS IN DILUTE COLLOIDAL DISPERSIONS: A LIGHT SCATTERING STUDY.** Photon correlation spectroscopy (PCS) is used to measure mutual diffusion coefficient  $D_m$  of  $\alpha$ -crystallin dispersions as a function of the volume fraction  $\phi$  occupied by these colloidal particles ( $0 < \chi < 0.1$ ). These results are compared to theoretical predictions for  $D_m(\chi)$ , whose keystone is the description of hydrodynamic interactions. (Edited author abstract) 27 refs.

Licinio, Pedro (Univ de Paris-Sud, Orsay, Fr); Delaye, Mireille. *J Colloid Interface Sci* v 123 n 1 May 1988 p 105-116.

**086890 FAR INFRARED ABSORPTION SPECTRA OF THE ANYMNETRIC ADDITION OF NEM AND EMB TO EGG ALBUMEN.** The authors have reported previously upon the far infrared spectra of models for epithelium glycoprotein gels. This work was related to

studies of olfactory detection where special attention was given to correlations observed between olfaction and FIR spectra of odourants. The present results are extensions of this work and relate to the problem of olfactory blocking agents. 10 refs.

Belmont, M.R. (Univ of Exeter, Exeter, Engl); Ambarek, A.H. *Infrared Phys* v 28 n 3 May 1988 p 199-200.

## Stability

**086891 STABILITIES OF LANTHANIDE-PROTEIN COMPLEXES.** After incubation of both serum and HSA solutions with radioactive lanthanide complexes the binding constants of the corresponding lanthanide-protein complexes formed in the protein solutions under physiologic conditions, pH: 7.4, temperature: 310 K, isotonic ionic strength: 0.15 mol/L, were determined. The association constants of the lanthanide-protein complexes formed both in serum and HSA-solutions are equal within the experimental error. In conclusion, serum albumin binding predominates for the radiolanthanides. With the decrease of the ionic radii from 1.034 Å (Ce) to 0.858 Å (Yb) the association constants increased by five orders of magnitude from  $\lg K_{pr} = 4.90$  (Ce) to  $\lg K_{pr} = 9.54$  (Yb). Further, a serum fractionation with alcohol was carried out to prove that the albumin fraction of serum is responsible for the lanthanide binding in blood. (Author abstract) 12 refs.

Schomaecker, Klaus (Central Inst of Nuclear Research, Dresden, East Ger); Mocker, Dagmar; Muenze, Rudolf; Beyer, Gerd-Juergen. *Appl Radiat Isot* v 39 n 3 1988 p 261-264.

## Structure See Also GENETIC ENGINEERING.

**086892 PROTEUS: A SUITE OF PROGRAMS FOR PREDICTION OF STRUCTURAL FEATURES OF PROTEINS USING AN APPLE IIe.** We have implemented several algorithms, developed by various authors for predicting structural features of proteins from their primary structure, on an Apple IIe and collected them in a suite, named PROTEUS. This suite incorporates: (i) methods for predicting secondary structure; (ii) the algorithm for computing the hydropathy profile using one out of five available sets of parameters; (iii) the algorithms for calculating the hydrophobic moment plot; and (iv) for performing the amphipathic analysis using one out of four available sets of parameters. The suite has a utility program for storing on a disk the sequence to be analyzed. As an example, we applied some of the methods included in PROTEUS to predict the structure of a mitochondrial leader peptide. The results suggest the occurrence of structural features possibly related to the import of proteins into mitochondria. (Author abstract) 24 refs.

Pascarella, Stefano (Univ La Sapienza, Rome, Italy); Bossa, Francesco. *Comput Appl Biosci* v 3 n 4 Nov 1987 p 325-331.

**086893 PROTEIN ENGINEERING.** The techniques of protein engineering are proving to be a revolutionary experimental tool for understanding protein structure-function relationships. Even at this early stage, proteins of improved characteristics for specific industrial and therapeutic uses have already been produced. Tailoring enzymatic properties for non-physiological substrate conditions, altering pH optima, changing substrate specificity, and improving stability have already been demonstrated to be feasible. Nevertheless, the ability to make useful proteins which radically differ from a natural structure or designing altogether new structures exceeds present understanding. (Author abstract) 41 refs.

Bryan, Philip N. (Genex Corp, Gaithersburg, MD, USA). *Biotechnol Adv* v 5 n 2 1987 p 221-234.

**086894 FLEXIBILITY AND RIGIDITY OF PROTEINS AND PROTEIN-PIGMENT COMPLEXES.** Proteins may be rigid or flexible to various degrees as required for optimal function. Flexibility of large parts of a protein, which rearrange or move are discussed. The author differentiates between several categories, although

the boundaries between them are diffuse: flexibility of peptide segments, order-disorder transitions of spatially contiguous regions, and domain motions. The domains may be flexibly linked to allow rather unrestricted motions or the motions may be constrained to certain modes. The various categories of large-scale flexibility are illustrated with examples. (Edited author abstract) 71 refs.

Huber, Robert (Max-Planck-Inst fuer Biochemie, Martinsried, West Ger). *Angew Chem (Int Ed Engl)* v 27 n 1 Jan 1988 p 79-88.

## Suspensions

**086895 STUDIES OF CAMEL CASEIN MICELLES: TREATMENT WITH SOLUBLE AND IMMOBILIZED NEURAMINIDASE.** Camel casein micelles were obtained from raw uncooled skim milk by ultracentrifugation, washing and then resuspending in UF-skim milk permeate. They were treated with neuraminidase, in both soluble and immobilized forms, to study the location and distribution of the glycosylated portion of camel casein micelle. Kinetic release of sialic acid, soluble in 12% TCA, was studied. Camel casein micelle contains 7.35 mg sialic acid per g casein; 99.3% of it was released with soluble neuraminidase, whereas only 90% was released with immobilized neuraminidase. This implies that about 90% of the glycosylated portion of camel casein micelle (glyco-k-casein-like component) is on the surface of the micelle. (Author abstract) 31 refs.

Mehaia, Mohamed A. (King Saud Univ, Riyadh, Saudi Arabia). *Carbohydr Polym* v 7 n 5 1987 p 361-369.

## Synthesis See Also BIOLOGICAL MATERIALS—Cartilage.

**086896 SYNTHESIS USING POLYMERIC REAGENTS.** It is shown that convenient and highly efficient condensation reactions take place by transferring polymer-bound electrophiles, the active esters, via a mediator, shadchan, to polymer-bound nucleophiles, the amines. On-line monitoring can be achieved - a most essential feature in planning a fully automatic, self-controlled machine for multistep syntheses. To widen the application scope of PRs (Polymeric Acyl-Transfer Reagents), we have also developed additional simple, convenient methods for preparation of polymers. Now we are able to maximize the loading of the PRs with protected amino acid and other reactive species, which should greatly expand the use of these methods. We believe that the mediator methodology is not limited to acylation and related processes but is also applicable to other chemical processes that involve the formation of activated intermediates. 23 refs.

Patchornik, Abraham. *CHEMTECH* v 17 n 1 Jan 1987 p 58-63.

**086897 PREPARATION OF  $^{15}\text{N}$ -LABELED L-ALANINE BY IMMOBILIZED L-ALANINE DEHYDROGENASE: DIFFERENTIAL INCORPORATION OF  $^{15}\text{N}$  IN BACTERIAL PROTEINS.** This paper describes a system for continuous synthesis of  $^{15}\text{N}$ -labeled L-alanine from lactic acid,  $^{15}\text{NH}_4\text{Cl}$  and NADH, which uses immobilized alanine dehydrogenase and soluble lactate dehydrogenase as enzyme sources. Lactic acid acts both as hydrogen donor for the regeneration of NADH and as pyruvate source, thus providing the carbon skeleton of L-alanine. *Citrobacter freundii* grown on synthetic media containing 17 unlabeled amino acids and L- $(^{15}\text{N})$ alanine as nitrogen source, incorporated 66% of  $^{15}\text{N}$  into alanine found in bacterial proteins. When  $^{15}\text{N}$ -labeled glutamic acid, aspartic acid or glycocol were added to the synthetic growth media, their  $^{15}\text{N}$  was 'diluted' among different amino acids of bacterial proteins. Isotope enrichment of L- $(^{15}\text{N})$ lysine found in newly



synthesized proteins of *C. freundii* was practically unchanged as compared to the isotope content of free amino acid in the growth medium. (Author abstract) 33 refs.

Presecan, Elena (Inst of Isotopic & Molecular Technology, Cluj-Napoca, Rom); Ivanof, Antipa; Mocanu, Aurel; Palibroda, Nicolae; Bologna, Margareta; Gorun, Victoria; Oarga, Monica; Barzu, Octavian. *Enzyme Microb Technol* v 9 n 11 Nov 1987 p 663-667.

**086898 IS AUTOMATED PEPTIDE SYNTHESIS SLOWING THE ADVANCE OF BIOMEDICAL RESEARCH?** Simultaneous multiple peptide synthesis (SMPS) is compared to solid phase synthesis of peptides. Automated technique (SMPS) can yield small amounts of many peptides in a shorter time, but the quality of the peptides may be better with manual techniques. 9 refs.

Houghten, Richard A. (Scripps Clinic & Research Foundation, La Jolla, CA, USA). *Trends Biotechnol* v 5 n 12 Dec 1987 p 322-324.

**086899 ROLE OF LYS SIDE CHAIN IN THE STABILIZATION OF  $\beta$ -TURN STRUCTURE.** Peptides containing Lys and Orn were synthesized to study the role of side chains in the formation of the  $\beta$ -turn structure. In contrast with peptides having a -Lys-Asp- sequence, peptides containing an -Orn-Asp- sequence do not adopt a  $\beta$ -turn structure. Analysis of the side chain rotamers shows that in Boc-Gly-Lys-Asp-OMe the Lys side chain can interact with the side chain of the neighboring Asp residue and this interaction contributes to the stabilization of the  $\beta$ -turn structure. The Orn side chain, instead of side chain-side chain interactions, interacts with the peptide backbone. (Author abstract) 19 refs.

Ishii, Hiroshi (Tokyo Natl Coll of Technology, Hachioji, Jpn); Okano, Tomoko; Maeji, N. Joe; Inoue, Yoshio; Chujo, Riichiro. *Polym J* v 20 n 1 1988 p 65-72.

**086900 PROTEIN ENGINEERING: METHODOLOGY, APPLICATIONS AND STATUS.** Developments in recombinant DNA (rDNA) technology have made selective alteration of primary amino acid sequences of proteins possible. Such manipulation using genetic engineering techniques has been referred to as protein engineering. Although this technology has seen only limited application in food research to date, this emerging and rapidly expanding technology offers exciting approaches to protein/enzyme modification studies, and may aid in the development of novel processes and/or more functional and nutritious proteinaceous foods. This review outlines some basic protein engineering methodology and strategies. In addition, examples are provided in which site-directed mutagenesis has been used advantageously in the specific modification of the enzymes subtilisin, lysozyme and chymosin, and of the casein proteins in milk and the storage proteins of potato tubers. These examples indicate the potential of protein engineering technology in investigations of structure-function relationships, stability, protein folding and conformation. (Author abstract) 128 refs.

Jackman, Robert L. (Univ of Guelph, Guelph, Ont, Can); Yada, Rickey Y. *Food Biotechnol (NY)* v 1 n 2 1987 p 167-223.

**086901 PROCEDURES AND A COMPUTER PROGRAM FOR THE DETERMINATION OF FRACTIONAL PROTEIN SYNTHETIC RATES BY NUMERICAL SOLUTION OF AN IMPLICIT EQUATION.** Fractional protein synthetic rates may be determined in vivo by infusion with a labelled amino acid and measurements of the specific radioactivities of the free and protein-bound amino acid. The calculation requires the solution of an implicit equation which is usually done by the laborious and inaccurate method of interpolation from a series of standard curves. In this report a BASIC computer program (PROSYN) is given which enables a quick and accurate solution by a numerical method. The basis of several solution methods is described; the PROSYN program is capable of using either of two (bracketing and the secant method) of these procedures. (Author abstract). 11 Refs.

Duggleby, Ronald G. (Univ of Queensland, St. Lucia, Aust); Ward, Leigh C. *Comput Biol Med* v 18 n 4 1988 p 245-251.

## Testing

**086902 FLUORESCENCE LIFETIME MEASUREMENTS OF MERCURY/PROTEIN COMPLEXES.** Fluorescence lifetime and steady-state fluorescence measurements are used to characterize various mercury/protein and mercury/protein/EDTA complexes. The proteins studied are ovalbumin,  $\alpha$ -chymotrypsinogen, and acid phosphatase. Mercury quenches fluorescence in ovalbumin with a change in lifetime, while in  $\alpha$ -chymotrypsinogen quenching occurs without a change in lifetime. No quenching by mercury is observed for acid phosphatase. EDTA causes a further small decrease in fluorescence for both mercury/ovalbumin and mercury/ $\alpha$ -chymotrypsinogen, while no change is observed for mercury/acid phosphatase. In all cases the decrease in fluorescence intensity is consistent with a static quenching mechanism. (Edited author abstract) 21 refs.

Pesek, Joseph J. (San Jose State Univ, San Jose, CA, USA); Abpikar, Hassan; Becker, Joseph F. *Appl Spectrosc* v 42 n 3 Mar-Apr 1988 p 473-477.

Wetting See BIOLOGICAL MATERIALS—Blood.

**PROTONS** See Also ACCELERATORS—Storage Rings; COPPER AND ALLOYS—Radiation Effects; CRYSTALS—Hysteresis; DATA STORAGE, SEMICONDUCTOR—Radiation Effects; DIELECTRIC MATERIALS—Radiation Effects; ION BEAMS—Production; LITHIUM PLATINUM ALLOYS—Forming; PARTICLE OPTICS; PHYSICS—High Energy; POLYMERS—Doping; SALTS—Spectroscopic Analysis; SEMICONDUCTING GALLIUM ARSENIDE—Radiation Damage; SEMICONDUCTOR DEVICES—Radiation Effects; SEMICONDUCTOR DEVICES, MOSFET—Radiation Effects; SOLAR CELLS—Radiation Damage; SPECTROMETERS, GAMMA RAY—Radiation Effects; THYRISTORS—Radiation Effects; WAVEGUIDES, OPTICAL—Electric Field Effects.

**086903 DYNAMIC NMR STUDY OF THE INTERFERENCE BETWEEN CYCLIC PROTON EXCHANGE, SELFASSOCIATION AND HINDERED ROTATION OF DIPHENYLFORMAMIDINE IN TETRAHYDROFURAN.** By measuring proton lifetimes as a function of concentration and of the deuterium fraction in the labile proton sites, it was established that two protons are transferred in every exchange process. Thermodynamic data of the association process obtained by the analysis of the chemical shifts, of the A/B populations and the proton lifetimes as a function of concentration agreed very well. These results are evidence that A forms only self-associated hydrogen bonded dimers with a cyclic structure in which the double proton transfer takes place. The observation of a kinetic HH/HD isotope effect of 20 at 178 K establishes this transfer as the rate limiting step of the overall proton exchange. (Edited author abstract) 71 refs.

Meschede, Ludger (Univ Freiburg, Freiburg, West Ger); Gerritzn, Detlef; Limbach, Hans-Heinrich. *Ber Bunsenges Phys Chem* v 92 n 4 Apr 1988 p 469-485.

**086904 MEASUREMENT OF  $^4\text{He-p}$  RECOIL CROSS SECTIONS.** The recoil cross sections of protons induced by  $^4\text{He}^+$  particles were experimentally determined in an energy range of 1.3-2.1 MeV at recoil angles of  $20^\circ$  and  $30^\circ$ . The angular dependence of the recoil cross section at 2.0 MeV was also measured. By using the principle of detailed balance, a calculation of S+ $^4\text{He-p}$  recoil cross sections were calculated from p- $^4\text{He}$  phase shift data. Good agreement between the experimental data and theoretical values was found. The results show that recoil cross section at low energies are non-Rutherford and are larger than the Rutherford value by approximately a factor of 2 at 2.0 MeV. (Author abstract). 9 Refs.

Wang, Hong (Fudan Univ, Shanghai, China); Zhou, Guo Qing. *Nucl Instrum Methods Phys Res Sect B* v B34 n 2 Aug 1988 p 145-151.

Applications See DATA PROCESSING.

Computer Simulation See INTEGRATED CIRCUITS—Radiation Effects.

## Concentration

**086905 ROLE OF PROTONS IN TRANSIENT ANODE EFFECTS AT PASSIVE IRON ELECTRODES.** Ionic transport processes in passivating films on iron are discussed under conditions where the films contain high concentrations of mobile protons. A rapid pH rise in the sulfate solution is shown to lead to an extraction of mobile protons from the film and to the development of negative space charge in the film. This produces a burst in the cationic dissolution current of the passive metal. (Author abstract) 31 refs.

Sukhotin, A.M. (M.I. Kalinin Polytechnic Inst, Leningrad, USSR); Lisovaya, E.V. *Sov Electrochem* v 23 n 3 Mar 1987 p 355-363.

Ion Exchange See ZEOLITES—Ion Exchange.

Measurements See Also SCINTILLATION COUNTERS.

**086906 HIGH EFFICIENCY PROTON POLARIMETER USING A LIQUID HELIUM TARGET.** A high efficiency (approximately  $1 \times 10^{-3}$  at  $A_p = -0.45$ ) polarimeter used for a secondary proton beam of 14-18 MeV energy is described. The polarimeter target is liquid helium held in a conical cell. Protons scattered at  $52^\circ \pm 8^\circ$  are detected by twelve Si detectors placed symmetrically around the beam axis. This polarimeter has been used for polarization transfer studies. (Author abstract). 7 Refs.

Sagara, K. (Kyushu Univ, Hakozaki, Jpn); Maeda, K.; Nakamura, H.; Aita, K.; Izumi, M.; Nakashima, M.; Nakashima, T.; Isoya, A. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 450-455.

**086907 LOW-FIELD PROTON GYROMAGNETIC RATIO  $\gamma_p$  EXPERIMENT AT THE ETL.** The low-field proton gyromagnetic ratio  $\gamma_p(\text{low})$  experiment at the Electrotechnical Laboratory (ETL) has been continued with the construction of a nonmagnetic building, precision solenoid, and dimensional measuring apparatus. A tentative value of  $\gamma_p(\text{low})_{\text{ETL86}}$  and its uncertainty are given:  $\gamma_p(\text{low})_{\text{ETL86}} = 2.6751289(59) \times 10^8 \text{ s}^{-1} \text{ T}^{-1}$  (ETL 2.2 ppm). The sources of uncertainty have been carefully investigated. The irregularity of the solenoid diameter and the resistance calibration mainly caused the large uncertainty. In order to reduce the uncertainties, some improvements have been made and others are planned. 13 refs.

Nakamura, Hisao (Electrotechnical Lab, Niihari-gun, Jpn); Kasai, Naoko; Sasaki, Hitoshi. *IEEE Trans Instrum Meas* v IM-36 n 2 Jun 1987, Sel Pap - Conf on Precise Electromagn Meas (CPEM/86), Gaithersburg, MD, USA, Jun 23-27 1986 p 196-200.

## Monitoring

**086908 POLARIZATION MONITORS FOR PROTON AND DEUTERON BEAMS BELOW 20 MeV.** Two polarimeters for proton and deuteron beams using the p+ $^4\text{He}$  scattering and the  $^3\text{He}(d,p)$  reaction, respectively, are described. They are placed downstream from a scattering chamber so as to monitor the beam polarization throughout an experiment. Two of the three components of proton spin and six of the eight components of deuteron spin can be measured simultaneously. (Author abstract). 5 Refs.

Sagara, K. (Kyushu Univ, Hakozaki, Jpn); Maeda, K.; Nakamura, H.; Izumi, M.; Yamaoka, T.; Nishida, Y.; Nakashima, M.; Nakashima, T. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 444-449.



**Radiation Effects** See SEMICONDUCTING SILICON—Doping.

**Research** See ACCELERATORS—Storage Rings.

**Resonance** See AMMONIUM COMPOUNDS—Physical Properties.

**Scattering** See Also MOLYBDENUM AND ALLOYS—Electronic Properties; RADIOGRAPHY—Industrial Applications; SEMICONDUCTING GALLIUM ARSENIDE—Thin Films.

**086909 TOPOGRAPHICAL EFFECTS OF ROUGH SAMPLES ON GRAZING ANGLE PROTON SCATTERING.** Experimental results for proton scattering from rough Al samples are presented. The spectra are different from those of polished samples; the peaks are wider and sometimes present a double distribution with an abrupt change at low energy. In addition changes in energy spectra are observed with sample rotation. Some of the experimental results are compared with those predicted by a theoretical model but the fitting is not as good as with polished samples. (Author abstract) 12 refs.

Barragan-Vidal, A. (UNAM, Mexico City, Mex); Garcia-Santibanez, F. *Nucl Instrum Methods Phys Res Sect B* v B28 n 3 Oct 1987 p 391-397.

**086910 ELASTIC SCATTERING OF PROTONS BY BERYLLIUM.** A new experimental technique has been developed to measure excitation functions for the  $^9\text{Be}(p,p)$  reaction. This technique uses thick targets and applies the elastic backscattering method. The angular distribution was measured for scattering angles from  $142^\circ$  to  $165^\circ$  in the proton energy region between 2300 and 2700 eV. Elastic scattering data were analyzed and fitted in terms of a combination of Breit-Wigner resonant cross sections and a constant background. The differential cross-section measurements were compared where possible to previous data using thin targets. Analysis of the present data indicates that the scattering is probably not s-wave but a mixture of p- and d-wave. The experimental technique is simple in practice and very time efficient. It can be used to make absolute measurements of the nuclear reaction or elastic scattering cross sections for many other projectile-target combinations. (Author abstract) 11 refs.

Langley, R.A. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Lewis, M.; Zuh, R.A. *Nucl Instrum Methods Phys Res Sect B* v B29 n 4 Jan 1988 p 599-602.

**086911 APPARATUS FOR THE MEASUREMENT OF SPIN DEPENDENT OBSERVABLES IN pp ELASTIC SCATTERING.** The present paper describes an apparatus used for the measurement of spin dependent observables in pp elastic scattering at SATURNE II. Fast electronics, on-line data acquisition, event selection and off-line analysis are also presented. (Author abstract) 19 refs.

Arignon, M. (CEN-Saclay, Fr); Bystricky, J.; Deregel, J.; Lehar, F.; De Lesquen, A.; Petit, F.; Van Rossum, L.; Fontaine, J.M.; Perrot, F.; Ball, J.; Lac, C.D. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 207-214.

**086912 APPLICATION OF THE EXPERIMENTAL THEORY OF CATASTROPHES TO ANALYSIS OF THE POLARIZATION CHARACTERISTICS OF ELASTIC SCATTERING OF INTERMEDIATE ENERGY PROTONS IN NUCLEI WITH ZERO SPIN.** The amplitude of elastic scattering in nuclei with zero spin of protons with an energy of  $E_p$  in a range of 100-1000 MeV is calculated. It is shown that at  $E_p \approx 200$  MeV the actual part of the scattering amplitude with turning of the spin has high sensitivity to the difference in the geometrical parameters of the spin orbital and central parts of the optical potential due to assembly catastrophe. (Author abstract) 12 refs.

Zavarzina, V.P.; Stepanov, A.V. *Sov Phys Lebedev Inst Rep* n 7 1987 p 14-18.

**086913 INFLUENCE OF THE FORM OF THE**

**OPTICAL POTENTIAL ON THE POLARIZATION CHARACTERISTICS OF ELASTIC SCATTERING OF INTERMEDIATE ENERGY PROTONS IN NUCLEI.** The polarization characteristics of elastic scattering P and Q are calculated for protons with an energy of 200 MeV in  $^{40}\text{Ca}$  and  $^{208}\text{Pb}$  nuclei for two models of the optical potential. It is shown that these characteristics are sensitive to the form of the optical potential. The causes of the violation of the conditions of applicability of the Kohler-Levinov theorem are investigated. (Author abstract) 6 refs.

Zavarzina, V.P.; Stepanov, A.V. *Sov Phys Lebedev Inst Rep* n 7 1987 p 19-23.

**086914 ANALYSIS OF THE FEATURES OF THE POLARIZATION CHARACTERISTICS OF ELASTIC SCATTERING OF PROTONS IN A  $^{12}\text{C}$  NUCLEUS AT ENERGIES OF  $E_p = 400$ -600 MeV.** The scattering amplitude, the polarizations, and the spin turn functions for elastic scattering of protons with an energy of  $E_p = 400$ -600 MeV in a nucleus are calculated within an optical model with phenomenological and microscopic potentials. The sensitivity and to the parameters of the optical potential is investigated. (Edited author abstract) 6 refs.

Zavarzina, V.P.; Stepanov, A.V. *Sov Phys Lebedev Inst Rep* n 7 1987 p 55-59.

**086915 INTEGRAL CROSS SECTIONS OF INELASTIC SCATTERING OF  $\alpha$ -PARTICLES WITH AN ENERGY OF 50.5 MeV IN NUCLEI OF  $1p$ - AND  $(2s-1d)$ -SHELLS AND THE SCATTERING MECHANISMS.** This work acquires and discusses experimental results about the integral cross sections of inelastic scattering of  $\alpha$ -particles with an energy of 50.5 MeV with excitation of a series of lower levels of  $^6\text{Li}$ ,  $^9\text{Be}$ ,  $^{12,13}\text{C}$ ,  $^{14}\text{N}$ ,  $^{20}\text{Ne}$ ,  $^{24}\text{Mg}$ , and  $^{28}\text{Si}$  nuclei. The values are discussed of the integral cross sections of forward scattering for a range of angles of  $20$ - $90^\circ\text{C}$  and of reverse scattering for a range of  $90$ - $160^\circ\text{C}$ . 11 refs.

Burtebaev, N.T.; Duisebaev, A.D.; Sadkovskii, V.S.; Feofilov, G.A. *Bull Acad Sci USSR Phys Ser* v 51 n 3 1987, Proc of the Second All-Union Conf on Chemilumin, Ufa, USSR, May 1986 p 191-196.

**Spectrum Analysis** See Also ACCELERATORS, CYCLOTRON—Applications; CAST IRON—Microanalysis; SPECTROMETERS.

**086916 ENERGY DEPENDENT PHASE SHIFT ANALYSIS OF PROTON-PROTON SCATTERING BETWEEN 700 AND 1300 MeV.** An energy dependent pp—pp phase-shift analysis for elastic proton-proton scattering is reported in the energy range between 700 to 1300 MeV. Almost all phase shifts smoothly connect with the previous results of the Saclay-Geneva phase shift analysis below 800 MeV. Due to recent Saturne II results the data base is now sufficiently abundant to perform such an analysis. Present results strongly disagree with the predictions of Arndt et al., for most phase shifts. Argand diagrams suggest a non-resonant behavior of the  $^3\text{F}_3$  partial wave and a resonance-like behavior for the  $^1\text{G}_4$  partial wave. (Author abstract) 69 refs.

Lehar, F. (CEN, Gif sur Yvette, Fr); Lechanoine-Leluc, C.; Bystricky, J. *J Phys (Paris)* v 48 n 8 Aug 1987 p 1273-1290.

**086917 DYNAMIC NUCLEAR POLARIZATION AND SPIN-LATTICE RELAXATION OF THE PROTON SPINS IN  $\text{Ca}(\text{OH})_2$ .** The dynamic nuclear polarization (DNP) of the proton spins in  $\text{Ca}(\text{OH})_2$  doped with  $\text{O}_2$ —centers was studied experimentally. The protons in the neighborhood of the  $\text{O}_2$ —centers which do not cross-relax with the other protons in the sample, due to their large hyperfine interaction with the  $\text{O}_2$ —centers, were identified. Using the position of the diffusion barrier, resulting from this identification, the spin-lattice relaxation process in  $\text{Ca}(\text{OH})_2$ : $\text{O}_2$  can be understood quantitatively. Also the shifts of the ESR-lines used for DNP, due to the demagnetizing field of the proton spins, can be calculated using the diffusion barrier. These shifts were

also observed experimentally and found to be in agreement with these theoretical calculations. (Author abstract) 17 refs.

Van der Zon, C.M.B. (Rijksuniversiteit Leiden, Leiden, Neth); Marks, J.; Wenckebach, W.Th.; Poulsen, N.J. *Physica B & C* v 145 n 2 May-Jul 1987 p 153-164.

**086918 RELATION BETWEEN DEPTH AND ENERGY IN CHANNELING EXPERIMENTS.** Spectra of protons backscattered from a silicon single crystal were measured at a bombarding energy of 2300 keV. A narrow resonance in the elastic scattering cross sections of protons from  $^{28}\text{Si}$ , at 2090 keV, shows up as a peak in the spectra. The position and the shape of this peak were found to vary when the beam alignment was changed from a random to an axial or planar crystal direction. These effects are attributed to a different energy loss distribution of the incoming protons in these three cases. The measured spectra were compared with spectra obtained from Monte Carlo simulations in which the dependence of the energy loss on the impact parameter of the collision is taken into account. The measured and simulated spectra were found to agree qualitatively. By analyzing the energy loss of the simulated trajectories, conclusions are drawn about the influence of the reduced energy loss in channeling directions on the energy to depth conversion in channeling experiments. (Author abstract) 17 refs.

Vos, M. (Univ of Groningen, Groningen, Neth); Boerma, D.O.; Smulders, P.J.M. *Nucl Instrum Methods Phys Res Sect B* v B30 n 1 Feb 1988 p 38-43.

## Theory

**086919 THEORY OF ADIABATIC PROTON TRANSFER IN HYDROGEN-BONDED COMPLEXES IN SOLVENTS OF LOW POLARITY.** The transfer of the proton from fragment A to fragment B is attended, not only by a displacement of ion  $\text{C}^-$  from A to B but also by a change in medium polarization. The authors adopt a simplified model for the calculation. The authors describe the medium polarization by the single effective dimensionless coordinate  $q$  and effective frequency  $\omega$ , and the ion  $\text{C}^-$  by the coordinate  $R$  and frequency  $\Omega$ . We shall simulate the adiabatic potential-energy surface of the reaction complex as a function of the classical reaction coordinates  $R$  and  $q$ . It is shown that even in the case of adiabatic reactions the medium will not set up a Frank-Condon barrier for ion  $\text{C}^-$  in its displacement to the transition configuration ( $R_{\text{eq}} \rightarrow R^*$ ). Medium reorganization occurs in configuration  $R^*$ , and corresponds to a redistribution of charge in the system in this configuration which is due to the proton jump from fragment A to fragment B. However, in contrast to nonadiabatic reactions, the relaxation characteristics of the medium do influence the dynamics of motion of the systems toward the transition configuration via the attenuation constant  $\Gamma_{\text{min}}$  which depends on to interaction constants of the ion and medium reaction modes with the thermostat. 4 refs.

Belousov, A.A. (Acad of Sciences of the USSR, Moscow, USSR); Kuznetsov, A.M. *Sov Electrochem* v 23 n 4 Apr 1987 p 476-479.

**Transport Properties** See Also METALS AND ALLOYS—Radiation Effects; PROTEINS—Analysis; SOLIDS—Theory; TITANIUM OXIDES—Ionic Conduction.

**086920 ON THE ACCURACY OF MEASURING PROTON FLUENCE BY BEAM INTEGRATION, FOR THE DETERMINATION OF STOPPING POWER.** The energy dependence of the stopping power can be determined from the height of backscattering spectra when for different energies the fluence of the projectiles is measured. We list the possible errors when the number of protons hitting the target is deduced from the integrated beam current. It is shown, e.g., that a proper correction for dead time in the multichannel analyzer requires a stable beam current. Taking account



of all effects discussed, we find that for proton energies larger than 60 keV the fluence can be determined with a precision better than 1%. This is confirmed by comparing the calculated and the measured backscattering yields from a Au- and a Ta-target. To facilitate the determination of the backscattering cross section of the shielded target nuclei we use a fit formula applicable to all atoms heavier than Al, which was obtained from calculations using the scattering integral. (Author abstract) 16 refs.

Golser, R. (Johannes-Kepler-Univ, Linz, Austria); Semrad, D.; Bauer, P. *Nucl Instrum Methods Phys Res Sect B* v B28 n 2 Sep 1987 p 311-316.

**086921 CROSS SECTION OF PROTON RETARDATION OVER A BROAD ENERGY RANGE.** In describing the cross section of proton retardation, three energy ranges are isolated. At high velocities (proton energy > 1.2 MeV), the Bethe-Bloch formula may be successfully used. The theory is used to describe the low velocity region (proton energy < 50-100 keV). The most difficult region to describe is that of intermediate energy, where there is a maximum in the curve of the retardation cross section as a function of the energy. In this case, empirical and semiempirical expressions are used. In each of these energy ranges, a different parameterization is used, and it is difficult to cross from one region to another. In connection with this, the problem of modifying the Bethe-Bloch expression so as to be applicable for the regions of low and intermediate energy is posed. 7 refs.

Pucherov, N.N.; Chesnokova, T.D. *Sov At Energy* v 62 n 1 Jan 1987 p 67-69.

**086922 METHOD FOR THE DETERMINATION OF PROTON ENERGY LOSS IN INTERMEDIATE THICKNESS SAMPLES BY PIXE MEASUREMENTS.** The proton energy loss in an intermediate thickness sample is determined from the decrease in the x-ray intensity of a reference element after the passage of the proton beam through the sample to be analyzed by PIXE. Using this method we have determined proton energy loss in superchlorine filter-paper (4 mg/cm<sup>2</sup>), which is used at the filtering stage of the single orifice cascade impactors. The results show good consistency for the several elements used in our experiment. The selection for the reference element is also discussed. (Author abstract) 11 refs.

Zhaohui, Hu (Acad Sinica, Beijing, China). *Nucl Instrum Methods Phys Res Sect B* v B34 n 3 Sep 1988 p 369-372.

**PSYCHROMETERS** See AIR CONDITIONING—Computer Aided Engineering; ENVIRONMENTAL ENGINEERING—Humidity Control; ATMOSPHERIC HUMIDITY—Calculations; THERMOCOUPLES—Fabrication.

## PUBLIC ADDRESS SYSTEMS

**086923 SPEECH ANNOUNCEMENT IN THE SNCB'S MAJOR RAILWAY STATIONS.** ACEC - at the request of the Belgian State Railways - has installed electronic public address systems in several Brussels stations. This was done to improve the quality of the information broadcast to passengers. This system provides for announcements of train information in four languages as well as facilities for communication with the electronic (traffic) regulation system and the signal box operator.

Demeur, J.; Nguyen, Ph.; Vanlieferinge, M. *ACEC Rev* n 2 1987 p 14-17.

**PUBLIC UTILITIES** See Also GAS PIPELINES—Control; HYDROELECTRIC POWER PLANTS; WATER RESOURCES—Management; WATER SUPPLY.

**086924 ON THE AUTOMATION OF A UNIFORM PUBLIC UTILITY REGISTRATION.** As a result of development in computer technique, a number of big, registration data bank systems has been realized in the past decade. In Hungary, bringing about modern graphic and alphanumeric information systems that ensure modern updating and data supply are much needed in several fields, thus in the field of land survey and public utility

registration. The paper gives a short summary about the present state of public utility registration in Hungary, mentions some foreign examples and informs about preparatory steps to realize the Budapest Public Utility Information System. (Author abstract) 14 refs.

Cseminiczky, L. (Technical Univ, Budapest, Hung). *Period Polytech Civ Eng* v 30 n 1-2 1986 p 37-52.

**Costs** See ENERGY MANAGEMENT.

**Rate Making** See WATER DISTRIBUTION SYSTEMS—Control; WATER SUPPLY; WATER SUPPLY—Belgium; WATER SUPPLY—Legislation.

**United Kingdom** See WATER SUPPLY.

**PUBLIC WORKS** See Also AMBULANCES.

**Computer Applications**

**086925 PUBLIC WORKS GOES HIGH TECH.** In the often complicated and complex world of public works, technology and new forms of automation are making life easier for engineers and managers. A supervisory control and data acquisition (SCADA) system, monitors numerous plant operations. The system also can turn wells on and off after a pump's water level reaches a specified point. Cities are employing computers and other forms of automation to reduce time and manpower hours. These applications range from monitoring water- and wastewater-treatment plants to hand-held field computers, computerized utility billings, financial and budgetary programs, fleet-maintenance and pavement-management systems, and three-dimensional mapping programs.

Darnell, Tim (American City & County, Atlanta, GA, USA). *Am City Cty* v 102 n 10 Oct 1987 7p between p 50 and 61.

**086926 SOFTWARE CAN AID PUBLIC-WORKS MANAGEMENT.** Managing a capital improvement program is one of the most difficult tasks facing a public-works director or city or county engineer. This article discusses how computer software can assist the public works manager in project execution.

Pinnell, Steven. *Am City Cty* v 103 n 7 Jul 1988 p 44-46.

**Developing Countries** See CONSTRUCTION INDUSTRY—Management.

**Earthquake Resistance**

**086927 SAN SALVADOR EARTHQUAKE OF OCTOBER 10, 1986 - PERFORMANCE OF LIFELINES.** Although the October 10, 1986 San Salvador earthquake was only a moderate event of magnitude 5.4 and the recorded ground motions had a relatively short duration, the high recorded peak accelerations caused substantial damage to lifelines. There was significant and widespread damage to buried lifelines. Long-distance telecommunications facilities were reportedly undamaged, but there was substantial loss of local phone service caused by damage to buildings, failures of equipment racks, and loss of emergency power (tilting of batteries). Power generating facilities (hydroelectric and geothermal) that supply electricity to San Salvador are located too far from the city to have been affected by the earthquake. As has been observed in past earthquakes, control and instrumentation systems and low-voltage power-supply equipment displayed an ability to withstand high ground accelerations. (Edited author abstract) 2 refs.

Morgan, James R. (Texas A&M Univ, College Station, TX, USA); Swan, Sam W. *Earthquake Spectra* v 3 n 3 Aug 1987 p 585-607.

**Maintenance**

**086928 COMPUTER SYSTEM CONTROLS ALL MAINTENANCE ACTIVITIES.** Lynn Haven, Florida, a city of 9,000 residents has created a system to monitor and control all maintenance activities throughout the public works department. The system monitors and

controls all activities. Every scheduled maintenance action is approved by issuing a work-order to the responsible department and is monitored through to completion. The system is also used to capture all those citizens' requests for service. If a call is received to pick up trash, an unscheduled work order is issued after the request is entered in the computer and it is monitored until the work is completed.

Hartenstein, Alan (Pitman-Hartenstein & Ashe Inc, Jacksonville, FL, USA). *Public Works* v 119 n 1 Jan 1988 p 60.

**086929 PROCEDURES AND DEVICES FOR UNDERWATER CLEANING OF CIVIL WORKS STRUCTURES.** Civil works structures must be continually evaluated for structural safety, stability, and operational adequacy. Proper inspection and evaluation of them to identify deficiencies will usually require some type of cleaning of the structure. A wide variety of underwater cleaning tools and methodologies have been developed and are currently in use in the offshore oil industry and by the US Navy. These tools range from hand-held scrapers to powered tools and high-pressure waterjets. Several tools have been specifically designed for removal of underwater debris. These tools include jet educators, dredges, and air lifts. This report summarizes underwater cleaning procedures and devices that are appropriate for use on civil works structures. The application, advantages, disadvantages, and operation of each type of equipment are discussed, along with recommendations for those tools best suited for specific conditions. (Author abstract) 16 refs.

Keeney, Carmela A. (US Naval Civil Engineering Lab, Port Hueneme, CA, USA). *Tech Rep US Army Eng Waterw Exp Stn REMR-CS-8* Nov 1987 54p.

**Management** See Also MAPS AND MAPPING—Computer Applications.

**086930 EXCELLENCE THROUGH MANAGEMENT LEVERAGE: AN ALTERNATIVE TO AMERICA IN RUINS.** Public institutions are in a state of crisis in their attempts to render basic services. The Pennsylvania Department of Transportation is a case in point that management performance is integral to a sound public organization. Public sector management is an important business. It represents roughly one-third of our economy. What public sector managers do is to provide the lubricants to a civilized society, a society in which private, social and economic aspirations can be realized. And finally, the public sector is not a place where the benefits of intelligent management are lost. On the contrary, the public sector fields are ripe for harvest using the tools of enlightened management. It is possible to achieve public sector excellence through management leverage. 10 refs.

Larson, Thomas D. *Civ Eng Pract* v 2 n 2 Fall 1987 p 25-34.

**086931 COST COMPARISON MODEL FOR CONTRACTING OUT GOVERNMENT SERVICES.** Faced with significant funding shortfalls for the construction, repair, maintenance, and operations of public infrastructure and delivery of public services, governments have searched for strategies to alleviate the funding shortages. Privatization has emerged as a promising alternative to traditional service-delivery approaches. Contracting out the operations of public services, a subset of privatization, offers significant cost savings through competitive bidding for public services. A model that provides a method for making valid cost comparisons between the total costs of private and public performance of public services is presented. Special attention is given to the computation of the additional costs of contract performance. A case study involving solid waste collection and disposal is provided to demonstrate the use of the cost comparison model. (Author abstract) 5 refs.

Jarrell, David A. (US Naval Facilities Engineering Command, Beaufort, SC, USA); Skibniewski, Mirosław J. *J Manage Eng* v 4 n 3 Jul 1988 p 260-271.



## Productivity

**086932 PUBLIC WORKS PRODUCTIVITY: BEYOND CUTBACK TO CREATIVITY.** This technical note is based on extensive research and interviews with public works directors in the USA. It examines the rapidly evolving field of public works productivity and reflects state-of-the-art management practices, such as the modernization of public works procedures and operations and increased inter-governmental co-operation among public agencies in North America. The topics examined include ways to better manage existing resources, programs to increase productivity, ways to raise revenues without increasing taxes and the use of more sophisticated financial techniques. Twenty-eight public works productivity trends now being used in local governments throughout the country are described.

Kemp, Roger L. (City Government, Placentia, CA, USA). *Civ Eng S Afr* v 29 n 9 Sep 1987 p 364-366.

## PULP

## Additives

**086933 MECHANISM OF FINES AND FILLER RETENTION IN NEWSPRINT FURNISHES: CHEMICAL ADDITIVES AND PAPER MACHINE WHITE WATER.** Pulp samples from various locations of a newsprint mill were treated with a number of chemical additives. Bentonite proved to adsorb the inorganic contaminants such as sodium silicate coming from the bleaching operation. Chemical additives such as bentonite, microtalc, and zirconium oxychloride were found to be effective in reducing the TOC, soluble lignin, and turbidity of the pulp slurry. X-ray diffraction analysis indicated that bentonite underwent lattice expansion, which could be the fundamental reason for its capability of adsorbing the contaminants in the white water, making it an effective retention aid in combination with polyacrylamide. Coflocculation of fines and filler with a suitable retention aid proved to be effective in improving retention. Cationic starch in combination with an anionic silicic acid colloid was able to produce clay-filled sheets with minimum loss in strength properties. (Author abstract) 18 refs.

Rahman, L. (Abitibi-Price Inc, Mississauga, Ont, Can). *Tappi J* v 70 n 10 Oct 1987 p 105-112.

## Analysis

**086934 SOLID-PHASE EXTRACTION TECHNIQUES IN THE PULP AND PAPER INDUSTRY.** Solid-phase extraction cartridges are an aid in the separation of organic species commonly found in pulp and paper mill systems. Defoamers, rosin sizes, deposits, and black liquor samples can be analyzed with these cartridges. The advantages of using these cartridges include smaller sample and solvent requirements, less labor per sample, and simpler use than with conventional solvent extraction techniques. (Author abstract) 12 refs.

Sweeney, Kevin M. (Int Paper Co, Mobile, AL, USA). *Tappi J* v 71 n 1 Jan 1988 p 137-140.

**086935 DISPERSED RESIN IN BLEACHED KRAFT PULP MILLS.** Several properties of the dispersed resin in bleached kraft pulp mills have been investigated. Average concentrations of resin particles in filtrates of pulps from various points along the process stream are reported. For each sampling location, the change in particle concentration with time of pulp sample storage at 5°C has been determined. In the future, this will enable rough estimation of original concentrations when samples must be measured a few days after collection. Size distributions of resin particles were the same at all sampling points, from which it follows that, in practice, the relationship between concentration and deposition rate is relatively unaffected by size distribution. Dispersed resin particles were negatively charged throughout the mills. The low charge observed in C-stage pulps was insufficient to confer stability, which further supports the hypothesis that the dispersed resin is heterocoagulated

with the fibers in this acidic stage. (Author abstract). 11 Refs.

Allen, L.H. (Pulp and Paper Research Inst of Canada, Pointe Claire, Que, Can); Lapointe, C.L. *J Wood Chem Technol* v 8 n 2 1988 p 289-298.

## Applications See MORTAR—Fiber Reinforcement.

**Bleached** See Also PAPER AND PULP MILLS—Modernization; PAPERMAKING; PULP MANUFACTURE—Bleaching.

**086936 EXTENDED DELIGNIFICATION, AND ALTERNATIVE TO CONVENTIONAL KRAFT PULPING.** Mill and pilot plant data for market-grade bleached pulp were evaluated. The pulp quality was equivalent to or better than that of bleached pulps obtained by conventional kraft pulping and bleaching techniques. However, operating parameters favored extended cooking in the rapid displacement heating process. These parameters were lower active alkali consumption, lower bleaching chemical demand, and lower bleach plant effluent liability. (Author abstract) 8 refs.

Mera, Fernando E. (Beloit Corp, Portland, OR, USA); Chamberlin, Jeffrey L. *Tappi J* v 71 n 1 Jan 1988 p 132-136.

**086937 RAPID CAUSTIC EXTRACTION OF CHLORINATED PULP.** Up to 94% of the lignin that can be removed in the first caustic extraction stage of a conventional process can be removed rapidly from well-chlorinated pulp with two countercurrent displacements with caustic. The time per displacement can be as short as 1.7 s. A slight loss in extraction efficiency is more than made up by improved washing efficiency. On a commercial scale, the chlorinated pulp can be formed into a sheet, washed, extracted twice, and washed three times on a six-stage horizontal washer. Caustic requirements are 2/3 that of a conventional extraction. Energy requirements are lower than in a conventional bleaching. This technology also presents an opportunity to lower the capital cost of a bleaching. (Author abstract) 13 refs.

Histed, J.A. (CIP Research Ltd, Hawkesbury, Ont, Can); Canovas, R. Vega. *Tappi J* v 71 n 3 Mar 1988 p 157-161.

**086938 PHOTOYELLOWING SIMULATION OF BLEACHED HIGH YIELD WOOD PULP BY LIGNIN MODELS INCLUDED IN A SOLID CARBOHYDRATE MATRIX.** A series of lignin model molecules was prepared, adsorbed and grafted (for the most appropriate one) on to bleached chemical pulp. The rates of brightness reversion of these solid materials under simulated solar light exposure were established and compared to that of bleached mechanical pulp (containing lignin). 4-hydroxy-3-methoxy acetophenone (acetovanillone or acetosyringone) 1 and 3, 5-dimethoxy-4-hydroxy acetophenone (acetosyringone) both incorporating  $\alpha$ -carbonyl and phenolic functions which have been claimed essential for an efficient coloration, did not prove to be very active in the solid state. In contrast,  $\alpha$ -carbonyl  $\beta$ -0-4 and  $\beta$ -1 structures with whether phenolic function or not, display an intense yellowing in this medium, and mimic well the brightness reversion of bleached mechanical pulp (especially the non phenolic  $\beta$ -0-4 chromophore adsorbed and grafted). These results are in contrast with those found in liquid ethanolic solution where acetovanillone 1 (conc. =  $10^{-2}$  M) and the  $\alpha$ -carbonyl 4-0-methylated  $\beta$ -0-4 dimer 3 (conc. =  $3.7 \times 10^{-3}$  M) were shown to undergo a similar yellowing. (Edited author abstract) 22 refs.

Castellan, Alain (CNRS, Talence, Fr); Girard, Philippe; Vanucci, Corinne. *J Wood Chem Technol* v 8 n 1 Mar 1988 p 73-90.

## Chemical

**086939 SODA ASH - THE PAPERMAKER'S ALTERNATIVE TO CAUSTIC SODA.** When caustic soda is unavailable or its price versus soda ash increases sharply, soda ash becomes an excellent alternative and a source of potentially significant savings. When making an economic comparison of the two products for kraft

pulping, calculate the prices on an equivalent sodium oxide product. In this case, it requires 1.31 times more dry soda ash than liquid caustic soda (dry bases) to obtain an equivalent sodium oxide content. In addition to the chemical's costs, the installation of soda ash storage and handling equipment must be considered. To facilitate handling, soda ash is often stored as a solution or as a slurry. Recently, an efficient hydrator, called the General Chemical Hydrator System, has become available, allowing a mill to convert dry soda ash on-site to either a liquid or a slurry. This system greatly simplifies the transfer of soda ash from rail hopper cars to storage.

Wortley, Barbara (General Chemical Corp). *PIMA Mag* v 70 n 7 Jul 1988 p 40-41.

## Chromatographic Analysis

**086940 CLASSAGE DES FIBRES PAPETIERES PAR CHROMATOGRAPHIE HYDRODYNAMIQUE CAPILLAIRE.** [Classification of Pulp Fibers by Capillary Hydrodynamical Chromatography]. The classification of pulp fibers with capillary hydrodynamic chromatography was studied quantitatively. With a tube of sufficient length and with the hypothesis that in the tube of diameter D the velocity distribution is parabolic, the mean radial position of fibers of mean length verifies a provided relation (a). The observed selectivity of classification depends on Reynolds number in the flow and on the constant K. For all experiments performed the selectivity followed a second provided relation. With a given set of experimental conditions the axial dispersion is the lower and the selectivity the higher is the value of K. (Author abstract) In French. 14 refs.

Elie, Pascale (CNRS, St. Martin D'Heres, Fr); Renaud, Maurice. *Entropie* v 23 n 136 1987 p 33-40.

## Cleaning

**086941 OPTIMIZED PULP CLEANING TAKES DISCIPLINE, ORGANIZATION.** Cleaning systems are designed for specific quality and tonnage requirements. The goal is to produce acceptable quality with the lowest possible energy consumption and minimal sewer loss. Cleaning systems are made up of successive stages of hydrocyclones. All hydrocyclones operate on a percentage basis. None removes all the contaminants, but most of the time, cleaning systems do an adequate job in producing quality paper. Probably the most common inefficiency of cleaning systems in the paper industry is wasting energy. Pumps, driven by electric motors, move pulp through pipes, valves and cleaners. The energy losses can occur throughout the system, or in one or more stages. Keeping a cleaning system operating at peak performance is a necessity. What is required to get the most out of a cleaning system on an ongoing basis is the organization and discipline to keep optimization a top priority.

Franko, Andrew (Fluid-Quip); Talbert, Ronald. *PIMA Mag* v 70 n 2 Feb 1988 p 29-30, 32-33.

**Composition Effects** See PAPERMAKING MACHINERY—Protection.

## Contamination

**086942 PLASTIC CONTAMINATION IN THE PULP MILL: AN OVERVIEW.** Plastic contaminants create serious quality problems for the papermaker. Major sources of plastic in the pulp mill are the chip supply, construction materials and consumer plastics. After proper identification the contaminants can then be traced back to source. An effective control program requires strong management commitment to succeed. This can be followed by the formation of a steering committee, education of mill personnel and installation of new cleaning systems if necessary. (Author abstract) 8 refs.

Robitaille, M.A. (St. Anne-Nackawic Pulp & Paper Co, Nackawic, NB, Can). *Pulp Pap Can* v 89 n 1 Jan 1988 p 121-125.



## Flocculation

**086943 FIBER FLOCCULATION IN PULP SUSPENSION FLOW: PART 2. EXPERIMENTAL RESULTS.** The purpose was to quantify the primary effects and the interaction effects of selected factors on floc size distribution and, hence, on the uniformity of fiber dispersion. Factors studied include consistency, velocity in turbulent flow, temperature, and fiber surface characteristics. Fiber dispersion is enhanced as consistency, fiber length, and temperature are decreased, with the first two variables being dominant. Velocity has a complex influence, but flocculation is generally minimized by increasing velocity in turbulent flow. Electrostatic field effects have a strong influence on the floc size distribution. These results are based on coupling the theoretical model of Part 1 with experiments using digital signal analysis of light transmission through flowing pulp. (Author abstract) 6 refs.

Hourani, Michel J. (Westvaco Corp Research Cent, Laurel, MD, USA). *Tappi J* v 71 n 6 Jun 1988 p 186-189.

## Grafting

**086944 XANTHATE METHOD OF GRAFTING. X. GRAFTING OF ACRYLAMIDE ONTO VERY-HIGH-YIELD CHEMITHERMOMECHANICAL BIRCH AND ASPEN PULPS.** Hardwood pulp (birch: Betula Papyfera Marsh, and aspen: Populus Tremuloides Michx) has been copolymerized with acrylamide using the xanthate grafting method. Grafting has been initiated using a redox system of ferrous ion and hydrogen peroxide. The effect of operating conditions on grafting parameters was also investigated. The factors studied were initial pH, time, and concentrations of hydrogen peroxide and acrylamide. When birch was used as a substrate, grafting parameters were as follows: grafting efficiency 82%, degree of conversion 35%, and polymer loading 60%. In the case of aspen, the maximum level of grafting efficiency, i.e., 87%, was reached with a polymer loading of 60%. Nevertheless, as in the case of birch, the conversion reached a rather low-level reading, i.e., 50%. Finally, some mechanical properties of paper sheets obtained through grafted pulps (dry and wet breaking lengths, dimensional stability, modulus, and extension at break) are compared to those of standard paper sheets. (Author abstract) 11 refs.

Kokta, Bohuslav V. (Univ de Quebec, Trois Rivières, Que, Can); Daneault, Claude. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2517-2526.

**Kraft** See Also PULP MANUFACTURE; PULP MANUFACTURE—Mathematical Models.

**086945 INFLUENCE OF OXYGEN DURING PRE-TREATMENT OF KRAFT PULP WITH NO<sub>2</sub>.** Large additions of O<sub>2</sub> during the pretreatment of modified or industrial kraft pulp with NO<sub>2</sub> under conditions which favored an autocatalytic generation of NO<sub>2</sub> from produced and added HNO<sub>3</sub> led to a decreased viscosity after a subsequent oxygen bleaching, if the comparison was made at high kappa numbers. The difference was less apparent when the oxygen bleaching was extended. The yield of pulp at a given kappa number was reduced by large O<sub>2</sub> additions. An increased yield of nitric acid contributed to these effects. (Edited author abstract) 11 refs.

Kalen, Gunnar (Mo och Domsjö AB, Örnsköldsvik, Sweden); Samuelson, Olof; Svedmark, Gunnar. *J Wood Chem Technol* v 7 n 2 1987 p 245-258.

**086946 OXYGEN BLEACHING OF KRAFT PULP: HIGH CONSISTENCY VS. MEDIUM CONSISTENCY.** An advantage with oxygen bleaching is that oxygen is cheap and that little electricity is needed for the production of the oxygen compared with the electricity requirement for other bleaching chemicals. Because organic chlorinated components are harmful to organisms living in water, the restrictions on the discharge of these components will probably become stricter. A big step forward to reduce such components is the introduction of

oxygen bleaching. In most cases, medium-consistency oxygen bleaching will probably be installed because the selectivity is slightly better than that of high-consistency oxygen. With pre-stages under development, such as that using nitrogen dioxide, PRENOX, the selectivity can be even better, and this improvement can be used for further delignification in the oxygen stage. Pulp viscosity at a given degree of delignification is slightly higher for medium-consistency bleaching than for high-consistency oxygen bleaching. 5 refs.

Idner, Kristina (Af-Industriins Processkonsult AB, Stockholm, Sweden). *Tappi J* v 71 n 2 Feb 1988 p 47-50.

**086947 RESIDUAL LIGNIN IN UNBLEACHED KRAFT PULP. PART I - ALKALI-EXTRACTION OF RESIDUAL LIGNIN FROM UNBLEACHED KRAFT PULP SOLUTION.** Unbleached kraft pulp containing 4.7% Klason lignin has been found to dissolve completely in several nonaqueous cellulose solvents. Extraction of the residual lignin in the unbleached kraft pulp from these solutions was attempted using several kinds of solvents for kraft lignin and hemicelluloses. When the solvents for only kraft lignin were used, a small amount of the residual lignin (< 7% of the original residual lignin) was extracted. On the other hand, 24% sodium hydroxide solution extracted approximately one-half of the residual lignin together with polysaccharides. These results indicate that the residual lignin has some chemical linkages with some polysaccharides. (Author abstract) 15 refs.

Isogai, Akira (Univ of Tokyo, Tokyo, Jpn); Ishizu, Atsushi; Nakano, Junzo. *J Wood Chem Technol* v 7 n 3 Sep 1987 p 311-324.

**086948 VARIABLES AFFECTING THE SWELLING OF KRAFT BLACK LIQUOR SOLIDS.** The swelling behaviour of kraft black liquor solids during pyrolysis was simulated by a simple laboratory test. The liquor variables affecting swelling were investigated. For liquors which swelled greatly, yielding chars with large pores, the swelling tendency was decreased by high amounts of dead load inorganics and/or soap, and by the aging of the liquors. (Edited author abstract) 7 refs.

Milanova, E. (Paprican, Pointe Claire, Que, Can). *J Pulp Pap Sci* v 14 n 4 Jul 1988 p 95-102.

## Leaching

**086949 MOLECULAR WEIGHTS OF LIGNOSULPHONATE AND CARBOHYDRATE LEACHED FROM SULPHITE CHEMIMECHANICAL PULP.** The molecular weights of both the lignosulphonate and carbohydrate fractions leached from sulfite chemimechanical pulps increased as the leaching proceeded. Lignosulfonate molecular weights rose from 1100 to 6100. Values for the carbohydrate fractions were lower, ranging from 6000 to 17000. For the lignin, the diameter of the equivalent sphere corresponding to the whole sample leached was considerably higher than the medium-pore diameter of the fiber. This discrepancy indicated that the lignosulfonate macromolecule in the fiber wall adopted a flat conformation. (Author abstract) 13 refs.

Willis, J.M. (McGill Univ, Montreal, Que, Can); Yean, W.Q.; Goring, D.A.I. *J Wood Chem Technol* v 7 n 2 1987 p 259-268.

**Mechanical** See Also PAPER—Printing Properties; PULP MANUFACTURE; PULP MANUFACTURE—Refining; PULP MANUFACTURE—Sulfonation.

**086950 CHARACTERIZING MECHANICAL PULPS FOR PAPERMAKING.** The works surveyed here demonstrate that: direct measurement of pulp-slurry properties can be used in place of handsheets as process control tests; a range of slurry tests utilizing filtration resistance and physical separation of pulp into particle-size classes have been and are being developed for on-line use; efforts directed at characterization of the fines fraction would be worthwhile; pulp-slurry tests based on optical and acoustical principles are developed to greater or lesser degrees; test equipment now being marketed can measure several pulp properties in concert; and better

instrumentation of mechanical pulping processes will enable better control of pulp quality through manipulation of process variables. 48 refs.

Veal, M.A. (Weyerhaeuser Co, Tacoma, WA, USA); Jackson, M. *Tappi J* v 70 n 10 Oct 1987 p 88-90.

**086951 USING THE DRAINAGE TIME TO EVALUATE MECHANICAL PULPS.** In most research papers on the characterization and evaluation of mechanical pulps, the characterization factors correspond to the average fiber length and shape of the particles in the pulp. Taking into account that the drainage behavior is important in evaluating a pulp, the authors studied the drainage phenomenon as it occurs in the standard sheet machine. They found that the drainage behavior can be characterized by only one parameter, the 'resistivity' (R) which can be readily determined from the drainage time test by using any sample weight within a wide range and using running water with no temperature requirements. 4 refs.

Zanuttini, Miguel A. (Inst of Cellulose Technology, Santa Fe, Argent). *Tappi J* v 71 n 2 Feb 1988 p 115-116.

**086952 1987 INTERNATIONAL MECHANICAL PULPING CONFERENCE - 'MECHANICAL PULP: CHALLENGING THE NEW FRONTIERS'.** This conference proceedings contains 32 papers on recent advances in mechanical pulping processes and applications. The topics discussed include refining and bleaching in pulp manufacturing, papermaking machines' energy consumption, paper quality, rejects sulfonation, paper printability and runnability, CTMP, and TMP processes. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10614 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (CPPA, Technical Section, Montreal, Que, Can). 1987 Int Mech Pulping Conf - 'Mech Pulp: Challenging the New Front'; Vancouver, BC, Can, Jun 2-5 1987 Publ by CPPA, Montreal, Que, Can, 1987 230p.

**Mechanical Properties** See CELLULOSE—Testing; PULP MANUFACTURE; PULP MANUFACTURE—Cooking; PULP MANUFACTURE—Thermomechanical Processes.

## Microscopic Examination

**086953 LASER TECHNOLOGY OFFERS NEW WAY TO MEASURE FURNISH COMPONENTS.** The basic principle of operation of the scanning laser microscope is presented. The light output from a laser diode is focused down to a diffraction-limited beam spot. At the focal point the light beam is very intense (light density greater than 1 MW/in<sup>2</sup>) and is able to pick up even smaller filler particles down to 1 micron in size. The size of an individual particle is determined by measuring how long it takes for the scanned beam to sweep across it. The laser beam is scanned at a fixed velocity so that the width of each backscattered light pulse (transit time) is a direct measurement of the size of that individual particle. The beam is scanned rapidly to make the device insensitive to variations in particle flow velocity. The device classifies particles into eight different size fractions, from 1 to 250 microns. To make sure the result are repeatable, each test sequence was repeated at least twice. Test results clearly show that the laser back-scattering technology is a very powerful tool to make measurements on pulp slurries that have not previously been possible with other kinds of devices.

Hanseler, Jamie (Univ of Washington, Seattle, WA, USA); McKean, William. *Pulp Pap Can* v 89 n 9 Sep 1988 6p.

## Mixing

**086954 SYSTEMS APPROACH TO CONSISTENCY CONTROL AND DRY STOCK BLEND.** A process control strategy to blend pulp on a fiber weight basis was developed for the wet end of the paper machine. There are several problems with conventional consistency control that adversely affect this strategy. These difficul-



ties include control loop interaction between furnish flow and consistency; variable process gain arising from changes in furnish flow and storage tank consistency; and variable process dead time also caused by changes in furnish flow. These problems can be solved with a new method for consistency control and a continuous self-tuning algorithm that uses only process data to adapt controller gain and reset. The benefits of using this system can include a reduction in furnish costs and blend variability, enhanced quality machine runnability, and a more uniform sheet. (Edited author abstract).

Dumdie, Dan P. (Daishowa America Co, Port Angeles, WA, USA). *Tappi J* v 71 n 7 Jul 1988 p 135-139.

## Moisture Effects

**086955 MEASUREMENT OF THE ELECTRICAL SPECIFIC CONDUCTIVITY OF A WET PULP WEB.** Wood pulp fibers generally contain electrolytes and dissociative groups, such as the carboxyl group. The dissociation of these groups depends on the physical state of water within the pulp web. Therefore, the relationship between the electrical conductivity and the amount of water in the wet pulp web can be expected to characterize the state of the water in the pulp web. This article describes the measurement of the electrical specific conductivity of wet pulp webs with water contents (g water/g fiber) ranging from about 30% to about 400%. The method used is one that was developed primarily for electrolyte solutions. This method uses an alternating-current bridge and is suitable for wet pulp webs because it avoids polarization at the electrodes. The experimental results show that specific conductivity can be used to evaluate the degree of pulp beating. 6 refs.

Yamauchi, T. (Kyoto Univ, Kyoto, Jpn); Murakami, K. *Tappi J* v 71 n 3 Mar 1988 p 177-178.

**Physical Properties** See Also PULP MANUFACTURE—Waste Liquor Utilization; PULP MATERIALS.

**086956 FIBRE-TO-FIBRE BONDS IN PAPER. PART I. MEASUREMENT OF BOND STRENGTH AND SPECIFIC BOND STRENGTH.** A technique has been developed for the determination of fiber-to-fiber bond strength and specific bond strength, i.e., bond-breaking energy per unit of sample area and bond-breaking energy per bond-broken optical surface area, respectively. The technique is based on the controlled delamination of the sample using a specially designed free-rotating wheel to maintain the same geometry throughout the whole measurement under slow, quasistatic conditions. Results obtained on a series of handsheets of bleached kraft pulp of different bonded area prepared under various beating and wet pressing conditions indicate clearly that bond strength increases with an increase of total bonded area while the specific bond strength remains nearly constant. (Edited author abstract) 23 refs.

Skowronski, J. (PAPRICAN, Pointe Claire, Que, Can); Bichard, W. *J Pulp Pap Sci* v 13 n 5 Sep 1987 p 165-169.

**086957 BIRCH THERMOMECHANICAL PULP FOR NEWSPRINT VIA THE OPCO TREATMENT.** The interstage Opco treatment of white birch TMP offers an attractive alternative for upgrading the strength of a white birch furnish. This implies that under optimal operating conditions, the second-quality white birch can be transformed into a high-quality pulp at high yield (96 percent). The tensile properties and tear strength of birch pulp are covered. 10 Refs.

Koran, Zoltan (Univ de Quebec a Trois Rivières, Trois-Rivières, Que, Can). *Tappi J* v 71 n 7 Jul 1988 p 82-86.

**Processing** See PULP MANUFACTURE—Bleaching.

## Spectroscopic Analysis

**086958 STUDY OF BEATEN PULPS BY MICRO-WAVE SPECTROMETRY.** The new technique of micro-

wave spectrometry has been used to study the hydration of beaten and unbeaten pulps - both kraft and sulphite. The aim is to clarify the concept of hydration in terms of the greasy or slippery feeling of beaten pulp suspensions. The authors describe their research methods and conclude that it is possible to quantify the term of hydration by the measurement of the dielectric properties of a sample of pulp. (Author abstract) 13 refs.

Henry, F. (Cent Technique du Papier, Grenoble, Fr); Brandt, A.; Noe, P. *Pap Technol Ind* v 28 n 9 Dec 1987 p 722-726.

**086959 ESTIMATION OF LIGNIN IN WOOD PULP BY DIFFUSE REFLECTANCE FOURIER-TRANSFORM INFRARED SPECTROMETRY.** A method has been developed for estimating lignin in unbleached pulps using diffuse reflectance Fourier-transform infrared spectrometry. The procedure is based on linear relationships found to exist between the area of the 1510-cm<sup>-1</sup> infrared band, measured on diffuse reflectance difference spectra, and kappa number and Klason lignin. These relationships, which serve as calibration lines for lignin estimation, apply to a range of hardwood and softwood pulps from high-yield and conventional kraft processes (1-20% lignin, 10-120 in kappa no.) and from the alkaline sulfite anthraquinone process. An unknown sample's 1510-cm<sup>-1</sup> band area is referenced against the calibration line to estimate its lignin content. This method is nondestructive, it requires no sample preparation other than drying, it employs no calculations, and it may be used on samples as small as 0.05 mg. (Author abstract) 13 refs.

Berben, Sally A. (Inst of Paper Chemistry, Appleton, WI, USA); Rademacher, John P.; Sell, Lowell O.; Easty, Dwight B. *Tappi J* v 70 n 11 Nov 1987 p 129-133.

**Sulfate** See PULP MANUFACTURE.

## Sulfite

**086960 PRESSURIZED GRINDING OF CHEMICALLY TREATED WOOD.** Mild sulfonation of softwood prior to mechanical defibration yields pulp with enhanced strength properties. Development of the chemi-groundwood process has been hampered by the dimensions of the raw material to be impregnated. This study shows that impregnation with sodium sulfite solutions at elevated temperature is successful at short impregnation times. Pressure grinding of the mechanically treated wood did produce CPGW pulps that in many respects are comparable to CTMP. Compared to the reference PGW pulps, the CPGW pulps had a higher long fiber content and 50-100% higher tensile and tear strengths, but optical properties suffered, as expected. (Author abstract)

Lucander, Mikael (Finnish Pulp & Paper Research Inst, Helsinki, Finl). *Tappi J* v 71 n 1 Jan 1988 p 118-124.

**086961 SULFITE MILLS MOVE TO CUT TOCl.** Strict anti-pollution laws in West Germany have led several big sulfite pulp mills to change their bleach sequences, reducing their total organic chloride discharges. (Author abstract)

Ducey, Michael. *PPI Pulp Pap Int* v 29 n 12 Dec 1987 p 54-55.

## Suspensions

**086962 THEORETICAL ASPECTS OF A PULP SUSPENSION FLOWING IN A CONVENTIONAL HYDROCYCLONE.** Industrial hydrocyclones separate dispersed dense material from a fluid of lower density. The presence of fibers impairs the separating efficiency by reducing the spin velocity in the main flow. In this study, a viscosity model for a pulp suspension in a hydrocyclone is used to obtain a numerical solution for the spin velocity. Calculated efficiency curves depend on the geometry and operating conditions of the hydrocyclone and on a parameter contingent on the concentration of the pulp suspension. (Author abstract) 12 refs.

Ferguson, J.W.J. (Univ of Leeds, Leeds, Engl). *Tappi J*

v 71 n 1 Jan 1988 p 125-128.

**086963 FIBER FLOCCULATION IN PULP SUSPENSION PART 1: THEORETICAL MODEL.** A theoretical model has been developed to provide quantitative relationships describing flocculation in pulp suspension flow. This model is based on the mass-action law and on the energy spectrum of the turbulent flow. Electrostatics contributions are calculated by minimizing the free energy of bound counterions using the Poisson-Boltzmann field. The model is supported by an experimental study based on digital signal analysis using light transmission through the flowing pulp. (Author abstract) 8 refs.

Hourani, Michel J. (Westvaco Corp Research Cent, Laurel, MD, USA). *Tappi J* v 71 n 5 May 1988 p 115-118.

**Testing** See Also PULP MANUFACTURE—Kraft Process.

**086964 STFI OPTI-KAPPA ANALYZER.** The content of lignin in the pulp is a very important parameter for the operation and control of the cooking and bleaching processes. One way of estimating the lignin content is through chemical determination of kappa number in the laboratory. The laboratory method measures the demand for potassium permanganate during oxidation of the pulp under certain standardized conditions, and thus provides an indirect determination of the lignin content. The STFI optical method, based on the ultraviolet (UV) light absorption by the lignin in the pulp, provides an alternative method of indirectly determining the lignin content.

Kubulnieks, Egils (Swedish Pulp & Paper Research Inst, Stockholm, Swed); Lundqvist, Sven-Olof; Pettersson, Thorulf. *Tappi J* v 70 n 11 Nov 1987 p 38-42.

**Thermomechanical** See Also PAPER—Newsprint; PULP MANUFACTURE—Bleaching; PULP MANUFACTURE—Refining; PULP MANUFACTURE—Screening.

**086965 VARIABLES IN CHEMI-THERMOMECHANICAL PULPING OF NORTHERN HARDWOODS.** In Mead's two-stage CTMP process, varying the caustic charge in the first stage had the greatest impact on refining energy and on pulp optical and physical properties, while the effect of sulfite in the second stage was also significant, especially at higher cooking temperatures. Main objective in this study of the two-stage process was to determine quantitative relationships between the major operating variables and the corresponding pulp properties obtained. 5 refs.

Prusas, Z.C. (Mead Central Research, Chillicothe, OH, USA); Rourke, M.J.; Uhrig, L.O. *Tappi J* v 70 n 10 Oct 1987 p 91-95.

**086966 USING CTMP FLUFF PULPS IN NONWOVEN PRODUCTS.** A new generation of CTMP fluff pulps has been developed for use in hygiene products. In laboratory tests, the FPPRI compared a 100% CTMP pulp with two Scandinavian and two North American kraft pulps. The results show significant improvements in quality and suggest that if pulp producers and converters co-operate, greater improvements and much wider uses are possible. It seems that proper shedding is the key - the converter can improve the quality of his products and save energy and raw material if his shredding system is right. (Author abstract)

Jousimaa, Timo (Finnish Pulp & Paper Research Inst). *Pap Technol Ind* v 29 n 1 Feb 1988 p 14-15, 18-19.

**086967 REFINER HYDROGEN PEROXIDE BLEACHING OF THERMOMECHANICAL PULPS.** The feasibility of the simultaneous pulping and bleaching of Norway spruce wood chips in the Kumagai Riki Kogyo (KRK) experimental pressurized laboratory refiner was investigated. Bleaches were made in both the primary and secondary stages of the TMP thermomechanical pulping process. All experimental work was aimed at developing operating parameters for refiner bleaching that do not require the use of scale-forming sodium silicate. Second-



ary-stage refiner bleaching using diethylenetriamine pentamethylene phosphonic acid (DTPMP) as a peroxide stabilizer produced comparable brightness gains (10.40%) with methods simulating tower bleaching at a much shorter reaction time, therefore avoiding the use of sodium silicate and expensive bleaching towers. (Author abstract) 6 refs.

Sharpe, Patrick E. (Sprout-Bauer Inc, Muncy, PA, USA); Rothenberg, Samuel. *Tappi J* v 71 n 5 May 1988 p 109-113.

**086968 APPROACH TO THE MEASUREMENT OF PULP RESIDENCE TIME IN A CHIP REFINER.** A method has been devised for measuring the residence time of pulp in a chip refiner. It is based on determining the mass of pulp between the bars of the refiner at a given time. This is done by deriving the stress/strain curve in compression of the pulp mat in the refiner and then matching the curve to an appropriate curve from a set obtained by compressing pulp pads of differing mass concentrations in a laboratory press. The compressive stress in the refiner is obtained by measuring the axial thrust, and the compressed thickness by measuring the true plate clearance. A preliminary application of the technique has indicated that an atmospheric chip refiner was operating at 16% of bar capacity during first-stage refining and at 5% during second-stage refining. The average radial velocity of the pulp, the number of bar impacts, and the average specific energy transfer have been calculated for each stage from these results. (Edited author abstract) 6 refs.

May, W.D. (PAPRICAN, Pointe Claire, Que, Can); McRae, M.R.; Miles, K.B.; Lunan, W.E. *J Pulp Pap Sci* v 14 n 3 May 1988 p 47-53.

**086969 OPERATION OF TNP SYSTEM AT THE DOMTAR MILL IN DONNACONA, QUEBEC.** The Donnacona mill produces groundwood specialty papers, using 100 PERCENT TMP pulp. The TMP system consists of three different lines. Each line has its own screening, cleaning, rejects refining and thickening equipment, with a common heat recovery system for the three lines. The mill produces newsprint specialties for offset printing at four different brightness levels: 60, 64, 68 and 71 ISO brightness. (Edited author abstract). 1 Ref.

Mercier, A. (Domtar Newsprint, Donnacona, Que, Can). *Pulp Pap Can* v 89 n 6 Jun 1988 p 106-107.

**Unbleached** See Also LIGNIN—Analysis.

**086970 STRENGTH POTENTIAL OF UNBLEACHED KRAFT PULPS.** Unbleached, bleachable-grade softwood kraft pulps made in a pilot plant were 20 to 40% stronger in tear-tensile performance than pulps made in mills from the same chips under similar pulping conditions. Unbleached hardwood kraft pulps, compared in the same way, showed no strength differences. Of the factors which might explain the softwood 'strength gap', one of the most likely is that after cooking is complete, the fibers are damaged physically as they are transferred from the pressure vessel to the atmospheric side of the mill. (Author abstract) 13 refs.

MacLeod, J.M. (PAPRICAN, Pointe Claire, Que, Can). *Pulp Pap Can* v 88 n 9 Sep 1987 p 103-107.

**Waste Utilization** See PAPER—Deinking.

**PULP DIGESTERS** See Also PULP MANUFACTURE—Cooking.

**086971 BASKET CASES: KRAFT PULPS INSIDE DIGESTERS.** The hanging of baskets in batch digesters has a long history in the chemical pulping industry, but the record of results is largely relegated to the private files of pulp and paper companies. This paper reviews the results of many such basket experiments in a variety of mills. What emerges is a comprehensive picture of the physical quality of pulp inside digesters at the end of kraft cooking, and a realization that the strength loss problem demands a solution. Never-blown 'basket' pulps from

kraft batch digesters processing softwoods are considerably stronger than the corresponding pulps blown from these digesters. This generality holds true across a range of softwood species and is not affected by whether the digester is heated directly or indirectly. The pulp inside many continuous digesters is probably also much stronger than the pulp which reaches the washers. The chemistry of cooking is generally satisfactory, but the physics of blowing is not. The strength loss problem caused by blowing will be solved only by finding an appropriate means to transport cooked material out of the digesters at the end of kraft pulping. 13 refs.

MacLeod, J. Martin (Pulp & Paper Research Inst of Canada, Pointe Claire, Que, Can); Pelletier, Lorraine J. *Tappi J* v 70 n 11 Nov 1987 p 47-53.

## Control

**086972 DISTRIBUTED CONTROL SYSTEM APPLICATIONS.** A dual vessel, hydraulic, continuous digester has been installed at Longview Fibre Company, Longview, Washington. The controls for the digester have been implemented in a microprocessor-based distributed system utilizing proven computer-based strategies. Such functions as production change, alkali-wood ratio, digester level, and diffuser control were included. Sensors were used to measure properties such as white liquor and cooking liquor strengths. The system was initially used extensively in a freestanding emulation mode for operator training. Examples of selected control functions are detailed to illustrate the ability to configure logic and calculation intensive strategies. (Author abstract) 4 refs.

Glenn, M. (Longview Fiber Co, Longview, WA, USA); Kurth, T.; Farrar, D. *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul Publ by TAPPI Press, Atlanta, GA, USA, 1985* p 15-17.

**086973 APPLICATION OF DISTRIBUTED CONTROL TO BATCH/KAMR DIGESTER OPERATION.** In 1981, James River Corporation converted twenty year old instrumentation on six batch and one Kamr digester to modern digital distributed control. Two geographically separated control rooms were combined and located next to existing washer and bleaching control rooms to achieve centralized control of pulp mill operations. CRT based regulatory controls were installed to interface directly with the process, and a supervisory host computer used to implement model based, advanced controls. Motor control and safety interlocking is all solid state programmable logic (PLC) - communicating with regulatory and supervisory controls on a common data highway. The conversion has been highly successful, resulting in a streamlining of pulping operations, implementation of more effective pulping control strategies and significant savings in energy, chemicals, higher yields and increased throughput. (Author abstract)

Huizinga, Philip W. (James River Corp, Pennington, AL, USA); Woolums, Larry L. *Process Technol: A Compil of Rec Eng Conf Pap on Process Control and Simul Publ by TAPPI Press, Atlanta, GA, USA, 1985* p 19-27.

## Energy Conservation

**086974 MILL EXPERIMENTS WITH DISPLACEMENT HEATING.** Digester steam savings of up to 45% were achieved from a displacement heating technique in an experimental digester. Digester heat was recovered by displacing the hot cooking liquor with brown stock washer filtrate. This hot liquor was used to pre-heat the white liquor charge and to be the black liquor charge. In order to reduce rejects and improve yield, the chips were steam packed and pre-steamed. The displacement heating would result in further energy savings at the deaerator and evaporators. (Author abstract)

Embley, D.F. (Irving Pulp & Paper Ltd, St. John, NB, Can); Cyr, M.E.; Savage, P.J. *Pulp Pap Can* v 89 n 1 Jan 1988 p 102-104, 106.

## Environmental Impact

**086975 SULPHITE DIGESTER EMISSIONS CONTROL AT BOISE CASCADE'S KENORA MILL.** Boise Cascade Canada's Kenora newsprint mill recently completed an extensive modernization program which included the conversion to an ultra-high-yield sulphite (UHYS) operation. To minimize CO<sub>2</sub> emissions from the digester relief procedure, a flash, flush, pump system was installed. Based on extensive emission testing prior to system design and post-performance compliance source tests, a reduction of SO<sub>2</sub> emissions of approximately 99 PERCENT was confirmed. (Author abstract). 3 Refs.

Ellard, R. (Boise Cascade Canada Ltd, Kenora, Ont, Can); Aquan-Yuen, M.; Urbanski, R.; Rusch, R.A. *Pulp Pap Can* v 89 n 6 Jun 1988 p 108-110.

**Optimization** See PULP MANUFACTURE—Kraft Process.

**PULP MANUFACTURE** See Also PAPER AND PULP MILLS—Corrosion; PAPER AND PULP MILLS—Port Cartier, Canada; PAPERMAKING; PULP—Kraft; PULP DIGESTERS; WOOD—Hydrolysis.

**086976 PRETREATMENT OF KRAFT PULP WITH NO<sub>2</sub> IN A TWO-STAGE PROCESS.** Pulps with kappa number 3.5 and an intrinsic viscosity of 950 dm<sup>3</sup>/kg were produced from industrial kraft pulp (softwood) by oxygen bleaching following pretreatment with 2% NO<sub>2</sub>. After treatment with NO<sub>2</sub> at 12% consistency without oxygen addition at modest temperature, the pulp was diluted with acid sodium nitrate solution to 5% consistency and kept at high temperature for 90-180 min in stage 2. The generation of NO<sub>2</sub> from HNO<sub>3</sub> is a most important reaction in this stage. Reactions between HNO<sub>3</sub> and the lignin explain the effects of dilution, temperature and oxygen addition. (Edited author abstract) 8 refs.

Samuelson, O. (Chalmers Univ of Technology, Goteborg, Sweden); Ojete, U. *J Pulp Pap Sci* v 13 n 5 Sep 1987 p 150-153.

**086977 ORGANOSOLV PULPING - METHODS AND PULP PROPERTIES.** Potential benefits of using organic solvents for the delignification of lignocellulosic materials are discussed. Main characteristics of organosolv pulping methods published in the literature are presented and softwood pulp yields and strengths are compared with corresponding values of Kraft and sulphite pulps. Yields of organosolv softwood pulps can be higher than yields of conventional pulps at equal kappa number. Tensile and tear strengths of softwood organosolv pulps fall between the corresponding values of Kraft and sulphite pulps. The published data shows that organosolv pulping methods have considerable potential in terms of delignification selectivity and papermaking quality. It is postulated that a more systematic research to reveal the relationships between the physical and chemical characteristics of organosolv fibres and pulp quality is needed so that the pulping methods can be modified and the full potential of organosolv processes utilized. (Author abstract) 143 refs.

Johansson, Allan (Technical Research Cent of Finland, Espoo, Finl); Aaltonen, Olli; Ylisen, Paula. *Biomass* v 13 n 1 1987 p 45-65.

**086978 SELLUN VALMISTUS ORGAANISILLA LIUOTTIMILLA. [Organosolv Pulping].** The article looks at organosolv pulping processes, i.e., delignification methods relying on organic solvents (alcohols, organic acids, organic peroxycids, phenols). The present stage of development and the advantages and disadvantages of the new processes are assessed through comparison with the kraft pulping process. (Author abstract) In Finnish. 33 refs.

Sundquist, Jorma (Oy Keskuslab-Centrallab AB, Helsinki, Finl); Laamanen, Lauri; Poppius, Kristiina. *Kem Kem* v 14 n 10 1987 p 843-847.



**086979 ANALYSIS OF A PART OF THE RECOVERY SYSTEM OF THE SULFATE PULP PROCESS.** A system analysis has been performed on a part of the chemical recovery system of the sulfate pulp process. This part begins with the smelt from the recovery boiler and ends with white liquor ready to use in the pulp digester. The analysis can be divided into three parts. In the first part the status of the present process was investigated. In the second part the principle design of the process of tomorrow was evaluated. Finally, in the third part the role of the returned lime and the produced lime mud were investigated. (Edited author abstract) 25 refs.

Theliander, Hans (Chalmers Univ of Technology, Goteborg, Sweden). *Chalmers Teknisk Doktorsavhandling* n 644 1987 28p.

**086980 REPAP'S ALCELL PROCESS: HOW IT WORKS AND WHAT IT OFFERS.** According to Repap, the Alcell pulp can be bleached to 90 ISO and the only effluent from the pulping process has a BOD content that is easily treated. Capital costs for a fully-commercial system would be low compared with a kraft mill because it does not require a recovery boiler, brownstock washer or a lime cycle. Production costs in an Alcell mill would be 85% of those in a kraft mill. By selling the lignin recovered a producer could further reduce costs.

Williamson, Peter N. (Pulp & Paper Canada, Don Mills, Ont., Can.). *Pulp Pap Can* v 88 n 12 Dec 1987 p 47-49.

**086981 ALCELL OFFERS SAVINGS WITH QUALITY PULPS, BY-PRODUCTS.** By using alcohol, Alcell eliminates odors and other environmental problems, normally associated with kraft pulping. Alcell pulps from hardwood are stronger than sulfite pulps, superior to TMP and comparable in strength to kraft pulp. Paper-making trials have shown that hardwood Alcell pulps can replace hardwood kraft pulp in furnishes that rely on softwood for their strength.

Pye, Kendall (Repap Technologies). *PIMA Mag* v 69 n 11 Nov 1987 p 21-23.

**086982 REVIEW OF THE PRODUCTION AND PROPERTIES OF ALPHABET PULPS.** The proliferation in recent years of new types of mechanical pulps which use mechanical energy and chemicals to transform wood chips to fibers has led to the popular term alphabet pulps. Each process has been assigned an alphanumeric designation to describe and distinguish it from others. This paper provides a general account of the history and rationale behind their developments and attempts to define and characterize the various processes and products in this spectrum and how they relate to the manufacture and printing properties of newsprint. (Author abstract) 29 refs.

Mackie, D.M. (MacMillan Bloedel Research, Vancouver, BC, Can); Taylor, J.S. *Pulp Pap Can* v 89 n 2 Feb 1988 p 58-66.

**086983 FORMATION OF ISOEUGENOL AND EUGENOL DURING THE CLEAVAGE OF  $\beta$ -ARYL ETHERS IN LIGNIN BY ALCOHOL-BISULFITE TREATMENT.** Treatment of guaiacylglycerol- and guaiacylpropanediol- $\beta$ -(2-methoxyphenyl) ethers at 160°C in 50% alcohol containing magnesium bisulfite was found to cleave the  $\beta$ -aryl ether linkages in these compounds to form isoeugenol and/or eugenol in up to 60% yield as well as comparable yields of guaiacol. The linkage in a nonphenolic model was not cleaved to a discernible extent. Both an alcohol and bisulfite were essential for this reductive cleavage which proceeded efficiently in ethanol and isopropanol but not efficiently in methanol, t-butanol or dioxane. Magnesium was a better base than sodium for the reaction. Ferriyl alcohol was proposed to be an intermediate compound of this cleavage reaction which reasonably explains the formation of isoeugenol and eugenol from wood during the alcohol bisulfite pulping process. (Author abstract) 20 refs.

Sakai, Kokki (Kyushu Univ, Fukuoka, Jpn); Takeuti, Hisakazu; Mun, Sung-Phil; Imamura, Hiroyuki. *J Wood Chem Technol* v 8 n 1 Mar 1988 p 29-41.

**086984 APPROACH TO MACERATION MECHANISM IN ENZYMATIC PULPING OF BAST FIBERS BY ALKALOPHILIC PECTINOLYTIC ENZYMES PRODUCED BY ERWINIA SPECIES.** Tissue maceration was generally elucidated by the action of endopolygalacturonase and endo-pectate or -pectin lyase (endo-PAL or -PNL). In a process of screening of *Erwinia* and *Pseudomonas* strains for enzymatic pulping of pectocellulosic bast fibers, it was found that their PAL productivity was not completely related with defibrillation activity, i.e., the fact that an *E.chrysanthemi* strain showed high PAL productivity but possessed rather low defibrillation activity. Moreover, defibrillation activity was parallel to the amount of neutral sugars released during pulping. Based on these facts, the maceration or enzymatic pulping of basts was estimated to proceed not only by cleavage of interfiber bonding caused by PAL action but also other factors. Among three possibilities proposed on the maceration mechanism of basts, it was elucidated by a concerted action of PAL and PNL with an aid of xylanase. In addition, a quantitative determinative method of maceration activity toward basts was also presented. (Author abstract) 25 refs.

Kobayashi, Yoshinari (Government Industrial Research Inst, Takamatsu, Jpn); Komae, Kozo; Tanabe, Hiroyuki; Matsuo, Ryukichi. *Biotechnol Adv* v 6 n 1 1988 p 29-37.

**086985 ORGANOSOLV DELIGNIFICATION OF SOUTHERN PINE - AN ALTERNATIVE PULPING PROCESS.** Aqueous ethylenediamine-ethanol-anthraquinone (EDA-EtOH-AQ) pulping of Southern Yellow Pine was studied for lignin removal and pulp yield. Temperature, time and ethylenediamine concentration in the solvent solution were studied and equations for lignin content and lignin-free yield were developed. Lignin content is decreased by an increase of temperature, time or EDA concentration. Lignin-free yield of pulp decreased with an increase in temperature or time, but increased with increasing EDA concentration. Overall, the solvent is selective, that is, large quantities of lignin are removed while the retention of cellulose remains high. (Author abstract) 9 refs.

Zargarian, K. (Univ of Alabama, Tuscaloosa, AL, USA); Aravamuthan, R.; April, G.C. *Chem Eng Technol* v 11 n 3 Jun 1988 p 195-199.

**086986 DARS IS THE KEY TO SULFUR-FREE PULPING.** Toyo Pulp, Japan, originally patented the use of ferric oxide to recover alkali from black liquor. APM Ltd. has developed the direct alkali recovery system (DARS), which uses a fluidized bed combustion system as the main unit. The process of recovering sodium hydroxide by burning black liquor with ferric oxide and leaching the product, that is, contacting it with hot water, is described. Process development, equipment selection, heat and mass balances, risks and rewards are discussed. Comparative data for DARS and Kraft mills are given.

Covey, Geoff H. (APM Ltd, Melbourne, Aust); Ostergren, Mark E. *Pap Trade J* v 169 n 5 May 1985 3p.

**086987 LATEST DEVELOPMENT TRENDS IN CONTROLLING THE MECHANICAL GROUNDWOOD PROCESS.** Control of production rate is a good compromise between production and quality. Control of specific energy consumption can be considered when production is not critical. Groundwood mill control can be achieved (a) by control of an individual grinder, (b) by control of a group of grinders, and (c) the rest of the groundwood process, including screening and cleaning. (Edited author abstract). 8 refs.

Karna, A. (Valmet Paper Machinery Inc, Jarvenpaa, Finl); Liimatainen, H.; Rusanen, H. *Tappi J* v 71 n 7 Jul 1988 p 87-92.

**086988 EFFECT OF GRAFTING ON THE PAPER PROPERTIES OF WOOD PULP.** Acrylate monomers (such as methyl, ethyl, butyl, and epoxypoly) were grafted onto chemithermomechanical pulps (aspen) by using the xanthate method of grafting. The grafted pulps and the mixture of grafted and nongrafted pulps were

formed in sheets that were hot pressed. The properties of the paper sheets of the resulting pulps - dimensional stability, porosity, water retention value, breaking length at dry and wet states, folding tension, tear and burst indices, elongation, energy, and Young's modulus were evaluated. Most of the paper properties deteriorated as a result of the grafting of hydrophobic monomers. But a special treatment, such as using acetone with grafted fibers, showed a positive effect over the nongrafted fibers. (Author abstract). 15 Refs.

Daneault, Claude (Univ du Quebec a Trois-Rivieres, Trois-Rivieres, Que, Can); Kokta, Bohuslav V.; Maldas, Debesh. *Tappi J* v 71 n 10 Oct 1988 p 173-176.

Bioconversion See Also WOOD—Decay.

**086989 BIOLOGICAL TREATMENTS OF PULPS.** This is a brief review which highlights the current research on applications of biotechnology to the upgrading of unbleached kraft and mechanical pulps. The potential applications include biological beating, biological treatment for dissolving pulp, and biological bleaching and brightening of pulps. The use of fungi and the enzymes cellulase, xylanase, and glucose oxidase for biological treatment of pulps is discussed. (Edited author abstract). 14 Refs.

Jurasek, L. (Pulp & Paper Research Inst of Canada, Pointe Claire, Que, Can); Paice, M.G. *Biomass* v 15 n 2 1988 p 103-108.

**086990 RECENT DEVELOPMENTS IN BIOTECHNOLOGY IN THE PULP AND PAPER INDUSTRY.** Biotechnology implies a technical utilization of biological processes. One of the most important biological processes in nature is the conversion of lignocellulosic materials (wood, straw, bagasse, etc.) to carbon dioxide, water and humic substances. The strategy at STFI has been to develop and achieve a thorough knowledge of the enzyme mechanisms employed by the white-rotters, particularly *Phanerochaete chrysosporium* (Syn. *Sporotrichum pulverulentum*) for the degradation of wood and wood components. Such basic knowledge now exists and forms a reasonably well established base for our biotechnical process developments. Two examples of biotechnical process developments for the forest industries are presented; one, biological pulping and delignification, entirely based on white-rot fungi and mutants thereof; and the other, purification of waste bleach waters, based on a mixture of fungi able to live on the organic materials in such waters. (Edited author abstract).

Eriksson, Karl-Erik (Swedish Pulp & Paper Research Inst, Stockholm, Sweden). *Biomass* v 15 n 2 1988 p 117-119.

**086991 IMPLICATIONS OF BIOTECHNOLOGY IN THE PULP AND PAPER INDUSTRY FROM THE MANAGEMENT PERSPECTIVE.** Biotechnology can be applied in both the manufacture of pulp and the treatment of the waste products produced. Some of the topics discussed are the selection of fungi for lignin degradation; bleaching water treatment; and water pollution control. The management aspects are also discussed. 4 Refs.

Koning, John (Univ of Wisconsin, Madison, WI, USA). *Biomass* v 15 n 2 1988 p 127-131.

## Biopulping

**086992 FUNGAL PRETREATMENT OF ASPEN CHIPS IMPROVES STRENGTH OF REFINER MECHANICAL PULP.** Pretreatment of wood chips with lignin-degrading fungi can improve the strength properties of unbleached refiner mechanical pulps. We studied the effect of two white-rot fungi (*Phanerochaete chrysosporium* and *Dichomitus squalens*) prior to refiner mechanical pulping. Strength and optical properties were compared in handsheets prepared from mechanical pulp of treated and untreated wood chips. Both fungal pretreatments resulted in handsheet strength properties better than the control when compared at an equivalent freeness. Fungal pretreatment decreased brightness and light-scattering.



tering coefficients but did not adversely affect opacity. Brightness of fungus-pretreated pulps was restored to that of the control by use of hydrogen peroxide bleaching. Lignin content of the chips was reduced by the fungal pretreatments. (Author abstract) 32 refs.

Myers, Gary C. (USDA, Madison, WI, USA); Leatham, Gary F.; Wegner, Theodore H.; Blanchette, Robert A. *Tappi J* v 71 n 5 May 1988 p 105-108.

**Bleaching** See Also CELLULOSE—Viscosity; LIGNIN—Nitration; PAPER AND PULP MILLS—Effluents; PAPER AND PULP MILLS—Optimization; PULP—Kraft; PULP—Sulfite; PULP—Thermomechanical.

**086993 BENEFITS OF BETTER MIXING.** The importance of better mixing and of measuring mixing efficiency in industrial chlorine dioxide bleaching is discussed. The conclusions are based on mill-scale measurements on tower and high intensity mixers and computer simulations. The computer is based on kinetic equations for chlorine dioxide bleaching. Brightness, shive content and chlorine dioxide consumption is affected by the width as well as the shape of the chlorine dioxide distribution. (Author abstract) 12 refs.

Backlund, B. (STFI, Stockholm, Swed); Bergnor, E.; Sandstrom, P.; Teder, A. *Pulp Pap Can* v 88 n 8 Aug 1987 p 62-68.

**086994 IMPACT OF THE CHLORINATION STAGE IN SHORTENED SEQUENCES.** The influence of chemical charge on bleachability and the potential for shortening sequences was investigated for softwood kraft pulps. An increase in the chlorination stage charge results in a lowering of the CE Kappa Number and an increase in the CE brightness. This, in turn, reduces the chlorine dioxide demand of the pulp necessary to reach a given final brightness. A benefit in brightness with added caustic in an E<sub>0</sub> stage as well as the opportunity for bleaching to high brightnesses in as few as three stages are also described. (Author abstract) 12 refs.

Kronis, J.D. (C-I-L Research Cent, Mississauga, Ont, Can); Young, J.J. *J Pulp Pap Sci* v 13 n 5 Sep 1987 p 135-144.

**086995 INTERSTAGE PEROXIDE BLEACHING-DERESINATION OF THERMOMECHANICAL PULP.** A novel process is proposed for the concurrent peroxide bleaching and deresination of refiner pulps in the interstage mode. Pilot scale trials of the process with a softwood TMP showed that the brightness gain, measured after secondary refining, was about equal to that achieved in conventional post-secondary peroxide bleaching. More than 50% of hexane-soluble extractives, including free fatty and resin acids, were removed by the interstage treatment. Tensile strength of interstage bleached TMP after secondary refining was 27% higher than that of unbleached control pulp and 22% higher than that of post-secondary bleached pulp at the same total specific refining energy. (Author abstract) 5 refs.

Ouchi, M.D. (Paprican, Vancouver, BC, Can); Wearing, J.T.; Miles, K.B. *J Pulp Pap Sci* v 13 n 6 Nov 1987 p J175-J178.

**086996 REACTION KINETICS IN OXYGEN BLEACHING.** The oxygen bleaching of wood pulp takes in an heterogeneous system involving oxygen (Gas), water (liquid), and fiber (solid). Inconsistent effects of process variables (reaction temperature, alkali concentration, and oxygen pressure) on the overall oxygen delignification rate of wood pulp in various reacting systems have been reported in the literature. An apparent intrinsic reaction rate model, excluding the interphase mass transfer effects, has been developed based on oxygen bleaching experiments in an agitated and ultralow-consistency (solids content) reactor. The apparent intrinsic reaction rate model shows a faster delignification rate than those reported in the literature. (Edited author abstract) 25 refs.

Hsu, C.L. (Georgia Inst of Technology, Atlanta, GA, USA); Hsieh, J.S. *AIChE J* v 34 n 1 Jan 1988 p 116-122.

**086997 COMPARISON BETWEEN BLEACHING SEQUENCES WITH ALKALINE EXTRACTION IN THE PRESENCE OF OXIDIZING AGENTS.** Sulfate pulp was bleached by CEH, CED and CEDED sequences, with a low charge of chlorine followed by an oxidative extraction stage, using either hydrogen peroxide or oxygen. Pulp and alkaline effluents resulting from the different procedures were evaluated and compared. E/P filtrate was less colored, but no other improvement in quality was detected. The bleached pulps showed similar values for brightness and strength. SEM revealed fiber damage to occur in E O, but without effect upon macroscopic properties. (Author abstract) 10 refs.

Bugajer, S. (Inst de Pesquisas Tecnológicas do Estado de Sao Paulo, Sao Paulo, Brazil); Danilas, R.M. *Pulp Pap Can* v 88 n 12 Dec 1987 p 169-172.

**086998 OXYGEN-BLEACHING PRACTICES AND BENEFITS: AN OVERVIEW.** Oxygen bleaching or delignification was developed as a commercially feasible process during the late 1960s and early 1970s in Sweden and South Africa. The use of oxygen delignification systems is increasing throughout the world. Experience has shown these systems can be used successfully to delignify kraft softwood and hardwood pulps, sulfite softwood and hardwood pulps, and specialty pulps. Oxygen-bleached pulps are used in a wide variety of products, including newsprint and writing papers, copy paper, grease proof paper, paper board, tissue, and diapers. The discharge of bleach plant pollutants and the operating cost of bleaching are reduced by use of an oxygen delignification system. The technology is compatible with new developments aimed at reducing the discharge of bleach plant effluents, such as extended delignification, NO<sub>2</sub> pretreatment, and ozone and peroxide bleaching. Oxygen delignification is expected to play a major role in the industry's efforts to develop an effluent-free bleached pulp mill. A list of oxygen delignification installations worldwide is presented here, and the experience gained to date is summarized. 12 refs.

Tench, Larry (Chemetics Int Co, Vancouver, BC, Can); Harper, Stuart. *Tappi J* v 70 n 11 Nov 1987 p 55-61.

**086999 BLEACHING AND BRIGHTNESS STABILIZATION OF HIGH-YIELD PULPS BY SULFUR-CONTAINING COMPOUNDS.** The stabilization against photo-induced discoloration of high-yield unbleached and peroxide-bleached chemimechanical pulps was studied. Various organic sulfur compounds initially bleached the pulps and subsequently retarded yellowing. The stabilizing activity of the sulfur compounds is strongly influenced by molecular structure. Particular thiols, such as 1-thioglycerol and glycol dimercaptoacetate, provided both bleaching and stabilization effects, whereas thioethers generally exhibited only a stabilizing action. Disulfides, sulfoxides, and sulfones were ineffective additives. (Author abstract) 10 refs.

Cole, Barbara J.W. (Univ of Maine, Orono, ME, USA); Sarkanen, Kyosti V. *Tappi J* v 70 n 11 Nov 1987 p 117-122.

**087000 LABORATORY STUDIES OF CHLOROFORM FORMATION IN PULP BLEACHING.** The effects of C-, E-, and H-stage bleaching parameters on chloroform production were studied in the laboratory for both softwood and hardwood kraft pulps. D-stage chloroform production was found to be minimal. The H stage is by far the largest chloroform producer (about 5-15 times the C, E, and D stages combined). The magnitude of the hypochlorite charge is the dominant factor affecting the amount of chloroform produced in the H stage. Although it is normally small, the C-stage chloroform production increases at a high temperature. Besides the C-stage temperature, C-stage chlorine charge and C-stage chlorine dioxide substitution are the primary factors affecting C- and E-stage chloroform production, which increases with the charge and decreases with the substitution. (Author abstract) 4 refs.

Crawford, R.J. (NCASI, Gainesville, FL, USA); Stryker, M.N.; Jett, S.W.; Carpenter, W.L.; Fisher, R.P.; Jain,

A.K. *Tappi J* v 70 n 11 Nov 1987 p 123-128.

**087001 RECOMMENDED METHOD FOR DESIGNATING BLEACHING STAGES.** The practice of designating bleaching stages and sequences using a symbolic shorthand has evolved through the years. Variations, combinations, and complexity in bleaching practices, however, coupled with variations in symbolism, have caused misunderstanding and errors regarding bleaching practices. This ambiguity has created the need for a common method of designating pulp bleaching stages. This paper gives recommendations to establish a coherent method for representing bleach plant stages and sequences. To facilitate clarity in communication, industry-wide adherence to these guidelines is urged.

Van Lee, Rick C. (Klockner Stadler Hurter Ltd, Montreal, Que, Can). *Tappi J* v 70 n 11 Nov 1987 p 185-188.

**087002 DISSOLVING PULPS FROM WHEAT STRAW BY SODA-ANTHRAQUINONE PULPING.** Dissolving pulps are obtained by subjecting prehydrolyzed Egyptian wheat straw to soda-anthraquinone pulping. The pulps obtained are satisfactorily bleached by the CEH sequence, while in the absence of anthraquinone an additional chlorite step should be applied to raise the degree of whiteness. A very important effect of anthraquinone takes place in the fine structure of the pulp whereby it increases the affinities toward water and alkali, lowers the crystallinity, and results in considerable improvement in the reactivity toward xanthation. Soda-anthraquinone pulps with suitable  $\alpha$ -cellulose content can be obtained by using the appropriate concentration of acid in prehydrolysis to hydrolyze a greater amount of the lower molecular weight carbohydrates before the soda-anthraquinone pulping. (Author abstract) 24 refs.

Abou-Stat, Mohamed A. (Cairo Univ, Giza, Egypt); El-Masry, Ahmed M.; Mostafa, Naglaa Y.S. *Ind Eng Chem Res* v 27 n 1 Jan 1988 p 153-156.

**087003 ROLE OF SILICATE IN PEROXIDE BRIGHTENING OF MECHANICAL PULP. PART II: THE EFFECTS OF RETENTION TIME AND TEMPERATURE.** The effects of retention time and temperature on the ability of silicate to improve the peroxide brightening of black spruce groundwood pulp were examined. The conditions were carefully optimized for each set of conditions. It was found that the maximum brightness obtainable is highest at low temperatures with long retention times. The optimum alkalinity does not differ with temperature over the range 25°C to 90°C. The amount of silicate required does not change with temperature, however the benefit derived from using silicate does decrease with increasing temperature. (Author abstract) 15 refs.

Ali, T. (Abitibi-Price Research Cent, Mississauga, Ont, Can); Fairbank, M.; McArthur, D.; Evans, T.; Whiting, P. *J Pulp Pap Sci* v 14 n 2 Mar 1988 p 23-28.

**087004 COMMUNICATIONS TO THE EDITOR: VISCOSITY-ENHANCING BLEACHING OF HARDWOOD KRAFT PULP WITH XYLANASE FROM A CLONED GENE.** We have produced clones of *E. coli* capable of endoxylanase or  $\beta$ -xylosidase production in the absence of cellulase, which could find potential application in lignincarbohydrate cleavage, especially for hardwood kraft pulps where xylan is the predominant hemicellulose, and can even be redeposited on the pulp during cooking. We now describe experiments which demonstrate that lignin removal can, indeed, be aided by treatment with xylanase from a cloned system, and that the resulting pulp retains viscosity as well as the required strength properties. Fragments of DNA containing the structural genes were inserted into the EcoRI site of the expression vector pKK 233-3 (Pharmacia P.L. Biochemicals) to give new plasmids named pKK 223-200 and pKK 233-300 for the endoxylanase and  $\beta$ -xylosidase. The expression vector contains a combined trp-lac promoter and an ampicillin resistance gene. The recombinant plasmids were introduced by transformation into *E. coli*



JM105, a thiamine proline-less mutant. The new clones, in the presence of isopropyl- $\beta$ -D-thiogalactoside (IPTG) produced more enzyme than the originals. 15 refs.

Paice, M.G. (Pulp & Paper Research Inst of Canada, Pointe Claire, Que, Can); Bernier, R. Jr.; Jurasek, L. *Biotechnol Bioeng* v 32 n 2 Jul 5 1988 p 235-239.

**087005 DTPMPA: POLYAMINO POLYPHOSPHONIC ACID AND ITS USE IN PAPER PROCESSES. PART 1: THE CHEMISTRY OF PULP BLEACHING WITH DTPMPA AND ITS IMPACT ON FINES RETENTION.** The performance of DTPMPA (diethylene triamine penta-methylene phosphonic acid) has been evaluated in different pulp bleaching processes. As a result of the effective peroxide stabilization, high brightness can be achieved, and a great amount of residual peroxide can be maintained. The selective complexation of metal ions which catalyze the decomposition of hydrogen peroxide means that DTPMPA can be efficiently used in pretreatment. The advantage of silicate-free formulations extends beyond the bleaching stage and can be perceived in other stages of the papermaking process. Some specific problems caused by silicates are identified. Examples of incompatibility with cationic retention aids are given. (Author abstract) 8 refs.

Kuczynski, Krzysztof (Monsanto Europe SA, Louvain La Neuve, Belg); Nijs, Hubert; May, Bronislav Henri. *Tappi J* v 71 n 6 Jun 1988 p 171-174.

**087006 OXYGEN BLEACHING FOLLOWING NO<sub>2</sub> TREATMENT BY A NEW PROCESS.** Oxygen bleaching of conventional kraft pulp after pretreatment with 2% NO<sub>2</sub> decreased the kappa number by 88% while maintaining a viscosity higher than that of most oxygen-bleached pulps produced industrially. After NO<sub>2</sub> treatment at high consistency and after dilution with weakly acidic sodium nitrate solution, which simulates spent liquor from the process, the pulp is ripened at a high temperature of around 90°C for 2 h. Generation of NO<sub>2</sub> from HNO<sub>3</sub> is a key reaction during ripening. (Author abstract) 8 refs.

Samuelson, Olof (Chalmers Univ of Technology, Goteborg, Swed); Ojteg, Urban. *Tappi J* v 71 n 6 Jun 1988 p 175-177.

**087007 OPTIMIZATION OF PEROXIDE BLEACHING SYSTEMS.** Process simulation was used to optimize peroxide bleaching systems including those with one and two stages with various recirculation strategies for bleaching mechanical pulps. When bleaching spruce to a high brightness of 80 percent ISO, savings of 6.50-7.00 dollars/o.d. metric ton of pulp can be made by installing a two-stage process compared to a one-stage process. All peroxide should be charged in the second stage, and peroxide filtrate is recycled to the first stage. Medium consistency in the first tower and high consistency in the second tower are recommended. (Author abstract).

Strand, E. (Sunds Defibrator AB, Sundsvall, Swed); Moldenius, S.; Koponen, R.; Viljakainen, E.; Edwards, L.L. *Tappi J* v 71 n 7 Jul 1988 p 130-134.

**087008 TO REMAIN COST COMPETITIVE, OLDER BLEACH PLANTS MUST BE UPGRADED.** The factors that constitute a modern, cost-effective bleach plant are presented and the primary objectives in upgrading an existing bleach plant outlined. Factors such as quality requirements, pulp grade, chemical prices and availability, pollution requirements are discussed from the perspective of plant upgrading. The key questions that must be addressed in establishing effective production capacity are given.

Forbes, David R. (Poyry-BEK, Raleigh, NC, USA). *Pulp Pap* v 62 n 10 Oct 1988 p 49-55.

**087009 TAPPI PROCEEDINGS - 1987 INTERNATIONAL OXYGEN DELIGNIFICATION CONFERENCE.** This conference proceedings contains 35 papers. Topics covered include: oxygen bleaching practices; integrated medium consistency oxygen delignification stage;

oxygen bleaching; rice straw pulping; enzymatic saccharification of grasses; alternative pretreatments before oxygen bleaching; effect of nitrogen dioxide pretreatments on properties of oxygen bleached kraft pulps; how to cope with Total Organically Bound Chlorine; pulp pretreatment with chlorine before oxygen delignification; SLC process; reaction of lignin with hydroxyl radicals; oxygen bleaching reaction kinetics; varying the purity of oxygen gas used in oxygen delignification; on-site pressure swing adsorption oxygen systems for the pulp and paper industry; catalysis in peroxide delignification; Sorbozon Process; modified cooking and oxygen bleaching for improved production economy and reduced effluent load; dimensioning oxygen delignification reactors; and operational experience with medium consistency oxygen delignification at Sendia Mill. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11590 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (TAPPI, Atlanta, GA, USA). *TAPPI Proc - 1987 Int Oxygen Delignification Conf, San Diego, CA, USA, Jun 7-12 1987* Publ by TAPPI Press, Atlanta, GA, USA, 1987 249p.

## Chemical Reactions

**087010 OXIDATION OF MONOHYDRIC ALCOHOLS WITH ANTHRAQUINONE AND ITS DERIVATIVES UNDER SODA PULPING CONDITIONS.** Monohydric alcohols as models for cellulose were reacted with anthraquinone (AQ) and three of its alkali-soluble derivatives in 1M sodium hydroxide at 170°C. Cyclohexanol and cyclohexanemethanol were selected as soluble secondary and primary alcohols, respectively, and the steroidal alcohols, lithocholic acid and cholestan-3 $\beta$ -ol, as less soluble models. In every case the AQs oxidized the alcohols, although cyclohexanemethanol and the insoluble cholestanol were oxidized only to a minor extent with AQ after 6 h. The efficacy of oxidation by the quinones was in the order sodium AQ-2-sulfonate (AMS) > AQ-2-carboxylic acid > 2-hydroxy-AQ > AQ. (Author abstract) 11 refs.

Wallis, Adrian F.A. (CSIRO, Clayton, Aust); Wearne, Ross H. *J Wood Chem Technol* v 7 n 4 Dec 1987 p 513-525.

**Chemistry** See Also LIGNIN—Condensation Reactions.

**087011 BEHAVIOR OF LIGNIN IN ORGANIC ACID PULPING. II REACTION OF PHENYLCOUMARANS AND 1,2-DIARYL-1,3-PROPANEDIOLS WITH ACETIC ACID.** In order to explain the behavior of phenylcoumaran and 1,2-diaryl-1,3-propanediol structures in acetic acid pulping, their lignin model dimers in the presence of creosol as a lignin aromatic nucleus model were cooked in 90% acetic acid at 180°C. About 50% of phenolic phenylcoumaran was consumed during a 3-hour reaction to yield phenylcoumarone, a stilbene derivative and a condensation product; but the non-phenolic model was very stable and was recovered as an acetate. On the other hand, phenolic and non-phenolic 1,2-diaryl-1,3-propanediols were unstable and were degraded within 1 hour to give stilbene derivatives as main products together with diarylmethanes and condensation products. (Author abstract). 20 Refs.

Yasuda, Seiichi (Nagoya Univ, Nagoya, Jpn). *J Wood Chem Technol* v 8 n 2 1988 p 155-164.

**087012 CHARGE-TRANSFER COMPLEXES IN KRAFT LIGNIN PART I: OCCURRENCE.** Charge-transfer complexes were found to occur between kraft lignin and an added model quinone, 3,5-di-tert-butyl-1,2-benzoquinone. The occurrence of charge-transfer interactions was also apparent in an oxidized kraft lignin with an increased quinone content. In these systems, free phenolic groups within the lignin were considered the donor species and ortho-quinones the complementary acceptor moieties. Carbon-14 labeling revealed that the quinone content of the investigated kraft

lignin averaged 3%. These quinones were determined to have a molar absorptivity of 528 L/mol-cm. Upon sodium borohydride reduction of this lignin, only one-third of the absorbance decrease could be accounted for by this number of quinones. The remaining two-thirds of the decrease in absorbance was assigned to the disruption of charge-transfer complexes. The quinones, therefore, played a dual role as a chromophore by participating as acceptor species in these complexes. (Author abstract). 27 Refs.

Furman, G.S. (Inst of Paper Chemistry, Appleton, WI, USA); Lonsky, W.F.W. *J Wood Chem Technol* v 8 n 2 1988 p 165-189.

**087013 CHARGE-TRANSFER COMPLEXES IN KRAFT LIGNIN PART 2: CONTRIBUTION TO COLOR.** Chelation and removal of transition metals from the kraft lignin employed in this study did not reduce the lignin's visible absorbance. Likewise, hydrogenation of carbon-carbon double bonds in this lignin also had no effect on its visible spectrum. This indicated that extended conjugated systems were not a significant contributor to the color of this lignin. Of the structures investigated, quinones were found to be the major visible-light absorbing chromophores. Since a large component of the quinone's absorption results from their participation in charge-transfer complexes (CTCs), CTC's were a significant contributor to the color of this lignin. (Edited author abstract). 9 Refs.

Furman, G.S. (Inst of Paper Chemistry, Appleton, WI, USA); Lonsky, W.F.W. *J Wood Chem Technol* v 8 n 2 1988 p 191-208.

**Chlorination** See PAPERMAKING MACHINERY—Mixers.

**Chromatographic Analysis** See CHROMATOGRAPHIC ANALYSIS—Ion Exchange.

**Contamination** See PULP—Additives.

**Control Systems** See Also PULP DIGESTERS—Control.

**087014 WOOD CHIP REFINER CONTROL.** The authors treat the control of a chip refiner to produce wood pulp, where the incremental gain between the motor load and the plate gap is subject to sudden changes due to pad collapse. Passive adaptive control with fault detection, active suboptimal dual control, and dual-control solutions are discussed. For dual control, the choice of the control criterion is crucial, as it must reflect the peculiarities of the process. Two nonquadratic performance indices are proposed, and the myopic solutions are computed. Simulations show the superior performance offered by these indices. 11 refs.

Dumont, Guy A. (Univ of British Columbia, Vancouver, BC, Can); Astrom, Karl Johan. *IEEE Control Syst Mag* v 8 n 2 Apr 1988 p 38-43.

## Cooking

**087015 CHEMI-MECHANICAL PULPING OF TAMARACK - PART I: EFFECTS OF CHIP COMPRESSION AND COLD WATER EXTRACTION.** Sodium sulfite cooks of tamarack chips were done to improve the strength properties of tamarack mechanical pulps. Chip compression by a plug screw feeder simplified the extractives' removal, increased the total ion content and significantly affected most of the sheet characteristics. Cold water extraction of chips prior to sulfonation influenced the total ion content and pulp yield but not the sheet properties. Tamarack CMP is low in brightness, about 33%. (Author abstract) 23 refs.

Law, K.N. (Univ du Quebec a Trois-Rivieres, Que, Can); Lapointe, M.; Valade, J.L. *Pulp Pap Can* v 88 n 8 Aug 1987 p 42-48.



**087016 COOKING LIQUOR ANALYZER: A NEW TOOL FOR CONTROLLING A CONTINUOUS DIGESTER.** A recently developed cooking liquor analyzer was installed at a continuous Kamyr digester for monitoring trials to find new methods for improving quality control. The analyzer is based on a new sampling and measuring concept, where a set of concentration data of lignin, dry solids and residual alkali are produced every five minutes from different digester circulations. A cross-correlation was made of the data obtained with a carefully monitored Kappa No. of the pulp. Measured concentration and Kappa No. profiles, cross-correlation functions and the resultant cooking models are presented in this paper. (Author abstract) 4 refs.

Tikka, P.O. (Afora Inc, Helsinki, Finl); Piironen, P. *Pulp Pap Can* v 88 n 10 Oct 1987 p 114-118.

**087017 STABILITY OF  $\alpha$ -ETHER TYPE MODEL COMPOUNDS DURING CHEMICAL PULPING PROCESSES.** In order to examine the stability of lignin-carbohydrate complexes (LCC) during alkaline chemical pulping, benzyl ether type LCC model compounds containing different non-phenolic units were synthesized and cooked under chemical pulping conditions. At least 80% of the starting substance was recovered unchanged, from soda, kraft and acid sulfite reactions indicating the benzyl ether linkage in this compound is stable during pulping. (Edited author abstract) 10 refs.

Taneda, H. (Univ of Tokyo, Tokyo, Jpn); Nakano, J.; Hosoya, S.; Chang, H.-M. *J Wood Chem Technol* v 7 n 4 Dec 1987 p 485-497.

**087018 ENHANCED CLEAVAGE OF  $\beta$ -ARYL ETHER BONDS IN LIGNIN MODEL COMPOUNDS DURING SULPHITE-ANTHRAQUINONE PULPING.** Under sulfite-anthraquinone (AQ) cooking conditions reduce anthraquinones, such as anthrahydroquinone or oxanthrone, promote cleavage of the  $\beta$ -ether bond in the free phenolic  $\beta$ -ether lignin model 1. This enhanced cleavage, and the products formed, can be rationalized by a mechanism involving formation of an adduct between the reduced quinone and the quinone methide 3. This adduct then fragments to afford the observed products. Wood sugars are capable of reducing AQ to the catalytically active form during sulfite-AQ cooling. Consequently, AQ can catalyze the cleavage of free phenolic  $\beta$ -aryl ether linkages in lignin when sugars are present. This finding explains why AQ is able to accelerate delignification during the initial phase of sulfite-AQ pulping. However, it does not provide the full story since it cannot explain why AQ catalyzes delignification during the bulk phase of sulfite-AQ pulping. (Edited author abstract) 27 refs.

Suckling, Ian D. (Forest Research Inst, Rotorua, NZ). *J Wood Chem Technol* v 8 n 1 Mar 1988 p 43-71.

## Cooling

**087019 NO SULFUR, NO CHLORINE: NO PROBLEM.** A new way of pulping straw has been operating at an Italian mill for a year now. It uses oxygen and soda for digesting and, eventually, ozone for bleaching. Wet pretreatment, digestion processes and the Lurgi recovery system is described.

Sutton, Peter. *PPI Pulp Pap Int* v 29 n 4 Apr 1987 p 48-50.

**Costs** See PAPER AND PULP MILLS—Waste Utilization.

**Energy Conservation** See PAPER AND PULP MILLS—Modernization.

**Energy Utilization** See PAPER AND PULP MILLS—Energy Conservation.

**Environmental Impact** See PAPER AND PULP MILLS—Modification.

**Equipment** See CHEMICAL EQUIPMENT: COMPOSITE MATERIALS—Manufacture; FLOWMETERS—Selection.

**Flow** See Also PULP—Flocculation.

**087020 FURTHER COMMENTS ON A VISUAL STUDY OF PULP FLOC DISPERSION MECHANISMS.** A knowledge of fiber and fluid interactions is crucial to the flow management aspects of the design of a paper machine. A visual study of the dispersion mechanism of pulp flocs in a controlled, turbulent Couette flow field was carried out to obtain qualitative information on fiber and fluid interactions. The turbulent Couette flow field was created by a moveable-wall, flow channel system. The dispersion sequences were recorded by high-speed camera, using both monocular and stereoscopic film techniques. (Author abstract). 10 Refs.

Wagle, D.G. (Int Paper Co, Tuxedo, NY, USA); Lee, William, C.; Brodkey, Robert, S. *Tappi J* v 71 n 8 Aug 1988 p 137-141.

**Kraft Process** See Also ACIDS—Forming; BOILER CORROSION AND DEPOSITS; FORESTRY—Research; LIGNIN—Measurements; PAPER AND PULP MILLS—Boilers; PAPER AND PULP MILLS—Construction; PAPERMAKING—Materials; PULP—Analysis; PULP—Unbleached.

**087021 KRAFT PULPING OF CRUSHED HARDWOOD CHIPS.** A 220 t/d crusher for pulpwood chips has been developed which is capable of controlling effective chip thickness by chip shearing followed by chip crushing. The benefits from using these treated chips are reduced pulp reject levels and reduced alkali charge requirements for kraft pulping. This chip crusher is described along with the results of laboratory pulping studies on crushed hardwood chips. Mill trials are briefly covered. (Author abstract) 13 refs.

Bryce, J.R.G. (Domtar Inc, Senneville, Que, Can); Lowe, R.W. *Pulp Pap Can* v 88 n 9 Sep 1987 p 99-102.

**087022 PHYSICAL DISTRIBUTION OF RESIN IN BLEACHED KRAFT PULP MILLS.** Quantities of resin dissolved, dispersed and attached to fibers were measured in pulp samples at various locations along the process streams of six fully bleached kraft pulp mills. Data were collected during periods of routine operation and provide a reference for future problem-solving during periods of rapid pitch deposition. Because the resin tends to be mostly attached to the fibers at low pH, the alkaline washers are the most effective points of pulp deresination. (Author abstract) 20 refs.

Allen, L.H. (Paprican, Pointe Claire, Que, Can); Lapointe, C.L. *Pulp Pap Can* v 88 n 12 Dec 1987 p 231-232, 234-239.

**087023 PROCESS CHEMISTRY AND CONTROL OF RAPID-DISPLACEMENT HEATING.** The rebirth of kraft batch cooking has become a reality. The modified batch processes combine the versatility of batch-type operation and improved heat economy. High-quality kraft pulp can be produced by a batch-digester house with the following advantages: Sixty percent less primary heat consumption; First washing stage in the digester; Extended delignification; Improved strength, with up to 15% more tear index. These benefits are achieved by arranging the digester design and cooking cycle so that the heat of an individual cook can be recovered and used in subsequent cooks. The upper-level digester-house management system is the crucial tool for maintaining and optimizing operation of the digester house. 14 refs.

Tikka, P.O. (AFORA Oy, Helsinki, Finl); Virkola, N.E.; Pursiainen, S.A.; Haemaclae, I.T. *Tappi J* v 71 n 2 Feb 1988 p 51-58.

**087024 FLASH X-RAY IMAGING OF KRAFT BLACK LIQUOR SPRAYS.** The requirements for an optimal black liquor spraying system are unique among combustion processes with respect to the high flow rates and the large droplet sizes required. The study of such large and coarse sprays is difficult via usual optical

imaging techniques. Flash X-ray radiography (FXR) is a unique and powerful tool for studying high speed, multiphase flows in general and kraft black liquor sprays in particular. This imaging technique is applicable to the problem of kraft black liquor sprays. (Author abstract) 12 refs.

Farrington, Theodore E. Jr. (Inst of Paper Chemistry, Appleton, WI, USA). *Tappi J* v 71 n 2 Feb 1988 p 89-92.

**087025 BUILDING A MECHANISTIC MODEL OF KRAFT-ANTHRAQUINONE PULPING KINETICS.** A study of kraft-anthraquinone pulping kinetics was conducted to develop a mechanistic model valid over the bulk and residual phases. A competitive sequential experimental design criterion was used to choose conditions for each pulping run. Iterations of experiment, data analysis, and choice of new experimental conditions were used to discriminate among candidate models and to obtain precise parameter estimates for the best models. The best delignification model incorporated three parallel pathways for lignin solubilization, a lignin condensation pathway, and a residual delignification pathway in which the condensed lignin is dissolved. The best models for dissolution of cellulose, glucomannan, and xylan were composed of two parallel pathways for peeling, two for stopping and one for chain cleavage. (Author abstract) 5 refs.

Burazin, M.A. (Inst of Paper Chemistry, Appleton, WI, USA); McDonough, T.J. *Tappi J* v 71 n 3 Mar 1988 p 165-169.

**087026 MULTIVALENT ION REMOVAL FROM KRAFT BLACK LIQUOR BY ULTRAFILTRATION.** Kraft black liquor (KBL) was ultrafiltered into permeate and retentate fractions. Whereas Na and K were concentrated in permeate solids, many higher valence ions were disproportionately found in retentate solids. Those elements concentrated include Ca, Mg, Al, and Fe. Si was less dependably retained. The retentate/permeate ratio of Ca, based on dry solids, was as little as 1.6 for a low-Ca northern softwood KBL and as high as 7.6 for a high-Ca southern hardwood KBL. Polysulfone ultrafiltration (UF) membranes of 50,000 molecular weight cutoff (MWCO) concentrated multivalent elements to a lesser extent than did 6000 or 20,000 MWCO membranes. (Edited author abstract) 9 refs.

Kirbaw, S. Alvin (Weyerhaeuser Co, Federal Way, WA, USA); Hill, Marquita K. *Ind Eng Chem Res* v 26 n 9 Sep 1987 p 1851-1854.

**087027 KRAFT PULPING STUDIES ON SESBANIA ACULEATA - THE OVER-ALL REACTION PATTERN.** The aim of the present investigation is to study more the factors that influence delignification in kraft pulping, such as chip size, effective alkali charge, sulphidity and temperature of cooking than the basic mechanism itself. The possibility of using Sesbania aculeata as a raw material for the paper industry has been examined by studying the essential properties such as density, delignification rate, beatability, bleachability and pulp yield. The results have shown that Sesbania aculeata has all these properties. (Edited author abstract) 12 refs.

Upadhyaya, J.S. (Univ of Roorkee, Saharanpur, India); Singh, Sunder Pal. *Res Ind* v 32 n 3 Sep 1987 p 148-159.

**087028 ROLE OF DIFFUSION DURING INITIAL DELIGNIFICATION OF ALKALINE PULPING.** The delignification curve for the earliest stage of alkaline pulping is predicated well by unsteady-state diffusion theory. The predicted lignin diffusivities are higher than those obtained from lignin leaching studies because the initial lignin has a low molecular weight. A large increase in diffusivity with temperature is explained on the basis of the increase in cell wall permeability with temperature and the possible reduction in lignin molecular weight with increase pulping temperature. The increase in the initial



delignification rate with the addition of sulfide is also attributed to a reduction in lignin molecular weight under kraft pulping conditions. (Author abstract) 13 refs.

Gustafson, Richard R. (Univ of Washington, Seattle, WA, USA). *Tappi J* v 71 n 4 Apr 1988 p 145-147.

**087029 VAPORIZATION FROM ALKALI CARBONATE MELTS WITH REFERENCE TO THE KRAFT RECOVERY FURNACE.** This paper examines the processes responsible for fume generation in the kraft furnace. Fume generation under oxidizing conditions was found to be an order of magnitude greater than under strongly reducing conditions. Addition of sodium hydroxide to the sodium carbonate-sulphide melt did not increase the fuming rate. Potassium and chloride levels in kraft furnace fume are lower than values calculated from equilibrium data; however, if the enhanced vaporization of sodium due to oxidizing conditions is taken into consideration, the low potassium and chloride levels in the fume can be explained. Raoult's law gives an accurate description of sodium chloride vaporization from a sodium carbonate-sulphide-chloride smelt under oxidizing conditions. (Author abstract). 13 Refs.

Cameron, J.H. (Inst of Paper Chemistry, Appleton, WI, USA). *J Pulp Pap Sci* v 14 n 4 Jul 1988 p 76-81.

**087030 ACID-SOLUBLE AND ACID-SOLUBLE LIGNIN CHARACTERISTICS IN KRAFT PULPING OF HYBRID SALIX CLONES.** The recombining characteristics of the Salix species, the possibility of rapid genetic improvement, clonal propagation, relatively short rotations, and the relative uniformity of the physical properties of the trees make selected hybrids of this species attractive for study. In our study, we characterized pulping properties among clones from different species and within species, using current shoots from stools that were one year old in 1982. Thirteen young clones from within and between species were used in the study. Three other Salix clones, 14 years old, were also included for additional comparisons. The apparent activation energy for kraft pulping of wood from different hybrid Salix clones ranges from 98 to 120 kJ/mol. The average activation energy is less than reported for species such as Eucalyptus regnans, revealing it as an ideal species for pulping. Acid-insoluble and acid-soluble lignin contents in pulp are strongly related to percent delignification; the relationship could be fitted by a second-order polynomial. 8 Refs.

Deka, G.C. (Univ of Toronto, Toronto, Ont, Can); Roy, D.N. *Tappi J* v 71 n 8 Aug 1988 p 153-154.

**087031 1987 KRAFT RECOVERY OPERATIONS SEMINAR.** This conference contains 34 papers dealing with Kraft Recovery Operations. Various topics covered include: recausticizing practice, rotary lime kilns, black liquor properties; chemical recovery boilers, recovery boiler cleaning; and corrosion and damage recovery boilers. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10746 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (TAPPI, Atlanta, GA, USA). *1987 Kraft Recovery Oper Semin, Orlando, FL, USA Jan 11-16 1987* Publ by TAPPI Press (TAPPI Notes), Atlanta, GA, USA 1987 305p.

## Materials

**087032 MINERALS IN PAPER. A QUALITY PARADOX.** A paper made entirely from fibers will be strong but is likely to be porous and have a rough surface, making it not very suitable for quality printing. Filler materials, especially minerals, have been found to reduce the porosity and roughness and improve the printability of printing and writing papers. The subsequent coating of paper with pigmented mixes brings about an equivalent quality improvement with typical coated papers having an inorganic content of one-third. Since the commonly used minerals are one-quarter of the cost of fiber there is a definite incentive for papermills to aim for maximum mineral contents. (Edited author abstract)

McConnell, David (Bowaters UK Paper Co). *Ind Miner (London)* v 247 Apr 1988 p 155, 157.

## Mathematical Models

**087033 MODELLING OF BATCH KRAFT PULPING AND OF KAMYR DIGESTERS.** A mechanistic model has been developed that predicts with high accuracy the batch Kraft pulping of both hardwoods and softwoods. This model has then been adapted to a Kamyr digester. It predicts: pulp yields; Kappa numbers; dissolution of lignin, cellulose, and hemicellulose; and both caustic and sulfide consumption during both steady state operation and hardwood-softwood swings. (Author abstract) 16 refs.

Christensen, T. (Purdue Univ, USA); Smith, C.C.; Albright, L.F.; Williams, T.J. *ISA Trans* v 27 n 2 1988 p 1-6.

**Optimization** See Also PAPERMAKING—Computer Simulation.

**087034 PROCESS OPTIMIZATION OF SODA-ANTHRAQUINONE PULPING OF DATE-PALM LEAVES.** The results of a second order regression analysis of the objective function (screened pulp yield) and the equality constraint (the Kappa No., indirect measure of lignin), produced equations which adequately described the behaviour of the process through the region studied. Three optimization methods were adopted and used to find the process conditions which could maximize the screened pulp yield at various levels of lignin content within definite ranges of the process conditions. The screened yield showed a maximum with the four variables mentioned. The results of optimization were later verified by performing experiments under the obtained optimum conditions. (Edited author abstract). 13 Refs.

Kassim, Waleed M. (Univ of Baghdad, Baghdad, Iraq); Abdul-Rahman, Zaid A.; Kashmoula, Talib B. *J Pet Res* v 7 n 1 Jun 1988 p 181-195.

**Process Control** See PAPER AND PULP MILLS—Flexible Manufacturing Systems; PULP—Testing.

**Pyrolysis** See PULP—Kraft.

## Quality Control

**087035 SIMPLE IMAGE ANALYSIS PROCEDURE FOR FIBRE WALL THICKNESS.** A simple equation derived from Corte's theory of fiber networks connects the fiber wall thickness to an easy image analysis measurement performed on a thin (2 g/m<sup>2</sup>) fiber network. (Author abstract) 5 refs.

Jordan, B.D. (Paprican, Pointe Claire, Que, Can). *J Pulp Pap Sci* v 14 n 2 Mar 1988 p 44-45.

## Reaction Kinetics

**087036 COMPRESSIVE ENERGY ABSORPTION IN THE PULPING KINETICS OF WHITE PINE: THE SHRINKING CORE MODEL.** Cylindrical rods 2.5 cm in diameter were kraft pulped with and without anthraquinone at 143°C with 46 g/L NaOH and liquor of 25 percent sulfidity. Samples were analyzed for lignin content. Compressive energy absorption (CEA) was measured as a function of radial position and time. As measured by CEA, the strength could be phenomenologically explained by a shrinking core model during the initial period. The lignin content, however, did not substantially decrease during this time. The strength-reducing reactions occur before significant delignification occurs, and these reactions follow a shrinking core model. (Author abstract). 5 Refs.

Tendam, Patrick A. (Marathon Oil Co, Findley, OH, USA); Lacksonen, James W. *Tappi J* v 71 n 7 Jul 1988 p 121-124.

**Refining** See Also PAPER AND PULP MILLS—Control Systems; PAPERMAKING MACHINERY—Design; PULP—Mechanical; PULP—Thermomechanical.

**087037 EFFECT OF REFINING PARAMETERS ON PAPER PROPERTIES.** A mathematical formula that describes the mechanism of refining is being used in paper-mills to improve product quality and cut manufacturing costs. The formula defines the number of impacts received by a fiber and the severity of those impacts, and optimum refining depends on getting the formula right for a given type of fiber - the number of impacts and their severity varies from fiber to fiber and from end product to end product. With too much refining, a weak fiber can be damaged, but with too little, a strong fiber will not be developed properly. The formula quantifies operating variables and relates them mathematically, and this can optimise virtually any refining situation. (Edited author abstract)

Danforth, Donald W. *Pap Technol Ind* v 28 n 5 Aug 1987 p 547-548, 550, 553.

**087038 WEAR CHARACTERISTICS OF REFINER PLATES.** Wear patterns were studied on used refiner plates from Canadian RMP, TMP and CTMP mills. Samples of both cast iron and cast stainless steel plates were examined. Bar rounding, clashing, and erosion (due to cavitation and/or liquid droplet impingement) were the most commonly observed wear patterns. (Edited author abstract) 18 refs.

Thompson, C.B. (PAPRICAN, Pointe Claire, Que, Can); Garner, A. *Pulp Pap Can* v 88 n 8 Aug 1987 p 80-83.

**087039 ABRASIVE REFINER PLATES FOR THE PRODUCTION OF MECHANICAL PULP.** It is possible to produce mechanical pulp with a newly developed abrasive plate on an industrial refiner. The abrasive plates were mounted on the stationary disc of a second-stage 42-1B Sprout Waldron refiner. When these plates were run against appropriate conventional plates mounted on the rotating disc, an extremely clean pulp was produced having a freeness of about 60 mL using a total specific energy of 6.8 GJ/metric ton. The pulp has a higher scattering coefficient and tensile strength but a lower tear strength than newsprint pulp produced on a conventional two-stage TMP system. There was no measurable loss of abrasive material during trials lasting approximately 7 h. (Author abstract) 7 refs.

Stationwala, M.I. (Pulp & Paper Research Inst of Canada, Pointe Claire, Que, Can). *Tappi J* v 70 n 10 Oct 1987 p 124-127.

**087040 USING THE REFINING PROCESS TO ENGINEER PULP PROPERTIES.** A refiner leaves its fingerprint on a pulp, and, as a result, single disc and double disc refiners produce pulps with different properties. Single disc pulp has superior web strength and dry tear strength due to its long-fibre content. But double disc pulp, with more fines and less long fibre, has higher apparent density and light scattering coefficient. The latest refining technology enables a mill to combine double disc and single disc refining to engineer the pulp for value-added grades. This technology is available at an economic price because the major components of the two refiners are identical. (Author abstract)

Jackson, M. (Sunds Defibrator); Ferrari, B.; Falk, Bo; Danielsson, O. *Pap Technol Ind* v 28 n 7 Oct 1987 p 661-667.

**087041 APPLYING HYDRODYNAMIC LUBRICATION THEORY TO PREDICT REFINER BEHAVIOUR.** Hydrodynamic lubrication theory has been used to relate the physical dimensions of bar surfaces in a mechanical pulp refiner to the plate-to-plate gap, refiner closing force, and motor load. The theory predicts the observed insensitivity of refining to the rounding of



leading edges on bars and shows the effect of bar height wear on closing force. The refiner's tolerance of tram variations is also predicted. (Author abstract) 15 refs.

Frazier, W.C. (Boise Cascade Research, Portland, OR, USA). *J Pulp Pap Sci* v 14 n 1 Jan 1988 p 1-5.

**087042 COMMERCIAL SYSTEM FOR THE CHEMI-MECHANICAL TREATMENT OF STONE GROUNDWOOD REJECTS (CTMP).** The paper describes a commercial system for the mild sulfonation of stone groundwood rejects prior to rejects refining. In the freeness range 100 to 110 mL CSF, the resulting refined rejects exhibit a Somerville shive content of 0.05 to 0.10%, a tensile index of 50 to 55 Nm/g and a brightness gain from 58% to 63% ISO brightness. Overall results on the final pulp showed a significant reduction in shive content, a 10 to 15% improvement in strength properties and a two-point gain in brightness level. (Author abstract)

Jackson, M. (Sunds Defibrator Ltd, Vancouver, BC, Can); Engstrom, B.; Rosander, E. *Pulp Pap Can* v 88 n 12 Dec 1987 p 201-204, 206.

**087043 RESISTANCE OF REFINER PLATE ALLOYS TO BAR ROUNDING.** Bar rounding takes place by a form of slurry abrasion, resulting from sand and grit entrained in the pulp. The influence of refiner plate metallurgy on this type of wear is examined in this work. A test rig for laboratory wear has been constructed that reproduces the slurry abrasion wear mechanism on the bar edges of refiner plates. Based on results for a typical selection of commercial refiner plate alloys, the test rig consistently ranked the materials in an order that correlated with field experience. For all the alloys tested, abrasive wear in white water was dependent upon both corrosion and abrasion resistance. In these environments, the low-alloy cast iron had the lowest wear resistance. The martensitic, stainless steel Alloy 6, and the high-chromium, cast-iron Alloys 2 and 4 had the highest wear resistance. 24 refs.

Thompson, C.B. (Pulp & Paper Research Inst of Canada, Pointe Claire, Que, Can); Garner, A. *Tappi J* v 71 n 6 Jun 1988 p 95-100.

#### Screening See Also PULP MATERIALS—Wood.

**087044 COMPARISON OF SLOTS AND HOLES IN THE SCREENING OF MECHANICAL PULP.** A high efficiency pressure screen has been evaluated to compare the performance screening mechanical pulp with slots and holes. The slots had lower capacity, freeness drop and fractionation. Removal of all sizes of shives, down to the smallest optically measurable was significantly superior with slots than with holes, or with centrifugal cleaners. Sheet strength and quality were higher with the slots. (Author abstract) 5 refs.

Hooper, A.W. (S.W. Hooper & Co, Montreal, Que, Can). *Pulp Pap Can* v 88 n 10 Oct 1987 p 57-62, 65.

**087045 IMPROVED OPERATION OF TMP PLANT THROUGH OPTIMIZATION OF SCREENING.** Compared to the screening of chemical and groundwood pulp, the technology in the screening of TMP is still rather young and potential for great improvement exists. Profile-style screen cylinders with slots have outperformed standard drilled cylinders in almost every respect. As a secondary effect on improved screening performance, shive concentration and thickening of rejects has greatly improved the efficiency in reject refining. (Author abstract) 6 refs.

Frejborg, F. (Ahlstrom Machinery Inc, Glens Falls, NY, USA). *Pulp Pap Can* v 89 n 1 Jan 1988 p 107-108, 110-112.

#### Sulfite Process

**087046 EXPERIENCE FROM HYDROSTATIC MEDIUM-CONSISTENCY OXYGEN DELIGNIFICATION AT RAUMA PULP MILL.** Since 1983 Rauma pulp mill has been operating a hydrostatic brown stock oxygen delignification system. This article describes the

operating history of the plant from its commissioning up until late 1985. The target delignification level of 50 to 55% was easily attained right from the start. The original concept has since been modified, the main objective being to develop a totally new control strategy and to improve stock pumping and oxygen mixing. In addition to the description of the oxygen stage itself, its implications elsewhere in the mill are discussed. (Edited author abstract) 3 refs.

Kovasin, K. (Rauma-Repol Oy, Rauma, Finl); Malmsen, E. *Pulp Pap Can* v 88 n 8 Aug 1987 p 36-39.

**087047 CHEMI-MECHANICAL TREATMENT OF SULPHITE PULP RESULTS IN LOW RESIN CONTENT, ADDITIONAL FUEL AND IMPROVED ENVIRONMENT.** To eliminate problems with resin, a system for dewatering was installed in Domsjö sulfite mill in 1980. By using the screw defibrator FROTA-PULPER in combination with alkali addition, it has been easy to control the content of extractives in the sulfite mill. The dissolved extractives are recovered by using a membrane filter system. After concentration, the extractives have a heat value close to that of fuel oil. Simultaneously the environment is improved. (Edited author abstract) 5 refs.

Lindahl, A. (Mo och Domsjö AB, Ornskoldsvik, Swed); Ostman, H.; Thorsell, L. *Pulp Pap Can* v 88 n 8 Aug 1987 p 57-60.

**087048 UTILIZATION OF BUDWORM-KILLED WOOD IN SULPHITE PULPING.** Stora Forest Industries, formerly Nova Scotia Forest Industries, has operated both market sulphite and newsprint mills before, during and after the budworm epidemic. Large quantities of budworm-killed spruce and fir were used in the market pulp operation but not for manufacturing groundwood. Trends in sulphite pulp processing and quality resulting from the use of budworm-killed wood are described. (Author abstract) 17 refs.

Wilson, G.G. (Stora Forest Industries, Port Hawkesbury, NS, Can); Johnston, D.W. *Pulp Pap Can* v 88 n 10 Oct 1987 p 70-73.

**087049 DEVELOPING NEW METHODOLOGY TO DETERMINE CHANGES TO THE LIGNIN MACROMOLECULE DURING DELIGNIFICATION.** It was observed that, during the early stages of lignin removal (<40%), only lignosulfonates of low molecular weight (paucidisperse) were solubilized. These substances are the so-called hemilignins. In an attempt to identify these materials, we evaluated different methods for their isolation and characterization. We developed an approach to determine first the bonding environments of specific carbons in lignin in intact plant tissue. This was achieved by administering specifically labelled <sup>13</sup>C lignin precursors to growing intact plants over extended durations of time. It now appears possible to determine the changes in bonding patterns of specific carbons during lignin removal. This now allows us to examine the process of delignification in a much more rational manner. 6 refs.

Lewis, Norman G. (Virginia Tech, Blacksburg, VA, USA); Eberhardt, Thomas L.; Luthe, Corinne E. *Tappi J* v 71 n 1 Jan 1988 p 141-142.

**087050 ULTRA-HIGH-YIELD PULPING - PART VI: THE EFFECT OF SULFONATION ON THE DEVELOPMENT OF FIBRE PROPERTIES.** Mild sulfonation of Norway spruce chips followed by disc refining increases the amount of stiff poorly collapsed long fiber causing increased tear index but no increase in breaking length. Almost complete sulfonation followed by refining at a given specific energy produced chemimechanical pulp with higher breaking length and density than those of refiner mechanical and chemimechanical pulps produced from low sulfonate content chips. These results were due to the high breaking length of the long fiber fractions. The decrease in specific scattering and opacity that accompanied the increase in breaking length is due primarily to the loss of scattering of the medium and short fiber fractions. (Author abstract) 16 refs.

Heitner, C. (PAPRICAN, Pointe Claire, Que, Can); Hattula, T. *J Pulp Pap Sci* v 14 n 1 Jan 1988 p 6-11.

**087051 NEUTRAL SULFITE-ANTHRAQUINONE PULPING FOR LINERBOARD: A LOWER TEMPERATURE AND MILD ALKALINITY APPROACH.** A laboratory study of neutral sulfite-anthraquinone (NSAQ) pulping for linerboard has been conducted under lower temperature and milder alkaline conditions than usual. The wood furnish included eastern Canadian softwood and softwood-hardwood mixtures. Preliminary test results showed that NSAQ pulping at 165°C would be sufficient to produce a satisfactory linerboard-grade pulp. At a pulping time of 50 min, the process would provide a 20% higher pulping yield than the usual kraft process. The NSAQ pulp strengths were comparable to strengths of the kraft pulps. (Author abstract) 13 refs.

Wong, Al (Arbocem Inc, Beaconsfield, Que, Can). *Tappi J* v 71 n 2 Feb 1988 p 83-87.

#### Sulfonation

**087052 CELL WALL SULFUR DISTRIBUTION IN SULFONATED SOUTHERN PINE LATEWOOD: VAPOR-PHASE COOKS.** The distribution of bound sulfur within the cell walls of sulfonated southern pine latewood chips has been studied experimentally. The effects of reaction time and Na<sub>2</sub>SO<sub>3</sub> concentration in the sulfonating liquor were studied in a 2 × 3 factorial experiment consisting of a series of vapor-phase cooks. Sulfur distributions were determined by scanning transmission electron microscopy with energy dispersive spectrometry. All treatments yielded a distribution characterized by a pronounced gradient of bound sulfur across the secondary wall. Sulfur counts decreased from a high value near the lumen to a minimum in the outer secondary wall and then increased toward a peak in the middle lamella. (Author abstract) 15 refs.

Heazel, T.E. (Inst of Paper Chemistry, Appleton, WI, USA); McDonough, T.J. *Tappi J* v 71 n 3 Mar 1988 p 129-133.

**087053 REJECTS SULFONATION.** The effect of sulfite charge, pulp consistency and treatment time on the sulfonation of TMP rejects or the long fiber fraction of the TMP furnish have been investigated. Properties such as sulfonate content, pulp yield, wet-web strength, dry sheet strength and optical properties are reported and discussed in terms of fiber properties for the process variables investigated. A flow diagram for rejects sulfonation is described and its basic features discussed. The benefits of rejects sulfonation for mechanical pulps are discussed by comparing properties of refined stone groundwood, thermomechanical and chemithermomechanical rejects with or without sulfonation. (Author abstract) 34 refs.

Barbe, M.C. (Hymac Ltd, Laval, Que, Can); MacDonald, J.E.; Cortez, L. *J Pulp Pap Sci* v 14 n 2 Mar 1988 p 28-36.

**087054 IMPROVING TMP PULP PROPERTIES BY SULFONATION: OPTIMIZATION OF SULFONATION PROCESS ALTERNATIVES.** Ultra-high yield pulps can be produced by modifying mechanical pulps through treatment with sodium sulfite. This sulfonation step can take place before refining the wood chips, between the first and second stages of refining, or in the rejects stream after screening but before refining the screen rejects. The sequence in which sulfonation, refining, and screening take place will affect the final pulp properties. Using the general energy and materials balance system (GEMS) a modular process simulation package, the authors studied the effects of sulfonation for several process configurations. A computer model was generated based on mill and laboratory data, and the computer found the configuration that would yield maximum savings. Additional study results are discussed. (Edited author abstract) 7 refs.

Haynes, J.B. (Univ of Idaho, Moscow, ID, USA); Strand, B.C.; Strand, E.K.; Viljakainen, E.; Edwards, L.L. *Tappi J* v 71 n 10 Oct 1988 p 123-127.



**Testing** See PULP—Mechanical.

**Thermal Effects** See WOOD—Hydrolysis.

**Thermomechanical Process** See Also PAPER AND PULP MILLS; PAPERBOARDS—Mechanical Properties; PULP—Physical Properties.

**087055 PROPERTIES OF MECHANICAL AND CHEMI-MECHANICAL JACK PINE PULPS: PART I - THERMOMECHANICAL PULPS.** This first report of a series presents properties of jack pine and black spruce thermomechanical pulps. Properties of jack pine thermomechanical pulps produced under different chip pre-treatment conditions are reported and compared to black spruce. These results complement previously reported studies on the properties of jack pine mechanical pulps. 6 refs.

Jossart, D. (Donohue Inc, Clearmont, Can); Barbe, M.C.; Lapointe, M.; Law, K.N. *Pulp Pap Can* v 89 n 4 Apr 1988 8p.

**087056 CHEMITHERMOMECHANICAL PULP FROM MIXED HIGH-DENSITY HARDWOODS.** To successfully utilize hardwood fibers in mechanical pulping, it is important to identify fundamental fiber characteristics that favorably influence paper properties and to understand how to best produce these pulps. Thus, the primary objective of our study was to determine the fundamental fiber features of CTMP from mixed, high-density hardwoods. The pulpwood was approximately 70 percent oak, 10 percent hickory, and 20 percent other high-density hardwood. Pulps with different fiber characteristics were produced by using different combinations of chemical, temperature, and pretreatment time. Chemical treatments were either alkaline sulfite or soda. The pulps were evaluated for fiber length distribution, fines content, specific surface area, specific volume, fiber strength, and fiber bonding indicators. Handsheets were tested for tensile strength, apparent density, and tear factor. 4 Refs.

Miller, Merwin L. (Miami Univ, Oxford, OH, USA); Shankar, V.; Peterson, R.C. *Tappi J* v 71 n 7 Jul 1988 p 145-146.

## Washing

**087057 MODELLING THE FILTRATION STAGE OF A PULP WASHER.** The thickening stage in the Pro-Feed washer was assumed to consist of two parts: mat formation and compression. The filtration model during thickening was based on the Kozeny-Carman equation. In the washing stage, submerged displacement takes place while, simultaneously, the pulp mat thickness increases. The modelling in this stage was based on continuity equations. For this example, softwood kraft pulp was studied. Diagrams are presented for the consistency profile during thickening as well as for the impact of varying inlet consistency on the final consistency after the thickening stage. For the washing stage, typical displacement velocity and consistency profiles are given. (Author abstract) 16 refs.

Koivas, K. (Rauma-Repola, Finl); Norden, H.V.; Ahonen, L. *Filtr Sep* v 25 n 1 Jan-Feb 1988 p 42-45.

**087058 AUTOMATED CONTROL OF WASHER SHOWER WATER AT ITT RAYONIER.** Simple, low-cost, automated shower-water control systems on two unbleached-stock washer lines have provided substantial savings in evaporator steam, chemicals, and secondary treatment costs. (Author abstract) 7 refs.

Sande, W.E. (ITT Rayonier Inc Research Cent, Shelton, WA, USA); Oestreich, M.A.; Poplasky, M.S.; Stewart, J.R. *Tappi J* v 71 n 3 Mar 1988 p 93-97.

**087059 OPTIMIZATION OF FILTER WASHER OPERATION AND CONTROL.** Washer models can be generally classified as descriptive or predictive. Descriptive models include the well known plot of displacement ratio against dilution factor. A descriptive model using the Norden E-factor has proven useful. On the other hand,

predictive models that involve filtration theory and flow in porous media are relatively few. The authors look at a new washer model as it is applied to optimize filter washing operation and control. To minimize total dissolved solids carryover from brownstock washing for a given shower flow, drum vacuum is the most important operating variable. The mat formation in the new model is described using Ruth's equation and a variable specific resistance (i.e., a compressible mat). 6 refs.

Han, Yushan (Univ of Idaho, Moscow, ID, USA); Edwards, Lou. *Tappi J* v 71 n 6 Jun 1988 p 101-104.

**087060 PULP VACUUM WASHERS ARE EFFICIENT AND RELIABLE WHEN PROPERLY DESIGNED.** The author presents piping and process design considerations that affect the performance of rotary vacuum washers, including a review of the vacuum washer design and associated items that influence the operation of washers. He also points out how washing performance can be optimized to improve the mill's black liquor recovery and pulp washing efficiency as well as profitability.

Perrault, Richard R. (Jaakko Poyry Inc, Raleigh, NC, USA). *Pulp Pap* v 62 n 10 Oct 1988 p 66-69.

**Waste Heat Utilization** See PAPER AND PULP MILLS—Water Recycling.

**Waste Liquor Utilization** See Also PAPER AND PULP MILLS—Waste Disposal.

**087061 VAPOR-PHASE COOKING OF BIRCH WITH RECYCLING OF SPENT IMPREGNATION LIQUOR.** Under the cooking conditions studied and with repeated liquor recyclings, it was possible to produce a sulfite CMP from birch, with 90% yield and good physical properties. Recycling of spent liquor for pulp production can be practiced without limit in a number of recyclings. Average steam consumption per cook including chip presteaming was about 2.57 kg per kg of wood. (Edited author abstract) 20 refs.

Lo, S.N. (Univ du Quebec a Trois-Rivieres, Trois-Rivieres, Que, Can); Baribeault, R.; Valade, J.L. *Pulp Pap Can* v 88 n 8 Aug 1987 p 50-55.

**087062 TAMPELLA RECOVERY SYSTEM FOR SMALL-SCALE PULP MILLS.** Tampella has developed a recovery system comprising the liquor burning in a package recovery boiler and the chemical conversion for sodium-based cooking processes. It is aimed at small-scale pulp mills and for mills where the recovery boiler is a bottle neck. (Author abstract) 1 ref.

Rimpi, P. (Tampella Ltd, Tampere, Finl); Hopia, R. *Pulp Pap Can* v 88 n 8 Aug 1987 p 72-75.

**087063 BLACK LIQUOR SOLIDS CONTENT: HOW HIGH IS UP?** The essential components of the black liquor system are a super-concentrator and a flash tank which are placed between the mix tank and the recovery boiler. Black liquor from the remainder of the evaporators is delivered to the mix tank at 62-65% solids. Liquor storage is done at this concentration. The system beyond the mix tank is at a solids content between 75% and 85%. With 75-85% liquor solids contents now in hand, the ultimate in treating black liquor as a pumpable liquid probably has been reached.

Grace, Thomas M. (Inst of Paper Chemistry). *PIMA Mag* v 69 n 10 Oct 1987 p 39-40.

**087064 KRAFT BLACK LIQUOR RECOVERY IN A FLUIDIZED BED: PART I - A REVIEW.** The Tomlinson recovery boiler has been the mainstay of the kraft pulping industry for over fifty years. It is clear, however, that the main drawbacks to this process are the large capital costs of new plant and the smelt-water explosion hazard. This paper examines some of the fundamental scientific information which supports the concept of fluid bed gasification as an alternative to the Tomlinson boiler. It is shown that a knowledge of thermodynamics is useful but insufficient to completely understand the behavior of the inorganic sulfur species

during pyrolysis and gasification of kraft black liquor. Recent key experimental investigations at McGill have demonstrated that solid state reduction of sodium sulfate to sodium sulfide is feasible. (Author abstract) 36 refs.

Fallavolita, J.A. (McGill Univ, Montreal, Que, Can); Avedesian, M.M.; Mujumdar, A.S. *Can J Chem Eng* v 65 n 5 Oct 1987 p 812-817.

**087065 ULTRA-HIGH-SOLIDS EVAPORATION OF BLACK LIQUOR.** Kraft black liquor evaporation systems have changed in the last two decades, with improvements in steam economy and reductions in evaporation costs. The ability to store, handle, and fire high-solids liquors and the capital costs of the high-solids equipment are the key factors that control the practicality and economic feasibility of increasing firing solids contents as high as possible. 13 refs.

Harrison, Ray E. (Weyerhaeuser Paper Co, Tacoma, WA, USA); Cheng, Peter J.; Crowell, Barbara A.; Ketcham, Elizabeth A. *Tappi J* v 71 n 2 Feb 1988 p 61-66.

**087066 1,1-DIARYLETHANES: NOVEL COMPOUNDS FROM ALKALI SPENT LIQUORS.** Five 1,1-diarylethanes were detected in three industrial alkali pulping spent liquors. Of these, two were novel compounds. The methylmethine linkages present in these compounds are expected to have formed during pulping. The degraded lignin and residual lignin in the pulp can therefore also be expected to contain methylmethine linkages. (Author abstract) 4 refs.

van der Klashorst, Gerrit H. (CSIR, Pretoria, S Afr); Strauss, Heinrich F. *J Wood Chem Technol* a2 p 325-331.

**Waste Utilization** See Also LIGNIN—Chemistry.

**087067 DESILICATION OF BLACK LIQUOR: PILOT PLANT TESTS.** In black liquor produced from rice straw, high silica contents have been a major obstacle against operating a recovery system. A pilot plant was set up in Egypt to continue research work on a semi-commercial scale. After three years and almost a hundred tests, operating and design criteria were obtained, and a desilication system consisting of three stages was established. These stages are: absorption of CO<sub>2</sub>; conditioning of treated black liquor; separation of silica sludge from black liquor. After modifications to the system, the pilot plant obtained desilication efficiencies of more than 90 percent. On the basis of these results, the first commercial installation of a desilication system has been built in Indonesia. (Edited author abstract) 8 Refs.

Kopfmann, K. (Pulp Mill Engineering Div, Munich, West Ger); Hudeczek, W. *Tappi J* v 71 n 10 Oct 1988 p 139-147.

## PULP MATERIALS

**087068 PHYSICAL CHARACTERISTICS OF PULPS OBTAINED FROM MESTA (HIBISCUS SABDARIFFA) PLANTS OF DIFFERENT AGES.** Kenaf (*Hibiscus cannabinus*) and mesta (*Hibiscus sabdariffa*) are excellent substitutes for traditional softwood pulp for the manufacture of newsprint. Pilot plant studies showed that it would be possible to produce high-strength mechanical pulp suitable for newsprint from whole mesta plant. Of the two species of mesta *Hibiscus cannabinus* is used as textile fiber, while fiber from *Hibiscus sabdariffa* is coarse, with more attention paid to this variety for making paper. Paper made of pulp from 150-day-old mesta plant was stronger by about 12% than that from 120-day-old mesta plant. The authors undertook a study to see the effect of age of mesta plant on the properties of the pulp and to find out the reason for the changes of the properties of paper. 12 refs.

Ray, P.K. (Indian Council of Agricultural Research, Calcutta, India); Das, B.K.; Day, A.; Banerjee, S.K. *Tappi J* v 71 n 2 Feb 1988 p 67-69.



**Bagasse** See ALSO PULP MANUFACTURE—Waste Liquor Utilization.

**087069 BAGASSE THE BASIS FOR NEWSPRINT MILL.** Located in northern Argentina, Papel del Tucuman produces about 100,000 tons/yr of newsprint grades from a furnish which is 90% semichemical bagasse pulp. All of the output is produced on a 7.6-m twin-wire PM from Voith-Brazil, with a design speed of 800 m/min. Besides standard 48.8-g newsprint, the mill makes improved newsprint with a higher brightness and higher basis weight of 60-70 g/m<sup>2</sup>. Since harvesting takes place for only five months during the year, the mill needs to store depithed bagasse during the sugar harvests to meet its needs in the rest of the year.

Bertagni, David (Papel del Tucuman, Tucuman, Argent.). *PPI Pulp Pap Int* v 29 n 7 Jul 1987 p 59-60.

**Chemical Analysis** See PULP MANUFACTURE—Kraft Process.

## Kenaf

**087070 KENAF NEWSPRINT IS A PROVEN COMMODITY.** This paper describes the trial operations and manufacture of kenaf pulp to make newsprint and discusses the results of this trial, future prospects and economics of using kenaf.

Young, Jim (Tappi Journal, Atlanta, GA, USA). *Tappi J* v 70 n 11 Nov 1987 p 81-83.

**Straw** See ALSO PULP MANUFACTURE—Bleaching; PULP MANUFACTURE—Cooling.

**087071 MORE AND BETTER USE OF CHINA'S STRAW.** China is the biggest producer of straw pulp in the world. Over 60% of its total pulp output comes from straw, mostly wheat. The technology of pulping this raw material continues to develop and there are some problems which remain to be solved. Solutions to these problems are being sought and will be helped by a new project. During the seventh five-year plan, research is to concentrate on further developing the technology of using non-wood fiber by coordinating the work of research units, design institutes and equipment manufacturers. One aim of this program is to build an integrated pulp and paper mill producing 30-50 tons/day of offset printing papers for books and magazines. These papers should contain more than 80% bleached wheat straw pulp. The site for the mill is Taizhou in Jiangsu Province.

Hai Feng, Xue (Xian Design Inst, China). *PPI Pulp Pap Int* v 30 n 3 Mar 1988 p 49.

**Sulfonation** See PULP MANUFACTURE—Refining.

## Waste Paper

**087072 REMOVAL OF SPECKS AND NONDISPERSED INK FROM A DEINKING FURNISH.** As the requirements for faster and higher quality printing have increased, so the ink types have become more sophisticated, and the fixing methods have moved toward fast, hard drying. This trend has led to deinking furnishes with even greater amounts of inks which, once dried, cannot be adequately dispersed by the conventional deinking techniques and which generate visible specks. Until now, it has been difficult to remove these particles. The result has been that paper mills have had to tolerate visible specks in the final product, which is not acceptable, or that they have had to try to eliminate such waste grades from the furnish, which is no longer practical. Consequently, a program has begun at our company to contend with the problem of specks. The result is that we now have some understanding of the behavior of specks, we are able to define methods for removing them, and we can predict the system performance. 2 refs.

McCool, Michael A. (Beloit Research Cent, Pittsfield, MA, USA); Silveri, Luigi. *Tappi J* v 70 n 11 Nov 1987 p 75-79.

**087073 TECHNO-ECONOMIC PROBLEMS IN**

**THE PRODUCTION AND USE OF WASTE PAPER PULP.** The paper discusses a recycling strategy for paper and process engineering aspects of waste paper pulp production. Subjects covered include manufacture and converting of new papers, removal of printing inks and stickies from waste paper pulp, and others.

Baumgarten, H.L. *Conserv Recycling* v 10 n 2-3 1987, Recycl of Mater, Sel Pap from the Fifth Int Recycl Congr, Berlin, West Ger, Oct 29-31 1986 p 109-123.

**Wood** See ALSO PAPER AND PULP MILLS—Brazil; PAPERMAKING MACHINERY—Design; PULP—Thermomechanical; PULP MANUFACTURE; PULP MANUFACTURE—Cooking; PULP MANUFACTURE—Reaction Kinetics; PULP MANUFACTURE—Sulfite Process; PULP MANUFACTURE—Sulfonation; WOOD—Bark Stripping; WOOD—Hydrolysis; WOOD—Oxidation.

**087074 EUROPEAN HARDWOODS - THE RAW MATERIAL OF THE FUTURE.** A three-year research program on Wood as a Renewable Raw Material has been completed by the EEC. The program had as its aim, the better use of Community raw materials and the development of enabling technology. This article summarizes the findings of the 21 scientists who reported at a seminar in Brussels last November. It is concluded that pulp and papermaking is entering an era of considerable change, and the technology of the future will make fully utilizable pulps from European hardwoods like poplar. (Edited author abstract) 21 refs.

Hendry, Ian. *Pap Technol Ind* v 28 n 6 Sep 1987 p 590-591, 594-595.

**087075 EUCALYPTUS CTMP MILL UNDER STUDY.** By 1997, clonal eucalyptus plantations in the Congo will produce 2 million m<sup>3</sup>/yr of wood. Plans for a market CTMP mill to use this resource are now under study. Clonal plantations produce a given volume of wood in 40% of the surface are required by traditional eucalyptus plantations in the Congo in the early 1970s and in 20% of the area required to produce the same volume of softwood in temperate regions. Plantation costs are 50% of those in temperate regions and the investment costs are only 10%. Plantations at present spread over 25,000 ha. The plantations established since 1978 are yielding around 20 m<sup>3</sup>/ha/yr, producing a current annual growth of 500,000 m<sup>3</sup>. New clones now available should yield at least 30 m<sup>3</sup>/ha/yr.

LaPlace, Yves (L'Unité d'Afforestation Industrielle du Congo); Cockram, Richard. *PPI Pulp Pap Int* v 29 n 7 Jul 1987 p 52-53.

**087076 WHEN THE FUTURE LIES IN THE FOREST.** Commercial forest plantations in Chile cover 1.2 million ha, of which 90% - 1.1 million ha - were radiata pine. This species is originated in California, where it is known as Monterey pine. Estimates show that a figure of 1.6 million ha will be reached by 1995. Radiata pine owes its success to its fast healthy growth under the climatic and environmental conditions found in central-southern Chile. Radiata pine grows at an average 22-23 m<sup>3</sup>/ha/yr, which compares favorably with about 7 m<sup>3</sup>/ha/yr for US Southern pine and 5 m<sup>3</sup>/ha/yr for Swedish pine. Chile's pulp exports are likely to reach 1.15 million tons by 1995, mostly for Asia and Europe.

Tuset, Antonio. *PPI Pulp Pap Int* v 29 n 6 Jun 1987 p 60-62.

**087077 UPGRADING WOOD CHIPS: THE PAPIRER PROCESS.** Much of the world's pulp and paper is produced from wood chips, the cost and quality of which have a marked effect on the profitability of a mill and on the marketing of its products. In recent years, the search for higher quality and/or cheaper sources of fiber has stimulated interest in developing better methods for upgrading chips. The Papirer process can make use of whole-tree chips, raw mill chips, chips from partially decayed trees, and chips from logging residues. 27 refs.

Berlyn, R.W. (Pulp & Paper Research Inst of Canada, Pointe Claire, Que, Can); Simpson, R.B. *Tappi J* v 71 n 3 Mar 1988 p 99-106.

**087078 PAPER SHEETS FROM BLENDED WOOD PULP WITH EGYPTIAN FLAX AND OKRA STALKS PULPS.** Mechanical strength of paper sheets prepared from blends of wood pulp with soda-pulped flax fibres, flax shives, okra stalks and hydrolysed flax fibres and shives was investigated. (Author abstract) 7 refs.

El-Kalyoubi, Samira F. (Nat'l Research Cent, Cairo, Egypt); Shukry, Nadia; Fadl, Naim A. *Res Ind* v 31 n 4 Dec 1987 p 282-285.

**087079 ON-LINE MEASUREMENT OF WOOD CHIP SIZE.** At STFI, an optical measurement system to determine the chip size distribution on-line has been developed. It is now installed in four Swedish mills. The measurement system has given important information about digester and chipper operation and has been used for the control of chip screening and chip blending. Other applications are also possible. The measurement system has been reported to be functionally available with good reliability.

Petterson, Andres (Swedish Pulp & Paper Research Inst, Stockholm, Swed); Olsson, Lars; Lundqvist, Sevn-Olof. *Tappi J* v 71 n 7 Jul 1988 p 78-81.

## PULSE AMPLITUDE MODULATION

**087080 INFLUENCE OF CYCLE SLIPPING ON THE ERROR PROBABILITY OF A PAM RECEIVER.** An evaluation is presented of the error probability of a pulse-amplitude modulation (PAM) receiver, which derives symbol timing from the received waveform by means of a synchronizer. The author points out that the conventional way of evaluating this error probability (using the distribution of the synchronizer's modulo-2 $\pi$  reduced phase error) does not take into account the effect of the synchronizer's cycle slips. A correct expression for the error probability is given, which uses the distribution of the so-called renewal phase. Simple but accurate approximations are derived for both the conventional and the correct error probability, which clearly show the influence of the characteristics of the PAM receiver. These approximate expressions indicate that, for a decreasing additive noise level at the receiver input, the conventional error probability becomes vanishingly small; the correct error probability approaches a nonzero value, which is inversely proportional to the mean time between slips. Hence, cycle slipping imposes a (sometimes rather large) lower limit on the attainable error probability. 13 refs.

Moeneclay, Marc (Univ of Ghent, Belg.). *IEEE Trans Commun* v COM-35 n 9 Sep 1987 p 961-968.

**PULSE CODE MODULATION** See ALSO DATA CONVERSION, DIGITAL TO ANALOG; DATA TRANSMISSION—Packet Switching; DATA TRANSMISSION—Synchronization; DIGITAL COMMUNICATION SYSTEMS; DIGITAL COMMUNICATION SYSTEMS—Multiplexing; DIGITAL COMMUNICATION SYSTEMS—Voice/Data Integrated Services; IMAGE PROCESSING—Image Coding; INFORMATION THEORY—Communication Channels; RADIO TRANSMISSION—Fading; SIGNAL PROCESSING—Digital Techniques; SPEECH—Coding; TELEVISION TRANSMISSION; TELEVISION TRANSMISSION—Performance.

**087081 DIGITAL PCM - AN ALTERNATIVE TO FM INSTRUMENTATION RECORDING.** Instrumentation tape recorders are used in a variety of applications where the requirements is to record the information from transducers for subsequent analysis. Until now FM recording has remained largely unchallenged in the field of instrumentation, partly because it is insensitive to varying tape parameters and can therefore provide more repeatable results. The price to pay for this increased performance is a narrow bandwidth: FM recorders cannot attain the same bandwidths as direct recording and so they consume more tape. Digital recording, on the other hand, is completely insensitive both to tape noise and transport speed variations: dynamic range is limited solely by electronic noise. Off-tape signals are identical to E-to-E



signals, and figures of 96db are easily achieved. This represents at least two orders of magnitude increase in range over FM recording.

Blame, Milke (Earth Data); Edwards, Dave. *New Electron* v 20 n 14 Jul 7 1987 p 49.

**087082 EVALUATION OF ADPCM CODERS FOR DIGITAL CIRCUIT MULTIPLICATION EQUIPMENT.** This paper describes test results for a set of experimental procedures designed to objectively measure the performance of four adaptive differential pulse-code modulation (ADPCM) algorithms that use signals other than voice. These algorithms have been under consideration by the International Telegraph and Telephone Consultative Committee (CCITT) as possible low-bit-rate coders for incorporation in digital circuit multiplication equipment. The results presented pertain to voiceband data modems operating at 9,600 bit/s or higher, and include analog performance measurements for each of the algorithms considered. (Author abstract) 19 refs.

Dimolitsas, S.; Corcoran, F.L.; Onufry, M.; Suyderhoud, H.G. *COMSAT Tech Rev* v 17 n 2 Fall 1987 p 323-345.

**087083 64 KBIT/S AUDIO SIGNAL TRANSMISSION APPROACHES USING 32 KBIT/S ADPCM CHANNEL BANKS.** Two simple 64-kb/s wideband coding approaches using 32-kb/s ADPCM (adaptive differential pulse-code modulated) channel banks are proposed and compared to CCITT 64 kb/s ADPCM, which is being recommended as CCITT G.722. These two, folding ADPCM and QMF ADPCM, are intended to pave the way for smooth transition from conventional 4-kHz band telephone systems to 7-kHz wideband systems in private networks. The first approach, supporting high-quality audio program transmission, requires only samplers and multiplexers at the input and output ports of the channel banks. In the second approach, samplers and multiplexers are replaced by quadrature mirror filters in order to increase coding quality. Performance test results for audio signal transmission show that these simplified approaches provide an inexpensive way to introduce wideband communication systems. 4 refs.

Iwadare, Masahiro (NEC Corp, Kawasaki, Jpn); Nishitani, Takao. *IEEE J Sel Areas Commun* v 6 n 2 Feb 1988 p 307-313.

**087084 ADPCM WITH A MULTIQUANTIZER FOR SPEECH CODING.** A speech coding algorithm with low complexity and a short processing delay is introduced. The proposed algorithm is ADPCM (adaptive differential pulse code modulation) with a multiquantizer (ADPCM-MQ). The input signal is processed in parallel by multiple ADPCM coders with different characteristics. Then the optimum ADPCM coder with minimum error power is dynamically selected for each frame. A 16-kb/s codec based on this algorithm has been implemented using two general-purpose digital signal processors (MB8764) with 8.3 ms of total processing delay. A segmental SNR of 19-21 dB was achieved at 16 kb/s; with postfiltering the segmental SNR was increased to 23-25 dB. Combined with the time domain compression scheme, the algorithm can be easily applied to 8-kb/s coding. It is also extensible to variable-rate coding. 15 refs.

Taniguchi, Tomohiko (Fujitsu Lab Ltd, Kawasaki, Jpn); Unagami, Shigeyuki; Iseda, Kohei; Tominaga, Syozi. *IEEE J Sel Areas Commun* v 6 n 2 Feb 1988 p 410-424.

**Analysis** See SPEECH—Coding.

**Applications** See IMAGE PROCESSING—Image Coding.

## Equipment

**087085 COMPACT 60-CHANNEL ADPCM TRANSCODER.** This paper describes the DTC-60A, a new 60-channel ADPCM transcoder for European CEPT networks. The DTC-60A implements a conversion between two 2048 kbps PCM streams and a single 2048 kbps ADPCM stream, using CCITT Recommendation 32 kbps

ADPCM algorithm (G.721). NEC developed ADPCM codec LSIs are used in per channel basis for mutual conversion between PCM and ADPCM signals, thereby reducing equipment cost, size and power consumption. Other important characteristics of the DTC-60A include easy maintainability, compliance with the CCITT Recommendation (G.761), and versatile programming and alarm display functions provided by the portable control terminal (PCT). (Author abstract) 5 refs.

Tamura, Makoto (NEC Miyagi Ltd, Jpn); Kato, Tadaharu; Harakawa, Kazuo; Hagi, Kazuo. *NEC Res Dev* n 86 Jul 1987 p 21-28.

## Mathematical Models

**087086 32 KBIT/S ADPCM ALGORITHM HAVING HIGH PERFORMANCE FOR BOTH VOICE AND 9.6 KBIT/S MODEM SIGNALS.** A description is given of an advanced 32-kb/s ADPCM (adaptive differential pulse code modulation) algorithm and its implementation in a single-chip custom LSI using 2-μm CMOS technology. The performance of the proposed codec, in terms of voice and modems operating at 1200-9600 b/s, is also discussed. The results indicate that the codec provides speech quality equivalent to that of the CCITT G.721 ADPCM and is capable of transmitting V.23 1200 b/s and V.27 and V.29 4800 b/s signals over at least four asynchronous tandem links. It can also transmit V.29 modem signals at 7200 b/s over at least four and at 9600 b/s over two asynchronous tandem links, and V.32 signals at 9600 b/s over four asynchronous tandem links. 12 refs.

Hosoda, Kenichiro (Oki Electric Industry Co, Tokyo, Jpn); Noguchi, Osamu; Yatsuzuka, Yohtarō. *IEEE J Sel Areas Commun* v 6 n 2 Feb 1988 p 262-273.

## Performance

**087087 COMBINING SOFT-DECISION DEMODULATION WITH BIT ERASURE CORRECTION AND WEIGHTING TO REDUCE THE EFFECT OF TRANSMISSION ERRORS IN LOG-PCM.** We analyze an improved soft-decision demodulation technique applied to μ-law pulse code modulation (PCM). The PCM-encoded waveforms are transmitted over Gaussian and Rayleigh fading channels by means of coherent phase shift keying modulation. Received bits which are unreliable are identified by means of soft-decision demodulation and erased. Each bit in the PCM word is assigned its own erasure threshold. The thresholds are optimized and are thus theoretically determined as a function of input power level to the quantizer, channel type and snr, and the relative mean-square error power that occurs when a PCM word containing an erased bit is estimated by means of prediction or interpolation. (Edited author abstract) 22 refs.

Lee, L. (Lehigh Univ, Bethlehem, PA, USA); Sundberg, C.E.W.; Wong, W.C. *IEE Proc Part F* v 134 n 7 Dec 1987 p 643-651.

**Sampling** See DATA STORAGE, MAGNETIC—Disk.

**Standards** See SPEECH—Coding.

**PULSE GENERATORS** See Also ELECTRIC SWITCHES—Vacuum Applications; ELECTROMAGNETIC WAVES—Transients; ELECTRON BEAMS—Production; ELECTRONIC CIRCUITS, PULSE SIGNAL—Analysis; LASER PULSES; LASERS—Accessories; LASERS, GAS; SIGNAL PROCESSING.

**087088 RANDOM PULSE GENERATOR WITH A UNIFORMLY DISTRIBUTED AMPLITUDE SPECTRUM.** The described pulse generator produces a white pulse amplitude spectrum in addition to an optional calibration peak. Amplitudes and pulse distances are nearly randomly distributed. The amplitude of the output pulses, with a width of 2 μs, ranges from 0.1 to 10 V<sub>p</sub>. The rate may be varied from 0.1 to 110 kips. The unit has been developed for applications in nuclear physics. It will mainly be used to test large experimental setups, and for calibration of parameters. In some cases, measurements of nonlinearities will be possible. Distortions of the white

spectrum which may occur if the pulses are converted by an ADC with amplitude dependent dead time (Wilkinson type) have been considerably reduced. (Author abstract) 3 refs.

Lauch, J. (Hahn-Meitner Inst, Berlin, West Ger); Nachbar, H.U. *Nucl Instrum Methods Phys Res Sect A* v A267 n 1 Apr 15 1988 p 177-182.

**087089 CAPACITANCE FREE GENERATION AND DETECTION OF SUBPICOSECOND ELECTRICAL PULSES ON COPLANAR TRANSMISSION LINES.** By reanalyzing an earlier experiment to generate subpicosecond pulses using photoconductive switches (1986), it is shown that to first order, the sliding-contact generation site has no capacitance. This conclusion is further supported by a double sliding-contact experiment where, to first order, neither the generation nor the detection site has any capacitance. This result removes the parasitic capacitance of the electrical circuit as one of the major difficulties to short electrical pulse generation using photoconductive switches. 12 refs.

Grischkowsky, Daniel R. (IBM, Yorktown Heights, NY, USA); Ketchen, Mark B.; Chi, C.-C.; Duling, Irl N.; Halas, Naomi J.; Halbout, Jean-Marc; May, Paul G. *IEEE J Quantum Electron* v 24 n 2 Feb 1988 p 221-225.

**087090 ERROR ANALYSIS OF A RATE GENERATOR TUNING LINEARITY.** One of the stages in designing microprocessor-controlled instruments is a thorough analysis of instrument blocks to adjust them to a more precise method of control. The analysis of a rate generator period is presented that shows two types of tuning and the errors involved. Simple expressions are derived here that can be used efficiently to determine maximum frequency or minimum period for assumed errors. 3 refs.

Rusek, Andrzej (Oakland Univ, Rochester, MI, USA). *IEEE Trans Instrum Meas* v 37 n 1 Mar 1988 p 81-85.

## Accessories

**087091 DAMPING OF RETURNING PULSES BETWEEN CHARGING SUPPLY AND SHAPING LINE.** A coaxial device is described for transmission of electrical energy from a pulse generator to a low-impedance shaping line the switching of which excites powerful short voltage pulses. To damp the pulses, the inner conductor is enclosed by an element of volume-resistive material, and controlled dischargers are installed between the outer conductor and the element. The device has operated effectively in charging of radial lines from an Arkad'ev-Marks generator to 500 kv in 1 μsec. (Author abstract) 10 refs.

Bukharov, V.F.; Gerasimov, A.I.; Fedotkin, A.S. *Instrum Exp Tech* v 30 n 5 Pt 1 Sep-Oct 1987 p 1113-1115.

**Analysis** See Also PULSE MODULATION—Analysis.

**087092 INPUT SECTION OF MAGNETIC PULSE GENERATOR WITH INDUCTIVE STORAGE DEVICE.** The operation of the input section of a magnetic generator that uses an inductive storage device and a switching transistor is analyzed. When a 12-v supply is used, output pulses of up to 1.2 kV are obtained with a capacitance of 200 pf. (Author abstract) 3 refs.

Vazhdaev, V.A. (Gorki Polytechnic Inst, USSR); Kataev, I.G.; Kononov, A.I. *Instrum Exp Tech* v 30 n 4 pt 1 Jul-Aug 1987 p 868-870.

## Applications

**087093 EINFACHER IMPULSGENERATOR FUER DIE NANOSEKUNDEN - PRUEFTECHNIK.** [Simple Pulse Generator Adapted to the Nanosecond Test Technique]. The nanosecond test technique is increasingly important in the development and quality control of modern systems of electric power. A simple pulse generator is described in which is frequently applied in the evaluation of electric insulations during short duration loads and in the solution of problems of electromagnetic



compatibility. (Edited author abstract) In German. 9 refs.

Haller, R. (TU Dresden, East Ger); Schmigel, P. *Elektrie* v 41 n 3 1987 p 93-96.

## Computer Applications

**087094 MICROPROCESSOR-BASED GPIB COMPATIBLE PROGRAMMABLE PULSE GENERATOR.** This paper presents a 'Microprocessor-based, GPIB Compatible programmable pulse generator' which can be programmed both in the local mode and the remote mode. The programming parameters are (i) frequency, (ii) width or duration and (iii) amplitude. A new technique called direct digital synthesis with microprocessor control has been used for the generation of square waves from 1Hz to 1MHz in steps of 1Hz. The pulse generator realized using the above technique has arbitrarily high resolution, high switching speed, very low power consumption, high reliability and low cost. Also, GPIB interface circuits have been incorporated for remote operation. (Author abstract) 2 refs.

Madivanan, S. (Naval Science & Technological Lab, Visakhapatnam, India); Shivaprasad, A.P. *IETE Tech Rev* v 4 n 3 Mar 1987 p 88-92.

**087095 MICROPROCESSOR BASED PULSE GENERATOR.** A microprocessor based pulse generation technique is discussed. The desired frequency, amplitude, duty cycle and polarity of the pulses are selected through the keyboard and effected with the help of software routines. (Edited author abstract) 3 refs.

Bendigeri, G.K. (Madras Inst of Technology, Madras, India); Mathialagan, A.; Gunasekaran, G. *J Inst Eng India Part ET* v 68 pt 1 Aug 1987 p 1-4.

## Design

**087096 DESIGNING A HIGH-SPEED PULSE GENERATOR.** The cost of fault isolation and correction rises exponentially as system build progresses from component level, through board, sub-system and system levels, with field repair costs at the top end of the scale. In the case of circuits where the critical timing paths may be exercised by a repetitive pulse train, it is often better to characterize these devices using dedicated parametric test equipment, to ensure that parameters such as setup and hold times, propagation delays, access times and maximum clock frequencies meet specifications. To perform these tests, the stimulus source used is typically a dedicated pulse generator. The key features required from a programmable pulse generator are discussed, and a pulse generator is described capable of supplying pulse repetition rates to 200MHz, sufficient for testing the maximum operating frequencies of LSITL, HCMOS and FAST.

Aitken, Mike (Datron Instruments). *New Electron* v 20 n 12 Jun 9 1987 p 43, 46.

**087097 STANDARD IMPULSE GENERATOR DESIGN BY SPECTRAL REPRESENTATION AND APPROXIMATION METHODS.** Designing standard impulse generator by analytical methods is a tedious task because of the complicated form of the relations between parameters and variables. This paper presents a new method which consists in the construction of associate and efficiency functions by spectral representation. Their minimization, by an iterative second order procedure built by approximation in the Hilbert space, guarantees an impulse whose distance from the desired standard form is minimal. (Author abstract) 3 refs.

Nicolae, D. *Rev Roum Sci Tech Ser Electrotech Energ* v 32 n 4 Oct-Dec 1987 p 449-455.

**Energy Storage** See ELECTRIC SWITCHES—Measurements; ELECTRIC SWITCHES—Vacuum Applications.

## Laser Applications

**087098 LASER TRIGGERED CHOPPED WAVE GENERATOR.** A 200-kV-dc SF<sub>6</sub>-insulated spark gap is

triggered by an ultraviolet laser pulse (KrF,  $\lambda = 249$  nm) to chop a 3/10  $\mu$ s pulse in less than 10 ns. By simply adjusting the internal delay of the laser, the pulse can be chopped anywhere on the front or on the tail, and at voltages as low as half of the spontaneous breakdown voltage of the gap. The shape and length of the waveform are precisely controlled, and jitter is reduced to less than 10 ns at 80% of the spontaneous breakdown voltage. 11 refs.

Parpal, J.-L. (Hydro-Quebec, Varennes, Que, Can); Mercure, H.P.; Mitchel, G.R. *IEEE Trans Power Delivery* v PWRD-2 n 4 p 1141-1144.

## Measurements

**087099 MEASURING THE PEAK CURRENT FROM UNIPOLAR POWER PULSE GENERATORS.** A new procedure is proposed for measuring powerful current pulses of sinusoidal form. The instrument is easy to calibrate and requires neither a reference instrument nor a powerful supply unit. A formula is presented for the peak current pulse at known values of the voltage across a storage capacitor and the duration of the pulse, with approximate formulas for the working conditions of current generators. 7 refs.

Kuznetsov, V.A.; Gromov, V.E.; Gurevich, L.I. *Sov Surf Eng Appl Electrochem* n 5 1986 p 109-112.

**Performance** See Also SQUARE WAVE GENERATORS—Performance.

**087100 HIGH-VOLTAGE PULSE GENERATOR WITH HIGH ACTUATION FREQUENCY.** A six-stage Arkad'ev-Marks generator with a voltage of up to 300 kv and an actuation frequency of up to 100 pulses/sec is described. The capacitance of the generator in discharge is 1.7 or 4.2 nF, the maximum pulse energy is 180 J, and the half-height pulse duration is 3-4.5  $\mu$ sec for a capacitive load. (Author abstract) 7 refs.

Kapishnikov, N.K. (Tomsk Polytechnic Inst, USSR). *Instrum Exp Tech* v 30 n 2 pt 1 Mar-Apr 1987 p 336-339.

**087101 NANOSECOND PULSE GENERATOR.** A nanosecond pulse generator is described that is implemented by avalanche transistors. The pulse amplitude is up to several hundred volts, the rise and fall times are approximately 1 nsec, and the repetition frequency is up to 10 KHz. (Author abstract) 4 refs.

Bernashevskii, G.A. (Acad of Sciences of the USSR, Moscow, USSR); Voroshen', V.I.; Milovanov, S.A. *Instrum Exp Tech* v 30 n 2 pt 1 Mar-Apr 1987 p 340-342.

**087102 RESONANT MEGAVOLT PULSE GENERATOR.** A compact pulse generator with a capacitive load is described that employs resonant voltage multiplication at the load. A 60-pF capacitor is charged to 1.1 Mv in a pulse with a rise time of 0.25  $\mu$ sec. The dimensions of the resonant generator are considerably smaller than those of known Tesla-coil voltage sources (by a factor of approximately 30 in volume). (Author abstract) 7 refs.

Zhel'tov, K.A.; Malygin, A.V.; Petrenko, A.N.; Shalimov, V.F. *Instrum Exp Tech* v 30 n 2 pt 1 Mar-Apr 1987 p 343-345.

**087103 CURRENT-PULSE GENERATOR FOR ELECTROMAGNET OF INDUCTION ACCELERATOR.** A thyristor generator is described that produces in the winding of the electromagnet of a betatron unipolar current pulses of sinusoidal and quasisinusoidal shape with deforming of the field at the beginning of an acceleration cycle and with a plateau on the pulse top at the end of a cycle. The current amplitude is controlled by a pulse-phase method. The generator is used in apparatus with a pulse duration of 1-10 msec, a maximum electromagnet field energy 45-450 J, a winding voltage of 960-1500 v, and a winding current of 100-500 A for a repetition frequency of 50-200 Hz. (Author abstract) 5 refs.

Baginskii, B.A. (Tomsk Polytechnic Inst, USSR);

Makarevich, V.N.; Shtein, M.M. *Instrum Exp Tech* v 30 n 3 pt 1 May-Jun 1987 p 512-514.

**087104 HIGH-VOLTAGE NANOSECOND PULSE GENERATOR WITH GIN-500-0.02/3 FOR STREAMER CHAMBER.** A high-voltage nanosecond pulse generator for a 2-meter streamer chamber and track spark chambers is described that contains a dual-shaping-line pulsed charge generator based on a stock GIN-500-0.02/5 unit. Transformer oil is used to insulate the main gaps of the charge generator; a pulse with an amplitude of up to 50 kv and a duration of 12.0 nsec is obtained with a matched line load (38  $\Omega$ ). A pulse with an amplitude of up to 300 kv is obtained at the load when nitrogen is used instead of transformer oil. The generator has operating lives of  $10^5$  and  $5 \cdot 10^4$  actuations in the former and latter cases, respectively. (Author abstract) 8 refs.

Aksinenko, V.D. (Joint Inst for Nuclear Research, Dubna, USSR); Glagoleva, N.S.; Dement'ev, E.A.; Kaminskii, N.I.; Matyushin, A.T.; Matyushin, V.T.; Nugrozhin, N.N.; Ryakhovskii, V.N.; Khushainov, E.K.; Shevchenko, E.A. *Instrum Exp Tech* v 30 n 3 pt 1 May-Jun 1987 p 601-603.

**087105 HIGH-VOLTAGE NANOSECOND PULSE GENERATOR FOR TRIGGERING OF MEGAVOLT PEAKING DISCHARGES.** A high-voltage nanosecond pulse generator is described that is designed for synchronous triggering of several megavolt peaking dischargers. It produces pulses with an amplitude of 300-200 kv and a rise time of 7-20 nsec for a variation of the total impedance of the lines of the transmission system of from 50 to 9  $\Omega$ . The triggering system of the generator ensures an actuation stability of  $\pm 10$  nsec for an isolation-circuit inductance of up to several tens of microhenries. (Author abstract) 3 refs.

Gromova, L.A. (Scientific-Research Inst of High Voltages, USSR); Evlampiev, S.B.; Korshunov, G.S.; Pichugina, M.T.; Sviridov, Yu.F. *Instrum Exp Tech* v 30 n 3 pt 1 May-Jun 1987 p 603-605.

**087106 HIGH-POWER NANOSECOND PULSE-TRAIN GENERATOR.** A generator is described that provides at the load a pulse train with a repetition frequency of  $10^3$ - $10^6$  Hz or higher. The pulses have an amplitude of up to 150 kv for a duration of 50 nsec. The generator contains two shaping and two transmission lines of KVI-300 low-impedance cable, which are connected in series with the load. The shaping lines are powered by two independently triggered voltage-pulse generators to produce a pause between pulses of  $> 10^{-6}$  sec. Due to loss reduction in the discharge circuit, the amplitude of the second pulse increases with an increase in the pause between pulses of up to 300 nsec, beyond which the curve is saturated. (Author abstract) 7 refs.

Isakov, I.F. (Scientific-Research Inst of Nuclear Physics, USSR); Logachev, E.I.; Opekinov, M.S.; Pechenkin, S.A.; Remnev, G.E.; Usov, Yu.S. *Instrum Exp Tech* v 30 n 3 pt 1 May-Jun 1987 p 606-608.

**087107 HIGH-VOLTAGE VARIABLE-DURATION PULSE GENERATOR.** A high-voltage generator is described that allows pulse duration T to be varied within wide limits and has high efficiency (at least 50% for  $T = 0.5 T_{max}$ ) and a stable output-pulse amplitude (within 10%). The generator provides pulses with an amplitude of up to 5 kv, a repetition frequency of up to 200 Hz, and a variable duration of 0-30  $\mu$ sec. The generator is used in the controller of an electron accelerator. (Author abstract) 3 refs.

Anisimova, T.E.; Akkuratov, E.V.; Gromovenko, V.M.; Nikonov, Yu.P.; Malinin, A.N. *Instrum Exp Tech* v 30 n 4 pt 1 Jul-Aug 1987 p 855-856.



**087108 HIGH-SPEED HIGH-VOLTAGE PULSE GENERATOR.** A high-voltage pulse generator is described that is triggered by pulses of negative polarity with an amplitude of  $\leq 0.5$  v and produces with a triggering delay of not over 35 nsec exponential pulses with an amplitude of  $\approx 4$  kv and a rise time of  $\approx 30$  nsec at the outputs of more than 20 cables. (Author abstract) 3 refs.

Ushakov, V.I. (Inst of Theoretical & Experimental Physics, Moscow, USSR). *Instrum Exp Tech* v 30 n 5 Pt 1 Sep-Oct 1987 p 1115-1117.

**Stability** See OSCILLOSCOPES, CATHODE RAY—Performance.

**Switching** See Also ELECTRIC SWITCHES—Electric Conductivity.

**087109 OPEN CIRCUIT SYSTEM FOR PULSED POWER APPLICATION.** The use of inductive energy storage for generation of pulsed high power current becomes an economically attractive alternative. However, it requires the high technique of open circuit device to invert the current of storage coil into load. In this paper, the present status of opening devices are surveyed. Principles and abilities of some types of open switches also are described. It is concluded that the GTO switch is most favorable to be adopted for the next plasma experimental machine of our project. (Author abstract) 77 refs. In Japanese.

Sato, Y. *Denshi Gijutsu Sogo Kenkyusho Iho* v 51 n 10 1987 p 765-792.

**PULSE MODULATION** See Also ELECTRIC INVERTERS—Analysis; ELECTRIC INVERTERS—Performance; ELECTRICAL ENGINEERING—Industrial Applications; PULSE TIME MODULATION.

#### Analysis

**087110 ERROR REDUCTION IN TWO-DIMENSIONAL PULSE-AREA MODULATION, WITH APPLICATION TO COMPUTER-GENERATED TRANSPARENCIES.** This report deals with the synthesis of band-limited functions that are generated by properly low-pass filtering a regular array of area-modulated unit-height pulses. Simply choosing the pulse areas proportional to the corresponding sample values of the band-limited function to be generated would result in an error. The exact relationship between the pulse areas and the corresponding sample values of the band-limited function to be synthesized is derived. Error reduction can be achieved by using this relationship to calculate the pulse areas from the required sample values; in principle, a band-limited function can thus be realized to any degree of accuracy. It is shown which amount of error reduction can be obtained when only a limited number of terms of the exact relationship is taken into account. The application to computer-generated half-tone transparencies is described. (Author abstract) 12 refs.

Bastiaans, M.J. (Eindhoven Univ of Technology, Eindhoven, Neth); Akkermans, A.H.M. *EUT Rep Eindhoven Univ Technol Dep Electr Eng* 87-E-172 May 1987 51p.

#### Microwaves

**087111 CORRECT TIMING OF SAMPLE-AND-HOLD SYSTEM IMPROVES LEVELING PERFORMANCE.** Conventional pulse modulation techniques for rf and microwave frequency sources usually place the modulating device downstream of the rf level detector. Although this method usually produces acceptable pulse envelopes, the insertion loss of the modulator severely limits the available rf output power. Unless some means of isolating the level detector from the pulse modulator is used, reflections often degrade the leveled power accuracy of the source. Most practical pulse modulators require more time to turn off than to turn on, thus creating an unavoidable compression of the rf pulse. Systron-Donner has developed and implemented a unique sample-and-hold technique that overcomes these limitations.

Rosenbaum, Mark J. (Systron Donner Corp, Concord, CA, USA). *Microwave J* v 30 n 5 May 1987 p 325-326, 328.

**PULSE TIME MODULATION** See Also DIGITAL COMMUNICATION SYSTEMS; ELECTRIC INVERTERS—Analysis; ELECTRIC MEASURING INSTRUMENTS—Circuits; OPTICAL COMMUNICATION—Mathematical Models; OPTICAL COMMUNICATION—Performance.

**087112 DETERMINATION OF AUTO-CORRELATION FUNCTION OF PULSE INTERVAL MODULATED SIGNALS.** The auto-correlation function of pulse interval modulated waves is determined from the knowledge of frequency components present in PIM spectrum. The auto-correlation function is computed and shown at three frequencies. The shape of the PIM auto-correlation function is similar to the shape of the auto-correlation function of rectangular wave modulated (RWM) signals. (Author abstract) 6 refs.

Tripathi, J.N. (Univ of West Indies, Trinidad, West Indies). *J Inst Eng India Part ET* v 68 pt 2-3 Nov 1987-Feb 1988 p 31-33.

**PULSE WIDTH MODULATION** See Also ANTENNAS—Arrays; CONTROL SYSTEMS—Modulation; ELECTRIC CONVERTERS, POWER TYPE; ELECTRIC CONVERTERS, POWER TYPE—Analysis; ELECTRIC CONVERTERS, POWER TYPE—Control; ELECTRIC CONVERTERS, POWER TYPE—Performance; ELECTRIC CONVERTERS, POWER TYPE—Switching; ELECTRIC CONVERTERS, STATIC; ELECTRIC CONVERTERS, STATIC—Performance; ELECTRIC FILTERS; ACTIVE; ELECTRIC INVERTERS; ELECTRIC INVERTERS—Components; ELECTRIC INVERTERS—Control; ELECTRIC INVERTERS—Switching; ELECTRIC MOTORS, STEPPING TYPE; ORTHOTICS—Functional Electric Stimulation; TELEVISION TRANSMISSION—Analysis.

**087113 INCREMENTAL METHOD OF PULSE WIDTH MODULATION FOR THREE-PHASE INVERTERS.** A novel pulse-width modulation technique for three-phase voltage-controlled inverters is presented. Description of a microprocessor-based modulator capable of completing in real-time all the computations required for adjustable frequency, magnitude and phase control of the inverter output voltage is provided. Experimental results are given. (Author abstract) 10 refs.

Legowski, Stanislaw (Univ of Wyoming, Laramie, WY, USA); Trzynadlowski, Andrzej M. *Int J Electron* v 64 n 5 May 1988 p 803-814.

**087114 NEW SPWM INVERTER WITH MINIMUM FILTER REQUIREMENT.** A new sinusoidal pulse width modulation (SPWM) control technique for simplifying the implementation of the SPWM method and minimizing the requirement of the voltampere rating of the inverter input filter is described and analysed. With the proposed modulation scheme, the regeneration of low-order harmonics caused by the input voltage fluctuation can be suppressed and the peak fundamental output voltage can be regulated rapidly and precisely by the dual voltage feedback control. Only a minimum voltampere rating of the inverter input filter is required for avoiding overmodulation. The theoretical results of the proposed approach with open-loop self-regulating property are discussed and experimentally verified. (Author abstract) 6 refs.

Lee, Jia-You (Nat'l Cheng-Kung Univ, Tainan, Taiwan); Sun, York-Yih. *Int J Electron* v 64 n 5 May 1988 p 815-826.

**087115 NOVEL SINUSOIDAL PULSE WIDTH MODULATION SCHEMES FOR VOLTAGE-SOURCE INVERTERS WITH FLUCTUATING INPUT VOLTAGE.** The optimum waveform parameters of pulse positions and pulse widths for voltage-source inverters with fluctuating input voltage are proposed. Eight types of modulation schemes are described for synthesizing the optimum low-distortion output waveforms, of which the harmonic spectra and the peak fundamental-value are almost insensitive to the input-voltage fluctuation, with a minimum voltampere rating of inverter input filter. For fluctuating inverter input voltage with

insufficient filtering, the type-VII and the alternative type-III modulation schemes are found to be especially suitable for practical implementation. Detailed descriptions of the suggested circuits with dual-feedback control for implementing two such modulation schemes are given. A peak-value detector that can rapidly produce the peak value of the inverter output voltage with a minimum time constant is also proposed. The theoretical results of the proposed approaches with open-loop self-regulating property are experimentally verified and compared with the conventional method. 14 refs.

Lee, Jia-You (Nat'l Cheng-Kung Univ, Tainan, Taiwan); Sun, York-Yih. *IEEE Trans Ind Electron* v 35 n 2 May 1988 p 284-294.

**Analysis** See Also ELECTRIC INVERTERS—Control.

**087116 HARMONIC ANALYSIS OF PWM INVERTER MODULATION STRATEGIES.** This paper presents the harmonic analysis of various pulse width modulation strategies used for the dc-ac converters. An efficient harmonics computation algorithm for piecewise continuous periodic waveforms has been derived. Fourier coefficients of experimentally obtained waveforms or simulation results can be calculated efficiently. Harmonic performance analysis of natural sampling, modified sub-harmonic control, symmetric/asymmetric uniform, sinusoidal pulse width modulation, and pulse position modulation strategies have been studied. Results can be used as guidelines for the modulation strategies selection in the PWM inverter design. (Author abstract) 13 refs.

Tzou, Y.Y. (Nat'l Chiao Tung Univ, Hsinchu, Taiwan); Wu, Y.C. *Int J Electron* v 64 n 3 Mar 1988 p 461-480.

**087117 ANALYSIS AND REALIZATION OF A PULSEWIDTH MODULATOR BASED ON VOLTAGE SPACE VECTORS.** A space vector concept for deriving the switching times for pulsewidth-modulated voltage source inverters is compared with the conventional sinusoidal concept. The switching times are deduced from assumptions for minimum current distortion, the resulting mean voltage values are shown, and the differences between these and the established sinusoidal PWM (pulse-width modulator) are elaborated. Based on an analytical calculation the current distortions and torque ripples are evaluated and compared with the values obtained with the conventional method. The space vector representation results in lower current harmonics and possibly a higher modulation index. A modulator based on an 8086 microprocessor has been implemented, and its performance is reported. 16 refs.

van der Broeck, Heinz Willi (Philips Forschungslab, Aachen, West Ger); Skudelny, Hans-Christoph; Stanke, Georg Viktor. *IEEE Trans Ind Appl* v 24 n 1 1988 p 142-150.

**Applications** See ELECTRIC DRIVE—Variable Speed; ELECTRIC INVERTERS—Analysis.

#### Components

**087118 THYRISTORBESTUECKTE PULSMODULATOREN FUER AMPLITUDENMODULIERTE RUNDFUNKSENDER.** [Thyristor-Based Pulse Modulators for Amplitude-Modulated Radio Transmitters]. The high-efficiency amplitude-modulated tone radio transmitters were equipped until a short time ago with tetrode-based pulse-duration modulators. These are now often substituted with thyristor-based circuits. BBC Brown Boveri manufactures semiconductor-based pulse step modulators (PSM) for carrier powers up to 600 kW. In addition to the high efficiency and longer life span the new systems are characterized by a dynamic carrier control and its special single-sideband transmission, using a novel digital technique. The paper describes the new modulator and reports on the first transmission experiment using a 500 kW short-wave transmitter. (Translated author abstract) In German. 6 refs.

Schminke, W. (Brown Boveri AG, Baden, Switz). *Bull Assoc Suisse Electr* v 78 n 17 Sep 5 1987 p 1045-1049.



## Computer Aided Analysis

**087119 MICROPROCESSOR DETERMINATION OF PWM SIGNALS USING SECOND-ORDER DIFFERENCE EQUATIONS.** A method is proposed for microprocessor determination of pulse-width modulated (PWM) signals. Two simultaneous digital difference equations representing the timing wave and a phase of the reference signal are solved. The computational algorithm is used to generate the PWM signals. 6 refs.

Agbinya, Johnson I. (Univ of Jos, Makurdi, Nigeria). *IEEE Trans Ind Electron* v IE-34 n 4 Nov 1987 p 494-496.

## Performance

**087120 MULTIPLE SIDETONE STRUCTURE IN PULSE WIDTH MODULATION.** Previously unreported sub-sidetones, not directly predictable from the currently accepted modulation formula, have been observed in the spectrum of a PWM signal excited by two sinusoidal tones of comparable amplitude. (Author abstract) 6 refs.

Wilson, B. (UMIST, Manchester, Engl); Ghassemloo, Z. *Electron Lett* v 24 n 9 Apr 28 1988 p 516-518.

**Selection** See ELECTRIC CONVERTERS, POWER TYPE—Components.

## Switching

**087121 EFFECTS OF SWITCHING ANGLE PHASE SHIFT ON PWM TECHNIQUES.** The behavior of some well-known pulse-width modulation (PWM) techniques is investigated under conditions of perturbed power-semiconductor gating signals. An evaluation of different PWM techniques is performed, considering the effect of PWM timing errors on the output spectra of switch-mode converters. A digital PWM modulator is proposed that minimizes gating logic signal phase shift. 11 refs.

Manias, Stefanos (Concordia Univ, Montreal, Que, Can); Wiechmann, Eduardo P.; Ziogas, Phoivos D. *IEEE Trans Ind Electron* v IE-34 n 4 Nov 1987 p 463-470.

**PULVERIZED FUEL** See Also CEMENT PLANTS—Kilns.

**Chemical Reactions** See COAL GASIFICATION.

**Combustion** See Also BOILER FIRING—Pulverized Fuel; FLAME RESEARCH.

**087122 ASH FORMATION DURING PULVERIZED COAL COMBUSTION. 1: AERODYNAMIC INFLUENCES.** The elemental composition of pulverized fuel boiler often differs markedly from that of the corresponding fly ash and coal ash. Evidence is given here to support the hypothesis that such chemical segregation could be induced by competition between aerodynamic drag and inertial forces on a particle in a curved streamline; this increases the probability of impacting the boiler walls for large particles of high density, leading to preferential deposition. A conventional air classifier was used to separate mono-sized samples of pulverized coal and char particles into aerodynamically different fractions, and to prepare vitrinite-char and inertinite-char concentrates. The relevance of such aerodynamic segregation is considered by comparing the enrichment (or depletion) of non-volatile elements in boiler ashes with that in ashes derived from air-classified char fractions. (Edited author abstract) 29 refs.

Unsworth, John F. (Shell Research Ltd, Chester, Engl); Cunliffe, Frank; Graham, Stephen C.; Morgan, Paul A. *Fuel* v 66 n 12 Dec 1987 p 1672-1679.

**Gasification** See COAL GASIFICATION—Phase Equilibria.

## Ignition

**087123 UEBER DIE ZUENDUNG IN BRAUNKOHLSTAUB-LUFT-STRAHLEN.** [Ignition in Brown Coal Dust/Air Jets]. An analytical evaluation of the ignition of coal dust/air mixtures is carried out. The ignition process is subdivided into an unsteady-state and a steady-state part. A balance sheet of the activation energy and released heat is set up for a must of volume. This calculation offers an insight into the ignition mechanism, in particular regarding the influence of the dust proportion of the mixture. (Translated author abstract) In German. 3 refs.

Neugebauer, Walter (ORGREB-Inst fuer Kraftwerke Vetschau, East Ger). *Energietechnik* v 37 n 5 May 1987 p 168-170.

**087124 TRANSIENT CONDUCTION IN A SPHERE WITH COUNTERACTING RADIATIVE AND CONVECTIVE HEAT TRANSFER AT THE SURFACE.** In some important industrial processes cold reactive powders are raised to their reaction or ignition temperature during passage from the entrance of a reactor toward a standing flame front. Changes in the particles during this pre-ignition phase are largely determined by the temperature history they experience. A model for heat transfer to and within a spherical particle during the pre-ignition phase is presented that yields predictions of the required temperature changes. Such predictions are needed for the refinement of reaction models. The predicted temperature histories are shown to be in excellent agreement with a numerical solution of the problem. (Author abstract). 10 refs.

Davies, T.W. (Exeter Univ, Exeter, Engl). *Appl Math Modelling* v 12 n 4 Aug 1988 p 429-433.

**PUMPING PLANTS** See Also CANALS—USSR; FLOOD CONTROL—Missouri; WATER DISTRIBUTION SYSTEMS—Optimization.

**087125 MEETING RISING WATER DEMANDS: NEW PUMPS ARE THE KEY.** In Oshkosh, long-term demand for water service had been on the rise for years, putting a strain on its water filtration plant. The city recognized the problem and in 1981 retained the consulting firm of Howard Needles Tammen & Bergendoff to study water treatment requirements. When it became evident that there was a need for modifications to the old high service pumping station, the concept of combining both the low lift and high service pumping facilities began to be explored. The consultant determined that economy and efficiency of operation could be achieved by combining both facilities in a single structure. With a total project cost of \$1,453,000, the net unit construction cost of the new pumping station was five cents per gallon. The new water pumping station is a single structure, unmanned and operated remotely from a new automatic control center in the existing water filtration building. It contains three 5-mgd rated low lift vertical turbine pumps. A fourth pump bay is available for another pump.

Curtis, John W. (Howard Needles Tammen & Bergendoff, Milwaukee, WI, USA); Konrad, Thomas J. *Public Works* v 118 n 11 Nov 1987 p 44-45.

**087126 WATER INDUSTRY ASSESSMENT OF PUMPING REQUIREMENTS.** The article seeks to identify the requirements of the water industry in respect of serviceability, maintenance, efficiency, and capital revenue costs. It deals with the assessment and trade-off of these elements in financial terms using DCF analysis techniques. The article also makes specific reference to the use of different methods of variable speed control as appropriate and is based on the end users' viewpoint.

Ellis, A.K. (Severn-Trent Water Authority, Engl). *World Pumps* Oct 1987 p 313-316.

**087127 PUMPING - SYSTEMS APPROACH.** Increased emphasis in recent years on plant economics at the design stage whether it be a process plant, a power plant or water works, has highlighted the importance of

matching the pumping equipment with its system. The article brings out that a good pumping system is not merely a cluster of highly efficient individual pieces of equipment but is an assembly of mutually dovetailed equipments engineered to meet the overall objectives. The systems approach emphasizes the importance of considering all relevant aspects of the whole system before any part of the system is selected. This approach will also establish the parameters of each equipment, avoid costly delays in commissioning and can lead to a better rapport among the client, the consultant and the manufacturer. (Edited author abstract)

Sathyanarayana, K. (AVP (Engineering) Kirloskar Brothers Ltd, Sangli, India). *J Indian Water Works Assoc* v 19 n 4 Oct-Dec 1987 p 281-285.

**087128 AUTONOMOUS SOLAR PHOTOELECTRIC STATION FOR LIFTING WATER.** The article examines the specifics of using autonomous solar water-lifting stations (SPES). Features of the operation of a thyristor-inverter circuit for a vibration pump are noted. The volt-ampere characteristics of SPES are given. (Author abstract) 1 ref.

Strebkov, D.S.; Krylov, V.M.; Ivanov, A.P.; Kidyashev, Yu.K.; Lemasov, B.I.; Rozhdestvenskii, A.M. *Appl Sol Energy* v 23 n 5 1987 p 92-94.

**Construction** See RESERVOIRS.

## Control

**087129 MULTIPLEXER SLASHES MAINTENANCE COSTS FOR WATER TREATMENT PLANT.** The article discusses the installation of a Dupline two-wire transmission systems for monitoring and control to control remote pumping stations at the Granby Water Treatment Plant in Quebec. The multiplexing system is manufactured by Electromatic Components, of Montreal. The Dupline is based on a single two-wire cable for two-way transmission of digital pulse codes. It consists of a standard two-wire transmission cable, transmitters, receivers and a channel generator. Up to 128 separate signals can be transmitted through each pair of wires. The plant is currently using 40 channels of the 128 available. The system is used to start and stop the pumps, monitor alarms and monitor the status of the various pumps. These and other aspects of the subject are discussed.

Burt, Leslie (Water & Pollution Control, Don Mills, Ont, Can). *Water Pollut Control (Don Mills Can)* v 125 n 2 Apr 1987 p 13.

## Electric Power

**087130 SEQUENTIAL LINEAR PROGRAMMING APPROACH TO SOLVE MIXED INTEGER PROGRAMMING PROBLEMS.** The optimal operation of pumps in a large water supply system under time-of-use electricity rates is formulated as a mixed integer programming (MIP) problem. The problem is solved using an iterative linear programming (LP) scheme. The scheme is applied to an actual world problem, the City of Inglewood Water Supply System. Computational results are presented and termination criteria for the solution scheme are discussed. (Author abstract). 11 Refs.

Torabi, M. (AT&T Bell Lab, Holmdel, NJ, USA); Dracup, J.A. *Comput Math Appl* v 15 n 12 1988 p 1029-1039.

## Energy Management

**087131 ENERGY MANAGEMENT CONSIDERATIONS AND THEIR APPLICATION.** The most significant use of energy by the water industry is in the consumption of electricity, which is attributable to the many pumping operations undertaken. For most water undertakings, this represents more than 85 percent of all energy used and involves several millions of pounds expenditure per annum. Therefore pumping operations warrant particular attention in energy management approach. Energy management can be related as a require-



ment to check both the economics of operations as well as to improve energy efficiency generally. With this consideration, examples are given of changes that have been made to pumping operations which are compatible with satisfying increasing demands for pumping and operational flexibility in an environment of rising energy costs. (Author abstract) 3 refs.

Brockton, C.N. (Bristol Waterworks Co). *J Inst Water Environ Manage* v 1 n 1 Aug 1987 p 111-116.

**Energy Utilization** See IRRIGATION—Pumping Plants.

**Equipment** See PUMPS—Design.

**Monitoring** See PUMPS—Efficiency.

**Operations Research** See PUMPS—Selection.

**Optimization**

**087132 STUDY ON THE OPTIMUM DEVELOPMENT FOR PUMPING PROJECT.** (Based on the principles of system analysis and consideration of pumping projects as an entirety, this paper discusses a new method for seeking the minimum installed capacity and energy consumption. The proposed method is considered an improvement over the water balance method in the planning and design of pumping projects. (Edited author abstract) In Chinese). 3 refs.

Luo Xinlei (Water Conservancy & Hydroelectric Power Bureau of Hunan Province, China). *Shuili Xuebao* n 7 1987 p 10-19.

**Performance**

**087133 POND CREEK PUMPING STATION SOUTHWESTERN JEFFERSON COUNTY, KENTUCKY.** A 1:20-scale pumping station model of the sump and gravity control, approach, stilling basin, and exit channel was used to investigate and develop a practical design that would provide satisfactory hydraulic performance. The pumping station and gravity control structures were combined by locating the gravity control below the sump. The pumping station consisted of four vertical pumps with a total capacity of 4,100 cfs. The gravity control section had a capacity for 17,000 cfs and consisted of an open-channel flow structure and tainter gate to maintain the pool. During operation of the pumps, surface vortices observed in the pump bays were eliminated by surface vortex suppressor beams. During operation of the gravity control structure, eddies and an unstable hydraulic jump observed in the stilling basin were eliminated by decreasing the rate of sidewall flare and strategically locating and increasing the height of the baffle blocks. (Author abstract)

Fletcher, Bobby P. (USAEWES Hydraulics Lab, Vicksburg, MS, USA). *Tech Rep US Army Eng Waterw Exp Stn HL-88-7* 100p.

**South Africa**

**087134 LOW-COST PUMPING STATION ON THE UMGENI RIVER.** The paper describes a pump station installed by the Umgeni Water Board to pump Umgeni river water from a point 16 km from the river mouth to a new water treatment works in Durban. An outline is given of the background to the establishment of the pump station and the constraints on its construction. The required performance criteria are detailed as well as the installed equipment.

Taylor, Graham; Ward, Graham. *S Afr Mech Eng* v 37 n 8 Aug 1987 p 350, 352-353.

**Testing**

**087135 TESTING OF A PUMPHOUSE WITH A HORIZONTAL CAPSULE UNIT.** The creation of pumphouses (PH) with high feed is necessary to the circulating water supply of high-power thermal and

nuclear power plants and large treatment systems. The equipment now in use at PH with axial pumps is based on layouts with elbowed water feed and discharge. However, this arrangement cannot meet the imposed requirements as a result of limitations on unit output and diameter of the impeller. For a number of years the Leningrad Polytechnic Institute has been conducting experimental and technical-economic studies to determine the parameters of low-head PH. A large power engineering experimental stand and a model unit were created to develop a design for a horizontal capsule unit. The purpose of the power hydraulic tests was to obtain universal characteristics of the capsule unit and to investigate the effect of the feed components on the operating characteristics. Measurements of all the operating parameters of the unit were carried out with standard calibrated instruments. 5 refs.

Vissarionov, V.I.; Elistratov, V.V. *Sov Energy Technol* n 10 1987 p 24-28.

**PUMPS** See Also AGRICULTURAL PRODUCTS; AQUIFERS—Testing; ELECTRIC CABLES—Cooling; FLOOD CONTROL—Utah; FLOW OF FLUIDS—Multiphase; MIXING—Automation; VIBRATIONS—Monitoring.

**087136 PUMPS FOR POWERING HYDRAULIC MINING EQUIPMENT.** The Chamber of Mines of SA Research Organization has for some years conducted investigation into ways of improving the mechanization of stopping operations. It has identified hydraulic power as one of the most suitable means of providing the necessary forces in confined spaces. The article describes the preparation of specifications for pumps for powering hydraulic mining equipment.

Stanton, Ken. *S Afr Mech Eng* v 37 n 8 Aug 1987 p 355-357.

**087137 NEW TRIPLE-SCREW PUMPS FOR PUMPING HIGH-VISCOSITY LIQUIDS.** New pumps were designed for pumping liquids of viscosity 10 to 60 cm<sup>2</sup>/sec with inlet pressure up to 7.65 MPa and exit pressure up to 9.61 MPa at delivery rates 0.333, 1.25, and 4.45 t/sec and rpm 800 to 1250. In the double-flow pumps, because of the herringbone threading of the screws, the axial forces on them are mutually balanced. The residual axial forces on the leading screw are absorbed by the ball bearing set in the forward roof of the pump. The bearing is lubricated with grease. The pump body is made of steel, the screws are of steel, and the casing is made of bronze. In the screws the sharp edge of the following screw is blunted by making a radial facet of length 0.025 d (here d is the outer diameter of the following screw). Such a facet ensures adequate reliability and wear resistance of screws when pumping pure mineral oils of optimum viscosity (0.37 to 4 cm<sup>2</sup>/sec). Tests demonstrate the operational reliability of these pumps. 5 refs.

Okorokov, V.M.; Verizhnikov, P.P.; Ryazantsev, V.M. *Chem Pet Eng* v 22 n 7-8 Jul-Aug 1986 p 361-362.

**087138 DIAPHRAGM METERING PUMPS: OPTIMIZED AND MORE SOPHISTICATED.** Diaphragm metering pumps make an important contribution towards a cleaner environment and increased safety in the chemical industry. Without these pumps it would no longer be possible to produce toxic, radioactive, or caustic media. Diaphragm metering pumps with a freely moving diaphragm (mostly made of PTFE) and fitted into a hydrodynamically optimized product chamber, with constant rear end position of the diaphragm (position control), are a reliable process component, which meets the requirements of environmental protection, accuracy, and a high degree of availability as well as low maintenance costs. In the case of diaphragm metering pumps with hydraulic support, the piston operates in a physiologically safe and pure hydraulic medium with excellent lubricating properties. The diaphragm, preferably made from PTFE and usually designed as multilayer units fitted with a diaphragm rupture indicator, separates the hydraulic fluid from the process fluid. The installation, maintenance and modular design of such pumps are discussed.

Anon. *Chem Ind Int (Engl Transl)* n 2 1987 p 20, 25-26.

**087139 HIGH-PRESSURE DIAPHRAGM PUMPS: IMPROVEMENTS - BUT NO NEW DEVELOPMENTS.** Diaphragm pumps can be used in all cases where abrasive fluids have to be pumped. Moreover, they have the advantage that even chemically aggressive media can be handled. Such pumps can be employed advantageously as continuously operating pumps for pressures of up to 500 bar or, in the same pressure range, as discontinuous/intermittent pumps and for metering purposes. The design, operation, regulation through added air, performance of diaphragm pumps and problems of material selection for them are discussed.

Anon. *Chem Ind Int (Engl Transl)* n 2 1987 p 34-37.

**087140 POWERMASTER PUMP AND MOTOR LINE FOR MOBILE HYDRAULIC SYSTEMS.** From its U.S. headquarters in Sterling, Va., Dowty Industrial Corp. markets a state-of-the-art mobile hydraulic product line. Products include high performance gear pumps in single and tandem combinations, power steering pumps, gear motors, high torque vane type rotary actuators, axial piston units, low speed high torque piston motors and auxiliary circuit components. An all cast iron, three part body construction is utilized. Cast iron construction is particularly important in mining applications.

Wilson, Rob. *Diesel Prog North Am* v 54 n 3 Mar 1988 p 12-13.

**087141 PLANNING HIGH-PERFORMANCE PUMPS FOR WATER TRANSPORTATION AND PIPELINE SERVICE WITH CAD TOOLS.** The article first describes the double-flow, one- to three-stage volute casing pump of the RDLP product line with axially split casing. Based on the mathematical relation between pump dimensions on the one hand and pump operating data and characteristic curves on the other hand, CAD is used to quickly find the best-suited pumps for a certain inquiry, compare their characteristics, choose from several alternatives and finally calculate the main dimensions, weights and quotation curves of these pumps and print them out together with a sectional drawing of the pump. With this method, design drawings of the pumps are no longer required. (Author abstract)

Bode, B.; Gorisch, A. *KSB Tech Ber* n 23e Mar 1988 p 47-52.

**087142 PROCEEDINGS OF THE FOURTH INTERNATIONAL PUMP SYMPOSIUM.** This conference proceedings contains 13 papers discussing results of investigations on industrial pumps for utility and petrochemical industries. It also discusses pumps used for slurry and solids handling. Pump vibration analysis for the amateur, and vibration monitoring of vertically mounted pumps are topics discussed. One paper discussed the effects of design features on centrifugal pump efficiency, while another discusses the effects of slurries on the centrifugal pump performance. Experiences with a numerical method of calculating slurry pump casing wear are discussed, and a paper analyses ways to reduce pump maintenance costs. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11184 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Bailey, Jean C. (Ed.) (Texas A&M Univ, College Station, TX, USA). *Proc of the Fourth Int Pump Symp, Houston, TX, USA, May 5-7 1987* Publ by Texas A&M Univ, College Station, TX, USA, 1987 205p.

**Analysis**

**087143 MODELING AND ANALYSIS OF THE DYNAMICS OF A VARIABLE-DISPLACEMENT VANE-PUMP WITH A PIVOTING CAM.** Variable-displacement vane-pumps, modulated by a pivoting cam, are used extensively in modern automotive transmissions. This paper presents a study of the dynamic and steady-state characteristics of such pumps. Their dynamics concern issues such as pressure fluctuations due to the dynamics of the internal mechanism and transient re-



sponse-time. Their steady-state characteristics concern limits on the operating envelope and the relationships among the operating variables. These analyses required the development of several models for this type of pump at different levels of detail. (Author abstract) 9 refs.

Karmel, A.M. (GM Research Lab, Warren, MI, USA). *J Dyn Syst Meas Control Trans ASME* v 110 n 2 Jun 1988 p 197-202.

**Applications** See Also COPPER MINES AND MINING—Drainage; OPTICAL COATINGS.

**087144 APPLICATION OF K<sub>h</sub>G TYPE OF ELECTRIC PUMP FOR PUMPING VISCOUS HEAT CARRIERS.** In order to widen the range of use of these electric pumps, we studied the scope of application of the 1.5KhG-3A-2.8-3 electric pump in a liquid heat supply system (LHS) working with a viscous heat carrier in the thermal zone (TZ) of an oscillating screw mixer. An analysis of the data obtained shows that, when organosilicon heat carriers are used, the period most dangerous from the point of possible failure of the electric pump is its starting period when the electric motor consumes maximum power and the heat carrier having a high viscosity and a low heat capacity at the temperature of the surroundings does not ensure effective cooling of the stator. As the temperature of the liquid being pumped rises, the parameters of the electric pump operation approach the calculated ones and reach the rated values above 110-120°C. Based on the results of these studies, a procedure was suggested. The proposed starting procedure makes it possible to widen the area of application of KhG type of electric pumps for pumping organosilicon heat carriers having a kinematic viscosity of not more than  $10^{-4}$  m<sup>2</sup>/sec and a specific heat of not less than 1.7 kJ/kg·K at the ambient temperature.

Basko, V.P.; Semenov, V.P.; Skachkov, E.D. *Chem Pet Eng* v 22 n 5-6 May-Jun 1986 p 211-213.

**087145 ARE PUMPS WORTHWHILE TURBINES?** Despite the extensive literature on the use of pumps as turbines, only very few well established applications using this knowledge have been reported; therefore, the lack of feedback on problems and experiences has not provided an adequate incentive to study more thoroughly the performance limitations and capabilities, and operational properties. To the authors' knowledge and experience, the application of pumps as turbines is to be recommended only for certain specific applications: where initial cost is more important than efficiency and a wider operating range; where flow is more or less constant; and where tested turbine data for the pump to be used are available. (Edited author abstract) 1 Ref.

Engeda, A. (Univ of Hannover, Hanover, West Ger); Rautenbert, M. *Int Water Power Dam Constr* v 40 n 7 Jul 1988 p 19-20.

## Axial Flow

**087146 RELATIONSHIP BETWEEN CAVITATION DEVELOPMENT AND THE VELOCITY AND PRESSURE FLUCTUATIONS OF AN AXIAL-FLOW PUMP.** The change in spectrums of velocity and casing wall pressure fluctuations due to cavitation was investigated, along with the change in the flow pattern through an axial flow impeller; analysis being carried out for a range under 10 kHz. The spectrums of pressure fluctuation measured on the impeller casing depend mainly on the tip clearance cavitation development. Levels of high frequency components over 1 kHz increase remarkably as cavitation grows, and there are no discrete components in the high frequency range. The energy of pressure fluctuation is much greater than that of velocity fluctuation under the cavitating condition. Thus, cavitation noise is concluded to be brought about by pressure fluctuations. (Author abstract) In Japanese. 7 refs.

Saito, Sumi. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 496 Dec 1987 p 3682-3690.

## 087147 EXPERIMENTAL INVESTIGATION OF

**THE PERFORMANCE OF A STIRRED AERATOR HAVING AN AXIAL FLOW PUMP IN INNER CASING.** A tested aerator considering a vertical cylindrical vessel with a coaxial inner casing, and an axial flow impeller arranged in an inner casing. As a circulatory flow is built up between the inner tube and the outer annulus, there is not any dead zone in the flow area in this new-type stirred aerator. Moreover, a high efficiency of the impeller may be expected compared with the conventional stirred vane. First, the effect of the existence of inner casing on the performance of aeration, and second, the effects of the air supply position, air flow rate, impeller speed and the diameter of air bubble on the oxygen transfer rate coefficient are studied. Moreover, the dissolution efficiency of the oxygen and the power consumption are investigated. (Edited author abstract) 4 Refs. In Japanese.

Ohba, Hideki; Nakashima, Yukitoshi; Umeda, Tatsuo; Umeda, Takeo. *Nippon Kikai Gakkai Ronbunshu B Hen* v 54 n 502 Jun 1988 p 1389-1393.

## Bearings

**087148 ON THE EFFECTIVENESS OF BrZn9-4 BRONZE THRUST BEARINGS IN HYDRAULIC PUMPS.** We study the effectiveness of hydraulic pump thrust bearings during operation in the Promgidrol P20-M2 noncombustible fluid. We determine the causes of unsatisfactory wear resistance of some bronzes, including BrZn9-4, with the use of lubricants containing glycerine. (Author abstract) 11 refs.

Bakakin, G.N.; Gavrilenko, Yu.A. *Sov J Frict Wear* v 8 n 2 1987 p 98-101.

**087149 RESIDUR - A MAINTENANCE-FREE BEARING ASSEMBLY FOR TUBULAR CASING PUMPS.** The operating environment of vertical guide bearings design used to date are presented. Several methods of bearing lubrication have been proved suitable, each with its own set of advantages and disadvantages. Aspects of wear and environmental concerns led to the development and testing of new materials. Silicon carbide appears to be the most economical solution for both the pump manufacturer and the user. Experimental research and an improved design of the bearing assembly resulted in a guide bearing whose advantages by far surpass those of previous design. The application of RESIDUR as bearing material met all expectations. (Author abstract) 4 refs.

Feldte, G. (KSB, Bremen, West Ger); Schulze, H. *KSB Tech Ber* n 23e Mar 1988 p 39-46.

**Blades** See HYDRAULIC TURBINES—Blades.

**Cavitation** See TURBOMACHINERY—Cavitation.

**Components** See Also GEARS—Stresses.

**087150 EFFECT OF RIBS IN THE RADIAL FEEDLINE ON THE EXTERNAL CHARACTERISTICS OF HELICAL-CENTRIFUGAL STAGE OF PUMP.** Experimental investigations carried out showed that the feedline influences the power, cavitation, vibration, and pulsation characteristics of the stage of the pump. Ribs ('tongues') and their arrangement in the radial feedline exert significant influence on the external characteristics of helical-centrifugal stage with power-speed coefficient  $n_p = 120$ . Experiments showed that at 0.75Q<sub>opt</sub>, Q<sub>opt</sub> and 1.25Q<sub>opt</sub> ribs and their arrangement do not influence much the vibration characteristics. However vibration characteristics were significantly influenced in the 0.5Q<sub>opt</sub> regime. Back currents act on the rib. This action is transmitted to the pump body components and increases their vibrations. This assumption is supported by traces of cavitation disturbances on the rib surface detected in the tests for determining the pump life. It is concluded that the power, cavitation and vibration characteristics of the helical-centrifugal stage could be altered by varying the number of ribs and their arrangement in the radial feedline.

Brazhnik, V.P. *Chem Pet Eng* v 22 n 11-12 Nov-Dec 1986

p 597-598.

**087151 PILOT PUMP USING THE WEIS-FOGH MECHANISM AND ITS CHARACTERISTICS.** An application of the Weis-Fogh mechanism to pumps was studied. A pilot pump was built and the characteristics were investigated experimentally, and it was shown that this mechanism works well for pumps. From the point of view of the specific speed, the characteristics of this pump are similar to those of diagonal flow pumps. The maximum efficiency was about 24%. A flow visualization about the wing was performed and clusters of vortices were found to be produced periodically in the wake. Some possibilities for raising the efficiency were discussed. (Author abstract) 11 refs. In Japanese.

Tsutahara, Michihisa; Kimura, Takeyoshi. *Nippon Kikai Gakkai Ronbunshu B Hen* v 54 n 498 Feb 1988 p 393-397.

## Computer Aided Design

**087152 CAD/CAM FOR PUMPS.** Factory automation is bringing engineering and manufacturing departments closer together all the time. It is therefore becoming more and more important to have a smooth, consistent, and reliable way to pass information sequentially from designers to manufacturers. Engineering and manufacturing software programs are usually designed for generic uses such as geometric modeling, computer-aided drafting, finite element modeling and analysis, numerical control machining packages, and other computer-aided engineering tasks. Yet, no CAD/CAM vendor can supply a complete package designed specifically for a company's particular product. A description is given of the use of off-the-shelf CAD software which has been combined with parametric programs to create an integrated system for the design and manufacture of centrifugal pump impellers.

Nell, Lev A. (Ingersoll-Rand Co, Phillipsburg, NJ, USA); D'Souza, Peter; Ozsoy, Tulga. *Mech Eng* v 109 n 8 Aug 1987 p 46-49.

**Computer Applications** See SOLAR RADIATION—Measurements.

## Computer Simulation

**087153 DIGITAL COMPUTER MODEL FOR PREDICTING REACTOR COOLANT PUMP BEHAVIOR.** The development of an improved model to determine the dynamic response of the primary heat transport pump during severe transients in a Canada deuterium uranium reactor is presented. A lumped parameter model is proposed. A control volume formulation is employed for centrifugal pumps. The mathematical formulation of this model is based on mass, momentum, and energy balances as well as on Euler's Theory of Turbomachines. Several constitutive relationships are adopted in the model to describe three-dimensional effects. In addition, the proposed model includes the consequent effect of different flow regimes and the slip between the two phases. Numerical results indicated that the proposed model favorably predicted the pump response and compared well with other pump-related models (Aerojet Nuclear Company) in the literature as well as in the experimental data. (Author abstract) 24 refs.

Sami, Samir M. (Univ of Sherbrooke, Sherbrooke, Que, Can); Tran, C. *Nucl Technol* v 79 n 3 Dec 1987 p 260-273.

**Construction** See METALS AND ALLOYS—Corrosion Resistance.

**Control** See Also PUMPS, ROTARY—Rotors; WASTE-WATER—Treatment.

**087154 PIPELINE MICROPROCESSOR CONTROL.** The traditional control scheme for a multiple pump booster system might use a suction controller, discharge controller, motor load controller, ramp function generator, signal selector, and auto-manual station. The same control scheme can be implemented using one multivariable microprocessor controller. The controller



can then be easily integrated into a CRT type distributed control system that is also handling discrete (logic) control for the other parts of the station. (Author abstract)

Williams, William J. (Yokogawa Corp of America, Peachtree City, GA, USA); Murray, Philip J. *InTech* v 35 n 2 Feb 1988 p 49-53.

**087155 ELECTRONIC CONTROLLERS FOR PUMPING APPLICATIONS.** The asynchronous cage rotor, three-phase induction motor was developed only slightly after the centrifugal pump and together they form one of the most common industrial systems. The cage rotor motor is very suitable power source for electronic controllers for pumping applications because it produces purely rational motion, with minimum vibration and a good power-to-weight ratio. It does however have one major disadvantage because its rotational speed is set by the frequency of the supply and the number of pole pairs in the winding. The motor also suffers 'slip' which means that it can never quite achieve these speeds; the slip will depend on the motor design and the load applied. The author discusses performance aspects of frequency converters. Tables are also given showing power comparisons for fixed speed and variable speed pumps. The advent of microprocessor control in frequency-converters has permitted a great range of control options to be offered integrally with the converter, including proportional control from level or flow transducers and control of both fixed-speed and variable-speed pumps from one transducer, in addition to the facility to vary the speed manually.

Brown, G. (ASEA). *World Pumps* v 52 n 2 Mar-Apr 1988 p 386-387.

**Control Systems** See Also EARTHMOVING MACHINERY—Excavators.

**087156 OPTIMAL CONTROL THEORY APPLIED TO A PUMP WITH SINGLE-STAGE ELECTROHYDRAULIC SERVOVALVE.** Optimal control theory is applied to the design of a pressure regulator for an axial piston pump and single-stage electrohydraulic valve combination. The control valve has been modeled and an optimal control law has been formulated. The time response curves due to a step input in flow rate and in current input to the servovalve have been obtained for the open loop and for the optimal control system. Comparison of the results has been made with previous work in which the supply valve to the swashplate actuators was not modeled. It is shown that controlled system modeling of the servovalve significantly improves system performance in terms of response frequency and pressure peaks. (Author abstract) 10 refs.

Akers, A. (Iowa State Univ, Ames, IA, USA); Lin, S.J. *J Dyn Syst Meas Control Trans ASME* v 110 n 2 Jun 1988 p 120-125.

**087157 PROCESS CONTROL APPLIED TO PUMP SYSTEMS.** An automatic controller is a device which compares the measured value of the process variable to be regulated (the regulating variable) with the reference value (set value) and generates a correcting variable having a certain desired time response. In case of a simple control system, the process variable could permanently deviate from the set value due to external disturbances. Contrary to this, a good automatic controller can adjust for interferences and variations of the parameters. Another benefit of an automatic controller is the ability of the regulated variable following the reference variable during process related changes of the reference variable. However, criteria such as energy conservation can also be taken into account when designing the automatic controller. (Edited author abstract) 4 refs.

Bieniek, K.; Handwerker, Th.; Kuch, J.; Schmitt, B.; Vogelsaenger, Th. *KSB Tech Ber* n 22e Sep 1988 p 46-50.

## Cooling

**087158 TESTING THE VENTILATION SYSTEM OF THE DRIVING MOTOR OF A GAS-PUMPING**

**UNIT.** Based on the results of testing the ventilation system, the following conclusions are drawn: The most effective motor cooling is achieved during simultaneous operation of certain blowers. The temperature of the stator of the working motor did not exceed 72°C at cooling air pressure 1 MPa and atmospheric temperature 28°C. After normal stopping, both the rotor and stator cooled to 50°C in 2 h, 45 min, and after two successive sudden stoppages, the rotor cooled to 50°C in 1 h, 30 min. Also effective was the cooling of the motor with blowers. In this case, the motor temperature did not exceed 76°C at cooling air pressure 0.75 MPa. After stopping the unit, the motor temperature fell to 50°C in 4 h. After two successive sudden stoppages, the rotor cooled to 50°C in 1 h, 53 min at atmospheric temperature 24°C. During simultaneous working of two blowers, the stator temperature in the working motor did not exceed 74°C at cooling air pressure 0.85 MPa and atmospheric temperature 25°C. The cooling of the motor after normal stoppage required 3 h, 10 min and after two successive sudden stoppages, 2 h, 10 min. On disconnecting three blowers, the stator temperature in a working unit rose steadily.

Krivshich, N.G.; Min'ko, V.M. *Chem Pet Eng* v 23 n 7-8 Jul-Aug 1987 p 397-398.

**Corrosion** See INDUSTRIAL PLANTS—Corrosion Protection; OIL FIELD EQUIPMENT—Pumps.

**Design** See Also CAVITATION—Control; PUMPS, RECIPROCATING—Noise Abatement.

**087159 DIAPHRAGM METERING PUMPS.** The diaphragm metering pump, with a free-moving diaphragm and controlled diaphragm operating positions, is a reliable item of process equipment. It meets the requirements of high accuracy, low maintenance costs, low downtime, and minimal pollution problems. Diaphragm pumps with control of the diaphragm positions are available in different designs. 6 refs.

Brauer, Ruediger (Brän & Luebbe GmbH, Hamburg, West Ger). *Chem Eng Prog* v 83 n 4 Apr 1987 p 18-24.

**087160 CENTRIFUGAL VERTICAL ELECTRIC PUMP SET - TYPE 2400V-25/100.** An electric pump set has been designed for installation in the pumping stations of the Volga-Don canal and other sites. The pump is driven by a DSV 565/140-28 synchronous motor rated at 32 MW and 13.8 kv. The size of the pump made it necessary to radically change the design of the flow zone compared to type-V centrifugal pumps. The main difference include mounting of the stator behind the impeller and adopting a cast/welded design for the spiral casing. The main innovation in the pump is the fact that the steel stator is of cast/welded design and the parts of the spiral casing are welded to it. This design makes it possible to reduce the weight by 30 tons compared to standard pumps, which have a cast casing. The cast impeller has two slit-type seals. The upper band of the impeller has holes to reduce the pressure at the shaft seals and also to reduce the axial force transmitted to the thrust bearing of the motor. The shaft seals are located in the pump cover. Water is discharged from the pump through a metallic pipe equipped with a hydraulically actuated disk valve with a nominal diameter of 2800 mm. The 2400V-25/100 pump set is disassembled through the hole in the motor stator. The shaft seals and guide bearing can be repaired without removing the electric motor. The main parts of the pump are made of carbon steel. The design provides for automatic protection and control of the pump.

Zadanovskii, L.G.; Gordeeva, R.V.; Zhukovskii, R.I. *Chem Pet Eng* v 22 n 5-6 May-Jun 1986 p 249-250.

**087161 METHOD OF DESIGNING THE TRANSFORMING MECHANISM OF PUMPING UNITS.** The transforming mechanism of pumping units is a hinged four-link mechanism constructed on the basis of symmetric and nonsymmetric kinematic circuits. With a symmetric circuit, the center of rotation of the crank is positioned on a straight line passing through points connecting the extreme positions of joining of the rocker and the equalizer. All the other cases correspond to the nonsym-

metric circuit. In designing the mechanism with the nonsymmetric circuit it is also necessary to define the offset angle, i.e., the angle formed by the positions of the rocker corresponding to the start and end of upward strokes of the head of the equalizer. The method in which the mechanism is designed on the basis of previously specified output parameters is preferred. It is recommended that one use the parameters which determine both the type of kinematic system of the transforming mechanism and its overall dimensions: the angle of sweep of the equalizer, and the offset angle. To simplify the application of the proposed method, it is necessary to represent the required quantities in a reduced form (in fractions of stroke length). The transforming mechanism can be determined from the author's equation. 1 ref.

Karaev, I.K. *Chem Pet Eng* v 22 n 5-6 May-Jun 1986 p 251-255.

**087162 DESIGN OF HYDRAULIC PUMPS FOR HIGH WATER BASE FLUIDS.** Hydraulic pumps and motors are generally not suitable for mobile equipment at pressures much above 15 MPa on high water base fluids. This paper discusses the design problems, particularly of piston units, and illustrates some of the Australian innovations that provide for improved durability and efficiency at elevated duties. (Author abstract) 13 refs.

Frazer, H.I. (Ifield Engineering Pty Ltd, Sydney, Aust). *Mech Eng Trans Inst Eng Aust* v ME 11 n 1 Mar 1986 p 23-31.

**087163 ADAPTIVE POWER CONTROL OF VARIABLE VANE PUMP.** The paper describes the theoretical analysis and experimental investigation of a vane pump adapted to power, summarizes a mathematical model of static and dynamic states of the system, and puts forward testing indexes, static design criteria and dynamic design criteria for minimum stable flow. This provides a theoretical basis and a testing method for designing power adapting pumps with good performance and high efficiency. (Edited author abstract) 10 refs. In Chinese.

Liu, Q.; Wan, B. *Jichuang Yu Yeya* n 1 1986 p 12-21.

## Diaphragms

**087164 BEANSPRUCHUNGSSIMULATION DER PUR-MEMBRAN EINER BLUTPUMPE. (Stress Simulation in the PUR Diaphragm of a Blood Pump).** Diaphragm pumps are used in medicine to assist or replace the cardiac function. The faults which occur in pneumatic blood pumps are mainly attributable to failure of the moving parts, i.e. the valves and in particular the diaphragm. In order to obtain precise information on the time-dependent state of stress in the diaphragm, the sequence of movements of a given diaphragm geometry is simulated by means of a FEM program package. The results obtained on a Dec computer are compared with basic values determined by analysis. (Author abstract) 5 refs. In German and English.

Knierbein, B.; Schleede, K.; Sturm, Ch.; Reul, H.; Messmer, B.J.; Rau, G. *Kunstst Ger Plast* v 78 n 5 May 1988 p 435-438.

## Diffusers

**087165 STUDIES ON DIFFUSER OF MIXED FLOW PUMP.** For the purpose of improving performance of a mixed flow pump, it is necessary to investigate not only an impeller but also a diffuser. The latter, however, has been investigated scarcely. Thus, in this report, the performance and internal flow of the mixed flow diffuser with vanes were clarified. The following conclusions were mainly derived. (1) The outlet flow angle is nearly constant under the range of the incidence angle  $-20^\circ < i_n < 0^\circ$ . (2) The pressure recovery coefficient becomes the maximum at  $i_n = 2^\circ$  approx. (3) The flow loss, however, take the minimum value at the negative incidence angle  $i_n = -20^\circ$  approx.  $-10^\circ$ , as the flow separation on the pressure surface is suppressed well by the secondary flow which runs toward its surface. (4) It is possible to predict the main flow using the presented



quasi-three-dimensional analysis, when a large separation does not occur on the vane surface. (Edited author abstract) In Japanese. 19 refs.

Toyokura, Tomitaro; Kanemoto, Toshiaki; Hayashi, Tomoyuki. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 496 Dec 1987 p 3672-3681.

**087166 INFLUENCE OF THE SUCTION SIDE DIFFUSER GEOMETRY ON THE PERFORMANCE OF RADIAL IMPELLER PUMPS.** The onset and spatial extension of impeller eye vortex of radial impellers depend both on the impeller geometry and the intake conditions. In a series of tests the influence of the ratio of impeller hub to impeller eye and diffusers of different lengths located upstream the impeller eye on pump performance were investigated. Of particular interest were the power consumption at shut off head, cavitation behaviour, and the inception point and length of the part load vortex. (Author abstract) 2 refs.

Amann, P. (KSB, Frankenthal, West Ger); Hergt, P.; Jaberg, H. *KSB Tech Ber* n 23e Mar 1988 p 3-8.

## Earthquake Resistance

**087167 SEISMIC RELIABILITY ANALYSIS OF VERTICAL PUMPS.** This paper deals with the evaluation of cumulative damage of the shaft of the vertical pump subjected to earthquake excitation. First, the friction force between the wearing and the impeller due to the breaking of water film is measured by experimental apparatus. Second, the fluid force between the impeller and the wearing is derived from Bernoulli's equation and is represented by a nonlinear equation containing added mass, added damping and added spring terms. Third, the equation of motion is derived and is integrated by Newmark's  $\beta$  method. Fourth, the torsional moment due to impact is calculated. Then, the maximum shear stress of the shaft is counted by both rain flow method and hysteresis loop method in order to estimate the cumulative damage, and the probability of the failure of the shaft is evaluated. (Author abstract) 6 refs. In Japanese.

Iwatsubo, Takuzo; Misawa, Yoshihisa. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 500 Apr 1988 p 882-889.

**Efficiency** See Also HEAT EXCHANGERS—Cooling; PUMPS, CENTRIFUGAL—Performance.

**087168 APPLICATION OF NUMERICAL METHODS IN DEVELOPMENT OF PALMIET PUMP-TURBINE.** The efficiency of the Palmiet pump turbine was improved through the application of an integrated numerical system. The article explains the procedure used on a low speed pump turbine with a head of 300 m and output of 250 MW. Principal results of the preliminary computation are compared with model measurements. The procedure was applied to the Palmiet pumped storage plant, South Africa. 5 refs.

Klemm, D. (J.M. Voith GmbH, West Ger); Schilling, R. *S Afr Mech Eng* v 37 n 9 Sep 1987 p 436-439.

**087169 UNIQUE ASPECTS OF PUMP EFFICIENCY.** It is often much more economical to buy a more expensive pump if it has a higher efficiency. In fact, cases are known in which a difference of 1% in efficiency has proven to be equal to the cost of the pump itself. Examples show that by considering piping, operating range and mechanics, a more efficient pump may not have a lower operating cost. 4 refs.

Yedidiah, S. *Hydrocarbon Process* v 66 n 10 Oct 1987 p 37-38.

**087170 PERFECTING PUMPS.** The article reviews some recent product releases designed to help users save energy and get more out of their pumping systems. For example, the SPP Control's system uses a thermodynamic method to determine pump losses. By taking direct measurements of the head change and the temperature rise in the pumped fluid, the system is able to give efficiency readings with a repeatability on the order of one percent-

age point, depending on the differential head. Identifying pumping equipment which is working at low efficiency enables maintenance work to be carried out in a cost effective manner.

Briggs, Ray. *Process Eng (London)* v 68 n 9 Sep 1987 p 83.

**087171 PUMP EFFICIENCY MONITORING IN THE WATER INDUSTRY.** In the UK the percentage of pumping plants operating unattended is steadily increasing as more telemetry and local automatic control systems are installed. This growing trend towards automatic operation while improving operational flexibility will have the undesirable effect of increasing the number of incipient faults which remain undetected, resulting in: (1) The increased likelihood of unexpected failure or breakdown. (2) Increased incidence of inefficient pump operation. This article is concerned with the latter point and in particular the measurement of pump efficiency on site. 9 refs.

Moore, Tim (BHRA, Cranfield, Engl). *Meas Control* v 21 n 4 May 1988 p 119-122.

## Ejectors

**087172 FORCED MIXER LOBES IN EJECTOR DESIGNS.** An experimental study was conducted at Western New England College to investigate the benefits of using forced mixer lobes in low-pressure ratio, ejector/diffuser systems. The results show over a 100 percent increase in both pumping and thrust augmentation when compared with conventional ejector designs. The test results also indicate that forced mixer lobes result in nearly complete mixing in very short ejector duct lengths and allow the use of aggressive diffuser designs without resulting in stall. The testing was conducted using an existing rectangular wind tunnel at Western New England College. The pumping capabilities of an ejector/diffuser system were investigated in the wind tunnel using three forced mixer lobe contours and a free splitter. The three lobe contours included high- and low-penetration symmetrical lobes and a state-of-the-art unsymmetrical lobe designed from turbofan jet engine application. (Edited author abstract). 13 refs.

Presz, Walter M. (United Technologies Research Cent, East Hartford, CT, USA); Morin, Bruce L.; Gousy, Robert G. *J Propul Power* v 4 n 4 Jul-Aug 1988 p 350-355.

**Electric Drive** See Also ELECTRIC MOTORS, INDUCTION.

**087173 TWO-MOTOR ELECTRIC DRIVE FOR PUMPS, FANS, AND COMPRESSORS.** The power of the contactless commutator in a two-motor asynchronous electric drive with pulse control in the circuits of the rotors is analyzed; the drive is intended for pumps, fans, and compressors operating on the centrifugal principle. The desirability of using a combination connection of rectifiers is validated and the circuit of a two-motor electric drive is given. (Author abstract) 7 refs.

Sokolov, M.M.; Kopyrin, V.S.; Shreider, Ya.I.; Patrik, A.A. *Sov Electr Eng* v 57 n 5 1986 p 57-60.

**087174 PERFORMANCE OPTIMIZATION OF INDUCTION MOTOR-PUMP SYSTEM USING PHOTOVOLTAIC ENERGY SOURCE.** The optimization of a photovoltaic pumping system based on an induction-motor-driven pump that is powered by a solar array is presented. The motor-pump subsystem is analyzed from the point of view of optimizing the power requirement of the induction motor, which has led to an optimum  $v-f$  relationship, useful in controlling the motor. The complete pumping system is implemented using a dc-dc converter, a three-phase inverter, and an induction motor-pump set. The dc-dc converter is used as a power conditioner and its duty cycle is controlled to match the load to the array. A microprocessor-based controller is used to carry out the load-matching. 5 refs.

Bhat, S.R. (Indian Inst of Science, Bangalore, India); Pittet, Andre; Sonde, B.S. *IEEE Trans Ind Appl* v IA-23

n 6 1987 p 995-1000.

**Energy Conservation** See COOLING TOWERS—Design.

**Energy Utilization** See DIESEL ENGINES—Cooling.

**Erosion** See SLURRY PIPELINES—Pumps.

**Evaluation** See PETROLEUM GAS, LIQUEFIED—Measurements.

**Failure** See HYDRAULIC MACHINERY—Maintenance.

**High Temperature Applications** See NUCLEAR POWER PLANTS—Pumps.

**Hydraulic Drive** See Also CONCRETE CONSTRUCTION—Pump Placing; DREDGES—Performance.

**087175 HYDRAULIC PUMP-ACCUMULATOR DRIVES.** In automatic molding lines, use is made of hydraulic pump accumulator drives with a constant system pressure maintained by a set of pumps and an accumulator. This article describes an hydraulic system for an automatic molding line. The pumps can be switched off when the accumulator is full. Peak loads are covered by the system, since the accumulator volume provides a maneuvering reserve and the motor ratings can be lowered. Hydraulic shock effects are minimized.

Bodanskii, I.M.; Butovskii, E.L.; Vestfrid, V.V.; Kellerman, Yu.I. *Sov Cast Technol* n 10 1986 p 43-45.

## Impellers

**087176 CAVITATION ASPECT AND FLOW PATTERN IN AN AXIAL-FLOW IMPELLER.** The relationship between pump performance and flow pattern under cavitating conditions was investigated using an axial-flow impeller. The flow pattern at the impeller outlet shows a remarkable change due to cavitation. Change in the pump head and the shaft power curves are closely related to the extent of cavitation growth on the suction side of the blades. The change in performance curves due to cavitation is caused by the change in the theoretical pump head brought about by the change in the flow pattern rather than by an increase of impeller loss. Near the tip section, the blade element efficiency shows a marked decrease with cavitation growth. (Author abstract) In Japanese. 11 refs.

Saito, Sumio. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 492 Aug 1987 p 2483-2491.

**087177 FLEXIBLE ANSWER TO PUMPING PROBLEMS.** The principal attractions of the flexible impeller pump include a true self-priming operation, a gentle pumping action with sensitive products, the ability to handle both liquids and solids, from water to viscous products with almost equal efficiency and the displacement of air or gas without re-printing. In addition the flexible impeller pump is easy to maintain and replacement parts are inexpensive. Limitations in terms of pressure and temperature make it generally unsuitable for process applications but it is regarded as the ideal answer for all liquid transfer duties. The author describes the areas of application of flexible impeller pumps where its advantages are not yet fully recognized.

Ford, Eric (ITT). *World Pumps* v 52 n 2 Mar-Apr 1988 p 389.

## Lining

**087178 POURED ANTI-FRICTION LINERS FOR RADIAL BEARINGS IN WATER PUMP BODIES.** The radial bearings used in water pumps are in short supply in the USSR. With a view to extending their useful life, the authors studied the production of steel half-shells with a poured lining of anti-friction alloy. The process consists of melting the alloy, preheating the shells in an induction furnace to the required pouring temperature, tinning the bearing surface, and pouring the babbit. The selected alloy was grade B83 babbit containing 10-12% Sb



and 5.5-6.5% Cu in a tin base.

Muinov, A.M.; Sadullaeva, T.M. *Sov Cast Technol* n 7 1987 p 79-80.

## Maintenance

**087179 CUSTOMER ACCESS KEY TO HYDRAULIC DISTRIBUTION.** In 1983, after perceiving a gap in the independent service market, Sundstrand Sauer decided to expand its existing network of authorized service centers. The existing centers located throughout North America did not provide end-user customers with a sufficiently 'close by' repair capability, the company felt. Sundstrand-Sauer established a formal program encompassing a worldwide network of distributor authorized service centers (DASCs) made up of company distributors. The program is signed both by distributor management and by Sundstrand-Sauer management. This article reviews the structure of the service center arrangement.

Anon. *Diesel Prog North Am* v 54 n 7 Jul 1988 p 14-15.

**Manufacture** See Also OIL FIELD EQUIPMENT—Pumps.

**087180 ROBOT-BASED SECTION FOR MANUFACTURING FLANGES.** Continuous efforts are made to eliminate monotonous and strenuous physical labor and to reduce the number of workers. These efforts are in two directions. The first is to develop robot-based technological cells (RTC). The second direction is to introduce robot-based technological units. The nature of the operation of the RTS and its individual parts is described. The working of each element of the section is also described.

Eranov, G.G.; Mangushev, Kh.A. *Chem Pet Eng* v 22 n 9-10 Sep-Oct 1986 p 469-471.

**087181 QUALITY AND SAFETY ARE MARKET-LED REQUIREMENTS.** IIT-Jabsco is a manufacturer of a range of pumps from flexible impeller types to lobe and drum pumps. The company has found that assured quality and safety are vital in their market. The assurance process starts in the design phase.

Anon. *Prod Eng (London)* v 66 n 10 Nov 1987 p 17-18.

**087182 DEMARCATION: HOW TO BREACH THE BARRIERS.** A 50% reduction in reworking faulty products has been achieved at Weir Pumps since the introduction of a self-inspection scheme less than a year ago. The improvement represents a drop from 10 to 5% in the time that direct labor spends bringing components into tolerance. But the benefits go beyond that, to include reduced problems in assembly and less field service work. The introduction of the self-inspection scheme completes a program, started 3 1/2 years ago, to achieve flexible working practices. It is the most recent of several ways in which the Glasgow-based company has sought to maintain its position as a leading manufacturer of pumping machinery and associated equipment. Others include investment in user-friendly CNC machine tools, the application of just-in-time manufacturing principles, and the introduction of flexible allocation of men and machines within and across product groups.

Anon. *Mach Prod Eng* v 146 n 3730 Jan 15 1988 p 41-44.

**087183 TWIN-CELL IBEX CAN PUMP UP THE VOLUME, EASILY.** Ibex Pumps of Hastings supplies the process industries world-wide with several thousand positive displacement pumps each year. Ibex has adopted a flexible production system by investing heavily in CNC. This article discusses the flexible production system.

Knutton, Peter. *Mach Prod Eng* v 146 n 3739 May 20 1988 p 43.

**Materials** See CAST IRON—Additives; COPPER ZINC LEAD MANGANESE ALLOYS—Forging.

## Mathematical Models

**087184 PARAMETER SENSITIVITY ANALYSIS FOR THE DYNAMIC MODEL OF A VARIABLE DISPLACEMENT AXIAL PISTON PUMP.** Sensitivity analysis is applied to an investigation of the influence of parameters on the dynamics of a variable displacement axial piston pump. Since an exact mathematical model of piston pump is complex and highly non-linear, the investigation of its dynamic characteristics for the variation of the system parameters by changing separate parameter values in sequence becomes very ineffective. In this paper, a parameter sensitivity was employed to analyze the effects of the system parameters systematically. The analysis was done on the exact non-linear dynamic model of the pump system which is represented by fourth-order dynamics. Based upon the simulation results, the degree of each parameter and the justification of order reduction was discussed in some detail. (Author abstract) 9 refs.

Kim, S.D. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Cho, H.S.; Lee, C.O. *Proc Inst Mech Eng Part C* v 201 n 4 1987 p 235-243.

## Measurements

**087185 INSTRUMENT FOR MEASURING THE VAPOR CONTENT IN PUMP SUCTION LINES.** A capacitive method for quantitative determination of the vapor content of liquid  $N_2O_4$ , and an instrument embodying it are described. Results of experiments under laboratory and field conditions are presented. (Author abstract) 9 refs.

Yermashkevich, V.N. (Belorussian Acad of Science, Minsk, USSR); Khrutskiy, A.V.; Razorenov, V.D. *Heat Transfer Sov Res* v 19 n 6 Nov-Dec 1987 p 137-143.

## Mechanical Drive

**087186 ECONOMICAL PUMP OPERATIONS THROUGH SPEED-CONTROLLED DRIVES.** In order to be able to meet part load starting and other technological conditions, it is often essential to control or vary pump speed. There are many alternatives of speed control and this article examines how, by varying pump speed, the efficiency and operating behavior of a pump can be almost ideally adapted to various deliveries.

Fechner, G. (Voith Turbo GmbH, Crailsheim, West Ger). *World Pumps* Jun 1987 p 176-177.

**087187 APPLICATION OF VARIABLE SPEED TO CENTRIFUGAL, OUTWARD-FLOW OR AXIAL-FLOW PUMP DRIVES.** This article discusses the main advantages from the application of speed variation to centrifugal outward flow or axial flow drives. Pump performance, efficiency and applications are discussed.

Vovard, J. (Jeumont-Schneider, Fr). *World Pumps* Jul 1987 p 202-205.

**Medical Applications** See Also BIOMEDICAL ENGINEERING; BIOMEDICAL ENGINEERING—Cardiovascular Surgery; DRUG PRODUCTS—Controlled Delivery; PROSTHETICS—Artificial Organs.

**087188 METHOD FOR TESTING VOLUMETRIC PUMPS.** This article describes a convenient method of checking the delivery rate of volumetric pumps at low flow rate settings. The method employs a tester previously described for use with syringe pumps. (Author abstract) 10 refs.

Nieman, M. (West of Scotland Health Boards, Glasgow, Scotl); Evans, A.L.; Steele, J.D. *J Med Eng Technol* v 11 n 4 Jul-Aug 1987 p 177-181.

**Performance** See Also COMPRESSORS—Reviews; FLOW OF FLUIDS—Viscous; FLUIDIC DEVICES—Performance; TURBOMACHINERY—Impellers.

**087189 PUMPS FOR DRILLING DEEP DRAINAGE WELLS.** A discussion is presented relative to the design and commercial production of new pumps and

improving the commercially produced borehole and deep-well drilling monoblock pumps for land reclamation purposes. Operational experience of borehole drilling pumps under vertical drainage conditions showed that the main factor affecting their reliability is the presence of suspended impurities in the water. To overcome this problem, the pumps are fitted with devices restricting the inflow of suspended impurities into the cavities of the pump and motor bearings. An outstanding feature of pumps used for vertical drainage is their low head and the small number of stages. As a rule, they have one, more rarely two, stages. It is shown that the reliability of pumps under conditions of vertical drainage should be examined with allowance for the operational conditions and the structural quality of the well.

Kirienko, P.I.; Chernyi, A.P.; Yurov, G.I. *Chem Pet Eng* v 22 n 9-10 Sep-Oct 1986 p 424-426.

**087190 REYNOLDS NUMBER EFFECTS ON REGENERATIVE PUMP PERFORMANCE.** Reynolds number effects on the performance of a conventional design regenerative pump were investigated, using glycerine-water mixtures, between an impeller tip speed Reynolds number,  $Re_T$ , of  $5 \times 10^3$  (all glycerine) and  $1.6 \times 10^6$  (all water). Results show that the maximum efficiency,  $\eta_m$ , can be expressed in terms of an output to loss ratio,  $\eta_m/1-\eta_m$ , which varies as  $Re_T^{0.203}$  for  $2.0 \times 10^4 < Re_T < 1.6 \times 10^6$  and as  $Re_T^{-1.156}$  for  $Re_T < 2.0 \times 10^4$ . These results are consistent with efficiency behavior reported in similar investigations on other types of turbomachines. Further, the design point flow coefficient increased over the range of Reynolds number investigated, while the design point head coefficient exhibited a maximum within this range. (Edited author abstract) 18 refs.

Hollenberg, J.W. (Cooper Union, New York, NY, USA). *J Eng Ind Trans ASME* v 109 n 4 Nov 1987 p 392-395.

**087191 PERFORMANCE ANALYSIS OF A NEW CONCEPT VISCOUS PUMP.** A new concept of a viscous pump is described and the pump performance is analyzed. A linear relation is found between the flow rate and discharge pressure. Optimization of the pump geometry for maximum flow rate is presented. The potential of the new pump is demonstrated by numerical examples for general and medical applications. Finally the effect of misalignment tolerances on pump performance is discussed. It is found that under the maximum possible misalignment flow rate is reduced by no more than 30 percent and discharge pressure by less than 54 percent. (Author abstract) 12 refs.

Etsion, I. (Technion, Haifa, Isr); Yaier, R. *J Tribol Trans ASME* v 110 n 1 Jan 1988 p 93-99.

**087192 ANALYTIC MODEL FOR PUMP PERFORMANCE IN CONDENSABLE TWO-PHASE FLOWS.** A versatile model based on first principles - now incorporating condensation and compressibility effects - predicts PWR pump performance under two-phase flow conditions. Capable of replacing the largely empirical models in such codes as RETRAN and RELAP, the new model overcomes deficiencies and eliminates uncertainties of the earlier models. The analytic model identified several factors that contribute strongly to pump performance degradation under two-phase flow conditions: acceleration of liquid as it flows through blades at the impeller exit, slip velocity between the liquid and vapor phases, and void fraction. The model's numerical prediction of pump head and torque degradation compared favorably with experimental data. In addition, the model identified vapor condensation as an ameliorating factor for pump performance. (Edited author abstract)

Anon. *Electr Power Res Inst Rep EPRI NP* 5529 Nov 1987 284p.

**087193 COMPARATIVE STUDY ON THE PERFORMANCE OF COIL PUMP WITH SINGLE INLET, TWO INLETS AND THREE INLETS.** In an earlier paper, the details of construction, methods of



testing and experimental results were presented for a single inlet rotating coil pump. In the present work, a concept of multiple inlets is instituted. Results of the performance of a coil pump with three inlets, two inlets and a single inlet are compared. Better performance in terms of lift and flowrate may be obtained by increasing the number of coils and increasing the number of inlets. 1 ref.

Ling, F.F. (Univ of Malaya, Kuala Lumpur, Malays); Ter, H.C.; Ng, H.C. *Int J Mech Eng Educ* v 16 n 2 Apr 1988 p 135-139.

## Pistons

**087194 RESEARCH ON A NEW TYPE OF AXIAL PISTON PUMP: AN OPEN CHANNEL AXIAL PISTON PUMP.** This paper presents a new principle for piston pumps, which possesses many advantages, such as those of being 'without a leakage line', being self-cooling and self-lubricating, and having multiway output, high pressure, high efficiency, long service life, light weight, simplicity of structure, ease of operation, and energy saving features, and it could be used to make new pumps with performances different from those of axial piston pumps now widely being used. It is proved through the test that the open channel piston pump is feasible in theory, reliable in operation and superior in performance. (Edited author abstract) 5 refs. In Chinese.

Wen, Desheng (North-East Heavy Machinery Inst, China). *Chi Hsieh Kung Ch'eng Hsueh Pao* v 23 n 2 Jun 1987 p 74-77.

**087195 CONTROL METHOD FOR HYDRAULIC RECOIL OF AXIAL PISTON PUMPS.** This paper analyzes and investigates the method of resistance to hydraulic impulse of oil distribution for some typical axial piston pumps, and gives relevant calculation formula. This is valuable for designing and studying axial piston pump with a new construction for resistance to hydraulic impulse of oil distribution. (Author abstract) 3 refs. In Chinese.

Na, C.; Wang, J. *Jichuang Yu Yeya* n 1 1986 p 29-40.

Plastics Applications See PLASTICS—Welding.

## Pressure Measurement

**087196 INTERIOR PUMP PRESSURE LOSS.** The article addresses the problem of fire departments when delivering the desired flow through a single outlet using large diameter supply hoses. The phenomenon is described using the air pressure and centrifugal pump as examples. Pressure build-up inside the pump may be the answer to the puzzle of vanishing pressure at the discharge.

Collier, Herman E. (Orlando Fire Dep, Orlando, FL, USA). *Fire Eng* v 140 n 12 Dec 1987 p 12.

## Quality Control

**087197 EXPERIENCE IN THE NONDESTRUCTIVE QUALITY CONTROL OF CAST PUMP HOUSINGS.** Several difficulties were encountered on adopting a nondestructive quality control system for thick-walled pump castings made from grade 00Kh12N3DL steel. They were inspected from the internal surface, after grinding to a surface roughness  $R_a = 6.3 \mu m$  (GOST 2789-73) for ultrasonic inspection, or  $R_a = 3.2 \mu m$  for color defectoscopy. The instruments used were type UDM-3 and DUK-66PM defectoscopes, as instructed by NPO TsNIITmash. Their sensitivities were adjusted on the basis of cast stepped specimens, after completing the entire production process along with the castings. The instrument sensitivities were additionally checked by comparison with ARD diagrams. It has been decided to use the UDM-3 defectoscope in the future, since it is more sensitive than the DUK-66PM type.

Pron, N.I.; Ogorodnii, V.G. *Sov Cast Technol* n 3 1986 p 71-72.

Reliability See Also COMPRESSORS—Diaphragms; OIL FIELD EQUIPMENT—Pumps.

**087198 FITNESS FOR PURPOSE - A SYSTEM DESIGN CONCEPT.** This article discusses how quality which is synonymous with fitness for purpose is achieved. A number of steps are specified and various aspects on life cycle cost and total cost of the product are discussed. Availability, reliability and maintainability are basic steps in the design process with reliability expressed in numerate statistical terms. The use of quality assurance levels is recommended to achieve realistic targets, depending on the duty and not only safety, particularly to ensure an appropriate economic return. (Edited author abstract) 19 refs.

Schwarz, K.K. *World Pumps* Sep 1987 p 263-267.

Reviews See Also OIL WELL PUMPING—Equipment.

**087199 HANDLING KAOLIN SLURRY.** A transportation package provided by Canadian Pacific Ships to Repap Enterprises Corporation of Canada has been in operation for over a year, demonstrating major cost advantages over alternative rail transport methods. A specially adapted ro-ro liquid bulk vessel transports kaolin (china clay) slurry from Savannah, Georgia to Repap's new Miramichi paper mill in New Brunswick. Five Mono Flexshaft SLR pumps provide both rapid cargo discharge at the quayside and critical re-circulation at sea to prevent settling. This article reviews design features of the pumping system. A second feature reviews twin elevator system for handling pallets in a speedy and expeditious manner. A third subject deals with the design of a transfer crane for a new floating fish factory. Special features of the crane permit the safe transfer of goods and personnel in open-sea conditions.

Anon. *Mar Eng Rev* Jun 1988 p 29-30,32.

Seals See Also SEALS—Fluid Dynamics; SEALS—Materials; SEALS—Performance.

**087200 MECHANICAL SEALS IN PAPER AND PULPING.** Mechanical seal leakages are considerably less than soft-packed glands. In many cases there is no apparent leakage whatsoever and generally a leakage of 0.002 lit/h is typical. With the development of seals capable of dealing with the problems imposed by the various liquids encountered in the paper and pulp industry, the substitution of mechanical seals for soft packings offers considerable savings in energy consumption. Mechanical seals operate for a considerably longer period of time and in some applications two to three years is quite common, without maintenance.

Anon. *World Pumps* Sep 1987 p 271.

**087201 FACE SEAL WITH CIRCUMFERENTIAL PUMPING GROOVES AND RAYLEIGH-STEPS.** This paper presents an analysis of a new noncontacting pumping seal. A hydrodynamic lubricating film is maintained due to Rayleigh-steps. If the low pressure side of the seal is filled with a fluid, the fluid can be pumped into the high pressure side by pumping grooves until the shaft speed reaches a limit value. The experimental results confirm the theoretical predictions for lubrication and sealing performance. Due to the high pumping ability in addition to the high stiffness of its hydrodynamic film, the seal can operate without wear and leakage for a high pressure fluid. (Author abstract) 5 refs.

Ikeuchi, K. (Kyoto Univ, Kyoto, Jpn); Mori, H.; Nishida, T. *J Tribol Trans ASME* v 110 n 2 Apr 1988 p 313-317.

**087202 ANALYSIS OF 'RINGING' PHENOMENA IN A WATER PUMP MECHANICAL SEAL (PART II).** It was shown in previous papers that the ringing sound in a water pump seal is generated by 'stick-slip' attributed to both the lubrication characteristics of the sealing surfaces and also the torsional vibration characteristics of component parts. Later, it was found that ringing can be classified into two types of acoustic sounds. One is a higher-frequency sound caused by the torsional vibration characteristics of the rotating parts. The other is a

lower-frequency sound related to the natural frequency of the stationary parts of the seal. This paper presents an experimental analysis of the lower-frequency sound caused by the torsional vibration of the stationary parts, and the theoretical background of the higher- and lower-frequency characteristics is analyzed. (Edited author abstract) 4 refs.

Kiryu, Kenji (Eagle Industry Co, Takahashi, Jpn); Yonehara, Yoshimitsu; Matsumoto, Sotosuke; Koga, Tadashi. *Tribol Trans* v 31 n 2 Apr 1988 p 269-275.

**087203 POSITIVE APPROACH TO HYDRAULIC PUMP SEALING.** The author describes seal designs which have achieved near-zero leakage. Radial shaft seals and mechanical face seals are described. A better understanding of design, CAD/CAM design technology, better methods of manufacture and improved materials will lead to a near perfect model in the near future.

Anon (Freudenberg Simrit Ltd, Leicester, Engl). *Power Int* v 34 n 394 Apr 1988 p 76-77.

**087204 EXPERIMENTAL STUDY ON THE STATIC AND DYNAMICS CHARACTERISTICS OF SCREW GROOVED SEALS.** Screw grooved annular seals are used in many heavy duty pumps such as boiler feed pumps. These annular seals have a significant effect on rotordynamics characteristics of the pumps. Studies on the dynamic characteristics of plain and circumferentially grooved annular seals have been published by many researchers. However, published works on screw grooved seals are few, and pump designers have not fully recognized the basic characteristics of screw grooved seals. Extensive experimental studies have been conducted for determining the basic characteristics of screw grooved seals. The leakage characteristics, load capacity, and dynamic characteristics for rotordynamic analysis were determined by using a specially designed test facility and test method. (Edited author abstract). 11 Refs.

Kanki, H. (Mitsubishi Heavy Industries Ltd, Takasago, Jpn); Kawakami, T. *J Vib Acoust Stress Reliab Des* v 110 n 3 Jul 1988 p 326-331.

**087205 INVESTIGATION INTO A MODIFIED PORT-PLATE SEAL OF AN AXIAL PISTON WATER PUMP.** The conventional design of an axial flow piston pump uses a port-plate face seal of an annular type at the interface between rotating and stationary parts. This paper describes a series of tests performed on a modified port-plate seal designed for use with water and run under varying conditions of pressure and flow. Certain phenomena emerge which may be attributed to the theory of elastic deformation applied to the sealing plate made from Tordon, a polymeric material. The application of axial load results in an inward transfer of flow for the existing seal design. (Author abstract). 9 Refs.

Webster, James (Univ of Strathclyde, Glasgow, Scotl); McGee, Joseph A. *Wear* v 127 n 1 Oct 1 1988 p 85-99.

**087206 INVESTIGATION INTO A MODIFIED PORT-PLATE-SEAL OF AN AXIAL PISTON WATER PUMP.** The conventional design of an axial flow piston pump uses a port-plate face seal of an annular type at the interface between rotating and stationary parts. This paper describes a series of tests performed on a modified port-plate seal designed for use with water and run under varying conditions of pressure and flow. Certain phenomena emerge which may be attributed to the theory of elastic deformation applied to the sealing plate made from Tordon, a polymeric material. The application of axial load results in an inward transfer of flow for the existing seal design. (Author abstract). 9 refs.

Webster, James (Univ of Strathclyde, Glasgow, Scotl); McGee, Joseph A. *Wear* v 127 n 1 Oct 1 1988 p 85-99.

## Selection

**087207 SELECTION FACTORS FOR PORTABLE PUMPS.** The most widely used portable pumps are the self-priming centrifugal, diaphragm, and submersible types. These pumps can be used in many ways: sump



pumping, dewatering construction sites, flood control, and implant transfer of corrosive viscous, or abrasive liquids. When self-priming centrifugal, diaphragm, and submersible pumps are not appropriate for the job, other options may include flexible impeller, gear, piston, plunger, progressive-cavity, peristaltic, lobe, screw and vane pumps. This article discusses pump characteristics, sample calculations, and other selection factors.

Foszcz, Joseph L. (Plant Engineering, Newton, MA, USA). *Plant Eng (Barrington Ill)* v 41 n 19 Oct 8 1987 p 42-48.

**087208 PUMP SYSTEMS & SELECTION CRITERIA FOR PUMPS.** This paper investigates the system and selection criteria for pumps. Pump duty point is a characteristic of Pump System Combination. The system resistance curve should not be too flat leading to high capital cost nor should it be too steep to cause high running cost. The pump characteristic curve should be as steep as possible but not too steep to cause maintenance problems. The pump duty point should preferably be selected left of best efficiency point, particularly when pumps are operating in parallel to ensure that the pumps always operate in the permissible operating zone. (Edited author abstract)

Koundinya, N.S. (Best & Crompton Engineering Ltd, Bombay, India). *J Indian Water Works Assoc* v 19 n 4 Oct-Dec 1987 p 269-273.

**087209 HOW TO BUY A PUMP: COSTS, RELIABILITY, AND EFFICIENCY.** This paper discusses the various parameters and components that should be considered before selecting a suitable pump for use in a paper and pulp mill. 14 refs.

Orr, David T (Orr's Words, Norcross, Ga, USA). *Tappi J* v 70 n 11 Nov 1987 p 180-182.

**Space Applications** See SATELLITES—Cryogenic Equipment.

## Stability

**087210 EXPERIMENTAL DETERMINATION OF THE DYNAMIC TRANSFER MATRIX FOR A PUMP.** Dynamic instability in pumping systems can be the cause of a wide variety of difficulties. Analytical investigations of the dynamic behavior of such systems depend on the proper mathematical model of the dynamic performance of the pump. This paper is concerned with the experimental means and analysis procedures for obtaining the transfer matrix representing the pump as a four-pole element. Direct measurement of the pulsating flow is omitted in favor of an indirect determination utilizing multiple pressure measurements in reference pipe sections attached to the pump. The method of parameter extraction from redundant experimental data, as well as the modeling by an equivalent electrical network is shown. (Edited author abstract) 17 refs.

Stirnemann, A. (Sulzer Brothers Ltd, Winterthur, Switz); Eberl, J.; Bolleter, U.; Pace, S. *J Fluids Eng Trans ASME* v 109 n 3 Sep 1987 p 218-225.

**087211 CHARACTERISTICS OF CALCULATING LOW-POWER ELECTRICAL IMPULSE PUMPS.** On the basis of the physical picture of the phenomena occurring in the working body during an electric discharge in electrohydrodynamic systems of the autonomous type, a method of calculating the region of stable operation of the system is proposed. On the basis of the proposed method the possibility of determining the parameters of a discharge circuit guaranteeing the reliable operation of an electrical impulse pump is shown, and an analysis of the effect of the circuit parameters on the region of stability is also given. (Author abstract) 3 refs.

Bugrov, A.N.; Kraev, M.V.; Nikitin, V.V. *Sov Surf Eng Appl Electrochem* n 3 1987 p 62-65.

## Strain

**087212 TAKING THE STRAIN OF HIGH PRESSURE PUMPING.** In critical applications such as petrochemical plants, offshore production platforms and nuclear power stations, bearings have to take the load. Horizontal flange mounted bearings have recently been developed to achieve substantial thrust capacity without the expense and bulk of a separate lubrication system. This article details the bearing design.

Anon. *World Pumps* Jul 1987 p 207.

**Submerged Motor** See Also DREDGES—Pumps; MINES AND MINING—Drainage; OIL FIELD EQUIPMENT—Pumps; SEWAGE PUMPING PLANTS—Retrofitting; TANKERS—Pumps.

**087213 SUBMERGED CARGO PUMPS: IDEAL FOR TOMORROW'S TANKER TRADES.** In the current climate of depression for both shipping and shipbuilding, the order book of Frank Mohn A/S, the Norwegian specialist in hydraulic submerged pumps and associated equipment, makes heartening reading. Product segregation, elimination of a pump room, pollution avoidance and general pump efficiency - even for crude carriers - are some of the benefits claimed for this liquid handling mode. This article reviews applications of this class of pump.

Anon. *Nav Archit* Sep 1987 p 295.

**087214 DESIGN AND APPLICATION OF MODERN SUBMERSIBLE MOTOR PUMPS.** Submersible motor pumps, traditionally used for dewatering and drainage, are now also found in industrial and service. These applications require adaptations to new service conditions. Design, motor explosion protection, and cooling system as well as monitoring of winding insulation resistance and shaft seal leakage of the motors are described. A comparison of the hydraulic performance of different impeller configurations, and materials of construction is proved. (Author abstract) 3 refs.

Heumann, A. (KSB, Pegnitz, West Ger). *KSB Tech Ber* n 23e Mar 1988 p 18-27.

**087215 FOUR 18-TON SUBMERSIBLE MOTOR PUMPS FOR THE REDEEN MINE.** For a new pumping station at a depth of 900 m four submersible motor pumps, each with a driving power of 2 MW and a weight of 18 tons, were supplied to Saarbergwerke AG. This report describes the water level control system in the mine, the reason for selecting submersible motor pumps and the special problems which arose during transport and installation of the long and heavy units in the mine.

Brueck, F. *KSB Tech Ber* n 23e Mar 1988 p 53-56.

**087216 NEW SUBMERSIBLE MOTOR PUMP TYPE AMA-DRAINER.** Submersible motor pumps are used by private households, municipal authorities, fire brigades, disaster control units, as well as in agriculture, the food industry, the chemical and metal-working industry etc. It is the strict division into individual modules forming self-contained functional units which makes the standardized modular design possible at all. The entire concept meets technical requirements by providing a light weight, handy design, which can be subjected to operation conditions more severe than the previous pumps. This was proven by extensive tests on twelve test pumps in continuous duty with intermittent loading over 5000 hours each, handling a 2% silica sand-water mixture at 65°C. (Edited author abstract)

Kochanowski, W. *KSB Tech Ber* n 22e Sep 1988 p 51-56.

**087217 KEEPING A HEAD OF PRESSURE.** The article discusses various types of pumps and pump applications in tunneling projects. Pump models from different manufacturers and their applications are described. The applications discussed include drainage, concrete pumping, dewatering, mucking pumps, and others.

Lock, Jim. *Tunnels Tunnelling* v 20 n 6 Jun 1988 p

75,77-78.

## Testing

**087218 LARGE-CAPACITY PUMP TEST HOUSE.** Pumps have to be tested to verify that the pumps as manufactured would demonstrate the performance characteristics as planned at the time of design. But, when the pumps are designed to deliver flow rates of the order of 40000 m<sup>3</sup>/hr, to be driven by drives of ratings of the order of 3000 kw often drawing from HT supplies of 1.8 kv (or higher up as 7.2 kv), it all becomes a huge and elaborate project to plan and commission a pump test house to test such large-capacity pumps.

Srivastava, R.K. (Worthington Pumps (India) Ltd, Calcutta, India). *J Indian Water Works Assoc* v 19 n 4 Oct-Dec 1987 p 305-309.

**087219 TESTING STUDY ON THE NEW TYPE VAPOUR-PRESSURIZING SOLAR PUMP.** A new type of vapor-pressurized solar water pump was developed. In this paper, the operation principle of the pump and its characteristics are described and analyzed. The test method is introduced. The test results indicate good agreement between calculations and measurements. (Edited author abstract). 3 Refs. In Chinese.

Du, Zhen-kao (Nanchang Energy Saving Technology Research Inst, China). *Taiyangneng Xuebao* v 8 n 4 Oct 1987 p 373-379.

## Vacuum Applications

**087220 SCROLL VACUUM PUMP.** Scroll machines have very good sealing characteristics, and the authors have attempted to develop a scroll vacuum pump. A rotating mechanism was employed instead of an orbiting mechanism from the point of view of load pattern and mechanical simplification. The axial and the radial sealing techniques were utilized. The radial sealing mechanism is particularly easy and effective due to the stationary seal line. A spiral with zero top clearance volume and a compact Oldham coupling were the other key technologies. Vacuums of 1 Pa (10<sup>-2</sup> Torr) for dry operation, and of 10<sup>-2</sup> Pa (10<sup>-4</sup> Torr) for oil flooded operation were achieved at 1 800 rpm. (Author abstract) 4 refs. In Japanese.

Morishita, Etsuo; Suganami, Takuya; Nishida, Mitsuhiro; Kitora, Yoshihisa; Yamamoto, Sakuei; Fujii, Kosaburo. *Nippon Kikai Gakkai Ronbunshu B Hen* v 54 n 498 Feb 1988 p 410-413.

**Valves** See Also PUMPS, RECIPROCATING—Wear.

**087221 MODIFICATION TO THE VALVE ON A NZHR PUMP FOR USE UP TO 3 kbar.** An improved ball valve for high pressures has been made by introducing an additional element of lenticular shape having the hardness of the ball. (Author abstract)

Polandov, I.N. (Moscow Univ, USSR); Kryukov, A.V.; Gulish, O.K.; Alekhina, N.S. *Instrum Exp Tech* v 30 n 3 pt 2 May-Jun 1987 p 740.

**087222 BALL-VALVE CONCRETE PUMPS.** More ball-valve pumps are in use than any other kind of concrete pump. Most are low-volume units with output capacities less than 30 cubic yards per hour. Although the small models are often called grout pumps, many can be used for structural concrete and shotcreting where low-volume output is suitable. They're used for repairing underwater concrete, filling fabric forms, placing concrete in heavily reinforced sections, and building bond beams for masonry walls. Some hydraulically driven models have pumped structural concrete at outputs exceeding 150 cubic yards per hour. The author explains how the ball valve works, describes pump drive mechanisms, and discusses pump safety.

Wilson, Francis C. *Concr Constr* v 33 n 2 Feb 1988 p 145-146, 148.



## Vanes

**087223 TORSIONAL FLUTTER OF GUIDE VANES IN PUMP STAGE OF PUMP-TURBINES.** This paper aims to yield a theoretical basis for the torsional flutter of guide vanes in the pump stage of pump-turbines. The guide vanes are assumed to oscillate torsionally about their axis with arbitrary intervane phase differences in the outward flow of pump stage. A theoretical analysis by the singularity method is developed for steady and unsteady flows of guide vanes under the assumption that the former is of finite order of magnitude compared with the latter of infinitely small order. Torsional flutter of guide vanes is shown to occur at low reduced frequency and for small valve opening for two intervane phase differences of  $90^\circ$  and  $270^\circ$ , and then some theoretical explanations are paid from notable features of unsteady pressure distributions and unsteady moment. (Edited author abstract) 9 refs. In Japanese.

Nishiyama, Tetsuo; Abe, Shinji; Takagi, Takeo. *Nippon Kikai Gakkai Ronbunshu B Hen* v 54 n 498 Feb 1988 p 322-329.

**087224 STABILITY AND REGULATION OF A VARIABLE-DISPLACEMENT VANE-PUMP.** Pressure fluctuations may develop in the hydraulic system of automatic transmissions, even under steady-state conditions. To analyze this phenomenon, a dynamic model was developed for a system which consists of a variable-displacement vane-pump, a regulator, and a resistive load. The model was linearized and reduced to generate a stability criteria for the pressure-regulation circuit. This criteria determines a critical frequency that the natural frequency of the pressure-regulation valve must exceed to assure stability. This critical frequency depends primarily on the damping of the spool of the pressure-regulation valve and on its position; the latter is a function of the regulation-chamber leakage characteristics. (Edited author abstract) 7 refs.

Karmel, A.M. (GM Research Lab, Warren, MI, USA). *J Dyn Syst Meas Control Trans ASME* v 110 n 2 Jun 1988 p 203-209.

**Vibrations** See Also PUMPS, CENTRIFUGAL—Cavitation; PUMPS, GEAR—Noise, Acoustic.

**087225 CASE HISTORY OF A VIBRATION PROBLEM IN A MULTISTAGE CRYOGENIC PUMP.** Vertical multistage pumps are designed to operate with long flexible shafts and many rotating stages in series, inside of flexible casing bundles and support structures. The vibrational characteristics of these pumps are complex. Modern experimental and analytical techniques may be required to troubleshoot such pumps. This applications article describes a combined experimental and analytical approach which led to the successful resolution of the severe vibration problem of a vertical multistage liquid nitrogen pump. (Author abstract) 4 refs.

Chang, C.M. (Union Carbide Corp, Tonawanda, NY, USA); Braun, F.W. *Lubr Eng* v 43 n 12 Dec 1987 p 916-922.

**087226 DIAGNOSING VIBRATION PROBLEMS IN VERTICALLY MOUNTED PUMPS.** This paper summarizes several recent efforts to develop and implement techniques to monitor and diagnose problems in submerged shaft vertical pumps. Projects based on iterative analytical and experimental efforts were implemented on several different types of vertical pumps typically found in power plants. This paper describes both the modeling and monitoring portions of these projects, including the 'lessons learned' in studying six vertically mounted pumps in operational power plants. (Author abstract) 15 refs.

Walter, T.J. (Mechanical Technology Inc, Latham, NY, USA); Marchione, M.M.; Shugars, H.G. *J Vib Acoust Stress Reliab Des* v 110 n 2 Apr 1988 p 172-177.

## Water Supply

**087227 VIBRATION PROBLEM OF LARGE CAPACITY PUMPS - A CASE STUDY.** Baghdad Water Supply Administration has executed Karkh Water Supply Scheme to provide drinking water to the population of over 3 million people of Baghdad City. Raw water is extracted from the River Tigris and is treated through the process of pre-settlement, clarification, filtration and disinfection. The treated water is then pumped over a distance of 40 kms through twin DI pipelines 2100/2300 dia from Treated Water Pumping Station to Reservoirs. The pumps for the TWPS for the 1st Stage of the Stream were commissioned in July 1985. On running of these pumps, excessive vibrations were noticed. This Paper brings to focus the phenomenon of vibration, its analysis and remedies effected to solve the problem.

Awasthi, J.P. (Continental Construction Ltd). *J Indian Water Works Assoc* v 19 n 4 Oct-Dec 1987 p 287-294.

## Wear

**087228 PROBLEM OF ADHESIVE WEAR OF PLUNGER-CYLINDER WALL FRICTION PAIR IN AXIAL PLUNGER PUMP AND ITS SOLUTION.** This paper sets up a mathematical model for calculating the thermal balance of a plunger-cylinder wall friction pair in an axial plunger pump, analyzes the cause of producing adhesive wear on the friction pair, and suggests a way to solve the problem. (Edited author abstract) 5 refs. In Chinese.

Song, J. *Jichuang Yu Yeya* n 6 1986 p 33-36.

**087229 WEAR IN A VANE PUMP.** The wear of vanes and a cam ring in a vane pump operating at high discharge pressure and high rotational speed is explained. The results of wear tests for different pump geometries and hydraulic fluids, are presented. In addition, it is shown that the occurrence of severe wear can be predicted from the film parameters and the value of PV. (Edited author abstract). 18 Refs. In Japanese.

Uneno, Hisanori (Kanazawa Univ, Kanazawa, Jpn). *J Jpn Soc Lubr Eng* v 33 n 6 1988 p 425-430.

## Wear Resisting

**087230 RAISING THE RESISTANCE OF MAINLINE PUMP PARTS TO HYDRAULIC ABRASION.** The surfaces of the working impellers, housings, and gasket recesses of mainline petroleum pumps are exposed to intensive wear from the abrasive action of the medium being pumped. In the interest of extending the service life of NM 2500×230 mainline pumps, we have performed experiments on reinforcing their gaskets and operating rotors with powdered mixtures based on boron carbide. It is shown that as the saturation temperature is raised from 900 to 1070°C, the content of graphite inclusions between the boridized layer and the base metal rises, and their cohesive strength drops as a result. The experimental results were confirmed by industrial tests on an NM 2500×230 centrifugal pump whose parts had been subjected to diffuse boridization; the pump's service life was raised by a factor of 2 to 2.5. Diffuse boridization in power mixtures has been put into production as a technological process. 3 refs.

Belousov, V.Ya.; Borisenko, V.V.; Zhuravlev, Yu.V. *Chem Pet Eng* v 23 n 5-6 May-Jun 1987 p 225.

## Welding

**087231 WELDING OF CRITICAL COOLANT PUMP COMPONENT - AN EXPERIENCE.** The welds in construction of components are required to pass various quality control tests almost ensuring zero defect level. Weldment as a whole also has to meet the critical dimensional requirements. Welding of one such component, the coolant pump shaft is discussed here. The results obtained on the job exceeded the expectations of all concerned. The experience of handling such jobs can induce more confidence in Indian equipment manufactur-

ers. The specifications involved may appear to be made with greater emphasis on safety, partly due to the cautious approach on part of makers of specifications.

Dakshinamurti, J.V. (D&H Secheron & Electrodes (P) Ltd, Madras, India). *Indian Weld J* v 19 n 1 Jan 1987 p 163-168.

**PUMPS, CENTRIFUGAL** See Also FLOW OF FLUIDS—Pumps; FLUE GASES—Desulfurization; WIND TURBINES—Design.

**087232 KREISELPUMPEN FUER RAUCHGAS-ENTSCHWEFELUNGSANLAGEN NACH KALKWASCHVERFAHREN.** [Centrifugal Pumps for Flue Gas Desulfurization Plants with Limestone Scrubbing Systems]. For the desulfurization of large power stations, flue gas desulfurization plants which apply limestone scrubbing systems are almost exclusively used. These plants make special demands on the scrubbing pumps which are needed for circulation of the chemically aggressive and mechanically wearing scrubbing suspension. In order to reach the required service life of at least 16000 operational hours, importance is attached to the hydraulic design, structural configuration and the selection of suitable corrosion- and wear-resistant materials. The article discusses materials of pump construction. In German. 7 refs.

Kratzer, A. *Brennst Waerme Kraft* v 39 n 1-2 Jan-Feb 1987 p 37-41.

**087233 NEW MARKET FOR CENTRIFUGAL PUMPS.** The author has outlined the present 'state of play' regarding the role of centrifugal pumps in modern industrial processes. The main factors affecting pump performance are discussed. Centrifugal and positive displacement pumps are compared. A discussion is also presented of the two major markets: the oil and gas industry and biotechnology. 6 refs.

Hughes, Simon (BHRA, Cranfield, Engl). *Chem Eng (London)* n 436 May 1987 p 40-42.

**087234 EFFECTS OF EXTERNAL MAGNETIC-FIELD PATTERNS ON THE CHARACTERISTICS OF A CENTRIFUGAL CONDUCTION PUMP.** It is usually assumed that the external magnetic field is homogeneous in research on unclosed MHD rotations in cells of a centrifugal conduction pump (CCP). In a real CCP, the constraints on the dimensions of the electromagnet mean that the magnetic field is usually very inhomogeneous, and that inhomogeneity can, in particular, be used to control the MHD flow, although so far no study of such effects has been made. We examine the effects of an axisymmetric external-field distribution. We also give measurements. 2 refs.

Muizhnieks, A.R.; Platonov, V.I.; Platonova, L.A.; Yakovich, A.T. *Magnetohydrodynamics* v 23 n 2 Apr-Jun 1987 p 208-210.

## Analysis

**087235 METHOD OF APPROXIMATE CALCULATION OF THE CHARACTERISTICS OF A CENTRIFUGAL CONDUCTION PUMP IN A NONZERO DISCHARGE REGIME.** Along with experimental and theoretical investigations of the internal structures of flows in cells of the centrifugal conduction pump (CCP) type the development of engineering methods of calculating the integral characteristics of a CCP is of interest. However, in connection with the turbulent character of the flow metal in the cell it is usually necessary to use empirically determined constants. An approximate method is proposed in this work for calculating the characteristics of a CCP in regimes with a large discharge, in which eddy viscosity is not considered and thereby empirical constants are not used. 4 refs.

Muizhnieks, A.R.; Platonov, V.I.; Platonova, L.A.; Krylov, Yu.A. *Magnetohydrodynamics* v 22 n 4 Oct-Dec 1986 p 426-430.



Applications See POWER GENERATION—Pumps.

Blades See DRAINAGE—Pumping Plants.

## Cavitation

**087236 DETECTION OF CAVITATION EROSION IN CENTRIFUGAL PUMPS.** This paper presents a method in which the minimum NPSH that a centrifugal pump can operate without risks of erosion can be deduced. It has been recognized that cavitation erosion can only be induced when vapor bubbles collapse near the boundary concerned. Presented in this paper are the results of experiments carried out on a centrifugal impeller in a closed circuit, which show that below the critical NPSH the erosion rate first increases, then decreases, and finally increases for a decreasing NPSH. (Author abstract) 4 refs.

Chan, W.K. (Nanyang Technological Inst, Singapore). *Int J Heat Fluid Flow* v 9 n 1 Mar 1988 p 74-77.

**087237 CAVITATION-EROSION IN CENTRIFUGAL PUMPS.** Cavitation is a complex phenomenon which is dependent on a multiplicity of physical parameters. In spite of intensive, world-wide research, material loss rates brought about by cavitation-erosion in pumps have not, up to the present, been calculated in advance to any useful extent. However, Sulzer has obtained good results through the systematic evaluation of experience gained from actual installations, coupled with a new calculation method. (Author abstract) 10 refs.

Gulich, J.F.; Rosch, A. *Sulzer Tech Rev* v 70 1 1988 p 28-32.

**087238 CAVITATION STUDIES OF CENTRIFUGAL PUMPS.** This presentation relates to the cavitation studies on centrifugal pumps wherein loss of performance and noise and vibration effects were evaluated experimentally together with visual observations. The details of the five experimental pumps (designated as IMP0, IMP1, IMP2, IMP3 and IMP4) employed for the investigation are presented together with typical results obtained. The 5 pumps were obtained by changing the impeller alone in the same casing. IMP0 was designed for a different set of data compared to the other impellers. IMP1, IMP2 and IMP3 have the same dimensions but have different number of vanes. IMP4, designed for the same data as that of IMP1, IMP2 and IMP3, has a different geometry. First, the cavitation-free performance of the five pumps were determined at various speeds. The points of optimum efficiency were then found out. 4 refs.

Kumaraswamy, S. (Indian Inst of Technology, Madras, India); Radha Krishna, H.C. *Irrig Power* v 45 n 1 Jan 1988 p 99-116.

## Control

**087239 PENNY WISE OR PUMP FOOLISH?** There are two ways to adjust the output of a centrifugal pump or fan. One can install a throttling device to vary the amount of flow, or one can control the speed of the impeller with an adjustable-speed drive. It is shown why it is more economical in the long run to install a variable speed drive instead of a cheap throttling device. The variable speed drive saves energy. Examples of calculations are given.

Rohan, Carolyn (Power Transmission Design, Cleveland, OH, USA). *Power Transm Des* v 30 n 4 Apr 1988 39-41.

## Corrosion Protection

**087240 PLASTIC PUMPS FOR CHEMICALS AND WASTES.** This article, describes some of the industrial pumps designed for coping with hostile and abrasive media. Centrifugal, pump and rotary models are described, with an example of each in a typical installation. (Edited author abstract)

Anon (Vanton Pump & Engineering Co, Hillside, NJ, USA). *World Pumps* n 11 Nov 1987 p 357-358.

## 087241 CENTRIFUGAL PUMPS FOR FLUE-GAS

**DESULPHURIZATION PLANTS USING THE LIME WASHING PROCESS.** Flue gas desulfurization large scale power stations is an aggressive and abrasive process. The author describes the demands made on scrubber pumps that influence their selection and the choice of materials of construction. (Author abstract) 8 refs.

Kratzer, A. (Klein Schanzlin & Becker AG). *World Pumps* n 11 Nov 1987 p 363-367.

## Design

**087242 PUMP BYPASSES. NOW MORE IMPORTANT.** Discoveries during the past two decades show that it is important to install automatic bypasses on many large centrifugal pumps. The advantages of utilization of bypasses are covered. Other topics discussed include stable pumping, bypass flow, and stable fluid flow. 12 refs.

Taylor, Irving (Bechtel Inc). *Chem Eng (New York)* v 94 n 7 May 11 1987 p 53-57.

**087243 CENTRIFUGAL PUMP WITH MAGNETIC COUPLING: NEW MATERIALS OPEN NEW MARKETS.** The use of bearing materials of great hardness, wear resistance and particularly good corrosion resistance as well as new magnetic materials make it possible for designers to advance the design features of glandless centrifugal pumps with permanent magnetic synchronous couplings for use by the chemical industry, with absolute operational reliability and long service life ranging among priorities. (Author abstract)

Anon. *Chem Ind Int (Engl Transl)* n 2 1987 p 30-33.

## Impellers

**087244 UNSTEADINESS OF PRESSURE DISTRIBUTION AND CAVITATION INCEPTION ON THE IMPELLER BLADES OF A CENTRIFUGAL PUMP.** Pressure distribution and cavitation inception near the inlet region of an impeller passage of a centrifugal pump were examined experimentally. Both at flow rates lower and higher than normal, the pressures on the blade surface of the impeller fluctuated nearly periodically with its circumferential position due to the non-uniform pressure distribution in the volute and the presence of the dividing ridge of the volute. From the measured pressure distributions on the blade surface at a fixed circumferential position, the pressure fluctuations were also found to be caused, especially at low flow rates, by turbulent fluctuations including the separation of flow from the blade surfaces. The quasi-periodic changes in the pressure distribution caused circumferential non-uniformity of the cavitation occurrence near the cavitation inception. (Edited author abstract) In Japanese. 5 refs.

Kikuyama, Koji; Minemura, Kiyoshi; Hasegawa, Yutaka; Murakami, Mitsukiyo. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 493 Sep 1987 p 2814-2823.

**087245 ANALYSES OF HYDRODYNAMIC RADIAL FORCES ON CENTRIFUGAL PUMP IMPELLERS.** Hydrodynamic interactions that occur between a centrifugal pump impeller and a volute are experimentally and theoretically investigated. The theoretical analysis considers the inability of the blades to perfectly guide the flow through the impeller, and also includes a quasi-one dimensional treatment of flow in the volute. Flow disturbances at the impeller discharge and the resulting forces are determined by the theoretical model. The model is then extended to obtain the hydrodynamic force perturbations that are caused by the impeller whirling eccentrically in the volute. Under many operating conditions, these force perturbations were found to be destabilizing. Comparisons are made between the theoretical model and the experimental measurements of pressure distributions and radial forces on the impeller. (Edited author abstract) 17 refs.

Adkins, D.R. (California Inst of Technology, Pasadena, CA, USA); Brennen, C.E. *J Fluids Eng Trans ASME* v 110 n 1 Mar 1988 p 20-28.

**087246 FLOW OF CAVITATION BUBBLES IN A CENTRIFUGAL PUMP IMPELLER.** To obtain the behavior of cavitation bubbles in a radial-flow impeller pump, the equation of motion of a bubble and the Rayleigh equation expressing the change in the bubble diameter are solved simultaneously based on the flow field calculated numerically by a three-dimensional finite element method for an idealized potential flow. And the effects of suction pressure, the size of bubble, and discharge rate of water are discussed. When the bubble is in the range of pressure lower than the critical one, it grows abruptly, and the trajectories of the bubble shift toward the shroud surface and the direction of impeller rotation. In such ranges, the cavitation bubbles grow to a visible size. When the discharge rate of water becomes larger, the shift of bubble trajectories is intensified. (Author abstract) 11 refs.

Minemura, Kiyoshi (Nagoya Univ, Nagoya, Jpn); Kikuyama, Koji; Murakami, Mitsukiyo; Uchiyama, Tomomi. *JSME Int J Ser 2* v 31 n 1 Feb 1988 p 30-38.

**087247 FLOW ANALYSIS IN TWO-DIMENSIONAL IMPELLER OF CENTRIFUGAL PUMP BY THE SURFACE SINGULARITY METHOD COMBINED WITH A FLOW-MODEL OF THREE-DIMENSIONAL BOUNDARY LAYER.** An iterative solution method has been developed for calculating flows in two-dimensional centrifugal pump impellers. The method was formed by combining an integral calculation method for a three-dimensional boundary layer on the whole channel wall with a surface singularity method for a two-dimensional inviscid core-flow. In the inviscid analysis, the blade shape and the area of flow passage were modified by calculated displacement thickness of boundary layer, and then a finite number of vortices were distributed on the modified blade surfaces with the Kutta condition at the outlet edge on the suction surface. This method was applied to flows in two impellers with different blade thicknesses. (Edited author abstract) In Japanese. 15 refs.

Furukawa, Akinori; Cheng, Ci-Chang; Sekiya, Takakichi; Takamatsu, Yasuo. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 494 Oct 1987 p 3038-3043.

**087248 USE OF TWO-LEVEL IMPELLERS IN PUMP CONSTRUCTION.** It is known that an increase in efficiency and other indicators of centrifugal pumps is based on developing and optimizing the flow-through part, mostly the impeller. Only one-level impellers have been used so far in pump construction. An important stage in impeller design is selection of the number of blades, which significantly affects both the structure of the stream and the characteristics of the impeller. The authors demonstrated the possibility of using two-level blading in tradition pump impellers with an output angle to 30°. In terms of efficiency and cavitation properties stages with two-level impellers with rational selection of the length, number and distribution of the blades of the second level are not inferior to (and even surpass) the better versions of one-level impellers. 8 refs.

Shkarbul, S.N.; Zharkovskii, A.A. *Sov Energy Technol* n 8 1987 p 25-28.

Low Temperature Effects See SUPERCONDUCTING MAGNETS—Pumps.

## Measurements

**087249 MEASUREMENTS ON THE VOLUTE CASING OF A CENTRIFUGAL PUMP.** The volute casing often employed in the design of centrifugal pumps, with its function of post-guidance and collecting space, is a simple and inexpensive component which at the same time renders high efficiencies possible. This article reports on measurements taken on a slow-running volute casing pump. Comparisons are made with earlier measurements on another test pump, described in the references. Both values were designed by the 'stagnation point' method and were provided with variable tongue thicknesses. The results confirm the reliability of this approach to the design for casing tongues of any thickness. 10 refs.



Wesche, W. (Sulzer Weise GmbH, Bruchsal, West Ger). *World Pumps* Oct 1987 p 321-324.

Medical Applications See BIOMEDICAL ENGINEERING—Cardiology.

## Packing

**087250 INFLUENCE OF LEAKAGE FLOW ON PRIMARY FLOW AHEAD OF CENTRIFUGAL PUMP OR COMPRESSOR ROTOR.** The stage scheme is widely used in multistage centrifugal pumps and compressors. In the literature there are no analytic relations connecting the shift of the shroud disk with the characteristic parameters of the centrifugal stage and reliability ensuring the indicated positive effect. The purpose of the present work is to obtain the relations. 4 refs.

Evgen'ev, S.S. *Sov Aeronaut* v 30 n 4 1987 p 94-96.

Performance See Also PUMPS—Diffusers.

**087251 SLIP FACTORS OF CENTRIFUGAL SLURRY PUMPS.** Experiments have been carried out in order to determine the effects on slip factor due to the various parameters affecting the performance characteristics of a centrifugal slurry pump. The experiments were conducted with water, sand slurry, and a glass bead slurry at three different pump speeds. Measurements of power, flow rate, head developed by the pump and the density of the slurry were made in order to obtain the characteristic curves of the pump. Using Euler's equation, equations were derived for calculating the slip and friction factors of the flow. The deduced slip factors for centrifugal slurry pump can be correlated well with suggested non dimensional groups. It shows a consistent trend of decreasing slip factor with increasing slurry mixture density and impeller rotation, or with a decreasing through flow rate. (Edited author abstract) 9 refs.

Sheth, K.K. (Centrifl-Huges, Claremore, OK, USA); Morrison, G.L.; Peng, W.W. *J Fluids Eng Trans ASME* v 109 n 3 Sep 1987 p 313-318.

**087252 EVALUATION OF FAILURE-FREE PERFORMANCE OF CENTRIFUGAL PUMPS.** The search for methods to increase efficiency and reliability of power generating machines and pump equipment, in particular, in all stages of development and operation, is of considerable practical importance. Centrifugal pumps (CP), requiring the functional characteristic of reliability, form a significant part of pump equipment. Reliability stems from failure-free operation, suitability for repair, lifetime and keeping quality of components. This article examines the question of obtaining quantitative indicators of failure-free operation of CP in the circulation systems for cooling of motors, diesel generators which serve low-potential steam boilers, desalinization units, and for pumping oil and its products. 3 refs.

Bashurov, B.P. *Sov Energy Technol* n 1 1987 p 31-35.

**087253 SELECTION OF OPTIMAL CONDITIONS FOR CENTRIFUGAL-PUMP OPERATION.** The authors determine the position of the optimal operating regime of a centrifugal pump for which the minimum value is attained for the total power required by pumps of any make. The assumptions used are outlined. To determine the desired position of the optimal regime, the authors express the pump's efficiency as a function of its operating regime. The results of computations of the total power required by all pumps for different optimal-regime positions. The saving in electric energy due to the shift in the optimal-regime position over the rated time to overhaul (20,000 h) is 1,168,000 kWh. Calculating the entire pump-discharge program, the saving in electric energy increases proportionally. 2 refs.

Kuznetsov, O.V.; Timbai, N.M. *Chem Pet Eng* v 22 n 5-6 May-Jun 1986 p 190-192.

**087254 EFFECT OF SOME ELEMENTS OF BLADE OUTLETS ON CHARACTERISTICS OF**

**CENTRIFUGAL PUMPS AND NATURE OF BOTTOM FLOW LINES.** The paper describes the results of an experimental examination of blade outlets in centrifugal pumps. It has been shown that reducing the number of channels in the guide apparatus from 8 to 6 enables one to eliminate a drop in the pressure characteristics of a pump with  $n_0 = 85$  at deliveries  $Q = (0.6 \div 0.8) Q_{opt}$ . The paper presents visually obtained traces of flow bottom lines whose nature reveals the fact that a considerable part of area at the inlet portion of the reverse channels is occupied by a vortex pushing the flow towards the concave side of the blade outlet. (Author abstract) In Russian. 3 refs.

Borshchev, I.O.; Zharkovskii, A.A.; Pleshanov, V.L.; Shkarbul, S.N. *Tr Leningradskii Politekh Inst im M I Kalinina* n 420 1986 p 39-43.

**087255 CONTROLLING THE OUTPUT OF CENTRIFUGAL PUMPS BY MEANS OF ELECTRONIC SPEED CONTROL.** Among many methods of controlling centrifugal pump output variable speed is the most economical. Operation and performance of variable speed electric motors, in particular the asynchronous motor, are described. A change in rotor circuit resistance or stator voltage will affect the rotor slip or speed of the rotor. Frequency control is even more economical using current or voltage inverters, the latter with pulse width modulation or pulse amplitude modulation. Pumping stations typically need to meet a set value curve of demand correlation between pressure increase and flow rate. In simple cases a fixed value set suffices. By example of a water supply station, a pressure booster unit and a recirculation system the use of speed control and the effects on operation and energy consumption are demonstrated. Trends of future developments in controls and monitoring technology are provided. (Author abstract) 16 refs.

Bieniek, K. (KSB, West Ger); Groening, N. *KSB Tech Ber* n 22e Sep 1988 p 16-31.

**087256 HYATRONIC m AND ms - AN ELECTRONIC CONTROL SYSTEM FOR CENTRIFUGAL PUMPS WITH INFINITELY VARIABLE SPEED.** The 'hyatronic', an application utilizing the variable speed controls described in 'Controlling the Output of Centrifugal Pumps by Means of Electronic Speed Control' illustrates the concept and characteristic features of a microprocessor controlled adjustable speed drive system. The advantages of this compact solution are demonstrated by several designs and performance ranges. Five examples show the versatility of this economical control device in heating system, municipal water supply, sewage treatment plants, and highly flexible industrial water supply systems. (Author abstract) 1 ref.

Kuntz, G. (KSB, West Ger). *KSB Tech Ber* n 22e Sep 1988 p 32-38.

Piping Systems See PIPING SYSTEMS.

Portable See PUMPS—Selection.

## Pressure Measurement

**087257 EXPERIMENTAL INVESTIGATION OF PRESSURE OSCILLATIONS OF LIQUID IN A CIRCULATION LOOP WITH OPERATION OF A CENTRIFUGAL PUMP.** The work described in this paper was devoted to experimental investigation of oscillating processes of single-phase flow of liquid in the circulation loop of a hydraulic rig, the arrangement of which is shown. The rig consisted of pipeline 1 of internal diameter 0.125 m, connected with tank 2 open to the atmosphere, centrifugal pump 3 of type 4NDV with an impeller having eight vanes and running at a speed of 2930 rev/min, and three valves 4, 5 and 6. Pipeline 1, with overall length of 30 m, has two straight sections each 6.5 m long, connected by a bend of radius 0.5 m. Pump 3 is mounted on fixed support and is connected to pipeline 1 via expansion joints. Pipeline 1 is fixed to rigid supports. Water flowrate is set by valve 6, valves 4 and 5 being fully open. 4 refs.

Karpenko, Yu.V. (All-Union Heat Engineering Inst, USSR); Korotchenko, G.I.; Nozdrin, G.N.; Fomichev, M.S. *Therm Eng* v 34 n 1 Jan 1987 p 41-43.

## Seals

**087258 HYDRODYNAMIC STIFFNESS OF CONTACTLESS SEALS.** The efficiency of rotating machines, in particular centrifugal pumps, depends significantly on their sealing units, that is on the influence of the hydrodynamic forces of the seals acting on the rotor. Incorrect choice of the construction of the seals of the flow-through section can lead to increased vibration of the machines. The objective of the tests to be described is to determine and compare the coefficients of hydrodynamic stiffness and flow characteristics of honeycomb, pitted-surface, labyrinth and smooth-gap seals. The results are summarized. 5 refs.

Gulyi, A.N. *Sov Eng Res* v 7 n 2 Feb 1987 p 17-21.

**087259 DRUCKVERTEILUNGEN IN SPALT-DICHTUNGEN MEHRSTUFIGER KREISEL-PUMPEN.** [Pressure Distributions in Clearance Sealings of Multi-Stage Centrifugal Pumps]. The inner clearance volume flow and important main parameters of radial flow pumps as f.i. the useful volume flow, the specific stage work and the efficiency depend on the clearance width of intake side sealing of rotor. Clearance width changes on advancing working hours by mechanical influences of the rotor. For determining influence of clearance width of sealing to main parameters and static pressure values at rotor outlet, within the wheel side space and at the clearance sealing, it has been studied in the range of clearance width from 0.23 until 1.90 mm. (Edited author abstract) In German. 4 refs.

Surek, D. (VEB Kombinat Pumpen und Verdichter, Halle, East Ger). *Maschinenbautechnik* v 37 n 5 May 1988 p 222-226.

Selection See WATER SUPPLY—Economics.

Space Applications See SATELLITES—Cryogenic Equipment.

## Submerged Motor

**087260 SUBMERSIBLE MOTORS AND WET-ROTOR MOTORS FOR CENTRIFUGAL PUMPS SUBMERGED IN THE FLUID HANDLED.** Submersible motors and wet-rotor motors, a specialized application of electric motor design, have demonstrated their versatility as centrifugal pump drives. The basic principles of the submersible pump, with dry rotor and wet rotor as well as the glandless pump in wet winding and canned rotor design, are presented. The applications, design and operational considerations, e.g. startup characteristics, friction losses of the wet rotor design, thermal losses and cooling, electrical insulation, are reviewed in detail. (Author abstract) 8 refs.

Bieniek, K. (KSB, Frankenthal, West Ger). *KSB Tech Ber* n 23e Mar 1988 p 9-17.

Valves See SEWAGE PUMPING PLANTS—Pumps.

## Vibrations

**087261 ROTOR DYNAMIC BEHAVIOR OF CENTRIFUGAL PUMPS.** This paper reviews the techniques available for response analysis of centrifugal pump rotors including dynamic effects of close-clearance running fit and effects of interaction of hydrodynamic impellers and casings. The paper also reviews the information available on lateral impeller excitation force data necessary to accurately predict amplitude response. The paper concludes with a review of attempts to predict amplitude responses and studies pertaining to unstable, subsynchronous whirling and nonlinearities present in pump rotors. 102 refs.

Verhoeven, J.J. (Byron Jackson Pumps, Etten-Leur, Neth); Gopalakrishnan, S. *Shock Vib Dig* v 20 n 1 Jan



1988 p 3-12.

## PUMPS, ELECTROMAGNETIC

## Analysis

**087262 COMPUTATIONAL METHOD FOR CYLINDRICAL INDUCTION MHD PUMPS IN THE ELECTRODYNAMIC APPROXIMATION.** In solving the problem of synthesis of an electrically short cylindrical pump it is necessary to employ design solutions that have not received wide dissemination in practice. In particular, it is possible to use a nontraditional structure of the magnetic conductor containing winding coils and a nonmagnetic gap with a liquid metal working medium. In the present work a mathematical model is used which makes it possible in a single algorithm to take into account the major known means for reducing the negative influence of the end effect. Addressing this requirement is the internal problem of the end effect in the small nonmagnetic gap approximation. Since an analytical approach does not make it possible within the framework of a single algorithm to account for the variety of design solutions, preference has been given to the numerical finite difference method. 10 refs.

Drits, M.S.; Zvane, G.Ya.; Mor, E.A.; Pukis, M.V. *Magnetohydrodynamics* v 23 n 1 Jan-Mar 1987 p 109-115.

**High Temperature Effects** See MAGNETOHYDRODYNAMICS—Pumps.

## Liquid Metals

**087263 LOCAL CHARACTERISTICS OF A CYLINDRICAL INDUCTION PUMP FOR  $Rm \gg 1$ .** Experiments, which thus far were performed on commercial electromagnetic pumps, did not permit studying the evolution of the velocity profile along the machine and establishing the effect of the characteristic parameters of the MHD interaction process on it. In addition, because of the peculiarities of the construction the indicated pumps had 'external' nonuniformities (nonuniform velocity profile at the inlet and nonuniform nonmagnetic gap), which contributed to the formation of a nonuniform velocity profile in the active zone. The problem addressed in this study is to clarify the above-mentioned dependences for maximum possible elimination of 'external' nonuniformities. 11 refs.

Kirillov, I.R.; Ostapenko, V.P. *Magnetohydrodynamics* v 23 n 2 Apr-Jun 1987 p 196-202.

**087264 CYLINDRYCZNE POMPY INDUKCYJNE DO TRANSPORTU CIEKLYCH METALI. CZESC I. POLE ELEKTROMAGNETYCZNE.** [Cylindrical Inductive Pumps for Transport of Liquid Metals. Part I. Electromagnetic Fields]. This work contains electromagnetic calculations of cylindrical inductive pumps for transport of liquid metals. Two-dimensional multilayer model with an external and internal inductor is analyzed. Division of a liquid metal into layers makes it possible to take into account irregular velocity distribution. Computational examples are presented in the second part of the work. (Edited author abstract) In Polish. 14 refs.

Sajdak, Czeslaw (Politechnika Slaska, Katowice, Pol). *Arch Elektrotech (Warsaw)* v 35 n 1 1986 p 3-17.

**087265 CYLINDRYCZNE POMPY INDUKCYJNE DO TRANSPORTU CIEKLYCH METALI. CZESC II. OBLICZENIA I POMIARY.** [Cylindrical Inductive Pumps for Transport of Liquid Metals. Part II. Calculations and Measurements]. Electromagnetic fields in inductive pumps are calculated using the 2-D cylindrical pump model with finite-length inductor windings presented in the first part of the article. Results of calculations were compared with measurements of magnetic induction and electrodynamic force acting on the metal. (Edited author abstract) In Polish. 2 refs.

Sajdak, Czeslaw (Politechnika Slaska, Katowice, Pol). *Arch Elektrotech (Warsaw)* v 35 n 1 1986 p 19-28.

**Stability** See MAGNETOHYDRODYNAMICS—Stability.

## Vibrations

**087266 SELF-EXCITED OSCILLATIONS IN AN INDUCTION MHD DRIVE.** Low-frequency oscillations of the flow rate, current, and pressure, which can be a significant amplitude, were recently discovered in a study of the operation of powerful induction MHD pumps. In studying self-excited oscillations in an induction MHD drive (IMHDD), one cannot neglect the fact that the source of generation is the entire nonlinear system containing the MHD pump and a pneumohydraulic load. Because it contains a significant volume of gas, potential energy can accumulate in the loop, which for a certain form of the  $p(Q)$  characteristic of the pump can lead to pumpage oscillations. In this paper we investigate the stability of a dynamic system consisting of an MHD pump and external pneumohydraulic circuit with lumped parameters. 13 refs.

Andreev, A.M.; Metlin, V.V.; Polovko, Yu.A.; Sidelnikov, B.V. *Magnetohydrodynamics* v 23 n 2 Apr-Jun 1987 p 224-230.

## PUMPS, GEAR

**Design** See Also PLASTICS MACHINERY—Pumps.

**087267 CIRCLE FORM AT END RECTANGLE UNLOADING GROOVE OF A GEAR PUMP AND ITS DESIGN CALCULATION.** If a circle-form-at-ends rectangle unloading groove is used, it would be possible to overcome the difficulties of making and maintaining the rectangle unloading groove and disadvantages of the poor unloading effect in a Type CB-B gear pump. This paper derives a theoretical calculation formula of designing the circle-form-at-ends groove. (Edited author abstract) In Chinese.

Du, Hanxun. *Jichuang Yu Yeya* n 6 1987 p 46-48.

**Efficiency** See PLASTICS—Coextrusion.

## Lubrication

**087268 END LUBRICATION AND SEALING IN GEAR PUMPS WITH FIXED END PLATES.** This paper presents the results of a theoretical and experimental investigation of the end balance of gears in pumps with fixed end plates. An analysis of the effect of misalignment of the gear bearings is developed and the values of minimum film thickness predicted by this theory are shown to agree with the values measured in a standard production pump. This work forms a part of an extended examination of the mechanical design of gear pumps. (Author abstract). 7 Refs.

Koc, E. (Univ of Birmingham, Birmingham, Engl); Hooke, C.J. *J Fluid Control* v 18 n 3 1988 p 52-69.

## Noise Abatement

**087269 SPRAWNOSC POMP ZEBATYCH Z ZAZEBIENIEM EWOLWENTOWYM.** [Efficiency of Involute Gear Pumps]. The effect of relieving the pocketed oil chamber on reducing gear pump noise is discussed. A description is given of a test stand and a testing procedure which revealed the presence of a moment due to hydraulic and mechanical losses which depends on the method of relieving the pocketed oil chamber. The methods of relieving the pocketed chamber are reviewed. (Translated author abstract) 4 refs. In Polish.

Kollek, Wacław (Inst Konstrukcji Eksploatacji Maszyn Politechniki Wrocławskiej, Wrocław, Pol); Ejsmund, Andrzej. *Przegl Mech* v 46 n 20 Oct (2) 1987 p 5-8.

## Noise, Acoustic

**087270 OBCIAZENIA DYNAMICZNE W POMPIE ZEBATEJ O ZAZEBIENIU ZEWNETRZNYM.** [Dynamic Loads in a Gear Pump with External Gear Wheels]. It is established that with an increase in the rotational

speed of a gear pump with external gear wheels, there is an increase in the fluctuation amplitude of the dynamic torque on the pump shaft and in the dynamic loading amplitude on the gear wheels. The lower the forcing pressure, the faster the increase in the dynamic loads in the pump occurs. The dynamic load on the gear wheels is transmitted via the bearings to the pump housing. It may then be concluded that an increase in the dynamic load on the gear wheels with an increase in the rotational speed is one of the causes of an increase in the noise level of the pump. In Polish. 4 refs.

Fiebig, Wiesław; Kollek, Wacław. *Przegl Mech* v 46 n 5 Mar 1 1987 p 16-19.

## PUMPS, JET See Also SHIP PROPULSION.

**087271 MECHANISM AND CALCULATION THEORY OF JET PUMP CAVITATION.** An analysis of the three stages in the mechanism of jet pump cavitation shows that jet pump cavitation depends on fluid pressure and on the varying characteristics of the turbulent jet boundary layer. The maximum suction flow rate is described in an all-round way. On the basis of this new concept, by using the theory of fluid mechanics is combination with the characteristics of turbulent jets, a set of equations for jet pump cavitation and simplified formulas for it are derived. Numerical solutions have been obtained over computers and verified by experimental results. (Edited author abstract) 13 refs.

Lu, Hongqi (Wuhan Inst of Hydraulic & Electric Engineering, China); Shang, Hongqi. *Sci Sin Ser A* v 30 n 11 Nov 1987 p 1174-1187.

## Applications

**087272 WATER JET PUMPS FOR TRANSPORTING SOLID MATERIALS (1ST REPORT, 90° BEND WITH A JET NOZZLE).** The experiments on the newly-developed water jet pumps, which have jet nozzles outside of water transporting pipes, show the practical usefulness for the water transportation of solid materials. The tested water jet pumps are (1) a 90° bend connected directly with a water jet nozzle, (2) a 30° elbow with a water jet nozzle and (3) a straight pipe with a conical jet nozzle. From the experiments on the 90° bend connected directly with the water jet nozzle at various positions, it is shown that the 90° bend connected directly with the water jet nozzle along the centerline has the same characteristics as the previously used water jet pumps, which have jet nozzles inside of water transporting pipes. (Author abstract). 10 Refs. In Japanese.

Kumagai, Teruo; Saito, Yoichi. *Nippon Kikai Gakkai Ronbunshu B Hen* v 54 n 502 Jun 1988 p 1385-1388.

## Cavitation

**087273 EXPERIMENTS ON CAVITATION PERFORMANCE OF JET PUMPS.** In order to improve the cavitation performance of jet pumps, cavitation inception as well as cavitation-stall-point are carefully and systematically observed under several hydrodynamic conditions in three typical test pumps, whose throat diameters are 10.2, 50.8 and 101.6 mm. Our comparison between the present results and some existing ones results in some useful conclusions on prediction of the inception and the stall point. (Edited author abstract) In Japanese. 11 refs.

Oshima, Ryoichiro. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 492 Aug 1987 p 2251-2258.

## Marine Applications

**087274 PROPULSION CONCEPT FOR SHALLOW-DRAUGHT VESSELS BY SCHOTTEL.** A strong demand for shallow water propulsion systems for low draught craft resulted in the development of the Schottel Pump-Jet system. The Schottel Pump-Jet consists of a semi-axial centrifugal pump with spiral housing ending in a nozzle. The pump draws water from underneath the craft and ejects it at an inclination of 15 degrees from a duct in the bottom of the vessel producing a



propulsion reaction in opposite direction. Since the installation of the first system a great deal of experience has been gained and at present there are eight different models of Pump-Jets available covering an output range between 60 and 400 kW and operating in a wide variety of applications.

Anon. *Holl Shipbuild* v 36 n 8 Oct 1987 p 56-58.

## Performance

**087275 STUDIES OF THE CONFIGURATION AND PERFORMANCE OF ANNULAR TYPE JET PUMPS.** In this paper, we investigated experimentally the relation between configuration and performance of the annular type jet pump and compared it with that of the central jet type. Twenty-five different kinds of pumps were used in the experiments. These pumps reached a maximum efficiency of thirty-six percent. This corresponds with that of the conventional central jet type pump. We also studied the effect of the swirl component in the driving jet, and compared it with the result without swirl component. (Author abstract) 9 refs.

Shimizu, Yukimaru (Mie Univ, Tsu, Jpn); Nakamura, Shogo; Kuzuhara, Sadao; Kurata, Shigemitsu. *J Fluids Eng Trans ASME* v 109 n 3 Sep 1987 p 205-212.

**087276 STUDIES ON THE OPTIMUM THROAT LENGTH OF JET PUMPS.** In order to improve jet-pump-performance, in this paper, the turbulent flow through a jet-pump-throat was carefully analyzed by using a simple flow model, and the results were compared with experiments on jet pumps from 8.3 to 100 mm in diameter  $d_t$ . The optimum throat length,  $l_{23opt}/d_t$ , was simply shown by  $l_{23opt}/d_t = A \log Re + B$  where  $A$ , and  $B$  are constants and  $Re$  is Reynolds number. We also found a superior pump with 40 percent of the maximum efficiency. (Author abstract) In Japanese. 14 refs.

Oshima, Ryoichiro. *Nippon Kikai Gakkai Ronbunshu B Hen* v 54 n 497 Jan 1988 p 125-129.

**087277 PERFORMANCE AND MODELING OF LIQUID JET GAS PUMPS.** This paper reports an experimental and theoretical study of a two-phase jet pump, involving a liquid primary flow and a gas secondary one. The ultimate objective was to produce a mathematical model and computer program for use with microcomputers in the industrial design of such gas pumps, the experimental phase of the project being required to produce empirical values for some of the variables used in the computer program. The major advance has been the ability of the mathematical model to predict performance under almost any operating conditions. (Edited author abstract) 7 refs.

Neve, R.S. (City Univ, London, Engl). *Int J Heat Fluid Flow* v 9 n 2 Jun 1988 p 156-164.

**PUMPS, RECIPROCATING** See Also PIEZO-ELECTRIC DEVICES—Pumps; PUMPS, CENTRIFUGAL—Design.

**087278 POSITIVE DISPLACEMENT RECIPROCATING PUMPS FOR LONG-DISTANCE HYDRAULIC TRANSPORT OF SOLIDS.** For continuous operation of slurry pipelines, the pumps are expected to give uninterrupted service over long periods. The different types of pumps manufactured by Wirth for this purpose are: horizontal piston pumps (duplex and triplex); horizontal plunger pumps (triplex); horizontal piston diaphragm pumps (duplex and triplex). A comparison is drawn between them. The best choice is the one that gives maximum availability and minimum operating costs. (Edited author abstract) 2 refs.

Bhambry, I.K. (Wirth Maschinen- und Bohrgeraete-Fabrik GmbH, Erkelenz, West Ger); Wallrafen, G. *Bulk Solid Handl* v 7 n 5 Oct 1987 p 687-694.

**087279 RESEARCH AND DEVELOPMENT OF RECIPROCATING PUMPS FOR HIGH CONCENTRATION COAL/WATER SLURRIES.** Large pipelines for transporting high concentration coal/water

slurries (CWS) are made possible due to use of high pressure reciprocating pumps. Advanced reciprocating pumps have been designed, based on experience of reciprocating compressors, to meet this emergent technology. Tests conducted on a prototype with CWS have confirmed the reliability of the solutions adopted for the most critical components. (Author abstract)

Giacomelli, E. (Nuovo Pignone); Graziani, F.; Mezzedimi, V.; Verdelli, A. *Quad Pignone* n 43 Jun 1987 p 43-51.

Applications See CHEMICAL EQUIPMENT—Pumps.

## Noise Abatement

**087280 RESEARCH ON THE PROBLEM OF REDUCING THE NOISE OF PISTON PUMP.** This paper analyzes mainly the inherent theory on how the swash plate type piston pump produces noise. It points out the focus of designing to reduce the noise, determines the formula for calculating the orifice and triangular groove of the noise-reducing valve plate, and calculates the changing curve of liquid pressure in the piston chamber by computer. Finally it confirms the correctness of the designing method through experiments. (Edited author abstract). 1 Ref. In Chinese.

Liucheng, Ma (Harbin Inst of Technology, China). *Chi Hsieh Kung Ch'eng Hsueh Pao* v 24 n 1 Mar 1988 p 20-29.

Performance See OIL WELL PUMPING—Stability.

## Piping Systems

**087281 PRESSURE PULSATIONS IN THE PIPING OF RECIPROCATING PUMPS.** Pressure pulsations in hydraulic systems, generated by reciprocating pumps, can cause serious problems with regard to plant safety and reliability. In particular, fatigue problems arise in high-pressure piping systems. The available knowledge is not sufficient for an accurate computation of pressure peaks in the piping of reciprocating pumps. A number of calculation models are available which, however, neglect both fluid compressibility and friction. This contribution presents a calculation method which allows a precise modeling of various pump installations. Comparison of calculated and experimental data shows a good agreement and provides a validation of the computational model. (Author abstract) 16 refs.

Vetter, Gerhard (Univ Erlangen-Nuernberg, Erlangen, West Ger); Schweinfurter, Friedrich. *Chem Eng Technol* v 10 n 4 Aug 1987 p 262-271.

## Wear

**087282 PRACTICAL INVESTIGATION OF WEAR IN PISTON PUMPS OPERATED WITH HFA FLUIDS WITH DIFFERENT ADDITIVES.** This paper examines the use of water-based hydraulic fluids in hydraulic pumps. Four different types of HFA fluid are reviewed in terms of properties and usage. In a research program, two principal fluids, a HFA micro emulsion and a HFA solution, were evaluated in relation to their wear protection capability in a short-term test procedure, and their operational behavior and confirmation of the short-term test procedure in a long-term test. The differences between the fluids are mainly in terms of wear of the test pumps. It is concluded that a performance standard similar to oil-based fluids has not yet been reached. (Author abstract) 7 refs.

Janko, K. (Univ of Karlsruhe, West Ger). *J Synth Lubr* v 4 n 2 Summer 1987 p 99-114.

**087283 VERSCHLEISS SELBSTAETIGER PUMPENVENTILE DURCH ABRASIVE SUSPENSIONEN.** [Wear of Automatic Pump Valves by Abrasive Suspensions]. In pumping of abrasive suspensions with reciprocating displacement pumps against high pressures, the pump valves prove to be subject to serious wear. The major kinds of wear are demonstrated by a tribological study. The rates of wear found for a real valve model with

a high pressure experimental setup depend upon the pressure and frequency of reciprocation. A design strategy and fabrication aspects are considered and compared with practical experience. (Edited author abstract) 16 refs. In German.

Vetter, Gerhard (Univ Erlangen-Nuernberg, Erlangen, West Ger); Stoerk, Ulrich. *Chem Ing Tech* v 59 n 5 May 1987 p 383-392.

## PUMPS, ROTARY

**087284 REDUCTION OF DELIVERY FLUCTUATION AND OPTIMUM TOOTH PROFILE OF SPUR GEAR ROTARY PUMPS.** The optimum tooth profile of spur gear pumps is calculated in the present paper, and a method of reducing delivery fluctuation is also proposed. Reduction of delivery fluctuation may be achieved through a delivery penalty or through a pump size penalty. Also given is a way of calculating pump delivery through the gear's cross-sectional area which corresponds to a given rack profile. (Author abstract) 4 refs.

Costopoulos, Th. (Natl Technical Univ of Athens, Athens, Greece); Kanarachos, A.; Pantazis, E. *Mech Mach Theory* v 23 n 2 1988 p 141-146.

## Computer Aided Design

**087285 MIXING AND MATCHING MODULAR PUMPS: THE CAD APPROACH.** In a move to get a more broadly specified range of pumps, manufacturers are turning to modular designs. The modular approach will allow customers match their applications more closely instead of getting the pump from a standard range which may not exactly meet the pumping capacity or energy consumption requirements. In addition, the modular approach will benefit users whose process requirements change.

Chynoweth, Emma. *Process Eng (London)* v 68 n 9 Sep 1987 p 77, 79.

## Design

**087286 DESIGN OF FZ CORROSION-RESISTING ROTOR PUMP.** The FZ series pumps are new-structure corrosion-resisting rotor pumps in the category of volume pumps. A pump consists of the pump body, the rubber seal ring, the compression ring and the front and rear covers. The pump body and rubber ring compose an entirely closed liquid cabinet. When the rotor is turning outside the liquid cabinet, the rubber seal ring is forced to change its shape and makes the liquid cabinet larger or smaller so that the liquid will be sucked in or discharged. The design calculation of the performance parameter for the pump is demonstrated in detail. (Author abstract) 3 refs. In Chinese.

Qi, Shengping (Qingdao Inst of Chemical Technology, Shangdong, China). *Huagong Jixie* v 14 n 6 1987 p 434-437.

## Noise Abatement

**087287 INVESTIGATION OF A SHOCK ABSORPTION STRUCTURE PUMP.** This paper analyzes the cause of poor noise reduction in a high pressure axial piston pump. It puts forward a design criterion. Methods of improving noise reduction are discussed. (Edited author abstract) 3 refs. In Chinese.

Ye, Min; Na, Chenglie. *Jichuang Yu Yeya* n 6 1987 p 25-28.

## Rotors

**087288 OBCIAZENIA ZESPOLU WIRNIKA W WIELOLOKOWEJ POMPIE OSIOWEJ.** [Loading the Rotor Assembly in an Axial-Flow Multipiston Pump]. It is confirmed that the problem of automatic control and regulation of the output of axial-flow multipiston pumps is much more complicated than would appear from papers on this subject presented in the published literature on



hydrostatic drives. The reason for this is the relatively large dynamic response of the adjustable pump rotor to the control mechanisms, which depends on the throttling pressure, the rpm and the position of the rotor. 3 refs. In Polish.

Bialy, Jaroslaw (Akademia Techniczna, Warsaw, Pol); Krasuski, Jan. *Przegł Mech* v 46 n 18 Sep (2) 1987 p 40-43.

**PUMPS, TURBINE** See Also FLOW OF FLUIDS—Analysis; HYDRAULIC MACHINERY; HYDRAULIC TURBINES.

## Marine Applications

**087289 DESIGN AND OPERATION OF PUMPS FURNISHED FOR MARINE CARGO SERVICE: PART II.** To a pump manufacturer, marine cargo service represents one of the most demanding applications for which he can design and furnish equipment. In addition to being subjected to the stresses encountered in a shipboard environment, cargo pumps must often perform over a wide range of operating conditions and handle multiple fluids with different viscosities, vapor pressures, specific gravities, temperatures, and material requirements. In this paper the author reviews characteristics of the different types of pumps used for marine cargo service, with an emphasis on the special features that should be incorporated into their design for this rigorous duty. Different types of automatic self-priming/stripping systems available for use with these cargo pumps are also examined. Pump operation is discussed, including the significant impact that system design has on proper pump performance. (Author abstract) 26 refs.

Sembler, William J. (Dresser Industries Inc, Harrison, NJ, USA). *Mar Technol* v 25 n 2 Apr 1988 p 75-104.

**Seals** See ROCKET ENGINES—Pumps.

## Service Life

**087290 INVESTIGATION INTO THE WEAR RESISTANCE OF PUMP TRANSMISSION SHAFTS.** The reliability and service life of artesian turbine pumps which supply water from a depth of 100-150 m are influenced mainly by the quality of the transmission shafts. Water, which is an aggressive medium, with particles of salts and sand suspended in it, contributes to the rate of wear. This article examines the results of an investigation and the possibility of increasing the wear resistance of pump transmission shafts by changing the parameters of the sizing operation used for their manufacture from round rolled steel. 7 refs.

Zaides, S.A.; Drushinina, T.Ya. *Sov Eng Res* v 7 n 4 Apr 1987 p 14-16.

## PUNCH PRESSES

### Control Systems

**087291 CASE STUDIES SHOW THE POWER OF NC.** Two significant developments have taken place in the field of numerical control systems for punch presses. These are a steep fall in the costs of micro-electronics; and a dramatic willingness on the part of even small companies to invest in automation. The author demonstrates in a number of application examples how today's numerically controlled punch presses are viable alternatives to other methods of fabrication.

Anon. *Mach Prod Eng* v 145 n 3726 Nov 4 1987 4p between p 39 and 45.

**Design** See METAL DRAWING.

**Efficiency** See MACHINE TOOLS—Evaluation.

**PYRITES** See Also FLOW OF FLUIDS—Suspensions.

**Decomposition** See BACTERIOLOGY—Adsorption.

### Electrochemistry

**087292 ELECTROCHEMICAL BEHAVIOR OF PYRITE IN SULFURIC ACID SOLUTIONS CONTAINING SILVER IONS.** A systematic electrochemical study of pyrite in  $H_2SO_4$  solutions containing dissolved silver was undertaken to gain more information about the transfer of silver ions to pyrite and their role in enhancing the direct oxidation of pyrite. The results of cyclic voltammetry experiments provide additional evidence of the formation of metallic silver on the  $FeS_2$  surface under open-circuit conditions. A pyrite electrode held at the open-circuit potential for 2h in the presence of  $10^{-3}$  M  $Ag^+$  exhibits a large and sharp anodic peak at about 0.7 V. The current associated with this peak is the result of the dissolution of metallic silver deposited during the initial conditioning period. (Edited author abstract) 24 refs.

Hiskey, J.B. (Univ of Arizona, Tucson, AZ, USA); Pritzker, M.D. *J Appl Electrochem* v 18 n 3 May 1988 p 484-490.

### Flotation

**087293 EFFECT OF SEMI-CONDUCTIVITY ON THE FLOTABILITY OF PYRITE.** This paper deals with the flotation behavior of pyrites from three different types of mineral deposits in the presence of different modifiers and an investigation of the effect of semi-conductivity on the flotability of pyrite. From the results of flotation experiments with the Hallimond tube and nitrogenated techniques, it is shown that under the conditions of suitable concentration of butyl xanthate and with  $NaOH$ ,  $CaO$ ,  $FeSO_4$ ,  $FeCl_3$ ,  $Na_2SO_3$ , and  $CuSO_4$  as modifiers, the flotabilities of pyrites are closely related to their semi-conductivities. In this work, a simple working model is established in terms of which differences in the flotation properties may be well illustrated by the influence of their semi-conductivities on the kinetics of electrochemical processes of the formation of dixanthogen on the pyrite surface or on anionic xanthate adsorption. (Edited author abstract) In Chinese. 14 refs.

Lin, Jinghong; Hu, Xigeng. *Zhongnan Kuangye Xueyuan Xuebao* v 18 n 1 Feb 1988 p 10-17.

**087294 ELECTROCHEMICAL CHARACTERIZATION OF PYRITES FROM COAL AND ORE SOURCES.** A preliminary investigation of the electrochemical behavior of pyrite samples from an ore and a coal source in alkaline borate solutions (pH 9.3) has been carried out by cyclic voltammetry, steady state polarization, and AC impedance measurements. Voltammetry and impedance results indicate that a product layer is initially formed on the ore pyrite during sample preparation. Such a layer is absent from the surface of the coal pyrite. Results of the steady state polarization and AC impedance techniques show that, under similar oxidizing conditions, coal pyrite begins to oxidize at potentials lower than the ore pyrite. The large difference in charge transfer resistance determined by the AC impedance measurements, shows that this technique is very sensitive for measuring reactivities of minerals. (Author abstract). 11 refs.

Briceno, A. (Pennsylvania State Univ, University Park, PA, USA); Chander, S. *Int J Miner Process* v 24 n 1-2 Sep 1988 p 73-80.

**Leaching** See Also GOLD ORE TREATMENT—Leaching.

**087295 BIOLIXIVIACION DE PIRITAS CUPRIFERAS MEDIANTE TECNICAS DE PERCOLACION A pH LIBRE.** [Bioleaching of Cupriferous Pyrites by Percolation at a Free pH]. The possibility of bacterial acid leaching as applied to cupriferous pyrites is reported. Experimental leaching in free pH conditions has been carried out. When *Thiobacillus ferrooxidans* is used, differences among copper, iron, and zinc extraction are observed. Results show remarkable differences between

chemical (sterile) and biological (bacterial) leaching, with selective copper and zinc dissolution in the latter case. (Edited author abstract) In Spanish. 17 refs.

Pozo, M. (Univ Autonoma de Madrid, Madrid, Spain); Campa, J.A.; Moreno, A. *Rev Metal (Madrid)* v 23 n 3 May-Jun 1987 p 155-164.

**Oxidation** See Also CONCRETE PRODUCTS—Slabs; MINES AND MINING—Wastes.

**087296 PASSIVATION OF PYRITE OXIDATION WITH METAL CATIONS.** Under the influence of anodic potentials greater than 0.5 V against SCE (saturated calomel electrode), pyrite slurred in acidic electrolytes is oxidized to water soluble ferric and sulfate ions. Experiments were conducted in a stirred Pyrex reactor provided with three electrodes, the anode being a platinum mesh. The rate of reaction of pyrite corrosion was observed to increase with electrolysis time. The autocatalytic reaction is brought about by the ferric ions produced during the course of the reaction. The rates of reaction, however, can be depressed by adding small quantities of copper and silver ions (both of these have lower redox potentials than that of the  $Fe^{2+}/Fe^{3+}$  couple) to the electrolyte. (Edited author abstract) 17 refs.

Lalvani, Shashi B. (Southern Illinois Univ at Carbondale, Carbondale, IL, USA); Shami, M. *J Mater Sci* v 22 n 10 Oct 1987 p 3503-3507.

**087297 KINETIC STUDY OF OXIDATION OF PYRITE SLURRY BY FERRIC CHLORIDE.** The aqueous oxidation of pulverized pyrite by ferric ion was investigated in a concentrated, acidic chloride solution. The ratio of the concentration of sulfate ion to elemental sulfur produced during the reaction was approximately 1.3, regardless of the leaching conditions such as temperature and acid concentration. The oxidation rate increased with decreasing acid concentration and increasing initial ferric chloride concentration and was retarded by an addition of ferrous ion. It was also found that the oxidation rate was not linearly related to the pyrite loading and the reciprocal of the particle diameter. A kinetic model was proposed assuming that fine mineral powder and irregular pits on the outer surface of the crushed pyrite are responsible for the high initial reaction rates. (Edited author abstract) 12 refs.

Kawakami, Koei (Kyushu Univ, Fukuoka, Jpn); Sato, Junko; Kusunoki, Koichi; Kusakabe, Katsuki; Morooka, Shigeharu. *Ind Eng Chem Res* v 27 n 4 Apr 1988 p 571-576.

**087298 KINETICS OF REACTIONS IN THE SYSTEM  $FeS_2-O_2-H_2O$  AT ELEVATED TEMPERATURES AND PRESSURES.** The aims of the investigation included the following: 1) elucidation of the chemical nature of the process and distribution of the oxidation products between the liquid phase (solution) and the solid residue; 2) determination of the thermodynamic and kinetic relationships of oxidation; 3) clarification of the possibility of oxidation of pyrite sulfur to sulfuric acid; 4) study of the possibility of using the  $H_2SO_4$  formed by oxidation for simultaneous leaching of nonferrous metals from the corresponding ores present together with pyrite in the autoclave. It was found that, depending on the temperature and other operating parameters, oxidation of  $FeS_2$  in an aqueous suspension at temperatures in the range 100-230° results in formation of  $FeSO_4$ ,  $Fe_2(SO_4)_3$  and  $H_2SO_4$  in solution and  $Fe_2O_3$ ,  $Fe_2O_3 \cdot (1-3)H_2O$ ,  $2Fe_3(SO_4)_2(OH)_5 \cdot 2H_2O$  and  $S^0$  in the solid residue. 5 refs.

Vrachar, R. (Belgrade Univ, Yugosl). *J Appl Chem USSR* v 60 n 7 pt 1 Jul 1987 p 1377-1382.



**087299 HOCHTEMPERATUR-OXIDATION-SPROZESSE IN EINEM PARTIKELSTRAHLSYSTEM MIT DEN KONZENTRATEN AUS Cu-Fe-S-MINERALIEN.** [High-Temperature Oxidation Processes in a Dispersed Particle Jet System of Cu-Fe-S Mineral-Bearing Concentrates]. In the present work the oxidation processes of chalcopyrite and bornite-bearing pure concentrates have been studied in dispersed particle jet reaction system by applying chemical methods, X-ray diffraction (XRD), electron micro-probe analysis (EPMA), ore micrography, and scanning electron micrography (SEM). The kinetic results of this work were discussed from the viewpoint of thermodynamics and energy balances. The average reaction (oxidation) rates were determined by evaluation of the dimensions of newly formed phases in the micrographs and of the retention of the reacted particles in the particle jet smelting system. (Edited author abstract) 22 refs. In German and English.

Kang, Jee-Soon. *Radex Rundsch* n 1 Mar 1988 p 520-535.

Reaction Kinetics See COAL—Desulfurization.

Separation See COAL PREPARATION—Heavy Media Separation.

## Structure

**087300 APPLICATION OF ANISOTROPIC ELECTRON DIFFRACTION TO DETERMINE THE DISPLACEMENT VECTOR OF STACKING FAULT IN PYRITE.** The stacking faults (SF) commonly observed in pyrite of various occurrences have fault planes parallel to the {100} planes. However, the displacement vector (R) of the SF is controversial in the literature. In the present study the components of R are confirmed directly using lattice imaging and g-R contrast analysis by taking advantage of the anisotropic electron diffraction spots (g) which enable the imaging of the {100} lattice planes. The contrast analysis and the lattice images by the anisotropic electron diffraction spots confirm that the displacement vector is consistent with the theoretical value of  $R = \langle 0.27, \frac{1}{2}, 0 \rangle$ . The component of  $\frac{1}{2}$  normal to the stacking fault plane [100] and the component of 0.27 lying within the stacking fault indicate that the stacking fault is not formed by simple shearing along the fault plane. 10 refs.

Hwang, Shyh-Long (Nat'l Sun Yat-Sen Univ, Kaohsiung, Taiwan); Shen, Pouyan. *J Mater Sci Lett* v 6 n 10 Oct 1987 p 1238-1240.

**087301 ELECTRONIC STRUCTURE OF PYRITES, PARTICULARLY  $\text{CuS}_2$  AND  $\text{Fe}_{1-x}\text{Cu}_x\text{S}_2$ : AN XPS AND MOESSBAUER STUDY.** The MND skewness of X-ray photoelectron spectroscopy (XPS) core levels is used to study the character of the wave functions at the Fermi level of a number of pyrites  $\text{MS}_2$  (M = Fe, Co, Ni, Cu). It is shown that the degree of mixing between the metal 3d  $e_g$  levels with the  $\pi^*$  levels of the  $\text{S}_2$  anion is essential in understanding the properties of these materials; while  $\text{FeS}_2$  can be described as  $\text{Fe}^{2+}(\text{S}_2)^{2-}$  with  $\text{Fe}^{2+}$  in the low-spin configuration,  $\text{CuS}_2$  is essentially  $\text{Cu}^+(\text{S}_2)^{-}$ . In the pyrite-type solid solutions  $\text{Fe}_{1-x}\text{Cu}_x\text{S}_2$  Cu again has a  $d^{10}$  configuration, while Fe retains the spin-paired  $d^6$  configuration, as shown by XPS and Moessbauer spectroscopy. (Author abstract) 14 refs.

Folmer, J.C.W. (Univ Groningen, Groningen, Neth); Jelinek, F.; Calis, G.H.M. *J Solid State Chem* v 72 n 1 Jan 1988 p 137-144.

Wetting See COAL—Wetting.

**PYROELECTRICITY** See Also CRYSTALS—Thermal Properties; INFRARED DETECTORS; LASER BEAMS—Measurements; ORGANIC COMPOUNDS—Dielectric Properties; ORGANIC COMPOUNDS—Phase Transitions; ORGANIC COMPOUNDS—Thin Films; PYROELECTRICITY—Research; RUBIDIUM COMPOUNDS—Electric Conductivity; SEMICONDUCTING TELLURIUM COMPOUNDS—Thin Films.

## Research

**087302 PYROELECTRICITY OF AROMATIC COMPOUNDS.** Recent studies of pyroelectricity in crystallized aromatic compounds - benzene derivatives - are discussed and summarized. The dielectric and pyroelectric behavior of some di- and trisubstituted benzenes as a function of temperature is presented. Experimental results are compared with evaluations based on the INDO-approximation including a self-consistent electrostatic crystal field approach. (Author abstract) 20 refs.

Weiss, Alarich (Technische Hochschule Darmstadt, Darmstadt, West Ger); Fleck, Silvia. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem, of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 913-918.

**PYROMETALLURGY** See Also LEAD SMELTING—Physical Chemistry.

**087303 ALL-EQUILIBRIUM CALCULATION OF HETEROGENEOUS SYSTEMS FOR PYROMETALLURGY.** A computer method for the all-equilibrium calculation of a heterogeneous system for pyrometallurgy is developed in this work. The principles of this method are explained mathematically, and the flow diagrams of calculation are shown. An example of calculation for the copper-smelting process is presented in this paper. (Edited author abstract) In Chinese. 4 refs.

Liu, Jianshe. *Zhongnan Kuangye Xueyuan Xuebao* v 18 n 1 Feb 1988 p 102-110.

**087304 NON-FERROUS PYROMETALLURGY - A CHANGING INDUSTRY.** The non-ferrous pyrometallurgical industry has been under extreme pressure since 1980 and significant changes are taking place, principally in the copper, nickel and lead industries. This paper reviews some of these changes, particularly with respect to smelter capacity, major technical trends, and the industry's response to increased energy costs and environmental constraints. The Canadian metal mineral production for 1985 has been estimated at a value of over \$8 billion, of which half is derived from copper, nickel, lead and zinc production. It is in our national interest that the Canadian industry remain competitive in the world market and continue its traditional contribution to the Canadian economy. (Author abstract) 14 refs.

Taylor, John C. (Jan H. Reimers & Associates Inc, Oakville, Ont, Can). *CIM Bull* v 81 n 913 May 1988 p 69-73.

## Computer Simulation

**087305 PROCESS PRECONCEPTION BY STEPWISE EQUILIBRIUM ANALYSIS (SEA), PART 2, COMPUTER METHOD: THE REDUCTION OF  $\text{AlCl}_3(\text{g})$  WITH MOLTEN MANGANESE.** The fundamental principles of computer SEA method have been described by demonstrating it in the simulation of a batch process reactor for the production of Al-Mn alloys from  $\text{AlCl}_3(\text{g})$  and Mn(l). The subject matter includes the use and caution of the Newton-Raphson (NR) loop, non-convergence in relation to trigger (initial approximate) roots, relevance of assessing minor species outside the NR loop, and so forth. It has been shown numerically that the SEA technique can also be used to simulate the performance of continuous process reactors operating under steady-state conditions. (Author abstract) 10 refs.

Nagamori, Meguru (Cent de Recherches Minerales, Ste-Foy, Que, Can); Chaubal, Pinakin C. *Metall Rev MMJ* v 4 n 2 Nov 1987 p 34-49.

**Physical Chemistry** See COPPER SMELTING—Chemical Analysis.

Reviews See METALLURGY—Reviews.

## Waste Utilization

**087306 THERMODYNAMIC PRINCIPLES OF THE STRIPPING OF MAGNETITE-CONTAINING SLAGS WITH  $\text{SO}_2\text{CH}_4\text{-N}_2$  MIXTURES.** Calculations are made of the compositions of the equilibrium mixtures forming in  $\text{CH}_4\text{-SO}_2\text{-N}_2$  systems at 1500 K in the range of  $\text{CH}_4/\text{SO}_2$  molar ratios from 0.5:1 to 2.5:1. It is shown that the dioxide conversion products can be used as reducing-sulfidizing for the stripping of magnetite-containing nonferrous metallurgical slags. (Translated author abstract) In Russian. 10 refs.

Tarasov, A.V.; Shishkina, L.D.; Kalnin, E.I. *Tsvet Met* n 1 Jan 1988 p 23-25.

**PYROMETERS** See Also FLAME RESEARCH—Temperature Measurement; STEEL—Continuous Casting.

**087307 METHOD OF DETERMINING THE TEMPERATURE OF A SPECTRAL RATIO BY A WIDE-BAND OPTICAL PYROMETER.** Pyrometric methods are used extensively to determine the temperature of heated bodies by a contactless method. The color temperature, defined as the temperature of an ideal black body (IBB) for which the ratio of the spectral densities of the IBB emission for the wavelengths  $\lambda_1$  and  $\lambda_2$  equals the corresponding ratio of the spectral densities of the object emission is often used as an estimate of the object temperature. Color pyrometers (spectral ratio pyrometers) are used to measure the color temperature. In this paper it is proposed to introduce the concept of an integrated color temperature (ICT). The ICT is defined in a unique manner for known spectrum band limits and by a known ratio of the object emission densities in two bands and does not require involvement of the concept of effective wavelength. It is also shown that the selectivity of the radiation detector does not hinder (with the exception of degenerate cases) the construction of a temperature scale based on measurement of the signal ratio from the pyrometer sensors receiving the emission energy of the heated object in two bands. 5 refs.

Krasnov, K.V.; Osipov, G.I.; Rostovtseva, V.V. *Meas Tech* v 30 n 3 Mar 1987 p 215-218.

**087308 PYROMETRE A FIBRE OPTIQUE POUR LA MESURE DES BASSES TEMPERATURES.** [Optical Fiber Pyrometer for Low Temperature Measurements]. Optical fibres made of fluoride glass allow surface temperature measurement of various objects uneasy to reach, mobile or located in adverse environments. Such an infrared fibre, with transmittance extending beyond 5  $\mu\text{m}$ , allows transmission of IR radiation to an IR sensor which transforms it into a usable signal. The set-up realised can take measurements down to 50°C, and 30°C in a next future. The sensor signal is pre-amplified and then processed by a lock-in amplifier. An IR reference internal source is used to deliver a known constant level to the sensor and allows absolute temperature measurements. The present measurement accuracy obtained with a blackbody at 200°C is  $\pm 0.5^\circ\text{C}$ . We are about to use such a device for monitoring irradiated fuel rods temperature in the Superphenix 1 breeder power plant. (Author abstract) 10 refs. In French.

Denayrolles, Yves (EDF, Chatou, Fr); Trouville, Bernard; Lemaquis, Jean-Claude. *Ann Telecommun* v 43 n 1-2 Jan-Feb 1988 p 88-93.

**Applications** See Also TUNGSTEN RHENIUM ALLOYS—High Temperature Effects.

**087309 RECENTS DEVELOPPEMENTS DE LA MESURE DES TEMPERATURES SANS CONTACT EN MILIEU INDUSTRIEL.** [Recent Developments in Contactless Temperature Measurement for Industrial Environment]. After recalling the theoretical background of thermal radiation, the author describes the pyrometer purpose and the benefits of a method involving no contact with the heat source. Advantages of existing pyrometers are discussed. Some examples of practical or industrial applications of pyrometry are presented as well as the latest developments brought to radiation measurement.



(Author abstract) In French.

Loroux, Thierry (Mesure Controle Commande SA, Issoudun, Fr). *Entropie* v 23 n 135 1987 p 13-17.

**087310 MESURE DES TEMPERATURES JUSQU'A 2800°C PAR PYROMETRIE A DILATATION.** [Temperature Measurement Up to 2800°C by Thermal Expansion Pyrometry]. A thermal expansion pyrometer may be an attractive solution for the measurement and regulation of high temperatures. It should rely on materials heat resistant enough to avoid any long term modification at the highest temperature of utilization and with coefficients on thermal expansion high enough to provide a good sensitivity. A stack of hot pressed pyrographite disks with a sheath of glassy carbon suits these conditions up to 2800°C under an inert or reducing atmosphere. There is no hysteresis between heating and cooling and the reproducibility of the measurement at 2800°C is better than 20°C. (Author abstract) In French. 3 refs.

Maire, J. (Le Carbone-Lorraine, Gennevilliers, Fr); Coulon, M. *Entropie* v 23 n 135 1987 p 19-21.

**087311 PYROMETRY ADVANCES EXPAND APPLICATIONS.** Various past and modern pyrometers are discussed. The incorporation of fiber optics and digital systems is pointed out. Several IR versions are described.

Tinham, Brian. *Control Instrum* v 19 n 12 Dec 1987 p 45, 47.

**087312 MEASUREMENT OF THE LINEARITY OF THE OUTPUT CHARACTERISTICS OF PYROELECTRIC RADIATION RECEIVERS.** Various methods of determining the linearity characteristics of pyroelectric radiation receivers are covered. The method of light addition was considered as having the highest accuracy and a large dynamic range. The measurement errors were discussed. As an application, the linearity of a silicon photodiode characteristics was determined. 9 refs.

Svet, D.Ya.; Bostandzhyan, Sh.G. *Meas Tech* v 30 n 1 Jan 1987 p 70-74.

## Design

**087313 DESIGN OF INFRARED PYROMETER WITH HIGH ACCURACY AND BROAD MEASUREMENT RANGE.** A microcomputer-controlled high-temperature pyrometer is designed. A mathematical model is derived. The design of hardware and software is described briefly. (Author abstract) 3 refs. In Chinese.

Wang, Bin (Northwest Optical Instrument Factory, China). *Hongwai Yanjiu A-Ji* v 7A n 1 1988 p 75-80.

## Performance

**087314 FIBER-OPTIC PYROMETER FOR TUYERE TEMPERATURE MEASUREMENT.** A system combining fiber optics and two-wavelength pyrometry has been developed for process control temperature measurement through operating tuyeres of copper smelting and converting furnaces. Application to zinc slag furnishing, nickel converting and other bath smelting operations is anticipated. Accurate and reliable performance under the adverse conditions found in the copper smelting industry has been demonstrated for the several installations completed since 1983. The paper reviews the optical and mechanical design of the instrument. Laboratory and on-line data demonstrating performance are also presented. (Author abstract) 5 refs.

Lucas, J.M. (Noranda Research Cent). *ISA Trans* v 27 n 1 1988 p 1-8.

## Portable

**087315 PORTABLE PYROMETRY: THE CASE FOR INFRARED.** Portable IR hot spot detectors and thermal imaging systems used in preventive maintenance, quality assurance and general trouble-shooting work are described, in particular the Minolta Compac C infrared

thermometer, Thermovision 450 thermal measurement and imaging system made by Agema Infrared Systems, the Raynger PM non-contact IR thermometers made by Calex Instrumentation, and Optex Thermo-hunter 5140 portable IR thermometer made by Digitron Instrumentation.

Proctor, Andrew. *Process Eng (London)* v 69 n 6 Jun 1988 p 61,63.

## Q

**QUALITY ASSURANCE** See Also AUTOMOBILE MANUFACTURE—Costs; CEMENT—Manufacture; CIVIL ENGINEERING—Design; COMPOSITE MATERIALS—Nonmetallic Matrix Composites; COMPUTER SOFTWARE; COMPUTER SOFTWARE—Software Engineering; DRUG PRODUCTS PLANTS—Quality Control; ELECTRONIC EQUIPMENT TESTING—Reliability; ENVIRONMENTAL TESTING—Radioactivity; MANAGEMENT SCIENCE; MECHANICAL VARIABLES MEASUREMENT—Position; NUCLEAR FUELS—Inspection; NUCLEAR POWER PLANTS—Quality Assurance; OCEAN ENGINEERING—Coastal Zones; PLASTICS SHEETS—Sheet Molding Compounds; PROCESS CONTROL; PRODUCTION ENGINEERING—Quality Control; PUMPS—Manufacture; QUALITY CONTROL; QUALITY CONTROL—Management; SECURITY SYSTEMS—Inspection; SHEET AND STRIP METAL—Testing; TELECOMMUNICATION SYSTEMS—India; VIBRATIONS.

**087316 PROBLEM-SOLVING METHOD AIDS QUALITY IMPROVEMENT.** The use of statistics for quality improvement achieves the greatest results when it operates within the framework of the problem-solving method. The problem-solving method (also called the scientific method) as applied to quality improvement has six steps. They are: problem identification, project team assignment, problem analysis, possible solutions, evaluation, and remedial action. They are not independent steps; they are interdependent and interrelated. Quality improvement is the goal and the problem-solving process a framework to achieve that goal. 5 refs.

Besterfield, Dale H. (Southern Illinois Univ, IL, USA). *Manuf Eng* v 99 n 4 Oct 1987 p 53-55.

**087317 DEVELOPMENT OF A MULTINOMIAL BASED ATTRIBUTES CONTROL CHART AND OC SURFACE.** This paper develops families of general case attributes control charts applicable to sorting operations. The charts are based on the multinomial distribution. Formulas and computer programs for the operating characteristics associated with the chart families are also developed. Possible applications are demonstrated through the use of an example. (Author abstract) 4 refs.

Kolarik, William J. (Texas Tech Univ, Lubbock, TX, USA); Jaisingh, Lloyd R. *Trans Ky Acad Sci* v 48 n 3-4 Oct 1987 p 55-61.

**087318 QUALITY TECHNOLOGY IN PRODUCT REALIZATION SYSTEMS.** This paper focuses on the role that quality technology plays in AT&T's product realization processes and systems. It describes the quality management system within the AT&T research and development community including the eleven principal quality management tasks. There are also descriptions of two software-based quality management tools: the System Used for Prediction and Evaluation of Reliability (SUPER) and the QC Toolkit for statistical quality control. (Author abstract) 8 refs.

Gundaker, Bruce F. (AT&T Bell Lab, Holmdel, NJ, USA); Martinich, David E.; Tortorella, Michael J. *AT&T Tech J* v 66 n 5 Sep-Oct 1987 p 5-20.

**087319 VARIANZANALYSE IN DER QUALITÄTSSICHERUNG.** [Variance Analysis in Quality Assurance]. Application of variance analysis is possible and expedient in those cases where statistical data in the form of measured values or parameters are available and when they are divided into groups on the basis of influence factors. This paper investigates the preconditions and possibilities for the use of variance analysis in statistical quality assurance for performing quality analyses and

quality comparisons after the completion of manufacturing lots as well as in the production input and output control. For this purpose among other things, a variance analysis of deviations is specially introduced. (Translated author abstract) In German. 5 refs.

Jehlich, Wolfgang; Schrocko, Winfried. *Wiss Z Tech Univ Karl Marx Stadt* v 29 n 3 1987 p 359-363.

**087320 YOU CAN HAVE YOUR PROFITS AND QUALITY, TOO.** Some suggestions are presented on how to start planning a quality assurance program for a company. Quality is defined as adhering to the specification of a given job. Involvement of all personnel in the program is emphasized. The preeminent role of the management is pointed out.

Anon. *Fastener Age* v 2 n 1 Jan-Feb 1988 p 20-21.

**087321 LAYERED MODEL FOR LIFE CYCLE ENGINEERING.** This paper seeks to present an alternative model of the engineering life cycle that is applicable to a number of engineering disciplines. At the same time the model seeks to address the fundamental failure of other models by trying to provide a framework within which to develop a project, grounded on the firm foundation of a quality assurance system conforming to an agreed national standard. Rules covering the bonding and traversal mechanism are described. (Author abstract)

Bibby, J.W. (Directorate General of Defence Quality Assurance, Bromley, Engl); Jones, I.E. *Qual Assur* v 14 n 2 Jun 1988 p 54-58.

**087322 STATISTICAL APPROACH TO QUALITY IN AUTOMATED MANUFACTURING.** The roles of some of the 'traditional' and recent concepts of quality engineering in an automated manufacturing environment are discussed. An overview of quality assurance activities is first given. This is followed by an explanation of the evolution of the applications of statistical quality control, and finally an examination is made of the need for such applications vis-a-vis automated manufacturing. 29 refs.

Goh, T.N. (Natl Univ of Singapore, Singapore). *Qual Assur* v 14 n 2 Jun 1988 p 59-63.

**087323 OVERALL QUALITY IMPROVEMENT—TOTAL QUALITY IMPROVEMENT (QI/TQI) PROGRAMME: FROM 1 PER CENT AQL TO 10 ppm.** This paper describes the quality improvements made in the four years from July 1982 to July 1986 in a company which is a major manufacturer of electronic components. Products include foil capacitors, delay lines, quick heat cathodes and metal precision parts for use in picture tubes, and also wire and lamp spirals, mainly for use in lighting. The paper tells how a coherent quality policy was developed and linked with company-wide initiatives and with plant and product group quality objectives. It gives a detailed account of the implementation program, and examples which illustrate the direct results of the various improvement activities. The paper also explains how quality awareness and sensitivity to customer needs have been strengthened, and how the company is managing to 'hold the gains' through audits and controls. (Edited author abstract) 1 ref.

Payne, B.J. (Mullard Blackburn, Engl). *Qual Assur* v 14 n 2 Jun 1988 p 69-77.

**087324 BEYOND QUALITY: TAKING SPC UPSTREAM.** Statistical process control (SPC) is an important tool for improving quality and productivity. Many companies are moving from manufacturing process quality control to product development quality control. One of the emerging technologies at the forefront of this movement is Quality Function Deployment (QFD). QFD helps companies design more competitive products, in less time, at lower cost and higher quality. QFD is aimed at detecting and solving quality problems at a much earlier



stage than is SPC. This article explores QFD concepts, and examines the longer-term limitations of reliance on SPC to achieve leadership in cost and quality. 2 refs.

Fortuna, Ronald M. (Ernst & Whinney, USA). *Qual Prog* v 21 n 6 Jun 1988 p 23-28.

**087325 NEW PARADIGM FOR QUALITY ASSURANCE.** A concept selection technique that uses the Quality Function Deployment (QFD) planning chart ensures customer needs are appropriately represented in the design. The focus is on satisfying customer needs. This approach favorably affects product quality and engineering efficiency before a design becomes reality - when there is maximum leverage to satisfy the customer. The concept selection technique uses QFD and allows the development team to become intimately familiar with product requirements prior to concept selection. This critical sequence improves the initial direction of the product development program. Many benefits that boost efficiency and product quality result from this improvement.

Kenny, Andrew A. (Eaton Corp, Carol Stream, IL, USA). *Qual Prog* v 21 n 6 Jun 1988 p 30-32.

**087326 QUALITY VS. SAFETY.** This article contrasts the broad concepts of quality with the specific responsibilities of safety. Quality assurance reduces failures; product safety reduces risks of hazards.

Rose, Manning I. (NCR Corp, Dayton, OH, USA). *Qual Prog* v 21 n 6 Jun 1988 p 70-71.

**Applications** See NUCLEAR FUELS—Quality Assurance.

**Calculations** See GLASS MANUFACTURE—Mathematical Models.

## Computer Aided Manufacturing

**087327 USE OF COMPUTERS IN QUALITY ASSURANCE SYSTEMS FOR LARGE MANUFACTURING AND CONSTRUCTION PROJECTS.** This conference proceedings contains 9 papers on the use of computers in quality assurance systems. Some of the topics covered are quality assurance: of data in database systems and information retrieval systems; of computer software; in the manufacture and testing of electronic components; in military command systems and in CAD/CAM. Quality assurance techniques, as well as management information systems relating to quality assurance are discussed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 08696 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Computing & Control Div, London, Engl). *IEE Colloq Dig* n 1986/39, Use of Comput in Qual Assur Syst for Large Manuf and Constr Proj, London, Engl, Mar 19 1986. Publ by IEE, London, Engl, 1986 var pagings.

## Computer Applications

**087328 ERFABRUNGEN MIT CAQ. [Experiences with CAQ].** Integrated quality assurance denotes involvement of all the relevant fields and thus all the phases of the product cycle. This again means integration of the computer aided quality assurance (CAQ) in all the appropriate data processing application systems. Such a solution is nowadays a multilayered problem and touches on almost all the areas of a production enterprise. A modern CAQ solution is therefore a complex subject which must be structured and implemented only step by step. (Translated author abstract) In German.

Winterhalder, L. *F&M Feinwerktech Messtech* v 95 n 6 Sep-Oct 1987 p CA126-CA128.

**087329 ASSURING QUALITY AND RELIABILITY OF COMPLEX ELECTRONIC SYSTEMS: HARDWARE AND SOFTWARE.** Some of the most recent trends in expanding the scope of traditional quality-assurance techniques to include all phases of design, develop-

ment, manufacture, and deployment, considering both hardware and software, are discussed. Emerging views on quality management are discussed. The life cycle of a product, beginning with the setting of requirements, and including assuring parts reliability, evaluating a fault-tolerant architecture, avoiding physical design hazards, enforcing software development methodology, measuring conformance to requirements in manufacture, and tracking performance in the field is considered. The author's goal is to review, in a general way, what can be accomplished through use of the various assurance techniques with references given to examples from the literature, which gives historical background as well as teaches the technical methods in detail. 66 refs.

Irland, Edwin A. (Bell Communications Research Inc, Red Bank, NJ, USA). *Proc IEEE* v 76 n 1 Jan 1988 p 5-18.

**Costs** See CONSTRUCTION INDUSTRY—Performance.

**Europe** See WELDING—Quality Assurance.

## Evaluation

**087330 OBJECTIVE QUALITY EVALUATION FOR LOW-BIT-RATE SPEECH CODING SYSTEMS.** An LPC (linear predictive coding) cepstrum distance measure (CD) is introduced as an objective measure for estimating the subjective quality of speech signals. Good correspondence between LPC CD and the subjective quality, expressed in terms of both opinion equivalent Q and mean opinion score, are shown. Good repeatability of objective quality evaluation using LPC CD is also shown. A method for generating an artificial voice signal that reflects the characteristics of real speech signals is described. The LPC CD values calculated using this artificial voice are almost the same as those calculated using real speech signals. The speaker-dependency of the coded-speech quality is shown to be an important factor in low-bit-rate speech coding. Even taking this factor into consideration, LPC CD is shown to be effective for estimating the subjective quality. 8 refs.

Kitawaki, Nobuhiko (NTT, Tokyo, Jpn); Nagabuchi, Hiromi; Itoh, Kenzo. *IEEE J Sel Areas Commun* v 6 n 2 Feb 1988 p 242-248.

## Inspection

**087331 SYSTEMATIC INSPECTION AND TEST PLANNING AS A MEANS OF PREVENTIVE QUALITY ASSURANCE.** Systematic inspection and test planning which incorporates all steps in the inspection process can be used to advantage in a manufacturing plant as a means of preventive quality assurance. The Siemens AG Nuernberger Maschinen- und Apparaterwerk (NMA) started to introduce standard inspection and test plans in 1985. These are now available for the most important product groups. (Author abstract) 3 refs.

Aunger, Herbert (Siemens AG); Rommelfanger, Horst. *Energy Autom* v 9 n 6 Nov-Dec 1987 p 30-33.

**Management** See Also PUMPS—Reliability; QUALITY CONTROL—Management; WIRE DRAWING—Quality Assurance.

**087332 FRAMEWORK FOR A SERVICE QUALITY ASSURANCE SYSTEM.** Some basic themes about quality control and quality assurance are given. The manufacturing quality control model starts with quality of design - the user-based approach, and identifies the product characteristics desired by the user. Standards are then established for those characteristics (product- and value-based approach), and the product is designed to meet those standards. In production, conformance to standards is measured (manufacturing-based approach) by testing and/or inspecting the output, and by monitoring the input materials and the production process. Nonstandard output is analyzed to determine the cause of failure, so that corrective action can be taken. 7 refs.

King, Carol A. *Qual Prog* v 20 n 9 Sep 1987 p 27-32.

**087333 QUALITY ASSURANCE CAN BE MANAGED EFFECTIVELY AS A DISTRIBUTED FUNCTION.** Recently a project was conducted, the purpose of which was to provide a quality assurance function where none previously existed and at the same time to verify the validity of a non-traditional solution to the quality control problem. This was done by first designing, then modeling and implementing a quality assurance function based on distributed rather than centralized responsibility. As discussed in the articles, at least in this case, the distributed system works and the theory was validated. The approach to the solution was; existing employee attitudes were measured to determine if attitudes toward quality needed to be improved; a paper model was constructed using the results of the employee survey and the needs of the company as a basis for the design; the system was implemented and the results measured against two criteria. 4 refs.

Thompson, Bruce A. (Votan, Fremont, CA, USA). *Ind Eng (Norcross GA)* v 20 n 2 Feb 1988 p 42-46.

**Optimization** See TEXTILES—Quality Assurance.

**Planning** See ELECTRONIC CIRCUITS—Quality Assurance.

## Research

**087334 ENGINEERING FOR QUALITY.** In the AE December 1987 Viewpoint feature, Dr. John Parnaby described the urgent need for change in UK manufacturing systems engineering. He has also provided AE with a reading list for those involved in this discipline. The author reviews these works and others just published in this literature survey feature which prefaces a series of contributed articles on Engineering for Quality to be published in succeeding issues of AE. (Edited author abstract) 17 refs.

Anon. *Automot Eng (London)* v 13 n 2 Apr-May 1988 6p.

**Robot Applications** See PAPER AND PULP MILL—Automation.

**Standards** See Also CASTINGS—Quality Assurance.

**087335 QUALITY ASSURANCE AND BS 5750.** Quality assurance systems can save millions annually by reducing quality defects, cutting production costs and enhancing the image and marketing power of a mill. Most firms with QA systems achieve payback within 3 to 15 months, and some are reporting a 20% increase in turnover. The paper describes BS 5750 - the UK's national standard for quality assurance - what it involves, and how it can help a company. (Author abstract)

Guest, David A. (Pira, Leatherhead, Engl); Allibone, Trudie. *Pap Technol Ind* v 28 n 5 Aug 1987 p 544-546.

**087336 BENEFITS OF AN IN-HOUSE QUALITY ASSURANCE PROGRAMME TO AN INTERNATIONAL INSPECTION COMPANY.** This paper describes how a company, which provides third party inspection and quality auditing services to construction, mechanical engineering and petrochemical industries, developed its own quality assurance program. This was designed to improve, in particular, written procedures, internal auditing and recruitment and training. BS5750: Part 2 was selected as the quality standard most appropriate to an international service company, and the authors give a detailed breakdown of how the standard was interpreted to ensure that the program would comply fully with its requirements. While the costs of the program are difficult to quantify, its benefits are considerable. (Author abstract)

Debenham, M.G.S. (British Inspecting Engineers Group); Allen, A.L. *Qual Assur* v 14 n 1 Mar 1988 p 21-25.



Switzerland See TELECOMMUNICATION SYSTEMS—Quality Assurance.

United Kingdom See PRODUCT LIABILITY—United Kingdom.

**QUALITY CONTROL** See Also ADHESIVES—Curing; AGRICULTURAL PRODUCTS—Storage; CEMENT—Manufacture; CERAMIC MATERIALS—Nondestructive Examination; CHEMICAL ENGINEERING—Calculations; CHEMICAL INDUSTRY—Quality Control; CHEMICAL REACTIONS—Fermentation; COAL PREPARATION—Process Control; CONCRETE—Inspection; CONCRETE—Mechanical Properties; CONCRETE INDUSTRY—Sri Lanka; COPPER AND ALLOYS—Sheet and Strip; COTTON—Analysis; FAILURE ANALYSIS—Optimization; FOUNDRY PRACTICE—Molding; IMAGE PROCESSING—Image Analysis; INDUSTRIAL ENGINEERING; INDUSTRIAL MANAGEMENT; INSPECTION; INSPECTION—Reliability; INVENTORY CONTROL; IRON ORE TREATMENT—Sintering; MEASUREMENTS—Computer Applications; METALS AND ALLOYS—Fabrication; NONDESTRUCTIVE EXAMINATION—Equipment; NUCLEAR FUELS—Mixed Oxides; OPTICAL FIBERS—Production; PHOTOGRAPHIC FILMS AND PLATES—Processing; PIPE, STEEL—Manufacture; PROCESS CONTROL; PROCESS CONTROL—Optimization; PROCESS CONTROL—Performance; PROCESS CONTROL—Reliability; PRODUCT LIABILITY; PRODUCTION CONTROL; PRODUCTION ENGINEERING; PROTECTIVE COATINGS—Powder; QUALITY ASSURANCE; RAILS—Manufacture; RELIABILITY—Estimation; RELIABILITY THEORY; SAMPLING; SAMPLING—Optimization; SCREWS—Manufacture; SEALS—Manufacture; STATISTICAL METHODS; STEEL—Continuous Casting; STEELMAKING—Physical Chemistry; ULTRASONIC TRANSDUCERS—Industrial Applications; WIRE—Manufacture; WOOL—Sampling.

**087337 USE OF QUALITY CIRCLES IN QUALITY IMPROVEMENT PROGRAMMES.** To implement an effective quality policy in any organization requires a total commitment to participation from all employees, and is best achieved through good communications and involvement. The Quality Circle concept provides a practical way of achieving these objectives. This paper describes the guidelines for introducing a successful program, traces some of the pitfalls to avoid, and discusses both the tangible and intangible rewards. (Edited author abstract)

Spencer, R.J. (Rolls-Royce Motors Ltd, Crewe, Engl). *Int J Technol Manage* v 2 n 2 1987 p 229-240.

**087338 LIEFERANTEN-AUDITS. [Supplier-Audits].** Only the supplier can really take care of guaranteed quality, and this cannot be 'somehow', but only systematically be secured. The consequence of these views is the installation of a QS-System at suppliers. The customer audits its effectiveness and afterwards appraises the suppliers. The general demands of a QS-System and the special requirements in single cases as well as the conduct and evaluation of the audits are discussed. (Edited author abstract) In German.

Wilhelm, F. *Kautsch Gummi Kunstst* v 40 n 8 Aug 1987 p 732-734.

**087339 QUALITAET IM SPANNUNGSFELD ZWISCHEN ANFORDERUNGEN UND KOSTEN. [Product Quality between Requirements and Costs].** Huber and Suhner AG pursues a consistent quality policy based on market needs and implemented by means of a company wide quality assurance system. Main object is established of mutual requirements together with customers, employees and shareholders. The correlation between quality and return on investment is demonstrated by analysis of quality cost data. Quality assurance guidelines and instructions applied systematically in design activities allow significant improvement of the R+D potential. (Edited author abstract) In German. 3 refs.

Widmer, H. *Kautsch Gummi Kunstst* v 40 n 8 Aug 1987 p 735-739.

**087340 SIMPLE METHOD FOR STUDYING RUN-LENGTH DISTRIBUTIONS OF EXPONENTIALLY WEIGHTED MOVING AVERAGE CHARTS.** A numerical procedure using integral equations is presented for the tabulation of moments of run lengths of exponentially weighted moving average (EWMA) charts. Both average run lengths (ARL's) and standard deviations of run lengths (SDRL's) are presented

for the two-sided EWMA chart assuming normal observations, along with an example illustrating how to design such a chart. The procedure given extends easily to many nonnormal cases and to one-sided versions of the EWMA chart. (Author abstract) 11 refs.

Crowder, Stephen V. (Corning Glass Works, Corning, NY, USA). *Technometrics* v 29 n 4 Nov 1987 p 401-407.

**087341 NOTE ON MULTIVARIATE CUSUM PROCEDURES.** Cumulative sum (CUSUM) procedures are among the most powerful tools for detecting a shift from a good quality distribution to a bad quality distribution. This article discusses the natural application of CUSUM procedures to the multivariate normal distribution. It discusses two cases, detecting a shift in the mean vector and detecting a shift in the covariance matrix. As an example, the procedure is applied to measurements taken on optical fibers. (Author abstract) 19 refs.

Healy, John D. (Bell Communications Research, Red Bank, NJ, USA). *Technometrics* v 29 n 4 Nov 1987 p 409-412.

**087342 QUALITY GURUS - PART 1: THE DEMING PHILOSOPHY.** There is a belief that higher quality costs more. In fact, higher quality costs less, according to some. Dr. W. Edwards Deming's Fourteen Points provide a philosophy of management to implement quality control. 5 refs.

Propst, Annabeth L. (Process Management Inst, Bloomington, MN, USA). *Mach Tool Blue Book* v 82 n 12 Dec 1987 p 38-42.

**087343 VENDOR RELATIONS: AN IMPORTANT PIECE OF THE QUALITY PUZZLE.** More sensible arrangements with vendors can boost quality because often vendors do not deliver component parts with sufficiently high quality. Some topics discussed by this paper are these: vendor relations and quality, quality guaranteed or improved by inspection, Deming's plan, price alone not being a criterion for purchase, the importance of the purchase agent, multiple sourcing, single sourcing, and writing contracts. 9 refs.

Gitlow, Howard S. (Univ of Miami, Coral Gables, FL, USA); Wiesner, Donald A. *Qual Prog* v 21 n 1 Jan 1988 p 19-23.

**087344 TAGUCHI APPROACH TO PARAMETER DESIGN.** In the words of G. Taguchi: The quality of a product is the (minimum) loss imparted by the product to the society from the time the product is shipped. 3 refs.

Byrne, Diane M. (Eaton Corp, Southfield, MI, USA); Taguchi, Shin. *Qual Prog* v 20 n 12 Dec 1987 p 19-26.

**087345 DON'T BE FOOLED BY THE MEASUREMENT SYSTEM.** The major purpose of an SPC/SQC program is to make sure that the process is controlled so that a quality product is consistently made - that is, to ensure that off-spec material is not produced. Control limits are usually determined from the data obtained from normal quality control tests. Thus, attention must be given to the test and measurement systems used to monitor quality-related parameters. One must be confident that when a change is made to the process it is in response to a process problem and not a variation or change associated with a test or measurement. In the experiences of the authors at a number of manufacturing locations, the measurement systems have been a major problem. Thus, it is advantageous to focus initially on the measurement systems - to establish their adequacy and remove assignable causes from them - before investigating process capability. This strategy played a role in a quality improvement effort that saved over \$3 million; the cases described are taken from that effort. 8 refs.

Bishop, Lane (Allied Signal Inc, Buffalo, NY, USA); Hill, William J.; Lindsay, Wayne S. *Qual Prog* v 20 n 12 Dec 1987 p 35-38.

**087346 IMPROVING PRODUCT RELIABILITY.** In the last three decades, reliability has become an

important measure of product performance. The emphasis started in military and space programs and has spread to most consumer goods. Reliability is 'the probability that a product will perform its intended functions under stated conditions for the specified time.' From this definition it can be seen that reliability is a probabilistic concept, involving a product's planned use, its operating environment, and time. The techniques discussed use those three elements to improve the reliability of products. 5 refs.

Burgess, J.A. (Westinghouse Power Transformer Plant, Muncie, IN, USA). *Qual Prog* v 20 n 12 Dec 1987 p 47-54.

**087347 PERFORMANCE INDICATORS - WHY, WHERE AND HOW?** The drive for 'total quality control' has strongly enhanced the interest for performance indicators in many companies. This paper briefly describes how useful performance indicators are designed, what can be done with them, how they should be employed and what pitfalls have to be avoided during implementation. It is shown that if properly used, they provide management at all levels with a tool to monitor and control their business. They indicate the quality of products and services, of activities and actions to improve affairs, and in this way are a welcome quantitative and non-financial complement to the traditional financial reports. 1 ref.

Fortuin, Leonard (Nederlandse Philips Bedrijven BV, Eindhoven, Neth). *Eur J Oper Res* v 34 n 1 Feb 1988 p 1-9.

**087348 TESTING FOR INTERACTIONS USING THE ANALYSIS OF MEANS.** An analysis of means (ANOM) procedure is suggested for testing the significance of two-factor interactions in fixed-effects balanced designs. When at least one factor is at only two levels, the suggested procedure uses the exact critical points for the ANOM. New critical points are given for the case in which both factors are at more than two but fewer than six levels. The procedure can be extended to higher-order interactions, but the quantities being plotted become so complex that they are of little use in assessing practical significance. (Author abstract) 10 refs.

Nelson, Peter R. (Rensselaer Polytechnic Inst, Troy, NY, USA). *Technometrics* v 30 n 1 Feb 1988 p 53-61.

**087349 SPECTRAL ANALYSIS IN QUALITY CONTROL: A CONTROL CHART BASED ON THE PERIODOGRAM.** This article is concerned with the development of a control chart that detects cycles in the process mean. The new control chart, the spectral control chart, is based on the periodogram. The value plotted at each point in time is the ratio of the largest periodogram ordinate to the average of all ordinates. When an observation falls above the prescribed control limit, an out-of-control signal is given. The spectral control chart is compared with the Shewhart and geometric moving average charts. (Edited author abstract) 23 refs.

Beneke, Margarita (Univ of Oklahoma, Norman, OK, USA); Leemis, Lawrence M.; Schlegel, Robert E.; Foote, Bobbie L. *Technometrics* v 30 n 1 Feb 1988 p 63-70.

**087350 METAMORPHOSIS OF THE QUALITY FUNCTION.** After World War II when Europe and Japan were busy rebuilding, North American industry has a monopoly on the market. In this economic climate, two different approaches to the quality function evolved: One, rooted in the economy's public sector, promoted quality assurance departments, while the other, rooted in the private sector, fostered quality control departments. The former subsists in a contractual environment; whereas the latter subsists in a marketing environment. Despite the distinct differences in their roots and initial missions, the quality assurance and the quality control function have common features. While a new appreciation of quality



control is emerging in the U.S., industrial leaders still do not think of quality improvement as a crucial way of improving cost effectiveness. 17 refs.

Stanenas, Al P. (Honeywell Ltd, Canada). *Qual Prog* v 20 n 11 Nov 1987 p 30-33.

**087351 VALUES-ORIENTED APPROACH TO QUALITY.** Since the late 1970s American industry has been in a headlong rush to replace quality systems that could only detect problems and defects with those that can prevent them. (Edited author abstract)

Gilbert, Ross J. (Kohler Co). *Qual Prog* v 20 n 11 Nov 1987 p 38-40.

**087352 NEW ZEALAND'S QUALITY CHALLENGE.** Political, economic, and social changes are having a profound effect on New Zealand's agriculture, manufacturing, and service sectors, presenting new challenges for the quality professional. Over the past decade much has been done to raise the level of awareness and understanding of the role of quality assurance in industry. Some topics discussed in this paper are these: documented quality systems, usually employed in large companies, and their general absence in small companies; consumer awareness of quality; new roles for quality professionals; quality improvement and industrial relations; research and development; and the avoidance of disillusionment with quality improvement efforts.

Wenmoth, Bryan A. (Massey Univ, Palmerston North, NZ). *Qual Prog* v 20 n 11 Nov 1987 p 45-47.

**087353 TOMORROW'S TOTAL QUALITY MANAGER.** In the tighter work scheduling of today's manufacturing, reworking a product has become prohibitively expensive. As a result, total quality at Westinghouse is defined as 'performance leadership in meeting customer requirements by doing the right things right the first time'. A discussion is given on how Westinghouse goes about enhancing the quality of its products and redefining the role of the quality manager. 1 ref.

Aquino, Michael A. (Westinghouse, Pittsburgh, PA, USA). *Qual Prog* v 20 n 11 Nov 1987 p 48-50.

**087354 QUALITY SERVICES: A NEW BUSINESS PARTNER.** For a company to adopt the new quality and business principles and achieve continual improvement in a time frame that will not let competitors erode the existing competitive advantages, an infrastructure must exist to provide quality technology, business and process improvement methodologies, and leadership and enthusiasm. The infrastructure must have a clear constancy of purpose to support line management in achieving this new-age thinking and competitive advantage. Eastman Chemicals Division (ECD) recognizes that quality is a strategic business issue. ECD's quality policy outlines its quality goal, the principles to follow, the operation policy for guidance, and the elements that support achievement of the goal. ECD developed a 'quality services' organization to help integrate and coordinate the activities that will lead to the policy's implementation. This new business partner is a function incorporated into ECD's infrastructure.

White, James R. (Tennessee Eastman Co); Dingus, Victor R. *Qual Prog* v 20 n 11 Nov 1987 p 56-60.

**087355 INTRODUCTION TO TAGUCHI METHODS.** The methods of quality improvement developed by Genichi Taguchi have already found widespread acceptance in Japan and the US. Based on a different way of thinking about quality, they use statistical analysis to ensure high product quality. Taguchi's thinking on quality is based on two fundamental concepts: that any loss in quality is defined as a deviation from a target, not a failure to conform to an arbitrary specification; and that high quality can only be achieved economically by being designed in from the start, not by inspection and screening. Taguchi's definition of quality is customer-oriented. Quality is the characteristic that avoids loss to society after the product is shipped. A loss of quality can therefore be measured in pounds, dollars or yen. His philosophy is

that adding features is not a way of improving the quality of a given product, only of varying its price and the market segment it is aimed at.

Taguchi, Genichi. *Engineering (London)* v 228 n 1 Jan 1988 p 1-11.

**087356 STATISTICAL QUALITY CONTROL IMPLEMENTATION.** Statistical Process Control, or SPC, is simply 'the application of statistical techniques, such as control charts, to control and improve a process to achieve uniformity in its output'. A process is any combination of manpower, machines, methods, materials and a measurement system (laboratory) which together produce an output, each of which contributing to the inherent variation observed in the outputs. The history of SPC is briefly recalled and the role of random variation in SPC is examined. The SPC tools, such as histograms, trend charts, control charts, flow charts, cause and effect diagrams, Pareto Charts, scatter diagrams, and experimental designs are explained and illustrated.

Ricks, W.H. (Union Carbide). *Fastener Age* v 2 n 1 Jan-Feb 1988 p 34-40.

**087357 'BREAKTHROUGH' APPROACH TO QUALITY IMPROVEMENT.** Traditional concepts of 'controlling quality levels' are no longer sufficient. The Juran approach urges companies to break the chain of the past, reaching improved quality levels on an ongoing basis. An organized step-by-step approach to creating breakthrough results is the hallmark of the Juran quality improvement process. The Juran Institute studies suggest that a reasonable objective for a company is to cut the costs of poor quality in half over a period of five years. This means cutting in two the product field failure rates, internal waste, and all other related costs associated with poor quality. The radical departure proposed by the Juran program is that each member of management personally engage in quality improvement. Typically, a quality steering committee (or council) comprising key operating members of the top management team is created. The steering committee determines the broad policy for the quality improvement programs, determines how training will be implemented throughout company management, and forms project teams to begin the process of improvement.

Anon. *Chem Eng Prog* v 84 n 4 Apr 1988 p 25-26.

**087358 QUALITY MANAGEMENT SYSTEMS IN HIGH-PERFORMANCE PLASTIC FILMS.** A three-fold model is proposed for a Quality Management System which is composed of the quality cycle, generic concepts for suppliers and customers, and continuous improvement. These items form a base for understanding the basic principles and the movement of information and action within a system. The three elements are: the quality circle; generic concepts for supplier-customer relations; and, continuous improvement. Methods for organizing quality teams and elements of the quality management system are given. The author also covers such topics as: Statistical analysis; segregated product and release plus supplier relations. 5 refs.

Hovermale, Ralph A. (Du Pont, Circleville, OH, USA). *Chem Eng Prog* v 84 n 4 Apr 1988 p 36-44.

**087359 EXCELLENCE THROUGH QUALITY IMPROVEMENT.** The author discusses factors leading to an improvement in product quality. A brief discussion is presented of the Juran program of Quality Improvement. An outline is given of the strategies required to achieve the goal of being recognized as the quality leader. The organization of a Quality team is highlighted and the emphasis on training is reviewed. A vendor improvement plan is also described.

Carroll, Connie E. (Union Carbide Corp, Seadrift, TX, USA). *Chem Eng Prog* v 84 n 4 Apr 1988 p 45-51.

**087360 ON-LINE STATISTICAL QUALITY CONTROL.** The authors show that the principal components of a process monitoring system and their functions must be clearly understood to properly apply SQC. Numeric

and nonnumeric data must be acquired from the sensors and lower-level devices, such as programmable and analog controllers that actually control the process. A database designed for process experimentation, display flexibility, and SQC must have the following features: storage of a value; file depths; logging of variables; log entry tagging; long term data storage; and, compressed data. Techniques for obtaining data for SQC charts are outlined. The need for maintaining two databases is explained along with the use of trend and scatter diagrams. The use of Pareto charts is also discussed.

Gimson, Guy D. (Allen-Bradley Co Inc, Highland Heights, OH, USA); Coleman, Gary G. *Chem Eng Prog* v 84 n 4 Apr 1988 p 58-64.

**087361 LABOR/MANAGEMENT PARTICIPATION: THE A.O. SMITH EXPERIENCE.** The immediate imperative behind the changes taking place at the company is survival in the tough automotive components business, but the long-term thrust is very definitely competitiveness through world-class quality with all its implications. The company and its unions have agreed that the way to get there is through a quality-focused notion of workplace democracy. Together, labor and management have embarked upon an ambitious program of joint planning and problem solving called B.E.S.T. (Bringing Employee Skills Together). The B.E.S.T. system represents a completely new approach to doing business at A.O. Smith. It is a form of labor/management participation that is creating an environment conducive to change. B.E.S.T. promotes quality by making full use of the skills, knowledge, and potential of the entire work force. These and other aspects of the subject are discussed.

Ryan, John. *Qual Prog* v 21 n 4 Apr 1988 p 36-40.

**087362 SETTING QUALITY GOALS.** Few subjects in the arena of quality and productivity evoke such extreme reactions as goal setting. Advice on this subject varies widely and is rarely specific or proven. Experience of both people who set goals and people who must meet them are almost universally frustrating, to say the least. And yet most people seem to have a basic need to set specific goals and to achieve them. Unfortunately, most goals lack that specificity; they fail to define both a rational objective and a time line for its achievement. What is needed is an empirically based goal-setting model for legitimate quality improvement process (QIP) activities. (Edited author abstract) 14 refs.

Schneiderman, Arthur M. *Qual Prog* v 21 n 4 Apr 1988 p 51-57.

**087363 QUALITY CONTROL BY SPECTRAL ANALYSIS.** The construction of an inspection procedure for devices which are working under mechanical stress is discussed. The underlying model assumes that vibration under a certain form of stress is nearly constant with a continuous spectrum. The observation of vibration at specified times leads to estimates of the spectral density functions. Two characteristic deviations between the estimated and the expected form of the spectral density function are discussed which are the basis of quality control charts. On the one hand, some measure for a global difference between these functions (e.g. integrated squared differences) and on the other hand, some measure for the greatest difference have to be used. For special measures concrete statistical inference is possible. (Author abstract) 7 refs.

Strelec, H. (Univ of Technology of Vienna, Vienna, Austria). *Int J Mater Prod Technol* v 3 n 1 1988 p 11-19.

**087364 EXPLANATION AND CRITIQUE OF TAGUCHI'S CONTRIBUTIONS TO QUALITY ENGINEERING.** This paper explains some of Taguchi's contributions to quality engineering and also provides a critical evaluation of his statistical methods. Our conclusion is that although on the one hand, Professor Taguchi's quality engineering ideas are of great importance and should become part of the working knowledge of every



engineer, on the other hand, many of the techniques of statistical design and analysis he employs to put these ideas into practice are often inefficient and unnecessarily complicated and should be replaced or appropriately modified. In this short article only an overview is attempted, but references are appended where these matters are discussed in greater detail. (Edited author abstract) 37 refs.

Box, George (Univ of Wisconsin-Madison, Madison, WI, USA); Bisgaard, Soren; Fung, Conrad. *Qual Reliab Eng Int* v 4 n 2 Apr-Jun 1988 p 123-131.

**087365 SIGNAL-TO-NOISE RATIO DEVELOPMENT FOR QUALITY ENGINEERING.** Dr. Taguchi developed the concept of signal-to-noise (SN) ratio in quality engineering to evaluate the performance of a system. The objective is to develop systems which are robust against noise factors. The SN ratio indicates the degree of the predictable performance of a product or process in the presence of noise factors. Parameter design of the Taguchi method optimizes the SN ratio in the domain of control factors, so that performance could be made insensitive to the noise factors in order to improve product quality. The SN ratio for four cases of dynamic characteristic problems is developed in this paper. This paper also gives the method to compute SN ratios for both equispaced and non-equispaced intervals for levels of signal factors. Two examples are presented to illustrate the method. (Edited author abstract) 12 refs.

Kapur, Kailash C. (Wayne State Univ, Detroit, MI, USA); Chen, Guangming. *Qual Reliab Eng Int* v 4 n 2 Apr-Jun 1988 p 133-141.

**087366  $\bar{X}$  CHARTS WITH VARIABLE SAMPLING INTERVALS.** This article considers the properties of the  $\bar{X}$  chart when the sampling interval between each pair of samples is not fixed but rather depends on what is observed in the first sample. The idea is that the time interval until the next sample should be short if a sample shows some indication of a change in the process and long if there is no indication of a change. The proposed variable sampling interval (VSI)  $\bar{X}$  chart uses a short sampling interval if  $\bar{X}$  is close to but not actually outside the control limits and a long sampling interval if  $\bar{X}$  is close to target. If  $\bar{X}$  is actually outside the control limits, then the chart signals in the same way as the standard fixed sampling interval (FSI)  $\bar{X}$  chart. (Edited author abstract) 16 refs.

Reynolds, Marion R. Jr. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Arnold, Jesse C.; Amin, Raid W.; Nachlas, Joel A. *Technometrics* v 30 n 2 May 1988 p 181-192.

**087367 APPLICATION OF CONDITION MONITORING TECHNIQUES TO PRODUCT QUALITY MONITORING.** Techniques normally associated with automated condition monitoring, such as dynamic analysis, spectrum comparison and fault diagnostics may be used to create a sensitive inspection technique for mechanical products capable of detecting faults not easily found from performance tests. This article outlines the concept of the technique, known as Product Quality Monitoring (PQM), examines some of the methods employed and discusses advantages, limitations and future development. (Author abstract)

Hughes, M.L. (BHRA, Cranfield, Engl). *Meas Control* v 21 n 4 May 1988 p 113-118.

**087368 AUTOMOTIVE CASE STUDY.** Eaton Corporation Controls Division realized that when the Quality Function Deployment (QFD) process was initially being viewed, a case study was needed as both a learning process and as an example to teach other interested groups. This article discusses how Eaton Corporation used an air conditioning part to clear the way for future QFD projects.

De Vera, Dennis (Eaton Corp, Carol Stream, IL, USA); Glennon, Tom; Kenny, Andrew A.; Khan, Mohammad A.H.; Mayer, Mike. *Qual Prog* v 21 n 6 Jun 1988 p 35-38.

**087369 ROLE OF TAGUCHI METHODS AND DESIGN OF EXPERIMENTS IN QFD.** Quality function deployment ties the product, user, value, and manufacturing viewpoints together in a continuous process of defining the product design and manufacturing requirements. The Taguchi loss function relates the user and manufacturing viewpoints to one another. Taguchi Methods, design of experiments, and QFD are complementary tools that should be used during the off-line phase of a product or process life cycle.

Ross, Philip J. (Saturn Corp, USA). *Qual Prog* v 21 n 6 Jun 1988 p 41-47.

**087370 QUALITY BY NUMBERS.** Statistical process control (SPC) is a collection of statistical techniques which, when applied to plant data, show variation of process or product variables. Displayed on charts, they allow plant management to assess the process's ability to perform consistently and measure subsequent performance changes. 'Statistics is very important because it allows you to recognise the significance of numbers,' says ICI's Dr. Arthur Thomas, a leading member of the company's SPC working party.

Atkinson, Nigel. *Process Eng (London)* v 69 n 4 Apr 1988 p 41, 43.

**087371 TESTS OF ELECTRONIC MEANS OF ACTIVE QUALITY CONTROL FOR DETERMINING THEIR TECHNICAL LEVEL.** The authors developed a method of comparative workshop tests for determining the technical levels of means of active quality control. In comparative workshop tests two measuring complexes take part simultaneously: one of them acts as measure of comparison, the other acts as the tested complex. Tests are made both with the entire measuring complex and with its principal component parts: the measuring head (MH) and the electronic transducer (ET). When only an MH or only an ET is tested, then the missing part of the tested complex of means of quality control is complemented by parts of the complex used as the reference complex. Three possible variants of complementing that are compared in comparative tests are given. The entire test period is divided into two equal cycles. The length of the tests (and the length of one cycle) depends on the required accuracy and reliability of their results, and by specifying these it is possible to determine the number of components to be processed during the time of the workshop tests. 2 refs.

Reshetov, A.G.; Shelemet'ev, V.D.; Kuz'michev, G.M.; Yastrebov, V.M.; Talaluev, V.V. *Chem Pet Eng* v 23 n 7-8 Jul-Aug 1987 p 412-414.

**087372 RESCREENING-A USER'S HISTORY AND RECOMMENDATIONS.** Rescreening is performed as a methodology implemented by the original equipment manufacturer to gain confidence in both the inherent quality found in the component parts and the integrity of the prior testing performed on them. Our history at Martin Marietta Electronics Systems demonstrates that rescreening is a viable quality control process. No uniform sequence of test elements is used in rescreening. The various original equipment manufacturers and their customers have specified a broad range of plans to rescreen parts based on the system stress, the required level of systems reliability, the history of parts failures and the physics of failure. 1 Ref.

Zata, Saul (Martin Marietta Electronics Systems Cent, Orlando, FL, USA); Seller, Sandra. *Eval Eng* v 27 n 8 Aug 1988 6p.

**087373 ROBUSTNESS OF MEAN  $E(X)$  AND  $R$  CHARTS.** The effect of nonnormality on  $E(X)$  and  $R$  charts is reported. The effect of departure from normality can be examined by comparing the probabilities that  $E(X)$  and  $R$  lie outside their three-standard-deviation and two-standard-deviation control limits. Tukey's  $\lambda$ -family of symmetric distributions is used here because it contains a wide spectrum of distributions with a variety tail area. The constants required to construct  $E(X)$  and  $R$  charts for the  $\lambda$ -family are computed. Control charts based on the assumption of normality give inaccurate results when the

tails of the underlying distribution are thin or thick. The validity of the normality assumption is examined by using a numerical example. 13 refs.

Chan, Lai K. (Univ of Manitoba, Winnipeg, Manit, Can); Hapuarachchi, K.P.; Macpherson, B.D. *IEEE Trans Reliab* v 37 n 1 Apr 1988 p 117-123.

**Applications** See ELECTRIC LAMPS, DISCHARGE—Testing.

**Automation** See Also SHAFTS AND SHAFTING—Computer Aided Manufacturing; VIDEO RECORDING—Equipment.

**087374 ARRANGEMENT FOR AUTOMATING STATISTICAL QUALITY CONTROL OF PRODUCTS.** An important stage in assuring quality of mass-produced items is that of inspection testing to check the conformity of their actual quality factors  $R$  with the requirements of the standards, technical assignments, and technical conditions. With binomial tests the method used for this, as a rule, is single-step inspection based on the checking theory of the Neumann-Pearson hypothesis. Its special feature is that the size of the samples is planned beforehand, and a decision as to whether a product conforms or not with the imposed requirements is made only once, i.e., after tests on all the specimens in a sample. Inherent drawbacks are discussed, along with appropriate solutions. 3 refs.

Korkh, L.N.; Radaev, N.N.; Suprunov, V.I. *Meas Tech* v 30 n 9 Sep 1987 p 857-859.

**Computer Applications** See Also INSPECTION—Computer Applications; IRON FOUNDRY PRACTICE—Computer Applications; PROCESS CONTROL; THERMOPLASTICS—Injection Molding.

**087375 CALCULATING THE COST EFFECTIVENESS OF TEST STRATEGIES.** Choosing a cost-effective test strategy for a product line is a complex issue. Considerations include such factors as the best stage to perform the testing, tester accuracy, tester cost, and the list goes on. This article provides guidelines that will simplify this complex task. In addition, it introduces a software tool that can make the task even easier. The article assumes a general model of manufacturing/test for an electronic product. It does a simple analysis of the effect of a stage of test/repair on the defect level passed on, and uses this simplified analysis to illustrate whether a test/repair stage is needed or not. The errors of this simplified approach are then pointed out. Each of these errors are handled by a spread sheet analysis of the problem, using a program that was developed for this purpose on Lotus 1-2-3, called TESAP (Test Strategy Assessment Program).

Hamilton, Steve (Hewlett Packard Co, Loveland, CO, USA). *Chilton's I&CS* v 60 n 11 Nov 1987 p 49-50, 55-57.

**087376 PC PROGRAM CALCULATES NORMAL PROBABILITIES.** Statistical quality control identifies the sources of manufacturing defects. To determine whether a given value is within specification, a normal probability distribution is integrated using a series expansion of the exponential function. This causes an overflow in most PCs because they limit the represented size of a number to less than  $10^{40}$ . Consequently, this limits the maximum size of  $n$  for which  $n!$  may be determined. To eliminate this difficulty, a more time-consuming series with better overflow controls is derived. The PC program which calculates the normal probabilities is presented in the article.

Murray, S. Scott (Quantum Corp, Milpitas, CA, USA). *Math Des* v 59 n 17 Jul 23 1987 p 124, 126.

**087377 FRAMEWORK FOR EXPERT SYSTEM DEVELOPMENT IN STATISTICAL QUALITY CONTROL.** We have proposed a framework for developing expert systems for statistical process control applications. The knowledge base is partitioned into three sets: domain-independent analysis rules, which determine



whether or not the sample observations indicate a lack-of-control; interpretive rules, which analyze the patterns in the chart in terms of process changes; and domain-dependent diagnostic rules, which assist in determining assignable causes and corrective action. This structure allows some portability between applications and customizing to specific applications. (Author abstract) 5 refs.

Evans, James R. (Univ of Cincinnati, Cincinnati, OH, USA); Lindsay, William M. *Comput Ind Eng* v 14 n 3 1988 p 335-343.

**087378 QUALITY CONTROL INFORMATION SYSTEMS: AN ENTITY-RELATIONSHIP APPROACH.** In this paper, we present an entity-relationship framework for integrating aspects of data, models, and expertise for a computerized quality control information system (QCIS). A significant feature of the approach is to provide a logical view of the information flow and software requirements in the QCIS environment. (Author abstract). 20 Refs.

Chen, Ye-Sho (Louisiana State Univ, LA, USA). *Int J Policy Inf* v 12 n 1 Jun 15 1988 p 87-100.

**Costs** See Also GLASS MANUFACTURE—Quality Assurance; INDUSTRIAL PLANTS—Costs; INSPECTION; PRODUCT DESIGN—Optimization.

**087379 QUALITY COST ANALYSIS: EXTEND THE BENEFITS.** The micro quality cost approach is valuable for determining and improving the effectiveness and efficiency of staff departments' activities; employees also become aware of the need to reduce waste in their department. This approach demonstrates that the quality system needs to be tailored to each staff department. Conducting the cost study, in fact, helps define an appropriate quality system. The micro quality cost approach extends the never-ending journey for quality improvement to the processes found in staff departments, supplementing the improvements tied to the end product. The traditional macro quality cost approach is still needed to document the entire company quality system and identify needed improvements that can be incorporated synergistically among departments. But the micro quality cost approach is an essential supplement. 1 ref.

Winchell, William O.; Bolton, Caroline J. *Qual Prog* v 20 n 9 Sep 1987 p 71-73.

**087380 QUALITY-RELATED COSTING: FINDINGS FROM AN INDUSTRY-BASED RESEARCH STUDY.** The paper summarizes the main limitations and omissions of the literature on quality control and provides guidance on the most authoritative reading of the subject. Experience acquired whilst carrying out the investigations at collaborating companies is reviewed and some of the major issues are discussed, including definitions of quality cost categories and elements, collection and reporting of quality cost data and the uses of quality costs. Alternatives are suggested to (or may be used to complement) the usual prevention-appraisal-failure approach to categorization of quality-related costs which is so firmly entrenched in both management thinking and the literature on the subject. (Edited author abstract) 29 refs.

Plunkett, J.H. (UMIST, Manchester, Engl); Dale, B.G. *Eng Manage Int* v 4 n 4 Jan 1988 p 247-257.

## Design

**087381 SIMULATING THE DESIGN AND ANALYSIS OF QUALITY CONTROL SYSTEMS IN MANUFACTURING.** A manufacturing system simulator with modules for the simulation of the inputs and the basic transformation elements of the interrelated manufacturing and quality system is developed. Using this simulator and a design procedure, the manufacturing system is simulated to provide the 'best' solution in terms of the incoming quality and the cost of inputs, quality levels and cost of manufacturing and assembly processes, and the inspection plans for the inspection stations of the manufacturing system. The best simulated solution is the solution that provides the most economical cost of producing the

products of the interrelated manufacturing and quality system for desired outgoing quality of the products. (Edited author abstract). 18 Refs.

Palaniswami, S. (Central Michigan Univ, Mount Pleasant, MI, USA); Hassan, M.Z. *Eng Costs Prod Econ* v 14 n 3 Sep 1988 p 217-227.

**Economics** See INDUSTRIAL ECONOMICS—Efficiency.

**Education** See Also ENGINEERING EDUCATION.

**087382 EDUCATING FOR QUALITY: A DIFFERENT APPROACH.** The concept of the approach is to make text material about quality principles available to authors and publishers for use in core course books. For example, future marketing core texts would contain information relating to the marketing department's responsibilities toward product quality and customer satisfaction. Accounting and finance texts would introduce quality costs concepts. Material for each core course would focus on unique aspects of quality appropriate to that course. Since all students must complete core courses, the plan would increase broad-based understanding of quality and quality control by all graduates. Obviously, this is important because managers in functional areas other than quality control have a major impact on product and service quality. Business school graduates are prime candidates to move into these managerial positions. 1 Ref.

Johnson, Ross H. (James Mason Univ, USA); Winchell, William O. *Qual Prog* v 21 n 9 Sep 1988 p 48-50.

## Equipment

**087383 STANDARDIZED SERIES OF ULTRASONIC INSTALLATIONS FOR THE QUALITY CONTROL OF WELDED JOINTS AND ROLLED SHEET.** The designing installations for mechanized ultrasonic quality control, the designers took into account the requirements concerning the reliable detection of flaws while high productivity is maintained, ensuring the tuning-out of interfering signals, lucid and reliable recording of the results of inspection, the possibility of readjustment for the inspection of different products, and reliable operation of assembly units and blocks of the installation, the Installations Incorporate Systems for scanning and for recording the result of inspection, acoustic units with transducers and automatic control units. The newly designed installations were supplied to a number of enterprises and they are used for inspecting welded joints in housings of apparatuses, courses, flat welded sheet, rolled sheet, etc. Experience with the introduction of mechanized installations shows that the greatest effect is attained when these installations are integrated in the technological production line of articles. 5 refs.

Bobrov, V.A.; Sushev, V.I. *Chem Pet Eng* v 23 n 5-6 May-Jun 1987 p 304-307.

## Inspection

**087384 OPTIMAL INSPECTION POLICIES IN A SERIAL PRODUCTION SYSTEM INCLUDING SCRAP REWORK AND REPAIR: AN MILP APPROACH.** The allocation of inspection effort problem for serial systems is formulated as a 0-1 mixed integer linear programming problem (MILP). This formulation permits any combination of scrap, rework, or repair at each station and allows the problem to be solved using standard MILP software packages. Moreover electronic spread-sheets may be used to easily calculate the relevant coefficients. An additional advantage of this approach when compared with the traditional dynamic programming approach is the ease with which the basic model may be modified. (Edited author abstract) 12 refs.

Bong Jin Yum (Korea Advanced Inst of Science & Technology, Seoul, South Korea); McDowell, Edward D. *Int J Prod Res* v 25 n 10 Oct 1987 p 1451-1464.

**087385 STATISTICAL TECHNIQUES APPLIED TO A MANUFACTURING PROCESS PROBLEM.** In any manufacturing industry, parts are manufactured

through various operations before they conform to their drawing specifications. Depending on the complexities of the part requirements, a single part such as an aircraft component may have to undergo more than 100 operations before it reaches its finished stage. If at the finished stage a dimension is found to be out of specification, quality and manufacturing engineers alike may encounter difficulties in tracking down the real culprits. This paper discusses the statistical techniques applied in tracing and identifying the causes of failure to comply with specifications. (Edited author abstract) 2 refs.

Goh, A.B. (Tandon Singapore Pte Ltd). *Qual Assur* v 13 n 3 Sep 1987 p 91-95.

**087386 EFFECTS OF INSPECTION ERROR ON A COMPLETE INSPECTION PLAN.** In a complete inspection plan, every incoming item is subject to variable inspection. If the inspection result indicates that an item fails to meet predetermined specification limits, the item is reworked so that its quality characteristic is exactly equal to the target value. The specification limits are determined by the tradeoff among the cost incurred by imperfect quality, cost of rework and cost of inspection. The economic and statistical effects of inspection error on the complete inspection plan are investigated. Two models with considerations of inspection error are developed under different rework schemes, then compared with the model without inspection error consideration. (Author abstract) 17 refs.

Tang, Kwei (Louisiana State Univ, Baton Rouge, LA, USA); Schneider, Helmut. *IIE Trans* v 19 n 4 Dec 1987 p 421-428.

**087387 SIMPLE INSPECTION SCHEME FOR TWO TYPES OF DEFECT.** For defect A, process control is at least as important as product screening. Low-cost, rapid sequential inspection takes place for a run of k consecutive type-A defectives. When this occurs, the production process is halted and, if necessary, adjusted, and the run of k defectives is discarded. The entire pre-run sequence is retained, forming the production run. No type-B defective are permitted, testing for this type of defect is expensive, so detection is by Dorfman screening of the production run. Features of interest are the choice of k in relation to the average length of a production run and the outgoing proportion defective, the average cost per production run of testing for attribute B, and the average number of items finally accepted for production run. (Edited author abstract) 13 refs.

Kemp, A.W. (Univ of St. Andrews, Scotl); Kemp, C.D. *J Oper Res Soc* v 39 n 3 Mar 1988 p 311-315.

## Instruments

**087388 MEASURING UP TO NEW DEMANDS.** Quality control is seen increasingly as a function which takes place at the machine, creating a need for portable and inexpensive measuring instruments and gauges. Besides being easy to use, they must be capable of capturing and analyzing the large amounts of data generated by statistical process control. The author introduces some of the new equipment available, including electronic calipers and hardness testers, in-process gauges, coordinate measuring machines, and noncontact optical inspection instruments.

Anon. *Mach Prod Eng* v 146 n 3742 Jul 1 1988 4p.

**Management** See Also INVENTORY CONTROL—Mathematical Models; JOB ANALYSIS; MACHINE SHOPS—Process Control; PAPER AND PULP MILLS—Quality Control; PRODUCT DESIGN—Optimization; PRODUCTION CONTROL—Scheduling; RELIABILITY—Computer Simulation.

**087389 QUALITY CIRCLES: TWO KEYS TO SUCCESS.** The issue of whether QC failures can be traced to techniques that are incompatible with employees' attitudes toward learning, work measurement, or the organizational setting at the time the training is begun. Because quality



circle problem-solving techniques are designed mainly for controlling and measuring processes that are adaptable to statistical quality control (SQC) (i.e., manufacturing settings), using these techniques in settings less adapted to SQC may lead to employee dissatisfaction with the process and, thus, QC failure. Most QC implementation programs use the common curricula or training techniques. These techniques include both problem-solving techniques and processes for developing group and team dynamics. However, the chosen curriculum's applicability to the organization's climate, structure, and personnel is not usually examined as a possible cause of circle failures. 10 refs.

Bagwell, Timothy C. *Qual Prog* v 20 n 9 Sep 1987 p 57-59.

**087390 PROCESS IMPROVEMENT.** Improvement of product quality depends on: understanding customer needs, designing the product to meet those needs, the design of the production process, and the knowledge of the product and production process. The responsibility for quality improvement in the evolution of a new product crosses many departments of an organization. The focus must be on identifying and improving the key processes in each function of each department. The greatest benefits of improving quality will occur during the design of the product and of the manufacturing processes. The key factor for success in improving quality will be people learning. Statistical methods will enhance the process of learning, as will an emphasis on teamwork. Only through a proper managerial environment, with every person working on improving quality to enhance customer satisfaction, will organizations be able to compete in the international marketplace. 4 refs.

Moen, Ronald D.; Nolan, Thomas W. *Qual Prog* v 20 n 9 Sep 1987 p 62-68.

**087391 PARAMETRIC APPRAISAL OF THE JIT SYSTEM.** Using a simulation model, some salient parameters such as (a) scheduling rules, (b) the effects of pull demands level, (c) the effects of the production Kanban size and the minimum Kanban level, and (d) the significance of the job mix are evaluated. The study shows that a common prevailing practice of assigning greater priorities to jobs with higher pull frequencies is not as efficient as a shortest process time based rule. Raising the pull demand in a Just-In-Time (JIT) system does not ensure a high process utilization level. Results also show that an increase in the production Kanban size and minimum output Kanban level improve the mean job tardiness but causes an escalation in the output Kanban inventory level. An enlarged product mix would actually produce better process utilization and mean job tardiness. (Edited author abstract) 9 refs.

Lee, L.C. (Nat'l Univ of Singapore, Singapore). *Int J Prod Res* v 25 n 10 Oct 1987 p 1415-1429.

**087392 MANUFACTURING QUALITY DENSITY, CONTROL AND MAINTENANCE.** A measure of quality density in manufacturing is expressed in terms of a manufacturing process propensity to 'output' units which are defectives, as a function of the manufactured production output, the manufacturing deterioration process, maintenance, quality control, and generally the risks a manufacturing process is subjugated to. Particularly, we assume that the production process induces 'shocks' which lead to poorer manufactured quality, while maintenance efforts are continually being employed to restore the process propensity to produce units of better quality. Quality control is used then to monitor the output quality of units produced. Using a methodology of level crossing in stochastic point processes, the stationary probability distribution of a manufactured output quality is defined. (Edited author abstract) 15 refs.

Posner, Morton J.M. (Univ of Toronto, Toronto, Ont, Can); Tapiero, Charles S. *Int J Prod Res* v 25 n 10 Oct 1987 p 1511-1521.

**087393 PROJECT PLANNING NETWORK IS INTEGRATED PLAN FOR IMPLEMENTING JUST-IN-TIME.** The integrated plan consists of 11

major phases including the precedence relationships, associated input-output links and required activities of each phase. An integrated approach for planning and implementing a JIT operating environment is constructed in the form of a project planning network to determine the duration of the entire project, identify potential bottlenecks and highlight critical activities. The 11 phases of this integrated approach for implementing JIT cover planning and analysis activities, formulating operating systems, and evaluation and improvement functions. 10 refs.

Nisanci, Ibrahim (Bradley Univ); Nicoll, Andrew D. *Ind Eng* v 19 n 10 Oct 1987 p 50-55.

**087394 TAGUCHI'S QUALITY PHILOSOPHY: ANALYSIS AND COMMENTARY.** This paper is an introduction to an interpretation of Taguchi's ideas. The seven most important basic elements of Taguchi's quality philosophy are discussed in detail, with definitions of key expressions, and the author helps to relate these ideas to the published literature. He believes that the impact Taguchi has made on Japanese companies has important lessons for anyone wishing to set up an improved total quality control program. (Author abstract) 24 refs.

Kackar, R.N. (AT&T Bell Lab, USA). *Qual Assur* v 13 n 3 Sep 1987 p 65-71.

**087395 QUALITY ENGINEERING BY DESIGN: TAGUCHI'S PHILOSOPHY.** Taguchi's philosophy recognizes the importance of both off-line and on-line quality control in reducing variation and its effects to the minimum, and embraces the entire engineering and manufacturing process. This paper looks at key topics such as loss function, performance variations, signal to noise, system design, and parameter and tolerance design. This last topic includes a detailed example to demonstrate the philosophy in practice. The author believes that Taguchi's economic outlook on sampling and process adjustment is yet to be fully appreciated in the United States. (Author abstract) 3 refs.

Barker, T.B. (Rochester Inst of Technology, Rochester, NY, USA). *Qual Assur* v 13 n 3 Sep 1987 p 72-80.

**087396 PERSPECTIVE ON THE TAGUCHI METHODS.** This paper takes a critical look at the Taguchi Methods and discusses the main concepts with the aid of examples. The author puts these underlying concepts and philosophies into the context of more conventional statistical approaches to quality assurance. He argues that much of the contribution made by the Taguchi Methods derives less from novel methodology than from the way they make statistical techniques comprehensible and easy to use for non-experts. (Author abstract) 18 refs.

Gunter, B. *Qual Assur* v 13 n 3 Sep 1987 p 81-87.

**087397 POWER OF TAGUCHI METHODS.** During the past three years, there has been a significant change in US quality thinking and engineering technology through the application of the Taguchi Methods. Although this change has developed slowly due to statistical controversy, this technology is beginning to have a great effect on US products. Applying the Taguchi Methods can significantly shorten the product development cycle, improve quality and reduce cost for US companies. (Edited author abstract)

Sullivan, L.P. (American Supplier Inst Inc). *Qual Assur* v 13 n 3 Sep 1987 p 88-90.

**087398 JUST-IN-TIME: MEETING THE COMPETITIVE CHALLENGE.** The article examines the way in which manufacturers have had to meet the challenge of stopping the decrease in the growth of American productivity, market share and profits. Successful implementation of just-in-time (JIT) and its requisite technologies can counteract the decline of American manufacturing with low cost/high quality products. Successful implementation of JIT and its requisite technologies will create a manufacturing environment that can meet the competitive challenges to American manufacturing with low-cost, high-quality products. JIT has proven to be an effective

execution system and, in combination with the planning and controls of its peripheral systems like materials requirement planning (MRP), robotics, and automation, can help American manufacturing increase its share of the world market. 10 refs.

Hannah, Kimball H. *Prod Invent Manage* v 28 n 3 3rd Quarter 1987 p 1-3.

**087399 SOME CONCLUSIONS ABOUT JIT MANUFACTURING.** This article presents some personal experiences with companies implementing just-in-time (JIT), some generalizations important to implementers, and some serious concerns for the future. In so doing, the goal is to move toward the next phase of JIT - the development of ways to leapfrog the time barriers imposed by incremental improvement and learning curve limitations. The bases of the article are the two APICS Study Missions which the author has made to Japan, interactions with other professional JIT implementers and discussions with senior management. 13 refs.

Burnham, John M. (Tennessee Technological Univ, Cookeville, TN, USA). *Prod Invent Manage* v 28 n 3 3rd Quarter 1987 p 7-11.

**087400 EASIER QUALITY CONTROL: COMBINING PROBLEM CLASSIFICATION WITH TIME SERIES ANALYSIS.** Operations managers sometimes fail to take advantage of effective techniques for quality assurance. This article introduces a new streamlined approach to statistical quality control; Acar's problem classification scheme is combined with current statistical methodology. The proposed method provides a more systematic approach to quality assurance and a smoother implementation than many current systems. The suggested approach is particularly suited for on-line use in real time as, for example, part of a flexible manufacturing system. 21 refs.

Acar, William (Kent State Univ, Kent, OH, USA); Booth, David E. *Prod Invent Manage* v 28 n 3 3rd Quarter 1987 p 53-58.

**087401 SYSTEMATIC PRODUCT-BREAKDOWN AND DOCUMENTATION, MAJOR TOOLS FOR PRODUCTIVITY IMPROVEMENT.** It will be shown that by developing the breakdown of the product into modules, assemblies and parts can be a major tool for improving productivity. In industries with a variety of product versions and customer requirements, the benefits are a shorter lead-time of orders and less stock. The challenge is to respond to a variety of functions and function requirements of the different product 'parts' with a minimum of different hardware elements and connections. Intending this, the engineer has a specific need for a reliable and rapidly accessible documentation system. An outline of such a system is given. (Author abstract) 5 refs.

Bikker, H. (Delft Univ of Technology, Delft, Neth); Van der Heyden, W. *Int J Prod Res* v 25 n 11 Nov 1987 p 1635-1644.

**087402 QUALITY AND PRODUCTIVITY: AN EXAMINATION OF SOME RELATIONSHIPS.** Two hypothetical mathematical relations between quality and productivity are presented. Net production and cost consequences of the two are examined. An empirically developed relation is also provided as indication that productivity improvement effort require study by quality assurance personnel. Suggestions for such study efforts are discussed. (Edited author abstract) 6 refs.

Hotard, Daniel G. (Southeastern Louisiana Univ, Hammond, LA, USA). *Eng Manage Int* v 4 n 4 Jan 1988 p 259-266.

**087403 JIT PURCHASING AS A QUALITY AND PRODUCTIVITY CENTRE.** Recently, Just-in-Time (JIT) purchasing practices have been recognized as a cornerstone of Japan's success in improving product quality and productivity. Traditionally, however, US



firms have treated purchasing functions as a 'profit centre'. This paper presents the proposition that US firms must recognize the potential of purchasing activities as 'quality and productivity centres' through successful implementation of JIT purchasing. Personal interviews have been conducted at four US manufacturing firms in an effort, first, to identify the major activities of JIT purchasing that have favorable effects on product quality and productivity and, second, to describe how these activities can improve product quality and productivity in US firms. (Author abstract) 7 refs.

Ansari, A. (Seattle Univ, Seattle, WA, USA); Modarress, Batoul. *Int J Prod Res* v 26 n 1 Jan 1988 p 19-26.

**087404 SOME FACTORS TO CONSIDER IN DEVELOPING A QUALITY-RELATED FEEDBACK SYSTEM.** This paper reports on work which has been carried out in an attempt to identify some of the key factors in the development of a quality-related feedback system associated specifically with major installations. The information being generated by users of computerized maintenance systems has, to date, been little used by manufacturers to initiate quality-improving changes. However, most manufacturers said they would use such data if it was offered. It is also pointed out that designers can play a key role in improving the quality of plant and equipment by requesting feedback information in those areas where there might be design uncertainty and by giving consideration to the possibility of condition monitoring when a product is being designed. (Edited author abstract) 12 refs.

Staveley, J.C. (Shell UK Ltd, Chester, Engl); Dale, B.G. *Qual Reliab Eng Int* v 3 n 4 Oct-Dec 1987 p 265-271.

**087405 DEMING'S WAY.** This paper discusses the teaching of W. Edwards Deming in Japan, which emphasizes lower costs due to higher quality of manufactured goods. Management systems for machines and people emphasize statistical methods, encouraging pride in workmanship, modern training methods and better communication between worker and management.

Tribus, Myron (AKT Systems & Energy Co, Hayward, CA, USA). *Mech Eng* v 110 n 1 Jan 1988 p 26-30.

**087406 USE OF STATISTICAL PROCESS/QUALITY CONTROL IN THE DEFENSE INDUSTRIES.** In 1987 a survey on quality was sent to 120 aerospace and electronics defense contractors (and some of their major divisions) throughout the nation. Half of the top 50 defense contractors in the nation participated. The survey was extensive (10 pages long) and covered issues of a more general nature relating to quality improvement efforts and philosophy. One section applied to the use of statistical process/quality control. In this section, use of SPC, training, administration and methods utilized were covered. This article addresses the responses to this section of the survey only.

ReVelle, Jack B. (Hughes Aircraft Co); Harrington, Hugh Jordan. *Ind Eng (Norcross GA)* v 20 n 2 Feb 1988 p 36-40.

**087407 SYSTEMS APPROACH TO THE IMPLEMENTATION OF JIT METHODOLOGIES IN LUCAS INDUSTRIES.** Competitive modern manufacturing business must operate total materials flow control systems to ensure low stock levels and short lead times. When a variety of products is produced, to achieve just-in-time operation relevant to the overall business time-constants, composite control systems are needed within the factory. These are supported by matching supply processes and levelled output scheduling. (Author abstract) 7 refs.

Parnaby, J. (Lucas Industries, Birmingham, Engl). *Int J Prod Res* v 26 n 3 Mar 1988 p 483-492.

**087408 PROTOTYPE EXPERT SYSTEM FOR SELECTING CONTROL CHARTS.** The emergence of expert systems provides new insight to specialists in manufacturing as a means of solving problems in their domains. The solutions of most manufacturing problems

are not deterministic and many alternate courses of action exist. In this paper, the structure of a prototype expert system, which provides support to the process or quality engineer in the selection of the proper type of control charts to use in tracking the state of the process, is explained. The functionality and operation procedures for executing this system are demonstrated on sample consultations and evolution of the system in time to reinforce existing input knowledge bases is described. (Author abstract) 17 refs.

Dagli, Cihan H. (Univ of Missouri-Rolla, Rolla, MO, USA); Stacey, Richard. *Int J Prod Res* v 26 n 5 May 1988 p 987-996.

**087409 MOVING FROM MANUFACTURING RESOURCE PLANNING TO JUST-IN-TIME MANUFACTURING.** Moving toward just-in-time (JIT) requires significant companywide effort. It means re-educating people, changing business policies and practices, and, finally, altering the information systems that support the production function. This article outlines the impact that JIT can have on these systems and suggests ways of handling the changes required. 22 refs.

Rao, Ashok (Babson Coll, Wellesley, MA, USA); Scheraga, David. *Prod Invent Manage J* v 29 n 1 1988 p 44-49.

**087410 DEMING - A PROPHET WITH NEW HONOUR.** The author describes Dr. W.E. Deming's philosophy of quality management, which will form a key part of an innovative quality management programme currently being developed by Ashridge in conjunction with the University of Tennessee. The Ashridge programme 'Improving Productivity through Quality' looks at what Deming has taught the Japanese, through some of his now celebrated - and still evolving - 'Fourteen Points for Management'.

Knight, Mike (Ashridge Management Coll, Engl). *Prod Eng (London)* v 67 n 4 Apr 1988 p 58-59.

**087411 STUDY OF JIT IMPLEMENTATION AND OPERATING PROBLEMS.** This paper reports the results of a survey of early implementers of the just-in-time (JIT) philosophy in the United States with particular emphasis on the identification of implementation problems and operating problems. There were 39 respondents to the survey who were in the process of implementing JIT. Five classes of implementation problems and eight classes of operating problems were identified. (Author abstract). 2 Refs.

Crawford, Karlene M. (Univ of Georgia, Athens, GA, USA); Blackstone, John H.; Cox, James F. *Int J Prod Res* v 26 n 9 Sep 1988 p 1561-1568.

**087412 'FAKE PULL' IN A KANBAN ENVIRONMENT: ACCEPTABLE TRADE-OFF OR VIOLATION OF PRINCIPLE?** The author believes that it is acceptable to violate this philosophy under certain conditions. If a manufacturing organization is considering implementing a fake pull concept, they should carefully evaluate the trade-offs and the conditions which can make it the correct decision and then develop contingency plans for the range of likely situations which would be candidates for this action. If these conditions are not met, then it is probably best to avoid a fake pull and, instead, to stop the line and bring pressure to bear to fix the problem. 8 Refs.

Hendrick, Thomas E. (Arizona State Univ, Tempe, AZ, USA). *Prod Invent Manage J* v 29 n 2 1988 p 6-9.

**087413 INFORMATIONAL AND ORGANIZATIONAL IMPACTS OF IMPLEMENTING A JIT SYSTEM.** The fundamental differences between JIT and traditional manufacturing processes are detailed. A JIT system and the types of information needed in a JIT environment are described. Some implications of converting to and operating a JIT system are discussed. 14 Refs.

Malley, John C. (Univ of Mississippi, University, MS, USA); Ray, Ruthann. *Prod Invent Manage J* v 29 n 2

1988 p 66-70.

**087414 PLANT 2 IS NUMBER ONE AT TRANE.** The article discusses how a quality improvement program helped to reduce costs and boost efficiency in an air conditioner manufacturing plant. Management commitment, quality awareness and recognition are some steps in the program that were given emphasis on. The backbone of the program are the error cause removal forms (ECR's).

Stratton, Brad (Quality Progress, Milwaukee, WI, USA). *Qual Prog* v 21 n 8 Aug 1988 p 27-30.

**087415 MEETING THE WORLDWIDE QUALITY CHALLENGE.** The evolution of the quality movement in the United States is divided into three periods wherein quality professionals are characterized as: advocates for statistical quality control; administrators for systems of quality control; advertisers selling quality consciousness. The U.S. must emphasize management, quality consciousness in organizational culture and quality technology. 12 Refs.

Marquardt, Donald W. (DuPont, USA). *Qual Prog* v 21 n 8 Aug 1988 p 34-37.

**087416 SIX STRATEGIES FOR BEGINNING THE QUALITY TRANSFORMATION, PART II.** Top managers learn to become leaders, exemplars and teachers of quality. Managers establish improvement projects that are carefully selected and guided by managers, conducted by cross-divisional teams using the scientific approach and coached by technical advisers. Top managers engage in quality transformation planning starting with a two-year blueprint for preparation, start-up and early expansion. Managers establish processes for the internal coordination, oversight and technical training and assistance needed to support quality improvement programs. Managers undertake specific efforts to change the organization's culture. Education and training are necessary to support the quality efforts. 12 Refs.

Scholtes, Peter R.; Hacquebord, Heero. *Qual Prog* v 21 n 8 Aug 1988 p 44-48.

**087417 GLOBAL SEARCH FOR QUALITY.** It is the supplier's responsibility to illustrate how its customers' requirements and expectations are translated into concrete specifications and physical action overseas. To achieve quality, it is important to adhere to the following: international regulations; communication; cultural context. The results of such attention to quality are: reduced manufacturing time; enhanced customer satisfaction; scrap reduction/rework elimination; easy housekeeping; enhanced management.

Yaus, Leo P. (Int Components Corp, Chicago, IL, USA). *Qual Prog* v 21 n 8 Aug 1988 p 51-53.

**087418 TOTAL QUALITY CONTROL WITH ACCENT ON PRODUCTION QUALITY MANAGEMENT.** The concept of quality loss function is discussed with an example. The difference between manufacturing tolerances and product tolerances is also illustrated. The importance of design of experiments for process improvement has been stressed. Difference between planned experimentation and conventional or classical experimentation has been explained with a view to stress the highly predictable results of the former. A few examples from American industry and some examples from Indian industry have been given to indicate what improvement are possible with designed experiments. (Edited author abstract). 21 Refs.

Puppala, B. (Jyoti Ltd, Baroda, India). *J Inst Eng India Part PR* v 69 n PR 1 Jul 1988 p 11-16.

**087419 PEOPLE: THE ONLY THING THAT WILL MAKE QUALITY WORK.** The manager of the Dow Chemical Company's aspirin facility found that employees are the key to continuous improvement. Under the Quality Service and Product Performance Program is a task force program wherein the employees give suggestions on



quality improvement. The results include almost a 50% improvement in attendance and a 28% reduction in manpower; off-grade production decreased by a factor of six, on-time shipment increased to 99.2%, and customer relations improved. And product quality, combined with the attitude that Dow would gladly work with the customer, were recognized throughout the industry. The improvements also paid off in another important parameter: employee morale. 1 Ref.

Bemowski, Karen (Quality Progress, Milwaukee, WI, USA). *Qual Prog* v 21 n 9 Sep 1988 p 63-67.

**087420 SUPPLIER CERTIFICATION-A POSITIVE RESPONSE TO JUST-IN-TIME.** The criteria for supplier certification are: having virtually no product-related lot rejections for a significant time period; having no nonproduct-related rejections for a stated period of time; having no production-related negative incidents for a stated period of time; having successfully passed a recent on-site quality system evaluation; having an agreed-upon specification; having a fully documented process and quality system; having the ability to furnish timely copies of certificates of analysis, inspection data, and test results; certification of bulk suppliers requires the correlation and validation of laboratory results; and the certification requirement for piece part or assembly suppliers is a demonstration of statistical process control. Supplier certification is important to remain competitive, thus attain greater quality; as an answer to just-in-time manufacturing, and because of the desire for peace and quiet.

Maass, Richard A. (Digital Equipment Corp, Salem, NH, USA). *Qual Prog* v 21 n 9 Sep 1988 p 75-80.

**087421 THREE LEVELS OF QUALITY.** An organization committed to an ongoing focus on quality must examine quality at three levels: organization, process, and individual. At each level, the organization needs to define its quality systems and standards, and then manage quality through improvement efforts. The organization that manages these three levels of quality creates a system context for its quality awareness education, its culture change efforts, and its quality monitoring and problem-solving tools. The organization, process, and individual levels are interdependent, linked together in a total system that ultimately determines the quality of an organization's products and services.

Brache, Alan P. (Rummeler-Brache Group); Rummeler, Geary A. *Qual Prog* v 21 n 10 Oct 1988 p 46-51.

**087422 ROOTS OF UNQUALITY.** Analysis of the national unquality problem indicates the following root causes: lack of knowledge and understanding of the quality discipline; failure by institutions of higher learning to provide degree programs in quality management and engineering; the emphasis by the Department of Defense (DOD) on endless audits and failure/penalty costs; ASQC's traditional emphasis on training, rather than professional education; Blind worship of the bottom line by short-term-motivated management; The constant adjustment of the work force to maximize profits regardless of its effect on quality. American business still faces significant problem areas: senior management, employee turnover, education, and the defense contracting system. The article examines each of these. 2 refs.

Goldstein, Raymond (Inst of the Electrical & Electronics Engineers). *Qual Prog* v 21 n 10 Oct 1988 p 55-58.

**087423 DISCOVERED: QUALITY'S MISSING LINK.** The quality cost system is a missing link in the flow of information from accounting back to production and quality management. A quality cost system (QCS) is an informational system that provides both instantaneous measurement and continual tracking of: total quality cost; the contribution of the five major categories (prevention, appraisal, failure, internal failure, and external failure); and any number of meaningful cost-benefit ratios such as total quality cost/sales, or procurement appraisal cost/purchased material cost. The use of system dynamics models in quality management system is presented. 5 refs.

Batson, Robert G. (Univ of Alabama, USA). *Qual Prog* v 21 n 10 Oct 1988 p 61-64.

**087424 AVOID THE JUST-IN-TIME TERRORS.** Successful operation as a just-in-time (JIT) manufacturer requires that the company first operate successfully with total quality assurance (TQA) principles. Design integrity, manufacturing repeatability, strong supplier-customer partnerships, and a clear understanding of the needs of the marketplace are key to the success of TQA and later for JIT manufacturing. Design engineering must adhere to product specifications and provide designs that are correct, complete, and manufacturable. Management must also provide training at every level so that all employees clearly understand their work, what they will be expected to do, what tools are necessary to do the job, and how to use the tools.

Westland, Cynthia Lane (Total Quality Systems Co, Lexington, MA, USA). *Qual Prog* v 21 n 10 Oct 1988 p 69-70.

**087425 QUALITY PLAN DEVELOPMENT: A KEY STEP TOWARD CUSTOMER ENTHUSIASM.** Some key attributes that quality professionals must possess to assist their business in achieving customer enthusiasm are: integrity, listening and communicating, cooperating, innovating, and leadership. A sound quality plan, developed and implemented in conjunction with these attributes, will move the business closer to success. An eight-step process for implementing quality improvement includes: obtaining management commitment; team forming; developing a vision; developing a policy statement; developing objectives and guidelines; reviewing current programs/projects; developing/implementing a formal review process; implementing the plan. 1 ref.

Sarazen, J. Stephen (Digital Equipment Corp). *Qual Prog* v 21 n 10 Oct 1988 p 72-75.

**087426 EDITED VERSIONS OF PAPERS PRESENTED TO THE 26TH INTERNATIONAL QUALITY ASSURANCE CONFERENCE, ENTITLED: 'BUSINESS IMPROVEMENT BY QUALITY METHODS'.** This journal contains 5 papers; all of which are indexed and abstracted separately. The topics discussed are: replacement of the use of animals for the quality control of insulin by high performance liquid chromatography; significant improvements to the quality of Duracell specialty battery products; the quality improvement process within Plessey Telecommunication Systems Ltd; quality improvement at work; quality improvements in a machine tool company. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10853 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *Qual Assur* v 13 n 4 Dec 1987, Ed Versions of Pap Presented to the 26th Int Qual Assur Conf, Entitled: 'Bus Improv by Qual Methods', Oxford, Engl, Sep 1987 p 97-121.

**087427 QUALITY IMPROVEMENT PROCESS WITHIN PLESSEY TELECOMMUNICATIONS SYSTEMS LTD.** Over the past four years Plessey Telecommunications Systems Ltd has been examining its management of quality and developing a quality strategy that will enable the business to thrive in the international market. This paper describes the processes used in undertaking the first phase of a lasting quality improvement process. The substantial improvements documented in this submission were achieved within the traditional framework of BS 5750. These improvements were in the areas of design, component assessment, manufacturing and test, reliability and training. 5 refs.

Casbourne, B.R. (Plessey Telecommunications Systems Ltd). *Qual Assur* v 13 n 4 Dec 1987, Ed Versions of Pap Presented to the 26th Int Qual Assur Conf, Entitled: 'Bus Improv by Qual Methods', Oxford, Engl, Sep 1987 p 108-111.

**087428 AMERICAN SOCIETY FOR QUALITY**

**CONTROL: 41ST ANNUAL QUALITY CONGRESS TRANSACTIONS (QUALITY: THE UNIVERSAL EQUATION FOR EXCELLENCE).** This congress proceedings contains 124 papers. The main topics discussed are: administrative applications; statistics; human resources; international aspects; food, drug and cosmetics; product safety and liability prevention; automotive; biomedical; aerospace and defense; computer technologies; inspection (tutorial); administrative applications (process control); quality costs; metrology; administrative applications (service industries); human resources (quality management); computer quality software; quality auditing; chemical/process industries; construction; reliability; construction (quality training); vendor-vendee relations; administrative applications (control systems). Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11249 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (ASQC, Milwaukee, WI, USA). *Annu Qual Congr Trans* 41st Minneapolis, MN, USA, May 4-6 1987. Publ by ASQC, Milwaukee, WI, USA, 1987 843p.

**087429 AMERICAN SOCIETY FOR QUALITY CONTROL 40TH ANNIVERSARY QUALITY CONGRESS TRANSACTIONS.** This congress transactions contains 117 papers, one of which is in abstract form only. The main topics discussed are: administrative applications; human resources (quality management); statistics; aerospace and defense; automotive; chemical/process industries; biomedical; quality auditing; human resources (quality communications); computer technologies; electronics; reliability; human resources (quality circles and beyond); energy; quality costs; human resources (statistical process control implementation); international; environmental; inspection; product safety and reliability prevention; food, drug, cosmetics; vendor-vendee relationships; construction; training for quality; calibration system technology. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11248 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (ASQC, Milwaukee, WI, USA). *Annu Qual Congr Trans* 1986, Am Soc for Qual Control 40th Anniv Qual Congr Trans, Anaheim, CA, USA, May 19-21, 1986. Publ by ASQC, Milwaukee, WI, USA, 1986. 760p.

**087430 THE PRI QUALITY ASSURANCE 1986 CONFERENCE.** This conference proceedings contains 9 papers, one of which is in abstract form only. The topics discussed are: the role of the UK Department of Trade and Industry in quality control for profit; national accreditation for quality; people and process control; the Ford Q101 quality system standard; product liability laws; quality assurance for fillers; quality assurance in raw material supply; quality assurance requirements in the batch mixing of rubber compounds; quality control computer systems.

Anon (Plastics & Rubber Inst, London, Engl). *The PRI Qual Assur 1986 Conf*, London, Engl, Apr 29-30 1986. Publ by Plastics & Rubber Inst, London, Engl, 1986 76p.

## Mathematical Models

**087431 PRODUCTION LEARNING AND QUALITY CONTROL.** This paper establishes a linkage between quality control, the production learning process and the firm's propensity to use quality control under various conditions. A stochastic dynamic programming approach together with a numerical example are used to compute quality control policies and justify the intensive use of quality control in manufacturing. Although the problem is formulated in general terms, a specific application using a curtailed sampling technique for quality control is solved completely. This solution is also used to discuss the various conditions under which quality control is used and the relationships of the quality control policy with learning and experience. (Edited author abstract) 31 refs.

Tapiero, Charles S. (Hebrew Univ). *IIE Trans* v 19 n 4



Dec 1987 p 362-370.

**087432 QUALITY CONTROL MODEL WITH LEARNING EFFECTS.** We present a model that extends a variant of the classic quality control/machine maintenance model by adding the concept of quality-based learning. The extension captures the idea that operators of a production process may be able to discover and eliminate defects in the system if, during an inspection, they find the process to be 'out of control'. Thus, the distinguishing feature of the model is that one inspects the process not only for the purpose of repairing the machine, but also in the hope that the machine will be caught in the act of producing defective output, so that a source of problems is uncovered and eliminated. The paper provides a characterization of optimal inspection policies. (Edited author abstract). 18 Refs.

Fine, Charles H. (MIT, Cambridge, MA, USA). *Oper Res* v 36 n 3 May-Jun 1988 p 437-444.

## Military Applications

**087433 NEW SPECS PENETRATE NDT INDUSTRY.** Two recently published military specifications pertaining to the liquid penetrant inspection process are now affecting the nondestructive testing (NDT) industry. One, MIL-I-25135D, controls the characteristics and quality of penetrant materials; the other MIL-STD-6866, controls how these materials are used. The two specs, under the jurisdiction of Grover Hardy, materials laboratory engineer at Wright-Patterson Air Force Base (WPAFB), were published with both military and commercial participation. The most significant advancement of MIL-I-25135D is the way in which sensitivity, or the penetrant's ability to find cracks, is evaluated. MIL-STD-6866, which governs the use of penetrants, incorporates the past 20 to 25 years of knowledge on the causes of penetrant system failure into one document.

Sherwin, Amos G. *Qual Prog* v 20 n 9 Sep 1987 p 77-78.

## Monitoring

**087434 EXACT RESULTS FOR SHEWHART CONTROL CHARTS WITH SUPPLEMENTARY RUNS RULES.** This article gives a simple and efficient method, using Markov chains, to obtain the exact run-length properties of Shewhart control charts with supplementary runs rules. Average run-length comparisons are made among the Shewhart  $\bar{X}$  chart with supplementary runs rules, the basic Shewhart  $\bar{X}$  chart, and the cumulative sum (CUSUM) chart. (Author abstract) 14 refs.

Champ, Charles W. (Southern Illinois Univ, Edwardsville, IL, USA); Woodall, William H. *Technometrics* v 29 n 4 Nov 1987 p 393-399.

**Optimization** See Also PRODUCT DESIGN—Reliability.

**087435 BEEFING UP QC.** The data collection process for quality control (QC) is streamlined by a personal computer (PC). A basic computer program is used on the PC to facilitate the downloading of collected data into spreadsheets. By using the device, the need to write the QC readings on paper to be fed later into the PC was eliminated. Because the Datacomputer is programmable, a program is created that, after readings are keyed in, will provide an average of the 10 readings entered, as well as tell the operator whether the readings are within specification ranges.

Dutton, Barbara (Manufacturing Systems, Wheaton, IL, USA). *Manuf Syst* v 6 n 2 Feb 1988 p 50, 52.

**Robot Applications** See PROCESS CONTROL.

**Sampling** See Also GARMENT MANUFACTURE—Quality Assurance; INSPECTION—Human Factors; MACHINE TOOLS—Quality Control; PROCESS CONTROL—Optimization; PRODUCT LIABILITY—Economics.

**087436 QUALITY CONTROL SAMPLING PLANS UNDER ZERO INVENTORIES: AN ALTERNATIVE**

**METHOD.** The nature of zero inventories and the related quality management concepts are discussed. The author reports an alternative QC methodology, called constant gross inspection (CGI), which has been practiced by some firms in east Asian nations such as Taiwan and Japan. Most of these firms have adopted some formal or informal systems which incorporate the zero-inventory philosophy. The assumptions behind the CGI method are basically consistent with the spirit of the zero-inventory philosophy. 6 refs.

Chung, Chen-Hua (Univ of Kentucky, Lexington, KY, USA). *Prod Invent Manage* v 28 n 2 Second Quarter 1987 p 37-42.

**087437 IMPROVEMENT OF VARIABLE SAMPLING PLANS BASED ON KULLBACK-LEIBLER INFORMATION.** A new and convenient design procedure for single sampling plans by variables is given by Arizono and Ohta (1986) based on the Kullback-Leibler information. In this paper an improvement of the original design procedure is presented and the revised procedure is compared with the Bayesian procedure. It is shown that the revised procedure is more applicable and exact than the original procedure, and is reduced to the Bayesian procedure in a special case. (Edited author abstract) 1 ref.

Arizono, Ikuo (Univ of Osaka Prefecture, Sakai, Jpn); Ohta, Hiroshi. *Int J Prod Res* v 25 n 9 Sep 1987 p 1393-1400.

**087438 MARRIAGE OF ZERO INVENTORIES AND CONDITIONAL SAMPLING PROCEDURES.** As the movement to zero-inventory pull-system lot quantities gains favor, inspection costs can dramatically increase when using sampling plans found in MIL-STD-105D. Conditional multiple sampling procedures presented herein will reduce the total inspection cost while maintaining adequate consumer/producer protection. These procedures must naturally be accepted and approved by the procuring authority and/or prime contractor. Not only will the total inspection level remain moderately small, but conditional sampling procedures allow you to utilize relevant sample information from related lots, which makes intuitive sense. If zero-inventory concepts are to be successfully implemented, the impact on other parts of the production process must be addressed and solved. 3 refs.

Baker, R.C. (Univ of Texas/Arlington, Arlington, TX, USA). *Prod Invent Manage* v 28 n 3 3rd Quarter 1987 p 27-30.

**087439 MULTIOBJECTIVE DECISION ANALYSIS FOR ACCEPTANCE SAMPLING PLANS.** This paper illustrates an approach to the design of Bayesian sampling plans which considers two criteria. The few previous attempts to design multiobjective Bayesian sampling plans have been based on expected values of the criteria. In this paper the authors present a design methodology which takes into consideration the distribution functions of the criteria after sampling inspection, and the utility function of the 'decision maker'. Illustrative examples of the use of the methodology are given as well as areas for further research. (Edited author abstract) 30 refs.

Evans, Gerald W. (Univ of Louisville, Louisville, KY, USA); Alexander, Suraj M. *IIE Trans* v 19 n 3 Sep 1987 p 308-316.

**087440 INSPECTION ERROR EFFECTS ON PERFORMANCE MEASURES OF A MULTISTAGE SAMPLING PLAN.** This paper generalizes previous work on double sampling to multistage sampling. It provides expressions for the O.C. curves, average outgoing quality and average total inspection in the presence of inspection error for all combinations of sample by lot dispositions. Furthermore, the sensitivity analysis is carried out from a more general algebraic standpoint. (Edited author abstract) 11 refs.

Maghsodloo, Saeed (Auburn Univ, AL, USA). *IIE Trans* v 19 n 3 Sep 1987 p 340-347.

**087441 MONITORING AS ESTABLISHING QUALITATIVE DEFINITENESS IN AN OBJECT.** Qualitative definiteness (quality) expresses an essential definiteness indistinguishable from the existence of the object, on account of which it is what it is and not some other object. A given object will have a set of different qualities, because each object can be evaluated from various viewpoints. Qualitative definiteness in an object is the objective essence of it, since it reflects what it objectively is and is independent of human consciousness of it. By property is meant the occurrence of an internal nature in the thing or object demonstrated by its interaction with other things. 7 refs.

Bolychevtsev, A.D.; Vaikhbrot, E.I.; Tsapenko, M.P.; Shenbrot, I.M. *Meas Tech* v 30 n 5 May 1987 p 401-404.

**087442 DISTRIBUTION OF DEFECTIVES DUE TO INSPECTION ERRORS IN 100% INSPECTED LOTS.** The occurrences of the error-failure to detect a defective unit-by the inspectors are described by Poisson distributions. The Poisson distributions are then mixed using a gamma distribution to reflect diversity among the inspectors in terms of their speed of inspection, skill, frequency of assignment to inspect the product, etc. The resulting compound distribution, which is the distribution of defectives in the inspected lots, turns out to be a negative binomial distribution. Estimation techniques to estimate the parameters the negative binomial distribution from sample data and the method to update the distribution of defectives in the lots using Bayesian technique are presented. Several numerical examples of the techniques are also provided. (Edited author abstract) 33 refs.

Dhaval, Dileep G. (Clark Univ, Worcester, MA, USA). *Int J Prod Res* v 25 n 12 Dec 1987 p 1729-1738.

**087443 SIMPLIFIED DESIGN PROCEDURE FOR MINIMAX SAMPLING PLANS BY ATTRIBUTES.** A minimax criterion was introduced by Fujino and Okuno (1981) for the unique determination of single sampling plans by attributes with given producer's and consumer's risk. A procedure was also proposed by them to get sampling plans based on a minimax criterion. A simplified design procedure for the minimax sampling plans is presented. The proposed procedure is based on a regression relationship in variates derived from the Wilson-Hilferty approximation. For practical purposes, some tables for designing the desired sampling plans are provided. (Edited author abstract) 13 refs.

Ohta, Hiroshi (Univ of Osaka Prefecture, Sakai, Jpn); Kanagawa, Akihiro. *Int J Prod Res* v 26 n 1 Jan 1988 p 143-156.

**087444 QUALITY CONTROL OF AN UNRELIABLE RANDOM FMS; WITH BERNOULLI AND CSP SAMPLING.** This paper provides a set of recursive equations for computing the AOQ (average outgoing quality) of an unreliable random FMS (flexible manufacturing system). The FMS is described using Whitt's approximation to a network of GI/G/S queues. Relationships between the operating and quality manufacturing characteristics of the FMS are found. Numerical examples are provided and the impact of outgoing quality variability on location of inspection in an FMS is discussed. This latter topic is left for further research however. (Author abstract) 16 refs.

Tapiero, Charles S. (Case Western Reserve Univ, Cleveland, OH, USA); Hsu, Lie-Fern. *Int J Prod Res* v 26 n 6 Jun 1988 p 1125-1135.

**087445 CORRECTION NOTE ON "MINIMUM COST QUALITY CONTROL TESTS"** An expected cost model of a process whose mean is controlled by an  $\bar{X}$ -chart is developed by Knappenger and Grandage. Some expressions used in the model are not in accordance with the procedure described by the authors. These



expressions are corrected in this note. The corresponding changes in the numerical example are also worked out here. (Edited author abstract). 1 Ref.

Nandii, S.N. (M.S. Univ, Baroda, India); Shah, D.K.; Phatak, A.G. *IIE Trans* v 20 n 2 Jun 1988 p 231-233.

**087446 DETERMINATION OF SINGLE-SAMPLING-ATTRIBUTE PLANS BASED ON MEMBERSHIP FUNCTIONS.** In using exact sampling plans, cases often arise in which large sample size is needlessly sought. A minimax criterion which relaxes the conditions on the risks for reducing the sample size was introduced by Fujino and Okuno. This paper presents a design procedure for relaxing the conditions on the risks by the membership functions used in fuzzy methodologies. The proposed procedure is general because it includes sampling plans based on the minimax criterion and exact sampling plans in the special cases. (Edited author abstract). 9 Refs.

Ohta, Hiroshi (Univ of Osaka Prefecture, Osaka, Jpn); Ichihashi, Hidetomo. *Int J Prod Res* v 26 n 9 Sep 1988 p 1477-1485.

**Standards** See Also INDUSTRIAL PLANTS—Quality Control; INSTRUMENTS—Calibration; NONDESTRUCTIVE EXAMINATION—Dyeing; QUALITY ASSURANCE—Management.

**087447 NEGOTIATING ZONES.** In any discussion of specifications, and particularly in one dealing with questionable lots beyond the traditional 'specification' limits, one must state that this is not in conflict with Taguchi's loss function. All companies should urge or even require their suppliers to not only meet specifications, but be centered and of sufficiently low variability that a process capability index ( $C_p$ ) of 1.3 can be met or exceeded. Establishing a negotiating zone in specifications should not take the place of effective and economical process control, but it can be used for those instances where the customer does not yet understand fitness-for-use criteria; the extensive experimentation would be prohibitively expensive due to cost of materials and products; conservative limits are required due to the high cost of using a run or lot of material not fit for use.

Burr, John T. *Qual Prog* v 20 n 9 Sep 1987 p 38-39.

**087448 PRODUCT QUALITY THROUGH THE STANDARD.** Improvement of product quality is the source of increase in labor productivity, conservation of resources, and expansion of trade relations. In this area a positive effect is exerted by the product quality control system, based on a system of interrelated standards regulating all preliminary and basic stages - from project and design developments to the quality of final products. The plant services developed more than thirty standards of this system, covering all stages of production: from input monitoring of feedstock to output monitoring of the quality of finished products. The principal type of product of in the authors plant is coal coke, which is used in nonferrous metallurgy. The comprehensive system permitted us, proceeding from feedstock quality, to achieve flexible control of the technological process, and as a result the quality indices of the finished coke were significantly higher than the specifications of the GOST standard. The plant adopted three-stage monitoring of the observance of technology to achieve the required product quality.

Mansurova, L.P. *Coke Chem (USSR)* n 12 1986 p 73-74.

**087449 DEVELOPMENT OF THE BS 5750 CONCEPT OF TOTAL QUALITY SYSTEM PROCEDURES.** The author traces the evolution of quality control from the industrial revolution to the present day. The adoption by the Japanese of quality control is discussed. An examination is made of BS 5750 which provides the framework for a quality management system that is effective within our culture, and can serve as a catalyst for establishing good management practices. It operates at the three levels of company policy, internal systems, and specific requirements. It is a 20-point check list that top management can use as an instrument to

change practices and secure the involvement of staff at every level. The headings apply in all situations, and comprehensive explanation of the requirements and guidance notes appear in the published specification. The interpretation of the concepts for a particular company must be developed and personalized by their own staff, and summarized in their 'quality system manual'. The three certifying bodies that assess conformance to the requirements of BS 5750 are given. 11 Refs.

Johnston, Denis. *Chem Ind (London)* n 11 Jun 6 1988 p 365-368.

**Testing** See DATA STORAGE, MAGNETIC—Disk.

## Ultrasonic Applications

**087450 REFLECTION OF LONGITUDINAL WAVES FROM A SEMI-INFINITE CRACK.** The article deals with the solution of the problem of the reflection of longitudinal waves, excited in a half-space by a piston transducer, from a semi-infinite crack. In the wave zone simple equations suitable for engineering estimates are obtained. The results of numerical calculations are presented. (Author abstract) 6 refs.

Danilov, V.N. (Moscow Mining Inst, Moscow, USSR); Basatskaya, L.V. *Sov J Nondestr Test* v 23 n 3 Mar 1987 p 186-191.

**QUANTUM THEORY** See Also CHARGED PARTICLES; CHEMICAL REACTIONS—Calculations; DIAMONDS—Crystallization; ELECTRIC CONDUCTIVITY; ELECTRODYNAMICS; ELECTRONS; ELECTRONS—Transport Properties; ELECTRONS—Tunneling; FERROELECTRIC MATERIALS—Phase Transitions; GRAPHITE; GRAVITATION; HALL EFFECT; HELIUM—Low Temperature Properties; ION SOURCES; LASER BEAMS—Effects; LASERS—Optical Pumping; LASERS—Theory; LASERS; SEMICONDUCTOR MATERIALS; LIGHT—Amplifiers; LIGHT—Coherent; LIGHT—Nonlinear Optical Effects; MAGNETIC MATERIALS; MAGNETISM—Theory; MAGNETOOPTICAL EFFECTS; MATHEMATICAL TECHNIQUES—Integration; MEASUREMENT THEORY; MECHANICAL VARIABLES MEASUREMENT—Position; METALS AND ALLOYS—Impurities; MOLECULES—Spectroscopic Analysis; OPTICAL COMMUNICATION—Theory; OPTICAL DEVICES—Optical Beam Splitters; OPTICS—Nonlinear; PHONONS—Theory; PHYSICS—Atomic; PHYSICS—High Energy; PHYSICS—Solid State; PLASMAS—Research; POLYACETYLENES—Spectroscopic Analysis; POLYMERS—Electronic Properties; RADIATION DETECTORS; SEMICONDUCTING ALUMINUM COMPOUNDS—Electronic Properties; SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers; SEMICONDUCTING GALLIUM ARSENIDE—Electronic Properties; SEMICONDUCTING GALLIUM ARSENIDE—Impurities; SEMICONDUCTING GALLIUM COMPOUNDS—Electronic Properties; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES—Structures; SEMICONDUCTOR DEVICES—Tunneling; SEMICONDUCTOR MATERIALS; SEMICONDUCTOR MATERIALS—Electronic Properties; SEMICONDUCTOR MATERIALS—Impurities; SEMICONDUCTOR MATERIALS—Microstructure; SEMICONDUCTOR MATERIALS—Physical Properties; SEMICONDUCTOR MATERIALS—Surfaces; SIGNAL THEORY—Synchronization; SOLIDS—Electronic Properties; SPECTROSCOPY—Theory; STATISTICAL MECHANICS; SUPERCONDUCTING DEVICES—Josephson Junctions; SUPERCONDUCTING MATERIALS—Crystalline; SUPERCONDUCTING MATERIALS—Physical Properties; SUPERCONDUCTIVITY.

**087451 MODERN ASPECTS OF QUANTUM THEORY OF CHARGE-TRANSFER PROCESSES.** Recent results in quantum mechanical theory of the elementary act of charge-transfer processes are reviewed. They involve nonadiabatic and adiabatic reactions of electron, proton and atom group transfer. Effects of stochastic motion along the reaction coordinate and fluctuational preparation of the potential barrier are discussed. A discussion is presented of the dependence of the symmetry factor on temperature, the reactions of atom and atom group transfer, and stochastic dynamics of reaction systems. 58 refs.

Kuznetsov, Alexander M. (Acad of Sciences of the USSR, Moscow, USSR). *Electrochim Acta* v 32 n 9 Sep 1987 p 1271-1278.

**087452 OPTIMAL CONTROL OF RESONANT INTERACTION BETWEEN LIGHT AND MATTER.** An iterative method of optimal control of quan-

tum-mechanical systems with the aid of resonant macroscopic electromagnetic fields is considered that can be used for systems of large dimension. Numerical results are obtained for the maximum inverse population of a three-level system excited by three fields, with relaxation taken into account. The utilization of this method shows that usually the greatest improvement is achieved at the first iteration, and that the number of iterations does not exceed ten. (Edited author abstract) 16 refs.

Kazakov V.A.; Krotov, V.F. *Autom Remote Control* v 48 n 4 pt 1 Apr 1987 p 430-434.

**087453 EFFECTIVE POTENTIAL IN QUANTUM MECHANICS WITH A NON-ABELIAN GAGING SYMMETRY.** A model is examined which has a gaging  $SO(N)$  symmetry and at  $N=3$  describes the dynamics of spatially uniform Yang-Mills fields. A collective coordinate method is used to calculate the energy of the ground state within large values of  $N$ . It is shown that the effective potential in the space of orbits, unlike the collective potential, is unlimited from below in this model. (Author abstract) 10 refs.

Solov'ev, M.A. *Sov Phys Lebedev Inst Rep* n 3 1987 p 30-35.

**087454 SUPERSYMMETRIC CASIMIR EFFECT IN FLAT HOMOGENEOUS CLIFFORD-KLEIN SPACE-TIME.** The Casimir effect in supersymmetric quantum field theories can occur in space-time with nontrivial topologies, due to the existence of topologically nonequivalent field configurations. This possibility is considered for the example of the supersymmetric Wess-Zumino model and the  $N=1$  supersymmetric Yang-Mills theory in flat homogeneous Clifford-Klein space-time with the topologies  $M_n = (S^1)^n \times R^{4-n}$ ,  $n=1, 2, 3$ . The occurrence of the Casimir effect in this situation is interesting from the point of view of constructing sensible cosmological scenarios of the early stages of the evolution of the Universe, in particular, the expanding Universe scenario. (Author abstract) 18 refs.

Goncharov, Yu.P. (M.I. Kalinin Polytechnic Inst, Leningrad, USSR); Bytsenko, A.A. *Sov Phys J* v 30 n 4 Apr 1987 p 353-357.

**087455 OSCILLATOR WITH A CENTRIFUGAL BARRIER.** We study the wave functions and energy levels of a one-dimensional oscillator with a centrifugal barrier of the form  $s(s+1)/x^2$ . It is shown that a barrier of this kind automatically implies the point potential  $A(s)\delta(x)/x$ . It is also shown that two different sets of even states are physically admissible, but that only one of these sets transforms continuously into the set of states of harmonic oscillator when the centrifugal barrier is allowed to vanish and is preferable for this reason. (Author abstract) 14 refs.

Gostev, V.B. (M.V. Molonov State Univ, Moscow, USSR); Mineev, V.S.; Frenkin, A.R. *Sov Phys J* v 30 n 5 May 1987 p 388-391.

**087456 BIOLOGICAL OBSERVABLES AND QUANTUM MEASUREMENTS.** An argument of theoretical biophysics is presented. It is seen that the supposed existence of the biological observables enables us to obtain a resolution of basic problems in quantum theory. (Author abstract) 10 refs.

Conte, E. (Lab di Radioattività e Metodologie Radioisotopiche, Bari, Italy). *Cybernetica* v 30 n 3 1987 p 31-37.

**087457 WORLD AS SYSTEM SELF-SYNTHESIZED BY QUANTUM NETWORKING.** The quantum, strangest feature of this strange universe, cracks the armor that conceals the secret of existence. In contrast to the view that the universe is a machine governed by some magic equation, we explore here the view that the world is a self-synthesizing system of existences, built on observer-participancy via a network of elementary quantum phenomena. The elementary quantum phenomenon



in the sense of Bohr, the elementary act of observer-participancy, develops definiteness out of indeterminism, secures a communicable reply in response to a well-defined question. The rate of carrying out such yes-no determinations, and their accumulated number, are both minuscule today when compared to the rate and number to be anticipated in the billions of years yet to come. The coming explosion of life opens the door, however, to an all-encompassing role for observer-participancy: to build, in time to come, no minor part of what we call its past - our past, present, and future - but this whole vast world. (Author abstract)

Wheeler, John Archibald. *IBM J Res Dev* v 32 n 1 Jan 1988 p 4-15.

**087458 QUANTUM DECAY AT A FINITE TEMPERATURE.** The phenomenon of quantum decay of a metastable state at a finite temperature is investigated. The case of a non-quasi-classical potential and optical dissipation is examined. It is shown that there is no shift from a mode of quantum tunneling to a mode of thermal activation in an approximation of the lifetime for such a potential. A general expression is found for the rate of decay, and it is investigated in different special cases. (Author abstract) 5 refs.

Zaikin, A.D.; Kosarev, I.M.; Panyukov, S.V. *Sov Phys Lebedev Inst Rep* n 9 1987 p 31-34.

**087459 ISOLATED RINGS OF MESOSCOPIC DIMENSIONS. QUANTUM COHERENCE AND PERSISTENT CURRENTS.** Persistent currents in small nonsuperconducting rings threaded by a magnetic flux are a manifestation of novel quantum effects in submicron systems. We present theoretical results for one-channel and multichannel systems concerning the dependence of the current amplitude on the number of channels and geometry, temperature, and degree of disorder. Inelastic scattering is considered for one-channel loops only. We also discuss the observability of the effect. (Author abstract) 18 refs.

Cheung, Ho-Fai (Univ of Washington, Seattle, WA, USA); Gefen, Yuval; Riedel, Eberhard K. *IBM J Res Dev* v 32 n 3 May 1988 p 359-371.

**087460 VOLTAGE-DEPENDENT SCALING OF THE QUANTUM RESISTANCE IN 1D DISORDERED SYSTEMS.** We have studied the voltage-dependent scaling of the resistance in a 1D disordered system by using a new Landauer-type resistance formula. The scaling behavior at high voltage is significantly different from the scaling law due to Anderson et al. The finite voltage difference between both ends of the wire leads to much better statistical behavior (in ensemble sense) of the resistance due to self-averaging over energy. Numerical results obtained for a simple model system illustrate the typical behavior that is expected to be of conceptual importance for real systems. (Author abstract) 22 Refs.

Lenstra, D. (Eindhoven Univ of Technology, Eindhoven, Neth); Smokers, R.T.M. *Physica B & C* v 151 n 3 Aug-1 1988 p 503-508.

**087461 QUANTUM MECHANICAL EFFECTS ON SPUTTER SOURCE ISOTOPE FRACTIONATION.** The negative ion production probabilities for ions of differing masses have been calculated for a simplified sputter source geometry using the formalism developed by Norskov and Lundqvist. The isotope fractionation derived from this probability is, as expected, a strongly varying function of the sputter cathode surface conditions. The results of these calculations using the carbon isotopes as an example are discussed with regard to their implications for accelerator mass spectrometry (AMS). (Author abstract) 9 refs.

Nadeau, M.-J. (Univ of Toronto, Toronto, Ont, Can); Kieser, W.E.; Beukens, R.P.; Litherland, A.E. *Nucl Instrum Methods Phys Res Sect B* v B29 n 1-2 Nov II 1987, Accel Mass Spectrom, Proc of the Fourth Int Symp, Niagara-on-the-Lake, Ont, Can, Apr 27-30 1987 p 83-86.

**Adsorption** See CATALYSIS—Theory.

**Calculations** See COPOLYMERS—Molecular Structure; HEAT TRANSFER—Radiation; POLYMETHYL METHACRYLATE—Copolymerization.

**Diffusion** See OPTICS—Mathematical Models.

## Mathematical Models

**087462 CYCLIC GEOMETRICAL QUANTUM PHASES: GROUP THEORY DERIVATION AND MANIFESTATIONS IN ATOMIC PHYSICS.** We present a derivation of the Berry quantum adiabatic phase using group theory. Our formalism is used to discuss possible manifestations in Atomic Physics and to investigate the new cyclic quantum phase recently introduced by Aharonov and Anandan. (Author abstract) 11 refs.

Bouchiat, C. (CNRS, Paris, Fr). *J Phys (Paris)* v 48 n 9 Sep 1987 p 1401-1406.

**087463 CONCEPTION OF GLUON DOMINANCE AND MULTIHADRON PRODUCTION.** Qualitative arguments are discussed for the model of gluon dominance (MGD) of the multihadron production process in hadron and relativistic nuclei interactions. Interpretations are given of basic regularities of the multi-hadron production in hadron collisions in the concrete variant of MGD-model of two-gluon fusion. Requirements are formulated for the behavior of the cross section of such a fusion following from the analysis of the production process. (Author abstract) 49 refs.

Kalinkin, B.N. (Joint Inst for Nuclear Research, Dubna, USSR); Shmonin, V.L. *Phys Scr* v 36 n 5 Nov 1987 p 737-742.

**087464 STUDIUL TEORETIC ASUPRA LASERULUI IN REGIM MODE-LOCKING CU MODULATOR ELECTROOPTIC IN CAVITATE CUPLATA.** [Theoretical Study on the Mode-Locking Operation Using Electrooptic Modulator in Coupled Cavity]. The coupled modes equations for a two cavity optical configuration are obtained in terms of the system normal modes. The studied optical configuration contains a loss or phase modulator placed inside an auxiliary passive cavity which is coupled to the active cavity. (Author abstract) In Romanian. 7 refs.

Popescu, I.M. (Inst Politehnic Bucuresti, Bucharest, Rom); Podoleanu, G.H.A. *Bul Inst Politeh Bucuresti Ser Electroteh* v 46-47 1984-1985 p 37-44.

**087465 SIMPLE AND IMPORTANT RULE IN THE QUANTUM THEORY OF LIGHT.** In the quantum theory of light, the emission and absorption of a light quantum by an electron in the atom is equivalent to the interaction of the electron with the equivalent classical vector potential. This is a simple and important rule. This paper gives the proof of this rule, and applies this rule to calculate the transition probability of the emission and absorption of light. (Author abstract) In Chinese.

Li Xizeng (Tianjin Univ, China). *Tianjin Daxue Xuebao* n 3 1987 p 111-115.

**087466 GENERALIZED ZETA-FUNCTION REGULARIZATION.** A generalized  $\zeta$ -function regularization is considered for computation of the superdeterminant of a matrix of differential operators in the case of a continuous spectrum. It is shown that in the general case the method makes us of a complete set of eigenfunctions of a certain system of integrodifferential equations. (Author abstract) 5 refs.

Lavrov, P.M. (Lenin Komsomol Pedagogical Inst, Tomsk, USSR). *Sov Phys J* v 30 n 5 May 1987 p 359-362.

**087467 INVERSE SCATTERING PROBLEM IN THE RELATIVISTIC QUASICLASSICAL APPROXIMATION.** We apply the quasipotential approach of quantum field theory to solve the inverse scattering problem in the relativistic quasiclassical approximation. We obtain expressions for reconstructing the quasipoten-

tial from the phase shifts and consider both nonrelativistic and ultrarelativistic cases. (Author abstract) 19 refs.

Solovtsov, I.L. (Gomel' Polytechnical Inst, USSR); Chernenchenko, Yu.D. *Sov Phys J* v 30 n 5 May 1987 p 366-371.

**087468 STACKEL SPACES OF AN ELECTROVACUUM WITH ISOTROPIC COMPLETE SETS. FORMULATION OF PROBLEM AND BASIC RELATIONS.** We consider the problem of the classification of the Stackel spaces of the electrovacuum with isotropic complete sets. The metrics of the spaces are represented in a form that is convenient for their investigation. We obtain necessary relations for the construction of the field equations. (Author abstract) 6 refs.

Bagrov, V.G. (Acad of Sciences of the USSR, Tomsk, USSR); Evseevich, A.A.; Obukhov, V.V.; Osetrin, K.E. *Sov Phys J* v 30 n 5 May 1987 p 371-375.

**087469 HAMILTONIAN OF A SYSTEM OF PARTICLES WITH ANOMALOUS MOMENTS IN THE NULL-PLANE FORMALISM.** A Hamiltonization of a system of interacting Bose and Fermi fields is performed. It is assumed that the fermions possess anomalous magnetic and intrinsic dipole moments. The Hamiltonization is conducted using the null-plane formalism in the gauge  $A^0 = A_3 = 0$ , which is an analog of the Coulomb gauge in a Cartesian coordinate system. (Author abstract) 10 refs.

Strokov, P.V. (S.M. Kirov Polytechnical Inst, Tomsk, USSR); Flesher, G.I. *Sov Phys J* v 30 n 5 May 1987 p 379-382.

**087470 QUANTUM NOISE AND QUANTUM LANGEVIN EQUATIONS.** The quantum Langevin equation of Ford, Kac, and Mazur is rederived and shown to be equivalent to an adjoint equation. This latter can be handled by means of van Kampen's cumulant expansion to yield derivations of the quasiclassical Langevin equation, stochastic electrodynamics, quantum optical, and quantum Brownian motion master equations (under appropriate conditions). The result of Benguria and Kac - that the quantum Langevin equation yields the Boltzmann distribution over energy levels in thermodynamic equilibrium - is also verified. (Author abstract) 19 refs.

Gardiner, C.W. *IBM J Res Dev* v 32 n 1 Jan 1988 p 127-136.

**087471 FINITE ELEMENT METHODS IN QUANTUM MECHANICS.** Wave functions in configuration space for quantum mechanical systems at a fixed energy are derived from a variational functional appropriate for both scattering states and bound states. The finite element method is applied to problems in one, two and three dimensions with discussions of the errors. A detailed description of calculations of three-body scattering amplitudes in a three-dimensional, hyperspherical formulation is provided, including a network construction. (Author abstract) 23 refs.

Linderberg, Jan (Aarhus Univ, Aarhus, Den). *Comput Phys Rep* v 6 n 1-6 Aug 1987, Finite Elem in Phys, Proc of the 1st Eur Grad Summer Course on Comput Phys, Lausanne, Switz, Sep 1-10 1986 p 209-242.

**Oscillations** See QUANTUM THEORY.

## QUARRIES AND QUARRYING

**087472 SOCIETE DES KAOLIN D'ARVOR: IMPORTANTES POSSIBILITES EN VOIE DE DEVELOPPEMENT.** [Arvor Kaolin Co.: Important Possibilities in Development]. On the Atlantic coast near Lorient, at a spot called Kergantic of the parish of Pleumeur, are located the quarry and the processing plant of the Arvor Kaolin Co. They present quite an unusual landscape. The whitish spoil heaps can be observed very far from the shore over the ocean. Some of the topics covered include Kaolin Treatment, and mica preparation. In French.

Anon. *Ind Miner Mines Carrieres* v 69 Nov 1987 p 571-574.



**087473 TARMAC LIMESTONE MINE CLEANS UP WITH NEW FILTER PLANT.** Once beset with emission and filter maintenance problems at a Derbyshire Limestone mine, Tarmac Quarry Products took the decision over five years ago to install new filter plant containing nearly 500 new style membrane filter bags. Pressure from local residents has long since ceased and now the mine's filtration system operates at over one thousand times the atmospheric emission efficiency level laid down by the Health and Safety Executive. (Author abstract)

Anon. *Mine Quarry* v 17 n 4 Apr 1988 p 27.

**087474 DISTRIBUTION OF QUARRIED MATERIALS.** Quarry products are characterized by high-volume (tonnage) flows of material having an intrinsically low value. As a result, a reduction in unit transport costs has been sought through economies of scale. Some topics discussed in this regard are the following: roads; rail; water transport; the future and its constraints (road, rail, and sea transport); and alternative methods. 6 refs.

Wilson, Herb (ARC Southern). *Quarry Manage* v 15 n 4 Apr 1988 p 33-35.

**LING, BLASTING COST.** An advanced emulsion/ANFO blend bulk explosives system has helped a Michigan quarry solve some difficult blasting problems and in the process reduce overall drilling and blasting costs up to 7%. The quarry is the Rockwood, Mich., silica sand and limestone operation of U.S. Silica, Michigan. The quarry produces about 300,000 tons of silica a year which is processed into sand for the glassware industry and silica sand for foundries.

Tarantino, Teresa. *Pit Quarry* v 80 n 3 Sep 1987 p 40, 42.

**087480 DIMENSIONAL STONE BLASTING IN FINLAND.** Smooth Blasting techniques are finding increasing use. They are already employed in large underground civil engineering works. The next logical step would be to use these methods in the development of long-term underground excavations needed in mines for large underground crusher houses, pump chambers and workshops. The techniques used in Finland for producing quarried dimension stone are described.

Smith, Mike. *Min Mag* v 157 n 4 Oct 1987 p 312-313, 315-317.

**087481 RECENT ADVANCES IN OPEN-PIT BLASTING.** This paper describes the recent major developments associated with coal overburden blasting that have led to these efficiency gains. It is hoped that quarry operators may become fully aware of these technical advances, so that this efficiency may be rapidly translated to their environment, allowing the same degree of competitive edge to occur in the domestic markets. The fast-growing minerals industry of the 1960s was quick to seize on the advantages of low-cost ANFO in all dry blasting applications. Research and development efforts were geared towards the development of the early water-proof slurry explosives. These were later refined to the small-diameter packaged water-gels such as Tovex, with its patented sensitizer MMAN.

Talbot, David (DuPont Ltd, Aust). *Quarry Manage* v 15 n 3 Mar 1988 p 31-32, 34.

**087482 LASER PROFILING AT MOORCROFT QUARRY.** If proposals for new Regulations and an Approved Code of Practice covering the use of explosive in quarries come into force, the changes relating to surveying and profiling will lead to renewed interest in improving these techniques. One company which believes it has an ideal solution is Rockclasers Ltd, now acting as agents for manufacturers of the 'Quarryman' laser profiling system. The article describes the operating principles of the system.

Anon. *Mine Quarry* v 17 n 1-2 Jan-Feb 1988 p 19-22.

**087483 A REVIEW OF BLAST DESIGN CONSIDERATIONS IN QUARRYING AND OPENCAST MINING.** Good blasts are the result of the correct choice of explosives, and good blast design. The diameter, length and inclination of blast holes, drilling pattern, type, quantity and utilization of explosives, rock type, firing sequence and delay timing all have an effect on the efficiency of the overall operation. If the highest overall efficiency and highest safety standards are to be achieved, all blasts must be properly designed and recorded for future reference. This paper reviews the basic factors leading to good design and discusses the role of computer-aided design and in particular the SABREX computer blast model.

Ball, Malcolm (Nobel Explosives Co). *Quarry Manage* v 15 n 6 Jun 1988 p 35-39.

**087484 REVIEW OF BLAST DESIGN CONSIDERATIONS IN QUARRYING AND OPENCAST MINING PART 2 INITIATION AND COMPUTERIZED DESIGN.** With the development of modern drilling equipment capable of drilling blast-holes cleanly and accurately and advanced surveying equipment for the precise determination of quarry face profiles, blasting design is simpler and more predictable. The use of computers may also predict blast results and permits adjustments to blast patterns and choice of explosives

without recourse to implementing these in the field. In spite of these modern aids to blast design, safe blasts need not necessarily follow accurate measurement and computer-aided design. It is a combination of these factors with understanding on the part of the operator which will ultimately lead to safe and efficient blasts. The computer aided design method SABREX is described.

Ball, Malcolm (Nobel's Explosives Co). *Quarry Manage* v 15 n 7 Jul 1988 3p.

## California

**087485 HIGH-GRADE AGGREGATES FROM NEW CALIFORNIAN QUARRY. TWO-MILE CONVEYOR SYSTEM GENERATES POWER.** Capable of producing 8,000 tons a day of high-grade aggregates for railway ballast, road base and other construction applications, a new quarry located in an environmentally sensitive area near Newberry Springs, California, was opened in February 1987. Owned by McKee Products Inc., the plant produces - 2in ballast from a solid andesite formation for the Santa Fe Railway Co. and a portion of its output is sold to the area construction industry. Railway ballast is processed at the quarry and delivered to a railway siding two miles away by a haul conveyor system.

Anon. *Quarry Manage* v 15 n 1 Jan 1988 31-32, 34.

## Computer Applications

**087486 MANAGEMENT INFORMATION SYSTEMS IN QUARRYING: MEETING THE QUARRY OWNER'S NEEDS.** This paper explores present-day management needs and expectations in relation to the types of information services now available. It attempts to draw together all the information needs of a quarry owner, suggests how the most up-to-date information systems can help handle this data, and explains how a management structure may be modified. The aspects of a quarry operation which can be assisted by an information system are identified and discussed.

Fuchs, Peter (Steeley Quarry Products Ltd). *Quarry Manage* v 14 n 10 Oct 1987 p 19-20, 23.

**087487 COMPUTER AID IN QUARRY DESIGN AND PLANNING.** Computer systems which assist management and engineers in the design and operation of quarries have been available for a number of years. This paper is concerned with aspects of these systems and their potential for improving the efficiency of quarry operations. A brief description of current mining computer-aided design (CAD) features is provided and the benefits of employing such systems are discussed. The introduction of these systems has been slow in the UK with most quarrying operations still carrying out designs on a manual basis. The reasons for this reluctance to adopt what is basically proven technology are examined. 17 refs.

Denby, Bryan (Univ of Nottingham, Engl). *Quarry Manage* v 15 n 5 May 1988 10p.

## Control Systems

**087488 NEW TECHNOLOGY INCREASES PRODUCTION AT MACHEN.** A recent installation on behalf of ARC Powell Duffryn at Machen Quarry in South Wales confirms that the introduction of new technology can significantly improve productivity and the efficiency of plant operation and also be totally accepted by the existing work force. This particular installation uses a suite of Gem-80 programmable controllers configured as a distributed control system which is distributed into distinct control areas: primary crushing, final bin blending control, secondary crushing control, tertiary crushing control, and rail loading control. Other information integrated into the overall control system is detailed plant status information relayed to the manager's office for display of a VDU terminal, and control of plant load shedding from information derived from maximum demand equipment sited in the primary substation.

Graves, G. (Advanced Control Systems Ltd of Leeds, Engl). *Quarry Manage* v 14 n 9 Sep 1987 p 37, 39.

## Alabama

**087475 HOOVER OPENS LIMESTONE QUARRY AT HUNTSVILLE.** Hoover Inc., a multi-plant aggregate producer headquartered in Laverne, Tenn., recently opened a 1.2 million t/y capacity limestone processing facility in Huntsville, Ala. The plant was designed to be efficient, yet simple to operate while producing a wide range of materials needed by the local market. The plant's crushers are described.

Michard, Don. *Pit Quarry* v 80 n 9 Mar 1988 p 46-49.

## Austria

**087476 WANDABBAU MIT STROSSENARTIGEM VERHIEB - ERFABRUNGEN DER STEIRISCHEN MONTANWERKE AG.** [Benched Highwall Mining - Experience of Steirische Montanwerke AG]. Steirische Montanwerke AG operate three quarries in Austria (at Leoben, Peggan and Bad Ischl) by benched highwall mining. Material is pushed down the benches to the main level, where the breaker is installed. The advantages and disadvantages of pushing down the material from the benches in comparison to truck haulage are discussed. In German.

Reska, Peter (Steirische Montanwerke AG, Leoben, Austria). *Berg Huetttenmaenn Monatsh* v 133 n 4 1988 p 181-183.

## Automation See CRUSHERS—Reviews.

## Blasting

**087477 BLAST VIBRATION PROBLEMS.** Quarries located close to communities often produce conflict based on environmental impact. One principal cause of such community relations problems is blasting. A blast delay sequence design based on frequency response spectra can help stem neighbor complaints.

Petro, Anthony J. (Vibra-Tech Engineers Inc); Anderson, Douglas A. *Pit Quarry* v 80 n 3 Sep 1987 p 32-34.

**087478 BLASTING WITH PRECISION.** Florida Rock Industries' quarry at Forest Park, Ga. is located on the southern edge of Atlanta a few miles from the Hartsfield International Airport. Florida Rock contracted with Vibra-Tech Engineers to prepare a Vibra-Map analysis of the quarry. The analysis defined specific delay intervals to be used between blast hole rows and between each hole in a row in order to minimize vibration at neighboring businesses and apartments.

Drake, Bob (Pit & Quarry, Chicago, IL, USA). *Pit Quarry* v 80 n 3 Sep 1987 p 36-37.

**087479 BULK EMULSION USE LOWERS DRIL-**



**087489 FLS - COMBIOLOGIC FOR INTEGRATED CONTROL OF QUARRY, RAW MEAL AND CLINKER PRODUCTION.** The CombiLogic has been developed and used by F.L. Smith (FLS) over recent years in connection with consultancy jobs and when creating plant layout and designs. Based on the available raw materials and oil or coal quality, CombiLogic is a valuable tool to ensure that the most economical plant design can be determined. Existing plants can benefit from the system by simulating how the remaining and sometimes misused quarry can be utilized in the most economical way. CombiLogic is a modern tool to assist in solving problems with difficult raw materials or, in some cases, to extend the lifetime of quarries by carrying out the necessary number of production simulations. On the environmental side it is possible to determine by simulation how the quarry landscape will look in the future by using the system's extensive array of excellent three-dimensional graphic facilities.

Anon. *World Cem* v 19 n 4 Apr 1988 p 123-124.

## Conveying

**087490 CONVEYING IN OPEN PITS.** The advantages of conveyor transport in surface mines and quarries, including economy, reliability and quietness of operation, are well known. Despite these advantages many operators are still concerned about the potential difficulties in maintaining conveyors close to a working face, being unaware of some of the more recent developments in this sector where Dowty Meco are regarded as one of the UK's leading manufacturers. The new developments are briefly reviewed.

Anon. *Mine Quarry* v 17 n 3 Mar 1988 p 19-20.

## Crushing and Grinding See Also CRUSHERS—Modification; SLATE.

**087491 WORLD'S LARGEST MOBILE CRUSHER IN TEXAS: REDLAND WORTH'S AUTOMATED PLANT AT SAN ANTONIO.** The author reports on a recent visit to Redland Worth's operations at San Antonio, Texas, to see the world's largest mobile primary crusher and their new, highly automated processing plant. The Redland Worth crusher is thought to be unique in that it is equipped with a pre-screening facility designed to their own specification, whereby the 4-in (100mm stone) is taken out of the feed ahead of the crusher at a rate of 2,500 tonnes/h and sent on a bypass chute to the crusher product conveyor, providing a bed of material on the belt to alleviate shock loading. The crusher will accept boulders up to 45ft maximum dimension and gives a product which is set 85% under 4in, with the largest stone being 6-8in.

Hill, Bernard (Quarry Management, Nottingham, Engl). *Quarry Manage* v 15 n 3 Mar 1988 p 9-16.

**087492 HYDRAULIC ROCK BREAKERS.** The problem of dealing with oversize boulders in the feed to the crusher is one which confronts almost every quarry crushing operation. By the use of a hydraulic boom system mounting an impact hammer the secondary breaking operation can be safely brought inside the crusher house. A hydraulic boom system is basically a stationary-mounted, slewing, articulated boom used to position a hydraulic hammer for the purpose of breaking oversize rocks in a feeder or crusher. The boom system consists of a pedestal bolted to either a concrete or a steel foundation. The hydraulic power is supplied by a self-contained power-pack.

Donahue, Bryan D. (Rammer Oy, Finl). *Quarry Manage* v 15 n 2 Feb 1988 p 15, 17, 19.

**087493 CONCEPT OF PRIMARY ROCK SIZING.** The twin-roll machine developed by MMD Mineral Sizing for primary rock reduction is referred to as a 'sizer' because it passes any material which does not require breaking. The size of the broken material can be controlled in all three planes, giving an accurately sized product. The tooth configuration acts like a rotating screen, allowing

undersize material to flow through with the minimum of energy usage. Material to be broken is then presented to the teeth in such a manner that the weakness of rock in tension is exploited to the best advantage, providing low kW per tonne figures. The article describes some recent applications in the UK and some other countries.

Flynn, Brian (MMD Mineral Sizing Ltd). *Quarry Manage* v 15 n 7 Jul 1988 p 29, 31.

## Drainage

**087494 ORIGIN OF NITROGEN COMPOUNDS IN WATER INFILTRATING INTO PORPHYRY QUARRY, ZALAS, SOUTHERN POLAND.** The paper deals with the problem of the origin of nitric compounds in the mine water entering porphyry quarry. A hydrogeological study of the natural and disturbed ground water regimes as a consequence of quarrying have shown that fecal and domestic sewage was the main source of nitrogen compounds in the water entering the porphyry quarry. The sewage contaminated the surface water which in turn infiltrated into the porphyry within the cone of depression. In addition to that,  $\text{NH}_4^+$  and  $\text{NO}_3^-$  ions penetrated into the surface water as the result of washing of nitrogen out of the soil and as a product of biochemical and chemical changes in the soil. A solution of unburnt explosives, used for the ground excavation was also a source of nitrogen compounds. (Author abstract) 6 refs.

Adamczyk, A.F. (Acad of Mines & Metallurgy, Cracow, Pol); Lesniak, T.C.; Motyka, J. *Int J Mine Water* v 6 n 2 Jun 1987 p 27-36.

## Dust Abatement

**087495 REDUCTION OF THE EFFECT OF BLASTING ON THE ATMOSPHERIC DUST CONTENT IN QUARRIES AND THE ENVIRONMENT.** Blasting in quarries is a very intense source of periodic dust release. Depending on the amount of simultaneously exploded charge and the size of the block, the amount of dust released into the quarry atmosphere may reach hundreds and thousands of kilograms. Dust released during breaking of rocks is partly carried by air currents from the quarry, although a significant part of it settles on various surfaces and it serves as a source of secondary dust formation which enters the air again. Therefore, in developing methods and ways of reducing entry of dust into the atmosphere from massive explosions during open-cast mining, it is necessary to consider measures preventing dust from flying up from the neighboring territory. Dust concentration in the dust-gas cloud at selected points was measured remotely by means of portable rotary blowers PRV-1M form special concrete bunkers. Simultaneously, wind velocity and direction; air temperature and moisture content in the exploded block and at the quarry surface were measured. 3 refs.

Bitkolov, N.Z. (Scientific-Research Inst of Water Transport Hygiene, Leningrad, USSR); Ivanov, I.I.; Pichuev, V.I. *Sov Min Sci* v 23 n 1 Jan-Feb 1987 p 44-50.

**087496 ROCK DUST CIRCUMSTANCES IN STONE QUARRYING AND PROCESSING PLANT.** Focusing on the large scale and the highly mechanized granite stone industries, the present state of dust circumstances in the quarry and the processing plant, the present state of dustproofing measures and the direction of their improvement are discussed. The principal items are as follows; Present state of stone industries; Results of dust survey; Valuation of the state of dust in the working environment; Present state of the dustproofing measures; and Direction of their improvement. (Edited author abstract).

Hagiwara, Yoshikazu. *Mem Sch Sci Eng Waseda Univ* n 51 1987 p 89-103.

Energy Resources See ROCK—Energy Resources.

## England

**087497 REDEVELOPMENT AT WHATLEY.** Following a £25 million redevelopment programme, Whatley quarry, one of the largest, most modern and efficient limestone quarries in Europe, has a potential production capacity of 10 million tonnes a year. The quarry supplies crushed rock for use throughout Southern England. Much of the extra output is destined for the South East where there is a need to replace diminishing local deposits of sand and gravel. The investment in new plant and equipment and improvements to the rail link mean that Whatley is set to meet the demand for aggregates well into the next century.

Anon. *Mine Quarry* v 17 n 1-2 Jan-Feb 1988 p 11-12, 13-15.

**087498 WHATLEY QUARRY, ENGLAND.** Whatley quarry, situated four miles west of Frome, Somerset, England, is one of the largest and most efficient limestone quarries in Europe. Operated by ARC, a UK producer of construction materials, it supplies crushed rock by both road and rail throughout much of southern England. Coated roadstone and precast concrete are also delivered locally by road. With the recent completion of a three-year redevelopment program the quarry now has a potential production capacity of up to 10 Mt/y. The article describes operations.

Anon. *Min Mag* v 158 n 6 Jun 1988 p 466-471.

**087499 NATURAL DIAMOND—A PAWSON TRADITION.** Woodkirk Brown York Stone has been quarried and worked in and around Morley, West Yorkshire, for nearly a century and a half. Today, fine grained sandstone blocks from Britannia Quarry are frame sawn using De Beers EMB natural diamond. The purpose-built factory has a production capacity in excess of 500 tons of block throughput per week. The article describes the sawing operations. 1 Ref.

Daniel, Paul. *Ind Diamond Rev* v 48 n 525 Feb 1988 p 44-46.

**087500 WHERE PRINCE BISHOPS ONCE RULED.** Dunhouse Quarry Co Ltd was established around 1926. From block extraction the Dunhouse Quarry Company turned its attention to the provision of primary and secondary sawing, polishing and masonry facilities on site. The article describes the diamond sawing equipment.

Anon. *Ind Diamond Rev* v 48 n 525 Feb 1988 p 53-55.

## Environmental Impact

**087501 ENVIRONMENTAL IMPACT OF QUARRYING.** The environmental programmes needed to ameliorate the impacts of quarrying have an inevitable cost to the operator. Just as inevitably, however, there are costs (to the operator, the broader community and the environment) of not implementing such programmes. The ultimate cost to the operator of non-implementation could be withdrawal of continued approval for the operation. It has to be recognized that the broader community will no longer accept environmentally inadequate activities and that effective environmental programmes are now regarded as a necessary part of quarrying operations. Implementation of these programmes as an ongoing part of the quarrying operation is the most effective and efficient way of achieving the desired outcome.

Holmes, P.J. (Environmental Protection Authority of Western Australia). *Quarry Manage* v 15 n 4 Apr 1988 p 37-40, 43.

Equipment See Also LIMESTONE—Chemical Analysis; PROTECTIVE COATINGS—Wear; SAND AND GRAVEL PLANTS—Equipment.



**087502 SELECTING THE RIGHT MACHINE FOR THE JOB.** Selecting the right type of equipment to load material depends on many factors. Some considerations are the application, site layout and set up, company history, and availability of required back up. For the quarry with production needs between 300 and 1,800 t/h, the hydraulic excavator - shovel or backhoe - is gaining more consideration by management.

Rokahr, Dietrich F. (Liebherr-America Inc). *Pit Quarry* v 80 n 5 Nov 1987 p 44, 46-47.

**087503 SAND PROCESSING, PRODUCT OPTIMIZATION AND WASTE TREATMENT - PART 3. CLASSIFICATION (CONTINUED).** Hindered-settling classifiers (hereafter referred to as HSCs) have a long history in mineral processing. The HSC has not been described previously in any Institute of Quarrying publication. A discussion of the machine is broken down below into four sections, as follows: principle of operation; mechanical construction and design parameters; classification efficiency - overflow and underflow products, and use of several HSCs in achieving multi-product classifications. The use of the HSC in de-sliming/dewatering, removal of heavy minerals and removal of lignite are also briefly discussed.

Littler, A. (ARC Southern Ltd). *Quarry Manage* v 114 n 11 Nov 1987 p 41-42, 45-48.

**087504 CENTRAL MAINTENANCE FACILITY SAVES MONEY.** With a central maintenance facility adjacent to company headquarters in LaVergne, Tenn., Hoover Inc. saves money on the upkeep and upgrading of equipment at its five quarry sites. One way the facility saves money is by enabling the company to buy parts and materials in bulk, distributing materials to each site as needed. Parts are stored and an inventory record is kept. Another way the company saves money is by performing most of its own maintenance.

Constantino, Darren. *Pit Quarry* v 80 n 1 Jul 1988 p 36-38.

**087505 JOEST SCREENING MACHINES FOR QUARRYING.** Modern screening technology must meet very demanding DIN and efficiency assurance standards. In many cases, conventional screening machines can no longer cope with those requirements. Unusual shaped fractions cause pegging of the screen deck, resulting in reduced screening efficiency and throughput. The Joest vibrating screens type SWZ (double-deck) and type SWD (triple-deck) have been developed to meet these demands. The screen body ties the screen deck and unbalance shaft drive together. For ease of maintenance of the screen decks there is sufficient space provided between the deck and body. 2 Refs.

Zuber, J. (Joest GmbH, Muenster, East Ger). *Bulk Solid Handl* v 8 n 3 Jun 1988 P362.

## Explosions

**087506 CHANGES IN THE CONCENTRATION OF DUST RELEASED DURING A MASSIVE QUARRY EXPLOSION.** With the intensification of mining processes the amount of simultaneously detonated explosives reaches 1000-1300 tons at individual open-pit iron mines. The dust-gas cloud formed during the explosion is polluting the atmosphere of not only the mines but also the regions adjacent to them. A quantitative estimation of the dust concentration in the dust-gas cloud is presented for determining the effect of harmful emissions of a quarry during massive explosions on pollution of the atmosphere and the earth's surface in areas adjacent to the quarry and for identifying sanitary-protective zones. 13 refs.

Beresnevich, P.V. (All-Union Scientific-Research Inst of Mining Safety, Krivoi Rog, USSR); Den'gub, V.I.; Nalivaiko, V.G. *Sov Min Sci* v 23 n 2 Mar-Apr 1987 p 178-181.

Federal Republic of Germany See Also LIME-STONE—Processing.

**087507 WEST GERMANY'S SECOND LARGEST LIMESTONE QUARRY.** Germany's second largest limestone quarry is located along with many others in the area around Menden and Balve, where the valuable raw materials to be found there are quarried and processed for various industrial applications. Rheinisch-Westfälische Kalkwerke AG (RWK) extract some 3.8 million tonnes per year, and their Hoennetal works, which has now been working for exactly 90 years, still has reserves in its Asbeck, Horst and Eisborn fields sufficient to extend the life of the quarry for another 30 years and more. Rheinische-Westfälische Kalkwerke AG, with their main offices in Wuppertal-Dornap, have four works employing over 1,000 people, and a yearly turnover of around DM250 million. Some topics discussed are the historical background, quarrying operations, the processing plant, markets, and environmental measures.

Anon. *Quarry Manage* v 15 n 4 Apr 1988 p 49-50.

## Florida

**087508 SUCCESSFUL QUARRY START-UP IN AN AGGRESSIVE MARKET.** When White Rock Quarries began its new operation, start-up costs, operating efficiencies and product quality were given extensive consideration. White Rock quarries contracted with Explosives Technologies International (ETI), the new company formed from the U.S. and Canadian explosives businesses of DuPont Co. to perform all drilling and blasting. ETI obtained necessary permits and insurance, conducted seismic tests and developed a blasting program based upon White Rock's long range plans for quarry development.

Drake, Bob. *Pit Quarry* v 81 n 3 Sep 1988 p 36-37.

France See Also CEMENT PLANTS—France.

**087509 BUDILLON-RABATEL: UNE ENTREPRISE DAUPHINOISE EN PLEIN ESSOR.** [Budillon-Rabotel: a Dauphine-Region Company Makes Rapid Strides]. Budillon-Rabatel SA, a company managed by N. Budillon-Rabatel, has as its principal activity the quarrying of alluvial deposits. Its also cover transport (for its materials) and public works as well as the gathering of refuse and the exploitation of waste. This article deals particularly with the quality located in the district of Izeaux (Isere) at a spot called 'The Cash from Below', where five people produce an average output of 250 tonnes/h. This is a gravel pit outside water. (Edited author abstract). In French.

Anon. *Ind Miner Mines Carrieres* v 70 Jun 1988 p 20-25.

## Georgia

**087510 TWO FLORIDA ROCK QUARRIES ADD HYDRAULIC EXCAVATORS.** Florida Rock Industries Inc. has upgraded the crushing capacity of its Forest Park Quarry and Tyrone Quarry in Riverdale, Ga. The hydraulic excavators reduce tire, maintenance, and production costs. The quarry operations are described.

Adams, Bruce. *Pit Quarry* v 80 n 5 Nov 1987 p 30, 32, 34.

Illinois See Also SAND AND GRAVEL PLANTS—Illinois.

**087511 TUNNEL PROVIDES ACCESS TO 35 YEARS OF RESERVES.** At its Romeo Quarry near Chicago, Material Service Corp. completed an 1,800-ft tunnel crossing underneath the Des Plaines River. The tunnel provides access to 35 years of aggregate reserves on the river's western side, while the eastern reserves are nearly depleted. Using in-house personnel, Material Service constructed the tunnel for approximately 80 percent less than the price quoted by underground contractors.

Drake, Bob; Constantino, Darren. *Pit Quarry* v 81 n 3 Sep 1988 p32,34-35.

## Land Reclamation

**087512 PLANNING SCHEMES FOR RECLUTIVATING THE CENTRAL ZONES OF WATER WASTES IN QUARRIES AT THE SEMILUKS REFRACORIES FACTORY.** The necessary condition for reactivating water dumps is the possibility of free movement of wheel and caterpillar transport over the surface of panned earth. Fulfilling this condition is possible for certain strength factors in weak, water-saturated clay soils of the central zones of the water dumps. Of the numerous artificial strengthening methods the simplest is the method of installing supporting sand cushions. Using an example, the authors examined the problem of determining the optimum thickness of the sand supporting cushion. 7 refs.

Chernyaev, V.F. (Voronezh State Univ, USSR); Litvinova, V.M.; Muzylev, N.A. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 34-39.

**087513 USING EXPLOSIVES IN RECLAMATION.** The cost of reclamation has become an important factor in quarry economics. As a result, operators are seeking to compare differences in reclamation costs when they have the option to choose one of the four basic methods of reclamation. This article describes the four methods which are backhaul and fill; highwall blasting; combined backfill and blasting; and simultaneous stripping, reclamation and production.

Postupack, Conny (Atlas Powder Co). *Pit Quarry* v 81 n 3 Sep 1988 p 28-30.

## Loaders

**087514 ENHANCED LOADER OFFERINGS COMPLICATE SELECTION PROCESS.** A guide to choosing the right wheel loader for pit and quarry applications is specified. When in the market for a wheel loader, the buyer should first identify specific needs by asking the following questions. What materials will be handled? What weight? What are travel distances? Will the machine be stockpiling or feeding a crusher? Will the machine have to negotiate grades or deal with soft underfoot conditions? What is desired production? Is production limited by crusher capacity or other job site factors? What is the required machine payload and cycle time? What other tasks might be required of the loader? What job site conditions might change? Increased volume? Physical expansion? Future requirements?

McBeth, D.F. (Caterpillar Inc, Peoria, IL, USA). *Pit Quarry* v 80 n 12 Jun 1988 p 26-29.

**087515 LOADERS FOR THE LONG HAUL.** Sand and gravel operations are perhaps best suited to changing to load and carry applications because material can usually be fed onto conveyors without the use of a primary crusher. Given an adequately sized conveyor and processing plant, limiting factors on production in such an operation become the distance from the hopper to the working face and loader speed. At any given distance between load and dump points, the relationship of loader (bucket) size and loader speed will determine actual production. A quicker, smaller loader may actually be more productive - not to mention less expensive to purchase and operate - than a larger machine.

Drake, Bob. *Pit Quarry* v 80 n 12 Jun 1988 p 36-38.

**087516 ARKANSAS QUARRY CUTS COSTS WITH SMALLER LOADER.** The Arkhola Sand & Gravel Co.'s Preston quarry operation has cut costs - without reducing productivity - by replacing its existing loader, which incorporated an 11-cu-yd bucket, with a smaller model. Located just outside Van Buren, Ark., the operation now utilizes a Kawasaki 110Z with a 7-cu-yd bucket as its primary loader. According to John Sulcer, Arkhola vice president, the older machine did a good job, but it was larger than needed. When time came for a replacement, a smaller loader was considered. 'By going to



the smaller, Kawasaki loader,' Sulcer says, 'we saved money on its initial cost without sacrificing productivity.' And, as a bonus, Sulcer says, 'we have a faster, more maneuverable loader.' The plant's capacity averages between 2,500 to 3,000 st/d with peak production at about 5,000 st/d. The new loader has been in operation for approximately 10 months, and Sulcer says there have been no major problems with it. He also reports significant savings in fuel costs, owing to its smaller rate per hour consumption than the 12-cylinder engine in the older machine.

McKain. *Pit Quarry* v 80 n 12 Jun 1988 p 41-42.

## Management

**087517 COMPETENCE ASSESSMENT AS AN AID TO MANAGEMENT IN QUARRYING. GRADERS, DOZERS AND TRACTOR SCRAPERS IN QUARRYING APPLICATIONS.** Members of management are required to contribute towards their achievement of company profitability by ensuring that their employees are properly qualified and organized to carry out their jobs. 'Properly qualified' implies skill, knowledge and understanding and also experience, or should the word be 'competence' to apply the skill and knowledge in a safe and efficient manner and to the standards required? There are various constraints, protective devices and protective systems which influence the requirement for safe and efficient operation. Protective systems include: Mines and Quarries Act 1956; Regulations made under this Act; Health and Safety at Work etc. Act 1974; and Codes of Practice.

Wilkinson, George (Quarry Products Training Council). *Quarry Manage* v 14 n 9 Sep 1987 p 23-26.

**Maryland** See CRUSHED STONE PLANTS—Automation.

**Mechanization** See LIMESTONE—England.

## Minnesota

**087518 HYDRAULIC EXCAVATOR MEETS GRANITE QUARRY CHALLENGE.** When operators of the St. Cloud, Minn. quarry, owned by Meridian Aggregates, increased the plant's capacity by 50 percent it became apparent that their eight-cu-yd rope shovel was not capable of maintaining the required production rate. After considering several options, management elected to buy a hydraulic excavator for face loading. Its advantages are improved mobility, lower operating cost and ability to match the increased production capacity of the processing system.

Michard, Don. *Pit Quarry* v 80 n 5 Nov 1987 p 49-50.

## New Zealand

**087519 EXTRACTION OF NARROW-SEAMED LIMESTONE DEPOSITS EXPERIENCE OF QUARRYING IN NEW ZEALAND'S POVERTY BAY AREA.** This paper considers the quarrying of road metal from highly disturbed and contorted limestone seams which exist at a limited number of sites within the Poverty Bay area of New Zealand's North Island. The material type and the geological deposits in the area differ from the massive blocks which are prevalent in the Te Kuiti area. While the basic quarrying principles are the same for both areas, the extraction techniques vary. In the Poverty Bay area a philosophy of winning every piece of stone must be adhered to in order to ensure the viability of the operation, whereas in the Te Kuiti situation the massive deposit lends itself to mass production and the by-passing of isolated or difficult outcrops.

Pulman, Stan (Cook County Council, NZ). *Quarry Manage* v 15 n 7 Jul 1988 p 19-22.

## Noise Abatement

**087520 CONSTAT, REDUCTION ET PREVISION DU BRUIT AUTOUR DES INSTALLATIONS**

**D'ELABORATION DES GRANULATS ET DES CARRIERES.** [Observation, Reduction and Prediction of Noise in the Vicinity of Aggregate Preparation Installations and Quarries]. This report deals with the study of noise in the vicinity of quarries and aggregate preparation installations. It covers an observation of noise levels produced by the equipment itself, and the results obtained in the vicinity of various sites; a description of ways and means of reducing noise, together with methods of successfully implementing a noise reduction programme; and a description of a method of predicting noise in the vicinity of installations, accompanied by examples of its application revealing the accuracy of the results obtained. In addition, acoustic elements, measurement methodology, and phenomena of propagation are described. (Edited author abstract) 146 refs.

Zouboff, V. (Lab Regional d'Angers, Fr). *Rapp Rech LPC* n 146 Jul 1987 154p.

## Open Pit

**087521 SUCCESSIVE INCREMENTS IN PIT DEPTH AS A FUNCTION OF THE DEGREE OF RATIONAL USE OF ENCLOSING ROCK.** An algorithm and programs have been developed for the estimation of the relative depth increment of open-pit working as a function of the degree of rational use of the enclosing rock in the initial quarry contours and beyond these limits. The model developed can be implemented on a computer. With a degree of rational use of the enclosing rock that is no greater than 25-30%, the exploitation of secondary minerals beyond the contours of the quarry has no significant influence on the increment in depth. The rational use of some of the enclosing rock at ore deposits permits complete working by the open-pit method, and thus yields an additional profit due to the reduction in loss of basic raw materials in the ground, the utilization of secondary production, and savings in the means for mine reconstruction. 1 ref.

Peshkova, M.Kh. *Sov Min Sci* v 23 n 3 May-Jun 1987 p 238-242.

## Philippines

**087522 MARBLECRAFT - 27 YEARS IN BUSINESS.** Marblecraft Inc. is one of the Philippines' longest established marble tile producers. The company buys in white, grey and pinkish red blocks to supplement production from its own quarry. The United States currently takes about 80% of finished tiles, whilst Australia and Japan are becoming important markets. Diamond machining methods at the processing plant are described.

Hayes, David. *Ind Diamond Rev* v 48 n 525 Feb 1988 p 51-52.

**Screening** See SCREENS AND SIEVES—Plastics Applications.

## South Carolina

**087523 MAKING THE BEST ROCK FROM AVAILABLE SOURCES.** The construction of earthfill dams for a pumped storage reservoir in Oconee County, S.C., is presenting production challenges for an on-site quarry. The reservoir - a portion of Duke Power Co.'s Bad Creek Hydroelectric Station project - will be part of a pumped storage system for generating electricity. Near the center of what will be the reservoir is the quarry. Dams are being built using the crushed stone.

Drake, Bob; Kuhar, Mark S. *Pit Quarry* v 81 n 3 Sep 1988 p 40-41.

**Texas** See CRUSHED STONE PLANTS—Automation.

## United Kingdom

**087524 AGGREGATE PROCESSING PLANT - THE WAY AHEAD: A REVIEW OF TRENDS IN CRUSHING AND ASSOCIATED EQUIPMENT.** The paper deals with the quarrying scene as it is today and as

foreseen for the years ahead. The author reviews current and future design concepts for plant and machinery under three specific headings which cover the majority of present and future plant work: mammoth quarries, conventional fixed-type plant and unitized plant. Essentially the paper relates to events in the UK market, but much of what is said has relevance to quarrying in Western Europe.

Massey, Joe (Pegson Ltd). *Quarry Manage* v 14 n 10 Oct 1987 p 27-28, 31-32, 35-36.

**087525 WHERE DO WE GO FROM HERE?** The UK South East Economic Planning Region generates approximately one-third of the demand for aggregates in England, amounting to some 55 million tons a year. Demand forecasts are that this tonnage will rise to 75 million tons by the turn of the century. The area contains virtually no rock and planning constraints on sand and gravel continue to increase in severity. This article is an analysis of future alternatives for the development of large quarry operations based on Redland Aggregates' experience at Mountsorrel.

Phillipson, George (Redland Aggregates Ltd). *Quarry Manage* v 15 n 5 May 1988 p 43-46.

## Wales

**087526 PENRHYN QUARRY.** Penrhyn slates are recognized worldwide for their high quality and durability in roofing applications. For over 200 years they have been produced at Penrhyn Quarry situated on the Cambrian slate belt of North Wales, and throughout this time the actual splitting of the quarried slate has changed little. Elsewhere in the operation, Penrhyn is keeping pace with modern quarrying methods and has had a major quarry modernization scheme with the accompanying investment in modern quarry plant.

Anon. *Mine Quarry* v 16 n 9 Sep 1987 p 9-12.

## Waste Disposal

**087527 CHINA CLAY TECHNOLOGY REDUCES WASTE.** At ECC's Moorcroft Quarry, the limestone formation contains clay within the fractured uppermost 15m of the deposit. An estimated 250,000 tonnes of heavily contaminated broken limestone was too dirty to be processed in the washing plant. An innovative system was employed to wash the contaminated limestone which used a 4in monitor and a centrifugal pump. The monitor can deliver 800-900 gal/min at 200 lb/in<sup>2</sup> into the dirtpile. Some 50-60 tonnes/h can be adequately washed.

Anon. *Quarry Manage* v 15 n 4 Apr 1988 4p between p 11 and 18.

**Waste Utilization** See SILICON CARBIDE—Recycling.

**Wastes** See MINES AND MINING—Wastes.

**QUARTZ** See Also CEMENT—Additives; CERAMIC MATERIALS—Silicon Nitride; ELECTRIC INSULATING MATERIALS—Ceramic; HYDROCARBONS—Adsorption; SALTS—Adsorption; THERMOLUMINESCENCE—Analysis; THERMOLUMINESCENCE—Measurements.

**087528 EFFECT OF ION ABSORPTION OF SOME METALS ON CYTOTOXICITY AND FIBROGENICITY OF QUARTZ DUST.** The comparative and experimental study was designed to investigate cytotoxicity and fibrogenicity of initial quartz dust and dust with absorbed cations (Ca<sup>2+</sup>, Zn<sup>2+</sup>, and Al<sup>3+</sup>). It was demonstrated that silica cytotoxicity and fibrogenicity are actively inhibited to force out mobile hydrogen. Due to the obtained results we can evaluate chemical affinity of some metal ions for silica as an antislucosis means. The presence of a significant number



of such metal ions provides the opportunity of receiving an effective antistatocilicosis means. (Author abstract) In Russian. 11 refs.

Ellansky, Yu.G.; Aronova, G.V.; Velichkovski, B.T.; Zykova, V.A.; Elinichnykh, L.N. *Gig Tr Prof Zabol* n 12 Dec 1987 p 24-27.

**087529 THERMOLUMINESCENCE (TSL) RELATED WITH THE  $[\text{SiO}_4/\text{Na}]$  CENTER IN QUARTZ.** A double excitation procedure performed on Na-swept quartz resulted in the appearance of an extremely strong TSL peak in the glow curve near 200 K. The formation and other characteristics of this sodium TSL peak were found to be fully analogous to those of the previously observed lithium associated TSL peak near 190 K. The sodium peak near 200 K should therefore be associated with the  $[\text{SiO}_4/\text{Na}]$  center. The sodium-swept samples also exhibit a very strong phosphorescence at 20 K which decays steeply on warming to 25 K. It was found to be related to the center responsible for the TSL peak near 200 K. (Author abstract) 5 refs.

Halperin, A. (Hebrew Univ, Jerusalem, Isr); Katz, S. *Solid State Commun* v 63 n 8 Aug 1987 p 697-699.

**087530 OBTAINING UNFIRED QUARTZ CERAMICS BY IMPREGNATING IN ETHYL SILICATES.** In the proposed method of obtaining unfired quartz ceramic, the contact area and the forces of interaction between the particles are increased by impregnating the unfired preforms with pure unhydrolyzed ethyl silicate or tetraethoxysilane immediately followed by their simultaneous hydrolysis and gelation within the product. In subsequent studies, treating in ammonia solution was replaced by hot water treatment. In this case, the temperature of water acts as a catalyst for hydrolysis and gelation of ethyl silicate instead of ammonia. When treating with water in the 80-100°C range, the maximum strength is obtained within 2 h. The strength remains unaltered during subsequent holding. 10 refs.

Matusevich, I.S. (State Scientific-Research Inst for Quartz Glass, USSR). *Refractories* v 28 n 7-8 Jul-Aug 1987 p 442-444.

## Acoustic Properties

**087531 SURFACE ACOUSTIC ATTENUATION IN QUARTZ.** The authors set themselves the task of measuring the phonon viscosity tensor components in samples of synthetic quartz and of constructing the attenuation surfaces in these crystals. They used samples of  $5 \times 5 \times 20$  mm for the measurements. The long side of the samples, along which the acoustic waves travelled, was oriented along the second and third order symmetry axes and also (100) plane (so-called BC and AC cuts). The attenuation was measured by an acoustooptic method at a frequency of 450 MHz. 7 refs.

Kim, V.S.; Lemanov, V.V.; Nasyrov, A.N. *Russ Ultrason* v 17 n 3 1987 p 98-102.

## Analysis

**087532 PETROGRAPHIC CORRELATIONS AND ANALYSIS OF FLUID INCLUSIONS IN HYDROTHERMAL QUARTZ CRYSTALS FROM FOUR WELLS IN THE MOMOTOMBO GEOTHERMAL FIELD, NICARAGUA.** Four wells of the geothermal field of Momotombo (Nicaragua) have been studied. Their primary and hydrothermal petrology have been described and correlations established. They are composed of andesites and tuffs. The description of the hydrothermal paragenesis allows us to conclude that the geothermal conditions are situated at the limit of the albite-zeolite and greenschist facies. In three of them, hydrothermal quartz crystals have been picked over and microthermometric measurements on their fluid inclusions gave homogenization temperatures ranging from 160 to 275°C. The fluid is assumed to be pure water of meteoric origin; boiling did not occur. But in MT 37 well there could be up to 0.83 moles % of  $\text{CO}_2$ , which would place the histograms in the vapor region of the curve. Gaseous inclusions were

analyzed, giving a mixture of  $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{N}_2$ . (Author abstract) 29 refs.

Combredet, Nicole (Societe de Prospection et d'Etudes Geothermiques, Argenteuil, Fr); Guilhaumou, Nicole; Corny, Gerard; Martinez Tiffer, Ernesto. *Geothermics* v 16 n 3 1987 p 239-254.

**Applications** See ACOUSTIC SURFACE WAVE DEVICES—Computer Aided Design; OPTICAL FIBERS; RESONATORS, CRYSTAL—Mathematical Models.

## Cleaning

**087533 QUARTZWARE CLEANING TECHNOLOGY.** Modular Quartzware Cleaners now provide complete removal of all organic and inorganic contamination without consuming clean room space or taking quartz items out of the clean room. Semiconductor quartzware must be totally cleaned of surface contaminations, both organic and elemental. Quartzware types include tubes, paddles, cantilevers, pull rods, water boats, thermocouple sheaths, bell jars, and epitaxial reactor jars. Two different types of cleaning processes are commonly done, using a variety of agents and equipment. Both processes can now be performed automatically in the Poly-Flow system.

Anon. *Solid State Technol* v 31 n 1 Jan 1988 p 79-80.

## Cooling

**087534 THEORETICAL AND EXPERIMENTAL STUDY OF RADIATIVE-CONVECTIVE HEAT TRANSFER DURING THE COOLING OF QUARTZ GLASS.** The cooling of quartz glasses in a vacuum is studied on the basis of numerical solution of a problem of radiative-conductive heat transfer which considers the temperature and spectral dependences of the optical and thermophysical parameters. An experimental study is made of the surface temperature of different quartz glasses during cooling. It is shown that the concentration of hydroxyl groups present in the glass has an effect on the temperature field. (Author abstract) 8 refs.

Galaktionov, A.V. (Acad of Sciences of the USSR, USSR); Mukhamed'yarov, K.S.; Petrov, V.A.; Stepanov, S.V. *High Temp* v 25 n 2 Mar-Apr 1987 p 250-255.

**Crushing and Grinding** See ORE TREATMENT—Crushing and Grinding.

## Crystal Lattices

**087535 LATTICE DYNAMICS OF CRISTOBALITE.** Dispersion relations are calculated in a number of symmetry directions for  $\alpha$ -cristobalite, using three force constants describing bond stretching, and bond bending at both silicon and oxygen atoms. A Keating representation is used for the first two, but for stability a Born potential was used to describe bending at the oxygen atom. The calculation shows that very-low-frequency zone-boundary transverse acoustic modes arise naturally in the perfect crystal, giving a density of states at low frequencies that explains the low-temperature heat capacity. (Author abstract) 18 refs.

Ahmad, N. (Cavendish Lab, Cambridge, Engl); Nex, C.M.M.; Phillips, W.A. *Philos Mag B* v 57 n 5 May 1988 p 677-683.

**Defects** See Also CRYSTALS—Dislocations; OPTICAL MATERIALS—Quartz Applications; OXIDES—Spectroscopic Analysis.

**087536 PERFECTION OF QUARTZ AND ITS CONNECTION TO CRYSTAL GROWTH.** The perfection of cultured quartz and its connection to growth processes is reviewed. The principal macroscopic imperfection, 'creative flawing', is shown to be the hydrothermal crystal growth analog of dendritic growth and can be eliminated by the proper choice of growth direction and manipulation of conditions to minimize the effects of diffusion. Acoustic loss (1/Q) is proportional to the infrared absorption at the OH stretch frequency and is most likely due to a small (a few hundred molecules)

number of aggregates of  $\text{H}_2\text{O}$ , although lesser quantities of OH, which charge-compensate  $\text{Al}^{3+}$  and  $\text{Fe}^{3+}$  at  $\text{Si}^{4+}$  sites, are also present. Techniques for preparing cultured quartz with Q equivalent to the best natural quartz are now routine. Radiation hardness is discussed in terms of impurity content. Impurity-decorated dislocations are shown to be the most probable cause of latent etch channels. Dislocations propagate from the seed but may be initiated by particulate inclusions and/or lattice parameter mismatch between the growth and the seed. Dislocation-free material can be grown by seed selection and procedures that eliminate inclusions. 80 refs.

Laudise, Robert A. (AT&T, Murray Hill, NJ, USA); Barnes, Robert L. *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 277-287.

## Dielectric Properties

**087537 DIELECTRIC PROPERTIES OF SYNTHETIC QUARTZ CRYSTALS.** The dielectric constant (K) and loss ( $\tan \delta$ ), hence the conductivity ( $\sigma$ ), of high-quality synthetic quartz crystals have been measured with the electric field parallel (or perpendicular) to the optical axis (c-axis). These measurements are carried out in the frequency region  $10^2$  to  $10^7$  Hz and in the temperature range 30 to 400°C. The temperature variation of K at different frequencies exhibits two regions: (i) a slow increase up to about 280°C which is frequency independent and (ii) a fast increase beyond 280°C which is frequency dependent, K having larger values at lower frequencies. Similar behaviour is exhibited by  $\tan \delta$ . Log  $\sigma$  against  $1/T$  plots show the usual extrinsic and intrinsic regions. The values for activation energy for conduction in the intrinsic region are calculated. (Edited author abstract) 16 refs.

De, Alok (Indian Inst of Technology, Kharagpur, India); Rao, K.V. *J Mater Sci* v 23 n 2 Feb 1988 p 661-664.

## Etching

**087538 VECTORIAL ANALYSIS FOR THE NUMERICAL SIMULATION OF THE SURFACE PROFILES OF ETCHED SINGLY-ROTATED QUARTZ PLATES.** The comparison of the theoretical etch profiles with the Z' etch profiles produced by repeated etchings on some singly-rotated quartz plates shows a complete agreement. A precise drawing of the etch rate-orientation relationships related to singly-rotated quartz crystals etched in a concentrated bifluoride solution is proposed, taking into account the results of the numerical simulation. The corrected etch rate vs. orientation plot is found to satisfy all the features required for the formation of etch profiles which exhibit the typical shapes observed experimentally. From the consistency between the experimental results and the theoretical results deduced from a kinematic theory of the dissolution, we can conclude that the shape of the etch profiles is essentially determined by the orientation of the quartz plate in agreement with a great number of previous experimental works. (Edited author abstract) 38 Refs.

Tellier, C.R. (Ecole Natl Supérieure de Mécanique et des Microtechniques, Besançon, Fr); Vialle, N.; Vaterkowski, J.L. *Surf Coat Technol* v 34 n 4 Jun 7 1988 p 417-439.

## Flotation

**087539 CATIONIC FLOTATION OF QUARTZ FROM AN ARTIFICIAL MIXTURE WITH HEMATITE USING HEXYLAMINE.** The cationic flotation of quartz was carried out from an artificial mixture (1:1 by weight) of fine grained ( $-10 \mu\text{m}$ ) quartz and hematite, using hexylamine acetate (HAA) and dodecylamine acetate (DAA) as collectors. Selective flotation of quartz was possible in the pH range 9-10 using HAA. The adsorption densities of DAA and HAA on quartz and hematite were measured at pH 9.8 and the relationship between the flotation behavior of both minerals and the surface coverage of collectors was established. (Edited author abstract) 29 refs.



Takeda, S. (Tohoku Univ, Sendai, Jpn); Usui, S. *Colloids Surf* v 29 n 2 Jan 29 1988 p 221-232.

**087540 FLOTATION SEPARATION OF COARSE GRAINED QUARTZ FROM A MIXTURE WITH HEMATITE FINES IN ALKALINE MEDIA IN RELATION TO THE ADSORPTION OF DODECYL AMMONIUM ACETATE.** Cationic flotation of coarse grained quartz from an artificial mixture with fine grained hematite was investigated in alkaline media (pH 9.8) using dodecyl ammonium acetate as a collector. Individual flotation of quartz and hematite was also carried out for comparison. Complete flotation of quartz is achieved at a surface coverage of DAA of about 6%, while complete flotation of hematite requires as much as 70% of surface coverage. Negative zeta potential of hematite becomes zero at an adsorption density of DAA corresponding to about 100% of surface coverage. This supports the adsorption mechanism of undissociated free amine molecules on fine grained hematite particles. Floatability of quartz decrease in the presence of hematite fines in spite of the fact that quartz acquires a sufficient amount of surface coverage of DAA, indicating that the depression of quartz flotation cannot be interpreted in terms of collector consumption by hematite fines. Depression of quartz flotation in mixed suspensions is due to the slime coating with hematite fines. (Edited author abstract) 30 refs. In Japanese.

Takeda, Susumu (Tohoku Univ, Jpn); Usui, Shinnosuke; Matsuoka, Isao. *Nippon Kogyo Kaishi* v 103 n 1198 Dec 1987 p 859-864.

## Ion Exchange

**087541 ELECTRODIFFUSION (SWEEPING) OF IONS IN QUARTZ - A REVIEW.** Sweeping, a high-temperature process that selectively exchanges monovalent ions in quartz, is reviewed. Sweeping is used commercially to replace interstitial alkalis with hydrogen. Electrodifffusion improves the radiation hardness of quartz oscillator crystals and lowers the etch channel density. Sweeping affects the substitutional aluminum with its associated alkali and the extended dislocation networks with their precipitated impurities. At high temperatures the interstitials are freed and swept down the open Z-axis channels by an applied electric field. These interstitials can then be swept out at the negative electrode, provided replacement ions, usually hydrogen, are brought in at the positive electrode. Thus, the alkali associated with the aluminum is replaced by a hydrogen, and the precipitates in the dislocation networks are modified so that they are less reactive to the etchants. With the field applied at a room temperature, a peak or plateau in the sample current is observed during warm-up near 250-300°C, followed by a decay at the 500°C sweeping temperature. When the current becomes steady, the sweeping is thought to be complete. While infrared and high-temperature resistance measurements are useful, EPR techniques seem to provide the most reliable test for complete ion exchange at the aluminum site. 61 refs.

Martin, Joel J. (Oklahoma State Univ, Stillwater, OK, USA). *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 288-296.

**Ionic Conduction** See SODIUM COMPOUNDS—Ionic Conduction.

## Measurements

**087542 IMPROVED METHOD FOR MEASURING QUARTZ CRYSTAL PARAMETERS.** A procedure is developed for measuring a crystal that involves calculating its admittance from the voltage transfer function of a suitable network incorporating the crystal. This admittance can be expressed in the form of a circle. Two initial measurements are taken from which an approximate circle is calculated. This circle is used to calculate the optimum measurement positions for the subsequent curve-fitting routines, those positions being symmetrically placed around the series resonance. Each measurement is an

average of a number of samples. The deviation from this average as well as the deviation from the circle defined by previous measurements is used to monitor the measurement. All the parameters are calculated by least-square curve fitting of the admittance circle and the variation of phase around the circle with frequency. Any measuring circuit complying with that specified by IEC standard 444 can be used, provided that it is computer controllable. The technique is flexible in that the user can choose between speed and accuracy. 5 refs.

Williamson, Roger J. (Standard Telecommunications Ltd, Harlow, Engl). *IEEE Trans Ultrason Ferroelectr Freq Control* v UFFC-34 n 6 p 681-689.

**Microstructure** See Also GEOLOGY—Switzerland.

**087543 GRAIN-BOUNDARY MIGRATION MICROSTRUCTURES IN A NATURALLY DEFORMED QUARTZITE.** In this study several grain-scale microstructures are presented that are thought to demonstrate the migration direction of once-mobile grain boundaries in a naturally deformed quartzite. An analysis is presented of the sense of migration of the boundaries, and the characteristics of the patterns of relative grain growth and shrinkage. Grain-boundary migration seems to be correlated with the relative crystallographic orientations of neighboring grains for the quartz-quartz grain boundaries, and the pattern of preferred grain growth is roughly symmetrical about the mica foliation plane. (Author abstract) 11 refs.

Jessell, M.W. (State Univ of New York at Albany, Albany, NY, USA). *J Struct Geol* v 9 n 8 1987 p 1007-1014.

**087544 PLANAR DEFECTS IN LOW TEMPERATURE QUARTZ.** {101 $\bar{1}$ } planar defects and a superstructure are described in quartz from a sedimentary chert and a deformed slicken side surface in granite. Both are interpreted as faults introduced during the cristobalite-quartz phase transformation. (Author abstract). 6 refs.

Wenk, H.R. (Univ of California, Berkeley, CA, USA); Shaffer, S.J.; van Tendeloo, G. *Phys Status Solidi A* v 107 n 2 Jun 1988 p 799-805.

**Mixing** See CEMENT—Hardening.

## Optical Properties

**087545 LOW TEMPERATURE PHOSPHORESCENCE AND THERMOLUMINESCENCE OF QUARTZ CRYSTALS.** The low temperature phosphorescence (below 50 K) and the thermally stimulated luminescence (TSL) of quartz in the range 10-360 K were investigated. Measurements were taken separately on samples from pure x- and pure z-growth sections, and remarkable differences in the TSL of the two growth section samples were found. A variety of TSL peaks were observed and thermal activation energies, emission spectra and order of kinetics were determined for most observed peaks. The low-temperature phosphorescence as well as many of the peaks in +Y and +Z samples, were found to emit at 380 nm. This emission was assigned to the release of electrons from various trapping levels and their recombination at the same luminescence center. The low temperature phosphorescence was found to be enhanced by a double irradiation procedure in a way similar to that needed for the production of the 190 K TSL peak. A tentative model for the emission of the low-temperature phosphorescence is suggested. (Edited author abstract) 20 refs.

Katz, S. (Hebrew Univ, Jerusalem, Isr); Halperin, A. *J Lumin* v 39 n 3 Jan 1988 p 137-143.

## Phase Transitions

**087546 BIREFRINGENCE AND  $\gamma$ -RAY STUDY OF THE IRREVERSIBLE BEHAVIOUR OF THE INCOMMENSURATE PHASE OF QUARTZ.** After a short history of the discovery of the incommensurate

phase of quartz, its properties are briefly presented. New results obtained mainly by birefringence measurements are presented on various irreversible phenomena (global hysteresis, time dependent pinning, and memory effect) which show the great influence of chemical impurities on the properties of the inc. phase of quartz. A simultaneous measurement by birefringence and  $\gamma$ -ray diffraction shows that these effects are produced by defect pinning of the inc. modulation. (Author abstract). 31 Refs.

Dolino, G. (CNRS, Saint-Martin-d'Heres, Fr); Mogeon, F.; Bastie, P. *Phys Status Solidi A* v 107 n 2 Jun 1988 p 559-570.

**Physical Properties** See Also CALCITE—Physical Properties.

**087547 CALCULATED CONVERSION RATE OF  $E_4'$  CENTERS INTO  $E_2'$  CENTERS IN ALPHA QUARTZ.** Recent cluster calculations by J.K. Rudra et al. are used to obtain a pseudo-Jahn-Teller adiabatic energy profile for the interconversion between  $E_4'$  centers and  $E_2'$  centers based on the structural models proposed. Reasonable values are obtained for the underlying parameters which lend some further support to the models. A reaction rate method is used to compute the temperature dependence of the conversion rate in either direction, as well as of the rate for reorientational flopping of Fowler's  $E_1'$  center. Thermally-activated tunneling is found to be the main factor controlling the conversions in most of the temperature range of any practical interest. (Edited author abstract) 9 refs.

Georgiev, M. (Bulgarian Acad of Sciences, Sofia, Bulg); Manov, A. *Solid State Commun* v 61 n 2 Jan 1987 p 141-144.

**087548 PSEUDO-JAHN-TELLER AND RELAXATION-RATE ANALYSES OF A MODEL FOR THE HYDRIDE ION AT THE  $E_4'$  CENTER IN ALPHA QUARTZ.** Calculated cluster data on the energy vs hydride-ion displacement for the  $E_4'$  center, as reported by Isoya, Weil, and Halliburton, are re-analyzed in terms of the Pseudo-Jahn-Teller effect. Values are obtained of the vibronic-mixing parameters giving credibility to our interpretation. Relaxation rates are computed of hydrogen transfer between two opposite off-center sites. (Edited author abstract) 12 refs.

Georgiev, M. (Bulgarian Acad of Sciences, Sofia, Bulg); Manov, A. *Solid State Commun* v 65 n 6 Feb 1988 p 513-517.

## Plasticity

**087549 PLASTIC STRAIN AND HYDROLYTIC SOFTENING IN  $\alpha$ -QUARTZ: THE ELECTRON MECHANISM.** Quartz is softened considerably by water in it. Two main types of explanation are usually proposed for this hydrolytic softening. (Author abstract) 12 refs.

Nylen, M.; Heggie, M.; Jones, R. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 159-162.

**Processing** See AMMONIUM COMPOUNDS—Solutions.

**Radiation Effects** See Also RESONATORS, CRYSTAL—Radiation Effects.

**087550 IRRADIATION EFFECTS ON THE LOW-TEMPERATURE THERMOLUMINESCENCE (TSL) OF QUARTZ CRYSTALS.** The TSL of synthetic quartz below room temperature (RT) was examined for x- and z-growth zone samples. Preirradiation at 320 K by  $10^4$ , 5 MeV electron pulses reduced very much the TSL peaks in the range 115-230 K and a peak at 70 K. Other TSL peaks below 110K did not change much, while peaks at 252 and 265 K were enhanced by the electron preirradiation. Room temperature X-preirradiation caused most TSL peaks first to increase, and they started to decrease only after several hours of RT irradiation. New TSL peaks at 136, 161 and 181 K appeared after



comparatively short RT irradiations. (Edited author abstract) 11 refs.

Halperin, A. (Hebrew Univ, Jerusalem, Isr); Katz, S. J. *Phys Chem Solids* v 49 n 5 1988 p 577-583.

**087551 DIELECTRIC PROPERTIES OF SYNTHETIC QUARTZ CRYSTALS IRRADIATED WITH  $\gamma$ -RAYS OR X-RAYS UNDER A HIGH ELECTRIC FIELD.** This note reports the results of measurements on dielectric constant and loss, hence conductivity, of synthetic quartz crystals irradiated with  $\gamma$ -rays or X-rays under a high electric field. The decrease in activation energy for conduction in the intrinsic region may be ascribed to the increase in charge carrier concentration. The quenched quartz crystals  $\gamma$ -ray irradiated for 90 h exhibit the lowest activation energy indicating that these samples contain the largest concentration of defects. 11 refs.

De, A. (Indian Inst of Technology, Kharagpur, India); Rao, K.V. *Phys Status Solidi A* v 106 n 1 Mar 1988 p K101-K105.

**087552 COMPARISON OF LONG-RANGE ACTIVATION TRANSFER IN GAMMA-RADIOLYSIS OF SINGLE CRYSTALLINE QUARTZ WITH AMORPHOUS SILICA.** [?]. Gamma-radiolysis of single crystalline quartz and amorphous fused silica of high purity was studied at 77 K by ESR spectroscopy. The aluminum-hole centers ( $Al_{\text{c}}^{+}$ ) in the  $\gamma$ -irradiated quartz, appear at doses as low as 250 rad. Their yields increase with increasing dose and reach plateau values at approx.  $10^4$  rad. The yields of the radiation damages, such as the oxygen-associated hole centers,  $E'$  centers and H atoms, in  $\gamma$ -irradiated silica, however, increase with increasing dose up to  $5 \times 10^6$  rad without reaching plateau values. The  $[Al_{\text{c}}^{+}]$  centers in quartz are also produced by illumination with 185 nm light. The G-values of radiation damages in quartz and silica were measured. The efficient production of the  $[Al_{\text{c}}^{+}]$  centers in the  $\gamma$ -irradiated quartz was interpreted in terms of long-range migration of mobile entities, such as a hole and an exciton. The migration range was estimated from the G-values and concentration of impurities. The mobile entities in quartz migrate through  $10^4$ - $10^5$   $SiO_2$  units, whereas those in silica migrate onl through 5-50  $SiO_2$  units. (Edited author abstract). 13 Refs.

Miyazaki, Tetsuo (Nagoya Univ, Nagoya, Jpn); Azuma, Naoto; YHoshida, Shin; Fueki, Kenji. *Radiat Phys Chem* v 32 n 5 1988 p 695-699.

**Spectroscopic Analysis** See Also GOLD DEPOSITS—Exploration.

**087553 STUDY OF THE SURFACE OF FUSED QUARTZ BY AUGER SPECTROSCOPY: INFLUENCE OF MELTS OF ALKALI-METAL BROMIDES ON THE CHEMICAL STABILITY OF SILICA GLASS.** In order to determine the influence of the cationic composition of melts on the chemical stability of gas-fused silica, we studied the interaction of silica glass with melts of alkali bromides in an inert medium (argon) under isothermal conditions at  $T = 1073$  K. Since the effects studied occur on the glass surface we used Auger electron spectroscopy (AES), as a sensitive method for analysis of surface layers, for studying these effects. It is found that the cationic composition of alkali bromide melts has a strong influence on the corrosion resistance of gas-fused quartz glass. Alkali-metal ions diffuse to a depth of 50  $\mu\text{m}$  from salt melts at  $T = 1073$  K. Bromide ions were not detected in Auger spectra of glasses treated with alkali bromide melts. 6 refs.

Ivanov, V.Sh.; Nechitailo, A.N.; Puchkov, L.V.; Savel'ev, V.N. *J Appl Chem USSR* v 60 n 1 pt 2 Jan 1987 p 164-166.

**087554 LIGHT SCATTERING FROM E-SYMMETRY AMPLITUDE IN THE INCOMMENSURATE PHASE OF QUARTZ.** Low frequency depolarized Raman spectra of quartz were investigated in the incommensurate phase near the  $\alpha$ - $\beta$  transition at  $T_c = 573^\circ\text{C}$ . A

weak mode, but underdamped in the temperature region close to the commensurate  $\alpha$  phase, was observed at about  $8\text{ cm}^{-1}$  with an intensity proportional to the square of the order parameter. The mode is assigned as the E-symmetry amplitudon which has been predicted to exist in the '3-k state' of the incommensurate phase, in addition to a totally symmetric A-amplitudon. (Author abstract) 13 refs.

Shigenari, T. (Univ of Electro-Communications Tokyo, Jpn); Abe, K.; Shionoya, T.; Haga, T.; Sugiyama, M. *Solid State Commun* v 64 n 3 Oct 1987 p 367-370.

## Spectrum Analysis

**087555 FAR INFRARED TRANSMISSION OF CRYSTAL QUARTZ AT 3 K.** We present transmission measurements of Z-cut crystal quartz at 3 K in the wavenumber range 60-180  $\text{cm}^{-1}$ . The results show that the absorption is extremely small and in fact on the average a factor of ten smaller than indicated by earlier measurements discussed in the literature. One consequence of our results is that crystal quartz is useful in the FIR as a substrate material for Fabry-Perot meshes used in cryogenic experiments. (Author abstract) 4 refs.

Nordh, Lennart (Stockholm Observatory, Saltsjobaden, Swed); Olofsson, Goran; Appleblad, Ove; Klynning, Lennart. *Infrared Phys* v 27 n 5 Sep 1987 p 305-308.

**Surface Properties** See DYES AND DYEING; SURFACE ACTIVE AGENTS—Adsorption.

## Surfaces

**087556 STABILITY OF THE HYDRATE LAYER ON THE SURFACE OF FUSED QUARTZ.** In this paper we report the results of a study of the hydrate layer on the surface of fused quartz. Certain resemblances were expected between silica samples of different structures and silicon coated with a thin film of natural oxide. The results demonstrate that the boundaries of stability of the hydroxyl layer are the same, 200°, on fused quartz as on silica gel. At higher temperatures the stability of OH groups is lower than on finely divided silicas. The rehydroxylation curve also shifts somewhat to lower temperatures. It is shown that the state of the hydrate layer on silicon is determined by the presence of an oxide layer on its surface. 12 refs.

Kol'tsov, S.I. (Leningrad Technological Inst, USSR); Kriul'kin, A.N.; Gromov, V.K. *J Appl Chem USSR* v 60 n 1 pt 2 Jan 1987 p 167-169.

**087557 THREE-PHASE CONTACT LINE MOVEMENT IN SYSTEMS WITH AND WITHOUT SURFACTANT.** The dependence of the receding contact angle on the speed of movement of the three-phase contact (tpc) after rupture of the thin liquid film during bubble/solid interaction has been investigated. The motion of the type on a quartz surface covered with an octadecylamine monolayer is described using molecular and hydrodynamic theories. For a surfactant-containing system (quartz/dodecylamine solution/air) it was found that the experimental results cannot be described completely by these theories. These discrepancies are thought to be due to surfactant transfer from the liquid/gas to the solid/gas interface during receding tpc motion, resulting in a decrease of the surfactant at the liquid/gas interface. (Author abstract). 11 Refs.

Hopf, W. (Acad of Sciences of German Democratic Republic, Freiberg, East Ger); Stechemesser, H. *Colloids Surf* v 33 n 1-2 Aug 1988 p 25-33.

**087558 FORCES BETWEEN QUARTZ SURFACES BEARING ADSORBED MACROMOLECULES IN GOOD SOLVENTS.** Direct measurements of interaction energy between two quartz glass filaments immersed in aqueous electrolyte solution have been carried out as a function of surface separation. The interaction profiles of poly(vinyl alcohol) (PVA), poly(vinyl pyrrolidone) (PVP), poly(ethylene oxide) (PEO) and methylhydroxypropylcellulose (MHPC) were estimated in aqueous electrolyte solution. The measurements were carried out with frac-

tionated and unfractionated polymers as well as with homo- and copolymers. In pure aqueous electrolyte solution the interactions were repulsive. Following 8-h adsorption of polymer the interactions were always repulsive, independent of the polymer sample. (Edited author abstract) 40 refs.

Goetze, Th. (Akad der Wissenschaften der DDR, Berlin, East Ger); Sonntag, H. *Colloids Surf* v 31 May 1988, Polym in Colloid Syst: Adsorpt, Stab and Flow, Proc of an Int Conf, Veldhoven, Neth, Sep 7-9 1987 p 181-201.

## Synthesis

**087559 SYNTHESIS, STRUCTURE AND ELECTRON SPECTRA OF FUSED QUARTZ DOPED WITH TITANIUM, CERIUM AND NEODYMIUM.** Vitreous silica doped with titanium, cerium or neodymium having specific optical properties was produced by fusing rock crystal or quartz minerals in an electrical vacuum furnace. The dissolution of titanium, cerium, and neodymium compounds in vitreous silica is facilitated by aluminum, either present in the raw material or introduced for this purpose in the form of added chemical compounds. The role of the doping ions in the structure was interpreted on the basis of their electron spectra. (Author abstract). 8 Refs.

Laczka, Maria (Mining & Metallurgical Acad, Cracow, Pol); Stoch, L. *Glastech Ber* v 61 n 8 Aug 1988 p 218-222.

**Synthetic** See CRYSTALS—Dislocations.

**Testing** See Also ASPHALT—Mechanical Properties.

**087560 FRAGMENTATION OF QUARTZ PARTICLES IN A LASER BEAM.** Experimental studies have shown that large quartz particles of radius approximately 20  $\mu\text{m}$  break up under the action of a TEA  $\text{CO}_2$  laser pulse. In calculating the distribution of the heat evolution within the quartz particles, we observe a strong dependence of the heat evolution in the particle on the particle radius. Fragmentation of the particles is a consequence of achievement of a critical temperature at the principle maximum of the heat evolution. (Author abstract) 6 refs.

Belov, N.N. (L. Ya. Karpov Scientific-Research Physicochemical Inst, Moscow, USSR). *Colloid J USSR* v 49 n 5 Sep-Oct 1987 p 864-866.

**Vibrations** See Also RESONATORS, CRYSTAL—Measurements.

**087561 ELECTRICALLY DRIVEN FLEXURAL RESONANT MODES IN SYMMETRICALLY ELECTRODED X-CUT AND Z-CUT QUARTZ DISCS.** While it is well known that flexural mechanical resonant modes can be electrically driven in specimens of quartz and other piezoelectric materials by the judicious choice of electrode patterns, specific experimental data, based on simultaneous interferometric observations of opposite surface points, are presented to show that symmetrically electroded X-cut and Z-cut quartz discs exhibit flexural resonant modes of quite large amplitudes. These resonances are not accompanied by detectable electrical disturbances in the AC-drive circuits. The existence of these modes is demonstrated for an X-cut quartz disc, and specific resonant modes of a Z-cut quartz disc are characterized in detail. 10 refs.

Chen, Peter J. (Sandia Natl Lab, Albuquerque, NM, USA). *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 1 Jan 1988 p 66-72.

**Wetting** See Also SURFACE ACTIVE AGENTS—Solutions.

**087562 STRUCTURAL COMPONENT OF DISJOINING PRESSURE IN WETTING FILMS OF NITROBENZENE FORMED ON THE LYOPHILIC SURFACE OF QUARTZ.** It has been shown that a structural component of disjoining pressure decreasing according to the exponential law as the layer thickness increases, arises in the wetting films of nitrobenzene formed on the lyophilic surface of quartz. A family of



isotherms have been obtained within a temperature range 293-333 K. The dependence of parameters on temperature has been determined, the parameters being characteristic of the transition of a wetting film into a thermodynamically nonequilibrium state. (Author abstract) 13 refs.

Derjaguin, B.V. (Acad of Sciences of the USSR, Moscow, USSR); Popovsky, Yu.M.; Goryuk, A.A. *Langmuir* v 3 n 5 Sep-Oct 1987, Pap from VIIIth Conf on Surf Forces, Moscow, USSR, Dec 3-5 1985 p 628-631.

## X-Ray Analysis

**087563 INVESTIGATION OF QUARTZ CRYSTALS WITH NON-HOMOGENEOUS DISTRIBUTIONS OF IMPURITY ATOMS BY X-RAY METHODS.** Long and section topography in transmission, plane wave topography in reflection, and precision lattice parameter determination are applied to the study of step like impurity atom distributions. The possibilities to describe the deformation fields anisotropic connected with these distributions by means of the theory of elasticity including effects are discussed. The applicability and limits of the methods for the measurement of deformation fields are investigated theoretically and experimentally. All methods yield the same values of parameters (step height and width) of the model within the ranges of experimental accuracy. Using the anisotropic theory of elasticity the results of the lattice parameter determination can yield information about the anisotropy of the quasi-plastic dilatation due to the defects. (Edited author abstract) 30 refs.

Haertwig, J. (Friedrich-Schiller-Univ, Jena, East Ger); Holy, V.; Kittner, R.; Kubena, J.; Lerche, V. *Phys Status Solidi A* v 105 n 1 Jan 1988 p 61-75.

**QUARTZ DEPOSITS** See SANDSTONE—Texas; GOLD DEPOSITS—Nigeria.

## R

**RADAR** See Also ANTENNAS—Directional Patterns; ANTENNAS—Radar; ANTENNAS, PARABOLIC—Reflectors; ELECTRIC CONNECTORS—Microwaves; ELECTRIC FILTERS, DIGITAL—Analysis; ELECTROMAGNETIC WAVES—Propagation in Ionosphere; MATHEMATICAL TECHNIQUES—Graph Theory; METEORITES—Measurements; MICROWAVE DEVICES; MICROWAVES—Applications; PETROLEUM PROSPECTING—Instruments; RADIO TRANSMISSION—Propagation Effects; RADIO TRANSMISSION—Propagation in Ionosphere; SIGNAL DETECTION—Noise, Spurious Signal; SIGNAL PROCESSING—Microwaves; VIDEO RECORDING.

**087564 ROLE OF HIGH SPEED FFT IN RADAR SIGNAL PROCESSING.** We describe the application of high speed fast fourier transform (FFT) processors in realtime radar signal processing. Three coherent radar signal processing techniques are considered: pulse Doppler radar (PDR); beamforming radar; and synthetic aperture radar. The emphasis of this paper is to apply low order (less than 64-point) FFTs to radars. As the number of FFT points increases, the computational requirements increase at a higher rate, since an N-point FFT requires  $\{N/2 \log_2 N\}$  complex multiplications and several additions. 7 refs.

Nuthalapati, C. (Honeywell Inc, Minneapolis, MN, USA). *Microwave J* v 30 n 10 Oct 1987 10p between p 163 and 180.

**087565 DETECTION PERFORMANCE OF MEM PROCESSOR IN RADAR APPLICATIONS.** Fast Fourier Transform (FFT) technique has been in use for processing the radar signals in doppler domain. The introduction of Maximum Entropy Method (MEM) by Burg has revolutionized the field of non-linear spectral estimation. Since MEM processor can yield high resolution spectral estimates even with short data lengths, it is becoming a good candidate for doppler domain processing of radar signals. In this paper, we obtain probability density functions for MEM spectra and show that they closely follow log-normal density function. The usual

detection performance criteria, i.e., probability of detection ( $P_d$ ) and probability of false alarm ( $P_{fa}$ ) are then obtained using log-normal density function. The detection performance of MEM processor is compared with that of FFT processor. It is observed that the MEM processor can yield better results compared to FFT processor when the doppler frequency of the radar return from a target does not coincide with the center frequencies of the FFT filter bank. (Author abstract) 10 refs.

Ajaya Kumari K. (Osmania Univ, Hyderabad, India); Reddy, V.U.; Yoganandam, Y. *J Inst Electron Telecom-mun Eng* v 33 n 1 Jan-Feb 1987 p 1-7.

**087566 MONOPULSE SSR SYSTEM.** Since the Secondary Surveillance Radar (SSR) has become the major radar sensor for Air Traffic Control (ATC), higher performance is being increasingly called for in automation of ATC Service (ATCS). The monopulse SSR system is able to determine the aircraft position accurately in limited replies from transponders, and to resolve various problems related to the conventional SSR system through the monopulse azimuth measurement technique. This paper reviews the features of the monopulse SSR system and then gives an outline and experimental evaluation results in a real radar environment of the monopulse SSR system developed by NEC. The experiment confirmed a remarkable improvement in azimuth accuracy and improved decoding probability for closely spaced targets. (Author abstract) 4 refs.

Takano, Hisao (NEC, Hisao, Jpn); Yamashita, Junji; Kawamura, Sho-ichiro; Yamazaki, Tsugio; Shigyo, Noriaki; Sato, Mitsuhiro. *NEC Res Dev* n 88 Jan 1988 p 57-64.

**087567 DIRECTION-FINDING WITH LINEAR PHASED ARRAYS USING EIGEN-ANALYSIS TECHNIQUES.** Radar direction-finding (DF) methods based on a model of the external environment as seen by a linear phased array can give improvements over conventional Fourier Transform based techniques. The more popular techniques, based on adaptive beam scanning and eigenanalysis of the array covariance matrix are analyzed. (Edited author abstract) 18 refs.

Starkey, P.G. *GEC J Res* v 5 n 4 1987 p 193-207.

**087568 SEPARATION DOPPLER ADAPTATIVE PAR DETECTION QUADRATIQUE DES CIBLES RADAR EN CONFUSION DE DISTANCE.** [Doppler Adaptive Separation of Distance Confused Radar Targets by Means of Quadratic Detection]. The possible improvement of the pulse Doppler radar processing to separate two targets that are confused in the distance range is studied. Particularly, real-time adaptive processing, based on the knowledge of some parameters is used. (Author abstract) 5 refs. In French.

de Reffye, Jerome (GERDSM-LE BRUSC, Six-Fours-les-Plages, Fr). *Ann Telecommun* v 43 n 1-2 Jan-Feb 1988 p 20-36.

**087569 DESIGN AND STUDY OF THE ELEVATION DIFFERENCE CHANNEL FEED OF THE SINGLE APERTURE MONOPULSE FEED SYSTEM.** The technique to generate the higher order modes  $TE_{11}$  and  $TM_{11}$  in the square waveguide, required for the E plane error single channel feed in the single aperture monopulse feed system, has been presented and the appropriate assembly for this purpose has been designed in the 8.5-9.0 GHz frequency band. The assembly can be incorporated as an E plane error signal channel feed in the design of a single aperture monopulse feed system. The features of the design are a suppressed cross-polarised component of the radiation field and a deep null in the E plane pattern at the bore sight axis of the feed. A qualitative explanation for the behaviour of the feed has been presented. (Edited author abstract) 3 refs.

Shukla, S.R. (Defence Electronics Research Lab, Hyderabad, India). *Def Sci J* v 37 n 3 Jul 1987 p 377-382.

**087570 NEUES PULSDOPPLER-RADAR.** [New Pulse Doppler-Radar]. A wave form design for a new

pulse doppler radar is discussed which shows the following characteristic features: short pulse length, very high pulse repetition frequency (VHPRF), and additionally a cyclic phase coding from pulse to pulse. This pulse doppler mode shows some advantages over MPRF and HPRF radars used in airborne applications and allows a simultaneous estimation of doppler frequency and target range in large unambiguous intervals. (Author abstract). 8 Refs. In German.

Rohling, Hermann; Borchert, Wolfgang. *NTZ Arch* v 10 n 7 Jul 1988 p 171-176.

**087571 HYBRID E-PULSE/LEAST SQUARES TECHNIQUE FOR NATURAL RESONANCE EXTRACTION.** A technique to extract the resonant frequencies of a radar target is presented. The scheme is completely automated, with only the number of natural modes expected and the beginning of late-time as inputs. Results using experimental data demonstrate the insensitivity of the method to random noise and to estimates of modal content. The technique is computationally efficient, taking only a few minutes to execute on a personal computer. 7 refs.

Rothwell, E.J. (Michigan State Univ, East Lansing, MI, USA); Chen, K.M. *Proc IEEE* v 76 n 3 Mar 1988 p 296-298.

**087572 COLLOQUIUM ON DISCRIMINATION AND IDENTIFICATION METHODS IN RADAR AND SONAR SYSTEMS.** Proceedings incorporates nine papers. Topics considered include: detection of radar targets in sea clutter, thermal noise, frequency agility, pattern recognition, radar target recognition algorithms, radar signatures, high-resolution radar, radar polarimetry, scattering matrices, target identification, close targets, antenna arrays, pulsed radar, and probability of false alarms. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 08720 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig* n 1986/69, Colloq on Discrim and Identif Methods in Radar and Sonar Syst, London, Engl, May 6 1986. Publ by IEE, London, Engl, 1986 var pagings.

## Analysis

**087573 TRIGONOMETRIC HIGH-RESOLUTION METHOD TO RESOLVE TWO CLOSE TARGETS.** Three-subaperture methods for estimating the elevation angles of two targets within the 3 db beamwidth for the main aperture of a linear array are discussed and applied to the case of a radar target in the presence of multipath over a smooth surface. Simulation results and comparison with the three-subaperture maximum-likelihood estimator by Cantrell et al. are presented. A four-subaperture technique to solve the in-phase and antiphase signal cases is suggested. (Author abstract) 7 refs.

Taha, A. (Univ of Technology, Loughborough, Engl); Hudson, J.E. *IEE Proc Part F* v 134 n 6 Oct 1987 p 597-601.

**087574 MONOGENIC FUNCTION RANGE RESOLUTION RADAR.** Sequences having peaky autocorrelation are useful in range resolution radar and in a homomorphic problem of detecting reflections in seismic exploration. The concept of correlative signal processing for system identification in these applications is extended to processing based on monogenic signatures. Some sequences having good monogenic signatures are listed. These yield sequence compression equal to the length of the sequences, and peak/sidelobe ratios or merit factors could be superior to those obtainable in correlative processing for the same length of sequences. The problems



in developing monogenic function radar are discussed and some solutions proposed. (Edited author abstract) 23 refs.

Moharir, P.S. (Univ of Roorkee, Roorkee, India); Venkata Rao, K.; Varma, S.K. *IEE Proc Part F* v 134 n 6 Oct 1987 p 620-628.

**087575 DISTORTION OF COMPLEX SIGNALS IN RADAR FREQUENCY CONVERTERS IN THE PRESENCE OF HETERODYNE-VOLTAGE INSTABILITY.** Much attention is now being paid to radio systems that employ coherent processing of complex microwave (MW) signals, which permits a substantial improvement in the energy and accuracy characteristics of the radio systems, but with a sharp increase in the amount of distortion of signals in amplifier-converter channels. Signal distortion by modulating interference is determined in such systems by the parameters of the signal interdependency function. It is important to determine the way in which the levels of the undistorted part and the interference component of this function depend on heterodyne-voltage instability in the millimeter waveband, since the avalanche-drift diodes (ADD) and Gunn diodes (GD) used as oscillators in this band have good modulation sensitivity with respect to amplitude and frequency. Formulas are derived which make it possible to evaluate the influence of the characteristics of heterodyne active elements and parameters of the heterodyne power source on signal distortion in frequency converters. 4 refs.

Gazhenko, V.V.; Drapii, V.A. *Radioelectron Commun Syst* v 30 n 9 1987 p 97-99.

**087576 SYSTEMATIC BEHAVIOR OF SIGNAL STATISTICS OF MST RADAR ECHOES FROM CLEAR AIR AND THEIR INTERPRETATION.** Signal statistics of data from the SOUSY-VHF radar were analyzed. Mean, variance, skewness and kurtosis of the distribution of the quadrature components of the signals as well as Nakagami coefficient of the amplitude distribution were calculated. We found a systematic behavior in the correlation between kurtosis and Nakagami coefficient, and we propose a stochastic model for its explanation. These stochastic effects on the signal are generated in the variable echoing process itself. Numerical simulation and analytical calculation of the model were carried out for comparison with the data. (Edited author abstract) 9 refs.

Kuo, Fu-Shong (Nat'l Central Univ, Chung-Li, Taiwan); Chen, Chih-Chen; Liu, Shu-Ing; Roettger, Jurgen; Liu, Chao-Han. *Radio Sci* v 22 n 6 Nov 1987 p 1043-1052.

**Applications** See Also AIR NAVIGATION—Air Traffic Control; BRIDGES, HIGHWAY—Stability; DIRECTION FINDING SYSTEMS—Mathematical Models; EARTH ATMOSPHERE—Remote Sensing; GEOLOGICAL SURVEYS—Electronic Equipment; GEOLOGY—Tectonics; GEOPHYSICS—Electronic Equipment; RAIN AND RAINFALL—Cloud Seeding; REMOTE SENSING; REMOTE SENSING—Australia; REMOTE SENSING—Equipment; REMOTE SENSING—Sudan.

**087577 EFFECTS OF VARIATION IN LOOK ANGLE AND WAVELENGTH IN RADAR IMAGES OF VOLCANIC AND AEOLIAN TERRAINS, OR NOW YOU SEE IT, NOW YOU DON'T.** A variety of geological targets can have similar radar backscatter and be indistinguishable when observed at particular wavelengths and/or look angles. Smaller look angles can provide images with superior surface type discrimination for areas of modest relief. In areas of low sand dunes when subsurface radar imaging can occur, it is possible to observe the surface dunes at one look angle and the subsurface at another. Multi-angle multiple wavelength images would increase the ability to interpret an observed landscape correctly. These observations have implications for the interpretation of radar images of other planets such as Venus. (Edited author abstract) 32 refs.

Blom, Ronald G. (JPL, Pasadena, CA, USA). *Int J Remote Sens* v 9 n 5 May 1988 p 945-965.

**087578 INTRODUCTION TO SUBSURFACE RADAR.** Subsurface radar techniques are increasingly being used for the detection and location of buried artifacts and structures within the upper regions of the earth's surface.

The paper reviews the work done to date in this field, laying emphasis on the range of applications and the need for system design to match the intended application. An overall design strategy is outlined, together with a more detailed treatment of a range of topics which are relevant to effective subsurface radar operation. These include the dielectric properties of earth materials, signal modulation schemes, design and construction of suitable antennas, and methods of signal processing. An assessment is made of future prospects, both technical and commercial, for this developing area of radar technology. (Edited author abstract) 224 Refs.

Daniels, D.J. (British Gas plc, Newcastle upon Tyne, Engl); Gunton, D.J.; Scott, H.F. *IEE Proc Part F* v 135-F n 4 Aug 1988 p 278-320.

**087579 EARLY DEVELOPMENTS IN GROUND-PROBING RADAR AT ERA TECHNOLOGY LTD.** A survey of the developments in ground-probing radar technology is presented, including hardware, software and field experience. Radars of advanced design with wide dynamic ranges, high resolution and capable of much higher data rates than previous systems have been built. They incorporate important developments in antennas, pulse generators and receiver design. The use of digital circuitry wherever possible has allowed great flexibility in the design, allowing signal processing to be readily included in real-time systems. A hierarchy of software has been implemented ranging from simple detection procedures to advanced target recognition algorithms. Ground-probing radars have been operated in a wide range of conditions for the detection of plastic mines, the inspection of civil engineering structures and the assessment of mineral resources. (Edited author abstract) 4 Refs.

Chignell, R.J. (ERA Technology Ltd, Leatherhead, Engl); Jackson, P.A.; Madani, K. *IEE Proc Part F* v 135-F n 4 Aug 1988 p 362-370.

**Calibration** See FORESTRY—Remote Sensing.

**Components** See PAVEMENTS—Nondestructive Examination.

**Computer Simulation** See AEROSPACE VEHICLE TRACKING—Mathematical Models.

**Countermeasures** See Also AMPLIFIERS, LOGARITHMIC—Design; RADAR EQUIPMENT—Protection.

**087580 SPECIFICATION, CALIBRATION AND TESTING OF PHASE INTERFEROMETERS.** Electronic warfare (EW) systems use radar pulse parameter measurements for threat detection, identification and location in order to apply countermeasures. Phase interferometers are of interest in EW systems because they provide a wide instantaneous field-of-view, a nearly constant system sensitivity across the field-of-view, and AOA (angle-of-arrival) measurement accuracy that is not a function of antenna gain. The inherently wide field-of-view and the greater AOA measurement accuracy make the phase interferometer an ideal candidate for AOA measurements used for pulse signal sorting applications. In this article particular emphasis is placed on the technical issues relating to system tradeoffs needed to adequately specify the performance of a phase interferometer, different methods of calibrating the phase interferometer, and how to test the performance of the phase interferometer. A short discussion of interferometer theory also is provided. 10 refs.

Horner, David W. (Litton-Amecon, College Park, MD, USA). *Microwave J* v 31 n 2 Feb 1988 11p between p 139 and 155.

**Cross Sections** See Also ELECTROMAGNETIC FIELDS—Mathematical Models; ELECTROMAGNETIC WAVES—Diffraction; FORESTRY—Remote Sensing; MILLIMETER WAVES—Scattering; OCEANOGRAPHY—Remote Sensing; RADAR SYSTEMS—Millimeter Waves; RADIO TRANSMISSION—Absorption; RADIO TRANSMISSION—Backscattering; REMOTE SENSING—Mathematical Models.

**087581 RADAR TARGET SIGNAL MODELING AND VALIDATION.** The performance of a radar system is greatly affected by the electromagnetic scattering properties of the targets to be tracked. A key target parameter is the radar cross section, defined as an effective area that scatters incident power in the direction of the radar receiver. Two target modeling approaches used at Raytheon and their validation are described. One of the methods computes a composite signal and equivalent cross section and glint from a number of discrete point scatters. The other method, a statistical model, combines filtered and scaled noise sources from a random number generator to produce the desired results. The outputs presented include plots of sample radar cross section, glint and angle tracking error histories as functions of target aspect and target aspect rate. There are also comparisons of results computed by the two methods, as well as with actual flight data. (Author abstract) 7 refs.

Bertolini, Anthony (Raytheon Co, Bedford, MA, USA); Long, J.H. *Simulation* v 50 n 4 Apr 1988 p 137-142.

**087582 DEPENDENCE OF SPECKLE STATISTICS ON BACKSCATTER CROSS-SECTION FLUCTUATIONS IN SYNTHETIC APERTURE RADAR IMAGES OF ROUGH SURFACE.** A theory is described to relate the statistical properties of the fields backscattered from rough surfaces to those of speckle in synthetic-aperture radar (SAR) images. Expressions are derived for the autocorrelation and cross-correlation functions of speckle intensity in both single-look and multilook images of stationary random rough surfaces in terms of the SAR system parameters and the autocorrelation function of the backscatter radar cross-section (RCS) fluctuations. It is shown that if the correlation scale of RCS fluctuations is comparable with or greater than SAR resolution, the correlation function of speckle intensity depend on those of the RCS fluctuations. This property, therefore, may be applied to image classification. Comparison of the theory with computer simulation shows good agreement. 13 refs.

Ouchi, Kazuo (King's Coll London, Engl); Tajbakhsh, Shahram; Burge, Ronald E. *IEEE Trans Geosci Remote Sens* v GE-25 n 5 Sep 1987 p 623-628.

**087583 CONSEQUENCES OF NONORTHOGONALITY ON THE SCATTERING PROPERTIES OF DIHEDRAL REFLECTORS.** The physical optics method was used to study the reduction of radar cross section (RCS) due to variation of the internal angle of a dihedral corner reflector. Singly, doubly, and triply reflected contributions are considered, so the results obtained are valid for all dihedral reflectors with internal angles greater than 60°. The reduction, RCS achievable for a given deviation from orthogonality, is dependent on the size of the reflector, in terms of wavelength of the incident radiation. For plate sizes in excess of a few wavelengths, very significant reductions in backscattered RCS can result from quite modest deviations from orthogonality. Nonorthogonality introduces deep interference nulls that are a function of plate size and the deviation angle into RCS patterns of these reflectors. It is shown that a small deviation angle in a reflector can meet the conditions for a interference null along the axis of symmetry. 5 refs.

Anderson, W.C. (Defence Science & Technology Organization, Adelaide, Aust). *IEEE Trans Antennas Propag* v AP-35 n 10 Oct 1987 p 1154-1159.

**087584 RADAR POLARIMETER MEASURES ORIENTATION OF CALIBRATION CORNER REFLECTORS.** The authors analyzed radar polarimeter signals from a set of trihedral corner reflectors located in the Goldstone Dry Lake in California, and observed three types of scattering behavior: i) Bragg-like slightly rough surface scattering that represents the background signal from the dry lake, ii) trihedral corner reflector scattering that returns the incident polarization, and iii) two-bounce corner reflector scattering resulting from a particular alignment of a trihedral reflector. In the latter case it is possible to measure within about 3° the orientation angle



of the apparent dihedral trough, even though the 2-m reflector is much smaller than the 10-m resolution element of the radar. Thus a radar calibration approach using trihedral corner reflectors is ensured, as three-bounce and two-bounce geometries lead to different cross sections and hence different inferred calibration factors. 8 refs.

Zebker, Howard A. (JPL, Pasadena, CA, USA); Norikane, Lynne. *Proc IEEE* v 75 n 12 Dec 1987 p 1686-1688.

**087585 HOW TO DESIGN AN 'INVISIBLE' AIRCRAFT.** Techniques for reducing radar cross sections to make aircraft harder to detect are examined. Studies to determine what elements contribute to the radar signature are discussed. The use of models and chambers that simulate the impact of radar on a distant target to test the effectiveness of proposed techniques is considered. The need for outdoor testing is discussed. 5 refs.

Adam, John A. (IEEE, New York, NY, USA). *IEEE Spectrum* v 25 n 4 Apr 1988 p 26-31.

**087586 RADAR BACKSCATTER CHARACTERISTICS OF TREES AT 215 GHz.** Millimeter-wave backscatter measurements are presented for various tree types taken during the 1987 growing season at Amherst, Massachusetts. These measurements were taken with a 215-GHz radar system that is capable of measuring backscatter for the VV (vertical transmit, vertical received), HH (horizontal transmit, horizontal received), VH, and HV polarizations. Geometrical optics modeling was used for the normalized radar cross section (RCS) of deciduous trees and the backscatter is shown to be characterized in terms of gravimetric leaf water content, the leaf area, and the foliage crown cover. Data are also provided for coniferous trees, although the geometrical optics model is not applicable in those cases. 15 refs.

Narayanan, Ram Mohan (Univ of Massachusetts, Amherst, MA, USA); Borel, Christoph C.; McIntosh, Robert E. *IEEE Trans Geosci Remote Sens* v 26 n 3 May 1988 p 217-228.

**087587 EXTINCTION CROSS SECTION OF A DIELECTRIC STRIP.** The problem of scattering of a plane electromagnetic wave by a dielectric strip is formulated in terms of an uncoupled system of three-part Wiener-Hopf equations by using a set of approximate boundary conditions derived and utilized recently. The resulting Wiener-Hopf problems are solved approximately for sufficiently large values of the width of the strip by using D. S. Jones' method (1964). An analytical formula is derived for the excitation cross section of the strip under consideration from which numerical values are obtained in specific situations and the results are presented graphically. The radar cross section of the strip is also computed for several special circumstances and these are presented separately. 10 refs.

Dowerah, Subratananda (Indian Inst of Science, Bangalore, India); Chakrabarti, Aloknath. *IEEE Trans Antennas Propag* v 36 n 5 May 1988 p 696-706.

**Design** See REMOTE SENSING—Equipment.

**Equipment** See ELECTRONICS PACKAGING.

**Imaging Techniques** See IMAGE PROCESSING.

**Laser Applications** See AIR POLLUTION—Particulate Emissions.

**Lunar Measurements**

**087588 MOON AS A CALIBRATION TARGET OF CONVENIENCE FOR VHF-UHF RADAR SYSTEMS.** Knowledge of the absolute, versus relative, performance characteristics of VHF and UHF radars used in geophysical applications is often important. We suggest that the Moon may form a convenient, easily tracked calibration target for many such radars. The lunar absolute radar scattering cross-section is large, reasonably well known (approx. 7% of the visible disk) and is essentially wavelength independent over  $6\text{ m} > \lambda > 1\text{ cm}$ .

The Arecibo 430-MHz radar system was calibrated using the Moon as the target. These measurements yielded cross sections of 4.0% and 4.6% for a special 6 w and the main 1.6-Mw transmitters, respectively. We develop and present the radar equation appropriate to all total power calibration procedures including the Arecibo 'worst case' calibration. We also discuss error levels, the necessity for averaging to obtain valid cross sections, and other practical difficulties associated with the technique. (Edited author abstract) 30 refs.

Mathews, J.D. (Pennsylvania State Univ, University Park, PA, USA); Breakall, J.K.; Sulzer, M.P. *Radio Sci* v 23 n 1 Jan-Feb 1988 p 1-12.

## Marine

**087589 X-BAND FMCW NAVIGATION RADAR.** Frequency Modulated Continuous Wave (FMCW) Radar has long been of interest. A 3 W solid state experimental X-band marine surface search and navigation radar has been built and evaluated. The construction of such a radar has been shown to be eminently practicable. The radar has a completely solid state transmitter with low weight and high reliability which has been mounted directly behind the antennas, avoiding the need for rotating r.f. feeds and long waveguide runs.

Stove, A.G.; Beasley, P.D.L. *Annu Rev Philips Res Lab* 1986 p 100-101.

## Materials

**087590 MATERIALS KEEP A LOW PROFILE.** In addition to the military's quest for bombers and fighter planes that can penetrate enemy territory unnoticed, there is also a need to hide ground-based objects from radar detection by aircraft. Covers for microwave transmitters or radar antennae, known as radomes, must protect the equipment inside while allowing signals to enter and exit without significant interference. Most nonmetallic materials are reasonably transparent to electromagnetic radiation (EMR). However, in the microwave region where most radars operate, the materials must be used carefully to prevent reflection and excessive absorption. Properties that are important for maximum transmission of EMR are a low dielectric constant and a low loss tangent.

Lewis, Clifford F. (Materials Engineering, Cleveland, OH, USA). *Mater Eng (Cleveland)* v 105 n 6 Jun 1988 p 37-41.

## Mathematical Models

**087591 MODELLING RADAR BACKSCATTER FROM VEGETATION.** Two types of model which relate radar backscatter from vegetated areas to system and target parameters have been studied. This paper contains the results of that analysis presented in a form suitable for comparison with measured backscatter and plant data. (Author abstract) 8 refs.

Deane, J.M. *GEC J Res* v 5 n 3 1987 p 182-188.

**Measurement Application** See Also OCEANOGRAPHY—Sea Ice; RAIN AND RAINFALL—Mathematical Models; REMOTE SENSING—Agricultural Applications; REMOTE SENSING—Environmental Applications.

**087592 ANALYSIS OF THE CHARACTERISTICS OF RADIO MEASUREMENT SYSTEMS USING MARKOV-CHAIN THEORETIC METHODS.** The probability characteristics of a measurement system consisting of a several discrete radio measurement devices are investigated; each measurement device contains search and detection devices and tracking systems. Expressions are obtained for the variances of the total errors of a radio system for determination of the position of an object and an integrated system utilizing data of radio electronic and independent meters. (Author abstract) 8 refs.

Ponomarenko, B.V. *Radioelectron Commun Syst* v 30 n 7 1987 p 33-37.

**087593 IMPULSE RADAR FOR IDENTIFICATION OF FEATURES IN SOILS.** In soils developed in

loess over glacial till, the presence and depth to clay layers, or fragipans, and other features are identified with radar. Radar evaluation of depths to soil features compares well with the soil pit and core descriptions by traditional methods. Regressions of radar-derived, actual depths of soil features are used to calibrate radar measurements. The calibration approach is verified by evaluation of radar depths and actual depths of soil features in five cores taken on the same transect, away from the pits. Radar measurements of depths to features in soils have several practical applications. (Author abstract) 20 refs.

Lyon, John G. (Ohio State Univ, Columbus, OH, USA); Mitchell, Charles A.; Zobeck, Ted M. *J Aerosp Eng* v 1 n 1 Jan 1988 p 18-27.

**087594 ESTIMATE OF THE ERROR, INTRODUCED BY ATMOSPHERIC TURBULENCE IN A MEASUREMENT OF THE RADIAL VELOCITY COMPONENT OF AN OBJECT BY A HETERODYNE RADAR.** When a wave of frequency  $f_0$  is reflected from an object moving with a radial velocity, a change occurs in its frequency because of the Doppler effect, as a result of which the radial component of the velocity of the object can be determined from the magnitude of the Doppler shift. Because wave propagation occurs in a turbulent atmosphere, the error in measuring the radial velocity depends on the conditions of the atmosphere. This error is evaluated. 5 refs.

Belen'kiy, M.S.; Lukin, I.P.; Mironov, V.L. *Sov J Commun Technol Electron* v 32 n 2 Feb 1987 p 178-179.

**087595 INVESTIGATION OF A RADIOMETER-SCATTEROMETER WITH A DEGENERATE PARAMETRIC AMPLIFIER.** A radiometer-scatterometer system with a degenerate parametric amplifier (DPA) at its input and operating on the homodyne reception principle is investigated theoretically and experimentally. It is shown that in such a system, the capabilities of the DPA are optimally used and all the properties of homodyne reception are preserved. (Author abstract) 5 refs.

Vorsin, N.N.; Mirovskiy, V.G.; Smirnova, L.A.; Tikhomirov, A.A.; Shamba, A.Sh.; Etkin, V.S. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 14-19.

**087596 ESTIMATING SOIL WATER EVAPORATION USING RADAR MEASUREMENTS.** Field studies were conducted to evaluate the application of radar reflectivity as compared with the shortwave reflectivity (albedo) used in the Idso-Jackson equation for the estimation of daily evaporation under overcast sky and subhumid climatic conditions. Soil water content, water potential, shortwave and radar reflectivity, and soil and air temperatures were monitored during three soil drying cycles. The data from each cycle were used to calculate daily evaporation from the Idso-Jackson equation and from two other standard methods, the modified Penman and plane of zero-flux. All three methods resulted in similar estimates of evaporation under clear sky conditions; however, under overcast sky conditions, evaporation fluxes computed from the Idso-Jackson equation were consistently lower than the other two methods. The shortwave albedo values in the Idso-Jackson equation were then replaced with radar reflectivities and a new set of total daily evaporation fluxes were calculated. This resulted in a significant improvement in computed soil evaporation fluxes from the Idso-Jackson equation, and a better agreement between the three methods under overcast sky conditions. 16 refs.

Sadeghi, Ali M. (Kansas State Univ, Manhattan, KS, USA); Scott, H.D.; Waite, W.P.; Asrar, G. *IEEE Trans Geosci Remote Sens* v 26 n 4 Jul 1988 p 490-493.

**Measurements** See ELECTROMAGNETIC WAVES—Propagation in Ionosphere; RADIO TRANSMISSION—Propagation Effects; WATER WAVES—Measurements.



**Meteorological** See Also ANTENNAS—Radiation; COMPUTER GRAPHICS—FLOODS—Prediction; METEOROLOGY—Clouds; RADAR INTERFERENCE—Finland; RAIN AND RAINFALL; RAIN AND RAINFALL—Estimation; RAIN AND RAINFALL—Measurements; RAIN AND RAINFALL—Remote Sensing; WATER WAVES—Remote Sensing; WIND EFFECTS—Measurements.

**087597 LE RADAR METEOROLOGIQUE DE TRAPPES ET L'ESTIMATION DES INTENSITES PLUVIEUSES EN SEINE-SAINT-DENIS. INTERET POUR LA GESTION DES RESEAUX D'ASSAINISSEMENT.** [Trappes' Meteorological Radar and Estimation of Rainfall Intensities in Seine-Saint-Denis]. The computer-assisted management scheme concerning the storm sewer system requires that the measurement and rainfall intensity forecast techniques be improved. The recording rain gauge networks have insufficiencies which should be made up for by weather radar. The study relating to this article seeks to assess the radar capacity for determining precipitations for the requirements of urban hydrology and this is based on a two months' campaign conducted during the Summer of 1982. Following a qualitative analysis of the data collected, various adjustment techniques relating to radar images were tested. The results obtained were compared with those deduced from an interpolation of rain gauge measurements alone. The role of the radar as part of the computer-assisted management scheme is being delineated. Simulation tests concerning the flow rates in urban catchment basins were carried out after an approximation of the effect of the surface water model in relation to precipitation measurement uncertainties was made. (Author abstract) In French. 22 refs.

Andrieu, H. (Lab Central des Ponts et Chaussees, Fr); Jacquet, G. *Houille Blanche* v 42 n 6 1987 p 447-457.

**087598 DEVELOPMENT OF KU-BAND FM-CW/PULSE-COMPRESSION RADAR FOR RAIN OBSERVATION ON A SLANT-PATH.** A Ku-band FM-CW/Pulse-Compression radar was developed in order to evaluate the performance of FM-CW and Pulse-Compression radars for rain observation and further to utilize this system to the study of microwave remote sensing of rain on a slant-path. With this radar the radar signal can be transmitted from the same antenna installed for propagation data acquisition such as 11.7-GHz BSE beacon signal and 12.0-GHz sky noise temperature. This configuration allows the close comparison of radar with the propagation data without errors due to spatial discrepancy between observing volumes. This paper describes the design and characteristics of the radar and method and result of radar calibration. Through the calibration, radar sensitivity was verified to be almost equal to that anticipated from the design. (Edited author abstract) 17 refs.

Kozu, Toshiaki; Nakamura, Kenji; Awaka, Jun; Takenchi, Makoto. *J Radio Res Lab (Jpn)* v 34 n 143 Nov 1987 p 95-113.

**087599 VISUALIZATION OF THE INFORMATION FROM A THREE-Dimensionally SCANNING RADAR RAINGAUGE.** We developed several color graphic screens which can visually represent both the distribution of echo intensity and the shape of the three dimensionally spread precipitation field, in order to investigate how fine resolution the radar information has. By the use of VCAPPI (Various Constant Altitude Plan Position Indicator), we can visually investigate three dimensional characteristics of the precipitation phenomena in meso- $\beta$  scale. Furthermore, by the use of FVCAPPI (VCAPPI for an arbitrary specified domain) and RRHI (in the form of the arrangement of fifteen RHIs), we can visually investigate characteristics in meso- $\gamma$  scale. In the case of very heavy rainfall which arose along Baiu front on the 21 July in 1986, from FVCAPPI and RRHI we can find a convective echo consists of several echo cells in various life stages. This means the convective echo is from a multi-cell storm. This fact can also be verified from RHTI (Range Height Time Indicator), which can visually represent the time series of an echo pattern in an arbitrary vertical section, by setting the vertical section along the storm moving direction. (Edited author abstract) In

Japanese. 9 refs.

Nakakita, Eiichi; Shiiba, Michiharu; Ikebuchi, Shuichi; Takasao, Takuma. *Doboku Gakkai Rombun-Hokokushu* v 9 n 5 May 1988 p 161-170.

**087600 LENS-EFFECT LOSS FOR DISTRIBUTED TARGETS.** The atmosphere, acting like a lens, causes a small loss in radar signal strength. Unlike atmospheric absorption, the lens-effect loss is different for distributed targets versus point targets. It is shown that for a distributed target uniformly filling the radar beam, the lens-effect loss (in decibels) is one-half the lens-effect loss for point targets. 4 refs.

Shrader, William W. (Raytheon, Wayland, MA, USA); Weil, Thomas A. *IEEE Trans Aerosp Electron Syst* v AES-23 n 4 Jul 1987 p 594-595.

**087601 CLOUD AND PRECIPITATION REMOTE SENSING AT 94 GHz.** The use of short millimeter-wave Doppler radars for the observation of clouds and precipitation is discussed. Attenuation and scattering (including Mie backscattering by raindrops) of this short-wavelength radiation by hydrometers is discussed as well as the sensitivity of such radars for the observation of clouds. 13 refs.

Lhermitte, Roger M. (Univ of Miami, FL, USA). *IEEE Trans Geosci Remote Sens* v 26 n 3 May 1988 p 207-216.

## Microwaves

**087602 MODELLING PROPAGATION EFFECTS IN THE USE OF S-BAND POLARISATION-DIVERSITY RADARS.** The effects of propagation through precipitation on polarization diversity radars at S-band are modelled. It is shown that in propagation through rain, although linearly polarized waves need not be significantly affected, the effect on circularly polarized returns is important. It is shown that a gate-by-gate correction process is not a satisfactory method of removing the propagation effects. However, it is shown that a derived linear parameter ZDR can be obtained from the circular parameters which is less affected by propagation. The modelling is extended to targets which comprise rain and hail. (Author abstract) 27 refs.

McGuinness, R. (Univ of Essex, Colchester, Engl); Holt, A.R.; Bebbington, D.H.O. *IEE Proc Part H* v 134 n 5 Oct 1987 p 423-430.

**087603 CORRECTION OF PROPAGATION EFFECTS IN S-BAND CIRCULAR POLARISATION-DIVERSITY RADARS.** A new method for correcting propagation effects in circular polarization diversity radars at S-band is described. By considering the transformation of the coherency matrix under the influence of propagation, it is shown that corrections can be derived from the correlation data of individual range gates. This avoids the use of any iterative gate-by-gate procedure previously shown to be unstable. Assuming the mean orientation of the precipitation particles is known to within  $1.2^\circ$ , it is found that essentially all the polarization information can be recovered with an acceptably small error. Application of the correction procedure to storm data verifies that use of the circular polarization technique at S-band can now be extended to heavy precipitation regions. (Author abstract) 10 refs.

Bebbington, D.H.O. (Univ of Essex, Colchester, Engl); McGuinness, R.; Holt, A.R. *IEE Proc Part H* v 134 n 5 Oct 1987 p 431-437.

**087604 FREQUENCY AND ANGLE-OF-INCIDENCE DEPENDENCE OF THE AVERAGE SCATTERING COEFFICIENT OF SOME SURFACES.** Radar signal scattering by different surfaces is considered. A semiempirical expression, derived using theoretical relations and the results of experiments performed under natural conditions, and describing the dependence of the average scattering coefficient (ASC) of some surfaces on the frequency and angle of incidence, is proposed in this paper. 3 refs.

Zamarayev, B.D.; Fuks, I.M. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 160-162.

**087605 SYSTEM APPLICATIONS OF MICROWAVE WAVES TO RADARS: MODERN TRENDS.** The impact of microwave technology on the performance of modern radar systems is outlined, together with the resulting design implications. The most advanced characteristics of the main microwave components are pointed out and proper use of combined technologies in such complex subsystems as electronically scanned antennas is shown to be essential in order to reach advanced performance and capabilities for new radars. Different types of antenna configurations are examined from the viewpoint of improvements required by the enhancement of radar characteristics. Similar considerations apply to other microwave radar subsystems. High degree of integration, use of advanced computer resource and techniques are shown to be fundamental in the design and development of advanced microwave components. Outstanding features of advanced radars, as 3D and multifunctional systems, are pointed out. The introduction of new capabilities envisaged or being introduced in radar systems has a deep impact on the requirements for microwave components. (Edited author abstract)

Esposito, Raffaele (Selenia SpA, Rome, Italy). *Alta Freq* v 56 n 10 Dec 1987, 17th Eur Microwave Conf and Workshop, Sep 7-11 1987 p 373-376.

**Military** See Also ANTENNAS—Radar; MILITARY ENGINEERING—Electronic Warfare.

**087606 PATRIOT RADAR IN TACTICAL AIR DEFENSE.** The Patriot radar is a C-band phased-array, multifunction radar that under the control of the weapon control computer in the engagement control station performs target search and track; missile search, track, and communications during midcourse guidance; and target-via-missile (TVM) terminal guidance. We describe the functions the radar performs and provide descriptions of the subsystems. The use of a multichannel, multifunction receiver and digital signal processor is emphasized to demonstrate the control and processing for multiple radar actions required to support the tactical air defense mission. Results of test program at the White Sands Missile Range is presented. (Edited author abstract)

Carey, David R. (Raytheon Co, Bedford, MA, USA); Evans, William. *Microwave J* v 31 n 5 May 1988 Sp.

**087607 RADAR 1935-45: TEN YEARS THAT CHANGED THE FACE OF WAR.** The paper presents a technical view of the historic ten years from 1935 to 1945 during which operational military radar was developed from the first operational CH (Chain Home) stations to the miniature APS-4 airborne 'poddie' radars which saw operational service at the end of the war. The events leading to the British and German military work are set down, and the principal contributions to wartime radar made from industry and the universities described. The paper ends with a review of the major evolutionary factors which made military radar so important to the Allied war effort during the course of the war. (Edited author abstract) 3 refs.

Martin, D.J. (Thorn EMI Electronics Ltd, Hayes, Engl). *J Inst Electron Radio Eng* v 58 n 2 Mar-Apr 1988 p 67-73.

**Millimeter Waves** See Also MILLIMETER WAVES—Propagation; SNOW AND SNOWFALL—Remote Sensing.

**087608 MILLIMETER-WAVE BISTATIC SCATTERING FROM GROUND AND VEGETATION TARGETS.** A 35-GHz bistatic radar system was used to measure the attenuation through trees and the bistatic scattering pattern of tree foliage. The data were found to be in good agreement with a first-order multiple scattering model. Measurements were also made to study the angular vibration of the bistatic scattering coefficient of a smooth



sand surface, a rough sand surface, and a gravel surface. The measurements, which were made for HH, HV (horizontal transmit, vertical receive), and VV polarization configurations over a wide range of the azimuth angle and the scattering angle, provide a quantitative reference for the design and use of millimeter-wave bistatic radar systems. 9 refs.

Ulaby, Fawwaz T. (Univ of Michigan, Ann Arbor, MI, USA); Van Deventer, Tahera E.; East, Jack R.; Haddock, Thomas F.; Colluzi, Michael Eugene. *IEEE Trans Geosci Remote Sens* v 26 n 3 May 1988 p 229-243.

**087609 MMWR/FLIR/ATR SENSOR FUSION: PROOF OF CONCEPT.** To improve the relocatable target capabilities of strategic aircraft a sensor fusion concept using a millimeter-wave radar (MMWR) and a forward-looking infrared (FLIR) system providing inputs to an auto target recognizer (ATR) has been developed. To prove this concept, a cooperative research effort is being conducted by a group of industry leaders in bomber avionics, MMWR, and ATR technologies. The author discusses the concept and the plan developed to test, evaluate, and demonstrate the expected performance. 1 ref.

Wolett, Jerry F. (Boeing Co, Seattle, WA, USA). *IEEE Aerosp Electron Syst Mag* v 3 n 6 Jun 1988 p 22-25.

**Noise** See SIGNAL FILTERING AND PREDICTION—Kalman Filtering.

**Noise, Spurious Signal** See SIGNAL DETECTION.

## Optimization

**087610 ON OPTIMIZING IMPORTANCE SAMPLING SIMULATIONS.** The importance sampling technique can result in large savings in simulation time for simulation of tail probabilities, but only when performed optimally. The authors derive criteria for optimal importance sampling simulation of an arbitrarily weighted sum of independent exponential variates. They illustrate the use of importance sampling for false-alarm threshold settings in square-law integrators and moving target indicator (MTI) delay line cancellers in the presence of Gaussian spectrum correlated clutter. For these systems, importance-sampling simulation can not be optimally performed. Hence, the authors apply a linear transformation to decorrelate the clutter and perform importance-sampling simulation optimally on the transformed system. 17 refs.

Parhi, Keshab K. (Univ of California, Berkeley, CA, USA); Berkowitz, Raymond S. *IEEE Trans Circuits Syst v CAS-34* n 12 Dec 1987 p 1558-1563.

**Performance** See ALSO ELECTROMAGNETIC WAVES—Propagation; ELECTROMAGNETIC WAVES—Propagation in Troposphere; MICROWAVES—Propagation in Troposphere; SIGNAL DETECTION—Mathematical Models; SIGNAL PROCESSING—Spectrum Analysis.

**087611 PERFORMANCE OF THE GREATER-OF AND CENSORED GREATER-OF DETECTORS IN MULTIPLE TARGET ENVIRONMENTS.** The greater-of (GO) constant false alarm rate (CFAR) detector selects the greater of the leading and lagging sets of the reference noise cells to minimize the effect of clutter and jamming. The performance of the GO detector is derived for the case where an arbitrary number of interfering targets are present in the leading and lagging reference noise cells. To improve its performance in this situation, the censored greater of (CGO) detector, which discards several of the largest samples on each side is analysed. Results presented show improvements for the CGO over the GO detector, especially when the number of interfering targets is less than the number of censored cells. (Author abstract) 8 refs.

Al-Hussaini, Emad K. (UAE Univ, Al Ain, United Arab Emirates). *IEE Proc Part F* v 135 n 3 Jun 1988 p 193-198.

## Radomes

**087612 ASYMPTOTIC APPROXIMATIONS IN RADOME ANALYSIS.** A detailed analysis is presented of assumptions and limitations of physical optics and stationary phase techniques for radome analysis. A two-dimensional ogival structure with an electric or magnetic line source inside is investigated. A method-of-moments analysis using J. H. Richmond's (1965) polarization current technique is performed to obtain reference results. Physical optics, uniform geometrical theory of diffraction, and stationary phase techniques of order 1 and 2 are analyzed. 15 refs.

Rengarajan, Sembiam R. (California State Univ, Northridge, CA, USA); Gillespie, Edmond S. Jr. *IEEE Trans Antennas Propag* v 36 n 3 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 405-414.

## Reflection

**087613 SECOND-ORDER SPECTRUM OF RADAR REFLECTION FROM THE SEA SURFACE.** For radar, backscattered radiation from the sea surface is calculated up to third-order terms, inclusively, in perturbation theory. An account is made of the directional pattern and the pulse characteristics of the radar radiation. The first- and second-order spectral intensities are determined, and they are compared with values in the literature. (Author abstract) 14 refs.

Bryukhovetskii, A.S. (Acad of Sciences of the Ukrainian SSR, USSR). *Radiophys Quantum Electron* v 30 n 6 Jun 1987 p 511-518.

**087614 MULTIPATH FADINGS OVER SEA AT 94 GHz.** Radar returns from sea targets sometimes are subject to deep amplitude fadings. These are caused by cancellation of the direct path wave with the wave specularly reflected by the sea surface. This is particularly true at small grazing angles. It appears that when mm-wave radars are used, one is not likely to observe such deep fadings, even at very small grazing angles. 1 ref.

Lohrmann, Dieter R. (US Naval Research Lab, Washington, DC, USA). *Microwave J* v 30 n 5 May 1987 p 381.

**Reliability** See RADAR INTERFERENCE—Clutter.

**Remote Sensing** See Also GEOLOGY—Remote Sensing.

**087615 ON THE CONTRIBUTION OF VOLUME SCATTERING TO THE MICROWAVE BACKSCATTERED SIGNAL FROM WET SNOW AND WET SOIL.** The contribution of volume scattering from the subsurface stratum of soil or snow to the backscattered radar signal decreases rapidly with increasing moisture content as compared to the contribution by rough-surface scattering. In order to obtain an evaluation of the relative importance of volume scattering of moist strata, a heterogeneous two-component mixture of water inclusions in a dry background medium is assumed and the formulation of the distorted Born approximation according to L. Tsang et al. is applied. Computed permittivities and backscatter cross-sections are compared with experimental data of situations with modest moisture content. From there, conclusions on the relative portion of volume scattering and on shape and size of the effectively-scattering water inclusions can be drawn. (Author abstract) 20 refs.

Schanda, Erwin (Univ of Bern, Bern, Switz). *Int J Remote Sens* v 8 n 10 Oct 1987 p 1489-1500.

## Reviews

**087616 PERSPECTIVE ON COMPLEX RADAR WAVEFORMS, ARRAYS AND PROCESSING.** The authors describe some of the more interesting and less known radar concepts. They attempt to identify potential payoffs and critical concerns. The methods discussed here were chosen so as to be generic and cover spatial, spectral

and temporal aspects of microwave signals. The topics covered are large time-bandwidth signals, distributed array radar, delta-k radar and multispectral sensor fusion. 11 refs.

Bruckheim, Arthur J. (Decision-Science Applications Inc, Arlington, VA, USA); Tomlinson, Philip G. *Microwave J* v 30 n 9 Sep 1987 8p between p 151 and 164.

## Simulation

**087617 PROCESSING OF RADAR OBSERVATION DATA BY ADAPTIVE KALMAN FILTERING.** In this paper, the processing of radar observation data is considered by an adaptive Kalman filtering algorithm. The noise statistics of the system are assumed to be unknown and time varying. Modification of the approximate model is considered by introducing the modification coefficients and fictitious noises. Simulation example shows the effectiveness of the proposed approach. (Author abstract) 5 refs.

Guangren, Duan (Heilongjiang Inst of Applied Mathematics, Harbin, China). *AMSE Rev* v 5 n 4 1987 p 1-7.

**087618 DUAL CHAMBER DESIGN REDUCES QUIET ZONE RIPLE/TAPER ERRORS.** As experience with compact ranges increases, new problems need solving, design changes are required, and improved systems result. This is the case of a dual-chamber design; it builds on the strengths of previous concepts. The strengths of this dual-chamber design are best understood by reviewing the design process that has transpired to this point. Putting the subreflector under the chamber floor minimizes aperture blockage and feed spillover. 11 refs.

Burnside, Walter (Ohio State Univ, Columbus, OH, USA). *Microwaves RF* v 26 n 5 May 1987 5p.

## Simulators

**087619 COMPACT RANGE TECHNOLOGY AND THE MARKETPLACE.** Compact ranges (room-sized radar range simulators) have recently attracted great interest and development efforts. This article focuses on technical issues such as the different configurations of the compact ranges, and techniques for reducing the detrimental effects of diffraction from the edges of a compact range reflector.

Johnson, R.C. (Georgia Tech Research Inst, Atlanta, GA, USA); Ryan, C.E. *Microwaves RF* v 26 n 5 May 1987 p 135-138.

**087620 TROUBLESHOOTING LIMITATIONS IN INDOOR RCS MEASUREMENTS.** Techniques for measuring radar cross-section (RCS) indoors have stirred much excitement in the last ten years. The controlled and protected indoor environment is more conducive to high-performance RCS measurements than outdoor ranges. Compact Antenna Test Ranges (CATRs), furthermore, have made it possible to make indoor, direct measurements that simulate outdoor farfield conditions. These CATRs exist in a variety of configurations, each of which has its own peculiar limitations. This article examines in detail some fundamental limitations inherent in all types of collimating devices.

Schluper, Bert (March Microwave Systems BV, Nuenen, Neth); Vokurka, Joseph. *Microwaves RF* v 26 n 5 May 1987 7p.

**Space Applications** See RADIO TRANSMISSION—Refraction.

**Surveillance Application** See Also ANTENNAS—Radar; NAVAL WARFARE—Electronic Equipment.

**087621 MESSENGER - A HIGH PERFORMANCE MONOPULSE SECONDARY RADAR SYSTEM.** After a description of secondary surveillance radar principles, this paper describes shortcomings of previous systems which have been eliminated by significant improvements to the antenna, to the direction finding technique used and to the processing of the large volume of data



received. These improvements have been embodied in Messenger, Marconi Radar's latest monopulse SSR system. The paper gives examples of the improved results measured during the Messenger system evaluation program. (Edited author abstract) 4 refs.

Cole, H.W. (Marconi Radar Systems Ltd). *GEC Rev* v 3 n 2 1987 p 86-97.

**087622 SPACE-BASED RADAR: NARROWING THE MAIN-BEAM CLUTTER SPECTRUM THROUGH THE USE OF A HIGH-ASPECT-RATIO ANTENNA.** With a space-based surveillance radar, the ability to detect slow-moving targets is compromised by returns from the earth's surface illuminated by the main beam of the antenna. An antenna design is presented that minimises the spectral width of main-beam earth clutter returned to space-based radars. The design maximises the aspect ratio of the antenna and aligns its long dimension with the satellite velocity vector. This ensures that the main-beam return is concentrated between two cones of constant velocity (isodops) whose separation is inversely proportional to the length of the antenna. (Author abstract) 2 refs.

Weber, Peter (McMaster Univ, Hamilton, Ont, Can); Haykin, Simon. *IEE Proc Part F* v 135 n 1 Feb 1988 p 73-81.

**087623 RADAR SURVEILLANCE OVER THE HORIZON.** An over-the-horizon (OTH) radar at decimetric wavelengths, corresponding to an extended high frequency (HF) band from 1 to 40 MHz, has become a practical proposition. In Britain, Marconi Radar Systems Ltd. has been active in OTH radar development and has made a major breakthrough in the development of medium range HF early warning systems. The prototype equipment gives complete air cover up to 300 km. A fully operational system could become available within two years. The phenomenon that Marconi Radar Systems has exploited in its system is that of vertically polarized surface wave propagation. The HF transmissions induce currents in the saline sea water that are coupled to electromagnetic wave travelling in the air over the sea surface. The transmitted signals are frequency modulated carrier waves (FMCW) and target range is measured by the frequency shift of the received signal. The separation of the Doppler-shifted frequencies is achieved by digital filtering using Fourier transform calculations.

Presdee, A.W. *Eng Dig (Toronto)* v 33 n 2 Feb 1987 p 28, 35.

**087624 OPTIMIZATION OF SURVEILLANCE RADAR WITH INSTRUMENTED RANGE.** The influence of the instrumented range on the selection of radar parameters for maximal detection range is described. Procedures for optimization of the performance of the radar by an appropriate setting of its parameters, for the specified instrumented range, are presented. 5 refs.

Rusnak, Ilan (RAFAEL, Haifa, Isr); Gertner, Izidor. *IEEE Trans Aerosp Electron Syst* v AES-23 n 5 Sep 1987 p 712-715.

**Synthetic Aperture** See Also FORESTRY—Remote Sensing; GEOPHYSICS—Remote Sensing; ICE—Remote Sensing; IMAGE PROCESSING; IMAGE PROCESSING—Theory; OCEANOGRAPHY—Sea Ice; RADAR IMAGING; RADAR IMAGING—Computer Aided Analysis; RADAR IMAGING—Mathematical Models; RADAR IMAGING—Spectrum Analysis; RADAR IMAGING—Theory; RADAR SYSTEMS; REMOTE SENSING; REMOTE SENSING—Agricultural Applications; REMOTE SENSING—Equipment; REMOTE SENSING—Sensors; SATELLITES—Electronic Equipment; SATELLITES—Observatories; VOLCANOES—Remote Sensing; WATER POLLUTION—Oil Spills; WATER WAVES—Imaging Techniques; WATER WAVES—Remote Sensing; WATER WAVES—Spectrum Analysis.

**087625 SYNTHETIC APERTURE RADAR (SAR) IMAGES OF MOVING TARGETS.** A method of isolating moving targets in airborne SAR data, by filtering to image only those targets within a certain radial velocity band, is presented. Corresponding SAR ground map and moving target indication (MTI) examples are given, showing good clutter cancellation and negligible overlap

between MTI bands. The examples are also used to illustrate the types of image defects which occur in SAR images of moving targets. (Edited author abstract) 14 refs.

Freeman, A.; Currie, A. *GEC J Res* v 5 n 2 1987 p 106-115.

**087626 RESULTS OF RESEARCH AND DEVELOPMENT ON SYNTHETIC APERTURE RADAR.** A synthetic aperture radar (SAR) is one of the promising microwave sensors for Earth observation. National Space Development Agency of Japan (NASDA) started preliminary study in FY 1978, recognizing the importance of active microwave remote-sensing. The research and development proceeded to definition/design phase in 1980, after the Earth Resources Satellite-1 (ERS-1) program was proposed. After the technology development on some technically critical components, the final SAR system test was completed in September 1985. Step by step, we could confirm that the design goal we had set up could be achieved. (Author abstract) 8 refs.

Itoh, Yasuyuki (National Space Development Agency of Japan, Sakuramura, Jpn); Hisada, Yasumasa. *Space Technol (Oxford)* v 7 n 4 1987 p 309-315.

**087627 APPLICATION OF PREDICTIVE COMPRESSION METHODS TO SYNTHETIC APERTURE RADAR IMAGERY - I.** Owing to the rapidly decaying autocorrelation function of synthetic aperture radar (SAR) imagery, predictive compression methods have not been widely used in image coding systems designed for SAR data. Because of the uncorrelated nature of SAR data, the prediction system design problem is approached from the point of view of statistics matching and decorrelation of reconstruction errors rather than minimization of the mean square error. It is demonstrated on 6 m resolution SAR magnitude data that a simple predictive coding system utilizing an unadaptive moving-average (MA) predictor and a Gaussian optimal quantizer can result in satisfactory reconstructed imagery at compression ratios of 2:1 to 4:1. Advantages of MA predictors are their lack of stability problems and their limited memory in the presence of channel errors. (Author abstract) 28 refs.

Werness, Susan A.S. (Environmental Research Inst of Michigan, Ann Arbor, MI, USA). *Opt Eng* v 26 n 12 Dec 1987 p 1200-1209.

**087628 APPLICATION OF PREDICTIVE COMPRESSION METHODS TO SYNTHETIC APERTURE RADAR IMAGERY - II.** Synthetic aperture radar (SAR) imagery can be described as consisting of bright point objects embedded in homogeneous or textured low intensity backgrounds. When predictive coding is used to compress such data, high quality reconstructions and larger compression ratios are obtained if large predictive errors are emphasized to a greater degree than in a minimum mean square error quantizer design. A large prediction error threshold quantizer is used alone and in conjunction with a small prediction error delta modulator to yield high quality reconstructions at compression ratios of 4:1 to 5:1. Smoothing of SAR data, while increasing redundancy, does not lead to better compression ratios when the predictive coding methods described are applied. (Edited author abstract) 9 refs.

Werness, Susan A.S. (Environmental Research Inst of Michigan, Ann Arbor, MI, USA). *Opt Eng* v 26 n 12 Dec 1987 p 1210-1218.

**087629 IMPROVING THE RESOLUTION OF SYNTHESIZED-APERTURE RADAR.** Synthesized-aperture radar (SAR) systems are widely used in investigating natural resources, in terrestrial and planetary cartography, in observation of ocean surfaces, etc. We consider two problems: (1) synthesis and investigation of an optimal algorithm for processing of the signal from a distributed target in an SAR system; (2) comparison of such an algorithm with known algorithms on the basis of resolution. We shall assume that the observed data take the form of a set of statistically independent vectors  $Y_i$  ( $i=1, L$ ), each made up of  $M$  samples of the observed data

at individual points of the SAR trajectory segment with length  $L_{EF}$ . 5 refs.

Doronskii, L.G. *Radioelectron Commun Syst* v 30 n 9 1987 p 94-96.

**087630 FILTER FOR REDUCING SPECKLE OF SYNTHETIC-APERTURE RADAR IMAGERY.** A nonlinear filter is proposed for reducing speckles in synthetic-aperture radar imagery. Basically, the filtering is performed by averaging; when a window includes an edge, pixels in the window are grouped into two according to their power level, and the mean power of the majority group is regarded as the power of the central pixel. This filtering is operated effectively when it is repeated two or more times with a small window, and gives a better result for preserving edges and smoothing in uniform region than the spatial average filter, the median filter, the adaptive filter, and the SSIR. (Author abstract) 10 refs.

Ueno, Hideyuki (Univ of Tokyo, Tokyo, Jpn); Hirose, Haruto. *Electron Commun Jpn Part 1* v 71 n 3 Mar 1988 p 92-100.

**087631 AZIMUTH DEPOLARIZATION AMBIGUITIES IN SYNTHETIC APERTURE RADAR.** The effects of target depolarization in measurements made by stationary microwave systems have been extensively investigated. The use of depolarized measurements can provide information not available in the like-polarized measurement alone. Depolarized measurements acquired by non-Doppler systems were susceptible to errors induced by the measurement antenna. We extend this previous research to non-stationary (Doppler) systems. (Author abstract) 10 refs.

Lukert, D.H. (Univ of Texas at Arlington, Arlington, TX, USA); Blanchard, A.J. *Int J Remote Sens* v 9 n 3 Mar 1988 p 527-542.

**087632 SAMPLING EFFECTS IN SQUARE-LAW DETECTED SYNTHETIC APERTURE RADAR.** An earlier letter demonstrated that a narrow synthetic radar beam may be generated from square-law detected radar pulses provided the return pulse is incoherent. This technique would have the advantage of reducing the required knowledge of the platform location to a fraction of the transmitted pulse length, rather than the fraction of the carrier wavelength required by a coherent synthetic aperture radar. The effect of sampling the aperture is now described, and it is shown that the sampling interval required to avoid unacceptable sidelobe levels can be greater than that required by coherent synthetic aperture radar. (Edited author abstract) 2 refs.

Wingham, D.J. (Univ Coll London, London, Engl). *Electron Lett* v 24 n 10 May 12 1988 p 645-646.

**087633 NEW AUTOMATIC TECHNIQUES FOR SMOOTHING AND SEGMENTING SAR IMAGES.** A new algorithm for smoothing synthetic aperture radar (SAR) images, which is based on the estimation of the most homogeneous neighbourhood around each image pixel, is presented. The algorithm preserves fine details while removing noise along edges as well as in flat areas. An edge detection technique, based on the smoothing algorithm, is presented. The algorithms are implemented in the spatial domain, and without the need to use a threshold value. The performances of the algorithms are compared (qualitatively and quantitatively) with several standard techniques, using real and simulated images. (Edited author abstract) 15 refs.

Ali, S.M. (King's Coll London, London, Engl); Burge, R.E. *Signal Process* v 14 n 4 Jun 1988 p 335-346.

**087634 ADAPTIVE SPATIAL-TEMPORAL PROCESSING OF RADIO SIGNALS IN ANTENNA SYSTEMS WITH A SYNTHESIZED APERTURE.** Aperture-synthesis methods are now widely used to increase the resolution of radar systems. Studies of the characteristic features of coherent processing of received signals in such systems have been performed before, but the prob-



lems arising in the use of adaptive antennas with a synthesized aperture have not been studied. The authors examine the principle of aperture synthesis as it applies to a radio link between a station on earth and an aircraft. 10 refs.

Rodimov, A.P.; Glushankov, Ye.I.; Kobin, S.V. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 162-164.

**087635 REMOVAL OF AZIMUTH DISTORTION IN SYNTHETIC APERTURE RADAR IMAGES.** The sources of distortion in Synthetic Aperture Radar (SAR) imagery are discussed. The Royal Signals and Radar Establishment airborne SAR system is described briefly and a phase correction scheme, based on autofocus measurement, to remove azimuth distortions is derived with the requirements for accuracy and update frequency of autofocus measurements. Examples of the application of the techniques to real SAR data are given. (Author abstract). 6 Refs.

Wood, J.W. (Royal Signal & Radar Establishment, Malvern, Engl). *Int J Remote Sens* v 9 n 6 Jun 1988 p 1097-1107.

**087636 DETECTION OF BURIED PLANT.** A wide-band microwave holographic method for imaging buried objects with high azimuth and range resolution is described. The method incorporates a synthetic aperture approach in pulse radar systems, originally designed for pulse-echo imaging, to improve azimuth resolution. The resolving capability of the method is discussed in terms of controlling parameters such as the synthetic aperture length, soil conductivity and dielectric constant, and antenna beamwidth. Since the propagation velocity of electromagnetic waves in soil, which varies from soil to soil, is an essential parameter for reconstructing object images by the method, a method of minimum squared error estimation of the propagation velocity from a pulse-echo image is proposed. Results of underground object image reconstruction from real pulse-echo data is reported to demonstrate high estimation accuracy of the propagation velocity and fine resolution of the reconstructed image. (Author abstract). 11 Refs.

Osumi, N. (NTT, Musashino, Jpn); Ueno, K. *IEE Proc Part F* v 135-F n 4 Aug 1988 p 330-342.

**087637 SAR DATA FILTERING FOR CLASSIFICATION.** The authors compare several filtering techniques to improve the classification of a synthetic-aperture (SAR) image. They separate thematic information and noise by speckle analysis, and they propose filters adapted to speckle models. The evaluation includes a brief theoretical analysis, a visual interpretation, a signal-to-noise ratio analysis, and a comparison of required computer times, as well as classification results. The study also shows the effect of active microwaves on crop identification in the case where there is a one-date one-look SAR image, the utilization of X-band and C-band, and HH polarization. 20 refs.

Durand, Jean M. (Lab d'Etudes et de Recherche en Teledetection Spatiale, Toulouse, Fr); Gimonnet, Bernard J.; Perbos, Jacqueline R. *IEEE Trans Geosci Remote Sens* v GE-25 n 5 Sep 1987 p 629-637.

**087638 EVALUATING ROUGHNESS MODELS OF RADAR BACKSCATTER.** A unique set of data collected for a soil moisture experiment has been used to evaluate three radar backscatter roughness models. The data were collected by the NASA space shuttle flight 41G (SIR-B) synthetic-aperture radar (SAR) in an intensively farmed area near Fresno, California. The SIR-B data swath included a large number of bare dry fields with a large variety of surface roughnesses. The small perturbation model gave the best results, particularly when fields with a definite periodic row structure were omitted. The standard deviation of surface heights appears to be a good measure of relative roughness conditions, but the correlation length did not appear to be a good descriptor of the surface nor did it seem to be related in any way to the measured backscatter. 5 refs.

Engman, Edwin T. (USDA, Beltsville, MD, USA); Wang,

James R. *IEEE Trans Geosci Remote Sens* v GE-25 n 6 Nov 1987, 1986 Int Geosci and Remote Sens Symp (IGARSS'86) - Remote Sens - Today's Solutions for Tomorrow's Inf Needs, Zurich, Switz, Sep 8-11 1986 p 709-713.

**087639 KNOWLEDGE-BASED SAR PROCESSING AND GEOCODING: THE ELEMENTARY COMPONENTS OF THE GERMAN PROCESSING AND ARCHIVING FACILITY FOR HIGH THROUGHPUT AND HIGH-PRECISION PROCESSING OF ERS-1 SAR DATA.** An end-to-end synthetic-aperture radar (SAR) processing system has been designed that is significantly different from existing ones. Requirements for high precision combined with high throughput of the generated products will be met by two systems: the knowledge-based intelligent SAR processor (ISAR) and the geocoding system. They represent the backbone of a distributed computer network engaged in SAR processing and image restitution within the German Processing and Archiving Facility for ERS-1, the first European remote-sensing satellite. The requirements for the system as well as the specific hardware and software concepts are described. 20 refs.

Noack, Wolfgang (DFVLR, West Ger); Popella, Axel; Schreier, Gunter. *IEEE Trans Geosci Remote Sens* v GE-25 n 6 Nov 1987, 1986 Int Geosci and Remote Sens Symp (IGARSS'86) - Remote Sens - Today's Solutions for Tomorrow's Inf Needs, Zurich, Switz, Sep 8-11 1986 p 758-769.

**087640 ERS-1 SYNTHETIC APERTURE RADAR FAST DELIVERY PROCESSOR.** The ESA ground station facility at Kiruna, Sweden will be responsible for the reception of ERS-1 data and its processing into fast delivery products. Due to its high latitude, Kiruna can receive data from 10 of 14 passes per day, making its processing throughput requirements among the highest in the ERS-1 network. A discussion is presented of the SAR processor system at Kiruna responsible for part of this product generation. A description of the ground station environment is presented as the context in which the processor must operate. The processor requirements are then discussed followed by descriptions of the hardware and software components. 2 refs.

George, Peter (Dettwiler & Associates Ltd, BC, Can); Guignard, Jean-Pierre. *IEEE Trans Geosci Remote Sens* v GE-25 n 6 Nov 1987, 1986 Int Geosci and Remote Sens Symp (IGARSS'86) - Remote Sens - Today's Solutions for Tomorrow's Inf Needs, Zurich, Switz, Sep 8-11 1986 p 770-774.

**087641 PREDICTION OF GEOMETRIC DISTORTIONS IN AIRBORNE SYNTHETIC APERTURE RADAR IMAGERY FROM AUTOFOCUS MEASUREMENTS.** The synthetic aperture radar (SAR) is an imaging system that achieves high azimuthal resolution by tracking individual point scatterers using their phase histories, with the expected phase history of a particular point scatterer being derived from the assumed motion of the airborne SAR platform. The aircraft carrying the SAR will be susceptible to extraneous across track motions and errors in the pulse spacing. The image will be defocused due to an error in the expected quadratic phase history, and the image will contain geometric distortions due to an error in the linear phase history. An autofocus technique can be used to focus the image and produce a measure of the quadratic phase error that in turn can be used to estimate the geometric distortions that will be present in the final image. These distortions can be independently measured by direct comparison with a map of the imaged area. A description is given of the application of these methods to some real SAR data and the results of the comparison of the measurements of autofocus and geometric distortions are discussed in terms of both the likely platform motions present and the viability of predicting geometric distortion using the autofocus measurements. 6 refs.

Blacknell, David (GEC, Chelmsford, Engl); Freeman, Anthony; White, Richard Geoffrey; Wood, James William. *IEEE Trans Geosci Remote Sens* v GE-25 n 6 Nov

1987, 1986 Int Geosci and Remote Sens Symp (IGARSS'86) - Remote Sens - Today's Solutions for Tomorrow's Inf Needs, Zurich, Switz, Sep 8-11 1986 p 775-782.

**087642 RECONSIDERATION OF AZIMUTH AMBIGUITIES IN SAR.** The traditional method of specifying and controlling azimuth ambiguities in synthetic-aperture radar (SAR) is through integrated energy balance measures. However, the most frequently observed azimuth ambiguities arise from ensembles of strong point reflectors in the principal sidelobe of the antenna which in turn are aliased into the processed Doppler bandwidth by the radar pulse repetition frequency (PRF). The authors consider the dependence of these ambiguities on radar wavelength and PRF. It is shown that such ambiguous image elements are strengthened in proportion to  $\lambda^{-2}$ , and  $\text{PRF}^{-1}$ . The theoretical structure is based on orbital SAR geometry, including Earth rotation. The work is applied to a SIR-B L-band radar scene in which azimuth ambiguities are clearly observed. The level and spatial position of these ambiguities are measured in the digital image. The results are extrapolated to higher frequency radars such as ERS-1 and Radarsat. It is concluded that for these C-band radars the point azimuth restraint is more relevant (and more binding) than the traditional energy balance method. 3 refs.

Raney, R. Keith (Canada Cent for Remote Sensing, Ottawa, Ont, Can); Princz, G. Julius. *IEEE Trans Geosci Remote Sens* v GE-25 n 6 Nov 1987, 1986 Int Geosci and Remote Sens Symp (IGARSS'86) - Remote Sens - Today's Solutions for Tomorrow's Inf Needs, Zurich, Switz, Sep 8-11 1986 p 783-787.

**087643 MOTION-COMPENSATED SAR IMAGE ISLR.** The integrated sidelobe ratio (ISLR) arising from errors in motion compensation is a critical figure-of-merit in evaluating the fidelity of modern synthetic-aperture radar (SAR) imagery. An analytical closed-form expression is derived here as a function of SAR array time, underlying motion-sensor accuracy, and limiting data bandwidth. 13 refs.

Bogler, Philip L. (Hughes Aircraft Co, Lawndale, CA, USA). *IEEE Trans Geosci Remote Sens* v GE-25 n 6 Nov 1987, 1986 Int Geosci and Remote Sens Symp (IGARSS'86) - Remote Sens - Today's Solutions for Tomorrow's Inf Needs, Zurich, Switz, Sep 8-11 1986 p 871-878.

**087644 NEW LOOK AT NONSEPARABLE SYNTHETIC APERTURE RADAR PROCESSING.** The author examines the nonseparable, template correlation approach to digital-strip-mode synthetic-aperture radar (SAR) phase history processing and concludes that it can now outperform the traditional separable approaches in the areas of speed, image quality, control simplicity, and flexibility. A working nonseparable frequency-domain SAR processor is described and evaluated. The image quality is seen to be superior to that resulting from the separable approaches. Based on the working intermediate hardware implementation, the author strongly suggests that future VHSIC and other advanced implementation will provide extremely fast (real time), high-quality, small, flexible SAR processors. 22 refs.

Di Cenzo, Alan (TRW, Redondo Beach, CA, USA). *IEEE Trans Aerosp Electron Syst* v 24 n 3 May 1988 p 218-223.

**087645 STRIP MODE PROCESSING OF SPOT-LIGHT APERTURE RADAR DATA.** The author shows how to process deramped (e.g., typical spotlight mode) synthetic-aperture-radar (SAR) data using mode processors, with no restrictions on antenna pointing. The basis of the approach is that although the deramped data does not contain a spatially invariant two-dimensional response to a point target, the range-compressed deramped data does. Range compression of the deramped data is performed simply by Fourier transforming each range line.



The method greatly increases the flexibility of current strip mode processors by extending their domain to a previously unsuitable class of data. 11 refs.

Di Cenzo, Alan (TRW, Redondo Beach, CA, USA). *IEEE Trans Aerosp Electron Syst* v 24 n 3 May 1988 p 225-230.

**087646 PHASE IMAGING BY REAL-ZERO CONVERSION AND ITS APPLICATION TO SYNTHETIC APERTURE RADAR.** A new method for generating an image of the unwrapped phase is discussed which is based on real-zero conversion of the data. The images produced by this method are of value in reducing the effects of clutter and identifying strong scatterers. (Author abstract) 8 refs.

Blackledge, J.M. (Univ of London, London, Engl); Burge, R.E.; Barratt, N.R. *J Phys D* v 20 n 11 Nov 1987 p 1438-1444.

**Tracking** See Also AEROSPACE VEHICLE TRACKING—Mathematical Models; DIRECTION FINDING SYSTEMS—Mathematical Models; INFORMATION THEORY—Correlation Theory; SIGNAL FILTERING AND PREDICTION—Mathematical Models; SIGNAL PROCESSING—Mathematical Models.

**087647 PROPERTIES OF A TRACKING FILTER WITH MANOEUVRING RADAR TARGET POSITION AND VELOCITY INPUTS.** If a radar has the ability to measure target velocity with high accuracy, it is advantageous to use these measurements to obtain more accurate estimates of the filtered position and velocity of a tracked radar target. Some properties of the Kalman optimum filter with measurement of target position and velocity are analyzed as is the possibility to suppress simultaneously the systematic error of target maneuver tracking and the position-measurement random noise. (Edited author abstract) 9 refs.

Lanka, Oldrich (Research Inst of Radio Engineering, Czech). *Tesla Electron* v 18 n 4 1985 p 117-124.

**087648 LOW-ANGLE TRACKING RADARS AND NON-LINEAR TIME-DELAY ESTIMATION.** A new approach, based on nonlinear time-delay estimation, is described for estimating the elevation angle in the combined presence of specular multipath and receiver noise—a situation that is encountered in the low-angle tracking radar environment. Estimation of the elevation angle is accomplished using the time delay between the signals impinging on the antenna array elements. Thus, the accuracy in the elevation angle estimation is dependent on the accuracy of the time-delay estimation algorithm. The formulation of the problem enables one to find the desired estimates independently of the reflection coefficient, which is a significant result. In the proposed approach, a newly derived non-linear filter due to the author is used. (Edited author abstract) 13 refs.

Abutaleb, Ahmed S. (Temple Univ, Philadelphia, PA, USA). *Int J Syst Sci* v 18 n 11 Nov 1987 p 2183-2196.

**087649 STATE ESTIMATION OF MANOEUVRING TARGETS FROM NOISY RADAR MEASUREMENTS.** Analytical results for tracking manoeuvring targets from noisy radar measurements are presented. A three-dimensional mathematical model based on Kalman filtering is discussed for the tracking of a manoeuvring aircraft using noisy measurements obtained from a three-dimensional radar. The measurement uncertainties and the manoeuvre characteristics are assumed to be known in polar coordinates, and are also assumed to be white Gaussian with zero mean and constant variance. These are coupled to the cartesian coordinate system selected for tracking operation. The elements of the covariance and Kalman gain matrices are expressed in terms of those which apply for tracking in polar coordinates. The steady-state results are expressed in compact form by appropriately partitioning the covariance matrices. The numerical computations of the steady-state filter parameters of the model agree with those obtained from the recursive Kalman filter matrix equations. Hence these results are of practical interest in developing trackers for

tracking manoeuvring aircraft and to eliminate the real-time execution of the complete filter equations. (Edited author abstract) 10 refs.

Ramachandra, K.V. (Electronics Radar Development Establishment DRDO Complex, Bangalore, India). *IEE Proc Part F* v 135 n 1 Feb 1988 p 82-84.

**087650 ANALYSIS OF NEAR-ZONE TARGET SCATTERING.** Some methods of analysing the scattering of airborne target are discussed. It is explained that the method of Geometrical Theory of Diffraction is suitable for the near-zone problems (when the distance from the target is comparable to the size of the target). The scatter field of a missile model is analysed and calculated applying Geometrical Theory of Diffraction. Under conditions of satisfying practical precision in engineering, the analysis is simplified by the main ray method. Making use of the geometric relations, the location of the rays is accurate and time-saving. The comparison of the calculated results with the experimental data shows the effectiveness of GTD in analysing target scattering. (Author abstract) 5 refs. In Chinese.

Xui, Hai; Wang, Wenbing. *Bingong Xuebao* n 2 May 1988 p 31-38.

**087651 SUBOPTIMAL FILTER DESIGN WITH PSEUDOMEASUREMENTS FOR TARGET TRACKING.** A suboptimal Kalman filter design method is presented for the problem of tracking a manoeuvring target. The design method is essentially based on linear target dynamics and linear-like structured measurements called pseudomeasurements. The pseudomeasurements are obtained by manipulating the original nonlinear measurements algebraically. The resulting filter has computational advantages over other filters with similar performance. Also, a variant of the Berg model is proposed as a target acceleration model under the assumption of a coordinated turn maneuver. The proposed model is consistent with the underlying assumption. Monte Carlo computer simulation results are included to demonstrate the effectiveness of the proposed suboptimal filter associated with the target acceleration model. 10 refs.

Song, Taek L. (Agency for Defense Development, Daejeon, South Korea); Ahn, Jo Young; Park, Chanbin. *IEEE Trans Aerosp Electron Syst* v 24 n 1 Jan 1988 p 28-39.

**087652 NTH-ORDER DYNAMICS TARGET OBSERVABILITY FROM ANGLE MEASUREMENTS.** Necessary and sufficient conditions are presented for the observability of the target's Nth-order dynamics, given direction measurements. The derivations are extremely simple and do not require the examination of an observability matrix or nonlinear differential equations. Previously published observability requirements for the first-order dynamics are shown to be necessary but not sufficient. 2 refs.

Fogel, Eli (Tadiran Ltd, Holon, Isr); Gavish, Motti. *IEEE Trans Aerosp Electron Syst* v 24 n 3 May 1988 p 305-308.

**087653 TRACKING MULTIPLE TARGETS WITH CORRELATED MEASUREMENTS AND MANEUVERS.** The problem of tracking N targets with correlation in both measurement and maneuver statistics is solved by transforming to a coordinate frame in which the N targets are decoupled. For the case of N identical targets, the decoupling is shown to coincide with a transformation to a set of nested center-of-mass coordinates. Absolute and differential tracking accuracies are compared with suboptimal results to show the improvement that is achieved by properly exploiting the correlation between targets. 7 refs.

Rogers, Steven R. (Nordem Systems, Norwalk, CT, USA). *IEEE Trans Aerosp Electron Syst* v 24 n 3 May 1988 p 313-315.

**087654 DIGITAL METHOD OF DEMODULATION AND FILTERING FOR ANGULAR ERRORS IN CONICAL SCAN TRACKING RADARS.** A simple digital method for demodulation and filtering of angular

errors in conical scan tracking radars is developed. It consists of studying the complex frequency spectrum of the modulated error signal. Evaluation of this digital processing is accomplished by means of computer simulation. Distortions in the estimation of the angular error phase angle due to the digital processing are investigated. (Edited author abstract) 4 refs.

Guesalaga, Andres R. (Univ Catolica de Chile, Santiago, Chile). *Microprocess Microprogram* v 23 n 1-5 Mar 1988, Short Notes - Euromicro '87. Microcomput: Usage, Methods and Struct, 1987 p 327-332.

## RADAR CIRCUITS

**087655 COMPARISON OF THE PERFORMANCE CHARACTERISTICS OF DOPPLER SHORT-RANGE SYSTEMS.** The following three schemes for designing Doppler short-range systems are compared: a system using an autodyne, where high-amplitude oscillations are generated and a small reflected signal is converted and amplified; a scheme in which generation and amplification are carried out in one unit and conversion occurs in a separate converter; and a scheme in which the oscillator and converter are coupled by a circulator, and the signal is not amplified. It is shown that the autodyne amplification in the second scheme is cancelled out by coupling losses and therefore has no advantage over the third scheme. (Edited author abstract) 7 refs.

Zubov, P.T.; Khotuntsev, Yu.L. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 20-24.

**087656 INVESTIGATION INTO PWB COMPONENT-PLACEMENT TRADEOFFS.** The tradeoffs between routing and reliability were measured for various component placements on a multilayer, primarily digital, printed wiring board (PWB). The PWB which was tested is typical of that used for ultrahigh-reliability radar units in an aerospace environment where conduction cooling is used. The results indicate that by using appropriate design tradeoffs through a sensitivity analysis, a design compromise can satisfy all the design requirements. 14 refs.

Pecht, Michael (Univ of Maryland, College Park, MD, USA); Palmer, Milton; Schenke, Wolfgang; Porter, Richard. *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 524-527.

## Analysis

**087657 LINEAR FM CHIRP FILTERS IN PULSE COMPRESSION RADARS.** Using a complex Fresnel integral algorithm, the authors extend results of other authors from a time-bandwidth product of 50 up to 720. They analyze a rectangular linear FM filter having a 300-MHz center frequency, 120-MHz bandwidth, and 6-μs dispersion time T. Two different methods of rectangular FM cosine square tapering are compared. In the first method, the tapers are of length T/12 at the two edges inside the dispersion time T, while in the second, tapers of length αT are added to the duration T (α = 0.05 and 0.1). The results show that the skirt steepness, the sidelobe rejection, and the Gibbs ripples of the wave spectrum, as well as the reduction of insertion loss and the suppression of Fresnel ripples, are best at α = 0.1. 9 refs.

El-Shennawy, Khamies M. (Alexandria Univ, Egypt); Alim, Onsy Abdel; Ezz-El-Arab, Mohamed A. *IEEE Trans Instrum Meas* v IM-36 n 3 Sep 1987 p 783-788.

**RADAR EQUIPMENT** See Also ANTENNAS—Reflectors.

Applications See AIRCRAFT—Wind Effects.

Efficiency See AIRSHIPS—Design.

Instruments See GLACIERS—Remote Sensing.



## Microwaves

**087658 ANALYSIS SHOWS EFFECTS OF AGING ON T/R MODULES.** Advantages of solid-state phased-array apertures are well documented. Development of this technology, in particular transmit/receive (T/R) modules, is advancing rapidly. This article discusses an investigation that took place to determine the effects of aging on a set of X-band T/R radar modules. Tests were conducted with one of the first active-aperture X-band radar T/R modules using hybrid microwave integrated circuits. These circuits rely on GaAs FETs for power amplification, and were developed to provide a reproducible and reliable T/R module that satisfies the requirements of operation in a multimode active-array radar. 5 refs.

Sliva, Randall J. (US Naval Weapons Cent, China Lake, CA, USA). *Microwaves RF* v 27 n 3 Mar 1988 p 79-80, 82, 84-85.

## Protection

**087659 RADAR TECHNOLOGY - WHERE NEXT?** Radar Equipment emits characteristic signals that can reveal the device's identity to an enemy operator. Changes in the design could remove this problem. Possible changes in radar equipment design to conceal its identity more effectively are discussed. (Edited author abstract)

Ashby, James. *Electron Power* v 33 n 7 Jul 1987 p 445-446.

**RADAR IMAGING** See Also ELECTRIC CABLES—Underground; GEOLOGICAL SURVEYS—Remote Sensing; IMAGE PROCESSING—Mathematical Models; MAPS AND MAPPING; MICROWAVES—Imaging Techniques; OCEANOGRAPHY—Sea Ice; PHOTOGRAMMETRY—Underwater; RADAR—Synthetic Aperture; SATELLITES—Weather.

**087660 STATISTICAL PROPERTIES OF RADAR IMAGES OF FLUCTUATING UNDERLYING SURFACES.** The process of the formation of radar images (RI) of fluctuating surface-distributed objects in radar sets with synthesized aperture is analyzed. Analytic expressions are obtained which describe the main statistical properties of such RIs and the degree of their smoothness in the case of incoherent storage of signals. It is shown that the statistical characteristics of RIs are invariant with respect to the magnitude of the correlation interval of the time fluctuations in the echo signal and the signal-to-noise ratio on RIs is practically independent of the degree of incoherent signal storage. (Author abstract) 9 refs.

Il'in, A.L.; Pasmurov, A.Ya. *Sov J Commun Technol Electron* v 32 n 4 Apr 1987 p 150-156.

**087661 SPACE-FREQUENCY CHARACTERISTIC OF IMAGE-FORMATION CHANNEL IN PRESENCE OF A LOCAL LAYER OF SCATTERING MEDIUM.** A relationship is obtained between the width of the space-frequency characteristic of an image-formation channel and the distance between a scattering medium and the object being observed. Approximate expressions are given for the space-frequency characteristics of the image-formation channel in the small-angle approximation. (Author abstract) 4 refs.

Yukhno, P.M.; Yarmoshevich, E.I. *Radioelectron Commun Syst* v 30 n 7 1987 p 12-15.

**087662 SYNTHESIS OF SOUNDING SIGNALS WITH LOW LEVEL OF OUT-OF-BAND RADIATION.** A regular method is proposed for synthesizing sounding signals with low side-lobe level (SLL) of the spectrum and the SLL of the indeterminacy function (IF) in a cross section along the frequency axis; the approach is based on amplitude modulation of the high-frequency harmonic signal of a two-level weight function. (Author abstract) 3 refs.

Marder, M.M.; Surkov, M.N.; Fedosov, V.P. *Radioelectron Commun Syst* v 30 n 7 1987 p 16-19.

**087663 SHUTTLE IMAGING RADAR A ANALY-**

**SIS OF LAND USE IN AMAZONIA.** We have made a comparison of data from Landsat multispectral scanner (MSS) and from the Shuttle Imaging Radar (SIR-A) L band HH polarization data for sites in the Amazon Basin. Results indicate that SIR-A backscatter from the undisturbed forest was lower than that from some disturbed areas and from flooded forests and that SIR-A brightness increases nonlinearly with the Landsat normalized difference vegetation index (NDVI). We hypothesize that the brightest radar returns in southern Amazonia are from newly cleared forests that are littered with standing and fallen tree boles that function as corner reflectors, and that backscatter will diminish from disturbed areas over time as fields are burned repeatedly. (Edited author abstract) 34 refs.

Stone, Thomas A. (US Marine Biological Lab, Woods Hole, MA, USA); Woodwell, George M. *Int J Remote Sens* v 9 n 1 Jan 1988 p 95-105.

**087664 ATMOSPHERIC CORRECTION OF THERMAL INFRARED IMAGES.** A method for estimating sea surface temperature (SST) from a single infrared (IR) channel together with an atmospheric model is investigated. Based on a simulated atmospheric height profile, the precipitable water and transmittance can be calculated as a function of height from the known atmospheric pressure, temperature and relative humidity on the ground. An effective transmittance (which is the ratio of the radiance at the satellite to that on the surface) is used to correct the effect of off-nadir scanner angle. Various data from the Heat Capacity Mapping Mission (HCMM), the Advanced Very High Resolution Radiometer (AVHRR) and other sources are used to evaluate the accuracy of the method. The SST derived agrees with available ground truth with a root mean square (r.m.s.) error of about 1 deg K. (Edited author abstract) 20 refs.

Zhirong, Li Z.R. (Dep of Scientific & Industrial Research, Lower Hutt, NZ); McDonnell, M.J. *Int J Remote Sens* v 9 n 1 Jan 1988 p 107-121.

**087665 ACQUISITION OF SPOT-1 HRV IMAGERY OVER SOUTHERN BRITAIN AND NORTHERN FRANCE, MAY 1986-MAY 1987.** The number and spatial distribution of SPOT-1 HRV images acquired over northern France and southern Britain during the first commercial year of the SPOT satellite system (officially 6 May 1986-6 May 1987) have been evaluated in response to concern about the lack of cloud-free imagery. The results confirm that despite large numbers of images being acquired per scene (1 panchromatic and 12 multispectral on average over northern France; 8 panchromatic and 12 multispectral over southern Britain) most are of limited use because of cloud cover. Only 30 per cent of the images collected (or 5 images/scene/year) have at least one quadrant with <25 per cent cloud cover and 10 per cent (or 2 images/scene/year) have <10 per cent cloud cover in each quadrant. (Edited author abstract) 4 refs.

Cushnie, Janis (Reading Univ, Engl). *Int J Remote Sens* v 9 n 1 Jan 1988 p 159-167.

**087666 BAYESIAN CLASSIFICATION OF SURFACE-BASED ICE-RADAR IMAGES.** The Bayes classification procedure has been used to discriminate types of sea ice based on images obtained from surface-based marine radars. The data sets were digitized images obtained from a dual-polarized Ku-band radar (16 GHz) and a like-polarized S-band radar (3 GHz) at a site located on the northern tip of Baffin Island, Canada. The images were range-compensated, and statistical properties of different ice types were determined. The observed histograms for different ice types were approximated by continuous density functions. The images were classified by maximizing the a posteriori probabilities obtained from Bayes' rule. The results suggest that there is sufficient information in the reflectivity to classify the different forms of ice using decision-theoretic pattern recognition techniques. 15 refs.

Murthy, Hema A. (Indian Inst of Technology, Madras, India); Haykin, Simon. *IEEE J Oceanic Eng* v OE-12 n 3 Jul 1987 p 493-502.

Analysis See RADAR—Synthetic Aperture.

## Applications

**087667 FMCW RADAR FOR HIDDEN OBJECT DETECTION.** The use of FMCW radar for the detection of hidden objects at short distances is described. The factors which influence the type of radar and the optimum parameters for FMCW radar are discussed. It is shown that FMCW radar is satisfactory for situations where a high resolution is needed at a short distance, such as the detection of flaws in building materials. Practical systems are described. Both FFT and non-Fourier methods are used for processing the radar returns. Multiple targets hidden in media can be revealed by digital subtraction or template matching using a numerical optimization procedure. The radar is shown to be capable of producing images of targets. (Edited author abstract). 19 Refs.

Oliver, A.D. (Queen Mary Coll, London, Engl); Cuthbert, L.G. *IEE Proc Part F* v 135-F n 4 Aug 1988 p 354-361.

## Computer Aided Analysis

**087668 RADIOMETRIC CORRECTION OF C-BAND IMAGERY FOR TOPOGRAPHIC EFFECTS IN REGIONS OF MODERATE RELIEF.** The combined effects of topography, slope, look angle, and aspect on C-band synthetic-aperture radar (SAR) data on the radiometric quality of SAR images in a region of moderate relief are examined. A correction method was used to attenuate the change of illumination across the swath due to the antenna pattern. Ground data were integrated into the analysis using a digital terrain model (DTM). Correction functions based on the cosine of the incidence angle were applied to the thematic classes and to the grouped classes in order to reduce the effects related to topography. It was found that it is possible to eliminate part of the radiometric variations created by moderate topographic relief. After the corrections were applied, a reduction was noted of the variance in the radiometric values of the spectral signatures of the cover types, which ranged between 3.03% and 9.47%, depending on the correction function used. No noticeable correction occurred of pixels with slopes less than 6° and at local incident angles less than 26°. However, the closer the slopes are to being perpendicular to the look direction, the stronger is the correlation between backscatter and slope angle. 17 refs.

Hinse, Mario (Univ of Sherbrooke, Que, Can); Gwyn, Q.H.J.; Bonn, F. *IEEE Trans Geosci Remote Sens* v 26 n 2 Mar 1988 p 122-132.

## Mathematical Models

**087669 SAR IMAGING OF VOLUME SCATTERERS.** The first renormalization scattering method is used to obtain an expression for the synthetic-aperture radar (SAR) complex image amplitude of a volume scatterer with an undulating boundary surface. This expression is then used to derive further expressions for correlations of such an image when the boundary is either deterministic or random. 8 refs.

Taket, N.D. (King's Coll London, Engl); Hall, T.J.; Burge, R.E. *IEEE Trans Geosci Remote Sens* v 26 n 2 Mar 1988 p 133-139.

Processing See RADAR—Synthetic Aperture.

Spectrum Analysis See Also RADAR—Cross Sections.

**087670 SPECTRAL PROPERTIES OF HOMOGENEOUS AND NONHOMOGENEOUS RADAR IMAGES.** Based on a two-dimensional, nonstationary white noise model for complex radar backscatter, the spectral properties of a one-look synthetic-aperture radar (SAR) system are derived. It is shown that the power spectrum of the complex SAR image is scene independent. It is also shown that the spectrum of the intensity image is in general related to the radar scene spectrum by a linear integral equation, a Fredholm's integral equation of the third kind. Under simplifying assumptions, a closed-form



equation giving the radar scene spectrum as a function of the SAR image spectrum can be derived. 13 refs.

Madsen, Soren Norvang (Technical Univ of Denmark, Lyngby, Den). *IEEE Trans Aerosp Electron Syst* v AES-23 n 4 Jul 1987 p 583-588.

## Theory

**087671 THEORY OF IMAGING WITH AIRBORNE SYNTHETIC APERTURE RADAR.** The theory of imaging with Airborne Synthetic Aperture Radar is presented using a solution to the approximate scattering problem that is based on the Born approximation. Scattering from both conductive and non-conductive structures is examined and inverse solutions presented. The effect of polarization is also examined. (Author abstract) 1 ref.

Blackledge, J.M. (London Univ, London, Engl). *Optik (Stuttgart)* v 78 n 1 Dec 1987 p 1-11.

**RADAR INTERFERENCE** See Also RADAR CIRCUITS—Analysis; RADAR RECEIVERS—Noise, Spurious Signal; RADAR SYSTEMS—Optimization; SIGNAL DETECTION—Optimization.

**087672 SPACE-TIME CORRELATION FUNCTION OF INTERFERING REFLECTIONS OF A RADAR SIGNAL.** The space-time correlation function is obtained for noise caused by reflection of a radar signal from the underlying surface at small angles of elevation. An expression is obtained for this function in closed form with minor constraints as a result of an analytic treatment. Allowance is made for the parameters of the underlying surface, the geometric characteristics of the receiving system, the width of the illumination radiation pattern, and the amplitude-phase modulation of the signal radiated. It is shown that the correlation function is separated (factored) into space and time functions. (Author abstract) 4 refs.

Zinov'ev, A.L.; Mikolenko, D.A.; Uglov, O.D. *Radioelectron Commun Syst* v 30 n 7 1987 p 1-6.

**087673 RECEPTION OF AN ELLIPTICALLY POLARIZED SPACE-TIME SIGNAL IN THE PRESENCE OF INTERFERENCE SET UP BY EXTERNAL SOURCES.** Processing that is optimal in the sense of the likelihood ratio is considered for a narrowband space-time elliptically polarized radio signal received in a background of noise set up by several sources and internal noise. It is shown that the effectiveness of polarization selection is determined, in addition to the familiar factors, by the relationships among the energy and polarization parameters of the external-source interference. (Author abstract) 3 refs.

Radzievskii, V.G.; Myazitova, L.Sh. *Radioelectron Commun Syst* v 30 n 7 1987 p 7-11.

**Clutter** See Also RADAR—Surveillance Application; RADAR RECEIVERS—Analysis.

**087674 SPATIAL CORRELATION IN K-DISTRIBUTED SEA CLUTTER.** The compound K-distribution model for sea clutter previously described in the literature provides the foundation for a quantitative treatment of the spatial and temporal correlation characteristics of the envelope of clutter returns. In the paper the compound K-distribution model is extended to cover the spatial characteristics of sea clutter. The relationship of these characteristics to the physical basis of the model is described, and methods for their simulation are discussed. The effects of different radar range resolutions are analyzed and these results compared with observations on real data. Quantitative techniques are derived for optimizing radar range resolution to give the best target detection performance in different clutter conditions, and some practical examples are presented. (Edited author abstract) 12 refs.

Watts, S. (Thorn EMI Electronics Ltd, Hayes, Engl); Ward, K.D. *IEE Proc Part F* v 134 n 6 Oct 1987 p 526-532.

**087675 ASYMPTOTICALLY OPTIMUM RADAR DETECTORS IN NON-RAYLEIGH CLUTTER.** The paper deals with the synthesis of the coherent asymptotically optimum detector (AOD) for fluctuating targets embedded in non-Rayleigh clutter. For the proposed detection scheme the asymptotic (large sample size) performance is evaluated. Comparison with the linear detector shows that, in principle, significant improvements are achievable by resorting to the AOD if the sample size is arbitrarily large. Since in radar system design the sample size is dictated by technological limits, the paper also investigates by computer simulation the performance of the AOD under such constraints. It turns out that the promises of the asymptotic theory cannot be achieved using moderately large sample sizes. A simple hybrid detection scheme is proposed that performs better than both the asymptotically optimum and the linear detectors in actual operational situations. (Edited author abstract) 13 refs.

Conte, Ernesto (Univ di Napoli, Naples, Italy); Izzo, Luciano; Longo, Maurizio; Paura, Luigi. *IEE Proc Part F* v 134 n 7 Dec 1987 p 667-672.

**087676 OPTIMISATION OF SIGNAL/CLUTTER RATIO USING POLARISATION DIVERSITY.** In the letter we consider criteria of use in formulating functionals for optimisation of polarisation-dependent back-scatter from radar targets. By employing the total backscattered power as a parameter, we show that optimisation of signal/clutter may be developed via partial knowledge of the average coherency matrices of targets and clutter. (Author abstract) 7 refs.

Cloude, S.R. (Univ of Dundee, Dundee, Scotl). *Electron Lett* v 24 n 4 Feb 18 1988 p 194-195.

**087677 CLUTTER ELIMINATION AND FEATURE ENHANCEMENT IN MULTIPOLARIZATION RADAR IMAGING AN INVARIATION APPROACH.** Multipolarization radar systems determine the scattering matrix associated with each element of the image to be constructed. Ways in which this information can be used to enhance radar images are reviewed, either by suppressing background noise or by enhancing features with known polarization signature. An imaging quantity designed to facilitate the recognition of such signatures is proposed. The elegance and convenience which can be achieved by concentrating on the eigenvectors and eigenvalues of the scattering matrix are emphasized. (Author abstract) 12 Refs.

Jackson, J.C. (Oxford Computer Services Ltd, Oxford, Engl). *Int J Remote Sens* v 9 n 8 Aug 1988 p 1399-1403.

**087678 PREDICTING CLUTTER DURING ANOMALOUS PROPAGATION CONDITIONS.** Excessive clutter caused by anomalous propagation conditions severely degrades radar performance in many regions of the world. This article describes methods that can be used to predict anomalous clutter amplitude for site-specific radar parameters, terrain features, and atmospheric conditions and to predict the effects of radar Doppler processing on evaporation-ducted sea clutter. (Author abstract) 11 Refs.

Lee, Susan C. (Johns Hopkins Univ Applied Physics Lab, Laurel, MD, USA); Maurer, Donald E.; Musser, Keith L. *Johns Hopkins APL Tech Dig* v 9 n 2 Apr-Jun 1988 p 101-109.

**087679 NUMERICALLY EFFICIENT CALCULATIONS OF CLUTTER MAP CFAR PERFORMANCE.** An alternative expression is derived for the false alarm probability of clutter map constant false alarm rate (CFAR), that was originally presented by R. Nitzberg (1966). The proposed expression converges more rapidly because the infinite product in the original expression is expressed instead as an infinite sum of products. 1 ref.

Levanon, Nadav (Tel-Aviv Univ, Isr). *IEEE Trans Aerosp Electron Syst* v AES-23 n 6 Nov 1987 p 813-814.

**087680 CLUTTER SUPPRESSION USING RECURSIVE AND NONRECURSIVE MTI FILTERS.** The

author calculates the effectiveness of clutter suppression of a moving-target-indicator (MTI) filter in tandem with a fast-Fourier-transform (FFT) Doppler filter bank, taking into account the transient response of the MTI filter. Both recursive and nonrecursive filters are considered. The analysis is extended to the high-pulse-repetition-frequency (PRF) case with clutter fold over. The results can be used to select key design parameters, including the MTI filter, the window size, and the initial transient segment to be discarded. Numerical examples are included. 4 refs.

Liu, Bede (Princeton Univ, Princeton, NJ, USA). *IEEE Trans Aerosp Electron Syst* v 24 n 3 May 1988 p 210-217.

**087681 NEW RESULTS ON LINEAR PREDICTION FOR CLUTTER CANCELLATION.** Some moving-target indicator (MTI) techniques are reviewed and those based on the linear prediction theory are examined. A description is given of the effects of the position of the reference sample in an MTI processor on cancelling clutter in a radar system. The analysis of this generalized linear prediction MTI is based on the evaluation of the receiving operating characteristics (ROCs), assuming that the clutter covariance matrix is known a priori as well as the matrix being estimated on line. It is shown by analytical evaluations and Monte Carlo simulations, that the performance is generally insensitive to the position of the reference sample. An additional analysis is carried out to compare the performance of the generalized linear prediction MTI with the MTI based on the Hsiao approach. It is seen that with the formation of the interference of two superimposed clutter sources the generalized linear prediction MTI suffers, in some cases, several decibels of loss. 11 refs.

Farina, Alfonso (Selenia SpA, Italy); Protopapa, Angelo. *IEEE Trans Aerosp Electron Syst* v 24 n 3 May 1988 p 275-285.

## Finland

**087682 TUTKAENKELEITA SUOMESSA. [Radar Angels in Finland].** Echoes registered by flight control radar systems in clear atmospheric areas where no visible objects could be observed, were often dubbed UFOs during the 1960s. Investigations into natural explanations for these echoes were also initiated, and methods of handling the signals in order to eliminate these phenomena from radar screens, were developed. This latter development is, however, the wrong approach for a meteorologist studying the dynamics of a clear atmosphere, as these signals are an object of great interest to a radar meteorologist. (Author abstract) 25 refs. In Finnish.

Sihvola, Ari (TKK, Finl). *Sahko* v 61 n 1 Jan 1988 p 60-67.

**Suppression** See ANTENNAS—Radar.

**RADAR, OPTICAL** See Also ATMOSPHERIC HUMIDITY—Measurements.

**087683 BISTATIC LIDAR FOR AEROSOL STUDIES.** A bistatic, continuous wave lidar system has been developed at the Indian Institute of Tropical Meteorology, Pune for the purpose of monitoring aerosol characteristics at the place. The system employs a Lexel Model 95-4, 4-Watt Ar<sup>+</sup> laser/Spectra-Physics Model 159, 5 Milliwatt He-Ne laser as the transmitter and a 25 cm Newtonian telescope and associated light/electronic measuring equipment as the receiver. A description of the experimental set-up is presented. The procedure for extracting aerosol information from the received scattered laser return signals is outlined. (Author abstract) 8 refs.

Devara, P.C.S. (Indian Inst of Tropical Meteorology, Pune, India); Ernest Raj, P. *IETE Tech Rev* v 4 n 11 Nov 1987 p 412-415.



**087684 ALGORITHMS FOR OBSERVING ANOMALOUS GAS CONCENTRATIONS BY RAMAN LIDAR.** The problem of the LIDAR detection of anomalous gas concentrations is formulated. Some simple suboptimal algorithms for Bayes and Neumann-Pearson observations by Raman LIDAR have been synthesized. Their efficiency has been determined. The applicability of the approximations and simplifications used has been checked in a closed numerical simulation, including a simulation of realizations of signals and noise for a set of parameter values of the LIDAR, the atmospheric-optics channel, and the gas. The processing of the data and the adoption of decisions were then simulated. (Author abstract) 5 refs.

Glazov, G.N.; Dubyagin, V.M. *Optoelectron Instrum Data Process* n 6 1987 p 82-88.

**Applications See AEROSOLS—Monitoring; AIR POLLUTION—Measurements; NITROGEN OXIDES—Environmental Testing; WATER WAVES—Remote Sensing.**

#### Infrared Radiation

**087685 EXPLORING THE RELATIONSHIPS BETWEEN LEAF NITROGEN CONTENT, BIOMASS AND THE NEAR-INFRARED/RED REFLECTANCE RATIO.** This paper presents the results of a pilot study that sought to explore the links between biomass, leaf 'kjeldahl' nitrogen red (R) and near-infrared (NIR) reflectance. It was observed that biomass was related to R and NIR reflectance and leaf kjeldahl nitrogen, but the variance in each relationship was high, despite taking into account leaf and soil moisture and site topography. It is proposed that much of the unexplained variance is due to different proportions of live, dead, erectophile and planophile biomass at each site. (Edited author abstract) 19 refs.

Plummer, S.E. (Univ of Sheffield, Sheffield, Engl). *Int J Remote Sens* v 9 n 1 Jan 1988 p 177-183.

#### Laser Applications

**087686 MONOSTATIC DOPPLER LIDAR BASED ON Nd:YAG LASER FOR MEASURING WIND VELOCITY.** A monostatic Doppler lidar based on a continuous Nd:YAG laser is developed for measuring the modulus of the wind velocity. At moderate levels of atmospheric turbulence, the limiting range of the measurements is 200 m. A series of atmospheric measurements is made. (Author abstract) 5 refs.

Bersenev, V.I.; Kaptsov, L.N.; Priezzhev, A.V. *Moscow Univ Phys Bull* v 42 n 5 1987 p 99-101.

**Measurement Application See OCEANOGRAPHY—Laser Applications.**

**Meteorological See Also EARTH ATMOSPHERE—Remote Sensing.**

**087687 AEROSOL-LIDAR FUER UMWELTSCHUTZ UND METEOROLOGIE.** [Aerosol Lidar for Environment Protection and Meteorology]. The design of different lidar systems is described with respect to applications in the fields of environment protection and meteorology. Lidar is based on scattering of pulsed laser radiation on molecules and particles of the atmosphere. The specifications for lasers, detectors and data systems are given. The problem of eye safety is discussed for practical applications. Examples for the use of lidar for slant-range visibility detection and plume dispersion measurements are presented. (Edited author abstract) In German. 84 refs.

Werner, Christian (DFVLR, Oberpfaffenhofen, West Ger); Streicher, Juergen. *Forschungsber Dtsch Forsch Versuchsanst Luft Raumfahrt* 87-43 1987 175p.

**087688 ALGORITHM FOR MEASURING A WIND VELOCITY COMPONENT BY A CORRELATION METHOD IN A PHOTON-COUNTING MODE AND ERROR OF THESE MEASUREMENTS.** An algorithm for determining the wind velocity by correlation LIDAR with signal recording in a photon-counting mode has been developed. A parabolic approximation of the

estimate of the correlation function by the method of least squares has been used. The measurement error which stems from fluctuations in the signals and noise in the receiving channel, in the transparency, and in the energy of the laser light has been analyzed. Simple approximate expressions have been found for estimating the measurement error. The workability of this new algorithm is illustrated through a numerical simulation of a correlation wind velocity gage. (Author abstract) 6 refs.

Astafurov, V.G.; Glazov, G.N. *Optoelectron Instrum Data Process* n 6 1987 p 89-93.

**Research See ATMOSPHERIC OPTICS.**

#### Synthetic Aperture

**087689 METHOD OF INSPECTION OF AN OPTICAL SYNTHETIC APERTURE RADAR PROCESSOR.** In this paper we take a general OSARP inspection as an example to explain the method of inspection of an OSARP. We relate the adjustable quantities of each adjustable assembly of the OSARP (Optical Synthetic Aperture Radar Processor) with each characteristic number of a SAR (Synthetic Aperture Radar) data film. The applicable range of the OSARP is obtained by testing the adjustable quantities. The imaging quality of the OSARP is inspected with the general testing targets and a shift lens. The advanced inspection of the OSARP is done with the simulated SAR data films. It is a different way, but the results are the same as the former. Finally, the SAR data film is processed to show the comprehensive imaging quality of the SAR and the OSARP. The experimental pictures and data presented in this paper are for reference only. The experimental results show that the method is applicable. (Author abstract) 7 refs. In Chinese.

Jin, You (Acad Sinica, China). *Guangxue Xuebao* v 7 n 12 Dec 1987 p 1099-1105.

#### Testing

**087690 AIRBORNE LIDAR EXPERIMENTS AT THE SAVANNAH RIVER PLANT - JUNE 1985.** The results of remote sensing experiments at the Department of Energy (DOE) Savannah River Nuclear Facility utilizing the NASA Airborne Oceanographic Lidar (AOL) are presented. The flights were conducted in support of the numerous environmental monitoring requirements associated with the operation of the facility and for the purpose of furthering research and development of airborne lidar technology. Areas of application include airborne laser topographic mapping, hydrologic studies using fluorescent tracer dye, timber volume estimation, baseline characterization of wetlands, and aquatic chlorophyll and photopigment measurements. Conclusions relative to the usability of airborne lidar technology for the DOE for each of these remote sensing applications are discussed. (Author abstract) 16 refs.

Krabill, William B. (NASA, Goddard Space Flight Cent, Wallops Island, VA, USA); Swift, Robert N. *NASA Tech Memo* 4007 1987 91p.

**RADAR RECEIVERS See Also SIGNAL DETECTION—Analysis.**

#### Analysis

**087691 PERFORMANCE ANALYSIS OF CA-CFAR IN THE PRESENCE OF COMPOUND GAUSSIAN CLUTTER.** Exact expressions are derived for the (ROCs) of a CA-CFAR radar processor subject to both internal noise and clutter (the last one modelled as compound Gaussian). They include previously known ROCs, e.g. for ideal CFAR. The effect of finite sample size is elicited in the example of K-distributed clutter. (Edited author abstract) 4 refs.

Conte, E. (Univ di Napoli, Naples, Italy); Longo, M.; Lops, M. *Electron Lett* v 24 n 13 Jun 23 1988 p 782-783.

**087692 ITERATIVE METHOD FOR RANGE SIDELobe SUPPRESSION FOR BINARY CODES.**

Binary phase coded waveforms are widely used in modern radar systems. In linear receivers the sidelobes present at the output of the compression filter cause a reduction of the useful dynamic range. The method presented is an iterative process where the process of inversion is repeated a number of times to reduce the output sidelobes. (Edited author abstract) 7 refs.

Abbasi, Z.A. (ZH Coll of Engineering & Technology, Aligarh, India). *Electron Lett* v 24 n 14 Jul 7 1988 p 889-890.

**Design See RADAR TRANSMITTERS—Design.**

#### Measurements

**087693 OBJECTIVE MEASUREMENT OF RECEIVER SENSITIVITY.** The sensitivity of radar receivers is checked with a pulsed radio frequency signal which is adjusted until the observed magnitude is distinguishable from the background noise level as displayed on an oscilloscope. Because of the noisy nature of the display the results are highly subjective, but by eliminating the idiosyncratic element, a calibration instrument has been designed to give a rapid and accurate presentation to the operator. (Author abstract) 3 refs.

Wyndham, B.A. (Royal Signals & Radar Establishment, Malvern, Engl); Nichols, T.B. *Electron Lett* v 23 n 25 Dec 3 1987 p 1388-1389.

#### Noise, Spurious Signal

**087694 INFLUENCE OF RECEIVER CROSS-MODULATION ON ATTAINABLE HF RADAR DYNAMIC RANGE.** The performance of an HF radar system should ideally be limited by environmental factors as opposed to instrumental limitations. In this study the influence of one such limitation, receiver cross-modulation, is quantitatively assessed. An expression is derived for the attainable dynamic range, relating it to the receiver's linearity and the signal environment in which it is required to operate. In common with cross-modulation experienced in other receiving systems, the dynamic range is independent of the strength of the desired signal. In the context of HF radar this means that should the system performance be limited by cross-modulation, any increase in signal and clutter levels achieved through increased radiated power will be accompanied by a corresponding increased noise floor. The system would remain internally noise-limited, and any potential increase in sensitivity would not be realized. 7 refs.

Earl, George Frederick (Defence Science & Technology Organization, Adelaide, Aust). *IEEE Trans Instrum Meas* v IM-36 n 3 Sep 1987 p 776-782.

**Optimization See Also SIGNAL DETECTION—Optimization.**

**087695 SUBOPTIMUM ADAPTIVE POLARISATION CANCELLERS FOR DUAL-POLARISATION RADARS.** Some suboptimum adaptive polarisation techniques for the cancellation of partially polarised disturbances are analysed. They are based on suitable use of the estimates of the crosscorrelation between the dual-polarisation received signals. The performances of these techniques are evaluated and compared with that of the optimum setting of polarisation on reception. It is shown that the performances of the suboptimum techniques are affected by a quite limited cancellation loss, and related to the antenna polarisation basis used on reception. Some implementation aspects of these techniques are discussed. (Edited author abstract) 20 refs.

Gherardelli, M. (Univ degli Studi di Firenze, Florence, Italy); Giuli, D.; Fossi, M. *IEE Proc Part F* v 135 n 1 Feb 1988 p 60-72.



**RADAR SYSTEMS** See Also SIGNAL FILTERING AND PREDICTION—Kalman Filtering.

**087696 MODELING OF RADAR SIGNALS.** When modeling the processing of signals in a radar system with synthesized aperture it is necessary to form the array of samples of the deterministic component of the signals received. This paper proposes scalar relationships that are convenient to use in developing a program to calculate the distance,  $R(t)$ , between the radar unit and a point target, for the very common variant in which the radar vehicle is in a circular orbit. 2 refs.

Goryachev, N.A. *Radioelectron Commun Syst* v 30 n 7 1987 p 81-83.

**087697 DOPPLERECHOS VON KRAFTFAHRZEUGEN IM UEBERHOLVORGANG.** [Doppler Echoes of Overtaking Maneuvers]. It is difficult to measure the speed of two vehicles by traffic-radar systems, if one of them is passing the other. This is due to problems in both separating the two different signal contributions and relating them to the corresponding vehicles. This paper analyzes Doppler echoes of overtaking maneuvers, which were recorded under conditions exactly defined. Furthermore, different methods of evaluation are discussed. (Author abstract) In German. 3 refs.

Schilling, Juergen (Technische Hochschule Darmstadt, West Ger). *Frequenz* v 42 n 1 Jan 1988 p 14-21.

**087698 INVARIANT GROUP METHOD FOR IDENTIFYING TARGET POSITIONS IN TRIANGULATING, MULTIPosition PASSIVE RADAR SYSTEMS.** Using the invariants of a local, one-parameter, continuous shift group, a new approach is developed for identifying target positions in triangulating, multiposition passive radars. Compared with existing methods, the new approach significantly reduces the required computer time. The probability characteristics of the method are given. (Author abstract) 10 refs.

Bulychev, Yu.G.; Taran, V.N. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 107-115.

**087699 POLARIZATION PROCESSING OF SIGNALS IN MULTICHANNEL TRANSMITTING-AND-RECEIVING SYSTEMS.** In the analysis of multichannel transmitting-and-receiving systems for processing space-time signals, the possibility of increasing the information content by employing differences in the polarization structure of the signals and noise was not studied in most papers. At the same time, it is well known that during active detection the quality of the operation of the entire system can be improved by optimizing the polarization parameters of the sounding signal and the subsystem used for processing the received signal. The authors show that for certain ratios of the polarization parameters of the useful and noise signals, polarization processing enables one to suppress the noise from the external source effectively, even in the case when both the target and the interference source are located along close or identical spatial directions. 5 refs.

Radziyevskiy, V.G.; Myazitova, L.Sh. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 157-160.

**087700 PROCEEDINGS OF THE 1988 IEEE NATIONAL RADAR CONFERENCE.** This proceedings contains 46 papers by various authors. The following topics are dealt with: radar systems and subsystems; radar techniques; synthetic-aperture radar (SAR); radar signal processing; millimeter-wave radars; radar scattering from sea surfaces; geophysical measurements; radar target detection in clutter environments; and modeling of radar-target signatures. Abstracts of individual papers can be found under the relevant classification. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11607 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEEE, Aerospace Systems Soc, Radar Systems Panel, USA). *Proc of the 1988 IEEE Natl Radar Conf, Ann Arbor, MI, USA, Apr 20-21 1988* Publ by IEEE,

New York, NY, USA, 1988. Available from IEEE Service Cent (cat n 88CH2572-6), Piscataway, NJ, USA 254p.

**Calibration**

**087701 USING THE SUN TO CHARACTERIZE RADAR SYSTEMS.** Solar electromagnetic radiation can be used as an external, calibration rf source for measuring radar-system performance parameters. A simply derived criterion will tell radar users if their system can be evaluated in this manner. Fortunately, this criterion is defined in terms of the parameters of the radar itself, and, therefore, is applicable to any radar system.

Doty, Arnold (EG&G Special Projects, Las Vegas, NV, USA). *Microwaves RF* v 26 n 10 Oct 1987 p 133-134.

**087702 SIR-B IMAGE CALIBRATION BY A CORNER REFLECTOR ARRAY.** SIR-B image data taken over a corner reflector array are analyzed to calibrate the image and to estimate the 3 dB resolution. Square trihedral corner reflectors having different radar cross-sections (RCSs) are successfully used to relate an image data number to RCS. RCS of the background surface is estimated and its effect is also included in the above relation. The 3 dB resolutions are estimated by two independent techniques. The results obtained from the two techniques agree with each other within their relative difference by 5.6 percent except for one case. The estimated resolutions are larger than those predicted by the Jet Propulsion Laboratory. The estimates should be regarded as the image resolutions and do not represent the sensor characteristics. (Author abstract) 9 refs.

Fujita, Masaharu (Kashima Space Research Cent, Kashima, Jpn); Naito, Hideyuki; Fugono, Nobuyoshi. *Int J Remote Sens* v 9 n 5 May 1988 p 849-856.

**Computer Applications** See SIGNAL PROCESSING—Digital Techniques.**Mathematical Models**

**087703 ANGULAR COORDINATE ESTIMATION IN THE PRESENCE OF SPATIALLY CORRELATED INTERFERENCE IN ADAPTIVE RADAR SYSTEMS.** The exact solutions of the likelihood equation are used to derive algorithms for estimating angular coordinates with correction and stabilization of direction-finding characteristics. These algorithms are shown to be naturally consistent with a broad class of adaptation procedures for a detection channel. (Author abstract) 7 refs.

Zhuravlev, A.K. *Sov J Commun Technol Electron* v 32 n 2 Feb 1987 p 16-23.

**Measurements**

**087704 EINFLUSS DER OSZILLATOR-KURZZEITSTABILITAET AUF DIE MESSGENAUIGKEIT VON CW-DOPPLERRADARGERAETEN.** [Effect of Oscillator Short-term Stability on the Measurement Accuracy of CW Doppler Radar Systems]. A limiting factor for the accuracy of speed measurements with a CW radar system is the short-term frequency stability of the oscillator. The evaluation of measurements made at 35-GHz oscillators shows, that the influence is negligible for short ranges, whereas it can cause problems for greater ranges. (Author abstract) In German. 5 refs.

Kadel, Gerhard (Technische Hochschule Darmstadt, West Ger). *Frequenz* v 42 n 1 Jan 1988 p 21-23.

**Military Applications**

**087705 COMPUTERS IN AIR DEFENCE.** The advent of radar signified a major advance in air defense technology and techniques. Rather than depend on visual observation and the hazards and limitations thereof, it became possible with radar to detect the presence of flying objects at much greater distances. The PPI display of a conventional air-surveillance radar permits an operator to scan the sky for several hundreds of kilometers all around.

Early radar-based air defense systems were dependent on human observation and decision making for detecting targets, identifying them, deciding on interception strategy and for recovering the interceptor after completion of his mission. This was feasible because, with a radar range of between 200 to 400 kilometers and aircraft speeds in the range of 500 kilometers per hour, up to 30 minutes warning was available before the target was overhead. (Edited author abstract)

Rao, P.V.S. (Tata Inst of Fundamental Research, Bombay, India). *Def Sci J* v 37 n 4 Oct 1987 p 507-513.

**Millimeter Waves** See Also RADAR—Meteorological; SNOW AND SNOWFALL—Remote Sensing.

**087706 DESIGN AND PERFORMANCE OF A 215 GHz PULSED RADAR SYSTEM.** A high-power 215-GHz pulsed radar system developed for remote-sensing applications is described that is capable of making backscatter measurements from terrain targets at ranges of several kilometers under normal atmospheric conditions. By using separate transmit and receive antennas, the amplitudes of the polarization matrix elements may be measured conveniently. A dedicated data acquisition system was developed allowing up to 15 range gates to be sampled at 100-ns intervals. Instrument stability of  $\pm 1.0$  dB yields accurate scattering measurements of a variety of terrestrial targets. System performance and calibration, together with measurements of snow backscatter coefficients made during early 1987, are discussed. 10 refs.

McIntosh, Robert E. (Univ of Massachusetts, Amherst, MA, USA); Narayanan, Ram M.; Mead, James B.; Schaubert, Daniel H. *IEEE Trans Microwave Theory Tech* v 36 n 6 Jun 1988 p 994-1001.

**087707 RAIN BACKSCATTER MEASUREMENTS AT MILLIMETER WAVELENGTHS.** The US Army Ballistic Research Laboratory (BRL) conducted an experiment in 1973 to measure the properties of radar backscatter from rain at millimeter wavelengths. Rain backscatter and attenuation were measured with pulse radars operating simultaneously at 9.375, 35, 70, and 95 GHz over a wide range of rain intensities while continuous measurements of raindrop size and rainfall rate were made. This report describes the measurement technique, details of the instrumentation, the data analysis procedure, and the rain backscatter data obtained from A-scope photographs and video tapes. 2 refs.

Richard, Victor W. (US Army Ballistic Research Lab, Aberdeen Proving Ground, MD, USA); Kammerer, John E.; Wallace, H. Bruce. *IEEE Trans Geosci Remote Sens* v 26 n 3 May 1988 p 244-252.

**Optimization**

**087708 OPTIMIZING SPACE PROCESSING OF SIGNALS IN A TWO-POSITION RADAR SYSTEM.** The utilization of diversity radar systems broadens the possibilities for spatial selection of signals and interference. We consider such selection in application to a short-base radar system with the aim of increasing the snr in detection of signals from remote targets in a background of passive interference (PI) from nearby reflectors. The need for utilization of such selection arises when the probe-pulse repetition frequency is high,  $F > c/2R_M$  ( $R_M$  is the maximum detection range;  $c$  is the wave propagation velocity) owing to superposition of short-range PI on the signals of remote target, making it impossible to implement time selection. We consider a two-position radar system with base  $b < R_M$  in which scanning is carried out by synchronous rotation of the receiving (Rc) and transmitting (T) antennas at constant angular velocity  $\Omega$ . 2 refs.

Ryndyk, A.G. *Radioelectron Commun Syst* v 30 n 9 1987 p 103-105.



## RADAR TRANSMITTERS

**087709 20 kW SOLID-STATE L-BAND TRANSMITTER FOR THE RAMP PSR RADAR.** A program known as the radar modernization project (RAMP) will replace all of Canada's primary and secondary surveillance radars used for air traffic control. Each of Canada's 22 major airports will have a terminal surveillance radar (TSR) site consisting of both primary (PSR) and secondary (SSR) surveillance radars. The use of L-band transmitters is discussed, covering the transmitter architecture, power amplifier modules, transistor device and circuits, and 1:14 divider/combiner. It is concluded that high-power solid-state transmitters at L band are realizable and competitive, offering improved performance, reliability, availability and maintainability compared to tube transmitters. As the cost of L-band transistor devices decreases and clever, cost-effective design techniques evolve, they can be expected to become even more competitive. 2 refs.

Merrill, Philip R. (Raytheon Co, Wayland, MA, USA). *Microwave J* v 31 n 3 Mar 1988 p 165-166, 168-173.

## Design

**087710 MMIC T/R MODULES AND APPLICATIONS.** Transient/receive (T/R) modules for phased array radars are examined from the viewpoint of the designer and of the purchaser. The systems that use T/R modules are described, and system-imposed constraints on module design are considered. The layout of a typical module is described in detail. 13 refs.

Chilton, R. Hunter (US Air Force Rome Air Development Cent, Griffiss AFB, NY, USA). *Microwave J* v 30 n 9 Sep 1987 8p between p 131 and 146.

**087711 X-BAND GaAs SINGLE-CHIP T/R RADAR MODULE.** The authors report on the development of a fully functional T/R (transmit/receive) module that integrates all RF functions onto a single chip of GaAs. They discuss circuit design, fabrication and RF performance. The module has shown good RF performance and DC yields.

Wisselman, W.R. (Texas Instruments Inc, Dallas, TX, USA); Witkowski, L.C.; Brehm, G.E.; Coats, R.P.; Heston, D.D.; Hudgens, R.D.; Lehmann, R.E.; Macksey, H.M.; Tsering, H.Q. *Microwave J* v 30 n 9 Sep 1987 p 167-170, 172-173.

**Measurements** See MILLIMETER WAVES—Propagation.

**RADIATION CHEMISTRY** See Also ACIDS—Chemical Reactions; ALKALI METAL COMPOUNDS—Radiation Effects; BENZENE—Radiation Effects; CHEMICAL REACTIONS—Synthesis; DOSIMETERS—Standards; DOSIMETRY; ETHANOL—Radiation Effects; FLUORINE—Radiation Effects; FLUORINE CONTAINING POLYMERS—Grafting; FLUOROHYDROCARBONS—Chemical Reactions; GLASS—Radiation Effects; HYDROCARBONS—Radiation Effects; IONS—Transport Properties; IRON COMPOUNDS—Radiation Effects; METHANOL—Oxidation; MOLYBDENUM COMPOUNDS—Chemical Reactions; NITROGEN—Radiation Effects; NUCLEIC ACIDS—Radiation Effects; ORGANIC COMPOUNDS—Radiation Effects; ORGANIC COMPOUNDS—Reaction Kinetics; ORGANIC COMPOUNDS—Synthesis; POLYETHYLENES—Molten; POLYMERS—Radiation Effects; RADIOACTIVE MATERIALS—Chemical Analysis; SEPARATION; SODIUM CHLORIDE—Radiation Effects; SOLUTIONS—Radiation Effects; WATER—Radiation Effects.

**087712 STUDY OF GEMINATE ION RECOMBINATION IN A SOLUTE-SOLVENT SYSTEM BY USING PICOSECOND PULSE RADIOLYSIS.** Kinetics behavior of geminate ion recombination in solute-solvent system such as biphenylcyclohexane system, was studied by using a picosecond pulse radiolysis. Experimental data of the geminate ion recombination agreed with theoretical time-behavior obtained by a new treatment which extends the Smolouchowski equation to the system in the presence of the solute. (Author abstract) 18 refs.

Yoshida, Y. (Univ of Tokyo, Tokai-mura, Jpn); Tagawa,

S.; Kobayashi, H.; Tabata, Y. *Radiat Phys Chem* v 30 n 2 1987 p 83-87.

**087713 EFFECTS OF HEAT AND RADIATION ON MAMMALIAN CELLS.** The well known naturally occurring antioxidant systems (reduced glutathione, superoxide dismutase, catalase and glutathione peroxidase) are not found to act as the main protective systems of the cell against hyperthermic cell killing. Evidence is presented that it is not the lipids of the membrane, but probably the membrane proteins which are critical primary molecular targets for hyperthermia. The readily peroxidizable polyunsaturated fatty acyl (PUFA) chains of phospholipids may be target molecules for radiation damage leading to interphase death but not leading to reproductive death. Repair of radiation-induced DNA lesions is probably the critical event in cell survival after radiation. This process is inhibited by hyperthermia. The synergism observed as a consequence of the interaction of heat and radiation may not always be explained by the rate of repair of DNA breaks. Especially in the case of fractionated heat treatments (inducing a state of thermotolerance) the situation seems more complicated. Heat-induced inactivation of DNA repair enzymes as well as heat-induced structural changes in chromatin (enhanced protein binding) may be processes that become critical. Thermotolerance does not always interfere with the process of heat radiosensitization. (Edited author abstract) 72 refs.

Konings, A.W.T. (Univ of Groningen, Groningen, Neth). *Radiat Phys Chem* v 30 n 5-6 1987 p 339-349.

**087714 MEMBRANE STRUCTURE AND RADIATION AND HYPERTHERMIC DAMAGE.** The general structure of the biological membrane and its involvement in cell damage from radiation and hyperthermic insults are discussed using bacterial cells as an example. Bacterial cells are useful models for these types of studies because they possess a simple membrane system whose composition can be readily altered. Also, various strains exist having different sensitivities to radiation and heat. The cell membrane, particularly the lipid component, is an important target in hyperthermic cell killing. The composition and organization of the membrane lipids can influence a cell's response to heat. Heat-induced changes in membrane lipids lead to altered distribution of E. coli proteins, particularly their translocation to the outer membrane. These and other aspects are discussed in this review. (Edited author abstract) 178 refs.

Yatvin, Milton B. (Univ of Wisconsin-Madison, Madison, WI, USA); Grummer, Mary A. *Radiat Phys Chem* v 30 n 5-6 1987 p 352-364.

**087715 PHYSICO-CHEMICAL BASIS OF RADIOSENSITIZATION BY IODINE COMPOUNDS.** In the field of biological radiation sensitization, iodine-containing sensitizers (ICS) can display various mechanisms of sensitization, namely biochemical, radiation-chemical and physical. A discussion in this regard includes the following topics: the historical background; the biochemical mechanisms of sensitization; the radiation chemical mechanism of sensitization (cell survival experiments, end points different from survival, and model and radiation chemical experiments); and sensitization through increase in absorbed dose. 68 refs.

Quintiliani, M. (CNR, Rome, Italy). *Radiat Phys Chem* v 30 n 5-6 1987 p 409-422.

**087716 MECHANISM OF RADIOSENSITIZATION BY ELECTRON-AFFINIC COMPOUNDS.** 'Electron-affinic' radiosensitizers generally mimic oxygen in modifying cellular radio-sensitivity, although not necessarily by the same molecular mechanisms. Useful mechanistic probes include quantitative relationships between chemical properties and efficacy, although the latter can usually be expressed only in terms of extracellular concentrations. The response vs concentration curves can also provide a test of a mechanistic model. Some possible mechanisms of radiosensitization are outlined: sensitization of damage from direct energy absorption; oxidation of radicals on the sugar/phosphate backbone of DNA;

oxidation of base radicals; and radiation-induced binding of radiosensitizers. Each model is approached from the viewpoint of the known redox relationships with radiosensitizers and competition with thiols which serve to reduce the effect. (Author abstract) 114 refs.

Wardman, Peter (Mount Vernon Hospital, Northwood, Engl). *Radiat Phys Chem* v 30 n 5-6 1987 P 423-432.

**087717 STOCHASTIC CALCULATIONS OF THE FAST DECAY OF THE HYDRATED ELECTRON IN THE PRESENCE OF SCAVENGERS - TESTS OF MODEL CONSISTENCY.** An excellent test of the efficacy of computer codes simulating the nanosecond diffusion and interaction of radiation-produced radicals is their ability to predict a broad range of data - for example time-dependent yields with and without scavengers. Using a Monte-Carlo transport code for the radiation-production of radicals in liquid water, together with a stochastic calculation of their interaction and decay, we investigate this point. Consistent use of these techniques yields, without adjustable parameters, the shape and absolute magnitude of the time decay of the hydrated electron in pure water, and also the measured time decay in the presence of both hydroxyl and hydrogen ion scavengers. (Author abstract) 33 refs.

Brenner, D.J. (Columbia Univ, New York, NY, USA). *Radiat Phys Chem* v 32 n 2 1988 p 157-162.

**087718 RADICAL-INDUCED OXIDATION OF GLUTATHIONE IN ALKALINE AQUEOUS SOLUTION.** The reactions of radicals of  $N_3$ ,  $CO_3^{•-}$ , and ROH with glutathione have been studied in basic aqueous solution. Whereas only the sulfur-centered GS radical is produced by the one-electron oxidants of the radicals of  $N_3$  and  $CO_3^{•-}$ , a strongly reducing radical is formed in pH-dependent yield by the radical of ROH and OH. The data are explained by pH-dependent conformational changes of glutathione on deprotonation of the amino and thiol groups. (Edited author abstract) 17 refs.

Eriksen, Trygve E. (Royal Inst of Technology, Stockholm, Sweden); Fransson, Gunilla. *Radiat Phys Chem* v 32 n 2 1988 p 163-167.

**087719 RADIATION-ENERGY PARTITION AMONG MIXTURE COMPONENTS: CURRENT IDEAS ON AN OLD QUESTION.** We review the basis of the familiar idea that the energy partitions among mixture components in the initial stage would be governed by the total electron fraction. For considerations of many problems in radiation chemistry, it is better to use the valence-electron fraction. We also point out recent developments in more detailed treatments, which indicate limitations of the very concept of the energy partition for the determination of the yields of initial molecular species that appear under irradiation. (Author abstract) 29 refs.

Swallow, A. John (Christie Hospital & Holt Radium Inst, Manchester, Engl); Inokuti, Mitio. *Radiat Phys Chem* v 32 n 2 1988 p 185-189.

**087720 RADIATION CHEMICAL AND MAGNETIC RESONANCE STUDIES OF AQUEOUS AGAROSE GELS CONTAINING FERROUS IONS.** Aqueous agarose gels containing ferrous ions sustain a radiolytic chain reaction, producing  $Fe^{3+}$ .  $G(Fe^{3+})$ -values up to 156 have been observed, independent of dose rate between 0.434 and 3.74 Gy  $min^{-1}$ . Dissolved oxygen is needed to maintain the chain reaction, and initial ferric yields are increased if the gel is oxygen saturated, or if the  $Fe^{2+}$  concentration is decreased. Longitudinal proton magnetic relaxation rates are increased in proportion to ferric production, permitting visualizing of dose levels in these gels by magnetic resonance imaging techniques. There is a potential for applications to radiation therapy treatment planning. (Author abstract) 7 refs.

Appleby, A. (Rutgers State Univ of New Jersey, New Brunswick, NJ, USA); Leghrouz, A.; Christman, E.A. *Radiat Phys Chem* v 32 n 2 1988 p 241-244.



**087721 APPLICATION OF RADIATION CHEMISTRY FOR CONSERVATION OF ARCHEOLOGICAL WATERLOGGED WOOD AND OSTEOLOGICAL OBJECTS.** The application of radiation chemistry to the conservation of archaeological objects is described. Methyl methacrylate is introduced into the voids of the objects to be conserved either by an exchange process or - if allowed by the mechanical strength of the object - by vacuum impregnation. It is neither necessary nor desirable to fill the object completely with the monomer that is subsequently polymerized with  $^{60}\text{Co}$   $\gamma$ -rays. (Author abstract) 24 refs.

Gaumann, Tino (ETH, Lausanne, Switz); Kowalski, Thomas S.; Menger, Andre. *Radiat Phys Chem* v 32 n 2 1988 p 275-280.

**087722 ESR STUDIES OF ION-MOLECULE REACTIONS OF ETHER, THIOETHER, AND OLEFIN RADICAL CATIONS IN THE  $\text{CF}_2\text{ClCFCl}_2$  MATRIX.** Several ion-molecule reactions of radical cations with their corresponding neutral molecules have been studied by ESR spectroscopy. The reactions were observed at low temperatures (80-130 K) in a mobile halocarbon matrix following the radiolytic generation of the radical cations from dilute solutions of the parent compound at 77 K. Although the end results of each reaction is the formation of a neutral radical, the mechanism can be formulated either as a proton transfer from the radical cation or as a hydrogen atom transfer from the neutral molecule, the reaction products being the same in each case. 51 refs.

Williams, Francon (Univ of Tennessee, Knoxville, TN, USA); Qin, Xue-Zhi. *Radiat Phys Chem* v 32 n 2 1988 p 299-308.

**087723 SODIUM-WATER CLUSTERS AND THEIR ROLE IN RADIATION CHEMISTRY.** Studies of sodium-water clusters are presented which could serve as models for the recently suggested intermediate species in the radiation chemistry of water. The ionization potentials and the lower excited states of sodium with  $n$ -water molecules are calculated by ab initio quantum chemistry methods. The ionization potential calculated at the SCF level for the water monomer is 4.10 eV, which becomes 4.34 at the MP2 correlation level. The experimental value is 4.379 $\pm$ 0.002 eV. Structural data is presented for the lower members of the sodium with  $n$ -water clusters. In addition the Hartree-Fock calculations indicate that there should be some strong charge transfer to solvent transitions at higher energies. (Author abstract). 19 Refs.

Dhar, S. (Louisiana State Univ, Baton Rouge, LA, USA); Kestner, Neil R. *Radiat Phys Chem* v 32 n 3 1988 p 355-360.

**087724 GAS-PHASE AND SOLUTION MECHANISM OF THE ISOTOPE EXCHANGE REACTION  $\text{OH}^- + \text{D}_2 = \text{OD}^- + \text{HD}$ : BEAM STUDY OF THE SOLVATED-ION REACTION  $\text{OH}^- \cdot \text{H}_2\text{O} + \text{D}_2$  IN THE COLLISION ENERGY RANGE 0-2 eV.** In a tandem mass spectrometer we have measured the excitation functions (reaction cross section as a function of collision energy) for the following solvated-ion reactant pairs:  $\text{OH}^- \cdot (\text{H}_2\text{O}) + \text{H}_2$ ;  $\text{OD}^- \cdot (\text{D}_2\text{O}) + \text{D}_2$ ; and  $\text{OH}^- \cdot (\text{H}_2\text{O}) + \text{D}_2$  - in the collision energy range 0-2 eV. Product channels include  $\text{H}_3\text{O}^-$ -type production, collision-induced dissociation of reactants and products ( $\text{OH}^-$  and  $\text{H}^-$  types) and isotopic mixing. These solvated-ion reactions are used to correlate the reactivity of the isotope exchange reaction  $\text{OH}^- + \text{D}_2 \rightarrow \text{OD}^- + \text{HD}$  occurring in the gas phase and solution, identifying a proton-transfer mechanism occurring within  $\text{H}_3\text{O}^-$  intermediate. (Author abstract). 27 Refs.

Henchman, Michael (Brandeis Univ, Waltham, MA, USA); Paulson, F. *Radiat Phys Chem* v 32 n 3 1988 p 417-423.

**087725 RADIATION-INDUCED REDUCTION OF VANADIUM(IV) TO VANADIUM(II) IN AQUEOUS PICOLINATE-FORMATE SOLUTIONS.** Quantitative reduction of  $\text{V(IV)(pic)}_n$  to  $\text{V(III)(pic)}_n$ , and then to

$\text{V(II)(pic)}_n$  ( $1 \leq n \leq 3$ ) occurs when  $\text{N}_2\text{O}$ -saturated formate solutions (pH 4.2-6.3) containing  $\text{V(IV)}$  and picolinic acid (2-carboxypyridine) are irradiated. Pulse radiolysis measurements show that  $\text{CO}_2^{\text{MIN}}$  reacts with picolinate only when the N-atom is protonated ( $k = 2.7 \times 10^8 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$ ). Reduction of  $\text{V(IV)(pic)}_n$  and  $\text{V(III)(pic)}_n$  is effected by the electron adduct of the protonated picolinate ( $\text{picH}^-$ ) with rate constraints at pH 4.2 of  $(3.5 \pm 0.2) \times 10^7 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$  for  $\text{V(IV)(pic)}_n$  and  $(6.9 \pm 0.4) \times 10^8 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$  for  $\text{V(III)(pic)}_n$ . No reduction of  $\text{V(II)(pic)}_n$  is observed. (Author abstract). 8 Refs.

Al-Hayali, Lamann J.H. (Univ of Leeds, Leeds, Engl); Buxton, George V. *Radiat Phys Chem* v 32 n 3 1988 p 425-428.

**087726 SPECTRAL AND KINETIC PROPERTIES OF INTERMEDIATES INDUCED BY REACTION OF HYDRATED ELECTRONS WITH ADENINE, ADENOSINE, ADENYLIC ACID AND POLYADENYLIC ACID: A MULTICOMPONENT ANALYSIS.** The overlapping transient optical absorption spectra obtained from pulse radiolysis experiments in which the hydrated electron reacted with adenine, adenosine, 5'-adenosine monophosphate and polyadenylic acid were measured and analysed. The analysis consists of a multi-component analysis which yields the number of different species and a set of orthonormal basis spectra. From this set of basis spectra together with a number of trial models for the possible kinetics of the different species the best model is determined by fitting the original data. In this way the molar absorptivity spectra and the kinetics of the species can be found. To describe all the spectra of the adenine-containing compounds in a consistent way we need, at most, three different species. (Author abstract). 20 Refs.

Visscher, Kees J. (Vrije Univ de Boelelaan, Amsterdam, Neth); Hom, Marinus; Loman, H.; Spoelder, Hans J.; Verberne, J.B. *Radiat Phys Chem* v 32 n 3 1988 p 465-473.

**087727 INTERACTION OF RADIATION-GENERATED RADICALS WITH MYOGLOBIN IN AQUEOUS SOLUTION-VI REDUCTION OF FERRIMYOGLOBIN BY  $\alpha$ -HYDROXYALKYL RADICALS.** G-values of the formation of ferromyoglobin (Mb) have been determined for the continuous  $\gamma$ -radiolysis of  $\text{N}_2\text{O}$ -saturated neutral aqueous solutions containing ferromyoglobin (Mb) and a series of aliphatic alcohols (RH) under conditions such that the competition for the primary  $\cdot\text{OH}$  radicals favors RH. A comparison of the efficiencies of reduction of Mb by the secondary organic radical formed via H-abstraction reactions with estimates from the literature of the fraction of  $\cdot\text{OH}$  attack at the C-atom  $\alpha$  to the  $\cdot\text{OH}$  group indicates that  $\alpha$ -hydroxyalkyl radicals are primarily responsible for the observed reduction. Significantly lower reduction yields are observed when RH = 1,2-diol, compared with the expected yields of strongly reducing 1,2-dihydroxyalkyl radicals; the initial reducing radicals convert into inactive  $\beta$ -ketoanion analogues so that the reduction of Mb is not kinetically competitive with the  $\beta$ -elimination process. Mb is useful as a probe of the occurrence of occurrence of slow conversion processes involving radiolytically-generated radicals. (Author abstract). 27 Refs.

Whitburn, Kevin D. (Framingham State Coll, Framingham, MA, USA); Hoffman, Morton Z. *Radiat Phys Chem* v 32 n 3 1988 p 487-491.

**087728 RELATIONSHIP BETWEEN GAS PHASE AND LIQUID PHASE ELECTRON PHOTODETACHMENT CROSS SECTIONS IN THE THRESHOLD REGION: APPLICATION TO ANTHRACENE AND PERFLUOROBENZENE ANIONS.** Previously we have presented a theory linking negative ion photodetachment cross-section data in the gas phase with that in the liquid. We combine this theory with applicable liquid phase data to estimate the gas phase threshold cross sections for electron photodetachment from perfluorobenzene and anthracene anions. (Author abstract). 26 Refs.

Baird, James K. (Univ of Alabama in Huntsville, Huntsville, AL, USA); Schuman, Thomas P. *Radiat Phys Chem* v 32 n 3 1988 p 493-496.

**087729 NANOSECOND PULSE RADIOLYSIS INVESTIGATION OF SOLUTE EXCITED STATES FORMATION IN 3-METHYLPENTANE AT LOW TEMPERATURES.** The influence of temperature down to 90 K, on the formation of excited states in the nanosecond pulse radiolysis of aromatic solutes (9,10-diphenylanthracene, naphthalene) in 3-methylpentane was investigated. Lowering the temperature decreases the yield of solute singlets and triplets generated during the pulse and extends the time range of excited state formation up to milliseconds. The mechanism of solute excited state formation in irradiated saturated hydrocarbons is discussed. (Author abstract). 41 Refs.

Mayer, J. (Technical Univ, Lodz, Pol); Szadkowska-Nicze, M.; Kroh, J. *Radiat Phys Chem* v 32 n 3 1988 p 519-524.

**087730 NATURE OF THE TRANSITIONS COMPRISING THE OPTICAL ABSORPTION SPECTRA OF SOLVATED ELECTRONS.** The theory of photoejection spectra of molecular anions is adapted for application to analyses of optical absorption data of solvated electrons in a number of different solvents. The results obtained generally support the identification of solvated electron optical absorption spectra entirely as bands of bound-to-continuum transitions and not as bound-to-bound transitions. Analyses of the absorbance behavior near the threshold for absorption lead to the conclusion that the solvated electron ground state deviates appreciably from spherical symmetry. Alternatively, the solvated electron ground state in  $\text{ND}_3$  may be nearly spherically symmetric with a thermally accessible excited state of lower symmetry. ? (Author abstract). 43 Refs.

Tuttle, Thomas R. Jr (Brandeis Univ, Waltham, MA, USA); Golden, Sidney; Rosenfeld, Glen. *Radiat Phys Chem* v 32 n 3 1988 p 525-535.

**087731 REACTIVITY OF H, OH AND  $e_{\text{aq}}^-$  WITH NICOTINIC ACID: A PULSE RADIOLYSIS STUDY.** The reactivity of aqueous nicotinic acid (NA) towards  $\text{OH}$ ,  $e_{\text{aq}}^-$  and H-atoms has been investigated in the pH-range 0.3-13.8. The OH attack on NA [ $k = (2.5 \pm 0.2) \times 10^9 \text{ M}^{-1} \text{ s}^{-1}$ ] and its N-protonated forms [ $k = (2.2 \pm 0.2)$ ] gives OH-adducts with pH-dependent optical spectra. The reaction of H-atoms with NA in the pH-range 6-12 [ $k = (6.0 \pm 0.5) \times 10^8 \text{ M}^{-1} \text{ s}^{-1}$ ] results in the formation of one type of transient, the H-Adducts on ring carbons ( $\gamma_{\text{max}} = 315 \text{ nm}$ ,  $\epsilon_{315} = 4500 \pm 200 \text{ M}^{-1} \text{ s}^{-1}$ ;  $\text{pK} = 6.7 \pm 0.2$ ). With the N-protonated forms of NA, however, two kinds of radicals are produced pyridinyl and H-adduct on ring carbons. The reaction of  $e_{\text{aq}}^-$  with NA was reinvestigated. The kinetic and spectroscopic data are in good agreement with those previously reported. (Edited author abstract). 25 Refs.

Solar, S. (Univ Wien, Vienna, Austria); Solar, W.; Getoff, N.; Holcman, J.; Sehested, K. *Radiat Phys Chem* v 32 n 3 1988 p 585-592.

Analysis See BIOLOGICAL MATERIALS—Radioactivity.

## Applications

**087732 MULTIPLE USES OF A JS 7400.** A radiation processing plant is described. It started operation in 1980, and the aim was to sell sterilization services of medical supplies to industries. Due to an economical recession in Brazil there was a fall in this market and as a consequence an occupancy 50% resulted. We had then to search for new markets in the field of high dose irradiation. The market had to be widened to a diversity of materials with a wide dose range. The materials to be irradiated are: potatoes and onions for sprout inhibition; tropical fruits for desinfection; dry foods and raw material for radurization; medical products for sterilization; impregnation of wood for wood polymer compound; diodes for the electronic industry; and gem stones for color changes. In order to attend such a wide range of doses special



arrangements and irradiation positions had to be developed at the plant. 4 refs.

Hutzler, R.U. (Embrarad Empresa Brasileira de Radiacoes SA, Sao Paulo, Braz); Vizeu, D.M. *Radiat Phys Chem* v 31 n 1-3, Progr in Radiat Process, Proc of the 6th Int Meet, Ottawa, Ont, Can, May 31-Jun 5 1987 p 357-361.

**Bibliographies** See NUCLEIC ACIDS—Radiation Effects.

## Denmark

**087733 APPROVAL AND CONTROL OF RADIATION PROCESSES, EB AND GAMMA.** The documentation which is needed for approval of radiation treated products includes a facility description and an initial plant commissioning procedure. The description of the facility must put particular emphasis on those parameters which in effect determine the dose in the product. For a gamma plant these are source strength and geometry, product conveyor geometry and mode of transport, and in a similar manner for electron accelerator plants, the beam characteristics, power and geometry, and product transport parameters. In order to maintain the correct dose, a routine monitoring system must be established. This consists of measurement and recording of the process parameters, and of routine dosimetry. For a gamma plant, the most important (and sometimes the only) variable parameter is the product speed (or dwell time), while for electron beam plants, the beam parameters must also be recorded. (Edited author abstract) 18 refs.

Miller, Arne (Riso Natl Lab, Roskilde, Den). *Radiat Phys Chem* v 31 n 1-3, Progr in Radiat Process, Proc of the 6th Int Meet, Ottawa, Ont, Can, May 31-Jun 5 1987 p 385-393.

**Environmental Testing** See Also PHOSPHORUS COMPOUNDS—Chemical Reactions.

**087734 ENVIRONMENTAL RADIOCHEMICAL ANALYSIS, PROCEEDINGS OF THE FIFTH SYMPOSIUM.** These two issues of the journal contain 49 papers presented at a meeting. Some of the topics discussed are: intercomparison exercise on the determination of plutonium in biological material; spiked natural matrix materials as quality assessment samples; ultra-clean underground counting facility for low-level environmental samples; atmospheric radon concentrations in dwellings in Slovenia, Yugoslavia; threat to the New York City drinking water supply - plutonium; marine alga *Fucus Spiralis* collected along the Belgian coast; determination of actinides in biological and environmental samples; and radionuclide levels in the river sediment near to a treated effluent outfall. All papers are abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11118 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Bates, T.H. (Ed.) (British Nuclear Fuels plc, Sellafield, Engl); Crook, M. (Ed.); Harvey, B.R. (Ed.); Lally, A.E. (Ed.); Salmon, L. (Ed.); Ware, A.R. (Ed.). *Sci Total Environ* v 69 Feb 1988 and v 70 Mar 1988, Environ Radiochem Anal, Proc of the Fifth Symp, Harwell, Engl, Oct 1-3 1986 2 vol, 850p.

## Equipment

**087735 PULSE RADIOLYSIS APPARATUS WITH A SCANNING LINAC AND SOME EXPERIMENTAL RESULTS.** The first set of pulse radiolysis apparatus in China with microsecond time resolution was built at Beijing Radiation Center (Institute of Low Energy Nuclear Physics, Beijing Normal University). The radiation source is a 5-MeV s-band scanning Linac which is mainly used as a radiator for doing radiation processing technology studies in this laboratory. In order to use this Linac as a radiation source in pulse radiolysis, some special designs of electronic, mechanical, optical and sample-holding systems were made. Several experiments

on pulse radiolysis of aqueous solution have been done successfully proving that this apparatus is very useful in our attempt to combine the industrial applications of radiation with the basic research of radiation chemistry in this laboratory. (Author abstract) 9 refs.

Zhao, Zhongwei (Beijing Normal Univ, Beijing, China); Liu, Andong; Tong, Zhongliang; Song, Yingxin; Hu, Huadan; Sun, Wanhua; Gu, Hongchun; Zhou, Ruiying. *Radiat Phys Chem* v 31 n 1-3, Progr in Radiat Process, Proc of the 6th Int Meet, Ottawa, Ont, Can, May 31-Jun 5 1987 p 319-325.

**Measurements** See DAIRY PRODUCTS—Radioactivity.

**Monitoring** See CONCRETE—Radiation Effects.

## Taiwan, China

**087736 CURRENT STATUS AND PROSPECTS OF RADIATION PROCESSING STUDIES IN TAIWAN, R.O.C.** The research on radiation processing in the past 5 years in Taiwan covers industrial application of radiation-induced polymerization and curing, medical application of radiosterilization of medical supplies, chemicals, and amniotic membrane for wound dressing as well as agricultural application of food irradiation and genogenesis etc. Radiation-induced polymerization, for example, applied on wood and bamboo plastic composite of methyl methacrylate, radiation curing on polyurethane and silicon rubber for biomedical materials used to separate oxygen from nitrogen and on crosslinking of pp and ps for artificial skin for wound dressing were all successful. The legislation on radiosterilization of medical supplies and food irradiation of 14 items has been approved by National Health Administration, R.O.C. in July of 1982 and January of 1985 respectively. Even 24 hrs-operation of 1 Mega curie irradiation plant at INER cannot satisfy the requirement for radiosterilization of medical supplies. (Edited author abstract) 21 refs.

Fu, Ying-Kai (Inst of Nuclear Energy Research, Lung-Tan, Taiwan). *Radiat Phys Chem* v 31 n 1-3, Progr in Radiat Process, Proc of the 6th Int Meet, Ottawa, Ont, Can, May 31-Jun 5 1987 p 293-300.

**RADIATION COUNTERS** See Also CARBON DIOXIDE—Radioactivity; COSMIC RAYS—Measurements; ENVIRONMENTAL TESTING—Radioactivity; NEUTRONS—Measurements; PARTICLE DETECTORS; RADIATION DETECTORS—Performance; RADIOACTIVITY MEASUREMENT; RADIOACTIVITY MEASUREMENT—Electronic Equipment.

**087737 TEST BEAM STUDIES OF A PROTOTYPE FOR THE BES BARREL SHOWER COUNTER.** A prototype of the barrel shower counter for the Beijing Spectrometer (BES) has been tested with electrons and pions in a momentum range from 0.2 to 2.0 GeV/c at the test beam line T1 KEK 12 GeV proton synchrotron. The preliminary results are now reported. Four kinds of gas mixture were used in the prototype: 40% Ar/60% isobutane, 44.5% Ar/44.5% CH<sub>4</sub>/11% methylal, 47% Ar/47% CH<sub>4</sub>/6% methylal, and 49.3% Ar/49.3% CH<sub>4</sub>/1.4% ethyl alcohol. The results show that using SQS tube as a sampling means in the BES shower counter is feasible for Beijing Electron Positron Collider (BEPC) energy region of 2×2.2/2.8 GeV. (Author abstract) 16 refs.

Lu, Chang-guo (Acad Sinica, Beijing, China); Que, You-kuen; Chou, Yue-hua; Gu, Wei-xun; Li, Pei-qin; Lu, Wei-da; Zhang, Yu; Zhu, Guo-sheng; Hu, Jia-wei; Chen, Sheng-nan; Gao, Cui-shan; Liang, Guo-ning; Zhang, Hao-yun; Tang, Fu-kun; Liu, Zhen-an; Gao, Zheng-wei. *Nucl Instrum Methods Phys Res Sect A* v A260 n 2-3 Oct 15 1987 p 318-328.

**087738 BEHAVIOR OF THALLIUM BROMIDE CONDUCTION COUNTERS.** A study at various temperatures has been made of approximately a dozen TlBr single crystals in order to find their properties as radiation induced conduction counters. Use of alpha particle sources showed whether holes or electrons were responsible for the observed behavior. Gamma ray studies showed

rudimentary spectrometry performance whereas alpha particles usually resulted in peaks of approximately 25% fwhm. Long rise times were observed in some crystals and shorter rise times in others, the variability accounting for as much as a factor of 6. The energy required to produce a free electron-hole pair was observed to be 10.3±2 eV. Breakdown phenomena were observed near room temperature and are described in the text. (Author abstract) 16 refs.

Ijaz-Ur-Rahman (Stanford Univ, Stanford, CA, USA); Fisher, W.A.; Hofstadter, R.; Shen, Jing. *Nucl Instrum Methods Phys Res Sect A* v A261 n 3 Nov 15 1987 p 427-439.

**087739 INVESTIGATIONS ON THE PHOTOELECTRON CONVERSION EFFICIENCY OF NaI(Tl) COUNTERS.** The photoelectron conversion efficiency of NaI(Tl) detectors has been measured by counting single photoelectron pulses of the detector output pulse train on a very fast storage oscilloscope. This result is compared with those obtained by the measurement of the achievable time resolution using the first photoelectron triggering technique. (Author abstract) 13 refs.

Alflen, M. (Johannes-Gutenberg-Univ, Mainz, West Ger); Kajcos, Zs.; Spiering, H.; Guetlich, P.; Albrecht, R.; Schulze, R.; Vilhjalmsen, H. *Nucl Instrum Methods Phys Res Sect A* v A265 n 3 Mar 15 1988 p 464-467.

**087740 OPERATING CHARACTERISTICS OF SANDWICH MICROCHANNEL PLATES.** A sandwich plate is a novel type of high-gain electron multiplier formed by bonding, in permanent contact, three standard (channel length-to-diameter ratio L/D = 40:1) image-intensifier multichannel plates. This geometry has advantages of mechanical and electrical simplicity when compared with conventional multiplate stacks. An evaluation of sandwich plates for X-ray photon counting is presented. Sandwich plate gain, gain uniformity, pulse height FWHM, dark noise, high-count-rate operation, and X-ray quantum efficiency are compared with previous measurements made with conventional two-stage MCP (microchannel plate) multipliers. 9 refs.

Pearson, J.F. (Univ of Leicester, Engl); Lees, J.E.; Fraser, G.W. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 520-523.

**087741 EVALUATION OF LONG LIFE (L<sup>2</sup>) MICROCHANNEL PLATES FOR X-RAY PHOTON COUNTING.** An evaluation is presented to Galileo Long-Life (L<sup>2</sup>) microchannel plates (MCPs) operated in pulse counting mode. Modal gain, pulse height FWHM, gain uniformity, and high-count-rate performance data are compared with measurements made with MCPs of conventional glass composition. Despite the absence of potassium (and hence, of the β-emitter <sup>40</sup>K) from the L<sup>2</sup> glass, dark count rates for the L<sup>2</sup> MCPs are about five-times higher than those of standard MCPs, due to the presence in the glass of the radioisotope <sup>87</sup>Rb. The measurements indicate that Galileo L<sup>2</sup> MCPs, even those with short channel lengths, have several desirable characteristics for photon-counting applications. They also confirm that changing the radioisotope composition of channel plate glass influences the dark noise count rate, further supporting an internal radioactivity noise model developed by the authors. 14 refs.

Fraser, G.W. (Univ of Leicester, Engl); Pearson, J.F.; Lees, J.E. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 529-533.

**087742 PROGRESS IN RESISTIVE PLATE COUNTERS.** Results of experimental tests on resistive plate counters of 6×0.5 m<sup>2</sup> area are reported. The results



show that this technique is suitable for time of flight measurements over large areas with a resolution of the order of 1 ns. (Author abstract) 5 refs.

Cardarelli, R. (Univ di Roma 'Tor Vergata', Rome, Italy); Santorico, R.; Di Biagio, A.; Lucci, A. *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 20-25.

**Components** See DATA CONVERSION, ANALOG TO DIGITAL—Design.

## Testing

**087743 COSMIC RAY TESTS OF 7.6 m DRIFT-TUBE COUNTERS AND THE READOUT ELECTRONICS SYSTEMS OF THE VENUS MUON DETECTOR.** This paper discusses preparations of drift-tube modules. The front-end electronics and the TKO system of the muon detector are explained. The procedure of the cosmic ray tests is described. Results and discussions of the tests are given. 10 refs.

Asano, Y. (Univ of Tsukuba, Jpn); Mori, S.; Moriya, M.; Shioden, M.; Yamagishi, Y.; Yoshida, M.; Ikegami, Y.; Kichise, M.; Nakano, I.; Shimomura, Y. *Nucl Instrum Methods Phys Res Sect A* v A259 n 3 Sep 15 1987 p 430-437.

**Thermal Effects** See PARTICLE DETECTORS.

**RADIATION DAMAGE** See Also BIOLOGICAL MATERIALS—DNA; GRAPHITE—Creep; METALS AND ALLOYS—Defects; METALS AND ALLOYS—Phase Equilibria; NICKEL ALUMINUM ALLOYS—Phase Transformations; SILICA—Ion Implantation; THERMOLUMINESCENCE—Measurements.

**087744 STABILITY OF IRRADIATION-INDUCED VOIDS BASED ON THE CUSP CATASTROPHE.** The aim is to investigate the stability of irradiation-induced voids. It is shown that catastrophe theory, which already turned out to be an excellent method to treat questions of stability in many fields of science and engineering, can also be applied to deal with the stability of voids. It admits to analyze the sensitive interplay of irradiation and material parameters as well as the key role of transmutant helium to void stability. Assuming that the helium gas within the cavities obeys the ideal gas law the proposed framework leads to an elementary catastrophe of the cusp type which demonstrates the range of the number of gas atoms being of physical importance. The potential associated with this catastrophe as a function of the cavity radius is characterized by one minimum and one maximum indicating the stable bubble radius and the unstable critical cavity radius, respectively. (Author abstract) 10 refs.

Simon, D. (Univ Osnabrueck, Osnabrueck, West Ger.) *J Nucl Mater* v 151 n 3 Feb 1988 p 269-274.

## Mathematical Models

**087745 DIRECT AND FAST COMPUTING METHOD FOR DAMAGE ENERGY DEPTH DISTRIBUTION IN ION IMPLANTED MATERIALS.** A theoretically simple and computationally fast method for calculating damage energy density distribution for ions implanted into noninsulating materials is presented. The effect of the energy transported by the recoiling target atoms is taken into account in order to extend the calculation to lower energies and the near-surface target region. It is found that the results obtained over energy and mass ranges of interest for ion implantation experiments are in good agreement with previously reported experimental and calculated damage distributions. Special emphasis is placed upon applications to surface studies, sputtering and amorphization of Si(111) surfaces, as recently reported in a REM study. (Author abstract) 36 refs.

Vieu, C. (CNRS, Toulouse, Fr); Claverie, A.; Faure, J.; Beauvillain, J. *Nucl Instrum Methods Phys Res Sect B* v

B28 n 2 Sep 1987 p 229-236.

**Microscopic Examination** See SEMICONDUCTING GALLIUM ARSENIDE—Ion Implantation.

**RADIATION DETECTORS** See Also ACCELERATORS, SYNCHROTRON; ACCELERATORS, SYNCHROTRON—Storage Rings; ASTROPHYSICS; BERYLLIUM AND ALLOYS—Radioactivity; BIOLOGICAL MATERIALS—Imaging Techniques; BIOMEDICAL ENGINEERING—Angiocardiology; CALORIMETERS; CHARGED PARTICLES—Separation; COSMIC RAYS—Detectors; DATA TRANSMISSION; DOSIMETERS—Calibration; DOSIMETERS—Evaluation; DOSIMETERS—Performance; ELECTRIC TRANSFORMERS; ELECTRON TUBES, ELECTRON MULTIPLIER; ELECTRONIC CIRCUITS; ELECTRONS—Measurements; GAMMA RAYS—Detection; GAMMA RAYS—Measurements; GAMMA RAYS—Polarization; GEIGER COUNTERS; ISOTOPES—Separation; LOGIC CIRCUITS; MILLIMETER WAVES; NEUTRONS—Detectors; NUCLEAR INSTRUMENTATION; NUCLEAR REACTORS, PRESSURIZED WATER—Radioactivity; PARTICLE DETECTORS; PHYSICS—High Energy; PLUTONIUM AND ALLOYS—Radioactivity; PROPORTIONAL COUNTERS—Performance; RADIOACTIVITY MEASUREMENT—Equipment; RESEARCH LABORATORIES; SEMICONDUCTOR DEVICES, CHARGE COUPLED; SEMICONDUCTOR DIODES, PHOTODIODE—Applications; SPECTROMETERS, X-RAY; SPECTROSCOPY, X-RAY; SPECTROSCOPY, X-RAY—Electronic Equipment; SPECTRUM ANALYSIS—Computer Simulation; SPECTRUM ANALYSIS—Mathematical Models; XENON—Radioactivity; X-RAYS—Imaging Techniques; X-RAYS—Measurements.

**087746 MONTE CARLO SIMULATIONS OF EFFECTS DUE TO DELTA RAYS IN ALUMINUM DRIFT-TUBE COUNTERS.** The spatial resolution of drift-tube counters of the VENUS muon detector in the test arrangement for cosmic muons was shown to have two distinct components. The first component, which corresponds to about 96% of the detection efficiency, has a normal distribution with an rms spatial resolution of about 1 mm. It is evident that the second component with about 3.6% of the total incident muons corresponds to events for which delta-rays generated inside the chamber wall are scattered closer to the sense wire or between the sense wire and the true tracks. Such confused track events are unavoidable in drift-tube counters with a single TDC scaler per cell. The general characteristics of phenomena caused by delta rays in drift-tube counters are studied by Monte Carlo simulations for various detector arrangements. The upper limits of the knock on electron yield and confused track rate are found to be respectively 14% and 6% of the total incident muons with medium energies of the order of 10 GeV or less in typical muon detector systems consisting of aluminum drift-tube counters and iron absorbers. For drift-tube counters with very thin aluminum walls these limits are reduced to about 11% and 5%, respectively. (Author abstract) 7 refs.

Asano, Y. (Univ of Tsukuba, Jpn); Mori, S.; Moriya, M.; Shioden, M.; Yamagishi, Y.; Ikegami, Y.; Nakano, I. *Nucl Instrum Methods Phys Res Sect A* v A259 n 3 Sep 15 1987 p 438-446.

**087747 PROTOTYPE FLASH ADC SYSTEM FOR THE CDF VERTEX TIME PROJECTION CHAMBER.** A prototype FASTBUS flash ADC system has been developed for readout of the CDF vertex time projection chamber, VTPC. The system has 8-bit flash ADCs and its sampling rate is up to 30 MHz. Cluster finding is made of a hardware module to reduce the data size without loss of the waveform information. We describe the design of the system, and report its performance. (Author abstract) 11 refs.

Abe, F. (Univ of Tsukuba, Jpn); Kondo, K.; Kurisu, M.; Mimashi, T.; Sekiguchi, M.; Takayama, H. *Nucl Instrum Methods Phys Res Sect A* v A259 n 3 Sep 15 1987 p 466-472.

**087748 'DELTA', A LARGE SOLID ANGLE DETECTION SYSTEM FOR HEAVY FRAGMENTS.** To detect the heavy fragments ( $Z > 8$ ) emitted at large angle ( $30^\circ < \theta < 150^\circ$ ) in heavy ion collisions at GANIL, a large solid angle detection system has been built. It consists of 18 independent cells surrounding the target, the beam axis being the revolution axis. In each cell, a fragment penetrates at first into a parallel plate avalanche counter

with localization which gives velocity, position and  $\partial E/\partial x$  measurements and then into an ionization chamber with longitudinal field for the residual energy measurement. The Z evaluation is performed over a large range of velocities ( $0.05 < E/A < 5$  Mev/u) for atomic numbers ranging from 8 to 90. (Author abstract) 10 refs.

Bougault, R. (ISMRA Univ, Caen, Fr); Duchon, J.; Gautier, J.M.; Genoux-Lubain, A.; Le Brun, C.; Lecolley, J.F.; Lefebvres, F.; Louvel, M.; Mosrin, P.; Regimbart, R. *Nucl Instrum Methods Phys Res Sect A* v A259 n 3 Sep 15 1987 p 473-479.

**087749 MONTE CARLO SIMULATION OF THE RESPONSE OF Si(Li) X-RAY DETECTORS TO PROTON INDUCED K X-RAYS OF LIGHT ELEMENTS ( $12 \leq Z \leq 32$ ) APPLIED TO EFFICIENCY DETERMINATION.** Measurements of proton induced K X-ray spectra of elements in the range  $12 \leq Z \leq 32$  have been performed, using two different Si(Li) detectors. A new detector model is deduced from the measured ratios of low energy background counts to photopeak counts. This detector model assumes both the existence of a surface layer with reduced charge carrier collection efficiency and the existence of a low concentration of small regions of detector defects, which have enhanced charge carrier recombination probability, within the volume of the Si(Li) detector, to explain the observed low energy background. Monte Carlo simulations of the response of two different Si(Li) detectors to K X-rays have been performed in order to quantify possible contributions of detector front contact and dead layer, respectively, to the measured X-ray spectra. Upper limits of those contributions and upper limits of dead layer thickness are given. The consequence of these results to detector efficiency calibration measurements are discussed. (Author abstract) 19 refs.

Geretschlaeger, M. (Johannes-Kepler-Univ Linz, Linz, Austria). *Nucl Instrum Methods Phys Res Sect B* v B28 n 2 Sep 1987 p 289-298.

**087750 RECORDING IONIZING RADIATION DOSES WITH THE AID OF TWO IMMISCIBLE DIELECTRIC LIQUIDS SITUATED IN AN ELECTRIC FIELD.** The authors of a previous article have shown that ionizing radiations can be recorded with a liquid-gas system. This article considers theoretical and experimental investigations of the possibility of recording ionizing radiations with a liquid-liquid system. The effective atomic number of the ionization medium can be changed within certain limits when an organic liquid-liquid system is employed. One can expect an increase in the sensitivity of liquid detectors relative to gas-filled detectors, and also increased measurement capabilities of neutron fluxes and compound radiations.

Suslov, A.P.; Patrusev, G.N.; Zavgorodnii, V.S.; Naumov, V.M. *Sov At Energy* v 62 n 1 Jan 1987 p 72-74.

**087751 SIGNAL RISE TIMES AND ENERGY RESOLUTION IN RADIAL SEMICONDUCTOR DRIFT CHAMBERS.** The risetimes expected in a semiconductor drift chamber (SDC) incorporating a constant drift field component to the electric field have been calculated. The combined influence of systematic risetime broadening and the random broadening processes has been determined and applied to some hypothetical test cases. It is predicted that the resolution of a 50 mm diameter SDC at 300 K will be limited by straggle in the dead layer for alpha particle spectrometry. The same detector could also detect 10 keV X-rays with an anticipated  $\sigma$  of 1.4 keV, limited by the electronic noise. (Author abstract) 15 refs.

Rawlings, K.J. (Harwell Lab, Engl). *Nucl Instrum Methods Phys Res Sect A* v A260 n 2-3 Oct 15 1987 p 346-352.

**087752 MAXIMAL AREA OF SUPERCONDUCTING TUNNELING JUNCTION X-RAY DETECTORS DETERMINED BY THE REQUIRED SIGNAL-TO-NOISE RATIO.** The intrinsically high energy resolution of superconducting tunneling junctions (STJ)



requires a low noise charge sensitive amplifier circuit. The noise sources of such a junction + amplifier circuit are discussed. The dominant noise sources are the series noise and the 1/f flicker noise of the FET input stage, amplified by the large input capacitance of the STJ-detector. Means to reduce this capacitance are discussed. Reducing the preamplifier noise by a factor of two and the height of the potential barrier of the insulating layer by two orders of magnitude, by keeping the large conductance of the junction constant, would allow an increase in junction area by a factor of 15. (Author abstract) 9 refs.

Twerenbold, Damian (ESTEC/SA, Noordwijk, Neth). *Nucl Instrum Methods Phys Res Sect A* v A260 n 2-3 Oct 15 1987 p 430-436.

**087753 INFLUENCE OF DIFFERENT DETECTOR PARAMETERS ON THE NEUTRON SENSITIVITY OF OSL DETECTORS.** On the basis of a method for the calculation of the neutron sensitivity of OSL detectors with a high content of hydrogen a systematic investigation of the influence of different detector parameters on the neutron sensitivity was carried out. The detector thickness, the thickness of the contact radiator, the luminophor contents and the grain size of the used luminophor influence the neutron sensitivity, first of all in the energy range of fast neutrons. Especially the use of small grain luminophor considerably increases the sensitivity whereas the other parameters have a small influence on the neutron sensitivity. (Author abstract) 17 refs.

Fellinger, Juergen (Dresden Technical Univ, Dresden, West Ger); Henniger, Juergen; Huebner, Klaus; Schmidt, Peter. *Nucl Instrum Methods Phys Res Sect A* v A260 n 2-3 Oct 15 1987 p 478-482.

**087754 NEW METHOD FOR MEASURING THE NEUTRON-INDUCED BACKGROUND IN BGO COMPTON-SUPPRESSED Ge DETECTORS APPLIED TO IN-BEAM  $\gamma$ -RAY STUDIES.** This paper describes a new method for determining the response of a BGO Compton-suppressed Ge detector to evaporation neutrons emitted in (HI, xn) reactions. It exploits the large difference between the attenuation of  $\gamma$ -rays and the attenuation of neutrons in a heavy metal absorber for measuring the neutron-induced  $\gamma$ -ray spectrum. An iterative procedure has been used to correct for the residual contribution of direct  $\gamma$  radiation in the measured spectrum. The method can easily be adapted to other types of  $\gamma$ -ray detectors. The technique does require a detailed knowledge of the detector response to  $\gamma$ -rays, both with and without the absorber. 7 refs.

Holzmann, R. (Argonne Natl Lab, Argonne, IL, USA); Ahmad, I.; Janssens, R.V.F.; Khoo, T.L.; Radford, D.C.; Drigert, M.W.; Garg, U. *Nucl Instrum Methods Phys Res Sect A* v A260 n 1 Oct 1 1987 p 153-156.

**087755 RESPONSE OF SODA GLASS DETECTORS TO ACCELERATED HEAVY IONS FOR CALIBRATION TO COSMIC RAY HEAVY IONS.** Pre-annealed and pre-etched samples of soda glass detectors have been exposed vertically to  $^{18}\text{Ar}$ ,  $^{26}\text{Fe}$ ,  $^{28}\text{Si}$ ,  $^{36}\text{Kr}$  and  $^{54}\text{Xe}$  ion beams of various energies at the Joint Institute of Nuclear Research (JINR) Dubna (Moscow) U.S.S.R. The exposed samples were etched in the new etchant (HF 48 vol% +  $\text{H}_2\text{SO}_4$  96 vol% +  $\text{H}_2\text{O}$  in the ratio of 6:1:18 with a small amount of Zn) at 40°C. The variation of etch pit diameter against etching time has been studied and the total etchable range for different heavy ions in this detector has been determined. The energy loss rate and range of the heavy ions in this detector have been computed theoretically. Finally, the response of the detector to the heavy ions and the relationship between the etch rate ratio and the corresponding energy loss rate have been studied. (Author abstract) 10 refs.

Kumar, Shyam (Kurukshetra Univ, Kurukshetra, India); Garg, A.K.; Gupta, S.K.; Sharma, A.P. *Appl Radiat Isot* v 38 n 11 1987 p 967-970.

**087756 CHARACTERISTICS OF SECONDARY-EMISSION DETECTORS UNDER GAMMA IRRADIATION.** Impulsive radiation from nuclear reac-

tors and strong-current accelerators in the dosage range up to  $1 \cdot 10^{13}$  rad/sec (1 rad = 0.01 Gy) is recorded using secondary-emission detectors (SED) with systems of axicylindrical, plane-parallel, and concentric spherical electrodes. In this paper the authors present the results of investigations of the characteristics of SED with plane-parallel stainless steel electrodes, and the design with a system of congruent spherical electrodes is described and its advantages for the determination of the dosage of  $\gamma$  radiation with uncertain spatial-angular and energy distributions are demonstrated. 8 refs.

Malyshev, E.K.; Chuklyayev, S.V.; Shchetinin, O.I. *Sov At Energy* v 62 n 3 Mar 1987 p 227-231.

**087757 MEASUREMENT OF THE ABSORPTION LENGTH AND ABSOLUTE QUANTUM EFFICIENCY OF TMAE AND TEA FROM THRESHOLD TO 120 nm.** The absorption length and absolute photoionization quantum efficiency of TMAE (tetraakis-dimethylamino-ethylene) and TEA (triethylamine) vapors have been measured in a wavelength interval from 120 to 280 nm. Both of these materials can serve as a photosensitive agent for ultraviolet photon detectors used in high energy and nuclear physics experiments and for medical imaging. The absorption length and absolute quantum efficiency are important parameters in the design of these detectors. We find that the quantum efficiency for TMAE has a peak of 58% at 146 nm and rises again toward shorter wavelengths. The TEA quantum efficiency reaches a peak of 33% at 153 nm and has a plateau of 17% below 135 nm. We fail to observe a second peak in TEA around 136 nm as has been previously reported. (Author abstract) 28 refs.

Holroyd, Richard A. (Brookhaven Natl Lab, Upton, NY, USA); Preses, Jack M.; Woody, Craig L.; Johnson, Randy A. *Nucl Instrum Methods Phys Res Sect A* v A261 n 3 Nov 15 1987 p 440-444.

**087758 NUCLEAR REACTIONS IN SILICON AND GERMANIUM DETECTORS AND PEAK INTENSITY LOSSES FOR HELIONS.** Using the optical model, with parameters that fit the elastic scattering data, the reaction cross sections of helions interacting with silicon and germanium have been obtained. With the reaction-energy relation and the reaction cross section as inputs, the peak intensity losses for helions in solid state detectors have been determined. It is found that the corrections to detection efficiency due to the reaction losses can be as high as 10 to 15% for 300 MeV helions. (Author abstract) 14 refs.

Kailas, S. (BARC, Bombay, India). *Nucl Instrum Methods Phys Res Sect A* v A261 n 3 Nov 15 1987 p 497-499.

**087759 UV AND XUV QUANTUM DETECTION EFFICIENCIES OF CsI-COATED MICROCHANNEL PLATES.** Quantum efficiency measurements are presented for CsI-coated microchannel plates in the waveband 25-200 nm. The influence of exposure to a humid atmosphere on the efficiency of the CsI-photocathode has been studied in great detail. Due to the very high susceptibility of CsI to humidity, particularly for wavelengths longer than 140 nm, the best quantum efficiencies have been obtained for a CsI-coated channelplate continuously stored in vacuum. The results are interpreted on the basis of photoelectron emission theory. (Author abstract) 26 refs.

Simons, D.G. (Lab for Space Research Leiden, Leiden, Neth); Fraser, G.W.; De Korte, P.A.J.; Pearson, J.F.; De Jong, L. *Nucl Instrum Methods Phys Res Sect A* v A261 n 3 Nov 15 1987 p 579-586.

**087760 STABLE OHMIC CONTACTS TO ZINC TELLURIDE.** Zinc Telluride is a wide, direct bandgap, II-VI compound semiconductor which, because of its high density, has potential as a gamma-ray detector. Ohmic contacts to this material using Au-Cg, Ag-Pt, Pt and Cu-Pt have been fabricated and tested at elevated temperatures. Specific contact resistivities ranged from  $4.9 \times 10^{-2}$  ohm-cm<sup>2</sup> to 1.0 ohm-cm<sup>2</sup> depending on the annealing process and/or operating temperature. Platinum yielded the lowest resistivity following stabilization at an operat-

ing temperature of 150°C. (Author abstract) 7 refs.

Hajghassem, H.S. (Univ of Arkansas, Fayetteville, AR, USA); Brown, W.D.; Luqman, M.M. *Microelectron Reliab* v 27 n 4 1987 p 677-684.

**087761 SUPERCONDUCTING TUNNEL DETECTORS IN RADIO ASTRONOMY.** A sensitive new radiation detector enables astronomers to explore regions of the universe hidden from optical telescopes, such as sites where stars are now being born. The detector, a superconducting tunnel device, is discussed, and its applications are reviewed.

Phillips, Thomas G.; Rutledge, David B. *Sci Am* v 254 n 5 May 1986 p 97-102.

**087762 FREJUS NUCLEON DECAY DETECTOR.** This paper describes the modular tracking calorimeter located in the Frejus Underground Laboratory. This detector has been designed to study nucleon stability and cosmic-ray physics through the interaction of neutrinos and cosmic-ray muons. The characteristics, trigger and monitoring systems, data acquisition as well as the performance of this detector are presented. 28 refs.

Berger, Ch. (RWTH Aachen, Aachen, West Ger); Hofmann, A.; Moench, H.; Raupach, F.; Schleper, P.; Schmitz, G.; Tutas, J.; Voigtlaender, B.; Arpesella, C.; Benadjal, Y.; Bernardin, Ph.; Blum, D.; Bourdaries, C.; Brugnol, J.; Corazzi, M.; Deuzet, G. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 463-495.

**087763 PROBLEM OF MATHEMATICAL PROCESSING OF EXPERIMENTAL RESULTS FROM SEMICONDUCTOR NUCLEAR RADIATION DETECTORS.** The use of a reduction method for processing experimental results from semiconductor detectors in the presence of a priori information about the nature of the measured signal is examined. The possibility of a dialog mode when processing the experimental results is indicated, when the researcher has the capability of acquiring more precise and reliable results with parametric assignment of the a priori information. (Author abstract) 4 refs.

Mitin, I.V. (Shodmonkulov, T.D.). *Moscow Univ Phys Bull* v 42 n 3 1987 p 28-33.

**087764 SIMPLE IMPLEMENTATION OF THE 'CURRENT INTEGRATION' METHOD.** The 'current integration' method is often used to detect small changes in the intensity of radiation when photon rates are too high for the use of conventional nucleonic counting equipment. When the measurement is made repeatedly in a cyclic fashion, as for example in Moessbauer spectroscopy, some simplifications can be made. We describe a circuit using only a few integrated circuit components which successfully implements the method, and give the conditions under which the simplifications are valid. (Author abstract) 4 refs.

Cranshaw, T.E. (UKAEA, Harwell, Engl). *J Phys E* v 21 n 1 Jan 1988 p 54-58.

**087765 TRANSITION RADIATION DETECTORS FOR ELECTRON IDENTIFICATION BEYOND 1 GeV/c.** Transition radiation detectors (TRDs) have been tested for the separation of electrons from pions in the momentum range between 1 and 6 GeV/c. Foams as well as fibers and foils served as radiator materials while two types of chambers, a longitudinal drift chamber (DC) and a multiwire proportional chamber (MWPC), both of 16 mm depth and dominantly filled with xenon, were used for detecting the transition radiation photons with a setup of four chambers. Analyzing the data we compared the methods of mean, truncated mean and of maximum likelihood of the total charge measurements and several methods of cluster analysis. As a result of the total charge measurements performed at test beams at CERN and DESY we obtained about 1% pion contamination at 90% electron efficiency for the polypropylene materials in the configuration of four modules with a total length of 40 cm.



An improvement by a factor of about two for the electron/pion discrimination can be obtained in the case of a detailed analysis of the clusters. (Author abstract) 25 refs.

Appuhn, R.D. (Univ Bonn, Bonn, West Ger); Heinloth, K.; Lange, E.; Oedingen, R.; Schlosser, A. *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 309-318.

**087766 ON THE PROPERTIES OF LOW-PRESSURE TMAE-FILLED MULTISTEP UV-PHOTON DETECTORS.** Single photoelectrons can be efficiently localized in low pressure (10-40 Torr) TMAE-filled multistep UV-photon detectors. We present, in detail, the results of a systematic study of the properties of such detectors operated with single electrons photoproduced in pure ethane, isobutane, and their mixtures with TMAE. The study includes gaseous amplification, single electron transport parameters, avalanche geometry, localization properties and secondary avalanche formation effects. Detectors based on this mode of operation are presently being developed for Cherenkov ring imaging in ultrarelativistic heavy ion collisions. Other applications are briefly discussed. (Author abstract) 25 refs.

Chechik, R. (Weizmann Inst of Science, Rehovot, Isr); Breskin, A. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 251-262.

**087767 LARGE-AREA FAST-TIMING DETECTORS DEVELOPED FOR THE TOFI SPECTROMETER.** Large-area fast-timing detectors have been developed for use in the TOFI spectrometer. A gridless detector was constructed in which secondary electrons emitted from a thin (approx. 80  $\mu\text{g}/\text{cm}^2$ ) target foil were transported isochronously to microchannel plate electron multipliers by crossed electric and magnetic fields. A novel convex anode was designed to reduce the time dispersion caused by the position at which the secondary electrons were collected. Timing performance for aluminum oxide target foils was found to be superior to that of carbon foils. Intrinsic timing resolutions of 68 and 109 ps fwhm have been measured for 5.4 MeV alpha particles from a thin  $^{241}\text{Am}$  source for two different detectors with active areas of 270 and 1000  $\text{mm}^2$ , respectively. Detection efficiencies in excess of 75% for alpha particles were measured. (Author abstract) 15 refs.

Kraus, R.H. Jr. (Clark Univ, Worcester, MA, USA); Vieira, D.J.; Wollnik, H.; Wouters, J.M. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 327-332.

**087768 IMPROVED MULTISTEP AVALANCHE DETECTOR SYSTEM FOR DIGITAL AUTORADIOGRAPHY.** We report the performance of an enhanced version of the Rutherford Appleton Laboratory digital autoradiography system. The multistep avalanche/multiwire proportional counter (MSA/MWPC) has been redesigned with a narrow (1 mm) avalanche gap which permits spatial resolution of better than 1 mm FWHM to be achieved with high energy beta emitting radiolabels ( $^{35}\text{S}$  and  $^{14}\text{C}$ ) for the first time. An improved, high resolution ( $512 \times 512$  pixel) digital imaging system and a simpler, more stable gas system are also described. (Author abstract) 10 refs.

Bateman, J.E. (Rutherford Appleton Lab, Didcot, Engl); Connolly, J.F.; Stephenson, R. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 430-435.

**087769 MEASUREMENT OF THE REACTION  $^3\text{H}(\gamma, \pi^-)^3\text{He}$  WITH POSITION SENSITIVE DETECTORS.** A solid state detector telescope has been built to detect the recoil nuclei in the reaction  $^3\text{H}(\gamma, \pi^-)^3\text{He}$ ; the differential cross section is presented as a function of photon energy for a fixed momentum transfer of  $q^2 = 4.2 \text{ fm}^{-2}$ . The quality of the data shows that the detector telescope is also well suited for measuring the coherent  $\pi^0$  photoproduction. (Author abstract) 3 refs.

Bellinghausen, B. (Univ Bonn, Bonn, West Ger); Gassen, H.J.; Noelke, G.; Reichelt, T.; Stipp, P.; Synal, H.-A. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb

15 1988 p 515-517.

**087770 FAST TIME-TO-DIGITAL CONVERTER FOR POSITION-SENSITIVE RADIATION DETECTORS WITH DELAY LINE READOUTS.** A fast time-to-digital converter (TDC) has been developed for use with position-sensitive radiation detectors having delay line readouts. The device is recommended for detector applications where high position resolution and low distortion are required at high rates. The device has 2 ns time resolution, less than 0.1% differential nonlinearity, and a recovery time of 70 ns. When used with a detector system having a delay line of temporal length  $\tau$ , the following performance has been achieved: (1) a position digitization of 1 position resolution element per ns of delay line; (2) an average dead time of  $(3/4\tau + 70) \text{ ns}$ ; (3) a maximum incident radiation rate of  $\approx 4/\tau$ ; and (4) a maximum conversion rate of  $\approx 1/(3\tau)$ . Discriminator circuits reduce pile-up distortion to negligible levels for rates as high as those listed above. Finally, two converters may be connected together for synchronous operation as required by 2-dimensional (x-y) detectors. (Author abstract) 3 refs.

Harder, Joseph A. (Brookhaven Natl Lab, Upton, NY, USA). *Nucl Instrum Methods Phys Res Sect A* v A265 n 3 Mar 15 1988 p 500-510.

**087771 NEUTRON DOSIMETRY WITH THE AID OF DETECTORS BASED ON A SUPERHEATED LIQUID.** The authors discuss why the technique used in the superheated droplet detector (termed SDD in subsequent references to foreign publications) is one of the promising techniques for individual dosimetry of neutrons. Reasons for the decision of adopting the SDD concept in practice are presented. 13 refs.

Ivanov, V.I.; Semashko, N.N.; Smirnova, N.S.; Salomatin, A.K. *Sov At Energy* v 63 n 1 Jul 1987 p 565-568.

**087772 THERMO- AND PYROELECTRIC DETECTOR FOR MEASUREMENT OF ENERGY AND TIME PARAMETERS OF PULSE-MODULATED RADIATION.** A radiation detector is described that combines thermoelectric and pyroelectric devices in a single solid-state element. The detector, which has an area of  $1 \text{ cm}^2$ , permits simultaneous measurement at one point in space of the pulse and average powers of pulse-modulated radiation. The detector has average-power and pulse-power conversion factors of 0.3 V/W and 1 mV/W and a time constant of 1  $\mu\text{sec}$ . A procedure is described for measurement of the power of the pulse-modulated radiation of a  $\text{CO}_2$  laser. (Author abstract) 3 refs.

Gerashchenko, O.A. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Kremenchugskii, V.L. *Instrum Exp Tech* v 30 n 5 pt 2 Sep-Oct 1987 p 1254-1255.

**087773 ENERGY RESOLUTION OF  $\text{HgI}_2$  DETECTORS OF X-RAY AND GAMMA QUANTA.** The present article reports on the results of an investigation of the spectrometric characteristics of uncooled semiconductor detectors on the basis of mercuric iodide. The authors determined the limitations which are imposed upon the energy resolution by noise of various origins and by the inhomogeneity of the crystal in the spectrometry of quanta in the energy range of  $10^3 \text{ keV}$ . The detectors under inspection had been manufactured from  $\text{HgI}_2$  single crystals grown from the gas phase. 8 refs.

Zaletin, V.M.; Krivozubov, O.V.; Torlin, M.A.; Fomin, V.I. *Sov At Energy* v 63 n 2 Aug 1987 p 652-655.

**087774 ELECTRON ATTACHMENT OF OXYGEN IN A DRIFT CHAMBER FILLED WITH XENON + 10% METHANE.** The existence of  $\text{O}_2$  contamination attenuates the pulse height and degrades its resolution in a drift chamber filled with xenon-methane (90/10) gas. The first measurement of the electron attachment coefficient due to oxygen in such a mixture is reported. (Author abstract) 11 refs.

Chiba, Y. (Hiroshima Univ, Hiroshima, Jpn); Hayaishibara, I.; Ohsugi, T.; Sakanoue, T.; Taketani, A.;

Terunuma, N.; Suzuki, Y.; Tsukamoto, A.; Yamamoto, H.; Fukushima, Y.; Kohriki, T.; Nakamura, S.; Sakuda, M.; Watase, Y. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 171-176.

**087775 X AND  $\gamma$  DETECTION WITH  $\text{HGL}_2$  SINGLE CRYSTALS OBTAINED BY THE FORCED FLUX METHOD.** Nuclear detection properties of mercuric iodide single crystals obtained by the forced flux method are presented for the X-ray domain and for  $\gamma$ -rays of 60 and 122 keV. We study the correlation between detector performance and material purification stage. (Author abstract) 15 refs.

Coupat, B. (Lab de Physique Corpusculaire); Fournier J.P.; Silga, M.; Omaly, J. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 213-218.

**087776 INTER-ELECTRODE CAPACITANCE OF WEDGE AND STRIP POSITION SENSING ELEMENTS.** A method of calculating the inter-electrode capacitances of wedge and strip position sensing elements is presented. Estimates made using the method are compared to measured values and found to be in reasonable agreement. An alternative formula is shown to be semiempirical, requiring calibration with similar, already manufactured, wedge and strips before it can be used. (Author abstract) 8 refs.

Thornton, John (Univ of Surrey, Guildford, Engl). *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 226-229.

**087777 SIMPLE PHOSWICH SYSTEM.** Normal phoswich detector systems use a combination of  $\text{NaI(Tl)}$  and  $\text{CsI(Na)}$  scintillators and require the application of careful pulse-shape discriminator techniques to resolve the two components in the scintillation light output which have decay constants of 250 and 630 ns respectively. These techniques provide a good anticoincidence veto efficiency for a relatively narrow range in the ratio of energy deposits in the two crystals and for a detector system whose temperature is carefully controlled. This paper describes the performance of a simple phoswich which makes use of the fast UV signal from a  $\text{BaF}_2$  crystal to provide a prompt veto signal. The performance to be expected from various combinations of a  $\text{BaF}_2$  anticoincidence crystal with other primary detectors is presented. These simulations have been verified by simple experimental tests. (Author abstract) 2 refs.

Ramsden, D. (Southampton Univ, Southampton, Engl); Zhang, S.N. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 230-236.

**087778 PROPOSAL FOR A NATIONAL FACILITY MARS: A MULTIDETECTOR ARRAY FOR REACTION STUDIES.** The proposal for MARS, a Multidetector Array for Reaction Studies is presented. MARS consists of a large, high-vacuum vessel enclosing an array of 128 scintillation detectors for use in the studies of heavy-ion collision at TASCC. The instrument will be funded and owned jointly by AECL and NSERC. (Author abstract).

Ball, G.C. (AECL, Chalk River, Ont, Can); Davies, W.G.; Forster, J.S.; Hagberg, E.; Horn, D.; Lone, M.A.; Pruneau, C.; Potvin, L.; Rioux, C.; Roy, R.; St-Pierre, C.; Drake, T.; Galindo-Uribarri, A. *At Energy Can Ltd AECL Rep* 9684 Mar 1988 151 pgs.

**087779 FAST MULTIANODE DETECTOR FOR SOLID STATE ULTRAVIOLET PHOTOELECTRON SPECTROSCOPY.** A new angle-resolving photoelectron spectrometer has been developed which uses a fast multianode parallel readout. The detector has been designed for high resolution ultraviolet photoelectron spectroscopy from solid surfaces using synchrotron radi-



tion. Examples of initial results with the detector using a rare gas discharge lamp are presented. (Author abstract). 24 Refs.

Padmore, T.S. (SERC Daresbury Lab, Warrington, Engl); Roberts, K.M.; Padmore, H.A.; Thornton, G. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 582-589.

**087780 PARALLEL-PLATE AVALANCHE CHAMBER WITH A GATED DRIFT-CHAMBER READOUT.** We describe a new high-rate detector suitable for x-ray imaging, ring imaging of Cherenkov light, and charged-particle tracking. The device is a parallel-plate avalanche chamber coupled to a gated drift-chamber readout. This design incorporates the advantages of parallel-plate avalanche chambers and drift-chamber readout methods, and avoids some of the disadvantages of both. The two-dimensional readout of the detection plane is obtained by time slicing in one dimension and cathode pads in the other. (Author abstract). 9 Refs.

Solomey, Nickolas (Univ of Geneva, Switz); Dominik, Wojciech; Santard, Jean-Claude. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 423-431.

**087781 NEW DETECTOR SYSTEM FOR DOUBLE BETA DECAYS.** We have designed and constructed a new detector system for searching for double beta decays. It consists of a stack of lithium-drifted, surface barrier silicon detectors interlayered with thin source foils. The segmentation greatly reduces backgrounds. The system is free from radioactive backgrounds above 2.5 MeV. The apparatus is also a versatile low background counting facility with high sensitivity. (Author abstract). 9 Refs.

Alston-Garnjost, M. (Lawrence Berkeley Lab, Berkeley, CA, USA); Dougherty, B.L.; Kenney, R.W.; Krivich, J.M.; Smith, A.R.; Tripp, R.D.; Walton, J.T.; Nicholson, H.W.; Dieterle, B.D.; Leavitt, C.P. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 475-482.

**087782 RADIOACTIVE SURFACE MONITOR FOR HUMAN BODY.** The body surface monitor has been used to the inspection of the radioactive contamination on the human body at exit of the radiation controlled area in the atomic power plant. Monitor could detect precisely activities by the many detectors having large effective area surrounding the body. Recently by the use of microprocessor, the monitor came to be intelligent having function to explain operational guide by CRT display, to diagnose the condition of measuring instrument and to treat data for conservation, analysis and report. As a result, maintenance of the monitor can be done easily and strictly. (Author abstract). 1 Ref. In Japanese.

Kohmo, Etsuo; Aoyama, Kei. *FAPIG* v 119 n 7 1988 p 46-52.

**087783 SMALL AREA HIGH PURITY GERMANIUM DETECTORS FOR USE IN THE ENERGY RANGE 100 eV TO 100 keV.** The performance of small-area high-purity germanium detectors used to detect X-rays in the energy range from 100 eV to 100 keV is discussed. The response at low, medium and high energies, the variation of detector performance with high voltage bias, and radiation hardness are covered. Good spectrum line shapes have been achieved even at ultralow energies. These detectors are intended for X-ray microanalysis in electron microscopes, where they offer the advantages of good high-energy detection efficiency, lower noise, and higher energy resolution compared to the conventional lithium-drifted silicon detector. 9 Refs.

Cox, C.E. (Link Analytical Ltd, Buckinghamshire, Engl); Lowe, B.G.; Sareen, R.A. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 28-32.

**087784 OBSERVATION OF LITHIUM DRIFTED SILICON DETECTORS USING SEM.** Sectional surfaces of the lithium-drifted silicon detector are observed using the scanning electron microscope (SEM). Cyclic striation lines are observed in the lithium-drifted region of

a detector made from a large-diameter silicon ingot. This is confirmed to be due to a cyclic fluctuation of donor impurity caused by a cyclic change of temperature during floating-zone processing. These materials are judged to be unsuitable for detector application. 6 Refs.

Watanabe, E. (JEOL Ltd, Tokyo, Jpn); Taira, M.; Kuwata, M.; Ikeda, T.; Husimi, K.; Miyachi, T.; Ohkawa, S. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 33-36.

**087785 LEAD IODIDE NUCLEAR SPECTROMETERS.** The preparation of radiation detectors from semiconducting lead iodide is discussed, and the performance of these devices as X-ray and gamma-ray spectrometers is evaluated. Detectors prepared from melt-grown crystals exhibit good energy resolution for low-energy (<10 keV) X-rays. The energy resolution for higher-energy photons is lower, consistent with the measured values of the electron and hole mobility-lifetime products. Measurements at elevated temperatures show that the detectors continue to operate well over 100°C. 9 Refs.

Lund, J.C. (Radiation Monitoring Devices Inc, Watertown, MA, USA); Shah, K.S.; Squillante, M.R.; Sinclair, F. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 89-92.

**087786 BALLISTIC DEFICITS IN PULSE SHAPING AMPLIFIERS.** The authors consider the problem of ballistic deficit, which is the loss of output signal amplitude due to the interplay between the finite charge-collection times in a detector and the characteristic time constants of the amplifier. Quantitative estimates of ballistic deficits have been developed by using numerical integration techniques on a microcomputer and by exact calculations using Laplace transforms. A practical procedure is developed in which an actual amplifier with even an unspecified complex-pole network can be accurately related to an equivalent semi-Gaussian shaping network the exact solution of which is known. Simple formulas for estimating ballistic deficits and resulting degradation in spectral energy resolutions are given. 3 Refs.

Loo, Billy W. (Lawrence Berkeley Lab, Berkeley, CA, USA); Goulding, Fred S.; Gao, Dexi. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 114-118.

**087787 BALLISTIC DEFICIT CORRECTION IN SEMICONDUCTOR DETECTOR SPECTROMETERS.** At high energies the energy resolution of  $\gamma$ -ray spectrometers using large-diameter coaxial germanium detectors can be dominated by ballistic-deficit effects, particularly when short processing times are used to permit high-rate operation. This results because that rise-time variations in the detector signal are reflected in amplitude fluctuations after the signals pass through pulse shapes. A method is described for compensating for these effects on a pulse-by-pulse basis, using the observation that the loss of amplitude for slowly rising signals is accompanied by a delay in the peak time of the shaped output signal. The simple analog corrector circuit uses a relationship whereby the amplitude deficit is roughly proportional to the square of the time delay in the peak. Results show considerable improvements in the energy resolution of germanium  $\gamma$ -ray spectrometers at high energies. 5 Refs.

Goulding, F.S. (Lawrence Berkeley Lab, Berkeley, CA, USA); Landis, D.A. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 119-124.

**087788 PEDESTAL DRIFT AND CABLE PICKUP PROBLEMS IN MULTIPLEXED ANALOG SIGNAL TRANSMISSION.** Sample-and-hold circuits followed by analog multiplexing are often used to reduce the number of cables required between large multielement high-energy detectors and their associated analog-to-digital converters. All sample-and-hold circuits have charge-injection pedestals that can vary with time, temperature, and power-supply voltages. These variations are often correlated among many channels so that total energy sums may

be degraded, even though individual pedestal drifts remain negligible. A double-sampling system is described that substantially decreases charge-injection pedestals and their variations. The effects of low-frequency pickup in long signal cables, which also tend to be correlated, are very much reduced as well. 3 Refs.

Bernier, R. (Lab de l'Accel Lineaire, Orsay, Fr); Breton, D.; Chase, R.L.; Parey, J.Y. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 131-132.

**087789 DESIGN OF A CHARGE SENSITIVE PRE-AMPLIFIER ON HIGH RESISTIVITY SILICON.** A low-noise, fast, charge-sensitive preamplifier was designed on high-resistivity, detector-grade silicon. It is built at the surface of a fully depleted region of n-type silicon, allowing it to be placed very close to a detector anode. The preamplifier uses the classical input-cascode configuration with a capacitor and a high-value resistor in the feedback loop. The output stage of the preamplifier can drive a load up to 20 pF. The power dissipation of the preamplifier is 13 mW. The amplifying elements are single-sided gate JFETs developed for this application. Preamplifiers connected to a low-capacitance anode of a drift-type detector should achieve a rise time of 20 ns and have an equivalent noise charge, after suitable shaping, of less than 50 electrons. This performance translates to a position resolution better than 3  $\mu$ m for silicon drift detectors. 6 Refs.

Radeka, V. (Brookhaven Natl Lab, Upton, NY, USA); Rehak, P.; Rrescia, S.; Gatti, E.; Longoni, A.; Sampietro, M.; Holl, P.; Struder, L.; Kemmer, J. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 155-159.

**087790 FLEXIBLE 128 CHANNEL SILICON STRIP DETECTOR INSTRUMENTATION INTEGRATED CIRCUIT WITH SPARSE DATA READOUT.** A full-custom CMOS integrated circuit for silicon strip detector systems has been designed, fabricated, and tested. The circuit contains 128 parallel data-acquisition channels and considerable peripheral circuitry. Each channel consists of a low-noise, low-power, charge-sensitive amplifier, a multistage autobalanced comparator, an analog multiplexer, nearest-neighbor logic, priority-search logic, and a share of a position-encoding read-only memory. The analog system can subtract both detector pedestal and leakage current on a channel-by-channel basis. A key feature of this design is the inclusion of on-chip sparse read-out circuitry, which allows efficient management of low-occupancy events. Designed for use at the Collider Detector Facility (CDF) at Fermilab, the circuit is suitable for large-scale silicon detector systems requiring a large, dense array of fast, low-power electronics. 6 Refs.

Kleinfelder, Stuart A. (Lawrence Berkeley Lab, Berkeley, CA, USA); Carithers, William C. Jr.; Ely, Robert P. Jr.; Haber, Carl; Kirsten, Frederick; Spieler, Helmut G. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 171-175.

**087791 RESULTS OF SILICON STRIP DETECTOR READOUT USING A CMOS LOW POWER MICROPLEX (MX1).** A system for reading out silicon strip detectors has been fabricated on a CMOS integrated circuit. The chip consists of an array of 128 amplifiers with a single multiplexed output. These chips have been bonded to a 256-channel silicon strip detector. Results are reported on the electrical parameters of the chips and on data taken during exposure of the instrumented detectors to minimum-ionizing beta particles. The radiation toler-



ance of the device has been investigated. The MX1 is working to specification and is presently being incorporated into equipment. 6 refs.

Seller, P. (Chilton, Rutherford Appleton Lab, Oxon, Engl); Allport, P.P.; Tyndel, M. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 176-180.

**087792 IN BEAM PERFORMANCE OF A LOW PRESSURE UV RICH DETECTOR.** A low-pressure multistep, TMAE-filled, UV-sensitive detector has been developed for Cerenkov ring imaging for ultrarelativistic heavy-ion experiments (HELIOS-CERN). A description is given of the detector structure and its basic properties, and the experimental setup and the detector performance in tests with high-energy electrons are presented. Three modes of readout are used: three-wire coordinates and flash analog-to-digital converters; pad readout; and optical recording of the avalanches. Single photons can be localized with an accuracy of  $\sigma \approx 2$  mm, mainly due to single-photoelectron diffusion and to chromatic dispersion in the radiator gas. The experimental  $N_0$  values obtained by the three methods are close to those expected, taking into account the various losses due to the test conditions. 19 refs.

Breskin, A. (Weizmann Inst of Science, Rehovot, Isr); Chechik, R.; Drees, A.; Fischer, P.; Fraenkel, Z.; Glassel, P.; Lamade, G.; Ries, H.; Sauvage, D.; Schon, A.; Schmoetten, E.; Specht, H.J.; Steiner, V.; Tseruya, I. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 404-408.

**087793 PAD READOUT FOR GAS DETECTORS USING 128-CHANNEL INTEGRATED PREAMPLIFIERS.** A novel two-dimensional readout scheme for gas detectors is presented that uses small metal pads with 2.54-mm pitch as an anode. The pads are read out via 128-channel VLSI low-noise peramplifier/multiplexer chips. These chips are mounted on  $2.8\text{ cm} \times 2.8\text{ cm}$  modules, which are directly plugged onto the detector backplane, delay-chained with jumpers, and read out sequentially. The readout has been successfully tested with a low-pressure, two-step, TMAE-filled, ultraviolet-sensitive ring imaging Cerenkov counter. A single-electron efficiency of  $>90\%$  was observed at moderate chamber gains ( $<10^6$ ). The method offers high electronic amplification, low noise, and high readout speed with a very flexible and compact design that is suited for space-limited applications. 11 refs.

Fischer, P. (Univ Heidelberg, West Ger); Drees, A.; Glassel, P.; Lamade, G.; Ries, H.; Schon, A.; Specht, H.; Breskin, A.; Chechik, R.; Fraenkel, Z.; Sauvage, D.; Steiner, V.; Tseruya, I.; Horisberger, R. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 432-435.

**087794 DETECTION OF COHERENT TRANSITION RADIATION AND ITS APPLICATION IN BEAM DIAGNOSTICS AND PARTICLE IDENTIFICATION.** The first observation of the angular distribution of coherent (resonant) transition radiation at soft-X-ray photon energies (1 to 3 keV) is reported. Two different radiators were constructed, each consisting of stack of eight foils of 3.5- $\mu\text{m}$ -thick mylar. One of the radiators was designed to demonstrate interfoil coherence and had foil-to-foil spacing of 8.5  $\mu\text{m}$  throughout the stack. The other radiator had large random spacings that prevented coherent interference between foils. These radiators were irradiated with electron beams with energies ranging from 63 to 97 MeV, and their angular distributions were compared. The distributions were symmetrical around the axis of the transition-radiation cone. For the coherent case the angle of peak photon emission was found to increase with increasing electron-beam energy; for the incoherent case the angle was found to decrease with increasing electron energy. The coherent case is contrary to the normally expected behavior and can be used as the basis of an electron beam-energy diagnostic. 19 refs.

Piestrup, M.A. (Adelphi Technology Inc, Palo Alto, CA, USA); Boyers, D.; Li, Quang; Moran, M.J.; Buskirk, F.R.; Maruyama, X.K.; Neighbours, J.R.; Robinson, R.M.; Snyder, D.L. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 464-469.

**087795 BACKGROUND REJECTION TECHNIQUES IN CCD X-RAY DETECTORS FOR ASTRONOMY.** A number of different charge-coupled devices (CCDs) have been exposed to gamma and beta sources in order to simulate the charged-particle background response of spaceborne X-ray astronomy detectors. Two rejection techniques have been investigated: energy veto and pixel-to-pixel anticoincidence. In the most favorable conditions, a rejection of  $>99.9\%$  has been obtained. The latter selection criterion can be used to reject X-ray data in which the event charge is incompletely collected. Improved X-ray energy resolution is obtained, and an upper limit to the Fano factor in silicon is measured. A novel technique for minimizing systematic errors in the X-ray-energy-to-charge-conversion factor is described. 14 refs.

Lumb, David H. (Univ of Leicester, Engl); Holland, Andrew D. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 534-538.

**087796 ONE-COORDINATE X-RAY DETECTOR OD-2.** A one coordinate X-ray detector for studies of X-ray structure is described. A space resolution of 0.15 mm (fwhm) can be attained up to a maximum counting rate of 270 kHz. Detector control, data acquisition and processing are performed by computer. (Author abstract) 3 refs.

Aulchenko, V.M. (Acad of Sciences of the USSR, Novosibirsk, USSR); Feldman, I.G.; Khabakhpashev, A.G.; Savinov, G.A.; Sidorov, V.A.; Usov, Yu.-V.; Yasenev, M.V. *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 78-81.

**087797 NEW PORTABLE HAND-HELD RADIATION INSTRUMENTS FOR MEASUREMENTS AND MONITORING.** Hand-held radiation monitors are often used to search pedestrians and motor vehicles for special nuclear material (SNM) as part of a physical protection plan for nuclear materials. Recently, the Los Alamos Advanced Nuclear Technology group has commercialized an improved hand-held monitor that can be used for both physical-protection monitoring and verification measurements in nuclear material control and waste management. The new monitoring instruments are smaller and lighter; operate much longer on a battery charge; are available with NaI(Tl) or neutron and gamma-ray sensitive plastic scintillation detectors; and are less expensive than other comparable instruments. (Edited author abstract) 6 refs.

Fehlau, P.E. (Los Alamos Natl Lab, Los Alamos, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 448-453.

**087798 MONOPOLE TRIGGER FOR THE STREAMER TUBE SYSTEM IN MACRO.** We report the study done on the streamer tube trigger for monopoles to be used in MACRO. The acceptance, trigger rate and electronic efficiency of the trigger system are discussed. (Author abstract) 4 refs.

Auriemma, G. (INFN, Rome, Italy); Battistoni, G.; Lamanna, E.; Petrer, S.; Piccinelli, G.; Ronga, F.; Sciubba, A. *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 249-254.

**087799 NON-ACCELERATOR PARTICLE PHYSICS, PROCEEDINGS OF THE WORKSHOP.** This conference proceedings contains 21 papers, all of which

are separately abstracted and indexed. Non-accelerator particle physics experiments are reviewed. Large underground detectors are discussed from a design review standpoint. High energy gamma-ray astronomy research is discussed, including experimental techniques as well as results. Solar neutrino measurements are presented, as well as high energy cosmic ray observations. Dark matter searches and the fundamental properties of particles are presented. The observation of neutrinos emitted from SN1987a was addressed. This supernova explosion is a rare and very historical event. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10887 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Melissinos, A.C. (Ed.) (Univ of Rochester, Rochester, NY, USA); Moskowitz, B.E. (Ed.). *Nucl Instrum Methods Phys Res Sect A* v A264 n 1 Feb 1988, Non-Accel Part Phys, Proc of the Workshop, Rochester, NY, USA, Jun 1-3 1987 130p.

**087800 LVD AT GRAN SASSO.** LVD is a large volume detector which will be installed in Hall A of the Gran Sasso Laboratory. This detector is 49 m long, 13.2 m high and 12 m wide. It contains 2280 m<sup>3</sup> of scintillator (1800 t) and 1800 t of steel. The geometric acceptance of LVD for an isotropic flux of particles is greater than 7000 m<sup>2</sup> sr. LVD is the ideal detector for detecting a stellar collapse, anywhere in our galaxy; for studying neutrino oscillations; for searching for the supersymmetric decay mode of the proton; and for looking at the boron neutrinos from the sun. LVD is a very competitive detector for detecting astrophysical neutrino emitting point sources, for performing dark matter searches, for studying single muon distributions, for detecting muon bundles and hence determining the primary cosmic ray composition, and for searching for massive monopoles and other ultra heavy particles. LVD is composed of 190 identical modules, of which the first 10% of these modules will be installed in 1987. (Edited author abstract) 33 refs.

Bari, C. (Univ of Bologna, Bologna, Italy); Basile, M.; Bruni, G.; Cara Romeo, G.; Castelvetti, A.; Cifarelli, L.; Contini, A.; Del Papa, C.; Giusti, P.; Iacobucci, G.; Maccarrone, G.; Massam, T.; Nania, R.; O'Shea, V.; Palmonari, F.; Perotto, E. *Nucl Instrum Methods Phys Res Sect A* v A264 n 1 Feb 1988, Non-Accel Part Phys, Proc of the Workshop, Rochester, NY, USA, Jun 1-3 1987 p 5-17.

**087801 MACRO DETECTOR AT THE GRAN SASSO LABORATORY.** The MACRO detector is presently under construction, its installation at Gran Sasso being planned to start in September 1987. It is a large area detector, the acceptance for isotropic particle fluxes being around 10,000 m<sup>2</sup> sr, designed to search for rare phenomena in the cosmic radiation. It makes use of three detection techniques: liquid scintillator counters, plastic streamer tubes, and track-etch. It will perform a search for GUT monopoles (or any supermassive charged penetrating particle), a survey of cosmic point sources of HE gammas and neutrinos, a systematic study of the penetrating cosmic ray muons, and will be sensitive to neutrino bursts from gravitational stellar collapses in the Galaxy. (Author abstract) 5 refs.

Calicchio, M. (INFN, Bari, Italy); Case, G.; Demarzo, C.; Erriquez, O.; Favuzzi, C.; Giglietto, N.; Nappi, E.; Posa, F.; Spinelli, P.; Baldetti, F.; Cecchini, S.; Giacomelli, G.; Grianti, F.; Mandrioli, G.; Margiotta, A.; Patrizi, L. *Nucl Instrum Methods Phys Res Sect A* v A264 n 1 Feb 1988, Non-Accel Part Phys, Proc of the Workshop, Rochester, NY, USA, Jun 1-3 1987 p 19-23.

**087802 SUPERCONDUCTING INDIUM DETECTORS FOR SOLAR NEUTRINOS.** We report on our progress in developing a superconducting indium neutrino detector. Two highlights are the quasiparticle trapping



mechanism, and the merger of technologies to provide a viable route for fabricating stable detector elements. (Author abstract) 16 refs.

Evetts, J.E. (Univ of Cambridge, Cambridge, Engl); James, J.H.; Lumley, J.M.; Morris, G.W.; Somekh, R.E.; Booth, N.E.; Goldie, D.J.; Hawes, B.M.; Hukin, D.A.; Lloyd, J.L.; Patel, C.; Salmon, G.L. *Nucl Instrum Methods Phys Res Sect A* v A264 n 1 Feb 1988, Non-Accel Part Phys, Proc of the Workshop, Rochester, NY, USA, Jun 1-3 1987 p 41-47.

**087803 CHICAGO AIR SHOWER ARRAY (CASA).** In order to improve the ultrahigh energy flux sensitivity beyond that of existing detectors a new class of very large detectors must be built. In this paper we will discuss one approach to this goal. (Author abstract) 13 refs.

Gibbs, Kenneth G. (Univ of Chicago, Chicago, IL, USA). *Nucl Instrum Methods Phys Res Sect A* v A264 n 1 Feb 1988, Non-Accel Part Phys, Proc of the Workshop, Rochester, NY, USA, Jun 1-3 1987 p 67-73.

**087804 STORAGE PHOSPHOR X-RAY DIFFRACTION DETECTORS.** The use of photostimulable storage phosphors as area detectors for X-ray diffraction is described. The elements of a basic acquisition system are explained and the principles of operation are reviewed. A simple model for the transfer of system signal and noise is derived, allowing determination of the detective quantum efficiency (DQE). Using this model, predicted storage phosphor performance can be compared with conventional detector technologies for tasks in X-ray diffraction. (Author abstract) 11 refs.

Whiting, Bruce R. (Eastman Kodak Co, Rochester, NY, USA); Owen, James F.; Rubin, Byron H. *Nucl Instrum Methods Phys Res Sect A* v A266 n 1-3 Apr 1 1988, Synchrotron Radiat Instrum, Proc of the Fifth Natl Conf, Madison, WI, USA, Jun 21-25 1987 p 628-635.

**087805 BaF<sub>2</sub>-MWPC GAMMA CAMERA FOR POSITRON EMISSION TOMOGRAPHY.** The construction and performance of a position sensitive detector for 511 keV annihilation radiation are described. The detector consists of a barium fluoride crystal sandwiched between two wire chambers which are operated with 45 and 50°C TMAE vapour. Energy, time and position resolution are presented. The advantages and limitations of the detector are discussed. We also present some preliminary data on other UV scintillators. (Author abstract) 19 refs.

Schotanus, P. (Delft Univ of Technology, Delft, Neth); Van Eijk, C.W.E.; Hollander, R.W. *Nucl Instrum Methods Phys Res Sect A* v A269 n 2 Jun 10 1988, Proc of the Int Symp on the Use of Wire Chambers in Med Imaging, Corsendonk, Belg, Jun 28-30 1987 p 377-384.

**087806 POSITION RESOLUTION, HIGH RATE BEHAVIOUR AND SPACE CHARGE INDUCED IMAGE DISTORTIONS OF A MULTIWIRED X-RAY DETECTOR FOR DIGITAL SUBTRACTION ANGIOGRAPHY.** This report describes investigations of position and energy resolution, high rate behaviour and space charge induced image distortions of a multiwire X-ray detector for noninvasive coronary angiography with synchrotron radiation. The requirements for multiwire detectors and the performance of a prototype are discussed. At a pressure of 8 bar a spatial resolution of 345  $\mu$ m (FWHM) and rates up to  $5 \times 10^9$  counts  $s^{-1} cm^{-2}$  have been achieved. At this pressure the energy resolution of the chamber is  $\Delta E/E = 53\%$  ( $E$  (keV))<sup>1/2</sup> for Ar/CO<sub>2</sub> = 99/1. (Author abstract) 7 refs.

Hell, E. (Univ of Siegen, Siegen, West Ger); Besch, H.-J.; Brabetz, L.; Kuhn, P.; Walenta, A.H. *Nucl Instrum Methods Phys Res Sect A* v A269 n 2 Jun 10 1988, Proc of the Int Symp on the Use of Wire Chambers in Med Imaging, Corsendonk, Belg, Jun 28-30 1987 p 404-414.

**Accessories** See SEMICONDUCTOR COUNTERS—Accessories.

## Analysis

**087807 POSITION SENSITIVE GAMMA-RAY DETECTOR WHICH EMPLOYS PHOTODIODE AND CSI(TL) CRYSTALS.** A compact CsI(Tl)/photodiode gamma-ray detector is described that is capable of locating the point of interaction of incident gamma-ray photons in the spectral region around 1 MeV. Laboratory tests are used to quantify both the spectral and positional resolutions of the detectors. Their likely application in space gamma-ray astronomy is discussed. 6 refs.

Dean, A.J. (Univ of Southampton, Engl); Graham, G.; Hopkins, C.J.; Ramsden, D.; Lei, Meng. *IEEE Trans Nucl Sci* v NS-34 n 4 Aug 1987, Fifth Conf on Real-Time Comput Appl in Nucl, Part and Plasma Phys, San Francisco, CA, USA, May 12-14 1987 p 1089.

**Applications** See Also IRON AND ALLOYS—Radioactivity.

**087808 USE OF A SiTEK POSITION SENSITIVE DETECTOR FOR SYNCHROTRON RADIATION BEAM MONITORING AND ALIGNMENT.** A SiTek Laboratories one-dimensional position sensitive detector has been tested for use as a synchrotron radiation beam position monitor. Results of the tests, and a review of the operation principles of the device, are presented. 3 refs.

Hanson, A.L. (Brookhaven Natl Lab, Upton, NY, USA); Kwiatek, W.; Jones, K.W. *Nucl Instrum Methods Phys Res Sect A* v A260 n 2-3 Oct 15 1987 p 529-533.

**Calibration** See Also RADIOACTIVITY MEASUREMENT—Instruments.

**087809 ABSOLUTE EFFICIENCY CALIBRATION FUNCTION FOR THE ENERGY RANGE 63-3054 keV FOR A COAXIAL Ge(Li) DETECTOR.** A new absolute efficiency calibration function for the energy range 63-3054 keV is reported. The proposed function works very well for different geometries (Petri, Marinelli, 750 cm<sup>3</sup> and 100 cm<sup>3</sup> beakers). We have used our own data as well as those from several other authors. (Author abstract) 12 refs.

Sanchez-Reyes, A.F. (Univ de Barcelona, Barcelona, Spain); Febrin, M.I.; Tejada, J.; Baro, J. *Nucl Instrum Methods Phys Res Sect B* v B28 n 1 Aug 1987 p 123-127.

**087810 STUDY OF A HIGH INTENSITY 746 keV NEUTRINO SOURCE FOR THE CALIBRATION OF SOLAR NEUTRINO DETECTORS.** We describe the test production of a 0.94 PBq (25,400 Ci) source of 746 keV neutrinos coming from the electron capture decay of <sup>51</sup>Cr. This is the first time that such a source has been produced. It was obtained by neutron activation of 12.5 kg of natural granular chromium at the Siloe reactor at Grenoble. If this nuclear reactor were devoted exclusively to the production of <sup>51</sup>Cr from natural chromium, we calculate that the highest activity that could be produced would be around 29 PBq (0.8 MCi) in 45 days of irradiation, for 125 kg of target. With chromium enriched in <sup>50</sup>Cr, we could get around 40 PBq (1.08 MCi) in an irradiation of 21 days, for 45 kg of target containing 17% <sup>50</sup>Cr. Such sources are planned for use in calibrating forthcoming solar neutrino detectors, especially the gallium detector to be installed in the Gran Sasso Underground Laboratory. (Edited author abstract) 23 refs.

Cribier, M. (CEN, de Saclay, Fr); Pichard, B.; Rich, J.; Spiro, M.; Vignaud, D.; Besson, A.; Bevilacqua, A.; Caperan, F.; Dupont, G.; Sire, P.; Gorry, J.; Hampel, W.; Kirsten, T. *Nucl Instrum Methods Phys Res Sect A* v A265 n 3 Mar 15 1988 p 574-586.

**087811 MODERN RADIATION THERMOMETERS: CALIBRATION AND TRACEABILITY TO NATIONAL STANDARDS.** Modern trend in radiation thermometry is to substitute the tungsten strip lamp with the silicon photodiode as a secondary temperature standard. Instruments built in this perspective are described.

The design of transfer standards of this kind must follow orthodox mechanical, optical and radiometric criteria, presented in this paper. The result is an instrument whose calibration can be either primary, by use of a fixed point and a monochromator, or secondary, by comparison with a primary radiation thermometer kept in a National Laboratory, or with a secondary standard calibrated against a national standard. (Author abstract) 33 refs.

Ruffino, Giuseppe (Univ of Rome, Rome, Italy). *Pure Appl Chem* v 60 n 3 Mar 1988, Invited Lect Presented 30th Microsymp on Macromol - Polym Supported Org Reagents and Catal, Prague, Czech, Jul 6-9 1987 p 341-350.

## Components

**087812 METHOD FOR SELECTING DETECTOR APERTURES FOR USE IN SRIXE.** A method is presented that will help in selecting the most appropriate detector aperture size for use in SRIXE synchrotron radiation induced X-ray emission measurements. The criterion for selection involves maximizing the fluorescence yield while minimizing background from scattered radiation. The method uses previously published expansions of the scattering cross sections, integrated over solid angle (into 90°), and solving for the value of the aperture aspect ratio where the crossover occurs between terms of the cross section that are proportional to solid angle and terms that change faster than the solid angle. (Author abstract) 9 refs.

Hanson, A.L. (Brookhaven Natl Lab, Upton, NY, USA). *Nucl Instrum Methods Phys Res Sect A* v A260 n 1 Oct 1 1987 p 264-275.

**Computer Applications** See Also GAMMA RAYS—Computer Aided Analysis.

**087813 LOS ALAMOS NEUTRON SCATTERING CENTER DATA ACQUISITION SYSTEM.** The data acquisition requirements for the Los Alamos Neutron Scattering Center (LANSCE) are summarized. It consists of a FASTBUS system controlled by a DEC VAXstation II/GPX. The FASTBUS subsystem features four custom high-performance modules interfaced to the VAX through the commercialized version of the QPI. Control and analysis are supported with the multiwindow graphics capability of the workstation. The relationship between the FASTBUS hardware and the host VAX system, as well as the network environment the couples the various LANSCE instruments together are discussed. The principal features of the FASTBUS hardware and associated data acquisition/analysis software are addressed. 14 refs.

Nelson, Ronald O. (Los Alamos Natl Lab, NM, USA); Cort, Gary; Gjovig, A.; Goldstone, J.A.; McMillan, D.E.; Ross, J.; Seal, J.; Machen, D.R. *IEEE Trans Nucl Sci* v NS-34 n 4 Aug 1987, Fifth Conf on Real-Time Comput Appl in Nucl, Part and Plasma Phys, San Francisco, CA, USA, May 12-14 1987 p 1017-1032.

## Computer Simulation

**087814 VECTORIZATION OF THE GEANT3 GEOMETRICAL ROUTINES FOR A CYBER 205.** Simulation studies of high energy physics experiments consume now the largest portion of the CPU time required to analyze an experiment. This is mainly due to the increasing complexity of experimental apparatus and higher energies. We present here the first results from vectorizing the CERN detector simulation code GEANT3. Preliminary vectorization of just the geometrical part of GEANT3 applied to the calorimeter of experiment D0 of Fermilab shows a factor of 3 gain in performance on a Cyber 205. (Author abstract) 9 refs.

Dekeyser, J.-L. (Florida State Univ, Tallahassee, FL, USA). *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 291-296.



**087815 MONTE CARLO SIMULATION OF A TRANSITION RADIATION DETECTOR.** This paper employs Monte Carlo simulations of the performance of a transition radiation detector (TRD). The program has been written for the TRD in the ZEUS spectrometer, which separates electrons from hadrons in the momentum range between 1 and 30 GeV/c. Both total charge method and cluster counting method were simulated taking into account various experimental parameters. In particular, it was found that the cluster counting method relies on a quantitative understanding of the background originating from the production of  $\delta$ -electrons by charged particles. The results of the Monte Carlo calculations are in agreement with experimental data obtained with prototypes within a systematic uncertainty of 20 percent. We applied our Monte Carlo program to studies in order to find an optimum layout for the TRD within available space in the ZEUS spectrometer. This method of cluster analysing improves the suppression of hadrons by a factor of about two compared to the total charge method. (Edited author abstract) 8 Refs.

Appuhn, R.D. (Univ Bonn, Bonn, West Ger); Lange, E.; Oedingen, R.; Paul E. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 387-392.

## Design

**087816 DESIGN AND CONSTRUCTION OF A HIGH PRESSURE XENON TIME PROJECTION CHAMBER.** The design and construction of a 300 l high pressure xenon gas time projection chamber (TPC) is discussed. This detector has been built to perform a sensitive search for double beta decay of  $^{136}\text{Xe}$ . (Author abstract) 17 refs.

Iqbal, M.Z. (California Inst of Technology, Pasadena, CA, USA); Henriksen, H.E.; Mitchell, L.W.; O'Callaghan, B.M.G.; Thomas, J.; Wong, H.T.-k. *Nucl Instrum Methods Phys Res Sect A* v A259 n 3 Sep 15 1987 p 459-465.

**087817 VERSATILE, LOW-COST PYROELECTRIC LASER POWER MONITOR FOR THE 1 mW TO 50 W RANGE.** A design of inexpensive PVDF pyroelectric radiation detectors of large aperture and dynamic range is described. The spectral response ranges from the visible into the FIR region. Constructional and performance details are given. (Author abstract) 10 refs.

Hammerich, Mads (Univ of Copenhagen, Copenhagen, Den); Olafsson, Ari. *J Phys E* v 21 n 1 Jan 1988 p 80-83.

**087818 DESIGN AND REJECTION STUDIES FOR A CYLINDRICAL TRANSITION RADIATION DETECTOR FOR THE UA2 UPGRADE.** A study of a compact and cylindrical transition radiation detector is described. A prototype has been built and tested with 40 GeV electrons and hadrons. The measurements have been done using 100 MHz FADC. We have compared different radiators and chamber geometries using various algorithms. The cluster counting and the total integrated charge methods give comparable results. A comparison between radiators of lithium and polypropylene is made. (Author abstract) 10 refs.

Ansari, R. (Lab d'Accelerateur Lineaire, Orsay, Fr); Chollet, J.C.; De Lotto, B.; Froidevaux, D.; Fayard, L.; Merkel, B.; Iconomidou-Fayard, L.; Moniez, M.; Parrou, G.; Repellin, J.P. *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 51-57.

**087819 HgI<sub>2</sub> ARRAY DETECTOR DEVELOPMENT PROJECT.** We report here on the project's current status. Major effort has occurred in several areas. We have developed techniques for producing multielement arrays on HgI<sub>2</sub> and constructed a testing system to evaluate our initial ideas for miniaturizing the array processing electronics. We have combined fiber optics with pulsed optical resetting in a novel way in order to be able to employ this reset scheme in the physically dense array environment. We present the results of crosstalk

testing using this new scheme, as well as electronic-noise and energy-resolution results on a recently fabricated HgI<sub>2</sub> detector array. Finally, we describe our current progress in eliminating charge division between neighboring detector elements through the use of entrance window masking. (Edited author abstract) 18 refs.

Iwanczyk, J.S. (Inst of Physics/USC, Marina del Rey, CA, USA); Warburton, W.K.; Hedman, B.; Hodgson, K.O.; Beyerle, A. *Nucl Instrum Methods Phys Res Sect A* v A266 n 1-3 Apr 1 1988, Synchrotron Radiat Instrum, Proc of the Fifth Natl Conf, Madison, WI, USA, Jun 21-25 1987 p 619-627.

**087820 DESIGN AND PERFORMANCE OF AN IMAGING PLATE SYSTEM FOR X-RAY DIFFRACTION STUDY.** A new readout system for a BaFBr:Eu<sup>2+</sup> photostimulable phosphor screen (imaging plate) was constructed by modifying a drum scanner, with a design optimized for X-ray diffraction and scattering applications. An effort was made to achieve a high detective quantum efficiency below 20 keV, a small pixel size (25  $\mu\text{m} \times 25 \mu\text{m}$ ), a low quantization noise (0.22%) using 12-bit A/D converters, and the capability to cover an inherent dynamic range (1:10<sup>5</sup>) of the photostimulated luminescence by using two photomultiplier tubes. This system is being used in several synchrotron radiation experiments: Laue diffraction of protein crystals, small angle diffraction from a single muscle fiber, powder diffraction from crystals in a diamond anvil cell, and time-resolved small-angle X-ray scattering from a synthetic polymer during stretching. (Author abstract) 15 refs.

Amemiya, Yoshiyuki (Natl Lab for High Energy Physics, Tsukuba, Jpn); Matsushita, Tadashi; Nakagawa, Atsushi; Satow, Yoshinori; Miyahara, Junji; Chikawa, Jun-ichi. *Nucl Instrum Methods Phys Res Sect A* v A266 n 1-3 Apr 1 1988, Synchrotron Radiat Instrum, Proc of the Fifth Natl Conf, Madison, WI, USA, Jun 21-25 1987 p 645-653.

Efficiency See Also GAMMA RAYS—Detection.

**087821 EFFICIENCY OF Si(Li) X-RAY DETECTORS AT LOW ENERGIES.** A method for determining the efficiency of a Si(Li) X-ray detector at low energies using a fluorescence X-ray source is described. The thickness of the Be X-ray window and of the Si dead layer can also be measured. Results obtained using the method are described and the effects of the gold contact and of a possible ice layer on the surface of the detector considered. (Author abstract) 12 refs.

Baker, C.A. (Rutherford Appleton Lab, Chilton, Engl); Batty, C.J.; Sakamoto, S. *Nucl Instrum Methods Phys Res Sect A* v A259 n 3 Sep 15 1987 p 501-505.

**087822 EMPIRICAL RELATION BETWEEN EFFICIENCY AND VOLUME OF HPGe DETECTORS.** F. Vano et al.'s empirical relation has been proved to be valid for HPGe detectors with large active volume range. New values of  $a$  and  $b$  are 0.6246 and -2.136 respectively. The slope of the efficiency curve is characteristic of detectors and independent of the geometry conditions within 2% error. It can be calculated within an error less than 3% in a certain energy range. (Author abstract) 3 refs.

Zhong, Cao (Inst of Atomic Energy, Beijing, China). *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 439-440.

**087823 COMPUTER PROGRAM FOR CALCULATING Ge(Li) DETECTOR COUNTING EFFICIENCIES WITH LARGE VOLUME SAMPLES.** A novel computing method has been developed to calculate the absolute photopeak efficiency of a Ge(Li) detector for cylindrical samples of different heights and diameters with variable density. For each point in the cylindrical sample the detection efficiency is calculated taking into account the distance from the detector and gamma ray attenuation and the efficiency is integrated numerically over the volume of the sample. The detector is approximated as a point detector with an experimentally determined effective

interaction depth. It is necessary to measure the absolute efficiency for a point source located on the detector axis at a known distance. Then the computer program calculates the absolute counting efficiency for any cylindrical sample and for any density. The measured and calculated values for two different cylinders and three different densities give a good (—12%) overall agreement. (Author abstract) 11 refs.

Zikovsky, L. (Ecole Polytechnique, Montreal, Que, Can); Chah, B. *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 483-486.

**087824 ABSORPTION EDGE TECHNIQUE FOR DETERMINATION OF INTRINSIC Ge DETECTOR PARAMETERS.** A systematic study of the intrinsic Ge detector efficiency in the energy region 2-20 keV is presented. The definition of the efficiency is discussed and auxiliary quantities introduced. The most influential construction parameters of the detector - the dead layer width and the thickness of the gold contact - are determined in separate measurements employing the differential counting technique in the vicinity of respective absorption edges. A simple analytical approximation to the efficiency is proposed. (Author abstract) 25 refs.

Budnar, M. (E. Kardelj Univ, Ljubljana, Yugosl); Glavic, D.; Kodre, A.; Smit, Z. *Nucl Instrum Methods Phys Res Sect B* v 31 n 3 May 1 1988 p 456-461.

**087825 GEOMETRIC EFFICIENCIES OF CIRCULAR DETECTOR AND SURFACE SOURCE ARRANGEMENTS - NUMERICAL SOLUTION AND EXPERIMENTAL VERIFICATION.** A numerical technique of determining the geometric efficiency for circular detectors exposed to surface sources is presented. Circular sources are primarily considered, but most other surface shapes can be accommodated by the technique. Independence laboratory measurements were made using accurately calibrated alpha sources and surface barrier detectors. The results confirm the accuracy of the numerical method. (Author abstract) 11 Refs.

Wilson, Owen J. (Australian Radiation Lab, Yallambie, Aust); Short, Stephen A. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 644-651.

Electronic Equipment See Also RADIOACTIVITY MEASUREMENT; SPECTROMETERS—Components.

**087826 DATA ACQUISITION SYSTEMS FOR LINEAR AND AREA X-RAY DETECTORS USING DELAY LINE READOUT.** Digital systems for fast readout of linear and area position sensitive detectors based on commercially available CAMAC modules are described. The first version of the system has been used extensively for synchrotron radiation work carried out at the EMBL outstation in Hamburg during the last five years. A second system allowing measurements at count rates up to 600 kHz on a continuous source has been recently installed. An overview of the complete acquisition and information processing system is also given. (Author abstract) 37 refs.

Boulin, C.J. (European Molecular Biology Lab, Heidelberg, West Ger); Kempe, R.; Gabriel, A.; Koch, M.H.J. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 312-320.

**087827 ENGINEERING TRADEOFFS IN MINIATURIZATION OF ELECTRONICS FOR VERY LARGE DETECTORS.** The author points out that very-large-scale detectors require a level of highly disciplined engineering if they are to be built within time and budgetary constraints, and that an excessive level of innovation in the design can be a hindrance rather than an advantage toward the chief end. He explores the issue of



how to judge the level to which electronics technology should be introduced into a detector design. He examines the cost/benefit tradeoffs.

Larsen, R.S. (Stanford Univ, CA, USA). *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 138-141.

**087828 HYBRIDIZED FRONT END ELECTRONICS OF THE CENTRAL DRIFT CHAMBER IN THE STANFORD LINEAR COLLIDER DETECTOR.** A description is given of the front-end electronics, which has been hybridized in order to accommodate high-packaging-density requirements. The hybrid package contains eight channels of amplifiers together with all the associated circuits for calibration, event recognition, and power-economy switching functions. A total of 1280 such hybrids are used. The amplifiers and associated circuits are described, and their performance is discussed. 8 refs.

Lo, C.C. (Lawrence Berkeley Lab, Berkeley, CA, USA); Kirsten, F.A.; Nakamura, M.; Jared, R.C.; Goulding, F.S.; Yim, A.; Moss, J.; Freytag, D.; Haller, G.; Larson, R.; Peregny, L. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 142-145.

## Evaluation

**087829 COMPARISON OF THREE DETECTORS FOR SOFT X-RAY DOSIMETRY.** Three methods of X-ray dosimetry were tested and compared for broadband synchrotron radiation in the photon energy range 500-6000 eV. A calorimetry technique using thermistors as both the temperature-sensing device and the radiation absorber was easy to implement and gave reproducible results. Radiochromic film was convenient to use and agreed with the calorimetry results, but with more scatter in the measurements. The formation of color centers (F-centers) in alkali halide crystals, specifically NaCl and LiF, provided interesting results but requires further research for the application to low energy synchrotron radiation. (Author abstract) 10 refs.

Meger, C.M. (Univ of Wisconsin, Madison, WI, USA); Pearson, D.W.; Deluca, P.M. Jr.; Wells, G.M.; Redaelli, R.; Cerrina, F. *Nucl Instrum Methods Phys Res Sect A* v A266 n 1-3 Apr 1 1988, Synchrotron Radiat Instrum, Proc of the Fifth Natl Conf, Madison, WI, USA, Jun 21-25 1987 p 608-611.

## Imaging Techniques

**087830 DELAY LINE READOUT OF MICROCHANNEL PLATES.** A two-dimensional delay line readout to be used with large-diameter (127-mm) microchannel plates (MCPs) has been developed. High spatial resolutions (25  $\mu$ m FWHM for an MCP gain of  $2 \times 10^7$ ) and excellent linearity of position readout (less than  $\pm 65$ - $\mu$ m deviation from linearity) have been achieved in a test setup using 30-mm-diameter MCPs coupled to 140-mm  $\times$  140-mm delay lines. Single-pass delays of only 176 ns allow system deadtimes of less than 1  $\mu$ s. This type of readout will be applied to imaging X-ray detectors to be used in protein crystallography. 11 refs.

Sobottka, Stanley E. (Univ of Virginia, Charlottesville, VA, USA); Williams, Mark B. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 348-351.

## Materials See Also SEMICONDUCTING SILICON—Electric Properties.

**087831 DETECTION OF IONIZING RADIATIONS BY NATURAL AND SYNTHETIC DIAMOND CRYSTALS AND THEIR APPLICATION AS DOSIMETERS IN BIOLOGICAL ENVIRONMENTS.** Experimental results demonstrate that synthetic diamond crystals with impurity concentrations carefully controlled during the synthesizing process are excellent ionizing radiation detectors in instances of in vivo radiation dosimetry. Because of their size and physical properties, synthetic diamond crystals would

lend themselves to electron beam dosimetry measurements in radiotherapy units. With slight modifications to the synthesizing process, the diamonds can be used as thermoluminescence dosimeters or as ionization chamber dosimeters. The nontoxic, tissue-equivalent diamond crystal dosimeters can be reused many times. (Edited author abstract) 30 refs.

Keddy, R.J. (Univ of the Witwatersrand, Johannesburg, S Afr); Nam, T.L.; Burns, R.C. *Carbon* v 26 n 3 1988 p 345-356.

## Medical Applications

**087832 PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON THE USE OF WIRE CHAMBERS IN MEDICAL IMAGING.** This conference proceedings contains 16 papers, all of which are separately indexed and abstracted. The papers consider topics on the use of wire chambers in medical imaging. Positron cameras are reviewed. Applications of proportional chambers, gamma cameras, and X-ray detectors are presented. Digital imaging, positron emission tomography, medical imaging, and image enhancement are discussed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11653 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Deconinck, Frank (Ed.) (Vrije Univ Brussel, Brussels, Belg); Defrise, Michel (Ed.); Tavernier, Stefaan (Ed.). *Nucl Instrum Methods Phys Res Sect A* v A269 n 2 Jun 10 1988, Proc of the Int Symp on the Use of Wire Chambers in Med Imaging, Corsendonk, Belg, Jun 28-30 1987 p 341-453.

## Performance See Also GEOPHYSICS—Exploratory; RADIOACTIVITY MEASUREMENT—Reliability.

**087833 SELECTION OF CRITERIA FOR ESTIMATION OF THE SPECTRAL SENSITIVITY OF A SET OF INTEGRAL DETECTORS.** The authors describe and study with test spectra a form for quantitative estimation of the spectral sensitivity of integral detectors that is based on specially determined coefficients of spectral sensitivity of individual detectors and the set as a whole. The authors also consider the possibility of organization - with the use of coefficients of spectral sensitivity - of a simple procedure for determining spectrum errors due to measurement-means errors that is easily implemented on small computers. The experimental results lead to the general conclusion that the proposed approach to estimation of the spectral sensitivity of a set of detectors shows good promise for practical application in the integral-detector method, although a number of its aspects require further development and improvement. 7 refs.

Koshelev, A.S.; Maslov, G.N.; Petrov, Yu.V. *Meas Tech* v 29 n 1 Jan 1986 p 53-57.

**087834 IMPROVEMENT OF ACCURACY OF COORDINATE DETERMINATION IN LEAD-GLASS DETECTOR CONTAINING ACTIVE CONVERTER.** The effect of an active converter on the accuracy of determination of the coordinates of positrons with an energy of 5 GeV in a hodoscopic shower detector is studied. It is shown that the space resolution is improved when the energy release in the active counter, in addition to the ratio of the signal amplitudes of adjacent cells, is taken into account in coordinate calculation. (Author abstract) 2 refs.

Blik, A.M. (Inst of High-Energy Physics, Serpukhov, USSR); Romanovskii, V.I.; Kolosov, V.N.; Solov'ev, A.S. *Instrum Exp Tech* v 30 n 2 pt 1 Mar-Apr 1987 p 285-287.

**087835 ONE-DIMENSIONAL ARRAY BASED ON Si(Li) DETECTORS FOR SCANNING X-RAY INTROSCOPES.** Si(Li) diffusion-drift semiconductor detectors (SD) are studied that are designed for one-dimensional multielement arrays for scanning x-ray introsopes. The working area of the detectors is  $10 \text{ mm}^2$ , and the thickness of the sensitive region is 22 mm. The

working range of dose rates is 0.05-10 R/min for radiator voltages of 100-120 kv. The SD sensitivities are 0.5 and  $0.65 \mu\text{A}/\text{cm}^2$  (R/min) for 100 and 120 Kv, respectively. The signal-to-noise ratios of the sensor (SD and operational amplifier), the temperature dependence of the sensor signals, and the effect of scattered radiation on the SD signal are studied. A detector module consisting of 16 elements is described. (Author abstract) 7 refs.

Petushkov, A.A. (Moscow Scientific-Industrial Organization 'Spektr', USSR); Musyankov, S.I.; Shchebiot, U.V.; Kaminskii, V.P. *Instrum Exp Tech* v 30 n 2 pt 2 Mar-Apr 1987 p 449-452.

**087836 EXTENSION OF THE SEMIEMPIRICAL GERMANIUM DETECTOR RESPONSE FUNCTION TO LOW ENERGY GAMMA RAYS.** A model for the spectral response function of large volume germanium gamma-ray detectors in the range of incident gamma-ray energies from 60 keV to 6.2 MeV has been developed and applied to a 39% high purity germanium detector. Functional forms for describing the various features of the response function are based either on empirical functions or on analytical expressions of the interaction mechanisms. Improved functions are formulated to give good agreement to the experimental spectra near the Compton edge in the Compton continuum of the primary and annihilation photons. To form the complete detector response function only nine linear and six nonlinear parameters are needed. Validity of the model is demonstrated by comparing the regenerated spectra of  $^{241}\text{Am}$ ,  $^{51}\text{Cr}$ ,  $^{137}\text{Cs}$ ,  $^{54}\text{Mn}$ ,  $^{28}\text{Al}$ ,  $^{37}\text{S}$ , and  $^{16}\text{N}$  and the synthesized spectra of  $^{24}\text{Na}$  and  $^{133}\text{Ba}$  using the response function to the equivalent experimental spectra. (Author abstract) 11 refs.

Lee, Myung C. (North Carolina State Univ, Raleigh, NC, USA); Verghese, K.; Gardner, R.P. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 430-438.

**087837 DETERMINATION OF THE DYNAMIC NONLINEARITY OF SEMICONDUCTOR AND COMBINED DETECTORS FOR COMPUTER-ASSISTED TOMOGRAPHY.** The experimental arrangement described reproduces values of the x-ray photon flux density that are typical of computer-assisted tomography ( $10^8$ - $10^{10} \text{ cm}^{-2} \cdot \text{sec}^{-1}$ ) and its rates of relative change. We give the results of determination of the dynamic nonlinearity  $\gamma^d$  of combined detectors [ $\text{CsI(Tl)} + \text{Si}$  photodiode and  $\text{CdWO}_4 + \text{FEU-60}$  photomultiplier] and semiconducting CdTe. The CdTe detector has the highest value,  $\gamma^d \geq 36\%$ , while  $\text{CdWO}_4 + \text{FEU-60}$  has the lowest values,  $\gamma^d \leq 1\%$ , on the trailing edge of the current signal. (Author abstract) 7 refs.

Tur'yanskii, A.G. (Scientific-Research Inst of the Cable Industry, Moscow, USSR); Kon'kov, V.V.; Fedoseeva, O.P. *Instrum Exp Tech* v 30 n 3 pt 2 May-Jun 1987 p 712-714.

**087838 SILICON DETECTORS FOR NUCLEAR RADIATION.** The working principle of Si radiation detectors is described, choosing a  $p^+nn^+$  structure as a typical device. The physical laws for interaction of corpuscular and gamma radiation with matter are discussed and the conditions for energy spectroscopy derived. For position determination of radiation, resistive charge division, integrated diode arrays, charge drift and charge transfer in CCDs are considered. The need for nuclear radiation detectors in research and technology is demonstrated. (Author abstract). 31 Refs.

Kemmer, Josef A. (Technical Univ Munich, Garching, West Ger). *Sens Actuators* v 15 n 2 Oct 1988 p 169-184.

**087839 SEMICONDUCTOR DETECTOR PERFORMANCE FOR LOW-ENERGY X-RAYS.** Factors that limit the capabilities of semiconductor detectors at photon energies below 5 keV include energy resolution, detector efficiency, and detector-related continuum background. These properties can be controlled to a certain extent by optimal detector design and fabrication tech-



niques. We describe measurements on the low energy response of Si(Li) detectors obtained using a tunable monochromatic source. Window thicknesses have been measured for a number of devices using different materials for the entry contact. The interpretation of these results in terms of existing detector window models is discussed. Results obtained using a new contact structure demonstrate that a dramatic reduction in window-related absorption in Si(Li) detectors can be achieved. (Author abstract) 6 refs.

Jaklevic, J.M. (Lawrence Berkeley Lab, Berkeley, CA, USA); Walton, J.T.; McMurray, R.E. Jr.; Madden, N.W.; Goulding, F.S. *Nucl Instrum Methods Phys Res Sect A* v A266 n 1-3 Apr 1 1988, Synchrotron Radiat Instrum, Proc of the Fifth Natl Conf, Madison, WI, USA, Jun 21-25 1987 p 598-601.

#### Research See Also PHYSICS—High Energy.

**087840 MILLIMETER AND SUBMILLIMETER DETECTION USING  $Ga_{1-x}Al_xAs/GaAs$  HETEROSTRUCTURES.** We have shown that a  $Ga_{1-x}Al_xAs/GaAs$  heterostructure can be used as a sensitive tunable detector of mm-wave/sub-mm-wave radiation. The mechanism for detection requires the application of a magnetic field varying from approximately 0.2T at 94GHz (3.2mm wavelength) to 6.2T at 2500GHz (119μm wavelength). The responsivity and N.E.P. at 3.2mm have been roughly estimated at 200V/W and  $5 \times 10^{-11}W/\sqrt{Hz}$  respectively. (Edited author abstract) 10 refs.

Smith, S.M. (Univ of Bath, Bath, Engl); Cronin, N.J.; Nicholas, R.J.; Brummell, M.A.; Harris, J.J.; Foxon, C.T. *Int J Infrared Millim Waves* v 8 n 8 Aug 1987 p 793-802.

#### Reviews

**087841 RECENT RESULTS FROM THE FREJUS EXPERIMENT.** Recent results from the Frejus experiment are discussed. Besides giving new limits on the nucleon lifetime we report on searches for Cygnus X3, SNA 1987a and dark matter induced events. In addition we present an analysis of the muon multiplicity deep underground in terms of the primary cosmic ray composition. (Author abstract) 8 refs.

Berger, Ch. (RWTH, Aachen, West Ger). *Nucl Instrum Methods Phys Res Sect A* v A264 n 1 Feb 1988, Non-Accel Part Phys, Proc of the Workshop, Rochester, NY, USA, Jun 1-3 1987 p 24-27.

**087842 D0 TRANSITION RADIATION DETECTOR.** The transition radiation detector (TRD) for the D0 experiment is currently under construction at SLAC. The first part of this paper reports on the tests performed with a prototype detector at the CERN PS. Chamber operation was studied with xenon gas and small additions of  $CO_2$ ,  $CH_4$ , or isobutane as quenchers. X-ray yields from lithium and polypropylene radiators were compared, with different analysis methods. The second part describes the design and construction of the cylindrical TRD, to be built and installed in the D0 Experiment (E740) at FNAL, which should provide a pion rejection factor of 50 for 90% electron efficiency. The first chamber of this 3-unit detector will be ready for test in April 1987, and the full TRD is planned to be assembled at the end of 1987. (Author abstract) 3 refs.

Detoef, Jean-Francois (CEA, Saclay, Fr); Ducros, Yves; Feinstein, Fabrice; Hubbard, J. Richard; Mangeot, Philippe; Mansoulie, Bruno; Teiger, Jacques; Zylberstein, Armand. *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 157-166.

#### Testing

**087843 TEST OF A  $BaF_2$ -TMAE DETECTOR FOR POSITRON-EMISSION TOMOGRAPHY.** A detector consisting of  $BaF_2$  scintillators and wire chambers has been tested for 511 keV gamma-rays. The wire chamber is filled with photosensitive tetrakis(dimethylamine)ethylene

(TMAE) vapour and is operated at a pressure of a few Torr, using different gases at various temperatures. Energy, time, and position resolutions are given for  $BaF_2$  crystals with sections of  $10 \times 10$  mm<sup>2</sup> and  $5 \times 5$  mm<sup>2</sup>. We discuss the potential of this gamma detector for positron-emission tomography (PET) and compare it with other systems. (Author abstract) 19 refs.

Mine, P. (CERN, Geneva, Switz); Charpak, G.; Santiard, J.-C.; Scigocki, D.; Suffert, M.; Tavernier, S. *Nucl Instrum Methods Phys Res Sect A* v A269 n 2 Jun 10 1988, Proc of the Int Symp on the Use of Wire Chambers in Med Imaging, Corsendonk, Belg, Jun 28-30 1987 p 385-391.

#### Thin Films

**087844 PHOTOMETRIC METHOD OF DETERMINING GOLD FILM THICKNESS OF NUCLEAR RADIATION SILICON DETECTORS.** The input window thickness of nuclear radiation silicon detectors (SFD) containing the surface barrier (Schottky barrier) is one of the most important characteristics of the primary transducer. The parameter is determined mainly by the thickness of the sputtering gold film. Since the radiometric properties of a detector, and in some cases, the applicability of the detector in principle, depend on the thickness of its input window, it is very important to know this parameter for each detector. A photometric method of assessing a detector's gold film thickness based on the photocurrent from a light passed through the sputtered metal layer is discussed. 3 refs.

Nikitin, B.A.; Zakharchuk, D.V.; Kovalev, I.I.; Nikolaeva, T.V.; Serushkina, E.S. *Meas Tech* v 30 n 2 Feb 1987 p 196-198.

**087845 APPLYING TELLEGEN'S THEOREM TO CALCULATE THE PULSE RESPONSES ON A MICROSTRIP DETECTOR'S STRIPS.** The pulse response on a strip of a microstrip detector is calculated while charge, generated in the detector by radiation, is being collected. Both cases, i.e., when the strip is going to collect the generated charge and when it does not, are evaluated. A method to calculate these pulses is presented. It is based on Tellegen's theorem by which it is shown that the current induced in a detector strip can be calculated by scaling the currents flowing inside the detector (resulting from the movement of the generated charges) by a reference field and then integrating these weighted currents. This field, which is determined separately, depends solely on the geometry of the detector. Its generality makes the method applicable to other induction problems as well. 12 refs.

ten Kate, Warner R. Th (Delft Univ of Technology, Neth). *IEEE Trans Nucl Sci* v NS-34 n 4 Aug 1987, Fifth Conf on Real-Time Comput Appl in Nucl, Part and Plasma Phys, San Francisco, CA, USA, May 12-14 1987 p 1076-1084.

**RADIATION EFFECTS** See Also ACCELERATORS; SYNCHROTRON; ADHESIVES—Curing; ALUMINA—Optical Properties; ALUMINUM LEAD ALLOYS—Internal Friction; AROMATIC POLYMERS—Degradation; CALCIUM COMPOUNDS—Dielectric Properties; CARBIDES—Amorphous; CARBON—Gasification; COPOLYMERS—Synthesis; COPPER NICKEL IRON ALLOYS—Decomposition; CYANIDES—Synthesis; DIELECTRIC MATERIALS—Surfaces; ELASTOMERS—Degradation; ELECTRON BEAMS—Applications; ELECTRONS—Emission; ENZYMES—Immobilization; FIRES—Mathematical Models; FOOD PRODUCTS—Fruits; FOOD PRODUCTS—Preservation; FOOD PRODUCTS—Processing; FOOD PRODUCTS—Radiation Effects; HYDROCARBONS—Ionization; HYDROCARBONS—Isomerization; IRON CHROMIUM NICKEL ALLOYS—Composition Effects; LASER BEAMS—Effects; LUMINESCENCE; MANGANESE COMPOUNDS—Dissolution; METALS AND ALLOYS—Ion Implantation; METALS AND ALLOYS—Mechanical Properties; NEUTRONS—Emission; NOISE, SPURIOUS SIGNAL—Thermal Noise; PHOSPHORS—Optical Properties; PLASTICS, REINFORCED—Glass Fiber; PLATES—Failure; PLUTONIUM COMPOUNDS—Oxidation; POLYCARBONATES—Etching; POLYMERS—Crosslinking; POLYMERS—Degradation; POLYMETHYL METHACRYLATE—Impurities; POLYPROPYLENE—Antioxidants; PROTEINS—Chemical Reactions; RADIOACTIVITY—Applications; SEMICONDUCTING GALLIUM COMPOUNDS—Ion Implantation; SEMICONDUCTING LEAD COMPOUNDS—Electric Properties; SEMICONDUCTING

SILICON—Defects; SEMICONDUCTOR DEVICES—Processing; SEMICONDUCTOR DIODES; SEMICONDUCTOR MATERIALS—Defects; SEWAGE TREATMENT PLANTS—Design; STAINLESS STEEL—Microstructure; TITANIUM AND ALLOYS—Corrosion; WASTEWATER—Treatment; X-RAY APPARATUS—Applications; ZIRCONIUM AND ALLOYS—Stress Corrosion Cracking.

**087846 DEVICE FOR IRRADIATING SAMPLES AT A LOW TEMPERATURE.** The processes taking place in various samples in an intense flux of nuclear radiation at a low temperature are studied in devices of the end 'loop', operating on liquid nitrogen. The loops consist of a liquid-nitrogen source, a cryostat holding the samples, inlet and outlet lines, and a radiation source. Such a device is designed to work only on expensive super-pure nitrogen. At the Institute of Mechanical Engineering of the Ukrainian Academy of Sciences, a new system for the low-temperature irradiation of samples was developed and tested. In this system the main coolant can be inexpensive industrial nitrogen, which has a composition satisfying GOST (All-Union State Standard) 9293-74 (96% nitrogen, 4% oxygen). 2 refs.

Makarov, A.A.; Basteev, A.V.; Muminov, M.I.; Lysenko, A.M. *Sov At Energy* v 63 n 3 Sep 1987 p 726-728.

**087847 FEDERAL APPROACH TO RADIATION ISSUES.** Formal interagency coordination action on radiation issues began with the creation of the Federal Radiation Council (FRC) in 1959 'to advise the President with respect to radiation matters.' The FRC then consisted of representatives of six federal agencies. When EPA was created in 1970, the FRC was abolished and many of its functions were transferred to EPA. Today representatives from those six agencies as well as 12 others comprise the Committee on Interagency Radiation Research and Policy Coordination (CIRRPC). This article discusses issues addressed by CIRRPC. Subjects covered include federal radiation policy, radiation compensation, radon, nonionizing radiation, food irradiation, and others. 17 Refs.

Young, Alvin L. (USDA, Washington, DC, USA); Dix, George P. *Environ Sci Technol* v 22 n 7 Jul 1988 p 733-739.

**087848 DIRECT EFFECTS OF IONIZING RADIATION UNIQUE TO MACROMOLECULES.** Radiation studies of macromolecules have revealed several effects which cannot be described by classical radiation physics and are not observed in radiation studies of simple diatomic gases: (1) the radiation damage to macromolecules depends on the temperature at which irradiation was performed; (2) polymeric molecules suffer radiation damage throughout the chain no matter where the primary ionization occurred; (3) there is only minimal appearance of radiation damage in other chains which are not covalently linked to the one suffering the primary ionization. These effects have been observed in radiation studies of all synthetic polymers and biologic macromolecules including proteins and nucleic acids. Data implicating free radicals in the temperature effects and studies concerning energy transfer in irradiated macromolecules provide a basis for the mechanisms involved in these effects. (Author abstract). 55 Refs.

Kempner, E.S. (NIH, Bethesda, MD, USA); Verkman, A.S. *Radiat Phys Chem* v 32 n 3 1988 p 341-347.

**087849 HIGH ENERGY PHOTOPHYSICS AND PHOTOCHEMISTRY: ASSIGNMENT OF INITIAL ELECTRONIC STATES OF FRAGMENTATION PROCESSES IN  $CO_2^{2+}$ .** The assignment of the electronic states of gas-phase molecular dications presents a number of difficulties. After discussing these problems a strategy for assignment, which collates the results of several experimental and theoretical techniques, is presented. The use of information from the fragmentation dynamics of dication states is proposed. Three states,  $\alpha$ ,  $\beta$  and  $\gamma$ , of  $CO_2^{2+}$ , whose appearance potentials were previously observed by photoion-photoion coincidence techniques at 37.9, 40.5 and 45 eV, respectively, are



assigned using the methods presented. The results also strongly support the value 37.7 eV for the appearance potential of the metastable ground state. Present limitation and future desirable progress of the assignment techniques are discussed. (Author abstract) 47 Refs.

Leach, Sydney (CNRS, Orsay, Fr). *Radiat Phys Chem* v 32 n 3 1988 p 563-572.

**Applications** See FOOD PRODUCTS—Radiation Effects; RADIATION CHEMISTRY—Taiwan, China.

**Computer Simulation** See Also DATA STORAGE, SEMICONDUCTOR—Radiation Effects; SEMICONDUCTOR DEVICES, MOS—Reliability.

**087850 ESTIMATING THE DIMENSIONS OF THE SEU-SENSITIVE VOLUME.** Simulations of the diffusion contribution to charge collection in SEU (single-event upset) events are carried out under the simple assumption of random walk. The results of the simulation are combined with calculations of the funneling length for the field-assisted drift components to determine the effective thickness of the sensitive volume element to be used in calculations of soft-error rates for heavy-ion-induced and proton-induced upsets in microelectronic circuits. Comparison is made between predicted and measured SEU cross sections for devices for which the critical charges are known from electrical measurements and the dimensions of the sensitive volume used are determined by the techniques described. The agreement is sufficient to encourage confidence that SEU rates can be calculated from first principles and a knowledge of the material, structural, and electrical characteristics of the device. 10 refs.

Abdel-Kader, W.G. (Clarkson Univ, Potsdam, NY, USA); McNulty, P.J.; El-Teaty, S.; Lynch, J.E.; Khondker, A.N. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1300-1304.

**087851 PREDICTING TRANSIENT UPSET IN GATE ARRAYS.** A simulation program for predicting dose rate upset has been adapted from the Power Analysis for Integrated Circuits Program (PANIC). The program provides analysis on the  $V_{cc}-V_{ss}$  difference at any location within the array as well as the amount of photocurrent being collected, as a function of design. The simulation has been compared to experiment for a specific design and was found to correlate to within 20% at 5 V, 5 refs.

Woodruff, Richard L. (United Technology Microelectronics Cent, Colorado Springs, CO, USA); Nelson, Donald A.; Scherr, Steven. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1426-1430.

## Electromagnetic Field Effects

**087852 NEW APPROACH TO VOLUMES IRRADIATED BY UNKNOWN SOURCES.** The authors suggest an approach to the characterization of electromagnetic environments irradiated by unknown sources. The approach is based on the numerical solution of Maxwell's equations subject to the constraints imposed by the measured values of the field at a small number of measurement points and by boundary conditions. A thorough examination of a method for the numerical solution is presented. The examples attempted demonstrate the approach but reveal deficiencies in the numerical method. Possible future directions are suggested. 25 refs.

Randa, J. (NBS, Boulder, CO, USA); Kanda, Motohisa. *IEEE Trans Electromagn Compat* v EMC-29 n 4 Nov 1987 p 273-281.

**Environmental Impact** See NUCLEAR POWER PLANTS—Accidents.

**Health Hazards** See Also RISK STUDIES—Health Risks; ULTRAVIOLET RADIATION—Measurements.

**087853 HUMAN EXPOSURE TO LOW LEVEL IONISING RADIATION.** A review is given of the

ionizing-radiation environment, covering natural and artificial sources. It is seen that with currently-accepted quality factors the progeny of radon-222 make the largest single contribution to human exposure. Medical radiation usage is the greatest artificial source. Stochastic effects of radiation and the usual approach to protection from radiation are discussed briefly. (Author abstract) 22 refs.

Paix, David (South Australian Inst of Technology, Adelaide, Aust). *Australas Phys Eng Sci Med* v 10 n 3 Jul-Sep 1987 p 144-154.

**087854 PRENATAL IRRADIATION AND CHILDHOOD CANCER.** Estimates of the relative risk of childhood cancer, following irradiation during fetal life, are reported. They are based upon extended case-control investigations of childhood cancer deaths in England, Wales and Scotland between 1953 and 1979 comprising 14,759 geographically-matched and birth-date-matched case/control pairs. The estimates were calculated using Conditional Logistic Regression (Miettinen-Breslow) techniques. This method of risk-estimation limits the distortion caused by confounding factors or by biased selection of controls. Through analyzing a range of reported exposures other than radiation, levels of general reporting and recording biases between cases and controls were also assessed. During this period of time, about 7 per cent of all childhood cancers, and 8 per cent of those with onset between the ages of 4 and 7 years, were caused by x-ray examinations. The dose-response relationship was one death per 990 obstetric x-ray examinations; or 2,000 deaths per  $10^4$  man-Gy. (Edited author abstract) 21 refs.

Knox, E.G. (Univ of Birmingham, Birmingham, Engl); Stewart, A.M.; Kneale, G.W.; Gilman, E.A. *J Soc Radiol Prot* v 7 n 4 Winter 1987 p 177-186.

## Industrial Applications

See Also DOSIMETRY.

**087855 PROGRESS IN RADIATION PROCESSING, PROCEEDINGS OF THE 6TH INTERNATIONAL MEETING.** This conference proceedings contains 120 papers on the most recent findings in radiation processing and research. The program of the conference provides a balance between industry, government and academia, while ensuring a balance between electron beam and gamma technologies. The main topics discussed include environmental applications, food irradiation, international developments, source technology developments, process control, dosimetry, irradiator design, polymers, biological applications, new applications, and general radiation processing applications. All papers are abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11109 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Fraser, F.M. (Ed.). *Radiat Phys Chem* v 31 n 1-3 and 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Ottawa, Ont, Can, May 31-Jun 5 1987 2 vol, 899p.

**087856 RADIATION APPLICATIONS RESEARCH AND FACILITIES IN AECL RESEARCH COMPANY.** There are currently two major industrial uses of ionizing radiation. One of these, sterilization of medical disposables, is based primarily on gamma radiation from  $^{60}\text{Co}$  while the other, curing, polymerizing, crosslinking and grafting of materials is based on machine-produced electron radiation. In the 60's and 70's Atomic Energy of Canada had a very active R&D program to discover and develop applications of ionizing radiation. Out of this grew the technology underlying the company's current product line of industrial irradiators. With the commercial success of that product line the company turned its R&D attention to other activities. Presently, widespread interest in the use of radiation for food processing and the possibility of developing reliable and competitive machine sources of radiation hold out the promise of a major increase in industrial use of radiation. In March 1985 a new branch, Radiation Applications Research, began operations with the objective of working closely with industry to develop and assist the introduction of new uses of ionizing radiation. Initial projects in

areas ranging from food through environmental and industrial applications have been assessed and the most promising have been selected for further work. 19 refs.

Iverson, S.L. (AECL, Pinawa, Manit, Can). *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 783-787.

**Mathematical Models** See BIOLOGICAL MATERIALS—DNA; BIOLOGICAL MATERIALS—Radiation Damage; SEMICONDUCTOR DEVICES, MOSFET—Radiation Effects.

## Measurements

**087857 RADIATION MEASUREMENTS AND RADIOECOLOGICAL ASPECTS OF FALLOUT FROM THE CHERNOBYL REACTOR ACCIDENT.** Fallout from the Chernobyl reactor accident has been monitored for about one year in Thessaloniki in Northern Greece. Fifteen different short-lived, three relatively long- and one long-lived fission products were identified in air, precipitation, soil, grass and milk samples. The iodine-131 and cesium-137 concentrations in air reached 6.5 and 3 Bq  $\text{m}^{-3}$  respectively, on 6 May, 1986. The external exposure dose rate rose to five times the normal background level. It was estimated that the accumulated dose equivalent to the adult thyroid from inhaled iodine-131 averaged 96  $\mu\text{Sv}$ , while the body burden from inhaled radioiodine nuclides averaged 2  $\mu\text{Sv}$ , 1000 times lower than that corresponding to the estimated dose equivalent from ingestion of food-stuff, which averaged 2 mSv for the first year after the accident. (Author abstract) 20 refs.

Papastefanou, C. (Aristotle Univ of Thessaloniki, Thessaloniki, Greece); Manolopoulos, M.; Charalambous, S. *J Environ Radioact* v 7 n 1 1988 p 49-64.

**Research** See FOOD PRODUCTS—Preservation; FOOD PRODUCTS—Radiation Effects; MICROWAVES—Health Hazards.

## Safety Codes

**087858 IONISING RADIATIONS REGULATIONS 1985 - IMPLICATIONS FOR THE RECORDING AND MONITORING OF PERSONAL RADIATION DOSES.** The Ionizing Radiations Regulations 1985, which came fully into operation on 1st January 1986, provide a coherent set of requirements for all forms of work with ionizing radiation. Of particular importance to many employers have been the changes in dose concepts, and hence in the requirements for the recording and monitoring of internal radiation doses, consistent with the principles of ICRP Publication 26. This paper describes those changes against the background of the previous UK requirements under the Nuclear Installations Act and the subsequent practical issues involved in demonstrating compliance. (Author abstract) 9 refs.

Coulston, D.J. (British Nuclear Fuels plc, Warrington, Engl). *J Soc Radiol Prot* v 7 n 4 Winter 1987 p 169-175.

**Simulation** See PHOTOGRAPHIC FILMS AND PLATES, COLOR—Radiation Effects.

## Spectrum Analysis

**087859 COMPARISON OF ONETRAN CALCULATIONS OF ELECTRON BEAM DOSE PROFILES WITH MONTE CARLO AND EXPERIMENT.** Electron beam dose profiles have been calculated using a multigroup, discrete-ordinates solution of the Spencer-Lewis electron-transport equation. This was accomplished by introducing electron-transport cross sections into the ONETRAN code in a simple manner. The purpose is to 'benchmark' this electron-transport model and to demonstrate its accuracy and capabilities over the energy range from 30 keV to 20 MeV. The results are compared with the measurements and TIGER Monte Carlo data published by G. J. Lockwood et al. (1980). In general, the ONETRAN results are smoother, agree with TIGER within the statistical error of the Monte Carlo histograms, and require about one-tenth the running time



of the Monte Carlo method. 17 refs.

Garth, J.C. (Rome Air Development Cent, Hanscom AFB, MA, USA); Woolf, S. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1551-1556.

**087860 TWO-DIMENSIONAL TRANSPORT EQUATION CALCULATIONS OF DOSE PROFILES DUE TO ELECTRON BEAM IRRADIATION.** The Spencer-Lewis equation for kilovolt electron transport in two dimensions was solved using a discrete-ordinates, diamond difference method. Calculations of dose profiles in 2-D were made for 200-keV electrons normally and isotropically incident on aluminum, and are compared with ACCEPT Monte Carlo calculations. Isodose contour plots are presented for 200-keV electrons making angles of 0° and 45° with the normal. Running times compare favorably with Monte Carlo. 10 refs.

Filippone, W.L. (Univ of Arizona, Tucson, AZ, USA); Woolf, S.; Garth, J.C. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1564-1568.

**Sublimation** See GRAPHITE—Sublimation.

**Thin Films** See Also CHARGED PARTICLES—Transport Properties.

**087861 BINARY COLLISION CASCADE PREDICTION OF CRITICAL ION-TO-ATOM ARRIVAL RATIO IN THE PRODUCTION OF THIN FILMS WITH REDUCED INTRINSIC STRESS.** It is well established that ion beam assisted desposition produces thin films that are more dense and contain less intrinsic stress than films deposited without energy input from an ion beam. In some cases, a critical ion-to-atom arrival ratio has been measured, above which the stress is reduced. We have calculated this critical arrival ratio using the binary collision approximation to simulate collision cascades. Good agreement with data in the literature is obtained by making the assumption that each deposited atom must lie within the volume affected by an ion induced cascade. This model is simple to implement and should provide predictive capability for other covalently bonded systems. (Author abstract) 29 refs.

Brighton, D.R. (US Naval Research Lab, Washington, DC, USA); Hubler, G.K. *Nucl Instrum Methods Phys Res Sect B* v B28 n 4 Nov 1 1987 p 527-533.

**087862 ANALYSIS OF GRAIN GROWTH DUE TO ION IRRADIATION OF THIN FILMS.** It has been reported recently that ion irradiation of thin films can lead to grain growth. In this paper, an analysis of grain growth in ion-irradiated thin films is discussed. It is based on establishing an analogy with thermally-activated grain growth. Recently reported experimental results are used to test the validity of the analysis. (Author abstract) 6 refs.

Ibrahim, A.M. (DeVry Inst of Technology, Toronto, Ont, Can). *Nucl Instrum Methods Phys Res Sect B* v B29 n 4 Jan 1988 p 650-652.

**RADIATION PROTECTION** See Also DOSIMETRY—Standardization; ELECTRONS—Spectrum Analysis; GAMMA RAYS—Attenuation; GAMMA RAYS—Transport Properties; NUCLEAR FUELS—Reprocessing; NUCLEAR POWER PLANTS—Accident Prevention; NUCLEAR POWER PLANTS—Accidents; NUCLEAR POWER PLANTS—Maintenance; POLYETHYLENES—Antioxidants; RADIOACTIVE WASTES—Geological Repositories; RADIOGRAPHY—Personnel Training.

**087863 DATA FOR USE IN PROTECTION AGAINST EXTERNAL RADIATION.** This report updates the ICRP Publication 21 (1973) by taking account of subsequent reports and data. Its objectives is to provide information and advice on the relationships between radiometric, dosimetric and radiation protection quantities for external radiation and on their practical utilization. The recommendations of the ICRP on limiting exposure to external radiation are collected in Section 2, and definitions of quantities and units are presented in

Appendix A. Methods of determining dose distributions are discussed in Section 3 with special attention paid, in Appendix B, to transport calculations. Section 4 contains a compilation of recommended data for interconverting the various radiation quantities in circumstances of idealized irradiation geometry, and there are supporting data on doses to organs in Appendix C. In Section 5, advice and information are offered on the application of the coefficients in practical circumstances; the use of the index, environmental, and individual quantities is discussed in Appendix D. Refs.

Anon. *Ann ICRP* v 17 n 2-3 1987 132p.

**087864 MEASUREMENT - A KEY TO THE SAFE USE OF IONISING RADIATION.** With the increasing industrial use of ionizing radiations, health and safety have become matters of general interest. Dose limits for the safe use of radiation are set internationally and in the UK, the National Physics Laboratory provides the standards which are the basis of protection measurements. (Edited author abstract)

Owen, Brian (British Inst of Non-Destructive Testing). *Br J Non Destr Test* v 29 n 6 Nov 1987 p 429-430.

**087865 RADIATION SHIELDING CALCULATIONS FOR A 70- TO 250-MeV PROTON THERAPY FACILITY.** Neutron shielding calculations for a 70- to 250-MeV proton cancer therapy facility have been carried out using the High Energy Transport Code and the one-dimensional discrete ordinates code ANISN. Calculations were performed for iron and water targets with incident proton energies of 150, 200, and 250 MeV. The angular dependence of the neutron spectrum was taken into account by averaging and reporting the spectrum in angular bins of 0 to 15, 15 to 30, 30 to 45, 45 to 60, 60 to 90, and 90 to 180 deg relative to the forward direction of the protons. Each of these various spectra was used as the source spectrum for an individual ANISN run in which the source was placed at the center of a sphere of typical concrete (i.e., density of 2.3 g/cm<sup>3</sup>) and the dose equivalent per proton was calculated as a function of radius. (Edited author abstract) 11 refs.

Hagan, W.K. (Science Applications Int Corp, San Diego, CA, USA); Colborn, B.L.; Armstrong, T.W.; Allen, M. *Nucl Sci Eng* v 98 n 3 Mar 1988 p 272-278.

**087866 PERSONAL DOSIMETRY AND THE NEW QUANTITIES IN RADIATION PROTECTION.** In ICRU Report 39, new quantities for environmental and individual monitoring are recommended which apply to all kinds of ionizing radiation. Whereas the quantities for environmental monitoring do not appear to pose serious problems, the quantities for individual monitoring raise questions as to the required spectral and angular response of monitors and the calibration procedures. It would be logical to use the directional dose equivalent as the reference quantity for their response. The relations between the new ICRU quantities and those used hitherto are discussed. Conversion functions between air kerma or neutron fluence and the new quantities are reproduced. (Edited author abstract) 23 refs.

Wagner, Siegfried R. *PTB Mitt* v 98 n 1 Feb 1988 p 45-51.

**087867 ADEQUATE RADIATION PROTECTION: A LINGERING PROBLEM.** In response to the increasing reports of significant incidents, IAEA Director General Dr. Hans Blix announced in September 1984 the creation of Radiation Protection Advisory Team (RAPAT) to assist Member States in assessing the existing state of their radiation protection activities and in determining their immediate and future needs. RAPATs generally consist of recruited internationally recognized experts and IAEA staff. The team expertise covers a wide range of areas from regulation to operational activities to allow for up-to-date advice on all matters involving ionizing radiation. The RAPAT experience so far unambiguously establishes that many developing countries simply lack the necessary infrastructure to implement a radiation protection policy based on international standards.

Rosen, Morris (IAEA, Vienna, Austria). *IAEA Bull* v 29 n 4 1987 p 34-36.

**Control** See NUCLEAR REACTORS, LIGHT WATER—Radiation Protection.

**Costs** See RISK STUDIES—Public Risks.

**Legislation** See RADIOGRAPHY.

**Materials** See Also GAMMA RAYS—Scattering.

**087868 SOIL: A RADIATION SHIELDING MATERIAL.** To support the use of soil as a suitable radiation protection material, the effects of soil grain size and pressure on  $\gamma$ -ray attenuation have been tested in the energy region from 279 to 1250 keV. The variation in linear - and mass - attenuation coefficients,  $\mu$  and  $\mu_m$ , with soil grain diameter is found appreciable and independent of soil chemical composition. The increase of  $\mu$  with pressure is only up to  $10^4$  kg/cm<sup>2</sup> pressure for soil particles of uniform grain size  $d=0.12 \pm 0.03$  mm. However, no significant change is seen in  $\mu_m$  with pressure. The half-thickness values for attenuation were calculated from present data have also been discussed for different  $\gamma$  radiations. (Author abstract) 13 refs.

Mudahar, G.S. (Punjab Agricultural Univ, Ludhiana, India); Sahota, H.S. *Appl Radiat Isot* v 39 n 1 1988 p 21-24.

**Measurements** See NUCLEAR POWER PLANTS—Computer Applications.

**Medical Applications**

**087869 OPTIMISATION OF RADIATION PROTECTION IN THE HEALTH SERVICE.** Accurate information is hard to come by regarding the collective doses received by patients and staff as a result of medical exposures. Data taken from the 1984 NRPB review indicates that action should be taken to reduce all doses particularly those to patients. Reference is made to a number of publications showing that doses received by patients in diagnostic procedures could be optimized. On the other hand whilst doses received by patients in therapeutic procedures cannot be reduced without reducing the effectiveness of treatment, attention has been directed to using optimization techniques to justify dose reduction to nursing staff. It is concluded that optimization techniques are neither generally used nor generally useful. Other hazards and other priorities have to be taken into account in allocating available resources. (Edited author abstract) 12 refs.

Davison, M. (West of Scotland Health Boards, Glasgow, Scotl). v 7 n 3 Autumn 1987 p 119-123.

**Monitoring** See IONIZATION—Health Hazards.

**Quality Control**

**087870 TECHNICAL NOTE: THE QUALITY FACTOR IN RADIATION PROTECTION.** Since the introduction of the concept of dose-equivalent, there has been a continuing debate on the parameters of this concept. In 1980 the International Commission on Radiological Protection (ICRP) and the International Commission on Radiation Units and Measurements (ICRU) established a Joint Task Group on Radiation Protection Quantities. The immediate reasons for this step were recent biological findings indicating that protection recommendations for some high-LET (linear energy transfer) radiations might not offer the same margin of safety as those for low-LET radiations. The Task Group's report is primarily focused on the problem of radiation quality and its quantitative treatment in radiation protection. The ICRU's report, the Quality Factor in Radiation Protection, is an attempt to summarize and clarify issues that surround the concept and quantifications of the quality factor. 2 refs.

Witherspoon, J.P. Jr. (Oak Ridge Natl Lab, Oak Ridge, TN, USA). *Nucl Saf* v 29 n 2 Apr-Jun 1988 p 194-195.



**Safety Codes** See RADIATION EFFECTS—Health Hazards.

**RADIATORS** See Also STEEL CORROSION—Protective Coatings.

**Aerospace Applications** See HEAT TRANSFER—Cooling.

### Computer Aided Design

**087871 ON OPTIMAL MATHEMATICAL DESIGN OF HIGH-TEMPERATURE RADIATORS.** A variant regularization method has been used to solve the inverse problem of radiative heat exchange between two smooth surfaces, one (the surface of the heater) being flat. The problem was considered in the following formulation: the field of temperatures and fluxes of resultant radiation at the surface of the product is specified while the temperature field of the heater is unknown. The generalized discrepancy principle for nonlinear improper problems was used to construct a regularizing function whose value is proportional to the energy of the heater self-radiation. Introduction of such a functional makes it possible to make the solution stable and to optimize the heater temperature field so as to minimize heat losses in the radiating system. (Author abstract) 5 refs.

Rusin, S.P.; Leonov, A.S. *Power Eng (New York)* v 25 n 4 1987 p 142-146.

**Efficiency** See HEAT TRANSFER—Radiation.

**Heat Transfer** See ELECTRIC TRANSFORMERS.

### Performance

**087872 EVALUATION OF SPACE RADIATOR PERFORMANCE BY SIMULATION OF INFRARED EMISSION.** The total performance of a droplet space radiator has been predicted by simulation of infrared emission spectra. Emission spectra for a droplet are simulated with the use of exact optical theory from the optical constant spectra of a low-molecular-weight silicone, which is a candidate for use as an emission medium of the radiator. Emissive power and total emittance are calculated from the simulated emission spectra for a droplet at different temperatures. It is found that the fourth-power temperature dependence of the emissive power of the blackbody and the temperature dependence of the emissivity inherent to the materials govern the emissive power of the droplet. (Edited author abstract) 13 refs.

Ohta, Koji (Case Western Reserve Univ, Cleveland, OH, USA); Graf, Robert T.; Ishida, Hatsu. *Appl Spectrosc* v 42 n 1 Jan 1988 p 114-120.

**Space Applications** See Also SPACECRAFT—Heat Transfer.

**087873 LIQUID SHEET RADIATOR.** A new external flow radiator concept, the liquid sheet radiator (LSR), is introduced. The LSR sheet flow is described and an expression for the length/width  $L/w$  ratio is presented. A linear dependence of  $L/w$  on velocity is predicted that agrees with experimental results. Specific power for the LSR is calculated and is found to be nearly the same as the specific power of a liquid droplet radiator, (LDR). Several sheet thicknesses and widths were experimentally investigated. In no case was the flow found to be unstable. (Author abstract) 14 refs.

Chubb, Donald L. (NASA, Cleveland, OH, USA); White, K. Alan III. *NASA Tech Memo* 89841 1987 11p.

**087874 LIQUID DROPLET RADIATOR DEVELOPMENT STATUS.** Development of the Liquid Droplet Radiator (LDR) is described. Significant published results of previous investigators are presented, and work currently in progress is discussed. Several proposed LDR configurations are described, and the rectangular and triangular configurations currently of most interest are examined. Development of the droplet generator, collec-

tor, and auxiliary components are discussed. Radiative performance of a droplet sheet is considered. The collision of droplets in the droplet sheet, the charging of droplets by the space plasma, and the effect of atmospheric drag on the droplet sheet are shown to be of little consequence, or can be minimized by proper design. The effect of atmospheric drag on a droplet sheet can also be minimized with proper design. The LDR is seen to be less susceptible than conventional technology to the effects of micrometeoroids or hostile threats. Methods for reducing spacecraft contamination from an LDR to an acceptable level are discussed. Preliminary results of microgravity testing of the droplet generator are presented. (Edited author abstract) 49 refs.

White, K. Alan III (NASA, Cleveland, OH, USA). *NASA Tech Memo* 89852 1987 27p.

**087875 HIGH TEMPERATURE RADIATOR MATERIALS FOR APPLICATIONS IN THE LOW EARTH ORBITAL ENVIRONMENT.** Radiators must be constructed of materials which have high emittance in order to efficiently radiate heat from high temperature space power systems. In addition, if these radiators are to be used for applications in the low Earth orbital environment, they must not be detrimentally affected by exposure to atomic oxygen. Four materials selected as candidate radiator materials (304 stainless steel, copper, titanium-6% aluminum-4% vanadium (Ti-6%Al-4%V), and niobium-1% zirconium (Nb-1%Zr)) were surface modified by acid etching, heat treating, abrading, sputter texturing, electrochemical etching, and combinations of the above in order to improve their emittance. (Edited author abstract) 9 refs.

Rutledge, Sharon K. (NASA, Cleveland, OH, USA); Banks, Bruce A.; Mirtich, Michael J.; Lebed, Richard; Brady, Joyce; Hotes, Deborah; Kussmaul, Michael. *NASA Tech Memo* 100190 Apr 20-24 1987 17p.

### Temperature Control

**087876 ELEKTRONISCHE HEIZKOERPER-REGELUNG.** [Electronic Control of Radiators]. The requirement of higher energy efficiency has promoted the installation of temperature control systems for individual rooms, even for central heating systems. The following systems are available: Thermostat valves for radiators: As a rule, with temperature control via reference values and with manual operation for constant temperature selection. The valves are commonly actuated by expansion elements. Remote-controlled temperature control systems for individual rooms with accurate temperature adjustment via potentiometers, operated either from within the room or from a central control panel, either manually or on the basis of programmed temperature and time values. These systems are recommended if rooms are used for different purposes and for overnight temperature reduction. Older systems usually had automatic control elements only for the heat source. Today, control systems for all individual rooms are available. The RAUMTRONIC electronic radiator control system is described. (Author abstract). 5 Refs. In German.

Mayer, Eugen. *Ki Klima Kaelte Heiz* v 16 n 7-8 Jul-Aug 1988 p 335-338.

**RADIO** See Also ANTENNAS—Reflectors; ELECTROMAGNETIC FIELD THEORY.

**087877 FROM GALENA TO GIGAHERTZ.** The author reminisces about the early days of radio. He describes the first radio sets and his entry into commercial radio in the 1920s. He discusses his work at GE, RCA, and Brunswick Balke Collender during the 1920s and military research he was involved in during the 1930s.

Richardson, Avery G. *IEEE Aerosp Electron Syst Mag* v 3 n 2 Feb 1988 p 2-8.

**Frequency Allocation** See Also BROADCASTING; COMMUNICATION SATELLITES—Orbits and Trajectories; FIRE PROTECTION—Communication Systems; RADIO BROADCASTING—Great Britain; RADIO BROADCASTING—Planning; RADIO INTERFERENCE—Legisla-

tion; RADIO SYSTEMS, MOBILE; RADIO SYSTEMS, MOBILE—Cellular Technology; TELECOMMUNICATION—Canada; TELECOMMUNICATION LINKS, MICRO-WAVE—Legislation; TELECOMMUNICATION LINKS, RADIO—Planning; TELEVISION BROADCASTING—Planning.

**087878 FREQUENCY PLANNING FOR MOBILE RADIO IN THE FUEL AND POWER INDUSTRIES.** After a description of the use of mobile radio in the fuel and power industries, the development of mobile networks over the period 1956-1979 is examined. This examination is concluded by describing a processor-based management system which was introduced to improve channel efficiency. Changes to the International Frequency Allocation Table require the fuel and power industries to move mobile services to a new frequency band and the design requirements for a regular frequency re-use strategy are discussed. Methods of dealing with the traffic densities found in the major urban areas are considered, together with the development of a computer aid for network planning. (Edited author abstract)

Walton, L. (Electricity Council, London, Engl). *J Inst Electron Radio Eng* v 57 n 6 Nov-Dec 1987 p 225-230.

**087879 RADIO TRANSMISSION FREQUENCIES AND STANDARDS.** Radio alarms are considered. The growth in the use of radio frequency allocation and licensing policy, type approval and the position of radio alarms in relation to the British Telecommunications Act are discussed. (Edited author abstract)

Maxwell, B.A. (DTI). *Electron Technol (London)* v 22 n 3 Mar 1988 p 46-48.

**087880 BERUECKSICHTIGUNG VON UKW-EINSTREUSIGNALEN BEI DER FREQUENZPLANUNG VON BREITBANDVERTEILNETZEN.** [Taking into Consideration VHF Crosstalk Signals for Frequency Allocation of Wideband Distribution Networks]. A calculation method is described which makes it possible to determine noisy VHF channels due to crosstalk. A relationship is derived between the off-air field strength of radio signals and the minimal necessary rf level of the wanted signals of the broadband distribution network. An illustrative example shows that about 25% of 204 available VHF channels are subject to crosstalk. In German. 12 refs.

Nold, Bruno. *Tech Mitt PTT* v 65 n 9 1987 p 430-434.

**087881 OVERALL FRAMEWORK OF SPECTRUM MANAGEMENT INTERNATIONALLY AND IN THE UK.** There is a worldwide requirement for frequency allocations to be agreed internationally through the mechanism of World Administrative Radio Conferences of the International Telecommunications Union. The output is a Table of Frequency Allocations contained in Article 8 of the International Radio Regulations. The need for more co-operation in frequency allocation matters in Western Europe in order to harmonize frequency provisions for some radio services is increasing; however, at a national level there will remain the need and scope for more detailed planning. In the future, managers of the radio spectrum at the international level will have to cope with the rapid growth in radiocommunications services and the development of new technologies. (Edited author abstract). 2 Refs.

Goddard, M. (Dep of Trade & Industry, London, Engl). *J Inst Electron Radio Eng* v 58 n 4 Jun 1988 p S2-S5.

**087882 SPECTRUM AND ORBIT RESOURCE MANAGEMENT FOR THE FIXED SATELLITE SERVICE.** The Fixed Satellite Service operates in areas of the frequency spectrum which are established by the ITU and are limited due to technological factors and availability. As more systems become operational, congestion will be inevitable and it is essential that regulatory procedures are used to ensure adequate protection of systems from unacceptable levels of interference whilst at the same time introducing efficient use of the limited spectrum/orbit resources such that access to them is assured and in an



equitable manner. This challenging task has been handled in an evolutionary manner within the ITU Radio Regulations over a number of years. This paper describes the current regulatory arrangements and the plans for further evolution of the management system in the near future. Examples of interference analysis are given to add practicality to a complex subject. (Author abstract). 5 Refs.

Thompson, P.T. (British Telecom Int, London, Engl). *J Inst Electron Radio Eng* v 58 n 4 Jun 1988 p S6-S14.

**087883 MANAGEMENT OF BROADCAST ANCILLARY SERVICES.** Planning and administration of allocations is devolved to a user group set up jointly by the UK Broadcasters. This group is known as the Broadcasters' Joint Frequency Management Group (JFMG). This paper outlines the events and considerations that led to the recommendation for frequency management by a user group. It looks at some of the users' service needs and the frequency solutions adopted. Briefly described is the computer data base system adopted by the group which keeps records of numerous allocations shared by many users throughout the country. (Edited author abstract). 9 Refs.

Griffiths, D.C. (Independent Broadcasting Authority, Winchester, Engl); Laven, P.A. *J Inst Electron Radio Eng* v 58 n 4 Jun 1988 p S30-S37.

**087884 FREQUENCY MANAGEMENT AND SPECTRUM UTILIZATION FOR HF BROADCASTING.** The background to frequency usage in High Frequency Broadcasting (HFBC) is briefly reviewed, with a description of the current HFBC regulatory procedures and the frequency management associated with an HF Broadcast Service. A brief history of past attempts at planning the HFBC spectrum up to the present day is given including the most recent activities which began in 1979 and culminated in the second session of the WARC HFBC in March 1987. (Author abstract). 4 Refs.

Davey, I.E. (BBC External Services Engineering, London, Engl). *J Inst Electron Radio Eng* v 58 n 4 Jun 1988 p S38-S44.

**087885 FREQUENCY ALLOCATION FOR A MOBILE RADIO TELEPHONE SYSTEM.** Several ways of allocating frequencies efficiently are suggested that are based on the use of Latin squares. A Latin square of order  $n$  is a square array of  $n$  rows and  $n$  columns, and involving  $n$  symbols each of which occurs  $n$  times within the square in such a way that all the different symbols occur once in each row and once in each column. This approach provides two alternative ways of arranging the transmitters for a mobile radio telephone system, one rectangular and the other close-packed hexagonal. In both cases optimal patterns for frequency allocation result. A solution using the least-possible number of frequencies for each case is given, as well as one that is ideal in the sense that all the transmitters that surround any particular one are provided with distinct frequencies. 8 refs.

Denes, J. (Computer Research & Innovation Cent, Budapest, Hung); Keedwell, A.D. *IEEE Trans Commun* v 36 n 6 Jun 1988 p 765-767.

**087886 MANAGEMENT OF THE RADIO SPECTRUM TO ACHIEVE MORE EFFICIENT UTILIZATION, ACCESS, AND NETWORK GROWTH.** The radio frequency spectrum in nontechnical terms is a valuable, highly contested natural resource. In the most simplistic terms it can be viewed as the central nervous system of our businesses. It is a key element in national security, provides for world-wide communications, and supports scientific ventures beyond our planet and solar system. (Author abstract)

Parlow, Richard D. (Nat'l Telecommunications & Information Administration, Washington, DC, USA). *Telematics Inf* v 2 n 1 1985, CSIS Conf: 'Forg a Global Telecommun Strategy', Washington, DC, USA p 47-54.

**087887 TELECOMMUNICATIONS DEMAND AND SPECTRUM MANAGEMENT POLICY.** The allocation of electromagnetic spectrum involves a substan-

tial level of controversy both in the United States and abroad. One often finds this controversy as an emotional one, especially because of a multitude of variables that must be considered make it extremely difficult to evaluate competing requirements. This study explores certain verifiable methodology to forecast telecommunications demands for developing sound spectrum management policies. (Author abstract) 1 ref.

Armes, Gerald L. (Spectrum Planning Inc, Richardson, TX, USA). *Telematics Inf* v 2 n 1 1985, CSIS Conf: 'Forg a Global Telecommun Strategy', Washington, DC, USA p 61-77.

**087888 COLLOQUIUM ON HF FREQUENCY MANAGEMENT.** The proceedings contains 9 papers (It is in summary form) dealing with the problems of frequency selection for HF radio links. International broadcasting bands; radio regulations; HF radio frequency prediction methods; HF interference models; skywave communication; optimum working frequencies; statistical interference information; propagation in ionosphere; skywave remote sensing; real-time channel evaluation and selection; and adaptive chirp modems are the major topics covered. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 09858 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig* n 1986/122, Colloq on HF Freq Manage, London, Engl, Nov 19 1986. Publ by IEE, London, Engl, 1986 var pagings.

**Measurements** See INSTRUMENTS; RADIO TRANSMISSION—Propagation Effects; RADIO TRANSMISSION—Propagation in Troposphere; TELECOMMUNICATION LINKS, SATELLITE.

**Microwaves** See RADIO SYSTEMS, DIVERSITY—Performance.

## Monitoring

**087889 NEW TRENDS IN RADIOMONITORING.** Recent progress in technology and improved measuring methods offer an attractive solution for monitoring. Up-to-date receiving systems together with digital signal processing may be used to form universal monitoring equipment which incorporates the conventional monitoring functions in one unit. There are ways to help the operator and cut the measuring time by using dedicated software for signal identification and interpolation of data. This article gave an overview of the results of research work carried out in the field of radiomonitoring. 17 refs.

Novak, I. *Telecommun J* v 54 n 12 Dec 1987 p 817-823.

**Reception Quality** See Also RADIO RECEIVERS—Performance; TELECOMMUNICATION LINKS, RADIO—Digital Devices.

**087890 DOUBLE-SIDEBAND SHORTWAVE-BROADCAST SIGNAL-QUALITY ESTIMATION ALGORITHM.** A method and related algorithm for assessing the quality of a full-carrier, double-sideband signal are presented that were developed through statistical processing of empirical measurements of parameters of the received signal before and after detection. Preliminary results are presented showing the comparison of the objective automated measurement ratings against subjective human listener ratings of overall quality on a five-level scale. The algorithm has been developed to gauge the perceived quality and, inferentially, the intelligibility of a broadcast composed of speech, given that the ultimate goal of a broadcaster is to have the message received and understood by the largest audience possible. The algorithmic measures apply to all broadcast program material; music, as well as speech. 33 refs.

Stehle, Roy H. (SRI Int, Menlo Park, CA, USA). *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 263-282.

## RADIO ALTIMETERS

**087891 RESPONSE CHARACTERISTICS OF A SHORT-RANGE, HIGH-RESOLUTION DIGITAL SONAR ALTIMETER.** The Datasonics Model ASA-920 digital sonar altimeter (DSA) is a compact, high-frequency (1 MHz), short-range (0.5-5 m) underwater sonar device originally designed as an altimeter for submarines. The DSA has previously been successfully used on a bottom-mounted tripod to measure changes in relative bed elevation at a point on the seafloor prior to and during a storm. Fixed to a rigid mounting on the seabed, the DSA produces a digital output that is proportional to the transducer elevation above the bed. The purpose of this report is to describe the response characteristics of the DSA. Tests using a flat steel plate and a flat sand bed as targets showed that the DSA is capable of resolving differences in elevation of at least 0.5 cm. A laboratory calibration demonstrated that the instrument response is linear. In general, the altimeter does not 'see' into the troughs of ripples when its height above the bed is more than eight times the ripple wavelength. In the field, the acoustic pulse is susceptible to interference by suspended particulate matter and bubbles. (Edited author abstract). 7 Refs.

Green, Malcolm O. (Coll of William and Mary, Gloucester Point, VA, USA); Boon, John D. III. *Mar Geol* v 81 n 1 pt 4 Jun 1988 p 197-203.

**RADIO ASTRONOMY** See Also IONOSPHERE—Research; SPACE RESEARCH; TIME MEASUREMENT—Research.

**087892 ANALYSIS OF THE POSSIBILITIES FOR STUDYING THE MOON AND THE PLANETS WITH THE HELP OF COSMIC SOURCES OF RADIO WAVES.** The possibilities of sounding the moon and the planets with the help of a cosmic source of radio waves are examined. It is shown that it is now possible to carry out experiments on radio sounding of the soil and plasma-spheres of the planets with the help of the earth's kilometer emission in the 100-500 kHz band. It is proposed that the reflected radiation be received on an artificial satellite orbiting the planet. (Author abstract) 13 refs.

Armand, N.A.; Pavel'yev, A.G.; Kucheryavenkov, A.I.; Shtern, D.Ya. *Sov J Commun Technol Electron* v 31 n 12 Dec 1986 p 165-171.

**087893 THEORY OF RADIO EMISSION FROM PULSARS (REVIEW).** We discuss in detail the properties of the plasma in a pulsar magnetosphere. We also present a brief review of the current state of the theory of the radio emission. A theory is used to determine the dielectric permittivity tensor for a relativistic plasma moving along the field lines of a curvilinear magnetic field enabling us to find the normal modes of oscillation in such a plasma. It is shown that when the plasma density is high enough, a hydrodynamic instability is excited, leading to the rapid growth of two of the normal modes of electromagnetic oscillations we called 'bending plasma modes.' We consider the specific conditions in pulsar magnetosphere show that the rapid build-up of the bending plasma modes of oscillation occurs in the close-range region of the magnetosphere. At distances of (30-300) R from the neutron star, these oscillations are transformed into the usual radio emission, directed along the magnetic field lines. The basic properties of this emission (the range of frequencies, the directional diagram, the intensity, and the polarization) are in overall agreement with the observational data. 63 refs.

Beskin, V.S. (USSR Acad of Sciences, USSR); Gurevich, A.V.; Istomin, Ya.N. *Radiophys Quantum Electron* v 30 n 2 Feb 1987 p 115-137.

## Australia

**087894 FROM WARTIME RADAR TO POSTWAR RADIO ASTRONOMY IN AUSTRALIA.** The special circumstances which led to Australia playing a leading part in the development of the new science of radio



astronomy are here described. Observational and instrumental breakthroughs were made in the late 1940's and in the 1950's, after which there was a transition to the "Big Science" era of radio astronomy. The Parkes Radiotelescope has played a notable part in that era. (Author abstract). 20 refs.

Bowen, E.G. (CSIRO, Aust.). *J Electr Electron Eng Aust* v 8 n 1 Mar 1988 p 1-11.

**087895 AUSTRALIAN CONTRIBUTION TO THE SCIENCE OF RADIOASTRONOMY.** Australia has made numerous major contributions to the science of radioastronomy and played a leading role in its early development. The history of the Australian effort is reviewed, from this early seminal work until the present day when contributions continue at an important level. Topics include: sea, two antenna, and grating array interferometers; solar spectroscopy; and radio observatories. (Edited author abstract). 55 refs.

Mills, B.Y. (Univ of Sydney, Aust.). *J Electr Electron Eng Aust* v 8 n 1 Mar 1988 p 12-23.

#### Equipment See Also RADIATION DETECTORS.

**087896 AN EXPERIMENTAL SUBMILLIMETRE HETERODYNE ARRAY RECEIVER.** An experimental array receiver is described which is intended for radioastronomical observations of the J=3-2 line of carbon monoxide. It consists of six medium antimonide mixers cooled to  $\approx 2\text{K}$  in a pumped helium cryostat, with rectangular feed horns arranged on a  $3 \times 2$  grid at the f/9 focus of the UK Infrared Telescope (UKIRT). Each detector is mounted in a length of fundamental mode waveguide and has an independently tunable backshort. Local oscillator power is provided by a frequency tripler pumped by a klystron, and is coupled to the array via a 'lossless' quasi-optical coupler which is described in detail. (Edited author abstract). 16 Refs.

Murphy, J.A. (Mullard Radio Astronomy Observatory, Cambridge, Eng); Padman, R.; Hills, R.E. *Int J Infrared Millim Waves* v 9 n 4 Apr 1988 p 325-350.

**087897 LOW NOISE SIS RECEIVER COVERING THE FREQUENCY RANGE 215-250 GHz.** A heterodyne receiver incorporating an SIS mixer for use on a radiotelescope operating at 1.3 mm wavelength is developed. The mixer has a minimum conversion loss of  $< 2$  dB and contributes less than 60 K to a total double side band receiver noise temperature of about 80 K at 220 GHz and 230 GHz. To our knowledge this represents the lowest receiver noise ever reported in this frequency range. (Edited author abstract). 15 Refs.

Blundell, R. (Domaine Univ de Grenoble, St. Martin d'Heres, Fr); Carter, M.; Gundlach, K.H. *Int J Infrared Millim Waves* v 9 n 4 Apr 1988 p 361-370.

#### Measurements

**087898 PHASE RETRIEVAL RADIO HOLOGRAPHY IN THE FRESNEL REGION: TESTS ON THE 30 m TELESCOPE AT 86 GHz.** The application of phase retrieval radio holography in the Fresnel region has been studied using an 86 GHz transmitter as signal source. Maps of the aperture-plane field distribution were made with a surface resolution of about 100 independent pixels across the telescope diameter. Over the 2.7 km propagation path used (0.005 of the far-field distance), the measurement accuracy was found to be determined by atmospheric scintillation. The root mean square measurement errors in the derived aperture-plane phase distribution were about 65 microns when expressed as axially resolved surface errors. The snr and dynamic range requirements are easy to fulfill in the Fresnel zone, while the necessary near field corrections can be applied with high accuracy. There are thus definite advantages to phase retrieval radio holography in this near field zone. (Author abstract) 7 refs.

Morris, D.; Hein, H.; Steppe, H.; Baars, J.W.M. *IEE Proc Part H* v 135 n 1 Feb 1988 p 61-64.

#### Microwaves

**087899 MICROWAVES: THE NEW HORIZONS OF RADIO ASTRONOMY.** Exciting discoveries were made in radio astronomy in previous years. The picture of the 'invisible' universe at radio wavelengths has emerged. Radio astronomy could give detailed information about numerous phenomena. The process of star formation is being studied in spectral lines - especially in the new millimetre/submillimetre frequency ranges. The death of a star - a supernova - can be studied in radio continuum. The energy balance thus observed gives us an understanding of basic physical processes in the nuclear reactions in the universe. The observation of pulsars, as a result of a supernova explosion, allows us to study condensed neutral matter. Observations of radio polarisation gave us new information about magnetic fields in galaxies. Beyond the Milky Way and other nearby galaxies great energy emissions are seen at radio wavelengths. Jet phenomena in the universe have been made visible by aperture synthesis radio telescopes. Radio telescopes probe the most distant fringes of the universe - using new microwave devices. (Author abstract)

Wielebinski, Richard (Max Planck Inst fuer Radioastronomie, Bonn, West Ger). *Alta Freq* v 56 n 10 Dec 1987, 17th Eur Microwave Conf and Workshop, Sep 7-11 1987 p 377-379.

**RADIO BROADCASTING** See Also ANTENNAS, LOOP—Directional Patterns; DATA TRANSMISSION—Synchronization; ELECTRON TUBES, TETRODE—Computer Aided Design; RADIO—Frequency Allocation; RADIO TRANSMITTERS—Evaluation; TELEVISION BROADCASTING; TRANSPONDERS—Microwaves.

**087900 PRINCIPLES OF MODULATION AND CHANNEL CODING FOR DIGITAL BROADCASTING FOR MOBILE RECEIVERS.** This article explains the benefits of using a system called Orthogonal Frequency Division Multiplexing to overcome the adverse effects of severe multipath propagation such as occurs in mobile reception. The signal is demodulated with the aid of a fast Fourier transform technique. Consideration is given to the digital coding arrangement. It is concluded that a concatenation of a convolutional code and a Reed-Solomon code gives excellent results. The feasibility of implementing such a system for the domestic market is discussed. (Edited author abstract) 26 refs.

Alard, Michel (CCETT, Fr); Lassalle, Roselyne. *EBU Rev Tech* n 224 Aug 1987 p 168-190.

#### Automation

**087901 VOA NETWORK CONTROL AND AUTOMATION.** The Voice of America's (VOA's) effort to design, develop, and implement a broadcast network control and automation system as part of a multiyear modernization program is described. A brief background discussion of the VOA network control system NCS, a description of the design, a description of a pilot system being built, and the current status of the effort are included.

Putkovich, Kenneth (Voice of America, USA). *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 301-305.

#### Computer Aided Analysis

**087902 METHODOLOGY AND COMPUTER TOOLS TO SEMI-AUTOMATE ASSESSMENTS OF SHORTWAVE BROADCAST COVERAGE RESULTING FROM MULTIPLE TRANSMISSIONS.** A computer-assisted methodology, developed for using a point-to-point ionospheric propagation and communications system performance model to assess shortwave broadcast coverage, is presented. The listening area is approximated by a set of geographic coordinates (test points), and the required power gain (RPRG) for the link from each transmitter site to each test point is computed using the IONCAP ionospheric communications analysis and prediction program. The broadcasts may originate simultaneously from a single site or from multiple-transmitter sites (i.e., multicast). Figures of merit are assigned

in terms of the RPG values, and area coverage statistics are computed for the simulated broadcasts. Three interactive computer programs were developed to permit a semi-automated multicast broadcast coverage analysis using IONCAP and a computerized equipment database. They are: propagation parameter set-up program; transmission plan set-up program; and, multicast analysis program. 27 refs.

Hagn, George H. (SRI Int, Arlington, VA, USA); Lee, Mary; Worthington, David R.L.; Harnish, Lawrence O. *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 283-291.

#### Computer Interfaces

**087903 WERTACHTAL SHORTWAVE BROADCASTING STATION.** A description of the Wertachtal, West Germany shortwave broadcasting station is presented, along with modifications to satisfy Voice of America (VOA) requirements. A brief description of proposed high-efficiency transmitters, and new computers and supervisory equipment is included. 3 refs.

Strohmayr, Johann (Wertachtal Shortwave Broadcasting Station, Ettlingen, West Ger). *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 306-308.

#### Control Systems

**087904 KONZEPT EINER DIGITALEN SENDEBEREICHE.** [Digital Programming Control Centre]. The article outlines a method of gradual digitization of the broadcasting centre. A parallel configuration of analogue and digital equipment can, without impacting on operating procedures, be used to set up a continuous transmission chain extending from the digital sound source, such as a compact disc reader or video recorder, to the listener's satellite receiver. (Author abstract). In German.

Bittel, Bertram; Fiedler, Ingo. *Rundfunktech Mitt* v 32 n 3 May-Jun 1988 p 116-119.

**Federal Republic of Germany** See RADIO SYSTEMS—Stations.

#### France

**087905 BROADCASTING NETWORKING via SINGLE PSTN 'B' CHANNELS.** At five sites worldwide, broadcasting stations now receive network programs from a Paris programming center, sent at 64 kbps, on a single bearer (B) channel of the French digital public switched telephone network (PSTN). Within the provisions of CCITT Recommendation G.722, these programs offer 'commentary-quality' sound, which am and fm radio listeners find fully satisfying for speech and all music programs except high fidelity. The end-to-end digital circuits that distribute programs originating in Europe to local broadcasting stations via the PSTN and the TELECOM 1 domestic satellite are presented. An application is outlined which transports three programs intercontinentally (1,2,3) and one (L) for broadcast in Paris. Program 2 originates in the Paris studio; the others start at remote locations. The conventional method of broadcast-grade audio transport requires the PSTN equivalent of three telephone channels per program, whether the PSTN is analog or digital.

Massiet du Bist, Bruno (France Telecom, Fr); Fric, Jacques; Schwartz, Arthur J. *Telecommunications* v 22 n 8 Aug 1988 p 57-59,67.

#### Great Britain

**087906 COLLOQUIUM ON THE OUTCOME OF THE FM SOUND BROADCASTING PLANNING CONFERENCE 1984.** The colloquium proceedings contains 4 papers. Topics covered include: background and general workings of the conference; national network radio in the UK; BBC and IBA local radio; and compatibility with other services. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 08449 in the Ei Engineering Meetings (TM) database produced by Engi-



neering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig* n 1985/77. Colloq on the Outcome of the FM Sound Broadcast Plann Conf 1984, London, Engl, Oct 10 1985. Publ by IEE, London, Engl, 1985 var pagings.

Legislation See RADIO—Frequency Allocation.

## Mathematical Models

**087907 MODELLHAFT BESCHREIBUNG DER QUANTITATIVEN UEBERTRAGUNGSKAPAZITAET ZUR BEURTEILUNG DER PLURALITAET BEI UKW-SENDERNETZEN.** [Mathematical Description of Quantitative Broadcast Capacity for Evaluation of the Plurality of VHF/FM Transmitter Networks]. The article describes a model serving for the quantitative evaluation of the broadcast capacity of terrestrial transmitters by means of a numerical terrain model and other spatial data. An analysis of the plurality is done through a logical configuration of the broadcast capacity of the various transmitters, i.e. the number of receivable programmes is determined as a function of the receiving site. (Author abstract) 6 refs. In German.

Seiler, Von Werner; Stoecker, Friedrich. *Rundfunktech Mitt* v 31 n 5 Sep-Oct 1987 p 209-220.

**087908 FITTING GRAPHS AND NUMERICAL TABLES FOR A SINGLE PARAMETER REPRESENTATION OF THE SHAPE OF PROGRAMME SOUND SIGNAL DISTRIBUTIONS.** In order to represent the statistical character of a sound signal simply and with a single parameter, numerical tables and graphs of theoretical distributions for the estimation of a parameter called the shape parameter of the distribution are presented. The theoretical distributions are based on a statistical model of broadcast signals which was derived from the analysis of variations in measured distribution. The statistical functions dealt with are pdfs (probability density functions) and cdfs (cumulative distribution functions) for instantaneous amplitude and power, for rms-valued intensity fluctuations, and for one-minute mean powers and peak powers. A list of the values of the shape parameter estimated for CCIR data is given, from which almost all the CCIR data can be reproduced by using the theoretical distribution curves and the numerical tables presented. 7 refs.

Ehara, Shiro (NHK, Tokyo, Jpn). *IEEE Trans Broadcast* v 34 n 1 Mar 1988 p 9-17.

Performance See ANTENNAS—Radiation.

## Planning

**087909 PLANNING FOR RADIO BROADCAST SERVICES.** Differing political requirements for radio broadcasting services have led to different planning solutions. In turn, this has led to various frequency planning techniques being applied in different countries. Because radio-wave propagation does not respect national boundaries, a degree of re-arrangement of idealized plans is inevitably needed to ensure that multiple sets of national broadcasting requirements can co-existence without excessive cross-border interference. One result is that a final agreed plan contains elements of different philosophies, together with modifications to enable co-existence, and no clear picture may emerge of any underlying coherent strategy. The latter may usually be found by examination of the detail for geographically distinct sub-regions, when it can be seen that the frequency planning techniques employed have much in common with those in use by some other services. 13 Refs.

Hunt, K.J. (European Broadcasting Union, Brussels, Belg). *J Inst Electron Radio Eng* v 58 n 4 Jun 1988 p S55-S64.

**087910 FUTURE OF HIGH FREQUENCY BROADCASTING.** Since the end of World War II the number of daily frequency hours used by high-frequency (HF) broadcasting (also known as shortwave and band 7,

3-30 MHz) has tripled. At present, approximately 35,000 daily frequency hours are carried in an HF spectrum that can barely accommodate half that amount. As a consequence, congestion is severe, and interference levels intolerably high. Attempts to remedy this situation by planning the high-frequency bands date back to 1947, but, thus far, they have not been successful. International planning conferences in 1984 and 1987 have shown a possibility for agreement; another conference is tentatively scheduled for 1992. Some broadcasters have attempted to solve their congestion problems by moving out-of-band, sometimes expanding their services into bands allocated to other services, such as amateur radio, fixed, aeronautical, and mobile. It is feared this trend will continue. The attempts that have been made to plan the HF bands in an effort to alleviate congestion are described and the outlook for the remainder of this century is discussed. 8 refs.

Leinwoll, Stanley (Radio Free Europe/Radio Liberty Inc, New York, NY, USA). *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 94-101.

**087911 RESULTS OF WARC-HFBC(87): TECHNICAL IMPLICATIONS.** The planning principles and technical parameters that were decided at the 1987 second session of the World Administrative Radio Conference (WARC) for the planning of the HF bands allocated to the broadcasting service (HFBC) are described. These planning principles and parameters are intended for use in developing test plans to satisfy the world's high-frequency broadcast requirements. Those parameters that were modified at the second session of the conference are discussed toward obtaining a workable and universally acceptable planning system for shortwave broadcasting. With reference to the results of the planning exercises that were used as the basis of decisions at the second session, the likely impact of these decisions on the HF broadcast planning process is described. Some issues that are likely to concern the US broadcasters in preparation for the third session of WARC are summarized in conclusion. 10 refs.

Rush, Charles (Nat'l Telecommunications & Information Administration, Boulder, CO, US); Jacobs, George; Richards, Warren. *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 102-108.

## Reliability

**087912 METHODOLOGY FOR MODELING THE RELIABILITY, AVAILABILITY AND MAINTAINABILITY (RAM) OF A GENERIC SHORTWAVE BROADCAST RELAY STATION.** A methodology for developing a reliability, availability and maintainability (RAM) model that is applicable to evaluating conceptual designs for shortwave broadcast relay stations is described. A generic relay station (GRS) that has nine major subsystems exclusive of the ionospheric propagation path is proposed. The reliability of the propagation path to the listeners is not addressed. An example of the use of the methodology is presented for the GRS and the sensitivity of the model results is studied for the most significant subsystems from a RAM standpoint: the satellite earth station that delivers the program feeds and the high-powered transmitters. 4 refs.

Willet, Jack H. (SRI Int, Menlo Park, CA, USA); Harvey, David L.; Hagn, George H. *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 242-262.

## Space Applications

**087913 TOWN CRIER TO WORLD SEER: A BROADCAST ODYSSEY.** A review of the development of broadcasting is given and thoughts are presented for its evolution into the 21st century. Although the terrestrial radio and television networks are unlikely to expand greatly in future, their usage may change, particularly to satisfy new interests in the broadcasting of data or information. Emphasis is placed on the importance of satellites in the next decade, for international programme supply, for delivery of radio and television to the home, and for satellite news gathering. The direct broadcasting of television by satellite to the home, starting in 1989 in

the UK, also offers exciting new opportunities for carrying higher-definition, widescreen pictures. It is suggested that in the next couple of decades a slowly changing balance between terrestrial, satellite and cable networks will be seen, with fibre optic connections to the home only starting to make an impact with new services in the next century. Most significant in the near future will be the way in which new delivery technology and new receiver developments will increase the choice of programmes and broadcast information services to the user. (Author abstract)

Forrest, John R. (Independent Broadcasting Authority, Winchester, Engl). *IEE Proc Part F* v 135 n 1 Feb 1988 p 1-6.

Standards See AMPLITUDE MODULATION—Performance; RADIO INTERFERENCE—Standards.

## Switzerland

**087914 RECEPTION OF RADIO AND TELEVISION PROGRAMMES IN SWITZERLAND.** The author evaluates the number of households that can receive radio and television programs if they own the necessary installations, starting with the coverage area of terrestrial transmitters, receiving antennas for satellite signals and the number of connections to the cable distribution networks. The PTT's responsibility is not limited to the transmission of signals. It also has to ensure use of the receiving installations at the best possible conditions. Therefore, it regulates the use of the radio frequency spectrum to assure efficient utilization. In English and French.

Steffen, Charles (PTT, Berne, Switz). *Tech Mitt PTT* v 65 n 10-11 1987 p 522-526, 541-542.

## United States

**087915 EARLY HISTORY OF U.S. INTERNATIONAL BROADCASTING FROM THE START OF WORLD WAR II.** At the time the US entered into World War II in 1941, there were eleven shortwave international broadcasting stations in the US, all privately owned by companies or foundations. Recognizing the psychological warfare potential of these facilities, the US Office of War Information (OWI), an agency under the Executive Office of the President, negotiated operating contracts with the owners and established studios in New York and San Francisco to provide government programming. This was the origin of the Voice of America. At the same time, budget requests were made to the US Congress and funds appropriated for shortwave facilities expansion and for certain overseas stations operated by the overseas branch of the OWI. The operational and expansion programs which increased the number of shortwave transmitters to 36 in eight station sites by the end of World War II are reviewed. At the end of the war, the OWI was replaced by the US Information Agency (USIA) with its international broadcast service operating the Voice of America. The further expansion of shortwave broadcasting under USIA is outlined. 4 refs.

Weldon, James O. *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 82-86.

**RADIO COMMUNICATION** See Also NAVAL VESSELS—Design; RADIO SYSTEMS—Japan; RADIO SYSTEMS, DIVERSITY—Performance.

**087916 RADIO COMMUNICATION THROUGH ROCK.** Electromagnetic waves do propagate through rock. Their ability to do so is a complex function of frequency, geological criteria (both electrical and physical) and antenna characteristics. This article reviews the work done over many years to solve the problems of transmission without having to rely on wave-guiding devices such as leaky feeders. 11 refs.

Austin, B.A. *Electron Wireless World* v 93 n 1619 Sep 1987 p 943-946.



**087917 TRACK TO TRAIN RADIO COMMUNICATION SYSTEM OF SWISS FEDERAL RAILWAYS.** Mobile radio communication systems are an important instrument of railway operations control. They must, however, take account of the user's requirements and of his infrastructure if genuine benefit and rationalization are to be achieved. Realizing the advantages of combining control and communications technology, Brown Boveri Radiocom developed the RANCOS family of radio network control systems. With it, a track to train radio communication system for railways has been built whose structure and user-friendliness will be the standard in the future. Brown Boveri, as general contractor, is fully responsible for the construction of Swiss Federal Railway's country-wide track to train communication system. The authors consider the objectives, the system configuration and its main features and benefits. The radio communication system will be tested on a specially equipped line in the spring of 1988. (Author abstract) 5 refs.

Werner, R. (Swiss Federal Railways, Turgi, Switz); Zufferey, C. *Brown Boveri Rev* v 74 n 12 Dec 1987 p 664-670.

**087918 MULTI-STATION PACKET-RADIO NETWORK.** A new structure for packet-radio networks, called the multi-station network, is suggested and analyzed. We describe the salient features of this structure that consists of a large number of nodes and several stations. We then focus on one of the main problems within the suggested structure, the problem of forwarding packets from the nodes to the stations through a shared radio channel. Two basic forwarding schemes are investigated and compared. The classical slotted ALOHA is considered as an access scheme to the shared channel. (Author abstract) 15 refs.

Sidi, Moshe (IBM, Yorktown Heights, NY, USA); Cidon, Israel. *Perform Eval* v 8 n 1 Feb 1988 p 65-72.

**087919 PROTECTION OF A NARROW-BAND BPSK COMMUNICATION SYSTEM WITH AN ADAPTIVE ARRAY.** The performance of an adaptive array when used with narrowband BPSK (binary phase-shift-keyed) communication signals is described. Earlier results for the performance of an adaptive array used with a standard BPSK signal when the array bandwidth is several times the signal bandwidth are extended to the case in which the array bandwidth is as small as possible, equal to the desired signal symbol rate. To realize such a bandwidth reduction, the BPSK signaling waveform is reshaped before transmission to prevent intersymbol interference. The performance of the optimal detector for the narrowband BPSK signal is determined when this detector operates behind an adaptive array that is subjected to CW interference. The bit error probability is obtained as a function of the desired signal and interference powers and arrival angles as well as the array bandwidth. 18 refs.

Ganz, Matthew W. (MIT, Lexington, MA, USA); Compton, R.T. Jr. *IEEE Trans Commun* v COM-35 n 10 Oct 1987 p 1005-1011.

**087920 CHARACTERIZING THE MULTIPATH AND DOPPLER SPREADS OF THE HIGH-LATITUDE METEOR BURST COMMUNICATION CHANNEL.** High-latitude propagation phenomena, such as scatter from the aurora and sporadic-E propagation, can alter the communication characteristics of the meteor communication channel. An experiment is described in which the fading and multipath profiles of the high-latitude meteor communication channel are characterized. The effects of high-latitude propagation phenomena on the capacity and reliability of meteor burst communication are discussed. 9 refs.

Weitzen, Jay A. (Signatron Inc, Lexington, MA, USA); Sowa, Michael J.; Scofield, Rob A.; Quinn, John. *IEEE Trans Commun* v COM-35 n 10 Oct 1987 p 1050-1058.

**087921 OPTIMUM COMBINING FOR INDOOR RADIO SYSTEMS WITH MULTIPLE USERS.** The

author studies the use of optimum combining to increase the capacity of narrowband in-building radio communication systems with multiple users. He considers systems consisting of a base station with numerous remotes in a Rayleigh fading environment and studies the problem of more users requiring channels than the number of channels available. A system is described that, with multiple antennas at the base station but only one antenna at each remote, uses optimum combining to suppress interfering signals. It is shown that this system, with M antennas at the base station, can achieve an M-fold increase in the number of users or tolerate M-1 interferers from other systems. Thus, with optimum combining, radio communications can be used in high-density, multiple-user environments, such as within buildings, even when only limited bandwidth is available. 20 refs.

Winters, Jack H. (AT&T Bell Lab, Holmdel, NJ, USA). *IEEE Trans Commun* v COM-35 n 11 Nov 1987 p 1222-1230.

**087922 DISTRIBUTED ANTENNAS FOR INDOOR RADIO COMMUNICATIONS.** The implementation of an indoor radio communications system serving an entire building from a single central antenna has been limited to small buildings and narrowband frequency-division multiple-access (FDMA)-type systems with limited reliability and flexibility, because of signal attenuation and multipath delay spread. The results of indoor radio propagation measurements of two signal distribution approaches that overcome these problems are presented. In the first, the building is divided into many small cells, each served from an antenna located in its own center, with adjacent cells operating in different frequency bands. In the second approach, the building is divided into one or more large cells, each served from a distributed antenna system or a leaky feeder that winds its way through the hallways. This approach eliminates the frequency-cell handoff problem of the first approach, while still greatly reducing multipath delay spread and signal attenuation compared to a centralized system. Sophisticated broadband TDMA-type systems that are flexible, robust, and virtually building-independent are thus possible. 13 refs.

Saleh, Adel A.M. (AT&T Bell Lab, Holmdel, NJ, USA); Rustako, A.J. Jr.; Roman, R.S. *IEEE Trans Commun* v COM-35 n 12 p 1245-1251.

**Applications** See ELECTRIC POWER SYSTEMS—Load Management.

**Equipment** See RADIO RECEIVERS—Remote Control; TELECOMMUNICATION LINKS, RADIO—Modular Construction.

**Mathematical Models** See AMPLITUDE MODULATION—Performance; RADIO SYSTEMS, MOBILE—Design.

**Microwaves** See Also CODES, SYMBOLIC—Error Correction.

**087923 MICROWAVE PERFORMANCE MONITOR APPLICATION AT THE BONNEVILLE POWER ADMINISTRATION.** Experience is reported with an automatic performance monitoring system which monitors pertinent operational parameters of seven major microwave systems. The microwave monitor (MWM) system provides operations and maintenance personnel with continuous measurement of each system's performance. The MWM detects gradual MW system degradation and impending failures before an outage occurs. This allows maintenance visits to be scheduled in advance. In addition, the MWM isolates problems to specific sections of each microwave system allowing rapid location and repair. The MWM also performs automatic diagnosis, and only requires remote terminals at the ends of each microwave system. It is suggested that the MW monitor can be used to evaluate the maintenance approach and procedures in use. 3 refs.

Street, Michael A. (Bonneville Power Administration, Portland, OR, USA); Borys, Stanley F. *IEEE Trans Power Delivery* v PWRD-2 n 4 p 992-998.

**Military Applications** See CRYPTOGRAPHY.

**Monitoring** See RADIO SYSTEMS—France.

**Optimization** See Also RADIO TRANSMISSION—Optimization.

**087924 VPLIV SELEKTIVNEGA PRESIHA NA LASTNOSTI DIGITALNIH RADIORELEJNIIH SISTEMOV ZA SREDNJE IN VISJE RAVNI PRENOSA.** [Properties of Medium to High Capacity Digital Radiorelay Systems Over Selective Fading Channel]. The article deals with some specific phenomena, encountered in planning of digital radiorelay equipment and communication links for medium and high transmission capacities. The development of monolithic integrated circuits using CMOS technology has made the technological unification of low and medium capacity systems a reality. The effect of a dispersive, frequency selective channel on the transmission of 34 Mbit/s QPSK and QAM signaling is analyzed. (Edited author abstract) In Slovenian. 27 refs.

Lavric, Andrej; Jeran, Dominik; Vugrinec, Joze; Javornik, Tomaz. *Elektroteh Vestn* v 54 n 5 Nov-Dec 1987 p 301-309.

**Performance**

**087925 RADIO COMMUNICATION TRENDS.** This paper describes a number of radio transmission systems presently in use in NTT, and reviews the current developmental trends in radio communications technologies and services. Microwave digital radio-relay systems have been used for various links in NTT. A new high capacity microwave digital system, which is now under development, is a novel long-haul digital radio system for ISDN trunk transmission links. Subscriber radio systems represent a new terrestrial radio application, used principally for high-speed or broadband subscriber loops. Satellite communications are employed for many purposes, such as for emergency security measures for inter- and intra-city transmission links, for communication with remote island locations, and for leased circuits. New satellite applications to integrated transit circuit systems for public networks and TV signal transmission systems are now being considered. (Edited author abstract) 14 refs.

Wasai, Hiromi (NTT, Jpn). *Jpn Telecommun Rev* v 29 n 4 Oct 1987 p 33-39.

**087926 MODERNE VERFAHREN DER FUNKKOMMUNIKATION IM VHF-BEREICH.** [Advanced Methods of Radio Communication in the VHF-Range]. VHF-radio communication has been reserved for military applications for some decades. Based on modern digital technologies the performance of the system was essentially improved. In this paper digital methods and modes of operation are presented and discussed. Furthermore future developments are outlined. (Author abstract) In German. 7 refs.

Rother, Dietrich (Standard Elektrik Lorenz AG, Pforzheim, West Ger). *Frequenz* v 42 n 2-3 Feb-Mar 1988 p 66-70.

**Planning**

**087927 NEW DEFINITION OF THE RADIO COVERAGE AREA.** Coverage area is defined as a statistical concept offering to planners and users of radio services more relevant data than different definitions currently used. Based on an appropriate field strength determination method which takes into account the local terrain irregularities, this definition yields a realistic picture of the efficiency of a transmitter in covering relevant areas. A computer program package enabling an easy and rapid determination of the coverage area, thus defined, is developed. For the prediction of the field strength, the 'clearance angle' method has been used. Several examples have been elaborated, the results of which justify the use of the definition proposed. (Author abstract) 13 refs.

Paunovic, D.S. *Telecommun J* v 54 n 10 Oct 1987 p 670-676.



## Selection

**087928 AUTOMATIC CHANNEL SELECTION USING TEMPLATE CORRELATION.** A new technique for automatic channel characterisation and selection in spectrally congested environments, known as 'template correlation', is described. Its performance under simulated conditions is illustrated. Modification of the basic technique to reduce the computational load, via a thresholding algorithm is discussed. (Author abstract) 4 refs.

Jowett, A.P. (Univ of Hull, Hull, Engl); Darnell, M. *Electron Lett* v 23 n 22 Oct 22 1987 p 1209-1211.

**RADIO DIRECTION FINDING** See Also ELECTRONIC EQUIPMENT—Design; SHIPS—Navigation Systems.

**087929 AR AND EIGENSTRUCTURE METHODS FOR ESTIMATING DIRECTION OF ARRIVAL OF MULTIPLE PLANE WAVES.** Estimation of angles of arrival of multiple plane waves is important in many applications. These applications include direction finding, air navigation and location of a ship or a submarine using SONAR. The problem has attracted the attention of many researchers and new techniques have emerged. In this paper, we present AR and Eigenstructure methods that have been recently proposed for bearing estimation. An attempt has been made to bring all these algorithms under a common theoretical framework. Some computer simulation results are also presented to demonstrate the performance of these methods. (Author abstract) 20 refs.

Umapathi Reddy, V. (Osmania Univ, Hyderabad, India); Yoganandam, Y.; Kumar, Rajender. *J Inst Electron Telecommun Eng* v 32 n 5 Sep-Oct 1986 p 361-373.

**087930 ELECTROMAGNETIC DIRECTION FINDING FROM AN ANTENNA ARRAY CONFIGURED NER ON ELLIPTIC CYLINDER.** An effort is made to attack the problem of electromagnetic direction finding (DF) by an antenna array configured near a perfectly conducting elliptic cylinder. Over the range of interest, the cylinder has an axial ratio that varies from 1:1 to 1:30. Results for the array with three wire dipoles show the practicality of such an array. (Author abstract) 17 refs.

Siakavara, K. (Univ of Thessaloniki, Greece); Sahalos, J.N. *Can J Phys* v 65 n 9 Sep 1987 p 1164-1170.

## Analysis

**087931 INFLUENCE OF INTERCHANNEL CONNECTIONS IN A RECEIVER AMPLIFIER CIRCUIT ON THE ACCURACY OF A MONOPULSE RADIO DIRECTION FINDER.** The hardware error of a monopulse radio direction finder results from the fact that the gain-phase characteristics of the channels in its receiver-amplifier circuit are not identical. We report results of an investigation into the influence of interchannel coupling on the accuracy of direction finding in an application to a situation important in practice, in which coupling takes place at the inputs of all intermediate frequencies simultaneously. To make the analysis specific we have selected as its object an amplitude sum-and-difference radio direction finder. 4 refs.

Tel'pukhovskaya, O.N. *Radioelectron Commun Syst* v 30 n 4 1987 p 83-85.

**RADIO EQUIPMENT** See Also MINING MACHINERY—Control; NICKEL MINES AND MINING—Communication Systems; RADIO SYSTEMS, MOBILE; TELECOMMUNICATION EQUIPMENT.

**087932 DRL 7000 7GHZ DIGITAL RADIO LINK 8 AND 34 MBIT/S.** The DRL 7000 Radio Link equipment belongs to the new generation of equipment dedicated to medium capacity local and regional area network applications. A high spectral efficiency modulation (16 QAM), and an automatically regulated transmitted power may be used to provide a high grade of service in crowded microwave environments. This equipment is associated with a complete range of auxiliaries to ensure high transmission reliability and network management. It

makes it fully compatible with high-capacity backbone link requirements. (Author abstract). 1 Ref.

Marchand, Ph.; Courseille, O. *Commutation Transm* v 10 n 3 1988 p 45-52.

**Alarm Systems** See RADIO—Frequency Allocation.

**Enclosures** See ELECTRONIC EQUIPMENT—Enclosures.

**Japan** See OPTOELECTRONIC DEVICES—Japan.

## Manufacture

**087933 COLLOQUIUM ON COMPUTER AIDED ENGINEERING FOR SURFACE MOUNTED SYSTEMS.** This conference proceedings contains 6 papers. The main subjects are computer aided engineering in surface mount assembly, automatic surface placement equipment, intelligent vision systems, surface mount technology, microelectronics research, design for testability, and automatic assembly systems. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 09862 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Computing & Control Div, London, Engl). *IEE Colloq Dig* n 1986/127, Colloq on Comput Aided Eng for Surf Mounted Syst, London, Engl, Dec 8 1986. Publ by IEE, London, Engl, 1986 var pagings.

## Testing

**087934 KNOWLEDGE-BASED TECHNIQUES FOR FAULT DETECTION IN DIGITAL MICROWAVE RADIO COMMUNICATION EQUIPMENT.** The application of two distinct approaches to the diagnosis of faults in digital communication equipment is examined. The selected artificial-intelligence approaches use either rule-based or machine-learning techniques. Faults up to 8-dB TWT (traveling-wave tube) overdrive, 10% spacing error in the signal constellation, and 5° nonorthogonality in the modulating carriers are introduced on an 11-GHz radio. Each approach shown is capable of diagnosing both the type and magnitude of the introduced faults, subject to certain constraints for each system. Results indicate that the machine learning system is more appropriate than the rule-based system for providing optimal adjustment of the radio, where the underlying mechanisms are too complex to allow simple rules of thumb to be applied. However, the rule-based technique has been shown to be suitable for areas with large nonlinearities. A combination of the two techniques would solve some of the problems caused by the suitability of each method to a specific problem type, the rule-based approach covering the areas with large nonlinearities and the machine learning system the more linear regions. This would help in simplifying the implementation as it would minimize the number of rules required for each different radio type. 11 refs.

Brown, Keith E. (Univ of Edinburgh, Edinburgh, Scotl); Cowan, Colin F.N.; Crawford, Tom M.; Grant, Peter M. *IEEE J Sel Areas Commun* v 6 n 5 Jun 1988 p 819-827.

**RADIO INTERFERENCE** See Also CAPACITORS—Applications; COMPUTERS, PERSONAL; DEMODULATORS—Noise, Spurious Signal; ELECTROMAGNETIC COMPATIBILITY—Reviews; ELECTROMAGNETIC COMPATIBILITY—Standards; ELECTRONIC EQUIPMENT—Electromagnetic Shielding; RADIO SYSTEMS, DIVERSITY; RADIO SYSTEMS, MOBILE—Analysis; RADIO SYSTEMS, MOBILE—Cellular Technology; SIGNAL DETECTION.

**087935 RT-70 - AN INTERFEROMETER ELEMENT.** The basic parameters of the Evpatoriya radiotelescope with a 360°-rotatable reflector 70 m in diameter, operating at wavelengths of 1.35 cm and 18 cm, are presented. This telescope is part of the Simeiz-Evpatoriya-Pushchino radiointerferometric grid. (Author abstract) 3 refs.

Aslanyan, A.M. (Acad of Sciences of the USSR, USSR);

Grishmanovskii, V.A.; Gulyan, A.G.; Ignatov, S.P.; Kostenko, V.I.; Kanevskii, B.Z.; Kozlov, A.N.; Kopelyanskii, G.D.; Matveenko, L.I.; Paptsenko, A.Kh.; Martirosyan, R.M.; Molotov, E.P.; Strukov, I.A.; Tarasov, V.B.; Timofeev, V.N. *Radiophys Quantum Electron* v 30 n 3 Mar 1987 p 255-260.

**087936 LEARNING TO WORK WITH RFI.** In state-of-the-art electronics packaging, the prevention of radio frequency interference (RFI) is about to become a major consideration for every UK designer and manufacturer. This article discusses the measures necessary to overcome three major problem areas associated with radio frequency emissions from electronic equipment. The need for some protective measures is also discussed.

Macmillan, Roy (Telemetrix Research). *New Electron* v 20 n 14 Jul 7 1987 p 38, 40.

**087937 POLAR OCCURRENCE MAP OF BROAD-BAND AURORAL HISS OBSERVED BY ISIS SATELLITES.** A polar map of the occurrence rate of broad-band VLF hiss was made from narrow-band VLF intensity data of 6 frequencies processed from ISIS electric field (50 Hz — 30 kHz) tapes of 347 ISIS-VLF passes received at Syowa station, Antarctica between June 1976 and January 1983. The high-latitude contour of occurrence rate of 0.3 lies at invariant latitude of about 82° for all local times. The low-latitude contour of 0.3 lies at 74° around 10 MLT (geomagnetic local time) and it extends down to 67° around 22 MLT. The low-latitude contour of 0.3 is approximately symmetric with respect to the 10-22 MLT meridian. Two regions of high occurrence rate above 0.5 lie between 76° and 78° in the afternoon sector and also between 78° and 81° in the late night-early morning sector. (Edited author abstract) 20 refs.

Ondoh, Tadanori. *J Radio Res Lab (Jpn)* v 35 n 144 Mar 1988 p 1-14.

**087938 VLF NOISES TRIGGERED BY WHISTLERS AS OBSERVED IN THE TOPSIDE IONOSPHERE.** Characteristics of whistler triggered emissions observed in the topside ionosphere are examined using ISIS-, -2 and DE-1 VLF electric field data (50 Hz — 30 kHz) received at Kashima station, RRL, Japan. Most of these emissions are LHR emissions which occur for a few seconds after whistlers near the lower hybrid resonance frequency at mid- and high-latitudes. Whistler triggered emissions are classified according to the type of whistler, i.e. ducted whistlers with a continuous trace over the full frequency range of the spectrum and non-ducted whistlers without a complete trace below  $f_{LHR}$ . (Edited author abstract) 10 refs.

Nakamura, Yoshikatsu; Ondoh, Tadanori. *J Radio Res Lab (Jpn)* v 35 n 144 Mar 1988 p 15-26.

**087939 COMPARATIVE STUDY OF VLF RADIO WAVE PHENOMENA FROM DE-1 AND ISIS SATELLITES RECEIVED AT KASHIMA, JAPAN.** Magnetospheric VLF radio wave phenomena have been interpreted using spectral analysis of plasma-wave electric field (650 Hz — 10 kHz) data from the DE-1 satellite received at Kashima, Japan. Chorus, narrow-band hiss, ELF hiss and whistler characteristics observed in the plasmasphere ( $L \leq 4$ ) by the DE-1 are similar to those of the corresponding VLF emissions observed by the low-altitude polar orbiting satellites, ISIS-1 and ISIS-2. In low-density ( $f_H > f_{UH}$ ) plasma of the high latitude magnetosphere, the electron plasma frequency is the upper limit frequency of the whistler-mode waves. (Edited author abstract) 15 refs.

Ondoh, Tadanori; Nakamura, Yoshikatsu; Watanabe, Shigeaki; Aikyo, Kazuhiro. *J Radio Res Lab (Jpn)* v 35 n 144 Mar 1988 p 27-42.

## Analysis

**087940 NONCOHERENT DELAY-LOCK PN TRACKING LOOP: IMPACT OF RFI AND NONIDEAL ARM-FILTER CHARACTERISTICS.** A noncoherent delay-lock PN tracking loop is investigated. The



approach used is one in which simulation and analysis are combined to generate tracking performance. Performance data are presented for pseudonoise (PN) phase jitter standard deviation and compared to theoretical results. The impact of radio frequency interference and gain/phase imbalances on PN tracking performance is determined, and performance data are given. It is suggested that self-noise terms and nonideal arm-filter characteristics may be significant factors in the investigation of PN tracking performance for those cases in which PN code timing synchronization is a major concern.

Comparetto, G. (M/A COM Linkabit, Vienna, VA, USA). *IEEE Trans Commun* v COM-35 n 11 Nov 1987 p 1240-1244.

**Crosstalk** See RADIO—Frequency Allocation; VEHICLES—Automation.

**Jamming** See Also DIGITAL COMMUNICATION SYSTEMS; RADIO TRANSMISSION—Spread Spectrum.

**087941 EFFECTS OF NAKAGAMI FADING ON ANTJAM PERFORMANCE REQUIREMENTS.** The effect of fading on antjam (AJ) performance is considered when the envelopes of both the desired signal and the jamming signal fade with a Nakagami distribution. Two cases are analysed for conventional systems. In the first case, the fading is assumed to be slow compared with the duration of the message. In the second case, the fading is assumed to be slow compared with the symbol duration but fast compared with the message duration. For both cases numerical results are included. (Edited author abstract) 5 refs.

Al-Hussaini, E.K. (UAE Univ, Al-Ain, United Arab Emirates). *Electron Lett* v 24 n 4 Feb 18 1988 p 208-209.

**087942 ERROR PROBABILITIES FOR DS SPREAD-SPECTRUM SYSTEMS USING AN ALE FOR NARROW-BAND INTERFERENCE REJECTION.** The effects of the least-mean-squares adaptive line enhancer (ALE) weight misadjustment errors on the bit error rate are investigated for a direct-sequence spread-spectrum binary communication system in the presence of strong narrowband interference. The converged ALE weights are modeled as the parallel connection of a deterministic FIR (finite-impulse response) filter and a random FIR filter. The statistics of the random filter are derived, assuming the output of the random filter to be primarily due to the jammer convolved with the random filter weights. This output is shown to be non-Gaussian and to cause significant error rate degradation in comparison to a Gaussian model. Error probability expressions are derived for the bit error rate, evaluated numerically, and compared to the corresponding error probabilities for a Gaussian model for the random filter output. For some typical system parameter values and error probabilities, it is shown that the Gaussian model yields performance results that are too optimistic by several decibels. 17 refs.

Bershad, Neil J. (Univ of California, Irvine, CA, USA). *IEEE Trans Commun* v 36 n 5 May 1988 p 588-595.

**087943 JAMMING TO THE HF BROADCASTING SERVICE.** The Institute for Telecommunication Sciences has been actively involved in an internationally coordinated monitoring program to determine the location of emitters of harmful interference (jamming) to the high-frequency (HF) broadcast service. Four monitoring programs were undertaken between October 1984 and June 1986. The procedures that have been used and the results that have been obtained are summarized. The locations of the emitters that cause jamming to the HF broadcast service are shown and selected characteristics of the jamming environment are described. The degree to which jamming that is directed to certain broadcasters adversely impacts the performance of other broadcast services that operate on the same or adjacent channels as the targeted broadcaster is examined. 7 refs.

Sowers, Mary W. (Nat'l Telecommunications & Information Administration, Boulder, CO, US); Hand, Gregory; Rush, Charles M. *IEEE Trans Broadcast* v 34 n 2 Jun

1988 p 109-114.

## Legislation

**087944 ITU PROTECTION AGAINST HARMFUL INTERFERENCE.** Harmful interference, which can make radio communication difficult, sometimes even impossible, has been abhorred by the ITU. Its presence infringes a country's right to communicate through radio waves; hence the presence of harmful interference amounts to violation of international law. The ITU, through the law laid down in the Radio Regulations, Edition of 1982, has protected law abiding countries against harmful interference. This paper makes a techno-legal study of the protection granted to law abiding countries against harmful interference under the law. (Author abstract) 10 refs.

Sharma, G.N. (Space Applications Cent, Ahmedabad, India). *Space Commun Broadcast* v 5 n 5 Nov 1987 p 365-370.

**087945 NEW RFI LEGISLATION AFFECTS THE UK MANUFACTURER.** The draft EEC directive on electromagnetic compatibility (EMC) Document 59/87/EN has now been submitted to the European Council of Ministers. The directive seeks to standardize EMC legislation throughout the EEC. It will, for the first time, regulate all electric and electronic appliances, equipment and installations (except motor vehicles and tractors) through the whole of the electromagnetic spectrum. A summary of the implications of the new draft EEC directive on electromagnetic compatibility is presented.

MacMillan, Ray. *New Electron* v 21 n 3 Mar 1988 p 59-60.

**Mathematical Models** See ANTENNAS—Arrays.

**Measurements** See NOISE, SPURIOUS SIGNAL—Theory.

**Standards** See Also ELECTROMAGNETIC COMPATIBILITY—Testing.

**087946 RFI STARTS TO INFLUENCE THE MARKET.** Metallic enclosures, being conductive, provide an effective screen for electromagnetic radiation. However, with the growing use of plastics housing and the closer packing of components, electrical interference is now a major problem. This article discusses a proposed legislation for the UK which is likely to be based on BS 6527 but may also encompass other standards relating to RFI. The article also shows how RFI is going to influence the equipment packaging market.

Henley, Simon. *New Electron* v 20 n 14 Jul 7 1987 p 29.

**087947 EARLY HISTORY OF RADIO INTERFERENCE.** The need for control of interference to broadcast reception together with the realization that differing controls could constitute trade barriers led to the establishment in 1934 of the CISPR (International Special Committee on Radio Interference). Agreement on basic measuring techniques, instrumentation design and suppression methods was achieved rapidly. Agreement on actual limits took longer. (Author abstract) 8 refs.

Jackson, G.A. (ERA Technology Ltd, Leatherhead, Engl). *J Inst Electron Radio Eng* v 57 n 6 Nov-Dec 1987 p 244-250.

**Suppression** See Also RADIO TRANSMISSION—Spread Spectrum; TELECOMMUNICATION LINKS, SATELLITE.

**087948 COCHANNEL OPERATION EVEN UNDER SEVERE CROSS-POLARIZATION INTERFERENCE.** Due to their greater vulnerability to cross-polarization interference, 64-QAM systems will require a cross-polarization interference canceller (XPIC) for virtually all links. Cancellers of this kind are paving the way to bandwidth efficiencies of up to 10 bit/s/Hz, without requiring 4096 modulation levels. This makes cochannel operation a highly attractive means of achieving

maximum bandwidth utilization for digital radio transmission. (Author abstract) 9 refs.

Lankl, Berthold (Siemens AG, Munich, West Ger); Nossek, Josef; Sebald, Georg. *Telcom Rep* v 11 n 2 Mar-Apr 1988 p 50-53.

**RADIO NAVIGATION** See Also AIR NAVIGATION; ANTENNAS; FREQUENCY STANDARDS—Applications; SATELLITES—Navigation Aids Application; SHIPS—Navigation Systems.

**087949 FUTURE CIVIL AVIATION NEEDS: RECOMMENDATIONS OF RTCA SPECIAL COMMITTEE 155.** In October, 1983 the Radio Technical Commission for Aeronautics (RTCA) established Special Committee 155 (SC-155) on user requirements for future communications, navigation and surveillance, including space technology applications through the year 2010. This paper summarizes the assumptions, the postulated environment, the user requirements and technology forecasts upon which the resulting conclusions and recommendations are based. (Author abstract)

Hardaker, William T. (RTCA, Washington, DC, USA). *Navigation* v 34 n 3 Fall 1987 p 250-259.

**087950 UPDATE ON THE BEHAVIOUR OF THE SOVIET UNION'S VHF SATELLITE NAVIGATION SYSTEM.** A previous paper on the USSR's VHF satellite navigation system is updated by observations covering the period from the middle of 1985 to the middle of 1987. The discussion relates to launch history, status, and investigations of special events concerning individual satellites. (Author abstract) 4 refs.

Daly, P. (Univ of Leeds, Leeds, Engl); Perry, G.E. *Space Commun Broadcast* v 5 n 5 Nov 1987 p 379-384.

**087951 EVALUATION METHOD OF POLYNOMIAL MODELS' PREDICTION PERFORMANCE FOR RANDOM CLOCK ERROR.** In satellite navigation systems such as the Global Positioning System, clock error is one of the major sources of error in precise pointing. In order to remove clock error, it is modeled as a second-order polynomial and the clock-error correction parameters are sent to users. However, a random clock error cannot be modeled as a second-order polynomial. Therefore, the time discrepancies due to random clock error must be taken into consideration for precise pointing. This paper proposes an analytical computation method for estimating the random clock error in the current system which makes use of the Allan variance characteristics of random clock error without random clock realization and a lot of simulation studies. Moreover, a numerical example based on the proposed method shows that the first-order polynomial model is better for predicting a random clock error than the second-order polynomial. (Author abstract) 5 refs.

Kosaka, Michitaka (Hitachi Ltd, Kawasaki, Jpn). *J Guid Control Dyn* v 10 n 6 Nov-Dec 1987 p 523-527.

**087952 INTERNATIONAL FUTURE NAVIGATION NEEDS: OPTIONS AND CONCERNS.** The paper examines likely needs which can be foreseen from civil users of navigation systems, be they aviation, marine, or land. Differences between users in the USA and in Europe are considered. The need for full international discussion is stressed as a prerequisite for trust in the system. It is also argued that the USA has as much to gain from such discussion as has the rest of the world. The paper concentrates on the Navstar Global Positioning System (GPS), which is seen as a considerable advance on earlier navigation systems. Nevertheless, the international community has several anxieties. Selective availability is likely to hurt US users as much as those in Europe and the integrity issue is an area where international discussion and cooperation is considered to be particularly valuable. (Author abstract) 8 refs.

Johannessen, Rolf (STC Technology Ltd, Harlow, Engl). *Navigation* v 34 n 4 Winter 1987-1988 p 279-289.



**087953 COVERAGE OF A RADIO BEACON-BASED DIFFERENTIAL GPS NETWORK.** A radio beacon-based system is being investigated by the U.S. Coast Guard for the communication of differential GPS (DGPS) messages. This system would add a digitally modulated subcarrier to transmissions from existing marine radio beacons, which operate in the 285 kHz to 325 kHz band. This paper discusses the prediction of DGPS/radio beacon signal coverage. Several coverage charts are presented as examples. The paper also lists which major U.S. harbors (8 million tons of cargo per year or more) can and cannot be covered if the DGPS subcarrier is installed on existing, continuous-broadcast radio beacons. The achievable signal coverage depends on which error correcting code is used, and the paper analyzes coverage for a 'rate 1/2' code and 'rate 1/8' code. (Edited author abstract) 13 refs.

Enge, K. (Worcester Polytechnic Inst); Ruane, Michael F.; Langlais, Diane. *Navigation* v 34 n 4 Winter 1987-1988 p 307-324.

**087954 LORAN-C IN THE 21ST CENTURY.** Worldwide activity in implementing or upgrading LORAN-C navigation systems is discussed, and improvements in transmitting equipment are briefly mentioned. Aviation, harbor, and diverse other applications are described.

Fuentes, Adeste F. (US Coast Guard Headquarters, Washington, DC, USA). *IEEE Aerosp Electron Syst Mag* v 2 n 12 Dec 1987 p 8-10.

**087955 RADIO VEHICLE POSITION REPORTING TECHNIQUE THAT IS PROTECTED FROM INTERCEPTION AND DIRECTIONAL FIXES.** Vehicles used to transport nuclear materials can determine their position with respect to an established grid by electronic means such as geosynchronous navigation satellite (GPS) or hyperbolic radio. It is frequently necessary to relay this position information via a radio link to a command center. If a modern data encryption technique is used, the usefulness of interception almost disappears. A hypothetical system is presented that is called burst mode frequency hopping (BMFH). The mobile transmitter sends very short modulated bursts that are hopped through a pseudo-random frequency map. Actual data are encrypted and then embedded in an interleaved error correcting code. (Edited author abstract) 18 refs.

Kraft, Clifford (AT&T Bell Lab, Naperville, IL, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?'. Newport Beach, CA, USA, Jul 12-15 1987 p 201-206.

## Analysis

**087956 EXPERIMENTAL MEASUREMENT AND CHARACTERIZATION OF IONOSPHERIC AND MULTIPATH ERRORS IN DIFFERENTIAL GPS.** Real-time differential GPS is fundamentally limited by a) signal estimation errors, b) satellite ephemeris errors, c) propagation decorrelation errors, and d) local multipath errors. In this paper we address the latter two error sources. An understanding of these is needed to establish an error budget for any monitor station network that the U.S. Coast Guard would consider for a nationwide system. 4 refs.

Sennott, J.W. (Bradley Univ, Peoria, IL, USA); Pietraszewski, D. *Navigation* v 34 n 2 Summer 1987 p 160-173.

**Applications See SATELLITES—Navigation Aids Application; VEHICLES—Navigation Systems.**

## Computer Applications

**087957 AUTONOMOUS NAVIGATION - WHEN WILL WE HAVE IT?** The utility of autonomous navigation for spacecraft operations is examined to define the related critical issues facing a spacecraft designer. From the various means available, relative navigation to other spacecraft, especially to GPS, is shown as the most cost-effective near-term means of approaching the goals of

autonomous navigation, without necessarily achieving real autonomy. The latter will evolve with our confidence in artificial intelligence technology as an essential prerequisite to truly autonomous spacecraft operating, including the navigation task. (Author abstract) 21 refs.

Treder, Alfred J. (Boeing Aerospace Co, Seattle, WA, USA). *Navigation* v 34 n 2 Summer 1987 p 93-114.

## Equipment

**087958 WHERE IN THE WORLD ARE WE?** The coordinate converter-equipped radionavigation receiver is now commonplace. Most U.S. civil charts are printed using North American Datum-1927, while coordinate converters are based on World Geodetic System-1972. The variations between these two common descriptions of the shape of the Earth range from zero to nearly 200 meters in U.S. waters. It is fortunate that the majority of precise navigation in the U.S. is performed utilizing systems (usually Loran-C) in their repeatable mode. Those systems employed in an 'absolute' accuracy sense are generally not accurate enough to be affected by problems with coordinate conversion (although differences between WGS-72 and local chart datums can be as much as 1/2 kilometer). The presence and growth of the Global Positioning System, a system with civil accuracies of 15 to 30 meters, will reveal the coordinate conversion problems heretofore disguised by use of less accurate systems. The marine electronics manufacturer, and ultimately the mariner, is thus faced for the next 5-10 years with an 'alphabet soup' of conflicting chart and coordinate converter datum/ellipsoid combinations. With no brilliant solution to offer, this paper relies on 'education of the consumer' as the only way out of this multivariable problem. (Edited author abstract) 2 refs.

Roeder, J.F. (Sperry Corp, Charlottesville, VA, USA). *Navigation* v 33 n 4 Winter 1986-1987 p 314-318.

**087959 FIELD TEST RESULTS PROVE GPS PERFORMANCE AND UTILITY.** Statistical and operational results of extensive government field-testing of the Rockwell-Collins Global Positioning System (GPS) units are summarized. The equipment has exhibited better than 16-m spherical-error probable-position accuracy in over 6300 hours of testing conducted during the past two years. One-channel, two-channel, and five-channel receivers were subjected to thorough evaluation. Their respective signal-processing and data-processing architectures are described. Data highlighting dynamic position accuracy, static position accuracy, acquisition times, and field reliability are presented. GPS equipment integration and operation with nine different host vehicles is described. The results of mission scenarios, such as area navigation, rendezvous, and weapon delivery, are presented. 9 refs.

Blank, R.W. (Rockwell Int Corp, Cedar Rapids, IA, USA); Rhodes, W.D. Jr. *IEEE Aerosp Electron Syst Mag* v 3 n 6 Jun 1988 p 11-21.

**Europe See SATELLITES—Navigation Aids Application.**

**Mathematical Models See Also SIGNAL FILTERING AND PREDICTION—Kalman Filtering.**

**087960 SHORT-RANGE RADIO NAVIGATION SYSTEMS: CURRENT STATUS AND PROSPECTS.** The problems of the development of short-range navigation aids as integrated multifunctional systems for the near future while implementing them in poorly equipped regions, ice-breaker fleets, and on remote oil platforms are discussed. Conclusions are drawn about the reasonability of utilization for those purposes of various modifications of the existing integrated short-range navigation systems. These systems provide highly accurate operation, have a convenient  $p$ - $\theta$  coordinate system, and are capable in some cases of providing the additional functions. 4 refs.

Pakholkov, Georgiy A. (All-Union Science Research Inst for Radio Equipment, Leningrad, USSR); Gromov, Genadiy N. *IEEE Aerosp Electron Syst Mag* v 3 n 1 Jan 1988 p 2-7.

**087961 FILTERING OF DISCONTINUOUS PROCESSES ARISING IN MARINE INTEGRATED NAVIGATION SYSTEMS.** A refined stochastic model for the errors of the Loran-C radio navigation aid is described, and it is shown how this model can be used to improve the performance of integrated navigation systems. In addition to the usual propagation errors, Loran-C time of arrival measurements are occasionally plagued with sudden intermittent errors of a particular magnitude and caused by receiver cycle selection errors. These result in sudden large jumps in the calculated position solution. Standard stochastic models, described by linear Ito differential equations driven by Wiener processes, cannot adequately describe the behavior of these cycle selection errors. Here, the Loran-C error has been modeled as the sum of a diffusion process, representing the normal propagation errors, and a pure jump process of Poisson type, representing the cycle selection errors. A simple integrated navigation system is then described, based on the Loran-C model and the standard dead reckoning (heading and speed) system model. Assuming that the observed process is governed by a linear stochastic difference equation, a recursive linear unbiased minimum variance filter is developed, from which the Loran-C and dead reckoning errors, and hence position and velocity, can be estimated. 11 refs.

Dabbous, T.E. (Univ of Ottawa, Ont, Can); Ahmed, N.U.; McMillan, J.C.; Liang, D.F. *IEEE Trans Aerosp Electron Syst* v 24 n 1 Jan 1988 p 85-102.

**Monitoring See SATELLITES—Navigation Aids Application.**

**Performance See RADIO RECEIVERS—Mathematical Models.**

**Reliability See Also SATELLITES—Navigation Aids Application.**

**087962 GPS SATELLITE-TO-USER RANGE ACCURACIES: A CALIBRATION EXPERIMENT.** GPS is required to deliver satellite ephemeris and clock predictions via satellite transmission to end users. From 20 October to 17 November 1986, the Aerospace Corporation, General Dynamics Corporation, IBM Corporation, the National Bureau of Standards, the Naval Surface Weapons Center, and the U.S. Naval Observatory independently tracked GPS satellites and demonstrated that the GPS predictions satisfied the GPS design requirements. Both single-frequency, clear/acquisition-code and dual-frequency, protected-code receivers were used in this test. 10 refs.

Feess, B. (Aerospace Corp, El Segundo, CA, USA); Iroz, J.; Satin, A.; Winn, B.; Wiseman, C.; Hermann, B.; Swift, E.; Beisner, H.; Allan, D.; Davies, D.; Weiss, M.; Klepczynski, W.; Withington, F. *Navigation* v 34 n 3 Fall 1987 p 229-249.

**087963 ACHIEVING GPS INTEGRITY AND ELIMINATING AREAS OF DEGRADED PERFORMANCE.** There are two concerns regarding the civil use of the Global Positioning System (GPS). The first is 'integrity,' which is the possibility that GPS transmits an erroneous navigation signal to the user. A malfunction of the atomic frequency standard in the satellite is regarded as a possible integrity problem. The second concern is the areas of degraded performance. This paper discusses an approach to the solution of each of these two issues. It is shown that a communications type geostationary satellite is a common element to the solution of both concerns. Also common to both is a network of integrity monitoring and control stations. The paper discusses a system to cover the North American continent and also how it might be expanded to become worldwide. (Edited author abstract) 2 refs.

Jorgensen, Paul S. (Aerospace Corp, Los Angeles, CA, USA). *Navigation* v 34 n 4 Winter 1987-1988 p 297-306.



## Robot Applications

**087964 DESIGN OF AN INTEGRATED NAVIGATION SYSTEM FOR ROBOTIC VEHICLE APPLICATIONS.** This paper describes the design process for an integrated navigation system appropriate for robotic vehicle applications. The Global Positioning System (GPS) is considered as a primary positioning sensor, with an inertial system utilized for dead reckoning. Several possible dead reckoning system options were considered, including magnetic-compass/odometer, Doppler radar, and both two and three accelerometer inertial systems. Accuracy, autonomy, resistance to countermeasures, and cost were considered in evaluating the navigation system design alternatives. A simulation which realistically models the robotic vehicle environment was utilized in predicting navigation system performance. The simulation, along with representative results for the selected configuration(s), is also described. (Author abstract) 1 ref.

Geier, G. Jeffrey (TAU Corp, Garden Grove, CA, USA); Cabak, Algyte; Sieh, Larry. *Navigation* v 34 n 4 Winter 1987-1988 p 325-336.

## United States

**087965 MID-CONTINENT LORAN-C EXPANSION.** The Coast Guard is extending the continental United States (CONUS) LORAN-C navigation system coverage as part of the Federal Aviation Administration project to incorporate LORAN-C into the National Airspace System. The increased coverage will expand the number of airports approved for LORAN-C nonprecision instrument approaches and enable direct Instrumental Flight Rules (IFR) routing by suitably equipped aircraft in and through the midcontinent region of the United States. The project will involve construction of a LORAN-C chain which will be linked to the existing CONUS chains. In addition to the aviation benefits, the midcontinent LORAN-C expansion will broaden the availability of LORAN-C positioning to a growing number of terrestrial users such as a resource management, emergency response and fleet management. 2 refs.

Sedlock, Andrew J. (US Coast Guard Headquarters, Washington, DC, USA). *IEEE Aerosp Electron Syst Mag* v 2 n 12 Dec 1987 p 11-14.

**RADIO RECEIVERS** See Also ANTENNAS; RADIO ASTRONOMY—Equipment; RADIO TELESCOPES—Equipment; RADIO TRANSMISSION—Spread Spectrum; RADIO TRANSMISSION—United Kingdom; STORAGE BATTERY VEHICLES—Control.

**087966 QUASIOPTIMUM ALGORITHMS FOR THE RECEPTION AND PROCESSING OF RADIO SIGNALS TAKEN INTO CONSIDERATION WITH ANOMALOUS TRACKING REGIMES.** Quasioptimum algorithms for the reception and processing of radio signals with anomalous tracking regimes taken into consideration are obtained using the methods of the Markovian theory of optimum nonlinear filtering and the poly-Gaussian approximation of the a posteriori probability density of the processes being estimated. The case of scalar observation, carrying information on a scalar process, is discussed in detail. The algorithms are generalized to the case of a vector observation and vector processes. The algorithms obtained are suitable for practical implementation and make it possible to use already known results for solving numerous important problems in the synthesis of circuits while taking anomalous tracking regimes into consideration. The high efficiency and operability of the proposed algorithms are demonstrated for a specific example, using the methods of mathematical simulation. (Author abstract) 18 refs.

Mironov, M.A.; Yarlykov, M.S. *Sov J Commun Technol Electron* v 31 n 12 Dec 1986 p 70-82.

**087967 SYNCHRODYNE A.M. RECEIVER: 3-CIRCUIT DETAILS OF THE DEMODULATOR AND R.F. STAGES.** The receiver section consists of a separate phase sensitive detector followed by a steep-cut low-pass filter, to give the required adjacent channel selectivity, and

some kind of muting circuit, in operation when the incoming signal is not in synchronism, to remove the off-tune whistle which is characteristic of the synchrodyne system. The adjustable steep-cut low-pass filter is built from a cascaded pair of 'bootstrap' filter circuits having a Q chosen to give a slope, for each section, of about 20dB/octave. The turn-over frequency is 9kHz, though this could be modified, as desired by the user, by proportional adjustments to the filter component values.

Hood, J.L. Linsley. *Electron Wireless World* v 93 n 1601 Mar 1986 p 58-61.

**087968 HOLOGRAPHIC SYSTEM WITH A RECEIVER APERTURE IN THE FORM OF A CIRCLE.** The possibility of forming radio images through the use of a receiver aperture in the form of a circle is examined. The basic expressions, characterizing the system to be described, are obtained theoretically. A comparative analysis is made of the radioholographic system, in which a receiver aperture in the form of a circle is used, compared with a full circular aperture; the advantages and disadvantages of the system are pointed out. The results obtained by means of experimental apparatus are given to confirm the theoretical conclusions. (Author abstract) 7 refs.

Belyachits, A.Ch.; Kukharchik, P.D.; Semenchik, V.G. *Sov J Commun Technol Electron* v 32 n 1 Jan 1987 p 90-98.

**087969 LOW COST SUPERREGENERATIVE SAW STABILIZED RECEIVER.** A superregenerative receiver that overcomes the problems of frequency drift and excessive bandwidth of the present state-of-the-art devices with little or no sacrifice in receiver simplicity and cost is described. The receiver makes use of a surface-acoustic-wave device to stabilize the center frequency and decrease the bandwidth of the regenerative circuit. The receiver provides a 20-dB improvement in sensitivity level, at least a factor-of-ten decrease in receiver bandwidth, quartz temperature stability, and a great reduction in the bandwidth of the emitted spectrum over that of conventional LC-controlled regenerative receivers. The performance more closely approximates that of a superheterodyne receiver but has the simplicity of a superregenerative receiver. This results in greater reception range together with greatly reduced risk of interference from other RF sources. 2 refs.

Ash, Darrell L. (RF Monolithics, Dallas, TX, USA). *IEEE Trans Consum Electron* v CE-33 n 3 Aug 1987, 1987 Int Conf on Consum Electron, Rosemont, IL, USA, Jun 3-5 1987 p 395-404.

## Automatic Testing

**087970 PROGRAMMIEREN MIT MENUES UND FORMULAREN: SOFTWAREPAKET VEREINFACHT DEN TEST VON FUNKGERAETEN.** [Programming with Menus and Forms: Software Package Simplifies Testing of Radio Sets]. The application of computer-aided IEC-bus controlled automatic test systems for radio sets was impeded in the past by the development of necessary programming. A user-friendly flexible software package is reported which facilitates the realization of an automatic test system. In German.

Quakulinsky, Horst. *Elektronik* v 36 n 18 Sep 4 1987 p 92-94.

## Components See Also SEMICONDUCTOR DEVICES—Applications.

**087971 AM-FM IC FOR HOME & CAR RADIO.** A high-quality AM/FM radio receiver IC for home and car radios is described that is characterized by a high degree of flexibility: It can be adapted to every type of receiver—ETR, MTR, with or without AM stereo, or with precise and soft tuning. Particular attention has been paid to the need to contain cost in volume production.

Anzini, Luigi (SGS Microelettronica SpA, Italy); Grazia-dei, Rinaldo; Rossi, Giorgio. *IEEE Trans Consum Electron* v CE-33 n 3 Aug 1987, 1987 Int Conf on Consum Electron, Rosemont, IL, USA, Jun 3-5 1987 p 327-332.

## Design See Also PHASE LOCKED LOOPS.

**087972 MINIATURE GPS RECEIVER.** The authors have designed and fabricated a miniature GPS receiver (MGR) for the Global Positioning System. They discuss the system requirements, the implementation strategy, the chip set architecture, the five custom integrated circuits that comprise the receiver, and the software design.

Hemesath, N.B. (Rockwell Int, Cedar Rapids, IA, USA); Bruckner, J.M.H.; Weber, R.J.; Young, J.P. *Microwave J* v 30 n 9 Sep 1987 10p between p 81 and p 100.

## Digital Devices

**087973 ZWEIDIMENSIONALE QUANTISIERUNG IN DIGITALEN KORRELATIONSEMPPFAENGERN FUER SPREAD-SPECTRUM-SIGNALE.** [Two-Dimensional Quantization in Digital Correlation Receivers for Spread-Spectrum Signals]. In digitally implemented correlation receivers for spread-spectrum signals, the complex-valued lowpass equivalent of the received signal has to be quantized. When analyzing and optimizing the quantizer a special difficulty arises from the fact that the quantization of a complex-valued signal represents a two-dimensional problem. In this paper, the theoretical fundamentals of two-dimensional complex quantization in digital correlation receivers as well as a technique for analyzing and optimizing two-dimensional quantizers will be presented. Two types of quantizers with two-dimensional quantization schemes structured according to rectangular and polar coordinates will be discussed as examples of great practical importance. Results of a numerical optimization of these two quantizers conclude the paper. (Author abstract). 21 Refs. In German.

Baier, Alfred (Philips Kommunikations Industrie AG, Nuremberg, West Ger); Baier, Paul W. *AEU Arch Elektron Uebertrag Electron Commun* v 42 n 3 May-Jun 1988 p 151-159.

## Mathematical Models

**087974 SENSITIVITY ANALYSIS OF QUASIOPTIMAL COMPLEX RECEIVERS AND THE PROCESSING OF PULSED AND CW SIGNALS.** Using the methods of optimal nonlinear Markov filter theory, equations are derived which make it possible to study the actual accuracy, noise-immunity, cutoff, and tracking characteristics of optimal complex receivers and processors of pulsed and CW signals. (Author abstract) 7 refs.

Artemenkov, V.S. *Sov J Commun Technol Electron* v 32 n 2 Feb 1987 p 9-16.

**087975 HIGH DYNAMIC GPS RECEIVER USING MAXIMUM LIKELIHOOD ESTIMATION AND FREQUENCY TRACKING.** A novel high dynamic Global Positioning System (GPS) receiver is presented and its performance characterized by analysis, simulation, and demonstration. The demonstration receiver is a broadband model capable of tracking a single simulated satellite signal in pseudorange and range rate. Pseudorange and range rate estimates are made once every 20 ms, using a maximum-likelihood estimator, and are tracked by means of a third-order fading memory filter in a feedback configuration. The receiver tracks pseudorange with rms errors of under 1 m when subjected to simulated 50 g, 40 g/s circular trajectories. The tracking threshold is approximately 28 dB-Hz, which provides a 12-dB margin relative to the minimum specified signal strength, assuming a 3.5-dB system noise figure and 0 dBi antenna gain. 10 refs.

Hurd, William J. (JPL, Pasadena, CA, USA); Statman, Joseph I.; Vilnrotter, Victor A. *IEEE Trans Aerosp Electron Syst* v AES-23 n 4 Jul 1987 p 425-437.

## Microwave Frequencies See AMPLIFIERS, MICRO-WAVE.



Miniature See ELECTRONIC CIRCUITS—Tuning.

## Noise

**087976 TRANSFORMATION OF IMPULSE AND GAUSSIAN NOISE IN A RADIO-RECEIVER CIRCUIT.** Our aim is to determine the mathematical expectation, correlation function, and spectral density of the response of a radio-receiver circuit to the account of impulse and Gaussian noise. It is assumed that the radio receiver circuit consists of a series-connected linear system and square-law detector. 7 refs.

Protsenko, L.D.; Steklov, A.V. *Radioelectron Commun Syst* v 30 n 4 1987 p 103-106.

**087977 CONVERTING TSS TO DETECTION RECEIVER SENSITIVITY.** Receiver sensitivity is frequently characterized by signal levels that achieve the tangential-signal-sensitivity (TSS) condition. An alternate approach characterizes receiver sensitivity with signal levels that achieve a given detection-to-false-alarm probability. But this probability is difficult to predict when equally strong RF and postdetection noise signals exist simultaneously in the postdetection filter. However, the detection-to-false-alarm probability can be calculated from a measured or analytically determined TSS requirement, when the RF and postdetection noise signals present compete with a simple, unmodulated pulse-input signal. 5 refs.

Remmel, John A. (Ford Aerospace & Communications Corp, Newport Beach, CA, USA); Smith, Richard. *Microwaves RF* v 26 n 13 Dec 1987 7p between p 113 and 125.

## Noise, Spurious Signal

**087978 ON FM THRESHOLD EXTENSION BY CLICK NOISE ELIMINATION.** The validity of the click noise method of S.O. Rice (1963) for describing the performance of an analog threshold-extending receiver is established within the scope of a simulated environment. The significance of the received signal envelope for enhancing the detection of clicks is examined, and it is shown that a reliable click detector must make use of signal memory. A 'genie-aided' errorless click detector could lower the FM threshold by at least 6 dB. Threshold extension of 2.75 dB is observed under simulated conditions, with a realizable, clicks-cancelling receiver at a modulation index of five. 18 refs.

Polacek, M. (Technion, Haifa, Israel); Shitz, S.; Bar-David, I. *IEEE Trans Commun* v 36 n 3 Mar 1988 p 375-380.

## Optimization

**087979 OPTIMAL FILTERING IN A MULTI-STAGE RECEIVER.** The features of optimal filtering in wideband receivers consisting of a number of noisy four-ports connected in series are considered. (Author abstract) 4 refs.

Mitsenko, I.D.; Legkiy, V.N. *Sov J Commun Technol Electron* v 32 n 3 Mar 1987 p 24-28.

## Performance

**087980 QUALITY IN A.M. BROADCAST RADIO.** A method for providing variable selectivity while maintaining a level I.F. frequency response is discussed. The aim is to provide a better quality of AM reception. The role of IF bandwidth, RF bandwidth, and IF stability is examined. 2 refs.

Kearsley-Brown, R. *Electron Wireless World* v 94 n 1624 Feb 1988 p 188-189.

**087981 EIN SYNCHRONER HOMODYNE-EMPFANGER FUER FM MIT VERBESSERTER EMPFINDLICHKEIT UND SELEKTIVITÄT.** [Synchronous Homodyne-Receiver for FM with Improved Sensitivity and Selectivity]. Compared with the heterodyne-receiver the synchronous homodyne-receiver in principle has a series of advantages. These advantages

however, are not available in the concrete receiving situation because of a too small useful sensitivity and selectivity of the usual underlying phase-locked loop. In the present paper a tanlock loop with increased selectivity is pointed out. Moreover, it is given a concept for effective drift control in the working condition of the phase-locked loop and in consequence for an essential improvement of the useful sensitivity. (Author abstract). 10 Refs. In German.

Kreutzer, Martin (Univ des Saarlandes, West Ger). *Frequenz* v 42 n 5 May 1988 p 147-152.

## Remote Control

**087982 EDDYSTONE 1995 SERIES OF V.H.F./U.H.F. COMMUNICATIONS RECEIVERS - A USER'S GUIDE.** The Eddystone 1995, a new high-performance general coverage v.h.f./u.h.f. communications receiver, with comprehensive signal reception and operating facilities, is described. The operating system, based on that developed for the Eddystone 1650 l.f./h.f. receiver, has been enhanced and extended for both the v.h.f./u.h.f. receiver and a new version of the l.f./h.f. receiver. Together, these matching equipments can monitor the complete 10kHz to 1.1GHz spectrum. Many of the operating improvements have been in tuning, scanning and sweeping, and particular attention is paid to these in these article. Built-in test equipment (BITE) is becoming standard to aid fault finding in sophisticated equipment. A method to provide reliable BITE and the way it can be used are described. For remote control, compatibility with a wide range of standard data communications equipments is essential. Use of such equipment with the new receivers is detailed, as is the use of a mixture of long and short commands to maximize speed of control for the widest variety of tasks. (Author abstract) 1 refs.

Sutton, R.T. *Commun Broadcast* n 29 Mar 1988 p 3-9.

## Single Sideband

**087983 MODE DETECTOR OF SSB RADIO.** Two different activity modes of an SSB radio system are defined: carried wave with or without modulation. A detector based on nonlinear functional filtration is proposed. The detector decides which of the two above defined modes of SSB radio activity is presented. The results are expressed in a 'radar language', i.e., the probability of detection as a function of input snr for a fixed probability of false alarm is given. (Edited author abstract) 7 refs.

Wulich, Dov (Ben-Gurion Univ of the Negev, Beer-Sheva, Israel); Yardeni, David. *Signal Process* v 13 n 3 Oct 1987 p 301-308.

**087984 SIGNAL PROCESSING TECHNIQUES IN DIGITALLY IMPLEMENTED RADIOS.** With the rapid advancements in digital VLSI circuit design and implementation there is a great incentive to explore the possibility of digitally implementing radio functions that had hitherto been performed exclusively by analog circuits. This offers the advantages inherent to all digital circuits of increased reliability, ease of manufacture and ease of testing. Furthermore, by using general purpose digital signal processors, this approach permits software reconfigurable hardware to be used thus allowing many different radio functions to be integrated into the same equipment. Increasingly high performance professional radios are being required to incorporate data modems, digitized voice, encryption, multipath compensation, channel equalization and other advanced functions. 1 ref.

Dewey, R.J. *Annu Rev Philips Res Lab* 1986 p 76-81.

Testing See DIGITAL COMMUNICATION SYSTEMS—Space Applications.

**RADIO SYSTEMS** See Also AMPLITUDE MODULATION—Analysis; ANTENNAS, DIRECTIVE—Radiation; CEMENT PLANTS—Production Control; DIGITAL COMMUNICATION SYSTEMS; DIGITAL COMMUNICATION SYSTEMS—Australia; DIVING APPARATUS; MILITARY COMMUNICATIONS; PHASE MODULATION—Phase Shift Keying; RADIO; TELECOMMUNICATION SYSTEMS.

**087985 CANONICAL APPROXIMATION IN THE PERFORMANCE ANALYSIS OF PACKET RADIO NETWORKS.** The purpose of this paper is to present the applications of the canonical approximation technique to performance analysis of multishop packet radio networks. The canonical approximation gives a closed-form approximation of global performance measures. The computational complexity of the method is independent of the size of the network, whereas the precision increases exponentially with the size of the system. The method is applied to analyze some packet radio networks operating under CSMA with perfect capture and C-BTMA protocols. (Author abstract) 12 refs.

Pinsky, Eugene (Columbia Univ, New York, NY, USA); Yemini, Yechiam; Sidi, Moshe. 1987 p 140-160.

**087986 HIGH CAPACITY DIGITAL RADIO RELAY SYSTEMS FOR THE 18 GHZ BAND.** A new, high capacity radio system family for the 18 GHz frequency band has been designed for use in local and regional networks. In order to achieve high transmission capacity, 16 QAM and cochannel operation are used, enabling a maximum of  $4 \times 140$  Mb/s (or  $12 \times 45$  Mb/s) to be transmitted via one RF with 110 or 80 MHz channel spacing, respectively. (Author abstract) 5 refs.

Otremba, Klaus (Siemens AG, Munich, West Ger); Steinkamp, Jan; Thaler, Hans-Joerg; Vogel, Klaus. *Microwave J* v 31 n 1 Jan 1988 11 p.

**087987 6 GHZ, 140 Mb/s DIGITAL RADIO SYSTEM WITH 256 SSQAM MODULATION.** A repeater has been developed for 6 GHz, 140 Mb/s digital radio using 256 stepped-square QAM (256 SSQAM) modulation with a 20 MHz bandwidth. This modulation technique reduces the effects of nonlinearity on RF power amplifiers, and thereby improves the system gain more than 2 db compared with conventional digital radio systems using square 256 ( $16 \times 16$ ) QAM modulation. In this paper we describe the system configuration and measured data to show that a 256 SSQAM digital radio system can be introduced for commercial use. (Author abstract) 9 refs.

Tahara, M. (NEC, Yokohama, Jpn); Deguchi, T.; Mizoguchi, S.; Yoshida, Y. *Microwave J* v 31 n 1 Jan 1988 9 p.

**087988 DETERMINATION OF CO-CHANNEL REUSE DISTANCE FOR CELLULAR RADIO SYSTEMS.** A detailed analysis of the multiple-source co-channel interference encountered in a cellular radio system is described in this paper. The analysis is conducted under different conditions: (1) no fading and no shadowing, (2) fast fading only and (3) both fast fading and shadowing. A model for determining the co-channel reuse distance for the centre-illuminated configuration is developed. The analysis results relate the co-channel reuse distance requirements with the protection ratios and the acceptable interference levels under different conditions of fading and shadowing. (Author abstract). 11 Refs.

Chan, G.K. (Nanyang Technological Inst, Singapore). *Eng J Singapore* v 14 n 1 1987 p 3-9.

**087989 CURRENT SUBSCRIBER RADIO AND RECENT TRENDS.** The system design is discussed, covering access configurations, frequency band, access scheme, modulation, and frequency reuse pattern. System performance, equipment design, and surveillance and



control are examined. Recent trends are described, namely, high-speed digital transmission and subscriber radio in switching networks. 19 refs.

Kurita, Osamu (NTT, Jpn); Yoshida, Teruaki. *IEEE Commun Mag* v 25 n 11 p 44-50.

**087990 AUTOMATIC DECISION THRESHOLD LEVEL CONTROL (ADTLC) IN DIRECT-SEQUENCE SPREAD-SPECTRUM SYSTEMS BASED ON MATCHED FILTERING.** An automatic decision-threshold-level control (ADTLC) algorithm for direct-sequence spread-spectrum systems is described and analyzed. Two parameters of interest, probability of false alarm  $P_a$  and probability of correct signal detection  $P_d$ , are controlled simultaneously. As an example, the implementation of the algorithm in several practical direct-sequence spread-spectrum receivers is discussed. A considerable advantage of this algorithm compared to the classical approach (constant false alarm probability control) to the problem has been demonstrated. 8 refs.

Glisic, S.G. (Inst of Electrical Engineering, Belgrade, Yugosl). *IEEE Trans Commun* v 36 n 4 Apr 1988 p 519-527.

**087991 COLLOQUIUM ON CLOCK RECOVERY AND SYNCHRONIZATION IN DIGITAL RADIO.** This colloquium proceedings contains 6 papers. Topics covered include: clock recovery and synchronization; coherent demodulators; code word selection for burst synchronization; synchronization in packet radio system; clock extraction in presence of multipath effects; and synchronization/acquisition in frequency-hopped system. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 09373 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig* n 1986/106, Colloq on Clock Recovery and Synchronization in Digital Radio, London, Engl, Oct 30 1986. Publ by IEE, London, Engl, 1986 var pagings.

**Analysis** See SPECTRUM ANALYSIS—Efficiency.

## Calculations

**087992 METHOD FOR CALCULATION OF STEADY-STATE PROCESSES IN NONLINEAR WEAKLY DAMPED SYSTEMS.** Nonlinear devices operating in periodic steady-state mode represent a large class of radioelectronic devices whose analysis presents serious problems. This applies primarily to weakly damped systems: frequency multipliers and dividers, mixers, self-excited oscillators, parametric amplifiers, etc. In these systems a transient may last for several tens of periods and its calculation leads to enormous expenditures of machine time. The published methods for fast determination of a steady-state process are inefficient or inapplicable in analysis of weakly damped systems. What is more, it is impossible in practice to utilize them to analyze systems described by partial differential equations. The algorithm to be proposed here yields a noticeable improvement in the solution of this problem. For time-domain analysis in a large signal regime nonlinear devices are usually described by a system of nonlinear differential equations. We represent the solution of such a system as a generalized vector function  $y^-(t)$ , which is the set of currents and voltages at the corresponding branches and nodes of the investigated circuit. 6 refs.

Kolesnik, Yu.G. *Radioelectron Commun Syst* v 30 n 7 1987 p 64-66.

**Components** See OSCILLATORS, MICROWAVE—Design.

## Computer Aided Design

**087993 COLLOQUIUM ON DIGITALLY IMPLEMENTED RADIOS.** This conference proceedings contains 5 articles on digitally implemented radios. Among the topics covered are: coherent AM demodulator for

direct conversion receiver; DSP modem techniques applied to digital radio; universal modulator by direct digital synthesis; and computer aided radio design system (CARDS). Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11354 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig* n 1987/40, Colloq on Digitally Implemented Radios, London, Engl, Apr 1 1987, Publ by IEE, London, Engl, 1987 var pagings.

## Computer Simulation

**087994 DISTRIBUTED SIMULATION AND PROTOTYPING TESTBED FOR RADIO COMMUNICATION NETWORKS.** The authors discuss the development of a tested, called the distributed simulation and prototyping testbed (DSPT), to model variable-connectivity radio networks. The DSPT constitutes a software environment in which distributed simulation and prototyping models of radio communication and command and control systems can easily be built. The environment consists of four separate software packages: communication simulation, communication monitor, scenario update/controller, and prototype node. These four packages work together to form a single distributed simulation and prototyping facility for communication network studies. They relieve the user from the need to consider many of the details that must be handled to implement a distributed testbed. Each package is easily extensible and can be tailored to specific networks, scenarios, monitor views, and prototyping needs. 18 refs.

Baker, Dennis J. (US Naval Research Lab, Washington, DC, USA); Hauser, James P.; Thoet, William A. *IEEE J Sel Areas Commun* v 6 n 1 Jan 1988 p 197-209.

**087995 MODELLING AND SIMULATION OF M-QAM DIGITAL RADIO SYSTEMS.** This paper describes a simulation case study of a high capacity digital radio link subject to frequency selective fading with M-QAM modulation and different types of channel encoding. The error rate of the uncoded M-QAM digital radio channel is estimated first. Then the performance of the encoded system using high rate cyclic and convolutional codes is assessed for the fading channel. (Author abstract) 5 refs.

Vucetic, Branka (Univ of Sydney, Sydney, Aust); Skellern, David; Miller, Michael; Zhang, Liren. *Math Comput Simul* v 30 n 1-2 1988, Simul Soc of Aust 1987 Conf, Melbourne, Aust, May 11-13 1987 p 69-73.

## Design

**087996 CHOOSING PREDICTIVE PARAMETERS FOR RADIOELECTRONIC APPARATUS.** In designing systems for maintenance of radioelectronic apparatus (REA) proper selection of the parameters used for monitoring and forecasting of REA state is very important. These are the predictive parameters (PP). The problem of selection of PP has not been dealt with adequately in the literature, and no allowance has been made for economic factors. This paper discusses the specification of a quantitative measure of the suitability of PP on the basis of a cost-reliability criterion for the effectiveness of technical maintenance (TM) with prediction of the state of the REA. 3 refs.

Illarionov, O.I.; Dmitrievskii, E.S.; Smirnova, L.I. *Radioelectron Commun Syst* v 30 n 7 1987 p 102-104.

**087997 SYSTEM AND MICROWAVE COMPONENT DESIGN IN 64 QAM DIGITAL RADIO.** Design and performance of a 6 GHz microwave radio relay system for 140 Mb/s transmission with 30 MHz channel spacing using the 64 QAM modulation scheme are reported. Information is provided on the design of some microwave radio components, such as the local oscillators, mixers, the high power transmitter amplifier and the low noise preamplifier in the receiver. Also included is a short description of the modem design

focusing on circuit concepts and technologies applied to achieve the high signal processing accuracy required for the utilized multilevel modulation scheme. (Author abstract) 4 refs.

Holz, Wolfgang (Standard Elektrik Lorenz AG, Pforzheim, West Ger); von Kameke, Bernhard. *Microwave J* v 31 n 1 Jan 1988 8 p.

## Digital Devices

**087998 256 QAM 400 Mb/s MICROWAVE RADIO SYSTEM.** This paper describes a newly developed 256 QAM 400Mb/s digital microwave radio system with 10 b/s/Hz effective spectrum efficiency. In order to achieve the system, new techniques for high-precision modems, high-effectiveness fading counter-measures, high-performance antennas etc. were developed. Field test results confirm that the 256 QAM digital radio equipped with these new techniques meets the outage objectives on plain radio-relay routes. This system is planned for commercial use. (Author abstract). 4 refs.

Murase, Takehiro (NTT, Jpn). *Jpn Telecommun Rev* v 30 n 2 Apr 1988 p 23-30.

## France

**087999 VHF-UHF RADIOMONITORING SYSTEM FOR FRENCH PTT.** The French postal administration is responsible for the technical quality of all communications in non-public radio services. This radio-monitoring task is now being handled in the Greater Paris area with its particularly high concentration of radiocommunications, with the aid of a modern DF and measuring system which is described. (Edited author abstract) 3 refs.

Ernst, Bernhard F. *News Rohde Schwarz* v 28 n 120 1988 p 20-24.

## Japan

**088000 PREMISES RADIO SYSTEMS IN JAPAN.** The description and use of premises radio systems in Japan are discussed. These system, which are suitable for radio communication within a short span, are composed of low-power radio equipment with carrier power output less than about 0.1 W. The discussion covers systems for telemetry/telecontrol, data transmission, radio paging, and automatic vehicle identification. 11 refs.

Nagami, Hisakuni (Ministry of Posts & Telecommunications of Japan, Jpn); Wakao, Masayoshi. *IEEE Commun Mag* v 25 n 10 Oct 1987 p 49-55.

## Microwaves

**088001 COCHANNEL INTERFERENCE BETWEEN POINT-TO-POINT URBAN MICROWAVE RADIO SYSTEMS.** Low-cost point-to-point radio systems are available at a number of frequencies in both the centimetre and millimetre wavebands for local business applications. In urban areas a high degree of cochannel operation is predicted, both for reasons of spectral efficiency, and because forecast demands exceed the number of available channels. The paper presents a probabilistic study of the limiting cochannel interference effects, based on an idealized flat circular locality model. The study indicates that high system populations, or area capacities, should be achievable. For example in a typical large metropolitan area, the predicted capacities for one way systems sharing a single channel, are several hundred for centimetre wave (13 GHz) systems, and several thousand for millimetre wave (39 GHz) systems. It is demonstrated that the area capacity is proportional to the square of the antenna diameter to wavelength ratio. There is thus a high incentive to employ equipment with relatively large antennas, and to operate wherever possible in the millimetre wavebands. (Edited author abstract) 11 refs.

Davies, W.S. (Telecom Australia Research Dep, Clayton North, Aust); Wende, D. *IEE Proc Part F* v 135 n 3 Jun 1988 p 225-232.



**088002 LAUNCESTON - MELBOURNE 140/68 Mbit/s MICROWAVE DIGITAL RADIO SYSTEM.** This article summarises the design development, construction and testing of a practical high capacity digital radio system operating via extremely long overwater paths across Bass Strait. To achieve satisfactory performance in such difficult propagation conditions required an unusual and complex approach incorporating two different adaptive equaliser techniques and dual frequency band operation each with space diversity receivers. (Author abstract). 4 Refs.

Johnston, G.B.; Davey, L. *Telecommun J Aust* v 38 n 1 1988 p 45-52.

## Performance

**088003 REDISTRIBUTION OF RESOURCES IN RADIO SYSTEMS OPERATING UNDER NONSTATIONARY CONDITIONS.** We consider a system of radioelectronic facilities operating with broadband signals. The system functions under nonstationary conditions determined by the mobility of the facilities, and by the variation in the characteristics of existing noise. The working elements of the system are radio channels (RC). A limited frequency-time resource (FTR)  $v = F \times T$ , is allocated for operation of the system, where F and T are the frequency band and time interval set aside. 3 refs.

Potashkin, V.G.; Khromykh, V.G. *Radioelectron Commun Syst* v 30 n 4 1987 p 89-92.

## Radiation Effects See ANTENNAS—Radiation.

## Stations See Also TRAFFIC SIGNS, SIGNALS AND MARKINGS.

**088004 ERIGEN POWER SUPPLY SYSTEM IN THE TRACK RADIO NETWORK OF THE SWEDISH STATE RAILWAYS.** One of the major problems encountered by the Swedish State Railways (SJ) when extending its track radio network in sparsely populated areas is how to power the base radio stations. Ericsson's primary power system ERIGEN is an alternative which gives freedom in the choice of site for a base radio station. An ERIGEN system has been in operation for some years at one of the SJ base radio stations along the inland main line. The solar and wind system is designed to power remote telecommunications plants situated far from the electricity mains. The authors describe the design of the system, its parts and also the operational results obtained during the 2 1/2 years of service (Edited author abstract) 3 refs.

Sandvik, Per (Swedish State Railways); Akerlund John. *Ericsson Rev (Engl Ed)* v 64 n 3 1987 p 116-122.

**088005 SENDERANLAGE 'HOHER MEISSNER' DES HEISSISCHEN RUNDFUNKS.** [Hessischer Rundfunk's 'Hoher Meissner' Transmitting Station]. The article begins with a description of the original station design and its transmitting facilities, followed by details of the disastrous fire of 16th July 1983. The final part sets out the conclusions drawn after the fire and describes the design features incorporated in the new station. These relate to the new building housing the MF transmitter, the links with the initial construction and the transformations done to the old building. (Author abstract) In German.

Frsiak, Karlheinz. *Rundfunktech Mitt* v 31 n 6 Nov-Dec 1987 p 282-289.

## Testing

**088006 ESTIMATE RESIDUAL BIT-ERROR RATIOS IN DIGITAL RADIOS.** Residual bit-error-ratio (RBER) testing is critical when evaluating digital radios. This figure of merit, recently endorsed by the CCIR in recommendation 594, helps to evaluate the overall performance of a digital communication system. RBER estimations need not follow the time-consuming rituals of traditional measurement routines. This article discusses two techniques which can help to reduce measurement times for testing residual bit-error ratios in digital radios.

6 refs.

Compston, Ian Kennedy (Hewlett-Packard Ltd, West Lothian, Scotl). *Microwaves RF* v 26 n 13 Dec 1987 p 81-82, 84-86.

## RADIO SYSTEMS, DIVERSITY See Also ANTENNAS, MOBILE—Arrays; DIGITAL COMMUNICATION SYSTEMS—Microwaves; TELECOMMUNICATION LINKS, SATELLITE—Computer Simulation.

**088007 NOISE STABILITY OF ALGORITHMS WITH SOLUTION FEEDBACK FOR DIVERSITY RECEPTION OF PHASE-KEYED SIGNALS.** Algorithms optimal in Gauss approximation, a block diagram for a quasicohherent receiver (QCR), and a formula for analyzing its noise stability have been obtained in the class of Markov processes for the case of diversity reception (DR) of phase-keyed (PK) signals and a statistically homogeneous channel with Rayleigh-type fading. We develop a method suitable for analysis of the noise stability of various varieties of suboptimal QCR with SFB that takes into account the specific features of operation of such devices in a stochastic radio channel. 6 refs.

Bortnikov, V.V.; Ivantsovskii, V.S. *Radioelectron Commun Syst* v 30 n 4 1987 p 58-60.

**088008 NOVEL ANTI-MULTIPATH MODULATION TECHNIQUE DSK.** A modulation technique called DSK (double phase-shift keying), which shows an interesting antipath feature over mobile frequency-selective fading environments, is introduced. The performance of this technique is shown for various multipath channels by waveform detection and theoretical bit error rate (BER) analysis, and numerical results of a laboratory experiment, which support the theoretical results, are presented. A generalized form of DSK is described, and investigations are made to clarify the antipath effect of DSK and to further explore the possibility of a narrowband scheme. A major result shows that this technique can give a form of diversity effect that is implicit in the arrival of signals via multiple paths with different delays. 28 refs.

Ariyavisitakul, Sirikit (Kyoto Univ, Jpn); Yoshida, Susumu; Ikegami, Umio; Takeuchi, Tsutomu. *IEEE Trans Commun* v COM-35 n 12 p 1252-1264.

**088009 CLIPPED DIVERSITY COMBINING FOR CHANNELS WITH PARTIAL - BAND INTERFERENCE - I: CLIPPED - LINEAR COMBINING.** Clipped-linear diversity combining is analyzed for receivers without side information. Communication systems with noncoherent demodulation, binary and M-ary orthogonal signaling, and diversity transmission are considered. The main source of interference is additive Gaussian partial-band interference, but a nonzero quiescent noise level is included in the analysis to account for wideband noise sources. Some of the results apply to general (non-Gaussian) interference. The numerical results demonstrate that clipped-linear combining can perform well in terms of both narrowband interference rejection capability and maximum signal-to-interference ratio requirement. A practical disadvantage of clipped-linear combining is that it relies on measurements of the signal output voltage. 13 refs.

Keller, Catherine M. (Northeastern Univ, Boston, MA, USA); Pursley, Michael B. *IEEE Trans Commun* v COM-35 n 12 p 1320-1328.

**088010 DIVERSITY AND CODING FOR FH/MFSK SYSTEMS WITH FADING AND JAMMING - I: MULTICHANNEL DIVERSITY.** The performance of diversity and/or coding is evaluated for FH/MFSK (frequency-hopped/multiple frequency-shift keyed) signaling over Rayleigh fading channels in the presence of jamming. The effects of partial-band tone and partial-band noise jamming on uncoded and coded systems are considered. The results indicate that FH/MFSK signaling with diversity provides satisfactory performance for jammed fading channels. For coded FH/MFSK signaling over fading channels, noise jamming may be more effective than tone jamming. The amount of im-

provement resulting from the use of diversity in conjunction with coding depends on many factors, including the nature of the channel, the degree of channel state information available at the decoder, the type of decoding, and the modulation alphabet size. 12 refs.

Stuber, Gordon L. (Georgia Inst of Technology, Atlanta, GA, USA); Mark, Jon W.; Blake, Ian F. *IEEE Trans Commun* v COM-35 n 12 p 1329-1341.

**088011 ERROR-CORRECTING CODES AND NONLINEAR DIVERSITY COMBINING AGAINST WORST CASE PARTIAL-BAND NOISE JAMMING OF FREQUENCY-HOPPING MFSK SYSTEMS.** Error probability analyses are performed for a coded M-ary frequency-shift keying system (MFSK) using L hops per M-ary word frequency-hopping spread-spectrum waveforms transmitted over a partial-band Gaussian noise jamming channel. The bit error probabilities are obtained for a square-law adaptive gain control receiver with forward-error-control coding under conditions of worst-case partial-band noise jamming. Both thermal noise and jamming noise are included in the analyses. Performance curves are obtained for both block codes and convolutional codes with both binary and M-ary channel modulations. The results show that thermal noise cannot be neglected in the analysis if correct determinations of the optimum order of diversity and the worst-case jamming fraction are to be obtained. It is shown that the combination of nonlinear combining, M-ary modulation, and forward-error-control coding is effective against worst-case partial-band noise jamming. 19 refs.

Lee, Jong S. (J.S. Lee Associates Inc, Arlington, VA, USA); French, Robert H.; Miller, Leonard E. *IEEE Trans Commun* v 36 n 4 Apr 1988 p 471-478.

## Analysis

**088012 SPACE DIVERSITY DETECTORS OF FLUCTUATING SIGNALS IN THE PRESENCE OF SPATIALLY CORRELATED INTERFERENCE.** Two classes of space diversity systems in which coherent compensation of spatially correlated interference is possible are examined. These are spatially coherent systems and systems with short-time spatial coherence. The concept of spatial coherence of signals and interference in a multi-positional system is refined. Optimality conditions are specified for some known algorithms for detecting fluctuating signals with varying degrees of spatial coherence in the presence of spatially correlated interference, and a number of new algorithms (including adaptive ones) are synthesized. (Edited author abstract). 15 Refs.

Chernyak, V.S. *Sov J Commun Technol Electron* v 32 n 9 Sep 1987 p 10-20.

**088013 MULTIPATH DIVERSITY RECEPTION OF SPREAD-SPECTRUM MULTIPLE-ACCESS COMMUNICATIONS.** The analysis of a multipath-combining receiver for direct-sequence spread-spectrum communications through a specular multipath channel is developed. The analysis applies to systems that use quadriphase-shift-keyed, offset quadriphase-shift-keyed, minimum-shift-keyed, or binary phase-shift-keyed modulation. The measures of performance are the signal-to-noise ratio and approximations to the error probability involving the signal-to-noise ratio. The performance of a multipath-combining receiver is determined for a single transmitter and for multiple interfering transmitters. The performance of the system is determined in terms of parameters of the signature sequences, which can be used as guides in selecting signature sequences for the system. Results are also given for the case of randomly generated signature sequences. 17 refs.

Lehnert, James S.; Pursley, Michael B. *IEEE Trans Commun* v COM-35 n 11 Nov 1987 p 1189-1198.

## Efficiency

**088014 LEISTUNGSFAEHIGKEIT VON MEHRANTENNEN-DIVERSITY FUER DEN UKW-**



**RUNDFUNK IM AUTO.** [Efficiency of Multiantenna VHF/FM Diversity Reception in Automobiles]. In VHF/FM reception, multipath propagation causes severe interference and disturbances in the received signal level. Large differences in propagation delays, co- and adjacent-channel interference, intermodulation effects and noise are encountered. All these distortions cause frequency shifts relating to the simultaneous variations of the rf and if signal amplitudes. The extent of these shifts and variations can be used as criteria governing the operation of a quasi-instantaneous interference detector. Using a fast antenna switch controlled by the detector, any form of VHF/FM receiver can be fitted with an antenna diversity system. The logarithm of the signal-quality improvement factor is found to be approximately proportional to the number of additional antennas. No additional tuning circuits are needed in the receiver. (Edited author abstract) 7 refs. In German.

Lindenmeier, Heinz; Manner, Ernst. *Rundfunktech Mitt* v 31 n 5 Sep-Oct 1987 p 221-228.

## Evaluation

**088015 EVALUATION OF SPECIFIC DIVERSITY COMBINERS USING SIGNALS RECEIVED BY VERTICALLY-SPACED BASE-STATION ANTENNAS.** A series of field trials has been conducted in which a 900 MHz cw signal was transmitted from a vehicle moving along a test route some 1.3 km from a base station. The recorded envelopes of the signals received on two vertically-separated antennas at the base station have been used in a computer simulation of two-branch predetection diversity reception. Several different systems have been simulated and the computed results show that the theoretical diversity advantages can still be obtained for an envelope cross-correlation ( $\rho_{env}$ ) of less than 0.7 for all strategies except switching. For a 1.3 km radius cell, a  $\rho_{env}$  less than 0.7 can be obtained using antennas with a vertical separation of about 12λ. It has been found that the cumulative distribution and level-crossing rates of the signal are substantially improved and the average fade duration is approximately halved. (Author abstract) 9 refs.

Adachi, F. (NTT Electrical Communications Lab, Yokosuka, Jpn); Feeney, M.T.; Parsons, J.D. *J Inst Electron Radio Eng* v 57 n 6 Nov-Dec 1987 p 218-224.

## Mathematical Models

**088016 MACROSCOPIC DIVERSITY PERFORMANCE MEASURED IN THE 800-MHZ PORTABLE RADIO COMMUNICATIONS ENVIRONMENT.** Analysis of 816-MHz residential propagation data is presented, demonstrating the usefulness of macroscopic selection diversity in combatting shadow fading produced by buildings and other large geographic features in the portable-radio communication environment. Macroscopic diversity can reduce the link margin needed for 99% reliability by 10 dB. The analysis of these data indicates that log-normal shadow fading is partially correlated on the paths between a portable user and several surrounding ports. A two-component shadow-fading model duplicates this behavior. One log-normal term is identical for all paths from a given location and characterizes the propagation losses associated with the location. A second log-normal component is independent for each path and characterizes the remainder of the path to the port. The model fits the propagation data as well. A standard deviation of 8 dB for the path-specific term fits subsets of the available data well and is consistent with the standard deviation of shadow fading in the mobile (vehicular) communication environment. 12 refs.

Arnold, H.W. (Bell Communications Research, Red Bank, NJ, USA); Cox, Donald C.; Murray, R.R. *IEEE Trans Antennas Propag* v 36 n 2 Feb 1988 p 277-281.

## Performance

**088017 FREQUENCY-DIVERSITY IMPROVEMENT IN n/1 HIGH-CAPACITY DIGITAL MICROWAVE RADIO.** Frequency diversity performance of

digital microwave radio is investigated. Improvement ratio in n/1 systems is computed, based on the improvement ratio in 1/1 systems and the frequency dependence of the latter. Computed curves showing the dependence of IR on the channel position and of the position of the standby channel are given. (Author abstract) 8 refs.

Frighes, I. (Budapest Technical Univ, Budapest, Hung). *Electron Lett* v 24 n 6 Mar 17 1988 p 327-329.

**088018 PACKET SELECTIVE MACROSCOPIC DIVERSITY BASED ON BUS CONTENTION FOR LOCAL AREA RADIO NETWORKS.** The utilisation of a CSMA/CD LAN as an inter-radio-port transmission medium and an autonomous macroscopic diversity, based on bus contention selective control, are proposed for a local area radio network. The diversity selection performance was analysed, and it is shown that satisfactory performance was obtained with the proposed scheme. (Author abstract). 5 Refs.

Serizawa, M. (Toshiba R&D Cent, Kawasaki, Jpn). *Electron Lett* v 24 n 15 Jul 21 1988 p 934-935.

## Protection

**088019 DIVERSITY PROTECTIONS FOR DIGITAL RADIO - SUMMARY OF TEN - YEAR EXPERIMENTS AND STUDIES.** A summary is presented of a series of critical experiments that led to recent discoveries of large improvement factors for digital radio performance by antenna pattern diversity, antenna angle diversity, frequency diversity, and space diversity. The measured diversity improvement factors for digital radio against multipath dispersive fading are larger than those predicted by the existing analog radio model by at least one order of magnitude. Applications of these findings will lead to substantial savings in the cost for diversity protections for digital radio routes. These discoveries stimulated the development of new models of diversity improvement factors for digital radio and the development of the DRDIV computer program for engineering digital radio routes. Background information is given on multipath fading and diversity concepts, and a glossary of terms is included. 43 refs.

Lin, Sing H. (Bell Communications Research, USA); Lee, Ted C.; Gardina, M.F. *IEEE Commun Mag* v 6 n 2 Feb 1988 p 51-63.

**RADIO SYSTEMS, MOBILE** See Also ANTENNAS—Impedance Matching; COMMUNICATION SATELLITES; DATA TRANSMISSION; DATA TRANSMISSION—Components; ELECTRIC SUBSTATIONS—Electronic Equipment; ELECTROMAGNETIC WAVES—Propagation in Guides; EQUALIZERS; FREQUENCY SYNTHESIZERS; NOISE; RADIO—Frequency Allocation; RADIO BROADCASTING; RADIO TELEPHONE; RADIO TELEPHONE—Italy; RADIO TELEPHONE—Paging Systems; RADIO TRANSMISSION—Noise; RADIO TRANSMISSION—Propagation Effects; SPEECH—Coding; TELECOMMUNICATION LINKS; SATELLITE—Analysis; TELECOMMUNICATION LINKS, SATELLITE—Equipment; TELECOMMUNICATION SYSTEMS, SATELLITE RELAY.

**088020 DESIGN OF DIGITAL SIGNAL PROCESSING QUADRATURE MODULATOR FOR DIGITAL FM AND ANALOG FM SIGNALS.** In the field of mobile communication, the transmission of picture and data signals in addition to conventional speech transmission requires modulators that are suitable to both analog and digital FM. In the present paper such a quadrature modulator is proposed which provides stable transmission characteristics by digital signal processing (DSP) techniques. The analysis is mainly aimed at additional noise effects due to the digital generation of analog FM signals. Based on the results of this analysis, a modulator design method providing sufficiently high noise suppression is presented in a flowchart form. (Edited author abstract) 14 refs.

Yamao, Yasushi (NTT, Jpn). *Electron Commun Jpn Part 1* v 70 n 10 Oct 1987 p 95-106.

**088021 HALF-BIT OFFSET DECISION FREQUENCY DETECTION OF DIFFERENTIALLY EN-**

**CODED GMSK SIGNALS.** An efficient frequency detection scheme for GMSK signal reception is described. In this scheme, a three-level eye opening of the frequency detector output at the decision instant offset by a half-bit is used to improve bit error rate (BER) performance. Experimental results for 16 kbit/s differentially encoded GMSK transmission with a premodulation filter bandwidth-bit duration product ( $B_bT$ )=0.25 (typical for mobile radio applications) show that the half-bit offset decision frequency detection scheme can improve BER performance, in comparison with conventional detection schemes. (Edited author abstract) 7 refs.

Ohno, K. (NTT Radio Communication Systems Lab, Yokosuka, Jpn); Adachi, F. *Electron Lett* v 23 n 24 Nov 19 1987 p 1311-1312.

**088022 CHARACTERISTICS OF ANTENNA PATTERN DIVERSITY BRANCHES IN URBAN MOBILE RADIO.** The performance of mobile communication is greatly degraded by the multipath fading which is a large problem in future digital mobile communication. We made a detailed analysis of the urban propagation characteristics and found that use of a directive antenna in a mobile station reduces the fading by the effect of antenna pattern itself. We suggested that excellent diversity branches can be realized by combining more than one directive antenna. This paper discusses first the basic condition for the antenna pattern diversity branches. Correlation characteristics are examined by measurement of 2- and 4-branches. The reduction of the fading is estimated by computer simulation based on the measured data. (Edited author abstract) 23 refs.

Ikegami, Fumio (Kyoto Univ, Kyoto, Jpn); Takeuchi, Tsutomu; Yoshida, Susumu. *Electron Commun Jpn Part 1* v 71 n 1 Jan 1988 p 95-105.

**088023 RADIO CHANNEL MEASUREMENT AND PREDICTIONS FOR FUTURE MOBILE RADIO SYSTEMS.** Digital mobile radio systems will require planning methods that provide accurate predictions of signal strength, distortion and interference for situations ranging from very small cells in dense urban locations to large rural cells. Topographic and land use data bases will find increasing use to enhance the accuracy of prediction models. The paper discusses the implications of these issues and reports on the work in progress at British Telecommunications Research Laboratories on land mobile radio propagation modeling and wide-band channel measurements. (Author abstract) 17 refs.

Huish, P.W.; Gurdanli, E. *Br Telecom Technol J* v 6 n 1 Jan 1988 p 43-53.

**088024 MOBILE-RADIO METHODS TAKE ACCOUNT OF NEW TECHNOLOGY.** The improved capability of communications equipment has been absorbed by the user and fueled demand for yet more progress measured by such parameters as spectrum efficiency, versatility, power economy, portability, cost and ease of use. The distributor and service engineer require low cost installation and test procedures. The paper reviews the mobile radio receiver and transmitter parameters which are most affected by changing component and design technology.

Belcher, Roger. *New Electron* v 21 n 3 Mar 1988 p 55-56, 58.

**088025 PERFORMANCE ANALYSIS OF ICMA/CD MULTIPLE-ACCESS FOR A PACKET MOBILE RADIO.** Throughput and channel capacity of a 1-persistent, idle-signal-casting multiple-access with collision detection (ICMA/CD) are theoretically analysed assuming an infinite population model. Then, the packet failure probability with a limited number of reschedulings is investigated. (Author abstract) 4 refs.

Adachi, F. (NTT Radio Communication Systems Lab, Yokosuka, Jpn); Ohno, K.; Kitagawa, M. *Electron Lett* v 24 n 8 Apr 1988 p 469-471.



**088026 DEVELOPMENT OF NARROW BAND MCA SYSTEM.** The existing MCA system which started service in October, 1982 has reached the limit of system capacity in proportion to the increase of mobile subscribers. A new MCA system with the same frequency band has been introduced in order to extend the system capacity. The new system narrows the channel separation from 25 kHz spacing to 12.5 kHz spacing. This paper introduces the system design and service functions of the new system, development concept, features of the equipment, development program and themes of study in the future. (Author abstract)

Tanaka, Masashi; Kasugai, Teruaki; Kojima, Jun-ichiro; Fukushima, Hiroyuki; Seki, Kenji; Kitakawa, Mitsuo. *NEC Res Dev* n 89 Apr 1988 p 89-101.

**088027 EXPERIMENTAL MOBILE SATCOMMS.** PRODAT is an experimental satellite communications relays system for data transmission between mobile users on land, at sea and in the air, and even by fixed users at home or office. It represents a critical part of PROSAT, an ESA-funded experimental satellite project for low cost aviation and maritime communications relay initiated in December 1981. Transmissions between the ground station and satellite are in the 4 to 6GHz range; 1.5 and 1.6GHz are employed between mobile terminals and the satellite for the forward and return links respectively. The PRODAT programme will provide aircrew data communications and passenger telex facilities via ground data networks throughout a flight without resorting to often unreliable HF radio links. PRODAT is part of Phase II of the ESA PROSAT project addressing advanced mobile communications techniques.

Britten, Paul (Racal-Decca Advanced Development). *New Electron* v 20 n 20 Dec 1987 p 61-62.

**088028 EXCESS DELAY POWER PROFILES MEASURED IN MOUNTAINOUS TERRAIN.** The paper reports on the results gained in Switzerland in a joint campaign of the PTTs of the Federal Republic of Germany and Switzerland. The results, based on more than 70,000 impulse responses measured in different mountainous areas, support the Recommendation of COST 207 to the GSM (Groupe Special Mobile) about the length of excess power delay profiles to be considered in the new digital mobile radio system. (Author abstract). 19 Refs.

Lorenz, Rudolf Werner (Forschungsinstitut der Deutschen Bundespost, Darmstadt, West Ger); Loew, Karl; Weber, Manfred; Kartaschoff, Peter; Merki, Peter; De Weck, Jean-Paul. *Alta Freq* v 57 n 2 Feb-Mar 1988 p 57-64.

**088029 PERFORMANCE OF PARTIAL RESPONSE CPM SYSTEMS WITH NARROWBAND CHANNEL AND LIMITER-DISCRIMINATOR DETECTION.** In the context of research developed to define the design criteria of a European digital public land mobile radio network, attention has been paid, in recent years, to partial response continuous phase modulation systems. In the authors' opinion, a crucial point of system design is determination of the actual spectral efficiency obtainable by means of these techniques through consideration of adjacent and cochannel interferences which are present in the cellular mobile radio network. At any rate, with a view to investigating this research area, a first step in the authors' opinion is to evaluate the behavior of CPM signals over narrowband channels and so the combined effects of intersymbol interference (due both to generation of the signal and to the channel) and noise have been evaluated in this paper for any choice of modulation pulse shaping. The implemented computer program allows general analysis of CPM systems with limiter-discriminator detection and symbol-by-symbol regeneration. (Edited author abstract). 13 Refs.

Andrisano, Oreste (Univ di Bologna, Bologna, Italy). *Alta Freq* v 57 n 2 Feb-Mar 1988 p 119-132.

**088030 NEW SPEECH SIGNAL SCRAMBLING METHOD FOR MOBILE RADIO APPLICATIONS.** Secure communications systems have acquired a particu-

lar importance today, especially as concerns mobile radiocommunications. At present, however, highly secure signal scrambling systems are limited in that they require frame synchronization; this not only limits the system's reliability but complicates its use. This paper presents a two-dimensional signal scrambling method based on digital signal processing techniques which eliminate the need for frame synchronization, but maintain an extremely high level of communications security. Such techniques include short-time Fourier analysis and the filter bank concept. The paper also discusses the use of special digital FIR filters which make it possible to completely implement the system algorithm via commercial processor software. As a result, the system can be configured with very little hardware. Finally, the paper presents an investigation of valid keys and available key space. (Author abstract). 6 Refs.

Del Re, Enrico (Univ di Firenze, Florence, Italy); Bresci, Graziano; Maffucci, Damiano. *Alta Freq* v 57 n 2 Feb-Mar 1988 p 133-138.

**088031 PROBLEMS OF ASSIGNED FREQUENCIES FOR PRIVATE MOBILE RADIO AND TWO SOLUTIONS.** Existing arrangements for private mobile radio (PMR) assignments are spectrum-inefficient. Trunked PMR systems are better but may not be able to cope with areas of densest demand. A proposal for scanning PMR is made and possible difficulties examined. (Author abstract). 3 Refs.

Coolican, M.V. (Dep of Trade & Industry, London, Engl). *J Inst Electron Radio Eng* v 58 n 4 Jun 1988 p S24-S29.

**088032 DIGITALER MEHRTRAEGER-DEMULPLEXER FUER DEN MOBILEN SATELLITENFUNK.** [Digital Multicarrier Demultiplexer for On-Board Application in Mobile Satellite Communication.]. This paper is focused on the description and the design of the hierarchical multistage method (HMM) for digital demultiplexing of an FDM signal being composed of L adjacent SPC signals. L is (preferably) a power-of-two, here L=32. This HMM approach to FDM demultiplexing applies bandpass sampling and is based on the processing of complex-valued signals by linear-phase FIR filters, where at any stage of the processing the respective signals are always oversampled by two. An electrical demonstration model has been constructed by cascading six identical specially designed signal processors. (Author abstract). 16 Refs. In German.

Goeckler, Heinz (ANT Nachrichtentechnik GmbH, Backnang, West Ger); Eyssele, Helmut. *Frequenz* v 42 n 6-7 Jun-Jul 1988 p 181-189.

**088033 DIGITALER DEMODULATOR FUER MOBILE SATELLITENFUNK.** [Digital Demodulator for Mobile Satellite Communication.]. Future mobile satellite communications systems for data and speech transmission require extensive signal processing on board satellites. This is necessary since both circuit switching and data regeneration are to be implemented in satellites. FDM demultiplexers for channel separation are required in satellites in order to realize switching functions. Data are then regenerated using channel-specific demodulators. The following paper describes the design, performance and realization of such a channel-specific demodulator. The requirements involving the demodulator, particularly synchronization, are very high due to the mobile communication channel with fading and Doppler offset. New frequency and timing loops as well as a status-controlled synchronization routine ensure high-speed synchronization of the demodulator, even if the quality of the channels is poor. An electrical demonstration model of the demodulator, developed in conjunction with an ESA contract, is realized with a 16 bit CMOS signal processor. (Author abstract). 12 Refs. In German.

Alberty, Thomas (ANT Nachrichtentechnik GmbH, Backnang, West Ger); Hespelt, Volker. *Frequenz* v 42 n 6-7 Jun-Jul 1988 p 190-199.

**088034 CAUSES OF BURST ERRORS IN MULTIPATH FADING CHANNEL.** The so-called irreducible

error due to frequency-selective fading is known to have a serious effect on mobile radio communication systems. Thus, the analysis of such errors is a prerequisite for making high-speed digital signal transmission over a fading channel feasible. The authors attempted to elucidate the physical mechanisms causing such errors using laboratory measurements of microscopical bit error rate. The results clarified some sources of burst errors in a multipath fading channel. In particular, large and rapid timing fluctuations of eye pattern due to severe delay distortion of the multipath channel was found to be the most dominant source of error. 20 refs.

Yoshida, Susumu (Kyoto Univ, Jpn); Ikegami, Fumio; Takeuchi, Tsutomu. *IEEE Trans Commun* v 36 n 1 Jan 1988 p 107-113.

**088035 WIDE-BAND PACKET RADIO FOR MULTIPATH ENVIRONMENTS.** A direct-sequence spread-spectrum packet radio is described that has versatile signal-processing and local-control capabilities designed to support the functions required of a robust mobile communications network. Noteworthy capabilities include eleven selectable data rates with accurate range measurements in a fading multipath channel. The radio uses a hybrid analog/digital signal processor and nonrepeating spreading codes for suppression of intersymbol interference and jamming. It incorporates two sets of monolithic surface-acoustic-wave convolvers as programmable matched filters with time-bandwidth products of 64 and 2000. The analog matched filters are coupled with binary postprocessing for the functions of detection, RAKE demodulation, and ranging measurements over a wide multipath spread. The data rate can be varied in response to channel conditions from 1.45 Mb/s down to 44 b/s with an almost ideal tradeoff in signal-processing gain from 18 dB up to 61 dB prior to multipath combining. 37 refs.

Fischer, Jeffrey H. (MICRILOR Inc, Wakefield, MA, USA); Cafarella, John H.; Bouman, Charles A.; Flynn, Gerard T.; Dolat, Victor S.; Boisvert, Rene. *IEEE Trans Commun* v 36 n 5 May 1988 p 564-576.

**088036 THEORETICAL EVALUATION OF SOFT DECISION GAIN FOR BLOCK FEC IN A LAND MOBILE RADIO CHANNEL.** The soft decision gain for the block FEC code transmitted with an arbitrary degree of bit-interleaving through a land mobile radio channel is theoretically evaluated. As a soft decision decoding scheme the Chase decoding is assumed and as a land mobile radio channel the multiplicative time-variant Rayleigh fading channel is assumed. The bit error rates (BER) are formulated both for the hard decision decoding and for the soft decision decoding in two modem cases of noncoherent BFSK and coherent BPSK, respectively. (Edited author abstract) 15 refs.

Miyagaki, Yoshiya (Okayama Univ of Science, Okayama, Jpn). *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 11 Nov 1987 p 1125-1132.

## Analysis

**088037 OUTAGE PROBABILITY CALCULATIONS FOR A MOBILE RADIO SYSTEM HAVING TWO LOG-NORMAL INTERFERERS.** Outage probability calculations are presented for the case when the transmission from a wanted base station is received by a mobile in the presence of two cochannel-interfering signals for the case where the transmissions suffer log-normal shadowing only. The calculations consider the need to achieve simultaneously both a sufficient snr and SIR to obtain satisfactory radio reception. (Author abstract) 6 refs.

Sowerby, K.W. (Univ of Auckland, Auckland, NZ); Williamson, A.G. *Electron Lett* v 23 n 25 Dec 3 1987 p 1345-1346.



**088038 GMSK FREQUENCY DETECTION USING DECISION FEEDBACK EQUALISATION.** Frequency detection of GMSK signals using one-bit decision feedback equalization (DFE) in conjunction with offset decision instant is presented. Experiments on a 16 kbit/GMSK signal reception with a premodulation filter bandwidth-bit duration product ( $B_bT$ ) of 0.25 (typical for mobile radio applications) show that, compared to MSK signal reception, a bit error rate (BER) of  $10^{-2}$  is obtained with a loss of about 4db in the signal energy per bit/noise power density ratio ( $E_b/N_0$ ) in the additive white Gaussian noise (AWGN) channels. In the cochannel interference limited channels, a BER of  $10^{-2}$  is obtainable at a signal/interference power ratio (SIR) about 5.5 db larger than in the case of MSK signal reception. (Author abstract) 6 refs.

Ohno, K. (NTT, Yokosuka, Jpn); Adachi, F. *Electron Lett* v 23 n 25 Dec 3 1987 p 1350-1351.

**088039 STATISTICAL PARAMETERS OF BROADBAND SIGNALS IN MULTIBEAM CHANNELS OF TRANSPORTATION RADIO SYSTEMS.** A discussion is currently under way as to the desirability of utilization in transportation radio communications systems of broadband signals (BBS) which, first, having increased information redundancy, ensure good communication stability in a complex noise environment; second, permitting code multiplexing of channels, they make possible effective solution of the problem of electromagnetic compatibility of radio facilities in ramified radio networks. The specific types of interference characteristic of transportation radio systems include multiplicative noise produced by multibeam propagation of radio waves and relative motion of transceivers. To evaluate noise immunity and synthesize optimal BBS receiver circuits it is necessary to construct a mathematical model of the broadband signal at the output of a multibeam channel, which is our subject in this paper. 4 refs.

Golovin, E.S.; Dremine, S.Yu. *Radioelectron Commun Syst* v 30 n 7 1987 p 90-93.

**088040 NARROWBAND DIGITAL MODEMS FOR LAND MOBILE RADIO.** The modems operate in the 900 MHz band and with a channel spacing of 25 kHz. Each transmitted signal from a mobile is a four-level QAM signal with an element rate of 12,000 bauds and a total bandwidth of 24 kHz. 20% redundancy is allowed for retraining and synchronization purposes, giving a useful transmission rate of 19,200 bit/s for each QAM signal. Coherent demodulation together with a new technique of combined signal-detection and channel-estimation are used at the receiver, for more accurate tracking of the rapidly fading signal. Two four-level QAM signals can be transmitted simultaneously over each separate frequency band, giving a resultant bandwidth efficiency of just over 1.5 bit/s per Hz for useful data. The independent fading of the two signals, together with the particular detection and estimation processes employed at the receiver, prevent any undue interference between the two signals. The signals fed from the base station to the mobiles are 16-level QAM signals, that are frequency division multiplexed, with a channel spacing of 25 kHz. Each signal has an element rate of 12,000 bauds and a total bandwidth of 24 kHz. Two mobiles are fed from any one 16-level QAM signal, and the bandwidth efficiency for useful data is again just over 1.5 bit/s per Hz. (Edited author abstract) 25 refs.

Clark, A.P. (Loughborough Univ of Technology, Loughborough, Engl); Brent, J.B. *J Inst Electron Radio Eng* v 57 n 6 Nov-Dec 1987 p 293-303.

## Applications

**088041 COMMUNICATIONS ON THE MOVE.** Technological advances and more available frequencies are allowing mobile communications to provide an increasing variety of services in an ever more pocket-sized form. Recent progress is reported.

Shaw, David (Philips Radio Communications Systems). *IEE Rev* v 34 n 2 Feb 18 1988 p 83-85.

**Cellular Technology.** See Also ANTENNAS—Applications; DATA TRANSMISSION; DATA TRANSMISSION—Applications; DIGITAL COMMUNICATION SYSTEMS; INFORMATION THEORY—Communication Channels; RADIO TELEPHONE—France; RADIO TRANSMISSION—Propagation Effects; SPEECH—Coding; TELECOMMUNICATION SYSTEMS, MOBILE—Applications; TELECOMMUNICATION SYSTEMS, SATELLITE RELAY.

**088042 CELLULAR TECHNOLOGY: IMPACT ON DEVELOPING AREAS.** This paper addresses the major characteristics of 800-900 MHz cellular technology to evaluate its application to meet the needs of developing areas. The analysis considers the application of the total access communications system (TACS) which is in widespread use in the United Kingdom and other parts of the world. The high capacity and economies of scale of TAS as well as the availability of ample radio frequency allocations are significant considerations. The paper presents typical cellular radio coverage areas for fixed, mobile, and portable subscriber units and provides an economic analysis of costs per subscriber for mixture of fixed and mobile subscribers. In conclusion the 800-900 MHz cellular radio service appears economically attractive in comparison to the costs of a wire-based network in developing areas. (Author abstract) 3 refs.

Borman, W.M. *Telecommun J* v 54 n 8 Aug 1987 p 512-518.

**088043 CELLULAR PORTABLE - MOVALPHONE.** This paper presents the outline, configuration and technologies used in realizing NTT's new cellular portable 'Movalphone', which was developed for outside use in response to strong demands for hand-held portable radio units. The 'Movalphone' is a 500 cm<sup>3</sup> transceiver unit about 750 g which has 1-w transmitter power. It was placed into commercial use in 1987. (Edited author abstract)

Kato, Kaoru (NTT, Jpn). *Jpn Telecommun Rev* v 29 n 3 Jul 1987 p 44-47.

**088044 CELLULAR NETWORK PLANNING IS MAXIMIZING SYSTEM ECONOMY.** Networks for mobile telephone are complex and need thorough planning and engineering. This is valid for the initial implementation, but to an even higher degree for the subsequent growth of the networks. Adaptation of nominal cell planning schemes to real world topography and traffic patterns requires powerful network planning tools. The economic impact of proper planning is strong, since the income from the network is directly related to the effective use of each radio channel. The authors describe some of the methods and tools for cellular network planning that are used to support projects and customers in this task. They emphasize the importance of initial planning for the mature system and of linking together radio measurements and theoretical radio propagation models. (Edited author abstract)

Lejdal, Jan-Olof (Ericsson Radio Systems AB); Lindqvist, Hans. *Ericsson Rev (Engl Ed)* v 64 n 3 1987 p 122-129.

**088045 CELLULAR RADIO TELEPHONY - THE RACAL-VODAFONE NETWORK IN GREAT BRITAIN.** With its cellular radio network in the United Kingdom, Racal-VODAFONE is the most successful mobile telephone operator in the world. From launch of the service in January 1985, over 100,000 subscribers were achieved by mid 1987, and coverage provided to over 90% of the population of the UK. The network uses Ericsson CMS88 technology and is centered around AXE 10 digital mobile telephone exchanges. As a result of additional subscribers joining at a world leader rate of over 5,000 per month, the network is being continually expanded towards a forecast capacity of over 300,000 subscribers by 1990. Additional frequencies are also being made available and the VODAFONE network will be enhanced to the new UK E-TACS standard early in 1988. (Author abstract)

Beddoes, Edward (Racal Vodafone Ltd); Pinches, Mike. *Ericsson Rev (Engl Ed)* v 64 n 3 1987 p 130-140.

**088046 ERICSSON TELEPHONES FOR CELLU-**

**LAR SYSTEMS.** Ericsson Radio Systems is continually engaged in developing new mobile telephone terminals to suit the growing customer demand and utilize the rapidly changing technical possibilities. The progress in component miniaturization and surface mounting production methods has now made the pocket telephone concept viable. It has also led to a new Ericsson generation of combined mobile and transportable products with approximately half the weight and size of those of the previous generation. The authors describe a new generation of products introduced in 1987 for the NMT systems. (Author abstract)

Jismalm, Greger; Rydbeck, Nils. *Ericsson Rev (Engl Ed)* v 64 n 3 1987 p 141-150.

**088047 MALAYSIA CELLULAR SYSTEM - PIONEER IN ASIA.** The mobile cellular telephone system in Malaysia, ATUR, has been in operation since January 1985. Subscriber growth has been steady throughout the country, and at a higher rate than anticipated. The system is also widely used to connect subscribers in rural areas, not yet provided with wire lines to the public telephone network. The authors describe early mobile telephone systems in Malaysia, implementation of the ATUR system, various market aspects and how the system capacity in the Kuala Lumpur area was increased through the introduction of small-cells. (Author abstract)

Harun, Mohamad Khir Bin; Omholt, Rudi. *Ericsson Rev (Engl Ed)* v 64 n 3 1987 p 151-159.

**088048 DIGITAL CELLULAR RADIO FOR THE FUTURE.** The experiences gained from cellular systems operating today, indicate that market expansion is often limited by system capacity. Frequency spectrum is a natural resource which is limited, but through development of new equipment it has been possible to utilize the frequency spectrum more efficiently. The resulting new system standards and network concepts introduced through the years have improved system capacity, but today's systems can still serve only a small fraction of the total population. The next generation of systems, to be used in the nineties, must be able to serve a broader market covering a substantial proportion of the consumer segment. (Author abstract) 7 refs.

Lindell, Filip (Ericsson Radio Systems AB); Swerup, Jan; Uddenfeldt, Jan. *Ericsson Rev (Engl Ed)* v 64 n 3 1987 p 160-168.

**088049 COCHANNEL MEASUREMENTS FOR INTERFERENCE LIMITED SMALL-CELL PLANNING.** In small-cell systems cochannel interference is a major design parameter. Measurements have been carried out at 150,450 and 900 MHz. The found dependences of the correlation coefficients on the angle are given. An empirical model is given and verified to calculate the necessary margin between the mean  $\langle C \rangle$  and the 90% exceeded C/I. (Author abstract) 2 refs.

van Rees, Jan (PTT Dr. Neher Lab, Leidschendam, Neth). *AEU Arch Elektron Uebertrag Electron Commun* v 41 n 5 Sep-Oct 1987 p 318-320.

**088050 PROPAGATION AND BIT ERROR RATIO MEASUREMENTS FOR A MICROCELLULAR SYSTEM.** Propagation measurements are provided for highway and city center microcells. Measurements along various motorways were taken with base station (BS) antennas at 10 m elevations. Pseudo-random binary sequences (PRBS) were transmitted via non-coherent FSK at 905 MHz. Low radiated power (16 mw into an 18-element Yagi) was used, and the signal level and bit error ratio (BER) were recorded by a mobile station (MS). The microcell length was found to be a function of the received field strength and, therefore, the BER. It was found that the cell lengths varied between 1 to 2 km for a BER of  $10^{-3}$  or better. Although the PDF of the received signal was Rician the microcell length was determined using the more pessimistic Rayleigh PDF. Two and three microcell clusters were considered. An



inverse fourth power law was observed, and the received signal power in the microcell varied linearly with radiated power. For power levels of only 1  $\mu$ W, error free transmission was found to occur over a cell length of 400 m. Measurements in the Harley Street area in Central London enabled us to study how signals propagate in a nearly rectilinear grid pattern of roads. A theoretical model was established that provided signal levels that were close to those measured. (Edited author abstract) 12 refs.

Chia, S.T.S. (Univ of Southampton, Engl); Steele, R.; Green, E.; Baran, A. *J Inst Electron Radio Eng* v 57 n 6 Nov-Dec 1987 p 255-266.

**088051 IMPLEMENTATION OF AN EXPERIMENTAL MODEM FOR CELLULAR MOBILE RADIO CHANNELS.** The design, simulation, and implementation of a modem specifically for use on mobile radio channels at frequencies allocated to the existing UK cellular system is described. A novel technique for transmitting two phase-modulated digital signals from two mobile vehicles on nominally the same carrier frequency, and performing detection and separation of them at the receiver is covered. The potential application of this system in cellular mobile radio is discussed, together with an assessment of typical improvements in system capacity that might be achieved. (Edited author abstract) 14 refs.

Smith, S.D. (Univ of Technology, Loughborough, Engl); Clark, A.P.; Brent, J.B.; Ahluwalia, K. *J Inst Electron Radio Eng* v 57 n 6 Nov-Dec 1987 p 287-292.

**088052 SPATIAL DISTRIBUTION OF TRAFFIC IN A CELLULAR MOBILE DATA NETWORK.** The position of a mobile terminal influences its probability to capture the central receiver in the base station of a cellular radio system using slotted ALOHA for multiple access. Integral transforms of the probability density function for the received power prove a useful tool for analyzing the relation between the spatial distributions of offered and throughput packet traffic in a mobile radio network with Rayleigh fading channels. A newly developed method to obtain the spatial distribution of throughput traffic from a prescribed spatial distribution of offered traffic is presented and illustrated with examples. Incoherent and coherent addition of interference signals is considered. The channel behavior for heavy traffic loads is studied. In both the incoherent and coherent case, the spatial distribution of offered traffic required to ensure a prescribed spatially uniform throughput is synthesized numerically. (Edited author abstract) 44 refs.

Linnartz, J.P.M.G. (Eindhoven Univ of Technology, Eindhoven, Neth). *EUT Rep Eindhoven Univ Technol Dep Electr Eng* 87-E-168 Feb 1987 128p.

**088053 SPATIAL DISTRIBUTION OF TRAFFIC IN A CELLULAR ALOHA NETWORK.** The position of a mobile terminal has a significant influence on its probability to capture the central receiver in a base station of a cellular radio system using slotted ALOHA for multiple access. Integral transforms of the received power probability density function prove a useful tool for analyzing spatial distributions of offered and throughput packet traffic in a mobile data network with Rayleigh fading channels. Both incoherent and coherent cumulation of interference signals are considered. In both cases, a uniform throughput distribution is synthesized numerically. (Author abstract) 9 refs.

Linnartz, Jean-Paul Marie Gerard (TNO, The Hague Neth); Prasad, Ramjee; Arnbak, Jens Christian. *AEU Arch Elektron Uebertrag Electron Commun* v 42 n 1 Jan-Feb 1988 p 61-63.

**088054 EUROPEAN PLANS - A CRITICAL ANALYSIS.** 1987 was the year in which a pan-European standard for cellular radio was agreed that will permit hand-over and international roaming. A broad spectrum of opinion as mobilized to make this happen, culminating with a meeting of the European Heads of State in London on 6 December 1986. A compromise standard was agreed

in an effort to incorporate the best features of all the proposals. The lower risk narrowband TDMA technology, so strongly advocated by the UK was adopted, with the French approach to the signal processing and a German voice coder.

Gosling, William (Plessey Co plc). *Electron Technol (London)* v 22 n 1 Jan 1988 p 5-8.

**088055 MOBILE RADIO COMES OF AGE IN THE ISDN.** The last decade has seen the introduction of the first system generation of switching systems using stored program control (SPC) technology. During the 1980s, these systems have been developed further to provide for digital speech transmission and the introduction of ISDN, which will enable speech and data to be transmitted via one standard network. This transition is now in full swing and will be given new impetus with the introduction of new services such as digital cellular radio. (Author abstract)

Rolle, Gerhard. *Telecom Rep* v 11 n 2 Mar-Apr 1988 p 44-45.

**088056 OUTAGE PROBABILITY CALCULATIONS FOR MULTIPLE COCHANNEL INTERFERERS IN CELLULAR MOBILE RADIO SYSTEMS.** The calculation of outage probability is discussed in relation to cochannel interference problems inherent in mature cellular radio systems. Outage probability equations for coverage only and for single cochannel interferer situation are reviewed, and examples of the application of these results to the estimation of the service area of a typical cellular base station are given. An analytical technique for multiple uncorrelated interferers in a Rayleigh fading environment is presented and the effect of several cochannel Rayleigh interferers on the service area of a cellular base station is examined. (Edited author abstract) 11 refs.

Sowerby, K.W. (Univ of Auckland, Auckland, NZ); Williamson, A.G. *IEE Proc Part F* v 135 n 3 Jun 1988 p 208-215.

**088057 EFFECTS OF THE INTERFERENCES IN CELLULAR DIGITAL MOBILE RADIO SYSTEMS USING FULL RESPONSE CPM WITH LIMITER-DISCRIMINATOR DETECTION.** Spectral characteristics of signals and bit error probability of transmission systems are analytically evaluated with reference to full response CPFSK systems with rectangular modulation pulse shaping and limiter-discriminator detection, applied on a typical cellular mobile radio network. The analysis is carried out in the case of four-level signals, in the presence of transmission nonlinearities and cochannel and adjacent channel interferences. The results obtained show that the spectral compactness cannot be assumed as a good index of a bandwidth-efficient modulation system. Moreover, in some significant cases, which differ because of vehicular locations, channel spacing and modulation parameters, they indicate the signal-to-noise ratios necessary at the receiver input to guarantee a fixed bit error probability, in both the base-to-mobile and mobile-to-base transmissions. (Author abstract) 16 refs.

Andrisano, Oreste (Univ di Bologna, Bologna, Italy); Corazza, Giorgio; Immovilli, Gianni. *Alta Freq* v 57 n 2 Feb-Mar 1988 p 109-117.

**088058 ON OPTIMUM AND SUBOPTIMUM COHERENT DETECTION OF CONTINUOUS PHASE MODULATION ON A TWO-RAY MULTIPATH FADING CHANNEL.** The performance of continuous-phase-modulation (CPM) transmission on a two-ray fading channel and received in white Gaussian noise is investigated. The optimum coherent maximum-likelihood (ML) detector and approximations thereof and their performance are studied by means of minimum Euclidean distance and simulated symbol error probability. A linear detector optimum at large signal-to-noise ratios is also studied, and its performance is given in terms of error probability. It is found that the loss in signal power due to the channel is small when the ML detectors are used for binary schemes with modulation index  $h = 1/2$ . The loss

for these schemes with a linear detector becomes significantly larger, especially with MSK transmission. Its performance can be improved significantly by using decision feedback, but the performance of the ML detector is still superior. 18 refs.

Svensson, N. Arne B. (Univ of Lund, Swed). *IEEE Trans Commun* v COM-35 n 10 Oct 1987 p 1041-1049.

**088059 ADVENT OF LAND MOBILE SATELLITE SERVICE SYSTEMS.** A recent Federal Communications Commission (FCC) decision that has allocated L-band (1.5 GHz, 1.6 GHz) spectrum to land mobile satellite systems to provide mobile radio, mobile telephone, data communication, and other services. In addition to these bands there is a Ku band at 14/12 GHz that provides feeder links for destination communications control and other functions. A description of the system is given, and the various factors involved in its realization are examined. Some of the operational, systematic, and technological considerations of the first-generation land mobile satellite service that would provide thin-route services to large land masses of North America are considered. The discussion covers the ground segment, propagation effects, orbital reuse, and link considerations and user capacity. 15 refs.

Pattan, Bruno (Federal Communications Commission, USA). *IEEE Trans Aerosp Electron Syst* v AES-23 n 5 Sep 1987 p 691-703.

**088060 QUEUEING-BLOCKING SYSTEM WITH TWO ARRIVAL STREAMS AND GUARD CHANNELS.** An approach to the study of a multichannel cutoff priority system for two Poisson arrival streams with distinct arrival rates and the same potential service time distribution is proposed. This approach makes it possible to obtain the state probabilities in simple closed-form expressions. These expressions provide a straightforward way to derive the distribution of the number of busy servers, the queue length distributions, and, above all, a very simple criterion for the stability of the system. The computations can still be easily carried out for large systems (e.g., 100 servers). The method can easily be extended from the infinite-queue-length case to a system with finite capacity. As applied to cellular radio, the method offers a means of increasing the total carried traffic while improving the perceived service quality. 23 refs.

Guerin, Roch (California Inst of Technology, Pasadena, CA, USA). *IEEE Trans Commun* v 36 n 2 Feb 1988 p 153-163.

**088061 NEW CELLULAR SCHEMES FOR SPECTRAL EFFICIENCY.** Assuming the constraint of an allocated frequency spectrum, two novel schemes are presented that improve spectral efficiency by more than 50 channels/cell. The two schemes are multiple channel bandwidth systems and one-third channel offset systems. A suggestion for integrating four schemes (underlay/overlay, diversity, multiple channel bandwidth, and one-third channel offset) to achieve maximum spectral efficiency is presented. The hybrid system can offer better performance because it takes advantage of the merits and performance of each individual scheme. 5 refs.

Lee, William C.Y. (PacTel Personal Communications, Irvine, CA, USA). *IEEE Trans Veh Technol* v VT-36 n 4 Nov 1987 p 188-192.

## Computer Aided Design

**088062 DEVELOPMENT OF PROPAGATION MODELS AND CAD TOOLS FOR THE PLANNING OF MOBILE COMMUNICATION NETWORKS.** The network planning for future small cell mobile communication systems, such as that of CEPT/GSM, require much more accurate propagation prediction models than those currently available. Further the great complexity of this network makes it unavoidable that for planning Computer Aided Design (CAD) methods be used. This paper presents the approach taken and the results obtained in the research of the Dr. Neher Laboratories with respect to



propagation modeling and the development of CAD tools for network planning. The propagation work is based on extensive field-strength and pulse amplitude measurements together with a detailed topographic data base. The analysis shows the limitations of the CCIR type of prediction model. As a start towards a new model, detailed analyses were performed on the relationship between measured data and topographic quantities, e.g. building height, road size and density etc. The 1st generation CAD planning tool is presented together with the experience obtained in its development and operational use. (Author abstract). 5 Refs.

Mawira, Agus (Dr. Neher Lab, Leidschendam, Neth); Stortelder, Ben. *Alta Freq* v 57 n 2 Feb-Mar 1988 p 83-88.

**Computer Simulation** See Also RADIO TELEPHONE—Mathematical Models.

**088063 COMPUTER SIMULATION OF A MOBILE PACKET RADIO SYSTEM.** A software simulator for a mobile packet radio system is described. Bitwise coherent addition of interfering DPSK-packets can be expected, resulting in a smaller throughput than achieved with incoherent addition, but higher than in a nonfading channel. (Author abstract) 8 refs.

Pluijmers, R. (Delft Univ of Technology, Delft, Neth). *Electron Lett* v 24 n 6 Mar 17 1988 p 316-317.

**088064 ETUDE ET REALISATION D'UN SIMULATEUR DE CANAL RADIOMOBILE A LARGE BANDE.** [Study and Implementation of a Wideband Mobile Radio Channel Simulator]. Recently, mobile/radio communications have made use of new digital modulation methods, in particular spread spectrum, in order to combat jamming and propagation multipaths and to work in multiple access. A channel simulator has shown itself very useful in order to test at low cost a 910 MHz mobile/radio transmission in a suburban site. After introducing the advantages of the direct sequence spread spectrum concept, this paper describes the mobile/radio transmission characteristics and defines the signal expression through the channel. From a thorough study of four types of simulators existing in the literature, an electrical scheme is derived, which can best reproduce a suburban transmission between a fixed transmitter and a mobile receiver. Principles and board arrangement of the simulator are presented. The measurement data obtained by the simulator have shown a good agreement with the field measurement data. (Edited author abstract). 11 Refs. In French.

Daniel, Annie (INSA de Rennes, Rennes, Fr); El Zein, Ghais; Salehudin, Mochamad; Citerne, Jacques. *Onde Electr* v 68 n 2 Feb 1988 p 82-89.

## Control

**088065 SERIAL BUS CONTROLLED AUDIO-PROCESSOR.** The conventional tone and volume controls in car radios using potentiometers require a lot of discrete components. They are expensive, need a lot of space, and reduce the reliability level. A description is given of a microprocessor-controlled audioprocessor providing all functions, including source selector, volume control, bass and treble control, balance and fade, on one chip, with only a few external components. It offers high performance with especially low distortion and noise.

Kirchlechner, Peter (SGS Design Cent, Grafting, West Ger). *IEEE Trans Consum Electron* v CE-33 n 3 Aug 1987, 1987 Int Conf on Consum Electron, Rosemont, IL, USA, Jun 3-5 1987 p 336-342.

## Control Systems

**088066 USERS VIEW OF MOBILE RADIO DATA.** The mobile data communication system used by the British Gas East Midlands to control their vehicle fleet is described. Two types of control systems are considered: 100 bits per sec four tone system, and 300 bits per sec FSK system which has error correction and protection. Both types of control systems are identical in concept in that

they provide: mobile queuing in order of arrival; automatic acknowledgement; call set up; automatic-base station selection; vehicle status and request; selective call; emergency call; and text transmission. The use of data signalling in channel management allows the maximum use of a single radio channel, saving voice calling and contention times, which can produce a saving of 30% of usable air time.

Corney, Max (British Gas East Midlands). *Electron Technol (London)* v 21 n 10 Nov-Dec 1987 p 196-197.

## Design

**088067 SET-THEORETIC APPROACH TO THE DESIGN OF MOBILE RADIO COMMUNICATIONS NETWORKS.** The set-theoretic approach to designing radio communications networks on the basis of mathematical techniques introduced on monotonic sets, for definite conditions imposed on the communication matrix of the subscriber set  $W$  of the radio network, makes it possible to design a radio communications system and to minimize the number of channels employed. The proposed method can be used to divide a set of subscribers  $W$  of any communications network into groups of subscribers which are in a definite sense the most uniform and closely connected. 8 refs.

Nikolayev, V.T.; Talyzin, V.N. *Sov J Commun Technol Electron* v 32 n 2 Feb 1987 p 54-63.

**088068 ASPEKTE DER WELLENBREITUNG FUER DIE WAHL DER UEBERTRAGUNGSBANDBREITE IM DIGITALEN MOBILFUNK.** [Aspects of Wave Propagation for the Selection of Transmission Bandwidth in Digital Mobile Radio]. It is pointed out that the channel access in FDMA, TDMA, CDMA or combinations of these techniques make possible a wide spectrum of technological solutions for the implementation of digital radio telephone networks. Criteria for the specification of the bandwidth of a system with optimal efficiency of frequency-band utilization are outlined. 13 refs. In German.

Lorenz, Rudolf W. (Forschungsinstitut der Deutschen Bundespost beim FTZ, Darmstadt, West Ger). *E&T Elektrotech Informationstech* v 105 n 4 Apr 1988 p 175-181.

**Electric Power Supplies** See ELECTRIC BATTERIES, SECONDARY—Applications.

**Equipment** See Also ANTENNAS, SLOT—Analysis; TELECOMMUNICATION SYSTEMS, SATELLITE RELAY—Equipment.

**088069 DAS AUTORADIO ALS KERN EINES MOBILEN KOMMUNIKATIONSZENTRUMS.** [Autoradio as the Core of a Mobile Communication Center]. The progress of microelectronics leads to the growth of electronics in automotive applications. Next to the electronic systems in automotive technology, automobile radios, navigation systems and mobile telephone are used as additional equipment. These lead to the development of a mobile communication center for the automobile driver. (Translated author abstract) In German. 3 refs.

Ehlers, Karsten (Volkswagenwerk AG, Wolfsburg, West Ger). *NTZ Nachrichtentech Z* v 40 n 6 Jun 1987 p 444-449.

## Europe

**088070 PROSPECTS FOR SATELLITE MOBILE RADIO SERVICES FOR EUROPE IN THE 1990S.** Growing interest in the potential of satellite mobile services in offering facilities complementary to those provided by the pan-European cellular radio network has stimulated a number of in-depth studies into possible system architectures. These activities are now coming together in a coordinated European program and this paper summarizes the service opportunities which are emerging and some of the major technical issues which must be addressed in preparation for viable commercial operations. (Author abstract) 8 refs.

Gardiner, J.G. (Univ of Bradford, Bradford, Engl). *J Inst Electron Radio Eng* v 57 n 6 Nov-Dec 1987 p 241-245.

**088071 EVOLUTION OF CELLULAR MOBILE COMMUNICATIONS SYSTEMS IN EUROPE.** In Europe, public mobile radiotelephone services started in the early 60's, using the 80 MHz and 160 MHz bands, with capacities of few channels and manual operation. In the 70's some countries introduced services at 160 MHz and 450 MHz with a few dozen channels and a first generation of automatic systems were implemented mainly in the 160 MHz band. In the early 80's a second generation of automatic systems was introduced using the cellular technique in the 450 MHz band and more recently some countries extended this kind of system in the 900 MHz band. Nowadays the demand for mobile radio systems is experiencing such a rapid expansion that an incredible amount of research has been undertaken to design new advanced systems, which will be able to make land mobile communications accessible to millions of subscribers on a variety of mobile transports; a European harmonization project will ensure continuous communications to mobile users travelling throughout Western Europe. (Author abstract) 11 refs.

Failli, Renzo (Soc Italiana per l'Esercizio delle Telecomunicazioni, Rome, Italy); Porzio Giusto, Pietro. *Alta Freq* v 56 n 10 Dec 1987, 17th Eur Microwave Conf and Workshop, Sep 7-11 1987 p 445-448.

## London, England

**088072 MOBILE RADIO DATA.** The mobile radio data system of the national Command & Control Centers, introduced in London by the British Automobile Association, is described. This is used to communicate with emergency vehicles responding to automobile breakdowns. To increase the channel capacity and communication speed, voice transmission is replaced by data transmission.

Mason, J.W. (Automobile Assoc). *Electron Technol (London)* v 21 n 10 Nov-Dec 1987 p 192-193.

**Mathematical Models** See RADIO TRANSMISSION—Fading.

**Measurements** See Also RADIO TRANSMISSION—Monitoring; RADIO TRANSMISSION—Reflection.

**088073 WIDE-BAND PROPAGATION MEASUREMENTS AT 900 MHz.** Results are presented of the number of measurements performed in the time-delay domain, according to the sounding technique referred to as 'radar pulse technique', in order to characterize a wideband mobile transmission channel. Different environments were examined: urban/suburban areas (Stuttgart FRG) and mountainous regions (Aosta Valley, I). Instantaneous echo profiles were investigated: statistical elaborations are presented in terms of cumulative distributions of synoptic parameters, such as average delays, delay spreads, delay windows and intervals. Some efforts were also devoted to study the problem of the variability of the channel, taking both space and time repeated measurements, and examining the evolution of the various echoes inside an impulse response. Finally, an attempt was made to characterize the locations where repeated measurements were carried out, by 'average delay profiles', and to compare them with the typical envelopes recently proposed by COST 207. (Author abstract). 8 Refs.

Damosso, Eraldo (CSELT, Turin, Italy). *Alta Freq* v 57 n 2 Feb-Mar 1988 p 65-74.

## Performance

**088074 MEAN LEVEL RECEIVER FOR FH-MFSK MOBILE RADIO.** The performance of parametric receivers such as the linear, the maximum likelihood and the hard limiter have been analyzed before for the detection of frequency-hopped multilevel frequency-shift keyed signals (FH-MFSK) in mobile radiotelephony. Nonparametric receivers such as the minimum rank sum receiver (MRSR) and the reduced rank sum receiver (RRR) were previously



considered. A receiver called the mean level receiver is analyzed. It is neither parametric nor nonparametric. It depends on the noise (or interference) distribution except for a scale parameter which may correspond to the noise power. The proposed receiver is distinguished by its easier implementation, constant false alarm rate and relatively good performance. (Edited author abstract) 11 refs.

Al-Hussaini, Emad K. (UAE Univ, Al-Ain, United Arab Emirates). *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 10 Oct 1987 p 968-974.

**088075 PHYSICAL OPTICS ESTIMATION OF URBAN MOBILE RADIO CHANNEL DELAY-DOPPLER RESPONSES.** Multipath radio propagation effects due to buildings that are large compared to the wavelength are readily analyzed by physical ray-optics techniques. Estimates of mobile radio channel delay-doppler response functions have been obtained by this approach for a mobile unit located in a long straight street lined by high buildings. The results, represented as limiting impulse set forms, show the main characteristics, including the street orientation dependence, evident in published experimentally determined delay-doppler functions. Mean field strength levels, also derived in the analysis, likewise show good agreement with the relative street orientation dependencies reported by other workers. (Author abstract) 19 refs.

Davies, William S. (Telecom Australia, Clayton North, Aust.). *AEU Arch Elektron Uebertrag Electron Commun* v 41 n 6 Nov-Dec 1987 p 341-346.

**088076 PERFORMANCE OF ACCESS STRATEGIES FOR D-TASI OVER MOBILE RADIO FADING CHANNELS.** Demand Time Assigned Speech Interpolation (D-TASI) has been proposed as a means of more efficiently using the radio spectrum allocated to mobile radio systems. In the D-TASI system, the delay experienced in accessing the message channel in order to transmit a voice packet is a major obstacle to the practical implementation of the system. Access schemes for D-TASI are considered. Three access schemes have been proposed and their theoretical models developed; computer software packages have also been developed to simulate the three proposed schemes - Aloha, Polling, and Table-driven. The probability of call blocking as a function of user population, voice channel traffic intensity and time-slot duration has been studied. (Edited author abstract) 12 refs.

Sheikh, A.U. (Carleton Univ, Ottawa, Ont, Can); Nguyen, N. *J Inst Electron Radio Eng* v 57 n 6 Nov-Dec 1987 p 304-311.

**088077 PERFORMANCE ANALYSIS OF GMSK FREQUENCY DETECTION WITH DECISION FEEDBACK EQUALISATION IN DIGITAL LAND MOBILE RADIO.** The bit-error-rate (BER) performance of premodulation Gaussian filtered MSK (GMSK) using frequency detection (FD) in conjunction with 1 bit decision feedback equalisation (DFE) is theoretically investigated. The introduction of the premodulation filter causes severe intersymbol interference (ISI) in the waveform of the input to the fm modulator. DFE is used for reducing the ISI effect and therefore improving the BER performance. Applying the analysis to additive white Gaussian noise (AWGN) channels (no fading) shows that a 1-bit DFE attains about 8.5 db  $E_b/N_0$  improvement at  $BER=10^{-3}$  for the premodulation filter bandwidth-time product  $B_bT=0.25$  when the receiver predetection bandpass filter bandwidth-time product BT is optimised. It is shown that the effect of error propagation due to DFE is negligible and the exact BER can be approximated by the BER that is obtained assuming the decision 1-bit prior is correct. The analysis is extended to Rayleigh fading channels. Both predetection and postdetection diversity reception are considered. When two-branch predetection maximal-ratio combining (MRC) is used, the 1-bit DFE attains about 6.3 db  $E_b/N_0$  improvement at  $BER=10^{-3}$  for  $B_bT=0.25$ . (Author abstract) 8 refs.

Adachi, F. (NTT Radio Communication System Lab, Yokosuka, Jpn); Ohno, K. *IEE Proc Part F* v 135 n 3 Jun

1988 p 199-207.

**088078 INFLUENCE OF ENVIRONMENTAL CONDITIONS ON BER FOR WIDEBAND MOBILE RADIO CHANNELS.** Mobile radio system performance is strongly influenced by random signal distortion due to severe radio propagation conditions. The paper presents the results of a software simulation, performed with the aim of analyzing the importance of the parameters and of the functions characterizing the different environmental conditions. As the basis for the computations, we assume the experimental results obtained in the research activity for the new digital Pan-European system. The results here presented are related to the irreducible probability of error for a BFSK system, which was thought to be the most appropriate for emphasizing the effect of the random channel. (Author abstract). 5 Refs.

Falciasacca, Gabriele (Univ di Bologna, Bologna, Italy); Frullone, M.; Riva, G. *Alta Freq* v 57 n 2 Feb-Mar 1988 p 75-82.

Quality Assurance See SPEECH—Coding.

Reliability See Also RADIO SYSTEMS, DIVERSITY—Mathematical Models.

**088079 BERECHNUNG DER UEBERTRAGUNGSSICHERHEIT VON ZEICHEN FUER MOBILFUNKSYSTEME.** [Calculation of Transmission Reliability of Signals for Mobile Radio Systems]. A statistical model is considered of received signals that are present in narrowband mobile radio systems. The simulation of such signals is considered. A computation method for the determination of the transmission reliability of signals is derived with the aid of simple statistical methods. 4 refs. In German.

Konig, Peter. *Tech Mitt PTT* v 66 n 2 1988 p 49-56.

**088080 OUTAGE PROBABILITY IN CELLULAR MOBILE RADIO SYSTEMS.** This paper presents two new methods for computing the outage probability of a cellular land mobile radio system with narrowband modulation and digital transmission of speech. They are well suited to compare different system solutions, since they take into account the main characteristics influencing the transmission performance, i.e., modulation methods, power control, antenna radiation patterns, adjacent- and co-channel interference arising from the frequency reuse, propagation impairments due to a log-normal shadowing fading and to fast Rayleigh fading. The paper reports some computations on the long-term median value of the useful to interfering signal ratio vs the position of the useful mobile unit in the service area. It gives the frequency reuse configurations acceptable according to the presented outage probability methods relevant to different mobile radio systems and compares the pertaining telephone traffic efficiencies. It also introduces the main features of a SCPC/FDMA mobile radio system. (Edited author abstract). 26 Refs.

Palestini, Valerio (CSELT, Turin, Italy); Zingarelli, Valerio. *Alta Freq* v 57 n 2 Feb-Mar 1988 p 97-108.

## Reviews

**088081 COVERAGE PREDICTION FOR MOBILE RADIO SYSTEMS OPERATING IN THE 800/900 MHZ FREQUENCY RANGE.** After an extensive list of definitions, a listing and brief description is given of a number of communication systems in the 800/900 MHz frequency bands. Modes of propagation are reviewed in depth and the effects of buildings, trees, and other interference are noted. Antenna characteristics and system losses are discussed. A variety of experimentally or theoretically based propagation models, developed to predict radio propagation in land mobile systems, are then examined. After listing and summarizing the major features of the models, the models are compared in terms of the environmental and propagation factors they account for, and in terms of the output information they provide. The median transmission loss predictions of various models are compared for a given base antenna site.

A detailed evaluation is provided to evaluated predictions obtained in the following basic situations: smooth terrain between base station and mobile; smooth terrain with a knife-edge obstacle located close to the mobile; and smooth terrain with a knife-edge obstacle at the midpoint of the path. Recommendations on measurement procedures are offered by the Committee on Radio Propagation. Factors affecting the choice of a propagation model for particular applications are discussed. 128 refs.

Shepherd, Neal H. (IEEE, New York, NY, USA). *IEEE Trans Veh Technol* v 37 n 1 Feb 1988 p 3-72.

## Space Applications

**088082 AVERAGE WAITING TIME FOR MOBILE RADIO TERMINALS ACCESSING A BATCH-PROCESSING DISPATCHER BY SATELLITE.** To minimize call set-up overheads, a demand assignment scheme for mobile radio networks over a satellite has been proposed, in which calls are processed by the network dispatcher in batches. The letter examines the average waiting time for calls to be processed under this service discipline. (Author abstract). 9 Refs.

Leung, V.C.M. (Chinese Univ of Hong Kong, Shatin, Hong Kong). *Electron Lett* v 24 n 15 Jul 21 1988 p 940-941.

**088083 MEASUREMENTS AND MODELS OF A LAND MOBILE SATELLITE CHANNEL AND THEIR APPLICATIONS TO MSK SIGNALS.** The fading and shadowing effects observed on land mobile satellite signals are characterized in statistical terms. Models are developed in terms of probability distribution of the signal's envelope and phase as well as its rate of change with time. The multipath fading and shadowing effects modeled are typical of those encountered in a mobile-satellite link in rural and suburban areas. The predictions of the models are compared with experimental data at 870 MHz and 1542 MHz. Applications of the models to predict performance of a minimum shift keying (MSK) signal at 2400 b/s show that: (1) large margins are required to compensate for the effects of fading and shadowing; (2) conventional coherent demodulation of a MSK signal may not be feasible due to phase variation caused by fading and shadowing; and (3) random FM has negligible effect on the probability of error of the MSK signal at 2400 b/s when frequency demodulation is used. 12 refs.

Loo, Chun (Communications Research Cent, Ottawa, Ont, Can). *IEEE Trans Veh Technol* v VT-36 n 3 Aug 1987 p 114-121.

## Standards

**088084 SPRACHCODEC FUER DAS EUROPAEISCHE FUNKFERNSPRECHNETZ.** [Speech Codec for the European Mobile Radio System]. The speech encoding algorithm is described which has been developed recently in the context of the standardization of the forthcoming European digital mobile radio system (D-net). The speech codec is based on the German codec proposal which has been selected by the CEPT 'Groupe Speciale Mobile' (GSM) as a result of extensive subjective listening tests. The encoding principle is a residual excited linear prediction technique using 'Regular-Pulse Excitation'. This proposal has been re-optimized by a Franco-German collaboration, by adding a long-term predictor. Thus the net-bit rate has been reduced from 14.77 kbit/s to 13.0 kbit/s. The present implementation is presented and the current status of the standardization is described. (Author abstract) In German. 13 refs.

Vary, Peter (Philips Kommunikations Industrie AG, Nuremberg, West Ger); Hofmann, Rudolf. *Frequenz* v 42 n 2-3 Feb-Mar 1988 p 85-93.

**088085 AUTOMATIC TUNING CAR RADIO BASED ON THE RADIO DATA SYSTEM.** The radio data system (RDS) is a standard for transmission of



supplemental information for FM sound broadcasting that was agreed upon by the European Broadcasting Union in 1984. A car radio with novel functions has been developed that is based on the RDS. An RDS decoder IC and an automatic tuning function are among the features of the radio. Increases in cost and assembly space required for the receiver circuits have been minimized through the use of a single RF front-end structure and the single-chip RDS decoder. 5 refs.

Taura, Kenichi (Mitsubishi Electric Corp, Amagasaki, Jpn); Tomohiro, Ryo. *IEEE Trans Consum Electron* v CE-33 n 3 Aug 1987, 1987 Int Conf on Consum Electron, Rosemont, IL, USA, Jun 3-5 1987 p 319-326.

**RADIO TELEPHONE** See Also DATA TRANSMISSION—Mathematical Models; DIGITAL COMMUNICATION SYSTEMS—Voice/Data Integrated Services; RADIO SYSTEMS, MOBILE—Design; RADIO SYSTEMS, MOBILE—Europe; RADIO SYSTEMS, MOBILE—Performance; TELECOMMUNICATION—Tasmania; TELECOMMUNICATION EQUIPMENT; TELECOMMUNICATION LINKS, SATELLITE—Brazilia, Brazil; TELECOMMUNICATION SYSTEMS, MOBILE; TELECOMMUNICATION SYSTEMS, MOBILE—Applications; TELEPHONE APPARATUS.

**088086 MULTI-TERMINAL CORDLESS TELEPHONE SYSTEM.** Cordless telephone systems have a fixed node (FN) and a mobile terminal node (MTN), and the radio link control between these nodes is performed autonomously. An enhanced radio link system, 'multi-terminal cordless telephone system,' that enables connecting multiple MTNs to a single FN has been developed and is discussed in this paper. The system features radio link control for collision avoidance and a state transition diagram are presented. An experiment for fluorescent light noise reduction by a syllabic compandor and the overall characteristics of some trial radio sets are also discussed. (Author abstract) In Japanese. 5 refs.

Kawasaki, Ryoji (NTT, Jpn); Ohta, Yuji; Murata, Yoshitoshi; Tate, Kazuyuki. *Denki Tsushin Kenkyusho Kenkyu Jitsuyoku Hokoku* v 36 n 10 1987 p 1381-1387.

**088087 HAND-HELD PORTABLE EQUIPMENT FOR CELLULAR MOBILE TELEPHONE.** A hand-held portable radio telephone has been developed for US and UK cellular systems. Using newly developed LSIs and other technologies, the HHP has a compact design and long operation time with a NiCd battery pack. The software implemented in the HHP is user-friendly and flexible, taking advantage of a dot matrix liquid crystal display. This paper also describes the optional equipment developed for the HHP. (Author abstract) 4 refs.

Tamura, Yoshiharu (NEC, Jpn); Maru, Tsuguo; Hirasawa, Naoki; Okuno, Hiroto; Komoda, Motoyoshi; Hotsumi, Minoru; Matsumoto, Hirofumi; Kimura, Katsuji. *NEC Res Dev* n 87 Oct 1987 p 34-43.

**088088 COHERENT DEMODULATOR FOR MOBILE AUTOMATIC TELEPHONY.** Digital transmission of speech is becoming a preferred solution for Mobile Automatic Telephony and cordless telephones. The proposed systems will operate above 900 MHz and at these frequencies the radio channels suffer from multipath and Rayleigh fading. As the received signal goes through deep fades the demodulator loses synchronization and produces a burst of errors while it is re-synchronizing. Coding techniques are used to detect and correct these bursts but coding complexity increases with burst length. Fast acquisition demodulators give shorter bursts and are therefore desirable. Most existing coherent demodulators use long time constants in their clock and carrier recovery circuits and hence take too long to synchronize. Non-coherent demodulators have been preferred because of their fast acquisition performance but give higher error rates. We describe a technique which allows coherent demodulators to acquire synchronization quickly. 5 refs.

Gurcan, M.K.; Gibson, R.W.; King, A.J.; Whitehead, R.N. *Annu Rev Philips Res Lab* 1986 p 86-87.

**088089 POCKET TELEPHONY FOR EVERYONE.** In February 1986 the EEC began a collaborative program

called Research into Advanced Telecommunications for Europe (RACE). The goal is to design an Integrated Broadband Communications Network (IBCN) for Europe. This report deals with the mobile radio component of the IBCN. This mobile service is targeted for the mid-1990s and aims to provide a single hand-held mobile telephone for applications. The subscriber would have a universal telephone number which he/she would use with any telephone desired.

MacNamee, R.J.G.; Gibson, R.W.; Vadgama, S.K. *Annu Rev Philips Res Lab* 1986 p 88-90.

**088090 MULTI-TERMINAL CORDLESS TELEPHONE SYSTEM.** This paper proposes a multi-terminal architecture for an enhanced cordless telephone system. Cordless telephone systems have a fixed node (FN) and a mobile terminal node (MTN). The radio link control between these nodes is performed autonomously. An enhanced radio link system, that enables connection of multiple MTNs to a single FN has been developed and is discussed in this paper. The system features, radio link control for collision avoidance and state transition diagram are presented. An experiment for fluorescent light noise reduction by a syllabic compandor and the overall characteristics of some trial radio sets are also discussed. (Author abstract) 5 refs.

Kawasaki, Ryoji (NTT Telecommunication Networks Lab, Jpn); Ohta, Yuji; Murata, Yoshitoshi. *Rev Electr Commun Lab (Tokyo)* v 36 n 1 Jan 1988 p 85-89.

**088091 RESOURCE ALLOCATION TECHNIQUE FOR FDMA SYSTEMS.** We present a resource allocation problem which can be viewed as a model for the problem of finding a compatible frequency plan for the required voice channels in FDMA mobile radio telephone systems. A general and efficient algorithm solving the problem approximately is described in detail. It relies on the determination of a priori bounds on the frequency demand combined with an iterative nondeterministic assignment strategy. The possibility of extending these ideas to TDMA systems is discussed briefly. (Author abstract). 30 Refs.

Gamst, Andreas (Philips GmbH, Hamburg, West Ger). *Alta Freq* v 57 n 2 Feb-Mar 1988 p 89-96.

**Europe** See RADIO SYSTEMS, MOBILE—Cellular Technology.

## France

**088092 PAN-EUROPEAN DIGITAL CELLULAR SYSTEM FOR MOBILE TELEPHONES.** In 1987, the European Conference of Post Offices and Telecommunications administrations (CEPT) decided to define a unique system of digital radiotelephony which is to be launched on the market in 1991. This system uses the TDMA (Time Division Multiple Access) technology to access the radio resource combined with frequency hopping and narrow-band operation. Matra Communication has already made the technical and architectural choices for the system it is offering to build a network of this type: specifically, decentralization of functions and equipment modularity. These choices have already been put into practice as part of the new development in the French high density radiotelephony network produced by Matra Communication for France Telecom. (Author abstract) 1 Ref.

Duplessis, P. (Matra Communication); Maillard, F. *Communication Transm* v 10 n 2 1988 p 5-14.

## Italy

**088093 CELLULAR MOBILE TELEPHONE SYSTEM RTMS.** The paper outlines some of the principal features of Radio Telephone Mobile System (RTMS), including a discussion on capacity in view of recently upgraded nationwide subscriber capacity objective of 200,000. Italy's 450 MHz first cellular radio system is considered, pointing out that RTMS's overall architecture has been made to conform to the nationwide expected subscriber density distribution, both in the major metro-

politan areas and in the other numerous cities. (Author abstract). 7 Refs.

Gulli, Giorgio (ITALTEL SIT, Milan, Italy); Ongaro, Decio; Piatti, Angelita; Quaglia, Francesco. *Alta Freq* v 57 n 2 Feb-Mar 1988 p 139-144.

## Japan

**088094 EMERGING TECHNOLOGY AND SERVICE ENHANCEMENT FOR CORDLESS TELEPHONE SYSTEMS.** A brief history of the development of cordless telephone systems in Japan is given. The efficient frequency utilization and upgraded service provided by this technology are discussed. A business cordless system is proposed for extended service areas using a portable telephone facility. The potential extension of this system to a local area portable telephone system is mentioned. 10 refs.

Hattori, Takeshi (NTT, Jpn); Sasaki, Akio; Momma, Kohji. *IEEE Commun Mag* v 26 n 1 Jan 1988 p 53-58.

## Mathematical Models

**088095 MODELING AN AUTOMATIC RADIO TELEPHONE NETWORK.** To study the performance of this radio telephone network, we perform simulations and use an iterative method including two steps: aggregation and disaggregation. The aggregation step corresponds to the simulation of each relay. Each relay is studied independently of the others. The outside influence is reduced to: the call rate from other relays and the entrance rate for vehicles from an outside area. The disaggregation step is the global study of the whole system. Each of the relays is replaced by a simple equivalent that is deduced from the preceding step. Before applying this iterative method, it is necessary to obtain the state probabilities of the displacement model. We assume that the vehicles spend an amount of time in each area that is exponentially distributed. Then by applying Chapman-Kolmogorov equations, we get a linear system whose solutions let us derive the expected values of the number of vehicles within each area. (Edited author abstract) 11 refs.

Becker, M. (INPG, Grenoble, Fr); Houeix, P.; Mazel, C. *Modell Simul Control C* v 10 n 2 1987 p 19-36.

## Paging Systems

**088096 UNI-DIRECTIONAL SATELLITE PAGING SYSTEM FOR LAND MOBILE USERS.** A satellite ground segment which is capable of supporting a uni-directional paging service for land mobile users is described. The system is configured around existing satellites and the VHF wide-area paging network. A suitable transmission format is proposed which employs multi-level frequency shift keying, dual time diversity and Reed-Solomon forward error correction. The anticipated performance of the transmission format is discussed. Proposed implementations of the mobile paging receiver and transmitter data-formatting modulation equipment are presented. (Author abstract) 11 refs.

Casewell, I.E. (Racal-Decca Advanced Development Ltd, Walton-on-Thames, Engl); Ferebee, I.C.; Tomlinson, M. *J Inst Electron Radio Eng* v 58 n 3 May 1988 p 92-98.

**Switzerland** See TELEPHONE EXCHANGES—Switzerland.

**RADIO TELESCOPES** See Also ANTENNAS—Feed Systems; EARTH ATMOSPHERE—Measurements; RADIO INTERFERENCE.

**088097 AUSTRALIA TELESCOPE ANTENNAS: REFLECTOR OPTICS AND FEED SYSTEM.** The Australia Telescope is expected to eventually operate over a very wide frequency range of 0.327 to 115 GHz. This paper outlines the reflector optics for the new 22 m



diameter Cassegrain reflectors and the associated feed system designed to meet this demand. (Author abstract) 4 refs.

James, G.L. (CSIRO, Epping, Aust). *J Electr Electron Eng Aust* v 7 n 4 Dec 1987 p 295-297.

Australia See RADIO ASTRONOMY—Australia.

## Equipment

**088098 A DUAL-CHANNEL COOLED GaAsFET RECEIVER FOR THE DOMINION RADIO ASTRONOMICAL OBSERVATORY 26-METRE RADIO TELESCOPE COVERING 1.35 TO 1.75 GHz.** A low-noise receiver for a radio telescope is described. Two identical three-stage GaAsFET amplifiers were built which give excess noise temperatures of less than 28 K with at least 34 dB gain between 1.35 and 1.75 GHz when operated at a physical temperature of 12 K. This noise temperature is measured at the cryostat input connectors. The physical temperature is maintained by a closed cycle helium refrigerator. Source-inductance feedback is used to allow optimum noise performance combined with good input match. Return loss is better than 15 dB across the band. Construction details of the amplifiers and their mounting in the cryostat are provided. Sample observational results are presented. (Author abstract). 18 Refs.

Walker, G. (Univ of Alberta, Edmonton, Alberta, Can); Vandelik, J.F.; Routledge, D.; Landecker, T.L.; Galt, J.A. *Can Electr Eng J* v 13 n 1 Jan 1988 p 3-7.

Microwaves See RADIO ASTRONOMY—Measurements.

**RADIO TRANSMISSION** See Also ANTENNAS—Computer Aided Design; ANTENNAS—Mathematical Models; ANTENNAS, DIRECTIVE—Phased Arrays; AUTOMOBILES—Door Locks; COMPUTERS, PERSONAL—Data Communication Equipment; ELECTROMAGNETIC WAVES—Diffraction; ELECTROMAGNETIC WAVES—Propagation in Ionosphere; EQUALIZERS; RADIO BROADCASTING—Mathematical Models; RADIO COMMUNICATION; RADIO TRANSMITTERS—Efficiency; ROTORS—Balancing; SHIPS—Communication Systems; SUPERCONDUCTING DEVICES; TELECOMMUNICATION LINKS, RADIO—Analysis.

**088099 PRIVATIZATION OF THE RADIO SPECTRUM.** The purpose of a previous study was to consider the practicality of spectrum pricing. The report proposes radical deregulation, which was not explicit in the brief.

Rudd, David. *Electron Wireless World* v 93 n 1619 Sep 1987 p 919-921.

**088100 LATERAL PROPAGATION OF RADIO WAVES ON THE DUSHANBE-LENINABAD METEOR RADIO PATH (PRELIMINARY RESULTS).** The results of experiments on radio-wave propagation on the dushanbe-Leninabad meteor radio path are given. The optimum orientations of the antenna systems relative to the axis of the path are chosen. The experimental data are compared with theoretical predictions obtained by the method of imitative statistical modeling. (Author abstract) 2 refs.

Karpov, A.V. (Kazan State Univ, USSR); Kodirov, A.; Mirdzhamalov, K.; Rubtsov, L.N. *Radiophys Quantum Electron* v 30 n 3 Mar 1987 p 268-270.

**088101 CHARACTERISATION OF h.f. RADIO DATA LINKS.** A complete h.f. link data logging system has been constructed and this will provide information on the h.f. channel which will be useful in the creation of an h.f. channel model. This will lead to the design of effective error protection codes for a digital speech communication link over h.f. radio. 6 refs.

McCarthy, K.P.; Mousley, T.J.; Young, B.D. *Annu Rev Philips Res Lab* 1986 p 90-94.

**088102 EFFET DE LA LONGUEUR DU TRAJET SUR LA SELECTIVITE D'UN CANAL EN PERIODE DE PROPAGATION PAR TRAJETS MULTIPLES.** [Effect of Path Length on Selectivity of a Multipath

Channel]. This paper uses the only experimental data available in order to check a previous theory dealing with the influence of the distance upon the quality of high bit rate digital transmission. The results seem to confirm the theoretical analysis. Therefore, assuming its correctness, an example is given which shows the variation of the impairment versus the length of the hop. (Author abstract) 10 refs. In French.

Lavergnat, Jacques (CNET, Issy-les-Moulineaux, Fr); Nkwawo, H. *Ann Telecommun* v 43 n 1-2 Jan-Feb 1988 p 14-19.

## Absorption

**088103 BETTER RCS DATA WITH ANECHOIC ABSORBER CHARACTERIZATION.** The first complete evaluation of anechoic absorbers will help compact range users get improved RCS measurements. The new measurement technique described eliminates the problems of the NRL arch method and is much different than other previously used methods. Instead of using the conventional NRL arch technique to evaluate anechoic absorbers, three different types of measurement techniques were used. The measured absorber results are useful in developing much needed chamber performance models. Knowledge of absorber material behavior can be used as input for computer programs for designing anechoic chambers and compact ranges. 10 refs.

Brumley, Steve (Motorola, Scottsdale, AZ, USA). *Microwaves RF* v 26 n 5 May 1987 p.

## Analysis

**088104 RADIO PROPAGATION CHARACTERISTICS IN UNDERGROUND STREETS CROWDED WITH PEDESTRIANS.** Radio-wave propagation characteristics are measured in an underground street crowded with pedestrians and the attenuation constant from 250 MHz to 12.4 GHz is derived. It is experimentally proven that the attenuation constant decreases with increasing frequency. In the analysis, the region with pedestrians is modeled as a lossy, homogeneous dielectric slab. Based on the method of effective dielectric constant, the field distribution and the attenuation constant are calculated. Although this method is an approximate approach, it is expected to work for the problem of propagation characteristics in guides crowded with pedestrians or obstacles. 15 refs.

Yamaguchi, Yoshio (Niigata Univ, Niigata, Jpn); Abe, Takeo; Sekiguchi, Toshio. *IEEE Trans Electromagn Compat* v 30 n 2 May 1988 p 130-136.

**Applications** See COAL MINES AND MINING—Communication Systems; TURBOGENERATORS—Fault Location.

## Attenuation

**088105 ATTENUATION ON AN EARTH-SPACE PATH IN RAIN AT 22 GHz.** It has been found that attenuation on an Earth-space path in rain at 22 GHz can be estimated by a combination of the CCIR method of predicting rain attenuation and a spectroscopic calculation of atmospheric attenuation based on aerological data. The magnitude of rain attenuation at 22 GHz is about 3.5 times that at 12 GHz, and atmospheric attenuation to be added to rain attenuation is about 2.5 dB at 22 GHz on paths to a broadcasting satellite in Japan. To avoid lengthy computations, a simplified method was derived for estimating atmospheric attenuation in rain on an Earth-space path at 22 GHz. 7 refs.

Ito, Shiro (NHK, Tokyo, Jpn). *NHK Lab Note* 351 Oct 1987 p.

**088106 IMPROVED PREDICTION METHOD FOR RAIN ATTENUATION IN SATELLITE COMMUNICATIONS OPERATING AT 10-20 GHz.** Several prediction methods for rain attenuation presented so far are evaluated using a common long-term data base (total 124 sets of measurements) for oblique propagation paths with frequencies of from 10 to 20 GHz, and an improved

prediction method reflecting the evaluation results performed is proposed. The evaluation results indicate that CCIR methods give relatively high precision, although in this respect, there is not such a great difference from other methods. The method proposed includes a rain area size parameter as a function of rain rate for 0.01% of the time to minimize the prediction error. It is verified that the method thus obtained gives the best precision, at the present time, for predicting rain attenuation on Earth-to-space propagation paths at 10-20 GHz. (Edited author abstract) Refs.

Yamada, M. (KDD, Tokyo, Jpn); Karasawa, Y.; Yasunaga, M.; Arbesser-Rastburg, B. *Radio Sci* v 22 n 6 Nov 1987 p 1053-1062.

**Automatic Testing** See ELECTRIC MEASUREMENTS—Computer Applications.

**Backscattering** See Also ANTENNAS—Reflection; ANTENNAS—Reflectors.

**088107 CALCULATION OF THE STATISTICAL CHARACTERISTICS OF BACK-SCATTERED SIGNALS IN A RANDOMLY IRREGULAR IONOSPHERIC WAVEGUIDE.** The reciprocity theorem is used to derive an expression for the correlation function of back-scattered signals in a randomly irregular ionospheric waveguide. The derivation takes into account the directivity of the transmitting and receiving antennas, the parameters of the radiated signal and receiving filter, nonstationarity of the ionosphere, and radio wave absorption. It is shown that the solution of the statistical problem is much simpler when one takes advantage of the quasiperiodic nature of the waveguide ray paths. Calculations are carried out for a model of a randomly irregular waveguide. (Author abstract) 6 refs.

Lagutkin, V.N. *Sov J Commun Technol Electron* v 32 n 2 Feb 1987 p 42-49.

**088108 BACKSCATTERING BY LOADED AND UNLOADED DIHEDRAL CORNERS.** An accurate mathematical model for the assessment of the backscattering from a loaded dihedral-corner reflector is solved using a technique which is a generalization of physical optics (PO) methods to loaded surfaces, improved by taking into account the lighting of each face by the rays diffracted by the edge of the other one. The inclusion of the currents due to such diffracted fields in the PO current distribution has been found relevant in order to improve the accuracy of the solutions. The solution is uniform with respect to the loading impedance; it coincides with a previously obtained solution for the perfectly conducting case, when the loading impedance approaches zero. 20 refs.

Corona, Paolo (Istituto Universitario Navale, Naples, Italy); Ferrara, Giuseppe; Gennarelli, Claudio. *IEEE Trans Antennas Propag* v AP-35 n 10 Oct 1987 p 1148-1153.

**088109 METHOD TO CORRECT HF SKYWAVE BACKSCATTERED SIGNALS FOR IONOSPHERIC FREQUENCY MODULATION.** A method is described to correct HF signals reflected by the ionosphere and backscattered by the sea surface for ionospheric frequency modulation, which produces spectral-line smearing. The statistical mean of the time derivative of the phase of the signal, weighted by the signal energy, is proposed as an estimator of this modulation. The accuracy of the estimator is measured and the efficiency of the signal processing is tested by synthetically contaminating high-quality signals obtained via sporadic E-layer propagation. Examples of data corrected for F2-layer ionospheric perturbations are shown. 15 refs.

Parent, Jacques (Univ Paris, Fr); Bourdillon, Alain. *IEEE Trans Antennas Propag* v 36 n 1 Jan 1988 p 127-135.



**088110 SPECIAL PROBLEMS IN APPLYING THE PHYSICAL OPTICS METHOD FOR BACKSCATTER COMPUTATIONS OF COMPLICATED OBJECTS.** The backscatter computation of complicated objects is carried by the physical optics (PO) method, known as the vector Kirchhoff approximation. The object is described by a geometrical model using flat plates (panels). These panels can be nonperfectly conducting and multilayered. The PO solution for the scattering matrix of a single multilayered panel is evaluated in detail using the Fresnel reflection coefficients. An example of the computed reflection coefficient of a two-layered medium is presented. The phase integral of the PO method is solved analytically. The hidden-surface problem is discussed, and the procedure for the treatment of doubly reflecting panels is described. For an ideal conducting cube with additional surfaces that generate shadow and double-reflection effects, the computed radar cross section (RCS) is compared with measurements. Computational results of the RCS for nonperfectly conducting panels are given. 7 refs.

Klement, Dieter (DFVLR Oberpfaffenhofen, Wessling, Germany); Preissner, Jürgen; Stein, Volker. *IEEE Trans Antennas Propag* v 36 n 2 Feb 1988 p 228-237.

**088111 APPLICATION OF A CONJUGATE GRADIENT FFT METHOD TO SCATTERING FROM THIN PLANAR MATERIAL PLATES.** The backscatter cross section is calculated for thin material plates with finite electric permittivity, conductivity, and magnetic permeability illuminated by a plane wave. The plates are assumed to be planar with an arbitrary perimeter. The integral equations are formed and solved by a combined conjugate gradient-fast Fourier transform (CG-FFT) method. The CG-FFT method was tested for several geometries and materials measured and computed backscatter results are compared for a perfectly conducting equilateral triangle plate, a square dielectric and magnetic plate, and a circular dielectric plate. The agreement between measured and computed data is generally good except toward edge-on incidence where several factors cause discrepancies. Accurate approximations to the geometry and far-field integrals become critical near edge-on incidence and, it is postulated that as the incidence angle approaches edge-on, the sampling interval and tolerance should be decreased. 14 refs.

Peters, Timothy J. (Univ of Michigan, Ann Arbor, MI, USA); Volakis, John L. *IEEE Trans Antennas Propag* v 36 n 4 Apr 1988 p 518-526.

**Computer Aided Analysis** See Also RADIO COMMUNICATION—Planning.

**088112 COMPUTER-AIDED VHF/UHF FIELD-STRENGTH PREDICTIONS.** The article proposes an empirical method for the calculation of field-strengths in the VHF and UHF broadcasting bands over known orographic profiles between the transmitting and receiving points. The profiles are obtained from the Italian terrain data bank. Allowances are made for various types of propagation: diffraction by different types of obstacles, troposcattering, super-refraction and tropospheric ducting over sea paths. A comparison is made between the calculated field-strengths and measurements taken in rural sites away from natural and artificial obstacles. An example is given of the way in which the propagation model has been applied to the calculation of interfering field-strengths in the service areas of the RAI broadcasting transmitters. (Edited author abstract). 27 Refs.

Riccardi, M. (RAT's Cent, Milan, Italy); Isola, C. *EBU Rev Tech* n 228 Apr 1988 p 68-77.

**Degradation** See RADAR INTERFERENCE—Clutter.

**Diffraction**

**088113 CHARACTERISTICS OF A RADIO SIGNAL FOR DIFFRACTION-TROPOSPHERIC PROPAGATION CONDITIONS.** The seasonal and diurnal variations of the characteristics of slow and fast fluctuations of the field in the intermediate zone of over-the-horizon propagation of radio waves are determined. It is shown that the dependence of the mean intensity and the fluctuations of the signal are in good agreement with the variability of the gradient of the dielectric constant of air. It is established that for the conditions of a distinctly continental climate for paths with the diffraction-tropospheric mechanism of propagation, the winter months are the worst period from the standpoint of electromagnetic compatibility. (Author abstract) 11 refs.

Chimitorzhiev, N.B.; Darizhapov, D.D.; Zhamsuyeva, G.S.; Tsydygov, D.Z. *Sov J Commun Technol Electron* v 31 n 12 Dec 1986 p 34-39.

**Equipment** See SIGNAL GENERATORS.

**Fading** See Also DIGITAL COMMUNICATION SYSTEMS; DIGITAL COMMUNICATION SYSTEMS—Synchronization; INFORMATION THEORY—Communication Channels; RADIO INTERFERENCE—Jamming; RADIO SYSTEMS; MOBILE; RADIO SYSTEMS, MOBILE—Performance; SIGNAL DETECTION; TELECOMMUNICATION LINKS, SATELLITE.

**088114 TRANSMISSION OF LOG-PCM VIA QAM OVER GAUSSIAN AND RAYLEIGH FADING CHANNELS.** The digital noise power due to transmission errors is determined for 8-bit  $\mu$ -law PCM,  $\mu=255$ , signals transmitted via M-level QAM,  $M=16, 64$  and  $256$ , over Gaussian and Rayleigh fading channels. The analytical results apply for various laws that map the 8-bit  $\mu$ -law PCM signal into the QAM format, and for different binary Gray codes used to represent the QAM signal points. In addition to the theoretical results expressed as overall speech snr as a function of channel snr for different input speech signal levels, simulations for Gaussian and mobile radio channels using speech signals are also presented. We conclude that the 256-level QAM system employing the best mapping law and Gray code has a gain of about 6 db in overall speech snr compared to transmission without coordination of the speech bits over a Gray-coded link. Corresponding gains for 16-level and 64-level QAM are marginally smaller. By increasing the number of QAM levels from 4 to 256, the required increase in channel snr per bit to maintain an overall speech snr of 30 db is approximately 12 db. The bandwidth efficiency increases by a factor of four. (Edited author abstract) 23 refs.

Steel, R. (Univ of Southampton, Southampton, Engl); Sundberg, C.-E.W.; Wong, W.C. *IEE Proc Part F* v 134 n 6 Oct 1987 p 539-556.

**088115 LOGARITHMIC PCM WEIGHTED QAM TRANSMISSION OVER GAUSSIAN AND RAYLEIGH FADING CHANNELS.** The transmission of 8-bit  $\mu$ -law PCM signals using M-level weighted QAM (WQAM),  $M=16, 64$  and  $256$ , over Gaussian and Rayleigh fading channels is examined. The weighting process modifies the positions of the QAM constellation points so that the overall distortion in the recovered information-bearing source signal is reduced. The PCM bits are mapped to the WQAM points such that the most significant bits have a lower probability of being in error than the least significant bits. Gray coding of the constellation points is also used. The WQAM systems have been optimized for the same average signal energy per transmitted symbol as for unweighted QAM. Optimized systems have also been derived for the same peak signal energy per symbol. The theoretical and simulation results using speech indicate that 16-level and 256-level WQAM have a gain of up to 3 and 5 db, respectively, over unweighted QAM for the Gaussian channel. The gains due to weighting for 16-level QAM operating over an ideal slow Rayleigh fading channel are up to 5 db. (Author abstract) 21 refs.

Sundberg, C.-E.W. (AT&T Bell Lab, Murray Hill, NJ, USA); Wong, W.C.; Steele, R. *IEE Proc Part F* v 134 n 6 Oct 1987 p 557-570.

**088116 CALCULATE BIT ERROR RATE FOR DIGITAL RADIO SIGNAL TRANSMISSION.** Several methods estimate the symbol error rate caused by imperfect transmission channels such as filters, nonlinear elements, multipath propagation, and channel interference. The author claims that the method presented is the only one relating the symbol error rate to the parameters of peak-to-peak amplitude and phase ripple, maximum gain slope, and maximum group delay distortion, which are commonly used to characterize and arbitrary linear transmission channel. This method calculates the performance degradation of quaternary phase-shift keying (QPSK), offset quaternary phase-shift keying (OQPSK), and M-ary phase-shift keying (MSK) signals transmitted over a wideband channel, exhibiting either sinusoidal amplitude ripple or sinusoidal phase ripple. 2 refs.

Sandberg, Jorgen (ESA, Noordwijk, Neth). *Microwaves RF* v 26 n 6 Jun 1987 p 97 and 106.

**088117 EFFECTS OF CORRELATED FADING ON LEVEL CROSSING RATES AND AVERAGE FADE DURATIONS WITH PREDETECTION DIVERSITY RECEPTION.** General expressions for the level crossing rate (LCR) and average fade duration (AFD) are obtained for several diversity combining schemes employing two-branch predetection reception of correlated Rayleigh fading signals. These expressions are obtained from joint and conditional probability density functions (PDFs) of the received signals, and lead to a unified treatment. This simplified method contrasts with the characteristic function approach used in previous investigations. Numerical results are presented for a space-diversity system using horizontally spaced antennas at a mobile station. It is shown that while the angle between the antenna axis and the direction of vehicle motion does not appear in the cumulative distribution function (CDF) of the combined output signal envelopes, it affects the LCR and AFD when the two fading signals are correlated. When the two antennas parallel with the direction of vehicle motion are used, the LCR can be reduced below the value obtainable from signals which fade independently. When the two antennas are perpendicular to the direction of vehicle motion, the AFD is loosely dependent on the antenna spacing and, provided the antenna spacing is not too small, is approximately half that for the no-diversity case. (Author abstract) 12 refs.

Adachi, F. (NTT Electrical Communications Lab, Yokosuka, Jpn); Feeney, M.T.; Parsons, J.D. *IEE Proc Part F* v 135 n 1 Feb 1988 p 11-17.

**088118 TRANSFER FUNCTION PARAMETERS IN MULTIPATH CHANNEL MODELLING.** Two alternative forms of representation of a multipath fading channel frequency response function are presented. Appropriate analytical expressions relating the two sets of characterisation parameters are derived. The results are applied to published data to illustrate their use. (Author abstract) 6 refs.

Raji, T. (Univ of Ife, Ile-Ife, Nigeria). *IEE Proc Part F* v 135 n 3 Jun 1988 p 262-264.

**088119 INVESTIGATION OF VARIOUS TYPES OF FADE EXPERIENCED ON A COASTAL MICROWAVE LINK ALONG THE RED SEA.** Various types of fading are identified on a 31 km microwave link along the Red Sea-Saudi Arabia. This study is based on analyzing chart recordings of the received signal level on 4 GHz and 6 GHz channels. Fade types are evaluated in terms of fade depth statistics, frequency selectivity and the possibility of diversity protection improvement. It is concluded that the main cause of outage is the simultaneous occurrence of power depression and multipath fading. Various options are cited for the needed solution. (Edited author abstract). 7 Refs.

Ali, Adel A. (King Saud Univ, Riyadh, Saudi Arabia); Al-Ruwais, Abdulaziz S. *J Eng Sci King Saud Univ* v 14 n 1 1988 p 57-65.

**088120 ERROR PROBABILITY FORMULA FOR M-ARY DPSK IN FAST RICIAN FADING AND GAUSSIAN NOISE.** A formula for the symbol error probability is derived for differential detection of M-ary phase-shift keying (MDPSK) in fast Rician fading and



white Gaussian noise. This formula is an extension of a result already known for MDPK in Gaussian noise interference. 4 refs.

Mason, L.J. (Communications Research Cent, Ottawa, Ont, Can). *IEEE Trans Commun* v COM-35 n 9 Sep 1987 p 976-978.

**088121 HILLY TERRAIN LOS FADEOUTS AND FRESNEL ZONE CONSIDERATIONS FROM RAY TRACING TECHNIQUES.** The Tiruttani-Tirupati line-of-sight (LOS) communication link situated in hilly terrain and operating at 7 GHz suffers severe fadeouts during the early hours of the day in the months of February and March. To investigate if the fadeouts are due to insufficient obstacle clearance along the entire propagation path, the authors determine whether the first Fresnel-zone clearance is secured under varied atmospheric conditions. A computer program was developed using the ray-tracing technique to trace the path of the radio ray under the varied meteorological situations encountered when the fadeouts were observed. It was found that the fadeouts were due to insufficient clearance at the hilltop, usually during subrefractive conditions. 9 refs.

Rao, D. Narayana (S.V. Univ, Tirupati, India); Murthy, M.J. Kesava; Sarkar, S.K.; Pasricha, P.K.; Dutta, H.N.; Reddy, B.M. *IEEE Trans Antennas Propag* v AP-35 n 11 p 1330-1333.

**088122 IMPACT OF FREQUENCY-SELECTIVE FADING ON DIGITAL LAND MOBILE RADIO COMMUNICATION AT TRANSMISSION RATES OF SEVERAL HUNDRED KBIT/S.** Computer simulations of mobile-radio-channel transfer functions have been performed using data from measurements in New York City and the city of Berne, Switzerland, and its outskirts. It is demonstrated that the impulse response may suffer considerably from large variations of the channel characteristics. It is concluded that powerful means of signal processing are necessary to safeguard digital land-mobile radio communication at transmission rates of several hundred kilobits per second. 15 refs.

Lorenz, Rudolf W. (Deutsche Bundespost, Darmstadt, West Ger). *IEEE Trans Veh Technol* v VT-36 n 3 Aug 1987 p 122-128.

**088123 EFFECTS OF MULTIPATH DELAY SPREAD ON TIMING RECOVERY.** Equations for the recovered timing for a squaring timing recovery circuit under multipath radio propagation are derived. Both coherent and differential detections are studied. If delay spread is much smaller than the symbol duration, the recovered timing can be approximated by the centroid of the power delay profile,  $p(t)$ . Two cases of timing loop bandwidth are considered. If the fading frequency is much lower than the bandwidth of the timing loop, the instantaneous sample of  $p(t)$  is used to generate the timing clock. If the fading frequency is much higher than the loop bandwidth, the ensemble average of  $p(t)$  over fading samples is used to recover the timing. A computer simulation of a system operating in a frequency-selective, slowly fading environment shows that for root mean square (rms) delay spread less than or equal to 0.1 of the symbol duration, a squaring timing loop with either narrow or wide bandwidth can properly determine the timing detection. The main mechanism of the irreducible bit error rate in this case is the closure of the eye-pattern instead of timing error. 11 refs.

Chuang, Justin C.-I. (Bell Communications Research, Red Bank, NJ, USA). *IEEE Trans Veh Technol* v VT-36 n 3 Aug 1987 p 135-140.

**088124 LOW ANGLE SIGNAL FADING AT 38 GHz IN THE HIGH ARCTIC.** The results from a 1984 microwave propagation experiment conducted at 83°N latitude to study the characteristics of low-angle fading at a frequency of 38 GHz are reported. By monitoring the continuous-wave (CW) signal transmitted from the orbiting LES-8 satellite, propagation data were gathered over a range of elevation angles from 1° to 21°. A total of three

sets of measurements were made in the spring, summer, and winter. These allowed comparisons to be made of the seasonal characteristics of low-angle fading in the Arctic. The experimental data were examined with respect to the atmospheric conditions observed. The results presented include the variation of the median signal level with the elevation angle, cumulative distributions of the received signal level, and fade-rate statistics. The amount of signal fading increased rapidly as the elevation angle decreased. Fading was most severe in the summer, which also had the highest fade rates. Very little fading was observed in the winter. 10 refs.

Lam, W.I. (Communications Research Cent, Ottawa, Ont, Can). *IEEE Trans Antennas Propag* v AP-35 n 12 Dec 1987 p 1495-1499.

**088125 FADE MEASUREMENTS AT L-BAND AND UHF IN MOUNTAINOUS TERRAIN FOR LAND MOBILE SATELLITE SYSTEMS.** Fading results related to land mobile satellite communications at L-band (1502 MHz) and UHF (870 MHz) are described. These results were derived from an experiment performed in a series of canyon passes in the Boulder, Colorado region of the US. The experimental configuration involved a helicopter as the source platform, which maintained a relatively fixed geometry with a mobile van containing the receiver and data-acquisition system. An unobstructed line of sight between the radiating sources and the receiving van was, for the most part, also maintained. In this configuration, the dominant mechanism causing signal fading (or enhancement) is a result of multipath. The resulting fade distributions demonstrated that at the 1% and 5% levels, 5.5- and 2.6-dB fades were on the average exceeded at L-band and 4.8- and 2.4-dB at UHF, respectively, for a path elevation angle of 45°. The canyon results as compared with previous roadside-tree-shadowing results demonstrate that the deciding factor dictating fade margin for future land mobile satellite systems is tree shadowing rather than fades caused by multipath. 9 refs.

Vogel, Wolfhard J. (Univ of Texas, Austin, TX, USA); Goldhirsh, Julius. *IEEE Trans Antennas Propag* v 36 n 1 Jan 1988 p 104-113.

## Imaging Techniques

**088126 SUPERRESOLUTION OF NEAR OR FAR FIELD COHERENT TARGETS USING APERIODIC ANTENNA ARRAYS.** A technique for obtaining high-resolution images of pointlike coherent targets using aperiodic antenna arrays is developed. Whereas existing superresolution techniques can be used to image coherent targets located only in the far field of periodic receiving arrays, this technique can be used to obtain high resolution images of targets in the near field also. The key to this technique is the use of multiple transmitters. Completely correlated (coherent) targets are decorrelated by transmitting sequentially from different locations, thereby enabling the use of modern superresolution techniques to estimate the target locations. An expression for estimating the variance of the target locations is derived, and is verified by empirical methods. For the same amount of transmitted power and the same number of receivers, this variance is shown to be an order of magnitude smaller than that of existing superresolution techniques. The practicality of this technique is demonstrated with experimental microwave data. 21 refs.

Subbaram, Harish M. (Univ of Pennsylvania, Philadelphia, PA, USA); Steinberg, Bernard D. *IEEE Trans Antennas Propag* v AP-35 n 11 p 1206-1216.

## Industrial Applications See INVENTORY CONTROL—Equipment.

## Mathematical Models

**088127 CONSTRUCTION OF CONSISTENT ESTIMATES.** A theorem which enables one to obtain consistent estimates of distribution parameters, when the generalized method of moments does not yield results, is formulated and proved. Rice's and Likhter's distributions are discussed as examples. The probabilistic characteris-

tics of the estimates obtained are determined. (Author abstract) 10 refs.

Anisimova, L.N.; Gorev, P.V.; Koldanov, A.P. *Sov J Commun Technol Electron* v 32 n 4 Apr 1987 p 84-89.

**088128 APPLICATION OF THE COMPENSATION THEOREM TO KNIFE-EDGE DIFFRACTION OVER A PLANE EARTH.** The problem of radio wave propagation over a simple knife-edge, with both transmitter and receiver at ground level, is considered by means of the vector form of the Compensation Theorem. The intervening ground is assumed to be flat and to have the same normalized impedance as the knife-edge. Analytical results for the attention factor are given for both perfectly and finitely conducting ground. (Author abstract). 3 refs.

Wu, Z. (Univ of Birmingham, Birmingham, Engl); Maclean, T.S.M.; Mehler, M.J.; Bagwell, D.J. *Int J Electron* v 65 n 1 Jul 1988 p 85-89.

## Microwaves

**088129 ON THE WORLD'S WAVELENGTH.** BNR engineers have developed a new digital microwave radio system, called the RD-6B, that employs efficient 64 quadrature amplitude modulation (QAM) techniques to increase the spectral efficiency of radio channels worldwide. The RD-6B incorporates new DM-140 signal processors and interfaces to transmit signals at 140 Megabits per second (Mbit/s), a standard transmission rate in Europe and in many other parts of the world.

Godfrey, Bryan; McNicol, John; Stoop, Peter; Weedmark, John. *Telesis* v 14 n 2 1987 p 36-45.

## Monitoring

**088130 SHORTWAVE BROADCASTING BAND SPECTRUM OCCUPANCY AND SIGNAL LEVELS IN THE CONTINENTAL UNITED STATES AND WESTERN EUROPE.** The initial results are described for monitoring using a mobile spectrum monitoring unit (MSMU) that has the capability of fast sampling of radio signals in the frequency spectrum between 2 MHz and 1 GHz. In the summer and fall of 1987, the MSMU was used to measure signal level and spectrum occupancy in the shortwave band (2-30 MHz) at four locations in the continental United States (CONUS) (i.e., Stanford, California; Ft. Huachuca, Arizona; Ft. Sill, Oklahoma; and Annapolis, Maryland) and at two locations in Europe (Seckenheim and Geinsheim, Federal Republic of Germany). After the measurement period, the recorded data were used to compute occupancy statistics at 111 signal amplitude thresholds. Comparison of spectrum-occupancy and signal-level data between CONUS and Europe is reported. 11 refs.

Hahn, George H. (SRI Int, Arlington, VA, USA); Stehle, Roy H.; Harnish, Lawrence O. *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 115-125.

## Noise

**088131 ON THE UNIVERSALITY OF THE METHOD OF CONVERTING THE ATMOSPHERIC RADIO NOISE DISTRIBUTION FUNCTION FROM BAND TO BAND USING A GENERALIZING EMPIRICAL MODEL.** The capabilities of a method (developed earlier by the author) of converting the atmospheric radio noise distribution function from band to band, using an empirical model whose parameters were directly calculated using a computer, were demonstrated on the basis of the experimental data. The method was illustrated for the case when the conversion factor of the bands  $\omega = B_2/B_1 > 1$  ( $B_1$  is the original bandwidth and  $B_2$  is the final bandwidth). The purpose of this paper is to show that the method of converting the distribution function is quite general and can be used for  $\omega < 1$ . The method exhibits universal properties and can be used to an equal extent for both increased or decreased receiver passband. 8 refs.

Osinin, V.F. *Sov J Commun Technol Electron* v 31 n 12 Dec 1986 p 216-217.



**088132 RANDOM FM NOISE WITH SELECTION COMBINING.** Random FM noise using two-branch selection combining with correlated Rayleigh fading signals is analyzed for land mobile radio systems. General expressions are derived for the cumulative distribution function and mean square value of the random FM noise; they can be applied to any type of diversity such as space, polarization, etc. Calculated results show that, if two horizontally spaced antennas parallel with the direction of vehicle motion are used at a mobile station, random FM noise can be significantly reduced for small antenna spacings. 6 refs.

Adachi, F. (NTT, Yokosuka, Jpn); Parsons, J.D. *IEEE Trans Commun* v 36 n 6 Jun 1988 p 752-755.

## Optimization

**088133 OPTIMUM PROPERTIES OF ENSEMBLES OF BINARY SEQUENCES.** It is shown that the families of Casami, Gold and bent functions are rigorously optimum functions with respect to the index of maximum correlation surge in an ensemble of given volume. They are asymptotically optimum with respect to the mean-square level of the periodic mutual uncertainty function in a symmetrical Doppler band. (Edited author abstract) 15 refs.

Ipatov, V.P.; Samoylov, I.M. *Sov J Commun Technol Electron* v 32 n 4 Apr 1987 p 49-54.

**Polarization** See ANTENNAS—Mathematical Models.

**Propagation** See Also RADIO SYSTEMS, MOBILE—Reviews.

**088134 HEINRICH HERTZ - THEORIST AND EXPERIMENTER.** It is argued that when Heinrich Hertz was appointed professor of physics at Karlsruhe in 1885 he was uniquely prepared for his historic experiments that opened the radio spectrum. Hertz made the first antennas and transmitter-receiver radio system and conducted a series of experiments which established that radio waves are identical to light except for their much greater length. His description of the radiation phenomenon remains the best ever written, revealing his tremendous depth of understanding of the subject. Hertz's training, studies, and experiments are recounted and measurements with a replica of his apparatus are described. 12 refs.

Kraus, John D. (Ohio State Univ, Columbus, OH, USA). *IEEE Trans Microwave Theory Tech* v 36 n 5 May 1988 p 824-829.

**088135 HIGH FREQUENCY SKY-WAVE PROPAGATION PREDICTIONS IN THE DESIGN OF BROADCAST SYSTEMS.** Classical methods used to predict the performance of point-to-point sky-wave systems are extended to the design of high-frequency broadcast systems through a summarizing procedure based on the use of time-location samples. Examples of frequency, antenna, and site selection are shown. It is concluded that predictions of these types are most useful when comparisons are involved; e.g., selection of antennas, choice of sites, etc. 1 ref.

Haydon, George W. (Lucas Consulting, Boulder, CO, USA); Lucas, Donald L.; Pinson, George Scott. *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 238-241.

**Propagation Effects** See Also ELECTROMAGNETIC WAVES—Attenuation; ELECTROMAGNETIC WAVES—Propagation in Troposphere; EXTRATERRESTRIAL ATMOSPHERES—Measurements; RADAR—Microwaves; RAIN AND RAINFALL—Analysis; TELECOMMUNICATION LINKS, SATELLITE; TELECOMMUNICATION LINKS, SATELLITE—Performance.

**088136 CHARACTERISING THE UHF FACTORY RADIO CHANNEL.** Portable UHF factory multipath measurement apparatus is being used to measure multipath delay profiles and narrowband fading at five large manufacturing sites in the mid-western US. Preliminary data indicate that typical RMS delay spreads range from 100 to 250 ns and that average cw path loss varies as distance to the power 2.2. This work is the first report of

multipath measurements in factory environments. (Edited author abstract) 7 refs.

Rappaport, T.S. (Purdue Univ, West Lafayette, IN, USA); McGillem, C.D. *Electron Lett* v 23 n 19 Sep 10 1987 p 1015-1017.

**088137 PROPAGATION OVER SHORT DISTANCES IN URBAN AND RURAL AREAS IN BAND II.** The article describes propagation measurements in Band II at distances from about 1 to 45 km from a transmitter in rural and urban areas in the western part of the Netherlands. The results are presented as curves showing field-strength as a function of distance. (Author abstract) 10 refs.

Doeven, J. *EBU Rev Tech* n 224 Aug 1987 p 191-197.

**088138 PARAMETRIC COUPLED SOLITONS IN TRANSMISSION LINES.** A method is proposed for suppressing dispersion distortions of a short radio pulse propagating in a transmission line. The conditions for which it is possible to have soliton wave packets with synchronous three-frequency interactions are found. It is shown that the intensity of a short data pulse can significantly exceed that of the two other waves, since the non-linear interaction is purely reactive. The results of numerical experiments are presented for realistic circuit parameters. (Author abstract) 14 refs.

Azimov, B.S.; Trukhov, D.B. *Sov J Commun Technol Electron* v 32 n 3 Mar 1987 p 1-8.

**088139 ESTIMATION OF THE DELAY OF SUPER-WIDEBAND RADIO PULSES IN A MEDIUM AS APPLIED TO PROBLEMS OF SUBSURFACE RADAR.** The time delay of super-wideband radio pulses consisting of one or several oscillation periods in an absorbing medium with relaxation (Debye) polarization is calculated. This delay is compared with the case of propagation in a medium with the same phase velocity as at the maximum of the pulse spectrum. It is shown that a calculation for the known characteristics of sea ice reveals significant errors in determining the thickness of a layer using the phase velocity. (Author abstract) 6 refs.

Finkel'shteyn, M.I.; Kraynyukov, A.V. *Sov J Commun Technol Electron* v 32 n 3 Mar 1987 p 125-131.

**088140 INFLUENCE OF RAYPATH PARAMETERS ON DIGITAL RADIO OUTAGE.** The received power frequency correlation coefficient taking account of amplitudes, phase path delays and angles of arrival of rays is derived theoretically to evaluate the frequency selectivity of multipath fading. An estimation of frequency selectivity reduction due to aperture antennas is presented by using ray tracing data. (Author abstract) 5 refs.

Serizawa, Y. (Central Research Inst of Electric Power Industry, Komae, Jpn); Takeshita, S. *Electron Lett* v 23 n 25 Dec 3 1987 p 1353-1354.

**088141 ESTIMATION OF EARTH ELECTRICAL PROPERTIES USING CW AND FMCW GROUND WAVE PROPAGATION AT HF.** HF ground wave propagation should be well suited to the measurement of ground electrical conductivity and dielectric constant. Despite this, such measurements have historically proven to be unreliable. We have employed both CW and FMCW techniques to measure the ground wave basic transmission loss over paths between 10 and 100 km in length through a variety of terrains covering an area of about 1000 km<sup>2</sup> and to a surface depth approaching 5. Use of FMCW modulation over the longer paths permits rejection of skywave interference. The data recorded over flat terrain covering about 300 km<sup>2</sup> are compared with calculations from a model which includes a nonlinear least squares optimization routine with conductivity and dielectric constant as adjustable parameters. In this way we believe that we have reliably determined average values of conductivity and dielectric constant to a precision of about 25%, and that with improved system calibration an accuracy of 10% should become attainable. Possible sources of error are discussed. (Edited author abstract) 12 refs.

Thomas, R.M. (Defence Science & Technology Organization, Adelaide, Aust); Haack, G.R. *J Electr Electron Eng Aust* v 7 n 3 Sep 1987 p 214-220.

**088142 RAIN RATE PROFILES OBTAINED FROM THE DYNAMIC BEHAVIOR OF THE ATTENUATION OF MICROWAVE RADIO SIGNALS.** A mathematical model is presented which links the dynamical properties of microwave radio signal attenuation to the spatial rain rate structure of intensive showers. The theoretical relation found between attenuation and its rate of change is verified by radio wave propagation measurements on a satellite-Earth path at 11.5 GHz. (Author abstract) 20 refs.

Bune, P.A.M. (Eindhoven Univ of Technology, Eindhoven, Neth); Herben, M.H.A.J.; Dijk, J. *Radio Sci* v 23 n 1 Jan-Feb 1988 p 13-22.

**088143 PROPAGATION OVER AN INHOMOGENEOUS IRREGULAR SURFACE.** A new integral equation has been obtained for the attenuation factor of a radio wave launched by an elevated element, as the wave propagates over a radially inhomogeneous surface of varying height, with an elevated current element as a receiver. In the analysis use is made of the vector form of compensation theorem, using the concept of a real surface impedance on the irregular surface together with that of an equivalent normalized surface impedance in air, at points which follow the contour of the irregular surface. The new integral equation generalizes previous work to treat arbitrary terrain, so that both gradual and sharp changes of terrain height, such as a cliff and a knife edge, are considered. The validity of the integral equation has been tested theoretically by comparison with alternative solutions for particular cases, and also by experiment. (Author abstract) 13 refs.

Wu, Z. (Univ of Birmingham, Engl); Maclean, T.S.M.; Bagwell, D.J.; Mehler, M.J. *Radio Sci* v 23 n 1 Jan-Feb 1988 p 33-40.

**088144 MODELLING OF UHF RADIO WAVE SIGNALS WITHIN EXTERNALLY ILLUMINATED MULTI-STORY BUILDINGS.** A reliable model for UHF radiowave signal propagation into and variability within buildings is required to aid in the planning of cellular mobile radio systems serving portable transceivers. However, no such model has been presented in the literature to date and, with the imminent introduction of cellular mobile radio into New Zealand, a study of this problem has been undertaken with the aim of developing a model suitable for New Zealand buildings and situations. Two initial phases of this study have been completed in which suitable equipment and data collection and analysis procedures were established by conducting measurements at 927 and 851 MHz in a single building and at 851 MHz in another, dissimilar building where there was a line-of-sight path to all but one floor in both buildings. A preliminary model investigation using the data from unobstructed floors has shown that the measured cumulative probability density function of the received signal on a floor is best modelled by the Suzuki (Rayleigh plus log-normal) distribution and that the median signal level is not overly dependent on floor height. (Author abstract) 24 refs.

Barry, P.J. (Univ of Auckland, Auckland, NZ); Williamson, A.G. *J Inst Electron Radio Eng* v 57 n 6 Nov-Dec 1987 p 231-240.

**088145 CHARACTERISTICS OF NON-IONIZED MEDIA AND RADIO-WAVE PROPAGATION IN EQUATORIAL AREAS - A REVIEW.** Characteristics of the non-ionized media in relation to radio propagation near the equator are reviewed. Topics covered include effective ground conductivity, radio refractivity, rain and



atmospheric gas attenuation in the troposphere. Important areas of need for future research are identified. (Author abstract) 33 refs.

Oyinloye, J.O. *Telecommun J* v 55 n 2 Feb 1988 p 115-129.

**088146 PERSONAL COMMUNICATION RADIO COVERAGE IN BUILDINGS AT 900 MHz AND 1700 MHz.** Radio coverage in buildings is compared at 900 MHz and 1700 MHz, with the level of signal decay through floors identified. The reduction in range obtained at 1700 MHz leads to a consideration of the effect it has on system dimensioning, equipment size and costs. (Author abstract). 3 Refs.

Motley, A.J. (British Telecom Research Lab, Ipswich, Engl); Keenan, J.M.P. *Electron Lett* v 24 n 12 Jun 9 1988 p 763-764.

**088147 ATTENUATION IN MELTING LAYER OF PRECIPITATION.** A model of the melting layer is employed on radar measurements to simulate the attenuation of radio waves at 12, 20 and 30 GHz. The attenuation in the melting layer is simulated to be slightly larger than that of rain with the same path length and precipitation intensity. The result appears to depend on the maximum reflectivity in the melting layer. (Author abstract). 4 Refs.

Klaassen, W. (Delft Univ of Technology, Delft, Neth). *Electron Lett* v 24 n 18 Sep 1 1988 p 1187-1188.

**088148 SPECTRAL VIEW OF WAVE PROPAGATION.** Wave propagation in environments characterized by weakly nonseparable conditions can be described by adiabatic modification of spectra pertaining to the unperturbed separable case. Recent developments are reviewed, with emphasis on approximate adiabatic transform relations and adiabatic invariants, which permit reduction of the direct weakly nonseparable wave problem to spectral form and, conversely, reconstruction of wave spectra from measured data. (Edited author abstract) Refs.

Felsen, L.B. (Polytechnic Univ, Farmingdale, NY, USA). *Radio Sci* v 22 n 6 Nov 1987, Int Symp on Electromagn Theory, Budapest, Hung, Aug 25-29 1986 p 848-858.

**088149 SOME NEW ASPECTS IN THE PROBLEM OF WAVES AND TURBULENCE.** Two questions are discussed. The first is the effect of turbulence intermittency on wave propagation. Such effects as bursts of scattering intensity or a sudden improvement of the image quality in turbulent media are connected with the turbulence intermittency. The second is the increase of a mean backscattering from objects surrounded by the random medium with large-scale inhomogeneities. (Edited author abstract) Refs.

Tatarskii, V.I. (USSR Acad of Sciences, Moscow, USSR). *Radio Sci* v 22 n 6 Nov 1987, Int Symp on Electromagn Theory, Budapest, Hung, Aug 25-29 1986 p 859-865.

**088150 COLLOQUIUM ON CROSS POLAR CANCELLATION TECHNIQUES.** Proceedings incorporate seven papers that deal with crosspolar cancellation and cancellers associated with frequency reuse. Topics considered include: antennas, telecommunication links, effects of rain and rainfall on satellite propagation paths, depolarization control, satellite broadcasting, static and adaptive cancellation, radio links, propagation measurements, ground station antennas at C-band, control systems, and transponders. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 08477 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig* n 1985/111, Colloq on Cross Polar Cancellation Tech, London, Engl, Dec 9 1985. Publ by IEE, London, Engl, 1985 var pagings.

## Propagation in Guides

**088151 SOLAR ACTIVITY DEPENDENCE OF MF SKY-WAVE FIELD STRENGTH IN THE NIGHT-**

**TIME.** MF nighttime sky-wave field strength measurements have been made for ten years on board Japanese ice-breaker 'Fuji' while on its yearly voyage from Japan to Antarctica along a north-south course of approximately 10,000 km. From these measurements, clear solar activity dependence is found in that the field strength for the sunspot maximum period is higher by about 9 dB than that for the minimum period. In order to investigate the dependence which is contradictory to the currently accepted one, a numerical analysis of the ionospheric absorption using three-dimensional ray tracing technique was applied to the nighttime model ionosphere having typical distributions of electrons and collision frequency. Results of the analysis support those of the on-board measurements. Contradiction of the solar activity dependence, however, remains unsolved. (Author abstract) 14 refs.

Kuriki, Isao; Igi, Seiji; Wakai, Noboru. *J Radio Res Lab (Jpn)* v 35 n 144 Mar 1988 p 43-56.

**Propagation in Ionosphere** See Also ANTENNAS—Directional Patterns; RADIO BROADCASTING—Computer Aided Analysis; RADIO COMMUNICATION; SATELLITES.

**088152 COMPARISON BETWEEN THE DATA OF THE OBLIQUE IONOGRAM AND THE H.F. DOPPLER IN THE SIMILAR PROPAGATION CONDITION.** The receiver for observing the oblique ionogram was constructed. It was successfully to receive the ionogram signals transmitted from Wakkanai, Akita, Yamagawa and Okinawa in 1986. Comparison among the oblique ionogram from Akita and both of the field strength and the frequency deviation of JY 8MHz signal transmitted from Nazaki is made. The oblique ionogram data were obtained by using the measuring equipment synthesized by Rubidium oscillator to identify the propagation mode for HF doppler observation. (Edited author abstract) In Japanese. 12 refs.

Mambo, Masayoshi (Kanazawa Univ, Kanazawa, Jpn); Nagano, Isamu; Tomura, Masaharu; Fukami, Tetsuo. *Mem Fac Technol Kanazawa Univ* v 20 n 1 Mar 1987 p 35-44.

**088153 RECONSTRUCTION OF THE STRUCTURE OF VOLUME INHOMOGENEITIES OF A MEDIUM.** Inverse problems of the reconstruction of the structure of bounded inhomogeneities in a medium from the scattered wave field of a point source are solved based on the scalar Helmholtz equation within the framework of the Born approximation and the method of smooth perturbations. The analysis is performed for the example of the problem of reconstructing the inhomogeneities of the isotropic ionosphere from scattered radio waves. Relations which enable one to determine the structure of the inhomogeneities with the Rayleigh limit of resolution with respect to the measured field in the Fresnel or Fraunhofer zone are obtained. Examples of the calculation of the resolution of the recording system are given. Integral equations whose solution enables the structure to be reconstructed with a resolution higher than the Rayleigh limit are derived. (Author abstract) 14 refs.

Gusev, V.D.; Kunitsyn, V.Ye. *Sov J Commun Technol Electron* v 32 n 1 Jan 1987 p 110-117.

**088154 ARTIFICIAL PERIODIC IRREGULARITIES AND ACOUSTOGRVITATIONAL WAVES IN THE LOWER IONOSPHERE.** Estimates are given on the effect of acoustogravitational waves on the parameters of artificial periodic irregularities in the lower ionosphere. It is shown that the relaxation time of the irregularities may experience temporal and spacial changes in amplitude proportional to the amplitude of acoustogravitational waves. (Author abstract) 6 refs.

Belikov, V.V.; Grigor'ev, G.I. *Radiophys Quantum Electron* v 30 n 3 Mar 1987 p 271-275.

**088155 DIAGNOSTICS OF ARTIFICIAL IONOSPHERIC TURBULENCE BY OBLIQUE SOUNDING.** We present the results of experimental investigations of artificial moderate-scale inhomogeneities ( $l_1 \approx 180-2000$

m) in the ionospheric F-layer, produced by intense radio waves. The investigations were performed by means of multifrequency oblique sounding along two tracks with lengths of approx. 300 km. We determine the dimensions of the inhomogeneities which contribute maximally to the scattering of the radio waves along these two tracks. We investigate the spectral shape of the amplitude fluctuations. (Author abstract) 14 refs.

Bakhmet'eva, N.V. (Scientific-Research Inst in Radiophysics, USSR); Ivanov, V.A.; Ignat'ev, Yu.A.; Frolov, V.A.; Shavin, P.B.; Shumakov, V.V. *Radiophys Quantum Electron* v 30 n 3 Mar 1987 p 281-286.

**088156 PECULIARITIES OF THE DEVELOPMENT AND SATURATION OF ARTIFICIAL IONOSPHERIC TURBULENCE DURING A HIGH-POWER DISTURBING TRANSMISSION.** The peculiarities of the wide-band anomalous attenuation of radio waves reflected in a region of the ionosphere disturbed by a high-power pumping wave are investigated experimentally. It is shown that saturation of the anomalous attenuation sets with an increase in the radiation power: Its intensity and time of development are stabilized. This indicates the saturation of the magnitude and spectrum of small-scale artificial inhomogeneities responsible for the effect of anomalous attenuation. The weakening of this effect in the process of development of large-scale artificial inhomogeneities is described. The results of an investigation of the initial stage of self-action of a high-power radio wave under the conditions of cyclic operation of the high-power transmitter are given. (Author abstract) 14 refs.

Berezin, I.V. (Scientific Research Inst of Radiophysics, USSR); Boiko, G.N.; Volkov, V.M.; Zyuzin, V.A.; Komrakov, G.P.; Leonov, A.M.; Maresov, A.N.; Ryzhov, V.A.; Solynin, V.A. *Radiophys Quantum Electron* v 30 n 6 Jun 1987 p 522-529.

**088157 ABLEITUNG EINES FUNKSIGNALMODELLS DER IONOSPHERISCHEN UEBERTRAGUNG.** [Derivation of the Ionospheric Propagation Model of Radio Waves]. In the propagation of HF as well as MF electromagnetic waves over long distances the field strength in the target region varies. It is possible to explain the causes of these variations by defining the properties of a waves' propagation medium and their mutual interactions. The reception of information carried by such a wave can be made quite impossible by fading effects. The random processes describing the radio waves' behavior in the target region may be obtained from Gaussian processes. This paper analyses the amplitude and phase relations between the wave components and defines the conditions for random character changes with Rayleigh distribution at the receiving antenna. (Author abstract) In German. 5 refs.

Vican, Ilja. *NTZ Arch* v 10 n 3 Mar 1988 p 81-85.

**088158 AUTOMATED DISPERSION INTERFEROMETER-POLARIMETER FOR STUDY OF THE IONOSPHERE AND RADIO-WAVE PROPAGATION.** A system is described for reception and automatic recording of signals of the Transitz navigation at coherent frequencies that provides data on the regular and fluctuational variations of amplitude, phase, delay, refraction, and polarization of radio waves as well as on the integral electron content, its space-time gradients, and heterogeneities of the electron concentration in the ionosphere. (Author abstract) 7 refs.

Solodovnikov, G.K.; Russkin, V.M.; Savenkov, A.V. *Instrum Exp Tech* v 30 n 5 Pt 1 Sep-Oct 1987 p 1130-1134.

**088159 VERTICAL ANGLE OF ARRIVAL OF HIGH-FREQUENCY SIGNALS PROPAGATING FROM THULE TO GOOSE BAY.** For brief periods in 1985 and 1986, the high-frequency radar system installed at Goose Bay, Labrador, was used to receive a signal transmitted from Thule, Greenland. With the dual an-



tenna arrays of the radar serving as an interferometer, it was possible to determine the vertical angle of arrival of the received signal. Two different experiments were performed. In one, the signal was swept in frequency from 8 to 20 MHz. In the other, eight discrete frequencies were used, with multiple samples taken for each frequency. From these data a Doppler power spectrum and a cross spectrum were formed, and the vertical angle of arrival was determined from the cross spectrum. Results often showed higher angles of arrival than would be expected, suggesting that the high-latitude ionosphere may exhibit unstratified structures (ionospheric tilts) that could significantly modify the nature of high-frequency communication channels. (Author abstract). 6 Refs.

Baker, Kile B. (Johns Hopkins Univ Applied Physics Lab, Laurel, MD, USA); Greenwald, Raymond A. *Johns Hopkins APL Tech Dig* v 9 n 2 Apr-Jun 1988 p 121-130.

**088160 STEERABLE ELF/VLF RADIATION PRODUCED BY AN ARRAY OF IONOSPHERIC DIPOLES GENERATED FROM HF HEATING.** A very low frequency (VLF) or extremely low frequency (ELF) dipole source has been created within the lower ionosphere by modulating the atmospheric dynamo currents with a ground-based high power HF source from the Arecibo Observatory. It was demonstrated that ELF or VLF generated in this way and injected into the earth-ionosphere waveguide could be received a few thousand kilometers away. The injection properties due to an array of ionospheric dipoles, as a function of array geometry and element currents, that will allow steerable ELF/VLF radiation within the earth-ionosphere waveguide, are investigated theoretically. The ionospheric array factors for a linear and a planar array of Hertzian dipole sources are developed and their properties examined. The principle of pattern multiplication is then applied to include the effect of the ionospheric array element. This provides a means for predicting the field strengths at a remote receiving site due to a steerable linear or planar array of ionospheric sources generated by high power HF periodic plasma heating. 22 refs.

Werner, Douglas H. (Pennsylvania State Univ, University Park, PA, USA); Ferraro, Anthony J. *IEEE Trans Antennas Propag* v AP-35 n 9 Sep 1987 p 1022-1030.

**088161 SHORTWAVE PROPAGATION PREDICTION METHODOLOGIES.** The status of ionospheric-propagation prediction models is examined, with particular emphasis on the use of these models by the shortwave-broadcast community. Their stand-alone capability for forecasts is found to be limited by the use of monthly median, statistical averages of archived ionospheric data, as well as by the use of imprecise control parameter inputs, such as the sunspot number. A variety of developing technologies are discussed for improvement of prediction models. Improvement may result from observations of coronal holes and other relevant solar features for long-term and short-term ionospheric predictions. Also discussed are a variety of other ionospheric measurement schemes for short-term ionospheric predictions, such as the use of vertical-incidence, oblique-incidence, and backscatter sensing from space. The application of this class of measurements for adaptive HF broadcasting systems is discussed. Incorporation of ray-tracing into propagation calculations in the prediction model is also considered. 47 refs.

Goodman, John M. (US Naval Research Lab, Washington, DC, USA); Reilly, Michael H. *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 230-237.

**Propagation in Plasma** See MATHEMATICAL TECHNIQUES—Finite Element Method.

**Propagation in Troposphere**

**088162 RECONSTRUCTION OF THE REFRACTIVE INDEX PROFILE OF THE TROPOSPHERE FROM MEASUREMENTS OF THE FREQUENCY OF SATELLITE SIGNALS.** The inverse problem of radiotransillumination of the earth's troposphere along a path between the earth and the satellite is solved theoretically,

based on Tikhonov's method of regularization for a one-dimensional spherically layered model, and experimentally. Numerical modeling is performed for conditions of normal and anomalous propagation of radio waves. The algorithm was used to determine the different altitude profiles of the refractive index of the troposphere from measurements of the Doppler shift of the frequency of radio signals from a satellite. (Author abstract) 10 refs.

Armand, N.A.; Andrianov, V.A.; Smirnov, V.M. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 52-58.

**Reflection** See Also TELECOMMUNICATION LINKS, RADIO.

**088163 AVERAGE FIELD ABOVE A HALF SPACE WITH A ROUGH SURFACE.** We find expressions for the reflection coefficients of the rough boundary of a layered half space in terms of the 'external' characteristics of a plane boundary. We construct the average Green's functions of the Maxwell equations and the equivalent dyadic impedance. (Author abstract) 8 refs.

Zhuk, N.P. (Kharkov State Univ, USSR). *Radiophys Quantum Electron* v 30 n 5 May 1987 p 451-456.

**088164 MULTIPATH DELAY SPREAD IN A HILLY REGION AT 210 MHZ.** A technique to determine the RF-transfer function and/or the individual delay profiles of reflections has been tested in a hilly region of Switzerland. Investigations of multipath propagation show that the delay spread between the first and the last significant path may be greater than 30 ms. The method of measurement is described, and the propagation conditions are illustrated by representative examples. 5 refs.

Zogg, Andreas (Swiss PTT, Bern, Switz). *IEEE Trans Veh Technol* v VT-36 n 4 Nov 1987 p 184-187.

**Refraction** See Also MILLIMETER WAVES—Propagation in Troposphere.

**088165 ATMOSPHERE REFRACTIVE INDEX FOR ULTRASHORT WAVES UNDER EXTREME CLIMATIC CONDITIONS.** The results of studies of the special features of the spatiotemporal distribution of the air refractive index for ultra-short waves under high latitude conditions are presented. Two types of seasonal variations of the surface values of the refractive index have been revealed on the basis of meteorological observations at five polar stations. The integral statistical distributions of the radiometeorological parameters are presented for each season separately. (Edited author abstract) In Russian. 6 refs.

Chimitorzhiev, N.B. (Darizhapov, D.D.); Zhamseuva, G.S. *Izv Akad Nauk SSSR Fiz Atmos Okeana* v 23 n 9 Sep 1987 p 956-961.

**088166 INVERSE PROBLEM OF REFRACTION IN THE EARTH'S ATMOSPHERE.** A new analytical solution is proposed for the inverse problem of refraction based on the reduction of the initial integral equation of an equation of the convolution type, which is solved by means of a Fourier transformation. The problems of regularization in the numerical solution of the inverse problem employing the fast Fourier transform and the Fourier-Bessel expansion are discussed. (Author abstract). 18 Refs.

Yakubov, V.P.; Simakova, N.A. *Sov J Commun Technol Electron* v 32 n 10 Oct 1987 p 85-91.

**088167 APPLICATION OF KOTEL'NIKOV'S THEOREM FOR DETERMINING THE CONDITIONS OF REGULARIZATION OF THE INVERSE PROBLEM OF REFRACTION.** The reasons for the appearance of instability in the solution of the inverse problem of refraction are analyzed using the discretization theorem (Kotel'nikov's theorem) and the exact analytical solution represented in the form of an integral transformation. The analysis shows that there exists a range in which the solution of the inverse problem is correct, occupying the spectral frequency range from 0 up to  $c/\pi$ , where  $c$  is a constant of the order of unity. In this

range the solution of the inverse problem is stable. The results of the analysis are illustrated by experimental data obtained in the course of one of the sessions of bistatic radar sounding of Venus. The analysis performed is of general value for all problems, which have an exponential order of incorrectness, including for problems of inversions of the Laplace, Stieltjes, and Mellin transforms in finite intervals. (Edited author abstract). 23 Refs.

Pavel'nev, A.G. *Sov J Commun Technol Electron* v 32 n 10 Oct 1987 p 91-101.

**Scattering** See Also ANTENNAS—Arrays; ELECTRIC LINES—Radiation Effects; RADAR—Cross Sections.

**088168 POWER OF A SIGNAL UNDER CONDITIONS OF RADIOACOUSTIC SOUNDING OF THE ATMOSPHERE.** The problem of the scattering of a continuous radio wave by an acoustic pulse propagating in the atmosphere is examined. An expression, which refines the formula found previously in [1], is obtained for the power of the received signal using the Gaussian approximation for the distribution of the fields on the radiators and apertures of the antennas. The characteristics of the operation of the antenna system in the problem of radioacoustic sounding of the atmosphere and the practical results following from this are discussed. (Author abstract) 6 refs.

Kon, A.I.; Tatarskiy, V.I. *Sov J Commun Technol Electron* v 32 n 1 Jan 1987 p 118-123.

**088169 RESONANCE SCATTERING OF RADIO WAVES IN THE ACOUSTICALLY DISTURBED IONOSPHERE.** We consider the resonance scattering of radio waves from an inhomogeneous nonstationary 'lattice' of disturbed electron density. The disturbance arises as a result of the influence of acoustic waves on the ionosphere. We obtain expressions for the reflection coefficient from the lattice in various cases. (Author abstract) 14 refs.

Plotkin, V.V. (Acad of Sciences of the USSR, USSR); Izraileva, N.I. *Radiophys Quantum Electron* v 30 n 5 May 1987 p 440-445.

**088170 CONSTRUCTION OF THE RADIO IMAGE OF AN OBJECT BY THE MAXIMUM PROBABILITY METHOD.** An algorithm for determining the number and parameters (amplitudes and coordinates) of scattering centers lying on the surface of a distant object based on the field recorded in a spatially separated system is synthesized by the maximum probability method. To simplify the procedure for constructing estimates, a recurrence algorithm, which enables one to obtain a solution of the problem with the required accuracy by a simpler method than for the solution of the exact system of nonlinear equations, is synthesized using the small-parameter method. The results of a numerical investigation of the efficiency of the algorithm are presented. (Author abstract). 6 refs.

Ryndin, Yu.G.; Chikin, A.M. *Sov J Commun Technol Electron* v 32 n 10 Oct 1987 p 102-106.

**Space Applications** See ELECTRON TUBES, TRAVELING WAVE—Testing.

**Spread Spectrum** See Also CODES, SYMBOLIC—Measurements; COMPUTER NETWORKS—Protocols; DIGITAL COMMUNICATION SYSTEMS; RADIO RECEIVERS—Digital Devices; RADIO SYSTEMS; RADIO SYSTEMS, MOBILE; TELECOMMUNICATION LINKS, SATELLITE.

**088171 REDUCTION METHOD OF TRACKING ERRORS DUE TO MULTIPATH WAVES IN DIRECT SEQUENCE SPREAD SPECTRUM SYSTEMS.** The spread spectrum (SS) communication is a communication system which has excellent characteristics against noise and is suited to the code-division multiplex. This paper describes a method which reduces the tracking phase error in DLL due to multipath waves in SS



communication system. The method is based on the model with a single multipath wave. (Edited author abstract) 6 refs.

Maruyama, Satoshi (Nagoya Inst of Technology, Nagoya, Jpn); Iwanami, Yasunori; Ikeda, Tetsuo. *Electron Commun Jpn Part 1* v 70 n 9 Sep 1987 p 118-126.

**088172 CONCEPT FOR A SPREAD SPECTRUM COMMUNICATIONS ELECTRONIC WARFARE ANALYSIS AND DESIGN LABORATORY.** The need for the Laboratory is first outlined. The Laboratory will basically have two functions: (a) to assess under laboratory conditions the performance and effectiveness of communications systems and communications electronic support measures (ESM) systems under realistic conditions, rapidly and inexpensively when the electronic threats and environmental parameters related to specific engagements are known and (b) to define the regime of effectiveness of communications and ESM systems and electronic counter-measures (ECM) techniques when the parameters related to the environment, the electronic threats and parameters of the systems under investigation are allowed to vary in a systematic manner. It is expected that the latter role will accelerate the evolution and development of novel communications systems, particularly for military roles, of communication ESM systems and ECM techniques. (Author abstract) 32 refs.

Fourikis, N. (Defence Science & Technology Organisation, Adelaide, Aust); Sobolewski, V.C. *J Electr Electron Eng Aust* v 7 n 2 Jun 1987 p 83-91.

**088173 LOCALISED SPREAD SPECTRUM NETWORK.** The need for many users to be able to communicate within a localized environment gave rise to the Local Area Network (LAN). This paper proposes the adaptation of Spread Spectrum techniques, which were originally developed for military use as a means of providing a jam resistant communication link, to a LAN, the objective being to develop a system capable of maintaining communications in a multiple access high noise environment. (Author abstract) 11 refs.

Simock, A.L. (Footscray Inst of Technology); na Ranong, C.; Leung, P. *J Electr Electron Eng Aust* v 7 n 2 Jun 1987 p 110-116.

**088174 MJERENJE STATISTIKE RADIOSIGNALA U REALNOM VREMENU.** [Real-Time Measuring of Radiosignal Statistics]. A method for the real-time measuring of radiosignal statistics is described. The measuring system consists of receiver, envelope detector, amplifier, analog-to-digital converter and computer. Computer program which controls the converter, calculate the statistics and produces the graphic representation of the results in probability co-ordinate system, is developed. (Edited author abstract) In Serbo-Croatian. 4 refs.

Njegac, R. (Inst Ruder Boskovic, Zagreb, Yugosl). *Elektrotehnika (Zagreb)* v 30 n 2-3 Mar-Jun 1987 p 51-57.

**088175 POWER SPECTRUM, ANTI-INTERCEPT AND SN RATIO CHARACTERISTICS OF DIRECT SEQUENCE SPREAD SPECTRUM COMMUNICATION SYSTEMS USING FIR AND IIR FILTERS.** The time series generated from a direct sequence spread spectrum (DS-SS) signal can be expressed in terms of an auto-recursive (AR) model. An all-zero FIR filter which are the inverse to each other, consist of the parameters of the AR model. We propose a spread spectrum communication system using a FIRF on the transmission side and an IIRF on the receiving side as well as a system using an IIRF on the transmission side and an FIRF on the receiving side. The former is called the DS-SS communication system using FIR-IIR filters and the latter the delay time in the delay element of the AR model of filters are selected properly by the former system, the mission signal can be spread more than that of the DS signal so that the density is lower and the peak value is suppressed. By the latter system, an optimum transmission becomes possible in the sense that the snr is maximum within the main lobe of the psd of the DS signal. (Edited author abstract) 17 refs.

Kusaka, Hiroji (Univ of Osaka Prefecture, Sakai, Jpn); Nishida, Fujio; Simazaki, Yoshihito. *Electron Commun Jpn Part 1* v 70 n 12 Dec 1987 p 84-94.

**088176 ON PERMUTATION INVARIANT SYMMETRIC MULTIPLE ACCESS CHANNELS WITH APPLICATION TO MULTIPLE ACCESS SPREAD-SPECTRUM.** We consider the permutation invariant symmetric M-user multiple access and multiple interference channels. It is shown that choosing equal information rates for all users does not decrease the possible achievable total rate (for given input statistics) or the maximal total capacity (found by maximization of the total rates over all the allowable input statistics). This total rate is equal to the mutual information between the output of the channel and the output of the multiple-access (permutation invariant) device. These results are applied to the M-user binary adder channel corrupted by Gaussian noise, which is used to model coded, quasi synchronized, multiple-access, binary direct sequence spread spectrum systems. Upper and lower bounds on the total maximal achievable rate of reliable transmission of information are evaluated or any M. For  $M \rightarrow \infty$  Gaussian capacity (under the same average power constraints) is approached with users operating at equal powers and equal rates simultaneously. (Author abstract) 36 refs.

Shamir, Shlomo (Technion-Israel Inst of Technology, Haifa, Isr). *AEU Arch Elektron Uebertrag Electron Commun* v 41 n 6 Nov-Dec 1987 p 347-355.

**088177 CYCLICALLY ORTHOGONAL SEQUENCES WITH LOW MULTIPLICITY OF VALUES DERIVED FROM QUADRATIC RESIDUES.** Orthogonal cyclic sequences with low multiplicity of values are given for application to spread spectrum communications systems. Two-, three-, and five-valued orthogonal cyclic sequences are obtained by representing real orthogonal cyclic sequences of length N by cosine series possessing phase constant of odd function, or even function with values  $\{0, \pi\}$ , and by relating the phase constant to quadratic residues of N. Three-valued orthogonal cyclic sequences are obtained by adding a dc component to quadratic residue sequences of these odd and even functions. A two-valued orthogonal cyclic sequence is obtained when a phase constant is given by a quadratic residue sequence of odd function multiplied by a constant. (Edited author abstract) 6 refs.

Tanada, Yoshihiro (Okayama Univ, Okayama, Jpn). *Electron Commun Jpn Part 1* v 71 n 1 Jan 1988 p 30-38.

**088178 NUTZUNG DER SPREAD-SPECTRUM-TECHNIK BEI KOMBINATION DER ASPEKTE NAVIGATION UND TELEKOMMUNIKATION IN SATELLITENSYSTEMEN (TEIL I).** [Application of Spread Spectrum Techniques in Combined Use for Navigation and Telecommunication in Satellite Systems (Part I)]. Spread spectrum techniques offer important advantages for the combined tasks of space-navigation and telecommunication. They are first explained with regard to ranging. Then three examples are presented: The Global Positioning System GPS, the Precise Range and Range Rate System PRARE and the Microwave Time and Ranging Experiment MITREX. The particular advantages of the spread spectrum techniques are, in these cases, the capability of code multiplexing, signal regeneration and low power spectral density, respectively. All three systems take advantage of the inherent flexibility and reliability. (Author abstract) 9 refs. In German.

Hartl, Von Philipp (Univ Stuttgart, West Ger); Schaefer, Wolfgang. *Frequenz* v 41 n 11-12 Nov-Dec 1987 p 321-328.

**088179 RAPID ACQUISITION SCHEME FOR SPREAD-SPECTRUM RADIO IN A FADING ENVIRONMENT.** A modified two-level scheme for coarse code acquisition of spread-spectrum signals in a fading environment is considered. The scheme uses a bank of passive correlators followed by a bank of active correlators. The passive correlators are matched to short sync prefixes, which are interspersed in the incoming signal.

The passive devices correlate over sliding windows (in time), providing a rapid search capability. Threshold exceedances of the passive correlators are used to initiate active correlation over longer time intervals so that high reliability of decision is obtained. The multiple sync prefixes reduce the probability of missing the signal in a fading environment. An analytical model based on queueing and detection theory results is developed, and optimization of the scheme is treated. A Gilbert model is used to characterize the signal fading on the channel. The performance in the presence of background noise with noise jamming is analysed. (Edited author abstract) 14 refs.

Wilson, N.D. (State Univ of New York, Stony Brook, NY, USA); Rappaport, S.S.; Vasudevan, M.M. *IEE Proc Part F* v 135 n 1 Feb 1988 p 95-104.

**088180 CORRELATION PROPERTIES OF DUAL-BCH, KASAMI AND OTHER SEQUENCES FOR SPREAD-SPECTRUM, MULTIPLE-ACCESS SYSTEMS.** Odd correlation functions and average interference parameters for dual-BCH, small sets of Kasami sequences and a new set of sequences are investigated. Results are presented for periods up to 255, and an investigation into the effects of choice of initial phase is included. Results indicate that the new sequences provide a level of multiple-access performance which is on average similar to other sequences, but is insensitive to variations in the statistics of the data used to modulate the sequences. (Author abstract) 12 refs.

Goswami, C.S. (Univ of Manchester, Manchester, Engl); Beale, M. *IEE Proc Part F* v 135 n 1 Feb 1988 p 114-117.

**088181 NUTZUNG DER SPREAD-SPECTRUM-TECHNIK BEI KOMBINATION DER ASPEKTE NAVIGATION UND TELEKOMMUNIKATION IN SATELLITENSYSTEMEN (TEIL II).** [Application of Spread Spectrum Techniques in Combined Use for Navigation and Telecommunication in Satellite Systems (Part II)]. This article discusses ranging problems. Discussed are: multiplex codes - gold codes, compressed codes, QPSK modulation; practical applications to GPS/NAVSTAR, PRARE (precise range and range rate equipment), and MITREX. In German. 2 refs.

Hartl, Philipp (Univ Stuttgart, West Ger); Schaefer, Wolfgang. *Frequenz* v 42 n 1 Jan 1988 p 29-34.

**088182 GENERALIZED ANALYSIS FOR A DUAL THRESHOLD SEQUENTIAL DETECTION PN ACQUISITION RECEIVER.** A dual threshold sequential detection receiver is analyzed and a general expression is derived which addresses the probability that the sequential detection pseudorandom noise (PN) acquisition procedure ceases after an arbitrary number of samples following which either a dismissal or detection declaration is made. This expression is made up of two terms which are related to crossing the upper and lower thresholds of a dual threshold receiver. In order to obtain a closed-form solution, an approximation was made in which the final expression was conditioned on the previous two samples. This expression is significantly more complex for dual threshold implementation as opposed to the single threshold/maximum sample time receiver design, and is needed in order to support a characteristic function approach in deriving acquisition probability as a function of time. 21 refs.

Compartetto, Gary M. (M/A COM Linkabit, Vienna, VA, USA). *IEEE Trans Commun* v COM-35 n 9 Sep 1987 p 956-960.

**088183 SPREAD-SPECTRUM MULTIPLE ACCESS USING WIDEBAND NONCOHERENT MFSK.** Two spread-spectrum multiple access systems which use wideband M-ary frequency-shift keying (MFSK) as the primary modulation are presented. A bit-error-rate performance analysis is presented and system throughput is calculated for sample C-band and Ku-band satellite



systems. Sample link analyses are included to illustrate power and adjacent satellite interference considerations in practical multiple access systems. 4 refs.

Maggenti, Mark A. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Ha, Tri T.; Pratt, Timothy. *IEEE Trans Aerosp Electron Syst* v AES-23 n 6 Nov 1987 p 767-775.

**088184 GENERALIZED MINIMUM SHIFT-KEYING MODULATION TECHNIQUES.** The simultaneous data demodulation and phase tracking of an MSK signal using the Viterbi algorithm is described, and two variations of MSK modulation are studied. The MSK with overlay is a dual-rate modulation technique in which low-rate and high-rate data are superimposed on an MSK signal. Here the demodulator uses the Viterbi algorithm to estimate both the low-rate and high-rate data simultaneously. The MSK with pseudorandom sequence spreading combats intentional or unintentional jamming. A simplified receiver for these spread-spectrum MSK signals is found that takes into consideration the effect of random phase perturbations. The performance of these demodulators is evaluated using transfer-function bounds for the bit error probability. For demodulation of the spread-spectrum MSK signal, a simplified receiver is derived, and its performance in the presence of continuous jamming is evaluated. 26 refs.

Sadr, Ramin (Univ of California, Los Angeles, CA, USA); Omura, Jim K. *IEEE Trans Commun* v 36 n 1 Jan 1988 p 32-40.

**088185 PERFORMANCE OF DS/SSMA COMMUNICATIONS IN IMPULSIVE CHANNELS - II: HARD-LIMITING CORRELATION RECEIVERS.** In part I it was demonstrated that impulsive channel noise can be a serious detriment to the performance of direct-sequence spread-spectrum multiple-access (DS/SSMA) communications when conventional linear correlation reception is used. Here, a hard-limiting correlator as an alternative for reception of multiple-access transmission in impulsive channels is considered. For K asynchronous binary PSK DS/SSMA users sharing a linear channel corrupted by impulsive noise that is modeled at the output of the front-end filter of the receiver, techniques are developed for analyzing bit error probabilities of this hard-limiting receiver by exact computation for short spreading sequences, by approximation for longer spreading sequences, and by asymptotic limits for infinitely long spreading sequences. Performance is compared to that of the linear correlator under a variety of conditions, showing that hard-limiting correlation reception can offer substantial improvement over conventional systems in impulsive channels. However, the linear receiver is more effective against multiple-access noise only, and so a tradeoff emerges between rejection of impulsive noise and rejection of multiple-access interference. 26 refs.

Aazhang, Behnaam (Rice Univ, Houston, TX, USA); Poor, H. Vincent. *IEEE Trans Commun* v 36 n 1 Jan 1988 p 88-97.

**088186 SPREAD-SPECTRUM MULTIPLE-ACCESS PERFORMANCE OF ORTHOGONAL CODES: IMPULSIVE NOISE.** A direct-sequence, spread-spectrum, multiple-access (SSMA) communication system that assigns a set of M-orthogonal sequences to each user is analyzed. An accurate model is incorporated for the impulsive noise that characterizes the LF and MF bands, so that the SSMA receiver operates in a combination of multiple-access interference and impulsive (atmospheric) noise. The performance of a linear receiver operating in such an environment is analyzed, and probability-of-error curves are presented. The presence of impulsive noise motivates the derivation and analysis of a nonlinear receiver that uses a variable-gain stage to suppress noise impulses. This receiver is effectively optimum when the signal amplitudes are below a certain bound and when the noise and interference samples are independent, or nearly so. However, the gain stage of this nearly optimum receiver depends on the noise model parameters including the various user delays. Consequently, a nonparametric receiver that incorporates a

simple clipper is also analyzed. The asymptotic relative efficiency of both receivers is determined. 25 refs.

Enge, Per K. (RACAL-Megapulse Inc, Bedford, MA, USA); Sarwate, Dilip V. *IEEE Trans Commun* v 36 n 1 Jan 1988 p 98-106.

**088187 PERFORMANCE OF FH/QPSK SIGNALS UNDER FREQUENCY SELECTIVE FADING AND PARTIAL BAND TONE JAMMING.** The probability of bit error is evaluated for a communication system using frequency hopping for jamming rejection and quadrature partial-response signaling for baseband modulation. The environment in which the system is operating is modeled as severe partial-band tone jamming under frequency-selective fading affecting both the signal and the jammer. Error-correction coding is used to improve the performance of the system. 3 refs.

Noor, Fazal (Concordia Univ, Montreal, Que, Can); Elhakeem, A.K.; Le Ngoc, Tho. *IEEE Trans Commun* v 36 n 1 Jan 1988 p 113-118.

**088188 REJECTION OF MULTIPLE NARROW-BAND INTERFERENCE IN BOTH BPSK AND QPSK DS SPREAD-SPECTRUM SYSTEMS.** The performance of direct-sequence spread-spectrum systems using a suppression filter in the presence of multiple narrowband interference with rational spectral densities is analyzed. Both BPSK and QPSK systems are considered, and analytical expressions for both the mean-square error of the filter output and the performance improvement are established. When the bandwidths of the narrowband components of the interference are all small, approximate expressions are obtained and used to provide further insight into the behavior of the system. Results are presented for the limiting case when the bandwidths approach zero (i.e., when multiple narrowband interference becomes multiple sinusoidal interference). 15 refs.

Wang, Yong-Cheng (Univ of California at San Diego, La Jolla, CA, USA); Milstein, Laurence B. *IEEE Trans Commun* v 36 n 2 Feb 1988 p 195-204.

**088189 PN CODE SYNCHRONIZATION EFFECTS ON NARROW-BAND INTERFERENCE REJECTION IN A DIRECT-SEQUENCE SPREAD-SPECTRUM RECEIVER.** The impact of imperfect synchronization on the performance of prediction-error interference rejection filters in noncoherent direct-sequence (DS) spread-spectrum communications is considered. Bit-error-rate (BER) analysis of binary DPSK (differential phase-shift keying) data modulation used in conjunction with direct-sequence spread-spectrum is used as a performance measure. A first-order noncoherent delay-lock loop is used for the pseudonoise (PN) code tracking. Conditional BER results for the DS/DPSK systems for fixed values of the code tracking error are obtained. The average BER of the system is then evaluated by averaging the conditional BER expressions over the probability density function of the code tracking error. Results include the effects of both a single fading tone and a narrowband Gaussian interferer on the overall system performance. Interferer offset frequency is considered in determining the code tracking loop noise as well as the receiver BER. 18 refs.

Goldberg, Steven H. (Univ of California, Santa Barbara, CA, USA); Iltis, Ronald A. *IEEE Trans Commun* v 36 n 4 Apr 1988 p 420-429.

**088190 MODULATABLE ORTHOGONAL SEQUENCES AND THEIR APPLICATION TO SSMA SYSTEMS.** A set of N-1 orthogonal sequences of period  $N^2$  is proposed, where N is a natural number. Each orthogonal sequence proposed can be modulated by N complex numbers of absolute value 1, so the modulated sequence is also orthogonal. When N is an odd prime number, the absolute value of the cross-correlation function between any two of the N-1 orthogonal sequences is constant and satisfies the mathematical lower bound. This property of the cross-correlation function is not changed when each of the two orthogonal sequences is modulated by N complex numbers of absolute value 1.

Two spread-spectrum multiple-access (SSMA) systems using these sequences are proposed. One system is an asynchronous SSMA system, using the proposed sequences unmodulated. The cochannel interference peak between any two channels in this system realizes the mathematical lower bound for an asynchronous SSMA system using a set of orthogonal sequences. The other system is a synchronous SSMA system without cochannel interference which uses the modulated form of the proposed sequences. 5 refs.

Suehiro, Naoki (Toshiba Corp, Jpn); Hatori, Mitsutoshi. *IEEE Trans Inf Theory* v 34 n 1 Jan 1988 p 93-100.

**088191 PERFORMANCE OF A CLASS OF PARALLEL SPREAD-SPECTRUM CODE ACQUISITION SCHEMES IN THE PRESENCE OF DATA MODULATION.** An acquisition procedure for data-modulated direct-sequence spread-spectrum systems is investigated. The correlation time is partitioned into subintervals, and the integration results in these subintervals are noncoherently combined for detection. The tradeoff between noncoherent combining loss and data modulation degradation guides the optimum choice of the number of subintervals. Two forms of data modulation are considered, namely, the alternate-data and random-data cases. The parallel acquisition schemes discussed allow multiple code-phase offsets to be examined at each test. The circular state diagram approach is used to analyze the performances of these schemes. The theory presented is valid for a class of such parallel schemes. 15 refs.

Cheng, Unjeng (JPL, Pasadena, CA, USA). *IEEE Trans Commun* v 36 n 5 May 1988 p 596-604.

**088192 PACKET ERROR PROBABILITIES IN FREQUENCY-HOPPED SPREAD-SPECTRUM PACKET RATIO NETWORKS - MEMORYLESS FREQUENCY-HOPPING PATTERNS CONSIDERED.** The packet error probability induced in a frequency-hopped spread-spectrum packet radio network is computed. The frequency spectrum is divided into q frequency bins. Each packet is exactly one codeword from an (M,L) Reed-Solomon code [M = number of codeword symbols (bytes); L = number of information symbols (bytes)]. Every user in the network sends each of the M bytes of his packet at a frequency chosen among the q frequencies with equal probability and independently of the frequencies chosen for other bytes (i.e., memoryless frequency-hopping patterns). Statistically independent frequency-hopping patterns correspond to different users in the network. Provided that K users have simultaneously transmitted their packets on the channel and a receiver has locked on to one of these K packets, the probability that this packet is not decoded correctly is evaluated. It is also shown that although memoryless frequency-hopping patterns are utilized, the byte errors at the receiver are not statistically independent; instead they exhibit a Markovian structure. 6 refs.

Georgiopoulos, Michael (Univ of Central Florida, Orlando, FL, USA). *IEEE Trans Commun* v 36 n 6 Jun 1988 p 720-723.

**088193 RAPID CODE ACQUISITION ALGORITHMS EMPLOYING PN MATCHED FILTERS.** The performance of four algorithms using pseudonoise matched filters (PNMFs), for direct-sequence spread-spectrum systems, is analyzed. They are: parallel search with fix dwell detector (PL-FDD), parallel search with sequential detector (PL-SD), parallel-serial search with fix dwell detector (PS-FDD), and parallel-serial search with sequential detector (PS-SD). The operation characteristic for each detector and the mean acquisition time for each algorithm are derived. All the algorithms are studied in conjunction with the noncoherent integration technique, which enables the system to operate in the presence of data modulation. Several previous proposals using PNMf are seen as special cases of the present algorithms. 26 refs.

Su, Yu T. (LinCom Corp, Los Angeles, CA, USA). *IEEE Trans Commun* v 36 n 6 Jun 1988 p 724-733.



## Standards

**088194 REVIEW OF CCIR VOLUMES IX (FIXED SERVICE USING RADIO-RELAY SYSTEMS) AND IV/IX (FREQUENCY SHARING AND COORDINATION BETWEEN SYSTEMS IN THE FIXED-SATELLITE SERVICE AND RADIO-RELAY SYSTEMS).** This article reviews the contents contained in Volume IX of CCIR and includes texts dealing with frequency sharing with Study Group 4. These texts are newly approved at the XVth CCIR Plenary Assembly after discussions at the Interim and Final meetings. 13 refs.

Takasugi, Toshio. *J Radio Res Lab (Jpn)* v 34 n 143 Nov 1987 p 141-171.

**Switzerland** See ELECTROMAGNETIC COMPATIBILITY—Legislation.

## Testing

**088195 EXPERIMENTAL STUDY OF PROPAGATION CHARACTERISTICS ON ROADS ON A SNOWY MOUNTAIN.** Experimental results of radio propagation characteristics on roads on snowy or snow-capped mountains are discussed. Propagation tests were carried out on the horizontal and vertical polarization characteristics in a frequency range from VHF to X-band. Field strengths along the road and field distributions in the cross section were measured. The attenuation constants in a straight-road section were obtained by the least-squares method using measured data. It is shown that the attenuation constants are experimentally minimum in a frequency range of 1-3 GHz for each polarization, and that field strengths in the cross section are close to cosine distribution in the horizontal direction, and in the vertical direction, increase nearly monotonically with increasing elevation. 8 refs.

Ohtaki, Yukio (Niigata Univ, Niigata, Jpn); Yamaguchi, Yoshio; Abe, Takeo. *IEEE Trans Electromagn Compat* v 30 n 2 May 1988 p 137-144.

**Theory** See WAVEGUIDE COMPONENTS—Couplers.

## United Kingdom

**088196 TOWARDS THE INTELLIGENT RADIO.** The author reports on RDS - the vhf Radio Data System and its implementation in the UK. The vhf Radio Data System described in this article is the product of the international working group which was set up by the EBU and in which the BBC was an active participant. The development and experimental period spanned the years 1974-1982, and several countries participated in the work. The objective was to develop a system which would be rugged enough to provide a viable service under all practical reception conditions, but would be compatible with the millions of receivers which already existed in the hands of the public to the extent of not generating any audible interference. Experimental transmissions over the last decade have proved the viability of the chosen system. 3 refs.

Shute, Simon (BBC). *Electron Wireless World* v 93 n 1620 Oct 1987 p 1023-1026.

**RADIO TRANSMITTERS** See Also ANTENNAS, DIRECTIVE—Directional Patterns; GEOPHYSICS—Electromagnetic; MODELS—Remote Control; RADIO BROADCASTING—United States; RADIO INTERFERENCE—Jamming; RADIO SYSTEMS, MOBILE; RADIO TRANSMISSION—Propagation in Ionosphere; TELECOMMUNICATION LINKS, SATELLITE.

**088197 MATERIAL TRACKING USING NON-DEDICATED TRANSMITTERS.** The use of existing high-power radar, television, or radio transmitters as nondedicated interrogators for medium and long-range tracking or identification systems may be applicable to monitoring nuclear material during transport or storage. The basis of this type system is that some character of the transmitter signal, such as modulation or timing, may be used to selectively actuate a remote transponder to transmit a single or coded pulse burst so that a base

station, receiving both the interrogation and response, could locate or identify the transponder. Although such a system severely constrains the designer by removing control of the interrogator frequency, coding, or operating status, the costs and complexities of design, construction, licensing, and operation of a high-power transmitter are also eliminated. Illustrative systems employing commercial radio and television signals are briefly discussed, and a detailed description is provided of a long-search radar in a non-dedicated mode to track small boats with transponders cooperatively or covertly placed. Design procedures and range projections for this system are presented along with some preliminary results obtained with reduced transmitter power. (Author abstract)

Mawhinney, Daniel D. (David Sarnoff Research Cent, Princeton, NJ, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 207-211.

**Components** See Also AMPLIFIERS, POWER TYPE—Design.

**088198 SAW STABILIZED MONOLITHIC PULSE AMPLITUDE MODULATED MICROTRANSMITTER.** A low-power SAW-stabilized monolithic micro-transmitter has been developed. This device replaces all of the RF circuitry in a low-cost transmitter, such as these used in wireless security systems, and makes it possible to meet FCC specifications without costly design iterations. The oscillator in the transmitter is controlled by a third-generator SAW resonator that eliminates the need for impedance-matching or phase-shifting networks in the signal feedback path. This type of resonator made the monolithic transmitter design possible. The theory of operation, system architecture, and performance are presented.

Robinson, J. Michael (RF Monolithics, Dallas, TX, USA). *IEEE Trans Consum Electron* v CE-33 n 3 Aug 1987, 1987 Int Conf on Consum Electron, Rosemont, IL, USA, Jun 3-5 1987 p 405-412.

## Efficiency

**088199 IMPROVED HIGH EFFICIENCY 500 KILOWATT SHORT WAVE BROADCAST TRANSMITTER WITH NOVEL FEATURES.** Some of the changes in international broadcaster's HF (high-frequency) transmitter needs are addressed, along with some adaptations in HF transmitter design to reflect those needs. The authors identify three fundamental changes in the emphasis of international broadcast transmitter requirements: due to increasing energy costs, more emphasis has been placed on equipment power efficiency; due to increasing labor costs, more attention is being paid to automation and ease of maintenance, i.e., manpower efficiency; and, third, because of spectrum crowding, improved spectral occupancy has become a concern, particularly with respect to transmitted signal purity, and spectral-efficient modulation modes. Several developments designed to meet these needs of broadcasters are described. The issue of power efficiency has been met with improved transmitter RF and modulator circuits. RF efficiency has been improved in part by lowering losses in RF output coupling circuits. This improvement is afforded by better network design, and better automatic tuning, i.e., tuning for best efficiency. More efficient RF output tubes have also been developed recently.

Mina, Adil; Weldon, J.O.; Hulsey, Gilmer. *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 134-136.

## Evaluation

**088200 EVALUATION OF 500 kW SHORTWAVE TRANSMITTERS AT THE VOICE OF AMERICA.** The Voice of America (VOA) has initiated a major program to modernize and expand its worldwide broadcast system. The program includes the procurement of 500-kW shortwave transmitters both for new stations and as replacements for aging and less efficient equipment in existing facilities. To develop and verify a specification for

new transmitters, four currently available 500-kW transmitters were purchased from separate vendors for evaluation at the VOA facility in Greenville, North Carolina. The intent of this off-the-shelf approach was to ensure a proper level of technical rigor in the specification without unduly restricting competition among suppliers. The evaluation focused on a variety of factors including installation, performance, operability, and maintainability. The procedures followed during the evaluation are described and some of the salient findings are presented.

Berman, Gerald A. (Voice of America, Washington, DC, USA); Garlington, Thomas R. *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 147-153.

## Modulation

**088201 MERITS OF MODERN TECHNOLOGY FOR TODAY'S HIGH POWER SHORT-WAVE TRANSMITTERS.** Recent developments of high-power shortwave transmitters are described, and practical experience with such transmitters is reported. Topics discussed are: high-level anode modulation, the pulse step modulator (PSM), the switching module, control of the PSM, the RF driver and final stage, and other modulation techniques. 13 refs.

Schminke, Wolfram (Asea Brown Boveri, Turgi, Switz). *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 126-133.

**Monitoring** See CONTROL SYSTEMS—Computer Interfaces.

**Multiplexing** See ANTENNAS—Arrays.

## United States

**088202 RENAISSANCE OF PRIVATELY-LICENSED SHORTWAVE BROADCAST STATIONS IN THE UNITED STATES.** The present status of privately licensed shortwave broadcast stations in the US is reviewed. The stations are identified, and their reasons for broadcasting are examined. The laws, rules, and regulations which permit these stations to operate in a world of government-funded stations are discussed, along with the technical standards that they are required to meet, and the particular technical problems that they face. 17 refs.

Jacobs, George (George Jacobs & Associates Inc, Silver Spring, MD, USA). *IEEE Trans Broadcast* v 34 n 2 Jun 1988 p 87-93.

**RADIOACTIVATION ANALYSIS** See Also CHEMICAL ANALYSIS—Activation; NEUTRONS—Sources.

**088203 OPTIMIZATION OF MULTIELEMENT GAMMA ACTIVATION ANALYSIS.** It is important and urgent to study the experience gained in applying the computational approach in order to develop methods for optimizing multielement  $\gamma$  activation analysis (GAA). In this work such a study is carried out based on the results of a comparison of computed and measured, in optimal regimes of  $\gamma$  spectra, activity induced by bremsstrahlung from electron accelerators in standard samples of igneous traprock (ST-1A standard). The regimes of activation and recording were calculated using the OPTIMUM program, developed in accordance with an optimization algorithm. The efficiency of the mathematical model was confirmed in previous experiments. 14 refs.

Davydov, M.G.; Kishel-gof, V.V.; Chapyzhnikov, B.A.; Shcherbachenko, V.A. *Sov At Energy* v 62 n 1 Jan 1987 p 43-48.

**088204 NEUTRON-ACTIVATION MEASUREMENTS IN INTENSE FIELDS OF REACTOR RADIATION.** The authors touch on the main aspects of standardization of neutron-activation measurements in intense reactor fields, indicate methods for development standardization of neutron-activation measurement means, and give practical recommendations for experi-



ment design. Standardized neutron-activation measurement means are being serially produced, the required nuclear-physics reference data are being systematized, and procedures for measurements and result processing are being developed. Reference data are presented that allow the necessary calculations for planning neutron-activation measurements to be performed. The principal quantity for preparation of neutron-activation detectors is the mass  $m$  of the nuclide target in the detector. The procedure for calculating this quantity is discussed. 4 refs.

Varyna, V.P.; Grigor'ev, E.I. *Meas Tech* v 29 n 1 Jan 1986 p 58-60.

**088205 RADIOACTIVATION MONITORING OF LOCAL SURFACE DAMAGE.** The processes causing surface damage on objects are complex and dissimilar. Apart from a uniform removal of an entire surface, one often observes local damage; scoring, discoloration, fretting corrosion, and erosion, knife-line corrosion and pitting, cavitation, etc. Monitoring the formation and development of cavities and pits is important for diagnosing the state of a component or a unit, for averting in due time a decrease in efficiency or failure of equipment, and for investigation of the damage mechanism and the development of measures for increasing the stability of materials. This article discusses radioactivation monitoring techniques applied to local surface damage. 16 refs.

Konstantinov, I.O.; Leonov, A.I.; Koshal', M.D.; Yavel'skii, M.B. *Sov At Energy* v 63 n 1 Jul 1987 p 505-509.

## Optimization

**088206 OPTIMIZING ROUTINE MULTIELEMENT ACTIVATION ANALYSIS.** Various nuclear-physics methods are used in analyzing materials, which are based on reactions produced by neutrons, high-energy photons, protons, deuterons, and alpha particles. These methods provide high sensitivity, accuracy, and rapidity. Various reactions may occur on irradiation, particularly in fast-neutron and high-energy gamma-ray activation. The authors examine existing and proposed criteria for optimizing gamma spectrometry, which have been used in optimal methods for routine multielement analysis of soils and plants by means of 14 MeV neutrons. Optimizing an activation-analysis method amounts to examining a function (optimization criterion) dependent on controlled parameters. The reliability and accuracy are very much dependent on the criterion and on the processing methods. 4 refs.

Novikov, A.I.; Stolyarova, E.L.; Savel'ev, I.B. *Meas Tech* v 30 n 1 Jan 1987 p 111-114.

**RADIOACTIVE MATERIALS** See Also AEROSOLS—Transport Properties; MOLYBDENUM AND ALLOYS—Isotopes; NUCLEAR ENGINEERING—Public Policy; NUCLEAR POWER PLANTS—Accident Prevention.

## Absorption

**088207 RADIONUCLIDE SORPTION METHODOLOGIES FOR PERFORMANCE ASSESSMENTS OF HIGH-LEVEL NUCLEAR WASTE REPOSITORIES: A PERSPECTIVE GAINED FROM AN NRC WORKSHOP.** A workshop to discuss the characterization and modeling of radionuclide sorption processes in rock-water systems relevant to the isolation of high-level nuclear waste in geologic repositories was held May 13-15 1986, by U.S. Nuclear Regulatory Commission staff and contractors. The key recommendations of the workshop were that (1) a limited understanding of sorption phenomena will be needed to demonstrate reasonable assurance of compliance with regulatory repository-performance requirements; (2) understanding of sorption phenomena must be developed through laboratory studies complemented by field studies and consideration of natural analogs; (3) both site-specific and more fundamental laboratory studies designed to elucidate sorption mechanisms will be necessary components of a successful sorption program; (4) methods of modeling sorption that are more sophisticated than the single-value  $K_D$  model will be needed to support repository-performance assess-

ments; and (5) the level of sophistication of sorption models will depend on the radionuclide(s) of interest, available supporting laboratory data, and the level of isolation performance assigned to sorption processes. (Author abstract) 50 refs.

Kelmers, A.D. (Oak Ridge Natl Lab, USA); Meyer, R.E.; Blencoe, J.G.; Jacobs, G.K. *Nucl Saf* v 28 n 4 Oct-Dec 1987 p 515-522.

## Adsorption

**088208 ADSORPTION OF NATURAL RADIONUCLIDES ON PYROLUSITE.** Analysis of Ra, Th, and Po in water samples and low active effluents from a U mining and milling complex generally involves pre-concentration of samples carried out by co-precipitation or by evaporation. This paper describes an alternative method by way of adsorption of these radionuclides on pyrolusite pebbles in a column and their subsequent elution with dilute  $HNO_3$ . Ninety-three to 99% Ra, 80 to 87% Po, and 90 to 98% Th could be separated into 300 mL of acid solution from water samples of the order of 10 to 20 L. The method is found to be inexpensive and more convenient than other methods, without sacrificing the efficiency of extraction. (Author abstract) 5 refs.

Markose, P.M. (BARC, Singhbhum, India). *Water Air Soil Pollut* v 35 n 3-4 Oct 1987 p 381-386.

## Analysis

**088209 SPONTANEOUS FISSION HALF-LIFE OF  $^{249}Cf$ .** The spontaneous fission half-life of  $^{249}Cf$ , which was calculated on the basis of the mass and the composition of the sample material, the exposure time, the recording efficiency, and the number of recorded fission tracks, is  $T_{s,f} = (8.5 \pm 0.5) \cdot 10^{10}$  years after averaging the results of the measurements made with two types of dielectric detectors. The ratio of the probabilities of  $^{249}Cf$  decay by  $\alpha$ -particle emission and spontaneous fission was calculated from the ratio of the intensities of  $\alpha$  decay and spontaneous fission:  $P_{\alpha}/P_{s,f} = T_{s,f}/T_{\alpha} = 2 (2.32 \pm 0.17) \cdot 10^8$ . 7 refs.

Tarantin, N.I.; Buklanov, G.V.; Kim Su Men; Korotkin, Yu.S. *Sov At Energy* v 62 n 5 May 1987 p 407-409.

## Applications

**088210 OPERATION OF AN INDUSTRIAL RADIATION PROCESSING FACILITY IN MEXICO.** A 10 year old JS-6500 industrial Cobalt 60 irradiator was installed in 1980 at the ININ Nuclear Center in Mexico with 960 kGy. The facility was commissioned with some minor changes with respect to the original AECL design, in order to give services to different industries and also to do research in several fields. During 1981-1984 the demand increased but never reached more than 50% of the capacity. At present, there are 34 different companies irradiating 48 different products. Even those within the same grouping require different minimum and maximum radiation doses, so the facility has been operated by combining products and volumes. The experiences are presented in this paper. Also, maintenance of the irradiator is discussed and some modifications to the original programme have been done due to the necessity to use local spare parts instead of imported ones. (Edited author abstract) 1 ref.

Torres, Gilberto C. (Inst Nacional de Investigaciones Nucleares, Mexico City, Mex). *Radiat Phys Chem* v 31 n 1-3, Progr in Radiat Process, Proc of the 6th Int Meet, Ottawa, Ont, Can, May 31-Jun 5 1987 p 281-291.

**088211 PROGRESS IN GAMMA PROCESSING OF COMMERCIAL PRODUCTS.** A survey of gamma radiation processing worldwide is presented. It is estimated that 30 to 40% of the world's medical disposable products are radiation sterilized. Food irradiation, on the other hand, is in the embryonic stage of its development but is showing great promise. Emerging applications for radiation processing in the cosmetics and pharmaceutical industries, as well as in sewage sludge and materials

processing, are currently being assessed. Today, cobalt 60 production capacity has increased by a factor of 4 to in excess of 50 million curies per annum. This capacity should be doubled in the next five to ten years. The United States leads the world in the use of industrial irradiators. However, in the rest of the world the markets are constantly increasing. The Far East has moved into second place, replacing the European market now in third place.

Fraser, F.M. (AECL, Kanata, Ont, Can). *Radiat Phys Chem* v 31 n 1-3, Progr in Radiat Process, Proc of the 6th Int Meet, Ottawa, Ont, Can, May 31-Jun 5 1987 p 303-308.

## Chemical Analysis

**088212 ANALYSIS OF TISSUE SAMPLES CONTAINING COLLOIDAL THORIUM DIOXIDE (THOROTRAST) OR ZIRCONIUM DIOXIDE (ZIRCONOTRAST): RADIOCHEMICAL PREPARATION AND ALPHA-SPECTROMETRY.** The aim of the present study is to assess the activity of the thorium isotopes, Th-232, Th-230, and Th-228 in tissue samples containing Thorotrast or Radiozirconotrust, i.e. Th-230 and Th-228 enriched Zirconotrust, in order to enable calculations of tissue doses. A procedure was developed for radiochemical processing of these samples, and a computerized alpha-spectroscopy system has been constructed for routine activity measurements. The procedure developed for sample preparation permitted complete radiochemical processing of the above tissue samples. With regard to the great number of samples to be measured and the expected counting times of more than 1500 min, a computerized alpha-spectroscopy system with a sample conveyor has been constructed. (Edited author abstract) 7 refs.

Dalheimer, A.R. (Inst fuer Strahlenhygiene, Neuherberg, West Ger); Kaul, A.; Said, M.D. *Sci Total Environ* v 70 Mar 1988, Environ Radiochem Anal, Proc of the Fifth Symp, Harwell, Engl, Oct 1-3 1986 p 335-353.

**Chemical Reactions** See NUCLEAR FUELS—Radiation Effects.

**Concentration** See AIR POLLUTION—Radiation Effects; FLOW OF WATER—Underground.

**Decontamination** See WASTEWATER—Decontamination.

**Diffusion** See Also AEROSOLS—Transport Properties; NUCLEAR POWER PLANTS—Accidents; NUCLIDES—Radioactive.

**088213 THREE-DIMENSIONAL GROUNDWATER FLOW AND ADVECTION DIFFUSION CODE FOR TREATING DECAY CHAIN OF RADIOACTIVE MATERIALS BY FINITE ELEMENT METHOD.** A code - PER8MIGR - based on finite element method, and incorporating an 8-node isoparametric elements has been developed for solving in 3-dimensional treatment the groundwater flow and advection diffusion equations involving the decay chain of radioactive substances. Galerkin's method is applied to discretize the permeability and advection diffusion equations, and linear matrix equations are solved by band matrix method. The Code is verified for applicability by agreement seen in benchmark tests for groundwater flow in which comparisons are made of the results obtained using the code with those of one- and three-dimensional analyses and with HYDROCOIN Level-1 Case-1 solution, and also in tests for nuclide, migration with the results obtained using other codes-AT123D, SWIFT, F.E.M. code of LBL and MIG3D in INTRACON test. The present work should permit accurate estimation of the flow and diffusion behavior to be expected of high- and low-level radioactive wastes in geological formation of complex geometry. (Author abstract) 10 refs.

Kawamura, Ryuji (Japan Information Service Ltd, Tokyo, Jpn). *J Nucl Sci Technol* v 24 n 11 Nov 1987 p 937-950.



**Environmental Impact** See Also AIR POLLUTION—Analysis.

**088214 PLUTONIUM AND Cs-137 IN AUTOPSY TISSUES IN GREAT BRITAIN.** Tissues removed at autopsy from members of the general public contain significantly higher concentrations of plutonium and <sup>137</sup>Cs in west Cumbrians than in people from three other regions of Great Britain. Several autopsy cases from Cumbria showed unusually high values of plutonium. Subsequently it was found that the subjects had been former employees of British Nuclear Fuels. (Author abstract) 7 refs.

Popplewell, D.S. (Nat'l Radiological Protection Board, Didcot, Engl); Ham, G.J.; Dodd, N.J.; Shuttler, S.D. *Sci Total Environ* v 70 Mar 1988, Environ Radiochem Anal, Proc of the Fifth Symp, Harwell, Engl, Oct 1-3 1986 p 321-334.

**Environmental Testing**

**088215 SEQUENTIAL ANALYTICAL METHOD FOR THE DETERMINATION OF U-238, Th-232, Th-230, Th-228, Ra-228 AND Ra-226 IN ENVIRONMENTAL SAMPLES.** Uranium and thorium isotopes are initially separated using tri-n-octyl phosphine oxide (TOPO) supported on a column of silica gel. The uranium isotopes are determined by alpha-spectrometry following extraction with TOPO onto a polymeric membrane. Thorium isotopes are coprecipitated with lanthanum fluoride before counting in an alpha spectrometer. Radium isotopes are separated by coprecipitation with mixed barium and lead sulphate. Radium-226 is determined with the radon emanation technique on a solution of the mixed barium and lead sulphates in ethylene-diamine tetra-acetic acid. Radium-228 is measured by its daughter product <sup>228</sup>Ac in a 2  $\pi\beta\gamma$  coincidence counter. (Edited author abstract) 7 refs.

Lauria, D.C. (Comissao Nacional de Energia Nuclear, Rio de Janeiro, Brazil); Godoy, J.M. *Sci Total Environ* v 70 Mar 1988, Environ Radiochem Anal, Proc of the Fifth Symp, Harwell, Engl, Oct 1-3 1986 p 83-99.

**Health Hazards** See Also RADON—Health Hazards.

**088216 FABRICATION OF DENSE LITHIUM FLUORIDE FOR NEUTRON SHIELDING.** Polycrystalline LiF suitable for use as a thermal neutron shielding material was fabricated by both hot-pressing and pressureless sintering to greater than 99.5% theoretical density. To achieve this, the poorly sinterable as-received LiF powder had to be (a) ball-milled to reduce particle size, (b) calcined to substantially remove porosity from the cubic particles, and (c) ball-milled again to break up agglomerates formed during calcination. (Edited author abstract) 8 refs.

Stewart, Martin W.A. (Australian Nuclear Science and Technology Organisation, Menai, Aust); Buykx, William J. *J Am Ceram Soc* v 71 n 2 Feb 1988 p C-68-C-69.

**Hydrolysis**

**088217 SIMULATING EQUILIBRIA IN TWO-PHASE SYSTEMS: H<sub>2</sub>O-HNO<sub>3</sub>-H<sub>2</sub>SO<sub>4</sub>-AN-(IV)-TRI-N-BUTYL-PHOSPHATE-N-ALKANES.** Authors have determined the constants for the complexing of U(IV) and Np(IV) with sulfuric acid in aqueous nitric acid in a continuation of a previous study by the method previously described, which has given data on the distributions of the elements for 30% solutions of tri-n-butyl phosphate (TBP) in n-alkanes, where a quantitative interpretation can be given for the equilibria in the heterogeneous systems. In this study, authors have refined the Extraction of Quadrivalent Pu, Np, and U Into TBP From Aqueous Nitric Acid. 16 refs.

Solovkin, A.S.; Rubisov, V.N.; Smelov, V.S.; Druzhnerukov, V.I.; Starikov, V.M.; Muratova, G.G. *Sov At Energy* v 62 n 5 May 1987 p 385-390.

**Inventory Control** See Also-CHEMICAL OPERATIONS—Measurements; MATHEMATICAL TECHNIQUES—Error Analysis; NONDESTRUCTIVE EXAMINATION—Standards; NUCLEAR FUELS—Accountability; NUCLEAR FUELS—Reprocessing; NUCLEAR FUELS—Safeguards; NUCLEAR POWER PLANTS—Safeguard Systems; PLUTONIUM AND ALLOYS—Radioactivity; RADIO TRANSMITTERS; RADIOACTIVITY MEASUREMENT.

**088218 MULTI-LEVEL ATTRIBUTES SAMPLING SCHEMES FOR MATERIAL ACCOUNTANCY VERIFICATION.** In order to verify the declared material accountancy values of a facility, a safeguards authority such as the International Atomic Energy Agency makes its own independent measurements of the contents of items in the material balance on a sampling basis. Because of advances in non-destructive assay technology, a number of alternative measurement methods may be available to make such verification measurements, each with its own level of accuracy and required measurement effort. It is shown how an arbitrary number of such techniques can be combined in an attributes sampling scheme that will guarantee a given probability of detecting a missing goal quantity. (Author abstract) 8 refs.

Sanborn, Jonathan B. (Brookhaven Nat'l Lab, Upton, NY, USA). *Nucl Mater Manage* v 16 n 1 Oct 1987 p 16-19.

**088219 IMPORTANCE OF UNDERSTANDING PROCESS HOLDUP - A DEPARTMENT OF ENERGY (DOE) VIEW.** Residual material in processing equipment is today and will in the future continue to be one of the major problems in controlling and accounting for nuclear material. Existing facilities were designed for product quantity, quality, and safety; not for minimization and quantification of residual material in process. With the development of measurement systems, and with enhanced material control and accounting practices and procedures, inventory differences have been emphasized. The improvement in processing input and output measurements has highlighted the problems of quantifying residual process material. The primary purpose for quantifying material held up in process is to determine the inventory difference and its related uncertainties or statistical variances. This quantification and its associated problems must be addressed if we are to prevent, deter, and detect theft and/or diversion of nuclear materials. (Author abstract). 1 Ref.

Hammond, Glenn A. (US DOE, Washington, DC, USA); Hawkins, Ron L. *Nucl Mater Manage* v 26 n 4 Jul 1988 p 12-14.

**088220 PROCESS HOLDUP - THE REGULATORY VIEW.** Performance-oriented safeguards regulations reflecting the different strategic value of special nuclear material were recently published as final rules. These rules have a significant impact on the requirements for holdup calculations and measurements. For licensees processing low enriched uranium, it is expected that few, if any, holdup measurements will be made for safeguards purposes. However, for licensees processing high enriched uranium or plutonium, the new regulations require extensive analysis of holdup measurements and estimations in modeling process flows, holdup, and yields for individual unit processes. Good quality holdup measurements and estimations will be required for both physical inventory and process monitoring purposes. (Author abstract). 4 Refs.

Brach, E. William (US Nuclear Regulatory Commission, Washington, DC, USA). *Nucl Mater Manage* v 26 n 4 Jul 1988 p 15-17.

**088221 HOLDUP - RELATED ISSUES IN SAFEGUARDING OF NUCLEAR MATERIALS.** Residual inventories of special nuclear materials (SNM) remaining in processing facilities (holdup) are recognized as an insidious problem for both safety and safeguards. This paper identifies some of the issues that are of concern to the safeguards community at-large that are related to holdup of SNM in large-scale process equipment. These issues range from basic technologies of SNM production to changing regulatory requirements to meet the needs of safeguarding nuclear materials. Although there are no

magic formulas to resolve these issues, there are several initiatives that could be taken in areas of facility design, plant operation, personnel training, SNM monitoring, and regulatory guidelines to minimize the problems of holdup and thereby improve both safety and safeguards at nuclear material processing plants. (Author abstract). 8 Refs.

Pillay, K.K.S. (Los Alamos Nat'l Lab, Los Alamos, NM, USA). *Nucl Mater Manage* v 26 n 4 Jul 1988 p 18-20.

**088222 OVERVIEW OF HOLDUP MEASUREMENT TECHNOLOGY.** 'Holdup' refers to special nuclear material (SNM) unintentionally deposited in or on process equipment or plant structure. Holdup arises through imperfections in the manufacturing process, accidents or failures of equipment, and deficiencies in plant and process equipment design. The origin of holdup, where it occurs in plants, and the methods of assay thus far found useful under conditions often found in nuclear fuel manufacturing installations are discussed. 3 Refs.

Zucker, Martin S. (Brookhaven Nat'l Lab, Upton, NY, USA). *Nucl Mater Manage* v 26 n 4 Jul 1988 p 21-25.

**088223 NUMATH: A NUCLEAR MATERIAL HOLDUP ESTIMATOR.** NUMATH is a computer program which provides near-real-time estimations of material compositions and inventories from previous inventory measurements, operating data, and available on-line process measurements - in a manner that is transparent to the computer terminal operator. In steady-state simulated-run testing, NUMATH produced estimates within 10% of the measured inventories for accountable materials. (Author abstract). 3 Refs.

Kirchinsky, Alan M. (Oak Ridge Nat'l Lab, Oak Ridge, TN, USA). *Nucl Mater Manage* v 26 n 4 Jul 1988 p 30-32.

**088224 INMM 28TH ANNUAL MEETING: 'SAFEGUARDS - A MATURE TECHNOLOGY?'** This conference proceedings contains 158 papers, all of which are separately indexed and abstracted. The papers consider topics in nuclear material management. Safeguard techniques are discussed in detail. Materials accountability and control systems are reviewed. Many papers are devoted to physical protection problems, including insider threats, as well as threat avoidance. Radioactive waste transport is also considered. Containment and surveillance, including security systems equipment, video systems, and video authentication, are also presented. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10542 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Inst of Nuclear Materials Management). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 776p.

**088225 SOME DEVELOPED PERFORMANCE CRITERIA.** This paper describes proposed performance criteria for weapons, test devices, and significant special nuclear material (SNM) parts. The criteria were developed from material control, accountability, and physical security measures. Guidelines discussed in this paper represent a first effort in developing a useful set of Department of Energy material control and accountability (MC&A) performance standards for weapon parts production facilities. (Author abstract)

Owings, Edward (Martin Marietta Energy Systems Inc, Oak Ridge, TN, USA); Erickson, Otto. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 81-83.

**088226 HOW ATTRACTIVE IS YOUR SNM?** The goal of a well designed safeguards system is the proper protection of various categories of Special Nuclear Material (SNM). In the past the quantity of SNM was the primary concern when defining categories. The form of the SNM is also important in a safeguards system. To a



diverter of material pure metal, for example, could be much more attractive than a nitrate solution. The design of a universal attractiveness table along with performance criteria for the safeguards system is a very complex problem. Several approaches to a solution will be discussed. (Author abstract) 2 refs.

Erkkila, Bruce H. (Los Alamos Natl Lab, Los Alamos, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 776p.

**088227 PERFORMANCE CRITERIA FOR CATEGORIES III AND IV NUCLEAR MATERIALS.** DOE policy requires that DOE facilities protect and control the use of nuclear materials in such a manner that national security, program continuity and the health and safety of the public are not adversely impacted. Current implementation of this policy is based largely on compliance to specified requirements. Such requirements have not addressed site-specific situations and do not provide a means to quantify how well an integrated safeguards system is achieving policy objectives. The proposed performance criteria for Categories III and IV nuclear materials which are in the early stages of development address the potential impact on public health and safety of the use of these quantities of materials. These criteria attempt to provide more clear and consistent guidance regarding graded protection than do the current orders. Details of the proposed criteria are presented from the standpoint of a laboratory facility rather than a production facility. (Author abstract)

Bingham, Carleton D. (US DOE, Argonne, IL, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 86-88.

**088228 PERFORMANCE CRITERIA - PERSONNEL DUTIES AND TRAINING.** Performance criteria require that a facility handling nuclear material be capable with some degree of probability to detect the theft or diversion of material within a given time interval. Compliance criteria are established for the minimum requirements in materials accounting. These criteria require levels of excellence from both the monitoring system and the personnel involved in the acquisition and interpretation of input data and response alarms. The duties and training expected of personnel operating in a safeguards organization are discussed. (Author abstract)

Haas, Francis X. (Rockwell Int, Golden, CO, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 89-91.

**088229 SYSTEMS ANALYSIS FOR MATERIALS CONTROL AND ACCOUNTANCY TECHNOLOGY.** The objective is to upgrade Materials Control and Accountancy (MC&A) technology over the flows of special nuclear materials throughout the DOE complex of fuel cycles. The program focus is to develop a 'Management Tool' for decision support in evaluating MC&A upgrades, and in validating the MC&A aspects of the Master Safeguards and Security Agreements (MSSA) effectiveness. The approach is the computerization of the nuclear materials flow charts, identification of key measurement locations in the production and product fuel cycle, and construct data information processing at each measurement location. The program is to provide the Office of Safeguards and Security (OSS) with a timely management decision support system in planning MC&A safeguards technology upgrades over the nuclear materials production and product cycles. (Author abstract)

Daly, T.A. (Argonne Natl Lab, Argonne, IL, USA); Bucher, R.G.; Rothman, A.B.; Charak, I.; Persiani, P.J. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 221-224.

**088230 WHERE DO THE NUCLEAR MATERIALS MANAGEMENT FUNCTIONS FIT IN THE MATERIALS CONTROL AND ACCOUNTABILITY**

(MC&A) PLAN? Nuclear Materials Management activities have reporting requirements that include (1) Annual Forecast, (2) Materials Management Plan, (3) Quarterly Status Report, (4) Assessment Report, and (5) Scrap and Excess Material Management. Data used to generate reports for both functions come from the same data base and source documents at most facilities. The separation of sponsoring groups at the DOE for NM Accountability and NM Management can and does pose problems for contractors. In this paper, we will try to separate and identify these overlaps at the Facility and DOE level. (Edited author abstract)

De Ver, E.A. (Los Alamos Natl Lab, Los Alamos, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 225-227.

**088231 NUCLEAR MATERIALS CONTROL AND ACCOUNTABILITY INTERNAL AUDIT PROGRAM AT THE OAK RIDGE Y-12 PLANT.** The internal audit program of the Nuclear Material Control and Accountability (NMC&A) Department at the Oak Ridge Y-12 Plant, through inventory-verification audits, inventory-observation audits, procedure audits, and records audits, evaluates the adequacy of material accounting and control systems and procedures throughout the Plant; appraises and verifies the accuracy and reliability of accountability records and reports; assures the consistent application of generally accepted accounting principles in accounting for nuclear materials; assures compliance with the Department of Energy (DOE) and NMC&A procedures and requirements. The internal audit program has significantly strengthened the control and accountability of nuclear materials through improving the system of internal control over nuclear materials. (Edited author abstract) 1 ref.

Lewis, T.J. (Martin Marietta Energy Systems Inc, Oak Ridge, TN, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 231-233.

**088232 INVENTORY DIFFERENCES: AN EVALUATION METHODOLOGY.** This paper discusses an evaluation methodology which is used for inventory differences at the Los Alamos National Laboratory. It is recognized that there are various methods which can be, and are being, used to evaluate process inventory differences at DOE facilities. The purpose of this paper is to share thoughts on the subject and techniques with those who are responsible for the evaluation of inventory differences at their facility. The authors feel that one of the most dangerous aspects of any evaluation technique, especially one as complex as most inventory difference evaluations tend to be, is to fail to look at the tools being used as indicators. There is a tendency to look at the results of an evaluation by one technique as an absolute. At the Los Alamos National Laboratory, several tools are used and the final evaluation is based on a combination of the observed results of a many-faceted evaluation. The tools used and some examples will be presented.

Heinberg, C.L. (Los Alamos Natl Lab, Los Alamos, NM, USA); Roberts, N.J. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 238-242.

**088233 SYSTEM TO FULLY AUTOMATE SPECIAL NUCLEAR MATERIALS ACCOUNTABILITY REPORTING FOR ELECTRIC UTILITIES.** The USNRC requires each licensee who is authorized to possess Special Nuclear Materials (SNM) to prepare and submit reports concerning SNM received, produced, possessed, transferred, consumed, disposed of, or lost. Yankee Atomic is developing an IBM PC-based computer code that fully automates the process of generating SNM accountability reports. The program, called SNMSP II, prints a number of summaries including facsimiles of the NRC/DOE-741, 742, 742C, and RW-859 reports in a format that can be submitted directly to the NRC/DOE. This paper discusses the major features of the code and

describes its implementation at Yankee. (Edited author abstract)

Pareto, Vittorio (Yankee Atomic Electric Co, Framingham, MA, USA); Venegas, Ramon. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 243-245.

**088234 NUCLEAR MATERIALS MANAGEMENT AND SAFEGUARDS SYSTEM (NMMSS).** This paper describes the Nuclear Materials Management and Safeguards (NMMSS) which is sponsored by the Department of Energy and the Nuclear Regulatory Commission. The system serves national security and program management interests, and international interests in the programs for the peaceful application of nuclear energy and nonproliferation of nuclear weapons. Within the scope applied and controlled under United States law and related International agreements, are US private nuclear industrial activities. In addition, its national and international scope enables it to provide service to other organizations such as the Arms Control and Disarmament Agency, the Department of State, and the US Congress. (Author abstract)

Baird, Patricia W. (Martin Marietta Energy Systems Inc, Oak Ridge, TN, USA); Jacobsen, Sharon E.; Matthews, William B. III; Pedigo, Roberta B. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 283-285.

**088235 EMERGENCY INVENTORY SYSTEM AT THE OAK RIDGE Y-12 PLANT.** A portable, computerized system for taking an emergency inventory of special nuclear materials (SNM) is in operation at the Oak Ridge Y-12 Plant. It is identified as the EIS (Emergency Inventory System). The components of the EIS are easily transported to any area of the plant where an inventory might have to be taken. The easy-to-use, menu-driven programming for the system is written in a widely used database management language that is standardized and easily upgraded. This paper discusses the development, operation, hardware, and software of the EIS. (Edited author abstract) 1 ref.

Smith, S.E. (Martin Marietta Energy Systems Inc, Oak Ridge, TN, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 290-292.

**088236 CONCEPT OF AN INTEGRATED QUALITY RECORD NUCLEAR MATERIAL ACCOUNTANCY SYSTEM.** RBU had already started in 1976 with the computerization of its nuclear material accountancy system. It used the hardware and the software which were at hand at that time. The development of the software needed about 3 years, and so, the system was fully introduced in 1979 and has been used since then with only minor changes. But with time, the overwhelming progress in computer and software technology has overcome the existing system. Upgrading the old system would need a lot of effort, so RBU decided to modernize its system fundamentally. The paper will describe the main changes between the present and the future systems. (Edited author abstract)

von Wachtendonk, Hans Juergen (Reaktor-Brennelement Union, Hanau, West Ger). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 333-334.

**088237 DESIGN METHODOLOGY FOR MATERIALS CONTROL AND ACCOUNTING INFORMATION SYSTEMS.** Modern approaches to nuclear materials safeguards have significantly increased the data processing needs of safeguards information systems. Implementing these approaches will require developing efficient, cost-effective designs. Guided by database design research, we are developing a design methodology for



distributed materials control and accounting (MC&A) information systems. The methodology considers four design parameters: network topology, allocation of data to nodes, high-level global processing strategy, and local file structures to optimize system performance. Characteristics of system performance that are optimized are response time for an operation, timeliness of data, validity of data, and reliability. The ultimate goal of the research is to develop a comprehensive computerized design tool specifically tailored to the design of MC&A systems. (Author abstract) 6 refs.

Helman, P. (Univ of New Mexico, Albuquerque, NM, USA); Strittmatter, R.B. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 345-351.

**088238 U.S. DEPARTMENT OF ENERGY INTERNATIONAL SAFEGUARDS PROGRAM - CONTAINMENT AND SURVEILLANCE ACTIVITIES.** Material accounting is currently the fundamental element of International Safeguards as applied by the International Atomic Energy Agency (IAEA), with Containment and Surveillance (C/S) serving an important complementary role. Because of limited IAEA resources and the increasing number of nuclear facilities, it is commonly recognized that increased reliance may have to be placed on C/S equipment. For more than a decade, C/S has been an important element of the DOE International Safeguards Program, with Sandia National Laboratories serving as the 'Center of Excellence' for the DOE C/S activities. These activities are divided into three major categories - C/S-based Safeguards Design and Strategies, C/S Technology Development, and Technology Exchange. This paper describes the objective of each of these activities, the principle accomplishments, the current activities and planned future activities. (Author abstract) 10 refs.

Myers, D.A. (US DOE, Washington, DC, USA); Mangan, D.L.; Sonnier, C.S. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 380-382.

**088239 SIMULATION MODEL FOR MATERIAL ACCOUNTING SYSTEMS.** A general-purpose model that was developed to simulate the operation of a chemical processing facility for nuclear materials has been extended to describe material measurement and accounting procedures as well. The model now provides descriptors for material balance areas, a large class of measurement instrument types and their associated measurement errors for various classes of materials, the measurement instruments themselves with their individual calibration schedules, and material balance closures. Delayed receipt of measurement results (as for off-line analytical chemistry assay), with interim use of a provisional measurement value, can be accurately represented. (Edited author abstract) 1 ref.

Coulter, C.A. (Los Alamos Natl Lab, Los Alamos, NM, USA); Thomas, K.E. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 478-482.

**088240 VARIANCE AND COVARIANCE CALCULATIONS FOR NUCLEAR MATERIALS ACCOUNTING USING 'MAVARIC'.** Determination of the detection sensitivity of a materials accounting system to the loss of special nuclear material (SNM) requires (1) obtaining a relation for the variance of the materials balance by propagation of the instrument errors for the measured quantities that appear in the materials balance equation and (2) substituting measured values and their error standard deviations into this relation and calculating the variance of the materials balance. MAVARIC (Materials Accounting VARIance Calculations) is a custom spreadsheet, designed using the second release of Lotus 1-2-3, that significantly reduces the effort required to make the necessary variance (and covariance) calculations needed to determine the detection sensitivity of a materials accounting system. (Edited author abstract) 2 refs.

Nasser, K.K. (Los Alamos Natl Lab, Los Alamos, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 489-493.

**088241 VARIANCE CALCULATIONS FOR MATERIALS ACCOUNTING SYSTEM DESIGN AND EVALUATION.** Error propagation/variance calculations are used for establishing alarm limits for materials balance closures. Variance calculations may also be employed in the evaluation of accounting system designs for a proposed facility, as well as for upgrades of existing facilities. Information from such an exercise may be used to allocate resources for system improvements and identify process areas that require strict access or material controls. Simplifying assumptions are normally required since detailed data are not available for proposed facilities and may be difficult to obtain for existing facilities. Transfer, inventory, and measurement data are input into a code that calculates the variance for each term in the materials balance equation. Provision should be made for treatment of measurement correlations and holdup. (Edited author abstract) 1 ref.

Thomas, K.E. (Los Alamos Natl Lab, Los Alamos, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 494-498.

**088242 NEW BRUNSWICK LABORATORY SAFEGUARDS MEASUREMENT EVALUATION PROGRAM.** The New Brunswick Laboratory (NBL) has been tasked by the US Department of Energy (DOE) Office of Safeguards and Security (OSS) to assess and evaluate the adequacy of measurement technology as applied to materials accounting in DOE nuclear facilities. Phase I of the Safeguards Measurement Evaluation Program, initiated during 1985, involved evaluation of the primary accountability measurement methods at six DOE Defense Programs facilities: Savannah River Plant, Portsmouth Gaseous Diffusion Plant, Y-12 Plant, Rocky Flats Plant, Rockwell Hanford Operations, and NBL. Samples of uranyl nitrate solution, dried plutonium nitrates, and plutonium oxides were shipped to the participants for assay and isotopic abundance measurements. Resulting data are presented and evaluated as indicators of current state-of-the-practice accountability measurement methodology, deficiencies in materials accounting practices, and areas for possible assistance in upgrading measurement capabilities. (Edited author abstract) 1 ref.

Cacic, C.G. (US DOE, Argonne, IL, USA); Trahey, N.M.; Zook, A.C. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 511-520.

**088243 OSE INSPECTION OF MATERIALS CONTROL AND ACCOUNTABILITY: REVIEW.** As part of its task to confirm that Department of Energy (DOE) field offices provide levels of security and safeguards commensurate with defined threats, the DOE Office of Security Evaluations (OSE) conducts inspections of the nuclear materials control and accountability (MC&A) systems at DOE facilities throughout the United States. Inspections are based on the DOE Safeguards and Security Standards and Criteria, tailored to the specific assets at and threats to each individual site. This paper reviews the process of inspecting MC&A systems during the planning, preinspection, and inspection/reporting phases. (Author abstract)

Coady, Kelly J. (US DOE, Washington, DC, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 531-534.

**088244 OSE INSPECTION OF MATERIALS CONTROL AND ACCOUNTABILITY: FIELD PERSPECTIVE OF INSPECTIONS.** The Inspection and Evaluation (I&E) process for materials control and accountability (MC&A) is discussed from the perspective of an 'inspector'. Methods of preparing for a visit by the I&E team and the operational and budget impacts of the I&E Standards and Criteria are briefly discussed. The I&E

process does not have to be traumatic, but it can be if the inspectors are not properly prepared and if ground rules and procedures have not been established. This paper presents the author's views and reflects his perspectives of the Office of Security Evaluations (OSE) MC&A process. In preparation for this paper, the author has talked at length with his peers and has included some of their perceptions of the I&E process. However, this paper is the sole responsibility of the author and does not constitute an official position of the Los Alamos National Laboratory or of any other entity. (Author abstract)

Roberts, N.J. (Los Alamos Natl Lab, Los Alamos, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 535-537.

**088245 INDEPENDENT FISSILE INVENTORY VERIFICATION IN A LARGE TANK EMPLOYING LUTETIUM DOUBLE SPIKES.** A 3000-liter feed adjustment tank containing over 2400 L of uranium solution was assayed for its contents using the double spiking technique of isotope dilution mass spectrometry. Lutetium was the double spike, with the natural element used as the initial spike and enriched <sup>176</sup>-Lu as the second. The ability of a remote sampling system was evaluated for its ability to introduce the lutetium and also to produce homogeneous sample solutions. The system was found to be satisfactory. Volumes of the tank can be measured to a precision of about 0.2%. The concentration of uranium was measured as 154.5 g/L uranium, thus giving a total of 382.3 kg in the tank as compared to the plant's best estimate of 383 kg. Uranium measurements were subjected to internal calibration calculations, with <sup>233</sup>-U and <sup>236</sup>-U being used as the reference isotope. (Edited author abstract) 4 refs.

Carter, J.A. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Walker, R.L.; May, M.P.; Smith, D.H.; Hebble, T.L. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 689-691.

**088246 CERENKOV GLOW VIEWING TECHNIQUE FOR SPENT FUEL VERIFICATION - CURRENT STATUS AND FUTURE PROSPECTS.** The Cerenkov Glow viewing technique is a simple, non-intrusive method of spent fuel verification, widely used by IAEA inspectors. In the course of 1986, Cerenkov Viewing Devices (CVDs) were used in about 179 inspections in 98 MBAs (Material Balance Areas). The paper discusses the current state of development of CVDs and also the limitations of the technique. (Edited author abstract) 12 refs.

Sanatani, S. (IAEA, Vienna, Austria). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 735-740.

Legislation See RADIOACTIVE WASTES—Disposal.

Measurements See Also NUCLEAR REACTORS—Accidents; SCALES AND WEIGHING; SECURITY SYSTEMS.

**088247 RADIOCAESIUM ON URBAN SURFACES IN WEST CUMBRIA FIVE MONTHS AFTER CHERNOBYL.** Following the accident at the Chernobyl nuclear power plant on April 26, 1986, heavy rainfall in early May led to the deposition of radiocaesium on urban and ground surfaces in parts of west Cumbria, UK. Measurements in the following September showed that most common urban constructional materials had intercepted and retained significant fractions of the radiocaesium incident on surfaces. In some cases, as much as two-thirds was retained. Although the amounts found in this survey present no significant radiation hazard, the high retention figures on some materials do indicate the limitations of weathering as a decontamination mecha-



nism and highlight the need for forced decontamination methods to be considered in nuclear accident contingency planning. 1 ref.

Sandalls, F.J. (UKAEA, Engl); Gaudern, S.L. *J Environ Radioact* v 7 n 1 1988 p 87-91.

## Military Applications

**088248 STATUS OF RADIOISOTOPE APPLICATIONS IN DEFENCE.** This paper reviews the current status of radioisotope applications in Defence - R&D Establishments, Defence Inspectorates, Ordnance Factories, Public Sector Undertakings under the Defence Ministry, Army, Navy and Air Force Establishments and Military Hospitals of India. It also lists the users of film badge service in Defence. Training programs in radioisotope applications in Defence conducted by DRDO organizations have also been highlighted. (Edited author abstract) 7 refs.

Bhatnagar, P.K. (Defence Lab, Jodhpur, India); Nagaratnam, A.; Subrahmanian, G.; Raghavan, S.V. *Def Sci J* v 37 n 3 Jul 1987 p 339-346.

**Packaging** See RADIOACTIVE WASTES—Disposal; RADIOACTIVE WASTES—Transportation.

## Production

**088249 APPLICATION OF ATOMIC MUTATIONS INCLUDED IN NUCLEAR REACTIONS,  $^{40}\text{Ar}(\gamma, p)^{39}\text{Cl}(\beta \text{ DECAY})^{39}\text{Ar}$ , TO SURFACE STUDY.** It has been found that the nuclear transformation processes which are initiated by photonuclear reactions can be used for studying the adsorption and chemical reactions taking place on solid surfaces. Chemically reactive  $^{39}\text{Cl}$  was produced by irradiating  $^{40}\text{Ar}$  with high-energy bremsstrahlung, and its blow was directed onto several material surfaces. The amount of chlorine absorption was ascertained by detecting its radioactivity. Desorption without heating the adsorber samples inevitably occurred owing to the nuclear decay of  $^{39}\text{Cl}$ . The adsorption and desorption rates were compared for several elements. A fast growth of oxide islands on sample surfaces was observed during the adsorption-desorption process. (Author abstract) 7 refs.

Ohkuma, Juzo (Osaka Univ, Osaka, Jpn). *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1433-1437.

## Radioactivity

**088250 NEUTRON PORTAL MONITOR FOR VEHICLES.** We have designed and built a portal vehicle monitoring system for detecting neutron-emitting special nuclear material (SNM) such as plutonium. Monte Carlo calculations were used to optimize the design of the 15-cm-deep  $\times$  122-cm-high  $\times$  244-cm-long detector chambers, which utilize  $^3\text{He}$  proportional counters inside a hollow polyethylene box. Results for a variety of parametric studies, including polyethylene thickness and detector number, are described. Our experimental measurements are in good agreement with the computer calculations. (Edited author abstract) 7 refs.

Coop, Kenneth L. (Los Alamos Natl Lab, Los Alamos, NM, USA); Fehlau, Paul E.; Atwater, Henry F. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 454-460.

**088251 CERENKOV GLOW OBSERVATIONS FROM SPENT FUEL.** The observation of Cerenkov glow from a fuel assembly is an attractive method of detecting the presence of radioactive material. The simple, hand-held instrumentation is very easy to use and does not require penetration of the water in the spent fuel pool. An obstacle to routine use of the instrument arises in that the standard night vision devices have a broad band wavelength response which required the pool area to be darkened. Various techniques used to limit the bandwidth of the devices for use in viewing the Cerenkov glow in the presence of facility illumination have furthered implemen-

tation. A properly specified, commercially available instrument has been used to make narrow band observations at two power reactors without interference from the facility illumination. (Edited author abstract) 10 refs.

Skalyo, John Jr. (Brookhaven Natl Lab, Upton, NY, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 741-745.

**Safe Handling** See Also NUCLEAR POWER PLANTS—Safeguard Systems; RADIOACTIVE WASTES—Geological Repositories; ROBOTS, INDUSTRIAL—Manipulators.

**088252 HOW MOBILE ROBOTS HAVE HELPED AT CHERNOBYL AND OTHER ACCIDENTS.** At several recent accidents, including Chernobyl, mobile robots assumed, with varying degrees of success, many of the tasks and missions that are normally conducted by the emergency response team. It is possible today to deploy off-the-shelf mobile robots in most hazardous situations, which include the nuclear, toxic chemical, civilian and military bomb disposal, firefighting, security, and mining-/tunnelling/excavation/construction industries. Mobile robots have been successfully employed at three recent accidents or incidents which the article discusses (U.S.S.R., Brazil and the U.S.).

Meieran, Harvey B. (PHD Technologies Inc, Pittsburgh, PA, USA). *Nucl Eng Int* v 33 n 405 Apr 1988 p 21-23, 26.

**088253 PROCEEDINGS OF THE 34TH CONFERENCE ON REMOTE SYSTEMS TECHNOLOGY (HELD IN CONJUNCTION WITH AMERICAN NUCLEAR SOCIETY WINTER MEETING).** The proceedings contains 38 papers. The papers are grouped under the following session headings: design and fabrication of remote handling equipment for waste vitrification facilities; advances in remote viewing, manipulation, and handling equipment; operations in waste processing, decontamination, and size reduction facilities; remote applications and development of robotic systems; remote maintenance in high radiation areas; and update on remote handling outside the United States. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10647 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (ANS, La Grange Park, IL, USA). *Proc Conf Remote Syst Technol* 34th, Washington, DC, USA, Nov 17-20 1986. Publ by ANS, La Grange Park, IL, USA, 1987 255p.

## Sampling

**088254 PHYSICO-CHEMICAL SPECIATION OF AIRBORNE  $^{131}\text{I}$  IN JAPAN FROM CHERNOBYL.** The physicochemical form of airborne  $^{131}\text{I}$ , released during the Chernobyl accident, was investigated in Japan during the period 6 to 19 May 1986. The proportions of  $^{131}\text{I}$  species identified during that period were: 19% particulate iodine, 5%  $\text{I}_2$ , 6% HOI and 70% organic iodides. These results are similar to those obtained in previous studies of airborne stable iodine in inland regions. A fraction of  $^{131}\text{I}$  which was adsorbed on particulate matter desorbed from it during the sampling process. (Author abstract) 11 refs.

Noguchi, Hiroshi (JAERI, Naka-gun, Jpn); Murata, Mikio. *J Environ Radioact* v 7 n 1 1988 p 65-74.

**Separation** See BIOMEDICAL ENGINEERING—Living Systems Studies.

**Solidification** See RADIOACTIVE WASTES—Analysis.

**Solutions** See COASTAL ZONES—Sedimentation.

**Spectroscopic Analysis** See RADIOACTIVE WASTES—Spectroscopic Analysis.

**Storage** See Also NUCLEAR FUELS—Storage.

**088255 MC-10 PWR SPENT-FUEL STORAGE CASK: TESTING AND ANALYSIS.** Successful testing confirmed that the Westinghouse MC-10 spent-fuel storage cask offers utilities a technically sound and practical way to meet the growing need for additional on-site storage. Moreover, in predicting the cask's thermal performance, the COBRA-SFS computer code, now being evaluated at the Pacific Northwest Laboratory, achieved good agreement with actual test data. The COBRA-SFS code performed well in predicting the shapes of the temperature profiles and the actual temperatures, with pre- and posttest results coming within 30°C of data. The agreement between predictions and measurements improved slightly in the posttest analysis, which corrected for a basket-to-inner-wall gap and for input errors. In shielding performance, the cask met design expectations, except that the bottom will require minor design modifications. (Edited author abstract)

Anon. *Electr Power Res Inst Rep EPRI NP* 5268 Jul 1987 260p.

## Thermodynamics

**088256 EQUILIBRIUM MEASUREMENTS AS A SOURCE OF ENTROPIES AND MOLECULAR CONSTANT INFORMATION.** The absolute entropies of a number of high temperature gaseous molecules with uncertain molecular constant assignments were derived from equilibrium measurements with accuracies of 1 to 2 cal·K<sup>-1</sup>·mol<sup>-1</sup>. These results were derived from measurement of reaction equilibrium constants over wide temperature ranges by application of second law analysis. The results give clear indications about the magnitudes of electronic level contributions of the lower-valent uranium and thorium halides, the symmetries and geometric structures of uranium and thorium tetrahalides, and about the low frequency vibrations of some M<sub>2</sub>SO<sub>4</sub> metal sulfate species. The general usefulness of this approach is discussed. (Author abstract) 18 refs.

Hildenbrand, D.L. (SRI Int, Menlo Park, CA, USA). *Pure Appl Chem* v 60 n 3 Mar 1988, Invited Lect Presented 30th Microsymp on Macromol - Polym Supported Org Reagents and Catal, Prague, Czech, Jul 6-9 1987 p 303-307.

**Tracers** See Also BIOMEDICAL EQUIPMENT—Radionuclides; CHEMICAL REACTIONS—Oxidation; COAL LIQUEFACTION; HYDROLOGY; HYDROLOGY—Mathematical Models; INTERMETALLICS—Diffusion; IONS—Adsorption; IRON CHROMIUM ALLOYS—Oxidation; MANGANESE COPPER ALLOYS—Diffusion; MINERAL EXPLORATION; MOLYBDENUM AND ALLOYS—Extraction; OCEANOGRAPHY—Radioactivity; ORE TREATMENT—Crushing and Grinding; ORGANIC COMPOUNDS—Synthesis; PROTEINS.

**088257 PREPARATION OF LABELLED  $^{38}\text{Cl}$  HYDROCARBONS BY RECOIL  $^{38}\text{Cl}$  ATOM REACTION AND DETECTION BY RADIO-GAS CHROMATOGRAPHIC TECHNIQUES.** A radio-gas chromatographic technique had been applied for the quantitative determination of the radioactive labeled  $^{38}\text{Cl}$  compounds obtained from the recoil  $^{38}\text{Cl}$  atom reaction with C<sub>2</sub>H<sub>4</sub>. Argon gas was added to the system as neutron flux monitor to calibrate the total radioactivity of  $^{38}\text{Cl}$  produced. I<sub>2</sub> and HI were added as a scavenger to remove the thermal radicals produced. The yields of radioactivity of CF<sub>2</sub>Cl<sup>38</sup>Cl and C<sub>2</sub>H<sub>5</sub><sup>38</sup>Cl depended on the initial mole fraction ratio of CF<sub>2</sub>Cl<sub>2</sub>/C<sub>2</sub>H<sub>4</sub>. The major product found was C<sub>2</sub>H<sub>5</sub><sup>38</sup>Cl (> 90%) when HI was added as scavenger. In the other system CF<sub>3</sub>Cl/C<sub>2</sub>H<sub>4</sub>/I<sub>2</sub> we studied the yields of inorganic and organic compounds labeled with  $^{38}\text{Cl}$ . The yield of H<sup>38</sup>Cl as a function of the mole ratio of CF<sub>3</sub>Cl/C<sub>2</sub>H<sub>4</sub> is shown. (Author abstract) 10 refs.

Lo, Jiunn-Guang (Natl Tsing Hua Univ, Hsinchu, Taiwan); Chao, Jiunn-Hsing; Chuang, Jui-Tang. *Appl Radiat Isot* v 38 n 9 1987 p 685-688.



**088258 WATER AND EARTH SCIENCES: ISOTOPES IN THE FIELD.** Nuclear techniques using isotopes are precise, modern tools for studying water resources. They can provide an adequate solution to the problem of the origin, distribution, and properties of water in a given region, especially when they are combined with all other tools available to hydrologists, hydrogeologists, and geochemists. This report shows how some countries are applying stable and radioactive elements to help track and solve hydrological problems.

Gonfiantini, Roberto (IAEA); Hut, Gert. *IAEA Bull* v 29 n 2 1987 p 13-19.

**088259 ELECTROPHILIC RADIOIODINE EXCHANGE LABELING IN AQUEOUS SOLUTIONS.** A new mechanism, combined with a new technique of radioiodine exchange labeling is presented. Temperature sensitive, iodine containing organic compounds can be labeled in this way as well as molecules with moderate reactivities. The labeling procedure was optimized with special respect to the required minimal reaction time and temperature. (Author abstract) 8 refs.

Sinn, H. (German Cancer Research Cent, Heidelberg, West Ger); Schrenk, H.H.; Clorius, J.H.; Maier-Borst, W. *Appl Radiat Isot* v 38 n 11 1987 p 921-925.

**088260 SYNTHESIS OF  $[^{11}\text{C}]$  IODOMETHYLCYCLOPROPANE, AN INTERESTING ALKYLATING REAGENT.** The synthesis of  $[^{11}\text{C}]$  iodomethylcyclopropane by a four-step procedure, starting from  $[^{11}\text{C}]$  carbon dioxide, is presented. The  $[^{11}\text{C}]$  carbon dioxide was trapped in a solution of cyclopropylmagnesium bromide and the acid was reduced to give the alcoholate. When treated with p-toluenesulfonyl bromide,  $[^{11}\text{C}]$  bromomethylcyclopropane was formed directly and then converted to the corresponding iodide by the Finkelstein reaction.  $[^{11}\text{C}]$  iodomethylcyclopropane was prepared in about 13% radiochemical yield (decay-corrected) and 80% radiochemical purity, with a reaction time of 20 min and a specific radioactivity in the order of 10-100 mCi/ $\mu\text{mol}$ . (Author abstract) 13 refs.

Rimland, A. (Univ of Uppsala, Uppsala, Swed); Langstrom, B. *Appl Radiat Isot* v 38 n 11 1987 p 949-951.

**088261 CONDITIONS FOR RADIOIODINATION OF ANTITHROMBIN III RETAINING ITS BIOLOGICAL PROPERTIES.** In order to obtain a radioiodinated antithrombin III (AT III) with a good labelling yield and optimal biological properties towards heparin, thrombin and its anti-AT III monoclonal antibodies, we compared the classical labelling methods and found them wanting. Thus, we perfected a new labelling procedure which fulfils the above requirements. (Author abstract) 26 refs.

Caix, J. (CNRS, Pessac, Fr); Perrot Minnot, A.; Beziade, A.; Vuillemin, L.; Belloc, F.; Baquay, Ch.; Ducassou, D. *Appl Radiat Isot* v 38 n 12 1987 p 1003-1006.

**088262 DEUTERIUM AND TRITIUM LABELING OF (3-XYNYL)CYCLOHEXANE BY CLEMMENSEN AND WOLFF-KISHNER REDUCTION.** Tritium-labeling of (3-xylyl)cyclohexane was investigated by deuterium-labeling on Clemmensen and Wolff-Kishner reduction of 2-3-xylylcyclohexane. Deuterium-labeling by the Clemmensen reduction was proved to be accompanied by isotope exchange via acid-catalyzed enolization of the carbonyl group. Thus, the labeled (3-xylyl)cyclohexane was a mixture of compounds with various numbers of deuterium atoms. Labeling by the modified Wolff-Kishner reduction gave a mixture of compounds labeled predominantly at position 2. (Author abstract) 9 refs.

Fukuoka, Masamichi (Natl Inst of Hygienic Sciences, Tokyo, Jpn); Tanaka, Akira; Nishimaki-Mogami, Tomoko. *Appl Radiat Isot* v 39 n 5 1988 p 391-396.

**Transport Properties** See Also THERMAL PLUMES—Mathematical Models.

**088263 MIGRATION BEHAVIOR OF RADIONUCLIDES ( $^{60}\text{Co}$ ,  $^{85}\text{Sr}$  AND  $^{137}\text{Cs}$ ) IN AQUIFER.** The

migration behavior of radionuclides ( $^{60}\text{Co}$ ,  $^{85}\text{Sr}$  and  $^{137}\text{Cs}$ ) in aquifer has been studied under a steady flow of water by using aquifer model apparatus. In this study, the radioactive solution containing  $^{60}\text{Co}$ ,  $^{85}\text{Sr}$  and  $^{137}\text{Cs}$  was injected as a point source and it was passed through the aquifer soil layer under the steady flow of water by using the aquifer model apparatus, in order to study the effects of the flow of water on the migration. 6 refs.

Ohtsuka, Yoshiro (JAERI, Tokai-mura, Jpn); Takebe, Shinichi; Yamamoto, Tadatoshi; Wadachi, Yoshiki. *J Nucl Sci Technol* v 25 n 2 Feb 1988 p 165-168.

**088264 1-D MODELLING OF RADIONUCLIDE MIGRATION THROUGH PERMEABLE AND FRACTURED ROCK FOR ARBITRARY LENGTH DECAY CHAINS USING NUMERICAL INVERSION OF LAPLACE TRANSFORMS.** This paper presents analytical solutions to Laplace-transformed radionuclide transport equations for arbitrary length decay chains in permeable and fractured rock. These can be combined to give approximate expressions for transport through heterogeneous media consisting of an arbitrary number of porous and/or fractured rock units. The time-dependent solutions are obtained by numerical inversion using Talbot's algorithm. This has been found to be a very efficient, accurate and flexible technique. (Author abstract) 54 refs.

Hodgkinson, D.P. (AERE, Harwell, Engl); Maul, P.R. *Ann Nucl Energy* v 15 n 4 1988 p 175-189.

## Transportation

**088265 BEFOERDERUNG RADIOAKTIVER STOFFE IN DER EG.** [Shipments of Radioactive Substances in the EC]. In the early eighties the European Communities, initially the Transport Directorate General and later the Energy Directorate General, saw the need to discuss shipments of radioactive substances within the EC countries, especially under some aspects of the nuclear fuel cycle. Under all conditions, smooth transport had to be ensured, e.g., from a nuclear power plant to a reprocessing plant. The Energy Directorate General of the European Communities therefore established a group of experts in 1982 who were to deal with problems associated with shipments of radioactive substances. One of their first major activities was the drafting of a report to the European Parliament in which the situation of shipments of radioactive substances within the EC was examined. The results of that report are outlined in the article. (Author abstract) In German.

Ridder, K. (EG-Arbeitsgruppe Befoerderung radioaktiver Stoffe, West Ger). *Atomwirtsch Atomtech* v 32 n 10 Oct 1987 p 510-511.

**088266 FORUM: SHIPMENT OF SPENT NUCLEAR FUEL FROM AUSTRALIA.** The Federal Government has agreed to ship spent nuclear fuel elements from Australia for reprocessing. This article gives the background to this operation which though unusual for Australia is a normal part of the international transport system. (Edited author abstract)

Coleby, D. *Nucl Spectrum* v 2 n 1 Mar 1986 p 8-12.

**088267 REVISION DER IAE-EMPFEHLUNGEN UND IHRE UMSETZUNG.** [Revised IAEA Recommendations and their Implementation]. Transports of radioactive materials are carried out on the basis of the recommendations made by the International Atomic Energy Agency (IAEA) about safe transports of radioactive materials (Safety Series No. 6). Transports of other dangerous goods are organized on the basis of United Nations (UN) recommendations (Orange Book). The IAEA recommendations were published in an amended version in 1985. The article contains an explanation of the way in which international transport organizations incorporate the 1985 version of the recommendations into internationally valid transport codes, such as ADR, RID, ADN, IATA-DGR, ICAO-TI, and the IMDG Code. (Author abstract) In German.

Ridder, K. *Atomwirtsch Atomtech* v 33 n 2 Feb 1988 p

76-79.

**088268 BASE TECHNOLOGY DEVELOPMENT ENHANCES STATE-OF-THE-ART IN MEETING PERFORMANCE REQUIREMENTS.** Sandia National Laboratories (SNL) has responsibility to the United States Department of Energy (DOE) for baseline technology to support the design of radioactive material transportation packages. To fulfill this responsibility, SNL works with industry, government agencies, and national laboratories to identify and develop state-of-the-art technology required to design and test safe, cost-effective radioactive materials packages. Principal elements of the base technology program include: 1) analysis techniques, 2) testing, 3) subsystem and component development, 4) packaging systems development support, and 5) technical support for policy development. (Author abstract)

Freedman, J.M. (Sandia Natl Lab, Albuquerque, NM, USA); Allen, G.C. Jr.; Luna, R.E. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 263-265.

**088269 PUBLIC CONCERNS ABOUT RADIOACTIVE MATERIAL TRANSPORTATION CAN BE REDUCED BY EFFECTIVE COMMUNICATION OF ENGINEERING DATA.** This paper presents information concerning the safety of transporting radioactive materials (RAM). This evaluation is supported by an examination of data for actual accidents and incidents that have occurred with RAM transport, a study of the regulatory test procedures used to certify RAM packagings and the comparison of RAM transport with that of other hazardous materials. A number of studies are summarized that show that RAM transportation has been a low risk operation for approximately four decades. (Edited author abstract) 10 refs.

McClure, James D. (Sandia Natl Lab, Albuquerque, NM, USA); Luna, Robert E. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 266-271.

**088270 CULTIVATING TRANSPORTATION RELATIONSHIPS: THE COMMUNICATIONS ENIGMA.** Transportation, a critical component of the Nuclear Industry's total mission, is an area where problems exist, especially as it relates to rail transportation. Cooperation between the Nuclear Industry and the Transportation Carrier Community is being negatively impacted by flaws in effective communication, which, if improved, can provide great benefits to both parties. This paper addresses the level of understanding which exists today, the areas which are especially troublesome and must be overcome, why it is important to the Nuclear Industry to make this effort, and, finally, the causes and suggested solutions for taking corrective action. The paper is not intended to answer all aspects of what is required, but rather provide a starting point of understanding from which to develop future programs. (Author abstract)

Nunn, Nell (Nunn, Yoest, Pritz & Associates Inc, Kansas City, MO, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 272-277.

**088271 TROUBLESOME TRANSPORTATION CONCERNS CAN BE MITIGATED - RADMAT TRACKING SYSTEM.** There are three troublesome institutional concerns which face every large-quantity radioactive materials shipment - routing, prenotification, and emergency response. DOE is developing a transportation tracking system, based on a rapidly developing technology to determine geographical location using geopositioning satellite systems. This technology will be used to track unclassified radioactive materials shipments in real-time. It puts those charged with monitoring transportation status on top of every shipment. Besides its practical benefits in the areas of logistics planning and



execution, it demonstrates emergency preparedness has indeed been considered and close monitoring is possible. This paper will describe the system's technical detail, DOE plans and policy for its implementation, and the state of satellite positioning technology. (Edited author abstract)

Harmon, Lawrence H. (US DOE, Washington, DC, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 278-281.

**088272 PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIALS (PATRAM '86), PROCEEDINGS OF AN INTERNATIONAL SYMPOSIUM.** This conference proceedings contains 159 papers which concern the packaging and transportation of radioactive materials. 9 papers are in French, one in Spanish, one in Russian. The rest are in English. The contributions span a broad range of topics which include policy, technical details, transport experiences, and administrative issues. Design of packaging systems for radioactive wastes is given ample coverage. Analysis and testing techniques of containers are reviewed. Cask materials are also discussed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11074 in the Ei Engineering Meetings (TM) database produced by Engineering Information Inc.

Anon. (IAEA, Vienna, Austria). *Int At Energy Agency, Proc Ser* 718, Packag and Transp of Radioact Mater (PATRAM '86), Proc of an Int Symp, Davos, Switz, Jun 16-20 1986. Publ by IAEA, Vienna, Austria, 1987 2 vol, 1414p.

**Waste Disposal** See Also RADIOACTIVE WASTES—Management.

**088273 UPDATED SCALING FACTORS IN LOW-LEVEL RADWASTE.** NRC regulations require utilities to list the quantities of several difficult-to-measure radionuclides in all low-level radioactive waste shipped to land disposal facilities. This research, verifying and extending conclusions reported earlier, proposes generic scaling factors to ease the utilities' financial burden for off-site analyses. Fifty-two plants participated in the study, adding two years of data to NP-4037 and bringing the number of off-site analyses in the EPRI 10 CFR 61 database to about 1300. This report, which substantiates the generic scaling factors first proposed in NP-4037, presents scaling factors for quantifying nickel-63 and iron-55, as related to cobalt-60 concentrations in BWR and PWR waste streams. Additionally, the report identifies plutonium-239 as the key isotope for determining other transuranic concentrations. (Edited author abstract)

Anon. *Electr Power Res Inst Rep EPRI NP* 5077 Mar 1987 156p.

**088274 METHODOLOGY FOR CALCULATING COMBUSTIBLE GAS CONCENTRATION IN RADWASTE CONTAINERS.** An NRC-approved procedure is now available for calculating hydrogen concentrations in sealed nuclear waste containers. Implemented on computer spreadsheets, the procedure is faster and less costly than the tests and measurements originally prescribed for predicting combustible gas generation. The calculated hydrogen concentrations were within an average of 20% of the concentrations measured prior to venting and shipment of the TMI-2 casks. On the basis of these results, the NRC agreed to accept model calculations as confirmation that low-level waste packages meet regulations governing combustible gas mixtures. (Edited author abstract)

Anon. *Electr Power Res Inst Rep EPRI NP* 4938 Mar 1987 116p.

**088275 DESIGNS AND COSTS OF LOW-LEVEL WASTE DISPOSAL FACILITIES.** To help utilities, EPRI is developing alternative designs for low-level radioactive waste disposal facilities. This report provides detailed conceptual designs for different disposal technologies, along with cost estimates for each alternative design

and projected worker exposure rates based on the quantity and radiologic nature of waste packages received for disposal. Development efforts resulted in designs for six LLRW disposal technologies: buried placement (trenches), covered structure, buried structure, buried modules, collocated covered modules and buried structure, and deep structure (mined cavity). Total cost estimates indicated that buried placement was the least expensive and deep structure the most expensive of the alternatives. (Edited author abstract)

Anon. *Electr Power Res Inst Rep EPRI NP* 5365 Aug 1987 2p.

**088276 FILTRATION IMPROVEMENT STUDY AT THREE MILE ISLAND UNIT 2.** Reduced water clarity impaired visibility in the reactor vessel at Three Mile Island Unit 2, interfering with defueling operations. This research, cosponsored by General Public Utility Nuclear Corporation, determined that a combination of two cationic polymers and diatomaceous earth could improve the ability of existing filtration equipment to maintain water clarity. Colloidal materials in the reactor coolant led to plugging of the porous metal screens. When used alone, commercially available filtering materials do not adequately prevent penetration of extremely fine particulates. Two coagulant aids composed of cationic organic polymers did destabilize the colloids. However, the use of polymers in combination with diatomaceous earth provided interparticle bridging, resulting in dramatic improvement in the filterability of the coolant as well as extremely high effluent clarity. (Edited author abstract)

Anon. *Electr Power Res Inst Rep EPRI NP* 5367 Oct 1987 112p.

**088277 ADVANCED RADIOACTIVE WASTE AS-SAY METHODS.** Nuclear power plants face increased restrictions in the classification of radioactive waste material, which can result in increased disposal costs. Two techniques identified in this study should improve accuracy in waste radioactivity measurements, thereby reducing handling and burial costs while keeping personnel radiation exposure as low as reasonably achievable. This study found that gamma-ray spectroscopy used with a neutron counting technique will improve analytic accuracy at reasonable cost while fulfilling ALARA requirements. For easy-to-sample wastes such as homogeneous evaporator bottoms or small volumes of mixed resin, comparisons between direct assay results and sampling results showed excellent agreement: 20%. (Edited author abstract)

Anon. *Electr Power Res Inst Rep EPRI NP* 5497 Nov 1987 288p.

**088278 LA GESTION A LONG TERME DES DECHETS RADIOACTIFS.** [Long-Term Management of Radioactive Waste]. After setting out the terms of reference of ANDRA (national agency for the management of radioactive waste), the author describes the current situation and the projects for the surface storage of waste of low and medium activity. He then discusses the work which has started on the construction of an underground laboratory for studying the storage of long life waste. (Author abstract). In French.

Faussat, Armand. *Rev Gen Nucl* n 1 Jan-Feb 1988 p 51-52.

**088279 SYSTEMS ENGINEERING IN NRC'S HIGH LEVEL WASTE PROGRAM.** In order to fulfill its statutory responsibilities in the national program for high level nuclear waste disposal, the Nuclear Regulatory Commission (NRC) has adopted a systems engineering approach. This paper discusses that approach, and its expected contributions to the overall NRC program. The paper covers 3 subjects: (1) Why NRC has adopted a systems engineering approach to fulfill its regulatory role in the national High-Level Waste (HLW) program, especially in repository licensing; (2) The current status of NRC's program and what it is designed to do; and (3) What NRC foresees as the benefits of a successful effort

in terms of safety, timeliness, and cost-effectiveness.

Rogers, Kenneth C. (US Nuclear Regulatory Commission, USA). *Nucl Plant J* v 6 n 4 Jul-Aug 1988 p 70-72, 74.

**RADIOACTIVE WASTES** See Also NUCLEAR REACTORS, BOILING WATER; NUCLEAR REACTORS, BREEDER—Spent Fuels; NUCLEAR REACTORS, FUSION—Environmental Impact; SPECTROMETERS, GAMMA RAY—Computer Applications.

**088280 RADIOACTIVE WASTES.** This Annual Literature Review article discusses radioactive wastes within the general topic of industrial wastes. Subjects covered include high-level and low-level wastes, retrievable storage, safety and risk assessment, and others. 116 refs.

Boegly, W.J. Jr.; Alexander, H.J. *J Water Pollut Control Fed* v 58 n 6 Jun 1986 p 594-600.

**088281 EVALUATING THE DURABILITY OF A SIMULATED NUCLEAR WASTE GLASS: A STATISTICAL APPROACH.** Multicomponent systems tests of the durability of fuel recycle waste glass are an important tool to assess the long-term performance of a nuclear waste isolation system. A fractional factorial design was chosen for these tests, with three parameters: the cation exchange capacity of clay, the ionic strength of groundwater, and the concentration of clay in groundwater. The dissolution behavior of a simulated nuclear waste form based on sodium borosilicate glass was investigated at these three levels. (Edited author abstract). 66 Refs.

Heimann, R.B. *At Energy Can Ltd AECL Rep* n 9058 1988 62p.

## Accident Prevention

**088282 RIGID PERFORMANCE REQUIREMENTS ASSURE PUBLIC SAFETY BY REGULATIONS.** Title 10, Part 71 of the Code of Federal Regulations (10 CFR 71) provides a set of prescriptive performance test requirements for spent nuclear fuel and high-level waste transport packaging containment systems. The hypothetical accident conditions, which involve a sequence of impact, puncture, fire, and water immersion events, are referred to as rigid because of their extremely prescriptive nature. These hypothetical accident events have now been placed within the context of real transportation accidents, at least for conventional austenitic stainless steel/lead gamma shielded cask designs. The assurance of public safety, including the issue of safety margin for very severe accident events, is discussed in this paper for both conventional and innovative cask design concepts. A particular risk assessment approach that follows from work at the Lawrence Livermore National Laboratory is suggested. (Author abstract) 6 refs.

Nickell, Robert E. (Applied Science & Technology, Poway, CA, USA); Glass, Robert E. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 246-250.

## Adsorption

**088283 ADSORPTION - DESORPTION STUDIES ON THE RADIUM-SILICA SYSTEM.** Uranium is extracted from its ores by sulphuric acid or by alkaline carbonate leaching. The uranium mill tailings from these processes are mildly radioactive because they contain most of the radium-226 initially present in the ore, either as radium sulfate or as radium carbonate. Adsorption of radium-226 on quartz is investigated. Adsorption isotherms are obtained for crystalline and sulphuric and hydrochloric acid-treated quartz samples at pH 1 and 10. Desorption of radium-226 from silica with EDTA and an EDTA-KCl mixture is also studied. It is found that radium-226 adsorbed on silica is difficult to desorb whereas radium deposited on silica as radium sulphate is easily removed in EDTA solutions. (Edited author abstract) 15 refs.

Nirdosh, I. (Lakehead Univ, Thunder Bay, Ont, Can);



Trembley, W.B.; Muthuswami, S.V.; Johnson, C.R. *Can J Chem Eng* v 65 n 6 Dec 1987 p 928-934.

## Analysis

**088284 DIE BESTIMMUNG VON PLUTONIUM IN ABFALLFASERN.** [Plutonium Assays in Waste Drums]. The events associated with the Transnuclear and Nukem nuclear fuel companies have revived the discussion about the methods, minimum quantities, accuracy and reliability of assaying for plutonium in waste drums. These problems are in no way new, but have always been of crucial importance in the work going on for a long time already for the development of methods of measurement for nuclear materials accountability and the determination of fissile material in alpha-bearing waste. Methods in which the drum is opened and the sample analyzed chemically are able to detect plutonium quantities in the submilligram range, but are too time consuming for routine application and raise problems in sampling heterogeneous waste. For this reason, those methods of measurement are preferred in which the radiation emitted by the sample is measured on the surface of the drum. (Edited author abstract) 15 refs. In German.

Kuehle, M. (Kernforschungszentrum Karlsruhe GmbH, Karlsruhe, West Ger); Ottmar, H.; Wuerz, H. *Atomwirtschaft Atomtech* v 33 n 4 Apr 1988 p 181-184.

**088285 CHEMICAL CHARACTERIZATION, LEACH AND ADSORPTION STUDIES OF SOLIDIFIED LOW-LEVEL WASTES.** Laboratory and field leaching experiments were conducted on solidified low-level waste from a commercial boiling water reactor. Chemical and radionuclide analyses performed on samples collected from the field and laboratory experiments indicate strong adsorption of  $^{134,137}\text{Cs}$  and  $^{85}\text{Sr}$  onto the Hanford soil. Approximately 0.5% of the available  $^{60}\text{Co}$  leached from the waste forms and migrated through the soil with a retardation factor of 1. Chemical constituents present in the reactor waste streams and found at elevated levels in the field and laboratory leachates include: sodium (1383 mg/L), sulfate (2230 mg/L), and nitrate (435 mg/L field only). Plausible solid phases that could be controlling the chemical and radionuclide concentrations in the leachate were identified using the MINTEQ geochemical computer code. (Edited author abstract) 22 refs.

Walter, M.B. (Pacific Northwest Lab, Richland, WA, USA); Serne, R.J.; Johnstone, D.L.; Yonge, D.R. *Nucl Chem Waste Manage* v 8 n 1 1988 p 55-67.

## Calcination

**088286 OPERATING PERFORMANCE OF THE NEW WASTE CALCINING FACILITY.** Reprocessing nuclear fuels at the Idaho Chemical Processing Plant (ICPP) to recover the unspent fissile material results in the generation of significant quantities of radioactive liquid wastes. Handling, treatment, and storage of these wastes are areas that have received considerable attention from the entire nuclear industry. Although no decision concerning 'permanent' disposition of these wastes has yet been reached, a new facility built by the U.S. Department of Energy (DOE) at the ICPP near Idaho Falls, Idaho, is providing the capability to solidify the liquid wastes and safely store them in underground bins. This article discusses the facility and design requirements, remote requirements, and operating results.

Bingham, G.E. (Westinghouse Idaho Nuclear Co, Idaho Falls, ID, USA). *Energy Prog* v 8 n 2 Jun 1988 p 98-99.

## Computer Aided Analysis

**088287 WEST VALLEY UPGRADES ITS MULTI-COMPONENT ASSAY SYSTEM.** The experience gained in modifying, developing and automating the West Valley radwaste assay system is potentially applicable elsewhere. The type of radionuclides, size of waste package, and density and form of the waste determine which of West Valley's four major assay subsystems is used. The four subsystems together form a comprehensive automated assay system. Using personal computers, the

full system automatically stores assay data; maintains inventories; streamlines recordkeeping; negates the need for duplicative, time-consuming data entry; automatically produces, manifests and generates reports; and performs statistical and mathematical analyses, data reduction, and classification.

McVay, Charlie (West Valley Nuclear Services Co, West Valley, NY, USA); Hoffman, Dean. *Nucl Eng Int* v 33 n 403 Feb 1988 p 51-52.

## Decontamination

**088288 MELTING OF URANIUM-CONTAMINATED METAL CYLINDERS BY ELECTROSLAG REFINING.** Melt refining as a means of uranium decontamination of metallic wastes by electroslag refining was examined. Electroslag refining was selected because it is easy to scale up to the necessary industrial levels. Various thicknesses of iron and aluminum cylinders with uranium concentrations close to actual metallic wastes were melted by adding effective fluxes for decontamination. Thin-walled iron and aluminum cylinders with a fill ratio (electrode/mold cross-section ratio) of 0.05 could be melted, and the energy efficiency obtained was 16 to 25%. The ingot uranium concentration of the iron obtained was 0.01 to 0.015 ppm, which was close to the contamination level of the as-received specimen, while for aluminum it was 3 to 5 ppm, which was a few times higher than the as-received specimen contamination level of approximately 0.9 ppm. (Edited author abstract) 15 refs.

Uda, Tatsuhiko (Hitachi Ltd, Hitachi, Jpn); Ozawa, Yoshihiro; Iba, Hajime. *Nucl Technol* v 79 n 3 Dec 1987 p 328-337.

**088289 DESIGN AND TESTING OF NATURAL-BLENDED ZEOLITE ION EXCHANGE COLUMNS AT WEST VALLEY.** A zeolite ion exchange system has been designed and fabricated for decontaminating various radioactive liquid wastes being generated during the decommissioning activities at the former nuclear fuel reprocessing plant in West Valley, New York. Variables affecting the column design and performance were investigated in the laboratory. Results of testing showed that the removal of the radioactive contaminants is strongly dependent upon waste composition and residence time. The use of a zeolite bed containing both a natural zeolite (phillipsite) and a processed zeolite (Linde A-51) were found to successfully handle the waste streams. (Author abstract) 1 ref.

Burn, P. (West Valley Nuclear Services Co, West Valley, NY, USA); Ploetz, D.K.; Saha, A.K.; Grant, D.C.; Skriba, M.C. *AICHE Symp Ser* n 259 v 83, Rec Progr in Adsorpt and Ion Exch. Publ by AIChE, New York, NY, USA p 66-72.

**088290 RADIOACTIVE DECONTAMINATION OF WASTE OIL BY FILTRATION, CENTRIFUGATION, AND CHELATION.** Laboratory studies were conducted on select physical and chemical processes for decontamination of a composite waste lubricating oil from a boil water reactor. Physical treatments included successive filtration through 25.8 and 1  $\mu\text{m}$  filters to remove particulate matter and centrifugal to remove water. Chemical treatment consisted of mixing the oil with an aqueous solution of the chelating agent ethylenediaminetetraacetic acid (EDTA) and centrifuging the resulting emulsion. The effectiveness of the treatment processes was evaluated by measuring radionuclide concentrations in the oil following each treatment step and calculating decontamination factors. The total activity of the oil was dominated by  $^{60}\text{Co}$ ,  $^{54}\text{Mn}$ , and  $^{137}\text{Cs}$ , although  $^{51}\text{Cr}$ ,  $^{58}\text{Co}$ ,  $^{59}\text{Fe}$ , and  $^{134}\text{Cs}$  were also present. Filtration consistently achieved decontamination factors of approximately 200, 100, and 40 for  $^{137}\text{Cs}$ ,  $^{54}\text{Mn}$ , and  $^{60}\text{Co}$ , respectively, and reduced concentrations of the other radionuclides below their detection limits. The overall decontamination factor for successive filtration, centrifugation, and chelation was in excess of 10,000 for  $^{54}\text{Mn}$  and  $^{137}\text{Cs}$  and on the order of 1000 for  $^{60}\text{Co}$ . (Edited author abstract) 14 refs.

Simiele, Gerald A. (Arizona Public Service Co, Phoenix, AZ, USA); Fjeld, Robert A.; Robertson, Carlton. *Nucl Chem Waste Manage* v 7 n 3-4 1987 p 257-263.

Diffusion See FLOW OF WATER—Underground.

**Disposal** See Also CARBON STEEL—Corrosion; CEMENT—Diffusion; CLAY—Chemical Reactions; INDUSTRIAL WASTES—Hazardous Materials; NICKEL CHROMIUM MOLYBDENUM IRON ALLOYS—Corrosion; NUCLEAR FUELS—Reprocessing; NUCLEAR FUELS—Waste Disposal; NUCLEAR POWER PLANTS—Economics; NUCLEAR POWER PLANTS—Waste Disposal; NUCLEAR REACTORS—Decommissioning; NUCLEAR REACTORS—Spent Fuels; NUCLEAR REACTORS, FUSION—Radioactivity; TUNNELS AND TUNNELING—Construction; WATER, UNDERGROUND—Ion Exchange.

**088291 DEACTIVATION OF LOW-ACTIVITY EFFLUENTS FROM ATOMIC ELECTRIC POWER PLANTS BY SELECTIVE INORGANIC SORBENT.** Large amounts of liquid waste are produced during the operation of atomic electric power plants. One of the possible technological solutions which would simplify the processing of waste water is to use synthetic inorganic sorbents that are selective mainly with respect to radionuclides  $^{137}\text{Cs}$ ,  $^{134}\text{Cs}$ , and  $^{60}\text{Co}$ , which provide the basic contribution to the radioactivity of the effluent from atomic electric power plants. The present article provides the results of long-term stand tests of composite sorbents based on ferrocyanides of tetravalent metals, describes the design of an experimental decontamination device for industrial use, and provides a technical and economic substantiation of its application. Two sorbents were chosen for testing as a result of preliminary experiments: sorbents based on zirconium ferrocyanide (ZFC) and titanium ferrocyanide (TFC). 8 refs.

Sharygin, L.M.; Moiseev, V.E.; Pyshkin, V.P.; Neshkov, P.F.; Kuz'mina, R.V.; Galkin, V.M.; Bragin, V.B.; Tsek, A.R. *Sov At Energy* v 62 n 1 Jan 1987 p 39-42.

**088292 OCEAN DISPOSAL OF HIGH LEVEL RADIOACTIVE WASTE: MIGRATION PATHWAYS IN SOILS.** This work is an investigation of the effectiveness of sub-seabed sediments as a barrier to radionuclide migration, when the sediments are deformed by the passage of a penetrometer, by hydraulic fractures or by faulting. The effect on diffusion coefficients of the pressures and temperatures encountered below 5 km of water, is discussed. The experimental section consists of a description of the method used to produce autoradiographs of soil samples and to obtain the distribution coefficients of promethium and iodide between clays and seawater. These are followed by experiments to determine diffusion coefficients for the migration of iodide through clay samples. The last part of the section describes the scanning electron microscopy, which was used to investigate the orientation of clay particles around a rapidly emplaced model projectile. The results of the studies are reviewed in terms of the effect that the deformations are likely to have on the rate of transport of radionuclides to the seabed. (Edited author abstract) 36 refs.

Gronow, Janet R. *Cambridge Univ Eng Dep Tech Rep CUED/D-Soils* 193 Dec 1986 92p.

**088293 STUDY OF THERMALLY INDUCED CONVECTION NEAR A HIGH-LEVEL NUCLEAR WASTE REPOSITORY IN PARTIALLY SATURATED FRACTURED TUFF.** We present simple estimates for velocities of buoyancy-driven flow of liquid and gas phases near a hypothetical high-level nuclear waste repository in partially saturated, fractured tuff. These estimates indicate that gas phase convection could take place with appreciable velocity, of the order of 20 m/year, while liquid convection is expected to be very slow, of the order of 0.1 mm/year. Detailed numerical simulations using an 'effective continuum' approximation to represent



fracture effects confirm these estimates and demonstrate a sensitivity of gas convection to the strength of binary diffusion. (Author abstract) 38 refs.

Tsang, Y.W. (Lawrence Berkeley Lab, Berkeley, CA, USA); Pruess, K. *Water Resour Res* v 23 n 10 Oct 1987 p 1958-1966.

**088294 CENTRIFUGE AND LABORATORY TESTS, MODELLING THE PENETRATOR CONCEPT FOR THE DISPOSAL OF HGW IN DEEP OCEAN SEDIMENTS.** The report is a summary of the work carried out at Cambridge University Engineering Department to investigate the geotechnical aspects of the subseabed disposal of heat generating waste. The problem of heat transfer and coupled consolidation around a heat source was studied both experimentally and numerically. Calculations of the temperature and pore pressure changes in the soil around a cylindrical heat source were made and verified by both laboratory tests and by centrifuge modeling at 100 times earth's gravity. It was shown that conduction was the major heat transfer process. The high velocity penetration of soil by projectiles was modeled on the Cambridge Geotechnical Centrifuge and this was followed by centrifuge tests in which there was subsequent heating of the projectile after firing. These dynamic tests showed that the projectile produced high pore pressures within the soil, which were quickly dissipated. (Author abstract) 25 refs.

Savvidou, C.; Schofield, A.N. *Cambridge Univ Eng Dep Tech Rep CUED/D-Soils* 192 1986 var pagings.

**088295 LOW-LEVEL RAD WASTE SEEKS HOME.** This article provides a brief synopsis of the technological, political, and cultural problems that will be encountered by the 52 governing bodies, and the generators of low-level radioactive waste as the states attempt to meet the December 31, 1992 deadline for the assumption of state responsibility under the 'Low-Level Radioactive Waste Policy Act' of 1980. The subjects covered include radioactive waste classification, waste management systems, and others. 3 refs.

Yoder, Kenyon D. (Miles Lab, Elkhart, IN, USA). *Pollut Eng* v 19 n 11 Nov 1987 p 49-51.

**088296 EMPIRICAL CORRELATIONS FROM WASTE GROUT FORMULATION DATA.** Data correlations have demonstrated systematic relationships between important variables in hydrofracture grout formulation. The data are taken from an investigation to determine conditions for eliminating drainable water from the grout system. The two most important variables affecting drainable water are the amounts of Attapulgit-150 clay in the dry-solids blends and the ratios in which the blends are mixed with the waste. Empirical equations were developed relating (a) volume percent of drainable water, (b) time for free water adsorption, (c) weight percent of clay, (d) dry-blend liquid-waste mix ratio, (e) compressive strength, (f) weight percent of fly ash, and (g) pumping flow rate required for turbulent flow through 51-mm-i.d. pipe. (Edited author abstract) 11 refs.

Tallent, Othar K. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); McDaniel, Earl W.; Dodson, Karen E.; Godsey, Terry T. *Nucl Technol* v 79 n 3 Dec 1987 p 348-358.

**088297 DISPOSAL OF RADIOACTIVE WASTE.** The technical basis for the geologic disposal of high-level waste and spent fuel was reviewed in the AAEC magazine Atomic Energy in Australia (Costello 1984). The present paper reviews updated national developments in geologic disposal and gives a brief summary of experience in the waste management aspects of decommissioning nuclear reactors. 15 refs.

Costello, J.M. (AAEC, Aust). *Nucl Spectrum* v 1 n 2 Sep 1985 p 5-7.

**088298 DUKE BUILDS A STATE OF THE ART RADWASTE FACILITY AT OCONEE.** A new radwaste facility currently under test at Oconee will cut by half the volume of waste generated by the station. The system includes a fluidized dryer/incinerator as well as

polymer and cement encapsulation. (Author abstract)

Anon. *Nucl Eng Int* v 32 n 399 Oct 1987 p 14-15.

**088299 CHARACTERISTICS OF RADIOACTIVITY CONTAMINATION OF SOIL AT THE NEVADA TEST SITE.** For 35 years the Nevada Test Site Complex has been contaminated by a combination of transuranic elements, fission products, and activation products. Within the nuclear detonation sites the initial radionuclide distribution depended upon the different types of nuclear tests (airburst, surface, or underground) and meteorological conditions at the time of each test. Results of this study show that the present distribution is the result of wind and water erosion, whereas site specific geomorphic features and pedogenic processes played secondary roles. The high temperatures of the detonations resulted in most of the radionuclides being incorporated into fused soil and rock materials which have very low solubilities in aqueous media. The glassy silicate contaminants vary in size, but most (91%) are greater than 0.1 mm in diameter. Therefore, the radioactivity contributed by the respirable (<0.1 mm) and respirable (<0.005 mm) particles in the soils is less than 9% of the total soil radioactivity, indicating that the site has a very low potential to off-site environmental and health hazards under natural conditions. (Edited author abstract) 36 refs.

Lee, S.Y. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Tamura, T.; Essington, E.H. *Nucl Chem Waste Manage* v 7 n 3-4 1987 p 179-190.

**088300 MODELING STUDY OF GEOCHEMICAL INTERACTIONS AT THE SHEFFIELD, ILLINOIS LOW-LEVEL RADIOACTIVE WASTE DISPOSAL SITE.** This report summarizes an attempt to model the geometrical behavior of leachate migration from the Sheffield, Illinois low-level radioactive waste disposal site. The reaction path code PHREEQE was used to simulate mixing between groundwater altered by trench leachate and ambient groundwater. The thermodynamic speciation code WATEQF was used to calculate the aqueous speciation and mineral saturation indices of the pertinent waters. The mass balance code BALANCE was used to predict the probable chemical reactions occurring as groundwater migrates. Results suggest that the most important factor influencing water quality is dilution. Chemical reactions that may also be affecting water chemistry are ion exchange, calcite precipitation, iron sulfide mineral dissolution, and exsolution of CO<sub>2</sub>. Limitations of the modeling include lack of consideration of reaction kinetics under surficial conditions, uncertainties in flowpaths, and limited reliability of thermodynamic data. The study suggests that anionic and gaseous radionuclides have the greatest potential for migration away from the site. (Author abstract) 17 refs.

Kelly, Walton R. (NRC, Washington, DC, USA). *Nucl Chem Waste Manage* v 7 n 3-4 1987 p 191-199.

**088301 EMANATION AND DISPERSAL OF TRITIATED WATER FROM DISPOSAL SHAFTS.** The source level of contamination induced by the presence of tritiated water (HTO) in the Banderier tuff near Los Alamos, New Mexico has been seen to decrease in all directions at the same time. This decrease in radioactivity with distance from the source has been measured around three different disposal shafts and found to be slower than the decrease in emanation rate with distance from the source. Physical factors, suspected of influencing HTO emanation, were entered as independent variables in a regression equation including measurements taken over a 14-month period. The physical variables studied were of thermal, hydrological, and meteorological origin. Only four variables were retained as significant. Air concentrations of HTO show a maximum during the warmer months and an overall minimum during the colder months. Emanation of HTO, shown to be strongly associated with daily heat flux amplitude, also at a maximum in summer and at noon, more than counterbalances higher dissipation due to increased turbulence occurring during the same period. (Edited author abstract) 9 refs.

Abee, W.V. (Los Alamos Natl Lab, Los Alamos, NM, USA); Nyhan, J.W. *Nucl Chem Waste Manage* v 7 n 3-4 1987 p 217-226.

**088302 ENVIRONMENTAL ASSISTED CRACKING BEHAVIOR OF A CANDIDATE NUCLEAR WASTE REPOSITORY CONTAINER MATERIAL IN SIMULATED HANFORD GROUNDWATER.** The environmentally assisted cracking (EAC) behavior of cast ASTM A27 Steel was studied in simulated Hanford groundwater at temperatures of 150°C and 250°C. Fatigue-crack growth tests were employed for this purpose, and the rationale for using cyclic loadings is discussed. An example is given whereby a tentative value of a threshold stress intensity factor for EAC is derived, and an illustration is then made showing the application of the threshold to a waste repository container. (Author abstract) 18 refs.

James, L.A. (Westinghouse Hanford Co, Richland, WA, USA). *Nucl Chem Waste Manage* v 7 n 3-4 1987 p 227-237.

**088303 REVIEW OF NATIONAL POLICIES AND PROGRAMMES.** Although there is a wide measure of agreement on how the different radioactive wastes arising from nuclear power programs can best be dealt with safely, there are significant variations in policy and timing between countries. In this survey, an attempt has been made to identify how policy is determined, and to indicate the progress being made in 15 countries. These countries are Belgium, Canada, China, Finland, France, West Germany, India, Italy, Japan, Netherlands, South Africa, South Korea, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

Masters, Richard. *Nucl Eng Int* v 32 n 401 Dec 1987 p 50-51, 53-56.

**088304 BENTONITE IN NUCLEAR WASTE DISPOSAL: A REVIEW OF RESEARCH IN SUPPORT OF THE BASALT WASTE ISOLATION PROJECT.** The Basalt Waste Isolation Project is investigating the feasibility and safety of a high-level nuclear waste repository in the Columbus River basalts. A mixture of crushed basalt and sodium bentonite is under investigation as packing material around individual waste containers. A 75:25 basalt/bentonite mixture, with a density of 2.1 g/cm<sup>3</sup>, is the BWIP reference packing material. This paper discusses various tests performed on the materials, and reports on such material characteristics as hydraulic conductivity, swelling pressure, dehydration, corrosion of steel and copper, sorption, and others. 48 refs.

Allen, C.C. (Westinghouse Hanford Co, Richland, WA, USA); Wood, M.I. *Appl Clay Sci* v 3 n 1 Jan 1988 p 11-30.

**088305 ON THE TIME-DEPENDENT BEHAVIOR OF A CYLINDRICAL SALT DOME WITH A HIGH-LEVEL WASTE REPOSITORY.** In a salt dome with a repository for high-level radioactive and heat-generating waste, thermal stresses develop. In this paper, results are presented of sensitivity analyses of the time-dependent behavior of a hypothetical salt dome having an HLW repository. The parameters varied are constants in the thermomechanical constitutive behavior of rock salt and surrounding sediments, and furthermore the thermal loading has been varied. The analyses are performed with the finite element program Golia on the same axisymmetric and homogeneous salt dome as previously reported. 10 refs.

Prij, Jan (Netherlands Energy Research Foundation, Le Petten, Neth). *Nucl Technol* v 80 n 3 Mar 1988 p 462-475.

**088306 TECHNOCRACY AND TRUST: NUCLEAR WASTE CONTROVERSY.** The Nuclear Waste Policy Act of 1982 requires the US Department of Energy (DOE) to develop a permanent nuclear waste repository. DOE is also required to conduct a program of consultation and cooperation with each of the effected states and Indian



Tribes. The program is characterized by a pervasive lack of trust that threatens to undermine the intent of the act. Rather than addressing the technical issues of nuclear waste disposal, this paper explores the issue of trust itself. The paper concludes that the crisis over nuclear waste cannot be resolved through technological solutions alone. The crisis involves the relationship of a citizenry to its institutions of power. To address such a crisis, the subject of trust itself and its requirements must be seriously examined. (Author abstract) 22 refs.

Bella, David A. (Oregon State Univ, Corvallis, OR, USA); Mosher, Charles D.; Calvo, Steven N. *J Prof Issues Eng v 114 n 1 Jan 1988 p 27-39.*

**088307 ESTABLISHING TRUST: NUCLEAR WASTE DISPOSAL.** The US effort to establish a permanent nuclear waste repository is threatened by a pervasive lack of trust that could undermine the entire program. Rather than examining the many technical debates involved, this paper addresses the pervasive and long-standing lack of trust. The subject of trust itself is explored. It is reasoned that the lack of trust is a function, not of the individuals involved, but of the decision-making process. An alternative process is presented. (Author abstract) 13 refs.

Bella, David A. (Oregon State Univ, Corvallis, OR, USA); Mosher, Charles D.; Calvo, Steven N. *J Prof Issues Eng v 114 n 1 Jan 1988 p 40-50.*

**088308 PROCESSING AND WASTE DISPOSAL NEEDS FOR FUSION BREEDER BLANKETS SYSTEMS.** We evaluated the waste disposal and recycling requirements for two types of fusion breeder blanket (solid and liquid). The goal was to determine if breeder blanket waste can be disposed of in shallow land burial, the least restrictive method under U.S. Nuclear Regulatory Commission regulations. Described in this paper are the radionuclides expected in fusion blanket materials, plans for reprocessing and disposal of blanket components, and estimates for the operating costs involved in waste disposal. (Author abstract) 19 refs.

Finn, P.A. (Argonne Natl Lab, Argonne, IL, USA); Vogler, S. *Fusion Eng Des v 5 n 4 Jan 1988 p 357-365.*

**088309 IMPACT OF D<sup>3</sup>He FUSION REACTORS ON WASTE DISPOSAL.** The suggestion that the surface of the moon may be mined for <sup>3</sup>He to be used as a fuel in terrestrial fusion reactors has recently been made. A fusion reactor based on the D<sup>3</sup>He reaction would have the advantage that most of the power produced would be in the form of charged non-radioactive particles. However, secondary D-D and D-T reactions also occur. A study is made of the consequences of the radioactivity induced by the neutrons from these reactions with respect to waste disposal. A generic first wall and shield 0.4 m thick consisting of 7% structure, 73% H<sub>2</sub>O and 20% void was used as a test case. (Edited author abstract) 11 refs.

Vogelsang, W.F. (Univ of Wisconsin-Madison, Madison, WI, USA); Khater, H.Y. *Fusion Eng Des v 5 n 4 Jan 1988 p 367-377.*

**088310 TREATMENT AND DISPOSAL OF TRITIUM CONTAINING WASTE AT MOUND.** First generation fusion machines will burn the hydrogen isotopes deuterium and tritium as fuel. Tritium, which is radioactive, must be handled carefully and any byproducts must be disposed of as radioactive waste. Tritiated waste will fall into one of three categories: gaseous, liquid, or solid. Sources and expected quantities of tritiated waste that are likely to be generated by a fusion machine will be discussed. Strategies, options and processes for dealing with tritium containing wastes will also be presented. Final disposition of each category of tritium contaminated waste is governed by regulations and guidelines. These regulations and guidelines, and how they might apply to a fusion reactor facility, will be outlined. (Author abstract) 10 refs.

Rogers, Michael L. (Monsanto Research Corp, Miamisburg, OH, USA). *Fusion Eng Des v 5 n 4 Jan 1988 p 415-419.*

**088311 STABILITY EVALUATION FOR CEMENT PACKAGE CONTAINING RADIOACTIVE WASTE.** In order to provide stable cement packages, ettringite formation, a major cause of cement deterioration, was studied theoretically and experimentally. A computer program was developed to calculate the chemical equilibrium compositions of a complex cement system. Higher curing temperature and the addition of NaOH were identified as effective methods to avoid ettringite formation. These findings were confirmed by measuring the amount of ettringite in solidified cement by an X-ray diffraction method. (Author abstract) 17 refs.

Chino, Koichi (Hitachi Ltd, Hitachi, Jpn); Kawamura, Fumio. *Nucl Technol v 81 n 1 Apr 1988 p 95-99.*

**088312 APPLICATION OF THE FINITE ELEMENT GROUNDWATER MODEL FEWA TO A RADIOACTIVE WASTE DISPOSAL SITE.** A finite element model for water transport through porous media (FEWA) has been applied to the unconfined aquifer at the Oak Ridge National Laboratory Solid Waste Storage Area 6 Engineered Test Facility (ETF). The model was developed in 1983 as part of a shallow land burial technology research program and was previously verified using several general hydrologic problems for which an analytic solution exists. Model application and calibration, as described in this paper, consisted of modeling the ETF water table for three specialized cases: a one-dimensional steady-state simulation, a one-dimensional transient simulation, and a two-dimensional transient simulation. In the one-dimensional steady-state simulation, the FEWA output accurately predicted the water table during a long period in which there were no human-induced or natural perturbations to the system. The input parameters of most importance for this case were hydraulic conductivity and aquifer bottom elevation. (Edited author abstract) 11 refs.

Davis, Edward C. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Craig, Paul M. *Appl Math Modelling v 12 n 2 Apr 1988 p 141-153.*

**088313 NEPTUNIUM MIGRATION IN OXIDIZING CLAYEY SAND.** The rate and mechanism of Np migration were investigated in a flowing water/clayey sand system under oxidizing conditions. A <sup>237</sup>Np-doped borosilicate glass was used as a source of containment in the migration experiments. A preliminary study of the chemical speciation of Np in the water leachate allowed identification of soluble cationic and anionic carbonate species of Np(V). The formation constants of Np(V) carbonate complexes were corrected for the ionic strength of the groundwater by making use of the Guggenheim-Scatchard specific interaction theory. The values were then used to model the partitioning of Np between the soil and the water phase. Analytical solutions of the transport equation were used for best-fit analysis of the Np column profiles. Both the sorption reaction and the dissociation kinetics were considered in the model. (Edited author abstract) Refs.

Bidoglio, G. (Commission of the European Communities, Ispra, Italy); Offermann, P.; Saltelli, A. *Appl Geochem v 2 n 3 May-Jun 1987 p 275-284.*

**088314 PRAXIS DER RADIOAKTIVEN ABFALL-BEHANDLUNG IM ZWIELICHT.** [Suspicious About the Practice of Radioactive Waste Treatment]. Two quite distinct events associated with the treatment and disposal of radioactive waste have created a turmoil in the past twelve months. In the discussions about the Hanau nuclear fuel industries, the pressure buildup in conditioned waste drums, which had been known for two years and had meanwhile been investigated in various places, was mixed up with the irregularities at Transnuklear either out of ignorance or intentionally. In the public, this was bound to create the impression as if the ballooning of a large number of waste drums as a result of gas evolution were connected with the goings-on at Transnuklear. Actually, however, these are two absolutely separate issues. 1 ref. In German.

Merz, E. (KFA, Juelich, West Ger). *Atomwirtsch Atom-*

*tech v 33 n 4 Apr 1988 p 173-174.*

**088315 UNREGELMAESSIGKEITEN BEI DER DEKLARATION VON ABFALLFAESSERN DURCH TRANSNUKLEAR/SCK MOL.** [Irregularities in the Declaration of Waste Drums by Transnuklear/SCK Mol]. In mid-December 1987, the competent ministries in the Federal Republic of Germany received some first indications of irregularities said to have occurred in the conditioning of low level radioactive waste from German nuclear power plants at the Belgian nuclear research center, SCK Mol. The first statement referred to forty conditioned drums shipped back to the intermediate storage facility with the Unterweser Nuclear Power Station (KKU) in September 1983. A second statement then indicated that a total of 321 drums containing waste from the Belgian BR-3 test reactor had been shipped into the Federal Republic. Subsequent investigations revealed that intermediate storage facilities in the Federal Republic at present hold some 2500 drums whose contents were either conditioned or graded in Mol. A number of drums were examined at the Karlsruhe and Juelich Nuclear Research Centers. The findings made in these examinations, and the consequences to be drawn from them, are presented. (Author abstract) In German.

Odoj, R. (KFA, Juelich, West Ger); Filss, P.; Wolf, J. *Atomwirtsch Atomtech v 33 n 4 Apr 1988 p 175-178.*

**088316 DRUCKAUFBAU UND BLAEHERSCHEINUNGEN AN 200-1-ABFALLFAESSERN.** [Pressure Buildup and Ballooning in 200 1 Waste Drums]. In addition to the generally known phenomenon of radiolytic gas evolution in cemented medium level radioactive waste, which mainly causes water from the cement matrix to be dissociated by radiation chemistry reactions producing hydrogen, there has recently been internal pressure buildup and ballooning as a consequence of gas evolution in a different kind of waste drums, namely drums filled with low level waste (LLW) compacted under high pressure. The results of investigations conducted to date are not yet sufficient to explain fully all processes going on in this waste. However, it has become clear what mixtures of substances are likely to create problems. (Author abstract) 2 refs. In German.

Lammertz, H. (KFA, Juelich, West Ger); Kroth, K. *Atomwirtsch Atomtech v 33 n 4 Apr 1988 p 178-180.*

**088317 RADIOACTIVE WASTE MANAGEMENT: FACILITIES AND PLANNING IN SWEDEN.** As far as the nuclear fuel cycle is concerned, Sweden differs from other countries in that the twelve nuclear power plants of the country, with an aggregate installed capacity of roughly 10,000 MW meeting 50% of the electricity requirement, are compelled by law to discontinue operation by the year 2010. Svensk Kaernbraenslehantering AB (SKB), the Swedish nuclear fuel cycle company, thus faces a precisely defined waste management volume totaling some 7000 te of spent fuel elements to be put into long term intermediate storage. For this purpose, the central Swedish intermediate storage facility for spent fuel elements, CLAB, has been built near the Oskarshamn nuclear power station on the Simpevarp peninsula. In late 1987, more than 3200 spent fuel elements with some 650 te of fuel were stored in the water pool. The Swedish repository for radioactive waste is being driven into the rock below the water level near the site of the Forsmark nuclear power station, one kilometer from the coast. (Edited author abstract)

Forstroom, H. (Swedish Nuclear Fuel & Waste Management Co, Stockholm, Swed); Papp, T. *Atomwirtsch Atomtech v 33 n 4 Apr 1988 p 198-201.*

**088318 ASSESSMENT OF CARBON STEEL CONTAINERS FOR RADIOACTIVE WASTE DISPOSAL.** The report describes a study of the corrosion of high level nuclear waste containers in geological disposal. It has concentrated on the use of carbon steel in granitic environments and has aimed at estimating the corrosion allowance required to achieve a 1000-year life. Experi-



tal and mathematical modelling studies have indicated that 216 mm of steel should be more than sufficient to prevent penetration by general or localized corrosion. There are sound mechanistic reasons to regard this value as an overestimate. The possibility of stress corrosion cannot be dismissed but because the process requires a certain minimum stress level before it can occur, it should be possible to avoid the problem by giving the containers a stress relief heat treatment. A conservative assessment has shown that microbial corrosion may cause a maximum additional metal loss of 13 mm. (Author abstract) 39 refs.

Marsh, G.P. (Harwell Univ, Engl); Taylor, K.J. *Corros Sci* v 28 n 3 1988 p 289-320.

**088319 ELIMINATION OF COBALT IN NUCLEAR VALVES.** The attribute unique to cobalt-base, wear-resistant alloys that make them attractive for nuclear valve applications is their high resistance to galling and sliding wear. Studies at AMAX, supported by EPRI, have identified a family of iron-base alloys, designated NOREM, that show resistance to galling wear as high as the cobalt-base ones. Other iron-base alloys also performed very well in these laboratory tests. These alloys also possess other properties needed for hardfacing applications. Loop tests of gate valves that will be hardfaced with these alloys have been initiated, and a plant demonstration will be organized. The outstanding properties of the NOREM alloys and the expectation that they can be produced at lower cost than the cobalt-base ones has spurred interest by valve manufacturers, a number of whom will be undertaking in-house evaluations. In valves designed to control or throttle coolant flow, the use of cobalt-base hardfacing alloys appear to be unnecessary. Some stainless steels that performed well in operating plants were identified. 9 refs.

Ocken, H. (EPRI, Palo Alto, CA, USA). *Nucl Plant J* v 6 n 3 May-June 1988 p 101-102.

**088320 INTERACTION OF CEMENT AND RADIOACTIVE WASTE FORMS IN MULTICOMPONENT SYSTEMS TESTS AT 200°C. PART 1: LEACHING AND SORPTION OF CESIUM, STRONTIUM AND ACTINIDES.** The release of Cesium-137, strontium-90, plutonium 239+240, americium-241 and curium-244 from used fuel and fuel recycle waste glass has been investigated in multicomponent systems tests in the presence of either cement or granite, calcium bentonite, Inconel 625 and saline groundwater at 200°C and 8.5 MPa. These represent potential engineered and natural barriers in a nuclear waste disposal vault. Attempts were made to determine the partitioning of the various radionuclides among the leach solution, and the cement, granite and clay solids. (Edited author abstract) 33 refs.

Heimann, Robert B. (AECL, Pinawa, Manit, Can). *Cem Concr Res* v 18 n 3 May 1988 p 389-400.

**088321 DRY ROD CONSOLIDATION ADVANCEMENTS IN THE OCRWM PROGRAMS.** Repackaging techniques for geological disposal of spent fuel are being investigated by the Idaho Operations Office of the U.S. Department of Energy. To start this program, the Idaho National Engineering Laboratory constructed remotely operated equipment to pull rods from assemblies and stack them horizontally in new containers. Forty-eight PWR assemblies were compacted in 1987. The data on rod pulling forces, external contamination, etc. are summarized. Five companies have submitted preliminary designs for prototype production systems. Three have been selected to complete these designs. One or two of the latter will be constructed and thoroughly tested in the next few years. (Author abstract) 2 refs.

Fisher, Margaret W. (US DOE, Idaho Falls, ID, USA). *JNMM* v 16 n 3 Apr 1988 p 15-18.

**088322 SCANNING AND HIGH-RESOLUTION AUGER ANALYSIS OF ZIRCONOLITE/PEROVSKITE SURFACES FOLLOWING HYDROTHERMAL TREATMENT.** Synroc is the generic term for waste forms based on assemblages of titanate minerals such as perovskite, zirconolite and hollandite. Two tita-

nate minerals, zirconolite with perovskite minor phase inclusions, have been subjected to hydrothermal chemical attack. The effects of the treatment have been investigated with scanning and high resolution Auger analysis. Both mineral surfaces act as substrates for carbonate precipitation. Dissolution was the main mechanism of attack of perovskite, followed by precipitation from solution and growth of TiO<sub>2</sub> on the phase regions. There was also precipitation of calcium as fluoride and phosphate and growth of these crystallites at random locations on the surface of the two-phase ensemble. The zirconolite phase regions were not affected by the hydrothermal treatment. (Edited author abstract) 15 refs.

Myhra, S. (Griffith Univ, Nathan, Aust); Delogu, P.; Giorgi, R.; Riviere, J.C. *J Mater Sci* v 23 n 4 Apr 1988 p 1514-1520.

**088323 SCHACHT KONRAD - EIN GEPLANTES ENDLAGER FUER RADIOAKTIVE ABFALLE. [Konrad Mine - A Projected Radioactive Waste Dump].** The Konrad mine is situated near the city of Salzgitte and is the youngest of all former iron mines in the area. It was closed down for economic reasons in 1976. It is planned to dump there waste which has a negligible thermal effect upon the surrounding rock (95% of the radioactive waste produced in the Federal Republic of Germany). Dumping of radioactive waste could be started by 1993. (Edited author abstract) 4 refs. In German.

Viehl, Eckart (Physikalisch-Technische Bundesanstalt, Braunschweig, West Ger). *Erzmetall* v 41 n 4 Apr 1988 p 183-190.

**088324 USEPA RADIOACTIVE WASTE DISPOSAL STANDARDS: ISSUED AND UNDER DEVELOPMENT.** The United States Environmental Protection Agency (EPA) has issued and is developing generally applicable environmental standards for the disposal of radioactive wastes. Standards have been issued for the disposal of spent nuclear fuel, high-level and transuranic wastes, and for uranium mill tailings. Standards are being developed for the land disposal of low-level radioactive wastes and for wastes considered 'Below Regulatory Concern.' Regulations for ocean disposal of low-level radioactive wastes are also under consideration. (Edited author abstract) 33 refs.

Holcomb, W.F. (US EPA, Washington, DC, USA); Clark, R.L.; Dyer, R.S.; Galpin, F.L. *Nucl Chem Waste Manage* v 8 n 1 1988 p 3-12.

**088325 VOLUMETRIC CHANGE OF SIMULATED RADIOACTIVE WASTE GLASSES IRRADIATED BY THE <sup>10</sup>B(n, α)<sup>7</sup>Li REACTION AS SIMULATION OF ACTINIDE IRRADIATION.** The density change of simulated radioactive waste glasses irradiated by the <sup>10</sup>B(n, α)<sup>7</sup>Li reaction was determined by a sink-float method as a function of irradiation exposure. Simulated waste glasses P0500, P0798 and GP98/12 swelled, while P0504 shrunk. The magnitude of the density change was less than 0.6% up to a fluence of 6.6 × 10<sup>25</sup> reactions/m<sup>2</sup>, which corresponds to the cumulative irradiation during a few tens of thousand years after disposal of the waste glass from the spent fuel irradiated up to 33000 MWD/MTU. The processes which play an important role on the density change have not been clarified, but it is likely that one of the processes is helium bubble formation which was clarified by a carbon replica technique, in association with transmission electron microscopy. (Author abstract) 13 refs.

Sato, Seichi (Kyushu Univ, Fukuoka, Jpn); Furuya, Hirotaka; Kozaka, Tetsuo; Inagaki, Yoshiro; Tamai, Tadaharu. *J Nucl Mater* v 152 n 2-3 May 1988 p 265-269.

**088326 CHEMICAL ASSOCIATIONS OF ARTIFICIAL RADIONUCLIDES IN CUMBRIAN SOILS.** The distributions of radionuclides in the surface layer of four soils of contrasting types from west Cumbria, UK, have been studied in detail. All the soils contain enhanced levels of artificial radionuclides derived from low-level discharges both to sea and to atmosphere from the British Nuclear Fuels reprocessing plant at Sellafield. The bulk of

the activity is held in the top 15 cm of soil profiles, suggesting that radionuclide mobility is limited. Sequential extraction experiments have identified major associations of plutonium with organic matter and of caesium with silicates but there is no preferential association of ruthenium with any single soil component. (Author abstract) 35 refs.

Livens, F.R. (Inst of Terrestrial Ecology, Cumbria, Scotl); Baxter, M.S. *J Environ Radioact* v 7 n 1 1988 p 75-86.

**088327 RADIOACTIVE WASTE MANAGEMENT IN THE UK.** In the UK, as in most industrialized countries, radioactive materials are used in the generation of electricity, and in industry, defence, medicine and research. There is a recognized need, reflected in government policy, to establish a permanent, safe disposal facility. Disposing of this waste is not an awesome task. Technically and logistically the problem is quite manageable. The greatest impediment to the establishment of a waste disposal facility is public perception of the risks associated with radioactive materials. For this reason, it is important to provide the public with full information on radioactive waste disposal, and to ensure that their concerns are fully discussed and understood.

McInerney, P.T. (UK Nirex Ltd). *Nucl Eng J Inst Nucl Eng* v 29 n 2 Mar-Apr 1988 p 34-36.

**088328 DISPOSAL R&D PROGRAMME OF UK NIREX LTD.** A review is presented of the large program of research and development specifically concerned with the long-term safety of radioactive waste disposal. This paper is concerned with the long-term safety of a repository deep underground or under the sea-bed, for which the Environment Departments are the regulating authorities. 4 Refs.

George D. (UK Nirex Ltd); Tasker, P.W. *Nucl Eng J Inst Nucl Eng* v 29 n 2 Mar-Apr 1988 p 52-56.

**088329 TECHNOLOGY AND ART OF NUCLEAR WASTE DISPOSAL.** The paper considers the issues and questions that face the public regarding nuclear waste management. It discusses the current method of nuclear waste management and the disposal methods that have been researched. It highlights key points in the Nuclear Waste Policy Act regarding technical criteria for geologic repository selection and requirements for public involvement in the selection process. The paper's theme encourages nuclear experts to develop the channels of communication with the public in an effort to fulfill the public's need to understand the issues. The history of the second nuclear waste repository project is provided for insight, and the agenda for the coming years is discussed. (Author abstract). 1 Ref.

Shipp, B.D. (Battelle Pacific Northwest Lab, Richland, WA, USA). *J Struct Eng* v 114 n 8 Aug 1988 p 1929-1934.

**088330 CUBIC ZIRCONIA AS A CANDIDATE WASTE FORM FOR ACTINIDES: DISSOLUTION STUDIES.** Canada's radioactive waste management activities include research programmes pertaining to the immobilization of highly radioactive nuclear fuel waste in durable host materials. Zirconia stabilized with 10 mol percent Y<sub>2</sub>O<sub>3</sub> or 15 mol percent CaO appears to be attractive because of its ability to incorporate actinides and long-lived <sup>93</sup>Zr, present in the irradiated fuel sheath, into the crystal lattice of its cubic form. Leaching studies were performed on cubic zirconia stabilized with 9.4 mol percent Y<sub>2</sub>O<sub>3</sub>. The experiments described confirmed the high durability of cubic zirconia under the temperature and groundwater salinity conditions anticipated in a nuclear waste disposal vault. 28 Refs.

Heimann, Robert B. (AECL, Pinawa, Manit, Can); Vandergraaf, T.T. *J Mater Sci Lett* v 7 n 6 Jun 1988 p 583-586.



**088331 DIRECT-ASSAY CHARACTERIZATION OF IRRADIATED HARDWARE, APPLICATION TO FUEL SKELETONS.** Nuclear power plants are reaching the limits of their capacity to store spent fuel and it will be some time yet before the DOE facility will accept the fuel for disposal. Disposal of irradiated hardware at PWRs has been slow, however, since the bulk of PWR volume has been fuel assemblies composed both of fuel rods and the skeletons (cages). However, Northern States Power estimates that rod consolidation (removal of the fuel rods from the cages and repackaging them with closer packing) could reduce the volume required for stored fuel by a factor of two. Effective consolidation requires disposal of the skeletons. The current Consolidation Demonstration Program at Prairie Island consolidated 36 fuel assemblies and was concluded in the spring of 1988 with the disposal of all skeleton material that meets burial criteria. This article reports on the program. 4 Refs.

Cline, James E. (Science Applications Intl Corp, Rockville, MD, USA); McCarten, Laura. *Nucl Plant J* v 6 n 4 Jul-Aug 1988 p 60-62.

**088332 INTEGRATING RADWASTE TREATMENT EQUIPMENT INTO RADWASTE PROCESSING SYSTEMS.** This paper focuses on how Duke Power Company is attempting to integrate the various radwaste treatment equipment and systems at Oconee Nuclear Station into processing systems that will enable the operators to process radioactive waste efficiently and economically. Both long-range plans and current activities are discussed.

Terrell, Michael S. (Duke Power Co, Charlotte, NC, USA). *Nucl Plant J* v 6 n 4 Jul-Aug 1988 2p.

**088333 EXPERIENCE WITH RADIOACTIVE WASTE INCINERATION AT CHALK RIVER NUCLEAR LABORATORIES.** Chalk River Nuclear Laboratories is a Nuclear Research Centre operated by Atomic Energy of Canada Limited. A full-scale waste treatment center has been constructed to process low- and intermediate-level radioactive wastes generated on-site. A batch-loaded, two-stage, starved-air incinerator for solid combustible waste is one of the processes installed in this facility. This paper presents a review of the performance of the incinerator during its six years of operation. In addition to presenting operational experience, an assessment of the starved-air incineration technique will also be discussed. (Edited author abstract). 8 Refs.

Le, V.T. (AECL, Chalk River, Ont, Can); Beamer, N.V.; Buckley, L.P. *At Energy Can Ltd AECL Rep* n 9722 Jun 1988 13p.

**088334 OVERVIEW OF THE MANAGEMENT OF LOW-LEVEL RADIOACTIVE WASTES IN CANADA.** In Canada, the program for the management of low-level radioactive wastes is one of continued reliance on interim storage methods while putting in place the policies, regulations and technologies for the transition to permanent disposal which should begin early in the 1990s. The Canadian regulatory authority has issued a policy statement on the objectives, requirements and guidelines for the disposal of radioactive wastes and has proposed a basis for the identification of a de minimis category. This article presents an overview of low-level radioactive waste management in Canada, including regulations, waste processing, safety, and storage concepts. 21 Refs.

Charlesworth, D.H. (AECL, Chalk River, Ont, Can); Howieson, J. *At Energy Can Ltd AECL Rep* n 9617 May 1988 12p.

**088335 DEVELOPMENT AND ACTIVE DEMONSTRATION OF ACID DIGESTION OF PLUTONIUM-BEARING WASTE.** At the Eurochem site, 800 kg of combustible alpha waste containing about 7 kg of plutonium were treated from March 1983 to July 1985 with the aim of concentrating the plutonium by oxidizing the waste and converting it into a soluble form so that the established purification process could be applied. In a batch process, shredded waste is oxidized with nitric acid in sulfuric acid. The digester content is then kept for

several hours at digestion temperature to complete the dissolution of plutonium dioxide. The cold digester content is then filtered and the plutonium-containing filter cake is sent to the plutonium purification system. The off-gases generated are freed from the acids by scrubbing. The process is demonstrated in a plant with a daily throughput of 10 kg of waste. (Edited author abstract). 10 Refs.

Wieczorek, Herbert (Kernforschungszentrum Karlsruhe, Karlsruhe, West Ger); Oser, Bernhard. *Nucl Technol* v 83 n 1 Oct 1988 p 49-55.

**088336 SAFEGUARDS PROBLEMS AND POSSIBLE SOLUTIONS WITH DEEP UNDERGROUND DISPOSAL OF USED NUCLEAR FUEL AND FUEL RECYCLE WASTE.** The disposal of used, radioactive, nuclear fuel and nuclear fuel recycle waste, which is often more radioactive, has been one of the major undertakings of the nuclear industry in many countries. Technology must be developed and facilities must be built for safe long-term storage or disposal of this used fuel and fuel recycle waste. In Canada, the United States, Sweden, Germany and other States, research and development work has been in progress for several years to find a satisfactory solution to this important problem. This work on used fuel and fuel recycle waste disposal has included studies and tests on: suitable locations for disposal; techniques for safe containment and disposal; and health and safeguards aspects. In this paper we will consider the problems and possible techniques for the application of IAEA safeguards to the nuclear material at these disposal facilities. (Author abstract) 5 refs.

Smith, R.M.; Jung, D.W. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 161-165.

**088337 PROCEEDINGS OF THE 1987 INTERNATIONAL WASTE MANAGEMENT CONFERENCE.** This conference contains 72 papers. The subject matter primarily concerns technical solutions to problems associated with processing, storage, and disposal of radioactive wastes. Topics discussed include international high level waste management, low level waste disposal, repository issues, solid waste processing, incineration equipment, nuclear fuel reprocessing, waste containers, transportation of irradiated material and spent fuel handling. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10874 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Oyen, L.C. (Ed.); Platt, A.M. (Ed.); Tosetti, R.J. (Ed.); Feizollahi, F. (Ed.). *Proc of the 1987 Int Waste Manage Conf, Hong Kong, Nov 29-Dec 5 1987* Publ by ASME, New York, NY, USA, 1987 486p.

**Encapsulation** See ALSO CALCIUM COMPOUNDS—Radiation Effects; GLASS—Vaporization; NUCLEAR FUELS—Reprocessing; STAINLESS STEEL—Corrosion; STEEL CORROSION—Radiation Effects.

**088338 GEODE PROCESS ACHIEVES HIGH VOLUME REDUCTION.** A combined crystallization and cementation system for nuclear power plant wastes, called Geode<sup>®</sup>, is being offered by Chem-Nuclear Systems in association with HPD, both of the United States. The system is part of Chem-Nuclear's turnkey approach to managing utility power plant wastes, in which it accepts the waste stream, processes it, packages it and disposes of it. The processing of liquid wastes with the Geode system is performed in two distinct but integrated, process steps. The first process step provides volume reduction of the liquid waste stream by use of a Mobile Crystallizer Unit (MCU). The second process step immobilizes and stabilizes the concentrated waste solution in disposable liners by use of a Mobile Cement Solidification Unit (MSU).

Presley, David (Chem-Nuclear Systems Inc, Columbia, SC, USA). *Nucl Eng Int* v 32 n 397 Aug 1987 p 53-54.

**088339 BEHAVIOUR OF COMPOSITES USED IN THE CONFINEMENT OF NUCLEAR WASTES.** 3.

**DIFFUSION OF IONS THROUGH EPOXIDE NETWORKS.** The diffusion of cesium and chloride ions through epoxide membranes was studied under a variety of conditions including self-diffusion, the presence of other salts in the aqueous solution, an excess of either reagent used in the manufacture of the membrane, the addition of various fillers in the epoxide network and two temperatures. At 23°C, the diffusion coefficient D was  $(2-6) \times 10^{-13} \text{ cm}^2 \text{ s}^{-1}$  for most systems, except when the epoxide was prepared with an excess of the dioxirane component or when untreated glass beads were added to the networks. In the latter instance D increased and most notably with glass beads. (Edited author abstract) 5 refs.

Nicaise, Elisabeth (EEP, St. Martin d'Heres, Fr); Gandini, Alessandro; Cheradame, Herve. *Br Polym J* v 19 n 6 1987 p 535-542.

**088340 SCANNING AUGER MICROSCOPY STUDY OF EUROPIUM PARTITIONING IN SPHENE GLASS-CERAMIC AND PHASE-SEPARATED GLASS.** This study was undertaken within the context of a major research program to evaluate sphene ( $\text{CaTiSiO}_5$ ) glass-ceramics as possible hosts for the radioactive wastes that could result from future recycling of used nuclear fuel. To minimize the release of radioactivity to the environment through waste-form leaching, it is important that most of the long-lived radionuclides be preferentially incorporated into the sphene lattice. The preferential partition of europium into the crystalline phase of sphene glass-ceramics has been unequivocally demonstrated by scanning Auger microscopy. Sphene crystals were located within the sodium aluminosilicate glass matrix by recording digital Auger images for calcium and titanium. Europium was positively detected, by Auger spot analysis, only within the sphene phase of the glass-ceramics. In addition, europium has been shown to be strongly associated with calcium and titanium in the phase-separated precursor glass. Secondary as well as primary phase-separation microstructure was identified in Auger images of the precursor glass for calcium, titanium and silicon. (Edited author abstract) 98 refs.

Hocking, W.H. (AECL, Pinawa, Manit, Can); Tait, J.C.; Hayward, P.J. *Appl Surf Sci* (1985) v 32 n 1-2 Jun 1988 p 193-217.

**088341 STRESS CORROSION RESISTANCE OF PURE COPPERS IN GROUND WATERS AND SODIUM NITRITE SOLUTIONS.** In view of the use of pure copper for encapsulating radioactive waste a programme of tests was undertaken to assess the propensity for stress corrosion cracking in synthetic ground water to which various additions were made. Of the additions studied, only sodium nitrite induced stress corrosion when present at concentrations in excess of  $0.001 \text{ mol l}^{-1}$  and above potentials that varied with nitrite concentration. Oxygen-free high conductivity and phosphorus deoxidised coppers behaved essentially identically. The effects of deaeration of nitrite solutions and raising the temperature to 80°C upon cracking were studied. (Author abstract). 9 Refs.

Benjamin, L.A. (Univ of Newcastle upon Tyne, Engl); Hardie, D.; Parkins. *Br Corros J* v 23 n 2 1988 p 89-95.

**088342 TITANATE CERAMICS FOR THE IMMOBILIZATION OF SODIUM-BEARING HIGH-LEVEL NUCLEAR WASTE.** The phase chemistries and microstructures of titanate-based ceramics containing simulated high-level nuclear waste with varying sodium contents were compared. Incorporation of relatively low sodium levels resulted in more complex phase assemblages. The aim of this work was to establish the mechanisms of sodium incorporation into titanate ceram-



ics and determine the degree to which the chemical properties of the waste form deteriorate with increasing sodium content. (Edited author abstract). 65 Refs.

Buykx, William J. (Australian Nuclear Science & Technology Organization, Menai, Aust); Hawkins, Kate; Levins, Desmond M.; Mitamura, Hisayoshi; Smart, Roger St. C.; Stevens, Geoffrey T.; Watson, Kenneth G.; Weedon, David; White, Timothy J. *J Am Ceram Soc* v 71 n 8 Aug 1988 p 678-688.

**088343 ADVANCED ROBOTICS MAY HANDLE NUCLEAR WASTE CASKS.** A robotic system that can check nuclear waste shipping casks for damage and exterior radiation contamination has been built and demonstrated at Sandia National Laboratories. The system was developed by engineers who are exploring new design concepts and technologies for such casks. Considerable research, testing, and design have been done at Sandia's Transportation Systems Development Department and elsewhere to ensure that shipping casks can be transported safely. The goal is casks that can shield radiation and be strong and secure enough to withstand severe accidents - high-speed crashes and fires.

Anon. *Natl Eng* v 92 n 8 Aug 1988 p 13,23.

**088344 ENCAPSULATION OF INTERMEDIATE LEVEL WASTES.** At present, intermediate level radioactive wastes (ILW) which arise from fuel fabrication and reprocessing operations at British Nuclear Fuel plc's (BNFL) Sellafield site are stored in bulk without pretreatment. The Company is now constructing facilities to encapsulate and package these wastes in a cement based matrix. This article presents a process description, and review of the encapsulation facilities.

Howarth, G.G. (British Nuclear Fuels plc, Engl). *Nucl Plant J* v 6 n 4 Jul-Aug 1988 5p.

Enclosures See CONTAINERS—Welding.

**Environmental Impact** See Also RADIOACTIVE MATERIALS—Absorption; WATER POLLUTION—Radioactive Materials.

**088345 RADIOACTIVE WASTE HIDDEN LEGACY OF THE ARMS RACE.** The soaring capital costs of waste cleanup are making the price of producing nuclear weapons astronomical. Roughly 45 cents of each dollar spent to make bomb-grade material now goes toward managing wastes. Cleanup and waste-handling operations already consume nearly 1 billion dollars yearly, almost an eighth of DOE's budget. Full cleanup of both radioactive and hazardous waste of DOE sites could cost 100 billion dollars. These costs are forcing DOE and Congress to reconsider the need for more plutonium. Progress in arms control could provide further impetus to sharply curtail plutonium production. It is argued that plutonium production, as well as soil dumping of radioactive waste, should halt immediately. EPA should enforce the same standards for DOE as for the private sector. (Edited author abstract).

Alvarez, Robert (Environment Policy Inst, Washington, DC, USA); Makhijani, Arjun. *Technol Rev* v 91 n 6 Aug-Sep 1988 p 42-51.

Evaporation See NUCLEAR POWER PLANTS—Wastes.

Filtration See NUCLEAR REACTORS, BOILING WATER—Filters.

Geochemistry

**088346 NATURAL GEOCHEMICAL ISOLATION OF NEUTRON-ACTIVATED WASTE: SCENARIOS AND EQUILIBRIUM MODELS.** A coupled geochemical/geohydraulic model is used to discuss and interpret possible mechanisms for contaminant transport and accumulation in inorganic environments. Scenarios are constructed incorporating computed system behavior. A comparison of potential contaminant concentrations with acceptable ones allows one to quantify the degree of geochemical isolation of the contaminant which a chosen

environment provides. Long lived waste, activated in the thermal neutron flux of a light water reactor, is classified using the proposed methodology and a very conservative scenario; beryllium, lead, molybdenum, selenium, tin and zirconium activated in the bulk of the reactor decommissioning waste (the bioshield) might be sufficiently isolated by the chemistry in common soils. (Edited author abstract) 55 refs.

Gruber, J. (Stanford Univ, Stanford, CA, USA). *Nucl Chem Waste Manage* v 8 n 1 1988 p 13-32.

**Geological Repositories** See Also EARTHQUAKES; GASES—Transport Properties.

**088347 OUT OF SIGHT, OUT OF MIND AT FORSMARK.** At Forsmark nuclear power station, 150 km north of Stockholm in Sweden, the world's first purpose-built nuclear waste repository for low- and intermediate-level radioactive waste has been built 1 km offshore and some 50 m below the seabed. This article discusses site geology, design of the repository, and tunneling.

Martin, David (Tunnels & Tunnelling, London, Engl). *Tunnels Tunnelling* v 19 n 9 Sep 1987 p 48-49.

**088348 SAFETY ANALYSES AND DERIVATION OF SITE-SPECIFIC REQUIREMENTS ON RADIOACTIVE WASTE FOR THE PLANNED GERMAN REPOSITORY 'KONRAD'.** A brief survey of the safety analyses procedure for the operational and post-operational phase of the planned German 'Konrad' repository is given. The geological formation that is planned only for the disposal of radioactive waste with negligible heat production is an iron ore bed. In the framework of the safety analyses, waste acceptance criteria are derived. These criteria concern the waste form, the waste packaging, and the radionuclide inventory. The potential radiation exposure during the operational and postoperational phase is given. (Author abstract) 8 refs.

Berg, Heinz Peter (Physikalisch-Technische Bundesanstalt, Braunschweig, West Ger); Ehrlich, Dietrich; Illi, Heinrich; Thomauske, Bruno R. *Nucl Technol* v 79 n 1 Oct 1987 p 92-99.

**088349 HYDROGEOLOGIE DES ROCHES IMPERMEABLES.** [Hydrogeology of Impermeable Rocks]. The hydrogeology of impermeable rocks plays a significant role in nuclear waste under-ground storage projects. This article first reviews sedimentary rocks with clay intercalations where the non-respect of certain equilibrium conditions between saline waters can lead to residual circulation. It also discusses hard rocks where fracturing is the determining factor. Finally, the salt-bearing deposits whose impermeability is subject to limitations related to risks of dissolution are dealt with. (Edited author abstract) In French.

Goguel, Jean. *Hydrogeologie* n 3 1987 p 155-160.

**088350 ENGINEERING GEOPHYSICAL STUDIES OF THE LOVISA NUCLEAR POWER PLANT SITE, FINLAND.** Field studies have been performed in the power plant area of Lovisa in southern Finland to evaluate the suitability of the local bedrock for disposal of low-level and intermediate-level reactor wastes. The aim of the borehole geophysical studies was to evaluate the geometry and properties of fracture zones in relatively homogeneous granite. Of the single-hole methods, the dipmeter method was used to determine the orientation of individual fractures. The sonic log was used to evaluate the openness (width or thickness) of fractures. Cross-hole methods such as the seismic and the mise-a-la-masse method were used to determine the geometry and continuity of fractured zones between boreholes. It was, in general, impossible to evaluate the continuity of single fractures. However, fracture sets can be identified based on the dipmeter data. The continuity of fracture zones can be evaluated with the combined results of single- and cross-hole methods. (Author abstract) 6 refs.

Rouhiainen, P.J. (Imatram Voima Oy, Helsinki, Fin). *Geophys Prospect* v 35 n 9 Nov 1987 p 1015-1029.

**088351 BEHAELTER FÜR DIE ENDLAGERUNG RADIOAKTIVER ABFÄLLE.** [Containers for the Final Storage of Radioactive Waste in the Konrad Mine]. The Konrad Mine near Salzgitter-Bleckenstedt is the planned repository for radioactive waste with negligible heat output. The article outlines the boundary conditions for the waste containers as resulting from the plans for the operations phase of the Konrad Mine. Also concepts of radiation protection in the facility and some aspects of mining technology are discussed. For the standardized waste container concept, which served as one of the basic criteria in planning the infrastructure of the Konrad Mine, possible uses, development potentials for volume minimization, and the requirements to be met are outlined. The concept to be employed in packaging radioactive waste, which has been elaborated on the basis of experience accumulated in the test emplacement in the Asse Salt Mine, of the results of research and development projects and, above all, of present practice (e.g., in nuclear power plants and at the national research centers), proves that radioactive waste can be conditioned properly so as to meet the preliminary emplacement conditions for the Konrad Mine. (Edited author abstract) In German. 10 refs.

Brennecke, P. (Physikalisch-Technische Bundesanstalt, Braunschweig, West Ger); Essmann, J.; Geiser, H.; Rittscher, D.; Schuchardt, M.C. *Atomwirtsch Atomtech* v 32 n 11 Nov 1987 p 537-541.

**088352 WIPP GETS READY FOR OPERATION.** The Waste Isolation Pilot Plant (Wipp) in the United States is now being readied for the receipt of first waste in late 1988. Extensive large scale tests are progressing well, yielding significant data on the design, operation and performance of salt repositories. Some topics discussed by this article are these: the reason for the existence of Wipp; validating the site and design; underground construction; surface construction; an experimental program; Wipp operations; RH TRU waste handling; and CH TRU waste handling.

Sadler, John W. *Nucl Eng Int* v 32 n 401 Dec 1987 p 57-58, 60-62, 65.

**088353 THERMOMECHANICAL ANALYSIS OF SOME PROPOSED SCHEMES FOR RADIOACTIVE WASTE DISPOSAL.** Solutions are presented for the steady state, thermomechanical response of an elastic half space containing either a vertical line source or a horizontal disc shaped source of heat. It is suggested that these solutions may be useful for predicting the long term behaviour of rock masses containing nuclear waste repositories; the solution for the line source being appropriate for the disposal of hot wastes in deep boreholes and the solution for the disc shaped source being applicable to disposal in underground galleries of significant lateral extent. It is demonstrated that in both cases the surface of the rock mass will heave and that there is potential for cracking of the rock overlying the repositories because of tensile stress changes induced in the region near the surface. (Edited author abstract) 7 refs.

Carter, J.P. (Univ of Sydney, Aust); Booker, J.R. *Res Rep Univ Sydney Sch Civ Min Eng* n R508 Sep 1985 28p.

**088354 DESIGNING SHAFTS FOR HANDLING HIGH-LEVEL RADIOACTIVE WASTES IN MINED GEOLOGIC REPOSITORIES.** Waste package conceptual designs developed in the United States by the U.S. Department of Energy's Office of Civilian Radioactive Waste Management are the basis for specifying the dimensions and weights of the waste package and transfer cask combinations to be hoisted in the waste handling shafts in mined geologic repositories for high-level radioactive waste. The hoist, conveyance, counterweight, and hoist ropes are then sized. Also taken into consideration are overwind and underwind arrestors and safety features required by the U.S. Nuclear Regulatory Commission. Other design features such as braking systems, chairing



system design, and hoisting speed are considered in specifying waste hoisting system parameters for example repository sites. (Author abstract) 20 refs.

Hambley, Douglas F. (Argonne Natl Lab, Argonne, IL, USA); Morris, John R. *Nucl Technol* v 80 n 3 Mar 1988 p 476-482.

**088355 LONG-TERM DISPOSAL OF RADIOACTIVE WASTE: AN INTERNATIONAL ISSUE.** Criteria and technology are falling into place throughout the international community for the disposal of radioactive wastes: near surface disposal for short-lived radioactive wastes, geologic emplacement for the long-lived radioactive wastes. Selection of disposal systems suitable for specific national situations requires extensive technical analysis, much of which includes chemical engineering. (Author abstract)

Lakey, L.T. (Pacific Northwest Lab, Richland, WA, USA). *Energy Prog* v 7 n 4 Dec 1987 p 196-200.

**088356 CHARACTERIZING FRACTURES AT POTENTIAL NUCLEAR WASTE REPOSITORY SITES WITH ACOUSTIC WAVEFORM LOGS.** Fractured igneous (i.e., granite, basalt) rock is one of the most important mediums currently under consideration for the disposal of High Level Nuclear Waste. Flow of groundwater through fractures is the most probable mechanism for transporting nuclides away from the storage facility. If flow velocities are low enough, nuclides will diffuse into and be adsorbed to the rock matrix, where they pose a minimal threat to mankind. Flow velocity is most sensitive to fracture aperture. Hence fracture aperture is a critical parameter to determine during site characterization studies. Small scale laboratory tests illustrate that normalized tube wave amplitude determined from a full waveform acoustic log is indicative of fracture aperture. Theory suggests normalized tube wave amplitude will be representative of the effective fracture aperture which controls permeability. (Edited author abstract) 26 refs.

Poeter, E.P. (Colorado Sch of Mines, Golden, CO, USA). *Log Anal* v 28 n 5 Sep-Oct 1987 p 453-461.

**088357 COMMENTS ON MODEL VALIDATION.** The present paper points out the importance and usefulness of recognizing the separate roles of processes and geometric structures in predictive modeling of the performance of a nuclear waste repository or underground injection disposal of toxic wastes. Based on this, a validation procedure is proposed. Furthermore, two stages and three elements of validation are described and discussed. Comments are made on the choice of measurables to be used to compare modeling results and field data in the validation procedure. (Author abstract) 8 refs.

Tsang, Chin-Fu (Lawrence Berkeley Lab, Berkeley, CA, USA). *Transp Porous Media* v 2 n 6 Dec 1987 p 623-629.

**088358 PERFORMANCE ASSESSMENT OF RADIOACTIVE WASTE REPOSITORIES.** The current plans for permanent disposal of radioactive waste call for its emplacement in deep underground repositories mined from geologically stable rock formations. The U.S. Nuclear Regulatory Commission and U.S. Environmental Protection Agency have established regulations setting repository performance standards for periods of up to 10,000 years after disposal. Compliance with these regulations will be based on a performance assessment that includes (i) identification and evaluation of the likelihood of all significant processes and events that could affect a repository, (ii) examination of the effects of these processes and events on the performance of a repository, and (iii) estimation of the releases of radionuclides, including the associated uncertainties, caused by these processes and events. These estimates are incorporated into a probability distribution function showing the likelihood of exceeding radionuclide release limits specified by regulations. (Author abstract) 27 refs.

Campbell, James E. (INTERA Technologies Inc, Austin, TX, USA); Cranwell, Robert M. *Science* v 239 n 4846 Mar 18 1988 p 1389-1392.

**088359 THERMAL IMPACT OF WASTE EMPLACEMENT AND SURFACE COOLING ASSOCIATED WITH GEOLOGIC DISPOSAL OF HIGH-LEVEL NUCLEAR WASTE.** This article is a study of the thermal effects associated with the emplacement of aged radioactive high-level wastes in a geologic repository, with emphasis on the waste characteristics, repository structure, and rock properties controlling the thermally induced effects; thermal, thermomechanical, and thermohydrologic impacts, determined mainly on the basis of previous studies that assume 10-yr-old wastes; thermal criteria used to determine the repository waste loading densities; and technical advantages and disadvantages of surface cooling the wastes prior to disposal as a means of mitigating the thermal impacts. Waste loading densities determined by repository designs for 10-yr-old wastes are extended to older wastes using the near-field thermomechanical criteria based on room stability considerations. Extension of the surface cooling period from 10 yr to longer periods can lower the near-field thermal impact but have only modest long-term effects for spent fuel. More significant long-term effects can be achieved by surface cooling of reprocessed high-level waste. (Edited author abstract) 134 refs.

Wang, J.S.Y. (Lawrence Berkeley Lab, Berkeley, CA, USA); Mangold, D.C.; Tsang, C.F. *Environ Geol Water Sci* v 11 n 2 Apr 1988 p 183-239.

**088360 STRUCTURE OF SALT FORMATIONS AND THE RELIABILITY OF BURYING SOLIDIFIED RADIOACTIVE WASTE.** A number of technological problems associated with the features of the salt medium are encountered when underground repositories of radioactive waste of high specific activity are created in rock-salt formations. An important aspect of such repositories is the migration of liquid inclusions under the influence of a temperature gradient; the inclusions usually being present in natural sites of rock salt. Such a transfer of liquid in the medium of the repository of solidified radioactive waste can cause a number of undesirable effects. This article discusses salt formation structure. The reliability of burying solidified radioactive waste is reviewed. 12 refs.

Nikiforov, A.S.; Polyakov, A.S.; Kashcheev, V.A.; Poluektov, P.P. *Sov At Energy* v 63 n 2 Aug 1987 p 601-607.

**088361 GERMAN KONRAD REPOSITORY PROJECT.** In the Federal Republic of Germany, it is planned to dispose of radioactive waste with negligible heat generation in the abandoned Konrad iron ore mine. Under the law, the Physikalisch-Technische Bundesanstalt (PTB) is the authorized applicant and thus responsible for the construction and operation of federal installations for the long-term storage and disposal of radioactive waste. On the basis of site-specific safety assessments covering the overall geological and hydrogeological situation, the technical concept of this facility including its scheduled mode of operation and the waste packages to be disposed of, the PTB has demonstrated the safety of the planned Konrad repository in the operational and post-operational phase. (Author abstract) 65 refs.

Berg, H.P. (Physikalisch-Technische Bundesanstalt, Braunschweig, West Ger); Brennecke, P.W.; Thomaske, B.R. *Prog Nucl Energy* v 20 n 3 1987 p 255-307.

**088362 ENDLAGER FUER RADIOAKTIVE ABFALLE.** [Final Storage for Radioactive Waste: Construction Practices Based on an Example of Final Storage for Low-Level and Medium-Level Radioactive Waste]. This article discusses the basic concepts for disposal and storage of low-level and medium-level radioactive waste. The geological, hydrological and material's data are reviewed in view of the possibilities for geological repositories. The waste container materials and enclosures are described. In German.

Gassner, Rolf (ETH, Baden, Austria); Nold, Andreas L. *Schweiz Ing Archt* v 105 n 21 May 21 1987 p 589-593.

**088363 LEARNING FROM NUCLEAR WASTE REPOSITORY DESIGN: THE GROUND-CONTROL**

**PLAN.** At present, under a U.S. Department of Energy program, three repositories for commercial spent fuel - in salt, tuff and basalt - are in the phase of site characterization and conceptual design, and one pilot project for defense waste in salt is under development. Because of strict quality assurance requirements throughout design and construction, and the need to predict and ascertain in advance the satisfactory performance of the underground openings, much intellectual energy has been expended to analyze underground openings in the unusual circumstances of the repository environment. In the long term, these efforts will lead to an improved understanding of rock behavior and improved methods of underground analysis and design. For the shorter term, a formalized ground control plan was developed, the principles of which may be applied to other types of projects. This paper summarizes the status of underground design and construction for nuclear waste repositories and presents some details of the ground control plan and its individual elements. (Edited author abstract) 10 refs.

Schmidt, Birger. *Tunnelling Underground Space Technol* v 3 n 2 1988 p 175-181.

**088364 EXPLORATORY SHAFT DESIGN FOR A HIGH-LEVEL WASTE REPOSITORY IN SALT.** The authors describe the exploratory shaft design for a high-level nuclear waste repository in salt. The exploratory shaft facility in salt is one of three facilities - one each in basalt, tuff and salt - to be developed for the Office of Civilian Radioactive Waste Management Program of the U.S. Department of Energy. The authors discuss design criteria for the shaft; the influence of the geotechnical conditions on shaft lining; the shaft construction process; the two types of shaft lining to be used; and determination of the loads on the shaft lining. (Author abstract) 9 refs.

Poppen, S.A.G.; Cooley, A.I.; Mirza, M.B. *Tunnelling Underground Space Technol* v 3 n 2 1988 p 183-192.

**088365 MODEL CALCULATIONS OF THE THERMOMECHANICAL EFFECTS IN THE NEAR FIELD OF A HIGH-LEVEL RADIOACTIVE WASTE REPOSITORY.** The final disposal of high-level radioactive waste in a salt dome affects the thermomechanical behavior of the surrounding rock salt due to the temperature rise caused by the heat generation of the radioactive waste. The near-field thermomechanical phenomena around several in situ temperature tests and a 300-m-deep conceptual borehole were studied numerically. Thermally induced closure of the boreholes and the strain-stress field distribution in the rock salt following the pressure load on the measuring probe surface and on the waste containers were determined. The calculations were performed with the commercial finite element program ADINA, taking into account the nonlinear and time-dependent behavior of the rock salt. The purpose of these investigations was a validation of the numerical methods, of the thermomechanical material parameters of rock salt, and of the model boundary conditions. (Edited Author abstract) 15 refs.

Pudewils, Alexandra (Kernforschungszentrum Karlsruhe GmbH, Karlsruhe, West Ger); Korthaus, Ekkehard; Koester, Rainer H. *Nucl Technol* v 82 n 1 Jul 1988 p 71-80.

**088366 CRACKING OF A NUCLEAR WASTE CONTAINER MATERIAL BY IRRADIATION IN A SIMULATED GROUNDWATER.** Fatigue-crack propagation tests were conducted on a container material (ASTM A27 steel) tested in Hanford groundwater at 150°C for application in a potential basalt repository. Tests were run at a single value of stress intensity factor on groups of identical specimens undergoing gamma irradiation and control specimens not exposed to irradiation. The gamma flux levels (approx. 123 rad/hour) were prototypic of the maximum levels expected at the outer surface of the waste container. A statistical evaluation



suggested that there were no significant differences between crack growth rates in the unirradiated and irradiated specimens. (Author abstract) 14 refs.

James, Lee A. (Westinghouse Electric Corp, West Mifflin, PA, USA). *Nucl Chem Waste Manage* v 8 n 1 1988 p 75-82.

**088367 SIMULATED HIGH-LEVEL NUCLEAR WASTE GLASS LEACHED IN ONE TYPE OF JAPANESE GROUNDWATER.** In the present study, we examined the leaching behavior of simulated HLW glass in the mine for an extended period of one year and seven months. The results obtained paved the way for estimating the order of normalized elemental mass loss for sodium in the glass leached in one type of groundwater by measuring the extent of leaching of the flat surface by scanning electron microscopy with energy dispersive X-ray analysis and by measuring the size and the number of the grooves. 8 refs.

Kamizono, Hiroshi (JAERI, Tokai-mura, Jpn); Nakamura, Haruto. *J Nucl Mater* v 152 n 2-3 May 1988 p 339-342.

**088368 REPOSITORY DESIGN & DEVELOPMENT.** This paper describes the general principles of deep disposal and the approach being followed by Nirex in the engineering design of a deep repository for low level waste (LLW) and intermediate level waste (ILW) and the selection of a suitable site. Finally Nirex's program of work over the next year or two is outlined. 3 Refs.

Beale, H. (UK Nirex Ltd). *Nucl Eng J Inst Nucl Eng* v 29 n 2 Mar-Apr 1988 p 38-43.

**088369 REPOSITORY DESIGN & DEVELOPMENT.** This paper describes the general principles of deep disposal and the approach being followed by Nirex in the engineering design of a deep repository for low level waste (LLW) and intermediate level waste (ILW) and the selection of a suitable site. Finally Nirex's programme of work over the next year or two is outlined.

Beale, H. (UK Nirex Ltd, Engl). *Nucl Eng J Inst Nucl Eng* v 29 n 2 Mar-Apr 1988 p 38-43.

**088370 DISPOSAL R&D PROGRAMME OF UK NIREX LTD.** This paper is concerned with the long-term safety of a repository deep underground or under the sea-bed, for which the Environment Departments are the regulating authorities. Guidance on the dose target for the performance of a repository in the UK was given more than three years ago. The authors suggest that at that time no other country was putting forward comparable limits, and indeed a number are still not doing so. This is an indication of the UK's lead in the regulatory sense, and is reflected in the lead in their ability to show that UK Nirex Ltd can meet the dose target for any repository that may be proposed. 4 Refs.

George, D. (UK Nirex Ltd, Engl); Tasker, P.W. *Nucl Eng J Inst Nucl Eng* v 29 n 2 Mar-Apr 1988 p 52-56.

**088371 DESIGN CRITERIA FOR AN UNDERGROUND NUCLEAR WASTE REPOSITORY.** Three sites have been chosen as candidates for America's first nuclear waste repository. Each is characterised by different geology which would assuredly influence the method of excavation selected. Comparisons are made between boring and blasting construction for the designs proposed for salt, volcanic tuff and basalt. Support requirements, ventilation and the ability of the geologic system to retard radionuclide migration are also directly influenced by the geology and excavation method. (Author abstract). 2 Refs.

Bohlke, Brenda Myers (Parsons Brinckerhoff Quade and Douglas Inc, USA); Monsees, James E. *Tunnels Tunneling* v 20 n 6 Jun 1988 p 53-56.

**088372 500 YEAR CONCRETE FOR A RADIOACTIVE WASTE REPOSITORY.** The IRUS repository planned at Chalk River for the belowground disposal of low level radioactive waste relies on the durability of

concrete for the required 500 year service life. A research program for the IRUS repository to design a durable concrete and also to predict its longevity under the repository environment is in progress. The methodology involves the identification of major degradation agents, and the assessment of the rate of diffusion of corrosive ions and/or the rate of advancement of the reaction front into the concrete. Accelerated test methods are being used on laboratory specimens in conjunction with extrapolation procedures to predict long-term durability from short-term data. The inherent limitations are also examined. (Author abstract). 12 Refs.

Philipose, K.E. (Chalk River Nuclear Lab, Chalk River, Ont, Can). *At Energy Can Ltd AECL Rep* n 9721 Mar 1988 15p.

**088373 SCIENTIFIC BASIS FOR NUCLEAR WASTE MANAGEMENT X.** This conference proceedings contains 71 papers of which two are represented by abstracts only. The papers are divided into the following groups: longterm projection of materials interactions; waste from performance; spent fuel; metal corrosion; low-level waste and materials; materials interactions; waste form performance; glass; Radiation effects; groundwater chemistry and interactions; and Rock/backfill performance. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11129 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Bates, John K. (Ed.) (Argonne Natl Lab, Argonne, IL, USA); Seefeldt, Waldemar B. (Ed.). *Mater Res Soc Symp Proc* v 84, Sci Basis for Nucl Waste Manage X, Boston, MA, USA, Dec 1-4 1986. Publ by Materials Research Soc, Pittsburgh, PA, USA, 1987 829p.

**088374 SITING, DESIGN AND CONSTRUCTION OF UNDERGROUND REPOSITORIES FOR RADIOACTIVE WASTES, PROCEEDINGS OF AN INTERNATIONAL SYMPOSIUM.** This conference proceedings contains 48 papers which concern siting, design, and construction of underground repositories for radioactive wastes. The objectives of the papers are to provide information regarding scientific, technical, engineering and safety bases for constructing underground repositories. Regulatory aspects are discussed. Disposal in shallow ground and rock cavities, and deep formations is considered. Repository designs and safety assessments are also reviewed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11229 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IAEA, Vienna, Austria). *Siting, Des and Construct of Underground Repos for Radioact Wastes, Proc of an Int Symp, Hannover, West Ger, Mar 3-7 1986* Publ by IAEA, Vienna, Austria, 1986 727p.

Heat Transfer See HEAT PIPES—Performance.

Ion Exchange

**088375 REMOVAL OF RADIOACTIVE CONTAMINANTS FROM WEST VALLEY WASTE STREAMS USING NATURAL ZEOLITES.** A variety of low-level radioactive waste streams are being generated from the decontamination and decommissioning of the former nuclear fuel reprocessing plant at West Valley, New York. To remove the radioactive contaminants from the solutions by ion exchange, natural zeolites, such as clinoptilolite, erionite, chabazite, and phillipsite, were felt to provide desired flexibility and capacity. Batch and column testing were conducted on these materials using waste streams containing radioactive cesium, strontium, and cobalt. Sorption coefficients, dynamic decontamination factors, capacity, and sorption kinetics were determined. Testing was conducted on prepared zeolites to provide comparative data. (Edited author abstract) 2 refs.

Grant, D.C. (Westinghouse R&D Cent, Pittsburgh, PA, USA); Skriba, M.C.; Saha, Anuj K. *Environ Prog* v 6 n 2 May 1987 p 104-109.

Leaching

**088376 ADSORPTION ON VARIOUS LEACH CONTAINER MATERIALS OF PLUTONIUM AND CURIUM LEACHED FROM NUCLEAR WASTE GLASSES.** Test pieces of quartz glass, PFA Teflon, gold and stainless steel, which are candidates for a leach container, were immersed in deionized water with the waste glass containing  $^{238}\text{Pu}$  or  $^{244}\text{Cm}$  in a Pyrex glass container at 100 degree C, and then they were decontaminated with dilute nitric acid. The quartz glass was found to have the smallest contamination of  $^{238}\text{Pu}$  and  $^{244}\text{Cm}$ . The adsorption amounts of  $^{244}\text{Cm}$  on the PFA Teflon and quartz glass were approximately the same, and for  $^{238}\text{Pu}$  the Teflon showed about twice the amount of adsorption as that measured on the quartz glass. Adsorption and desorption of curium and plutonium were discussed in relation with difference of materials, time dependence and acidity of leachate. (Edited author abstract) 11 refs.

Banba, Tsunetaka (JAERI, Tokai, Jpn); Tashiro, Shingo; Nukaga, Kiyoshi; Sagawa, Tamio; Nomura, Masayuki. *Nucl Chem Waste Manage* v 8 n 1 1988 p 45-54.

Management

**088377 REDUCES: A PRACTICAL APPROACH TO RADWASTE MANAGEMENT AND MINIMIZATION.** The purpose of this article is to present the REDUCES concept, a practical approach for both the evaluation of radwaste volume reduction programs and the management and minimization of radioactive wastes. Seven basic techniques are described, which can be used at nuclear facilities for the reduction of radwaste volumes. They are: reutilization, ending generation, decontamination, using filtration, compaction, employee participation, and segregation. 4 refs.

McClung, Leon (United Energy Services Corp); Kriemelmeyer, Diane. *Nucl Plant J* v 5 n 4 Jul-Aug 1987 4p between p 12 and 30.

**088378 ISSUES IN LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT.** As a result of the breakdown of the nation's radioactive waste management system in 1979, Congress has set a 1992 deadline for states to join together in regional 'compacts' to manage and dispose of their own low-level radioactive waste. This article describes the challenges and opportunities associated with developing a new generation of waste management technologies and their institutional infrastructure, and earning the public's confidence in them. It is written from the perspective of the Chair of the Central Midwest (IL-KY) Compact Commission, but the issues are generic. In fact, their resolution is likely to set precedents for the way we deal with other hazardous wastes in the future. (Author abstract) 6 refs.

Bullard, Clark W. (Central Midwest Compact Commission for Low-Level Radioactive Waste Management). *JAPCA* v 37 n 11 Nov 1987 p 1337-1341.

**088379 STOCKER, GERER, SURVEILLER LES DECHETS RADIOACTIFS.** [Storing, Managing, Monitoring Radioactive Wastes]. The 'Agence Nationale pour la Gestion des Dechets radioactifs' (National Agency for Radioactive Waste Management) which in France is the organization responsible for this management, distinguishes two main categories of waste. First, the so called short life waste, whose radioactivity becomes negligible in less than 300 years. This waste, produced at a rate of approximately 30,000 m<sup>3</sup> per year, packaging and packing included, is managed industrially. Its definitive storage is now established on the surface, at the La Manche Center near the La Hague Plant. At the beginning of the 1990s this center will be backed-up by a new center located in the Aube. Second, the so called long life waste whose storage, at the beginning of the 21st century, will be by deep geological burying (some hundreds of meters deep) in a structure which is leaktight or very impermeable and which has been stable for millions of years. Four geographical areas have now been prospected. They corre-



spond to four different geological media, clay (Aisne), granite (Deux-Sevres), shale (Maine et Loire) and salt (Ain). (Edited author abstract) In French.

Faussat, Armand (ANDRA, Fr). *Rev Energ* v 38 n 397 Nov 1987 p 580-587.

**088380 LA GESTION A LONG TERME DES DECHETS RADIOACTIFS.** [Long-Term Management of Radioactive Waste]. After setting out the terms of reference of ANDRA (National agency for the management of radioactive waste), the author describes the current situation and the projects for the surface storage of waste of low and medium activity. He then discusses the work which has started on the construction of an underground laboratory for studying the storage of long life waste. (Author abstract) In French.

Faussat, Armand (l'ANDRA, Fr). *Rev Gen Nucl* n 1 Jan-Feb 1988 p 51-52.

**088381 RADIOACTIVE WASTE MANAGEMENT IN THE UK.** In the UK, as in most industrialized countries, radioactive materials are used in the generation of electricity, and in industry, defence, medicine and research. Their use brings many benefits, but, at the same time results in the production of small quantities of radioactive waste. Disposing of this waste is not an awesome task. Technically and logistically the problem is quite manageable. The greatest impediment to the establishment of a waste disposal facility is public perception of the risks associated with radioactive materials. This article presents a review of the type of waste generated, and the waste management policy in the United Kingdom.

McInerney, P.T. (UK Nirex Ltd, Engl). *Nucl Eng J Inst Nucl Eng* v 29 n 2 Mar-Apr 1988 p 34-36.

**088382 PROCEEDINGS OF THE SECOND INTERNATIONAL CONFERENCE ON RADIOACTIVE WASTE MANAGEMENT.** This conference proceedings contains 123 papers. The main topics discussed are: storage and disposal of radioactive wastes; hydrology and geochemistry; transportation of radioactive wastes; buffer and backfill materials; public attitudes; uranium tailings - environmental and safety issues; site investigations and geomechanics; applications and technology of concrete; economic and engineering assessments of waste facilities; regulatory requirements and licensing; modelling studies; mine/mill tailings modelling; matrix materials/container design; chemistry and fuel durability; hydrogeologic/biosphere modelling; radioactive waste processing; uranium tailings decommissioning; future options for waste management. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11423 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Canadian Nuclear Soc, Toronto, Ont, Can). *Proc of the Second Int Conf on Radioact Waste Manage, Winnipeg, Manit, Can, Sep 7-11 1986* Publ by Canadian Nuclear Soc, Toronto, Ont, Can, 1986 80bp.

## Nondestructive Examination

**088383 MOBILE NON-DESTRUCTIVE ASSAY SYSTEM.** A mobile system for non-destructive assay (NDA), developed at the Los Alamos National Laboratory, provides accurate and sensitive measurements for transuranic (TRU) isotopes contained in 208-l drums of miscellaneous nuclear wastes. The NDA unit consists of four major subsystems: an assay chamber, counting and digital electronics, data acquisition, and a neutron generator. It performs both active and passive neutron waste measurements. The former determines the amount of fissile isotopes at a sensitivity level of 1 mg plutonium. The latter determines spontaneous fission and ( $\alpha$ , n) isotopes at a comparable level. A complete assay consists of sequential active and passive measurements. (Edited author abstract) 8 refs.

Colarusso, A.P. (Los Alamos Natl Lab, Los Alamos, NM, USA); Audas, J.H.; Bieri, J.M.; Herrera, G.C.; Hastings, R.D.; Horton, W.S.; Kuckertz, T.H.; Kunz,

W.E.; Medvick, P.A.; Vogel, P.A.; Caldwell, J.T. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 375-379.

**Packaging** See RADIOACTIVE MATERIALS—Transportation.

**Processing** See Also AMERICIUM; ION EXCHANGERS—Stability.

**088384 IN-PLANT TESTING OF RADWASTE ION-EXCHANGE MATERIALS.** Utilities want to reduce the costs associated with ion-exchange processing of radioactive waste liquids. The in-plant testing method, demonstrated on a pilot scale in this project, gives utility personnel the necessary tool for reducing radwaste liquid ion-exchange processing costs as well as for improving volume reduction factors. For waste chemistry, the liquid streams in this study comprised a variety of chemical and radiochemical constituents, and the composition of the waste was highly variable. The chemical equivalent concentrations of nonradioactive species - which were several orders of magnitude greater than those for the radioactive constituents - were the exhausting species for the rad-waste ion-exchange system. (Edited author abstract)

Anon. *Electr Power Res Inst Rep EPRI NP* 5099 Jul 1987 368p.

## Radiation Effects

**088385 VOLUMETRIC CHANGE OF SIMULATED RADIOACTIVE WASTE GLASS IRRADIATED BY ELECTRON ACCELERATOR.** Density changes of simulated radioactive waste glasses, silica glass and Pyrex glass irradiated by an electron accelerator were measured by a 'sink-float' technique. The density changes of the waste and silica glasses were less than 0.05%, irradiated at 2.0 MeV up to the fluence of  $1.7 \times 10^{17}$  e/cm<sup>2</sup>, which were remarkably smaller than that of Pyrex glass of 0.18% shrinkage. Precision of the measurements in the density changes of the waste glass was lower than that of Pyrex glass possibly because of the inhomogeneity of the waste glass. (Author abstract) 16 refs.

Sato, Seichi (Kyushu Univ, Fukuoka, Jpn); Furuya, Hiroaki; Inagaki, Yaohiro; Kozaka, Tetsuo; Sugisaki, Masayasu. *J Nucl Sci Technol* v 24 n 11 Nov 1987 p 920-924.

**Radioactivity** See STRONTIUM AND ALLOYS—Radioactivity.

**Solidification** See Also NUCLEAR FUELS—Reprocessing.

**088386 INFLUENCE OF NON-TECHNICAL POLICIES ON CHOICES OF WASTE SOLIDIFICATION TECHNOLOGIES.** Several statutes and regulations dealing with the disposal of low-level radioactive wastes are shown to promote non-technical policies which could unduly affect the choice of technology for solidifying wastes. The most influential of these non-technical policies is volume reduction, whether adopted explicitly in statutory language or implicitly by basing disposal fees solely on waste volume. In either case, there is no evidence that those who adopted this policy considered its possible adverse effects of this policy on public health and safety and the environment. To avoid the potential for such adverse consequences, the explicit and implicit consequences of non-technical policies must be fully evaluated to ensure that they do not unduly influence technical decisions on the proper choice of waste treatment, including solidification. (Author abstract).

Trubatch, Sheldon L. (Commonwealth Edison Co, IL, USA). *Nucl Plant J* v 6 n 4 Jul-Aug 1988 5p.

## Spectroscopic Analysis

**088387 PRECIPITATION OF ACTINIDES AS FLUORIDES OR HYDROXIDES FOR HIGH-RESOLUTION ALPHA SPECTROMETRY.** Management of

radioactive wastes requires sensitive, accurate and reliable analytical procedures by which the radionuclides of interest can be determined in a wide variety of sample types. Procedure are given for precipitating and mounting all actinides from thorium through californium for high-resolution alpha spectrometry by two mutually complimentary systems. One system involves precipitation of fluorides from dilute acid in which most actinides can be separated from each other and from many common interferences by proper use of oxidizing and reducing agents. Elements forming strong fluoride complexes such as iron, titanium, zirconium, etc., do not interfere, but calcium interferes seriously. The other system involves precipitation of hydroxides from strongly alkaline solutions of ethylenediaminetetraacetic acid in which large quantities of calcium can be tolerated. More importantly, the latter system can be used to recover actinides coprecipitated with barium sulfate, which in turn permits use of potassium fluoride fusion to guarantee complete dissolution of the most refractory types of samples. (Edited author abstract) 12 refs.

Sill, Claude W. (EG&G Idaho Inc, Idaho Falls, ID, USA). *Nucl Chem Waste Manage* v 7 n 3-4 1987 p 201-215.

**Storage** See Also GLASS—Radiation Effects; NUCLEAR REACTORS—Spent Fuels.

**088388 PERMEABILITY OF HTR FUEL ELEMENT GRAPHITE FOR TECHNETIUM, CESIUM, AND NEPTUNIUM.** Spent fuel from the operating German High Temperature Gas Cooled Reactor THTR-300 will not be reprocessed but stored in a final repository after suitable conditioning. An accidental ingress of water into the repository could lead to the formation of a brine solution which may corrode the multiple barrier system components and leach radionuclides from the fuel microspheres. It was shown that radionuclides permeate through graphite to a considerable extent, especially from fuel elements undergoing pressure cycles when stored under a brine solution. (Edited author abstract) 1 ref.

Brodde, Berthold-G. (Nuclear Research Cent Juelich GmbH, Juelich, West Ger); Merz, Erich R. *Am Ceram Soc Bull* v 66 n 8 Aug 1987 p 1262-1264.

**088389 CALCULATING SAFE STORAGE AND SHIPPING PERIODS FOR SEALED RADWASTE CONTAINERS.** Certain forms of nuclear waste, when subjected to ionizing radiation, produce combustible mixtures of gases. The production of these gases in sealed radioactive waste containers represents a significant safety concern for the handling, shipment, and storage of waste. (Author abstract) 4 refs.

Flaherty, James E. (EG&G Idaho Inc). *Nucl Plant J* v 5 n 4 Jul-Aug 1987 p 48-50.

**088390 EINSATZ VON BEHAELTERN FUER DIE ENDLAGERUNG RADIOAKTIVER ABFAELLE IN DER SCHACHTANLAGE KONRAD.** [Use of Containers for the Final Storage of Radioactive Waste in the Konrad Mine]. The final storage radioactive waste with negligible heat development is planned in the Konrad Mine near Salzgitter-Bleckenstedt. The authors report on containers which are to be used for this waste. Based on the concept for standardized waste container, one of the planning fundamentals for the Konrad Mine, they describe the application possibilities for various containers, the potential for volume reduction and the demands on these containers. (Author abstract) In German. 23 refs.

Brennecke, Peter (Physikalisch-Technische Bundesanstalt, Braunschweig, West Ger); Essmann, Juergen; Geiser, Heinz; Rittscher, Dieter; Schuchardt, Manfred C. *At Strom* v 33 n 4-5 Jul-Oct 1987 p 116-123.

**088391 CONDITIONING AND HANDLING OF TRITIATED WASTES AT CANADIAN NUCLEAR POWER FACILITIES.** Ontario Hydro operates a 10,000 MW capacity nuclear power system utilizing the CANDU



pressurized heavy water reactor design. The use of  $D_2O$  as moderator and coolant results in the production of about 2400 Ci\* of tritium per MWe-yr. As a result, there is significant Canadian experience in the treatment, handling, transport and storage of tritiated wastes. Ontario Hydro operates its own reactor waste storage site which includes systems for volume reduction, immobilization and packaging of wastes. In addition, a facility to remove tritium from heavy water is presently being commissioned at the Darlington nuclear site. Experience to date, operational procedures being developed and ongoing R&D in this area are described. (Edited author abstract) 4 refs.

Krochmalnek, L.S. (Ontario Hydro, Toronto, Ont, Can); Krasznai, J.P.; Carney, M. *Fusion Eng Des* v 5 n 4 Jan 1988 p 337-342.

**088392 MANAGEMENT OF TRITIUM-CONTAMINATED WASTES AT THE ETHEL FACILITY.** In the frame of JRC's 1984-87 Fusion Technology Programme and with the aim of contributing to tritium R&D for NET, the Commission of the European Communities decided in July 1985 to construct the European Tritium Handling Experimental Laboratory (ETHEL) on the site of the Ispra Establishment. ETHEL is a facility designed to handle a maximum inventory of 100 g tritium. Its detailed design study was started in January 1987 and its commissioning is foreseen for end 1989-beginning 1990. Being well aware of the lack of an efficient, economic and safe technology in the field of tritiated waste management, extensive laboratory research on tritiated waste treatment, conditioning and containment inside multibarrier systems, has been proposed by the research staff of the Ispra Establishment as one of the experimental activities to be performed at ETHEL. Current practices to be applied for routine management of tritiated waste generated during the normal ETHEL operations, as well as objectives of the experimental research that the JRC staff specifically intend to perform in the field of tritiated waste management strategy, are described. (Author abstract) 35 refs.

Mannone, F. (Commission of the European Communities, Ispra, Italy); Dworschak, H. *Fusion Eng Des* v 5 n 4 Jan 1988 p 385-399.

**088393 DUKE LOOKS TO EMPLOY NUHOMS CONCRETE MODULES AT OCONEE.** The NUHOMS concrete modular storage system has been licensed in the United States and a large capacity version of the system is currently undergoing licensing review for use at the Oconee station. The system design is flexible enough to accommodate either on-site storage or centralized away from reactor storage. Transport system interfaces are being evaluated for potential direct acceptance of NUHOMS canisters at either an MRS or a repository. (Author abstract)

McConaghy, W.J. (NUTECH Engineers, San Jose, CA, USA); Deese, R.J. *Nucl Eng Int* v 33 n 403 Feb 1988 p 44-46.

**088394 NIREX SITE INVESTIGATIONS - PROBABLY THE MOST THOROUGH EVER UNDERTAKEN.** When the decision to terminate site investigation in four possible sites for low-level nuclear waste storage - Elstow, Bradwell, Fulbeck and Kilingholme - was taken, the curtain descended on what was probably the largest combination of site investigation operations ever undertaken in the UK. This work was notable not only for its scale, but also for its thoroughness, and had the original plans been carried out, it might well have been held up as an example. The Oxford Clay appeared to be a particularly suitable formation for the disposal of waste in shallow trenches. Some idea of the work involved in these site investigation operations can be gained by considering the operation at Elstow described in this study.

Anon. *Ground Eng* v 21 n 2 Mar 1988 p 9-10, 12.

**088395 MODIFICATION TO SEGREGATE HIGH-ACTIVITY AND LOW-ACTIVITY RESIN AT BRAIDWOOD STATION.** This paper describes a recent modification made to the radwaste system at Commonwealth Edison Company's Braidwood Station to provide

a tank dedicated to the storage of low-activity spent resin, thereby allowing the existing spent-resin storage tank to be dedicated to the storage of high-activity spent resin. The existing spent-resin tank was originally designed for the storage of spent resin from the primary system, such as that from the primary coolant demineralizers, and of low-activity spent resin from the steam generator blow-down and radwaste demineralizers.

Thuot, James R. (Commonwealth Edison Co, IL, USA); Petro, John R.; Elquindy, Hoda. *Nucl Plant J* v 6 n 4 Jul-Aug 1988 p 63-65.

**088396 ELECTRONIC PROTECTION AND MONITORING OF THE NATION'S FIRST INDEPENDENT SPENT FUEL STORAGE INSTALLATION.** Above-ground dry storage of spent nuclear fuel presents unique protection problems for the Commercial Power Generating Industry. This paper examines an actual low cost approach to remote monitoring and intrusion detection at the first of these sites. Today I will relate some experiences as a participant in the successful search for a cost-effective electronic security system design solution for this first Independent Spent Fuel Storage Installation (ISFSI).

Evenson, W.J. Jr. (Stellar Systems Inc, Milford, CT, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 470-473.

**Transportation** See ALSO CONTAINERS; CONTAINERS—Materials; CONTAINERS—Standards.

**088397 SENDING LOVIISA'S FUEL TO RUSSIA.** All spent fuel from the Loviisa nuclear power station on the south-eastern coast of Finland is returned to the plant's supplier, V/O Atomenergexport (AEE) of the Soviet Union. The return is carried out using Soviet transport casks and railway wagons specially designed for VVER-440 spent fuel. Road transport trailers owned by IVO are used to transfer the casks from Loviisa railway station to the power plant and back.

Koskivirta, Ossi (Imatran Voima Oy, Helsinki, Finl). *Nucl Eng Int* v 33 n 403 Feb 1988 p 46-47.

**088398 RADIATION DOSE IMPACTS RESULTING FROM VARIATIONS IN THE TRANSPORTATION-RELATED ACTIVITIES IN A SYSTEM FOR MANAGEMENT OF SPENT NUCLEAR FUEL.** In the commercial nuclear spent-fuel management system, potential changes are being considered that will improve the transportation-related aspects of the system. The U.S. Department of Energy (DOE) has recognized that alternative options could be implemented in the authorized waste management system to achieve some improvements. Analyses have been performed for the DOE related to radiation doses in the system to the public and workers that would result from potential changes in the transportation-related aspects in the system. The primary alternatives studied to reduce radiation doses concern increasing transportation cask capacity. (Author abstract) 33 refs.

Schneider, Kenneth J. (Pacific Northwest Lab, Richland, WA, USA); Pelto, Peter J.; Lavender, Jay C.; Daling, Philip M.; Fecht, Barbara A. *Nucl Technol* v 82 n 1 Jul 1988 p 106-113.

**088399 PACKAGING AND TRANSPORT OF RADIOACTIVE WASTES.** To ensure the safe and efficient operation of a national radioactive waste disposal facility it is important that the wastes are put in a form which is not only suitable for interim storage and for transport, but also meets the requirements for final disposal. Packaging the wastes to meet these diverse requirements is the responsibility of the waste producers. However, to ensure a coherent scheme, Nirex in close collaboration with waste producers, is co-ordinating the development of packaging standards and guidelines and also developing an integrated transport system. 10 Refs.

Smith, M.J.S. (UK Nirex Ltd). *Nucl Eng J Inst Nucl Eng* v 29 n 2 Mar-Apr 1988 p 44-50.

**088400 PACKAGING AND TRANSPORT OF RADIOACTIVE WAST.** To ensure the safe and efficient operation of a national radioactive waste disposal facility it is important that the wastes are put in a form which is not only suitable for interim storage and for transport, but also meets the requirements for final disposal. Packaging the wastes to meet these diverse requirements is the responsibility of the waste producers. However, to ensure a coherent scheme, Nirex in close collaboration with waste producers, is co-ordinating the development of packaging standards and guidelines and also developing an integrated transport system. This article reviews packaging techniques employed by Nirex, and discusses the transportation program developed by this company. 10 Refs.

Smith, M.J.S. (UK Nirex Ltd, Engl). *Nucl Eng J Inst Nucl Eng* v 29 n 2 Mar-Apr 1988 p 44-50.

**088401 APPLICATION OF LIFE CYCLE COST ANALYSES IN EVALUATION OF NUCLEAR WASTE TRANSPORTATION SYSTEM ALTERNATIVES.** Nuclear waste transportation, an essential part of the DOE's overall waste management responsibilities, entails moving discharged spent fuel (SF) from various US reactors to a geologic repository, possibly via a monitored retrievable storage facility. The SF will be moved in special transportation casks, designed to satisfy stringent performance criteria. Various cask designs, all satisfying the performance criteria but differing in certain other design features, will be considered for the transportation role. This paper discusses the use of life cycle cost (LCC) as an aid in choosing among basic cask design features, and in assessing certain transportation system operating alternatives. The LCC approach is illustrated through analyses of several examples representing competing cask design concepts, cask design features, and system operating options. (Author abstract) 3 refs.

Boggs-Mayes, C. (US DOE Chicago Operations Office, USA); Peterson, R.W.; Dippold, D.G.; Brentlinger, L.A. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 104-109.

**088402 ISSUE RESOLUTION PROCESS IN THE CIVILIAN RADIOACTIVE WASTE TRANSPORTATION PROGRAM.** The Civilian Radioactive Waste Management (OCRWM) Program consists of various technical and institutional program activities which engender concern from the general public and from policymakers at federal, state, and local levels. This paper will define the process being used to identify and resolve institutional issues, show how the technical and institutional issues interface and are addressed, and briefly describe four specific activities which illustrate the process of resolving institutional issues in the Transportation program. (Edited author abstract) 2 refs.

Holm, Judith A. (US DOE, Chicago, IL, USA); Denny, Susan. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 114-118.

**088403 UPDATE OF NUCLEAR WASTE POLICY ACT TRANSPORTATION ACTIVITIES.** As directed by the Nuclear Waste Policy Act of 1982 (NWPA), the Department of Energy (DOE) is developing a nationwide system for transporting spent nuclear fuel and high-level radioactive waste from commercial power plants to deep geologic repositories for disposal. Development of the transportation system incorporates the following work elements: operational planning, support systems development, cask system development, systems analysis, and institutional activities. This paper focusses on the technical aspects of the system. (Edited author abstract)

Callaghan, Eugene F. (US DOE, Washington, DC, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 251-254.



**088404 TMI-2 TRANSPORTATION PROGRAM - DESIGN CONSIDERATIONS FOR THE NUPAC 125-B CASK HANDLING AND LOADING/UNLOADING EQUIPMENT.** Removal, transport and receipt of core debris from the damaged reactor at Three Mile Island Unit 2 (TMI-2) required the design of transport cask handling and 'dry' loading and unloading equipment. The system for 'dry' (not underwater) loading of the transport cask includes; 1) equipment for handling the cask, 2) equipment for loading core debris canisters into the cask at TMI, and 3) equipment for removing the canisters in a hot cell facility. This paper reviews the technical design operational parameters and summarizes lessons learned in the design, testing, startup and use of the equipment provided for the TMI-2 Transportation Program. (Edited author abstract)

Schoker, Duane S. (Nuclear Packaging Inc, Federal Way, WA, USA); Schmitt, Richard C.; Barkanic, R.J. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 255-262.

**088405 NINO CASK-LOADING SAFEGUARDS SYSTEM.** It is, in general, difficult to determine by means of camera-surveillance techniques what is loaded into spent-fuel casks being prepared for shipment from light-water reactors to other reactors, reprocessing facilities, or long-term storage. Furthermore, the expected high frequency of cask loadings in the coming years would place too great a burden on the IAEA and Euratom inspectorates if each had to be observed by an inspector. This paper presents an alternative to both inspector presence at cask loading and operator assistance in applying seals; this alternative is called the No Inspector, No Operator system (NINO). (Edited author abstract) 10 refs.

Fiarman, Sidney (Brookhaven Natl Lab, Upton, NY, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 412-416.

## United States

**088406 HIGH LEVEL WASTE MANAGEMENT IN USA.** In U.S.A., spent nuclear fuels generated from nuclear power plants are to be directly disposed in repository. Until the repository commences, spent nuclear fuels must be managed under institutional control such as high-burnup, expansion of spent nuclear fuel storage pool capacity. In the report, the status of the countermeasures with regard to spent nuclear storage and the disposal plan of high level waste are described including the current topics. Outline of the regulation in U.S.A. with regard to high level waste is also described. (Author abstract) In Japanese. 22 refs.

Fukudome, Kazuyuki. *FAPIG* n 117 1987 p 33-39.

**Vitrification** See Also CERAMIC MATERIALS—Hot Pressing; GLASS—Crystallization; GLASS MANUFACTURE—Physical Chemistry; NUCLEAR FUELS—Reprocessing; RADIOACTIVE MATERIALS—Safe Handling.

**088407 INCORPORATION OF SIMULATED NUCLEAR ASHES IN BASALT: AN EXPERIMENTAL INVESTIGATION.** In order to fabricate a vitrocristalline material by a thermal procedure, several compositions and contents of simulated radioactive ashes have been mixed with an alkali basalt. Morphologies and compositions of phases have been studied as a function of parent-material composition and thermal treatment. Uranium and thorium are entirely trapped in the residual glass phase. Basalt is able to accommodate large variations in ash content and composition. (Edited author abstract) 25 refs.

Lebeau, Marie-Jose (CNRS, Montpellier, Fr); Girod, Michel. *Am Ceram Soc Bull* v 66 n 11 Nov 1987 p 1640-1646.

**088408 UK FINDS A SOLUTION FOR NUCLEAR WASTE.** Unless the problem of high level nuclear waste disposal is adequately addressed the nuclear power indus-

try will continue to decline. The French have demonstrated that this waste can be safely handled and stored more easily if it is first vitrified. Britain will use the French technology in its first vitrified high level nuclear waste plant now being built at Sellafield in the northwest of England.

Smith, Douglas J. (Power Engineering, Tulsa, OK, USA). *Power Eng (Barrington Ill)* v 92 n 6 Jun 1988 p 44-47.

**088409 THREE-DIMENSIONAL ANALYSIS OF MICROWAVE HEATING SYSTEM WITH SQUARE-TYPE FURNACE.** The use of microwave heating for fusing and solidifying waste is considered. L. J. B. Bergeron's method (1941) for electromagnetic analysis problems involving complex boundary and medium conditions in three-dimensional space is applied to a microwave-heating-furnace-heated material, and the fundamental characteristics of the electromagnetic field in the system are determined. 14 refs.

Tejika, Y. (Hokkaido Univ, Sapporo, Jpn); Komatsu, F.; Masaki, T.; Yoshida, N.; Fukai, I. *IEEE Trans Nucl Sci* v NS-34 n 4 Aug 1987, Fifth Conf on Real-Time Comput Appl in Nucl, Part and Plasma Phys, San Francisco, CA, USA, May 12-14 1987 p 1065-1069.

**RADIOACTIVITY** See Also BAUXITE ORE TREATMENT—Magnetic Separation; BIOLOGICAL MATERIALS—Radiation Effects; GAMMA RAYS—Absorption; RADIATION EFFECTS.

## Applications

**088410 LOHNBESTRAHLUNGSZENTREN ALS SCHRITTMACHER DER INDUSTRIELLEN NUTZUNG.** [Toll Irradiation Centers to Pioneer Industrial Use of Radiation]. Treatment with ionizing radiation can greatly improve the quality and the characteristics of use of many industrial products. A major obstacle to the use of this technique, especially in small businesses, is the need to purchase irradiation facilities of the proper size, which require high load factors to be run economically. An obvious solution ensuring the desired high throughput are toll irradiation facilities serving a number of customers. If this approach is to work, the facilities must provide a broad spectrum of radiation energies and powers and must be designed flexibly enough to meet rapidly changing requirements without time consuming retooling and, perhaps, even run in simultaneous operation. (Edited author abstract). In German.

Wiesner, L. (Wiesner GmbH, West Ger). *Atomwirtsch Atomtech* v 33 n 6 Jun 1988 p 297-301.

**Control** See NUCLEAR POWER PLANTS—Site Selection.

**Environmental Impact** See NUCLEAR POWER PLANTS—Accidents; WATER SUPPLY—Radiation Effects.

## Health Hazards

**088411 RISK OF LEUKAEMIA IN SEASCALE FROM RADIATION EXPOSURE.** This paper has reviewed an assessment by the National Radiological Protection Board of the risks of radiation-induced leukaemia in children and young persons in Seascale over the period of operation of the Sellafield nuclear fuel reprocessing plant up to 1980. The analysis has shown that in the study population of 1,225 children born in the village between 1945 and 1979, and followed to 1980, 0.1 radiation-induced leukaemias would be expected in children under 20 years of age from all radiation sources. This corresponds to risk of about one in 12,250 for the average child in the study population. 10 refs.

Stather, J.W. (Natl Radiological Protection Board, Didcot, Engl); Dionian, J.; Brown, J.; Fell, T.P.; Muirhead, C.R. *Nucl Eng J Inst Nucl Eng* v 28 n 5 Sep-Oct 1987 p 138-142.

**088412 OBSERVATION OF HEALTH EFFECTS OF LOW LEVEL IONIZING RADIATION IN OC-**

**CUPATIONALLY EXPOSED POPULATIONS.** There is controversy over the correct method of extrapolating from observations made on populations exposed to high doses of ionizing radiation (where carcinogenic effects may be unequivocally demonstrated) to obtain risk estimates for occupationally exposed persons and members of the general public who may be chronically exposed at low levels. Direct observation of the effects of chronic low level exposure may one day be possible in workers in the UK nuclear industry. This paper reviews several studies currently under way in this country and examines the potential of such work for quantifying the risk. (Edited author abstract) 19 refs.

Harte, G.A. (CEGB, London, Engl). *Nucl Eng J Inst Nucl Eng* v 29 n 1 Jan-Feb 1988 p 12-18.

## Industrial Applications

**088413 RADIOISOTOPES AND RADIATION TECHNOLOGY IN INDUSTRY.** Industrial radiation processing is based on the use of radiation as a source of energy to induce specific chemical, physical, and biological changes. On the other hand, applications of isotopes in industry, either as sealed sources or as tracers, rely on the measurements of physical signals which monitor properties of interest. This article offers an overview of radiation processing and tracer applications which are perhaps lesser known, although widely applied for the benefit of industry.

Guizerix, Jacques (IAEA); Markovic, Vitomir; Airey, Peter. *IAEA Bull* v 29 n 2 1987 p 20-24.

**Mathematical Models** See Also NEUTRONS—Emission.

**088414 ERRORS FOUND IN EXPRESSIONS GIVEN BY SCHAEFFER AND BY SELPH FOR RADIATION FLUX IN RECTANGULAR STRAIGHT DUCT.** Assuming the entrance of a rectangular straight duct to be uniformly covered with a film of radiation source, and the radiations to be emitted into the duct at intensities proportional to  $\cos^2\theta$  ( $\theta$ : Angle of radiation incidence), the unscattered component of radiations along the duct axis is shown. This consequently proves the fallacy of the expressions given by Schaeffer and by Selph for the same assumptions. (Edited author abstract) 5 refs.

Yamakoshi, Hisao (Ship Research Inst, Mitaka, Jpn); Itoh, Yasuyoshi. *J Nucl Sci Technol* v 24 n 11 Nov 1987 p 881-886.

**Monitoring** See Also NUCLEAR POWER PLANTS—Radioactivity.

**088415 RADIOACTIVITY MONITORING OF THE WATER CYCLE FOLLOWING THE CHERNOBYL ACCIDENT.** Details are given of the radioactivity monitoring programs following the Chernobyl accident. Measurements of gross beta activity in samples of rainwater, raw water, treated water, waste products from water treatment plants, and sewage sludges, are tabulated. On a limited sampling regime fallout in the Longdendale water catchment, three months after the accident, was investigated and shown to be mainly absorbed onto grass and soil. Water treatment processes were found to be effective in removing radioactive fallout from raw water, and concentrating it into the waste treatment products. The disposal of these waste products is discussed. (Author abstract) 9 refs.

Jones, F. (North West Water Authority); Castle, R.G. *J Inst Water Environ Manage* v 1 n 2 Oct 1987 p 205-217.

**Transport Properties** See Also NUCLEAR REACTORS, GAS COOLED—Fission Products.

**088416 DISCRETE ANGLE BIASING IN MONTE CARLO RADIATION TRANSPORT.** An angular biasing procedure is presented for use in Monte Carlo radiation transport with discretized scattering angle data. As in more general studies, the method is shown to reduce statistical weight fluctuations when it is combined with the exponential transformation. This discrete data appli-



cation has a simple analytic form that is problem independent. The results from a sample problem illustrate the variance reduction and efficiency characteristics of the combined biasing parameter  $p$  and the preferential direction  $\Omega_0$  used in the combined biasing schemes. (Author abstract) 28 refs.

Cramer, S.N. (Oak Ridge Natl Lab, Oak Ridge, TN, USA). *Nucl Sci Eng* v 98 n 4 Apr 1988 p 279-298.

**088417 ANALYTICAL STUDY OF LEAKAGE ESTIMATORS IN MONTE-CARLO SIMULATION OF RADIATION TRANSPORT.** Variance reduction characteristics of estimators, employed to obtain leakage in Monte-Carlo simulation of deep-penetration problems, are studied. Analytical expressions are developed for the first and second moments of leakage, for a 1-D slab field, with forward/backward scattering, for the various estimators, using the weight moments equation formulation. The estimators studied are the last event estimator and the next event estimator. Survival biasing, normally employed in deep-penetration problems, is also considered. The variance reduction properties of the estimators are compared as a function of scattering probability and anisotropy in scattering. (Author abstract). 10 Refs.

Indira, R. (Indira Gandhi Cent For Atomic Research, Kalpakkam, India). *Ann Nucl Energy* v 15 n 5 1988 p 261-269.

**RADIOACTIVITY MEASUREMENT** See Also AEROSOLS—Filtration; CERENKOV COUNTERS; DOSIMETERS—Calibration; GAMMA RAYS—Measurements; IONIZATION CHAMBERS—Electronic Equipment; IRON AND STEEL ANALYSIS—X-Ray Analysis; LEAD AND ALLOYS—Radioactivity; MATHEMATICAL TECHNIQUES—Approximation Theory; NUCLEAR ENERGY—Fission Reactions; NUCLEAR REACTORS—Core Meltdown; NUCLIDES—Radioactive; PARTICLE DETECTORS; PROTEINS—Measurements; RADIATION CHEMISTRY—Environmental Testing; RADIATION DETECTORS; RADIOACTIVE MATERIALS—Analysis; RADIOACTIVE MATERIALS—Inventory Control; RADIOACTIVE WASTES—Nondestructive Examination; RADIOGRAPHY—Neutron; SPECTROSCOPY, NUCLEAR RADIATION; TERBIUM—Isotopes; WASTEWATER—Radioactivity; WATER ANALYSIS—Radioactivity; WELDS—Nondestructive Examination; XENON—Radioactivity.

**088418 NEW DETERMINATION OF TRUE NET COUNT-RATES WITH 'PROPORTIONAL' SOURCES OF A RADIOISOTOPE.** In the whole range of observed total count-rates with a constant background rate  $R_b$ ,  $R_1 + R_b$ ,  $R_2 + R_b, \dots$ , a new simple evaluation procedure has been elaborated for accurate determination of the experimental observed-to-true net rate ratios  $R_1/R_1^0 > R_2/R_2^0 > \dots$ , by a series of 'proportional' sources of the same radioisotope. This new evaluation procedure for determining the linear and nonlinear portions of  $R_j/R_j^0$  vs  $R_j$  over the whole range of the observed net count-rate  $R_j$ , in addition, gives a new accurate and simple procedure for evaluating the rational overall resolving time  $\tau'$  from the linear portion of  $R_j/R_j^0$  vs  $R_j$ , where  $j=i=p+1$  to  $n$ . 9 refs.

Ujhelyi, Cs. (Inst of Nuclear Research, Debrecen, Hung). *Appl Radiat Isot* v 38 n 9 1987 p 717-727.

**088419 OPTIMAL MEASUREMENT TIME FOR SHORT-LIVED WEAK RADIOACTIVE SOURCES.** It is shown that an optimal measurement time can be simply determined for short-lived weak sources. The calculated values are presented in a widely applicable graphic form. (Author abstract) 1 ref.

Bikit, I. (Univ of Novi Sad, Novi Sad, Yugoslavia); Slivka, J. *Nucl Instrum Methods Phys Res Sect A* v A260 n 2-3 Oct 15 1987 p 550-552.

**088420 RADIATION ENVIRONMENT OF AN MT-22 MICROTRON.** The main purpose of the present work is to carry out full-scale measurements of the radiation fields around an operating electron accelerator, an MT-22 microtron, and to compare these with estimates based on published recommendations. Measurements made with the aid of activation detectors showed that the flux density of scattered thermal neutrons in the microtron

room ranged from  $10^5$  to  $2 \cdot 10^5 \text{ cm}^{-2} \cdot \text{sec}^{-1}$ . The presence of thermal neutrons causes the formation of isotope  $^{41}\text{Ar}$  with a concentration which, in the absence of air exchange, is close to the maximum allowable limit for the air of industrial workplaces. At the same time, the radiation effect of the  $^{13}\text{N}$  and  $^{15}\text{O}$  isotopes produced in the air as a result of the bremsstrahlung is negligible. 12 refs.

Teterev, Yu.G. *Sov At Energy* v 62 n 5 May 1987 p 396-400.

**088421 LISOL, A TECHNIQUE FOR LIQUID SCINTILLATION ON-LINE MEASUREMENTS.** A new measuring device, called LISOL, for Liquid Scintillation On-Line, has been developed for the detection of alpha and beta-emitting radiotracers in liquid flows. The principle involves continuous withdrawal of a small fraction of the streaming liquid, to which is added acid to suppress hydrolysis and sorption, and a liquid scintillator cocktail, after which the mixture passes a measuring cell viewed by photomultipliers. The advantage of the new device is demonstrated by measuring the distribution (D) of the pure beta-emitter  $^{147}\text{Pm}$  between aqueous  $\text{Na(H)-ClO}_4$  and benzene in the presence of acetylacetone. Reproducible D-values are obtained down to  $\leq 10^{-4}$  and at  $\text{pH} \leq 9$ , where  $\text{Pm(III)}$  is strongly hydrolyzed. (Author abstract) 9 refs.

Albinsson, Y. (Chalmers Univ of Technology, Goteborg, Sweden); Ohlsson, L.-E.; Persson, H.; Rydberg, J. *Appl Radiat Isot* v 39 n 2 1988 p 113-120.

**088422 COMPARISON OF MONTE CARLO SIMULATIONS WITH FISSION TRACK OBSERVATIONS IN APATITE.** Monte Carlo simulations have been made of the revelation of fission tracks through the cleavage plane of a crystal. The distributions of quantities that are normally measured (track dip angle  $\Phi$ ; projected length  $P$  onto the cleavage plane; and depth,  $Z$  measured vertically from the etched surface to the end-point of the track) have been calculated. The derived distribution of spatial length and angle to the reference axis have also been calculated. The effects on these of a gaussian distribution of fission track range, of bulk etching, and of scanning bias have been evaluated. It is shown that, provided that the bulk etching rate is measured, reliable determination of the mean and standard deviation can be obtained. The simulations have been compared with experimental data for apatite crystals cut in the basal plane or in the prismatic plane. (Edited author abstract) 4 refs.

Al-Khalifa, I.J.M. (Arabian Gulf Univ, Manama, Bahrain); Major, J.V. *Nucl Tracks Radiat Meas* v 13 n 4 1987 p 185-195.

**088423 ANISOTROPIC ETCHING CHARACTER OF SPONTANEOUS FISSION TRACKS IN ZIRCON.** The anisotropic etching character of spontaneous fission tracks in zircon was examined to ensure the reliability of the external detector method. The effect of anisotropic etching on the etching efficiency was evaluated using detailed progressive etching experiments. For zircons whose track density is around  $1 \times 10^6 \text{ cm}^{-2}$ , the angular distribution of etched tracks is found to be isotropic under optimal etching condition, in contradiction to the former studies. (Author abstract) 9 refs.

Sumii, Tomoaki (Kyoto Univ, Kyoto, Jpn); Tagami, Takahiro; Nishimura, Susumu. *Nucl Tracks Radiat Meas* v 13 n 4 1987 p 275-277.

**088424 COMPARISON OF THREE PROCEDURES FOR DETERMINING TRUE NET COUNT-RATES WITH "PROPORTIONAL" SOURCES OF A RADIOISOTOPE.** Three procedures have been published for the exact evaluation of the true net count-rates  $R_1^0 < R_2^0 < \dots$  from directly observed total rates  $R_1 + R_b < R_2 + R_b < \dots$  of 'proportional' sources of a radioisotope. In this work the experimental values of observed-to-true net rate ratio,  $R_j/R_j^0 < 1$ , were evaluated from the linear ( $j=i$ ) and nonlinear ( $j=k$ ) portions of  $R_j/m_j$  vs  $R_j$ . Kohman's method had to be modified to

derive a relation between  $R_j/m_j$  and  $R_j^2/m_j$  for evaluating the apparent rational overall resolving time per count,  $\tau_N$ , and an approximate value of the true net rate per unit mass of a radioisotope solution,  $(R/m)_N^0$ , from  $R_j/m_j$  vs  $R_j^2/m_j$ . 7 Refs.

Ujhelyi, Cs. (Inst of Nuclear Research, Debrecen, Hung). *Appl Radiat Isot* v 39 n 7 1988 p 631-638.

**088425 MEASUREMENT CAMPAIGNS FOR HOLDUP ESTIMATION.** The derivation of technically defensible holdup estimates is described. Considerations important in the planning of measurement campaigns to provide necessary data are reviewed and the role of statistical sampling is discussed. By design, the presentation is nonmathematical and intended for a general audience. (Author abstract). 2 Refs.

Picard, R.R. (Los Alamos Natl Lab, Los Alamos, NM, USA). *Nucl Mater Manage* v 26 n 4 Jul 1988 p 9-11.

**088426 DOSE ESTIMATES FROM THE CHERNOBYL ACCIDENT.** The Lawrence Livermore National Laboratory Atmospheric Release Advisory Capability (ARAC) responded to the Chernobyl nuclear reactor accident in the Soviet Union by utilizing long-range atmospheric dispersion modeling to estimate the amount of radioactivity released (source term) and the radiation dose distribution due to exposure to the radioactive cloud over Europe and the northern hemisphere. In later assessments, after the release of data on the accident by the Soviet Union, the ARAC team used their meso-scale-to-regional-scale model to focus in on the radiation dose distribution within the Soviet Union and the vicinity of the Chernobyl plant. (Author abstract). 21 Refs.

Lange, Rolf (Lawrence Livermore Natl Lab, Livermore, CA, USA); Dickerson, Marvin H.; Gudiksen, Paul H. *Nucl Technol* v 82 n 3 Sep 1988 p 311-323.

**088427 PARAMETRIC MODELLING OF TEMPORAL VARIATIONS IN RADON CONCENTRATIONS IN HOMES.** The  $^{222}\text{Rn}$  (radon) concentrations in the living area, the basement, and the underlying soil of a New Jersey home have been measured at half-hour intervals over the course of a year, as have indoor and outdoor temperatures, wind speed and direction, indoor-outdoor and basement-subslab pressures; in addition, periods of furnace operation have been logged. A preliminary version of a mathematical model is developed that demonstrates the dependence of the radon concentrations on the environmental variables and the extent of furnace use, with the purposes of improving the ability to predict occurrences of elevated concentrations in general, increasing the usefulness of short-term measurements in particular, and assisting in the devising of remedial measures. The possibility of determining the model parameters from knowledge or measurement of geological and structural characteristics is discussed. 6 refs.

Revzan, K.L. (Lawrence Berkeley Lab, Berkeley, CA, USA); Turk, B.H.; Nero, A.V.; Sextro, R.G. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 550-555.

**088428 USE OF LOW-BACKGROUND GERMANIUM DETECTORS TO PRESELECT HIGH-RADIO-PURITY MATERIALS INTENDED FOR CONSTRUCTING ADVANCED ULTRALOW-LEVEL DETECTORS.** The use of ultra-low-background germanium-diode gamma-ray spectrometers to measure the concentrations of radionuclides in a variety of materials is described. Bulk shielding materials that were examined included contemporary lead, 150-year-old lead, 400-year-old lead, pre-1945 battleship steel, and electrorefined copper. Typically, the samples were constructed such that a thickness of 5 cm or more of material completely surrounded the detector except for the end connected to the liquid nitrogen dewar. Several experiments were performed to gauge the effects of shielding materials on the observed cosmogenic neutron flux. Another experiment was performed at ground level using



one of the germanium diodes fabricated with superclean materials (copper can and cryostat, custom solder, indium o-ring, etc.) and 5-, 10-, and 15-cm-thick low-activity passive Pb shielding to determine the effects of bulk shielding on the observed background. The results are presented and discussed. 3 refs.

Arthur, R.J. (Pacific Northwest Lab, Richland, WA, USA); Reeves, J.H.; Miley, H.S. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 582-585.

**088429 TECHNIQUES IN RADIONUCLIDE METROLOGY, PROCEEDINGS OF AN ICRM SEMINAR.** This conference proceedings contains 25 papers, all of which are separately indexed and abstracted. The papers consider techniques in radionuclide metrology. Standardization of radionuclides is given ample coverage. Coincidence methods are discussed. Spectrometry, techniques for radioactivity measurement, calorimetry, and analytical techniques are reviewed. Proportional counters, radiation detectors, ionization chambers, and scintillation counters are included in the presentations. Materials used in radionuclide metrology are also presented, and data acquisition systems are covered. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10590 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Mann, W.B. (Ed.); Taylor, J.G.V. (Ed); Coursey, B.M. (Ed.). *Appl Radiat Isot* v 38 n 10 1987, Tech in Radionuclide Metrol, Proc of an ICRM Semin, Rome, Italy, Jun 15-16 1987 148p.

**088430  $4\pi\beta\text{-}\gamma$  COINCIDENCE COUNTING BY USING A LIVE-TIMED BI-DIMENSIONAL DATA-ACQUISITION SYSTEM.** Efficiency functions were measured by using a bi-dimensional data-acquisition system and a magnetic tape subsystem. In the measurement, the data of pulse height and time relation of  $\beta$  and  $\gamma$  signals were recorded on a magnetic tape. After measurement, all data stored on the tape were analyzed and the efficiency functions were obtained by the 'computer-discrimination method'. This method was applicable for the sources with disintegration rates lower than 15 kBq and the smooth efficiency functions were obtained for the nuclides of  $^{59}\text{Fe}$  and  $^{134}\text{Cs}$  in short time. (Author abstract) 6 refs.

Miyahara, Hiroshi (Nagoya Univ, Nagoya, Jpn); Kitaori, Shooji; Watanabe, Tamaki. *Appl Radiat Isot* v 38 n 10 1987, Tech in Radionuclide Metrol, Proc of an ICRM Semin, Rome, Italy, Jun 15-16 1987 p 793-797.

**088431 THEORY AND CAPABILITIES OF A  $4\pi\beta\text{-}\gamma$  COINCIDENCE SYSTEM WITH CUMULATIVE DEAD TIMES.** A  $4\pi\beta\text{-}\gamma$  coincidence system working with cumulative dead times, and associated electronics is described. The corresponding theoretical formulae are presented. For testing both electronics and formulae, high-activity sources of  $^{60}\text{Co}$  (up to 1.2 MBq) have been measured successfully. Their estimated uncertainties at one standard deviation were less than 0.25%. (Author abstract) 4 refs.

Chauvenet, B. (CEN, Gif-sur-Yvette, Fr); Bouchard, J.; Vatin, R. *Appl Radiat Isot* v 38 n 10 1987, Tech in Radionuclide Metrol, Proc of an ICRM Semin, Rome, Italy, Jun 15-16 1987 p 799-804.

**088432 SOME DEVELOPMENTS IN THE COX-ISLAM THEORY OF COINCIDENCE CORRECTIONS, INCLUDING THE EXTENSION OF THE COMPUTER-DISCRIMINATION METHOD.** Exact and high-order approximate formulae to correct  $\beta\text{-}\gamma$  coincidence-counting data were derived by Smith based on the theory of Cox and Islam, and in this paper the approximation is generalized to allow unequal resolving times, and also exact explicit formulae are given for the cases of equal dead times and for one dead time being twice the other. The approach is further developed to cover the case of computer discrimination in either a single channel or simultaneously in both  $\beta$  and  $\gamma$  channels. The

single  $\beta$ -channel case requires the accumulation of  $\beta$  spectra in coincidence and anticoincidence with  $\gamma$  pulses. Simultaneous discrimination requires accumulation of such spectra as a function of both  $\beta$  and  $\beta$  energy. (Author abstract) 6 refs.

Smith, David (NPL, Teddington, Engl). *Appl Radiat Isot* v 38 n 10 1987, Tech in Radionuclide Metrol, Proc of an ICRM Semin, Rome, Italy, Jun 15-16 1987 p 813-821.

**088433 DECAY COUNTING IN THE AGE OF AMS.** Up to the advent of AMS, all the accomplishments of  $^{14}\text{C}$  dating, and the studies of  $^{10}\text{Be}$  and other long-lived radionuclides, were made by low-level decay counting, the technique pioneered by W.F. Libby. It will hardly be news to people at this conference that, while much was accomplished in the three decades when counting prevailed, the world has now changed decisively. I will try to give an account of where low-level counting was 'before the revolution,' and of what its usefulness is today. There are still some remarkable examples of its application, the best being the neutrino experiment of Raymond Davis, and its potential successors. Some cosmogenic nuclides, whose half-lives are less than  $10^3$  yr, are still best measured by decay; this will continue unless the overall ion yield of AMS systems rises markedly from present levels. One long-lived nuclide,  $^{53}\text{Mn}$ , is still best measured by neutron activation as  $^{312}\text{d}$   $^{54}\text{Mn}$ , but this may not continue. (Author abstract) 20 refs.

Arnold, James R. (Univ of California, San Diego, La Jolla, CA, USA). *Nucl Instrum Methods Phys Res Sect B* v B29 n 1-2 Nov 11 1987, Accel Mass Spectrom, Proc of the Fourth Int Symp, Niagara-on-the-Lake, Ont, Can, Apr 27-30 1987 p 424-426.

Applications See EROSION.

Calibration See RADON—Radioactivity.

Classification See NUCLEAR REACTORS—Accidents.

Electronic Equipment

**088434 EFFECT OF TWO DEAD TIMES IN SERIES ON COINCIDENCE MEASUREMENTS.** Dead times in series occur in any counting device where detector signals are electronically amplified, selected for pulse height by a discriminator (or pulse-height analyzer) and fed through a dead-time unit producing a dead time, which has very often been designed to establish definite dead time losses. The problem of two dead times in series has been treated by J.W. Mueller. No attempt, however, seems to have been made up to now to investigate this problem for the electronics of a coincidence system. In this paper two dead times in series are considered that are found either in one or in both channels of a coincidence system. Correlation formulas with experimental evidence are given which allow the deviations from results, which were calculated by taking only one dead time per channel into account, to be estimated. (Author abstract) 7 refs.

Funck, E. (Physikalisch-Technische Bundesanstalt, Braunschweig, West Ger). *Appl Radiat Isot* v 38 n 10 1987, Tech in Radionuclide Metrol, Proc of an ICRM Semin, Rome, Italy, Jun 15-16 1987 p 805-811.

Equipment See Also PERSONNEL—Radioactivity.

**088435 OPTIMUM GEOMETRY OF LARGE MARINELLI-TYPE VESSELS FOR IN-SITU ENVIRONMENTAL SAMPLE MEASUREMENTS WITH  $\text{Ge(Li)}$  DETECTORS.** Using the peak efficiencies calculated by the PEAK code for 8 and 18%  $\text{Ge(Li)}$  detectors, the optimum geometry of large Marinelli-type vessels (5-60 L), under which the peak efficiency has its maximum value, was obtained in the energy region from 365 to 1332 keV. The result showed that the optimum geometry holds when the sample thickness in the axial and radial directions are equal. (Author abstract) 10 refs.

Suzuki, Takashi (Tokyo Metropolitan Isotope Research Cent, Tokyo, Jpn); Inokoshi, Yukio; Chisaka, Haruo; Nakamura, Takashi. *Appl Radiat Isot* v 39 n 3 1988 p

253-256.

**088436 MICROGEMS EMPLOYS THE POWER OF THE PROCESSOR.** In a further development of the Guardian Environmental Monitoring System (GEMS) GEC Energy Systems has produced a new outstation with a better performance and lower power requirements. The new 'MicroGEMS' employs a microprocessor to perform trending and to provide for in situ interrogation of stored data and parameter changing using a portable personal computer. This article reviews design highlights of this system. (Edited author abstract).

Gould, John (GEC, Whetstone, Engl). *Nucl Eng Int* v 33 n 409 Aug 1988 p 53-54, 56.

Instruments See Also IONIZATION—Measurements; PARTICLE DETECTORS; RADIATION DETECTORS.

**088437 CALIBRATION OF A SOLID STATE NUCLEAR TRACK DETECTOR FOR THE MEASUREMENT OF INDOOR LEVELS OF RADON AND ITS DAUGHTERS.** Time-integrated measurements of environmental radiation levels are commonly carried out using solid state nuclear track detectors (SSNTD). These detectors are particularly suitable for monitoring indoor radiation, however they should be calibrated for the measurement of the levels of radon (Rn) and its daughters likely to be found in dwellings. This paper reports the results of experiments conducted to calibrate cellulose nitrate film LR-115 type II, which is used for the measurement of Rn levels in indoor environments of dwellings in India. The detector was exposed to varying concentrations of Rn inside an exposure chamber both in Bare- and in Cup-with-membrane modes. The calibration factors obtained are given. (Edited author abstract). 20 Refs.

Subba Ramu, M.C. (Bhabha Atomic Research Cent, Trombay, India); Muraliedharan, T.S.; Ramachandran, T.V. *Sci Total Environ* v 73 n 3 0715 1988 p 245-255.

**088438 DATA PROCESSING AND DISPLAY ALGORITHMS FOR PORTABLE INSTRUMENTS.** Data processing and display algorithms that have general utility to the processing of statistically poor data and its subsequent presentation on digital or digitally generated analog displays have been developed for microprocessor-based portable radiation instrumentation. By using a modified exponentially weighted filter, the data displayed become easy to interpret in a much shorter amount of time than normally required. The apparent time constant can be dynamically adjusted based on the statistical validity of the data. Related algorithms are used for the simulation of an analog meter movement and for handling range changing on digital displays. When used together, these algorithms produce an accurate, stable presentation of data that is also considered visually pleasing. 3 refs.

Alley, Gary T. (Oak Ridge Natl Lab, TN, USA); Bauer, Martin L. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 559-561.

**088439 COMPUTER-CONTROLLED TESTING AND CALIBRATION OF HEALTH PHYSICS INSTRUMENTS.** A microcomputer-controlled CAMAC system has been adapted for automated testing and calibration of health physics survey instruments. Once the survey instrument is mounted, the system automatically performs tests for angular dependence or geometry dependence. The instruments are positioned by a computer-controlled stepping motor, read-out is performed by an autoranging digital voltmeter, and data are stored on computer disks. The results of an angular response test are presented. 3 refs.

Swinth, K.L. (Pacific Northwest Lab, Richland, WA, USA); Sisk, D.R. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 567-570.



## Japan

**088440 ENVIRONMENTAL RADIOACTIVITY AROUND TOKAI-WORKS AFTER THE REACTOR ACCIDENT AT CHERNOBYL.** Following the reactor accident at Chernobyl, environmental samples of air, rain water and agricultural and marine products were collected and analyzed by gamma- and alpha-spectrometry. The highest concentrations of  $^{131}\text{I}$  in the environmental samples were as follows:  $1.0 \times 10^{-1}$  Bqm $^{-3}$  (aerosol-associated in air);  $3.0 \times 10^{-1}$  Bqm $^{-3}$  (gaseous in air);  $2.1 \times 10^2$  Bq kg $^{-1}$  (plants);  $1.4 \times 10^1$  Bq litre $^{-1}$  (milk). Other nuclides such as  $^{95}\text{Zr}$ ,  $^{95}\text{Nb}$ ,  $^{103}\text{Ru}$ ,  $^{106}\text{Ru}$ ,  $^{125}\text{Sb}$ ,  $^{129\text{m}}\text{Te}$ ,  $^{132\text{I}}$ / $^{132}\text{Te}$ ,  $^{134}\text{Cs}$ ,  $^{137}\text{Cs}$ ,  $^{140}\text{Ba}$ / $^{140}\text{La}$ ,  $^{141}\text{Ce}$  and  $^{144}\text{Ce}$  were also observed in various environmental samples. Based on the monitoring results at one dairy farm, we have derived an equation to model the transport of  $^{131}\text{I}$  from pasture grass to milk. This equation was then applied to the data from two other farms around Tokai-Works and the calculated  $^{131}\text{I}$  activities in milk were compared with those measured. The equation shows good predictive capabilities for quantification of the peak concentrations of  $^{131}\text{I}$  in milk but underestimates longer-term activities. (Edited author abstract) 7 refs.

Ishida, Junichiro (Power Reactor & Nuclear Fuel Development Corp, Tokai-mura, Jpn); Miyagawa, Naoto; Watanabe, Hitoshi; Asano, Tomohiro; Kitahara, Yoshihisa. *J Environ Radioact* v 7 n 1 1988 p 17-27.

## Reliability

**088441 SENSITIVITY ESTIMATION FROM A MODEL FOR A RADIOISOTOPE PRESSURE SENSOR.** Pressure sensors based on  $\alpha$ -particle ionization have substantial advantages and are increasingly used in physics experiments and industrial processes, while they also provide a basis for data-acquisition suites. Therefore, much attention is being given to the design of them and to extending the working ranges and improving the sensitivity. A sensor has been designed and tested that improves the sensitivity and stability. 11 refs.

Chernyshev, V.A. *Meas Tech* v 30 n 5 May 1987 p 490-493.

**Standardization** See Also SCINTILLATION COUNTERS—Applications.

**088442 MULTIPLE-CHANNEL 2- AND 3-FOLD COINCIDENCE COUNTING SYSTEM FOR RADIOACTIVITY STANDARDIZATION.** The advantages of a multiple-channel coincidence unit for  $4\pi\beta$ - $\gamma$  liquid scintillation radioactivity standardization are discussed. A microcomputer-controlled counting system is described, and compared with an older 3-channel coincidence system, against which it has been tested. The multiple-channel system shows potential for greater precision. (Author abstract) 6 refs.

Simpson, B.R.S. (Natl Accelerator Cent, Faure, S Afr); Meyer, B.R. *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 436-440.

**Standards** See IRON AND ALLOYS—Radioactivity.

**United Kingdom** See AIR POLLUTION—Radioactivity.

**RADIOGRAPHY** See Also IMAGE PROCESSING—Medical Applications; MICROFILM; PROSTHETICS—Hip Prostheses; RADIATION DETECTORS; WELDS—Defects.

**088443 COMPUTED TOMOGRAPHY USING URA CODED APERTURE CAMERAS.** In order to obtain a three-dimensional compressed core image in the inertial confinement fusion (ICF) experiment, a new technique for computed tomograph using uniformly redundant arrays (URA)-coded aperture cameras (URA-CT) has been developed. The URA coded aperture camera is known for its high Sn-ratio and large collection efficiency. In this technique we try to reconstruct three-dimensional objects from their coded images obtained using two orthogonal URA coded aperture cameras. In com-

puter simulations, we have obtained a good estimate of the object with a relative error of less than 10%. The principle of URA-CT, computer simulation results and the possibility of applying URA-CT for imaging the three-dimensional compressed core in ICF experiments are presented. (Edited author abstract) 4 refs.

Chen, Yen-Wei (Osaka Univ, Jpn); Miyana, Noriaki; Yamanaka, Masanobu; Izawa, Yasukazu; Yamanaka, Chiyo; Tamura, Shinichi. *Technol Rep Osaka Univ* v 37 n 1865-1888 Mar 1987 p 29-33.

**088444 INVESTIGATION ON INHERENT UNSHARPNESS OF DIFFERENT SCREEN MATERIALS FOR 8 MV X-RAYS AND CO $^{60}$   $\gamma$ -RAYS.** Inherent unsharpness has been investigated for screens of lead, steel, tantalum, and polyethylene with thicknesses between 0.02 mm and 2 mm (as available). The radiations used were Co $^{60}$  gamma-rays and 8 MV X-rays from a linac. According to expectation, the inherent unsharpness increases with screen thickness and depends on energy of course. For both energies the steel and tantalum screens exhibit the lowest unsharpness values at usual and comparable screen thicknesses. When a steel filter is placed between Co $^{60}$  source and film, the width of the measured unsharpness curve is nearly doubled. This is due to the superimposition of a geometric unsharpness caused by the scattered radiation originating from the steel filter. (Edited author abstract) 10 refs.

Stade, Jurgen; Khan, Asghar Ali; Heidt, Heinrich. *Br J Non Destr Test* v 30 n 1 Jan 1988 p 28-30.

**088445 EFFECT OF THE 1985 IONISING RADIATIONS REGULATIONS ON A SERVICE INSPECTION COMPANY.** The Ionizing Radiations Regulations, laid before Parliament on 4th September 1985, were introduced as a result of EEC directives that member nations comply with recommendations made in a 1978 report by the International Commission for Radiological Protection. This article attempts to identify the significant changes and requirements resulting from the 1985 Ionizing Radiations Regulations and examine their effect on the administration and operations of a service inspection company engaging in Industrial Radiography.

Outhwaite, D. (Quality Inspection Services Training Div). *Br J Non Destr Test* v 30 n 2 Mar 1988 p 103-105.

**088446 DISCUSSION ON THE FORMULA FOR CALCULATING THE RELATIVE SENSITIVITY IN DOUBLE-WALL SINGLE-IMAGE RADIOGRAPHIC INSPECTION.** Based on the theory testing data and problems found in work, the paper discusses the formula for calculating the relative sensitivity in double-wall single-image radiographic inspection formulated in standard SD 143-85, and puts forward a more reasonable formula. (Author abstract) 8 refs. In Chinese.

Xianpo, Chen. *Wusun Jiance* v 10 n 4 Apr 1988 p 91-93.

**088447 ASSESSMENT OF THE PRESENT STATUS OF X-RAY TELEVISION-FLUOROSCOPY-REAR-TIME RADIOGRAPHY.** Television-fluoroscopic equipment applications should be assessed in terms of the flaw sensitivity required in a particular application. Real-time radiography equipment design is a complex problem in which the performances of individual components - conversion screen, camera, pixel matrix, line raster, etc. need to be matched to one another if high quality images are required. If flaw sensitivities equivalent to those attainable on film are required, these cannot at present be achieved with equipments which do not use computer image enhancement and projective magnification, except perhaps when using very high energy X-rays. If computer image enhancement is used, IQI sensitivities equal to those obtainable on film can be attained on a considerable range of specimen thickness, but the flaw sensitivity, in particular crack sensitivity, will be much poorer than attainable on film. To attain crack sensitivities similar to film radiography, even with 'normal film techniques', projective magnification and digital image enhancement are necessary. Additional respects of the subject are discussed. 4 Refs.

Halmshaw, R. *Br J Non Destr Test* v 30 n 4 Jul 1988 p 257-258.

**Applications** See Also PRINTED CIRCUITS—Measurements; WELDS—Defects; WELDS—Nondestructive Examination; WELDS—Testing.

**088448 APPLICATION OF ELECTORADIOGRAPHY IN THE ENERGY RANGE OF IONIZING RADIATION 0.3-6.0 MeV.** The article presents the experimental results of irradiation of steel up to 250 mm thick with radiation from sources  $^{192}\text{Ir}$ ,  $^{137}\text{Cs}$  and of betatrons MIB-4 and PMB-6 obtained on electroradiographic plates PER2-3-P and PER4-3-P: Comparative results obtained in x-ray radiographic films RT-1 and RM-1 with the use of intensifying screens VP-2 are also presented. (Edited author abstract) 4 refs.

Kavalyauskas, R.A.; Kaminskas, A.I.; Semenov, Yu.V. *Sov J Nondestr Test* v 23 n 8 Aug 1987 p 523-527.

**088449 SILVER DISPERSAL IN IMAGE ENHANCEMENT FOR ENGINEERING RADIOGRAPHIC FILMS.** A method is considered for intensifying the silver image in a radiographic film, which is based on raising the coupling capacity of the silver in the primary image, which is based on silver dispersal. Measurements have been made on the sensitometric, structural, and radiographic parameters of films given this treatment. Silver dispersal is found to retain the flaw-detection sensitivity while reducing the exposure time by a factor 2.5-3 when RT-12 or D7 Structurix film is used; if the initial exposure time is retained, one can use a low-silver film type RT-12 m, whose silver content is half. (Author abstract) 12 refs.

Biktimirov, R.S. (Lenin Byelorussian Univ, Moscow, USSR); Kapustin, V.I.; Korzun, G.M.; Krusser, T.B.; Kudryavtsev, M.F.; Rakhmanov, S.K.; Shablov, S.V. *Sov J Nondestr Test* v 23 n 8 Aug 1987 p 530-534.

## Automation

**088450 RADIOGRAPHIC EXAMINATION TAKES ON AN AUTOMATED IMAGE.** Automation can be effectively applied to nondestructive testing (NDT). Until recently film radiography used in NDT was largely a manual process, involving the shooting of a series of x-rays, manually positioned and manually processed. In other words, much radiographic work is being done the way it was 50 years ago. Significant advances in automation have changed the face of manufacturing, and industry has shared in the benefits brought by such progress. A telling example was found in the assembly operations of the Parlex Corporation, Methuen, Mass., the manufacturer of flexible-rigid multilayer circuits containing as many as 24 layers. In one assembly produced for a missile nose cone, holes had to be accurately drilled through 20 layers, leaving 2 mils of copper around each hole for good contact and reliability. Standard alignment tests, using Quality Conformance Test Coupons, indicated misalignment of the holes, and nearly \$80,000 worth of circuit board assemblies were scheduled to be scrapped. This paper discusses the installation of an in-line radiography system which was put in operation by the Parlex Corporation. The system was built around the Du Pont NDT Daylight Module. The system conclusively demonstrated that the drilling was in fact accurate and that the boards would perform as specified.

Aman, J. (DuPont, Wilmington, DE, USA). *Weld J (Miami Fla)* v 67 n 2 Feb 1988 p 57-58.

**Computer Applications** See WELDS—Defects.

**Contrast Media** See Also CONCRETE—Cracking.

**088451 STUDIES ON THE APPLICATION OF POLYSACCHARIDES IN PREPARATION OF BARIUM SULFATE FOR DOUBLE CONTRAST RADIOGRAPHY.** Polysaccharides, produced by *Sporocytophaga* Sp., were reported and used as an additive with protective and coagulative effects in the manufacture of barium sulfate. As a result, the quality of medicinal



barium sulfate is much improved and the radiographs more satisfactory. The process of preparation of barium sulfate is simplified and cost of production reduced. (Edited author abstract) 9 refs. In Chinese.

Song, Qui-jing (Shandong Univ, China); Jiang, Bo-ying; Wang, Zu-nong. *Zhongguo Shengwu Yixue Gongcheng Xuebao* v 6 n 4 Dec 1987 p 227-230.

**Defects** See NONDESTRUCTIVE EXAMINATION—Defects.

**Diagnostic Applications** See Also BIOMECHANICS—Joints.

**088452 ORTHODONTIC ANALYSIS AND TREATMENT PLANNING: A SUITE OF PROGRAMS FOR PERFORMING CENTROID CEPHALOMETRICS.** The lateral skull radiograph is essential in the diagnosis of facial dys harmony and the planning and evaluation of corrective orthodontic treatment. The classical cephalometric analysis of the lateral radiograph involves the construction of lines and planes based on anatomical landmarks to form a reference system. A new approach to cephalometric measurement based on centres of area (i.e. centroids) has recently been developed. A suite of programs is described for performing various types of centroid analysis ranging from a simple analysis of facial and cranial segments to template matching of cyclical curves. Sample runs are presented. Many of the programs are data-driven which means that they can be readily adapted to new situations. The system is currently being re-written to run in a more standardized environment. (Author abstract) 9 refs.

Wastell, D.G. (Univ of Manchester, Manchester, Engl); Johnson, J.S.; Jones, J.A.H.; Bennett, N. *Comput Methods Prog Biomed* v 26 n 3 May-Jun 1988 p 259-265.

**088453 DIGITAL RESTORATION OF SCINTIGRAPHIC IMAGES BY A TWO-STEP PROCEDURE.** A two-step procedure for restoring scintigraphic images is described. The first step uses a local-statistics algorithm for improvement in signal-to-noise ratio by smoothing the Poisson noise. The second step aims at improvement in spatial resolution by removing the linear blur using the iterative restoration algorithm. Some results of computer simulations and restoration of scintigraphic images that demonstrate the effectiveness of the proposed procedure are presented. 16 refs.

Maeda, Junji (Hokkaido Univ, Sapporo, Jpn); Murata, Kazumi. *IEEE Trans Med Imaging* v MI-6 n 4 p 320-324.

**088454 APPLICATION OF A COHERENT IMAGE PROCESSOR TO THE ENHANCEMENT OF RADIOLOGICAL IMAGES.** Results of the investigation of the viability of using a coherent optical processor to improve image quality prior to digitization and analysis are presented. Optical processing of small (20 mm × 20 mm) and large (100 mm × 100 mm) radiological images to improve contrast and enhance edges is demonstrated. A brief summary of the principle of operation of the coherent optical processor is given. Results obtained with the apparatus described here are presented and discussed. 6 refs.

Taylor, A.J. (Univ of Manchester Inst of Science & Technology, Engl); Valera, M.S.I.; Kvasnik, F. *IEEE Eng Med Biol* v 7 n 1 Mar 1988 p 34-38.

**088455 FAST POINT SPREAD FUNCTION COMPUTATION FROM APERTURE FUNCTIONS IN HIGH-RESOLUTION POSITRON EMISSION TOMOGRAPHY.** The problem of extracting point spread functions from detector aperture functions in high-resolution PET is addressed. In the limit of very small size detectors relative to the ring dimensions, assumptions are made that lead to a fast and simple computation model yielding point spread functions with negligible errors due to the reconstruction algorithm. The method allows one to assess accurately the intrinsic performance of a PET tomograph, and it appears to be adequate to relate the imaging capabilities in every point of the camera reconstruction field to the geometric and physical characteris-

tics of the detection system. The method was developed as an investigation tool to help design the next generation of very-high-resolution PET tomographs. 27 refs.

Schmitt, D. (Univ of Sherbrooke, Que, Can); Karuta, B.; Carrier, C.; Leconte, R. *IEEE Trans Med Imaging* v 7 n 1 Mar 1988 p 2-12.

**Gamma Ray** See Also CHEMICAL PLANTS—Testing; ROLLING MILL PRACTICE—Measurements.

**088456 FOLLOWING THE TRACKS OF DISEASE.** Positron emission tomography (PET) for medical imaging is discussed. Positron production methods, PET systems operational principles, and the experiments of several British research groups with the PET techniques are outlined. 5 refs.

Moore, Glenis. *Electron Power* v 33 n 8 Aug 1987 p 496-498.

**088457 DEVELOPMENT OF GAMMA RADIOGRAPHIC EQUIPMENT AND DISCUSSION ON RELATED PROBLEMS.** The selection of shielding material for radiography and the advantages of self-made U<sub>r</sub> as shielding material are dealt with. Our own opinions are given on the designing of the equipment structure and transmission gear and the calculation for shielding. (Author abstract) In Chinese.

Dongyu, Chen; Leqing, Bao. *Wusun Jiance* v 10 n 4 Apr 1988 p 94-96.

## Imaging Techniques

**088458 ENHANCEMENT OF CHEST RADIOGRAPHS WITH GRADIENT OPERATORS.** Reference is made to the Sobel and Roberts gradient operators used to enhance image edges. Overall, the Sobel operator was found to be superior to the Roberts operator in edge enhancement. A theoretical explanation for the superior performance of the Sobel operator was developed based on the concept of analyzing the x and y Sobel masks as linear filters. By applying pill-box, Gaussian, or median filtering prior to applying a gradient operator, noise was reduced. The pill-box and Gaussian filters were more computationally efficient than the median filter with approximately equal effectiveness in noise reduction. 19 refs.

DaPonte, John S. (Southern Connecticut State Univ, New Haven, CT, USA); Fox, Martin D. *IEEE Trans Med Imaging* v 7 n 2 Jun 1988 p 109-117.

## Industrial Applications

**088459 IMAGING WITH HIGH ENERGY PARTICLES.** Nuclear scattering of 1 GeV protons has been used to radiograph objects. It allows 3-D radiography without any move of the object and beam. Its sensitivity to atomic numbers is very different from the one given by classical methods and it allows one to study more easily heavy materials like iron or uranium. Because of the specific properties of proton-proton scattering, it is able to obtain 3-D radiography of the hydrogen content in objects. The method is described and radiographies of defects in iron and of a hydrogen target are shown. (Author abstract) 5 refs.

Saudinos, J. (CEN Saclay, Gif sur Yvette, Fr). *J Opt* v 18 n 4 Jul-Aug 1987 p 193-198.

**Neutron** See Also FLOW OF FLUIDS—Two Phase; NUCLEAR FUELS—Mixed Oxides; TOBACCO—Combustion.

**088460 STANDARDIZATION FOR DETERMINING IMAGE QUALITY IN THERMAL NEUTRON RADIOGRAPHIC TESTING.** Neutron radiography is relatively recent technology developed mainly for non-destructive testing. One of the applications of this technique is the pre- and post-irradiation testing of nuclear fuel elements. The determination of the quality of a neutron radiography system facility is based upon evaluation of images obtained from the standard indicators. In the present study, three types of standard

indicators were put to a test: (1) Sensitivity Indicator (SI), (2) Beam Purity Indicator (BPI), and (3) Beam Purity Indicator-Fuel (BPI-F). 3 refs.

Yamagata, Hiroshi (Kyoto Univ, Osaka, Jpn); Yoneda, Kenji; Fujie, Shigenori; Kanda, Keiji; Katsurayama, Kosuke. *Annu Rep Res React Inst Kyoto Univ* v 19 1986 p 116-123.

**088461 DEEP PENETRATION RADIOGRAPHY USING 24.5 keV NEUTRONS.** This communication describes a series of experiments which has been made to demonstrate the ability of fast neutrons to radiograph objects through more than 150 mm of steel. 2 refs.

Beynon, T.D. (Univ of Birmingham, Birmingham, Engl); Constantine, G. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 526-527.

**088462 INTERNATIONAL NEUTRON RADIOGRAPHY NEWSLETTER NO 15 - NRW TEST PROGRAM - PART 1.** The NRW, constituted in 1979, has proposed in 1981 to perform a Test Program with the aim to determine the suitability of existing standards for the control of radiography image quality in neutron radiography of nuclear reactor fuel. The other objective of the Test Program was to investigate with what accuracy the dimensions can be measured from neutron radiographs. Eleven NR facilities from 6 member countries have participated. They were the following: Geesthacht (FRG), Harwell (UK), Mol (Belgium) (2 facilities), Petten (The Netherlands) (4 facilities), Riso (Denmark), Saclay (France) and Fontenay-aux-Roses (France).

Domanus, J.C. *Br J Non Destr Test* v 30 n 1 Jan 1988 p 40-42.

**088463 DEVELOPMENT OF A NON-REACTOR NEUTRON RADIOGRAPHIC ASSEMBLY USING A 12 MeV LINEAR ELECTRON ACCELERATOR.** A description is given of the development of a neutron radiography assembly which does not use a nuclear reactor. The neutron radiographic technique developed can in some circumstances detect explosives in metal ordnance with a greater sensitivity than X-radiography. (Author abstract) 4 refs.

Ratcliffe, B.J. (British Inst of Non-Destructive Testing). *Br J Non Destr Test* v 30 n 2 Mar 1988 p 94-98.

**088464 QUANTITATIVE ESTIMATIONS IN NEUTRON CAPTURE RADIOGRAPHY.** Theoretical models are proposed for the calculation of the local concentrations, in a specimen, of nuclides such as <sup>6</sup>Li, <sup>10</sup>B, <sup>14</sup>N or <sup>17</sup>O, from the corresponding local densities of tracks on the detectors. Several different cases have been studied: i) one or several types of particle involved, ii) initial energy of the particles below, or above the 'upper threshold of detection', iii) possible nonnegligible abrasion of the detectors during etching and (iv) contribution of background tracks originating from the detectors themselves. The theoretical equations have been applied to the interpretation of experimental data. (Author abstract) 26 refs.

Thellier, M. (CNRS, Mont-St.-Aignan, Fr); Hennequin, E.; Heurteaux, C.; Martini, E.; Petterson, M.; Fernandez, T.; Wissocq, J.C. *Nucl Instrum Methods Phys Res Sect B* v B30 n 4 Apr 1 1988 p 567-579.

**088465 INVESTIGATION INTO THE USE OF TRACK-ETCH IMAGING TO PRODUCE NEUTRON RADIOGRAPHS FROM A NON-REACTOR NEUTRON SOURCE.** A study is described of the use of cellulose nitrate with an enriched boron-10 converter screen for producing neutron radiographs from the RARDE non-reactor neutron assembly. Investigation into the required exposure and etching times has been made together with the measurement of unsharpnesses. The study shows that track-etching gives a sharper image



than that obtained with the dysprosium transfer technique and the image is available for viewing in a much shorter time. (Author abstract) 5 refs.

Ratcliffe, B.J. *Br J Non Destr Test* v 30 n 3 May 1988 p 183-188.

**088466 APPLICATION OF NEUTRON RADIOGRAPHY FOR FLUID FLOW VISUALIZATION.** Real-time thermal neutron radiography has been applied to the visualization of fluid flows. Since neutrons can penetrate metal casings, the technique may be useful for the visualization of fluids flowing inside metal enclosures, etc. The technique described involves shadowgraph imaging of neutron-opaque tracer materials (either solid or fluid particles) as they convect in a stream of neutron-transparent ambient fluid. Real-time motion pictures of several simple flows have been recorded, from which velocities, regions of flow separation, rate of mixing, and other information about the flow field can be obtained. The neutron radiography facility at the Penn State Breazeale Nuclear Reactor and the studies performed to determine viable liquids useful in neutron radiography applications are described. Some examples of successful flow visualizations are also presented. (Author abstract) 7 refs.

Cimbala, John M. (Pennsylvania State Univ, University Park, PA, USA); Hughes, Daniel E.; Levine, Samuel H.; Sathianathan, Dhushy. *Nucl Technol* v 81 n 3 Jun 1988 p 435-445.

**088467 REAL-TIME NEUTRON RADIOGRAPHY SYSTEM PERFORMANCE-MEASUREMENTS AND METHODS.** The real-time neutron radiography facility at the University of Virginia (UVA) was designed to be a flexible neutron imaging facility. This paper describes the methods and measurements implemented to characterize the changes in the radiographic system performance. These include standard measurements of the neutron flux, neutron-to-gamma ratio, the effective collimator length-to-aperture diameter (L/D) ratio, and effective neutron temperature. In addition to these measurements, a method has been implemented to measure the collimator effectiveness and imaging system performance by measuring the modulation transfer function (MTF) of the imaging system. 14 Refs.

Sulcoski, Mark F. (Univ of Virginia, Charlottesville, VA, USA); Tobin, Kenneth W.; Brenizer, Jack S. Jr. *Nucl Technol* v 82 n 3 Sep 1988 p 355-362.

## Noise, Spurious Signal

**088468 NOISE AND GRANULARITY IN RADIOGRAPHS.** A model handling the noise and granularity in radiographs is presented. The calculated noise level vs. film density is compared with experimental results for Agfa Gevaert D4 and D7 films. The agreement is quite good. (Author abstract) 21 refs.

Segal, Y. (Technion-Israel Inst of Technology, Haifa, Isr); Ingman, D.; Bushlin, Y. *Mater Eval* v 46 n 4 Mar 1988 p 513-517.

## Personnel Training

**088469 CASE FOR AN ASNT CENTRAL CERTIFICATION PROGRAM FOR INDUSTRIAL RADIOGRAPHERS.** This paper evaluates the current regulations for radiation safety training. An inherent weakness of the current system is a lack of uniform training for all radiographers, together with a lack of consistent evaluation of their comprehension of radiation safety principles and practices. Each licensee must provide its own resources to develop and implement its training and evaluation programs. The public and the employee depend on the licensee's resolve, ability, and conscience to perform this training and to evaluate the radiographer's comprehension of safety principles and practices. It is concluded that for this and some other reasons ASNT should move now to answer the nation's need for uniform radiation safety training and certification of radiographers.

Rosier, Gregory A. (FMC/NSD, Fridley, MN, USA).

*Mater Eval* v 46 n 8 Jul 1988 p1041.

**Standards See MATHEMATICAL TECHNIQUES—Sensitivity Analysis.**

**X-Ray See Also BIOMEDICAL ENGINEERING—Computerized Tomography; BIOMEDICAL EQUIPMENT; CASTINGS—Monitoring; CASTINGS—X-ray Analysis; FLOW OF FLUIDS—Granular Materials; GRANULAR MATERIALS—Density Measurement; IMAGING TECHNIQUES; MICROSCOPIC EXAMINATION—Transmission Electron Microscopy; NONDESTRUCTIVE EXAMINATION; PRINTED CIRCUITS—Nondestructive Examination; PULP MANUFACTURE—Kraft Process; ROCKET ENGINES—Nondestructive Examination; ROLLING MILL PRACTICE—Nondestructive Examination; SEMICONDUCTING SILICON—Growth; WELDS—Inspection; WELDS—Nondestructive Examination; X-RAY FILMS—Density Measurement; X-RAY FILMS—Spectrum Analysis.**

**088470 AUTOMATIC DELAY CONTROLLER.** An automatic delay controller is described for a system for radiographic recording of high-speed processes whose speed varies from experiment to experiment. The controller has been used with a MIRA-5B/1 source of single x-ray pulses. The controller is implemented by integrated circuits of series 155 and permits discrete variation of the trigger-pulse delay in the range of (1-16)H, where H is the distance between the detectors of the phase of the high-speed process. The accuracy of locking of the trigger pulse of the x-ray radiator onto a given phase of the process under study is 1  $\mu$ sec. The trigger-pulse delay range is 0-999  $\mu$ sec. (Author abstract) 3 refs.

Lozovoi, L.N. (Leningrad Scientific-Industrial Organization 'Burevestnik', USSR). *Instrum Exp Tech* v 30 n 2 pt 2 Mar-Apr 1987 p 453-456.

**088471 X-RAY EXPOSURE METERS.** More attention should be paid to the development of a radiographic exposure meter, particularly in view of the variables that are possible in a radiographic technique - change in film speed, source-to-film distance, etc. The penalties in loss of image quality in getting the exposure wrong are quite considerable. A typical radiographic film requires a dose of about 2 roentgens to produce a density 2.0, and the most convenient system would be to measure the integrated radiation dose reaching the film under the critical region of the specimen during the exposure and cut off the X-ray set automatically as soon as a preset dose has been achieved. One practical solution should be to make an exposure with the measuring instrument in position but without film, and then give the same exposure on a film. This will at least save the cost of trial films on a strange specimen, and also save on film processing time for the trial exposures. 1 ref.

Anon. *Br J Non Destr Test* v 30 n 1 Jan 1988 p 18.

**088472 BEAM-SCANNING X-RAY FLAW DETECTOR.** Measurements have been made on the performance in eliminating the scattered background in a scanning device with optimized collimation parameters. Some characteristics are given for a scanning x-ray flaw detector for use with xeroradiography. (Edited author abstract) 7 refs.

Gusev, E.A. (Flaw Detection Research Inst, Moscow, USSR); Novitskiy, F.N. *Sov J Nondestr Test* v 23 n 5 May 1987 p 303-306.

**088473 ELECTORADIOGRAPHY OF OBJECTS WITH COMPLEX CONFIGURATION.** The electro-physical and spectral characteristics of electroradiographic plates are well known but the kinetics of the processes occurring in the semiconductor layer at the time of X-ray inspection of an object with complex configuration, and also the effect of these processes on the image have been insufficiently studied. The article shows that the blurring of the images of boundaries (the effect of 'slight etching') observed in electroradiography of objects with complex configuration is due to peculiarities of the kinetic processes occurring in semiconductor plates at the time of exposure. (Edited author abstract) 4 refs.

Altukhov, A.A. (Research Inst of Introspect, Moscow, USSR); Gusev, E.A.; Lomonosov, V.V.; Sosnin, F.R. *Sov*

*J Nondestr Test* v 23 n 6 Jun 1987 p 440-443.

**088474 LIMITATIONS IN GAP WIDTH MEASUREMENTS BY X-RAY RADIOGRAPHY.** The use of radiography as a quantitative tool for determining the width and depth of cracks is discussed. It is shown that in most cases the extraction of dimensional information from radiographs may lead to erroneous results. The effects of oblique geometry and a blurring line spread function are modelled. The calculated results are compared with experimental findings. (Author abstract) 11 refs.

Segal, Y.; Trichter, F. *NDT Int* v 21 n 1 Feb 1988 p 11-16.

**088475 APPLICATION OF THE AUTOMATIC FOLLOW-UP SYNCHRONIZER.** A new kind of multifunctional device for accurate synchronization is introduced. It has good anti-interference quality even when operating in a very strong electro-magnetic field. Satisfactory results of application are achieved in X-ray photography, high speed photography, multispark dynamic photoelastic and electrical measurements etc. (Author abstract) 2 refs. In Chinese.

Yang, Yemin. *Binggong Xuebao* n 2 May 1988 p 56-60.

**088476 LOW BACKGROUND X-RAY FLUORESCENCE SYSTEM FOR MICROSPHERE QUANTIFICATION.** An automated low-background X-ray fluorescence detection system was developed for measuring blood flow rates by the microsphere technique. An X-ray beam was polarized to lower Compton scattering. A Si(Li) detector was used for efficient characteristic X-ray detection with preferentially decreased sensitivity for Compton scattering, a CaF<sub>2</sub> scintillation detector was engaged in the anticoincidence method to lower the background, and risetime rejection was used for the same purpose. Solutions of 1 cm<sup>3</sup> each of Rb, Mo, Ag, I, La and Gd with concentration of 0.2-2.0 ppm were measured for 80 min and those of 2.0-20 ppm were measured for 10 min. For Ag the net counting rate was appr. 75 counts/min/ppm. The anticoincidence detector lowered the background by 10% in the region of Ag X-rays. The linear relation between net counts and actual element concentration held up to 1000 ppm for Ag solutions. 12 refs.

Morita, Y. (Univ of California, San Francisco, CA, USA); Hosier, K.E.; Lorenz, V.; Kaufman, L.; Mori, H.; Hoffman, J. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 691-697.

**RADIOMETERS See Also AGRONOMY—Remote Sensing; BIOLOGICAL MATERIALS—X-Ray Analysis; BIOMASS—Monitoring; CARBON—Radioactivity; ECOSYSTEMS—Remote Sensing; MASERS—Design; OCEANOGRAPHY—Temperature Measurement; RADAR—Measurement Application; REMOTE SENSING; REMOTE SENSING—Agricultural Applications; REMOTE SENSING—Environmental Applications; SATELLITES—Remote Sensing; SATELLITES—Weather; SEMICONDUCTING GALLIUM ARSENIDE—Spectroscopic Analysis; WELDING—Nondestructive Examination.**

**088477 NEW OPTO-THERMAL RADIOMETRY TECHNIQUE USING WAVELENGTH-SELECTIVE DETECTION.** We report the development of a new optothermal radiometry technique, using wavelength-selective detection. The measurement principle is similar to that of opto-thermal transient emission radiometry (OT-TER), but includes a grating monochromator as part of the signal detection system, to enable opto-thermal transients at selected infrared wavelengths to be studied. The technique offers the ability to separate the effects associated with the absorption of exciting light from those of infrared emission. Changes of opto-thermal decay time with emission wavelength can therefore be related to the



infrared absorption spectrum of the sample. First observations on  $\text{TiO}_2$  excited by uv laser light are presented. (Author abstract) 9 refs.

Imhof, R.E. (Strathclyde Univ, Glasgow, Scotl); Whitters, C.J.; Birch, D.J.S.; Thornley, F.R. *J Phys E* v 21 n 1 Jan 1988 p 115-117.

**088478 CHOICE OF THE PARAMETERS OF RADIOMETRIC SYSTEMS WITH DISCRETE SCANNING OF THE RADIATION FIELD.** An expression characterizing the capability of a radiometric system to separately reproduce low-contrast elements of a radiation field is derived. This expression is used to solve the problem of the optimum choice of the size of the detector aperture in the scanning direction and the digitization step for radiometric systems with discrete field scanning. Expressions are derived for the upper and lower limits on the digitization operator with a stepped interpolation. (Author abstract) 9 refs.

Gorbunov, V.I.; Zav'yalkin, F.M.; Solodushkin, V.I.; Udod, V.A. *Optoelectron Instrum Data Process* n 4 1987 p 20-25.

**088479 ABSOLUTE RADIOMETER.** The All-Union Physical Optics Measurements Institute has set up the state special standard for the unit of intensity of illumination for solar radiation and has developed an absolute radiometer fitted with an automatic temperature-stabilization system, which enables one to measure intensity of illumination at the level of the best foreign radiometers. The detector is a conical cavity having a base of diameter 12 mm and a vertex angle of  $15^\circ$ . The cavity is formed by electrolytic deposition. This produces the highest thermal conductivity in the detector and high uniformity in the wall thickness. To prevent the copper from oxidizing on prolonged use, the cavity is coated with a thin layer of gold. The inner surface of the cone is coated with black matte enamel. The measurements are made in two phases (irradiation and substitution). The radiometer includes a system for regulating the current in the substitute winding and maintaining a constant temperature in the detector cavity. 7 refs.

Ivashkova, L.Yu.; Il'in, A.S.; Pavlovich, M.N.; Sapritskii, V.I.; Verevicheva, M.A.; Men'shikov, V.V.; El'kin, B.S. *Meas Tech* v 30 n 8 Aug 1987 p 757-762.

**088480 OPTICAL CHARACTERISTICS OF THE NON-IMAGING TUBULAR FLUX COLLECTOR.** A calculation of the Field Of View (FOV) profile of the Non-Imaging Tubular Flux Collector (NITFC) is presented and the optical efficiency of the system is examined with reference to its application in hand-portable ground-based radiometers. FOVs are calculated for both circular and square detectors and non-intuitive results are obtained. The effects of the optical properties upon the choice of filters is also considered. (Author abstract). 6 Refs.

Canas, A.A.D. (Imperial Coll, London, Engl); Creeke, M.A. *Int J Remote Sens* v 9 n 8 Aug 1988 p 1383-1392.

**088481 ON THE APPLICABILITY OF SPECTRORADIOMETERS TO PHOTORECEIVER CALIBRATION USING SYNCHROTRON RADIATION.** Methods for determining the spectral sensitivity of a photoreceiver based on the use of synchrotron radiation have been discussed. The basic requirements for the construction of a spectroradiometer intended for photoreceiver gradation based on the use of synchrotron radiation have been determined through a theoretical analysis. (Author abstract) 1 ref.

Kvachka, V.I. (All-Union Inst for Optical & Physical Measurements, Moscow, USSR). *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 332-333.

**Applications** See Also ELECTRIC CONTACTS—Measurements; MATERIALS TESTING—Nondestructive Examination; REMOTE SENSING—South America; SATELLITES—Remote Sensing; SOLAR RADIATION—Measurements; WATER RESOURCES—Remote Sensing.

**088482 RADIOMETRIC SKY TEMPERATURE MEASUREMENT AT 35 AND 89 GHz.** Much interest has recently been shown in the use of millimeter-wave receivers in the atmospheric absorption windows at 35 and 89 GHz. In some applications, the usefulness of such systems depends on sky temperature. This article describes a set of radiometric sky temperature measurements carried out by PRL over a six-month period from July 26, 1984 to January 25, 1985. Radiometric sky temperature was measured twice a day in both W-band and Ka-band against elevation. The measurements were carried out over the above-mentioned period using a dual frequency radiometer and automatic measurement system. 3 refs.

Sayers, A.D. *Annu Rev Philips Res Lab* 1986 p 110-113.

**Automation** See Also AIR POLLUTION—Monitoring.

**088483 DEVELOPMENT OF A VERSATILE AUTOMATIC SPECTRORADIOMETER IN BROAD WAVELENGTH BAND.** A novel automatic spectroradiometer which incorporates a C-G type grating double monochromator as its main unit and an electronic computer for operation control and data processing is described in this paper. Characterized by high versatility, fully automatic continuous operation in a broad wavelength band and extensive applications, it can be used to measure, in an automatic way, the spectral radiant emittance, color temperature and color rendering index of incandescent, gas discharge and line spectrum lamps as well as the relative spectral sensitivity of various photo-detectors. The measuring repeatability is better than  $\pm 1$  percent (excluding the extreme working ends in both the UV and IR regions). (Author abstract). 11 Refs.

Pao, Hsueh-Cheng (Shanghai Jiao Tong Univ, China). *Instrumentation in China* Instrumentation in China, Technical Papers. English Language Edition of Selected Articles Originally Published in the Chinese Journal of Scientific Instrument 1987. Publ by ISA, Research Triangle Pk, NC, USA, 1987 p 153-163.

**Calibration** See Also REMOTE SENSING—Equipment.

**088484 IMPROVED CALIBRATION SCHEME FOR AVHRR-2.** The in-flight two-point calibration of the AVHRR-2 radiometer introduces an error in the brightness temperature derived from the 11  $\mu\text{m}$  and 12  $\mu\text{m}$  channels, due to the non-linearity of the sensor response. The NOAA Users' Guide recommends assuming a negative value for the open space radiance to reduce this error for the range 225-310 K. This range however is too large for typical sea surface temperature variations, and differences as great as 0.4 deg K are still present in the derived 11  $\mu\text{m}$  brightness temperature. This error is further amplified in the sea surface temperature, when estimated with the split window technique, as can be shown by radiative transfer model calculations. For this reason, a new practical calibration scheme is proposed to minimize the error due to the non-linearity of the sensor response, over the range of radiances from the sea surface. (Author abstract) 20 refs.

Dalu, G. (CNR, Rome, Italy); Viola, A. *Int J Remote Sens* v 8 n 10 Oct 1987 p 1501-1508.

**088485 NBS SCALE OF SPECTRAL IRRADIANCE.** This paper describes the measurement methods and the instrumentation used in the realization and transfer on the NBS scale of spectral irradiance. The basic measurement equation for the irradiance realization is derived. The spectral responsivity function, linearity of response, and 'size of source' effect of the spectroradiometer are described. The analysis of sources of error and the estimates of uncertainty are described. The assigned uncertainties ( $3\sigma$  level) in spectral irradiance range from 2.2% at 250 nm to 1.0% at 654.6 nm to 6.5% at 2400 nm. (Author abstract) 20 refs.

Walker, James H. (NBS, Gaithersburg, MD, USA); Saunders, Robert D.; Jackson, John K.; McSparron, Donald A. *J Res Natl Bur Stand (US)* v 93 n 1 Jan-Feb 1988 p 7-20.

**088486 MOYENS D'ETALONNAGE DE RADIOMETRES.** [Means for Calibration of Radiometers]. This paper describes possible means to calibrate the optical power meters used for measurements for the power output of optical fibers. We describe the primary standards to be used with the local measurement means. We also show how laser diodes can be used for the calibration of any system at a power level of about 1 mW. (Edited author abstract). 2 Refs. In French.

Le Calvez, Y. (CNET, Lannion, Fr). *Onde Electr* v 68 n 5 Sep 1988 p 39-41.

**Circuits** See AMPLIFIERS, INTERMEDIATE FREQUENCY—Design.

**Design**

**088487 DEVELOPMENT OF ELECTRICALLY CALIBRATED PNEUMATIC RADIOMETER.** This paper presents a new type of absolute radiometer - Electrically Calibrated Pneumatic Radiometer (ECPR). A prototype has been manufactured and experiments have been performed, showing that this radiometer has the ability of doing absolute measurement on radiation from far-infrared to ultraviolet. This instrument has enlarged the measuring range of the cavity radiometer by an order of magnitude. The measuring accuracy is estimated to be 0.7 percent. (Author abstract). 4 Refs. In Chinese.

Xiaofan, Feng (Acad Sinica, China); Mochang, Wang. *Hongwai Yanjiu A-ji* v 7A n 3 1988 p 231-235.

**088488 SEQUENTIAL FILTER IMAGING RADIOMETER (SFIR) - A NEW INSTRUMENT CONFIGURATION FOR EARTH OBSERVATIONS.** The sequential filter imaging radiometer (SFIR) concept is presented, contrasted with other sensor configurations, and its strengths and weaknesses are discussed. In a pushbroom SFIR the optics image the scene onto a long, narrow area array. The length of the array defines the field of view. The spectral defining filters are sequentially placed over the full array, a sample of data for that band is taken, and then the next filter is placed in front of the array. All filters are placed over the array in the time that it takes for the image of the scene to advance the array width. Thus, the entire scene is observed in each band and the sensor can be configured such that resampling is not required to register the bands to each other. 7 refs.

Maxwell, Marvin S. (ORI Inc, Rockville, MD, USA). *IEEE Trans Geosci Remote Sens* v 26 n 1 Jan 1988 p 82-88.

**088489 DIGITAL RADIATION METER DESIGN.** This article introduces the design and implementation of a black body radiation digital meter. It employs hybrid processor circuitries in such a way that the output is displayed digitally through a novel dual-slope type nonlinear ADC. In this technique both the radiation measurement and the A/D conversion are obtained. An analogue output radiation measurement reading is also obtainable. Linear and digital ICs have been used in this circuit. (Author abstract) 2 refs.

Taha, Saleem M.R. (Univ of Baghdad, Baghdad, Iraq); Abdul-Karim, Majid A.H. *Sens Actuators* v 12 n 4 Nov-Dec 1987, Pap Presented at the 2nd Int Meet on Chem Sens, Bordeaux, Fr, Jul 7-10 1986 p 405-413.

**Digital Readout**

**088490 NON-OPTIMAL DETECTION LOSSES IN DIGITAL RADIOMETERS.** Non-optimal detection losses in digital radiometers due to temporal sampling of thermal noise and a detector response of non-optimal shape are analyzed. Three classes of detector response are examined: one- and two-sided power laws; exponential; and one- and two-sided hard limiters. Conditionally



optimal detector responses for all three classes, in the sense of minimizing detection loss, are found. (Author abstract). 2 Refs.

Vagapov, A.M.; Kravets, L.G. *Sov J Commun Technol Electron* v 32 n 9 Sep 1987 p 83-87.

Evaluation See AEROSOLS—Monitoring.

## Heat Transfer

**088491 HEAT LOSSES FROM SPHERICAL RADIOMETERS WHEN THEY ARE USED IN THE AIR.** The article investigates the reasons for lower precision of measurement of radiant heat fluxes in the air in comparison to measurements in vacuum conditions. (Author abstract) 15 refs.

Shcherbina, D.M.; Mavashov, Yu.Z. *Appl Sol Energy* v 23 n 2 1987 p 40-44.

Infrared See THERMOGRAPHY—Calibration.

## Mathematical Models

**088492 INVARIANT DETECTION OF TARGETS USING A CORRELATION RADIOMETER.** The problem of the optimum detection of a thermal target using a two-channel radiometer with unstable amplification circuit is considered. An expression is obtained for the asymptotically sufficient detection statistics, which is invariant with respect to changes in the gains in the channels. (Author abstract) 12 refs.

Murza, L.P. *Sov J Commun Technol Electron* v 32 n 4 Apr 1987 p 29-34.

Measurements See MILLIMETER WAVES—Propagation.

Microwaves See Also SNOW AND SNOWFALL—Spectrum Analysis.

**088493 THERMOMETRY OF IMPEDANCES BY CORRELATION RADIOMETRY.** Theoretical considerations and experiments indicate how the temperature of an impedance  $Z(f)$  and its position on the line connected to the two inputs of a correlation radiometer can be deduced from the radiometric signals. Such a process should be considered for thermometric applications based on the analysis of the radiometric signal produced by a nonisothermal lossy line. (Author abstract) 6 refs.

Lauer, P. (CNRS, Villeneuve d'Ascq, Fr); Leroy, Y.; Van de Velde, J.C.; Mamouni, A. *Electron Lett* v 23 n 25 Dec 3 1987 p 1348-1350.

**088494 GROUND-BASED MICROWAVE RADIOMETRIC OBSERVATIONS OF THE TEMPORAL VARIATION OF ATMOSPHERIC GEOPOTENTIAL HEIGHT AND THICKNESS.** Since 1981, the Wave Propagation Laboratory of the US NOAA has operated a ground-based zenith-viewing microwave radiometer. The radiometer, designed to measure precipitable water vapor, cloud liquid, and temperature profiles, has two moisture-sensing channels and four temperature-sounding channels. Data from this system, taken at Denver, Colorado, are used to derive geopotential heights and thicknesses from the surface (about 830 mbar) to 300 mbar. Time series and spectra of several directly measured and inferred quantities are analyzed for different meteorological situations: a period of unusual calm in surface pressure, a frontal passage, and a gravity wave event. Such ground-based radiometers provide temporal continuity not hitherto available as well as high sensitivity. Comparisons of these data with various sources of ground truth, including radiosondes, satellite cloud observations, and arrays of microbarographs show excellent agreement. 15 refs.

Ciotti, Piero (NOAA/ERL, Boulder, CO, USA); Westwater, Ed R.; Decker, Martin T.; Bedard, Alfred J.; Stankov, B. Boba. *IEEE Trans Geosci Remote Sens* v GE-25 n 5 Sep 1987 p 600-615.

## Noise, Spurious Signal

**088495 NOISE PROCESSOR FOR MODULATION RADIOMETER.** The device alternates two signal-processing algorithms: one for the absence of noise, which is the usual case in radiometry, and another that employs the moving average of the least values, over time intervals that contain noise pulses. The effect of noise that exceeds the fluctuational sensitivity threshold by a factor of up to  $10^3$  is practically completely eliminated by the device. The sensitivity of the radiometer is impaired by not more than 10% in this case. (Author abstract) 4 refs.

Gorbachev, A.A. (Scientific-Research Radiophysics Inst, Gorki, USSR); Danilov, V.I.; Modeev, Yu. I. *Instrum Exp Tech* v 30 n 4 pt 1 Jul-Aug 1987 p 844-847.

Performance See Also THERMAL VARIABLES MEASUREMENT; THERMOMETERS—Performance.

**088496 30  $\mu$ m HETERODYNE RECEIVER.** Advantages and constraints of remote measurements using heterodyne spectroscopy near 30  $\mu$ m are discussed. The state of the art of wideband HgCdTe photomixers and PbSnSe diode laser local oscillators being developed for far infrared heterodyne receivers is described. The first compact 30  $\mu$ m heterodyne radiometer was built and initial results at 28  $\mu$ m show about 2% mixer efficiency for a 500 MHz bandwidth receiver. Factors limiting receiver performance are discussed, along with the projected sensitivity of new interdigitated-electrode HgCdTe photoconductor mixers being developed for operation up to 200  $\mu$ m. (Author abstract) 15 refs.

Kostiuk, Theodor (NASA, Greenbelt, MD, USA); Spears, David L. *Int J Infrared Millim Waves* v 8 n 10 Oct 1987, Pap Presented at the Submillimeter (Terahertz) Receiver Technol Conf, Lake Arrowhead, CA, USA, Apr 7-8 1987 p 1269-1279.

Reliability See Also EARTH—REMOTE SENSING.

**088497 PRELIMINARY ASSESSMENT OF RADIOMETRIC ACCURACIES FOR MOS-1 SENSORS.** The Marine Observation Satellite 1 (MOS-1) is Japan's first Earth-Observation satellite and it carries three different types of sensors, namely the Multispectral Electronic Self Scanning Radiometer (MESSR), the Visible and Thermal Infrared Radiometer (VTIR) and the Microwave Scanning Radiometer (MSR) (National Space Development Agency of Japan 1985). MOS-1 was successfully launched on 19 February 1987. Radiometric characteristics of the sensors on board MOS-1 were assessed using pre-launch data and simulations taking into account sea surface conditions, influences due to Sun glitter, atmospheric effects, etc. This paper clarifies the reasons for the determination of the specifications of the three sensors and to assess the radiometric performance of the sensors taking into account some external effects on radiances. (Edited author abstract) 13 refs.

Arai, Kohei (Nat'l Space Development Agency of Japan, Jpn). *Int J Remote Sens* v 9 n 1 Jan 1988 p 5-21.

Remote Sensing See REMOTE SENSING—Instruments.

Standards See IODINE—Radiation Effects.

RADIOSONDES See Also METEOROLOGY—Measurements; REMOTE SENSING—Environmental Applications.

**088498 NEW GENERATION OF HIGH SPEED, HIGH PRECISION AND HIGH RESOLUTION MARINE C-T-D SONDERS FOR IN SITU MEASUREMENTS - PART I.** The ocean research needs an enormous amount of data about a number of marine parameters respectively measuring values with high accuracy, resolution and which can be measured very fast in situ. The basis for the possibility of this aim depends on progresses first of all in the creation of knowledges about fitted sensors and electronic circuits. Therefore, progress in the development of new and best fitted sensors and new

circuitries lead to progress in marine research and vice versa. Examples are given for that in respect to a new generation of C-T-D sondes system. (Edited author abstract) 15 refs.

Kroebe, Werner. *Mar Technol* v 18 n 3 Sep 1987 p 85-91.

**088499 NEW GENERATION OF HIGH SPEED, HIGH PRECISION AND HIGH RESOLUTION MARINE C-T-D SONDERS FOR IN SITU MEASUREMENTS - PART 2.** Ocean research needs an enormous amount of data about a number of marine parameters respectively measuring values with high accuracy, resolution and which can be measured very fast in situ. The basis for the possibility of this aim depends on progresses first of all in the creation of knowledges about fitted sensors and electronic circuitries. Hence progresses in the development of new and best fitted sensors and new circuitries lead to progresses in marine research and vice versa. Examples are given for that in respect of a new generation of C-T-D sondes systems. (Edited author abstract) 16 refs.

Kroebe, Werner. *Mar Technol* v 18 n 4 Dec 1987 p 149-154.

## RADIUM

### Environmental Testing

**088500  $^{226}\text{Ra}$  DETERMINATION BY ELECTRODEPOSITION.** In general the activity of this radionuclide is calculated through the analysis of its daughter  $^{222}\text{Rn}$ , or by observing the growth of a activity of an Ra sample. In this work a method for electrodeposition of Ra from a  $\text{HCl} + \text{CH}_3\text{COONH}_4$  aqueous solution is given. With it, yields of 70-90% are achieved. Consequently this paper evaluates the possibilities of using this procedure as a last step of a radiochemical method for separation of Ra. (Edited author abstract) 10 refs.

Garcia-Tenorio, R. (Univ de Sevilla, Seville, Spain); Garcia-Leon, M. *Sci Total Environ* v 69 Feb 1988, Environ Radiochem Anal, Proc of the Fifth Symp, Harwell, Engl, Oct 1-3 1986 p 225-238.

### Radioactivity

**088501 ON THE INFLUENCE OF LEAD DAUGHTERS ON RADIUM DETERMINATION.** When the isotopic composition of the radium contained in a sample is obtained by measuring at different times the alpha-activity of the Ra fraction obtained by coprecipitation with Ba, the contribution of the daughters of the lead coprecipitated with the radium must be taken into account. (Author abstract) 7 refs.

Aena, M.L. (CIEMAT, Madrid, Spain); Crespo, M.T. *Appl Radiat Isot* v 39 n 2 1988 p 177-178.

Removal See WATER SUPPLY—Standards; WATER, UNDERGROUND—Solutions.

### Spectroscopic Analysis

**088502 DETERMINATION OF RADIUM-226 IN ORES, NUCLEAR WASTES AND ENVIRONMENTAL SAMPLES BY HIGH-RESOLUTION ALPHA SPECTROMETRY.** The determination of radium-226 by alpha spectrometry has been investigated critically to determine the exact experimental conditions necessary to achieve these objectives. Refractory solids such as soils, ores, and tailing from uranium mills are dissolved completely by fusion with potassium fluoride in the presence of barium-133 tracer. The fluoride cake is then transposed with sulfuric acid to a pyrosulfate fusion with simultaneous volatilization of all silica and fluoride. Radium is precipitated with barium already present in the sample by addition of lead perchlorate to a dilute hydrochloric acid solution of the pyrosulfate cake. The resulting insoluble sulfates are dissolved in an alkaline solution of diethylenetriaminepentaacetic acid, and the radium and barium sulfates are reprecipitated with acetic acid. Some data on radium-226 in wastes and environmental samples and methods for its removal are presented. (Edited author



abstract) 16 refs.

Sill, C.W. (EG&G Idaho Inc, Idaho Falls, ID, USA). *Nucl Chem Waste Manage* v 7 n 3-4 1987 p 239-256.

## Standards

**088503 NEW WORKING RADIUM-226 MASS-UNIT STANDARD.** The  $^{226}\text{Ra}$  mass standard is a standard set of 25  $^{226}\text{Ra}$  gamma sources: 18 Soviet sources, which contain radium salt (radium bromide) in glass ampules; and seven Czechoslovakian sources in capsules of a platinum-iridium alloy with a length of from 13 to 22 mm and a wall thickness of  $0.50 \pm 0.05$  mm. The standard includes a comparator with a  $4\pi$  ionization chamber. Sources with  $^{226}\text{Ra}$  masses of from 1 to 200 mg were compared with specimens No. 5427 by the usual procedure while the sources with a  $^{226}\text{Ra}$  mass of less than 1 mg were compared with another specimen. Values of  $^{226}\text{Ra}$  mass in the sources that make up the working standard obtained by comparison with the state special standard are given. 6 refs.

Gubkin, E.S.; Drichko, A.F.; Karavaev, F.M. *Meas Tech* v 29 n 1 Jan 1986 p 51-52.

**RADON** See Also AIR POLLUTION—Indoor; PARTICLE DETECTORS; PHOSPHATE MINES AND MINING—Geology.

**088504 RADON BARRIERS FOR UNDERGROUND URANIUM MINE USE.** Research was performed to assess the feasibility of barrier membrane substances in restricting the diffusion transport of radon gas. Specific tests were conducted, both within laboratory and in situ environments to determine radon gas concentration ratios across a barrier of interest and emanation rate variation resulting from application of such materials. Of the six materials examined only two (polysulfide copolymer and polyethylene terephthalate materials) were capable of maintaining radon concentrations within the initially radon-free chamber at levels less than 5% of the source concentration levels. These same materials were also effective in reducing the unrestricted emanation rate of radon by 99.0% and 99.8%, respectively. (Edited author abstract) 16 refs.

Archibald, James F. (Queen's Univ, Kingston, Ont, Can); Hackwood, H. James. *CIM Bull* v 80 n 908 Dec 1987 p 39-42.

**088505 EFFECT OF COMPOST AND SOIL COVERS ON RADON EMANATION FROM URANIUM TAILINGS.** The effects of covering materials on radon emanations were investigated. Granular materials with air in the spaces allow radon to pass freely. Moist covers of compost or soil decrease radon emanation from tailings. Water-saturated covers were more effective, freezing the tailings with these covers further decreased radon escape. Although radon diffusion through water-saturated powders appears to be slow and inefficient, about 25% of the radon escaping from the grains diffuses to the surface and emanates when no cover is present. (Edited author abstract) 12 refs.

McCorkell, Robert H. (CANMET-EMR, Ottawa, Ont, Can); Silver, Marvin. *CIM Bull* v 80 n 908 Dec 1987 p 43-45.

**Concentration** See AIR POLLUTION—Indoor; URANIUM MINES AND MINING—Wastes; WATER WELLS—Testing.

## Environmental Impact

**088506 VARIATION OF RADON LEVELS IN U.S. HOMES WITH VARIOUS FACTORS.** A program combining 70,000 purchased and 3,500 random selection-no charge measurements with extensive questionnaires is described. Winter and spring-fall measurements average about 60 percent and 40 percent, respectively, higher than summer measurements. Basements average 2.5 times higher radon levels than upper floors. Tightening of homes since 1974 has increased radon levels by less than 10 percent, but well-weatherized houses have 40 percent

higher levels than poorly weatherized houses. Open windows reduce levels by a factor of about 2.5. Low-cost newer houses have much lower levels than more expensive newer houses, but among older houses this is reversed. Low income families have substantially lower radon levels than average. Additional aspects of the subject are discussed. (Edited author abstract)

Cohen, Bernard L. (Univ of Pittsburgh, Pittsburgh, PA, USA); Gromicko, Nickifor. *JAPCA* v 38 n 2 Feb 1988 p 129-134.

**Environmental Testing** See Also RADIOACTIVITY MEASUREMENT—Instruments.

**088507 INDOOR RADON LEVELS IN CUMBERLAND COUNTY, PA.** Measurements was made of radon levels in 165 randomly selected homes in Cumberland County, PA during Winter 1984-1985. The average and mean levels were found to be  $9.1 \pm 0.7$  pCi/L and  $6.3 \pm 0.5$  pCi/L, respectively, many times normally encountered levels. Average and mean radon levels are reported vs. various house characteristics. (Author abstract) 4 refs.

Cohen, Bernard L. (Univ of Pittsburgh, Pittsburgh, PA, USA); Nason, Richard. *Environ Int* v 13 n 3 1987 p 293-297.

**088508 VARIATION OF LONG-LIVED RADON DAUGHTERS IN PRECIPITATION.** A determination is described which is based on low energy photon spectrometry of  $^{210}\text{Pb}$  and subsequent radiochemical separation, followed by alpha spectrometry, of  $^{210}\text{Po}$ . Results from a long-term observation (five years) are reported and discussed. (Author abstract) 13 refs.

Rosner, G. (Gesellschaft fuer Strahlenund & Umweltforschung Muenchen mbH, Neuherberg, West Ger). *Sci Total Environ* v 69 Feb 1988, Environ Radiochem Anal, Proc of the Fifth Symp, Harwell, Engl, Oct 1-3 1986 p 179-190.

**Health Hazards** See Also WATER SUPPLY—Contamination.

**088509 EVALUATION DE L'EXPOSITION NATURELLE DUE A L'INHALATION DES AEROSOLS RADIOACTIFS ISSUS DU RADON A L'INTERIEUR DES LOCAUX D'HABITATION.** [Evaluation of Natural Exposure Due to the Inhalation of Radioactive Aerosols Descended from Radon Within Residential Buildings]. Since 1980, the Atomic Energy Commissariat in France has been carrying on a pilot study aimed at measuring the alpha potential energy of short-life descendants of radon. This parameter characterises in effect the internal exposure to inhaled natural radioelements. A particular study has been undertaken in the Finistere department in 1984-1986. This region, situated at the extreme west of the country covers an area of 7000 km<sup>2</sup> and is rich in granite soils, especially in the north west and south. The results of this study are presented. Its originality was in the fact that the measurements were carried out jointly by means of integrated active and passive dosimeters. The experimental techniques are described. No clear impact of radioactive exposure on health situation has been determined. 11 refs. In French.

Rannou, Alain (CEA, Fontenay-Aux-Roses, Fr); Mouden, Andre; Tymen, Georges. *J Aerosol Sci* v 19 n 1 Feb 1988, Troisiemes Journ d'Etud sur les Aerosols COFERA, Paris, Fr, Dec 9-10 1986 p 27-32.

**Measurements** See AIR POLLUTION—Indoor; GASES—Permeability, Mechanical.

## Permeability, Mechanical

**088510 MEASUREMENT OF RADON PERMEABILITY THROUGH SOME MEMBRANES.** A mixture of gaseous radioisotopes with different half-lives can be separated by passing it from one volume to another through an appropriate intervening barrier or membrane so that short-lived radioisotopes decay before reaching the detector kept at a suitable position after the barrier. This separation technique is ideally suited for use along with

the solid state nuclear track detectors and has been attempted by a number of scientists for separation of thoron ( $^{220}\text{Rn}$ ) and radon ( $^{222}\text{Rn}$ ). A number of membranes evaluated for their suitability for these applications have been discussed in this paper. Natural latex rubber and cellulose nitrate membranes of suitable thickness have been found best suited among the membranes studied. (Author abstract) 10 refs.

Ramachandran, T.V. (BARC, Bombay, India); Lalit, B.Y.; Mishra, U.C. *Nucl Tracks Radiat Meas* v 13 n 1 1987 p 81-84.

**Radioactivity** See Also ATMOSPHERIC RADIOACTIVITY.

**088511 HUMAN EXPOSURE TO RADON DECAY PRODUCTS.** Much concern has been expressed about the radiation exposures resulting from radioactive discharges from the nuclear industry. Yet, on average, only about 0.1% of the average person's exposure is due to this practice. The majority, according to current estimates somewhat less than 90%, of the average person's exposure is received from natural radiation sources, the remainder being largely due to medical procedures and fallout from weapons tests. After discussing the variation in exposure to radon decay products, the author considers some of the different ways of reducing the harmful effects including increased ventilation. (Edited author abstract) 13 refs.

Wrixon, A.D. (Nat'l Radiological Protection Board, Didcot, Engl). *H&V Eng* v 59 n 675 p 19-22, 29.

**088512 INDOOR CONCENTRATION OF RADON AND ITS DAUGHTERS IN A MULTISTOREY BUILDING.** Long-term measurements of radon and its daughters in nineteen different rooms of a multistorey building in Aligarh having different types of environmental conditions have been performed. CR-39 solid state nuclear track detectors were used to measure the radon concentration. Variations of radon concentration due to height from ground level, ventilation conditions, convection air currents and materials placed inside were investigated. The highest value of radon has been found in the basement and the ground floor rooms which indicates the influence of subsoil emanation. No appreciable effect was observed with height above ground. Our study also reveals that ventilation conditions, convection air currents, housed materials such as books, papers, etc., affect the radon concentration. (Author abstract) 19 refs.

Khan, A.J. (Aligarh Muslim Univ, Aligarh, India); Varshney, A.K.; Prasad, Rajendra; Tyagi, R.K. *Nucl Tracks Radiat Meas* v 13 n 1 1987 p 77-80.

**088513 INDOOR RADON GAS AND ITS DETECTION WITH KODAK PLASTIC FILM.** The indoor radon problem is reported from the Swedish standpoint. The radon sources, problems with the radon daughters, the radon detector Kodak LR115-II and some experimental results are discussed from a teaching point of view of the subject. (Author abstract) 22 refs.

Jonsson, G. (Univ of Lund, Lund, Swed). *Nucl Tracks Radiat Meas* v 13 n 1 1987 p 85-91.

**088514 GENERATOR FOR  $^{222}\text{Rn}$  DECAY PRODUCTS.** In extracting and working uranium ores and in using emanating sources containing  $^{226}\text{Rn}$ , one provides radiation monitoring of the air by means of radiometers operating with the natural aerosols and recording either the bulk activity  $q$  ( $\text{Bq} \cdot \text{m}^{-3}$ ) or the latent energy  $E_a$  ( $\text{J} \cdot \text{m}^{-3}$ ) in the daughter products from the radon. The measures planned to implement GOST 8.090-79 on metrological support to measurements of bulk activity and latent energy from radon daughter products has led the authors to devise a generator based on accumulating radon and its short-lived daughter products in a closed



volume by the use of an emanating  $^{226}\text{Ra}$  source. This article presents theoretical background of the radon generator. 5 refs.

Kuznetsov, Yu.V.; Kustova, V.L.; Meshcheryakov, V.G.; Rostunov, S.G.; Khlebnikov, V.P.; Lekhtmakher, S.O. *Meas Tech* v 30 n 6 Jun 1987 p 589-591.

**088515 RADON IN AIR CALIBRATION PROCEDURE: A PRIMARY METHOD.** A procedure has been developed for preparing 3 to 9-l volumes of air under natural conditions with a known concentration of  $^{222}\text{Rn}$  to be used for calibrating radon systems. Air is passed into a plastic bag through a standard  $^{226}\text{Ra}$  solution (prepared by the U.S. National Bureau of Standards) contained in an emanation flask. This plastic bag retains  $^{222}\text{Rn}$  with little loss into or through the bag walls. The mean ratios of the  $^{222}\text{Rn}$  in the air at 2 and 7 days after filling to that immediately after filling were  $0.992 \pm 0.006$  and  $0.969 \pm 0.008$ , which suggests a rate of radon loss into the bag of  $0.4 \pm 0.1\%$  day. (Edited author abstract) 6 refs.

Lucas, H.F. (Argonne Natl Lab, Argonne, IL, USA); Markun, F. *Nucl Sci Eng* v 99 n 1 May 1988 p 82-87.

**Removal** See WATER TREATMENT—Aeration.

## Sampling

**088516 APPLICATION OF A RECURSION FORMULA TO AIR SAMPLING OF RADON DAUGHTERS.** The analytical solution to compartment models with time-independent coefficients can in general be expressed in terms of easy memorizable functions with recursive properties. The only restriction is that the model must be of a nonfeedback type. In this contribution the recursive formalism is applied to air sampling of serially decaying radon daughter products. (Author abstract) 6 refs.

Samuelsson, Christer (Lund Univ, Lund, Swed). *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 457-462.

## RAILROAD ACCIDENTS

**Deraiment** See Also RAILS—Stresses.

**088517 GETTING SAFER IN THE '80s.** The number of train accidents per million train-miles dropped from 6.01 in 1985 to 4.87 in 1986. The rate for employee injuries on a per-man-hour basis and the rate for grade crossing accidents on a per million vehicle basis also improved in 1986. The steady improvement in the 1980s was a natural result of railroad improvement programs. Railroads have continued to spend large amounts of money to maintain highway grade-crossing safety devices and to educate the public about the potential hazards of ignoring rail-highway crossing warnings. The increased spending is directly linked to deregulation. The Federal Railroad Administration takes credit for improved safety, which it believes resulted from imposition of federal track and equipment standards.

Roberts, Robert. *Mod Railroads* v 42 n 10 Oct 1987 p 33-35.

## RAILROAD PLANT AND STRUCTURES

See Also RAILROAD SIGNALS and SIGNALING—Centralized Control; RAILROADS—Research; TUNNELS and TUNNELING—Construction; TUNNELS and TUNNELING—Design.

**088518 REMOVAL AND REPLACEMENT OF A ONE HUNDRED YEAR OLD FOUNDATION SYSTEM ?.** The New Jersey Transit Corporation came into being as a corporate entity on January 1, 1983. The birth of that corporation brought with it an inheritance of a number of predecessor commuter rail road lines. These rail lines included such systems as the Delaware Lackawanna and Western; Erie-Lackawanna; the Pennsylvania Railroad and Conrail. The inheritance included Rolling Stock; dedicated routes and trackage; maintenance facilities - both direct and leased; stations and other properties. Plans had been made to improve various aspects of the

system. Two of the major improvements included an upgrading of the electric traction system and the construction of a Rail Equipment Maintenance Facility (REM-F). Due to the uncertainty of subsurface conditions and the potential effect on piling operations, the building footprint would be excavated to the top of the glacial sands. The approximate eight foot head of water anticipated during the twelve foot excavation would be controlled by the installation of an impervious membrane and the use of pumping. This study describes the sequence of foundation removal and replacement of all rail equipment maintenance buildings.

MacDonald, John A. (Morrison-Knudsen Engineers, NY, USA). *Munic Eng J* v 74 Fall 1987 p 35-43.

**Air Conditioning** See AIR CONDITIONING—Energy Conservation.

## Concrete Construction

**088519 CP RAIL LOOKS TO MORE EFFICIENT FUTURE.** The huge construction project high in the Rockies of British Columbia includes the building of two tunnels and six bridges over a 21-mile double-track stretch of rugged terrain and will cost \$600 million. Among outstanding accomplishments one stands out, construction of Mt. Macdonald Tunnel. The tunnel also features a ventilation system unique to this hemisphere. Another first is the use in both tunnels of a system of slab track called Pact-Track. Another record is the tunnel boring machines set a production record of 62.78 meters of rock excavation by a 6.7-meter diameter machine in a 24-hr. period.

Roberts, Robert. *Mod Railroads* v 42 n 11 Nov 1987 p 19, 21, 23.

**Construction** See Also BRIDGES, RAILROAD—Construction; ELECTRIC RAILROADS—Berlin, Federal Republic of Germany; ELECTRIC RAILROADS—Federal Republic of Germany; ELECTRIC RAILROADS—Reviews; RAILROAD YARDS and TERMINALS—Classification Yards; RAILROADS—Cuba; RAILROADS—Federal Republic of Germany; RAILROADS—France; RAILROADS—Italy; RAILROADS—Netherlands; RAILROADS—Planning; RAILROADS—Yugoslavia; SUBWAYS—Chicago, Illinois; SUBWAYS—Vienna, Austria.

**088520 ELECTRIFICATION OF THE DSB MAIN LINES - DESCRIPTION OF THE OVERHEAD CONTACT SYSTEM.** As a result of the introduction of electric traction on the main lines of the Danish railways, an overhead contact system (OCS) for power supply to the electric locomotives is to be erected over 2100 single track kilometers. The wires are supported on a number of different constructions, of which the mast is the most common. The components included in the OCS have formed the subject of research work. The result has been an OCS which can be operated at 200 km/h, has a minimum cost regarding production, installation and maintenance, and gives a good architectural and functional adaptation to the surrounding landscape. The power supply installation is a 25 kV/50 Hz a.c. system, in contrast to the 15 kV d.c. of the Copenhagen suburban electrified system. The 25 kV/50 Hz system was selected, since it is the optimum for Denmark nowadays. 7 refs.

Olesen, Preben (DSB, Copenhagen, Den); Naeser, Johannes; Andersen, Lars. *Elektr Bahnen* v 85 n 5 1987 p 139-142, 144-146.

**088521 INBETRIEBNAHME DES ERSTEN ABSCHNITTES DER NBS MANNHEIM-STUTTGART; ANLAGEN DER ELEKTRISCHEN ZUGFÖRDERUNG.** [Commissioning of the First Section of the New Mannheim-Stuttgart High-Speed Line; Electric Traction Facilities]. At the end of May 1987 a 38-km section of the new Mannheim-Stuttgart high-speed line was put into operation. For power from supply purposes the existing 110-kV-traction current line Mannheim to Karlsruhe has been combined with the new traction current line into a quadruple line. At the new Wiesental substation the electric power is stepped down to 15 kV and fed into the overhead contact line. The new high-speed line section designed for 250 km/h was equipped with the

recently developed Re 250 overhead contact line. (Edited author abstract) 7 refs. In German.

Russ, Franz (NBS Karlsruhe der Bahnbauzentrale, Karlsruhe, West Ger). *Elektr Bahnen* v 85 n 5 1987 p 153-157.

**088522 CONSTRUCTION OF PLANNED SHINKANSEN LINES.** The expansion of the Shinkansen railway network has been carried forward in conformity with the Law for the Construction of a Nationwide Shinkansen Railway Network enacted in May 1970. The project involves five lines, namely, Morioka-Aomori, Aomori-Sapporo, Tokyo-Osaka via Takasaki and Komatsu, Hakata-Kagoshima, and Hakata-Nagasaki. Since these lines are not expected to have as large a ridership as the already existing Shinkansen lines, every effort is being made to hold construction costs within tight limits at both the planning and engineering stages.

Minemoto, Mamoru (JNR). *Jpn Railw Eng* v 27 n 1 Jun 1987 p 7-11.

**088523 FOUR ISLANDS BECOME ONE.** With the introduction of the next JR Group timetable in April, both Hokkaido and Shikoku will for the first time enjoy through train services to Honshu, which was joined by undersea tunnel to Kyushu in 1942. Thus the four main islands of Japan will have a unified 1067 mm gauge network. The link to Shikoku called for the construction of a total length of elevated structures of 12.3 km across five small islands with 9.4 km over the Seto inland sea. There are three suspension bridges with central spans of 940, 990 and 1100 m; two cable-stayed bridges with central spans of 420 m; and one cantilever truss bridge. The connection to Hokkaido, the Seikan Tunnel, is the world's longest. In constructing it, all kinds of geological difficulties were encountered, and it was necessary over much of the distance to bore a conical pattern of holes ahead of each drive through which grout could be injected to stem the inflow of water. Both the cost and the time necessary to drive the tunnel were seriously underestimated.

Anon. *Railw Gaz Int* v 143 n 12 Dec 1987 p 801-803.

**088524 LE SAUT-DE-MOUTON DE LA NOUVELLE VOIE SNCF DU RACCORDEMENT FERROVIAIRE GENEVE-AEROPORT.** [Flyover Carrying the New SNCF Track on the Geneva Airport Rail Link]. A 6 km double-track line was needed to provide a rail link to Geneva airport. It runs along the line from Geneva to Lyons, via La Plaine frontier station, from just outside Geneva station and over a distance of 3.5 km. So as to maintain a passenger railway link between Geneva and France, an additional track complying with SNCF regulations had to be built; it runs over a flyover passing beneath the tracks of the CFF line to the airport, which it then follows on the southern side. This article describes the different types of work involved and the difficulties encountered in building this structure. (Edited author abstract) In French.

Nieth, Rodolph (CFF, Geneva, Switz); Mouchet, Pierre L.; Boissonnard, Robert; Deleglise, Bernard; Rojas, Johnny; Herrera, Fernando. *Rev Gen Chemins Fer* v 106 n 10 Oct 1987 p 35-52.

**088525 PLANUNG UND BAU DER OSTWEST-S-BAHN IM HAUPTBAHNHOF NEUSS.** [Planning and Construction of the East-West S-Bahn Line at Neuss Main Station]. The construction of the 82-km East-West S-Bahn line from Hagen to Moenchengladbach is necessitating major new building and rebuilding work at the point of intersection of several lines on the left bank of the Rhine at the approaches to Neuss main station. In this connection a description is given of the rearrangement of the tracks being carried out in order to



separate the new suburban services from the long-distance lines, including the construction of a number of flyovers. In German. 5 refs.

Form, Egbert (Hauptabteilung Projekte Bautechnik, Cologne, West Ger). *Eisenbahningenieur* v 38 n 11 Nov 1987 6p between p 547 and 555.

**088526 WORLD'S FIRST 300 Km/H TRACK GOES IN.** Twenty months ahead of the formal opening civil works on the Paris-Le Mans leg of TGV-Atlantique are almost complete. The only major civil engineering work remaining on this section is the construction of the second bore of the 4.8 Km Villejust Tunnel and completion of a new interchange station at massy outside Paris. With the first TGV-A prototype train due to be unveiled in May 1988, SNCF is well on course for inaugurating the World's first 300 Km/h train service at the beginning of October 1989.

Anon. *Railw Gaz Int* v 144 n 2 Feb 1988 p 82-83.

**088527 NEW LINES HOLD THE KEY TO BAHN 2000.** The principle underlying Bahn 2000 is that trains will be able to run between certain major interchange stations in less than 60 min, so that they can all arrive just before the hour and depart just afterwards, thus creating the maximum number of opportunities for quick connections. In this way, journeys can be made swiftly and conveniently all over Switzerland. Apart from providing extra capacity where it is most needed, Bahn 2000 concentrates infrastructure investment on key links between major stations which at present take just over 1 h. It includes four new line construction project, as well as a large number of schemes designed to raise the speed, capacity and convenience of existing routes. At the same time the private railways are planning to provide matching improvements to raise capacity and speeds.

Anon. *Railw Gaz Int* v 144 n 2 Feb 1988 p 91.

**088528 SPAIN LAUNCHED ON HIGH SPEED QUEST.** The Spanish National Railways (Renfe) has started construction of a new 250 km/hr route from Madrid to Andalucia. This new line will put Cordoba just 2 h from the capital compared with the present fastest journey time of 4 h 19 min. To achieve this, the existing Madrid-Ciudad Real line, used at the moment by only four daytime passenger trains and one overnight service, will be completely rebuilt as a double track electrified main line aligned for 250 km/h. South of Puertollano a new line will be constructed through open country to Alcolea just east of Cordoba. This translates into 340.8 km of high speed line, including the various spurs to link with other routes.

Hughes, Murray. *Railw Gaz Int* v 144 n 2 Feb 1988 p 101-103.

**088529 CP WIPES OUT INVESTMENT BACKLOG.** For the first time in 60 years, the Portuguese government is committed to a major railway investment program. A new plan for investment in the national rail network up to the end of the century calls for completion of a new railway bridge over the Douro River at Porto, construction of a rail crossing on an existing road bridge over the Tagus in Lisbon, upgrading of the rail network in the Lisbon area and construction of a link between the isolated Algarve line and the Tagus bridge, and improvement of rail links between Portugal and Spain.

Anon. *Railw Gaz Int* v 144 n 2 Feb 1988 p 107-109.

**088530 DER AUSBAU DER TAUERNBAHN.** [Upgrading the Tauern Line]. The double-tracking of the Tauern line is being carried out primarily to increase the transport capacity of this important transit link within the network of the Austrian Federal Railways. At the same time, a gradual increase in train frequency can be achieved through the elimination of bottlenecks and a significant increase in maximum speed can be achieved through structural improvements in the line. The upgrading work, particularly on the southern approach to the Tauern Tunnel, requires a large number of technically demanding civil-engineering structures, owing to the very difficult

terrain over this stretch. These structures include some large reinforced concrete arch bridges. In German.

Potucek, Walter. *OIAZ Oesterr Ing Archt Z* v 132 n 11-12 Nov-Dec 1987 p 393-395.

**088531 ELEKTRIFIZIERUNG DER STRECKE NUERNBERG-LAUF (LINKS DER PEGNITZ).** [Electrification of the Nuremberg-Lauf Line (Pegnitz Left Bank)]. In connection with the introduction of S-Bahn operation in Nuremberg the Nuremberg-Lauf line on the left bank of the Pegnitz has been electrified. Class Re 160 overhead contact lines have been erected on this 17-km stretch. The power will be delivered from the existing Nuremberg substation. Through the construction of a new 110-kV traction current line the twin feeding of this substation from the 110-kV mains has made progress. For the 15-kV-feeding a new sectioning point was installed in the Nuremberg main station. The 50 Hz electric power supply installations were correspondingly adapted. (Edited author abstract) In German.

Gabler, Rudolf (Bundesbahndirektion Nuernberg, Nuernberg, West Ger). *Elektr Bahnen* v 85 n 11 1987 p 373-374, 376.

**088532 DIE KUNSTBAUWERKE ZUR EINFUEHRUNG DER NEUBAUSTRECKE HANNOVER-WUERZBURG IN DEN WUERZBURGER HAUPTBAHNHOF.** [Structures Required to Route the New Hannover-Wuerzburg Rail Link into Wuerzburg Central Station]. It is necessary to connect the new rail link to the existing railway system in Wuerzburg. The solution entails the railway line crossing a Federal road and three sets of railway tracks on a 153 m long prestressed concrete beam which runs over three spans. This hollow-girder superstructure links up to a 133 m long frame structure with two and three supporting members respectively, and to a 287 m long ramp structure. The aim was to skillfully integrate these structures into the landscape of the Main Valley. (Edited author abstract) In German.

Schwarz, Ortwin (Projektgruppe H/W Sued der Bahnbauzentrale, Nuernberg, West Ger); Hofmann, Rudolf; Bischoff, Rudolf. *Beton Stahlbetonbau* v 83 n 3 Mar 1988 p 61-64.

**088533 GESTALTUNG UND INSTANDHALTUNG DER BAUTECHNISCHEN INFRASTRUKTUR DER DB FUER DEN HOCHGESCHWINDIGKEITSVERKEHR.** [Layout and Upkeep of the German Federal Railway's Civil Engineering Infrastructure for High-Speed Traffic]. This article begins by defining the requirement profile for the civil engineering infrastructure by reference to DB's high-speed services plans. These provide for mixed traffic comprising heights trains with wheelset loads of 22.5 tons at 100 kph and passenger trains at 250 kph on newly built lines and up to 200 kph on modernized existing lines. On the later, this will necessitate adaptation of the fixed structures by removing bottlenecks, extending platforms and modifying signalling equipment, plus the authorization of higher limits for the existing superelevation and free lateral acceleration in curves. The article then looks at the layout planning for track and switches on the new lines and describes the installation of the permanent way. It concludes with an overview of the planned upkeep system aimed at maximizing availability of the lines by coordinating various tasks and minimizing speed-restricted sections. (Edited author abstract) In German.

Naue, Konrad H. (Deutsche Bundesbahn, Frankfurt Am Main, West Ger); Neuhofer, Wolfram. *Eisenbahningenieur* v 39 n 3 Mar 1988 p 81-87.

**088534 ELECTRIFICATION DE LA LIGNE MORET-NEVERS.** [Electrification of the Moret-Nevers Line]. The electrification of the Moret-Nevers line, known as the Bourbonnais line, marks the completion of an important stage in the improvement of services to the Massif Central. Two electrification systems have been employed: 1500 V dc from Moret to the south of Montargis so as to continue the installation of a single-current supply system in the Paris outer suburban area

and enable in the near future a regular-interval train service to be provided of the Paris suburban type; 25 kV ac from the south of Montargis to Nevers so that nonstop Paris-Nevers trains can be operated at a commercial speed of 135 km/h. Furthermore, signaling has been modernized by installing color-light automatic block equipment from Moret to the south of Montargis and restricted permissive automatic block equipment as far as Nevers. The renovation of passenger buildings and the construction of underpasses and car parks have improved the amenities provided passengers and should result in an appreciable increase in traffic. (Edited author abstract) In French.

Journet, Marcel (l'Equipeement a la Region de Paris Sud-Est, Fr); Pilaire, Alain. *Rev Gen Chemins Fer* n 3 Mar 1988 p 5-16.

**088535 DIE NEUE BAHN NACH ANDALUSIEN SPANIEN ORIENTIERT SICH BEI SEINEN NEU- UND AUSBAU-STRECKEN AM BEISPIEL DER DEUTSCHEN BUNDESBahn.** [New Railway to Andalusia, Spain Follows the Model of the German Federal Railway for its New and Modernized Lines]. This paper deals with the construction of the new high-speed electrified line from Madrid to Cordoba. The work involved includes the upgrading of an existing single-track line from Madrid to Brazatortas via Ciudad Real to a high-capacity double-track line, the construction of a wholly new double-track line from Brazatortas to the outskirts of Cordoba, and the construction of two small connecting segments just south of Madrid the new line will be more than 100 km shorter than the line currently used, which runs via Manzanares and is single-track over a rugged stretch through the Despenaperros Pass. Travel times on the new line will be reduced to less than half those on the old line. The new high-speed line will not be a purely passenger line, as in the case of the French TGV, but will carry mixed passenger and freight traffic like the new high-speed lines being built in West Germany. 4 Refs. In German.

Pospischil, Reinhard (Technischen Univ Muenchen, Munich, West Ger). *Eisenbahningenieur* v 39 n 7 Jul 1988 p 323-325.

## Crossing Gates

**088536 BASIC CONCEPTION OF ELECTRONIC LEVEL CROSSING SYSTEM.** In recent years, the introduction of microelectronics into railway signaling systems has been promoted. Now, the introduction of microelectronics into a level crossing system is anticipated. A level crossing system consists of a train detector, a level crossing alarm, a level crossing signal, a crossing gate, an obstacle detector and a fault detector. These devices are still controlled on an electromagnetic relay logic basis. This paper clarifies problems in an existing level crossing system, proposes technical measures for the introduction of microelectronics, and discusses the functions and effects of the new system. (Edited author abstract)

Kumagai, Toshio (Signal & Telecommunications Lab, Jpn). *Q Rep Railw Tech Res Inst (Jpn)* v 28 n 1 Mar 1987 p 13-14.

**Crossings** See Also HIGHWAY SIGNS, SIGNALS AND MARKINGS; HIGHWAY TRAFFIC CONTROL; TUNNELS AND TUNNELING—Railroad.

**088537 EVALUATING GRADE-SEPARATED RAIL AND HIGHWAY CROSSING ALTERNATIVES.** The research project documented in this report was initiated in response to the need for a systematic and credible tool to make decisions regarding alternatives for improving deteriorated bridges separating highways and railroads. A growing number of these bridges are in need of rehabilitation or replacement. The report is divided into two parts. The first part, the research report, provides background information and covers the approach used to address the research objective including, as well, a detailed discussion of the findings dealing with the objective. It



describes current practice regarding the decision-making processes used by state governments and railroads regarding deteriorated, grade-separated rail/highway crossings. The second part, consisting of two appendices, presents the decision-making framework in detail. Appendix A is the User's Guide to applying the framework and provides a step-by-step description of how one may use the framework. Case studies (Appen. B) are provided to illustrate the application of the framework.

Taggart, R.C. (Ernst & Whinney, Washington, DC, USA); Lauria, P.; Groat, G.; Rees, C.; Brick-Turin, A. *Natl Coop Highw Res Program Rep* 288 Jun 1987 87p.

**088538 EXPERT SYSTEM FOR THE EVALUATION OF RAIL/HIGHWAY CROSSINGS.** This paper describes the stages in the development of an expert system for evaluating and prioritizing highway/railroad grade crossings for safety improvements in the state of Virginia. In the identification stage, the four main aspects of the problems are identified. They are the participants in this project and their roles, the problem to be solved, the resources required, and the objectives in building the expert system. The next stage, the conceptual analysis, deals with recognizing the key concepts and relations forming the basis of the system. The formalization stage describes how the expert's knowledge is formalized within the framework of the selected tools, and the implementation stage describes how the formalized knowledge is codified into a computer program. Finally, suggestions are provided for turning the current prototype system into a full-scale expert system. (Edited author abstract) 5 refs.

Faghri, Ardeshtir (Virginia Transportation Research Council, Charlottesville, VA, USA); Joshua, Sarah C.; Demetsky, Michael J. *J Comput Civ Eng* v 2 n 1 Jan 1988 p 21-37.

**088539 MICROELECTRONIC ALARM AND PROTECTION CONTROL FOR LEVEL CROSSING EQUIPMENT.** Microelectronic Alarm and Protection Control for Level Crossing Equipment (Abbreviated as MAPLE) has been developed to automate control of level crossings and to renew obsolescent installations with the least investment. Features of the MAPLE with built-in microcomputers are: high reliability, compactness in size; capability of indicating detailed information to passers-by, easy and simplified maintenance work, and standardized design applicable to any of the level crossings.

Kumagai, Toshio (Railway Technical Research Inst, Jpn). *Jpn Railw Eng* v 27 n 2 Sep 1987 p 18-20.

**088540 PACKAGING CROSSING SAFETY PROBLEMS AWAY.** This package concept is the process by which the company receives an order to prepare the engineering plans, assemble all the necessary material, perform shop wiring and testing - in essence to do everything to deliver the complete system. The initial engineering, material, fabrication and 'delivery' services in a given package might include: field inspection services; budget preparation; specification writing; site surveying; circuit design and plan preparation; all control system components; relays; power supplies; signal structures and other wayside equipment. Field inspection as part of the package might encompass manpower and equipment for putting into proper operation all material necessary for the project.

Anon. *Railw Track Struct* v 84 n 5 May 1988 p 50-51.

**088541 P.C. PROGRAM FOR GRADE CROSSING SAFETY.** Called GIS, the Grade Crossing Improvement Schedule Software Package is designed to help those responsible for grade crossing safety to establish priorities in their grade crossing improvement efforts. The program consists of entering data into a large data base, then using the numbers in the Department of Transportation accident prediction model to estimate the number of accidents likely to occur at a particular crossing during a specific number of years. GIS can be run on the IBM PC, XT, AT, or a 100-percent compatible machine having a minimum of 512 K of memory. It is a menu-driven program. That is, the user selects desired options from a screen of

alternatives, and continues on until new data is entered, edited, deleted, or possibly a desired report might be printed.

Anon. *Railw Track Struct* v 84 n 5 May 1988 p 52-53.

**088542 NEW DEVICES IMPROVE CROSSING SAFETY.** Active advance warning devices (AAWDs) are one area of interest. Recently, three devices that would conform to current MUTCD signing practices were studied. Each had the following features: A primary advance grade crossing sign, such as W10-w or similar in design. A supplemental watch for trains plate mounted below the primary sign. A pair of alternately flashing yellow beacons mounted above and below the signs already described. Study results are discussed. Speed sensors are another important area of study. Constant warning time (CWT) systems are used to give a uniform time between activation of the signal and arrival of the train at the crossing. A nationwide study found 6,300 crossings equipped with CWT, and 13,100 more that could be equipped with the systems.

Anon. *Better Roads* v 58 n 7 Jul 1988 p 44,47.

## Earthquake Resistance

**088543 EXPERIMENTAL STUDY ON PREVENTION OF EMBANKMENT DEFORMATION DUE TO LIQUEFACTION OF SANDY GROUND.** In preparing for future large earthquakes in the Tokai district, model embankment experiments were carried out using a large-sized vibrational table to confirm the method of preventing Tokaido Shinkansen embankments from deforming due to ground liquefaction induced by earthquakes. The relationships between liquefaction occurrence characteristics and ground properties, and the effects of four kinds of countermeasures were investigated. It was concluded that the sheet pile enclosure method is the most effective one for embankment deformation prevention. (Edited author abstract) 1 ref.

Nasu, Makoto (Geotechnical Engineering & Disaster Prevention Lab, Jpn); Fujisawa, Hajime; Hikimoto, Keiichi. *Q Rep Railw Tech Res Inst (Jpn)* v 28 n 1 Mar 1987 p 5-8.

Federal Republic of Germany See RAILROAD TRANSPORTATION—Federal Republic of Germany.

Fire Protection See TUNNELS AND TUNNELING—Railroad.

## Ice Problems

**088544 STUDY FOR ICICLE PREVENTION BY ADIABATIC TREATMENT IN RAILWAY TUNNEL.** The prevention of icicle and side ice formation in railway tunnels is an ever-recurring subject. Recently, icicle prevention by adiabatic treatment of tunnel linings has been developed and has been adopted in many railway tunnels. This paper summarizes analyses of the icicle/frost damage in tunnels, including adiabatically treated old tunnels and newly constructed tunnels, and a suggestion is made about the availability and designing of this prevention. (Edited author abstract) 3 refs.

Okada, Katsuya (Geotechnical Engineering & Disaster Prevention Lab, Jpn). *Q Rep Railw Tech Res Inst (Jpn)* v 28 n 1 Mar 1987 p 1-4.

Maintenance See Also RAILROAD TRANSPORTATION—Management.

**088545 AMTRAK'S BEAR COMPLEX.** The 167-acre complex consists of four buildings which total over 233,000 square feet. The largest, the Main Shop, houses three departments: System Equipment Overhaul, Mechanical, and Material Control. Each year an average of 210 machines, primarily track maintenance equipment, undergo overhauls. Every piece is routed from the field to the shop and back by the railroad's tractor trailers. And the machinery's every move is monitored and managed by an IBM 36 System and two compatible personal computers. The system's memory also includes maintenance and work

histories, repair schedules of all equipment and vehicles, as well as the Bear Complex's entire inventory.

Anon. *Railw Track Struct* v 83 n 11 Nov 1987 p 30-32.

**088546 GREAT SALT LAKE AT BAY.** The Southern Pacific (SP) and Union Pacific (UP) railroads have committed themselves to a safeguard against repeated flooding of the Great Salt Lake. This protection takes the form of the West Desert Pumping Project (WDPP). The WDPP is fundamentally a large evaporation pond, supported by a complex which includes a heavy duty pumping station. The project is located just west of the Great Salt Lake. It will forestall future inundations and damage to the SP and UP railroad structures, and to other commercial properties adjacent to the Lake.

Anon. *Railw Track Struct* v 84 n 3 Mar 1988 p 46, 48-51.

**088547 ABDICHTUNG VON INGENIEURBAUWERKEN AUF ACRYLBASIS.** [Acrylate-Based Sealing for Engineering Structures]. The renewal of faulty sealing on arch bridges with high earth cover or on other engineering structures presenting difficult working conditions previously constituted a technical problem that could only be solved at high cost and virtually always involved considerable disruption of operations. A first attempt was made at the Karlsruhe Bundesbahn Directorate in 1982 to renew faulty insulation by means of an acrylate-based gel substance. The process has meanwhile been successfully applied to other structures. (Author abstract) In German.

Meseck, Henry (Bundesbahndirektion Karlsruhe, Karlsruhe, West Ger). *Eisenbahningenieur* v 39 n 2 Feb 1988 p 59-60, 62-63.

**088548 EDV-UNTERSTUETZTE ARBEITSVORBEREITUNG FUER DIE INSTANDHALTUNG MASCHINENTECHNISCHER UND ELEKTROTECHNISCHER ANLAGEN.** [EDP-assisted Job Preparation for the Maintenance of Mechanical and Electrical Installations]. German Federal Railways (DB) is compelled to minimise costs for the stationary installations required for railway operation. In order to attain and safeguard the requisite level of productivity in the otherwise fairly low-profile 'auxiliary service', that is, maintenance, the organisation of the interplay between men, materials and installations is of paramount importance. The project 'EDP-assisted job preparation for the maintenance of mechanical and electrical installations', the pilot phase of which has been concluded, and which is currently being prepared for introduction in the field, represents a data capture and exploitation system by means of which job volume, scheduling and location can be largely determined in advance in order to avoid periods of slackness. At the same time it offers improved data accuracy. (Author abstract) In German.

Hentschke, Hans-Juergen (Zentrale Datenverarbeitung der DB, Frankfurt, West Ger); Kammerer, Helmut. *Eisenbahningenieur* v 39 n 4 Apr 1988 p 129-136.

**088549 'HOW CAN I STAY AHEAD IN TURNOUT CARE?'** The easiest method in avoiding turnout problems is to make sure that the rail is supported on sound ties, that a sufficient number of gage-holding and plate-holding spikes are present, and that everything is supported in turn on good quality, well consolidated ballast. Sometimes, the addition of a Point Guard Rail will help give each wheel passing through the turnout an extra push. Some track owners have had successful results from the installation of resilient rail fasteners on all of their switch ties. At least one railroad has gone as far as installing a gage plate four ties ahead of the toe of the points, complete with security rail braces.

Smith, Allan D. (Industrial Track Consultant). *Railw Track Struct* v 84 n 7 Jul 1988 p 59-60.

**088550 SUCCESSFUL SHORT LINE UPGRADING.** The rehabilitation program had to be tailored resourcefully to comply with the restricted funding. Thus, by



replacing only those ties which had failed completely, renewal tie quantity was held down to an average of 1300 per mile. Secondhand ties were purchased. The railway installed enough new anchors to provide box-anchoring on eight ties per 39-foot length of rail. Secondhand plates have been used to replace numerous broken plates. A quarry located about four miles from its track is capable of supplying suitable dolomitic limestone for ballast. With the exception of a very few that had been rebuilt recently and prior to the program, all the other crossings are being rebuilt. Switch ties are being replaced selectively.

Ahl, Robert E. *Railw Track Struct* v 84 n 7 Jul 1988 p 61-64.

**Maintenance of Way** See Also SUBWAYS—Paris, France.

**088551 RECTIFICATION OF RAIL GEOMETRY ON NETHERLANDS RAILWAYS.** For corrective maintenance of welded rail Netherlands Railways (NS) employs the mobile STRAIT facility to straighten welds. Since 1986, the mobiles STRAIT facility has been equipped with a rail head claw, which results in a large economic benefit compared to the earlier STRAIT version with the hook because ballast no longer has to be dug out. This makes possible a cost reduction of about 20% weld. 3 refs.

Esveld, Coenraad (Netherlands Railways, Neth). *Rail Eng Int* v 16 n 4 1987 p 7-11.

**088552 REVENUE GROWTH BUYS DYNAMIC STABILISERS.** Within the next six months, British Rail will take delivery from Plasser & Theurer of nine dynamic track stabilisers (DTS). Together with two machines that BR already owns, they will be deployed on the principal routes north and west of London so that time can be cut from InterCity schedules. BR anticipates that commercial speeds can be increased by around 5 per cent through a reduction in the present timetable allowance for temporary restrictions of speed (TRS), thanks to the use of DTS and other techniques, such as accurate profiling of the ballast bed using laser guided machines. TRS allowances on some routes, such as the East Coast main line from London to Edinburgh, will be cut in the new timetable starting on May 16, and further reductions will be phased in over two or three years.

Anon. *Railw Gaz Int* v 144 n 2 Feb 1988 p 93.

**088553 FINDINGS CONCERNING MECHANISED MAINTENANCE OF SWITCHES AND CROSSINGS.** Taking Plasser & Theurer's Unimat 08-275 as an example, the author indicates the features which a track maintenance machine must possess in order to ensure good switch and crossing maintenance. It is shown that only with laterally displaceable units and individually tiltable tamping tines it is possible to achieve perfect tamping of narrow sections around the diamonds, guard rails, guide rails, deflecting blades, etc. For excellent tamping quality, it is of great importance to adjust the penetration depth of the tamping tines. Pressure vibration tamping according to the principle of nonsynchronous uniform pressure guarantees absolutely uniform results. For switch tamping it is particularly important that the operators have an excellent view of the work area.

Klotzinger, Erwin (Austrian Federal Railways, Vienna, Austria). *Rail Eng Int* v 17 n 1 1988 p 21-24.

**088554 BALANCING THE 'INS' AND 'OUTS' OF MoW.** The article examines the problem of short lines/new lines regarding the estimation of their track needs before knowing if projected revenues would support the desired maintenance-of-way or rehabilitation programs. The question of whether to outsource track work or do it in-house demands far more than just a cost comparison. Rather than simply trying to save money, short line engineering departments report that other factors take center stage when they decide to contract out track work. Other factors new railroads have to look at include track conditions, long-term plans and traffic mix.

Borzo, Greg. *Mod Railroads* v 43 n 9 May 1988 p 27, 29.

**088555 DEVELOPMENT OF MECHANISATION ON THE PERMANENT WAY IN AUSTRIA IN RELATION TO THE ECONOMIC SUCCESS.** Mechanization on Austrian Federal Railways began in 1950, when a foreign-made, mechanical track tamping machine was put into service. In 1953 Messrs. Plasser & Theurer started production in Linz of the first hydraulic tamping machine (work output approx. 80 m/hour). The uniform construction of the tracks makes them suitable for fully mechanized work and this opened the way for rapid development. The first Automatic Lining Machine, AL 202, went into service in 1963. The average output of this machine was 105 m/hr. From 1962 onwards Switch Tamping Machines were also in use in order to be able to tamp mechanically switches and crossings. In order to partly restore the lateral stability of the track lost during lifting and tamping, the ballast between the sleepers must be consolidated. For this purpose sleeper crib consolidators (BKV 112) were introduced. Adequate amounts of ballast filled into the track are essential to avoid track buckling. After tamping and lining there should be a uniform ballast profile. This was achieved using Ballast Distributing and Grading Machines (USP 3000). To ensure high quality and at the same time an economical use of track maintenance machines in the track intervals available, Austrian Federal Railways was the first railway in 1967 to use groups of machines known under the name of 'Mechanised Maintenance Train' (MDZ). Another important milestone in the course of mechanization of permanent way work was the development of the Track Tamping Machine Mainliner Duomatic 07-32 SLC and the Switch Tamping and Lining Machine Plassermatic 07-275.

Klotzinger, Erwin (Austrian Federal Railways, Vienna, Austria). *Rail Eng Int* v 17 n 2 1988 p 4-10.

**088556 HISTORIC DATA ON TRACK GEOMETRY IN RELATION TO MAINTENANCE.** The program of work of the ORE Committee D 161 was initiated to determine how the dynamic interaction between vehicle and track influences track deterioration and the subsequent need for track maintenance and renewal. This paper examines the basic concepts of this work on the basis of an analysis of historic track data and reports the most important conclusions to date. It is shown how the development of systematic track geometry inspection by modern accurate recording cars allows the local track quality to be quantified at regular intervals. The data thus obtained can be used to optimize maintenance work, especially for tamping machines. 8 Refs.

Anon. *Rail Eng Int* v 17 n 2 1988 p 16-19.

**088557 LABORATORY STUDIES ON MUD-PUMPING INTO BALLAST UNDER REPETITIVE RAIL LOADING.** The maintenance of permanent way laid on weak subgrade soils has posed problems to the Indian Railways due to differential settlements leading to incorrect alignment of track. In most cases these problems are found due to pumping of mud into ballast under the influence of repetitive wheel loads. This phenomena is also accompanied by loss of substantial percentage of ballast into the subgrade soil thereby reducing the percentage of recovery of ballast for reuse. The Indian Railways now contemplates to tackle these twin problems of differential settlement and loss of ballast by interposing a geotextile layer in between the ballast and the subgrade. In this paper the associated problems faced by the Indian Railways are described. An attempt has also been made to fabricate a repetitive loading apparatus to study the influence of molding water content, soil texture and the geofabric protection minimizing the differential settlement and pumping effect on fines into the ballast. Relevant experimental data are presented and conclusions are reported. (Edited author abstract). 4 Refs.

Boomintahan, S. (College of Engineering, Madras, India); Srinivasan, G.R. *Indian Geotech J* v 18 n 1 Jan 1988 p 31-47.

## Manufacture

**088558 KOMPLETTBEARBEITEN GESCHMIEDETER EISENBAHNPUFFER IM 8-MIN-TAKT.** [Complete Machining of Forged Railway Buffers in 8-Minute Cycles]. For reasons of improving efficiency and productivity, Karl Georg GmbH & Co. KG, Neitersen, decided to convert the production of forged railway buffers from individual conventional machines to a new production facility permitting maximum reduction of idle times. Minimum set-up times for 12 different components had to be accounted for. The manufacturing cell to be completed within 12 months was built by Maschinenfabrik Heyco, Heynen GmbH & Co. KG, Derschen. (Edited author abstract) In German.

Klement, Joachim; Merkel, K.A. *Werkstatt Betr* v 121 n 5 May 1988 p 363-366.

## Modernization

**088559 LA SUPPRESSION DES PASSAGES A NIVEAU DE LA LIGNE B DU RER.** [Elimination of Level Crossings on RER Line B]. After explaining the problems encountered with level crossings on the southern part of RER Line B and giving an historical account of the efforts made to finance their elimination, the authors describe the start of this work and the various methods under consideration for the construction of the underpasses beneath the railway line. The reasons and the various methods under consideration for the construction of the underpasses beneath the railway line are cited. An example why preference is being given to prefabricated sections and shifting on air cushions. (Edited author abstract)

Lenoir, Jean-Jacques (RATP, Paris, Fr); Taillebois, Andre. *Rev Gen Chemins Fer* v 106 n 6 Jun 1987 p 29-42.

**Peoples Republic of China** See TUNNELS AND TUNNELING—Railroad.

**Stations** See Also RAILROAD SIGNALS AND SIGNALING—Interlocking; RAILROAD YARDS AND TERMINALS—Italy; SUBWAYS—Electric Lighting.

**088560 GROSSE HALLE KOELN Hbf - EIN NICHT ALLTAEGLICHES PROJEKT AUS DER SICHT DES KORROSIONSSCHUTZES.** [Main Concourse of Cologne Central Station an Unusual Project from the Standpoint of Corrosion Protection]. The task called for renovation of the over 90-year-old structure above the heads of around 110,000 travellers a day. The unusual features of the corrosion-protection work included the practical circumstances that had to be considered, the need for complex temporary structures and the three-week execution cycles. The article also looks at problems that arose with regard to quality control, the nature of the structure and measures to protect the workers involved and the environment. (Edited author abstract). In German.

Huehner, Reinhold (Brueckenbauhof Koeln, West Ger); Rott, Johannes; Kuenzer, Joerg. *Eisenbahningenieur* v 38 n 8 1987 p 381-389.

**088561 VERKEHRSZENTRUM GELSENKIRCHEN HAUPTBAHNHOF: EIN BEISPIEL FUER NEUZEITLICHEN STAEDTEBAU DRUCH VERKEHRSVERKNUEPFUNG.** [Gelsenkirchen Central Station Transport Center: An Example of Modern Urban Planning with Transport System Links]. The specialist literature has hitherto given scarcely any consideration to how the creation of transport system links around city stations can achieve not only benefits for transport but also improvements in the appearance of the city. This article discusses this topic and describes one of the five major transport system link centers recently completed in the Ruhr agglomeration, that at Gelsenkirchen Central Station. A detailed description is given of the layout of this four-level station, which accommodates not only long-distance and suburban trains of the German Federal Railway



but also local underground tramway lines and a bus station. Also described are the changes made to upgrade the surrounding shopping area. In German.

Tschiesche, Werner (Bundesbahndirektion Essen, West Ger); Koch, Heribert; Korn, Horst. *Eisenbahningenieur* v 38 n 9 Sep 1987 p 436, 438-447.

**088562 GLI IMPIANTI DI STAZIONE E LA LORO ANALISI TOPOLOGICA.** [Station Track Plans and Their Topological Analysis]. Analysis of the topological properties of station plans and their development in the form of matrices, graphs and graphic prospecti. These properties make it possible to develop a design procedure for station plans on the basis of an orderly analysis of the ensemble of solutions which satisfy given circulation requirements. Mention is lastly made of the applicability of the method to other transport systems. (Author abstract) 9 refs. In Italian.

Corazza, Giuseppe Romolo (Univ di Roma, La Sapienza, Italy); Musso, Antonio. *Ing Ferrov* v 42 n 11 Nov 1987 p 643-652.

**088563 BUILDING AUTOMATION IN THE NEW ZURICH STATION.** The SICOS 2000 building automation system has been selected for the new extension to Zurich Central station (including the Zurich District Railway station). The Swiss Federal Railways plan the phased installation of more than 40 autonomous local DDC (direct digital control) stations between 1987 and 1992. These control stations will serve energy optimization for over 200 plants (heating and air conditioning), providing agreeable room and zone conditions appropriate to their particular usage. (Author abstract) 3 refs.

Shutler, M. *Sulzer Tech Rev* v 70 1 1988 p 16-18.

**088564 HIGH LEVEL STEEL FOR PORTSMOUTH STATION.** Stepping aside from its present tendency to refurbish historic railway architecture, British Rail have chosen to replace the Victorian high level canopy over Portsmouth and Southsea station with an exposed lattice beam portal frame structure. To support the new 150mm thick reinforced concrete platform, with shear studs and a 12mm non-slip screed, a steel frame was erected on top of the existing steelwork. Structurally, the canopy used to be tied into the viaduct but is now completely separate, so that the viaduct carries only the tracks and platform. The 70m long canopy in eight bays consists of pin-ended exposed lattice portal frames, 9m high and spanning 15m. These portals support 1200mm deep triangular lattice beams which in turn, carry the barrel vault roof structure.

Anon. *Civ Eng (London)* May 1988 p 38-39.

Temperature Measurement See RAILS—Laying.

**Track** See Also BRIDGES, RAILROAD—Structural Analysis; BUILDINGS—Structural Design; CARS—Street Railroad; GRANULAR MATERIALS—Mechanical Properties; RAILROAD YARDS AND TERMINALS—Computer Aided Design; RAILROAD YARDS AND TERMINALS—Equipment; RAILROADS—India; RAILS—Heating; RAILS—Maintenance; RAILS—Manufacture; RAILS—Measurements; RAILS—Structural Analysis; WOOD PRESERVATION.

**088565 'SUPER SYSTEM' FOR BALLAST UNDERCUTTING/CLEANING.** Ballast undercutting and cleaning system which is designed to keep pace in modern, high-speed track rehabilitation work consists of shoulder ballast cleaning with full section undercutting/cleaning. This marriage of different methods for ballast rectification permits rates of almost ½ mile per hour in reconstituting contaminated ballast in track. At the same time, if it is desired, the system can return treated ballast immediately to the undercut track to keep the ties and rail as near as possible to their former elevations. The problems affecting track stability that these processes must overcome are discussed.

Anon. *Railw Track Struct* v 83 n 10 Oct 1987 p 17-18, 20-21.

**088566 BN 'SWATS' TRACK MAINTENANCE**

**CHORES.** The Swat team concept is being demonstrated vividly by the customized approach the track people are taking in maintaining Burlington National (BN's) heavily trafficked mainline segment between Alliance and Lincoln, Nebraska. As part of a track improvement effort, the BN employed four ballast undercutter/cleaners, each of these units being backed by full-support working consists including a ballast train and necessary surfacing machinery. Among other contributing equipment were special switch and crossing rail grinding machines.

Anon. *Railw Track Struct* v 83 n 10 Oct 1987 p 26, 28-30.

**088567 GRINDER PROFILES RAIL SELECTIVELY.** The nature of transitional track geometries, along with restricted clearances and rail cross-sectional variations at switches, have made computer control a must for precise, modern spot grinding. Loram's SX Rail Grinder (called the SX-16, if there are sixteen grinding stones mounted on the unit) is designed to produce an effective rail profile and to eliminate surface defects within special track sections. The 16-stone version of the SX Grinder employs grinding patterns that cover six sections in profile along the ball of the rail. In improving the relationship between the switch and stock rail, the machine is capable of grinding at angles from plus-60-degrees gage to minus-45-degrees field. The field and gauge surfaces are ground first, followed by treatment of the rest of rail ball area during the remaining increments.

Anon. *Railw Track Struct* v 83 n 10 Oct 1987 p 32-33.

**088568 ZUR GENAUIGKEITSABSCHAETZUNG EINER NALENZ-AUFNAHME.** [Estimating the Accuracy of a NALENZ Survey]. As part of current rationalization efforts, studies are under way on how far the Nalenz procedure can be utilized to determine setting-out measurements for excentrically marked tracks. This would involve polygonal trace measurements related to the definition points of the actual track position between opposing marking bolts in addition to actual rise measurements. In both cases detailed investigation of the means to arrive at a sound assessment of the achievable degree of accuracy is necessary in order to determine where the procedure can be utilized rationally. (Author abstract) 6 refs. In German.

Schuh, Peter (Bahnbauzentrale, Nuremberg, West Ger). *Eisenbahningenieur* v 38 n 7 Jul 1987 p 331-334.

**088569 EINSATZ DER FESTEN FAHRBAHN AUF DEN NEUBAUSTRECKEN DER DEUTSCHEN BUNDESBahn.** [Use of a Hard Roadway on the German Federal Railway's New Lines]. As an alternative to the ballast bed, a Rheda-type hard roadway was laid in two tunnels on the German Federal Railway's new lines, based on 14 years of experience with this type of roadway on running tracks. This article reports on development work, experimental work on hard roadway renewal technology, and the installation of such a roadway in the Muehlberg tunnel. (Edited author abstract) 13 refs. In German.

Hilliges, Dieter (Dyckerhoff & Widmann AG, West Ger). *Eisenbahningenieur* v 38 n 7 Jul 1987 p 347-353.

**088570 ESTIMATION OF THE FATIGUE STRENGTH OF FRAME MEMBERS IN RAIL STRAIGHTENING MACHINES HAVING A CYCLIC ACTION.** Straightening machines (SM) of types VPR-1200 and VPRS-500 used in construction, repair and maintenance of railway track, usually fail as a consequence of frame damage. The frames are made in the form of complex three-dimensional structures of the bar type, mainly of channels and rolled plate material. Their loading is predominantly dynamic in character, and damage in use occurs basically as a result of the development of fatigue cracks. The influence of constructional factors on the resistance to fatigue failure of welded constructions of SM frames was investigated on testpieces closely approximating the standard frame members.

Bunin, B.B. *Sov Eng Res* v 7 n 2 Feb 1987 p 15-17.

**088571 BENEFITS OF THE NEW SOUTH WALES RAIL TRACK UPGRADING PROGRAMME 1977-82.** The track conditions current in 1977, and the rates of deterioration at that time are studied. Also the long term effects of these on the running of trains and system reliability are determined for 1982, should the upgrading program not have been carried out. These include the increases in train running times due to the excitation of speed restrictions, and the level of disruption caused by the increasing frequency of major derailments. The improved track condition evident as a result of the upgrading program is considered and the benefits to the efficiency of train running in the State Rail Authority determined. A statistical analysis of the improved track condition from Track Recording Car data is provided. Additional aspects of the subject are discussed. (Edited author abstract)

Archer, D.J. (State Rail Authority of New South Wales, Aust). *Mech Eng Trans Inst Eng Aust* v ME 9 n 4 Nov 1984 p 262-266.

**088572 LUBRICATION OF RAILROAD WHEELS AND TRACK.** A study is made of the geometry of the wheel/rail interface and of the changes in the rail configuration as a result of plastic deformation and mean. The variables affecting lubrication and wear are discussed, as well as the mechanisms of lubricant application. The results of field trials in which lubricants were compared in wayside lubricators are presented. 6 refs.

Okon, Leonard W. (Century Lubricating Oils Inc). *NLGI Spokesman* v 51 n 9 Dec 1987 p 364-369.

**088573 IMPROVING TUNNEL TRACK.** This paper describes briefly the magnitude of the problem facing the railroad industry in confronting track maintenance in tunnels. It outlines some approaches to tunnel track rehabilitation. It also offers some practical hints, with brief touches upon cost comparisons, in regard to the different types of tunnel track work described. Some background on the magnitude of the tunnel track is given.

Abbott, Russell A. (CSX Transportation). *Railw Track Struct* v 83 n 11 Nov 1987 p 24, 26, 28-29.

**088574 SMOOTHING THE 'HEAVY HAUL' TURNOUT.** The author's own 'ultimate' in modern turnouts for heavy haul track in North America includes: curved, 'chamfered' design of a 'flexible' switch with asymmetrical switch-point sections; rail hold-down by modern elastic fastenings; and swing nose frog. The turnout described 'provides the smoothest, most continuous path possible that the wheels can take as they travel through it.' This capability, affords the same benefits railroads now get from properly aligned and well-supported CRWR in their mainline track. These benefits include extension of turnout component life, plus a significant lowering of M/W costs. Both stem from the reduction of the dynamic loads imparted to the turnout elements.

Birkinshaw, John. *Railw Track Struct* v 83 n 12 Dec 1987 p 21-25.

**088575 FINITE ELEMENT ANALYSIS OF TRACK STABILITY.** During the period from November 1986 to August 1987 a theoretical study was made of horizontal track stability under the influence of temperature loads. The first phase of the research concentrated on problem analysis and model design, the second phase on testing and verification of the computer program SPAT. It was found that SPAT is able to calculate the stability of tracks with an arbitrary geometry under temperature and/or concentrated loads. The program can also be used for research into the relationship between curve radius and temperature for which instability or large lateral displacements occurs. 5 refs.

van Hengstum, L.A. (Netherlands Railways, Neth). *Rail Eng Int* v 16 n 4 1987 p 18-20.



**088576 IMPROVING PROCUREMENT OF SPECIAL TRANSIT TRACKWORK.** In building the Long Beach-Los Angeles light rail transit line, the Los Angeles County Transportation Commission (LACTC) chose to let a separate, special contract for procuring turnout materials. This strategy encouraged competition between suppliers by calling for a special trackwork design attractive to both domestic and foreign manufacturers, yet one which would not compromise quality or performance. The commission's task was made all the more difficult because of the wide disparity between the existing domestic and foreign designers. In order to promote equal interest in the project among foreign and domestic suppliers, the Commission adopted a hybrid design employing many of the desirable features of European and American trackwork practices, but without giving a price advantage to any particular supplier.

Jackson, Bertie. *Railw Track Struct* v 84 n 1 Jan 1988 p 34-36.

**088577 LOAD FACTOR METHOD FOR DYNAMIC TRACK LOADINGS.** Design of track structural components and foundations is based upon design loads higher than the nominal static values. These design loads generally have been determined using dynamic impact factors as multipliers of the nominal static loads. A review of commonly used impact factors is given, as dependent upon track and vehicle characteristics, and operating conditions. Field measurements of the distribution of static and dynamic wheel loads at five sites are presented. A load factor method, derived from the field measurements, is given that can be used to characterize the distribution of track loads. Although a single wheel or axle load may be appropriate for the design of certain structural components, multiple axle loadings should be used to estimate stresses and deformations that result at depth, or to analyze the loadings on buried structures. An approach is outlined to characterize the complex multiple axle dynamic load distribution for use in a probability-based design procedure. (Edited author abstract) 20 refs.

Stewart, Harry E. (Cornell Univ, Ithaca, NY, USA); O'Rourke, Thomas D. *J Transp Eng* v 114 n 1 Jan 1988 p 21-39.

**088578 EFFECT OF NONLINEAR PARAMETERS ON STRESSES IN RAILROAD TRACKS.** A nonlinear formulation is presented for the analysis of railroad tracks. The finite element discretization is used for a rail element which includes all the deformation modes of the rail. The stiffness of the fasteners, ties, and roadbed is included by a set of springs. A parametric study is carried out to examine the effect of the nonlinear deformations and degradation on stresses and deformations. (Author abstract) 32 refs.

Arbabi, Freydoon (Michigan Tech Univ, Houghton, MI, USA); Fang Li. *J Struct Eng* v 114 n 1 Jan 1988 p 165-183.

**088579 SULLA SCELTA DI UN IDONEO RACCORDO PLANO-ALTIMETRICO NELLE CURVE DI LINEE FERROVIARIE AD ALTA VELOCITA'. [Choice of Suitable Plano-Altimetric Connections Between Curves on High-Speed Railroad Lines].** A study is carried out to identify the plano-altimetric connections on railway curves, for high-speed lines, which guarantee continuity in the dynamic stresses in the horizontal and vertical plane, for the purpose of reaching maximum passenger comfort. The advisability is affirmed that the vertical connection for the superlevation of the external rail be a sinusoidal curve with a contemporary planimetric connection by means of a bi-parametric curve. The determination of all the parameters necessary for contouring can be carried out rapidly by using a computer of modest capacity. In Italian. 10 refs.

Tesoriere, Giovanni (Univ di Palermo, Italy); Simone, Luigi. *Ing Ferrov* v 42 n 9 Sep 1987 p 505-514.

**088580 GAUGING TURNOUT PROBLEMS AND COSTS.** The author gives his analysis on the correlation

between heavy loads and increased turnout costs. He used interviews and surveys of suppliers and railroaders. The results of the surveys and the analysis are discussed.

Anon. *Railw Track Struct* v 84 n 2 Feb 1988 p 31-33.

**088581 Y-STAHLSCHWELLENGLEIS MIT ASPHALTTRAGSCHICHTEN FUER DEN EISENBAHN-NOBERBAU - ERPROBUNG IN DER PRAXIS. [Y-Steel Tie Track with Asphalt Basis for Railroad Superstructure - Practical Testing].** Extensive supplementary measurements (geometrical track position and its changes, measurements of stresses and settlement, noise measurements, temperature measurements) as well as a fire test and a derailment experiment on the Salzgitter experimental track section, over a period of 3 years, are described. Based on the results of these measurements and on the behavior of two test track sections set up in 1986 within the West German railroad network, it is concluded that this is a stable and maintenance-free railroad track. (Translated author abstract) 10 refs. In German.

Beecken, Gerhard (Deutsche Shell AG, Hamburg, West Ger). *Bitumen* v 49 n 4 4th Quarter 1987 p 165-171.

**088582 GREAT SALT LAKE AT BAY PART 4 - PROTECTING THE UP MAINLINE.** This article is the final segment of a three part series on Southern Pacific problems with the Great Salt Lake. The article describes how Union Pacific's mainline was protected from wave action during storms. It also discusses how the level of the Great Salt Lake was controlled.

Anon. *Railw Track Struct* v 84 n 4 Apr 1988 p 28-31.

**088583 ON-SITE CUSTOMIZING OF CROSSING SURFACES.** The article discusses the use of an on-site PCM (portable cutting machine) to custom-configure each non-standard panel as needed for quick placement into the track. The PCM is outfitted with a circular saw and a carbide-tipped milling head, powered by a 25 kw generator. The PCM is also a self-contained unit, mounted on a goose-neck trailer pulled by a 1-ton truck.

Anon. *Railw Track Struct* v 84 n 5 May 1988 p 47-48.

**088584 THEORETICAL ANALYSES ON VIBRATION OF BALLASTED TRACK.** The settlement of ballasted track has been considered to depend on the ballast vibration. In this report, 12 cases of measured track vibration are systematically analyzed, and the coefficients necessary for theoretical analyses are determined. Then, the effects upon track vibration of track structure such as rail, tie and ballast depth, vehicle unsprung mass and wheel/rail roughness are investigated. (Author abstract) 1 ref.

Sato, Yoshihiko (Track Lab); Odaka, Tatsuo; Takai, Hideyuki. *Q Rep RTRI (Jpn)* v 29 n 1 Feb 1988 p 30-32.

**088585 CHARACTERISTICS OF CONSOLIDATED BALLAST ON ELEVATED STRUCTURE OF TOKAIDO SHINKANSEN AND PROPOSALS FOR ITS TREATMENT.** To know the characteristics of consolidated ballast - fouled with fines derived from the ballast itself or transformed into solid mass of ballast and such particles - on elevated structure of Tokaido Shinkansen, laboratory tests were performed using 16 samples of ballast taken from various sections of track laid with different kinds of rocks. Results of these tests clarified the conditions under which the ballast consolidates: voids in the ballast mass are filled with small broken pieces of ballast as well as fines, the fines acting as 'bonding' materials in wet condition, and the ballast is dried up and compressed to an increased density. They also show that samples of consolidated ballast can disintegrate when they are soaked in water and applied with a slight force. On the basis of these results, we propose new ideas of treating degraded ballast.

Katayama, Morihiko (Track Lab); Takagi, Kinai. *Q Rep RTRI (Jpn)* v 29 n 1 Feb 1988 p 33-40.

**088586 DEVELOPMENT OF VIBRATION-DECREASING SLAB TRACK OF TYPE G AND ITS**

**PRATICAL USE.** The type G vibration-decreasing slab track has been developed with improvements over the characteristics of the track slab spring constant and the stress distribution of type A slab track. Its structural features are as follows: the slab mat has grooves which make it possible to reduce restrictions to the deformation by having a free surface; a piece of soft polyethylene is glued under the track slab at the central part of its width; and the slab supporting spring constant of the end part is made larger than that of the intermediate part. Thus this slab track can be used in practice as a standard structure of vibration-decreasing slab track. This paper describes the process of its development, its structure and the results of a performance test on the Koga section of the old narrow-gauge Tohoku line north of Tokyo. (Edited author abstract).

Sato, Yoshiko (Railway Technical Research Inst, Jpn); Ohishi, Fujio; Ando, Katsutoshi. *Q Rep RTRI (Jpn)* v 29 n 2 May 1988 p 51-55.

**088587 DEVELOPMENT OF A WELD PROCEDURE TO REPAIR JOINTS IN A RAILROAD-TYPE TRACK.** This report describes the steps in the development of a weld repair procedure for a precision railroad-type track upon which instrumented carriages run as they tow ship models through the water. The track is located at the David Taylor Research Center, Carderock, Md., the U.S. Navy's principal research, development and test center for a broad range of new vehicle-related concepts. The task was to rebuild the rail to the original dimensions with weld metal of the same wear resistance (hardness). A specialized weld-repair application provides procedure and design information that can be applied to many welding problems. 5 Refs.

Siewert, T.A. (NBS, Boulder, CO, USA). *Weld J (Miami Fla)* v 67 n 8 Aug 1988 p 17-23.

**088588 PERFORMANCE OF LARGE-SCALE MODEL SINGLE TIE-BALLAST SYSTEMS.** Large-scale models of a single tie-ballast system were constructed over artificial ballast support that had variable compressibility. The principal objectives of the experimental work were to investigate the influence of load level and ballast support compressibility on the rate of accumulation of permanent deformations and ballast degradation. The test results show that at a given load level the rate of tie settlement is quite sensitive to ballast support compressibility. A competent ballast support resulted in a deformation-log tonnage response that was essentially linear. However, progressively weaker supports gave increasing semilogarithmic rates of settlement with tonnage. For a given support compressibility, a critical load level was identified that, if exceeded, led to a dramatic increase in settlement rate. (Edited author abstract). 13 Refs.

Raymond, Gerald P. (Queen's Univ, Kingston, Ont, Can); Bathurst, Richard, J. *Transp Res Rec* n 1131 1987 p 7-14.

**088589 APPLICATION OF PETROGRAPHIC ANALYSIS TO BALLAST PERFORMANCE EVALUATION.** An interpretation is presented of ballast performance test results that uses the information obtained from petrographic analysis of ballast material to help assess the importance of this technique as a means of evaluating ballast. Fourteen ballast materials were used in this study. These were tested in a special ballast box apparatus under differing conditions of equivalent wheel load, material gradation, and number of load cycles. Mill abrasion and ballast cementing tests were also performed on these materials and Los Angeles abrasion values were obtained from the ballast suppliers. Identification of the mineral composition and texture of the ballast material, as well as inherent planes of weakness such as foliation and cleavage, can be accomplished using petrographic analysis. With a few exceptions, petrographic analysis was



found to provide a reasonable explanation of the performance of the ballast materials in each of the tests. (Edited author abstract). 16 Refs.

Boucher, Debra, L. (Parsons, Brinckerhoff, Quade & Douglas Inc, New York, NY, USA); Selig, Ernest, T. *Transp Res Rec* n 1131 1987 p 15-25.

**088590 PRODUCTION AND TESTING OF BALLAST.** The traditional method of selecting ballast has been based on physical testing of representative specimens to ensure that materials have adequate wearing resistance, toughness, physical stability, and strength to meet predetermined criteria. Tests such as magnesium sulphate soundness or abrasion resistance give indirect evidence of how the ballast properties can be expected to change in the track structure. None of the tests currently employed, with the exception of gradation, gives direct information to explain the physical behavior and chemical stability of a ballast source. This paper demonstrates a rational methodology for the selection of natural rock ballast sources. To obtain the most cost-effective investment in ballast, source selection, site investigation, quarry design, quality control, and selection of specifications should be based on the geologic characteristics of the source. (Edited author abstract). 6 Refs.

Clifton, A.W. (Clifton Associates Ltd, Regina, Sask, Can); Watters, B.R.; Klassen, M.J. *Transp Res Rec* n 1131 1987 p 26-34.

**088591 TRACK EVALUATION AND BALLAST PERFORMANCE SPECIFICATIONS.** A variety of laboratory tests has traditionally been used in the selection of a material and gradation for ballast. The results of the laboratory tests are commonly used to reject or accept material for use as ballast and rarely imply benefits or costs of selecting alternative materials or gradations. In this paper are presented the results of a track sampling and evaluation program to determine the performance of ballast, subballast, and the subgrade on Canadian Pacific (CP) Rail. A simple method was developed to determine if a significant portion of maintenance of the track structure is attributable to the subballast and subgrade. The concept of ballast life is presented with a relationship between ballast quality and grading. CP Rail specifications for the selection of a ballast material and the processing of ballast are also presented. (Edited author abstract). 8 Refs.

Klassen, M.J. (Canadian Pacific Rail, Calgary, Alberta, Can); Clifton, A.W.; Watters, B.R. *Transp Res Rec* n 1131 1987 p 35-44.

**088592 EVALUATION OF BALLAST MATERIALS USING PETROGRAPHIC CRITERIA.** Mineralogy is a major factor in determining overall rock hardness and physical durability, chemical weathering potential, composition and quantity of derived fines, and degree of susceptibility to wetting and drying. Rock texture also affects hardness and is important in influencing toughness, relative susceptibility to freeze-thaw degradation, and mechanical stability in track. Most of the standard tests commonly applied to ballast materials essentially provide a measure of a combination of petrographic properties; consequently, the results of the tests can be predicted to within certain limits. Numerous techniques, including the use of microscopes and X-ray diffraction equipment, can be applied in the study of the fines fraction of track samples to determine the nature and source of the material. Three ballast types in use by Canadian Pacific (CP) Rail are discussed to demonstrate the influence of petrographic properties on performance. (Edited author abstract). 14 Refs.

B.R. Watters (Univ of Regina, Regina, Sask, Can); Klassen, M.J.; Clifton, A.W. *Transp Res Rec* n 1131 1987 p 45-58.

**088593 SUBGRADE AND BALLAST REQUIREMENTS FOR L25-TON CARS.** The main points relating to the performance of railway track subgrades are outlined. Particular consideration is given to the effect of increasing axle loads from 30 tonnes, standard on 100-ton

cars, to 36 tonnes, estimated as probable for 125-ton cars. Two aspects are discussed, new track construction and upgrading existing track. On existing construction, where subgrade stability is borderline, an appropriate ballast lift to maintain or increase the existing factor of safety may be determined. For new construction, various aspects of subgrade preparation are briefly reviewed. These include the importance of adequate compaction, the treatment of subgrade soils with cement, and the treatment of subgrade soils with lime. Special aspects of dealing with swelling soils or high-sulfate soils, where avoidance is uneconomic, are also mentioned. For existing track on chronically unstable clay subgrades or unstable embankments, consideration should be given to cement or lime slurry pressure injection. (Edited author abstract). 23 Refs.

Raymond, Gerald, P. (Queens Univ, Kingston, Ont, Can). *Transp Res Rec* n 1131 1987 p 64-73.

**088594 TRACK COMPONENTS FOR L25-TON CARS.** Each track component is considered in turn and its engineering development is reviewed. Maintenance equipment is similarly reviewed. Ties and fasteners are identified as items to which an engineered approach could produce significant advances in cost-effective track. A detailed description is then given of the dynamic behavior of ties and how it is influenced by impact loading from equipment. Development of tie design from in-track measurements and the benefits of engineered tie pads are also discussed. Finally, suggestions are given for track for 125-ton cars, and the need to control damage caused by defective wheels is identified. (Author abstract). 23 Refs.

Buckett, John (CXT Systems, Herndon, VA, USA); Firth, Derek; Surtees, John, R. *Transp Res Rec* n 1131 1987 p 74-80.

**088595 RAILROAD TRACK STRUCTURE PERFORMANCE UNDER WHEEL IMPACT LOADING.** Increased use of high-productivity railcars of 100- and 125-ton capacity has pushed current track structure designs to the limit. The higher axle loads result in a tighter load tolerance. The dynamic response of concrete ties and fastener systems to impact loading is quite different from that of traditional wood-tie track. In this paper, results of recent studies of concrete-tie track structural dynamics are discussed in the context of wheel and rail impact loading. These studies include a correlation between the experiments at the Facility for Accelerated Service Testing and revenue traffic load environments, an investigation of Northeast Corridor concrete-tie cracking problems, and recent work on extreme-value wheel loads due to freight car wheel profile geometries. The need for dynamic systems analysis in the design of track structures is emphasized by examples of tie, fastener, and insert response to impact loading. (Edited author abstract). 9 Refs.

Harrison, Harold, D. (Salient Systems Inc, Worthington, OH, USA); Ahlbeck, Donald, R. *Transp Res Rec* n 1131 1987 p 81-88.

**088596 COMPONENT IDENTIFICATION AND INVENTORY OF U.S. ARMY RAILROAD TRACKAGE.** Recognizing the need to effectively plan track maintenance and rehabilitation of the U.S. Army's 3,000 track miles at 81 installations, the U.S. Army, through the Construction Engineering Research Laboratory, has developed a preliminary maintenance management system called RAILER I and is developing an improved system called RAILER II. Both systems define what needs to be managed through component identification and inventory and determine track condition through inspection. In this paper, the track component identification procedures for both systems are explained and the RAILER I system track inventory elements are defined along with a method for field data collection. The fundamental component is a track segment, a relatively uniform portion of track that constitutes the basic management unit. Other components identified are track networks, tracks, turnouts, and curves. Surveyor 100-ft stations are used for locating key component and inventory elements. (Edited author abstract). 3 Refs.

Uzarski, D.R. (US Army Construction Engineering Research Lab, Champaign, IL, USA); Plotkin, E.; Wagers, S.K. *Transp Res Rec* n 1131 1987 p 89-98.

**088597 USE OF GEOSYNTHETICS IN THE DESIGN OF RAILROAD TRACKS.** An innovative approach was used for an Amtrak Northeast Corridor Improvement Project (NECIP) in Boston for track structure support to accommodate low-strength organic clay and high groundwater beneath the railroad tracks. The new track structure uses a combination of geomembranes and geotextiles to maintain groundwater at or near prevailing level to avoid settlement of adjoining structures and provide a dry, stable foundation support for the tracks. This innovative track support system cost only about 40 percent of a pile-supported concrete slab similar to that used in the section of track west of this project. Considerations that led to the combination of a conventional railroad track structure and geosynthetics are described. (Author abstract). 12 Refs.

Lacy, Hugh, S. (Mueser Rutledge Consulting Engineers, New York, NY, USA); Pannec, Jamil. *Transp Res Rec* n 1131 1987 p 99-106.

**088598 DIRECT FIXATION FASTENER-ITS PAST AND ITS FUTURE IN RAPID TRANSIT.** When compared to most other trackwork components, direct fixation fasteners are relatively new products in transit applications at North American transit authorities. In the past, some difficulties have been experienced by procuring operators as well as fastener suppliers in specification compliance and effective part design. With the introduction of newer, more technically advanced direct fixation fasteners at various authorities, a reevaluation of the older style of specifications and testing procedures is necessary to avoid past difficulties and provide a more effective qualified product to the authorities. Past procurement practices and proceedings in general are reviewed with suggestions for possible improvements to balance trackwork and the vibrational requirements in specifications for direct fixation fasteners. (Author abstract). 1 ref.

Gildenston, Robert F. (Lord Corp, Erie, PA, USA). *Transp Res Rec* n 1152 1987 p 49-55.

Track Inspection See Also RAILS—Measurements.

**088599 REAL TIME DIGITAL PROCESSING OF TRACK IRREGULARITIES IN TIME OF SPEED-UP ON TOKAIDO AND SANYO SHINKANSEN.** To get good riding quality in high speed trains on Shinkansen, it is necessary to manage long wave components of track irregularities from a viewpoint of vehicle dynamics. It is made clear that the data collected by the track inspection car on Shinkansen provide information precise enough over a long wave range up to 100 m. Based on this result, the real time digital processing machine to calculate the track irregularities through riding quality filters aboard the track inspection car has been developed, and it was put into practical use on Tokaido and Sanyo Shinkansen in early 1987 on the occasion of their speed-up to 220 km/h. (Author abstract) 2 refs.

Sato, Yoshihiko (Track Lab); Fujimori, Soji; Yoshimura, Akiyoshi. *Q Rep RTRI (Jpn)* v 28 n 2-4 Nov 1987 p 42-47.

Track Switches See Also ELECTRIC RAILROADS—Austria.

**088600 BETRIEBLICHE AUSWIRKUNGEN BAUTECHNISCHER MASSNAHMEN BEI WERKBÄHNEN.** [Effect of Constructional Measures on the Operation of Works Railways.] The computing model Zebra is a planning instrument designed to allow the determination of the effects of various technical and organizational measures on shunting operation. The rating criteria involved are the operating sequence in time, the load and the safety of the shunters. As several switching engines are frequently operating simultaneously in a track zone, the computing model Zebra has been expanded to cover also the mutual influences. The computing model Zebra has already been successfully



used as a decision aid in planning tasks and operational investigations. (Edited author abstract) 3 refs. In German.

Wolters, Wilhelm (Univ Hannover (IVE), Hanover, West Ger). *Stahl Eisen* v 107 n 14-15 Jul 20 1987 p 41-45.

**088601 ON STANDARDIZING TURNOUTS.** The major parameters to be considered in turnout standardization are the frog number, length of switch, switch angle, if any, the type of switch (for example, curved split switch vs. straight split switch), and the rail weight and section. The discussion pertains to freight railroad and commuter rail systems only. Nevertheless, several of the concepts and ideas presented are applicable also to heavy-rail and light-rail transit systems. Refs.

Cohen, Paul I. (Port Authority of New York & New Jersey). *Railw Track Struct* v 83 n 12 Dec 1987 p 26-28.

**088602 VERSUCHSEINBAU EINER BETONSCHWELLENWEICHE AUF FESTER FAHRBAHN IM BAHNHOF SCHWETZINGEN.** [Experimental Installation of a Concrete Sleeper Switch on a Solid Roadbed at Schwetzingen Station]. Unballasted permanent way designs were largely restricted to open track in the past. At present, there are only one-off switch designs. With a view to adapting switches to the Rheda system that is also being laid on the new Hanover-Wuerzburg line, a prototype was laid at Schwetzingen station in June 1986; if it proves successful, it may be adopted as the standard design, especially in tunnels. (Edited author abstract) In German. 1 ref.

Kaluza, Ulrich. *Eisenbahningenieur* v 38 n 12 Dec 1987 p 603-607.

**088603 DIE WEICHE AUF Y-STAHLSCHWELLEN.** [Switch on Y-shape Steel Sleepers]. The article presents the first-ever switch using Y-shape steel sleepers, the result of extensive development work by Krupp-Kloekner GmbH (SKK). This innovative switch sleeper system was designed under the auspices of SATO (asphalt permanent way research group for railborne transport). (Author abstract) In German.

Bosshammer, Juergen (Schmiedewerke Krupp-Kloekner GmbH, Bochum, West Ger). *Eisenbahningenieur* v 39 n 5 May 1988 p 199-201.

**088604 CHARACTERISTICS OF LATERAL FORCE ACTING AT GUARD RAIL ON TURNOUT.** The guard rail for a rigid frog in a turnout receives a large lateral force from the inside surface of the wheel and is one of the major factors limiting the train speed in turnouts of narrow gauge lines. To clarify the characteristics of this lateral force, a high-speed running test up to 160 km/h over a guard rail was carried out under fully controlled conditions. Then a computer simulation and a lateral loading test of the guard rail were performed to obtain further information. As a result, the effects of the guided displacement of the wheel, the train speed, the flangeway clearance and the lateral rigidity of the guard rail on the lateral force were ascertained. (Edited author abstract).

Sato, Yasuo (Railway Technical Research Inst, Jpn); Miura, Shigeru; Hashimoto, Shoichi; Sato, Yoshihiko. *Q Rep RTRI (Jpn)* v 29 n 2 May 1988 p 62-66.

**088605 THYSSEN-RANGIERTECHNIK-ENTWICKLUNGSTENDENZEN UND STAND DER TECHNIK.** [Thyssen Shunting Technology - Development Trends and State-of-the-Art]. Most of the European shunting yards are partly mechanized, i.e. equipped with manually controlled primary retarders and drag shoe brakes in the sorting tracks. This leads to inadequate carriage quality and high operating costs. Using fully automated hump yards, carriage quality and economic efficiency can be increased considerably in the system-related shunting of individually loaded wagons. Performance-targeted graded shunting techniques using suitable equipment have proved their value and are available for the shunting yards still existing in the railway network. With several types of controlled retarders, wagon hauling systems and piston retarders for automatic speed control, Thyssen's shunting technology offers solutions in the form

of a complete system. 2 Refs. In German.

Heinritz, Manfred (Thyssen Unformtechnik, Remscheid, West Ger); Meuters, Gunter. *Thyssen Tech Ber* v 20 n 1 1988 p 137-146.

**Track Ties** See Also BOLTS AND NUTS—Manufacture.

**088606 CASE FOR CONCRETE TIE TURNOUTS.** It is sufficient to know that for lower maintenance purposes, the design requirements for concrete ties, whether for turnouts or track, depend on the impact loadings generated by wheel tread defects. The Hamersley Iron heavy haul railroad in Australia had this in mind when it decided in 1982 to change out all its timbered turnouts to those secured on prestressed concrete ties. The new installations are the first of their kind in that country and the first to feature fully cast-in shoulders to secure the rail clips. When completed, some 60 1:20 and 1:12 turnouts will serve a 190-mile mainline. The basic motivation for the change to concrete turnouts was cost.

Wesselmann, Carl. *Mod Railroads* v 42 n 10 Oct 1987 p 43-44.

**088607 DESIGN AND MANUFACTURE OF CONCRETE SLEEPERS FOR QUEENSLAND RAILWAYS.** A Contract was let in January 1982 for the manufacture of 500,000 prestressed concrete sleepers at Paget, Mackay. These sleepers are committed to the construction of new branch lines, spurs, and mainline duplications to handle coal traffic from mines being developed by private consortia. Further tenders have been awarded. A track laying machine capable of high productivity in the installation of the permanent way consisting of concrete sleepers and heavy rail is being acquired. These tracks offer strong, economic, low maintenance structures to permit efficient haulage of huge quantities of coal. The paper outlines the procedure adopted for the calling of the first major tender, the assessment of the most suitable Contractor, the establishment of the facility, as well as discussing a typical day's production. (Edited author abstract)

Nibloe, I.M. (Queensland Railways, Aust). *Mech Eng Trans Inst Eng Aust* v ME 9 n 4 Nov 1984 p 281-289.

**088608 BETTER TRACK NEEDS BETTER TIE INSPECTION.** Members of the Tie Working Group of the AAR Track Maintenance Research Committee feel strongly that guesswork in tie inspection must be reduced to a minimum. Economical timbering programs start with the implementation of standardized tie counts based upon clear and unambiguous descriptions of what truly constitutes a 'bad' tie. Then when marking ties for removal, special care must be taken to eliminate all clusters of three or more adjacent bad ties.

Roney, M.D. *Railw Track Struct* v 83 n 11 Nov 1987 p 19, 21-23.

**088609 FIRE PROTECTION OF BRIDGE TIES.** The New York City Transit Authority is rendering ties on two bridges in Brooklyn that are resistant to fire by use of NONFLAM. NONFLAM is a patented, emulsified fire retardant. It is essentially an elastomeric polymer which contains fillers and binders. After curing, it becomes a tough, but flexible coating that is weather resistant also. The fillers and binders it contains help hold together all of its components and add strength and longevity during its service life. The approach to NONFLAM application, evolved by the Transit Authority employs a three-man crew, plus a foreman. Two men each handle an application 'wand' - essentially an airless spraying unit. It keeps the material directed where it is needed and minimizes splatter. *Railw Track Struct* v 84 n 2 Feb 1988 p 19, 21-22.

**088610 TRACK: A MATERIAL DIFFERENCE.** In recent years, track engineers' options have expanded and they continue to expand, year by year. But it is perhaps in the cross-tie market that the greatest choice is available-treated wood, concrete (one-piece or dual-block), reconstituted, hard-hard wood, and, for some specialized

applications, steel. So long as wood supplies last and treated wood ties are available at prices that make sense economically, there's no question about the replacement cross-tie that will be dominant: It will be wood. But for special applications, concrete has already penetrated in the U.S. Reconstituted ties had a questionable reputation, but the problems with them have apparently been overcome. Steel cross-tie will continue to be a minor part of the business, but hard-hard wood ties might eventually become widely used.

Welty, Gus (Railway Age, New York, NY, USA). *Railw Age* v 189 n 3 Mar 1988 p 31-32, 34, 36.

**088611 DAMAGES IN CONCRETE RAILWAY SLEEPERS IN FINLAND.** Properties of the concrete mix, the production process and the structure of sleepers provided the basis for the examination of damages in railway sleepers. Damaged sleepers have been examined using petrographic, analytical and physical methods. Deterioration process was found to be caused by initial microcracks in the concrete structure. The cracks were formed during production; primarily caused by intensive heat treatment, which due to thermal movement and stresses produces a strong formation of microfissures and forms unstable chemical compounds in the concrete. Once the pattern of damage was established, the manufacture of concrete sleepers was changed to the extent of abandoning heat treatment. (Edited author abstract) 2 refs.

Tepponen, Pirjo (Lohja Corp); Eriksson, Bo-Erik. *Nord Concr Res* n 6 Dec 1987 p 199-209.

**088612 SMALLER TIES, BIGGER SAVINGS.** The economics of using smaller railroad ties are overwhelmingly in favor of 6-inch grade ties for use on short lines and regionals. They cost an average of 5.24 dollars less than 7-inch ties, and can mean a savings of one-third. Design constraints and economic analyses are presented.

Winger, James W. (Brawn Inc). *Mod Railroads* v 43 n 11 Jun 1988 p 22-25.

**Underpasses** See ROADS AND STREETS—Accident Prevention.

**RAILROAD ROLLING STOCK** See Also BRIDGES, RAILROAD—Vibrations; CARS—Control Systems; CARS—Couplings.

**Accident Prevention**

**088613 SICHERHEITSTECHNISCHE EINRICHTUNGEN DER NEUEN DOPPELTURBIBWAGEN FUER DIE BAYERISCHE ZUGSPITZBAHN.** [Safety-Engineering Features of the New Double Motor Cars for the Bayerische Zugspitzbahn]. In the middle of 1987 the Bayerische Zugspitzbahn put into service two new twin sets using a rack as well as adhesion. The slope of the track has a maximum of 250‰ and this, together with the complication of the two traction modes, makes special safety measures necessary. These safety features include a line section recognition system, a system for monitoring driver braking behavior systems for controlling the rack and pinion brakes, and an emergency braking system for passenger use. (Edited author abstract). 1 Ref. In German.

Roth, Werner (Siemens AG, Erlangen, West Ger). *Elektr Bahnen* v 86 n 8 Aug 1988 5p.

**Adhesion**

**088614 ADHESIVE/SEALANT CUTS RIVETING AND PREVENTS LEAKS FOR HAULER.** This case history discusses two applications of Uniroyal's Silaprene adhesive/sealant by Norfolk Southern Railway. Stretch trailers and rail compatible trailers are assembled and repaired with the product. Features and benefits of the adhesive/sealant are examined.

Anon. *Adhes Age* v 30 n 13 Dec 1987 p 26.



## Air Conditioning

**088615 OUTLINE OF LARGE SCALE CLIMATE TESTING FACILITIES FOR ROLLING STOCK.**

With a view to developing high-performance rolling stock, making the most use of the latest technologies, the author's firm is equipped with climate testing facilities capable of verifying the performance of air-conditioning centering on ventilation and cooling/heating functions under every conceivable climatic condition. These facilities are designed so as to house an entire coach completely for research and development of performance of air-conditioning equipment and of heat insulation of entire coach body as well as for attainment of quality assurance of the coach. An outline of these climate testing facilities is presented.

Kobayashi, Ken Ichi (Kawasaki Heavy Industries Ltd, Jpn). *Jpn Railw Eng* v 27 n 2 Sep 1987 p 14-17.

**088616 DRUCKERTUECHTIGTE REISEZUGWAGEN FUER NEUBAUSTRECKEN: GRUNDLAGEN, LOESUNGEN FUER KLIMAAANLAGEN.** [Pressure-Tight Passenger Coaches for New Lines. Fundamentals and Possible Solutions for Air-Conditioning Systems]. High-amplitude fluctuations of air pressure occur in railway tunnels which are passed through at high speed. These pressure fluctuations cause great annoyance to the passengers and train staff. This article describes the behaviour of the air pressure inside a passenger coach in response to external pressure fluctuations. As a consequence, measures for protection against the effects of pressure fluctuations are required. Such measures are to prevent the annoying effect of pressure fluctuations inside a coach. Possible ways of measuring and evaluating the effectiveness of the protection system are described. The paper also deals with the fundamental technical solutions available for equipping the air-conditioning system of passenger coaches with a protection against pressure fluctuations. The system chosen for the German Federal Railway rolling stock is described. (Edited author abstract) 6 refs. In German.

Klingel, Rolf (Bundesbahn-Zentralamt Minden, Minden, West Ger). *Z Eisenbahnes Verkehrstechn Glaser's Ann* v 112 n 1 Jan 1988 p 10-18.

## Axles

**088617 LAGERUNGSKONZEPTION UND WERKSTOFFE FUER RADSATZLAGER IN MODERNEN LAUFWERKEN VON HOCHGESCHWINDIGKEITS-UND NAHVERKEHRSFAHRZEUGEN.** [Bearing System Concept and Materials for Axle Bearings in Modern Bogies for High-Speed and Suburban Rolling Stock]. Extensive fundamental investigations were necessary to develop an appropriate bearing system concept for high-speed traffic. A Type TBU tapered roller bearing assembly proved to be the most suitable axle bearing for high-speed duty. Its friction torque characteristic is significantly lower than that of cylindrical roller bearings and self-aligning roller bearings. The axle bearing housings of advanced rail vehicles may consist of light alloy or nodular iron castings. In addition, 'Germanite', a high-strength bainitic nodular cast iron is available for this purpose. In suburban traffic, new light-weight cylindrical roller bearings are being introduced. This saves weight and enables the use of smaller size housings. The bearing reliability is improved by the use of a plastic cage as could be proved in hot box model tests. Moreover, in the case of cylindrical roller bearings, the plastic cage features easier maintenance than the brass cage so far used and is therefore being applied to an ever-increasing extent in suburban and main line vehicles. In bearings of standard design, the polyamide cage has proved successful in millions of applications. (Edited author abstract) 23 refs. In German.

Benz, Von Dieter (SKF GmbH, Schweinfurt, West Ger). *Z Eisenbahnes Verkehrstechn Glaser's Ann* v 111 n 11-12 Nov-Dec 1987 p 458-467.

## Bearings

**088618 ROLLER BEARING FAILURES: ASME LOOKS AT THE ISSUES.** The article examines: whether the standards for new/reconditioned bearings are adequate; whether increasing the age of bearings in service is a problem; the exact mechanism of final failure of a bearing when heated up; what can be done to improve in-service detection of faulty bearings. The question of whether preventive maintenance can help is also addressed. Failure cause categories - internal, external and misapplication - are also discussed. New detection methods are also presented.

Shedd, Tom. *Mod Railroads* v 43 n 6 Apr 1988 p 37-40.

**Bogies** See Also BRAKES—Design; CARS, RAIL MOTOR; LOCOMOTIVES, ELECTRIC.

**088619 LE BOGIE Y 237.** [Bogie Type Y 237]. The article describes the features of the bogie type Y 237 used in cars of the TGV high-speed train. The best results of this bogie are also presented. In French.

Daffos, J. (SNCF, Fr). *Soudage Tech Connexes* v 41 n 3-4 Mar-Apr 1987 p 100-103.

**088620 MANAGING THE DESIGN AND DEVELOPMENT OF A NEW BOGIE USING MODERN COMPUTER BASED SYSTEMS AND TECHNIQUES.** Early in 1985 British Rail Engineering Ltd recognized the need for a new bogie suitable for a wide range of world railway requirements. During the development of this bogie, the T11, computer aided design techniques were used extensively to compress the time scales and to give increased confidence in the performance of the end product. (Author abstract)

Guyler, David A.; Pennington, Keith W. *Rail Eng Int* v 16 n 3 1987 p 5-8.

**088621 EXPERIMENTE ZUR SPURFUEHRUNG.** [Experiments on Wheel-Rail Guidance]. New findings have been revealed by comparative investigations on an experimental running gear designed for operation as a two-bogie unit with individually driven wheels or as a two-bogie unit with axle drive and a conventional type MD 42 bogie. The tests have confirmed considerations and calculations according to which individually driven wheels ensure better guidance than conventional wheelsets. As a result of a systematic approach to the experiments, the prevailing concepts concerning the guidance mechanism has to be corrected in at least two respects: the top speed limit for the wheel/rail system - if existing at all - is above 500 km/h; and the amount of energy converted in the wheel-to-rail contact, the wheel wear, the track wear and obviously also the rolling noise can be substantially reduced by the use of individually driven wheels. Running gears with individually driven wheels can be built at minimum cost, as shown by the example of the two-bogie unit with individually driven wheels. (Edited author abstract) 6 refs. In German.

Frederich, Fritz (Technische Hochschule Aachen, Aachen, West Ger). *Z Eisenbahnes Verkehrstechn Glaser's Ann* v 111 n 6 Jun 1987 p 171-179.

**088622 WEITERENTWICKELTE GUETERWAGEN-DREHGESTELLE DER DEUTSCHEN BUNDESBahn FUER 22,5 t RADSATZLAST - WIEDER NACH DEM LENKACHSPRINZIP.** [German Federal Railway's Improved Freight Car Bogies for 22.5-Ton Axle Load Retain the Principle of Radial Axle Adjustment]. About 10 years ago, German Federal Railway placed new production-type bogies for Class 665 into service. Despite good experience and low maintenance costs, a thorough modification became necessary in order to improve the cost effectiveness and to match the brake to the more severe demands due to higher speeds at an axle load of 22.5 t. Well-proven components, such as the standard wheelset for an axle load of 22.5 t, the parabolic spring and many parts of the link suspension and brake rigging, have been retained. Radial axle adjustment, featuring minimum track stressing especially on routes with many curves, was

also retained. The new bogies have meanwhile been internationally adopted as standard equipment together with the reinforced Y 25 L bogies. (Edited author abstract) 20 refs. In German.

Mueller, Lothar (Bundesbahnberrat, Minden, West Ger); Niermeyer, Wilfried. *Z Eisenbahnes Verkehrstechn Glaser's Ann* v 111 n 6 Jun 1987 p 188-197.

**088623 UNEVEN AND ACCELERATED WHEEL WEAR IN STANDARD THREE PIECE BOGIES.** In practice, a wide range of wheel wear rates are found on standard three piece bogies used for heavy haul applications. Identification of the major causes of this variance in wheel wear rate procedures or design tolerance bogie maintenance in real cost savings. This paper considers those factors concerned directly with bogie symmetry that will affect bogie wheel wear performance. Two bogie computer models developed at B.H.P.'s Melbourne Research Labs. for investigating vehicle and track operations at Mt. Newman Mining and Hammersley Iron, are used to quantify bogie performance. 3 refs.

Stone, P.M. (BHP, Melbourne Research Lab, Aust). *Mech Eng Trans Inst Eng Aust* v ME 9 n 4 Nov 1984 p 290-294.

**088624 NEUE ERKENNTNISSE UEBER DAS VERSCHLEISSVERHALTEN VON GUETERWAGENDREHGESTELLEN.** [New Findings Concerning the Wear Behavior of Freight Car Bogies]. The wear characteristics of the wheel/rail system are an essential criterion in assessing existing or new bogie designs. Based on test results obtained on roller rigs, a model is developed for estimating the loss of material to be expected at the wheel-rail interface. The wear behavior of the three basic car bogie designs is illustrated by the examples of the Y 25 rigid-axle bogie of the French National Railways, the type 665 steerable-axle bogie of the German Federal Railway (DB), and the cross-anchor bogie of South African Transport Service (SATS). The Y 25 rigid-axle bogie proves to be particularly unfavorable in terms of wheel and rail wear. There is little difference between DB's steerable-axle bogie 665 and the SATS cross-anchor bogie. On the whole, the cross-anchor bogie shows better performance with regard to the amount of material loss due to wear and the loss of material as a function of the wheel profile. (Edited author abstract) In German. 25 refs.

Specht, Wolfgang. *Z Eisenbahnes Verkehrstechn Glaser's Ann* v 111 n 9 Sep 1987 p 271-280.

**088625 PRUEFUNG VON DREHGESTELLRAHMEN FUER REISEZUGWAGEN NACH DEM UIC-MERKBLATT 515 VE.** [Testing of Bogie Frames for Passenger Cars According to UIC Leaflet 515 VE]. Appendix 4 of UIC Leaflet 515, relating to the testing of bogie frames, has been revised in order to meet the requirements for up-to-date design of bogies and to cover the possibilities nowadays available in the field of proof testing. Based on experience made available by a few European railways, the leaflet specifies the procedures for proving the ability of the frames to resist plastic deformation at abnormal loads and the fatigue strength of this highly and intricately stressed component. The ability to withstand plastic deformation is proved by a static test during which exceptionally high forces are simultaneously applied to the frame in the vertical and lateral directions. The fatigue strength is proved by static simulation of dynamic service conditions and by means of the fatigue test. With static simulation, the most important force combinations arising during service are compared in a manner enabling the stresses measured to be analyzed with the aid of fatigue strength diagrams. The force combinations are the conclusive extract from the cumulative operating stress endured during a period of 30 years. The fatigue strength of the bogie frame can be experimentally verified within a period of two to three months by repeated application of the cyclically varying quasi-static and dynamic force components. All three tests are



required for proving the cyclic strength and thus form an integrated test program. (Edited author abstract) In German. 7 refs.

Leluan, Alain (SNCF, Vitry-sur-Seine, Fr); Schenk, Herwig. *Z Eisenbahnes Verkehrstechn Glaser's Ann* v 111 n 9 Sep 1987 p 287-293.

**088626** COMPORTAMENTO IN CURVA DEI CARRELLI FERROVIARI AD ASSILI E A RUOTE INDIPENDENTI. [Behavior on Curves of Rail Bogies with Axles and with Independent Wheels]. A comparison is made between the trim and the forces acting in curves on traditional bogies and on bogies with independent wheels, using a static mathematical model defined and checked with experimental on-line tests, carried out by the Office IV of the FS Rolling Stock and Motive Power Department. (Author abstract) In Italian. 5 refs.

Panagin, Romano. *Ing Ferrov* v 42 n 9 Sep 1987 p 485-504.

**088627** DIE VERWENDUNG VON RADIAL GESTEUERTEN RADSATZEN FUER TRIEBFAHRZEUGE. [Use of Radially Steered Wheel Sets for Traction Units]. South African railways (SATS) have developed a new bogie with self-steering wheel sets for traction units. For curves of radius greater than 120 m flange contact is completely avoided. The design is now in the prototype stage for trial in two twin units of the Vienna U-bahn. SATS will fit these bogies for the first time into the BR 14 E locomotive. (Edited author abstract) In German. 5 refs.

Scheffel, Herbert (South African Transport Services, Pretoria, S Afr). *Elektr Bahnen* v 85 n 11 1987 p 359-362, 364.

**088628** RUNNING OF RAILWAY VEHICLES THROUGH SMALL-RADIUS CURVES - STANDARD-DESIGN BOGIE AND BOGIE WITH SELF-STEERING AXLES. The ability of bogies to round small-radius curves - without creep or wheel flange-rail contact - eliminates derailment risks, reduces wheel and rail wear appreciably, and improves energy efficiency. For many railways, it is the decisive criterion for selecting a particular type of rolling stock. This article analyses the results obtained with a mathematical model simulating the semi-static behavior of the bogie in a small-radius curve. Results obtained with a conventional-design bogie are compared with those recorded, under matching test conditions, with a self-steering bogie on which considerable research has been conducted in South Africa.

Joly, R. *Rail Int* v 19 n 4 Apr 1988 p 31-42.

**088629** LASTKOLLEKTIVE FUER EISENBAHN-RADSATZLAGERGEHAUSE. [Service Loading Combinations for Railway Axlebox Housings]. Service loading combinations are an important prerequisite for the effective use of finite-element programs in the design of railway axle-box housings. Since the rail system is not in a homogeneous condition, a variety of loading combinations are derived to cover the external influences in an optimum manner. This is done by describing the track conditions in subnetworks as precisely as possible and by evaluating the data by mathematical modelling of equivalent systems representing the track-vehicle system. To calculate the loading combinations, the operating conditions, the magnitude and sequence of the operating loads and the damage accumulation hypotheses must be taken into consideration. The latter are also used to determine the remaining life of the axle-box housings. The individual loading combinations are mixed according to the probability of their occurrence to form the global service loading combination. Apart from being clearly organized, this method of deriving the global service loading combination offers the benefit of modelling any desired track system by combining and weighting stored or standardized loading combinations of subnetworks. (Author abstract) 4 refs. In German.

Waechter, Klaus; Geyer, Karl-Eberhard. *Z Eisenbahnes Verkehrstechn Glaser's Ann* v 112 n 3 Mar 1988 p 90-96.

**088630** FAHRDYNAMIK VON LAUFDREHGESTELLEN FUER HOHE GESCHWINDIGKEITEN, ERLAUTERT AM DREHGESTELL MD 52-350 FUER ICE-MITTELWAGEN. [Dynamics of the Movement of Unpowered High-Speed Bogies, Explained by the Example of the MD 52-350 Bogie for ICE Centre Cars]. Following a description of design features governing the running behaviour, MD 52-350 bogie test results are presented. In trial runs, 345 km/h have been reached so far without exceeding any limit values. Running behaviour simulations were carried out on a rolling test stand at speeds of up to 385 km/h. Calculations of the running behaviour are compared with test results. 7 Refs. In German.

Lohmann, Alfred (Waggon Union, Siegen, West Ger); Bieker, Guido. *Thyssen Tech Ber* v 20 n 1 1988 p 111-118.

**Brakes** See Also RAILROADS—Automatic Train Control.

**088631** BEHAVIOR OF PHOSPHIDE EUTECTIC IN CAST IRON AT THE WORKING TEMPERATURE OF BRAKE SHOES. The consumption of cast iron brake shoes in rail transport systems can be reduced by prolonging their useful life. The most promising way of enhancing the performance of cast iron is to alloy it with phosphorus. The wear resistance and friction properties of the shoes will depend on the amount and properties of the phosphide eutectic. A study has been made of the structure and properties of the phosphide eutectic in cast iron at the working temperature of the brake shoes in railroad rolling stock. Examinations of the surface layers on high-phosphorus iron specimens have shown that the phosphide eutectic plays a significant part in the formation of brake shoe surfaces. Due to the presence of both phosphides and phosphates, the surface layer acquires phenomenal properties, including superior flowability, seizure resistance and resilience, which contribute towards high friction properties and wear resistance.

Levintov, B.L.; Larin, T.V.; Astashkevich, B.M.; Bashava, L.A. *Sov Cast Technol* n 3 1986 p 5-7.

**088632** LES EQUIPEMENTS DE FREINAGE DES FUTURES RAMES TGV TRAINSET. [Brake Gear on Future Atlantic TGV Train-Sets]. The brake gear to be installed in the Atlantic TGV trainsets incorporates the latest technological developments. In particular, the selection of nonventilated high-power discs, with sintered metal linings and a high-performance antiskid device, ensures good braking at the maximum speed of 300 km/h and obviates any need for wheel braking on carrying bogies. The brake gear is lighter, running noise is less and traction power consumption is reduced. The extensive use made of electronic equipment has brought the quality and safety of braking up to a high standard and simplifies maintenance. (Edited author abstract) In French.

Boiteux, Michel (SNCF, Fr); Christians, Bernard. *Rev Gen Chemins Fer* v 106 n 9 Sep 1987 p 7-20.

**088633** ON THE COOLING OF DISC BRAKES ON A TRAIN. This article describes experiments to measure cooling rates of wheel mounted brake discs in a train. The results obtained compare well with the laboratory data and theoretical predictions. It is concluded that shielding by preceding structures under the train, by the wheel rim and pads can reduce cooling appreciably. 6 refs.

Tanvir, M.A. *Rail Int* v 19 n 3 Mar 1988 p 37-42.

**088634** HIGH SPEED FRICTION CHARACTERISTICS OF METALLIC MATERIALS FOR BRAKE DISCS. Cladding materials, forged steel, etc., have been proposed as new brake disc materials, because their resistance to thermal crack propagation is higher than that of conventional disc materials, and they can be used with high-speed rolling stock. Past investigations have confirmed that they possess high resistance to thermal crack propagation. In this paper, their friction and wear characteristics, as determined in high-speed friction tests of the linings used with the SHINKANSEN vehicles, are reported. It is concluded that the influence of the graphite

shape in cast iron on the friction and wear characteristics is negligible; cladding materials are useful to improve the total performance of brake discs; and the friction and wear characteristics of forged steel are different from those of cast iron. (Edited author abstract) 2 refs.

Tsujiyama, Taro (Metals Lab, Jpn). *Q Rep Railw Tech Res Inst (Jpn)* v 28 n 1 Mar 1987 p 29-32.

**088635** DYNAMIC PROCESSES CAUSED BY TRACK UNEVENNESSES IN BRAKED RAILWAY VEHICLES. Unevennesses always present in railway tracks give rise to vibrations in the vehicles moving along the rails. In vehicles equipped with direct friction-brakes, vertical exciting effects act upon the sprung vehicle parts through the brake suspension system with the intervention of friction-forces acting upon the wheel-sets when the brake gear is in action. The formation of a dynamic model is described which is suitable for the examination of exciting effects transmitted through the brake suspension system, and the description of the system is given as required for digital simulation taking into consideration a two-axle vehicle equipped with block-brakes. The results obtained can be applied directly to the case of bogie vehicles. (Edited author abstract) 6 refs.

Zobory, I. (Technical Univ, Budapest, Hung); Peter, T. *Period Polytech Transp Eng* v 15 n 2 1987 p 171-183.

**088636** DEVELOPMENT OF COMPOSITE MATERIAL TO SUIT THE RAILWAY APPLICATIONS. It is believed that most of the problems encountered in railway systems and wheel failures are due to the use of cast-iron brake linings. In this paper, new formulations of molded asbestos composites adequate for railway brake shoes are proposed. The new formulations consist mainly of fiber asbestos (chrysotil type) phenolic formaldehyde resin and other additives to moderate the tribological properties of the formulations. The proposed new composite materials were prepared and then tested to evaluate their mechanical and tribological properties. A great number of specimens were tested to allow the performance of statistical analysis. The aim of this statistical study is to control the preparation of the proposed formulations to obtain the least deviation from the standard mean. (Edited author abstract) 12 refs.

Kouta, F.H. (Cairo Univ, Egypt); Khatib, A.A.; Salama, M.S. *Modell Simul Control B* v 14 n 2 1988 p 23-38.

**088637** DER GROSSPRUEFSTAND UND ZUG-SIMULATOR DER KNORR-BREMSE. [Knorr's Full-Scale Test Rig and Train Simulator]. The full-scale test rig contains the full-size brake equipment of a 200-car train with a main brake pipe having a total length of 2500 m. The test rig is linked to a process computer for real-time calculation of brake forces from the measured brake cylinder pressures. The traction of the locomotive, the tractive resistance and the force due to running down gradients of a given line are also simulated by the computer. The computer continuously outputs the actual speed, the distance covered and line graphics. After completion of the test, the longitudinal forces and the accelerations at each car are computed from the stored data. This information serves to assess the riding comfort and the risk of train separation or derailment. The train simulator provides the manufacturers and their customers with an efficient, time-saving and cost-saving research tool for the investigation and selective improvement of the braking system. (Author abstract) 5 refs. In German.

Breinl, Walter; Gerum, Eduard. *Z Eisenbahnes Verkehrstechn Glaser's Ann* v 112 n 3 Mar 1988 p 76-82.

**088638** ELEKTRODYNAMISCHES BREMSSEN IN VERBINDUNG MIT DER STEUERUNG FUER REIBUNGSBREMSSEN. [Electrodynamic Braking in Combination with Control for Friction Brakes]. The braking systems used on today's rail vehicles have to meet stringent requirements with regard to brake performance, safety, economy and comfort. This paper describes the different brake control system configurations and their



characteristic features and discusses possible ways of supplementing the dynamic brake by the use of the friction brake. The methods used include, in particular, the various modes of blending. Examples are given to show how an optimum overall braking system can be obtained by combining the individual braking systems with due consideration of vehicle and system-related parameters and especially by making use of microprocessors. (Edited author abstract) In German.

Wagner, Rudolf (Siemens AG, Erlangen, West Ger); Lohmeier, Paul. *Z Eisenbahnwes Verkehrstechn Glaser's Ann* v 112 n 4 Apr 1988 p 119-124.

**088639 UNTERSUCHUNGEN MIT DER ZUSATZ-BREMSE BEI INDUSTRIEBAHNEN.** [Studies of the Performance of the Emergency Brake on Industrial Railways]. The BOA brake tables include only a general rule for determining the permissible vehicle weight to be observed in braking vehicles from the low speeds frequently experienced in the operation of industrial railways. Verein Deutscher Eisenhuettenleute has commissioned an investigation of the braking properties of rolling stock using only the locomotive brake (the emergency brake). More than 1000 stopping distance measurements made on a number of different industrial railways are being used as a basis for deriving a simplified formula for calculating the stopping distance and for establishing brake diagrams which show the relationship between the permissible stopping distance, the speed at commencement of application and the permissible vehicle weight for given locomotives and line conditions. The results obtained enable high vehicle weights to be hauled by such stock. (Edited author abstract) 6 refs. In German.

Voss, Gerhard (Univ Hannover, Hannover, West Ger). *Z Eisenbahnwes Verkehrstechn Glaser's Ann* v 112 n 4 Apr 1988 p 125-130.

**088640 EISENBAHN-SCHEIBENBREMSBELA-GE FUER HOCHLEISTUNGSBREMSEN.** [Railway Disk Brake Pads for Heavy-Duty Applications]. With the new concepts for fast passenger services (Intercity Express of the German Federal Railway and the TGV Atlantique of the French National Railroads, the requirements on the performance of brake discs as well as brake pads are constantly increasing. For some years the manufacturers of brake linings have been trying to avoid the use of asbestos fiber in their production of new friction materials. This article first outlines the present state of development of nonasbestos formulas. Then it discusses the limits for heavy-duty application of organic brake pads. In addition, the question of development, testing and application of sintered materials is considered, and new optoelectronic measuring-methods are explained. Finally, alternative friction materials are cited. (Edited author abstract) In German.

Franz, Peter (Jurid Werke GmbH, Reinbeck, West Ger). *Z Eisenbahnwes Verkehrstechn Glaser's Ann* v 112 n 4 Apr 1988 p 131-138.

**088641 AUSLEGUNG UND LEISTUNGSGR-ENZEN VON SCHEIBENBREMSEN.** [Design Characteristics and Performance Limits of Disc Brakes]. The load mechanisms and material properties which determine the performance limit of disc brakes on railroad vehicles are discussed. In addition, methods of evaluating the service life of disc brakes and brake pads with allowance for service load combinations are presented. (Edited author abstract) 5 refs. In German.

Saumweber, Eckart (Knorr-Bremse AG, Munich, West Ger). *Z Eisenbahnwes Verkehrstechn Glaser's Ann* v 112 n 4 Apr 1988 p 139-143.

**088642 DIE DYNAMIK BEIM BREMSEN SCHNELLFAHRENDER REISEZUEGE.** [Braking Dynamics of High-speed Passenger Trains]. Vehicles for international use within Europe are equipped with compatible automatic air brakes. Location of the controller at the air supply point means that no separate energy supply or control is required on the vehicle, but the effectively long line of flow of the control signal prohibits the

application of brakes simultaneously throughout the length of the train. Consequently, there is congestion and strain in the system and a need for extra braking as train length increases. With so-called braking accelerators these drawbacks can be alleviated, and, as is generally known, they can be avoided altogether with electropneumatic control, at the cost of extra equipment for the purpose. With correct coupling to the electric brakes on the locomotives all vehicles can be made to brake simultaneously and with similar retarding characteristics. (Author abstract). 10 Refs. In German.

Hendrichs, Wolfgang (Bundesbahn-Versuchsanstalt, Minden, West Ger). *Elektr Bahnen* v 86 n 6 1988 p 200-207.

**088643 DIE EP-BREMSE-NICHT NUR EIN BAUS-TEIN DES NOTBREMSEUEBERBRUECKUNG-SKONZEPTES.** [Electropneumatic Brake - Not Just a Component of a Standby Automatic Brake]. Following a brief discussion of the systems for direct and indirect control of the electropneumatic (EP) brake, the basic arrangement and mode of operation of the German Federal Railway's indirect system for control of the EP brake are described in detail. Mention is made of its characteristic features compared to a purely pneumatic brake. Owing to the completely uniform response of the brakes all the way down the train, no slack action develops while the brakes are being applied or released even on trains with the most adverse coupling conditions. On the basis of comprehensive tests on level track and gradients, the brake department of the railway's research institute at Minden determined a number of properties of the indirectly controlled EP brake. The EP brake operates in very fine steps and at a uniform and precisely adjustable rate. Accurate target braking is possible even for long passenger trains. Short application and release times are attainable with the EP brake without loss in riding comfort. To operate the indirect acting EP brake, the driver does not have to accustom himself to new conditions. Accurate target braking is possible right away. (Edited author abstract). 4 Refs. In German.

Hendrichs, Wolfgang (Bremstechnik und Bundesbah-noberrat, Minden, West Ger); Credner, Wolf-Dieter Meier. *Z Eisenbahnwes Verkehrstechn Glaser's Ann* v 112 n 6 Jun 1988 p 215-222.

**088644 DIMENSIONIERUNG UND VERGLEICH-BARKEIT VON SCHWUNGMASSEN - REIBUNG-SPRUEFFSTAENDEN.** [Dimensioning and Comparing Inertia Type Brake Dynamometers]. In the course of modernizing the test equipment installed in the brake department of the German Federal Railway's testing institute at Minden, the existing large brake dynamometer was equipped with an electronic inertia simulator at the end of 1987. The paper covers the physical relationships characterizing the operation of inertia-type dynamometers from idling to retarding braking with electronic inertia simulation and compares the results of recent performance tests. The comparability of the test results obtained with different types of inertia-type brake dynamometers is discussed as well. (Edited author abstract). In German.

Hendrichs, Wolfgang (Bundesbahn-Versuchsanstalt Min-den, Minden, West Ger). *Z Eisenbahnwes Verkehrstechn Glaser's Ann* v 112 n 5 May 1988 7p.

**088645 DAS STATISCHE, DYNAMISCHE UND THERMISCHE VERHALTEN VON MAGNET-SCHIENENBREMSEN.** [Static, Dynamic and Thermal Behavior of Electromagnetic Rail Brakes]. Recently, the eddy-current brake has been proposed as an adhesion-independent brake in addition to the electromagnetic rail brake used in railway operation for decades. As a basis of discussion for comparisons between the two braking systems the electromagnetic rail brake is evaluated with regard to static performance on the basis of laboratory tests with a brake balance and with regard to dynamic and thermal performance on the basis of the test runs on German Federal Railway lines. (Edited author abstract). In German.

Hendrichs, Wolfgang. *Elektr Bahnen* v 86 n 7 1988 p

224-228.

Components See CARS—Passenger; RAILROAD TRANSPORTATION—Magnetic Levitation.

## Computer Simulation

**088646 REAL-TIME SIMULATION FOR TRAF-FIC CONTROL COMPUTER OF NEW KRT TRAN-SIT SYSTEM.** A real-time simulation system for the KRT (Kobelco Rapid Transit System) traffic-control computer has been developed. It is useful in each stage of design, programming, debugging, and practical training of the computer. This paper describes the configuration, functions, outline of processing, and features of the simulation system. (Author abstract) In Japanese. 2 refs.

Abe, Makoto; Ozawa, Takeshi. *R&D Res Dev Kobe Steel Ltd* v 37 n 4 Oct 1987 p 53-56.

## Control

**088647 VYVOJ AUTOMATICKYCH REGULAC-NICH SYSTEMU DIESELELEKTRICKYCH KOLEJOVYCH VOZIDEL ZAMERENYCH NA US-PORY MATERIALU A SPOTREBY ENERGIE V PROVOZNICH PODMINKACH.** [Development of Automatic Control Systems of Diesel-Electric Railway Vehicles Aimed at Saving of Materials and Energy Consumption in Service]. The historical development of electric transmission systems is discussed. Attention is mainly on their control systems. Diesel-electric transmissions are analyzed with dc and induction traction motors, and different control systems ranging from contact controllers to modern digital controllers are discussed. The diagnostics of diesel-engines and electric transmission operation are examined. Perspectives on the development of large power diesel-electric transmissions and new driving systems are presented. (Edited author abstract) In Czech. 11 refs.

Jansa, Frantisek. *Elektrotech Obz* v 76 n 11 Nov 1987 p 631-637.

Control Systems See Also CARS—Computer Simu-lation.

**088648 MIKROCOMPUTER-ANTRIEBSS-TEUERUNG FUER ICE.** [Microcomputer Traction Control for Intercity Expresses]. The SIBAS-16 microcom-puter control system for railway vehicles has hitherto been primarily targeted toward local services. It has proved itself well able to cope with all present-day traction needs such as dc current supplies and controls. The traction control apparatus of the ICE is the first application of SIBAS-16 techniques to a traction system with four-quadrant working, voltage regulation, and variable-frequency operation. The modular structure of the hardware and software is retained, and the expenditure on electronics is expected to be reduced by 40 percent compared with existing techniques. (Edited author abstract). 7 Refs. In German.

Gedeon, Georg; Klausecker, Karl; Lang, Wolfram. *Elektr Bahnen* v 86 n 7 1988 p 229-235.

Corrosion Protection See CARS—Freight.

## Deformation

**088649 FESTIGKEIT VON REISEZUGWAGEN-DAECHERN URSACHEN DER BEI SERIENWA-GEN DER BAUART BPMZ 291 AUFGETRETENEN VERFORMUNGEN IM DACHBEREICH TEIL 1.** [Strength of Passenger Coach Roofs. I. Causes of the Roof Deformations Occurring in Coaches of the Bpmz 291 Series]. From 1981 until 1986, a total number of 500 second-class Bpmz 291 open-style coaches were purchased. During service, abnormal damage (undulations) occurred in the roof above the fourth window near the middle of the coach, partly in localized areas, but in most cases extending across the entire section. Damage of this kind was detected for the first time in September 1985, but has meanwhile been experienced on about 35 percent of all



coaches. It can be concluded from the uniform appearance of the defects experienced and still being experienced that the roof structure is subjected to excessive compressive forces which, in conjunction with superimposed oscillations, cause buckling of the filigree type beaded sheet material. Neither abnormally high stresses due to the service conditions nor inadequate dimensioning of the body structure, consisting of a vertically loaded beam resting on two supports with cantilevers, can be ruled out as the cause of the failures. To investigate the mechanism of the unprecedented, frequent failures and to identify their probable cause, the loading conditions were simulated on adequately sized compression test specimens. As expected, it was thus possible to reproduce the kind and scope of the failures in accordance with the original event. Using different plate dimensions (bead spacing, plate thickness, transition radius) and materials, it was experimentally confirmed that optimized dimensions will result in a considerably higher safety against failure not only for larger but also for smaller roof sections. (Edited author abstract) In German.

Bayer, Otto. *Z Eisenbahnwes Verkehrstsch Glasers Ann* v 112 n 6 Jun 1988 p 208-214.

**Design** See Also ELECTRIC RAILROADS—Sydney, Australia; RAILROADS—Austria; RAILROADS—France.

**088650 NEUE DOPPELTRIEBWAGEN MIT ADHAESIONS- UND ZAHNRADANTRIEB FUER DIE BAYERISCHE ZUGSPITZBAHN.** [New Rack-Rail Twin Self-Propelled Units for the Bayerische Zugspitzbahn]. The Zugspitze, the highest mountain in West Germany (2966 m), is reached by a meter-gauge rack-railway, which is operated by the Bayerische Zugspitzbahn. Services are, in part, still made up of the original rolling stock built in 1930. To retire these maintenance-intensive coaches, but primarily to improve the timetable and to shorten the journey time, it was decided to purchase new coaches. The rolling stock to be procured will consist of short-coupled twin sets for rack-rail operation. The two car bodies of lightweight steel construction are supported on four identical bogies, each of which is equipped with a downhill driving axle and an uphill carrying axle. The gearing can be changed over for the adhesion or rack mode. The electrical equipment includes freon-cooled dc choppers and a microcomputer-based system for control functions. The braking equipment, comprising five braking systems, is specifically designed to meet the requirements of the rack mode. The safety equipment accounts for the complicated conditions resulting from two different modes of operation and two rack sections with different top speeds. The vehicles are still under construction and have been scheduled to be placed in service in mid-1987. (Edited author abstract) In German.

Ehrhardt, Paul (Bayerische Zugspitzbahn AG, Garmisch-Partenkirchen, West Ger). *Z Eisenbahnwes Verkehrstsch Glasers Ann* v 111 n 4 Apr 1987 p 115-123.

**088651 NEUE INTERCITY-WENDEZUEGE FUER DEN VERKEHR ZWISCHEN DEN NIEDERLANDEN UND BELGIEN.** [New Intercity Push-Pull Trainsets for Service Between the Netherlands and Belgium]. Both the Belgian Railways (SNCB) and the Netherlands Railways (NS) have decided to replace their old push-pull sets operating on the heavily worked line between Amsterdam and Brussels by new ones. SNCB has ordered 12 Class 11 dual-voltage locomotives and Netherlands Railways' order for 59 passenger coaches includes 11 driving trailers. This paper covers the mechanical equipment of the locomotive and contains a particularly comprehensive description of the electrical equipment which is partly required to meet very exacting requirements such as, for instance, regarding the maximum permissible rms value of the harmonic currents in both networks. The passenger coaches and driving trailers are described in great detail by referring to the plan views and to all components, such as unfinished car bodies, large capacity compartments, kitchen facilities, telephone box, running gear, brakes, heating and ventilation systems and power supply. (Edited author abstract) In German.

Venemans, Dirk Willem (NV Nederlandse Spoorwegen, Utrecht, Neth); Schoester, Adriaan; Squilbin, Michel; Schmidt, Rolf. *Z Eisenbahnwes Verkehrstsch Glasers Ann* v 111 n 7 Jul 1987 p 208-219.

**088652 DIE NEUE GENERATION VON HOCHGESCHWINDIGKEITSZUEGEN DER SNCF - DIE FAHRZUEGE FUER DIE STRETKE TGV ATLANTIQUE.** [New Generation of High-Speed Trains of the SNCF Rolling Stock for the TGV Atlantic Line]. For its new high-speed TGV Atlantic line, the SNCF has developed modified versions of the present TGV Sud-Est sets. A wide range of fundamental features has been retained, especially in the field of safety. New items include the use of three-phase synchronous traction motors, heavy-duty anti-lock disc brakes with microprocessor control, and an improved pantograph for 300 km/h running. Interior comfort has been enhanced considerably. (Author abstract) In German.

Lacote, Francois (SNCF, Paris, Fr). *Elektr Bahnen* v 85 n 7 1987 p 227-234.

**088653 NETWORK ROLLS OUT WESSEX ELECTRICS.** The new five-car Class 442 EMU's are to be used for the London-Weymouth service upon completion of the Bournemouth-Weymouth electrification in May 1988. Based on the successful MkIII coaches developed in the early 1970s, the Class 442s have full air-conditioning and a combination of face-to-face and face-to-back seating. The first Southern Region units designed for 160 km/h, they have 23 m car bodies against the former standard of 20 m. To keep down the £37 m cost of the 24 sets, they use 750 V dc traction motors and camshaft resistance switching recycled from the 1966 built Class 432 sets which they are replacing.

Anon. *Railw Gaz Int* v 144 n 2 Feb 1988 p 113.

**088654 IC-EXPRESS: DER NEUE TRIEBZUG FUER DEN HOCHGESCHWINDIGKEITSVERKEHR DER DB.** [IC-Express: the New Multiple Unit for High-speed Traffic on the German Federal Railway]. Distinctly reduced running times and improved comfort will characterize the Intercity-Express (ICE). From 1991, 41 ICE multiple units with about 250 to 280 km/h will be utilized on the two new high-speed lines Mannheim-Stuttgart and Hannover-Wuerzburg. The construction of the traction units started in 1987; the construction of the intermediate coaches is scheduled to start in 1988. (Edited author abstract) In German. 4 refs.

Voss, Martin (Hauptverwaltung der DB, Frankfurt am Main, West Ger). *Elektr Bahnen* v 85 n 9 Sep 1987 p 299-306, 308-309.

**088655 SHUTTLE BIDDERS FACE TECHNICAL CHALLENGE.** Designing wagons to carry cars, buses and lorries under the English Channel at 160 km/h presents formidable problems; critical components will be prototyped to ensure that fire hardness and environmental standards can be met. The need for a number of detail changes has emerged since conceptual designs were prepared in 1986. The largest passenger-carrying rail vehicles ever built (in terms of gross volume) are now to be even bigger, with the width of the single-deck tourist shuttles increased by 100 mm to 4.1 m. Gone are the picture windows, banished by the need for shuttle wagons to contain a fire for 30 min - long enough for a train to clear the Tunnel and enter a special emergency siding at either terminal. They are replaced by armored glass 'portholes'. A major change is the decision to standardize platform height at 1 050 m above rail, instead of having alternate high and low platforms for the double-deck shuttles. This has led to a need to alter the design of the double-deck shuttles. The single-deck tourist shuttle loading wagons are also different with half the length of the wagon being covered by telescopic sliding hoods.

Anon. *Railw Gaz Int* v 144 n 3 Mar 1988 p 182-183.

**088656 DAS KONZEPT INTERCITY - EXPRESS ALS SYSTEMKOMPONENTE EINES KUENFTIGEN HOCHGESCHWINDIGKEITSVERKEHRS.**

[Intercity Express As a System Component of a Future High-Speed Transport Network]. With the procurement of the electrically powered trainsets, following the end of the project planning phase for a normal production train, the Intercity Express (ICE) project is now on the verge of implementation. A wide spectrum of products and facilities, based on faster and more comfortable trains, such as Intercity (IC), Euro-City (EC) and Interregio (IR), and linked to the future ICE lines, is intended to strengthen the position of Deutsche Bundesbahn in the transport market. This paper describes the requirements to be met by the new generation of vehicles due to the extensive test program performed with the Intercity Experimental and gives a look at possible applications of the ICE technology in high-speed freight traffic and in the form of an 'IC-Europa' in a future European high-speed network. (Edited author abstract) 5 refs. In German.

Spoehrer, Walter (Abteilung Elektrotechnik, Munich, West Ger). *Z Eisenbahnwes Verkehrstsch Glasers Ann* v 111 n 11-12 Nov-Dec 1987 p 363-370.

**088657 HOCHGESCHWINDIGKEITZUG X2 FUER DIE SCHWEDISCHEN STAATSBAHNEN.** [X2 High-Speed Train for Swedish State Railways]. Swedish State Railways have planned a high-speed network which can be reached via short links by 70% of the Swedish population and will be fully operational in 1993. An order for 20 six-car trainsets of Class X2 was placed with Asea Traction. The trainsets, equipped with high-performance ac drives, bogies with 'resilient' axle adjustment and an active body tilt control system, can negotiate curves at a 30% higher speed. Journey times on the Swedish network lines with many curves can thus be shortened by up to 25% without making any changes to the permanent way. This paper describes the background of the high-speed project, the concept of the new train, the design of the mechanical and electrical equipment, as well as the control systems of the power car and the coaches. (Edited author abstract) In German.

Lundgren, Jan (Asea Traction AB, Vaesteras, Swed). *Z Eisenbahnwes Verkehrstsch Glasers Ann* v 111 n 11-12 Nov-Dec 1987 p 393-400.

**088658 I TRENI ETR 500 PER IL SISTEMA AD ALTA VELOCITA DELLE FS.** [ETR 500 Trains for the FS (Italian State Railroads) High-Speed System]. The ETR 500 trains are designed to be integrated into the High-Speed System. This article summarizes the problems connected with the typological choice of the stock and the directions followed in the design of the trains to take account of the peculiarities of high-speed running. (Author abstract) 4 refs. In Italian.

Casini, Carlo (Direzione Centrale Materiale Rotabile, Italy). *Ing Ferrov* v 43 n 1-2 Jan-Feb 1988 p 7-27.

**088659 LOESUNGSKONZEPTIONEN FUER PERSONENUEBERGAENGE UND EINSTIEGSTUEREN IN DRUCKTUECHTIGEN REISEZUEGEN DES HOCHGESCHWINDIGKEITSVERKEHRS.** [Concepts for Corridor Connections and Doors in Pressure-Tight High-Speed Passenger Trains]. The rolling stock for the planned high-speed passenger traffic on the German Federal Railway's new lines with high proportions of tunnels must be pressure-tight to a certain extent. This includes pressure tight corridor connections between the cars and pressure-tight passenger doors. Both components had to be newly developed. While different technical solutions were obtained for the corridor connections on the permanently coupled Intercity Express (ICE) trainsets with power cars at the ends and on the UIC-compatible passenger coaches, which can be grouped in a variety of configurations, the design concepts for the passenger doors are universally applicable. The solutions adopted by the railway are described. (Edited author abstract) 5 refs. In German.

Ortmann, Werner (Bundesbahn-Zentralamt Minden, Minden, West Ger). *Z Eisenbahnwes Verkehrstsch Glasers Ann* v 112 n 1 Jan 1988 p 19-32.



**088660 DRUCKERTUECHTIGTE UEBERGANGSTUEREN, FENSTER UND WAGENKAESTEN FUER REISEZUGWAGEN DES HOCHGESCHWINDIGKEITSVERKEHRS.** [Pressure-Tight Corridor Connections, Windows and Car Bodies for High-Speed Passenger Trains]. A completely pressure-tight passenger coach must be equipped with pressure-tight corridor connections and windows and with a pressure-tight body. This paper describes the technical measures to be implemented to convert the corridor connections, windows and bodies of existing passenger coaches to a pressure-tight design. (Author abstract) 4 refs. In German.

Fabel, Peter (Innovative Fahrzeugausstattungen MbH, Fuerth, West Ger); Hoffmann, Eberhard. *Z Eisenbahnwes Verkehrstech Glasers Ann* v 112 n 1 Jan 1988 p 33-35.

**088661 EASTERN OPERATORS EYE BI-LEVELS.** Double-deck commuter coaches are about to reappear in the eastern U.S. The Long Island Rail Road has placed an order for a dozen prototype locomotive-hauled bi-level coaches. LIRR's double-deckers, capable of seating 180 riders vs 120 on standard coaches, will go into test service in the fall of 1990 on the railroad's Port Jefferson branch. Not long after LIRR places its prototype order, the Massachusetts Bay Transportation Authority plans to issue an RFQ for 60 to 100 locomotive-hauled bi-levels to serve Boston area commuters. An interested bystander will be New Jersey Transit Rail Operations, which later this year may take its first steps toward acquiring around 50 bi-levels. Bi-level cars are already being successfully used on commuter lines out of Chicago and San Francisco.

Anon. *Railw Age* v 189 n 4 Apr 1988 p 55-56.

**088662 DER NEUR KLIMATISIERTE ABTEIL-/GROSSRAUM-REISEZUGWAGEN 2. KLASSE DER DEUTSCHEN BUNDESBahn.** [German Federal Railway's New Air-Conditioned Second-Class Compartment/Saloon Coach]. Since 1981, a new concept for the interior design of a compartment vehicle has been developed as part of a program for air-conditioning the second-class rolling stock for intercity services. The developing and building of prototypes for a 26.4-meter long compartment coach, having a total of 64 seats, with conventional compartments and saloon-type compartments at mid-span of the vehicle were started in 1986, using the design of the existing air-conditioned second-class saloon coach as a basis. The interior fittings include new, reclining seats with a glass-reinforced plastic shell. Each seat has a folding table integrated into the arm rest. The seats are arranged in groups of six, four and two and as single seats. New luggage racks and lots of glass are characteristic features of the new interior design. To make the vehicles airtight when passing or entering tunnels on newly built lines, new corridor connections, end doors, passenger doors, retention toilets, an upgraded air-conditioning system with pressure ventilators and pressure valves as well as airtight windows and a reinforced car body were developed. (Edited author abstract). In German.

Muenther, Juergen (Bundesbahn-Zentralamt Minden (Westf.), Minden, West Ger). *Z Eisenbahnwes Verkehrstech Glasers Ann* v 112 n 6 Jun 1988 p 196-203.

**088663 RIC-GROSSRAUMWAGEN FUER DIE DEUTSCHE REICHSBAHN.** [RIC Saloon Coaches for Deutsche Reichsbahn]. The commission to develop and build 10 first and second class saloon coaches has enabled VEB Wagonbau, Bautzen, to produce and put into service passenger coaches which meet the steadily growing international demands for higher comfort and higher speeds. Prompted by the development of these coaches, the subcontractors attended to a number of development problems and took the necessary steps to implement series production. All efforts were planned to make new assemblies and equipment available for all future versions of the new train. The assemblies and the two types of saloon coaches are briefly described. The 10-coach train was subjected to comprehensive tests and trial runs and placed in regular service in the Deutsche Reichsbahn network in January 1986. The train has so far been running on the Berlin-Rostock and Berlin-Prague routes and will also be

used for service between Dresden and Berlin. (Edited author abstract). In German.

Steinborn, Guenter (VEB, Bautzen, West Ger); Wilke, Ralf. *Z Eisenbahnwes Verkehrstech Glasers Ann* v 112 n 6 Jun 1988 p 204-207.

**088664 DER NEUE ELEKTRISCHE TRIEBZUG DER ITALIENISCHEN STAATSBahnen, BAUREIHE ETR 450, FUER DEN HOCHGESCHWINDIGKEITSVERKEHR - EINE FORTENTWICKLUNG DES 'PENDOLINO'.** [Italian State Railways' New Class ETR 450 Electric Trainset for High-Speed Service - a Further Development of the 'Pendolino']. Following successful trial runs of the Class ETR 401 prototype train with tilting suspension, known as 'Pendolino', Italian State Railways (FS) have developed the new Class ETR 450 to production-stage level. An order for 14 trains has been placed. This paper describes the different variants of car construction, the light-alloy structure of the car bodies and their interior fittings, the bogies and their drive system and the electrical equipment. In conclusion, a brief description is given of Italian State Railways' Class ETR 500 high-speed train planned for the nineties. (Edited author abstract). 4 Refs. In German.

Messerschmidt, Wolfgang. *Z Eisenbahnwes Verkehrstech Glasers Ann* v 112 n 5 May 1988 p 163-4,166-8.

**088665 PROCEEDINGS OF THE 1988 JOINT ASME-IEEE RAILROAD CONFERENCE.** This conference contains 20 papers. The subject matter concerns the design, fabrication, testing and operation of railroad rolling stock, plants and structures, advanced control systems, and communication systems. These items are associated with freight vehicles, subways, rapid transit equipment and commuter transportation. Economic considerations are discussed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Hawthorne, V.T. (Ed.) (LTK Engineering Services, Philadelphia, PA, USA); Kneschke, T. (Ed.). *Proc of the 1988 Joint ASME-IEEE Railroad Conf, Pittsburgh, PA, USA, Apr 13-14 1988* Publ by ASME, New York, NY, USA, 1988 179p.

## Economics

**088666 EINKAUF VON SCHIENENFAHRZEUGEN - KONTINUITAET UND WANDEL IN DER BESCHAFFUNGSPOLITIK DER DEUTSCHEN BUNDESBahn.** [Purchasing Railway Rolling Stock. Continuity and Changes in the Purchasing Policy of the German Federal Railway]. Against the background of the 'DB 90' corporate strategy, which is aimed at an improvement of the economic situation of the German Federal Railway, the impact of purchasing-related services and costs on corporate success is gaining in significance to an ever increasing extent. Changes are bound to occur in the activities of the railway's purchasing departments both internally right from the start of the planning phase of an investment and externally in dealing with outside vendors. To improve productivity during the implementation of the 'DB 90' program, investment efforts must focus on fields where corporate success is to be expected in the medium and long term. The innovation in the purchasing sector manifests itself in the efforts made by the purchasing departments to activate the known and latent innovation potential of the market for the railway on a competitive basis, thus offering the most cost-effective solution to the operating units responsible for providing and selling the railway's services. (Edited author abstract). 2 Refs. In German.

Gemeinhardt, Wolfgang (Deutschen Bundesbahn, Frankfurt am Main, West Ger). *Z Eisenbahnwes Verkehrstech Glasers Ann* v 112 n 5 May 1988 p 159-162.

**088667 ENERGIEKOSTEN UND VERWENDUNG VON TRIEBFAHRZEUGEN IM NAHVERKEHR.** [Energy Costs and Use of Tractive Units in Short-Distance Traffic]. The Italian State Railways operate short-distance traffic on lines with heavy and light traffic. They use long train sets with locomotives of high performance and diesel and electric multiple units. Locomotives of class E 646 and E 424 and multiple units of class ALn 801, ALn 724 and ALn 668 and 663 are used for this purpose. On lines with heavy traffic the trend at present is toward an increase in comfort and a reduction in travel time. As criteria for decision-making the authors introduce the specific parameters of performance in kWh/seat, vehicle weight in t/seat, and energy consumption in kWh/seat. The kWh/seat ratio should have a value of 3 to 4. (Edited author abstract). In German.

Franchi, Riccardo (Ente Ferrovie Dello Stato, Florence, Italy); Zecchi, Ruggero. *Elektr Bahnen* v 86 n 8 Aug 1988 p 244-248.

## Electric Drive

**088668 L'AZIONAMENTO ELETTRICO DELLE MOTRICI DEL TRENO AD ALTA VELOCITA ETR 500 DELLE FERROVIE DELLO STATO.** [Electric Drive of the Power Cars for the Italian State Railroads High-Speed Train ETR 500]. After recalling the main performances and characteristics required by the FS for the high-speed train ETR 500, an illustration is given of the choices made in deciding the electric drive for the power cars. In the first place, the choice of the three-phase drive technique, which makes it possible to obtain the greatest specific power in the traction motors, an optimal exploitation of adhesion, high flexibility is illustrated. The type of three-phase drive is with voltage inverter and three-phase asynchronous motors, with a choice which favors the optimization of the motors and running dynamics, at the cost of a greater complexity of the converter and regulation, liable, however, to considerable simplification with the envisaged subsequent introduction of GTO converters and new control techniques with microprocessors. (Edited author abstract) In Italian.

Morisi, Luigi (Tecnomasio Italiano Brown Boveri, Italy). *Ing Ferrov* v 43 n 1-2 Jan-Feb 1988 p 35-40.

**Electric Equipment** See Also ELECTRIC RAILROADS—West Berlin.

**088669 L'EQUIPAGGIAMENTO ELETTRICO DEL TRENO ETR 500 PER IL SISTEMA AD ALTA VELOCITA DELLE FS.** [Electric Equipment of the ETR 500 Train for the FS (Italian State Railroads) High-Speed System]. A description is given in the article of the main characteristics of the electrical equipment of the ETR 500. In particular, examination is made of the traction drive and the choices made for the definition of the auxiliary services which form an integrated electrical system between the power and trailer units. Another important aspect developed for the ETR 500 is the system of remote control and automation of the train which permits the centralized control of all the train equipment with a high degree of reliability; lastly the problem of the diagnostics of the equipment and relative supervision system is dealt with. In Italian.

Gomisel, Giorgio (Direzione Centrale Materiale Rotabile, Italy). *Ing Ferrov* v 43 n 1-2 Jan-Feb 1988 p 28-34.

**Federal Republic of Germany** See RAILROAD TRANSPORTATION—Federal Republic of Germany.

## Fire Protection

**088670 FIRE PROTECTION ON TRAINS.** The hazards from fire in a moving vehicle are similar to the hazards from fire in a building and similar steps must be taken to detect the presence of fire, to prevent it from spreading and to extinguish it in this special circumstance. This paper describes the different methods that can be used to provide an effective fire protection system from trains. The various system requirements are set out and a selection is made of the type of system required and the equipment needed to perform each task. Each element of the system, consisting of detection, control and monitoring and extinguishment, is dealt with separately and its



advantages and disadvantages are given. Finally, an assessment is made of the applications of the system, and reliability, testing, maintenance and safety features are discussed. (Edited author abstract)

Dee, A.W. (Walter Kidde Co, Lichfield, Engl). *Proc Inst Mech Eng Part D* v 201 n 3 1987 p 217-227.

**France** See Also CARS—Springs and Suspensions.

**088671 LES CARACTERISTIQUES GENERALES DU TGV ATLANTIQUE.** [General Characteristics of the TGV Atlantique High-Speed Train]. The article presents the main characteristics of the future TGV-A in relation to the TGV-SE now in operation. The new line and connected cities and future car sets are reviewed. The performances, comfort, and savings are printed out. (Edited author abstract) In French.

Garde, R. (SNCF, Fr). *Soudage Tech Connexes* v 41 n 3-4 Mar-Apr 1987 p 82-87.

**Friction**

**088672 INVESTIGATION INTO THE STATE OF ADHESION BETWEEN RAILS AND WHEELS BY SLIPPING ADHESION TEST TRUCK.** Quantitative analysis of the phenomena of adhesion between the rails and wheels is essential to properly control the behavior of rolling stock. Therefore, a number of investigations have been carried out in many countries. However, most of these investigations have been made in laboratory rooms, the rate of slipping has been mostly within the minute range of creep, and the data obtained in them have not necessarily been in good compatibility with those of field tests. In view of this situation, the author designed and constructed a test truck based on an entirely new idea, and ran a passenger car equipped with this special truck on a test track in the JR Omiya Factory. Although the test distance was not long, the real state of the adhesion, which changes continuously along the direction of the rails, was clearly reproduced. (Edited author abstract). 6 Refs.

Nagase, Kazuhiko (Railway Technical Research Inst, Jpn). *Q Rep RTRI (Jpn)* v 29 n 2 May 1988 p 80-85.

**Inspection**

**088673 DIAGNOSETECHNIK UND IHRE BEDEUTUNG FUER DIE DEUTSCHE BUNDESBAHN.** [Diagnostic Techniques and Their Significance to the German Federal Railway]. Diagnostics can be useful in all fields of a railway enterprise that are concerned with the operation and handling of vehicles and stationary equipment. On-line diagnostic systems (internal diagnostics) permanently installed in the object to be diagnosed provide up-to-date information for the operating and maintenance staff, with plain-text displays and matching operator's controls serving as man-machine interfaces. Automatic self-diagnosis can be implemented as a convenient variant of the internal diagnostics by the use of microprocessors. Utilizing such a diagnostic system and integrating it into the vehicle structure, operating concept and maintenance strategy is a goal of both the German Federal Railway and international standardization efforts within the UIC. (Edited author abstract) In German.

Schultes, Guenter (Deutsche Bundesbahn, Mainz, West Ger). *Z Eisenbahntechnik Verkehrstechnik Glaser's Ann* v 111 n 5 May 1987 p 158-162.

**088674 DIAGNOSE BEI LOKOMOTIVEN UND TRIEBWAGEN IM FERN- UND NAHVERKEHR.** [Diagnostics for Locomotives and Trains for Long-Distance and Short-Distance Traffic]. The components of modern rail vehicles have become very complex in order to be capable of meeting the requirements with respect to safety, comfort and cost effectiveness. A significant step towards achieving the inherent goal of automatic failure diagnostics has been made possible by the use of novel digital data processing techniques. The possibilities for failure analysis increase with the amount of useful information available. For this reason, development is proceeding in the direction of distributed processing units which

are linked to a central fault memory by a bus system. Special events along with the necessary commands are presented to the driver on a display unit and are stored in nonvolatile read-write memories for the purpose of preventive maintenance. Data are evaluated by means of small visual display units, printers, recorders or PCs, enabling trained staff to identify the root causes within a short time. This development will eventually lead to wireless condition monitoring on a routine basis with storage of the results in a fully computerized data base. (Edited author abstract) In German. 3 refs.

Urbanke, Christian (Siemens AG, Erlangen, West Ger). *Z Eisenbahntechnik Verkehrstechnik Glaser's Ann* v 111 n 5 May 1987 p 163-168.

**Light Weight**

**088675 TRENDS IN WEIGHT REDUCTION OF ROLLING STOCK.** From the viewpoint of economical management, passenger car weight reduction is now an important theme of railway engineers in Japan. In this paper new technologies recently developed for weight reduction are described. For example, some new technologies concerned with improved aluminum alloy or stainless steel car bodies and bolsterless trucks are explained. In addition, weight reduction of passenger car seats, truck frames and wheel axles is mentioned. (Edited author abstract)

Arai, Hiroshi (Railway Technical Research Inst, Jpn). *Jpn Railw Eng* v 27 n 3 Dec 1987 p 2-4.

**088676 ENTWICKLUNG DES STAHLER X 5 Cr Ni Mo Ti 15 2 (WERKSTOFFNUMMER NR. 1.4589) FUER S-BAHNWAGEN.** [Development of the X 5 CrNiMoTi 15 2 Steel (Materials No. 1.4589) for Urban Railway Cars]. A discussion is presented of the development of the 1.4589 steel has made available to the manufacturer a material that enlarges considerably the range of stainless materials for the construction of railroad cars. This steel has made it possible to come much closer to the final goal of achieving cost-effective lightweight construction with increased travel security, maximum corrosion resistance and long service life. In German.

Werny, Kuno (Thyssen Edelstahlwerke AG, Krefeld, West Ger). *Thyssen Tech Ber* v 20 n 1 1988 p 127-135.

**Magnetic Levitation**

**088677 MAGLEV APPROACHES TOWARD PRACTICAL USE.** In 1970 Japanese National Railways began the development of a magnetic levitation transport system using superconducting magnets. In December 1979, a laboratory vehicle, the ML 502 attained a maximum speed of 517 km/h. Since 1980, numerous tests, such as multiple-unit operation, manned operation, and operation on a guideway with irregularities, have been carried out by the MLV001 vehicle with satisfactory results. This led to the construction of a prototype vehicle, the MLV002, which is described in this paper, as well as a circulating-current-type cycloconverter and a maglev system passenger transportation plan.

Tanaka, Hisashi (Railway Technical Research Inst, Jpn). *Jpn Railw Eng* v 27 n 1 Jun 1987 p 2-6.

**088678 DEVELOPMENT OF PERSISTENT-CURRENT SWITCH.** This paper presents an experimental persistent-current switch for superconducting coils of Maglev cars. The persistent-current switches, of which off-on operation is an alternation between normal state and superconducting state of a superconducting wire effected by heating and cooling, are attached to the ends of the superconducting coils of Maglev cars. To develop a light-mass and small-size persistent-current switch the on-state of which can be supplied with a large electric current while the off-state is given a high electric resistance. The author and his colleagues at the Maglev Laboratory designed and experimentally manufactured a switch consisting of 10 slender switch elements connected in parallel. Its mass was about 4kg, the current capacity being over 700A, and the off-state resistance about 100Ω.

(Edited author abstract). 2 Refs.

Nemoto, Kaoru (Railway Technical Research Inst, Jpn). *Q Rep RTRI (Jpn)* v 29 n 2 May 1988 p 56-61.

**Maintenance** See Also COAL MINES AND MINING—Underground Transportation; LOCOMOTIVES—Maintenance; RAPID TRANSIT—Singapore.

**088679 ANALYSIS METHOD OF MAINTENANCE DATA IN ROLLING STOCK RELIABILITY ADMINISTRATION - RELIABILITY ESTIMATION FROM RANDOMLY LEFT TRUNCATED AND RIGHT CENSORED DATA IN RESTORATION-RENEWAL PROCESS.** To evaluate and reconstruct a rolling stock maintenance system, it is necessary to know the reliability of the rolling stock and/or its equipment. Statistical analysis of field maintenance data is a powerful tool for reliability estimation, but two methodological problems must be solved in order to perform such an analysis. One is the data incompleteness, due to observation during a limited period. The other is a failure-mixture situation where in case of failure the equipment is renewed or partially repaired to be used again. In this paper, a maximum likelihood estimation method is proposed for analyzing these kinds of data. Assuming a Weibull lifetime distribution, the estimation error of this method is evaluated by Monte Carlo simulation. A modified version of the Kaplan-Meier estimate and the hazard plotting method for the same data is also developed. (Edited author abstract) 5 refs.

Fukuoka, Hiroshi (Transportation Planning Lab, Jpn). *Q Rep Railw Tech Res Inst (Jpn)* v 28 n 1 Mar 1987 p 25-28.

**Management**

**088680 PLANNING AND CONTROL OF TRACTIVE AND ROLLING STOCK: WHY NOT LEARN FROM OTHER SECTORS?** One way of improving performance within the planning and control of tractive and rolling stock is to look at, how other sectors do it. It is argued that the railway sector could learn from the road transportation sector in matters of goods transportation. In this sector there is tremendous development going on including extensive use of computers for planning, navigation, positioning and the whole area of goods information systems. In the paper an overview of this development is presented, including new technologies like digital maps, digital radio communication systems and satellite positioning systems. (Edited author abstract)

Matthiesen, P.H. (Deutsche Strassenbahn). *Rail Int* v 18 n 12 Dec 1987 p 37-39.

**Materials**

**088681 PASSENGER TRAINS.** Recent years have seen an upsurge in the development of new materials for use in passenger trains. These developments have taken place in three principal areas: bogie materials; materials for surface finishing; and, materials for cab and coach components. Performance, cost-effectiveness and, above all, safety are key factors in specifying new materials for surface and underground passenger trains. This article discusses cost problems, forgings and composites, and high-performance paints.

Sutton, Allan (British Rail Engineering, Derby, Engl). *Engineering (London)* v 228 n 4 Apr 1988 p 222-223.

**New Zealand** See LOCOMOTIVES, ELECTRIC—Design.

**Painting**

**088682 PROTECTION ET ESTHETIQUE DES VOITURES A VOYAGEURS.** [Protection and Esthetic Appearance of Passenger Cars]. The author describes the painting and anticorrosion surface treatment of the iron and steel parts used to make passenger cars during the different stages of their manufacture, including the very thin parts. In addition, a new high-performance plant for carrying out the painting and corrosion-protection operations is described. In French.



Pieton, Jean-Francois (Societe De Dietrich, Fr). *Rev Gen Chemins Fer* n 3 Mar 1988 p 33-37.

**Performance** See Also RAILROAD TRANSPORTATION—Management.

**088683** ERFABRUNGEN MIT ELEKTRISCHEN NAHVERKEHRSTRIEBWAGEN BEI DEN OESTERREICHISCHEN BUNDESBAHNEN. [Experience with Electric Suburban Railcars on the Austrian Federal Railways]. Since 1929, the Austrian Federal Railways (OeBB) have been utilizing EMU's (class ET 10) especially developed for suburban traffic. After 1945, the multiple unit class 4030 was developed with a classic drive technique for regional traffic in the greater Vienna area. This EMU has proved very well in the version of 1956. The class 4030.200 is a further development coping with the increased demands on the rapid transit system of Vienna. Finally, new aspects of suburban traffic have resulted in the development of the class 4020 EMU's with phase-angle control. A report is given on the operational experience and adaptation measurements on these 15 kv/16 2/3 Hz of the OeBB for areas with high population density. (Edited author abstract) In German. 4 refs.

Rotter, Richard. *Elektr Bahnen* v 85 n 10 1987 p 325-326, 328-335.

### Pressure Measurement

**088684** COMPRESSIBLE AND LEAKY TRAINS IN TUNNELS. It is hypothesized that phase differences commonly observed between computed and measured pressure histories in railway tunnels may be caused in part by reduced acoustic wave speeds in the annular regions of flow alongside trains. Such reductions in wave speed are shown to be a possible consequence of the compressibility of trains and/or the leakage of air into and out of trains. These effects are shown to be capable in principle of reducing the effective wave speed. (Edited author abstract) 8 refs.

Vardy, A.E. (Univ of Dundee, Scotl); Fox, J.A. *Proc Inst Mech Eng Part D* v 201 n 3 1987 p 209-215.

### Protective Coatings

**088685** ELASTOMERIC LININGS IN TANK CARS FOR CORROSIVE SERVICE. Rubber lining has been used for severe corrosion protection in tank cars for the past 45 to 50 years. Rubber properties, along with low durometer hardness, are essential for the performance of a corrosion protection system in a tank car. The chemical resistance and ability to withstand physical movement make rubber linings the ideal corrosion protection for the interiors of many tank cars. Of equal importance is the application of these materials to the steel tank car interiors. The rubber lining must be permanently vulcanized to the tank car interior with no leaks through the lining to the steel.

Haines, Fred H. (Proco Inc). *J Prot Coat Linings* v 4 n 11 Nov 1987 p 42-47.

### Repair

**088686** PROCES TECHNOLOGICZNY NAPRAWY WAGONOWYCH ZESTAWOW KOLOWYCH. [Technological Process of the Repair of Railway Car Wheel Sets]. A description is given of the repair process lines for railway car wheel sets at Ponar-Bipron's railway rolling stock repair plant. Problems connected with the repairs of the wheel sets in flow-type process lines are discussed, and some advances in the mechanization and automation of the transport and storage of wheel sets are cited. In Polish.

Joneczko, Jerzy (Ponar-Bipron, Zabrze, Pol); Debicki, Jerzy. *Przegl Mech* v 46 n 17 Sep 1 1987 p 10-14.

**Scheduling** See RAILROAD TRANSPORTATION—Traffic Control.

**Speed Control** See RAILROADS—Automatic Train Control.

### Stability

**088687** EXPERIMENTAL STUDY OF RAILWAY TRUCK DYNAMICS USING A ROLLING STOCK TEST APPARATUS. In order to clarify the hunting stability of railway trucks, a rolling stock test apparatus has been constructed. Several kinds of high speed trucks have been tested in the course of development of an advanced Shinkansen truck. A detailed description of the test procedure, typical test results, and the correlation with linear/nonlinear analysis is provided in the present paper. Through the experimental and analytical study, it has been clarified that we can properly investigate truck hunting behavior by using this apparatus and that the nonlinear analysis can give a quantitative explanation. (Author abstract) In Japanese. 8 refs.

Hirano, Yoshio; Sakamoto, Haruo; Ishikawa, Ryutaro; Yamamoto, Miyuki. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 492 Aug 1987 p 1735-1742.

**088688** LIMIT CYCLE BEHAVIOR OF A FLEXIBLE TRUCK. We calculate the variation in critical speed of a flexible truck as a function of limit cycle amplitude and truck parameters (i.e., shear and bending stiffnesses, and truck geometry), by means of a perturbation procedure. We find that the creep force nonlinearity is dominant, and that it can cause the nonlinear critical speed to be either lower or higher than the linear critical speed, depending on the values of the two stiffnesses. (Author abstract) 12 refs.

Whitman, A.M. (Villanova Univ, Villanova, PA, USA); Molyneux, J.E. *J Appl Mech Trans ASME* v 54 n 4 Dec 1987 p 930-934.

### Stresses

**088689** RADIAL AXLE FREIGHT CAR TRUCKS GENERATE SAVINGS. The standard (conventional or three-piece) truck holds two wheel sets parallel to each other and provides no mechanism to steer the wheels around curves. The wheels, therefore, approach a curve at a large angle of attack forcing the flange (the raised guiding edge) of a steel wheel against the rail and producing lateral force on the rail. The problem associated with conventional rail-car trucks have inspired the search over many years for an improved truck that would reduce wheel and rail wear. One of the solutions proposed, to which Canadian researchers have devoted considerable development effort over the last several years, has been the radial axle steering-arm truck.

Anon. *TRNews* n 134 Jan-Feb 1988 p 12-13.

### Structural Design

**088690** NEW RECOMMENDATIONS FOR THE STRENGTH DESIGN OF URBAN TRANSIT RAIL VEHICLES IN THE FEDERAL REPUBLIC OF GERMANY. The recommendations for the strength design of urban transit rail vehicles, developed on the basis of the guidelines and units of the new BOStrab regulations, contain some new features. These include specification of precise input data, such as vehicle loads, traction stresses, impact forces, etc.; easily repeatable representation and calculation of the various loads, applying the principle of progressive subdivision into modular groups; listing all stress combinations relevant to tram cars, enabling stress analysis in terms of yield strength and fatigue limit to be carried out with a considerably higher accuracy than so far possible; and application of lower safety factors in the stress analysis relating to the yield strength due to more precise input data and calculation methods. The new recommendations will thus contribute to improving the lightweight design required for urban transit rail vehicles. (Edited author abstract) 13 refs.

Bugarcic, Helmut. *Z Eisenbahnwes Verkehrstech Glaser's Ann* v 112 n 3 Mar 1988 p 83-89.

### Sweden

**088691** SWEDISH HIGH SPEED TRAIN. In August 1986 the Swedish State Railways (SJ) awarded a contract to Asa Traction for a fleet of 20 high speed trains for delivery between 1989 and 1994. The contract also includes an option on a further 32 trains for delivery later on. With the introduction of the high speed train, Sweden is taking a step forward comparable to the electrification of the main line railway network earlier this century. The result will be a 25 per cent reduction in travelling times.

Anon. *Energy Dig* v 16 n 4 1987 p 6-10.

### Telemetering

**088692** NEW GENERATION ETDS. CSXT now has 900 locomotives equipped with telemetry end-of-train devices. Bulk commodity, intermodal consists join cabooseless operations. Industrywide, end-of-train telemetry devices (ETDs) are used on more than 4,000 train starts per day compared to 1,700 in January 1985.

Anon. *Mod Railroads* v 42 n 11 Nov 1987 p 24, 26.

### Testing

**088693** LA NOUVELLE METHODE UIC D'ESSAIS DE CHASSIS DE BOGIES DE VOITURES. [New UIC Method For Testing the Frames of Passenger Car Bogies]. A new version of UIC Leaflet 515 defines the static tests to be made on all types of passenger car bogie frames before they are accepted for international traffic. A detailed description of these tests is given together with the justification for them, their advantages and their drawbacks. The manner in which these tests are interlinked and provide a double check is explained, as is the method by which they are carried out by the West German and French railways at their test centers at Minden and Vitry-sur-Seine, respectively. (Edited author abstract) In French.

Schenk, Herwig (DB, Minden, Germany); Leluan, Alain. *Rev Gen Chemins Fer* v 106 n 6 Jun 1987 p 5-16.

**088694** ROLLING STOCK TESTING PLANT CAPABLE OF TESTING AT A SPEED OF 450 KM/KM/H. The existing rolling stock testing plant of the Railway Technical Research Institute has become superannuated and requires renewal. The new plant will be a system capable of testing rolling stock with two bogies in running status. A maximum testing speed of 450 km/hr was chosen with a view to train speedups in the future.

Hoshiya, Shunji (Railway Technical Research Inst, Jpn). *Jpn Railw Eng* v 27 n 1 Jun 1987 p 12-15.

**088695** EXTENSIVE TESTING OF BRAKING DEVELOPMENTS OF HIGH SPEED TRAINS. Lucas Girling's braking test rig at their Merseyside plant in the UK facilities extensive testing of braking systems for future high speed power cars and passenger coaches. This test rig constitutes a dynamometer installation consisting of a series of inertia wheels, a drive motor forming a speed control and an energy input/output device, a controller and data acquisition and processing system, ancillary dust extraction and ventilation equipment and noise absorbing safety guards. The flexibility and high resolution which digital control enjoys makes it practicable to simulate actual vehicle roadload conditions with gradients and secondary (e.g., dynamic) braking automatically applied.

Tickle, Colin J.F. (Lucas Girling Ltd, Engl). *Rail Eng Int* v 16 n 4 1987 p 12-14.

**088696** VERSUCHE MIT DEM INTERCITY-EXPERIMENTAL. [Tests with the Intercity-Experimental]. The Intercity-Experimental train (ICE/V) is at present undergoing an extensive series of tests. So far, the required results have been obtained for the overhead contact system, the air conditioning plant and the acoustics. Running tests which have hitherto been possible have



been very encouraging. The test series are scheduled to be completed by the beginning of 1989. (Edited author abstract) In German. 4 refs.

Kurz, Heinz (Bundesbahn-Zentralamt Muenchen, Munich, West Ger). *Elektr Bahnen* v 85 n 9 Sep 1987 p 291-294, 296-298.

**088697 SIMULATIONSPROGRAMME-UNVERZICHTBARE HILFSMITTEL ZUR AERODYNAMISCHEN VERSUCHSOP-TIMIERUNG.** [Simulation Programs - An Indispensable Aid in Optimizing Aerodynamic Tests]. Calculations based on the use of physical/mathematical models for simulation have enabled empirical test results to be verified. The possibilities available for mathematical modeling during physical testing must be explored prior to starting with any practical tests. A very large number of sets of measurements are required for statistical verification of the empirical results. The comparisons made in this paper between the measured and computed results are bound to convince even purely practically oriented specialists of the enormous possibilities of a proven and mature simulation program. (Edited author abstract). 9 Refs. In German.

Sachs, Detlef (Bundesbahn-Zentralamt Muenchen, Munich, West Ger). *Z Eisenbahnwes Verkehrstech Glasers Ann* v 112 n 6 Jun 1988 p 223-228.

**088698 ZETA PLOTS NEW WORLD SPEED RECORD FOR DIESEL TRACTION.** British Railways's Research Division now has at its disposal a sophisticated instrumentation test coach known as Argus. Argus has been designed to cover a wide spectrum of engineering tests ranging from vehicle dynamics through to strain in components under service conditions. It also has the ability to test innovative ideas at speeds around 140 mph, measuring the many necessary parameters as well as collecting and processing the resultant data in real-time. This new system pioneered the use of large disks and a drum pen plotter on a moving train, which is a relatively hostile environment for such equipment. A Zeta 8 plotter, supplied by AM Computer Graphics, enables real-time graphical displays and the production of report quality figures to be plotted on-line during the testing.

Anon. *Rail Eng Int* v 17 n 2 1988 P20.

**088699 CERTIFICATION AND MONITORING TEST MEASUREMENTS; FEASIBILITY OF NOISE LIMIT VALUES FOR DISC- AND TREAD-BRAKED ROLLING STOCK.** Wheel tread condition is a predominant factor in noise emission of railway vehicles. It is argued that its development trend during mileage accumulation after reprofiling should be taken into account when setting standards for both noise emission levels and measuring regulations. Today's practice is not well tuned to railway technology and operating experience. (Edited author abstract) 7 refs.

Kaper, H.P. (Netherlands Railways, Utrecht, Neth). *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 351-354.

## Vibrations

**088700 EIN ORTSBEWEGLICHES VERFAHREN ZUR MESSUNG DER ROLLINE.** [Mobile System for Measuring the Rolling Line]. The predetermination of dimensioning quantities for vehicle components is gaining ever-increasing importance. The reasons for this are both the state of the art in computing techniques and the increasingly higher demands on the quality of the vehicles which can no longer be satisfied by purely empirical methods. The representation of the vehicle as a mathematical model require an exact description of the external disturbance variables. In the case of rail vehicles these consist primarily of the track irregularities that excite forced vibrations. The mathematical model of these stochastic disturbances must reflect as comprehensively as possible the real conditions while being easy to manipulate. These requirements are currently met in the best

possible way by the rolling line for the lateral dynamics as defined by Wickens in 1968. Combining several disturbances, it represents the real conditions to a high degree. In addition, the rolling line is easy to treat, because it comprises only one disturbance function. Its successful application has so far not been practicable, because no suitable measuring methods have been available. Such methods are the subject matter of this paper. (Edited author abstract) In German. 11 refs.

Waechter, Klaus (Hochschule fuer Verkehrswesen 'Friedrich List' Dresden, Dresden, East Ger); Geyer, Karl-Eberhard. *Z Eisenbahnwes Verkehrstech Glasers Ann* v 111 n 5 May 1987 p 148-155.

**088701 MATHEMATISCHES FAHRBAHN/FAHRZEUG-MODELL ZUR ERMITTLUNG VON BEMESSUNGSDATEN BEI STOCHASTISCHER ERREGUNG.** [Mathematical Model of the Track-Vehicle System for Determining Design Data under Stochastic Excitation Conditions]. To ensure the general acceptance of lightweight construction for vehicle components, the stresses acting on them must be precisely known. To solve these problems, numerical computations are being used to an ever increasing extent in addition to the purely experimental approach. The principal advantage is that they allow for easier variation of the track and vehicle parameters. The prerequisite for applying the computational method is the development of an equivalent system representing the vehicle and its mathematical formulation. To represent the track conditions, the energy in the frequency range (power spectral density) has proved as useful analytical tool. The initial data derived from equations based on systems theory must be linked with the data describing the use of the vehicle (load added, traveling speed). Grouping the resulting triads of values according to maximum values yields the load collective as a replica of the real stresses. The shock and force impulses of interest for component dimensioning can likewise be analyzed in the frequency domain by applying the formula established by RICE. (Edited author abstract) In German 3 refs.

Waechter, Klaus (Hochschule fuer Verkehrswesen 'Friedrich List' Dresden, Dresden East Ger); Geyer, Karl-Eberhard. *Z Eisenbahnwes Verkehrstech Glasers Ann* v 111 n 9 Sep 1987 p 281-286.

**088702 UBERLEGUNGEN ZUR STRUKTURDYNAMIK VON SCHIENENFAHRZEUGEN.** [Comments on the Structural Dynamics of Rail Vehicles]. Rail vehicles are flexible structures which vibrate in response to exciting forces. Modal analysis is used to describe the natural frequency characteristics of rail vehicle structures and to calculate forced structural vibrations. This paper suggests how structural vibrations can be reduced. (Edited author abstract) 20 refs. In German.

Frederich, Fritz (RWTH, Aachen, West Ger). *Z Eisenbahnwes Verkehrstech Glasers Ann* v 111 n 11-12 Nov-Dec 1987 p 377-383.

**088703 DIE BETRIEBSFESTIGKEIT SCHWINGEND BEANSPRUCHTER STRUKTUREN VON EISENBAHNFAHRZEUGEN.** [Serviceability of Cyclically Loaded Rail Vehicle Structures]. The need to achieve optimum lightweight design of rail vehicles in terms of adequate safety and maximum cost effectiveness calls for more consistent application of a design concept based on cyclic strength. With a given limited life and knowledge of the service loading combinations, the long service of life required in railway engineering can be achieved with adequate reliability by a specific excursion of the endurable stresses. In order to be able to apply the 3 concept of cyclic strength in the course of design work, a few prerequisites have to be fulfilled. The design loads and loading conditions for dimensioning and testing must describe the service loadings in such a way that their dynamic characteristics are fully covered. The deformations of the structure must be simulated in a dynamic manner by calculations and experiments to enable the number and magnitude of the local stress cycles which cause damage to the material to be determined. Stress-induced damage to highly stressed areas in the

structure can be quantified by means of Woehler lines describing the fatigue strength properties of the materials by defining states of combined stress and by applying the linear damage accumulation rule. (Edited author abstract) 56 refs.

Schenk, Herwig (Bundesbahn-Versuchsanstalt Minden, North Rhine-Westphalia, West Ger). *Z Eisenbahnwes Verkehrstech Glasers Ann* v 111 n 11-12 Nov-Dec 1987 p 384-392.

## Welding

**088704 WELDING STANDARDISATION AND DEVELOPMENTAL ACTIVITIES ON INDIAN RAILWAYS.** The author briefly reviews the history of the Indian railway system and its present size. Current standards for welding are cited. The article covers boilers, engine blocks and other components of steam and diesel locomotives and their welding fabrication and repair.

Sarkar, N.K. (Western Railway, Bombay, India). *Indian Weld J* v 20 n 1 Jan 1988 p 285-299.

## Wheels

See Also CARS—Stability; RAILS—Lubrication.

**088705 DYNAMIC ANALYSIS OF HIGH SPEED RAILWAY TRUCKS FOR THE SHINKANSEN.** A numerical simulation approach of railway vehicle dynamics has been developed to improve the analytical accuracy and to analyze the problems which could not be properly assessed by the conventional linear analysis. It takes nonlinear characteristics of wheel/rail profiles, creep force saturation, and vehicle suspensions into consideration. In the present paper, first dynamic performances of high speed railway trucks for the Shinkansen were evaluated, and then the effects of truck parameters on the dynamic performance were investigated. It is clarified that data calculated by this approach is in better agreement with that by experiment than that by a linear analysis and that the lower lateral stiffness of the secondary suspension improves both ride quality and curving performance. (Author abstract) In Japanese. 14 refs.

Yamamoto, Miyuki; Nakata, Machi. *Sumitomo Met* v 39 n 3 Aug 1987 p 234-244.

**088706 SIMULATION UND EXPERIMENTELLE VERIFIKATION DES RAD/SCHIENE-ROLL-PRUEFSTANDS.** [Simulation and Experimental Verification of the Roller Test Facility]. A simulation model of the roll test stand located at Munich and loaded by a rail car tractor is discussed including its technical structure, the governing physical equations of motion and the simulation program structure. Both the set up time of the mathematical and numerical models and the computation time have been considerably reduced (by a factor of 20) using a symbolic computer language. The simulation results are compared with the experimental results gained from test facility measurements. (Author abstract) In German. 12 refs.

Hahn, H.; Siegl, G. *Ing Arch* v 57 n 5 1987 p 329-348.

**088707 ASSESSMENT OF WHEEL MAINTENANCE PRACTICES BY COMPUTER MODELING.** The paper describes the concept and development of a computer model which can be used as a management aid in evaluating wheel maintenance practices on economic and technical grounds. The model is capable of simulating the railroad system costs which are directly and indirectly sensitive to changes in the condition of the wheel fleet. By estimating the population distribution of wheels in terms of their condition, the model calculates the effects of varying system parameters on wheel machining and replacement requirements, fuel usage, rail wear and the costs associated with each of these factors. Implicit



assumptions contained in the model and possible applications of the model are also discussed. (Author abstract) 3 refs.

Davis, D.C. (BHP, Melbourne Research Lab, Aust). *Mech Eng Trans Inst Eng Aust* v ME 9 n 4 Nov 1984 p 295-300.

**088708 EXPERIMENTAL REPRODUCTION OF WHEEL FLAT.** Wheel skiddings are easily caused by a decrease in wheel-rail adhesion. They sometimes cause wheel-flat damage during braking. Wheel-flat reproduction was attempted for the purpose of developing a wheel material which has a higher resistance to the occurrence of flat damage. A two-roller testing machine in which a skidding device was incorporated suitably, was designed and manufactured for the reproduction test. The device can give rise to wheel skidding by two operations. One is the oil feed to the contact zone between the two rollers while the other is the brake application to the wheel-roller axle. The wheel skidding produces a wheel-flat whose occurrence is thought to be governed by both the lubrication condition and the flash temperature. The reproduced flat damage has nearly the same morphology as that of wheels in service with respect to the appearance of the deformed surface layer and the formation of thermal cracks in the layer. (Edited author abstract) 16 refs. In Japanese.

Kigawa, Takehiko (Railway Technical Research Inst, Kokubunji, Jpn). *J Jpn Soc Lubr Eng* v 32 n 10 1987 p 748-755.

**088709 RAILWAY WHEELSETS - A CRITICAL REVIEW.** This paper gives a brief history of the evolution of wheelsets and then outlines the changes that have occurred in their design in the last 30 years, mainly due to the change to diesel and electric traction. Technical problems are discussed and the principal lines of research which have followed are described. As a result, tired wheels centers have largely been replaced by monoblock wheels with hardened trends, disc brakes have been introduced and the unmachined cast-steel wheel has become a serious competitor to the traditional forged and rolled wheel. Of great importance is the introduction of computer analysis of wheel stresses which has led to modifications to the wheelset to reduce stress and to set limiting values. (Edited author abstract) 40 refs.

Wise, S. (British Railways Board, Derby, Engl). *Proc Inst Mech Eng Part D* v 201 n 4 1987 p 257-271.

**088710 PARAMETRICALLY EXCITED BEHAVIOR OF A RAILWAY WHEELSET.** The dynamic response of rail vehicles is affected by parameters such as wheel-rail geometry, track gage, and axle load. Variations in these parameters, as a rail vehicle moves down the track, can cause instabilities that are related to parametrically excited behavior. This paper reports on the use of Floquet Theory to predict the stability and instability regions for a single wheelset subjected to harmonic variations in wheel-rail geometry, track gage and axle load. Time studies showing the response of a wheelset to various initial conditions are also included. The results show that harmonic variations in the wheel-rail geometry can influence the behavior of a wheelset significantly. (Edited author abstract) 35 refs.

Lieh, J. (Clemson Univ, Clemson, SC, USA); Haque, I. *J Dyn Syst Meas Control Trans ASME* v 110 n 1 Mar 1988 p 8-17.

**088711 RADDURCHMESSER AN SCHIENENFAHRZEUGEN OPTOELEKTRONISCH GEMESSEN.** [Measurement of Railroad Car Wheel Diameter by Optoelectronic Devices]. A new method for checking the actual diameter of wheels while in motion is described. This monitoring speeds up maintenance of the rolling stock and improves safety of railroad transportation. In German. 12 refs.

Pfeifer, T.; Molitor, M.; vom Hemdt, A. *ATP Automatisierungstech Prax* v 29 n 4 1987 p 173-178.

**088712 IMPROVEMENT IN THE RELIABILITY**

**AND QUALITY OF RAILROAD WHEELS.** Service conditions of railroad wheel pairs have been made more demanding by the increase in rail transport in the USSR. To improve the reliability of these wheels, a series of fundamental improvements must be made in wheel material and design, the manufacturing practice, and wheel inspection. The author's plant takes steps at all stages of production to prevent the steel from becoming saturated with hydrogen, the presence of which leads to the formation of flakes in wheels. With this in mind, consistent inspection of the product to determine the hydrogen content is practiced. In steelmaking technology, the most promising method is single-slag steelmaking in electric furnaces, vacuum degassing, and deoxidation and modification with aluminum. The resulting steel contains a minimal amount of oxygen (0.0035-0.0040%) and hydrogen (no more than  $4 \text{ cm}^3/100 \text{ g}$ ), while the wheels made from it have a uniform macrostructure, a low content of nonmetallic inclusions, and rims and webs with high ductility and impact toughness. The cold shortness threshold is lowered by  $40-60^\circ\text{C}$ .

Staroselskii, M.I. (K. Libknekt Nizhedneprovsk Pipe Plant, USSR). *Metallurgist (USSR)* v 31 n 7-8 Jul-Aug 1987 p 253-255.

**088713 VIBRATION REDUCTION OF A RAILWAY WHEEL BY CANTILEVER-TYPE DYNAMIC DAMPERS (1ST REPORT, THEORETICAL ANALYSIS).** The lateral vibration of a wheel with cantilever-type dynamic dampers is analyzed theoretically by making use of the modal analysis and the receptance method. The damper is assumed to have two degrees of freedom: rotation and translation. Consequently, a moment and a lateral force acted between the damper and the wheel. The following results have been obtained by numerical calculations. When the damper is set such that the free end faces to the outside, the force and the moment act to reduce the vibration. When the mass of the damper is  $1/100$  of that of the wheel and the length of the cantilever is  $1/5$  of the wheel's radius, the vibration can be reduced significantly. (Author abstract) In Japanese. 7 refs.

Zhang, Weiming; Matsuhisa, Hiroshi; Honda, Yoshihisa; Sato, Susumu. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 497 Jan 1988 p 117-123.

**088714 APPROXIMATE MODEL WITH AN INFINITE NUMBER OF VEHICLES FOR ANALYSIS OF COUPLED VIBRATIONS BETWEEN RAILWAY VEHICLE WHEELS AND RAIL IN THE VERTICAL DIRECTION.** This paper presents an approximate model with an infinite number of vehicles in which an infinite number of wheels are arranged with a certain periodicity on the top of an infinitely long and straight rail installed on a distributed spring in the vertical direction. This model is very effective for the analysis of the coupled vibrations between railway vehicle wheels and a rail for the case of a great number of wheels. Using the analytical model, the contribution of the rail to the coupled vibrations was examined for each section partitioned by wheels over the length per Shinkansen vehicle. As a result, it became clear that the vibration of the rail between the wheels of a truck is dominant in a frequency region lower than  $2 \text{ kHz}$ , and that of rail near a coupler between vehicles is also important in a frequency region higher than  $1.5 \text{ kHz}$ . (Author abstract) 12 refs. In Japanese.

Sueoka, Atsuo; Ayabe, Takashi; Kawakami, Mitsunori; Tamura, Hideyuki. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 500 Apr 1988 p 842-850.

**088715 ALLOWABLE CRACK SIZES FOR RAILWAY WHEELS AND RAILS.** Determined are the critical crack sizes and crack growth characteristics for train car wheels and rails. Service and test limit size of cracks need to be distinguished in view of the difference between subcritical and the onset of rapid crack propagation. Probabilistic calculations have many advantages, but they cannot accurately predict either the real critical minimum crack size  $(a_c)_{\min}$  or the real maximum crack growth increment  $\Delta a_{\max}$ . As representative values of the minimum critical crack size  $a_c^*$  and the maximum crack growth increment  $\Delta a^*$  are chosen for the calculations,

therefore, the values which have a survival and crack growth probability, respectively, of 90%. Safety factors  $S(a)$  and  $S(a^*)$  are needed to account for the scatter of  $a_c$  and  $\Delta a$  for probabilities of more than 90%. Probabilistic fracture mechanics is applied to analyze the behavior of transverse cracks in the rim of tread-braked monobloc wheels, transverse head cracks in rails and aluminothermic rail welds. (Edited author abstract) 17 refs.

Edel, K.-O. (Wissenschaftlich-Technisches Zentrum, Brandenburg-Kirchmöser, East Ger). *Theor Appl Fract Mech* v 9 n 2 Apr 1988 p 75-82.

**088716 LIFE PREDICTION OF THERMALLY CRACKED RAILWAY WHEELS: GROWTH ESTIMATION OF CRACKS WITH ARBITRARY SHAPE.** A computer program for railway wheel life prediction has been developed incorporating an elastoplastic calculation of both the residual stress field induced by shoe-braking and the superposed alternat rolling contact stresses. The possibilities of unstable propagation of surface cracks, crack arrest, fatigue propagation through a complex stress field and crack detention on reaching the threshold value have been accounted for. An approximate method for crack growth prediction is used providing bounds for instantaneous crack front position and estimations of crack shape within short computing times. Some examples of application for an UIC R7 wheel are presented. (Author abstract) 31 refs.

Meizoso, A. Martin (Centro de Estudios e Investigaciones Tecnicas de Guipuzcoa, San Sebastian, Spain); Sevillano, J. Gil. *Theor Appl Fract Mech* v 9 n 2 Apr 1988 p 123-139.

**088717 EXPERIMENTAL REPRODUCTION OF WHEEL-FLAT.** Wheel-flat reproduction was attempted for the purpose of developing a wheel material which has a higher resistance to the occurrence of flat damages. A two-roller testing machine, in which a skidding device was incorporated suitably, was designed and manufactured for the reproducing test. The device can give rise to wheel-skidding by two operations. One is the oil feed to the contact zone between the two rollers and the other is the brake application to the wheel-roller axle. The reproduced flat damage has nearly the same morphology as that of the wheels in service with respect to the appearance of the deformed surface layer and the formation of heat checks in the layer. The occurrence of a wheel-flat is thought to be governed by both the lubrication conditions and flash temperature. (Author abstract). 5 refs.

Kigawa, Takehiko (Railway Technical Research Inst, Kokubunji, Jpn). *J JSLE Int Ed* n 9 1988 p 53-56.

## RAILROAD SIGNALS AND SIGNALING

See Also ELECTRIC RAILROADS—Hong Kong.

Automation See RAPID TRANSIT.

Centralized Control See Also LIGHT RAIL TRANSIT—Pittsburgh, Pennsylvania; RAILROAD ROLLING STOCK—Design; RAILROADS—Traffic Control; SUBWAYS—Signal Systems.

**088718 ZENTRALSTELLWERK FULDA FUER DIE NEUBAUSTRECKE HANNOVER - WUERZBURG.** [Fulda Central Signal Box for the New Hannover-Wuerzburg Line: New Building, Conversion and Expansion Work]. The timely completion of the Fulda central signal box in September 1985, using SpDr S600 technology from Siemens AG in Braunschweig, laid the foundation for the on-schedule start of track layout conversion work at Fulda station for the new Hannover-Wuerzburg line. The conversion work will span the period 1983-1990 and include a total of 89 construction phases and 28 signal work phases. The SpDr S600 signalling equipment has proved to be very advantageous in particular on account of the rapid succession of building phases. With the start of operations on the Fulda-Wuerzburg section of the line, work is nearing completion on transforming the central signal box into a remote control



centre, using the F70 remote control system supplied by Standard Elektrik Lorenz (SEL) AG of Stuttgart with a ZN P800 magazine train describer from Philips in Kiel, and a centre for continuous wayside control using SEL technology. (Author abstract) In German.

Huesmann, Heiner (Projektgruppe NBS, Frankfurt, West Ger). *Eisenbahningenieur* v 39 n 4 Apr 1988 p 147-154.

**088719 MICROPROCESSOR-BASED RAILWAY INTERLOCKING CONTROL WITH LOW ACCIDENT PROBABILITY.** A laboratory model incorporating a microprocessor-based system to control signals and points and to monitor track circuits is described. Approach locking and backlocking controlled through a programmable timer are included. The model consists of a control panel with entrance-exit type control, namely, a switch and a pushbutton for each route. Light-emitting diodes take the place of signal lamps. Points are simulated by means of three position-neutral polar relays. A method of reducing the probability of accidents associated with this type of control is presented. It consists of duplicating the input channels and utilizing redundant input data. 2 refs.

Rao, V. Purnachandra (Indian Railway Inst of Signal Engineering & Telecommunications, Secun); Venkatachalam, P.A. *IEEE Trans Veh Technol* v VT-36 n 3 Aug 1987 p 141-147.

**Interlocking** See Also RAILROADS—Automatic Train Control; SUBWAYS—London, England.

**088720 BAHN 2000 PROMPTS SBB RESIGNALING.** The introduction of an improved fixed-interval service throughout Switzerland (called Bahn 2000) will mean 2 min headways on many main lines and maximum speeds of 200 km/h. To achieve these objectives new signalling and automatic train control are needed. To upgrade existing signalling would magnify the present deficiencies and lead to more complicated illogical colour codes. Swiss Federal Railways (SBB) therefore decided to develop a different system fulfilling the requirements of Bahn 2000 which also overcame existing deficiencies. The chosen strategy relies on speed-control signalling indicating to the driver the permitted speed. Each signal indicates permission to proceed and the permitted speed; all signals are 'combined', in that each is an 'advance' or distant for the next.

Anon (Swiss Federal Railways). *Railw Gaz Int* v 143 n 10 Oct 1987 p 669-672.

**088721 SOLID-STATE INTERLOCKING IN RAILWAY SIGNALLING, SMILE AND  $\mu$ -SMILE.** Two types of solid-state interlocking systems are presented. SMILE, applicable to a large station, is composed of multi-microprocessors for realizing various automated functions flexibly, while  $\mu$ -SMILE with a simple structure, is applied to a small station. The fail-safe technology and system architecture of these systems are shown. A network of electronic signaling terminals for reducing the total length of signaling cables in a station is also given. The characteristics of safety and reliability are predictably better than those of a relay interlocking system by 100 times. 12 sets of SMILE and 3 sets of  $\mu$ -SMILE are operating in Japan Railways. (Author abstract) 3 refs.

Akita, Katsuji (Safety & Telecommunications Lab); Nakamura, Hideo; Watanabe, Toshikatsu. *Q Rep RTRI (Jpn)* v 28 n 2-4 Nov 1987 p 36-41.

**088722 EVOLUTION DES EQUIPEMENTS DE SECURITE SUR LES LIGNES A UNE SEULE VOIE.** [Development of Safety Equipment on Single-track lines]. Substantial changes are being made to the safety equipment on SNCF single-track lines. Once they are completed there should no longer be any lines carrying passenger traffic on which the only safety system is the telephone block. Different systems therefore are or will be in service. An important program for installing interlocked block equipment is being implemented. Lines carrying only light traffic which do not require heavy-duty equipment are being fitted with the CAPI system which,

with its microcomputers, gives a higher level of safety to messages exchanged by the telephone block. Fortified by the experience acquired in Cerdagne with a line operated by radio, research is being carried out to develop an economical system which, by combining computer techniques, data transmission by radio and train passage detectors, should enable a very satisfactory level of safety to be obtained on lines carrying light traffic, while at the same time being inexpensive to operate. (Edited author abstract) In French.

Savelli, Gilbert (SNCF); Van Deth, Francois. *Rev Gen Chemins Fer* v 107 n 4 Apr 1988 p 41-50.

**088723 BLOCK AUTOMATIQUE A PERMISSIVE RESTREINTE DE VOIE BANALISEE 'S'.** [Restricted Permissive Automatic Block for 'S' Two-Way Working on Single Track]. To provide single-track lines with an interlocking block, the SNCF is developing at the same time as the conventional single-track manual block a restricted permissive automatic block known as the BAPR for 'S' two-way working track. On lines provided with this system, trains are spaced automatically because their location is detected either by track circuits or axle counters. On the other hand in contrast to the practice in the centralized control system the points and their protective signals are still operated by hand. (Edited author abstract) In French.

Lazard, Georges (SNCF). *Rev Gen Chemins Fer* v 107 n 4 Apr 1988 p 51-54.

**Japan** See RAILROAD ROLLING STOCK—Computer Simulation.

**Modification** See RAILROAD PLANT AND STRUCTURES—Construction.

**Performance** See RAILROAD PLANT AND STRUCTURES—Crossings.

**Sweden** See RAILROADS—Automatic Train Control.

**RAILROAD TRANSPORTATION** See Also ELECTRIC TRACTION; RAILROAD PLANT AND STRUCTURES—Track Switches; TUNNELS AND TUNNELING—Reviews.

**088724 CFF RAIL LINK TO GENEVA AIRPORT.** In Switzerland, CFF have been operating a rail link from Zurich Central to Kloten Airport since June 1980, thus affording air passengers a convenient, direct and quick getaway from or access to the airport by train. In the case of Geneva, the concept involved extending the Lausanne-Geneva double-track line as far as the Airport to cater for direct and IC train services. By comparison with a straightforward shuttle service between the Airport and Geneva, this solution enables users to access most of the country's main cities and regions or inversely the Airport itself without train transfer at Cornavin. This was the background against which the definitive specification for the rail link project was developed. The article describes the project, operations, traffic projections, project cost/profitability.

Nieth, R. (CFF, Geneva, Switz). *Rail Int* v 19 n 5 May 1988 p 13-16.

**Accident Prevention** See RAILROAD ACCIDENTS—Derailment.

**Accidents** See Also HIGHWAY TRAFFIC CONTROL.

**088725 ACCIDENT CAUSATION ANALYSIS AT RAILROAD CROSSINGS PROTECTED BY GATES.** This study identifies probable causes of and factors responsible for accidents occurring at railroad crossings protected by gates. Two important goals were to (a) compare the results obtained for the two types of warning systems activating the gates: fixed distance and constant warning time systems, and (b) test the hypothesis that extended, or widely variable, warning times create a lack of credibility in warning signals. These objectives were achieved by statistically analyzing accident data obtained from the National Rail-Highway Crossing Inventory and

the Railroad Accident/Incident Report files for the period 1975 through 1984. An accident classification by circumstance (movement and position of the car in relation to the tracks and the trains) highlighted some causes and factors responsible for the different types of accidents. (Edited author abstract) 10 refs.

Halkias, John A. (Florida Inst of Technology, Melbourne, FL, USA); Blanchard, Laurence. *Transp Res Rec* 1114 1987 p 123-130.

**Analysis** See RAPID TRANSIT—Planning.

**California** See RAILROADS—Planning.

**Communication Systems** See Also FREIGHT HANDLING—Control Systems; RAILROADS—Automatic Train Control; TELECOMMUNICATION SYSTEMS—Federal Republic of Germany.

**088726 GERMAN RAIL TAKES THE HICOM TRAIN.** A modern transport service like the Deutsche Bundesbahn (DB), the Federal Republic's national railroad, could not perform its many and varied functions without an efficient, high-availability communications network. The automatic railroad exchanges (referred to here by their German abbreviation 'Basa') form the nodal points of its present-day communications network. The first of a total of six scheduled pilot Basa using the Hicom system has been in operation since December 5, 1986. With this ISDN communication system from Siemens, German Rail has taken its communications into the digital age. (Edited Author Abstract). 3 refs.

Lies, Gerhard (Deutsche Bundesbahn, Cologne, West Ger); Meuter, Werner. *Telcom Rep* v 10 n 4 Jul-Aug 1987 p 184-189.

**088727 HERMES-DATA TRANSMISSION SYSTEM OF THE INTERNATIONAL UNION OF RAILWAYS.** The HERMES system is a computer system linking up the UIC Railway computer centres by means of a data transmission network. The article follows the development of the project from its inception in 1971 to its phase of operational and geographical expansion in 1987. The writer describes the different components of the system, link-up possibilities and applications. He also shows how a large-scale project with international repercussions and effects on the development of the member networks was integrated into the UIC's general organization. (Edited author abstract).

Marty, G. (UIC General Secretariat). *Rail Int* v 19 n 6 Jun 1988 p 3-11.

**088728 DOCIMEL, AN INTERNATIONAL PROJECT INVOLVING EUROPEAN MEMBER RAILWAYS OF UIC AND CIT.** DOCIMEL (Document Cim Electronique) is designed to develop computerised interfaces between the Railways, their customers, customs and other transport modes as much as possible, so as to limit data capture operations to the strict minimum, and in the longer term to eliminate the physical dispatch of documents, and thereby improve transport quality. Each consignment will be recorded on a computer file, itself triggered by the supply of data from shippers, such data being then supplemented during the actual transport process. Initially, the system could be applied in traffic between those Railways linked into the HERMES international railway data transmission network, in other words DB, SNCB, DSB, SNCF, FS, BR, and CFF at the present time. (Edited author abstract).

Troliet, H. (Service Juridique des CFF, Berne, Switz). *Rail Int* v 19 n 6 Jun 1988 p 17-23.

**Computer Applications** See RAILROADS—Automatic Train Control.

**Computer Simulation**

**088729 COMPUTER SIMULATION: A TOOL FOR CONTROLLING THE TRANSPORTATION OPERATING PLAN.** Management's tasks in guiding a corporation are to plan, organize, and control. In a transporta-



tion company, the transportation operating plan is the tool by which all activities are organized. Control of the operating plan takes place at two levels: 1. First Level - Top management is responsible for long-term control and effectiveness of the transportation plan. 2. Second Level - Division management is responsible for short-term, daily implementation of the transportation plan. Computer simulation is a cost effective management tool which can be used at either the first or second level to control the operating plan. This paper describes specific simulation models and how they are applied to solve railroad operating problems. Corporate benefits are discussed, and factors for insuring successful use of the models are highlighted. (Author abstract)

Wolf, G.P. (Norfolk Southern Corp, Atlanta, GA, USA). *Rail Int* v 18 n 12 Dec 1987 p 26-33.

## Control

**088730 CONTROL OF SIGNALS AND POINT MACHINES IN INTERLOCKING SYSTEM ERILOCK 850.** Computer-controlled interlocking systems for railway yards include object controllers, which supervise and control objects in the railway yard, such as signals and point machines. In the computerized all-electronic interlocking system ERILOCK 850, the object controllers are microprocessor-controlled and, unlike earlier versions, there are no safety relays. The requirement for fail-safe operation has greatly influenced the design of the object controllers. The author describes the principles and structure of the object controllers, particularly the design methods used to ensure fail-safe operation. (Author abstract) 1 ref.

Celinski, Kristoffer. *Ericsson Rev (Engl Ed)* v 64 n 4 1987 p 182-188.

## Costs

**088731 ROLE OF COMPUTERS IN THE COMMERCIAL POLICY OF SA TRANSPORT SERVICES.** A new sophisticated integrated accounting system (INTAC), catering to more than 80,000 clients, was implemented on 1 October 1987. It combined the latest available technology with streamlined accounting procedures - linking a countrywide on-line network to a dedicated mainframe computer via various systems: 491 on-line terminals at 120 sites, 10 dedicated data capturing mini systems with 215 terminals and three document reading systems. This latter system, using laser technology, is capable of handling 60,000 to 100,000 freight and accounting documents daily and will account for R5 billion per annum. An additional feature is that 95 percent of tariffing takes place automatically, which enhances accurate accounting.

Coetzee, G.J.S. (SA Transport Services). *Rail Int* v 19 n 6 Jun 1988 P12.

## Developing Countries

**088732 I TRASPORTI FERROVIARI NEI PAESI IN VIA DI SVILUPPO. SITUAZIONE E PROSPETTIVE.** [Railroad Transport in the Developing Countries, Situation and Prospects]. Physical and functional characteristics of the railway transport networks in the developing countries (P.V.S.) are presented. A definition of normalized parameters which permit a summary assessment of the 'state of the art' of railway transport in these countries is given. The areas involved in the railway system are brought out, taking account of the connection existing between the various traffic basins. Useful indications for the drawing up of development plans and projects for the sector, to be carried out in successive time phases, are outlined. (Edited author abstract) 6 refs. In Italian.

Cirillo, Bruno (Comitato Consultivo Consiglio d'Amministrazione, Rome, Italy); Imperatrice, Fabrizio. *Ing Ferrov* v 42 n 12 Dec 1987 p 734-751.

**Diesel Engines** See DIESEL ENGINES.

**Economics** See Also RAPID TRANSIT—Environmental Impact; RAPID TRANSIT—Personnel.

**088733 EUROPAEISCHE SCHNELLBAHN-NETZE VERKEHRS- UND IMAGEPOTENTIAL FÜR DIE BAHNEN.** [European High-Speed Railway Networks and Their Impact on the Transport and Image Potential of the Railways]. Do railways stand at the threshold of a 'brave new world', offering profitable, rapid, clean, safe and fuel-efficient services, with the ability to carry more passengers without making additional claims on precious land? Both experience from the considerable impacts on the market caused by high-speed trains and model computations on European high-speed rail networks demonstrate that the high-speed concept can open new perspectives to railways' long-distance passenger transport. High-speed rail networks generate considerable traffic and image potentials, but their realization requires actions which meet the market requirements. (Edited author abstract). In German.

Eberlein, Dieter (DFVLR, Cologne, West Ger); Neusser, Hans-Gustav. *Z Eisenbahnes Verkehrstechn Glaser Ann* v 112 n 5 May 1988 8p.

**Efficiency** See RAILROADS—Modernization.

## Energy Conservation

**088734 DEVELOPMENT OF A FUEL CONSERVATION PROGRAM.** Illinois Central Gulf (ICG) formed a group to address energy issues, particularly at reducing diesel fuel costs. A one-meter system, the fuel auditor, was developed which provided direct readings electronically to the research car. The group's findings included: fuel savers; dynamic brake; aerodynamics and engineer performance.

Bolla, Wayne F. (Planning Section Inc). *Mod Railroads* v 42 n 10 Oct 1987 p 37-38, 40.

**088735 NUMERICAL METHOD FOR MINIMUM ENERGY PROBLEM OF TRAIN CONTROL.** A new algorithm for the numerical solution of the energy optimal control of a train is suggested. The tractive characteristics of the engine, the piecewise constant upper limit of the velocity and the variable railway profile are given, and the exact time interval is prescribed. The method is based on Pontryagin's maximum principle for the systems with bounded state and control variables and on the simulation results. (Author abstract) 8 refs.

Fidler, J.; Tuzar, A. *Probl Control Inf Theory* v 16 n 3 1987 p 223-231.

**088736 ENERGY CONSUMPTION: 'INTO THE 21ST CENTURY WITH THE TRAIN - SAVE ENERGY AND SAVE THE ENVIRONMENT'.** According to the most recent estimates, the earth's mineral oil reserves will only last for another 35 years. Bearing in mind this forecast, measures are going to have to be introduced to cut back on mineral oil consumption in the German transport sector, which at present accounts for half the use of mineral oil in the country. Today, rail transport, particularly electric traction, already offers a means of saving energy. Energy sources can be saved and the worrisome situation concerning noxious emissions into the atmosphere, which are expected to reach dangerous levels at the turn of the century, can be considerably improved. (Edited author abstract)

Harprecht, W. *Rail Int* v 18 n 10 Oct 1987, Int Environ Symp: Eur Railw - An Asset for the Environ, Mannheim, West Ger, Oct 22 1987 p 58-62.

## Environmental Impact

**088737 ECOLOGICAL FACTOR IN THE EVALUATION OF SOCIAL COSTS FOR RAIL, ROAD AND WATERWAY TRANSPORT.** The results of different ongoing studies and investigations would suggest, by way of a universally-recognized conclusion, that environmen-

tal pollution at several levels (air, water, soil, natural resources, noise, etc.), is showing disturbing signs of worsening, given the extremely harmful effects of these different compounded factors. Bearing in mind that the population explosion is set to continue, and that the technico-scientific revolution is irreversible, it is vital relentlessly to safeguard the quality of our environment, since this in the final analysis is what determines the equilibrium of the system. What should and can be done rightaway on a more extensive basis is to acquire more detailed knowledge about our surrounding environment at all levels through system methods. In this sense, environmental system research will provide indications as to the relevance of socio-economic development measures, their real economic efficiency and, more importantly, their long-term effects on the environment. The negative social and ecological implications of transport activities on the surrounding environment are determined, and various influencing factors have been taken into consideration in the analysis and calculations.

Rurac, D.G. (INCERTRANS, Rom); Roxin, I.; Cretu, I. *Rail Int* v 18 n 8-9 Aug-Sep 1987 p 47-55.

**Europe** See AIR TRANSPORTATION—Europe.

**Federal Republic of Germany** See Also RAILROADS—Magnetic Levitation; RAPID TRANSIT—Magnetic Levitation.

**088738 DIE ZUKUNFT DER DEUTSCHEN BUNDESBAHN.** [Future of the German Federal Railway]. Employing 255,000 people, the German Federal Railway is by far the most important transport company in the Federal Republic. It transports annually two billion passengers and over 300 million tons of goods by rail and road thus offering extensive services in the transport sector. A report is presented on the 'Federal Railway' company and its environment in order to permit a correct judgement of the changes that have occurred within the German Federal Railway on the one hand, and to show the prospects of the 'new railway company' within the framework of a changed innovative company management on the other hand. In German.

Gohlke, Reiner (Deutschen Bundesbahn, Frankfurt am Main, West Ger). *Thyssen Tech Ber* v 20 n 1 1988 p 25-37.

**088739 ANFORDERUNGEN DES HOCHGESCHWINDIGKEITSVERKEHRS-DER ICE ALS GEEIGNETES ZUGSYSTEM.** [High-Speed Traffic Requirements - ICE as a Suitable Train System]. This report describes the preconditions required for high-speed traffic, and the ICE train system as the German Federal Railways' and the German industry's solution to high-speed traffic requirements. With their own developments, Thyssen Henschel and Waggon Union will contribute decisively to the development and manufacture of the ICE. The ICE network is scheduled to be opened at the beginning of 1991. 6 Refs. In German.

Buchholz, Karl-Heinz (Thyssen Industrie AG, Kassel, West Ger); Lipsius, Johannes-Martin; Schwendt, Lutz. *Thyssen Tech Ber* v 20 n 1 1988 p 81-99.

**France** See RAILROAD ROLLING STOCK—France.

**Freight** See Also RAILROADS—Austria; RAILROADS—Denmark; RAILS—Testing; REFUSE DISPOSAL—Transportation.

**088740 BN'S EXTRAORDINARY EXPEDITERS.** The Burlington Northern (BN) Railroad's Expediter trains are a solid success. In the two and a half years since the network began running, Expediter has virtually become the standard nomenclature for short, fast, frequent intermodal trains operated by two-member crews and offering truck-competitive service in the short-to-medium distance range. BN is achieving a high degree of flexibility by networking most Expediters through its route structure like passenger trains. Expediters simply stop and drop a block, then pull into the clear so a new



block can be coupled on to the hind end. The result is not only less terminal delay, but a better ride for the trailers and their contents.

Plous, F.K. Jr. (Railway Age, New York, NY, USA). *Railway Age* v 188 n 11 Nov 1987 5p between p 30 and 48.

**088741 BOOSTING CAPACITY IN COAL CORRIDORS.** With 70% of China's motive power fleet still steam, it is easy to appreciate how much the network must be modernised to raise capacity. Electric traction handles only 19.4 million tonnes, so expanding the fleet of electric locos is a major priority. Similar emphasis is also being accorded to other methods of achieving extra capacity. Dedicated unit trains will operate on heavy haul routes such as the 650 km Daqing line from Datong to Qinhuaogao. Construction of this route began in 1984 and will be completed on schedule with opening throughout in 1991. It will carry coal from the mines in Shanxi province both for export and domestic consumption in cities on the eastern littoral. Principal motive power on the Daqing line will be the twin-unit Shaoshan 4 electric loco rated at 6 400 kW. A single loco of this type will be able to handle a train of 6000 tonnes, while double heading will permit a trailing load of 10,000 tonnes.

Yin, Zhenyuan. *Railway Gaz Int* v 143 n 12 Dec 1987 p 812.

**088742 UEBERLADEBRUECKEN FUER DIE BAHNVERLADUNG.** [Transshipment Platforms for Loading onto Rail]. When goods are moved out of containers, the end points of the tracks are not necessarily the end of the transport path. In order to level the way for loading vehicles between the ramp and the container, the German Federal Railway's central office at Minden and the freight transportation industry have jointly developed a solution for the loading and unloading of large containers carried in freight cars that meets all safety requirements for straight track installations. Adjustable-level crossings made it simple to incorporate the container into the loading area. (Edited author abstract) In German.

Schmidt, Roman (Roman Schmidt & Partner). *Eisenbahningenieur* v 38 n 10 Oct 1987 p 490-493.

**088743 EINE INITIATIVE DER FRANZOESISCHEN STAATSBAHNEN: EILGUTTRANSPORT MIT HOHEN GESCHWINDIGKEITEN (160 KM/H).** [Fast Freight Surface at High Speeds (160 Km/hr): An Initiative of the French National Railways]. To win back shares in the freight traffic market lost to road-based competitors, the project ETNA (development of technologies for improving the product) will be launched by SNCF as an experiment starting in 1988. Using a computer-based system, freight trains will be made up as unit trains for three classes of service, i.e. very urgent, urgent and less urgent freight, and thus be fully utilized. The trains will run at speeds between 100 and 160 km/h. The number of slower trains will be reduced. Owing to the high operating speeds, the cars will have to be modified at the bogies or replaced with new designs. (Edited author abstract) In German.

Forray, Roger (SNCF, Paris, Fr); Pons, Henry. *Z Eisenbahntechnik Verkehrstechnik Glasers Ann* v 111 n 11-12 Nov-Dec 1987 p 375-376.

**088744 UNE NOUVELLE ETAPE DE L'INFORMATISATION DU CALCUL DES COUTS MARCHANDISES: LE MODELE 'TRAINS COMPLETS'.** [Further Stage in the Computerization of Freight Cost Calculations: the 'Complete Train-Load' Model]. A computer-based system for calculating diminishing marginal costs (GEC costs), applied to forwardings in separate cars made up into groups, has been in operation since 1984. This system has been extended to complete train-load traffic by creating a separate model which has been used by the marketing team since the beginning of 1987. In the same way as the system processing groups of cars, it is a facility available in real time from any point on the system by means of a linked terminal or a Minitel. It provides details of the optimum routing of a train and the cost price (actual marginal cost) which must be known before embarking on commercial negotiations. This article ex-

plains the system very generally, placing emphasis on the basic options selected, after briefly describing the actual calculation process. (Edited author abstract) In French.

Soudry, Pierre (SNCF, Fr); Pige, Jean-Christophe. *Rev Gen Chemins Fer* v 107 n 1 Jan 1988 p 33-39.

**088745 LE SYSTEME INFOSUIVEUR DU SERNAM: UNE ETAPE IMPORTANTE.** [SERNAM Info-monitoring System: an Important Stage]. The parcel carrier today has to face many problems which give the profession a new technological dimension and make it increasingly complex. To achieve the performance required by the market, mastery of the flow of information becomes just as vital as that of the flow of freight. SERNAM intends to progress rapidly in this sphere and the SERNAM-EXPRESS info-monitoring system is the first expression of this intention. It enables the location of each consignment in the transport chain to be determined in almost real time by means of electronic gates (passed obligatorily or contingently) and thus to provide information to the transport operators and the customers on the progress of their consignments. This system is a powerful tool helping to provide a higher quality service and better transparency. (Edited author abstract) In French.

De Saint-Exupery, A. *Rev Gen Chemins Fer* v 107 n 2 Feb 1988 p 55-61.

## Fuel Economy

**088746 RAILROADS STRETCH FUEL DOLLARS... WITH ADDITIVES.** An on-going test in revenue service on a southwestern railroad will try to determine optimum levels for wax crystal modifiers, or flow improvers, as well as for kerosene. The primary fuel filter of the locomotive operating on untested fuel failed after nine or 10 weeks of service, while those treated continued to operate through the entire test. Another apparent benefit was that more complete combustion with less soot and carbon and carbon deposits. Fuel stabilizers can improve the performance of low-cost fuels. In some cases, the fuel treatment can be expensive.

Anon. *Mod Railroads* v 42 n 12 Dec 1987 p 47.

**088747 ENERGY AND TRANSPORT: THE INDIAN EXPERIENCE.** Changes in commercial energy consumption are reviewed. Major determinants of increase in energy demand and change in the demand mix are identified as: (i) expansion of economic activity; (ii) intermodal shifts, and (iii) developments in the energy efficiency of each mode. Rail and road still continue to be the major modes of transport in the country, although air traffic has witnessed the fastest growth. The distinct shift from rail to road during the past two decades has been discussed, and factors underlying the accelerated growth of diesel demand for both rail and road transport are identified. (Edited author abstract)

Dunkerley, Joy (Resources for the Future, Washington, DC, USA); Gadhook, Charu; Hoch, Irving; Thukral, Kapil. *Pac Asian J Energy* v 1 n 1 Jan 1987 p 1-12.

## Italy

**088748 L'OFFERTA VIAGGIATORI E MERCI PER L'ORARIO 1987-88.** [Passenger and Freight Services Offered by the 1987/88 Timetable]. The authors illustrate the timetable brought into force on 31.5.1987, bringing out the innovations regarding both passenger and freight trains. With the new timetable there will be appreciable improvements for all services, both as an increase in commercial speeds and in the services offered: the more qualifying innovations are the regular spacing of passenger trains on the Rome-Milan route and a wider supply of freight services during the summer period. An extensive documentation is given of the various parameters tied to the infrastructures affecting the drawing up of the timetable, of the criteria adopted and of the changes introduced on the lines of the network also in relation to traffic flows, in particular for the freight service. (Author abstract) In Italian.

D'Addio, Michele (Collegio Ingegneri Ferroviari Italiani,

Italy); Romano, Luigi. *Ing Ferrov* v 42 n 8 Aug 1987 p 413-434.

## Magnetic Levitation

**088749 CONTROL METHOD FOR A TWIST RESPONSE TYPE OF ELECTROMAGNETICALLY LEVITATED TRUCK AND ITS EXPERIMENTS USING DIGITAL CONTROL THEORY.** The magnetically levitated railway using normal conducting magnetics has a disadvantage (in comparison with railway using superconducting magnets): it is difficult to widen the air-gap length. The amount of energy required to maintain levitation can be reduced by decreasing the air-gap length. In practice, however, many technical problems have to be solved to reduce the air-gap length, including the response characteristics to the rail discontinuity at rail joints and height difference due to cant. This paper discusses the features and control methods of twist response type electromagnetically levitated truck and presents its digital control performances. 8 refs.

Nakagawa, Toshiko (Yokohama Natl Univ, Yokohama, Jpn); Yamamura, Sakae; Nakanishi, Kunio. *Electr Eng Jpn* v 107 n Sep-Oct 1987 p 94-101.

**Management** See Also RAILROAD PLANT AND STRUCTURES—Track; RAPID TRANSIT—Planning; RAPID TRANSIT—Poland.

**088750 NOW...FOR SOMETHING RATHER DIFFERENT.** The author, 1987 Railway Division chairman, reviews the changes that have taken place on the railways since his first early association with British Railways. The author describes a program of continual development and change, from the introduction of the first diesel locomotive to electrification, and the important part new technology has played in the changes. (Edited author abstract)

Casey, M.V. (British Railways Board). *Proc Inst Mech Eng Part D* v 201 n 4 1987 p 245-256.

**088751 EFFICIENCY AND TECHNICAL DEVELOPMENT - CZECHOSLOVAKIAN RAILWAYS COME UP WITH LONG TERM SOLUTIONS.** The article traces the efficiency/technical development of Czech railways from 1950, since the strong upsurge in economic development, to the present. The increase in development is closely linked with the development facilities for its personnel whose productivity is continually increasing. Other important factors leading to railway efficiency are also discussed.

Chovan, R. *Rail Int* v 19 n 4 Apr 1988 p 3-7.

**088752 MANAGEMENT AND MODERNIZATION OF THE ITALIAN STATE RAILWAYS.** The Italian State Railways (FS) combines both modern techniques and older installations. It is confronted with certain shortcomings, notably in capacity and productivity. A number of recent measures should rectify this situation: the adoption of enterprise management, greater financial means for the realization of investments, the improvement of services, introduction of high speed, etc. This ambitious program, to which the company management is deeply committed, will give the railway the place it deserves within the Italian and European transport systems. The programme is discussed in terms of passenger service, freight traffic, and investments.

Grateau, R. *Rail Int* v 19 n 4 Apr 1988 p 17-23.

**Marketing** See RAILROAD ROLLING STOCK—Economics; RAILROADS—Austria.

**Netherlands** See RAPID TRANSIT—Planning.

## Noise, Acoustic

**088753 PREDICTION PROCEDURE FOR RAIL TRANSPORTATION GROUND-BORNE NOISE AND VIBRATION.** A procedure has been developed for predicting groundborne noise and vibration caused by rail transportation systems. The primary focus is the estimation of low-level, low-frequency groundborne noise and



vibration between 6.3 and 200 Hz in residential and commercial buildings near at-grade and subway track. Two particular features of the method are the use of impact-testing procedures to characterize vibration propagation in soils and the use of 1/3 octave band force densities to represent specific vehicle and track systems. Directions for future research are discussed, including numerical modeling of subway structures and vibration propagation in soils, truck and track dynamics, and propagation of vibration through buildings. (Author abstract). 14 refs.

Nelson, James, Tuman (Wilson, Ihrig & Associates, Inc., Oakland, CA, USA); Saurenman, Hugh, J. *Transp Res Rec* n 1143 1987 p 26-35.

#### Operations Research See RAILROAD PLANT AND STRUCTURES—Stations.

Optimization See ELECTRIC RAILROADS—Paris, France; ELECTRIC RAILROADS—Zurich, Switzerland; RAILROADS—France.

#### Personnel

**088754 PROBLEMS OF OCCUPATIONAL HYGIENE AT RAILWAY TRANSPORT FACILITIES.** Complex investigation of vital problems of occupational hygiene at railway transport and construction facilities along with the underground railway plays an important role in consistent improvement of working conditions and health protection of numerous workers engaged at the enterprises of the Ministry of Transportation and Ministry of Transportation Construction of the USSR. The study provides for the improvement of preventive sanitary surveillance during transportation construction and reconstruction, introduction of new processes and technology, development and implementation of the state and industry standards, normative, instructive and methodological documents ensuring labor protection and safety, morbidity reduction and accident prevention among workers. (Author abstract) In Russian. 4 refs.

Prokhorov, A.A. *Gig Tr Prof Zabol* n 4 Apr 1988 p 6-9.

#### Planning

**088755 PITTSBURGH'S RAIL TRANSIT RENAISSANCE.** The success of the first phase of the rail rebuilding program is leading Port Authority Transit (PAT) and the Allegheny County Board of Commissioners to study the development of a new rail line between downtown and the North Side. Bus ridership in this corridor exceeds 50,000 riders daily. Study and implementation of transit alternatives are necessary to accommodate the growth anticipated in this already heavily transit-patronized region. The interurban lines are also proposed to be rebuilt to light-rail standards. Transit in Pittsburgh is changing. The conversion of an on-street trolley network into a modern, grade-separated subway/light rail operation and the construction of bus-only roadways are representative of a progressive transit system preparing for the demands of the next century.

Beim, Joseph (Storch Associates, Westbury, NY, USA). *ITE J* v 58 n 7 Jul 1988 p 43-46.

**088756 DEFINITION OF ACCESSIBILITY FOR RAILWAY STATIONS AND ITS IMPACT ON RAILWAY PASSENGER DEMAND.** The article discusses the notion of accessibility and presents the special factors and the issues involved in its definition for (intercity) railway stations. It chooses the form that statistically explains better the changes in the number of passengers using a station. The methodology followed in order to do this can be used as a guideline for determining the type of index that would best explain the data in other similar situations. Having selected an index, a simple regression model has been made that connects this accessibility index to the number of passengers using the station. The type of this relation, its statistical characteristics, and its sensitivity are discussed and some useful overall conclusion reached. The data used and a first application of the results refer to the railway network of Greece. (Edited

author abstract). 15 Refs.

Giannopoulos, G.A. (Engineering Univ of Thessaloniki, Greece); Boulougaris, G.A. *Rail Int* v 19 n 7 Jul 1988 p 27-32.

**088757 NEW LINE CONSTRUCTION IN THE FEDERAL GERMAN RAILWAYS.** The two newly constructed lines, Hanover-Wurzburg and Mannheim-Stuttgart, are the core of the network modernisation concept for the Federal Germany Railways. The disturbed topography in the central highlands, habitation density and population structure as well as the relatively elongated route of the line have resulted in a great number of tunnels. The high proportion of tunnels and above all the unaccustomed lengths in Federal Railways terms, travelled at a maximum speed of 250 km/h, call for overall verification of accident provision strategy. Access roads are to be provided to the tunnel portals for fire brigade rescue vehicles and helicopter landing places are to be indicated. 18 refs. In English and German.

Linkerhaegner, Wilhelm (Federal German Railways, West Ger). *Glueckauf Transl* v 123 n 8 Apr 23 1987, 20. Shaft-Sinking and Tunnelling-Colloq - 40 Years VBS, Berlin, West Ger, Feb 5-6 1987 p 247-251.

#### Quality Control

**088758 PASSENGER TRAINS AND SERVICE, QUALITY FOLLOW-UP.** This article gives an account of how Danish Railroad's traffic production has taken up the challenge of an actual quality control from around 1982 and later. This has not been on the basis of strict theoretical viewpoints or with the help of advanced statistical methods, but through a pragmatic attitude towards management and system development. This article is concerned only with that part of quality control which is related to the actual train journey.

Kristensen, O.D. (Danish State Railways, Den). *Rail Int* v 18 n 8-9 Aug-Sep 1987 p 9-16.

#### Research

**088759 AUSTRALIAN RAILWAY RESEARCH AND DEVELOPMENT ORGANISATION AND OTHER TRANSPORT BODIES.** The Australian Railway Research and Development Organization (ARRDO) was formed in 1977. Its work was directed toward the financial and managerial problems of the five government rail systems in Australia. The systems were facing huge deficits. Two crises occurred. In 1983, ARRDO's output became almost nil. With a new management structure, its output resumed, but by 1985 it was falling behind with a new research program. Further reorganization occurred to fit a reduced program to the staff available and output continued, but in May 1986 came the decision to dissolve the organization. In this paper, the research programs and output are discussed and compared with those of the Australian Road Research Board and the Bureau of Transport Economics. ARRDO was more introspective than the other two, and its failure to communicate effectively its research results with the rail systems may have led to its demise. (Edited author abstract) 20 refs.

Pretty, R.L. *Trans Inst Eng Aust Multi Discip Eng v GE11* n 2 Nov 1987 p 75-84.

#### Route Analysis

**088760 RAIL FREIGHT TRANSPORTATION: A REVIEW OF RECENT OPTIMIZATION MODELS FOR TRAIN ROUTING AND EMPTY CAR DISTRIBUTION.** This paper describes two types of rail transportation problems in detail. These are train routing and makeup, and empty car distribution problems. Some of the recent optimization models which address these problems are reviewed and the areas for potential improvements in rail transportation literature are identified. The type of interactions which exist between routing, makeup, and empty car distribution decisions are highlighted and potential areas for future research are identified. (Author abstract) 65 refs.

Haghani, Ali E. (Northwestern Univ, Pittsburgh, PA, USA). *J Adv Transp* v 21 n 2 Summer 1987 p 147-172.

**088761 ROLE OF TRAMWAYS IN THE FUTURE BUDAPEST TRANSPORT SYSTEM.** This paper reviews the exciting plans for the construction of a Metro Network and the reduction in the roll of tramways, against the background of the anticipated growth in car ownership. The paper argues that the best policy may be to invest the capital funds available, after Metro line 3 reaches the Ujpest District centre, in the gradual upgrading of the tramway network to an 'Express' standard, with a speed of 25 km/h, stops of about 0.5 km tramlines separate from other road traffic, and the pre-emption of traffic signals to remove the effects of general traffic congestion. Such a policy could be completed by 2000 giving a fast rail network including Metro of over 150 km, providing a competitive alternative to the private car. (Edited author abstract) 6 refs.

Lesley, L. (Liverpool Polytechnic, Engl). *Period Polytech Transp Eng* v 15 n 2 1987 p 147-160.

#### Scheduling See Also RAILROADS—Japan.

**088762 PREDICTING DISPATCHING DELAYS ON A LOW SPEED, SINGLE TRACK RAILROAD.** This paper presents queueing models for predicting dispatching delays on single track, low speed rail lines with widely spaced passing locations. Because of scheduling unpredictabilities, we assume Poisson arrivals of trains. Because of the slow transit speeds, we assume that trains traveling in the same direction can do so on close headways. We also assume siding capacity of passing locations is not limiting. Under these assumptions, we calculate expected delays on individual segments of single track and for segments of single track with an alternate route. (Author abstract) 7 refs.

Greenberg, Betsy S. (Univ of Texas, Austin, TX, USA); Leachman, Robert C.; Wolff, Ronald W. *Transp Sci* v 22 n 1 Feb 1988 p 31-38.

**088763 PREDICTING DISPATCHING DELAYS ON A LOW SPEED, SINGLE TRACK RAILROAD.** This paper presents queueing models for predicting dispatching delays on single track, low speed rail lines with widely spaced passing locations. Because of scheduling unpredictabilities, we assume Poisson arrivals of trains. Because of the slow transit speeds, we assume that trains traveling in the same direction can do so on close headways. We also assume siding capacity at passing locations is not limiting. Under these assumptions we calculate expected delays on individual segments of single track and for segments of single track with an alternate route. (Author abstract). 7 Refs.

Greenberg, Betsy S. (Univ of Texas, Austin, TX, USA); Leachman, Robert C.; Wolff, Ronald W. *Transp Sci* v 22 n 1 Feb 1988 p 31-38.

#### Toronto, Canada

**088764 SIMULATION MODEL OF SHARED RIGHT-OF-WAY STREETCAR OPERATIONS.** Described in this paper is the Queen Streetcar model, a large FORTRAN program currently under development that simulates light-rail vehicle operations on the Queen Route in Toronto. This service operates in mixed traffic and on a reserved right-of-way over a 21-mi route. The model is designed to analyze the impact of a range of operating policies on the regularity of streetcar service. Specifically, the model is intended to allow examination of operating procedures and then permit comparison with alternate means of regulating service, such as alternative short-turn strategies; use of a centralized automatic vehicle monitoring system; and introduction of traffic signal priorities for transit vehicles, reserved rights-of-way, or larger capacity vehicles, or both. The model proceeds by computing the amount of time that each streetcar will spend in a logical set of 'states' within each link within the network, where streetcar states include moving in a link, loading and unloading passengers at a stop, and so forth. (Edited author abstract). 2 refs.



Miller, Eric J. (Univ of Toronto, Toronto, Ont, Can); Bunt, Paul D. *Transp Res Rec* n 1152 1987 p 31-41.

## Traffic Control

**088765 PLANNING, ALLOCATION AND CONTROL OF ROLLING STOCK DESIGNING AND EXPLOITING SYSTEMS TO MEET BUSINESS OBJECTIVES.** The trend of development on British Rail in regard to systems of automatic data capture for the control and movement of rolling stock is briefly described. The implications of information technology developments on the traditional railway multi tiered management structures has caused and will continue to cause a change in the level at which strategic and tactical decisions can be made. The direct involvement of production workers with computer systems continues as hardware technology and software 'user friendliness' continues to develop. The author does not believe that the peak of Information Technology growth has yet been reached and the integration of large separate systems will become the next major thrust of development as organizational development continues. (Edited author abstract)

Scobey, B.J. (British Rail). *Rail Int* v 19 n 1-2 Jan-Feb 1988 p 52-60.

**088766 RAILWAY OPERATIONS CONTROL.** Plans for the future development of the national economy provide for a further increase in traffic on Soviet Railways. This calls for measures to improve railway operations substantially for advanced-technology applications and for optimized utilization of existing technical means. The article deals with measures being taken by the railways to improve the system of management, to implement modern means of mechanization and automation, to increase the length and weight of trains, to compile optimum train schedules, etc. (Author abstract)

Sotnikov, E.A. (All-Union Railway Scientific Research Inst, USSR). *Rail Int* v 19 n 4 Apr 1988 p 9-16.

## USSR

**088767 USSR RAILWAY TRANSPORT - 150 YEARS.** The Soviet railroads were, and will be the decisive type of transport for the USSR conditions. Such an importance of railway lines is explained by their high carrying capacity and maximum suitability for realization of transportations of bulk commodities, saving of power and labor costs per unit of shipment, low prime cost, practical independence upon climatic conditions, ecological purity. In the USSR the railway transport incorporates apart from 32 railroads, which have administrative self-supporting, also 11 rapid transit systems in the largest cities of the country, more than 100 factories manufacturing spare parts and performing repair of rolling stock, signalling and telecommunications, electrical equipment and switches, about 150 enterprises of industrial transport.

Kalinichev, V.P. *Rail Int* v 19 n 3 Mar 1988 p 29-32.

**RAILROAD YARDS AND TERMINALS** See Also RAILROAD PLANT AND STRUCTURES—Track Switches.

**Assembly** See FREIGHT HANDLING.

## Classification Yards

**088768 BRUECKEN IN GROSSVER-SCHIEBEBAHNHOEFEN.** [Bridges in Large Marshalling Yards]. Large marshalling yards serve to rationalize shunting operations and require, in addition to the construction of sets of classification tracks, the construction of arrival and departure tracks, as well as reconstruction of the passenger track network in the area occupied by the marshalling yard. The required nonintersecting movement of various types of traffic, of necessity, dictated the construction of numerous new railroad and road bridges, as is illustrated in this paper by the recently completed central marshaling yard of Vienna and the Villach Sud marshaling yard, which is still under construction.

In German.

John, Edgar (Potucek, Walter). *OIAZ Oesterr Ing Archiv Z* v 132 n 11-12 Nov-Dec 1987 p 407-413.

**088769 MODERNISATION DU TRIAGE DE VENISSIEUX.** [Modernization of the Venissieux Marshalling Yard]. The considerable volume of freight traffic handled in the area of Venissieux, on the outskirts of Lyons, led to the decision by the management of the SNCF Lyons Region to modernize the existing marshalling yard, dating from 1928, which had undergone little change since then. The modernization scheme has cost 120 million francs and will enable the number of train formation sidings to be increased from 18 to 24, car braking to be automated by the installation of car retarders on each sorting siding and the operation of the points to be modernized. The modernized marshalling yard was inaugurated for the summer service of 1988. It will enable the many customers working from the area to benefit from more numerous direct services and the organization of local services to be adapted to requirements as and when necessary. (Edited author abstract). In French.

Germain, Rene (SNCF, Lyon, Fr); Colombaud, Bernard. *Rev Gen Chemins Fer* n 5 May 1988 p 25-29.

## Computer Aided Design

**088770 COMPUTER AIDED DESIGN (CAD) IN A MODULAR DESIGNING OF TRACK LAYOUT IN RAILWAY STATIONS.** The principal structural features of the newly-developed method are modular; the matrices of the co-ordinates of each unit track section are calculated within two orthogonal co-ordinate systems; it is structurally programmed in BASIC; use has been made of procedures permitting an optimization of a possibly large part of the track layouts to be designed. The functional features of this method are: use can be made, for design purposes, not only of professional micro-computers but also of home ones (C-64); an interactional calculating method. An example is discussed to illustrate this approach. 12 Refs.

Baluch, H. (Polish State Railways, Pol). *Rail Int* v 19 n 6 Jun 1988 p 31-37.

## Design

**088771 RAILWAY ARCHITECTURE AND THE BRUNEL AWARDS.** The article addresses the question of why there is going to be a considerable change in station architecture. It examines history and the reasons why stations have developed in their present form, the factors that influence that form and their comparison with the factors which will cause this change in the whole concept of a station. It also shows how the Brunel Awards have been developed to encourage this change in design concept.

Taylor, R. (BR, GB). *Rail Int* v 19 n 5 May 1988 p 17-22.

**Equipment** See Also RAILROAD TRANSPORTATION—Freight.

**088772 MOBILE SPIKE RECLAMATION.** The Spike Reclaimer picks up used spikes, cleans them, and sets them back down for reinstallation. The Reclaimer consists of a tumbler, jib crane, canopy, and a push car. The Reclaimer moves down the track at approximately 300 feet per minute, its magnetic, 5-foot-diameter wheels picking up any spikes left by the spike puller. The spikes are then carried to a chute and dropped on a conveyor belt which takes them to the cleaning tumbler. At 15 revolutions per minute, the 5-foot tumbler contains about 800 spikes, and as spikes are added at the front of the tumbler, the cleaned spikes overflow at the rear of the tumbler on a continuous basis.

Anon. *Railw Track Struct* v 84 n 7 Jul 1988 p 73.

**Inventory Control** See RAILROAD PLANT AND STRUCTURES—Maintenance.

## Italy

**088773 LE STAZIONI DI SMISTAMENTO.** [Marshalling Yards. Operating Problems and Programs for the FS]. The recent energy into operation of the new Bologna S. Donato foodstuff marshalling yard, completely automated with the target shooting system, has aroused considerable interest, not only among personnel operating in the particular freight traffic sector, but also among those, railwaymen or otherwise, who follow with attention the events of the railway world in all its manifestations. This paper aims above all at clarifying the reasons which induced the FS to considerably potentiate the system of selection of freight consignments with the creation of new, fully automated marshalling yards, as well as providing a synoptic documentation on the installations already completed or under construction. (Author abstract). 5 Refs. In Italian.

Fortini, Mario. *Ing Ferrov* v 43 n 5 May 1988 p 243-256.

**RAILROADS** See Also TUNNELS AND TUNNELING—Railroad.

**088774 INFORMATION AND COMMUNICATION SYSTEMS FOR RAILWAYS.** As modern railway and transit systems are increasingly designed with emphasis on speed and passenger/freight capacity, prompt yet accurate relay of information related to train operation and safety has become the primary concern of railway communication systems. At the same time, more general movements toward networking, digital signal processing, and optical communications are making an impact on railway data-communication systems. This article introduces such recent developments as wireless train-wayside communication systems, systems for transmission of monitored images, and systems for new media such as CATV and Videotex at stations and on Shinkansen "bullet trains" to provide more sophisticated functions and services.

Takahashi, Keiichi (Mitsubishi Electric Corp, Tokyo, Jpn); Ogata, Masaharu. *Mitsubishi Electr Adv* v 43 Jun 1988 p 4-5.

**Accident Prevention** See Also RAILROAD PLANT AND STRUCTURES—Crossings; RAILROAD ROLLING STOCK—Telemetering; TUNNELS AND TUNNELING—Ice Problems.

**088775 DISASTERS SUFFERED (DURING THE PAST TWENTY YEARS) AND MEASURES AGAINST THEM.** The author notes a steady and substantial decline in the number of disasters that have occurred on Japanese railways over the past 20 years. More than 8,000 disasters per year in the mid-1960s have been reduced to a range from 1,000 to 1,400 occurrences for the past 1 or 2 years, which is a decrease to about 1/6 in 20 years. Measures that have been taken to prevent the occurrence of bridge collapses, landslides, rockfalls, track flooding and clay intrusion are reviewed.

Katayose, Norio (East Japan Railway Co, Jpn). *Jpn Railw Eng* v 27 n 2 Sep 1987 p 21-24.

**088776 SICHERHEITSTECHNIK: DIE ZUMUT-BARKEITSGRENZE FUER SICHERHEITSAUF-WENDUNGEN.** [Safety Engineering: The Acceptability Limit for Safety Expenditures]. In this paper, an attempt is made to derive a quantitative limit on the payoff from safety measures adopted by railroads. The analysis is based on general economic dependences applied in conjunction with the objectively permissible prediction possibilities of probability theory. In addition, the importance of the concept of the probabilistic effectiveness of safety measures in the relative evaluation of such measures is indicated. 7 refs. In German.

Pierick, K. (Univ Braunschweig, West Ger). *Rail Int* v 18 n 10 Oct 1987, Int Environ Symp: Eur Railw - An Asset for the Environ, Mannheim, West Ger, Oct 22 1987 p 63-67.



## Air Conditioning

**088777 ADVANCED AIR-CONDITIONING SYSTEM FOR TRAINS.** Roughly 85% of all commuter trains in the Tokyo metropolitan area are air-conditioned. However, since train air-conditioning equipment is generally automatically controlled, with on-off operation performed intermittently, very precise temperature control is not possible. For this reason, the passenger environment tends to be either too cool, or, during seasonal heavy rains, too hot and humid. Nowadays, with advances in microprocessor-control technology and variable-speed motor control, we are witnessing an evolution from merely cooling railcar interiors to very precise control of cooling and humidity, making it possible to respond more flexibly to demands for greater passenger comfort. And, if entire integrated systems are developed, including power supplies, the equipment can be made more compact, lightweight, and energy-efficient. Some air conditioning system test results are included.

Kaga, Atsushi (Mitsubishi Electric Corp, Tokyo, Jpn). *Mitsubishi Electr Adv v 43* Jun 1988 p 19-21.

**Australia** See Also RAILROAD TRANSPORTATION—Research.

**088778 RESTORING AND OPERATING THE PICHIRI RICHÍ RAILWAY.** The Pichi Richi Railway is the most significant remaining section of South Australia's pioneering railways. It is noted for its early use of concrete, its dry masonry walling and its wrought and cast iron bridges. The Pichi Richi Railway Preservation Society is entirely run by volunteers, as a working museum operating steam trains for the public using historical procedures. A well defined management strategy has been developed, but the Society still faces many problems. (Author abstract) 4 refs.

Stacy, W.S. *Trans Inst Eng Aust Multi Discip Eng v GE11 n 2* Nov 1987 p 85-91.

**Austria** See Also BRIDGES, RAILROAD—Reconstruction; RAILROAD PLANT AND STRUCTURES—Construction.

**088779 150 JAHRE EISENBAHNEN IN OESTERREICH.** [150 Years of Railways in Austria]. The year 1837, on the 23rd November of which a passenger train hauled by a steam locomotive ran from Floridsdorf near Vienna to Deutsch-Wagram, is the beginning of the railways in Austria. Soon afterwards, numerous north-south and east-west connections were built. Also after the introduction of electric traction in 1904, the development of the motive power units was always influenced by the predominantly mountainous character of the Austrian landscape with its numerous upgrades and downgrades and often narrow curves. This article describes the history of the railways in Austria by highlighting the development of the rail vehicles and ends with a look at the future of Austrian Federal Railways which have launched extensive projects designed to make the railways of Austria a reliable link in a European long-distance network. (Edited author abstract) In German.

Haintz, Helmut (Oesterreichische Bundesbahnen, Vienna, Aust). *Z Eisenbahnes Verkehrstechn Glaser Ann v 111 n 11-12* Nov-Dec 1987 p 350-362.

**088780 LONG DISTANCE PASSENGER TRAFFIC: THE RAILWAY AT A WATERSHED: NEW OPPORTUNITIES IN LONG-DISTANCE TRAFFIC.** The Austrian Federal Railways (ÖBB) are opting for fundamental and far-reaching modernization and structural modification, which are essential if the railway is to constitute an attractive and environment-friendly alternative among the transport modes in the market. To increase market share, ÖBB is proposing to introduce two classes at high-speed trains - namely, EuroCity (EC) trains for travel between major cities in Austria and abroad, and Intercity (IC) trains for travel between large Austrian cities. Maximum running speeds of 200 km/h are planned for EC and IC trains, which will give revenue speeds of up to 160 km/h and achieve considerable cuts in today's

journey times. In addition, ÖBB are planning Interregio trains as feeder services for the EuroCity and Intercity trains: the rolling stock used in them will permit running speeds of up to 160 km/h, giving revenue speeds of up to 100 km/h.

Sittler, H. (Oesterreichischen Bundesbahnen, Austria). *Rail Int v 13 n 10* Oct 1987, Int Environ Symp: Eur Railw - An Asset for the Environ, Mannheim, West Ger, Oct 22 1987 p 5-7.

**088781 COMBINED TRANSPORT: THE NEED FOR ENVIRONMENT-FRIENDLY TRANSPORT THROUGH THE ALPS.** Whereas in 1970 rail and road handled roughly equal proportions of freight traffic in transit through Austria, stagnation in the volume of rail transport has meant a fourfold increase in road traffic. The main burden is borne by the Inn Valley-Brenner route which handles some 42% of all holiday transit traffic (i.e., some 8 to 9 million private cars per year) and 75% of all road freight transit traffic. As a direct result, the Austrian Federal Government has devised a transport corridor concept giving priority to combined transport and conventional rail transport to relieve congestion on transit routes across Austria. In connection with the Brenner route, the Austrian Government is sponsoring measures to enlarge tunnels to UIC C/1 gauge, improve signalling and operating techniques so that train headway can be shortened, driven the line around Innsbruck and introduce new, still to be developed heavy tandem multicurrent locomotives to remove the need for a further locomotive at the start of the Brenner gradient and for a change of locomotive when crossing the frontier into Italy.

Halbmayer, K. (Wirtschaft & Verkehr, Vienna, Austria). *Rail Int v 13 n 10* Oct 1987, Int Environ Symp: Eur Railw - An Asset for The Environ, Mannheim, West Ger, Oct 22 1987 p 16-19.

**Automatic Train Control** See Also CARS—Street Railroad; RAILROAD ROLLING STOCK—Control; RAILROAD TRANSPORTATION—Traffic Control.

**088782 ATCS HARDWARE GOES IN TO PROVE CONCEPT.** On one point, all of the major US and Canadian railways are agreed: the projected returns on investment in advanced train control systems look very attractive indeed. Union Pacific - often regarded as an industry leader when it comes to innovative technology - has already decided to install a Level 30 system throughout its 264 km North Platte subdivision, and Canadian Pacific expects to have all the elements of Level 30 in operation next year on its 320 km line between Calgary and Edmonton. Many other lines have hardware on test. Indeed, the installation of conventional CTC is rapidly winding down in the belief that ATCS offers the opportunity to do a much better job at lower capital and maintenance cost.

Anon. *Railw Gaz Int v 143 n 10* Oct 1987 p 663-666.

**088783 AUTOMATIC TRAIN CONTROL SYSTEM - HONG KONG MASS TRANSIT RAILWAY CORPORATION.** This paper will give an overview of the automatic train control system used on the mass transit railway system. This topic will be covered, firstly, by outlining the reasons for the use of automatic train control systems and the basic principles of system design that required to be adopted. The emphasis will be placed on the Trainborne system and equipment.

Gaffney, Phil (Hong Kong Mass Transit Railway Corp). *Meas Control v 20 n 7* Aug-Sep 1987 p 104-110.

**088784 RIO GRANDE: TESTBED FOR C&S INNOVATION.** General Railway Signal is running multiphase tests of its SPACERAIL vital radio-based signal and control system over about 150 miles of Denver & Rio Grande Western railway line. Now, the cooperative testing arrangement on SPACERAIL is well into its second phase, after completion last July of Phase 1 work which consisted primarily of demonstrations of the system's ability to read track-based transponders reliably and of the ability to communicate effectively using the existing train radio network. In Phase 2, the objectives are to

demonstrate the system's ability to nonvital control movements based on zone occupancy data and existing CTC interlocking data. For this phase, a partial signal system will be emulated on Rio Grande's 38-mile line between Bond, Col., and Phippsburg.

Welty, Gus (Railway Age, New York, NY, USA). *Railw Age v 188 n 10* Oct 1987 p 51-52.

**088785 TRAIN SPEED CONTROL BASED ON TRACK MAINTENANCE CONDITION, RAINFALL AND EARTHQUAKE.** Japanese National Railways (JNR) developed a train speed control system on the basis of track maintenance conditions, rainfall and earthquakes in order to ensure safe operation of Shinkansen trains, which run at speeds of over 200 km/h. For Shinkansen train speed control adjustment based on track maintenance condition, inspection trains measure the track condition once every ten days. In the event of heavy rain, trains are stopped when the rainfall per hour or the continuing rainfall in a day exceeds specified value. To monitor earthquakes, seismometers are installed along the Shinkansen track. (Edited author abstract)

Ino, T. (Kanazawa Inst of Technology, Jpn). *Rail Int v 13 n 11* Nov 1987 p 18-23.

**088786 NEW SHINKANSEN MU CARS CLAIM-ABLE TO BE AN 'INTELLIGENT TRAIN': INFORMATION SYSTEM WITH SHINKANSEN MU CARS.** A new series of Shinkansen MU cars is provided with various information systems. With the conventional series, the main information system was a train radio system which was used mainly for train dispatching and only partially for common telephone service to onboard passengers. The new 'Series 100' MU train is also equipped with other information systems, such as a monitoring system, an onboard passenger guidance system, and automated public address system and a radio broadcasting relay system. In 1989, the ground facilities for the train radio system will adopt LCX (leaky coaxial cables), and the onboard passenger telephone service will be reinforced.

Ishikawa, Sakae (Central Japan Railway Co, Jpn). *Jpn Railw Eng v 27 n 2* Sep 1987 p 10-13.

**088787 TRAIN OPERATION CONTROL IN THE FUTURE.** In order to revitalize railways, future planning and radical changes to train operation control systems are needed. For this, it is necessary to operate trains flexibly with fewer staff members, and also to introduce telecommunication technology and information processing technology efficiently, with full consideration of the costs and maintenance work for operation control systems. The concept which the author proposes is to operate trains with intelligence by means of terminals with intelligence, such as electronic interlocking systems. The system executes the decentralized control of trains and stations, with centralized supervision and regulation. Various kinds of technology have reached satisfactory levels for implementation of the proposed system. (Edited author abstract)

Sasaki, T. (Japanese Natl Railways, Jpn). *Rail Int v 19 n 1-2* Jan-Feb 1988 p 49-51.

**088788 FEC: SYSTEM-WIDE WITH ATC.** The freight-only Florida East Coast Railway has begun preliminary work that will lead to installation of an ATC system on its Jacksonville-Miami main line. Harmon Industries is supplying the equipment, both on-train and off. FEC is getting a total hardware package from Harmon, which will include Electro Code 4 microprocessor-based dc-coded track circuitry. Harmon's Phase Motion Detector system for grade-crossing protection, along with some Harmon Crossing Processor equipment, and the manufacturer's Locomotive Speed Limiter in its Ultra-Cab 40 design.

Welty, Gus. *Railw Age v 189 n 2* Feb 1988 p 28-30.



**088789 AUTOMATISCHE ZUGKONTROLLE - ATC-SYSTEM - BEI DEN DAENISCHEN STAATS-BAHNEN.** [Automatic Train Control (ATC) System for the Danish State Railways]. This paper describes the development of an automatic train control system which has been specifically designed for the signalling system and the rolling stock of the Danish State Railways. The objectives, the strategy for the gradual introduction of the ATC system, the technical solution, the safety requirements and the time schedule are discussed. (Edited author abstract) In German.

Frosig, Poul (Daenische Statsbahnen, Copenhagen, Den). *Z Eisenbahnes Verkehrstech Glasers Ann* v 111 n 11-12 Nov-Dec 1987 p 474-481.

**088790 NEC: THE ROCKY ROAD TO ATC.** The Federal Railroad Administration has now completed administrative action to start a process that should result in the elimination of non-Automatic Train Control freight operations on the Washington-Boston spine of the Northeast Corridor by July 1, 1990. Conrail has requested bids from numerous suppliers for prototypes, to its performance specifications, of a 'braking profile system.' Similar to conventional ATC in requiring that any change to a more restricting signal indication will result in an automatic brake application if not acknowledged within eight seconds, after acknowledgement BPS leaves control of the train with the engineer, provided that he keeps train speed within a profile that will satisfy the signal indication.

Armstrong, John H. (Railway Age, New York, NY, USA). *Railw Age* v 189 n 3 Mar 1988 p 61-62.

**088791 ECONOMICS OF AUTOMATIC TRAIN CONTROL IN SWEDEN.** From 1980 to 1985 a new fail-safe intermittent ATC system has been introduced in Sweden, today covering 90% of the Swedish traffic. The system helps the driver by giving him information and intervenes in case of danger. The investment costs exceed 400 MSEK (million Swedish kroner) and the annual costs are approximately 7 MSEK. With the ATC system it has been possible to simplify tracks and optical signals. ATC as a basic component in the signalling system will also facilitate many profitable future functions, for example, centralized systems using transponders for train position indication and radio for transmission, but the primary aim of ATC was to increase safety, and this aim has also been achieved. (Author abstract)

Forsgran, K.L. (Ericsson Signal Systems AB, Swed); Sjoeborg, A. *Electr Veh Dev* v 7 n 2 Apr 1988 p 54-55.

**088792 DEVELOPMENT OF AN ON-BOARD ENERGY-SAVING TRAIN OPERATION SYSTEM FOR THE SHINKANSEN ELECTRIC RAILCARS.** The authors have studied energy saving train operation methods for the Shinkansen electric railcars and propose a simple and effective one which can be implemented in a microprocessor-based on-board system for assisting the motorman's operation. Running tests of the accommodation train service for comparing energy consumption between the motorman's actual train operation and the proposed method using this on-board system were carried out on the Tohoku-Shinkansen line. In these tests, whose scheduled running time had about 6% of margin to the planned minimum running time, about 10% energy saving was obtained by the proposed train operation method with a high precision of on-schedule control. (Author abstract) 2 refs.

Yasukawa, Shinobu (Rolling Stock Lab, Jpn); Fujita, Shinichi; Hasebe, Takehisa; Sato, Koichi. *Q Rep RTRI (Jpn)* v 28 n 2-4 Nov 1987 p 54-62.

**088793 BN AND ARES: 'CONTROL' IN A NEW DIMENSION.** If the Advanced Railroad Electronics System (ARES) proves to be only equal to the sum of its parts - seven major subsystems - it will be a substantial accomplishment in railroad communications, command and control. But Rockwell International's ARES, now well along in testing on Burlington Northern, may turn out to be greater than the sum of the parts. The heart of ARES is the data management system, with its main

element an on-board data management unit that provides for both the integration and automation of information exchange among the various on-train systems and the interface with the ground-based ARES system. ROCS, an advanced control and dispatching system, generates orders, does safety-monitoring, determines compliance with instructions, optimizes the flow of traffic and helps the dispatcher in making his decisions. In its present configuration, the ROCS work station has five multiple-color CRT displays. The train location system has attracted the most attention, mainly because of its use of the Navstar Global Positioning System (GPS).

Welty, Gus (Railway Age, New York, NY, USA). *Railw Age* v 189 n 5 May 1988 p 24-26.

**088794 AUFSTELLEN VON BREMSTAFELN FUER STRECKEN MIT LINIENZUGBEEINFLUSSUNG.** [Compilation of Braking Charts for Lines Using Continuous Inductive Automatic Train Control]. The German Federal Railway's lines and rolling stock for speeds above 160 km/h are equipped for continuous inductive automatic train control (ATC). For the practical application of the continuous inductive ATC scheme, so-called braking charts are required which define the relationship between stopping distance, permissible speed, percentage of brake power and route gradient. The railroad has set up braking charts for gradients of 0, 5 and 12.5%, which apply for speeds up to 300 km/h and percentages of brake power of 100 to 240. The method used in setting up the braking charts is described. A specification for brake performance weighting (based on percentages of brake power) for speeds from 160 to 300 km/h was developed as well. In addition, the railroad has prepared a table for determining the brake characteristic to be preset in a continuous inductive ATC system, taking into account the permissible speed, the available brake percentage and the gradient. (Edited author abstract) 5 refs. In German.

Braun, Alfred (Bundesbahn-Zentralamt Minden, Minden, West Ger). *Z Eisenbahnes Verkehrstech Glasers Ann* v 112 n 4 Apr 1988 p 108-118.

**088795 ICE - DIAGNOSE AUS DER SICHT DER ZUGFOERDERUNGSTECHNIK.** [Incorporating Traction Equipment Functions in the ICE Diagnostic System]. An ICE diagnostic system designed to incorporate the traction equipment functions will enable the technical preparatory services to be rendered by the driver to be minimized. This will be accomplished by providing for automatic rigging up and automatic preparations for running, including automatic brake testing. In addition, it will be possible to display the reference inputs for operation on centralized display units in the cab indicator area, to provide for smoother service operation by direct indication of fault causes along with the necessary corrective action, and to dispense with trouble lists. (Edited author abstract). 4 Refs. In German.

Schrobenhauser, Walter (Bundesbahn-Zentralamt Muenchen, Munich, West Ger). *Z Eisenbahnes Verkehrstech Glasers Ann* v 112 n 5 May 1988 p 170-175.

**088796 RADAR DETECTOR FOR AUTOMATIC CONTROL OF TRAINS.** The system consists of simple beacons, which are entirely passive and fixed along the rails according to the required codes, and a radar transceiver working at low level in the X-band. The antenna is constituted by a cylindrical horn and a dielectric lens. The transceiver is based on a specially adapted commercial low-cost module. The results obtained on the antenna base as well as those performed during actual working are presented. (Author abstract) 10 refs.

Pistre, J.D. (Univ de Bordeaux I, Talence, Fr); Zardini, Ch.; Drabowitch, S. *Sens Actuators* v 12 n 4 Nov-Dec 1987, Pap Presented at the 2nd Int Meet on Chem Sens, Bordeaux, Fr, Jul 7-10 1986 p 313-322.

Canada See TUNNELS AND TUNNELING—Construction.

Communication Systems See RADIO COMMUNICATION.

## Computer Aided Design

**088797 20 JAHRE GEOMETRISCHE DATEN-VERARBEITUNG BEI DER DEUTSCHEN BUNDESBAHN.** [Twenty Years of Geometrical Data Processing on the German Federal Railway]. A computer-aided automatic drawing system called geometrical data processing was introduced on the Federal German Railway in 1967. This has enabled technical plans and drawings, and graphical presentations of figures in the form of bar charts and graphs, to be produced automatically with the aid of precision drawing apparatus, supported by a comprehensive and complex set of software. The effectiveness of the automatic drawing system could be further enhanced in conjunction with CAD systems. (Edited author abstract) In German.

Keitmann, Hans Peter (Deutschen Bundesbahn, Frankfurt am Main, West Ger); Schwick, Ludwig. *Eisenbahntechnik* v 39 n 1 Jan 1988 p 24-27.

## Computer Applications

**088798 FUNCTIONAL TESTING OF MICROCOMPUTER RAILWAY INTERLOCKING EQUIPMENT.** The tests are carried out under real circumstances or by their simulation. Simulation is an excellent method if the tests to be performed on real systems are too expensive, slow or dangerous to the environment. Taking this into consideration it is worthwhile to test the station interlocking systems by the simulation of their operation and the railway traffic without connection to on-site equipment. (Author abstract) 4 refs.

Tarnai, G. (Technical Univ, Budapest, Hung). *Period Polytech Transp Eng* v 15 n 2 1987 p 161-169.

**088799 APPLICATIONS OF COMPUTER SYSTEMS TO RAILWAY SYSTEMS.** The recent technological refinements and plummeting costs of computer systems have proved a great boon to railway and other transportation systems. The uses of computers in railway systems are not limited to the usual tasks (accounting, salary calculations, etc.) but also extend to many operations peculiar to railway systems, helping to raise efficiency and cut manpower requirements. This article outlines the Corporation's achievements in applying computers to tasks exclusive to railway systems such as train operation, the supply of electric power to trains, and depot and station management.

Takahashi, Keichi (Mitsubishi Electric Corp, Tokyo, Jpn); Nagashima, Makoto. *Mitsubishi Electr Adv* v 43 Jun 1988 p 6-7.

**088800 TRAIN-INFORMATION MANAGEMENT SYSTEM.** The vigorous application of power semiconductor devices and computer technology has brought many benefits for on-board train equipment and systems, improving overall performance, enhancing reliability, supporting more sophisticated functions, and cutting energy and manpower requirements. By serial linking of all on-board equipment, the entire train and all its equipment can be regarded as a single integrated system, and train information managed in a coordinated, unified manner. Such a scheme enables great simplification of I/O interfaces, and eliminates the need for many of the fittings and connection boxes previously required. The adoption of such train-information management systems (TISs), which enable the reorganizing and streamlining of on-board equipment and functions in a simplified configuration, is under way in Japan and elsewhere. This article describes the construction, functions, and features of a TIS



recently delivered for use in Australia. Mitsubishi Electric has also delivered a TIS employing a fiber-optic serial-data line for use on subways in Japan.

Moriha, Kenji (Mitsubishi Electric Corp Itami Works, Jpn). *Mitsubishi Electr Adv* v 43 Jun 1988 p 8-9.

**Concrete Construction** See RAILROAD PLANT AND STRUCTURES—Track Ties.

## Construction

**088801 UNDERPINNING CONSIDERATIONS FOR DESIGN UNIT A-140, METRO RAIL TRANSIT PROJECT.** The proposed rail transit system, Section A-140 of the Southern California Rapid Transit District, consists of two cut-and-cover stations and approximately 1.5 mi of twin bore tunnel. Along the proposed alignment are numerous structures many of whose foundations rest above the invert of the proposed tunnels or adjacent to the proposed station excavation. Consideration is given to protection of structures along the proposed route. The influence zones for tunnel mining and station excavation, based on design criteria, available literature, and past experience, are established. Settlements of the buildings within the influence zone are predicted and compared with the estimated allowable settlements. Those buildings whose predicted settlements exceed allowable settlements are thereby identified. (Edited author abstract) 9 refs.

Hampton, Delon (Delon Hampton & Associates Chartered, Washington, DC, USA); Jin, J. Scott. *Transp Res Rec* 1104 1986 p 18-25.

**088802 COMPUTERIZED PROJECT PLANNING.** Since its introduction in the late 70's, PLANTRAC software has been used for construction, plant engineering and other applications at some 1500 sites around the world. In New York, London and Istanbul, the software package is currently helping to manage railway construction and rehabilitation programs. One of the software's key features is its capability to analyze and present in the form of discussion documents the different responsibilities of various departments such as civil engineering, architecture, and mechanical engineering. The printouts are formatted to fit a standard form; and each provides start and finish dates as well as the float and current status of each activity. With the Computerline software, network diagrams are used to draw up work plans and then to monitor progress against it.

Brind, Alan (Golden Group of Waltham, Waltham, MA, USA); Pears, Wally; Manne, Steven. *Railw Track Struct* v 84 n 7 Jul 1988 p 70-72.

**Control** See ARTIFICIAL INTELLIGENCE—Expert Systems.

**Costs** See RAILS—Standards.

## Cuba

**088803 CUBA STRIVES TO RAISE RAIL CAPACITY.** The end of the 1970s and the early 1980s saw the launching of Cuban Railway modernization program. Since then, the principal objective has been to rebuild the standard gauge central main line from Habana to Santiago de Cuba. The intention is to cut journey times, with maximum speed of passenger trains raised initially to 140 km/h; freight will run at 100 km/h. A second phase of work will in due course raise the line speed ceiling to 200 km/h on certain parts of the route. Work entails complete reconstruction of the track which is being relaid with 50 kg/m rails and monobloc concrete sleepers. About 70 per cent of the formation has had to be rebuilt, with curve radii increased to 2,000 m and steepest gradients reduced to 1.2 per cent. Large numbers of level crossings are being replaced by bridges, while marshalling yards and freight depots are being enlarged, the objective in this case being to bring about a major increase in capacity.

Pina, Fernando Fornet (Cuban Ministry of Transport). *Railw Gaz Int* v 143 n 11 Nov 1987 p 736-737.

**Denmark** See Also RAILROAD TRANSPORTATION—Quality Control.

**088804 FREIGHT TRAFFIC: RAILWAYS: A SAFE, ENVIRONMENT-FRIENDLY MODE FOR THE CARRIAGE OF DANGEROUS GOODS.** Rapid growth in the dangerous goods transport sector and the attendant problems and risks have further highlighted the fact that safe carriage of such goods is important, not just for those directly concerned, but also for the community as a whole. Recent headline-hitting events have focused attention on the relative merits of the different modes in terms of safety and potential threats to the environment for the carriage of dangerous goods, and here the railway comes out well. The essential thing is to make this fact clear in discussions and, above all, to illustrate the possibilities for improving safety and reducing the risk of pollution inherent in the carriage of dangerous goods by the use of modern technology. Remarkable developments in this connection are illustrated in this paper concerning the transport of such goods on the Danish State Railways.

Sloth, N. (Danische Staatsbahnen, Den). *Rail Int* v 13 n 10 Oct 1987, Int Environ Symp: Eur Railw - An Asset for the Environ, Mannheim, West Ger, Oct 22 1987 p 20-22.

**Developing Countries** See RAILROAD TRANSPORTATION—Developing Countries.

**Economics** See RAILROAD PLANT AND STRUCTURES—Maintenance.

**Environmental Impact** See METEOROLOGY—Climatology.

**Europe** See Also RAILROAD TRANSPORTATION—Economics.

**088805 INTERNATIONAL ENVIRONMENT SYMPOSIUM: EUROPE'S RAILWAYS - AN ASSET FOR THE ENVIRONMENT.** This conference proceedings contains 13 papers on the railway as an environmentally friendly mode of transport and state-of-the-art technical developments by railways to protect the environment. Of the papers presented 2 are in German and the rest in English. Topics discussed include the marketing of long-distance passenger train service, the expansion of suburban train service in the Zurich area, regional passenger service in France, upgrading rail freight service in the province of Tyrol in Austria, the transporting of hazardous freight in Denmark, the construction of new high-speed railway lines in the Federal Republic of Germany, the construction of a new high-speed passenger rail line in France, a new local railway line serving new suburbs of Amsterdam, research on railway-related noise and railway-induced ground vibrations, the railroad as an energy-efficient mode of transportation, a cost/benefit analysis of expenditures on railroad safety measures, and the role of occupational medicine in protecting railway workers. All papers are indexed and abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11122 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Group of Twelve Railways of the European Communities). *Rail Int* v 13 n 10 Oct 1987, Int Environ Symp: Eur Railw - An Asset for the Environ, Mannheim, West Ger, Oct 22 1987 69p.

**Federal Republic of Germany** See Also CARS, RAIL MOTOR—Design; RAILROAD PLANT AND STRUCTURES—Construction; RAILROAD PLANT AND STRUCTURES—Stations; RAILROAD PLANT AND STRUCTURES—Track Switches; RAILROAD ROLLING STOCK—Bogies; RAILROAD ROLLING STOCK—Design; RAILROAD ROLLING STOCK—Testing; RAILROAD TRANSPORTATION—Planning.

**088806 NEW LINES: THE GERMAN FEDERAL RAILWAY'S CONSTRUCTION PROGRAMME - AN ACTIVE CONTRIBUTION TO PROTECTING THE ENVIRONMENT.** The German Federal Railways will be playing a greater role on the transport market following the completion of its high-speed train project, achieved through the modernisation and extension of the network

as well as the introduction of a new generation of trains. The German Federal Railways are making an active contribution to environmental protection by attracting customers to the new lines and incorporating measures to protect the environment and countryside into the planning and construction of their projects. These measures include landscaping, energy conservation, noise reduction, air and water projection, and accident prevention.

Linkerhaegner, W. (Bahnbauzentrale der DB, West Ger); Amann, H. *Rail Int* v 13 n 10 Oct 1987, Int Environ Symp: Eur Railw - An Asset for the Environ, Mannheim, West Ger, Oct 22 1987 p 23-27.

**France** See Also BRIDGES, RAILROAD—Reconstruction; RAILROAD PLANT AND STRUCTURES—Construction; RAILROAD PLANT AND STRUCTURES—Modernization; RAILROAD SIGNALS AND SIGNALING—Interlocking; RAILROAD TRANSPORTATION—Freight; RAILROAD YARDS AND TERMINALS—Classification Yards.

**088807 DER TGV ATLANTIK UND DIE GEGENWAERTIGEN PERSPEKTIVEN EINES EUROPAEISCHEN HOCHGESCHWINDIGKEITSNETZES.** [TGV Atlantique and Current Prospects of a European High-Speed Network]. Following trials with prototype trains, normal production of the TGV Atlantique trains has now been started. The first train is scheduled for delivery to the French National Railways (SNCF) in 1988. In the meantime, SNCF is developing plans for linking the two new lines (South East and Atlantique) to the proposed Northern and Eastern lines thus creating a French high-speed network. A European high-speed network comprising TGV services is being envisaged for the time horizon around the year 2000. However, to this end, numerous problems due to the different technical and operational conditions of the European railways have to be solved. (Edited author abstract) In: German.

Lacote, Francois (SNCF, Paris, Fr). *Z Eisenbahnes Verkehrstechn Glaser Ann* v 111 n 11-12 Nov-Dec 1987 p 371-374.

**088808 TGV ATLANTIQUE: A NEW LINE FOR 22 MILLION INHABITANTS.** Work on the new high-speed TGV Atlantique line started in 1985 and has followed the anticipated schedule with opening of service planned in two stages: the western branch to Le Mans in 1989, and the south west branch to Tours in 1990. Time saving of the order of one hour, will put Rennes and Nantes within two hours of Paris, Bordeaux within three hours, and Toulouse within five hours. An innovation is represented by increased comfort thanks to a new suspension with pneumatic membranes with variable transverse flexibility and by a radical transformation of damping connections between coaches. Then there is innovation or rather revolution in traction thanks to the new autopiloted synchronous electric engine. The 'Atlantique' will travel at 300 km/h with a power of 10,400 kw distributed between 8 engines, compared to the TGV Sud-Est train which develops only 6000 kw at a speed of 270 km/h with 12 engines of the same mass and size.

Anon. *Rail Eng Int* v 17 n 1 1988 p 4-5, 7.

**088809 REGIONAL TRAFFIC: SNCF AND THE REGIONS - A PARTNERSHIP FOR SUCCESS.** Regional rail services are one of the key components that characterize the true dimension of the SNCF public service function. They concern over 600 lines, adding up to some 26,000 km of track on which these services very frequently have to coexist with fast and express trains, and which play a vital role in local community life. With the new TER train sets, the rolling-stock fleets of the regional railways are being renewed for use on modern, new, bright-liveried, comfortable and high-performance regional trains. Over 50% of the regional railway rolling-stock will have been renewed by 1990.

Chauvineau, J. (SNCF, Fr). *Rail Int* v 13 n 10 Oct 1987, Int Environ Symp: Eur Railw - An Asset for the Environ, Mannheim, West Ger, Oct 22 1987 p 13-15.



**088810 NEW LINES: TGV ATLANTIC AND THE ENVIRONMENT.** This article explains the way the protection of the environment has been taken into account in the construction of the new TGV Atlantic high-speed line. The measures taken include the relocation of farm holdings, the safeguarding of forest land and wildlife, the protection of surface and underground waters, and the reduction of noise and vibrations.

Chambron, E. (TGV Atlantic, Fr); Escaron, J. *Rail Int* v 13 n 10 Oct 1987, Int Environ Symp: Eur Railw - An Asset for the Environ, Mannheim, West Ger, Oct 22 1987 p 28-35.

Freight See LOCOMOTIVES—Performance.

Great Britain See RAILROAD PLANT AND STRUCTURES—Maintenance of Way.

## India

**088811 INDIAN RAILWAYS ON THE WAY TOWARDS A MODERN TRANSPORT SYSTEM.** Indian Railways operates the largest railway network in Asia and the fourth-largest in the world (after the USA, the USSR and Canada) and taken as a single enterprise constitutes the world's second-largest railway company. The main emphasis of Indian Railways' development program is on the track itself: expansion, strengthening for improved performance, maintenance safety, also including switches, structures such as bridges, and all other installations and equipment of direct relevance to the track. The laying of long welded rails, continuously welded track and track construction mechanisation using modern permanent way machinery and equipment are on the increase. For many years now, absolute priority has been attached to the electrification of the heavily-used main lines. Since about 1951 there has been a gradual conversion of all the principal trunk lines, in particular on the 'rectangular' main network (comprising the Bombay-Delhi-Calcutta-Madras-Bombay lines) from 1500-volt dc to the more powerful and above all cheaper-to-install 25 kV/50 Hz single-phase 'industrial' ac system.

Stier, Guenter (Bundesverband Deutscher Eisenbahnen, Cologne, West Ger). *Rail Eng Int* v 17 n 1 1988 p 12-13, 15-16.

## Industrial

**088812 SAMMELN UND VERTEILEN SCHWEPUNKT DER AUFGABEN VON WERK- UND INDUSTRIEBAHNEN.** [Collection and Distribution - Key Assignments for Industrial and In-Plant Railways]. The costs involved in short-distance haulage, i.e., costs originating in collecting and distributing the merchandise, today account for most of the costs in railway haulage. A description is given here of Gemeinschaftsbetrieb Eisenbahn und Hafen (EH) which hauled a total of 60 million tons in fiscal 1986/87, with more than one third of this tonnage taken care of by DB (German Federal Railways) in cooperation with EH while two thirds were hauled by EH. An outline is given of the particular requirements governing the collecting and distributing operation. Further details are provided on the remotely controlled railway movements at EH and the 'PRODIS' program system which is being adopted as a computer-assisted means of organization, positioning, information and control to supply local control stations. In German.

Jesberg, Karl-Heinz (Eisenbahn & Hafen, Duisburg, West Ger). *Thyssen Tech Ber* v 20 n 1 1988 p 175-179.

## Insulation

**088813 USE OF CELLULAR PLASTIC IN SWEDISH RAILWAYS TO INSULATE THE TRACK AGAINST FROST.** The history of the use of insulation against frost in railways is briefly described. The properties of the best material currently available - extruded cellular plastic of polystyrene (Styrofoam, Styrodur, Eco-prim) - are described. Stress-strain curves are also detailed, showing the highest limits allowed for deformation and

the lowest breaking force allowed for material in a railway track. Dynamic tests and tests with different petroleum products are also described. The paper also deals with the application of the material to the track. The value of extruded cellular plastic as insulation against frost damage with different applications is reviewed. In this respect it is noted that only prescribed qualities are used and that the materials are continuously controlled at delivery. (Edited author abstract). 4 Refs.

Sandergren, Erik (Swedish State Railways, Stockholm, Swed). *Transp Res Rec* n 1146 1987 p 28-32.

Italy See Also RAILROAD TRANSPORTATION—Italy.

**088814 FS ACCELERATES PLAN TO DEVELOP ALTA VELOCITA CONCEPT.** Italian Railways (FS) is now showing determination to press ahead with plans to introduce a national network of high speed lines. FS' Alta Velocita (high speed) project was conceived as a way of consolidating development already in hand and at the same time relaunching intercity rail transport throughout Italy. The plan is to develop a T-shaped network linking Torino, Milano and Venezia in the north with Firenze, Roma and Napoli to the south. The partly-completed Roma - Firenze direttissima forms a key link in the chain, but already plans are being developed for third and fourth lines to round out the network. Massive new line construction lies at the core of the AV project, but much more is involved. Along with the new lines will come a new generation of 300 km/h rolling stock in the shape of the ETR500 trainsets, with the tilting ETR450 fleet providing a 250 km/h stopgap before eventual use on connecting services to areas off the new line network.

Anon. *Railw Gaz Int* v 143 n 12 Dec 1987 p 822-823.

**088815 SISTEMA FERROVIARIO ITALIANO AD ALTA VELOCITA: STUDIO DI FATTIBILITA** [High Speed Italian Railroad System: Feasibility Study]. This study completed in June 1986 was prepared by a working group of the Italian State Railroads (FS). It consists of three parts: General Report (presented in a condensed version), Demand and Supply, and Technical Proposal (presented in full). The main suggestion is the construction of two trunk high-speed lines: Milan-Naples via Bologna, Florence and Rome, and Turin-Venice via Milan and Verona. The General Report discusses various possibilities of increasing the speeds, or particular sections, the potential commercial traffic and the principal project options. The Demand and Supply section discusses the traffic volumes, present and future, and the possible improvements, especially as to the running times between the main traffic nodes, such as Milan and Rome and the rest of Italy attempting to develop an optical solution. The last section, Technical Proposal, considers the infrastructure necessary to implement the project, presenting plans for some new track routes, urban functions, electric traction and signaling, rolling stock and maintenance solution. In Italian.

Rizzotti, Silvio; Cagnano, Maurizio; Rizzo, Vito; De Marinis, Pierluigi; Dentato, Antonio; Esposito, Michele; Giachetti, Giulio; Giuliani, Luigi; Pujia, Vito. *Ing Ferro* v 43 n 3 Mar 1988 p 93-167.

Japan See Also CARS—Coupling; RAILROAD PLANT AND STRUCTURES—Construction; RAILROAD ROLLING STOCK—Magnetic Levitation; RAILS—Welding.

**088816 REVISION OF TRAIN DIAGRAMS IN JR GROUP AFTER ONE YEAR OF OPERATION AS PRIVATE RAILWAYS.** In interurban transportation, the latest revision of train diagrams for the recently divided and privatized Japanese National Railways indicates the through trains for the first time between Honshu and Hokkaido and between Honshu and Shikoku, and reinforces the high-speed railway network of Shinkansen and conventional lines by increasing the number of trains and greatly reducing interurban travel time. In urban transportation, an increase in the number of trains, train speedup and improvement in train connection are easing traffic congestion in commuter trains, making the train diagrams easier to use, and thus improving transportation

services. As a result, the scale of revision of train diagrams of the JR Group as a whole is represented, in terms of the number of trains per day, by an increase from 469 to 527 for Shinkansen trains, from 1,141 to 1,208 for conventional-line limited-express and express trains, from 20,003 to 21,891 for conventional-line ordinary trains, and from 808 to 836 for freight trains.

Tokairin, Tamotsu (East Japan Railway Co, Jpn). *Jpn Railw Eng* v 27 n 4 Mar 1988 p 1-4.

**088817 SHINKANSEN NOISE: RESEARCH AND ACHIEVEMENTS IN COUNTERMEASURES FOR SHINKANSEN NOISE.** In 1982, the Tohoku and Joetsu Shinkansen lines were opened. The result is the present Shinkansen network that runs through Japan from north to south, leading to improvement in railway services, together with the provision of new, efficient connections with conventional lines. The problems of noise and vibration from Shinkansen train operation were posed mainly in relation to railway viaducts in urban areas. The Japanese National Railways (JNR) has made efforts for noise reduction, obtained many achievements, and put them into practical use on the Shinkansen lines. In the early stage of studies, there were many virgin areas for JNR staff, such as measurement technology, estimation methods, and noise alleviation technology. With the start of full-scale testing at a general test center in 1975, various studies and the development of effective measures made a great step forward. In March 1985, the maximum speed on the Tohoku Shinkansen was increased to 240 km/h. (Edited author abstract)

Kikuchi, I. (Japanese Natl Railways, Tokyo, Jpn). *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 381-389.

London, England See RAPID TRANSIT—Automatic Train Control.

Magnetic Levitation See Also CARS—Stability; RAPID TRANSIT—Magnetic Levitation.

**088818 DAS INTERESSE DER DEUTSCHEN WIRTSCHAFT AM TRANSPRAPID.** [Interest of German Trade and Industry in the Transrapid System]. The Federal Ministry of Transport commissioned, in 1969, the Study of High-Performance High-Speed Rail Systems. Within the framework of this study the conclusion was reached that the development of a magnetic levitation system would be of practical relevance with regard to transport policy and the national economy. Primarily involved in the development of magnetic levitation technology are those industrial enterprises which have a tradition of transportation engineering. Included among these is also Thyssen Industrie AG Henschel in Munich, which has been prominently involved in the development and construction of the Transrapid and of the test facility in Emsland, Federal Republic of Germany. The characteristics and advantages of the magnetic levitation system, as well as the milestones in the history of its development, are discussed in detail; future possibilities of using and marketing the Transrapid are described. In German.

Raschbichler, Hans Georg (Neue Verkehrstechnologien, Munich, West Ger). *Thyssen Tech Ber* v 20 n 1 1988 p 75-80.

**088819 EINSATZFELDERSTUDIE USA KORRIDOR LAS VEGAS-LOS ANGELES.** [Regional Application Study USA Las Vegas-Los Angeles Corridor]. By including magnetic levitation technology in international planning at an early stage, the advantages of this new system can be demonstrated. In this connection, the results of the studies on the Las Vegas-Los Angeles link are of special importance. They speak in favour of a magnetic levitation system when the transrapid magnetic levitation system and progressive wheel-on-rail systems are compared. The characteristics of the magnetic levitation system are described, and a detailed account is given



of the study phases between 1982 and 1987. The opening of the Las Vegas-Los Angeles line is envisaged even before 1995. 8 Refs. In German.

Wackers, Manfred (Thyssen Industrie AG Henschel, Munich, West Ger); Dickhart, William. *Thyssen Tech Ber* v 20 n 1 1988 p 219-226.

**088820 DEZENTRALE ENERGIEVERSORGUNG FUER DEN LANGSTARORANTRIEB-WEITERENTWICKLUNGSPOTENTIAL FUER DIE M-BAHN.** [Decentralized Power Supply for Linear Motor Applications. Further Developments Potential for the Magnetic Railway.]. The known advantages of linear motors are further reinforced by decentralizing the power supplies. The components of the line motor will be fed with direct current, which will be converted first directly on the spot. There are noteworthy reductions in problems of layout and changes to service programs. A good measure of redundancy is a further advantage, as is an increase in safety. The energy consumption is lower than with centrally fed motors, because only the motor sections which have an immediate traction-generating function will be energized. These advantages are of special importance in transport-engineering applications in the industrial sector, for example, for underground use in coal mining. (Edited author abstract). In German.

Hoffman, Bernhard (AEG Magnetbahn GmbH, Starnberg, West Ger). *Elektr Bahnen* v 86 n 8 Aug 1988 p 256-260.

**Maintenance** See Also RAILROAD PLANT AND STRUCTURES—Crossings; RAILROAD PLANT AND STRUCTURES—Maintenance of Way; RAILROAD PLANT AND STRUCTURES—Track.

**088821 ALLOCATING RAILROAD MAINTENANCE FUNDS BY SOLVING BINARY KNAPSACK PROBLEMS WITH PRECEDENCE CONSTRAINTS.** The United States is faced with allocating funds from a limited budget to the repair or replacement of railroad track segments on military bases. The problem can be modeled as a very large binary knapsack problem having a single budget constraint and multiple precedence constraints. A procedure has been developed to convert this original problem into an equivalent knapsack problem with a single constraint and significantly fewer variables. The new knapsack problem, still too large to be solved optimally, is then solved efficiently by a heuristic which provides answers within a few percent of optimality. Furthermore, the quality of the solution improves with the size of the problem. (Author abstract) 16 refs.

Melching, Charles S. (Vrije Univ Brussel, Belg); Liebman, Judith S. *Transp Res Part B* v 22B n 3 Jun 1988 p 181-194.

## Management

**088822 OUTLINE OF JR-NET.** This article describes JR-NET, which enables various systems of the JR group of privatized Japanese railways to exchange data. JR-NET is a large-scale computer network consisting of a packet-switching system, which forms the core of the network, a data processing system, a facsimile switching system and a network supervisory and control system. The network covers the whole of Japan, and the number of subscribed hosts and terminals is now about 2500. (Edited author abstract)

Fujii, Kazuaki (Railways Information System Co, Jpn). *Jpn Railw Eng* v 27 n 4 Mar 1988 p 11-15.

## Modernization

**088823 LES RESEAUX A GRANDE VITESSE DANS LE MONDE.** [High-speed Railway Networks in the World.]. The development of truly high-speed transport networks superimposed on existing networks is a recent phenomenon. Japan led the way in the construction of high-speed lines when, to the Tokyo-Osaka Shinkansen opened on 1st October 1964, was added the following year the second section of the Tokyo-Osaka-Kobe motorway. At the present time Japan has more than 1,800 km of

railway lines suitable for 210 and 240 km/h operation, as well as airline services and motorways over the same routes. In 1981, the TGV was added to the airline services and motorways on the French southeast axis to form the first European high-speed network. A second European high-speed network will open in 1989 on the Atlantic front, to be followed by others in the North of France, West Germany, Italy, Britain, Spain, Austria, Sweden and Switzerland. The North European TGV and the Channel Tunnel will contribute to form a grid of European high-speed networks. (Edited author abstract) In French.

Batisse, Francois (SNCF, Fr). *Rev Gen Chemins Fer* v 107 n 4 Apr 1988 p 5-39.

## Monitoring

**088824 OPERATIONAL EXPERIENCE OF THE MICROCOMPUTER REMOTE MONITORING INSTALLATIONS USED BY THE MAV.** A remote monitoring installation produced in the MMG-Automatik workshop was introduced in 1986 on the Hatvan-Miskolc-Mezozombor line of the Hungarian Railroads. This installation also uses single-processor systems in the stations. The amount of information collected has been increased considerably. A multi-processor system with eight processors is in place in the computer center. One processor operates as a monitor/processor and two of them provide data transmission. One processor controls the seven auxiliary processors that switch the lamps (more than 8000) in the recording panel. The other processors have arithmetical tasks. The installations will provide a large number of services: acknowledgments to the recording panel, displays with magnification, displays to show the timetable with train numbers, printers to register the timetable and records (e.g. switching on replacement signals, trailing points). For the time being, only acknowledgments to the recording panel are switched. (Edited author abstract)

Hegedus, G. (MAV). *Rail Int* v 18 n 8-9 Aug-Sep 1987 p 20-28.

**Netherlands** See Also RAILS—Noise, Acoustic.

**088825 NEW LINES: THE NEW FLEVO LINE, AN ENVIRONMENT-FRIENDLY PROJECT.** In 1987 Netherlands Railways (NS) began operations on the first section of a new suburban railway line to Almere new town. The whole line is due for completion in 1988. The line in question is the so-called 'Flevo Line' that is being built out to Lelystad in the heart of the IJsselmeer polder area. The authors describe how allowance was made in this project for environmental considerations. At the time it was not yet mandatory in the Netherlands to examine the impact of this type of project on the environment, but the NS may be said to have acted as precursors in this respect, so that the project can be described as environmentally friendly. The measures taken include nature conservation measures, noise abatement measures, and measures to prevent pollution of soil and water. 12 refs.

van Hasselt, J.-C. (Nederlandse Spoorwegen NV, Neth); Kaper, H.P. *Rail Int* v 13 n 10 Oct 1987, Int Environ Symp: Eur Railw - An Asset for the Environ, Mannheim, West Ger, Oct 22 1987 p 38-44.

**Noise Abatement** See Also ACOUSTIC WAVES—Propagation; TUNNELS AND TUNNELING—Railroad.

**088826 ZWEIGETEILTE SCHALLSCHUTZWAND AUF DER GLEMTALBRUECKE DER DB-NEUBAUSTRECKE MANNHEIM-STUTTGART.** [Split Sound-Insulation Wall on the Glemstal Bridge of the New Mannheim-Stuttgart Rail Link of West German Railways.]. A 4.50 m high sound-insulation wall was erected on both sides of the Glemstal Bridge in order to reduce rail traffic noise on the new high-speed rail link. It was decided to split the structure into two sections - an exterior wall on the cornice and an interior wall on the service beam - for aesthetic reasons and for the benefit of the bridge investigation was specially developed for maintenance work on the bridges of the new rail link. The paper reports on the overall design, production and installation of the

exterior sound-insulation wall, as well as on structural measures for the interior sound-insulation wall. (Edited author abstract) In German. 1 ref.

Bienstock, Rudolf (Bahnbauzentrale, Karlsruhe, West Ger); Eisert, Hans Dieter. *Beton Stahlbetonbau* v 83 n 3 Mar 1988 p 70-74.

**Noise, Acoustic** See Also ACOUSTIC VARIABLES MEASUREMENT—Standards; BUILDINGS—Vibrations; RAILROAD ROLLING STOCK—Testing; RAILROAD TRANSPORTATION—Noise, Acoustic; SUBWAYS—Noise, Acoustic.

**088827 SURVEY OF RAILROAD OCCUPATIONAL NOISE SOURCES.** Measured noise levels are presented for various railroad industry noise sources, including railroad classification yards, locomotives, and cabooses. Alternative control methods for sound reduction are outlined. (Author abstract). 4 Refs.

Urman, Stephen, C. (DOT, Washington D.C., USA). *Transp Res Rec* n 1143 1987 p 22-25.

**088828 PROCEEDINGS OF THE FOURTH INTERNATIONAL WORKSHOP ON RAILWAY AND TRACKED TRANSIT SYSTEM NOISE.** Proceedings incorporates 25 papers. Emphasis is on acoustic noise phenomena associated with railroads, streetcars, subways and similar transportation facilities. Methods of noise reduction and government regulations relating to noise pollution are considered. Topics covered include: elastomer rail support systems, railroad-induced vibrations in neighboring buildings, vibrations caused by streetcars and appropriate control measures, Japanese and Dutch railroad lines, noise prediction methods, sound propagation experiments, noise emission testing, community response to streetcar and railroad noise, interferometry applications, acoustic imaging, diesel engine exhaust noise, wheel/rail noise and roughness measurements, and noise generation due to rail/wheel contact. All papers are separately indexed and abstracted. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11060 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 203-429.

**088829 WHEEL/RAIL ROLLING NOISE: WHAT DO WE KNOW? WHAT DON'T WE KNOW? WHERE DO WE GO FROM HERE?** A review of the current state of knowledge of wheel/rail rolling noise is presented. Mechanisms for noise generation, sources of noise, predictive models and means for control are presented. Areas where additional research is required are suggested. It is pointed out that although considerable progress in expanding our understanding of wheel/rail rolling noise has occurred in the past ten years, there are still many areas of controversy and many areas where firmly based scientific information is lacking. (Edited author abstract) 31 refs.

Remington, P.J. (BBN Lab Inc, Cambridge, MA, USA). *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 203-226.

**088830 NOISE GENERATION IN RAILWAY WHEELS DUE TO RAIL-WHEEL CONTACT FORCES.** In urban rapid transit systems the squealing noise of railway wheels during the passage through narrow curves is troublesome to passengers and city dwellers. Frequency analyses of measured curving-noise levels show that the bending vibrations of the wheel disks excited by stick-slip motion between the wheel rim and the rail are the main sources of this sound radiation. To get insight into the dynamics of the noise generation it is necessary to understand the bending vibration behavior of a wheel disk as well as the sound radiation mechanisms and the generation of self-sustained oscillations in the contact



area. The paper deals with a theoretical model which comprises all three parts of the problem. The natural bending vibrations of the wheel are calculated by means of a finite element-model. The forced and self-sustained oscillations are determined using modal expansion techniques. The radiated sound pressure and sound power due to wheel oscillations. Here, an acoustical quality level is introduced to classify the various types of wheel disks. The major assumptions in the paper are rigid rails and point contact between wheel and rail. (Edited author abstract) 28 refs.

Schneider, E. (Univ Hannover, Hannover, West Ger); Popp, K.; Irretier, H. *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 227-244.

**088831 WHEEL CORRUGATION ON NETHERLANDS RAILWAYS (NS): ORIGIN AND EFFECTS OF 'POLYGONIZATION' IN PARTICULAR.** New intercity trains on NS are quiet when new, but with time the growth of wheel tread corrugation gradually leads to increased noise levels. The phenomenon of 'polygonization' is discussed, including its origin and effects on noise emission. Attempts at combating this source of noise are reported. (Author abstract) 7 refs.

Kaper, H.P. (Netherlands Railways, Utrecht, Neth). *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 267-274.

**088832 INTERFEROMETRIC ACOUSTIC IMAGING OF RAILWAY NOISE.** Far field acoustics deals with intensity distribution as a function of angle  $\alpha$  and frequency  $\nu$ . Interferometric processing is able to display the radiated intensity as a function of  $\nu$  and  $\alpha$  even for moving sources such as trains. A time constraint defines the duration of observation to avoid blur effects. With these techniques, acoustic imaging is able to describe the radiated noise by wheels with damped or undamped webs. The damping effect decreases the emitted level mainly in the 1 kHz and 2 kHz octave bands. (Author abstract) 9 refs.

Escudie, B. (ICPI, Lyon, Fr); Chiollaz, M.; Parent de Curzon, E. *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 303-310.

**088833 STUDY INTO SOURCES OF WAGON NOISE: MEASUREMENT OF SOUND ENERGY GENERATED BY VEHICLE BODIES AND RUNNING GEAR.** The paper describes measurements carried out to identify and quantify the sources of sound connected with the bodywork and running gear of railway wagons. Tests were conducted in France. Of the two methods adopted for test purposes, one was a conventional technique using a set of omnidirectional microphones placed vertically at vehicle gauge limit, and the other involved near-field interferometry based on the use of a flat acoustic antenna also placed at the edge of the track. The results of the measurements showed that for the 18 wagons of six different types studied, most of the sound energy radiated came from the running gear. (Edited author abstract) 1 ref.

Parent de Curzon, E. (SNCF, Paris, Fr); Beguet, B. *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 311-320.

**088834 COMMUNITY RESPONSE TO RAILWAY NOISE: A REVIEW OF SOCIAL SURVEYS.** Studies on the effects of railway noise on the neighbourhood differ in their design, acoustic and sociological measurement and in their evaluation methods. There are only a few studies with emphasis on the effects of shunting yards, high-speed trains and urban train systems, and therefore only the results concerning free-flow railway traffic are summarized. 30 refs.

Moehler, U. (Planungsbuero Obermeyer, Munich, West

Ger). *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 321-332.

**088835 IMPACT NOISE FROM RAILROADS.** Human response to impact noise, generated by wheel flats and rail joints of electric trains, was investigated in a laboratory experiment. The loudness of train noise containing impact components was compared with train noise with no impact components. A method of paired comparisons was used to evaluate the loudness of the test sounds. The results indicate that the wheel flat noise increases the loudness of train noise by 3 db and the rail joint noise increases it by 5 db (outdoor listening condition) and 7 dB (indoor listening condition) at the same equivalent sound energy level. (Author abstract) 2 refs.

Kaku, J. (Kobayasi Inst of Physical Research, Tokyo, Jpn); Yamashita, M. *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 333-337.

**088836 REACTIONS TO RAILWAY NOISE IN DENMARK: A CORRECTION.** An improved noise prediction model has been used in re-analysis of interview results previously reported. The corrected results are now in use as the basis for Danish guidelines for acceptable railway noise at sites of new houses. (Author abstract)

Andersen, T.V. (Natl Agency of Environmental Protection, Copenhagen, Den); Kuhl, K.; Relster, E. *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 339-340.

**088837 RAILWAY NOISE EXPOSURE: A POSSIBLE METHOD OF ESTABLISHING CRITERIA FOR ACCEPTABILITY.** This paper reviews an earlier study carried out in Great Britain, which has compared annoyance responses to aircraft, road traffic and railway noise. It is concluded that sufficient information exists to enable differences in responses to road traffic and railway noise to be estimated. The paper proposes that these estimates can be used to formulate guidelines for criteria for railway noise exposure. (Author abstract) 7 refs.

Walker, J.G. (Univ of Southampton, Southampton, Engl). *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 347-349.

**088838 NOISE QUESTIONS: 'RAILWAY NOISE' - REVIEW OF STUDIES PERFORMED BY ORE SPECIALISTS COMMITTEE C 163.** The problem of noise has been under study by the Office for Research and Experiments (ORE) of the International Union of Railways (UIC) for well over twenty five years. Over this period, six Specialists Committees have investigated the problem, and Committee C163, which is currently tackling the task, comprises experts from 16 railways. The efforts being deployed rate special mention, and the aim of this article is to take stock of what has been accomplished in the sphere of railway noise and to identify the ground that still remains to be covered.

de Curzon, E. Parent (SNCF, Paris, Fr). *Rail Int* v 13 n 10 Oct 1987, Int Environ Symp: Eur Railw - An Asset for the Environ, Mannheim, West Ger, Oct 22 1987 p 46-50.

Norway See LOCOMOTIVES, ELECTRIC—Performance.

Peoples Republic of China See LOCOMOTIVES, ELECTRIC—Design.

Personnel See Also ARTIFICIAL INTELLIGENCE—Expert Systems.

**088839 HEALTH: RAILWAY AND ENVIRONMENT, A CONTRIBUTION FROM THE RAILWAY MEDICAL SERVICE.** This article describes the historical development of occupational medicine and the railway medical service, and gives practical examples of collaboration between specialist technical and medical departments. It refers to the increasingly close connections

between health and safety at work and protection of the environment, both of which are now indissolubly linked. This is illustrated by a discussion of noise attenuation at work-places and the protection of workers from the effects of chemical substances.

Brinkrolf, H. (UIMC, West Ger). *Rail Int* v 18 n 10 Oct 1987, Int Environ Symp: Eur Railw - An Asset for the Environ, Mannheim, West Ger, Oct 22 1987 p 69-70.

Planning See Also RAILROAD ROLLING STOCK—Management; RAILROAD TRANSPORTATION—Computer Simulation.

**088840 CONSTRUCTION DE 137 km DE VOIE FERREE EN ALGERIE: LA LIAISON JIJEL RAMDANE-DJAMEL.** [Construction of 137 km of Railway in Algeria: the Jijel-Ramdane-Djamel Line]. Described is the railway line helping to open up the eastern end of Petite Kabylie and linking the port of Jijel to the future steel plant of El Milia. Civil engineering work is to be completed by mid-1988 and the line opened to traffic by the end of 1989. Running eastward, the line encounters successively a coastal dune zone, the narrow valley of Oued Zeggar. The adopted design speed is 120 km/h. The line includes 65 bridges, a prestressed concrete viaduct, eight tunnels, 23 million m<sup>3</sup> of earthworks, stations, housing and a ballast pit. The various phases of project completion are reviewed, with emphasis on the particularly interesting design of certain bridges. (Author abstract) In French.

Bernhardt, G. (Bouygues Travaux Publics, Fr). *Travaux* n 626 Nov 1987 p 35-44.

**088841 HIGH-SPEED RAIL IN CALIFORNIA: THE DREAM, THE PROCESS, AND THE REALITY.** The 1983 high-speed rail proposal between Los Angeles and San Diego, California, was initiated by the American High Speed Rail Corporation (AHSRC), a private firm. The 130-mi, electrically powered 3.1 billion dollars system was to be based on the high-speed technology and design of the Japanese bullet train. The route was to be largely within or parallel to existing Interstate highway (I-5) and railroad right-of-way. The project proved to be very controversial, with the proponents eventually unable to obtain financing to continue. Opposition to the project centered mainly on environmental and economic impacts. Important considerations were noise, vibration, and visibility; beach access and lagoons; safety and property values; and transportation, namely, Amtrak service, local traffic and circulation, and local public transportation. The professional community seriously questioned AHSRC's ridership estimates and methodology. (Edited author abstract) 22 refs.

Smith, George, C. (California Department of Transportation, Sacramento, CA, USA); Shirley, Earl. *Transp Res Rec* n 1143 1987 p 36-43.

Poland See RAILROAD ROLLING STOCK—Repair.

Portugal See RAILROAD PLANT AND STRUCTURES—Construction.

Productivity See ELECTRIC RAILROADS—United States.

Queensland, Australia See RAILROAD PLANT AND STRUCTURES—Track Ties.

Research

**088842 BENEFITS ACHIEVED THROUGH RESEARCH IN HEAVY HAUL RAILROADS.** Mt. Newman Mining Co. and Hamersley Iron railroad research commenced in 1973 in response to specific technical problems which at that time threatened to increase significantly the railroad operating costs and to limit the potential for rapid expansion of production. The benefits obtained have extended beyond the solution of operating technical problems and the research is now being used to assist the achievement of railroad strategic objectives. Complex programs have evolved which would not have been possible without organizational commitment to an



ongoing research process. Emphasis is now placed on increased cost-effectiveness and the need for accurate research information has accelerated the establishment of computer data bases. (Edited author abstract) 26 refs.

Wallwork, W.D. (Mt. Newman Mining Co, Aust); Fitzgerald, B.W. *Mech Eng Trans Inst Eng Aust* v ME 9 n 4 Nov 1984 p 257-261.

Spain See RAILROAD PLANT AND STRUCTURES—Construction.

## Stability

**088843 STABILITY OPTIMIZATION OF MULTI-AXLE RAILWAY VEHICLES POSSESSING PERFECT STEERING.** The general form of the equations of motion of multi-axle railway vehicles are used to establish the conditions which the elastic stiffness matrix (which describes the nature and configuration of the suspension elements connecting the wheelsets) must satisfy in order to achieve perfect steering on curves, an adequate margin of stability and optimal response to cant deficiency. These conditions are illustrated by application to the most general form of symmetric three-axle vehicle and it is shown that an adequate margin of stability can be obtained for an optimized set of parameters which allows perfect linear curving. The class of configurations studied allows for unequal wheelset conicities and inter-wheelset asymmetry within the assumption of overall vehicle symmetry. (Author abstract) 14 refs.

Wickens, A.H. (Railway Technical Cent, Derby, Engl). *J Dyn Syst Meas Control Trans ASME* v 110 n 1 Mar 1988 p 1-7.

## Structural Analysis

**088844 SYSTEM AND STRUCTURAL ANALYSIS CONCERNING RAIL MOTOR VEHICLES.** A unitary methodology for the system and structural analysis is applied to the mechanisms that make up a rail motor vehicle. It points out the progressive-modular manner of considering a complex spatial system. Parallel constructive-functional analysis is used revealing significant design peculiarities. Elements of the graph theory are applied to the consideration of kinematic chains. Simple and complex kinematic chain mechanisms are characterized structurally. (Author abstract) 9 refs.

Ionescu, Theodor (Inst for Research & Technological Design in Transports, Bucharest, Rom). *Mech Mach Theory* v 22 n 5 1987 p 473-480.

**088845 CX [Dynamic Measurements in the Research and Development of Rail Vehicles].** This paper reviews the measurements which are necessary to all aspects of vehicle dynamics as applied to rail vehicles. Although an attempt has been made to introduce some reference to measurements made in Europe and America, the detailed discussion has been limited to those techniques employed by British Rail. This has the advantage that the discussion can be first hand and therefore more specific. For convenience the measurements have been collected together under four broad headings: 1. Measurements of rail system data, 2. Measurements of vehicle parameters, 3. Measurements to validate theory and predictions, and 4. Measurements of vehicle performance. (Author abstract) 36 refs.

Lyon, Derek (Railway Technical Cent, Derby, Engl). *Veh Syst Dyn* v 16 n 3 1987 p 149-165.

Sweden See RAILROAD ROLLING STOCK—Design.

Switzerland See RAILROAD PLANT AND STRUCTURES—Construction.

Traffic Control See Also TRANSPORTATION—Reviews.

**088846 MODERNISATION DU POSTE DE COMMANDEMENT (PC) DE LYON.** [Modernization of Lyons Traffic Control Center]. A large number of trains (TGV and conventional trains) are routed through the

Lyons railway complex everyday. The safety devices are operated from many signal boxes. Progressively these signal boxes have been provided with train monitoring equipment. To enable the Traffic Control Center to supervise and organize traffic through Lyons, all the train monitoring information is transmitted to the Control Center and shown on the visual display units of the different traffic controllers concerned. The sequence of trains passing through Lyons is recorded by actual graphs printed on paper by a tracing table. This article describes the new equipment provided for staff working at the Lyons Traffic Control Center. (Edited author abstract) In French.

Savarzeix, Rene (SNCF, Fr); Soudee, Roland. *Rev Gen Chemins Fer* v 106 n 10 Oct 1987 p 17-22.

**088847 DISPATCHING, 'STAR WARS' STYLE.** Union Pacific has awarded a contract to the Union Switch & Signal Division of American Standard for the consolidation of all dispatching operations in a CTC center at Omaha, Neb. Work on the project has already started, and UP will begin phasing in the new center late in 1988. When the consolidation is complete, dispatchers at the Omaha office will control all traffic on some 21,000 miles of line, including both CTC and dark territory. The Omaha facility will employ technology that Union Switch introduced on the UP at Portland, Ore., a little over a year ago. The Portland CTC office was equipped with the first color, video-projected railroad territory display. The new Omaha office also will feature a video-projected territory display, utilizing a rear-screen projection system.

Anon. *Railw Age* v 188 n 12 Dec 1987 p 42.

**088848 REALISIERUNG VON SICHEREN BAHNSTEUERUNGSSYSTEMEN MIT MODERNSTER RECHNERTECHNIK.** [Railway Control Systems Based on Failsafe Microcomputers]. Railway control systems have to meet stringent safety and reliability requirements. The SEL solution is to apply parallel microcomputers and comparators for the results. Two examples in conjunction with the problems which arise are described. Particularly the advantages to be obtained from the use of high level languages and hardware components which are readily available are discussed. (Author abstract) 7 refs. In German.

Andexser, Werner (Standard Elektrik Lorenz AG, Stuttgart, West Ger); Steiner, Manfred. *Frequenz* v 42 n 2-3 Feb-Mar 1988 p 43-50.

**088849 UP MOVES TO CONSOLIDATE ALL DISPATCHING AT OMAHA.** Using an expanded and refined version of the video-projected territory display system pioneered at Portland, Ore., Union Pacific will consolidate nine train dispatching centers into one. The new Union Pacific dispatching center will be located in Omaha, Neb., the railroad's headquarters city. While the large-screen video-projected territory display is the focal point of attention in the Portland office, it's the center's highly sophisticated computer-aided dispatching system (CADS) that has had the greatest impact on expanding the capabilities of dispatchers. The consolidated Omaha dispatching center is being designed using much of the same technology that was implemented at Portland; however, the Omaha CADS will be approximately six times larger than the one in use at Portland. With the capability to control traffic on some 21,000 miles of trackage, the Omaha control center will foster the most powerful and comprehensive dispatching operation in the world.

Anon. *Railw Age* v 189 n 3 Mar 1988 p 56-57, 59.

**088850 CONSTRUCTION OF NEW GENERAL CONTROL SYSTEM IN TOKAIDO SHINKANSEN LINE.** More than twenty years have passed since the inauguration of the Tokaido Shinkansen line, which has grown into a major rail traffic artery in Japan. Following the recent construction of new stations on this line, the CTC system and the traffic control system (COMTRAC) at the General Control Center in Tokyo were extensively modified and improved. In the new control system, a

CRT-based train movement representation system has been introduced to promote efficiency and speed up dispatching work and also to save space in the General Control Center room. (Edited author abstract)

Kato, Shin ichiro (Central Japan Railway Co, Jpn). *Jpn Railw Eng* v 27 n 4 Mar 1988 p 8-10.

Turkey See LOCOMOTIVES, DIESEL—Electric Drive.

USSR See LOCOMOTIVES, ELECTRIC—Design.

## Vibrations

**088851 WAVELENGTH OF HUNTING MOTION OF A SOFT TRUCK.** The wavelength of hunting motion is one of basic quantities expressing the hunting motion characteristics of a railway vehicle. Though formulae for a single wheel-set and a rigid truck are well known, they are not applicable to a soft truck, in which horizontal suspension stiffness between the axle box and truck frame is small. In this paper, an approximate expression for the wavelength of a soft truck is presented and verified with measured data. (Author abstract) In Japanese. 4 refs.

Koyanagi, Shiro; Yoshioka, Takeyasu. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 492 Aug 1987 p 1728-1734.

**088852 VIBRATIONS IN THE GROUND: RAILWAY INDUCED GROUND VIBRATIONS.** This paper describes the research program of committee D151 of the Office of Research and Experiments of the International Union of Railways. This committee has studied how the characteristics of vehicles, such as the roughness of the wheels, affects ground vibration and the manner in which the vibrations decay with distance. The committee has also studied the response of people to vibrations and possible damage to plastered masonry. The effect of special types of track construction in reducing vibration and the long-term performance of these systems has been examined for underground railways. Studies are still in progress to test antivibration measures placed alongside main line tracks in the open. (Edited author abstract)

Frederick, C.O. (British Railways Board, Engl). *Rail Int* v 18 n 10 Oct 1987, Int Environ Symp: Eur Railw - An Asset for the Environ, Mannheim, West Ger, Oct 22 1987 p 51-57.

Virginia See COAL INDUSTRY—Virginia.

## Wheels

**088853 HEAT HARDENING OF ROLLED RAILROAD WHEELS.** Wheel life improvement through better heat hardening processes has been considered. The standard requirements to wheels as specified by Soviet standards for the past two decades have been reviewed. An evaluation of wheel properties vs. quenching rate has been made. (Author abstract) 3 refs.

Miroshnichenko, N.G.; Staroseletskiy, M.I.; Shmakov, E.N.; Uzlov, V.I. *Sov Mater Sci Rev* v 1 n 1 1987 p 95-98.

**088854 DESIGN STRENGTH OF HEAT HARDENED ROLLED WHEELS.** Fatigue strength and its relation with brittle fracture resistance characteristics KCU and KIC have been considered. The stressed state of wheel disk has been analyzed for heat hardened wheels. The fatigue strength of wheel steel normalized to actual mean cycle stresses during cyclic loading of wheels in operation has been analyzed. It has been shown that compressive stresses in a real product can be regarded as a design strength margin. (Author abstract) 4 refs.

Danchenko, N.I.; Perkov, O.N.; Mironov, P.F.; Podolskiy, S.E. *Sov Mater Sci Rev* v 1 n 1 1987 p 99-102.

## Yugoslavia

**088855 YUGOSLAV RAILWAYS.** Developments on Yugoslav Railways (JZ) during 1986 and the first half of 1987 were affected significantly by unfavorable conditions in the country which constituted no less than a major



economic crisis. So there was a slow-down in the pace of modernization and in implementation of the national plan to make JZ the principal mode of long-distance transport. Notwithstanding the economic difficulties, in the 18 months to mid-1987 a number of important investment projects were completed, including the reconstruction of the line from the port of Koper through Divaca to Jesenice and the Austrian border, the opening of the line from the Albanian border to Titograd, the starting of construction of the 45 km line between Tuzla and Zvornik, completion of the electrification of the main trunk line from Jesenice to Gergelija, and electrification of the line from Bosanski Novi to Knin.

Zurkovic, N. *Dev Railw* 1988 p 83-84.

**RAILS** See Also RAILROAD PLANT AND STRUCTURES—Maintenance of Way; RAILROAD PLANT AND STRUCTURES—Track.

**088856 STAHLFAHRWEGE FUER DIE MAGNETSCHNELLBahn TRANSRAPID-DIE EINSATZREIFE.** [Steel Tracks for the High-Speed Magnetically-Levitated Train Transrapid-Mono-Beam Steel Track Developed to State of Service Readiness]. The development of steel tracks for the high-speed magnetically levitated train Transrapid and their utilization in test tracks, including switches, is described. It is supplemented by the further development of standard elevated tracks and the elaboration of special solutions. The track systems that have been built and put into service up to now confirm the advanced state of development of magnetic levitation in the Federal Republic of Germany. 6 Refs. In German.

Schwindt, Gert (Thyssen Industrie AG Henschel, Munich, West Ger); Kindmann, Rolf. *Thyssen Tech Ber* v 20 n 1 1988 p 199-207.

**Costs** See RAILROAD PLANT AND STRUCTURES—Track.

## Crack Propagation

**088857 MODELING OF EMBEDDED FATIGUE CRACKS IN RAILROAD RAILS.** A first-generation fatigue crack growth model has been developed which realistically models the patterns of subsurface shells and detail fracture crack growth that are commonly observed in railroad rails. (These types of defects are further described in the Introduction.) The key assumptions upon which the model is based are reviewed and the input data on railroad rail residual stresses and wheel-induced stresses are described. Examples of the predicted growth patterns for shells and detail fractures are shown and compared to actually observed growth patterns. Apparent deficiencies in the model are discussed and probable avenues for improvement in the accuracy of the crack growth life estimates are identified. (Author abstract). 14 Refs.

Rice, R.C. (Battelle Columbus Div, Columbus, OH, USA); Rungta, R. *Fatigue Fract Eng Mater Struct* v 11 n 3 1988 p 189-203.

**088858 STUDY OF SURFACE CRACK INITIATION DUE TO BIAxIAL COMPRESSION/SheAR LOADING.** This paper proposes a mechanism for surface crack initiation in rolling contact elements; it is based on the assumption that ductility exhaustion of the immediate surface layer taken place due to the incremental accumulation of surface plastic deformation. This deformation pattern is related to the nature of the combined compression-shear loading acting on the contact zone. An experimental technique employing a new design of biaxial specimen and loading apparatus has been developed and used to quantify empirically the features of the flow process leading to crack initiation. Results of the study are discussed in relation to failure characteristics of the railhead. (Author abstract). 18 Refs.

Ghoniem, H. (Univ of Rhode Island, Kingston, RI, USA); Kalousek, J. *Eng Fract Mech* v 30 n 5 1988 p 667-683.

**Cutting** See RAILROAD PLANT AND STRUCTURES—Track.

**Defects** See CARS—Vibrations.

**Deformation** See Also STEEL—Mechanical Properties.

**088859 DEVELOPMENT OF TEXTURE IN DEFORMED LAYERS UNDER RUNNING SURFACE OF RAIL.** In order to clarify the mechanism of initiation of rolling contact fatigue cracking, so called shelling, on the running surface of rails in railway track, the characteristics of the deformed rail surface layer have been investigated by means of electron microscopes (SEM, TEM) and X-ray apparatus comparing the rolling-contacted test pieces and cold-rolled test pieces. A texture is formed as a result of the simple slip deformation of crystals in the deformed surface layer of rails used in track and the rolling contact fatigue-tested rails. This texture disappeared at the topmost surface because of the occurrence of some random plastic deformation. On the contrary, the texture of the cold-rolled test pieces results from the complex slip deformation of crystals and does not disappear at the surface. (Author abstract) In Japanese. 14 refs.

Kashiwaya, Kenji (Railway Technical Research Inst, Kokubunji, Jpn); Inoue, Yasuo; Satoh, Yukio; Matsuyama, Shinsaku. *Zairyo* v 36 n 407 Aug 1987 p 786-791.

**Economics** See RAILROAD PLANT AND STRUCTURES—Track Ties.

**Fastening** See Also RAILROAD PLANT AND STRUCTURES—Track.

**088860 DIRECT FIXATION-THE CUSTOMIZED FASTENING.** The design of a direct fixation fastening system can be quite complex in comparison to the fasteners for conventional freight track. Moreover, there are reasons for this other than just securing the rail laterally, vertically, and longitudinally. Given the generally "fixed" nature of the transit structure supporting the rail, the direct fixation fastener must also compensate for the loss of some of the benefits offered by tie and ballast track construction. At the same time, the fastener may be required to perform additional specialized functions.

Anon. *Railw Track Struct* v 83 n 11 Nov 1987 p 34, 36.

**088861 HOW RESILIENT PADS PROTECT CONCRETE SLEEPERS.** One of the ways of avoiding damage to concrete sleepers by dynamic forces is to isolate the sleeper from the rail by using a resilient rail pad. However there has been some reluctance to adopt these pads because they allow greater movement of the rail relative to the sleeper which must increase the likelihood of wear or fatigue problems arising with fastening components. Pandrol International Ltd decided to tackle this problem by devising a method whereby the movement of the rail - in all directions - could be measured under passing traffic. They came up with the Dichroic Displacement Measuring System, which uses a non-contacting optical arrangement to measure rail movement to accuracies better than  $\pm 0.01$  mm at frequencies in excess of 2 kHz. Using this system, it was demonstrated that softer pads which achieve large reductions in sleeper strain will not increase the risk of clips or insulators failing prematurely.

Rhodes, David (Pandrol Int Ltd). *Railw Gaz Int* v 144 n 2 Feb 1988 p 85-87.

## Fatigue

**088862 FATIGUE ANALYSIS OF A RAIL SUBJECTED TO CONTROLLED SERVICE CONDITIONS.** A fatigue analysis was conducted on a rail that was placed in the Facility of Accelerated Service Testing (FAST) after a detail fracture was detected in service. The initial detail crack produced in service was grown to failure under controlled FAST conditions simulating service. Knowledge of the FAST wheel/rail load history for this rail made it an ideal candidate for quantitative

fatigue crack growth analysis. The investigation revealed that undulations in the detail fracture surface were caused by changes in the direction of traffic. The angle of the fracture surface, with respect to the running surface of the rail, was measured for each direction change. These results showed that the angles did not change significantly as the depth of the crack increased, relative to the running surface. (Edited author abstract) 5 refs.

Rice, R.C. (Battelle Columbus Div, Columbia, OH, USA); Rungta, R. *Fatigue Fract Eng Mater Struct* v 10 n 3 1987 p 213-222.

**088863 EVALUATION OF THE FATIGUE CRACK GROWTH AND FRACTURE TOUGHNESS CHARACTERISTICS OF RAIL STEELS.** The fatigue crack growth and fracture toughness characteristics of six rail steels have been evaluated. The overall test program included tensile testing, the determination of the longitudinal residual stresses, fatigue crack growth tests, and static and dynamic fracture toughness determinations. In addition fatigue crack growth was studied in rail heads with the effects of residual stress taken into account. The six rails differed in processing histories as well as composition and consisted of a standard carbon rail, a fully heat-treated rail, two Cr-Mo rails, a Cr-V rail, and a head-hardened rail. With the exception of the head-hardened rail, residual tensile stresses were present in the head and base of all other rails. (Edited author abstract) 14 refs.

Ochi, Yasuo (Univ of Electro-Communications, Chofu, Jpn); McEvily, A.J. *Eng Fract Mech* v 29 n 2 1988 p 159-172.

**Fracture** See Also STEEL—Fracture.

**088864 EFFECT OF SERVICE LOADING ON SHELL GROWTH IN RAILS.** A study is made of the relatively benign shelling fractures observed in the railhead. In particular, the tendency of these horizontal fractures to turn into a vertical detail fracture during fatigue crack propagation is considered. A two-dimensional linear elastic fracture mechanics model is combined with a proposed fatigue crack path stability model to study the effects of the complex stress state in the rail on this crack turning process. The results indicate that the leading edge of the shell will tend to turn down into the rail while the trailing edge will propagate to the surface for a short shell. However, once the shell reaches some calculated length, both ends will tend to grow to the surface. The most significant finding is that if the shell grows through the length of instability, it will grow in a stable in-plane manner. Finally, the analysis is compared to field observations. (Author abstract) 35 refs.

Farris, T.N. (Northwestern Univ, Evanston, IL, USA); Keer, L.M.; Steele, R.K. *J Mech Phys Solids* v 35 n 6 1987 p 677-700.

**Grinding** See RAILROAD PLANT AND STRUCTURES—Track.

**Heat Treatment** See Also STEEL HEAT TREATMENT—Cooling; STEEL HEAT TREATMENT—Quenching.

**088865 HEAT TREATMENT OF RAILROAD RAILS.** Current heat treatment methods and novel heat treatment processes developed by the Ukrainian Research Institute of Metallurgy for railroad rails have been described. The advantages and disadvantages of various rail heat hardening techniques have been emphasized. (Author abstract)

Babich, A.P.; Kazarnovskiy, D.S. *Sov Mater Sci Rev* v 1 n 1 1987 p 105-107.

**088866 NAPREZENIA W HARTOWANYCH SZYNACH.** [Stresses in Hardened Rails]. In world metallurgical practice thermal improvement of rails which increases their exploitation properties is being carried out. Hardening which causes significant instantaneous and internal stresses is a basic operation in thermal improve-



ment. The reason for internal stresses formation and the methods of their measurement in rails thermally improved dope has been analyzed. (Edited author abstract) 12 refs. In Polish.

Parkiny, Ryszard (Politechnika Czeszochowska, Czeszochowa, Pol); Piekarska, Wieslawa; Pawlak, Andrzej. *Hutnik* v 54 n 6 Jun 1987 p 178-182.

## Heating

**088867 HEATING OF POINTS UNDER CONDITIONS OF HEAVY SNOW FALL: THE SBB.** The article briefly describes the equipment used and measures taken to maintain normal winter services in Swiss railways (SBB). Particular guidelines have been established for operating basic services under extreme weather conditions. If particularly heavy snow falls occur, the optional use of points is reduced to the absolutely essential, especially when there are not enough staff available for snow clearance. As part of normal investment, and where necessary, points will be heated on the heel points on long stretches of track. Gas heating systems will also be equipped with electric distance lighting and remaining strategic points equipped with heating. In areas where there are regular heavy snow falls, signals will be equipped with lense heating systems and points with weather-proof interlock caps.

Stalder, O. (SSB Management, Bern, Switz); Vogel, W. *Rail Int* v 19 n 3 Mar 1988 p 33-35.

**Inspection** See RAILROAD PLANT AND STRUCTURES—Track Inspection.

**Joints** See RAILROAD PLANT AND STRUCTURES—Track.

## Laying

**088868 TEMPERATURE AND RAIL LAYING.** Recent research indicates that the rail laying temperature is not constant with time. It appears to vary as a function of traffic and maintenance activity, and has an overall tendency to decrease. This results in rail neutral temperature that is below the rail laying temperature. Correspondingly, there is a greater potential for high longitudinal compressive forces to build up in the rail. The results of the mentioned research are illustrated. These results strongly suggest that simply setting a rail laying temperature, particularly a high temperature, is not sufficient in itself to guarantee the elimination of track buckling. Rather, a comprehensive effort based on an understanding of the phenomenon and its mechanisms is needed to properly establish and implement an effective track maintenance and buckling prevention program. 3 refs.

Zarembski, Allan M. (ZETA-TECH Assoc). *Railw Track Struct* v 84 n 3 Mar 1988 p 12, 14.

## Lubrication

**088869 WHEEL/RAIL LUBRICATION:** The results of laboratory research and field tests to advance lubrication technology were covered in the Symposium on Wheel/Rail Lubrication. Presentations ranged from tests on lubricants to detailed studies of fuel savings and the numerous lubricating systems now available. These include: locomotive mounted lubricators; wayside electronic lubricators; oil lubrication; predicting wheel/rail wear tests; locomotive-mounted wheel flange systems.

Anon. *Railw Track Struct* v 83 n 10 Oct 1987 p 34-35.

**088870 OIL LUBRICATION - AN EFFECTIVE ALTERNATIVE.** With lubrication, friction forces are cut to less than one-third of those between dry rail and wheel flanges. Wheel scream, a serious problem for some rapid transit routes, is virtually eliminated. Wheel life can be extended by a factor between three and ten. The mechanism that supplies these benefits is more complex than mere separation of wheel and rail with a film of oil. In fact, straight mineral oil will not survive the loads. To survive such loads, the oil must contain chemical additives which will react with the rail and wheel to form a boundary film.

It is this chemical film, not the oil itself, which provides friction reducing anti-wear benefits. 2 refs.

Pugh, James R. (Lubriquip-Houdaille Inc, Cleveland, OH, USA). *Railw Track Struct* v 84 n 4 Apr 1988 p 32-33.

**088871 RAIL LUBRICATION: THE SEARCH FOR SOLUTIONS.** There's no longer any doubt about the substantial bottom-line benefits of universal rail lubrication. Now, railroads are looking for the lubricant that will do the job best - and safest. An official of the Transportation Test Center believes that research efforts should be aimed at developing and testing lubricants that can stand up to what might be called ultra-high-extreme pressures, not just the stresses that can be met by what the producers now regard as extreme-pressure additive lubricants. Some of this kind of work is happening. For example, Oregon Technical Laboratory is regarded as being in the lead in lab test techniques. Lubrizol is regarded as being in the lead in working with materials that will withstand the 100,000-psi stresses. Meanwhile, the Transportation Test Center will be looking at a number of factors regarding lubrication, testing and optimums as part of the program budget for 1989.

Welty, Gus (Railway Age, New York, NY, USA). *Railw Age* v 189 n 5 May 1988 p 32-33.

**Maintenance** See Also CARS—Dumpers; RAILROAD PLANT AND STRUCTURES—Track; RAILROAD PLANT AND STRUCTURES—Track Ties; RAILROAD ROLLING STOCK—Bearings.

**088872 COST EFFECTIVE REHABILITATION OF SHORT (AND NOT-SO-SHORT) LINES.** The author examines the aspects of rehabilitating short line railroads. The differences between short line and class I operations and conditions are presented. These differences fall under three categories: physical, institutional and economic. The author also offers practical tips on putting limited resources to best use.

Ahlfi, Robert E. *Railw Track Struct* v 84 n 4 Apr 1988 p 20-27.

**Manufacture** See Also STEELMAKING—Basic Oxygen Process.

**088873 HARTOWANIE INDUKCYJNE SZYN KOLEJOWYCH NA SWIECIE.** [Induction Hardening of Rails Worldwide]. Problems of induction hardening of rails are discussed on the basis of literature data from all over the world. The hardening of rails along their entire length, as well as the hardening of their end parts, is acquiring ever greater practical importance. This is related to prevailing conservation trends in the world with regard to both material and energy. Rails with a hardened surface layer possess much greater durability than conventional rails. The main rail hardening technologies used in various countries are discussed. (Translated author abstract) 34 refs. In Polish.

Wieczorek, Tadeusz (Politechnika Slaska, Katowice, Pol). *Hutnik* v 53 n 12 Dec 1986 p 327-329.

**088874 LA PRODUZIONE DI ROTAIE DA COLATA CONTINUA ALLA DELTASIDER DI PIOMBINO.** [Production of Rails at Deltasider's Piombino Works Using the Continuous Casting Route]. Deltasider's Piombino Works is the sole producer of rails in Italy, and is compatible with similar firms in other countries as regards the production of rails by the continuous casting route. Putting a new continuous caster on stream, it was possible to undertake an in-depth program of study in collaboration with the Italian state railways' technical staff. It has been found that the continuous casting route is better controlled than the traditional ingot route. (Edited author abstract) In Italian.

Panciatichi, P.L.; Piccini, F. *Metall Ital* v 79 n 6 Jun 1987 p 473-479.

**088875 MODERN RAIL MANUFACTURING.** The metallurgical steps taken at Thyssen Stahl AG to produce high-quality rails with uniform properties, a low hydrogen

content, high cleanness and low segregation, have included the Thyssen Blowing Metallurgy (TBM) process, vacuum treatment and the continuous casting of blooms. By modernizing the section mill to change over from the single to the two-heat process it has been possible to introduce CC-blooms into the rolling process to supply rails up to a length of 60 m with an excellent surface condition and extreme dimensional accuracy. (Edited author abstract) 19 refs.

Schmedders, Herbert (Thyssen Stahl AG, Duisburg, West Ger); Wick, Klaus. *MPT Metall Plant Technol* v 10 n 6 Jun 1987 8p between p 58 and 72.

**088876 FINITURA E ISPEZIONE DELLE ROTAIE.** [Finishing and Inspection of Rails]. This article describes qualitative problems found during rail finishing and inspection on the basis of experience at Nuova Deltasider's Piombino works. The discussion concerns surface defects, inner defects, straightness, inspection methods and material flow after inspection. A description of the flashwelding system is also provided. This article emphasizes the results obtained by the introduction of new technologies such as continuous casting and a new rail straightening line. 1 ref. In Italian.

Anguillesi, L. (Nuova Deltasider Milano, Italy); Iachino, G.; Piccini, F. *Metall Ital* v 80 n 3 Mar 1988 p 213-219.

**088877 MODERNE SCHIENENERZEUGUNG BEI DER THYSSEN STAHL AG.** [Modern Rail Manufacture at Thyssen Stahl AG]. Thyssen Stahl AG has adopted metallurgical processes required to make rails of great quality with unvarying properties, low hydrogen content, excellent oxidic purity, and low segregation: They involve the TBM process, vacuum treatment with controlled carbon deoxidation and continuous bloom casting. In addition, as a result of modernization of the blooming and structural mills, it has become possible to roll continuously cast blooms into rails of up to 60 m in delivered lengths, with a very good surface condition and close tolerances. The product mix includes both naturally hard rails of up to 1200 MPa in minimum tensile strength and heat-treated rails. Finally, a modern testing line and an efficient quality assurance system make sure that rails of top quality are supplied to customers throughout the world. 22 Refs. In German.

Bienzeisler, Herbert (Walzwerk Bruckhausen und Ruhrort, West Ger); Schmedders, Herbert; Wick, Klaus. *Thyssen Tech Ber* v 20 n 1 1988 p 147-159.

**Materials** See STEELMAKING—Physical Chemistry.

## Measurements

**088878 USING RAIL INFORMATION.** Track measurement technology has advanced to the point where it is now possible to obtain reliable information about the condition of the head of rail. This data can be derived for a large stretch of track, or even an entire railroad. Such modern systems now include the capability of measuring both the transverse and longitudinal profiles of the rail by means of high-speed inspection vehicles. Also, the methods involved in the use of this technology furnish an extremely large volume of measurement data. This must be analyzed and converted into usable information. 1 ref.

Zarembski, Allan M. (ZETA-TECH Assoc). *Railw Track Struct* v 84 n 1 Jan 1988 p 12.

**088879 MEASUREMENT OF TRACK ALIGNMENT AND CURVATURE.** Several systems of measurement have been used earlier but what is needed is a measuring system able to produce two separated data channels - longwave curvature and shortwave wave alignment profile. A method of measurement able to make this distinction was first derived by British Rail as part of the design of their High-Speed Track-Recording Car (HSTRC) and has been in use ever since as part of the BR standard system. The HSTRC was designed for high-speed operation and has made successful measure-



ments at speeds of 220 km/h, although it is now normally operated at speeds below 180 km/h. The methods used are described. 11 refs.

Lewis, R.B. (British Rail Research, Derby, Engl). *Rail Int* v 19 n 7 Jul 1988 p 17-23.

**Noise, Acoustic** See Also CARS—Street Railroad; WHEELS—Vibrations.

**088880 WHEEL/RAIL NOISE GENERATED BY A HIGH-SPEED TRAIN INVESTIGATED WITH A LINE ARRAY OF MICROPHONES.** Radiated noise generated by a high-speed electric train traveling at speeds up to 250 km/h has been measured with a linear array of microphones mounted along the wayside in two different orientations. The test train comprised at 103 electric locomotive, four Intercity coaches, and a dynamo coach. Some of the wheels were fitted with experimental wheel-noise absorbers. By using the directional capabilities of the array, the locations of the dominant sources of wheel/rail radiated noise were identified on the wheels. For conventional wheels, these sources lie near or on the rim at an average height of about 0.2 m above the railhead. The effect of wheel-noise absorbers and freshly turned treads on radiated noise were also investigated. (Author abstract) 10 refs.

Barsikow, B. (DFVLR, Berlin, West Ger); King, W.F. III; Pfizenmaier, E. *J Sound Vib* v 118 n 1 Oct 8 1987 p 99-122.

**088881 EXPERIMENTAL ANALYSIS OF WHEEL/RAIL NOISE BY NEAR FIELD ACOUSTICAL IMAGING.** A near field acoustical imaging method applied to the localization and analysis of rolling noise sources on a wheel of a railway tracked vehicle is presented. This method consists in using an acoustical plane microphone array (mounted on the vehicle), which may be moved depending on the wheel/rail part being investigated. A space-frequency processing of the acoustical signals given by the array makes it possible to evaluate the acoustical energy radiated by the area considered, in a given octave band. (Edited author abstract) 4 refs.

Wetta, P. (MetraVib RDS, Ecully, Fr); Beguet, B.; Parent de Curzon, E. *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 255-265.

**088882 DUTCH RAILWAY NOISE PREDICTION SCHEMES.** A calculation scheme for the prediction of noise levels along railway lines was completed in 1984 and has been applied since then in the framework of the Dutch Noise Pollution Act. The scheme makes it possible to calculate the equivalent sound levels  $L_{Aeq}$  at receiver positions up to distances of 1500 m and can be used in almost every situation except large railway yards and large stations. A simplified calculation method working in dB(A) was derived for situations without any screening by obstacles such as barriers. The source model is based on investigations of wheel/rail noise. The source strength and the factors that influence the emission were derived from measurements. The propagation of railway noise over large distances can be predicted by the propagation model that has been used for road traffic noise and industrial noise. The models differ only for the propagation in the region near the source. (Author abstract) 4 refs.

van Ruiten, C.J.M. (TNO, Delft, Neth). *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 371-379.

**088883 ELASTOMER RAIL SUPPORT SYSTEMS: PROBLEMS IN DYNAMIC TESTING.** Methods of dynamic testing in use for elastomer rail support systems are described and compared with respect to the significance of the results for the prediction of the behaviour of the installed system in reality. The discussion leads to proposals for test procedures matching the demands of the design engineer charged with the selection of a special product. (Author abstract) 10 refs.

Melke, J. (TUV Rheinland eV, Cologne, West Ger); Switaiki, B. *J Sound Vib* v 120 n 2 Jan 1988, Proc of the Fourth Int Workshop on Railw and Tracked Transit Syst Noise, Noordwijkerhout, Neth, Oct 24-26 1985 p 421-429.

**Performance** See RAILROAD ROLLING STOCK—Wheels.

**Stability** See RAILROAD PLANT AND STRUCTURES—Track.

**Standards** See Also RAILROAD PLANT AND STRUCTURES—Track Switches.

**088884 CHANGING THE GAUGES OF A WHOLE RAILWAY NETWORK. THE SITUATION IN SPAIN.** This report outlines the major drawbacks and marginal benefits, for Spain, of operating a rail network built to a different track gauge than that used elsewhere in Europe. The report develops arguments for solving this problem through an integrated plan providing for track modernization and renewal of the locomotive and rolling stock fleet. As part of this plan, the whole network would be upgraded over some 40 years, with provisional axle and bogie changeover facilities which would never remain in the same place for more than 5 years at a time. The standard-gauge solution (1435 mm) would be adopted as from Irun frontier on selected lines of route depending on track condition and other circumstances. It is evaluated that this track changeover program for the Miranda-Irun, Palencia-Santander and Madrid Palazuelo lines of route will cost an extra 5 million pesetas on average per kilometer. (Edited author abstract).

Gargallo, Lluís Battle I. *Rail Int* v 19 n 7 Jul 1988 p 7-15.

**Steel** See STEEL—Mechanical Properties; STEEL HEAT TREATMENT—Stresses.

## Stresses

**088885 MEASUREMENT OF RESIDUAL SHEAR STRESSES NEAR THE SURFACE OF A RAIL HEAD.** This report describes an experiment designed to measure residual shear stresses near the surface of a rail head. It is shown that the shear stresses in the rail are very small, despite the predictions of the theory. The measurements taken in this experiment also enable the longitudinal, vertical and lateral residual stresses in the rail to be estimated. These results are compared with previous experimental measurements and with theoretical predictions.

Bower, A.F. (British Railways Technical Cent, Derby, Engl); Chesswright, P.R. *Cambridge Univ Eng Dep Tech Rep CUED/C-Mech* 41 1987 21p.

**088886 RAIL DEFECT TYPE VS. DERAILMENT RISK.** That the likelihood of a derailment and its associated cost have a significant effect on rail replacement strategies should come as no surprise to anyone. As the cost of derailment increases, the rail must be removed from track at an earlier point in its life. Earlier investigations into the probability of rail-caused derailments, revealed that the occurrence rate for such incidents is approximately one per 100 to 200 service breaks. The types of rail defects were divided into the following two classifications based on the stress-causing mechanism: flexure stress-dependent failures; contact/residual stress-dependent failures. 3 Refs.

Zarembski, Allan M. (Zeta-Tech Assoc). *Railw Track Struct* v 84 n 7 Jul 1988 p 12,14.

## Structural Analysis

**088887 ON THE VERTICAL MODULUS IN THE STANDARD RAILWAY TRACK ANALYSIS.** The evolution of analyses for longitudinal and cross-tie tracks, and of the closely connected concept of the track modulus, is reviewed. It is then shown that some of the notions introduced during the past century and used to this date, in connection with its definition and determination, have no physical bases and are incorrect. The proper definition

of the track modulus is discussed. This is followed by a review of the various field methods for its determination and the presentation of a simple method which uses any car or locomotive available. (Author abstract)

Kerr, A.D. (Univ of Delaware, Newark, DE, USA). *Rail Int* v 18 n 11 Nov 1987 p 37-45.

**088888 LATERAL STABILITY OF TRACK.** To calculate rail's buckling forces it will be necessary to know the geometrical properties of rails and track lateral resistance. This one, which is a function of weight, spacings and dimensions of cross-ties; of profile and dimensions of embankment and of ballast's compactness, may be determined by means of in situ tests. For the Brazilian rail TR-68 (68 kg per meter) the buckling loads will be comprised of between 700 and 1200 kN, depending on the lateral resistance of the track. Equations are given that allow: the evaluation of the rail's buckling forces; and the calculation of the critical variation of temperature. 3 refs. (Inst de Pesquisas Technologicas, Sao Paulo, Braz). *Rail Int* v 19 n 4 Apr 1988 p 43-45.

**Structural Design** See RAILROAD PLANT AND STRUCTURES—Track.

**Testing** See Also RAILROAD PLANT AND STRUCTURES—Track Switches; STEEL—Deformation.

**088889 PUEBLO PREPS FOR HAL TEST.** HAL, the Heavy Axle Loading test program which will get under way early in 1988 at the Transportation Test Center at Pueblo. HAL will be working with 315,000 pounds, weight on rail. In full-scale train operation, TTC is planning to put 100 million to 200 million gross tons on track in the High Tonnage Loop of the Facility for Accelerated Service Testing. When HAL testing is completed, railroads should have a far better idea of what heavy loading does to track than they have ever had before. And there will be a substantial data base from tests of 100-ton loadings for comparison purposes.

Welty, Gus (Railway Age, New York, NY, USA). *Railw Age* v 188 n 9 Sep 1987 p 83, 85.

**088890 INVESTIGATION ON A LOW-ALLOY STEEL RAIL OF TENSILE STRENGTH 1078N/MM<sup>2</sup>.** The necessity and the basis of compositional design of a low alloy rail steel of TS 1078N/mm<sup>2</sup>, as well as its experimental manufacture results, are described in this paper. The experimental results indicated that the abrasion-resistant rail steel SiMnV of a special class possesses high strength and good toughness, and it is suitable for the production conditions of Anshan Iron and Steel Co., and suitable in terms of the utilization of natural resources in China. The test carried out in the railway proved that its service life is over three times that of medium manganese rail steel. (Edited author abstract) In Chinese. 4 refs.

Liu, Baosheng (Anshan Iron & Steel Co, China). *Kang T'ieh* v 22 n 6 Jun 1987 p 26-32.

**088891 COMPARISON OF THE WEAR PROCESS FOR EUTECTOID RAIL STEELS: FIELD AND LABORATORY TESTS.** There is a need for a reliable laboratory test with which to determine the influence of metallurgical properties on the wear resistance of railroad rails. It is now well established that, in order to be relevant, such a test must reproduce the essential features of the wear process occurring in the field. In this investigation, a detailed examination of the gauge face of a rail used in unlubricated curved track under well-documented conditions has been carried out using a combination of optical and scanning electron microscopy. The results are compared with those from a similar study of the wear surfaces of rail steel specimens tested in both a pin-on-disk and a twindisk rolling contact wear testing



device. It is shown that, provided the test conditions are chosen carefully, an adequate simulation can be produced. (Author abstract) 12 refs.

Danks, D. (Oregon Graduate Cent, Beaverton, OR, USA); Clayton, P. *Wear* v 120 n 2 Dec 1 1987 p 233-250.

**088892 TEST AND FATIGUE OF THE RAIL.** The rail as the most significant element of the railway track has been developed even in recent decades both in relation with its mechanical and chemical parameters. The steels of rail are to be classified in the brittle or in the transition zone of fracture. This circumstance ought to be changed in order to be able to reduce the rail failures and weld ruptures in winter time. The fatigue cracks in the rail, their propagation and the classification of these cracks under the safety limit is of importance from the point of view of a safety railway operation. The author investigates the occurrence of such deficiencies under the safety limit as well as the time-dependent propagation of them and gives answers to the questions relating to the classification and development of the kidney-formed cracks caused by the fatigue of the rail steel. (Edited author abstract)

Kecskes, S. (Technical Univ, Budapest, Hung). *Period Polytech Civ Eng* v 31 n 1-2 1987 p 3-50.

**Vibrations** See Also RAILROAD ROLLING STOCK—Brakes; WHEELS—Vibrations.

**088893 COST CUTTING FOR QUIETER TRACK.** The 'Cologne Egg' is a rail fastening system which is a ballastless spring system in track without a 'mass'. Developmental work continues on the new fastening system, and has resulted in the design of 'Turnout Eggs'. The Cologne Egg can be employed with great advantage on wooden ties without ballast support, such as on bridges. It can also be used in more conventional aerial and tunnel track having highly compacted ballast. Still, track spring mats are an excellent means of noise and vibration insulation in new tunnels or on bridge and aerial structures.

Braitsch, Ing Hans (Cologne Transport System, West Ger). *Railw Track Struct* v 83 n 11 Nov 1987 p 37-38.

**Wear** See Also CARS—Wheels; RAILROAD PLANT AND STRUCTURES—Maintenance; RAILROAD ROLLING STOCK—Bogies; RAILROAD ROLLING STOCK—Stresses; WEAR OF MATERIALS; WHEELS—Wear.

**088894 ANALYSIS OF ROLLING CONTACT WITH KINEMATIC HARDENING FOR RAIL STEEL PROPERTIES.** This study presents calculations of two-dimensional rolling contact deformation for rail steel properties. Finite element analyses, previously carried out for perfect plasticity, are extended to the kinematic hardening behavior of rail steel. A three-parameter elastic-linear-kinematic-hardening-plastic description of the cyclic stress-strain behavior of rail steel is inserted in the finite element model. Steady-state results are obtained after two translations. The effects of the kinematic hardening at three relative peak pressures  $p_0/k_k = 4.0, 4.5$  and  $5.0$  are examined. The calculations evaluated the rim distortion, the cyclic plastic strains and the residual stresses, the shakedown limit for kinematic hardening and the effects of strain-amplitude-dependent kinematic properties. The calculations reveal that the kinematic hardening of rail steel produces substantial alterations relative to the deformation and residual stresses associated with perfect plasticity. Cyclic strains are an order of comparable relative contact pressures. (Edited author abstract) 18 refs.

Bhargava, V. (Vanderbilt Univ, Nashville, TN, USA); Hahn, G.T.; Rubin, C.A. *Wear* v 122 n 3 Mar 15 1988 p 267-283.

**088895 RIFFELBILDUNG AUF EISENBAHN-SCHIENEN - WECHSELSPIEL ZWISCHEN KURZZEITDYNAMIK UND LANGZEIT-VER-SCHLEISSVERHALTEN.** [Rail Corrugation - Interaction Between Transient Dynamic Effects and Long-Term Wear Behavior]. The mechanism leading to the initiation of corrugations on apparently smooth rails is explained as

a feedback process between the wheel and rail oscillations (transient dynamic effects) and wear phenomena (long-term behavior). Using a completely linear short-term dynamic model, the wheelset is described in the frequency range up to 2000 Hz in terms of its natural modes. The high-frequency processes in the contact area as well as the behavior of the discretely sleeper-supported track are interpreted in terms of frequency responses. Small periodic irregularities of the rail profile result in periodically varying contact forces and, as revealed by a linear long-term wear model, in periodic rail wear. The profile disturbances stimulating the oscillations are thus either magnified or reduced. In the course of time, the wavelengths experiencing a particular magnification in the feedback process involving transient effects and wear are 'filtered out'. The completely linear model provides a first insight into the corrugation mechanism by identifying those structural vibrations and parameter combinations which are particularly susceptible to wear. (Edited author abstract) 21 refs. In German.

Knothe, Klaus (Technische Univ Berlin, Berlin, West Ger); Valdivia, Anton. *Z Eisenbahnwes Verkehrstech Glaser Ann* v 112 n 2 Feb 1988 p 50, 52-57.

**088896 DEVELOPMENT OF RAIL/WHEEL HIGH SPEED CONTACT FATIGUE TESTING MACHINE AND EXPERIMENTAL RESULTS.** Currently, rail shelling is a kind of rolling contact fatigue failures are causing considerable expenditure for rail renewal on the Shinkansen lines. To cope with this situation a rail/wheel high-speed contact fatigue testing machine has been developed. This machine features additional functions for simulating the dynamic conditions between rails and wheels and for clarifying the high-speed rolling contact fatigue mechanism of rails, including the occurrence of rail shelling. This report presents technical details of this machine and several experimental results of traction coefficient tests and rolling contact fatigue tests using it. (Edited author abstract) 6 Refs.

Ishida, Makoto (Railway Technical Research Inst, Jpn); Satoh, Yukio. *Q Rep RTRI (Jpn)* v 29 n 2 May 1988 p 67-71.

**088897 EFFECT OF PROFILES ON THE RAIL SURFACE DEFECT IN HEAVY HAUL RAILWAYS.** (THE STUDY OF CONTACT PROBLEM BETWEEN RAIL AND WHEEL - III). Excess reduction of rail wear under rail/wheel lubrication causes surface defects on high strength rails as a result of contact between rail and wheel. The author's previous presentation reported the effect of wear and contact stress on the surface fatigue defects of high strength rail specimens. In this paper, the anti-surface fatigue property of four kinds of rail profiles was examined by stress analysis and experiments. 2 refs.

Sato, Meiji (Nippon Steel Corp, Kitakyushu, Jpn); Kageyama, Hideaki; Sugino, Kazuo; Bekku, Toshio. *Trans Iron Steel Inst Jpn* v 27 n 12 1987, Prepr for the 113th ISIJ Meet, Part VI, Tokyo, Jpn, Apr 1-3 1987 p B.308.

**Welding** See Also RAILROAD PLANT AND STRUCTURES—Maintenance of Way.

**088898 STUDY OF THE CRACK RESISTANCE OF RAIL STEEL WITH A WELD SEAM.** An analysis shows that the main cause of the failure of welded rails is the development of fatigue cracks in the weld zone from manufacturing defects. A method of accelerated high-frequency cyclic loading of samples with weld seams has been developed which makes it possible to determine the crack resistance of rail steel produced by various methods. An optical caustic method for determining the crack resistance of model samples with a weld seam and defects near it has been tested. In Russian. 6 refs.

Filin, A.N.; Radugina, L.A.; Chelyshev, N.A.; Gul'nyashkin, V.N. *Izv Vyssh Uchebn Zaved Chern Metall* n 10 1987 p 51-54.

**088899 APPLICATION OF LONG RAILS IN JA-**

**PAN.** The laying of long welded rails to eliminate joints in rails, which are the greatest defect of railway tracks, is now widely practiced throughout the world. In this article, studies aimed at solving the problems in realizing long-rail tracks, formulating an applicable theory, confirming safety, etc., performed in Japan are cited. Then the article discusses the conditions for track alignment, applicable methods of welding, the relation to ambient temperature and the transporting of long rails. In addition it describes supervisory technique and maintenance methods for long rails after they are laid down. (Edited author abstract) 4 refs.

Suzuki, Shun ichi (East Japan Railway Co, Jpn). *Jpn Railw Eng* v 27 n 3 Dec 1987 p 12-15.

**088900 ULTRA LIGHT WELDING CLAMP FOR HIGH QUALITY WELD GEOMETRY.** For the positioning of rail ends prior to thermit welding many methods have been applied, varying from wooden blocks plus wedges to all kinds of welding frames. In general these frames have the disadvantage of being heavy, unable to control the degrees of freedom per rail end independently and they don't allow for measurement of the adjusting parameters in a simple way. In response to this problem, Netherlands Railways has developed a new ultralight-weight welding, clamp (about 15 kg) which, when used in combination with an electronic straight edge, ensures a substantially better thermit weld geometry. 3 refs.

Esveld, Coenraad. *Rail Eng Int* v 17 n 1 1988 p 8-9, 11.

**088901 THERMIT - WELDING OF RAILS: OLD RECIPE FOR MODERN TRACK.** Thermit-welding has the capability of autonomously producing a certain quantity of steel with clearly-defined characteristics, without needing recourse to external energy sources; in other words without help from fixed and heavy equipment. This technique, through reliance on non-cumbersome appliances, is ideal for rail welding on busy tracks which cannot afford lengthy out-of-service periods. The fact that the consistency of the weld portions is well blended means that differently-alloyed elements - carbon steel on manganese steel - can amalgamate without problem, resulting in elimination of all track points. Thermit-welding is an extremely reliable process.

Gibert, F. (Aluminothermique, Fr). *Rail Int* v 19 n 5 May 1988 p 8-11.

**RAIN AND RAINFALL** See Also AEROSOLS—Atmospheric; AQUIFERS—Hydrology; ELECTROMAGNETIC WAVES—Propagation; ELECTROMAGNETIC WAVES—Scattering; FLOODS—Analysis; FLOODS—Estimation; HYDROLOGY; LANDSLIDES—Analysis; LANDSLIDES—Toronto, Ontario; PAVEMENTS—Concrete; PAVEMENTS—Deformation; ROADS AND STREETS—Noise, Acoustic; RUNOFF—Chemical Analysis; RUNOFF—Control; RUNOFF—Mathematical Models; SOILS—Permeability; TELECOMMUNICATION LINKS, MICROWAVE—Analysis; TELECOMMUNICATION LINKS, MICROWAVE—Attenuation; TELECOMMUNICATION LINKS, SATELLITE—Attenuation; WATER RESOURCES—Groundwater.

**088902 USE OF RADAR TO DERIVE A STORM INTENSITY-DURATION CURVE.** One solution for obtaining a large amount of closely spaced in intensity-duration values is to use weather radar. Using weather radar data, intensity-duration curves could be produced routinely for any set of prespecified locations. The radar data thus have the potential for facilitating the identification of the return period of rainfall events quickly, cheaply, and precisely when the long-term intensity-duration curves are available. As a pilot project to demonstrate the feasibility of the method and the potential of the radar data, computer software was developed to derive from archived radar data, intensity-duration-values for up to a 2,500 km<sup>2</sup> area for a given storm. (Edited author abstract) 17 refs.

Wojtiw, L. (Alberta Research Council, Edmonton, Alberta, Can). *Water Resour Bull* v 23 n 5 Oct 1987 p 849-855.



Africa See HYDROLOGY—Africa.

**Analysis** See Also FLOODS—Analysis; FLOODS—Design; MICROWAVES—Attenuation; RUNOFF—Estimation.

**088903 MORE ABOUT RAINFALL RATES AND THEIR PREDICTION FOR RADIO SYSTEMS ENGINEERING.** Owing to the interest raised by the effect of precipitation on the design of satellite or terrestrial radiocommunication systems at high frequencies, it is important to have a mathematical or semiempirical model which correctly accounts for rainfall rate cumulative distributions whatever the climatic region. An empirical model is suggested, based on two parameters: the rain rate value  $R_{0.01}$  (mm/h) in the considered location, and a parameter which depends on the geographical characteristics of this location. This model allows the calculation of instantaneous rain rate cumulative distributions, depending on the use of CCIR hydrometeorological zones, or CCIR contours of rainfall intensities exceeded for 0.01% of the time:  $R_{0.01}$  (mm/h). (Edited author abstract) 24 refs.

Moupfouma, F. (CNET, Issy les Moulineaux, Fr.) *IEE Proc Part H* v 134 n 6 Dec 1987 p 527-537.

**088904 ANALYSIS OF RAINFALL DATA FOR AGRICULTURAL PLANNING.** The rainfall data of 19 years (1967-85), obtained from observatories located at three different tehsil headquarters (namely, Tikamgarh, Jataara and Niwadi) in Tikamgarh district, a part of the Bundelkhand region of Madhya Pradesh, have been statistically analyzed. Drought, normal and abnormal years as well as months have been presented. The weekly data of rainfall has been found to be useful for the management practices than monthly, seasonal or annual data. The expected rainfall at 80%, 50% and 10% chances have been presented for the planning of agricultural operations and cropping program. (Author abstract) 7 refs.

Sharma, H.C. (G.B. Pant Univ of Agriculture & Technology, Pantnagar, India); Tiwari, Y.D.; Shrivastava, R.N.; Chouksey, R.S. *J Inst Eng India Part AG* v 68 n 1 Aug 1987 p 5-10.

**088905 ANALYSIS OF THE DESIGN STORM TIME-INTENSITY PATTERN FOR MEDIUM AND SMALL WATERSHEDS.** The present method for the computation of the design storm is based on point precipitation and only the recurrence frequency of annual maximum values for durations is considered. In order to analyze the method commonly used in practice for the derivation of the design storm pattern, three hydrological stations with different control areas were selected. Based on the areal average rainfall and an analysis of the correlation between storms and floods, a reasonable method for determining the design storm pattern can be obtained. As a result of this analysis, it is reasonable to synthesize and select the design storm pattern for medium and small watersheds from the areal storm pattern corresponding to the observed major floods for watersheds of similar size, and then to derive the storm pattern by controlling the subsegments which have the same frequency. (Edited author abstract) 5 refs.

Qian Wang Cheng (Hydrological General Station of Guangdong Province, Canton, China). *J Hydrol* v 96 n 1-4 Dec 15 1987 p 305-317.

**088906 FACTORS AFFECTING DEVELOPMENT OF HUFF CURVES.** The effects of three factors that affect storm identification on F.A. Huff curves were investigated. The effect of sampling interval on Huff curves is minor, allowing the use of more readily available hourly precipitation data by practicing engineers. The method of identifying individual storms using the critical duration of dry periods between rainfall periods also has a minor effect, in spite of large differences between critical duration estimates, making Huff curves relatively insensitive to estimates of critical duration. There is a significant effect of season of year on Huff curves. Huff curves have potential for more widespread practical use as design

storms. (Edited author abstract) 9 refs.

Bonta, J.V. (USDA-ARS, Coshocton, OH, USA); Rao, A.R. *Trans ASAE* v 30 n 6 Nov-Dec 1987 p 1689-1693.

**088907 PRECIPITATION CHARACTERISTICS FROM VARIABLE, HOURLY AND DAILY DATA BASES.** A continuous 35-year detailed time-depth record of precipitation in central Missouri was used to develop variable, hourly and daily time bases of the same precipitation sequence. The three time bases were searched in turn for precipitation event periods according to a two parameter event definition. Events were identified by a minimum depth and a minimum time without precipitation between events. Summary statistics showed high coefficients of variation and coefficients of skew for most event characteristics. The event characteristics of duration, interlude, depth and kinetic energy were similar for the variable and hourly time base data. The duration and depth characteristics were essentially identical. Thus, the hourly time base data may be adequate for certain design or simulation applications where these characteristics are important. Additional study results are discussed. (Edited author abstract) 8 refs.

Kramer, L.A. (USDA-ARS, Columbia, MO, USA). *Trans ASAE* v 30 n 6 Nov-Dec 1987 p 1706-1712.

**088908 COMPARISON OF FOUR DESIGN-STORM HETEROGRAPHS.** Dimensionless mass curves for four types of design storms representing different degrees of flexibility in rainfall and intensity pattern were investigated: F.A. Huff curves, a simple triangular shape, a complex trapezoid-rectangular shape, and a complex triangular shape. Little variation was found in dimensionless mass curves when the duration of the maximum intensity burst of rainfall was varied over two orders of magnitude for S- and D-type patterns. Little variation was found in dimensionless mass curves when time-to-peak was varied from one storm quartile to the next for Y-, S-, and D-type patterns. Huff curves were the most flexible of the four patterns investigated. (Edited author abstract) 7 refs.

Bonta, J.V. (USDA, Coshocton, OH, USA); Rao, A.R. *Trans ASAE* v 31 n 1 Jan-Feb 1988 p 102-106.

**088909 EXTREME RAINFALL FOR AFRICA AND OTHER DEVELOPING AREAS.** Methods are presented for estimating rainfall intensities with a minimum of data. Equations are given for use with 20-yr return period monthly rainfall amounts and with daily rainfall extremes. Depth-duration and depth-frequency ratios of extreme rainfall amounts have been found to be remarkably uniform within large and diverse geographical areas. This appears to be true for all of Africa. Large expenditures are being made to improve the collection of hydrologic and meteorologic data in the Sahel of Africa. Known ratios and relationships presented herein can improve the use of the existing long records and of data currently being collected. Greater emphasis on training in the use of the climatic data base is now available, and the need to be improved is recommended. (Edited author abstract) 13 refs.

Hargreaves, George H. (Utah State Univ, Logan, UT, USA). *J Irrig Drain Eng* v 114 n 2 May 1988 p 324-333.

**088910 CORRELATION PROPERTIES OF RAINFALL RATES IN THE UNITED KINGDOM.** Rainfall-rate data acquired from the UK Meteorological Office are analyzed to obtain spatial correlation properties of rainfall rates at 23 locations in the UK. Correlation coefficients of the rainfall rates between two locations are derived, and dependences of separation distance, season, and integration time on the coefficients are clarified. Conditional correlation coefficients, obtained from rainfall-rate data only larger than 1 mm/h at both locations simultaneously, are obtained and related to the nonconditional coefficients. Joint probability distributions of rainfall rates at two locations are approximated by a bivariate log-normal distribution function, in which a modified correlation coefficient is used. (Edited author abstract) 10 refs.

Fukuchi, H. (Univ of Bradford, Bradford, Engl.) *IEE Proc Part H* v 135 n 2 Apr 1988 p 83-88.

**088911 SPATIAL DISTRIBUTION OF PRE-WARM FRONT RAINFALL IN THE MEDITERRANEAN AREA.** Evidence is given of the distribution of pre-warm front rainfall at the meso- $\gamma$  scale, together with a discussion of the main mechanisms producing this variability. An inland region in the Mediterranean area is considered. The selected rainfall type is commonly considered the most regular inasmuch as it is usually unaffected by extended convective motions. Despite this, within a storm a large variability in space was observed. For 90% of measurements, the typical deviations from the area-average total depth ranged from -40 to 60% and the storm ensemble-average rainfall rate over a hilly zone was 60% greater than that in a contiguous low-land zone generally placed upwind. This variability is largely explained in terms of forced uplift of air mass over an envelope type orography. Additional aspects of the subject are discussed. (Edited author abstract) 16 refs.

Corradini, C. (Natl Research Council, Perugia, Italy); Melone, F. *Nord Hydrol* v 19 n 1 1988 p 53-64.

**088912 ANALYSIS OF RAINFALL SERIES IN THE DESIGN OF URBAN DRAINAGE CONTROL SYSTEMS.** Intensity-duration-frequency curves are traditionally used in the design of urban runoff treatment and management systems. The uniform intensity for a specified duration and return period is selected for a design storm without consideration of the inter-event dry periods between two successive rainfall events. For many purposes, especially those related to urban storm pollution control and receiving water impacts, the cumulative effects of successive storm events must be taken into account. This fact requires the selection of design storms where the minimum inter-event dry periods are adjusted to the effect in question. This paper discusses the concept of inter-event dry periods for evaluation of design storms derived from a rainfall record. As an example the rainfall record for the city of Odense, Denmark, has been analyzed. The basic statistics as well as the importance of the concept will be illustrated. (Author abstract) 18 refs.

Hvitved-Jacobsen, Thorkild (Univ of Aalborg, Aalborg, Den); Yousef, A. *Water Res* v 22 n 4 Apr 1988 p 491-496.

**088913 ESTIMATION OF CATCHMENT RAINFALL UNCERTAINTY AND ITS INFLUENCE ON RUNOFF PREDICTION.** Interpolation of spatially varying point precipitation depths introduces uncertainties in the estimated mean areal precipitation (MAP). This paper describes a geostatistical approach - the Kriging method - to calculate the daily MAP on real-time basis. The procedure provides a linear unbiased estimate with minimum estimation variance. The structural analysis of the random precipitation field is automatized by relating the time-varying semivariogram model to the sample variance. This is illustrated on data from a Danish IHD catchment. The conceptual rainfall-runoff model NAM incorporated into a Kalman-filter algorithm is applied to investigate the effects of uncertainties in MAP on the runoff predictions. Measurement and processing errors are not included in the investigation. (Author abstract) 18 Refs.

Storm, B. (Technical Univ of Denmark, Lyngby, Den); Jensen, K. Høgh; Refsgaard, J.C. *Nord Hydrol* v 19 n 2 1988 p 77-88.

**088914 SPATIAL AND TEMPORAL SCALES IN RAINFALL ANALYSIS-SOME ASPECTS AND FUTURE PERSPECTIVES.** Aspects of spatial and temporal rainfall variability and rainfall analysis in relation to some water management problems are surveyed and discussed. It is concluded that relevant modelling of hydrological processes in which the rainfall is a driving force is vital with respect to possibilities of finding solutions to increasing environmental problems following urbanization and industrialization. However, modern



computer methods and our knowledge of the spatial and dynamic properties of rainfall fields are seldom used in practical engineering applications. This causes errors and uncertainties in the calculated output. Bridging the gaps between researchers and engineers may overcome some of these problems. It is also argued that experimental studies in a variety of climates and physiographical conditions using an interdisciplinary approach are needed in order to further investigate the scale and dynamics of spatial rainfall variability. (Author abstract). 125 Refs.

Berndtsson, Ronny (Lund Univ, Lund, Sweden); Niemczynowicz, Janusz. *J Hydrol* v 100 n 1-3 Jul 30 1988 p 293-313.

**088915 FITTING EQUATIONS TO FAMILIES OF DIMENSIONLESS CUMULATIVE HYETOGRAPHS.** The simultaneous fitting of a family of curves using linear programming LP is illustrated by fitting equations to families of design storms known as Huff curves. Tenth degree polynomials are fitted to 12 9-curve families. The results showed that the LP method generally works well, but that it is possible that constraints may not be satisfied in intervals between data points used in the formulation of the problem, and that numerical problems may result if a high degree polynomial is used. The effects of these numerical problems are dependent on the particular data set being used, but the errors in the design-storm illustration were not important for the flood-estimation objective for which they were developed. (Edited author abstract). 13 Refs.

Bonta, J.V. (North Appalachian Experimental Watershed, Coshocton, OH, USA); Rao, A.R. *Trans ASAE* v 31 n 3 May 6 1988 p 756-760.

## Arizona

**088916 RAINFALL INTENSITIES FOR SOUTH-EASTERN ARIZONA.** Small watershed storm runoff in the southwestern United States is dominated by intense, short-duration convective rains of limited areal extent. Storm drainage design is often based on rainfall information published by the National Weather Service in the National Oceanic and Atmospheric Administration (NOAA) Atlas 2 series. In NOAA Atlas 2, short-duration rainfall is derived by an extrapolation procedure from maps of 6-hr and 24-hr rainfall amounts with different frequencies. In this study, intensity-duration-frequency values for 1 hr and less, based on data from a dense network of rain gauges in southeastern Arizona, are compared to similar values derived from NOAA Atlas 2. Differences in rainfall intensities obtained from the two methods are illustrated by simulating and comparing peaks and volumes of runoff. Refs.

Osborn, Herbert B. (USDA-ARS, Tucson, AZ, USA); Renard, Kenneth G. *J Irrig Drain Eng* v 114 n 1 Feb 1988 p 195-199.

**Australia** See AIR POLLUTION—Acid Rain; GEOTHERMAL WELLS—Australia.

## Bermuda

**088917 OCCURRENCE AND DISTRIBUTION OF TRACE ORGANIC COMPOUNDS IN BERMUDA PRECIPITATION.** Data are presented on the chemical composition of 36 rainwater events sampled in Bermuda during 1983 and 1984. Samples were analyzed for alpha and gamma isomers of hexachlorocyclohexane, chlordane and dieldrin. Mean concentrations with standard errors found were  $854 \pm 217 \text{ pg l}^{-1}$  for  $\alpha$  HCH,  $126 \pm 27 \text{ pg l}^{-1}$  for  $\gamma$  HCH,  $77 \pm 17 \text{ pg l}^{-1}$  for chlordane and  $158 \pm 27 \text{ pg l}^{-1}$  for dieldrin. The data indicate that higher concentrations of  $\alpha$  HCH and  $\gamma$  HCH in rainwater are associated with air masses originating in North America. The concentrations of the compounds in precipitation are highly variable and the deposition of the compounds is extremely episodic. The wet fluxes of chlordane and dieldrin are discussed in relation to deep-sea sediment trap measurements collected at 3200 m in the Sargasso Sea 25 km southeast of the rainwater sampling site and indicate a wet flux of  $78\text{--}115 \text{ ng m}^{-2} \text{ yr}^{-1}$  for chlordane and

$217\text{--}237 \text{ ng m}^{-2} \text{ yr}^{-1}$  for dieldrin which is 6-8 times higher than the measured deep-sea flux. (Author abstract). 31 Refs.

Knap, Anthony H. (Bermuda Biological Station for Research Inc, St. Georges, Bermuda); Binkley, Kandace S.; Artz, Richard S. *Atmos Environ* v 22 n 7 1988 p 1411-1423.

## Canada

**088918 RAINFALL AND RUNOFF EROSION INDICES FOR EASTERN CANADA.** Rainfall and runoff erosivity indices for the eastern Canadian provinces of Quebec and Ontario were calculated from the once-in-2 year, 6 h rainfalls. Isoerodent maps were then plotted. Annual erosivity indices which account for winter and snowmelt conditions are also included. A monthly distribution of the erosivity index is presented. Design personnel now have access to more precise erosivity indices, covering a wider geographical location. The availability of the isoerodent maps will enhance the quality of soil erosion and conservation studies in eastern Canada. (Author abstract) 10 refs.

Madramootoo, Chandra A. (McGill Univ, Que, Can). *Trans ASAE* v 31 n 1 Jan-Feb 1988 p 107-110.

**Chemical Analysis** See Also AIR POLLUTION—Analysis; SULFUR COMPOUNDS—Environmental Testing.

**088919 RAINWATER ANALYSIS: A COMPARISON BETWEEN PROTON-INDUCED X-RAY EMISSION AND GRAPHITE FURNACE ATOMIC ABSORPTION SPECTROSCOPY.** Rainwater was collected and analyzed for trace metals by graphite furnace atomic absorption spectroscopy (GFAAS) and proton-induced x-ray emission (PIXE). For the PIXE analysis, a nonselective preconcentration technique was used to dry the samples onto polystyrene films. Good agreement was found in the concentrations for the elements determined in common (Cu, Fe, Mn, Pb, and Zn), even though the PIXE analysis had some problems with sample contamination. An advantage of the PIXE analysis is that 26 elements can be determined simultaneously. The elements P, S, K, Ca, V, Mn, Fe, Ni, Zn, As, Br, and Pb had concentrations significantly higher than the chemical blank and detection limits and thus could be routinely analyzed by PIXE. The technique is promising for the other elements Ti, Cr, Co, Cu, Ga, Ge, Se, Rb, and Sr. (Edited author abstract) 30 refs.

Hansson, Hans-Christen (Univ of Lund, Lund, Sweden); Ekholm, Ann-Kristin; Ross, Howard B. *Environ Sci Technol* v 22 n 5 May 1988 p 527-531.

**088920 COMPARISON OF RADM AND OSCAR PRECIPITATION CHEMISTRY DATA.** This study examines the relationships between predictions of the Regional Acid Deposition Model (RADM) and observed precipitation chemistry patterns associated with frontal storm systems. Three episodes, monitored as part of the Oxidation and Scavenging Characteristics of April Rains (OSCAR) program and referred to as OSCAR I, OSCAR II and OSCAR IV, were analyzed. The temporal and spatial variations of chemical concentrations in rainfall and deposition of  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{H}^+$  and  $\text{NH}_4^+$ , as well as rainfall amounts observed, at up to 36 stations, were compared with the corresponding RADM grid-average predictions. Quantitative comparisons for each grid-point pair were made using average fractional differences, which are defined as the difference in the observations and predictions divided by the sum of the observations and predictions. Study limitations and results are discussed. (Edited author abstract). 27 Refs.

Middleton, Paulette (State Univ of New York at Albany, Albany, NY, USA); Chang, Julius S.; Del Corral, John C.; Geiss, Heiner; Rosinski, James M. *Atmos Environ* v 22 n 6 1988 p 1195-1208.

## Chemistry

**088921 INFLUENCE OF ALTITUDE ON RAINFALL COMPOSITION AT GREAT DUN FELL.** The influence of altitude on rainfall composition and wet deposition has been investigated at Great Dun Fell in northern England. Measurements of rainfall at eight altitudes between 250 and 850 m on the western slopes of the hill show marked changes in both amount and composition when orographic cloud is present and a west or southwest wind is blowing. On average (20 precipitation events from Autumn 1984 and Spring 1985), the rainfall at the summit (847 m) exceeded that at 250 m by a factor of 2, and concentrations of  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{Cl}^-$ ,  $\text{NH}_4^+$  and  $\text{H}^+$  were larger at the summit by factors of between 2.2 and 3.1. Thus, wet deposition at the summit was larger than at 250 m by about a factor of 5. The concentrations of major ions in orographic cloud at 847 m exceeded concentrations in rain by a factor of between 2.0 and 3.9. A large change occurred in the concentrations of major ions in orographic cloud with altitude, decreasing with increasing altitude from cloud base. Additional study results are discussed. (Edited author abstract). 13 Refs.

Fowler, D. (Inst of Terrestrial Ecology, Midlothian, Scotl); Cape, J.N.; Leith, I.D.; Choularton, T.W.; Gay, M.J.; Jones, A. *Atmos Environ* v 22 n 7 1988 p 1355-1362.

**088922 INFLUENCE OF ALTITUDE ON WET DEPOSITION COMPARISON BETWEEN FIELD MEASUREMENTS AT GREAT DUN FELL AND THE PREDICTIONS OF A SEEDER-FEEDER MODEL.** The influence of topography on rainfall rate and chemical composition has been investigated at Great Dun Fell in northern England. The measurements at eight different altitudes between 250 and 850 m above sea-level on the western slopes of Great Dun Fell (GDF) show, in the presence of a cap cloud on the hill and a west or southwest wind flow, a marked increase in both rainfall amount and concentration of major ions with altitude. Three case studies of the variation in rainfall rate and chemical composition with altitude when the seeder-feeder mechanism was operating are described and compared with model predictions. Associated measurements of the cap cloud microphysics and chemistry were also made. The case studies show close agreement between model predictions and measured values for changes in chemical composition and wet deposition with altitude. Additional aspects of the study are discussed. (Edited author abstract). 9 Refs.

Choularton, T.W. (UMIST, Manchester, Engl); Gay, M.J.; Jones, A.; Fowler, D.; Cape, J.N.; Leith, I.D. *Atmos Environ* v 22 n 7 1988 p 1363-1371.

## Classification

**088923 CLUSTERING DAILY RAINFALL RECORDS PRODUCES INDEPENDENT RANDOM VARIABLES IN STOCHASTIC HYDROLOGY.** A rain storm is defined to be a sequence of rainfalls that are originated from an individual synoptic-scale meteorological disturbance, such as a typhoon, frontal wave, etc. A concept of the rain cluster is introduced as the most conceivable substitute for the rain storm. The number of occurrences, and the amount of rainfalls, of the rain cluster can be taken as the new mutually independent random variables. Consequently, well-known probability distributions in the statistics can strictly be applied for the new variables, because these distributions are based on the assumption that the variables in question should be mutually independent and random. Other related concepts, such as a no-rain run and a cluster interval, are also introduced. A case study concerns with the daily rainfalls observed under AMeDAS from 1975 to 1986 at Hitoyoshi, Kyushu, Japan. (Edited author abstract) 17 refs.

Takashima, Yasuo (EPDC Int Ltd, Tokyo, Jpn). *J Hydroscl Hydrol Eng* v 5 n 2 Feb 1988 p 65-83.



**Cloud Seeding** See Also METEOROLOGY—Atmospheric Precipitation; RUNOFF.

**088924 USE OF RADAR DATA ON PRECIPITATION TO EVALUATE CLOUD-SEEDING RESULTS.** Described is a method of estimating the number of experimental units needed to establish the effect of cloud seeding in order to regulate precipitation. It is shown that the use of radar information on fields of precipitation in large areas, which is distinguished by higher spatial and temporal resolution than the rain gage grid, lets us obtain original data, based on which we can substantially improve planning and evaluating the results of experiments on active measure for regulating precipitation. Based on analyzing statistical characteristics of fields of precipitation layers during various time intervals conclusions are formed about the optimal placement of control polygons and the merit of shifting to shorter experimental units in regulating precipitation. (Author abstract) 11 refs.

Koloskov, B.P.; Mel'nichuk, Yu.V.; Shipilov, O.I. *Sov Meteorol Hydrol* n 2 1987 p 13-19.

**Dielectric Properties** See ELECTRIC INSULATORS—Testing.

## Diffusion

**088925 CONSTANT RATE RAINFALL INFILTRATION: A VERSATILE NONLINEAR MODEL - 1. ANALYTIC SOLUTION.** Analytic solutions are presented for a nonlinear diffusion-convection model describing constant rate rainfall infiltration in uniform soils and other porous materials. The model is based on the Darcy-Buckingham approach to unsaturated water flow and assumes simple functional forms for the soil water diffusivity  $D(\theta)$  and hydraulic conductivity  $K(\theta)$  which depend on a single free parameter  $C$  and readily measured soil hydraulic properties. These  $D(\theta)$  and  $K(\theta)$  yield physically reasonable analytic moisture characteristics. The relation between this model and other models which give analytic solutions is explored. (Edited author abstract) 55 refs.

Broadbridge, P. (CSIRO, Canberra, Aust); White, I. *Water Resour Res* v 24 n 1 Jan 1988 p 145-154.

**088926 CONSTANT RATE RAINFALL INFILTRATION: A VERSATILE NONLINEAR MODEL - 2. APPLICATIONS OF SOLUTIONS.** In paper 1 (Broadbridge and White, this issue) an analytical nonlinear model for constant rate rainfall infiltration was proposed which promised considerable versatility. In it a wide range of soil hydraulic properties are generated through the variation of a single free parameter  $C$ . Here three techniques are advanced for determining this parameter. The first, a one-dimensional technique, involves simultaneous determination of sorptivity and wetting front position. The second uses measured values of surface water content at long infiltration times for rainfall rates less than the saturated conductivity. In the third, three- and one-dimensional flow rates are measured on the same soil sample. All are suitable for field applications. The mathematically simple, traveling wave approximation agrees well with observations at comparatively short infiltration times. Finally, field and laboratory measured times to ponding are predicted satisfactorily by the model's analytic expression. (Edited author abstract) 20 refs.

White, I. (CSIRO, Canberra, Aust); Broadbridge, P. *Water Resour Res* v 24 n 1 Jan 1988 p 155-162.

**Drainage** See Also WATERSHEDS—Hydrology.

**088927 HYDROGRAPH ANALYSIS AS A BASIS FOR RAINFALL-RUNOFF MODELLING.** A great deal of information about the water balance of a catchment can be deduced by analysis of the hydrograph of runoff recorded at the outlet of the catchment. This paper describes procedures whereby inconsistencies between rainfall and runoff data, relationships between baseflow discharge and groundwater storage, partial areas of

surface runoff and surface storage capacities can be deduced by analysis of streamflow and rainfall records. The method is illustrated by analysis of data from the 7 sq km Back Creek catchment in southeastern Queensland. (Author abstract) 6 refs.

Boughton, W.C. *Trans Inst Eng Aust Civ Eng* v CE29 n 1 Feb 1987 p 28-33.

**Environmental Testing** See Also LEAD COMPOUNDS—Environmental Testing.

**088928 BACTERIAL UTILIZATION OF FORMIC AND ACETIC ACID IN RAINWATER.** Rain samples were collected aseptically, during 1983 and 1984, in Charlottesville, Virginia to determine the ability of bacteria in precipitation to utilize formate and acetate. The total number of bacteria, as counted by Acridine Orange Direct Counts, was one to two orders of magnitude greater from April to September ( $10^5$  cells  $\text{ml}^{-1}$ ) than during the rest of the year ( $10^3 - 10^4$  cells  $\text{ml}^{-1}$ ). Formate and acetate concentrations ranged between 6-23 and 3-9  $\mu\text{M}$  respectively and were higher from June to September. Heterotrophic uptake on the day of collection was not different from the controls, but after incubation at room temperature for a minimum of three days, the turnover rate constants were 0.14 and  $0.17\text{h}^{-1}$  for formate and acetate, respectively. Total bacterial counts increased an order of magnitude during that interval. These turnover rate constants were used to calculate losses of 44 and 24  $\mu\text{mol l}^{-1}\text{day}^{-1}$  of formic and acetic acid, respectively, and results are discussed. (Edited author abstract) 42 refs.

Herlihy, Linda Jolley (Univ of Virginia, Charlottesville, VA, USA); Galloway, James N.; Mills, Aaron L. *Atmos Environ* v 21 n 11 1987 p 2397-2402.

**Estimation** See Also RADAR—Meteorological; RUNOFF—Components; SOILS—Moisture Determination; SOILS—Physical Properties.

**088929 ALGORITHM FOR RAIN RATE ESTIMATION BY MOS-1 MSR.** Microwave brightness temperatures expected to be measured by MOS-1 MSR over rain are calculated over the ocean background. The influence of ocean surface wind is evaluated by using a composite rough surface model. An algorithm for rain rate estimation by MOS-1 MSR is developed for each season of a year based on the calculation. (Edited author abstract) 11 refs.

Fujita, Masaharu (Ministry of Post & Telecommunications, Jpn); Miyagawa, Yuji. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 8 Aug 1987 p 699-702.

**088930 ON THE ACCURACY OF AREAL RAINFALL ESTIMATION: A CASE STUDY.** The issue of the accuracy of areal rainfall estimation is discussed through a case study on a catchment area in the Cevennes region of France. The basic tool for the analysis is a 'scaled estimation error variance' which is computed from a scaled climatological variogram model of the rainfall field. We show how this variance provides a theoretical criterion to compare the accuracy that can be expected with three linear estimators (Thiessen, spline, and kriging) for various networks' densities. To support the methodology an experimental validation of the scaled estimation error variance computation is performed, using 'reference' areal rainfall values computed with a very high density network. (Author abstract) 19 refs.

Lebel, T. (CNRS, Fr); Bastin, G.; Obled, C.; Creutin, J.D. *Water Resour Res* v 23 n 11 Nov 1987 p 2123-2134.

**088931 APPLICATION OF KRIGING TO ESTIMATING MEAN ANNUAL PRECIPITATION IN A REGION OF OROGRAPHIC INFLUENCE.** Estimates of mean annual precipitation (MAP) over areas are the starting point for all computations of water and chemical balances for drainage basins and surface water bodies. Any errors in the estimates of MAP are propagated through the balance computations. The failure of the raingage network to adequately sample the region of interest is evaluated by applying kriging in two different

approaches to estimating MAP in New Hampshire and Vermont, USA. The data base is the 1951-1980 normal precipitation at 120 raingages in the two states and in adjacent portions of bordering states and provinces. In the first approach, kriging is applied directly to the MAP values, while in the second, kriging is applied to a precipitation delivery factor that represents the MAP with the orographic effect removed. The second approach had a considerably smoother error surface and, thus, is generally preferable as a basis for point and areal estimates of MAP. (Edited author abstract) 44 refs.

Dingman, S. Lawrence (Univ of New Hampshire, Durham, NH, USA); Seely-Reynolds, Diana M.; Reynolds, Robert C. *Water Resour Bull* v 24 n 2 Apr 1988 p 329-339.

**088932 ESTIMATION DE LAMES D'EAU SPATIALES A L'AIDE DE DONNEES DE PLUVIOMETRES ET DE RADAR METEOROLOGIQUE - APPLICATION AU PAS DE TEMPS JOURNALIER DANS LA REGION DE MONTREAL.** [Comparative Study of Areal Rainfall Estimation Methods Using Rain Gage and Radar Data - Application to Daily Rainfall Events Observed in the Montreal Region]. Several areal rainfall estimation methods using rain gage and weather radar data are reviewed including: (1) Thiessen's and Kriging methods relying on rain gage measurements only; (2) the classical cumulative procedure after transformation of reflectivity measurements using a standard Z-R relationship for conventional radar measurements alone; and (3) the uniform calibration method (using a constant multiplicative factor or a nonlinear regression) and the simplified cokriging method (previously proposed by the authors) for rain gage-radar combinations. The results show that the methods taking into account the spatial variability of rainfall (kriging, simplified cokriging) work much better than more classical approaches. Furthermore, the optimal combination of radar and rain gage information through simplified cokriging leads to better results than each measurement system alone for six out of eleven cases (especially for those presenting high areal variability). (Edited author abstract) 18 refs. In French.

Delrieu, G. (Inst de Mecanique de Grenoble, St. Martin d'Heres, Fr); Bellon, A.; Creutin, J.D. *J Hydrol* v 98 n 3-4 Apr 15 1988 p 315-344.

**088933 ESTIMATION DE LA PLUVIOMETRIE PENTADAIRE AU BURKINA FASO PAR L'INDICE DE PRECIPITATION ESOC (EPI).** [Estimating Five-Day Rainfall in Burkina Faso with the Help of the ESOC Precipitation Index (EPI)]. The purpose of this study is to estimate five-day rainfall using the Precipitation Index (EPI) calculated at the European Space Operations Cent (ESOC) based on the data from the Agency's Meteosat geostationary meteorological satellite. A statistical cloud-indexing method, linking the accumulated precipitation and the fractional coverage of clouds over a fixed area, is used. The cold clouds are assumed to be precipitating. The precipitation data from the meteorological network of Burkina Faso have been used to verify the method. The study covers a period of one year. (Edited author abstract) 11 refs. In French.

Diallo, A.A. (European Space Operations Cent, Ouagadougou, Burkina Faso); Turpeinen, O.M. *ESA J* v 11-12 n 4-1 1987-1988 p 55-68.

**088934 USING LIGHTNING FOR RAINFALL ESTIMATION IN FLORIDA.** The objective of this study was to evaluate the feasibility of using remote sensing methods, such as lightning technique, to quantify the area rainfall. Lightning and rainfall data collected during 1977 and 1978 by the Thunderstorm Research International Program located at the Kennedy Space Center were used in this study. The results showed that an increase of 1 lightning flash/min appears to be equivalent to an increase in rainfall of about 1.6 mm. Also, each increment in maximum flashing rate (FM) per minute is likely to be equivalent to increase of hourly rainfall by 1 mm. Using the FM appears to be a better tool for the area-average



rainfall (RA) estimation than using average flashing rate. The RA can be predicted based on the FM with an equation of  $RA = 0.467 + 0.562 FM$  ( $r^2 = 0.74$ ). (Author abstract). 18 Refs.

Shih, S.F. (Univ of Florida, Gainesville, FL, USA). *Trans ASAE* v 31 n 3 May 6 1988 p 750-755.

Europe See TELECOMMUNICATION LINKS—Europe.

Evaluation See HYDROLOGY—Mathematical Models.

## Florida

**088935 VARIATION OF DAILY RAINFALL DISTRIBUTION IN SOUTH FLORIDA.** Daily rainfall data gathered from Lake Alfred, Ft. Myers, Clewiston, Belle Glade, and West Palm Beach Weather Stations were used in this study to analyze rainfall variation in south Florida. The results showed that the chance of rainfall occurrence is about 25% during the dry season (November through April) and 75% during the wet season (May through October). The chance of rainfall occurring during the second half of the dry season (February, March, and April) showed a significant decrease since 1960. A particularly significant decrease was shown for the month of April. This decrease in the chance of rainfall at the time of dry season could have a serious impact on water management in south Florida. (Author abstract) 10 refs.

Shih, S.F. (Univ of Florida, Gainesville, FL, USA). *Trans ASAE* v 31 n 1 Jan-Feb 1988 p 149-153, 160.

Gages See Also AIR POLLUTION—Acid Rain; HYDROLOGY—Sampling; RADAR—Meteorological.

**088936 AUTOMATIC RAIN GAUGE FOR CONTINUOUS, REAL TIME DETERMINATION OF RAINWATER CHEMISTRY.** An automatic rain gage has been developed, capable of collecting rainwater and analyzing it continuously for the ions  $H^+$ ,  $NH_4^+$ ,  $Na^+$ ,  $Ca^{2+}$ ,  $NO_3^-$ ,  $Cl^-$ ,  $SO_4^{2-}$  and for dissolved  $H_2O_2$ . The wet-only rain collector, based on an inverting V-tray arrangement, is mounted on the roof of a small caravan, which contains the analysis equipment. Data are recorded on disk by a microcomputer, which also handles automatic calibration and other control functions. The caravan as a whole is a fairly comprehensive, transportable air and rainwater monitoring package. The advantage of the rainwater sampling method is that instantaneous concentrations are measured continuously rather than daily or weekly averages; and that problems of deterioration of stored samples are eliminated. (Edited author abstract) 18 refs.

Ames, D.L. (CEGB, Leatherhead, Engl); Roberts, L.E.; Webb, A.H. *Atmos Environ* v 21 n 9 1987 p 1947-1955.

**088937 LOW-COST COMPUTER INTERFACED RAIN GAUGE.** A conventional tipping bucket rain gauge was directly interfaced with a battery-powered portable lap top computer for digital data acquisition, storage, processing, and uploading to a mainframe computer system. A simple software program was written in BASIC to allow rainfall data recordings of each 0.254 mm of rain with a time resolution of 1 s. The method provides an inexpensive means to improve the time resolution of tipping bucket rain gauges, reduces the costs associated with data processing, and decreases data analysis time. (Author abstract) 15 refs.

Williams, R.G. (USDA, Tifton, GA, USA); Erdman, M.D. *Comput Electron Agric* v 2 n 1 Sep 1987 p 67-73.

**088938 ATMOSPHERIC DEPOSITION SAMPLER INTERCOMPARISON.** Two wet/dry atmospheric deposition sampler types were compared for 1 yr. The resistance required to open each of ten collectors was determined. Additionally, the opening and closing history of each sampler was recorded using a microdata logger with a resolution of 1 min. The frequency distribution of amount of time that a collector was open was used to evaluate the comparability of opening and closing of each collector. Weekly amounts of rainfall for each of the

collectors was used to determine the efficiency of collection as compared to a Belfort 5-780 weighing rain gage. The performance of a collector as determined by the efficiency of collection and also by the distribution of frequencies of times that a sampler was exposed to precipitation were statistically different for the different sampler configurations. (Author abstract) 10 refs.

Graham, Richard C. (US Military Acad, West Point, NY, USA); Robertson, John K.; Schroder, Leroy; Lafemina, John. *Water Air Soil Pollut* v 37 n 1-2 Jan 1988 p 139-147.

**088939 NUMERICAL EXPERIMENTS ON THIENEN WEIGHTS OF RAINGAUGES.** A computational method for determining Thiessen weights is developed using existing mathematical theory. The approximations and the possible error inherent in the method are also discussed giving the limitations. However, for many situations which are encountered in practice, this method can be used to find the respective weights. The paper does not aim at recommending Thiessen weight method over Isohyetal method or any other method to be applied to catchment for the purpose of hydrologic analysis.

Palaniappan, A.B. (Nat'l Inst of Hydrology, Roorkee, India). *Irrig Power* v 45 n 1 Jan 1988 p 91-98.

**088940 OBJECTIVE RAINFALL EVALUATION IN RADAR HYDROLOGY.** A newly developed bivariate statistical analysis is compared to several rainfall analyses, namely the radar univariate analysis, the reciprocal-distance raingage interpolation model, the Brandes field adjustment procedure, and the 'optimum' raingage analysis. A number of statistics are also computed and used to evaluate the results. Several warm-season storms are examined over the Grand River basin above Cambridge in southern Canada. Based on the selected criteria, the analyzed storms indicate that, in general, most of the techniques in the comparison performed similarly, with the exception of the radar univariate analysis, which is considered unsatisfactory. (Author abstract). 20 Refs.

Dalezios, Nicolas R. (Intera Technologies Ltd, Calgary, Alberta, Can). *J Water Resour Plann Manage* v 114 n 5 Sep 1988 p 531-546.

**088941 DIGITISING PLUVIOGRAPHS.** A scheme for digitizing daily pluviographs from Dines-type automatic raingages is described. The data set derived from digitization consists of a division of time into periods of variable length in which rain is assessed as having fallen at a steady rate. The results obtained from the digitized data contain fewer errors than data extracted manually from the pluviographs. It is estimated that 98 percent of the rainfall in rain periods of any length lie within 0.1 mm of the true amount, and that the time resolution of the system is about 2.5 minutes. (Author abstract). 3 Refs.

Sansom, John (New Zealand Meteorological Service, Wellington, NZ). *J Hydrol NZ* v 26 n 2 1987 p 197-209.

## Hydrology

**088942 INFILTRATION INTO A UNIFORM SAND COLUMN WITH A CENTRAL, SMALL AND CYLINDRICAL SPACE FILLED WITH A COARSER SAND.** This paper deals with an investigation of the confined infiltration of rainwater into a heterogeneous field consisting of a uniform sand column (outer domain) which centrally contains a vertical, small coarser sand cylinder (inner domain) connected to the surface of the column. Attention is paid especially to the effect of pore air on the infiltration. At first, in order to examine the effect of the existence of the inner domain and its depth on the infiltration, an infiltration experiment under ponding and constant-flux conditions is carried out by changing the kind of sand of the inner domain, i.e., the diameter of the sand, and the diameter and depth of the inner domain, where the sand used is initially air-dry. During the experiment, water content, the pore-air pressure at the bottom of the sand column and the infiltration rate are measured. Next, the experimental results are discussed, using the fundamental equation of movement of water and

pore air and referring to the results for infiltration into a homogeneous sand column. (Edited author abstract) 15 refs.

Ishihara, Yasuo; Shimojima, Eiichi; Minobe, Yujin. *Bull Disaster Prev Res Inst Kyoto Univ* v 37 pt 3 Sep 1987 p 107-145.

## Israel

**088943 RAINFALL VARIATIONS IN THE GALILEE (ISRAEL), I. VARIATIONS IN THE SPATIAL DISTRIBUTION IN THE PERIODS 1931-1960, AND 1951-1980.** Mean monthly rainfall from different stations in the Galilee (northern Israel) for the periods 1931-1960 and 1951-1980, have been correlated with longitude, latitude and altitude of each station. A seasonal pattern of the explained variance ( $r^2$ ) by each of the variables has been found. At the beginning of the rainy season, the rainfall is correlated strongest with the longitude of the stations, during the main rainy season with the altitude and at the end of the rainy season with the latitude of the stations. In the latter period (1951-1980) the correlation with latitude is weaker than in the first period (1931-1960). The decrease in the correlation may be attributed to a shift in the depressions' tracks in the Eastern Mediterranean and to cloud seeding. (Edited author abstract) 19 refs.

Kutiell, H. (Univ of Haifa, Haifa, Isr). *J Hydrol* v 94 n 3-4 Oct 30 1987 p 331-344.

**088944 RAINFALL VARIATIONS IN THE GALILEE (ISRAEL), II. VARIATIONS IN THE TEMPORAL DISTRIBUTION BETWEEN 1931-1960 AND 1951-1980.** Mean monthly rainfalls from different stations in the Galilee (northern Israel) for the periods 1931-1960 and 1951-1980, have been correlated with longitude, latitude and altitude of each station. A seasonal pattern of the explained variance ( $r^2$ ) by each of the variables has been found. At the beginning of the rainy season the rainfall is correlated most strongly with the longitude of the stations, during the main rainy season with the altitude and at the end of the rainy season with the latitude of the stations. In the latter period (1951-1980) a retardation of the rainfall regime is observed. A greater portion of the annual total falls during the spring time (March-April) while a parallel decrease in the winter (January-February) rains is observed. The spatial distribution of this retardation and some of its implications are discussed. (Author abstract) 7 refs.

Kutiell, Haim (Univ of Haifa, Haifa, Isr). *J Hydrol* v 99 n 1-2 May 15 1988 p 179-185.

## Kerala, India

**088945 RAINFALL FREQUENCY STUDIES FOR KERALA REGION.** The daily rainfall data for 80 years from 98 stations in the Kerala region has been analyzed to arrive at the return periods of 2 to 100 years for rainfall durations of one to three days. The annual maximum values have been made use of to relate the magnitude of rainfall to return periods. Gumbel's extreme value distribution has been resorted to, considering its advantages. Frequency interpolation nomograms presented in the paper will be useful in estimating the return periods. The study will be of use to those involved in design of hydraulic structures. (Author abstract) 17 refs.

James, E.J. (Cent for Water Resources Development & Management, Kerala, India); Saseendran, S.A.; Chandrasekharan, M.E.; Anitha, A.B. *J Inst Eng India Part CI* v 68 n 2 Sep 1987 p 74-81.

**Mathematical Models** See Also METEOROLOGY—Atmospheric Precipitation; RADIO TRANSMISSION—Propagation Effects; RUNOFF—Mathematical Models.

**088946 ARE RAIN RATE PROCESSES SELF-SIMILAR?** Scaling or self-similarity is an important issue which has attracted considerable attention and has partic-



ularly inspired a certain trend in rainfall modeling. We clarify the implication, with respect to self-similarity, of the facts that the probability of rain tends to increase with the size of the area of observation and that the distribution of rain rate contains an atom at zero. These properties observed in precipitation processes lead to subtle difficulties which are not compatible with self-similarity. (Edited author abstract) 4 refs.

Kedem, Benjamin (Univ of Maryland, College Park, MD, USA); Chiu, Long S. *Water Resour Res* v 23 n 10 Oct 1987 p 1816-1818.

**088947 ON PARAMETER ESTIMATION OF TEMPORAL RAINFALL MODELS.** Characteristics and moment estimators of temporal rainfall models such as Poisson rectangular pulse (PRP), Neyman-Scott white noise (NSWN), and Neyman-Scott rectangular pulse (NSRP) are investigated. It is shown that PRP and NSWN have a correlation structure like that of an autoregressive moving average (ARMA) (1, 1) model whereas the NSRP has a dependence structure like that of an ARMA (2, 2). The admissible regions of lag-1 and lag-2 autocorrelations are derived to demonstrate that in general they are more restricted than their ARMA counterparts. An additional property denoted as variance ratio, which is intimately related to the scale of fluctuation of a process, is defined and used for model comparison. The correlation and variance ratio plots are used to select the appropriate model for each month. (Edited author abstract) 16 refs.

Obeyskera, J.T.B. (Colorado State Univ, Fort Collins, CO, USA); Tabios, G.Q. III; Salas, J.D. *Water Resour Res* v 23 n 10 Oct 1987 p 1837-1850.

**088948 STATISTICAL MODELING OF SPACE-TIME RAINFALL USING RADAR AND RAIN GAGE OBSERVATIONS.** A statistical framework for modeling space-time rainfall using radar and rain gage observations is developed. Three principal tasks are involved in implementing our statistical model. These tasks are referred to as sampling (that is, characterization of the error structure of radar and rain gage measurements of rainfall, modeling), (that is, specification of a stochastic model for space-time rainfall), and parameter estimation. It is emphasized that sampling, modeling, and parameter estimation are interrelated and equally important tasks. Our statistical model is applied to daily rainfall fields in the tropical Atlantic region covered by the GATE experiment. (Author abstract) 25 refs.

Smith, James A. (Interstate Commission on the Potomac River Basin, Rockville, MD, USA); Krajewski, Witold F. *Water Resour Res* v 23 n 10 Oct 1987 p 1893-1900.

**088949 DISAGGREGATION OF DAILY RAINFALL.** A parameter-efficient model for disaggregating daily rainfall into individual storms is presented. This model allows simulation of the number of rainfall events (storms) in a day, and the amount, duration, and starting time of each event, given only the total rainfall on that day and on the preceding and following days. Twenty-three years of data for July and August, from a gage on the Walnut Gulch Experimental Watershed, were used to find the appropriate model structure and to estimate parameters. Statistical tests indicate that simulated sequences of storms compare favorably with observed sequences, and that the disaggregation model structure and parameters identified for one gage provide a satisfactory fit for three stations within a 121 km radius where elevation differs by as much as 244 m, and mean annual rainfall differs by up to 76 mm. (Author abstract) 21 refs.

Hershenson, J. (Pima County Dep of Transportation & Flood Control, Tucson, AZ, USA); Woolhiser, D.A. *J Hydrol* v 95 n 3-4 Nov 30 1987 p 299-322.

**088950 STOCHASTIC MODELS OF RAINFALL FOR PLANNING CONSTRUCTION TO REGULATE SURFACE RUNOFF.** A generator of random pulse which simulate rain is tuned on the basis of studied statistical principles of rainfall in a given locale. Results are given from statistical analysis of 420 rains in Minsk in

terms of the following parameters: duration of rain-free period, duration of rain, layer of precipitation during rain, rain intensity, etc. A scheme for generating the proper pulse sequences is given. (Author abstract) 3 refs.

Gordin, I.V.; Netchaev, A.P.; Vinitskaya, A.A. *Sov Meteorol Hydrol* n 5 1987 p 70-75.

**088951 DAILY RAINFALL-RUNOFF MODEL FOR A MOUNTAINOUS BASIN.** A new daily rainfall-runoff model for a mountainous basin is proposed in this paper. Its parameters are readily determined by hydrographic measurements. It is simple, relatively clear in its physical meaning, and includes all runoff components. In the model, a basin is considered to be composed of two parts: the saturated area and the infiltration area. Direct runoff parameters are determined from the relationship between storm rainfall and direct runoff. The groundwater runoff is expressed by the storage function and its parameter is determined from base-flow recession curves. In addition, moisture in excess of normal soil moisture is considered to become groundwater recharge. The applicability of the model is assessed by comparing it with observed data from an experimental basin in Japan. (Author abstract) 7 refs.

Ando, Yoshihisa (Tokyo Metropolitan Univ, Tokyo, Jpn). *J Hydroscl Hydrol Eng* v 5 n 2 Feb 1988 p 53-64.

**Measurements** See Also **AQUIFERS—Recharging; HYDROLOGY.**

**088952 INTERPRETATION DE MESURES DU RADAR RODIN DE TRAPPES POUR LA CONNAISSANCE EN TEMPS REEL DES PRECIPITATIONS EN SEINE-SAINT-DENIS ET VAL-DE-MARNE: INTERET POUR LA GESTION AUTOMATISEE D'UN RESEAU D'ASSAINISSEMENT.** [Interpretation of Trappes Rodin Radar Measurements for the Real-Time Knowledge of Rainfall in Seine-Saint-Denis and Val-De-Marne: Advantages for the Automated Management of a Drainage System]. The project for the automated management of the Seine-Saint-Denis drainage system calls for an improvement of the techniques of measuring and forecasting rainfall. Rainfall measurement systems have certain inadequacies which weather radar can remedy. This work, which attempts to evaluate the capacity of radar to determine rainfall for purposes of urban hydrology, is based on a series of measurements over a period of two months during the summer of 1982. After a qualitative analysis of the data gathered, various techniques of calibration of radar images are tested. The results are compared with the estimation deduced from pluviographic measurements alone. The role of radar in the automated management project is envisaged. (Edited author abstract) In French. 76 refs.

Andrieu, Herve (Lab Central des Ponts et Chaussees, Fr). *Rapp Rech LPC* n 147 Aug 1987 225p.

**088953 RAIN MEASUREMENT RESULTS DERIVED FROM A TWO-POLARIZATION FREQUENCY-DIVERSITY S-BAND RADAR AT WALLOPS ISLAND, VIRGINIA.** A dual-polarization radar located at the NASA Wallops Flight Facility, Wallops Island, Virginia, is described. This radar operates with a slow polarization switch having a cycle time of 0.7 s and also incorporates a frequency diversity technique to achieve independent sampling over short intervals of time. Rain-rate measurements derived from the dual-polarization radar and from high-resolution rain gauges located at a remote site are compared. Average percent differences in rainfall of less than 5% and 16% were demonstrated when comparing the dual-polarization radar measurements with the low- and high-resolution rain gauges, respectively. Excellent correlation of the rain rates was in evidence during one rain day. The rain measurement cases examined were limited to only light rain rates (< 7 mm/h). 4 refs.

Goldhirsh, Julius (Johns Hopkins Univ, MD, USA); Rowland, John; Musiani, Bert. *IEEE Trans Geosci Remote Sens* v GE-25 n 6 Nov 1987, 1986 Int Geosci and

Remote Sens Symp (IGARSS'86) - Remote Sens - Today's Solutions for Tomorrow's Inf Needs, Zurich, Switz, Sep 8-11 1986 p 654-661.

## North Carolina

**088954 EFFECT OF STORM TYPE ON RAINWATER COMPOSITION IN SOUTHEASTERN NORTH CAROLINA.** During 1983-1987, the most acidic rain and highest sulfate and nitrate concentrations occurred in rain from local summer thunderstorms, followed by rain from continental frontal storms, with the least acidic rain coming from coastal storms. Seasonal variation was observed for rainwater pH from continental storms, with the most acidic rain in the summer. Thunderstorm nitrate concentrations were high enough to affect seasonal averages for nitrate concentration because thunderstorms are a warm-season type of rain. Coastal storm rainwater did not show seasonal changes; this type of rainwater is similar in pH, sulfate, and nitrate concentrations to rainwater in remote areas of the world. Additional aspects of the study are discussed. (Edited author abstract) 47 refs.

Willey, Joan D. (Univ of North Carolina at Wilmington, Wilmington, NC, USA); Bennett, Ramona I.; Williams, Jeanne M.; Denne, Robert K.; Komegay, Cynthia R.; Perlotto, Mark S.; Moore, Beth M. *Environ Sci Technol* v 22 n 1 Jan 1988 p 41-46.

## Peoples Republic of China

**088955 ANNUAL DRIVE RAIN INDEX FOR CHINA.** A map showing the driven rain index for the People's Republic of China is presented with the results from 32 cities and tables listing provinces affected by moderate and severe rain penetration. The results show that driven rain is a serious problem in the southern coastal regions of China. Designers should therefore take special care when designing and specifying building envelopes in this region. 3 refs.

Sauer, P. *Build Environ* v 22 n 4 1987 p 239-240.

**pH Effects** See **AIR POLLUTION—Argentina; CONCRETE—Chemical Attack.**

**Pressure Effects** See **SOILS—Surfaces.**

## Radioactivity

**088956 DETERMINATION OF RADIOIODINE SPECIES IN RAIN WATER COLLECTED AT TSUKUBA NEAR TOKYO.** The distribution of radioiodine (<sup>131</sup>I) species in rain water collected at Tsukuba in May 1986 was studied using the isotopic exchange method. Organic-soluble forms of radioiodine were not observed. Iodide (I<sup>-</sup>) was the predominant species, and the concentration of iodate (I<sup>+</sup> O<sub>3</sub><sup>-</sup>) was less than half that of I<sup>-</sup>. The results were compared with those for <sup>131</sup>I produced by neutron-irradiation of uranyl nitrate. (Author abstract) 4 refs.

Seki, R. (Univ of Tsukuba, Sakura-mura, Jpn); Endo, K.; Ikeda, N. *J Environ Radioact* v 6 n 3 1988 p 213-217.

**Remote Sensing** See Also **RADAR—Meteorological; SNOW AND SNOWFALL—Remote Sensing.**

**088957 DUAL-POLARIZATION RADAR ESTIMATION OF RAINFALL PARAMETERS COMPARED WITH GROUND-BASED DISDROMETER MEASUREMENTS: OCTOBER 29, 1982 CENTRAL ILLINOIS EXPERIMENT.** Rainfall parameters estimated from dual-polarization radar measurements using the differential-reflectivity technique are compared with ground-based disdrometer measurements located 47.1 km from the radar. This case study is based on data obtained during and experiment in central Illinois on October 29, 1982. Both empirical and model relationships between radar observables and rainfall parameters are tested. The differential-reflectivity technique is compared with the conventional Z-R and is shown to provide improvements in the estimation of rainfall rate by radar. The analysis



includes consideration of the spatial and temporal factors relating the radar-scattering volumes to the location and duration of ground-based disdrometer measurements. The significance of these factors (mainly due to the horizontal and vertical motion of raindrops) in radar-disdrometer comparisons is evident in the results. 48 refs.

Aydin, Kultegin (Pennsylvania State Univ., University Park, PA, USA); Direskenli, Haldun; Seliga, Thomas A. *IEEE Trans Geosci Remote Sens* v GE-25 n 6 Nov 1987, 1986 Int Geosci and Remote Sens Symp (IGARSS'86) - Remote Sens - Today's Solutions for Tomorrow's Inf Needs, Zurich, Switz, Sep 8-11 1986 p 834-844.

**Sampling** See Also AIR POLLUTION—Acid Rain.

**088958 DESIGN AND USE OF A COLLECTOR FOR THE IN SITU ISOLATION OF PARTICULATE TRACE ORGANIC SPECIES IN PRECIPITATION.** Extracts of particulate organic matter were examined for discrete rainfall events from metropolitan Los Angeles, California, using an in situ filtration technique. Filtration efficiency was 98% for the collection of extractable organic C associated with particles having nominal diameters greater than 0.22  $\mu\text{m}$ . Organic background levels of less than 260 ng per sample were determined. Rainwater particle samples were extracted with repeated hexane and benzene: isopropanol (2:1) solvent additions using ultrasonic agitation. Extract mixtures were quantified by high-resolution gas chromatography (HRGC) and were adjusted for component losses with perdeuterated recovery standards. Molecular analyses indicated major anthropogenic contributions from petroleum and combustion sources, and for some samples, the significant input of microbial lipid components as well. Minor amounts of vascular plant waxes were also present in most cases. These mixed inputs of both anthropogenic and biogenic materials compared closely with previous source determinations for carbonaceous aerosol particles in the Los Angeles air basin. (Edited author abstract) 49 refs.

Mazurek, M.A. (Oregon State Univ, Newport, OR, USA); Simonet, B.R.T.; Standley, L.J.; Friedman, D.; Beeman, C. *Water Air Soil Pollut* v 36 n 1-2 Nov 1987 p 171-192.

**Simulation** See Also FLOW OF WATER—Underground; IRRIGATION—Sprinkler Systems; SOILS—Erosion; WATER RESOURCES—Arid Regions.

**088959 PROGRAMMABLE METHOD FOR SMALL DETENTION POND DESIGN USING THE MODIFIED RATIONAL METHOD WITH SIMULATED ROUTINGS.** This paper reviews the concept of on-site storm water detention and develops a programmable method for sizing small detention ponds using the modified rational method with simulated routings. The procedure can be programmed for use in hand-held calculators or translated into a FORTRAN code for use on microcomputers. The intent of this paper is to provide engineers with a tool for sizing small detention ponds which would meet design criteria which specify use of the rational equation. 22 refs.

von Zweck, Peter (Albert H. Half Associates, Dallas, TX, USA). *Tex Civ Eng* v 58 n 3 Mar 1988 p 13-19.

**088960 STORM PATTERN EFFECT ON INFILTRATION, RUNOFF, AND EROSION.** A programmable rainfall simulator was used to study the effects of variable intensity storm patterns on infiltration, runoff, and erosion. When rain was applied to an initially dry soil, peak runoff rates were four to 20 times greater from storms having maximum intensities occurring near the end of the storm than peak rates from storms of uniform intensity or storms having their maximum intensities occurring early in the storm. Soil loss from late peaking storms was two to eight times that from early peaking storms. Runoff and soil loss from a storm of a given pattern occurring on a wet soil was greatest when preceding storms had maximum intensities occurring very early in the storm. Apparent infiltration rate varied with rainfall intensity, which was likely caused by spatial variability of infiltration rates. (Author abstract) 26 refs.

Flanagan, D.C. (Purdue Univ, West Lafayette, IN, USA);

Foster, G.R.; Moldenhauer, W.C. *Trans ASAE* v 31 n 2 Mar-Apr 1988 p 414-420.

**088961 RUNOFF AND EROSION FROM RAINFALL SIMULATOR PLOTS ON SAGEBRUSH RANGELAND.** A rainfall simulator was used to determine runoff, infiltration, and soil loss from 1 m<sup>2</sup> shrub and interspace plots on a sagebrush dominated site in southwestern Idaho. Interspace areas produced 2½ times as much runoff and 8 times as much soil loss as from shrub canopy zones at this range site. High soil moisture conditions preceding rainfall simulation runs resulted in lower infiltration rates, increased runoff, and no significant difference in soil losses. Removal of shrub canopy did not significantly influence soil losses. Results of this study show the importance of understanding spatial variability in infiltration and the wide differences in potential erosion from shrub and interspace areas when predicting sagebrush rangeland erosion and applying erosion models on rangeland. (Author abstract) 26 refs.

Johnson, C.W. (USDA-ARS, Boise, ID, USA); Gordon, N.D. *Trans ASAE* v 31 n 2 Mar-Apr 1988 p 421-427.

**Storage** See WATER RESOURCES—Developing Countries; WATER SUPPLY—Water Quality.

**Telemetering**

**088962 ANALYSIS OF ALGORITHMS FOR THE RETRIEVAL OF RAIN-RATE PROFILES FROM A SPACEBORNE DUAL-WAVELENGTH RADAR.** The ability to retrieve rain-rate profiles from a dual-wavelength spaceborne radar system operating at 13.6 and 35 GHz is analyzed. The fundamental problem of extracting either the attenuation and/or the reflectivity from the backscatter echo, which contains both contributions, is addressed. Three algorithms, the backscatter, the attenuation coefficient, and the dual-wavelength methods, are examined. These algorithms are tested using four rain-rate profiles derived from radar measurements. In particular, measured (true) values are compared with calculated (retrieved) rain rates applying the algorithms with superimposed uncertainties assuming a suggested spaceborne dual-wavelength radar system. Error values of rain rates are determined where these values reflect failure of the assumptions utilized in the derivation of the algorithms, rain backscatter noise, and instrument noise. It is concluded that no single technique gives rise to a panacea in the making of accurate rain measurements and that difficulties exist with each method. 28 refs.

Goldhirsh, Julius (Johns Hopkins Univ, Laurel, MD, USA). *IEEE Trans Geosci Remote Sens* v 26 n 2 Mar 1988 p 98-114.

**RAMAN SCATTERING** See Also AMMONIUM COMPOUNDS—Phase Transitions; CALCIUM COMPOUNDS—Spectroscopic Analysis; COPPER AND ALLOYS—Surfaces; CRYSTALS—Crystal Lattices; CRYSTALS—Lattice Vibrations; CRYSTALS—Optical Properties; DIELECTRIC MATERIALS—Thin Films; FERROELECTRIC MATERIALS—Optical Properties; FIBER OPTICS; FIBER OPTICS—Laser Applications; FLUORESCENCE; FLUORESCENCE—Analysis; GASES—Temperature Measurement; HAFNIUM COMPOUNDS—Spectrum Analysis; LASERS—Optical Pumping; LASERS, CARBON DIOXIDE; LASERS, DYE—Optical Pumping; LASERS, DYE—Tuning; LASERS, FREE ELECTRON—Optimization; LASERS, SOLID STATE—Resonators; LEAD COMPOUNDS—Phase Transitions; MAGNETIC SEMICONDUCTORS—Physical Properties; MANGANESE COMPOUNDS—Spectroscopic Analysis; MERCURY COMPOUNDS—Spectroscopic Analysis; NIOBIUM COMPOUNDS—Physical Properties; OPTICAL FIBERS; OPTICAL FIBERS—Performance; OPTICAL FIBERS—Spectrum Analysis; OPTICAL PUMPING—Theory; OSCILLATORS—Performance; PLASMAS—Production; POTASSIUM COMPOUNDS—Optical Properties; SEMICONDUCTING CADMIUM COMPOUNDS—Spectroscopic Analysis; SEMICONDUCTING CADMIUM COMPOUNDS—Thin Films; SEMICONDUCTING FILMS—Measurements; SEMICONDUCTING GALLIUM ARSENIDE—Etching; SEMICONDUCTING GALLIUM ARSENIDE—Impurities; SEMICONDUCTING GALLIUM ARSENIDE—Optical Properties; SEMICONDUCTING GALLIUM ARSENIDE—Physical Properties; SEMICONDUCTING GALLIUM ARSENIDE—Spectroscopic Analysis; SEMICONDUCTING GALLIUM COMPOUNDS; SEMICONDUCTING GALLIUM COMPOUNDS—Chemical Vapor Deposition; SEMICONDUCTING GALLIUM COMPOUNDS—Electronic Proper-

ties; SEMICONDUCTING GERMANIUM—Optical Properties; SEMICONDUCTING GLASS—Optical Properties; SEMICONDUCTING GLASS—Spectroscopic Analysis; SEMICONDUCTING INDIUM COMPOUNDS; SEMICONDUCTING INDIUM COMPOUNDS—Charge Carriers; SEMICONDUCTING SILICON—Optical Properties; SEMICONDUCTOR DEVICES—Spectroscopic Analysis; SEMICONDUCTOR MATERIALS—Charge Carriers; SEMICONDUCTOR MATERIALS—Electronic Properties; SEMICONDUCTOR MATERIALS—Ion Implantation; SEMICONDUCTOR MATERIALS—Spectrum Analysis; SODIUM AND ALLOYS—Spectroscopic Analysis; SOLID SOLUTIONS—Physical Properties; SUPERCONDUCTING MATERIALS; SUPERCONDUCTING MATERIALS—High Temperature Effects; SUPERCONDUCTING MATERIALS—Optical Properties; SURFACE PHENOMENA—Electromagnetic Field Effects; ULTRAVIOLET RADIATION—Nonlinear Optical Effects.

**088963 RAMAN SCATTERING STUDIES IN A-Si:H FILMS CONTAINING MONO- & DI-HYDROGEN-LIKE SPECIES.** Structural disorder in the hydrogenated amorphous silicon (a-Si:H) films has been studied by Raman scattering (RS). The a-Si:H films were prepared by rf glow-discharge induced dissociation of silane diluted in argon. The order in these films was evaluated from the TO-bandwidth in their Raman spectra. The relative abundances of monohydrogen (Si-H) and dihydrogen-like species (H-Si-H) in these films were measured by IR absorption spectroscopy. The increase in disorder (as measured by Raman spectroscopy) is found to be directly related to the increase in intensity of the 2080 cm<sup>-1</sup> IR peak. (Edited author abstract) 30 refs.

Kshirsagar, S.T. (Nat'l Chemical Lab, Poona, India); Mamdapurkar, J.B.; Khaladkar, N.R.; Sinha, A.P.B. *Indian J Pure Appl Phys* v 25 n 3 Mar 1987 p 104-109.

**088964 OBSERVATION OF STIMULATED RAMAN SCATTERING AND NONLINEAR PULSE BROADENING AT 1.32  $\mu\text{m}$  IN MONOMODE OPTICAL FIBRES.** We have observed stimulated Raman scattering and nonlinear enhanced pulse broadening at 1.32  $\mu\text{m}$ . We used two monomode optical fibres with zero-dispersion wavelengths of 1.28 and 1.55  $\mu\text{m}$ . This enabled us to observe the effect of dispersion on the interaction length for Raman scattering. (Author abstract) 11 refs.

Blow, K.J. (British Telecom Research Lab, Ipswich, Engl); Nelson, B.P. *IEEE Proc Part J* v 134 n 3 Jun 1987 p 161-162.

**088965 EFFECTS OF GROUND STATE DEPLETION OF ATOMS IN STIMULATED RAMAN SCATTERING OF METAL VAPORS.** The effects of ground state depletion of atoms on the characteristics of stimulated Raman scattering in metal vapors are studied by simultaneously solving the rate-equation of the atom energy levels related in the Raman scattering, and the equations describing the energy-conversion from the focused pump laser pulses to the Raman down-converted pulses. The ground state of metal atoms are depleted most strongly in the regions near the focal spots of the pump beams because of the higher intensities of light and smaller available medium volume in those regions. This will result in the unsymmetrical shapes of the Raman-shifted pulses for the front and rear edges, and will reduce the energy-conversion efficiency. (Author abstract) In Chinese. 9 refs.

Huo, Yunsheng (Fudan Univ, Shanghai, China); Lou, Qihong; Ding, Zian; Wang, Renwen. *Guangxue Xuebao* v 7 n 7 Jul 1987 p 591-596.

**088966 NONLINEAR THEORY OF STIMULATED SCATTERING OF ELLIPTICALLY POLARIZED LIGHT WAVES.** A theory of stationary stimulated light scattering is constructed for arbitrary elliptical polarizations of both exciting and Stokes waves. The effectiveness of transformation of exciting radiation into a Stokes wave and the change in the state of the polarization of the interacting waves are studied. A method is proposed which makes it possible to determine in one laser pulse both the amplification constant and the width of the



amplification band of the stimulated scattering from the precession of the polarization ellipse of the Stokes wave. (Author abstract) 5 refs.

Grigor'ev, S.F.; Zaskal'ko, O.P. *Sov Phys Lebedev Inst Rep* n 4 1987 p 17-20.

**088967 ROTATIONAL RAMAN SCATTERING USING MOLECULAR NITROGEN GAS FOR CALIBRATION OF THOMSON-SCATTERING APPARATUS.** Anti-Stokes rotational Raman lines in molecular nitrogen gas were used for the calibration of Thomson-scattering apparatus. It was found that molecular nitrogen gas is suitable for a vessel having strong stray light. The polarization ratio was 0.16 using linear-polarized laser light. (Author abstract) 9 refs.

Yamauchi, Toshihiko (JAERI, Tokai, Jpn); Nakazawa, Ichiro. *Jpn J Appl Phys Part 1* v 26 n 11 Nov 1987 p 1933-1934.

**088968 STIMULATED RAMAN SCATTERING IN HYDROGEN AND METHANE MIXTURE.** Stimulated Raman scattering effect in hydrogen and methane mixture is investigated, using the frequency-doubled output (532nm) of a Nd<sup>3+</sup>:YAG lasers as the pumping source. For different ratios of the mixture, both SRS lines and combinations of H<sub>2</sub> and CH<sub>4</sub> are observed by an optical spectrum analyzer (OSA WP-4); and shifts of SRS lines are found. It shows suppression and coupling between hydrogen and methane in the mixture. A preliminary explanation about the experimental results is discussed in the paper. (Edited author abstract) In Chinese. 4 refs.

Zhao Zhensheng (Acad Sinica, China); Pan Zhonghan; Shen Deli; Cui Yiben; Hu Xuejin. *Guangxue Xuebao* v 7 n 11 Nov 1987 p 990-994.

**088969 'COHERENCE PEAK' IN TIME-RESOLVED COHERENT RAMAN SCATTERING.** A signal overshoot ('coherence peak') is predicted for coherent Raman scattering, if the excitation pulses and the probe pulse overlap in time. We discuss the conditions in detail, under which this phenomenon occurs. Experimental results are reported for benzene and liquid nitrogen which agree well with our theoretical expectations. (Author abstract) 10 refs.

Kohles, N. (Univ Bayreuth, Bayreuth, West Ger); Aeckhtner, P.; Laubereau, A. *Opt Commun* v 65 n 5 Mar 1 1988 p 391-396.

**088970 OPTIMUM SURFACE ROUGHNESS FOR SURFACE ENHANCED RAMAN SCATTERING.** Surface enhanced Raman scattering from copper phthalocyanine thin films deposited onto Ag films roughened by underlayers of gas-evaporated Si particles was investigated. The surface roughness was systematically varied by varying the average size of Si particles. Results of quantitative intensity measurements indicate that there exists an optimum surface roughness depth for SERS. The maximum enhancement factor obtained is approximately  $1.5 \times 10^4$  and a crude estimate of the optimum roughness depth is of the order of 100 Angstrom. The origin of presently observed enhancement is thought to be purely electromagnetic, involving the excitation of the surface plasmon modes via the surface roughness. (Author abstract) 12 refs.

Koh, R. (Kobe Univ, Kobe, Jpn); Hayashi, S.; Yamamoto, K. *Solid State Commun* v 64 n 3 Oct 1987 p 375-378.

**088971 RAMAN SCATTERING OF LIGHT IN A CERAMIC WITH OCTAHEDRAL OXYGEN GROUPS.** The spectra of Raman scattering of light in superconducting ceramics are found and they are compared with the corresponding spectra of barium titanate and lithium niobate. The RS spectra were found using the 'for reflection' arrangement. (Author abstract) 5 refs.

Golovashkin, A.I.; Gorelik, V.S.; Ivanenko, O.M.; Mitzen, K.V.; Faizullov, T.F. *Sov Phys Lebedev Inst Rep* n 10 1987 p 26-30.

**088972 ROUGHNESS DEPENDENCE OF SERS OF CRYSTAL VIOLET ADSORBED ON SILVER SURFACE.** Surface Enhanced Raman Scattering is observed from submicron-size silver particles of average uniform size and shape produced on the silver surface by an etching process. The particles grew in size when the etching time duration was increased. The Raman intensity, which is produced by a monolayer of crystal violet adsorbed on Ag surface, was found to first increase as the size of Ag particles increased, to reach a maximum and then to decrease as the size of Ag particles kept increasing. 13 refs.

Lee, K.C. (Nat'l Central Univ, Chung-Li, Taiwan); Chen, S.S. *Opt Commun* v 67 n 2 Jun 15 1988 p 119-123.

**088973 STABILIZED PULSE COMPRESSION BY MULTIPLE-ORDER STIMULATED RAMAN SCATTERING WITH GROUP VELOCITY DISPERSION.** We investigate the influence of group velocity dispersion on modelocked pulses depleted by multiple order stimulated Raman scattering in a single mode fiber. Measurements of the pump pulse self-phase-modulation spectrum and compressibility in long fibers indicate the formation of a linear chirp over most of the pump pulse spectrum. In the presence of third Stokes generation, stimulated Raman scattering and group velocity dispersion combine to clamp the pump pulse energy and produce ultrastable compressed pulses as short as 550 fs. (Author abstract). 20 Refs.

Heritage, J.P. (Bell Communications Research, Red Bank, NJ, USA); Weiner, A.M.; Hawkins, R.J. *Opt Commun* v 67 n 5 Aug 1 1988 p 367-372.

## Analysis

**088974 FREQUENCY DEPENDENCE OF RAMAN CROSS SECTION OF CH<sub>4</sub>  $\nu_1$  LINE DETERMINED WITH COHERENT RAMAN SPECTROSCOPY.** A determination of the absolute Raman cross sections of gases using stimulated Raman gain or inverse Raman spectroscopy is discussed. These coherent Raman methods were applied to determine the absolute Raman cross sections of the  $\nu_1$  line of gaseous methane at several visible pumping frequencies. (Author abstract) 12 refs.

Taira, Yoichi (Univ of Electro-communications, Chofu, Jpn); Uchikoba, Fumio; Takuma, Hiroshi. *Jpn J Appl Phys Part 1* v 26 n 11 Nov 1987 p 1807-1810.

**Applications** See Also INTERNAL COMBUSTION ENGINES—Temperature Measurement; OPTICAL FIBERS—Optical Properties; OXYGEN—Measurements.

**088975 TWO-CHANNEL FIBRE RAMAN AMPLIFICATION FOR WAVELENGTH DIVISION MULTIPLEXED SYSTEMS.** The simultaneous amplification of two wavelength-division, multiplexed channels is of interest for long-haul high data capacity links. The use of fiber Raman amplification in this application is discussed, and the trade-off between on/off ratio and gain is evaluated as a function of channel spacing. The analysis is performed in the pump nondepletion region, and the effect of optical bandpass filtering on this trade-off is presented. (Author abstract) 10 refs.

Dakss, Mark L. (GTE Lab Inc, Waltham, MA, USA); Melman, Paul. *IEE Proc Part J* v 135 n 2 Apr 1988 p 96-100.

## Efficiency

**088976 HIGHLY EFFICIENT LINEARLY POLARIZED RAMAN GENERATION IN A GERMANIA-CORE OPTICAL FIBER.** The letter reports efficient Raman generation and polarization switching effects in a high-germania-content optical fiber, with a small  $2 \mu\text{m}^2$  core area. 10 db Raman amplification has been observed in 5m of fiber at a pump power of 2w. The Raman emission is only generated along the birefringence axes of the fiber. (Edited author abstract) 8 refs.

Davison, A.S. (Univ of Cambridge, Cambridge, Engl); White, I.H. *Electron Lett* v 23 n 25 Dec 3 1987 p

1343-1345.

**Mathematical Models** See Also LIGHT—Amplifiers.

**088977 RAMAN SCATTERING BY LONGITUDINAL MODES IN IONIC SUPERLATTICES.** A linear response theory of Raman scattering by the longitudinal polar optical modes in ionic superlattices is considered. Derivations are first given for the characteristics response functions whose poles define the dispersion relation. This is examined in an application to a specific GaAs/Ga<sub>1-x</sub>Al<sub>x</sub>As superlattice predicting the familiar zone-folding effects. From the response functions we derive the scattering cross section, taking proper account of the polarization selection rules in cubic materials. This leads to the derivation of the Raman intensities of the folded modes and their variation with the scattering geometry. Results appropriate for the normal incidence backscattering case are deduced and compared with the corresponding experimental data. (Author abstract) 20 refs.

Babiker, M. (Univ of Essex, Colchester, Engl). *Physica B & C* v 145 n 2 May-Jul 1987 p 111-123.

**Measurements** See Also DYES AND DYEING—Spectroscopic Analysis; GLASS—Spectroscopic Analysis; SEMICONDUCTING GALLIUM ARSENIDE—Doping; SEMICONDUCTING GALLIUM ARSENIDE—Optical Properties; SEMICONDUCTING GALLIUM COMPOUNDS—Impurities; SEMICONDUCTING GLASS—Optical Properties; SEMICONDUCTING GLASS—Spectroscopic Analysis; SEMICONDUCTING INDIUM COMPOUNDS—Charge Carriers.

**088978 ROTATIONAL RAMAN GAIN SUPPRESSION IN H<sub>2</sub>.** We report measurements of rotational Raman gain suppression in H<sub>2</sub> in the transient regime. These measurements, along with qualitative observations of the Stokes spatial distribution under different gain conditions, demonstrate that the gain suppression is confined to a narrow region around the phase matching angle for collimated beams with relatively low gain per unit length. For focused beams with higher gain per unit length the suppressed region can extend to the forward direction, resulting in a two- to three-fold estimated increase in the Raman threshold. (Edited author abstract) 18 refs.

Duncan, M.D. (US Naval Research Lab, Washington, DC, USA); Mahon, R.; Tankersley, L.L.; Reintjes, J. *Opt Commun* v 64 n 5 Dec 1 1987 p 467-473.

**088979 RAMAN SCATTERING IN THE HIGH T<sub>c</sub> SUPERCONDUCTORS MBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-x</sub>.** We report Raman scattering measurements of MBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-x</sub> (M = Y, Sm, Eu) polycrystalline superconductors in the region of Cu-O stretching vibrations. Four peaks are seen. On the basis of the factor group analysis given here they are assigned to two Raman allowed and two ir-allowed LO modes. The latter are probably induced by disorder (e.g., O-vacancies). (Author abstract) 15 refs.

Liu, Ran (Max-Planck-Inst fuer Festkoeperforschung, Stuttgart, West Ger); Merlin, R.; Cardona, M.; Matzsch, H.J.; Bauhofer, W.; Simon, A.; Garcia-Alvarado, F.; Moran, E.; Vallet, M.; Gonzalez-Calbet, J.M.; Alario, M.A. *Solid State Commun* v 63 n 9 Sep 1987 p 839-841.

**Spectrum Analysis** See Also AMMONIUM COMPOUNDS—Spectrum Analysis; BENZENE—Radiation Effects; GLOW DISCHARGES—Spectrum Analysis; LASERS, SOLID STATE—Optical Pumping; POTASSIUM COMPOUNDS—Phase Transitions; SEMICONDUCTING GALLIUM ARSENIDE—Etching; TITANIUM COMPOUNDS—Spectrum Analysis.

**088980 PICOSECOND STIMULATED RAMAN SCATTERING IN P<sub>2</sub>O<sub>5</sub>-SiO<sub>2</sub> BASED SINGLE MODE OPTICAL FIBRE.** Spectral and temporal investigations of cascade, picosecond, stimulated Raman scattering in SiO<sub>2</sub> based single mode optical fibre with a high (approximately 7 mol%) concentration of P<sub>2</sub>O<sub>5</sub> is reported. At a pump wavelength of 1.06  $\mu\text{m}$  and for peak powers of approximately 25 kW, enhancement in the spectrum at a frequency shift approximately 1300 cm<sup>-1</sup>



was observed due to the overlap of the 1st Stokes of the  $P=0$  vibrational mode (approximately  $1330\text{ cm}^{-1}$ ) and the third Stokes ( $3 \times 440\text{ cm}^{-1}$ ) of the Si-O-Si vibrational mode. This process provides the generation of a powerful source of picosecond pulses at  $1.24\text{ }\mu\text{m}$ . For higher peak powers launched into the fibre (approximately  $60\text{ kW}$ ) an intense continuum extending up to  $1.6\text{ }\mu\text{m}$  was recorded. (Author abstract) 19 refs.

Gomes, A.S.L. (Imperial Coll, London, Engl); Da Silva, V.L.; Taylor, J.R.; Ainslie, B.J.; Craig, S.P. *Opt Commun* v 64 n 4 Nov 15 1987 p 373-378.

**088981 THRESHOLD MEASUREMENTS OF STIMULATED RAMAN SCATTERING IN GASES USING PICOSECOND KRF LASER PULSES.** We have measured the thresholds of stimulated Raman scattering in a number of gases using 20 ps pulses from a Krf laser system. Stimulated scattering has been observed with methane, hydrogen, ammonia and sulphur hexafluoride below 5 atm pressure using pulse energies up to  $200\text{ }\mu\text{J}$ . Under the same conditions, no stimulated scattering could be obtained in oxygen or nitrogen. Measurements agree well with transient stimulated Raman scattering theory. (Author abstract) 20 refs.

Everall, N.J. (Rutherford Appleton Lab, Didcot, Engl); Partanen, J.P.; Barr, J.R.M.; Shaw, M.J. *Opt Commun* v 64 n 4 Nov 15 1987 p 393-397.

**Theory** See LASER BEAMS—Spectrum Analysis; SEMICONDUCTOR MATERIALS—Spectrum Analysis.

**RAMP GENERATORS** See THYRISTORS—Automatic Testing; AMPLIFIERS—Noise, Spurious Signal.

**RANGE FINDERS** See Also IMAGE SENSORS; IMAGING TECHNIQUES.

**088982 AUTORANGING/AUTOFOCUS: A SURVEY OF SYSTEMS, PART 2.** This part of a comprehensive review of devices and systems employed in ranging and autofocusing describes some more active systems. Active conjugate systems and skew beam devices are discussed. 5 refs.

Wolpert, H.D. (Loral Electro-Optics Systems, Pasadena, CA, USA). *Photonics Spectra* v 21 n 8 Aug 1987 p 127-128, 130.

## Automation

**088983 AUTORANGING/AUTOFOCUS: A SURVEY OF SYSTEMS, PART 3.** This article discusses several kinds of active autoranging systems - that is, those requiring active illumination in order to function, and passive systems, those that require only ambient light. The main topics are interferometric techniques, speckle techniques, passive triangulation systems, and image analysis systems. 14 refs.

Wolpert, H.D. (Loral Electro-Optics Systems, Pasadena, CA, USA). *Photonics Spectra* v 21 n 9 Sep 1987 6p between p 133 and 142.

## Calibration

**088984 METROLOGICAL SUPPORT TO LINEAR MEASUREMENTS IN THE RANGE 24-75,000 m.** The most effective standard means of measurement are calibrated baselines whose lengths are measured with certified standard rangefinders. When one determines the lengths of such measures, one uses comparator Invar wires or tapes and precision rangefinder. As development has not been completed on the metrological chain relating standard precision rangefinders to the primary standard for the unit of length, there are two lines of development in this test scheme. One is based on using engraved measures and basic instruments to determine the baseline lengths, with the instruments including 24-m Invar wires. The second metrological chain in the state test scheme is supported by the use of a precision rangefinder having a range of action up to  $10\text{ km}$  and a standard deviation  $\pm(0.3+5.10^{-7} D)\text{ mm}$ , where  $D$  is the measured length, which the is currently under test. Studies being conducted

to increase the range of action of the rangefinders to  $20\text{ km}$  without reduction in the accuracy. These rangefinders are to be used as standard means of measurement in devising a network of calibration baselines that are also to be used as precision working means of measurement for various economic purposes. 4 refs.

Andrusenko, A.M. (Genike, A.A.); Gerasimenko, M.G.; Pushkarev, G.P.; Sugachev, O.L. *Meas Tech* v 30 n 7 Jul 1987 p 638-639.

**Computer Applications** See COMPUTERS, MICROCOMPUTER—Applications.

**Laser Applications** See Also ROBOTS, INDUSTRIAL—Mobile.

**088985 SIGNALS AND NOISE IN LASER RANGING.** Optical-ranging through the atmosphere is considered. The following main tasks are undertaken in this book: exposition, from a unified standpoint, of the methods used to calculate the characteristics of the signals and of the noise; development, for the signals and for the noise, of models suitable for analysis and synthesis of laser-ranging systems; demonstration of the use of the theoretical results to calculate the energy and accuracy properties of laser ranging systems; consideration of methods for effective monitoring of the state of the atmosphere along the ranging path; demonstration of the feasibility of adaptive-compensation reception methods. 131 refs.

Zuev, V.E. *J Sov Laser Res* v 8 n 4 Jul-Aug 1987 426p.

**088986 SOLID-STATE LASER RANGEFINDERS ACQUIRE NEW CAPABILITIES.** In the future, solid-state laser rangefinders will operate at eye-safe wavelengths and perform with improved characteristics. Greater efficiency, longer range, and multitarget capability are among the development goals discussed in this paper. (Edited author abstract) 6 refs.

Danckwerth, Thomas (Litton Laser Systems Div, Apopka, FL, USA). *Laser Focus (Littleton Mass)* v 23 n 11 Nov 1987 8p between p 86 and 97.

**RAPID TRANSIT** See Also ELECTRIC RAILROADS—Federal Republic of Germany; ELECTRIC RAILROADS—Great Britain; MOTOR BUS TRANSPORTATION; RAILROAD PLANT AND STRUCTURES—Track; SUBWAYS—Management; TUNNELS AND TUNNELING; URBAN PLANNING—Transportation.

**088987 SIGNALLING AND TRAIN CONTROL - THE KEY TO URBAN MASS TRANSIT PERFORMANCE.** This paper identifies the performance aims of urban mass transit railways and describes how modern systems of signalling and train control, such as those developed for Singapore, contribute to the realisation of these aims. The three elements of Automatic Train Control are defined as Automatic Train Protection, Automatic Train Operation and Automatic Train Supervision, and each of these sub-systems and the functions it performs is described. The paper further describes how modern microprocessor digital signalling techniques are used to realise a highly versatile modular system that can meet the requirements of a wide range of applications. (Edited author abstract)

Howard, T.S. (Westinghouse Signals Ltd). *Hong Kong Eng* v 16 n 4 Apr 1988 p 23-30.

**088988 TAXI 2000 PERSONAL RAPID TRANSIT SYSTEM.** TAXI 2000 is the result of a comprehensive process of 'top-down' design optimization beginning 'from scratch' and subject to a variety of practical constraints. It builds on over two decades of work on automated transit in virtually every industrialized country and on a comprehensive theory of transit economics and technology developed by the author. The system's low cost is a result of discovery of optimum configurations and of technology advances not available a decade ago. The paper includes a description of the system and the process of and basis for its development; discussions of technical areas of dependability, safety, evacuation and rescue, power requirements, and performance; discussions of the

state of development, development plans, process of certification, and problems in implementation of the PRT concept. (Author abstract). 9 Refs.

Anderson, J. Edward (Taxi 2000 Corp, Revere, MA, USA). *J Adv Transp* v 22 n 1 Spring 1988 p 1-15.

**088989 RECENT PROGRESS BY JNR ON MAGLEV.** An overview is given of the Japanese National Railways (JNR) Maglev system, which uses superconducting magnet levitation and linear synchronous motor (LSM) propulsion. The progress made has included a speed of  $517\text{ km/h}$  reached by experimental vehicle ML500, a three-car test run by the MLU001 vehicle, manned test runs, and test runs with aberrations purposely introduced into the guideway. A maximum speed of  $352\text{ km/h}$  was achieved for the three-car train. After noting guideway and power supply facility components, the MLU001 and MLU002, the discussion centers on the vehicle body, carriages, superconducting magnets, and helium liquifier and refrigerator units. 14 refs.

Kyotani, Y. (Technova Inc, Tokyo, Jpn). *IEEE Trans Magn* v 24 n 2 Mar 1988, Tenth Int Conf Magnet Technol, Boston, MA, USA, Sep 21-25 1987 p 804-807.

**088990 HIGH SPEED MAGLEV TRANSPORT SYSTEM TRANSRAPID.** The TRANSRAPID 06 II (TR06 II) vehicle prototype of the Transrapid application system is characterized by noncontacting electromagnetic support and guidance technology and a synchronous iron-cored long-stator motor for propulsion. A brief overview is presented of the TR06 II vehicle, linear motor, and guideway. 11 refs.

Meins, J. (Thyssen Industries AG, Munich, West Ger); Miller, L.; Mayer, W.J. *IEEE Trans Magn* v 24 n 2 Mar 1988, Tenth Int Conf Magnet Technol, Boston, MA, USA, Sep 21-25 1987 p 808-811.

## Automatic Train Control

**088991 DESIGN PRINCIPLES OF AUTOMATIC CONTROL FOR THE LONDON DOCKLANDS LIGHT RAILWAY.** The London Docklands light railway is an automated, intermediate capacity transit system serving the redeveloped Docklands area to the east of central London. A service interval down to  $3\text{ }1/3$  minutes is provided, and a system operating concept has evolved of unmanned (remotely supervised) stations, and automatically-driven trains carrying an attendant who supervises the train and checks tickets. This system concept has provided many challenges to signal engineers, to produce a control system which would meet all the operational requirements, without necessarily having the complexity (and cost) normally associated with a 'heavy rail' metro. (Author abstract)

Barnard, R.E.B. (GEC-General Signal Ltd, UK). *Electr Veh Dev* v 7 n 2 Apr 1988 p 52-54.

## Birmingham, United Kingdom

**088992 ELECTRIC METRO PROJECT LAUNCHED IN BIRMINGHAM.** A light rail passenger transit system to be known as the Midland Metro is being planned for an increase in the United Kingdom which will radiate from Birmingham and throughout the Black Country. Whenever possible, discussed railway lines and existing highways will be used as routes. (Author abstract)

Anon. *Electr Veh Dev* v 6 n 4 Oct 1987 p 127.

**Communication Systems** See TELECOMMUNICATION SYSTEMS—Canada.

**Components** See ESCALATORS—Environmental Impact.

## Computer Aided Design

**088993 RELIABILITY OPTIMIZATION IN CABLE SYSTEM DESIGN USING A FUZZY UNIFORM-COST ALGORITHM.** Reliability optimization



methods for computer-aided design of a rapid-transit-system line that was previously proposed by the authors (1988) was useful for simple systems with a small number of sections. There is a combinatorial explosion in the time complexity for the computation of the configuration vector and the solution runs into difficulty very quickly with an increased number of sections. Use is made of a fuzzy optimization algorithm. This aspect is addressed here so that a more general problem can be solved. The strategy is to divide the system into smaller blocks and find solution sets for the smaller blocks using an efficient search strategy, which are then searched for an overall minimal solution. 10 refs.

Das Gupta, Sushil (Temple Univ, Philadelphia, PA, USA); Al-Musawi, Muhammad Jawad. *IEEE Trans Reliab* v 37 n 1 Apr 1988 p 75-80.

## Computer Applications

**088994 OVERSEAS APPLICATIONS OF MICROCOMPUTERS ON A TRANSPORTATION PLANNING AND ENGINEERING DESIGN PROJECT.** Calibration of a complex four-step transportation modeling system, as well as testing of numerous alternatives were successfully accomplished on microcomputers. A wide range of engineering applications, structural analyses, cost estimation, project control and scheduling, and cost control tasks also were accomplished for which the microcomputer was found to be an indispensable tool. Tabulations of data and results, computer-generated graphics, and the word processing capabilities of microcomputers permitted the efficient production of a large number of complex project reports (in two languages) on time and in a cost-effective manner. Staff training of personnel without previous computer experience was surprisingly easy and was accomplished within a very short period of time due to the user friendliness of modern software. (Edited author abstract)

Dehghani, Youssef (Parsons Brinckerhoff Quade & Douglas Inc, Tampa, FL, USA); Kudlick, Walter; Strombom, Cathy; Grantz, Walter. *Transp Res Rec* 1108 1987 p 60-65.

**088995 'TRACEC-ALPES' SUB-STATION COMPUTERS FOR THE TELECONTROL OF THE ELECTRICAL POWER DISTRIBUTION EQUIPMENT OF THE CHARLEROI LIGHT RAIL TRANSIT SYSTEM.** Within the framework of the construction of the Charleroi light rail transit system, some lines are in service, while others are under construction or only at the project stage. The power distribution telecontrol system must therefore adapt itself to network growth and, to achieve this, a distributed architecture has been designed and progressively brought into service which makes extensive use of the TRACEC-ALPES substation computers. The present article describes that part of the telecontrol system which is already operational. In a final stage, the telecontrol system will also be used to control traffic. (Author abstract)

Avet, L.; Barbarin, S.; de Rubinat, J.-M.; Monseu, Ph.; Quinet, M. *ACEC Rev* n 4 1987 p 24-28.

## Concrete Construction

**088996 NEW CONCEPT IN STRUCTURAL DESIGN FOR MEXICO CITY ELEVATED METRO.** The author describes the design and construction features of the new elevated line of Mexico City's Metro. This 5.6 km (3.5 mile) long structure, with beams spanning 40 m (131.23 ft), uses precast prestressed concrete extensively together with some innovative structural design solutions. Subjects covered include seismic performance, structural elements, stations, and others. (Edited author abstract)

Rioboo Martin, Jose Ma. (Rioboo Consulting Engineers, Mexico City, Mex). *PCI J* v 33 n 1 Jan-Feb 1988 p 112-141.

**Costs** See **LIGHT RAIL TRANSIT—Buffalo, New York.**

## Environmental Impact

**088997 COMPARATIVE ENVIRONMENTAL IMPACTS OF DIFFERENT MODES.** While modern railway systems in general are considered to have comparatively low environmental impacts, high speed rail systems require special attention to ecological appraisal. Two case studies are presented - the new rail lines of the West German Federal Railways, and the Europe-an high speed rail project Paris-Brussels-Cologne/Amsterdam - which show that environmental compatibility can be costly and time-consuming. However, it would seem that the environment would not be a main issue for the proposed Amsterdam-Groningen-Hamburg connection if it primarily used existing rail lines. (Author abstract)

Gand, H. (Ministry of Transport, Bonn-Bad Godesberg, West Ger). *Transportation* v 14 n 2 1987, Workshop on High Speed Rail, Gieten, Neth, May 1987 p 139-145.

## Equipment

**088998 AERODYNAMICS OF URBAN TRANSIT VEHICLES.** The paper discusses the problems of wind loading of urban transit vehicles in the context of the overturning problem. It is shown that vehicles will respond to gusts of the order of only a few seconds in duration. The available aerodynamic information for vehicle shapes is reviewed, as is the nature of the wind environment in urban areas. The implications of these data are placed in simplified probabilistic perspective that suggests that the risk of overturning can become very significant if a number of factors are unfavorable. While the details of assessing the risks more precisely are described and have been developed in detail elsewhere, they cannot be applied to this problem until better information for particular cases is developed. Better data on both vehicle aerodynamics and the wind statistics for actual vehicle routes are needed. (Author abstract) 22 refs.

Surry, David (Univ of Western Ontario, London, Ont, Can); Cooper, Kevin R.; Davenport, Alan G. *Can J Civ Eng* v 15 n 1 Feb 1988 p 37-48.

## Exhibitions

**088999 FUTURE OF TRANSIT TECHNOLOGY: LESSONS FROM EXPO 86.** Expo 86, the World Exposition held last year in Vancouver, Canada, was the largest, special-category world's fair ever staged, with 54 international participants. Given the designated theme of transportation and communications, it is interesting to interpret the statements made by the participants in regard to particular sub-theme areas such as urban transit. This paper reviews the presentations (exhibits, demonstrations, conferences, and seminars) developed by all participants in Expo 86 in regard to urban transit technology, and assesses the significance and direction of technological developments in the areas of vehicle and terminal design, network and system operation and control, and planning and management systems. (Author abstract) 3 refs.

Rice, R.G. (McGill Univ, Montreal, Que, Can). *J Adv Transp* v 21 n 3 Winter 1988 p 239-253.

## France

**089000 REGIONAL IMPACT OF THE TGV.** Evidence on the regional impact of the TGV high speed rail line between Paris and Lyons is provided, on the basis of surveys carried out both before and after its inauguration. The timing of the TGV and the nature of the surveys are explained, while the analysis contrasts the impact on the Paris and Rhone-Alps regions at each end of the TGV line. Tourism and service industries are the main subjects of the research. (Author abstract) 11 refs.

Bonnafous, A. (Univ of Lyons, Fr). *Transportation* v 14 n 2 1987, Workshop on High Speed Rail, Gieten, Neth, May 1987 p 127-137.

## Guideways

**089001 GUIDEWAY DESIGN AND CONSTRUCTION FOR VANCOUVER ADVANCED LIGHT RAPID TRANSIT.** The Vancouver Advanced Light Rapid Transit (ALRT) System consists of 21.4 km of grade-separated guideway between the cities of Vancouver and New Westminster. Of the total length 16.6 km are elevated, 1.3 km are in tunnel, and 3.5 km are at grade. The guideway beam concept was developed in concrete with the requirement that direct track fixation be used without a second pour. The beams are post-tensioned, following erection into two- and three-span continuous structures, encastre at the internal supports, with single pot bearing at the expansion ends. Quality assurance for all materials and construction was critical to the successful completion and operation of the system. Production of the precast guideway beams for the project was undertaken by two separate contractors. The cost of the transit system including 114 vehicles and all operation and control equipment was budgeted for a maximum expenditure of \$854 million of which approximately \$240 million was for civil works for the guideway, stations, and maintenance yard. Construction of the guideway began in August 1983 and was completed in December 1985. The guideway began operation January 1, 1986 on time and on budget. (Edited author abstract)

Mills, Donald L. (Acres Int Ltd, Vancouver, BC, Can). *Can J Civ Eng* v 14 n 3 Jun 1987 p 347-362.

**089002 PRECAST GIRDERS FOR THE DECKS OF THE VANCOUVER RAPID TRANSIT SYSTEM.** The new metropolitan railway system stretches 21.40 km through Vancouver, to connect the port area to the suburban New Westminster district in only 27 minutes, comprising 13 intermediate stops. The route comprises 2 km of tunnel; 6 km run at grade level and 14 km on a viaduct running 6-8 m above ground level. 1118 straight and curved segments were precast having a varying box section. These girders were cast using form-works consisting of 1.50 m long elements mounted on a mobile frame, enabling the translation in both vertical and horizontal directions and permitting rotation so as to facilitate following the curved profile of the deck axis. (Author abstract) In Italian and English.

Anon. *Ind Ital Cem* v 57 n 11 Nov 1987 p 700-717.

**089003 NEW GUIDEWAY TRANSIT SYSTEMS.** The trend in Japan is toward a concentration of population in urban centers, resulting in traffic congestion, noise, and pollution. Thus, as a means of revitalizing population centers, hopes have been placed on new forms of pollution-free mass transportation, positioned between conventional train transportation and road traffic, and adapted to the urban environment. Since residential areas are often located far from the city centers, new transportation systems have emerged as a means for mass commuting from suburban homes to urban workplaces. These systems encompass both monorails and medium-capacity guided systems. The latter include conventional rubber-tire systems, as well as linear-motor-driven, steel-wheel guideway transit systems.

Takahashi, Keiichi (Mitsubishi Electric Corp, Tokyo, Jpn); Ono, Kazumi. *Mitsubishi Electr Adv* v 43 Jun 1988 p 2-3.

## Ireland

**089004 DUBLIN AREA RAPID TRANSIT.** The paper describes the principal elements of the Dublin Area Rapid (DART), together with details of project management during the construction phase, and operating experience since the service was introduced in 1984. The DART is a modern electrified transit system that runs on a 36 km double line route through Dublin. The system uses the latest developments in signalling, traffic control, and communication, to minimise the operating staff requirements. Chopper controlled semipermanently coupled units are combined to make 4 car or 6 car trains, to operate on the 1500 v dc electrified line from Howth to Bray, seven days a week. By using a blended regenerative-rheostatic



electric braking system, these units operate with minimum energy consumption for the required schedule speed. Remote control of all power switches, level crossing, and CCTV supervision, all contribute to maximum flexibility of system operation. DART was the first electrified line in Ireland. (Edited author abstract) 12 refs.

Waters, C.D. (DART, Dublin, Irel); Farrell, M.; Grainger, R.P.; Leahy, P.J.; Mellitt, B. *IEE Proc Part B* v 135 n 3 May 1988 p 134-150.

Japan See CARS—Monorail.

London, England See ELECTRIC RAILROADS—Automation.

Magnetic Levitation See Also RAILROADS—Magnetic Levitation; RAILS.

**089005 TECHNIK UND SICHERHEIT DES TRANSPRAPHID-SYSTEMS.** [Technology and Safety of the Transrapid System]. The use of the function principles of electromagnetic support and guidance technique and the synchronous iron-cored long-stator propulsion has permitted construction and realization of a transportation system with many outstanding features. Some of these properties can be proven by analyzing endurance tests under simulated operating conditions in the laboratory and test results of the Transrapid Test Facilities in Emsland at speeds up to 412 kmph. The results of testing of the guideway of the south loop of the TVE track, the prototype Transrapid 07 vehicle and of the new propulsion and operations control system form the basis for proving the serviceability of the Transrapid maglev system. 9 Refs. In German.

Miller, Luitpold (Thyssen Industrie AG Henschel, Munich, West Ger). *Thyssen Tech Ber* v 20 n 1 1988 p 189-197.

**089006 EINSATZFELDERSTUDIE NEUER SCHNELLBHANSYSTEME IN DER BUNDESREPUBLIK DEUTSCHLAND UND DIE ANWENDUNG DES MAGNETBAHNSYSTEMS TRANSPRAPHID IM KORRIDOR RHEIN/MAIN-RHEIN/RUHR.** [Study of Application Fields for the New Rapid Transit Systems in the Federal Republic of Germany and Utilization of the Transrapid Magnetic Levitation System in the Rhine/Main-Rhine/Ruhr Corridor]. A discussion is presented of the extensive programs for the development of high-speed train systems such as the ICE wheel-on-rail system and Transrapid 07 magnetic levitation system which are suitable as modern high-speed systems. Advantages and disadvantages of the technologies for specific applications are discussed. Results of a feasibility study for the Transrapid system in the Federal Republic of Germany are also provided. It is shown that prospects are excellent for the Rhine/Main-Rhine/Ruhr corridor to become the first region where the magnetic levitation system is used. 5 Refs. In German.

Forst-Luerken, Reinhard (Thyssen Industrie AG Henschel, Munich, West Ger); Alexy, Rainer. *Thyssen Tech Ber* v 20 n 1 1988 p 209-218.

Marseilles, France

**089007 MARSEILLES INTEGRATED TRANSPORT SYSTEM.** To be fully effective, metro lines must be connected with other modes of transport. This principle has been applied in the city of Marseilles, France. First, a very good interchange between the two metro lines and the national and suburban railway has been developed in the Saint-Charles main railway station. This interchange connects with the adjacent intercity bus terminal. Second, at every metro station, access facilities and neighborhood development were planned. Third, bus stations and car parks were installed at main rail stations. All this was made possible by early coordinated planning. (Author abstract)

Croc, Michel (Soc du Metro de Marseille, Fr). *J Adv Transp* v 21 n 3 Winter 1988 p 255-262.

Montreal, Canada See SUBWAYS—Montreal, Canada.

Noise, Acoustic See RAILROADS—Noise, Acoustic.

## Operations Research

**089008 DWELL TIME OF TRAMS ON CALCUTTA ROADS - A CASE STUDY.** The need to develop an estimation procedure of dwell time required for varying number of transit vehicle-users at scheduled stations is primarily felt for scheduling the operational modes. Properly apportioned dwell time at different stations, however, can optimize overall running time, curtail unused hauling time and ensure safety to the passengers while alighting from and boarding to the transit vehicles. Determination of the relationship between the number of users and dwell time is useful for scheduling trips in Metro Railways and other guided track vehicles such as light rail transits and trams. With necessary modifications, the concept may also be utilized in long distance bus services, railways and waterway services. (Author abstract) 1 refs.

Bhattacharya, A.K. (Transportation Planning & Traffic Engineering Directorate, Calcutta, India). *J Inst Eng India Part CI* v 68 Mar 1988 p 257-260.

**089009 QUICK ESTIMATION OF QUEUEING DELAY FOR PASSENGERS EXITING A RAPID TRANSIT STATION.** A method for estimating queueing delay for passengers exiting a rapid transit station is described. The method requires estimates of the average number of people exiting each train, average headway, and average service rate as inputs. The average delay is easily calculated with a hand calculator. (Author abstract). 2 refs.

Hall, Randolph W. (Univ of California, Berkeley, CA, USA). *Transp Res Rec* n 1152 1987 p 11-13.

## Personnel

**089010 CONVERSION TO ONE-PERSON OPERATION OF RAPID-TRANSIT TRAINS.** This report presents the findings and conclusions of a study (1) to evaluate the issues that must be addressed in contemplating conversion of two-person systems to one-person operation including the identification of those issues unique to the particular systems, and (2) to develop a framework for an economic assessment of the effects of implementation of one-person operation. No recommendations that any specific rapid transit system be converted from two- to one-person train operation were to be made. The principal effort of this study was associated with visits to 16 heavy-rail rapid-transit systems in the United States and Europe to solicit opinions and obtain data and information relative to the issues, problems, and problem solutions associated with conversion of heavy-rail rapid-transit systems to one-person train operation. (Edited author abstract) 8 refs.

Hoess, J.A. (Battelle Memorial Inst, Columbus, OH, USA); Murphy, P.J. *Rep Natl Coop Transit Res Dev Program* 13 Dec 1986 49p.

**089011 CONVERSION OF RAPID-TRANSIT TRAINS TO ONE-PERSON OPERATION.** Battelle Columbus Division in conjunction with the National Cooperative Transit Research and Development Program, recently conducted a study of one-person operation of multiple-unit trains for improving the cost-effectiveness of heavy-rail rapid-transit systems. On the basis of the study findings, it is judged that while there are many problems to be resolved, conversion of many of the six older U.S. rapid-transit systems with two-person operation of multiple-unit trains to one-person operation is technically feasible. Such conversion will generally follow an evolutionary process. That is, rather than systemwide conversion of all services and lines at one time, systems will most likely convert those services or lines that are most compatible to one-person operation first, followed by conversion of less compatible services or lines over time. The most compatible services include new lines, lines or services with new or rehabilitated cars or facilities, and

off-peak service. (Edited author abstract).

Hoess, Joseph A. (Battelle Columbus Div, Columbus, OH, USA). *Transp Res Rec* n 1152 1987 p 56-58.

## Planning See Also SUBWAYS—Management.

**089012 TRANSIT SYSTEMS FOR TODAY'S URBAN POPULATIONS.** Urban transit projects require designers and builders to work closely with each other and the community to solve countless interlocking problems. An overview is given of how designers, builders and local residents have responded to these challenges. Some structures reviewed include: Washington D.C.'s Metro Center; Boston's Redline Subway Extension; Philadelphia's Frankford Elevated Railway; St. Louis's Light Rail Transit; Buffalo, New York's Light Rail Network.

Regan, Thomas J. Jr.; D'Eramo, Domenic E. *Constr Specifier* v 41 n 4 Apr 1988 p 74-83.

**089013 QUANTITATIVE ANALYSIS OF RAPID TRANSIT ALIGNMENT ALTERNATIVES.** Honolulu's first-stage rapid transit corridor was identified according to existing bus ridership. The first-stage corridor was divided into seven evaluation segments where all alternatives converge. The net total cost of each alternative for each segment was estimated, using a set of yardsticks. These yardsticks were developed to efficiently estimate the different costs and benefits of different alignment alternatives, without requiring detailed designs of each alternative or running elaborate computer models. The yardsticks estimate differences in rapid transit system costs, feeder bus costs, ridership generation, and joint development for each alignment alternative. The quantitative alignment and station evaluation methodology offers system designers a simple and reasonable way to make tradeoffs between different objectives.

Schabas, Michael (Rapid Transit Planning, Honolulu, HI, USA). *Transp Q* v 42 n 3 Jul 1988 p 403-416.

**089014 WORKSHOP ON HIGH SPEED RAIL.** This workshop proceedings contains 6 papers. The topics discussed are: determinants of northern high-speed railway; regional impacts of new transport infrastructure - a multi-sectoral potentials approach; the regional impact of the TGV; comparative environmental impacts of different modes; forecasting passenger travel demand-international aspects; transport systems in the future. All papers are indexed and abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10580 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Ashley, D.J. (Ed.). *Transportation* v 14 n 2 1987, Workshop on High Speed Rail, Gieten, Neth, May 1987 p 97-165.

**089015 DETERMINANTS OF A NORTHERN HIGH-SPEED RAILWAY.** This is the first of two background papers sponsored for the Symposium by the Administrative Commission for the north of the Netherlands. The authors have assembled the available information on current rail travel patterns in the corridor of the proposed high speed rail line to Scandinavia and on the historical trends in travel in this corridor. On the basis of this information, their assessment of the likely future European high speed rail network and evidence on the elasticities of demand for rail travel, the authors have then estimated the traffic potential of the proposed Amsterdam-Groningen-Hamburg high speed rail link under four scenarios. (Author abstract) 8 refs.

Savelberg, Fons (Netherlands Economic Inst, Rotterdam, Neth); Vogelaar, Hans. *Transportation* v 14 n 2 1987, Workshop on High Speed Rail, Gieten, Neth, May 1987 p 97-111.



**089016 REGIONAL IMPACTS OF NEW TRANSPORT INFRASTRUCTURE: A MULTISECTORAL POTENTIALS APPROACH.** This is the second of two background papers sponsored for the Symposium by the Administrative Commission for the north of the Netherlands. Its purpose is to provide an indication of the effects of the proposed high speed rail line between Amsterdam, Groningen and Hamburg on employment in the corridor. The authors review the techniques of forecasting these effects discussed in the literature. The 'potentials' approach is adopted for their analysis, the mathematics and underlying assumptions of which are presented. This model is run to provide an estimate of the impact on regional employment of three variants of the proposed rail line. (Author abstract) 29 refs.

Evers, G.H.M. (Univ of Groningen, Groningen, Neth); Van Der Meer, P.H.; Oosterhaven, J.; Polak, J.B. *Transportation* v 14 n 2 1987, Workshop on High Speed Rail, Gieten, Neth, May 1987 p 113-126.

**089017 FORECASTING PASSENGER TRAVEL DEMAND - INTERNATIONAL ASPECTS.** The differing demand forecasting approaches adopted on a variety of European international travel studies are described in this paper. These include four models used on the studies of the Paris-Brussels-Cologne/Amsterdam high speed rail line, the model used in appraising the proposed Channel Tunnel rail services and the EC TASC model system. Contrasting features of these forecasting procedures are highlighted. (Author abstract) 6 refs.

Ashley, D.J. (MVA Consultancy, Woking, Engl). *Transportation* v 14 n 2 1987, Workshop on High Speed Rail, Gieten, Neth, May 1987 p 147-157.

**089018 TRANSPORT SYSTEMS IN THE FUTURE.** The paper reviews the major features of the transport policy of the European Community. It makes an assessment of the likely characteristics of future transport supply. It identifies the particular competing developments in road and air transport which would affect the success of high speed rail investments such as that proposed between Amsterdam, Groningen and Hamburg. (Author abstract)

Frohmeyer, A. (Commission of the European communities, Brussels, Belg). *Transportation* v 14 n 2 1987, Workshop on High Speed Rail, Gieten, Neth, May 1987 p 159-165.

## Poland

**089019 INCREASE IN TRAIN SPEEDS THROUGH MODERNISATION OF THE POLISH RAILWAY INFRASTRUCTURE.** The policy of Polish State Railways (PKP), quite apart from catering for introduction of higher speeds on a phased basis (120 km/h - 140 km/h - 160 km/h and over), also provides for thorough modernization of the entire system through: superstructure consolidation; development of electrification; automation of key marshalling yards; general introduction of automatic block signalling; modernization of several other installations. This ambitious program is gradually taking shape, despite the funding problems encountered. Already passenger train speeds are being steadily increased and freight transit times speeded up.

Semrau, A. (Politechniki Gdanskiej, Pol). *Rail Int* v 19 n 4 Apr 1988 p 25-28.

**Route Analysis** See REGIONAL PLANNING—Transportation.

**Scheduling** See Also SUBWAYS—Sapporo, Japan.

**089020 PASSENGER DELAY IN A RAPID TRANSIT STATION.** An analytical queueing model for predicting passenger delay in a busy rapid transit station is developed and tested. The model accounts for the 'lumpy' arrival pattern of passengers exiting trains. Passenger delay is divided into two components: 'standard' delay and 'interference' delay. Standard delay is the delay incurred when all of the passengers on a train are served

before the next train arrives. Interference delay is the added delay when the next train arrives before all of the passengers are served. (Edited author abstract) 5 refs.

Hall, Raldolph W. (Univ of California, Berkeley, CA, USA). *Transp Sci* v 21 n 4 Nov 1987 p 279-292.

**Singapore** See Also TUNNELS AND TUNNELING—Construction.

**089021 BISHAN DEPOT-ZENTRALWERKSTATT FUER DIE METRO SINGAPUR.** [Bishan Depot - Central Repair Shop for the Singapore Subway]. The most modern urban mass transportation system between Yio Chu Kang and Tao Payoh on November 7, 1987, the Bishan depot workshop was completed and commissioned in August 1987. The outstanding design of the maintenance and repair workshop equipped with custom-made top-quality facilities warrants reliability and attractiveness of the mass transportation system. A team of transportation, mechanical engineering, and control technique engineers, in cooperation with experienced project managers, successfully solved the difficult assignments which required the handling of a great number of interfacing activities. In German.

Jordans, Bruno (Thyssen Engineering, Essen, West Ger); Kracht, Winfried; Mueller, Olaf; Reese, Horst. *Thyssen Tech Ber* v 20 n 1 1988 p 161-174.

**Switzerland** See ELECTRIC RAILROADS—Switzerland.

## Testing

**089022 ERSTE ERFAHRUNGEN BEI DER ERPROBUNG DER NEUEN S-BAHN-TRIEBZUEGE FUER DIE BERLINER VERKEHRS-BETRIEBE (BVG).** [First Experience with the New S-Bahn Multiple-Train Unit Testing for the Berlin Transit Service (BVG)]. The putting into service of four Type 480 S-Bahn twin-units by the BVG in Berlin solved several organizational and pressing problems. During the test period the prototype covered well over 100 000km and the knowledge gained led to optimization of supply filters and the motor controllers, as well as improvement of details which were likewise incorporated in the first build. Only a few points are still to be decided, balancing attractiveness against cost, and the manufacturers are now resolving them. (Author abstract) 4 refs. In German.

Beier, Kurt (Berliner Verkehrs-Betriebe (BVG), Berlin, West Ger). *Elektr Bahnen* v 86 n 4 1988 p 124-130.

## United States

**089023 CHOOSING THE WRONG TECHNOLOGY: OR HOW TO SPEND BILLIONS AND REDUCE TRANSIT USE.** In spite of a broad consensus among transportation analysts that bus rapid transit, whether operating on exclusive rights-of-way or on uncongested high occupancy vehicle lanes or general purpose limited access facilities, provides higher performance and has significantly lower costs per passenger trip than rail transit in medium and low density cities, nearly all Sunbelt cities are building or planning heavy or light rail systems. This paper reviews previous studies of the cost-effectiveness of heavy and light rail transit with bus-rapid transit and the growing experience with busways and transitways and concludes, once again, that some form of bus rapid transit would be a far more effective way of providing improved transit in these cities than heavy or light rail transit. Not only would bus rapid transit be substantially cheaper, but it would provide a higher quality of service than light or heavy rail transit for virtually all users. Finally, the paper speculates on the reasons for the continued, 'blind' commitment to rail transit by policymakers in Sunbelt cities and on the refusal of policymakers in all but a few of these cities to even consider bus rapid transit. (Author abstract) 13 refs.

Kain, John F. (Harvard Univ, USA). *J Adv Transp* v 21 n 3 Winter 1988 p 197-213.

**Zurich, Switzerland** See ELECTRIC RAILROADS—Zurich, Switzerland.

**RARE EARTH COMPOUNDS** See Also ARSENIC COMPOUNDS; BORIDES; CATALYSTS—Supported; COPOLYMERS—Synthesis; FLUORINE COMPOUNDS; INTERMETALLICS; INTERMETALLICS—Electric Conductivity; INTERMETALLICS—Magnetic Properties; INTERMETALLICS—Phase Transitions; INTERMETALLICS—Thermodynamic Properties; INTERMETALLICS—X-Ray Analysis; IRON COMPOUNDS; LANTHANUM COMPOUNDS; MAGNETIC MATERIALS—Phase Transitions; MAGNETIC SEMICONDUCTORS—Physical Properties; MAGNETS—Powder Metal; MOLYBDENUM COMPOUNDS—Electric Conductivity; MONAZITE—Melting; POWDER METAL PRODUCTS—Electric Conductivity; REFRACTORY MATERIALS—Alumina; SUPERCONDUCTING MATERIALS—Electric Properties; SUPERCONDUCTING MATERIALS—Electronic Properties; SUPERCONDUCTING MATERIALS—Magnetic Properties; SUPERCONDUCTING MATERIALS—Microstructure; SUPERCONDUCTING MATERIALS—Physical Properties; SUPERCONDUCTING MATERIALS—Research; SUPERCONDUCTING MATERIALS—Strain; SUPERCONDUCTING MATERIALS—Structure; SUPERCONDUCTING MATERIALS—Transport Properties; SUPERCONDUCTING MATERIALS—X-Ray Analysis; SUPERCONDUCTIVITY—Theory.

**089024 CRYSTALLOGRAPHIC STUDIES OF THE SYSTEMS  $MAI_2-MGa_2$  ( $M \equiv Yb, Ca, Eu, Sr$ ).** The systems  $MAI_2-MGa_2$  with  $M \equiv Yb, Ca, Eu, Sr$ , have been examined structurally. Extended solid solutions were found of the structure types:  $MgCu_2$ ,  $CeCu_2$ ,  $CaIn_2$  and  $AlB_2$ . (Author abstract) 11 refs.

Landelli, A. (Univ di Genova, Genoa, Italy). *J Less Common Met* v 135 n 2 Nov 1987 p 195-198.

**089025 CANTED SPIN STRUCTURES IN  $R_2Fe_{14}B$  ( $R \equiv Th, Er$ ).** The canted, basal-plane magnetic structure in  $Tm_2Fe_{14}B$  is discussed in terms of a phenomenological model incorporating both magnetic exchange and crystal field interactions. The second-order crystal field is insufficient to explain the observed canting angles; at least fourth-order terms must be considered. Possible canting in  $Er_2Fe_{14}B$  is also considered. (Author abstract) 13 refs.

Cadogan, J.M. (Trinity Coll, Dublin, Ire). *J Less Common Met* v 135 n 2 Nov 1987 p 269-275.

**089026 WEITERE METASTABILE VERBINDUNGEN MIT TUNNELSTRUKTUR  $BaCa_2Er_{10}O_{18}$  UND  $BaCa_2Yb_{10}O_{18}$ .** [Additional Metastable Compounds with Tunnel Structure  $BaCa_2Er_{10}O_{18}$  and  $BaCa_2Yb_{10}O_{18}$ ]. Single crystals of the unknown compounds  $BaCa_2Er_{10}O_{18}$  (A) and  $BaCa_2Yb_{10}O_{18}$  (B) were prepared by a high-temperature  $CO_2$ -laser technique and investigated by X-ray work. (A) and (B) are metastable compounds with an  $Ln_{10}O_{18}^{6-}$  framework. Two types of tunnels built up by this framework are occupied statistically and in a disordered manner by  $Ba^{2+}$ ,  $Ca^{2+}$  and  $Ln^{3+}$  ions. The relationship with compounds of the formula  $AB_2Ln_6O_{12}$  are discussed. (Author abstract) 11 refs. In German.

Mueller-Buschbaum, Hk. (Christian-Albrechts-Univ zu Kiel, Kiel, West Ger); Mevs, H. *J Less Common Met* v 136 n 1 Dec 1987 p 193-199.

**089027 CRYSTALLOGRAPHIC STUDY OF  $YCo^{3+}_{1-2x}Co^{2+}_xPt^{4+}_xO_3$  AND  $DyCo^{3+}_{1-2x}Co^{2+}_xPt^{4+}_xO_3$ .** The crystal structures of single crystals of  $YCo^{3+}_{1-2x}Co^{2+}_xPt^{4+}_xO_3$  and  $DyCo^{3+}_{1-2x}Co^{2+}_xPt^{4+}_xO_3$  have been examined at room temperature, and shown to be isostructural with  $GdFeO_3$ , which belongs to space group  $P6_{3mm}$ . The overall expansion of octahedra caused by substitution of platinum enhances the distortion of rare-earth dodecahedra by moving 4 out of 12 oxygens further away from the rare-earth ions, as shown by the rotation of octahedra along the [110] axis. No order has been found for  $Co^{2+}$ ,  $Co^{3+}$ , and  $Pt^{4+}$ . (Author abstract) 34 refs.

Liu, X. (State Univ of New York, Stony Brook, NY, USA); Prewitt, C.T. *CHEMTECH* v 17 n 8 Aug 1987 p 371-379.



**089028 HERSTELLUNG, REINIGUNG UND CHARAKTERISIERUNG VON SELTENERDDIPH-THALOCYANINEN.** [Preparation, Purification and Characterization of Rare Earth Diphthalocyanine]. The synthesis and purifications of rare earth diphthalocyanines of holmium, earth and thulium is described. In connection with their vacuum sublimation behavior. The thermal properties of the compounds are more closely examined. Further characterization took place by means of IR and mass spectra and of the complexometric metal determination. (Translated author abstract) 17 refs. In German.

Starke, Manfred; Tschistjakow, Oleg Dimitrijewitsch. *Wiss Z Tech Univ Karl Marx Stadt* v 29 n 2 1987 p 311-313.

**089029 SOME NOVEL TERNARY  $\text{ThMn}_{12}$ -TYPE COMPOUNDS.** Ternary compounds based on the tetragonal  $\text{ThMn}_{12}$  structure are formed when rare earth elements (R) are combined with iron and elements M ( $\text{M} \approx \text{Si, Ti, V, Cr, Mo, or W}$ ). A structure determination was made for  $\text{NdFe}_{10}\text{Mo}_2$ , showing that the molybdenum atoms occupy only one of the three available crystallographic sites in this structure type. Detailed investigations of the systems  $\text{YFe}_{12-x}\text{V}_x$  showed that there is a substantial range of solid solubility extending approximately from  $x = 1.5$  to  $x = 3$ . Curie temperatures were determined for the two series  $\text{YFe}_{10}\text{M}_2$  and  $\text{GdFe}_{10}\text{M}_2$  and were found to depend strongly on the component M. (Author abstract) 5 refs.

De Mooij, D.B. (Philips Research Lab, Eindhoven, Neth); Buschow, K.H.J. *J Less Common Met* v 136 n 2 Jan 1988 p 207-215.

**089030 BINARY PHASE DIAGRAMS OF THALLIUM WITH GADOLINIUM, TERBIUM AND DYS-PROSIUM.** The Tb-Tl and Dy-Tl systems have been studied by differential thermal analysis, X-ray examination, metallography, and microprobe analysis. A reinvestigation of the Gd-Tl system has been also carried out in the 35 - 47 at.% thallium composition range. In the Tb-Tl system the following intermetallic compounds exist:  $\text{Tb}_2\text{Ti}$  (decomposes at  $1040^\circ\text{C}$ ),  $\text{Tb}_5\text{Ti}_3$  (m.p.  $1290^\circ\text{C}$ ),  $\text{Tb}_5\text{Ti}_{3+2x}$ ,  $\text{TbTi}$  (m.p.  $1300^\circ\text{C}$ ),  $\text{Tb}_3\text{Ti}_5$  (decomposes at  $1000^\circ\text{C}$ ) and  $\text{TbTi}_3$  (m.p.  $940^\circ\text{C}$ ). The Dy-Tl system shows the following phases:  $\text{Dy}_2\text{Ti}$  (decomposes at  $1190^\circ\text{C}$ ),  $\text{Dy}_5\text{Ti}_3$  (m.p.  $1340^\circ\text{C}$ ),  $\text{Dy}_5\text{Ti}_{3+2x}$ ,  $\text{DyTi}$  (m.p.  $1300^\circ\text{C}$ ),  $\text{Dy}_3\text{Ti}_5$  (decomposes at  $1000^\circ\text{C}$ ) and  $\text{DyTi}_3$  (m.p.  $940^\circ\text{C}$ ). For both systems four eutectics and two peritectics occur. From the reinvestigation of the Gd-Tl system a congruent melting for the  $\text{Gd}_5\text{Ti}_3$  phase and the existence of a new phase ( $\text{Gd}_5\text{Ti}_{3+2x}$ ) have been proposed. (Edited author abstract) 21 refs.

Saccone, A. (Univ di Genova, Genoa, Italy); Delfino, S.; Cacciamani, G.; Ferro, R. *J Less Common Met* v 136 n 2 Jan 1988 p 249-259.

**089031 RARE-EARTH-METAL COBALT PHOSPHIDES WITH  $\text{HoCo}_2\text{P}_2$ ,  $\text{Sc}_5\text{Co}_{19}\text{P}_{12}$  AND  $\text{YCo}_5\text{P}_3$ -TYPE STRUCTURES.** New ternary rare-earth-metal cobalt phosphides were prepared by reaction of the elemental components in a thin flux. The compounds  $\text{R}_5\text{Co}_{19}\text{P}_{12}$  ( $\text{R} \approx \text{Y, Gd - Lu}$ ) crystallize with the hexagonal  $\text{Sc}_5\text{Co}_{19}\text{P}_{12}$  structure, which was refined for  $\text{Ho}_5\text{Co}_{19}\text{P}_{12}$  from single-crystal counter data to a residual of  $R = 0.033$  for 746 structure factors and 24 variable parameters. The new compounds  $\text{GdCo}_5\text{P}_3$ ,  $\text{ErCo}_5\text{P}_3$  and  $\text{TmCo}_5\text{P}_3$  crystallize with the closely related  $\text{HoCo}_5\text{P}_3$ - and  $\text{YCo}_5\text{P}_3$ -type structures respectively. (Edited author abstract) 31 refs.

Jakubowski-ripke, Ursula (Univ Muenster, Muenster, West Ger); Jeitschko, Wolfgang. *J Less Common Met* v 136 n 2 Jan 1988 p 261-270.

**089032 COMPLEX FORMATION VS. DISPROPORTIONATION: LANTHANIDE(II) CHLORIDES,  $\text{MCl}_2$  ( $\text{M} \approx \text{Nd, Sm, Eu, Dy, Tm, Yb}$ ), UNDER THE INFLUENCE OF ALKALI CHLORIDES.** The products of the action of alkali metals ( $\text{A} \approx \text{Li, Na}$ ) on lanthanide(III) chlorides,  $\text{MCl}_3$  ( $\text{M} \approx \text{Nd, Sm, Eu, Dy, Tm, Yb}$ ), principally  $\text{ACl} + \text{MCl}_2$  or  $\text{LiCl} + \text{LiM}_2\text{Cl}_5$ , were reacted with CsCl in sealed tantalum containers. Complex formation ( $\text{CsMCl}_3$ ) and disproportionation (to  $\text{Cs}_2\text{AMCl}_6 + \text{M}$ ) are the competing reaction types. The presence of alkali chloride ( $\text{LiCl, NaCl}$ ) has no effect on complex formation of  $\text{M} \approx \text{Eu, Yb}$ , and only minimal effect for  $\text{M} \approx \text{Sm}$ . For  $\text{M} \approx \text{Tm}$  disproportionation is the principal and for  $\text{M} \approx \text{Dy, Nd}$  the exclusive process. (Edited author abstract) 17 refs.

Schleid, Thomas (Justus-Liebig-Univ, Giessen, West Ger); Meyer, Gerd; Morss, Lester R. *J Less Common Met* v 137 Feb 1 1988 p 187-193.

**089033 ON THE TERNARY RARE EARTH ALLOYS:  $\text{RAlPb}$  COMPOUNDS.** The ternary phases of rare earths alloyed with gold and lead in the stoichiometric ratio 1:1:1 were studied by metallographic and X-ray analyses. Their structural characteristics are briefly discussed and compared with those of all the 1:1:1 ternary phases pertaining to the  $\text{CaIn}_2$ -type and the  $\text{MgAgAs}$ -type structures. The role of the dimensional factor in determining the structural type is examined. (Author abstract) 8 refs.

Marazza, R. (Univ di Genova, Genoa, Italy); Rossi, D.; Ferro, R. *J Less Common Met* v 138 n 2 Mar 15 1988 p 189-193.

**089034 ON THE TEMPERATURE DEPENDENCE OF HYDROGEN SITE OCCUPANCY IN RARE EARTH DIHYDRIDES.** Previous work claimed that the observed anomalous temperature dependence of octahedral(o)-site occupation in f.c.c. rare earth dihydrides could be explained by interaction effects not involving optic mode vibrations. We show that this conclusion was based on an erroneous assumption about the role of the chemical potential in determining the thermal equilibrium solution to lattice-gas-model equations. A correct derivation is given, and we conclude that such interactions cannot be the source of the anomaly. (Edited author abstract) 13 refs.

Patterson, J.D. (Florida Inst of Technology, Melbourne, FL, USA); Richards, Peter M. *J Less Common Met* v 138 n 2 Mar 15 1988 p 281-287.

**089035 TERNARY PNICTIDES  $\text{Mn}_{12-x}\text{Pn}_x$  ( $\text{M} \approx \text{Sr}$  AND RARE EARTH METALS,  $\text{Pn} \approx \text{Sb, Bi}$ ) WITH DEFECT  $\text{CaBe}_2\text{Ge}_2$  AND DEFECT  $\text{ThCr}_2\text{Si}_2$  STRUCTURES.** The compounds  $\text{Mn}_{12-x}\text{Sb}_x$  ( $\text{M} \approx \text{La, Ce, Pr, Nd, Sm, Gd, Tb, Dy, Ho, Er}$ ) and  $\text{Mn}_{12-x}\text{Bi}_x$  ( $\text{M} \approx \text{La, Ce, Pr, Nd, Sm, Gd, Tb, Dy}$ ) crystallize with a defect  $\text{CaBe}_2\text{Ge}_2$  structure, which was refined from single-crystal X-ray data for  $\text{LaNi}_{11.5}\text{Sb}_2$  ( $R = 0.014$  for 17 variable parameters and 328 structure factors).  $\text{SrNi}_{12-x}\text{Sb}_x$  and  $\text{EuNi}_{12-x}\text{Sb}_x$  have a defect  $\text{ThCr}_2\text{Si}_2$  structure, which was refined for  $\text{EuNi}_{11.5}\text{Sb}_2$  to a residual of  $R = 0.030$  (10 variables, 189 structure factors). The compounds have relatively large homogeneity ranges with differences in the cell volumes of up to 3%. The temperature dependence of the electrical conductivity of  $\text{LaNi}_{12}$  is associated with conversion of heavy-rail  $-x\text{Sb}_2$  indicates metallic behavior. Some results of phase equilibria studies of the corresponding ternary systems are reported. (Edited author abstract) 20 refs.

Hofmann, W.K. (Univ Dortmund, Dortmund, West Ger); Jeitschko, W. *J Less Common Met* v 138 n 2 Mar 15 1988 p 313-322.

**089036 NEW  $\text{Th}_2\text{Si}_2$ -TYPE REPRESENTATIVES,  $\text{LnCr}_2\text{Si}_2$  ( $\text{Ln} \approx \text{Sm, Tb - Lu}$ ).** New  $\text{LnCr}_2\text{Si}_2$  phases with  $\text{Ln} \approx \text{Sm, Tb - Lu}$  were synthesized and shown to crystallize in the  $\text{ThCr}_2\text{Si}_2$  structure. In these metallic compounds chromium carries no localized magnetic moment. Ytterbium in  $\text{YbCr}_2\text{Si}_2$  is virtually trivalent at room temperature. Of all  $\text{LnCr}_2\text{Si}_2$  phases only  $\text{GdCr}_2\text{Si}_2$  and  $\text{TbCr}_2\text{Si}_2$  order magnetically above 1.6 K.  $\text{YCr}_2\text{Si}_2$  and  $\text{LuCr}_2\text{Si}_2$  are not superconducting down to this temperature. (Author abstract) 21 refs.

Dommann, A. (ETH, Zurich, Switz); Hulliger, F.; Baerlocher, Ch. *J Less Common Met* v 138 n 1 Mar 1 1988 p 113-121.

**089037 CRYSTAL STRUCTURE AND FLUORESCENCE PROPERTIES OF  $\text{R}_2\text{Zr}_2\text{O}_7$  AND  $(\text{R}_{1-x}\text{Eu}_x)_2\text{Zr}_2\text{O}_7$  COMPOUNDS.**  $\text{R}_2\text{Zr}_2\text{O}_7$  and  $(\text{R}_{1-x}\text{Eu}_x)_2\text{Zr}_2\text{O}_7$  ( $\text{R} = \text{La, Pr, Sm, Eu, Gd, Tb, Er, Y}$ ) were prepared at  $1600^\circ\text{C}$  in air and their fluorescent properties were studied. The crystal structures of these compounds were pyrochlorite-type for the light rare earths and  $\text{CaF}_2$ -type for the heavy rare earths, respectively. However,  $\text{Gd}_2\text{Zr}_2\text{O}_7$  and  $\text{Y}_2\text{Zr}_2\text{O}_7$  showed broad and small (111) X-ray diffraction peaks which are characteristic of the pyrochlorite-type structure. Further, annealing at  $1500^\circ\text{C}$  increased the intensity and the sharpness of the (111) peak of  $\text{Gd}_2\text{Zr}_2\text{O}_7$ . When the compounds were excited by the 254 nm line, only the Eu-doped  $\text{La}_2\text{Zr}_2\text{O}_7$ ,  $\text{Gd}_2\text{Zr}_2\text{O}_7$  and  $\text{Y}_2\text{Zr}_2\text{O}_7$  showed emission spectral due to  $\text{Eu}^{2+}$  ions. (Edited author abstract) 6 refs.

Otaki, Hitoshi (Osaka Municipal Technical Research Institute, Osaka, Japan); Kido, Hiroyasu; Hoshikawa, Takeshi; Shimada, Masahiko; Koizumi, Mitsue. *Yogyo Kyokai Shi* v 96 n 2 1988 p 124-126.

**089038 X-RAY DETERMINATION OF DEBYE TEMPERATURES OF SOME RARE EARTH DIALUMINIDES.** Debye temperatures, Debye-Waller factors and r.m.s. amplitudes of vibrations are calculated for seven rare earth dialuminide intermetallic compounds from  $\text{LaAl}_2$  to  $\text{ErAl}_2$  with increasing atomic number of the rare earth element. The values of Debye temperatures obtained by the researchers by the X-ray method are compared with those available from elastic and specific heat measurements. It is observed that the Debye temperature decreased from  $\text{LaAl}_2$  to  $\text{PrAl}_2$  and increased from  $\text{DyAl}_2$  to  $\text{ErAl}_2$  except for  $\text{GdAl}_2$  which showed an increased Debye temperature. A plot of the Debye temperature vs. the reciprocal of the lattice parameter showed the deviation of  $\text{GdAl}_2$  from the other rare earth dialuminide compounds investigated. (Edited author abstract) 19 refs.

Appa Rao, B. (Osmania Univ, Hyderabad, India); Bhaskara Sastry, V.; Kistiah, P.; Satyanarayana Murthy, K. *J Less Common Met* v 139 n 2 May 1988 p 241-247.

**089039 NATURE OF THE  $4f$  SPIN IN HIGH  $T_c$  SUPERCONDUCTORS CONTAINING PARAMAGNETIC RARE-EARTH ELEMENTS  $\text{REBa}_2\text{Cu}_3\text{O}_{7-y}$  ( $\text{RE} \approx \text{Gd, Dy, Ho, Er AND Tm}$ ).** Single-phase high  $T_c$  superconductors,  $\text{REBa}_2\text{Cu}_3\text{O}_{7-y}$  ( $\text{RE} \approx \text{Gd, Dy, Ho, Er AND Tm}$ ) were prepared and their magnetic susceptibilities were measured from 77 to 300 K. The obtained Curie-Weiss temperatures were  $-1.2, -5.8, -2.1$  and  $-14$  K for  $\text{Dy}^{3+}, \text{Ho}^{3+}, \text{Er}^{3+}$  and  $\text{Tm}^{3+}$  respectively, indicating that the  $4f$  spins are delocalized to a small extent and the orbital quenching occurs in the normal conducting range. This was supported by the results of electron spin resonance (ESR) measurements. The influence of the magnetic spins on the superconductivity and the relaxation mechanisms responsible for the ESR line-shapes are discussed. (Author abstract) 11 refs.

Maeda, Atsushi (Research Development Corp of Japan, Tsukuba, Jpn); Tajima, Hiroyuki; Satake, Tohru; Kuroda, Haruo; Takui, Takeji; Itoh, Koichi. *J Less Common Met* v 139 n 2 May 1988 p 305-314.

**089040 SYNTHESIS AND CRYSTAL STRUCTURE OF  $\text{K}_2\text{U}_2\text{O}_7$  AND MOSSBAUER ( $^{237}\text{Np}$ ) STUDIES OF  $\text{K}_2\text{Np}_2\text{O}_7$  AND  $\text{CaNpO}_4$ .**  $\text{K}_2\text{U}_2\text{O}_7$  single crystals have been synthesized from a melt containing uranium, niobium oxides and potassium carbonate. The crystal structure of  $\text{K}_2\text{U}_2\text{O}_7$  has been determined. This study led to three possible distributions for the oxygen vacancies: on the uranyl bond, on the oxygen atoms of the equatorial plane of the uranyl polyhedron or on both of these two sites. A Mossbauer ( $^{237}\text{Np}$ ) study of the isotopic compound  $\text{K}_2\text{Np}_2\text{O}_7$  showed that the vacancies are located on the oxygen positions in the equatorial plane of the neptunyl ion. Mossbauer spectra of  $\text{CaNpO}_4$  have been recorded at 4.2 K and 77 K. The isomeric shift value for



this compound has been attributed to a neptunium (VI) ion with a coordination number of eight. (Edited author abstract) 7 refs.

Jove, Jose (CNRS, Paris, Fr); Cousson, Alain; Gasperin, Madeleine. *J Less Common Met* v 139 n 2 May 1988 p 345-350.

**089041 THERMOELECTRIC POWER OF RZnSi COMPOUNDS.** The thermoelectric power,  $S$ , of ternary rare-earth zinc silicides  $RZnSi$  was measured. The absolute values of  $S$  increased linearly with temperature, and the value of  $dS/dT$  for  $RZnSi$  decreased with increasing atomic number of rare-earth atom,  $Z$ . These results and the speculation on the basis of a free electron model indicated that the change in  $S$  and  $dS/dT$  with increasing  $Z$  of  $RZnSi$  was caused by the change in the concentration of conduction electrons due to the lanthanoid contraction. (Author abstract) 6 refs.

Kido, Hiroyasu (Osaka Municipal Technical Research Inst., Osaka, Jpn); Hoshikawa, Takeshi; Shimada, Masahiko; Koizumi, Mitsue. *Yogyo Kyokai Shi* v 96 n 3 1988 p 336-337.

**089042 TEMPERATURE-DEPENDENT ENERGY TRANSFER FROM  $^5D_3$  AND  $^5D_4$  STATES OF  $Tb^{3+}$  TO  $Sm^{3+}$ .** The present study deals with the interaction of  $^5D_3$  and  $^5D_4$  states of  $Tb^{3+}$  when  $Sm^{3+}$  ions are incorporated in a  $LaCl_3$  matrix. A dipole-dipole interaction mechanism is suggested for the transfer of energy from  $^5D_3$  and  $^5D_4$  states of  $Tb^{3+}$  to  $Sm^{3+}$ . Temperature-dependent study reveals multiphonon relaxation of the  $LaCl_3$  matrix. (Author abstract) 12 refs.

Kandpal, H.C. (Nat'l Physical Lab, New Delhi, India); Joshi, K.C. *J Phys Chem Solids* v 49 n 5 1988 p 555-560.

**089043 CALCULATION OF ELECTROSTATIC CRYSTAL FIELD PARAMETERS OF RARE EARTH HYDRATED SINGLE CRYSTALS.** The calculation of point charge and dipolar contributions to the crystal field parameters is outlined and the properties of the latter are discussed. This procedure is applied to Pr-ethylsulfate and Yb-ethylsulfate. The positions of the dipole centres and charge centres are estimated on the basis of the structure of these two compounds. The computed total crystal field parameters, taking the screening and scaling factors into consideration, are in reasonable agreement with those derived from experimental data except for  $C_{20}$ . (Edited author abstract) 18 refs.

Neogy, D. (Univ of Burdwan, West Bengal, India); Mukherjee, A.K.; Purohit, T. *Phys Status Solidi A* v 106 n 1 Mar 1988 p 173-180.

**089044 NEW TERNARY COMPOUNDS:  $RMnGa$  (R: RARE EARTH METALS) AND THEIR SPIN GLASS-LIKE BEHAVIOUR.** We have found a series of ternary compounds  $RMnGa$  (R: rare earth metals) hitherto unknown. They have a crystal structure with a high symmetry; a cubic Laves phase,  $C15$ . Electrical resistivity and magnetic susceptibility were measured from the liquid He temperature to the room temperature. The most of these samples were found to show spin glass-like behavior. (Author abstract) 7 refs.

Tagawas, Y. (Hiroshima Univ, Hiroshima, Jpn); Inaba, K.; Sakurai, J.; Komura, Y. *Solid State Commun* v 66 n 9 Jun 1988 p 993-994.

## Aging

**089045 BEHAVIOUR OF RARE EARTH SESQUIOXIDES EXPOSED TO ATMOSPHERIC CARBON DIOXIDE AND WATER.** The behavior of the rare earth sesquioxides, when exposed to atmospheric water and carbon dioxide under ordinary conditions of temperature and pressure, is reviewed. Data corresponding to eleven samples from seven different oxides systematically investigated by x-ray diffraction (XRD), IR spectroscopy, thermogravimetry (GT) and temperature-programmed decomposition (TPD), are reported. The BET surface areas of all these samples are also given. In accordance with the results summarized, upon exposure to air, the

lanthanide sesquioxide all become hydrated and carbonated in bulk. In some cases, the behavior has been found to depend on the origin of the samples, which prevents the generalization of definite sequences of reactivity for the whole series of oxides. (Edited author abstract) 73 refs.

Bernal, S. (Univ of Cadiz, Puerto Real, Spain); Botana, F.J.; Garcia, R.; Rodriguez-Izquierdo, J.M. *React Solids* v 4 n 1-2 Oct 1987 p 23-40.

Analysis See MINERALOGY—Silicates.

Applications See ANTENNAS, DIPOLE.

Bonding See SUPERCONDUCTING MATERIALS—Bonding.

Chelation See ION EXCHANGE RESINS—Solutions.

Chemical Analysis See SUPERCONDUCTING MATERIALS.

Chromatographic Analysis

**089046 DETERMINATION OF 13 RARE EARTH IMPURITIES IN HIGHLY PURE  $Gd_2O_3$  BY P215-HCl EXTRACTION CHROMATOGRAPHY-ICP-AES.** A new chemical-ICP-AES method for the determination of 13 rare earth (La to Nd, Sm, Tb to Lu, Y) impurities in high purity  $Gd_2O_3$  was represented. The RE impurities were separated from the matrix and concentrated by extraction chromatography in which a new extractant di (1-methyl heptyl) phosphoric acid (P215) was used as the stationary phase. Then the ICP emission spectrometry was employed to determine the trace amounts of RE impurities. All the result data of 13 RE could be read directly from the terminal of a computer at the same time. Hence the new method is rapid.  $25\text{ cm}^3$  of  $0.28\text{ mol/dm}^3$  HCl was used to elute elements from La to Sm first. Then  $45\text{ cm}^3$  of  $0.5\text{ mol/dm}^3$  HCl was applied to elute the matrix Gd, and finally  $120\text{ cm}^3$  of  $2.0\text{ mol/dm}^3$  HCl was employed to elute elements from Tb to Lu and Y. Experimental result showed that both good recovery and precision were obtained. This method can be applied to determining trace amounts of RE in  $Gd_2O_3$  with a purity more than 99.999%. (Author abstract) In Chinese. 4 refs.

Li, Ling-ying (Nankai Univ, China); Ma, Jin-qiu; Jin, Gu. *Xi You Jin Shu* v 6 n 4 Nov 1987 p 284-289.

**089047 SEPARATION OF LIGHTER RARE EARTH METAL IONS BY CENTRIFUGAL COUNTERCURRENT TYPE CHROMATOGRAPHY WITH DI-(2-ETHYLHEXYL)PHOSPHORIC ACID.** A centrifugal countercurrent type chromatography (Centrifugal Partition Chromatography) was applied to separations of lighter rare earth metal ions ( $LaCl_3$ ,  $CeCl_3$ ,  $PrCl_3$ ,  $NdCl_3$ ,  $SmCl_3$  and  $EuCl_3$ ) first time. The results obtained by using di-(2-ethylhexyl)phosphate (D2EHPA) showed that this technique is successfully usable for the laboratory-scale separations, though the numbers of theoretical plate calculated from the chromatograms were considerably lower than expected. (Edited author abstract) 23 refs.

Araki, T. (Shimane Univ, Matsue, Jpn); Okazawa, T.; Kubo, Y.; Ando, H.; Asai, H. *J Liq Chromatogr* v 11 n 1 Jan 1988 p 267-281.

Crystal Lattices See Also POTASSIUM COMPOUNDS—Crystal Lattices.

**089048 ELASTIC BEHAVIOUR OF  $Ce_3S_4$  AND  $La_3S_4$ .** The hydrostatic pressure and temperature dependences of the elastic stiffnesses of the cubic,  $Th_3P_4$  structure compounds  $Ce_3S_4$  and  $La_3S_4$  have been measured using the ultrasonic pulse echo overlap technique. Although  $Ce_3S_4$ , unlike  $La_3S_4$  ( $T_c = 103\text{ K}$ ), does not undergo a phase transition when its temperature is lowered to 16 K, its elastic stiffnesses soften with decreasing temperature (in a similar manner but less markedly than those of  $La_3S_4$ ); this lattice instability indicates an incipient phase transition. In both compounds the elastic constants increase under pressure: the long-wavelength

acoustic-mode Gruneisen parameters are all positive, and the application of pressure does not induce acoustic phonon-mode softening. (Author abstract) 8 refs.

Futterer, H. (Ruhr-Univ Bochum, Bochum, West Ger); Bach, H.; Saunders, G.A.; Sidek, H.A.A. *J Mater Sci* v 23 n 1 Jan 1988 p 121-125.

Crystallization See Also FERROELECTRIC MATERIALS—Synthesis.

**089049 CRITICAL POINT FOR THE VALENCE TRANSITION IN  $Sm_4Bi_3$ .**  $Sm_4Bi_3$  which crystallizes in the cubic anti- $Th_3P_4$  structure undergoes a first-order, isostructural valence transition near 26 kbar pressure at ambient temperature. Thermoelectric power exhibits a distinct anomaly at this pressure-induced phase transition. A significant result of the present high-pressure, high-temperature study is that the semimetal-metal phase boundary in the P-T plane terminates at a critical point. (Author abstract) 12 refs.

Shubha, V. (Nat'l Aeronautical Lab, Bangalore, India); Ramesh, T.G. *Solid State Commun* v 63 n 9 Sep 1987 p 779-781.

## Decomposition

**089050 THERMAL DECOMPOSITION OF CURIUM TETRAFLUORIDE AND TERBIUM TETRAFLUORIDE.** The thermal decompositions of both curium and terbium tetrafluorides have been studied using mass spectrometry to monitor the effluent from a Knudsen cell containing the condensed fluoride. Curium tetrafluoride was found to decompose at  $330-430^\circ\text{C}$  in vacuum. A Second Law enthalpy of  $26.3 \pm 2\text{ kcal/mole}$  (at  $370^\circ\text{C}$ ) is derived from van't Hoff plots of results obtained for the decomposition reaction. Decomposition fluorine pressures are derived and comparison is made with related studies of terbium tetrafluoride carried out in conjunction with the curium experiments. The results are compared both with data reported in the literature for lanthanide and actinide tetrafluorides and with predictions that have been made for  $CmF_4$ . (Author abstract) 16 refs.

Gibson, John K. (Oak Ridge Nat'l Lab, Oak Ridge, TN, USA); Haire, Richard G. *J Solid State Chem* v 73 n 2 Apr 1988 p 524-530.

## Dehydration

**089051 THERMAL DEHYDRATION OF  $Ln$ -MONTMORILLONITE ( $Ln = La, Nd, Gd, Ho, Yb, Lu$ ).** The present work aims to study the dehydration behavior of montmorillonite saturated with  $Ln(III)$  ( $Ln = lanthanum, neodymium, gadolinium, holmium, ytterbium, lutetium$ ). In a previous paper the anomalous pattern of lutetium on dehydration of the lanthanide trihydroxides to the sesquioxides was shown. In the present letter the dehydration reaction of hydrated  $Lu(III)$ , as a montmorillonite exchangeable cation, is compared with the dehydration reaction of the other lanthanides. At the same time, the very recent relationship found between the slope of the thermogravimetric diagrams (in the temperature range  $250$  to  $450^\circ\text{C}$ ) and the nature of  $ns$  and  $(n-1)d$  exchangeable cations has been applied to the 4f ions. 10 refs.

Poyato, J. (CSIC, Seville, Spain); Sanchez, P.J.; Tobias, M.M.; Trillo, J.M. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1047-1049.

Doping See CATALYSTS—Activity; ELECTRODES—Materials.

## Elasticity

**089052 ELASTIC MODULUS-POROSITY RELATION IN POLYCRYSTALLINE RARE-EARTH OXIDES.** Many equations have been previously proposed to describe the elastic modulus-porosity relation of brittle solids. The equations are not applicable to all materials over a wide range of porosity. A new equation representing elastic modulus-porosity relation of brittle solids has been proposed. It has been shown that the proposed



equation describes best the Young's modulus-porosity data of six rare-earth oxides over a wide range of porosity reported by previous investigators. The equation suggests that there was some kind of ordered packing in all the oxides. (Author abstract) 23 refs.

Phani, K.K. (Central Glass & Ceramic Research Inst, Calcutta, India); Niyogi, S.K. *J Am Ceram Soc* v 70 n 12 Dec 1987 p C362-C366.

**Electric Conductivity** See Also SUPERCONDUCTING MATERIALS—Magnetic Field Effects; SUPERCONDUCTING MATERIALS—Magnetic Properties; SUPERCONDUCTING MATERIALS—Measurements; SUPERCONDUCTING MATERIALS—Transport Properties; THORIUM COMPOUNDS—Electric Conductivity; ZIRCONIUM COMPOUNDS—Electric Conductivity.

**089053 ELECTRICAL CONDUCTION IN NON-METALLIC RARE-EARTH SOLIDS.** The energy band model proposed more than fifty years ago has been quite successful in explaining the genesis of charge carriers in semiconductors. Schematic energy band diagrams for the genesis of charge carriers in non-metallic rare-earth solids have been presented. It has been shown that positions of 4f bands have significant effect on the genesis and nature of charge carriers, their conduction mechanism and magnitude of electrical conductivity ( $\sigma$ ) and Seebeck coefficient ( $S$ ) of the solid. Relevant relations have been given for both  $\sigma$  and  $S$  in different situations. Experimental data on rare-earth sesquioxides ( $\text{R}_2\text{O}_3$ ), rare-earth tungstates [ $\text{R}_2(\text{WO}_4)_3$ ] and rare-earth molybdates [ $\text{R}_2(\text{MoO}_4)_3$ ] in the intrinsic range have been explained as examples for the validity of energy band diagrams. (Edited author abstract) 24 refs.

Lal, H.B. (Univ of Gorakhpur, Gorakhpur, India); Gaur, Kanchan. *J Mater Sci* v 23 n 3 Mar 1988 p 919-923.

**089054 TEMPERATURE AND CONCENTRATION DEPENDENCE OF THE ELECTRICAL RESISTIVITY IN  $(\text{RE})_2\text{Co}_2$  ( $\text{RE}$  = RARE EARTH ELEMENT).** We study the influence of magnetic scattering processes on the temperature dependence of the electrical resistivity. This influence is caused by localized 4f-moments and spin-fluctuations. The pronounced minima in  $\rho$  vs.  $T$  curves observed in the diluted RE-region are discussed in terms of enhanced spin-fluctuations and of Kondo type scattering processes. (Author abstract) 11 refs.

Gratz, E. (Technical Univ Vienna, Austria); Pillmayr, N.; Bauer, E.; Hilscher, G. *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 159-161.

**Electric Properties** See Also GLASS—Electric Properties; SEMICONDUCTOR MATERIALS—Electric Properties; SUPERCONDUCTING MATERIALS—Anisotropy.

**089055 SUPERCONDUCTIVITY AND MAGNETIC ORDERING IN THE MIXED TERNARY  $\text{Er}_{1-x}\text{Rh}_{1+x}\text{Sn}_{3.6}$  SYSTEM.** The superconducting transition temperature  $T_c$  as well as the magnetic ordering temperature  $T_m$  have been determined in the mixed ternary compound  $\text{Er}_{1-x}\text{Rh}_{1+x}\text{Sn}_{3.6}$  as a function of the Er concentration.  $T_c$  decreases from 3.13 K for  $\text{YRh}_{1.1}\text{Sn}_{3.6}$  to 1.1 K for  $\text{ErRh}_{1.1}\text{Sn}_{3.6}$ . Reentrant superconductivity has been found for  $x > 0.6$ . The application of the models of Abrikosov and Gorkov, Maekawa and Tachiki, and Roshen and Ruvalds to this system is discussed. (Edited author abstract) 18 refs.

Houwman, E.P. (Univ of Twente, Enschede, Neth); Van de Pasch, A.W.M.; Flokstra, J. *Physica B & C* v 145 n 2 May-Jul 1987 p 215-221.

**089056 ELECTRICAL AND THERMOELECTRIC TRANSPORT PROPERTIES OF  $\text{RZn}$  AND  $\text{Rcd}$  COMPOUNDS ( $\text{R} = \text{Tb}, \text{Gd}, \text{Nd}, \text{Pr}$ ).** We present the results of an extended investigation of the transport properties of the CsCl structure intermetallic compounds  $\text{GdZn}$ ,  $\text{TbZn}$ ,  $\text{GdCd}$ ,  $\text{TbCd}$ ,  $\text{PrCd}$  and  $\text{NdCd}$  (all single crystals), using high resolution measurements of the electrical resistivity ( $\rho$ ,  $d\rho/dT$ ) and the thermoelectric power ( $S$ ,  $dS/dT$ ), from 4.2 up to 300 K. A detailed

analysis of the data is presented in the vicinity of the different phase transition present along the series: of magnetic and spin reorientation types. Finally, new experimental evidence is given on the CsCl lattice instability in Rcd intermetallic compounds. (Author abstract) 34 refs.

Pinto, R.P. (Univ Do Porto, Porto, Port); Amado, M.M.; Braga, M.E.; Sousa, J.B.; Morin, P.; Aleonard, R. *J Magn Magn Mater* v 72 n 2 Apr 1 1988 p 152-166.

## Electrochemistry

**089057 ELECTROCHEMICAL BEHAVIOR OF RARE-EARTH MAGNET ALLOYS IN VARIOUS SOLUTIONS.** Electrochemical behavior of rare earth magnet alloys  $\text{SmCo}_5$ ,  $\text{Sm}_2\text{TM}_{17}$ , and  $\text{Nd-Fe-B}$  in various aqueous solutions was investigated. Although they are very reactive both in air and aqueous solutions, passivation is still possible in orthophosphoric acid. The ability to passivate, the passivated current density, and breakdown voltage of the passivated films were found to be related to the content of rare earth element, single- or multiple-phase state, and iron content of the alloys, respectively. Galvanic current density of the coupled pairs between one of the magnet alloys and one of the biomedical alloys (amalgam, Co-Cr, and Ni-Cr alloys) was found to be within 3-15  $\mu\text{A}/\text{cm}^2$  in synthetic saliva. However a large value of 25  $\mu\text{A}/\text{cm}^2$  between a Nd-Fe-B magnet and a Ni-Cr alloy was observed. 8 refs.

Chin, T.S. (Nat'l Cheng Kung Univ, Tainan, Taiwan); Chang, R.T.; Tsai, W.T.; Hung, M.P. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1927-1929.

## Electrolysis

**089058 PREPARATION METHODS OF RARE EARTH METALS AND THEIR ALLOYS.** This review describes the main applications, a short history of the past preparation methods and applications, and today's major preparation methods which include molten salt electrolysis and metallothermic reduction of rare earth salts. Special attention is devoted to the recent developments of the production processes for obtaining the metals and precursor alloys which are used as raw materials to produce high-performance rare earth-transition metal permanent magnets. Production processes for neodymium metal, however, will be described separately in the issue appearing in the near future. (Author abstract). 169 Refs. In Japanese.

Itoh, Katsuhisa; Nakamura, Eiji; Sasaki, Sigeaki. *Sumitomo Keikinzoku Giho* v 29 n 2 Apr 1988 p 29-46.

**Electronic Properties** See Also SUPERCONDUCTING MATERIALS—Magnetic Properties.

**089059 COLOUR GROUPS AND SPIN WAVES. SYMMETRY ANALYSIS OF THE SPIN WAVE SPECTRUM IN HEXAGONAL MANGANITES  $\text{LMnO}_3$  ( $\text{L} = \text{Er}, \text{Ho}, \text{Lu}, \text{Sc}, \text{Tm}, \text{Y}$ ).** The calculation of the spin wave spectrum by the symmetry analysis method is given in this work. The symmetry calculations are based on the P-type color group as the symmetry group of magnetic structure. It is consistent with the exchange approximation of the spin wave Hamiltonian. The method is applied to the spin wave spectrum calculation for hexagonal manganites  $\text{LMnO}_3$  ( $\text{L} = \text{Er}, \text{Ho}, \text{Lu}, \text{Sc}, \text{Tm}, \text{Y}$ ) and wave vector  $q = (0, 0, \mu)$ . As a result the 4 spin wave branches dependent on 4 exchange integrals are given, two of which are nondegenerated. The  $\lambda^2(q) \rightarrow 0$  with  $q \rightarrow 0$  for two branches. (Author abstract) 14 refs.

Sikora, W. (Acad of Mining & Metallurgy, Cracow, Pol); Gurin, O.V.; Syromyatnikov, V.N. *J Magn Magn Mater* v 71 n 2 Jan 1988 p 225-234.

**089060 MEAN-FIELD THEORY OF INTERMEDIATE VALENCE/HEAVY FERMION SYSTEMS.** In recent years the class of materials known as intermediate valent, Kondo-lattice or heavy-fermion systems has aroused much interest. The unusual properties of these

materials arise from the behavior of their 4f- (or 5f-) electrons. The strong electron-electron interactions within the 4f shell cause the f-bands of these rare earth or actinide metal containing species to show very high masses. Thus the densities of states are very high, leading to correspondingly high specific heats and magnetic susceptibilities. A mean field theory is described, based on the Anderson lattice model, in which these properties are straightforwardly explained. Its relationship to the  $1/N$  expansion, and the corrections to mean field, are outlined. (Author abstract) 79 refs.

Newns, D.M. (IBM, T.J. Watson Research Cent, Yorktown Heights, NY, USA); Read, N. *Adv Phys* v 36 n 6 Nov-Dec 1987 p 799-849.

## Extraction

**089061 INTERFACIAL EFFECTS IN A MULTI-STAGE MIXER-SETTLER OPERATION.** A pilot-scale mixer-settler with twenty-one stages was used to investigate the interfacial tension change during extraction cycle for the complicated system:  $\text{NdCl}_3\text{-SmCl}_3\text{-EuCl}_3\text{-GdCl}_3\text{-TbCl}_3\text{-DyCl}_3\text{-HCl}$ -1 D2EHPA-kerosene. Interfacial tension, total rare earth (TRE) concentrations in both phases, aqueous acidities, and organic entrainment in the raffinate, etc., were measured for each stage. Murphree stage efficiencies based on organic phase were calculated and related to the interfacial tension profiles. In general, the lower the interfacial tension, the higher the stage efficiency observed. For the extraction section, the stage efficiency ranged from 80 percent - 100 percent, but for stripping (including scrubbing) section, it varied from 100 percent - 15 percent. For high acidic stripping agent, 5 M HCl, the relatively lower stage efficiency might be due to the protonation of the acidic extractant, therefore the interfacial resistance increased significantly. From the information of stage efficiency, mass transfer direction, and interfacial tension versus solute concentration etc., the Marangoni effect could be used to explain the interfacial phenomena of this complicated extraction system. The results of real stream tests in this investigation will be useful in future plant design. (Author abstract). 24 Refs.

Hornig, Jiin-Shiung (Inst of Nuclear Energy Research, Taiwan); Lu, Daluh; Hoh, Ying-Chu. *J Chem Technol Biotechnol* v 42 n 4 1988 p 277-288.

## High Temperature Properties

**089062 HIGH TEMPERATURE BEHAVIOUR OF UNSTABLE  $\text{EuPd}_2\text{Si}_2$  AND REFERENCE  $\text{MPd}_2\text{Si}_2$  COMPOUNDS ( $\text{M} = \text{ALL RARE EARTHS AND ALKALINE EARTHS}$ ).** Thermal behavior and lattice parameters were determined for all  $\text{RPd}_2\text{Si}_2$  compounds together with  $\text{CaPd}_2\text{Si}_2$  and  $\text{SrPd}_2\text{Si}_2$  ( $\text{ThCr}_2\text{Si}_2$ -type) phases. The fluctuating valence system  $\text{EuPd}_2\text{Si}_2$  was investigated in the temperature range 100-800 K. Its lattice constants were compared with those for the reference compounds  $\text{CaPd}_2\text{Si}_2$  and  $\text{GdPd}_2\text{Si}_2$  and the fractional valence was derived at each temperature. Magnetic susceptibility measurements in the same temperature range confirmed the sharp valence change from 2.7 to 2.3 between 150 and 200 K and a room temperature value of 2.27. (Author abstract) 28 refs.

Palenzona, A. (Univ di Genova, Genoa, Italy); Cirafici, S.; Canepa, F. *J Less Common Met* v 135 n 2 Nov 1987 p 185-194.

**Ion Implantation** See GADOLINIUM COMPOUNDS—Magnetic Properties.

**Ionic Conduction** See PHOSPHATES—Ionic Conduction.

**Ionization** See GADOLINIUM COMPOUNDS.

**Low Temperature Effects** See SUPERCONDUCTING MATERIALS—Electronic Properties; SUPERCONDUCTING MATERIALS—Low Temperature Effects.



Low Temperature Properties See INTERMETALLICS—Magnetic Properties.

**Magnetic Properties** See Also CALCIUM COMPOUNDS—Magnetic Properties; GALLIUM COMPOUNDS—Magnetic Properties; INTERMETALLICS—Magnetic Properties; MAGNETIC MATERIALS—Composition Effects; MAGNETIC MATERIALS—Ferromagnetism; MAGNETIC MATERIALS—Magnetic Properties; MAGNETIC MATERIALS—Thermal Effects; SUPERCONDUCTING MATERIALS—Magnetic Properties; SUPERCONDUCTING MATERIALS—Thermal Effects; SUPERCONDUCTIVITY—Analysis.

**089063 ANGULAR DEPENDENCE OF THE COERCIVE FORCE OF TEXTURED RARE EARTH PERMANENT MAGNETS.** On the basis of model calculations experimental results on the angular dependence of the coercivity  $H_c$  and the remanence coercivity  $H_p$  of hard magnetic materials of the type  $\text{SmCo}_5$ ,  $\text{Sm}_2(\text{Co, Fe, Cu, Zr})_{15}$  and  $\text{Nd}_2\text{Fe}_{14}\text{B}$  are discussed. In the model coherent rotation as well as incoherent magnetization jumps (e.g.,  $180^\circ$ -Bloch walls) are included. The texture is described by an axial symmetric distribution of the easy axes with only one parameter. For  $\text{Sm}_2(\text{Co, Fe, Cu, Zr})_{15}$  the model explains irreversible ( $H_R(\theta)$ -curves as well as reversible ( $H_R(\theta) - H_c(\theta)$ ) magnetization processes in good agreement with the experiments, whereas stronger deviations exist for  $\text{SmCo}_5$  and  $\text{Nd}_2\text{Fe}_{14}\text{B}$ , especially in the  $H_R(\theta)$ -curves. These deviations should be caused by other reversible magnetization processes. (Author abstract) 37 refs.

Jahn, L. (Hochschule fuer Verkehrswesen 'Friedrich List', Dresden, East Ger); Elk, K.; Schumann, R. *J Magn Magn Mater* v 68 n 3 Sep 1987 p 335-343.

**089064 DIRECT CALCULATION OF THE ENERGIES OF MAGNETIC STRUCTURES IN COMPOUNDS WITH RKKY EXCHANGE.** The model of indirect exchange interaction of localized spins developed by Ruderman and Kittel, Kasuya and Yoshida on the basis of the s-d model of S.V. Vonsovskiy has proved fruitful in investigation of the magnetic properties of a number of compounds of rare earth metals. The energy of a system of localized magnetic moments interacting via conduction electrons by means of indirect RKKY exchange can be expressed mathematically. The proposed method for improving convergence of the lattice sums gives a simple calculation for the RKKY exchange energy in different magnetic structures. Unlike approximate methods, high accuracy can be obtained and the adequacy of the actual RKKY model in a given compound judged reliably. 9 refs.

Sinityn, Ye.V. (Sverdlovsk Mining Inst, USSR); Reymer, V.A. *Phys Met Metallogr* v 60 n 5 1985 p 172-175.

**089065 ANISOTROPY OF THE MAGNETIZATION AND OF THE IRON HYPERFINE FIELD IN  $\text{R}_2\text{Fe}_{17}$  COMPOUNDS.** A single crystal of the hexagonal  $\text{Y}_2\text{Fe}_{17}$  compound has been prepared. The exact composition,  $\text{Y}_2\text{Fe}_{18.9}$  has been refined through X-ray measurements. A large anisotropy of the magnetization is associated with the large magnetocrystalline anisotropy. Moessbauer experiments have been performed at 4.2 K under high magnetic fields. A large anisotropy of the orbital contribution to the hyperfine field is deduced. This can explain the anomalies of the hyperfine field observed in  $\text{Tm}_2\text{Fe}_{17}$  and  $\text{ErFe}_3$  when magnetization reorientations occur with temperature. (Author abstract) 13 refs.

Averbuch-Pouchot, M.T. (Lab de Cristallographie, Grenoble, Fr); Chevalier, R.; Deportes, J.; Kebe, B.; Lemaire, R. *J Magn Magn Mater* v 68 n 2 Aug 2 1987 p 190-196.

**089066 ON THE TEMPERATURE DEPENDENCE OF THE SUBLATTICE MAGNETIZATIONS IN  $\text{TbCu}_2$ .** Calculations based on molecular and crystal field models were used for the interpretation of the temperature dependence of the sublattice magnetizations found by neutron diffraction in the antiferromagnetic compound  $\text{TbCu}_2$ . The observed dependence is explained as a result of comparable amounts of exchange and crystal field energy in this compound. (Author abstract) 5 refs.

Divis, M. (Charles Univ, Prague, Czech); Zajac, S.; Sima,

V.; Smetana, Z. *J Magn Magn Mater* v 68 n 2 Aug 2 1987 p 253-256.

**089067 MAGNETIC PROPERTIES OF SOME  $\text{RCO}_2\text{B}_2$  AND  $\text{RCO}_4\text{B}_4$  COMPOUNDS.**  $\text{RCO}_2\text{B}_2$  ( $\text{R} = \text{Pr, Nd, Sm, Gd}$ ) and  $\text{RCO}_4\text{B}_4$  ( $\text{R} = \text{Pr, Nd, Sm}$ ) compounds have been investigated by X-ray and magnetometry techniques in the temperature range 4.2-300 K. These compounds crystallize in tetragonal crystal structures of the types  $\text{CeAl}_2\text{Ga}_2$  and  $\text{CeCo}_4\text{B}_4$ , respectively, with lattice parameters decreasing for increasing atomic weight of the rare earth ion. All compounds order magnetically with the Curie temperatures much below room temperature. Anomalous magnetic behavior is observed for  $\text{RCO}_4\text{B}_4$  alloys. (Author abstract) 12 refs.

Jurczyk, M. (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Pedziwiatr, A.T.; Sankar, S.G.; Wallace, W.E. *J Magn Magn Mater* v 68 n 2 Aug 2 1987 p 257-260.

**089068 THERMAL AND MAGNETIC PROPERTIES OF  $\text{TbCl}_3$ .** The specific heat of polycrystalline  $\text{TbCl}_3$  was measured in the temperature range  $1.65 \text{ K} < T < 100 \text{ K}$ . Magnetization and susceptibility of  $\text{TbCl}_3$  were determined on polycrystalline and single crystal samples between  $1.7 \text{ K} < T < 350 \text{ K}$ . Our experimental data show ferromagnetic order of  $\text{TbCl}_3$  below  $T_c = (3.65 \pm 0.03) \text{ K}$ . The magnetic entropy  $S_{\text{mag}}$  lost during ordering as calculated from the specific heat nearly corresponds to  $\ln 2$  indicating the ordering of a  $S = \frac{1}{2}$  magnetic system. In the ordered state the magnetic moment orients along the crystallographic  $a$ -axis. The saturation moment is  $(8.1 \pm 0.1) \mu_B$ . The critical parameters  $S_{\text{mag}}(T_c)$  and  $T_c/\theta$  are determined and compared with theoretical calculations for 3D-Ising magnets. Our results are in best agreement with a previous neutron investigation performed by Murasik et al. (Author abstract) 30 refs.

Kremer, R. (Max-Planck-Institut fuer Festkoerperforschung, Stuttgart, West Ger); Gmelin, E.; Simon, A. *J Magn Magn Mater* v 69 n 1 Oct 1 1987 p 53-60.

**089069 MAGNETIC PROPERTIES OF  $\text{RNi}_2\text{Si}_2$  COMPOUNDS ( $\text{R} = \text{RARE EARTH}$ ).** We report an extensive study of the magnetic properties of tetragonal  $\text{RNi}_2\text{Si}_2$  compounds ( $\text{R} = \text{Pr, Nd, Gd, Tb, Dy, Ho, Er, Tm}$ ), through resistivity, neutron diffraction, susceptibility and magnetization experiments. All compounds exhibit complex incommensurate antiferromagnetic structures, while a transition occurs in  $\text{TbNi}_2\text{Si}_2$  between a modulated phase and a simple antiferromagnetic structure, stable at low temperature. The magnitude of the bilinear exchange interactions deviates from the Gennes law and the direction of the ordered magnetic moments presents anomalies across the series, including the probable existence of other types of interactions between the rare earth ions. (Author abstract) 28 refs.

Barandiaran, J.M. (Univ del Pais Vasco, Lejona, Spain); Gignoux, D.; Schmitt, D.; Gomez Sal, J.C.; Rodriguez Fernandez, J. *J Magn Magn Mater* v 69 n 1 Oct 1 1987 p 61-70.

**089070 EFFECT OF RHODIUM SUBSTITUTION ON THE MAGNETIC PHASE TRANSITIONS IN  $\text{Ho}(\text{Co}_{1-x}\text{Rh}_x)_2$ .** A detailed study has been made of the magnetic properties of the cubic Laves phase compounds  $\text{Ho}(\text{Co}_{1-x}\text{Rh}_x)_2$  with  $x = 0.02; 0.05; 0.08; 0.12; 0.16$  and  $0.25$ ; with particular attention given to the nature of magnetic phase transitions. Pronounced discontinuities are observed at the magnetic ordering temperature of the compounds with  $x < 0.1$ , indicative of a predominantly first order magnetic phase transition. In alloys with  $x > 0.1$  the transition is second order. However, the change from first order to second order is not sudden but gradual. This change in the character of phase transition has been attributed to a reduction in the exchange field acting on cobalt atoms as a result of rhodium substitution. This series has been compared and contrasted with  $\text{Ho}(\text{Co}_{1-x}\text{X}_x)_2$ , where  $\text{X} = \text{Ni}$  and  $\text{Cu}$ . (Author abstract) 10 refs.

Tari, A. (King Fahd Univ of Petroleum & Minerals, Dhahran, Saudi Arabia). *J Magn Magn Mater* v 69 n 3

Nov 1987 p 247-252.

**089071 MAGNETIC AND  $^{57}\text{Fe}$  MOSSBAUER STUDIES OF COLLINEAR SPIN ROTATION IN  $\text{Ho}_2\text{Fe}_{14}\text{B}$ .** Magnetic properties of  $\text{Ho}_2\text{Fe}_{14}\text{B}$  compounds have been studied by the  $^{57}\text{Fe}$  Mossbauer effect and magnetization measurements. The axes of easy and hard magnetizations lie along the  $[001]$  and the  $[100]$  directions in the tetragonal structure, respectively, above  $T_{SC} = 58 \text{ K}$ . From the comparison of the Mossbauer results with the magnetization measurements, it became clear that the Fe and the Ho moments tilt collinearly from the  $c$ -axis to the  $[110]$  direction throughout the temperature range of 4.2-58 K, and the canting angle reaches to  $22^\circ$  at 4.2 K. The Mossbauer spectra are consistently resolved with six subspectra above  $T_{SC}$  and with twelve below  $T_{SC}$ , together with reasonable site-assignments. We have estimated the mean Ho moment at  $10.0 \mu_B$ , using the mean Fe moment of  $2.3 \mu_B$  derived from the average hyperfine field or using the magnetization of  $\text{Y}_2\text{Fe}_{14}\text{B}$  as the Fe-sublattice magnetization of  $\text{Ho}_2\text{Fe}_{14}\text{B}$ . (Author abstract) 23 refs.

Fujita, Akira (Tohoku Univ, Sendai, Jpn); Onodera, Hideya; Yamauchi, Hiroshi; Yamada, Motohiko; Yamamoto, Hisao; Hirotsawa, Satoshi; Sagawa, Masato. *J Magn Magn Mater* v 69 n 3 Nov 1987 p 267-275.

**089072 MAGNETOELASTIC COUPLING AND SPIN REORIENTATION IN  $\text{RECo}_5$  UNIAXIAL MAGNETS ( $\text{RE} = \text{Pr, Dy, Ho}$  AND  $\text{Y}$ ).** II. Magnetostriiction measurements, between approx. 5 and 300 K, of powder aligned samples of the uniaxial compounds  $\text{RECo}_5$  ( $\text{RE} = \text{Pr, Ho, Dy}$  and  $\text{Y}$ ) for strong applied magnetic fields up to 15 T are reported. The strains have been measured, parallel, perpendicular and at  $45^\circ$  from the  $c$ -axis, with the field applied also along these directions. These sets of measurements allow us to determine the six irreducible magnetoelastic coupling constants. Anomalies on the strains, associated with the spin reorientation (SR) regime are observed. The thermal variation of the strains is well explained by the standard magnetostriction model including as ingredients exchange striction and the single-ion anisotropic one, as well as a dependence on the angle of reorientation under field. The point charge model of the crystalline magnetoelastic field is far from agreement with the present results. (Edited author abstract) 42 refs.

del Moral, A. (CSIC, Zaragoza, Spain); Algarabel, P.A.; Ibarra, M.R. *J Magn Magn Mater* v 69 n 3 Nov 1987 p 285-298.

**089073 SPIN GLASS BEHAVIOUR IN THE RARE EARTH TERNARY STANNIDE  $\text{HoRh}_{1-x}\text{Sn}_3$ .** Dynamic susceptibility measurements on  $\text{HoRh}_{1-x}\text{Sn}_3$  have been performed in the vicinity of its magnetic transition at  $T_M = 1.7 \text{ K}$ .  $\chi'(T)$  exhibits a cusp-like peak, which is substantially depressed when an external field of a few mT is applied. Below  $T_M$  a strong frequency dependence of the susceptibility is found. The results are very similar to those of classical spin glass systems. This fact, together with an analysis of the structural disorder present in this compound, indicates also a spin glass behavior for  $\text{HoRh}_{1-x}\text{Sn}_3$ . Results on other phase II ternary stannides as, e.g., the reentrant magnetic superconductor  $\text{ErRh}_{1-x}\text{Sn}_3$  may be interpreted likewise. (Author abstract) 21 refs.

Lazaro, F.J. (Univ de Zaragoza, Zaragoza, Spain); van de Pasch, A.W.M.; Flokstra, J. *J Magn Magn Mater* v 71 n 1 Dec 1987 p 10-16.

**089074 CONDUCTION ELECTRON POLARIZATION EFFECTS IN  $\text{Gd}_{1-x}\text{RE}_x\text{Ag}$  ( $\text{RE} \equiv \text{Y, Lu, La, Er}$ ).** The magnetic susceptibilities of  $\text{Gd}_{1-x}\text{Y}_x\text{Ag}$ ,  $\text{Gd}_{0.5}\text{Lu}_{0.5}\text{Ag}$ ,  $\text{Gd}_{0.5}\text{La}_{0.5}\text{Ag}$  and  $\text{Gd}_{0.5}\text{Er}_{0.5}\text{Ag}$  compounds were measured over a large temperature range. The Curie-Weiss law is obeyed for all investigated samples. The effective magnetic moments per gadolinium atom are higher than the theoretical values. The gadolinium concentration dependence of the excess moment has been



analysed and the best estimate was obtained when the susceptibility of the gadolinium 5d electrons is taken into account. (Edited author abstract) 17 refs.

Szade, J. (Silesian Univ, Katowice, Pol). *J Less Common Met* v 136 n 1 Dec 1987 p 101-109.

**089075 MAGNETIC STRUCTURE CHANGES OBSERVED BY NEUTRON DIFFRACTION IN THE SYSTEM  $TbGe_{1-x}Si_x$  ( $0.4 \leq x \leq 1.0$ ).** Various Si-rich compounds ( $0.4 \leq x \leq 1.0$ ) of the type  $TbGe_{1-x}Si_x$  (CrB-type) were studied by means of neutron diffraction over an extensive temperature range. As a function of temperature and concentration three different magnetically ordered phases were observed. These comprise the commensurate antiferromagnetic structures with propagation vectors  $k=[001/2]$  and  $k=[1/2 \ 0 \ 1/2]$ , and an incommensurate magnetic structure with a propagation vector  $k=[q_x \ 0 \ q_z]$ . For a fixed composition and with increasing temperature the values of  $q_x$  and  $q_z$  were found to decrease and increase, respectively. All transitions between magnetically ordered phases were observed to be of first order. The experimental data obtained in the course of the present investigation, together with those obtained previously, have been used to construct a magnetic phase diagram for the system  $TbGe_{1-x}Si_x$ . (Author abstract) 17 refs.

Schobinger-Papamantellos, P. (ETHZ, Zurich, Switz); Buschow, K.H.J. *J Magn Magn Mater* v 71 n 2 Jan 1988 p 134-146.

**089076 MAGNETIC BEHAVIOR OF  $R_2Fe_{14}B$  HYDRIDES ( $R=Gd, Tb, Dy, Ho$  AND  $Er$ ).**  $R_2Fe_{14}B$  systems, with  $R=Gd, Tb, Dy, Ho$  and  $Er$  were hydrogenated to the composition  $R_2Fe_{14}BH_x$ , where  $x$  ranges from 3.7 to 5.4. The determination of saturation magnetizations  $M_s$ , Curie temperatures  $T_C$ , spin-reorientation temperatures  $T_{SR}$  and anisotropy fields  $H_A$  of the fully hydrogenated  $R_2Fe_{14}B$  systems ( $R$ =a heavy rare earth) is reported. These are compared to the data for the host materials. In addition, the dependence of the lattice dimensions,  $M_s$ ,  $T_C$ ,  $T_{SR}$  and  $H_A$  on hydrogen concentration for two systems, the Gd- and Dy-containing compounds, were established. (Edited author abstract) 18 refs.

Zhang, L.Y. (Carnegie Mellon Univ, Pittsburgh, PA, USA); Pourarian, F.; Wallace, W.E. *J Magn Magn Mater* v 71 n 2 Jan 1988 p 203-211.

**089077 MAGNETIC ANISOTROPY IN THE SYSTEM  $La_2Fe_{14-x}Co_xB$  AND ITS RELATION TO THE SYSTEM  $Nd_2Fe_{14-x}Co_xB$ .** We have studied the system  $La_2Fe_{14-x}Co_xB$  by means of X-ray diffraction, magnetic measurements and singular point detection (SPD) measurements. We present experimental data on the concentration dependence of the lattice constants, Curie temperatures, saturation magnetization and anisotropy fields. Attention is mainly given to the determination of anisotropy fields, which were also studied as a function of temperature in the range from 4.2 K to the corresponding Curie temperatures. The experimental information obtained for the system  $La_2Fe_{14-x}Co_xB$  was used to distinguish the relative anisotropy contributions of the neodymium sublattice and 3d sublattice in  $Nd_2Fe_{14-x}Co_xB$ . (Author abstract) 11 refs.

Groessinger, R. (Univ of Technology, Vienna, Austria); Kirchmayr, H.; Buschow, K.H.J. *J Less Common Met* v 136 n 2 Jan 1988 p 367-373.

**089078 MAGNETIC MOMENTS AND LOW-TEMPERATURE HEAT CAPACITY IN A MAGNETIC FIELD OF SOME  $REPd_3$  COMPOUNDS.** Magnetization measurements on single crystalline  $REPd_3$  ( $RE=Pr, Nd, Dy, Ho$ ) intermetallic compounds in the temperature range 2 to 100 K and for magnetic fields up to 8 T are discussed. Also we present measurements of the molar heat capacity on polycrystalline  $REDd_3$  ( $RE=Pr, Nd, Tb, Dy, Ho, Er$ ) compounds for different magnetic fields in the temperature range 1.5 to 17 K. The experimental results are interpreted in terms of a cubic crystalline electric field using a simple molecular field approximation for the exchange interaction. A comparison of the

reduced crystal field parameters for the  $REPd_3$  compounds shows systematic behavior and supports the physical relevance of the applied Model. (Author abstract) 21 refs.

Drewes, W. (Univ Muenster, Muenster, West Ger); Leson, A.; Schelp, W.; Purwins, H.G. *J Phys F Met Phys* v 18 n 1 Jan 1988 p 137-152.

**089079 FIRST ORDER MAGNETIZATION PROCESS IN  $Pr_2Fe_{14}B$  SINGLE CRYSTAL.** High-field magnetization process in  $Pr_2Fe_{14}B$  single crystal has been studied in static magnetic fields up to 230 kOe. The spontaneous magnetization is along the [001] direction of the tetragonal structure down to 1.5 K. When the field is applied along the [100] and [110] directions at low temperatures, magnetization jumps are observed at about 130 kOe and 160 kOe, respectively, which are considered to correspond to the first order magnetization process (FOMP). Observed features of the magnetization curves including FOMP and their temperature dependence are well reproduced by the calculations based on a simplified Hamiltonian. (Edited author abstract) 11 refs.

Hiro Yoshi, H. (Tohoku Univ, Sendai, Jpn); Kato, H.; Yamada, M.; Saito, N.; Nakagawa, Y.; Hirose, S.; Sagawa, M. *Solid State Commun* v 62 n 7 May 1987 p 475-478.

**089080 EFFECT OF  $Dy$  AND  $Co$  SUBSTITUTIONS ON THE SPIN-REORIENTATION PHENOMENA IN  $Tm_2Fe_{14}B$  ALLOYS.** Partial substitution of Fe by Co atoms (up to  $x=4$ ) in  $Tm_2Fe_{14-x}Co_xB$  alloys results in an increase of spin-reorientation temperature. This is believed to be due to a change in the magnetocrystalline anisotropy from a plane to an easy axis with increasing temperature. In contrast, gradual replacement of Tm by Dy results in a marked decrease in the spin-reorientation temperature. This is attributed to the stronger crystal field interaction in Dy-rich systems. Both Co and Dy substitutions in  $Tm_2Fe_{14}B$  enhance the magnetic ordering temperature. A magnetic phase diagram is proposed on the basis of results obtained in this study. (Author abstract) 15 refs.

Pourarian, F. (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Jiang, S.Y.; Sankar, S.G.; Wallace, W.E. *Solid State Commun* v 63 n 12 Sep 1987 p 1119-1121.

**089081 CRYSTAL STRUCTURE AND MAGNETIC PROPERTIES OF  $RE_2In$  COMPOUNDS.** This paper reports on the structural and magnetic properties of the binary compounds  $RE_2In$  ( $RE \equiv Ce, Nd, Gd, Tb, Dy, Ho, Er$ ) measured by X-ray diffraction and magnetometry. The crystal structure of  $RE_2In$  compounds is hexagonal and of the  $Ni_2In$  type. For these compounds, the chemical bonding is analyzed taking into account the interatomic contacts controlling the cell dimensions. The results of magnetometric measurements show that the samples are ferromagnetic, except  $Ce_2In$  and  $Er_2In$  which are paramagnetic. The magnetic properties of  $RE_2In$  compounds are discussed. (Edited author abstract) 5 refs.

Bazela, W. (Politechniki Krakowskiej, Cracow, Pol); Szytula, A. *J Less Common Met* v 138 n 1 Mar 1988 p 123-128.

**089082 X-RAY EXAMINATION, ELECTRICAL AND MAGNETIC PROPERTIES OF  $R_3Co$  SINGLE CRYSTALS ( $R \equiv Y, Gd, Dy$  AND  $Ho$ ).** Single crystals of  $Y_3Co$ ,  $Gd_3Co$ ,  $Dy_3Co$  and  $Ho_3Co$  were obtained by the Czochralski method from a levitated melt. A description of the crystal growth technology is given. The crystal quality was examined by X-ray methods. Electrical resistivity and magnetic susceptibility have been measured.  $Y_3Co$  exhibits Curie-Weiss behavior with  $\mu_{eff} = 1 \mu_B$  (formula unit)<sup>-1</sup>. It is the first evidence for the existence of a magnetic moment on cobalt atoms in such a low concentration region.  $Gd_3Co$ ,  $Dy_3Co$  and  $Ho_3Co$  show an effective moment that is enhanced by  $1 \mu_B$  relative to the theoretical value for  $R_3Co$ , assuming that only the  $R^{3+}$  ions contribute a magnetic moment equal to the free ion value. (Edited author abstract) 12 refs.

Talik, E. (Univ of Silesia, Katowice, Pol); Szade, J.; Heiman, J.; Winiarska, A.; Winiarski, A.; Chelkowski, A.

*J Less Common Met* v 138 n 1 Mar 1988 p 129-136.

**089083 X-RAY, ELECTRICAL, MAGNETIC AND PRESSURE EXPERIMENTS ON  $RIn$  ( $R \equiv Y, Gd, Tb, Dy, Ho$  AND  $Er$ ).** YIn, GdIn, TbIn, DyIn, HoIn and ErIn were obtained in the form of polycrystalline samples. X-ray examinations were performed. A pressure-induced structural transformation was observed. The magnetic susceptibility was measured up to 1000 K and the magnetic effective moments and  $\theta$  values were determined. Electrical measurements of GdIn, ErIn and YIn were carried out and the magnetic resistivities were estimated. The problems of the crystal structure of RIn were discussed. (Author abstract) 15 refs.

Talik, E. (Univ of Silesia, Katowice, Pol); Heimann, J.; Chelkowski, A. *J Less Common Met* v 138 n 1 Mar 1988 p L15-L19.

**089084 MAGNETIZATION AND SUSCEPTIBILITY STUDIES OF  $LaCu_{4.3}Mn_{0.7}$ .** AC-susceptibility and magnetization measurements of  $LaCu_{4.3}Mn_{0.7}$  below 60 K are reported. The susceptibility resembles an ordering of ferromagnetic-type to occur at 49 K. The magnetization shows that only 1% of the total manganese moment participates in this ordering. (Author abstract) 7 refs.

Kosiorowska, J. (Inst of Nuclear Physics, Cracow, Pol); Van Noort, D.; Bajorek, A.; Van Duynveldt, A.J. *Physica B & C* v 147 n 2-3 Jan-Feb 1988 p 316-318.

**089085 MAGNETOCRYSTALLINE ANISOTROPY OF  $R_2Fe_{14}B$ ,  $R = Dy, Ho, Gd$ , MEASURED USING HIGH FIELD TORQUE MAGNETOMETRY.** Values are presented of uniaxial magnetocrystalline anisotropy constants, calculated from torque measurements for  $R_2Fe_{14}B$ ,  $R = Dy, Ho$  and  $Gd$ , from 4.2 K to room temperature. The basal plane anisotropy calculated from torque measurements for  $Gd_2Fe_{14}B$  from 100 to 300 K is also reported. These anisotropy results are related qualitatively to the crystal structure and electronic structure of the rare earth ions. (Author abstract) 8 refs.

Hawton, M.J. (Univ of Durham, Durham, Engl); Corner, W.D. *J Magn Magn Mater* v 72 n 1 Mar 1988 p 52-58.

**089086 MAGNETIC DOMAINS AND DOMAIN WALL ENERGIES IN RARE EARTH-IRON-BORON INTERMETALLICS.** Using the Bitter technique magnetic domain structures have been observed in single crystals of  $Gd_2Fe_{14}B$  and  $Dy_2Fe_{14}B$  and in large grains of  $Nd_2Fe_{14}B$  and  $Ho_2Fe_{14}B$ . By measuring the spacing  $W_1$  of domain boundaries on surfaces perpendicular to the easy c-axis values of domain wall energy  $\gamma$  have been obtained using the technique of Bodenberger and Hubert. Calculations of  $\gamma$  using measured magnetic parameters are in reasonable agreement with those observed except for the Gd compound. It is suggested that in this case the Bodenberger and Hubert model may not be valid. Changes of domain patterns have been observed throughout a complete hysteresis cycle. Examples for  $Nd_2Fe_{14}B$  are shown and the relevance of these observations to the behaviour of magnets made from this material is discussed. (Author abstract) 13 refs.

Corner, W.D. (Univ of Durham, Durham, Engl); Hawton, M.J. *J Magn Magn Mater* v 72 n 1 Mar 1988 p 59-66.

**089087 ELECTRORESISTANCE OF A SINGLE CRYSTAL  $ErRh_4B_4$  IN THE FERROMAGNETIC PHASE.** Recently Genicon et al. have observed a strong dependence of the resistance on the applied magnetic field  $H$  in the ferromagnetic phase of the reentrant superconductor  $ErRh_4B_4$ . Interpretation of a sharp change in the resistance under magnetization observed for a single crystal of  $ErRh_4B_4$  is suggested on the basis of peculiarities of the conduction electron motion in the vicinity of domain walls. 9 refs.

Zakharov, Yu.V. (Kirensky Inst of Physics, Krasnoyarsk, USSR); Mankov, Yu.I.; Titov, L.S. *J Magn Magn Mater* v 72 n 1 Mar 1988 p 114-116.



**089088 MAGNETIC AND CRYSTALLOGRAPHIC PROPERTIES OF TERNARY RARE-EARTH COMPOUNDS OF THE TYPE  $R_2Fe_{14}C$ .** Ternary tetragonal compounds of the composition  $R_2Fe_{14}C$  were observed for  $R=Nd, Sm, Gd, Tb, Dy, Ho, Er, Tm$  and  $Lu$ . The lattice constants of these compounds were determined. Also determined were the magnetic properties, comprising the temperature dependence of the magnetization in the range 4.2–700 K and the field dependence of the magnetization at 4.2 K in fields up to 35 T. These latter measurements were made on magnetically-aligned powders with the field parallel and perpendicular to the alignment direction, making it possible to determine the anisotropy fields. The magnetocrystalline anisotropy, consisting of contributions due to the Fe and rare-earth sublattice, was found to be of comparable magnitude in  $R_2Fe_{14}C$  and  $R_2Fe_{14}B$ . (Author abstract) 15 refs.

De Boer, F.R. (Univ of Amsterdam, Amsterdam, Neth); Zhang, Zhi-dong; De Mooij, D.B.; Buschow, K.H.J.; Huang, Yin-kai. *J Magn Magn Mater* v 72 n 2 Apr 1 1988 p 167-173.

**089089 MAGNETIC STRUCTURE AND PROPERTIES OF EQUIATOMIC RARE EARTH GERMANIDES.** Magnetic measurements were made on the compounds  $EuGe$ ,  $DyGe$  and  $TmGe$ . The first two compounds order antiferromagnetically at 20 K and 37 K respectively. For  $TmGe$  antiferromagnetic ordering is observed below 4.2 K. The magnetic structure of orthorhombic  $DyGe$  was investigated by neutron diffraction and shown to be antiferromagnetic with propagation vector  $k=[00\frac{1}{2}]$ . The magnetic properties of all RGe compounds ( $R$ =rare earth metal) are reviewed. It is shown that the magnetic coupling constant changes from positive to negative as the RGe series is passed through. (Author abstract) 15 refs.

Buschow, K.H.J. (Philips Research Lab, Eindhoven, Neth); Schobinger-Papamantellos, P.; Fischer, P. *J Less Common Met* v 139 n 2 May 1988 p 221-231.

**089090 CRYSTAL GROWTH, IR AND RAMAN SPECTRA, THERMAL DECOMPOSITION AND MAGNETIC PROPERTIES OF  $KLn(CrO_4)_2$  ( $Ln=Pr, Nd, Sm$ ).** The double chromates of formula  $KLn(CrO_4)_2$  ( $Ln=Pr, Nd, Sm$ ) were prepared as single crystals by hydrothermal synthesis from the oxides  $Pr_6O_{11}$ ,  $Nd_2O_3$  and  $Sm_2O_3$  respectively and  $K_2Cr_2O_7$  solution at 150°C in sealed tubes. These compounds were also obtained as microcrystalline powders in the above-mentioned hydrothermal process and by solid reaction of the oxides  $Pr_6O_{11}$ ,  $Nd_2O_3$  and  $Sm_2O_3$  with  $KNO_3$  at 450°C. These materials are isostructural with  $KLa(CrO_4)_2$  which crystallizes in the monoclinic system with space group  $P2_1/c$  and  $Z=4$ . Crystallographic data, IR and Raman spectra, thermal decomposition and magnetic properties of these compounds were studied. (Author abstract) 18 refs.

Bueno, I. (Univ Complutense, Madrid, Spain); Garcia, O.; Parada, C.; Saez Puche, R. *J Less Common Met* v 139 n 2 May 1988 p 261-271.

**089091 MAGNETIC PROPERTIES OF RARE EARTH DISILICIDES  $RSi_2$ .** The magnetic properties of the rare earth disilicides ( $RSi_2$ ) have been re-investigated. We confirm the occurrence of ferromagnetism in  $PrSi_2$  and antiferromagnetism in  $GdSi_2$ ,  $TbSi_2$  and  $HoSi_2$ .  $NdSi_2$  orders at  $T_N = 10$  K and  $ErSi_2$  orders at  $T_C = 4.5$  K. Crystal field effects are important throughout the entire series. (Author abstract) 10 refs.

Pierre, J. (CNRS, Grenoble, Fr); Slaud, E.; Frachon, D. *J Less Common Met* v 139 n 2 May 1988 p 321-329.

**089092 STRUCTURE AND MAGNETIC PROPERTIES OF THE  $LaCo_5P_5$ -TYPE COMPOUNDS  $PrCo_5P_5$  AND  $EuCo_5P_5$ .** The new compounds  $PrCo_5P_5$  and  $EuCo_5P_5$  were prepared by reaction of the elemental components in a tin flux. They crystallize with the  $LaCo_5P_5$ -type structure, which was refined for  $EuCo_5P_5$  from single-crystal X-ray diffractometer data to a residual of  $R=0.028$  for 4881 structure factors and 48 variable parameters.  $LaCo_5P_5$  is Pauli paramagnetic.  $PrCo_5P_5$  and

$EuCo_5P_5$  exhibit Curie-Weiss behavior with magnetic moments corresponding to those of  $Pr^{3+}$  and  $Eu^{2+}$  and paramagnetic Curie temperatures  $\theta$  of 20 K and 6 K respectively. (Edited author abstract) 17 refs.

Rechuis, M. (Univ Muenster, Muenster, West Ger); Jeitschko, W.; Moersen, E.; Mueller-Warmuth, W. *J Less Common Met* v 139 n 2 May 1988 p 359-369.

**089093 CRYSTALLINE ELECTRIC FIELD EFFECTS IN THE MAGNETIC PROPERTIES OF HEXAGONAL PRASEODYMIUM COMPOUNDS.** The high field magnetization and the magnetic susceptibility of hexagonal praseodymium compounds are calculated on the basis of a molecular field Hamiltonian, including the CEF potential, a Zeeman term, and isotropic exchange interactions. At low temperatures it is shown that the full magnetic moment of the  $Pr^{3+}$  ion is always reached in a stepwise manner for a magnetic field applied along the c-axis. Perpendicular to the c-axis this occurs only in the case of a  $\Gamma_4$  ground state. This is a pure CEF effect, resulting from the crossing of the ground state by an excited state with a higher magnetic moment. The temperature dependence of the magnetic susceptibility would have a maximum corresponding to an appreciable population of an excited state with a greater magnetic moment. Some hexagonal Pr compounds are considered in which the discussed effects are or should be observable. (Author abstract) 13 refs.

Mrachkov, J. (Georgi Nadjakov Inst of Solid State Physics, Sofia, Bulg); Leyarovski, E. *Physica B & C* v 150 n 3 Jun 1988 p 404-413.

**089094 EFFECT OF SUBSTITUTION OF Al AND Mo ON THE MAGNETIC PROPERTIES OF  $R_2Fe_{12-x}T_xCo_2B$  ( $R$ = SYNTHETIC MISCHMETAL, DIDYMIUM AND NEODYMIUM).** Effect of a small amount of Al and Mo on the crystallographic and magnetic properties of Co-doped  $R_2Fe_{14}B$  has been studied on the  $MM_2Fe_{12-x}T_xCo_2B$  and Didymium  $Fe_{12-x}T_xCo_2B$  systems. All of the alloys studied crystallize in the tetragonal  $Nd_2Fe_{14}B$  structure. The unit cell volume is found to decrease by substituting iron by aluminum and increase when iron is replaced by molybdenum. All the substitutions performed result in an increase of the anisotropy field. The Curie temperatures and saturation moments decrease. For example, in Didymium  $Fe_{12-x}T_xCo_2B$  at room temperature,  $H_A=89$  kOe,  $M_s=31.4 \mu_B$  and  $T_C=701$  K. (Author abstract). 3 Refs.

Jurczyk, M. (Polish Acad of Sciences, Poznan, Pol). *J Magn Magn Mater* v 73 n 2 Jun 1988 p 199-204.

**089095 SINGLE-CRYSTAL MAGNETIC SUSCEPTIBILITY AND CRYSTAL-FIELD INVESTIGATION OF TERBIUM PHOSPHATE IN THE TETRAGONAL PHASE.** The dc magnetic susceptibility of  $TbPO_4$  in the tetragonal phase has been measured from room down to liquid nitrogen temperatures for external field orientations both perpendicular and parallel to the c-axis. A fairly good theoretical explanation of the magnetic behavior of  $Tb^{3+}$  in  $TbPO_4$  observed by us and other workers over a wide range of temperature (300–4 K) was obtained using the revised crystal field and taking the internal field through mean-field approach. The electronic heat capacity is computed which shows two Schottky anomalies one at approximately 10 K and the other at approximately 55 K in partial agreement with available experimental information. The interaction of the nuclear spin with the electric field gradient and the hyperfine magnetic field is studied; an anomaly in the nuclear heat capacity is located at approximately 70 mK. (Edited author abstract). 28 Refs.

Sen, Harabhusan (Burdwan Univ, West Bengal, India); Wanklyn, B.M.; Neogy, D. *J Magn Magn Mater* v 73 n 2 Jun 1988 p 221-228.

**089096 HIGH FIELD MAGNETIZATION OF  $R_2Fe_{14}B$  COMPOUNDS MEASURED UP TO 55 T.** Magnetic field induced spin reorientation was studied in  $R_2Fe_{14}B$  ( $R=Nd, Tm$  and  $Er$ ) single crystals up to 55 T

under pulsed high magnetic fields and also up to 23 T by means of a hybrid magnet. The incipient stage of the transition from ferri- to ferromagnetism was clearly observed in the magnetization curve along the [100] and [110] directions in  $Er_2Fe_{14}B$  and  $Tm_2Fe_{14}B$  crystals. The transition fields were roughly estimated to be 70 T and 55 T along the [100] direction for Er and Tm compounds, respectively. The forced spin reorientation transition was measured in  $Nd_2Fe_{14}B$  crystal along the [100] direction at various temperatures. A steep increase of magnetization appeared at 200 K with decreasing temperature. The magnetization processes were also measured along several directions within the c-plane. When the field direction approached [110], the distinct transition diminished. 11 refs.

Kido, G. (Tohoku Univ, Sendai, Jpn); Kajiwara, S.; Nakagawa, Y.; Hirotsawa, S.; Sagawa, M. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3107-3109.

**089097 IMPROVEMENT IN MAGNETIC PROPERTIES OF  $(Sm, Pr)Co_{4.6}$  ALLOYS BY A CCIA TREATMENT.** A CCIA (controlled cooling and isothermal aging) treatment was adopted to check the reproducibility problem of  $(Sm, Pr)Co_{4.6}$  presented by M. Velicescu (1982) and to improve the magnetic properties of  $(Pr_xSm_{1-x})Co_{4.6}$  alloys. It was shown that controlled cooling rate between sintering and isothermal aging temperatures profoundly affects the scattering of magnetic property data. By this CCIA treatment the composite  $(Sm, Pr)Co_{4.6}$  alloy was shown to preserve merits of both  $SmCo_5$  and  $PrCo_5$  alloys. 9 refs.

Chen, Swe-Kai (ITRI, China); Heh, Shiang-Jiun; Jin, Fu-Teh. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1635-1637.

**089098 STRUCTURAL AND MAGNETIC PROPERTIES OF  $R_2Fe_{14}BH_x$ .** The properties of  $R_2Fe_{14}B$ -series high-performance permanent magnets are shown to have basic characteristics very sensitive to hydrogen absorption. The cell parameters, Curie temperature, magnetization, anisotropy constants, and coercivity vary nonlinearly with the hydrogen content. Moreover, it is shown how hydrogen absorption can be used as a tool to obtain a better understanding of the possible mechanisms that drive the spin reorientation phenomena. 24 refs.

Fruchart, D.; Pontonnier, L.; Vaillant, F.; Bartolome, J.; Fernandez, J.M.; Puertolas, J.A.; Rillo, C.; Regnard, J.R.; Yaouanc, A.; Fruchart, R.; Heritier, P.L. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1641-1643.

**089099 MICROSTRUCTURE AND MAGNETIC PROPERTIES OF  $Tb-Dy-Fe_{1.9}$ .** Materials of the composition  $Tb_xDy_{1-x}Fe_{1.9}$  ( $x=0.27, 0.3$ , and  $0.5$ ), have been prepared by a contained float-zone growth technique. These materials have been found to exhibit magnetostrictive strains greater than 1000 microstrain with magnetomechanical coupling coefficients on the order of 0.6. Microstructural investigations have highlighted the complex relationship between the magnetic domain structure and the inherent defect structure of the materials. All alloys were prepared using sublimed-quality rare earth metals and spec-pure iron. Microstructure observations were carried out using both optical and electron microscopes. The strain measurements were made using conventional techniques. The measurement of the magnetomechanical coupling coefficient ( $k_{33}$ ) was carried out using a resonance method. 7 refs.

Jenner, A.G.I. (Univ of Salford, Engl); Lord, D.G.; Faunce, C.A. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1865-1867.



**089100 VARIATIONS IN TEMPERATURE COEFFICIENT OF ANISOTROPY AND COERCIVITY IN FINE PARTICLES OF Nd<sub>2</sub>Fe<sub>14</sub>B TYPE RECORDING MATERIALS THROUGH SUBSTITUTIONS.** A theoretical and experimental study is reported on how to modify the temperature dependence of coercivity,  $H_c(T)$ , in  $R_2Fe_{14}B$  type compounds ( $R$  = rare earth) through modifications of the temperature dependence of anisotropy field,  $H_A(T)$ . This is accomplished by partial substitutions on R sites. Experimentally it is found that for  $Y_2Fe_{14}B$  fine particles (approx. 1- $\mu$ m), values of  $H_c$  are in the range of 1 kOe. For these materials, a slightly positive  $H_c(T)$  is obtained near 300 K. Stable  $H_A(T)$  and  $H_c(T)$  near 300 K are obtained, e.g., with  $Nd_{0.2}Y_{0.8}Fe_{14}B$ , while strongly increasing  $H_A(T)$  and  $H_c(T)$  are obtained with small substitutions of Er for Y in  $Y_2Fe_{14}B$ . More complex  $H_A(T)$  and  $H_c(T)$  can be obtained in more complex systems. 7 refs.

Higgins, B.E. (Univ of California at San Diego, La Jolla, CA, USA); Oesterreicher, H. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1880-1882.

**089101 MAGNETOCRYSTALLINE ANISOTROPY OF SOME  $R_2Fe_{14}B$ -BASED QUASITERMINARY COMPOUNDS.** A study is presented of the magnetocrystalline anisotropy of the quasiternary systems  $(Pr_{1-x}Er_x)_2Fe_{14}B$  and  $(Pr_{1-x}Sm_x)_2Fe_{14}B$  in which, with increasing  $x$ , the easy-magnetization direction changes from easy axis to easy plane. Magnetization measurements on samples aligned magnetically at room temperature have been carried out in fields up to 20 T at temperatures ranging from 4.2 K to room temperature. The data of the easy-axis compounds are analyzed in terms of the anisotropy constants up to sixth-order, taking into account the misalignment of the grains in the magnetically-aligned samples. Special emphasis is given to the influence of the Sm and Er substitutions on the first-order magnetization process and the anisotropy energy of  $Pr_2Fe_{14}B$ . 13 refs.

Yang, Fu-ming (Univ of Amsterdam, Neth); Zhao, Ru-Wen; Li, Xin-Wen; Huang, Ying-Kai; de Boer, F.R.; Radwanski, R. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1945-1947.

**089102 MAGNETIC INSTABILITIES IN THE RARE EARTH-3d COMPOUNDS.** Due to the evolution of the band structure through the series, the rare earth R-3d metal compounds form outstanding tools for the study of the 3d and/or 4f magnetic instabilities. Such instabilities are illustrated in this paper for three types of systems: i) the Y-Ni system with a special emphasis on the 'thermal spontaneous magnetization' observed in  $Y_2Ni_7$ ; ii) the R-Co system where 'collective electron metamagnetism' and Co antiferromagnetism are observed in the  $RCO_2$  (as in  $ThCo_2$ ), and in  $La_2Co_{1.7}$  and  $La_2Co_3$ , respectively; iii) the Ce-Ni system where the 4f instability is quite characteristic in the CeNi intermediate valence compound in which large magnetovolume effects were determined. (Author abstract) 21 refs.

Gignoux, D. (CNRS, Grenoble, Fr). *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 81-87.

**089103 STABILITY OF Mn MOMENTS AND SPIN FLUCTUATIONS IN  $RMn_2$  (R: RARE EARTH).** On the basis of the results of thermal expansion and NMR measurements, the stability of Mn moments and spin fluctuations in  $RMn_2$  are discussed. It has been shown that the interatomic distance of  $RMn_2$  plays a crucial role in determining the Mn magnetism in  $RMn_2$ . (Author abstract) 5 refs.

Wada, H. (Kyoto Univ, Kyoto, Jpn); Nakamura, H.; Yoshimura, K.; Shiga, M.; Nakamura, Y. *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 134-136.

**089104 NMR STUDY OF HYPERFINE INTERAC-**

**TIONS IN  $R_{1-x}Lu_xFe_2$  ( $R$  = Gd, Tb).** Spin-echo NMR measurements on  $^{155}Gd$ ,  $^{159}Tb$  and  $^{175}Lu$  have been done for the cubic Laves phase compounds  $Gd_{1-x}Lu_xFe_2$  and  $Tb_{1-x}Lu_xFe_2$ . The observed hyperfine fields of Gd and Lu in those compounds increase with increasing Lu concentration. The concentration dependence of the Lu hyperfine field is qualitatively discussed. (Author abstract) 14 refs.

Shimizu, K. (Toyama Univ, Toyama, Jpn). *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 178-180.

**089105 LOW TEMPERATURE MAGNETIC ANISOTROPY OF THE  $RRh_2Si_2$  SYSTEM (R: RARE EARTH ELEMENTS).** The magnetic anisotropy of  $RRh_2Si_2$  which has an AFI type magnetic structure can be explained well using a single  $R^{3+}$  ion Hamiltonian which includes the crystal field term and the isotropic exchange term under the two dimensional molecular field approximation, when appropriate crystal field parameters are adopted. (Author abstract) 8 refs.

Takano, Y. (Nihon Univ, Tokyo, Jpn); Ohhata, K.; Sekizawa, K. *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 242-244.

**089106  $^{55}Mn$  NUCLEAR MAGNETIC RESONANCE STUDIES IN  $RMn_2Ge_2$  ( $R$  = RARE EARTHS).** The  $^{55}Mn$  NMR in  $RMn_2Ge_2$  ( $R$  = La, Nd and Gd) were observed as a function of temperature. In Nd and Gd compounds the  $^{55}Mn$  NMR frequencies exhibit anomalous temperature dependence owing to the effects of rare earth sublattices. The ordering temperatures of the Nd and Gd sublattices are found to be 30 and 95 K, respectively. (Author abstract) 4 refs.

Hiraoka, K. (Hiroshima Univ, Hiroshima, Jpn); Hihara, T.; Shigeoka, T.; Fujii, H.; Okamoto, T. *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 255-257.

**089107 SUBLATTICE MAGNETIZATION AND MAGNETIZATION PROCESS IN  $TbCu_2$ .** The  $TbCu_2$  compound exhibits antiferromagnetism and has two nonequivalent Tb sites below 54 K ( $= T_N$ ). The magnetization for the a-axis increases discontinuously at critical field and saturates at high fields. The magnetization process and magnetic moments have been analyzed in terms of the molecular field theory including the crystal-field interaction. (Author abstract) 3 refs.

Iwata, N. (Yamaguchi Univ, Yamaguchi, Jpn); Kimura, T.; Shigeoka, T.; Hashimoto, Y. *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 279-281.

**089108 HYPERFINE FIELD AT IMPURITY  $^{156}Gd$  NUCLEI IN  $TbT_2$  AND  $TbT_3$  COMPOUNDS ( $T$  = Fe AND Co).** The time integral  $\gamma$ - $\gamma$  perturbed angular correlation has been measured on  $^{156}Gd$  nuclei in  $TbFe_2$ ,  $TbFe_3$ ,  $TbCo_2$  and  $TbCo_3$  compounds. An obvious correlation is indicated between the hyperfine fields at Gd and Tb nuclei in corresponding compounds, and experimental results are discussed. (Author abstract) 13 refs.

Shinohara, T. (Tohoku Univ, Sendai, Jpn); Furusawa, A.; Hayashibe, S.; Kanazawa, M.; Sato, M. *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 282-284.

**089109 Co QUASI-UNIDIMENSIONAL STAKING VERSUS MAGNETISM IN THE  $RCo_{1-x}E$  INTERMETALLIC ( $R$  = La, Pr, Nd).** The  $RCo_{1-x}E$  intermetallic compounds crystallize in a simple but original crystallographic structure characterized by a quasi-linear staking of the cobalt atoms. Using the property of the lanthanides contraction the coherence of the Co chains has been studied with La, Pr, Nd and some pseudobinary compounds. In connection with this peculiar crystallographic structure the Co magnetism in these  $RCo_{1-x}E$  compounds

has also been studied. While  $LaCo_{1-x}E$  exhibits a basal plane triangular anti-ferromagnetic structure under a Neel temperature of 146 K, a collinear ferromagnetic structure is observed in  $PrCo_{1-x}E$  and  $NdCo_{1-x}E$  with a Curie temperature of 142 and 202 K, respectively. Within a chain the arrangement of the Co moments is ferromagnetic in all the three compounds. The antiferromagnetism of  $LaCo_{1-x}E$  is explained through the strong hybridization between the Co 3d electrons and the La 5d electrons. (Edited author abstract)

Ballou, R. (CNRS, Grenoble, Fr); Gignoux, D.; Lemaire, R.; Schweizer, J. *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 288.

**089110 MAGNETIC PROPERTIES OF  $TbCu_4Pd$  AND  $TbCu_4Pt$ .** Magnetizations of  $TbCu_4Pd$  and  $TbCu_4Pt$  with cubic structures have been measured from 4.2 to 300 K. The Curie temperature of  $TbCu_4Pd$  is obtained to be 76 K with the asymptotic Curie temperature  $\theta_p = 79$  K. For  $TbCu_4Pt$ ,  $\theta_p$  is 34 K. The results are discussed in terms of the RKKY theory. (Author abstract) 7 refs.

Abe, S. (Tohoku Univ, Sendai, Jpn); Kaneko, T.; Yamauchi, H.; Yoshida, H.; Nakazawa, H.; Kamigaki, K. *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 289-290.

**089111 MAGNETIC CHARACTERISTIC OF A SINGLE CRYSTAL  $TbNi_3$  COMPOUND.** Measurement of magnetization and susceptibility on  $TbNi_3$  single crystal have been carried out. The compound exhibits the canted spin structure, in which the direction of magnetic moment changes from b-c and a-b-plane in the sequence of increasing temperature. The magnetization curve at 4.2 K was investigated by the molecular field theory. (Author abstract) 3 refs.

Hashimoto, Yuzo (Fukuoka Univ of Education, Fukuoka, Jpn); Fujii, Hironobu; Okamoto, Tetsuhiko; Makiyama, Yoshikazu. *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 291-293.

**089112 NUCLEAR MAGNETIC RESONANCE STUDY OF  $RCO_5$  ( $R$  = Y, Ce, Pr, Nd, Sm, Gd, Tb, Dy AND Ho).** The nuclear magnetic resonance of  $^{59}Co$  nuclei in magnetic domains of  $RCO_5$  ( $R$  = Y, Ce, Pr, Sm, Gd, Tb, Dy and Ho) has been measured under external fields up to about 55 kOe at 4.2 K. To assign the observed NMR signals to each Co site, the  $^{59}Co$  nuclear magnetic resonance of  $R(Co_{1-x}Ni_x)_2$  has also been measured under the same conditions. The results of NMR studies show that the orbital contribution to the  $^{59}Co$  hyperfine field is very large at the 2c site in  $RCO_5$ . (Author abstract) 4 refs.

Yoshie, H. (Shinshu Univ, Matsumoto, Jpn); Ogino, K.; Nagai, H.; Tsujimura, A.; Nakamura, Y. *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 303-305.

**089113 PRECISION DETERMINATION OF MAGNETOCRYSTALLINE ANISOTROPY CONSTANTS IN  $R_2Fe_{14}B$  INTERMETALLIC COMPOUNDS.** An effective method has been proposed based on least mean squares fitting calculations combined with a digital data processing technique to determine the magnetocrystalline anisotropy constants in high energy product permanent magnet materials,  $R_2Fe_{14}B$ , from torque curve measurements. The magnetization process has also been discussed based on the torque data. (Author abstract) 10 refs.

Ono, F. (Okayama Univ, Okayama, Jpn); Ohtsu, Y.; Yamada, O. *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 319-321.



**089114 CRYSTAL FIELD THEORY OF MAGNETISM IN  $R_2Fe_{14}B$ .** A systematic study of the spin structure and magnetization process in a series of  $R_2Fe_{14}B$  ( $R$ : rare earth ion) compounds has been made using a combined crystalline electric field (CEF) and molecular field approximation. For the compounds of heavy  $R$ , experimental results are explained almost satisfactorily in terms of the same set of parameters of CEF and molecular field. (Author abstract) 5 refs.

Yamada, M. (Tohoku Univ, Sendai, Jpn); Kato, H.; Hiroyoshi, H.; Yamamoto, H.; Nakagawa, Y. *J Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 328-330.

**089115 MAGNETIC PROPERTIES OF  $R_2Co_{14}B$  COMPOUNDS ( $R = La, Nd, Gd$ ).** From magnetization measurements on single crystals of  $R_2Co_{14}B$  ( $R = La, Nd$  and  $Gd$ ), the values of magnetic moments for the  $Co$  and  $R$  ions and anisotropy constants have been estimated. The difference of the anisotropy constants between  $R_2Co_{14}B$  and  $R_2Fe_{14}B$  compounds is discussed from the experimental results. (Author abstract) 5 refs.

Yamauchi, H. (Tohoku Univ, Sendai, Jpn); Yamamoto, H.; Hirose, H.; Sagawa, M. *J Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 340-342.

**089116 MAGNETIC PROPERTIES OF  $R_2(Fe, Co, Al)_{14}B$  COMPOUNDS WHERE  $R = Pr$  AND  $Nd$ .** The results of magnetic measurements performed on  $Pr_2Fe_{14-x-y}Co_yAl_yB$  and  $Nd_2Fe_{14-x-y}Co_yAl_yB$  alloys having  $x \leq 7$  and  $y \leq 0.7$  are reported. In addition to cobalt, the small aluminum content leads to materials having high Curie temperatures and anisotropy fields. The magnetic properties of the above systems are analyzed in correlation with the crystal structure. (Author abstract) 9 refs.

Burzo, E. (Central Inst of Physics, Bucharest, Rom); Plugaru, N.; Pop, V. *J Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 343-344.

**089117 HIGH FIELD MAGNETIZATION MEASUREMENTS ON  $Tb_2Fe_{14}$  AND  $Er_2Fe_{14}B$  SINGLE CRYSTALS.** High field magnetization measurements between 4.2 and 275 K have been performed on single crystals of  $Tb_2Fe_{14}$  and  $Er_2Fe_{14}B$ . The results obtained have been accounted for by a set of exchange and crystal field parameters. The latter were obtained by a direct scaling from values obtained in a detailed study of  $Nd_2Fe_{14}B$ . (Author abstract) 8 refs.

Gavigan, J.P. (CNRS, Grenoble, Fr); Givord, D.; Li, H.S.; Yamada, O.; Maruyama, H.; Sagawa, M.; Hirose, S. *J Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 416-418.

## Measurements

**089118 MAGNETIC AFTEREFFECT IN RARE EARTH-IRON-BORON MAGNETS.** The temperature dependences of the aftereffect coefficient  $S_v$  and the coercive force  $iH_c$  have been measured from 4.2 K to 300 K on two specimens prepared from sintered magnets of  $Pr_8Y_7Fe_{77}B_8$  (sintered at 1060°C and 1100°C). The latter has higher maximum energy products. The  $S_v$  values of both have a maximum at 60 K and 150 K respectively. This is a new behavior which can not be explained by any theory proposed until now. 13 refs.

Shi, J. (Okayama Univ, Okayama, Jpn); Yamada, O.; Maruyama, H.; Sagawa, M.; Hirose, S. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3122-3124.

**089119 HIGH FIELD AND TEMPERATURE DEPENDENT MAGNETISATION MEASUREMENTS ON SOME  $Re_2Co_{17}$  SINGLE CRYSTALS.** Single crystals of  $Pr_2Co_{17}$  and  $Nd_2Co_{17}$  have been grown using a tri-arc Czochralski method. High-field magnetization

measurements up to 35 T have been performed on  $Pr_2Co_{17}$  and  $Nd_2Co_{17}$  at 4.2 K. The experimental curves show very large anisotropy; for fields along the  $c$  axis in  $Pr_2Co_{17}$  and along the  $a$  axis in  $Nd_2Co_{17}$  the magnetization does not reach the saturation value within this field range. Furthermore, the hard axis shows in both compounds a nonzero spontaneous magnetization indicating a cone structure with cone angles of about 26° and 7° for  $Pr_2Co_{17}$  and  $Nd_2Co_{17}$ , respectively. Low-field (up to 6 T) temperature-dependent magnetization measurements (4.2-300 K) show that in both compounds the cone angle remains visible up to 300 K, but for  $Pr_2Co_{17}$  the cone angle is drastically reduced above 150 K. These two  $RE_2TM_{17}$  compounds ( $RE$  stands for a rare-earth metal and  $TM$  stands for a transition metal) with a cone structure are compared with other  $RE-TM$  compounds with a cone structure. 11 refs.

Verhoef, R. (Univ of Amsterdam, Neth); Franse, J.J.M.; de Boer, F.R.; Heerom, H.J.M.; Matthaei, B.; Sinnema, S. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1948-1950.

## Microscopic Examination See Also NEODYMIUM COMPOUNDS—Microscopic Examination.

**089120 DISORDERED INTERMEDIATE STAGE IN THE REDUCTION OF  $Tb_{11}O_{20}$  OR  $Tb_2O_{12}$  TO C-TYPE  $Tb_2O_3$  IN THE ELECTRON MICROSCOPE.** A thin crystal of  $Tb_{11}O_{20}$  with a patch of  $Tb_2O_{12}$  has been observed to reduce in the high-resolution electron microscope to  $Tb_2O_3$  (C-type). In both cases the reduction occurred through a disordered intermediate stage which was of fluorite structure. The  $Tb_2O_3$  was observed to grow into this disordered region in patches previously termed cooperative emergence in a nucleation controlled ordering process. Whereas transformation (reaction) between  $Tb_{11}O_{20}$  and  $Tb_2O_{12}$ , for example, would be expected to be cooperative and displacive, the transformation to a C-type structure would be reconstructive and, thus, the intermediate stage of disorder is not unexpected. (Edited author abstract). 5 refs.

Bouletix, Claude (Arizona State Univ, Tempe, AZ, USA); Eyring, Leroy. *J Solid State Chem* v 75 n 2 Aug 1988 p 291-295.

**089121 OPTICAL OBSERVATION OF CLOSURE DOMAINS IN TERFENOL-D SINGLE CRYSTALS.** Optical differential interference contrast microscopy is used to observe the topological features in surfaces of single crystal Terfenol-D ( $Tb_{0.3}Dy_{0.7}Fe_{1.95}$ ) which arise from macroscopic lattice tilts due to the magnetostrictive strain between neighboring magnetic domains at the surface. The domain configurations observed can all be interpreted as being composed of low-energy 71° and 109° walls which have components of magnetization normal to the surface. Domain widths on the order of 2  $\mu$ m can readily be resolved. Observations from surfaces polished parallel to (110) and (112) are presented as a function of temperature, between 250 K and 350 K, and as a function of magnetic field applied parallel to the specimen surface. 10 refs.

Lord, D.G. (Univ of Salford, Engl); Elliot, V.; Clark, A.E.; Savage, H.T.; Teter, J.P.; McMasters, O.D. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1716-1718.

**089122 MICROSTRUCTURAL CHARACTERISATION OF TERNARY RARE EARTH-IRON ALLOYS.** The microstructures of ternary alloy compositions based on the highly magnetostrictive  $(Tb,Dy)Fe_2$  compounds have been investigated by SEM (scanning electron microscope) metallography. The influence of preparation route and heat treatment on the prevailing microstructure has been examined. As-cast and annealed induction melted material have both been examined as a function of iron composition. Lattice parameter variations with composition and heat treatment have been observed. The detailed microstructures have been characterized by BSE imaging, X-ray microanalysis, and electron microprobe

analysis. Interpretation of the results has led to the suggestion of a modified phase diagram in the region of the Laves phase compound. 7 refs.

Westwood, P. (Univ of Birmingham, Engl); Abell, J.S.; Pitman, K.C. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1873-1875.

## Microstructure

**089123 NEW PHASES OF ERBIUM OXIDES.** Two new polymorphic erbium oxides have been found in small grains of nanophase ceramics by means of electron microscopy; one has a face-centered cubic (fcc) structure with lattice parameter  $a=0.374$  nm, the other has a monoclinic structure with  $a=0.359$  nm,  $b=0.562$  nm,  $c=0.344$  nm and  $\beta=119.3^\circ$ . The formation of these oxides is also discussed. (Author abstract). 14 Refs.

Li, Zonquan (Argonne Natl Lab, Argonne, IL, USA); Hahn, H.; Siegel, R.W. *Mater Lett* v 6 n 10 Jun 1988 p 342-346.

## Optical Properties See Also LASERS, SOLID STATE—Materials; TELLURIUM COMPOUNDS—Optical Properties.

**089124 LUMINESCENCE PROPERTIES OF  $Eu^{3+}$  AND  $Tb^{3+}$  IN  $Ln_2O_4X$  OXYHALIDES ( $Ln=X$ : Y-Cl, Y-Br, Gd-Br).** The luminescence properties of  $Eu^{3+}$  and  $Tb^{3+}$  in  $Y_2O_4Cl$ ,  $Y_2O_4Br$ , and  $Gd_2O_4Br$ , a family of oxyhalides with high chemical stability, have been investigated. The emission results from rare earth ions lying in two different sites. Spectral distributions and efficiencies are compared to those of the related  $Eu^{3+}$  or  $Tb^{3+}$  doped  $LnOx$  compounds. The efficiency is of the same order of magnitude for UV excitation into the  $Eu^{3+}$  charge transfer or  $Tb^{3+}$  5d bands, but much lower for excitation through the host lattice (i.e., by x-ray or electron beam). (Author abstract).

Es-Sakhi, B. (Univ de Bordeaux, Talence, Fr); Guillen, F.; Garcia, A.; Fouassier, C.; Hagenmuller, P. *J Electrochem Soc* v 135 n 8 Aug 1988 p 2099-2102.

**089125 INVESTIGATION OF LUMINESCENT  $Eu$ -DOPED SESQUIOXIDES  $Ln_2O_3$  ( $Ln = In, Sc, Y, La, Gd, Lu$ ) AND SOME MIXED OXIDES BY  $^{151}Eu$  MOESSBAUER SPECTROSCOPY.** Luminescent  $Eu$ -doped sesquioxides  $Ln_2O_3$  ( $Ln = In, Sc, Y, La, Gd, Lu$ ) and some mixed oxides have been investigated with  $^{151}Eu$  Moessbauer spectroscopy. The spectra are interpreted by using crystallographic and luminescence data. Effects of  $Eu$  concentration, substitution and crystal structure on the isomer shift are discussed in terms of  $Eu-O$  distance, coordination number and covalency. For the compounds with the cubic modification, no preferential site occupation by  $Eu^{3+}$  ions on the two available crystallographic sites can be concluded. (Author abstract). 23 Refs.

Hintzen, H.T. (Philips Research Lab, Eindhoven, Neth); Van Noort, H.M. *J Phys Chem Solids* v 49 n 8 1988 p 873-881.

## Phase Diagrams See Also SUPERCONDUCTING MATERIALS—Magnetic Properties.

**089126 MAGNETIC PHASE DIAGRAM OF  $Ho_{1-x}Ge_1-xSi_x$  STUDIED BY NEUTRON DIFFRACTION AND MAGNETIC MEASUREMENTS.** Several samples ( $0.2 \leq x \leq 1.0$ ) of  $HoGe_{1-x}Si_x$  (CrB type) were studied over an extensive temperature range by neutron diffraction. The relative stability of the two existing magnetic structures with wave vectors depends on both the temperature and composition. The corresponding stability regions are shown in a magnetic phase diagram. The Neel temperature  $T_N$  and the transition temperature  $T_{IC}$  between the lock-in structure and the incommensurate structure increase with silicon content. The magnetic moments of  $Ho$  are confined to a direction close to the  $c$ -axis ( $5-7^\circ$ ) over the whole temperature range and order with a pure sinus modulation between  $T_{IC}$  and  $T_N$ . (Edited author abstract) 12 refs.



Schobinger-Papamantellos, P. (Inst fuer Kristallographie und Petrographie ETHZ, Zurich, Switz); Buschow, K.H.J. *J Solid State Chem* v 70 n 2 Oct 1987 p 249-261.

**Phase Transitions** See Also MAGNESIUM YTTRIUM NEODYMIUM ALLOYS—Heat Treatment; MAGNETIC MATERIALS—Pressure Effects.

**089127 FIRST ORDER PHASE TRANSITIONS IN RARE-EARTH HEXABORIDES.** Thermal expansion measurements made using capacitance dilatometry to determine the first or second order nature of the Neel transitions and incommensurate-commensurate transitions in  $\text{PrB}_6$ ,  $\text{NdB}_6$  and  $\text{GdB}_6$  are reported. (Author abstract) 7 refs.

Ali, Naushad (Southern Illinois Univ, Carbondale, IL, USA); Kahrizi, Mojtaba; Steinitz, M.O. *Solid State Commun* v 65 n 3 Jan 1988 p 183-184.

**089128 RESISTIVE BEHAVIOUR OF  $\text{PrH}_{2+x}$  COMPOUNDS AT THE APPROACH OF THE METAL-INSULATOR TRANSITION.** Electrical measurements for  $\text{PrH}_{2+x}$  compounds with  $0 \leq x \leq 0.75$  show a metallic behavior below room temperature. There is strong evidence in favor of structural ordering (short range for  $x < 0.1$  and long range for  $x > 0.2$ ) within the H sublattice for all concentrations  $x$ . A qualitative analysis of the phonon resistivity and of the disorder resistivity implies a strong reduction in the carrier density with increasing  $x$ ; this places this system near to a metal-insulator transition as in  $\text{CeH}_{2+x}$  and  $\text{LaH}_{2+x}$ . We observe also that the mobility of the H atoms increases with increasing  $x$ . (Author abstract). 23 Refs.

Burger, J.P. (CNRS, Orsay, Fr); Daou, J.N.; Vajda, P. *Philos Mag B* v 58 n 3 Sep 1988 p 349-356.

**Physical Properties** See Also MAGNETIC MATERIALS—Ferromagnetism; MAGNETIC SEMICONDUCTORS.

**089129 COOPERATIVE ENHANCEMENT OF THE KONDO EFFECT IN HEAVY-FERMION SYSTEMS.** Influence of high concentration of f electrons on the Kondo effect is studied by use of the self-consistent perturbation theory with respect to hybridization. It is shown that partial delocalization of f electrons leads to cooperative enhancement of the Kondo resonance in the f-electron density of states. (Author abstract) 14 refs.

Kim, C.-I. (Tohoku Univ, Sendai, Jpn); Kuramoto, Y.; Kasuya, T. *Solid State Commun* v 62 n 9 Jun 1987 p 627-631.

**089130  $\text{YbPd}_2\text{Si}_2$ , A MODERATE HEAVY FERMION SYSTEM.** Heat capacity of  $\text{YbPd}_2\text{Si}_2$  has been measured in the temperature range 1.5 to 20 K. The coefficient of the electronic heat capacity  $\gamma$  is found to be 203 mJ/Yb-mole, comparable to those for heavy fermion materials. It is observed that the present compound obeys the  $\chi(\text{O})/\gamma$  correlation as reported for some Yb compounds in literature. (Author abstract) 14 refs.

Dhar, S.K. (Tata Inst of Fundamental Research, Bombay, India); Sampathkumaran, E.V.; Vijayaraghavan, R.; Kuntzler, R. *Solid State Commun* v 61 n 3 Feb 1987 p 479-481.

**089131 FERMI SURFACE NESTING IN RARE EARTH DIHYDRIDES.** A new type of Fermi surface nesting is proposed for the dihydrides of rare earths. It is now possible to explain the antiferromagnetic spin structure of most systems based on the energy bands and Fermi surface calculated by Gupta and Burger. (Author abstract) 6 refs.

Liu, S.H. (Oak Ridge Natl Lab, Oak Ridge, TN, USA). *Solid State Commun* v 61 n 2 Jan 1987 p 89-91.

**089132 QUASI-PARTICLE ENERGY OF 4f-STATES IN RARE SYSTEMS: WEAK CORRELATION REGIME.** We have calculated the quasi-particle energy for the localized 4f-rare earth states, described in the Ramirez-Falicov-Kimball (RFK) model. The Coulomb correlation between the f-localized states and d-iten-

erant states is considered in the weak correlation regime, beyond the usual Hartree-Fock approximation. It is found that, for reasonable values of the parameters of the model, one can obtain a bimodal structure for the f-f Green's function. (Author abstract) 15 refs.

Troper, A. (Cent Brasileiro de Pesquisas Fisicas, Rio de Janeiro, Braz); da Cunha Lima, I.C. *Solid State Commun* v 61 n 3 Jan 1987 p 195-198.

**089133 CRYSTAL FIELD AND MAGNETIC MOMENTS OF RARE-EARTH IONS IN  $\text{REBa}_2\text{Cu}_3\text{O}_{7-x}$  ( $\text{RE} = \text{Ce}, \dots, \text{Yb}$ ).** The superposition model is used to predict the values of the fourth- and sixth-order crystal-field parameters and consequently also the nature of magnetic moments of rare-earth ions in superconducting orthorhombic phase of  $\text{REBa}_2\text{Cu}_3\text{O}_{7-x}$  ( $\text{RE} = \text{Ce}, \dots, \text{Yb}$ ). A similarity between the coordination dodecahedra of rare-earth ions in  $\text{REBa}_2\text{Cu}_3\text{O}_{7-x}$  and garnets is used. The low-temperature magnetic moments of rare-earth ions are anisotropic and partially quenched. The quantitative conclusions are in general hampered by strong dependence of the magnetic moments on the crystal-field parameters of second order. As the superposition model gives no useful prediction for these parameters, it will be necessary to determine them by fitting to suitable experimental data. (Author abstract) 13 refs.

Nekvasil, V. (Inst of Physics, Prague, Czech). *Solid State Commun* v 65 n 10 Mar 1988 p 1103-1106.

## Pressure Effects

**089134 PRESSURE DEPENDENCE OF THE CURIE TEMPERATURE OF INTERMETALLIC COMPOUNDS  $\text{R}_2\text{Fe}_{14}\text{B}$  ( $\text{R} = \text{Y}, \text{Ce}$ , AND  $\text{Nd}$ ).** Strong negative pressure dependence of the Curie temperature ( $T_c$ ) is observed in  $\text{R}_2\text{Fe}_{14}\text{B}$  compounds. The values of  $dT_c/dP$  are pressure dependent in the range of between  $-30$  to  $+100$  K/GPa.  $T_c$  of  $\text{Ce}_2\text{Fe}_{14}\text{B}$  is found to be increased by a heating under a 0.55 GPa pressure. (Author abstract) 9 refs.

Nagata, H. (Sumitomo Special Metals Co, Osaka, Jpn); Hirosawa, S.; Sagawa, M.; Ishibashi, A.; Endo, S. *J Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Intermet Compd, Kyoto, Jpn, Apr 20-22 1987 p 334-336.

## Production

**089135 LITHIATED RARE-EARTH THIOSPINELS AND SELENOSPINELS.** The spinels  $\text{A}[\text{Ln}_2]\text{X}_4$  with  $\text{A} = \text{Cd}$  or  $\text{Mg}$  and  $\text{X} = \text{S}$  or  $\text{Se}$  were prepared for  $\text{Ln} = \text{Ho}, \text{Er}, \text{Tm}, \text{Yb}$ , and  $\text{Y}_{2-x}\text{Yb}_x$  ( $x = 0.0, 1.0, \text{or } 2.0$ ). Lithiation with n-butyllithium was attempted in the hope of obtaining both mixed-valent and intermediate-valent compounds as well as a continuous variation of the Fermi energy from below to within a localized  $4f^n$  configuration. Formation of the mixed-valent compounds  $\text{Li}_x\text{Mg}[\text{Yb}_{2-x}^{3+}\text{Yb}_x^{2+}]\text{X}_4$ ,  $\text{X} = \text{S}$  or  $\text{Se}$ , with the spinel  $[\text{Yb}_2]\text{X}_4$  framework was accomplished, but lithium displaced cadmium from the cadmium spinels and magnesium from  $\text{Mg}[\text{Tm}_2]\text{Se}_4$ , which frustrated attempts to obtain an intermediate-valent compound of variable electron/atom ratio. (Author abstract) 11 refs.

De La Mora, Pablo (Inorganic Chemistry Lab, Oxford, Engl); Goodenough, John B. *J Solid State Chem* v 70 n 1 Sep 1987 p 121-128.

## Reduction

**089136 REDUCTION OF PRASEODYMIUM AND TERBIUM HIGHER OXIDES: CHEMICAL REACTIONS SIMILAR TO DIFFUSIONLESS PHASE TRANSITIONS.** Some solid state chemical reactions such as a change in the degree of oxidation can occur without a great displacement of the atomic positions of one kind of atom in a structure. When praseodymium and terbium oxides are reduced, the rare earth atom movement is less than the cation crystallographic distances in the fluorite-related structure. This means that the chemical transformation occurs without a great change in the

framework of one kind of atom. The relative positions of these atoms are nevertheless slightly modified as in a diffusionless phase transition. In the Pr and Tb oxides the deformation changes both the volume and the shape of the structural unit. A displacement tensor can be defined for these chemical transformations. (Edited author abstract) 9 refs.

Boulesteix, C. (Arizona State Univ, Tempe, AZ, USA); Eyring, L. *CHEMTECH* v 17 n 8 Aug 1987 p 458-465.

**Separation** See ION EXCHANGERS—Performance.

## Solutions

**089137 TETRAD-EFFECTS IN THE STABILITIES OF LANTHANIDE DTPA 2-PICOLINATE BILIGAND COMPLEXES.** The occurrence of tetrad-effects has been observed in some binary lanthanide complexes. But no satisfactory explanation has been put forward so far. The authors investigate the occurrence of tetrad-effects in the biligand complexes of the lanthanides. In this communication the results of our studies on the biligand complexes of the type  $[\text{Ln.A.L}]$  of all the lanthanides with DTPA [A] and 2-picolinic acid [L] are reported. The formation constants of the binary complexes along with the  $\Delta \log K$  values are presented. 15 refs.

Limaye, S.N. (Dr. Harisingh Gour Vishwavidyalaya, Sagar, India); Saxena, M.C. *J Electrochem Soc India* v 36 n 4 Oct 1987 p 281-283.

**Solvent Extraction** See RARE EARTH ELEMENTS—Solvent Extraction.

**Specific Heat** See Also CRYOGENICS.

**089138 HEAT CAPACITIES OF LAVES PHASE COMPOUNDS  $\text{RMn}_2$  ( $\text{R} = \text{Y}, \text{Gd}$  AND  $\text{Er}$ ).** Measurements of heat capacity indicate that the Mn moment in  $\text{YMn}_2$  has an itinerant character and an additional  $C_M$  is observable even above  $T_N$ . In  $\text{GdMn}_2$ , the Gd moments are in disorder at  $T_N$  simultaneously with the Mn moments. The CEF contributions in  $\text{ErMn}_2$  are observed and are calculated using a single-ion Hamiltonian. (Author abstract) 6 refs.

Okamoto, T. (Hiroshima Univ, Hiroshima, Jpn); Nagata, H.; Fujii, H.; Makihara, Y. *J Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Intermet Compd, Kyoto, Jpn, Apr 20-22 1987 p 139-141.

**089139 SPECIFIC HEAT MEASUREMENTS OF  $(\text{Ho}, \text{YCo}_2)$  AND  $(\text{Dy}, \text{YCo}_2)$ .** We report on concentration- and temperature-dependent specific heat measurements of  $(\text{Dy}_x\text{Y}_{1-x})\text{Co}_2$  in the temperature range from 1.5 to 60 K in comparison with recent results of  $(\text{Ho}_x\text{Y}_{1-x})\text{Co}_2$ . The magnetic contribution to the specific heat,  $C_m$ , is analysed with regard to the appearance of spin-fluctuations and in terms of spin-glass phenomena. The loss of magnetic entropy in the dilute RE-concentration range indicates presumably an instability of the RE-moments. (Author abstract) 9 refs.

Pillmayr, N. (Technical Univ Vienna, Austria); Schmitzer, C.; Gratz, E.; Hilscher, G.; Sechovsky, V. *J Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Intermet Compd, Kyoto, Jpn, Apr 20-22 1987 p 162-164.

**Spectroscopic Analysis** See Also MAGNETIC MATERIALS—Spectroscopic Analysis; OXIDES—Reduction.

**089140 SPECTRA AND STRUCTURE OF BORATOTUNGSTATES (MOLYBDATES) OF EUROPIUM-ACTIVATED LANTHANIDES.** The luminescence and excitation spectra, and also the IR absorption spectra of compounds with mixed anions - boratotungstates (molybdates) and certain tungstates and molybdates were investigated. The spectroscopic features of the structure of the compounds were revealed. In particular, it is shown that the high intensity of the low-frequency



electronic-vibrational bands is a characteristic feature of chain-type borate anions. The special features of the structure of the compounds  $\text{Ln}_2\text{O}_9\text{EuO}_9$  were determined. It is shown that their structure is not chain-type. The crystal lattice of these compounds is constructed out of distorted plane trigonal borate and  $\text{WO}_6^{6-}$  anions. The structure is distinguished by disorder. The symmetry of the luminescence centers is no higher than  $C_{2v}$ . In Russian. 12 refs.

Dzhurinskii, B.F.; Zolin, V.F.; Tsaryuk, V.I.; Lysanova, G.V.; Komova, M.G.; Markushev, V.M. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 9 Sep 1987 p 1525-1530.

**089141 SPECTRAL DETERMINATION OF THE 'CERAMIC' IMPURITIES IN EUROPIUM, GADOLINIUM, AND DYSPROSIUM OXIDES.** Extension of the application of rare-earth element (REE) oxides as structural materials and coating assumes the utilization of ceramic technology such as briquetting, firing, grinding, etc. Material contamination by the so-called 'ceramic' impurities ( $\text{SiO}_2$ ,  $\text{MgO}$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{Al}_2\text{O}_3$ , et al.) inevitably occurs here. Methods for the spectral determination of  $\text{Al}_2\text{O}_3$ ,  $\text{SiO}_2$  and  $\text{Fe}_2\text{O}_3$  impurities in Eu, Gd, and Dy oxides in the interval 0.03-0.4% and the MgO impurity within 0.5-1.5% limits are elucidated in this paper (magnesium oxide is used as a sintering initiator). Because of the absence of appropriate standard specimens, the calibration graphs are obtained by using synthetic mixtures prepared from highly pure oxides by mechanical mixing. 6 refs.

Alapin, B.G. (Ukrainian Scientific-Research Inst of Refractories, Khar'kov, USSR); Terletskaia, N.K. *Ind Lab (USSR)* v 53 n 4 Apr 1987 p 328-329.

**089142 LUMINESCENCE OF CERIUM (3+) ACTIVATED RARE EARTH SILICOPHOSPHATES.** Rare earth silicophosphates with a general formula  $\text{RE}_2\text{O}_3 \cdot 0.10\text{SiO}_2 \cdot 0.95\text{P}_2\text{O}_5$  (RE represents La or Gd and these formula are simplified as LSP or GSP respectively) were synthesized and developed as good host materials for making phosphors. A systematic investigations on the luminescence properties of  $\text{Ce}^{3+}$ -activated silicophosphates of lanthanum and gadolinium are reported. 3 refs.

Huang, Zhupo (Peking Univ, Beijing, China); Ma, Guoling. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 163-164.

**089143 LUMINESCENT PROPERTIES OF DIBENZYL SULFOXIDES OF RARE EARTH NITRATES**  $\text{Ln}(\text{NO}_3)_3 \cdot 3(\text{C}_6\text{H}_5\text{CH}_2)_2\text{SO}$  ( $\text{Ln} = \text{Sm}^{3+}$ ,  $\text{Eu}^{3+}$ ,  $\text{Tb}^{3+}$ ,  $\text{Dy}^{3+}$ ). Excitation and emission spectra of dibenzylsulfoxide and its complexes with rare earth nitrates were studied. Their compositions are  $\text{Ln}(\text{NO}_3)_3 \cdot 3(\text{C}_6\text{H}_5\text{CH}_2)_2\text{SO}$  where  $\text{Ln} = \text{Sm}^{3+}$ ,  $\text{Eu}^{3+}$ ,  $\text{Tb}^{3+}$ ,  $\text{Dy}^{3+}$ ;  $0 < (\text{C}_6\text{H}_5\text{CH}_2)_2\text{SO} = \text{DBSO}$ . Their crystal structures belong to triclinic, space group is  $P\bar{1}$ . 2 refs.

Su, Qiang (Acad Sinica, Changchun, China); Lu, Yuhua. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 290-291.

**089144 IMPACT CROSS SECTION OF  $\text{ErF}_3$  CENTERS IN  $\text{ZnS}$  THIN FILM.** We used quasi-molecular beam epitaxial method to prepare  $\text{ZnS:ErF}_3$  thin film and obtained  $\text{ErF}_3$  lumocent in  $\text{ZnS}$  thin film. It was found for the first time that the impact cross section of  $\text{ErF}_3$  lumocent, about  $8 \times 10^{-16} \text{ cm}^2$ , was larger than that of  $\text{Er}^{3+}$  centers. (Author abstract) 4 refs.

Luo, Baozhu (Acad Sinica, Changchun, China); Yu, Jiaqi; Zhong, Guozhu. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 786-787.

**089145 EFFECT OF MICROSTRUCTURAL MATRIX REARRANGEMENTS ON ELECTROLUMINESCENCE OF  $\text{SiO}_2\text{:TbF}_3$  FILMS.** Microstructural matrix rearrangements caused by doping with  $\text{TbF}_3$  and annealing of amorphous  $\text{SiO}_2$  films are investigated. It is shown that the  $\text{TbF}_3$  molecules dissociate during the film

deposition and Tb substitutes Si in  $\text{SiO}_4^{4-}$  tetrahedra. The trivalent Tb forms after the film annealing, which leads to the appearance of the electroluminescence. (Author abstract) 3 refs.

Vlasenko, N.A. (Acad of Science of the Ukrainian SSR, Kiev, USSR); Romanova, G.Ph.; Fenchokha, B.V.; Khomchenko, V.S. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 792-793.

**089146 CRYSTAL STRUCTURES AND SPECTRAL PROPERTIES OF RARE EARTH ALKALINE EARTH NIOBATES.** We have now studied the crystal structures and spectral properties of  $\text{M}_2\text{Y}_{0.94}\text{Ln}_{0.06}\text{NbO}_6$  ( $\text{M} = \text{Ca}, \text{Sr}, \text{Ba}$ ;  $\text{Ln} = \text{Eu}, \text{Sm}, \text{Dy}$ ). The emission spectra of the  $\text{Eu}^{3+}$  ion are strongly dependent on the site symmetry. The phosphors were prepared by solid-state reactions at  $1400^\circ\text{C}$ . Their crystal structures were checked by X-ray powder diffraction with Rigaku X-ray Diffractometer GelGerfex 2028. Excitation and emission spectra were taken with a HITACHI MPF-4 spectrophotometer. (Edited author abstract) 3 refs.

Zhang, Jingjun (Acad Sinica, Changchun, China); Lu, Feng; Su, Ciang. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 897-898.

**Spectrum Analysis** See NEODYMIUM COMPOUNDS—Spectrum Analysis.

## Stability

**089147 ESTIMATION OF THERMAL-STABILITY CHARACTERISTICS OF RARE-EARTH ELEMENT NIOBATES IN THE HIGH-TEMPERATURE REGION.** The thermal stability of a series of REE niobates at the melting point were calculated from phase diagrams of the REE oxide-niobium oxide system by the method of thermodynamic analysis using the model of ideal associated solutions. The effect of temperature and composition on the degree of thermal dissociation of niobates was shown. A correlation was established but with the characteristics of thermal stability and electric conductivity of REE orthoniobates in the high-temperature region. The degree of donor-acceptor interaction of REE and niobium oxides in the compounds was determined by the method of notching of electro-negativities, and the correspondence of its values with the thermal stability of niobates was shown. (Author abstract) 9 refs.

Teterin, G.A.; Zinchenko, V.F.; Kuz'min, V.E.; Babich, T.G.; Minaev, I.M. *Sov Prog Chem* v 53 n 9 1987 p 8-12.

**Structure** See Also MAGNETIC MATERIALS—Structure.

**089148 STRUCTURAL CHEMISTRY AND MAGNETIC BEHAVIOR OF TERNARY GALLIDES  $\text{REAu}_x\text{Ga}_{4-x}$ , RE = La, Ce, Pr, Nd, AND Sm.** Two new series of ternary gallides with the chemical formulas ( $\text{La}, \text{Ce}, \text{Pr}, \text{Nd}, \text{Sm}$ ) $\text{Au}_{1.5}\text{Ga}_{2.5}$  were synthesized from the elements by arc melting. From X-ray powder diffraction analysis the  $\text{REAu}_x\text{Ga}_{4-x}$  series of compounds was found to be isotypic and crystallize with  $\text{BaAl}_4$  type of structure; the homogeneity range at  $600^\circ\text{C}$  of each of the  $\text{REAu}_x\text{Ga}_{4-x}$  phases was established, revealing remarkable deviations from Vegard's rule. At  $600^\circ\text{C}$  the  $\text{REAu}_x\text{Ga}_{4-x}$  phases of the  $\text{BaAl}_4$  type were observed to be in thermodynamic equilibrium with a structure variant crystallizing at the composition  $\text{REAu}_{1.5}\text{Ga}_{2.5}$  and with a narrow homogeneous range. (Edited author abstract) 5 refs.

Grin, Y.N. (Univ Wien, Vienna, Austria); Rogl, P.; Hiebl, K.; Wagner, F.E.; Noel, H. *J Solid State Chem* v 70 n 2 Oct 1987 p 168-177.

**089149 CRYSTAL STRUCTURE AND MAGNETIC PROPERTIES OF PSEUDOTERNARY  $\text{TbRh}_{2-x}\text{M}_x\text{Si}_2$  ( $\text{M} = \text{Ru}, \text{Ir}$ ) COMPOUNDS.** The structural and magnetic characteristics of the pseudoternary  $\text{TbRh}_{2-x}\text{M}_x\text{Si}_2$  ( $\text{M} = \text{Ru}, \text{Ir}$ ) compounds were studied. The compounds crystallize in the tetragonal  $\text{ThCr}_2\text{Si}_2$ -type struc-

ture. The magnetic data were collected in the temperature range 70-300 K. Their magnetic susceptibilities satisfy the Curie-Weiss law in the temperatures higher than 130 K. The magnetic moment of the rare earth atom is larger than of the free  $\text{Tb}^{3+}$  ion. A modified RKKY theory with included interaction between the conduction electrons was applied to explain the variation of properties of the compounds. (Author abstract) 18 refs.

Jaworska, T. (Jagellonian Univ, Cracow, Pol); Szytula, A. *Solid State Commun* v 63 n 4 Jul 1987 p 311-314.

**089150 STRUCTURAL INVESTIGATION OF PRASEODYMIUM POTASSIUM HEXACYANOFERRATE (II) TETRAHYDRATE,  $\text{PrKFe}(\text{CN})_6 \cdot 4\text{H}_2\text{O}$ .** Single-crystal and powder X-ray diffraction data, thermal gravimetric analysis, and infrared spectral data are present for  $\text{PrKFe}(\text{CN})_6 \cdot 4\text{H}_2\text{O}$ . The crystal structure has been determined by single-crystal diffractometry and refined by the least-squares method to yield  $R = 0.0149$  and  $R_w = 0.0155$ . The praseodymium ions are linked nonlinearly to the  $\text{FeC}_6$  octahedra by cyanide bridges. Cavities within the structure are occupied by potassium ions and zeolitic water molecules which are within hydrogen bonding distance to the water molecules which are bonded to the nine-coordinated praseodymium ions,  $\text{PrN}_6(\text{H}_2\text{O})_3$ . (Edited author abstract) 16 refs.

Mullica, D.F. (Baylor Univ, Waco, TX, USA); Sappenfield, E.L.; Perkins, H.O. *J Solid State Chem* v 73 n 1 Mar 1988 p 65-70.

**089151 STRUCTURE AND  $^{57}\text{Fe}$  MOSSBAUER EFFECT IN  $\text{R}_2\text{Fe}_{14}\text{C}$  COMPOUNDS.** The crystal structure of the ternary compound  $\text{Lu}_2\text{Fe}_{14}\text{C}$  was determined and shown to be isotypic with  $\text{Nd}_2\text{Fe}_{14}\text{C}$ .  $^{57}\text{Fe}$  Mossbauer spectra were taken of the compounds  $\text{Lu}_2\text{Fe}_{14}\text{C}$  and  $\text{Gd}_2\text{Fe}_{14}\text{C}$  at 300 K and 10 K. Analysis of the spectra showed that the average iron moment in  $\text{R}_2\text{Fe}_{14}\text{C}$  is approximately the same as in  $\text{R}_2\text{Fe}_{14}\text{B}$ . The Mossbauer spectra were decomposed into six subspectra according to the six different iron sites in  $\text{R}_2\text{Fe}_{14}\text{C}$ . There are considerable differences in the sizes of the iron moments associated with the six iron sites. (Author abstract) 12 refs.

Denissen, C.J.M. (Philips Research Lab, Eindhoven, Neth); de Mooij, B.D.; Buschow, K.H.J. *J Less Common Met* v 139 n 2 May 1988 p 291-298.

**089152 STRUCTURAL AND PHOTOLUMINESCENT PROPERTIES OF FULLY-HYDRATED LANTHANON URANYL PHOSPHATES.** A re-investigation of the lamellar lanthanon derivatives of hydrogen uranyl phosphate ( $\text{HUO}_2\text{PO}_4 \cdot 4\text{H}_2\text{O}$  (HUP)) is reported. When prepared from both HUP and n-butylammonium uranyl phosphate ( $\text{n-C}_4\text{H}_9\text{NH}_3\text{UO}_2\text{PO}_4 \cdot 3\text{H}_2\text{O}$  (BAUP)) the fully-hydrated LnUP compounds have the approximate composition  $\text{Ln}_{1/3}\text{UO}_2\text{PO}_4 \cdot x\text{H}_2\text{O}$  ( $\text{Ln} = \text{La}, \text{Ce}, \text{Pr}, \text{Nd}, \text{Eu}, \text{Gd}, \text{Tb}, \text{Dy}, \text{Yb}$ ;  $x = 3.7-4$ ). Interlamellar spacings parallel the trend in lanthanon size and range from 11.1 Å for the lanthanum derivative to 10.7 Å for the ytterbium compound; these distances decrease by 2.5-2.8 Å if the LnUP compounds are air dried. With the exception of cerium, praseodymium, neodymium and europium derivatives, which are only weakly emissive, the other LnUP samples emit efficiently at 295 K when excited with blue or near-UV light. (Edited author abstract) 10 refs.

Rosenthal, Guy L. (Univ of Wisconsin-Madison, Madison, WI, USA); Ellis, Arthur B. *J Less Common Met* v 139 n 2 May 1988 p 299-304.



**089153 DETERMINATION STRUCTURALE DE LA FORME DE HAUTE TEMPERATURE DU COMPOSE  $\text{La}_4[\text{Ge}_3\text{O}_{10}][\text{GeO}_4]$ : ANALYSE COMPARATIVE DES STRUCTURES TRICLINIQUES DES GERMANATES DE TERRES RARES DE FORMULE GLOBALE  $\text{Ln}_2\text{Ge}_2\text{O}_7$ .** [Structural Determination of the High-Temperature Phase of Compound  $\text{La}_4[\text{Ge}_3\text{O}_{10}][\text{GeO}_4]$ : Comparative Analysis of the Triclinic Structures of Rare Earth Germanates of the Form  $\text{Ln}_2\text{Ge}_2\text{O}_7$ ]. The rare-earth germanates  $\text{Ln}_2\text{Ge}_2\text{O}_7$  have been structurally determined as three triclinic structural forms ( $\text{Ln} = \text{La-Gd}$ ) and one tetragonal ( $\text{Ln} = \text{Gd-Lu}$ ). The structural determination of the high temperature form  $\text{La}_2\text{Ge}_2\text{O}_7$ , which is presented here, gives rise to a fourth triclinic structural type. The complete description of the  $\text{Ln}_2\text{Ge}_2\text{O}_7$  phases, stable at ordinary pressure, is thus achieved. Refinement was carried out by the heavy atom method on a model which could be elaborated after the comparative study of the three triclinic forms. (Edited author abstract) 21 refs. In French.

Vetter, Genevieve (Lab de Chimie du Solide Mineral, ESPCI, Paris, Fr); Queyroux, Francine. *J Solid State Chem* v 73 n 2 Apr 1988 p 287-297.

**089154 FORMATION AND LUMINESCENCE OF LOWER SYMMETRICAL TELLURITE ANTI-GLASS PHASES.** Two series of nonstoichiometric lanthanoid tellurite phases have been identified which are similar to cubic ( $\text{Ln}_2\text{TeO}_6$ ) anti-glass phases with  $\text{CaF}_2$  defect structure. Their X-ray diagrams indicate low-symmetrical  $\text{CaF}_2$  superstructures. Monoclinic (or pseudotetragonal) subcells were determined. Antilattice disorder is consistent with the  $\text{Eu}^{2+}$  and  $\text{Te}^{4+}$  luminescence of one series, but can be excluded for the other one. (Author abstract) 23 refs.

Troemel, M. (Inst fuer Anorganische Chemie, Frankfurt, West Ger); Muench, E.; Blasse, G.; Dirksen, G.J. *J Solid State Chem* v 76 n 2 Oct 1988 p 345-354.

## Sublimation

**089155 MASS SPECTROMETRIC AND WEIGHT-LOSS EFFUSION MEASUREMENTS OF THE SUBLIMATION OF THULIUM TRIIODIDE.** The equilibrium vapour pressure over solid thulium triiodide between 874 K and 1032 K was measured by determining the effusion of vapour out of a Knudsen cell by means of mass spectrometry (MS) and weight loss (WL). A significant dimer concentration was found in this temperature range. From the experiments second-law thermodynamic data were derived. (Edited author abstract) 23 refs.

Dettingmeijer, J.H. (Philips Lighting Div Eindhoven, Neth); Diehl, H.R. *J Less Common Met* v 139 n 2 May 1988 p 331-343.

**Synthesis** See Also MAGNETIC MATERIALS—Antiferromagnetism.

**089156 SYNTHESIS AND PHASE EQUILIBRIA OF OXIDE COMPOUNDS AND SOLID SOLUTIONS BASED ON RARE EARTH OXIDES.** The formation and phase stability of the intermediate compounds and solid solutions in binary systems  $\text{R}_2\text{O}_3$ -other oxides ( $\text{R} = \text{Rare earth}$ ) are discussed with regard to ionic scale parameter of field strength, lattice energy and site self-potentials in sublattices. The intermediate compounds and their phase relations are summarized in the systems  $\text{R}_2\text{O}_3$ - $\text{WO}_3$ . Equilibrium phase diagrams for  $\text{La}_2\text{O}_3$ ,  $\text{Nd}_2\text{O}_3$  and  $\text{Y}_2\text{O}_3$  are revised from previously reported ones. In fluorite-related phases of  $\text{R}_3\text{TaO}_7$ , the smaller R ions led to the formation of the more disordered and higher symmetric phases. The phase diagrams of the solid solutions in the system  $\text{ZrO}_2$ - $\text{CeO}_2$  or  $\text{Y}_2\text{O}_3$  are also reviewed from the point of view of stable and metastable equilibria. The metastability seems to be caused by slow diffusion of cation and fast diffusion of anion and by martensitic phase transformation in the fluorite-related phases. The formation and stability of the high valence state of cations in the B-site of the perovskite lattice  $\text{ABO}_3$  are explained by the contribution of deep site self-potential

at the B-site. (Edited author abstract) In Japanese. 44 refs.

Yoshimura, Masahiro. *J Jpn Soc Powder Powder Metall* v 34 n 9 Nov 1987 p 421-430.

**089157 EFFECT OF THE COOLING RATE ON THE PHASE COMPOSITION OF RARE-EARTH TITANATES.** For compounds of the types  $\text{Ln}_2\text{TiO}_5$  and  $\text{Ln}_2\text{Ti}_2\text{O}_7$  ( $\text{Ln} = \text{La-Lu, Y, Sc}$ ) with a decrease in the ionic radius of the lanthanide and an increase in the quenching rate a tendency toward the formation of a more highly symmetrical structure is noted, which is in keeping with the behavior of these compounds in the equilibrium state. The use of 'ultraprapid' quenching broadened the range of existence of the fluorite-type cubic structure to  $\text{Ti}_2\text{TiO}_5$  and that of pyrochlore to  $\text{Sm}_2\text{Ti}_2\text{O}_7$ . 'Ultraprapid' quenching of compounds of composition  $\text{Ln}_4\text{Ti}_9\text{O}_{24}$  led to a transition to the amorphous state, which is apparently attributable to the nearness of the compositions of these phases to the eutectic points, for which there is a well-known tendency to glass formation due to the high viscosity. As in metal systems, at high cooling rates suppression of peritectic reactions and the formation of single-phase samples occurred. 8 refs. In Russian.

Azimov, S.A.; Gulamova, D.D.; Suleimanov, S.Kh. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1875-1880.

**089158 PHYSICO-CHEMICAL AND SPECTROSCOPIC STUDIES OF CRYSTALS OF THE ALKALI - RARE EARTH FLUORIDES  $\text{K}_2\text{LnF}_5$ .** The compounds  $\text{K}_2\text{LnF}_5$  ( $\text{Ln} = \text{Nd, ... Lu, Y}$ ) and  $\text{K}_2\text{LnF}_5$  ( $\text{Ln} = \text{Gd, La, Y}$ ), activated with  $\text{Nd}^{3+}$  ions, have been synthesized by the hydrothermal method. Spectroscopic studies of this series of compounds have been carried out. It is shown that the compounds  $\text{K}_2\text{LnF}_5$ - $\text{Nd}^{3+}$  are convenient agents for the excitation of stimulated emission in the near-infrared range using spectroscopic methods, an estimate is made of the  $\text{Nd}^{3+}$  ion distribution coefficient during hydrothermal synthesis of  $\text{K}_2\text{GdF}_5$ - $\text{Nd}^{3+}$  crystals. In Russian. 12 refs.

Kaminskii, A.A.; Sarkisov, S.E.; Kurbanov, K.A.; Dem'yanets, L.N.; Khaidukov, N.M. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 12 Dec 1987 p 2049-2055.

**Thermal Effects** See Also SUPERCONDUCTING MATERIALS.

**089159 THERMAL REACTIONS OF HYDRATED HEXAGONAL  $\text{RPO}_4 \cdot n\text{H}_2\text{O}$  ( $\text{R} = \text{Tb OR Dy}$ ,  $n = 0.5$  TO 1).** The thermal reactions of hydrated hexagonal  $\text{RPO}_4 \cdot n\text{H}_2\text{O}$  ( $\text{R} = \text{Tb OR Dy}$ ,  $n = 0.5$  to 1) were studied at 20° to 1800°C in air under atmospheric pressure. The hydrated hexagonal forms were dehydrated at 180° to 250°C. Thereafter, no significant changes in structure were seen up to 800°C ( $\text{R} = \text{Tb}$ ) or 700°C ( $\text{R} = \text{Dy}$ ). The water corresponding to  $n\text{H}_2\text{O}$  was zeolitic water. Anhydrous hexagonal  $\text{RPO}_4$  gradually transformed into the monazite structure at 900°C ( $\text{R} = \text{Tb}$ ) or 800°C ( $\text{R} = \text{Dy}$ ), then into the xenotime structure at temperatures above 1100°C ( $\text{R} = \text{Tb}$ ) or 900°C ( $\text{R} = \text{Dy}$ ). (Author abstract) 12 refs.

Hikichi, Yasuo (Nagoya Inst of Technology, Nagoya, Jpn); Sasaki, Toshio; Suzuki, Suguru; Murayama, Kyouhei. *J Am Ceram Soc* v 71 n 7 Jul 1988 p C.354-C.355.

**Thermal Expansion** See INTERMETALLICS—Thermal Expansion.

## Thermal Properties

**089160 ANOMALOUS STRONG DIVERGENCE OF THE SPECIFIC HEAT OF  $\text{ErIn}_3$  AT THE ANTIFERROMAGNETIC TRANSITION.**  $\text{ErIn}_3$  crystallizes in a cubic  $\text{AuCu}_3$ -type structure in which  $\text{Er}^{3+}$  ions form a simple cubic lattice. In this note we report the specific heat of  $\text{ErIn}_3$  near the antiferromagnetic transition. The measurements were performed on a single crystal (cubic shape, mass 170 mg) in magnetic field applied along the  $\langle 001 \rangle$  axis by using an adiabatic type calorimeter. Single crystals of  $\text{ErIn}_3$  were grown from the melt by the Bridgman method. The purity of the starting materials was 3N and 6N for erbium and indium, respectively. 21

Refs.

Czopnik, A. (Polish Acad of Science, Wroclaw, Pol); Madge, H.; Stalinski, B. *Phys Status Solidi A* v 107 n 2 Jun 1988 p K151-K155.

## Thermodynamic Properties

**089161 THERMODYNAMIC CHARACTERISTICS OF LANTHANUM, PRASEODYMIUM, NEODYMIUM, AND GADOLINIUM MONOBISMUTHIDES.** Materials based on monobismuthides of rare-earth metals, including lanthanum, praseodymium, neodymium, and gadolinium, are promising for semiconductor technology and microelectronics. Information on the thermodynamic properties of these compounds is limited to calorimetric data on the enthalpies of formation and a qualitative description of the high-temperature behavior of praseodymium monobismuthide in vacuum. Investigation of the high-temperature behavior in vacuum by the Knudsen effusion method in combination with mass spectrometric, chemical, and x-ray diffraction analyses makes it possible to establish the composition of the vapor, the type of evaporation reaction, and the presence and extent of the area of homogeneity and to determine the partial pressure of the components of the vapor and calculate the enthalpy of the reaction and other thermodynamic characteristics. 8 refs.

Viksmann, G.Sh. (Acad of Sciences of the Ukrainian SSR, USSR); Gordienko, S.P. *Sov Powder Metall Met Ceram* v 26 n 7 Jul 1987 p 570-577.

## Thermodynamics

**089162 SIMPLE CUBIC PEROVSKITES AS COMPONENTS IN  $\text{R}_{1-y}\text{Na}_y\text{Ba}_2\text{Cu}_3\text{O}_x$  ( $\text{R} = \text{Ce, Pr, Tb}$ ).** Simple cubic perovskites derived from  $\text{RBaO}_3$  appear in the X-ray diagrams of materials with nominal composition  $\text{R}_{1-y}\text{Na}_y\text{Ba}_2\text{Cu}_3\text{O}_x$  with  $\text{R} = \text{Ce, Pr, Tb}$ .  $\text{Y}_{1-y}\text{Bi}_y\text{Ba}_2\text{Cu}_3\text{O}_x$  also contains this structure type. Materials are not superconducting at 77 K. The absence of  $\text{YBa}_2\text{Cu}_3\text{O}_x$  type structures in these cases is explained on thermodynamic arguments considering the high stability of phases  $\text{R}^{4+}\text{Ba}^{2+}\text{O}_3$  which dominate the phase diagram. (Author abstract) 6 refs.

Smith, M.G. (Univ of California at San Diego, La Jolla, CA, USA); Farthash, A.; Zhang, J.; Oesterreicher, H. *Mater Lett* v 6 n 7 Apr 1988 p 208-210.

## Thin Films

**089163 STUDY OF THE STABILITY OF Co-RICH  $\text{TbFeCo}$  THIN FILMS.** The effect of cobalt-content on the stability of  $\text{Tb}(\text{Fe}_{1-x}\text{Co}_x)$ , ( $x$  varying from 40 to 100%) thin films (about 100 nm thick) was investigated in relation to structural, chemical, and magnetooptic (MO) properties. Unprotected and  $\text{SiO}_2$ -protected films were prepared by electron-beam coevaporation, MO hysteresis loops were obtained with a polar Kerr-effect measurement system. Low-energy X-ray microprobe analysis and induced coupled plasma techniques were used for chemical analysis and structural properties were studied by transmission electron microscopy. Incubation tests were performed to follow the aging of the samples. Static electrochemical tests were carried out to determine their resistance to corrosion. An explanation of the results is proposed based on both oxygen species diffusion and structural modifications. 8 refs.

Gimenez, C. (CRT, Chalon-sur-Saone, Fr); Urban, A.; Vitton, J.P. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1738-1740.

**089164 FILMS OF RARE EARTH OXIDES FORMED BY ELECTRON BEAM EVAPORATION.** Rare earth oxides can effectively be deposited by electron beam evaporation. The films thus formed are dense and non-porous and adhere to various metal substrates. The strength of the bond between the films and the substrates



is greatly affected by the treatment of the substrate prior to deposition (the substrate needs to be roughened). The structure of the films is affected to a small degree by the substrate condition and deposition parameters. The orientation of the films is dependent on the substrate temperature. The characteristics of erbium oxide and yttrium oxide films are presented. (Author abstract) 2 refs.

Adams, R.O. (Rockwell Int, Golden, CO, USA); Digital-lonardo, A.; Nordin, C.W. *Thin Solid Films* v 154 n 1-2 Nov 12 1987, Pap Presented at the Int Conf on Metall Coat - Part II, San Diego, CA, USA, Mar 23-27 1987 p 101-108.

## Wetting

**089165 INFLUENCE OF THE REACTION RATE OF METALLIC MELT WITH THE CATION OF THE SOLID PHASE ON THE WETTABILITY OF RARE-EARTH OXIDES.** The aim of this work was the investigation of the influence of the reaction rate of the melt with the cation of the oxide substratum on the wettability in oxide-metal systems. This problem was studied by comparing experimental data on the reaction contact and wettability by one metal of two oxides which were different both in the Gibbs energies for the formation of wetted oxides and the energies of reaction of metals of cations of oxides with the wetting metal. The authors studied the time and temperature relationships for the wetting of oxides of erbium  $\text{Er}_2\text{O}_3$  ( $-\Delta G^\circ(\text{f}1150^\circ\text{C}) = 1478 \text{ kJ/mole}$ ) and  $\text{Al}_2\text{O}_3$  ( $-\Delta G^\circ(\text{f}150^\circ\text{C}) = 1212 \text{ kJ/mole}$ ) with germanium. A study was made of the contact reaction in these systems and a comparison was made of the temperature dependence of wetting with the temperatures at which the reaction products are fixed. 7 refs.

Zhuravlev, V.S. (Acad of Sciences of the Ukrainian SSR, USSR); Frumina, N.I.; Naichik, Yu.V.; Fenchka, B.V.; Verkhovodov, P.A. *Refractories* v 28 n 9-10 Sep-Oct 1987 p 561-564.

## X-Ray Analysis See Also INTERMETALLICS—Magnetic Properties.

**089166 PREPARATION OF RARE-EARTH DISILICATES AND THEIR X-RAY DIFFRACTION STUDIES.** The aim of the present study was two-fold. Firstly, to establish the experimental conditions to get polymorphic rare-earth disilicates,  $\text{R}_2\text{Si}_2\text{O}_7$  (R = Er, Ho, Dy, Tb) by solid state reaction in the temperature range 1150 to 1500°C. Secondly, to study thermal transport properties of these rare-earth disilicates by a newly developed transient hot-strip method THS since, it is reported that THS method was successful for simultaneous measurement of thermal conductivity and thermal diffusivity of loose building materials like dune, sand, brick powder, cement etc. at room temperature and normal pressure. Since the chemical structures of rare-earth disilicates are reported to be complicated, it was therefore planned to study thermal properties of powdered samples. This letter describes only the preparation and identification of polymorphic rare-earth disilicates. 10 refs.

Maqsood, Asghari (Quaid-i-Azam Univ, Islamabad, Pak); Izhar-Ul-Haq. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1095-1097.

## RARE EARTH ELEMENTS See Also ALUMINUM AND ALLOYS—Amorphous; BERYLLIUM AND ALLOYS—Structure; CATALYSTS—Materials; COBALT AND ALLOYS—Magnetic Properties; ERBIUM AND ALLOYS; INTERMETALLICS—Physical Properties; IONS—Chemical Reactions; ISOTOPES—Applications; LUMINESCENCE—Calculations; MAGNESIUM AND ALLOYS—Electronic Properties; MAGNETIC MATERIALS; MAGNETIC MATERIALS—Anisotropy; MAGNETIC MATERIALS—Magnetic Properties; MAGNETIC MATERIALS—Production; MAGNETIZATION—Process; MAGNETS—Materials; MAGNETS—Thermal Effects; SEMI-CONDUCTING GALLIUM ARSENIDE—Growth; STEEL; STEEL HEAT TREATMENT—Carburizing; URANIUM COMPOUNDS—Impurities.

**089167 INVERSE PHOTOEMISSION SPECTRAL INTENSITY OF RARE-EARTH METALS.** The intensity of inhibited radiation of electrons arising during

radiation-induced trapping of an electron in free 4f-states of rare earth metals is examined. The intensity of emission as a function of electronic energy attains a maximum in the soft X-ray range. The intensity distribution of the transition is primarily governed by the localization radius of free 4f-states in the metals. (Author abstract) 11 refs.

Pavlychev, A.A. (Leningrad State Univ, USSR); Shulakov, A.S.; Kondrat'yeva, I.V. *Phys Met Metallogr* v 60 n 5 1985 p 62-66.

**089168 RESOURCES AND SEPARATION OF RARE EARTHS.** From 200 types of mineral containing rare earth elements, monazite, bastnaesite, xenotime and ion absorption ore are the most valuable. World reserves of rare earth minerals amount to 45 million tons of contained rare earth oxides (REO). China, with reserves of 36 million tons, accounts for 80% of total world reserves. To obtain high purity rare earth elements on an industrial scale, ion exchange and solvent extraction methods are explored. (Edited author abstract) In Japanese.

Akasi, Tsuneo. *J Jpn Soc Powder Powder Metall* v 34 n 9 Nov 1987 p 453-460.

**089169 GEOLOGICAL OCCURRENCE OF ELEMENTS CONSUMED IN THE ELECTRONICS INDUSTRY.** Although many elements are consumed in the electronics industry, the review is confined to silicon, the rare earths, gallium, germanium, selenium, tellurium and indium. The electronic metals show different crustal abundances. The associations of gallium with bauxite and of germanium, indium, selenium and tellurium with base-metal sulphide deposits - and their concentration within such deposits - indicate that they will continue to be recovered as by-products. Growth in demand and rising prices for these elements could stimulate increased recovery from existing operations and - in the case of germanium and gallium - initiate the search for independent sources. The resources of rare-earth elements are large in relation to current demand and the prospects for new discoveries are good. 27 refs.

Highley, D.E.; Slater, D.; Chapman, G.R. *Trans Inst Min Metall Sect C* v 97 Mar 1988, Proc of the Twelfth Annu Commod Meet of the Inst of Min and Metall, London, Engl, Dec 3 1987 p 34-42.

## Analysis

**089170 MICELLAR SOLUBILIZING SPECTROPHOTOMETRIC DETERMINATION OF CERIUM GROUP OF RARE EARTH USING CHLOROPHOSPHONAZO-P-BENZOYL-GLYCINE.** The analytical property of the system RE-CPA-P-BG-CPB in the presence of alcohol have been studied. A blue complex is formed in  $0.16\text{--}0.32 \text{ mol/dm}^3$  HCl medium. Experiments show that the system is more sensitive and more selective than the system RE-CPA-P-BG for determining rare earths. The apparent molar absorption coefficient for cerium is  $1.65 \times 10^5 \text{ l.mol}^{-1}.\text{cm}^{-1}$  at 681nm. The method has been applied to the determination of cerium in synthetic magnesium alloys and cast aluminum with satisfactory results. (Edited author abstract) In Chinese. 1 ref.

Wang, Qiao-yun (Jiangxi Polytechnic Univ, China); Ouyang, Chong-xue; Luo, Run-xian; Yin, Zhen-zhou. *Xi You Jin Shu* v 6 n 1 Feb 1987 p 67-70.

**089171 DETERMINATION OF TRACE COPPER (II) IN RARE EARTH WITH METHOD OF CATALYTIC PHOTOMETRY.** A new analytical method of catalytic photometry based on the reaction of  $\text{H}_2\text{O}_2$  and arsenazo I using  $\text{Cu}^{2+}$  as catalyst and a,a'-dipyridyl as activator in a medium of  $\text{H}_2\text{SO}_4$  has been studied. A new method of determination of trace copper (II) has been established. Its sensitivity is  $4 \times 10^{-4} \mu\text{gCu}^{2+}/\text{cm}^3$ . The range of determination is from 0.01 to  $0.12 \mu\text{g Cu}^{2+}/25\text{cm}^3$ . The method was applied to determination of trace copper (II) in rare earths with satisfactory results. (Edited author abstract). 7 Refs. In Chinese.

Chen, Guo-Shu (Jiangxi Univ, China); Huang, Yu; Hu,

Yin-Gou. *Xiyou Jinshu* v 7 n 1 Feb 1988 p 55-58.

## Applications See Also STEEL HEAT TREATMENT.

**089172 METALLURGICAL APPLICATIONS OF YTTRIUM AND THE LANTHANIDES.** Far from being scarce, the rare earth elements are prevalent in the earth's crust and common in diverse industrial applications. From their beginnings as lighter flints, lanthanide metals have progressed to applications in superconductors and hydrogen storage alloys. They are widely used in iron and steel production, and their physical properties are being exploited in high-strength permanent magnets and magneto-optic data recording. (Author abstract) 25 refs.

Kilbourn, Barry T. (Molycorp Inc, White Plains, NY, USA). *J Met* v 40 n 5 May 1988 p 22-25.

## Electric Conductivity

**089173 HIGH-TEMPERATURE ELECTRICAL RESISTIVITY OF RARE-EARTH METALS WITH VARIABLE VALENCE.** The electrical resistivity of compounds of rare-earth metals at high temperatures is calculated on the basis of allowance for the background mechanism of scattering and the hybridization of local electron states with the states of conduction electrons. An analytic expression is obtained for resistivity in a strong hybridization approximation. It follows from the expression that electrical resistivity may have a negative temperature coefficient within a broad range of high temperatures. The use of a three-band (s, d, f) model makes it possible to explain experimental data on the resistivity of certain rare-earth metals. (Edited author abstract) 7 refs.

Povzner, A.A. (Ural Wood Technology Inst, USSR); Abel'skii, Sh.Sh. *High Temp* v 24 n 6 Nov-Dec 1986 p 808-811.

## Electric Properties

**089174 CRYSTALLINE ELECTRIC FIELD EFFECTS IN DILUTE ALLOYS OF RARE EARTH METALS.** A theory is developed for interpreting the effects of the crystalline electric field in non-magnetic metals containing small quantities of magnetic rare earth impurities. The experimentally detected regularities in the behavior of the crystalline-electric-field-Hamiltonian parameters for various dilute alloys with heavy rare earth metals have been analyzed. Parameters of the model crystal potentials are determined for the non-magnetic metals magnesium, scandium, yttrium and lutetium. It can be concluded that the Friedel oscillations in the effective electrostatic interaction between the ions in the metals have observable consequences for the crystal-field parameters. (Author abstract) 19 refs.

Orlov, V.G. (I.V. Kurchatov Inst of Atomic Energy, Moscow, USSR); Jensen, J. *J Magn Magn Mater* v 71 n 3 Feb 1988 p 279-284.

## Electrolysis

**089175 STUDY ON THE PREPARATION OF RE-ALLOY BY FUSION ELECTROLYSIS.** A rare earth-aluminum alloy was prepared by codeposition in fusion electrolysis with molten cryolite as the electrolyte and  $\text{RE}_2\text{CO}_3$  and  $\text{Al}_2\text{O}_3$  as raw materials. The main advantage of this process are that Ce is easily maintained in the trivalent state. The  $\text{Ce}_2\text{O}_3$  derived from  $\text{RE}_2(\text{CO}_3)_3$  is dissolved out and its solubility in molten cryolite is high. Effects of molten salt composition and temperature on the electrolysis have been investigated. In Chinese. 18 refs.

Li, Ping (Acad Sinica, China); Lu, Hua-yi; Lu, Lian-qin; Du, Fu-yang; Liu, Shu-lan; Tang, Ding-xian. *Xi You Jin Shu* v 6 n 1 Feb 1987 p 27-31.

## Electronic Properties

**089176 ELECTRONIC STRUCTURE OF THE RARE-EARTH IONS AS ANALYZED BY THE NEW FRAMES IN PHYSICS.** After a short introduction of



new concepts in physics, the electronic structure and its significance in material engineering are explained. The real shape of the classical orbits, an understandable description of self spin orbit coupling, and electronic multiplet structures of rare earth ions are presented. (Edited author abstract) In Japanese. 8 refs.

Iida, Shuichi. *J Jpn Soc Powder Metall* v 34 n 9 Nov 1987 p 481-484.

## Exploration

**089177 AVAILABILITY OF RARE EARTHS.** Bastnasite, the world's principle source of rare earths, is mined as a primary product in the United States and as a byproduct of iron-ore mining in China. Significant quantities of rare earths are also recovered from monazite, primarily a byproduct of heavy-mineral sands. Smaller quantities of rare earths, especially yttrium, are obtained from the yttrium-rich mineral xenotime. 16 refs.

Hedrick, James B. (US Dep of the Interior, Washington, DC, USA). *Am Ceram Soc Bull* v 67 n 5 May 1988 p 858-861.

## Extraction

**089178 USE OF CROWN ETHERS AS SYNERGISTS IN THE SOLVENT EXTRACTION OF TRIVALENT ACTINIDES AND LANTHANIDES BY 1-PHENYL-3-METHYL-4 TRIFLUOROACETYL PYRAZOLONE-5.** The synergistic extraction of trivalent Am, Cm, Cf and Eu with mixtures of 1-phenyl-3-methyl-4-trifluoroacetyl pyrazolone-5 (HPMTFP) and a crown ether dicyclohexano-18-crown-6 (DCH18C6) or monobenzo-15-crown-5 (B15C5) has been studied in chloroform. With DCH18C6 the synergistic species extracted are M(HPMTFP)<sub>3</sub> (HPMTFP)<sub>3</sub>(DCH18C6) where M = Am, Cm and Eu and Cf (PMPTFP)<sub>3</sub> (DCH18C6), whereas with B15C5 the species are M(HPMTFP)<sub>3</sub>n(B15C5), n being 1 or 2 for all these metal ions. The possibility of high coordination numbers for these metal ions in these systems and the probable reasons for the abnormal order of synergistic constants namely  $K_2 \gg B_1$  have been discussed. (Author abstract) 23 refs.

Mathur, J.N. (BARC, Bombay, India); Khopkar, P.K. *Solvent Extr Ion Exch* v 6 n 1 Feb 1988 p 111-124.

**High Pressure Effects** See GADOLINIUM AND ALLOYS—Phase Transitions.

## Magnetic Properties

**089179 MAGNETIC AND CRYSTAL STRUCTURAL PROPERTIES OF NEW INTERMETALLIC COMPOUNDS IN R-Ti-Fe SYSTEM.** The magnetic and structural properties of R-Ti-Fe system were investigated. It was found that the Ti rich alloy includes a ternary compound having a ratio of R to Ti to Fe of 1:1:10 and a tetragonal structure. SmTiFe<sub>10</sub> has a high saturation magnetization and an anisotropy field with T<sub>C</sub> of 310°C. It is a candidate for a hard magnetic material. Fe replacement by Co in RTiFe<sub>10</sub> compounds increases the Curie temperature and the same ternary compound exists in R-Ti-Co systems. (Edited author abstract) In Japanese. 6 refs.

Ohashi, Ken; Tawara, Yoshio; Osugi, Ryo; Yokoyama, Toshikazu. *J Jpn Soc Powder Metall* v 34 n 9 Nov 1987 p 478-480.

**Marketing** See SEMICONDUCTOR MATERIALS—Marketing.

## Microstructure

**089180 PHONON-ASSISTED STRUCTURAL TRANSITIONS IN A ONE-IMPURITY ANDERSON MODEL.** Impurity displacements in metallic systems have been investigated in relation to the phenomenon of valence fluctuations and structural transitions in rare earths. A one-impurity Anderson model has been employed which includes electron-phonon coupling in its hybridization term. Structural transitions were found to

increase the hybridization (i.e. the virtual bound state width) for average impurity displacements. Our results are compared with recent values for cerium metal and the agreement is reasonably good. (Edited author abstract) 10 refs.

Marin, F.P. (Univ Central de Venezuela, Caracas, Venez). *J Less Common Met* v 136 n 1 Dec 1987 p 1-7.

**089181 PHASE TRANSFORMATION IN THE RARE EARTH-COBALT ALLOYS.** The phase relationship and phase transformation in rare earth-cobalt (R-Co) alloys were investigated using a pair approximation. The structures of the alloys investigated were RCo<sub>5</sub> (CaCu<sub>5</sub> type), R<sub>2</sub>Co<sub>17</sub> (Th<sub>2</sub>Zn<sub>17</sub> type), and R<sub>2</sub>Co<sub>7</sub> (Gd<sub>2</sub>Co<sub>7</sub> type). It proposed that RCo<sub>5</sub> and R<sub>2</sub>Co<sub>17</sub> phases coexist stably with each other because the value of ordering energy depends on the distance between atoms. The phase separation of RCo<sub>5</sub> → RCo<sub>5</sub> + R<sub>2</sub>Co<sub>17</sub> in Sm-Co and Gd-Co alloys follows spinodally if ordering of the Th<sub>2</sub>Zn<sub>17</sub> type occurs. The composition of the eutectoid transformation RCo<sub>5</sub> → R<sub>2</sub>Co<sub>7</sub> + R<sub>2</sub>Co<sub>17</sub> shifts to the Co-rich side with decreasing ordering temperature and increasing eutectoid temperature. (Author abstract) 28 refs. In Japanese.

Hasaka, Masayuki (Nagasaki Univ, Nagasaki, Jpn); Wan, Yong; Uchiyama, Yasuo; Koga, Hideto. *Nippon Kinzoku Gakkaishi* v 52 n 2 Feb 1988 p 150-156.

## Molten

**089182 ISOTHERMAL COMPRESSIBILITY AND SOUND VELOCITY OF LIQUID RARE EARTH METALS.** The simple one-component plasma (OCP) model has been applied to the isothermal compressibilities of liquid rare earth metals. The calculated results are in fair agreement with those estimated from the long-wavelength limit of liquid structure factors and the well-known relation between the isothermal compressibility and the surface tension. The velocity of sound has been calculated by the Percus-Yevick (PY) phonon model using recently measured low-angle structure data. The OCP model appears to provide a fair description of the thermodynamic properties of liquid rare earth metals. (Author abstract) 20 refs.

Yokoyama, I. (Nat'l Defense Acad, Yokosuka, Jpn); Naito, S.; Waseda, Y. *J Less Common Met* v 136 n 1 Dec 1987 p 25-29.

**Optical Properties** See GLASS—Doping.

**Phase Equilibria** See VANADIUM AND ALLOYS—Phase Equilibria.

## Physical Properties

**089183 ANALYSIS OF DATA ON THE DENSITIES OF LIQUID RARE-EARTH METALS FROM THERMODYNAMIC PARAMETERS.** Calculations have been performed on the pseudopotential parameters and packing coefficients in a hard-sphere reference system for rare-earth metals near their melting points on the basis of minimum Helmholtz free energy if the calculated and observed values for the resistivity agree. The results have been used in calculating the thermodynamic parameters in the liquid state. Theory is in satisfactory agreement with experiment. A method is proposed for analyzing measurements on the temperature coefficient of the density, where there are sometimes substantial differences in the data. (Edited author abstract) 10 refs.

Kiselev, A.I. (Acad of Sciences of the USSR, USSR); Kononenko, V.I. *High Temp* v 25 n 3 May-Jun 1987 p 355-359.

**Production** See RARE EARTH COMPOUNDS—Electrolysis.

**Radiation Effects** See Also X-RAYS—Emission.

**089184 RELATIVE INTENSITY DATABASE OF L-SHELL LINES OF LANTHANIDES AND ANALYSIS OF THE PIXE SPECTRA.** The PIXE spectra

resulting from proton beam bombardment in the energy range of 1 to 2.5 MeV of the thin targets of 14 lanthanides were measured using a Ge detector to obtain a relative intensity database of the L-shell lines. The database utilizes the relativistic Hartree-Slater (RHS) emission rates reported by Scofield. To correct the other quantities affecting the relative intensities such as L-subshell ionization cross sections etc., empirical factors are introduced and the values are determined by the least squares method. The reduced chi-squared value is  $0.85 \pm 0.4$  for 90 spectra. The relative intensities of Nd, Dy and Yb obtained at 2 MeV are compared with the recent ECPSSR approach by Cohen and Harrigan, and it is found that these results are in fairly good agreement. (Edited author abstract) 11 refs.

Hirokawa, T. (Hiroshima Univ, Hiroshima, Jpn); Nishiyama, F.; Kiso, Y. *Nucl Instrum Methods Phys Res Sect B* v B31 n 4 Jun 1 1988 p 525-534.

**Separation** See Also YTTRIUM COMPOUNDS—Purification.

**089185 STUDIES ON SEPARATION OF RARE EARTH ELEMENT COMPLEXES WITH IMINODIACETATE ACID ON STRONGLY BASIC ANION EXCHANGERS IN DIFFERENT FORMS.** Purification of yttrium from dysprosium, holmium, erbium and ytterbium has been studied on the strongly basic anion exchanger Dowex 1X4 in an acetate form and for comparison in an iminodiacetate form. The rare earth element solutions complexed with iminodiacetate acid Ln(imda)<sub>2</sub> were separated using frontal analysis. The obtained results show the significant effect of an anion exchanger form on separation of Ln(imda)<sub>2</sub> complexes. An acetate form of the anion exchanger proves particularly effective and economical in yttrium separation from dysprosium, holmium and erbium but IDA form for yttrium separation from ytterbium. (Author abstract) 11 refs.

Hubicka, H. (Maria Curie-Skłodowska Univ, Lublin, Pol). *Solvent Extr Ion Exch* v 6 n 2 Apr 1988 p 361-374.

**Solubility** See Also ALUMINUM AND ALLOYS—Impurities.

**089186 INTERACTION BETWEEN RARE EARTH ELEMENTS AND CARBON IN LIQUID IRON.** The influence of rare earth elements on carbon solubility, interaction coefficients as well as equilibrium constants of RE<sub>2</sub>C formation in liquid iron were investigated at 1300, 1400, 1500 and 1600°C. Ce, Y, La, Nd and Sm may increase the solubility of C in liquid iron. In Chinese. 4 refs.

Du Ting (Central Iron & Steel Research Inst, Beijing, China); Yue Kexiang. *Chin Shu Hsueh Pao* v 23 n 4 Aug 18 1987 p B207-B210.

## Solvent Extraction

**089187 TEMPERATURE EFFECT ON THE SYNERGISTIC SOLVENT EXTRACTION OF LANTHANOIDES.** The synergistic solvent extraction of Pr, Gd and Yb with mixtures of HTTA and Aliquat 336 in CCl<sub>4</sub>, C<sub>6</sub>H<sub>6</sub> and CHCl<sub>3</sub> at 288, 298, 308 and 318 K has been studied. The values of the equilibrium constants as well as the values of the thermodynamic parameters have been calculated. (Author abstract) 18 refs.

Dukov, I.L. (Higher Inst of Chemical Technology, Sofia, Bulg); Genov, L.Ch. *Solvent Extr Ion Exch* v 5 n 5 1987 p 977-987.

**089188 SOLVENT EXTRACTION OF RARE EARTH ELEMENTS WITH Di(2-ETHYLHEXYL)-PHOSPHORIC ACID DILUTED WITH SHELLSOL 71.** Rare earth elements are extracted with di(2-ethylhexyl)-phosphoric acid (D2EHPA, HA) in SHELLSOL 71 through a cation exchange reaction. The distribution ratios are proportional to the minus third power of H<sup>+</sup> concentration and the m-th power of D2EHPA concentra-



tion ( $m=2\pm 2.2$ ). The evaluated separation factors demonstrated that the D2EHPA-SHELLSOL 71 system is a promising one for the mutual separation of rare earth elements. (Author abstract) In Japanese. 8 refs.

Hirashima, Yoshiyuki (Kinki Univ, Higashiosaka, Jpn); Oki, Tsuneo; Shiokawa, Jiro. *Chem Express* v 3 n 6 Jun 1988 p 331-334.

#### Spectroscopic Analysis See Also X-RAY ANALYSIS.

**089189 MATRIX EFFECTS IN THE SEPARATION OF RARE-EARTH ELEMENTS, SCANDIUM, AND YTTRIUM AND THEIR DETERMINATION BY INDUCTIVELY COUPLED PLASMA OPTICAL EMISSION SPECTROMETRY.** Due to sensitivity and reproducibility, inductively coupled plasma optical emission spectrometry (ICP-OES) has developed into a very promising technique in the determination of the rare-earth elements (REE), Sc, and Y. However, the changing composition of natural samples may cause severe problems during separation from concomitant elements (matrix elements). In this study a simplified version of REE separation from 8 major and 27 trace elements is proposed. Some major matrix elements, depending on their kind and quantity, cause a specific depression of recovery rates of light REE (LREE) during the ion exchange process. (Edited author abstract) 31 refs.

Zachmann, D.W. (Technische Univ Braunschweig, Braunschweig, West Ger). *Anal Chem* v 60 n 5 Mar 1 1988 p 420-427.

**089190 HOMOGENEOUS LINEWIDTHS AND PHOTON ECHO DECAY RATES OF RARE EARTH AND TRANSITION METAL IMPURITIES IN GLASSES.** We outline a general theory of homogeneous linewidths and photon echo decay rates of rare earth and transition metal impurities in glasses. The near-quadratic temperature dependence observed in the homogeneous linewidth for  $T \geq 10$  K is attributed to a Raman process involving low-lying harmonic vibrational modes which co-exist with ordinary sound waves. We calculate the temperature dependence of the linewidth for  $10\text{K} < T < 300\text{K}$  using a density of states for these modes obtained from inelastic neutron scattering studies of vitreous silica. 6 refs.

Huber, D.L. (Univ of Wisconsin, Madison, WI, USA); Putikka, W.O. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 567-568.

**089191 FRANK TOMKINS'S CONTRIBUTION TO THE DETERMINATION OF SPINS AND NUCLEAR MOMENTS AND TO THE ANALYSIS OF THE LANTHANIDE AND ACTINIDE SPECTRA.** Various aspects of the important work of F.S. Tomkins in atomic spectroscopy are reviewed. Several American and European laboratories have benefitted from the skill of Tomkins in preparing efficient light sources from minute amounts of radioactive species. He has brought a decisive contribution to the impressive progress in the understanding of the lanthanide and actinide spectra. 47 refs.

Blaise, Jean (CNRS, Orsay, Fr); Gerstenkorn, Simon. *Nucl Instrum Methods Phys Res Sect B* v B31 n 1-2 Apr II 1988, Proc of the Symp on At Spectrosc and Highly Ionis At, Lisle, IL, USA, Aug 16-21 1987 p 85-92.

#### Thin Films See Also FILMS—Magnetic Properties.

**089192 SPUTTERED FILMS OF TbDyFe.** Sputtered thin films of the ternary alloy ( $\text{Tb}_x\text{Dy}_{1-x}$ )  $\text{Fe}_2$  in the compositional range  $0.2 < x < 0.4$  are investigated in view of their potential use in magnetic sensor device applications. Pertinent crystallographic and magnetic features are studied using optical and electron microscopy and magnetometry on as-deposited and annealed films. Hysteresis loop parameters are found to be sensitive to the composition of the films, as is the sense of the magnetic anisotropy in the films. Estimates of the magnetostriction of the films give a high value for the  $\text{Tb}_{0.3}\text{Dy}_{0.7}\text{Fe}_2$

composition. 6 refs.

Lacey, E.T.M. (Univ of Salford, Engl); Lord, D.G.; Grundy, P.J. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1713-1715.

#### Trace Analysis

**089193 DETERMINATION OF RARE EARTH ELEMENTS, GALLIUM AND CHROMIUM IN RARE EARTH-GALLIUM GARNET CRYSTALS.** Gallium garnet crystals containing rare earth elements were decomposed in a sealed teflon either with sulfuric acid at  $200^\circ\text{C}$  for 16 h or with hydrochloric acid at  $140^\circ\text{C}$  for 16 h. Gallium was separated chromatographically by anion exchange resin from other elements in the sample solution, and determined by titration with EDTA. Gadolinium, scandium, yttrium, lanthanum and lutetium in the sample solution were determined by direct or back titration with EDTA, and neodymium and chromium by spectrophotometry. Analytical results of eight samples are presented. (Author abstract) In Japanese. 16 refs.

Yajima, Yoshiyuki (Nat Inst for Research in Inorganic Materials, Jpn); Kobayashi, Michiko; Einaga, Hisahiko. *Yogyo Kyokai Shi* v 95 n 10 1987 p 1012-1017.

#### Transport Properties

**089194 TRANSPORT OF TRIVALENT LANTHANIDES IN A  $\text{H}_2\text{O}-\text{CHCl}_3-\text{H}_2\text{O}$  LIQUID MEMBRANE SYSTEM CONTAINING A CROWN ETHER CARBOXYLIC ACID.** Neutral crown ethers do not transport trivalent lanthanide cations in a  $\text{H}_2\text{O}-\text{CHCl}_3-\text{H}_2\text{O}$  liquid membrane system. With the addition of a carboxylate group to a macrocyclic polyether, as in the case of sym-dibenzo-16-crown-5-oxyacetic acid, high efficiencies of transporting trivalent lanthanides were observed across the  $\text{H}_2\text{O}-\text{CHCl}_3-\text{H}_2\text{O}$  liquid membrane. The crown ether carboxylic acid also showed significant selectivity for the lanthanides studied in this system. (Author abstract) 12 refs.

Tang, Jian (Univ of Idaho, Moscow, ID, USA); Wai, C.M. *J Membr Sci* v 35 n 3 Feb 1988 p 339-345.

#### X-Ray Analysis See Also ROCK—X-Ray Analysis.

**089195 DETERMINATION OF THE CONCENTRATIONS AND DISTRIBUTIONS OF RARE-EARTH ELEMENTS IN MINERAL AND ROCK SPECIMENS USING THE VEPP-4 SYNCHROTRON RADIATION.** Results are presented on X-ray fluorescence determination of the K-series of rare-earth elements (REE) in rocks using synchrotron radiation (SR) from the VEPP-4 storage ring. In a direct, instrumental determination, the detection limit is  $5 \times 10^{-5}\%$ . The procedure for chemical preconcentrating which allows the detection limit to be reduced to  $10^{-6}\%$  is described. The SRXFA technique has also been employed to study the spatial distribution of REE in rock specimens by scanning with an SR beam. (Author abstract) 17 refs.

Baryshev, V.B. (Inst of Nuclear Physics, Novosibirsk, USSR); Gilbert, A.E.; Kozmenko, O.A.; Kulipanov, G.N.; Zolotarev, K.V. *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 272-278.

#### RAYON FABRICS

Bending See RAYON YARN—Elasticity.

#### Printing

**089196 WET PRINTING OF RAYON AND POLYESTER/RAYON FABRICS.** The authors review the preparation stage, process routes and printing recipes for 100% rayon. The printing of polyester/rayon blends poses specific problems in dye selection and processing methods. These problems and an innovative approach to them are discussed. (Author abstract) 26 refs.

Provost, J.R. (ICI plc, Manchester, Engl); Shay, B.M. *Text Chem Color* v 20 n 4 Apr 1988 p 29-32.

#### RAYON YARN

##### Elasticity

**089197 EFFECT OF TWIST ON FLEXURAL RIGIDITY AND ELASTIC RECOVERY OF ACRYLIC-VISCOSE ROTOR-SPUN YARNS.** All-viscose fiber yarns showed higher flexural rigidity and lower elastic recovery. An increase in twist led to a significant increase in yarn flexural rigidity. The rigidity of the fibers being blended and their position in the yarn also affected the flexural rigidity of the blended yarn. (Author abstract) 7 refs.

Kaushik, R.C.D. (Technological Inst of Textiles, Bhiwani, India); Salhotra, K.R.; Tyagi, G.K. *Indian J Text Res* v 12 n 4 Dec 1987 p 220-221.

##### Spinning

**089198 EFFECT OF TWIST ON CHARACTERISTICS OF ACRYLIC-VISCOSE ROTOR-SPUN YARNS.** Yarn twist has a great influence on the characteristics of ring-spun yarns. The impact of yarn twist could be very different in the case of rotor-spun yarns owing to rotor yarn's structural difference with ring-spun yarns. The effect becomes even more complex because of the non-homogeneous characteristics of the blend fibers. This study reports the contribution of twist to the breaking strength, extension at break, and any association between twist loss and yarn unevenness in acrylic-viscose rotor-spun yarns. (Author abstract) 8 refs.

Kaushik, R.C.D. (Technological Inst of Textiles, Bhiwani, India); Salhotra, K.R.; Tyagi, G.K. *Indian J Text Res* v 12 n 3 Sep 1987 p 139-141.

**089199 INFLUENCE OF DOUBLING ON CHARACTERISTICS OF ACRYLIC-VISCOSE RAYON ROTOR-SPUN YARNS.** Rotor-spun yarns possess a lower mean breaking strength than the corresponding ring-spun yarns owing to the incidence of wrapper fibers and twist loss. Doubling twisting improved the tenacity of acrylic-viscose rayon yarns markedly by increasing the inter-fiber cohesion in the yarn. (Author abstract) 9 refs.

Kaushik, R.C.D. (Technological Inst of Textiles, Bhiwani, India); Salhotra, K.R.; Tyagi, G.K. *Indian J Text Res* v 12 n 3 Sep 1987 p 142-145.

**089200 CONTRIBUTION OF FIBER LENGTH AND FIBRE DENIER TO CHARACTERISTICS OF RING- AND ROTOR-SPUN VISCOSE RAYON YARNS.** Contrary to the view held so far that the strength of rotor-spun yarns is relatively insensitive to fiber length, the maximum tenacity is observed for fibers of 38 mm length. Rotor yarns spun either from finer or longer fibers exhibit lower breaking extension. The unevenness decreases with increase in fiber length in ring-spun yarns but shows an upward trend in rotor-spun yarns. (Author abstract) 10 refs.

Kaushik, R.C.D. (Technological Inst of Textiles, Bhiwani, India); Salhotra, K.R.; Tyagi, G.K. *Indian J Text Res* v 12 n 3 Sep 1987 p 146-148.

#### REAMING See BORING.

#### RECORDING See Also MAGNETIC DEVICES, THIN FILM—Mathematical Models.

**089201 ZAPIS PIONOWY - NOWY SPOSOB REJESTRACJI MAGNETYCZNEJ.** [Vertical Recording - New Procedure of Magnetic Registration]. Characteristics of vertical magnetic recording technique are presented. Basic physical phenomena in the magnetic head - medium interaction are discussed. Methods of both write and read by means of heads and media of different designs are presented. (Edited author abstract) In Polish. 11 refs.

Depta, Robert. *Elektronika* v 28 n 5 1987 p 19-21.



**089202 AUDIO ANALYSIS VII: DIGITAL COPYING OF COMPACT DISKS.** The Son PCM-601 Digital Audio Processor turns digital audio signals into a video signal and vice versa. It has analog and digital audio inputs and outputs. Because of its modest 1400 dollars retail price and specifications that are similar to professional units, it is often used to record master tapes used to make compact disks (CDs). Its digital input and a VHS videocassette recorder's (VCR) 6-hr recording time make it appear to be an attractive device for copying CDs. The paper explains how PCM recording on videotape works, and discusses such subjects as CD changers, selecting a VCR, video quality, and various uses for the Sony PCM-601. 5 refs.

Greenspun, Philip (MIT, Cambridge, MA, USA). *Comput Music J* v 12 n 3 Fall 1988 p 52-57.

**089203 HIGH DENSITY MAGNETIC RECORDING HEAD SLIDER FOR SMALL RIGID DISK.** The new negative pressure slider called NNP slider has been developed for the attainment of high density recording in magnetic disk drives. The NNP slider has high stiffness and a very small flying height of 0.1  $\mu\text{m}$  independent of the disk velocity. And in using an actual disk (a sputtered disk), the NNP slider can follow the vertical run-out of the disk and fly stably, even though the flying height may fluctuate due to the undulation or roughness of the disk. Therefore, crash phenomena do not occur. The stable flying of the NNP slider can bring out the best properties of the sputtered disks. 2 refs.

Tomiyasu, H. (Matsushita Electric Co, Kumamoto, Jpn); Fukakusa, M.; Sato, K.; Kanai, K. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3467-3469.

## Analysis

**089204 FREQUENCY COMPOSITION OF PERTURBED SLIDER MOTION.** This report describes the motion of a 3370 type slider as a function of frequency and interface speed. The data is plotted as three dimensional surfaces which are very useful in delineating natural air bearing frequencies from driving frequencies caused by mechanical perturbations.

Banks, W. (IBM, San Jose, CA, USA); Kroeker, R.; Nunnelley, L. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3462-3463.

**Components** See FILMS—Magnetic Properties.

## Computer Simulation

**089205 FAST TAKE-OFF NEGATIVE PRESSURE SLIDER.** Using computer simulation, the flying characteristics of a conventional positive pressure head slider and two types of zero-load negative pressure head sliders are compared. By experiment, we confirmed that the FTO prototype head impacts little on the medium during CSS, and also has superb flying stability. 6 refs.

Yoneoka, S. (Fujitsu Ltd, Atsugi, Jpn); Yamada, T.; Aruga, K.; Ooe, T.; Takahashi, M. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3464-3466.

**Density** See DATA STORAGE, MAGNETIC; MAGNETIC MATERIALS—Research; SIGNAL DISTORTION—Noise, Spurious Signal.

**Equipment** See OSCILLOSCOPES, CATHODE RAY.

**Ferrite Applications** See Also DATA STORAGE, MAGNETIC—Disk.

**089206 FILM HEAD READ RESOLUTION AND FREQUENCY RESPONSE ANALYSIS.** The read resolution of a ferrite recording head is determined by its gap length, which also determines its writability. However, under broad conditions of practical interest, the read resolution of a film head can be shown to depend primarily on the sum of the poletip and gap lengths  $P1 + g + P2$ . This

permits choosing the sum to give needed resolution while independently optimizing the gap for writing. This paper describes conditions under which the resolution of a head is determined by: gap and head-to-medium spacing, the sum of poletip and gap lengths (Pp for short), and head-to-medium spacing or head-to-medium spacing only. Pure longitudinal recording is assumed, and the resolution determining factors are derived by a closed form frequency analysis. 4 refs.

Arnoldussen, Thomas C. (IBM, San Jose, CA, USA). *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3152-3154.

**089207 RECORDING CHARACTERISTICS OF SEMIHARD MN-ZN FERRITE SPUTTERED DISKS.** Thin films of ferrite such as  $\text{Co-}\gamma\text{Fe}_2\text{O}_3$  and  $\text{BaFe}_{12}\text{O}_{19}$  are useful for magnetic layers in high density recording disks. However, they have to be deposited on the substrates at considerably high temperatures (e.g., 250 and 500°C, respectively). In this study, Mn-Zn ferrite films with relative high coercive forces have been prepared at substrate temperature as low as 100°C, using 'Facing Targets Sputtering' apparatus. Their read/write characteristics have been evaluated by means of a conventional ring head. The reproduced signals exhibited dipulse waveforms with dipulse ratios of 0.3. A recording density  $D_{50}$  of about 60kFRPI was attained. 4 refs.

Naoe, Masahiko (Tokyo Inst of Technology, Tokyo, Jpn); Yata, Michio; Matsumoto, Kazuo. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3429-3431.

**Instruments** See Also DATA CONVERSION, ANALOG TO DIGITAL; OSCILLOSCOPES, CATHODE RAY.

**089208 SIGNAL CONDITIONING AND ANALOG-TO-DIGITAL CONVERSION FOR A 4-MHz, 12-BIT WAVEFORM RECORDER.** The analog-to-digital converter (ADC) in the HP 5183A Waveform Recorder samples at a rate of four million samples per second and provides 12 bits of amplitude resolution. Key features of the analog circuitry include the design of a modern discrete operational amplifier, a discrete sample-and-hold circuit, series-parallel ADC topology with pipelined ADC timing, a low-noise oscillator, and pseudorandom noise to improve the ADC's linearity. Digital signal processing techniques can be used on the raw digital data to increase the signal-to-noise performance; these techniques include averaging multiple measurements and oversampling (with respect to input signal bandwidth) followed by digital filtering. These issues are discussed in detail. 1 ref.

Gee, Albert; Young, Ronald W. *Hewlett Packard J* v 39 n 1 Feb 1988 p 15-22.

**089209 DIGITAL DESIGN OF A HIGH-SPEED WAVEFORM RECORDER.** This article examines how the design of the HP 5185A Waveform Recorder digital hardware provides the ability to capture and focus upon the portion of the signal conveying the desired information. A design overview is followed by a discussion of the digital system, timing issues, DC-to-250-MHz operation, pipeline partitioning, data deceleration, the analog-digital trigger, and two-channel synchronous data storage. 3 refs.

Pon, Rayman W.; Bird, Steven C.; Deane, Patrick D. *Hewlett Packard J* v 39 n 1 Feb 1988 p 32-38.

**089210 WAVEFORM RECORDER DESIGN FOR DYNAMIC PERFORMANCE.** The authors describe the relation between various types and sources of phase noise and the effects of this noise on amplitude errors when sampling high-slew-rate signals. They then discuss considerations related to the choice of oscillator topology, circuit design, and component selection to achieve the required performance in the SAW reference oscillator, that is, less than 2 ps rms phase jitter. Finally, they review how dynamic performance is measured and outline the closed-form sine wave curve fitting algorithm used in production testing of the HP 5185A. 10 refs.

Frohning, Brian J.; Peetz, Bruce E.; Unkrich, Mark A.;

Bird, Steven C. *Hewlett Packard J* v 39 n 1 Feb 1988 p 39-47.

**Magnetic Field Effects** See MICROSCOPIC EXAMINATION—Scanning Electron Microscopy.

**Materials** See Also COBALT CHROMIUM ALLOYS—Magnetic Properties; COBALT CHROMIUM ALLOYS—Wear; FERRITES—Measurements; FILMS—Metallic; LUBRICANTS—Thin Films; MAGNETOOPTICAL DEVICES; MAGNETOOPTICAL DEVICES—Magnetic Properties; MAGNETOOPTICAL DEVICES—Protective Coatings.

**089211 ON THE ORIGIN OF  $K_U$  IN AMORPHOUS RE-TM MAGNETO-OPTIC RECORDING MATERIALS.** Exchange anisotropy was recently proposed as the origin of uniaxial perpendicular anisotropy in some Re-Tm thin films. This magnetic anisotropy arises from the exchange interaction between the ferrimagnetic matrix and acicular shaped single domain ferromagnetic regions. Rotational hysteresis measurements on GdCo films show a non-vanishing value of the rotational magnetic hysteresis for magnetic fields greater than the magnetic anisotropy field ( $H_K$ ). Such a behavior, first discovered in Co-CoO, is a necessary but not a sufficient condition for exchange anisotropy. A two dimensional idealized model of the amorphous RE-TM thin film that exhibits exchange anisotropy is proposed. 8 refs.

Meiklejohn, W.H. (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Luborsky, F.E.; Frischmann, P.G. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2272-2274.

**089212 TRANSITION POSITION AND AMPLITUDE FLUCTUATION NOISE MODEL FOR LONGITUDINAL THIN FILM MEDIA.** This paper presents a transition noise model for square wave recording on longitudinal thin film media considering two sources of noise model for square wave recording on longitudinal thin film media considering two sources of noise: phase shift (or transition jitter) and amplitude. The transition jitter noise is due to random fluctuations in the transition positions, while the amplitude noise is due to random shape fluctuations in the transitions. It is assumed that random medium coercivity fluctuations cause transition position fluctuations. It is assumed that random medium coercivity fluctuations cause transition position fluctuations. The random transition shape fluctuations are modeled by allowing the transition parameter  $a$  to be a random variable. These transition parameter variations are assumed to be caused by random medium magnetization fluctuations. Each written transition produces a demagnetizing field that affects the positions and shapes of subsequent transitions. The properties of both types of noise are discussed. (Edited author abstract) 6 refs.

Barany, Alexander M. (Univ of California at San Diego, La Jolla, CA, USA); Bertram, H. Neal. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2374-2376.

**089213 NEW COMPOSITE-CORE HYBRID THIN FILM RING HEAD.** A new inductive ring head configuration has been designed which utilizes a composite substrate of magnetic and nonmagnetic members for thin film processing and thereby has several features that are advantageous to a high density recording head; these are 1) thin film poles, 2) etched track widths, 3) no secondary ferrite gap, 4) low reluctance bulk ferrite superstructure, and 5) ordinary wire wound coils. (Author abstract) 4 refs.

Dugas, Matthew (Advanced Research Corp, Minneapolis, MN, USA); Judy, Jack. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2407-2409.

## Mathematical Models

**089214 NONLINEAR SUPERPOSITION IN SATURATION RECORDING OF DISK MEDIA.** The magnetic readback signal is generally assumed to be made up of linearly superposed single transition responses. As the transition spacing is reduced, this property is seen not



to hold. With particular disks, we find the head signal can be reconstructed as a linear superposition of variably spaced individual transitions, while with cobalt alloy film disks, both the spacing and the amplitude of individual transitions vary as a function of the data. This behavior is interpreted by a self-consistent 2D recording model, linear superposition improves dramatically with low  $M_t$  disk media. (Author abstract) 6 refs.

Melas, C. Michael (IBM, San Jose, CA, USA); Arnett, Patrick; Beardsley, Irene; Palmer, Dean. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2079-2081.

**089215 DYNAMICS OF HEAD-DISK CONTACT-IMPACT IN MAGNETIC RECORDING.** One of the critical areas of the magnetic storage process is the dynamics of suspending a magnetic recording head over a rotating rigid disk while maintaining a finite clearance between the disk and the slider carrying the head. A simulation tool is developed and applied to analyze the dynamics of a slider flying under the influence of aerodynamic forces and subject to intermittent contact by rapidly moving disk surface defects such as localized asperities. 10 refs.

Ponnaganti, V. (Santa Clara Univ, CA, USA); Kane, T.R.; White, J.W. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3435-3437.

**089216 TRANSITION BETWEEN SLIDING AND FLYING OF A MAGNETIC RECORDING SLIDER.** We investigate the dynamics of a magnetic recording slider of a rigid disk file during its transition between sliding and flying. The slider is modeled as a three degree-of-freedom system, capable of lift, pitch, and roll. In addition to considering loads from air pressure, inertia, and the suspension arm, we also consider impulsive loads arising from slider/disk collisions. A coefficient-restitution model is introduced. Numerical results are provided for typical conditions of disk velocity, suspension preload, and surface roughness. 7 refs.

Benson, Richard C. (Univ of California at San Diego, La Jolla, CA, USA); Talke, Frank E. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3441-3443.

**Measurements** See Also MAGNETIC TAPE—Magnetic Properties.

**089217 SIMULTANEOUS MEASUREMENT OF HEAD-DISK SPACING AND REPRODUCED OUTPUT IN FLEXIBLE PERPENDICULAR MAGNETIC RECORDING DISK DRIVE.** The authors have successfully developed a new system capable of measuring the dynamic spacing between head and flexible disk. By using this system with the single-pole head, spacing changes and amplitude variations of reproduced output can be measured simultaneously as continuous data. The main purpose of the present paper is to describe this new measuring method for spacing loss. Data of the relation between head-disk spacing and reproduced output is additionally shown as an example. 9 refs.

Muratomi, Y. (Mitsubishi Electric Corp, Amagasaki, Jpn); Miwa, H.; Tani, T.; Ikenaga, A.; Shimogai, H. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3444-3446.

**089218 MEASUREMENT METHOD FOR THE SPACING FLUCTUATION OF A HEAD SLIDER IN A MAGNETIC DISK DRIVE.** The fact that disk wavy deformation brings about an increase in head friction force and causes damage was revealed experimentally. The RSM method, which can be used to evaluate head slider spacing fluctuation, induced by disk waviness, was investigated. Taking into account spacing loss in recording, spacing fluctuation measured by the RSM method was in good agreement with that estimated theoretically. 6 refs.

Ohtsubo, Y. (Toshiba Corp, Kawasaki, Jpn); Kawashima, N.; Marumo, H. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr

14-17 1987 p 3450-3452.

**089219 COMPARISON OF OPTICAL AND CAPACITIVE MEASUREMENTS OF SLIDER DYNAMICS.** A simultaneous slider air bearing thickness measurement is made using capacitive and optical techniques. The first technique measures the capacitance between a conducting disk and a probe attached to the slider, and the other measures the optical path length using interferometry. A quartz disk with a transparent conductive coating is used for this experiment. Measurements are made simultaneously at three corners of the slider from DC to 100 kHz. The DC flying height measurements agree to within 7 nm while the AC fluctuations agree to within the noise level of each technique (0.2 nm). 7 refs.

Best, G.L. (IBM, San Jose, CA, USA). *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3453-3455.

**089220 ACCURATE MEASUREMENT AND EVALUATION OF DYNAMIC CHARACTERISTICS OF FLYING HEAD SLIDER FOR LARGE-CAPACITY FAST-ACCESS MAGNETIC DISK STORAGE.** This paper presents a highly accurate method of measuring flying head height over a wide frequency range using visible laser interferometry. In addition, methods are presented for evaluating the slider dynamic response due to medium excitation, head arm excitation and minute bumps on the medium. 4 refs.

Ohkubo, T. (NTT, Musashino, Jpn); Hayashi, T.; Mitsuya, S. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3456-3458.

**089221 MOTION PICTURES OF AIR BEARING DYNAMICS UNDER STRESSED CONDITIONS.** We present here a study of the motion of an air-bearing slider at low flying heights as it accesses over a particulate disk and interacts with asperities on the surface. The measurements are made using a capacitance technique, with a specially made multi-sensor slider and high bandwidth electronics. The slider's motion is captured using a fast digitizer and reconstructed in motion picture format. Three data sets are discussed as examples of the different types of motion which can occur due to the slider-disk interaction. 4 refs.

Hoyt, R.F. (IBM, San Jose, CA, USA); Millman, S.E.; Horne, D.E. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3459-3461.

**089222 REDUCING FLYING HEIGHT DEGRADATION DUE TO TRACK ACCESS ACCELERATION ACTING ON A MAGNETIC HEAD SLIDER.** Flying height fluctuations in a magnetic head slider were measured during track access using an optical interferometric technique. It was found that flying height of the front rail decreases while that of the rear rail increases due to acceleration during track access. An analytical model of the flying height degradation is presented to predict the flying height degradation for both Watrous and Winchester suspensions. By reducing installation angle of the flexure element, it is possible to reduce the flying height degradation. The flying height degradation can also be reduced by reducing slider mass and offset in the flexure mounting surface from the slider mass center and by increasing slider's air bearing stiffness. 6 refs.

Tokuyama, M. (Hitachi Ltd, Tsuchiura, Jpn); Yamaguchi, Y.; Takeuchi, Y.; Shimizu, I. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3470-3472.

## Noise, Spurious Signal

**089223 SPECTRAL MODEL FOR TIME-BASE DISTORTIONS IN MAGNETIC RECORDING.** Time-displacement errors (also called time-base errors) cause signal distortion which is modelled as uncorrelated output noise of a linear time-invariant system. The power

spectrum of this noise along with the system's complex frequency response characterize overall system performance. These two quantities depend, functionally, on the time-displacement error. The theory developed here is applied to flutter effects in analog magnetic recording. The result is a parametric description for noise power spectrum, frequency response, signal-to-noise ratio, and coherence between input and reproduced signals. The only parameter required in this parametric description is the rms value of the time-displacement error. Representative laboratory measurements are included to show generally good agreement between theory and experiment. (Author abstract) 18 refs.

Totzek, Ulrich (Ruhr-Univ Bochum, Bochum, West Ger); Preis, Douglas; Bohme, Johann F. *AEU Arch Elektron Uebertrag Electron Commun* v 41 n 4 Jul-Aug 1987 p 223-231.

**089224 NOISE OF LOW-COERCIVITY SINGLE-LAYER PERPENDICULAR RECORDING MEDIA.** The noise of single layer CoCr media is investigated. A model is developed by treating the medium as a collection of columns. It appears that there is a strong correlation between magnetization direction of the columns. Neighboring columns tend to have the same magnetization polarity, indicating exchange interaction. It is concluded that the media consist of domains. The domain width increases with the medium thickness. These domains can also result in a poor signal response at short wavelength. (Author abstract) 10 refs.

de Bie, R.W. (Philips Research Lab, Eindhoven, Neth); Luijckx, S.B.; Zieren, V.; Schrauwen, C.P.G.; Bernards, J.P.C. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2091-2093.

**089225 EFFECT OF TEXTURIZING ON THE MAGNETIC AND RECORDING PROPERTIES OF PLATED RIGID DISKS.** Texturizing of rigid disk surfaces is used to reduce the area of contact between the head and the disk, and thus reduce the stiction and friction forces in contact start-stop applications. We investigated the effects of circumferential texturizing on the magnetic properties, the recording performance, and the noise of thin film disks prepared by electroless chemical deposition. 7 refs.

Judge, J.S. (Data General Corp, Durham, NH, USA); Spiliotis, D.E. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3402-3404.

## Optimization

**089226 OPTIMUM RECORDING CRITERIA FOR THREE-REGION THIN-FILM MAGNETIC HEADS.** Optimum recording criteria for three-region thin-film heads were derived using a comparison of the NiFe film anisotropy field with the yoke field values, computed with an extended transmission-line model. Karlquist's equation for the longitudinal fringe field was also used in order to obtain the magnetizing region boundaries of the head. On the basis of these criteria, the linearity of the yoke regime can be evaluated and the optimum design of single-turn three-region recording heads can be performed. (Author abstract) 15 refs.

Ciureanu, Petru (Inst for Computer Technique & Informatics, Bucharest, Rom). *J Magn Magn Mater* v 72 n 1 Mar 1988 p 71-79.

## Performance

**089227 EFFECT OF CIRCUMFERENTIAL TEXTURE ON THE PROPERTIES OF THIN FILM RIGID MAGNETIC RECORDING DISKS.** The magnetic recording medium of C/CoNiCr/Cr was DC magnetron sputtered onto rigid disk substrates of various circumferential textures. The texture was characterized by mechanical and optical surface profilometry. Texture increased circumferential coercivity and squareness. Recording signal and signal-to-noise ratio improved while



overwrite worsened. Structural inhomogeneities in the carbon overcoat along the texture lines increased with texture. Texture improved the head-disk friction characteristics and increased the head lift-off time during start-up. Too coarse a texture led to performance degradation. 3 refs.

Simpson, E.M. (Magnetic Peripherals Inc, Minneapolis, MN, USA); Narayan, P.B.; Swami, G.T.K.; Chao, J.L. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3405-3407.

## Sampling

**089228 ADAPTIVE SAMPLE RATE: A FIRST-GENERATION AUTOMATIC TIME BASE.** When capturing transient signals, it is desirable to use a high sample rate to preserve input signal details. This limits the maximum recording time of the measurement. In the HP 5183A Waveform Recorder with Option 301 Adaptive Sample Rate (ASR), the input signal is sampled at the selected fast rate only when there is significant detail present, and at a much slower rate when there is no significant detail. Thus ASR maximizes the recording time without compromising signal integrity. The ASR implementation and the underlying signal processing theory are examined. 9 refs.

Page, Richard W.; Nelson, Nancy W. *Hewlett Packard J* v 39 n 1 Feb 1988 p 23-25.

**Sensors** See Also FILMS—Magnetic; MAGNETIC FIELD MEASUREMENT; MAGNETOSTRICTION—Magnetic Field Effects.

**089229 HIGH SENSITIVITY SINGLE-POLE HEAD WITH TRANSVERSE RETURN-PATH CORE OF FLUX.** A highly sensitive low noise and narrow-track width, main pole driven type single-pole head has been developed. This head is called TRF head (single-pole head with transverse return-path core of flux flow). It is a kind of main pole driven type single-pole head which operates only on one side of the recording medium, and is based on a new idea incorporated in the flux return-path portion, to improve the recording and reproducing sensitivity and to reduce its system noise. The THF head is especially effective for the recording and reproducing with narrow track widths. The development of this head has resolved the problem of insufficient sensitivity in conventional single-pole heads which was a barrier to using narrow track widths, and has provided the prospect of using narrow track width heads necessary for high density digital video recording. (Author abstract) 4 refs.

Numazawa, Junji (Japan Broadcasting Corp, Tokyo, Jpn); Yoneda, Yoshiro; Aruga, Fusayoshi; Horiuchi, Tsuyoshi. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2476-2478.

**089230 EFFICIENCY IMPROVEMENT OF ONE-SIDED PROBE HEADS FOR PERPENDICULAR RECORDING ON DOUBLE-LAYER MEDIA.** Two-dimensional lumped reluctance modeling shows that the real efficiency of the well-known W-shaped single-pole head, or WSP, is very low, but can be improved by more than 10 db by designing a new triangular coil-chamber geometry. The model also indicates that narrowing the track width with respect to the core width results in a further 5 db increase in output. Furthermore, a new head design, the V-shaped single-pole head (VSP), which shows some distinct advantages with respect to manufacturability, has also been modeled. The experimental results obtained from measurements on VSPs are in good agreement with the model calculations. Despite its somewhat lower efficiency (compared to a WSP with the same triangular coil chamber), this VSP yields >12 db output improvement compared to conventional WSP with a rectangular coil chamber and a wide track. (Edited author abstract) 9 refs.

Zieren, V. (Philips Research Lab, Eindhoven, Neth); Ruigrok, J.J.M.; Piena, M.U.; Luijckens, S.B.; Sillen, C.W.M.P.; Verbunt, J.P.M. *IEEE Trans Magn* v

MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2479-2481.

**089231 SINGLE-TURN PERPENDICULAR THIN FILM HEADS.** This paper describes thin film heads, intended for use with CoCr perpendicular recording media, which were designed to bring the highest possible efficiency both in ring-type and pole-type constructions. The heads are of single-turn structure to minimize the yoke length, and all the magnetic films are deposited on substantially flat planes to avoid magnetic degradation. By employing such a scheme, both ring-type and pole-type thin film heads are shown to have efficiency comparable to that of VHS-type ferrite video heads. (Author abstract) 9 refs.

Nakamura, Kazuo (Matsushita Electric Industrial Co, Moriguchi, Jpn); Echigo, Noriyasu; Yohda, Hiroshi; Mitani, Satoru; Kaminaka, Nobuyuki. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2482-2484.

**089232 STUDY ON CHARACTERISTICS OF IMPROVED PERPENDICULAR RECORDING WRITE HEAD WITH LARGE-SCALE HEAD MODEL.** By using a large-scale write head model for perpendicular recording, the relations of the peak value (Hyp) of the perpendicular write field component and the spatial resolution of the field distribution in the X-direction with dimensions of the head model have been studied. The calculated results from a reluctance model are also presented to explain the measured results. (Author abstract) 4 refs.

Zhao, Yu Heng (Southwest Inst of Applied Magnetism Sichuan, China); Chen, Yi Xi; Zhang, Ming Li. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2488-2490.

**089233 YOKE TYPE MAGNETORESISTIVE HEADS WITH SUPPRESSED BARKHAUSEN NOISE.** Dependence of the Barkhausen noise occurrence on the shape of magnetoresistive (MR) elements was studied. Attention was paid to the flux closure scheme in which an MR element is shaped into a 'picture frame' geometry called closed type MR element (CTMR element) with a small gap since the MR element of such configuration was not likely to be limited by the track pitch and width requirements when built in the multitrack head construction. MR characteristics at various small points of the CTMR element were measured using a Kerr-effect microscope to verify the Barkhausen noise suppression effect of the element. Then, 18-track yoke type MR elements were fabricated and compared for the reproducing characteristics. The comparison revealed that both noise level and higher harmonic distortion were about 10db lower with CTMR elements than with stripe MR elements. (Edited author abstract) 4 refs.

Nagata, Y. (Matsushita Electric Industrial Co, Osaka, Jpn); Fukazawa, T.; Wada, K.; Tosaki, Y.; Aoi, T. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2500-2502.

**089234 YOKE MAGNETORESISTIVE HEAD FOR HIGH TRACK DENSITY RECORDING.** For high track density magnetic recording, a new yoke MR head, which has two kinds of yoke elements and center-tapped differential MR elements, has been developed. The track width (2.7µm) of the head is determined by its yoke thickness. Magnetic anisotropy control of the yoke elements and differential MR elements configuration provide low noise and high sensitivity. Output voltage  $40\mu V_p-p/\mu m$  at 25 FRPM and less than -30db second harmonic distortion were obtained for 3µm recorded track width. Further, C/N values, which is the signal to noise ratio measured with a 10 kHz bandwidth, increased by 3db with differential MR elements configuration. This head has the potential to achieve high track density recording. (Author abstract) 12 refs.

Maruyama, T. (NEC, Kawasaki, Jpn); Yamada, K.; Tanaka, H.; Ito, S.; Urai, H.; Kaneko, H. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int

Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2503-2505.

Switching See FILMS—Magnetic Properties.

Testing See Also MAGNETIC DEVICES—Measurements.

**089235 HEAD CONTACT PRESSURE AND SLOW SPEED SLIDING TEST ON COATED MAGNETIC DISKS.** An analytical method to determine apparent contact pressure between a coated magnetic disk and head during slow speed sliding is proposed. Results of analysis show that as sliding velocity increases, contact force gradually decreases but apparent contact pressure peaks at a velocity slightly lower than that of the trailing edge take-off. A slow speed head sliding test was performed to compare the analytical and experimental results. Validity of contact pressure analysis was confirmed through friction force measurement during the test. However, disk lifetime change with sliding velocity did not coincide with that of the peak contact pressure. This indicates that the contact pressure has little effect on the sliding test lifetime. 8 refs.

Kawakubo, Y. (Hitachi Ltd, Tokyo, Jpn); Seo, Y.; Tokuyama, M.; Tanaka, K. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3438-3440.

## Theory

**089236 NEW THEORETICAL APPROACH TO DIGITAL MAGNETIC RECORDING.** The significance of the form of the assumed magnetization variation is studied in calculations of transition widths, output voltage waveforms and the effects of pulse crowding. While different transitions tend to have limited effects on pulse widths and output voltage waveforms, the effects on pulse-crowding roll-off curves are shown to be important, showing the need for a very accurate knowledge of the transition profiles. Error function and hyperbolic-tangent-shaped transitions are investigated, following evidence from T.C. Arnoldussen and H.C. Tong (1980) that the former may be nearer to the true transition shape. 9 refs.

Noyau, R.H. (Manchester Polytechnic, Engl); Middleton, B.K.; Miles, J.J.; Williams, E.W. *IEEE Trans Magn* v 24 n 2 Mar 1988, EMMA '87: Eur Magn Mater Appl Conf, Salford, Engl, Sep 14-16 1987 p 1811-1813.

## Thin Films

**089237 WILLIAMS-COMSTOCK TYPE MODEL FOR SAWTOOTH TRANSITIONS IN THIN FILM MEDIA.** We describe a model of the write process of sawtooth transitions on longitudinal thin film media. The width of the transitions is determined by the combined action of the head and dipolar fields against the coercivity of the film. We use the model to predict the dependence of transition width and location of the transition center on flying height, gap width, and write current for a Karlqvist head field. The transition width approaches the minimum permitted by the transition's dipolar field for low flying height. Unlike models of the write process on particulate media, it predicts that the transition does not relax after the film leaves the write head. (Author abstract) 7 refs.

Muller, M.W. (Washington Univ, St. Louis, MO, USA); Murdock, E.S. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2368-2370.

## Vibrations

**089238 COMPARISON OF HEAD/DISK SPACING FLUCTUATION ON HARD AND STRETCH-SURFACE RECORDING DISKS.** The dynamics of head/disk systems used in magnetic recording disk drives has been studied and compared between flying head sliders on hard and stretch-surface disks. It was found that the air bearing resonances on the SSR disk are much higher than on the rigid disk, and they are not likely to be excited on the SSR disk by the mechanical



resonances of other components of the system. 7 refs.

Zhu, L-Y (Univ of California, Berkeley, CA, USA); Bogy, D.B. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3447-3449.

**RECREATION CENTERS** See Also SHOPPING CENTERS—Design; URBAN PLANNING—Edmonton, Alberta; WATER RESOURCES—Management; WATER TREATMENT PLANTS—Design.

**089239 ATTRAKTIONEN AUS STAHL FUER VERGUEGUNGSPARKS.** [Attraction Steel Structures for Amusement Parks]. Attractions for amusement parks are sophisticated structures, which are show a great number of static and dynamic problems and also require special solutions for machinery. The engineer has to solve oscillating and fatigue problems, since most of the buildings are subjected to stimulating oscillations from wind forces or dynamic forces as well. (Author abstract) In German.

Pannocha, H. *Stahlbau Rundsch* n 69 Oct 1987 p 20-21.

## Bombay, India

**089240 NEW SPORTS COMPLEX FOR BOMBAY.** The article discusses a new sports complex built in one of the eastern suburbs of Bombay. Located in Mulund, the complex includes gymnasium, swimming pool, games hall, overhead water tank, sports training centre, staff quarters, etc. The complex was constructed by B. E. Billimoria and Company, Bombay. Features of the complex are described in the article.

Anon. *Indian Concr J* v 61 n 12 Dec 1987 p 317-320.

**Chelyabinsk, USSR** See STADIUMS—Electric Lighting.

## Dubuque, IA

**089241 GAS DETECTION SYSTEM PROTECTS DUBUQUE RACING TRACK.** The Dubuque Greyhound Park is a new \$12-million greyhound racing and parimutuel wagering complex constructed over a 120-acre landfill. Planners in Dubuque managed the methane problem by installing a sophisticated combustible-gas detection system throughout the 43-acre race track. The permanently installed monitoring system, manufactured by MSA (Mine Safety Appliances Company) of Pittsburgh, Pennsylvania, coupled with a rather simple but effective built-in ventilation system, has reduced the possibility of a methane explosion. Consisting of an underground network of plastic pipes, the ventilation system draws out trace amounts of methane using wind-propelled turbines situated on the roof tops of several park buildings. If the turbines are unable to adequately ventilate a pocket of methane, the permanent monitoring system will alert track personnel well before a potentially dangerous situation can arise.

Anon. *Public Works* v 119 n 6 May 1988 p 64-65.

**Electric Lighting** See ELECTRIC LIGHTING—Flood-lighting.

## Energy Utilization

**089242 EXPERIENCE IN INTRODUCING AN INTEGRATED SYSTEM FOR HEAT AND COLD SUPPLY AT A RESORT.** The article gives a diagram, the principle of operation, and results of testing an integrated system for heat and cold supply at a resort facility, including a solar heating system, heat pump, and traditional boiler room. The unit savings of fuel from use of solar water heaters is 150 kg of equivalent fuel per 1 m<sup>2</sup> of collector. (Author abstract)

Meladze, N.V.; Grdzeldze, T.A. *Appl Sol Energy* v 23 n 2 1987 p 88-91.

**New Jersey** See REFUSE DISPOSAL—Land Fill.

**Nondestructive Examination** See NONDESTRUCTIVE EXAMINATION.

## Planning

**089243 IDENTIFYING CRITICAL ISSUES IN RECREATION PLANNING AND MANAGEMENT: IMPROVING THE MANAGEMENT-RESEARCH PARTNERSHIP.** The 'nominal group' process is a proven technique to systematically arrive at a consensus about critical information needs in recreation planning and management. Using this process, 41 managers who attended a 1983 conference on river management identified 114 specific information needs grouped under 11 general questions. Clearly, some concerns of administrators are researchable; many are not. (Author abstract). 29 Refs.

Schomaker, John H. (US Fish & Wildlife Service, Bloomington, MN, USA); Lime, David W. *Water Resour Bull* v 24 n 3 Jun 1988 p 593-598.

## Plastics Applications

**089244 COMPOSITE REPLACES WOOD IN BOWLING LANES.** A polyester glass-mat monolithic structure provides an ABC-sanctioned surface with all the desirable characteristics of hard maple. But the plastic replacement costs less to install, lasts up to five times longer, and can be used as a cover over old lanes or as a new unit. (Author abstract)

Goeden, H. (Glastic Co, Cleveland, OH, USA); Ricci, N. *Mod Plast* v 64 n 8 Aug 1987 p 80, 96.

## Riyadh, Saudi Arabia

**089245 DESIGN AND CONSTRUCTION OF THE DIPLOMATIC CLUB, RIYADH.** In No. 1, January 1987, issue the authors presented their paper using a number of color slides to describe the whole design and construction process for the project, which represented the work of clients, architects, contractors, and the whole of the engineering team. Some parts of this presentation, which expanded on the paper, contributed new material which the authors felt might be of interest to readers. These contributions cover the choice of fabric materials for the translucent membrane tents, and the management of the design work. (Edited author abstract)

Happold, E.; Baley, T.A.; Liddell, W.I.; Pugh, J.W.E.; Webster, R.H. *Struct Eng Part A* v 65A n 10 Oct 1987 p 377-382.

## Welding

**089246 WELDING GIVES A WILD RIDE TO THEME PARKS AROUND THE WORLD.** This paper describes welding procedures performed by Fabriweld Company in amusement parks. A description is given of the fabrication of roller coaster tracks. The fabrication of the tracks entails a solid understanding of trigonometric functions. It takes about a year of training for the welders to get a good understanding of the layout and fabrication of the tracks. A typical weldment consists of a 12-in.-diameter pipe strongback that acts 5-in.-diameter schedule 80 pipes that become the track on which the cars ride, and the 1/2- to 3/4-in.-thick plates that make the saddles, which attach to the strongback as supports for the tracks.

Cullison, Andrew (Welding Journal, Miami, FL, USA). *Weld J (Miami Fla)* v 67 n 3 Mar 1988 p 37-38, 40.

**REDUNDANCY** See Also DATA STORAGE, DIGITAL—Random Access; ELECTRONIC EQUIPMENT—Reliability; ELEVATORS—Accident Prevention; FAILURE ANALYSIS; RELIABILITY THEORY; ROBOTS, INDUSTRIAL—Manipulators; SYSTEM STABILITY—Criteria.

**089247 COST ANALYSIS OF A TWO UNIT, THREE STATE STANDBY REDUNDANT COMPLEX SYSTEM WITH TWO TYPES OF REPAIR**

**FACILITIES UNDER WAITING.** This paper deals with the cost analysis of a two unit, three state standby redundant complex system, incorporating the concept of two types of repair facilities, viz. minor and major repair. The concept of waiting time for the major repair of the failed system has also been introduced. The system can suffer from two types of failures, namely catastrophic and partial. Failure and waiting times of units follow exponential time distribution, whereas repair of units follows general time distribution. Using the supplementary variable technique, Laplace transforms of probabilities of the complex system being in various states have been computed. Using Abel's lemma, steady state behavior has also been examined. Some important graphs have been sketched at the end to highlight the important results. (Edited author abstract) 10 refs.

Gupta, P.P. (M.M.(P.G.) Coll, Modinagar, India); Singhal, Anju; Sharma, R.K. *Microelectron Reliab* v 27 n 6 1987 p 959-963.

**Computer Aided Analysis** See STRUCTURAL DESIGN—Safety Factor.

**Estimation** See STATISTICAL METHODS—Reliability.

**Monitoring** See COMPUTERS, MICROCOMPUTER—Reliability.

## Optimization

**089248 SIMPLE METHOD FOR OPTIMAL REDUNDANCY ALLOCATION FOR COMPLEX NETWORKS.** A simple method for optimum redundancy allocation for complex networks is presented. A new heuristic criterion is introduced for solving the problem by decomposing the same in two phases. After finding all minimal path sets of the system in phase I, we choose a minimal path set having the highest value of the 'sensitivity factor'. In phase II we add one component to the stage having the largest value of the selection factor among the stages of the selected minimal path set. This procedure is continued until no more redundant component can be added within the available resources. The proposed method is simple, easily computerizable, fast and capable of handling problems subject to any number of constraints. (Edited author abstract) 17 refs.

Bala, Renu (Regional Engineering Coll, Kurukshetra, India); Aggarwal, K.K. *Microelectron Reliab* v 27 n 5 1987 p 835-837.

**089249 NEW HEURISTIC ALGORITHM FOR CONSTRAINED REDUNDANCY-OPTIMIZATION IN COMPLEX SYSTEMS.** A heuristic algorithm is given that solves the problem of constrained redundancy optimization in complex systems using minimal path sets. The algorithm gives an optimal solution in most cases without much special computational effort, although the solution is not necessarily the global optimum. Two examples are given to compare the performance of this algorithm with that of existing methods. 7 refs.

Shi, Dinghua (Shanghai Inst of Railway Technology, Shanghai, China). *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 621-623.

**Repair** See RELIABILITY THEORY.

**REFLECTOMETERS** See Also FIBER OPTICS—Laser Applications; FIBER OPTICS—Sensors; MAGNETIZATION—Measurements; MICROWAVE MEASUREMENTS; MICROWAVE MEASUREMENTS—Impedance; MICROWAVE MEASUREMENTS—Power; OIL TANKS—Measurements; OPTICAL FIBERS—Testing; TELECOMMUNICATION CABLES—Submarine.

**089250 OPTICAL TIME-DOMAIN REFLECTOMETER FOR LONG 1.5-μm BAND OPTICAL FIBER CABLES.** An optical time-domain reflectometer (OTDR) for measuring long 1.5-μm band optical transmission lines



has been developed. A 1.59- $\mu\text{m}$  optical pulse generated from a  $\text{P}_2\text{O}_5$ -highly-doped optical fiber pumped by a 1.32- $\mu\text{m}$  Nd:YAG laser pulse is used as an optical source. A 103-km-long dispersion-shifted optical transmission line is tested using the OTDR. The result shows that the one-way dynamic range of the OTDR is estimated to be more than 30 db. (Author abstract) 7 refs.

Noguchi, Kazuhiro (NTT, Jpn); Suzuki, Kazunori; Uesugi, Naoshi. *Rev Electr Commun Lab (Tokyo)* v 35 n 5 Sep 1987 p 541-545.

**089251 HP FINDS A WAY TO PROBE DEEP INTO OPTICAL LINES.** Hewlett-Packard's HP 8145 A reflectometer is described that is bringing data correlation to optical time-domain reflectometers. Engineers will be able to look miles deeper into a glass fiber to spot a fault, as well as to make measurements faster than with any conventional instrument. As repeater distance gets longer because of more powerful lasers, lower-loss fibers, and more sensitive receivers, it is becoming increasingly difficult to characterize performance or find faults in optical transmission cables. The 8145 addresses this problem by increasing the distance over which reflectometers operate by up to 56%, depending on the wavelength and fiber type.

Gosch, John. *Electronics* v 60 n 18 Sep 3 1987 p 81-82.

**089252 REFLECTOMETRE A HAUTE RESOLUTION.** [High Resolution Reflectometers]. Measurement capabilities of a single mode optical time domain reflectometer (OTDR) are given. Fault location accuracy is 1 m (when the group index of refraction is known) and spatial resolution is 3 m. (Author abstract) 5 refs. In French.

Soulage, Guy (Cent de Recherches de la CGE, Marcoussis, Fr); Arnould, Francois; Jurczykzy, Michel; Tardy, Andre. *Ann Telecommun* v 43 n 1-2 Jan-Feb 1988 p 83-87.

**Applications** See IRRIGATION—Scheduling; TELECOMMUNICATION CABLES—Measurements.

## Calibration

**089253 ESTIMATING THE RESIDUAL ERROR FROM CALIBRATING A REFLECTOMETER WITH A SLIDING TERMINATION.** A sliding termination is often used to approximate to  $\Gamma=0$  when calibrating a reflectometer with equivalent generator mismatch  $\Gamma_G$ . The paper shows that a residual error of  $|\Gamma_G|^2 |\Gamma_T|^2$  results (where  $|\Gamma_T|$  is the amplitude of reflection from the variable phase load and \* denotes complex conjugate) and compares this error with the precision of available calibration standards. (Author abstract) 9 refs.

Griffin, E.J. (Royal Signals & Radar Establishment, Great Malvern, Engl); Hodgetts, T.E. *IEE Proc Part H* v 134 n 6 Dec 1987 p 560-562.

**089254 SIX-PORT REFLECTOMETER AND ITS COMPLETE CALIBRATION BY FOUR STANDARD TERMINATIONS.** An alternative nonlinear method to calibrate the six-port reflectometer is developed. Using this method, four standards and an iterative procedure are needed to calibrate the reflectometer. Experimental results show that this method converges very rapidly, provides a good accuracy in calibration parameters and at the same time avoids degenerate solutions which produce unwanted singularities in the measurement. (Author abstract). 12 Refs.

Ghannouchi, F.M. (Ecole Polytechnique, Montreal, Que, Can); Bosio, R.G. *IEE Proc Part H* v 135 n 4 Aug 1988 p 285-288.

**089255 NEW SIX-PORT CALIBRATION METHOD USING FOUR STANDARDS AND AVOIDING SINGULARITIES.** An explicit linear method using four known standards to calibrate a six-port reflectometer is presented. The calibration parameters are obtained using only linear equation techniques to facilitate encoding the computation in low-level computer language. The method shows that no singularities appear

over the calibration frequency range, contrary to other methods using the same reflectometer. 16 refs.

Ghannouchi, Fadhel M. (Ecole Polytechnique de Montreal, Que, Can); Bosio, Renato G. *IEEE Trans Instrum Meas* v IM-36 n 4 Dec 1987, IMTC/1987: The Fourth IEEE Instrum and Meas Technol Conf, Boston, MA, USA, Apr 27-29 1987 p 1022-1027.

## Design

**089256 MEASUREMENT OF MICROWAVE DEVICE PARAMETERS WITH THE AID OF MULTITERMINAL REFLECTOMETERS.** Measurement of complex microwave parameters with the aid of twelve-terminal reflectometers is based on the determination of phase shifts between microwave signals from the results of measurement of relative powers dissipated in the reflectometer arms. This method allows simple calibration and automation of measurements in automatic microwave circuit analyzers (AMA) based on a twelve-terminal reflectometer and general-purpose computer. The portability of twelve-terminal reflectometers makes it possible to connect them directly to the device being tested so that a large number of simple and inexpensive reflectometers can be combined into multichannel parallel AMAs for measuring the wave scattering parameters of multiterminal devices. In this paper the authors discuss the problems associated with the design and calibration of individual twelve-terminal reflectometers that form the main components of AMAs. 8 refs.

Yatskevich, V.A. *Meas Tech* v 30 n 3 May 1987 p 279-285.

**089257 TIME-OF-FLIGHT NEUTRON REFLECTOMETER FOR SURFACE AND INTERFACIAL STUDIES.** A time-of-flight neutron reflectometer constructed for surface and interfacial studies, and installed at the ISIS pulsed neutron source, is described. One of its important design features is its inclined incident beam, since this allows both liquid- and solid-surface phenomena to be investigated. Measurements are presented to show the performance of the instrument, and new representative results, which include studies of liquid surfaces, Langmuir-Blodgett films, and thin-film multilayers, are included as illustrations of the scientific potential of the method. (Author abstract) 23 refs.

Penfold, J. (Rutherford Appleton Lab, Engl); Ward, R.C.; Williams, W.G. *J Phys E* v 20 n 11 Nov 1987 p 1411-1417.

## Infrared

**089258 1.5- $\mu\text{m}$ -BAND OPTICAL TIME DOMAIN REFLECTOMETER FOR SINGLE-MODE OPTICAL FIBER USING A  $\text{P}_2\text{O}_5$ -HIGHLY-DOPED FIBER RAMAN LASER.** A wide-dynamic-range 1.5- $\mu\text{m}$ -band optical time-domain reflectometer (OTDR) for single-mode optical fibers using a  $\text{P}_2\text{O}_5$ -highly-doped fiber Raman laser light source and a cooled Ge-p-i-n photodiode is realized for the first time. The stimulated-Raman-scattering properties of  $\text{P}_2\text{O}_5$ -doped single-mode fiber are investigated. Using this fiber and an Nd:YAG laser operating at 1.32  $\mu\text{m}$ , a high-power light pulse at 1.59  $\mu\text{m}$  is generated with high efficiency. Using the stimulated-Raman-scattering light as the light source and a high-sensitivity optical receiver, a 1.5- $\mu\text{m}$ -band OTDR having a one-way dynamic range of 35 dB is realized. 14 refs.

Suzuki, Kazunori (NTT, Tokai, Jpn); Noguchi, Kazuhiro; Uesugi, Naoshi. *J Lightwave Technol* v 6 n 1 Jan 1988 p 94-99.

## Laser Applications

**089259 AUTOMATIC LASER INTERFERENCE REFRACTOMETER FOR STUDYING THE DISPERSION OF GASES.** An interference refractometer, for studying the dispersion of optically transparent gases in the visible and near-IR ranges (0.4-1.1  $\mu\text{m}$ ) of the spectrum, is described. The refractometer employs a

radiation selection block, which is used for periodic sequential input of radiation with different wavelengths into the interference refractometer, which raises the reliability of the determination of the coefficients in the dispersion equation for different states of the gas and reduces severalfold the time required for performing the experiments. (Edited author abstract) 10 refs.

Mishchenko, Yu.V. *Instrum Exp Tech* v 30 n 3 pt 2 May-Jun 1987 p 689-693.

## Mathematical Models

**089260 COMPARATIVE STATISTICAL STUDY OF SOME PROPOSED SIX-PORT JUNCTION DESIGNS.** Reflection coefficient measurements obtained from six-port reflectometers are analyzed from a statistical and geometrical point of view. The analysis concentrates on the effect of using noisy power meters. A simply computed, geometrically interpretable estimator of the reflection coefficient possessing certain optimality properties is derived. A suitable performance measure for this estimator is calculated for a number of different six-port designs as the true reflection coefficient ranges over the area of the Smith chart. For each design, a contour map of the measure allows for easy comparison of the designs in different regions of the Smith chart. 18 refs.

Berman, Mark (Natl Measurement Lab, Lindfield, Aust); Somlo, Peter I.; Buckley, Michael J. *IEEE Trans Microwave Theory Tech* v MTT-35 n 11 p 971-977.

## Microwaves

**089261 SINGLE-HORN REFLECTOMETRY FOR IN SITU DIELECTRIC MEASUREMENTS AT MICROWAVE FREQUENCIES.** The ability of single-horn reflectometry to determine reflectivity and, hence, calculate dielectric properties using plane-wave interpretation theory, has been investigated experimentally. The horn is part of a portable field unit operating at X-band and was placed above various natural materials. Good results were obtained for water and saline ice, which were flat and lossy, but not for an electrically thick sheet of fresh lake ice, for which reflectivity at the bottom interface was strong. 10 refs.

Arcone, Steven A. (US Dep of the Navy, Hanover, NJ, USA); Larson, Richard W. *IEEE Trans Geosci Remote Sens* v 26 n 1 Jan 1988 p 89-92.

## Performance

**089262 NOVEL METHODS FOR ULTRAHIGH-FREQUENCY ELECTRO-OPTIC TIME-DOMAIN REFLECTOMETRY.** We propose a new approach to time-domain reflectometry utilizing picosecond electro-optic sampling and counter-propagating electrical pulses on a coplanar transmission line. This method enables direct acquisition of the incident and reflected waveforms at the interface between a device and transmission line without requiring temporal separation between the waveforms or deconvolution of the effect of the transmission line on the waveforms. (Author abstract) 4 refs.

Jackson, T. (Univ of Rochester, Rochester, NY, USA); Nees, J.; Vallee, R.; Mourou, G. *Electron Lett* v 23 n 21 Oct 8 1987 p 1130-1131.

**089263 OTDR SPLICE LOSS MEASUREMENTS: AN EXPLANATION.** When splicing optical fibers, OTDRs (Optical Time Domain Reflectometers) are often used to monitor and optimize splice loss. Their primary use may be in finding fiber breaks for emergency restoration. They are also used to measure fiber attenuation and connector or splice loss in installed cable systems. We are often asked why OTDR measurements differ from loss or attenuation measured by a source and power meter, and



why splices and connectors sometimes show a 'gain' in violation of common sense and physical laws. These and related questions are discussed.

Hayes, Jim. *TE&M* v 91 n 21 Nov 1 1987 p 76-77.

**089264 NEW TECHNIQUE IN O.T.D.R.** Using a new correlation technique, time-domain reflectometry measurements of optical fibre are obtained 64 times faster than is possible with conventional single-pulse methods, given the same laser, receiver and optical coupling. Special emphasis is placed on backscattering impulse response, performance parameters and signal-to-noise ratio considerations. 11 refs.

Newton, Steve. *Electron Wireless World* v 94 n 1627 May 1988 p 496-500.

## Testing

**089265 SIX-PORT REFLECTOMETER.** A six-port reflectometer consisting of a symmetrical five-port waveguide junction and a directional coupler was analyzed, constructed and tested. Theoretical and experimental results showed that the circuit yielded optimum q-point distributions over the waveguide bandwidth. Actual measurements taken using the prototype reflectometer indicated that accuracies of  $\pm 0.05$  in magnitude and  $\pm 0.5^\circ$  in phase were obtainable. (Author abstract) 7 refs.

Yeo, S.P. (Nat'l Univ of Singapore, Singapore); Ang, A.L. *Electron Lett* v 23 n 21 Oct 8 1987 p 1160-1161.

## REFRACTOMETERS

### Applications

**089266 FIBER OPTIC REFRACTOMETER FOR SPECIES CONCENTRATION MEASUREMENT IN A MICROWAVE ENVIRONMENT.** A miniature fiber optic refractometer has been developed to measure the species concentration of a fluid which is heated in a microwave oven. The probe, which measures the local fluid temperature and refractive index, is easily constructed using a commercially available fiber optic thermometer and standard laboratory equipment. (Edited author abstract) 6 refs.

Bergman, T.L. *J Microwave Power Electromagn* v 22 n 3 1987, Radio Freq Ind Appl, 1987 p 181-183.

### Design

**089267 OPTICAL FIBRE REFRACTOMETER FOR LIQUIDS USING TWO MEASUREMENT CHANNELS TO REJECT OPTICAL ATTENUATION.** A method is proposed to implement an optical fiber sensor for the measurement of the refractive index of liquids whose optical attenuation may not be considered negligible. The fibers can be immersed directly in the liquid, or placed outside a transparent cell. Three mathematical models are developed for these two configurations and we show that the second configuration is more advantageous. Experimental measurements tend to confirm the validity of one of the three models. (Author abstract) 12 refs.

Laguesse, M. (Univ de Liege, Liege, Belg). *J Phys E* v 21 n 1 Jan 1988 p 64-67.

**REFRACTORY MATERIALS** See Also BASIC OXYGEN CONVERTERS—Lining; BLAST FURNACES—Lining; CERAMIC MATERIALS—Research; ELECTRODES—Materials; FURNACES, HEATING—Modernization; GLASS FURNACES—Regenerators; KILNS—Lining; STEEL—Continuous Casting; STEEL—Heat Transfer.

**089268 BENEFICIATION OF ALUMINOSILICATES AND MAGNESIA SECONDARY REFRACTORIES.** A source of economizing on refractory raw materials is more use of consumer scrap, that is, secondary refractories. The authors studied samples of aluminosilicate refractory scrap from blast furnace stoves, steel pouring ladles, checker brick and roofs of various furnaces. For beneficiation treatment the use of magnetic

separation is recommended. 4 refs.

Baranovskii, N.I. (Uralmekhanobr, USSR); Klyachin, V.V.; Rogozina, V.G.; Bortnikova, N.V. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 43-46.

**089269 ERMOLD, EIN NEUES PRODUKT FUER BEREICHE IM WANNENBERBAU, DIE ERHOEHEN TEMPERATURWECHSELBEANSPRUCHUNGEN UNTERLIEGEN.** [ERMOLD, A New Product for Superstructures of Glass Tank Furnaces Subjected to Increased Thermal Shocks]. The article reports on the features of ERMOLD refractories which fill a gap between fusion cast products and classical refractories. Based on finely ground fusion-cast material, ERMOLD products exhibit an excellent resistance to thermal shock and, because of their dense structure with limited porosity, can be used successfully in furnace superstructures. The paper describes more specially the application of ERMOLD for injector blocks and doghouse counterarches. (Edited author abstract) In German.

Moreau, R. (SEPR, Paris, Fr); Michel, A.; Zanoli, A. *Sprechsaal* v 120 n 9 Sep 1987 p 723-728.

**089270 ERGEBNISSE ZUR BRUCHMECHANISCHEN BEWERTUNG FEUERFESTER BAUSTOFFE.** [Results of an Evaluation of Fracture Mechanical Characteristics of Refractory Materials]. The purpose of this study was to examine the applicability of fracture mechanics test methods to heterogeneous heavy clay ceramics. The effect of the test condition and the fracture mechanical characteristics of refractory materials are investigated. When examining the validity of service life prediction in the range of low temperatures, a satisfactory agreement of the experimental results with the predictions was achieved. In the range of high temperatures, this agreement was obtained only in case of high static loads. (Translated author abstract) 15 refs. In German.

Schulle, Wolfgang (Bergakademie Freiberg, Freiberg, East Ger); Kotrc, Michal. *Sprechsaal* v 120 n 10 Oct 1987 p 871-874, 876, 879.

**089271 PERICLASE COMPOSITIONS: A THERMOMETER FOR MAGNESIA-CHROMITE REFRACTORIES.** Statistical analysis of published data on the compositions of periclases coexisting with spinel has been used to model mathematically the temperature-dependence of the limiting composition of periclase for the temperature range 1700°C to below 1400°C. The 'blocking temperature' (approximately the temperature of effective cessation of diffusion) of periclases from common refractory compositions is in the range 1350 to 1400°C. This is substantially below the peak firing temperature of manufacture and also below the usual temperature of use of periclase-chromite refractories. The compositions and the proportions of periclase and spinel in refractories used above the blocking temperature vary with changes of temperature, with important consequences for refractory microstructure and performance. (Author abstract) 16 refs.

Butler, B.C.M. (Univ of Oxford, Oxford, Engl); Suli, E.E. *Br Ceram Trans J* v 87 n 1 Jan-Feb 1988 p 14-16.

**089272 HOLLOW CORUNDUM SPHERES FOR HIGH TEMPERATURE THERMAL INSULATION.** Hollow corundum spheres offer possibilities for developing high-quality structural and thermal insulation refractories for lining thermal units including those working in hydrogen-containing atmospheres at a service temperature exceeding 1700°C. The authors developed a technological route for the production of hollow electrocorundum spheres intended for manufacturing highly refractory thermal insulation products, concrete bodies, and loose charges. The technology was tested under industrial conditions. 8 refs.

Karlin, V.V. (All-Union Scientific-Research Inst VNIASH, USSR); Khizhnyak, N.P.; Engel'brekt, V.G.; Permikina, N.M.; Evdokimova, Z.U.; Panov, G.A.; Belogradov, A.G.; Gromov, S.Yu. *Refractories* v 28 n 7-8 Jul-Aug 1987 p 386-389.

**089273 INTRODUCTION OF THE PRODUCTION OF VIBROCAST CORUNDUM AND MULLITE-CORUNDUM BURNER BLOCKS FOR SINTERING HEARTHES AT WESTERN SIBERIA METALLURGICAL COMBINE.** One of the means of reducing the specific fuel composition in sintering machine hearths is the use of flat flame burners. To provide satisfactory operation of the burners and an increase in hearth service life it is necessary to use heat resistant mullite-corundum burner blocks which are large parts with a weight of up to 280 kg and more in them. This article presents the results of introduction into Western Siberia Metallurgical Combine of the production of these parts. Mixtures based on corundum, fused mullite, alumina, mullite-corundum chamotte, and clay developed in the Ukrainian Scientific-Research Institute for Refractories were used. 5 refs.

Primachenko, V.V. (Ukrainian Scientific-Research Inst for Refractories, USSR); Anisimova, T.A.; Kustov, B.A.; Sel'skii, B.I.; Zibarev, N.A.; Titov, N.V. *Refractories* v 28 n 7-8 Jul-Aug 1987 p 395-398.

**089274 THERMAL INSULATION MATERIALS BASED ON SPHERICAL CORUNDUM.** For the lining of thermal equipment with a hydrogen-containing medium and a working temperature up to 1800°C corundum refractories, which are characterized by the optimum combination of physicochemical and thermomechanical properties, are promising. To obtain corundum thermal insulation parts with more than 99 wt.%  $Al_2O_3$  a mixture of G-00 and GK (85-95%  $\alpha-Al_2O_3$ ) aluminas and foam polystyrene was used. After firing the parts had an apparent density of 1.05-1.08 g/cm<sup>3</sup>, a compressive strength of 7.5-20 N/mm<sup>2</sup>, and an additional volumetric shrinkage at 150°C of less than 1%. For the purpose of obtaining shrinkage-free thermal insulation corundum parts it is desirable to use a porous filler of aluminum oxide distinguished by a constant volume in heating to 1800°C. Hollow corundum granules (spherical corundum) produced by inflation of molten corundum meet these requirements. 5 refs.

Permikina, N.M. (Eastern Refractory Inst, USSR); Evdokimova, Z.U.; Kukuruzov, A.P.; Panov, G.A. *Refractories* v 28 n 7-8 Jul-Aug 1987 421-424.

### Additives

**089275 EFFECT OF PHOSPHATE BINDERS ON THE STRENGTH OF THE MATERIAL BASED ON ELECTROCORUNDUM AND PYROPHYLLITE.** This paper deals with a study of the material obtained by introducing pyrophyllite into the composition (body) of a corundum concrete based on a phosphate binder (pyrophyllite addition is known to change the properties of the concrete significantly). Addition of pyrophyllite to the system of corundum concrete produced using phosphate binders leads to a reduction in the temperature of setting (hardening) up to room temperature, an increase in the strength at moderate temperature (up to 973°K), a significant resistance to softening in the 973-1273°K range, and an improved thermal shock resistance. The increase in the strength during the heating process can be attributed to the formation of complex polymeric forms of aluminum and silicon phosphates in the material which largely remain amorphous when heated up to 1723°K at a rate of 0.5-1°K/min. Above 1473°K, a small amount of a liquid phase (silicon pyrophosphate) forms in the material whose quantity decrease with increasing pyrophyllite content. 7 refs.

Mikhashchuk, E.P. (Acad of Sciences of the Ukrainian SSR, USSR); Karpinos, D.M.; Amirov, R.A.; Ozeran, A.E.; Shayakhmetov, U.Sh. *Refractories* v 28 n 3-4 Mar-Apr 1987 p 119-123.

**Alumina** See Also ALUMINA—Mechanical Properties; ALUMINA—Sintered; BLAST FURNACES—Refractory Materials; CERAMIC MATERIALS—Hardening; COMPOSITE MATERIALS—Fracture; FURNACES, MELTING—Refractory Materials; LADLES—Lining.



**089276 VARIATIONS IN SINTERING KINETICS AND MICROSTRUCTURE OF ALUMINA WITH CHROMIUM AND MOLYBDENUM ADDITIONS.** Chromium and molybdenum were introduced into alumina through gel synthesis. Both elements are soluble in aluminum hydroxide and low-temperature (<1400°C) aluminum oxide. In the course of transformation from hydroxide to oxide, the evaporation-condensation of vapour phase (below 1000°C) causes shrinkage of the porous compact due to particle rearrangement and growth through capillary drag and adsorption. Subsequently, differences in agglomerate structure, grain growth, solute atmosphere and densification arise because of variations in the crystallochemical behavior of chromium and molybdenum. The solute atmospheres of chromia-vacancy and molybdenum metal reveal sub-grain boundaries and dislocations. In chromia-alumina solid solution these defects annihilate and contribute to densification (98%th) with increase in temperature to 1600°C. However, with further rise in temperature to 1700°C, the solid solution desinters to 85%th and creep cavities show transition from grain boundary to lattice creep. In Mo-Al<sub>2</sub>O<sub>3</sub> composite the defects are locked by molybdenum solute, and as a result there is an insignificant increase in densification (30%th at 1600°C). (Author abstract) 36 refs.

Raman, S.V. (Brookhaven Natl Lab, Upton, NY, USA). *J Mater Sci* v 22 n 9 Sep 1987 p 3161-3166.

**089277 STRUCTURE FORMATION OF WATER SUSPENSIONS OF ALUMINA CONTAINING POLYSTYRENE ADDITIONS.** A study was made of the effect of the diameter of polystyrene balls and the pH of the suspension, with sulfite fly additions, on the rheological and structural-mechanical properties of the alumina suspensions and the properties of the heat-insulating articles. It was found that the optimum casting properties are possessed by suspensions of two casting ranges: pH=2.5 (acid deflocculation) and pH=9.5 (alkaline deflocculation). The optimum stabilizing additive is 2% sulfite fly. The tests established the possibility of making porous corundum articles with excellent properties by the casting method. 5 refs.

Sandutsa, T.M. (Ukrainian Scientific-Research Inst of Refractories, USSR); Pisareva, N.V.; Gaodu, A.N.; Degtyareva, E.V. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 8-12.

**089278 SINTERING OF CERMETS BASED ON CORUNDUM AND MOLYBDENUM.** Use of corundum powder in molybdenum-containing cermets makes it possible to decrease the temperature required for obtaining dense materials by approximately 100°. In order to produce dense materials, it is necessary to limit the initial porosity of the compacts. Increasing the degree of dispersion of molybdenum obtains a material possessing more uniform structure and higher density and strength. The presence of molybdenum decreases recrystallization of corundum grains and obtains a stable structure that is resistant to high temperature heating cycles. 6 refs.

Fedotov, A.V. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 24-27.

**089279 STRONG CERAMIC IN THE Al<sub>2</sub>O<sub>3</sub>-ZrO<sub>2</sub>-Y<sub>2</sub>O<sub>3</sub> SYSTEM.** This paper deals with a study of the microstructure and some properties of ceramics of the Al<sub>2</sub>O<sub>3</sub>-ZrO<sub>2</sub> system containing Y<sub>2</sub>O<sub>3</sub>. Y<sub>2</sub>O<sub>3</sub> was introduced as a stabilizing additive. Its content was varied from 1 up to 8 mole% with respect to ZrO<sub>2</sub>. A highly dense ceramic based on the eutectic composition obtained using 3 mole% Y<sub>2</sub>O<sub>3</sub> addition. The ceramic has a fine grained structure and high hardness and strength. 3 refs.

Lukin, E.S. (D.I. Mendeleev Moscow Chemical Technology Inst, USSR); Vlasov, A.S.; Astakhova, N.M.; Bykova, E.V. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 63-65.

**089280 EFFECT OF THE ADDITIONS OF THE WASTE PRODUCTS OF RARE-EARTH ELEMENTS ON THE PROPERTIES OF MULLITE-ZIRCON SUSPENSIONS.** The effect of rare earth compounds on the rheological properties of mullite-zircon suspensions was studied. The optimum interval of casting

was established. The effect of the compounds on the sintering process was also studied. It is possible to decrease the sintering temperature by 100°C (up to 1450°C) without loss of thermal shock resistance of the products. 1 ref.

Degtyareva, E.V. (Ukrainian Komsomol KhADI, USSR); Gud', O.T.; Lisovaya, E.D.; Romaniv, O.N.; Maistruk, P.G. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 65-69.

**089281 STUDY OF THE PROCESS OF MULLITE FORMATION IN THE CORUNDUM-CLAY AND CORUNDUM-QUARTZITE SYSTEMS UNDER LOAD.** Protective refractory coatings and rammed linings made from high alumina bodies are widely used in the induction channel mixers (holding furnaces) for molten iron. During service, constancy of volume of such coatings is ensured owing to mullite formation which involves volumetric expansion. The authors studied the effect of compressive load and temperature on the process of mullite formation in alumina systems produced from electromelted corundum and clay or Ovruchsk quartzite incorporating orthophosphoric acid as a binder. The application of a stress of 0.4 N/mm<sup>2</sup> intensified the process of mullite formation. Increasing the firing temperature from 1300 up to 1500°C led to an increase of the mullite content in specimens fired with and without load. 11 refs.

Pirogov, Yu.A. (Ukrainian Scientific-Research Inst of Refractories, USSR); Savel'ev, V.N.; Belova, E.K.; Boiko, Yu.F.; Alekseeva, O.A. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 70-72.

**089282 OBTAINING SHRINK-FREE MULLITE LIGHTWEIGHT CERAMICS IN THE AlF<sub>3</sub>-Al<sub>2</sub>O<sub>3</sub>-SiO<sub>2</sub> SYSTEM.** The authors investigated about 60 compositions with different ratios of AlF<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, and SiO<sub>2</sub>. Using the mullite forming mechanism it is possible to synthesize mullite during firing of the goods without preheating the starting components. The solid phase synthesis of crystals of mullite leads to self-reinforcing of the ceramic material. The experimental batches showed that it is possible to obtain mullite articles with an apparent density of 0.65-2.00 g/cm<sup>3</sup>. 8 refs.

Goncharov, Yu.I. (I.A. Grishmanov Technology Inst for Building Materials, Belgorod, USSR); Skomorkhin, V.Yu. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 105-109.

**089283 HIGH-ALUMINA CERAMIC POSSESSING HIGH THERMAL SHOCK RESISTANCE.** The aim of this investigation is to produce a heat-resistant material with good mechanical and electrical insulating properties and a low firing temperature. To prepare the specimens, we used the electrocorundum and alumina. The industrial aluminum chromium phosphate binder (ACPB) was used as a bonding agent. The obtained corundum materials containing ACPB are characterized by high thermal shock resistance and satisfactory mechanical and electrophysical properties. This is achieved owing to the formation of the aluminous (aluminum) phosphate cement that ensures strong bonds between corundum grains and facilitates their conversion into large agglomerates. 6 refs.

Glazacheva, M.V. (All-Union Scientific Research Inst of Electrical Ceramics, USSR); Medvedovskii, E.Ya.; Kharitonov, F.Ya.; Cherepanov, A.M. *Refractories* v 28 n 5-6 May-Jun 1987 p 238-241.

**089284 OPTIMIZING THE PROPERTIES OF CORUNDUM-BASED THERMAL INSULATION PRODUCTS USING THE METHOD OF EXPERIMENTAL PLANNING.** This paper deals with a study on the selection of granulometry of a corundum filler using the method of experimental planning for the purpose of optimizing the properties of pure corundum thermal insulation products of complex configuration. In these studies, we used hollow corundum spheres or a porous corundum chamotte (having 99.3-99.7 wt.% Al<sub>2</sub>O<sub>3</sub>) as a filler. We studied the effect of the limiting grain size and the type of filler on the apparent density and the ultimate compressive strength of the corundum-based thermal insulation prod-

ucts. The paper gives the characteristics of the factors affecting the properties of the corundum-based thermal insulation products. A complete factorial experiment made it possible to derive an equation that takes into account the qualitative and quantitative factors. 5 refs.

Sandutsa, T.M. (Ukrainian Scientific-Research Inst of Refractories, USSR); Kvasman, N.M.; Pisareva, N.V.; Gaodu, A.N.; Degtyareva, E.V. *Refractories* v 28 n 5-6 May-Jun 1987 p 310-313.

**089285 INFLUENCE OF PRELIMINARY COMPACTION OF THE MIXTURE ON THE QUALITY OF CHAMOTTE REFRACTORIES.** A method of production of ladle brick making it possible to eliminate scrap of parts for separation, reduce their porosity, and increase the compressive strength has been developed. Under the conditions at the Borovichi Refractory Combine the porosity dropped from 17.3-18.4 to 15.5-17.1% while the compressive strength increased from 27-40 to 68.6-93.0 N/mm<sup>2</sup>. The desirability of use of Kudinov deposit semiacid kaolinite-hydromicaceous clay as a raw material for the production of dense ladle brick and the possibility of use of Ust'e-Brynkino deposit BLP-1 clay have been shown.

Afanas'ev, Yu.V. (All-Union Refractory Inst, USSR); Fleer, S.A.; Red'ko, G.S. *Refractories* v 28 n 9-10 Sep-Oct 1987 p 519-523.

**089286 INFLUENCE OF THE COMPOSITION AND STRUCTURE OF ALUMINA-CONTAINING SLIDE PLATES ON THEIR FAILURE AND SERVICE.** The authors studied the composition of type KP-95 corundum plates after service in 160-ton ladles in order to reveal the basic physicochemical parameters responsible for their corrosion and erosion resistance. 7 refs.

Zhukovskaya, A.E. (All-Union Refractory Inst, USSR); Kazakov, S.V.; Kortel', A.A.; Mel'nikova, G.G.; Shapurko, L.A.; Sherman, E.A.; Karas', G.E. *Refractories* v 28 n 9-10 Sep-Oct 1987 p 528-533.

**089287 REFRACTORY OF THE PAST FOR THE FUTURE: MULLITE AND ITS USE AS A BONDING PHASE.** Mullite is one of the most widely encountered and important compounds found in many industrial ceramic products. However, it is rare in nature, occurring uniquely on the Isle of Mull off the west coast of Scotland. Mullite as a bonding phase exhibits high refractoriness, low creep rate, low thermal expansion and thermal conductivity, good chemical and thermal stability, and good toughness and strength. 56 refs.

Skoog, Andrew J. (Univ of Missouri-Rolla, Rolla, MO, USA); Moore, Robert E. *Am Ceram Soc Bull* v 67 n 7 Jul 1988 p 1180-1185.

**089288 STRENGTHS OF FUSED AND TABULAR ALUMINA REFRACTORY GRAINS.** The room-temperature strengths of individual grains of two fused and two tabular aluminas were measured in compression, and the data were analyzed using Weibull statistics. Microstructures of the as-received grains and their fractured surfaces were observed by scanning electron microscopy. The results are interpreted in terms of the microstructures of the grains. (Edited author abstract). 22 refs.

Bertrand Philip T. (Univ of Washington, Seattle, WA, USA); Laurich-McIntyre, Suzanne E.; Bradt, Richard C. *Am Ceram Soc Bull* v 67 n 7 Jul 1988 p 1217-1221.

**089289 COMPUTER SIMULATION STUDIES OF PERFECT AND DEFECTIVE SURFACES IN Cr<sub>2</sub>O<sub>3</sub>.** This communication demonstrates an application for computer simulation techniques to determine the energies of perfect surfaces and of defects near those surfaces. The work presented here concentrates on Cr<sub>2</sub>O<sub>3</sub>, determining the perfect surface energies of five low-index planes and



the vacancy formation energies as a function of distance from the two lowest-energy planes. (Author abstract). 7 Refs.

Lawrence, P.J. (Univ of Bath, Bath, Engl); Parker, S.C.; Tasker, P.W. *J Am Ceram Soc* v 71 n 8 Aug 1988 p C.389-C.391.

**Analysis** See **CHEMICAL ANALYSIS**—Laser Applications.

## Applications

**089290 STATO E PROSPETTIVE NELLA FABBRICAZIONE E NEGLI IMPIEGHI DEI REFRACTORI.** [State and Prospects in the Processing and Application of Refractories]. Recent advances in the development of refractory products are presented in connection with the technological changes occurring within the consumer industries, and future trends in the development and application of refractory materials are discussed. (Author abstract) In Italian. 10 refs.

Majdic, A. (Forschungsinstitut der Feuerfest-Industrie, Bonn, West Ger). *Ceramurgia* v 17 n 6 Nov-Dec 1987 p 239-245.

**Bonding** See Also **FURNACES, MELTING**—Refractory Materials; **PHENOLIC RESINS**.

**089291 REGULARITIES OF VIBRATORY COMPACTION OF REFRACTORY BODIES BASED ON PHOSPHATE BINDERS.** The relative effect of the parameters on the properties of the vibratory compacted specimens decreases in the following order: the moisture content of the body, the content of the finely milled fraction, the static pressure, the duration of application of static pressure, and the amplitude of vibrations. The optimum values of moisture content are as follows: ( $5 \pm 0.3\%$ ) for chrome-magnesite bodies, ( $4 \pm 0.2\%$ ) for corundum bodies, and ( $10 \pm 0.5\%$ ) for chamotte bodies. In this case, in all the bodies, the content of the dispersed phase varies in the 28-32% range. The following are the optimum parameters of the vibratory compaction process at a frequency of 50 Hz: static pressure —  $0.5 \text{ N/mm}^2$  for chrome-magnesite and corundum bodies and  $0.25 \text{ N/mm}^2$  for chamotte bodies; duration of application of static pressure — 60 sec; and amplitude —  $0.6-0.7 \text{ mm}$ . The specimens obtained using these parameters had a density difference of not more than 4% (abs.) along their height. 20 refs.

Vorob'ev, V.K. (Kucherenko Central Scientific-Research Inst, USSR); Chernyakhovskii, V.A. *Refractories* v 28 n 3-4 Mar-Apr 1987 p 195-201.

**Carbon** See Also **CERAMIC MATERIALS**—Fibers; **FURNACES, MELTING**—Refractory Materials.

**089292 MULLITE-CORUNDUM RAMMING MASS CONTAINING GRAPHITE AND SILICON CARBIDE ADDITIVES.** This paper deals with a study of the optimum content of the graphite and silicon carbide additives in a mullite-corundum body produced incorporating a binder based on orthophosphoric acid; for this purpose, the simplex-grid method of experimental planning was used. The content of  $\text{Al}_2\text{O}_3$  in the original body amounted to not less than 88% and the  $\text{P}_2\text{O}_5$  content was 2.5-3.0%. We used crystalline graphite (GOST 5279-74) containing approximately 98% particles having a minus 0.09-mm size and the No. 12/6 grade silicon carbide (GOST 3647-80). Based on the conducted studies, authors developed a composition (system) of mullite-corundum body containing 10-13% graphite and 5-6% silicon carbide that makes it possible to produce rammed linings having fairly high strength, high resistance of the action of molten cupola slag and cast iron, and relatively low degree of oxidation of the graphite additive. 8 refs.

Pirogov, Yu.A. (Ukrainian Scientific-Research Inst of Refractories, USSR); Soloshenko, L.N.; Kvasman, N.M. *Refractories* v 28 n 3-4 Mar-Apr 1987 p 117-119.

**089293 KINETICS OF BURNING-UP OF CARBON IN PITCH- AND COAL TAR (RESIN)-IMPREG-**

**NATED PERICLASE PRODUCTS.** It was established that the kinetics of the burning-up process of the carbonaceous substance has an exponential nature and in semilogarithmic coordinates, it can be described by a straight line relationship  $\log C = \alpha + \tan \alpha \tau$ . The intensity of burning-up of the carbonaceous substance increases with increasing test temperature. The rate of burning-up of the carbonaceous substance in the pitch-impregnated specimens is slightly less than that observed in the coal tar (resin)-impregnated specimens. Heat treatment of the impregnated products slows down burning-up of the carbonaceous substance. 3 refs.

Leve, E.N. (Ukrainian Scientific-Research Inst of Refractories, USSR); Antonov, G.I.; Shcherbenko, G.N.; Grivakova, Zh.A.; Kulik, A.S.; Gribanova, N.Ya.; Ryschenko, S.I. *Refractories* v 28 n 3-4 Mar-Apr 1987 p 192-195.

**089294 PROPERTIES OF GRAPHITE-CONTAINING CRUCIBLES.** A study of the thermal conductivity and the electrical resistivity of graphite-containing crucibles shows that these properties significantly depend on the type of the crucible and the zones in different parts of a given crucible. The properties can vary from product to product because of the differences in the compositions and the size fractions of the original raw materials, the postfiring differences in the material, and the structural non-uniformities resulting from compaction. We established the differences in the properties of the graphite-containing crucibles as a function of temperature. Heating the crucibles in an oxidizing atmosphere leads to partial burning-off (depletion) of their main component (graphite) and to a reduction of the thermal and electrical conductivity of the material of the crucibles. The thermal conductivity of the crucibles working in carbon dioxide atmosphere is 5-10% less than that of the crucibles working in argon atmosphere. 4 refs.

Bol'shakova, N.V. (All-Union Scientific-Research Inst of Electrothermal Equipment, USSR); Il'in, A.M.; Frenkel', P.G. *Refractories* v 28 n 5-6 May-Jun 1987 p 242-247.

## Casting

**089295 AQUEOUS SLIPS BASED ON SILICEOUS SCHUNGITES LYDITES.** We studied the properties of the aqueous slips based on siliceous schungites (lydites) and proved the possibility of using them for casting intricate components. With increasing duration of milling, an increased aggregate-stability of the aqueous slips was achieved. Addition of electrolytes decreases the viscosity of the slips, but the aggregate-stability in the regions of the minimum viscosity is less than that obtained without electrolyte additions. 4 refs.

Suvorov, S.A. (Lensovet Leningrad Technological Inst, USSR); Fishchev, V.N.; Nefedova, O.M.; Kanunnikov, L.A.; Kalinin, Yu.K. *Refractories* v 28 n 5-6 May-Jun 1987 p 247-250.

**089296 RATIONAL ELECTRIC SCHEDULES FOR ELECTRIC FURNACES USED TO MELT CORUNDUM REFRACTORIES.** Special attention has been paid in recent years to the development of fusion-cast refractories which is mainly due to their unique properties - the absence of penetrable porosity, high structural density, thermomechanical strength, and corrosion resistance. USSR has organized the large-scale production of fusion-cast baddeleyite corundum and corundum refractories. The melting of these refractories is done in electric arc furnaces. The electric melting technology for the baddeleyite-corundum materials has been mastered, but until now we have lacked data on the rational electrical schedules for the process, their relationship with the productivity of the furnace, and the consumption of electricity per ton of melt. To solve these problems we carried out industrial tests. The test method specifies the bath parameters, short circuit and transformer, with simultaneous registration of the technological parameters (furnace output and specific consumption of electricity). 3 refs.

Rudakov, B.P. (All-Union Inst of Electrofused Refractories, USSR); Bogolyubov, G.D.; Kozlov, O.V. *Refracto-*

*ries* v 28 n 5-6 May-Jun 1987 p 261-264.

**Chemical Analysis** See **CERAMIC MATERIALS**—Forming.

**Chemical Attack** See Also **BLAST FURNACES**—Refractory Materials.

**089297 FORMATION OF THE CRUST ON THE SURFACE OF THE LINING OF MINING AND BENEFICIATION COMBINE PELLETIZING MACHINES.** At present in the USSR most of the iron ore pellets are produced on iron ore pelletizing machines differing both in design and in productivity. The lining service conditions of these heating units differ as the result of the dissimilar technical parameters (mineral composition of the concentrate, basicity of the charge, temperature characteristics of firing), the aerodynamic parameters of the gas passages (filtration and dynamic resistance of the layer of pellets, dust content of the atmosphere), and features of fuel consumption. The investigations conducted show that the greatest increase in lining life may be obtained by the use of refractories and coatings resistant to the action of molten iron silicate materials. Increasing the lining resistance of the high temperature zones makes it possible to reduce down/time by 50-100 h and to obtain savings as the result of the reduction in repairs and additional production of more than 50,000 tons of pellets in a single pelletizing machine. 8 refs.

Reikhardt, L.V. (Eastern Refractory Inst, USSR); Perepelitsyn, V.A.; Bezhaev, V.M. *Refractories* v 28 n 5-6 May-Jun 1987 p 287-295.

**089298 INTERACTION OF ZINC WITH THE CERMET INSERTS IN INDUCTION FURNACE LININGS.** In the service of channel induction furnaces convective heat exchange between the induction unit and the bath is very important. If a directed process of heat and mass transfer is absent, then in the melting channel there are formed zones in which the metal temperature is more than  $100^\circ\text{C}$  higher than its temperature in the bath of the electric furnace. For low-melting metals such as zinc this significantly influences the melting process and the condition of the aluminosilicate linings used. Failure of the aluminosilicate lining occurs both as the result of the reduction in its high-temperature strength and from chemical interaction of the refractory with ZnO. The authors developed a method of heating the induction unit lining in a reducing atmosphere of carbon. Commercial carbon is highly effective thermal insulator and the losses of weight in heating to  $500^\circ\text{C}$  do not exceed 3.5%. In the compacted condition the material has a high electrical conductivity and therefore induction heating of the channel occurs. The presence of the cermet insert provides more favorable conditions for service of the furnace channel lining. 10 refs.

Snegirev, A.I. (Acad of Sciences of the USSR, USSR); Fotiev, A.A.; Zhuravlev, V.D.; Milova, G.D. *Refractories* v 28 n 5-6 May-Jun 1987 p 350-353.

**Coatings** See Also **ZIRCONIUM COMPOUNDS**—Synthesis.

**089299 DISCUSSION: PROBLEMS IN THE USE OF TORCH GUNITING FOR REPAIRING THE LINING OF HEATING EQUIPMENT AND PRODUCTION OF BLOCK REFRACTORY PARTS. SELECTION OF COMPOUNDS FOR TORCH GUNITING OF OPEN-HEARTH ROOFS.** Based on the properties of periclase-chromite refractories, which are recommended for open hearth roofs, it is assumed that gunited coatings formed from periclase-chromite compounds would meet the service requirements (high heat resistance and refractoriness, satisfactory porosity, etc.). In conducting the present investigations charges with weight ratios of periclase and chromite of 100:0, 90:10, 80:20, 70:30, 60:40, 30:70, and 0:100 were prepared and also charges based on scrap of used periclase-chromite roof brick with additions of periclase powder in the following weight ratios: 100:0; 90:10; 80:20; 70:30; 60:40. The life of the coatings was 10 heats in comparison with 4-5 heats for a periclase coating. The results of laboratory



and experimental production tests showed the promise of using periclase-chromite compounds for torch guniting of open hearth roofs. 7 refs.

Boteva, V.Yu. (Don Scientific-Research Inst for Ferrous Metallurgy, USSR); Petrenko, Yu.M.; Murav'ev, V.N.; Mishchenko, V.A. *Refractories* v 28 n 5-6 May-Jun 1987 p 278-281.

**089300 DISCUSSION: PROBLEMS OF THE USE OF TORCH GUNITING FOR REPAIR OF THE LININGS OF THERMAL EQUIPMENT AND PRODUCTION OF BLOCK REFRACTORY PARTS. FEATURES OF LINING WEAR OF CHAMBERS FOR DRY QUENCHING OF COKE.** A promising method of preventive repairs of the quenching chamber lining is torch guniting. Such a method is developed based on systematic repair of the worn layer on the whole area of prechamber and slanted passage lining during periods of hot downtimes of the coking chambers. The expected saving from torch guniting of units for dry quenching of coke is the result of the significant economy in refractories and labor costs in routine and major repairs. 2 refs.

Shershnev, A.A. (All-Union Refractory Inst, USSR); Rusakov, Yu.V.; Kulichkov, G.F.; Kruchinin, M.S.; Naumkin, V.A.; Efremenko, G.N.; Omel'chenko, A.D. *Refractories* v 28 n 5-6 May-Jun 1987 p 341-343.

**Computer Simulation** See CERAMIC MATERIALS—Calculations.

## Concrete

**089301 DEVELOPMENT AND INTRODUCTION OF COMPOSITIONS OF HEAT-RESISTANT CONCRETES AND OF A NEW DESIGN AND METHOD OF PREPARATION OF THE LINING OF HOT TOPS.** In developing a mechanized method of preparation of hot top linings at Makeevka Metallurgical Combine the authors aimed at developing a hot top with a two-layer lining consisting of permanent and working layers. Heat-resistant concretes were used for preparation of the two-layer lining. The compressive strength, density and heat resistance properties were determined. 7 refs.

Zavadskii, M.Ya. (Dnepropetrovsk Construction Engineering Inst, USSR); Pryadko, V.M.; Vinogradov, N.M.; Morozov, A.D.; Netreba, V.N.; Prilepskii, V.I.; Okunskii, D.Sh.; Dronov, L.N.; Gabrev, D.F. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 52-55.

**089302 ANOMALOUS NACHWACHSEN VON KORUND-FEUERBETONEN UND DESSEN VERHINDERUNG.** [Anomalous Swelling of Corundum Refractory Concrete and Its Prevention]. The fact that corundum refractory concretes bonded with high-alumina cements are subject to irreversible swelling is often underestimated. The exact amount of the expansion remains profoundly unknown, considering the type of corundum aggregates, the grain size distribution of the mixture, the type of the high-alumina cement used, the temperature, as well as other factors that may interfere. Obviously, this negative property of the corundum refractory concretes cannot always be eliminated completely. However, provided that a proper refractory concrete composition is adopted, the values of irreversible expansion can be kept low enough to make the service applications feasible to clarify the effects which cause irreversible expansion of alumina refractory concretes experiments were run with refractory concretes incorporating three types of corundum aggregates (bubble alumina, fused alumina and tabular alumina) and six types of high-alumina cements. (Edited author abstract) 12 refs. In German.

Liska, Jan (Forschungsinstitut fuer Huettenkeramik, Bratislava, Czech). *Sprechsaal* v 120 n 10 Oct 1987 p 894, 897-905.

**089303 RICHTWERTE FUER DIE WAERMELEITFAEHIGKEIT VON FEUERBETONEN.** [Guidelines for Thermal Conductivity of Refractory Concretes]. Relationships between the green density and

thermal conductivity of dried insulating refractory concretes and dense fireclay and high-alumina concretes are given. The established relationships should be used for a general evaluation of thermal conductivity values of common refractory Concretes thermal conductivity was determined by three methods (hot-wire-, ASTM and a comparison method). Differences between the thermal conductivity values of these test methods are shown. (Edited author abstract) 9 refs. In German.

Routschka, Bonn G. (Forschungsinstitut der Feuerfest-Industrie, Bonn, West Ger). *Keram Z* v 39 n 12 Dec 1987 p 858-863.

**089304 USING SLATE QUARTZITE FOR MAKING FILLERS FOR MONOLITHIC LININGS OF STEEL-CASTING LADLES.** In steel-melting plants wide use is being made of siliceous monolithic linings for steel ladles, made by casting from self-setting refractory concrete, using crystalline quartzite as the filler. The East Institute of Refractories USSR is studying the possibility of expanding the raw material base for the production of siliceous fillers. The Institute carried out some physico-chemical and mineralogical investigations of the materials and studied the possibility of beneficiating, and determined the technological properties of concrete based on the enriched raw materials. This article presents and discusses the results of these investigations.

Flyagin, V.G. (East Inst of Refractories, USSR); Solodova, L.I.; Gamzikova, S.D.; Grishpun, E.M.; Kravtsov, V.M.; Vudrina, Zh.A.; Bepamyatnykh, V.I. *Refractories* v 28 n 5-6 May-Jun 1987 p 258-260.

**089305 KINETICS OF HYDRATION AND ACTIVITY OF MONOCALCIUM DIALUMINATE AND THE HIGH-ALUMINA CEMENTS BASED ON IT.** In recent years, there has been an abrupt increase in the requirement of high-alumina cements (HAC) for producing concrete lining of thermal units in various industrial sectors. This paper presents the results of systematic laboratory and industrial studies on the activity of HAC obtained by various methods. In order to evaluate the effect of the production method of monocalcium dialuminate  $\text{CaO} \cdot 2\text{Al}_2\text{O}_3(\text{CA}_2)$  on its hydraulic properties, we studied the hydration kinetics of the materials that were synthesized by sintering and melting. The activity of high-alumina cements based on  $\text{CA}_2$  mainly depends on the milling fineness. The specific features of chemical and, consequently, mineralogical composition have a significant effect on the rate of the setting process during the initial period. The type and the quality of the original raw materials used for obtaining clinkers in electric arc furnaces do not significantly affect its quality provided that the required mineralogical composition, proper melting regime, and removal of the detrimental components from the oxide melt are ensured. 12 refs.

Zaldat, G.I. (Ural Scientific-Research Inst, USSR); Kukui, S.M. *Refractories* v 28 n 5-6 May-Jun 1987 p 313-317.

**089306 METAL RESISTANCE OF REFRACTORY CONCRETES BASED ON PHOSPHATE BINDERS.** The authors studied the resistance of fused magnesite, corundum, and quartzite-based materials produced using phosphate binders to molten aluminum and copper. It was established that the materials based on fused magnesite and corundum are most stable in molten aluminum. The materials based on fused magnesite have the maximum resistance to molten copper. 2 refs.

Pushkin, S.A. (Ivanovsk Chemical-Technology Inst, USSR); Komlev, V.G.; Sychev, M.M. *Refractories* v 28 n 7-8 Jul-Aug 1987 p 438-440.

**Corrosion** See Also PROTECTIVE COATINGS—Borides.

**089307 CORROSION OF REFRACTORY MATERIAL UNDER THE ACTION OF FORCED CONVECTION FLOW BY MEANS OF THE ROTATING CYLINDER FACE AREA AT 1500°C.** The corrosion rates of various refractory materials in a container glass

melt (sodium-calcium silicate basis) were determined quantitatively under the action of forced convection flow by means of the rotating cylinder face area at 1500°C as compared with those of 1400°C. The applied of occasionally occurring crystalline or textural alterations during corrosion, which possibly can be detected only in experiments of extended duration. (Edited author abstract) 9 refs.

Dunkl, Michael (Technische Univ Berlin, Berlin, West Ger); Brueckner, Rolf. *Glastech Ber* v 60 n 8 1987 p 261-267.

**089308 AUTORADIOGRAPHIC STUDY OF CORROSION OF REFRACTORIES.** In glass-melting furnaces the downward facing surfaces of the refractories are subjected to increased wear as a result of vertical cellular corrosion. A comparative study was made of the character of the interaction between a container-glass melt and a refractory in various sections (the side surface with traditional wear and the horizontal surface facing the glass damaged by the action of vertical cellular corrosion). The autoradiograms and the photomicrography indicate that an intrinsic feature of all refractories, regardless of where they interact with the melt, is that the calcium from the melt penetrates the refractory along the weak links for fused-cast refractories, the glass phase; for sintered refractories, by the binder and the micro- and macrocracks. 4 refs.

Lisenenkova, S.B. (State Scientific-Research Inst of Glass, USSR); Kucheryavyi, M.N.; Bursteva, T.A. *Glass Ceram* v 44 n 7-8 Jul-Aug 1987 p 336-339.

**Creep** See COKE OVENS—Refractory Materials.

## Crystallization

**089309 EFFECT OF THE COOLING RATE OF THE MELT OF THE STRUCTURE OF ELECTROSMELTED FORSTERITE REFRACTORIES.** The cooling rate of the melt and the crystallization conditions are the main factors in the technology of producing fused refractories and they determine the structure of the material. To study the effect of these factors on the structure of fused forsterite, batches based on serpentinites from the Dzhetysayinsk deposits with additions of metallurgical magnesite were melted, followed by cooling at a rate of 100°C/min and quenching in water or oil. Quenching in water obtains crystalline material which contains no glass phase. The development and stabilization of a dendrite structure producing a strengthened interphase bond increases the strength of the refractory product. 2 refs.

Bolotov, Yu.A. (Alma-Ata Energy Inst, USSR). *Refractories* v 28 n 1-2 Jan-Feb 1987 p 85-88.

**089310 MODELING THE CRYSTALLIZATION OF THE GLASSY PHASE OF FUSED BADDELEYITE-CORUNDUM REFRACTORIES.** The glassy phase of baddeleyite corundum refractories containing 33% of  $\text{ZrO}_2$  has been studied by many research workers. To determine the composition of the glass phase of the refractories, 'high-temperature' and 'low-temperature' methods have been used. To obtain specimens using the first method, the refractories were heated to 1300-1700°C. As a result, drops of the glass phase appeared on the surface and these were collected and chemically analyzed. For the second method, selective dissolution of the milled refractory was carried out in 5% HF. In this case, the crystal framework of the refractory was virtually insoluble and the glass phase went into solution. Next, the amount and composition of the phase were determined. The amount of glass phase in the specimens of thin sections of refractories was evaluated using a petrographic method. 5 refs.

Verlotskii, A.A.; Rublevskii, I.P.; Kalinin, V.B.; Lokshina, A.E. *Glass Ceram* v 43 n 11-12 Nov-Dec 1986 p 526-530.



## Deformation

**089311 INVESTIGATING THE DEFORMATION PROPERTIES OF MORTARS.** In this article we present experimental data from an investigation of the deformation of mortars at varying temperatures and loads and make an attempt to describe the creep curves using the theory of thermoviscoelasticity. We studied specimens of chamotte, mullite-siliceous and dinas mortars. The specimens were cast from mortars in molds and dried in a thermostat for 5-6 h at 110°C. The capacity of the mortars to resist significant compression will contribute to the weakening of the annular and axial stresses in the structure. The results of the studies may be used for designing heating equipment. 4 refs.

Shklyar, F.R. (VNIIMT, USSR); Surgucheva, E.L.; Toritsyn, L.N. *Refractories* v 28 n 5-6 May-Jun 1987 p 321-324.

## Density

**089312 INCREASING THE APPARENT DENSITY OF CAST BADDELEYITE-CORUNDUM PRODUCTS FOR MAKING OPTICAL GLASS.** Apparent density is used as the main characteristics of the case refractories of the baddeleyite-corundum composition. In order to facilitate the production of optical glass, the Podolsk Refractories Factory is manufacturing products corresponding to the BKCh-33 and BKCh-34 grades and having an apparent density not less than 3.4 and 3.6 g/cm<sup>3</sup>, respectively. The experience gained during the service of these products showed that the formation of striae and bubbles becomes intense when the central porous zone of the beam comes into contact with the glass mass. In order to eliminate the shrinkage cavity from the body of the beam and to improve the absolute density of the products, the authors produced experimental castings using a cylindrical riser. 4 refs.

Gutman, V.I. (All-Union Inst of Refractories, USSR); Sokolov, A.N.; Aleksandrov, B.P.; Lazorenko, V.N.; Shodogubov, V.D.; Khodenkov, V.M.; Artamonov, V.I.; Naumenko, V.A.; Klimenko, V.A.; Koshelevskii, A.G.; Smelyi, A.I. *Refractories* v 28 n 7-8 Jul-Aug 1987 p 390-394.

**089313 INCREASING THE DENSITY OF ELECTROMELTED REFRACTORIES USING ELECTROMAGNETIC EFFECT DURING THE PROCESS OF CASTING (POURING) AND CRYSTALLIZATION.** Density is one of the most important technological properties of refractory materials. Application of an electromagnetic field during the process of pouring the melt into the mold and crystallization has a positive effect on the density of filling the molds. In the presence of an electromagnetic field, density increases by 26% on average. 3 refs.

Ashimov, U.B. (Alma-Ata Power Inst, USSR); Abrakmanov, E.A. *Refractories* v 28 n 7-8 Jul-Aug 1987 p 440-442.

## Doping

**089314 EFFECT OF ANNEALING AND ELECTRON IRRADIATION ON THE STATE OF PARAMAGNETIC CENTERS IN CUBIC BORON NITRIDE.** A study was made of the effect of isothermal annealing and electron irradiation on the EPR spectra of polycrystalline samples of cubic boron nitride. It was found that the nature of the paramagnetic defects is similar in the two cases. It is suggested that the observed EPR signals are caused by annealing-resistant and electron-irradiation-resistant complexes based on nitrogen vacancies and interstitial atoms. In Russian. 9 refs.

Shipilo, V.B.; Rud', A.E.; Leushkina, G.V.; Kuz'min, V.S.; Ugolev, I.I. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 12 Dec 1987 p 1993-1997.

**Drying** See PETROLEUM REFINERIES—Refractory Materials.

**Elasticity** See COKE OVENS—Refractory Materials.

**Erosion** See PROTECTIVE COATINGS—Refractory Materials.

## Eutectics

**089315 FORSTERITE-BADDELEYITE SYSTEM.** A comparison of the experimental and calculated liquidus curves showed that the forsterite-baddeleyite system is fairly well described by a regular-solution model and may be categorized as a simple eutectic system with a eutectic composition of 83.2 mol.% Mg<sub>2</sub>SiO<sub>4</sub> and a melting point of 2038 K. By thermodynamic analysis of the system the existence of two solid-solution ranges - one based on forsterite (up to 1.2 mol.% ZrO<sub>2</sub>) and one based on baddeleyite (up to 63.9 mol.% Mg<sub>2</sub>SiO<sub>4</sub>) - at the eutectic temperature is established. In Russian. 6 refs.

Suvorov, S.A.; Sennova, A.A. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 4 Apr 1987 p 662-664.

## Failure

**089316 STRESSED AND STRAINED STATE AND FAILURE OF REFRACTORIES UNDER THERMAL ACTION.** Failure of a refractory is a complex irreversible thermally activated process occurring under the action of molten metal or hot gases in which the physical and chemical aspects of failure are closely related, mutually dependent, and mutually strengthen each other. For investigations of the failure process tests of refractory specimens were made on a unit developed by the All-Union Refractory Institute. To evaluate the intensity of failures, visual inspection with a metallographic microscope, determination of the change in the rate of passage of ultrasonic vibrations in the specimens after the tests, and the sonic resonant method were used. The materials tested were periclase, quartz and mullite-corundum. 2 refs.

Kuznetsov, A.T. (All-Union Inst of Refractories, USSR); Kokushkin, I.V.; Senyavin, N.K.; Shershnev, A.A. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 110-114.

**089317 PROCESSES OF THE ACTION OF IRON AND ITS COMPOUNDS ON A REFRACTORY.** Iron and its oxides participate in all processes of failure of the refractory linings of metallurgical equipment. This may be explained by the high thermodynamic activity of iron in both the liquid and solid phase. Based on the temperature conditions of service, equipment in which such action occurs primarily in the solid and highly viscous phase, such as machines and equipment for firing of pellets (temperature in the working space from 800 to 1300°C) and equipment in which the interaction occurs primarily in the liquid phase such as open hearth, double bath, and electric furnaces and oxygen converters (temperature in the melting space 1600-1800°C) are discussed. 10 refs.

Freidenberg, A.S. (Ural Scientific-Research Inst for Ferrous Metallurgy, USSR); Perepelitsyn, V.A. *Refractories* v 28 n 7-8 Jul-Aug 1987 p 465-471.

## Fiber Reinforcement

**089318 THERMAL INSULATION OF THE RISER OF AN ALUMINUM CASTING WITH FIBER MATERIALS.** At present in a number of plants automatic machines are used for casting of aluminum pistons. Thermal insulation of the riser is provided by a sleeve of Marinite thermal insulation material. We have investigated the possibility of production of materials of this type from fibrous components (asbestos, kaolin wool, basaltic fiber, perlite) by methods of pressing with various binders (orthophosphoric acids clay, lime-silica binder). Based on investigations conducted, with phosphate and clay hardening the optimum charge composition must include 28.5% fibrous component, 28.5% perlite, and 14.5% clay. The fibrous constituent must have fibers with a length of not more than 0.5 mm to obtain a sufficiently good part surface in pressing to eliminate erosive action of

the solidifying metal. The fibers serve as a reinforcing component providing the heat resistance and strength of the material. 2 refs.

Efimov, G.V. (Acad of Sciences of the USSR, USSR). *Refractories* v 28 n 5-6 May-Jun 1987 p 295-298.

## Fireclay

**089319 CONCENTRATION OF MULLITE AND THE DEGREE OF CONVERSION IN FIRECLAY FIRED AT 1100°C.** The authors studied the effectiveness of various complex additives on mullite formation in fireclay. The chemical composition of the clay was % (by weight): SiO<sub>2</sub> 68.70, Al<sub>2</sub>O<sub>3</sub> 19.80, Fe<sub>2</sub>O<sub>3</sub> 0.99, TiO<sub>2</sub> 1.20, CaO 0.26, MgO 0.21. The additives consisted of oxyfluoride fused flux (not less than 90% CaF<sub>2</sub>) and the eutectic mixture of CaF<sub>2</sub>+MgF<sub>2</sub> obtained by fusing the original components at 1100°C. Composition of the aluminosilicate mass, including the chamotte, the fireclay, and the additive of oxyfluoride flux is recommended for making the channel elements for lining the induction units of furnaces for remelting cathode zinc. 25 refs.

Snegirev, A.I. (Acad of Sciences of the USSR, USSR); Gimpelman, E.Ya.; Pivovarov, V.I.; Zholobova, L.S.; Fotiev, A.A. *Refractories* v 28 n 9-10 Sep-Oct 1987 p 565-570.

**Firing** See Also KILNS—Simulation; KILNS—Temperature Control.

**089320 TURBULENT DIFFUSION IN THE FLAME OF A ROTARY KILN.** During firing of refractory materials in rotary kilns, combustion of the fuel occurs by mixing with the oxidizer in a turbulent diffusion flame with participation of solid particles in the form of dust of the material being fired. The process of mixing the fuel with the oxidizer is determined by turbulent diffusion. 13 refs.

Strekotin, V.V. (Eastern Refractory Inst, USSR); Telegin, A.A.; Lisin, F.N.; Malysheva, O.I. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 47-51.

**089321 USE OF RAMAN SPECTROSCOPY IN A COMPLEX INVESTIGATION OF THE FIRING OF SERPENTINITES.** In the present work during a study of the firing behavior of serpentinites from the Dzhetysay deposits an attempt was made to carry out the analysis using the method of Raman spectroscopy (combined scatter - KRS). The Raman method of measurement revealed no change in the phase composition of the material fired at above 1373°K right up to the melting point. Thus, the use of the Raman microscopic method for studying the behavior of Dzhetysay serpentinites during heating established that the mineral formation after decomposition of the serpentinites commences with the separation of the structures of clinostatite, then enstatite and forsterite, and furthermore we established the low-temperature synthesis of these monomineral phases which researchers had previously not established. We also revealed monomineral complex consisting of a mechanical mixture of clinostatite, enstatite, and forsterite, which are not registered by the conventional methods. 6 refs.

Ashimov, U.B. (Alma-Atinsk Inst of Power Engineering, USSR); Arymbaev, O.Z.; Bolotov, Yu.A.; Zaretskaya, N.P. *Refractories* v 28 n 3-4 Mar-Apr 1987 p 149-153.

**089322 SHAFT OVEN FOR HEATING FINELY DIVIDED MATERIALS.** A shaft oven has been developed to dry and fire various powders, including powders with high water contents, in continuous operation at temperatures up to 1200°C. We give some design and working characteristics of the apparatus used for decarbonization and high-temperature firing in the production



of high-purity substances and reagents, in particular, rare-earth oxides. There was virtually no loss of the fired material. 4 refs.

Glazachev, V.S. (Automatic Instruments Research Inst, USSR); Prozorov, E.N. *Refractories* v 28 n 5-6 May-Jun 1987 p 270-271.

**089323 PROPERTIES AND BEHAVIOR OF PERICLASE-CARBON SYSTEMS DURING THE FIRING PROCESS UNDER OXIDIZING CONDITIONS.** In order to define the physicochemical processes occurring when forming periclase-carbon concrete products that are intended for lining the walls of electric steelmaking furnaces and converters, we studied the properties of fine-grained composites after firing in air at 1000 and 1650°C. The results show that it is not advisable to introduce more than 20% graphite into the composition of the periclase-carbon refractories because, in this case, the strength of the products decreases significantly and their porosity increases. The temperature corresponding to the beginning of carbon depletion does not depend on its content in the body and amounts to 550-560°C. Caustic periclase introduced for achieving additional low-temperature densification of the structure with reduced degree of carbon depletion did not give the expected effect: the temperature at which carbon depletion begins does not depend on its content in the body.

Ivashchenko, L.V. (L.I. Brezhnev Dnepropetrovsk Metallurgical Inst, USSR); Romanoyskii, L.B.; Shevchenko, G.I.; Khoroshayin, L.B.; Perepelitsyn, V.A.; Popova, V.I. *Refractories* v 28 n 5-6 May-Jun 1987 p 301-305.

**089324 VAPOR-PHASE RECRYSTALLIZATION (REDEPOSITION) PROCESSES IN PERICLASE-CARBON PRODUCTS.** The recrystallization process of periclase and silicates from a vapor phase is observed when firing the periclase-graphite products in air at 1710-1720°C. We studied the mechanism of vapor-phase recrystallization of periclase and forsterite in the periclase-carbon products. The formation of secondary crystals of periclase and forsterite occurs from the gaseous phase simultaneously with their crystallization in the form of filamentary and dendritic crystals in the developed cavity and with recrystallization of isometric periclase. 8 refs.

Khoroshavin, L.B. (L.I. Brezhnev Dnepropetrovsk Inst of Metallurgy, USSR); Perepelitsyn, V.A.; Boriskova, T.I.; Ivashchenko, I.V.; Romanovskii, L.B. *Refractories* v 28 n 5-6 May-Jun 1987 p 306-309.

**089325 BURNING CLINKER FOR HIGH-ALUMINA CEMENT IN A ROTARY KILN.** We prepared clinker for high-alumina cement in a rotary kiln and determined the material balance in firing when preparing the raw mixtures with two methods: granulation in a plate granulator and briquetting on a roller press. It is shown that much less dust removal (4%) is ensured by firing the briquets obtained on the roller press. The aluminous cement obtained with this technology has a high graded strength. 3 refs.

Kvyatkovskii, O.V. (All-Union Inst of Refractories, USSR); Sokolov, A.N.; Fleer, S.A.; Ashkinadze, G.Sh.; Osipova, L.Ya.; Orekhov, P.D.; Krasnitskaya, L.A. *Refractories* v 28 n 5-6 May-Jun 1987 p 333-334.

**089326 MATHEMATICAL MODEL OF HEATING OF THE MATERIAL IN A LAYER WITH OCCURRENCE OF PROCESSES OF ITS THERMAL DECOMPOSITION.** Shaft kilns are used for firing refractory materials and are equipped with layer heat exchangers. Heating is accompanied by endothermic reactions of decomposition, which significantly complicate thermal calculations. This article presents a mathematical model of heating of the material in a layer in the presence of a decomposition reaction taking into consideration the determining factors of the decomposition and based on a mathematical description of the kinetics of the decomposition reaction and of the processes of heat and mass exchange in the material of the layer. The model describes nonsteady heating of a stationary layer of material and

may be used for computerized thermal calculations of heat exchange equipment with crosswise and countercurrent flows. 5 refs.

Novikov, V.L. (All-Union Refractory Inst, USSR); Abakumov, V.G. *Refractories* v 28 n 5-6 May-Jun 1987 p 335-340.

## Fracture

**089327 STRUCTURE AND FRACTURE OF CORUNDUM-MULLITE REFRACTORIES.** Introducing mullite-containing components and additives initiating the formation of secondary mullite at the active surfaces of corundum crystals into corundum bodies changes the structure and the nature of resistance to crack propagation during mechanical loading owing to the increased duration of delayed fracture. The thermal shock resistance increases due to increased limiting deformation and work of fracture. The highly developed contact surface between corundum and mullite through the fine-grained matrix phase containing microcracks is a characteristic feature of the structure. 10 refs.

Nemets, I.I. (I.A. Grishmanov Belgorodsk Technological Inst of Building Materials, USSR); Gvozdi, V.S.; Belik, Ya.G. *Refractories* v 28 n 9-10 Sep-Oct 1987 p 555-558.

## Heat Resistance

**089328 HEAT RESISTANCE OF FUSED AND CAST BADDELEYITE-CORUNDUM REFRACTORIES.** This article presents certain results of investigation of the heat resistance of BKCh-33 baddeleyite-corundum parts. The heat resistance of specimens from different zones of BKCh-33 production parts was investigated by the method of radial thermal flow. Specimens the microstructure of which is distinguished by the minimum quantity of defects, a fine crystalline structure of the products of combined crystallization of baddeleyite and corundum, and uniform distribution of glassy phase have the highest heat resistance, which should be taken into consideration in the production of refractories in industry. 9 refs.

Kolomeitseva, E.F. (State Scientific-Research Inst for Glass, USSR); Popov, O.N.; Kolomeitsev, V.V. *Refractories* v 28 n 3-4 Mar-Apr 1987 p 221-225.

## Heat Resisting

**089329 METHOD OF DETERMINING THE HEAT RESISTANCE OF REFRACTORIES UNDER CONDITIONS OF BENDING LOAD.** In the present article the authors suggest a method and an installation TER-IN-110 intended for a broad range of users (industrial laboratories as well as research laboratories) which makes it possible, with little labor, to determine the heat resistance of refractories with different structure and to record the instant of rupture. 7 refs.

Kazakyavichyus, K.A. (Acad of Sciences of the LitSSR, Kaunas, USSR); Zabolka, A.I.; Yanukenas, V.I.; Vakk, E.G.; Korshunov, V.S.; Danilov, F.P. *Ind Lab (USSR)* v 53 n 7 Jul 1987 p 646-649.

## Heat Transfer

**089330 TEMPERATURE, HEAT FLUX, AND GROWTH KINETICS FOR A METAL CRUST ON A REFRACTORY.** The assumptions of ideal thermal contact and semiinfinite refractory lining have been used in an analytic solution for the crust kinetics. The solution has an advantage over a numerical one as it enables one to analyze the effects of the various physical factors. The solution has been obtained in terms of dimensionless variables, particularly as a function of the unique dimensionless parameter, which enables one to evaluate crustal development for any physical conditions. Further improvement to the solution can be obtained by incorporating the nonideal refractory-liquid contact. 2 refs.

Kuznetsov, A.T. (All-Union Refractories Inst, USSR); Magel, R.K.; Sibikin, A.B. *Refractories* v 28 n 5-6 May-Jun 1987 p 272-277.

**089331 EMISSIVITY OF ALUMINOSILICATE REFRACTORIES.** Experimental data was obtained on the dependence of the emissivity of refractories on temperature and chemical composition. The article reports results of a study of the integral normal emissivity of different grades of aluminosilicate refractories in relation to their chemical composition and temperature during heating in air in the temperature range 600-2100°K and during heating in vacuum, with a vacuum pressure to  $10^{-3}$  mm Hg, in the temperature range 600-1800°K. The refractory specimens were bars measuring  $35 \times 35 \times 3$  mm or  $40 \times 40 \times 5$  mm, depending on the grade of refractory. The roughness parameters of the specimens were measured on a MIS-11 binary microscope. (Edited author abstract) 2 refs.

Taimarov, M.A. (Kazan Inst of Chemical Engineering, USSR); Garifullin, F.A.; Davletbaeva, D.Z. *J Eng Phys* v 53 n 3 Sep 1987 p 1027-1031.

## Impurities

**089332 INFLUENCE OF STRUCTURAL DEFECTS ON THE ELECTRONIC PROPERTIES OF INTERSTITIAL ALLOYS - II. METAL SUBSTITUTIONAL IMPURITIES.** The LMT0-Green's function method is used for the study of the electronic structure of refractory interstitial alloys (TiC, TiN, VC, NbC) containing isolated substitutional impurities in the metal sublattice. The impurities considered are 3d- and some of the 4d-metals. The presence of LDOS resonances in the region of the matrix DOS minimum has been revealed for elements of the VIa-VIIa subgroups. Self-consistent spin-polarized calculations provide estimates of the values of the local magnetic moments for the above impurities. The special features of metal impurity electron distributions with 'anomalous' alloying are discussed for TiC-Mo, TiN-Mo, TiN-Ni, wherein Mo and Ni atoms have been implanted at sites of the non-metal sublattice. The calculational results are compared with available X-ray emission spectra of the alloys  $Ti_x V_y C_z$  and  $Ti_x Nb_y C_z$ . (Author abstract) 20 refs.

Ivanovsky, A.L. (Acad of Sciences of the USSR, Sverdlovsk, USSR); Anisimov, V.I.; Lichtenstein, A.I.; Gubanov, V.A. *J Phys Chem Solids* v 49 n 5 1988 p 479-486.

## Machining

**089333 HARD-PART MACHINING: A CERAMIC SUCCESS STORY.** Hard-part machining (HPM), simply put, is the machining of extremely hard workpieces using ceramic inserts. It is not a new concept, but its success rate has improved dramatically over the past ten years with the emergence of uniform ceramic inserts. HPM requires less processing time, reduces capital investment, and generally improves end product quality and durability. Uniform ceramic consistency in chemical content, metallurgical and physical properties, and dimensional control makes HPM performance as predictable as that of any other mechanical process.

Bordui, Dave (NTK Cutting Tools, Southfield, MI, USA). *Cutting Tool Eng* v 39 n 4 Aug 1987 p 54, 57.

**Magnesia** See Also FURNACES, METALLURGICAL —Refractory Materials; KILNS—Lining; MAGNESIA —Manufacture.

**089334 SINTERING BEHAVIOR OF ULTRAFINE MAGNESIA PREPARED BY CHEMICAL VAPOR REACTION.** Sintering behavior of ultrafine CVD-MgO, which is characterized by a high purity and nonagglomeration, was studied at temperatures from 600°C to 1500°C in air with emphasis on the particle size effect. The sinterability increased remarkably with decreasing the particle sizes in the starting powders. Owing to nonagglomeration, CVD-MgO showed a higher sinterability than those of the powders produced by solid-state reactions. (Edited author abstract) 13 refs.

Kato, Akio (Kyushu Univ, Jpn); Toda, Yasuhiko. *Mem Fac Eng Kyushu Univ* v 47 n 2 Jun 1987 p 135-143.



**089335 OBTAINING FUSED PERICLASE IN THE OKB-955N ORE-THERMIC FURNACE WITH A TRIANGULAR BATH.** We identified the factors influencing the process of forming the nonmeltable heat-insulating layers of the block during the melting of brucite raw materials in an ore-thermic furnace designated OKB-955N. A furnace was proposed with a bath in the form of a triangular, truncated pyramid with rounded edges, facilitating a considerable reduction in the thickness of the nonmelting heat-insulating layer, especially the skin of the block, the specific consumption of raw materials and the volume of manual and mechanical handling operations, and also giving some improvement in the quality of the periclase. The highest cost-benefit factors for operating the furnaces are obtained by combining the triangular baths with a forced melting cycle. The parameters for a high-capacity furnace with a triangular bath were examined. 4 refs.

Simonov, K.V. (Central Power Inst for Ferrous Metals, USSR); Koptelov, V.N.; Kirzhner, D.I.; Zinnurov, F.Z. *Refractories* v 28 n 5-6 May-Jun 1987 p 325-332.

**089336 POROUS FORSTERITE PARTS FOR PURGING OF METAL WITH INERT GASES.** The possibility of using forsterite gas-permeable parts for the purging of metal with inert gases in the steel ladle has been established. The wear of the forsterite tuyeres did not exceed the wear of porous parts of fused periclase. A rational method of production and the structural and physical properties of forsterite tuyeres are investigated.

Kurilova, L.Ya. (V.I. Lenin Nizhnetagil Metallurgical Combine, USSR); Zakharov, S.A.; Vydrina, Zh.A.; Muratov, A.A.; Shevtsov, A.L.; Visloguzova, E.A.; Chervyakov, B.D. *Refractories* v 28 n 5-6 May-Jun 1987 p 348-349.

**089337 PETROGRAPHIC INVESTIGATION OF MgO-BASED TUNDISH COATING MATERIAL BEFORE AND AFTER SERVICE.** Petrographic methods were used to study the microstructures and constituent phases of MgO-based tundish coating material before and after service, and hence to deduce the microstructural and phase changes that took place during service. The behaviour of the coating material at high temperatures was then understood from a consideration of phase equilibria in some pertinent systems. (Edited author abstract) 16 refs.

Wu, Jang-An (Nat'l Cheng Kung Univ, Tainan, Taiwan); Yang, Houn-Yi. *Br Ceram Trans J* v 87 n 2 Mar-Apr 1988 p 58-63.

**089338 PERFORMANCE OF MAGNESIA-CARBON BRICKS IN VACUUM AT HIGH TEMPERATURE.** The chemical-structural profiles of four types of MgO-C bricks with 15 to 24% carbon in contact with three different types of slag at temperatures of 1650 and 1700°C in vacuum were examined. Retardation of slag penetration owing to the presence of graphite was demonstrated. The corrosion resistance of the MgO is strongly dependent on the slag composition and increases with the basicity of the slag. (Edited author abstract) 19 refs.

Quon, D.H.H. (CANMET, Ottawa, Ont, Can); Bell, K.E. *J Can Ceram Soc* v 60 n 4 Dec 1987 p 39-44.

**089339 DIE SPIRZHAFTUNG BASISCHER FEUERFESTER PFLEGEMASSEN.** [Adherence of Basic Refractory Maintenance Mixes]. The adherence of a gunning mix is determined by its plasticity. This results from the rheological properties of the fines portion of the mix mixed with water. The viscosity of aqueous suspensions of sintered magnesite fines was determined at 30, 50, 70 and 90°C by means of a rotational viscometer. Besides, the influences of the fineness of grinding, and of different binder additives (neutral and alkaline Na-silicate, Na-polyphosphate) were included in the investigations. High yield points are already formed in a pure MgO suspension within a few minutes. They are enhanced by higher temperatures, finer grain size distributions of the fines, and by sodium silicate additions. (Author abstract) 8 refs. In German and English.

Siegl, Walter M. *Radex Rundsch* n 1 Mar 1988 p 503-519.

**089340 MODELOVANIE PROCESU AGLOMERACIE METODOU VYSKOTEPLONEJ MIKROSKOPIE.** [Modelling Sinter Process by Blast Furnace Microscopy Method]. The MgO effect is recorded in sintering process modelling by the blast furnace microscopy method. MgO-CaO-Fe<sub>2</sub>O<sub>4</sub> and MgO-MnO-SiO<sub>2</sub> ternary systems have been studied. Shrinkage values were measured in individual systems depending on temperature. Melting temperatures have been verified. (Edited author abstract) 16 refs. In Czech.

Jakubeczyova, Dagmar (Sav, Kosice, Czech); Majercak, Stefan; Vadasz, Pavol. *Hutn Listy* v 42 n 6 Jun 1987 p 397-401.

**089341 EFFECT OF COAL SLAG ON THE MICROSTRUCTURE AND CREEP BEHAVIOR OF A MAGNESIUM-CHROMITE REFRACTORY.** The present paper relates the results of an investigation of the role of coal slag composition on penetration and creep behavior of a MgCr<sub>2</sub>O<sub>4</sub> refractory. The data suggest a strong correlation between structural stability of the refractory and the viscosity of the intergranular vitreous phase that forms in the refractory as a consequence of slag penetration. The lower the viscosity of the vitreous phase, the more readily the surface of the refractory disintegrates. 27 Refs.

Wiederhorn, Sheldon M. (NBS, Gaithersburg, MD, USA); Krause, Ralph F. Jr.; Sun, Jing. *Am Ceram Soc Bull* v 67 n 7 Jul 1988 p 1201-1210.

**089342 SHAPE AND SIZE OF CRYSTALLINE MgO PARTICLES FORMED BY THE DECOMPOSITION OF Mg(OH)<sub>2</sub>.** Decomposition of Mg(OH)<sub>2</sub> at 300° to 400°C yields MgO crystals with often unequal edge lengths which, from counting of crystal planes in high-resolution transmission electron micrographs, range from 0.8 to 2.4 nm, in agreement with conclusions of Moodie and Warble. Optical diffractograms and electron diffraction patterns yield concordant results. (Edited author abstract). 10 Refs.

Kim, M.G. (Lawrence Berkeley Lab, Berkeley, CA, USA); Dahmen, U.; Searcy, Alan W. *J Am Ceram Soc* v 71 n 8 Aug 1988 p C.373-C.375.

**089343 EFFECT OF SINTERING ATMOSPHERE ON DENSIFICATION OF MgO-DOPED Al<sub>2</sub>O<sub>3</sub>.** The densification behavior of Al<sub>2</sub>O<sub>3</sub>-MgO has been studied in O<sub>2</sub> and N<sub>2</sub> atmospheres. Powder compacts have been sintered at 1600°C for 0.5 to 8 h. For some specimens the sintering atmosphere has been changed after 30 min of sintering. Irrespective of sintering atmosphere, sintered densities are approximately the same up to 99% relative density, implying that the capillary pressure effect dominates the atmosphere effect for most of the densification stage. (Edited author abstract). 8 Refs.

Paek, Y.K. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Eun, K.-Y.; Kang, S.-J.L. *J Am Ceram Soc* v 71 n 8 Aug 1988 p C.380-C.382.

#### Magnesite See Also MAGNESITE—USSR.

**089344 EVALUATION OF THE SLAG RESISTANCE OF RESIN-BONDED CONVERTER REFRACTORIES.** Slag erosion of converter refractories occurs due to a physicochemical interaction involving impregnation of the refractory material with slag and chemical dissolution with the formation of refractory compounds. This paper deals with a study of the failure mechanism of periclase converter refractories produced using a resinous binder and presents a rapid method of evaluating slag resistance based on data on the flow rate of the slags. Experimental evaluation of the results of thermodynamic analysis was carried out based on a study of the state of the refractory specimens after impregnation with a basic slag at 1500-1620°C. The slag composition was 13% Al<sub>2</sub>O<sub>3</sub>, 10% SiO<sub>2</sub>, 42% CaO, 4% MgO, 7% P<sub>2</sub>O<sub>5</sub>, 3% MnO, and 21% FeO. 7 refs.

Kin, T.V. (Moscow Inst of Steels & Alloys, USSR); Minaev, Yu.A. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 20-23.

**089345 INTERCONNECTION OF THE PROPERTIES OF PERICLASE CHROMITE ARTICLES MANUFACTURED FROM COARSE PLUS FINE-MILLED CHAMOTTE.** An analysis has been made of periclase-chromite articles manufactured at the Nikitov Dolomite and Panteleimonsk Refractory Plants. A statistical evaluation has been made of the properties and the interconnection between them has been established. The properties analyzed are density, porosity, compressive strength and thermal shock resistance. 2 refs.

Kamenetskii, Yu.L. (Ukrainian Scientific-Research Inst of Refractories, USSR); Novikova, O.I.; Antonov, G.I. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 72-76.

**089346 DETERMINATION OF THE WEIGHT PERCENT OF CHROMIUM OXIDE IN MAGNESIA CHROME-CONTAINING MATERIALS AND PARTS ON A BARS-3 INSTRUMENT.** The method developed is designed for rapid production inspection of production in the range of 8-60% Cr<sub>2</sub>O<sub>3</sub> and of finished production in the 10-30% range. The time for analysis of a single sample, including preparation, is 4-5 min. The actual spread obtained between the results of two parallel measurements is 0.3% with Cr<sub>2</sub>O<sub>3</sub> from 8 to 30 wt.% and 0.8% with Cr<sub>2</sub>O<sub>3</sub> from 30 to 60 wt.%. The method, which is designed for production control, has been certified in accordance with the plant standard. At present work is being done in Magnesite Combine on preparation for certification of a method of measurement of the weight percent of calcium oxide in magnesite powders and of iron oxide in powders with the addition of siderite on the BARS-3 instrument.

Bibaev, V.M. (Magnesite Combine); Krasnova, O.V. *Refractories* v 28 n 3-4 Mar-Apr 1987 p 162-163.

**089347 UNFIRED PERICLASE PLATES FOR STEEL TEEMING LADLE SLIDE GATES.** Because of their low heat resistance fired plates crack after teeming of a single heat and become unsuitable for teeming of a second heat. To eliminate these disadvantages a method for unfired periclase plates with a phosphate binder has been developed. Powdered lignosulfonate is used as the organic plasticizer and inhibitor reducing the rate of interaction of the polyphosphate with MgO and CaO in the stage of preparation of the mixture and the hardening green compact in pressing. To increase the strength of the freshly pressed compact, caustic magnesite powder is also added. 6 refs.

Simonov, K.V. (Magnesite Combine, USSR); Mezentsev, E.P.; Bibaev, V.M. *Refractories* v 28 n 7-8 Jul-Aug 1987 p 451-455.

**089348 ACTIVATED SINTERING OF MgO-CaO SERIES.** The high purity natural MgO-CaO materials, although difficult to sinter, are important lining materials for use in BOF and secondary steelmaking. A study on activated sintering of the MgO-CaO series was carried out with high purity natural carbonates as starting materials. It was found that the densification processes would be practically complete when heating the calcined hydrates at 1400°C. (Edited author abstract) 9 refs.

Li Guangping (Luoyang Inst of Refractories Research, Luoyang, China). *Sci Sintering* v 19 n 3 Sep 1987 p 167-178.

**089349 PERICLASE POWDERS ALLOYED WITH CARBON.** Carbon alloying of various periclase powders in an atmosphere of propane-butane at 800°C (0.5-h soaking) facilitates the incorporation in their composition of up to 4.3% C. During heating in air the carbon from the alloyed powders burns out at 480-840°C. Carbon alloying of periclase powders reduces the hydration degree. 2 refs.

Khoroshavin, L.B. (East Inst of Refractories, USSR); Perepelitsyn, V.A. *Refractories* v 28 n 9-10 Sep-Oct 1987 p 495-498.



**089350 PHASE TRANSFORMATIONS IN PERICLASE-CARBON REFRACTORIES DURING OXIDATION-REDUCTION REACTIONS OF THE COMPONENTS.** Under the conditions of converter steelmaking, the main components of the periclase-carbon refractories, viz., magnesium oxide and carbon, are thermodynamically incompatible. Thus, oxidation-reduction reactions of the oxide (periclase and graphite ash) and the carbonaceous constituents lead to a decrease of the weight content of MgO and to an increased content of the silicates. Reduction of the compounds of iron and silicon contained in periclase and graphite is accompanied by the formation of a condensed metallic iron- and silicon-bearing phase that is sensitive to the changes occurring in the oxidation potential and temperature at the working surface. 14 refs.

Suvorov, S.A. (Lensovet Leningrad Technological Inst, USSR); Denisov, D.E.; Borisov, V.G.; Shapiro, E.Ya.; Kazakov, S.V.; Vezikova, R.M. *Refractories* v 28 n 9-10 Sep-Oct 1987 p 498-504.

**089351 CREEP BEHAVIOUR OF NATURAL DOLOMITIC CARBON-BONDED MAGNESITE BRICKS.** Creep-rate measurements have been carried out on carbon-bonded bricks containing high magnesia synthetic grains or natural dolomitic magnesite clinkers. In spite of the fact that  $\text{Fe}_2\text{O}_3$  is reduced during heating, creep behaviour of bricks containing natural dolomite was found to be comparable to that of bricks containing high purity magnesia synthetic grains. However, the creep behaviour of these carbon-bonded bricks is better than that of fired magnesia bricks. (Edited author abstract) 6 refs.

Allaire, C. (Alcan Int Ltd, Jonquiere, Que, Can); Dallaire, S.; Rigaud, M. *J Can Ceram Soc* v 60 n 4 Dec 1987 p 45-48.

## Manufacture

**089352 MODERNISATION AT REFRATECHNIK.** Refratchnik produces refractory materials, both shaped and unshaped products for the cement, iron and steel and non-ferrous metal industries. The process stages of setting, firing, unloading, palletizing and packaging have been automated. Its main specialization, is in refractory products for the cement industry. 85% of the products are exported to over 70 countries.

Anon. *Refract J* v 62 n 5 Sep-Oct 1987 p 10-14.

## Marketing See Also CERAMIC PLANTS—Reviews.

**089353 REFRACTORY RAW MATERIALS IN 1992.** The refractories industry is one of the most conservative and cautious with respect to changes and innovations, particularly in raw materials. Whereas monolithic specialty refractories will gradually replace shapes in many applications, it is quite probable that in 1992 the major refractory raw materials in the Western World will continue to be bauxite, magnesite, clays/kaolins, and chromite. The proportion of chromite used will likely diminish gradually because of environmental factors. 16 refs.

McCracken, William H. (F&S Alloys and Minerals Corp, Pittsburgh, PA, USA). *Am Ceram Soc Bull* v 67 n 7 Jul 1988 p 1155-1157.

**089354 RAW-MATERIAL IMPACTS ON THE REFRACTORIES INDUSTRY.** The steel industry is the predominant end user of refractories worldwide. Anticipated changes and the foreseen restructuring that certain traditional steel producing regions will undergo, as well as certain trends in steelmaking practices, will thus affect the refractories industry. Trends in consumption of raw materials such as dead-burned magnesia, chromite, and calcined bauxite also will have major impacts on the industry.

Kandianis, Fotis (Possehl Inc, Paramus, NJ, USA). *Am Ceram Soc Bull* v 67 n 7 Jul 1988 p 1158-1160.

## 089355 TRENDS IN THE EUROPEAN REFRAC-

**TORIES INDUSTRY.** The Western European refractories community has problems due to the declining steel industry. However, there are definite opportunities available if refractories companies are prepared to think more in 'money values' and less in 'tonnage volume'.

Longin, Hellmut (Radex-Heraklith Industriebeteiligungs AG, Vienna, Aust). *Am Ceram Soc Bull* v 67 n 7 Jul 1988 p 1161-1162.

**089356 OUTLOOK FOR THE REFRACTORIES INDUSTRY IN JAPAN.** The iron and steel industries are trying to overcome the international competition by improving quality and increasing the ratio of high-value-added products from a technical viewpoint. This industry suffers from excess manufacturing capacity. As a result, overall refractories consumption also has decreased. The number and types of refractories should increase in response to the diversifying needs of users. This will require refractories manufacturers to improve process, evaluation, and quality-control technologies. 16 Refs.

Sakano, Yoshiro (Kawasaki Refractories Co, Hyogo, Jpn); Takahashi. *Am Ceram Soc Bull* v 67 n 7 Jul 1988 p 1164-1175.

**Measurements See DILATOMETERS—Reviews; GLASS FURNACES—Refractory Materials.**

**Mechanical Properties See Also FURNACES, METALLURGICAL—Refractory Materials.**

**089357 EFFECT OF COMPOSITION AND THE AMOUNT OF SPHERICAL-PARTICLE ALUMINOUS FILLERS ON THE DENSITY AND STRENGTH OF CORUNDUM REFRACTORIES.** To find the effect of the batch composition on the compressive strength and density of the composites, a simplex-grid method of experimental planning was used. The calculations were done using a program which we had improved. Mathematical models were obtained in the form of fourth-degree polynomials. It is shown that the strength of the composites is greater the smaller the size of the particles of filler. 2 refs.

Suvorov, S.A. (Lensovet Leningrad Technological Inst, USSR); Kapustina, S.N.; Fishcher, V.N.; Tarnavskaya, I.A. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 77-82.

**089358 ROLE OF STRUCTURE AND CAPACITY FOR ENERGY ABSORPTION IN INCREASING THE STRENGTH AND CRACK RESISTANCE OF REFRACTORY CERAMICS.** The structure of refractory ceramics in the main predetermines their strength. If the technology ensures consistency of density in the material then with an increase in the grain sizes (d, m) of the structure there is a reduction in strength ( $\sigma_{\text{rup}}$ , N/mm<sup>2</sup>). As regards the crack resistance ( $K_{1c}$ , N/mm<sup>3/2</sup>) depending on the characteristics through which it is expressed, the role of grain size in altering  $K_{1c}$  is not always clearly seen. This article analyzes the influence on the magnitude  $\sigma_{\text{rup}}$  and  $K_{1c}$  of the structure made up of grains having irregular size and shapes, and also the structure which possesses the capacity to absorb energy of deformation. It is shown how the characteristics of strength and crack resistance can be predicted and improved. 23 refs.

Prantskyavichyus, G.A. (Acad of Sciences of the Lithuanian SSR, USSR). *Refractories* v 28 n 7-8 Jul-Aug 1987 p 362-368.

**089359 STRUCTURAL-MECHANICAL PROPERTIES OF CORUNDUM BODIES CONTAINING A POROUS FILLER.** The authors studied the structural-mechanical properties of granular corundum bodies in relation to the form, amount of additives consisting of surface active substances, and the type of porous filler. A positive influence on the forming properties of the bodies based on spherical corundum and porous corundum briquet is exerted by the incorporation of technical lignosulfonate. It is advantageous to use 0.05% solution for the spherical corundum and 2% solution for the briquet. An addition of GKZh-11 in amounts of 0.05% is desirable only for bodies based on spherical corundum.

The addition of these agents increases the plasticity of the bodies on account of reducing the internal friction between the particles. 17 refs.

Degtyareva, E.V. (Kharkov Komsomol Automobile Road Inst of the Ukraine, USSR); Sandutsa, T.M. *Refractories* v 28 n 7-8 Jul-Aug 1987 p 430-433.

**089360 INFLUENCE OF THE TYPE OF ALUMINA AND ADDITIVES ON THE PROPERTIES OF CORUNDUM HEAT-INSULATING REFRACTORY.** The authors show the advantage of using as the bonding part of the batch finely milled and unfired alumina grade G-00, and as the filler - unmilled alumina GK. By varying the concentrations and composition of the additives, it is possible to obtain corundum lightweight refractories with densities of 0.75-1.1 g/cm<sup>3</sup> and compressive strengths of 2-10 N/mm<sup>2</sup>. With an increase in the firing temperature the apparent density and strengths increase, and at 1780°C their values come within the range of 1.0-1.35 g/cm<sup>3</sup> and 5-25 N/mm<sup>2</sup>. In order to reduce the after-contraction of the goods fired at 1750°C it is desirable to use  $\text{Cr}_2\text{O}_3$  as additive. To increase the strength after firing at 1780°C MgO should be used. 5 refs.

Degtyareva, E.V. (Kharkov Komsomol Ukraine Automobile Road Inst, USSR); Sandutsa, T.M.; Pisareva, N.V. *Refractories* v 28 n 9-10 Sep-Oct 1987 p 475-478.

**089361 FRACTURE MEASUREMENTS OF REFRACTORIES: PAST, PRESENT, AND FUTURE.** A review of the methods used for testing of refractories is given. The development of the work-of-fracture test and its extensive application to the microstructural design of refractories has been accompanied by an increasing interest in the application of fracture-mechanics techniques to structural ceramics such as SiC, Si<sub>3</sub>N<sub>4</sub>, SiAlON, etc. The successful application of the work-of-fracture test to refractories has led to the application of other types of fracture mechanics test to refractories, too. These tests usually consider the parameter known as the stress intensity in the opening mode. 17 Refs.

Bradt, Richard C. (Univ of Washington, Seattle, WA, USA). *Am Ceram Soc Bull* v 67 n 7 Jul 1988 p 1176-1178.

## Melting

**089362 MEASUREMENT OF THE MELTING POINT OF REFRACTORY MATERIALS BY LASER SURFACE HEATING.** An automated setup for determining the melting point of refractory materials is described. The method involves heating of the surface of a sample mounted in a high-pressure chamber with a laser beam and monitoring the temperature of the heated surface with a two-wavelength pyrometer. The melting and freezing points are then determined, as in conventional thermal analysis, from the plateau in the heating and cooling curves. Results are presented for zirconium and sintered alumina which are in agreement with literature data and thus demonstrate the usefulness of the technique. (Author abstract) 2 refs.

Kirillin, A.V. (USSR Acad of Sciences, Moscow, USSR); Kostanovskii, A.V.; Vinogradov, V.L. *High Temp High Pressures* v 19 n 5 1987 p 473-475.

## Microanalysis See MICROANALYSIS—Applications.

**Microstructure See Also BASIC OXYGEN CONVERTERS—Refractory Materials.**

**089363 SCANNING ELECTRON MICROSCOPY OF INDUSTRIAL LOW-FLUX DOLOMITE REFRACTORY CLINKERS.** Microstructural features of the industrial low-flux dolomite refractory clinkers produced in a coal-fired rotary kiln were investigated by scanning electron microscopy combined with energy-dispersive X-ray spectroscopy. SEM micrographs of polished sections of an unhydrated clinker indicated that the impurity phase, which is located between periclase and lime grains, has a glassy appearance and occasionally contains dicalcium silicate in the form of rods; most of the silicon, aluminium and iron concentrates in the impurity



phase in which CaO content is high and MgO is low. The impurity phase on the surface of the clinkers has a marked effect on the enhancement of hydration resistance. Several microstructural features are reported and discussed. (Author abstract) 2 refs.

Pan, H.C. (China Steel Corp, Kaohsiung, Taiwan); Lo, Y.C. *J Mater Sci* v 22 n 11 Nov 1987 p 4061-4066.

Microstructures See CERAMIC MATERIALS—Fracture.

## Nondestructive Examination

**089364 NONDESTRUCTIVE RADIOWAVE METHOD OF INSPECTION AND ITS ROLE IN INCREASING PRODUCT QUALITY.** This article gives an analysis and a basis for use of nondestructive inspection of refractory part quality by measurement of their dielectric parameters by a radiowave method for evaluation of the effectiveness of functioning of a composite system of product quality control and development of measures for increasing quality. The use of the radiowave nondestructive testing method makes it possible to activate purposeful work on increasing the quality of refractory parts and to accomplish 100% inspection for critical parts. The instruments for making the measurements may be assembled on the module principle from standard general purpose elements and units mass produced by industry. Sometimes it is desirable to develop specialized measuring instruments oriented toward solution of specific and narrower problems of nondestructive and production testing. The production of such specialized inspection instruments may be organized centrally in the subindustry, using a standard element base. 21 refs.

Sloushch, V.G. (All-Union Refractory Inst, USSR). *Refractories* v 28 n 3-4 Mar-Apr 1987 p 158-162.

**089365 DEFECT DETECTION IN REFRACTORIES USING THE RADIATION METHOD.** Radiation methods are useful for detecting hidden defects in refractories (large pores and cavities) with minimum dimensions of 2.5-3% of the size of the article in the direction of radiation. Overpressing and thermal cracks are detected with openings of 0.15 mm or more and a depth of spread of not less than 10-15 mm. The main parameters of radiation methods for checking refractories are the supply voltage to the x-ray tube, the distance from the source of radiation to the test object and the length of the control section. 7 refs.

Nyun'kin, V.V. (All-Union Inst of Refractories, USSR); Rapoport, Yu.M.; Yablonik, L.M. *Refractories* v 28 n 7-8 Jul-Aug 1987 p 425-429.

**089366 NONDESTRUCTIVE ACOUSTIC SONIC METHOD OF INSPECTION FOR CERTIFICATION OF FINISHED REFRACTORY PARTS.** A nondestructive method of inspection of finished refractory parts was developed by the All-Union Institute for Refractories. As a result an interrelationship between resonant frequency and open porosity apparent density, and compressive strength was established. Regression equations were derived for open porosity, apparent density, and compressive strength of types ShKU-13, ShKU-15, ShKU-16, ShKU-38, and ShA-5 ladle parts. Nomograms were constructed. 8 refs.

Nerubashchenko, L.I. (Zaporozhe Industrial Inst, USSR); Buryak, N.R.; Panova, Zh.I.; Pel'tek, Yu.A.; Matsneva, N.V.; Boricheva, V.N.; Senyavin, N.K.; Zelig, G.Ya.; Yudovina, V.B.; Belokrys, G.A.; Sorokina, A.A.; Puzik, L.V. *Refractories* v 28 n 7-8 Jul-Aug 1987 p 456-460.

## Optical Properties

**089367 BIDIRECTIONAL REFLECTING PROPERTIES OF CORUNDUM REFRACTORY.** This article deals with an experimental investigation of the reflecting properties of industrial corundum in the IR spectrum both at room temperatures and when heated to 1500°K with subsequent cooling in air. The spectral relationship with the coefficients of reflection for these materials was

obtained from spectrophotometric measurements. Heating of the specimens was carried out by focusing the thermal radiation of an optical furnace. The chemical composition of the refractories was Al<sub>2</sub>O<sub>3</sub> 97, TiO<sub>2</sub> 1.5, SiO<sub>2</sub> 0.5, Fe<sub>2</sub>O<sub>3</sub> 0.1. 3 refs.

Zapechnikov, V.N. (Moscow Evening Metallurgical Inst, USSR); Pushkin, V.T.; Averkov, E.I.; Zen'kovskii, A.G. *Refractories* v 28 n 9-10 Sep-Oct 1987 p 571-573.

## Oxidation

**089368 APPRAISEMENT OF SiC OXIDATION PROTECTION OF ALUMINA-GRAPHITE REFRACTORIES: II - OXIDATION BETWEEN 1 Atm. AND 10<sup>-10.5</sup> Atm.** Six alumina-graphite samples containing SiC or Si or both were oxidized at 1400°C in O<sub>2</sub>, air or CO-CO<sub>2</sub> mixtures corresponding to oxygen pressures between 1 atm and 10<sup>-10.5</sup> atm and their behavior compared with that of a sample containing no addition. Thermogravimetric and quantitative X-ray diffraction show that if SiC protection is effective at low oxygen pressure, it is because the formation of silica is spatially dissociated from the SiC oxidation. The first stage of the reaction drives off SiO<sub>2</sub> leaving the SiC surface accessible to gas. The same is true for Si. This silica production, first vitreous and then transforming into cristobalite, leads to mullite formation at the corundum grain surface or deep in the alumina formed from the bauxite. Thermodynamic calculations show that a significant equilibrium shift takes place in the oxidation reaction of the silicon carbide and the silicon. (Edited author abstract) 9 refs.

Georges, A. (CNRS, Vandoeuvre les Nancy, Fr); Jeannot, F.; Gleitzer, C.; Tassot, P.; Guenard, C. *Br Ceram Trans J* v 86 n 5 1987 p 146-149.

**089369 MECANISMES D'OXYDATION DES REFRACTAIRES DU TYPE ALUMINE - GRAPHITE - SiC.** [Mechanisms of the Oxidation of Alumina-Graphite-SiC-Type Refractories]. The bricks made of alumina, graphite and SiC (AGS) are used at the present time in the coatings of torpedo for the pig iron treatment and transport. The SiC and silicon additions aim to protect the graphite by delaying its oxidation. The present study has investigated the kinetics and mechanisms of oxidation in an oxidizing atmosphere: air, CO<sub>2</sub>, O<sub>2</sub> and oxido-reducing: CO-CO<sub>2</sub> mixtures with 25 to 90% CO, for 6 different brick samples from 3 suppliers. A comparison of the products shows the following: from the binding material pyrolysis, one quality stands out with a less reactive carbon; the corundum-based refractories behave better toward oxidation than the bauxite-based ones; and silicon is not the most determinant component as regards the corrosion by gases; the origin (and hence the nature and characteristics) of SiC is preponderant, at least up to 1400°C; one sample is, in all departments, better than the other, and this has been confirmed during industrial use. (Edited author abstract) 8 refs. In French.

Georges, Annick (CNRS, Nancy, Fr); Gleitzer, Charles; Guenard, Claude; Tassot, Patrick. *Cah Inf Tech Rev Metall* v 85 n 2 Feb 1988 p 153-164.

Ozonization See ORGANIC COMPOUNDS—Ozonization.

Performance See Also AEROSPACE VEHICLES—Materials; DIE CASTING—Energy Conservation; GLASS FURNACES—Thermal Insulation.

**089370 SERVICE OF REFRACTORIES IN THE LINING OF A BATCH VACUUM TREATMENT UNIT IN TREATMENT OF CHROMIUM STEELS.** Vacuum treatment was used for ladle treatment of chromium steels melted in 100-ton electric arc furnaces with subsequent pouring on a continuous casting machine. To determine the features of service of the refractories of a vacuum treatment unit, about 600 heats were analyzed. The limits of the variations in the temperature of the steel before and after its treatment in the vacuum treatment unit and also the times and numbers of cycles of vacuum treatment were determined. The results are presented. 7

refs.

Chirikhin, V.F. (Orsk-Khalilovo Metallurgical Combine, USSR); Soldatchenko, N.N.; Sorokolet, G.P.; Borisovskii, E.S.; Sokolov, A.N.; Kvyatkovskii, O.V.; Krivko, V.A. *Refractories* v 28 n 5-6 May-Jun 1987 p 343-347.

## Phase Diagrams

**089371 PHASE DIAGRAM OF THE CaAl<sub>2</sub>O<sub>4</sub>-CaCrO<sub>4</sub>-CaAl<sub>4</sub>O<sub>7</sub> PSEUDOSYSTEM.** The authors conducted laboratory experiments in order to study the melting points of the compositions existing in the CaAl<sub>2</sub>O<sub>4</sub>-CaCrO<sub>4</sub>-CaAl<sub>4</sub>O<sub>7</sub> triangle. Mixtures were fired at the maximum temperature of 1600°C. The melting point and the phase composition of the frits were determined after firing. The phase diagram was also computed using regression analysis. 8 refs.

Mel'nik, M.T. (Kharkov Inst of Civil Engineers, USSR); Doronin, E.V. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 27-28.

Physical Properties See Also GLASS FURNACES—Refractory Materials.

**089372 REFRACTORIES HfC AND HfN - A SURVEY. III: CEMENTED CARBIDES AND COATINGS.** In the first part of this study the physical properties of the refractories HfC and HfN were summarized from data given in the literature. The second part of the study was extended to cover their phase relationships with other carbides and nitrides of the Groups IV to VI, while the third part published in this issue deals with their use in cemented carbides and as hard coatings. The most important development was the addition of TiC to allow cutting speeds to be raised. This was followed by the addition of TaC. In parallel with alloying development in cemented carbides, much work has been done to reduce both the grain size and the residual porosity as they affect toughness and also the wear resistance. (Author abstract)

Perry, A.J. (GTE Valerou Corp, Troy, MI, USA). *Powder Metall Int* v 19 n 6 Nov 1987 p 17-19.

**089373 APPARATUS FOR DETERMINING THE THERMOPHYSICAL CHARACTERISTICS OF REFRACTORIES BASED ON AUTOMATIC PROCESSING OF THE EXPERIMENTAL RESULTS.** Two methods are commonly employed for determining the thermophysical properties of refractories: the stationary (steady-state) method using a plate specimen and the nonstationary method using a heated wire. However, certain inherent shortcomings restrict the field of their application. It is possible to overcome these shortcomings using the method of constant power source that was developed at the Laboratory of Heat Physics, Institute of Applied Physics, Academy of Sciences of the Belorussian SSR. The method involves specimen heating using a flat heating element supplied with a constant electrical power and recording the temperature changes in the zone of the heating element and in the specimen at a specified distance from the heating element. The advantages of this method include simplicity in assigning the boundary conditions, completeness of determining the thermophysical properties, and the possibility of carrying out the measurements without a standard (reference) specimen. The signals of the differential thermocouples are amplified transformed into binary-decimal code by the analog-to-digital converter. The input device accomplishes communication of the analog-to-digital converter with the microcalculator and controls the operation of the microcalculator. 8 refs.

Shashkov, A.G. (Acad of Sciences of the Belorussian SSR, USSR); Voitenko, A.G. *Refractories* v 28 n 5-6 May-Jun 1987 p 250-255.

Porosity See POROUS MATERIALS.

Processing See CERAMIC MATERIALS—Injection Molding; SILICA—Fused.



## Protective Coatings

**089374 STUDY OF PROTECTIVE PLASMA COATINGS.** One method of improving the service life of refractories is to employ protective coatings that are capable of improving their corrosion and erosion resistance. In this work, plasma coatings were sprayed onto substrates made from chamotte, periclase, corundum, graphite, and quartz glass. Electrocorundum, a mixture of corundum and quartz glass, a mixture of corundum and zirconium dioxide, and zirconium dioxide (fused, calcium oxide stabilized) were used as coatings. Plasma coating of the specimens improves some important service characteristics such as slag resistance and gas permeability. 5 refs.

Sherstnev, A.A. (North-Western Correspondence Polytechnic Inst, USSR); Gaenko, N.S.; Savel'chikova, I.L.; Mel'nikova, G.G.; Borovskii, Yu.F. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 59-62.

**089375 CHEMICAL AND MINERALOGICAL EXAMINATION OF A  $4\text{Cr}_2\text{O}_3\cdot\text{MgO}$  COATING APPLIED TO A BLOATING FIRECLAY BRICK.** A basic oxide coating has been applied to the working face of a bloating fireclay ladle brick to increase chemical resistance to a basic steelmaking slag. The expansion characteristics of various  $\text{Cr}_2\text{O}_3$  and  $\text{MgO}$  coating mixtures have been measured with a 4:1 molar ratio  $\text{Cr}_2\text{O}_3$  to  $\text{MgO}$  being most compatible with the refractory over 25-1450°C. Evidence of a reaction to form a chromium-rich layer is presented and associated mineralogical changes in the parent refractory are described. It is postulated that this increase in basicity should reduce refractory corrosion at the slag-refractory-gas interface. (Author abstract) 18 refs.

Caley, W.F. (Technical Univ of Nova Scotia, Halifax, NS, USA); Kanary, L.E.; Clarke, D.B. *Can Metall Q* v 26 n 3 Jul-Sep 1987 p 259-264.

**089376 EROSION-CORROSION RESISTANT COATINGS FOR COAL-FIRED BOILER TUBES I: MATERIALS SELECTION AND EVALUATION.** A series of refractory paints, enamels, glasses, glass ceramics, and commercial refractory cements and mortars were tested as potential coating materials for the protection of tubes in coal-fired boilers. Coatings deposited on typical boiler tube steels by brushing or spraying were subjected to firing procedures which simulate conditions in a coal-fired boiler, and evaluated in terms of adhesion, shock resistance and expansion during thermal cycling, and of their resistance to particulate erosion. (Edited author abstract) 28 refs.

King, H.W. (Technical Univ of Nova Scotia, Halifax, NS, Can); Murphy, J.G. *J Can Ceram Soc* v 60 n 4 Dec 1987 p 13-20.

**089377 EROSION-CORROSION RESISTANT COATINGS FOR COAL-FIRED BOILER TUBES II: PERFORMANCE TESTS OF THERMAL EXPANSION MATCHED COATINGS.** Mixtures of refractory mortars and cements with thermal expansion coefficients which closely match those of ferritic boiler tube steels have been identified as potential materials for erosion-corrosion protection coatings for coal-fired boiler tubes. Coatings of these materials, in both the fired and unfired conditions, were exposed to flue gas entrained fly ash for 200 h in a coal-fired utility boiler and subsequently evaluated with respect to surface condition and adherence. (Edited author abstract) 9 refs.

Murphy, J.G. (Technical Univ of Nova Scotia, Halifax, NS, Can); King, H.W.; Mayer, P. *J Can Ceram Soc* v 60 n 4 Dec 1987 p 21-25.

**Quality Assurance** See STEELMAKING—Ladle Process.

## Quality Control

**089378 PROCEDURE OF MEASURING THE WEIGHT CONTENT OF THE LEANING AGENT IN THE CHARGE BY ELUTRIATION.** The quality of refractory products and materials is determined to a large

extent by quality control of technological processes, in particular, by the accuracy of dosing the initial components. In collaboration with the Boganovich Refractories Plant, the Vostochnyi Institute of Refractories (VostIO) developed a method of conducting measurements concerning the weight content of the leaning agent in the charge (in the 50-90% range) according to the elutriation method. 1 ref.

Presnova, V.G. (Vostochnyi Inst of Refractories, USSR); Kuzevanova, G.I.; Subbotina, V.G.; Ustyugov, N.V. *Refractories* v 28 n 7-8 Jul-Aug 1987 p 444-445.

**Redox** See GLASS FURNACES—Refractory Materials.

## Research

**089379 APPLICATION OF REFRACTORIES: A COLLECTION OF PAPERS PRESENTED AT THE 89TH ANNUAL MEETING OF THE REFRACTORIES DIVISION.** This proceedings contains 16 papers on the main subject of the refractory materials. Main topics discussed are: alumina refractories performance; corrosion resistance of refractories, especially against molten glass attacks; refractories in the process of aluminum metallurgy; kiln lining; steel ladle lining; quality assurance and control in production of refractory materials. Also, the process control and personnel training for application of statistical methods in process and quality control are discussed. Technical and professional papers from this conference are indexed and abstracted from the conference code no. 11016 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. (American Ceramic Soc, Refractories Div, Westerville, OH, USA). *Ceram Eng Sci Proc* Jan-Feb 1988, Appl of Refract: A Coll of Pap Presented at the 89th Annu Meet of the Refract Div, Pittsburgh, PA, USA, Apr 27-29 1987. Publ by American Ceramic Soc Inc, Westerville, OH, USA, 1988 157p.

**Reviews** See Also FOUNDRY PRACTICE—Refractory Materials.

**089380 ANDALUSITE.** Andalusite is a member of the sillimanite group of minerals which comprise andalusite, sillimanite and kyanite. All three minerals have the same chemical composition ( $\text{Al}_2\text{O}_3\cdot\text{SiO}_2$ ) but possess different crystal structures and differ slightly in their physical properties. In this contributed article the author examines the properties, occurrence, production and markets for andalusite.

Anon. *Min Mag* v 158 n 5 May 1988 p 417, 419-420.

**Selection** See FURNACES, METALLURGICAL—Refractory Materials.

## Separation

**089381 SEPARATION OF SECONDARY REFRACTORIES BY TYPE BY RADIORESONANCE AND X-RAY RADIOMETRIC METHODS.** An analysis of the results obtained shows that in both cases the periclase-chromite variety differs significantly (by four or five times) in the analytical parameter, which is related to the Ti and Cr content, from the other types and therefore in x-ray radiometric separation may be separated from aluminosilicate and periclase refractory scrap. Aluminosilicate and periclase secondary refractories of a different degree of change differ weakly in the analytical parameters for Cr, Fe, and other combinations of elements other than Ti. For the latter the difference is about three times, which is insufficient for reliable separation since with the use of algorithms in the spectrometric variation on the prototype separator the energy area of recording of the characteristic x-ray radiation of titanium must be increased. This will lead to leveling of the difference between the analytical parameters of aluminosilicate and periclase secondary refractories for titanium and as the result to the impossibility of sorting. Therefore x-ray radiometric separation is of practical interest only as a method of separation of the periclase chromite variety of refractories. 4 refs.

Baranovskii, N.I. (Ural Scientific-Research & Design Inst for Beneficiation & Mechanical Working of Minerals, USSR); Rogozina, V.G.; Bortnikova, N.V.; Koronchevskii, A.V.; Trufanov, A.M.; Fedorov, Yu.O. *Refractories* v 28 n 3-4 Mar-Apr 1987 p 217-220.

**Service Life** See BASIC OXYGEN CONVERTERS—Refractory Materials; BLAST FURNACES—Refractory Materials; COKE OVENS—Refractory Materials; GLASS FURNACES—Refractory Materials; KILNS—Lining.

## Silica Brick

**089382 SPECTRAL REFLECTING CHARACTERISTICS OF DINAS REFRACTORY.** In this work an investigation was made of vitreous dinas produced by the Pervouralsk Dinas Plant. The chemical composition of the dinas (wt.%) was 93.0  $\text{SiO}_2$ , 3.5 CaO, and 3.5  $\text{Al}_2\text{O}_3$  and the open porosity 22%. Refractories in the as-received condition and also after 6 months of service in a glass melting furnace were investigated. Experiments were made on determination of the angular distribution of the intensity of the reflected radiation. 4 refs.

Zapechnikov, V.N. (Moscow Evening Metallurgical Inst, USSR); Pushkin, V.T.; Zen'kovskii, A.G. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 92-94.

**089383 STATISTICAL DATA ON THERMAL EXPANSION IN DINAS REFRACTORIES FOR COKING OVENS.** Statistical data have been obtained on the temperature dependence of the thermal expansion for dinas refractories for coking ovens in the range from 20 to 1400°C. The temperature coefficient of linear expansion does not vary monotonically as the temperature rises and has peaks near the temperatures of the phase transformations in tridymite, cristobalite, and quartz. The thermal expansion curves for dinas brick show hysteresis due to the phase transitions in silica. 3 refs.

Vishnevskii, I.I. (Ukrainian Refractories Research Inst, USSR); Shapovalov, V.S. *Refractories* v 28 n 5-6 May-Jun 1987 p 265-269.

**089384 EFFECT OF PYROPHYLLITE ON THE PROPERTIES OF DINAS.** This article contains the results of research into the effects of pyrophyllite on the properties of dinas refractories and is aimed at studying the possibility of extending the reserves of quartzite raw materials for their production. Pyrophyllite  $3\text{Al}_2\text{O}_3\cdot 4\text{SiO}_2\cdot 2\text{H}_2\text{O}$  belongs to the micaceous group of materials. Its chemical composition,  $\text{Al}_2\text{O}_3$  28.3,  $\text{SiO}_2$  66.7,  $\text{H}_2\text{O}$  5.0. Impurities are encountered as  $\text{MgO}$  (up to 5%),  $\text{Fe}_2\text{O}_3$ , CaO, alkalis, and titania. Specimens of dinas with additions of only pyrophyllitic slates have a compressive strength of 9-12.2 N/mm<sup>2</sup> and open porosity of 23-23.5% with additions of quartz-pyrophyllitic slate 11.6-13.5 N/mm<sup>2</sup> and 23.1-23.5%. The conversion of the quartzite is moderate - the density of the dinas is 2.38-2.41 g/cm<sup>3</sup>. 9 refs.

Turchinova, L.N. (Ukrainian Scientific Research Inst of Refractories, USSR); Bulakh, V.L.; Romanenko, S.N.; Pyatikop, P.D.; Kushchenko, A.V. *Refractories* v 28 n 7-8 Jul-Aug 1987 p 368-373.

**Silicon Nitride** See CERAMIC MATERIALS—Silicon Nitride.

**Sintering** See Also CERAMIC MATERIALS—Porosity; MAGNESIUM COMPOUNDS—Additives; POWDER METALLURGY—Sintering.

**089385 EFFECT OF ATMOSPHERE ON THE SINTERING PROCESS OF THE MIXTURES OF CAUSTIC MAGNESITE AND CHROMIUM ORE.** In the high temperature state, the mixtures of the experimental composition are represented by a solid solution of chromium spinellid in periclase (in CO atmosphere as well as in air). Air cooling of the frits is accompanied by the isolation (precipitation) of a secondary spinellid and the transformation  $\text{FeO} \rightarrow \text{Fe}_2\text{O}_3$ , which does not virtually occur in CO atmosphere. When heated in CO atmosphere,



the sinterability of the experimental mixtures is inferior to that observed when heated in air; in this case, some depletion of magnesium and chromium oxides occurs due to their sublimation. 8 refs.

Romanovskii, L.B. (L.I. Brezhnev Dnepropetrovsk Metallurgical Inst, USSR); Terekhin, V.A.; Krivusha, L.V.; Koren, L.N. *Refractories* v 28 n 3-4 Mar-Apr 1987 p 127-132.

**089386 INVESTIGATING THE MAGNESIUM OXIDE SINTERING PROCESS.** The casual relationship between the densification of magnesium-oxide compacts and the elimination of pores during isothermal sintering at various temperatures on the one hand and the shaping pressure applied in the preparation of compacts and the duration of isothermal sintering on the other, were investigated. The densities of the various sintered specimens were determined, and micrographs were obtained. The process of densification undergone by magnesium oxide specimens during sintering was approximated by a polynomial expression. In German and English. 8 refs.

Petric, N. (Technoloski Fakultat, Split, Yugosl); Petric, B.; Mirosevic-Anzulovic, M.; Bogdanic, N. *CFI Ceram Forum Int Ber DKG* v 65 n 1-2 Jan-Feb 1988 p 7-10.

**089387 SINTERING OF  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  COMPOUNDS.** Heating of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  compacts above about 930°C is shown to induce liquid formation. Presence of the liquid phase results in excellent densification, but limited superconducting properties. Sintering below 930°C occurs primarily by solid-state diffusion. Although the density of these samples is low, the superconducting properties are similar to those of the dense materials produced via liquid-phase sintering. The highest current densities ( $\approx 500 \text{ A/cm}^2$ ) have been obtained in these solid-state sintered samples. (Author abstract) 11 refs.

Shi, D. (Argonne Natl Lab, Argonne, IL, USA); Capone, D.W. II; Goudey, G.T.; Singh, J.P.; Zaluzec, N.J.; Goretti, K.C. *Mater Lett* v 6 n 7 Apr 1988 p 217-221.

## Solidification

**089388 DIRECTIONALLY SOLIDIFIED STRUCTURE OF  $\text{MgO-ZrO}_2\text{-X(X: Ca, Y, Al, Si)}$  EUTECTICS.** Directionally solidified structure of  $\text{MgO-ZrO}_2$  eutectic with small amounts of additives ( $\text{CaO}$ ,  $\text{Y}_2\text{O}_3$ ,  $\text{Al}_2\text{O}_3$  and  $\text{SiO}_2$ ) has been investigated. The oriented microstructure with lamellar and fibrous morphologies has been obtained in the case of  $\text{CaO}$  and  $\text{Y}_2\text{O}_3$  additions, in which the additives can be dissolved in the  $\text{ZrO}_2$  matrix. On the other hand, the cell boundaries have been developed with a small amount of  $\text{Al}_2\text{O}_3$  and  $\text{SiO}_2$ . In the case of  $\text{SiO}_2$  addition, the precipitation of  $\text{Mg}_2\text{SiO}_4$  has been observed at the  $\text{MgO/ZrO}_2$  interface. It nucleates coherently at the  $\text{MgO}$  side of the interface in the early stage of precipitation. This results from the small solubility of the additives in  $\text{MgO}$ . (Author abstract). 19 Refs. In Japanese.

Echigoya, Jun-ichi (Tohoku Univ, Sendai, Jpn); Suto, Hajime. *Nippon Kinzoku Gakkaishi* v 52 n 6 Jun 1988 p 595-602.

## Spectroscopic Analysis

**089389 APPLICATION OF THE METHOD OF ATOMIC ABSORPTION FOR ANALYZING NON-FERROUS METALS IN REFRACTORIES AFTER SERVICE IN THE FURNACES OF NONFERROUS METALLURGY.** Copper, cobalt, and nickel are present in insignificant amounts (0.01-0.1%) in the raw materials used for producing refractories. In view of this, nonferrous metals appear in refractories mainly due to the interaction of the melt with the lining. As compared to chemical methods, the developed methods of atomic absorption analysis of nonferrous metals are selective, rapid, less laborious, and avoid the necessity of using platinum crucibles. 5 refs.

Ushakova, T.G. (Vostochnyi Inst of Refractories, USSR); Lapteva, T.N. *Refractories* v 28 n 9-10 Sep-Oct 1987 p 504-507.

**Stability** See TUNGSTEN AND ALLOYS—Stability.

**Stresses** See Also BASIC OXYGEN CONVERTERS—Refractory Materials.

**089390 INTERNAL STRESSES OF REFRACTORY BODIES AND THE METHODS OF THEIR CONTROL.** Internal stresses develop during drying and heating of concrete lined thermal units of the selected regime of increasing the temperature is incorrect. These stresses can lead to sudden brittle fracture of the refractories, disarrangement of their structure, chipped surfaces, cracks, etc. Nondestructive control methods (NCM) and analytical methods are used to obtain information on the characteristics of the material and on the changes occurring due to the internal stresses. We conducted studies on the heat resistant concretes using a 2.5 MHz integrated direct emitter of a UDM-IM defectoscope as a finder head. During the process of ultrasonic sounding, the error did not exceed 0.15%. The nondestructive methods of studying the internal stresses and the theoretical concepts of reliability make it possible to evaluate the quality of the structures. 3 refs.

Boruk'ko, V.I. (Dnepropetrovsk Civil Engineering Inst, USSR); Mustafin, Yu.I.; Shpir'ko, N.V.; Gannik, N.I. *Refractories* v 28 n 5-6 May-Jun 1987 p 256-257.

## Synthesis

**089391 EFFECT OF PRESSURE ON THE ATOMIC STRUCTURE OF ULTRADISPERSED TITANIUM NITRIDE.** It is established that at pressures up to 7.7 GPa the structure type, lattice period and composition of ultradispersed titanium nitride do not undergo significant changes during pressing. Noting a slight increase in the rms displacements of the atoms, quantitative data are obtained by harmonic analysis of the shapes of the neutron-diffraction lines concerning an increase in the microdistortions of the lattice and a decrease in the size of the coherent scattering regions in pressed TiN powders during an increase in the pressing pressure. In Russian. 7 refs.

Petrutina, V.F.; Andreev, Yu.G.; Kuzenkova, M.A.; Bozhko, S.A.; Zelenyuk, F.M.; Miller, T.N.; Grabis, Ya.P. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 4 Apr 1987 p 575-580.

**089392 SYNTHESIS OF CORDIERITE FROM NATURAL MATERIALS IN THE PRESENCE OF  $\text{Al}_2\text{O}_3$ -CONTAINING COMPONENTS.** The authors examined some reactions in the synthesis of cordierite from natural materials and alumina. The volume changes occurring during these reactions, the yield of cordierite, and the value of the Gibbs free energy have been calculated. The most favorable method under industrial conditions is to synthesize cordierite from a mixture of talc, kaolin and alumina. The phase composition of the cordierite sinters based on these materials has been studied. The synthesis can be done in the presence of  $\text{Al}_2\text{O}_3$ -containing components on condition that the firing temperature does not exceed 1659°K when the sintering is effected in parallel. 8 refs.

Zobina, L.D. (V.I. Lenin Kharkov Polytechnic Inst, USSR); Semchenko, G.D.; Tarnopol'skaya, R.A.; Belik, Ya.G.; Kharitonov, F.Ya.; Rudnitskaya, V.P. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 82-84.

**089393 SYNTHESIS OF  $\text{WO}_3$  WHISKER CRYSTALS BY PYROHYDROLYSIS OF  $\text{WF}_6$ .** Filamentary  $\text{WO}_3$  single crystals up to 50 mm in length have been obtained from the reaction between water vapor and  $\text{WF}_6$  emanating from a Teflon-like material saturated with this compound. A study was made of the effect of the synthesis conditions on the growth rate and yield of the single crystals. A probable model of the process is proposed which allows for plugging of the pores in the bulk of the Teflon-like material, cyclical expulsion of the plugs formed, and their accretion. 9 refs. In Russian.

Rakov, E.G.; Teslenko, V.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 5 May 1987 p 802-806.

**089394 PHASE COMPOSITION OF THE PRODUCTS FORMING DURING AN ELECTRIC EXPLOSION OF MIXTURES OF NIOBIUM AND CARBON.** It is established that during an electric explosion of mixtures of niobium powder (containing 0.12 wt.% H) and graphite powder in water, multiphase products including  $\text{NbC}_x\text{O}_y$ ,  $\text{Nb}_2\text{C}_x\text{O}_y$ ,  $\text{NbO}$ ,  $\text{NbO}_2$ ,  $\text{Nb}_2\text{O}_5$ , Nb and C are formed. With an increase in the carbon concentration in the mixture the total quantity of oxycarbide phases in the product increases, while that of the oxide phases decreases. Moreover, the lattice periods of the oxycarbides obtained increase, which indicates an increase in their carbon concentration. 13 refs. In Russian.

Pavlov, I.E. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 927-931.

**089395 SYNTHESIS OF HIGH TEMPERATURE MATERIALS BY SELF-PROPAGATING COMBUSTION METHODS.** Highly exothermic reactions can become self-sustaining and will propagate through the reactant mixture in the form of a combustion wave. As the combustion wave advances, the reactants are converted to the product(s). The use of such reactions to prepare materials has been commonly referred to as the self-propagating high temperature synthesis (SHS) method. Combustion synthesis is claimed to produce materials with superior properties relative to those prepared by conventional methods. 90 refs.

Munir, Zuhair A. (Univ of California, Davis, CA, USA). *Am Ceram Soc Bull* v 67 n 2 Feb 1988 p 342-349.

**089396 SOLID-STATE COMBUSTION SYNTHESIS OF CERAMICS AND ALLOYS IN REDUCED GRAVITY.** Possible microgravity effects are explored in the combustion synthesis of ceramics and alloys from their constituent elements. Molten intermediates are typically present during the combustion process, thereby offering the chance for natural convection to take place. Numerical simulations suggest that the combustion front in concert with gravity may act as a partial zone-refinement mechanism which is attempting to sweep out porosity in the sample. Contrary to suggestions by dimensional analysis, no effects on the combustion rate are seen. An analytical model of the combustion velocity as a function of the gravitational field and the spreading rate of molten material gives the correct order of magnitude of the gravity effect as measured by centrifuge experiments. (Author abstract). 41 Refs.

Valone, S.M. (Los Alamos Natl Lab, Los Alamos, NM, USA); Behrens, R.G. *NASA Contract Rep* n 4163 Jul 1988 84p.

**Temperature Measurement** See CEMENT PLANTS—Kilns.

**Testing** See Also KILNS—Rotary.

**089397 ERFAHRUNGEN BEIM EINSATZ EINES ULTRAMIKROHARTTESTERS ZUR PRUEFUNG VON DUENNEN HARTSTOFFSCHICHTEN.** [Experiences in the Hardness Testing of Thin Refractory Coatings using an Ultramicrohardness Tester]. Hardness testing of thin refractory coatings imposes serves demands on sample preparation, the measurement device and the measurement procedures. This paper reports on ultralow-load hardness testing of thin TiN, HfN, and NbN coatings (1-3  $\mu\text{m}$ , rf magnetron sputtered, high-speed steel substrates) by means of an ultramicrohardness tester mounted in a scanning electron microscope. The determination of true coating hardness without interference of the substrate is offset by a relatively large systematic error, mainly due to the difficulties in determining the indentation diagonals in the region of 1  $\mu\text{m}$ . Microhardness measurements were performed for comparison. 4 refs. In German and English.

Kuehnemann, Sabine (Max-Planck-Inst fuer Metallforschung, Stuttgart, West Ger); Kopacz, Uwe; Jehn, Hermann. *Prakt Metallogr* v 24 n 8 Aug 1987 p 382-390.



**089398 EVALUATING THE BEHAVIOR OF SOME TYPES OF CERAMICS DURING TESTING IN A STREAM OF HIGH-TEMPERATURE GAS.** The article presents the results of determining the resistance to frequent heatings of materials having a dense structure and which are based on high-alumina ceramics. We established the capacity of a range of ceramics to withstand high rates of thermal stress (frequent heating). Thus, the spalling-resistant quartz ceramics and aluminum titanate can withstand repeated frequent heating to temperatures above 1400°C, practically close to their fusing temperatures. Nonspalling-resistant materials based on corundum and mullite chamotte withstand frequent heating to much lower temperatures (up to 1200°C). Incorporating into the corundum of zircon and aluminum titanate increases the resistance to frequent heating at higher temperatures (1500°C and above). The increase in the content of  $Al_2O_3$  in the mullite chamotte increases its capacity for frequent heating. 12 refs.

Baranova, T.F.; Anufriev, A.V.; Pen'kov, I.I.; Kelin, Yu.I. *Refractories* v 28 n 5-6 May-Jun 1987 p 317-320.

### Thermal Conductivity

**089399 DIE EIGENSCHAFTEN GESCHAEUMTER FEUERLEICHTSTEINE: MESSUNG UND BERECHNUNG DER WAERMELEITFAEHIGKEIT.** [Properties of Lightweight Foamed Refractories: Measurement and Computation of Thermal Conductivity]. A number of theories are known for the computation of thermal conductivity. Starting from samples of quartz-containing materials, silica and corundum with varying porosity, measurements were carried out which were then compared to computations based on various theoretical models. The theory developed by Ondracek proved to be the only applicable one in case of lightweight foamed refractories. The paper discusses this fact, taking into account the influence of radiation. In German. 14 refs.

Hennicke, H.W. (TU Clausthal-Zellerfeld, West Ger); Jeschke, P.; Neuenburg, M. *Keram Z* v 39 n 9 Sep 1987 p 602-604, 607-609.

**089400 VERGLEICHENDE BEURTEILUNG VON WAERMELEITFAEHIGKEITSDATEN.** [Comparative Assessment of Data for Thermal Conductivity]. Thermal conductivity is an important identification figure for the user of refractories. Mainly three different methods of measurement are applied for its determination. It is stated that very often the circulating data of thermal conductivity differ largely from the measured values. Likewise there are discrepancies between the measured values of the ASTM- and the hot-wired-method. The manufacturers of refractories are recommended to check their tables and to change to measured values. (Author abstract) In German.

Kroenert, W. (RWTH Aachen, Aachen, West Ger). *Keram Z* v 39 n 10 Oct 1987 p 691-694.

**089401 VERGLEICHENDE BEURTEILUNG VON WAERMELEITFAEHIGKEITSDATEN.** [Comparative Assessment of Data for Thermal Conductivity]. Thermal conductivity is an important identification figure for the user of refractories. Mainly three different methods of measurement are applied for its determination. It is stated that very often the circulating data of thermal conductivity differ largely from the measured values. Likewise there are discrepancies between the measured values of the ASTM- and the hot-wire-method. The manufacturers of refractories are recommended to check their tables and to change to measured values. (Author abstract) 19 refs. In German.

Kroenert, W. (RWTH Aachen, Aachen, West Ger). *Keram Z* v 39 n 8 Aug 1987 p 773-779.

**089402 THERMAL CONDUCTIVITY OF MONOLITHIC REFRACTORIES.** Thermal conductivities of various refractory castables were measured using various test methods and were compared with the manufacturers' data. A computer-driven comparative unit that measures

'K' by matching it against known standards appears to produce the most consistent data. A simple approach that uses hot- and cold-face temperatures to calculate K is outlined. This method requires very little equipment and effort and produces results that agree with those of sophisticated apparatus. (Author abstract). 16 Refs.

Crowley, Michael S. (Amoco Corp, Naperville, IL, USA); Young, Jack S. *Am Ceram Soc Bull* v 67 n 7 Jul 1988 p 1196-1200.

### Thermal Expansion

**089403 CONSIDERATIONS ON SOME THERMAL APPLICATIONS FOR CORDIERITE AND CORDIERITE-MULLITE MATERIALS.** The extrusion of cordierite ceramic monolithic supports for automobile exhaust catalysis involves extreme shaping conditions that lead to heavily directional microstructural properties. Observations made on extruded cordierite-mullite kiln furniture during fast firing indicate the transferability of microstructural characteristics. What proves to be of advantage in the first case must be viewed as a cause of premature failure in the second. An explanation is offered for the occurrence of anisotropic expansion behavior and its subsidence as a result of thermal after treatment. In German and English. 11 refs.

Rasch, H. (Fachhochschule Rheinland-Pfalz/Koblenz, Hoehr-Grenzhausen, West Ger). *CFI Ceram Forum Int Ber DKG* v 64 n 11-12 Nov-Dec 1987 p 454-458.

**089404 THERMAL SHOCK RESISTANCE STUDY OF SIX REFRACTORIES.** Results of an investigation to correlate the thermal shock resistance of six commercial refractory bricks with their thermal diffusivity and thermal expansion are presented. In the present study only one brick broke in thermal quenches from 550°C. For the others the thermal shock resistance was evaluated by measuring the strength loss in quenches from various temperature levels. (Edited author abstract) 12 refs.

Mirkovich, V.V. (CANMET, Ottawa, Ont, Can); Bell, K.E. *J Can Ceram Soc* v 60 n 4 Dec 1987 p 49-53.

**089405 EFFECT OF ANISOTROPIC THERMAL EXPANSION ON THE STRENGTH OF PHOSPHATE-BONDED  $Al_2O_3$  BICRYSTALS.** Alumina bicrystals were produced using sodium metaphosphate as the bonding agent. The room-temperature tensile strengths of bicrystals containing no crystallographic mismatch, or controlled amounts of twist, tilt, and combinations of twist and tilt mismatch were determined. These results indicated that the strength of the bicrystal grain boundaries decreased as the amount of residual stress present increased. (Edited author abstract). 9 Refs.

Soltani, Morteza (Georgia Inst of Technology, Atlanta, GA, USA); Benzel, James F. *Am Ceram Soc Bull* v 67 n 7 Jul 1988 p 1211-1216.

**089406 SECONDARY EXPANSION OF MULLITE REFRACTORIES CONTAINING CALCINED BAUXITE AND CALCINED CLAY.** The kinetics of the secondary expansion of a 72 percent-alumina aluminosilicate refractory, containing either calcined bauxite and calcined clay or tabular alumina and calcined clay, were studied as a function of time, temperature, and particle size. Rapid heating of specimens to isothermal reheating temperatures, followed by rapid cooling, was used to minimize heating and cooling effects. Mullitization, accompanied by volume expansion, occurred during the isothermal reheating of the specimens containing calcined bauxite. (Edited author abstract). 8 Refs.

Huang, Bai Y. (Iowa State Univ, Ames, IA, USA); Mcgee, Thomas D. *Am Ceram Soc Bull* v 67 n 7 Jul 1988 p 1235-1238.

**Thermal Properties.** See Also CERAMIC MATERIALS—Applications; FURNACES, METALLURGICAL—Heat Transfer; LADLES—Lining.

**089407 CRACK RESISTANCE OF CORUNDUM REFRACTORIES OVER A WIDE RANGE OF TEM-**

**PERATURES.** In this paper, authors studied the effect of temperature on the parameter  $K_{IC}$  and the value of  $K_I$  of a group of corundum refractories having different structures. The ultimate bend strength  $\sigma_{bnd}$  and the critical stress intensity factor  $K_{IC}$  of a group of corundum refractories were determined over a wide range of temperatures. It was shown that the temperature dependences of  $\sigma_{bnd}$  and  $K_{IC}$  have a similar nature. In the refractories having the usual porous structure, the rate of decrease of  $K_{IC}$  with increasing temperature is less than that of  $\sigma_{bnd}$ . Owing to this, the coefficient of crack resistance  $K_I$  of the refractories increases at high temperatures. The refractories having a porous-fissured structure, exhibit an almost identical reduction of  $\sigma_{bnd}$  and  $K_{IC}$  with increasing temperature and the magnitude of  $K_I$  increases very insignificantly. 5 refs.

Peras, A.Ya. (Acad of Sciences of the Lithuanian SSR, USSR); Yuzapavichyus, A.D.; Karaseva, M.D. *Refractories* v 28 n 3-4 Mar-Apr 1987 p 124-127.

**089408 SUSPENDED REFRACTORY STRUCTURES.** This paper reviews briefly some aspects of refractories engineering, with special reference to suspended refractory structures of both brick and monolithic materials. The very latest developments, however, in suspended refractory materials incorporate the advantages of low thermal mass (LTM) and monolithic format. As in the case of dense refractories there are indications that the monolithic format is growing extremely fast. This is because of the relatively easier, cheaper installation combined with better mechanical properties and longer life. Some very advanced engineering has produced some extremely effective materials and systems. The two main product ranges are those of ultralight weights - gun mixes and moldables.

Anon. *Refract J* v 62 n 6 Nov-Dec 1987 p 12, 14.

### Thermodynamic Properties

**089409 APPARATUS FOR COMPLEX STUDY OF THE THERMODYNAMIC PROPERTIES OF ELECTRICALLY CONDUCTING MATERIALS UNDER CONDITIONS OF IMPULSIVE HEATING WITH A HIGH-DENSITY CURRENT.** A method for studying the thermophysical properties of refractory electrically conducting materials at high temperatures and pressure, based on rapid heating of the sample with a high-density current, is studied. The basic elements of the experimental apparatus, in particular, the high-speed two-channel brightness pyrometer, which enables recording the temperature of microobjects in the interval 2500-6000°K with temperature growth rates of up to  $10^8$  K/sec, are described in detail. The setup is intended for studying the heat capacity and electrical resistance of refractory electrically conducting materials near their melting lines. (Author abstract) 7 refs.

Sheindlin, M.A. (Acad of Sciences of the USSR, USSR); Senchenko, V.N. *High Temp* v 25 n 2 Mar-Apr 1987 p 281-286.

**Thermodynamics** See LADLES—Refractory Materials.

**USSR** See Also KAOLIN.

**089410 SUITABILITY OF ZAVADOV DEPOSIT DOLOMITES FOR USE AS RAW MATERIAL.** The Middle Devonian Zavado deposit of dolomites is located in the Ternopol region of the USSR. For refractory applications the use of preliminary grinding and briquetting improves sintering but does not provide significant advantages in comparison with firing in granular form. The material meets the requirements for patching and filling the sills of hearth furnaces. 4 refs.

Antonov, G.I. (Ukrainian Scientific-Research Inst for Refractories, USSR); Grivakova, Zh.A.; Maslov, A.G. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 95-100.



## Waste Utilization

**089411 PRODUCTION OF REFRACTORIES FROM GRAPHITE METALLURGICAL WASTE PRODUCTS.** Graphite-containing refractory products are increasingly being used for lining converters, electric furnaces, steel ladles, equipment for out-of-furnace processing of metals, and for casting steel. At present the USSR refractories industry is using crucible graphite grade GT. The authors studied graphite obtained from graphite metallurgical wastes from the point of view of using it for the manufacture of refractories instead of GT-graphite from ore. 8 refs.

Aksel'rod, L.I. (All-Union Inst of Refractories, USSR); Denisov, D.E.; Materikin, Yu.V.; Khudyakov, N.G.; Evstigneeva, A.A.; Mashkovtseva, N.A.; Kharitonov, G.M. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 40-43.

**Wear See BASIC OXYGEN CONVERTERS—Refractory Materials; FURNACES, MELTING—Lining.**

## Wear Resisting

**089412 TESTS OF REFRACTORIES IN ARGON-OXYGEN REFINING OF METAL.** For the purpose of selection of the most wear resistant refractories suitable for service in the cylindrical portion of an argon-arc refining unit the authors conducted comparative tests of parts of different types in the lining of a 10-ton steel melting unit. As the result of comparative tests it was established that the most resistant of the tested materials is the periclase-spinel refractory with the addition of chrome-alumina-spinel. These parts are recommended for lining the cylindrical portion of a pilot argon-oxygen refining unit. 10 refs.

Gushchin, V.Ya. (All-Union Inst for Refractories, USSR); Shapiro, E.Ya.; Pavlenko, A.P.; Semin, A.E.; Savinin, V.P.; Kostyanov, B.M.; Mezentsev, E.P. *Refractories* v 28 n 5-6 May-Jun 1987 p 282-287.

**Wetting See Also ELECTRODES—Materials.**

**089413 WETTABILITY OF SOLID OXIDES BY LIQUID IRON ALLOYS UNDER REDUCED PRESSURE.** Different values of surface tension and contact angle were obtained by different furnaces whose heating elements were molybdenum and graphite, respectively. This can be explained by a difference in partial pressure of oxygen in the furnaces. The values of surface tension obtained by the furnace whose heating element was graphite were higher than previous work. This is caused by an extremely low oxygen pressure in this work compared with those in previous work. The difference in the wetting of  $Al_2O_3$  and  $MgO$  with liquid iron alloys can be attributed to the difference in solubilities of Al and Mg in liquid iron. (Edited author abstract) In Japanese. 22 refs.

Nogi, Kiyoshi (Osaka Univ, Suita, Jpn); Ogino, Kazumi; Kurachi, Tetsuma. *Tetsu to Hagane* v 74 n 4 Apr 1988 p 648-655.

**Zirconia See Also ALUMINA—Coatings; BONDING—Dissimilar Materials; CEMENT PLANTS—Kilns; CERAMIC MATERIALS—Additives; CERAMIC MATERIALS—Crack Propagation; CERAMIC MATERIALS—Fabrication; CERAMIC MATERIALS—Fracture; CERAMIC MATERIALS—Injection Molding; CERAMIC MATERIALS—Mechanical Properties; CERAMIC MATERIALS—Phase Equilibria; CERAMIC MATERIALS—Phase Transitions; CERAMIC MATERIALS—Sintering; CERAMIC MATERIALS—Zirconia; CERAMIC PRODUCTS—Crack Propagation; ELECTROLYTES, SOLID—Electric Conductivity; ELECTROLYTES, SOLID—Thin Films; METAL FINISHING; MIXING; PISTONS—Reliability; PROTECTIVE COATINGS—Ceramics; PROTECTIVE COATINGS—Plasma Spraying; RADIOACTIVE WASTES—Disposal; SILICA—Chemical Vapor Deposition; ZIRCON—Reduction; ZIRCONIUM COMPOUND—S—Phase Transitions.**

**089414 ANTI-PHASE BOUNDARIES IN TETRAGONAL ZIRCONIA.** Using specimens prepared by arc melting and sintering, antiphase boundaries (APB's) in yttria partially stabilized zirconia were observed by transmission electron microscopy. APB's are introduced

in the tetragonal phase during cubic-tetragonal displacive transformation on cooling. Inter-APB distance decreases with  $Y_2O_3$  content, but in the range of 5 to 7 mol%  $Y_2O_3$ , it is kept at a constant value of about 0.05  $\mu m$ . In an 8 mol%  $Y_2O_3$  specimen, APB's cannot be observed. When a quenched tetragonal specimen is annealed, APB density decreases and APB's become flattened lying on {111} planes. (Edited author abstract) In Japanese. 9 refs.

Suto, Hajime (Tohoku Univ, Sendai, Jpn); Sakuma, Taketo; Yoshikawa, Noboru; Higuchi, Yoshikatsu. *Nippon Kinzoku Gakkaishi* v 51 n 8 Aug 1987 p 710-714.

**089415 MEASUREMENT OF FRACTURE TOUGHNESS AND EFFECT OF LOADING RATE ON ITS VALUE IN PSZ AND  $Si_3N_4$  CERAMICS.** The dynamic fracture toughness was measured by the impact response curve method using a strain gage attached to the specimen in the instrumented Charpy impact test. The static fracture toughness test using precracked specimens can evaluate the lower limits of static fracture toughness in contrast with conventional methods. Dynamic fracture toughness in partially stabilized zirconia has been observed to increase monotonously with loading rate K, while that in  $Si_3N_4$  decreases at first and then increases with increase of K. (Edited author abstract) In Japanese. 28 refs.

Kobayashi, Toshiro (Toyoashi Univ of Technology, Toyohashi, Jpn); Matsumura, Kenji; Ikawa, Hideki; Motoyoshi, Kenya. *Nippon Kinzoku Gakkaishi* v 51 n 8 Aug 1987 p 723-729.

**089416 PARTIALLY STABILIZED ZIRCONIA COMPACTS OBTAINED BY CENTRIFUGAL CONSOLIDATION.**  $ZrO_2$  powders containing 2 and 2.5 mol%  $Y_2O_3$  were dispersed in nitric acid aqueous solution at pH 3 with the aid of high power (1 kw) ultrasonic agitation. Centrifugal force was applied for sedimentation and compaction. Three-point bending tests were carried out. The highest strength was 1.9 GPa in the case of a specimen containing 2 mol%  $Y_2O_3$ . Coarse agglomerates were condensed at the bottom of the consolidated body and no segregation of  $Y_2O_3$  took place along the centrifugal direction. Application of a high centrifugal force was effective for further compaction. (Edited author abstract) In Japanese. 22 refs.

Yoshikawa, Noboru (Tohoku Univ, Sendai, Jpn); Suto, Hajime. *Nippon Kinzoku Gakkaishi* v 51 n 8 Aug 1987 p 762-768.

**089417 EFFECT OF SINTERING TIME ON THE STABILITY OF  $Y_2O_3$  PARTIALLY STABILIZED ZIRCONIA.** In the present investigation on the mechanical properties of 2 and 3 mol%  $Y_2O_3$ -bearing partially stabilized  $ZrO_2$  (Y-PSZ) prepared with coprecipitation powders, it was found that the maximum toughness was obtained by sintering for several hundred ks at 1573 K. In order to understand this, a structural analysis was performed by TEM-EDS and XRD. In the specimen sintered at 1573 K for 3.6 ks, each grain consisted of an almost average composition of the specimen. After prolonged sintering, the grain size was kept under 1  $\mu m$ , but the composition of each grain began to change continuously toward the equilibrium values of the tetragonal or cubic phase alternatively. This type of phase separation in ultrafine polycrystals is considered spinodal decomposition without a modulated structure. With the decrease of  $Y_2O_3$  content in the tetragonal phase, the stability of Y-PSZ decreased and toughness changed. (Edited author abstract) In Japanese. 10 refs.

Suto, Hajime (Tohoku Univ, Sendai, Jpn); Li, Jing-feng. *Nippon Kinzoku Gakkaishi* v 51 n 8 Aug 1987 p 769-773.

**089418 HIGH-TEMPERATURE DEFORMATION OF A FINE-GRAINED ZIRCONIA.** Deformation tests have been undertaken, up to large strains, on fine-grained zirconia polycrystals and we report the first results in this letter. They concern tests, performed up to strains near 50%, during which the microstructure evolution has been observed, by transmission electron microscopy (TEM), in a parallel direction with the mechanical behavior of the

material. The material was a commercial sintered zirconia partially stabilized with yttria (about 3 mol%). The main result of TEM observations concerns the microstructure evolution which is generally weak, even after a strain of nearly 50% at 1300°C. 23 refs.

Duclos, R. (Univ des Sciences et Techniques de Lille Flandres-Artois, Villeneuve d'Ascq, Fr); Crampon, J. *J Mater Sci Lett* v 6 n 8 Aug 1987 p 905-908.

**089419 YTTRIA-ZIRCONIA: EFFECT OF MICROSTRUCTURE ON CONDUCTIVITY.** Complex impedance measurements and detailed analysis of the grain-boundary microstructure have been made on fully stabilized yttria-zirconia sintered bodies as a function of grain size. The prereacted yttria-zirconia powder used in this study was obtained from a commercial source. The powder has very high reactivity and starts sintering around 1200°C. The densification process is complete around 1350°C but the grain growth continues almost linearly with sintering temperature. The grain size variation obtained was between 1 and 30  $\mu m$ . The grain-boundary resistivity when plotted against grain size showed an inflection in the vicinity of 1500°C sintering temperature. These results have been explained in terms of the grain-boundary microstructure changing with the sintering temperature. The thickness of the grain-boundary layer determined from impedance data and transmission electron micrographs are in reasonably good agreement. The activation energy for the grain-boundary resistivity was only slightly higher than that for the lattice resistivity. (Author abstract) 14 refs.

Badwal, S.P.S. (CSIRO, Aust); Drennan, J. *J Mater Sci* v 22 n 9 Sep 1987 p 3231-3239.

**089420 INFLUENCE OF CRYSTAL LATTICE DEFECTIVENESS ON THE PROPERTIES OF SOLID SOLUTIONS BASED ON  $ZrO_2$ .** It is shown that the parameter of the crystal lattice of cubic solid solutions based on zirconium dioxide stabilized with oxides of yttrium, ytterbium, and calcium is increased with a rise in their concentrations, and hardly alters for the solid solution  $ZrO_2$ - $Sc_2O_3$ . In the solid solutions of  $Y_2O_3$ ,  $Sc_2O_3$ , and CaO in zirconium dioxide there is a reduction in the x-ray densities with an increase in the concentration of stabilizing additives. For the solid solutions  $ZrO_2$ - $Yb_2O_3$  there is an increase in the x-ray density with rise in the concentration of ytterbium oxide. The introduction of 9-13% stabilizing oxides ensures the highest density for the ceramics. 9 refs.

Chusovitina, T.V. (East Inst of Refractories, USSR); Ust'yantsev, V.M.; Tretnikova, M.G.; Toropov, Yu.S. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 13-16.

**089421 INCREASING THE STRENGTH OF CERAMICS MADE OF ZIRCONIUM DIOXIDE DUE TO EUTECTOID DECOMPOSITION OF SOLID SOLUTIONS IN THE SYSTEM  $ZrO_2$ - $MgO$ .** Ceramics made from partly stabilized zirconium dioxide are being increasingly used in science and technology owing to their high strength and impact strength. Among the most promising materials of this type are solid solutions of magnesia in zirconia which also possess excellent thermal shock resistance. The aim of the present work was to study the influence of the amount of  $MgO$  and the firing schedule on the strength of the ceramics. Specimens of  $ZrO_2$  containing  $MgO$  2.8, 3.0, and 3.2% were evaluated. The material possessing the optimum properties was used to make fibers which were tested for drawing copper wire. 6 refs.

Geichev, V.G. (VNIInergotsvetmet, USSR); Pliner, S.Yu. *Refractories* v 28 n 1-2 Jan-Feb 1987 p 88-90.

**089422 AUTOCATALYSIS AND MICROSTRUCTURAL FEATURES IN AGEING OF A 3mol% Y-TZP.** Aging kinetics of a 3mol% Y-TZP at temperatures of 120-400°C in air and in approximately 0.1 MPa water-vapor atmosphere exhibit different features. In air, it is typified by the sigmoidal form; while in water, a character-



istic exponential is observed. A new phase of  $d=0.3027-0.2979$  nm was produced on aging under the same conditions both in air and in water atmosphere. Based on a set of superlattice streaking spots observed by selected-area diffraction pattern (SADP), it is suggested that the excess of  $Y^{+3}$  solute, or oxygen vacancies,  $Vo$ , may have given rise to these extra diffraction spots. (Author abstract) 19 refs.

Lu, Hong-Yang (Industrial Technology Research Inst, Hsinchu, Taiwan); Lin, Hong-Y; Chen, San-Yuan. *MRL Bull Res Dev* v 1 n 1 Mar 1987 p 1-9.

**089423 EFFECT OF  $Y_2O_3$  AND  $Nd_2O_3$  ADDITIVES ON THE STRUCTURE AND STABILITY OF  $ZrO_2$ -BASED PHASES IN ALLOYS OF THE  $Al_2O_3$ - $ZrO_2$  SYSTEM.** Additions of 12 wt.%  $Y_2O_3$  or 30 wt.% yttrium concentrate (with respect to  $ZrO_2$ ) to a charge of composition 75 wt.%  $Al_2O_3$  + 25 wt.%  $ZrO_2$  make it possible to obtain stabilized  $ZrO_2$  in samples synthesized by alloying. Upon the introduction of 30 wt.%  $Nd_2O_3$  a 60% stabilized  $ZrO_2$  is formed. The stabilized phase has the  $\beta$ - $ZrO_2$  structure in the case of additives no greater than 12 wt.%  $Y_2O_3$  and a structure characteristic of  $\gamma$ - $ZrO_2$  (F) in the case of a 15 wt.%  $Y_2O_3$  content. In the case of 10-30 wt.%  $Nd_2O_3$  or 15-30 wt.% yttrium concentrate the stabilized  $ZrO_2$  constitutes a mixture of a disordered solid solution with a structure close to  $\gamma$ - $ZrO_2$  (F) and an ordered solid solution with the pyrochlore structure,  $\gamma$ - $ZrO_2$  (II). 6 refs. In Russian.

Gladkov, V.E.; Fotiev, A.A.; Ivashinnikov, V.T.; Viktorov, V.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 955-957.

**089424 DIP COATING OF ZIRCONIA AND MIXED ZIRCONIA FILMS.** When glycols (except ethyleneglycol) were added to an isopropanol solution of zirconium n-butoxide, the corresponding glycolates were formed by the alcohol exchange reaction, and the precipitation of oxide by hydrolysis was strongly suppressed. Diethylene glycol was most effective as the glycol additive for the precipitation retarder. The film thickness can be controlled by the alkoxide concentration, water/alkoxide ratio, and the pulling-up rate of the substrate plate. The maximum thickness of uniform transparent zirconia films obtained in one dipping-drying-heating cycle was about 1500 Å. Much thicker films can be obtained by repeating the cycle. (Edited author abstract) In Japanese. 18 refs.

Takahashi, Yasutaka (Gifu Univ, Gifu, Jpn); Niwa, Katsuhiko; Kobayashi, Keisuke; Matsuki, Michiyasu. *Yogyo Kyokai Shi* v 95 n 10 1987 p 942-948.

**089425 INFLUENCE OF  $Y_2O_3$  ADDITION ON THE TRANSFORMATION BEHAVIOR OF  $ZrO_2$  IN  $Al_2O_3$ - $ZrO_2$  COMPOSITES.** The effect of  $Y_2O_3$  content on the stress-induced transformation of  $ZrO_2$  in sintered  $Al_2O_3$ - $ZrO_2$  composites was studied by using laser Raman spectroscopy and X-ray diffraction method, and their mechanical properties, such as Young's modulus, bending strength, Vickers hardness and fracture toughness, were measured. The Raman measurement of  $ZrO_2$  phases on the fracture and tensile surfaces after bending test indicated that the stress-induced transformation proceeded more extensively in the composites with low  $Y_2O_3$  contents and near the fracture surfaces. Consequently, fracture toughness increased with decreasing  $Y_2O_3$  content, and this tendency was related to the stress-induced transformation and the presence of microcracking. (Edited author abstract) In Japanese. 19 refs.

Arachori, Tadahisa (Sumitomo Metal Industries Ltd, Jpn); Iwamoto, Nobuya; Umesaki, Norimasa. *Yogyo Kyokai Shi* v 95 n 10 1987 p 949-954.

**089426 SIZE CONTROL OF  $ZrO_2$  AGGREGATED PARTICLES BY CHLORIDE-COEEXISTED HYDROLYSIS AND SINTERING THEM.** The effect of metal chlorides added to  $ZrOCl_2$  solutions on the crystallization of monoclinic  $ZrO_2$  in high temperature hydrolysis was studied. It was found that an increase in the amount of chloride ions decreases the crystallinity and forming rate of  $ZrO_2$  and increase the size of  $ZrO_2$  aggregated particles.

The  $ZrO_4$  aggregated particles were grown to about 0.4  $\mu$ m by hydrolysis at 150°C. Compacts of ultrafine powder obtained by hydrolysis densified at lower temperatures, along with larger shrinkage due to lower compactability. (Edited author abstract) In Japanese. 17 refs.

Kato, Etsuro (Nagoya Inst of Technology, Nagoya, Jpn); Ezoe, Masanobu; Kondo, Masayasu; Murase, Yoshio; Matoba, Koji. *Yogyo Kyokai Shi* v 95 n 10 1987 p 984-990.

**089427 FROTTEMENT LUBRIFIE DE LA ZIRCONIE.** [Lubricated Friction of Zirconia]. The use of zirconia as the jacket material of recently designed diesel engines poses the problem of choosing the segment material and a suitable lubricant. Tests of various combinations of materials and lubricants make it possible to ascertain the wear behavior of the ceramic and the temperature resistance of the lubricants. It is shown that the nature of the counter-abrading material has very little effect on the friction coefficient and wear rate. Tests at increasing temperature showed that silicone-based lubricants have a maximum utilization temperature which is higher than that of ester-based lubricants. It is noted that wear phenomena in zirconia are related to the nature of the lubricant - namely, plastic deformation streaks without noticeable material loss in the case of the ester-based lubricant; and material loss in the form of excessive corrosive wear associated with plastic deformation in the case of the silicone-based lubricant. In French. 7 refs.

Maurin-Perrier, P. (CNRS, Ecully, Fr); Kapsa, P.; Vacher, B.; Gauthier, A. *Mec Mater Electr* n 422 Sep-Oct 1987 p 3-7.

**089428 INVESTIGATION OF MICROSTRUCTURAL CHANGES AND SPECTRAL CHARACTERISTICS OF TANTALA STABILIZED ZIRCONIA REFRACTORIES.** Several samples of zirconia doped tantala have been prepared and well sintered. Measurements of X-ray diffraction, infrared absorption spectra and bulk density were carried out before and after an absorbed energetic gamma radiation dose ( $5.26 \times 10^6$  rd.). Result obtained were consistent and explained on the basis of the interactions of tantala dopant (at high temperature and energetic gamma radiation with zirconia and stabilized zirconia lattices. (Author abstract) 6 refs.

Abou Sekkina, M.M. (Tanta Univ, Tanta, Egypt); Ewaida, M.A.; Ibrahim, E.M.; Al-Adawy, A.A. *Polym Degradation Stab* v 19 n 3 1987 p 273-278.

**089429 MICROSTRUCTURE OF ZIRCONIA FILMS DEPOSITED WITH ION ASSISTANCE.** Zirconia films were deposited in vacuum from an electron-beam hearth with simultaneous ion bombardment from a Kaufman source. The effects of argon, oxygen and nitrogen ions were investigated, together with those of temperature and substrate type. For amorphous substrates, without ions, X-ray and electron diffraction showed that amorphous films were produced at room temperature. Deposition on to 300°C amorphous substrates produced the monoclinic form. Ion assistance converted the structure to cubic. It was found that deposition on to KCl (100) substrates also produced the cubic form at elevated temperatures, with or without ions. High-resolution microscopy showed that these films were crystallography oriented with either  $\langle 100 \rangle$  or  $\langle 110 \rangle$  normal to the KCl substrate. (Edited author abstract) 11 refs.

McKenzie, D.R. (Univ of Sydney, Aust); Cockayne, D.J.H.; Seats, M.G.; Martin, P.J.; Sainty, W.G.; Netterfield, R.P. *J Mater Sci* v 22 n 10 Oct 1987 p 3725-3731.

**089430 PREPARATION OF  $ZrO_2$ -FILM BY OXIDATION OF  $ZrCl_4$ .** This letter presents the preparation method and structural description of highly oriented monoclinic  $ZrO_2$  film made by the oxidation of  $ZrCl_4$  under atmospheric pressure. The film was 8  $\mu$ m thick and exhibited a columnar structure. Each grain grew out of the substrate and had facets at the deposition surface. No pore was observed in the film. Good adhesion to the substrate was confirmed for up to 4  $\mu$ m of the film thickness. 11 refs.

Yamane, Hisanori (Tohoku Univ, Sendai, Jpn); Hirai, Toshio. *J Mater Sci Lett* v 6 n 10 Oct 1987 p 1229-1230.

**089431 WEAR OF PARTIALLY STABILIZED ZIRCONIA: SLIDING VS. ROLLING CONTACT.** Transformation toughened partially stabilized zirconia (PSZ) was observed to have a much lower weight loss in sliding wear tests compared to rolling wear tests. In the sliding contact, the stress state in the stationary member is constant except for asperity variation in the moving member. In rolling contact, the stress state in the roller varies as it goes through contact much as the stress varies in fatigue loading. In brittle ceramics, rolling wear testing is a method of investigating fatigue properties which cannot be determined by conventional methods. Two ceramics were tested, PSZ (3 w/o MgO) and for comparison,  $Si_3N_4$ . 5 refs.

Brazza, J.F. (Northwestern Univ, Evanston, IL, USA); Cheng, H.S.; Fine, M.E. *Scr Metall* v 21 n 12 Dec 1987 p 1705-1710.

**089432 THERMAL SHOCK RESISTANCE OF YTTRIA-DOPED TETRAGONAL ZIRCONIA POLYCRYSTALS: EFFECT OF SOLVENT IN QUENCHING TEST.** Because of superior mechanical properties, such as high fracture strength and high fracture toughness, yttria-doped tetragonal zirconia polycrystals (Y-TZP) have received special attention in the field of structural application. In the present study, thermal shock resistance of Y-TZP was determined by using various solvents as quenching media and the experimental data were examined by heat-conduction mechanisms. The results indicate that the cracks in Y-TZP were propagated because the thermal stress was significantly smaller than the bending fracture stress. It is suspected that the tetragonal-to-monoclinic phase transformation at the crack tips plays a significant role in the propagation of the cracks in the presence of water and some organic solvents. 19 refs.

Sato, T. (Tohoku Univ, Sendai, Jpn); Fukushima, T.; Endo, T.; Shimada, M. *J Mater Sci Lett* v 6 n 11 Nov 1987 p 1287-1290.

**089433 TEILSTABILISIERTES ZIRKONOXID ALS FESTELEKTROLYT ZUR ELEKTROCHEMISCHEN SAUERSTOFFAKTIVITÄTSMESSUNG IN METALLSCHMELZEN.** [Partially Stabilized Zirconium-Oxide as Solid Electrolyte for the Electro-Chemical Measurement of Oxygen Activity in Metal Smelting]. The electro-chemical measurement of the oxygen concentration of steel-smelting is done quickly and safely with the help of  $ZrO_2$ -probes. The theory of ion-conduction and the construction of the probe are described. (Author abstract) In German. 2 refs.

Ferdinand, S. *Keram Z* v 39 n 10 Oct 1987 p 703-704.

**089434 EFFECT OF LIGHT ASH OF SOLID FUELS ON ZIRCONIA REFRACTORIES.** The application of coals worsens the service conditions of the refractory lining in thermal units because of the corrosion of refractories by light (fly) ash. We studied the resistance of zirconia refractories to the action of the mixtures of light ash of two types of coals and an alkali additive (potash  $K_2CO_3$ ). The refractories were produced using commercial purity zirconium dioxide and had an open porosity of 14-22%, an apparent density of 4.6-4.75 g/cm<sup>3</sup>, and an ultimate compressive strength of 150-200 N/mm<sup>2</sup>. The action of the melts of the light ash containing potash additive on zirconia refractories leads to their destruction due to destabilization of the cubic solid solution of CaO in  $ZrO_2$  accompanied by the formation of  $\alpha$ - $ZrO_2$ , melilites, and a glass phase and the formation of spinellids, pyroxenes, and fayalite if iron-bearing compounds are present in the ash. 8 refs.

Usatikov, I.F. (Ukrainian Scientific-Research Inst of Refractories, USSR); Vol'fson, R.E.; Privalova, N.G.; Sukhonos, Yu.B. *Refractories* v 28 n 5-6 May-Jun 1987 p 235-237.



**089435 SURFACE PROPERTIES OF GEL-DERIVED ZIRCONIA FIBRES.** In this letter, the surface area, average pore diameter, density measurements and adsorption isotherms of zirconia fibers derived from sol-gel technology are reported. Zirconia fibers were derived from the zirconium hydroxy hydrogel using the gel process. The surface-area analysis and pore-volume and pore-size distribution measurements were carried out by the BET method with krypton as the adsorbate. 2 refs.

Jada, Sivananda S. (Manville Service Corp, Denver, CO, USA). *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1368-1370.

**089436 ELECTRICAL CONDUCTION IN YTTERBIUM-DOPED ZIRCONIA AT ELEVATED TEMPERATURES.** Electrical conductivity measurements in  $\text{Yb}_2\text{O}_3$ -stabilized zirconia were carried out using an ac four-point probe method on cylindrical samples of an even diameter of 5 mm. The samples were prepared from an intimate mixture of  $\text{ZrO}_2$  and  $\text{Yb}_2\text{O}_3$  and presintered at 800°C for 20 h. The final sintering processes were carried out after machining the samples at 1750°C for 24 h or at 1900°C for 16 h. The density of the samples was more than 95% theoretical. Electrical conductivity measurements on zirconia doped with different amounts of  $\text{Yb}_2\text{O}_3$  showed that the conductivity decreases with increase in the dopant concentration. The phenomenon was explained by the formation of certain types of associates in the crystal structure. 4 refs.

Moztarzadeh, F. (Materials & Energy Research Cent, Tehran, Iran). *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1385-1386.

**089437 SYNTHESIS AND CHARACTERIZATION OF FULLY/PARTIALLY STABILIZED ZIRCONIA POWDERS.** The present report describes the synthesis of reactive powders, powder morphology and evaluation of powders by thermal analysis technique. The progress in sintering and densification of compacts was followed from apparent density measurement. The phases present were identified by X-ray powder diffraction and the microstructure of sintered bodies using scanning electron microscopy (SEM). It is concluded that: (a) The finer the particle size the larger is the specific surface area; (b) increased calcia addition resulted in decreasing densification; (c) 20 mol% additive shows an absence of monoclinic phase. 9 refs.

Mondal, B. (Indian Inst of Technology, Karagpur, India); Virkar, A.N.; Chattopadhyay, A.B.; Paul, A. *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1395-1398.

**089438 EFFECT OF DOPANT CONCENTRATION ON THE GRAIN BOUNDARY AND VOLUME RESISTIVITY OF YTTRIA-ZIRCONIA.** In this letter the results of impedance measurements on several yttria-zirconia compositions are described. Impedance measurements were made over the temperature range 375 to 600°C and a frequency range of 1 Hz to 1 MHz. The major phases present were either tetragonal or a mixture of tetragonal and cubic. At low temperatures the volume conductivity of the tetragonal phase appears to be comparable with or better than that of the cubic phase. This may be a consequence of the inherently low dopant concentration in the tetragonal phase (less interaction among defects). 9 refs.

Badwal, S.P.S. (CSIRO, Clayton, Aust). *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1419-1421.

**089439 WETTABILITY BETWEEN ZIRCONIA CERAMICS AND THE LIQUID METALS COPPER, NICKEL AND COBALT.** Polished discs of polycrystalline zirconia stabilized with 5 wt% CaO and with a purity of 99% were used as substrate in the wetting experiments. The measured wetting angles, together with literature data of the surface energies of liquid metals were used for the calculation of the work of adhesion,  $W_a$ . Linear extrapolation of  $W_a$  to the metal's melting point indicates that nickel has a higher value of work of adhesion as compared with the metals copper and cobalt. This result shows that non-wetting systems can form a strong interface which influences positively the mechanical properties of sintered metal-ceramic composite material. 8 refs.

Nikolopoulos, P. (Univ of Patras, Patras, Greece); Sotiropoulos, D. *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1429-1430.

**089440 EFFECT OF ALUMINA ADDITIONS ON THE GRAIN BOUNDARY AND VOLUME RESISTIVITY OF TETRAGONAL ZIRCONIA POLYCRYSTALS.** There has been much interest in a new class of strong engineering ceramics based on fine-grained yttria partially stabilized zirconias (Y-TZP). This study reports the effect of  $\text{Al}_2\text{O}_3$  content on the microstructure, grain boundary and volume resistivity of these materials. The Arrhenius plots for the total resistivity of RZY2. 5-10 $\text{Al}_2\text{O}_3$ , magnesia partially stabilized zirconia and yttria (10 mol%) stabilized zirconia show that the former material has the highest conductivity below about 450°C. Y-TZP ceramics containing alumina are candidates for applications requiring a combination of high strength and good oxygen ion mobility. 12 refs.

Rajendran, S. (CSIRO, Clayton, Aust); Drennan, J.; Badwal, S.P.S. *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1431-1434.

**089441 HIPING OF  $\text{ZrO}_2$ -TRANSFORMATION-TOUGHENED GLASS-CERAMICS PREPARED BY THE SOL-GEL PROCESS FROM METAL ALKOXIDES.**  $\text{ZrO}_2$ -containing ceramics have recently become of interest because of their high strength and fracture toughness, which are attributed to the stress-induced transformation of tetragonal (t-)  $\text{ZrO}_2$ . Using the metal alkoxide sol-gel process, we have prepared the monolithic glass-ceramics in the system  $\text{ZrO}_2$ - $\text{SiO}_2$  containing up to 60 mol% (75 wt%)  $\text{ZrO}_2$ . In the present work, to obtain the high-strength glass-ceramics, the powders were hot-isostatically pressed (hiped). High-strength glass-ceramics were obtained by hiping the t- $\text{ZrO}_2$  precipitated glass-ceramics. The hiping was more effective in consolidating the glass-ceramics containing large pores. 10 refs.

Nogami, Masayuki (Aichi Inst of Technology, Toyota, Jpn); Nagasaka, Katsumi. *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1479-1480.

**089442 METASTABLE TETRAGONAL ZIRCONIA IN THE  $\text{ZrO}_2$ - $\text{YF}_3$ - $\text{YO}_{1.5}$  SYSTEM.** In the pseudo binary systems  $\text{ZrO}_2$ -YOF included in the  $\text{ZrO}_2$ - $\text{YF}_3$ - $\text{YO}_{1.5}$  ternary system, samples of 3.0-7.7 mol% YOF within the region of tetragonal single phase at 1300°C were isostatically hot pressed at 1200°, 1300° and 1450°C under 200 MPa for 3 h. For  $\text{ZrO}_2$ -7.7 mol% YOF, a metastable tetragonal zirconia single phase was obtained as a sintered body. For other samples (> 7.7 mol% YOF) most of the tetragonal phase transformed diffusionlessly to a monoclinic phase during cooling. According to measurement by DTA, the tetragonal phase in the  $\text{ZrO}_2$ -YOF system transformed at higher temperatures than that in the  $\text{ZrO}_2$ - $\text{YO}_{1.5}$  system. This seems to be caused by more distorted cells of the tetragonal and monoclinic phases as the result of F<sup>-</sup> doping. Stress induced transformation is confirmed for the metastable tetragonal phase. (Edited author abstract) In Japanese. 5 refs.

Yoshimura, Masahiro; Okano, Yoshio; Somiya, Shigeyuki. *J Jpn Soc Powder Powder Metall* v 34 n 9 Nov 1987 p 441-444.

**089443 BONDING OF Y-PSZ WITH Ti-10 WT% CO BINARY MIXED POWDER COMPACT BY LIQUID PHASE SINTERING.** Using Ti-10 wt% Co binary mixed powder compact as the insert material, bonding behavior of Y-PSZ was examined under the coexistence of solid and liquid by liquid phase sintering. Bonding was carried out at 1473 K for 3.6 ks under pressure of 1-9 MPa by hot pressing. The highest bending strength of 213 MPa was achieved in the specimen bonded under 3 MPa. There were large grains in the center region of Ti-Co alloy after bonding, while near the Y-PSZ/Ti-10% Co interface small grains were observed. The interfacial strength between Y-PSZ and Ti-Co alloy is assumed to be higher. (Edited author abstract) In Japanese. 8 refs.

Majima, Kazuhiko; Yamao, Norihito; Shouji, Keichirou.

*J Jpn Soc Powder Powder Metall* v 34 n 9 Nov 1987 p 491-493.

**089444 STRUCTURAL STUDIES ON THE  $\text{ZrO}_2$ - $\text{Y}_2\text{O}_3$  SYSTEM BY ELECTRON DIFFRACTION AND ELECTRON MICROSCOPY III.** The oxygen-ion displacements in modulated structures for 10-50 mol%  $\text{Y}_2\text{O}_3$ - $\text{ZrO}_2$  can be assigned in terms of the frozen in distortions of the molecular vibrational modes of an oxygen ion cube. This assignment clarifies that the displacement of the 10 mol%  $\text{Y}_2\text{O}_3$ - $\text{ZrO}_2$  structure type (a deformed fluorite structure) decreases and that of the  $\text{Y}_2\text{O}_3$  structure type increases as the amount of  $\text{Y}_2\text{O}_3$  increases. The displacement of the  $\text{Y}_2\text{O}_3$  type already occupies 75% in 20 mol%  $\text{Y}_2\text{O}_3$ - $\text{ZrO}_2$  and 97% in 50 mol%  $\text{Y}_2\text{O}_3$ - $\text{ZrO}_2$  in the microdomains of modulated structures. The decrease of the ionic conductivity with the content of  $\text{Y}_2\text{O}_3$  can be attributed to an increase in the volume of microdomains with the  $\text{Y}_2\text{O}_3$ -type displacement. The arc-shaped diffuse scattering observed in 20 and 40 mol%  $\text{Y}_2\text{O}_3$ - $\text{ZrO}_2$  originates from the presence of various orientations and different intervals of the periodic anti-phase boundaries. (Author abstract) 12 refs.

Suzuki, Susumu (Tohoku Univ, Sendai, Jpn); Tanaka, Michiyoshi; Ishigame, Mareo. *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 1983-1987.

**089445 INFRARED STUDY OF SULFATED ZIRCONIA.** Fourier transform infrared spectroscopy and vacuum microbalance methods have been used to study the sulfation of zirconium oxide. Sulfation could be carried out by oxidizing either  $\text{H}_2\text{S}$  or  $\text{SO}_2$  in excess  $\text{O}_2$  at 450°C and the infrared spectrum showed an intense three component band near 1375  $\text{cm}^{-1}$  accompanied by a complex profile having at least six components between 1100 and 800  $\text{cm}^{-1}$ . Two surface sulfate species were formed after oxidation of between 10 and about 250  $\mu\text{mol g}^{-1}$ , and although the extent of formation of each was dependent on the quantity oxidized, the total band area between 1400 - 1350  $\text{cm}^{-1}$  was a linear function of the quantity of  $\text{H}_2\text{S}$  or  $\text{SO}_2$  introduced into the infrared cell. Both species contain a single SO oscillator and their structures are possibly of the type  $(\text{ZrO}_3)\text{SO}$  resident on different crystal faces of  $\text{ZrO}_2$ . A third species is formed at higher coverages and its suggested structure is a  $\text{S}_2\text{O}_7$  type species in which four of the oxygen atoms are bonded to surface Zr atoms, there being one SOS bridge and two uncoupled SO oscillators. All three sulfate species have similar thermal stabilities (decomposition between 600 and 800°C) and are reduced at the same rate in hydrogen (the IR bands disappear rapidly between 450 and 475°C). Finally, sulfation could also be carried out via impregnation of  $\text{ZrO}_2$  with  $\text{H}_2\text{SO}_4$ ,  $(\text{NH}_4)_2\text{SO}_4$  or  $\text{Zr}(\text{SO}_4)_2$  followed by heating under vacuum at 450°C. (Edited author abstract) 18 refs.

Bensitel, M. (Univ de Caen, Caen, Fr); Saur, O.; Lavalley, J.-C.; Morrow, B.A. *Mater Chem Phys* v 19 n 1-2 Mar 1988 p 147-156.

**089446 TRANSFORMATION TOUGHENING IN LARGE-GRAIN-SIZE  $\text{CeO}_2$ -DOPED  $\text{ZrO}_2$  POLYCRYSTALS.** The fracture and transformation behavior of tetragonal polycrystalline  $\text{ZrO}_2$  alloys containing 18 mol%  $\text{CeO}_2$  (Ce-TZP) was investigated. In the absence of applied stress the tetragonal phase was found to be stable in large-grained samples at room temperature. The monoclinic phase was detected in regions of high residual stress near hardness indentations although no evidence of a wake of monoclinic phase along the fracture surface was observed. (Edited author abstract) 38 refs.

Coyle, Thomas W. (US Naval Research Lab, Washington, DC, USA); Coblenz, William S.; Bender, Barry A. *J Am Ceram Soc* v 71 n 2 Feb 1988 p C.88-C.92.

**089447 AGING BEHAVIOR OF CERIA-STABILIZED TETRAGONAL ZIRCONIA POLYCRYSTALS.** A commercial ceria-stabilized tetragonal zirconia polycrystal is shown not to degrade at low temperatures. Slight strength decrease is found for elevated-temperature



treatments, which is not related to formation of the monoclinic phase. A possible mechanism to explain the behavior based upon the ferroelastic nature of the tetragonal phase is proposed. (Author abstract) 13 refs.

Matsumoto, Roger L.K. (Ceramtec Inc, Salt Lake City, UT, USA). *J Am Ceram Soc* v 71 n 3 Mar 1988 p C.128-C.129.

**089448 SYNTHESIS OF THE ORTHORHOMBIC PHASE OF  $2Y \cdot ZrO_2$ .** A mixture of tetragonal and monoclinic  $2Y \cdot ZrO_2$  powder was treated from 400° to 800°C and from 4 to 7 GPa for 30 min. The products were identified by powder XRD, Raman spectroscopy, and TEM. Results indicated that an orthorhombic phase was synthesized at  $T = 400^\circ$  to  $600^\circ C$ . The orthorhombic phase always coexisted with the tetragonal phase in the products. The amounts of the tetragonal phase before and after treatment remained largely unchanged, whereas the amount of new orthorhombic phase was nearly the same as the decreased amount of the monoclinic phase. (Edited author abstract) 5 refs.

Ohtaka, Osamu (Osaka Univ, Toyonaka, Jpn); Kume, Shoichi; Iwami, Tsutomu; Urabe, Kazunori. *J Am Ceram Soc* v 71 n 3 Mar 1988 p C.164-C.166.

**089449 PREPARATION OF MONODISPersed Y-DOPED  $ZrO_2$  POWDERS.** 3 mol% Y-doped  $ZrO_2$  powders prepared by the controlled hydrolysis of metal alkoxides were monodispersed and grown to 0.5  $\mu m$  after 5 h ageing. The as-prepared powder was amorphous and hydrated but transformed into a tetragonal single phase by heating. Furthermore, the  $Y_2O_3$  concentration of each particle was almost the same in all particles. The synthesis conditions such as ageing time, ageing temperature and water concentration greatly affected the particle morphology. The refluxing of the alkoxide solution was particularly necessary to prepare the monodispersed particles. On the basis of the variation of size distribution with ageing time, the mechanism of particle growth was discussed. (Author abstract) 16 refs.

Uchiyama, Kiyoshi (Tokyo Inst of Technology, Tokyo, Jpn); Ogihara, Takashi; Ikemoto, Tadashi; Mizutani, Nobuyasu; Kato, Masanori. *J Mater Sci* v 22 n 12 Dec 1987 p 4343-4347.

**089450 LOW TEMPERATURE PHASE EQUILIBRIA AND ORDERING IN THE  $ZrO_2$ -RICH REGION OF THE SYSTEM  $ZrO_2$ -CaO.** From co-precipitated powder samples, the solid state reactions occurring between room temperature and 1500°C in the  $ZrO_2$ -CaO system have been studied. At low temperatures, compositions containing <25 mol% CaO show a complex picture of phase transformation and ordering in the system. From the obtained results the singular reactions have been established. By using DTA, X-ray diffraction and SEM techniques, the extent of the tetragonal and cubic zirconia solid solution fields has been established. From the above experimental results a new tentative phase diagram is given for the  $ZrO_2$ -rich region of the system,  $ZrO_2$ -CaO. (Edited author abstract) 19 refs.

Duran, P. (CSIC, Madrid, Spain); Recio, P.; Rodriguez, J.M. *J Mater Sci* v 22 n 12 Dec 1987 p 4347-4356.

**089451 YTTRIA MIGRATION IN Y-TZP DURING HIGH-TEMPERATURE ANNEALING.** The microstructural and phase changes occurring during the high temperature (1300 to 1550°C) annealing of tetragonal yttria-zirconia (Y-TZP) were studied using X-ray fluorescence, X-ray diffraction, and TEM. Two processes occurred simultaneously involving the diffusion of yttrium. The Y-TZP partitioned into yttria-rich and yttria-poor phases throughout the material, because the material lies in a two-phase field of the yttria-zirconia phase diagram. The other process involved the segregation of yttrium to the surface, the extent of which was shown to vary with the state of the surface (ground or polished), annealing temperature, and silica content. Migration of yttrium to the surface caused a significant surface composition change (i.e. from 4.7 wt%  $Y_2O_3$  at room temperature to 8.9 wt%  $Y_2O_3$  at 1550°C for 3 h), resulting in a

microstructure and phase composition different from the bulk. (Author abstract) 6 refs.

Whalen, P.J. (Allied Signal Inc, Morristown, NJ, USA); Reidinger, F.; Correale, S.T.; Marti, J. *J Mater Sci* v 22 n 12 Dec 1987 p 4465-4469.

**089452 DEVELOPMENT OF DOMAIN STRUCTURE ASSOCIATED WITH THE DIFFUSIONLESS CUBIC-TO-TETRAGONAL TRANSITION IN  $ZrO_2$ - $Y_2O_3$  ALLOYS.** Microstructural change associated with the diffusionless cubic-to-tetragonal (c-t) transition was examined in arc-melted  $ZrO_2$ - $Y_2O_3$  alloys with yttria content 3 to 5 mol%. It was found that a two-step microstructural change occurred during the transition. A domain structure with antiphase domain boundary-like contrast is formed initially and plate-like or lenticular features later. The domain size decreases with increasing yttria content of the alloy. The change of domain size seems to be related to the change in  $T_0$  temperature with composition. The nature of the c-t transition is discussed in this paper. (Author abstract) 16 refs.

Sakuma, T. (Univ of Tokyo, Hongou, Jpn). *J Mater Sci* v 22 n 12 Dec 1987 p 4470-4475.

**089453 METASTABLE RETENTION OF A HIGH-PRESSURE PHASE OF ZIRCONIA.** A high-pressure phase of zirconia, stable above 3.3 GPa at room temperature, can be retained metastably, at ambient room conditions of pressure and temperature by appropriate thermal/pressure treatments. The amount of high-pressure phase retained depends on the thermal treatment, hydrostatic environment, and particle size of the starting powder. The results support the idea that the high-pressure transformation in zirconia is initiated at nucleation centers whose population can be minimized by appropriate thermal treatments. The results also point out the importance of high pressure as a source of controllable driving force to induce the transformation in zirconia, thus permitting the use of annealing treatments to change the population of defects involved in nucleating the transition. (Author abstract) 15 refs.

Da Jornada, J.A.H. (NBS, Gaithersburg, MD, USA); Piermarini, G.J.; Block, S. *J Am Ceram Soc* v 70 n 9 Sep 1987 p 628-630.

**089454 TOUGHENING BEHAVIOR INVOLVING MULTIPLE MECHANISMS: WHISKER REINFORCEMENT AND ZIRCONIA TOUGHENING.** Since the contribution of transformation toughening increases with the local crack resistance (which is proportional to the toughness of the matrix),  $ZrO_2$  particles were added to a toughened, whisker-reinforced ceramic matrix. Analysis revealed that the combination of these multiple toughening agents should result in ceramic composites tougher than that achieved by either mechanism by itself, or the sum of the two processes. The toughness of mullite could be increased 1.8- and 2.4-fold with a 20 vol% addition of  $ZrO_2$  particles or SiC whiskers, respectively. However, when 20 vol% of both  $ZrO_2$  particles and SiC whiskers were added, the toughness was increased at least 3-fold with monoclinic m- $ZrO_2$  and by >5-fold with tetragonal t- $ZrO_2$ . (Edited author abstract) 6 refs.

Becher, P.F. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Tiegs, T.N. *J Am Ceram Soc* v 70 n 9 Sep 1987 p 651-654.

**089455 LOW-TEMPERATURE AGING OF t- $ZrO_2$  POLYCRYSTALS WITH 3 mol%  $Y_2O_3$ .** A kinetic study of the aging behavior of tetragonal zirconia polycrystals (TZPs) from 100°C suggests that there exists a critical grain size of 0.52  $\mu m$  below which the tetragonal symmetry can be retained. Property degradation of TZPs at low temperatures is connected with transformation-induced microcracking. It is reported here that the temperature range of 100° to 400°C in which degradation occurs could be explained by an infinite incubation time for the lower limit and by the martensite starting temperature for the upper limit. (Author abstract) 21 refs.

Lu, Hong-yang (Industrial Technology Research Inst, Hsinchu, Taiwan); Chen, San-yuan. *MRL Bull Res Dev* v 2 n 1 Mar 1988 p 71-78.

**089456 STABILITY OF TETRAGONAL  $ZrO_2$  PHASE IN  $Al_2O_3$  PREPARED FROM Zr-Al ORGANOMETALLIC COMPOUNDS.** Zr-Al organometallic compounds have been spray-dried and heated at temperatures 600 to 1400°C to prepare  $ZrO_2$ - $Al_2O_3$  composite powders. The powders consist of balloon-like particles 0.5 to 2  $\mu m$  in diameter with homogeneously dispersed tetragonal  $ZrO_2$  grains 0.1 to 0.2  $\mu m$  in diameter. The tetragonal fraction of  $ZrO_2$  in the composite powders is higher than that in the powders prepared from sols of  $Zr(OBu)_4$  and  $Al[OCH(CH_3)_2]_3$ . The fraction is affected by the organofunctional group in the Zr-Al compounds. (Author abstract) 14 refs.

Yoshimatsu, Hideyuki (Industrial Technology Cent of Okayama Prefecture, Okayama, Jpn); Kawasaki, Hitoshi; Osaka, Akiyoshi. *J Mater Sci* v 23 n 1 Jan 1988 p 332-336.

**089457 COMMENT ON 'A STRUCTURAL STUDY OF METASTABLE TETRAGONAL ZIRCONIA IN AN  $Al_2O_3$ - $ZrO_2$ - $SiO_2$ - $Na_2O$  GLASS-CERAMIC SYSTEM.'** In a publication on the study of crystallization of gels in an  $Al_2O_3$ - $ZrO_2$ - $SiO_2$ - $Na_2O$  glass-ceramic system, Fagherazzi et al. obtained a sharp exothermic peak at about 940°C in the differential thermal analysis (DTA) curve which they ascribe to the crystallization of tetragonal zirconia. The author has reproduced the experiment and obtained a similar sharp exothermic peak at about 955°C. X-ray diffraction results at this temperature revealed that presence of strong tetragonal zirconia peaks plus medium peaks at high angles of the cubic spinel phase and weak peaks at 2 $\theta$  which Osaka ascribed to the formation of a metastable (2:1) mullite phase. The sharp exotherm as obtained by Fagherazzi et al. could not possibly be due to the crystallization of zirconia, but the metastable mullite phase instead. The apparent broad and diluted exotherm just prior to the sharp peak as obtained by the author is consequently ascribed to the crystallization of tetragonal zirconia. 8 refs.

Low, I.M. (Univ of Sydney, Sydney, Aust). *J Mater Sci Lett* v 7 n 2 Feb 1988 p 111-112.

**089458 BONDING OF Y-PSZ WITH Ti-10 WT% Co BINARY MIXED POWDER COMPACT BY LIQUID PHASE SINTERING.** Partially stabilized zirconia (PSZ) is one of the most promising candidates for structural ceramics because of its high toughness and strength. In most applications PSZ is assumed to be used together with structural metals, and a few investigations have been carried out regarding its bonding to metals. The purpose of the present work is to examine the bonding behavior of Y-PSZ under the coexistence of solid and liquid by liquid phase sintering of a metallic interlayer, Ti-Co binary mixed powder compacts, and to compare the results to those obtained in the previous experiment from the viewpoint of the thickness of Ti-10 wt% Co binary mixed powder compacts used as the inserting metal. 3 refs.

Majima, K. (Osaka Univ, Suita, Jpn); Yamao, N.; Shouji, K. *J Mater Sci Lett* v 7 n 2 Feb 1988 p 173-175.

**089459 TRANSFORMATION PLASTICITY OF  $CeO_2$ -STABILIZED TETRAGONAL ZIRCONIA POLYCRYSTALS: I. STRESS ASSISTANCE AND AUTOCATALYSIS.** Transformation plasticity in  $CeO_2$ -stabilized tetragonal zirconia polycrystals due to the tetragonal-to-monoclinic transformation was studied by inducing volumetric and shear deformation under compression and bending between the burst temperature of martensite (monoclinic) formation ( $M_b$ ) and the burst temperature of austenite (tetragonal) formation ( $A_b$ ). The stress-strain curve features a load drop, a perfect plastic regime, and an extended strain-hardening regime before the exhaustion of transformation. Macroscopic shear bands formed in the perfect plastic regime. The yield stress has a strong, positive pressure and temperature sensitivity but is strain-rate sensitive only in the last stage of deformation. These results are rationalized in terms of stress assistance to the transformation which, in a homogeneous tetragonal polycrystal, may propagate autocata-



lytically. Autocatalysis can be impeded by a second phase, such as monoclinic  $ZrO_2$  or  $Al_2O_3$ , and is suppressed at higher temperature. (Edited author abstract) 24 refs.

Reyes-Morel, Patricio E. (Univ of Michigan, Ann Arbor, MI, USA); Chen, I-Wei. *J Am Ceram Soc* v 71 n 5 May 1988 p 343-353.

**089460 IDENTIFICATION OF t' PHASE IN  $ZrO_2$ -7.5 wt%  $Y_2O_3$  THERMAL-BARRIER COATINGS.** The presence of nontransformable tetragonal (t') phase in plasma-sprayed  $ZrO_2$ - $Y_2O_3$  coatings enhances the stability of the coating during high-temperature exposure. In this paper, we describe the importance and procedure for correctly identifying t' phase in X-ray diffraction patterns of the as-sprayed and heat-treated coatings. The results agree with the phase diagram. (Edited author abstract) 12 refs.

Muraleedharan, Kuttanellur (Defence Metallurgical Research Lab, Hyderabad, India); Subrahmanyam, Jandhyala; Bhaduri, Sarit B. *J Am Ceram Soc* v 71 n 5 May 1988 p C.226-C.227.

**089461 POLYMORPHIC MIXES OF ZIRCONIA FROM A BORATE GLASS MELT.** Yttria-stabilized zirconia crystals were produced by devitrification within a sodium borate glass containing zirconia and yttria. Yttria (3, 6, or 10 mol%) in zirconia was added as part of the starting material of the glass batch. Phase separation and crystallization occurred during the cooling and subsequent heat treatment of the glasses. The zirconia powders obtained after leaching away the sodium borate had surface areas between 16 and 48  $m^2/g$ . X-ray diffraction traces revealed a mixture of monoclinic, tetragonal, and cubic phases, the phase ratios of which depended on the composition of the glass. (Author abstract) 7 refs.

De Villiers, Dan R. (CSIR, Pretoria, S Afr); Kingon, Angus I.; Res, Miloslav A. *J Am Ceram Soc* v 71 n 5 May 1988 p C.244-C.246.

**089462 INDENTATION CREEP IN SINGLE-CRYSTAL CUBIC ZIRCONIA AT ROOM TEMPERATURE.** Indentation creep of yttria- and calcia-stabilized single-crystal zirconia has been observed at room temperature. The Knoop hardnesses decreased by 15% and 12% of their conventional short-time values, respectively, for indentation times of 100,000 s. (Author abstract) 6 refs.

Carter, Graham M. (Univ of Exeter, Exeter, Engl); Henshall, John L.; Hooper, Robert M. *J Am Ceram Soc* v 71 n 5 May 1988 p C.270.

**089463 LOCAL STRUCTURES AROUND Y ATOMS IN  $Y_2O_3$ -STABILIZED TETRAGONAL  $ZrO_2$ .** Local structures around  $Y^{3+}$  ions in stabilized tetragonal  $ZrO_2$  with the chemical compositions of 94  $ZrO_2 \cdot 6 YO_{1.5}$  (Y 6) and 86  $ZrO_2 \cdot 4 YO_{1.5} \cdot 10 CeO_2$  (Y 4) were studied by Y K EXAFS (extended X-ray absorption fine structure) analysis. Using  $Y_2O_3$  crystals (Y-O=2.28 Å, six-fold coordination) as a reference sample, average Y-O distances for Y 6 and Y 4 samples were estimated to be 2.31 and 2.35 Å, respectively, by the curve-fitting method. Y atoms in the tetragonal zirconias seem to locate at seven-fold coordination sites, judging from the atomic distances. The average Y-cation distances for Y 6 and Y 4 samples were calculated to be 3.70 and 3.73 Å, respectively. They are longer than the average cation-cation distances calculated from the lattice dimensions, but shorter than the average Y-Y distance of 3.77 Å in the  $Y_2O_3$  crystals. A  $Zr_7Y_2O_7$  cluster was proposed as a model for local structures around  $Y^{3+}$  ions. (Edited author abstract) 25 refs. In Japanese.

Morikawa, Hideki (Tokyo Inst of Technology, Yokohama, Jpn); Shimizugawa, Yutaka; Marumo, Fumiaki; Harasawa, Takeshi; Ikawa, Hiroyuki; Tohji, Kazuyuki; Udagawa, Yasuo. *Yogyo Kyokai Shi* v 96 n 3 1988 p 253-258.

**089464 EFFECTS OF HIGH-TEMPERATURE-AND HIGH-PRESSURE-WATER ON THE LOW**

**TEMPERATURE DEGRADATION BEHAVIOUR OF Y-TZP.** The effects of high-temperature (200°-800°C)- and high-pressure (5 or 100 MPa)-water on the low-temperature degradation behavior of Y-TZP were investigated. Tetragonal (t) to monoclinic (m) transformation is markedly accelerated by the existence of water, under the hydrothermal condition at 200°-300°C, the surface of the specimen is spalled by the stress accompanied by the expansion of t-m transformation. The spalled layers and the surfaces of the unspalled bulk specimen consist of almost m-phase ( $\approx 90$  vol%). From SEM observation on these specimens, large cracks occurred from the corner of the specimen by the stress concentration, and then they propagated parallelly to the surface of the specimen and caused the spalling. (Edited author abstract) 17 refs. In Japanese.

Yoshimura, Masahiro (Tokyo Inst of Technology, Yokohama, Jpn); Noma, Tatsuo; Kawabata, Katsuichi; Somya, Shigeyuki. *Yogyo Kyokai Shi* v 96 n 3 1988 p 265-270.

**089465 FRACTURE BEHAVIOR OF  $Y_2O_3$  DOPED TETRAGONAL ZIRCONIA POLYCRYSTALS.** This paper discusses the relationships between some mechanical properties and fracture behavior in Y-TZP. Test specimens of Y-TZP were prepared by sintering powder produced by the solution technique, and their mechanical properties were measured and the stress-induced transformation on the fracture surface was analysed by Raman spectroscopy. The monoclinic phase ratio on the fracture surface was correlated with bending strength but not with the critical stress intensity factor. A distinct difference was observed in the morphology of the fracture surface between specimens with strength higher and lower than 80 kg/mm<sup>2</sup>. (Edited author abstract) 14 refs. In Japanese.

Ogata, Tomohiko (Toray Industries Inc, Otsu, Jpn); Kihara, Masahiro; Nakamura, Kouji; Kobayashi, Keisuke. *Yogyo Kyokai Shi* v 96 n 3 1988 p 310-316.

**089466 EFFECT OF HIGH PRESSURE TREATMENT ON THE MECHANICAL PROPERTIES OF Y-TZP.** TZP (tetragonal zirconia polycrystal), has a higher toughness than pure  $ZrO_2$ . In the present work,  $Y_2O_3$ -doped TZP (Y-TZP) was treated at high pressure and the mechanical properties (hardness and toughness) were examined. The volume fraction of the monoclinic phase ( $V_m$ ) was about 20%; however, the  $V_m$  of the high pressure treated specimens (except the specimens treated at room temperature) was low, e.g. 7% for the specimen treated at 5 GPa, 1400°C. Therefore, the effect of the stress-induced transformation did not contribute to the toughening. X-ray diffraction analysis showed that residual stress accumulated in the tetragonal lattice after the high pressure treatment. The residual (compressive) stress could be considered an agent of the toughness improvement. 13 refs.

Noma, T. (Tokyo Inst of Technology, Yokohama, Jpn); Sawaoka, A.B.; Yoshimura, M.; Somya, S. *J Mater Sci Lett* v 7 n 3 Mar 1988 p 212-214.

**089467 OBTENTION OF Y-TZP WITH TRANSFORMABLE GRAINS AT ROOM TEMPERATURE FOR IMPROVED MECHANICAL PROPERTIES.** The development of engineering ceramics utilizing zirconia relies on the stability of tetragonal precipitates. The stress-induced tetragonal to monoclinic  $ZrO_2$  martensitic transformation is characterized by  $M_s$ , the temperature at which the transformation begins (upon cooling) in the absence of an applied stress. Accordingly, the maximum toughness attainable at room temperature by Y-TZP (tetragonal zirconia polycrystalline stabilized by yttria) will be reached for a value of  $M_s$  close to room temperature. In this paper it is shown how it has been possible to obtain Y-TZP with a martensitic start temperature as low as 50°C. The authors used a fine-grained commercial powder doped with 1.5 and 2 mol%  $Y_2O_3$ . 6 refs.

Bastide, B. (CRICERAM, Jarrie, Fr); Odier, P.; Coutures, J.P. *J Mater Sci Lett* v 7 n 3 Mar 1988 p 289-290.

**089468  $ZrO_2$  TRANSFORMATION TOUGHENING CRITERIA.** Transformation toughening influences toughness by means of  $ZrO_2$  phase transformation in a process zone. The micromechanisms of events occurring prior to the  $ZrO_2$  phase transformation are poorly understood and have not been reported in the literature. This letter elucidates the micromechanisms of phase transformation in the process zone and highlights the criteria that must be compiled with before phase transformation of metastable  $ZrO_2$  particles can be achieved. A suitable matrix for transformation toughening should possess a high yield strength ( $\geq 450$  MPa), a close match in elastic modulus with  $ZrO_2$  and a strong interfacial bond strength or shear strength. 16 refs.

Low, I.M. (Univ of Auckland, Auckland, NZ). *J Mater Sci Lett* v 7 n 3 Mar 1988 p 297-299.

**089469 NATURE AND EFFECTS OF DEFECTS INTRODUCED DURING FABRICATION OF ZIRCONIA ENGINEERING CERAMICS.** Zirconia engineering ceramics are naturally brittle, but have a toughness superior to other ceramic materials. Whereas their toughness can be controlled by both choice of composition and heat treatment, the strength is determined by the flaw size in combination with the toughness. The generation of individual flaws during all stages of the manufacturing process, from powder preparation and compaction by various routes through sintering and final machining, largely determines the final flaw population. Often flaws characteristic of the individual process stages can be identified, and some will be described. Methods for minimising the effectiveness of such flaws will be discussed with a view to optimising mechanical properties. (Author abstract) 13 refs.

Allen, T.M. (British Ceramic Research Ltd, Stoke on Trent, Engl); Birkby, I.; Stevens, R. *Powder Metall* v 31 n 1 1988 p 23-27.

**089470 THERMAL DIFFUSIVITY OF PARTIALLY AND FULLY STABILIZED (YTTRIA) ZIRCONIA SINGLE CRYSTALS.** Laser flash measurement of thermal diffusivity of  $ZrO_2$  single crystals partially and fully stabilized with  $Y_2O_3$  were compared with measurements for polycrystalline cubic  $ZrO_2$ , and single crystals and polycrystals of  $Al_2O_3$  and  $MgAl_2O_4$ . In general, the thermal diffusivities of the  $ZrO_2$  materials examined initially decrease with increasing temperature. (Edited author abstract) 30 refs.

Youngblood, G.E. (MERDI, Butte, MT, USA); Rice, Roy W.; Ingel, Robert P. *J Am Ceram Soc* v 71 n 4 Apr 1988 p 255-260.

**089471 ERRORS IN ELASTIC CONSTANT MEASUREMENTS IN SINGLE CRYSTALS.** A general analysis is presented of the errors involved in calculations of the elastic constants of single crystals from wave speed measurements. Results are presented graphically for the most probable errors, misorientation of the single-crystal samples for the wave speed measurements. Specific numerical results are presented for elastic constants typical of yttria-stabilized zirconia single crystals. (Edited author abstract) 36 refs.

Ingel, Robert P. (US Naval Research Lab, Washington, DC, USA); Lewis, David. *J Am Ceram Soc* v 71 n 4 Apr 1988 p 261-264.

**089472 ELASTIC ANISOTROPY IN ZIRCONIA SINGLE CRYSTALS.** Results are presented for the measured single-crystal elastic constants of yttria-stabilized zirconia, for yttria contents of 1.7 to 20 mol%. The results cover a range of materials which vary from a mixture of monoclinic, tetragonal, and cubic to those which are fully cubic. These single-crystal measurements are used to calculate the bounds on the elastic moduli for polycrystalline materials. Comments are made on the



elastic anisotropy of zirconia relative to a number of other single-crystal ceramics. (Edited author abstract) 43 refs.

Ingel, Robert P. (US Naval Research Lab, Washington, DC, USA); Lewis, David. *J Am Ceram Soc* v 71 n 4 Apr 1988 p 265-271.

**089473 DEHYDRATION OF HYDROUS ZIRCONIA WITH METHANOL.** The washing of hydrous zirconia with alcohols to reduce the incidence of hard agglomerates on subsequent drying is well known. The results of methanol dehydration of hydrous zirconia (zirconium hydroxide),  $[\text{Zr}_2(\mu\text{-OH})_2(\text{OH})_2(\text{H}_2\text{O})_2] \cdot x\text{H}_2\text{O}$ , show that only  $\mu\text{-OH}$  groups are unaffected. This suggests two things: First, the removal of nonbridging hydroxyl groups and water with alcohols such as methanol leads to a reduction/elimination of hard agglomerates. Second, hard agglomerate formation is associated with condensation reactions. (Edited author abstract) 16 refs.

Jones, Stanley L. (Alcan Chemicals Ltd, Buckinghamshire, Engl); Norman, Colin J. *J Am Ceram Soc* v 71 n 4 Apr 1988 p C190-C191.

**089474 TWINNING AND MICROCRACKING ASSOCIATED WITH MONOCLINIC ZIRCONIA IN THE EUTECTIC SYSTEM ZIRCONIA-MULLITE.** Crystallography and morphology of twins and microcracks in the eutectic system mullite-zirconia are discussed in view of the tetragonal-to-monoclinic transformation and associated toughening mechanisms. Specific twin relationships were observed in monoclinic  $\text{ZrO}_2$ . Microdiffraction revealed closely related crystallography of monoclinic twins and microcracks. The number of twin variants depend on the monoclinic  $\text{ZrO}_2$  particle size. A method to calculate twinning shear strain using microcrack morphology is suggested. (Edited author abstract) 8 refs.

Dravid, Vinayak P. (Lehigh Univ, Bethlehem, PA, USA); Notis, Michael R.; Lyman, Charles E. *J Am Ceram Soc* v 71 n 4 Apr 1988 p C219-C221.

**089475 FORMATION OF ZIRCONIA FIBRES ON UNIDIRECTIONAL FREEZING OF A GEL.** A zirconia hydrogel prepared by dialysing  $\text{ZrOCl}_2$  aqueous solution against water buffer was unidirectionally frozen in a cylindrical polyethylene cell which was immersed in a  $-78^\circ\text{C}$  cold bath at various rates. Freezing rate,  $R$ , and temperature gradient,  $G$ , at the frozen gel front were continuously measured during freezing. It was found that zirconia fibers longer than 20 mm are formed when  $G/R = 2$  to  $8^\circ\text{C h cm}^{-2}$ . Either lower or higher  $G/R$  values gave only fragmental zirconia. The results were interpreted in terms of cellular growth of ice crystals. (Edited author abstract) 6 refs.

Kokubo, T. (Kyoto Univ, Uji, Jpn); Teranishi, Y.; Maki, T.; Sakka, S. *J Mater Sci* v 23 n 3 Mar 1988 p 1126-1130.

**089476 RHEOLOGICAL AND TECHNOLOGICAL PROPERTIES OF ZIRCONIA SUSPENSIONS STABILIZED WITH VARIOUS AMOUNTS OF CALCIUM OXIDE.** The authors identified the influence of the phase composition on the nature of the rheological curves. They studied the rheological properties of calcium zirconate and identified the optimum conditions for casting water suspensions. The change in the rheological properties of the suspensions is interpreted from the viewpoint of the magnitude of hydration and kinetically bonded liquid. There is a link between the rheological properties of the heterophase suspensions and the change in  $\zeta$ -potential. The change in the rheological properties of the suspension by means of small amounts of surface active agents of the organic alcohol types in the optimum pH range makes it possible to obtain articles with outstanding properties, including those from compositions containing  $\text{CaO}$  up to calcium zirconate. 13 refs.

Shulik, I.G. (Ukrainian Scientific-Research Inst of Refractories, USSR); Usatkov, I.F.; Alekseenko, A.S.; Kaplan, F.S.; Degtyareva, E.V.; Lisovaya, E.D. *Refractories* v 28 n 9-10 Sep-Oct 1987 p 479-488.

**089477 QUARTZ-ZIRCON UNFIRED REFRACTORIES**

**FOR LINING STEEL TEEMING LADLES.** A composition and method of production of unfired quartz-zircon refractories based on coarse-grained powders of slowly degenerating quartzite and clay-zircon binder with the addition of orthophosphoric acid have been developed. The composition and properties of the refractory provide a resistant monolithic lining with a dense slag-resistant sintered zone. The wear per heat is 1.4-3.1 times less than that of chamotte ladle brick. 8 refs.

Bondar', Yu.D. (All-Union Refractory Inst, USSR). *Refractories* v 28 n 9-10 Sep-Oct 1987 p 513-518.

**089478 PROPERTIES OF THE FLUORITE-TYPE SOLID SOLUTIONS IN THE  $\text{ZrO}_2\text{-HfO}_2\text{-CaO}$  SYSTEM AND MATHEMATICAL PROCESSING OF THE EXPERIMENTAL RESULTS.** The authors determined the X-ray and pycnometric density levels of fluorite-type solid solutions of the  $\text{ZrO}_2\text{-HfO}_2\text{-CaO}$  system. It is shown that for the solid solutions in the ternary system, electroneutrality of the lattice is retained during the substitution of the ions of zirconium and hafnium owing to the formation of anion vacancies. The equations of the regression lines were obtained and the correlation coefficients were calculated. These equations describe the linear dependence of the density, coefficient of linear thermal expansion and melting points on the concentration of the additives. 5 refs.

Zoz, E.I. (Ukrainian Scientific-Research Inst of Refractories, USSR); Yakovenko, N.G. *Refractories* v 28 n 9-10 Sep-Oct 1987 p 546-550.

**089479 ACID WASHING OF MILLED STABILIZED ZIRCONIA AND ITS INFLUENCE ON THE PROPERTIES OF CERAMICS.** Ceramics made from tetragonal zirconia possess high toughness and impact strength. The most effective technology for their production is slip casting. The slip is obtained by wet milling of powdered solid solutions based on zirconia in a water medium using steel ballmills followed by solution of the tramp iron in HCl. In this paper the authors studied the influence of the form and amount of acid on the completeness of removing the tramp iron. The most promising of the acids studied is HCl (in respect to density of the slip and strength of the specimens). In order of decreasing effectiveness are acetic, perchloric, nitric, H<sub>2</sub>SO<sub>4</sub> and oxalic acid. 6 refs.

Pliner, S.Yu. (All-Union Research Inst for Nonferrous Metals Powder Engineering, USSR); Komolov, Yu.I.; Kovalenko, K.P.; Ushakova, S.B.; Peichev, V.G.; Polezhaev, Yu.M. *Refractories* v 28 n 9-10 Sep-Oct 1987 p 559-561.

**089480 SINTERING OF 3 MOL%  $\text{Y}_2\text{O}_3\text{-TZP}$  AND ITS FRACTURE AFTER AGEING TREATMENT.** TZP ceramic of 99.7% theoretical density was obtained by pressureless sintering a commercial co-precipitated 3 mol%  $\text{Y}_2\text{O}_3\text{-ZrO}_2$  powder at  $1400^\circ\text{C}$  for 10 h. Fracture surfaces of the aged material revealed that the fracture was typified by an intergranular mode in areas where the phase was mainly tetragonal, whereas the transgranular mode was found predominantly in the area containing more monoclinic phase. Microcracks induced by the (t)  $\rightarrow$  (m) transformation provided short paths for water to accelerate the property degradation of TZP on low-temperature ageing in a humid atmosphere. (Author abstract) 29 refs.

Chen, San-Yuan (Industrial Technology Research Inst, Chung, Taiwan); Lu, Hong-Yang. *J Mater Sci* v 23 n 4 Apr 1988 p 1195-1200.

**089481 TRANSFORMATION ZONE SHAPE IN CERIA-PARTIALLY-STABILIZED ZIRCONIA.** Observations of the steady-state transformed zone around a quasistatically grown crack in Ce-TZP are reported for various temperatures between  $-40$  and  $100^\circ\text{C}$ . At room temperature, the zone length ahead of the crack is  $200\text{ }\mu\text{m}$ , which is larger than the zone height of  $40\text{ }\mu\text{m}$ . At lower temperatures, shear bands emanating from the crack tip extend to a few millimeters at the lowest temperature investigated ( $-40^\circ\text{C}$ ). A modification of the DBCS model of plastic yielding is presented using a collinear array of

half-lines of strain to represent the room temperature transformed zone. The shear component of the transformation strain does not affect the toughening due to such collinear zones. Estimates of the critical transformation stress and volume fraction transformed compare favourably with experimental data. Some implications for the modelling of transformation-induced plasticity are briefly discussed. (Edited author abstract) 29 refs.

Rose, L.R.F. (Aeronautical Research Lab, Melbourne, Aust); Swain, M.V. *Acta Metall* v 36 n 4 Apr 1988 p 955-962.

**089482 PREPARATION AND THERMAL EVOLUTION OF SOL-GEL DERIVED TRANSPARENT  $\text{ZrO}_2$  AND  $\text{MgO-ZrO}_2$  GEL MONOLITH.** Transparent gel monoliths of pure and  $\text{MgO}$ -doped zirconia having dopant concentrations in the range 0 to 15 mol% were prepared by chemical polymerization of zirconium n-propoxide and magnesium acetate tetrahydrate using 2-methoxy ethanol as solvent. The thermal evolution was studied by differential thermal analysis, X-ray diffraction and transmission electron microscopy. The crystallization of pure and doped zirconia gels occurred in the temperature range  $360$  to  $450^\circ\text{C}$ . The first crystalline phase to appear is tetragonal for pure and 2 mol% doped zirconia and cubic for 3 to 15 mol% doped samples. Both crystallization and decomposition temperatures increase with increasing dopant concentration, approaching a saturation value for 10 mol% doped samples. Transformation of the cubic to the monoclinic phase takes place via a metastable tetragonal phase. A linear relationship between the lattice parameter of cubic zirconia and  $\text{MgO}$  concentration has been established. X-ray diffraction studies have also revealed that the entire amount of  $\text{MgO}$  used in preparing doped zirconia gels remains in a single  $\text{MgO-ZrO}_2$  crystalline phase formed initially by thermal treatment. (Author abstract) 42 refs.

Kundu, P. (Central Glass & Ceramic Research Inst, Calcutta, India); Pal, D.; Sen, Suchitra. *J Mater Sci* v 23 n 5 May 1988 p 1539-1546.

**089483 MECHANICAL PROPERTIES AND MICROSTRUCTURES OF CO-PRECIPITATION DERIVED TETRAGONAL  $\text{Y}_2\text{O}_3\text{-ZrO}_2\text{-Al}_2\text{O}_3$  COMPOSITES.**  $\text{Y-TZP-Al}_2\text{O}_3$  specimens (2.5 mol%  $\text{Y}_2\text{O}_3\text{-ZrO}_2$  and 5 to 30 wt%  $\text{Al}_2\text{O}_3$ ) were prepared from coprecipitated powders and their mechanical properties were studied. The addition of alumina improves the density after sintering at  $1500^\circ\text{C}$  and reduces the degradation of their densities due to porosity formation when the materials are sintered above  $1500^\circ\text{C}$ . Near theoretical density could be achieved for most of the samples after HIPing at  $1500^\circ\text{C}$  for  $\frac{1}{2}$  h at 200 MPa pressure. The fracture strength of the HIPed specimens was in the range 2.0 to 2.4 GPa and the stress intensity factor was in the range 3.5 to 6.0  $\text{MPa m}^{1/2}$ . The mechanical strength was not degraded seriously after autoclaving in water at  $175^\circ\text{C}$  for 24 h. The surface layer of transformed monoclinic zirconia was less than  $70\text{ }\mu\text{m}$  thick even after autoclaving at  $175^\circ\text{C}$  for 5 days. (Author abstract) 32 refs.

Rajendran, S. (CSIRO, Clayton, Aust); Swain, M.V.; Rossell, H.J. *J Mater Sci* v 23 n 5 May 1988 p 1805-1812.

**089484 PREPARATION OF  $\text{ZrO}_2\text{-Y}_2\text{O}_3\text{-Fe}_2\text{O}_3$  FILMS BY A RI-CO-SPUTTERING METHOD.** The single monoclinic and tetragonal phase appeared for  $<0.2$  mol percent and  $>3.6$  mol percent ( $\text{Y}_2\text{O}_3\text{-Fe}_2\text{O}_3$ ), respectively. The monoclinic and tetragonal mixed phase with the same ( $\text{Y}_2\text{O}_3\text{-Fe}_2\text{O}_3$ ) content appeared for 0.2-3.6 mol percent ( $\text{Y}_2\text{O}_3\text{-Fe}_2\text{O}_3$ ). The single monoclinic and tetragonal phase were stable during aging between  $673\text{-}1473\text{ K}$  in air. In the mixed phase films, the tetragonal phase transformed isothermally to the mono-



clinic phase without ( $Y_2O_3 + Fe_2O_3$ ) content change during aging between 1073-1473 K in air. (Edited author abstract). 6 Refs. In Japanese.

Shigematsu, Toshihiko; Narita, Masaki; Nakanishi, Norihiko. *J Jpn Soc Powder Powder Metall* v 35 n 3 Apr 1988 p 205-207.

**089485 PREPARATION OF FINE COMPOSITE POWDER OF MULLITE-ZIRCONIA FROM METAL ALKOXIDES.** A mullite precursor was prepared by partial hydrolysis of metal alkoxides and mixed with zirconium alkoxide to yield homogeneous and fine mullite-zirconia composite powder with a mean particle size of about 60 nm at 1200°C. Tetragonal zirconia was identified by X-ray diffraction in the temperature range from 1200 to 1700°C. The article discusses the surface energy effect and the constraint of the rigid mullite-matrix. (Edited author abstract). 10 Refs. In Japanese.

Suzuki, Hisao; Nagata, Hiromitsu; Suyama, Yoko; Saito, Hajime. *J Jpn Soc Powder Powder Metall* v 35 n 3 Apr 1988 p 211-214.

**089486 FORMATION OF A ZINC OXIDE/YTTRIA-STABILIZED ZIRCONIA INTERFACE.** Zinc oxide was deposited on the (111) face of an yttria-stabilized zirconia single crystal using the chemical vapor phase method. Zinc vapor was obtained by reducing polycrystalline ZnO in hydrogen at 1200°C. The deposition of the ZnO was accomplished by the reoxidation of zinc vapor at temperatures of 1300° to 1345°C. (Author abstract). 2 Refs.

Schneider, Susan C. (Marquette Univ, Milwaukee, WI, USA); Seitz, Martin A.; Choudhury, Apurba. *J Am Ceram Soc* v 71 n 7 Jul 1988 p C.321-C.322.

**089487 DOMAIN SWITCHING AS A TOUGHENING MECHANISM IN TETRAGONAL ZIRCONIA.** Evidence for a toughening contribution from domain switching, a deformation mode akin to twinning, has been sought in uniaxial tension and compression, biaxial compression, and on the fracture surfaces of several tetragonal zirconia polycrystalline (TZP) ceramics. Only in biaxial compression was domain switching found. In other cases, textures of both the tetragonal and monoclinic phases were due to stress coupling with transformation shear strain. The lower bound of the critical stress for domain switching is placed at the bend strength of TZP, which can exceed 1000 MPa. Although thermal activation may lower the critical stress sharply, at lower temperatures, domain switching is not likely to be an important toughening mechanism. (Author abstract). 23 Refs.

Li, Bao-Shun (Univ of Michigan, Ann Arbor, MI, USA); Cherng, Jyh-Shiarn; Bowman, Keith J.; Chen, I-Wei. *J Am Ceram Soc* v 71 n 7 Jul 1988 p C.362-C.364.

**089488 TIME-DOMAIN SPECTROSCOPY.** A method for investigating the properties of YSZ by time-domain spectroscopy is described. Simple calculation shows that there are cases where this spectroscopy can distinguish processes not separable by classical Baerle impedance spectroscopy. Several measurements were performed to demonstrate the ability of this method to investigate the electro-physical properties of YSZ. (Author abstract). 4 Refs.

Hrobar, M. (Acad of Sciences, Bratislava, Czech); Travnec, I. *Phys Status Solidi A* v 107 n 1 May 1988 p 235-238.

**089489 BEHAVIOUR OF  $ZrO_2$  IN  $Y_2O_3-Al_2O_3-SiO_2$  GLASSES.** The behavior of zirconia in yttria-alumina-silica glasses has been studied as a precursor to the preparation of glass ceramics. Heat treatment at lower temperatures results in reduction of the yttria content of the zirconia phase often accompanied by phase transformation. It is possible to retain up to 100 percent of transformable tetragonal zirconia in the product by careful selection of the starting yttria content and the quenching treatment. (Edited author abstract). 13 Refs.

Cheng, Y. (Univ of Newcastle upon Tyne, Newcastle

upon Tyne, Engl); Thompson, D.P. *Br Ceram Trans J* v 87 n 3 May-Jun 1988 p 107-110.

**089490 MODIFICATION OF INDENTATION CRACK IN TZP CERAMICS BY THERMAL TREATMENT.** Crack healing and crack tip rounding can occur if the indented specimens are treated above the  $ZrO_2(t) \rightarrow ZrO_2(m)$  transformation temperature therefore fracture strength recovery can be achieved. The mechanisms responsible for the crack healing and crack tip rounding are suggested to include both deformation and diffusion at the treatment temperature. The grain rearrangement caused by the  $ZrO_2(m)$  YLD  $ZrO_2(t)$  transformation in the crack opening process zone may also be responsible for crack healing and crack tip rounding during thermal treatment. The transformation-induced compressive stress is thought to be released during the annealing and this may have a negative effect on recovery of fracture strength. 21 Refs.

Wang, J. (Univ of Leeds, Leeds, Engl); Stevens, R. *J Mater Sci Lett* v 7 n 6 Jun 1988 p 560-562.

**089491 ROLE OF INTERFACE-CONTROLLED DIFFUSION CREEP ON SUPERPLASTICITY OF YTTRIA-STABILIZED TETRAGONAL  $ZrO_2$  POLYCRYSTALS.** In order to identify the deformation mechanism of superplasticity in Y-TZP, deformation parameters were determined by tension and tensile creep tests. This letter presents a model in which it is assumed that superplasticity of fine-grained materials is related to interface-controlled diffusion creep, while materials with a large grain size are deformed by Nabarro-Herring creep. The material was fabricated by sintering coprecipitated  $ZrO_2$  powder containing 2 mol percent  $Y_2O_3$ . If the model is correct, pure diffusional creep will be observed in the limited case of large grain size or in the case of very slow cation diffusivity. The effective lattice diffusivity for creep had a value of  $1.88 \times 10^{-11} \text{ cm}^2 \text{ sec}^{-1}$  at 1450°C. 23 Refs.

Wakai, Fumihiko (Government Industrial Research Inst, Nagoya, Jpn); Nagono, Takayuki. *J Mater Sci Lett* v 7 n 6 Jun 1988 p 607-609.

**089492 SUPERPLASTIC PROPERTIES OF A FINE-GRAINED YTTRIA-STABILIZED TETRAGONAL POLYCRYSTAL OF ZIRCONIA.** Yttria stabilized tetragonal Zirconia polycrystal, Y-TZP, was subjected to high temperature tensile tests in a vacuum ( $10^{-3}$  Pa). Superplasticity in fine-grained Y-TZP, as first reported by F. Wakai et al. has been demonstrated to be reproducible. In addition, a high elongation value of 350 percent has been obtained at 1550°C. The microstructure of the Y-TZP appears to be stable at 1450°C but grain growth takes place in specimens tested at 1550°C. 12 Refs.

Nieh, T.G. (Lockheed Missiles & Space Co, Palo Alto, CA, USA); McNally, C.M.; Wadsworth. *Scr Metall* v 22 n 8 Aug 1988 p 1297-1300.

**089493 STABILIZATION OF ZIRCONIA SINTERED WITH TITANIUM.** Electron and X-ray diffraction studies show that zirconia sintered with 5 to 15 mol% titanium under a vacuum of  $10^{-1}$  to  $10^{-2}$  torr was partially stabilized as cubic and tetragonal phases, whose amounts increase with increasing Ti content. The stabilization of  $ZrO_2$  is due to the dissolution of TiO which forms as a second phase in the sintered specimen. The grain size of  $ZrO_2$  decreases with increase in Ti. (Edited author abstract). 17 Refs.

Lin, C.L. (Nat'l Sun Yat-Sen Univ, Kaohsiung, Taiwan); Gan, D.; Shen, P. *J Am Ceram Soc* v 71 n 8 Aug 1988 p 624-629.

**089494 TRANSFORMATION PLASTICITY OF  $CeO_2$ -STABILIZED TETRAGONAL ZIRCONIA POLYCRYSTALS: II, PSEUDOELASTICITY AND SHAPE MEMORY EFFECT.** A macroscopic shape memory effect is demonstrated by first deforming a  $CeO_2$ -stabilized tetragonal zirconia polycrystal ( $Ce$ -TZP) between the  $M_b$  and  $A_b$  temperatures and then recovering the shape changed by heating above  $A_b$ . Shape changes

effected above  $A_b$  are immediately recoverable during unloading, giving rise to a pseudoelastic behavior. Deformation texture is reversible when the shape strain recovers. The operation of pseudoelasticity and shape memory effect is rationalized in terms of martensitic nucleation statistics, the stability of thermoelastic martensite, and internal stresses at the martensitic interface. The implications on transformation plasticity and transformation toughening are explored. (Edited author abstract). 32 Refs.

Reyes-Morel, Patricio E. (Univ of Michigan, Ann Arbor, MI, USA); Cherng, Jyh-Shiarn; Chen, I-Wei. *J Am Ceram Soc* v 71 n 8 Aug 1988 p 648-657.

**089495 IN SITU MARTENSITIC TRANSFORMATION IN A TERNARY  $MgO-Y_2O_3-ZrO_2$  ALLOY: I, TRANSFORMATION IN TETRAGONAL  $ZrO_2$  GRAINS.** The martensitic transformation in tetragonal  $ZrO_2$  grains in a ternary  $MgO-Y_2O_3-ZrO_2$  alloy has been studied using in situ observations in the transmission electron microscope. Transformation occurred by the nucleation and growth of monoclinic laths; thermoelastic equilibrium can be maintained at different extents of transformation by continuously varying the applied stress. The product phase was always twinned. (Edited author abstract). 30 Refs.

Lee, Ran-Rong (Case Western Reserve Univ, Cleveland, OH, USA); Heuer, Arthur H. *J Am Ceram Soc* v 71 n 8 Aug 1988 p 694-700.

**089496 IN SITU MARTENSITIC TRANSFORMATION IN A TERNARY  $MgO-Y_2O_3-ZrO_2$  ALLOY: II, TRANSFORMATION IN TETRAGONAL  $ZrO_2$  PRECIPITATES.** The stress-induced martensitic transformation of t- $ZrO_2$  precipitates in a ternary  $MgO-Y_2O_3-ZrO_2$  alloy has been studied in situ in the transmission electron microscope. The transformation occurs autocatalytically and takes place by piecewise growth of two twin-related m- $ZrO_2$  variants. Unloading causes retransformation of partially transformed precipitates. The martensitic transformation in this system is clearly thermoelastic. (Edited author abstract). 29 Refs.

Lee, Ran-Rong (Case Western Reserve Univ, Cleveland, OH, USA); Heuer, Arthur H. *J Am Ceram Soc* v 71 n 8 Aug 1988 p 701-706.

**089497 STRUCTURAL CHANGES BY MECHANICAL AND THERMAL STRESSES OF 2.5-MOL-%  $Y_2O_3$ -STABILIZED TETRAGONAL  $ZrO_2$  POLYCRYSTALS.** Structural changes of 2.5-mol-%  $Y_2O_3$ -stabilized tetragonal  $ZrO_2$  polycrystal fractured surfaces, as well as ground, polished, and annealed surfaces, were studied by X-ray diffraction. Much greater intensity of the (200) tetragonal peak than (002) was found on the thin surface layer of the ground specimen, but not on the fracture surface. The intensity changes were discussed in relation to the toughening mechanism. (Author abstract). 6 Refs.

Kitano, Yukishige (Toray Research Cent Inc, Otsu, Jpn); Mori, Yuuji; Ishitani, Akira; Masaki, Takaki. *J Am Ceram Soc* v 71 n 8 Aug 1988 p C.382-C.383.

**089498 NOVEL STUDIES ON THE THERMOELECTRO-MECHANICAL PROPERTIES OF TANTALA-DOPED ZIROCONIA REFRACTORIES.** Samples of single doped zirconia refractories have been prepared and sintered at different temperatures according to the ceramic procedure. Comprehensive measurements have been made on these samples including dynamic hardness and DC-electrical conductivity before and after gamma irradiation ( $\sim 26 \times 10^7$  rad). Results obtained have been explained, interpreted, correlated and discussed in detail as functions of mole% tantalum and sintering temperature. (Author abstract). 7 Refs.

Ewaide, M.A. (Al-Monoufia Univ, Egypt); Abou Sekina, M.M.; Ebrahim, E.M.; Al-Adawy, A.A. *Polym Degradation Stab* v 21 n 3 1988 p 227-235.



**089499 STRUCTURE IN GROUND SURFACES OF  $Y_2O_3$ -DOPED TETRAGONAL ZIRCONIA POLYCRYSTALS.** The tetragonal zirconia phase showed a remarkable preferred orientation by grinding, in addition to the formation of both monoclinic and rhombohedral phases through phase transformation under stress. The preferred orientation of the tetragonal phase consisted of the plane (001) parallel to the grinding surface can be explained in terms of the ferroelastic behavior based on the switching of the crystallographic axis  $[100] \rightleftharpoons [001]$  of the tetragonal phase. By thermal annealing at temperatures up to 1073 K, both the monoclinic and rhombohedral phases disappeared. The preferred orientation of the tetragonal phase, however, has remained even after annealing at temperatures up to 1473 K. The formation of (001)  $[110]$  grinding texture specified in terms not only of the plane (001) parallel to the grinding surface but also of the direction  $[110]$  parallel to the grinding direction was revealed through the X-ray pole figure measurements. (Edited author abstract). 18 Refs. In Japanese.

Hasegawa, Hideo (Toyota Central Research & Development Lab Inc, Aichi, Jpn). *Nippon Kinzoku Gakkaishi* v 52 n 6 Jun 1988 p 603-608.

**089500 HERSTELLUNG UND EIGENSCHAFTEN VON GASDRUCKGESINTERTEM ZIRKONOXID.** [Fabrication and Material Properties of Gas-Pressure Sintered Zirconia.]. Following calcination in the air, oxide materials that have been post-densified in a carbon atmosphere show a substantial loss in strength compared to non-calcined materials. If post-densification takes place in an oxygen atmosphere, this phenomenon does not take place. The paper investigates the influence of the gas atmosphere (Ar or Ar/ $O_2$ ) on the strength of TZP-ZrO<sub>2</sub> manufactured by means of gas pressure sintering. This method is compared to conventional hot densification processes (sintering, sinter/HIP, hot axial pressing). Samples manufactured by means of the gas sintering process in an Ar/ $O_2$  atmosphere show the highest strength values and very low variations. TT Fabrication and Material Properties of Gas-Pressure Sintered Zirconia. (Author abstract). In German.

Kessel, H.U. (KCE Sondermaschinen GmbH, Roedental, West Ger); Kolaska, H.; Dreyer, K. *Keram Z* v 40 n 6 Jun 1988 p 426-430.

**089501 STRESS-INDUCED TRANSFORMATION DURING COMPRESSION OF  $ZrO_2$ -4 mol%  $Y_2O_3$ .** In order to determine the relation between the stress-induced transformation and the mechanical behavior of PSZ more sensitively, uniaxial compression tests were employed. The stress-strain curves obtained at temperatures from 673 to 773 K are shown. The linearity in the stress-strain relation terminates at about 1.0 percent nominal strain. Over the strain, a peculiar mechanical behavior exhibiting a yield point and subsequent plastic deformation is observed in this temperature range. At temperatures other than in this range, the stress-strain curves retained their linearity up to fracture. 3 Refs.

Shimbo, M. (Kanazawa Inst of Technology, Ishikawa, Jpn); Ueki, M.; Miyano, Y.; Ishihara, S.; Fujita, T. *J Mater Sci Lett* v 7 n 8 Aug 1988 p 877-878.

**089502 SINTERING BEHAVIOUR OF HIGHLY AGGLOMERATED ULTRAFINE ZIRCONIA POWDERS.** The sintering behavior of highly agglomerated ultrafine zirconia powders can be described by a combination of mechanisms such as neck formation and shrinkage, fissure formation and growth, pore growth, grain growth, pore rearrangement shrinkage, and pore entrapment. There exist two optimum sintering temperatures: one is due to the competition between neck formation and shrinkage, fissure formation and pore growth; the other is due to the competition between pore shrinkage and pore entrapment, both resulting from grain growth. It is also found that an increase of green density which is caused either by a different consolidation pressure, a different preparation method, or a different calcination temperature results in a decrease of sintered bulk density. This can be explained by the state of agglomeration and the uniformity of powder packing. (Author abstract). 25 Refs.

Wu, Jenn-Ming (Nat'l Tsing Hua Univ, Hsinchu, Taiwan); Wu, Chih-Hsyong. *J Mater Sci* v 23 n 9 Sep 1988 p 3290-3299.

**089503 ELECTRICAL CONDUCTIVITY OF  $(ZrO_2)_{0.85}(CeO_2)_{0.12}(Y_2O_3)_{0.03}$ .** A number of zirconia-based materials show promise as electrode materials in magneto-hydrodynamic (MHD) generators. As a part of an exploratory program to find suitable materials for graded electrode applications in MHD generators, partially stabilized and fully stabilized sintered ceramic materials were prepared and characterized. The oxygen ion transference number  $t_{ion}(O^{2-})$  and electrical conductivity were measured up to 1670 K in the oxygen partial pressure range 1 to  $10^{-6}$  atm. The activation energies for conduction were determined. The electrical properties are characterized by mixed conduction, ionic and electronic. The observed conductivity data are explained in terms of the defect equilibrium reactions between tetravalent  $Ce^{4+}$  and trivalent  $Ce^{3+}$  ions. (Edited author abstract). 17 Refs.

Patil, D.S. (BARC, Trombay, India); Venkatramani, N.; Rohatgi, V.K. *J Mater Sci* v 23 n 9 Sep 1988 p 3367-3374.

**089504 CHARACTERIZATION OF R.F.-SPUTTERED ZIRCONIA COATINGS.** R.f.-sputtered zirconia coatings with alumina and yttria were characterized by X-ray photoelectron spectroscopy, electron spin resonance and thin film X-ray diffraction. From the X-ray diffraction results, the as-deposited zirconia coatings were found to be amorphous and they remained amorphous after annealing at 1123 K for 15 min. It was deduced from the X-ray photoelectron spectroscopy results that zirconium ions in the amorphous zirconia coating possess a higher net charge than that of ions in ordinary ZrO<sub>2</sub>. Further, the formation of electron-trapped centers was indicated by the observation of an electron spin resonance absorption at  $g = 1.97$ . Crystallized zirconia coatings seem to be less resistant to corrosion than as-deposited zirconia coatings, as inferred from acoustic emission analysis. It was found that crystallization leads to a marked decrease in the loss tangent of the sputtered zirconia coating. (Author abstract) 14 refs.

Iwamoto, Nobuya (Osaka Univ, Ibaraki, Jpn); Makino, Yukio; Kamai, Masayoshi. *Thin Solid Films* v 153 Oct 26 1987, Pap Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 233-242.

**089505 TOTAL ENERGY CALCULATIONS FOR  $ZrO_2$ .** Total energy calculations are presented for zirconia in its tetragonal and cubic structure. The results show that the phase transition from tetragonal to cubic is driven by the thermal motion of the oxygen atoms. The theoretical value of the cohesive energy is in good agreement with experiment. The electric field gradients are in agreement with the experimental values obtained from Perturbed Angular Correlation measurements. This indicates that the lattice distortion around the probe tantalum nucleus is small. (Author abstract) 16 refs.

Jansen, H.J.F. (Oregon State Univ, Corvallis, OR, USA); Gardner, J.A. *Physica B & C* v 150 n 1-2 May 1988, Proc of the Int Conf on Electr Struct and Phase Stab in Adv Ceram, Argonne, IL, USA, Aug 17-19 1987 p 10-18.

**089506 STABILITY LIMITS IN THE MONOCLINIC-TETRAGONAL TRANSFORMATIONS OF ZIRCONIA.** A variety of experimental data obtained from single crystals and powders of zirconia has been examined to obtain the stability limits of the tetragonal and monoclinic phases. These limits are used to delineate the possible modes of transformation at different temperatures in the light of a nonclassical theory of nucleation. The theory predicts an asymmetric relation between three critical temperatures  $T^*$ ,  $T_0$ , and  $T_c$ . Transformation by nucleation and growth occurs only in the range  $T_0$ - $T_c$  during cooling and in the range  $T^*$ - $T_0$  during heating. Below  $T_0$ , transformation proceeds homogeneously in a manner akin to spinodal decomposition. In the neighborhood of  $T_c$ , the metastable tetragonal phase can have a long lifetime. It is assumed that the driving mechanism of transformation comes from the partial softening of a

particular shear mode of lattice vibration. An indirect evidence in support of this assumption comes from the linear relationship between the transformation temperature of a zirconia/hafnia solid solution and the reciprocal effective cation mass. (Author abstract) 31 refs.

Garvie, R.C. (CSIRO, Clayton, Aust); Chan, S.-K. *Physica B & C* v 150 n 1-2 May 1988, Proc of the Int Conf on Electr Struct and Phase Stab in Adv Ceram, Argonne, IL, USA, Aug 17-19 1987 p 203-211.

**089507 POLYMORPHIC TRANSFORMATIONS OF ZIRCONIA.** The polymorphic transformations of zirconia are elucidated as displacive transformations originating from the softening or partial softening of appropriate elastic constants. From expansions of the free energy in powers of symmetry-adapted homogeneous strains, all the possible symmetry and thermodynamically allowed transformation paths starting from the cubic and tetragonal parent phases are obtained. It is found that transformations that start from the cubic parent phase involve cubic invariants and are necessarily of a discontinuous (first order) nature because of symmetry. However, transformations that start from the tetragonal parent phase do not involve cubic invariants. They can be of a discontinuous or continuous (higher than first order) nature depending on whether the fourth order invariants are negative or positive. It is also found that the orientations of the different variants of each product phase and the stress-free coherent interfaces between them are all predetermined by the symmetry of the starting parent phase. (Author abstract) 18 refs.

Chan, S.-K. (Argonne Natl Lab, Argonne, IL, USA). *Physica B & C* v 150 n 1-2 May 1988, Proc of the Int Conf on Electr Struct and Phase Stab in Adv Ceram, Argonne, IL, USA, Aug 17-19 1987 p 212-222.

**089508 ZIRCONIA DYNAMICS STUDIED BY PAC SPECTROSCOPY.** Relaxation of  $^{181}\text{Ta}$  nuclei due to diffusion of oxygen vacancies in cubic zirconia/yttria has been measured by perturbed angular correlation spectroscopy. The activation energy of the vacancy jump rate is found in a temperature range above 750°C and is in reasonable agreement with the activation energy of ionic conduction. Preliminary results of a  $^{111}\text{In}/^{111}\text{Cd}$  perturbed angular correlation investigation of high-temperature monoclinic and tetragonal zirconia are also reported. (Author abstract) 19 refs.

Gardner, John A. (Oregon State Univ, Corvallis, OR, USA); Jaeger, H.; Su, H.T.; Warnes, W.H.; Haygarth, John C. *Physica B & C* v 150 n 1-2 May 1988, Proc of the Int Conf on Electr Struct and Phase Stab in Adv Ceram, Argonne, IL, USA, Aug 17-19 1987 p 223-229.

**089509 EXAFS STUDY OF YTTRIA STABILIZED CUBIC ZIRCONIA.** EXAFS (Extended X-ray Absorption Fine Structure) studies of cubic  $(ZrO_2)_{1-x}(Y_2O_3)_x$  are reported for the concentration range  $0.09 < x < 0.4$ . When the trivalent Y ions are substituted for the tetravalent Zr ions,  $O^{2-}$  vacancies are also introduced for charge compensation. However, the distribution of the  $O^{2-}$  vacancies in the structure is not known. In this EXAFS study, systematics of disorder and vacancy distribution on the oxygen sublattice are monitored from both the Zr and Y sites as Y, and hence  $O^{2-}$  vacancy content, is varied. It is observed that oxygen vacancies occur adjacent to both Y and Zr ions but preferentially in proximity to Zr. (Author abstract) 18 refs.

Veal, B.W. (Argonne Natl Lab, Argonne, IL, USA); McKale, A.G.; Paulikas, A.P.; Rothman, S.J.; Nowicki, L.J. *Physica B & C* v 150 n 1-2 May 1988, Proc of the Int Conf on Electr Struct and Phase Stab in Adv Ceram, Argonne, IL, USA, Aug 17-19 1987 p 234-240.

## REFRACTORY METALS

### Applications

**089510 TUNGSTEN AND OTHER REFRACTORY METALS FOR VLSI APPLICATIONS II, PROCEEDINGS OF THE 1986 WORKSHOP.** The proceed-



ings contains 46 papers. The papers are grouped under the following headings: practical and device considerations for refractory metal usage in VLSI; selective tungsten-selectivity loss and nucleation on insulators; CVD tungsten-fundamental reaction and growth studies; recent CVD process and equipment developments; blanket CVD tungsten-metal gate applications and adhesion studies; chemical vapor deposition of molybdenum from MoF<sub>6</sub>; characteristics of CVD tungsten films in device structures; properties of refractory metals deposited by sputtering or evaporation; reactive ion etching of refractory metal films; and recent new papers. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10611 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Broadbent, Eliot K. (Ed.) (Signetics Corp., Philips Research Lab Sunnyvale, Sunnyvale, CA, USA). *Tungsten and Other Refrac Met for VLSI Appl II, Proc of the 1986 Workshop, Palo Alto, CA, USA, Nov 12-14 1986* Publ by Materials Research Soc, Pittsburgh, PA, USA, 1987 426p.

## Corrosion Resisting

**089511 RESISTANCE A LA CORROSION DES ALLIAGES DE TITANE, DE ZIRCONIUM OU DE TANTALE DANS LES MILIEUX CHLORES OU CHLORURANTS. CARACTERES PRINCIPAUX.** [Corrosion Resistance of Titanium, Zirconium or Tantalum Alloys in Chlorinated or Chloridizing Media. Key Features]. With respect to their general corrosion resistance, the three materials titanium, zirconium and tantalum can be classed upwards in that order. However, titanium (for oxidizing environments) and zirconium (for reducing environments) are complementary, whereas zirconium alone out of the three metals is able to resist alkaline solutions. These different behaviors are illustrated schematically in a diagram in which the range of application of each material is outlined. The beneficial effects of alloying additions in the case of titanium are shown. Economically, the use of these materials in the higher price bracket is justified in aggressive environments whenever a reduction in maintenance overhead, continuous production, productivity gains through higher operating temperature or pressure, and high purity products obtained under top safety conditions are management priorities. (Edited author abstract) In French. 45 refs.

Tricot, Roland (Cie Compagnie Europeenne du Zirconium Cezus). *Mater Tech* v 75 n 7-8 Jul-Aug 1987 p 297-307.

**089512 L'UTILISATION DES ACIERS ET ALLIAGES REFRACTAIRES DANS L'INDUSTRIE PETROCHIMIQUE.** [Use of Refractory Steels and Alloys in the Petrochemical Industry]. After a brief review of some of the high-temperature corrosion problems encountered in the petrochemical industry, the various factors which determine the resistance to these types of attack are considered. The importance of establishing the real service conditions through the use of constitutive and phase stability diagrams is emphasized. These considerations are used both to interpret empirically established material selection criteria and to indicate possible paths for future alloy development. (Edited author abstract) In French. 17 refs.

Rouby, M. (Imphy SA); Davidson, J.H. *Mater Tech* v 75 n 7-8 Jul-Aug 1987 p 315-318.

## Creep

**089513 SINGLE CRYSTALS OF REFRACTORY METALS.** Molybdenum (Mo) and tungsten (W) are greatly expected as a superior heat-resistant material in the fields of energy, aerospace, intelligence and electronics allied industries. However, these materials suffer from brittleness near room temperature after recrystallization or welding. It is generally accepted that such an embrittlement is due to the existence of grain boundaries. Thereby, a single crystal would basically solve the problem concerning the intergranular brittleness. There are several methods to prepare a single crystal of refractory metal:

electron-beam floating zone method and strain-annealing method. In this work, first, essential factors for growth techniques of a large-scale single crystal of refractory metal were clarified. Secondly, the mechanical properties, particularly low-temperature ductility and creep resistance of the single crystal were characterized. 9 refs.

Hiraoka, Yutaka; Fujii, Tadayuki. *Trans Natl Res Inst Met (Tokyo)* v 30 n 1 Mar 1988 p 31-32.

**Failure** See MOLYBDENUM TUNGSTEN ALLOYS—Fracture.

**Fatigue** See METALS AND ALLOYS—Heat Resisting.

## Impurities

**089514 MULTIELEMENT ULTRATRACE ANALYSIS OF MOLYBDENUM WITH HIGH PERFORMANCE SECONDARY ION MASS SPECTROMETRY.** Electron beam melting has been used to obtain ultrapure refractory metals that are gaining importance in metal oxide semiconductor-very large scale integration (MOS-VLSI) processing technology, fusion reactor technology, or as superconducting materials. Although the technology of electron beam melting is well established in the field of production of very clean refractory metals, little is known about the limitations of the method because the impurity level of the final products is frequently below the detection power of common methods for trace analysis. A suitable method for quantitative multielement ultratrace bulk analysis of molybdenum with SIMS has been developed. Detection limits of the analyzed elements from 10<sup>-7</sup> g/g down to 10<sup>-12</sup> g/g have been found. Additional information about the distribution of the trace elements has been accumulated. (Edited author abstract). 17 Refs.

Virag, A. (Univ of Technology, Vienna, Austria); Friedbacher, G.; Grasserbauer, M.; Ortner, H.M.; Wihartitz, P. *J Mater Sci* v 3 n 4 Jul 8 1988 p 694-704.

## Industrial Applications

**089515 REFRACTORY METALS: APPLICATIONS IN THE GLASS AND CERAMICS INDUSTRIES.** Refractory metals and, in particular, molybdenum and tungsten, are increasingly being used for the melting, homogenization, transportation and processing of glass and ceramic wool, shaped parts, tubes etc. Characteristics such as high melting point, good corrosion and creep resistance, high hot strength, good workability and machinability make these materials eminently suitable for such applications. This paper describes the refractory metal applications in glass and ceramic industries. (Edited author abstract)

Schider, Siegfried (Metallwerk Plansee GmbH, Reutte/Tirol, Austria). *Glass* v 65 n 5 May 1988 p 185-187.

## Ion Implantation

**089516 STUDY OF THE SURFACE LAYERS OF GROUP IVA METALS WITH IMPLANTED SILICON IONS.** The implantation of Si<sup>+</sup> ions with energies of 30 or 16 keV into Ti, Zr and Hf at room temperature leads to amorphization of the surface layer of the metal. During annealing at 870 K an amorphous surface layer of hafnium and titanium with implanted silicon ions, owing to a reaction with oxygen in the residual atmosphere, is converted into an amorphous solid solution of monoclinic HfO<sub>2</sub> or TiO<sub>2</sub> with Si, which prevents further oxidation of the metal. The layers of amorphous alloy are thermally stable up to 1270 K. In the case of annealing of Zr with implanted Si ions at a temperature no higher than 870 K oxidation of the surface amorphous layer in a residual oxygen atmosphere occurs, as well as crystallization of the layer to ZrO<sub>2</sub>. Analogous phenomena are observed in the case of hafnium, into which oxygen ions or a small dose of silicon ions are implanted. 9 refs. In Russian.

Kovneristiy, Yu.K.; Vavilova, V.V.; Krasnopertsev, V.V.; Galkin, L.N.; Kudyshev, A.N.; Klechkovskaya, V.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p

932-936.

**Processing** See REFRACTORY MATERIALS—Applications.

**Recovery** See WASTEWATER—Treatment.

## Reviews

**089517 RECENT ADVANCES IN AEROSPACE REFRACTORY METAL ALLOYS.** Refractory metals are prime candidates for many high temperature aerospace components because of their high melting points and inherent creep resistance. The use of refractory metals is often limited, however, by poor room temperature properties, inadequate oxidation resistance at elevated temperatures, or difficulties associated with joining or welding. Recent advances in the understanding of the role of oxygen in room temperature brittle behaviour problems, especially in molybdenum alloys, are described. The oxidation behaviour of refractory alloys at elevated temperatures in complex environments has also been re-evaluated and a clear understanding of the appropriate environments requiring protective coatings has emerged. Current research is emphasising the development of creep resistance of refractory alloys that are inherently oxidation resistant. The long term creep resistance of refractory alloys has been the subject of research for space nuclear applications and progress in this area is discussed. The effectiveness of carbides in molybdenum and tungsten alloys designed for high temperature creep resistance has been reanalysed. The origins of brittle behaviour in welded alloys are described. Examples are also given of novel solid state joining developments in tungsten and molybdenum alloys below and above their recrystallisation temperatures. Novel developments are underway in particulate refractory metals, specifically encompassing rapid solidification processing. (Edited author abstract). 115 Refs.

Wadsworth, J. (Lockheed Missiles and Space Co, Palo Alto, CA, USA); Nieh, T.G.; Stephens, J.J. *Int Mater Rev* v 33 n 3 1988 p 131-150.

**Sputtering** See CHROMIUM AND ALLOYS—Thin Films.

## Testing

**089518 EFFECT OF TEST TEMPERATURE ON TENSILE AND FATIGUE PROPERTIES OF NICKEL-BASE HEAT-RESISTANT ALLOYS.** A series of tensile and strain controlled low-cycle fatigue tests were conducted at temperatures ranging from RT to 900°C on a nickel-base heat-resistant alloy, Hastelloy XR-II, which is one of the candidate alloys for applications in the process heating high-temperature gas-cooled reactor (HTGR). Fatigue tests at room temperature and all tensile tests were conducted in air, while fatigue tests at and above 400°C were conducted in the simulated HTGR helium environment. In those tests the effect of test temperature on tensile and fatigue properties was investigated. (Edited author abstract) 15 refs.

Tsuji, Hirokazu (JAERI, Tokai-mura, Jpn); Nakajima, Hajime. *J Nucl Mater* v 151 n 1 Dec 1987 p 1-9.

**089519 CRITICAL POINT DATA OF REFRACTORY METALS, ALUMINUM OXIDE AND URANIUM DIOXIDE USING THE HOCH-ARPSHOFFEN METHOD.** The Hoch-Arpschoffen method was used to determine the critical constants of titanium, molybdenum, aluminum oxide and uranium dioxide. In this method, the density of the liquid as a function of the temperature (but not necessarily close to the critical temperature) is required to obtain the critical temperature T<sub>c</sub> and the critical density d<sub>c</sub>. The density of liquid UO<sub>2</sub>, coexisting with gas, was calculated between the melting point and the critical point. (Edited author abstract) 20 refs.

Hoch, Michael (Univ of Cincinnati, Cincinnati, OH, USA). *J Nucl Mater* v 152 n 2-3 May 1988 p 289-294.



Thin Films See SEMICONDUCTING GALLIUM ARSENIDE—Surfaces.

### Transport Properties

**089520 TRANSPORT IN REFRACTORY METALS AND THEIR INTERACTION WITH  $\text{SiO}_2$ : COMPARISON OF TUNGSTEN AND MOLYBDENUM.** We have investigated sputtered and electron-beam-evaporated thin films of tungsten and molybdenum deposited onto  $100 \text{ Å}$   $\text{SiO}_2$ . These two refractory metals have comparable room temperature resistivities ( $5\text{--}6 \mu\Omega/\text{m}$ ) and a work function at the midgap between  $n^+$  and  $p^+$  polycrystalline silicon. Therefore both can be considered for application as a gate electrode in submicron very large scale integration technology. We have probed their interaction with  $\text{SiO}_2$  using Auger spectroscopy, cross-sectional transmission electron microscopy (CTEM) and with current-voltage (I-V) characteristics of molybdenum and tungsten metal/oxide/semiconductor (MOS) capacitors as a function of the annealing temperature. We have also measured electrical resistivity in the  $4\text{--}300 \text{ K}$  temperature range to ascertain the differences and the similarities between the two. We find that, in terms of resistivity, the difference between the two metals is slight. (Edited author abstract) 16 refs.

Krusin-Elbaum, L. (IBM, Yorktown Heights, NY, USA); Abolfotoh, M.O.; Lin, T.; Ahn, K.Y. *Thin Solid Films* v 153 Oct 26 1987, Pap. Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 349-358.

### Waste Utilization

**089521 PRODUCTION OF ARTIFICIAL TANTALUM CONCENTRATES BY COMPLEX TREATMENT OF WASTES FROM THE REFRACTORY-ALLOY INDUSTRY.** A study is made of the material composition of tantalum intermediate products forming during complex treatment of certain types of Tungsten wastes containing  $0.8$  to  $2\%$  Ta. Artificial tantalum concentrates are a new type of raw material, and a study of the phase distribution of the main components makes it possible to determine ways of treating tantalum-containing cake. (Translated author abstract) In Russian. 6 refs.

Petrova, V.A.; Reznichenko, V.A.; Palant, A.A.; Butakov, L.G.; Stepanova, V.V. *Tsvet Met* v 5 May 1987 p 63-65.

**REFRIGERANTS** See Also CRYOGENICS; FREONS—Thermodynamic Properties; REFRIGERATING MACHINERY—Compressors.

**Ammonia** See Also AMMONIA—Thermal Properties.

**089522 BASIC-2 PROGRAM FOR THE 'PSYCHROMETRIC PROBLEM' OF AMMONIA, IN NEUTRAL GAS ABSORPTION REFRIGERATION UNITS.** The 'psychrometric problem' for small neutral gas absorption refrigeration units concerns among others the determination of the mass fraction of the  $\text{NH}_3/\text{H}_2$  gas mixture, when the 'dry' and 'wet bulb' temperatures are known. By the present work, the values of the mass fraction for various combinations of 'dry' and 'wet bulb' temperatures are computed and the relevant program codes are given. The pressure range compiles the steps of  $17.5$  bar,  $20$  bar,  $22.5$  bar,  $25$  bar, and  $27.5$  bar, i.e. the usual operating conditions of these units. (Author abstract) 11 refs.

Kouremenos, D.A. (Nat'l Technical Univ of Athens, Athens, Greece); Stegou-Sagia, A. *Adv Eng Software* v 9 n 4 Oct 1987 p 211-217.

### Applications

**089523 UTILISATION DE NOUVEAUX REFRIGERANTS POUR LES POMPES A CHALEUR A HAUTE TEMPERATURE.** [Using New Refrigerants for High Temperature Heat Pumps]. This paper presents experimental results obtained with high temperature heat pumps working with new refrigerants: a pure fluid R142b

and non-azeotropic mixtures of R12 and R114, all these fluids being CFC's. Results are good as far as for R142b experimental results are in good relation with theory and permit to hope for the production of energy at  $95^\circ\text{C}$  in good conditions and for non-azeotropic mixtures, our tests can explain the behavior of these mixture when leakages appear on heat pumps. In French.

Blaise, Jean-Claude (Electricite de France, Fr); Dutto, Thierry. *RGE Rev Gen Electr* n 10 Nov 1987 p 15-19.

### Components

**089524 SOLUBILITY OF REFRIGERATION OIL IN R-22 REFRIGERANT.** This work investigates the influence of distillation range and hydrocarbon composition of oils on their solubility in R-22 refrigerant. The mutual solubilities were determined on measured quantities of oil and refrigerant in a glass ampule with a magnetic stirrer, the ampule being either sealed or closed with a plug. For the investigation of the influence of the hydrocarbon composition of refrigeration oil on its mutual solubility with R-22 coolant, the experimental oil KhM-35 was subjected to adsorptive separation on silica gel, segregating the paraffinic-naphthenic and aromatic hydrocarbons. It is shown that the naphthenic-paraffinic hydrocarbons have the poorest solubility, the aromatic hydrocarbons the best solubility. The oil solubility improves with increasing content of aromatic hydrocarbons in the blend.

Dovgopolyi, E.E. (All-Union Scientific-Research Inst for Petroleum Processing, USSR); Avanesova, A.S.; Potanina, V.A.; Vasil'eva, N.I. *Chem Technol Fuels Oils* v 23 n 7-8 Jul-Aug 1987 p 331-334.

### Composition Effects

**089525 CHOICE OF WORKING FLUIDS FOR NON-AZEOTROPIC MIXED-REFRIGERANTS AIR CONDITIONING SYSTEMS.** Non-azeotropic mixed-refrigerants air conditioning is a potential energy saving process of removing heat from a space. Desirable non-azeotropic mixed refrigerants should possess physical, thermodynamic, and chemical properties which permit their efficient operation in air conditioning systems. In addition to economical considerations, there should be no danger to health in case of their escape due to leaks or other causes in an air conditioning system. These physical, thermodynamic, chemical, economical, safety and specific properties are listed and discussed briefly in this paper. (Author abstract) 6 refs.

Wu, Chih (US Naval Acad, Annapolis, MD, USA). *Energy Convers Manage* v 27 n 4 1987 p 385-387.

### Condensation See Also VAPORS—Condensation.

**089526 CONDENSATION OF REFRIGERANT MIXTURES R22 + R114 INSIDE A HORIZONTAL TUBE.** Experimental study of the condensation of pure and mixed refrigerants of R22 and R114 inside a spirally grooved horizontal tube is carried out for a tube-in-tube counter flow type condenser in the ranges of  $3\text{--}21$  bar of pressure and  $26\text{--}70 \text{ kg/h}$  of mass flow rate. Axial distributions of refrigerant, tube wall and cooling water temperatures, wall heat flux and vapor quality are graphically shown and circumferential distribution of tube wall temperature is also shown. The characteristic of the local Nusselt number depends on the molar fraction, while the average Nusselt number can be correlated well by an equation, which is modified from a previously established equation for pure refrigerants inside a smooth tube. (Author abstract). 19 Refs. In Japanese.

Koyama, Shigeru; Fujii, Tetsu; Miyara, Akio; Takamatsu, Hiroshi; Yonemoto, Kazuo. *Nippon Kikai Gakkai Ronbunshu B Hen* v 54 n 502 Jun 1988 p 1447-1452.

### Energy Conservation

**089527 LE FROID DANS LES SURFACES COMMERCIALES - 2. LES ECONOMIES.** [Cooling of Commercial Surfaces - 2. Savings]. Reduction of energy

costs of a refrigerating unit with a large surface is not a priority task of refrigeration equipment users. Energy costs amount to only  $0.1\text{--}0.4\%$  of the total budget of a supermarket. Nevertheless, considerable savings can often be made. The second part of this investigation discusses the possibilities of reducing consumption costs. The measures that can be implemented to improve the cooling installation are specified, namely: improvement of the final utilization of the cold; improvement of the production and distribution of the cold; recuperation of the heat energy; measures and tests implemented on 2 units of equipment; a freezer and a vertical cabinet. In French.

Labordesque, C. (CoSTIC, Fr); Schann, C. *Promoclim E* (1986) v 18 n 3 May-Jun 1987 p 147-164.

### Evaluation

**089528 THERMODYNAMISCHER VERGLEICH VON KAEITEMITTELN FUER DEN EINSATZ IN WAERMEPUMPEN UND KAEITEMASCHINEN, EINFLUSS DER UNTERKUEHLUNG UND ANSAUGUEBERHITZUNG.** [Thermodynamic Comparison of Refrigerants for Use in Heat Pumps and Refrigerating Machines]. The theoretical cold-vapor machine operation is used as a theoretical reference process of single-stage cold-vapor compression refrigerating machines and heat pumps. Its ratings are smaller than in the Carnot process in conformity with quality levels 'K' and 'H' for refrigerating or heating pump operation. For refrigerants R 13B1, R 602, R 22,  $\text{NH}_3$ , R 12, R 114, R 11 and R 113, these quality levels and the effect of subcooling and suction overheat of refrigerants on the ratings and volumetric refrigerating and heating capacities of the theoretical cold-vapor machine operation are determined and presented for comparisons. Hints at the application of parameters to the real process complete the statements. (Edited author abstract) 7 refs. In German.

Lehnguth, M. (Technische Univ Karl-Marx-Stadt, East Ger). *Luft Kaelte tech* v 23 n 3 1987 p 144-148.

**089529 DES FLUIDES REFRIGERANTS MOINS POLLUANTS: COMMENT? QUAND? [Less Polluting Cooling Fluids: How and When?]** This current report presents the possible solutions in the face of possible governmental regulations on the use of CFC's in the air conditioning and refrigeration industry because of their potential for exhaustion of the ozone layer. The wide range of applications for small quantities of CFC's renders problematical their replacement by other fluids. However, the possibility of mixing the known fluids could result in the identification of fluids possessing the thermodynamic qualities sought and respecting environmental balance. (Author abstract) In French. 9 refs.

Schulz, W. (Carrier sa, Montluel, Fr). *RGE Rev Gen Electr* n 10 Nov 1987 p 20-24.

### Flow

**089530 NUCLEATE AND CONVECTIVE BOILING OF REFRIGERANTS IN CHANNELS WITH NATURAL CIRCULATION.** Despite the considerable number (up to 6-8 according to different classifications) of two-phase flow regimes with developed boiling in tubes there are apparently only two main regimes of precritical heat transfer, i.e. nucleate and convective. This point of view is conclusively confirmed when studying boiling of refrigerants in the case of forced motion in a channel and at the present time, while it is not generally acknowledged, it is at least the most extensive. Realization of convective boiling with natural circulation is of course possible only in sufficiently long channels. The authors demonstrate that with boiling of refrigerants in channels with natural circulation, as with forced motion, together with nucleate boiling it is possible for a convective boiling regime to exist. 8 refs.

Klimenko, A.V. (Moscow Power Inst, USSR); Zvonarev, A.K.; Balashov, E.V. *Therm Eng* v 34 n 4 Apr 1987 p 213-216.



**Freons** See Also FREONS—Thermodynamic Properties; HEAT PUMP SYSTEMS—Thermodynamics.

**089531 DAS FCKW-PROBLEM FUER DIE KÄLTE-TECHNIK.** [Fluorochlorohydrocarbons, a Problem in Refrigeration Engineering]. Fluorochlorohydrocarbons were first developed in the early thirties, specifically for use in refrigeration engineering. Being both nonflammable and non-toxic, they were considered to be safety refrigerants. However, new findings in the last two decades have raised some misgivings concerning their continued use as refrigerants. 13 refs. In German.

Hesse, Ullrich; Kruse, Horst. *Ki Klima Kälte Heiz* v 16 n 4 Apr 1988 p 173-177.

**089532 THERMODYNAMIC STATE SURFACE AND CYCLE ANALYSIS FOR REFRIGERANT 114.** An equation of state for Refrigerant 114 ( $\text{CClF}_2$ ,  $\text{CClF}_2$ ) was formulated based on available PVT measurements, taking the thermodynamic consistency into consideration. The developed equation of state is expressed by the reduced Helmholtz function as a function of reduced temperature and reduced density. Derived isochoric specific heat capacity, isobaric specific heat capacity, speed of sound and vapor pressure were critically examined. The developed equation is effective for a range of temperatures 200 to 550 K and of pressures up to 20 MPa, which corresponds to the density range up to  $1750 \text{ kg/m}^3$ . With the aid of the proposed equation, the cycle analysis for the heat pump, refrigeration and Rankine cycle was carried out, and it became clear that Refrigerant 114 is a suitable working fluid especially for high-temperature heat pump systems. (Author abstract) 19 refs.

Kagawa, Noboru (Toshiba Corp, Yokohama, Jpn); Narita, Hiroshi; Uematsu, Masahiko; Watanabe, Koichi. *JSM E Int J Ser 2* v 31 n 1 Feb 1988 p 112-118.

**Heat Transfer** See HEAT TRANSFER—Boiling Liquids; HEAT TRANSFER—Films.

**Impurities** See REFRIGERATING MACHINERY—Lubricating Oils.

**Oil Pollution** See HEAT PUMP SYSTEMS—Performance.

## Performance

**089533 METHODS FOR COMPARING THE PERFORMANCE OF PURE AND MIXED REFRIGERANTS IN THE VAPOUR COMPRESSION CYCLE.** Methods of comparing pure and mixed refrigerants are considered by computing the coefficient of performance and the heating capacity for an ideal vapour compression cycle for R22/R114 and R22/R11 mixtures. For comparisons based only on one characteristic condensation temperature and one evaporation temperature, the results depend entirely on how the characteristic temperatures are defined. A method specifying the heat transfer fluid temperatures and a total heat exchanger area per unit capacity is thought to offer a comparison applicable to both pure and mixed refrigerants. Using this method, the effects of compressor superheat, heat exchanger approach temperatures, and the match of refrigerant and heat transfer fluid temperatures are discussed. (Author abstract) 21 refs.

McLinden, M.O. (NBS, Gaithersburg, MD, USA); Radermacher, R. *Int J Refrig* v 10 n 6 Nov 1987 p 318-325.

## Phase Equilibria

**089534 MEASUREMENTS OF PVT<sub>x</sub> PROPERTIES FOR THE R 13B1+R 114 SYSTEM.** The PVT<sub>x</sub> properties for the R 13B1+R 114 system have been measured by the constant-volume method coupled with several isothermal expansion procedures. The results for four different compositions of 25, 50, 70, and 80 wt% R 13B1 cover the range of temperatures 303-443 K and the range of pressure 0.5-10.3 MPa, which corresponds to the density variation from 150 to  $1200 \text{ kg/m}^3$ . The experimental uncertainties of the temperature, pressure, density, and

mass fraction measurements were estimated to be no greater than 8 mK, 2.0 kPa, 0.15%, and 0.12%, respectively. The dew and bubble points were determined. (Author abstract) 7 refs.

Hosotani, Shiro (Keio Univ, Yokohama, Jpn); Maezawa, Yukishige; Uematsu, Masahiko; Watanabe, Koichi. *J Chem Eng Data* v 33 n 1 Jan 1988 p 20-23.

**089535 MEASUREMENTS OF THE VAPOR-LIQUID COEXISTENCE CURVE FOR THE R 13B1+R 114 SYSTEM IN THE CRITICAL REGION.** Measurements of the vapor-liquid coexistence curve in the critical region for the refrigerant mixture of bromotrifluoromethane ( $\text{CBrF}_3$ , R 13B1) and 1,2-dichloro-1,1,2,2-tetrafluoroethane ( $\text{CClF}_2\text{CClF}_2$ , R 114) were made by visual observation of the disappearance of the meniscus at the vapor-liquid interface within an optical cell. Eighteen saturated-vapor densities and 21 saturated-liquid densities for four different compositions of 25, 50, 70, and 80 wt% R 13B1 between 345 and 406 K were obtained in the range of densities  $356\text{-}1166 \text{ kg/m}^3$ . The experimental error of temperature, density, and mass fraction was estimated within  $\pm 15 \text{ mK}$ ,  $\pm 0.5\%$ , and  $\pm 0.05\%$ , respectively. On the basis of these measurements, the critical curve of the R 13B1+R 114 system is determined and compared with several predictive methods. In addition, new correlation so as to represent the composition dependence of the critical parameters for the R 13B1+R 114 system is proposed. (Author abstract) 19 refs.

Higashi, Y. (Keio Univ, Yokohama, Jpn); Kabata, Y.; Uematsu, M.; Watanabe, K. *J Chem Eng Data* v 33 n 1 Jan 1988 p 23-26.

## Phase Transitions

**089536 NUCLEATE POOL BOILING OF REFRIGERANT/OIL MIXTURES.** Experimental data are presented for the boiling of Refrigerant-113 and of mixtures of Refrigerant-113 and an oil (Shell Clavus-68) from horizontal electrically heated tubes. Pure-refrigerant boiling data for the finned tube showed that the effect of finning decreased considerably as the heat flux was increased and that the heat flux for a given temperature difference could actually be lower with the fin tube than the plain tube for large heat fluxes. The effect of oil was to decrease the heat transfer coefficient by an amount greater than expected on the basis of its mole fraction. The presence of the oil induced a complex variation of heat transfer coefficient around the surface of the tube. (Edited author abstract) 13 refs.

Bell, K.I. (Nat'l Engineering Lab, Glasgow, Scotl); Hewitt, G.F.; Morris, S.D. *Exp Heat Transfer* v 1 n 1 1987 p 71-86.

## Selection

**089537 QUEST FOR ALTERNATIVES.** In the search for alternatives to the fully halogenated CFC (chlorofluorocarbon) refrigerants there are not a limitless number of compounds from which to choose. Rather, it has been demonstrated by both theoretical and empirical reasoning that this same class of compounds - the chlorofluorocarbons - remains the clear choice by virtue of their stability, excellent thermodynamic and health and safety characteristics, and familiarity to both manufacturers and users. However, some of the previously acceptable CFC compounds are no longer acceptable because of environmental considerations. By approaching the problem from the molecular structure, the properties of the various CFC compounds could be treated in a systematic way. This approach revealed a range of CFC compounds that should be environmentally acceptable as well as retaining the other attributes of the fully halogenated CFC refrigerants. The initial research efforts should be directed towards CFC compounds from this region of mixtures where the major component is from this region. 13 refs.

McLinden, Mark O. (NBS, USA); Didion, David A. *ASHRAE J* v 29 n 12 Dec 1987 8p between p 32 and 42.

## Surface Tension

**089538 MEASUREMENTS OF THE SURFACE TENSION OF THREE REFRIGERANTS, R 22, R 115, AND R 502.** The surface tension was measured on three fluorocarbon refrigerants, R 22 (chlorodifluoromethane,  $\text{CHClF}_2$ ), R 115 (chloropentafluoroethane,  $\text{CClF}_2\text{CF}_3$ ), and R 502 (azeotropic mixture of 48.9 wt percent R 22 and 51.1 wt percent R 115), by using the capillary rise method. The results cover the range of temperatures from 273 K to a temperature close to the critical point of each substance. The uncertainty of surface tension measurements was estimated to be less than  $\pm 0.16 \text{ mN/m}$ . For R 115 and R 502, van der Waals type correlations were developed based on the present results. (Author abstract) 22 refs.

Okada, Masaaki (Technological Univ of Nagaoka, Nagaoka, Jpn); Arima, Takahisa; Hattori, Masaru; Watanabe, Koichi. *J Chem Eng Data* v 33 n 4 Oct 1988 p 399-401.

## Thermodynamic Properties

**089539 ENTROPY-VOLUME PLANE: A NEW APPROACH TO ON-LINE CALCULATION OF REFRIGERANT PROPERTIES.** Implementation of new techniques for real-time control and failure detection of HVAC & R equipment requires fast and accurate methods for on-line calculation of the thermodynamic properties of refrigerants. This paper presents a new approach to such on-line property calculations using a technique evolved from a new specific entropy-specific volume plane. The special feature of constant temperature lines in this entropy-volume plane provides the basis for the proposed fast, simple and accurate method. The results of a case study on R12 are presented with an accuracy in temperature calculations of within  $0.5^\circ\text{C}$  and higher. (Author abstract) 18 refs.

Shoureshi, R. (Purdue Univ, West Lafayette, IN, USA); McLaughlin, K. *Int J Refrig* v 10 n 6 Nov 1987 p 326-330.

**089540 SURFACE TENSION CORRELATIONS FOR SEVERAL FLUOROCARBON REFRIGERANTS.** The available experimental data of surface tension for 17 different fluorocarbon refrigerants have been compiled, compared and discussed systematically. So as to represent the temperature dependence of the surface tension, correlations with common functional forms have been established by using the reliable data. Compiled surface tension values by the present correlations have been tabulated with estimated uncertainties for the wide ranges of temperatures. (Edited author abstract) 40 refs.

Okada, Masaaki (Technological Univ of Nagaoka, Jpn); Watanabe, Koichi. *Heat Transfer Jpn Res* v 17 n 1 Jan-Feb 1988 p 35-52.

## Thermodynamics

**089541 POTENTIAL NAVAL SHIPBOARD APPLICATION OF NONAZEOTROPIC ENERGY CONVERSION.** The thermodynamic performance of an energy conversion device may be improved potentially by using a nonazeotropic mixture in a vapor cycle. A nonazeotropic mixture has a temperature distribution parallel to that of the surrounding fluid with which heat transfer takes place during the evaporation and condensation processes. Interest has increased in recent years in the use of nonazeotropic refrigerant mixtures to improve the performance of energy conversion devices. This report surveys developments in nonazeotropic energy conversion, describes the theory of a nonazeotropic energy conversion cycle, predicts energy savings possible from use of nonazeotropic energy conversion devices, and discusses potential naval shipboard application of such an energy conversion cycle. (Author abstract) 35 refs.

Chih, Wu (US Naval Acad, USA); Hwang, Baochuan C. *Nav Eng J* v 99 n 6 Nov 1987 p 39-51.



**089542 GENERAL METHOD FOR THE THERMODYNAMIC EVALUATION OF HEAT PUMP WORKING FLUIDS.** Worldwide experience with Rankine cycle prime movers demonstrates that organic fluids have the potential of meeting future needs of high temperature heat pumps. Many promising candidate fluids exhibit a complex molecular structure, which imparts a peculiar character to the thermodynamics of the heat pump cycle. Since reliable tables of thermodynamic properties are unavailable for most of the fluids of potential interest, a general method was worked out which requires a small amount of data to evaluate the energy performance of different fluid classes. Cycle quality, defined as the ratio of actual to ideal COP\*, is recognized to be a function of the following main parameters: complexity of the fluid molecular structure, reduced temperature at which evaporation is performed; fractional temperature lift,  $\Delta T/T_c$ . For fluids having rather complex molecules both technical feasibility (owing to condensation during compression) and energy performance are unsatisfactory unless regenerative precooling of the liquid prior to expansion is applied. (Edited author abstract) 17 refs.

Angelino, G. (Politecnico di Milano, Milan, Italy); Invernizzi, C. *Int J Refrig* v 11 n 1 Jan 1988 p 16-25.

**REFRIGERATING MACHINERY** See Also AGRICULTURAL PRODUCTS—Cooling; AIR CONDITIONING—Health Hazards; CRYOGENICS; REFRIGERATION—Solar; REFRIGERATORS—Defrosting.

**089543 SPECIFICNOST PROBLEMATIKE OPTIMALIZACIJE RASHLADNIH CIKLUSA.** [Specific Problems Encountered When Optimizing Cooling Cycles]. The paper introduces specific problems encountered when optimizing the cooling cycles limited to gas and vapour-compressor type refrigerating machines. The obtained results disclose a narrow relationship of relevant parameters with the nature of the cooling agent in the sense of finding out the optimum cooling factor. (Author abstract). 12 Refs. In Serbo-Croatian.

Belegu, Faruk (Univ u Kosova, Pristina, Yugosl). *Strojstvo* v 30 n 1 Jan-Feb 1988 p 35-43.

**Absorption** See Also AIR CONDITIONING—Solar Energy Systems; HEAT PUMP SYSTEMS; HEAT PUMP SYSTEMS—Computer Simulation; HEAT PUMP SYSTEMS—Performance; SOLAR RADIATION—Collectors.

**089544 ABWAERMEBETRIEBENE ABSORPTIONSKAELTEANLAGE IN DER KARTOFFELVERWERTUNG HOLLABRUNN.** [Absorption Type Refrigerating System using Waste Heat at Hollabrunn Potato Processing Plant]. The use of industrial waste heat reduces primary energy consumption and, in consequence, lowers the air pollution level. Process heat recovery and process water heating with waste heat are common practice today. In view of the high cost of refrigeration, cold generation using waste heat is particularly attractive for production processes and deep-freeze storage halls. The pilot system installed at the Hollabrunn potato processing plant shows that absorption-type refrigerating systems can compete with the commercial compression-type refrigerating systems, both with regard to their control characteristics and to their investment cost. (Author abstract) In German.

Podesser, E. *Ki Klima Kaelte Heiz* v 15 n 12 Dec 1987 p 535-536.

**089545 NEW EJECTOR-ABSORBER CYCLE TO IMPROVE THE COP OF AN ABSORPTION REFRIGERATION SYSTEM.** A modified ejector-absorber absorption refrigeration cycle is presented and analysed. Results for an R-22/DME-TEG system with a 0.5 heat-exchanger effectiveness and a 0.85 nozzle (diffuser) efficiency are computed for the conventional as well as the modified cycle. A considerable improvement in COP is observed for the latter. (Author abstract) 12 refs.

Chen, Li-Ting (Nat'l Tsing-Hua Univ, Hsinchu, Taiwan). *Appl Energy* v 30 n 1 1988 p 37-51.

**089546 SIMULATION STUDIES OF THE BEHAVIOUR OF A HEAT PIPE-ASSISTED SOLAR ABSORPTION REFRIGERATOR.** Simulation work on an intermittent-duty, heat pipe-assisted, solar-operated aqua-ammonia absorption refrigerator is reported. The low-thermal mass collector is the integral evaporator of an acetone-copper heat pipe which delivers the collected energy isothermally to a distant generator. The shell-and-tube type generator receives the energy by vapour condensation. The condenser is air cooled. A separate R-22/steel heat-pipe system serves to cool the absorber tanks via a radiation/convection panel. Heat and mass balances are outlined on several units. The resulting equations are solved for day and night operation. It is concluded that both the initial solution (absorbent) concentration and the absorber temperature must be kept low for adequate ice production. (Author abstract) 11 refs.

Al-Hindi, R.R. (King Abdulaziz Univ, Jeddah, Saudi Arabia); Khalifa, A.M.A.; Akyurt, M. *Appl Energy* v 30 n 1 1988 p 61-80.

**Compressors** See Also COMPRESSORS; COMPRESSORS—Design; COMPRESSORS—Testing; CRYOGENICS—Equipment; PISTONS—Packing; POWER GENERATION—Solar Energy; REFRIGERATORS—Control; VALVES AND VALVE GEAR—Measurements.

**089547 UNTERSUCHUNGEN AN KAEITEMITTEL-SCHRAUBENVERDICHTERN ZUR AUFLADUNG, ECONOMIZERBETRIEB.** [Investigation of Refrigerant Screw Compressors for Recharging and Economizer Operation]. To raise the power efficiency of refrigerating plant and refrigerating units equipped with screw compressors, frequent use is made of the comparatively simple economizer scheme. Experimental investigations of small-size screw compressors have revealed that a rise in refrigerating capacity and in power efficiency up to 50 per cent can be attained by recharging. The charger required on the compressor is easy to design and build. (Edited author abstract) In German.

Kinne, L. (VEB Kombinat Ilka Luft- und Kaeltechnik). *Luft Kaelte tech* v 23 n 3 1987 p 131-134.

**089548 MOUNTING INSTRUCTIONS FOR INSTALLATION OF PARALLEL COMPRESSORS.** Parallel compressors are a solution to the problem of balancing variable refrigeration loads. Maneurop compressors, version ER, are made for this application and are supplied with an oil sight glass and oil equalization connection. The equalization fitting is located above the oil level which ensures a connection without oil loss and preserves the gas pressure equalization. In order to ensure in all cases a good oil return, it is preferable to limit the installation of parallel compressor to three.

Anon. *Aust Refrig Air Cond Heat* v 41 n 5 May 1987 p 45-48.

**089549 OIL-FLOODED PROPYLENE REFRIGERATION SCREW COMPRESSOR.** Kobe Steel has developed and is manufacturing oil-flooded refrigeration screw compressors for a variety of fields, and they have received a high reputation for efficiency, operational ease, and maintenance from users around the world. Refrigerants used for oil-flooded screw refrigeration compressors are mainly halocarbon compound refrigerants (R22, R12) and  $\text{NH}_3$ . Kobe Steel has developed a new oil-flooded propylene refrigeration compressor, to satisfy the need for using a refrigerant propylene ( $\text{C}_3\text{H}_6$ ), which is produced in abundance at chemical plants. (Author abstract)

Anon. *Kobelco Technol Rev* n 2 Aug 1987 p 63.

**089550 SEMIHERMETIC SCREW COMPRESSORS FOR REFRIGERATION SYSTEMS AND THEIR APPLICATIONS.** Hitachi, Ltd. has recently developed two series of semihermetic screw compressors for refrigeration systems and applied condensing units. These series include 30 - 45 kW single-stage compressors (3 models) for 0 through  $-35^\circ\text{C}$  evaporating temperature, and 22 - 55 kW two-stage compressors (3 models) for  $-30$  through  $-60^\circ\text{C}$  evaporating temperature. Hitachi, Ltd. has also developed a new rotor profile and a double-casing

structure, which are applied to these compressors. (Edited author abstract) 2 refs.

Nozawa, Shigekazu (Hitachi Ltd, Jpn); Izushi, Minetoshi. *Hitachi Rev* v 36 n 3 Jun 1987 p 163-168.

**089551 COMPACT ROTARY COMPRESSORS FOR REFRIGERATORS AND DEHUMIDIFIERS.** The newly developed rotary compressors for refrigerators are 25% lighter, 65% smaller in space-occupancy volume and 13% higher in EER (energy efficiency ratio) than conventional reciprocating compressors and have a higher energy and space saving ability. While the newly developed rotary compressors for handy-type dehumidifiers, are 50% lighter, 70% smaller and 28% higher in EER than conventional reciprocating compressors. (Author abstract)

Sekigami, Kazuo (Hitachi Ltd, Jpn); Tagawa, Shigetaro; Takebayashi, Masahiro. *Hitachi Rev* v 36 n 3 Jun 1987 p 169-176.

**089552 INCREASING THE ENERGY EFFICIENCY OF CENTRIFUGAL COMPRESSORS FOR REFRIGERATING MACHINES.** A calculation was performed for single-stage and double-stage compressors by changing  $\epsilon/\epsilon_{\text{nom}}$  and for a few values of the variation in efficiency when one operates under nominal  $\Delta\eta_{\text{ad}}$  conditions. The results of the calculation show that, for the example cited, a double-stage compressor in continuous operation under nominal conditions ( $Q_{\text{OAV}}/Q_{\text{OAVnom}} = 1$ ) is 7% more economical than the single-stage one. The smaller the  $Q_{\text{OAV}}$ , the smaller the advantage and, if  $Q_{\text{OAV}}/Q_{\text{OAVnom}} < 0.7$ , it is more advantageous to use a single-stage compressor. When the  $\Delta\eta_{\text{ad}}$  drops, the single-stage compressor asserts its superiority at the higher  $Q_{\text{OAV}}/Q_{\text{OAVnom}}$  values. From the analysis carried out one reaches the conclusion, viz., given the operating efficiency now attained by the stages at high  $M_1$  numbers, in conditioning systems it is advisable to use double-stage compressors. The author also considers the effects on efficiency and  $M_1$  numbers of the dimensions of impellers of single-stage compressors manufactured for conditioning systems. 4 refs.

Nuzhdin, A.S. *Chem Pet Eng* v 22 n 11-12 Nov-Dec 1986 p 599-603.

**089553 MATHEMATICAL MODELS FOR OPTIMIZATION OF THE CENTRIFUGAL STAGE OF A REFRIGERATING COMPRESSOR.** A general approach to creating mathematical models of energy and head losses in the flow part of the centrifugal compressor has been evolved. The specific form of the mathematical model depends on the problems to be solved by it. The mathematical model of the pressure head and efficiency of a two-section stage is meant for determining its characteristics and for optimizing by variance calculations. It permits one, for instance, to determine the characteristics of the stage in a wide range of  $M_0$  variation (up to 1.4), to select the optimum profile (shape) of the impeller and the diffuser in the meridian plane, and to determine the optimum entrance angle of the vane grid of the combined diffuser (CD) which ensures coordinated operation of the CD. 3 refs.

Nuzhdin, A.S. *Chem Pet Eng* v 23 n 1-2 Jan-Feb 1987 p 18-23.

**089554 EXPERIMENTELLE ANALYSE DES VERDICHTERHALTENS BEIM EINSATZ NICH-TAZEOTROPER KAEITEMITTELGEMISCHE.** [Experimental Analysis of Compressor Behavior with Nonazeotropic Refrigerant Mixtures]. In the last few years, a number of investigations have been made on refrigerating systems using non-azeotropic refrigerant mixtures. The results provide only general information on the refrigerating cycle as a whole. For an analysis of the component behavior, systematic measurements were made on a reciprocating piston compressor. The measurements are presented in the form of diagrams showing the refrigerating capacity, required power, volumetric effi-



ciency, and efficiency with different concentrations of the refrigerant mixture R 22/R114. (Author abstract) In German. 5 refs.

Quast, U.; Kruse, H. *Ki Klima Kaelte Heiz* v 15 n 11 Nov 1987 p 493-496.

**089555 ERMITTLUNG DER BETRIEBSZUVERLAESSIGKEIT VON KAEITEMITTELVERDICHTERN IM SCHIFFSEINSATZ.** [Determining the Dependability of Marine Refrigerant Compressors]. On 18 ships of Deutfracht-Seereederei (DSR) Rostock, studies were undertaken of the operational behaviour of refrigerant compressors in cargo hold, food supply and air-conditioning plants. The calculation of dependability parameters was made in conformity with a computer program developed by Technische Universitaet Magdeburg in which the total compressor running time can be considered. (Author abstract) 4 refs. In German.

Loechel, E. (VEB, East Ger). *Luft Kaelte tech* v 24 n 1 1987 p 38-40.

**089556 COMPRESSORS: AN APPRAISAL.** Refrigeration is the process of removing heat. We generally take this to mean the removal of heat at temperatures below ambient. The purpose may be to cool something down or to keep it cool and, at one time, the only application was in the preservation of food and drink. The compressor used for this purpose is a mechanical device, hence mechanical refrigeration systems. This is the basis of the vapor compression cycle. Following early work and the first practical circuits, the vast majority of refrigeration systems have worked on the principle of vapor compression, and it is most unlikely that this will ever be displaced from its dominant position. Author evaluates the wide range of compressors on the market beginning with a look at piston types. Development of vapor compression cycle and refrigerants are also discussed. (Edited author abstract)

Trott, A.R. *Aust Refrig Air Cond Heat* v 42 n 2 Feb 1988 p 20-26.

**089557 BETRIEB EINES HERMETISCHEN SCHRAUBENVERDICHTERS IN VERBINDUNG MIT EINEM STATISCHEN FREQUENZUMFORMER.** [Operation of a Hermetic Screw Compressor with Static Frequency Inverter]. The performance and operation characteristics of a hermetic screw are shown with a frequency range from 10 to 100 cycl., using a static frequency inverter. The inverter has a considerable influence on the start, regulation and operation characteristics of the compressor and also on the efficiency of the entire plant. Due to the favorable regulation characteristics of compressor and inverter, this combination is especially suitable for direct evaporation plants. The comparison with conventional water coolers is being discussed. (Author abstract). In German.

Stenzel, Adalbert. *Ki Klima Kaelte Heiz* v 16 n 7-8 Jul-Aug 1988 p 325-328.

## Computer Aided Design

**089558 SOFTWARE REFRIGERATION PLANT DESIGN.** The increased use of computers by refrigeration engineers has contributed to more effective work practices. Suppliers of refrigeration equipment, system designers, and those operating refrigeration systems are all interested in the application of computers to optimize plant performance, and to improve accuracy in design. Many companies have, or will write their own programs with specific features, but there is also a place for general packages. General packages will be in the form of technical design aids rather than incorporating optimization routines. This is because optimization means different things to different people, thus making development of a generally applicable optimization routine almost impossible. This paper discusses desirable features in refrigeration design computer software and how these can be incorporated in programs. Examples using a commercially available package 'RADS' are given. 3 refs.

Cleland, Andrew C. (Massey Univ, Palmerston North,

NZ). *Aust Refrig Air Cond Heat* v 41 n 7 Jul 1987 40, 42.

**Computer Simulation** See WATER COOLING SYSTEMS—Design.

**Condensers** See Also REFRIGERATION—Design.

**089559 EVAPORATIVE COOLING ON CONDENSER COILS.** Rejection of heat from refrigeration plant can be accomplished in a number of ways, once-through water, cooling towers with heat exchangers or direct air cooling. All of these have advantages and disadvantages but for direct cooling of condenser coils there is another option, the evaporative condenser. An evaporative condenser is the combination of a cooling tower with a shell and tube condenser with the circuit reduced to a single item of equipment. The extra heat transfer step of condenser water in the cooling tower/condenser combination is eliminated and hence the unit permit a reduction of the condensing temperature/pressure and so a reduction in the absorbed power of the compressor.

Izard, Mark (Baltimore Aircoil Ltd). *Heat Air Cond J* v 58 n 661 Jul 1987 p 18, 20.

**089560 ERFABRUNGEN BEI DER LEISTUNGSPRUEFUNG VON LUFTGEKUEHLTEN VERFLUESSIGERN NACH DIN 8970.** [Experience with Performance Tests of Air-Cooled Condensers in Accordance with DIN 8970]. With the passing of the certification program relating to DIN 8970, there is now the possibility for manufacturers of air-cooled, forced-draft condensers to have the capacities, volume flow rates, as well as the sound values examined by DIN testing offices and, after the test has been successful, to apply for a DIN emblem with registration number. The paper describes briefly the experiences gained by KUEBA during the DIN test, now completed, and what had been the prerequisites for the test. (Edited author abstract). In German.

Halamek, Bruno. *Ki Klima Kaelte Heiz* v 16 n 9 Sep 1988 p 379-380.

**Control** See REFRIGERATION—Industrial.

## Design

**089561 HIGHER FLOW TEMPERATURE FOR FINER CHILLER CONTROL.** Britain's variable climate makes control of chillers much more difficult than in foreign parts. The swings in temperature and load follow no regular seasonal patterns, so more complicated modulation problems arise. For this reason this study recommends using the slightly higher than usual flow temperature of 7°C unless the more conventional 5.5°C is important to maintain (in dewpoint plants). Raising the flow water temperature gives more control flexibility albeit at the expense of larger cooling coils, pipework and related equipment.

Anon. *Heat Air Cond J* v 58 n 661 Jul 1987 p 16.

**Efficiency** See CRYOGENICS—Mathematical Models.

**Energy Utilization** See Also AGRICULTURAL PRODUCTS—Cooling.

**089562 EXPERIMENTELLE UNTERSUCHUNGEN UND ENERGETISCHE BEWERTUNG VON KLEINKAELEAGGREGATEN.** [Experimental Investigations and Energetic Assessment of Compact Refrigeration Aggregates]. The report describes investigations carried out on two compact refrigeration aggregates with refrigerating capacities of 400 w and 640 w. A special experimental apparatus permitted measurements over a wide range of room temperatures and ambient temperatures. For an energetic assessment of the refrigeration aggregates, the coefficients of performance, terminal capacities, performance levels, exergetic efficiencies and exergy losses were determined. 3 Refs. In German.

Engelhorn, Hans Rudolf. *Ki Klima Kaelte Heiz* v 16 n 10 Oct 1988 p 422-426.

**Evaporators** See Also HEAT TRANSFER—Boiling Liquids; OFFICE BUILDINGS—Air Conditioning; REFRIGERATION; REFRIGERATORS—Defrosting; VALVES AND VALVE GEAR—Mathematical Models.

**089563 QUESTION OF PRESSURE.** Putting in three units to do the work of one wasn't all plain sailing; but an adjustment put the job to rights. Following repeated failures, it was agreed that an old 9 kW open air cooled unit for a walk-in dairy produce cold room just had to go! Inside the room, suspended from the ceiling, were three forced draught evaporators, each with four fans, one blower at each end with the third one at the center of a long wall, towards the end of which was a large door capable of accepting a fork lift truck. On the opposite long wall was a further door leading to the packing room so the fork lift could enter, load up then pass straight through as required.

Collett, L.J. *Aust Refrig Air Cond Heat* v 41 n 8 Aug 1987 p 32, 35.

**089564 MEAN HEAT FLUX CONCEPT IN EVAPORATOR DESIGN.** With regard to wall superheat variation along the evaporator heating surface, a method has been devised to estimate the mean heat flux with respect to inlet and outlet temperatures of the evaporator fluids. Uncertainties involved in using the conventional logarithmic mean temperature difference method are avoided. Diagrams are used to demonstrate the application of the method to refrigeration and heat pump systems in which hydrocarbon compounds are the working fluids. Sample problems illustrate the effectiveness of the method. (Author abstract) 11 refs.

Kayansayan, N. (Dokuz Eylul Univ, Bornova, Turk). *Int J Refrig* v 11 n 1 Jan 1988 p 46-51.

**089565 USING HOT-GAS SPRAYED ALUMINUM COATINGS FOR EVAPORATORS OF REFRIGERATING MACHINES.** Tests were conducted on coatings produced at various air pressures and stable process parameters. The main parameters of the spraying process (distance, travel speed of the metal spraying gun, wire feed rate, arc voltage) were selected on the basis of the requirement to stabilize the spraying process and produce coatings of the required thickness. The investigation showed that the intensity of heat exchange in boiling of R-22 refrigerant on the steel surface with aluminum CPCs is high. After appropriate pilot-plant verification of the results, the hot-gas sprayed aluminum coatings can be recommended for the manufacture of heat exchanging surfaces of the freon evaporators. 10 refs.

Dyundin, V.A.; Solov'ev, A.G.; Protasov, G.A.; Lopukhin, V.I.; Vol'nykh, Yu.A.; Klyueva, K.D. *Chem Pet Eng* v 22 n 11-12 Nov-Dec 1986 p 603-606.

**089566 BERECHNUNG UND AUSWAHL WASSERBEAUFSCHLAGTER VERDAMPFER.** [Calculation and Selection of Water-Charged Evaporators]. Next to the compressor, the heat exchangers are the most important functional elements of a refrigeration plant. Heat exchanger design and selection are crucial factors determining the performance and economic efficiency of a refrigeration system. In German. 7 refs.

Hage, Manfred. *Ki Klima Kaelte Heiz* v 16 n 2 Feb 1988 p 71-75.

**089567 STUDY ON FLOW IN HORIZONTAL AGITATED THIN-FILM EVAPORATORS (1ST REPORT, LIQUID-FILLET IN STEADY TWO-DIMENSIONAL FLOW).** A liquid-fillet is formed in front of the rotor blades in thin-film evaporators. The shape of the fillet varies along the axis so that an axial flow is induced in the fillet. Furthermore, the shape of the fillet varies periodically as the blades rotate due to the circumferential variation of the gravitational effect. However, these secondary effects are disregarded and steady two-dimensional flow in the circumferential direction is theoretically examined. The influences of viscosity and the amount of fluid in the casing as well as the tip clearance effect of



blades on the thickness of the liquid-fillet are predicted, and good agreement with experimental data is demonstrated. The secondary effects disregarded in the present analysis will be presented in following papers. (Author abstract) 3 refs. In Japanese.

Senoo, Yasutoshi; Nakamura, Katsutaka. *Nippon Kikai Gakkai Ronbunshu B Hen* v 54 n 498 Feb 1988 p 472-477.

**089568 ENHANCED HEAT TRANSFER TUBES FOR THE EVAPORATOR OF REFRIGERATING MACHINES (2ND REPORT, OPTIMIZED COMBINATION OF SHELL-SIDE AND TUBE-SIDE ENHANCEMENTS).** The tubes in this study have internal ribs and porous structures to enhance boiling of refrigerants on external surface. The ribs are provided by the application of a roller on the external surface, so that a part of the external surface is recessed with a certain pitch. Consequently, the tube-side enhancement reduces the enhanced area on the shell-side surface due to the inability to machine the porous structure on the recesses. Based on the experimental data, an analysis is performed so as to find the optimum pitch for the provision of internal ribs, where the enhancements on the tube-side and the shell-side are best utilized. (Author abstract) In Japanese. 8 refs.

Takahashi, Kenji; Nakayama, Wataru; Kuwahara, Heikichi; Yanagida, Takehiko. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 494 Oct 1987 p 3082-3087.

**089569 ENHANCED HEAT TRANSFER TUBES FOR THE EVAPORATOR OF REFRIGERATING MACHINES (3RD REPORT, EVAPORATIVE HEAT TRANSFER FROM HORIZONTAL TUBES IN THIN FILM FLOW).** On heated horizontal tubes having the porous surface, a falling film of R-11 was evaporated at atmospheric pressure. The heat transfer coefficient of liquid film evaporation is higher than that of pool boiling when the wall superheat is small; however, the enhancement ratio reduces on the surface structure where the pool boiling heat transfer coefficient is already high. The appearance of dry spots on the porous surface was observed only at a small flow rate close to the threshold value for complete dry-out. Another advantage brought by the porous surface is the virtual elimination of hysteresis phenomena. (Edited author abstract) In Japanese. 9 refs.

Kuwahara, Heikichi; Yasukawa, Akira; Nakayama, Wataru; Yanagida, Takehiko. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 494 Oct 1987 p 3088-3092.

**089570 PRACTICAL APPLICATION OF THE CORRESPONDING STATES PRINCIPLE IN HEAT TRANSFER ENGINEERING.** Thermodynamic generalization methods based on reduced pressures proposed in the 1960s are reviewed and updated to reflect the current state of the art. These corresponding states principles (CSP) generalization techniques provide the fluid flow system engineer and the heat exchanger designer with an additional tool that is simple, effective, and above all, more reliable, particularly in evaporator and condenser design practice, than current conventional semiempirical correlations. (Author abstract) 29 refs.

Soumerai, Henri P. (HED Soumerai & Associates, Fislisbach, Switz). *Heat Transfer Eng* v 9 n 2 1988 p 19-28.

**089571 MONITORING FROST GROWTH IN EVAPORATORS IS A COMPLEX PROCESS.** The calculation method used in this work is based on correlations for the airflow pressure drop, the heat transmission and the frost growth rate. The last of these factors is the most important. For this reason a vast theoretical and experimental work has been done in order to find a good way to calculate the frost growth rate. Frost deposits formed in an evaporator decrease its capacity as a result of increased heat resistance, decreased airflow and decreased evaporation temperature. Because so many variables need to be considered, a calculation of a frost-forming process is necessarily complex. A computer program exists that calculates the cooling capacity after a certain

time of frost growth. However, for the most common applications a calculation can be made by the help of a few nomograms. 5 refs.

Malhammar, Ake. *Aust Refrig Air Cond Heat* v 42 n 4 Apr 1988 7p.

**089572 FAULTS IN COMMERCIAL EVAPORATOR AND CONDENSER FAN MOTORS.** There are a variety of evaporator and condenser fan motors available in the market. Author describes the basic set of procedures to follow to locate the faults and rectify them while they are in service.

Norfolk, E. *Aust Refrig Air Cond Heat* v 41 n 12 Dec 1987 p 34.

**089573 VERDUNSTUNGSKUEHLUNG - ZUSAMMENSTELLUNG DER THEORETISCHEN GRUNDLAGEN UND EXPERIMENTELLE UEBERPRUEFUNG, TEIL 2: ERWEITERTE HAUPTGLEICHUNG.** [Evaporative Cooling - Review of Theoretical Fundamentals and Experimental Studies. Part 2: Extended Primary Equation]. The paper presents the theoretical fundamentals of the extended primary equation of evaporative cooling and the solution by the incremental temperature method. A description is given of the contradiction between the temperature dependency of the experimentally defined evaporation parameter and the Merkel number. Also the latest research results after Hauenschild are reported who was able to settle this contradiction by considering the heat transfer resistance of water. (Edited author abstract). 36 Refs. In German.

Reschke, G. (KDT, East Ger); Stach, H. *Luft Kaeltech* v 24 n 2 1988 p 100-103.

## Heat Exchangers

**089574 OVERALL EFFICIENCIES OF LOW-GRADE ENERGY RANKINE-CYCLE ENGINES AS FUNCTIONS OF THEIR PERFORMANCE FACTORS.** To maximize these efficiencies some performance factors (such as evaporator and condenser saturation temperatures, the isentropic efficiency of the expander, the magnitude of the superheat and the working fluid and Rankine-cycle engine type) affecting the overall efficiencies of Rankine-cycle engines, using refrigerants 113 and 114 as working fluids, are studied. The analysis of the calculations shows that the overall efficiencies of Rankine-cycle engines can be increased with the increase of the saturation temperature of the evaporator and the isentropic efficiency of the expander, the reduction of the saturation temperature of the condenser, using refrigerant 113 as working fluid in the cycle instead of R-114. (Edited author abstract) 7 refs.

Morcos, V.H. (Univ of Technology, Baghdad, Iraq). *Heat Recovery Syst CHP* v 7 n 6 1987 p 473-479.

## Lubricating Oils

**089575 EIGENSCHAFTEN DES KAELEMASCHINENOEL LUEFRIGOL XK 30 UND DIE SEINER GEMISCHE MIT KAELEMITTELN.** [Properties of Refrigerating Machine Oil Luefrigol XK 30 and Its Mixtures with Refrigerants]. A description is given of essential physical properties of the newly developed refrigerating machine oil Luefrigol XK 30. Graphs plot the dependence of viscosity, steam pressure and density on the temperature and concentration of the oil mixtures with refrigerants R 13, R 22 and R 13B1. (Author abstract) 1 ref. In German.

Heide, R. (VDI-Wasserdampfakeln). *Luft Kaeltech* v 23 n 3 1987 p 160-162.

**089576 LABORUNTERSUCHUNGEN DER TRIBOLOGISCHEN EIGENSCHAFTEN VON KAELEMASCHINENOELN UNTER KAELEMITTELEINFLUSS.** [Laboratory Tests of the Tribological Characteristics of Refrigerating Machine Oils under the Influence of Refrigerants]. To judge the tribological behavior of refrigerating machine oils, an apparatus was built up on the ALMEN-WIELAND principle so as to

make tests under the simultaneous influence of various refrigerants. In order to assess the oil grades, reference was made to the load bearing capacity of steel/steel test bearings. The test results obtained from various oils with R 12 and R 22 are reported. (Author abstract) In German. 4 refs.

Lippold, H. (VEB Kombinat ILKA Luft- und Kaeltechtechnik, East Ger); Reinhold, S. *Luft Kaeltech* v 23 n 4 1987 p 218-220.

## Lubrication

**089577 EFFECT OF OIL ON THE PERFORMANCE OF HEAT PUMPS AND REFRIGERATORS - PART ONE. EXPERIMENTAL TEST FACILITY.** Details are given of a computer-controlled experimental test-bed which allows detailed investigations to be made of the influence of lubricating oil on the performance of refrigeration plant. The general nature of the observed effects are discussed and some preliminary results are presented. These demonstrate both how the test-rig can be used to record transient phenomena, and how the data can subsequently be analyzed to produce charts of system performance under closely specified experimental conditions. (Edited author abstract) 23 refs.

McMullan, J.T. (Univ of Ulster, Coleraine, North Irel); Murphy, N.; Hughes, D.W. *Heat Recovery Syst CHP* v 8 n 1 1988 p 53-68.

Maintenance See REFRIGERATION—Energy Conservation.

## Management

**089578 OPTIMUM COGENERATION STRATEGIES FOR A REFRIGERATION PLANT.** The operation of an idealized industrial refrigeration plant having cogeneration capacity is analyzed using the linear programming model ELMO. The optimum operating strategies for the chilling sets and the steam turbine are determined for a simple time-of-use electricity tariff and for various refrigeration loads. The refrigeration load required for a manufacturing process, along with steam and electricity loads, can be met by a combination of electric and steam-driven centrifugal chillers and an absorption refrigerator operating on low pressure steam. A pass-out turbo-alternator can generate some of the plant electricity needs using high pressure steam from a gas boiler. The marginal production cost of chilled water varies considerably as the load increases, reflecting a varying minimum cost operating strategy for the different chillers. (Author abstract) 12 refs.

deL. Musgrove, A.R. (CSIRO, Lucas Heights, Aust); Maher, K.J. *Energy (Oxford)* v 13 n 1 Jan 1988 p 1-8.

## Mathematical Models

**089579 MODELISATION D'UN SYSTEME DE REFRIGERATION SOLAIRE ASSOCIANT CAPTEURS SOLAIRES A EVAPORATION DIRECTE ET MOTOCOMPRESSEUR.** [Modeling a Solar Refrigeration System Including Solar Collectors for Direct Evaporation and Motor Compressor]. The solar system investigated works with only one fluid for the collection, driving and the refrigeration cycles, owing to the fact that the working fluid partially vaporizes inside the collectors. In order to feed the motor with only vapor, a vapor separator is placed between the driving loop and the collection loop, in which the fluid flows by gravity. Modeling the behavior of each component of the system provides the basis of a global model for the motor-compressor unit performances, like the temperature level and the fluid flowrates in the collector as a function of parameters such as the collection loop dimensions, the volumetric ratio of the motor and compressor, the shape of the motor cycle, the ambient temperature and the solar irradiation variations. (Edited author abstract) In French. 15 refs.

Zein, A. (INSA de Lyon, Villeurbanne, Fr); Lallemand, M.; Lallemand, A. *Entropie* v 22 n 129 1986 p 51-61.



Noise Abatement See REFRIGERATORS—Noise.

Optimization See COOLING WATER.

Performance See AIR CONDITIONING—Equipment.

Quality Assurance

**089580** UEBERSICHT UEBER PRUEFZEICHEN AM BEISPIEL KALTTECHNISCHER PRODUKTE. [Approval Seals in the Refrigeration Industry]. The introduction of approval seals for components and products of the refrigeration industry has been discussed for some time. The advantages of these seals and some possible approval procedures are outlined. (Author abstract) In German.

Krug, N. *Ki Klima Kaelte Heiz* v 15 n 10 Oct 1987 p 461-463.

Thermodynamics See Also CARS—Refrigerator; REFRIGERATION—Industrial.

**089581** EXERGETISCHE ANALYSE UND BEWERTUNG VON KOMPRESSIONSKAELE- UND KOMPRESSIONSWAERMEPUMPENPROZESSEN. [Exergetic Analysis and Evaluation of Compression Refrigerating Machines and Heat Pump Processes]. Real refrigerating machines and heat pumps require much more driving power than would be necessary in a completely reversible process control by involving the environment. Exergetic analyses reveal the cause of losses. A detailed exergetic analysis is made of the single plant sections and the total process of compression refrigerating machines and compression heat pumps which is quantitatively supported by measuring results obtained from a cold water set. A presentation of the exergetic variables of the process in the T-S plot and a reference to the treatment of complete refrigerating plant and heat pump installations conclude the description. (Author abstract). 21 Refs. In German.

Lehnguth, M. (Univ Karl-Marx-Stadt, East Ger). *Luft Kaeltech* v 24 n 2 1988 p 89-95.

Valves See VALVES AND VALVE GEAR.

Waste Heat Utilization See STORE BUILDINGS—Waste Heat Utilization.

REFRIGERATING PIPING SYSTEMS See REFRIGERATING MACHINERY—Evaporators.

REFRIGERATION See Also AGRICULTURAL PRODUCTS—Cooling; AIR CONDITIONING—Computer Simulation; AIR ENGINES; CRYOGENICS—Equipment; HEAT PUMP SYSTEMS—Thermodynamics; PRESSURE VESSELS—Stresses; REFRIGERATING MACHINERY—Energy Utilization; SKATING RINKS.

**089582** VERDUNSTUNGSKUEHLUNG - ZUSAMMENSTELLUNG DER THEORETISCHEN GRUNDLAGEN UND EXPERIMENTELLE UEBERPRUEFUNG - TEIL 1: MERKELSCHES HAUPTGLEICHUNG. [Evaporative Cooling - Theoretical Principles and Experimental Verification - Part 1: Merkel Main Equation]. Part 1 of this paper describes the theoretical principles of Merkel's main equation of evaporative cooling and the four most important methods of solving this equation. Further, the assumptions and simplifications made by Merkel are considered and two equations given for the calculation of Lewis' factor. (Author abstract) In German. 22 refs.

Reschke, G. (Akad der Wissenschaften der DDR, East Ger). *Luft Kaeltech* v 23 n 4 1987 p 216-218.

Absorption

**089583** ANALYSIS OF A PRESSURE DRIVEN ABSORPTION REFRIGERATION CYCLE. This study presents an analysis of a pressure driven absorption refrigeration cycle which utilizes a membrane separation process to achieve refrigerant-absorbent (R/A) separation. Since the performance of such membranes cannot be

predicted generally, the analysis is accomplished by computing cycle performance as a function of the effectiveness of the membrane separation process. The net refrigeration effect and work input are determined based on thermodynamic property data for several working fluid combinations, and desirable characteristics for refrigerant-absorbent pairs are identified. The solubility parameter is used to characterize the potential for separation by candidate membrane materials. The absorbent tetraethylene glycol dimethyl ether (E-181) is found to have good potential for separation from Refrigerants 21 and 22 by typical membranes such as cellulose acetate. Additional aspects of the subject are discussed. (Edited author abstract) 5 refs.

Beasley, Donald E. (Clemson Univ, Clemson, SC, USA); Hester, J. Charles. *Int J Energy Res* v 12 n 1 Jan-Mar 1988 p 175-184.

Applications See CARBON DIOXIDE—Liquefaction.

Defrosting

**089584** ADAPTIVE DEFROST. The adaptive defrost concept operates on demand, initiating a defrost cycle only when needed, thereby saving energy and yet maintaining refrigeration system efficiency. This is accomplished by automatically adjusting the frost accumulation period to achieve an optimal predetermined defrost time. The optimal defrost time is previously determined for the particular refrigeration system and programmed into the control. The next frost accumulation time period is made a function of the optimal defrost time, the previous frost accumulation time, and the previous actual defrost time. The system thus operates according to the following relationships:  $T_a = (a - 1) + K(D_o - D_a)$ , where  $T_a$  = length of the next frost accumulation period;  $T(a - 1)$  = length of the last frost accumulation period;  $D_o$  = optimal defrost time;  $D_a$  = length of the actual defrost time; and  $K$  = system constant that determines the multiple by which the frost accumulation period will change for each increment of error in the defrost time.

Allard, John (GE, Morrison, IL, USA); Heinzen, Robert. *IEEE Trans Ind Appl* v 24 n 1 1988 p 39-42.

Design See Also FOOD PRODUCTS PLANTS—Expansion.

**089585** VARIOUS FLOW RATES IN CONDENSER WATER CYCLE. The flow rate for the condenser water cycle is usually taken at some arbitrary value for design purposes. Most frequently with mechanical refrigeration, a rate of 3 gpm/ton is used. How would the system be affected if we were to change the design flow rate? If we look at the refrigeration machine only, we see that higher condenser flow rates will result in lower energy consumption at the compressor motor. However, as we increase the flow rates, condenser water pump horsepower increases proportionately, pipe size increases, and cooling tower size increases. The original purpose for this investigation was to find the point where the total energy consumption was least. What we found was that, over a practical range of flow rates, the total energy consumption was about the same. The unexpected finding was that the combined cost of chiller, piping and cooling tower is least at the lowest flow rates. The evaluation is made for two sizes of refrigeration machines. A 60-ton reciprocating system is evaluated over the range of 2 gpm/ton up to 6 gpm/ton. A 300-ton centrifugal system is evaluated over the range of 1.5 to 3 gpm/ton.

Waller, Bertram. *ASHRAE J* v 30 n 1 Jan 1988 p 30-32.

Efficiency

**089586** HOW ADAPTIVE DEFROST MAINTAINS REFRIGERATION SYSTEM EFFICIENCY. The adaptive defrost concept provides a demand defrost system which initiates a defrost cycle only when needed, thus saving energy by eliminating unnecessary defrosts yet maintaining refrigeration system efficiency. This is accomplished by automatically adjusting the frost accumulation period to achieve an optimal predetermined defrost time.

The optimal defrost time is previously determined for the particular refrigeration system and programmed into the control. The next frost accumulation time period is made a function of the optimal defrost time, the previous frost accumulation time, and the previous actual defrost time. (Author abstract)

Heinzen, Robert A. (Paragon Electric Engineering & Quality Assurance, WI, USA). *Aust Refrig Air Cond Heat* v 42 n 4 Apr 1988 p 12, 14-16.

Electric Power

**089587** ON A TOTAL ELECTRIC POWER EVALUATION FOR A REFRIGERATOR SYSTEM WITH RESPECT TO THE AMBIENT TEMPERATURE VARIATIONS. This paper is concerned with an evaluation of the total electric power of a refrigerator with respect to variations of the ambient temperature. An evaluation of the total electric power is firstly established by using mathematical models of the refrigerator system with parameters estimated under a certain ambient temperature. Secondly, increment of the total electric power by the ambient temperature variation is evaluated by the gain schedule scheme. Finally, after assuming the relation between the ambient temperature variation and a few parameters of the mathematical models, evaluation of the total electric power of a refrigerator system is performed. (Author abstract) In Japanese. 3 refs.

Sunahara, Yoshifumi; Ohse, Nagato; Kawamura, Takao. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 492 Aug 1987 p 1800-1806.

Energy Conservation

**089588** ENERGIEKOSTENREDUZIERUNG BEIM BETRIEB EINER ZENTRALEN GROSSKAELEANLAGE DURCH OPTIMIERUNG DER KOMPONENTEN UND DER BETRIEBSBEDINGUNGEN. [Energy Cost Reduction in Large Central Refrigeration Units by Optimization of Components and Operating Conditions]. An 11 MW refrigeration unit was installed in 1984 at the Sandbochum shaft of Heinrich-Robert mine, Hamm, of the RAG. The plant was extended to a net refrigerating capacity of 15 MW in 1986. The surface refrigeration plant provides air conditioning for the working points below the 1000 m level via a cold-water network with a length of 70 km. Investments for the whole cooling system amounted to DM 30 million. The annual operating costs are in the range of DM 8.5 million, of which nearly DM 6.5 million (about 76%) are energy costs. The additional capital recovery factor is not considered in these figures, which clearly indicate why the reduction of energy consumption was an important planning aspect from the very beginning. (Author abstract) 4 refs. In German.

Bothe, Achim; Mueller, Georg. *Ki Klima Kaelte Heiz* v 16 n 5 May 1988 p 222-225.

**089589** ENERGY CONSERVATION IN REFRIGERATION SYSTEMS - CENTRIFUGAL CHILLERS. The object of this paper is to provide means to conserve energy in the refrigeration systems, primarily the centrifugal chillers. The centrifugal chillers consume 20 per cent to 30 per cent of the electrical power consumed by a building facility. The object is to run these machines in the most energy-efficient way. 7 refs.

Gupta, V.P. (ASHRAE). *Aust Refrig Air Cond Heat* v 42 n 3 Mar 1988 p 30, 32.

Energy Storage See BUILDINGS—Cooling.

Equipment See CRYOGENICS—Equipment.

Fans See FANS—Testing.

Industrial See Also FOOD PRODUCTS—Freezing; REFRIGERATING MACHINERY—Compressors.

**089590** EXERGETIC ANALYSIS OF COMPOUND MECHANICAL REFRIGERATION SYSTEMS. An



exergetic analysis is conducted on compound mechanical refrigeration systems. Plant exergetic efficiencies, equipment irreversibilities, and their sensitivity to main system parameters are evaluated for several typical component arrangements, for R12 refrigerant. The use of a flash tank for separation, desuperheating, and with a subcooling coil seems the best solution; highly recommendable, in a higher evaporating temperature range, is the set-up using an auxiliary compression and the economized cycle. For these systems, a detailed sensitivity analysis is presented. (Author abstract) 15 refs.

Mastrullo, Rita (Univ di Napoli, Naples, Italy); Mazzei, Pietro. *Heat Recovery Syst CHP* v 7 n 5 1987 p 401-412.

**089591 APPLYING CONTROL VALVES FOR INDUSTRIAL REFRIGERATION.** The author discusses some applications for automatic control valves and regulators for industrial refrigeration systems. Liquid recirculation systems and Gravity flooded systems are described.

Berry, Keith (Thermofrost Cryo Ltd, Aust). *Aust Refrig Air Cond Heat* v 42 n 3 Mar 1988 4p.

**089592 COMPARISON BETWEEN CONVENTIONAL CONTROLS AND NEW ELECTRONIC SYSTEMS.** When comparing installations controlled by conventional automatic controls and those controlled by new electronic systems, both technical and economic considerations clearly indicate that a decentralised control combined with centralised override and monitoring is the most practical solution. Using an existing, small refrigeration plant in a poultry dressing station as an example, author examines alternative forms of automation seen in relation to the automatic controls currently in use. With the exception of the electronically-controlled capacity regulator of the screw compressor, all mounted automatic controls are based on self-acting regulation principles.

Neldeberg, P. (Danfoss A/S, Nordborg, Den). *Aust Refrig Air Cond Heat* v 42 n 4 Apr 1988 7p.

**089593 REFRIGERATION FOR HORTICULTURE.** Nearly all fresh produce requires cooling, storing and transporting under conditions of uniform temperature and very high relative humidity if deterioration is to be minimised. In Australia most post harvest facilities have not been designed to obtain optimum conditions. This may be due to a lack of understanding of the product needs and how they interact with the environment. In part, it is also due to a lack of specialised refrigeration systems, and information regarding cost benefits to obtain and maintain post harvest environments closer to the optimum conditions. This paper explains the nature of fresh produce, the interaction with its environment and provides some refrigeration design guidelines. (Author abstract) 53 refs.

Blacker, Keith (Koldtek). *Aust Refrig Air Cond Heat* v 41 n 10 Oct 1987 5p.

**Optimization** See REFRIGERATION—Defrosting.

## Simulation

**089594 REFRIGERATION SYSTEM SIMULATION TO REDUCE ENERGY CONSUMPTION.** In refrigeration systems based on vapour compression, pure substances (i.e. ammonia, ethylene, and propane, etc.) are generally used as cooling media. In this case, the evaporation and condensation proceed at constant temperature. In practice, however, the cooling media may also contain additional components. This is the case when technological streams are used for this purpose. If so, the evaporation and condensation take place in a temperature range, modifying the compression and heat exchange conditions. An application of the MASTEP flowsheeting programme for refrigeration system analysis is presented. Case studies were carried out to investigate how the energy consumption depends on the concentration of additional components in propane as cooling medium. Generation of the model, the calculation strategy and some results are discussed. (Edited author abstract) 3 refs.

Csermely, Z. (Hungarian Oil & Gas Research Inst, Veszprem, Hung); Simon, F.; Timar, L. *Hung J Ind Chem* v 15 n 3 1987 p 341-347.

**Solar** See Also AIR CONDITIONING—Solar Energy Systems; HEAT PUMP SYSTEMS.

**089595 PERFORMANCE OF AN AQUA-AMMONIA ABSORPTION SOLAR REFRIGERATOR AT SUB-FREEZING EVAPORATOR CONDITIONS.** Ice making by means of a solar-assisted aqua-ammonia absorption refrigeration unit at sub-freezing evaporator conditions is considered in terms of its technical and economic feasibility. A computer-aided thermodynamic analysis is performed for various ranges of operation parameters, three climatic locations varying from 15°N to 43°N latitude and four solar collector types, i.e. flat plate, compound parabolic collector, and east-west and north-south axis tracking concentrators. In order to use an air-cooled condenser, the simulation is predicted on an absorber temperature of 35°C and a condenser temperature of 38°C. The results indicate that for generator pressures of 1.02 to 2.07 MPa, generator temperatures greater than 120°C are required. At these conditions, the COP is on the order of 0.5 and a conventional flat plate collector is not satisfactory. For the three climates, the compound parabolic collector (CPC) has a higher output than an east-west axis tracking concentrator but less than the north-south tracker. (Edited author abstract) 15 refs.

Clerx, M. (Univ of California, Berkeley, CA, USA); Trezek, G.J. *Sol Energy* v 39 n 5 1987 p 379-389.

**089596 EXPERIMENTAL INVESTIGATION OF A SOLAR-EJECTOR FREON REFRIGERATING MACHINE.** Preliminary analysis of solar cold generators and investigation of radiation conditions in the southern Ukraine enabled us to decide on a solar-ejector machine operating on Freon-142, with a flat-plate solar collector, as the simplest to design and service, reliable and safe. A diagram of an experimental solar-ejector Freon refrigeration machine (SEFRM) is shown. It is shown that ejector refrigerating machines operating on Freon-142 are promising. The SEFRM provides for production of cold at 8-10 °C with a fairly high conversion factor (up to 0.16) for 5 hr/day in conditions of sufficient intensity of solar radiation (700 W/m<sup>2</sup> or more).

Shchetinina, N.A.; Petrenko, V.A.; Zhadan, S.Z. *Appl Sol Energy* v 23 n 3 1987 p 74-77.

**089597 OPTIMUM HEAT-TRANSFER RESISTANCE OF THE OUTER ENCLOSURES OF A FRUIT-AND-VEGETABLE STOREHOUSE WITH SOLAR COOLING.** The article considers the procedure for calculating the economically optimum heat-transfer resistance of an agricultural fruit-and-vegetable storehouse with solar cooling. (Author abstract) 2 refs.

Shadiev, S.; Kamilov, O.S.; Mirzakhodzhaev, R.M. *Appl Sol Energy* v 23 n 2 1987 p 104-105.

**089598 REFRIGERATION SOLAIRE PAR REACTION SOLIDE-GAZ: FAISABILITE PHYSICO-CHIMIQUE SUR UNE MAQUETTE DE LABORATOIRE.** [Solar Refrigeration by Solid-Gas Reactions: Physical-Chemistry Feasibility Tests on a Laboratory Device]. Solid-gas reactions may be used in solar-powered refrigeration systems. The chosen pair is LiCl/methylamine which is well suited to ice production under warm climatic conditions. After determination of the optimal implementation of the reactive mixture, we tested the feasibility of such a system on a laboratory device. The reproducibility of the reactions and performances obtained were satisfactory. A production of 1 kg of ice per kg of reactive solid and a COP of 0.067 have been obtained. (Author abstract) 20 refs.

Balat, M. (CNRS, Perpignan, Fr); Crozat, G. *Int J Refrig* v 11 n 1 Jan 1988 p 33-40.

**089599 BEHAVIOR OF A HOUSEHOLD ABSORPTION-DIFFUSION REFRIGERATOR ADAPTED TO AUTONOMOUS SOLAR OPERA-**

**TION.** This article presents a study on the thermal performance of a solar refrigerator that is simple to use. The unit was developed from a commercial absorption-diffusion type refrigerator that had a flat plate collector substituted for this generator. An ammonia-water solution and hydrogen was used in the system. Since there is no hot thermal storage to operate the system continuously, cooling occurs during daytime only. The heat is rejected by natural air convection. A series of experiments was performed in which the system was solar powered and also operated in a solar simulator, in order to know the effects of the ambient temperature on the behavior of the apparatus. (Author abstract) 5 refs.

Gutierrez, F. (Univ Nacional Autonoma de Mexico, Mexico City, Mex). *Sol Energy* v 40 n 1 1988 p 17-23.

**089600 NUTZUNG DER SOLARTECHNIK ZUR KAELTE- UND EISERZEUGUNG IN ENTWICKLUNGSLAENDERN.** [Using Solar Energy for Refrigeration and Ice Production in Developing Countries]. Three solar energy projects, namely, the Sonntlan in Mexico, Daxing in China, and Solar Village in Indonesia, in which the Technical University of Reinland, West Germany, is involved, are described and evaluated. In German. 3 refs.

Wiesner, W. *Ki Klima Kaelte Heiz* v 16 n 1 Jan 1988 p 37-40.

**089601 PARAMETRIC EFFECTS ON THE PERFORMANCE OF A SOLAR-POWERED SOLID ABSORPTION REFRIGERATOR.** Further tests were carried out on a solar powered solid absorption refrigerator. The solid absorbent was CaCl<sub>2</sub> treated with CaSO<sub>4</sub> to increase its resistance to compacting and disintegration, while maintaining a good absorbent granule porosity. The refrigerant was NH<sub>3</sub>. Tests were carried out over the annual climatic variations at Nsukka, Nigeria. In addition, the generation stage was started at nominal pressure of 900, 500, and 200 kPa to determine the effect of charging pressure on the COP. The experiments also provided longer-term performance tests of the absorption/generation capability of the absorbent. Cooling was obtained for all test months except for July and August. For the dry and the harmattan climates, the useful overall COP varied over 0.017 to 0.053 and 0.008 to 0.042, respectively. Maximum daily useful cooling and ice production were 833.3 kJ/m<sup>2</sup> and 1.65 Kg/m<sup>2</sup>, from the 1.41 m<sup>2</sup> collector. The available overall COP initially increased with charging pressure but became insensitive to it at higher pressures. (Edited author abstract) 12 refs.

Iloje, O.C. (Univ of Nigeria, Nsukka, Nigeria). *Sol Energy* v 40 n 3 1988 p 191-195.

**089602 COMPARISON OF THE EFFICIENCY OF VARIOUS WAYS OF HEATING THE GENERATOR OF A SOLAR-EJECTOR FREON REFRIGERATING MACHINE.** The article examines various schemes for heating the generator of an SEFRM, gives formulas for determining the average temperature of the solar receiver's surface, and shows that an open scheme for the heat-transfer medium's circulation is the most efficient. (Author abstract) 2 refs.

Shchetinina, N.A.; Zhadan, S.Z.; Petrenko, V.A. *Appl Sol Energy* v 23 n 4 1987 p 83-86.

**089603 MODELING AND SIMULATION STUDIES ON SINGLE/DOUBLE-EFFECT ABSORPTION CYCLE USING WATER-MULTICOMPONENT SALT (MCS) MIXTURE.** This communication presents an investigation on modeling and simulation studies of single/double-effect absorption cooling systems using a water-multicomponent salt mixture vis-a-vis water-LiCl-CaCl<sub>2</sub>-Zn(NO<sub>3</sub>)<sub>2</sub> solution as a working fluid. The computer modeling/simulation is based on mass, material, and heat balance equations for each component of the system. Effects of different input variables used for the computer modeling and simulation studies are investigated and a detailed parametric study of the double-effect cycle is carried out. A comparative study of the water -



multicomponent salt (MCS) mixture and the conventional water - LiBr mixture is also presented for both single-stage and double-effect absorption cycles. It is found that the cooling COP of the double-effect cycle is nearly twice of the single-stage cycle for both of the working fluids under the same operating conditions. The system feasibility and constraints are also discussed. (Edited author abstract) 17 refs.

Kaushik, S.C. (Indian Inst of Technology, New Delhi, India); Gadhi, S.M.B.; Agarwal, R.S.; Kumari, R. *Sol Energy* v 40 n 5 1988 p 431-441.

**089604 PERFORMANCE LIMITATIONS OF ADSORPTION CYCLES FOR SOLAR COOLING.** Adsorption cycles for solar cooling are described and past work reviewed. Zeolites have been used as adsorbents in many systems, but this work concentrates on activated charcoal adsorption. A general study of the cycle thermodynamics shows that provided the latent heat of the refrigerant exceeds about 1000 kJ/kg and the concentration change exceeds about 10% then the coefficient of performance (COP) can only be slightly improved by further increase. Looking at activated charcoal in particular, the Dubinin-Astakhov (D-A) equation is used to predict cycle COPs based on limited data available for chosen refrigerants and carbons. Of the refrigerants that are subatmospheric at  $-10^{\circ}\text{C}$ , methanol, acetonitrile, methyl amine, and  $\text{NO}_2$  are suitable, with methanol giving the best COP. Of the refrigerants above atmospheric pressure at  $-10^{\circ}\text{C}$ , ammonia, formaldehyde, and  $\text{SO}_2$  are suitable. Overall, methanol gives the best COP, with 0.5 being achievable in a single-stage cycle. (Author abstract) 23 refs.

Critoph, R.E. (Warwick Univ, Coventry, Engl). *Sol Energy* v 41 n 1 1988 p 21-31.

**089605 SOLAR POWERED SOLID ADSORPTION COLD STORE.** Experimental results obtained on a 12 cubic meter solar-powered solid-adsorption cold store are presented. These results are compared to the predictions of a simplified model. On the basis of this model, performance of a similar installation under various conditions (locations, orientation) and other technological possibilities are given. (Edited author abstract). 23 Refs.

Grenier, Ph. (CNRS, Orsay, Fr); Guilleminot, J.J.; Meunier, F.; Pons, M. *J Sol Energy Eng Trans ASME* v 110 n 3 Aug 1988 p 192-197.

**089606 OPERATIONAL RESULTS OF THE 13 kW/50 m<sup>3</sup> SOLAR-DRIVEN COLD STORE IN KHARTOUM, THE SUDAN.** Experimental test results on a 13-kw solar-driven absorption refrigerator, located at Khartoum, The Sudan, are presented. Design considerations and cost aspects of the solar-driven refrigerator are given as well. The test shows that the solar-driven refrigerator performed satisfactorily during nine months of operation. However, continued tests have to show the ultimate system performance. (Author abstract). 10 Refs.

Sloetjes, Wim (Stork Product Engineering, Amsterdam, Neth); Haverhals, Jaap; Kerkdijk, Kees; Porsius, Rob; Stolk, Ad; El Karib, Asha; Yousif, Kahil; Hassan, Hassan Wardi. *Sol Energy* v 41 n 4 1988 p 341-347.

## Thermodynamics

**089607 ADIABATIC EXPANSION-EXHAUST REGENERATIVE REFRIGERATING CYCLE.** This paper proposes a new closed cryogenic refrigerating cycle, the adiabatic expansion-exhaust regenerative cycle, which may be called a modified Gifford-McMahon (G-M) cycle. A cryocooler with this cycle has the advantages of simple construction, long unattended continuous running time and vibration-free operation, similar to G-M cryocoolers. This cycle can also be used in one-stage or multistage cryocoolers. A comparison between this cycle and the G-M cycle, the operating procedure and a thermodynamic analysis of the new cycle are presented in this paper. (Author abstract) 4 refs.

Wan, Weiwu (Jiaotong Univ, Xian, China). *Cryogenics* v 27 n 10 Oct 1987 p 577-581.

**089608 THERMODYNAMIC CYCLES FOR REFRIGERATION AND HEAT TRANSFORMER UNITS  $\text{H}_2\text{O}/\text{LiBr}$ .** The exact theoretical refrigeration and transformer thermodynamic cycles, of units working with  $\text{H}_2\text{O}/\text{LiBr}$ , are presented on the enthalpy-temperature as well as on the temperature-entropy diagram. The heat quantities involved have been calculated for many such cycles. Afterwards the results have been correlated by short relations allowing fast computation of the related quantities. The fast algorithm obtained can be used to predict optimal operating conditions in a very short computer time even if personal computers are used to 8 refs.

Kouremenos, Dimitrios A. (Nat'l Technical Univ of Athens, Greece); Rogdakis, Emanuel D. *Forsch Ingenieurwes* v 54 n 2 Mar 1988 p 39-47.

**089609 ANWENDUNGSBEISPIELE ZU EINER METHODE DER THERMODYNAMISCHEN BEWERTUNG OHNE EXERGIE-BERECHNUNG.** [Application Examples of a Method of Thermodynamic Evaluation Without Exergy Calculation.]. It is demonstrated, by means of several numerical examples from the field of refrigerating engineering, with each example being reproducible in all details, that the proposed method of thermodynamic evaluation without exergy calculation was developed for a transparent and practicable application. Employing the same scheme of calculation in all cases, the method can be used to evaluate a wide variety of different processes, including mixing, dissociation and substance conversion processes (chemical reactions). These may be time-independent or time-dependent processes in production systems which are in a state of immobility or movement. (Author abstract). 2 Refs. In German.

Bauer, Bernhard. *Ki Klima Kaelte Heiz* v 16 n 9 Sep 1988 p 384-388.

## Transportation

**089610 REFRIGERATED TRANSPORT BY SEA.** Sea transport of refrigerated goods is a vital link in the cold chain conveying perishables from producer to consumer. Despite the unprecedented crisis at present afflicting marine transportation and shipyards, sea refrigerated transport has experimented with important advances in the last few years. A 'reefer' ship is today a complex structure, with a great deal of computer technology and automation installed onboard. Ships are always ships, they may have lost some of the fascinating allure of the past, only to become sophisticated, specialized and efficient tools, up to the expectations of today's way of life. This paper concentrates on cargo ships and fishing vessels and omits references to the specialized vessels required for liquefied gases. (Author abstract)

Dellacasa, A. (Termomeccanica Italiana, La Spezia, Italy). *Int J Refrig* v 10 n 6 Nov 1987 p 349-352.

**REFRIGERATORS** See Also CRYOGENICS; ELECTRIC POWER GENERATION—Energy Resources; SUPERCONDUCTING MAGNETS—Cooling.

**089611 LE FROID DANS LES SURFACES COMMERCIALES: 1 - LES EQUIPEMENTS.** [Refrigeration of Commercial Surfaces - 1. Equipment]. A description of various kinds of commercial refrigerators and freezers and of their various centralized or decentralized arrangements for different food products is presented. In French.

Laberdesque, C.; Schann, C. *Promoclim E* (1986) v 18 n 2 Mar-Apr 1987 p 71-92.

**089612 KOMPAKTKAELTESAETZE FUER DEN UNIVERSELLEN BETRIEBSINSAATZ DER LAGER-RAUM- UND TRANSPORTRAUMKUEHLUNG.** [Packaged Refrigerating Sets for Universal Use in Warehouse and Transport Space Cooling]. Automatic and ready-to-plug packaged refrigerating sets with low space requirement and little installation work are in increasing use also in larger spaces up to 5,000 m<sup>3</sup>. Thanks

to the equipment of refrigerated rail cars, VEB Kombinat ILKA Luft- und Kaelletechnik have gained ample experience in this field for decades. New types of higher capacity are due to be introduced into production. A description is also given of another development which gives special consideration to the optimum adaptation of the refrigerating set to universal service with optional chilled or frozen goods storage and maintenance of emergency operation. This is of utmost importance for the equipment of refrigerated rail cars. (Author abstract) In German.

Schroth, H.-H. (VEB, East Ger). *Luft Kaelte tech* v 24 n 1 1988 p 20-23.

**089613 MEHRZWECKKUEHLHAUSER AUS DER DDR.** [Multipurpose Cold Stores from the GDR]. The enterprise engaged in the industrial refrigerating plant engineering in the GDR is briefly presented. Its services are explained on the example of cold stores implemented in practice. A review is given of the type series of multipurpose cold stores with decentralized coolant supply offered to the market. (Edited author abstract). In German.

Kopp, Alfred. *Ki Klima Kaelte Heiz* v 16 n 9 Sep 1988 p 382-383.

Absorption See REFRIGERATION—Solar.

Accessories See CRYOSTATS—Measurements.

Closed Cycle See CRYOGENICS—Equipment.

Compressors See CAST IRON—Wear.

Computer Aided Manufacturing

**089614 MANUFACTURING REFRIGERATORS WITH PEOPLE-BASED AUTOMATION.** In 1986 General Electric opened the doors to a new, computer-integrated manufacturing facility in Columbia, TN. The mission of the plant was to build, at a rate of 1.5 million units/year, rotary refrigerator compressors that are 50% smaller, weigh 50% less, and have 60% fewer parts than typical reciprocating units. In 1987, GE's Louisville, KY plant was given the task of building 1000 + refrigerators/day, in 100 different models, using the compressors manufactured in the Columbia facility. GE Fanuc Automation North America, Inc. has been supporting GE Appliances in this two-phase project, which is now just about completed. GE Fanuc designed and implemented a plant-wide information system called ACONS (automated compressor on-line system) for the Columbia facility, and designed a SMART (shop management recording and tracking) system for the Louisville plant. The article details the hardware and software aspects of each portion of this project, and outlines the planning, implementation, and manufacturing strategies that were needed to bring the project to successful completion.

Labs, Wayne (I&CS, Radnor, PA, USA); Kuhfeld, Ron. *Chilton's I&CS* v 61 n 2 Feb 1988 p 46-49.

## Control

**089615 CAPACITY CONTROL OF A REFRIGERATION SYSTEM USING A VARIABLE SPEED COMPRESSOR.** Research on capacity control of refrigeration systems and heat pumps is reviewed. An experimental liquid chilling system has been developed and used to investigate the influence of the control system on plant transients and energy consumption. Changing capacity by varying compressor speed resulted in significant energy savings. (Author abstract) 15 refs.

Wong, A.K.H. (South Bank Polytechnic, London, Engl); James, R.W. *Build Serv Eng Res Technol* v 9 n 2 1988 p 63-68.

Defrosting See Also REFRIGERATION—Efficiency.

**089616 THERMAL RESISTANCE OF FROST ON A FINNED AIR COOLER.** Results are given from



measuring the thermal resistance of frost on finned air coolers. We have measured resistances for frost on finned air coolers having corridor-type tube bundles and various fin stacks. The apparatus was built up from sections of length 170 mm, which each contained two longitudinal rows of tubes and five transverse ones, diameter 25 mm and pitches 70 and 76 mm correspondingly. The flat solid fins were made of 0.4 mm steel. The set thermal conditions were provided by an independent refrigerator. The coolant was ammonia, and its temperature was measured along with the temperatures of the tube walls, ribs, and air by means of thermocouples. The heat load was determined from the heat balances for the air and coolant, and the flow rates were measured. 9 refs.

Chepurnoi, M.N. (Vinnitsa Polytechnic Inst, USSR); Shnaider, V.E.; Lomakin, V.N.; Sinyuk, N.I. *J Eng Phys* v 52 n 3 Mar 1987 p 307-309.

**089617 BEREIFUNG UND ABTAUUNG VON LUFTKUEHLERN: THEORETISCHE GESICHTSPUNKTE, VERSUCHSERGEBNISSE, STANDARD NEN 1876, SYSTEMOPTIMIERUNG.** [Ice Formation and Defrosting of Air Coolers: Theoretical Aspects, Test Results, Standard NEN 1876, System Optimization]. During a period of more than ten years fundamental research on frost formation and defrosting behavior of lamel-type air cooler has been carried out. Experiments have been performed to support the Dutch Standard for testing air coolers NEN 1876. This standard gives an objective description of the performance of air coolers under being conditions. For the system designer it is very important to judge the average cooling performance and coefficient of performance during the total cycle, consisting of a cooling period and a defrosting period. For these values two dimensionless numbers were derived, which make it possible to determine - by using computer models - the optimum cooling period until defrosting starts. Finally, the use of the developed theories for (cost) optimization of refrigerating plants and the latest experiences with the Dutch standard for air coolers NEN 1876 are discussed. (Author abstract) 12 refs. In German.

Machielsen, H.M. *Ki Klima Kaelte Heiz* v 16 n 4 Apr 1988 p 178-183.

**089618 HOT GAS DEFROST FOR INDUSTRIAL REFRIGERATION.** Frost buildup on evaporator surfaces is a common occurrence with many refrigeration applications. Moisture from air infiltration and often from products in a freezer or cold room condenses and freezes on cold surfaces. The evaporator, being the coldest surface in the room, attracts much of this moisture. When the evaporator surface temperature is below 32 F, ice forms on it. This must be periodically removed before it becomes so great that operating performance suffers. The most common method used to defrost industrial evaporators is with hot gas. Defrosting evaporator coils is essential in ammonia and halocarbon refrigeration systems. Too few, too many, and too long defrost cycles waste energy and money. The paper shows how to handle hot gas defrost safely and economically.

Strong, Arthur P. (Parker Hannifin Corp, Wheeling, IL, USA). *Heat Piping Air Cond* v 60 n 7 Jul 1988 p 71-83.

**089619 ADAPTIVE DEMAND DEFROST AND TWO-ZONE CONTROL AND MONITOR SYSTEM FOR REFRIGERATION PRODUCTS.** A defrost system that adapts to usage patterns and ambient conditions is described. The following parameters determine the interval between defrost operations: the amount and duration of door openings, the length of previous defrost operations, and the current freezer temperature. A two-temperature control system which allows the user to independently select freezer and fresh-food compartment temperatures is also discussed. The compressor run time and the air flow to the fresh-food compartment are controlled to achieve the desired results. These controls have been incorporated in a total control and monitor system which was recently introduced. The other features of this control are also briefly described.

Knoop, Donald E. (Le Tourneau Coll, Longview, TX,

USA); Tershak, Andrew T.; Thieneman, Michael. *IEEE Trans Ind Appl* v 24 n 2 1988 p 337-342.

## Design

**089620 SIMULATION OF CRYOGENIC BATCH FREEZERS.** A simplified mathematical model is proposed to evaluate the performance of batch cryogenic freezers (cabinets). The comparison with experimental data is satisfactory. The influence of operative variables on the freezing process is analysed through the model. From the users point of view, this work makes possible an evaluation of production rates and the calculation of the cabinet freezing incidence time on production costs. (Author abstract) 13 refs.

Reynoso, R.O. (UNLP, La Plata, Argent); De Michelis, A. *Int J Refrig* v 11 n 1 Jan 1988 p 6-10.

**089621 NOVEL TOP-LOADING 20 mK/15 T CRYOMAGNETIC SYSTEM.** A new type of dilution refrigerator is described with easy loading of the sample directly into the dilute phase in the mixing chamber. Electrical, optical and mechanical services to the sample are readily incorporated and electrically insulating tails allow the use of high and variable magnetic fields. A sample temperature of 20 mK in a field of 15 T has been achieved. (Author abstract) 3 refs.

Reinders, P.H.P. (Univ of Sussex, Brighton, Engl); Springfield, M.; Hilton, P.; Kerley, N.; Killoran, N. *Cryogenics* v 27 n 12 Dec 1987 p 689-692.

Efficiency See HEAT PUMP SYSTEMS—Efficiency.

Electric Power See AGRICULTURAL PRODUCTS—Refrigeration.

Energy Conservation See ELECTRIC APPLIANCES—Energy Conservation.

## Manufacture

**089622 PREDICT PROBLEMS & PREVENT THEM...BY MANAGING DATA.** To effectively manage automation's processes requires appropriate tools. Two of GE's refrigerator assembly plants - one in Louisville, Ky., and one in Columbia, Tenn. - use factory control and information systems that let factory personnel anticipate problems and stop them before they happen. The SMART (Shop Management Recording and Tracking) system, includes some key quality control tools and oversees an automated subassembly area, two final assembly lines, supporting fabrication machines, and several overhead conveyor systems. The Automated Compressor On-Line System (ACONS) is used to monitor data flow.

Allen, Linda G. (Automation, Cleveland, OH, USA). *Automation (Cleveland)* v 35 n 1 Jan 1988 p 72-74, 76.

## Noise

**089623 GERAEUSCHE IN KALTEANLAGEN UND DEREN PRAKTIISCHE BESEITIGUNG.** [Noise and Noise Abatement Measures in Refrigeration Systems]. Noise reduction specifications have become more rigid for the field of refrigeration equipment, air conditioning systems and heat pumps these last few years, especially in domestic HVAC systems which affect humans most directly. To comply with these requirements, producers, planners and fitters must work together even more closely than before. In German. 6 refs.

Koerner, F. *Ki Klima Kaelte Heiz* v 16 n 1 Jan 1988 p 25-29.

Performance See Also REFRIGERATION—Solar.

**089624 SOLAR COLLECTOR OPERATING TEMPERATURES FOR MAXIMUM COEFFICIENT OF PERFORMANCE OF AN ABSORPTION REFRIGERATION SYSTEM.** For an absorption refrigeration system, the coefficient of performance (COP) increases as the energy supply temperature increases. This discrepancy shows that any solar collector-absorption refrigerator

combination will have an optimum operating temperature. An attempt has been made to determine the optimum operating temperatures of a linear solar concentrator with a tubular receiver for maximum coefficient of performance of an absorption refrigeration system. The effects of absorber temperature, emissivity of absorber and wind loss coefficient on the heat loss factor has been taken into account in obtaining the optimum system performance. (Edited author abstract) 4 refs.

Mazumder, R.K. (Univ of Dhaka, Bangladesh); Bhowmik, N.C.; Hussain, M.; Huq, M.S. *Energy Convers Manage* v 27 n 3 1987 p 285-287.

Selection See FOOD PRODUCTS—Cold Storage.

## Temperature Control

**089625 TECHNICAL NOTE: DESIGN OF A 16-CHANNEL TEMPERATURE MONITOR.** A system was designed to monitor and display the temperature of thirteen refrigerators in the hospital's clinical laboratory. The system includes programmable high and low alarms, a panel meter to display temperature, yellow light-emitting diodes (LEDs) for refrigerator indication, red LEDs for high alarms, and green LEDs for low alarms. The system presented here has been in operation for over three years and has been shown to be reliable, inexpensive, and useful for periodic data collection. (Author abstract)

Loney, John W. (California Univ of Pennsylvania, California, PA, USA). *J Clin Eng* v 13 n 2 Mar-Apr 1988 p 139-143.

## Vibrations

**089626 STUDY OF NOISE AND VIBRATION IN THE MOTOR-COMPRESSOR UNIT OF HOME REFRIGERATORS.** Higher demands have been expected of refrigerators with respect to their noise level, which mainly depends on performance characteristics of the motor-compressor unit. It is difficult to control the noise level produced by the refrigerator under the circumstances of large batch conveyor production since the environmental noise (in the shop) exceeds the allowed limits of noise by 15-20 decibels. In Saratov's Polytechnical Institute research work aimed at investigating disturbances and vibrations of the motor compressor was carried out. It resulted in a procedure for routine monitoring of refrigerator noise by its vibration level. 2 refs.

Glazunova, I.S.; Lipskii, G.K.; Pal'm, M.Yu.; Yudin, F.F. *Vib Eng* v 2 n 1 1988 p 27-33.

REFUSE DISPOSAL See Also BORON; INDUSTRIAL WASTES—Management.

**089627 HOUSEHOLD WASTE THREATENS HAULER AND LANDFILL SAFETY.** The U.S. Environmental Protection Agency (EPA) reports that household hazardous wastes have been found in the environment. The agency also says that indirect evidence suggests that these wastes contribute to groundwater contamination detected at a number of municipal disposal sites around the country. The agency is developing a proposal with new standards for municipal waste sites. The proposal will include standards for groundwater monitoring and corrective actions to deal with contamination. It will not, however, specifically exclude household hazardous waste from municipal landfills.

Adkins, Janis M. *World Wastes* v 30 n 10 Oct 1987 p 38-39.

**089628 PROGRESSI NELLE TECNOLOGIE DI TRATTAMENTO E SMALTIMENTO DEI RIFIUTI SOLIDI URBANI.** [Developments in Technologies for the Treatment and Disposal of Solid Urban Wastes]. Systems and methods of treatment of solid wastes, such as composting, recycling, incinerating and dumping are described. Some innovations introduced in Italy are also



dealt with on the basis of a comparison with the developments which have taken place in other countries. (Author abstract) In Italian.

Mantellini, G. (De Bartolomeis SpA, Milan, Italy). *Energ Alternative Habitat Territ Energ* v 9 n 46 Mar-Apr 1987 p 122-126.

**089629 LESSONS FROM THE FAR EAST.** Japan is considered by many to lead the way in garbage control. Recycling has been a way of life in Japan for over a century, largely because the country has no choice. This article discusses two books that describe the Japanese approach to management and recycling of wastes: Garbage Management in Japan: Leading the Way, by Allen Hershkowitz and Eugene Salerni; and Recycling '87: Turning Waste Into Resources, The Clean Japan Center.

Logsdon, Gene. *BioCycle* v 29 n 6 Jul 1988 P29.

## Analysis

**089630 MUNICIPAL SOLID WASTE COMPOSITION AND THE BEHAVIOR OF METALS IN INCINERATOR ASHES.** The composition of municipal solid wastes (MSW) from residential service areas was categorized and residuals from MSW incineration were examined for metal content and leachability. Sample size, sampling methodology, segregation by category and homogeneity of service area were determined to be dominant factors influencing the composition of MSW. There were notable differences in metal content of the fly and bottom ash residuals. Lead and zinc were the dominant trace metals in both ash residuals. Concentrations of cadmium and lead leached from the flyash were found to exceed EP limits. Lead and cadmium of both bottom ash and flyash fail proposed TCLP extraction limits by even larger margins. Permanent elimination of high-temperature process ashes, classified as hazardous, must be demonstrated. (Edited author abstract) 30 refs.

Clapp, T.L. (Rutgers, The State Univ, Piscataway, NJ, USA); Magee, J.F. II; Ahlert, R.C.; Kosson, D.S. *Environ Prog* v 7 n 1 Feb 1988 p 22-30.

## Auckland, New Zealand

**089631 SOLID WASTE DISPOSAL TECHNIQUES IN AUCKLAND OVER THE LAST 40 YEARS.** This paper traces the continuing efforts that have been made in Auckland over forty years to make better use of the community's solid waste. A petition to Government to investigate the composting of municipal wastes was followed by the setting up of a pilot plant by Auckland City Council and Government on a shared basis. The successful experiments enabled the Council to establish the country's first major mechanical composting plant after full overseas investigation by the author, who later was again able to recommend a solution to the disposal problems in West Auckland and was instrumental in establishing a solid waste baling and recycling station for the Waitamata City Council. Details of the pilot and major composting plants have been published but this fuller description of the solid waste baling system has not been recorded. (Author abstract) 6 refs.

Hutchinson, George A. *Trans Inst Prof Eng NZ Civ Eng Sect* v 14 n 2 Jul 1987 p 101-104.

## Baltimore, Maryland

**089632 BALTIMORE SHAPES UP AND GETS WISE TO WASTE.** After years of deterioration, the future looks bright for the city's incineration, recycling and landfill plans. The Baltimore Resource Energy Systems Co. (BRESKO), whose parent company is Wheelabrator-Frye, became a welcome replacement to a former pyrolysis plant that baked solid waste and reduced it to an ash-like material. In 1987, the BRESKO incinerator processed 723,000 tons of solid waste, up from 719,900 tons in 1986 and 671,600 tons in 1985. Overall for 1987, the plant sold 270,000 megawatts of electricity to Baltimore Gas and Electric Co. and sold over a billion pounds of steam to Baltimore Steam Co. These and other

aspects of the subject are discussed.

Brumback, Teresa. *World Wastes* v 31 n 8 Aug 1988 p 32-36.

**Bioconversion** See BIOGAS—Production.

**Cairo, Egypt** See WASTE DISPOSAL—Composting.

**Collection** See Also MOTOR TRUCKS—Refuse Collecting; REFUSE INCINERATORS—Waste Heat Utilization.

**089633 SOURCE SEPARATION IN AUSTIN.** Since 1982, Austin, Texas (population 450,000) has operated a curbside recycling program in the Solid Waste Services Division of the Department of Transportation and Public Services. Currently, 86,000 homes are serviced with curbside collection of source-separated newspaper, glass bottles and jars, and metal cans. During 1986, 4,000 tons of recyclables were collected by municipal crews. Ten (two person) collection crews collect recyclables from 50 recycling routes with an average size of 1,720 homes per route weekly. A combination truck/trailer system is used with seven Eager-Beaver 'Recycler 6' being the most prominent of the 13 trailers and seven two-ton stake body trucks being the majority of the 12 trucks. Assuming 120,000 homes will be serviced by 1988, it is estimated that the program will be collecting 10,800 tons of recyclable material per year.

Abramowitz, Richard (Dep of Transportation & Public Services, Austin, TX, USA). *BioCycle* v 28 n 8 Sep 1987 p 36-37.

**089634 CASH INCENTIVES AND THE RIGHT COLLECTION EQUIPMENT SAVE CITY MILLIONS.** A unique cash incentive program based on collected weight rather than number of stops - and on 31-yard rear-loaders rather than the more common 20- and 25-yarders - has resulted in five-year savings for Springfield, Massachusetts of \$2.7 million. The larger packers have enabled the city to handle all residential pickup with 11 vehicles instead of the 18 formerly used, resulting in reduced labor, fuel, depreciation, and maintenance costs totaling \$540,000 annually. Each three-man crew and its high-compaction loader now accumulates its union-accepted daily norm of 56,000 lb in two loads instead of the three or four loads required by the smaller haulers formerly used. These and other aspects of the program are discussed.

Anon. *Public Works* v 119 n 1 Jan 1988 p 56-57.

**089635 GOOD CASE FOR AUTOMATED COLLECTIONS.** With the elimination of lifting and carrying, users of the cart system are finding fewer health-related worker complaints. There has been a significant drop in back and hand injuries, and the job has become less strenuous for workers. By upgrading sanitation jobs, companies and municipalities are finding an improved on-the-job attitude. Productivity levels are rising, along with the longevity of collection workers. In addition to the reduced number of stops, the cart system may also save time at each stop. The average back yard service clocks in at 1:04 minutes. Additional savings have been realized as a result of the size of the carts. For private collection contractors, the cart system has proved to be cost-efficient as well as pleasing to the public.

Gates, Verna. *World Wastes* v 31 n 5 May 1988 p 41-42.

**089636 STUDY ON SEASONAL FLUCTUATION OF COLLECTED AMOUNT OF MUNICIPAL SOLID WASTE.** Seasonal fluctuation of collected amount of municipal solid waste in Sapporo is studied. In order to make characteristics of fluctuation pattern clear, collected amounts are normalized giving special consideration to national holidays and their next collection days on which amounts of waste sharply change. Correlation coefficients, moving averages and autocorrelation function are calculated to give quantitative information on the fluctuation pattern and to make comparison among different districts or years. In addition detailed investigations are carried out on the increase of waste in the periods

of December to January and March to May. Strong relationship between snow-thawing and people's behavior of waste production is confirmed. (Author abstract) In Japanese. 4 refs.

Matsuto, Toshihiko; Koyama, Keiichi; Tanaka, Nobutoshi. *Doboku Gakkai Rombun-Hokokushu* v 9 n 5 May 1988 p 201-208.

**089637 PHONE IN-TOSS OUT: THE BIRTH OF A PROGRAM.** This article reviews the 'pick up by appointment' program for refuse disposal which is used in Greece, New York. Collection techniques, scheduling, and public education are discussed.

Low, Thomas A. *Public Works* v 119 n 8 Jul 1988 p 72-73.

**089638 ANOTHER SUCCESS STORY FOR AUTOMATED COLLECTION.** The sanitation department was able to reduce its fleet of five manual sideloaders to a fleet of three new automated sideloaders. Requirements included long life, low maintenance, and air-over-hydraulic controls for fewer moving parts. The new system uses an automated arm, operator-controlled from the cab, that does all the lifting. One health and safety benefit is the elimination of lifting and handling of the refuse receptacles by collection crews. Since implementation of the container system, there has been a noticeable decrease in trash littering the area.

Bruhn, Robert (Streets & Sanitation Dep, Bountiful, UT, USA). *Public Works* v 119 n 9 Aug 1988 p62.

## Combustion

**089639 FATE OF SOME TRACE ELEMENTS IN FLUIDISED-BED COMBUSTION AND GASIFICATION PROCESSES.** Coal and municipal waste (MSW) contain many trace elements which are released upon combustion and gasification and have toxic forms at certain concentrations. These pollutants must be removed, if increasingly stricter emission standards are to be met. Cadmium (Cd), lead (Pb), zinc (Zn), and mercury (Hg) were selected for study and multicomponent, multiphase equilibrium calculations were carried out to determine which elements volatilize upon combustion and gasification and which ones condense upon cooling the flue gases. It was also intended to determine the distribution of the trace element species in the product streams. Both fluidised-bed combustion and gasification processes were studied having coal and municipal solid waste as fuel. (Edited author abstract) 41 refs.

Mojtahedi, Wahab (Technical Research Cent of Finland, Espoo, Finl); Backman, Rainer; Larjava, Kari. *Publ Tech Res Cent Finl* 42 Dec 1987 44 p.

**Composting** See Also AGRICULTURAL ENGINEERING—Waste Utilization; ORGANIC COMPOUNDS—Chemical Analysis; SEWAGE TREATMENT—Sludge Disposal.

**089640 NEW APPROACH IN SCHENECTADY.** Schenectady, New York, is the first to build and operate a composting plant using the American Bio Tech, Inc. in-vessel system. The Schenectady system is modular in design, with four full-size composting cells-two bioreactors for actual composting and two reactors for curing. There is also a fifth half cell used to condition the material prior to being loaded into the bioreactor. The mixture of sludge, sawdust and recycled compost is placed in this conditioning cell for about 24 hours, after which it is conveyed back to the mixer so that any necessary adjustments can be made. The material is then loaded into the bioreactor where there is a 13 to 14 day detention time, after which it is transferred to the cure cells where it stays for an additional 14 days.

Goldstein, Nora. *BioCycle* v 29 n 1 Jan 1988 p 28-30.

**089641 SHORTER HAULS FOR LEAVES.** 1987 set an all-time record for composting vegetative wastes with



many communities planning to launch programs in 1988. Composting is rapidly becoming the major method of leaf disposal. Jersey, New York, Pennsylvania and Massachusetts' new Recycling Act mandates that composting facilities be available to process leaves to keep them out of landfills. A similar law for Pennsylvania which passed overwhelmingly in the State Senate. The article presents examples of some old and new programs currently in operation.

Anon. *BioCycle* v 29 n 1 Jan 1988 p 34-35.

**089642** **TESTING IN PAPER BAGS.** A New Jersey leaf composting experiment turned up one strategy for success: using bags. The goals: to test the usefulness of bags similar to Umbro Corp.'s maintenance bag (SF-716) as a receptacle for leaves and yard waste for residential users; and to observe the results of incorporating this bag into a composting system. Particular activities undertaken were: surveying public acceptance of this bag compared to other bags for leaf collection; gauging the effectiveness of this bag in holding leaves and other typical yard wastes (twig, weeds, garden debris) under normal use and weather conditions; composting the bags and leaves (according to guidelines provided by Rutgers University's Department of Environmental Science); and drawing conclusions on how to utilize a compostable bag in collection and composting of leaves. Study methods and results are discussed.

Petto, Paul A. *Waste Age* v 19 n 5 May 1988 p 71, 74-75.

**089643** **EUROPEAN COMPOSTING STUDY TOUR.** A fact-finding study tour of Europe was conducted last October by the Michigan Department of Natural Resources for the state's opinion leaders to determine the feasibility of using compost technology to process municipal solid waste. The tour group had the unique opportunity to visit a wide variety of approaches to resource recovery alternatives. They ranged from composting of yard wastes and mixed municipal solid waste to pyrolysis of organic refuse, methane products by anaerobic digestion of organics to various types of source and site separation recycling collection programs integrated with various types of composting projects.

Koser, Wayne S. (Michigan Dep of Natural Resources, MI, USA). *BioCycle* v 29 n 6 Jul 1988 p 26-28.

**089644** **30 YEARS OF REFUSE/SLUDGE COMPOSTING.** The composting plant in Duisburg, Germany celebrated its 30th anniversary in December, 1987. The plant serves 95,000 inhabitants in a suburban region of mainly one and two family houses with gardens. At present, the plant processes household waste nine months of the year, and during the three autumn months, treats leaves from the entire city as well as manure from the slaughterhouse and zoo. While garbage and other wastes can be composted together, it is most urgent to treat the large seasonal quantities of garden waste; secondly, these components yield an especially good quality compost. This article discusses the garbage/sludge composting process, and sale of products.

Ernst, A.A. (Duisburg/Huckingen Compost Facility, West Ger). *BioCycle* v 29 n 6 Jul 1988 p 34-35.

**089645** **TRENDS IN YARD WASTE COMPOSTING.** A series of thorough tests conducted in Switzerland and West Germany resulted in information regarding the sources of heavy metal contents in domestic garbage and demonstrated that the selection of compostable garbage can be based on definable criteria and that compost derived from consistent separation of garbage collection would meet the requirements. The trend toward yard waste composting has clearly taken hold and has produced, albeit on a small scale, plants with 200 to 25,000 tons annual capacity. The tipping fee for the treatment of organic waste is about 30 dollars to 50 dollars per ton. In Uzwil, Switzerland, a local cooperative operated a combined garbage incineration and composting plant from 1969 to 1984. The plant was renovated and some new

equipment was added in order to process and compost yard waste. The capacity of the plant is 10 tpd. In 1987, approximately 45,000 citizens were served by the plant and the amount of yard waste composted came to 1,200 tons. The article discusses the plant design and performance, as well as design of larger plants, product evaluation, and market potential. 6 Refs.

Mayer, M. (Buhler Brothers Ltd, Uzwil, Switz); Hofer, H.; Maire, U. *BioCycle* v 29 n 6 Jul 1988 p 60-62.

Denmark See WASTE DISPOSAL—Composting.

Digestion See Also BIOGAS—Production.

**089646** **DYNAMIC SIMULATION OF A TWO-PHASE ANAEROBIC DIGESTION SYSTEM FOR SOLID WASTES.** In this article, a two-phase system for the digestion of wastes with a high solid content is simulated. The solids are charged to the hydrolyzer and then leachate recirculation is activated until biodegradation is nearly complete. Several parameters are tested, namely moisture, leachate recirculation flow rate, and hydrolyzer-methanizer volume ratio. The results show that recirculation rate is an important parameter subject to optimization, with optimal values corresponding to hydrolyzer hydraulic retention times below 1 day. The quantity of recirculating water must be the highest possible. As a consequence, the organic load to the methanizer is reduced, making thus possible the use of a smaller methanizer volume. (Author abstract) 11 refs.

Mata-Alvarez, Joan (Univ of Barcelona, Barcelona, Spain). *Biotechnol Bioeng* v 30 n 7 Nov 1987 p 844-851.

**089647** **RECENTI TENDENZE PER LO SMALTIMENTO DEI RIFIUTI URBANI ECOLOGICAMENTE ED ENERGETICAMENTE POSSIBILI.** [Recent Trends in Urban Solid Waste Digestion and Their Environmental and Energetic Feasibility]. The problem of solid waste treatment is investigated from a particular point of view, assuming different systems of treatment to be well known as far as their main features are concerned and mainly focusing on their feasibility with regard to environmental economical and social-political conditions. Recent and most evidenced trends are reviewed as detected in those countries where environmental goals are particularly aimed at, mainly those concerned with solid waste disposal and treatment. Reference is finally made to the Italian situation, to its particular aspects and the reasons which created the same as well as to different solutions involved and their justification. (Author abstract) In Italian.

Cocchi, Giuliano (SpA Forni ed Impianti Industriali Ingeg De Bartolomeis, Milan, Italy). *Termotecnica (Milan)* v 41 n 9 Sep 1987 p 39-42.

**089648** **ENVIRONMENTAL CHARACTERIZATION STUDY OF A PROOF-OF-CONCEPT MUNICIPAL SOLID WASTE DIGESTION PLANT: POMPANO BEACH, FLORIDA.** An environmental investigation on a 100 ton/day anaerobic digestion plant has been conducted. All input and output streams were analyzed for physical, chemical and microbiological impact. Some mutagenic studies were also conducted. Numerous samples were analyzed over a period of three years for variables of regulatory concern. A few samples were intensively analyzed for trace and ultratrace compounds in the USEPA priority pollutant list. Some batch leaching tests were conducted to estimate the impact of liquid effluents on local soils. (Author abstract) 20 refs.

Sengupta, Subrata (Univ of Miami, Coral Gables, FL, USA); Wong, Kau-Fui V.; Nemerow, Nelson; Strietfeld, Murray; Narasimhan, Ramarathnam; Tilles, Arno. *Conserv Recycling* v 10 n 4 1987 p 281-298.

**089649** **ANAEROBIC DIGESTION OF A CELLULOSIC FRACTION OF DOMESTIC REFUSE BY A TWO-PHASE RUMEN-DERIVED PROCESS.** The results presented in this study demonstrate that the application of the RUDAD process results in a high-rate digestion of cellulosic wastes such as domestic refuse.

Moreover, the process was demonstrated to be stable over extended periods of time, which is a prerequisite for an industrial application of the system. 17 Refs.

Zwart, K.B. (Univ of Nijmegen, Nijmegen, Neth); Gijzen, H.J.; Cox, P.; Vogels, G.D. *Biotechnol Bioeng* v 32 n 5 Aug 20 1988 p 719-724.

## Economics

**089650** **HOUSEHOLD REFUSE: RECOVERY OR DISPOSAL? RESEARCH FOR A NEW ECONOMIC OPTIMUM.** The alternatives of recovery or disposal of household refuse (MSW) lead to a conflict between the logic of the classical market-economy, with decreasing returns of scale, and that of public service - often undertaken by private companies (privatisation) - with increasing returns of scale. The problem is first considered in the same urban area. To reach the financial optimum for the municipality, one condition is a 'pay-back', for the service, to the recovery sector. It is also necessary to examine the effects of a generalization of the pay-back solution at a macro-economic level. The result also depends on the practical rules of auction and collection (selective and extensive, or exhaustive). In addition the integration of the recovery with the disposal, and vice versa, is examined. (Author abstract) 4 refs.

Bertolini, Gerard E. (CNRS, Fr). *Conserv Recycling* v 10 n 4 1987 p 321-330.

Environmental Impact See HEAVY METALS—Analysis.

Equipment See WASTE DISPOSAL—Composting.

## Fermentation

**089651** **METHANIZATION: ECONOMICAL ALTERNATIVE FOR SOLID WASTE DISPOSAL.** In La Buisse, France, a syndicate of 16 small communities uses a unique waste disposal facility to dispose of its municipal solid wastes. The disposal process, which combines resource recovery, methanization, and incineration, benefits the communities two ways. The key to the Valorga process is anaerobic fermentation. The La Buisse facility, which is located near Grenoble, was originally a composting plant. In 1984, the methanization unit and the refining unit were added. The facility has a treatment capacity of about 15,000 tons of domestic waste per year, or 60 tpd. The system at La Buisse accelerates the methane digestion process and reduces fermentation time. The 400-cubic meter digestion system at La Buisse yields a daily output of about 2,000 cubic meters.

Bonhome, Michel (Valorga, Vendargues, Fr); Clauquin, Catherine. *Public Works* v 119 n 6 May 1988 p 60-62.

## Florida

**089652** **FLORIDA MAY NOT HAVE ITS ACT TOGETHER.** In 1979, the Department of Environmental Regulation (DER), conscious of the state's high water table and sandy soil, organized a Resource Recovery Council. Acting under authority of a state law, the Council directed 19 of the state's most populous counties to come up with resource recovery and comprehensive solid waste management plans. That early planning effort is probably the reason Florida leads the nation today in refuse-to-energy. Nine plants are on-line, four are under construction, and another five are on the drawing boards. Eight counties are conducting feasibility studies. The bottom line: By 1995, the state thinks it will have 18 facilities operating, with a total capacity of 22,000 tpd. But with the state's current generation of about 66,000 tons of refuse per day and its high-growth future, the state's disposal capacity may never catch up to its needs.

Mattheis, Ann H. (Waste Age). *Waste Age* v 19 n 2 Feb 1988 p 97-98, 101-102.



**Incineration** See Also AIR POLLUTION—Analysis; FLUE GASES—Analysis; HAZARDOUS MATERIALS—Environmental Impact; REFUSE INCINERATORS; RISK STUDIES—Health Risks; ROADBUILDING MATERIALS—Waste Utilization; SLAGS—Recycling; WASTE DISPOSAL—Incineration; WASTE UTILIZATION—Economics.

**089653 INCENERIMENTO DEI SOTTO-PRODOTTI E RESIDUI CIVILI ED INDUSTRIALI: SOLUZIONI NAZIONALI ED ESTERE E PROBLEMATICHE RELATIVE.** [Incineration of Municipal and Industrial By-products and Residues: Solutions Adopted in Italy and Abroad and Related Problems]. A wide range of the most commonly used incineration systems and basic selection criteria according to the type of waste to be incinerated is submitted to the attention of specialist design technicians and operators. A brief outline of the Italian situation and of the trend in the most representative foreign countries is given. (Author abstract) In Italian.

Carminati, Antonio (Snampoprogetti S. Donato Milanese, Milan, Italy). *Termotecnica (Milan)* v 41 n 9 Sep 1987 p 61-63.

**089654 SMALTIMENTO DEI RESIDUI DEGLI IMPIANTI DI RICUPERO TERMICO DA SOTTO-PRODOTTI CIVILI E INDUSTRIALI.** [Disposal of Residues from Municipal and Industrial Waste Incineration Heat Recovery Plants]. Fly ashes produced in urban and industrial waste incinerators and retained by electrostatic precipitators are classified as hazardous. Therefore, the phenomena that occur upon their disposal in landfills are very important. Heavy metal concentration, chemical stability and safe solidification feasibility is evaluated, with reference to the up-to-date documentation. (Edited author abstract) 7 refs. In Italian.

Pappacoda, Enzo (Soc Tradeco, Ingegneria Ambientale, Milan, Italy); Vaccina, Ettore. *Termotecnica (Milan)* v 41 n 9 Sep 1987 p 65-75.

**089655 ASSESSING THE HEALTH RISKS FROM MUNICIPAL WASTE INCINERATION: AN EXAMPLE FROM PHILADELPHIA.** In July 1986, Philadelphia Mayor W. Wilson Goode announced that he would commission a risk assessment for a controversial trash-to-steam plant proposed by his administration. The risk assessment led to a hardening of positions for and against the plant. A team of Philadelphia-area physicians hired ICF-Clement Associates, a Washington-based consulting firm, to perform the analysis. The risk assessment team had to answer two questions: 1) What health risks are associated with emissions from the facility? 2) Will the plant's emissions increase the incidence of cancer in South Philadelphia, the proposed site for the plant? In its analysis, ICF-Clement used a formalized risk assessment procedure.

Nash, Jennifer. *Environ Impact Assess Rev* v 7 n 3 Sep 1987 p 249-252.

**089656 THERMISCHE MUELLVERWERTUNG AUS DER SICHT DES UMWELTSCHUTZES.** [Thermal Refuse Treatment from the Standpoint of Environmental Protection]. Garbage disposal in the state of Bavaria by combustion and pyrolysis is discussed measures for recovering useful products of the combustion process and for recycling waste heat are cited. The question of sorting out problematic waste for separate combustion is considered. Refuse incinerator emission limits required to meet clean-air legislation are indicated. The conditions of formation of dioxins and furans during refuse incineration are discussed. In German.

Eichele, G. (Bayerisches Staatsministerium fuer Landesentwicklung und Umweltfragen, Munich, West Ger). *Gas Wasser Waerme* v 41 n 12 Dec 1987 p 396-399.

**089657 IMPORTANT ISSUES RELATED TO AIR POLLUTION AT MUNICIPAL SOLID WASTE FACILITIES.** This paper presents a discussion of municipal solid waste (MSW) combustion and emission control. The issues of combustion technology, of available air pollution control systems, and of public health are explored in order

to present an overview of the state-of-the-art of combustion and air pollution control at facilities that burn unprocessed MSW or processed forms such as refuse-derived fuel (RDF). The discussion also includes a presentation of the results of a study sponsored by the Minnesota Pollution Control Agency (MPCA), and performed by Cal Recovery Systems, Inc. (CRS), for the purpose of assisting the MPCA in the development of performance and operating guidelines for MSW combustion facilities to be sited in Minnesota. (Author abstract)

Savage, G.M. (Cal Recovery Systems Inc, Richmond, CA, USA); Bordson, D.L.; Diaz, L.F. *Environ Prog* v 7 n 2 May 1988 p 123-130.

**089658 HEATING VALUE OF MUNICIPAL SOLID WASTE.** This paper describes the processes that are used to calculate the heating value of municipal solid waste in France. The calculation can be done either by using the thermal-balance method of a furnace or a furnace-boiler unit, or by sorting the refuse and calculating the heating value of the homogeneous components. Both methods are described in this paper. The first method measures the heating value of the refuse that is injected into the furnace; the furnace becomes a calorimeter in which thermal balance is achieved on measuring the input and output heats. The second method consists of sorting a 100 kg refuse sample into piles that are as homogeneous as possible so that it can be considered as unchanging. The heating value is determined for each component and the lower heating value of the whole sample is calculated. The advantages and drawbacks of both methods are discussed. (Author abstract) 1 ref.

Finet, C. (Traitement Industriel des Residus Urbains, Paris, Fr). *Waste Manage Res* v 5 n 2 Jun 1987 p 141-145.

**089659 MUELLVERBRENNUNG IN WASSERGEKUEHLTEN DREHROHRROST.** [Refuse Incineration in a Water-cooled Rotary Combustor]. The system described is an alternative to grate systems and rotary barrels with refractory lining. The rotary combustor barrel consists of water cooled tubes and perforated webs. As a result of optimum combustion conditions there are economical and environmental advantages. (Author abstract) In German.

Guttenbrunner, Manfred. *Stahlbau Rundsch* n 70 Apr 1988 p 12-13.

**089660 BETONTECHNISCHE BERICHTE. VERWERTUNG VON MUELLVERBRENNUNGSRUECKSTAEENDEN ZUR HERSTELLUNG ZEMENTGEBUNDENER BAUSTOFFE.** [Utilisation of Refuse Incineration Remnants for the Production of Cement-Bound Building Material]. An estimated 30 million tons of minerals, recycled building materials and secondary materials of lesser quality could annually be improved by the use of hydraulic binding agents to such an extent that they could be used as firm, durable and ecologically safe building materials. This way, high-quality raw materials and valuable dumping ground space could be saved. For every material in question a technological utilisation concept has to be developed. The Research Institute of the Cement Industry is developing such a concept for the utilisation of refuse incineration remnants for hydraulically bound support layers and for the concrete of secondary components as a pilot project. The aim of the experiment is to investigate durability, strength and deformation behaviour, constancy of volume and improvement of ecological properties which can be achieved by using appropriate binding agents. (Edited author abstract). 6 Refs. In German.

Schmidt, M. *Beton* v 38 n 6 Jun 1988 p238,241-245.

**089661 ENVIRONMENTAL IMPLICATIONS OF INCINERATION OF MUNICIPAL SOLID WASTE AND ASH DISPOSAL.** Environmental contamination from particulate and gaseous emissions containing heavy metals, polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF), polycyclic aromatics (PCA), acids and other compounds from such incinerators, as well as safe ash disposal, are of great

concern. Concentration ranges of elements and organic toxicants in incinerator ashes, emissions and cooling waters are given. The literature is reviewed concerning the effects of incinerator operating parameters on emissions. Incinerators equipped with modern pollution control devices (electrostatic precipitators, fabric filters, dry scrubbers, spray towers) and operated at optimum temperature with sufficient oxygen, turbulence (mixing) and residence time for complete combustion appear to minimize ash, elemental, gaseous and organic emissions. Environment aspects of municipal solid waste incineration are also considered and reviewed. (Edited author abstract). 180 Refs.

Lisk, Donald J. (Cornell Univ, Ithaca, NY, USA). *Sci Total Environ* v 74 n 1 Aug 1988 p 39-66.

Italy See WASTE DISPOSAL—Planning.

Jackson County, Michigan

**089662 PROGRESSIVE LANDFILL DESIGN MAKES JACKSON MODEL COUNTY.** The article is the first of a two-part series that examines the waste disposal program in Jackson County, Mich. The community's plan includes a new landfill - the subject of this article - and a 200 ton-per-day waste-to-energy facility. Although the incinerator is the more unique factor in the Jackson solid waste management equation, the landfill is an essential element in the overall plan. The landfill project is being developed in two phases. Only 35 acres are actually used for disposal. This project replaces an older landfill, closed in 1984, that was operated by the City of Jackson. Subjects covered include accounts computerization, tipping fees, landfill cell design, liners and others.

Hastreiter, Joe. *World Wastes* v 30 n 12 Dec 1987 p 26, 28.

Japan

**089663 SOLID WASTE REUSE IN JAPAN.** Solid waste management has come a long way in Japan in recent times. Recycling in Japan has been actively conducted by the government, municipalities, special bodies and volunteer groups. Most municipalities request households to separate refuse into three or more categories at source. This paper reviews the various reuse and recycling methods employed in Japan for handling solid wastes and provides statistics for these methods. Projects underway are discussed.

Fujita, Kenji; Kaneko, Hidehiro. *BioCycle* v 28 n 6 Jul 1987 p 28-32.

**Land Fill** See Also BIOGAS; BIOGAS—Quality Control; BIOGAS—Recovery; CLAY—Permeability; GAS DETECTORS—Computer Applications; GAS DETECTORS—Sampling; GAS MANUFACTURE—Waste Utilization; HAZARDOUS MATERIALS—Waste Disposal; LAND RECLAMATION—Planning; METHANE—Energy Utilization; METHANE—Production; PLASTICS SHEETS—Stability; SOILS—Contamination; SOLIDS—Waste Disposal; SYNTHESIS GAS; WASTE DISPOSAL; WASTE DISPOSAL—Recycling; WASTEWATER—Sludge Disposal; WATER POLLUTION; WATER POLLUTION—Canada; WATER POLLUTION—Underground.

**089664 SELECTING THE RIGHT SITE.** By following certain tactics and techniques, a public works director or other community officials can create a positive environment for a resource-recovery facility. While an existing landfill is an ideal site for a resource-recovery plant, a heavily industrialized area also is a good choice. The land has been zoned for commercial use, and the proximity to energy-purchasing customers may provide an economic benefit. Locations creating new traffic patterns through residential areas should be avoided. Once a site is chosen, the public needs to be sold on the idea. Opposition will occur, but if the program presents the facts there is no need to focus on the negative and assume a defensive position. The objective is to organize the 'project team'



with a plan of action. With virtually every waste-management project, the key to a successful public-acceptance campaign is advance planning.

Hunt, Patricia. *Am City City* v 102 n 8 Aug 1987 p RR6-RR7.

**089665 LANDFILL DRILLING - THINK SAFETY FIRST.** The contents of landfills are disposed of so that there is no subsequent human contact with them. Numerous problems that can be encountered when drilling at landfill sites are highlighted. In many cases sufficient information can be obtained through perimeter investigations and/or remote sensing. Problems encountered by the drill crews may be in part caused by an anxious, uninformed, and unsympathetic client, inflexible and incomplete specifications, design engineers who lacked field experience, inadequate air monitoring devices, and improper personnel protective equipment. The National Water Well Association has attempted to inform the ground water monitoring industry of the hazards of waste site activities through its five-day Safety at Hazardous Materials Sites Training course.

Maslansky, Steven P. *Water Well J* v 41 n 12 Dec 1987 p 26-27.

**089666 APPLICATION OF THE KENTUCKY NATURAL RESOURCES INFORMATION SYSTEM IN THE EVALUATION OF SANITARY LANDFILL SITE SUITABILITY.** This paper describes a project being implemented by the Kentucky Natural Resources and Environmental Protection Cabinet to assist local governments to better understand siting considerations and to identify potential landfill sites. The state's Natural Resources Information System (KNRIS), an automated geographic information system, is being used by local governments to conduct landfill site suitability analyses at a cost of less than \$150. (Edited author abstract) 8 refs.

Barnett, Russell (Kentucky Natural Resources & Environmental Protection Cabinet, Frankfort, KY, USA); Crosswell, Peter; Dryden, Wally. *Geo Processing* v 3 n 2 Jul 1986 p 119-142.

**089667 INFLUENCE OF IRRIGATION WITH LEACHATE ON BIOMASS PRODUCTION AND EVAPOTRANSPIRATION ON A SANITARY LANDFILL.** The influence of irrigation with leachate on biomass production and evapotranspiration was studied on three sanitary landfills in southern Finland in 1982 - 1984. Irrigation with leachate increased biomass production significantly. The quality of the irrigation water and substrate, mode of irrigation and tree species also influenced biomass production. In a willow stand, 30% of the irrigation and precipitation was intercepted. Evapotranspiration calculations based on biomass production measurements, water consumption per unit dry matter produced and interception measurements gave results similar to the values obtained with the Penman - Monteith equation. Irrigation with leachate was found to increase evapotranspiration on a sanitary landfill. The evapotranspiration of the mini-rotation plantations during the growing season amounted to 600-700 mm. (Author abstract) Refs.

Ettala, Matti (Paavo Ristola Ltd, Salpakangas, Finl). *Aqua Fenn* v 17 n 1 1987 p 69-86.

**089668 UNDERLINING SECURITY FOR INCINERATOR ASH.** The article discusses a Millbury, Mass. facility that is using an ash monofill for disposing of approximately 375 tons of incinerator ash each day. Designed, built and operated by Wheelabrator, formerly Signal Environmental System Inc. of Hampton, N.H., the plant burns up to 1500 tons per day of solid waste from central Massachusetts. Incinerator ash from the Millbury plant is deposited at an ash monofill in Shrewsbury, Mass. The thirteen-acre site incorporates a single composite liner, consisting of two feet of compacted clay underneath a 60-mil HDPE geomembrane, manufactured and installed by Gundle Lining Systems Inc., Houston.

Cadwallader, Mark (Gundle Lining Systems Inc, Houston, TX, USA). *World Wastes* v 30 n 12 Dec 1987 p 29.

**089669 PVC CAP PROTECTS GROUNDWATER BENEATH LANDFILL.** As filled portions of the Lantana Sanitary Landfill are closed, Florida state law requires that they be capped, because the facility, which opened in the 1960s, lacks a bottom liner. The capping operation began early in 1987, with them membrane being installed in five to ten-acre increments. To protect the groundwater, the waste authority has specified a 1.3-million sq ft, 20-mil flexible PVC membrane supplied by Staff Industries, Inc., Detroit, Michigan. This article discusses materials selection, membrane installation, and erosion control considerations.

Hammond, Mark (Palm Beach County Solid Waste Authority, West Palm Beach, FL, USA). *Public Works* v 118 n 12 Dec 1987 p 34.

**089670 SYNTHETIC LINERS: A LOOK AT THE BASICS.** Flexible membrane liners (FMLs) are entering the forefront of the waste containment field, due to legislation protecting surface waters as well as groundwater protection regulations. Selecting a geomembrane can be complicated. No single membrane is universally suited for every application. The compatibility of chemicals the liner is likely to encounter with the liner material itself, while important, is only one of many characteristics to evaluate. This article presents basic information on the materials for selection and application of geomembranes in land fill applications.

Wilson, Felon R. (Seaman Corp, Wooster, OH, USA). *Waste Age* v 18 n 10 Oct 1987 p 139-140, 142, 144.

**089671 LAND-COVER MONITORING WITH SPOT FOR LANDFILL INVESTIGATIONS.** As an extension of an airphoto-based inventory of active and inactive waste storage and disposal sites in a New York county, SPOT satellite images were evaluated to determine their capacity for monitoring land-cover changes that could be significant in landfill investigations. A panchromatic and a multispectral image of 25 1.5-by-1.5-km sites were displayed and minimally enhanced (contrast stretched and enlarged) on a digital image processing system, where the imaged test sites were compared visually to the most recent 1:24,000-scale U.S. Geological Survey topographic maps. Significant changes - disturbed, reclaimed, and developed land; recently exposed soil; ponded water; and new or removed structures - were interpreted and delineated, based only on the images and maps. (Edited author abstract) 18 refs.

Philipson, Warren R. (USDA Agricultural Research Service, Beltsville, MD, USA); Barnaba, Eugenia M.; Williams, Vicki L.; Ingram, Arlynn. *Photogramm Eng Remote Sens* v 54 n 2 Feb 1988 p 223-228.

**089672 AUFBEREITUNG UND NUTZUNG VON DEPONIEGAS.** [Treatment and Utilization of Land-Fill Gas]. The gas forming in land fills as a result of bioconversion of organic refuse components must be disposed of. If possible, the disposal costs should be reduced through an economical utilization of the gas. Problems arise in the disposal when halogenated hydrocarbons appear in this biogas quite often as a result of the evaporation of spent solvents. During combustion, corrosive hydrogen chloride and, under certain circumstances, toxic compounds such as chlorinated dioxins and furans arise from the chlorinated hydrocarbons. The potential of land-fill gas, possible forms of economical utilization of it, and the required treatment of the gas are discussed. (Translated author abstract) In German. 22 refs.

Hedden, Kurt (Univ Karlsruhe, Karlsruhe, West Ger). *GWF Gas Wasserfach Gas Erdgas* v 128 n 11-12 Nov-Dec 1987 p 573-578.

**089673 BEACH COUNTY RESORTS TO STATE-OF-THE-ART LANDFILL.** The article discusses the recent construction of a facility in Cape May County, New Jersey, where conditions and regulations called for state-of-the-art construction. Any liquid escaping from Cape May County's landfill could leach into a sensitive aquifer below - one which serves all of southern New Jersey. A leachate containment system, using geo-

membranes, was incorporated into the facility's design to prevent contamination. With the site's first cell nearing capacity, municipal officials evaluated performance of their initial design before constructing the site's second cell. The system used in Phase I was judged successful at keeping landfill liquids out of the high water table; the same system is specified for Phase I-B. Subjects covered include the groundwater protection system, primary liner, and membrane seam testing.

Anon. *Waste Age* v 19 n 3 Mar 1988 p 95-96.

**089674 APPLICATION OF GEOPHYSICAL METHODS IN ENVIRONMENTAL AND MUNICIPAL ENGINEERING: THEORETICAL STUDY.** The purpose of the work described in this paper was to select suitable instrumentation for groundwater contamination surveys using geophysical methods. It is shown that galvanic resistivity methods are highly suitable for environmental surveys. The resolution meets the needs in shallow exploration of the earth, and multiarray profiling-sounding systems are even cost-effective in the field. The very large resistivity range that can be mapped with the method is a very advantageous property. Electromagnetic methods are theoretically suitable and coming in the future, but the currently available instrumentation does not cover high frequencies or the early time transients required. When applied in shallow soundings together with the vertical electromagnetic sounding technique, the combined inverse solution is more reliable. The use of soil temperature measurements in evaluating hydrogeologic conditions in groundwater flow systems was found to be unfeasible due to complications in interpreting the data. 112 refs.

Saksa, Pauli (Technical Research Cent of Finland, Espoo, Finl); Korkealaakso, Juhani. *Valt Tek Tutkimuskeskus Tutkimuksia* 505 Oct 1987 124p.

**089675 OVERVIEW OF LANDFILL BOTTOM LINER HYDRAULICS.** Landfill bottom liners are important elements in the analysis and design of solid waste disposal facilities. This study presents an overview of several models, describing the flow over and through liners. The examined models are compared against data from a laboratory investigation. A quasi-steady state (QSS) and a transient (TS) model yield the most complete description of linear hydraulics, and allow for estimation of the system's collection efficiency. The TS model performed slightly better than the QSS model, although the latter has the advantage of simplicity. The hydraulic conductivities of the liner and the drainage layer and the leachate accretion rates are parameters whose magnitudes must be known with relative accuracy for good evaluation of system performance. (Author abstract) 12 refs.

Demetropoulos, Alexander C. (Univ of Patra, Patra, Greece). *Water Resour Bull* v 24 n 1 Feb 1988 p 49-56.

**089676 PRETREATING LANDFILL LEACHATE WITH PEAT TO REMOVE METALS.** In this investigation, the capacity of peat to treat two different landfill leachates was determined. Freundlich isotherms showed that, for the tested metals (Cd, Cr, Cu, and Pb), an increased time of contact increased the level of adsorption over the entire range of influent values studied. In addition, metal interaction may play an important role in the adsorption of metals from leachate, as the various metal ions compete for the available adsorption sites on the peat. Column studies using two leachates, one from a municipal refuse fill (Al, Ca, Cd, Fe, Mg, Mn, Na, Pb), and one from a fill which receives mainly oil and fly ash (Al, Ca, Cr, Fe, Mg, Mn, Na, Pb, and Y), were conducted to establish design parameters for full-scale design. The efficiency of treatment was evaluated as a function of factors important for developing filter design criteria. (Edited author abstract) 15 refs.

McLellan, J.K. (Univ of Maine, Orono, ME, USA); Rock, C.A. *Water Air Soil Pollut* v 37 n 1-2 Jan 1988 p 203-215.



**089677 HAZWASTE DUMPERS, KEEP OUT!** Chambers Development Co., Inc., is a publicly held, Pittsburgh-based, company that owns eight sanitary landfills and one transfer station. This large company's system uses high- and low-tech strategies to protect landfill integrity. At each landfill, except for a single gate, all possible site entrances have been either fenced in or made inaccessible via construction of a berm (behind which is a deep trench). The gate is manned full-time. During the day, trained gatekeepers keep an eye on every load, and the company's site manager performs random checks of the landfill. At unannounced times every day, four trucks pull up to a separate dump site, where the crews go through the trash carefully. Cameras record (on videotape) everything at the gate, every moment of the day and night. In addition, a further check, which involves the construction of scaffolds and the use of photoionization meters, has been in place since 1987.

Anon. *Waste Age* v 19 n 4 Apr 1988 p 121-122, 124.

**089678 GEOMEMBRANES FOR MUNICIPAL SOLID WASTE LANDFILLS.** Synthetic liners are highly attractive because of their negligible permeability and good chemical resistance. Liner technology has progressed to where the choice of synthetics for the 1980s is between some high quality polymers. High density polyethylene (HDPE), however, is the material of choice for solid and hazardous waste landfill applications. This article discusses the installation of a 12-acre HDPE lined landfill for Leon County, Florida, the first municipal landfill to be lined with a flexible membrane in the capital area of Florida.

Mathieson, Michael C. (Gundle Lining Systems Inc, Houston, TX, USA); Cadwallader, Mark W. *Public Works* v 119 n 6 May 1988 p 80-81.

**089679 POLYETHYLENE DRAINAGE NETS INCREASE LANDFILL CAPACITY.** Polyethylene nets used to provide drainage in landfills significantly increase their storage capacity. The nets replace the thicker sand and gravel covering layer normally used in landfills and also permit steeper side-wall angles. The nets consist of polyethylene strands that are cross-melt extruded to form a three-dimensional grid-like structure about ¼-in. thick. The interlocking strands result in a very strong netting. This configuration has very low compressibility and high capacity for liquid and/or gas flow. These characteristics allow the polyethylene netting to provide the same drainage channel as a much thicker layer of sand and gravel. It also allows the construction of steep side slopes.

Anon. *Public Works* v 119 n 6 May 1988 p 93.

**089680 PROBLEMS SURFACE FOR SWAT GAS PROGRAM.** A new California law (the Calderon Bill - AB3525 and AB3374) requires that landfills conduct rigorous tests to monitor their sites for toxic gas emissions. These Solid Waste Assessment Tests (SWAT) are expected to cost landfill operators millions of dollars in test fees and remedial actions. Enacted in 1986, the bill will produce a site-by-site inventory of gases entering the environment from active and inactive landfills. Compliance to the bill has been slow. A lack of money, time and proper lab equipment has slowed compliance with the air component of California's new SWAT program.

Doyle, Harry (Varian, Walnut Creek, CA, USA); Kirshen, Norman. *World Wastes* v 31 n 5 May 1988 p 30-31.

**089681 NITRIFICATION AND SUBSEQUENT DENITRIFICATION IN THE LAYER OF INCINERATOR RESIDUE.** Nitrification and denitrification in the semi-aerobic landfill of the circulatory type are experimentally studied. This landfill method is characterized by the circulation of leachate and has the advantage of the rapid decrease in the concentrations of organic matter and total-nitrogen with time. It was found that both nitrification and denitrification are caused in the reactors and that 0.94 g of organic carbon was consumed for the denitrification of 1 g of nitrogen. (Edited author abstract) 8 refs.

Shimaoka, Takayuki (Kyushu Univ, Fukuoka, Jpn);

Matsufuji, Yasushi; Hanashima, Masataka; Awaya, Yochi. *Mem Fac Eng Kyushu Univ* v 47 n 4 Dec 1987 p 261-274.

**089682 INFILTRATION AND HYDRAULIC CONDUCTIVITY AT A SANITARY LANDFILL.** High infiltration rate at a sanitary landfill indicates surface runoff to be small. This is why it is necessary to move the snow cover from the site and establish short-rotation plantation on the site in order to reduce infiltration and leachate discharge. The saturated hydraulic conductivity varied widely at two sanitary landfills differing in disposal technology and in different parts of the same site, too. This should be taken into account when water balance models are used. To allow management of the water movement and levels in the refuse, the landfills should have drainage systems at the bottom of the site. This is also necessary for controlling the degradation of the refuse. 19 refs.

Ettala, Matti (Paavo Ristola Ltd Consulting Engineers, Hollola, Finl). *Aqua Fenn* v 17 n 2 Feb 1988 p 231-237.

**089683 DESIGN AND OPERATION OF LEACHATE CONTROL MEASURES AT COMPTON BASSETT LANDFILL SITE, WILTSHIRE, U.K.** This paper describes the conversion of a difficult landfill, inherited by Wiltshire County Council during local government re-organization in 1974, into a high-standard landfill, providing containment of wastes. It can now provide the capacity to continue to receive wastes for at least the next 30 or 40 years. An essential feature of these works is an on-site, automated leachate treatment plant. The design philosophy and difficulties encountered during the commissioning of the plant are described in this paper. Initial difficulties in treating large quantities of methanogenic leachate from saturated areas of waste have been overcome by a novel scheme, whereby a high-strength organic waste stream from a local jam factory is blended with the influent leachate streams for optimum treatment conditions. (Author abstract) 5 refs.

Robinson, Howard (Aspinwall & Co, Shrewsbury, Engl). *Waste Manage Res* v 5 n 2 Jun 1987 p 107-122.

**089684 TESTING LARGE LANDFILL SITES BEFORE CONSTRUCTION OF GAS RECOVERY FACILITIES.** The great variability in landfill refuse characteristics such as moisture, pH, temperature, cellulose content, age, and cover make it difficult to extrapolate test data from one site to another. The quantity of raw extractable gas from 23 GSF test sites was found to range from 4 to 29 l m<sup>-3</sup> day<sup>-1</sup> (0.11-0.78 CFID/CY) of refuse. By field testing of sites, the probability of a successful project can be greatly enhanced. On large landfills, the benefits of extensive testing outweigh initial costs. In addition to determining potential gas production, well tests also determine: the location of high perched water zones; concentrations of corrosive trace contaminants so that adequate pretreatment facilities can be designed; and composition of refuse samples to determine the rate of decay. This allows the developer to optimize plant size, resulting in maximum return on investment. (Edited author abstract) 7 refs.

Siegal, Joan P. (GSF Energy Inc, Signal Hill, CA, USA). *Waste Manage Res* v 5 n 2 Jun 1987 p 123-131.

**089685 HIGH BTU LANDFILL GAS RECOVERY UTILIZING PRESSURE SWING MDEA PROCESS.** The extraction and processing of landfill gas to pipeline quality specifications is a viable method for recovering landfill gas. A plant operating at the Central Disposal Sanitary Landfill in Pompano Beach, Florida, employs a proprietary process involving a methyldiethanolamine (MDEA) based solvent. The process utilizes a combination pressure-swing and thermal solvent-regeneration procedure which dramatically reduces energy requirements relative to those of traditional amine processes. Much of the equipment is skid mounted and modularized which reduces field installation costs and facilitates future removal to other sites. (Author abstract)

Dinsmore, Harold L. (John Zink Co, Tulsa, OK, USA). *Waste Manage Res* v 5 n 2 Jun 1987 p 133-139.

**089686 CRACK FORMATION IN SOIL LANDFILL COVERS DUE TO THERMAL CONTRACTION.** Soil landfill covers in the northern United States experience ground freezing to depths of 2 m or more. During periods of decreasing winter temperatures, thermal contraction will increase tensile stresses creating the potential for crack formation. A drop of only 2 or 3°C will generate significant tensile stresses. Climatological data show larger drops in temperature. Frozen cover soils are comparatively weak in tension. Cracks, once initiated, can propagate unstably through the frozen soil, and may extend deeper than the tensile stresses to which they owe their growth. Simple elastic soil behaviour used with thermal strains does not provide adequate information for predicting thermal contraction and crack formation. Information is needed on the thermal contraction behaviour of frozen soils, on the extent to which soil creep will reduce the tensile stresses, and on criteria suitable for preventing crack formation. (Edited author abstract) 8 refs.

Andersland, Orlando B. (Michigan State Univ, East Lansing, MI, USA); Al-Moussawi, Hassan M. *Waste Manage Res* v 5 n 4 Dec 1987 p 445-452.

**089687 NATURAL ATTENUATION MECHANISMS OF LANDFILL LEACHATE AND EFFECTS OF VARIOUS FACTORS ON THE MECHANISMS.** The paper identifies mechanisms by which landfill leachate is attenuated by soil and aquifer. The mechanisms are: adsorption, biological action, cation and anion exchange reactions, dilution, filtration, and precipitation reactions. Each mechanism is discussed separately. The major attenuation mechanism is identified for many municipal landfill leachate constituents. Effects of leachate velocity, degree of saturation, organic and inorganic matter in soil, clay type, soil fabric and soil stratigraphy on attenuation is discussed. (Author abstract) 45 refs.

Bagchi, Amalendu (Wisconsin Dep of Natural Resources, Madison, WI, USA). *Waste Manage Res* v 5 n 4 Dec 1987 p 453-464.

**089688 PROBLEMS ASSOCIATED WITH BUILDING ON LANDFILL SITES.** Potential hazards facing landfill site developers are gas production, attack of building materials and subsidence. At some sites successful development may be possible provided that buildings are designed to overcome these problems. Design criteria are given with particular emphasis being placed on methods for preventing gas ingress. Examples of suitable buildings, which have been erected in the U.K. and the U.S.A. are given. (Author abstract) 24 refs.

Emberton, J.R. (Harwell Lab, Didcot, Engl); Parker, A. *Waste Manage Res* v 5 n 4 Dec 1987 p 473-482.

**089689 WATER AND ELEMENT BALANCES OF MUNICIPAL SOLID WASTE LANDFILLS.** A major problem of sanitary landfills is the assessment of element transfers from inputs to outputs as a function of time. The prediction of gas and leachate generation is necessary for this purpose. Water and element balances for the non-metals carbon, nitrogen, fluorine, phosphorus, sulfur and chlorine and the metals iron, copper, zinc, cadmium, mercury and lead were investigated in four municipal solid waste landfills of various ages. Data from these mass balances were then used to develop a method that permits elucidation of the behaviour of landfill in its most active phase, i.e. that in which relatively high gas generation occurs. (Author abstract) 11 refs.

Baccini, P. (Swiss Federal Inst for Water Resources & Water Pollution Control, Duebendorf, Switz); Henseler, G.; Figi, R.; Belevi, H. *Waste Manage Res* v 5 n 4 Dec 1987 p 483-499.

**089690 LANDFILL LINER SYSTEMS KEEP WASTE FROM WATER.** Presently, more than half of all Americans rely on underground supplies for drinking water. Years of careless waste disposal and ignorance are threatening these very important reservoirs. Once contam-



inated, groundwater is difficult, if not impossible, to clean. At present, more than 200 foreign substances have been detected in this country's groundwater supplies. Therefore, a powerful impetus exists separate to design and construct land fills property to form effective barriers being waste from uncontaminated water. Liner systems form the critical components of these barriers. The hazardous-waste containment regulations require double-liner systems incorporating synthetic geomembranes. Liner-system criteria will be of EPA and presented as a way to comply with the performance standard.

Cadwallader, Mark (Gundle Lining Systems, Houston, TX, USA). *Am City Cty* v 103 n 5 May 1988 p 46.

**089691 TAKE BACK THE LAND.** Municipal sludge applied to land devastated by strip mining has brought thousands of acres of Ohio, Illinois, and Pennsylvania land back to life. Every year, municipal wastewater treatment facilities in the U.S. produce nearly 7 million dry metric tons of wastewater sludge. Experts' warnings that the figure will double by the year 2000 coupled with the high cost of incineration, shrinking landfill space and a movement away from ocean dumping made a search for new disposal options a necessity. Researchers have found that the organic matter and nutrients in treated sludge can help reclaim these ravaged areas. This paper describes some results of sludge application to the Pennsylvania Superfund site to restore plants and wildlife.

Anon. *Civ Eng (New York)* v 58 n 2 Feb 1988 p 52-55.

**089692 CONSTRUCTION GUIDE-LINERS.** Proper installation of geomembrane-soil composite lining systems for waste containment requires careful construction detail, monitoring and weather watching. Several types of geomembrane material are available for hazardous waste containment, the most frequently used being semicrystalline linear low-density polyethylene and crystalline high-density polyethylene. Both materials have shown chemical resistance to a broad range of wastes. In 1985, EPA's Minimum Technology Guidance on Double Liner Systems for Landfills and Surface Impoundments recommended a double lining system consisting of: primary leachate collection and removal system (for landfills); primary geomembrane liner; secondary leachate collection and removal system; and secondary composite liner, a geomembrane overlying a minimum of 3 ft of compacted clay.

Buranek, Dennis (Emcon Associates, San Jose, CA, USA). *Civ Eng (New York)* v 57 n 11 Nov 1987 p 62-64.

**089693 DETERMINATION OF HEAVY METALS IN SAMPLES OF URBAN SOLID WASTES BY MEANS OF THE ICP ATOMIC SPECTROMETRY TECHNIQUE.** The concentration of elements of environmental significance in the leachate from landfills of urban solid wastes was determined by means of Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES). The suitability of extraction tests which simulate the leaching process were undertaken. Both highly toxic elements (As, Cd, Co, Cr, Pb and V) and elements present at major concentrations (Al, B, Cu, Fe, Mn, Ni and Zn) were quantified at different levels within and under the landfill. Results showed that the extraction test recommended by EPA is acceptable in order to simulate natural leaching compared with the amounts of the elements which are brought into solution after digestion with nitric acid. Furthermore, significant correlations were found in the landfill composition at different levels for element pairs such as Al-Mn, Co-Cr, Co-Cu, Co-Fe, Co-Mn, Co-Zn, Cr-Fe, Cr-Mn, Cu-Fe, Cu-Zn, Fe-Mn, Fe-Zn, Mn-Zn and Pb-Zn. (Author abstract). 10 Refs.

Aimonti, A. (Istituto Superiore di Sanita, Rome, Italy); Caroli, S.; Musmeci, L.; Piccioni, A.; Ziemacki, G. *Sci Total Environ* v 71 n 3 Jun 1 1988 p 495-500.

**089694 NEW HONG KONG LANDFILL DEMANDED EXTENSIVE PLANS.** Mott, Hay & Anderson, a Hong Kong-based consulting engineering firm, has designed an imaginative landfill system incorporating

extensive monitoring. The development of the Western New Territories (WENT) landfill, which will have a capacity of 56 million cubic meters, is one of the largest landfill sites in the world to have been designed from start to finish. The environmental security of the landfill has yet to be proved; but if it is successful, Hong Kong will have been provided with a facility for the disposal of industrial, commercial and domestic wastes well into the twenty-first century, thereby removing both a potential source of pollution and a possible constraint on industrial development so vital to the economic health of the city.

Shimell, Pamela (World Wastes, Atlanta, GA, USA). *World Wastes* v 31 n 7 Jul 1988 p 30-32,34.

**089695 LANDFILL CAPACITY: EVALUATING THE ESTIMATES.** The Environmental Institute for Waste Management Studies (EIWMS) at the University of Alabama has evaluated the feasibility of estimating the current capacity of U.S. landfills. The availability of demographic data and pertinent information on municipal waste landfills was compiled to determine the feasibility of a stratified random survey of landfill capacity in the United States. The article discusses past study efforts, and survey findings, including aggregate life of landfills in New York, remaining capacity of landfills in Alabama, and more.

LaMoreaux, P.E. Sr. (Univ of Alabama, Tuscaloosa, AL, USA); Moffett, T.B.; Whitaker, L.E. *World Wastes* v 31 n 7 Jul 1988 p 64-66.

**089696 STATE-OF-THE-ART MANHOLES.** The East Landfill Expansion in Outagamie County, Wis., has three times as many piping system access points as conventional landfills. Integrated systems make the landfill function as a biomass reactor with controlled capture of leachate and landfill gas. The leachate and gas systems are designed with the capability for closed-circuit television camera inspection. Access to the extensive network is provided by 22 precast concrete manholes and 65 PVC riser pipes. The design of the manholes is described.

Stecker, Philip P. (Donohue & Associates, Sheboygan, WI, USA). *Waste Age* v 19 n 8 Aug 1988 p 140-142,144.

**089697 PLASTIC BOTTLES BECOME LANDFILL CAP.** If results of a New Jersey landfill test of a new bonded membrane are positive, the application of recycled plastic beverage bottles as a landfill cap could lead to another use for the material - and savings to landfill owners, in substituting the membrane for costly clay in steep-slope landfill capping applications. Officials of the Hackensack Meadows Development Commission (HMDC) are running the test on the nonwoven geotextile. Spun from post-consumer plastic bottles, the geotextile in this application is bonded to a Hypalon-based containment membrane. The material is used to eliminate slippage of cover soils on steep slopes. Subjects covered include a discussion of the problems with clay, cost and performance benefits of the recycled plastics membrane, and others.

Anon. *Waste Age* v 19 n 7 Jul 1988 p 97-99.

**089698 BARGE TOWN PIGGYBACKS ITS LANDFILL.** Waste disposal officials in the town of Islip are taking landfill construction to new heights. Islip has not been able to obtain permission to expand from the state's Department of Environmental Conservation (DEC). As an interim measure, it has succeeded in gaining the regulators' consent to construct a new cell on top of a portion of the unlined landfill that had already been closed and capped. The vertical expansion, called 'piggybacking,' has raised the height of the 30-acre landfill another 80 feet. The net effect: Islip town officials gained 1.8 million cubic yards of new refuse disposal capacity. Three acres have been set aside for disposal of ash from the town's refuse-to-energy plant (now under construction).

Anon. *Waste Age* v 19 n 9 Sep 1988 p 131-132.

**089699 EMPFEHLUNGEN DES ARBEITSKREISES GEOTECHNIK DER DEPONIE UND ALTSTÄTEN DER DEUTSCHEN GESELL-**

**SCHAFT FUER ERD UND GRUNDBAU e.V.. [Recommendations of the Committee on 'Geotechnik der Deponien und Altstätten' (Geotechnics of Landfills and Contaminated Land) of the German Geotechnical Society].** The committee on 'Geotechnik der Deponien und Altstätten' published seven finalized recommendations so far, which are dealing with site investigations, design of new land fills and with suitability tests for mineral liner material. The paper outlines four draft recommendations on composite liner systems, on sample collection and handling, on test fields for bottom and surface liner systems and on modeling the plume of contamination on site. (Author abstract). 27 Refs. In German.

Jessberger, Hans Ludwig (Ruhr-Univ Bochum, Bochum, West Ger). *Bautechnik* v 65 n 9 Sep 1988 p 289-300.

**089700 CLAYEY BARRIER ASSESSMENT FOR IMPOUNDMENT OF DOMESTIC WASTE LEACHATE (SOUTHERN ONTARIO) INCLUDING CLAY-LEACHATE COMPATIBILITY BY HYDRAULIC CONDUCTIVITY TESTING.** The current use of engineered clayey barriers to control the chemical flux entering the groundwater adjacent to landfill sites is discussed. New analytical methods to predict flux-time relationships controlled by advection and diffusion are presented briefly, followed by an assessment of macropore flow problems inherent in laboratory and especially field-compacted clays. The clay-leachate compatibility of southern Ontario (Sarnia) clays is then assessed with respect to domestic waste leachate using hydraulic conductivity as the assessment tool. The dominant role of channel flow through macropores, even in very carefully controlled laboratory samples, is emphasized, as is the critical role of soil smectite and vermiculite in retardation of species such as  $K^+$  from domestic leachate. The Sarnia brown and gray clays seem compatible with domestic waste leachate at least with respect to hydraulic conductivity,  $k$ . In spite of extensive  $K^+$  retardation, leachate effected a slight decrease in  $k$  of the water-compacted brown and grey samples. (Edited author abstract). 28 Refs.

Quigley, Robert M. (Univ of Western Ontario, London, Ont, Can); Fernandez, Federico; Rowe, R. Kerry. *Can Geotech J* v 25 n 3 Aug 1988 p 574-581.

**089701 DETERMINATION OF ORGANIC VOLATILES IN AMBIENT AIR IN THE AREA OF A LANDFILL.** A study has been performed to analyse organic volatiles in ambient and soil air in the area of a landfill situated next to the city of Bielefeld. This dump has been filled up for years with very different, partially unknown wastes (solvents from metalworking industry, waste oils, sludges from galvanisation processes etc.). Finally the dump was covered with soil up to 2m and was used as a housebuilding area. The objective of this study was to quantify the influence of the landfill gas production on the quality of the ambient urban air.

Koenig, H.P. (Fraunhofer Inst of Toxicology & Aerosol Research, Hanover, West Ger); Lahl, U.; Kock, H. *J Aerosol Sci* v 18 n 6 Dec 1987, Aerosols in Sci, Med and Technol with Spec Emphasis on Urban and Environ Air Pollut, Hanover, West Ger, Sep 9-11 1987 p 837-840.

**Leachate Treatment** See Also HAZARDOUS MATERIALS—Wastes; PHENOLIC RESINS—Wastes; SEWAGE TREATMENT—Sludge Disposal; WASTEWATER—Treatment.

**089702 REMOVAL OF ORGANICS FROM LEACHATES BY ANAEROBIC FILTER.** A laboratory-scale study was conducted on two anaerobic filters at several loading rates and four hydraulic detention times. Feed substrates were landfill leachates taken from a recently opened landfill (Keele Valley) and from an older site (Brock North) which had been closed for about 8 years. The strong raw leachate from the new landfill had a COD of 14,000 mg  $l^{-1}$ , a BOD/COD ratio of 0.7 and a COD/P value of 17,900. The partially stabilized leachate from the older landfill had a COD of only 3,750 mg  $l^{-1}$ .



<sup>1</sup>, a BOD/COD ratio of 0.3 and a COD/P value of 30,640. Results from the treatment of the two leachates were compared with those from a previous study of a 'mature' landfill (Beare Road). It was demonstrated that the anaerobic filter could reduce the COD of leachate from landfills of different ages by 90%, at loading rates of 1.26-1.45 kg COD m<sup>-3</sup> d<sup>-1</sup>. (Edited author abstract) 20 refs.

Henry, J.G. (Univ of Toronto, Toronto, Ont, Can); Prasad, D.; Young, H. *Water Res* v 21 n 11 Nov 1987 p 1395-1399.

**089703 TREATMENT OF LEACHATE FROM A SOLID WASTE LANDFILL SITE USING A TWO-STAGE ANAEROBIC FILTER.** Raw leachate was treated using a two-stage upflow anaerobic filter process. Leachate from a solid waste landfill site, which received both municipal and industrial wastes, contained high organic matter (17-21 g/L COD, 13-14 g/L BOD, and 3.5-4.6 g/L volatile acids), and low metal (Zn and Fe) concentrations. Depending on sampling time, leachate composition and characteristics varied considerably. At an organic loading up to 4 g COD/day<sup>2</sup> media area, the BOD and COD removal percentages were 98 and 91%, respectively. The biofilters were also effective for metal removal. However, the filter effluent contained a high concentration of ammonia. System overloading was characterized by the accumulation of large quantities of volatile acids and by a low ratio of alkalinity/volatile acids, resulting in low COD removal and reduced gas production. Once the first filter was upset, the second stage could only partially respond to the volatile acids accumulated in the effluent of first filter. (Author abstract) 41 refs.

Wu, Y.C. (New Jersey Inst of Technology, Newark, NJ, USA); Hao, O.J.; Ou, K.C.; Scholze, R.J. *Biotechnol Bioeng* v 31 n 3 Feb 20 1988 p 257-266.

**089704 IDENTIFICATION AND QUANTIFICATION OF VOLATILE ORGANIC SPECIES DURING MICROBIAL TREATMENT OF LEACHATE.** Sequential anaerobic/aerobic microbial populations, in a packed-bed configuration, were employed to biodegrade leachate from a high priority superfund site. Leachate characteristics included up to 100 ppm (as carbon) volatile organic priority pollutants. Identification and quantification of these pollutants at key steps in the biodegradation process is important. A method employing purge and trap concentration followed by gas chromatographic separation was developed for accurate identification and quantification of the volatile compounds of interest. Results obtained from application of this method to the leachate treatment process indicated that 84 to 99% of the specific volatile priority pollutants were biodegraded, under anaerobic conditions, during steady-state operation. (Author abstract) 6 refs.

Sikkema, Stephen (Rutgers State Univ of New Jersey, Piscataway, NJ, USA); Dienemann, Erik; Ahlert, Robert; Kosson, David. *Environ Prog* v 7 n 2 May 1988 p 77-83.

**089705 N-BUTYRATE CATABOLISM IN THE TREATMENT OF A SEMI-SYNTHETIC LANDFILL LEACHATE ON ANAEROBIC FILTER UNDER SEQUENTIAL FEEDING CONDITIONS.** Calculations of the kinetics of volatile fatty acids removal in an anaerobic filter showed that methane production from n-butyrate was not consistent with  $\beta$ -oxidation when the reactor was operated under sequential feeding conditions. Under these conditions, n-butyrate might be anaerobically catabolized by decarboxylation. Iso-butyrate was formed at about 25% of the total amount of n-butyrate removed. After 13 days of continuous feeding, the material balance was consistent with the  $\beta$ -oxidation mechanism and the formation of iso-butyrate became negligible. N-butyrate decarboxylation may therefore be a transient catabolic pathway, although the reason why decarboxylation is preferred to  $\beta$ -oxidation under conditions such as sequential feeding is not clear. Results of similar experiments on acetate removal were consistent with theoretical expectations under conditions of both sequential and continuous feeding. (Author abstract) 18 refs.

Gourdon, R. (INSA, Villeurbanne, Fr); Comel, C.; Vermande, P.; Veron, J. *Biomass* v 15 n 1 1988 p 11-24.

**089706 REMOVAL OF ORGANICS FROM LEACHATE BY THE COMBINED PROCESS OF A FACULTATIVE PRE-TREATMENT POND AND AN AERATED LAGOON AT A SEA-BASED SOLID WASTE DISPOSAL SITE.** Leachate was collected from the sea-based North Port Solid Waste Disposal Site, Osaka City, and a bench-scale treatment of the combined process of a facultative pre-treatment pond and an aerated lagoon was applied for more than 120 days. The maximum BOD removal rate coefficient and COD-manganese removal rate coefficient were 0.090/day and 0.018/day, respectively. These values were obtained when the retention time of the facultative pre-treatment pond was 25 days. But, if the retention time was beyond or below 25 days, both removal rate coefficients were smaller. Therefore, we concluded that the optimum retention time of a facultative pre-treatment pond was 25 days. This was reconfirmed by the Gel-Permeation Chromatography of the treated leachate, a method for evaluating wastewater treatability proposed by Tambo and Kamei. Furthermore, the Gel-Permeation Chromatography pattern of the treated leachate in the bench-scale experiment coincided with that obtained by the actual field test. Additional study results are discussed. (Edited author abstract) 10 refs.

Takamizawa, K. (Osaka City Inst of Public Health & Environmental Sciences, Osaka, Jpn); Yamamoto, O.; Fukunaga, I.; Inoue, Z.; Honda, A. *Water Sci Technol* v 19 n 12 1987, Waste Stab Ponds, Proc of an IAWPRC Spec Conf, Lisbon, Port, Jun 29-Jul 2 1987 p 101-107.

**Leaching** See WATER, UNDERGROUND—Contamination.

#### Legislation

**089707 HOUSEHOLD HAZARDOUS WASTE: A DANGER TO THE PUBLIC?** This paper describes the household hazardous waste collection programs. Programs to collect household hazardous wastes generally have five goals: Increase public awareness of hazardous materials found in homes and their potential health and environmental impact; Educate residents as to the best methods of household hazardous waste disposal; Remove household hazardous wastes from homes, reducing exposure and potential injury; Reduce danger to refuse collectors and other sanitation workers; and Provide for proper disposal of household hazardous wastes. The survey by U.S. Environmental Protection Agency defines the hazardous municipal waste disposal methods.

Anon. *Am City Cty* v 103 n 5 May 1988 p 48-52.

**Management** See Also HAZARDOUS MATERIALS—Waste Disposal; REFUSE INCINERATORS—Waste Heat Utilization.

**089708 ROUTING: CAREFUL Q&A IS CRITICAL.** There are a number of nationally marketed software packages for waste haulers (and many more on a regional level) that deal with certain aspects of routing. This article discusses various aspects to consider in evaluating and selecting routing packages. Subjects covered include database considerations, billing requirements, route information, driver reports, and others.

Hopper, Charlie (Nat'l Software Systems, Eau Claire, WI, USA). *World Wastes* v 30 n 11 Nov 1987 p 34.

**089709 SOLID WASTE MANAGEMENT IN INDONESIA: STATUS AND POTENTIAL.** The increasing arisings of municipal solid wastes constitute a serious environmental problem for the developing countries. Urbanisation has magnified the need for adequate solid waste disposal. This article examines the present situation of solid waste management in Indonesia in general and Jakarta in particular. The available disposal methods are presented and analyzed, while possible options to improve the overall management of wastes are discussed on the basis of the available technologies. These are evaluated in

terms of compatibility with the wastes produced in Indonesia. (Author abstract) 16 refs.

Maniatis, K. (Pusat Penelitian Dan Pengembangan Hasil Hutan, Bogor, Indones); Vanhille, S.; Martawijaya, A.; Buekens, A.; Verstraete, W. *Resour C. serv* v 15 n 4 Nov 1987 277-290.

**089710 WASTE MANAGEMENT SYSTEM IS COMPUTER CONTROLLED.** The article discusses computerization of the New York City sanitation system, which handles about 25,000 tpd of refuse. The problems to be solved include a wide assortment of different equipment added over the years, plus a computer system already under contract with which everything else must interface. The Department of Sanitation uses two basic methods to dispose of its refuse: incineration and landfilling. The system discussed involved devising and standardizing the system to weigh loaded refuse trucks at the city's landfills, incinerators, and marine transfer stations, capturing the data, and interfacing the data with the city's host computer.

Anon. *Public Works* v 118 n 11 Nov 1987 p 56-57.

**089711 MANAGING HAZWASTE WITHIN A MUNICIPAL WASTE SYSTEM.** Small Quantities of hazardous waste that used to be routinely accepted at sanitary landfills are now being given a 'second look' by municipal and private sector managers and regulators. These professionals are changing their operations to keep the waste out of the non-hazardous system, to protect workers, equipment and the environment, and to minimize future liabilities and costs. Under federal law, hazardous waste is solid waste that is on a regulatory list or exhibits one of the following four characteristics: Ignitability. The substance has a flash point of less than 140 degrees F, e.g. solvents, paint thinners. Reactivity. The substance reacts violently with water, gives off toxic vapors or fumes, or is explosive. Corrosivity. The substance is very acidic or caustic, e.g. sulfuric acid, sodium hydroxide. Toxicity. The substance releases any of eight metals or six pesticides in a prescribed test. Post-inventory procedures and the training of staff members are also discussed.

Voell, Anthony T. *World Wastes* v 31 n 2 Feb 1988 p 26-27.

**Monitoring** See COASTAL ZONES—Sedimentation.

**Netherlands** See WASTE DISPOSAL—Composting.

**Panama City, FL** See REFUSE INCINERATORS—Waste Heat Utilization.

**Peoples Republic of China** See Also WASTE DISPOSAL—Recycling.

**089712 SOLID WASTES QUALITY CHANGES AND MANAGEMENT IN CHINA.** The cultural revolution of China has brought about considerable and significant change in the composition and quality of the solid wastes produced. The solid waste management techniques and related problems for China in general and China in particular form the text of this presentation. Subjects covered include refuse analysis, refuse storage and transportation, hazardous wastes, resource recovery, and others. 4 refs.

Dongmei, Yu. (Asian Inst of Technology, Bangkok, Thailand); Bhargava, D.S. *J Inst Eng Ind* v 68 pt 1 Oct 1987 p 23-28.

#### Processing

**089713 SYSTEM FOR PREPARATION AND PRODUCTION OF RDF (REFUSE DERIVED FUEL) FROM A SOURCE-SEPARATED FRACTIONATION OF MSW (MUNICIPAL SOLID WASTE) IN NARASHINO.** The RDF production system relates to the effective use of resources and to reduce landfill bulk, and consists of the following two subsystems: A pre-treatment subsystem, which recovers valuable resources such as iron, aluminium or glass from a source-separated fraction of MSW. An RDF production subsystem, which



produces RDF by processing combustibles such as paper and plastic, which are separated from raw wastes at the pre-treatment subsystem. The arrangement and features of this system are discussed.

Ishii, Yoshiaki (Ebara Corp, Tokyo, Jpn); Ishii, Noboru; Iida, Yuichi. *Conserv Recycling* v 10 n 4 1987 p 229-236.

**089714 TO SHRED, OR NOT TO SHRED?** Shredding of municipal waste prior to landfilling, which can conserve landfill space by eliminating the need for daily cover, may soon be a more widely considered strategy. Specialized shredders have been developed to handle materials ranging from wood to construction waste to steel-belted tires, helping in the recyclability of these waste materials. But municipal waste processing, not recycling, is the predominant reason for shredding. It is not a widespread application, however. Despite three decades of availability, municipal waste shredders are used by less than a dozen major facilities in North America. Experts differ sharply over shredding's costs and benefits. This article discusses advantages of shredding, European shredders, applications, and other aspects of the subject.

Jones, David R. *Waste Age* v 19 n 6 Jun 1988 p 114-115, 117-118.

**Recycling** See Also PLASTICS—Recycling; PLASTICS—Waste Utilization; SEPARATORS—Magnetic.

**089715 TWIN CITIES BEGIN NEW ERA IN MANAGING AREA'S WASTES.** Most of the solid waste from the Twin Cities, Minnesota area is currently disposed in landfills, but by 1990 four-fifths of the region's waste will be processed at resource recovery plants. Instead of land disposal, most of this northern metropolitan area's wastewater will be recycled or used to produce energy. The Twin Cities' move away from landfills toward a solid waste system built on refuse-derived fuel and mass burn plants took 10 years of Minnesota State Legislature involvement. This article discusses what went into the decade of planning at the regional, county and city levels that was involved to work out the current system.

Reddick, Ken. *World Wastes* v 30 n 8 Aug 1987 p 39-40, 42.

**089716 COMPARATIVE EFFECTIVENESS OF REWARD AND COMMITMENT APPROACHES IN MOTIVATING COMMUNITY RECYCLING.** The relative effectiveness of commitment and incentive techniques in promoting newspaper recycling was compared. Some homeowners were asked to make a formal, signed commitment to recycle newspapers. Others received tokens exchangeable for back-up reinforcements of goods and services each time they recycled. A combined commitment plus token reinforcer group, and an untreated control group were also included. Following five treatment weeks, all the contingencies were removed during three follow-up weeks. Study results are discussed. The findings indicate that commitment techniques have considerable impact in motivating individuals to recycle and that they may be able to overcome some of the limitations often encountered by incentive-based programs in promoting resource conservation. (Edited author abstract) 35 refs.

Katzev, Richard D. (Reed Coll, Portland, OR, USA); Pardini, Anton U. *J Environ Syst* v 17 n 2 1987-88 p 93-113.

**089717 RECYCLING COMING OF AGE.** Recycling programs are taking off around the country, prompted by the solid-waste crisis and more sophisticated ways of handling and selling the materials. Some examples of recycling programs in the USA are given and a brief history of recycling is sketched. Rural recycling in Wilton, NH, and urban recycling in New Jersey and Massachusetts are discussed as indicating future trends.

Goldofas, Barbara. *Technol Rev* v 90 n 8 Nov-Dec 1987 p 28-35, 71.

**089718 TRANSFER STATION RECYCLES 100 TONS PER DAY.** California's Marin Resource Recovery Center receives over 350 tons per day of mixed waste,

diverting 30 percent for beneficial use. The \$9 million resource recovery facility is enclosed within a 130,000 square-foot-building, which combines both receiving and processing of waste from the public, and from roll-off debris box trucks. The facility has been designed to rely on sorters to recover several recyclable materials. In addition, the facility is capable of mechanically processing large loads of wood and yard waste. This article discusses various aspects of the facility, waste handling, and operational efficiency.

Southworth, Matthew J. (Cal Recovery Systems, Richmond, CA, USA); Diaz, Luis F. *BioCycle* v 28 n 10 Nov-Dec 1987 P 34-35.

**089719 7,500,000 PEOPLE, TWO LANDFILLS.** With nine of its remaining 11 landfills scheduled to close by mid-1988, New Jersey is gearing up to implement its mandatory source separation and recycling act. The framework for the actual recycling programs within the state with each county responsible for completing a district (i.e. county) recycling plant. The Recycling Act provides several approaches to stimulate the markets for the more than 1,750,000 tons of materials that will be available annually. The article discusses these subjects, along with program provisions for special materials, and financing.

Glenn, Jim. *BioCycle* v 28 n 10 Nov-Dec 1987 P 36-38.

**089720 THRIFTY YANKEES RECYCLE & SAVE.** With a capital investment of \$21,800 and a practical approach to design, Peterborough, New Hampshire, recycles 650 tons of refuse per year, which it claims is 45% of its solid waste. Sale of recyclables produces \$15,000 in revenue; and Peterborough taxpayers save another \$354,000 in avoided disposal costs. Recycling expenses in 1986 - \$29,440 - did not include the cost of disposal of non-recyclable refuse. This is baled and stacked in a sanitary balefill, located behind the recycling center and next to the town's old landfill. Part of the center's success stems from Peterborough's never having provided municipal waste collection. This article discusses recyclables, marketing, and other aspects of the program.

Grady, Julie C. *Waste Age* v 18 n 12 Dec 1987 p 39-40, 42.

**089721 CO-OPERATION WORKS IN VIRGINIA.** When the RDF plant in Portsmouth, Va., swings into full operation in January, it will become the centerpiece of perhaps the most complete solid waste disposal system in the United States. The plant is the work of the Southeastern Public Service Authority (SPSA), regional authority founded in 1973 by eight local governments that encompass nearly 2,000 square miles and a population of 950,000 people. As a result of its efforts, the area's ecosystem no longer handles pollutants from six sub-standard landfills, two old air-polluting refuse incinerators, and one obsolete military facility that burned an estimated 800,000 gallons of fossil fuel annually.

Masley, Ed. *Waste Age* v 18 n 12 Dec 1987 p 45-46, 50, 53.

**089722 WASTE RECOVERY IN EUROPE.** This is the first of a two-part article on European refuse processing. It presents a 'tour guide' to 12 European plants which extract recyclable materials from refuse. The article highlights both products and unit processes in Great Britain, France, Spain, Italy, Austria, Germany, the Netherlands and Sweden. Part One looks at the expectations for these plants, few of which had progressed much beyond shake-down at the time the original research was done.

Abert, James C. (Nat'l Soft Drink Assoc, Washington, DC, USA). *Waste Age* v 18 n 10 Oct 1987 p 65-66, 70-72.

**089723 RECYCLING'S FUTURE IS NOW.** The article discusses operations at the 150-acre landfill property owned by the city of Palo Alto, Calif. - home of one of the oldest and most comprehensive municipal recycling programs in the United States. Part of the operation includes a curbside program in addition to the drop-off

center. Subjects covered include collection operations, classification works, materials processing, markets, and others.

Salimando, Joe. *Waste Age* v 18 n 10 Oct 1987 p 75, 77-78, 80.

**089724 MORE ON EUROPEAN WASTE RECOVERY.** The article concludes a two-part series presenting a 'guide' to 12 European resource recovery plants, based on research done for the World Bank. It compares plant realizations with expectations builders had for them. Plant locations are in Germany, Austria, France, Italy, Sweden, the Netherlands and the U.K.

Abert, James C. (Nat'l Soft Drink Assoc, Washington, DC, USA). *Waste Age* v 18 n 11 Nov 1987 p 62-63, 66.

**089725 MATERIALS RECOVERY FACILITIES.** The first Materials Recovery Facility (MRF) was begun as a research and development project in 1975 by Resource Recovery Systems. In the early 1980s, the company launched the first full-scale MRF at Groton, Connecticut, and a publicly-owned-and-operated facility followed in Islip, New York. Since then, two additional plants started operating. At least five more facilities should be in operation by spring, 1988 in the U.S. This article discusses the need for MRFs, the technology, and ownership/operator arrangements.

Glenn, Jim. *BioCycle* v 29 n 1 Jan 1988 p 24-27.

**089726 RESOURCE RECOVERY PLANT NOT A HEALTH RISK.** The fear of cancer-causing compounds from the stacks of the world's largest mass burn, resource recovery facility was recently put to rest with a 120-page report presented to the Pinellas County Board of County Commissioners. This report summarized a detailed health risk assessment prepared by HDR Engineering, Inc., Tampa, Florida as part of the air emissions testing program conducted for Unit 3 of the Pinellas County Resource Recovery Facility. A simultaneous testing program for non-criteria pollutants was conducted under the joint efforts of the Florida Department of Environmental Regulations, Pinellas County, the California Air Resources Board, and Wheelabrator Environmental Systems Inc. The study and its findings are discussed.

Van Derman, Bob (Solid Waste Management, Pinellas County, FL, USA). *Public Works* v 119 n 3 Mar 1988 p 64-65.

**089727 WHAT A RISK ASSESSMENT IS - AND HOW IT CAN HELP IN SITING.** Increasingly, risk assessment plays an important role in resource recovery planning and policy-making. Yet often the purposes and potential of these analyses are not clear to those who commission them. Resource recovery facility planning and siting can be improved by decision-makers who understand the risk assessment process. This article discusses what risk assessments are and how they are accomplished. Subjects covered include emission estimates, environmental fate of pollutants, risk and health effects, and others.

Fontana, Perry H. (Woodward-Clyde Consultants, San Francisco, CA, USA). *Waste Age* v 19 n 4 Apr 1988 p 331-332, 334.

**089728 EVOLUTION OF THE INDIANAPOLIS RESOURCE RECOVERY FACILITY.** The article discusses the background and studies that led to the Indianapolis Resource Recovery Facility (IRRF), which is under construction and scheduled for commercial operation in early 1989. The IRRF will serve as the central disposal point for the consolidated City of Indianapolis and Marion County. It consists of three mass burn combustion units using the Martin Reverse-Reciprocating Stoker Grate. Each combustion unit will have the capacity to process 787.5 tpd of municipal refuse, converting each



ton of refuse into 4,500 lb of steam for Indianapolis Power and Light Co. These and other aspects of the subject are discussed.

Stevens, P.L.; Henderson, J.S.; Tulli, R.R.; Mills, G.A. *Public Works* v 119 n 6 May 1988 p 86-89.

**089729 COLLECTING & PROCESSING RECLAIMED MATERIALS.** The article, the second in a series, discusses considerations for the solid waste professional in making an intelligent choice among the many technological options for collecting, processing, and storing recycled materials. Subjects covered include initial planning considerations, specialized collection equipment, balers and shredders, and others.

Walsh, Patrick (Univ of Wisconsin-Madison, WI, USA); O'Leary, Phil. *Waste Age* v 19 n 2 Feb 1988 p 106-108, 110, 112.

**089730 MATERIALS RECOVERY SYSTEM FOR SOURCE-SEPARATED NONCOMBUSTIBLE RUBBISH AND BULKY WASTE IN NISHINOMIYA.** Since 1980, the city of Nishinomiya has been recovering materials from source-separated non-combustible and bulky waste to reduce the amount of final disposal. Materials amounting to 33-39% of the throughput are recovered in the Shredding and Separation Facility, which consists of a manual separation system, a mechanical separation system, a shredder, a pair of shears and incinerators. The facility system is shown in order of processing of the waste. The secondary pollution control, safety equipment, instrumentation, etc., are also described. The recovery percentage and use of revenues are explained in detail. (Author abstract)

Adachi, Yoshihiro (Water Disposal Dep, Nishinomiya, Jpn). *Conserv Recycling* v 10 n 4 1987 p 217-227.

**089731 WELL-EQUIPPED FACILITY RECYCLES WASHINGTON WASTES.** Washington state's largest solid waste recycling facility now is operating inside an 80,000-square-foot building formerly used for storing and cutting steel. The converted plant is operated by Rabanco Recycling Co. The south Seattle plant processes waste from the collection routes of Seattle Disposal, serving the south half of Seattle, and Rabanco's collection company in the city of Kent, south of Seattle, as well as from a new curbside recyclables collection program in south Seattle and curbside recycling demonstration projects involving several Rabanco-served suburban areas. The objective is to run the recycling plant at 500 to 600 tons per day. Subjects covered include specialized equipment, marketing, and others.

Johnson, Bruce (World Wastes, Atlanta, GA, USA). *World Wastes* v 31 n 7 Jul 1988 p 54-55,77.

**089732 CRYOGENIC COMMUNION IN SCRAP RECYCLING.** The technical basis and the pros and cons, including market and economic factors, of cryogenic communion in the processing of scrap metal, plastic and rubber are described. A serious deterrent to realization of the advantages to be gained by cryogenic communion is the high cost of liquid nitrogen and many commercial operations have failed because of this cost factor. (Author abstract). 41 Refs.

Daborn, G.R. (Dep of Trade and Industry, Stevenage, Engl); Derry, R. *Resour Conserv Recycl* v 1 n 1 Mar 1988 p 49-63.

**089733 RECYCLING IN GREECE.** The Association of Communities and Municipalities in the Attica Region (ACMAR) has constructed a mechanical separation and materials recovery pilot facility which has a capacity of 2 tons per hour (8 hours per day, 5 days per week). There will be a two-months test operation that will seek to optimize facility output. The elements that are under investigation are: Cleanness of the recovered materials; Materials marketability; Cost/benefit analysis for the possibility of the expansion of this disposal method in Greece. The capital cost reached 560,000 U.S. dollars, while the facility will be operated by a five member staff.

Frantzis, Ioannis (Assoc of Communities & Municipalities in the Attica Region). *BioCycle* v 29 n 6 Jul 1988 p 30-31.

**089734 HOUSEHOLD REFUSE RECYCLING IN FRANCE.** A regional plant located a few miles outside St. Brieu in the Chatelets region of France receives 25,000 tons per year of urban solid waste generated by the 20 townships composing the SICTOM. Initial treatment stage transforms the fermentable organics in the household refuse into high quality compost. This stage was commissioned in March, 1986. In June, the landfill was found insufficient for the disposal of the rejects, and an incineration plant was set up with a system to sell recovered heat to local industry. Rejects have now been reduced to about 10 percent by weight of incoming material.

Levasseur, J.P. (Omnium de Traitements et de Valorisation, Courbevoie, Fr). *BioCycle* v 29 n 6 Jul 1988 p 32-33.

**089735 RECYCLING TAKES THE LEAD.** NBCM has been involved in the development of recycling systems for several communities. These projects typically begin with an analysis of the amount and type of waste generated by the community. Once the approximate amount of recyclable material is known, potential purchasers in the secondary materials markets can be contacted to determine what local outlets exist. BCM enters this information into a multi-dimensional spreadsheet with an array of headings. This allows easy update and quick reference and provides the groundwork for a market sensitivity analysis. Several options for collecting recyclable material exist, including curbside collection by recycling crews, drop-off centers where residents are paid in cash for their recyclables.

Murray, Kevin (BCM Engineers, Plymouth Meeting, PA, USA). *Public Works* v 119 n 9 Aug 1988 p 52-53.

**089736 COUNTY LAUNCHES RECYCLING PROGRAM.** Mobilizing broad-based support - from political leaders, the private sector, and the leaders, the private sector, and the general public - was a critical ingredient to curbside recycling. Gaining political support for program concept eventually translated into budget allocations. Private industry, too, lent the county's recycling program invaluable technical expertise, experience, and financial contributions. The carefully designed implementation plan, with exhaustive data collection built into the first phase, will enable the county to proceed with designing the county-wide program, using the collection equipment, processing operations, and collections procedures found most effective. Extensive public education and promotion of the program also contributed to the success of the first phase of curbside recycling. Householders were aware of the program and how to participate.

Dorn, Betsy (Mecklenburg County Recycling, Charlotte, NC, USA). *Public Works* v 119 n 9 Aug 1988 p 63-66.

**089737 DEVELOPING A RECYCLING PROCESSING CENTER.** While markets for recyclable materials continue to develop, there will always be some materials that cannot be recycled because markets do not exist or technologies for reusing the materials do not exist. Landfills will always be needed. Some wastes are also better incinerated than recycled. This article covers recycling in conjunction with other techniques for managing wastes. Many communities are combining recycling programs with other waste processing technologies, as opposed to sending all nonrecyclable materials to a landfill. This multiprocess approach has become commonly known as "integrated waste management." Subjects covered include a systems approach to planning a recycling center, composting, process options, and others.

O'Leary, Philip (Univ of Wisconsin, Madison, WI, USA); Walsh, Patrick. *Waste Age* v 19 n 7 Jul 1988 p 100-102.

## Storage

**089738 DESIGN AND CONSTRUCTION OF A LARGE REFUSE SILO FOR MAXIMUM HEAT RECOVERY BY INCINERATION.** In Sapporo, a large

refuse silo was constructed at the Shinoro Incineration Plant, in order to store the paper and wooden fractions of refuse generated during summer and to burn them during winter for increased energy recovery. From this experience in designing, constructing and operating the silo, the following conclusions were made: (1) An efficient operation of incineration plants becomes practical throughout the year for cities like Sapporo where seasonal changes in refuse generation are greater, due to the local climate and other special conditions. (2) An increased heat recovery and use, meeting the highest demand of heat during winter, can be attained. (3) Economically, construction and operation of a refuse silo under the circumstances mentioned above can be very cost-effective. (4) Special cares and precautions for fire prevention are found necessary in operating a large storage silo for shredded refuse.

Hashimoto, Akio (Sapporo City Hall, Jpn); Iwamura, Shunji; Gotoh, Sukehiro. *Conserv Recycling* v 10 n 4 1987 p 209-216.

## Transfer Stations

**089739 SNAPSHOT OF SMALL TRANSFER STATION COSTS.** The article discusses four types of facilities and their capital, operational, and maintenance costs, based on the assumption that the unit is built in Massachusetts. Size range varies with population and type of community served: small: 5 tpd capacity, serving a residential community of 2,000-3,000 people; 20 tpd, serving a primarily residential community of 8,000-10,000 with typical commercial support facilities; 65 tpd, for approximately 25,000 people, serving a slightly higher level of commercial and industrial facilities within city limits; and 150 tpd, typically serving a community of 50,000 people with a moderate level of commercial/industrial development. Data are adjusted to May, 1987, cost indices.

Zuena, Anthony J. (SEA Consultants Inc, Cambridge, MA, USA). *Waste Age* v 18 n 12 Dec 1987 p 85-87.

**089740 SHREWSBURY TAMES TIME.** The article discusses how a small municipality got around long landfill lines by cutting round trips from four per day to one. Shrewsbury, NJ, did this by switching to a refuse transfer system designed especially for small communities. Thanks to the switch, the borough eliminated 12 weekly round trips to the landfill. The sanitation workforce was reduced from six men to two. The new system does not use a single bulldozer, transfer trailer, or building, and the public works yard serves as a 'mini' transfer station.

Anon. *Waste Age* v 18 n 12 Dec 1987 p 99, 102.

**089741 TRANSFORMATION OF A TRANSFER STATION.** New York City's Department of Sanitation (DOS) is performing architectural facelifts on older transfer units facilities - where refuse is moved from trucks to barges. One such project involves redesigning and updating a unique marine transfer station (MTS) in Manhattan. This station will transfer 3000 tons of refuse daily and serve as a 'model facility' that brings together the words of art, education, and sanitation. The MTS will educate the public about how the DOS copes with 25,000 tons of refuse generated daily by New Yorkers. An observation gallery's monitors will show all of the station's operations. Environmental video art and documentaries will also be shown.

Zarillo, Anthony (New York City's Dep of Sanitation); Foerster, Richard. *Waste Age* v 18 n 9 Sep 1987 p 39-40, 42.

**089742 NEW N.J. STATION MOVES LARGE VOLUME OF WASTES.** 442 Waste Management Inc. opened a \$4 million facility in Newark, New Jersey, to recycle materials and transfer the remaining waste out of state. The transfer station is among the largest of its kind in New Jersey and is said to be equipped with some of the latest, most efficient equipment. The time needed to process 10



tons of waste is only about seven minutes. This article discusses the transfer station equipment and operations.

Anon. *World Wastes* v 31 n 4 Apr 1988 p 118.

## Transportation

**089743 MOVING WASTES ON RAIL MAY HELP CONTAIN THE CRISIS.** As siting landfills near urban centers become virtually impossible, transportation becomes an increasingly important element of a refuse management plan. The idea of railroading wastes to distant disposal sites is not new, but increasing problems are driving some to reconsider this option. These and other aspects of the subject are discussed.

Adler, Cy A. *World Wastes* v 30 n 12 Dec 1987 p 20-21.

**089744 SHRINKING NORTHEAST FILLS FORCE LONG-DISTANCE HAULS.** Long-distance hauling of solid waste from cities in New York, Pennsylvania, New Jersey and other areas of the East coast started out as a cost issue. Recently, however, waste transportation has centered around the availability of a facility to burn, bury or otherwise handle the waste. No one wants the landfills, the waste-to-energy plants or the transfer stations. So old landfills close, new ones are discouraged, and the expansion of existing sites is resisted. The result is that garbage is hauled 400-500 miles or more from New York City to Ohio, or from Boston, Newark, Trenton and Philadelphia to upstate New York. This article discusses the issues involved, including the economics of it.

Voell, Paula; Voell, Anthony. *World Wastes* v 31 n 3 Mar 1988 p 32, 34.

**Waste Utilization** See Also BIOMASS—Energy Resources; FUELS—Refuse Derived Fuels; PLASTICS—Recycling.

**089745 MANAGING WASTE-TO-ENERGY: THE OPERATORS' PERSPECTIVE.** During this phase of the project, it is the responsibility of the plant or operations manager to assemble all the information needed to operate and maintain the plant. Although it is common practice for the supplier to furnish manuals containing guidelines, only the operations manager can review these manuals and develop procedures that reflect true operational procedures. Begin by designing a flow diagram and then numbering the equipment in sequence. Next, lay out the 'Equipment Spec Sheet'. This should be a one-page grid with information such as make, model, dimensions (overall and effective), main shaft and sprocket sizes, and speeds and angles of incline. In addition to the Equipment Spec Sheet, a second sheet should contain a brief explanation of the piece of equipment. Additional subjects covered include information categories, computerization considerations, and others.

Brunner, Kenneth C. *World Wastes* v 30 n 10 Oct 1987 p 22, 24.

**089746 MANAGING WASTE-TO-ENERGY: THE OPERATORS' PERSPECTIVE.** The article is the last in a 6-part series describing the operator's role in the development of a successful waste-to-energy project. It discusses various factors to consider and to deal with in developing an effective maintenance program, including analysis of tasks to be performed, review of lubrication requirements and lubricants, maintenance scheduling, and others.

Brunner, Kenneth C. *World Wastes* v 30 n 11 Nov 1987 p 27-28.

**089747 INTEGRATED RESOURCE RECOVERY SYSTEM.** This paper describes one combination of waste management subsystems based upon actual trials and experience. Recyclable materials are ferrous metal, glass, aluminum, plastics and paper fiber. Alternatively, the paper fiber and/or plastics also can be processed into a refuse-derived fuel. In the system, these various fractions are isolated along with a highly organic fraction suitable for composting alone or with sewage sludge. The integrated system provides for direct recovery of 60 percent of

the incoming solid waste stream in the form of recyclable secondary materials, along with the capability of increasing recovery to 80 percent using additional processing subsystems.

Diaz, Luis F. (Cal Recovery Systems, Richmond, CA, USA); Savage, George M.; Golueke, Clarence G. *BioCycle* v 28 n 10 Nov-Dec 1987 p 47-52.

**REFUSE INCINERATORS** See Also AIR POLLUTION—Gaseous Effluents; FUELS—Refuse Derived Fuels; HYDROCARBONS—Aromatic; JOINTS—Expansion; ORGANIC COMPOUNDS—Chemical Reactions; RADIOACTIVE WASTES—Disposal; REFUSE DISPOSAL—Analysis; REFUSE DISPOSAL—Florida; REFUSE DISPOSAL—Incineration; SEWAGE TREATMENT—Sludge Disposal; TURBOGENERATORS; WASTE DISPOSAL—Incineration; WASTE UTILIZATION.

**089748 STUDY OF THE BEHAVIOUR OF MUTAGENS IN WASTEWATER AND EMISSION GAS FROM A MUNICIPAL INCINERATOR EVALUATED BY MEANS OF THE AMES ASSAY.** We have investigated the mutagenic activity of extracts from the wastewater of sewage treatment plants in municipal waste incinerators and evaluated the relative contribution of various routes of emission from the incinerator to the total output of mutagens. The mutagenicity of wastewater extracts from a complete combustion incinerator was 10% of that from an incomplete combustion unit. About 90% of all the mutagens produced in a municipal incinerator are discharged into the atmosphere as emission gases, and 10% are disposed of in the wastewater treatment plants. Most of the mutagens in wastewater treatment plants are not decomposed by normal aeration times, but are removed by adsorption onto suspended solids. (Author abstract) 14 refs.

Kamiya, Akio (Gifu Pharmaceutical Univ, Gifu, Jpn); Ose, Youki. *Sci Total Environ* v 65 Sep 1987 p 109-120.

**089749 CATALYTIC EFFECTS OF FLY ASH FROM WASTE INCINERATION FACILITIES ON THE FORMATION AND DECOMPOSITION OF POLYCHLORINATED DIBENZO-P-DIOXINS AND POLYCHLORINATED DIBENZOFURANS.** The thermal behavior of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) on electrostatic precipitator ash (fly ash) from waste incinerators was studied at 300 °C under 'oxygen deficient' and 'oxygen surplus' conditions. On the basis of evidence presented, a mechanism for this fly ash catalyzed reaction is proposed, which starts with the formation of chlorine from metal chlorides and leads finally to a de novo synthesis of PCDD and PCDF. The findings reported will have consequences for the interpretation of PCDD/PCDF formation and decomposition in waste incineration facilities and will aid in minimizing PCDD and PCDF emission from such facilities. (Edited author abstract) 10 refs.

Hagenmaier, Hanspaul (Univ of Tuebingen, Tuebingen, West Ger); Kraft, Michael; Brunner, Hermann; Haag, Roland. *Environ Sci Technol* v 21 n 11 Nov 1987 p 1080-1084.

**089750 240 t/d WATER COOLED ROTARY COMBUSTOR MUNICIPAL REFUSE INCINERATION PLANT DELIVERED TO RYUSEN-EN (KUMIAI) PUBLIC COOPERATION.** The article describes the features of the IHI rotary combustor-type (RC) refuse incinerator which is capable of recovering energy with higher efficiency than other incinerators. Seven RC incinerators operate, proving its higher heat-recovery efficiency. A 240 t/d municipal refuse RC incineration plant (120 t/d x 2 units) recently delivered to Ryusen-en (Kumiai) Public Cooperation is equipped with a fully automatically controlled refuse crane, an automatic combustion control system, etc. (Edited author abstract) 4 refs.

Sasaki, Tohru (IHI, Tokyo, Jpn). *IHI Eng Rev (Engl Ed)* v 20 n 2 Apr 1987 p 68-72.

**089751 RECENT FINDINGS ON THE FORMATION AND DECOMPOSITION OF PCDD/PCDF IN MUNICIPAL SOLID WASTE INCINERATION.** The

thermal formation of PCDD/PCDF in fly ashes of refuse incineration plants preferably in the low-temperature region of the boiler at 300°C is fully confirmed. Important parameters for the reaction of formation are the oxygen content and the water vapor in the offgas. Elemental carbon in the fly ash acts as an adsorbent to the precursor compounds. The oxidation of carbon may serve as a basis for the mechanism of PCDD/PCDF formation. Both reactions proceed by the Deacon process scheme. The catalytic action of CuCl<sub>2</sub> can be counteracted by the addition of NH<sub>3</sub>. (Author abstract) 11 refs.

Vogt, H. (Nuclear Research Cent Karlsruhe, Karlsruhe, West Ger); Metzger, M.; Stieglitz, L. *Waste Manage Res* v 5 n 3 Sep 1987 p 285-294.

**089752 COMPARISON OF AIR POLLUTION CONTROL SYSTEMS FOR MUNICIPAL SOLID WASTE INCINERATORS.** A major hurdle to be overcome by the proponents of municipal solid waste incineration is the popular misconception of uncontrollable and threatening air emissions of toxic pollutants from these plants. Flakt Canada Ltd has developed a dry adsorption system (DAS) with reactors, and quasi-dry or wet/dry lime slurry absorption systems with spray dryers (DRY-PAC) which achieve the high removal efficiencies required by the ever more restrictive environmental regulations. Results of acid gas removals range up to 98 percent for HCl and 95 percent for SO<sub>2</sub> as measured at commercial plants and over an extensive testing program at a pilot plant (summer of 1985) at the municipal incinerator in Quebec City, Canada. Organic removals for the toxic chlorinated dioxins and furans approach 99.9 percent plus under most fabric filter temperatures at the Quebec City pilot facility, while similar removal values are obtained at full-size installations in Europe. In evaluating the two systems, the completely dry injection system (DAS) has a capital and operating cost advantage for incinerators of 250-300 T/d of MSW. No difference was determined, however, in acid gas removal efficiencies for the two alternatives. 12 Refs.

Frame, Grant B. (Flakt Canada Ltd, Ottawa, Ont, Can). *JAPCA* v 38 n 8 Aug 1988 p 1081-1087.

Australia See HOSPITALS—Waste Disposal.

## Combustion

**089753 STUDY OF CATALYTIC REDUCTION OF NO<sub>x</sub> IN FLUE GAS FROM A MUNICIPAL REFUSE INCINERATOR (EXPERIMENTAL RESULTS OF NO<sub>x</sub> REMOVAL TEST PLANT).** The catalytic reduction process of NO<sub>x</sub> by NH<sub>3</sub> has been applied mainly to the clean combustion flue gases of LPG or LNG, which do not contain the harmful component which reduces the catalyst activity. This paper describes the experimental results of a survey for the catalytic reduction removal of NO<sub>x</sub> from dirty gas containing higher concentrations of HCl, SO<sub>x</sub> and dust emitted from a municipal refuse incinerator. The effects of reaction temperature, space velocity and the amount of NH<sub>3</sub> injection on the NO<sub>x</sub> removal efficiency are studied experimentally, and the change of V<sub>2</sub>O<sub>5</sub>-TiO<sub>2</sub> catalyst performance with time is examined; and the regeneration techniques for catalysts are also discussed on the basis of the results of the heat treatment. (Author abstract) 8 refs.

Morimune, Takaaki (Tokyo Metropolitan Univ, Tokyo, Jpn); Hirayama, Naomichi. *JSME Int J Ser 2* v 31 n 1 Feb 1988 p 135-139.

## Computer Aided Analysis

**089754 INCINERATOR MODEL USES LOTUS.** This article describes one way to build a computerized model specifically designed for incinerators. If the model is built to cover a wide spectrum of incinerator applications, it can provide a consistent means of quickly comparing design configurations and operating conditions. A builder may write such a model in any computer language. The author built his model in the Lotus 1-2-3 spreadsheet.



Marks, Charles H. (Charles Marks & Associates, Boston, MA, USA). *Waste Age* v 18 n 12 Dec 1987 p 188, 190.

## Control

**089755 REFUSE INCINERATOR OPERATION GUIDANCE EXPERT SYSTEM.** The refuse incinerator operation guidance expert system is a system which aids operation when the automatic combustion control system is difficult. By applying knowledge engineering, operation know-how of skilled operators is transferred to knowledge bases. The characteristics of this system lie in that the mutual interference between manipulators and states can be eliminated by a hierarchical structure of knowledge representation and a prediction method. The hierarchical structure of knowledge representation is also effective in the development of programs. (Edited author abstract) 11 refs.

Ase, Hajime; Tsukioka, Tetsuzo; Yamagishi, Makoto; Onishi, Yasunori; Kogasaka, Yoshihisa; Shibuya, Eiichi. *Nippon Kokan Tech Rep Overseas* n 52 Apr 1988 p 50-58.

**089756 CONTROL OF NKK-LIMAR (SEMI-DRY TYPE HCl REMOVAL SYSTEM).** In designing the control system for LIMAR (Semi-dry Type HCl Removal System), the generated HCl concentration was continuously measured in a dusty environment to determine the essential points that would make it possible to analyze the characteristics of the process. The measurements revealed that difficulties of controller design by large disturbances and process delay in operation of HCl analyzer. For this reason, a state predictor control system was adopted as the control system to resolve the problem of unreacted slaked lime. A feed forward control system with a capability of maintaining satisfactory controllability when variations occur in the slaked lime slurry concentration was developed. (Edited author abstract) 3 refs.

Ase, Hajime; Fujii, Satoshi; Yamagishi, Miki; Miyaji, Tsuneharu; Nara, Hisao; Sakai, Masao. *Nippon Kokan Tech Rep Overseas* n 52 Apr 1988 p 59-64.

**Design** See Also HAZARDOUS MATERIALS—Combustion.

**089757 IMPROVED DESIGN AND OPERATIONAL PRACTICES FOR MUNICIPAL SLUDGE INCINERATORS.** Municipal sludge incinerators have experienced many design and operational problems. The Environmental Protection Agency (EPA) has sponsored a sludge incinerator study to identify the nature and extent of design and operational problems, to identify possible problem solutions, and to determine the technical applicability for use in municipal sludge treatment systems. Study results are documented in an EPA report and summarized in this paper. This paper describes process configurations and related equipment, operational characteristics, common problems and solutions, and design and operational considerations related to sludge incineration. 2 refs.

Gilbert, Walter G.; Evans, Francis L. III; Wall, Howard; Reardon, Francis X.; Gowen, Elizabeth M. *J Water Pollut Control Fed* v 59 n 11 Nov 1987 p 939-943.

**089758 BUILDING UTILITIES DESIGN METHOD OF REFUSE INCINERATION PLANT.** Incineration plants are required to harmonize with an urban environment as well as have excellent efficiency. On the basis of this concept, this paper gives a design method for building utilities of a refuse incineration plant. It includes detailed ideas for designing a ventilation system for large and hot areas, a fire fighting system for a special building which is not covered by code of standards, and a heat recovering system which is an important factor for the planning of the incineration plant. (Author abstract) 5 refs.

Otsuka, Tenji (Nippon Kokan KK, Jpn); Funahashi, Hideki; Kogayu, Tomoyuki; Mitsunami, Masuichi; Terasaki, Kiyotaka; Nagami, Tatsuo. *Nippon Kokan Tech Rep Overseas* v 50 Sept 1987 p 51-61.

## Duluth, Minnesota

**089759 DULUTH RESURRECTS ITS CO-DISPOSAL PLANT.** A shredder explosion in 1982 at the co-disposal plant underlay a 6-year, \$5 million effort to redesign and retrofit the plant for safer, more efficient operation. The Western Lake Superior Sanitary District's (WLSSD) plant has become a source of pride for this Great Lakes community. Every working day, the plant turns 400 tons of solid waste into a fluff-like refuse-derived fuel (RDF) - which is used to burn sludge processed out of 34 million gallons of sewage. This article discusses studies that were conducted, process line equipment and other aspects of the subject.

Mattheis, Ann H. *Waste Age* v 19 n 2 Feb 1988 p 83-84, 86.

**Emission** See Also FLUE GASES—Analysis.

**089760 PROBLEMS ASSOCIATED WITH THE MEASUREMENT OF PCDD AND PCDF EMISSIONS FROM WASTE INCINERATION PLANTS.** Fly ash and stack gases from municipal waste and industrial incinerators in the F.R.G. have been analyzed for dioxins (PCDD) and PCDF. Most of the currently used procedures of stack gas sampling for PCDD/PCDF have been compared and were found to be equally effective. Differences are found, however, in the recovery of surrogates added to the sampling train before sampling, which makes it difficult to validate the sampling procedure. Thirty samples of stack gas from a single (old) municipal waste incinerator showed wide variation in PCDD/PCDF emission, indicating that single measurements are not useful in characterizing a plant for average PCDD/PCDF emission. The variations found under steady conditions can be explained by the proposed mechanisms of PCDD/PCDF formation and decomposition at low temperatures catalyzed by fly ash. Incineration of hospital waste and pyrolytic reclamation of copper in cables and aluminium produced significant emission of PCDD/PCDF. (Edited author abstract) 26 refs.

Hagenmaier, Hanspaul (Univ of Tuebingen, Tuebingen, West Ger); Brunner, Hermann; Haag, Roland; Kraft, Michael; Luetzke, K. *Waste Manage Res* v 5 n 3 Sep 1987 p 239-250.

**089761 PCDD AND PCDF EMISSIONS AND POSSIBLE HEALTH EFFECTS: REPORT ON A WHO WORKING GROUP.** An international group of experts, convened by the WHO Regional Office for Europe, discussed the health risks of PCDD and PCDF emissions from the incineration of municipal sewage sludge (MSS) and municipal solid waste (MSW) at a meeting in Naples, Italy, held 17-21 March 1986. A detailed analysis of emission data has shown that old and badly operated incinerators will emit up to many thousand ng Nm<sup>-3</sup> of PCDD and PCDF, while most modern, highly controlled and carefully operated plants will emit them at a very low level. It is still not known what contribution municipal incinerator emissions make to the overall environmental load and, consequently, human exposure. For modern incineration plants this contribution was estimated to be in the range of about a tenth to a few percent of the total background daily body burden [assumed to be 1-5 pg of 2,3,7,8-TCDD (dioxin) equivalents per kilogram body-weight and day]. (Edited author abstract) 25 refs.

Suess, Michael J. (WHO, Copenhagen, Den). *Waste Manage Res* v 5 n 3 Sep 1987 p 257-268.

**089762 RISK FROM EXPOSURE TO POLYCHLORINATED DIBENZO-P-DIOXINS AND DIBENZOFURANS EMITTED FROM MUNICIPAL INCINERATORS.** Incineration of wastes seems to be one of the major sources of PCDDs and PCDFs (dioxins). 2,3,7,8-TCDD is one of the most toxic chemicals known and has been found to have teratogenic and carcinogenic activities in animals. A modification of the multistage model is utilized for extrapolating high-dose, two-year animal cancer bioassay data to estimate human cancer risk for long-term, low-dose human exposure. The upper limit of incremental cancer risk is  $3.3 \times 10^{-3}$  for a continuous

lifetime exposure to 1 pg m<sup>-3</sup> of TCDD in ambient air. With the exception of 2,3,7,8-TCDD and a mixture of 1,2,3,6,7,8- and 1,2,3,7,8,9-HxCDDs, the chronic toxicity data on the rest of the 75 PCDD and 135 PCDF congeners are badly deficient. In the absence of chronic bioassay data on other PCDDs and PCDFs, several TCDD equivalent approaches have been proposed for risk assessment on other congeners or mixtures. This paper compares the various approaches. (Edited author abstract) 72 refs.

Mukerjee, Debdas (US Environmental Protection Agency, Cincinnati, OH, USA); Cleverly, David H. *Waste Manage Res* v 5 n 3 Sep 1987 p 269-283.

**089763 OPTIMIZATION OF COMBUSTION CONDITIONS TO MINIMIZE DIOXIN EMISSIONS.** Polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) may enter an incinerator with the waste, be created in poor combustion or form in post-combustion zones under certain conditions of temperature and oxygen. Tests of MSW burning plants shows a wide range of emission of PCDD and PCDF. Mixing effectiveness, tightness of control, moisture, furnace and post-furnace temperatures, and the use of lime and reduced temperatures for acid-gas control all have an effect on emissions of trace organics. Carbon monoxide (CO), oxygen, moisture and furnace temperature have been found to be closely related to PCDD/PCDF emissions. By control of temperature and/or oxygen, and the use of CO as an indicator, it is possible to find and maintain optimum combustion conditions so as to minimize dioxins and furans. Plants having acid-gas controls reduce emissions below those achieved by good combustion alone. (Edited author abstract) 25 refs.

Hasselriis, Floyd (Gershman, Brickner & Bratton Inc, Falls Church, VA, USA). *Waste Manage Res* v 5 n 3 Sep 1987 p 311-326.

**089764 ORIGIN AND HEALTH RISKS OF PCDD AND PCDF.** PCDD/PCDF are ubiquitous in the emissions of trash-burning incinerators. They are synthesized in the cooler parts of the incinerator, and emissions are not reduced by controlling combustion conditions. Estimates of maximum lifetime risks of PCDD/PCDF emissions range over two orders of magnitude from a minimum of one per million. This risk is greater than that which has triggered regulatory procedures against airborne carcinogens by U.S. EPA. Computations based on PCDD/PCDF in adipose tissue of a representative sample of the U.S. population indicate a national lifetime cancer risk of 330-1400 per million depending on the choice of equivalence methodology. In comparison, U.S. EPA has regulated environmental exposure to benzene based on a national lifetime cancer risk of 71.4. Because waste-burning incinerators contribute significantly to this risk, it is the authors' opinion that their PCDD/PCDF emissions should be reduced if U.S. EPA is to be consistent in its regulatory practice. (Author abstract) 62 refs.

Commoner, Barry (Queens Coll, Flushing, NY, USA); Shapiro, Karen; Webster, Thomas. *Waste Manage Res* v 5 n 3 Sep 1987 p 327-346.

**089765 TOTAL ORGANIC CARBON EMISSIONS FROM MUNICIPAL INCINERATORS.** Total carbon (TC), carbonate carbon (CC) and total organic carbon (TOC) were determined in bottom ash, filter dust and flue gas of Swiss municipal solid waste (MSW) incinerators. The highest TOC load was found in the bottom ash (2-3 g kg<sup>-1</sup> MSW), followed by the filter dust (0.1-1.0 g kg<sup>-1</sup> MSW) and the flue gas (0.05-0.3 g kg<sup>-1</sup> MSW). The composition and behaviour of the bulk of TOC in these products is not yet known. In order to minimize the risk of leaching organic substances as well as metals due to biological, chemical and physical reactions of the products



of incineration in a landfill, it is suggested the incineration process be optimized towards complete combustion. (Author abstract) 12 refs.

Brunner, Paul H. (Swiss Federal Inst for Water Resources & Water Pollution Control, Duebendorf, Switz); Mueller, Markus D.; McDow, Stephen R.; Moench, Hermann. *Waste Manage Res* v 5 n 3 Sep 1987 p 355-365.

## Energy Conservation

**089766 CERAMIC FIBER LINED INCINERATION SYSTEM OF REGENERATIVE TYPE MEETS CLEAN AIR STANDARDS IN COGENERATIVE USE.** To help meet EPA clean air standards, Mannington Resilient Floors Div. of Mannington Mills, Inc., Salem, N.J., has installed a new regenerative fume incineration system. In addition to meeting these standards by burning volatile organic solvents which are released during the printing of resilient sheet vinyl flooring, the system allows the recycling of warm air for heating the building and thereby will save about \$58,000 per year in fuel costs. Furthermore, overall operating economy is achieved because this system is 95% efficient. The steel incinerator shell is lined with ceramic fiber modules, Manville Z-Blok refractory, which were chosen to withstand temperatures up to 2300°F (1260°C), as well as for their strength and abrasion-resistance.

Anon. *Ind Heat* v 55 n 4 Apr 1988 p 28.

**089767 CHARACTERISTICS OF INCINERATORS WITH HEAT RECOVERY CAPABILITY.** A wide range of equipment is available for incinerating wastes and recovering the heat released as useful energy. These heat recovery incinerators (HRIs) can be grouped into four categories: starved-air modular, rotary kiln, excess-air grate, and fluidized bed combustion. State-of-the-art HRI technology has been reviewed to update the military knowledge base. Findings represent data collected from approximately 30 manufacturers of this equipment through literature review, direct survey work, and information exchange with other facilities investigating this area. The different technologies and products available are compared and evaluated for potential application at military installations. (Edited author abstract).

Griggs, K. (US Army Construction Engineering Research Lab, Champaign, IL, USA); Chamberlin, G.; Ducey, R.; Schanche, G. *Tech Rep US Army Corps Eng Constr Eng Res Lab* v E-88 n 4 Apr 1988 p 9-77.

## Energy Utilization

**089768 ENERGY RECOVERY FROM REFUSE INCINERATION.** This conference proceedings contains 7 papers discussing energy recovery aspects from refuse incineration. Operational performance of waste-to-energy plants and economic incentives for recovering energy from refuse are topics considered. The design, construction, and first five years' operation of a municipal waste incinerator with energy recovery are discussed. One paper describes the production of steam from the combustion of solid wastes, while another presents experience obtained with steam and power generation from municipal wastes. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10761 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Inst of Mechanical Engineers, London, Engl). *Energy Recovery from Refuse Incineration, Strathclyde, Scotl, Feb 26 1985* Publ by Inst of Mechanical Engineers, London, Engl, 1985 64p.

**Environmental Impact** See Also ORGANIC COMPOUNDS—Environmental Testing; REFUSE DISPOSAL—Recycling; SOIL POLLUTION—Analysis.

**089769 DIOSSINA SI DIOSSINA NO? [Incinerators; Dioxine Yes or No?].** The lack of correct information about incineration technologies is creating unmotivated apprehension. With the modern types of high destructive power furnaces the dioxine risk in urban incinerators is practically nonexistent. (Author abstract) In Italian. 60

refs.

Maltese, Paolo. *Mater Plast Elastomeri* n 2 Feb 1987 p 78-87.

**089770 CADMIUM AND LEAD CONTENT OF SUSPENDED PARTICULATE MATTER EMITTED FROM A U.K. REFUSE INCINERATOR.** Suspended particulate matter (SPM), sampled from the stack of a large refuse incinerator in the UK, contained markedly elevated levels of Cd (1600  $\mu\text{g g}^{-1}$ ) and Pb (3%). These values were similar to those previously reported for several other incinerators in Europe, but the Pb concentrations were lower than in the SPM from three American incinerators. Calculation of the metal concentration ratio SPM/fly ash for the UK incinerator revealed a three-fold enrichment of the two metals on the SPM. Similar ratios were obtained for several other European incinerators; this correspondence in metal partitioning was linked to the use of electrostatic precipitators in these facilities. The SPM metal data obtained in this study were used to estimate atmospheric emissions of 0.5 t Cd year<sup>-1</sup> and 11 t Pb year<sup>-1</sup> from the incinerator. These results are discussed in the paper. (Edited author abstract) 13 refs.

Wadge, A. (King's College London, London, Engl); Hutton, M. *Sci Total Environ* v 67 n 1 Nov 1987 p 91-95.

**089771 HOW PLANT OPERATORS CAN MINIMIZE EMISSIONS.** To attain the lowest achievable emission rate from such a facility, plant operators must be well-trained - in both furnace and emission control device operations. This article deals with operating practices that have been shown to help minimize various emissions. Subjects covered include metals and plastics refuse, battery recycling, stoker, grate and furnace operation, and others.

Clarke, Majorie (New York City Dep of Sanitation, New York, NY, USA). *Waste Age* v 18 n 12 Dec 1987 8p between p 156 and 170.

**089772 AIR POLLUTION CONTROL STATUS REPORT.** Public concern about potential health and environmental effects of emissions has accompanied the national trend to construction of refuse-to-energy plants in recent years. The need for refuse incineration and the manifestation of public concerns have stimulated researchers and government agencies worldwide to focus their attention on control of emissions from refuse-burning plants. This article presents the results of current research into various emissions control topics. Refuse-to-energy emissions control trends in five key areas, including equipment, plant design and operations, are covered in this first of a three-part series.

Clarke, Majorie (Dep of Sanitation, New York, NY, USA). *Waste Age* v 18 n 11 Nov 1987 10p between p 102 and 117.

**089773 WIRKSAMKEIT VON PRIMAER- UND SEKUNDAERMASSNAHMEN ZUR DIOXINMINDERUNG IN MUELLVERBRENNUNGSANLAGEN. [Effectiveness of Primary and Secondary Measures for the Reduction of Dioxin in Refuse Incineration Plants].** The concentration of polychlorinated organic compounds in fly ash can be much more effectively reduced by a simple thermal after-treatment of the fly ash than is possible by using combustion engineering measures. Concentration reductions of more than 95% have been attained. This paper reports on tests undertaken at the Stuttgart Refuse Incineration Plant with regard to the reduction of polychlorinated dibenzodioxins and polychlorinated dibenzofurans. (Edited author abstract) In German. 13 refs.

Hasenkopf, O. (Technische Werke der Stadt Stuttgart AG, Stuttgart, West Ger); Nonnenmacher, A.; Aucher, E.; Hagenmaier, H.; Kraft, M. *VGB Kraftwerkstech* v 67 n 11 Nov 1987 p 1069-1073.

**089774 ENVIRONMENTAL LEVELS OF CADMIUM AND LEAD IN THE VICINITY OF A MAJOR REFUSE INCINERATOR.** This study examines whether the atmospheric release of Cd and Pb from a

refuse incinerator in London has caused contamination of the local environment. Sampling networks were established for street dusts, surface soils, vegetation and total deposit gauges in areas up to 5 km downwind and upwind from the incinerator. Measurements of Cd and Pb indicate there is neither a marked nor an extensive contamination by these metals in the downwind area. However, dust Cd values decreased with distance from the incinerator in this area and Cd deposition rates were higher than in the upwind area. Nevertheless, most Cd values obtained in the downwind area were similar to those previously reported for other parts of London while Pb values were often lower. Appreciable Cd contamination was found within the grounds of the incinerator, the values being about 4-50-fold higher than in either the upwind or downwind areas. The extent of Pb contamination in this small area was more limited, with values being about twice those found in the two study areas. Additional study results are discussed. (Edited author abstract) 27 refs.

Hutton, M. (King's Coll London, London, Engl); Wadge, A.; Milligan, P.J. *Atmos Environ* v 22 n 2 1988 p 411-416.

**089775 IS LEAD A BIG PROBLEM?** More than 12 million tons of lead are used each year in the U.S. When disposed, it has been thought, this material could pose a serious hazard to human health. But the facts, when studied, produced good news: very little of the nation's lead ends up in the municipal waste stream. If a 4,000-ton sample of refuse processed at the Resource Authority of Sumner County (RASCO) plant in Gallatin, Tenn., is typical, less than 3% of this lead ends up in the nation's refuse. This article discusses the subject in terms of operations and environmental testing results for RASCO, covering recycling, mercury and cadmium removal, the effect of burning on lead, and related topics.

Roos, Charles E. (Nat'l Recovery Technologies, Nashville, TN, USA). *Waste Age* v 19 n 2 Feb 1988 p 54-56.

**089776 RELATION BETWEEN TOXIC INPUTS AND DIOXIN AND FURAN OUTPUTS FOR MUNICIPAL-WASTE INCINERATORS (MWIs).** Using our simplified model for dioxin and furan production in MWIs, we have estimated the required changes in toxic inputs to produce n-fold increases in the outputs of toxic equivalents (TEs). Since waste inputs generally reside on the furnace grates for about 30 min, TE output-variations should be considered for time periods equal to or longer than about 30 min. With these long averaging times, the amounts of toxic-input augmentations required for 10-fold output increases in full-scale MWIs become unreasonably large, except for the deliberate use of MWIs as toxic-waste burners. With very clean MWIs, substantial toxic-waste incineration may be combined with burning of municipal wastes on a controlled basis. (Author abstract). 5 Refs.

Penner, S.S. (Univ of California, San Diego, CA, USA). *Energy (Oxford)* v 13 n 4 Apr 1988 p 389-391.

**089777 MODEL ANALYSIS OF METAL PARTITIONING IN A HAZARDOUS WASTE INCINERATION SYSTEMS.** The 1984 Amendments to the Solid Waste Act require that wastes listed under the Resource Conservation and Recovery Act (RCRA) be analyzed to assess the feasibility of further banning from land disposal. Incineration is expected to be used more often for disposing of either the banned wastes directly or the residues of various treatment processes. Incineration of hazardous wastes, municipal wastes and industrial sludges produces some extent of trace metals. This paper provides a preliminary model concept for analyzing metal partitioning during incineration. The paper concludes that a model for predicting metal partitioning phenomena is feasible and could reduce costs in conducting metal emission testing in the field. (Author abstract). 11 Refs.

Lee, C.C. (US EPA, Cincinnati, OH, USA). *JAPCA* v 38 n 7 Jul 1988 p 941-945.



**089778 COMPARATIVE GENETIC ACTIVITY OF SAMPLES COLLECTED FROM TWO DIFFERENT URBAN WASTE INCINERATORS.** The genotoxic activity of samples obtained from the urban incinerator of Florence was analyzed. The results were compared with those obtained with samples drawn from the urban Snamprogetti incinerator of Schio (Vicenza), where halogenated acids contained in the smoke are neutralized with lime wash in a salification column. Samples were tested using prokaryotic (*Salmonella typhimurium* TA98, TA100 and TA102 strains) and eukaryotic (*Saccharomyces cerevisiae*, D7 strain) microorganisms. The results point out a clear difference in the genotoxic activity of the samples drawn from the two urban waste incinerators examined. This can be due either to the different cycles of incineration or to the different composition of the urban wastes to be incinerated. However, the former hypothesis, i.e. the presence of a more complete purification cycle in the Schio incinerator, seems to be the most likely. 10.

Vellosi, R. (CNR, Pisa, Italy); Galli, A.; Rossi, F.; Morichetti, E.; Bronzetti, G. *Bull Environ Contam Toxicol* v 41 n 3 Sep 1988 p 461-468.

#### Federal Republic of Germany

**089779 EMISSION OF TRACE ORGANICS FROM MUNICIPAL SOLID WASTE INCINERATORS - RATIONALE OF NATIONAL GUIDELINES IN THE FEDERAL REPUBLIC OF GERMANY.** In the Federal Republic of Germany a working party has developed recommendations for dealing with the dioxin problems posed by waste incineration. According to these recommendations limit values for dioxin emissions are neither necessary nor practical. However, from the point of view of preventive environmental protection, dioxin emissions should be further reduced as far as is possible with present-day technology. The TA Luft (Technical Instructions for Maintaining Air Quality) contains stipulations and advice on this. The most significant of the solid residues from waste incinerators are the filter ashes as they have a high dioxin content. The working party of Laender (states) has compiled a catalogue of recommendations for the disposal of filter ashes. The transport of solid residues from solid waste incinerators is controlled under the Abfallgesetz (Waste Act) and regulations passed in connection with this act and under the Gefahrgutverordnung Strasse - GGVS (Regulation on the transport of dangerous freight by road). (Edited author abstract) 9 refs.

Barniske, L. (Umweltbundesamt, Berlin, West Ger). *Waste Manage Res* v 5 n 3 Sep 1987 p 347-354.

#### Fluidized Bed

**089780 FLUID BED COMBUSTION: LESSONS LEARNED.** With increasing frequency, fluid bed combustion (FBC) is mentioned as the technology selected in new waste-to-energy plants. There has, however, been relatively little action. Despite this lack of experience with municipal waste, fluid bed combustion has a long history. It has been used successfully for over 25 years in sewage sludge combustion, industrial waste combustion, and, in recent years, in coal-fired boilers. Proponents say the technology can decrease emissions and reduce ash disposal problems. This article presents an overview of what has been accomplished, in real terms, in full-size commercial plants designed and built to burn MSW in fluid beds. Case histories are discussed for Lausanne, Switzerland; Franklin, Ohio; Thunder Bay, Ontario; and Duluth, Minnesota.

Kleinau, J.H. (Fluid Bed Inst of America, Fairfield, IA, USA). *Waste Age* v 19 n 4 Apr 1988 5p between p 274 and 284.

**Fuels** See REFUSE DISPOSAL—Storage.

**Health Hazards** See REFUSE DISPOSAL—Incineration.

#### Kyoto, Japan

**089781 OUTLINE OF KYOTO SOUTH NO. 1 WASTE INCINERATION PLANT, 600 METRIC T/DAY CAPACITY.** The Kyoto South No. 1 Waste Incineration Plant was handed over to the city of Kyoto in November of 1986. This plant is equipped with many new technologies to satisfy such requirements as strict pollution control, waste heat utilization, resource recovery of waste, and automation of the plant. Plant equipment is described.

Teratsujii, Kazuhiro. *Nippon Kokan Tech Rep Overseas* n 51 Dec 1987 p 70-72.

#### Los Angeles, California

**089782 POLLUTANTS SAY 'UNCLE' AT COMMERCE PLANT.** The 350-tpd Commerce, Calif., refuse-to-energy plant is a mass-burn facility, built by the city of Commerce and the Los Angeles County Sanitation District. It has been found to have air emissions among the lowest of any operating plant. Overfire and underfire air, sucked in off the plant's roof, is supplied to a Foster Wheeler boiler; refuse is burned on Detroit Stoker grates. Air then is put through thermal de-NOx treatment (from Exxon) and a spray-dry scrubber and baghouse (from Research Cottrell) before being released. Continuous emissions monitors (from Lear Siegler) check air quality as it leaves the boiler (where ammonia and oxygen are monitored), and at the stack. Stack monitors measure six air components: oxygen, nitrogen oxide, carbon monoxide, carbon dioxide, water, and sulfur dioxide. These and other aspects of the plant equipment and operations are discussed in the article.

Salimando, Joe. *Waste Age* v 19 n 5 May 1988 p 77-78, 80, 82.

#### Materials

**089783 EXPERIENCE WITH NICKEL CONTAINING ALLOYS IN APPLICATIONS IN WASTE INCINERATORS.** A laboratory study was conducted of various nickel base alloys and some austenitic stainless steels in a mixed oxidant environment containing O<sub>2</sub>, N<sub>2</sub>, SO<sub>2</sub> and HCl at temperatures varying from 593 to 927°C (1100 to 1700°F). Field studies with nickel alloys in waste incinerators were also conducted. Upon completion of exposure, all specimens were weighed to allow for the calculation of the mass change per unit area. The specimens were then sectioned and metallographically mounted. The metal loss and depth of maximum attack were measured on the unetched mounts of selected test runs. Finally, these microstructures were examined by SEM and selected specimens were used to extract the surface scales for X-ray diffraction (XRD) by anodic dissolution in a 10% HCl-methanol mixture. Test results are presented. 3 refs.

Ganesan, P. (Inco Alloys Int Inc, Huntington, WV, USA); Smith, G.D. *Ind Heat* v 54 n 12 Dec 1987 p 18, 20, 22.

#### Refractory Materials

**089784 BASICS OF REFRACTORY.** Refractory protects refuse-to-energy plant components. Refractory is a material used to form a protective lining on the inner boiler tube walls; it protects the walls from the products of combustion. This article discusses refractory material and its importance in refuse-to-energy plant operation and maintenance. Subjects covered include early plant problems, types of refractory materials, installation, and others.

Johnson, Donald K. (Norton Co, Worcester, MA, USA). *Waste Age* v 18 n 11 Nov 1987 p 76-78, 80.

**Temperature Control** See GAS BURNERS—Performance.

**Testing** See Also AIR POLLUTION—Control.

**089785 HOW TO HANDLE ACCEPTANCE TESTING OF WASTE-TO-ENERGY PLANTS.** Two of the key guarantees provided when constructing a resource recovery or waste-to-energy plant are capacity and energy production. This article discusses the acceptance testing procedures necessary to verify that these guarantees have been met. Emphasis is given to the measurement of refuse Higher Heating Value (HHV) during tests and the effect of HHV on the final results.

Thomas, David (Ogden Martin Systems Inc). *Power Eng (Barrington Ill)* v 91 n 10 Oct 1987 p 34-37.

**Waste Disposal** See Also REFUSE DISPOSAL—Incineration; REFUSE DISPOSAL—Land Fill.

**089786 TREATMENT OF WASTE WATER FROM REFUSE INCINERATION PLANTS.** The waste-water purification systems used at the Bamberg waste incinerator are described as an example of how easily such critical waste water can be treated. Water from flue gas scrubbers and ash washing which contains mercury, heavy metals and salts is precipitated with lime and trimercaptotriazine (TMT15) in two stages to produce an effluent that meets the strong discharge standards of the F.R.G. (Author abstract) 12 refs.

Reimann, Dieter O. (Stadt & Landkreis Bamberg, Bamberg, West Ger). *Waste Manage Res* v 5 n 2 Jun 1987 p 147-157.

**Waste Heat Utilization** See Also COMBUSTION—Fluidized Beds; REFUSE DISPOSAL—Baltimore, Maryland; REFUSE DISPOSAL—Recycling.

**089787 AKRON RDF PLANT FINALLY HITS STRIDE.** Today, the Akron Recycle Energy Systems (RES) is receiving more than 900 tpd of municipal solid waste and tires. The plant is in the midst of the longest sustained period of uninterrupted service in its seven-year operating history. But the Akron RES has not always operated at this level. The facility has been beset with technical, financial, and safety problems throughout its troubled past. An explosion in December, 1984, capped the troubles; it killed three persons, injured others, and shut down the facility for 10 months. An important additional fact: with the addition of a \$1.1 million city subsidy, the plant's cost of operation is competitive with present landfill costs. This article discusses the plant revenue problems, explosions, changes in operating arrangements, waste processing, steam production, and other aspects of the subject.

Sowa, Linda A. (Akron, OH, USA); Spencer, David B. *Waste Age* v 18 n 10 Oct 1987 6p between p 127 and 135.

**089788 SAUGUS: PLANT AS 'UNIVERSITY'.** As the oldest operating commercial refuse-to-energy plant in the U.S., the 1,500-tpd Saugus RESCO is a milestone in the waste services industry. It is owned by Wheelabrator Environmental Systems, Inc. This plant is sometimes called the 'University of Resource Recovery', because of its operator training program, and because the Saugus RESCO operating history has spawned many improvements to subsequent plants. This forerunner of the modern generation of incinerators, after some major modifications, has been operating consistently and efficiently without a shutdown since October, 1975. This article discusses current operations at the plant, financing modifications, and other aspects of the subject.

Grady, Julie C. *Waste Age* v 18 n 11 Nov 1987 p 46-48.

**089789 CITY RDF PLANT STOPS BURNING CASH.** Citizens of Columbus, Ohio, were well ahead of their time in 1977 when they voted to build one of the nation's first and largest trash-burning power plants. When it was finally finished in 1983, the project was two years late - and \$70 million over budget. Also, the plant did not perform up to expectations. In its first year, the plant averaged 772 tpd, short of the 2,000-plus daily tons



for which it was designed. Three years later, things have changed. Thanks to the city's investment of \$12 million in the 'Big Fix' program, completed this year, the plant has finally achieved reliability in burning its intended daily capacity. Additional city investments are being made, as well as an annual subsidy of the plant's operating budget that tops \$10 million. This article discusses the background of the project, ash handbag system, fuel processing and feed, economics, and other aspects of the subject.

Todd, Gordon (R.W. Beck & Associates). *Waste Age* v 18 n 11 Nov 1987 p 50-52, 54, 58.

**089790 ARMY LEARNS, AND LEARNS.** The U.S. Army has purchased six small-scale refuse burning facilities in the past eight years. This article discusses what can go wrong in small-scale refuse-burning facility design, construction, operations, and maintenance. It is based on studies of the problems by the Energy Systems Division of the Construction Engineering Research Laboratory (CERL) of the U.S. Army Corps of Engineers.

Salimando, Joe. *Waste Age* v 18 n 11 Nov 1987 p 70-72, 74.

**089791 REGIONAL APPROACH WORKS.** The article discusses how cooperation in building refuse-to-energy plants in the Baltimore metropolitan area has thus far averted capacity problems. It traces the background of the problem in the area and how this led the Northeast Maryland Waste Disposal Authority, the participating subdivisions, representatives of the governor's office, and the Maryland Environmental Service to negotiate the Northeast Maryland Regional Solid Waste Management Agreement (the 'Regional Agreement'). The Agreement set forth priority activities and short- and long-range goals for solid waste management in the region through 1985. These and other aspects of the subject are discussed.

Gagliardo, Michael A. (Northeast Maryland Waste Disposal Authority, Baltimore, MD, USA). *Waste Age* v 18 n 11 Nov 1987 5p between p 81 and 90.

**089792 HAULERS GET INTO REFUSE-TO-ENERGY.** This article discusses the smaller waste service company's involvement in refuse-to-energy. The small band of hauling company executives who have developed projects or are trying to do so agree that a privately held, local waste company has some advantages over a larger competitor in bringing a refuse-to-energy plant from concept to reality. Company owners interviewed say that not all hauling company owners can break into this field, but if they have certain qualities they can develop a project that will work. The article explores these qualities by presenting case history applications that discuss companies in Connecticut, South Carolina, Maine, Georgia and New York.

Spleen, Tony (Waste Age, Washington, DC, USA). *Waste Age* v 18 n 11 Nov 1987 5p between 91 and 101.

**089793 MUNICIPAL WASTE-TO-ENERGY MARKETPLACE TO EXCEED \$20 BILLION DURING NEXT TEN YEARS.** In response to a waste disposal crisis in the United States, the municipal waste-to-energy (W-T-E) marketplace has rapidly emerged during the last decade. The driving force in this marketplace is the lack of adequate landfill space throughout the country. While the future for suppliers of W-T-E technology and equipment is bright, there is little doubt that this emerging marketplace will plateau in the coming years. Through the years, design enhancements and the development of new technologies resulted in more reliable and efficient plants. Increases in tipping fees, as well as a developing marketplace for electricity and steam sales also enhanced the economics of the waste-to-energy marketplace. In response to a shortage in landfill space, economically viable incineration technologies, and increasing markets for products (e.g. electricity, steam, and recyclable materials) the United States waste-to-energy marketplace has thrived. By the end of 1991, almost 200,000 tons per day of capacity will exist in the U.S.

Jacobs, Steve (Resource Marketing Internat). *Strategic*

*Plann Energy Manage* v 7 n 4 Spring 1988 p 54-57.

**089794 WASTE-TO-ENERGY WITH A FLORIDIAN FLAIR.** The Bay County Resource Management Center is a 38 million dollars, 510-tpd waste-to-energy plant situated near Panama City, Florida. Because of a high water table in the area, local haulers deposit loads on a tipping floor, where front-end loaders push the wastes on one of two vertical conveyers. These take the wastes up and into two combustors. The facility has one of the best air emissions and performance records of the new generation of refuse-burning facilities. Since its May 1, 1987, opening, the facility has achieved near-100 percent availability. Recent tests conducted by the Florida Department of Environmental Resources on the plant's particulates indicate prove that it's a good neighbor: the plant releases only 66 percent of the particulate emissions allowed by state regulation. This article discusses the background of how the plant came to be, planning aspects, plant equipment and operators, and other aspects of the subject.

Mattheis, Ann H. *Waste Age* v 19 n 7 Jul 1988 p 113-114.

## Wastes

**089795 INCINERATOR ASH SPARKS HEATED DEBATE ON TOXICITY.** The question of ash toxicity was never fully examined by the industry or EPA until March 9, 1987, when the Environmental Defense Fund (EDF) announced the results of a study on ash from 30 resource recovery plants around the U.S. EDF noted that the levels of lead and cadmium were partially high in the ash. The group obtained its data from EPA ash tests from old and new, mass-burn and refuse-derived fuel facilities throughout the country. EPA has circulated a draft document spelling out proper sampling procedures and tests for determining ash toxicity. The design of EPA's ash sampling plan involves two components: one, to determine the average property of the waste; and, second, to determine if the wastes change over time. These and other aspects of the subject are discussed.

Darcey, Susan (World Wastes, Atlanta, GA, USA). *World Wastes* v 30 n 10 Oct 1987 p 32, 34, 36.

**089796 LEACHING OF TOXIC METALS FROM INCINERATOR ASHES.** The RCRA Extraction Procedure (EP) is a laboratory test intended to characterize the leaching of a waste codisposed in municipal, landfill waste. The purpose of this research was to fully characterize the leaching properties of some resource recovery ashes. To do this, four resource recovery ashes were leached under field conditions simulating monodisposal and codisposal practices. Monodisposal, as referred to here, is disposal of a resource recovery ash in a separate landfill, and codisposal means disposal of the ash in a landfill where untreated municipal wastes are also disposed. The leaching characteristics of the four ashes were also compared using four laboratory waste extraction tests. 14 refs.

Francis, C.W.; White, G.H. *J Water Pollut Control Fed* v 59 n 11 Nov 1987 p 979-986.

**089797 CONFUSION AND QUESTIONS ABOUT ASH.** The Environmental Defense Fund recently alleged that most ash residues from refuse-to-energy facilities will fail the U.S. EPA test which determines whether a given substance is a hazardous waste because of its characteristics. Public supporters of this technology, local officials, and the financial community have been questioning the validity of using waste-to-energy facilities as an environmentally safe disposal option for municipal solid waste (MSW). This article presents some of the known facts concerning incinerator ash, testing methodologies, and disposal options. Subjects covered include ash residue characteristics, refuse and ash testing, disposal options, and others.

Repa, Edward (Nat'l Solid Wastes Management Assoc). *Waste Age* v 18 n 9 Sep 1987 p 89-90, 92, 183.

**089798 ABSENCE OF ASBESTOS IN MUNICIPAL SEWAGE SLUDGE ASHES.** In earlier studies, asbestos

was found in sewage sludges in several cities in the United States using x-ray diffraction, high power light optical microscopy, polarized light, microscopy or electron microscopy. In a number of cities in the United States, sewage sludge is incinerated at temperatures up to 1000°C. Temperatures of 550°C or higher dehydroxylate the asbestos lattice resulting in alteration or even destruction of the mineral (EPA 1982). Since refractive index and other key parameters used to identify asbestos minerals change above 550°C it was of interest to analyze for the presence of asbestos in typically produced municipal sludge ashes. In the work reported here, sewage sludge ashes from 10 American cities were obtained and analyzed for the presence of asbestos. 5 refs.

Patel-Mandlik, Kusum J. (Environmental Science & Engineering Inc, Gainesville, FL, USA); Manos, Charles G.; Lisk, Donald J. *Bull Environ Contam Toxicol* v 40 n 5 May 1988 p 703-706.

**REGIONAL PLANNING** See Also EARTHQUAKES—Legislation; HOUSING; HYDROELECTRIC POWER PLANTS; REFUSE DISPOSAL—Recycling; REFUSE INCINERATORS—Waste Heat Utilization; SEWAGE TREATMENT—Lagoons; WATER RESOURCES—Management.

**089799 OPTIMIZED GRAVITY MODELS FOR COMMODITY TRANSPORTATION.** This study is based on a comprehensive commodity flow survey done in Alberta in 1977, which covered the full range of commodity flows by different modes of transportation. The survey data is grouped into specific commodity categories and a set of O-D tables has been developed. The O-D tables are the basis for the development of gravity models for commodity flows. A set of gravity models, one of each commodity category, has been developed to represent the commodity flows on a province-wide basis. The gravity model for each category has been calibrated by an optimization technique that uses a power function and regression analysis. The calibrated gravity model is termed the 'optimized gravity model' to indicate the new technique of calibration. The developed models are acceptable as shown by statistical measures and commodity haul frequency diagrams. (Author abstract) 8 refs.

Ashtakala, B. (Concordia Univ, Montreal, Que, Can); Narasimha Murthy, A.S. *J Transp Eng* v 114 n 4 Jul 1988 p 393-408.

**089800 TRANSPORTATION ELEMENTS OF ENVIRONMENTAL IMPACT ASSESSMENTS AND REPORTS.** During 1986 ITE sponsored five seminars in various parts of the United States on the subject of Site Impact Traffic Evaluation (SITE). In conjunction with these seminars, local instructors conducted a survey of the cities and counties in each region where a seminar was conducted, and in selected other cities. ITE Committee 6Y-36 was requested to summarize the results of this survey to serve as a reference for those who are involved in creating or updating requirements for impact studies. The summary is presented. The survey addressed seven issues: The existence of guideline documentation; The enforcement of study requirements; When a study is required; The definition of scope of the study; Trip generation methodology requirements; Trip distribution and assignment technique required and Capacity analysis methodology and criteria. 1 ref.

Anon (Inst of Transportation Engineers, Washington, DC, USA). *ITE J* v 58 n 6 Jun 1988 p 69-75.

## Communication Systems

**089801 SPATIAL DISTRIBUTION OF TELEMATICS: MODELING AND EMPIRICAL EVIDENCE.** In this paper we deal with the spatial distribution of telematics (a conflation of telecommunication and informatics) and the regional characteristics influencing it. We are interested in this topic because basically telematics could essentially alter the regional structure. Therefore, in the first section we construe a simple cost-minimizing model in order to derive factors impacting on the telematics endowment of a region. In the next section the hypotheses derived from this model are completed by



sociological determinants of the regional telematics equipment. In the second part of the paper we test our hypothesis with the aid of an economic study and of a questionnaire study. The sample is confined to two telematic tools, namely telefax and teletex, and geographically to the German state of Bavaria. (Edited author abstract) 22 refs.

Genosko, Joachim (Univ of Regensburg, West Ger). *Technol Forecast Soc Change* v 32 n 3 Nov 1987 p 281-293.

## Computer Applications

**089802 TRACKING LAND SUPPLY FOR GROWTH MANAGEMENT.** Accurate land supply information often is the missing link in growth management programs. Properly designed computerized land record systems can perform a vital role by continuously tracking the changing attributes of vacant land supply. With this form of decision support, growth policies need not contribute to land and housing price inflation through overconstraining land supply. A national study of land supply monitoring systems documents their current status and emerging potential, and offers guidelines on overcoming both technical and institutional pitfalls involved in the initiation and use of such systems. (Author abstract) 33 refs.

Bollens, Scott A. (Univ of North Carolina, Chapel Hill, NC, USA); Godschalk, David R. *J Am Plann Assoc* v 53 n 3 Summer 1987 p 315-327.

**089803 FORECASTING ON THE PC: A PLANNER'S GUIDE TO TIME SERIES PACKAGES.** This article reviews three types of microcomputer time series packages: general-purpose statistical packages with time series modules, business forecasting packages, and econometric packages. First author describes alternative approaches to generating forecasts. Next he evaluates 15 packages in terms of ease-of-use, computational abilities, model diagnostics, and quality of graphics, highlighting the strengths and weaknesses of each package. The review concludes with recommendations on those packages that are best suited for specific planning applications. (Author abstract) 1 ref.

Cervero, Robert (Univ of California, Berkeley, CA, USA). *J Am Plann Assoc* v 53 n 4 Autumn 1987 p 510-520.

**089804 L'INFORMATIQUE AU SERVICE DE L'AMENAGEMENT REGIONAL ET LOCAL.** [Data Processing in the Service of Regional and Local Development]. The Urban development Institute of the Ile de France region of France (IAURIF) has implemented many data processing systems: data banks videotex services, software, etc. the article describes the contents of these different systems and the way they are used. In general, what is involved is urban data: bibliographies, environment, regional organization, mapping, soil use, plans, statistics, demography, community management, and so on. (Author abstract) In French.

Pommellet, P. (IAURIF, Fr). *Travaux* n 625 Oct 1987 p 1-9.

**Ecology** See WATER RESOURCES—Management.

**Economics** See HOUSING—Developing Countries; SEWERS—Planning.

**Education** See Also ENGINEERING EDUCATION.

**089805 EDUCATION FOR INTERNATIONAL DEVELOPMENT PLANNING: AN APPROPRIATE MISSION FOR WESTERN UNIVERSITIES?** There have been dramatic increases in the numbers of students from developing nations in planning and architectural programs in American universities. This trend raises serious questions about the appropriateness of such programs to the professional capabilities required for practice in developing countries. The ideal nature of academic programs designed to meet these needs is discussed in relation to existing programs both in 'the west' and in

developing nations. An experimental program at the University of Cincinnati is described as one potential solution to the problem. (Author abstract)

Noe, Samuel V. (Univ of Cincinnati, Cincinnati, OH, USA). *Int J Hous Soc Appl* v 11 n 4 1987 p 277-292.

## Energy Utilization

**089806 ANALYSE DES ENERGIE- UND LEISTUNGSBEDARFS LAENDLICHER SIEDLUNGEN UND MOEGELICHKEITEN DER RATIONELLEN BEDARFSDECKUNG.** [Analysis of the Energy and Power Demand in Rural Areas and Ways to Efficiently Satisfy This Demand]. The elaboration of concepts for the future integrated energy supply to rural settlements is still in its initial stages. This paper analyzes the state and development of rural settlement and production structures and makes an attempt to determine qualitatively and quantitatively the present and future specific power and energy demand. The possibilities of utilization of the renewable and environmental energy resources are evaluated. (Translated author abstract) In German. 11 refs.

Kraft, Guenther (Technische Univ Dresden, East Ger). *Energietechnik* v 37 n 7 Jul 1987 p 260-263.

**Environmental Impact** See HIGHWAY SYSTEMS—Planning.

## France

**089807 L'ELABORATION DU NOUVEAU SCHEMA DIRECTEUR ROUTIER NATIONAL.** [Working Out the New National Master Plan]. The author first defines the overall legislative framework of an extensive yet limited master plan for infrastructures. The new highway master plan falls within the definition. He then looks into the criteria applied not only to the decision to set up the plan, but also to its features: criteria relative to users, value for town and country planning and for regional development. Particular importance is given to the financial aspects of the plan. (Author abstract) In French.

Blanchard, J. *Travaux* n 627 Dec 1987 p 4-7.

**Human Factors** See ROADS AND STREETS—Rural.

**Illinois** See ENERGY UTILIZATION—Mathematical Models.

**India** See ROADS AND STREETS—Environmental Impact.

**Indiana** See WATER RESOURCES—Management.

## Land Reclamation

**089808 PLANNING EGYPTIAN VILLAGES IN NEW RECLAIMED AREAS WITH REGARD TO ACCOMMODATION OF BIOGAS TECHNOLOGY.** Biogas technology (BGT) can be one of the appropriate technologies in the context of the development of desert areas. A viable model is proposed for application of BGT in the new desert community areas. The model involves a novel architectural design and house planning to optimize the role of BGT as attached to the whole community and the exploitation of its energy, fertilizer and sanitation. (Author abstract). 2 Refs.

Hamad, M.A. (Nat'l Research Cent, Cairo, Egypt); El-Gammal, M.A.; Mitry, N.R.; El-Halwagi, M.M. *J Inst Eng India Part IDP* v 68 n 3 Jun 1988 p 48-52.

**Land Use** See Also AERIAL PHOTOGRAPHY; AQUACULTURE; HIGHWAY SYSTEMS—Planning; INFORMATION RETRIEVAL SYSTEMS—Applications; LAND RECLAMATION—Revegetation; MAPS AND MAPPING; RADIOACTIVE WASTES—Storage; REMOTE SENSING—Agricultural Applications; SOILS—Productivity; SURVEYING; TRAFFIC SURVEYS; URBAN PLANNING—Phoenix, Arizona; URBAN PLANNING—Zoning; WATER POLLUTION—Analysis; WATER RESOURCES.

**089809 MULTIPURPOSE LAND INFORMATION SYSTEMS: TECHNICAL, ECONOMIC, AND INSTI-**

**TUTIONAL ISSUES.** Advances in computer, surveying, and mapping technology have had a marked impact on the economic barriers to multipurpose land information systems. This has opened the way for institutional innovations that may help to achieve the data sharing and spatial registration objectives identified in the 1980 National Research Council report on multipurpose cadastre. This paper explores the application of geographic information systems technology to build multipurpose land information systems as a means of dealing with the land records modernization problem. (Author abstract) Refs.

Ducker, Kenneth J. (Portland State Univ, Portland, OR, USA). *Photogramm Eng Remote Sens* v 53 n 10 Oct 1987 p 1361-1365.

**089810 RESULTS OF THE DANE COUNTY LAND RECORDS PROJECT.** This paper presents the results of the Dane County Land Records Project, a four-year research venture involving numerous local, state, and federal agency cooperators. The project has developed, tested, and evaluated a concept for a multipurpose land information system. Components of this concept have included reliance on individual data layers maintained by legislatively mandated agencies and a common mathematical reference system to permit integration of the layers. The project investigated means to improve data input efficiency through scanners, satellite geopositioning, and remote sensing imagery. The project also investigated means to improve interdisciplinary and interagency efforts, using cooperative agreements, weekly project meetings, and user training. (Edited author abstract) Refs.

Niemann, Bernard J. Jr. (Univ of Wisconsin-Madison, Madison, WI, USA); Sullivan, Jerome G.; Ventura, Stephen J.; Chrisman, Nicholas R.; Vonderohe, Alan P.; Mezera, David F.; Moyer, D. David. *Photogramm Eng Remote Sens* v 53 n 10 Oct 1987 p 1371-1378.

**089811 URBANIZATION AND LANDSAT MSS ALBEDO CHANGE IN THE WINDSOR-QUEBEC CORRIDOR SINCE 1972.** Quantitative determination of anthropogenic land use change from space observations has been carried out by comparing urban area expansion in the Montreal, Ottawa and Quebec regions, three representative centres of the economic heartland of the Windsor-Quebec corridor in eastern Canada. Land use monitoring using Landsat satellite data shows a marked process of utilization since 1972 (Montreal: + 70 per cent, Quebec: + 40 per cent and Ottawa: + 11 per cent). The total amount of rural and forest land converted to urban use is estimated. The induced mean ground Multispectral Scanner (MSS) albedo decrease, computed from the corrected satellite reflectance, is in the order of -0.001 to -0.005. This impact of urbanization is inferred to be similar over south-eastern Canada, using statistical data from governmental agencies. This change could be large enough to affect the regional climate since trends of past urban growth rates and extrapolation of the present rate to the end of the century are significant. (Author abstract) 30 refs.

Royer, Alain (Univ de Sherbrooke, Sherbrooke, Que, Can); Charbonneau, Lise; Bonn, Ferdinand. *Int J Remote Sens* v 9 n 3 Mar 1988 p 555-566.

**089812 LINEAR VILLAGES COULD REVIVE THE RAILWAYS.** With the relaxation of planning regulations, and a new emphasis on alternative uses for redundant agricultural land, local authorities will be under pressure to develop new criteria for allowing developments to take place. This can be done, during the necessary re-drawing of strategic planning maps, by using rural railway lines, which in some cases are suffering a decline, as a focus for the development of linear villages where no one lives more than 10 minute walk from the station, and enabling these lines to play a fuller part in providing rural public transport.

Harris, Peter. *Surveyor (Sutton Engl)* v 168 n 4967 Oct 22 1987 p 16-19.



Legislation See ROADS AND STREETS—Design.

## Public Policy

**089813 COMMUNITY ENERGY PLANNING: WINDS OF CHANGE FROM THE SAN GORGONIO PASS.** The electric power industry is changing in significant ways, but local planners have not yet clearly articulated their role in guiding the changes. This article seeks to clarify that role by reporting and interpreting what happened in Palm Springs, California, when local planners confronted intense pressure to help foster development of wind energy. Instead of guiding the change local planners impeded development. They were locked in to traditional ways of thinking and responding to the situation, which precluded them from exploring innovative alternatives. (Author abstract) 41 refs.

Throgmorton, James A. (Argonne Natl Lab). *J Am Plann Assoc* v 53 n 3 Summer 1987 p 358-367.

Recreational Facilities See Also HIGHWAY SYSTEMS—Construction.

**089814 FADD-DOMBORI UDOLTERULET. [Report-Area of Fadd-Dombori].** Between the village of Gerjen and the outlet of the Sio River two dead-channels are found on the right bank of the Danube River. They are the dead-channels of Fadd and of Tolna. The hydrographical and hydrometeorological features of the area are favourable for recreation. Especially, at the dead-channel of Fadd-with a water surface of 1 to 8 km<sup>2</sup>, and with a storage capacity of 6.6 million m<sup>3</sup> at the highest permitted water level-where a considerable vacationing area came recently into being suitable for a simultaneous recreation of several thousand people. The water supply of the area is satisfactory but canalization does not exist. The water regime of the dead-channel of Fadd is determined primarily by the position of the groundwater table, and secondly by the amount of precipitation. In the water stage time-series of the dead-channel of Fadd some characteristic fluctuations could be observed. The regime is characterized by the high-waters in spring and early summer, and by lows around the end of autumn. For the improvement of the water quality in the dead-channel of Fadd total canalization and wastewater treatment would be needed beyond temporary partial solutions. (Edited author abstract) 4 refs. In Hungarian.

Bratan, Maria (Kozep-dunantuli Vizugyi Igazgatóság, Szekesfehervar, Hung). *Vizugyi Kozl* v 29 n 2 1987 p 275-285.

**089815 HARBOR REVIVED.** In Racine Wis., a harbor rehabilitation turns a defunct commercial harbor into a money making playground. Every year, 85 different ethnic groups hold their own festivals in Racine. A site on the southwestern shore of the harbor was selected and the festival park planning began. With plans for the shoreline development underway, the redevelopment plan was soon expanded to include the harbor water itself. With the decision to turn the harbor into a recreational boaters' sanctuary, Warzyn Engineering Inc., Madison, Wis. was brought in to plan a 900-1,000 slip, full-service marina and conduct the hydrographic, topographic and geotechnical surveys necessary for the planning process.

Ryan, Larry W. *Civ Eng (New York)* v 57 n 9 Sep 1987 p 44-46.

**089816 OCCURRENCE OF ROTAVIRUSES AND ENTEROVIRUSES IN RECREATIONAL WATERS OF OAK CREEK, ARIZONA.** Recent epidemiological studies have shown a relationship between swimming in recreational waters meeting bacteriological standards and gastroenteritis with a suggested viral etiology. No previous studies have been conducted in the United States on the occurrence of human pathogenic enteric viruses in freshwater recreational areas. The presence of enteroviruses and rotaviruses was investigated in Oak Creek, Arizona, a heavily used recreational area. Water samples were filtered through positively charged filters, eluted with beef extract, and assayed for human enteroviruses and rotaviruses. Eighteen of the 41 recreational water samples

were positive for enterovirus or rotavirus. Of these, nine samples exceeded the Arizona State recommended limit of 1 PFU 40 l<sup>-1</sup> for full body contact in effluent dominated recreational waters. Several virus positive samples met the recommended fecal coliform standards (200 CFU 100 ml<sup>-1</sup>) for recreational waters indicating the inadequacy of bacterial standards for monitoring viral water quality. (Edited author abstract) 32 refs.

Rose, Joan B. (Univ of Arizona, Tucson, AZ, USA); Mullinax, Rebecca L.; Singh, Shri N.; Yates, Marylynn V.; Gerba, Charles P. *Water Res* v 21 n 11 Nov 1987 p 1375-1381.

Research See Also ROADS AND STREETS—Rural.

**089817 PECS' CASE, HUNGARY.** The Pecs' report is a team work between a Hungarian community planning researcher and a planner. Their case study report is based on work carried out within the IRC (International Researchers Cooperation) and on a seminar on Pecs. The town of Pecs, which has a population of 174,000 is the central place of the Baranya region and constitutes an integral part of the economic structure of the region. The emphasis is laid on the connection between national policy and local development, and more on the regional than on the local level. The strength of the Pecs Report lies in its description of how conditions for planning and planning policy is stagnating. The overall pattern is the same as in countries with free-market economies, that is to say it includes the centralization of decision-making and responsibility, deregulation and democratic trends in combination with declining economic resources for local agencies. 51 refs.

Vajdovich-Visy, Elizabeth (Swedish Council for Building Research); Ormosy, Victor. *Doc Swed Counc Build Res D7* 1987 59p.

Transportation See Also HIGHWAY SYSTEMS—Developing Countries; HIGHWAY SYSTEMS—Planning; HIGHWAY SYSTEMS—Rural; TRANSPORTATION—Traffic Control.

**089818 COMPILING DESIGN STANDARDS FOR DEVELOPMENT REVIEW.** Metropolitan area transportation plans and planning processes have been in existence in most areas for well over 20 years. Many local government agencies charged with street and road planning responsibilities do not have a comprehensive set of design standards for development review. To develop a comprehensive manual of design standards, it is recommended that the following procedures be followed: 1. Review and update all existing standards. 2. Review and include or reference ordinances and codes pertaining to development. 3. Review and include state standards where appropriate or relevant. 4. Review and include standards developed and adopted by other local agencies where appropriate. 5. Review nationally recognized publications from the American Association of State Highway and Transportation Officials, the Institute of Transportation Engineers, the Federal Highway Administration, and others. Proposed standards should conform with nationally accepted standards.

Stewart, Bret; Lalani, Nazir. *ITE J* v 58 n 1 Jan 1988 p 37-39.

**089819 INTERCITY TRANSPORTATION DEVELOPMENTS IN TAIWAN, R.O.C.: AN OVERVIEW.** Over the past three decades, Taiwan, Republic of China, as a developing country, has consistently given priority to the development of its transportation system. During the 1970s, when the government implemented the highly successful Ten Major Construction Projects, one-half of the projects were directly related to transportation development. Today the Taiwanese government is proceeding on the Fourteen Important Economic Development Projects, four of which are directly related to transportation development. This article covers intercity transportation in Taiwan. In doing so, it discusses Taiwan's economic development, describes the existing transportation system, and outlines planned development.

Chang, Chia-Juch. *ITE J* v 58 n 4 Apr 1988 p 27-32.

**089820 VANCOUVER REGIONAL TRANSIT SYSTEM.** Transit services in Vancouver are provided as a partnership between the provincial government and local municipalities in the Vancouver area. BC Transit, a provincial crown corporation, is responsible for planning and funding transit services throughout British Columbia. The Vancouver network consists of diesel and trolley bus routes, the SkyTrain rail rapid transit system, and the unique SeaBus ferry service - all of which link 16 municipalities in the Vancouver area into one fully integrated transit system. This paper describes the Vancouver regional transportation network.

Glover, Bob (BC Transit, BC, Can). *ITE J* v 58 n 5 May 1988 p 19-22.

**089821 MATERIAL NEEDS.** One of the first significant trunk road schemes of the post-war period built to eliminate a nationally known bottleneck on the A30 through the region, was that of the Honiton Bypass, a trunk road scheme of the 1960s. This project was subsequently followed by further trunk road schemes and county programmes in the 1960s and 1970s, culminating in the extension of M5 westwards from Bristol to Exeter. In the 1980s a further major programme of trunk road contracts and county schemes have been completed or remain under construction. This paper identifies the scale, timing and geographical impact of the trunk road programme of the 1980s on the provision of construction materials. The paper also considers those factors that influenced ECC Quarries in their decision on how to prepare for the impending construction programme and in particular how to source the materials and service the North Devon Link 2A Contract, Tiverton to South Molton. (Edited author abstract)

Shove, G.R. *Highw Transp* v 35 n 5 May 1988 p 100-101, 103-104.

## United States

**089822 REGIONAL DEVELOPMENT, PLANNING AND HOUSING IN THE UNITED STATES: A CASE STUDY, ANDERSON TOWNSHIP, OHIO.** The terms regional development and regional planning are closely related to the strong suburban movement which is the most salient broad characteristic of housing development in the U.S. This movement, however, is the fourth major demographic phase in national growth, and has roots in the earlier three. One community, Anderson Township, is studied as a rather typical unincorporated area linked to a large city, Cincinnati. Its growth patterns, successes and failures at planning, and social and economic influences, offer insights to the dynamics of the American housing marketplace. (Author abstract)

Dorsey, Robert W. (Univ of Cincinnati, Cincinnati, OH, USA). *Int J Hous Sci Appl* v 11 n 4 1987 p 313-324.

Water Supply See Also GEOLOGY—Hydrology; WATER RESOURCES—Planning.

**089823 AUGMENTATION OF WATER SUPPLY FOR JAMNAGAR CITY.** Gujarat Water Supply and Sewerage Board (GWSSB) has been implementing water supply and sewerage projects in the Gujarat State (estimated cost, Rs. 120.62 crores). The project includes 5 urban water supply schemes, 4 sewerage schemes, 7 regional rural water supply schemes (255 villages) and 111 individual rural water supply schemes. Of the urban water supply schemes, Jamnagar Water Supply Scheme (Source: Und-Dam-I), estimated to cost Rs. 858.80 lacs will bring additional water supply of 25 mld. to the city. GWSSB is executing the project on behalf of Jamnagar Municipal Corporation (JMC).

Patel, V.R. (GWSSB, Jamnagar, India). *J Indian Water Works Assoc* v 19 n 3 Jul-Sep 1987 p 189-194.

**089824 PIPE DREAMS.** With new and improved pipes on the market and others, such as cast gray-iron, going out of style, finding the right pipe to supply city and



county residents with drinking water may become difficult and complicated. Most localities find it necessary to use a variety of water-transmission pipes for different areas due to varying soil and terrain conditions, even over a small geographic area. Different kinds of pipes include concrete-pressure, ductile-iron, PVC and welded-steel.

Darnell, Tim (American City & County, Alpharetta, GA). *Am City Cty* v 102 n 9 Sep 1987 p 56-58, 60.

**089825 BLASHFORD LAKES: SUPPLYING WATER INTO THE NEXT CENTURY.** A novel scheme by Wessex Water Authority is steadily taking shape near Ringwood in Dorset and parts of Hampshire, designed to safeguard the region's water supply into the next century. The Blashford Lakes project, which will eventually hold over 3000 megalitres of water, is made possible by an area of gravel pits just to the north of Ringwood. Gravel extraction has been taking place here since before World War II, and some pits are still being worked. As the water table is only about 2m down, gravel working below this level has resulted in the natural formation of several lakes. These lakes, plus others being created as gravel extraction continues, form the basis of an ambitious water storage and treatment complex linked to the area's distribution system, which will supply treated water as and when needed.

Buttfield, Anne. *Civ Eng (London)* Aug 1987 p 47-49.

**089826 SYNTHESSE VON FUNKTION UND GESTALTUNG: DAS WASSE WERK MOERS-GERDT.** [Synthesis Between Function and Design]. In order to secure the water supply to private households and industry in the Wesel-Krefeld-Moenchengladbach region and the adjacent territories on the left banks of the Rhine, the ground water reserves in the fields of Binsheim, Ginderich and Wardt-Moermtter will be utilised by being extended step by step. The reserves amount to approximately 140 mio m<sup>3</sup>/100 m<sup>2</sup>. The Moers-Gerdt water works built as part of the development project is an example of long-term planning and step-by-step development for drinking water supply. An expansion to six times the capacity is planned and has been taken into account during construction. The water works is an example of an excellent synthesis between operational functions with practical engineering and structural design which considers the environment and the ergonomics of the workplace. (Author abstract) 1 ref. In German.

Falcke, Klaus; Wilms, Juergen. *Beton* v 38 n 4 Apr 1988 p 129-132.

**089827 CATALYST FOR REGIONALIZATION OF RURAL WATER SYSTEMS.** A computerized hydraulic data management program (CHDMP) was developed for a case study in Nelson County, Kentucky. University professors, graduate students, and two water utilities' staffs cooperated in network analysis employing computer hardware and software. The utilities' staffs were taught the science and technology of hydraulic model preparation, simulation, and analysis for the case study distribution systems. As an integrated system, the model contained 294 pipes, 234 nodes, six pumps, and 11 tanks. Each utility's problem areas were identified and some of the individual and mutual benefits of hydraulic planning were illustrated. A dialogue resulted between the managers. (Edited author abstract). 17 Refs.

Miller, C.E. (Univ of Louisville, Louisville, KY, USA); Hamilton, L. *Water Resour Bull* v 24 n 3 Jun 1988 p 677-684.

**Zoning** See FLOOD CONTROL; FLOOD CONTROL—Costs.

**RELATIVITY** See Also ASTROPHYSICS; ELECTRODYNAMICS; ELECTROMAGNETIC WAVES—Propagation in Plasma; ELECTRON BEAMS—Mathematical Models; ELECTRON TUBES, MAGNETRON—Design; PARTICLE BEAMS—Analysis; ROCKETS AND MISSILES.

**089828 SOBRE O MOVIMENTO RELATIVISTA DE UMA BARRA INDEFORMAVEL.** [Relativistic Movement of an Underformable Bar]. A study of the

unidimensional movement of an undeformable bar (in the sense of Born) has been carried out with total generality. Derivation methods of the relativistic transformation formulas are presented, the analysis and physical interpretation being illustrated by means of a geometrical description. (Author abstract) In Portuguese. 9 refs.

Cayolla, J. (Siderurgia Nacional, Port). *Tecnica (Lisbon)* v 87 n 1 Jun 1987 p 43-49.

**Theory** See Also PHYSICS—Theory.

**089829 METHOD FOR ANALYZING COORDINATE SINGULARITIES IN THE GENERAL THEORY OF RELATIVITY.** A general method for analyzing singularities of metrics is developed. Metrics are regularized and invariant operations are calculated, which must not change with regularization. This method is inspected in relation to the Schwarzschild metric. (Author abstract) 9 refs.

Gertsenstein, M.E. (M.V. Lomonosov State Univ, Moscow, USSR); Melkumova, E.Yu. *Sov Phys J* v 30 n 3 Mar 1987 p 217-219.

**089830 INVARIANT AND CONTRACTED ACTIONS OF A PHYSICAL SYSTEM IN THE GENERAL THEORY OF RELATIVITY.** A study was made of the difference between the invariant action  $S_R$  and the contracted action  $S_G$  for the global problem: an isolated physical system as a whole. The actions are considered as functions of the upper limit; in the center-of-mass system their difference is distinct from zero (10). In an example from Newtonian mechanics this is shown to be related to the fact that the invariant Lagrangian contains second derivatives. The formulas for the energy-momentum vector as an action gradient and their quantum generalizations are valid only for the contracted action. (Author abstract) 14 refs.

Gertsenstein, M.E. (M.V. Lomonosov Moscow State Univ, USSR); Solovoi, L.G. *Sov Phys J* v 30 n 9 Sep 1987 p 786-790.

**RELAXATION PROCESSES** See Also BIOMEDICAL ENGINEERING—Laser Applications; CARBON STEEL—Strain; CELLULOSE—Low Temperature Properties; COPOLYMERS—Dielectric Properties; COPOLYMERS—Solutions; COPPER PLATINUM ALLOYS—Physical Properties; DIELECTRIC MATERIALS—Physical Properties; DYSPROSIUM COMPOUNDS—Magnetic Properties; GASES, INERT; GLASS—Acoustic Properties; GLASS—Dielectric Properties; GLASS—High Temperature Effects; GLASS—Ionic Conduction; GLASS—Low Temperature Effects; GLASS—Spectroscopic Analysis; GLASS—Spectrum Analysis; GLASS, METALLIC—Structure; HYDROGEN—Low Temperature Effects; HYDROGEN—Vibrations; INDIUM TIN ALLOYS—Aging; IONS—Hydration; IRON AND ALLOYS—Amorphous; LASERS, EXCIMER; LASERS, SEMICONDUCTOR—Modes; LATEXES—Dielectric Properties; LIQUIDS—Spectroscopic Analysis; LIQUIDS—Surface Tension; MAGNETIC MATERIALS—Antiferromagnetism; MAGNETIC MATERIALS—Thin Films; MAGNETIZATION; MAGNETS—Magnetic Properties; MECHANICS; MECHANICS—Oscillations; MIXING—Diffusion; MIXTURES—Research; NUCLEAR MAGNETIC RESONANCE; NYLON POLYMERS—Spectroscopic Analysis; PHOSPHORS—Research; PLASMAS—Collision Processes; PLASTICS FILMS—Mechanical Properties; POLYAMIDES—Dielectric Properties; POLYBUTADIENES—Stresses; POLYESTERS—Research; POLYETHYLENE TEREPHTHALATE—Aging; POLYETHYLENE TEREPHTHALATE—Stresses; POLYETHYLENES—Molecular Structure; POLYMERS—Amorphous; POLYMERS—Analysis; POLYMERS—Mechanical Properties; POLYMERS—Melting; POLYMERS—Research; POLYMERS—Solutions; POLYMERS—Spectroscopic Analysis; POLYMERS—Structure; POLYMERS—Surfaces; POLYMERS—Viscoelasticity; POLYMETHYL METHACRYLATE—Molecular Weight; POLYMETHYL METHACRYLATE—Specific Heat; POLYSTYRENES—Molecular Weight; POLYSTYRENES—Solutions; PROTEINS—Spectroscopic Analysis; QUARTZ—Physical Properties; RUBBER, SYNTHETIC—Stresses; RUBIDIUM COMPOUNDS—Impurities; SEMICONDUCTING ALUMINUM COMPOUNDS—Electronic Properties; SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers; SEMICONDUCTING GALLIUM ARSENIDE—Optical Properties; SEMICONDUCTING GLASS—Dielectric Properties; SEMICONDUCTING ZINC COMPOUNDS—Photoconductivity; SEMICONDUCTOR MATERIALS—Charge Carriers; SEMICONDUCTOR MATERIALS—Plasma; SILICON TIN ALLOYS—Amorphous; SOLIDS—Order-Disorder; SOLIDS—Transport Properties; STRESSES; SUPERCONDUCTING MATERIALS; SUPER-

CONDUCTING MATERIALS—Thin Films; TEXTILE FIBERS—Heat Treatment; THERMOPLASTICS—Electric Properties; VISCOELASTICITY—Theory; ZIRCONIUM AND ALLOYS—Mechanical Properties; ZIRCONIUM COPPER ALLOYS—Amorphous.

**089831 RELAXATION OF METASTABLE ATOMS IN THE INTERPULSE PERIOD IN A REPETITIVE PULSE LASER ON SELF-LIMITED TRANSITIONS.** The effect of the parameters of the probing radiation on resonance-adsorption measurements of the concentrations of metastable atoms in lasers based on self-limited transitions is analyzed. It is established that the effect of transillumination of the medium by the probing radiation on the measurements can be reduced substantially by reducing time pulse duration of the sounding radiation. Analysis of the relaxation of the plasma parameters in the interpulse period in a bismuth-vapor laser established that in pulsed lasers based on self-limited transitions the behavior of the concentration of metastable atoms as a function of time is determined not only by the relaxation of the electron temperature, but also by the restoration of the concentration of atoms in the ground state. (Author abstract) 12 refs.

Klimovskii, I.I. (Acad of Sciences of the USSR, USSR); Selezneva, L.A. *High Temp* v 25 n 4 Jul-Aug 1987 p 592-596.

**Analysis** See Also SOLIDS—Stresses.

**089832 ANALYTICAL TREATMENT OF RELAXATION PROCESSES IN FREE JETS.** There are a number of important advantages in using free jets, compared to other experimental methods in physical kinetics among them the possibility of realizing the simplest one-dimensional radial steady flow; the self-modeling nature of the structure of the jet and the distribution of parameters in it; and the possibility of controlling the rates of relaxation processes. The author develops an analytical method of solving a system of relaxation equations of the detailed balance type, describing, for an appropriate choice of rate constants, rotational and vibrational relaxation, and also nonequilibrium condensation (the quasicheical model). After transforming from the population densities to smoother functions, and after a nonlinear change of variables, the system reduces to a form which is much easier to solve (both analytically and numerically). It is shown that for isentropic flow, there are several zones along the axis of the jet having different relaxation mechanisms. An iterative method of solving the system of relaxation equations is described. The method uses an optimum choice of the zeroth approximation in each of the zones. 15 refs.

Strel'chenya, V.M. *J Appl Mech Tech Phys* v 28 n 2 Mar-Apr 1987 p 194-199.

**Calculations** See LIQUIDS—Viscosity; METALS AND ALLOYS—Physical Properties.

**Computer Simulation** See POLYMERS—Research.

**Low Temperature Effects** See GLASS—Physical Properties.

**Mathematical Models** See POLYSTYRENES—Physical Properties; SOLIDS—Ionic Conduction.

**Measurements** See LASERS, GAS—Research; NICKEL AND ALLOYS—Stresses; POLYETHERS—Phase Transitions; SOLIDS—Spectroscopic Analysis.

**Research** See COBALT AND ALLOYS—Stresses; FERROMAGNETIC METALS—Amorphous; GLASS—Measurements; GLASS—Research; ZINC COMPOUNDS—Molten.

**Theory** See Also GLASS—Phase Transitions.

**089833 THEORY OF DIFFUSIONAL RELAXATION OF THE COMPOSITION IN POLYDISPERSE POLYMER MELTS.** A general method is proposed helping to take into account the influence of polydispersity on relaxation processes in polymer melts. The relaxation of composition is considered in the melt of



two polymers far from the spinodal. Polydispersity leads to the appearance of a second relaxation time  $t_2$  considerably longer than the relaxation time  $t_1$  in a monodisperse system. For  $t \approx t_1$  relaxation of composition occurs by an exponential law, in the interval  $t_1 < t < t_2$  relaxation is of a power character again giving way to an exponential one at  $t \approx t_2$ . (Edited author abstract) 10 refs.

Semenov, A.N. (Lomonosov State Univ, Moscow, USSR); Yerukhimovich, I.Ya. *Polym Sci USSR* v 28 n 10 1986 p 2253-2260.

**RELAY PROTECTION** See Also ELECTRIC INSTRUMENT TRANSFORMERS—Transients; ELECTRIC MOTORS—Overcurrent Protection; ELECTRIC MOTORS—Protection; ELECTRIC POWER SYSTEMS—Protection; ELECTRIC RELAYS—Computer Applications.

**089834 CHARACTERISTICS OF CURRENTS APPLIED TO MEASUREMENT ELEMENTS OF ZERO-SEQUENCE PROTECTION APPARATUS.** Higher harmonic components and aperiodic components of zero-sequence current are investigated. The sinusoidal component of forced frequency is taken as the working signal. The relative value of noise is determined, together with the duration of noise existence and the coefficient of desensitization of current measurement elements with respect to short-circuit transient currents. (Author abstract) 7 refs.

Podgornyi, E.V.; Rybalkin, A.D.; Nudel'man, G.S. *Sov Electr Eng* v 58 n 5 1987 p 78-84.

**089835 PROTECTIVE RELAYS.** The successful operation of a medium-voltage distribution system depends on the proper selection and setting of the switchgear relays. The author discusses electromechanical relays, solid-state relays, overcurrent relays, setting the pickup point and time dial, and relay operation and construction.

Freund, Arthur (Electrical Construction & Maintenance, New York, NY, USA). *ECM Electr Constr Maint* v 86 n 1 Jan 1987 p 79-85, 134.

**089836 39TH ANNUAL CONFERENCE FOR PROTECTIVE RELAY ENGINEERS.** Proceedings incorporate fourteen papers that emphasize the use of relay protection techniques in electric power systems. Topics considered include: cogeneration plants, power distribution systems, power transmission lines, substations, over-voltage protection, lightning arrestors, protection of electric motors and turbomachinery, rotors, boilers, coal-fired plants, steam generators, waste heat utilization, uses of fiber optic communication and telecommunication equipment in the operation of power plants, nuclear power plants, use of computer hardware and software, automatic testing, fault locating relays, and computerized data retrieval from a central computer. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10717 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *Annu Conf Prot Relay Eng* 39th, College Station, TX, USA, Apr 14-16 1986 var pagings.

## Computer Aided Analysis

**089837 HADAMARD FILTERING TECHNIQUE APPLIED TO DIGITAL DISTANCE RELAYING.** This paper reports a high speed digital distance protection algorithm based on modified Hadamard filtering technique. The values of R and X of a transmission line were computed for S-L-G fault using simulated fault data. Off line digital computer results show fast operating speed, good accuracy and fast convergence of the computed values of R and X as compared to ordinary Hadamard filtering and rectangular transform technique. Because of low computer burden microprocessor implementation of the scheme may be easily achieved. (Author abstract). 6 Refs.

Ghoshal, S.P. (Regional Engineering Coll, Durgapur, India); Basu, S.K.; Choudhury, S. *J Inst Eng India Part EL* v 68 n 6 Jun 1988 p 237-245.

**Computer Aided Design** See ELECTRIC POWER TRANSMISSION—Protection.

**Computer Applications** See Also ELECTRIC POWER SYSTEMS—Relay Protection.

**089838 MICROPROCESSOR-BASED OVERFLUXING RELAY FOR A GENERATOR TRANSFORMER.** This paper describes a microprocessor-based overfluxing relay meant to protect a generator transformer under over-excitation conditions. The relay continuously monitors the system voltage and frequency and takes alarm and trip decisions on the basis of transformer iron losses computed by the microprocessor. An alarm signal is given when the total iron loss exceeds a predetermined threshold value continually for half a second and a trip signal is issued if the condition continues for 5-99 s (adjustable). The operating value of iron loss is adjustable over the range of 1.1 to 1.5 times the iron loss at rated voltage and rated frequency. A relay prototype based on an 8-bit microprocessor 8085 A has been tested successfully in the laboratory. (Author abstract) 5 refs.

Verma, H.K. (Univ of Roorkee, Roorkee, India); Basha, A.M. *J Microcomput Appl* v 10 n 3 Jul 1987 p 229-236.

**089839 FAST (1-SHIFT) ORTHOGONAL FUNCTIONS FOR EXTRACTION OF THE FUNDAMENTAL FREQUENCY COMPONENT FOR COMPUTER RELAYING.** For high speed impedance relaying, differential relaying and many other relaying functions employing a digital computer, it is necessary to extract the fundamental frequency component from a highly distorted post-fault relaying voltage or current. For this, the known methods employ either Fourier, Walsh or Harr algorithms. This paper describes a new set of odd/even orthogonal functions and compares its performance with other methods with respect to computational speed and frequency response. High computational speed is achieved by employing predetermined right-shift operations and avoiding any direct multiplications. (Author abstract) 3 refs.

Paithankar, Y.G. (V. Regional Coll of Engineering, Nagpur, India). *Electr Power Syst Res* v 14 n 3 Jun 1988 p 233-236.

**089840 APPLICATION OF BLOCK PULSE FUNCTIONS FOR SIGNAL RECOGNITION IN POWER SYSTEM RELAYS.** An algorithm based on block pulse functions was developed for fundamental-frequency-component calculation in power-system relaying signals. The proposed algorithm is computationally simple and can be used with any sampling frequency. The algorithm is better suited for microprocessor-based power-system protective relays. 6 refs.

Kolla, S.R. (Univ of Toledo, OH, USA). *Proc IEEE* v 75 n 12 Dec 1987 p 1695-1696.

**089841 CAPE SYSTEM: COMPUTER-AIDED PROTECTION ENGINEERING.** The authors describe a Computer-Aided Protection Engineering (CAPE) System that has been designed and partially implemented as a productivity aid for protection or relay engineers. The CAPE System integrates interactive short-circuit studies, relay setting calculations, the coordination of protective zones, and the calculation of transmission line parameters into a process that is uniform and effective. A description is given of the modules of which the system is composed, the CAPE database manager, and the engineering workstation.

Cauthen, Robert H. (Georgia Power Co, Atlanta, GA, USA); McCannon, Walter P. *IEEE Comput Appl Power* v 1 n 2 Apr 1988 p 30-34.

## Computer Interfaces

**089842 STUDIES OF DISTANCE PROTECTION WITH A MICROPROCESSOR FOR SHORT TRANSMISSION LINES.** A type of zero-sequence-reactance relay suited to short transmission lines with a microprocessor is introduced. It has greater fault tolerance and is less sensitive to the load current,

especially in midsubstation. A new derivative-Fourier filter has been developed that can eliminate the influence of higher harmonics and restrain the damped DC component in the power system. Based on the analysis and calculation, a fault-detection scheme that operates correctly when a power swing follows a fault is presented. Power-swing blocking and fault-phase selection are discussed, and a complete, microprocessor-based protection system is discussed. 6 refs.

Zhen, Li (China Electric Network, Wuhan, China); Zhang, Zhi-Jing. *IEEE Trans Power Syst* v 3 n 1 Feb 1988, IEEE Power Ind Comput Appl Conf, Montreal, Que, Can, May 18-21 1987 p 330-336.

## Equipment

**089843 SYNTHESIS OF MEASURING DEVICES FOR RELAY PROTECTION AS A GRADIENT SELF-ADJUSTING SYSTEM.** Transmission line distance-type measuring devices with acceptable characteristics can be based quite simply on dynamic object identification theory. The advantages of dynamic monitoring insuring a fast response have been confirmed experimentally. (Edited author abstract). 9 refs.

Bachmann, U.; Vanin, V.K.; Ginovker, A.M.; Pavlov, G.M.; Pechkovskii, A.V. *Electr Technol USSR* n 2 1987 p 1-14.

## Monitoring

**089844 SOURCES OF STIMULUS SIGNALS FOR AUTOMATIC MONITORING SYSTEMS OF ELECTRICAL RELAY-PROTECTION APPARATUS.** The production of solid-state relay protection apparatus (RPA) makes problems associated with automation of technical monitoring and diagnostics in the production process particularly acute. It is especially important to employ automated monitoring and diagnostics systems (AMDS) in production of solid-state RPA for 6-10-kV distribution networks. Design principles are considered for sources of stimulus signals for automatic system intended for technical monitoring of relay-protection apparatus. 5 refs.

Borisov, V.A.; Grigor'ev, V.G.; Yariz, N.A. *Sov Electr Eng* v 58 n 5 1987 p 73-77.

**RELIABILITY** See Also AIR—Fractionation; AIRCRAFT—Safety Factor; AIRCRAFT, MILITARY—Maintenance; BEARINGS—Antifriction; COAL MINES AND MINING—Underground Transportation; COMPUTER AIDED DESIGN—Military Applications; COMPUTER AIDED ENGINEERING; COMPUTER NETWORKS—Local Networks; COMPUTER SOFTWARE—Failure; COMPUTER SYSTEMS, DIGITAL—Analysis; COMPUTER SYSTEMS, DIGITAL—Fault Tolerant Capability; COMPUTER SYSTEMS, DIGITAL—Multiprocessing; CONSUMER PRODUCTS—Testing; CONTROL SYSTEMS, DISTRIBUTED PARAMETER—Controllability; DIESEL ENGINES—Design; DIESEL ENGINES—Fatigue; DIESEL ENGINES—Supercharging; ELECTRIC CIRCUIT BREAKERS—Maintenance; ELECTRIC LINES—Aerial Conductors; ELECTRIC NETWORKS; ELECTRONIC EQUIPMENT—Computer Aided Engineering; ENVIRONMENTAL ENGINEERING; FAILURE ANALYSIS; FAILURE ANALYSIS—Mathematical Models; GAS TURBINES—Performance; HYDRAULIC STRUCTURES—Design; HYDROELECTRIC POWER PLANTS—Planning; INTEGRATED CIRCUIT MANUFACTURE—Failure; LAMINATED PRODUCTS—Design; MATERIALS SCIENCE; MATHEMATICAL STATISTICS; MATHEMATICAL STATISTICS—Monte Carlo Methods; NUCLEAR POWER PLANTS—Maintenance; OIL WELL PRODUCTION—Sub-sea Production System; PRINTED CIRCUITS—Computer Aided Design; PROBABILITY; PROBABILITY—Random Number Generation; PRODUCTION ENGINEERING; PRODUCTION ENGINEERING—Quality Assurance; PUMPS—Earthquake Resistance; QUALITY ASSURANCE—Computer Applications; QUALITY CONTROL; RISK STUDIES; SIGNAL PROCESSING—Synchronization; STEAM TURBINES—Heat Exchangers; STRUCTURAL ANALYSIS; STRUCTURAL DESIGN; STRUCTURAL DESIGN—Loads; STRUCTURAL DESIGN—Optimization; STRUCTURAL DESIGN—Safety Factor; SYSTEMS ANALYSIS; SYSTEMS ENGINEERING; SYSTEMS SCIENCE AND CYBERNETICS; SYSTEMS SCIENCE AND CYBERNETICS—Man Machine Systems; VACUUM PUMPS—Electric Drive.



**089845 DEVELOPMENT OF THE DYNAMIC FAULT TREE USING MARKOVIAN PROCESS AND SUPERCOMPONENT.** In the Markovian approach for fault tree, the concept of the supercomponent is introduced in order to reduce the number of system states and the size of the transition matrix. Now, a number of basic events are considered to be one component in the Markovian process. Using the proposed dynamic fault tree analysis, a sample calculation is performed. As a result, the unavailability is much less than the value for the static fault tree analysis. Namely, the conservatism of the current analysis is excluded in this paper. The dynamic behavior of each system state and of the overall system is well analyzed. The interactions between the supercomponent tested and the supercomponent not tested are dynamically analyzed, too. (Edited author abstract) 13 refs.

Kwang Sub, Jeong (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Soon Heung, Chang; Tai Woon, Kim. *Reliab Eng* v 19 n 2 1987 p 137-160.

**089846 LIFETIME-COST RATIO ANALYSIS FOR DETERMINING OPTIMAL COMPLETE REPAIR STRATEGY.** This paper considers the finding of an optimal complete repair strategy for a 3 state system with Markovian deterioration. The approach followed here is based upon optimizing a function of both a reliability index for the system, which is chosen here as the expected systems lifetime, and the cost of achieving this reliability index. (Author abstract) 10 refs.

Alidrisi, Mustafa M. (King Abdul Aziz Univ, Jeddah, Saudi Arabia). *Microelectron Reliab* v 27 n 4 1987 p 647-648.

**089847 ON COMPUTING THE REPAIR COST OF A MAINTAINED RELIABILITY SYSTEM WITH KNOWN REPAIR COST FUNCTION AND PROBABILITY OF REPAIR.** In this paper, a simplified analytic cost model for maintained reliability system under opportunistic repair scheme is discussed. Life cycle cost curves under various operating life cycle times and linear repair cost function are derived. (Author abstract) 6 refs.

Ntuen, Celestine A. (North Carolina A&T State Univ, Greensboro, NC, USA). *Microelectron Reliab* v 27 n 4 1987 p 737-740.

**089848 STATE OF RELIABILITY DESIGN SPECIFICATIONS IN CANADIAN INDUSTRIES: A SURVEY.** This paper presents the findings of a recent survey conducted on 'reliability design specifications in Canadian manufacturing and service industries'. The survey is based upon a questionnaire mailed to various manufacturing and service industries in Canada. The questionnaire covered different aspects of organizational structure, reasons for emphasis on reliability and maintainability, areas of reliability engineering requiring improvement, most important parameters in equipment reliability specification, measures to improve system/equipment reliability, use of international or U.S. Military standards (reliability) in design specifications, reliability techniques and parameters specified when procuring an item, etc. (Edited author abstract)

Dhillon, Balbir S. (Univ of Ottawa, Ottawa, Ont, Can); Rayapati, Subramanyam N. *Microelectron Reliab* v 27 n 4 1987 p 755-779.

**089849 FUNKTIONELLE DARSTELLUNG DER ZUVERLÄSSIGKEITSTHEORETISCHEN STRUKTURTECHNISCHER SYSTEME DURCH ORTHOGONALFORMEN IHRER STRUKTURFUNKTION.** [Functional Representation of the Reliability Structure of Technical Systems by Orthogonal Forms of their Structural Function]. The reliability structure function of a technical system is given in the disjunctive normal form based on the minimal path set. The problem treated consists in transforming this representation of the structural function into a logically equivalent disjunctive normal form with orthogonal summands. An efficient numerical algorithm is developed whose aim is to determine orthogonal forms as short as possible. (Author

abstract) In German.

Beichelt, F.; Spross, L. *MSR Mes Steuern Regeln* v 30 n 11 1987 p 496-499.

**089850 REDUNDANT CONSECUTIVE-k SYSTEMS.** Redundancy has long been used in system design to boost reliability. We introduce redundancy into the consecutive-k (-out-of-n) systems which have recently been widely studied. We study three problems: (i) compute the reliabilities for such systems, (ii) assign components with various working probabilities to a given system to maximize its reliability, (iii) select a system under hardware constraints to maximize the reliability (Edited author abstract) 15 refs.

Hwang, F.K. (AT&T Murray Hill, NJ, USA); Shi Dinghua. *Oper Res Lett* v 6 n 6 Dec 1987 p 293-296.

**089851 IN-SERVICE RELIABILITY ESTIMATES FROM MAINTENANCE DATA.** One of the major problems in reliability engineering is the accurate feedback of reliability data when equipment has entered service. This paper describes one such case where an equipment user is interested in the reliability of equipment in service but has only limited resources to feedback reliability data. This paper describes the available raw data provided from a reporting system which records maintenance actions on each in-service equipment for work loading and spares planning purposes. The method developed to analyze this data to provide reliability estimates is discussed together with a validation exercise. Wider application of the method is considered feasible where data recording is similar to that considered in this paper. (Author abstract) 1 ref.

English, Colin (Rex, Thompson & Partners, Farnham, Engl). *Reliab Eng Syst Saf* v 21 n 3 1988 p 163-173.

**089852 INTERVAL UNEFFECTIVENESS DISTRIBUTION FOR A k-OUT-OF-n MULTISTATE RELIABILITY SYSTEM WITH REPAIR.** This paper deals with a parallel load-sharing reliability system with cold standby redundancy and ample repair facilities. We have n identical parallel units, of which at most k units are operating simultaneously. If less than k units are available, the system operates at a proportionally reduced level. For this system, an approximate method is given for the calculation of the probability distribution of that proportion of the system capacity that cannot be used in a given time period. The method is based on an approximation of the k-out-of-n multistate system by a two-state single component. Validation of the approximation using Monte-Carlo simulation shows satisfactory performance. (Edited author abstract). 8 Refs.

Van Der Heijden, M.C. (Vrije Univ, Amsterdam, Neth); Schornagel A. *Eur J Oper Res* v 36 n 1 Jul 1988 p 66-77.

**089853 ON CONSECUTIVE-k-OUT-OF-n: F SYSTEMS.** A brief survey of the consecutive-k-out-of-n: F system is given. Through the use of structure function and using network diagrams to represent the system, system reliability and algorithms for generating all the minimal path and cut sets are obtained. A lower bound and three upper bounds of the systems reliability are given. (Edited author abstract). 19 Refs.

Chan, Fung-Yee (Univ of Winnipeg, Winnipeg, Manit, Can); Chan, Lai K.; Lin, Gwo Dong. *Eur J Oper Res* v 36 n 2 Aug 1988 p 207-216.

**089854 ON THE FIRST FAILURE TIME OF DEPENDENT MULTICOMPONENT RELIABILITY SYSTEMS.** Multicomponent reliability systems are considered, where component failure and repair completion rates depend on the state, ages and current repair durations of the other components. This is a generalization of a model of S.M. Ross. Sufficient conditions on the sets of rates which imply stochastic ordering between first failure times of two such systems are found. Sufficient conditions on the rates which imply that the first failure time of such a system is new better than used (NBU) are given. A counterexample to an apparently stronger result of D.R. Miller is also given. (Edited author abstract). 20

refs.

Shaked, Moshe (Univ of California, CA, USA); Shanthikumar, J. George. *Math Oper Res* v 13 n 1 Feb 1988 p 50-64.

**089855 RELIABILITY '85 - PROCEEDINGS, VOLUME 1.** This conference proceedings contains 32 papers. The topics covered are: reliability management and training; mathematical modeling; reliability of electronic systems; life-cycle costing; reliability, availability, and maintainability (RAM) modeling; and reliability of software and computer systems. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10630 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (UKAEA, Natl Cent for Systems Reliability, Warrington, Engl). *Reliab '85 - Proc, Vol 1, Jul 10-12 1985* Publ by UKAEA, Warrington, Engl, 1985 var pagings.

**089856 RELIABILITY '87, PROCEEDINGS.** This conference proceedings contains 63 papers. The main topics discussed are: electronic systems; availability modeling; design and development case studies; human factors; software and computer systems; data collection and analysis; reliability, management training and costing; mathematical modeling; dependent failure analysis; probabilistic safety assessment; military systems; reliability of offshore systems. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11589 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (UKAEA, Natl Cent of Systems Reliability, Warrington, Engl). *Reliab 87, Proc, Engl, Apr 14-16 1987* Publ 1987 2v.

**089857 RELIABILITY - KEY TO INDUSTRIAL SUCCESS, PROCEEDINGS.** Proceedings incorporates 27 papers that are grouped into six sections dealing with: system reliability and maintainability; reliability program management; mechanical and electromechanical reliability; reliability estimations, predictions and modeling; reliability life testing and failure analysis; and electronic and electrical reliability. Topics considered include: finite element methods, MIL-HDBK-217, electrochemical motor protector reliability, automotive electronics, built-in tests in next generation of airborne radar, test site analysis, SLAM (scanning laser acoustic microscopy), accelerated life testing, fault tree analysis, statistical methods, reliability growth evaluation, software reliability, mechanical equipment reliability, hermetic motor reliability, reliability bath-tub curve models, quantitative design objectives, environmental stress screening (ESS) techniques, material reliability for next generation aircraft, preventive maintenance, component failure prevention, and computer-aided design. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11657 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Sundaresan, Sonny G. (Ed.) (Copeland Corp, Sidney, OH, USA); Kececioglu, Dimitri (Ed.). *Reliab - Key to Ind Success, Proc, Los Angeles, CA, USA, Mar 24-26 1987* Publ by ASM Int, Metals Park, OH, USA, 1987 206p.

**089858 ANNUAL RELIABILITY AND MAINTAINABILITY SYMPOSIUM, 1988 PROCEEDINGS.** This conference proceedings contains 80 papers. The following topics are dealt with: space systems, logistics, error-correction codes, software tools, reliability, maintainability, availability, mathematical techniques, US Air Force programs, reliability growth analysis, supportability and warranties, software reliability and maintainability, future aspects, US Army R&M programs, testability, built-in tests, management, combat resilience, CAD/CAM/CALS, military initiatives, and US Department of Defense and NATO military studies. Technical and



professional papers from this conference are indexed and abstracted with the conference code no. 11603 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEEE, Reliability Soc, New York, NY, USA). *Proc Annu Reliab Maintainability Symp* 1988, Annual Reliab and Maintain Symp, 1988 Proc, Los Angeles, CA, USA, Jan 26-28 1988. Publ by IEEE, New York, NY, USA, 1988. Available from IEEE Service Cent (cat n 88CH25510), Piscataway, NJ, USA 433p.

**Analysis** See Also BEAMS AND GIRDERS—Concrete; PROPELLERS—Fatigue; STRUCTURAL ANALYSIS; STRUCTURAL ANALYSIS—Optimization; STRUCTURAL ANALYSIS—Reliability; STRUCTURAL DESIGN; STRUCTURAL DESIGN—Optimization; WATER DISTRIBUTION SYSTEMS—Optimization; WATER POLLUTION—Monitoring.

**089859 APPROXIMATE METHODS FOR NON-LINEAR TIME-VARIANT RELIABILITY ANALYSIS.** Exact solution of reliability of structures under stochastic loadings is generally difficult. Various approximate methods have been developed based on an outcrossing rate analysis. Several first-order and second-order asymptotic methods are examined and compared in terms of the analytical and numerical efforts required as well as the accuracy of each method. Numerical examples are carried out, including one on the reliability of a structure with direction-sensitive resistance under the action of vector wind force to underscore the advantage and disadvantage of each method in practical applications. (Author abstract) 8 refs.

Wen, Y.K. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA). *J Eng Mech* v 113 n 12 Dec 1987 p 1826-1839.

**089860 ACCELERATED FAILURE TIME MODELS FOR RELIABILITY DATA ANALYSIS.** Despite the popularity of the proportional hazards model (PHM) in analyzing many kinds of reliability data, there are situations in which it is not appropriate. The accelerated failure time model (AFT) then provides an alternative. In this paper, a unified treatment of the accelerated failure time model is outlined for the standard reliability distributions (Weibull, log-normal, inverse Gaussian, gamma). The problem of choosing between the accelerated failure time models and proportional hazard models is discussed and effects of misspecification are reported. The techniques are illustrated in the analysis of data from a fatigue crack growth experiment. (Author abstract) 18 refs.

Newby, M. (Univ of Bradford, Bradford, Engl). *Reliab Eng Syst Saf* v 20 n 3 1988 p 187-197.

**089861 SWITCHING-ALGEBRAIC ANALYSIS OF CIRCULAR CONSECUTIVE-K-OUT-OF-n: F SYSTEMS.** Switching-algebraic techniques are utilized in a simple and instructive derivation of the  $O(kn)$  recursive relation for a circular consecutive-k-out-of-n:F system with non-identical components. In addition, the boundary conditions associated with this recursive relation are developed. Consequently, an exact closed-form expression for system unreliability is obtained for the special case  $\{n \leq 2k\}$ . Finally, simple formulas are given for the Birnbaum importance of system components. (Author abstract) 13 refs.

Rushdi, Ali M. (King Abdulaziz Univ, Jeddah, Saudi Arabia). *Reliab Eng Syst Saf* v 21 n 2 1988 p 119-127.

**089862 RELIABILITY ANALYSIS IN DISTRIBUTED SYSTEMS.** Reliability of a distributed processing system is an important design parameter that can be described in terms of the reliability of processing elements and communication links and also of the redundancy of programs and data files. The traditional terminal-pair reliability does not capture the redundancy of programs and files in a distributed system. Two reliability measures are introduced: distributed program reliability, which describes the probability of successful execution of a program requiring cooperation of several computers, and distributed system reliability, which is the probability that all the specified distributed programs for the system are

operational. These two reliability measures can be extended to incorporate the effects of user sites on reliability. An efficient approach based on graph traversal is developed to evaluate the proposed reliability measures. 25 refs.

Raghavendra, C.S. (Univ of Southern California, Los Angeles, CA, USA); Kumar, V.K. Prasanna; Hariri, S. *IEEE Trans Comput* v 6 n 2 Feb 1988 p 352-358.

**089863 OVERVIEW OF COLLECTION, ANALYSIS, AND APPLICATION OF RELIABILITY DATA IN THE PROCESS INDUSTRIES.** Issues relevant to the collection, analysis, and application of reliability data are discussed. In terms of analysis, attention is given to: current common practice and its limitations; the need for feedback-to-data collection process; lack of high-quality software for reliability analysis; contribution of exploratory analysis techniques; problems of small data sets and of overinterpretations; and critical need for sensitivity analysis in reliability studies. In terms of applications, attention is given to the alternative purposes for which such reliability data can be used: safety, cost, legislation, and system availability evaluation; maintenance and replacement decisions; logistic support and spares provisioning; initial design and quality changes; and procedural and monitoring changes. 21 refs.

Bendell, Tony (Trent Polytechnic & Services Ltd, Nottingham, Engl). *IEEE Trans Reliab* v 37 n 2 Jun 1988 p 132-137.

**089864 RELIABILITY ANALYSIS OF PUMPS FOR URANIUM SOLUTIONS.** Air-operated diaphragm pumps transfer a solution of highly enriched uranyl nitrate in nitric acid between process steps and recirculate the solution for mixing and filtration. In evaluating the data from manufacturers and performing limited testing, certain limitations have been noted on the application of the air-operated dual-diaphragm pump. In particular, the potential detrimental effects due to relatively high inlet suction pressure have led to the recommendation that an alternative pump be used on tall tanks and that precautions be taken to limit spill-potential on pumps used with shorter tanks. By manifolding the air exhaust from each pump in a manner yet to be determined, the spill potential can be substantially reduced. The high noise levels (approaching 90 dB) should be reduced.

Hoffmeister, John A. (Martin Marietta Energy Systems, Oak Ridge, TN, USA). *IEEE Trans Reliab* v 37 n 2 Jun 1988 p 144-148.

**Calculations** See Also COMPRESSORS—Design; COMPRESSORS—Diaphragms; COMPRESSORS—Valves; FAILURE ANALYSIS.

**089865 ONE-SIDED CONFIDENCE BANDS FOR CUMULATIVE DISTRIBUTION FUNCTIONS.** In this article, the construction of one-sided confidence bands is described. The case of the general location-scale parameter model is discussed, and formulas for the normal and extreme-value models are given as illustrations. A simple numerical example is also included. (Edited author abstract) 12 refs.

Cheng, R.C.H. (Univ of Wales, Cardiff, Wales); Iles, T.C. *Technometrics* v 30 n 2 May 1988 p 155-159.

**Computer Aided Analysis** See Also PAVEMENTS—Performance.

**089866 DEVELOPMENT OF AN INTEGRATED FAULT TREE ANALYSIS COMPUTER CODE MODULE BY MODULARIZATION TECHNIQUE.** A computer code MODULE is developed to carry out the three major tasks in system reliability analysis at one run, which are the generation of minimal cut sets, the importance analysis and the uncertainty analysis. The MODULE is compared with other codes for two selected examples. The results show that the MODULE can perform the above tasks without highly increasing computation time compared with other codes. Therefore, it can reduce the user efforts in preparing data at each task. It can run also in IBM-PC/compatibles. (Author abstract) 4 refs.

Han, Sang Hoon (Korean Advanced Energy Research Inst, Choongnam, South Korea); Kim, Tae Woon; Yoo, Kun Joong. *Reliab Eng Syst Saf* v 21 n 2 1988 p 145-154.

**089867 INTERACTIVE RELIABILITY ANALYSIS ON A MICROCOMPUTER.** This paper describes an interactive menu-driven tool for reliability analysis on a microcomputer. The tool can analyze series-parallel reliability networks with K-out-of-N redundancy structures. The user can configure and input structures in this class using a hierarchical approach involving nested components. Given the characteristics of the ultimate building blocks of the structure, the software computes cost and availability measures for the overall structure and all of its components. (Author abstract). 7 Refs.

Assad, A.A. (Univ of Maryland, College Park, MD, USA); Ball, M.O.; Golden, B.L.; Jeffs, V.J. *Am J Math Manage Sci* v 8 n 1-2 1988 p 59-91.

**089868 RAPID: RECURSIVE ALGORITHMIC PIVOTAL DECOMPOSITION PROGRAM FOR COMPLEX STRUCTURAL RELIABILITY ANALYSIS.** A short personal-computer program for complex structural reliability analysis is presented. The program is written in BASIC and it pivots uni- or bidirectional components for decomposition fully automatically. Computational experience with the program is described. 8 refs.

Park, Kyung S. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Cho, Byung C. *IEEE Trans Reliab* v 37 n 1 Apr 1988 p 50-53.

**Computer Applications** See MACHINE TOOLS—Reliability.

**Computer Simulation**

**089869 UNCERTAINTY IN RELIABILITY EVALUATION PROCESSES AND A SIMULATION APPROACH TO TREATING IT.** The causes of uncertainty are discussed for three different situations: (a) in the process of designing new systems, when failure data are not yet available, (b) after performing reliability test and gathering failure data, and (c) in mission reliability prediction. It is concluded that, in performing reliability prediction or failure rate prediction, one should use interval estimates rather than point estimates. These intervals can be used to perform component classification and then, employing simulation, to obtain tables or scattergrams for the mean time between failures of a system or for system reliability. (Edited author abstract) 15 refs.

Vujosevic, Mirko (Mihajlo Pupin Inst, Belgrade, Yugosl). *Eur J Oper Res* v 32 n 2 Nov 1987 p 245-250.

**Costs** See REDUNDANCY.

**Database Systems** See DATABASE SYSTEMS—Distributed.

**Estimation** See Also RAILROAD ROLLING STOCK—Maintenance.

**089870 BAYESIAN RELIABILITY ANALYSIS OF SERIES SYSTEMS OF BINOMIAL SUBSYSTEMS AND COMPONENTS.** A Bayesian procedure is presented for estimating the reliability of a series system of independent binomial subsystems and components. The method considers either test or prior data (perhaps both or neither) at the system, subsystem, and component level. Beta prior distributions are assumed throughout. Inconsistent prior judgments are averaged within the simple-to-use procedure. The method is motivated by the following practical problem. It is required to estimate the overall reliability of a certain air-to-air heat-seeking missile system containing five major subsystems with up to nine components per subsystem. The posterior distribution of the overall missile-system reliability from which the required estimates are obtained is computed. (Author abstract) 18 refs.

Martz, H.F. (Los Alamos Natl Lab, Los Alamos, NM,



USA); Walter, R.A.; Fickas, E.T. *Technometrics* v 30 n 2 May 1988 p 143-154.

**089871 MASURA FISHER A INFORMATIEI SI UTILIZAREA EI IN FIABILITATE SI CONTROLUL STATISTIC AL CALITATII.** [Fisher's Measure of Information and its Applications in Reliability and Quality Control]. The paper analyzes the derivation of the a priori distribution in Bayesian estimation of reliability and conformity by the method of comparing the prior and the experimental information. Fisher's information is used as a common measure. Precautions to be taken in using prior information are pointed out. (Author abstract) 3 refs. In Romanian.

Mihalache, A. *Bul Inst Politeh Bucuresti Electron* v 48 1986 p 81-85.

**Evaluation** See Also CONTROL SYSTEMS—Reliability; ELECTRIC EQUIPMENT—Reliability; ELECTRIC POWER SYSTEMS—Interconnection; ELECTRIC POWER TRANSMISSION, HVDC—Reliability; RESERVOIRS—Reliability; STRUCTURAL ANALYSIS—Calculations; SYSTEMS ANALYSIS—Reliability.

**089872 APPLICATIONS OF THE HYBRID AUTOMATED RELIABILITY PREDICTOR.** The Hybrid Automated Reliability Predictor (HARP) is a software package that implements advanced reliability modeling techniques. In this paper we present an overview of some of the problems that arise in modeling highly reliable, fault tolerant systems, loosely divided into model construction and model solution problems. We then describe the HARP approach to these difficulties, which is facilitated by a technique called behavioral decomposition. The bulk of this paper presents examples of the evaluation of some typical fault tolerant systems, including a local area network, two fault tolerant computer systems (Carnegie-Mellon University multiprocessor system C.mmp, and Software Implemented Fault Tolerance (SIFT), and two examples of flight control systems. (Author abstract) 25 refs.

Bavuso, Salvatore J. (NASA, Hampton, VA, USA); Dugan, Joanne Bechta; Trivedi, Kishor; Rothmann, Beth; Boyd, Mark. *NASA Tech Pap* 2760 Dec 1987 27p.

**089873 PROBABILITY INTEGRATION BY DIRECTIONAL SIMULATION.** Reliability evaluation methods based on directional simulation for structural reliability analysis is treated herein. The methods can be used to check results obtained by a first- or second-order reliability method. Directional importance sampling based on first- and second-order reliability results is used to reduce the variance on the probability estimator. Sampling densities and procedures for important types of failure surface considered in the space of independent and standardized Gaussian variables are set up. The types include hyperspheres, hyperplanes, rotationally symmetrical hyperparaboloids, surfaces defining a convex polyhedral failure set, as well as series-systems failure surfaces. (Author abstract). 17 Refs.

Bjerager, Peter (Stanford Univ, Stanford, CA, USA). *J Eng Mech* v 114 n 8 Aug 1988 p 1285-1302.

**Health Hazards** See BIOMEDICAL ENGINEERING—Health Hazards.

**Mathematical Models** See Also AUTOMATA THEORY—Finite Automata; COMPUTER SOFTWARE—Reliability; COMPUTER SYSTEMS, DIGITAL—Reliability; CONTROL SYSTEMS, STOCHASTIC—Reliability.

**089874 RELIABILITY OF A TEST PROCEDURE FOR IDENTIFYING DEFECTIVE COMPONENTS.** Fast and simple tests for detecting defects in components (or units) may be less reliable but they have obvious advantages over those that are exact but more costly and/or time-consuming. In this study, a model is proposed for predicting the reliability of a test procedure where simple and exact tests are combined so as to minimize the number of costly and time-consuming tests. The maximum likelihood method is used to estimate the necessary parameters, such as the actual number of abnormal units in a multi-unit system under test, and the

probabilities of correctly and incorrectly identifying a unit as abnormal. (Author abstract) 11 refs.

Sim, S.H. (Ontario Hydro Research Division, Toronto, Can). *Eur J Oper Res* v 34 n 3 Mar 1988 p 345-350.

**089875 DEVELOPMENT AND UTILIZATION OF A GENERALIZED THREE-STATE MODEL.** The basic component representation used in many studies of reliability and availability in the two-state model in which the component is designated as being in the up or down state. In some cases, however, the component can reside in an in-between state, and a three-state representation is required. This representation is often used to model large generating units in power system adequacy or security evaluation. The inclusion of the third or derated state in this case can have an appreciable influence on the calculated system risk. The basic three-state model can be utilized in a wide range of applications using both limiting and time dependent state probabilities. This paper illustrates the development of a generalized three-state model and presents a basic set of equations which can be utilized in a wide range of applications. The utility of the model is illustrated by three specific applications taken from the power systems area. (Author abstract) 5 refs.

Billinton, R. (Univ of Saskatchewan, Saskatoon, Sask, Can); Chu, K. *Reliab Eng Syst Saf* v 21 n 1 1988 p 47-57.

**089876 INFLUENCE OF IMPERFECT KNOWLEDGE ON THE FAILURE BEHAVIOUR OF PERIODICALLY TESTED STANDBY COMPONENTS.** A reliability model for periodically tested standby components is introduced, which takes into account hardware component failure as well as its interaction with the imperfect failure detection and recovery process. As the parameters of the model are not directly observable, they have to be calculated from properties of operational experience which are functions of the model parameters. This model can be applied to explain model uncertainties arising from the user of simpler models both qualitatively and quantitatively, especially with respect to the evaluation of operational experience on component failure behavior. (Author abstract) 4 refs.

Doerre, P. (Kraftwerk Union AG, Offenbach, West Ger). *Reliab Eng Syst Saf* v 21 n 3 1988 p 175-188.

**089877 STUDY OF A 2-UNIT SYSTEM WITH 'RANDOM BREAKDOWN' OF THE REPAIR FACILITY.** A two-unit cold standby system supported by a single repair facility is considered. The units after each repair do not behave as new and a unit can be repaired exact  $k$  ( $k < \infty$ ) times. The failure time distribution of either unit is different after each repair. The repair facility is subjected to random breakdown with exponential lifetime and exponential repair time distributions. The availability and reliability measures and the MTBF are provided for the model. (Author abstract). 3 refs.

Bhat, K. Shankar (Madras Christian Coll, Madras, India); Gururajan, M.; Nayak, Panduranga. *Microelectron Reliab* v 28 n 3 1988 p 369-371.

**089878 ONE UNIT RELIABILITY SYSTEM SUBJECT TO RANDOM SHOCKS AND PREVENTIVE MAINTENANCE.** In this paper we consider two systems each consisting of one unit. The operating unit is subject to random shocks which occur at random times. Due to the shock the following may happen: (i) the unit is not at all affected by the shock; (ii) the failure rate of the unit increases from  $\lambda_0$  to  $\lambda_1$ ; (iii) the unit fails. The failure time of the unit is exponentially distributed. The repair, shock and preventive maintenance times follow general distributions. In System 2 there is provision of preventive maintenance, whereas in System 1 there is no provision of preventive maintenance. There is one repair man available in each system. In this paper the mean time to system failure, steady state availabilities and the impact of shocks on these are studied. In System 2 the effect of the preventive maintenance on MTSF and steady-state availabilities is investigated. (Author abstract). 8 Refs.

Al-Ali, Abdul Ameer (Univ of Roorkee, Roorkee, India); Murari, K. *Microelectron Reliab* v 28 n 3 1988 p 373-377.

**089879 COMPARISON OF ALGORITHMS FOR TERMINAL-PAIR RELIABILITY.** Four algorithms for the terminal-pair reliability problem are compared. Nelson, Lin, Shooman, and Dotson algorithms are used in this study. It is shown that the Dotson algorithm is the fastest among the terminal-pair reliability algorithms analyzed. The Dotson algorithm is suited not only for numerical reliability, but for obtaining symbolic expression for the terminal-pair reliability with no additional effort. By modifying the Dotson algorithm the efficiency can be further improved. The modifications to this algorithm are listed and the reliability of the modified Dotson algorithm is computed. 10 refs.

Yoo, Y.B. (Montana State Univ, Bozeman, MT, USA); Deo, Narsingh. *IEEE Trans Reliab* v 37 n 2 Jun 1988 p 210-215.

**Optimization** See Also ELECTRIC POWER SYSTEMS—Reliability; HYDRAULIC TURBINES—Impellers.

**089880 OPTIMAL RELIABILITY DEMONSTRATION FOR BINOMIAL TESTING SITUATION.** Design and reliability requirements depend upon the available technology and its state of the art design capability and requirements of the customer. A product is designed and developed based on these requirements. Reliability requirements must take into consideration costs related to testing, risks related to type I and type II errors and other cost elements related to fielded products such as maintenance burden. The purpose of this paper is to model the decision making process for determining the reliability requirements and associated optimal test strategies to demonstrate these requirements for binomial testing situation. Optimization models consider cost elements related to design and development, testing, and inherent risks involved in accepting the product based on testing. (Author abstract) 6 refs.

Kapur, Kailash C. (Wayne State Univ, Detroit, MI, USA). *Reliab Eng* v 19 n 2 1987 p 103-111.

**089881 RELIABILITY GROWTH - MYTH OR MESS.** The author argues that reliability growth is not necessarily well defined in the literature. Therefore he suggests that in all papers on reliability growth the author should identify what kind of reliability growth process they have in mind and, if data are being analyzed, which factors are held constant or randomized to smooth out the effects. 2 refs.

Wong, Kam L. (Kambee Industries, Manhattan Beach, CA, USA). *IEEE Trans Reliab* v 37 n 2 Jun 1988 p 209.

**Planning** See ELECTRIC POWER TRANSMISSION—Reliability.

**Prediction** See BUILDING MATERIALS—Performance.

**Testing** See ELECTRIC RELAYS—Evaluation.

## Theory

**089882 COHERENT CONTINUOUS SYSTEMS AND THE GENERALIZED FUNCTIONAL EQUATION OF ASSOCIATIVITY.** A theory of coherent continuous systems is outlined. Systems are to be decomposed hierarchically into modules. For this purpose, some results on the structure of continuous functions are adapted to generalize the classic 3-Modules Theorem of binary systems. Consideration of the modular structure of coherent continuous systems leads naturally to the generalized functional equation of associativity  $G(g(u,v), w) = H(u, h(v, w))$  involving four unknown 2-place continuous functions. The functional equation is solved under some regularity conditions motivated by the properties of coherent continuous systems. The solutions obtained give rise to generalized notions of parallel and series system structures. (Author abstract) 22 refs.

Mak, King-Tim (Univ of Illinois at Chicago, IL, USA). *Math Oper Res* v 12 n 4 Nov 1987 p 597-625.



**089883 CLASS OF BETTER MEAN RESIDUAL LIFE AT AGE  $T_0$ .** The conditional mean remaining life of an item of age  $t$  is called the mean residual life (MRL) at age  $t$ . In this paper we introduce a better mean residual life at  $t_0$  (BMRL- $t_0$ ) class of life distributions, where the MRL decreases initially during  $[0, t_0]$  and then for  $t \geq t_0$  the MRL at time  $t$  is not greater than the MRL at  $t_0$ . It is shown that the BMRL- $t_0$  class contains the DMRL class, but it is a proper subclass of the NBUE class. The dual class of worse mean residual life at  $t_0$  (WMRL- $t_0$ ) is defined by reversing the direction of inequality. Some characteristics of these two classes are presented. We also develop the tests of exponentiality against the BMRL- $t_0$  (WMRL- $t_0$ ) alternatives. (Author abstract) 11 refs.

Kulasekera, Karunaratna B. (Univ of Nebraska, Lincoln, NE, USA); Park, Dong Ho. *Microelectron Reliab* v 27 n 4 1987 p 725-735.

**089884 AXIOMATIC CHARACTERIZATIONS OF CONTINUUM STRUCTURE FUNCTIONS.** A continuum structure function is a non-decreasing mapping from the unit hypercube to the unit interval. Axiomatic characterizations of the continuum structure functions based on the Barlow-Wu and Natvig multistate structure functions are derived. Unlike the binary case, where there is only one definition of component relevancy, a variety of definitions of varying strength are possible. (Edited author abstract) 6 refs.

Kim, Chul (State Univ of New York at Stony Brook, NY, USA); Baxter, Laurence A. *Oper Res Lett* v 6 n 6 Dec 1987 p 297-300.

**RELIABILITY THEORY** See Also CODES, SYMBOLIC—Error Correction; COMPUTER SOFTWARE—Reliability; COMPUTER SYSTEMS, DIGITAL—Mathematical Models; DECISION THEORY AND ANALYSIS—Estimation; ELECTRIC EQUIPMENT—Reliability; ELECTRIC NETWORKS—Analysis; ELECTRIC POWER DISTRIBUTION—Reliability; ELECTRONIC EQUIPMENT—Reliability; FAILURE ANALYSIS; FAILURE ANALYSIS—Mathematical Models; INSPECTION; INSPECTION—Sampling; MAINTAINABILITY; MATHEMATICAL STATISTICS—Monte Carlo Methods; MATHEMATICAL TECHNIQUES—Graph Theory; OIL WELL DRILLING—Blowout Prevention; OPTIMIZATION; PROBABILITY—Queueing Theory; PROBABILITY—Random Processes; PROBABILITY—Theory; RADIO SYSTEMS, MOBILE—Reliability; STRUCTURAL ANALYSIS; STRUCTURAL ANALYSIS—Earthquake Resistance; STRUCTURAL DESIGN—Reliability; SWITCHING SYSTEMS—Reliability; SYSTEMS ANALYSIS—Costs; SYSTEMS ANALYSIS—Reliability; SYSTEMS ENGINEERING—Redundancy; SYSTEMS SCIENCE AND CYBERNETICS—Man Machine Systems; SYSTEMS SCIENCE AND CYBERNETICS—Reliability; SYSTEMS SCIENCE AND CYBERNETICS—Theory; TELECOMMUNICATION SYSTEMS—Performance; TELECOMMUNICATION SYSTEMS—Reliability.

**089885 CONDITION PARAMETER BASED APPROACH TO CALCULATION OF RELIABILITY CHARACTERISTICS.** The classical approach to the calculation of reliability characteristics is based on the probability distribution of time to failure. The system under consideration is accepted as a 'black box' which performs the required function until it fails. This paper presents an 'engineering' approach to the calculation of reliability characteristics which attempts to obtain the same results at the same time providing information about 'what is going on inside the box'. According to the new approach, reliability characteristics have been determined using the probability distribution of a relevant conditions parameter which fully describes the condition of the system in every instant of operating time. It is applicable to those systems whose components fail gradually. This approach offers greater potential for practical application in maintenance theory. The proposed approach can also be used as a method for accelerated testing or reliability of engineering systems and their components. (Edited author abstract) 6 refs.

Knezevic, J. (Univ of Exeter, Exeter, Engl). *Reliab Eng* v 19 n 1 1987 p 29-39.

**089886 ADAPTATION OF ACTIVE-INACTIVE TIMES OF SUPERVISORY SYSTEMS FOR MAXIMISING SYSTEM AVAILABILITY.** An approach is presented for determining the optimum active and inactive

times of supervisory systems which are used for the protection of a system. The system is modeled by the Markov model, which is continuous in time and alternates between two and three discrete states. A Lagrangian function for constrained optimization is built and Newton's method is used to solve the resulting multidimensional nonlinear equations. An example is used to illustrate the approach. (Author abstract) 7 refs.

Kontoleon, J.M. (Univ of Thessaloniki, Thessaloniki, Greece). *Reliab Eng* v 19 n 1 1987 p 41-47.

**089887 FORMULAE FOR THE AVAILABILITY, MEAN UPTIME AND MEAN DOWNTIME OF A REPAIRABLE, REDUNDANT SYSTEM WITH ONLY A SINGLE REPAIR FACILITY.** Conventional formulas for r-out-of-n ( $r/n$ ) repairable, redundant systems generally give unrealistically high estimates of the system availability and mean uptime and unrealistically low estimates of the system mean downtime. This paper develops formulas based on analysis of a simple queueing system formed when only a single repair facility is available and compares the results with those obtained by conventional methods. (Author abstract) 3 refs.

Lee, P. *GEC J Res* v 5 n 2 1987 p 124-127.

**089888 METHOD FOR REDUCING THE NUMBER OF PRODUCT TERMS IN A SYMBOLIC RELIABILITY EXPRESSION.** Among methods for deriving a symbolic reliability expression between two specified vertices ( $s, t$ ) in a network, a tree-expansion method proposed herein generates an expression in summation form with fewer product terms and computes it very fast. We show by computer experiments that the modified tree-expansion method can reduce the number of product terms and its running time. (Edited author abstract) 9 refs.

Higashiyama, Youichi (Ehime Univ, Matsuyama, Jpn); Ariyoshi, Hiromu. *Electron Commun Jpn Part 1* v 70 n 9 Sep 1987 p 50-58.

**089889 ON THE ASYMPTOTIC BEHAVIOUR OF MEAN RESIDUAL LIFE FUNCTION.** The mean residual life (MRL) function is useful in defining a good decision-making criterion for replacement policies and in solving burn-in problems. It provides a more descriptive measure of the aging process than the hazard rate. A relationship between the asymptotic values of the mean residual life function and the hazard rate of a generic continuous distribution function is derived. It is also shown that the derivative of the MRL function of a positive random variable always tends to zero as  $t \rightarrow \infty$ . (Edited author abstract) 10 refs.

Calabria, R. (CNR, Naples, Italy); Pulcini, G. *Reliab Eng* v 19 n 3 1987 p 165-170.

**089890 RELIABILITY ANALYSIS OF TUBULAR JOINTS IN OFFSHORE STRUCTURES.** Reliability analysis of single tubular joints and offshore platforms with tubular joints is presented. The failure modes considered are yielding, punching, buckling and fatigue failure. Element reliability as well as systems reliability approaches are used and illustrated by several examples. Optimal design of tubular joints with reliability constraints is discussed. (Edited author abstract) 12 refs.

Thoft-Christensen, P. (Univ of Aalborg, Aalborg, Den); Sorensen, J.D. *Reliab Eng* v 19 n 3 1987 p 171-184.

**089891 TWO DUPLEX UNIT STANDBY SYSTEM WITH TWO TYPES OF REPAIR.** This paper is concerned with a two duplex unit standby system involving two types of repair, i.e. cheaper and costlier. When the cheaper repairman does not repair the failed duplex unit within a tolerable time (maximum cheaper repair time) the costlier repairman is called on to do the repair. The time to failure of a duplex unit is taken to be negative exponential, while the repair time distribution is arbitrarily distributed. The system is analysed by using the supplementary variable technique to obtain various related measures. (Author abstract) 4 refs.

Singh, H.R. (Ravishankar Univ, Raipur, India); Singh, S.K.; Shukla, Sindhu. *Microelectron Reliab* v 28 n 1 1988 p 11-14.

**089892 GERT ANALYSIS OF SAMPLING PLAN FOR SYSTEM RELIABILITY.** The Graphical Evaluation and Review Technique (GERT) has been applied to modelling of an acceptance sampling plan for a two component parallel system exhibiting standby redundancy. (Edited author abstract) 10 refs.

Shankar, Gauri (Ravishankar Univ, Raipur, India). *Microelectron Reliab* v 28 n 1 1988 p 23-25.

**089893 SYSTEM RELIABILITY DESIGN WITH DETERIORATIVE COMPONENTS.** In constrained optimum system reliability problems, the reliability of each component is usually assumed to be fixed, and the optimal number of redundancies at each stage is determined. However, in the real world the component reliability decreases as component deteriorates; i.e. the component reliability is dependent on its age. This paper presents a system reliability optimization problem with deteriorative components. We formulate this problem as a parametric nonlinear integer programming problem where the objective function has a time parameter  $t$ . A solution method is proposed for solving it. We believe that this model can provide useful information for decision makers and reliability designers. (Edited author abstract) 5 refs.

Jan, Rong-Hong (Nat'l Chiao Tung Univ, Hsinchu, Taiwan); Chern, Maw-Sheng. *Microelectron Reliab* v 28 n 1 1988 p 43-58.

**089894 ON ESTIMATING THE SHAPE PARAMETER OF THE WEIBULL DISTRIBUTION BY SHRINKAGE TOWARDS AN INTERVAL.** This paper proposes some shrunken estimators for the shape parameter of the Weibull distribution under censored sampling when some a priori or guessed interval containing the parameter  $\beta$  is available. Extensions of the work done in Pandey and Singh (1984) have been considered. Comparisons of the proposed estimators with the usual unbiased estimator, in terms of mean squared error are made. It is found that the proposed estimators are preferable to the usual estimator in some guessed interval of the parameter space of  $\beta$ . (Author abstract) 14 refs.

Pandey, B.N. (Banaras Hindu Univ, Varanasi, India); Malik, H.J. *Microelectron Reliab* v 27 n 6 1987 p 1017-1026.

**089895 GO-FLOW: A NEW RELIABILITY ANALYSIS METHODOLOGY.** A new reliability analysis methodology, GO-FLOW, is presented. Detailed explanations and two examples of GO-FLOW analysis are given. The GO-FLOW is a success-oriented system analysis technique. The modeling technique produces the GO-FLOW chart, which is composed of operators and signal lines and represents a function of the system. A signal does not represent a 'change of condition' but some physical quantity or information. The intensity of a signal represents the probability of actual or potential existence of a physical quantity, the probability that some information exists, or a time interval between two successive time points. The examples of analysis show the applicability of the GO-FLOW method to a phased mission problem (a boiling water reactor emergency core cooling system) and to a time-dependent unavailability analysis (a pressurized water reactor auxiliary feedwater system). The GO-FLOW has proved to be a valuable and useful tool for system reliability analysis. (Author abstract) 11 refs.

Matsuoka, Takeshi (Ship Research Inst, Tokyo, Jpn); Kobayashi, Michiyuki. *Nucl Sci Eng* v 98 n 1 Jan 1988 p 64-78.

**089896 SOME EXTREMAL PROBLEMS IN RELIABILITY THEORY.** Two extremal problems in reliability theory are examined. In one of them, exact lower estimates for the probability of failure-free operation of a system in the class of unimodal distributions with two



fixed moments are found. In the other, an  $M|G|m$  queueing system in which the renewal time is a random variable which is Khinchin-infinitesimal, is examined. It is proven that if formation of a queue for renewal is allowed in the system, one can choose the renewal time such that the probability of failure of the system in the busy interval along nonmonotonic trajectories is comparable with the probability of the same event in combination with monotonic trajectories. (Author abstract) 10 refs.

Kovalenko, I.N.; Stoykova, L.S. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 57-62.

**089987 FAILURE RATE OF HIGHLY RELIABLE SYSTEMS WITH STANDBY.** Formulas are given for the failure rate of highly reliable multicomponent renewable semi-Markovian systems. Heuristic principles, the justification for which is based on the use of phase amalgamation algorithms, are used in the derivation of the formulas. (Author abstract) 7 refs.

Korolyuk, V.S. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 62-66.

**089988 MODEL WITH ESTIMATION OF AN ABSOLUTELY GUARANTEED TIME OF FAILURE-FREE OPERATION.** The problem of estimating the absolutely guaranteed time of failure-free operation  $\mu$  in a simple model is examined. The investigation is made on the basis of a Bayesian approach. It is shown that the process which describes the variations in the a posteriori density of the parameter  $\mu$  converges weakly to a definite Markov process with discrete intervention of chance. (Author abstract) 8 refs.

Belyayev, Yu.K.; Makarov, A.P. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 66-73.

**089989 ESTIMATES OF THE APPROXIMATION OF FLOWS OF WEAKLY DEPENDENT EVENTS BY POISSON FLOWS.** Explicit estimates in problems of approximating nonhomogeneous flows of weakly dependent events generated in Markov systems by Poisson flows are given. An approximation of the flow of failures of systems of the  $M_n|M|1$  type with a controlled input flow under conditions of fast servicing and  $m \rightarrow \infty$  by means of a simple flow is obtained. (Author abstract) 16 refs.

Anisimov, V.V. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 83-89.

**089900 INVARIANCE OF THE CONVERGENCE RATE OF THE METHOD OF ACCELERATED MODELING OF THE NONSTATIONARY READINESS COEFFICIENT OF AN ALTERNATING PROCESS.** An algorithm for the statistical estimation of the nonstationary readiness coefficient of systems in which the shift of periods of operability and failure is described by an alternating renewal process, is proposed. It is shown that the relative error of the estimate obtained by using this algorithm for a realization of system operation remains bounded when the failure duration approaches zero. (Author abstract) 8 refs.

Mar'yanovich, O.T. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 169-173.

**089901 TWO-SIDED ESTIMATE OF THE MATHEMATICAL EXPECTATION OF THE THROUGHPUT OF TWO-POLE NETWORKS WITH UNRELIABLE ARCS.** A two-pole network with unreliable arcs is examined. Each arc exists with a given probability. A two-sided estimate of the mathematical expectation of the throughput of the network is proposed. The need for such examination arises in the analysis of communication networks, transport systems, etc. 10 refs.

Netes, V.A. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 186-189.

**089902 DETERMINATION OF THE STRUCTURAL PARAMETERS OF COMPLEX SYSTEMS.** The author considers a system with repair which considers of  $V$  arbitrarily (in reliability sense) connected identical

units. The time to failure and the repair time of each unit are exponentially distributed. The failed units are repaired by a repair organ which consists of a  $r$  repair units,  $r=1, \dots, V$ . He proposes an analytical method for the determination of structural parameters. 4 refs.

Zhuk, P.I. *Cybernetics* v 23 n 3 May-Jun 1987 p 425-432.

**089903 DISTRIBUTION OF MAXIMUM FLOW WITH APPLICATIONS TO MULTISTATE RELIABILITY SYSTEMS.** This paper describes an efficient Monte Carlo sampling plan for estimating the distribution of maximum flow in a directed network whose arcs have random capacities. The proposed sampling plan uses an easily computed a priori upper bound on the complementary distribution function to obtain an unbiased point estimator with smaller variance than the estimator obtained by crude Monte Carlo sampling. The paper also describes procedures for interval estimation and for assessing when the sampling experiment has achieved a specified accuracy. To facilitate sampling, we use cumulative processes to characterize deterioration, leading to the treatment of arc capacities as being multinormally distributed. (Edited author abstract) 20 refs.

Fishman, George S. (Univ of North Carolina, Chapel Hill, NC, USA). *Oper Res* v 35 n 4 Jul-Aug 1987 p 607-618.

**089904 AVAILABILITY OF A SYSTEM WITH SPARE PLUG-IN UNITS.** A new method to obtain the availability of a cold standby series system with spare units is presented. Two models are considered. The first is a series system with spare units. The other is  $m$  series systems with common spare units. The availabilities are solutions of nonlinear simultaneous equations and are obtained numerically. (Edited author abstract) 3 refs.

Yanagi, Shigeru (Nat'l Defense Acad, Yokosuka, Jpn); Sasaki, Masafumi. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 12 Dec 1987 p 1203-1207.

**089905 RELIABILITY CONCEPTS UNDER THE THEORY OF EVIDENCE.** This paper presents an approach to reliability theory from the point of view of the theory of evidence. The basic assumption is that the time to failure (life) of an equipment is a variable characterized by means of an evidence on the real line, instead of a probability distribution (the classical model). Firstly some concepts of Dempster-Shafer's theory of evidence for a non-necessarily finite set are given. Then the fundamental concepts under the formulation of Dempster-Shafer's theory are introduced. (Author abstract) 13 refs.

Delgado, M. (Univ de Granada, Granada, Spain); Moral, S. *Eur J Oper Res* v 35 n 1 Apr 1988 p 89-97.

**089906 RELIABILITY PREDICTION USING ALTERNATIVE METHODS.** Alternative methods may be used for predicting reliability, when approved by the Project Manager. This section outlines these methods and the conditions under which they may be applied. The alternative methods covered by this section are: crystal ball, astrological, wet finger, miscellaneous techniques (Tarot cards, ouija boards, tea leaves, etc.) and witchcraft.

Anon. *Qual Reliab Eng Int* v 4 n 1 Jan-Mar 1988 p 3.

**089907 INHERENT UNRELIABILITY OF RELIABILITY DATA.** The availability of good data is crucial to good reliability prediction. Two contrasting cases are noted: (1) when a large amount of experience with components is available but data are not collected and (2) when systems are so innovative that no reliability experience is available. The relationship of reliability to incompleteness of knowledge and the acausal nature of statistical/probabilistic models is discussed. The difficulty of assigning any absolute similarity between any one component and the members of a particular reliability set is outlined. It is concluded that engineering judgement must always play a vital role in reliability estimation. (Author abstract) 5 refs.

Mallagh, C. (Leeds Univ, Leeds, Engl). *Qual Reliab Eng Int* v 4 n 1 Jan-Mar 1988 p 35-39.

**089908 RELIABILITY AND MTTF EVALUATION OF A REPAIRABLE COMPLEX SYSTEM UNDER WAITING.** This paper deals with the reliability and mean time to failure (MTTF) evaluation of a complex system under waiting incorporating the concept of hardware failure and human error. Failure rates of the complex system follow exponential time distributions, whereas repair follows a general repair time distribution. Laplace transforms of various state probabilities have been evaluated and reliability is obtained by the inversion process. A formula for variance of time to failure has been developed. A particular case is also given to highlight some important results. (Edited author abstract) 1 ref.

Gupta, P.P. (M.M. (PG) Coll, Modinagar, India); Kumar, Arvind. *Microelectron Reliab* v 27 n 5 1987 p 815-818.

**089909 MTTF AND MTFF OF A  $k$  OUT OF  $n$  SYSTEM.** The distributions of operating and repairing time of a  $k$  out of  $n$  system are analysed when the system reaches the steady state. The MTTF would be a lower bound for the MTFF if the system starts at a state where all components are operating like new. (Author abstract) 5 refs.

Kiu, Sun-Wah (Hong Kong Polytechnic, Hong Kong). *Microelectron Reliab* v 27 n 5 1987 p 913-922.

**089910 PROBABILISTIC PROPERTIES OF THE EXPONENTIAL DISTRIBUTION.** The exponential distribution is popular for modeling the lifetimes of components and systems. Probabilistic properties of the exponential distribution are scattered throughout textbooks and journal articles. This paper contains proofs of twelve properties of the exponential distribution that are useful for characterizing the distribution and statistical inference. (Author abstract) 2 refs.

Leemis, Lawrence M. (Univ of Oklahoma, Norman, OK, USA). *Microelectron Reliab* v 28 n 2 1988 p 257-262.

**089911 ANALYSIS OF A SIMPLE DEBUGGING MODEL.** A system has an unknown number of faults. Each fault causes a failure of the system, and is then located and removed. The failure times are independent exponential random variables with common mean. A Bayesian analysis of this model is presented, with emphasis on the situation where vague prior knowledge is represented by limiting, improper, prior forms. This provides a test for reliability growth, estimates of the number of faults, an evaluation of current system reliability, a prediction of the time to full debugging, and a model checking procedure. Three examples are given. (Author abstract) 31 refs.

Raftery, Adrian E. (Univ of Washington, Seattle, WA, USA). *Appl Stat* v 37 n 1 1988 p 12-22.

**089912 SOME CONSIDERATIONS ON RELIABILITY THEORY AND ITS APPLICATIONS.** In this paper we discuss some main topics with reliability theory and its applications. These include for example, modeling of systems of dependent components, identification of critical components, modeling of repairable systems, and the use of multistate models. The starting point for the discussion is B. Bergman's review paper on reliability theory and its application. (Author abstract) 32 refs.

Aven, Terje (Rogaland Univ, Stavanger, Norw). *Reliab Eng Syst Saf* v 21 n 3 1988 p 215-223.

**089913 TWO-STAGE LIFE TEST FOR THE EXPONENTIAL PARAMETER.** A two-stage test procedure is proposed for the exponential parameter that combines Type I and Type II censoring. The test will allow user to specify the maximum time and number of failures required for a decision in a two-stage sampling scheme. A study of



the expected time and the expected number of failures at decision suggests additional advantages of the test. (Author abstract) 9 refs.

Fairbanks, Kenneth (Murray State Univ, Murray, KY, USA). *Technometrics* v 30 n 2 May 1988 p 175-180.

**089914 EVALUATION OF AVAILABILITY COEFFICIENT OF A COMPLEX SYSTEM OF NONHOMOGENEOUS ELEMENTS UNDER LIMITED RENEWAL.** A method for evaluating the availability coefficient of complex engineering systems with various types of structural standby under limited renewal is proposed. The method is based on joint utilization of Boolean reliability models and queueing networks. (Author abstract). 4 Refs.

Gagin, A.A. *Sov J Comput Syst Sci* v 26 n 1 Jan-Feb 1988 p 101-108.

**089915 METHOD FOR EVALUATING ALL THE MINIMAL CUTS OF A GRAPH.** A technique is introduced to determine all minimal cuts for all the sink nodes in a nonplanar network. The algorithm uses a subset method and an iterative process to achieve high efficiency. For an N-sink node network there are  $(2^N-1)$  possible combinations of nodes (nonempty subsets). These subsets are checked against several criteria to see if they can be transformed into minimal cutsets. An iterative process is used to generate these nonempty subsets efficiently so that the number of subsets to be checked is about  $(2^N-1)/2$ . Since this algorithm generates all the minimal cutsets for all nodes in one operation, it is faster than conventional methods that compute them for one sink node at a time. Tests using random graphs showed a small CPU time per minimal cutset. 5 refs.

Jasmon, G.B. (Univ of Malaya, Kuala Lumpur, Malays); Foong, K.W. *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 539-545.

**089916 RELIABILITY OF SYSTEMS WITH CONSECUTIVE MINIMAL CUTSETS.** A class of system cutsets called consecutive minimal cutsets is defined. A simple algorithm is presented for computing exactly the reliability of systems with this property. A generalized class of consecutive-k-out-of-n:F systems, called consecutively connected systems, is shown to have this property. 16 refs.

Shanthikumar, J. George (Univ of California, Berkeley, CA, USA). *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 546-550.

**089917 FAILURE PROBABILITY OF STRICT CONSECUTIVE-K-OUT-OF-N:F SYSTEMS.** A system with n components in sequence is a strict consecutive-k-out-of-n:F system if and only if it fails when at least k consecutive components have failed, but isolated strings of component failures of length less than k do not occur. The failure probability function of a strict linear consecutive-k-out-of-n:F system is given in a closed form. The calculation of the failure probability of a strict circular consecutive-k-out-of-n:F system is reduced to the linear case. 4 refs.

Kossov, Andreas (Wismar Technological Univ, West Ger); Preuss, Wolfgang. *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 551-553.

**089918 MODIFIED TECHNIQUE FOR COMPUTING NETWORK RELIABILITY.** S. H. Ahmad (1982) has published a technique to compute the reliability of a network without resorting to paths or cutsets. The technique uses a random choice of next node connected to the previous node in the construction of a tree, which can lead to a large number of terms in the reliability expression. A modified version of the Ahmad technique is presented that always produces a reliability expression with the same or fewer terms as the original technique. 7 refs.

Ahmad, S. Hasanuddin (King Abdul Aziz Univ, Jeddah, Saudi Arabia); Jamil, A.T.M. *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 554-556.

**089919 RELIABILITY MODELING AND EVALUATION FOR NETWORKS UNDER MULTIPLE AND FLUCTUATING OPERATIONAL CONDITIONS.** A simple multistate Markov process is used to model a component and a system of any configuration under several operational conditions. Using the model, a simple tie-set approach calculates availability and frequencies of system failure for various conditions; a cut-set approach calculates probabilities of the system being in a particular condition. There are two interpretations of operational conditions: (1) environmental conditions such as weather or stress, and (2) other operating conditions that occur in several sequential or fluctuating phases. As the system is assumed at any moment to be under a condition with a certain probability or weight, some relative reliability measures can be further obtained simply to identify which conditions are disastrous. 15 refs.

Yuan, John (Nat'l Tsing Hua Univ, Hsinchu, China); Lin, Chin-Hu; Chang, Say Jau; Lai, Shen-Hua. *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 557-564.

**089920 MEAN TIME TO ACHIEVE A FAILURE-FREE REQUIREMENT UNDER PROVISIONS OF SPARE AND REPAIR.** The author considers a one-unit system supported by a repair facility and a single spare. This unit is put on test. When the unit fails, the spare instantaneously takes over as the new operating unit, and the failed unit is repaired. The system fails when the unit, currently operating, fails before the repair of the latest failed unit is completed. The testing is continued until several ( $s > 0$ ) consecutive time units of failure-free operation are obtained. This is a failure-free test and  $s$  is a failure-free requirement. These tests have been proposed when a consumer wants assurance that a unit will survive failure-free for a certain period. The author obtains an expression for the mean test time to achieve a failure-free requirement under the provisions of spare and repair. 3 refs.

Ebrahimi, Nader (Northern Illinois Univ, DeKalb, IL, USA). *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 565-567.

**089921 BAYES RELIABILITY GROWTH MODEL FOR A DEVELOPMENT TESTING PROGRAM.** The problem of estimating the reliability of a system during development is considered. The development process has several stages, and at each stage binomial test data are obtained by testing a number of such systems on a success/fail basis. Marginal posterior distributions are derived under the assumption that the development process constrains the reliabilities to be nondecreasing and that the prior distribution for reliability at each stage is uniform. Simulation models are designed to facilitate testing for the validity and computation of the Bayesian model with ordered reliabilities as well as to compare results with other reliability growth models. 9 refs.

Fard, Nasser S. (Northeastern Univ, Boston, MA, USA); Dietrich, Duane L. *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 568-572.

**089922 COMPUTING MAXIMUM-LIKELIHOOD PARAMETER ESTIMATES OF THE GENERALIZED GAMMA DISTRIBUTION BY NUMERICAL ROOT ISOLATION.** The generalized gamma distribution (GGD) is important in reliability modeling and includes as special cases the Weibull, gamma, and exponential distributions. Unfortunately, the numerical difficulties associated with fitting the GGD to data have been a major impediment to its wider use. The parameter likelihood equations (LEs) can possess no solution or

several solutions, and the Newton-Raphson method is, in general, poorly behaved when applied to the LEs. An algorithm is described that uses a heuristic root isolation method to circumvent these difficulties. The algorithm can be used to determine the maximum-likelihood estimates of the parameters of the GGD or to indicate that none exists. 14 refs.

Wingo, Dallas R. (Bell Communications Research, Red Bank, NJ, USA). *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 586-590.

**089923 COMPARISON OF THE PREDICTION OF FUTURE ORDER STATISTICS FOR THE 2-PARAMETER GAMMA DISTRIBUTION.** The author considers the prediction of future order statistics based on type-II censored samples from the two-parameter gamma distribution with unknown scale parameter and semi-known shape parameter. Among the four predictors considered, the cross-validator predictor performed best in terms of guaranteed efficiency. An advantage of this estimator is that it uses only the mean values of order statistics and not the covariances, which are more difficult to compute. 18 refs.

Balasooriya, Uditha (Nat'l Univ of Singapore, Singapore). *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 591-594.

**089924 FITTING AND OPTIMAL GROUPING ON GAMMA RELIABILITY DATA.** Two statistics are presented for testing gammality on the basis of complete and incomplete random samples with unknown scale parameter. The distributions of the test statistics were approximated by using Monte Carlo simulation. The power of the statistics is investigated with respect to several alternatives. Statistical methods are presented for reliability measurement from grouped data on items from a gamma life distribution. The maximum method is used to estimate reliability, and tables are given for asymptotically optimal inspection time of the life tests which are monitored only periodically. 7 refs.

Wei, Duan (Bur of Statistics, Taipei, Taiwan); Shau, C.K. *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 595-599.

**089925 SOME OPTIMAL DESIGNS FOR GROUPED DATA IN RELIABILITY DEMONSTRATION TESTS.** Optimal demonstration test designs using grouped inspection data from logistic, log-logistic, normal/Gaussian and log-normal distributions are studied. The test statistics of the mean life and reliability for the distributions are considered. Tables for optimally spaced inspection of these distributions are obtained. 4 refs.

Wei, Duan (Bur of Statistics, Taipei, Taiwan); Bau, Jinn-Jomp. *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 600-604.

**089926 SEQUENTIAL TEST FOR THE RATIO OF TWO CONSTANT FAILURE RATES.** An exact sequential test is given for two similar types of equipment in terms of the ratio of their constant failure rates. The plans are useful for incentives in comparative life testing of equipment during its constant-failure-rate period. The theory and equations for the tables are developed and the related references are included. Three test plans are summarized. 4 refs.

Oksoy, Dolun (Alfred Univ, NY, USA). *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 605-612.

**089927 SIMPLE BAYES TEST OF EQUALITY OF EXPONENTIAL MEANS.** An approximate  $\chi^2$ -test statistic tests the homogeneity of scale parameters of several



exponential distributions from a Bayes viewpoint under types I and II censoring. The quantiles of the statistic are simulated and found to be very close to the exact quantiles of a  $\chi^2$  distribution. 12 refs.

Shoukri, M.M. (Univ of Windsor, Ont, Can). *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 613-616.

**089928 RELIABILITY OPTIMIZATION WITH THE LAGRANGE-MULTIPLIER AND BRANCH-AND-BOUND TECHNIQUE.** A method has been developed for constrained reliability optimization problems that incorporates the Lagrange multiplier method and the branch-and-bound technique. The Lagrange multiplier method treats the number of redundancies as real numbers. Once a real number solution is obtained, the branch-and-bound technique is used to obtain the integer solution. The optimization method is applied to the redundancy allocation problem for a four-stage series system, and to the reliability-redundancy allocation problem for a five-stage series system with three nonlinear constraints. The results show that the proposed method is better than previous methods for both problems. 16 refs.

Kuo, Way (Iowa State Univ, Ames, IA, USA); Lin, Hsin-Hui; Xu, Zhongkai; Zhang, Weixing. *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 624-630.

**089929 COMMENT ON 'MULTISTATE MARKOV MODELS AND STRUCTURAL PROPERTIES OF THE TRANSITION-RATE MATRIX' BY G. CARAFO.** Three points are raised by the commenter regarding the title paper (1986): (1) he provides explicit information on the meaning of the entries of the system state probability vector  $p$  for different forms of the system transition-rate matrix, which is not given in the paper; (2) he suggests changes to two assumptions in the paper, thus making it clear that the transition rates are constants; and he points out that the Kronecker algebra property No. 4 given in the paper is equality. 1 ref.

Nahman, Jovan M. (Univ of Belgrade, Yugosl). *IEEE Trans Reliab* v R-36 n 5 Dec 1987, 1987 Proc - Reliab & Maint in Comput-Aided Eng Workshop, Leesburg, VA, USA, Aug 25-26 1987 p 639.

**089930 BOUNDING NETWORK-RELIABILITY USING CONSECUTIVE MINIMAL CUTSETS.** A subset of consecutive minimal cutsets of the set of cutsets is used to develop an efficient algorithm to compute an upper bound for the reliability of a network. The reliability is the probability that a path consisting only of functioning arcs exists between the source and the sink of the network. The nodes of this network are perfect, but the arcs are independent and either function or fail with known probabilities. For the case of source-to-sink planar networks, an approach to obtain a lower bound for the reliability of the network is also presented. Examples illustrate the use of the algorithm and show that the upper bound is, in many cases, better than that obtained by A. W. Shogan (1976). 21 refs.

Shanthikumar, J. George (Univ of California, Berkeley, CA, USA). *IEEE Trans Reliab* v 37 n 1 Apr 1988 p 45-49.

**089931 RELIABILITY BOUNDS FOR DEPENDENT FAILURES.** Upper and lower bounds are obtained for the reliability of a series system with statistically dependent component failures. The method can be applied to series subsystems when these are obtained by decomposing a complex system. Numerical examples illustrate the use of the method. 5 refs.

Parkinson, D.B. (Univ of Liverpool, Engl). *IEEE Trans Reliab* v 37 n 1 Apr 1988 p 54-56.

**089932 DIRECT ALGORITHM FOR COMPUTING RELIABILITY OF A CONSECUTIVE-K CYCLE.** A consecutive-k cycle is a circular system such that the system fails if and only if any  $k$  consecutive components

all fail. Reliabilities for consecutive-k cycles are usually computed by recursive equations. However, most recursive equations proposed so far for the cycle involve reliabilities for consecutive-k lines, requiring two passes where the first pass computes only the line reliabilities. A recursive equation involving cycles only is proposed that is simpler in form but much harder to understand on intuitive grounds. Another advantage is that the proposed cycle recursion has the same form as a line recursion previously proposed. Thus a uniform treatment of lines and cycles is possible. This uniform approach is used to obtain some explicit solutions of both line and cycle reliabilities for  $2 \leq k \leq 4, 6$  refs.

Du, D.Z. (MIT, Cambridge, MA, USA); Hwang, F.K. *IEEE Trans Reliab* v 37 n 1 Apr 1988 p 70-72.

**089933 RELIABILITY OF AN M-OUT-OF-N SYSTEM WHEN COMPONENT FAILURE INDUCES HIGHER FAILURE RATES IN SURVIVORS.** An m-out-of-n-G system is composed of statistically independent and identically distributed components with exponential lifetimes. The reliability of such a system is obtained under the assumption that the failure of a component changes the failure rate of the surviving components. 4 refs.

Scheuer, Ernest M. (California State Univ, Northridge, CA, USA). *IEEE Trans Reliab* v 37 n 1 Apr 1988 p 73-74.

**089934 STATISTICAL SIMULATION METHODS FOR INVESTIGATING THE STRUCTURE OF RELIABILITY OPTIMIZATION.** Qualitative and quantitative techniques for reliability sampling plans are described. An example shows how to apply the techniques to detect service life and the effectiveness of reliability. The relationships between sample size, confidence limits, number of failed units during the test, and the fraction of reliable units is shown. By statistical simulation, 55 practical sampling plans were developed. The statistical simulation, with the aid of finite differences and computer analysis, provided a good solution of the authors' research problems. The distribution of the data corresponds rather accurately to the given curves, which are the inverses of the functions of the theoretical distribution based on the formalized approach. 5 refs.

Rashed, A.F. (King Abdul Aziz Univ, Saudi Arabia); Metwally, M. *IEEE Trans Reliab* v 37 n 1 Apr 1988 p 81-87.

**089935 TEST OF THE EXPONENTIAL MTBF AND COMPARISON OF POWER FUNCTIONS IN THE RANDOM CENSORING CASE.** A hypothesis test procedure is given for testing the parameter of an exponential distribution when the reliability data are randomly censored. The effects of the severity of the censoring are studied with respect to the power functions of the test. Some remarks are made on the inadequacy of the Epstein type of testing procedure in the random censoring case. 7 refs.

Kim, Jee Soo (GTE Lab Inc, Waltham, MA, USA). *IEEE Trans Reliab* v 37 n 1 Apr 1988 p 103-107.

**089936 MINIMIZING THE TOTAL SAMPLE SIZE WHEN MULTIPLE 1-SHOT SYSTEMS ARE COMPARED AGAINST A COMMON BASELINE.** A test design is determined for simultaneously comparing the individual reliabilities of each of multiple alternative one-shot systems against the reliability of a single baseline, with a common specification for the size and power of each alternative-vs-baseline comparison. Using the procedure of Y. J. Lee (1984), the total sample size (baseline plus alternatives) can be minimized by setting the ratio of the number of baseline system replicates to the number of replicates for each alternative system equal to the root of the number of alternative systems. 7 refs.

Fries, Arthur (Inst for Defense Analyses, Alexandria, VA, USA). *IEEE Trans Reliab* v 37 n 1 Apr 1988 p 108-110.

**089937 CENSORED LIFE-DATA ANALYSIS USING LINGUISTIC VARIABLES.** Parameter estimates for censored life data using ordinary censoring methods

(noninformative censoring) can be biased when the cause of censoring for a unit is related to its final life (informative censoring). An algorithm is presented for obtaining estimated life times for informatively censored units. It is based on linguistic variable concepts from fuzzy set theory. These estimates are combined with the lifetimes for actual failed units to form a complete sample for parameter estimation purposes. 13 refs.

Wang, Jyh-Hone (Univ of Iowa, Iowa City, IA, USA); Littschwager, John M.; Raz, Tzvi. *IEEE Trans Reliab* v 37 n 1 Apr 1988 p 111-116.

## Costs

**089938 COST LIMIT REPLACEMENT POLICY UNDER IMPERFECT REPAIR.** A repair cost limit policy is studied for a system whose repair cost can be estimated by inspection. When a system fails, the repair cost is estimated and repair is undertaken if the estimated cost is less than a predetermined limit  $L$ ; otherwise, the system is replaced. After repair, the system is as good as new with  $(1-p)$  or is minimally repaired with  $p$ . The s-expected cost rate is used as a criterion for optimization. The existence and uniqueness of optimum  $L$  are studied for the case of Weibull time-to-failure distribution and negative exponential repair cost distribution. (Author abstract) 14 refs.

Yun, W.Y. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Bai, D.S. *Reliab Eng* v 19 n 1 1987 p 23-28.

## Estimation

**089939 MODIFIED SHRINKAGE TECHNIQUE FOR ESTIMATION OF THE EXPONENTIAL SCALE PARAMETER.** A method of minimizing the mean square error (MSE) of the modified shrunken estimator of the scale parameter of the exponential population is considered. The method used is modified shrinkage of the minimum variance unbiased linear estimator (MVULE) towards a prior in the parameter space. The modified shrunken estimator is: (i) independent of prior  $\theta_0$ ; (ii) better than the MVULE given by Epstein and Sobel; (iii) better than the shrunken estimator given by Thompson, in the sense of having a smaller MSE. (Author abstract) 5 refs.

Shah, M.C. (Univ of Rajasthan, Jaipur, India); Parmar, Renu. *Microelectron Reliab* v 28 n 1 1988 p 19-21.

**089940 IMPROVING THE LOWER BOUND FOR THE RELIABILITY WHEN THE STRENGTH DISTRIBUTION IS GAMMA AND THE STRESS DISTRIBUTION IS CHI-SQUARE.** This paper investigates the lower bound for the reliability of a system when the strength distribution is gamma with parameters  $\alpha$  and  $\theta$  and the stress distribution is chi-square with parameter  $r$ . It is shown that the lower bound is a function of  $\alpha$  when  $\theta$  and  $r$  are fixed. The moment estimator and the maximum likelihood estimator for  $\alpha$  are determined and the lower bound for the reliability using these estimators is computed and compared. (Author abstract) 4 refs.

Jaisingh, Lloyd R. (Morehead State Univ, Morehead, KY, USA). *Microelectron Reliab* v 28 n 1 1988 p 27-41.

**089941 SHRINKAGE TESTIMATOR FOR SCALE PARAMETER OF AN EXPONENTIAL DISTRIBUTION.** A shrinkage estimator, based on a test of hypothesis when an initial estimate of the scale parameter is available, has been proposed. The salient feature of the proposed estimator is that, being dependent on the test statistic, it removes arbitrariness in the choice of the shrinkage factor of a given level of significance. Expressions for bias, mean square error and relative efficiency with respect to the conventional estimator have been



derived. It has been shown that by taking the square of the shrinkage factor the relative efficiency of the estimator can be increased. (Edited author abstract) 4 refs.

Pandey, B.N. (Banaras Hindu Univ, Varanasi, India); Srivastava, Rakesh. *Microelectron Reliab* v 27 n 6 1987 p 949-951.

**089942 ESTIMATION OF RELIABILITY INDICES WHEN SEVERAL FAILURE CAUSES ARE ACTIVE.** It is necessary to develop procedures for the analysis and calculation of reliability which take into account the diversity of operating conditions. We demonstrate the importance of taking into account the diversity of conditions when setting up the estimation procedure. 9 refs.

Kordonskiy, Kh.B.; Rastrigin, V.L.; Shul'kin, Z.A. *Sov J Comput Syst Sci* v 25 n 3 May-Jun 1987 p 46-50.

**Mathematical Models** See Also PROBABILITY—Mathematical Models; RELIABILITY.

**089943 USE OF SPARE TIME IN SINGLE-SERVER SYSTEMS WITH TWO TYPES OF FAILURE.** One distinguishes between two types of failure in engineering systems, depending on the outcome of the loss of operability. If a failure does not lead to the destruction (loss of value) of the results of preceding operation, but causes only a delay in performing the task for the duration of the restoration of operability, then it is called a nondestructive (or nondepreciating) failure of the first type. Semi-Markov reliability models of an element are considered, and explicit expressions for the probability of task completion for exponential distributions are found. Here we present a generalization of earlier results to the case of a system of arbitrary structure in the class of semi-Markov models of operation. 5 refs.

Cherkosov, G.N. *Sov J Comput Syst Sci* v 25 n 3 May-Jun 1987 p 51-56.

**089944 REVIEW OF DISCRETE AND CONTINUOUS DISTRIBUTIONS IN REPLACEMENT MODELS.** The probabilistic characteristics of discrete distributions are reviewed, referring to the corresponding results for continuous distributions. Further, we discuss typical replacement models, such as those of block and age, applying to specific distributions. We summarize the results in several tables for ease of comparison and application to the real system. (Author abstract) 8 refs.

Kaio, Naoto (Hiroshima Shudo Univ, Hiroshima, Jpn); Osaki, Shunji. *Int J Syst Sci* v 19 n 1 Jan 1988 p 171-177.

**Optimization** See Also SYSTEMS ANALYSIS—Reliability.

**089945 OPTIMAL STANDBY PROBLEMS AND A UNIVERSAL GENERATING FUNCTION.** Classical problems of optimal standby for a sequential system are examined: maximization of the reliability with constraints on the cost and minimization of the cost for a prescribed reliability. A computational algorithm is proposed which is based on the use of a universal generating function. 14 refs.

Ushakov, I.A. *Sov J Comput Syst Sci* v 25 n 4 Jul-Aug 1987 p 79-82.

**089946 COST OPTIMAL-(N\*,n\*) PARALLEL RELIABILITY SYSTEMS.** This paper adds to the work of N. Venugopal et al. and T. Nakagawa on optimization techniques for reliability systems based on varied criteria. The new concept of the 'cost-optimal-(N\*,n\*) system', based on comprehensive cost considerations is introduced and results obtained for optimal parallel reliability systems (that is, with optimal units, N\*, subjected to optimal repairs, n\*). The operational use and applicational value of the results are demonstrated through numerical work concentrating on some typical random laws governing the stochastic failure patterns. (Author abstract). 4 Refs.

Venugopal, N. (Univ of Tirupati, Tirupati, India); Reddy, C. Rami; Bai, M. Meenakshi. *Int J Syst Sci* v 19 n 8 Aug 1988 p 1623-1629.

**REMOTE CONTROL** See Also CAMERAS—Underwater; CODES, SYMBOLIC—Theory; CONTROL EQUIPMENT, ELECTRIC—Applications; DATA TRANSMISSION—Packet Switching; ELECTRIC CIRCUIT BREAKERS—Sulfur Hexafluoride; INFRARED DEVICES—Applications.

**Computer Interfaces** See Also RAILROADS—Monitoring.

**089947 BUILD AN INFRARED REMOTE CONTROLLER.** Infrared signaling is used because of its low cost and limited interference with other remote-controlled appliances. The design and construction of a custom hand-held infrared transmitter and receiver, called the IRCOMM is presented. The transmitter circuit can be constructed as a small inexpensive hand-held controller or expanded to implement a 62-key wireless keyboard. The receiver is equally uncomplicated and intended to provide a convenient link between the user and the home control system.

Garcia, Steve. *Byte* v 12 n 2 Feb 1987 p 101-110.

**Mathematical Models** See Also DISPLAY DEVICES—Remote Control.

**089948 COMPARISON OF POSITION AND RATE CONTROL FOR TELEMANNIPULATIONS WITH CONSIDERATION OF MANIPULATOR SYSTEM DYNAMICS.** Position and rate control are the two common manual control modes in teleoperations. Human operator performance using the two modes is evaluated and compared. Simulated three-axis pick-and-place operations are used as the primary task for operation. First, ideal position and rate control are compared by considering several factors, such as joystick gain, joystick type, display mode, task, and manipulator work space size. Then the effects of the manipulator system dynamics are investigated by varying the natural frequency and speed limit. Experimental results show that ideal position control is superior to ideal rate control, regardless of joystick type or display mode, when the manipulation work space is small or comparable to the human operator's control space. Results also show that when the manipulator system is slow, the superiority of position control disappears. Position control is recommended for small-work-space telemanipulation tasks, while rate control is recommended for slow wide-work-space telemanipulation tasks. 23 refs.

Kim, Won S. (Univ of California, Berkeley, CA, USA); Tendick, Frank; Ellis, Stephen R.; Stark, Lawrence W. *IEEE J Rob Autom* v RA-3 n 5 Oct 1987 p 426-436.

**Space Applications** See ROBOTICS—Space Applications.

**Standards** See Also VIDEO RECORDING—Remote Control.

**089949 ESBUS - EIN FERNWIRKSTANDARD FUER STUDIOANLAGEN.** [ESbus, A Remote Control Standard for Studio Equipment]. In order to ensure the future compatibility of different makes of studio control systems and equipment, the EBU and SMPTE in the early eighties set up working groups, working first independently and then in close co-operation, to define a standard for a remote control system for studio equipment. The author, himself a member of these working groups, retraces the history of these studies and, using easy-to-follow examples, explains the layer model now in widespread use to describe data transmission characteristics. He then goes on to outline the basic characteristics of the layers of the new ESBUS standard. Different variants of the ESBUS configuration corresponding to various applications are also outlined. (Author abstract) 15 refs. In German.

Trissl, Karl-Heinz (Ludwig-Maximilians-Univ, Munich, West Ger). *Rundfunktech Mitt* v 32 n 1 Jan-Feb 1988 p 6-18.

**REMOTE SENSING** See Also ELECTROMAGNETIC WAVES—Scattering; GLACIERS—Remote Sensing; IMAGE PROCESSING; IMAGE PROCESSING—Applications; IMAGE PROCESSING—Evaluation; IMAGE PROCESSING—Image Analysis; IMAGE PROCESSING—Military Applications; IMAGE PROCESSING—Optimization; IMAGE PROCESSING—Reconstruction; MAPS AND MAPPING—Alaska; OCEAN ENGINEERING—Instruments; PHOTOGRAMMETRY; RADAR—Measurement Application; SHIPS—Navigation Systems; SOLAR RADIATION—Measurements; SOLIDS—Ultrasonic Applications; URBAN PLANNING; WATER POLLUTION—Oil Spills; WATER RESOURCES—Evapotranspiration.

**089950 STATISTICAL OPTICAL MODEL FOR LIGHT REFLECTION AND PENETRATION THROUGH SAND.** The aggregate soil reflectance is an important parameter in remote sensing. It was found that soil reflectance initially decreases with an increase in moisture content and subsequently increases with higher moisture content. The present work embodies an attempt to analyze this effect and explain its physics. A new concept of cut-off thickness is evolved to interpret optical characteristics of sand as a multi-layer process. A statistical phenomenological model is developed to account for the observed dependence of the aggregate reflectance of sand and the cut-off thickness of various fractions of sand. The presence of moisture is found to affect the optical characteristics in two different ways. (Edited author abstract) 2 refs.

Neema, D.L. (SGS Inst of Technology & Science, Indore, India); Shah, Ajay; Patel, A.N. *Int J Remote Sens* v 8 n 8 Aug 1987 p 1209-1217.

**089951 REMOTE SENSING METHODOLOGIES AND GEOGRAPHY.** Remote sensing is a technique used in scientific and technological approaches to geographical research. In the scientific approaches the motivation is curiosity, the goal is knowledge and the methodology is often induction to derive theory and then deduction to verify theory. In the technological approaches the motivation is human need, the goal is the application of knowledge and the methodology is design. This review discusses both approaches, concentrating on the problems of taking a scientific approach and the unwillingness of geographers to accept an often more suitable technological approach. It is argued throughout that both types of approach can be valid, both can be useful and both are suitable methodologies for remote sensing in geography. (Edited author abstract) 140 refs.

Curran, Paul J. (Univ of Sheffield, Sheffield, Engl). *Int J Remote Sens* v 8 n 9 Sep 1987 p 1255-1275.

**089952 VISUALISATION, PAR THERMOGRAPHIE AERIENNE, DES ECHANGES HYDRODYNAMIQUES ENTRE LA NAPPE PHREATIQUE, LES COURS D'EAU ET LES GRAVIERES DANS LA PLAINE DU RHIN AU NORD DE STRASBOURG.** [Aerial Thermal Imagery of Hydrodynamic Exchanges Among the Aquifer, Streams and Gravel Pits in the Rhine Plain North of Strasbourg]. The article discusses the impact of gravel pits in Alsace. Aerial thermal imagery was used to analyze a complex hydrodynamic exchange system north of Strasbourg which included the aquifer, gravel pits with water, ditches and streams. Aerial infrared imagery obtained during a thaw made it possible to visualize the directions of the low-water hydrodynamic exchanges between the different components of the hydraulic system using the 'stenothermic' property of the ground water. For the three main gravel pits, the different parts of the steep banks participating in the ground water exchanges were identified. (Edited author abstract) In French. 7 refs.

Dürbec, Andre (Ecole Natl des Ingenieurs des Travaux Ruraux et des Techniques Sanitaires, Strasbourg, Fr); Muntzer, Paul; Zilliox, Lothaire. *Bull Soc Fr Photogram Teledetect* n 102 1986 p 25-36.



**089953 ESTIMATED CORRECTIONS FOR THE ATMOSPHERE IN REMOTE SENSING PROBLEMS.** This paper makes an attempt to offer a unification of the procedure of atmosphere corrections in remote sensing problems. To this end, optical characteristics (required for calculating) of the reference atmosphere are presented for three visible spectral bands. The transfer operators of the atmosphere are determined. These operators relate the surface albedo function with the radiance distribution in a layer. The Monte Carlo method is used for the calculations. 4 refs.

Usikov, D.A. (Acad of Sciences of the USSR, Moscow, USSR); Fomenkova, M.N. *Acta Astronaut* v 15 n 11 Nov 1987 p 945-949.

**089954 DISPLAYING SATELLITE IMAGES ON A MICROCOMPUTER.** Remote sensing using satellite imagery has become an important tool in geology, agriculture and land use management. The Australian mining industry is a leader in the development and application of computerized image processing techniques to display satellite data as an aid to mineral and oil exploration. This has been particularly true for LANDSAT data and the combining of these data with other geophysical and geological information. A case history on Plumridge Lakes in Western Australia is briefly described. 4 refs.

Roger, Ken (Narrogin Senior High Sch, Aust). *Aust Min* v 79 n 10 Oct 1987 p 18, 20.

**089955 SATELLITE-DERIVED COLOR - TEMPERATURE RELATIONSHIP IN THE ALBORAN SEA.** Improved understanding of biooptical responses to physical and chemical processes in the ocean can be obtained through the analyses of ocean color - temperature relationships using satellite data. These data can be used to trace the mixing of water masses along the frontal zones and to suggest patterns of subsurface and horizontal advection. To illustrate this concept, the ocean color and sea surface temperature relationships in the Alboran Sea are derived from the Coastal Zone Color Scanner (CZCS) (color) and the Advanced Very High Resolution Radiometer (AVHRR) (sea surface temperature) satellite data. Near-coincident (2.5 h) images from these satellite systems are registered and converted into quantitative estimates of biooptical properties and sea surface temperature. Water masses are classified based on unsupervised clustering analyses of these satellite-derived parameters. (Edited author abstract) Refs.

Arnane, Robert A. (NSTL, MS, USA). *Remote Sens Environ* v 23 n 3 Dec 1987 p 417-437.

**089956 CANOPY REFLECTANCE MODEL BASED ON AN ANALYTICAL SOLUTION TO THE MULTIPLE SCATTERING EQUATION.** An approximation to the radiative transfer equation for solar radiation in relatively full, homogeneous plant canopies is presented and solved analytically for solar zenith angles less than 60°. The model predicts reflectance at any depth in the canopy and in any direction and may be inverted with bidirectional reflectance measurements. It may be analytically integrated over the hemisphere at any depth, which makes it useful for energy balance studies, in particular for calculating albedo and intercepted photosynthetically active radiation. The fact that it may be calibrated with directional reflectance measurements and the exact nature of the solution may make it an improvement over the two-stream approximation as applied to canopy scattering problems. (Edited author abstract) Refs.

Camillo, Peter (NASA, Greenbelt, MD, USA). *Remote Sens Environ* v 23 n 3 Dec 1987 p 453-477.

**089957 EXTRACTION OF SPECTRAL HEMI-SPHERICAL REFLECTANCE (ALBEDO) OF SURFACES FROM NADIR AND DIRECTIONAL REFLECTANCE DATA.** A radiative transfer model was used to explore how the error in inferring spectral hemispherical reflectance ( $\rho_\lambda$ ) from nadir reflectance values varies as a function of wavelength, solar zenith

angle, leaf area index and leaf orientation distribution. Secondly, a technique using multiple spectral nadir reflectance values to infer  $\rho_\lambda$  for a single wavelength was tested using field data. In addition, several techniques that use multiple off-nadir view angles taken in azimuth planes were tested using field data. These latter techniques were very accurate and are ideally suited to present and future sensor systems that scan in a known azimuth plane and other scanning radiometers or view fore and aft in a known azimuth plane (e.g., Advanced Solid-State Array Sensor (ASAS), Moderate Resolution Imaging Spectrometer (MODIS), High Resolution Imaging Spectrometer (HIRIS)). (Edited author abstract) 26 refs.

Kimes, D.S. (NASA, Goddard Space Flight Cent, Greenbelt, MD, USA); Sellers, P.J.; Diner, D.J. *Int J Remote Sens* v 8 n 12 Dec 1987 p 1727-1746.

**089958 MAXIMUM LIKELIHOOD CLASSIFICATION, OPTIMAL OR PROBLEMATIC? A COMPARISON WITH THE NEAREST NEIGHBOUR CLASSIFICATION.** The maximum likelihood and the nearest neighbor classification algorithms are reviewed, particularly from the point of view of user/analyst requirements. The two algorithms were put to use for the classification of Landsat TM data of agricultural scenes and accuracy with respect to 'ground truth' was evaluated using different parametric settings. Results show that within the maximum likelihood classification, accuracies and errors can vary to a considerable degree depending on the formation of the statistical classes from the training data. More interestingly, it was found that the nearest neighbor algorithm produced higher accuracies and was judged to be more robust, but it has computer implementation problems with high data dimensionality. (Author abstract) 8 refs.

Ince, Fuat (Marmara Research Inst, Gebze, Turk). *Int J Remote Sens* v 8 n 12 Dec 1987 p 1829-1838.

**089959 ATMOSPHERIC CORRECTION OF THERMAL INFRARED DATA USING MULTI-HEIGHT DATA ACQUISITION.** Information acquired using a Daedalus AADS 1230 thermal infrared scanner flown at three different altitudes has been analyzed with a view to determining whether these data could be used to determine path transmittance and radiance with subsequent correction of the remotely-sensed radiant temperatures for atmospheric effects. The results are given and it is demonstrated that under conditions of the type described the variation of surface temperature with time for a variety of surface types proved to be greater than the correction necessitated by path effects. It is concluded that this method of atmospheric correction is unsuitable whenever changes of surface temperature of the order of 1 deg K or more take place within the time span of the data acquisition. (Edited author abstract) 8 refs.

Djavadi, D. (Univ of Dundee, Dundee, Scotl); Anderson, J.M. *Int J Remote Sens* v 8 n 12 Dec 1987 p 1879-1884.

**089960 EVALUATION OF THE STEREOSCOPIC ACCURACY OF THE SPOT SATELLITE.** The SPOT-1 in-flight assessment period for restitution of terrain relief took place from March to November 1986 under the direction of the French Institut Geographique National (IGN). For this purpose, two test regions in the south of France were chosen, and ground control points and check points were selected in these regions before launch of the SPOT satellite. The following process was used: plotting of ground control points, and modeling of SPOT viewing geometry; plotting of check points, and calculation of their restituted positions; and calculation of deviations from the real positions. These operations were performed on a TRASTER/MATRA analytical stereo-plotter using SPOT software compiled by the IGN. The analysis of the results shows that the specifications have been reasonably well met, with restitution accuracies always under 10 meters in planimetry and 7 meters in elevation. (Edited author abstract) 3 refs.

Rodriguez, V. (Inst Geographique Natl, Toulouse, Fr); Gigord, P.; de Gaujac, A.C.; Munier, P.; Begni, G. *Photogramm Eng Remote Sens* v 54 n 2 Feb 1988 p

217-221.

**089961 GONIOMETRIC MEASUREMENTS OF A SPRAY-PAINTED BARIUM SULFATE REFERENCE PANEL.** Goniometric measurements of a spray-painted barium sulfate reference panel were made to determine its Lambertian characteristics in the visible and near-infrared (400-1100 nm) range for zenith angles from 0° to 80°. Errors in Lambertian response varied with zenith angle and wavelength and ranged from 0 to 52% in the visible and .03 to 30% in the near-infrared. The non-Lambertian Behavior of a reference panel can cause considerable error when its radiance data is used in the calculation of reflectance factors or in the characterization of irradiance conditions. A technique to correct calculated reflectance factors of field targets collected under clear sky conditions for the non-Lambertian response of a spray-painted barium sulfate reference panel is described. (Author abstract) 8 refs.

Leshkevich, George A. (NOAA, Ann Arbor, MI, USA). *Remote Sens Environ* v 24 n 2 Mar 1988 p 287-296.

**089962 SIR-B EXPERIMENTS IN JAPAN. III. STATUS OF SIR-B DATA COLLECTION OVER JAPAN.** The STS-17/Challenger was launched on October 5, 1984 and performed a 7-day mission. In spite of many problems with the data transmitting system via TDRS, about 50 percent of the data planned for Japanese experiments was collected. The SIR-B image data which can be analyzed for the three themes proposed by RRL include two scenes for the calibration experiment, one for the rice experiment, and one for the oil-pollution experiment. (Author abstract) 11 refs.

Umehara, Toshihiko; Inomata, Hideyuki. *J Radio Res Lab (Jpn)* v 35 Special Issue n 2 Mar 1988 p 55-59.

**089963 SATELLITE DETECTION OF BLOOM AND PIGMENT DISTRIBUTIONS IN ESTUARIES.** Using a form of vector analysis of satellite spectral data, it is possible to distinguish variations in water color and pigment concentrations from changes in turbidity. In turbid water (reflectance >0.01), the orientation of a spectral vector depends predominantly on organic pigment absorption. Turbidity controls the total reflectance. A reflectance model is developed. The bias and pixel errors combined produce an error of about  $\pm 60\%$ , although bloom composition may produce some additional error. The results indicate that this method can identify blooms in estuaries where the reflectance is between 0.01 and 0.07 and, with some calibration, may provide estimates of chlorophyll for concentrations greater than 5  $\mu\text{g/L}$ . (Edited author abstract) 27 refs.

Stumpf, Richard P. (NOAA, Washington, DC, USA); Tyler, Mary A. *Remote Sens Environ* v 24 n 3 Apr 1988 p 385-404.

**089964 REMOTE SENSING AND IMAGE PROCESSING REQUIREMENTS FOR EULERIAN FLOW FIELD ESTIMATIONS.** Reported in this article are research results pertaining to an assessment of remote sensing and image processing technology for supplying useful information to numerical models which derive estimates of a hydrodynamic surface flow field. The role of remote sensing and image processing in this research is to provide time-sequential tracer distribution information over a water surface which is used as input to the flow estimating numerical model. Technical and scientific considerations concerning remote sensing tracers, platforms and sensors, as well as image processing procedures involving atmospheric corrections, geometric/radiometric processing and spatial aggregation are discussed. (Edited author abstract) 25 refs.

Stow, Douglas A. (San Diego State Univ, San Diego, CA, USA). *Int J Remote Sens* v 9 n 3 Mar 1988 p 351-364.



**089965 RADIOMETRIC CORRECTION FOR ATMOSPHERIC AND TOPOGRAPHIC EFFECTS ON LANDSAT MSS IMAGES.** This paper shows how the effects on the Landsat MSS data are estimated, allowing for the transfer theory of radiation in the atmosphere-ground system. First, the authors present the theoretical basis of the atmospheric effect correction system (AECS) which corrects for atmospheric effects on the Landsat MSS data over a flat terrain. Then the authors propose a simple radiometric correction method which can remove both the atmospheric and topographic effects from the Landsat MSS data over a rugged terrain. In addition, the authors have applied it to a mountainous test area with known digital terrain data and obtained satisfactory results. (Edited author abstract) 41 refs.

Kawata, Yoshiyuki (Kanazawa Inst of Technology, Ishikawa, Jpn); Ueno, Sueo; Kusaka, Takashi. *Int J Remote Sens* v 9 n 4 Apr 1988 p 729-748.

**089966 CROSSED ORBIT INTERFEROMETRY: THEORY AND EXPERIMENTAL RESULTS FROM SIR-B.** In a conventional imaging radar interferometer, two receiving antennas separated slightly in the cross-track direction view the same scene and altimetry information is deduced from the phase differences between the corresponding pixels in each image. It is possible to perform the same measurements with only one antenna by making two images of the scene on two separate passes; for SIR-B this involved imaging on two separate orbits. If the two orbits are parallel and separated in the cross-track direction, altitude information is derived exactly as in the two-antenna interferometer and the baseline is determined by the orbit separation. (Edited author abstract) 5 refs.

Gabriel, Andrew K. (JPL, Pasadena, CA, USA); Goldstein, Richard M. *Int J Remote Sens* v 9 n 5 May 1988 p 857-872.

**089967 CARTOGRAPHIC FEATURE EXTRACTION WITH INTEGRATED SIR-B AND LANDSAT TM IMAGES.** A digital cartographic multisensor image database of excellent geometry and improved resolution was created by registering Shuttle Imaging Radar-B (SIR-B) images to a rectified Landsat Thematic Mapper (TM) reference image and applying intensity-hue-saturation enhancement techniques. When evaluated against geodetic control, RMSE<sub>XY</sub> values of approximately  $\pm 20$  m were noted for the composite SIR-B/TM images. The completeness of cartographic features extracted from the composite images exceeded those obtained from separate SIR-B and TM image data sets by approximately 10 and 25 percent, respectively, indicating that the composite images may prove suitable for planimetric mapping at a scale of 1:100,000 or smaller. (Edited author abstract) 19 refs.

Welch, R. (Univ of Georgia, Athens, GA, USA); Ehlers, Manfred. *Int J Remote Sens* v 9 n 5 May 1988 p 873-889.

**089968 DEPENDENCE OF IMAGE GREY VALUES ON TOPOGRAPHY IN SIR-B IMAGES.** This paper focuses on the use of a high resolution digital elevation model (DEM) to aid in rectifying and enhancing synthetic aperture radar images. Using a synthetic backscatter image, the SIR-B images are manually rectified and resampled to remove geometric distortions caused by topography. In a second step, an improved reflectance function of incidence angle is derived from the DEM and the rectified image and this function is used to reduce radiometric effects of topography yielding an albedo image which clearly shows the thematic, as opposed to topographic, content of the image. (Edited author abstract) 8 refs.

Domik, G. (Vexcel Corp, Boulder, CO, USA); Leber, F.; Cimino, J. *Int J Remote Sens* v 9 n 5 May 1988 p 1013-1022.

**089969 DEMONSTRATION OF STEREOPHOTOGRAMMETRY WITH COMBINED SIR-B AND LANDSAT TM IMAGES.** Shuttle Imaging Radar-B (SIR-B) and Landsat Thematic Mapper (TM) images can be viewed stereoscopically if the illumination geometries

are compatible. To create the stereoscopic effect points must be coregistered. Simplified stereophotogrammetric equations permit the height of an object above a reference plane to be crudely calculated from the target offset toward the SIR-B radar antenna with reference to its position on a TM image. Precision is limited by pixel resolution and target correlation. Future spaceborne imaging radar missions will offer the potential for topographic mapping in many areas where TM coverage is available. (Author abstract) 12 refs.

Bloom, Arthur L. (Cornell Univ, Ithaca, NY, USA); Fielding, Eric J.; Fu, Xiu-Yen. *Int J Remote Sens* v 9 n 5 May 1988 p 1023-1038.

**089970 EFFECT OF COHERENT SCATTERING IN SPACEBORNE AND AIRBORNE SAR IMAGES.** Radar imagery obtained by the Shuttle Imaging Radar-B (SIR-B) is compared to high resolution aircraft imagery of the same urban and agricultural areas close to the city of Montreal, Canada. It is clear that the SIR-B radar is more sensitive than the aircraft radar to reflections from extended, along-track radar targets. The effect is evident for both urban and agricultural areas in which the street or field orientation is near parallel to the radar azimuth direction. It is likely that such reflectivity enhancement is due to coherent combination of the scattered field from appropriate scattering centers. The paper considers the observed phenomena and probes potential scattering models to explain the results. (Author abstract) 10 refs.

Raney, K.R. (RadarSAR Project Office, Ottawa, Ont, Can); Gray, A.L.; Princz, J.G. *Int J Remote Sens* v 9 n 5 May 1988 p 1039-1049.

**089971 USE OF VARIOGRAMS IN REMOTE SENSING: I. SCENE MODELS AND SIMULATED IMAGES.** Variograms are the tool used to link models of ground scenes to spatial variation in images. Explicit variograms are calculated for simple models of ground scenes consisting of randomly located discs on a continuous background. By incorporating the effect of the IFOV of the sensor through a process called regularization, explicit variograms for images of these scene models are derived. Verification of the explicit variograms is accomplished by simulating images that match the assumed scene model and sensor parameters and calculating empirical variograms for these images. (Edited author abstract) 27 refs.

Woodcock, Curtis E. (Boston Univ, Boston, MA, USA); Strahler, Alan H.; Jupp, David L.B. *Remote Sens Environ* v 25 n 3 Aug 1988 p 323-348.

**089972 USE OF VARIOGRAMS IN REMOTE SENSING: II. REAL DIGITAL IMAGES.** An improved understanding of the nature and causes of spatial variation in images would provide a basis for the development of new image analysis techniques that use spatial data in more logical ways. Empirically calculated variograms from real digital images demonstrate many of the findings of previous theoretical research using a disc model of scenes and simulated images including: (1) the heights of variograms are related to the density, or proportion of an area covered by objects, (2) the range of influence of a variogram is related to the size of the objects in the scene, and (3) the shape of the variogram becomes more rounded as the variance in the distribution of the sizes of objects increases. In addition, empirically calculated variograms show the periodicity in ground scenes and reveal anisotropy. (Edited author abstract) 6 refs.

Woodcock, Curtis E. (Boston Univ, Boston, MA, USA); Strahler, Alan H.; Jupp, David L.B. *Remote Sens Environ* v 25 n 3 Aug 1988 p 349-379.

**089973 PRESPECTIVE IMAGE FROM THE SPOT-1 HRV SENSOR.** It is now possible to co-register multispectral digital imagery at high spatial resolution with geographical reference data such as DEMs (Digital Elevation Model). These co-registered data sources can therefore be used to generate perspective terrain images. The multispectral imagery often contains information more representative of our visual perception of the ground

surface and therefore has great potential for modeling topography for applications such as landscape assessment and land use planning. An image was generated by registering a SPOT-1 HRV multispectral image to a DEM at a scale of 1:25000. The viewpoint was chosen in order to view vegetational trends along contours and to provide a cross-section across an area of varied relief. The I<sup>2</sup>S System 600 software includes a function which takes a single-band elevation image and a three-band color file, plots a perspective view of an elevation model and colors it. Suitable color inputs might be a multispectral image, topographic or thematic data. The user is able to specify the co-ordinates of the viewpoint (altitude, azimuth and distance), the focus of viewing and the degree of vertical exaggeration. 4 Refs.

Jones, A.R. (Inst of Terrestrial Ecology, Bangor, Wales); Settle, J.J.; Wyatt, B.K. *Int J Remote Sens* v 9 n 9 Sep 1988 p 1405-1407.

**089974 SPOT IMAGE QUALITY. TWENTY MONTHS OF EXPERIENCE.** Since SPOT is an operational and commercial remote sensing system, the quality of the data must be guaranteed during the whole satellite lifetime. Just after launch, during the so-called in-flight assessment period, the raw data quality was analyzed and the parameters for the preprocessing ground-based system were determined. Then, the quality of the preprocessed image was controlled. During the operational period, the quality of the images is periodically analyzed. The evolution of both radiometric and geometric image quality parameters since the SPOT launch is presented and discussed. (Edited author abstract) 7 Refs.

Begni, Gerard (Cent Natl d'Etudes Spatiales, Toulouse, Fr). *Int J Remote Sens* v 9 n 9 Sep 1988 p 1409-1414.

**089975 ESTIMATION OF MULTIPLE REFLECTION AND LOWEST ORDER ADJACENCY EFFECTS ON REMOTELY-SENSED DATA.** The aims of this paper are (i) to investigate the lowest-order adjacency effect and the effect of multiple reflections between the ground and the atmosphere on the Advanced Very High Resolution Radiometer (AVHRR) channel 1 and channel 2 reflectances and on the normalized difference vegetation index (NDVI) and (ii) to make a comparison between global irradiances calculated from two empirical relations, one theoretical and the other experimental. The effect of multiple reflection on each channel reflectance is about 1.2 per cent so that the NDVI is not affected by including a multiple reflection term in the atmospheric correction algorithm. The lowest-order adjacency effect in channel 1 is about 7 per cent and in channel 2 is about 5 per cent and the NDVI changes by about 0.5 per cent which is negligible. These results show that the multiple-reflection and lowest-order adjacency effects can be ignored if one is interested in the NDVI. (Edited author abstract) 11 Refs.

Singh, S.M. (Univ of Reading, Reading, Engl). *Int J Remote Sens* v 9 n 9 Sep 1988 p 1433-1450.

**089976 SPECULAR, DIFFUSE, AND POLARIZED IMAGERY OF AN OAT CANOPY.** Light, polarized by specular reflection, has been found to be an important part of the light scattered by several measured plant canopies. The authors investigate for one canopy the relative importance of specularly reflected sunlight, specularly reflected light from other sources including skylight, and diffusely upwelling light. Polarization images are used to gain increased understanding of the radiation transfer process in a plant canopy. Analysis of the results suggests that properly analyzed polarized remotely sensed data, acquired under specific atmospheric conditions by a specially designed sensor, potentially provide measures of physiological and morphological states of plants in a canopy. 30 refs.

Vanderbilt, Vern C. (Purdue Univ, West Lafayette, IN, USA); de Venecia, Kurt J. *IEEE Trans Geosci Remote Sens* v 26 n 4 Jul 1988 p 451-462.



**089977 APPLICATIONS OF MICROWAVES TO REMOTE SENSING.** Extensive theoretical studies as well as laboratory and field measurements of rough-surface scattering and emission from agricultural soil and sea surface and of volume scattering and emission from snow and vegetation yield a considerable comprehension of the interaction of microwaves with the molecular properties and the geometrical features of these media. Hence algorithms have been derived which allow the interpretation of air- and space-borne radiometer- and radar-data in terms of natural parameters. The absorption lines of atmospheric constituents in the millimeter wave range can be utilized to measure with radiometers various trace gases and other parameters, like temperature, throughout the strato- and mesosphere. Knowledge of spectroscopic parameters of the considered molecules, high spectral resolution of the measured lines and special inversion algorithms of the radiation transfer allow the determination of the height distribution of constituents and temperature with a resolution of less than 10 km. (Author abstract) 41 refs.

Schanda, Erwin (Univ of Bern, Bern, Switz). *Alta Freq* v 56 n 10 Dec 1987, 17th Eur Microwave Conf and Workshop, Sep 7-11 1987 p 399-403.

## Africa

**089978 REMOTE SENSING AND AFRICAN DEVELOPMENT PROGRAMMES.** The objective of this study is to determine the role which remote sensing can play in providing inputs into the solution of the national and regional problems which have affected the African economies the past fifteen years. Limited application of science and the low level of technology have been given among the root causes of Africa's economic problems. Lack of information and data on African member States' natural endowments continue to impede the rate of development of resources. Remote Sensing as a tool to provide the information required for rational planning and development, and control of the environment is discussed. References are made to sub-regional and regional technical co-operation ventures aimed at paving the way for provision of adequate, timely and reliable data for planning. (Edited author abstract). 3 Refs.

Adedeji, Adebayo (Economic Commission for Africa, Addis Ababa, Ethiop). *Photogrammetria* v 43 n 1 Sep 1988 p 17-24.

**Agricultural Applications** See Also AGRICULTURE—Remote Sensing; MAPS AND MAPPING; MICROWAVES—Propagation.

**089979 ANALYTICAL FRAMEWORK FOR EXTRAPOLATING EVAPORATION MEASUREMENTS BY REMOTE SENSING SURFACE TEMPERATURE.** By relating horizontal changes in evaporation to horizontal changes in surface temperature an analytical framework is formalized, by which a point measurement of evaporation can be extrapolated from a single area of uniform vegetation to a wider area of mixed vegetation. The assumptions and simplifications implicit in this technique are examined and it is shown that the relationship between the horizontal variation in evaporation and the horizontal variation in surface temperature depends strongly on the aerodynamic transfer resistance and the horizontal variation in air temperature. (Author abstract) 8 refs.

Gash, J.H.C. (Inst of Hydrology, Wallingford, Engl). *Int J Remote Sens* v 8 n 8 Aug 1987 p 1245-1249.

**089980 CANOPY REFLECTANCE OF SEVEN RANGELAND PLANT SPECIES WITH VARIABLE LEAF PUBESCENCE.** Spectroradiometric canopy light reflectance measurements of seven rangeland weed species with variable leaf pubescence characteristics were made at six wavelengths: 0.45, 0.55, 0.65, 0.85, 1.65, and 2.20  $\mu\text{m}$ . The weeds consisted of three species with dense leaf pubescence, two species with sparse pubescence, and two nonpubescent species. Field (biological) measurements were related to spectral measurements of the plant species. Discriminant and factor analysis results showed that

increased reflectance in the visible (0.45-, 0.55-, and 0.65- $\mu\text{m}$ ) wavelengths distinguished dense from sparse and nonpubescent species. (Edited author abstract) 24 refs.

Everitt, J.H. (USDA, Weslaco, TX, USA); Richardson, A.J. *Photogramm Eng Remote Sens* v 53 n 11 Nov 1987 p 1571-1575.

**089981 WHITETAIL DEER FOOD AVAILABILITY MAPS FROM THEMATIC MAPPER DATA.** A map indicating potential food availability for whitetail deer was prepared from 4 Thematic Mapper (TM) data. Land-cover information was derived from the TM data using an unsupervised classification technique, compared with digitized ground truth, and input to a Geographic Information System (GIS) the GIS delineated regions around land covers classified as escape cover, producing a 'distance map.' Relative for values assigned to the classified forage categories when combined with the 'distance map' produced the food availability map. (Edited author abstract) 16 refs.

Ormsby, James P. (NASA, Greenbelt, MD, USA); Lunetta, Ross S. *Photogramm Eng Remote Sens* v 53 n 11 Nov 1987 p 1585-1589.

**089982 INTEGRATING SPHERE TRANSMISSOMETER FOR FIELD MEASUREMENT OF LEAF TRANSMITTANCE.** A simple field-rated transmissometer is described for rapidly determining the normal hemispherical transmittance ( $T(0, 2\pi)$ ) of leaves measured in situ in the four Landsat wavelength bands. The transmissometer requires direct solar illumination of the leaf sample. It collects the transmitted light with an integrating sphere and measures the collected light using a commercially available radiometer. The transmittances determined by the transmissometer are comparable with those measured by a laboratory spectrophotometer with an integrating sphere attachment. (Author abstract) 12 refs.

Vanderbilt, C. (Purdue Univ, West Lafayette, IN, USA); DeWitt, D.P.; Robinson, B.F. *Opt Eng* v 26 n 12 Dec 1987 p 1191-1196.

**089983 CALCULATION OF CANOPY BIDIRECTIONAL REFLECTANCE USING THE MONTE CARLO METHOD.** For a calculation of the plant canopy bidirectional reflectance distribution function (BRDF) the Monte Carlo method is used. The plant architecture is given by a rather universal mathematical model which allows to consider such structural parameters as canopy density and height, the number of leaves per plant, distance between leaves dimensions and orientations of leaves and stems, etc., and their influence on the shape of the BRDF as a function of solar and view directions. To quantify these effects, a series of numerical experiments has been carried out. The information content of the BRDF about canopy architecture is the largest, if it is determined in the principal plane. (Edited author abstract) 22 refs.

Ross, J.K. (Estonian Acad of Sciences, Estonia, USSR); Marshak, A.L. *Remote Sens Environ* v 24 n 2 Mar 1988 p 213-225.

**089984 ESTIMATION OF WHEAT CANOPY RESISTANCE USING COMBINED REMOTELY SENSED SPECTRAL REFLECTANCE AND THERMAL OBSERVATIONS.** A procedure is developed for determining actual canopy resistance ( $r_c$ ) from the combined use of remotely sensed spectral reflectance and thermal observations. The procedure entails three basic steps. Attention is focused on establishing a relationship between the resistance and temperature ratios for a wheat canopy by using models to simulate canopy reflectance,  $r_{cm}$ ,  $T_p$ , and  $T_{sm}$ . The modeled relationship is found to be stable for a range of leaf area index values, meteorological conditions, and times of data acquisition and compares favorably with an empirical relationship developed using field data collected over wheat. (Edited author abstract) 24 refs.

Hope, A.S. (San Diego State Univ, San Diego, CA, USA).

*Remote Sens Environ* v 24 n 2 Mar 1988 p 369-383.

**089985 SIR-B EXPERIMENTS IN JAPAN. IV. EXPERIMENTAL RESULTS. 2. RICE CROP EXPERIMENT.** Remote sensing of rice fields in Japan was executed using a microwave imaging radar in the SIR-B experiments. Imaging data taken over the Ohgata-mura test site were analyzed to study the microwave backscattering characteristics of rice plants and crop classification. There was a difference in image intensity between the rice fields and the surrounding area. However, we found out no meaningful difference in the image intensity of the rice fields before and after harvest. Also, the correlation between the image intensity and the rice plant conditions was not clear. The investigation of crop classification also gave no significant results. The present results may be mainly attributed to the delay of the experimental term from August to October. (Edited author abstract) 6 refs.

Yoshikado, Shin; Ichinose, Masaru; Satake, Makoto. *J Radio Res Lab (Jpn)* v 35 Special Issue n 2 Mar 1988 p 77-84.

**089986 CANOPY REFLECTANCE OF SOYBEAN AS AFFECTED BY CHRONIC DOSES OF OZONE IN OPEN-TOP FIELD CHAMBERS.** The relationship between canopy reflectance and ozone ( $O_3$ ) treatment was investigated in a field experiment with soybean growing in 3-m diameter, 2.4-m high open-top exposure chambers. The objectives were to develop an understanding of the pattern of reflectance changes induced by this air pollutant and to investigate how these changes might ultimately be related to yield. Correlations were obtained between the reflectance data and visual estimates of non-green leaf area, a widely-used technique for rating pollutant injury. Correlations between the reflectance data and visual estimates of non-green leaf area were high, indicating that rates of senescence could be estimated by either means. (Edited author abstract) 20 refs.

Cure, William W. (North Carolina State Univ, Raleigh, NC, USA); Nusser, Sarah M.; Heagle, Allen S. *Photogramm Eng Remote Sens* v 54 n 4 Apr 1988 p 499-504.

**089987 RADIATIVE SURFACE TEMPERATURES OF THE BURNED AND UNBURNED AREAS IN A TALLGRASS PRAIRIE.** This study was conducted in a natural tallgrass prairie area in the Flint Hills of Kansas. Our objective was to evaluate the surface radiative temperatures of burned and unburned treatments of the grassland as a means of delineating the areas covered by each treatment. Burning is used to remove the senescent vegetation resulting from the previous year's growth. Surface temperatures were obtained in situ and by an airborne scanner. Burned and unburned grass canopies had distinctly different diurnal surface radiative temperatures. Measurements of surface energy balance components revealed a difference in partitioning of the available energy between the two canopies, which resulted in the difference in their measured surface temperatures. The magnitude of this difference is dependent on the time of measurements and topographic conditions. (author abstract) 17 refs.

Asrar, G. (Kansas State Univ, Manhattan, KS, USA); Harris, T.R.; Lapiant, R.L.; Cooper, D.I. *Remote Sens Environ* v 24 n 3 Apr 1988 p 447-457.

**089988 POTATO CROP DISTRIBUTION AND SUBDIVISION ON SOIL TYPE AND POTENTIAL WATER DEFICIT. AN INTEGRATION OF SATELLITE IMAGERY AND ENVIRONMENTAL SPATIAL DATABASE.** This study examines the use of multitemporal Landsat satellite radiance values to classify the potato crop. Using this data, the distribution and area of the crop within the Kincardine and Deeside District of Grampian Region is presented. The area and individual locations identified are found to be comparable to Department of Agriculture and Fisheries for Scotland statistical returns. The study also integrates the spatial distribution database with soil and potential water deficit data to



generate statistical information on the proportion of the potato crop growing on drought susceptible soils. (Author abstract) 16 refs.

Wright, G.G. (Macaulay Land Use Research Inst., Aberdeen, Scotl); Morrice, J.G. *Int J Remote Sens* v 9 n 4 Apr 1988 p 683-699.

**089989 MODELLING PLANTING CONFIGURATION AND CANOPY ARCHITECTURE EFFECTS ON DIURNAL LIGHT ABSORPTION CHANGES IN COTTON.** A simplified model that accounts for diurnal solar zenith and azimuth angle illumination changes and plant geometry effects on photosynthetically active radiation (PAR) was developed. Plant growth measurements estimated by the model were significantly correlated with observed measurements during crop development. Model-estimated heliographic leaf elevation trends agreed with published results for cotton canopies. APAR, relative to incident PAR, was generally lower for east-west rows than for north-south rows during crop development. (Edited author abstract) 35 refs.

Richardson, Arthur J. (USDA, Weslaco, TX, USA); Wiegand, Craig L. *Int J Remote Sens* v 9 n 4 Apr 1988 p 701-714.

**089990 ASSESSMENT AND MONITORING OF SPARSELY VEGETATED RANGELANDS USING CALIBRATED LANDSAT DATA.** Measurements of the cover of vegetation were made at a network of 58 permanent 30 ha sites within a semi-arid shrub rangeland from 1981 to 1984. These vegetation data were used to calibrate Landsat data to produce images of 'COVER', a composite variable comprising all the percentage cover of living (shrubs, grass, etc.) and non-living (litter) plant material. The complementary variable was 'BARE' soil (100 - COVER). The regression equations included only Multispectral Scanner band 5 (MSS5) and were used to generate images of COVER for the years 1981, 1982 and 1984 for each of the five major rangeland types within the 25,000 km<sup>2</sup> test area. These COVER images were incorporated into a Geographical Information System (GIS) and used to assess and monitor the behavior of individual rangeland types and pastoral properties over the 1981-1984 period which included a severe drought in 1982-3. (Edited author abstract). 24 Refs.

Graetz, R.D. (CSIRO, Lyneham, Aust); Pech, R.P.; Davis, A.W. *Int J Remote Sens* v 9 n 7 Jul 1988 p 1201-1222.

**089991 CONTINENTAL SCALE VARIABILITY IN VEGETATION REFLECTANCE AND ITS RELATIONSHIP TO CANOPY MORPHOLOGY.** We have measured the spectral canopy reflectance, biomass and projected leaf area index (LAI) of widely-dispersed plots of a North American coastal plant (salt marsh cord grass) in an attempt to identify potential impacts of continental-scale environmental variability on the assumptions underlying remote vegetation analysis. We found that important systematic changes in the canopy geometry and resultant near-infrared reflectance of this plant occurred within its 17° latitudinal range. Continental assessment of biomass using spectral indices would be severely affected by the observed differences. Use of spectral indices to assess more fundamental radiative transfer properties of the canopy, such as projected LAI, is not subject to the observed latitudinal changes, suggesting that large area studies can more reliably address canopy parameters such as adsorbed photosynthetically active radiation. The observed canopy changes also have potential functional consequences for the plant which would be of considerable ecological interest, particularly if similar trends are found for other plants and regions. (Edited author abstract). 33 Refs.

Bartlett, D.S. (NASA Langley Research Cent, Hampton, VA, USA); Hardisky, M.A.; Johnson, R.W.; Gross, M.F.; Klemas, V.K.; Hartman, J.M. *Int J Remote Sens* v 9 n 7 Jul 1988 p 1223-1241.

**089992 EVALUATION OF SINGLE-BAND-VIDEO AND VIDEO-BAND-BASED INDICES FOR GRASS-**

**LAND PHYTOMASS ASSESSMENT.** Single-band-video and video-band-based vegetation indices (composite images) were evaluated for their potential to assess phytomass production within grass plots that were fertilized with five rates of nitrogen. Eleven single-band images were acquired by equipping four black-and-white video cameras [three of them visible (0.40 to 0.70  $\mu$ m) and one visible/infrared (IR) (0.40 to 1.1  $\mu$ m) sensitive] with visible and IR narrowband filters. Thirteen vegetation indices were produced on an image processor from the various single-band (composites) images: green/red, IR/blue, IR/green, IR/yellow-green, IR/yellow, IR/orange, IR/orange-red, IR/dark orange-red, IR/red, IR/dark red, IR/deep dark red, normalized difference vegetation index (NDVI), and transformed vegetation index (TVI). Digital data were obtained from the 24 images and regressed on amounts of phytomass. (Edited author abstract). 25 Refs.

Everitt, J.H. (USDA, Weslaco, TX, USA); Escobar, D.E.; Villarreal, R. *Photogramm Eng Remote Sens* v 54 n 8 Aug 1988 p 1177-1180.

**089993 CHARACTERIZATION OF VEGETATION WITH COMBINED THEMATIC MAPPER (TM) AND SHUTTLE IMAGING RADAR (SIR-B) IMAGE DATA.** Based on TM and SIR-B image data for Fresno County, California, in October 1984, we found that the sensors provided quantitative information on the amounts of herbaceous and woody vegetation in a given field. Optical reflectance spectra responded primarily to green, foliar biomass, and L-band (23-cm) backscattering coefficients related primarily to standing, woody biomass. A simple progressive transformation of the concatenated spectra produced three continuous measures of biophysical condition, F<sub>1</sub>, F<sub>2</sub>, and F<sub>4</sub>. These indicated the percent ground cover, the green leaf-area index (or standing green biomass per unit area), and the woody biomass per unit area, respectively. (Author abstract). 12 Refs.

Paris, Jack F. (California Inst of Technology, Pasadena, CA, USA); Kwong, Helenann H. *Photogramm Eng Remote Sens* v 54 n 8 Aug 1988 p 1187-1193.

**089994 THE DERIVATION OF GLOBAL ESTIMATES FROM A CONFUSION MATRIX.** This letter suggests a way in which a confusion matrix can be used to correct image classification results to provide estimates of area statistics under different cover types. The matrix is commonly used in three ways. First, it is used to estimate the overall accuracy (or consistency with ground data) of the classification technique. Second, it is used to identify the specific errors affecting individual categories. Third, it is used to measure the extent to which the interpretation technique over- or underestimates a particular category and may therefore be used to adjust values obtained by the classification method to yield global estimates for an image. This letter proposes an alternative approach to this third use. The method has been conceived in the context of agricultural land cover categories classified on satellite sensor data but has a much wider potential relevance to many other cover mapping and estimating problems in remote sensing. (Edited author abstract). 4 Refs.

Hay, A.M. (Univ of Sheffield, Sheffield, Engl). *Int J Remote Sens* v 9 n 8 Aug 1988 p 1395-1398.

**089995 PRINCIPAL COMPONENT ANALYSIS OF AERIAL VIDEO IMAGERY.** Aerial video images of an agricultural test site were analyzed using principal component analysis and image processing techniques. The site (six treatments and four replications of cotton, sorghum, cantaloupe, johnsongrass, pigweed and soil) was imaged using blue, yellow-green, red and infrared filters over the lenses of four black-and-white video cameras on 31 May and 24 July 1983. Results indicate that the number of components required to represent the four band data sets accurately was three for the May data and two for the July data. (Edited author abstract). 12 Refs.

Kramber, W.J. (Indiana State Univ, Terre Haute, IN, USA); Richardson, A.J.; Nixon, P.R.; Lulla, K. *Int J*

*Remote Sens* v 9 n 9 Sep 1988 p 1415-1422.

**089996 EFFECTS OF SOIL MOISTURE, SURFACE ROUGHNESS, AND VEGETATION ON L-BAND EMISSION AND BACKSCATTER.** Measurements with Shuttle Imaging Radar B (SIR-B) at 1.28 GHz and an airborne multiple-beam push-broom radiometer at 1.4 GHz were made over a number of agricultural fields near Fresno, California during October 7-10, 1984. These measurements provided a unique data set for studies of microwave emission and backscatter from surfaces of various characteristics. The effects of surface roughness and vegetation (alfalfa and lettuce) were analyzed with respect to the responses of microwave emission and backscatter to soil-moisture variations. A theoretical model (Kirchhoff approximation) was used to assess these effects. It was found that for microwave emission, the effect of surface roughness is less significant compared to that of vegetation. However, the surface roughness was shown to play a dominant role compared to the vegetation cover in the microwave backscatter. The two roughness parameters in the theoretical model calculations were the surface correlation length and the standard deviation of surface height. These parameters were found to be affected strongly by the soil-texture effect in the emissivity calculations. A disagreement was found between the calculated and the observed scattering coefficients if the measured surface correlation length and standard deviation of surface height were input to the model. 27 refs.

Wang, James R. (NASA, Greenbelt, MD, USA); Engman, Edwin T.; Mo, Tsan; Schumge, Thomas J.; Shive, J.C. *IEEE Trans Geosci Remote Sens* v GE-25 n 6 Nov 1987, 1986 *Int Geosci and Remote Sens Symp (IGARSS'86) - Remote Sens - Today's Solutions for Tomorrow's Inf Needs*, Zurich, Switz, Sep 8-11 1986 p 825-833.

**Alaska** See Also MAPS AND MAPPING—Alaska.

**089997 DETECTION AND IDENTIFICATION OF ARCTIC LANDFORMS: AN ASSESSMENT OF REMOTELY SENSED DATA.** The capabilities of remote sensing data to detect landforms on the Arctic Coastal Plain of northern Alaska were investigated. The detection and identification of thaw lakes, drained lake basins, polygonal ground patterns, pingos, eolian dunes, and drainages were assessed with both airborne and satellite-acquired data. The data included Landsat Multispectral Scanner (MSS), Thematic Mapper Simulated (TMS), NS001 (similar to multispectral SPOT), Seasat, and airborne radar. The remote sensing data were digitally enhanced and compared to baseline geomorphic maps derived from aerial photography. Generally, more landforms were detected and recognized from analysis of the multispectral images than radar images because of the sensitivity of visible and infrared wavelengths to differences in vegetation and soil moisture. (Edited author abstract) 11 refs.

Dean, Kenneson G. (Univ of Alaska, Fairbanks, AK, USA); Morrissey, Leslie A. *Photogramm Eng Remote Sens* v 54 n 3 Mar 1988 p 363-371.

**Applications** See Also MAPS AND MAPPING—Design; METEOROLOGY—Clouds; METEOROLOGY—Storms; OZONE—Measurements; PETROLEUM PROSPECTING; SEAWATER—Temperature Measurement.

**089998 1986 ASPRS-ACSM FALL CONVENTION - ASPRS TECHNICAL PAPERS.** This conference proceeding contains 48 papers, 4 of which appear in abstract form only. Among the subjects covered are the following: U.S. Geological Survey's Landsat image mapping program, using Landsat imagery for development of geographic information data base, applications of photogrammetry, aerial photography, advanced image display and processing using microcomputers, and remote sensing of vegetation and terrain features using Landsat MSS digital data. Technical and professional papers from this confer-



ence are indexed and abstracted with the conference code no. 11218 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (American Soc of Photogrammetry & Remote Sensing, Falls Church, VA, USA). *Tech Pap Am Soc Photogramm Fall Tech Meet* 1986, Anchorage, AK, USA, Sep 28-Oct 3 1986. Publ by American Soc of Photogrammetry & Remote Sensing, Falls Church, VA, USA 415p.

## Australia

**089999 SIR-B STEREO-RADARGRAMMETRY OF AUSTRALIA.** We report on further results of an ongoing program of radargrammetric experimentation with Space Shuttle Imaging Radar (SIR-B) data. Six stereo models of orbits over Australia were processed in an analytical stereo plotter. Height accuracies were up to  $\pm 25$  m or 1.8 times the range resolution. This is better than in previous SIR-B stereo work, probably due to better image quality. Some inconsistencies were encountered between look angle geometries and height measurement accuracies. While general observations about earlier SIR-B stereo results were confirmed, inconsistencies with theoretical expectations could not be fully explained. (Edited author abstract) 10 refs.

Leberl, F. (Vexcel Corp, Boulder, CO, USA); Mayr, W.; Domik, G.; Kobrick, M. *Int J Remote Sens* v 9 n 5 May 1988 p 997-1011.

## Computer Applications See Also CONTROL SYSTEMS—Computer Applications.

**090000 SIMULATIONS OF DATA COMPRESSION OF SATELLITE GEOPHYSICAL DATA.** Data compression techniques are frequently discussed for data which are in the form of images. Some forms of geophysical data can be considered as matrices, similar to images. Results are shown of the effectiveness of several compression techniques on data from the plasma wave experiments flown on three scientific satellites. The use of actual data shows that an average telemetry bandwidth saving of a factor of two or three can be achieved without serious degradation. This saving can be used to increase the data quality, usually by way of improved resolution (either spectral or spatial), when regions of scientific interest are encountered. (Author abstract) 14 refs.

Gough, M.P. (Univ of Sussex, Brighton, Engl); Germon, R.; Thompson, J.A.; Wooliscroft, J.L.C. *Int J Remote Sens* v 8 n 8 Aug 1987 p 1219-1227.

**090001 EXPERT SYSTEMS AND SPATIAL DATA MODELS FOR EFFICIENT GEOGRAPHIC DATA HANDLING.** Existing geographic information systems need to be more flexible and efficient to effectively handle large quantities of spatial data acquired by remote sensing systems and from conventional map sources. Partial solutions to this problem may come from the implementation of improved spatial data models in expert systems. It is suggested that expert systems offer possibilities for making geographic information systems more efficient and user-friendly. Improved spatial data models for expert geographic information systems include hierarchical tessellation models. Research is suggested to determine the most appropriate spatial data model. (Author abstract) Refs.

Ripple, William J. (Oregon State Univ, Corvallis, OR, USA); Ulshoer, Veit S. *Photogramm Eng Remote Sens* v 53 n 10 Oct 1987 p 1431-1433.

**090002 THEMATIC MAPPER AND SPOT INTEGRATION WITH A GEOGRAPHIC INFORMATION SYSTEM.** This paper describes several integration problems and the Landsat Digital Image Analysis System (LDIAS) used at the Canada Centre for Remote Sensing (CCRS). Experiments have been conducted integrating a forestry geographic information system for the province of British Columbia with LDIAS and SPOT imagery with city information. Some of the difficulties encountered require the use of non-algorithmic solutions which use

symbolic reasoning. (Edited author abstract) 10 refs.

Goodenough, David G. (Canada Cent for Remote Sensing, Ottawa, Ont, Can). *Photogramm Eng Remote Sens* v 54 n 2 Feb 1988 p 167-176.

**090003 REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM TECHNIQUES FOR AQUATIC RESOURCE EVALUATION.** The spread of aquatic plants in Lake Marion, South Carolina, necessitated an assessment of the trends in vegetation growth and water quality. Aquatic vegetation maps at 1:10,000 and 1:24,000 scale were produced by photogrammetric techniques from color infrared aerial photographs recorded on six dates between 1972 and 1985. These and other vector map products depicting bathymetry and herbicide applications were converted to raster format (25-m grid cells) to form a cartographic database for the 170 km<sup>2</sup> study area. Statistical data on nutrients, dissolved oxygen, biological oxygen demand, and turbidity obtained from South Carolina Department of Health and Environmental Control and U.S. Environmental Protection Agency records were also input to the database. A PC-based GIS was then used to relate macrophyte distributions to environmental factors influencing aquatic plant growth. (Edited author abstract) 15 refs.

Welch, R. (Univ of Georgia, Athens, GA, USA); Remillard, M. Madden; Slack, R.B. *Photogramm Eng Remote Sens* v 54 n 2 Feb 1988 p 177-185.

**090004 REMOTE SENSING: THE UNHERALDED COMPONENT OF GEOGRAPHIC INFORMATION SYSTEMS.** The integration of descriptive and statistical data into computer based management information systems (MIS), and the subsequent planning model development utilizing operations research techniques, set the stage and provided the rationale for the establishment and maintenance of natural resource information systems as an integral part of the management function. Generally considered a product before its time, digital image processing languished as an operational tool while the supporting technologies of digital mapping and database management combined with MISs already in place to form the basis of computer-aided geographic information systems (GIS). The introduction of SPOT satellite data in the mid-80s with resolutions and capabilities more compatible with on-going GISs, and the explosive development of microcomputer technology, has provided a unique opportunity to reintroduce digital imagery. (Edited author abstract) 2 refs.

Robinson Barker, G. (SPOT Image Corp, Reston, VA, USA). *Photogramm Eng Remote Sens* v 54 n 2 Feb 1988 p 195-199.

**090005 BRIGHTNESS TEMPERATURE ALGORITHMS FOR LANDSAT THEMATIC MAPPER DATA.** Simple and accurate algorithms with appropriate parameters are presented for converting the TM-4 and TM-5 Band-6 digital numbers into brightness temperatures. These algorithms are at least by an order of magnitude more accurate than the algorithms suggested by J.C. Lansing and J.L. Barker. However, the algorithms presented in this paper are still dependent on the focal plane temperature. 7 refs.

Singh, S.M. (Univ of Reading, Engl). *Remote Sens Environ* v 24 n 3 Apr 1988 p 509-512.

**Environmental Applications See Also AGRICULTURE—Remote Sensing; COAL MINES AND MINING—Waste Disposal; RADIOMETERS—Reliability; SATELLITES—Remote Sensing; SOILS—Moisture Determination; SOILS—Sediments; WATER POLLUTION—Oil Spills.**

**090006 DERIVATION OF VEGETATION INDICES FROM AVHRR DATA.** The reliability of a 1-week composited normalized difference vegetation index has been evaluated by using a cloud-screening algorithm applied to the visible and near-infrared data from the Advanced Very High Resolution Radiometer on NOAA-9. It is found that in some areas of the U.S. Great Plains this satellite sensor product may not be reliable due

to the high frequency of cloud occurrence. Using the example of day-to-day variation in the observed clear-sky radiances for one target, the vegetation index is shown to have maxima at high off-nadir and low solar zenith angles; this behavior has been examined in detail. Some recommendations to improve the compositing technique are given. (Author abstract) 17 refs.

Gutman, George (NOAA, Washington, DC, USA). *Int J Remote Sens* v 8 n 8 Aug 1987 p 1235-1243.

**090007 GEOBOTANICAL INVESTIGATION BASED ON LINEAR DISCRIMINANT AND PROFILE ANALYSES OF AIRBORNE THEMATIC MAPPER SIMULATOR DATA.** This paper discusses the application of linear discriminant and profile analyses to detailed investigation of an airborne Thematic Mapper Simulator (TMS) image collected over a geobotanical test site. This investigation was specifically concerned with the exploitation of premature leaf senescence as an indicator of geobotanical stress. Senescence is a natural and normal aging process which occurs in leaf tissue prior to abscission from the plant. It is found that changes in canopy reflectance and thermal emittance of the deciduous flora overlying geochemically anomalous areas are consistent with the biophysical changes which are known or presumed to occur as a result of injury induced in metal-stressed vegetation. 24 refs.

Schwaller, Mathew R. (NASA, Greenbelt, MD, USA). *Remote Sens Environ* v 23 n 1 Oct 1987 p 23-34.

**090008 FRESNEL FIELD INTERACTION APPLIED TO SCATTERING FROM A VEGETATION LAYER.** Models for scattering from a vegetation layer treated as a collection of discrete scatterers usually assume far field interaction among scatterers. In a real vegetation medium such as a deciduous forest or a soybean field it is not always true that each leaf is in the far field of other leaves. This paper examines the additional effect when scatterers are permitted to be in the Fresnel zone of one another. Both disc-shaped and needle-shaped leaves are considered. It is found that in general this causes the backscattering coefficient to be lower for the disc-shaped leaves and may be higher or lower for the needle-shaped leaves depending upon polarization, incidence angle, and frequency than those computed under the assumption of conventional far field interaction. (Author abstract) 12 refs.

Fung, A.K. (Univ of Texas at Arlington, Arlington, TX, USA); Chen, M.F.; Lee, K.K. *Remote Sens Environ* v 23 n 1 Oct 1987 p 35-50.

**090009 EVALUATION OF SATELLITE DERIVED LAND COVER CHARACTERISTICS FOR GLOBAL CLIMATE MODELLING.** A preliminary evaluation of the suitability of a currently operational satellite data archive, namely the NOAA global vegetation index (GVI) product, as a basis for providing information on land cover characteristics for global climate modelling has been undertaken by comparing it to several existing data bases of soil and vegetation cover. It is found that temporal composites of GVI values often continue to change beyond the accepted compositing period of three or four weeks. In extreme cases the addition of another week to the compositing period changes over 90% of the pixels. Selection of GVI class boundaries is found to be rather hard and is probably a strong function of the classification technique employed. The resulting GVI classes are generally explicable by reference to other archival material although this study identifies some specific cases of locational divergence from 'consensus' classification. Additional aspects of the subject are discussed. (Edited author abstract) 53 refs.

Thomas, G. (Univ of Liverpool, Liverpool, Engl); Henderson-Sellers, A. *Clim Change* v 11 n 3 Dec 1987 p 313-347.



**090010 RELATIVE SENSITIVITY OF NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI) AND MICROWAVE POLARIZATION DIFFERENCE INDEX (MPDI) FOR VEGETATION AND DESERTIFICATION MONITORING.** Assuming a simple form for the relationship, a simple equation relating MPDI (Microwave Polarization Difference Index) and NDVI (Normalized Difference Vegetation Index) was derived. Comparing with actual data from Nimbus 7/SMMR at 37 GHz and NOAA/AVHRR, Channels 1 and 2, the proposed formula represents correctly the general tendency of data. It is then shown that there exists a limit characteristic of a particular type of cover which has to be analyzed, given by  $NDVI = 0.13 \pm 0.02$ , for which both indices are equally sensitive to the variation of vegetation, and below which MPDI is more efficient than NDVI. The scatter of the data around the theoretical curve obtained is briefly analyzed. It is suggested that, despite the dispersion due to the processing itself, this spreading could give some insight into the relationship between water content and chlorophyll absorption at pixel size scales. (Edited author abstract) 21 refs.

Becker, Francois (NASA, Goddard Space Flight Cent, Greenbelt, MD, USA); Choudhury, Bhaskar J. *Remote Sens Environ* v 24 n 2 Mar 1988 p 297-311.

**090011 ESTIMATING SURFACE SOIL MOISTURE FROM SATELLITE MICROWAVE MEASUREMENTS AND A SATELLITE DERIVED VEGETATION INDEX.** Normalized 18 GHz microwave brightness temperatures ( $T_B$ ) and a vegetation index were calculated from satellite radiometer data, and subsequently used in conjunction with climatically modeled surface moisture estimates to calibrate a simple physically based soil moisture model. Test sites within the U.S. Southern Great Plains were chosen for their range of climatic conditions from east to west. Normalized  $T_B$  values correlated well with soil moisture when the data were segregated by vegetation index range, but less so when all data were combined. With the introduction of a vegetation index parameter, the model accounted for approximately 70% of the variability in modeled surface soil moisture. (Edited author abstract) 33 refs.

Owe, Manfred (NASA, Goddard Space Flight Cent, Greenbelt, MD, USA); Chang, Alfred; Golus, Robert E. *Remote Sens Environ* v 24 n 2 Mar 1988 p 331-345.

**090012 MICROWAVE VEGETATION INDEX: A NEW LONG-TERM GLOBAL DATA SET FOR BIOSPHERIC STUDIES.** The feasibility of monitoring regional and global vegetation using visible and near-infrared reflectance observations by AVHRR on board NOAA satellites has been demonstrated. The difference of vertically and horizontally polarized brightness temperatures ( $\Delta T$ ) at 37 GHz frequency (wavelength about 8 mm) of the scanning multichannel microwave radiometer (SMMR) on board the Nimbus-7 satellite has been processed as monthly composites of global observations from January 1979 to December 1985. The major factor determining the magnitude of  $\Delta T$  are scattering and absorption of microwave radiation by the vegetation, but one could also see the effects of surface roughness, open water (lakes and rivers) and snow cover on the observations. The  $\Delta T$  data have been found to be highly correlated with the normalized difference vegetation index derived from AVHRR, rainfall and drought over the Sahel, seasonal variation of atmospheric  $CO_2$  concentration at Mauna Loa, land surface evaporation and primary productivity over hot arid and semi-arid regions of Africa and Australia. 3 refs.

Choudhury, Bhaskar J. *Int J Remote Sens* v 9 n 2 Feb 1988 p 185-186.

**090013 SIMULATION OF SOLAR ZENITH ANGLE EFFECT ON GLOBAL VEGETATION INDEX (GVI) DATA.** The aim of this paper is to investigate the effect of solar zenith angle on the normalized difference vegetation index (NDVI) derived from the Advanced Very High Resolution Radiometer (AVHRR) channel 1 (red) and channel 2 (near-infrared) data. The NDVI as a function of solar zenith angle are simulated for a

nadir-looking sensor. Simulation is essentially the inverse of atmospheric correction of remotely-sensed data. Calculations are made for the four surface cover types, namely, the high, moderate and low green-leaf vegetation densities and bare soils. The results show that the NDVI for bare soil remains constant for solar zenith angles up to about 60°, then decreases for solar zenith angles above this. (Edited author abstract) 10 refs.

Singh, S.M. (Univ of Reading, Reading, Engl). *Int J Remote Sens* v 9 n 2 Feb 1988 p 237-248.

**090014 RADIOMETRIC LEAF AREA INDEX.** The aim of this study was to develop a practical measure of vegetation amount that was sensitive to canopy geometry. This measure was termed the radiometric leaf area index (RLAI) and comprised measurements of leaf area index (LAI), leaf inclination or curvature and the area of the canopy visible to the sensor. RLAI, evaluated on simulated and laboratory-derived data, was sensitive to canopy geometry but, like LAI, suffered from a high measurement error. (Edited author abstract) 55 refs.

Curran, P.J. (Univ of Sheffield, Sheffield, Engl); Wardley, N.W. *Int J Remote Sens* v 9 n 2 Feb 1988 p 259-274.

**090015 EFFECT OF MEASUREMENT ERROR AND CONFUSION FROM VEGETATION ON PASSIVE MICROWAVE ESTIMATES OF SOIL MOISTURE.** When using passive microwave sensors to estimate soil moisture it is important to understand the sensitivity of the estimate to (1) the effects of confusion due to surface roughness and vegetation and (2) the effect of measurement error due to noise. The sensitivity of error in soil moisture estimates to passive microwave measurement error as a function of vegetation is presented using a simple model and measurements. Roughness confusion is not considered. The direct problem is defined as investigating the sensor response as the dependent variable to the parameter of interest while the inverse problem uses the parameter of interest as the dependent variable. The inverse method must be used for operational remote sensing applications. (Edited author abstract) 10 refs.

Theis, S.W. (Texas Instruments Inc, Dallas, TX, USA); Blanchard, A.J. *Int J Remote Sens* v 9 n 2 Feb 1988 p 333-340.

**090016 REMOTE SENSING OF SOIL MOISTURE CONTENT OVER BARE SOIL AT MICROWAVE FREQUENCIES.** Results of radiometric measurements over bare soil obtained with horizontally polarized microwave radiometers at 1.55 and 19.1 GHz are presented. The observed normalized brightness temperatures were used to estimate the soil moisture content using the radiative transfer model. It is found that the r.m.s. difference between observed and estimated soil moisture content is comparable to the standard deviation found in ground measurement of soil moisture content. (Author abstract) 10 refs.

Vyas, A.D. (Gujarat Univ, Ahmedabad, India); Trivedi, A.J.; Calla, O.P.N.; Rana, S.S.; Sharma, S.B. *Int J Remote Sens* v 9 n 2 Feb 1988 p 341-347.

**090017 DIFFERENCES IN VISIBLE AND NEAR-IR RESPONSES, AND DERIVED VEGETATION INDICES, FOR THE NOAA-9 AND NOAA-10 AVHRRs: A CASE STUDY.** This study evaluates the differences in the visible and near-IR responses of the Advanced Very High Resolution Radiometers (AVHRR) of the National Oceanic and Atmospheric Administration (NOAA)-9 and -10 satellites for coincident sample locations. The study also evaluates the differences in vegetation indices computed from those data. The data were calibrated to reflectance values with coefficients supplied by NOAA. The visible and near-IR reflectance values and the derived vegetation index values of the NOAA-9 AVHRR were usually greater than those of the NOAA-10. Visible and near-IR reflectance values exhibited trends that appeared to be related to the satellite scan angles at the examined sample locations. Linear relationships were developed between the vegetation indices of the two systems. The vegetation index values for the NOAA-9

and NOAA-10 AVHRR displayed nearly constant differences for a variety of surface features. The results suggest that, with appropriate gain and offset, the vegetation indices of the two sensor systems may be interchangeable for assessment of land surfaces. (Edited author abstract) 26 refs.

Gallo, K.P. (NOAA/NESDIS, Washington, DC, USA); Eidenshink, J.C. *Photogramm Eng Remote Sens* v 54 n 4 Apr 1988 p 485-490.

**090018 REFLECTANCE SPECTRA OF SUBARCTIC LICHENS.** Lichens constitute a major portion of the ground cover of high latitude environments, but little has been reported concerning their in situ solar spectral reflectance properties. Knowledge of these properties is important for the interpretation of remotely sensed observations from high latitude regions, as well as in studies of high latitude ecology and energy balance climatology. The spectral reflectance of common boreal vascular plants is similar to that of vascular plants of the midlatitudes. The dominant lichens, in contrast, display variable reflectance patterns in visible wavelengths. The relative reflectance peak at 0.55  $\mu m$ , common to green vegetation, is absent or indistinct in spectra of pervasive boreal forest and tundra lichens, despite the presence of chlorophyll in the inner algal cells. (Edited author abstract) 26 refs.

Petzold, Donald E. (Univ of Maryland, College Park, MD, USA); Goward, Samuel N. *Remote Sens Environ* v 24 n 3 Apr 1988 p 481-492.

**090019 USE OF DIGITAL TERRAIN DATA IN THE INTERPRETATION OF SPOT-1 HRV MULTISPECTRAL IMAGERY.** This paper describes the complementary use of digital terrain information and SPOT-1 HRV multispectral imagery for the study and mapping of semi-natural upland vegetation. A digital terrain model was derived for a 10 by 10 km study area in southern Snowdonia, Wales, and was used to generate slope and aspect images. A model was developed as a first-order approximation of changes in radiance with local topography, assuming Lambertian behavior of vegetation canopies. The model was implemented for the study area to assess its use in suppressing the effects of relief on scene radiance. Subsequently the model was refined to describe non-Lambertian reflectance. (Author abstract) 14 refs.

Jones, A.R. (NERC Remote Sensing Applications Cent, Bangor, Wales); Settle, J.J.; Wyatt, B.K. *Int J Remote Sens* v 9 n 4 Apr 1988 p 669-682.

**090020 SATELLITE DATA AND GEOGRAPHIC INFORMATION SYSTEM FOR LAND USE CLASSIFICATION.** Landsat Multispectral Scanner System (MSS) data in conjunction with the unsupervised classification technique of Earth Resources Laboratory Application Software (ELAS) were used to determine land use/land cover classifications. The Landsat computer compatible tapes (CCT) for February 9, 1976 were analyzed to spectrally classify unique land use/land cover conditions within the Econlockhatchee (Econ) River basin, Florida. The results showed that the scatter diagrams of Band 4 (0.5-0.6  $\mu m$ )-Band 7 (0.8-1.1  $\mu m$ ) and Band 4-Band 6 (0.7-0.8  $\mu m$ ) can be utilized as well as the traditional Band 5 (0.6-0.7  $\mu m$ )-Band 7 scatter diagram approach for classifying land use/land cover. Both the zoom transfer scope and the geographic information system have been demonstrated to be very useful tools for land use/land cover classification of Landsat data. (Edited author abstract) 17 refs.

Shih, Sun F. (Univ of Florida, Gainesville, FL, USA). *J Irrig Drain Eng* v 114 n 3 Aug 1988 p 505-519.

**090021 ESTIMATING SOIL WETNESS USING SATELLITE DATA.** Improved estimates of soil wetness were obtained using observations from both the NIMBUS-7 Scanning Multichannel Microwave Radiometer (SMMR) and the NOAA-7 Advanced Very High Resolution Radiometer (AVHRR). SMMR 6.6 GHz frequency, horizontal polarization, brightness temperature ( $T_{BH}$ )



was first correlated with soil wetness, as computed using an Antecedent Precipitation Index (API) model, for a number of SMMR ground resolution areas involving a fairly wide range of vegetation densities. Linear regression results were used to develop a diagnostic model for soil wetness using SMMR and AVHRR data only. The model was found to be useful in describing four levels of soil wetness as compared to three levels when vegetation was not considered. (Edited author abstract). 4 Refs.

Choudhury, Bhaskar J. (NASA, Greenbelt, MD, USA); Golus, Robert E. *Int J Remote Sens* v 9 n 7 Jul 1988 p 1251-1257.

**090022 THEORETICAL ESTIMATE OF TROPOSPHERIC WATER VAPOUR ATTENUATION AT 94GHz FROM RADIOSONDE DATA.** The attenuation of millimetre wave bands at the atmospheric window at 94 GHz originates mainly from water vapor, while the oxygen attenuation exhibits a minimum at this window. A theoretical estimate of the water vapor attenuation has been made from the radiosonde data during the MONEX (Monsoon Experiment) period by the India Meteorological Department. A monomer model is assumed here and the theoretical spectral line equation given by Croom, for water vapor, has been utilized to estimate the contribution of two adjacent water vapor lines (at 22.235 and 183.311 GHz) to the 94 GHz attenuation by an extrapolation technique. The results are discussed in the light of current knowledge of water vapor attenuation at millimetre wave bands. (Author abstract). 15 Refs.

Sen, A.K. (Inst of Radio Physics & Electronics, Calcutta, India); Karmakar, P.K.; Dev Gupta, A.K.; Mitra, A.; Sehra, J.S.; Ghosh, S.N. *Int J Remote Sens* v 9 n 7 Jul 1988 p 1259-1266.

**090023 CLOUD COVER DISTRIBUTION IN INDONESIA.** Indonesian spatio-temporal cloud cover distribution was quantified to allow planners to forecast probabilities for remote sensing data acquisition. The original data consisted of four randomly chosen Geostationary Meteorological Satellite displays per month from 1981 to 1985, which were analyzed with a microcomputer after a 1° 15' pixel size digitization. Iterative interactive factorial analyses combined with a parallelepiped classifier clustered data by grouping pixels with similar profiles. For all classes, pixel profiles were linearly combined to provide a small number of classes with high pixel-class correlations. A 0.7 correlation threshold led to 18 classes for all land areas. Statistics of Landsat and SPOT images, grouped by class, were used to verify, calibrate and improve class profiles. This led to quantified temporal profiles of probability of acquiring remotely-sensed data with a given cloud cover percentage for any Indonesian land and marine area. (Author abstract). 5 Refs.

Gastellu-Etchegorry, J.P. (Gadjah Mada Univ, Yogyakarta, Indonesia). *Int J Remote Sens* v 9 n 7 Jul 1988 p 1267-1276.

**090024 PREDICTIVE MODELS FOR REMOTELY-SENSED DATA ACQUISITION IN INDONESIA.** Indonesian spatio-temporal cloud cover distribution was quantified with the aid of Geostationary Meteorological Satellite (GMS) and Landsat data. For all land areas iterative interactive factorial analyses grouped GMS-derived pixels with similar cloud cover profiles into 18 classes. Statistics of Landsat and SPOT images, grouped by class, were used to quantify temporal profiles of probability of acquiring remotely-sensed data with 10 per cent, 20 per cent and 30 per cent cloud cover for any Indonesian land area. Analysis of the spatio-temporal characteristics of local climatic conditions permitted one to explain these profiles and to verify the validity of their seasonal variations for long periods. These profiles were fitted with a seventh-order polynomial for use in computer simulation of predictive models of remotely-sensed data acquisition. (Author abstract). 10 Refs.

Gastellu-Etchegorry, J.P. (Gadjah Mada Univ, Yogyakarta, Indonesia). *Int J Remote Sens* v 9 n 7 Jul 1988 p 1277-1294.

**090025 AIRBORNE LASER PROFILE DATA FOR MEASURING EPHEMERAL GULLY EROSION.** The feasibility of using airborne laser measurements of surface heights as a method for providing information on ephemeral gully erosion was investigated. Laser profile data were obtained over control fields with both artificial and natural gullies and recorded at 4000 pulses per second at a nominal aircraft speed of 25 meters per second and altitudes of 50 and 100 meters. A moving average filter was used to remove random noise and surface microroughness effects. Analysis of the data from the artificial and natural gully fields clearly indicated the location and cross section of gullies as small as 50 cm wide and 15 cm deep. These results demonstrated the feasibility of the approach because the tested conditions were what would be considered very small gullies. (Edited author abstract). 10 Refs.

Jackson, T.J. (USDA, Beltsville, MD, USA); Ritchie, J.C.; White, J.; LeSchack, L. *Photogramm Eng Remote Sens* v 54 n 8 Aug 1988 p 1181-1185.

**090026 COMPOSITE L-B AND HH RADAR BACKSCATTERING MODEL FOR CONIFEROUS FOREST STANDS.** The radar backscattering model developed by J.A. Richards et al. (1987) has been improved and further tested in this research. The trunk term may now be calculated from the exact solution to the electromagnetic wave equations instead of the corner reflector equation. Rough surface models have been introduced into the radar model, so that the forward reflectance and the backscattering from the ground surface are now calculated from the same model and, thus, are consistent. The simulated results show that the match of backscattering coefficients for eight forest stands between SIR-B image data and the simulated results are satisfying, and that the trunk term now seems to be convincingly established as the dominant term in the L-band HH radar return from coniferous forest stands. (Edited author abstract). 15 Refs.

Sun, Guoqing (Univ of California, Santa Barbara, CA, USA); Simonett, David S. *Photogramm Eng Remote Sens* v 54 n 8 Aug 1988 p 1195-1201.

**Equipment** See Also GLACIERS—Optical Properties; MINERALS—Spectroscopic Analysis; PHOTOGRAMMETRY—Cameras; RADAR—Applications; RADAR—Synthetic Aperture; RADAR SYSTEMS—Calibration; SPECTROMETERS—Evaluation; SPECTROSCOPY—Applications; WASTE DISPOSAL—Ocean Dumping.

**090027 APPLICABILITIES OF IMAGING RADAR FOR CLASSIFICATION OF FOREST VEGETATION.** This paper reviews woodland and agricultural aspects of land use, based on the author's experience with SEASAT-SAR, SAR-580 and SIR-B imagery. It presents potential applications as well as the limitations of the microwave remote sensing sensor for operational tasks of land-use inventory. The exclusive use of radar in woodland applications is only conceivable in cases where immediate information might be essential (e.g. forest fires, floods). Present potential use of microwave remote sensing for practical purposes is characterized by a close cooperation between radar as a 'first look instrument' and other inventory procedures (e.g. aerial photography), which work in a more detailed way. The advantage of microwave sensing is its independence of weather and illumination. (Edited author abstract). 16 Refs.

Kessler, Ralf (Univ of Freiburg, Freiburg, West Ger). *Photogrammetria* v 41 n 4 Sep 1987 p 221-232.

**090028 TRANSPORTABLE HEMISPHERICAL ILLUMINATION SYSTEM FOR MAKING REFLECTANCE FACTOR MEASUREMENTS.** An artificial source of stable, hemispherical illumination has been developed to facilitate the collection of reflectance factor measurements of targets of interest in a laboratory environment. The light source consists of a 76 cm (30 in.) aluminum hemisphere which has been coated internally with barium sulfate paint. Illumination is provided by two banks of lamps, each consisting of eight 62-W quartz halogen bulbs which have tungsten filaments. An internal baffle precludes the viewing of any direct beam of light. A

simple metal structure has been developed to hold the hemisphere and all peripheral equipment, such as spectrometers, radiometers, and cameras, in place during data collection. The entire set up can be easily disassembled and packed in airline approved shipping cases to facilitate transportation to remote laboratory facilities. (Edited author abstract). 10 Refs.

Williams, Darrel L. (NASA, Greenbelt, MD, USA); Wood, Frank M. Jr. *Remote Sens Environ* v 23 n 1 Oct 1987 p 131-140.

**090029 POTENTIAL APPLICATIONS OF DIGITAL IMAGE ANALYSIS SYSTEMS FOR DISPLAYING SATELLITE ALTIMETRY DATA.** DIPIX ARLES II and a Perceptron EASI/PACE digital image analysis systems were used for displaying geoidal and sea-surface heights. These data sets were transferred to image files for display. Black-and-white and color density slicing, and enhanced color display techniques were employed to better visualize these surfaces. An analytical relief shading program was developed to make the small local undulations in height visible. The shape and orientation of the various surfaces were compared by a differencing program specifically written for this purpose. The processing and display techniques employed offered additional capabilities in examining and interpreting the displayed surfaces. (Edited author abstract). 10 Refs.

Yazdani, Rostam (Univ of New Brunswick, Fredericton, NB, Can); Christou, Nikolaos; Derenyi, Eugene. *Photogramm Eng Remote Sens* v 53 n 11 Nov 1987 p 1545-1548.

**090030 MEASUREMENTS OF THE BACKSCATTER AND ATTENUATION PROPERTIES OF FOREST STANDS AT X-, C- AND L-BAND.** The new airborne multiband scatterometer (DUTSCAT) promises to be a useful tool for research in the field of active microwave remote sensing. An evaluation of the use of this system for research in forestry is given. Besides accurate  $\sigma^0$  values, the system can acquire information on the vertical distribution of backscattering. Through inversion of the multilevel model,  $\sigma^0$  can be divided in contributions from a number of layers (three or four). An experiment with large corner reflectors placed on the forest floor was conducted in an effort to gain more insight into the attenuating properties of the forest canopy. The measurements of attenuation properties together with the division of  $\sigma^0$  in contributions from several layers simplifies the model-construction effort considerably. (Author abstract). 8 Refs.

Hoekman, D.H. (Wageningen Agricultural Univ, Wageningen, Neth). *Remote Sens Environ* v 23 n 3 Dec 1987 p 397-416.

**090031 EXPLORATION OF CRUSTAL/MANTLE MATERIAL FOR THE EARTH AND MOON USING REFLECTANCE SPECTROSCOPY.** Near-infrared reflectance spectra have been acquired (a) for Moses Rock diatreme in SE Utah using an airborne imaging spectrometer (AIS) and (b) for small areas in and around the large lunar impact crater Copernicus using spectrometer on earth-based telescopes. The high spectral resolution and precision of these data allow several mineral components of surface material to be identified and analyzed in a spatial context. The derived mineralogical information is used to address specific geological problems. For the terrestrial study, the distribution of the measured abundance of mantle-derived ultramafic microbreccia across Moses Rock dike indicates that flow stabilized into a few channels during the violent eruption. (Edited author abstract). 52 Refs.

Pieters, Carle M. (Brown Univ, Providence, RI, USA); Mustard, John F. *Remote Sens Environ* v 24 n 1 Feb 1988 p 151-178.



**090032 AIS RADIOMETRY AND THE PROBLEM OF CONTAMINATION FROM MIXED SPECTRAL ORDERS.** Airborne Imaging Spectrometer data from Mono Lake, CA, are studied in order to establish the spectral radiance of test areas under solar illumination. The objective is to provide a method of atmospheric correction for major absorbers from the spectrometer data themselves. Crucial to the analysis is radiometric calibration of the instrument. Good agreement is found between calculated and measured radiances for uniform surface targets (beaches), but simulations of atmospheric properties with LOWTRAN 6 lead to unreasonably low values of atmospheric precipitable water. Absorptions from carbon dioxide are not detected in the AIS data, but are strongly present in the LOWTRAN 6 model. The apparent low contrast of all atmospheric absorption bands leads to a study of contamination from overlapping spectral orders in the AIS data. (Edited author abstract) 18 refs.

Conel, J.E. (JPL, Pasadena, CA, USA); Adams, S.; Alley, R.E.; Hoover, G.; Schultz, S. *Remote Sens Environ* v 24 n 1 Feb 1988 p 179-200.

**090033 SELECTING THE SPATIAL RESOLUTION OF SATELLITE SENSORS REQUIRED FOR GLOBAL MONITORING OF LAND TRANSFORMATIONS.** The spatial resolutions of the next generation of sensors for the global monitoring of vegetation is assessed with particular reference to the proposed Moderate Resolution Imaging Spectrometer (MODIS). The main innovative use of such instruments will lie in their ability to monitor land transformations at global and continental scales. Reliable monitoring is shown to rely on the success with which the changes in the phenomena being analyzed can be separated from other temporal changes. Depending on the type of spatial change being monitored, sensor properties such as accuracy of registration, resolution and radiometric sensitivity are shown to have greatest importance. (Edited author abstract) 46 refs.

Townsend, J.R.G. (Univ of Reading, Reading, Engl); Justice, C.O. *Int J Remote Sens* v 9 n 2 Feb 1988 p 187-236.

**090034 INTEGRATED CAMERA AND RADIOMETER FOR AERIAL MONITORING OF VEGETATION.** The design requirements for a broad-band red and near infrared radiometer for monitoring vegetation from a light aircraft are discussed and an instrument which incorporates these characteristics, called an integrated camera and radiometer (ICAR), is described. It consists of two downward-looking, spectral radiometers and a solar radiometer coupled with a 35 mm camera and a data-logger in a convenient payload for mounting in a light aircraft. The distinctive features of the ICAR are the synchronization of the camera and radiometers, the equivalence and acts as a programmable data-logger. (Edited author abstract) 24 refs.

Prince, S.D. (Queen Mary Coll, London, Engl); Willson, P.J.; Hunt, D.M.; Halstead, P. *Int J Remote Sens* v 9 n 2 Feb 1988 p 303-318.

**090035 TWO ADAPTIVE FILTERS FOR SPECKLE REDUCTION IN SAR IMAGES BY USING THE VARIANCE RATIO.** This paper presents some experimental results on the properties of image speckle along with two adaptive filters that are useful for speckle reduction. An investigation of available SIR-B digital image data over Australia shows that speckle is non-white Gaussian noise and fits a multiplicative noise model in which the noise, uncorrelated with signal, has a mean of 1 and a constant standard deviation. The non-uniform spectrum can be represented by an empirical formula. Based on these results, two adaptive filters have been designed, a moving average filter and a combined moving median filter. (Edited author abstract) 28 refs.

Li, Changle (Univ of New South Wales, Kensington, Aust). *Int J Remote Sens* v 9 n 4 Apr 1988 p 641-653.

**090036 DETERMINATION OF THE VERTICAL PATTERN OF THE SIR-B ANTENNA.** Determination of the antenna pattern is important for a spaceborne

Synthetic Aperture Radar such as Shuttle Imaging Radar-B (SIR-B). For SIR-B the antenna was so large that apart from one section, no complete pattern could be measured on the ground. Attempts were made to measure the pattern while the shuttle was in space by using ground receivers and active radar calibrators. The method used and described is a supplement to these measurements. The vertical pattern of an antenna can be extracted from radar signals returned from regions whose scattering coefficients versus incidence angle characteristics are suitably flat and uniform. The method used here shows that the main vertical lobe of the SIR-B antenna is slightly wider than previously reported. (Edited author abstract) 7 refs.

Moore, Richard K. (Univ of Kansas, Lawrence, KS, USA); Hemmat, Mehrzad. *Int J Remote Sens* v 9 n 5 May 1988 p 839-847.

**090037 RADIOMETRIC CALIBRATION ANALYSIS OF SIR-B IMAGERY.** The second flight of the NASA Spaceborne Imaging Radar (SIR-B) collected nearly 8 hours of digital synthetic-aperture radar (SAR) data of the Earth's surface. This paper analyzes the performance of the SAR to determine the accuracy of the relative radiometric calibration of these data. Procedures are presented for deriving accuracy estimates as well as limitations under which these estimates are valid. The impact on calibration of an RF breakdown in the primary antenna feed system cable is evaluated. An analysis of the platform stability based on the SAR echo data is also presented in conjunction with its resultant effect on the calibration accuracy. Finally, numerical error bounds are derived with guidelines on their utilization. (Author abstract) 24 refs.

Wall, Stephen D. (JPL, Pasadena, CA, USA); Curlander, John C. *Int J Remote Sens* v 9 n 5 May 1988 p 891-906.

**090038 COMPARATIVE EVALUATION OF THE LARGE FORMAT CAMERA, METRIC CAMERA, AND SHUTTLE IMAGING RADAR-A DATA CONTENT.** Large Format Camera (LFC) photography, Metric Camera (MC) photography, and Shuttle Imaging Radar-A (SIR-A) data were evaluated on their thematic contents in satisfying the requirements for topographic mapping at 1:100,000 scale. The study area of Mobile, Alabama-Pensacola, Florida was selected because of the availability of these three types of images. It was found that the LFC photography, while suffering from geometric inaccuracy due to its use of forward motion compensation and a 23 by 46-cm format, provided nearly complete areal features and a sufficient amount of linear features for topographic mapping. (Edited author abstract) 12 refs.

Lo, C.P. (Univ of Georgia, Athens, GA, USA). *Photogram Eng Remote Sens* v 54 n 6 pt 1 Jun 1988 p 731-742.

**090039 PROCEDURES FOR USING SIGNALS FROM ONE SENSOR AS SUBSTITUTES FOR SIGNALS OF ANOTHER.** Long-term monitoring of surface conditions may require a transfer from using data from one satellite sensor to data from a different sensor having different spectral characteristics. Two general procedures for spectral signal substitution are described in this paper, a principal-components procedure and a complete multivariate regression procedure. They are evaluated through a simulation study of five satellite sensors (MSS, TM, AVHRR, CZCS, and HRV). For illustration, they are compared to another recently described procedure for relating AVHRR and MSS signals. The multivariate regression procedure is shown to be best. TM can accurately emulate the other sensors, but they, on the other hand, have difficulty in accurately emulating its shortwave infrared bands (TM5 and TM7). (Author abstract) 6 Refs.

Suits, G. (Environmental Research Inst of Michigan, Ann Arbor, MI, USA); Malia, W.; Weller, T. *Remote Sens Environ* v 25 n 3 Aug 1988 p 395-408.

**090040 NAVIGATION OF AVHRR IMAGERY.** The NOAA series of satellites are launched in almost circular, Sun-synchronous polar orbits at an altitude of about 850

km above Earth. One of the most important instruments on board these satellites is the Advanced Very High Resolution Radiometer (AVHRR) whose data is transmitted to ground along with much other data using the spacecraft's High Resolution Picture Transmission Link. The method described is designed to work at any time after data reception, i.e. it can be used to navigate imagery which has been achieved. It can be used with sectorized images and essentially the technique described provides an overlay which under program control merges with the image to produce an accurately gridded product on a photo-facsimile machine. 7 Refs.

Brush, R.J.H. (Univ of Dundee, Dundee, Scotl). *Int J Remote Sens* v 9 n 9 Sep 1988 p 1491-1502.

**090041 DUT AIRBORNE SCATTEROMETER.** An airborne scatterometer system operating at six frequencies simultaneously between 1 and 18 GHz has been developed for the measurement of the microwave scattering of vegetation, forests, sea and other targets. After a description of the instrument, some C- and L-band results are presented. The system is described and means for data processing are discussed. 6 refs.

Snoeijs, Paul (Delft Univ of Technology, Delft, Neth); Swart, Peter J.F. *Int J Remote Sens* v 8 n 11 Nov 1987, Int Symp on Microwave Signatures in Remote Sensing, Goteborg, Swed, Jan 19-22 1987 p 1709-1716.

**090042 VERY ACCURATE C-BAND NOISE SCATTEROMETER/RADIOMETER SYSTEM.** A combined noise scatterometer/radiometer operating in the C-band is described. The radiometer is of the noise-injection type, achieving a high degree of accuracy and stability (better than 0.5 deg K). The noise scatterometer is based on design techniques normally only found in the realm of radiometers, and, through this, extraordinary stability is ensured (better than 0.03 dB). The instrument is intended for precise comparison of brightness temperatures and backscatter coefficients. (Author abstract) 5 refs.

Skou, Niels (Technical Univ of Denmark, Lyngby, Den). *Int J Remote Sens* v 8 n 11 Nov 1987, Int Symp on Microwave Signatures in Remote Sensing, Goteborg, Swed, Jan 19-22 1987 p 1717-1723.

**Imaging Techniques** See Also IMAGE PROCESSING; IMAGE PROCESSING—Image Analysis; RADIOMETERS—Design.

**090043 SINGLE-SOURCE THREE-DIMENSIONAL IMAGING SYSTEM FOR REMOTE SENSING.** A recent development in three-dimensional imaging is the application of VISIDEP technology to surveillance and reconnaissance. The results of efforts to develop a single-source system using a moving platform are reported. These tests demonstrate the feasibility of such a system. Although film was used to achieve the present results, electronic imaging can be used to generate near-real-time three-dimensional video images with delays of less than 3 s. With the continued development of high density video and digital imaging, improved image resolution is achievable. The theoretical basis, testing results, and projections for future development are presented. Potential applications and expectations are discussed. (Edited author abstract) 21 refs.

McLaurin, A. Porter (Univ of South Carolina, Columbia, SC, USA); Jones, Edwin R.; Cathey, LeConte. *Opt Eng* v 26 n 12 Dec 1987 p 1251-1256.

**090044 APPLICATION OF PERCEPTUAL COLOR SPACES TO THE DISPLAY OF REMOTELY SENSED IMAGERY.** An attempt is made to show how perceptually uniform color spaces can improve significantly the interpretability of displays and remotely sensed geoscientific imagery. A computational framework encompassing the mapping of data into perceptually uniform color spaces is presented, and practical application of this framework to various types of geophysical data is described. Applications include the depiction of informative data variables in specified lightness and saturation



ranges, the effective utilization of chromatic contrast in multispectral data displays, and representations of more complex integrated data sets. 32 refs.

Robertson, Philip K. (Cent for Spatial Information Systems, Canberra, Aust); O'Callaghan, John F. *IEEE Trans Geosci Remote Sens* v 26 n 1 Jan 1988 p 49-59.

**090045 OBJECT-ORIENTED FEATURE EXTRACTION METHOD FOR IMAGE DATA COMPACTION.** A novel, online, unsupervised feature-extraction method for high-dimensional remotely sensed image data compaction is proposed. This method is directed at the reduction of data redundancy in the scene representation of satellite-borne, high-resolution multispectral sensor data. The algorithm partitions the observation space into an exhaustive set of disjoint objects, and pixels belonging to each object are characterized by an object feature. The set of object features, rather than the pixel features, is used for data transmission and classification. Illustrative examples of high-dimensional image data compaction are presented, and the feature representation performance is investigated. Example results show an average compaction coefficient of more than 25 to 1 when this method is used; the classification performance is improved slightly by using object features rather than the original data, and the CPU time required for classification is reduced by a factor of more than 25 as well. The feature extraction CPU time is less than 15% of CPU time for original data classification. 10 refs.

Ghassemian, Hassan (Purdue Univ, West Lafayette, IN, USA); Landgrebe, David A. *IEEE Control Syst Mag* v 8 n 3 Jun 1988 p 42-48.

India See BAUXITE DEPOSITS—India.

**Instruments** See Also ICE—Measurements; RADIOMETERS—Calibration; SATELLITES—Instruments; SENSORS—Calibration; SOILS—Moisture Determination.

**090046 SOME USEFUL OBSERVATIONS IN THE ANALYSIS OF BRIGHTNESS TEMPERATURE DATA ACQUIRED BY THE BHASKARA-II SATELLITE MICROWAVE RADIOMETER (SAMIR) SYSTEM.** The second Indian remote sensing satellite Bhaskara-II has three microwave radiometers operating at 19.35, 22.235 and 31.4 GHz. Brightness temperature ( $T_B$ ) data have been acquired by these radiometers during the period from December 1981 to July 1983 comprising 325 passes. The ground resolution of these radiometers is about 125 km circular diameter. These data have the highest potentiality for the use in sea, land- and snow-/ice-based studies. A considerable amount of work has been carried out by the Indian scientists using these data and a lot more will follow. In view of this, an attempt is made in this paper to summarize some of the useful observations regarding the reliability and nature of the data. These observations can be useful guidelines in the interpretation of  $T_B$  data. (Author abstract) 16 refs.

Rao, K.S. (Indian Inst of Technology, Bombay, India); Mohan, B.K.; Narasimha Rao, P.V.; Karale, R.L. *Int J Remote Sens* v 8 n 10 Oct 1987 p 1523-1530.

**090047 PRINCIPLES OF FIELD SPECTROSCOPY.** Field spectroscopy involves the study of the interrelationships between the spectral characteristics of objects and their biophysical attributes in the field environment. In this article the principles of the subjects are explained and its historical development reviewed with reference to the instruments and methods adopted. Field spectroscopy has a role to play in at least three areas of remote sensing. Firstly, it acts as a bridge between laboratory measurements of spectral reflectance and the field situation and is thus useful in the calibration of airborne and satellite sensors. Secondly, it is useful in predicting the optimum spectral bands, viewing configuration and time to perform a particular remote sensing task. Thirdly, it provides a tool for the development, refinement and testing of models relating biophysical attributes to remotely-sensed data. (Edited author abstract) 117 refs.

Milton, E.J. (Univ of Southampton, Southampton, Engl). *Int J Remote Sens* v 8 n 12 Dec 1987 p 1807-1827.

**090048 MICROLIGHT AIRCRAFT FOR RADIO-METRIC SURVEYING APPLIED TO LAND RESOURCES ASSESSMENT AND MONITORING IN MALI (WEST AFRICA).** A microlight aircraft has been used to obtain and record concurrent, near-continuous, spectral responses in the MSS and SPOT bands over various ground features. The experiment was performed in Mali, along the Niger River, during November, 1985. The airborne instrumentation, developed as a prototype for this experiment, also included flying-height measurements by a laser range-finder and a color video-camera. Spectral data and flying height (5 to 80 m) were scanned over 0.1 s and recorded on the audio channel of a videotape, after multiplexing and analog to digital conversion (8 channels). It is concluded that the measuring and recording system, although light and simple, proved to be very efficient for automatic survey in a tropical environment; spectral reflectance profiles are feasible in a very short time over a wide range of objects; and microlight aircraft are proving to be highly suitable as platforms for low-cost aerial survey including large-scale photography and complementary to conventional methods. (Edited author abstract). 6 Refs.

Gregoire, J.-M. (Commission of the European Communities, Ispra, Italy); Hubaux, A.; Zeyen, R. *Photogrammetria* v 43 n 1 Sep 1988 p 37-44.

**Laser Applications** See Also INFRARED IMAGING; LASERS—Applications; LASERS, SOLID STATE—Q Switching; SEAWATER—Surfaces.

**090049 STATISTICAL PARAMETERS OF THE REFLECTED SIGNAL IN LASER SEA SURFACE SENSING.** A study is made of the conditions for the formation of the reflected signal in laser sea surface sensing. Two limiting cases are considered: the far zone and the near zone. (Author abstract) 11 refs.

Grigor'ev, P.V.; Lomonosov, A.M.; Solntsev, M.V. *Bull Acad Sci USSR Phys Ser* v 51 n 2 1987, Proc of the Twelfth All-Union Conf on Coherent and Nonlinear Opt, Moscow, USSR, Aug 26-29 1985 p 1-5.

## Mathematical Models

**090050 SIMPLE MODEL TO ESTIMATE THE DAILY VALUE OF THE REGIONAL MAXIMUM EVAPOTRANSPIRATION FROM SATELLITE TEMPERATURE AND ALBEDO IMAGES.** We have tried an adaptation of the radiation model proposed by FAO, applicable in any area, for the estimation of the regional maximum evapotranspiration, ET, from temperature and albedo images obtained from a satellite. This model is based on the relationships derived. By applying this model to the Valentian Region (Spain) we have obtained an estimation of the maximum daily evapotranspiration to an accuracy of 20 percent. (Edited author abstract) 44 refs.

Caselles, V. (Univ of Valencia, Valencia, Spain); Delegido, J. *Int J Remote Sens* v 8 n 8 Aug 1987 p 1151-1162.

**090051 APPLICABILITY OF PHYSICAL OPTICS THIN PLATE SCATTERING FORMULAS FOR REMOTE SENSING.** The authors evaluate the applicability of simple formulas for scattering from flat plates that were developed using an extended physical optics (PO) procedure. These formulas take on especially simple forms (denoted here as TPO) when the plates are electrically very thin. The authors consider circular plates (disks) and show that when the radius-to-thickness ratio ( $a/t$ ) is large, the TPO formulas give accurate backscatter cross sections for all incidence angles. The PO formulas are not usable for angles of incidence near or at edge-on to the flat surfaces of the disk. On the other hand, complex polarization rate information is lost with TPO. It has been argued elsewhere that TPO should hold even for electrically small disks provided  $a/t$  is large. The authors show here that TPO gives results accurate (with some exceptions) to approximately 4% when  $a/t$  approximately 200 for Rayleigh disks. These results are obtained primarily by comparing TPO computational results with an exact numerical procedure. 12 refs.

Willis, Thomas M. (Univ of Michigan, Ann Arbor, MI, USA); Weil, Herschel; Le Vine, David M. *IEEE Trans Geosci Remote Sens* v 26 n 2 Mar 1988 p 153-160.

**090052 MODELING THE GAP PROBABILITY OF A DISCONTINUOUS VEGETATION CANOPY.** A model is presented for the gap probability of a discontinuous vegetation canopy, such as forest, savanna, or shrubland. The case in which the distribution of individual canopy sizes and shapes is known and individual canopies are randomly distributed but do not overlap, and the case in which the canopies do intersect and/or overlap such that foliage density remains constant within the overlap area are both considered, although an exact solution is provided only for the latter. A comparison of modeled gap probabilities with observed gap probabilities for a Maryland (US) pine stand (as taken from the literature) shows good agreement for zenith angles of illumination up to about 45°. Above 45°, the fit worsens, presumably because the horizontal branch structure of the pine canopy is less attenuating as the illumination angle approaches the horizon. Two simple indexes that are functions of leaf area index, leaf angle distribution, and count density (number per square unit of area) and size (base radius and height) of plant canopies (assumed to be spherical or ellipsoidal) are also derived. These are used to determine which conditions are to be considered. 20 refs.

Li, Xiaowen (Chinese Acad of Sciences, Beijing, China); Strahler, Alan H. *IEEE Trans Geosci Remote Sens* v 26 n 2 Mar 1988 p 161-170.

**090053 INTERNATIONAL SYMPOSIUM ON MICROWAVE SIGNATURES IN REMOTE SENSING.** This conference proceedings contains 12 papers. Individual papers are abstracted and indexed separately. Topics covered include: a scattering model for conducting random surfaces; approximate model for microwave brightness temperature of the sea; remote sensing of wave patterns; wind-fetch dependence of Seasat scatterometer measurements; microwave signatures of snow crusts; modelling of radar backscattering from low-salinity ice; interpretation of Seasat radar-altimeter data over sea ice; measurement of backscatter from conifers; multi-band-scatterometer data analysis of forests; the DUT airborne scatterometer; and, a very accurate C-band noise scatterometer/radiometer system. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11030 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Askne, J. (Ed.) (Chalmers Univ of Technology, Dep of Radio & Space Lab, Goteborg, Swed). *Int J Remote Sens* v 8 n 11 Nov 1987, Int Symp on Microwave Signatures in Remote Sensing, Goteborg, Swed, Jan 19-22 1987 p 1579-1723.

**090054 SCATTERING MODEL FOR PERFECTLY CONDUCTING RANDOM SURFACES: I. MODEL DEVELOPMENT.** The standard integral equation for the surface current is solved iteratively to obtain an estimate of the surface current on a perfectly conducting randomly rough surface. The far-zone scattered fields and the backscattering coefficients for vertical, horizontal and cross-polarizations are then computed using this current estimate. The polarized backscattering coefficients are explicit functions of the surface parameters and reduce to the Kirchhoff solution in the high-frequency region and to the first-order perturbation solution in the low-frequency region. (Edited author abstract) 29 refs.

Fung, A.K. (Univ of Texas at Arlington, Arlington, TX, USA); Pan, G.W. *Int J Remote Sens* v 8 n 11 Nov 1987, Int Symp on Microwave Signatures in Remote Sensing, Goteborg, Swed, Jan 19-22 1987 p 1579-1593.

**090055 SCATTERING MODEL FOR PERFECTLY CONDUCTING RANDOM SURFACES: II. RANGE OF VALIDITY.** By following an approach similar to that of C. Efthimiou, a condition for the validity of the approximate surface current density has been found. The condi-



tion indicates that the surface current is accurate in both the high- and the low-frequency regions and also in the intermediate-frequency region. Although the condition was derived from a particular correlation function, it should be indicative of the general case because all realistic correlation functions are monotonically decreasing and the rate of descent is controlled by the correlation parameter. 8 refs.

Pan, G.W. (South Dakota State Univ, Brookings, SD, USA); Fung, A.K. *Int J Remote Sens* v 8 n 11 Nov 1987, Int Symp on Microwave Signatures in Remote Sensing, Goteborg, Swed, Jan 19-22 1987 p 1595-1605.

**090056 APPROXIMATE MODEL FOR THE MICROWAVE BRIGHTNESS TEMPERATURE OF THE SEA.** A modified two-scale model is proposed for scattering and emissivity calculations for certain classes of random rough surfaces. It is based on an approach by M.L. Burrows and by G.S. Brown, but it has been extended to bistatic scattering by lossy dielectric surfaces, and it incorporates modified Fresnel reflection coefficients and a simple correction for multiple-scattering effects. The method is shown to be applicable to the ocean surface for light and moderate winds. A contracted form of the radiative-transfer equation is proposed and the included Wentz correction for surface scattering is discussed. This could lead to a method that could be both simple and accurate enough for real-time inversion algorithms in microwave remote sensing. (Author abstract) 30 refs.

Guissard, A. (Univ Catholique de Louvain, Louvain-la-Neuve, Belg); Sobieski, P. *Int J Remote Sens* v 8 n 11 Nov 1987, Int Symp on Microwave Signatures in Remote Sensing, Goteborg, Swed, Jan 19-22 1987 p 1607-1627.

**090057 REMOTE SENSING OF WAVE PATTERNS WITH OCEANOGRAPHIC IMPLICATIONS.** First, a general review is presented of wave-current interaction processes (for horizontal shears) and their effect on radar backscatter and radar imagery (SAR/RAR). Then numerical results on the refraction of wave energy trajectories by complex bottom topography (finite depth) and a linear shear current are presented. For deep water, the wave-energy trajectories are given for mesoscale currents (e.g. eddies and double-vortex configurations). The focusing of wave energy by variable currents should have important influence on the spatial scale of wind stress over the ocean, and on optical and acoustic properties of the upper layer of the ocean. (Author abstract) 22 refs.

Sheres, David (US Naval Research Lab, Washington, DC, USA); Chen, Davidson T.; Valenzuela, Gaspar R. *Int J Remote Sens* v 8 n 11 Nov 1987, Int Symp on Microwave Signatures in Remote Sensing, Goteborg, Swed, Jan 19-22 1987 p 1629-1640.

**090058 MODELLING OF RADAR BACKSCATTERING FROM LOW-SALINITY ICE WITH ICE RIDGES.** Radar backscattering from a snow-free ice surface characterized by an exponential correlation function is studied for conditions typical in the Baltic Sea. The C-band backscattering coefficient from first-year ice is normally found to be characterized primarily by the air-ice surface roughness. However, if the salinity and temperature are low, as in the Baltic Sea, both volume scattering and ice-water surface scattering might contribute. Even more important than scattering from the level ice is scattering from the ice ridges, and a simple approach is taken to characterize the properties of ice ridges and the corresponding scattering. (Author abstract) 12 refs.

Johansson, Roland (Chalmers Univ of Technology, Goteborg, Swed); Askne, Jan. *Int J Remote Sens* v 8 n 11 Nov 1987, Int Symp on Microwave Signatures in Remote Sensing, Goteborg, Swed, Jan 19-22 1987 p 1667-1677.

**Measurements** See Also RADAR SYSTEMS—Millimeter Waves; SOILS—Moisture; SOILS—Moisture Determination.

**090059 EMISSIVITIES OF QUARTZ AND SAHARA DUST POWDERS IN THE INFRARED REGION (7-17  $\mu$ m).** Emissivities of quartz and Sahara dust

powders are computed in the infrared wavelength region (7-17  $\mu$ m) by the doubling method, together with those of a plane surface. The effect of particle size on emissivities is evaluated. A cloudy atmosphere model is used for radiative transfer in condensed powders, where a size distribution of powders is given. Particle sizes are enlarged 2, 20, and 200 times for a comparison purpose. Sahara dust powders show rather small emissivity change with particle size in comparison with that of quartz powders. These results may be used for the further development of remote sensing techniques applied to surface emissivity measurements. (Edited author abstract) 14 refs.

Takashima, T. (Meteorological Research Inst, Tsukuba, Jpn); Masuda, K. *Remote Sens Environ* v 23 n 1 Oct 1987 p 51-63.

**090060 DIRECTIONAL REFLECTANCE FACTOR DISTRIBUTIONS FOR TWO FOREST CANOPIES.** Directional reflectance factor distributions were measured over one pine (*Pinus silvestris*) and one spruce stand (*Picea abies*), with sun elevations in the range 30-50°. Measurements were made from a helicopter at 200 m altitude, using a handheld radiometer with wavelength bands centered at 0.68, 0.85, and 1.6  $\mu$ m. Assuming bilateral symmetry, only one half of the hemisphere was measured, with 45° azimuthal and 15° zenithal increments, up to 60° off-nadir. Both stands showed a highly anisotropic reflectance especially in the red band and less pronounced differences in the 0.85  $\mu$ m band. It was found that at 27° off-nadir in a WNW direction the reflectance increased by a factor of up to 1.6, as compared to nadir measurement. (Edited author abstract) 12 refs.

Kleman, Johan (Univ of Stockholm, Stockholm, Swed). *Remote Sens Environ* v 23 n 1 Oct 1987 p 83-96.

**Microwaves** See ICE—Remote Sensing.

**Millimeter Waves**

**090061 MILLIMETERWAVE NETWORK ANALYZER BASED SCATTEROMETER.** The Millimeterwave Polarimeter (MMP) is a network-analyzer-based scatterometer and reflectometer system that has been developed in support of a program to characterize radar clutter at 35, 94, and 140 GHz. A Hewlett-Packard 8510A network analyzer is used in the MMP system as a signal conditioner and processor to facilitate real-time data reduction, to reduce the short time-delay leakage noise inherent in traditional FM/CW radar, and to further enhance the signal-to-noise ratio of the system through signal processing techniques. Operation of the system at millimeter wavelengths is achieved with upconversion and harmonic downconversion. The use of harmonic downconverters permits low-frequency signal connections between components of the system and allows easy reconfiguration in either scatterometer, bistatic, or reflection/transmission modes. 3 refs.

Ulaby, Fawwaz T. (Univ of Michigan, Ann Arbor, MI, USA); Haddock, Thomas F.; East, Jack R.; Whitt, Michael W. *IEEE Trans Geosci Remote Sens* v 26 n 1 Jan 1988 p 75-81.

**Monitoring** See FORESTRY—Remote Sensing.

**Multispectral Scanners** See Also AGRICULTURE—Remote Sensing; COASTAL ZONES—Remote Sensing; FORESTRY—Remote Sensing; GLACIERS—Remote Sensing; IMAGE PROCESSING; IMAGE PROCESSING—Remote Sensing; INFORMATION RETRIEVAL SYSTEMS—Nonbibliographic; IONOSPHERE—Measurements; MAPS AND MAPPING; MAPS AND MAPPING—Borneo; RADAR IMAGING; SATELLITES; SENSORS—Design.

**090062 USING LANDSAT MULTISPECTRAL SCANNER DATA TO ESTIMATE SUSPENDED SEDIMENTS IN MOON LAKE, MISSISSIPPI.** Suspended sediments are a major factor affecting water quality in many aquatic ecosystems. Research was undertaken to determine the application of digital spectral data collected by the multispectral scanner (MSS) on the Landsat satellite for estimating suspended sediments in aquatic ecosystems where mean annual concentrations of

suspended sediments are greater than 50 mgL<sup>-1</sup>. This study showed that digital spectral data from the Landsat satellites can be used to locate and monitor surface-suspended sediments in aquatic ecosystems. With such a digital computer technique, entire regions can be surveyed quickly to locate aquatic ecosystems with suspended sediment problems. (Edited author abstract) 46 refs.

Ritchie, Jerry C. (USDA, Beltsville, MD, USA); Cooper, Charles M.; Jiang, Yongqing. *Remote Sens Environ* v 23 n 1 Oct 1987 p 65-81.

**090063 COMPARISON OF LANDSAT MSS PIXEL ARRAY SIZES FOR ESTIMATING WATER QUALITY.** A problem in the analyses of Landsat Multispectral Scanner (MSS) data is sampling pixels representative of the area being used for calibration. This study reports the analyses of different size pixel arrays for estimating water quality variables. Nested arrays of pixels with sizes of 5 by 5, 3 by 3, and 2 by 2, and the single center pixel of the 5 by 5 array were sampled at five different locations in the lake where water quality variables had been measured. Fourteen Landsat scenes for the period between January 1983 and June 1985 were analyzed. Analysis of variance (ANOVA) found no significant differences in mean pixel values due to the size of the pixel arrays. (Edited author abstract) 20 refs.

Ritchie, Jerry C. (USDA, Beltsville, MD, USA); Cooper, Charles M. *Photogramm Eng Remote Sens* v 53 n 11 Nov 1987 p 1549-1553.

**090064 AIRCRAFT MSS DATA REGISTRATION AND VEGETATION CLASSIFICATION FOR WETLAND CHANGE DETECTION.** Portions of the Savannah River floodplain swamp were evaluated for vegetation change using high resolution aircraft multispectral scanner (MSS) data. Image distortion from aircraft movement prevented precise image-to-image registration in some areas. However, when small scenes were used, a first-order linear transformation provided registration accuracies of less than or equal to one pixel. A larger area was registered using a piecewise linear method. Five major wetland classes were identified and evaluated for change. Phenological differences and the variable distribution of vegetation limited wetland type discrimination. Using unsupervised methods and ground-collected vegetation data, overall classification accuracies ranged from 84 per cent to 87 per cent for each scene. Results suggest that high-resolution aircraft MSS data can be precisely registered, if small areas are used, and that wetland vegetation change can be accurately detected and monitored. (Edited author abstract) 31 refs.

Christensen, E.J. (EG&G Energy Measurements Inc, Las Vegas, NV, USA); Jensen, J.R.; Ramsey, E.W.; Mackey, H.E. Jr. *Int J Remote Sens* v 9 n 1 Jan 1988 p 23-38.

**090065 FORECASTING PATTERNS OF SOIL EROSION IN ARID LANDS FROM LANDSAT MSS DATA.** The model is based on the erosion cell mosaic approach and exploits the high degree of temporal and spatial autocorrelation in the erosion process on flat alluvial plains. The model used for forecasting change is a first-order simultaneous autoregressive (s.a. r.) process which can reproduce changes in mean, variance and spatial autocorrelation. This model expresses each pixel value as a function of those of its neighbors plus a noise term. The forecasting procedure involves fitting a s.a. model to an area, obtaining the values of the underlying pattern (noise) series by inverse filtering and then obtaining a forecast by filtering the underlying pattern series using a prototype s.a. model for a more (or less) degraded state. (Edited author abstract) 16 refs.

Pickup, G. (CSIRO, Alice Springs, Aust); Chewings, V.H. *Int J Remote Sens* v 9 n 1 Jan 1988 p 69-84.

**090066 AUSTRALIAN LANDSAT STATION AT X-BAND.** The ALS/CSIRO Signal Processing Experiment was devised to gain experience in the acquisition and processing of high-quality-image data from the thematic



mapper on the Landsat V satellite. These data are relayed to earth on an 8212.5 MHz radio link at a rate of 85 Mb s<sup>-1</sup>. The ALS 9.14-m-diameter antenna at Alice Springs is currently being modified by CSIRO to allow collection of these data on an experimental basis. The changes necessary and the expected system performance of the modified antenna are outlined. The aim was to obtain design and fabrication experience with a minimum of cost and with no impact on the normal MSS operations of ALS. Design was based on a two-year lifetime and is far from an operational system. (Author abstract) 20 refs.

Cooper, D.N.; Parsons, B.F.; Moore, G.G.; Kennedy, R.A.; James, G.L.; Wilcockson, B.; van der Meulen, G.C.J. *J Electr Electron Eng Aust* v 7 n 4 Dec 1987 p 285-294.

**090067 INTERANNUAL LANDSAT-MSS REFLECTANCE VARIATION IN AN URBANIZED TEMPERATE ZONE.** The focus of this work is to assess the possibility of using Landsat satellite data for the quantitative parametrization of land-surface properties and to track the temporal variability of these same parameters over the past 10 years. The results show that, for the Montreal study area, the yearly mean albedo underwent a significant decreasing trend (-0.05) since 1972 due to processes of urbanization, deforestation, and decreasing farmland. The effects of these respective land-surface alterations are discussed. For the whole data base, the year-to-year NVI fluctuations correlate with the cumulative amount of summer precipitation which in turn is related to the mean summer evapotranspiration and global solar radiation. (Edited author abstract) 43 refs.

Royer, Alain (Univ de Sherbrooke, Sherbrooke, Que, Can); Charbonneau, Lise; Teillet, Philippe M. *Remote Sens Environ* v 24 n 3 Apr 1988 p 423-446.

**090068 IMPROVED DARK-OBJECT SUBTRACTION TECHNIQUE FOR ATMOSPHERIC SCATTERING CORRECTION OF MULTISPECTRAL DATA.** An improved dark-object subtraction technique is demonstrated that allows the user to select a relative atmospheric scattering model to predict the haze values for all the spectral bands from a selected starting band haze value. The improved method normalizes the predicted haze values for the different gain and offset parameters used by the imaging system. Examples of haze value differences between the old and improved methods for Thematic Mapper Bands 1, 2, 3, 4, 5, and 7 are 40.0, 13.0, 12.0, 8.0, 5.0, and 2.0 vs. 40.0, 13.2, 8.9, 4.9, 16.7, and 3.3, respectively, using a relative scattering model of a clear atmosphere. In one Landsat multispectral scanner image the haze value differences for Bands 4, 5, 6, and 7 were 30.0, 50.0, 50.0, and 40.0 for the old method vs. 30.0, 34.4, 43.6, and 6.4 for the new method using a relative scattering model of a hazy atmosphere. (Edited author abstract) 20 refs.

Chavez, Pat S. Jr. (US Geological Survey, Flagstaff, AZ, USA). *Remote Sens Environ* v 24 n 3 Apr 1988 p 459-479.

**090069 SPECTRAL-TEMPORAL INDICES FOR DISCRIMINATION.** Multi-temporal data from a spacecraft typically involve a number of spectral bands recorded at a number of overpasses or times. Canonical variates for discrimination between a number of groups are derived when the same discriminant coefficients for bands (i.e. spectral indices) are assumed to hold for all times. The calculations reduce to simultaneous between-groups to within-groups analyses of a linear combination of bands and a linear combination of times. The approach is discussed in the context of a study of crop discrimination using Landsat MSS data. (Author abstract) 7 refs.

Campbell, N.A. (CSIRO, Wembley, Aust); Kiiveri, H.T. *Appl Stat* v 37 n 1 1988 p 51-62.

**090070 DIRECTED BAND RATIOING FOR THE RETENTION OF PERCEPTUALLY-INDEPENDENT TOPOGRAPHIC EXPRESSION IN CHROMATICITY-ENHANCED IMAGERY.** Enhancements

of multispectral imagery, intended for visual interpretation of geological information, are typically designed to increase the discriminability of band-variant surface reflectance features. Band ratioing has been commonly used for this purpose with various degrees of success. A disadvantage of band ratioing has been the loss of topographic expression and surface albedo information or, in some cases, the perceptual convolution of both topographic expression and albedo information with band-variant reflectance information. (Edited author abstract) 18 refs.

Crippen, Robert E. (JPL, Pasadena, CA, USA); Blom, Ronald G.; Heyada, Jan R. *Int J Remote Sens* v 9 n 4 Apr 1988 p 749-765.

**090071 NON-PARAMETRIC TEST OF OVERLAP IN MULTISPECTRAL CLASSIFICATION.** Difficulties are encountered when a pixel may be assigned to more than one class according to the information gleaned from training sets. The following question arises: Is there real overlap or are the training sets spectrally discrete? A general algorithm is presented which quantifies the degree of overlap of classes defined by training sets drawn from an image. Test results show that age classes within a forest plantation are spectrally discrete, even though poor classification accuracies were obtained using conventional classifiers. (Edited author abstract) 5 refs.

Skidmore, A.K. (Australian Natl Univ, Canberra, Aust); Forbes, G.W.; Carpenter, D.J. *Int J Remote Sens* v 9 n 4 Apr 1988 p 777-785.

**090072 ARTIFICIAL GCPs IN AIRCRAFT AND SATELLITE SCANNER IMAGERY.** Results are presented of an experiment to determine the feasibility of providing artificial ground control points (GCPs) for controlling geometrical rectification procedures which are necessary to correct airborne scanner data and satellite imagery. These tests suggest that if proper consideration is given to the various factors governing the detectability of targets, more accurate ground control may be provided. (Author abstract) 20 refs.

Chisholm, N.W.T. (Univ Coll of Wales, Aberystwyth, Wales); Collin, R.L. *Int J Remote Sens* v 9 n 4 Apr 1988 p 799-821.

**090073 ETUDE GEOGRAPHIQUE DE LA COTE NORD DU SENEGAL A PARTIR DES DONNEES SATELLITAIRES MOMS-1.** [Geographic Study of the North Coast of Senegal Obtained from Satellite MOMS-1]. A discussion is presented of the basic characteristics of the MOMS (Modular Optoelectronic Multispectral Scanner) system (ground resolution 20 × 20m), the operations undertaken and the photographic and digital products resulting from them. Then, after a description of the types of landscapes and their evolution, the data-procedures are discussed: histogram production; mathematical transformations for smoothing; automatic detection of landscape-boundaries based on their luminance values by Sobel non-linear filtering; calculation of indices representing ground brilliance and classification; cartographic expression of the results. (Edited author abstract) 13 refs. In French.

Diaw, A.T. (CNRS, Dakar, Senegal); Joly, G. *Bull Soc Fr Photogramm Teledetect* n 108 1987 p 5-23.

**090074 LOW-LEVEL SEGMENTATION OF MULTISPECTRAL IMAGES VIA AGGLOMERATIVE CLUSTERING OF UNIFORM NEIGHBOURHOODS.** A segmentation approach based on the concept of unsupervised classification of pixels is presented. Mean feature vectors of the classes are obtained from agglomerative-type clustering of the feature values computed over uniform neighbourhoods. Two assumptions are made in this development. The first is that at least one uniform neighbourhood can be found for each of the different categories present in the image. The second is that feature vectors of neighbourhoods representative of a particular category are similar to each other, but different from those of neighbourhoods belonging to other categories. The scheme has been applied to the segmentation of a

three-band multispectral image of a terrain with satisfactory results. The method is computationally efficient, and requires minimal memory; hence it can be used in real time. (Author abstract). 14 Refs.

Amadasun, M. (Imperial Coll of Science & Technology, London, Engl); King, R.A. *Pattern Recognit* v 21 n 3 1988 p 261-268.

**090075 CALCULATION OF RADIANT SENSITIVITY FOR SPACE-BOURNE MULTISPECTRAL SCANNER.** Calculation of radiant sensitivity for a space-borne multispectral scanner is presented. The calculating method of radiant sensitivity and the principle of design for the scanner are given. (Author abstract). 4 Refs. In Chinese.

Xinzhai, Han (Harbin Inst of Technology, China). *Hong-wai Yanjiu A-ji* v 7A n 3 1988 p 213-217.

**090076 BATHYMETRY STUDIES ON THE COASTAL WATERS (RED SEA) OF JEDDAH, SAUDI ARABIA, USING SHUTTLE MOMS-01 DATA.** MOMS (Modular, Optoelectronic Multispectral Scanner) data recorded from the Space Shuttle flight STS-7 have been used to investigate water depths in the Red Sea in the vicinity of Jeddah, Saudi Arabia. An exponential relationship between pixel intensity (digital number) and water depth was observed. However, the r.m.s. deviation of the fit of the data to control points from the hydrographic charts for the area was about 3.7 m which is much too large for operational bathymetric work. The reason for this is the low sensitivity of the instrument and the non-suitability of the spectral bands. (Edited author abstract). 4 Refs.

Cracknell, A.P. (Univ of Dundee, Dundee, Scotl); Ibrahim, M. *Int J Remote Sens* v 9 n 6 Jun 1988 p 1161-1165.

**090077 DETECTION OF FOREST CHANGE IN THE GREEN MOUNTAINS OF VERMONT USING MULTISPECTRAL SCANNER DATA.** This study evaluates the potential of Landsat Multispectral Scanner (MSS) data to monitor long term changes in high-elevation coniferous forests. August 1973 and 1984 MSS data from the Green Mountains of Vermont were used. Following co-registration and standardization of data sets, color density slices of 0.75 µm and 0.95 µm band difference images were produced. False color composites using either (a) the 1973 0.65 µm and 0.75 µm band in conjunction with the 0.75 µm band difference data set or (b) the 1973 0.65 µm and 0.95 µm band in conjunction with the 0.95 µm band difference data set, were also produced. It is believed that the reflectance decreases noted for the high-elevation coniferous forests are related to the forest decline process and are associated with reduction in green leaf biomass and/or the increased levels of mortality and higher amounts of dead branches accompanying this reduction in biomass. (Edited author abstract). 25 Refs.

Vogelmann, James E. (Univ of New Hampshire, Durham, NH, USA). *Int J Remote Sens* v 9 n 7 Jul 1988 p 1187-1200.

**090078 SELECTING A SPATIAL RESOLUTION FOR ESTIMATION OF PER-FIELD GREEN LEAF AREA INDEX.** For any application of multispectral scanner (MSS) data, a user is faced with a number of choices concerning the characteristics of the data; one of these is their spatial resolution. A pilot study was undertaken to determine the spatial resolution that would be optimal for the per-field estimation of green leaf area index (GLAI) in grassland. By reference to empirically-derived data from three areas of grassland, the suitable spatial resolution was hypothesized to lie in the lower portion of a 2-18 m range. To estimate per-field GLAI, airborne MSS data were collected at spatial resolutions of 2 m, 5 m and 10 m. The highest accuracies of per-field



GLAI estimation were achieved using MSS data with spatial resolutions of 2 m and 5 m. (Author abstract). 16 Refs.

Curran, Paul J. (Univ of Sheffield, Sheffield, Engl); Williamson, H. Dawn. *Int J Remote Sens* v 9 n 7 Jul 1988 p 1243-1250.

**090079 HIGH RESOLUTION OF COLOR COMPOSITE IMAGE FROM SPOT AND LANDSAT DATA.** The Landsat/TM (thematic mapper) has 7 bands. It can make 7 images with 7 TM bands and do multispectral imaging. The resolution of the Landsat/TM is 30 m. The resolution of the Spot/HRV (High Resolution Visible Imaging System)/P mode is 10 m and that image is very clear. But the Spot/HRV P mode has only 1 band and it cannot make color images. The authors succeeded in creating new multispectral color images with a resolution of 10 m from Landsat/TM and Spot/HRV. The requirements for the color image composition are (1) spectral patterns of images of Landsat and Spot are the same, or (2) the two spectral patterns are not the same but the distribution of the space patterns is the same. (Edited author abstract). 2 Refs. In Japanese.

Oshima, Taichi; Sakai, Yoshiki; Ohike, Kouji. *Bull Coll Eng Hosei Univ* n 24 Mar 1988 p 79-86.

**090080 AUTOMATIC CONTROL OF IMAGE SIGNAL OF MSS.** A method is presented to transform the image signal into a reasonable distribution. About 98.76% of the image signal is fully distributed over the A/D converting range. The data transmitting efficiency is greatly increased. The proportion of the image data in the whole data flow is increased from 55% to 89%. The hardware system and control program are also developed to implement this method, and some experimental results are given. (Author abstract). 2 Refs. In Chinese.

Quan, Hong (Acad Sinica, Shanghai, China); Xue, Yongqi; Shen, Mingming. *Hongwai Yanjiu A-ji* v 7A n 4 1988 p 251-258.

**090081 EFFECTIVE RESOLUTION ELEMENT OF LANDSAT THEMATIC MAPPER.** As part of the U.K.'s contribution to NASA's Landsat Image Data Quality Analysis (LIDQA) program the system performance of the Thematic Mapper (TM) scanner has been studied by the determination of the Effective Resolution element (ERE), a measure of its spatial resolution. In this paper, an estimate of the ERE has been determined from a simulation of the spatial responses of the Primary Focal Plane (PFP) detectors, bands 1-4, of both Landsat-4 and Landsat-5 and from image-derived values using a band 4 Landsat-5 TM scene of the U.K. A value derived by spatial response simulation of the Landsat-4 MSS near-infrared (NIR) detectors, band 4, was also determined for comparative purposes, but as yet no values have been produced for either TM scanner to cover the detectors on the Cold Focal Plane (CFP), bands 5-7. (Edited author abstract). 17 Refs.

Wilson, Andrew K. (NERC Computer Services, Swindon, Engl). *Int J Remote Sens* v 9 n 8 Aug 1988 p 1303-1314.

**090082 EFFECT DE LE RESOLUTION SPATIALE SUR DES PROPRIETES STATISTIQUES DES IMAGES SATELLITES: UNE ETUDE DE CAS.** [Effect of Spatial Resolution on the Statistical Properties of Satellite Images: A Case Study.]. The AVHRR instrument on board the NOAA satellites has a very high repetitivity but a very low spatial resolution. In our research we proposed to monitor the normalized vegetation index with this low-resolution instrument. It is therefore of interest to examine the relations between high- and low-resolution images for using the AVHRR data as a means of interpolation between two MSS images. This problem is addressed here using satellite images of an important agricultural region in France. The effect on the higher-order statistical properties is studied through the transformation of the images' textures by progressively degrading the MSS images. It is shown that a threshold, which depends on the scene, exists on the resolution below which all statistical information disappears. (Edited au-

thor abstract). 10 Refs. In French.

Kong, Xiang Ning (CNET, Moulinaux, Fr); Vidal-Mijar, Daniel. *Int J Remote Sens* v 9 n 8 Aug 1988 p 1315-1328.

**090083 SEGMENTATION OF REMOTELY-SENSED IMAGES BY A SPLIT-AND-MERGE PROCESS.** A system for the segmentation and region-based classification of remotely-sensed imagery has been developed and tested. The segmentation process involves a split-and-merge algorithm and a quadtree data structure. Both the segmenter and the classifier utilize texture information. Experimental classification results show that the method can lead to an improvement in average performance (AP), and a corresponding reduction in average confusion (AC). The segmentation requires substantial computation and the setting of the segmentation parameters is also fairly tedious (though some means of automating this should be possible). However, for many applications the increase in classification accuracy achievable may make these limitations acceptable. 16 Refs.

Cross, A.M. (Univ of Reading, Reading, Engl); Mason, D.C. *Int J Remote Sens* v 9 n 8 Aug 1988 p 1329-1345.

**090084 MODEL-BASED REMOTELY-SENSED IMAGERY INTERPRETATION.** We present a model-based remotely-sensed image interpretation expert system embedded in a knowledge-based geographic information system (KBIS). The KBIS consists of four sub-systems: a pictorial data base system, an image interpretation expert system, a computer-aided planning system, and a computer-aided cartographic system. The image interpretation expert system represents ecological knowledge and other expert knowledge by frames. Its reasoning process consists of a forward reasoning based on the Bayes classification of Landsat imagery, a backward reasoning using frame knowledge and reasoning using a spatial consistency model. A forest inventory study was conducted in Shaxian county, in the southern part of China, using this expert system. The results have shown a significant improvement. Building image interpretation expert systems within knowledge-based pictorial systems is very convenient and efficient because there are well-organized data, knowledge and procedures available. (Author abstract). 6 Refs.

Wu, Jian-Kang (Univ of Science & Technology of China, Hefei, China); Cheng, Dou-Shen; Wang, Wen-Tao; Cai, Deng-Lin. *Int J Remote Sens* v 9 n 8 Aug 1988 p 1347-1356.

**090085 ALGORITHM FOR AUTOMATIC ATMOSPHERIC CORRECTIONS TO VISIBLE AND NEAR-IR SATELLITE IMAGERY.** An algorithm is developed for automatic atmospheric correction of satellite imagery of the Earth's surface. The algorithm is based solely on the satellite image being corrected and on climatology of the area. It is applicable to low resolution (1 km field of view) and high resolution (10-80 m field of view) imagery of land areas for the solar spectrum. The algorithm requires that some pixels in the image will correspond to dense dark vegetation as the surface cover. Once the presence of such pixels is established, the algorithm automatically chooses these pixels, derives the atmospheric optical thickness (a measure of the amount of haze) and corrects the image. The correction algorithm was applied to clear and hazy Landsat Multispectral Scanner images of the same area in the Washington D.C. and the Chesapeake Bay region. The algorithm, in its present form, can be applied to satellite imagery that includes at least two channels in the visible part of the spectrum, preferably blue and red. (Edited author abstract). 42 Refs.

Kaufman, Yoram J.; Sendra, Claudia. *Int J Remote Sens* v 9 n 8 Aug 1988 p 1357-1381.

**090086 DETECTION OF CIRCULAR GEOLOGICAL FEATURES USING THE HOUGH TRANSFORM.** The Hough transform is a technique commonly used in the field of computer vision for detecting lines and shapes in digital imagery. The application of this method

to the detection of circular geological structures in Landsat Multispectral Scanner imagery is described. The method was successful in identifying most of these features apparent to the human analyst, in addition to a number of errors of commission. It is proposed that the error rate is tolerable for this particular application. (Author abstract). 6 Refs.

Cross, A.M. (Univ of Reading, Reading, Engl). *Int J Remote Sens* v 9 n 9 Sep 1988 p 1519-1528.

**090087 SOME RESULTS OF A MOS - 1 AIRBORNE VERIFICATION EXPERIMENT - MULTISPECTRAL ELECTRONIC SELF - SCANNING RADIOMETER (MESSR).** The Marine Observation Satellite-1 (MOS-1) was launched on February 19, 1987. In order to develop the distortion correction methods for MOS-1 data and the evaluation methods for the MOS-1 earth observation system, the National Space Development Agency of Japan (NASDA) conducted a MOS-1 airborne verification experiment in Kanto and Hokkaido, Japan in 1984 and 1985 by using three airborne sensors equivalent in performance to MOS-1 sensors in collaboration with many related agencies. The airborne MESSR is a multispectral electronic self-scanning radiometer developed by modifying an engineering model of the MOS-1 MESSR, which is capable of observing in visible and near-infrared wavelengths with CCD detector elements. Some results from the airborne MESSR are presented. 5 refs.

Maeda, Korehiro (Nat'l Space Development Agency, Jpn); Kojima, Masahiro; Azuma, Yoshio. *IEEE Trans Geosci Remote Sens* v GE-25 n 6 Nov 1987, 1986 Int Geosci and Remote Sens Symp (IGARSS'86) - Remote Sens - Today's Solutions for Tomorrow's Inf Needs, Zurich, Switz, Sep 8-11 1986 p 788-795.

**090088 TRANSFORMATION FOR ORDERING MULTISPECTRAL DATA IN TERMS OF IMAGE QUALITY WITH IMPLICATIONS FOR NOISE REMOVAL.** A transformation known as the maximum noise fraction (MNF) transformation, which always produces new components ordered by image quality, is presented. It can be shown that this transformation is equivalent to principal components transformations when the noise variance is the same in all bands and that it reduces to a multiple linear regression when noise is in one band only. Noise can be effectively removed from multispectral data by transforming to the MNF space, smoothing or rejecting the most noisy components, and then retransforming to the original space. In this way, more intense smoothing can be applied to the MNF components with high noise and low signal content than could be applied to each band of the original data. The MNF transformation requires knowledge of both the signal and noise covariance matrices. Except when the noise is in one band only, the noise covariance matrix needs to be estimated. One procedure for doing this is discussed and examples of cleaned images are presented. 6 refs.

Green, Andrew A. (CSIRO, North Ryde, Aust); Berman, Mark; Switzer, Paul; Craig, Maurice D. *IEEE Trans Geosci Remote Sens* v 26 n 1 Jan 1988 p 65-74.

**090089 ATMOSPHERIC EFFECT ON SPECTRAL SIGNATURE - MEASUREMENTS AND CORRECTIONS.** Measurements of the atmospheric effect on the spectral signature of surface cover were conducted during hazy conditions over the Chesapeake Bay and its eastern shore. In the experiment the upward radiance was measured by an airborne scanning radiometer in nine spectral bands between 465 and 773 nm, above and below the haze layer. Simultaneous measurements of the aerosol optical thickness and its vertical distribution were conducted. The results of the measurements are used to study the spectral dependence of the atmospheric effect on remote sensing of water bodies and vegetated fields (forest, corn field, and pasture), and to verify theoretical predictions. It is suggested that the radiances over dark areas (e.g., water in the near IR and forest in the visible) can be used to derive the aerosol optical thickness as is



done over oceans with the CZCS satellite images. Combined with climatological information, the derived optical thickness can be used to perform corrections of the atmospheric effect. Examples of the derivation of the aerosol optical thickness and correction of the upward radiances are given. 28 refs.

Kaufman, Yoram J. (NASA, Greenbelt, MD, USA). *IEEE Trans Geosci Remote Sens* v 26 n 4 Jul 1988 p 441-450.

Nigeria See URBAN PLANNING—Remote Sensing.

## Noise, Spurious Signal

**090090 NOISE REMOVAL FOR SPOT HRV IMAGERY.** SPOT HRV imagery acquired in 'double' mode displays near vertical striping occurring every seven or eight pixels in the down-track scan direction. Six digital image restoration procedures have been examined for suppressing or removing this noise. Image restoration by filtering in the spatial frequency domain was found to be the most effective procedure. However, although less effective at noise removal, a simple median filtering procedure could be used with greatly reduced computational cost. (Author abstract) 9 refs.

Quarby, N.A. (Univ of Reading, Reading, Engl). *Int J Remote Sens* v 8 n 8 Aug 1987 p 1229-1234.

## Norway

**090091 FJORD TEST - NAVSTAR GPS.** Parts of Norway have very narrow fjords and sounds with high, steep sides. In such places the NAVSTAR-GPS signals periodically will enter the mountain shadow in relation to vessels in the fjord. When the signal is thus occluded there is a theoretical possibility that the GPS receiver may pick up a reflection of the signal from the opposite mountain wall and use it in its navigational calculations. This presents a hazard, especially at times of poor visibility. It is therefore important to determine whether this problem is merely a theoretical possibility or whether it must be taken into account when navigating by GPS. This article presents a test to investigate this problem. (Author abstract) In Norwegian.

Ekseth, Roger (Norwegian Mapping Authority, Stavanger, Norw). *Kart Plan* v 47 n 5 Nov 1987 p 483-487.

## Research

**090092 NUMERICAL DERIVATION OF A HYDRODYNAMIC SURFACE FLOW FIELD FROM TIME SEQUENTIAL REMOTELY SENSED DATA.** This paper reports research findings involving the development and initial testing of a unique methodology which combines numerical fluid dynamics modeling and remote sensing techniques to derive surface flow information for a hydrodynamic region. The methodology is unique in that it involves an inverse model of hydrodynamic tracer conservation which utilizes tracer information derived from remote sensing and subsequent image processing to generate a surface flow field. The flow field is generated in a Eulerian framework—that is, the flow is described at fixed points in space over the entire field. A numerical model based on a two-dimensional tracer conservation equation is developed and tested with simulation maps of time varying tracer distributions. The model derives a solution of the stream function (i.e., flow) field by solving a finite difference version of a partial differential conservation equation. (Edited author abstract) 28 refs.

Stow, Douglas A. (San Diego State Univ, San Diego, CA, USA). *Remote Sens Environ* v 23 n 1 Oct 1987 p 1-22.

**090093 POSSIBLE TECHNIQUES FOR LITHOLOGIC DISCRIMINATION USING THE SHORT-WAVELENGTH-INFRARED BANDS OF THE JAPANESE ERS-1.** The possible techniques for lithologic discrimination using sensor data with the short-wavelength-infrared (SWIR) bands of the Japanese ERS-1 satellite were examined in a preliminary manner prior to its expected operation in 1991. Reflectance data

of typical minerals and rocks measured by the IRIS spectroradiometer were used in the examination to simulate hypothetical sensor response patterns prior to actual measurements by the satellite sensor. Two indices corresponding to the response patterns of alunite and calcite are proposed as to be useful for discrimination of the minerals and the rock types. (Edited author abstract) 24 refs.

Yamaguchi, Yasushi (Geological Survey of Japan, Tsukuba, Jpn). *Remote Sens Environ* v 23 n 1 Oct 1987 p 117-129.

**090094 SEMIVARIOGRAM IN REMOTE SENSING: AN INTRODUCTION.** The Earth's surface and remotely sensed imagery contain spatial information that, if quantified, could be used to optimize many sampling procedures in remote sensing. Until recently a suitable and simple technique for the spatial characterization of surfaces was not readily available. Due to the development of regionalized variable theory there is a near-ideal tool, the semivariogram. The semivariogram is a function that relates semivariance to sampling lag. This function can be estimated using remotely sensed data or ground data and represented as a plot that gives a picture of the spatial dependence of each point on its neighbor. This paper provides an introduction to the semivariogram and indicates how it could be employed in remote sensing research. (Edited author abstract) Refs.

Curran, Paul J. (Univ of Sheffield, Sheffield, Engl). *Remote Sens Environ* v 24 n 3 Apr 1988 p 493-507.

## Scandinavia

**090095 SCANDINAVIAN ACTIVITIES IN THE LIS/GIS AREA.** Before a Land or Geographic Information System (LIS/GIS) can be fully utilized for planning and decision making, an integrated database must be developed. The Scandinavian countries are currently building geocoded record keeping systems concerning population, property, topography, and tax records. As these national computerized databases near completion, their immediate and potential usefulness is quickly becoming apparent at all levels of government and industry. Sizable investment, however, are required in order to implement and operate a large LIS/GIS. In addition, datasets are often duplicated for use in different systems or are simply incompatible. Major cost reduction benefits, therefore, can only be realized by standardizing database content and format and by encouraging cooperation and exchange of data between the agencies concerned with their maintenance and use. (Author abstract) 9 refs.

Andersson, Ulf (Nat Land Survey, Gavle, Swed); Rystedt, Beng. *Photogramm Eng Remote Sens* v 54 n 2 Feb 1988 p 201-204.

## Sensors

**090096 SIR-B EXPERIMENTS IN JAPAN. II. SURFACE ACTIVITY. 1. SENSOR CALIBRATION EXPERIMENT. a. DISUSED AKITA AIRPORT TEST SITE.** A sensor calibration experiment was proposed as part of SIR-B experiments in Japan, together with the rice crop experiment and the ocean oil-pollution detection experiment. This sensor calibration experiment was intended (1) to establish a transfer function from image data to radar backscattering characteristics, (2) to evaluate 3-dB resolutions, (3) to verify the ability to resolve two closely-spaced targets, and (4) to clarify sidelobe structures due to range and azimuth compressions. The disused Akita Airport was chosen as the main test site for the calibration experiment on the first three objectives. This paper describes the test site, the design of the corner reflectors, and briefly predicts the results. (Author abstract) 10 refs.

Ichinose, Masaru; Echizenya, Yoshimatsu; Kamata, Mitshiro; Kawai, Eiji; Hiromoto, Norihisa; Uratsuka, Seiho; Fujita, Masaharu. *J Radio Res Lab (Jpn)* v 35 Special Issue n 2 Mar 1988 p 3-10.

**090097 SIR-B EXPERIMENTS IN JAPAN. II. SURFACE ACTIVITY. 1. SENSOR CALIBRATION**

**EXPERIMENT. b. SAROBETSU WILD-LAND TEST SITE.** In the SIR-B calibration experiment to establish the SIR-B transfer function, to evaluate the 3-dB resolutions, and to check the SIR-B ability to resolve two closely-spaced targets, two test sites were chosen in addition to the main test site at the disused Akita Airport. The other sites were chosen to evaluate the influence of background clutter on the apparent imaging characteristics of SIR-B. These two test sites were Sarobetsu wild-land in Hokkaido, and Yamagawa Port and Yamagawa Radiowave Observatory, Radio Research Laboratory in Kagoshima. This paper describes the ground activity at the Sarobetsu test site. Conditions at the test site are described as well as the arrangement and setting of corner reflectors as standard radar reflectors. Anticipated results by SIR-B imaging are also discussed. (Author abstract) 4 refs.

Naito, Hideyuki; Okamoto, Satoshi; Shiro, Isao; Fujita, Masaharu. *J Radio Res Lab (Jpn)* v 35 Special Issue n 2 Mar 1988 p 11-16.

**090098 SIR-B EXPERIMENTS IN JAPAN. II. SURFACE ACTIVITY. 1. SENSOR CALIBRATION EXPERIMENT. c. YAMAGAWA TEST SITE.** In the SIR-B calibration experiment to establish the SIR-B transfer function, to evaluate the 3-dB resolutions, and to check the SIR-B ability to resolve two closely-spaced targets, two test sites were chosen in addition to the main test site at the disused Akita Airport. The other two sites were chosen to evaluate the influence of background clutter on the apparent imaging characteristics of SIR-B. These two test sites were Sarobetsu wild land in Hokkaido, and Yamagawa Port and Yamagawa Radiowave Observatory, Radio Research Laboratory in Kagoshima. This paper describes the ground activity at the Yamagawa test site. Conditions at the test site are described as well as the arrangement and setting of square trihedral corner reflectors. Anticipated results for the SIR-B imaging are also discussed. (Author abstract) 4 refs.

Nishimuta, Ichizo; Mitsudome, Hiroto; Ohya, Haruo; Fujita, Masaharu. *J Radio Res Lab (Jpn)* v 35 Special Issue n 2 Mar 1988 p 17-22.

**090099 SIR-B EXPERIMENTS IN JAPAN. II. SURFACE ACTIVITY. 1. SENSOR CALIBRATION EXPERIMENT. d. KASHIMA TEST SITE.** The SIR-B calibration experiment had two major objectives: to clarify the imaging characteristics of SIR-B, and to evaluate the sidelobe structure of SIR-B. This paper describes the ground activity for the evaluation of the sidelobe structure. Large diameter antennas in Kashima Space Research Center, Radio Research Laboratory, were chosen as targets with very large radar cross sections, so that the SIR-B sidelobe responses due to the targets stand out over the background clutter. The radar cross section of the antennas was intended to be controlled by placing a metal plate or a wave absorber on the primary feed horns. Three 1.1-m corner reflectors were deployed as standard radar targets in reclaimed land near Kashima Space Research Center. (Edited author abstract)

Okamoto, Ken'ichi; Nakamura, Kenji; Awaka, Jun; Fukuchi, Hajime; Fujita, Masaharu. *J Radio Res Lab (Jpn)* v 35 Special Issue n 2 Mar 1988 p 23-27.

**090100 SIR-B EXPERIMENTS IN JAPAN. IV. EXPERIMENTAL RESULT. 1. SENSOR CALIBRATION EXPERIMENT.** Among the test sites for the SIR-B calibration experiment, the Sarobetsu test site was successfully imaged twice on ascending and descending orbits. The SIR-B image data taken over the test site are analyzed to calibrate the image and to estimate the 3-dB resolution. Square trihedral corner reflectors with different radar cross sections (RCS) are used to relate the image data number to RCS. The RCS of the background surface is estimated and its effect is also included in these relations. The 3-dB resolutions are estimated by two independent techniques. The results of these two techniques agree with each other; however, the estimated



resolutions are larger than those predicted by the Jet Propulsion Laboratory. (Edited author abstract) 11 refs.

Fujita, Masaharu; Naito, Hideyuki; Oda, Tadashi. *J Radio Res Lab (Jpn)* v 35 Special Issue n 2 Mar 1988 p 61-75.

## South America

**090101 CHARACTERIZATION AND CLASSIFICATION OF SOUTH AMERICAN LAND COVER TYPES USING SATELLITE DATA.** Various methods are compared for carrying out land cover classifications of South America using multitemporal Advanced Very High Resolution Radiometer data. Fifty-two images of the normalized difference vegetation index (NDVI) from a 1-year period are used to generate multitemporal data sets. Three main approaches to land cover classification are considered, namely the use of the principal components' transformed images, the use of a characteristic curves procedure based on NDVI values plotted against time, and finally application of the maximum likelihood rule to multitemporal data sets. Comparison of results from training sites indicates that the last approach yields the most accurate results. (Edited author abstract) 30 refs.

Townshend, J.R.G. (Univ of Maryland, College Park, MD, USA); Justice, C.O.; Kalb, V. *Int J Remote Sens* v 8 n 8 Aug 1987 p 1189-1207.

## Sudan

**090102 COMPARATIVE ANALYSIS OF DYKE LINEAMENTS MAPPED FROM SHUTTLE IMAGING RADAR AND LARGE FORMAT CAMERA PHOTOGRAPHY IN HYPERARID AREAS OF THE EASTERN DESERT, EGYPT, AND RED SEA HILLS, SUDAN.** The Red Sea Hills (Sudan) and Eastern Desert (Egypt) have been selected, as areas with hyperarid climate, for a comparative study of SIR-B radar imagery and Large Format Camera (LFC) spaceborne photography. Some areas with extensive sand sheets in which dikes and dike swarms were partially outcropping were studied in detail and a dike lineament analysis was made using the different remote sensing data sets. Particularly from the LFC photos much detail could be obtained through stereo analysis. It appeared that the radar images revealed some information on the dike rocks covered by a shallow sand layer, otherwise invisible on Landsat and LFC images. (Edited author abstract) 8 refs.

Koopmans, B.N. (Int Inst for Aerospace Survey & Earth Sciences, Enschede, Neth). *Int J Remote Sens* v 9 n 5 May 1988 p 981-995.

## Technology Transfer

**090103 MANAGING REMOTE SENSING TECHNOLOGY TRANSFER TO DEVELOPING COUNTRIES: A SURVEY OF EXPERTS IN THE FIELD.** The transfer of Landsat-related remote sensing technology from the United States to developing countries was examined in this research. A survey of experts in the field of remote sensing technology was conducted to determine what they perceived as the major obstacles to remote sensing technology transfer (RSTT). Usable questionnaire responses were received from 666 professionals in 66 countries. Responses of participants representing developed countries, developing countries, and international organizations were compared in order to identify similarities and differences in their perceptions of the RSTT obstacles. In addition to examination of individual questionnaire items, the data were analyzed further to reveal underlying issues that must be recognized and addressed if remote sensing technology is to be successfully applied to development activities. (Author abstract) 5 Refs.

Specter, Christine (Florida Int Univ, Miami, FL, USA). *Photogrammetria* v 43 n 1 Sep 1988 p 25-36.

## Temperature Measurement

**090104 IMPACT OF SPECTRAL EMISSIVITY ON THE MEASUREMENT OF LAND SURFACE TEMPERATURE FROM A SATELLITE.** The split-window method for measuring surface temperature is applied to land surface. In order to relate land surface temperature to the two brightness temperatures measured from space in the two channels of interest (namely, AVHRR 4 and AVHRR 5), several formulae are derived and their accuracies are discussed. It is shown that in order to infer land surface temperature from space, it is therefore necessary to know the surface spectral emissivity to good accuracy. Possible methods to determine it are then proposed and discussed. (Edited author abstract) 24 refs.

Becker, F. (NASA, Greenbelt, MD, USA). *Int J Remote Sens* v 8 n 10 Oct 1987 p 1509-1522.

**RESEARCH LABORATORIES** See Also ACCELERATORS—Beam Dynamics; ADHESIVES—Testing; BIOMEDICAL EQUIPMENT—Computer Aided Design; CAVITATION—Research; CHEMICAL LABORATORIES—Standards; COMPUTER SOFTWARE—Software Engineering; DIESEL ENGINES—Design; IONS—Research; RADIATION DETECTORS; SPECTROSCOPY—Research.

**090105 ESTABLISHING AND USING A VLSI LABORATORY.** Establishing a CAD laboratory is one of the first steps in promoting high tech design through the student body. This kind of program will help as a tool in the educational instruction as well as promote much closer working relationships with the appropriate industry. This paper describes in detail the approach used by Temple University in establishing and utilizing VLSI workstations for more automated integrated circuits design. The workstations are utilized for undergraduates as well as graduate interactions. However, a number of the undergraduate and graduate students would be involved in the practical research and development of the VLSI designs. (Edited author abstract) 4 Refs.

Delalic, Z.J. (Temple Univ, Philadelphia, PA, USA). *Int J Appl Eng Educ* v 3 n 6 1987 p 577-582.

**090106 GRAN SASSO UNDERGROUND LABORATORY.** The Gran Sasso Underground Laboratory, located on a side of the road tunnel under the Gran Sasso Massif, not far from Rome, is nearly completed. The status of construction and outfitting of experimental halls is reported, as well as future plans to improve safety and available room for experiments. (Author abstract) 5 refs.

Bellotti, E. (Univ degli Studi, Milan, Italy). *Nucl Instrum Methods Phys Res Sect A* v A264 n 1 Feb 1988, Non-Accel Part Phys, Proc of the Workshop, Rochester, NY, USA, Jun 1-3 1987 p 1-4.

Argentina See ACCELERATORS—Reviews.

Asia See FIRE PROTECTION—Research.

## Climate Control

**090107 THERMAL STORAGE WITH EMS CONTROL.** An in-house application of ice thermal storage controlled by a centralized energy management system is described in detail. The combined system is installed and operating in the newly remodeled Trane Technology Center in La Crosse, Wisconsin, near the east bank of the Mississippi River. This northern location has an average of 7,540 heating degree days and 683 cooling degree days. For this region, the design dry-bulb cooling temperature is 91 F and wet-bulb is 75 F. An energy management system (EMS) equipped with equation processing is used to control and monitor the thermal storage system components. Equation processing is a user definable control program within the software of the EMS. The routines are written in a language similar to elementary Fortran statements.

Herro, Michael; Roach, Robert. *ASHRAE J* v 30 n 5 May 1988 p 29-32, 34.

Computer Applications See Also CATALYSTS—Testing; ENVIRONMENTAL TESTING—Computer Applications.

**090108 AUTOMATION OF SCIENTIFIC RESEARCH AND DESIGN: THE KEY TO ACCELERATION OF SCIENTIFIC AND TECHNICAL PROGRESS.** Methodological problems discussed relate to the shaping of concepts for computer-aided scientific analysis and design of complex engineered systems (ES) on the basis of fundamentally new methods for performance of design tasks (full automation of all SREDW steps, complex utilization of modern computers and advanced mathematical methods) and the development of computer-aided scientific research and design systems. It is shown that introduction of the methods described permit significant reduction of SREDW lead times and improve the design quality of complex ES. (Author abstract) 8 refs.

Nesterenko, G.S.; Fedosov, E.A. *Sov Mach Sci* n 3 1987 p 1-12.

**090109 PLANNING FOR LABORATORY COMPUTING AND COMMUNICATIONS.** Alcoa Laboratories replaced earlier ad hoc efforts with an ongoing computing resource planning activity operating on an annual cycle based on the schedule for capital and operating budgets. The activity has the following characteristics: management support; integration with and support of the laboratory budgeting process; broad participation of all laboratory divisions/departments; leadership from outside the central Computing Section; involvement of computing specialists and generalists; short-term plans flow from long-range goals; plans based on needs of laboratory people. The success of this approach to planning for laboratory communication and computing resources has been established. 15 Refs.

Schilling, Peter E. (Alcoa); Lezark, Alex P. *Res Technol Manage* v 31 n 4 Jul-Aug 1988 p 39-43.

Computer Interfaces See ELECTRIC EQUIPMENT—Testing.

## Concrete

**090110 SANDWICH-TYPE CONSTRUCTION PROJECT IS CAST-IN-PLACE.** This paper describes the design and construction of new facilities for a major pharmaceutical company in New Jersey. The cast-in-place structural concrete project consists of a chemical research building, a medical development building, and a scientific information center that includes a library and small auditorium. It was decided to use a prestressed concrete structural system with sandwich-type roofs and walls. This type of concrete building has a relatively large thermal mass, which is required for heat balance. To further reduce heat loss, double-glazed lightly tinted open windows were used for all buildings. To reduce noise propagation from floor to floor, neoprene interfaces were introduced at the joints between columns, walls, and beams. (Edited author abstract)

Komendant, August E. *Concr Int* v 10 n 1 Jan 1988 p 36-39.

## Construction

**090111 NEUBAU EINES MEHRGESCHOSSIGEN WERKSTATTGEBÄUDES IN STAHLVERBUND-BAUWEISE FUER DAS FORSCHUNGS- UND INGENIEURZENTRUM DER BAYERISCHEN MOTORWERKE AG.** [Multistorey Factory Building in Composite Construction for the New BMW Research and Engineering Center in Munich]. The factory building for the new BMW research and engineering center in Munich has been built with a fire-resistant composite construction. The bottom flanges of the beams and girders remain visible and unprotected so that they can be used to mount manufacturing and conveyer units. This type of construction is suitable particularly for industrial multistorey buildings with high live loads including fork-lift trucks, and increased requirements on fire resistance. (Edited



author abstract) In German. 7 refs.

Gehm, W.; Muess, H.; Schaub, W. *Bauingenieur* v 62 n 9 Sep 1987 p 407-417.

**Contracts** See ENGINEERING RESEARCH—Contracts.

**Energy Management** See COGENERATION PLANTS—Reviews.

**England** See ACCELERATORS—Performance.

**Evaluation**

**090112 GM's HEALTHY PAIN.** This paper discusses the job functions of those involved in research and development with particular emphasis on the role played by a laboratory in a company's business objectives. General Motors recently arrived at a method by which to estimate the minimum profitability of the research laboratories. The method involves agreeing with the operating division on a value to be placed on the dozen or so most profitable items developed by the research division. The method depends on the fact that every year, a few extremely valuable items are developed and put to use. These items more than pay for the research part of the organization.

Frosch, Robert A. (GM Corp, Warren, MI, USA). *Mech Eng* v 109 n 12 Dec 1987 p 23-25.

**Federal Republic of Germany** See ACCELERATORS—Maintenance.

**Great Britain**

**090113 THORN EMI CENTRAL RESEARCH LABORATORIES - AN ANECDOTAL HISTORY.** A merger in the youthful British record industry over five decades ago brought together some exceptional talent. Thus started a tradition of excellence leading to achievements such as high-definition TV and the CAT scanner. (Author abstract) 9 refs.

Lodge, J.A. (THORN EMI Central Research Lab, Hayes, Engl). *Phys Technol* v 18 n 6 Nov 1987 p 258-268.

**Heat Exchangers** See AIR CONDITIONING—Solar Energy Systems.

**India** See ACCELERATORS—Reviews.

**Japan** See ACCELERATORS, VAN DE GRAAFF—Retrof-  
itting.

**Marine Applications**

**090114 DESIGN OF THE UNIVERSITY OF NEW ORLEANS SHIP-OFFSHORE UNIVERSITY LABORATORY FOR OFFSHORE INDUSTRY SUPPORT.** On July 23, 1987, the University of New Orleans (UNO) dedicated its new Engineering Building, which houses a 38.3 m x 4.57 m x 0.2.134 m deep ship-offshore university laboratory tow tank. This paper covers the initial stages of the project and summarizes the towing tank design for ship-offshore testing. The tank is configured for three purposes: 1) conventional ship research in deep water with calm water or waves; 2) offshore structure testing with provision for observation and anchoring; 3) shallow water research in calm water, current, and waves. (Author abstract) 12 refs.

Latorre, R. (Univ of New Orleans, New Orleans, LA, USA). *J Energy Resour Technol Trans ASME* v 110 n 3 Sep 1988 p 133-140.

**Modernization**

**090115 CAD IN AN UNCOMMON ROLE.** A London based multi disciplinary practice is claiming that its development of the use of CAD systems for design co-ordination, presentation and tightening up the design process, has provided a basis for the successful extension of these techniques into the forbidden territory of refurbishment. In May last year the YRM Partnership was

presented with a design brief to update the Courtauld Institute of Biochemistry for the Ludwig Institute of Cancer Research and University College London. The £3.5 million scheme centres on the upgrading of an existing 1920s building to incorporate modern laboratory and office facilities and was to be carried out on a relatively small budget and on a tight schedule. Some 15 months later the laboratory is ready for occupation, completed on time and within budget and the YRM Partnership and its newly established structures division is toasting its first refurbishment project carried out using a CAD System.

Anon. *Civ Eng (London)* Oct 1987 p 21-22.

**Netherlands** See STREET LIGHTING—Research.

**Peoples Republic of China** See ACCELERATORS; TRIBOLOGY—Research.

**Productivity** See Also INDUSTRIAL MANAGEMENT.

**090116 MEASURING AND IMPROVING LABORATORY PRODUCTIVITY/PRODUCTION.** The article examines a typical quality program for a 3M manufacturing unit. The conclusion was that manufacturing's quality program is based on: meeting product specifications; meeting customer requirements; doing-it-right the first time; and just-in-time processing. The expected productivity results are: less inventory, less labor, less capital, and less process time. The article also examines inventory in a laboratory and just-in-time processing.

Krogh, Lester C. (3M Co). *Res Manage* v 30 n 6 Nov-Dec 1987 p 22-24.

**090117 ENVIRONMENTAL INFLUENCES ON MANAGING RESEARCH ORGANISATIONS.** Research productivity might well be defined in terms of a wider range of indicators than numbers of papers published or patents awarded. Industrial policy in America is quite fragmented in comparison with that in Europe or Japan, and the uncertainty this creates may contribute to malfunctions in research endeavors. Politicization seems to be intensifying in all of America's larger organizations, but the injection of political intrigue into research organizations can have consequences more disastrous than might be expected.

Muspratt, Murray A. (Univ of Illinois, Urbana, IL, USA). *Eng Manage Int* v 5 n 1 Apr 1988 p 71-80.

**Quality Control** See Also MANAGEMENT—Research and Development Application; PRODUCT DESIGN; PRODUCT DESIGN—Planning; PRODUCT DESIGN—Reliability.

**090118 MEETING THE NEW QUALITY CHALLENGE.** The new quality challenge is to transform the research and development organization into a Total Quality Company culture. This starts with an educational process, of every person on the staff, in the philosophy, principles and tools of the modern quality management process. Everyone throughout the organization must be involved. This transformation will not be quick or easy, and will require well-thought-out plans and strategies. And most important of all, success in this quality transformation demands high prioritization and active management leadership.

Murray, Thomas J. (Eastman Kodak Co). *Res Manage* v 30 n 6 Nov-Dec 1987 p 25-30.

**090119 BETTER THAN TAGUCHI ORTHOGONAL TABLES.** There has been a great amount of publicity about Taguchi orthogonal tables. This paper will evaluate the pros and cons of that approach. In addition an American approach, having the same initial goals of the Taguchi approach, will be presented in detail, representing a significant improvement in meeting those goals without confounding interactions with any main effect or with other interactions. In addition, this constructive alternative generally requires a much smaller number of tests. (Author abstract) 6 refs.

Shainin, Dorian (Shainin Consultants Inc, Manchester, CT, USA); Shainin, Peter. *Qual Reliab Eng Int* v 4 n 2 Apr-Jun 1988 p 143-149.

**Reviews** See ACCELERATORS—Beam Injection.

**Safety Codes**

**090120 MATRIX MANAGEMENT: A WORKABLE APPROACH TO SAFETY.** The Lawrence Livermore National Laboratory conducts a variety of research programs that have state-of-the-art safety problems to control. The personal growth and development of safety professionals at the Laboratory in solving program safety issues has led to national leadership by LLNL in a number of technical safety areas. A matrix management approach to safety ensures effective, timely support for research projects. It provides a 'systems' look at complex research projects and reduces the potential for errors and omissions through joint and multiple safety reviews. This approach is now being adapted to varying degrees at other facilities requiring high ratios of safety support. A similar structure may well be suitable for companies that, like LLNL, have multiple facilities - a safety team located at each facility tied to a corporate department. 4 refs.

Crites, Thomas R.; Montgomery, David L. *Prof Saf* v 33 n 1 Jan 1988 p 11-14.

**Tokyo, Japan** See ROBOTICS—Research.

**United States** See ACCELERATORS, VAN DE GRAAFF—Reviews; MATERIALS SCIENCE—Research.

**Welding** See WELDING—Plasma Arc.

**RESERVOIRS** See Also DAMS—Earthquake Resistance; DAMS—Foundations; DAMS, ARCH—Earthquake Resistance; DAMS, EMBANKMENT—Alberta; FLOW OF WATER—Vortex Flow; IRRIGATION CANALS—Water Supply; NUCLEAR POWER PLANTS—Cooling Water; WATER POLLUTION—Control; WATER RESOURCES—Optimization; WATER WAVES—Measurements.

**090121 RESERVOIR BOTTOM CONDITIONS AND HYDRODYNAMIC PRESSURES ON STRUCTURES.** In this paper, boundary conditions of a general, absorptive reservoir bottom are derived, and a method for analyzing hydrodynamic pressures on rigid structures with the general conditions is presented. In the studies, the reservoir bottom is idealized as laminated elastic media; and the water, as a compressible but non-viscous liquid. The point collocation method is used to investigate water pressures on dams due to horizontal harmonic ground motion. Based on the results from typical examples, some important characteristics of water pressures and water loads on rigid dams with general absorptive reservoir bottoms are illustrated. (Edited author abstract) In Chinese. 5 refs.

Fu, Zuoxin (Hohai Univ, China); Lu, Ruiming. *Shuili Xuebao* n 5 1987 p 28-35.

**090122 50 m<sup>3</sup> FERROCEMENT WATER RESERVOIR IN CANAR, ECUADOR.** The 50 m<sup>3</sup> domed ferrocement tank for water storage, the first in Ecuador, was constructed in San Rafael, Canar Province. The detailed construction procedure is described and each construction step is illustrated with photographs. Considerable savings in material cost (66%) and construction time (about 50%) were realized by employing ferrocement instead of reinforced concrete. Based on the procedure outlined here, 25 ferrocement reservoirs of various capacities have been built in Ecuador. (Author abstract) 2 refs.

McPeak, M. (TECOGEN Inc, Waltham, MA, USA). *J Ferrocem* v 17 n 3 Jul 1987 p 223-229.

**090123 PUMPING STATIONS AT PLOVER COVE RESERVOIR AND TOLO CHANNEL AQUEDUCT, HONG KONG.** The rapidly increasing demand for water in Hong Kong has been met by importing substantially



more raw water from China. These recent increases have required major additional works at Plover Cove reservoir including two large pumping stations. Operational requirements that the reservoir remain in use throughout construction and the location of the works in a scenic area have imposed special design considerations. The new stations have deeper draw-offs than the existing pumping station and economic studies resulted in totally different solutions for each station. Tai Mei Tuk B is a wet-well station of 1390 million liters per day (ML/day) capacity sited in the reservoir and connected to the shore by a 300 m long bridge, all supported on deep piled foundations. The pumps will deliver water through siphon pipes laid over the bridge. A major factor in the design and contract documentation was the need to leave scope for ingenuity to overcome the unusual construction conditions. The Paper describes the development of the designs for permanent works and indicates how provision was made for flexibility of construction method. (Edited author abstract) 4 refs.

McMeekan, J.F. (Binnie & Partners, Hong Kong); Yue, K.P. *Proc Inst Civ Eng (London)* v 82 Dec 1987 p 1089-1119.

**090124 TEMPORARY WORKS FOR THE PUMP-ING STATIONS AT PLOVER COVE RESERVOIR, HONG KONG.** The Paper describes the design and construction of the three most interesting temporary works schemes at Plover Cove. Two structures were built in the reservoir whose operating level could vary by as much as 18 m during construction. One, the Tai Mei Tuk B pumping station, was cast above water and lowered by an 8500 t capacity jacking system. The other, Harbour Island intake tower, was built in a gravity cofferdam of unusual design capable of providing dry working conditions 29 m below reservoir level. Also described for this Paper is the deep vertical excavation in decomposed sandstone for the Harbor Island pumping station. (Author abstract) 2 refs.

Calkin, D.W. (Kier Ltd); Mundy, J.K. *Proc Inst Civ Eng (London)* v 82 Dec 1987 p 1121-1144.

**090125 RUNOFF IMPOUNDMENT FOR SUPPLEMENTAL IRRIGATION IN TEXAS.** Large amounts of runoff occur in the eastern part of Texas that could be collected in small impoundments and utilized for crop production. Farmers in water-surplus basins or subbasins can apply for a permit to divert surface water into small on-farm impoundments to be used for supplemental irrigation. The costs for runoff collection and two supplemental irrigations, which amount to a total of 4 in./yr., are estimated to be approximately \$60/acre/year. Depending upon the crop produced, the estimated increase in gross income from supplemental irrigation ranges from about \$80 to more than \$100 per acre annually. (Author abstract) 15 refs.

Krishna, J.H. (Texas Agricultural Experiment Station, Temple, TX, USA); Arkin, G.F.; Martin, J.R. *Water Resour Bull* v 23 n 6 Dec 1987 p 1057-1061.

**090126 NUTRIENT BUDGET FOR A HYPERTROPHIC RESERVOIR.** A nutrient budget for the shallow, hypertrophic Ardleigh Reservoir, a pumped storage scheme in eastern England, is described for the period 1979-1982. Algal succession in the reservoir was typical of eutrophic waters, with maximum chlorophyll-a of 98 mg m<sup>-3</sup>. Although the reservoir did not stratify thermally, the concentrations of Soluble reactive phosphorus (SRP), Mn and Fe increased in bottom waters during summer. The weight ratio of inorganic N to inorganic P ranged from 720 to 5. On average, SRP represented 72% of the total P content of the reservoir. Some 44% of water input was of pumped river water, 48% being of direct catchment flow. The specific loading of SRP was 5.014 g m<sup>-2</sup> yr<sup>-1</sup>. Strategies of P control are discussed in relation to loading models. (Edited author abstract) 22 refs.

Redshaw, C.J. (Univ of Essex, Colchester, Engl); Mason, C.F.; Hayes, C.R.; Roberts, R.D. *Water Res* v 22 n 4 Apr 1988 p 413-419.

**090127 EINFLUSS DER STANDZEIT IN WASSERBEHAELTERN AUF DIE WASSERQUALITÄT: BERICHT UEBER EIN F + E-VORHABEN.** [Influence of Residence Time in Water Reservoirs with Regard to Water Quality]. For reservoirs with the function of long-term storage of drinking water there are no guide values available up to now about the change of water quality during residence time. In 5 reservoirs with different types of water, wall surface, methods of water treatment and reservoir cleaning 11 long-term storage tests of 17 to 126 days duration were carried out. The result was that storage of 5 to 7 days in reservoirs with cement lining surfaces does not affect the water quality. The bacterial growth-stimulating influence of chlorinated rubber coating and of chemical cleaners was shown. Accompanying laboratory tests proved that measurement of bacterial growth rate allows us to predict the long-term reaction for each water type. (Author abstract) 5 refs. In German.

Baur, Albert; Eisenbart, Karl. *GWF Gas Wasserfach Wasser Abwasser* v 129 n 2 Feb 1988 p 109-115.

**090128 AVANTAGES ET INCONVENIENTS DES BASSINS DE STOCKAGE A L'AMONT DES PRISES D'EAU.** [Advantages and Inconveniences of Storage Basins Upstream of Intakes]. Despite some advantages of reservoirs upstream of intakes, such as self-purification and decantation of water, regulation of river beds, homogenization of water, there are certain inconveniences, in particular the development of the algae, the risk of anaerobiosis with the presence of dissolved metals such as iron, and manganese during the periods of stratification. In Servile, Spain an upstream reservoir has been satisfactorily used in recent years during drought periods. A study of this case is presented. In French.

Gonzalez Rull, Juan Antonio (EMASESA, Seville, Spain). *Water Supply* v 5 n 3/4 1987, Uniting the World of Water, Rome, Italy, Nov 3-7 1986 p SS6.10-SS6.12.

## Algae

**090129 PREDICTION OF NUISANCE BLUE-GREEN ALGAL GROWTH IN NORTH CAROLINA WATERS.** A study was made of the possibility of application of the author's recently developed set of empirical models predicting the summer mean biomass of blue-green algae (mm<sup>3</sup> m<sup>-3</sup>), and models predicting the relative biomass of blue-greens in the phytoplankton as tools to help manage North Carolina water resources experiencing nuisance blue-green algal growth. Statistical analysis of data from 34 reservoirs suggested that none of the above models for blue-green algae were applicable to North Carolina reservoirs. The reasons for the lack of fit are not yet clear, but may include effects of non-algal turbidity, hydraulic flushing, and inorganic carbon availability. (Edited author abstract) 50 refs.

Smith, Val H. (Univ of North Carolina, Chapel Hill, NC, USA). *Rep Water Resour Res Inst Univ NC* n 233 May 1987 34p.

**090130 APPLICATION OF PYROLYSIS-GAS CHROMATOGRAPHY-MASS SPECTROMETRY TO THE CHARACTERIZATION OF HUMIC SUBSTANCES RESULTING FROM DECAY OF AQUATIC PLANTS IN SEDIMENTS AND WATERS.** Pyrolysis-GC-MS, elemental analysis and i.r. spectroscopy reveal major differences between humic substances from aquatic plants (algae and aquatic phanerogams) and lagoonal, marine and lacustrine deposits. Algae are enriched in proteins and their pyrolysis yields numerous nitrogenous by-products (alkylpyroles, nitriles and alkylpyridines) along with aromatic compounds which are thought to reflect the decomposition of individual amino-acids (styrene, toluene, phenol and p-cresol). These compounds are less abundant in the pyrolysis products of humic substances from phanerogams with increasing amounts of methoxyphenols, characteristics of lignins. In the deposits of the Kerguelen Islands and of a 'blue lake' in Greenland, the importance of algal populations is emphasized by pyrolysis products corresponding to nitrogenous and carbohydrate derivatives. (Edited

author abstract) 35 refs.

Gadel, F. (Univ de Perpignan, Le Pecoq, Fr); Bruchet, A. *Water Res* v 21 n 10 Oct 1987 p 1195-1206.

**090131 IMPACT OF ROTIFER GRAZING ON POPULATION DYNAMICS OF GREEN MICROALGAE IN HIGH-RATE PONDS.** In high-rate algal ponds, the grazing activity of rotifers such as *Brachionus rubens* or *B. calyciflorus* often leads to a replacement of *Scenedesmus* species by *Microcystis* *pusillum*. In contrast to many other green microalgae including *Scenedesmus*, *Microcystis* *pusillum* with fully developed spines (setae) cannot be eaten by *Brachionus*. Ecological conditions for population shifts between *Scenedesmus* and *Microcystis* are, therefore, interpreted as a response of the rotifers rather than being due to physiological properties of the algae. Another effect of rotifer grazing on the microbial flora of high-rate ponds is the development of large stable flocs consisting of bacteria and microalgae. (Author abstract) 19 refs.

Schlueter, Manfred (Kernforschungsanlage Juelich GmbH, Juelich, West Ger); Groeneweg, Joost; Soeder, Carl J. *Water Res* v 21 n 10 Oct 1987 p 1293-1297.

**090132 EFFECT OF TOXICANTS ON ALGAL SINKING RATES.** A fluorometric technique was used to measure sinking rates of *Scenedesmus acuminatus* following exposure to Cl and Cu. Observed rates became larger in proportion to chemical dosage. The maximum values were 6.4×ambient at 7.5 g m<sup>-3</sup> chlorine and 7.0×ambient at 40 g m<sup>-3</sup> Cu. In comparison, a maximum increase in sinking rate of 5.4×ambient was achieved with 49 g m<sup>-3</sup> alum. Microscopic observations indicated that cell lysis and flocculation resulted from exposure of algal cells to toxicants. (Author abstract) 27 refs.

Pekkala, C.M. (Univ of Florida, Gainesville, FL, USA); Koopman, B. *Water Air Soil Pollut* v 36 n 1-2 Nov 1987 p 155-162.

**090133 COAGULATION AND REMOVAL OF ALGAE, RESULTING FROM WATER STORAGE UPSTREAM OF RAW WATER INTAKES.** Different treatment configurations on both industrial and pilot plant scale have been evaluated in their ability to cope with high algae loads in reservoir water to be treated. The following unit operations were investigated and compared as to their operational performance: sedimentation/filtration, flotation/filtration, preoxidation/direct filtration. Coagulants used were ferric chloride, alum and polyaluminumchloride. Quantitative and qualitative plankton counts were carried out by microscopy. By means of particle counting within the range of 1 to 200 microns, the efficiency of different solid-liquid separation processes was assessed. Preoxidation and/or three-layer bed filtration may be possible process improvements to deal with algae in a more effective way, 3 refs.

Janssens, J.G. (Antwerp Water Works, Antwerp, Belg); Meheus, J. *Water Supply* v 5 n 3/4 1987, Uniting the World of Water, Rome, Italy, Nov 3-7 1986 p SS6.6 - SS6.7.

**090134 ADVANTAGES AND DISADVANTAGES OF WATER STORAGE UPSTREAM OF INTAKES.** Pre-treatment storage reservoirs are constructed for reserve use or to overcome possible pollution. They may have some positive effects on the quality of the water such as, for example, the mixing and homogenizing of the water supply, the self-purification and decanting of suspended solids or, on the other hand, they may provoke the deterioration of qualitative characteristics because of eutrophication phenomena. The Municipal Water and Gas Board of Genoa, manages three aqueducts, one of which is directly fed by a river, whilst the others are fed by two artificial reservoirs. The experience acquired in the management of the two basins, in particular of the Brugnato Reservoir, which presents clear symptoms of eutrophy, and is always carefully checked for this reason, is discussed. Various solutions which tend to check the



growth of algae are described. The best solution is the elimination of the causes which make eutrophication possible.

Conio, Dott. O. *Water Supply* v 5 n 3/4 1987, Uniting the World of Water, Rome, Italy, Nov 3-7 1986 p SS6.7-SS6.10.

## Analysis

**090135 DEVELOPMENT OF A SURROGATE PARAMETER TO DETERMINE THE TRIHALOMETHANE FORMATION POTENTIAL OF TWO RESERVOIRS.** Two reservoirs supplying the drinking water to the greater New Haven area were analyzed for various parameters that may influence the formation of trihalomethanes (THMs). Of special interest was the development of a surrogate parameter by which the potential of these waters to form THMs could be accurately predicted. It was found that ultraviolet (UV) absorbance at 254 nanometers is an excellent predictor of the maximum THM formation in these reservoirs. Differences in the nature and quantity of organic matter between reservoirs were noted to cause slight differences in maximum THM formation potential. The low correlation between extinction coefficients and THM formation potential suggests that molecular size and weight of the organic matter is not a primary determinant in the formation of THMs. (Author abstract) 47 refs.

Ceraso, Jane (Office of Environmental Health Programs, Olympia, WA, USA). *J N Engl Water Works Assoc* v 101 n 4 Dec 1987 p 382-400.

## California

**090136 HYDROGEN ION CONCENTRATION AND ALKALINITY OF RESERVOIR WATER IN THE SIERRA NEVADA, CALIFORNIA, AND CORRELATIONS WITH AIR POLLUTANTS.** Pardee reservoir supplies water for the east San Francisco Bay Area from a large forested drainage basin located in the Sierra Nevada foothills, extending east to the crest of the mountain range. Analyses of weekly data of reservoir discharge water indicate that  $[H^+]$  has been increasing (1954-1985 data) and alkalinity decreasing (1944-1985 data). Hydrogen ion concentration and alkalinity of reservoir water are correlated with  $NO_x$  (and  $SO_2$  to a lesser extent) emissions from the San Francisco Bay Area. Emissions of  $NO_x$  are about four times greater than those of  $SO_2$ . A lag-time of 3 to 4 yr improves the correlations, especially those of  $SO_2$ . Greatest increases in  $[H^+]$  occur in spring when the snowpack is melting. In the 1950s, spring melt had a dilution effect on  $[H^+]$ , but now  $[H^+]$  increases during spring melt. The paper discusses an explanation for the seasonal variations observed. (Edited author abstract) 10 Refs.

McColl, J.C. (Univ of California, Berkeley, CA, USA). *J Environ Qual* v 17 n 3 Jul-Sep 1988 p 425-430.

**Concrete Construction** See WATER, UNDERGROUND—Storage.

## Design

**090137 OPTIMIZATION OF THE PARAMETERS FOR CASCADE STATIONS WITH INTERBASIN COMPENSATING REGULATION.** On the basis of existing mathematical models of choosing reservoir parameters, this paper for the first time suggests the use of nonlinear programming (NLP) model. When the construction sequence of cascade development is determined, NLP will be used under the constrained conditions of reservoir storages, current discharges, installed capacities and annual power energy. With interbasin compensating regulation of some reservoirs and joint operations of some thermal plants in an electric system, by using NLP, it is possible at the same time to optimize the reservoir parameters under the objective function of minimizing the total cost of electric system. The model is capable of handling 1720 independent variables and 8660 linear and nonlinear constrained conditions. A case study of optimization of the cascade development projects on the Lan-

cang River is discussed. (Author abstract) In Chinese. 7 refs.

Shi, Xican (Tsinghua Univ, China); Wang, Hao. *Shuili Xuebao* n 9 1986 p 1-7.

**090138 JOINT RESERVOIR AND AQUEDUCT DESIGN AND OPERATION.** Numerical quadrature methods are used to solve the integral equations for steady-state reservoir-storage density functions. The resulting approximations are used in a variety of problems with particular emphasis on the joint optimization of the design and operation of reservoirs and water delivery systems. Basic examples, to illustrate the use of the methods, expose several interesting economic tradeoffs present in reservoir operation, and factors affecting these tradeoffs are characterized and categorized. More involved examples show the interdependence of target deliveries, delivery capacities, and the probabilistic nature of the water supplies in joint optimization problems. (Edited author abstract) 21 refs.

Flynn, Lawrence E. (Univ of California, Davis, CA, USA); Marino, Miguel A. *J Water Resour Plann Manage* v 114 n 2 Mar 1988 p 179-196.

**Dredging** See WATER TREATMENT—Color Removal.

**Environmental Impact** See Also WATER SUPPLY—Environmental Impact; WATER SUPPLY—Hungary.

**090139 SEISMICITY AROUND BRAZILIAN DAM RESERVOIRS.** A mechanism of earthquake generation by reservoir impounding is proposed here with particular application to the Brazilian cases and to areas subject to low confining stress conditions in stable regions. Six artificial lakes are described and the associated earthquake sources are discussed in terms of natural or induced seismicity. Cases reported here have shown an alteration of the original seismic stability in dam sites, after reservoir loading, as observed by the inhabitants or records from Brasilia's seismological station. All cases appear to be related to an increase in pore pressure in permeable rocks or fracture zones which are confined between impermeable rock slabs of more competent rock. (Edited author abstract) 9 refs.

Coelho, P.E.F.P. (Univ of Western Ontario, London, Ont, Can). *Environ Geol Water Sci* v 10 n 3 1987 p 149-158.

**090140 RESERVOIR INDUCED SEISMICITY - A NEW MODEL.** Deficiencies of different existing models on 'Reservoir Induced Seismicity' have been discussed and a new mathematical model, which enhances a better understanding of triggering mechanism in terms of changes in effective stresses, in situ stresses and water level variations, has been discussed in this paper. In the model fractured rock is simulated by a fluid-filled elastic material subject to Mohr-Coulomb failure criterion. The model has been found to be capable of responding effectively to site specific attributes. It can recognize and explain the phenomenon of time lag observed in several actual cases. It is also capable of simulating stabilization of rock-reservoir system after a period of activities that follow the initial stage of filling. One dimensional and two dimensional, isotropic and anisotropic cases have been analyzed and the model predictions have been found to agree qualitatively with the field observations. (Author abstract) 26 refs.

Saxena, S.K. (Illinois Inst of Technology, Chicago, IL, USA); Metin Ger, A.; Sengupta, A. *Int J Numer Anal Methods Geomech* v 12 n 3 May-Jun 1988 p 263-281.

**Fluid Dynamics** See FLOW OF WATER—Analysis.

## Hydrodynamics

**090141 OUTLINE OF AN EARTH SLOPE IN THE WATERLINE PART OF LARGE CANALS AND RESERVOIRS.** The cross-sectional outline of large unlined earth canals in the waterline zone can be determined by means of a scheme of the interaction of the channel flow with the soil composing the banks. Authors

consider that a freely standing vertical bank forms on the canal bank as a result of the removal of soil particles by water during wave motion into the channel flow. Any method of calculating slope stability should be used for calculating the most dangerous surface of failure of a vertical bank. Using the variational method, authors examined what curves of sliding are most dangerous in the case of a vertical slope composed of homogeneous soil. In solving this problem authors used the two most prevalent methods of assigning the distribution of stresses on the sliding surface according to the assumptions of Terzaghi and Mozhevitinov. The factor of safety against sliding when determining stresses by Terzaghi's model was determined. 6 refs.

Girgirdov, A.D. *Hydrotech Constr* v 21 n 8 Aug 1987 p 488-493.

**Inlets** See HYDROELECTRIC POWER PLANTS—Pumped Storage.

## Ion Exchange

**090142 ASUPRA PASTRARIL ECHILIBRULUI IONIC IN INJECTAREA APELOR IN ZACAMINT.** [On the Maintenance of the Ionic Balance in the Reservoir Water Injection]. The paper presents the laboratory simulation, in conditions reproducing the reservoir, of the formation water filtration, which water has lost its carbon dioxide when reaching the surface. This test shows the lowering of the receptivity index. This is a consequence of the strong ionic exchange, which is outlined by the X-ray-structural and chemico-spectral analyses and by the filtrated water characteristics variation. Based upon the laws of the ionic exchange in reservoir conditions, the receptivity of the petroliferous collectors can only be maintained if the ionic balance of the original conditions is preserved at reservoir opening. (Author abstract) In Romanian. 26 refs.

Parealabescu, I.D. (Inst de Petrol si Gaze Ploiesti, Rom); Nistor, I. *Mine Pet Gaze* v 38 n 3 Mar 1987 p 135-143.

## Japan

**090143 AVANTAGES ET INCONVENIENTS DU STORAGE EN AMONT DE PRISES D'EAU.** [Advantages and Disadvantages of Water Storage Upstream of Intakes]. The Tokyo upstream water storage system is described and their advantages and disadvantages are noted. In Japan, the construction of storage reservoirs is inevitable in order to develop new water resources. The greatest advantage of constructing them upstream of intakes is that it is possible to increase available water quantity by regulating the river flow. However, the storage reservoirs cause many problems such as deterioration of water quality unless they are well-managed. Especially, it is necessary to pay attention to eutrophication of the reservoirs. The construction of storage reservoirs greatly influences the living of dwellers or the nearby natural environment. Japan is a mountainous country and has many steep sided rivers. Much mud and sand may flow into the storage reservoirs unless sufficient measures are taken against washout of the surface of the mountains. Actually, several of the storage reservoirs in Japan are suffering from the accumulation of mud and sand. In English, French.

Kawakita, Kazunori (Tokyo Metropolitan Government, Tokyo, Jpn); Yamazaki, Shozo. *Water Supply* v 5 n 3/4 1987, Uniting the World of Water, Rome, Italy, Nov 3-7 1986 p SS6.1-SS6.6.

## Leak Detection

**090144 GROUTING AND DRAINAGE OF THE PATEA DIVERSION TUNNELS.** The reservoir for the Patea Hydro-Electric Scheme is in part contained by a natural ridge of Tertiary sandstones. During construction of the scheme, the river was diverted beneath this ridge through twin concrete lined diversion tunnels. The tunnels were subsequently plugged, and the contact between the tunnel lining and parent rock was grouted with both curtain and contact grouting. Drains were provided to



reduce the ground water pressures surrounding the tunnels downstream of the plugs. Some time after reservoir filling, a flow of lake water developed into one of the tunnels through the relief drains. This paper describes the search work involved in determining the flow path, the techniques used in grouting, and the design philosophy adopted in the drainage installation. (Edited author abstract).

Carter, R.P. (Beca Carter Hollings & Ferner Ltd, Wellington, NZ); Toan, D.V.; Riley, P.B. *Trans Inst Prof Eng NZ Civ Eng Sect* v 15 n 1 Mar 1988 p 1-8.

## Management

**090145 COMPARISON OF RESERVOIR LINEAR OPERATION RULES USING LINEAR AND DYNAMIC PROGRAMMING.** Optimal monthly release policies are derived for Hoover Reservoir, located in Central Ohio, using chance-constrained linear programming and dynamic programming-regression methodologies. Important characteristics of the former approach are derived, discussed, and graphically illustrated using Hoover Reservoir as a case example. Results indicate that, for the mean detention time and the corresponding safe yield target water supply release under existing design of Hoover Reservoir, the dynamic programming policies produce lower average annual losses while achieving at least as high reliability levels when compared to policies derived under the chance-constrained linear programming method. (Edited author abstract) 10 refs.

Bhaskar, Nageshwar Rao (Univ of Louisville, Louisville, KY, USA); Whittlatch, E. Earl. *Water Resour Bull* v 23 n 6 Dec 1987 p 1027-1036.

**090146 MANAGEMENT OF A CASCADE OF RESERVOIRS UNDER SURPLUS INFLOW CONDITIONS.** The problem of managing the operating regimes of cascades of reservoirs is investigated. Functioning of the cascade is subject to a set of requirements - sanitary, transport, municipal, fishery, power, irrigation, etc. As usual, the problem is raised of satisfying these requirements given in the form of inequalities for the largest possible number of years in the investigated time interval. The solution of this main problem (problem 1) was given previously in a class of dispatcher's rules of management by means of an algorithm for finding so-called lower critical volumes, which single out zones of firm releases in the set of states of the cascade. In the previous solution nonreturnable withdrawals for irrigation were assigned in the form of fixed, although time-dependent, quantities, which made it possible to regard them as a component (as a rule, with a 'minus' sign) of the local inflow. A new problem is examined in this paper, which is aimed at finding the rules of withdrawal. 3 refs.

Agasandyan, G.A. (Acad of Sciences of the USSR, USSR). *Water Resour* v 14 n 3 May-Jun 1987 p 219-228.

**090147 LA MODELISATION DE LA SEDIMENTATION ET SON IMPORTANCE EN GESTION DE RESERVOIRS.** [Sedimentation Modeling and Its Importance for Reservoir Management]. A hydropower system is often managed to achieve maximum performance. In a watershed where the silting phenomena are significant, this type of operation may cause a high rate of reservoir silting. This paper describes a mathematical model which uses a transport equation of the solid phase (suspension and bed load) to study the progressive silting of two reservoirs Daesti and Rm. Vilcea on the Olt river cascade development in Rumania. Various regimes of operation were simulated as well as their influence on reducing silting during the flood. (Edited author abstract) 9 refs. In French.

Oana, A. (Ecole Polytechnique de Montreal, Que, Can); Marche, C. *Can Water Resour J* v 13 n 2 May 1988 p 39-47.

**090148 ALGORITHM FOR SELECTIVE WITHDRAWAL FROM STRATIFIED RESERVOIR.** A method to simulate the withdrawal of water from a stratified water body is introduced. The method can

handle large withdrawals within a single time step and therefore allows the use of relatively long time steps, considerably reducing computational expense. Good agreement with the experimental work of other researchers is found. The results of simulations incorporating the algorithm into the dynamic reservoir model DYRESM are shown for Wellington Reservoir in Western Australia. (Author abstract) 17 refs.

Hocking, Graeme C. (Univ of Western Australia, Netherlands, Aust); Sherman, Bradford S.; Patterson, John C. *J Hydraul Eng* v 114 n 7 Jul 1988 p 707-719.

## Mathematical Models

**090149 DIFFUSION THEORY FOR STOCHASTIC STORAGE ANALYSIS.** In this study, a new analytical method based on the theory of continuous Markov diffusion processes is presented for approximating the equilibrium cumulative distribution function of storage in a finite reservoir. Storage can reside on the reservoir boundaries or at any level between these barriers. The storage distribution function, then, is expected to have discrete mass concentrations on both boundaries and a continuous probability density between the reservoir boundaries. Accordingly, the proposed method of analysis entails a two part procedure. The first step finds the equilibrium form of the continuous storage density function between the reservoir barriers while the second step evaluates the boundary mass concentrations corresponding to the equilibrium probability that the reservoir is empty or full. The analytic procedure is developed on the premise that away from the boundaries of a finite reservoir, the time evolution of the storage probability density function behaves as a one-dimensional diffusion process and therefore may be described with the Fokker-Planck equation. 143 refs.

Buchberger, Steven G. (Univ of Texas, Austin, TX, USA). *Tech Rep Univ Tex Austin Cent Res Water Resour* 224 Mar 1988 229p.

## Optimization

**090150 IMPROVED ALGORITHMS FOR RESERVOIR CAPACITY CALCULATION INCORPORATING STORAGE-DEPENDENT LOSSES AND RELIABILITY NORM.** Two algorithms that improve upon the sequent-peak procedure for reservoir capacity calculation are presented. The first incorporates storage-dependent losses (like evaporation losses) exactly as the standard linear programming formulation does. The second extends the first so as to enable designing with less than maximum reliability even when allowable shortfall in any failure year is also specified. Together, the algorithms provide a more accurate, flexible and yet fast method of calculating the storage capacity requirement in preliminary screening and optimization models. (Author abstract) 7 refs.

Lele, Sharad M. (Indian Inst of Science, Bangalore, India). *Water Resour Res* v 23 n 10 Oct 1987 p 1819-1823.

**090151 MODELLING AND OPTIMIZATION OF PARALLEL RESERVOIRS HAVING NONLINEAR STORAGE CURVES UNDER CRITICAL WATER CONDITIONS FOR LONG-TERM REGULATION.** This paper deals with the problem of parallel reservoirs having nonlinear storage-elevation curves (quadratic functions) for long-term regulation under critical water conditions using the minimum norm formulation. To overcome these nonlinearities, we introduce a set of pseudo-state variables. A set of optimizing equations is obtained. The proposed method is efficient in computing time and in calculating the expected benefits of generation from the system during the critical period. Numerical results are reported for a real system in operation consisting of two rivers; each river has two reservoirs in series. The results are relevant to multireservoir hydroelectric power systems. (Edited author abstract) 9 refs.

Christensen, G.S. (Univ of Alberta, Edmonton, Alberta, Can); Soliman, S.A. *J Optim Theory Appl* v 55 n 3 Dec 1987 p 359-376.

**090152 IMPLICIT STOCHASTIC MODEL FOR RESERVOIR YIELD OPTIMIZATION.** The implicit stochastic model is aimed at solving the specific problem of the optimal reservoir yield when the demand is not known. A three-level algorithm is proposed for the reservoir yield computation. At the first level, the simulation is used for computing the value of objective function. At the second level, computation of the seasonal reservoir operating rules is presented. The approach used for deriving the reservoir operating rules is based on the nonlinear unconstrained multivariable search of M.J.D. Powell. The third level is used for estimating the single multipurpose reservoir yield. The Fibonacci search procedure is used for the optimization of the reservoir at this level. The model is used in reservoir analysis for the water resources master plan of the Republic of Serbia, Yugoslavia. In this case, 49 reservoirs were analyzed. (Edited author abstract) 20 refs.

Simonovic, Slobodan (Univ of Manitoba, Winnipeg, Manit, Can). *Water Resour Res* v 23 n 12 Dec 1987 p 2159-2165.

**090153 DERIVING THE NONLINEAR RISK-BENEFIT ALGORITHM FOR RESERVOIRS.** The Nonlinear Risk-Benefit (NRB) Algorithm includes risk as one of the objectives in a multiple-objective optimization problem. The NRB Algorithm is derived by extending the Surrogate Worth Trade-Off method to quadratic programming. This category of problem is common in water resources planning and design, especially multipurpose reservoir systems. Consequently, an example is given using the algorithm for optimally operating a multipurpose reservoir. (Author abstract) 31 refs.

Uan-On, Thanakorn (Mahidol Univ, Bangkok, Thai); Helweg, Otto J. *Water Resour Bull* v 24 n 2 Apr 1988 p 261-268.

## Planning See Also FLOOD CONTROL—USSR.

**090154 WROCLAW KORYNEKI TARZOK ES ELLENORZO VIZSGALATAIK.** [Reservoirs Around Wroclaw and Their Supervision]. The characteristics in the construction, usage and operation of dams located in south-west Poland are similar to those available in Hungary. Therefore, their planning, construction and the structural checks are comparable to each other, in the two countries. The authors deal in this paper with the geological, hydrological and constructional problems of the dams of Mietkow and of Dobromierz. These earth-dams fulfill multiobjective tasks such as, water supply, flood protection, industrial water production, navigation, recreation and sports. The methods of observation and measurement are quite similar in the two countries and the Polish instrument-industry is well-prepared to produce modern tools for different technical purposes. (Edited author abstract) 6 refs. In Hungarian.

Gresz, Istvan (Vizgazdalkodasi Tudomanyos Kutatkozpont, Budapest, Hung); Nagy, Istvan Miklos. *Vizugyi Kozl* v 69 n 2 1987 p 264-273.

**090155 PREDICTION OF WATER QUALITY IN PLANNED RESERVOIRS IN THE TROPICAL ZONE.** The hydrochemical regime of reservoirs during the first months after their filling is formed under the effect of a number of factors, the main one being the effect of the flooded soils of the reservoir bed and vegetation. The flooded soils and rocks and the remains of trees, shrubs, and meadow vegetation release into the water diverse organic and biogenic materials influencing the hydrochemical and oxygen regimes of reservoirs and their sanitary state. A prediction of water quality in a planned reservoir makes it possible to estimate possible concentrations of pollutants and their dynamics in the first months and years of existence of the reservoir and the volume of necessary works on clearing and preparing the bed of the future reservoir. By using appropriate transformation coefficients and the appropriate method of predicting water quality in planned reservoirs it is possible to predict with greater reliability the changes in the water quality



during the first months and years of existence of practically all reservoirs of Southwestern Asia which will be created in regions of ferrallitic and ferrallitic-margallitic soils with vegetation characteristic for the tropical zone. 6 refs.

Malutin, A.N. (Acad of Sciences of the USSR, USSR); Mairanovskii, F.G.; Tikhonova, N.V. *Water Resour* v 14 n 2 Mar-Apr 1987 p 189-193.

**090156 TEMPERATURE ANALYSIS HOWARD A. HANSON RESERVOIR, WASHINGTON; MATHEMATICAL MODEL INVESTIGATION.** The US Army Engineer District, Seattle, is presently evaluating the impacts of proposed additional water storage at Howard A. Hanson Reservoir in Washington State. The impacts of raising the conservation pool on the reservoir thermal profiles and release temperatures for several study years are investigated. A mathematical model examined impacts of raising the pool with and without structural modification to the existing outlet works. Optimization procedures were used to provide optimum number of and elevations for the additional ports. Significant improvement in release temperatures for the raised pool could be achieved with a multilevel outlet structure as compared to the existing outlet works. The method for calculating the reliability index is given in Appendix A. Appendix B lists monthly temperature release statistics for existing conditions, and Appendix C lists the calculated average release temperature for the reservoir. (Edited author abstract). 12 Refs.

Schneider, Michael L. (US Army Engineer Waterways Experiment Station, Vicksburg, MS, USA); Price, Richard E. *Tech Rep US Army Eng Waterw Exp Stn n HL-88-22* Sep 1988 86p.

## Recreational Facilities

**090157 RECREATION RESOURCE ALLOCATION MODEL FOR PUBLIC DRINKING RESERVOIRS.** A management model was developed for determining optimal mixes of recreation activities at public drinking reservoirs. Quabbin Reservoir, located in Central Massachusetts, served as a case study for the Model. An interdisciplinary research team was formed to study (1) the impact of selected recreation activities on the water quality, (2) public demand and willingness to pay for selected recreation activities at Quabbin and (3) the cost-benefits associated with increases in recreation at Quabbin. The results of the research yielded a comprehensive Recreation Resource Allocation Model. The model includes the following procedures: the determination of demand for recreation activity packages, pollution transport modelling and water quality carrying capacity and recreation carrying capacity. These inputs to the optimization of the recreation management model were utilized in formulating alternative plans which were tested for their impacts given the management objectives and constraints of the study. (Author abstract) 9 refs.

Gross, M. (Univ of Massachusetts, Amherst, MA, USA); Klar, L.R. Jr; McKean, L. *Aqua (Oxford)* n 2 1988 p 81-84.

## Reliability

**090158 RELIABILITY EVALUATION OF RESERVOIR SYSTEMS.** Systems with reservoirs or storages are a particular case of what is called failure delay systems, for which, contrarily to the classical reliability systems, failure occurs under two conditions: the occurrence of a particular failure, i.e. a cut set, and moreover its continuous presence for a given time (random or fixed). This paper deals with reliability modeling of water reservoir systems. The three models developed and the corresponding REX software package are presented, which use for reliability evaluation and optimization of such systems is illustrated by several numerical examples. (Author abstract). 6 Refs.

Limnios, N. (Univ de Technologie de Compiègne, Compiègne, Fr). *Reliab Eng Syst Saf* v 23 n 1 1988 p 65-73.

## Safety Codes

**090159 RESERVOIR SAFETY PROGRAMME IN NORTHERN IRELAND.** Following publication of early proposals for the Reservoirs Act 1975, a systematic program of reservoir investigation and repair work was carried out by the Department of the Environment for Northern Ireland, Water Service. The paper describes the full procedure followed for data collection, inspections, risk classification and stability and hydraulic investigations of 60 'large raised reservoirs' impounded by dams up to 42 m high and up to 148 years old. Also described are examples of some unusual repair works carried out, and the implementation of a recording, monitoring, and inspection system which now continually oversees all of the reservoirs involved. (Author abstract) 6 refs.

Cooper, G.A. (Ferguson & McIlveen). *J Inst Water Environ Manage* v 1 n 1 Aug 1987 p 39-51.

**090160 RESERVOIR SAFETY.** Water impounded in a reservoir has considerable potential to cause damage, destruction and even death. For this reason, periodic reviews of reservoir structures have been required by law for over fifty years. The recently implemented 1975 Reservoirs Act imposes more stringent regulations than ever before, and the Department of the Environment has been sponsoring research to support the new legislation. Some of the work is being conducted by Hydraulics Research, who recently held a seminar to examine some of their findings, and discuss the latest legislation. (Author abstract)

Anon. *Civ Eng (London)* Mar 1988 p 38-42, 44.

## Sampling

**090161 PHOSPHATE EXCHANGE CHARACTERISTICS OF WET AND DRIED SEDIMENT SAMPLES FROM A HYPERTROPHIC RESERVOIR: IMPLICATIONS FOR THE MEASUREMENTS OF SEDIMENT PHOSPHORUS STATUS.** This paper examines changes in the phosphate exchange characteristics induced in sediment samples by drying during preparation for analysis. Comparison of selected sediment parameters measured in wet and dried subsamples of a range of sediments from hypertrophic Hartbeespoort Dam showed that air drying resulted in major changes in their physical and chemical composition. Particle size distribution in the dried sediments showed a shift towards larger particles, particularly in samples in which smaller particles were abundant, indicative of irreversible aggregation of finer particles. Drying decreased the bioavailable phosphorus (NTA-extractable) content of sediments but reduced the phosphate buffering capacity and increased the phosphate equilibrium concentrations by a factor of 3, thereby increasing the phosphate release potential of dried sediments. (Edited author abstract) 19 refs.

Twinch, A.J. (CSIR, Pretoria, S Afr). *Water Res* v 21 n 10 Oct 1987 p 1225-1230.

**Sedimentation** See Also DAMS—Monitoring; LAKES—Sedimentation; WATERSHEDS—Hydrology.

**090162 SLUICE DIMINISHING FOR DESILTING RESERVOIRS.** Experience of hydraulic flushing through low-level sluices to clear reservoir sedimentation is reviewed by the authors, and guidelines are presented for calculating the optimum dimensions for the sluices. It is demonstrated that, although applications of the flushing technique have so far mainly been for relatively small capacity reservoirs, the technique is now proving successful in large reservoirs, for example in the USSR and China. (Author abstract) 12 refs.

Paul, T.C. (Irrigation & Power Research Inst, Punjab, India); Dhillon, G.S. *Int Water Power Dam Constr* v 40 n 5 May 1988 p 40, 42-44.

**090163 PLANNING THE USEFUL LIFE OF A RESERVOIR.** A simplified method for the calculation of reservoir sedimentation rates is proposed; this can be used to reveal the loss of a reservoir's capacity in a given time

period or its total useful life. The author has refined the equations incorporated in his original article on the subject, which was published in *Water Power & Dam Construction* in December 1978. (Author abstract)

Gill, M.A. (Detroit Water & Sewage Dep, Detroit, MI, USA). *Int Water Power Dam Constr* v 40 n 5 May 1988 p 46-47.

**Seepage** See GRAVITY WAVES—Mathematical Models.

**South Carolina** See QUARRIES AND QUARRYING—South Carolina.

**Temperature Measurement** See GEOTHERMAL WELLS—Measurements.

**Texas** See LAKES—Texas.

## Theory

**090164 RANDOM CHOICE METHOD: STRUCTURAL STABILITY OF A CONSERVATION EQUATION IN RESERVOIR DYNAMICS.** The validity of representing the nonlinear part of a conservation equation by a finite number of node points is discussed. The difference between the solutions of the original and approximate problems obtained by the random choice method is analyzed in a probabilistic manner, and is found to stay small with a probability close to one for a finite time depending on the discretization. (Author abstract) 19 refs.

Pettersen, Oystein (Univ of Bergen, Bergen, Norw). *SIAM J Numer Anal* v 24 n 5 Oct 1987 p 997-1007.

**Underground** See Also OIL FUEL—Storage.

**090165 DEEP WASTEWATER RESERVOIRS IN ISRAEL - I: LIMNOLOGICAL CHANGES FOLLOWING SELF-PURIFICATION.** Ma'ale Kishon, one of the largest reservoirs storing wastewater for irrigation in Israel, has a surface area of 1.3 km<sup>2</sup>, depth of 9 m and volume of 12 million m<sup>3</sup>. Secondary effluent enters the northern basin and after a mean retention period of 6 weeks, flows into the southern one. Due to this two-basin structure, changes taking place during the water storage can be detected. The differences between the two basins were quantitatively studied by an interdisciplinary team. The sanitary, physico-chemical and biological variables indicated an improvement in water quality, leading to an increased ecosystem stability and a safer environmental performance. These results suggest that deep reservoirs of the type here described serving for wastewater disposal and reuse may have a wide application also in other countries having warm, subtropical climates. (Author abstract) 6 refs.

Dor, Inka (Hebrew Univ of Jerusalem, Isr); Kalinsky, Iris; Eren, Jahob; Dimentman, Chanan. *Water Sci Technol* v 19 n 12 1987, Waste Stab Ponds, Proc of an IAWPRC Spec Conf, Lisbon, Port, Jun 29-Jul 2 1987 p 317-322.

**Wave Effects** See HYDROELECTRIC POWER PLANTS—Hydrodynamics.

**RESISTORS** See Also ELECTRIC CIRCUIT BREAKERS—Components; ELECTRIC NETWORKS, NONLINEAR—Topology; ELECTROSTATICS.

**090166 NEW COMPOSITE MATERIALS FOR HIGH-CAPACITY RESISTORS.** Principal types of high-capacity composite-type resistors, such as the beted (electrically conductive concrete), LKS (linear ceramic), tyrite, Morganite, etc., are considered. Relying on these investigations, it is concluded that it is necessary to use new resistive composite materials (RCM) based on sodium silicate and high-temperature rubber binders for



high-capacity resistors operating under the conditions of short-time or long-time inclusion. (Translated author abstract) In Russian. 6 refs.

Gorelov, V.P.; Pugachev, G.A. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 15 Aug 1987 p 123-126.

**090167 NETWORK RESISTOR ALLOWS MORE CHIPS IN ELECTRONIC UNITS.** The network resistor that enables multiple resistance elements to be installed at one time implements cost savings, reduction in the resistor-occupied area on PCBs and efficient operation of installing equipment; thereby more chips can be installed in the electronic unit. As a surface installing part the network resistor comes as a chip resistor, flat package (SOP type) resistor, chip carrier resistor and micro-network chip. (Edited author abstract)

Honda, Yoshio (KOA Co.). *JEE J Electron Eng* v 24 n 252 Dec 1987 p 38-39.

**090168 STUDY ON NON-REACTIVE REFERENCE RESISTOR (RRU) FOR  $F_r$ -METER.** The impedance-frequency characteristics of a VHF quartz-crystal unit can be accurately explained according to an equivalent circuit containing the fifth parameter ( $R_5$ ). In this paper, it is described that a new RRU (Reference Resistor for everyday Use) is developed by making use of non-reactive resonance frequency ( $f_r$ ) calculated from the equivalent circuit mentioned above for the initial calibration of an  $F_r$ -meter's fixture. The non-reactive frequency ( $f_r$ ) measured by an  $F_r$ -meter's fixture, which has been already calibrated by the new RRU, are compared with the values measured by the Drop Method system in the range of 10-125 MHz. The compared results are very agreed, therefore it is found that the RRU mentioned in this paper is better than the conventional RRU. (Author abstract) 4 refs.

Omura, Yoshimasa; Watanabe, Yasuaki; Ushiyama, Hiroshi. *Mem Fac Technol Tokyo Metropol Univ* n 37 1987 p 3815-3822.

**Applications** See **ELECTRIC GROUNDING—Accident Prevention**; **INTEGRATED CIRCUITS, HYBRID—Fabrication**; **THYRISTORS—Switching**.

## Contacts

**090169 EFFECT OF SHEET RESISTANCE MODIFICATIONS UNDERNEATH THE CONTACT ON THE EXTRACTION OF THE CONTACT RESISTIVITY: APPLICATION TO THE CROSS KELVIN RESISTOR.** The influence of sheet-resistance modifications underneath the contact on the extraction of the contact resistivity is investigated. A generalized scaling theory has been applied to the modeling of the cross Kelvin resistor. It is shown that the errors associated with the contact sheet resistance modification could become appreciable in low-resistance metallizations of interest in VLSI. 10 refs.

Scorzoni, A. (CNR, Bologna, Italy); Finetti, M. *IEEE Trans Electron Devices* v 35 n 3 Mar 1988 p 386-388.

## Design

**090170 NEW CMOS RESISTOR IMPLEMENTATION FOR LINEAR IC APPLICATIONS.** A new CMOS implementation for a linearized floating resistance is presented, where the resistor value depends only on the  $\beta$  of a matched set of nMOS transistors, and on a bias current  $I_B$ ; it is independent of the threshold voltage  $V_T$ . Simulated worst-case linearity for a unity-gain amplifier is around 1% for a  $\pm 2$  v output swing. (Author abstract) 5 refs.

Vanpeteghem, P.M. (Texas A&M Univ, College Station, TX, USA); Rice, G.L. *Electron Lett* v 24 n 5 Mar 3 1988 p 288-290.

**090171 HIGH-SOUND QUALITY FILM RESISTOR.** High-sound-quality film resistors have been developed by the improvements in the constituent materials and the structure is as follows: (1) Resistor element with low distortion and low temperature coefficient of resistance

value, (2) Resistance trimming method considering low distortion and audio frequency characteristics, (3) Non-magnetic cap with low distortion, (4) Hermetic seal construction. (Edited author abstract) In Japanese. 4 refs.

Yanase, Tsuneo (Matsushita Electronic Components Co, Jpn); Mori, Hiroki. *Natl Tech Rep Matsushita Electr Ind Co* v 32 n 2 Apr 1988 p 114-119.

**090172 ELECTROCHEMICAL ADJUSTMENT OF THIN FILM Ti-Pd RESISTORS.** In this study a plating technique is described which allows adjustment of Ti-Pd resistors and minimizes changes in design geometry, characteristics. The approach is advantageous in that it provides a method for either increasing or decreasing the resistor value. This plating-deplating process uses a pencil-like electrochemical cell which immobilizes or restricts the plating electrolyte to the area immediately over the resistor without need for a mask; it is similar in nature to anodic trimming. A lower resistance is obtained by plating a thin layer of gold onto the resistor. The removal of the palladium (or deplating) yields a higher value resistor. The approach permits more uniform sheet resistivity changes and minimizes the impedance discontinuities seen in strip-line resistors adjusted by other conventional methods of adjustment. 7 refs.

Sharp, D.J. (Sandia Natl Lab, Albuquerque, NM, USA); Norwood, D.P. *Thin Solid Films* v 153 Oct 26 1987, Paper Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 387-399.

**Electric Conductivity** See Also **POLYMERS—Conductivity**.

**090173 DISORDER-INDUCED NONLINEAR CONDUCTIVITY.** We consider an electrical network of resistors in two dimensions. Each resistor has a threshold value for the potential drop below which it becomes an insulator. If the thresholds are randomly distributed, the current flowing through the total network is not proportional to the external voltage. A new nonlinear relation between current and voltage appears. (Author abstract) 7 refs.

Roux, S. (CNRS, Paris, Fr); Herrmann, H.J. *Europhys Lett* v 4 n 11 Dec 1 1987 p 1227-1231.

## Electric Properties

**090174 FREQUENCY DEPENDENCE OF RESISTIVE COMPONENT OF IMPEDANCE OF SILICON THIN-FILM RESISTORS.** A high-value resistor based on silicon thin film is described whose noise and frequency characteristics considerably surpass those of manufactured resistors. The frequency dependence of the resistive component of impedance is studied to determine the noise and frequency characteristics of the silicon thin-film resistors. The results permit calculation of the energy equivalent of the noise of resistors in nuclear-radiation detection units at any temperature from their frequency characteristic at room temperature. (Author abstract) 7 refs.

Belogurov, S.V.; Gostilo, V.V.; Yurov, A.S. *Instrum Exp Tech* v 30 n 4 pt 2 Jul-Aug 1987 p 978-979.

**090175 STUDY ON NON-REACTIVE REFERENCE RESISTOR (RRU) FOR  $F_r$ -METER.** The impedance-frequency characteristics of a VHF quartz crystal unit can be accurately explained according to an equivalent circuit containing the fifth parameter ( $R_5$ ). In this paper, it is described that a new RRU (reference resistor for everyday use) is developed by making use of non-reactive resonance frequency ( $f_r$ ) calculated from the equivalent circuit mentioned above for the initial calibration of an  $F_r$ -meter's fixture. The non-reactive frequency ( $f_r$ ) measured by an  $F_r$ -meter's fixture, which has been already calibrated by the new RRU, are compared with the values measured by the drop method system in the range of 10-125 MHz. The compared results are very agreed, therefore it is found that the RRU mentioned in this paper is better than the conventional RRU. (Author abstract). 4 Refs.

Omura, Yoshimasa (Tokyo Metropolitan Univ, Tokyo, Jpn); Watanabe, Yasuaki; Ushiyama, Hiroshi. *Mem Fac Technol Tokyo Metropol Univ* n 37 1987 p 3815-3822.

**090176 ELECTRICAL PROPERTIES OF CONDUCTIVE MATERIALS USED IN THICK-FILM RESISTORS.** Layers of conductive oxide powders ( $\text{IrO}_2$ ,  $\text{RuO}_2$  and  $\text{Bi}_2\text{Ru}_2\text{O}_7$ ) were prepared on alumina substrates by a thick film technique. The films were fired at 875°C for different dwell times. The temperature dependence of resistance was measured in the range -196 to 850°C. SEM observations of the initial powders and the resistive layer surface after firing, as well as X-ray diffraction investigations, were carried out. The  $\text{RuO}_2$  and  $\text{IrO}_2$  oxides exhibit a high sintering ratio and the resistance of the fired layers increases with temperature as in the single crystal. The R(T) curve for  $\text{Bi}_2\text{Ru}_2\text{O}_7$  layers is in qualitative agreement with the polycrystalline material. The role of the grain surface area and the regions between the grains is dominant. (Author abstract). 23 Refs.

Dziedzic, A. (Technical Univ, Wroclaw, Pol); Golonka, L. *J Mater Sci* v 23 n 9 Sep 1988 p 3151-3155.

**Evaluation** See **STRAIN—Measurements**.

## Fabrication

**090177 NOVEL SCALED-DOWN OXYGEN-IMPLANTED POLYSILICON RESISTOR FOR FUTURE STATIC RAM'S.** A scaled-down high resistor (1  $\mu\text{m}$  or less in length) for future static RAMs was realized by using slow arsenic diffusion in oxygen-implanted polysilicon, by which arsenic is partially doped to form a polysilicon interconnection layer. The current-voltage characteristics of the oxygen-doped polysilicon resistors were almost linear, and the marked decrease in resistance for higher applied voltage, observed in undoped polysilicon, was not found. The field-effect modulation of the resistance in the oxygen-doped polysilicon was much less than that of an undoped one. 5 refs.

Saito, Ryuichi (Hitachi Ltd, Ibaraki, Jpn); Sawahata, Yasuo; Momma, Naohiro. *IEEE Trans Electron Devices* v 35 n 3 Mar 1988 p 298-301.

## Failure

**090178 TRANSIENT THERMAL FAILURE MODE IN METAL FILM RESISTORS.** A failure mode has been observed in metal film resistors when they are subjected to single shot high voltage pulses. The conductor fails at a high field point which may be inherent in the design or may be due to manufacturing defects. The localized nature of the failure leads to the conclusion that there is a closed loop mechanism: the decrease in thermal diffusivity of the structure with rising temperature leads to an increase in the rate of temperature rise. (Author abstract) 6 refs.

Vardigans, S.V.G. (Metropolitan Coll of Further Education, Watford, Engl); de Cogan, D.; Henini, M. *J Phys D* v 20 n 11 Nov 1987 p 1454-1456.

## Grounding

**090179 APPLICATION AND DEVELOPMENT OF A CERAMICS RESISTOR FOR USE AS A NEUTRAL GROUNDING RESISTOR (NGR).** A super-compact SF<sub>6</sub>-gas-insulated neutral grounding resistor (NGR) is presented that uses recently developed high-power resistors made of a novel ceramic material. The microstructure, voltage-current characteristics, and current-carrying characteristics of the resistor element are examined. The composition and features of the NGR are discussed. 1 ref.

Shirakawa, S. (Hitachi Ltd, Hitachi, Jpn); Owada, S.; Iimura, N.; Kurita, K.; Yamazaki, T.; Shindo, K.; Yamauchi, Y. *IEEE Trans Power Delivery* v 3 n 1 Jan 1988 p 183-186.



**Magnetic Field Effects** See MAGNETIC FIELDS—Sensors.

**Manufacture** See Also CHROMIUM SILICON ALLOYS—Thin Films.

**090180** MASSENPRODUKTION VON AXIALEN DÜNNSCHICHT-WIDERSTÄNDEN FÜR ALLGEMEINE ANWENDUNGEN VON 0,1 OHM BIS 10 GIGAOHM. [Mass Production of General-Purpose Axial-Lead Thin Film Resistors from 0.1 to 10 Gigaohms]. A coater of high productivity is described allowing random coating at a high confidence level by means of magnetron sputtering. Based on four different target materials, and on non-reactive as well as partially reactive dc magnetron sputtering, it is possible to cover a range of sheet resistances from 1 Ohm/sq to 25 kOhms/sq; a range which, as a rule, embraces more than 98% of the total resistor assortment. By introducing another RF-sputterable resistor material the resistance range may even be extended to 10 MOhms/sq. (Edited author abstract) In German. 13 refs.

Bierbrauer, L. (VEB Kombinat Elektronische Bauelemente, Teltow, East Ger); Mueller, A.; Partesch, J.; Heisig, U.; Heinrich, A. *Vak Tech* v 37 n 1 Feb 1988 p 5-13.

**Materials** See RUTHENIUM COMPOUNDS—Electric Properties.

## Mathematical Models

**090181** STOCHASTIC ANALYSIS OF EDGE EFFECTS ON PLANAR RESISTORS. An analytical theory based on a perturbation approach is presented to model planar resistors with a stochastic edge. The theoretical analysis is confirmed by Monte Carlo simulations. (Author abstract) 5 refs.

De Mey, G. (Ghent State Univ, Ghent, Belg). *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 4 Dec 1987 p 191-196.

**Measurements** See ELECTRIC NETWORKS, NONLINEAR—Electric Properties.

## Microstructure

**090182** INFLUENCE OF PROCESS VARIABLES ON MICROSTRUCTURE AND V-I CHARACTERISTICS OF MULTICOMPONENT ZnO-BASED NONLINEAR RESISTORS. Studies have been made of the process variables such as calcination, initial particle size, and postsintering on density, microstructure, V-I characteristics, and energy-handling capability of a ZnO-based composite: 87.325 wt% ZnO+0.1% Nb<sub>2</sub>O<sub>5</sub>+3.5% Sb<sub>2</sub>O<sub>3</sub>+6% Bi<sub>2</sub>O<sub>3</sub>+0.55% CoO+0.7% MnO<sub>2</sub>+0.9% Cr<sub>2</sub>O<sub>3</sub>+0.9% NiO+0.025% Al(NO<sub>3</sub>)<sub>3</sub>. The nonlinear characteristics were found to be improved by the calcination of a ZnO+Nb<sub>2</sub>O<sub>5</sub> mixture at 1200°C for 1 h. The postsintering heat treatment was found to rejuvenate V-I characteristics of the degraded sample to a greater extent. (Edited author abstract) 24 refs.

Asokan, T. (Indian Inst of Science, Bangalore, India); Iyengar, G.N.K.; Nagabushana, G.R. *J Am Ceram Soc* v 70 n 9 Sep 1987 p 643-650.

## Performance

**090183** OVERVIEW OF HIGH VOLTAGE RESISTOR CHARACTERISTICS. High voltage resistors find use in a wide range of applications similar to low voltage applications: they control or limit current, drop or divide voltage, and form loads. However, high voltage applications add a new set of problems because resistor characteristics that are insignificant at low voltages assume a greater significance at high voltages. Important high voltage resistor characteristics are considered, such as absolute tolerance, temperature coefficient, voltage coefficient, load life stability, ratio tolerance, ratio temperature coefficient, and ratio voltage coefficient.

Reed, Dave (Caddock Electronics). *Powerconverters Intell*

*Motion* v 14 n 5 May 1988 p 48, 50-53.

**Reliability** See OVERVOLTAGE PROTECTION—Equipment.

**Stability** See ELECTRIC NETWORKS, LINEAR—Stability.

**Testing** See Also SEMICONDUCTOR MATERIALS—Impurities; STRAIN—Measurements; ZINC COMPOUNDS; ZINC COMPOUNDS—Doping.

**090184** SPREADING RESISTANCE ERROR IN THE VERTICAL KELVIN TEST RESISTOR STRUCTURE FOR THE SPECIFIC CONTACT RESISTIVITY. The spreading resistance error in the vertical Kelvin test resistor (VTR) structure is studied based on an analytic approach. It is found that it is always less than the error existing in the horizontal test structures and can be expressed as the product of the sheet resistance and the square of the junction depth of the conductor resistor divided by a factor approximately equal to 2. 12 refs.

Lee, Chung Len (Nat'l Chiao Tung Univ, Hsin Chu, Taiwan); Yang, Wen Luh; Lei, Tan Fu. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 521-523.

## Thermal Effects

**090185** TEMPERATURE DEPENDENCE OF ELECTRICAL CONDUCTION IN CARBON-EPOXY RESIN RESISTORS. It is well known that the carbon black (CB) - polymer resin resistor is advantageous because of its cheap manufacturing cost. However, there are also disadvantages such as: large temperature coefficient of resistance (TCR), and large humidity dependence of resistance. This paper attempts to clarify the mechanism of electrical conduction, especially its temperature dependence, experimentally and theoretically to obtain more information about producing low TCR resistors. Temperature dependence of resistivity for the mixture made of CB and epoxy resin can be explained well with a deliberately modified conduction mechanism based upon Scarisbrick's model, incorporating the thermal expansion of resin and the thermally activated conduction process in the model. (Edited author abstract) 16 refs.

Nakamura, Shuhei (Mie Univ, Tsu, Jpn); Ito, Atsushi; Kato, Hikaru; Ogasawara, Sachio; Sawa, Goro; Orita, Satoru; Tsubota, Kazunari. *Electron Commun Jpn Part 2* v 70 n 10 Oct 1987 p 96-109.

## Thermal Properties

**090186** DVM/DMM APPLICATIONS: SIMPLIFIED RESISTOR TEMPERATURE COEFFICIENT TEST SYSTEM. The temperature coefficient (TC) of a resistor is an important consideration to equipment design engineers. With current technology, evaluation of resistors can be accomplished by using an accurate 6½-digit digital multimeter (DMM). The DMM must be designed to make four-terminal resistance measurements and compensate for thermal EMF error voltages (offset compensation).

Kocher, Don (Keithley Instruments Inc, Cleveland, OH, USA); Green, Bob. *Eval Eng* v 27 n 8 Aug 1988 p 40-41, 43-44.

## Thick Films

**090187** NEW MODEL FOR ELECTRON MOVEMENT IN A THICK FILM RESISTOR AND ITS APPLICATION TO ANALYSIS OF THE STRUCTURE AND CONDUCTION MECHANISM IN THESE RESISTORS. A new model has been developed to explain the strain behaviour of thick film resistors. In this model, the electron moves in a meandering way through the resistor. By measuring the strain sensitivity and applying the meander model on it, information is obtained about the structure of the thick film resistor and the strain sensitivity of the micro-electron paths in the resistor. The latter can be a useful tool in testing models that describe conduction mechanisms in thick film resistors. In this research, measurements on the strain sensitivity of thick film resistors were made using a

four-point-bending bridge and the four-point-resistance measurement was made using special probes. Long, narrow enamel-coated steel substrates were used to enhance the accuracy of the measurements. (Author abstract) 14 refs.

Winkler, E.M. (Delft Univ of Technology, Delft, Neth); Steenvoorden, G.K. *Thin Solid Films* v 152 n 3 Sep 28 1987 p 487-497.

**090188** QUALITY AND QUANTITY IN THICK-FILM RESISTORS. Thick-film resistors can be produced in quantity as well as in quality, using well-planned techniques. The effective and economical fabrication of thick-film resistors requires the use of design methods and production controls adequate to obtain high yields. To appreciate the basic problems involved, it is convenient to think of thick-film resistors as one-way potentiometers, in which it is possible to increase the value up to a certain point, but not to decrease it under ordinary conditions. The goal is therefore to obtain a distribution of resistor values after the firing process in such a way that the resulting values are at or below the maximum value allowed by the circuit design, but above the minimum value, to avoid excessive trimming. This goal requires both effective design techniques and process controls.

Sargent, Jerry E. (Sargent & Sargent, Colorado Springs, CO, USA). *Electron Packag Prod* v 28 n 1 Jan 1988 p 70-72.

**090189** JUST A TRIM, PLEASE. Precision trimming with a multiple-trim sequence can help manufacturers keep pace with rapidly evolving hybrid technology and increasing circuit density. Since constraints on trimming increase as the geometry of hybrid resistors shrinks, improved trimming techniques are crucial. With smaller resistors, factors such as geometry, topography and heat dissipation from trimming take on greater significance. A trim technique is introduced that helps overcome problems in large resistors. In this article, the making of a 0.030-in.-square, eight-resistor network illustrates this trim procedure. All the resistors in the network are matched to within 0.03%.

Couch, Bruce (Teradyne Inc, Boston, MA, USA). *Circuits Manuf* v 28 n 4 Apr 1988 p 49-50.

**090190** PERCOLATION NETWORK FOR THICK RESISTIVE FILMS. A random resistance network with double percolation has been proposed for thick resistive films (TRFs). This network has been developed on the basis of our two previous models of these films' structure and conduction mechanism. Two types of resistances: (i) constriction resistance, and (ii) barrier resistance for thermally activated tunneling, have been included. Monte Carlo calculations of the network resistance ( $R_{RN}$ ) vs temperature ( $T$ ) have been presented using the data found for RuO<sub>2</sub>-based TRFs. It has been shown how the network parameters: volume fraction of conducting component,  $v$ , ratio of diameters of insulating and conducting particles,  $\chi$ , ratio of barrier resistance to constriction resistance,  $r$ , and probability  $p_1$  of the bond occupancy by constriction resistance, influence the shape of the characteristics,  $R_{RN}$  vs  $T$ . It has been found that proper choice of large  $r$  values together with relatively small  $v$ ,  $\chi$  and  $p_1$  values results in flat  $R_{RN}$  vs  $T$  characteristics which are consistent with the observation for real TRFs. An interpretation based on the deterministic resistance network has been given. (Edited author abstract) 21 refs.

Kusy, A. (Technical Univ of Rzeszow, Rzeszow, Pol); Listkiewicz, E. *Solid State Electron* v 31 n 5 May 1988 p 821-830.

**090191** PHASE EQUILIBRIA IN THE RuO<sub>2</sub>-Bi<sub>2</sub>O<sub>3</sub>-PbO SYSTEM. The proposed Bi<sub>2</sub>O<sub>3</sub>-RuO<sub>2</sub> phase diagram is shown. The melting temperature of the eutectic composition (around 80 percent Bi<sub>2</sub>O<sub>3</sub>) is 745°C, some 15 K higher than the temperature of the  $\alpha$ -Bi<sub>2</sub>O<sub>3</sub> to  $\delta$ -Bi<sub>2</sub>O<sub>3</sub> phase transition. At 950°C, Bi<sub>3</sub>Ru<sub>3</sub>O<sub>11</sub> transforms into Bi<sub>2</sub>Ru<sub>2</sub>O<sub>7</sub>. The ternary phase diagram (subsolidus) of



$\text{RuO}_2\text{-Bi}_2\text{O}_3\text{-PdO}$  is also presented. There is no ternary compound. The tie lines are between  $\text{PdO-Bi}_2\text{Ru}_2\text{O}_{11}$  and  $\text{Bi}_2\text{Ru}_2\text{O}_{11}\text{-Bi}_2\text{PdO}_4$ . The results indicate that there is no reaction between the conductive phase in thick film resistors (either  $\text{RuO}_2$  or bismuth ruthenate) and  $\text{PdO}$  during the firing of thick film circuits. 11 refs.

Hrovat, Marko (Jozef Stefan Inst, Ljubljana, Yugosl); Bernik, Slavko; Kolar, Drago. *J Mater Sci Lett* v 7 n 6 Jun 1988 p 637-638.

**090192 NITROGEN-FIREABLE RESISTORS; EMERGING TECHNOLOGY FOR THICK-FILM HYBRIDS.** A nitrogen-fireable base-metal thick-film resistor system compatible with copper conductors has been developed. A lanthanum hexaboride conductive phase is used to make resistor compositions in the range  $10\ \Omega/\text{2b-}10\ \text{k}\Omega/\text{2b}$ , and doped tin oxide is used as the conductive in the  $10\ \text{k}\Omega/\text{2b-}1\ \text{M}\Omega/\text{2b}$  resistance range. A transfer program to move this technology from the research laboratory to full commercial availability is underway. The environmental stability of 44 lots made in pilot, prototype, and manufacturing scale runs have been evaluated and confirm lot-to-lot reproducibility. Lanthanum boride members show good environmental stability under all conditions. Doped tin oxide members are humidity-sensitive and require encapsulation. When encapsulated with an organic material, all grades show maximum changes of less than 1% after 1000 h of exposure to  $85^\circ\text{C}/85\%$  relative humidity. 20 refs.

Donohue, Paul C. (DuPont, Wilmington, DE, USA); Hormadaly, Jacob; Needes, Christopher R.S.; Horowitz, Samuel J.; Knaak, Joachim F. *IEEE Trans Compon Hybrids Manuf Technol* v CHMT-10 n 4 Dec 1987, Contrib from the 37th Electr Compon Conf, Boston, MA, USA, May 1987 p 537-544.

**Thin Films** See Also SILICON CHROMIUM ALLOYS—Thin Films; WAVEGUIDES, RECTANGULAR—Attenuation.

**090193 KINETICS OF THIN FILM RESISTOR STABILISATION.** Thin film resistors are manufactured by photolithography methods, using a nickel-chromium alloy vacuum deposited on a ceramic substrate. In order to stabilize the resistors, a high temperature heat treatment in an air furnace is undertaken, during which the resistors are partially oxidized. It was found that the extent of reaction can be expressed as  $p=6 \times 10^4 \exp(-7400/T) t^{1/3}$ . A temperature of  $325^\circ\text{C}$  is recommended for practical applications. It involves a 30% resistance increase after an hour, while standard deviation is less than 2%. (Author abstract) 12 refs.

Goldberg, I.A. (Ministry of Defence, Haifa, Isr); Klein, I.E.; Hershkovich, M. *Microelectron J* v 19 n 1 Jan-Feb 1988 p 34-40.

**090194 TA-Si-C HIGH RESISTIVITY THIN FILMS FOR THERMAL PRINTING HEADS.** Ta-Si-C thin films have been developed for thermal printing heads, and the effect of composition on the film properties has been studied. The results show that: (1) when Ta-Si-C thin films are formed, the composition of the film does not agree with the target composition; (2) the addition of carbon to Ta/SiC mixtures suppresses recrystallization during high-temperature treatment; (3) excellent characteristics are achieved with thermal printing heads using Ta-Si-C thin films formed using a target with more than 20% carbon in a Si/C mixture; and (4) irreversible resistance changes are very small in thermal printing heads containing more than 20% carbon when external heat is applied. These findings indicate that Ta-Si-C is an excellent material for use in thermal printing heads. 9 refs.

Nakamori, Tomohiro (Oki Electric Industry Co, Hachioji, Jpn); Tsuruoka, Taiji; Kanamori, Takashi; Shibata, Susumu. *IEEE Trans Compon Hybrids Manuf Technol* v CHMT-10 n 3 Sep 1987, Second Int Electron Manuf Technol (IEMT) Symp, San Francisco, CA, USA, Sep 15-17 1986 p 446-451.

**090195 CHARACTERIZATION, EVALUATION,**

**AND COMPARISON OF LASER-TRIMMED FILM RESISTORS.** Methods for predicting the performance of laser-trimmed film resistors taking into account the properties of the heat-affected zone (HAZ) are discussed. A figure of merit based upon a sensitivity function called HAZ sensitivity,  $\text{SHAZ}$ , is introduced which is useful for determining aging and temperature effects of an arbitrary film-resistor geometry with an arbitrary trim strategy.  $\text{SHAZ}$  is also shown to be useful in predicting performance of ratio-matched resistor structures. The proposed technique is incorporated in FIRE, a Fortran program for analyzing arbitrary film structures with a given trim path. Examples using popular resistor geometries and trimming algorithms illustrating the use of the suggested figure of merit are presented. The performances of these structures are compared quantitatively. 13 refs.

Ramirez-Angulo, Jaime (Texas A&M Univ, College Station, TX, USA); Geiger, Randall L.; Sanchez-Sinencio, Edgar. *IEEE J Solid State Circuits* v SC-22 n 6 Dec 1987, 1987 Int Solid-State Circuits Conf (ISSCC), New York, NY, USA, Feb 1987 p 1177-1189.

**090196 NEW LASER-TRIMMED FILM RESISTOR STRUCTURES FOR VERY HIGH STABILITY REQUIREMENTS.** The drift with time and/or temperature of laser-trimmed film resistors limits the effective accuracy attainable from laser-trimmed resistor circuits. This accuracy is dependent on the geometries of the film resistors and on the trimming process. Novel film resistor structures that practically and significantly improve the effective ultimate accuracy attainable with laser-trimmed film resistors over both time and temperature are proposed. The structures are evaluated using computer simulations. This technique is substantiated with an example that shows an improvement in resolution of 4 bits when compared to that attainable with conventional bar resistors. 8 refs.

Ramirez-Angulo, J. (Texas A&M Univ, College Station, TX, USA); Geiger, Randall L. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 516-518.

**RESONATORS** See Also ACCELERATORS, LINEAR—Accessories; ACCELERATORS, LINEAR—Performance; ACOUSTIC SURFACE WAVE FILTERS—Noise, Spurious Signal; AMPLIFIERS—Design; ELECTRIC FILTERS, MICROWAVE—Design; ELECTRON BEAMS; FERRITE DEVICES; LASERS—Resonators; LASERS, SOLID STATE—Resonators; LASERS, SOLID STATE—Tuning; MICROSTRIP DEVICES; MICROSTRIP DEVICES—Synthesis; OSCILLATORS—Computer Aided Design; OSCILLATORS, MICROWAVE—Performance; OSCILLATORS, SOLID STATE; SIGNAL GENERATORS; WAVEGUIDES; WAVEGUIDES, DIELECTRIC—Components.

**090197 IMPROVED CIRCULAR DISK 3-DB HYBRIDS.** Methods of improvement on a planar-circuit-type 3-db hybrid consisting of a four-port circular disk-shaped resonator are proposed and described. Great improvement is obtained by rearrangement of the four ports upon consideration of the higher-order resonant modes and/or addition of a capacitive stub at the circumference of the resonator. Furthermore, the bandwidth of the hybrid is broadened considerably by adding an impedance step between the resonator and each 50- $\Omega$  coupling port. These improvements also are confirmed experimentally. (Edited author abstract) 9 refs.

Ohta, Isao (Himeji Inst of Technology, Himeji, Jpn); Hagino, Ichiro; Kaneko, Takenori. *Electron Commun Jpn Part 2* v 70 n 12 Dec 1987 p 66-77.

**090198 RAREFICATION OF THE SPECTRUM OF A WAVEGUIDE-DIELECTRIC RESONATOR.** In a previous paper attention was drawn to the possibility of controlling the distribution of the spectrum of resonance frequencies of a waveguide-dielectric resonator by an appropriate choice of the critical frequencies (or dimensions) of the beyond-cutoff and resonant regions. However, there is no quantitative estimate available of the maximum achievable rarefaction of the resonance frequencies of the dominant and closest higher modes of oscillation of a waveguide dielectric resonator. In this article such an estimate is given for a rectangular waveguide-dielectric resonator. 3 refs.

Kapilevich, B.Yu. *Radioelectron Commun Syst* v 30 n 5 1987 p 99-101.

**090199 EFFECT OF LIQUID FAILURE ON ITS VIBRATIONS IN THE RESONATOR.** Formation of powerful hydroshocks in pipelines at excitation frequencies far from natural vibration frequencies of an ideal single fluid column is considered in terms of continuum mechanics. The algorithm for computing transient processes in a liquid is based on the Lax-Vedroff combined method with the flow correction. Data of numerical and experimental calculations are compared. The appearance of hydroshocks is accounted for by a rise in the gas content and drop in the natural vibration frequency of a fluid column up to the value equal to that of the excitation frequency. (Author abstract) In Russian. 18 refs.

Galiev, Sh.U.; Yakovtsov, A.V.; Zelenyuk, N.I. *Probl Prochn* n 12 Dec 1987 p 95-99.

**090200 ON THE STUDY OF MICROSTRIP RING AND VARACTOR-TUNED RING CIRCUITS.** Equivalent circuits have been derived for microstrip ring and varactor-tuned ring resonators. It was found that the resonant frequency is slightly lower as the coupling gap becomes smaller. The effects are small and generally negligible unless a very small coupling gap is used. Varactor-tuned ring resonators were developed with a tuning bandwidth of up to 15% of the operating frequency. The use of a dielectric covering layer reduced the insertion loss of the resonant ring to less than 1 dB. 24 refs.

Chang, Kai (Texas A&M Univ, College Station, TX, USA); Martin, Scott; Wang, Fuchen; Klein, James L. *IEEE Trans Microwave Theory Tech* v MTT-35 n 12 Dec 1987, 1987 MTT-S Int Microwave Symp, Las Vegas, NV, USA, Jun 9-11 1987 p 1288-1295.

**090201 INDUCED SYNCHROTRON RADIATION.** At present, much effort is devoted to obtaining induced radiation from electrons moving in a periodic magnetic field in a free electron laser. It is of interest to find the conditions for generating induced synchrotron radiation, due to the circular motion of charge in a magnetic field. An open resonator for generating induced synchrotron radiation over a substantial arc of the orbit is proposed. 1 ref.

Kapitza, S.P. (Acad of Sciences of the USSR, Moscow, USSR). *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 43.

**090202 PROCEEDINGS OF THE 41ST ANNUAL FREQUENCY SYMPOSIUM, 1987.** The proceedings includes 84 papers. The following topics are dealt with: nonlinear resonator theory; electrodiffusion and point defects; atomic frequency standards; etch channels and dislocations; resonator processing; hydrogen masers and distribution; digital techniques; microwave and millimeter oscillators; frequency control circuitry; measurement theory and specifications; instrumentation and time transfer; surface acoustic wave devices; piezoelectric materials and devices; sensors and transducers; frequency synthesizers; UHF resonators and oscillators; linear resonator theory; and quartz crystal oscillators. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10775 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (US Army Electronics Technology & Devices Lab, USA). *Proc Annu Freq Control Symp* 41st, Philadelphia, PA, USA, May 27-29 1987. Publ by IEEE, New York, NY, USA, 1987. Available from IEEE Service Cent (Cat n 87CH2427-3), Piscataway, NJ, USA 554p.

**Analysis** See Also INTEGRATED CIRCUITS—Substrates.

**090203 MODE CHARTS OF GYROMAGNETIC PLANAR RING RESONATORS.** The modes and frequencies of demagnetized and magnetized planar disc,



triangular, wye and hexagonal resonators have already been described in the literature. Another resonator which has the required symmetry is the ring resonator. We give the resonant frequencies of this type of gyromagnetic resonator. (Edited author abstract) 15 refs.

Helszajn, J. (Heriot-Watt Univ, Edinburgh, Scotl); Nisbet, W.T.; Sharp, J. *Electron Lett* v 23 n 24 Nov 19 1987 p 1290-1291.

**090204 ACCURATE ANALYSIS OF ARBITRARILY SHAPED PATCH RESONATORS ON THIN SUBSTRATES.** Based on a generalized edge boundary condition (GEB), an accurate analysis method for arbitrarily shaped microstrip patch resonators is developed. The edge of the patch and its feeding line are first discretized as a series of connected segments. Next, an equivalent voltage and an equivalent current are defined on each segment. This boundary of the patch and the feeding line can be viewed as an interface between two networks. The first takes into account the coupling under the patch. The second represents the dynamical edge effects and the coupling over the top side of the patch. This general and computer-efficient approach is then successfully applied to determine the input impedance of some commonly used probe-fed and strip-fed patch resonators. 21 refs.

Martinson, Thomas M. (Univ of Colorado, Boulder, CO, USA); Kuester, Edward F. *IEEE Trans Microwave Theory Tech* v 36 n 2 Feb 1988 p 324-331.

**Applications** See Also ANTENNAS—Analysis; LASERS, SEMICONDUCTOR—Spectrum Analysis; MICROWAVE GENERATION—Noise, Spurious Signal; OSCILLATORS—Design; WAVEGUIDE COMPONENTS—Circuits.

**090205 APPLICATIONS OF SAW RESONATORS IN HIGH-PERFORMANCE INSTRUMENTATION.** The role that SAW (standing-acoustic-wave) resonators have come to play in high-performance test instrumentation is reviewed. The contributions made by SAW resonators in a number of Hewlett-Packard (HP) instrument applications are detailed. SAW-controlled oscillators are now the preferred design for precision frequency-control applications in the frequency range 200 MHz-1 GHz. The challenges in device design, fabrication, packaging and testing for these demanding applications are discussed. 17 refs.

Bray, Robert C. (Hewlett-Packard Co, Santa Rosa, CA, USA). *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 331-341.

**Computer Aided Design** See Also ELECTRIC FILTERS, ELECTROMECHANICAL—Computer Aided Design.

**090206 PC PROGRAM EVALUATES HIGHER ORDER MODES IN SHIELDED DIELECTRIC RESONATORS.** The procedure described is an approximate computational tool that is suitable for a personal computer (PC). The objective of the procedure is to evaluate resonant frequencies of the higher order modes in dielectric resonators inside a covered microstrip box. 12 refs.

Kajfez, Darko (Univ of Mississippi, University, MS, USA). *Microwave J* v 31 n 5 May 1988 8p.

## Cooling

**090207 COOLED DIELECTRIC RESONATORS FOR FREQUENCY STABILIZATION.** The characteristics of a new type of high-Q oscillatory system - cooled open dielectric resonators (DR) made of single-crystal leucosapphire - are studied theoretically and experimentally. A system of equations for the natural frequencies of the anisotropic dielectric resonator and the results of a numerical investigation of the system and an experimental evaluation of the accuracy are presented. The effect of the structural elements on the Q-factor of the resonator is examined. The behavior of the temperature coefficient of the resonance frequency  $\alpha_w$  of the leucosapphire DR in the temperature range 300-2 K is studied. The characteris-

tics of centimeter- and millimeter-band oscillators, which have been developed, based on the cooled leucosapphire DR are presented. (Edited author abstract). 20 Refs.

Bun'kov, S.N.; Vtorushin, B.A.; Yegorov, V.N.; Konstantinov, V.I.; Masalov, V.L.; Smirnov, P.V. *Sov J Commun Technol Electron* v 32 n 9 Sep 1987 p 165-173.

## Cylinders

**090208 RESONANT FREQUENCIES OF WHISPERING-GALLERY DIELECTRIC RESONATOR MODES.** Whispering-gallery dielectric resonator modes have shown their usefulness in millimeter wave integrated circuits. A method for the determination of the resonant frequencies of the whispering-gallery modes of cylindrical dielectric resonators is presented. Theoretical and experimental results are given. A comparison with other methods is made. (Edited author abstract) 8 refs.

Jiao, X.H. (CNRS, Limoges, Fr); Guillon, P.; Bermudez, L.A. *IEE Proc Part H* v 134 n 6 Dec 1987 p 497-501.

**Design** See Also ELECTROMAGNETIC WAVES—Scattering; GYROTRONS—Millimeter Waves.

**090209 WHISPERING-GALLERY MODES HERALD DR MM-WAVE USE.** At millimeter wavelengths, cylindrical dielectric resonators used in microwave integrated circuits become impractical. If conventional TE, TM, or hybrid modes are used, DRs will have dimensions that are impractically small. This article discusses how with only a slight configuration change, dielectric resonators (DRs) can be used as filters in the millimeter-wave range, with some unique electromagnetic radiation modes doing the work. 14 refs.

Guillon, P. (Univ de Limoges, Limoges, Fr); Jiao, X.H.; Auxemery, P.; Bermudez, L.A. *Microwaves RF* v 26 n 9 Sep 1987 8p between p 85 and 96.

**090210 PAVING THE WAY FOR STABILIZED DR OSCILLATORS.** The usefulness of dielectric resonators for frequency-stable oscillator circuits has been limited because the resonant frequency of the DR itself is not stable with variations in temperature. Moreover, the frequency change is not a straightforward function of the temperature change. This article presents an analytical approach which can simplify the modeling of dielectric-resonator temperature stability. 4 refs.

Jacques, Roger (CNET, Lannion, Fr). *Microwaves RF* v 26 n 9 Sep 1987 p 103-104, 106, 108.

**090211 SIMPLE EQUATIONS QUICKLY DESIGN CYLINDRICAL DRS.** Dielectric-resonator (DR) frequency, height, and radiation factors for TE<sub>018</sub> modes of operation have been difficult to calculate. Rigorous mathematical methods are computationally complex, making their use in practical applications almost prohibitive, and, the simpler, approximate methods are too inaccurate. However, the closed-form expressions derived are easy to use and more accurate than previous methods. 10 refs.

Mongia, Rajesh K. (Indian Inst of Technology, New Delhi, India); Bhat, Bharathi. *Microwaves RF* v 26 n 9 Sep 1987 5p between p 121 and 128.

**090212 COUPLING ANALYSIS MATCHES SPHERICAL DRS TO MICROSTRIP LINES.** Conventional, cylindrical dielectric resonators are difficult to use for millimeter wavelength applications because their dimensions are too small for easy manufacturing. Spherical dielectric resonators, however, are easier to produce at small dimensions. But, for these spherical resonators, predicting the coupling between the resonator and a microstrip transmission line has been traditionally difficult. This difficulty is eliminated with a coupling analysis and the resulting equations. 12 refs.

Julien, Anne (Univ de Limoges, Limoges, Fr); Guillon, Pierre Y. *Microwaves RF* v 26 n 9 Sep 1987 5p between p 133 and 140.

**090213 TWO-DIODE GUNN GENERATOR WITH A QUASIOPTICAL RESONATOR.** One of the most important problems in modern microwave electronics is to increase the power of semiconductor millimeter-band generators. This can be solved by using different constructions. However, the most widely used method is to add the powers of several diodes in a common resonator. In this case, it is possible to achieve acceptable summation, but at the price of reducing the frequency tuning range, which usually does not exceed a few percent. In this communication, we present the results of experimental investigations of the power and frequency characteristics of a two-diode Gunn generator with a quasioptical resonator. 9 refs.

Smorodin, V.V. *Radioelectron Commun Syst* v 30 n 5 1987 p 64-66.

**Dielectric Properties** See Also ELECTRIC FILTERS, BANDPASS—Design; OSCILLATORS, MICROWAVE—Stability.

**090214 COUPLING OF NON-AXIALLY-SYMMETRIC HYBRID MODES IN DIELECTRIC RESONATORS.** A method is developed for the rigorous calculation of the coupling coefficient between dielectric resonators excited in non-axially-symmetric hybrid modes. The technique is based on solving the boundary value problem for the fields and resonant frequencies in the combined two-resonator structures. A simplified circuit model representing the two coupled resonators is used to reduce the problem of coupling calculations to that of finding the resonant frequencies of two separate single resonators without solving the detailed boundary value problem. Experimental measurements of the coupling between the two lowest hybrid modes were performed to verify the models, and were found to be in excellent agreement with the calculations. 8 refs.

Zaki, Kawthar A. (Univ of Maryland, College Park, MD, USA); Chen, Chunming. *IEEE Trans Microwave Theory Tech* v MTT-35 n 12 Dec 1987, 1987 MTT-S Int Microwave Symp, Las Vegas, NV, USA, Jun 9-11 1987 p 1136-1142.

**090215 PROPERTIES OF SHIELDED CYLINDRICAL QUASI-TE<sub>0mn</sub>-MODE DIELECTRIC RESONATORS.** Comparison of the Rayleigh-Ritz method and the mode-matching method for computations of quasi-TE<sub>0mn</sub>-mode frequencies and unloaded Q factors of shielded dielectric resonators is presented. Rigorous bounds for the true quasi-TE<sub>0mn</sub>-mode frequencies are assessed. Influence of various parameters on the resonant frequencies, unloaded Q factors, and the temperature coefficients of the resonant frequency is demonstrated for many shielded dielectric resonator structures. Different approaches to unloaded-Q-factor computations are discussed and numerically compared. 12 refs.

Krupka, Jerzy (Polytechnic of Warsaw, Pol). *IEEE Trans Microwave Theory Tech* v 36 n 4 Apr 1988 p 774-779.

## Electric Properties

**090216 INPUT IMPEDANCE AND LOADED QUALITY FACTOR OF A PROBE EXCITING DIELECTRIC RESONATOR.** Using a dielectric resonator in microwave filter applications, several types of excitations can be considered. An HEM<sub>118</sub>-mode filter, used in satellite applications, utilizes coaxial probes for the coupling of dielectric resonators with the external ports. In the paper the authors present the determination of the input impedance and of the coupling parameters between a probe and a dielectric resonator, when the pin is placed in the radial plane of a structure containing a cylindrical dielectric resonator. (Author abstract) 7 refs.

Vigneron, S. (Univ de Limoges, Limoges, Fr); Guillon, P. *IEE Proc Part H* v 135 n 3 Jun 1988 p 163-166.

## Evaluation

**090217 ELECTRIC FIELDS AND LOSSES IN LUMPED ELEMENT RESONATORS FOR ESR SPECTROSCOPY.** This paper presents closed expressions for the electric field in lumped element resonators



used for ESR spectroscopy and an evaluation of the frequency dependence of the dielectric losses. The dielectric losses depend on the type of resonator used and the results show that multi-gap resonators are very effective in reducing their effect. The comparison between magnetic and electric losses indicates that, for properly designed resonators and sample diameters of the order of 15-20 mm, the magnetic losses will predominate. (Author abstract) 15 refs.

Sotgiu, A. (Univ dell'Aquila, L'Aquila, Italy); Momo, F.; Gualtieri, G.; Adriani, O. *J Phys E* v 20 n 12 Dec 1987 p 1487-1490.

## Fabrication

**090218 MICROWAVE BULK-ACOUSTIC-WAVE REFLECTION-GRATING RESONATORS.** A technique for fabrication of bulk-acoustic-wave (BAW) resonators operating at fundamental frequencies between 1 and 10 GHz is presented. The resonators utilize a reflection grating made by optical holographic methods in iron-doped lithium niobate. Q factors of 30000 at 1 GHz have been demonstrated. Extension to Q of 10000 at 10 GHz appears feasible. Projected limitations to performance are discussed. The high Q at the high fundamental frequency directly results in low-phase noise. Phase-noise measurements of BAW resonator-stabilized oscillators operating at 1.14 GHz are presented. The single-sideband noise floor of  $<-140$  dBc/Hz is shown to be in agreement with an analytical model. Projected improvements in the devices and circuits promise performance of  $<-160$  dBc/Hz. 23 refs.

Oates, Daniel E. (MIT, Lexington, MA, USA); Pan, Jeffrey Y. *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 315-322.

**090219 SAW RESONATOR DESIGN AND FABRICATION FOR 2.0, 2.6 AND 3.3 GHz.** Direct-write electron-beam lithography has been used to fabricate surface-acoustic-wave (SAW) resonators in quartz at 2.05, 2.60, and 3.30 GHz. Typical 2.05 GHz devices show unloaded Q factors of about 2700 and insertion losses of about 9 dB. The best 2.60 GHz devices have unloaded Q of about 2000 with insertion losses less than 11 dB. Preliminary 3.3 GHz devices have shown unloaded Q of about 1600 and insertion losses of 17 dB. These results are for devices tested in chip form in a 50- $\Omega$  system. The fabrication of a fundamental-mode resonator with center frequency exceeding 2.6 GHz is claimed to be unmatched in the literature. These results are due in part to improvements in design and electron-beam direct-write capabilities. Design and fabrication of SAW resonators above 2 GHz are described, test results for several wafers including preliminary phase noise measurements for devices at 2 GHz are reported, and problems associated with testing these devices are discussed. 13 refs.

Pendergrass, Larry L. (Hewlett-Packard Co, Santa Rosa, CA, USA); Studebaker, Lawrence. *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 372-379.

## Ferrite

**090220 NOUVELLE METHODE DE DETERMINATION DES PARTIES REELLES DES PARAMETRES ELECTRIQUES ET MAGNETIQUES DES RESONATEURS A FERRITES SATURES ET NON SATURES.** [New Method of Determination of Real Parts of Dielectric and Magnetic Parameters of Saturated and Nonsaturated Ferrite Resonators.]. Real parts of dielectric and magnetic material parameters of saturated and partially magnetized ferrites are determined in the frequency range: 2.5-4 GHz. Formulas of the tensor permeability elements are not used for the calculation of these parameters which are deduced from the degenerated resonant frequencies of the  $TM_{020}$  and  $TM_{-210}$  modes. These frequencies are measured in an appropriate metallic cavity containing a ferrite disk suitable for a 2 GHz circular. (Edited author abstract). 14 Refs. In French.

LeRoux, Pascal (CNRS, Limoges, Fr); Jecko, Francoise; Forterre, Gerard. *Ann Telecommun* v 43 n 5-6 May-Jun 1988 p 314-322.

## Ferrite Applications

**090221 THREE-PORT FERRITE RESONATOR CIRCUIT USING COPLANAR WAVEGUIDE.** A three-port magnetically-tunable ferrite resonator circuits proposed, which uses a ferrite resonator and coplanar waveguide on a dielectric substrate. This circuit has both resonator and isolator properties, and is applicable to a magnetically-tunable oscillator using with an active component. It is not necessary to use an additional isolator for reducing the influence of the reflected power on the oscillation. Experiments are done with YIG and CaVG ferrite. The existence of an optimum position for placing ferrite to obtaining the maximum non-reciprocity, is ascertained by the theoretical and experimental results. This circuit is simple in construction, and suitable for wide-band operation. 6 refs.

Ohwi, Koichi (Nat'l Defense Acad, Yokosuka, Jpn); Okada, Fumiaki. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3748-3750.

Hysteresis See RESONATORS, CRYSTAL—Thermal Effects.

## Impedance Matching

**090222 IMPEDANCE MATCHING AND STABILIZATION OF RF RESONATORS.** The study of nuclei possessing high angular momenta demands beams of heavy ions with an energy sufficient to overcome the Coulomb barrier for relevant combinations of projectile and target. This demand has motivated the design and construction of a postaccelerator for the 9 MV tandem Van de Graaff at the Niels Bohr Institute. In connection with the postaccelerator system presently being installed at the NBI tandem, general considerations and formulae for resonator matching and stabilization are presented. 9 refs.

Westergaard, J. (Niels Bohr Inst, Riso, Den); Olesen, M.C.; Knudsen, P.; Hansen, N.J.S.; Hagemann, K.A.; Elbek, B.; Borggreen, J. *Nucl Instrum Methods Phys Res Sect A* v A268 n 2-3 May 20 1988, Seventh Tandem Conf, Proc, Berlin, West Ger, Apr 6-10 1987 p 525-530.

Mathematical Models See Also COMBUSTION—Oscillations; LASERS, SOLID STATE—Resonators.

**090223 STATISTICAL MODEL OF AN ADAPTIVE TWO-MIRROR UNSTABLE RESONATOR.** The cancellation of phase fluctuations of a wave field in an open unstable resonator is discussed. Cancellation effectiveness is investigated both within the resonator and at its output. Cancellation outside the resonator is shown to be more effective for phase variations of higher dynamic range. Features of an adaptive resonator compared with adaptation without an optical resonator system are pointed out. (Author abstract) 7 refs.

Kislov, V.I.; Taranenko, V.G. *Sov J Commun Technol Electron* v 32 n 6 Jun 1987 p 32-38.

**090224 EINE ASYMPTOTISCHE METHODE ZUR BERECHNUNG NICHTLINEARER HELMHOLTZRESONATOREN.** [Asymptotic Method for Calculating Nonlinear Helmholtz Resonators.]. The acoustic nonlinearity of a Helmholtz resonator is caused by the fact that the flow resistance of the orifice increases with increasing particle velocity amplitude. By extending the asymptotic method of Krylov, Bogoljubov and Mitropolski we calculate the nonlinear oscillations in the tube-resonator-system, the amplitudes of the higher harmonics, the resonance curves and the decay of the amplitudes caused by the nonlinear dissipation. In addition the method enables us to include further nonlinear or dissipative effects, to treat other forms of external excitation or to consider tubes with Helmholtz resonators coupled at both ends. In all cases the numerical evaluation

only takes a very short time. (Edited author abstract) In German. 21 refs.

Ochmann, M. (Inst Fuer Technische Akustik, Berlin, West Ger). *Acustica* v 65 n 1 Dec 1987 p 11-20.

**090225 HIERARCHY OF TERMS IN A MULTI-POLE EXPANSION.** In the classical multipole expansion the various terms (dipoles, quadrupoles etc.) are ranked according to powers of the wavenumber k. When  $k \rightarrow 0$  the dominant terms are those of lowest powers, provided the moments are k-independent. However, this situation does not always hold, and the hierarchy may be upset when the current structure markedly changes with k. The point is illustrated by the example of the confined modes of a dielectric resonator. (Author abstract) 2 refs.

Van Bladel, J. (Univ of Ghent, Ghent, Belg). *Electron Lett* v 24 n 8 Apr 1988 p 492-493.

Measurements See DIELECTRIC MATERIALS—Measurements.

Microwaves See Also WAVEGUIDES, RECTANGULAR—Analysis.

**090226 ANALYSE DER ANKOPPLUNG DIELEKTRISCHER RESONATOREN AN MIKROSTRIP-LEITUNGEN.** [Analysis of Dielectric Resonators Coupled to Microstrip Lines.]. This paper presents an analysis of cylindrical dielectric resonators coupled to one and two microstrip lines. The coupling parameters and the elements of the electric equivalent networks are calculated. The effects of the change of parameters are investigated. The dielectric resonator coupled to two microstrip lines acts as a bandpass filter. This structure is analysed with open- and short-circuited as well as match-terminated transmission lines. Methods for the measurement of unloaded and loaded quality factors are discussed. Measured data of a 6-GHz dielectric resonator in bandstop filter configuration are presented. (Author abstract) 17 refs. In German.

Slawitschka, Ladislaus (Siemens AG, Munich, West Ger). *Frequenz* v 41 n 10 Oct 1987 p 254-260.

**090227 APPROXIMATE RELATIONS FOR CALCULATING THE RESONANCE FREQUENCY OF  $H_{018}$  MODES OF OSCILLATION OF CYLINDRICAL DIELECTRIC MICROWAVE RESONATORS.** The solution of boundary value problems on the  $H_{018}$  modes of circular cylindrical dielectric microwave resonator in free space and with plane and metal screens reduces to a complex form of characteristic equations. It is possible to solve them by numerical methods using high-speed computers having effective algorithms for calculating cylindrical Bessel functions of the first kind and MacDonald functions of different orders as part of their software, but this involves a considerable amount of computer time. The calculations can be simplified considerably and carried out using a microcomputer or microcalculators if one uses simple approximate relations, which are obtained in the present paper by making use of the particular features of the solutions of the characteristic equations. 6 refs.

Chernii, B.S. *Radioelectron Commun Syst* v 30 n 5 1987 p 92-95.

**090228 IMPROVING EXCITATION EFFICIENCY OF DISK DIELECTRIC RESONATORS.** In most self-excited microwave oscillator circuits that use disk dielectric resonators (DDR) to stabilize the frequency, the resonators are excited by the radiating aperture of a metallic waveguide. For a specified level of the DDR loaded Q,  $Q_1$  waveguide coupling devices (exciters) make it possible to obtain stronger coupling with a DDR than coaxial, microstrip, or other devices. Owing to diffraction losses of energy in excitation of the DDR a decrease in the distance between the radiating aperture and the resonator surface is accompanied by a drop in the loaded Q of the DDR that is more rapid than the increase in the coupling coefficient  $\beta_{cp}$ . The problem of improving the efficiency of



existing waveguide exciters therefore remains acute. We show that by going from single to multielement coupling devices it is possible to realize more fully the advantage of a DDR in terms of  $Q$  when compared with other kinds of resonators. Selective excitation of oscillations at the required DDR modes is ensured. 2 Refs.

Ivanov, E.N.; Karachev, A.A.; Tsarapkin, D.P. *Radioelectron Commun Syst* v 30 n 10 1987 p 67-69.

**090229 EXPERIMENTAL CHARACTERIZATION OF MULTIMODED MICROWAVE RESONATORS USING AUTOMATED NETWORK ANALYZER.** A computer-assisted procedure for accurate determination of microwave-resonator lumped-element equivalent circuit parameters is described. The technique is based on vector network analyzer measurements, and is applicable to multiple resonant modes in close frequency proximity as well as isolated single resonances. Data from either reflection or reaction type measurements may be numerically processed by the same procedure. Results are presented and discussed for several shielded dielectric resonator cases of practical interest. 12 refs.

Wheless, W. Perry Jr. (Univ of Alabama, Tuscaloosa, AL, USA); Kajfyz, Darko. *IEEE Trans Microwave Theory Tech* v MTT-35 n 12 Dec 1987, 1987 MTT-S Int Microwave Symp, Las Vegas, NV, USA, Jun 9-11 1987 p 1263-1270.

**090230 TUNABLE MICROWAVE RESONATORS AND OSCILLATORS USING MAGNETOSTATIC WAVES.** The status of magnetostatic wave (MSW) straight-edge resonators (SERs) and their applications in tunable oscillator circuits are reviewed. The resonators are based on magnetostatic waves propagating in high- $Q$  cavities fabricated in thin ferrimagnetic yttrium iron garnet (YIG) films. The resonance frequency of these resonators can be tuned using a bias magnetic field. The theory of operation and design criteria for the straight-edge resonators are described with emphasis on the effect of the resonator parameters on the tuning range, power handling, and phase noise performance. The use of the SER as the frequency-selective element in oscillator circuits is reported. Examples of tunable oscillators are included. 31 refs.

Ishak, Waguih S. (Hewlett-Packard Co, Palo Alto, CA, USA); Kok-Wai, Chang; Kunz, William E.; Miccoli, Giuseppe. *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 May 1988 p 396-405.

## Millimeter Waves

**090231 NEW EXPERIMENTAL RESULTS OF MILLIMETRE-WAVE WHISPERING GALLERY MODE DIELECTRIC RESONATORS EXCITED BY MICROSTRIP LINES.** The letter presents an experimental investigation of planar millimetre-wave dielectric resonators acting on whispering gallery modes and excited by microstrip lines. Experimental results including measured resonant frequencies and loaded quality factors obtained in both  $K_a$  bands (26.5-40 GHz and 90-100 GHz) will be presented. (Author abstract). 3 Refs.

Jiao, X.H. (CNRS, Limoges, Fr); Cros, D.; Auxemery, P.; Guillon, P. *Electron Lett* v 24 n 13 Jun 23 1988 p 797-798.

## Multiplexing

**090232 FOUR-PORT FIBRE-OPTIC RING RESONATOR.** A novel device is described, formed by taking one of the outputs of a  $3 \times 3$  fused optical coupler back to one of the inputs to form a fibre optic ring resonator with two inputs and two outputs. The device can be used for narrowband wavelength division multiplexing and for switching of optical signals. (Author abstract) 2 refs.

Davies, P.A. (Univ of Kent, Canterbury, Engl); Abd-el-Hamid, G. *Electron Lett* v 24 n 11 May 26 1988 p 662-663.

## Optimization

**090233 QUALITY FACTOR OPTIMISATION OF COAXIAL RESONATORS.** The optimum shape of the inner conductor of a coaxial resonator with constant resonance frequency yielding maximum  $Q$  is obtained by applying the Rayleigh-Ritz method for the analysis and the conjugate gradient method for function maximization. The shape of the inner conductor is approximated by a polygon and the resulting factor is 8.8%. (Author abstract). 10 Refs.

Zhu, N. (Univ Stuttgart, Stuttgart, West Ger); Landstorfer, F.M. *Electron Lett* v 24 n 14 Jul 7 1988 p 862-863.

**Oscillations** See Also GYROTRONS—Analysis; WAVEGUIDES, OPTICAL—Oscillations.

**090234 INTERACTION EFFECTS OF AZIMUTHAL OSCILLATIONS IN DIELECTRIC DISK RESONATORS.** In order to achieve high and ultrahigh  $Q$  levels in the microwave and EHF wave bands it is advisable to use open dielectric resonators with azimuthal oscillations (DRAO) in the form of dielectric disks. In order to eliminate the deleterious consequences of the interaction effects several measures are necessary: the implementation of measures for controlling the oscillation spectrum of the DRAO; a discrimination of nonoperating oscillations; an optimization of the construction of the coupling devices; and the elimination of harmful defects in the shape of the dielectric resonators. 6 refs.

Vzyatyshev, V.F.; Rayevskiy, G.P. *Sov J Commun Technol Electron* v 32 n 7 Jul 1987 p 127-129.

**Performance** See Also ELECTRODES—Performance.

**090235 BETTER COUPLING MODEL OF DR TO MICROSTRIP ENSURES REPEATABILITY.** The lack of simple, accurate models for determining performance dielectric resonators (DRs) coupled to microstrip lines makes repeatable design of DR filters and oscillators extremely difficult. An examination of some DR coupling models will clarify why one model is a more accurate method of predicting unloaded  $Q$  of the DR. This model includes resistive losses and loaded  $Q$ , and is valid with or without the use of dielectric spacers between the DR and the substrate. 10 refs.

Champagne, Patrick (Canadian Marconi Co, Montreal, Que, Can). *Microwaves RF* v 26 n 9 Sep 1987 p 113-114, 116-118.

**090236 FIBRE RING RESONATOR WITH FINESSE OF 1260.** A fibre ring resonator constructed by a strand of single-mode fibre and a mechanically lapped directional coupler is demonstrated. The finesse of the resonator was measured to be as high as 1260. Methods to improve the coupler characteristics are discussed. The device can be used as a high-resolution optical spectrum analyser. (Author abstract) 5 refs.

Yue, C.-Y. (Tsinghua Univ, Beijing, China); Peng, J.-D.; Liao, Y.-B.; Zhou, B.-K. *Electron Lett* v 24 n 10 May 12 1988 p 622-623.

**090237 LINEAR RESONATOR IN PHOTOREFRACTIVE BSO WITH TWO PUMP BEAMS.** A linear resonator using a new amplification mechanism in BSO is reported. The gain can be optimised for a particular frequency detuning of one pump beam. (Author abstract) 6 refs.

Erbschloe, D.R. (Univ of Oxford, Oxford, Engl); Solymar, L. *Electron Lett* v 24 n 11 May 26 1988 p 683-684.

**Quartz Applications** See RESONATORS, CRYSTAL—Mathematical Models.

## Spectrum analysis

**090238 FREE OSCILLATIONS IN A COAXIAL-WAVEGUIDE RESONATOR.** The problem of determining the spectrum of free oscillations in a coaxial-waveguide resonator (CWR) is discussed in a rigorous

formulation. A uniqueness theorem is proved. A rigorous mathematical model describing the spectrum of natural axially symmetric oscillations in the resonator is constructed and the corresponding calculation algorithm is proved and realized. The natural oscillations in a CWR are analyzed in detail and classified. A relationship between the excitation of natural oscillations and the scattered characteristics is established. (Author abstract) 9 refs.

Sirenko, Yu.K.; Shestopalov, V.P.; Yashina, N.P. *Sov J Commun Technol Electron* v 32 n 7 Jul 1987 p 60-67.

## Stability

**090239 THERMAL STABILITY OF PHASE-CONJUGATE RESONATOR.** The condition for thermal stability of the phase-conjugate resonator (PCR) is derived by means of the transfer matrix method. It is pointed out that the PCR is not certainly thermo-stable if only the condition  $G_1 G_2^{-1/2}$  is satisfied. Therefore, optimal design of the PCR is necessary in order to obtain high-quality output beams. The localization phenomenon of compensating distortions by using phase-conjugate techniques can be explained with the results obtained in this paper. (Author abstract) 6 refs. In Chinese.

Lu, Baida (Sichuan Univ, Chengdu, China); Cai, Bangwei; Wang, Shaomin. *Guangxue Xuebao* v 8 n 2 Feb 1988 p 140-144.

**090240 EFFECT OF FREQUENCY SHIFT ON THE STABILITY AND MODE PROPERTIES OF STIMULATED SCATTERING PHASE-CONJUGATE RESONATORS.** The effect of frequency shift on the stability and mode properties of Stimulated Scattering Phase-Conjugate Resonators (SSPCR) has been studied by introducing the generalized self-consistency condition and the Stimulated Scattering Phase-Conjugate Mirror (SSPCM)'s transfer matrix that has explicit variable frequency. (Author abstract) 3 refs. In Chinese.

Liu, Jinsong (Northwest Telecommunication Engineering Inst, Xian, China). *Guangxue Xuebao* v 8 n 4 Apr 1988 p 308-311.

**090241 BISTABLE PROPERTIES OF A NONLINEAR FABRY-PEROT RESONATOR WITH ACOUSTOOPTICAL INTERACTION.** The effect of acoustooptical (AO) interaction on the bistable properties of a Fabry-Perot (FP) resonator into which a nonlinear medium is inserted, is studied theoretically. It is shown in the Bragg diffraction approximation that for low diffraction efficiency over the length of the resonator AO interaction leads primarily to modulation of phase detuning from exact resonance of the FP resonator. In this case AO interaction may either only transfer the system from one stable state to another in the vicinity of the threshold fields for onset of bistability or, if the AO interaction in the resonator is efficient, it can lead to strong modulation of the radiation passing through and reflected from the resonator, when over one period of the sound the dependence of the amplitude of the transmitted signal on the amplitude of the input signal encompasses the entire hysteresis loop. (Edited author abstract). 4 Refs.

Gulyayev, Yu. V.; Isadzhanyan, Ye. G.; Shkerdin, G.N. *Sov J Commun Technol Electron* v 32 n 9 Sep 1987 p 57-61.

## Temperature Measurement

**090242 INVESTIGATION OF TEMPERATURE CHARACTERISTICS OF SINGLE CRYSTAL SAPPHIRE DISK DIELECTRIC RESONATORS.** To define the value of  $\alpha_\omega$  more accurately, single crystal sapphire disk resonators were studied in the temperature range between 2°K and 300°K. The measurements were performed in the 8-10 GHz band. Disk DRs (Dielectric Resonators) were made of single crystal sapphire grown using the State Optical Institute method. The types of the induced oscillations, geometrical dimensions  $D$  and  $L$ , and the disk geometric axis deviation from the crystal's optical axis  $\Delta\phi$  for the studied resonators are given. The



Q-factor of the DR was measured using the dynamic method and recording the resonant curve on a two-coordinate plotter, which also allowed us to control the structure and the shape of the resonant curve. An analysis of the experimental data indicates that in the region of liquid-helium temperature, the  $\alpha_{\omega}(T)$  behavior of the single crystal sapphire disk resonators has an anomalous character, which is determined by the impurities in the crystal. Stabilizing the DR temperature in the region where  $\alpha_{\omega}(T) \approx 0$  will allow one to increase substantially the stability and the reproducibility of the natural resonant frequency of the DRs, which are used for frequency stabilization. 9 refs.

Bun'kov, S.N.; Konstantinov, V.I.; Masalov, V.L.; Smirnov, P.V. *Meas Tech* v 29 n 2 Feb 1986 p 101-103.

## Testing

**090243 FREQUENCY CHARACTERISTIC OF A WAVEGUIDE WITH A DIELECTRIC RESONATOR.** When a dielectric resonator is connected to a waveguide, in addition to intense resonance perturbation of the microwave field at frequencies close to the resonance frequency for all modes of oscillation of the dielectric resonator, there is also a comparatively weak perturbation of the field, which, in the frequency band employed, does not have a resonance form. This nonresonant background is due to large values of the volume of the dielectric resonator and the permittivity of the materials employed. This paper takes into account the nonresonant perturbation, which leads to asymmetry of the amplitude-frequency characteristics of structures with dielectric resonators, in order to increase the accuracy of these characteristics. 6 refs.

Il'chenko, M.E. *Radioelectron Commun Syst* v 30 n 5 1987 p 96-98.

## Theory See Also LIGHT—Optical Resonators.

**090244 THEORETICAL RADIATION RESISTANCE OF AN ISOLATED SLOT RING RESONATOR.** The theoretical radiation resistance of an isolated slot ring resonator is expressed by means of an analytical formula. The result is deduced from the radiation resistance of an equivalent circular loop of the same size when Babinet's principle is applied. Results are compared with recent theoretical and experimental ones. (Author abstract) 4 refs.

Dubost, G. (Univ de Rennes I, Rennes, Fr). *Electron Lett* v 23 n 18 Aug 27 1987 p 928-930.

## Thin Films

**090245 THIN-FILM BULK-ACOUSTIC-WAVE RESONATOR-CONTROLLED OSCILLATOR ON SILICON.** A composite ZnO bulk-acoustic-wave thin-film resonator (TFR) has been fabricated on a silicon substrate with a double-diffused bipolar junction transistor (BJT). Fabrication techniques unique to the integration of the TFR are discussed. The integrated TFR-BJT structure was configured as a VHF Pierce oscillator circuit with a fundamental frequency of 257 MHz. Phase noise is better than  $-90$  dBc/Hz at a 1-kHz offset. Temperature stability is  $-8.5$  ppm/°C from 5°C to 65°C and  $-3.75$  ppm/°C from  $-55$ °C to 5°C. The integration of the TFR with active components is viewed as a development toward large-scale RF circuit integration. 8 refs.

Burkland, W.A. (Iowa State Univ, Ames, IA, USA); Landin, A.R.; Kline, G.R.; Ketcham, R.S. *IEEE Electron Device Lett* v EDL-8 n 11 Nov 1987 p 531-533.

## Vibrations See Also VIBRATIONS—Measurements.

**090246 NONLINEAR VIBRATIONS AND HYSTERESIS OF MICROMACHINED SILICON RESONATORS DESIGNED AS FREQUENCY-OUT SENSORS.** Experimental observation of nonlinear vibrations and hysteresis of micromachined silicon resonators is reported. The experimental results are explained using a simple model in which the restoring force acting in the

resonator contains a small cubic term. The effects will impose a limit to the maximum amplitude which can be excited while still maintaining reliability of these devices as frequency-out sensors. (Author abstract) 6 refs.

Andres, M.V. (Univ of Surrey, Guildford, Engl); Foulds, K.W.H.; Tudor, M.J. *Electron Lett* v 23 n 18 Aug 27 1987 p 952-954.

**090247 NUMERICAL CALCULATION OF THE NATURAL FREQUENCIES OF A RESONATOR WITH A DIELECTRIC LAYER HAVING AN ARBITRARY PERMITTIVITY PROFILE.** A numerical method is proposed for calculating the natural frequencies of a resonator containing a dielectric layer with an arbitrary permittivity profile. A dispersion equation for the resonance frequencies is obtained, special features of the algorithm are discussed, and results of the analysis of some specific types of resonators are presented. (Author abstract) 6 refs.

Kapilevich, B.Yu. *Sov J Commun Technol Electron* v 32 n 4 Apr 1987 p 8-12.

**090248 MICROPHONIC SENSITIVITY OF SURFACE-ACOUSTIC-WAVE RESONATORS.** The shift in resonant frequency due to acceleration has been measured for surface-acoustic-wave resonators (SAWRs). SAWR devices were subjected to vibration from 5 Hz to 10 kHz with peak accelerations ranging from  $10^{-2}$  to  $10^3$  g. The vibration was applied both normal to and in the plane of propagating surface wave yielding microphonic sensitivities on the order of 1 ppb/g. To confirm the results of the direct measurement method, an oscillator loop was closed around the vibrated SAWR and the magnitudes of the FM sidebands were measured to indicate the resulting frequency shift. Several bulk crystal resonators were also measured and it was found that the microphonic sensitivities were generally comparable in magnitude to those of the SAWRs but spanned much wider ranges. 14 refs.

Kolner, Brian H. (Hewlett-Packard Lab, Palo Alto, CA, USA). *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 365-371.

**RESONATORS, CAVITY** See Also ARCHITECTURAL ACOUSTICS; ELECTRIC FILTERS, BANDPASS—Attenuation; ELECTRIC FILTERS, BANDPASS—Dielectric Properties; ELECTROMAGNETIC FIELDS—Calculations; ELECTRON TUBES, KLYSTRON—Analysis; GAS TURBINES—Noise Abatement; HARMONIC GENERATION—Mathematical Models; LASER BEAMS—Amplifiers; LASERS—Mode Locking; LASERS—Modes; LASERS—Performance; LASERS—Q Switching; LASERS—Resonators; LASERS, DYE—Mode Locking; LASERS, DYE—Resonators; LASERS, GAS—Control; LASERS, GAS—Performance; LASERS, SEMICONDUCTOR—Modes; LASERS, SEMICONDUCTOR—Modulation; LASERS, SEMICONDUCTOR—Noise, Spurious Signal; LASERS, SEMICONDUCTOR—Resonators; LASERS, SEMICONDUCTOR—Tuning; PLATES—Vibrations; SPECTRUM ANALYZERS—Acoustic Wave Effects; WAVEGUIDES, DIELECTRIC—Attenuation.

**090249 HIGH-Q SAPPHIRE LOADED SUPERCONDUCTING CAVITY RESONATOR.** This paper describes the microwave properties of a sapphire loaded superconducting cavity resonator. We report measurements of energy confinement, evanescent field scale lengths and radiation losses. We report high-quality factors, in excess of  $10^9$  at cryogenic temperatures, for a resonator based on a sapphire element mounted inside a superconducting cavity. From the measured properties we show that resonators of this type have potentially valuable applications as ultra-high-stability oscillators, high-Q filters and as low phase noise frequency sources. (Author abstract) 16 refs.

Blair, D.G. (Univ of Western Australia, Nedlands, Aust); Jones, S.K. *J Phys D* v 20 n 12 Dec 14 1987 p 1559-1566.

**090250 DIE BERECHNUNG VON RESONANZEN IN HOHLRAEUMEN MIT DER RANDELEMENT-METHODE.** [Calculation of Resonances in Cavities with the Boundary Element Method]. This article describes the

application of the boundary element method (BEM) on the calculation of airborne sound resonances in a cavity. The exact resonance frequencies can be calculated as well as the complete amplitude spectrum. The calculation is complex and hence yields also phases. Thus, the complete acoustical behavior of an air-filled cavity can be numerically determined. This example illustrates the efficiency of BEM even for rough approximations. (Author abstract) In German. 2 refs.

Thomann, Ch. (Berufsschule III der Stadt Zuerich, Zurich, Switz). *Appl Acoust* v 23 n 4 1988 p 247-262.

**090251 EFFECTS ON THE RESONANT FREQUENCIES CAUSED BY LOADING A SPHERICAL CAVITY WITH A DIELECTRIC SPHERE.** An extensive investigation has been carried out of the properties of a conducting spherical cavity filled with a lossless homogeneous dielectric and concentrically loaded with another lossless homogeneous dielectric. This report contains a portion of the results obtained in the course of this investigation. Also presented and discussed are the effects on the cavity system eigenvalues of changing the radius of the dielectric load sphere. This is done for a wide range of relative dielectric strength for the media within the cavity. Specifically, results for relative strengths of 3, 10, and 1/3 are given. The appropriate derivations of the eigenvalue equations are presented. Analysis of the results suggests a broad variety of practical applications. (Edited author abstract) 5 refs.

Libelo, Louis F. (US Army Lab Command, Adelphi, MD, USA); Pisane, Guy E.; Ziolkowski, Richard. *Harry Diamond Lab Tech Rep HDL TR* 2130 Apr 1988 92p.

**090252 STACKING RESONATORS TO INCREASE THE BANDWIDTH OF LOW-PROFILE ANTENNAS.** A method of increasing the bandwidth of low-profile cavity-backed slot and microstrip patch antennas without appreciably adding to the antenna dimensions is presented. This idea incorporates the stacking of structures which have close resonant frequencies. Energy is coupled between cavities via carefully placed slots in the common wall. An approximate two-and-a-half-fold increase in input impedance bandwidth was observed for a certain cavity-backed slot antenna. 9 refs.

Smith, H.K. (Univ of Illinois, Urbana, IL, USA); Mayes, Paul E. *IEEE Trans Antennas Propag* v AP-35 n 12 Dec 1987 p 1473-1476.

**090253 VOLTAGE FREQUENCY CONTROL OF A SUPERCONDUCTING CAVITY STABILIZED OSCILLATOR.** A simple electrical tuning method for a superconducting cavity is described. Tuning is achieved by a reflection-type varactor phase shifter coupled loosely by a directional coupler to the transmission line which conducts the RF power to the cavity. The tuning section is outside of the cryogenic environment, and the tuning characteristics can be adjusted simply by changing the coupling coefficient of the coupler. The general characteristics of the method are discussed. The tuning properties of a superconducting cavity stabilized oscillator (SCSO), using a superconducting cavity as a frequency discriminator, are then calculated. The calculations are confirmed by preliminary experiments using a manual phase shifter in the 9.2-GHz SCSO. Tuning ranges similar to commercial precision quartz crystal oscillators can be easily obtained. 12 refs.

Komiyama, Bokuji (Radio Research Lab, Koganei, Jpn). *IEEE Trans Instrum Meas* v 37 n 1 Mar 1988 p 133-136.

**Acoustic Properties** See MICROPHONES—Calibration.

**Analysis** See Also LASERS—Resonators.

**090254 SIMULATION OF A PLASMA-FILLED RECTANGULAR CAVITY.** The paper deals with experimental studies of the resonance properties of an x-band rectangular cavity filled with an isotropic lossless stationary plasma for the dominant mode, using plasma simulation technique by a two-dimensional strip medium. The



experimental results are in good agreement with the theoretical results. An analysis of a plasma filled iris-coupled cavity is also presented. (Edited author abstract) 13 refs.

Prasad, Ramjee (Univ of Dar es Salaam, Dar es Salaam, Tanzania); Khan, Iqbal A.; Prasad, Rajendra. *Modell Simul Control A* v 14 n 4 1987 p 17-26.

**090255 ANALYSIS OF RING CAVITY OPTICALLY BISTABLE SYSTEMS WITH TWO PARTIALLY REFLECTING MIRRORS OF UNEQUAL TRANSMISSIVITY.** The general ring cavity optically bistable systems with two partially reflecting mirrors of unequal transmissivity are analyzed. In the mean field approximation the steady state equation is given, and the linear stability analysis of the steady states is performed. It is found that when the ratio of transmissivity  $T_1/T_2$  varies, the bistable loop changes its size and even the systematic behavior varies from the bistability mode into the amplification mode. (Edited author abstract). 10 Refs. In Chinese.

Liguo, Luo (Shandong Univ, China); Jishu, Chen. *Hongwai Yanjiu A-ji* v 7A n 3 1988 p 161-170.

## Applications

**090256 QUASI-OPTICAL RESONATOR FOR MILLIMETER AND SUBMILLIMETER WAVE SOLID-STATE SOURCES.** A new cavity for millimeter and submillimeter-wave solid-state oscillators is demonstrated. The cavity consists of a Fabry-Perot resonator with a grooved mirror. It has a high Q-value and may be used for power combining of solid-state sources. The authors report X-band model experiments on a Gunn diode oscillator using this cavity. (Edited author abstract). 3 Refs.

Mizuno, K. (Tohoku Univ, Sendai, Jpn); Ajikata, T.; Hieda, M.; Nakayama, M. *Electron Lett* v 24 n 13 Jun 23 1988 p 792-793.

## Calculations

**090257 Q FACTOR OF A CYLINDRICAL CAVITY WITH A COAXIAL PROTRUSION.** A rigorous method for carrying out an electrodynamic calculation of the characteristic  $E_{0np}$  oscillations of a cylindrical cavity with a coaxial protrusion, taking into account the finite conductivity of the walls, is examined. The analysis is performed by the modified method of residues, extended here to the problem of characteristic oscillations. Approximate analytic relations are obtained for the Q factor and the results of numerical calculations for  $E_{010}$  oscillations are presented. They are compared with measurements and it is shown that they agree well with the theoretical results and with experiment. (Author abstract) 17 refs.

Rodionova, V.N.; Slepian, G.Ya. *Sov J Commun Technol Electron* v 32 n 1 Jan 1987 p 129-136.

**090258 IMPLEMENTATION OF A RESONANT CAVITY PACKAGE ON MIMD COMPUTERS.** The task of calculating the lowest few eigenvalues of Maxwell's equations for a resonant cavity of moderately complicated shape easily exhausts the capacity of present-day computers. Massively parallel MIMD-systems would provide the necessary memory size and computing power, but the problems of implementing the algorithms are not solved yet. The present paper studies some ways of partitioning the computation for an existing software package and evaluates the resulting requirements for memory size, communication capabilities and computing power. It turns out that for realistic communication networks the minimal size of a subtask that can efficiently be treated by one processor is quite large, thus placing a limit to the reasonable amount of parallelism for a given problem size. (Author abstract) 11 refs.

Steffen, Bernhard (KFA, Juelich, West Ger). *Parallel Comput* v 7 n 1 Apr 1988 p 55-63.

## Cylinders

**090259 UNIFIED APPROACH TO DETERMINATION OF MODES IN CYLINDRICAL CAVITIES AXISYMMETRICALLY LOADED WITH DIELECTRICS.** Based on a variational expression, a unified approach for the determination of all modes in cylindrical cavities axisymmetrically loaded with dielectrics is presented. This approach employs one-dimensional finite-element basis functions along the r-axis, and uses a penalty term to alleviate the resulting spurious modes. Using this technique, the resonant frequencies of several cavities are calculated. (Author abstract) 8 refs.

Mirshekar-Syahkal, D. (Univ of Essex, Colchester, Engl); Mohammed Taheri, M. *Electron Lett* v 23 n 22 Oct 22 1987 p 1177-1178.

**Design** See LASERS—Resonators; LASERS, SEMICONDUCTOR—Resonators.

**Dielectric Properties** See ANTENNAS—Directional Patterns.

## Electric Properties

**090260 DUAL RESONANCE.** Dual resonant modes in hollow cavities, and in dielectric resonators occur in degenerate pairs, having either identical, or closely situated, resonant frequencies. Equivalent circuits for the input impedance of such dual-mode resonators are analyzed and the behavior of the impedance locus, typically observed with the vector network analyzer, is described. (Edited author abstract) 8 refs.

Kajfetz, Darko (Univ of Mississippi, University, MS, USA). *IEE Proc Part H* v 135 n 2 Apr 1988 p 141-144.

**Ferrite Applications** See ELECTROMAGNETIC FIELDS—Calculations.

**Laser Applications** See LASERS, SEMICONDUCTOR—Mathematical Models.

## Magnetic Shielding

**090261 FIELD PATTERNS OF  $TM_0$  MODES IN A SHIELDED DIELECTRIC RESONATOR.** The resonant modes in a cylindrical dielectric resonator located within a cylindrical shielding cavity are studied by means of the finite integral technique. The field patterns of five lowest transverse-magnetic modes are presented, and the controversies of the mode designations are discussed. (Author abstract) 9 refs.

Kajfetz, D. (Univ of Mississippi, University, MS, USA); Lebaric, J. *Electron Lett* v 23 n 18 Aug 27 1987 p 944-946.

## Materials

**090262 POSSIBLE HIGH-FREQUENCY CAVITY AND WAVEGUIDE APPLICATIONS OF HIGH TEMPERATURE SUPERCONDUCTORS.** The authors discuss possible implications of high temperature superconductors for cavity and waveguide operation and describe possible applications. Based on experimental evidence a variety of microwave/far infrared resonator and waveguide components might be developed with high temperature superconductivity materials. These relatively small scale applications do not require thick materials, electrical contacts, special materials interfacing as in semiconductor devices, or special structural support. However, there are a number of obstacles that may inhibit their development. The RF surface resistance can be severely affected by boundaries, random grain alignment, and the presence of nonsuperconducting material.

Cohn, D.R. (MIT, Cambridge, MA, USA); Bromberg, L.; Halverson, W.; Lax, B.; Woskov, P.P. *Int J Infrared Millim Waves* v 8 n 12 Dec 1987 p 1503-1524.

**Mathematical Models** See Also ELECTRIC NETWORKS, LUMPED PARAMETER—Applications; LASERS, RING—Resonators; LASERS, RING—Theory; LASERS, RING—Tuning; SEMICONDUCTING INDIUM COMPOUNDS—Radiation Effects.

**090263 EIGENMODE OF AN ANNULAR STABLE RESONATOR.** An approximate analytic expression has been obtained for the eigenmode of an empty annular stable resonator under the condition that the thickness of the annular laser beam is sufficiently smaller than its mean radius. It has also been shown that the annular stable resonator may be designed using standard methods which are used in the design of the conventional stable resonator. 3 refs.

Takada, Youichi (Industrial Research Inst, Kashiwa, Jpn); Saito, Hideaki; Fujioka, Tomoo. *IEEE J Quantum Electron* v 24 n 1 Jan 1988 p 11-12.

**Measurements** See Also LASERS, SEMICONDUCTOR—Tuning.

**090264 IMPROVED METHOD FOR RESONANT-FREQUENCY PERTURBATION MEASUREMENTS.** To meet a requirement for accurate, detailed field measurements in linear accelerator test structures, a novel method of measuring small changes in cavity resonance frequency has been applied to the resonant-frequency perturbation technique. This method enables the cavity resonance frequency to be measured accurately and quickly, and avoids both the problems of lack of sensitivity of on-resonance measurements and of cavity coupling variation. (Author abstract) 13 refs.

Land, D.V. (Univ of Glasgow, Glasgow, Scotl). *Electron Lett* v 23 n 21 Oct 8 1987 p 1166-1167.

**Microwaves** See Also CLOCKS, ATOMIC—Mathematical Models; ELECTRIC CABLES—Nondestructive Examination; WAVEGUIDE COMPONENTS—Couplers.

**090265 INVESTIGATION OF HEMISPHERICAL RESONATOR FOR AN ENERGY STORE.** High-power microwave pulses can be generated by the slow storage of energy in a resonant cavity, and the subsequent discharge of this energy in a time interval much less than the storage time. The amplitude of the radio pulse obtained depends on the volume of the cavity, its Q, the stored energy density, and the nature of the operation of the switching device. The simplest method of increasing the level of stored energy in the resonant system is to increase its volume while simultaneously choosing the optimum geometry. We give some results of an investigation of a superdimensional hemispherical copper resonator for the purpose of using it as an energy store when generating microwave pulses. 6 refs.

Avgustinovich, V.A.; Avgustinovich, L.Ya.; Artemenko, S.N.; Yushkov, Yu.G. *Radioelectron Commun Syst* v 30 n 2 1987 p 91-93.

**090266 MEASUREMENTS OF HIGH- $T_c$  SUPERCONDUCTIVITY IN A MICROWAVE CAVITY.** Measurements on a cylindrical microwave cavity with yttrium barium copper oxide end-plates show that this new class of superconductor has low loss at microwave frequencies. Low-loss microwave components operating at liquid nitrogen temperatures could be built using this compound. (Author abstract) 2 refs.

Percival, T.M.P. (CSIRO, Lindfield, Aust); Thorn, J.S.; Driver, R. *Electron Lett* v 23 n 23 Nov 5 1987 p 1225-1226.

**090267 DIELECTRIC RESPONSE OF MATERIAL MEDIA USING THE DETUNING OF A RESONANT MICROWAVE CAVITY.** The technique of dielectric response of a medium loading a resonant cavity has been used to monitor all phases of matter. Results are given on the dielectric response of bound (vicinal) water in germinating wheat seeds, phase change for liquid solid and other phase phenomena. From preliminary measurements in phase change of  $H_2O$  and  $CS_2$  we predict that phase



changes in liquid crystals may be monitored by suitable changes in the temperature of the loaded cavity. (Edited author abstract)

Roberts, J.; Shafer, F.; Smith, D.; Prakash, V. *J Microwave Power Electromagn* v 22 n 3 1987, Radio Freq Ind Appl, 1987 p 185-186.

## Millimeter Waves

**090268 PLANAR OROTRON EXPERIMENTS IN THE MILLIMETER-WAVELENGTH BAND.** The planar orotron is introduced and shown to be a viable source of moderate power and of millimeter and submillimeter wavelength radiation. The resonator is a slow-wave structure consisting of a rectangular metal grating which is opposed by a planar conducting boundary. The device operates in the surface harmonic mode: electrons interact with axially traveling waves which evanesce above the grating surface, and the amplified radiation leaves the resonator in parallel with the beam axis. Operation in both the forward and the backward mode is possible. The resonator cavity is designed to enhance longitudinal reflections, and thereby enhance the output power and efficiency. The output frequency and tuning range are determined by the grating parameters. Experiments performed in the backward mode have produced radiation from 30 to 110 GHz at power levels ranging from 100 W to 2 kW. The efficiencies vary from 1 to 7%. The measured frequencies are closely predicted by a theory which is also presented. 10 refs.

Marshall, E.M. (Dartmouth Coll, Hanover, NH, USA); Phillips, P.M.; Walsh, J.E. *IEEE Trans Plasma Sci* v 16 n 2 Apr 1988 p 199-205.

## Optimization See LASERS—Resonators.

## Performance

**090269 SLOTTED TUBE CAVITY: A COMPACT RESONATOR WITH EMPTY CORE.** A compact and lightweight cavity with empty core and quasiumiform field distribution in the central region is described. In contrast with dielectric-loaded cavities, only metallic losses are present. Thus the quality factor is reasonably high. A rigorous analysis method, yielding the resonant frequencies and field distribution, is presented. Theoretical results are compared with measurements. (Edited author abstract) 17 refs.

Spicopoulos, T. (Ecole Polytechnique Federale de Lausanne, Lausanne, Switz); Gardiol, F. *IEE Proc Part H* v 134 n 5 Oct 1987 p 405-410.

**090270 OPEN-CAVITY RESONATOR AS HIGH-Q MICROSTRIP CIRCUIT ELEMENT.** A simple method of coupling an open-cavity resonator mode to a microstrip line is described. An effective Q of several thousand is expected well into the millimeter-wave range. Experimental results from an X-band model are compared with theory. (Author abstract) 3 refs.

Stephan, K.D. (Univ of Massachusetts, Amherst, MA, USA); Young, S.L. *Electron Lett* v 23 n 19 Sep 10 1987 p 1028-1029.

**090271 CALCULATION AND ANALYSIS OF FREQUENCY PROPERTIES OF SPECIAL AXISYMMETRIC RESONATORS OF HYDROGEN QUANTUM FREQUENCY DISCRIMINATORS.** One of the most promising directions in the implementation of oscillators is the development of a frequency standard on the basis of a hydrogen quantum discriminator (HQD) which has a relatively narrow spectral line making it possible to use an analog resonator-frequency tuning system and thus considerably to reduce the instrument size by using small-size devices. We describe a mathematical model for fast calculation and analysis of the frequency characteristics of special axisymmetric (SAS) HQD resonators. 4 refs.

Belyaev, A.A.; Savin, V.A. *Meas Tech* v 30 n 2 Feb 1987 p 154-157.

**090272 INTERACTION OF AN OSCILLATOR WITH A CAVITY RESONATOR IN THE PRESENCE OF NONLINEAR COUPLINGS WITH DELAY.** The interaction of a high-frequency self-excited oscillator with a cavity resonator when there are delays in the feedback circuit of the oscillator and in the nonlinear coupling between the oscillator and the resonator is studied using the asymptotic method of the nonlinear theory of oscillations. Stationary oscillations and transients with a slow variation of the delay are studied. (Author abstract) 2 refs.

Ivanitskaya, O.V.; Rubanik, V.P. *Sov J Commun Technol Electron* v 32 n 6 Jun 1987 p 71-76.

**090273 EFFECT OF PARAMAGNETIC IMPURITIES ON FREQUENCY OF SAPPHIRE-LOADED SUPERCONDUCTING CAVITY RESONATORS.** The frequency of a sapphire loaded superconducting cavity has a temperature dependence displaying a turning point at approximately 6K. The authors show how this phenomenon can be explained in terms of the superconducting surface reactance and a low level of paramagnetic ion impurity in the sapphire. (Author abstract) 6 refs.

Jones, S.K. (Univ of Western Australia, Nedlands, Aust); Blair, D.G.; Buckingham, M.J. *Electron Lett* v 24 n 6 Mar 17 1988 p 346-347.

## Stability

**090274 STABILITIES IN GAUSSIAN CAVITY MODE.** The electric field injected into a unidirectional ring cavity with spherical mirrors is assumed to be the TEM<sub>10</sub> mode of a Gaussian beam. In the framework of the single transverse mode model, the stabilities of the stationary state case and the purely absorptive case are discussed. The results show that the instabilities may appear. (Author abstract) 6 refs. In Chinese.

Xijun, Fan (Shandong Normal Univ, China). *Hongwai Yanjiu A-Ji* v 7A n 3 1988 p 175-183.

## Theory See Also LASERS—Theory.

**090275 METHOD OF THE RIEMANN-HILBERT PROBLEM IN THE SPECTRAL THEORY OF TWO-DIMENSIONAL OPEN RESONATORS. SPECTRAL CHARACTERISTICS.** Using the operator-function method, the spectral characteristics of two-dimensional open resonators (OR) with cylindrical reflectors are analyzed theoretically in the situation when the wavelength is comparable with the resonator dimensions. The limits of applicability of the asymptotic modes of open resonators are established. (Author abstract) 6 refs.

Koshparenok, V.N.; Melezhih, P.N.; Poyedinchik, A.Ye.; Shestopalov, V.P. *Sov J Commun Technol Electron* v 32 n 5 May 1987 p 142-150.

## Vibrations

**090276 WANDSCHWINGUNGEN EINES HELMHOLTZ-RESONATORS.** [Wall Vibrations of a Helmholtz Resonators]. The eigenfrequency behavior of an ultrasonic resonator is investigated experimentally by interferometry under feedback-free condition. The simple apparatus and the first results are presented. In German. 10 refs.

Sedlacek, M. (Univ Wien, Vienna, Austria). *Acustica* v 65 n 1 Dec 1987 p 48-49.

## RESONATORS, CRYSTAL

**090277 PROBLEMS IN IMPROVING CRYSTAL RESONATORS RELIABILITY.** Although the surface mounting technology has been considerably improved by making chip parts, the configuration of a crystal resonator varies so much that a configuration that would make surface mounting possible is desired. The author discusses basic directions for improvements to be done in crystal resonators design. These include a right choice of materi-

als for a holder, use of silver palladium thin films for electrodes, and soldering seal technology. (Edited author abstract)

Sato, Shoichiro (Daiwa Shinku Corp). *JEE J Electron Eng* v 25 n 253 Jan 1988 p 46-48.

**090278 INTERNATIONAL CONFERENCE ON FREQUENCY CONTROL AND SYNTHESIS.** This conference proceedings contains 23 articles dealing with various topics in the field of frequency control and synthesis. Among the subjects covered are: Frequency-temperature characteristics of AT crystal units; Overtone filter crystals design; Hysteresis effects in quartz crystal resonators; Reproducible SAW filters; Atomic oscillators; Stable frequency Sources; T-transmission three-port; Quartz resonator parameters measurement; Multichannel FM synthesizer; RF synchronization of LEP accelerator; and Microprocessor control of loose-locked oscillator. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11279 in the Ei Engineering Meeting (TM) database produced by Engineering Information, Inc.

Anon (IERE, London, Engl). *Publ Inst Electron Radio Eng* n 75, Int Conf on Freq Control and Synth, Guilford, Engl, Apr 8-10 1987. Publ by IERE, London, Engl, 1987 185p.

## Fabrication

**090279 SURVEY OF QUARTZ BULK RESONATOR SENSOR TECHNOLOGIES.** The term 'bulk resonator' is used to include a variety of vibrational modes. The survey is broken down by type of resonant mode, namely thickness shear, single-ended flexural, double-ended flexural, and torsional. Where appropriate, the discussion of each type of resonant mode includes items related to the frequency-control applications of the particular mode to emphasize the cross fertilization occurring between frequency control and sensor work. 76 refs.

EerNisse, Errol P. (Quartztronics Inc, Salt Lake City, UT, USA); Ward, Roger W.; Wiggins, Robert B. *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 323-330.

## Manufacture See OSCILLATORS, CRYSTAL.

## Mathematical Models

**090280 ANALYSIS OF TRAPPED ENERGY RESONATORS WITH TABS.** A theoretical model is presented for analyzing the effects of tab electrodes on trapped energy resonators with rectangular electrodes. A tab of a strip type extending along the Z' axis on an AT-cut rectangular plate is treated. The model is based on the mode-matching method so that it can accurately describe two-dimensional displacement fields. Equations that determine the resonant frequencies, mode shapes, and mode strength are derived. The calculated results of resonant frequencies and inductances for AT-cut third overtone resonators are compared with measured results. It is shown from the comparison between experiment and theory that the model predicts well the strong acoustical effects of tabs on anharmonic trapped modes having phase reversals in the tab direction and little effect on the main and other anharmonic spurious modes. 8 refs.

Sekimoto, Hitoshi (Tokyo Metropolitan Univ, Tokyo, Jpn); Nakata, Hozumi; Miura, Masaaki. *IEEE Trans Ultrason Ferroelectr Freq Control* v 34 n 6 p 674-680.

**090281 APPROXIMATE EXPRESSION FOR THE MOTIONAL CAPACITANCE OF A LATERAL FIELD RESONATOR.** A simple approximate expression is obtained for the motional capacitance of a lateral-field



quartz resonator. Comparison with measured values for fundamental-mode and third-overtone SC-cut resonators shows agreement within 10-50%. 7 refs.

Smythe, R.C. (Piezo Technology Inc, Orlando, FL, USA); Tiersten, H.F. *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 May 1988 p 435-436.

**090282 FOUR-FREQUENCY PROCESS FOR COUPLED-DUALS USING ERROR-CORRECTED S-PARAMETER MEASUREMENTS.** Although the four-frequency measurement process has been used successfully on coupled dual crystals from 9.4 MHz to 21.4 MHz, discrepancies between the crystal data and filter data at 45 MHz and 57.5 MHz suggested an error problem associated with the measurement system. To eliminate the errors, a twelve-term error model was chosen and the equations were derived for use with an automatic network analyzer. The details of the direct deviation of the four-frequency measurement process are given in which the two resonator frequencies and the synchronous peak separation frequency (SPSF) of a coupled dual crystal are calculated from the two frequencies of the zeros of the short-circuit driving point impedance, and the two frequencies of the zeros of the open-circuit driving point impedance. Determination of the four frequencies from the error-corrected S parameters is discussed, as well as the analysis of an external capacitor placed across the output circuit to obtain a more convenient distribution of the four frequencies. A comparison is made between data taken on the original fixture and data taken on an automatic network analyzer using error-corrected S parameters. 10 refs.

Roberts, Gerald E. (GE, Lynchburg, VA, USA). *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 306-314.

## Measurements

**090283 X-RAY BRILLOUIN SCATTERING OF MOESSBAUER RADIATION BY AN OSCILLATING QUARTZ CRYSTAL.** The elastic and inelastic scattering from x-cut quartz single crystal is investigated by means of Mossbauer diffractometry from the (112-0) Bragg plane using a  $^{57}\text{Co}$ -source and a Mossbauer absorber for the energy analysis. When the crystals is excited to piezo-electric vibrations in the MHz-range, inelastically scattered quanta are resolved. The phonon energies are in the range  $40\text{ neV} < h\Omega_q < 150\text{ neV}$ . (Author abstract) 15 refs.

Jex, H. (Univ Ulm, Ulm, West Ger); Mueller, U. *Phys Status Solidi B* v 143 n 1 Sep 1987 p 317-324.

**090284 SCHWINGQUARTZ-DATEN - MIT NETZWERK-ANALYSATOREN GEMESSEN.** [Measurement of Data of Crystal Resonators Using Network Analyzers]. A measurement method is described which makes it possible to determine the equivalent data of quartz resonators up to a frequency of 200 MHz. Measurement errors and calibration measurements are minimized. In German. 3 refs.

Neuscheler, Friedrich. *Elektronik* v 36 n 19 Sep 18 1987 Sp between p 155 and 162.

**Quartz Applications** See Also OSCILLATORS, CRYSTAL—Quartz Applications.

**090285 SUPPRESSION OF ANHARMONIC SPURIOUS MODES IN QUARTZ RESONATORS BY MODIFIED ELECTRODE DESIGN USING CHARGE CANCELLATION.** One important problem in the design of the thickness vibration resonator is how to suppress the anharmonic higher-order spurious mode which is generated near the main resonant frequency. It is easy to realize a single resonant characteristic by the design based on the trapped energy theory, but the area of the electrode and, consequently, the inductance, are limited. This paper proposes a method which improves this point and increases the degrees of freedom in the design, suppressing the anharmonic spurious mode by

adding a mass to the edge of the electrode and by cancelling the charge. A modified circular electrode structure is proposed in which the peripheral part (ring) of the electrode has a larger thickness. The third overtone resonator is analyzed, and it is shown theoretically that the dominant (3, 3, 1) spurious mode is suppressed by the charge cancellation, thereby realizing a resonator with an essentially single resonant characteristic over a wide frequency range. The charge cancellation characteristics for the spurious mode are strongly dependent on the platebacking of the ring electrode. The data for the optimum design are summarized in a table. (Edited author abstract) 5 refs.

Sekimoto, Hitoshi (Tokyo Metropolitan Univ, Tokyo, Jpn); Ihara, Toshiyuki; Nakata, Hozumi; Miura, Masaaki. *Electron Commun Jpn Part 1* v 71 n 4 Apr 1988 p 26-33.

**090286 STATE OF THE ART OF FLICKER FREQUENCY NOISE IN BAW AND SAW QUARTZ RESONATORS.** Experimental results of the last 15 years are reviewed. Noise properties of crystal filters and oscillators are reported, along with practical measurements. It is shown that the additional phase fluctuations are compensated by frequency fluctuations and vice versa. With the assistance of these theoretical results the flicker and white frequency noise coefficients,  $h_{-1}$  and  $h_0$ , respectively, are plotted versus unloaded Q and carrier frequency  $f_0$  for the measured and published crystal oscillator noise characteristics. The dependence of  $h_{-1} \approx 10^{-12.75} Q^2$  is verified. 63 refs.

Kroupa, Venceslav F. (Inst of Radio Engineering & Electronics, Prague, Czech). *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 3 May 1988 p 406-420.

## Radiation Effects

**090287 LOW- AND MEDIUM-DOSE RADIATION SENSITIVITY OF QUARTZ CRYSTAL RESONATORS WITH DIFFERENT ALUMINUM IMPURITY CONTENT.** The results of low (4.0-radiation) and medium (1000 rad)-radiation tests on AT quartz crystal resonators with aluminum impurity content of 0.79 and 8.3 PPM are discussed. The radiation tests were conducted with two  $^{60}\text{Co}$  sources that generate photons with a mean energy of 1.25 MeV. The dose rate at the quartz crystal blanks was approximately 4.0 rad(Si)/h, which represents approximately ten times the dose rate experienced in the radiation environment of a low earth orbit. A mathematical analysis of the frequency susceptibility versus total accumulated dose revealed that a least-squares fit of the  $df/f$  versus accumulated dose R data is of the type  $df/f(R) = AR^B$  where A and B are real rational coefficients. Interpretation of this result is presented, together with data on the Allan variances and aging rates of the oscillators during and after the radiation tests. 14 refs.

Suter, Joseph J. (Johns Hopkins Univ, Laurel, MD, USA); Maurer, Richard H. *IEEE Trans Ultrason Ferroelectr Freq Control* v UFFC-34 n 6 p 667-673.

**Spectrum Analysis** See HYSTERESIS—Spectrum Analysis.

**Stability** See LASERS, SOLID STATE—Resonators.

## Thermal Effects

**090288 TEMPERATURE HYSTERESIS OF FREQUENCY IN QUARTZ RESONATORS.** The causes of temperature hysteresis in quartz resonators have not as yet been fully explained. In what follows, an explanation is offered for the frequency-change effect that reveals the mechanism of phenomena occurring during a temperature change in a resonator under various conditions. A quantitative evaluation is made of the factors that determine the resulting frequency change. 8 refs.

Tartakovskii, I.I. *Meas Tech* v 30 n 6 Jun 1987 p 563-566.

## RETAINING WALLS

**090289 EARTH-ANCHORED WALL AIDS RECONSTRUCTION WORK.** The New York Department of Transportation encountered a problem in its \$150-million program to improve vehicular traffic flow on the Long Island Expressway. For a stretch of 1650 feet, insufficient embankment width existed to construct a traditional retaining wall for a two-lane, collector-distributor roadway. To solve this problem, design engineers Berger, Lehman Associates, and the DOT came up with the solution of a permanent earth-anchored wall. The design generally uses steel H-piles on 8-ft. centers. Timber lagging is installed as excavation progresses. As the tie location points are reached, holes are drilled for them, usually at a 15-degree angle with the horizontal - except where existing utilities or foundations dictate greater slopes - and anchors are placed, grouted, stressed, and tested. Excavation is continued and the process repeated until final subgrade is reached.

Anon. *Better Roads* v 57 n 10 Oct 1987 p 48.

**090290 STUDIES ON THE JOINT STRUCTURE BETWEEN FOOTING CONCRETE AND STEEL SHEET PIPE PILE WALL.** Several joints between footing concrete and steel sheet pile wall have been used, but their shear transfer mechanisms of the joint have not been made clear fully under present conditions. Therefore small scale and large scale model tests with some different joints including a new proposed joint are carried out, and their shear transfer mechanism has been investigated based on tests. Consequently, the proposed joint structure which has sufficient shear transfer capability and construction efficiency has been applied successfully at Katsushika Edogawa line, Metropolitan expressway in Japan. (Author abstract) In Japanese. 16 refs.

Abiko, Toshio; Kujirai, Hiroshi; Izumi, Kimihiko; Morimoto, Akihiro. *Doboku Gakkai Rombun Hokoku-shu* v 8 n 390 Feb 1988 p 47-56.

**090291 REINFORCEMENT OF AN ANCHORED SHEETPILE WALL WITH ADDITIONAL LOWER TIE-RODS.** A new technology has been developed in Japan to reinforce anchored sheetpile walls which are suffering from over-stressing or instability due to corrosion or excessive deepening, by installing supplementary lower tie-rods under the existing tie-rods. The installation technique for the lower tie-rods by lateral boring method and design/analysis procedures for this kind of sheetpile wall are explained, being accompanied with test and field work data and design examples. (Author abstract). 8 refs.

Ishiguro, K. (Nippon Tetrapod Co Ltd, Shinjuku, Tokyo); Miyata, Y. *Bull Perm Int Assoc Navig Congr* v 61 1988 p 87-104.

## Analysis

**090292 STATIC ANALYSIS MODEL FOR DOUBLE SHEET-PILE WALL STRUCTURES.** A calculation model for estimating static behavior when a double sheet-pile wall structure is subjected to horizontal force is proposed, and a comparison is made between the results of calculations and those of model tests to examine the validity of the calculation model. The calculation model is based on the theoretical solution obtained by assuming that the portion of the structure above ground level is a composite of sheet piles and sand fill and that the portion below ground level consists of sheet piles receiving horizontal resistance from the ground, taking into consideration the elasto-plastic characteristics of the sand fill and the subsurface soils. (Edited author abstract) 13 refs.

Ohoi, Kouichi (Ministry of Transport, Yokosuka, Jpn); Takahashi, Kunio; Kawai, Yutaka; Shiota, Keisuke. *J Geotech Eng* v 114 n 7 Jul 1988 p 810-825.

## Computer Aided Design

**090293 COMPUTER-AIDED DESIGN OF RETAINING WALLS.** The analysis of retaining walls by trial-and-error is a time-consuming process. The paper



presents a comprehensive and accurate method of design of retaining walls of various shapes with the help of computer analysis. Subjects covered include a discussion of the computer program, program input, and application examples. 2 refs.

Chalisgaonkar, Rajendra (Irrigation Design Organisation, Roorkee, India). *Indian Concr J* v 61 n 12 Dec 1987 p 330-333.

**Concrete Construction** See Also SHORE PROTECTION.

**090294 CANTILEVERED CONTIGUOUS PILED RETAINING WALL.** The project involved the construction of a concrete retaining wall (which will eventually be given a brick cladding to conform with the appearance of the superstore), some 13m high, adjacent to a number of buildings situated on the rear boundary of what will be the superstore's car park for shoppers' vehicles. The wall was designed as a contiguous piled structure, on top of which has been provided a reinforced concrete waling beam, followed by installation of temporary ground anchors to tie the wall back, stressed to give support to the top of the piles. Excavation was then undertaken to expose the 97 piles which, acting as 750mm-diameter vertical beams, had been augered to depths of between 5 and 12m.

Barfoot, Jack. *Concrete (London)* v 21 n 10 Oct 1987 p 13-14.

**090295 HEAVILY-ANCHORED RETAINING WALLS ON OKEHAMPTON BY-PASS.** There are three principal retaining walls designated as south, north and inter-carriageway. The south wall is on the high side of the cutting, and is quite critical because of its effect on the haul road on what is a site with limited access. This south wall has also posed certain problems in its construction, for example, in its variance of height and in the need to cast its in situ panels in single pours. The method of construction is explained including the use of a light shutter to construct the panels in single pours.

Barfoot, Jack. *Concrete (London)* v 22 n 2 Feb 1988 p 24-26.

**090296 NEWBIGGIN SEA DEFENCE WILL BRING LOCAL 'PEACE OF MIND'.** At an early stage in conception, the consulting engineers undertook a survey of Newbiggin Bay's patterns of wind, waves and tides, using a mathematical model to hypothesise the worst storm conditions likely in the next 50 years. Based on this, they assessed the environmental and economic options, and subsequently tested a scale model in a hydraulic tank. The project is 400m in length, sited on the foreshore and covering the worst-affected area, which is the center of Newbiggin at Bridge Street. It consists of a series of precast and in-situ reinforced-concrete beams on imported filling, in front of a new curved deflector wave wall situated generally seaward of the old sea wall, part of which has suffered severe storm damage in the past.

Barfoot, Jack. *Concrete (London)* v 22 n 6 Jun 1988 p 15-16, 18-19.

**Construction** See Also PILES—Concrete; SUBWAYS—Stations.

**090297 HOLDING BACK THE EARTH.** Precast concrete for retaining walls has several strong advantages over cast-in-place techniques. The quality of precast concrete is generally higher and the control over quality is much better due to the ability to tightly control casting conditions. Another advantage of precast systems is the rapidity of construction - especially on-site construction. The precast systems vary, but a typical installation rate is about 1000 ft<sup>2</sup> (019 m<sup>2</sup>) per shift using only a five-man crew. That, of course, does not account for labor to produce the precast members, but still results in a significant price advantage. There are several distinct types of precast retaining walls. Reinforcing the backfill to create a self-supporting block of soil is one method that has gained increasing popularity around the world. Other retaining wall systems that are now on the market are essentially modern equivalents of that most ancient of all

retaining walls: the gravity wall. 10 refs.

Palmer, William D. (Concrete Int Design & Construction, Detroit, MI, USA). *Concr Int* v 9 n 11 Nov 1987 p 26-33.

**090298 CONFORTATION PROVOISIRE D'UN TALUS DE DEBLAI PAR CLOUAGE.** [Provisional Consolidation of a Cutting Slope by Nailing]. This article describes a case of the provisional repair of a chalk debris slope in an urban site by means of nailing. This remedial work was undertaken following an earth slide which occurred during the building of a reinforced concrete retaining structure at the bottom of an urbanized slope. After an earth abutment had been sent in place at the toe, nailing made it possible to stabilize the slope in a very short time and to build the retaining structure initially planned. The article describes the design of the nailing, the techniques employed, and their adaptation to the difficulties encountered. (Author abstract) In French.

Pioline, Michel (Lab Regional de Rouen, Fr). *Bull Liaison Lab Ponts Chaussees* n 149 May-Jun 1987 p 37-43.

**Earthquake Resistance** See PORT STRUCTURES—Quay Walls; SOIL MECHANICS—Pressure Effects.

## Failure

**090299 COLLAPSE OF DIAPHRAGM WALLS RETAINING CLAY.** Five centrifugal model tests are reported which illustrate aspects of the collapse of stiff cantilever retaining walls embedded in overconsolidated clay. The drainage of a heavy fluid in flight was used to simulate the effects of excavation, following the establishment of a high initial groundwater level. Two modes of collapse were observed with unproped walls. The temporary stability of walls with small penetration was interrupted by the hydraulic action of a water-filled crack opening on the retained side of the wall. The long-term rotational failure of walls of deeper penetration was also observed, involving distributed strains in 'active' and 'passive' zones which could lead ultimately to sliding on shear rupture surfaces. An analysis was developed based on admissible stress fields, with active and passive zones switching about a pivot point, so that the unproped wall could satisfy the conditions of both moment and force equilibrium. (Edited author abstract) 14 refs.

Bolton, M.D. (Cambridge Univ, Engl); Powrie, W. *Geotechnique* v 37 n 3 Sep 1987 p 335-353.

**090300 COLLAPSE OF DIAPHRAGM WALLS.** In this discussion, M.P. O'Reilly, Ove Arup & Partners, discusses what the author noted as the presence of numerous small ruptures at angles of approximately 90-Phi to the main slip surfaces. The clay, as one might expect, given its high overconsolidation ratio, behaves in a rather brittle manner and it is likely that stress concentrations induced by the markers would facilitate the formation of rupture surfaces. Such a clay structure, it may be surmised, will exhibit rupture along surfaces precipitated by these 'stress concentrators'. The author's reply is included.

Bolton, M.D.; Powrie, W. *Geotechnique* v 38 n 2 Jun 1988 p 324-325.

## Materials

**090301 APPLICATION OF TUBULAR STEEL PIPES AS STRUCTURAL ELEMENTS FOR RETAINING WALLS - PART 2.** In this sequel to the article which appeared in The Dock & Harbour Authority, February 1986, three more examples are given of projects recently implemented in this way, namely a quay wall at Antwerp and two quay walls in Rotterdam. Further, the application of such composite walls, consisting of tubes in combination with two or three Larsen sheet piles is particularly of interest in the case of (drained) construction pits and trenches where, due to a substantial difference of head, water pressure (contrary to what is normally the case with most quay wall structures) plays a dominant role; or where very high demands are made on the stiffness of the structure. (Edited author abstract).

Risselada, J. *Dock Harbour Auth* v 68 n 800 Apr 1988 p 293-297.

## Performance

**090302 LONG-TERM PERFORMANCE OF CANTILEVERED RETAINING WALLS.** This paper addresses the measured performance of four permanent cantilevered wall systems that have been in service for about two years. The continuous profiles of lateral movement with depth, as obtained from inclinometers installed within or directly behind the wall section, are used with beam equation analytical procedures to track the change in active and passive pressure responses with time. The time response of measured lateral movements at the top-of-wall and at the excavation line can be modeled by a rate process theory approach. 14 refs.

Williams, Charles E. (McBride-Ratcliff & Associates, Houston, TX, USA); Focht, John A. *Tex Civ Eng* v 57 n 10 Dec 1987 p 12-17.

**Pressure Effects** See Also WATER WAVES—Pressure Measurement; WATER WAVES—Wind Effects.

**090303 AT-REST TO ACTIVE EARTH PRESSURE TRANSITION.** An approximate analytical procedure is described to estimate the developed lateral earth pressures behind a rigid retaining wall experiencing outward tilt about the base with horizontal cohesionless backfill soil. Included are various stages of wall tilt, starting from an at-rest condition to a full-active condition. The at-rest condition is defined as a stage of no-wall tilt, whereas the full-active condition occurs when the soil elements along the entire depth of the wall are in an active state. The predictions from the developed method of analysis are compared with model test measurements. The comparisons show very good agreement at various stages of retaining wall tilt. Examples are provided to illustrate the transition of the lateral earth pressures behind a smooth and a rough retaining wall. (Edited author abstract) 12 refs.

Bang, S. (South Dakota Sch of Mines & Technology, Rapid City, SD, USA); Kim, H.T. *Transp Res Rec* 1105 1986 p 41-47.

**090304 DYNAMIC EARTH PRESSURES WITH DIFFERENT WALL MOVEMENT MODES.** Dynamic active earth pressures against rigid retaining structures with dry cohesionless backfill are investigated based on the observations of the shaking table model experiment with different wall movement modes: rotation about the base, rotation about the top, translation and a combination of these. The earth pressure distribution, total dynamic thrust, incremental dynamic thrust and their points of application are discussed in detail. It was found that the dynamic active earth pressure distribution is strongly influenced by the wall movement mode particularly at a low level of horizontal acceleration, while inertial body force effect becomes dominant at a high acceleration level. Soil arching developed near the wall top for rotation about the top mode and high residual stress region near the wall base for rotation about the base mode are significantly attributed to the earth pressure distribution. (Edited author abstract) 10 refs.

Ishibashi, Isao (Old Dominion Univ, Norfolk, VA, USA); Fang, Yung-Show. *Soils Found* v 27 n 4 Dec 1987 p 11-22.

**090305 PASSIVE LATERAL EARTH PRESSURE DEVELOPMENT BEHIND RIGID WALLS.** An analytical solution procedure is described to estimate the developed passive lateral earth pressures behind a vertical rigid retaining wall rotating about its toe or top into a mass of cohesionless soil. Various stages of wall rotation, from an at-rest state to an initial passive state to a full passive state, are considered in the analysis. A condition of failure defined by a modified Mohr-Coulomb criterion and equilibrium conditions are used to obtain the necessary equations for solution. The development of friction



along the wall surface at various stages of wall rotation is also taken into account in the analysis. Finally, the results predicted by the developed method of analysis are compared with those obtained from the experimental model tests on loose and dense sand. The comparisons show good agreements at various stages of wall movement. (Author abstract). 10 Refs.

Bang, S. (South Dakota Sch of Mines & Technology, Rapid City, SD, USA); Kim, H.T. *Transp Res Rec* n 1129 1987 p 63-67.

## Stability

**090306 PARAMETRIC STUDY OF THE STABILITY OF EMBEDDED CANTILEVER RETAINING WALLS.** In the design of an embedded earth retaining structure the geometry is adjusted to achieve a prescribed factor of safety against overturning. There are at present a number of methods which can be used to assess the stability of an embedded retaining wall, each of which gives a different value of the factor of safety for a stable wall configuration. To achieve a measure of consistency in the design of this type of structure, information is therefore needed on the interrelations between the methods. This report gives results from a parametric study which used four different methods to assess the stability of an embedded cantilever wall retaining 5 metres of ground. The effect on the factors of safety of variations in individual input parameters is illustrated and the findings compared with the values of factor of safety currently recommended for design. (Author abstract) 13 refs.

Symons, I.F. (TAISEI Corp, Yokohama, Jpn); Kotera, H. *Res Rep Transp Road Res Lab* 116 1987 15p.

**090307 LATERAL STABILITY OF COMPRESSIBLE WALLS.** The author has shown how the compressibility of a retaining wall may affect its stability. Wall settlements relative to fill can produce a shear reversal at the soil-wall interface which modifies the inclination of the active pressure. The tangential component of the resultant at the wall base increases whereas the normal one decreases. The factor of safety against sliding decreases accordingly. There may be some other reasons for lateral stability reductions related to underlying soil compressibility and wall stiffness. As an example, the case of large lateral displacements of a harbour quay is briefly described in this discussion. The author's reply is included. 1 Ref.

O'Rourke, T.D. *Geotechnique* v 38 n 2 Jun 1988 p 317-318.

## Structural Analysis See Also COASTAL ENGINEERING—Research.

**090308 DISPLACEMENT DEPENDENT EARTH PRESSURES.** The method of designing retaining walls is incomplete without displacement criteria and the bulk of literature available on earth pressures does not consider this aspect. In the present study, a simple and sufficiently accurate analysis has been proposed to find the variation of earth pressure with wall displacement when wall undergoes translation, rotation about bottom and rotation about top in active and passive conditions. The analysis also gives pressure distribution for any displacement under any mode of wall movement and for both active and passive conditions. The presented results of parametric study and their comparison with reported experimental results reveal the effectiveness of the analysis. (Author abstract) 12 refs.

Saran, Swami (Univ of Roorkee, Roorkee, India); Viladkar, M.N.; Krishna Reddy, R. *Indian Geotech J* v 17 n 2 Apr 1987 p 121-141.

## Structural Design

**090309 BEHAVIOR OF EMBEDDED CANTILEVER RETAINING WALLS - THE RESULTS OF A FINITE ELEMENT STUDY.** The design of cantilever retaining walls is based on approximate limit equilibrium calculations which assume a point of zero movement

occurs at some depth near the toe of the wall. This paper describes the results of a finite element study to check the validity of this technique. The accuracy of the calculated embedment is checked, and the influence of parameters such as initial soil stress and construction procedure is evaluated. An elasto-plastic constitutive law is used to model soil behavior. Results indicate that the limit equilibrium method gives a very reasonable estimate of the embedment depth required to ensure stability. The maximum bending moment calculated using this technique was found to be greater than the corresponding values from the finite element analyses. Some reduction in bending moment, as calculated by the limit equilibrium method, may therefore be warranted. (Edited author abstract) 3 refs.

Fourie, A.B. (Univ of Queensland, Aust); Potts, D.M. *Res Rep Ser Univ Queensl Dep Civ Eng* n CE83 Aug 1987 32p.

## Testing See EMBANKMENTS—Components.

**RHENIUM AND ALLOYS** See Also CARBON MONOXIDE—Adsorption; IRON AND ALLOYS—Electronic Properties; MOLYBDENUM AND ALLOYS—Failure.

**090310 RHENIUMEXTRAKTION AUS MOLYBDATLOESUNGEN.** [Extraction of Rhenium from Molybdate Solutions]. A solvent extraction process for direct recovery of pure ammonium perrhenate from sulfuric acid molybdate solutions has been developed. This separation is possible by modifying the basicity of amines with TOPO. The conventional solvent extraction processes require two independent solvent systems in addition to using two stripping solutions, nitric acid and ammonia. In contrast, only one solvent extraction system is used in the present development and by adjusting the pH of ammonia, rhenium and molybdenum are stripped stepwise. (Edited author abstract) In German. 12 refs.

Kaehler, Joerg; Gock, Eberhard. *Erzmetall* v 14 n 3 Mar 1988 p 132-137.

## Electrodeposition See RHENIUM PLATING.

**Isotopes** See OSMIUM AND ALLOYS—Spectroscopic Analysis.

**Oxidation** See BARIUM COMPOUNDS—Phase Diagrams.

## Phase Diagrams

**090311 PHASE EQUILIBRIUM DIAGRAMS OF TERNARY RHENIUM SYSTEM WITH VANADIUM, NIOBIUM AND MOLYBDENUM.** Phase equilibrium diagrams have been constructed for the ternary systems V-Nb-Re, V-Mo-Re and Nb-Mo-Re. In the two which contain vanadium, a compound with the A-15 structure on the V-Re edge extends a little way into the composition triangle. There is no previously published information on these ternary systems. Data have been published on the binary systems which combine to form the three ternaries. 4 refs.

Smol'yaninova, E.A.; Stribuk, E.K.; Tyavlovskii, V.I. *Russ Metall Met* n 3 1987 p 204-206.

## Radiation Effects See NEUTRONS—Absorption.

## Reduction

**090312 SPECIAL FEATURES OF CATHODIC RHENIUM REDUCTION FROM ACIDIC PERRHENATE SOLUTIONS.** Despite the large amount of work that has been done in cathodic rhenium reduction, different and sometimes even contradictory opinions exist as to the effect of solution acidity on the mechanism of rhenium reduction. An attempt was made to define more accurately the role of hydrogen ion concentration in cathodic rhenium reduction. The dependence of perrhenate reduction rate on  $pH_0$  was found to exhibit two distinct maxima at similar  $pH_0$ -values. They were attributed to two mechanisms of cathodic rhenium reduction

from aqueous perrhenate solutions and to a nonequilibrium change in ionic composition of the region at the cathode which occurs as the cathodic process actually proceeds. (Edited author abstract) 16 refs.

Arzhankov, S.I. (Acad of Sciences of the Byelorussian SSR, Minsk, USSR); Petrovich, V.A.; Tabulina, L.V. *Sov Electrochem* v 23 n 3 Mar 1987 p 285-288.

## Surfaces See CARBON DIOXIDE—Adsorption.

**Vapor Deposition** See RHENIUM COMPOUNDS—Thin Films.

**X-Ray Analysis** See RUBIDIUM—X-Ray Analysis.

**RHENIUM COMPOUNDS** See Also INDIUM COMPOUNDS—X-Ray Analysis; MOLYBDENUM COMPOUNDS.

**090313 INTER- AND INTRAMOLECULAR EXCITED-STATE INTERACTIONS OF SURFACTANT-ACTIVE RHENIUM(I) PHOTOSENSITIZERS.** A new series of surfactant-active complexes of the form  $[(bpy)Re(CO)_3NC(CH_2)_nCH_3]^+$ ,  $n = 0-17$ , have been synthesized and characterized. These complexes exhibit a unique intramolecular perturbation of their excited-state manifold by the normally passive alkyl chain. Intramolecular fold back, a strong function of chain length, alters the solvent environment around the excited portion of the molecule with a concomitant change in the state energies and decay paths. Molecular models, cyclodextrin binding studies, absorption and emission spectroscopy, excited-state lifetime measurements, and oxygen-quenching studies support this model. The alkyl chain can function as a molecular switch and invert the lowest excited states in the molecules at low temperature. Energy level diagrams are developed that explain both room-temperature and 77 K results. (Author abstract). 46 Refs.

Reitz, G.A. (Univ of Virginia, Charlottesville, VA, USA); Demas, J.N.; DeGraff, B.A.; Stephens, Eileen M. *J Am Chem Soc* v 110 n 15 Jul 20 1988 p 5051-5059.

## Electric Properties See CRYSTALS—Growing.

**Spectroscopic Analysis** See CATALYSTS—Supported.

## Thin Films

**090314 SOME PROPERTIES OF  $ReSi_2$ .** Thin films of  $ReSi_2$  were prepared by the co-evaporation of rhenium and silicon. The structure of the films is compared with the previously reported structure of this compound. The resistivity and Hall coefficient of the films were measured from 4.2 K to 523 K. Optical transmission measurements were also carried out. The films display semiconducting properties (p-type) characteristic of a small band gap, in agreement with measurements reported for bulk and single-crystal samples. The discrepancy between these results and recent band calculations, indicating a potentially high conductivity, is briefly discussed. (Author abstract). 45 Refs.

Krontiras, C. (Semiconductor Lab, Espoo, Finl); Gronberg, L.; Suni, I.; D'Heurle, F.M.; Tersoff, J.; Engstrom, I.; Karlsson, B.; Petersson, C.S. *Thin Solid Films* v 161 Jul 1988 p 197-206.

## RHENIUM PLATING

**090315 PULSED ELECTRODEPOSITION OF RHENIUM.** In pulse plating, two diffusion layers are formed, comprising a pulsating layer adjacent to the cathode and a stationary layer extending to the bulk of the electrolyte. Using very short pulses the pulsating layer remains very thin; hence the concentration gradient is very high, allowing the application of very high current densities during the pulse without exceeding the mass transport limitation. Since increase of current density appears to favor improved properties to electrodeposited rhenium, pulse plating thus offers interesting possibilities in this context. 9 refs.



Puippe, J.C.I. *Theory and Pract of Pulse Plating* Publ by American Electroplaters & Surface Finishers Soc, Orlando, FL, USA, 1986 p 177-187.

**090316 STRUCTURE AND X-RAY DENSITY OF ELECTROCHEMICALLY DEPOSITED RHENIUM FILMS.** The formation of masking coatings is one of the problems that arise during the preparation of x-ray patterns. Local electrodeposition of heavy metals is used primarily for this purpose. The electrodeposition of rhenium was carried out at a constant cathode current density and room temperature. The investigations conclude that electrochemically deposited rhenium films can be used as a material for the masking coatings of x-ray patterns since the absorption coefficients of the x-ray radiation of the films are superior to traditionally employed materials and surpass them in terms of corrosion resistance and simplicity of production. 4 refs.

Petrovich, V.A. (Minsk Radio Engineering Inst, USSR); Fedenkov, A.L.; Shepurev, S.Yu. *Prot Met* v 23 n 4 Jul-Aug 1987 p 509-510.

**RHENIUM VANADIUM NIOBIUM ALLOYS** See RHENIUM AND ALLOYS—Phase Diagrams.

**RHEOLOGY** See Also BIOLOGICAL MATERIALS—Blood; BIOMEDICAL ENGINEERING—Hemodynamics; BITUMINOUS MATERIALS—Research; CARBON BLACK—Suspensions; CLAY MINERALS—Physical Chemistry; COAL SLURRIES—Ignition; COATINGS—Additives; EXPLOSIVES—Viscosity; FIBERS, NONTEXTILE—Microstructure; FLOW OF FLUIDS—Non Newtonian; FOOD PRODUCTS—Viscoelasticity; GEOTEXTILES—Creep; GRINDING MILLS—Ball Milling; OIL SANDS—Processing; ORE TREATMENT—Crushing and Grinding; PAINT—Additives; PETROLEUM REFINING; PLASTICS FILMS—Casting; PLASTICS, REINFORCED—Fibers; POLYMERIZATION; POLYMERS—Blending; POLYMERS—Solutions; POLYMERS—Viscoelasticity; POWDER METALLURGY—Injection Molding; POWDERS—Amorphous; REFRACTORY MATERIALS—Zirconia; ROCK—Deformation; ROLLING MILL PRACTICE—Hot Rolling; RUBBER—Viscoelasticity; SEWAGE PUMPING PLANTS; STARCH; SYNTHETIC FIBERS—Spinning; THERMOPLASTICS—Fiber Reinforcement.

**090317 DIMENSIONALLY INVARIANT VISCOSITY FUNCTION.** The use of classical dimensional analysis in viscosity modelling is discussed. The method suggests relations between model parameters and molecular characteristics of a polymeric system. (Author abstract) 12 refs.

Stastna, J. (Univ of Windsor, Windsor, Ont, Can); De Kee, D. *Can J Chem Eng* v 65 n 5 Oct 1987 p 877-879.

**090318 CONSIDERATION OF THE YAMAMOTO NETWORK THEORY WITH NON-GAUSSIAN CHAIN SEGMENTS.** The molecular network theory due to Yamamoto has been considered, and the effect of modeling the network segments as non-Gaussian chains has been investigated. By using a non-Gaussian free energy expression for the entanglement creation function and a constant breakage function, one finds that the resulting material functions will depend on the number of subunits in the network segments. For short segments, an initial increase with shear rate occurs in the viscosity. Introduction of a slip coefficient to remove the affine deformation assumption results in shear thinning behavior, which becomes more pronounced for long polymer segments. Depending on the network segment length and the slip coefficient, it is shown that our choice of entanglement creation and destruction functions leads to the results of Lodge's theory for affine non-Gaussian chains on one hand, and to Fuller and Leal's predictions for non-affine Gaussian chains on the other. (Edited author abstract) 10 refs.

Vrahopoulou, E.P. (Univ of Illinois, Urbana, IL, USA); McHugh, A.J. *J Rheol* v 31 n 5 Jul 1987 p 371-384.

**090319 TRANSIENT PROCESSES OF FLOW OF ELASTOVISCOPLASTIC MEDIA IN LONG CHANNELS.** The article deals with the special features of the rheodynamics and thermophysics of the shear strain of elastoviscoplastic media in long channels when a pressure

gradient is suddenly imposed. It was shown that there may be two kinds of transient regimes. The type of transient regime is determined by the parameter  $\beta_0$ , which depends on the yield point, the width of the channel, the jump of the pressure gradient, as well as by the curvature of the channel. 7 refs.

Dorniyak, O.R. (Acad of Sciences of the Belorussian SSR, Minsk, USSR); Zal'tsgendler, E.A.; Khudis, B.M.; Shul'man, Z.P. *J Eng Phys* v 51 n 5 Nov 1986 p 1272-1278.

**090320 PREDICTING THE VARIATION OF THE RHEOLOGIC CHARACTERISTICS OF COMPONENTS FROM MR MATERIAL IN THE OPERATING CONDITIONS OF A GAS TURBINE ENGINE.** The results are reported of a study of the variation of rheological properties of vibroinsulators and dampers made of an MR material as affected by long storage and operation stresses. Analytic relations have been derived for predicting the change of the rheological properties of MR products in various stages of their storage and operation use. (Author abstract) 6 refs.

Belousov, E.I.; Troinikov, A.A. *Sov Aeronaut* v 30 n 3 1987 p 14-17.

Calculations See SUSPENSIONS—Rheology.

**Mathematical Models** See Also BIOLOGICAL MATERIALS—Blood; BIOMECHANICS—Joints; CERAMIC MATERIALS—Plasticity; COMPOSITE MATERIALS—Extrusion; FLOW OF FLUIDS—Ducts; FLOW OF FLUIDS—Porous Materials; FLOW OF FLUIDS—Two Phase; FLOW OF SOLIDS—Granular Materials; LUBRICATION—Elastohydrodynamic; POLYMERS—Rheology; SOILS—Mechanical Properties; SUSPENSIONS—Rheology; TEXTILES—Nonwovens.

**090321 FOAM AND EMULSION RHEOLOGY: A QUASISTATIC MODEL FOR LARGE DEFORMATIONS OF SPATIALLY-PERIODIC CELLS.** Foams and emulsions, for our purposes, are fluid/fluid dispersions in which the continuous phase is liquid and the disperse phase is gas or liquid. Here we develop a two-dimensional model for the quasistatic response of large-gas-fraction foams and concentrated emulsions to large deformations. 25 refs.

Kraynik, Andrew M. (Sandia Natl Lab, Albuquerque, NM, USA); Hansen, Marion G. *J Rheol* v 30 n 3 June 1986 p 409-439.

**090322 STUDY OF IMPACT INTERACTION BETWEEN COMMUTATING CONTACTS AS FUNCTION OF THEIR SURFACE FINISH.** Deformations of contacting bodies in commutating devices considering magnitudes of their kinetic energy are commensurable with asperities dimensions on their surfaces (specified by state standard GOST 2789-73). This fact calls for consideration of surface roughness in the analysis of contact closing. A dynamic collision model is based on an elasto-plastic rheological model of colliding bodies. This model conforms to the results of experimental studies. An elasto-plastic model of the material near contact zone is transformed into a non-linear elasto-plastic mathematical model of the given collisions. 2 refs.

Vlasov, V.A.; Rodin, V.I.; Urushev, S.V.; Shvartz, M.I. *Vib Eng* v 1 n 1-4 1987 p 337-345.

**090323 SYMPOSIUM ON APPLICATIONS OF EQUATIONS OF STATE IN RHEOLOGY AT THE 57TH ANNUAL MEETING OF THE SOCIETY OF RHEOLOGY.** This publication contains 11 papers by various authors dealing with applications of equations of state in rheology. The major theme was the addition of time as a variable to PVT equations of state and the consideration of stress fields other than just hydrostatic pressure, specifically shear and tension. Topics included relaxation processes; amorphous solid polymers; electric conduction in polymers; and zero-shear viscosity of liquid mixtures. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10548 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *J Rheol* v 30 n 4 Aug 1986, Symp on Appl of Equat

of State Rheol at the 57th Annu Meet of the Soc of Rheol, Ann Arbor, MI, USA, Oct 1985 204p.

**090324 RELATION BETWEEN EQUATION OF STATE AND RELAXATIONAL PROCESSES: MELT AND GLASS.** The purpose of this paper is to review the physical basis and some consequences of a workable equilibrium theory which is also involved in the discussions of other contributors to the symposium. Continuing on this basis, we consider the connection between the equilibrium melt and the glass, both from the standpoint of quasi-equilibrium and of time phenomena. 36 refs.

Simha, Robert (Case Western Reserve Univ, Cleveland, OH, USA). *J Rheol* v 30 n 4 Aug 1986, Symp on Appl of Equat of State Rheol at the 57th Annu Meet of the Soc of Rheol, Ann Arbor, MI, USA, Oct 1985 p 693-706.

**Measurements** See CLAY—Additives; ELASTOMERS—Radiation Damage; FOOD PRODUCTS—Extrusion; LIQUIDS—Rheology; PLASTICS—Rheology; POLYBUTADIENES—Rheology; POLYETHYLENES—Rheology; SUSPENSIONS—Measurements; SUSPENSIONS—Rheology; THERMOPLASTICS—Quality Control.

Research See FLOW OF FLUIDS—Non Newtonian.

Suspensions See IRON OXIDES—Suspensions.

Theory

**090325 CONSTITUTIVE EQUATION INCLUDING COMPRESSIBILITY EFFECTS.** Rheological theory including volume (compressible) effects is important in a practical sense in that many polymer processes involve rapid cooling to a final, typically nonequilibrium, glassy state. There are also compressible effects in the sense of Poisson's ratio - that is, deformation-induced volume changes occur even at constant temperature. In earlier work we (Snow and Bogue) set down a generalized constitutive equation which includes these various effects. The integral statement there is quite complicated, however, and is difficult to execute except in the simplest deformations. The present work is a restatement of the prior formulation in a more tractable and slightly modified form. (Author abstract) 22 refs.

Ko, Wen-Chien (Univ of Tennessee, Knoxville, TN, USA); Bogue, Donald C. *J Rheol* v 31 n 6 Aug 1987 p 425-438.

Thermal Effects See POLYMERS—Rheology.

Thin Films

**090326 PROCESSING AND CHARACTERIZATION OF CELLULOSE TRIACETATE FILMS FROM ISOTROPIC AND LIQUID CRYSTALLINE SOLUTIONS.** The work reported here is motivated by two factors: the awareness that CTA can form lyotropic liquid crystals having the possibility of controlled structure and an interest in films that have properties derived from being processed through an intermediate liquid crystalline state. Thus a process was developed to fabricate films and then characterize and study the properties of these films. To this end then we report on the film fabrication process and some rheological experiments; permeation studies of the films; and SAXS, SEM, DSC, WAXS, mass density, birefringence and mechanical characterization of these films. 21 refs.

Omatete, O.O. (Univ of Tennessee, Knoxville, TN, USA); Bodaghi, Hassan; Fellers, John F.; Browne, Colin L. *J Rheol* v 30 n 3 Jun 1986 p 629-659.

**RHEOMETERS** See Also COATINGS—Testing; ELECTRIC EQUIPMENT—Calculations; POLYMERS—Viscosity.

**090327 UNE NOUVELLE GENERATION DE RHEOMETRES.** [New Generation of Rheometers]. Monsanto have just developed their 6th generation of



rheometers. These new devices comprise the Oscillating Disc Rheometer Monsanto ODR 2 000, the Moving Die Rheometer MDR 2 000 and the viscometer Mooney MV 2 000. They present with other characteristics an advanced torque measurement system which improves the precision and result reproducibility. In French.

Anon. *Rev Gen Caoutch Plast* v 65 n 677 Apr 1988 p 99-102.

## Analysis

**090328 ANALYSIS OF A NEWLY DEVELOPED DAMPED-OSCILLATION RHEOMETER: NEWTONIAN LIQUID.** The behavior of a newly developed damped-oscillation rheometer was analyzed for Newtonian liquids from both theoretical and experimental points of view. This rheometer consists, essentially, of a cylindrical tube suspended from a torsion wire that is filled with the liquid to be tested. In order to determine the relationship between the rheological parameters of the liquid and the period or the logarithmic damping factor measured by this rheometer, a Newtonian liquid was considered as a first test liquid. Based on various assumptions, the equations of motion for the liquid and the cylindrical tube were solved simultaneously. Numerical solutions and approximate analytical solutions valid for certain ranges of the parameters were obtained. The results are compared with experimental results which we measured using this rheometer. (Author abstract) 2 refs.

Murata, Tadayoshi (Tokyo Metropolitan Univ, Tokyo, Jpn); Date, Munehiro; Kaibara, Makoto. *Jpn J Appl Phys Part 1* v 26 n 8 Aug 1987 p 1234-1240.

## Applications

**090329 ASSEMBLY AND USE OF A COMPUTERIZED TORQUE RHEOMETER.** The personal computer has started a revolution in the way data is collected and stored by bringing computer capabilities within the economic reach of even the smallest company. Computer data acquisition and manipulation expands the usefulness of the already valuable torque rheometer as a tool for both rheological studies and routine quality control testing. Analysis of more fundamental rheological properties than just the traditional torque vs. time curve is possible without the time consuming manual data manipulation. Data storage and recall of routine or Q.C. testing for accurate comparisons of results is made easier. Torque rheometer uses made easier by the use of a computer are reviewed. Also given are details of how to hook up a personal computer to an existing torque rheometer. (Author abstract) 21 refs.

Brown, Randy J. (Sterling Engineered Products, Elkhart, IN, USA). *J Vinyl Technol* v 9 n 1 Mar 1987 p 28-34.

## Performance See FLOW OF FLUIDS—Measurements.

## Strain

**090330 CONTROL OF STRAIN RATE IN A SHEET-INFLATION RHEOMETER.** In the experimental study of nonlinear viscoelasticity, it is found that a material's response depends on the size, rate, and kinematics of the deformation. While uniaxial extension is now fairly widely used in the study of polymeric liquids, there has been less success with the generation of controlled, uniform, biaxial extension. Several methods have been used to generate this type of deformation. The earliest was the sheet inflation technique, which has been used to study raw elastomers, rubbery thermoplastics and bread dough. The problem of controlling the strain rate has limited its application to such materials. The sheet inflation techniques may still be the most attractive basis for a simply performed test that can yield meaningful data on a wide range of materials, including molten thermoplastics. The authors address the problem of controlling the strain in such a way as to maintain a constant strain rate. 17 refs.

Yang, Ming-Chien (McGill Univ, Montreal, Que, Can); Dealy, John M. *J Rheol* v 31 n 2 Feb 1987 p 113-120.

## Theory

**090331 BOUNDARY EFFECTS ON THE DRAG OF AN OSCILLATING SPHERE: APPLICATIONS TO THE MAGNETIC SPHERE RHEOMETER.** The effect of a closed, nearby boundary on the drag of a small, oscillating sphere in an incompressible, linearly viscoelastic medium is studied. Through a perturbation procedure the functional dependence of the drag on the complex oscillatory Reynolds number is determined and shown to differ from that of the unbounded case. These results allow one to account for boundary effects in the determination of the complex viscosity using the magnetic sphere rheometer. This paper is motivated by the rheological study of materials purified in minute quantities such as intracellular protein, thus the need for small chamber sizes for use with the rheometer and the need for boundary corrections for the drag. (Author abstract) 18 refs.

Sellers, H.S. (Johns Hopkins Univ, Baltimore, MD, USA); Schwarz, W.H.; Sato, M.; Pollard, T. *J Non Newtonian Fluid Mech* v 26 n 1 Nov 1987 p 43-55.

**RHODIUM AND ALLOYS** See Also CATALYSTS—Materials; CATALYSTS—Supported; RARE EARTH COMPOUNDS—Magnetic Properties.

## Extraction

**090332 EXTRACTION OF RHODIUM FROM AQUEOUS NITRIC ACID BY DINONYLNAPHTHALENE SULPHONIC ACID.** The extraction of rhodium from aqueous nitric acid using dinonylnaphthalene sulfonic acid has been investigated. The extraction occurs readily from 0.1M to 1.0M nitric acid and, since the rhodium is extracted as  $[Rh(H_2O)_6]^{3+}$  into the inverted micelles of the organic solution, equilibration times are less than 5 minutes. Extraction is enhanced by the addition of nitrite ion to form  $[Rh(H_2O)_5NO_2]^{2+}$  as the extracted species. (Author abstract) 18 refs.

Patel, N.M. (Loughborough Univ of Technology, Loughborough, Engl); Thornback, J.R. *Solvent Extr Ion Exch* v 5 n 4 1987 p 633-647.

## Isotopes

**090333  $^{105}Rh$  AS A POTENTIAL RADIOTHERAPEUTIC AGENT.** The production of 35.5-h  $^{105}Rh$  (560- and 250-keV betas) by neutron activation of  $^{104}Ru$  followed by beta decay of 4.4-h  $^{105}Ru$  is discussed. A simple procedure for producing  $^{105}Rh$  in 10-100 mCi quantities at specific activities of 700-10,000 Ci/mmol is described. (Author abstract) 15 refs.

Grazman, B. (Univ of Missouri, Columbia, MO, USA); Troutner, D.E. *Appl Radiat Isot* v 39 n 3 1988 p 257-260.

## Spectroscopic Analysis

**090334 STUDIES OF HIGHLY SENSITIVE COLOR REACTION OF IRIUM WITH THIO-MICHLER'S KETONE.** 4,4'-Bis(dimethylamino)thiobenzophenone (Thio-Michler's ketone, TMK) has been found to be more sensitive than the commonly known iridium reagents for determination of iridium. A sensitive spectrophotometric method has been established for determining microgram amounts of iridium with TMK. The method can be applied to the direct spectrophotometric determination of iridium in rhodium, platinum and their mixtures. (Edited author abstract) In Chinese. 5 refs.

Yao, Feng-ji (Peking Univ, China); Xu, Shao-jun; Ci, Yun-xiang. *Xi You Jin Shu* v 6 n 2 May 1987 p 145-148.

**Structure** See RUTHENIUM AND ALLOYS—Structure.

**Surface Properties** See HYDROCARBONS—Adsorption.

**Surfaces** See HYDROGEN—Adsorption.

**RHODIUM COMPOUNDS** See Also CATALYSTS—Materials; CATALYSTS—Structure; PHOTOCONDUCTING MATERIALS; ZIRCONIUM COMPOUNDS—Stability.

**090335 PHASE RELATIONS, THERMOCHEMISTRY AND SUPERCONDUCTIVITY IN THE Zr-Rh SYSTEM.** The phase relations in the Zr-Rh system were reinvestigated by differential thermal analysis, levitation thermal analysis, X-ray analysis electron microprobe analysis, microstructural examinations and measurements of the superconducting transition temperatures. A new complete phase diagram is presented. Owing to the occurrence of martensitic transformations, the central part of the diagram is particularly complicated. Observed enthalpies of formation are given for three intermediate compounds. (Author abstract) 27 refs.

Jorda, J.L. (Univ de Geneve, Geneva, Switz); Graf, T.; Schellenberg, L.; Muller, J.; Cenazul, K.; Gachon, J.C.; Hertz, J. *J Less Common Met* v 136 n 2 Jan 1988 p 313-328.

**090336 RHODIUM AND IRIUM OXOMETALLATES - A NEW CLASS OF SOLID MICROPOROUS MATERIALS.** Organometallic Keggin ion complexes, exemplified by  $[(Ph_3P)_2Rh(CO)]_4SiW_{12}O_{40}$  and  $[(Ph_3P)_2IrH_2]_3PW_{12}O_{40}$ , have been characterized by solid state NMR and X-ray absorption spectroscopy. They constitute a new class of chemically microporous solids and illustrate the use of large molecular metal oxide clusters to form extensible lattices in which coordinately unsaturated organometallic cations may be stabilized and studied. In some cases, these cations are mobile and form bimetallic species. The reactions of these materials in olefin isomerization, hydroformylation, hydrogenation, dehydrogenation and C-H activation processes are described. (Author abstract) 16 refs.

Siedle, A.R. (3M, St. Paul, MN, USA); Newmark, R.A.; Gleason, W.B.; Skarjune, R.P.; Hodgson, K.O.; Roe, A.L.; Day, V.W. *Solid State Ionics* v 26 n 2 Feb-Mar 1988 p 109-117.

**Adsorption** See CATALYSTS—Synthesis.

**Applications** See CATALYSTS—Materials.

**Decomposition** See CATALYSTS—Materials.

**Recovery** See CATALYSTS—Rhodium Compounds.

**Spectroscopic Analysis** See CATALYSTS—Materials.

## Testing

**090337 IR STUDY OF THE ANCHORING OF HYDRIDOCARBONYL TRIS (TRIPHENYLPHOSPHINE)-RHODIUM(I) TO CROSSLINKED PHOSPHINATED POLYSTYRENES.** Attachment of  $RhH(CO)(PPh_3)_3$  to polystyrene- $CH_2PPh_2$  gels is accompanied initially by complete loss of CO and H ligands, yielding probably coordinatively unsaturated surface rhodium-phosphine cluster complexes. Prolonged interaction of these clusters with  $CO/H_2$  gives rise to different types of supported Rh-carbonyl clusters, but no hydrido ligands. Only the first-mentioned species are active hydrogenation catalysts under mild conditions. (Author abstract) 18 refs.

Paetzold, E. (Acad of Science of GDR, Rostock, East Ger); Pracejus, H.; Oehme, G. *J Mol Catal* v 42 n 3 Nov 2 1987 p 301-306.

## Thermal Effects

**090338 THERMAL DECOMPOSITION OF  $Rh_6(CO)_{16}$  ON  $\alpha$ -ALUMINA.** The heating of  $Rh_6(CO)_{16}$  adsorbed on  $\alpha$ -alumina to 400°C in either He or  $H_2$  gave primarily carbon monoxide resulting from the thermal decarbonylation of the cluster. A little  $CO_2$  was also formed at higher temperatures in either He or  $H_2$ . At these higher temperatures under  $H_2$  a small amount of  $CH_4$  was



also produced, but no evidence for the presence of higher hydrocarbons could be found. (Author abstract) 16 refs.

Augustine, Robert L. (Seton Hall Univ, South Orange, NJ, USA); Pierson, Christopher G. *J Mol Catal* v 43 n 1 Nov 2 1987 p 7-14.

## RHODIUM METALLOGRAPHY See RHODIUM VANADIUM ALLOYS—Phase Diagrams.

## RHODIUM VANADIUM ALLOYS

### Phase Diagrams

**090339 RHODIUM-VANADIUM SYSTEM.** The Waterstrat-Manuszewski phase diagram has been accepted and is shown. Data pertaining to the invariant reactions in this diagram are summarized. A synopsis of crystal structure and lattice parameter data for the system is given. 12 refs.

Smith, J.F. (Iowa State Univ, Ames, IA, USA). *J Alloy Phase Diagrams* v 3 n 3 Sep 1987 p 143-147.

**RINGS** See Also BEARINGS—Roller; CYLINDERS—Buckling; DOMES AND SHELLS—Buckling; DYNAMICS; PENDULUMS; PENDULUMS—Stability; PLATES—Buckling.

### Analysis

**090340 ANALYSIS OF RINGS OF AN ARBITRARY SHAPE.** It is shown that, based on an analysis of the coefficients of Fourier series expansion of the moments arising in a ring of arbitrary shape, loaded in its plane by an arbitrary load, it is possible, first, to develop an applied method of analysis of noncircular rings, and, secondly, to identify a number of classes of sufficiently general loads for which the analysis is carried out in an elementary fashion. (Translated author abstract). In Russian. 5 refs.

Kaplan, Yu.I. *Izv Vyssh Uchebn Zaved Mashinost* n 8 1987 p 8-11.

**Concrete Construction** See OIL TANKS—Foundations; OIL TANKS—Structural Analysis.

**Deformation** See Also BEAMS AND GIRDERS—Curved.

**090341 CRUSHING ANALYSIS OF BRACED METAL RINGS USING THE EQUIVALENT STRUCTURE TECHNIQUE.** This paper presents a development of the equivalent structure technique to account for some of the effects of strain-hardening in structures undergoing plastic bending. The lateral compression of symmetrically deforming braced rings is analyzed and the results compared with corresponding experimental data. The effects of strain-hardening on the analytical results both in the small deformation post-collapse regime and at large deformations prior to the onset of unstable deformations are discussed. (Author abstract) 19 refs.

Reddy, T.Y. (UMIST, Manchester, Engl); Reid, S.R.; Carney, J.F. III; Veilette, J.R. *Int J Mech Sci* v 29 n 9 1987 p 655-668.

**090342 CRUSHING AN ELASTIC-PERFECTLY PLASTIC RING BETWEEN TWO POINT LOADS.** A thin ring with elastic-perfectly-plastic moment curvature relation is crushed by two point loads. The non-linear governing equations are solved by perturbations and numerical integrations. It is found that the ring may have none, one or two pairs of plastic hinges depending on the normalized force and  $\lambda$ , a non-dimensional parameter characterizing plasticity. Sudden collapse of the ring is possible. Partial spring-back due to irreversibility is determined. (Author abstract). 8 Refs.

Wang, C.Y. (Michigan State Univ, East Lansing, MI, USA). *Int J Non Linear Mech* v 23 n 3 1988 p 205-216.

**Design** See SPACE SHUTTLES—Equipment.

### Elasticity

**090343 ON THE CONSTRAINED ELASTIC RING.** The problem of a thin elastic ring contained within a smooth rigid cavity is considered for the case where the ring is subjected to a radial point load. The problem is approached as a moving intermediate boundary problem in the calculus of variations and a closed-form analytical solution is obtained. Numerical results are presented for several cases, revealing unstable behavior of the ring configuration. (Author abstract) 9 refs.

Bottega, W.J. (Rutgers Univ, Piscataway, NJ, USA). *J Eng Math* v 22 n 1 1988 p 43-51.

### Failure

**090344 UNRESTRAINED OUT-OF-PLANE BUCKLING OF MONOSYMMETRIC RINGS.** Rings which are loaded by a uniformly distributed radial inward load may buckle out of the plane of the ring. This paper is concerned with out-of-plane buckling of rings of monosymmetric section with the axis of symmetry oriented radially. It is assumed that there are no restraints against buckling displacements. A new solution to the problem is derived and compared extensively with existing analytical solutions and finite element analysis. All the existing solutions are shown to be either limited in application or in error. The new solution compares well with finite element analyses, provided there is no distortion of the cross-section. (Author abstract) 10 refs.

Teng, J.G. (Univ of Sydney, Aust); Rotter, J.M. *Res Rep Univ Sydney Sch Civ Min Eng* n R536 Dec 1986 40p.

### Forging

**090345 INCREMENTAL FORGING FOR THE PRODUCTION OF RING-SHAPED COMPONENTS.** Incremental forging of the ring blanks allows to purposefully control the flow of material at substantially reduced deformation power and to produce ring blanks in a wide dimensional range. An analysis of the elementary theory and of the tests made in an integrated open-die forging plant has shown the existence of definite relationships between the forging parameters and the geometry of the ring produced, and the possibility of appropriately controlling the flow of material. Incremental forging allows thus both to expand and reduce the inside diameter and to optimize the initial rings for the ring rolling process. It makes it possible, moreover, to produce rings with discontinuous sections, e.g. with too-things. The application of incremental forging results thus in a considerably higher flexibility of the production process. (Author abstract) In German with English abstract. 11 refs.

Welschhof, Klaus (RWTH, Aachen, West Ger); Kopp, Reiner. *Stahl Eisen* v 108 n 2 Jan 25 1988 p 79-84.

**Magnetic Field Effects** See ELECTRIC CONDUCTORS—Transients.

**Manufacture** See Also AIRCRAFT ENGINE MANUFACTURE; FORGING—Energy Conservation; METAL FORMING; ROLLING MILL PRACTICE.

**090346 RING ROLL MILL - A HIGHLIGHT OF NEW FORGE DEVELOPMENT.** A new ring rolling mill recently went into service at Wm. Oxley & Co. Ltd., Parkgate, Rotherham, U.K. Custom-designed around the needs of Oxley and its principal customers, the new mill produces rings with outer diameters from 125 mm to 1480 mm. It specializes in the manufacture of small to medium sized batches of rings in special steels, nickel-based, titanium alloys and superalloys, all of which are of the highest quality. (Author abstract)

Anon. *Metalurgia* v 54 n 11 Nov 1987 p 504, 506, 507-508.

**090347 IMPROVING THE ACCURACY OF SIZED RINGS.** The accuracy of annular articles can be improved

by sizing using plastic expansion or compression. At the Kurgansk Production Association for Accessory and Chemical Machine Building, a series of experimental research was conducted to: determine the possibilities of sizing by plastic expansion and compression of blanks and articles with a wide range of dimensions (200-200 mm), and produce recommendations on the process conditions for stable sizing; determine the magnitude and nature of elastic recovery of articles after the removal of sizing load, and the nature errors; and determine the influence of material hardening on the accuracy of the sizing process and on the required press force. 4 refs.

Bubnov, V.A. *Sov Forg Sheet Met Stamping Technol* n 2 1987 p 80-84.

### Materials

**090348 PRODUCTION OF TEFLON SHEATHS FOR RUBBER RINGS WITH CIRCULAR CROSS SECTION.** To improve the reliability of the entire seal and to reduce expenditure of scarce material, a new method of making Teflon sheaths was developed. The technology of making the sheaths consists of the following: The Teflon blank is mounted in the lathe chuck and the end face is undercut. Then the blank is turned to the specific diameter. With a view to the cross-sectional diameter of the rubbish ring, grooves are turned along the blank at the distance  $1 = k \cdot r_d$  from each other. When the operation is finished, a rubber ring is slipped over the blank, and it is aligned by the forming tool mounted in the tool holder. The tool must have a sharp cutting edge and a forming front face made in the shape of a torus with radius  $d/2 +$  thickness of the sheath. The Teflon sheath can also be formed without the rubber ring. 4 refs.

Zemskov, V.A.; Shataev, E.V. *Chem Pet Eng* v 23 n 7-8 Jul-Aug 1987 p 354-356.

### Mathematical Models

**090349 DYNAMIC RESPONSE OF A ROTATING THICK RING TO FORCE OR DISPLACEMENT EXCITATION.** The dynamic response of a rotating thick ring is obtained, subjected to either force or displacement excitation. The equations of motion are formulated in an inertial reference frame, with account taken of ring extensibility, transverse shear, rotatory inertia, rotation, initial stress due to pressure loading and an elastic foundation. A receptance approach is utilized for obtaining the solutions. These receptances have the special property of not following reciprocity because of Coriolis effects. Critical speeds corresponding to zero natural frequencies as observed in the inertial reference frame are found in free vibration. The damping effects on the forced vibrations are studied by using a structural damping model. The dynamic responses to different force or displacement excitations are compared. In particular, a tangentially constrained displacement excitation is investigated that can result in a considerable reaction torque to the ring support. (Author abstract) 9 refs.

Lin, J.L. (Purdue Univ, West Lafayette, IN, USA); Soedel, W. *J Sound Vib* v 121 n 2 Mar 8 1988 p 317-337.

### Nondestructive Examination

**090350 SENSITIVITY DISTRIBUTION IN THE CROSS SECTION OF A RING DURING 'TANDEM' INSPECTION.** The sensitivity of the ultrasonic inspection of rings is calculated for a combination double transceiver probe. The influence of the inspection parameters and the structural features of welded joints on the evolution of the sensitivity levels in different zones of the joint is discussed. (Author abstract) 5 refs.

P'yankov, V.A. (Ya.M. Sverdlov Motorostroitel' Industrial Union, Perm, USSR). *Sov J Nondestr Test* v 23 n 4 Apr 1987 p 261-265.

### Oscillations

**090351 INFLUENCE OF INTERNAL RESONANCE ON THE NON-LINEAR OSCILLATIONS**



**OF A CIRCULAR RING UNDER PRIMARY RESONANCE CONDITIONS.** An accurate set of equations of motion, developed previously by the authors, is used to analyze the large amplitude forced oscillations of a thin circular ring. Qualitative and quantitative information about the primary response of a ring subjected to either a distributed harmonic in-plane or a distributed harmonic out-of-plane load is obtained by the method of multiple scales. The response due to the in-plane excitation or a ring in the presence of an internal resonance indicates that purely planar oscillations are unstable over a major portion of the primary resonant peak, and that nonplanar oscillations exist over certain ranges of excitation frequencies. For certain values of excitation frequencies, the presence of unsteady motions with no exchange of energy between the in-plane and the out-of-plane modes is indicated. Internal resonance is shown to have no effect on the primary resonant peak due to the out-of-plane excitation. However, over certain other ranges of excitation frequencies, the in-plane bending mode is also excited (at the same order) and the resulting response is non-planar. (Edited author abstract) 13 refs.

Maganty, S.P. (Arizona State Univ, Tempe, AZ, USA); Bickford, W.B. *J Sound Vib* v 122 n 3 May 8 1988 p 507-521.

## Pressure Effects

**090352 MECHANISM ANALYSIS OF THE POST-BUCKLING RESPONSE OF A CIRCULAR RING UNDER EXTERNAL PRESSURE.** Of recent interest, in the context of pipeline designs, is how the plastic post-buckling pressure collapse sequence of a circular ring may be related to the approximation of the propagation pressure. A simple rigid plastic mechanism analysis, incorporating strain-hardening effects, is presented for the analysis of the plastic post-buckling response of a circular ring under external pressure. Results are found to compare favourably with those obtained through more elaborate studies. (Edited author abstract). 5 refs.

Tam, Christophe K.W. (Univ Coll London, London, Engl); Croll, James G.A. *Thin-Walled Struct* v 6 n 2 1988 p 109-117.

## Strain See FLYWHEELS—Stresses.

## Stresses See Also STRUCTURAL DESIGN—Stresses; TIRES—Radial.

**090353 ON TORSION AND SHEAR IN A RING SECTOR.** The shear stresses in a ring sector of circular cross-section were determined by O. Goehner using a method which takes into account a twisting moment. However, this method does not consider the stress field produced by a shear force which also acts on every cross-section. The present paper extends the method of Goehner by considering this shear force. The stress function introduced by Goehner is modified to include a term which contains a stress correction coefficient K. The stress equations containing K do not contribute to the moment equation, so such terms agree exactly with Goehner's solution. The correction coefficient K, though physically significant, is small. Four terms are developed in the series solution, by the method of successive approximation. (Edited author abstract) 5 refs.

Lang, H.A. (LANG - Research West, Santa Monica, CA, USA). *Res Mech* v 22 n 4 1987 p 301-311.

**090354 OUT-OF-PLANE BUCKLING OF RESTRAINED MONOSYMMETRIC RINGS.** Rings are commonly used at junctions between shell segments in pressure vessels, tanks and silos. Often the ring is in circumferential compression and is susceptible to failure by buckling. This buckling is usually restrained by the adjacent shell segments, which prevent translation and elastically restrain rotation of the point of attachment. The ring is normally not loaded at its centroid or shear center. This paper presents an analysis of the buckling of a monosymmetric ring under these conditions. Four versions of the theory are presented, which make progressively less restrictive assumptions relating to the ring as a

'thin ring'. The analytical predictions are compared with numerical stability assessments from a finite element shell buckling analysis. (Edited author abstract) 15 refs.

Teng, J.G. (Univ of Sydney, Aust); Rotter, J.M. *Res Rep Univ Sydney Sch Civ Min Eng* n R510 Oct 1985 61p.

**090355 TRANSIENT THERMAL STRESS ANALYSIS OF CIRCULAR CERAMIC RINGS.** Structural ceramics are the materials most expected to realize improvements in the efficiency and reliability of heat engines. This report presents a transient thermal stress analysis of circular ceramic rings, the inner and outer boundaries of which are heated by a hot environment through a given heat transfer. Taking four kinds of ceramics, silicon nitride, silicon carbide, zirconia and alumina, it focuses on how the material characteristics of those ceramics influence the thermal stresses which arise in the circular ceramic rings. Since the temperature distribution depends on the thermal conductivity and stress components, a quantity  $\alpha E T$  (product of thermal expansion coefficient, Young's modulus and temperature), the computed results show that the maximum values of thermal stress in the zirconia and alumina rings are considerably higher than the ones in the silicon nitride and silicon carbide rings. (Author abstract) In Japanese. 8 refs.

Amada, Shigeasu. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 500 Apr 1988 p 616-620.

**090356 STUDY OF THE STRESSED STATE OF AN ORTHOTROPIC RING ON THE BASIS OF VARIOUS THEORIES.** In an exact statement and in terms of approximate theories (classical theory, Timoshenko theory, and a refined theory suggested by one of the authors), the stressed-strained state is studied of an orthotropic ring of a medium thickness acted upon cyclically by a symmetrical ring with two types of loading are described. (Author abstract). 4 Refs.

Rodionova, V.A.; Fomina, N.A. *Leningrad Univ Mech Bull* n 4 1987 p 31-36.

**090357 GENERAL SOLUTION TO THE DISTRIBUTION OF STRESSES IN A CIRCULAR RING COMPRESSED BY TWO FORCES ACTING ALONG A DIAMETER.** This paper develops the solution for the stresses in a circular ring compressed by two forces acting along a diameter. Solutions to this problem have been published before, but only for special cases. The solution presented here is general; it is valid for any ratio of inside diameter to outside diameter. It is assumed that this is a problem in two-dimensional elasticity. The solution is obtained by using the method of superposition. The stresses in a disk compressed by two equal and opposite forces acting along a diameter are added to the stresses in a ring. (Edited author abstract). 4 Refs.

Chianese, R.B. (Westinghouse Electric Corp, Orlando, FL, USA); Erdlac, R.J. *Q J Mech Appl Math* v 42 pt 2 May 1988 p 239-247.

**090358 GENERAL SOLUTION TO THE DISTRIBUTION OF STRESSES IN A CIRCULAR RING COMPRESSED BY TWO FORCES ACTING ALONG A DIAMETER.** This paper develops the solution for the stresses in a circular ring compressed by two forces acting along a diameter. Solutions to this problem have been published before, but only for special cases. The solutions presented here is general; it is valid for any ratio of inside diameter to outside diameter. It is assumed that this is a problem in two-dimensional elasticity. The solution is obtained using the method of superposition. (Edited author abstract). 4 Refs.

Chianese, R.B. (Westinghouse Electric Corp, Orlando, FL, USA); Erdlac, R.J. *Q J Mech Appl Math* v 41 pt 2 May 1988 p 239-247.

## Structural Analysis

**090359 UNRESTRAINED OUT-OF-PLANE BUCKLING OF MONOSYMMETRIC RINGS.** Rings which are loaded by a uniformly distributed radial inward load may buckle out of the plane of the ring. This paper is

concerned with out-of-plane buckling of rings of monosymmetric section with the axis of symmetry oriented radially. It is assumed that there are no restraints against buckling displacements. A new solution to the problem is derived and compared extensively with existing analytical solutions and finite element analysis. All the existing solutions are shown to be either limited in application or in error. The new solution compares well with finite element analyses, provided there is no distortion of the cross section. (Author abstract) 12 refs.

Teng, J.G. (Univ of Sydney, Aust); Rotter, J.M. *J Constr Steel Res* v 7 n 6 1987 p 451-471.

**090360 CONTRIBUTION TO THE OPTIMAL NUMBERING OF A RING STRUCTURE.** An optimal element numbering of a pipeline system containing rings is considered. In order to minimize the front width two possible cases of ring structure are analysed and solved in different manners. An example is shown of a typical one having both types of rings. By applying the automatic procedure for element numbering, the front width can be reduced by approximately 40%. The algorithm and FORTRAN 77 programme are presented, as well as input and output data for the example. (Author abstract) 1 ref.

Marjanovic, Ljiljana (Univ of Belgrade, Belgrade, Yugoslavia); Sedmak, Aleksandar. *Comput Struct* v 28 n 5 1988 p 573-578.

**090361 BUCKLING OF RINGS IN COLUMN-SUPPORTED BINS AND TANKS.** This paper deals with the out-of-plane buckling of annular plate rings in column-supported bins and tanks. The stress distributions in such rings are first examined using a finite element shell analysis. A closed-form solution for the buckling of rings under non-uniform circumferential stresses is then derived. Numerical results from the closed-form solution are compared with those from a finite element shell buckling analysis, and close agreement is found. The significant effect of stress non-uniformity on the buckling predictions is demonstrated. Finally, simplified equations are given which are suitable for structural design purposes, and which closely model the predictions of the more rigorous solution. (Edited author abstract) 25 refs.

Teng, J.G. (Univ of Sydney, Sydney, Aust); Rotter, J.M. *Res Rep Univ Sydney Sch Civ Min Eng* R 552 Sep 1987 35p.

**090362 BUCKLING OF RESTRAINED MONOSYMMETRIC RINGS.** Rings are commonly used at junctions between shell segments in pressure vessels, tanks, and silos. Often the ring is in circumferential compression and is susceptible to failure by buckling. This buckling is usually restrained by the adjacent shell segments, which prevent translation and elastically restrain rotation of the point of attachment. The ring is normally not loaded at its centroid or shear center. This paper presents an analysis of the buckling of a monosymmetric ring under these conditions. Four versions of the theory are presented, which make progressively less restrictive assumptions relating to the ring as a 'thin ring.' The analytical predictions are compared with numerical stability assessments from a finite element shell buckling analysis. The classical thin ring solution is shown to be satisfactory for most practical purposes. (Author abstract). 15 Refs.

Teng, Jin-Guang (Univ of Sydney, Sydney, Aust); Rotter, J. Michael. *J Eng Mech* v 114 n 10 Oct 1988 p 1651-1671.

## Testing See Also DOMES AND SHELLS—Buckling.

**090363 WERKSTOFFPRUEFUNG AN MASSGEPRESSTEN KOHLENSTOFF-RINGEN.** [Material Testing on Molded-to-Size Carbon Rings]. In order to characterize molded-to-size carbon seal rings, it is important to determine the flexural strength and Young's modulus. The common, small diameter-shapes, however, do not allow to cut test beams from fabricated parts. Therefore, the 'C-ring-test' is used. The given calculation method remains valid for generally 'symmetric' cross-sections and for strongly curved beams up to a ratio



radius/ring thickness  $\geq 1$ . Only increasing asymmetry is accompanied by greater deviations from the calculated data. The results from the well-known 3-point-test for straight bars lead to the same material data as those from the 'C-ring-test'. (Edited author abstract) In German. 10 refs.

Mueller, R. (Ringsdorf-Werke GmbH, Bonn, West Ger); Thiele, W. *Spechsaal* v 120 n 8 Aug 1987 p 648-650.

## Vibrations

**090364 RESPONSE OF ROTATING RINGS TO HARMONIC AND PERIODIC LOADING AND COMPARISON WITH THE INVERTED PROBLEM.** The harmonic and periodic forced vibrations of rotating rings are derived and investigated. The modal expansion technique yields the forced solution, which is characterized by four generalized co-ordinates associated with each  $n$  (circumferential wave number). The inextensional assumption is presumed, when flexural vibration is the only important component, to reduce the order to the system. The closed form solutions to the harmonic load cases, once concentrated, once distributed, are demonstrated and interpreted. The approach is then extended to periodic loads, where Fourier sine and cosine series is applied. Examples depict the numerical responses to all the cases being derived. The solutions of a stationary ring subjected to traveling loads are also solved for comparison. Their difference is investigated and interpreted from various viewpoints. (Author abstract) 15 refs.

Huang, S.C. (Purdue Univ, West Lafayette, IN, USA); Soedel, W. *J Sound Vib* v 118 n 2 Oct 22 1987 p 253-270.

**090365 EIGENVALUES OF RINGS WITH RADIAL SPRING ATTACHMENTS.** Natural frequencies and modes of a circular ring deviating from axisymmetry due to multiple radial springs are obtained by utilizing the natural frequencies and modes of the axisymmetric ring. The problem of a non-axisymmetric ring due to an unlimited number of radial spring connections is formulated in a general form. Numerical results are presented for up to three radial spring connections. This is of practical interest since radial stiffness variations exist in many complicated structures such as tires. (Author abstract) 23 refs.

Allaei, D. (Univ of Mississippi, University, MS, USA); Soedel, W.; Yang, T.Y. *J Sound Vib* v 121 n 3 Mar 22 1988 p 547-561.

**090366 PHASE VELOCITY OF A PRESSURE WAVE ON THE AXIS OF AN ACOUSTIC FIELD OF A CIRCULAR RING IN AN ACOUSTIC Baffle.** This paper is concerned with the so-called local velocity of a harmonic pressure wave of a circular ring vibrating with a constant velocity amplitude. The ring is placed in an infinite rigid acoustic baffle. The local propagation velocity was calculated on the axis conducted from the center of the ring perpendicularly to its surface. The propagation velocity changes from infinity for  $z = 0$  (singular point) to a constant value,  $c_0$ , for  $z$  equal to about 10 times the external radius of the ring. (Author abstract) 6 refs.

Wyrzykowski, Roman (Higher Pedagogical Sch in Rzeszow, Rzeszow, Pol). *Arch Acoust* v 11 n 4 1986 p 331-337.

**090367 ON GENERAL IN-PLANE VIBRATIONS OF ROTATING THICK AND THIN RINGS.** Complete sets of equations of motions for general in-plane vibrations of rotating thick and thin rings on elastic foundations are derived. The thick ring theory takes account of the effects of extensibility, transverse shear, rotary inertia and rotation, as well as the effects of initial stresses due to pressure loads and centrifugal force. The consistency of the formulation is demonstrated by reducing it to classical ring theories based on inextensional or negligible shear deformation assumptions. Predictions of frequencies for bending and extensional type vibrations are close to experimental data for non-rotating thick rings. It is argued that inextensional assumptions in thick ring theories are

improper because extensional coupling effects are as important as shearing effects, especially for the rotating ring. The correct quadratic displacement terms in the strain-displacement relations, necessary for the complete description of initial stress effects, are discussed. (Edited author abstract) 19 refs.

Lin, J.L. (Purdue Univ, West Lafayette, IN, USA); Soedel, W. *J Sound Vib* v 122 n 3 May 8 1988 p 547-570.

**RISK STUDIES** See Also BRIDGES, HIGHWAY—Failure; BUILDINGS—Lightning Protection; COMPUTERS—Fire Protection; FIRE PROTECTION—Mathematical Models; GEOTHERMAL ENERGY—Economics; HOUSING—Economics; NUCLEAR POWER PLANTS—Accident Prevention; NUCLEAR POWER PLANTS—Earthquake Effects; SEISMOLOGY—Australia; SYSTEMS SCIENCE AND CYBERNETICS—Mathematical Models; TRANSPORTATION—Route Analysis.

**090368 POTENTIAL APPLICATIONS OF FUZZY SETS IN INDUSTRIAL SAFETY ENGINEERING.** This paper discusses potential applications of fuzzy set theory to risk analysis in the area of industrial safety engineering. Vagueness and imprecision in mathematical quantification of risk are equated with fuzziness rather than randomness. The concept of risk evaluation, using linguistic representation of the likelihood of the occurrence of a hazardous event, exposure, and possible consequences of that event, is proposed. The approximate reasoning technique based on fuzzy logic is used to derive fuzzy values of risk. (Author abstract) 39 refs.

Karwowski, Waldemar (Univ of Louisville, Louisville, KY, USA); Mital, Anil. *Fuzzy Sets Syst* v 19 n 2 Jun 1986 p 105-120.

**090369 APPLICATIONS OF THE GENERALIZED BIAS OPERATOR FOR UNCERTAINTY ANALYSIS.** A new uncertainty analysis method based on the generalized bias operator method is presented. The new method can be used for those cases in which the other uncertainty analysis methods cannot be applied, due to the lack of or the incomplete knowledge about the input parameter's uncertainties, or due to an inadequate model. The method presented can be applied in those cases in which at least one of the system's responses is measured and the accuracy of the measurements is better than the deviation between the measured and the calculated value obtained. The theory of the method is presented, as well as methods to obtain the special sensitivity matrices associated with the method. (Author abstract) 4 refs.

Ronen, Yigal (Ben-Gurion Univ of the Negev, Beer-Sheva, Isr). *Nucl Sci Eng* v 98 n 1 Jan 1988 p 82-86.

**090370 PROBABILITY DISTRIBUTIONS AND THEIR PARTITIONING.** The partitioned multiobjective risk method (PMRM) was developed for solving risk-based multiobjective decisionmaking problems. Based on the premise that the expected value concept is not sufficient for proper decisionmaking, the PMRM generates a number of conditional expected value functions (or risk functions) by partitioning the probability axis into probability ranges. The goal of partitioning the probability axes is to have better information on extreme events for decisionmaking purposes. These conditional expectations are dependent on the chosen partitioning points. This paper analyzes how conditional expectations are sensitive to variations in partitioning. One of the risk functions is a measure of extreme and catastrophic events. By using the relationship between this particular risk function and the statistics of extremes the sensitivity analysis is simplified. In many practical applications, it is difficult to determine which type of distribution function best represents the random process. (Edited author abstract) 12 refs.

Karlsson, Per-Ola (Univ of Virginia, Charlottesville, VA, USA); Haines, Yacov Y. *Water Resour Res* v 24 n 1 Jan 1988 p 21-29.

**090371 COMPARISON OF FORMULAE FOR PREDICTING RAIL-HIGHWAY CROSSING HAZARDS.** New models for assessing the need for improvements have been developed, and five models were evalu-

ated: the U.S. Department of Transportation (DOT), Peabody-Dimmick, NCHRP Report 50, Coleman-Stewart, and New Hampshire - were evaluated using a data base maintained by the Virginia Department of Highways and Transportation. In addition, the performance of the methods for predicting the EAR were compared by using the chi-square test and the power factor. The results indicated that the DOT formula outperformed the other four methods in both the evaluative and comparative analyses, and thus were recommended for use. The priority list produced by this formula is only one criterion used in determining the need to improve conditions at any crossing. (Edited author abstract) 1 ref.

Faghri, Ardeshir (Dep of Highway & Transportation, Charlottesville, VA, USA); Demetsky, Michael J. *Transp Res Rec* 1114 1987 p 152-155.

**090372 APPLICATIONS OF RISK ASSESSMENT TECHNIQUES TO HAZARDOUS WASTE MANAGEMENT.** Applications of risk assessment techniques to hazardous waste management are briefly discussed in terms of selecting appropriate waste management technologies assessing operating sites, setting priorities for clean up of problem sites, determining the appropriate level of clean up and planning new facilities. A specific case history involving risk assessment for the siting of a waste management facility in the Province of Ontario, Canada is described in more detail. Risk estimates are provided for exposure via inhalation and ingestion of potentially contaminated local water, crops, meat and milk. The predicted risk are compared to risks of death from selected voluntary and involuntary exposures. (Author abstract) 8 refs.

Scott, Michael P. (Environmental Resources Ltd, London, Engl). *Waste Manage Res* v 5 n 2 Jun 1987 p 173-181.

**090373 HANDLING OF ACCEPTABLE RISKS.** This paper examines some of the problems associated with the handling of risk and, in particular, the arguments that may be deployed in favour of reducing particular forms of risk. The paper suggests that, whilst risk can always be reduced, the costs involved vary enormously in terms of benefits achieved. Governments should be concerned to maximize overall risk reduction for any given level of expenditure. To treat each risk separately and independently can lead to a non-optimal allocation of resources. (Author abstract). 8 refs.

Moore, Peter G. (London Business Sch, Engl). *J Oper Res Soc* v 39 n 7 Jul 1988 p 629-636.

## Agricultural Applications

**090374 ANALYSIS OF DAMAGE OF U.S. SOYBEAN YIELDS FROM 1982 ACID DEPOSITION LEVELS.** Experimental data were compiled for seven soybean varieties studied at four different locations in the U.S. for a period of one to three years. Three dose-response functions (linear, quadratic, and Weibull) were fitted, as appropriate, to the experimental data. Effects of acid deposition on soybean yields were estimated by combining variety-specific dose-response and production data. These calculations suggest that U.S. soybean production (2.2 billion bushels in 1982) would increase by 3.2 million bushels with a 10% reduction in 1982 hydrogen ion concentration levels in all counties where soybeans were grown, and by almost 70 million bushels with uniform improvement to pH 5.2. These estimates are based on many simplifying assumptions and are subject to several important sources of uncertainty explored in this study. The calculated changes are small in comparison with effects from other natural and anthropogenic stresses. (Author abstract) 32 refs.

Moskowitz, Paul D. (Brookhaven Natl Lab, Upton, NY, USA); Medeiros, William H.; Oden, Neal L.; Thode, Henry C. Jr.; Coveney, Elizabeth A.; Rosenthal, Robert E. *Risk Anal* v 7 n 3 Sep 1987 p 371-388.



## Analysis

**090375 DESIGN-SAFETY ENHANCEMENT THROUGH THE USE OF HAZARD AND RISK ANALYSIS.** The application of qualitative and quantitative hazards/risk analysis methods is discussed. Two examples of both qualitative and quantitative methods are discussed. The relative advantages of each, as well as relative manpower requirements for their application, are examined. The two qualitative analysis examples are: 1) hazards and operability (HAZOP) analysis, based on the conceptual design analysis of an offshore gas-processing platform, and 2) a qualitative fault-tree analysis based on a design review of a land-based oil-processing facility. The two quantitative analysis examples are: 1) the use of event sequence diagrams (ESDs) for the risk analysis of a batch chemical-operation plant, and 2) an event-tree analysis relative to the consequences of the loss of electric power for the same batch plant. In these examples, design operations and maintenance-safety enhancements that have been implemented are identified. 7 refs.

Mulvihill, Robert J. (Fluor Daniel, Irvine, CA, USA). *IEEE Trans Reliab* v 37 n 2 Jun 1988 p 149-158.

**090376 HOW TO IMPROVE THE EFFECTIVENESS OF HAZARD AND OPERABILITY ANALYSIS.** The key elements that make the hazards and operability (HAZOP) technique effective for identifying chemical process hazards are outlined. Six categories of problems that can sometimes reduce the effectiveness of HAZOP and even prevent it from discovering some major hazards are explained. Several examples are included to show how lack of experience, failure to communicate, management shortcomings, complacency and poor loss-prevention practices, a shortage of technical information, and other limitations, each contribute to the problem. Practical solutions are recommended for countering the difficulties and for making the HAZOP a more effective risk-management tool. 6 refs.

McKelvey, Thomas C. (NUS Corp, Gaithersburg, MD, USA). *IEEE Trans Reliab* v 37 n 2 Jun 1988 p 167-170.

**Assessment.** See Also BUILDINGS—Earthquake Resistance; CARCINOGENS; CARCINOGENS—Analysis; CHEMICAL PLANTS—Design; CIVIL ENGINEERING—Economics; COKE PLANTS—Static Electricity; COMPUTER SYSTEMS, DIGITAL—Reliability; DAMS—Missouri; DECISION THEORY AND ANALYSIS; EARTHQUAKES; EARTHQUAKES—Estimation; ELECTRIC POWER PLANTS—Service Life; ELECTRIC WIRING, BUILDINGS—Bonding; ELECTROSTATICS; ENERGY RESOURCES—Extraction; FIRE FIGHTING EQUIPMENT—Sprinkler Systems; GAS PIPELINES—Accidents; GAS TURBINES—Accident Prevention; NUCLEAR POWER PLANTS—Accident Prevention; NUCLEAR POWER PLANTS—Aging; NUCLEAR POWER PLANTS—Earthquake Effects; NUCLEAR POWER PLANTS—Evaluation; NUCLEAR POWER PLANTS—Safeguard Systems; NUCLEAR REACTORS—Containment Vessels; NUCLEAR REACTORS—Core Disruptive Accident; NUCLEAR REACTORS—Earthquake Resistance; NUCLEAR REACTORS, PRESSURIZED WATER; NUCLEAR REACTORS, PRESSURIZED WATER—Loss of Coolant Accident; NUCLEAR REACTORS, PRESSURIZED WATER—Reliability; PETROLEUM INDUSTRY; PIPELINES—Earthquake Resistance; POPULATION STATISTICS—Research; PRODUCT LIABILITY; REFUSE DISPOSAL—Recycling; RELIABILITY; ROADS AND STREETS—Accidents; SAMPLING; SEWAGE TREATMENT—Sludge Disposal; SEWERS—Storm Drainage; STEEL STRUCTURES—Earthquake Resistance; STRUCTURAL ANALYSIS; TUNNELS AND TUNNELING—Contracts; WATER SUPPLY—Accident Prevention.

**090377 ESTIMATION OF LONG-TERM RISK FROM CANADIAN URANIUM MILL TAILINGS.** A methodology is presented for assessing the risk from Canadian uranium mill tailings piles. The methodology is based on the 'set of triplets' concept and uses an event tree to identify various scenarios representing the performance of a pile over its 1,000-year design life. Compartment-type mathematical models are used to quantify the movement of hazardous substances through the environment. Numerical examples are given of both 'level 1' (straight probabilistic) and 'level 2' (probability of frequency) type analyses. (Author abstract) 10 refs.

Murray, M.L. (SENES Consultants Ltd, Willowdale, Ont, Can); Chambers, D.B.; Knapp, R.A.; Kaplan, S.

*Risk Anal* v 7 n 3 Sep 1987 p 287-298.

**090378 ESTIMATED SOIL INGESTION RATES FOR USE IN RISK ASSESSMENT.** Assessing the risks to human health posed by contaminants present in soil requires an estimate of likely soil ingestion rates. In the past, direct measurements of soil ingestion were not available and risk assessors were forced to estimate soil ingestion rates based on observations of mouthing behavior and measurements of soil on hands. Recently, empirical data on soil ingestion rates have become available from two sources (Binder et al., 1986 and van Wijnen et al., 1986). Although preliminary, these data can be used to derive better estimates of soil ingestion rates for use in risk assessments. Estimates of average soil ingestion rates derived in this paper range from 25 to 100 mg/day, depending on the age of the individual at risk. Maximum soil ingestion rates that are unlikely to underestimate exposure range from 100 to 500 mg. A value of 5,000 mg/day is considered a reasonable estimate of a maximum single-day exposure for a child with habitual pica. (Author abstract) 12 refs.

LaGoy, Peter K. (ICF-Clement Associates Inc, Washington, DC, USA). *Risk Anal* v 7 n 3 Sep 1987 p 355-359.

**090379 CHEMICAL HEALTH EFFECTS ASSESSMENT METHODOLOGY FOR AIRBORNE CONTAMINANTS.** Chemical Health Effects Assessment Methodology (CHEM) is a new procedure for assessing hazardous properties of airborne toxic contaminants. CHEM evaluates substances for four major health effect categories: carcinogenicity, mutagenicity, reproductive/developmental toxicity, and toxic effects other than the first three. Three elements are considered in the assessment: weight of evidence, potency, and severity of effect. This approach produces a profile of toxic properties of chemicals which preserves their unique multidimensional character and highlights data gaps. (Author abstract) 19 refs.

Brown, Halina Szejnwald (Clark Univ, Worcester, MA, USA); West, Carol Rowan; Bishop, Donna R. *Risk Anal* v 7 n 3 Sep 1987 p 389-402.

**090380 HAZARD, RISK AND PLANNING.** During the last two decades the process industries overseas have evolved systematic and powerful techniques for identifying process hazards. Five activities need to be completed in adequate detail. The first four need to be addressed by the industry in evolving a development application and the fifth needs to be addressed by the local authority in concert with the public. They are: 1. Hazard identification. 2. Equipment and system failure frequency estimates. 3. Consequence calculations. 4. Overall estimation of risk. 5. Assessment of acceptability. A discussion is presented of equipment and system failure frequency estimates, consequence calculations, estimation of risk, and assessment of acceptability.

Green, Glen S. (Enerdyne, Wollongong, Aust); Johnston, Norm W. *CEA Chem Eng Aust* v 12 n 2 Jun 1987 p 10-12.

**090381 EXPERT OPINION USE FOR PROBABILITY ASSESSMENT IN SAFETY STUDIES: MAIN TOPICS AND ELEMENTS OF AN APPLICATION-ORIENTED RESEARCH PROGRAM.** Current probability assessment approaches are almost exclusively based on failure data as stored in a limited number of databases. Associated with these databases are several shortcomings, causing probability assessments to be rather unreliable. Moreover, the analyst must resort to expert opinions for the assessment of failure probabilities. This paper presents an overview of the main topics that were identified in an introductory literature survey and of the key questions which are currently addressed in application-oriented research on this subject. (Edited author abstract) 28 refs.

Van Steen, Jacques F.J. (TNO, Apeldoorn, Neth). *Eur J Oper Res* v 32 n 2 Nov 1987 p 225-230.

**090382 ASSESSMENT OF RISK AT SUPERFUND**

**SITES.** There is general agreement in the risk assessment community on the broad categories of activities to be performed (i.e., exposure, hazard, and risk assessment), but the method of analysis for each element within an activity is presently not uniformly established. The objective of this paper is to describe judgmental decisions that must be made by the risk assessors during the design and execution of a Superfund site assessment, with a focus on the issues of uncertainty and exposure scenarios. The assessment at Western Processing, Washington, is used as an example of the substantial expert judgment required in choosing the analytical methods and appropriate assumptions. (Edited author abstract) 9 refs.

Lincoln, David (CH2M Hill, Bellevue, WA, USA). *Environ Prog* v 6 n 4 Nov 1987 p 212-216.

**090383 MANAGING HAZARDOUS WASTE RISKS UNDER THE MASSACHUSETTS 'SUPERFUND' LAW.** Different options and strategies for managing hazardous waste risks are presented. Experience in Massachusetts under a state 'Superfund' law (Chapter 21E) as applied to the selling, buying, and financing of real estate is drawn upon. The approach discussed is that with a thorough site assessment involving historical research and if required, soil and ground water examination, the parties (sellers, buyers, and lenders) through use of a variety of special devices may successfully consummate real estate transactions. These devices include use of indemnification agreements, escrow funds, title insurance, and in some cases involve accomplishment of tank and contaminated soil removal before closing the real estate transaction. (Edited author abstract)

Paulsen, Frederick S. (Greenman, Grossman & Duffy, Boston, MA, USA). *Environ Prog* v 6 n 4 Nov 1987 p 236-239.

**090384 RISK FACTOR: ACCEPTANCE AND ACCEPTABILITY.** Any assessment of the risks potentially arising from nuclear installations will always be expressed in probabilistic terms, and decisions on a level of risk that can be accepted must therefore involve an element of judgment. Public acceptance of such decisions will depend on the trust that people are willing to place in the industry and in the regulatory authorities. The procedures by which decisions are taken must be seen to be both open and competent. Procedures will have to be targeted towards achieving the necessary high level of trust and credibility. (Author abstract) 41 refs.

Roberts, L.E.J. (Univ of East Anglia). *Nucl Energy* v 26 n 6 Dec 1987 p 349-359.

**090385 PROJECTIONS OF CANCER RISKS ATTRIBUTABLE TO FUTURE EXPOSURE TO ASBESTOS.** To assess the maximum possible impact of further government regulation of asbestos exposure, projects were made of the use of asbestos in nine product categories for the years 1985-2000. A life table risk assessment model was then developed to estimate the excess cases of cancer and lost person-years of life likely to occur among those occupationally and nonoccupationally exposed to the nine asbestos product categories manufactured in 1985-2000. These estimates were made under the assumption the government regulation remains at its 1985 level. Use of asbestos in the nine product categories was predicted to decline in all cases except for friction products. The risk assessment results show that, although the cancer risks from future exposure to asbestos are significantly less than those from past exposures, in the absence of more stringent regulations, a health risk remains. (Author abstract) 26 refs.

Mauskopf, Josephine A. (Research Triangle Inst, Research Triangle Park, NC, USA). *Risk Anal* v 7 n 4 Dec 1987 p 477-486.

**090386 USE OF RISK ASSESSMENT METHODS IN THE CERTIFICATION OF DECONTAMINATED BUILDINGS.** Accidental events such as fires, explosions, and leaks often result in large-scale contaminations of



buildings with toxic chemicals. After decontamination, the certification for original use requires testing for residual contamination. The two basic kinds of sampling plans in use up to recently both fall short of the required performance. Their deficiencies are analyzed in terms of the scientific questions implicit in both the sampling plan and the subsequent statistical evaluation. A sampling strategy of a new kind is proposed and discussed in the same context. It is motivated by concern for the long-term safety of the building's occupants and is, therefore, based on factors important in risk assessment. Three different sampling plans are derived in the framework of this methodology, two of which have already been used in actual certification proceedings. (Author abstract) 18 refs.

Seiler, Fritz A. (Inhalation Toxicology Research Inst., Albuquerque, NM, USA); Davis, Herbert T.; Kominsky, John R.; Ronan, Richard J.; Kowka, Christopher D. *Risk Anal* v 7 n 4 Dec 1987 p 487-495.

**090387 PROBABILISTIC RISK ASSESSMENT: A LOOK AT THE ROLE OF ARTIFICIAL INTELLIGENCE.** A review of traditional Probabilistic Risk Assessment (PRA) methods used in the nuclear power industry is presented. The shortcomings of the current PRA methods are pointed out. A method of performing a PRA is proposed and is computerized. The role of artificial intelligence in developing and performing the proposed PRA approach is discussed. The proposed PRA approach is verified by comparing the results to previously performed PRAs. The comparisons have supported the adequacy and completeness of results of the proposed model. A discussion of how the proposed method can be used as an expert system to verify plant status following loss of plant hardware is also presented. (Author abstract) 36 refs.

Wang, J. (Univ of Maryland, College Park, MD, USA); Modarres, M.; Hunt, R.N.M. *Nucl Eng Des* v 106 n 3 Mar 1988 p 375-387.

**090388 ENGINEERING RISK AND HAZARD ASSESSMENT.** This publication contains 13 papers. These papers deal with issues such as short- and long-term hazards, setting priorities in safety, fault analysis for process plants, hazard identification and safety assessment of human-robot systems, plant fault diagnosis expert systems, knowledge based diagnostic systems, fault tree analysis, modeling of computer security systems for risk and reliability analysis, risk analysis of fatigue failure, fault evaluation of complex system, probabilistic risk analysis, and expert systems for fault detection. All papers are separately indexed and abstracted.

Anon. *Eng Risk and Hazard Assessment* 2 v 1988.

**090389 FAULT TREE ANALYSIS FOR PROCESS PLANTS.** In striving for the improvement of the safety of technical systems numerous formalized procedures for plant safety analysis have been developed. Most of the methods such as Failure Mode and Effects Analysis (FMEA) or Hazard and Operability studies (HAZOP) are qualitative and normally used on their own. They may be applied, however, in preparation of a fault tree analysis, a method usually employed for calculating the probability or expected frequency of an undesired event in a technical system. Safety is the concern, in the case of process plants, as this event may be an explosion, a fire, or a toxic release. In this paper, the concern is with fault tree analysis and its application to process plant safety. Undesired and initiating events in industrial plants are identified using a computer aided search. A case study is presented for a fault tree analysis of a process plant fabricating hexogen. 42 refs.

Hauptmanns, Ulrich (Gesellschaft fuer Reaktorsicherheit, Cologne, West Ger). *Eng Risk and Hazard Assessment* v 1 p 21-60.

**090390 MODULARIZATION METHODS FOR EVALUATING FAULT TREES OF COMPLEX TECHNICAL SYSTEMS.** Fault tree analysis is one of the most important techniques for system modeling and has been widely used in risk assessments together with

event tree models. A fault tree is a graphic representation of the logical relationships between events in a system which result in a prespecified undesired state of it, defined as the top-event of the fault tree. The basic concepts for the deductive elaboration of a fault tree from a top-event are presented. The most frequently used analytical methods for fault tree analysis are based on the determination of the minimal cut sets (MCSs). These are the smallest conjunctions of basic events that lead to the top-event, and are independent from the failure data. The examination of the MCSs provides information about failure modes and weak points of the system and can possibly suggest ways by which the system could be improved. This article proposes a general module concept which allows for an efficient modularization, and gives a method for selecting and evaluating them. The evaluation algorithm presented here is only valid for coherent systems. 19 refs.

Yllera, Javier (Technical Univ, Berlin, West Ger). *Eng Risk and Hazard Assessment* v 2 p 81-99.

**090391 RISK ASSESSMENT - BLACK ART OR SCIENCE?** Risk may be defined as a compound measure of the probability and magnitude of an adverse effect occurring as the result of some activity, and therefore it can be expressed in many different ways depending on its application, e.g. number of lives lost per year, frequency of chromosomal damage etc. It covers all aspects of life and in most cases can either be avoided or its effects reduced in some way or another. In order to achieve reduced risk, however, the possibilities of an 'accident' occurring must be assessed and relevant safety procedures developed. This process of assessment and safety development is known as 'risk assessment'. Measures of risk are discussed. 8 refs.

Moore, Glenis. *IEE Rev* v 34 n 4 Apr 21 1988 p 151-153.

**090392 RISKIEN MINIMOINTI SUUNNITTELUVAIHESSA.** [Minimizing Risks at the Engineering Stage]. The article focuses on hazards leading to property damage and interruption of production in the chemical industry, with a look as well at personal safety and the environment. The author's suggestions for the elimination and reduction of risks at the engineering stage are based on an analysis of major recent losses and on international loss statistics. Distinctive features and applications of the most common methods of risk analysis are reviewed. The status of quantitative risk analyses for chemical processes is examined, and reliability of models used to estimate the magnitude of potential losses is discussed. (Author abstract) In Finnish.

Nygaras, Yngve. *Kem Kem* v 15 n 4 1988 p 362-365.

**090393 RISIKOANALYSE VON DER PLANUNG BIS ZUM BETRIEB.** [Risk Analysis from Planning to Operation]. The most effective and economical method of avoiding loss is to carry out a risk analysis in the planning stage. This analysis consists of risk recognition, risk assessment and risk limitation. The material, liability and personal risks arising during operation are usually dealt with by three measures - reduction (preventive measures), transfer (insurance) and by the concern carrying the risks themselves. Because of its importance to the economic operation of the installation, risk analysis represents a central management task and is a constituent part of the general policy of the undertaking. (Author abstract). 7 Refs. In German.

Franck, E. *Maschinenschaden* v 61 n 3 1988 p 97-102.

**090394 SEISMIC HAZARD PREDICTION USING A PROBABILISTIC-FUZZY APPROACH.** This paper presents a description for extending seismic hazard prediction concepts from probability theory to fuzzy set theory. The aim is to develop a model for seismic hazard prediction able to reproduce both the randomness and the imprecision in conjunction with earthquake occurrences. A particular emphasis is placed upon the treatment of information within a probabilistic-fuzzy mathematical model using the extension principle. (Author abstract). 15 Refs.

Frangopol, Dan M. (Univ of Colorado, Boulder, CO,

USA); Ikejima, Kenji; Hong, Kappyo. *Struct Saf* v 5 n 2 Jun 1988 p 109-117.

**090395 A FORTRAN PROGRAM FOR MULTIVARIATE SURVIVAL ANALYSIS ON THE PERSONAL COMPUTER.** In this paper a FORTRAN program is presented for multivariate survival or life table regression analysis in a competing risks' situation. The relevant failure rate (for example, a particular disease or mortality rate) is modelled as a log-linear function of a vector of (possibly time-dependent) explanatory variables. The explanatory variables may also include the variable time itself, which is useful for parameterizing piecewise exponential time-to-failure distributions in a Gompertz-like or Weibull-like way as a more efficient alternative to Cox's proportional hazards model. Maximum likelihood estimates of the coefficients of the log-linear relationship are obtained from the iterative Newton-Raphson method. The program runs on a personal computer under DOS; running time is quite acceptable, even for large samples. (Author abstract). 7 refs.

Mulder, Paul G.H. (Erasmus Univ, Rotterdam, Neth). *Comput Methods Prog Biomed* v 27 n 2 Sep-Oct 1988 p 175-188.

**090396 SOURCES OF AND EFFECTS OF INTEREXPERT CORRELATION: AN EMPIRICAL STUDY.** Expert estimates are relied on as sources of data whenever experimental data are lacking, such as in risk analysis. Correlation between experts poses problems in the aggregation of multiple estimates. The sources and structure of interexpert correlation are identified, and some of the ramifications are discussed. Expert estimates were found to correlate to the experts' problem-solving techniques and not to any features of their professional backgrounds. The paths that experts used to reach solutions included algorithms and assumptions. Both assumptions and algorithms were found to correlate to the answers because they are integral parts of the path. In addition, correctness of assumptions was found to correlate to the accuracy of the answers. 22 refs.

Booker, Jane M. (Los Alamos Natl Lab, NM, USA); Meyer, Mary A. *IEEE Trans Syst Man Cybern* v 18 n 1 1988 p 135-142.

**090397 RISK ASSESSMENT OF MIXED-WASTE SITES.** Techniques for assessing worker and public risks attributable to atmospherically-released contaminants from a mixed-waste site are presented. The techniques are used to assess, for several different remedial actions, the risk to workers and the public from nonradiative chemicals atmospherically released from several waste sites. Other models and health risk procedures can be used to assess radioactive releases and other applicable environmental media, i.e., surface and ground water. The risks from nonradioactive contaminants that were calculated from the atmospheric pathway are low, no site or site remediation option, taken individually or summed, posed an unacceptable risk to the public. Risks to workers were also well below thresholds accepted by society. 6 refs.

Montague, David F. (JBF Associates Inc, Knoxville, TN, USA); Holton, Gregory A. *IEEE Trans Reliab* v 37 n 2 Jun 1988 p 178-191.

**090398 RISK EVALUATION SYSTEM FOR FACILITY SAFEGUARDS AND SECURITY PLANNING.** The Risk Evaluation System (RES) is an integrated approach to determining safeguards and security effectiveness and risk. RES combines the planning and technical analysis into a format that promotes an orderly development of protection strategies, planning assumptions, facility targets, vulnerability and risk determination, enhancement planning, and implementation. In addition, the RES computer database program enhances the capability of the analyst to perform a risk evaluation of the facility. The computer database is menu driven using data input screens and contains an algorithm for determining



the probability of adversary defeat and risk. Also, base case and adjusted risk data records can be maintained and accessed easily. (Author abstract)

Udell, C.J. (Westinghouse Hanford Co, Richland, WA, USA); Carlson, R.L. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 50-53.

**090399 COLLOQUIUM ON THE MANAGEMENT OF RISK.** This conference proceedings contains 5 papers. The main topics are containment of risk in business, methods and tools of risk assessment, managing risk in engineering development, human reliability factors in engineering development, human reliability factors in technology management, and management of risk in software development. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11369 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Management & Design Div, London, Engl). *IEEE Colloq Dig* 1987/56, Colloq on the Manage of Risk, London, Engl, May 6 1987. Publ by IEE, London, Engl, 1987 var pagings.

### Computer Aided Analysis

**090400 SCIENTIFIC KNOWLEDGE ACQUISITION DURING THE EXTENSION OF GSA: AN EXPERT SYSTEM FOR GENERIC SAFETY ANALYSIS.** Generic safety analysis (GSA) is implemented on the EMYCIN expert system shell, consists of approximately 150 safety related rules, and runs on a VAX 11-750 computer. To extend GSA, a specialized empirical knowledge base was developed that described the available slip resistance found for various combinations of surfaces, shoes, and contaminants. We chose to directly collect data during a large controlled experiment. The collected data was initially organized by applying statistical methods. After the statistical results were classified into conceptually meaningful categories, a set of rules was easily described and added to the system. The conclusion was that GSA describes an extendable framework that can organize and selectively apply very specialized safety ergonomics research. (Edited author abstract) 26 refs.

Lehto, Mark R. (Purdue Univ, West Lafayette, IN, USA); Miller, James M. *Int J Ind Ergon* v 2 n 1 Nov 1987 p 61-75.

**090401 DEMOS: A COMPUTER AID FOR ENGINEERING - ECONOMIC POLICY MODELING AND UNCERTAINTY ANALYSIS.** A non-procedural environment for engineering-economic policy modeling and uncertainty analysis (called Demos) and an advanced graphic interface to this system (called Demaps) are described. A variety of experimental studies, which critically evaluated these systems, are discussed. These studies demonstrate the importance of adopting an empirical approach to the evaluation of computer systems for decision support and policy analysis and emphasize the limits to which powerful computer aids can be a substitute for knowledge and careful thought. Properly designed, such systems make it easy to examine, exercise, modify and critique, the models they support. This should make it possible to expose these models to more thorough critical peer review, which, over this, could revolutionize the field of quantitative policy analysis. (Author abstract). 25 Refs.

Morgan, M. Granger (Mellon Univ, Pittsburgh, PA, USA); Henrion, Max; Wiecha, Charles. *Large Scale Syst* v 13 n 1 1988 p 61-82.

### Computer Applications

**090402 SENSITIVITY AND UNCERTAINTY STUDIES OF THE CRAC2 COMPUTER CODE.** We have studied the sensitivity of health impacts from nuclear reactor accidents, as predicted by the CRAC2 computer code, to the following sources of uncertainty: (1) the

model for plume rise, (2) the model for wet deposition, (3) the meteorological bin-sampling procedure for selecting weather sequences with rain, (4) the dose conversion factors for inhalation as affected by uncertainties in the particle size of the carrier aerosol and the clearance rates of radionuclides from the respiratory tract, (5) the weathering half-time for external ground-surface exposure, and (6) the transfer coefficients for terrestrial foodchain pathways. Predicted health impacts usually showed little sensitivity to use of an alternative plume-rise model or a modified rain-bin structure in bin-sampling. Health impacts often were quite sensitive to use of an alternative wet-deposition model in single-trial runs. Uncertainties in the inhalation dose conversion factors have important effects on early injuries in single-trial runs. (Edited author abstract) 33 refs.

Kocher, D.C. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Ward, R.C.; Killough, G.G.; Dunning, D.E. Jr.; Hicks, B.B.; Hosker, R.P. Jr.; Ku, J.-Y.; Rao, K.S. *Risk Anal* v 7 n 4 Dec 1987 p 497-507.

### Costs

**090403 COST-EFFECTIVENESS OF RISK-REDUCTION MEASURES FROM A NATIONAL VIEWPOINT: A CASE STUDY OF THE ANGRA NUCLEAR PLANT IN BRAZIL.** In this paper a systemic or national approach to cost-effectiveness analysis of risk-reduction measures is reviewed, and its advantages and limitations are discussed. The method is applied to the problem of the cost-effectiveness of increasing the Angra 3 NPP containment wall thickness from the present 60 cm to 180 cm thick in order to prevent damage to the reactor core in case of a direct commercial aircraft crash on it. It is concluded that this measure is not cost-effective if the referred approach is considered. (Author abstract) 24 refs.

de Oliveira, Luiz Fernando Seixas (UFRJ, Rio de Janeiro, Brazil); da Motta Barros, Edson Benigno; Fleming, Paulo Victor; Rosa, Luiz Pinguelli. *Risk Anal* v 7 n 3 Sep 1987 p 321-328.

### Evaluation

**090404 APPLICATION OF A HAZARD AND OPERABILITY STUDY TO HAZARD EVALUATION OF AN ABSORPTION HEAT PUMP.** A hazard evaluation for a double-effect, absorption heat pumps is presented. The primary technique for the hazard evaluation was a hazard and operability (HAZOP) study; this is a brainstorming approach conducted by a multidisciplinary team. The approach stimulates creativity of the team members to generate ideas. The team consisted of a HAZOP leader, the heat-pump project manager, a thermohydrologist, a corrosion specialist, a toxicologist, and a risk analyst. The majority of the team members were already involved in the design and analysis of heat pump. 2 refs.

Shafaghi, Ahmad (Rohm & Haas Co, Bristol, PA, USA); Cook, F. Bert. *IEEE Trans Reliab* v 37 n 2 Jun 1988 p 159-166.

**Health Risks** See Also AEROSOLS—Health Hazards; AIR POLLUTION—Environmental Impact; AIR POLLUTION—Particulate Emissions; CARCINOGENS—Environmental Impact; CHEMICAL OPERATIONS—Accidents; ENVIRONMENTAL PROTECTION—Computer Applications; FOSSIL FUEL POWER PLANTS—Emissions; OCCUPATIONAL DISEASES—Pulmonary; SULFUR COMPOUNDS—Environmental Impact; WATER POLLUTION—Environmental Impact.

**090405 THYROID CANCER RISK FROM EXPOSURE TO IONIZING RADIATION: A CASE STUDY IN THE COMPARATIVE POTENCY MODEL.** Considerable controversy exists about the relative risk of thyroid cancer following exposure to external radiation compared to the risk after exposure to internally deposited <sup>131</sup>I. The human epidemiological data are equivocal, and studies are not directly comparable owing to differing ages at exposure, dose ranges, and periods of follow-up. Limited experimental data at low dose ranges support the hypothesis of equal potency in animals. This report utilizes a relative potency model to reconcile data from

different sources, and to provide an estimate of thyroid cancer risk following human exposure to <sup>131</sup>I. We utilize data from epidemiological studies of external radiation and <sup>131</sup>I exposure in humans and data from an experimental animal study. This analysis shows that the data provide no compelling evidence to suggest that the risks accompanying external radiation or <sup>131</sup>I exposure are different. (Author abstract) 33 refs.

Laird, Nan M. (Harvard Univ, Boston, MA, USA). *Risk Anal* v 7 n 3 Sep 1987 p 299-309.

**090406 INFANT EXPOSURE ASSESSMENT FOR BREAST MILK DIOXINS AND FURANS DERIVED FROM WASTE INCINERATION EMISSIONS.** A formula is presented for calculating the infant daily dose of dioxin equivalents from breast milk on the basis of the maternal daily intake. Application of the formula suggests that an infant breast-fed for 12 months would receive around 10% of the cumulative exposure dose per body weight that would be received by an adult with 50 years of exposure, and that the contribution of dioxin equivalent from breast milk to an infant's body concentration would amount to 1.7 times the concentration in the mother. However, dioxin and furan emissions from a source calculated to result in worst-case lifetime cancer risks of the order of 1 in 100,000 are only likely to increase breast milk concentrations by around 1%-10% of the levels that have been detected in several countries. This finding suggests that there are major sources of dioxins and furans other than from municipal solid waste incineration that need to be identified. (Edited author abstract) 17 refs.

Smith, Allan H. (Univ of California, Berkeley, CA, USA). *Risk Anal* v 7 n 3 Sep 1987 p 347-353.

**090407 RESULTS FROM THE TOTAL EXPOSURE ASSESSMENT METHODOLOGY (TEAM) STUDY IN SELECTED COMMUNITIES IN NORTHERN AND SOUTHERN CALIFORNIA.** Volatile organic compound levels (VOCs) in breath, personal air, fixed outdoor air and drinking water samples were measured and compared for a probability sample of individuals in Los Angeles and Antioch/Pittsburg, California, during 1984. In addition, comparisons were made between seasons (winter vs spring) in Los Angeles for individuals sampled in both seasons. For most comparisons, 13 VOC levels were examined for breath, personal and outdoor air samples and four VOCs for water samples. In addition to the results for VOC levels, the paper also briefly describes (i) the sampling procedures used to obtain the study participants, (ii) the collection of air, breath and water samples, and (iii) selected results from the quality assurance procedures used in this study. (Edited author abstract) 10 refs.

Hartwell, T.D. (Research Triangle Inst, Research Triangle Park, NC, USA); Pellizzari, E.D.; Perritt, R.L.; Whitmore, R.W.; Zelon, H.S.; Sheldon, L.S.; Sparacino, C.M.; Wallace, L. *Atmos Environ* v 21 n 9 1987 p 1995-2004.

**090408 CANCER DOSE-RESPONSE EXTRAPOLATIONS.** New dose-response modeling techniques can incorporate representations of the exposure in terms of dose scales based on cell turnover rates, repair processes, immune system responses, and physiological and pharmacokinetic models of absorption, delivery, metabolism, and elimination of chemicals. These new techniques can incorporate distributions of individual background exposure levels and individual susceptibilities to low levels of a chemical. They also can incorporate such factors as low-dose linearity on a biologically relevant scale, and others. This article discusses the subject in terms of relevant dose scales, individual susceptibilities, modeling through time, and related topics. 8 refs.

Sielken, Robert L. Jr. (Sielken Inc, Bryan, TX, USA). *Environ Sci Technol* v 21 n 11 Nov 1987 p 1033-1039.

**090409 EXPOSURE ASSESSMENT.** Exposure assessment is an explicit and central component of the



quantitative risk assessment procedures that are routinely used to formulate chemical regulatory decisions. In its purest form, an exposure assessment identifies all individuals or population subgroups that have been exposed to a chemical and assembles sufficient analytical chemistry data to allow quantitative calculation of the actual doses received by the exposed individuals or populations. The problems of assembling data to achieve quantitative descriptions of exposure cross many disciplinary boundaries. This article discusses the role and practice of exposure assessment, exposure modeling, and other aspects of the subject. 24 refs.

Severn, David J. (ICF-Clement Inc, Washington, DC, USA). *Environ Sci Technol* v 21 n 12 Dec 1987 p 1159-1163.

**090410 METHODOLOGY FOR THE SELECTION OF ENVIRONMENTAL DISPERSION MODELS IN HEALTH RISK ASSESSMENTS.** Criteria for the selection of environmental dispersion models in health risk assessments are analyzed. The state of knowledge on the health effect exerts a dominant influence on this evaluation, which focuses on averaging procedures, the resolution in space and time, and error propagation. Uncertainties in the cause-effect relationship are the final contributions to the error of the result. Intermediate calculations should neither increase this error unduly nor be carried out with an accuracy significantly better than that which can be achieved in estimating the health effects. In this context, a methodology for performing credible calculations with an effort commensurate with the state of knowledge is discussed. (Author abstract) 21 refs.

Seiler, Fritz A. (Lovelace Biomedical & Environmental Research Inst, Albuquerque, NM, USA). *Environ Int* v 13 n 4-5 1987 p 351-357.

## Management

**090411 KNOWLEDGE-BASED SYSTEMS AND FUZZY SETS IN RISK MANAGEMENT.** An integrated microcomputer-based knowledge system is developed for risk management in construction. The system (Expert-Risk) applies the concepts of fuzzy set theory to evaluate the overall risk of a project. It is also integrated with various relational data bases that provide the system with financial and cost data necessary for bankruptcy and risk analysis. Today's construction industry involves more dynamic and uncertain planning than ever before. Without professional risk management, decision makers cannot systematically approach complex problems. The system provides a more definitive perception of the overall risk of a construction project, and a more rational basis for contingency planning and evaluation. The system allows management to focus on those risk factors which have significant impact on planning. (Author abstract) 20 refs.

Kangari, Roozbeh (Georgia Inst of Technology, Atlanta, GA, USA); Boyer, Leroy T. *Microcomput Civ Eng* v 2 n 4 Dec 1987 p 273-283.

**Mathematical Models** See Also CARCINOGENS—Health Hazards; WATER SUPPLY—Planning.

**090412 UTILIZING PROBABILISTIC RISK ANALYSES (PRAS) IN DECISION SUPPORT SYSTEMS.** One of the most useful applications of probabilistic risk analysis (PRA) is to use the PRA to identify the risk importances of design features, plant operations, and other factors that can affect risk. Risk importance as it is commonly used in PRA terminology, is generally the impact on risk that a factor has. The definition and concept of risk importance will be discussed. The risk importance focused upon are those which are derived from the logic structure of the PRA. The logic structure of the PRA includes the fault tree and event tree models, the failure combinations causing undesired events (the minimal cut sets), and the success paths preventing undesired events (the minimal path sets). The structural and logical information in a PRA provides valuable criteria by which to evaluate importances of risk contributors and changes. 4 refs.

Vesely, William E. (Science Applications Intl, Columbus, OH, USA). *Eng Risk and Hazard Assessment* v 2 p 101-116.

## Military Purposes

**090413 RISK ANALYSIS METHODOLOGIES DEVELOPED FOR THE US DEPARTMENT OF DEFENSE.** This paper summarizes a number of quantitative activities which were sponsored by the US Department of Defense in attempts to minimize or control risks associated with military facilities or military testing. A definition of risk and risk management is presented first. This is followed by discussions of: (1) explosive safety risk management including the effects of blast and debris; (2) risk management applied to testing of missiles at national ranges; and (3) risk management associated with minimizing risks due to fire and natural hazards (wind, flood and earthquake) at military facilities. The discussions summarize both the models to compute risk and the methods used to help the decision maker select the conditions which minimize risk within his operating constraints. (Author abstract) 17 refs.

Collins, Jon D. (ACTA Inc, Torrance, CA, USA). *Reliab Eng Syst Saf* v 20 n 2 1988 p 87-115.

**Occupational Risks** See Also ACCIDENT PREVENTION—Human Factors; ELECTRIC POWER PLANTS—Accident Prevention; GLASS FIBER—Manufacture; HAZARDOUS MATERIALS—Evaluation; INDUSTRIAL HYGIENE—Research; INDUSTRIAL TRUCKS—Accidents; INDUSTRIAL WASTES—Hazardous Materials; PESTICIDES—Toxicity; ROBOTS, INDUSTRIAL—Accidents; VIBRATIONS—Health Hazards.

**090414 EVALUATION OF THE VALIDITY OF FOUR HAZARD IDENTIFICATION METHODS WITH EVENT DESCRIPTIONS.** The aim of the investigation was to develop a new method for evaluating the validity of safety analyses with incident and accident descriptions, and to use the approach on some common methods of safety analysis. For this purpose descriptions of disturbances and accidents were collected at seven Finnish process plants. This resulted in 51 incident descriptions. Complementary material (18 incidents) was collected from the FACT data bank. The evaluation concerned four methods - hazard and operability study (HAZOP), action error analysis (AEA), failure mode and effect analysis (FMEA), and management oversight and risk tree (MORT). The basic idea of the evaluations was to use the descriptions of accidents and disturbances as indicators of the real accident contributors, and to decide which of them would have been identified if the methods had been applied in a plant-wide analysis. The results show a total validity of 0.55 of the methods in the cases used in the evaluations.

Suokas, Jouko (Technical Research Cent of Finland, Espoo, Finl); Pyy, Pekka. *Valt Tek Tutkimuskeskus Tutkimuksia* 518 Jan 1988 63p.

**090415 NOW OR LATER? A NUMERICAL COMPARISON OF SHORT- AND LONG-TERM HAZARDS.** The author previously presented one of the first papers on the use of numerical methods for comparing the different risks to which employees in the process industries are exposed. Since then such methods have been used for setting priorities between different acute risks and the literature on the subject is now extensive. This paper suggests an extension of these methods to hazards which take a long time, typically several decades, to produce their effects. Consider a substance X, the product of an industrial process, which can cause harm in two distinct ways: (1) it may leak out of the plant, vaporize, mix with air, and be ignited, thus injuring or killing people by fire or explosion. (2) exposure of employees to small quantities of the vapor for long periods for many years may cause industrial disease which may lead to premature death. Usually different people, using different criteria and financed by different budgets are responsible for dealing with two hazards. Finding a way to talk to them both at the same time is like finding a way of communicating at the same time to people who speak different languages. This is attempted in this paper. 34 refs.

Kletz, Trevor A. (Loughborough Univ of Technology, Engl). *Eng Risk and Hazard Assessment* v 1 p 1-9.

**Perception** See COST ACCOUNTING; ENVIRONMENTAL ENGINEERING—Public Policy.

**Public Risks** See Also ACCIDENT PREVENTION—Netherlands; APARTMENT HOUSES—Fire Resistance; BUILDINGS—Earthquake Resistance; BUILDINGS—Fires; HAZARDOUS MATERIALS—Spills; NUCLEAR POWER PLANTS—Safeguard Systems.

**090416 PROBABILISTIC RELIABILITY ANALYSIS, QUANTITATIVE SAFETY GOALS, AND NUCLEAR LICENSING IN THE UNITED KINGDOM.** Although unpublished, the use of quantitative safety goals and probabilistic reliability analysis for licensing nuclear reactors has become a reality in the United Kingdom. This conclusion results from an examination of the process leading to the licensing of the Sizewell B PWR in England. The licensing process for this reactor has substantial implications for nuclear safety standards in Britain, and is examined in the context of the growing trend towards quantitative safety goals in the United States. (Author abstract) 23 refs.

Cannell, William (Commission of the European Communities Joint Research Cent, Ispra, Italy). *Risk Anal* v 7 n 3 Sep 1987 p 311-319.

**090417 ON WEIGHING GAINS AND INVESTMENTS AT THE MARGIN OF RISK REGULATION.** Analysts have long noted an apparent discrepancy in the level of investment seemingly necessary to meet 'acceptable' levels of public safety. At the margin of risk regulation, i.e., where safety determination is judged acceptable, the traditional cost-benefit calculus appears to contribute obvious rationale to the final political decision. Efforts are now being made to introduce a measure of consistency into the application of risk-cost benefit analysis to radiological protection. This paper reviews these efforts from a UK perspective. It also looks at how the issue was treated in a public setting through the Sizewell B Public Inquiry. (Author abstract) 27 refs.

O'Riordan, Timothy (Univ of East Anglia, Norwich, Engl); Kemp, Ray; Purdue, H. Michael. *Risk Anal* v 7 n 3 Sep 1987 p 361-369.

**090418 RISK-BASED ANALYSIS OF EXTREME EVENTS.** Mathematical expectation has traditionally been used in solving risk-based decisionmaking problems. However, this concept is not appropriate for decisionmaking that affects public policy because it conceals extremes by commensurating events of different magnitudes and probabilities of occurrence. A theory relating conditional expectation to the statistics of extremes is developed in this paper. This expectation can now be viewed as the conditional expected risk given the occurrence of an event with a return period that equals or exceeds n years. The theory highlights the importance of using both the conditional and the unconditional expected risk in decisionmaking. This fact has previously been recognized in the partitioned multiobjective risk method (PMRM), a risk analysis methodology based on the concept of conditional expectation. The theory proposed in this paper provides a formulation for analyzing the sensitivity of subjectively chosen parameters in the PMRM. (Edited author abstract) 15 refs.

Karlsson, Per-Ola (Univ of Florida, Charlottesville, VA, USA); Haines, Yacov Y. *Water Resour Res* v 24 n 1 Jan 1988 p 9-20.

**090419 DEVELOPING A RISK/COST FRAMEWORK FOR ROUTING TRUCK MOVEMENTS OF HAZARDOUS MATERIALS.** As the United States continues to increase its dependence on industrial technologies which require hazardous materials and generate hazardous wastes, concern is mounting over the safe transport of hazardous cargo. It is estimated that 1.5 billion tons of hazardous cargo are moved through the nation's transportation systems (excluding pipeline), with



truck as the primary mode of transport. Because of the dynamic nature of exposure to the population and environment associated with the transport of hazardous cargo, it is important to develop an accurate representation of this type of transport risk, and to structure a framework for designating a permanent set of shipping routes based on optimizing across risks and costs. This paper describes a methodology which has been developed that incorporates risk and cost into a framework for optimizing the routing of truck movements of hazardous materials. Considerable attention is focused on the risk estimation part of this process, as this is a subject of much uncertainty and of considerable significance to policymakers. The resulting methodology is applied in a regional setting to illustrate its use as an analysis tool. Enhancements to the model structure and extensions beyond the truck routing problem are also discussed. (Author abstract) 19 refs.

Abkowitz, Mark (Rensselaer Polytechnic Inst, Troy, NY, USA); Cheng, Paul Der-Ming. *Accid Anal Prev* v 20 n 1 Feb 1988 p 39-51.

**090420 SETTING PRIORITIES IN SAFETY.** The author believes that not everything possible can be done to prevent every conceivable risk to life, however unlikely or trivial. Sufficient resources are never available. The decisions to be made are these: which risks to remove or reduce first, and which to leave until later, perhaps indefinitely. In other words, we have to set priorities. If a more systematic and more defensible method is found, then there are two distinct approaches: remove or reduce first those risks which exceed a particular level or remove or reduce first those risks that are cheapest to remove or reduce. This paper describes and compares the two methods with particular reference to the process industries, though much of what will be said is relevant to other industries. 28 refs.

Kletz, Trevor A. (Loughborough Univ of Technology, Engl). *Eng Risk and Hazard Assessment* v 1 p 11-19.

**090421 DETERMINING AN ACCEPTABLE LEVEL OF RISK.** A de manifestis level is a ceiling above which events are inherently unsafe and should be regulated without regard for cost. The authors recommend that a population-based de manifestis level be adopted to establish the level above which cancer risks should be considered inherently unsafe and regulated - no matter what the cost. 10 Refs.

Travis, Curtis C. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Hattemer-Fey, Holly A. *Environ Sci Technol* v 22 n 8 Aug 1988 p 873-876.

**090422 COMPARATIVE PERSPECTIVE OF RISK MANAGEMENT IN THE UNITED STATES AND JAPAN.** A comparative analysis of risk management approaches in the United States and Japan is presented. It is shown there are important differences between the two countries in the approaches and the sources utilized to manage risks. The Japanese approach, which uses administrative guidance, informal persuasion, and education in its governance activities, is contrasted with the more open and adversarial policy-making process in the United States. These general characteristics of governance carry squarely over into each country's characteristic risk-management processes. Four case studies are presented. 12 refs.

Kawamura, Kazuhiko (Vanderbilt Univ, Nashville, TN, USA). *IEEE Technol Soc Mag* v 6 n 3 p 3-11.

**Risk Studies** See NUCLEAR MEDICINE—Health Care.

## Theory

**090423 THEORY OF POSSIBILITY AND FUZZY SETS.** This report begins with a review of traditional methods of risk analysis the application of risk analysis in the construction industry and discussion of the special conditions in that industry. Then a brief introduction to the theory of fuzzy sets is presented. Special properties are described which characterize methods based on fuzzy sets.

Another theory which is based on the theory of fuzzy sets is possibility theory. The difference between fuzzy sets and possibilities is that possibilities can be used in conjunction with uncertain outcomes, while fuzzy sets are sets with fuzzy boundaries. This means that possibility theory may be regarded as an alternative to probability theory. The principal object of this report is to present three new methods of risk analysis and decision making. The three new methods which have been developed by the author (Indication of risk, Fuzzy ranking and Merging of subjective opinions) are presented both theoretically and by means of examples. 29 Refs.

Andersson, Leif. *Doc Swed Counc Build Res* n 8 1988 167p.

**RIVER BASIN PROJECTS** See Also HYDROLOGY—Analysis; RIVERS—Management; WATER RESOURCES—Management.

**090424 DUNAI VIZLEPCSO RENDSZER FOL-DRENGESSEL SZEMBENI ALLEKONYISAGA.** [Stability of the Danube Barrage System Against Earthquakes]. After some information about the origin of earthquakes and about classification according to their nature, some theoretical statements are presented by the author followed by a listing of the earthquakes in Hungary. These events were all attached to three rather characteristic and dangerous break-lines. In case of the Czechoslovak-Hungarian Danube Barrage System, experts of the two countries outlined the situation for the expected earthquake-occurrences. The stability of these earthworks was investigated by deterministic and stochastic methods. Deterministic investigations were carried out by using the Peterson-relationship. Stochastic methods apply random variables like isoseismic lines and their safety factors. The standard deviations of these safety variables were determined in the levees of the reservoirs and upstream canal. Then the probability of collapsing was calculated by assuming normal and exponential distribution. According to these investigations, the probability of breaking-down of the main structures was less than 5 percent. (Edited author abstract) 15 refs. In Hungarian.

Misteth, Endre. *Vizugyi Kozl* v 69 n 2 1987 p 184-205.

**090425 BI-NATIONAL DEVELOPMENT OF THE COLUMBIA RIVER.** Building large and costly water resources schemes is always a complex problem, usually involving special interest groups, and many technical, financial and other experts. When the projects and their associated benefits are spread across more than one nation, the problems are compounded. The Columbia River Treaty, between Canada and the United States, came into being to address some of these problems, and to allow the development of one of the world's largest hydroelectric power systems. After outlining the history of the Columbia River development, following the signature of the Treaty, the authors review current procedures and note how various problems are overcome. (Author abstract)

Dodge, N. (US Army Corp of Engineers, Portland, OR, USA); Newton, T. *Int Water Power Dam Constr* v 40 n 3 Mar 1988 p 33-35.

## Brazil

**090426 INTEGRATED WATER DEVELOPMENT PROJECT OF GRAVATAI RIVER BASIN, BRAZIL.** The integrated Water Resources Development Project of Gravatai River Basin was prepared by the National Drainage Works Department (DNOS) and the German Agency for Technical Cooperation (GTZ). An attempt was made to use the capacity available in other departments and specialized institutes. The objective is to provide information for the departments involved in water resources management so as to enable them to establish specific terms for each hydrographic basin to complement the Federal, state and municipal laws. The basin problems were considered in this work including all aspects related to water resources development. Conclusions were presented as to flow regulation, flood protection, domestic and industrial wastewater, water supply, irrigation, environ-

mental conservation and navigation. (Edited author abstract) 1 ref.

Aoki, Ricardo (Dep Nacional de Obras de Saneamento, Porto Alegre, Braz). *Water Sci Technol* v 19 n 9 1987, Dev in River Basin Manage, Proc of an IAWPRC Conf, Sao Paulo, Braz, Aug 13-15 1986 p 59-68.

## Burkina Faso, Africa

**090427 BARRAGE DE NIOFILA ET AMENAGEMENT DE LA PLAINE DE DOUNA AU BURKINA FASO (EX-HAUTE-VOLTA).** [Nioufila dam and Douna Plain Development in Burkina Faso]. Although located in the Sahel, Burkina Faso has many medium sized rivers allowing the setup of hydraulic development projects at an acceptable cost. The article describes two of these projects: the Douna Plain Development and, immediately upstream, the Nioufila dam. The latter is an earthen flood regulation structure 3,000 m long, 4.5 m at the crest, with a slope of 2 to 1. The Douna Plain Development, which follows it, includes - during an initial phase - an irrigated perimeter of 600 ha (1500 ha later on) with 35,600 m of canals, 16,000 m of which have a concrete lining, access lanes and a drainage network. (Author abstract) In French.

Ducloux, P. (Entreprise Muller Freres, Fr). *Travaux* n 626 Nov 1987 p 19-22.

## Danube River

**090428 NAGYMAROSI VIZLEPCSO ALATTI DUNA-MEDER VIZSGALATA.** [Investigation of the Danube River-Bed Downstream of the Water Power Station of Nagymaros]. Planning of the Hydraulic Barrage System of Bos-Nagymaros was initiated in 1952. A feasibility study was finished up in 1968. During the first phase of planning, the necessary conclusions on the bed-conditions were drawn down on the basis of several surveys performed in 1963. The design discharge was determined as 3000 m<sup>3</sup>/s at the power station of Nagymaros. In order to increase the capacity of the power station, this discharge was planned to be carried by the cross-section just downstream of the power station with a water level that was lowered by 0.80 m compared to the present situation with the condition that the coordinated new backwater curve must join the original curve at Budapest on the same, original level. According to the Author's opinion this desired state of the river-bed has been already attained due to large-scale ongoing industrial excavations along the ominous river-stretch from Nagymaros till Budapest. In other words, there is no need for further voluminous excavations to achieve a more economic operation of the power station. (Edited author abstract) In Hungarian.

Csoma Janos (Vizgazdalkodasi Tudományos Kutatóközpont, Budapest, Hung). *Vizugyi Kozl* v 69 n 1987 p 288-296.

## Design

**090429 CONSIDERATION ON THE PROBABILISTIC ESTIMATION OF MAXIMUM HYDROLOGICAL QUANTITIES OCCURRENCE.** It is very important in the river-works design to estimate maximum hydrological quantities occurrence, such as the heavy rainfall and the flood. In this paper, assuming that the annual maximum values follow the log-normal distribution, we consider the distribution of the maximum values which occur within the lifetime of structure for river-works. And analyzing the data from four stations (Kanazawa, Toyama, Fukui and Nanao), we find that the hydrological variable in accordance with large return period is nearly equal to the value which is the mode of the annual maximum values distribution that can occur within the lifetime of the structure. Furthermore we suggest the statistical method to evaluate the occurrence times and magnitude when severe hydrological events occurred repeatedly in a fixed interval. (Author abstract) In Japanese. 8 refs.

Takase, Nobutada; Ujihashi, Yasuyuki; Ogawa,



Masahiro. *Doboku Gakkai Rombun-Hokokushu* v 9 n 5 May 1988 p 225-228.

## Drainage

**090430 VIZRENDEZES ES FEJLESZTÉSE AZ ALSO-TISZA-VIDEKI VIZUGYI IGAZGATÓSÁG TERÜLETÉN.** [Land-Drainage and its Development in the Area of the Lower-Tisza Valley Regional Water Authority]. The introduction of flood-protection in the Tisza Valley in the last century secured the conditions of a safe agricultural production over one-fifth of the area of Hungary and promoted transportation, traffic, industrial development and the living-conditions of its inhabitants. The continuous system consisting of levees, however, closed off the drainage of logging waters from the protected area in its natural way and created a new problem: called land-drainage. Land-drainage cannot function without dense and well-maintained canal-networks, without a structure-system for water diversion and without pumping-stations, occasionally. A coordinated development and operation of the canals of different order and purpose is a basic task of this technical field. To foster coordinated development, the Lower-Tisza Valley Regional Water Authority had ordered to prepare in 1976-1978 a conceptual plan for land-drainage development in the counties of Csongrad, Bekes and Bacs-Kiskun. Beside constructing the necessary earthworks and structures, the Regional Water Authority was eager to help the accomplishment of the work-phases of complex amelioration especially through the construction of automatically controlled, prefabricated pumping stations and of pipe-drainage systems. (Edited author abstract) 2 refs. In Hungarian.

Csizmadi, Karoly (ATV VIZIG, Szeged, Hung). *Vizugyi Kozl* v 69 n 1 1987 p 75-85.

## India

**090431 CRUCIAL ISSUES IN GEOTECHNICAL ENGINEERING OF WATER RESOURCE PROJECTS.** The difficulties experienced in geotechnical investigations of some river valley projects have been presented. The importance of systematic investigations has been stressed in order to evolve safe and economical design. The experiences from Salal Hydro electric Project, Loktak Hydro electric Project and Srisaillam Hydro electric Project have been described. The need for a specialized cadre in geotechnical engineering devoted to water resource development projects has been stressed. (Author abstract). 13 Refs.

Madhavan, K. (Central Water Commission, New Delhi, India). *Indian Geotech J* v 18 n 1 Jan 1988 p 1-30.

## Legislation

**090432 HYDRO DEVELOPMENT ON INTERNATIONAL RIVERS.** A considerable portion of the world's remaining hydro potential, which is technically and economically exploitable, is on rivers which flow through more than one country. The development of these valuable resources is often delayed while lengthy negotiations between neighbouring countries take place. This article looks at some of the legal, technical, economic and environmental issues which have to be addressed when bi-national schemes are constructed. (Author abstract) 10 refs.

Focsa, V. *Int Water Power Dam Constr* v 40 n 3 Mar 1988 p 38-39.

**Management** See Also WATER RESOURCES—Sudan.

**090433 TARAWERA RIVER MANAGEMENT PLAN.** The pulp and paper industry was established on the banks of Tarawera River in the 1950s. The site was chosen for two principal reasons, the availability of the river both as a source of water and a medium for effluent disposal and the availability of geothermal energy. Concern in the 1980s at the polluted state of the Tarawera River below the industrial discharges, coupled with proposals for expansion of the established industry led to

a requirement for the preparation and adoption of a Management Plan for the river and its catchment. The paper discusses the plan, its preparation and the implications for the pulp and paper industry at Kawerau. (Edited author abstract).

Jones, Jeff (Bay of Plenty Catchment Commission, NZ); Shirley, John C.; Slabber, Kees. *Trans Inst Prof Eng NZ Civ Eng Sect* v 15 n 1 Mar 1988 p 9-15.

**090434 PREPRINTED PROCEEDINGS OF THE 4TH INTERNATIONAL CONFERENCE ON RIVER BASIN MANAGEMENT.** This conference proceedings contains 28 papers. The topics covered include: river basin management; water quality management; river basin habitat elements; estuary division into homogeneous areas; integrated water development projects; geographic information system in river basin management; surface water quality management; monitoring of heavy metals in water and sediments; water resource planning; water quality indices; wastewater treatment system optimization; estuarine water quality dispersion mathematical models; oasis-systems management; innovative financing techniques; water resources management socio-economical development; water quality management regulatory policy. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11018 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Dep of Water & Electric Power, Braz). *Prepr Proc of the 4th Int Conf on River Basin Manage, Sao Paulo, Braz, Aug 13-15 1986* Publ by Int Assoc on Water Pollution Research & Control, London, Engl 300p.

## Mathematical Models

**090435 IRRIGATION PLANNING MODEL FOR DAMODAR-BARAKAR RIVER BASIN.** The Damodar-Barakar river basin is an inter-state basin falling in the states of Bihar and West Bengal. According to an agreement between the governments of Bihar and West Bengal regarding sharing of water in the basin, the share of Bihar is limited to a meagre quantity. Therefore, it is important to utilize the water in a more scientific way to derive the optimum benefit. In the basin, while planning an irrigation project, the areas of crops are fixed arbitrarily on the basis of total 75% dependable inflow. Hence, keeping all these in view, a linear programming model for irrigation planning has been developed considering periodical inflow of 10 days and evaporation losses for the whole year to serve as a guideline for irrigation planning in the Bihar portion of the basin. (Edited author abstract) 7 refs.

Prasad, Mahabir (Dep of Water Resources & Flood Control, Bihar, India). *J Inst Eng India Part CI* v 68 Jul 1987 p 19-26.

**Nile River** See RIVERS—Control.

**Optimization** See RESERVOIRS—Design.

## Philippines

**090436 LESSONS FROM EIA FOR BICOL RIVER DEVELOPMENT IN PHILIPPINES.** Beginning in 1975, the Bicol River Basin Development Program (BRBDP) embarked on a plan to develop the Rinconada area by providing integrated projects for rural development. Environmental studies were done, but largely in response to procedural requirements of the U.S. Agency for International Development; the Philippine environmental impact statement requirements were not taken seriously. The resulting environmental assessment was inadequate and failed to predict negative impacts that followed project implementation, particularly construction of the Lake Buhí regulation project. The controversy caused by the adverse effects necessitated follow-on environmental studies and engineering works and enhanced the BRBDP's appreciation of environmental impact assessment as a practical planning tool. (Author abstract). 12 Refs.

Abracos, Ramon (Univ of the Philippines at Los Banos, Philipp); Ortolano, Leonard. *J Water Resour Plann Manage* v 114 n 5 Sep 1988 p 517-530.

## Saskatchewan

**090437 WATER QUALITY DETERIORATION DURING INTERBASIN TRANSFER IN SASKATCHEWAN.** Two existing diversion schemes have been studied over a period of 15 years. These two schemes and one proposed diversion scheme are reviewed with a direct interest in identifying potential and actual causes of water quality deterioration which exists now or may exist in the future. Specifically the diversion schemes are: (1) the Qu'Appelle diversion with water being discharged into the Qu'Appelle River from Lake Diefenbaker for enhancement of drinking water quality for the cities of Regina and Moose Jaw and to provide irrigation water downstream, and (2) the Saskatoon Southeast Water Supply System with water being transferred from Diefenbaker Lake to multi-purpose users in a 120 kilometer long arc south and east of Saskatoon. The quality of the diverted waters in both schemes undergoes rapid and permanent deterioration which results in lower value supplies for irrigation, industrial, and domestic uses. Additional study results are discussed. (Edited author abstract). 7 Refs.

Davis, E. (Univ of Saskatchewan, Saskatoon, Sask, Can); Sauer, E.K. *Can Water Resour J* v 13 n 3 Jul 1988 p 50-59.

## Taiwan

**090438 WATER CLASSIFICATION IN THE TANSUI RIVER BASIN IN TAIWAN.** This paper is based on a study conducted to assess and classify the Tansui river in Taiwan, taking into consideration several relevant parameters. The classification was performed using a new approach. First, the current general uses of the river were assessed; classification was then made by river area, and the priority uses of each. Second, existing water quality was assessed using an indexing approach, specifically the River Pollution Index (RPI). This takes into account all relevant pollution variables, eg. DO, BOD, coliform count, etc. to determine the level of water quality at different reaches of the river. Finally, a classification of the Tansui river based on its existing water quality and specific best usage was made. (Author abstract). 4 Refs.

Lohani, B.N. (Asian Inst of Technology, Bangkok, Thailand); Maw-Sen, Chuang. *Int J Water Resour Dev* v 3 n 3 Sep 1987 p 154-164.

## USSR

**090439 AMERICAN SCIENTIST ON INTERBASIN WATER TRANSFER IN THE USSR.** Among the American authors who have already elucidated various aspects of this problem for a comparatively long time is Western Michigan University Professor Ph. Micklin - a prominent specialist in the USA on water resources of the USSR and problems of their territorial redistribution. In his work the American scientist actively uses Soviet official government documents, scientific journals, monographs, etc. An analysis of the Soviet literature and his own scientific studies enabled Micklin on the whole to thoroughly discuss the problem. Certain points of his works of interest also for the Soviet reader are discussed in this paper. 15 refs.

Timashev, I.E. (Moscow Univ, USSR). *Water Resour* v 14 n 2 Mar-Apr 1987 p 199-202.

**RIVERS** See Also AQUIFERS—Recharging; DAMS—Construction; HYDROELECTRIC POWER PLANTS—Optimization; IRRIGATION—Water Supply; SOILS—Sediments; STREAM FLOW; WATER POLLUTION; WATER POLLUTION—Oil Spills; WATER POLLUTION—Water Quality; WATER RESOURCES—Management.



**090440 DISTRIBUTION OF CHEMICALS IN RIVERS DURING CONTAMINATION AND RECOVERY.** Differential equations that describe the fate of chemicals in rivers as they transfer, react, and volatilize, both during contamination and recovery are developed. Explicit analytical solutions are presented for the unsteady distribution of the substance in the aqueous and sediment phases assuming a constant partition coefficient. The solutions are expressed in terms of three parameters, dimensionless distance  $Z$ ; dimensionless time  $T$ ; and the conservation index  $K$ , which equals 1 for conservative nondegrading substances, and zero for infinitely fast loss or degradation. All three parameters are instrumental in defining limits for important asymptotic cases. (Edited author abstract) 14 refs.

Basmadjian, Diran (Univ of Toronto, Toronto, Ont, Can); Quan, Franklin. *J Environ Eng* v 113 n 6 Dec 1987 p 1185-1201.

**090441 DESIGN AND CONSTRUCTION OF AN ARTIFICIAL CANOE SLALOM COURSE AT HOLME PIERREPONT, NOTTINGHAM.** The artificial canoe slalom course opened by HRH the Princess Anne on 13 September 1986 makes the National Water Sports Centre at Holme Pierrepont one of the most comprehensive and easily accessible centres for canoe sports in the world. Funded by the Sports Council, Nottinghamshire County Council and the British Canoe Union at a cost of £2.2 million, the course is the first purpose-built international standard artificial canoe slalom facility in the UK. The course is three miles downstream of Nottingham on the River Trent and allows part of the river flow to bypass Holme Sluices. The discharge of the course can be varied to modify the difficulty of the water features to suit differing levels of expertise. Extensive use was made of hydraulic models in the design of the course which takes the form of an irregular series of stepped pools connected by horizontal trapezoidal channels. (Author abstract) 6 refs.

Peters, J.R. (Nottinghamshire County Council, Engl). *Munic Eng (Inst Civ Eng)* v 4 n 6 Dec 1987 p 317-330.

**090442 METHOD FOR MANAGING RIVER ABSTRACTIONS AND PROTECTING THE ENVIRONMENT.** An improved method has been developed to assess and control the quantity of water available to river abstractions. The methodology quantifies the sensitivity of the river environment to abstraction by a weighting system, and uses this to establish, on a subcatchment basis, maximum permissible volumes of abstraction and minimum permissible river flows. Guidelines developed from the methodology have been used as the basis for determining applications for abstraction licenses in North Yorkshire, before being extended to cover the rest of the Yorkshire Water area. (Author abstract) Refs.

Drake, P.J. (Yorkshire Water Authority); Sherriff, J.D.F. *J Inst Water Environ Manage* v 1 n 1 Aug 1987 p 27-38.

**090443 DURBAN - TOO MUCH WATER - TOO LITTLE WATER.** The exceptional continuous heavy rain in the catchments of the major Natal rivers flowing through Durban caused very high flood levels to occur. The magnitudes of the floods are considered, as are the means of determination of the flows. The major damage due to the high flows of the rivers, particularly in respect of the Umgeni and Umlaas Rivers, created major problems in maintaining water supply and waste water treatment services in the entire densely populated metropolitan area. The steps taken to deal with these problems are outlined. Also considered are the effects of property flooding, damage to other services and the resultant change in river regimes. (Author abstract)

Davis, A.B. (Durban City Engineer's Dep, S Afr); MacLeod, Neil A. *Civ Eng S Afr* v 30 n 1 Jan 1988 p 21, 23-25, 27-28.

**090444 CHANNEL CHANGE, FLUVIAL GEOMORPHOLOGY AND RIVER ENGINEERING: THE CASE OF THE AFON TRANNON, MID-WALES.** The Afon Trannon, a gravel-bed river in

mid-Wales with a catchment area of 72 km<sup>2</sup>, has recently been the subject of an engineering flood protection scheme. Geomorphological investigations are described which attempt to pinpoint the lessons of the scheme. Historical studies of floodplain sediments and channel change indicate firstly, an initially rather stable channel, but secondly a considerable, early history of channelization which may still have repercussions for system stability. This early channelization has now been modified in the recent scheme. Contemporary field study by survey and sediment tracing using the magnetic technique indicates the present instability of the sediments in a meandering channel given a trapezoidal cross-section and varied banks. Low-flow adjustments are as important as flood adjustments in the lower, straightened reach. (Edited author abstract) 20 refs.

Leeks, G.J. (Inst of Hydrology, Staittle, Wales); Lewin, J.; Newson, M.D. *Earth Surf Processes Landforms* v 13 n 3 May 1988 p 207-223.

**Bank Erosion** See Also CANALS; CANALS—Bank Erosion; HYDROELECTRIC POWER PLANTS—Standardization; STREAM FLOW—Mathematical Models.

**090445 RIVERBANK STABILITY ANALYSIS. I: THEORY.** In this paper, a slope stability analysis for steep banks is used in conjunction with a method to calculate lateral erosion distance, to predict bank stability response to lateral erosion or bed degradation. The failure plane angle, failure block width, and volume of failed material per unit channel length may be calculated for the critical case. These parameters define the bank geometry following failure and form the starting point for subsequent analyses. The calculation procedure is illustrated by a worked example. Following mass failure slump, debris accumulates at the bank toe. The debris is removed by lateral erosion prior to further oversteepening or degradation generating further mass failures. Any process-based model for channel width adjustment must account for the combined effects of lateral erosion and mass instability in producing bank instability. (Edited author abstract) 14 refs.

Osman, Akode M. (Univ of Khartoum, Khartoum, Sudan); Thorne, Colin R. *J Hydraul Eng* v 114 n 2 Feb 1988 p 134-150.

**090446 RIVERBANK STABILITY ANALYSIS. II: APPLICATIONS.** Bank retreat occurs by a combination of lateral erosion by the flow and mass failure under gravity. A new analysis of bank erosion and failure is developed, using a critical shear-stress concept to account for lateral erosion and a slope stability criterion for mass failure. In this paper, we apply the analysis to two problems of bank retreat often encountered by practicing engineers dealing with alluvial channels. The first application is to the prediction of degradation downstream of a dam for the case in which bed lowering causes bank instability. The second application is to the modeling of flow in channel bends and the prediction of the equilibrium cross section. (Edited author abstract) 12 refs.

Thorne, Colin R. (US Army Waterways Exper Station, Vicksburg, MS, USA); Osman, Akode M. *J Hydraul Eng* v 114 n 2 Feb 1988 p 151-172.

## Bank Protection

**090447 OLD RIVER OVERBANK STRUCTURE, LOUISIANA: HYDRAULIC MODEL INVESTIGATION.** Physical hydraulic model tests were conducted to investigate the hydraulic performance of the stilling basin and evaluate riprap stability and scour potential with the existing overbank structure. Most tests were conducted in a 1:25-scale section model of six bays and one abutment. Other tests were conducted in a 1:44-scale section model and the existing 1:120-scale general model. A variety of operating configurations with alternate bays and panels in each of the six bays were used to determine adequate operating conditions and limits of safe operation for the total 73-bay structure. Tests were conducted for the full range of anticipated operating conditions with consecutive bays fully open and fully closed, and with controlled flow

through each of these timber panel configurations in each bay of the structure. Controlled flow through partially opened bays with staggered timber panels was the most satisfactory manner of operating the overbank structure and, therefore, is the recommended plan. (Edited author abstract)

Grace, John L. Jr. (USAED, New Orleans, LA, USA); Oswalt, Noel R.; Rothwell, Edward D. *Tech Rep US Army Eng Water Exp Stn* HL-88-5 Mar 1988 80p.

**Bolivia** See WATER RESOURCES—Bolivia.

**Brazil** See WATER POLLUTION—Analysis.

**Bridport, England** See FLOOD CONTROL—Mathematical Models.

## Cape Fear River

**090448 CORRELATIONS BETWEEN BASIN DEVELOPMENT PARAMETERS AND WATER-QUALITY CHARACTERISTICS OF THE CAPE FEAR RIVER AT LOCK 1 NEAR KELLY, NORTH CAROLINA.** Water-quality data from long-term (24 years) fixed-station monitoring at the Cape Fear River at Lock 1 near Kelly, N.C., and various measures of basin development are correlated. Subbasin population, number of acres of cropland in the subbasin, number of people employed in manufacturing, and tons of fertilizer applied in the basin are considered as measures of basinwide development activity. Linear correlations show statistically significant positive relations between both population and manufacturing activity and most of the dissolved constituents considered. Negative correlations were found between the acres of harvested cropland and most of the water-quality measures. The amount of fertilizer solid in the subbasin was not statistically related to the water-quality measures considered in this report. For the chemicals evaluated, manufacturing and population sources are more closely associated with water quality in the Cape Fear River at Lock 1 than are agricultural variables. (Edited author abstract) 9 refs.

Crawford, J. Kent; Harned, Douglas. *Geol Surv Water Supply Pap (US)* 2310 Dec 1986 p 25-33.

**Classification** See RIVER BASIN PROJECTS—Taiwan.

**Contamination** See Also FLOW OF FLUIDS—Pipes.

**090449 FACTORS AFFECTING METAL PARTITIONING DURING RESUSPENSION OF SEDIMENTS FROM THE DETROIT RIVER.** The release of previously deposited substances from sediments may represent a significant source of contaminants to the overlying water. Of special concern is the partitioning between aqueous- and sediment-phase heavy metals in response to resuspension events induced by hydrodynamic forces. In this paper results from a set of field experiments are reported in which sediment cores from three stations in the Trenton Channel of the Detroit River were artificially resuspended. Statistical analysis of the data indicated that the concentrations of the dissolved metals Cd, Co, Cu, Ni, Pb, and Zn in the overlying water varied inversely with pH ( $p < .05$ ) and directly with time when the pH was below 7.5. These results are interpreted in terms of surface sorption reactions, particle size distributions, and mass transfer controls on metal-sediment reaction rates. (Edited author abstract) 18 refs.

Theis, Thomas L. (Clarkson Univ, Potsdam, NY, USA); Young, Thomas C.; DePinto, Joseph V. *J Great Lakes Res* v 14 n 2 1988 p 216-226.

**Control** See Also WATER TREATMENT PLANTS—Waste Disposal.

**090450 WATER QUALITY AND DIATOM COMMUNITIES IN TWO CATALAN RIVERS (N.E. SPAIN).** Benthic diatom assemblages have been used to evaluate the water quality of two rivers subjected to marked human influences. These rivers, the Llobregat and the Ter, are located in N.E. Spain, and supply water for



industrial, agricultural and urban requirements of roughly three million people. The diatom communities in the headwaters are similar in both rivers (*Achnanthes minutissima*, *Cymbella ventricosa*, *Gomphonema angustatum*). In the river Ter significant pollution modifies this community and *Nitzschia palea*, *Nitzschia gandersheimiensis* and *Gomphonema parvulum* appear as the most tolerant species. In the Llobregat, the pollution from the salt mine operations also modifies the diatom assemblage. Reservoirs in the river Ter improve the quality of water and a community of *Fragilaria* sp. pl. becomes dominant downstream. (Edited author abstract) 30 refs.

Sabater, Sergi (Univ Barcelona, Barcelona, Spain); Sabater, Francesc; Tomas, Xavier. *Water Res* v 21 n 8 Aug 1987 p 901-911.

**090451 ZALA VIZGYUJTOJENEK EROZIOS VIZONYAI ES HATASUK A FELSZINI VIZEK MINOSEGERE.** [Erosion in the Catchment of the Zala River]. First, the triggering and influencing factors initiating non-point (areal) erosion were evaluated. Individual factors were afterwards weighted according to characteristic slopes, precipitation and soils (taken as constant or barely unchanged). Based on this information, erosion endangerment or erosion potential of an area were calculated and presented. Modification of applied agrotechnical measures has been recommended with due regard on soil-protection. Changes in land use were also proposed with consideration on the agroecological potential. In practice, the pollution-load of the Zala river was evaluated on the basis of measured sodium-phosphorus-potassium values in the different cross-sections. The values were correlated to the types and amount of the pollutants originated in the particular area. It has become clear that diffusive pollutants (stimulated by soil-degradation) are essential from the point of view of water quality in the tributaries. (Edited author abstract) 18 refs. In Hungarian.

Dezseny, Zoltan; Lendvai, Zoltan. *Vizgyi Kozl* v 69 n 1 1987 p 60-74.

**090452 MESURES DE LA QUALITE DES RIVIERES: STATIONS AUTOMATIQUES.** [Measurement of River Water Quality: Automatic Measuring Stations]. Automatic measuring stations are often used as warning stations to protect drinking intakes; they constitute also significant tools for the study and modeling of natural phenomena and treatment processes. These aspects and various techniques are presented with emphasis on recent achievements. Automatic measuring stations are not yet well developed because of their costs, technological difficulties, personal requirements, and inadequate regulations. The development of this kind of instrumentation will proceed together with an opening of the French designers towards the foreign market and with improved regulation. Moreover, it is necessary to develop new sensors in order to cover a great number of chemical matter while an increase in the number of instruments. (Author abstract) 12 refs. In French.

Journet, J.M. (Agence de l'Eau Artois-Picardie, Douai, Fr); Randon, G.; Odier, M.; Lutz, M.; Cognet, L. *Houille Blanche* v 42 n 4-5 1987, Mes en Riviere et en Reseaux d'Assainissement, Situat Actuelle et Perspect - CR, Nov 26-27 1986, Fr p 347-354.

**090453 LE REGLAGE DES NIVEAUX PAR BARRAGES MOBIILES POUR DES OUVRAGES A FAIBLES RETENUES. LES BARRAGES MOBIILES ADAPTES AUX FAIBLES RETENUES.** [Water Level Regulation in Rivers by Navigation Barrages in the Case of Small Heads]. Taking advantage of the information relating to older navigation barrages, we have looked at the evolution of modern barrages with electro-mechanical command systems. For low heads (3 to 5 m), we suggest to build single element barrages, because of the use of an upper element reduces too much the stiffness of the barrage. Our study develops the concept of a single element barrage, which can be lifted and lowered, and which is applied to a segment gate. We present a draft project for a barrage with 3×30-meter spans and a 5-meter head. (Author abstract) In French, English. 4 refs.

Dehousse, N.M. (Univ de Liege, Liege, Belg); Rigo, Ph. *Bull Perm Int Assoc Navig Congr* n 57 1987 p 34-43.

**090454 OLD RIVER CONTROL AUXILIARY STRUCTURE; HYDRAULIC MODEL INVESTIGATION.** Model tests of the Old River Control Auxiliary Structure were conducted to investigate and develop a design that would provide satisfactory flow characteristics in the approach channel, at the abutments, over the spillway, in the stilling basin, and in the exit channel, and determine the adequacy of the riprap protection proposed for the approach and exit channels. The approach channel provided satisfactory flow to the spillway for all anticipated flow conditions. A design for the approach training walls was developed. Spillway discharge characteristics were determined for the following flow conditions: free uncontrolled flow, submerged uncontrolled flow, free controlled flow, and submerged controlled flow. Tests indicated that the downstream portion of the stilling basin training wall could be lowered for a length of 63 ft without impairing hydraulic performance. (Edited author abstract).

Fletcher, B.P. (NTIS, Springfield, VA, USA); Bhramayana, P. *Tech Rep US Army Eng Waterw Exp Sta* v HL-88 n 14 Jun 1988 111p.

**090455 NEW METHOD FOR THE CONTROL OF THE RIVER NILE.** This paper introduces a new stochastic control method, Extended Linear Quadratic Gaussian control, that appears to be particularly promising for the management of complex reservoir configurations such as the River Nile system. The method is introduced by means of a short case study related to the regulation of the Equatorial Lakes in the Nile basin. If the necessary data are available, the method can be easily adapted to the entire Nile system and used to investigate a variety of management issues. (Author abstract). 13 Refs.

Georgakakos, Aristidis P. (Georgia Inst of Technology, Atlanta, GA, USA); Marks, David H. *Int J Water Resour Dev* v 3 n 2 1987 p 133-141.

Danube See HYDROELECTRIC POWER PLANTS—Nagygyaros, Hungary.

Discharge See Also BRIDGE PIERS—Scour; DAMS, EMBANKMENT—Construction; FLOODS—Analysis; FLOODS—Tokyo, Japan; HYDROLOGY—Database Systems; RUNOFF—Estimation; STREAM FLOW; WATER POLLUTION—Control.

**090456 CROSS-CHANNEL MIXING AND ITS EFFECT ON SEDIMENTATION IN THE ORINOCO RIVER.** At high discharge, cross-channel mixing of water in the Orinoco River main stem requires several days and up to 500 km of downriver transit for completion. During mixing, substantial amounts of <0.063 mm sediment are lost from suspension. The water closest to the left bank appears to lose the most, probably by deposition onto the floodplain. This occurs in two ways. First, sediment-laden left-bank tributaries draining the Andes, such as the Apure, deposit sediment in distributary systems following impoundment by the Orinoco backwater. Second, when sediment-laden waters from the Andes actually join the Orinoco, the slow nature of cross-channel mixing causes the water and sediment to be confined more to the left side of the channel. (Edited author abstract) 20 refs.

Stallard, R.F. (Princeton Univ, Princeton, NJ, USA). *Water Resour Res* v 23 n 10 Oct 1987 p 1977-1986.

**090457 EFFECT OF LARGE-SCALE AFFORESTATION ON TARAWERA RIVER FLOWS.** Over 250 km<sup>2</sup> of the Tarawera catchment (906 km<sup>2</sup>) in the central North Island, New Zealand, was planted in pine forest between 1964 and 1981. This change has affected flow of the River Tarawera. Between 1964-81 annual, summer and winter Tarawera flows showed significant reductions of 10.9 m<sup>3</sup>/s, 11.4 m<sup>3</sup>/s and 9.6 m<sup>3</sup>/s respectively. Simple flow models for the Tarawera, and two neighboring catchments that had undergone little landuse change, showed that about 4.5 m<sup>3</sup>/s of these reductions, 13% of the mean flow over the calibration period, could be attributed to afforestation while the remainder was due to

decreased rainfall. The reduction attributed to afforestation was in accord with the results of small catchment studies. (Author abstract) 17 refs.

Dons, A. (Otago Catchment Board, Dunedin, NZ). *J Hydrol* v 25 n 2 1986 p 61-73.

**090458 SYNTHESIS OF MONTHLY FLOW DURATION CURVES FOR UNGAUGED WATERCOURSES.** Monthly flow duration curves (FDCs) were required to allow economic and financial analyses to be performed for small run-of-river hydro stations, unconnected with a regional electricity grid, where the output was used mainly for crop-processing. This Technical Note describes an empirical method for synthesizing monthly FDCs from limited hydrological data for small-catchment ungauged watercourses. The method involves comparisons on monthly rainfall on a limited number of gaging-station catchments with monthly rainfall on the ungauged catchments, and an assumption that the respective FDCs have the same shape. (Author abstract) 2 refs.

Wilson, E.M. (Univ of Salford, Engl). *Proc Inst Civ Eng (London)* v 83 pt 2 Sep 1987 p 637-641.

**090459 EVALUATION OF THE SLOPE-AREA METHOD FOR COMPUTING PEAK DISCHARGE.** An evaluation of 70 slope-area measurements on higher gradient streams (strength slopes greater than 0.002) throughout the United States showed that peak discharge measurements were affected by n-values, scour, expansion and contraction losses, viscosity, velocity distribution, unsteady flow, number of cross sections, state of flow, and stream slope. In many places, measurement error can be as great as, or can exceed, 100 percent, which leads to over-estimation of the actual peak discharge. This can result in misleading maximum flood values, flood-frequency analyses, and overdesign of flood-plain structures. A brief discussion of these problems, tentative solutions, and research needs is presented. The critical-depth method of computing peak discharge provides the most reasonable results in higher gradient streams. (Author abstract) 38 refs.

Jarrett, Robert D. *Geol Surv Water Supply Pap (US)* 2310 Dec 1986 p 13-24.

**090460 TOTAL LINEAR RESPONSE MODEL (TLR) AND THE LINEAR PERTURBATION MODEL (LPM).** In this paper, two models are introduced for the river forecasting system. One is named TLR, which is based on the assumption that the total rainfall and total discharge are related by a linear and time invariant system. The other one by the name of LPM is suggested for rivers whose seasonal variation is relatively predictable and in this model the series of departures from the normal (seasonal) behavior in rainfall and discharge are related by a linear and time invariant system. To date, these two models have been applied with promising results to a number of large rivers with single (or multiple) input and single output. The application of the TLR and the LPM to the Three Gorges catchment of the Changjiang (Yangtze) River yields successful results. (Author abstract) In Chinese. 5 refs.

Wen, Kang (Nanjing Research Inst of Hydrology & Water Resources, China); Liang, Gengchen. *Shuili Xuebao* n 6 1986 p 1-10.

**090461 DEBITMETRIE: PRECISION DES STATIONS DE JAUGEAGE.** [Discharge Measurements: Gaging Station Accuracy]. Gaging stations data are used in order to establish annual reports of river's discharge. These data are continuous records of water level and intermittent discharge measurements. From them are established stage-discharge curves for a given river. This operation involves many of uncertainties. The ways to fit such curves to the data and to estimate their accuracy in the discharge medium range are explored. The greatest uncertainties arise in the curve's extrema and with the curves fitting according to artificial or natural and



seasonal flow condition changes. Unfrequent gaging may lead to strong temporarily systematic errors. (Author abstract) 13 refs. In French.

Masson, J.M. (USTL, Montpellier, Fr); Ghio, M.; Lallement, Ch.; Parsy, C.; Philippe, J.P. *Houille Blanche* v 42 n 4-5 1987, Mes en Riviere et en Reseaux d'Assainissement, Situat Actuelle et Perspect - CR, Nov 26-27 1986, Fr p 333-338.

**090462 STUDY OF HYDRAULIC BEHAVIORS OF RIVER EFFLUENT AT CORIOLIS FORCE DOMINATING FIELD BY REMOTE SENSING.** River effluents discharged into coastal water zones around the Honshu Islands in Japan are visualized by Landsat data with a view to observe behavior extremely far from river mouths. Landsat data indicate that the effluents in this sea area are affected significantly by oceanic currents such as the Branch of the Tsushima Current in the Sea of Japan and the Kuroshio Current in the Pacific Ocean. In the Sea of Japan, the river effluents at the extremely far field have a tendency to flow north along the coastline. In the Pacific Ocean, large scale eddies, which are formed by interaction between various oceanic current systems, may entrain the coastal water masses in them. (Edited author abstract) 3 refs.

Onishi, Sotoaki (Science Univ of Tokyo, Noda, Jpn); Baba, Kyohel. *J Hydrosoci Hydraul Eng* v 5 n 1 Jul 1987 p 39-48.

**090463 LONG RANGE STREAMFLOW AND WORLD CONTINENTAL RUNOFF FLUCTUATIONS SINCE THE BEGINNING OF THIS CENTURY.** Fifty major rivers, distributed all around the world, have been selected and since the beginning of this century their mean annual discharge fluctuations have been studied by filtering methods. In the first part of this work, the authors determine what are the great hydroclimatic periods which have affected the different drainage basins. In the second part, the runoff fluctuations of each continent are reconstituted using the discharge fluctuations of some selected and representative rivers. Thus, the world continental runoff fluctuations are calculated by summing the fluctuations of the different continent runoffs. The world continental runoff is greatly influenced by the Asiatic Continent. Furthermore, North American and European runoffs fluctuate in opposition while South American and African runoffs present synchronous fluctuations. Additional aspects of the study are discussed. (Edited author abstract) 45 refs.

Probst, J.L. (Inst de Geologie, Strasbourg, Fr); Tardy, Y. *J Hydrol* v 94 n 3-4 Oct 30 1987 p 289-311.

**090464 INFLUENCE OF CHANNEL WIDTH ON BED LOAD TRANSPORT CAPACITY.** The influence of channel width on bedload capacity in river reaches of given slope, water discharge, and channel-bed material is examined. The view that transport capacity is a decreasing function of width is shown to be dependent upon an invalid premise. A contrary view - that transport capacity increases as channel width increases - is also considered. Conclusions based on the second view are shown to be inconsistent with transport formulas or are restricted to channels at a near-threshold state. The existence of an optimum width that maximizes capacity is demonstrated. This is a consequence of the nature of the relationship between bedload transport rates and flow intensity (notably a threshold condition) and of the relationship between flow resistance and depth. Expressions are derived for the optimum channel width and are shown to predict Gilbert's flume observations. Problems are considered in applying this approach to natural channels. (Author abstract) 30 refs.

Carson, Michael A. (McGill Univ, Montreal, Que, Can); Griffiths, George A. *J Hydraul Eng* v 113 n 12 Dec 1987 p 1489-1509.

**090465 DISCALC: A COMPUTER ALGORITHM FOR COMPUTING THE FLOW CHARACTERISTICS OF FLOOD DISCHARGES IN STREAM CHANNEL CROSS SECTIONS.** DISCALC is a com-

puter program that calculates uniform-flow characteristics of flood discharges within stream-channel cross sections. It eliminates computational bias by calculating hydraulic measures based on their precise mathematical definitions. The algorithm contains an iterative routine that converges on the desired discharge by changing the vertical position of the water surface within the stream-channel cross section. The program is capable of handling single thread as well as multithread channels. It also contains options for displaying results on a color monitor or a plotter. (Edited author abstract) 17 refs.

Rhoads, Bruce L. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA). *Comput Geosci* v 13 n 5 1987 p 495-511.

**090466 EFFECT OF RUNOFF VARIABILITY ON DEFORMATION OF ERODIBLE CHANNELS NEAR STRUCTURES.** At present a large number of works having a genetic basis are devoted to an analysis of channel transformations near engineering structures. However, as many natural phenomena, the fluvial process has also stochastic properties, and therefore also the stochastic basis should be used along with the genetic in its study. The stochastic component of the fluvial process is determined by the asynchronism of the transient flows of the liquid phase in the river channel and the solid phase in its bottom region. A study of processes of channel deformations from a stochastic standpoint makes it possible to prove that series of morphological characteristics have the property to lose correspondence with the initial hydrological series with respect to probability. Data of on-site observations were analyzed for an experimental confirmation of the foregoing. A bridge across a large river with a readily mobile channel (channel braiding) was selected as the object with complex hydrological and morphological conditions. 4 refs.

Zheleznyakov, G.V.; Pisarev, Yu.V. *Hydrotech Constr* v 21 n 4 Apr 1987 p 220-224.

**090467 CHANNEL DISCHARGE MEASUREMENT BY THERMODILUTION.** An investigation was conducted to determine the feasibility of applying thermomodulation technology to discharge measurements in small open channels. A series of tests were performed in which the time-temperature dilution curves were recorded and analyzed. The independent variables included the channel discharge, the injectate drop height, the volume of tracer, and the mixing distance. Flows ranged from 0.67 cfs to 2.45 cfs with Froude numbers less than 0.30. The results indicated that the thermomodulation technique is a feasible method for discharge measurement. An empirical expression was derived to determine the approximate mixing distance as a function of the flow depth. (Edited author abstract) 10 refs.

Wittler, Rodney J. (Colorado State Univ, Fort Collins, CO, USA); Abt, Steven R.; Sanders, Thomas G. *Water Resour Bull* v 23 n 6 Dec 1987 p 1109-1115.

**090468 ERRORS IN SLOPE-AREA COMPUTATIONS OF PEAK DISCHARGES IN MOUNTAIN STREAMS.** During an evaluation of 70 slope-area measurements on higher-gradient streams (stream slopes greater than 0.002) throughout the United States, peak discharge measurements were found to be affected by n values, scour, expansion and contraction losses, viscosity, unsteady flow, number of cross sections, state of flow and stream slope. Problems due to measurement error can often be as great as or greater than 100% and leads to overestimation of the actual peak discharge. This can result in misleading maximum flood values, erroneous flood-frequency analyses and overdesign of flood-plain structures. A brief discussion of these problems, tentative solutions and research needs is presented. The critical-depth method of computing peak discharge provides the most reasonable results in higher-gradient streams. (Author abstract) 30 refs.

Jarrett, Robert D. (US Geological Survey, Denver, CO, USA). *J Hydrol* v 96 n 1-4 Dec 15 1987 p 53-67.

**090469 STUDY OF RIVER REAERATION AT**

**DIFFERENT FLOW RATES.** The lower Tarawera River in New Zealand is a fast-flowing, turbulent water body that is used for the disposal of wood-pulp mill wastes. A number of gas tracer measurements are carried out to measure the reaeration coefficient,  $K_2$ , at different flow rates. The magnitudes of the results are best described by energy dissipation models. Such models are better able to describe reaeration in turbulent waters having appreciable surface disruption. Results show that  $K_2$  decreases slightly, but significantly, as flow rate increases and that this trend is better described by a surface renewal model than by energy dissipation models. The trend with flow is incorporated into the energy dissipation model by using nonlinear regression to develop an expression for the escape coefficient that is a function of the flow rate. (Edited author abstract) 30 refs.

Wilcock, Robert J. (Ministry of Works & Development, Hamilton, NZ). *J Environ Eng* v 114 n 1 Feb 1988 p 91-105.

**090470 CALCULATING BED LOAD DISCHARGE IN UNSTUDIED RIVERS DURING LOW FLOW PERIOD.** Based on the graphic method of identifying ridges of different orders of magnitude in the structure of the bottom relief, we can determine bed forms which constitute the main form of transport of bed load during the low flow period. The parameters of the bed forms are functions of the size of the rivers, calculated by the arbitrary dichotomy scheme of E.A. Chernykh. With an increase in the size of the stream the height increases and the rate of movement of ridges of a given size decreases. Empirical dependences are obtained for calculating these ridge characteristics. They are the basis for determining the bed load discharge in unstudied segments of rivers. (Author abstract) 6 refs.

Alekseevskii, N.I.; Gaikovich, A.B. *Sov Meteorol Hydrol* n 8 1987 p 80-85.

**090471 METHOD OF CALCULATING REFORMATIONS OF BRAIDED RIVER BEDS WITH VARIABLE HYDROLOGICAL CONDITIONS.** The method is based on the use of hydrological-morphometric dependences. The magnitude of channel-forming discharge, which is part of them, is calculated by the method of N.I. Makkaveev, which considers the variation of the water regime through the transformation of the discharge frequency curve. The method considers the redistribution of discharge among arms upon a change in their morphometric characteristics. Calculation of the reformation of a segment of the lower course of the Yenisei R. is presented as an example. (Author abstract) 10 refs.

Alabayan, A.M.; Sidorchuk, A.Yu. *Sov Meteorol Hydrol* n 10 1987 p 65-70.

**090472 COMPUTATION OF RIVER FLOW AND BED-LOAD TRANSPORT.** The George Washington University (GWU), Washington, D.C. and the Research Centre for Water Resources (VITUKI), Budapest, undertook a joint research project in cooperation between the U.S. National Science Foundation and the Hungarian Academy of Sciences. This joint research project, 'Computation of River Flow and Bed-load Transport' was conducted in the period 1983 to 1986. This report summarizes the main results of the project. Using a step-by-step method of computation of flow and bed-load transport, a full description of river channel changes becomes feasible, provided no transverse water and sediment flows occur (basically straight channels are assumed). The verification and application of the developed method were performed by using the observed data for the Danube and Raba Rivers in Hungary. 27 refs.

Alfoldi, Laszlo (Research Cent for Water Resources Development, Budapest, Hung); Szollosi-Nagy, Andras. *VITUKI Kozl* 46 1987 115p.



**090473 SOME CONSIDERATIONS CONCERNING THE OPTIMAL CALCULATION OF STAGE-DISCHARGE FUNCTIONS.** Different methods of the computation of curves describing the relation between stage and discharge of a river profile are discussed. Using several measurements of passed years one tries to compute such curves as close to reality as possible. This information is needed for the purpose of water conservation and water supply and the objective of optimal operation of power plants. (Edited author abstract) 4 refs.

Zarzer, E.A. (Oberösterreichische Kraftwerke AG, Linz, Austria). *Z Oper Res Ser B* v 31 n 6 1987 p 193-212.

**090474 RIVER FLOW FORECASTING FOR MULTIPLE TIME PERIODS.** The performance of a river flow forecasting model employing a Kalman filtering algorithm was evaluated for increasing forecast lead times. The expected decrease in forecast accuracy was quantified and a decrease in forecast precision was noted for increased lead times. The merits of external estimates of meteorological inputs to the model were evaluated through an examination of different forecasting options. It was revealed that even noisy estimates of meteorological events improved the flow forecasts. (Author abstract) 7 refs.

Burn, Donald H. (Univ of Manitoba, Winnipeg, Manit, Can). *Can J Civ Eng* v 15 n 1 Feb 1988 p 58-65.

**090475 BEDFORM LENGTH AND VELOCITY PULSATIONS IN ALLUVIAL CHANNELS.** It is conjectured that the low-frequency turbulence in alluvial channels is engendered at the separation points of the large eddies in the lee of bedforms. These points are taken as the locations of point sources of pressure disturbances, and their influence throughout the flow region is determined using the normal-mode analysis of the linear hydrodynamic stability theory for inviscid fluids. The analysis predicts that the spatial rate of decay, with respect to depth, of the standard deviation of velocity fluctuations is closely related to the bedform length. The theoretical predictions are borne out reasonably well by the observed data. (Author abstract) 16 refs.

Mahmood, Khalid (George Washington Univ, Washington, DC, USA); Haque, Muhammad I. *J Waterway Port Coastal Ocean Eng* v 114 n 3 May 1988 p 315-330.

**090476 RIVER HYDROLOGICAL FORECASTS.** Discussed are the major stages of development of scientific research on developing and improving the method used to make river hydrological forecasts in the USSR during the Soviet era. The general concepts which form the basis of modern methods of hydrological forecasts and problems of their development in the near future are discussed. (Author abstract)

Zhidikov, A.P. (Hydrometeorological Scientific Research Cent of the USSR, USSR); Koren, V.I. *Sov Meteorol Hydrol* n 11 1987 p 1-7.

**090477 MODEL OF RIVER FLOW FORECASTING FOR A SMALL FORESTED MOUNTAIN CATCHMENT.** A model for quantitatively expressing the hydrological cycle in a forested mountain catchment is proposed as a HYCYMODEL. HYCYMODEL is able to predict both short- and long-term hydrographs because the model parameters remain independent of time. It shows a good applicability for ten years of continuous data at both hourly and daily intervals for the Kiryu catchment - a forested mountain basin. Since HYCYMODEL does not need hydrograph separation between storm flow and base flow, it is a particularly attractive model. (Author abstract) 52 refs.

Fukushima, Yoshihiro. *Hydrol Processes* v 2 n 2 Apr-Jun 1988 p 167-185.

**090478 EFFECT OF THE CROSS-SECTIONAL SHAPE OF A CANAL ON THE PARAMETERS OF STEEP TRAVELING SURGES.** Steep traveling surges in canals and rivers are formed upon a comparatively rapid change in the discharge of water at the starting or

end site. This is due to opening or closing of gates, change in the operating regime of a hydroelectric station or pumping station, emptying of lock, etc. In an extreme case steep surges of increased intensity are formed upon failure of a dam or other water-impounding structure. The shallow-water wave forming, depending on the rate of change in the discharge at the site and distance from the site, can be discontinuous (in the form of a moving hydraulic jump, which is usually called a bore) or continuous (in the form of a positive surge or negative surge). An analytical solution to reveal completely the degree of effect of the cross-sectional shape of a canal or river on the surge parameters, is presented. 4 refs.

Mishuev, A.V. *Hydrotech Constr* v 21 n 8 Aug 1987 p 447-455.

**090479 STEELE BAYOU GRAVITY CONTROL STRUCTURE VICKSBURG, MISSISSIPPI.** A hydraulic model was used to evaluate various schemes to eliminate the severe turbulence and eddies that have caused drastic erosion problems downstream of the Steele bayou drainage structure. Significant bottom scouring and bank sloughing have occurred during the outflows following spring floods. The study was conducted to develop a solution for the excessive scour in the channel reach between Mississippi Highway Bridge No. 465 and the Steele Bayou structure where a 40-ft-deep by 600-ft-wide scour hole developed in the prototype. The longitudinal dikes, recommended as a result of the model tests, were installed in 1985 and have performed well through a period of relatively high water. (Author abstract).

Fenwick, W.B. (USAWEWS Hydraulics Lab, Vicksburg, MS, USA). *Tech Rep US Army Eng Waterw Exp Stn* v HL-88 n 12 Jun 1988 var paging.

**090480 ALLUVIAL CHANNEL HYDRAULICS.** The regime of any conveyance channel in alluvium depends on the interrelationships of sediment transport, channel resistance and bank stability. The regime concept was originally based on empirical relations. In more recent years the empiricism of the original method has been replaced by process-based methods. The empirical approach to the hydraulics of alluvial channels has been updated by physically based formulae for sediment transport and resistance. Physical modelling using scaled down representations of rivers and estuaries has been used for almost a century, but it requires the correct simulation of the relevant processes. The coming of a better understanding of the physics of sediment transport and the complexity of alluvial channel roughness leads to the conclusion that only in very restricted circumstances can scale models simulate closely the full-size condition. However, the quantification of these processes has been instrumental in the development of computational models which avoid such 'scale effects'. (Edited author abstract). 40 Refs.

Ackers, Peter. *J Hydrol* v 100 n 1-3 Jul 30 1988 p 177-204.

## Diversion

**090481 BASIC HYDROLOGIC STUDIES FOR ASSESSING IMPACTS OF FLOW DIVERSIONS ON RIPARIAN VEGETATION: EXAMPLES FROM STREAMS OF THE EASTERN SIERRA NEVADA, CALIFORNIA, USA.** This article describes methods for collecting relevant hydrologic data, and reports the results of such studies on seven stream reaches proposed for hydroelectric development in the eastern Sierra Nevada, California, USA. The methods described are: (a) preparing geomorphic maps from aerial photographs, (b) using well level records to evaluate the influence of streamflow on the riparian water table, (c) taking synoptic flow measurements to identify gaining and losing reaches, and (d) analyzing flow records from an upstream-downstream pair of gages to document seasonal variations in downstream flow losses. In the eastern Sierra Nevada, the geomorphic influence on hydrology and riparian vegetation were pronounced. Examples of which are discussed in the article. 19 refs.

Kondolf, G. Mathias (Johns Hopkins Univ, Baltimore, MD, USA); Webb, J. Warren; Sale, Michael J.; Felando,

Thomas. *Environ Manage* v 11 n 6 Nov 1987 p 757-769.

**090482 EFFECTS OF DIVERSIONS ON THE NORTH AMERICAN GREAT LAKES.** A research project evaluated the effects of interbasin diversion on the Great Lakes system and on the industries that depend on the maintenance of historical water levels, namely hydropower and commercial navigation. The simulation approach employed in this research and some of the important findings are presented. The approach is similar to that used in recent government studies of Great Lakes water level regulation. Several significant modifications were made specifically addressing the diversion issue. Aggregate annual impacts to hydropower and shipping resulting from a diversion of 10,000 cubic feet per second were found to vary from 60 to 100 million dollars. Increases in impacts as a function of diversion rate are nonlinear for the navigation industry. (Edited author abstract) 10 refs.

David, Martin H. (Univ of Wisconsin, Madison, WI, USA); Joeres, Erhard F.; Loucks, Eric D.; Potter, Kenneth W.; Rosenthal, Stuart S. *Water Resour Bull* v 24 n 1 Feb 1988 p 141-148.

**Dredging** See Also DREDGES—Applications.

**090483 SEDIMENTATION OF DREDGING CUTS IN SAND BOTTOM RIVERS.** Dredging cuts made in navigable rivers of the USSR when spring flood waters are subsiding, are subsequently sedimented again and dredging operations are required to be repeated. This article deals with some factors causing sedimentation of cuts and states that the main one is the flowing in of soil from lateral slopes of cuts being flattened. A mathematical model of the sedimentation process of cuts based on the analogy between the above process and those of diffusion and heat propagation is shown. The intensiveness of sedimentation is governed by the river sediments discharge. A method of sedimentation forecasting enabling one to calculate the course of cut sedimentation, is worked out. (Author abstract)

Grishanin, K.V. (Leningrad Water Transport Inst, USSR); Lavgyn, A.M. *Bull Perm Int Assoc Navig Congr* v 59 Oct-Dec 1987 p 50-55.

**090484 LOWER MISSISSIPPI RIVER PROJECT BEGINS.** Author describes the project to deepen the Mississippi River Ship Channel from 40 feet to 45 feet, from the Gulf of Mexico to mile 181 near Donaldsonville, Louisiana. Cutterhead contracts, cost sharing and fresh water supply plan are also described.

Anon. *World Dredging Mar Constr* v 23 n 8 Aug 1987 p 4-5.

**090485 TEXAS FIRM FIGHTS BRAZOS RIVER AT S&G DREDGING OPERATION.** Author describes the dredging operation conducted at the Brazos River in Texas. Continually vascillating currents and river elevations of the Brazos river presented a challenge for the company in their sand and gravel dredging operation.

Anon. *World Dredging Mar Constr* v 23 n 9 Sep 1987 p 16-18.

**Ecology** See Also HYDROELECTRIC POWER PLANTS—Construction; SEWAGE TREATMENT PLANTS—Effluents; WATERSHEDS—Management.

**090486 PROBLEMS OF MONITORING THE ENVIRONMENT OF THE SHALLOW NEARSHORE ZONE OF THE VOLGA MOUTH.** The natural conditions of the shallow Volga nearshore zone and adjacent shallow part of the North Caspian are decisive for the migration, spawning, and foraging of young valuable fish species and for maintaining the ecosystems of the Astrakhan biosphere reserve located in the Volga mouth. Among the main problems of monitoring the natural conditions of this region are monitoring of the dynamics of the drainage network, flooding of the delta shoreline, dynamics of the overgrowth of the mouth nearshore zone



by macrophytes, regime of the currents, water quality, biological productivity, etc. The Institute of Water Problems, Academy of Sciences of the USSR, is systematically elaborating scientific and methodological problems of monitoring (including cartographic) the mouth regions of rivers. The methodological basis of investigating the natural environment of river mouths is the combined use of data of on-site observations, aircraft and satellite multispectral photographs, and other remote-sensing observations. Its possibilities for the Volga mouth are discussed in this paper. 9 refs.

Krasnozhan, G.F. (Acad of Sciences of the USSR, USSR); Konyushko, V.S. *Water Resour* v 14 n 1 Jan-Feb 1987 p 41-46.

**090487 ASSESSING FLUSHING-FLOW REQUIREMENTS FOR BROWN TROUT SPAWNING GRAVELS IN STEEP STREAMS.** The authors evaluated flushing flows on reaches proposed for hydroelectric diversions on seven streams in the eastern Sierra Nevada, California, with wild populations of brown trout (*Salmo trutta*). Methods for estimating flushing flows from flow records, developed from studies in other localities, produced widely differing results when applied to the study streams, probably reflecting differences in the hydrologic and geomorphic characteristics of the streams on which the methods were developed. Tracer gravel experiments demonstrated that all sampled gravels were washed out by the flows of 1986, a wet year. Size analyses of gravel samples and hydraulic data from field surveys were used in tractive-force calculations in an attempt to specify the flow required to flush the gravels. Results suggest that the tractive-force approach may not be generally applicable to small, steep streams where nonuniform flow conditions prevail. (Edited author abstract) 27 refs.

Kondolf, G.M. (Johns Hopkins Univ, Baltimore, MD, USA); Cada, G.F.; Sale, M.J. *Water Resour Bull* v 23 n 5 Oct 1987 p 927-935.

**Ecosystems** See Also ECOLOGY—Environmental Testing; WATER POLLUTION—Water Quality; WATER-SHEDS.

**090488 PHYTOPLANKTON BIOMASS AND PRODUCTION IN THE RIVER MEUSE (BELGIUM).** The biomass and production of the phytoplankton in a relatively unpolluted reach of the River Meuse (Belgium) were followed through two years (1983 and 1984). Chlorophyll *a* varied from 0.2 to about 120 mg m<sup>-3</sup>, and production ranged between 0.05 and 5.78 gC m<sup>-2</sup> d<sup>-1</sup>. The mean photosynthetic quotient (PQ) was 1.25. The parameters of the light-photosynthesis relationship ( $P_{opt}$  and  $I_k$ ) were calculated and related to the variations of temperature and light in the water column. A simple model allowed calculations of the annual production, which was estimated to be 494 gC m<sup>-2</sup> yr<sup>-1</sup> in 1983 and 547 gC m<sup>-2</sup> yr<sup>-1</sup> + U 1 in 1984. Finally, a simple model is developed, which explains the relationship between phytoplankton development and discharge. (Edited author abstract) 27 refs.

Descy, J.-P. (Facultes Univ, Brussels, Belg); Servais, P.; Smits, J.S.; Billen, G.; Everbeco, E. *Water Res* v 21 n 12 Dec 1987 p 1557-1566.

## Energy Resources

**090489 ROLE OF SMALL HYDROELECTRIC STATIONS IN THE RATIONAL USE OF SMALL RIVERS.** The construction of small hydrostations as part of multipurpose water-management systems is planned on the basis of technical and economic calculations with consideration of the requirements of all participants of the complex. The construction of hydrostations on small rivers in mountain regions is most expedient; at the same time it is necessary to cautiously approach the problem of mass construction of small hydrostations on plains, which is related to comparatively large flooding of fertile floodplain lands, siltation of reservoirs, and other undesirable consequences. The construction of small hydrostations can become one of the integral parts of the approach to solving the problem of the most rational use of water

resources of small rivers. 10 refs.

Velikanov, A.L.; Zakachurina, E.V. *Hydrotech Constr* v 21 n 2 Feb 1987 p 108-112.

**Energy Utilization** See TURBOMACHINERY—Water Supply.

**England** See FLOOD CONTROL; FLOOD CONTROL—Mathematical Models.

## Environmental Testing

**090490 EVALUATION OF SIZE-DISTRIBUTION EFFECTS AND LABORATORY PRECISION IN THE ANALYSIS OF BOTTOM MATERIALS.** Bottom-material samples were collected at two sites on the Cuyahoga River in Cuyahoga and Portage Counties, Ohio. Multiple samples were collected from one cross section at each site and separated into three fractions based on particle size. Significant differences in metal concentrations were observed within cross sections as well as between sites. The coefficient of variability within the cross-sections decreased as the particle size decreased in the analyses for chromium, copper, iron, and lead, whereas the variability remained constant for manganese and zinc. Metals concentrations, however, generally increased as particle size decreased. An 'index of discrimination' indicated that the less than 20-micrometer fraction was superior for detecting between site-differences in concentrations of metals in the bottom materials. Additional study results are discussed. (Edited author abstract) 14 refs.

Helsel, Dennis R.; Koltun, Gregory F. *Geol Surv Water Supply Pap (US)* 2310 Dec 1986 p 1-11.

**090491 STABILITY OF RHODAMINE WT DYE IN TRIAL STUDIES OF SOLUTE TRANSPORT IN AN ACIDIC AND METAL-RICH STREAM.** Rhodamine WT and sodium chloride were concurrently injected for a period of 24 hours into the naturally acidic water of the Snake River (Montezuma, Colo.). Spatial variations in the concentrations of chloride, sodium, sulfate, and fluoride were observed. The variations are slight; however, they are qualitative indicators of inflow and (or) reactivity in this metal-rich stream. Water samples collected for rhodamine WT determination were stored for several days before analysis. A decrease in fluorescence associated with the water chemistry occurred in the samples obtained in the Snake River above the confluence with Deer Creek. Results obtained in batch experiments support the conclusions of the solute-transport experiment. The apparent stability of the rhodamine WT was time dependent and related to the location of the course of the bulk water from the stream and to whether or not the dye was added immediately after collection of the bulk water. (Edited author abstract) 11 refs.

Bencala, Kenneth E.; McKnight, Diana M.; Zellweger, Gary W.; Goad, Julie. *Geol Surv Water Supply Pap (US)* 2310 Dec 1986 p 87-85.

**090492 DEVELOPING MANAGEMENT GUIDELINES FOR RIVER NITROGENOUS OXYGEN DEMAND.** Incubation studies were used to evaluate the possibility of modeling, the effect of nitrification on river DO. Planktonic nitrification could be modeled by the Monod growth equation. Best-fit Monod parameter estimates showed that planktonic nitrification significantly depletes DO only if reoxygenation coefficient (base *e*) is less than 4 day<sup>-1</sup>, ammonium exceeds 1.5 g/m<sup>3</sup>, and travel times exceeds approximately 9 days. A reliable model of benthic nitrification can only be obtained if a corroboration survey is carried out at a markedly different ammonium load from the initial calibration survey. The wide range in reported decay coefficients and nitrification rates precludes reliable predictions of new ammonium discharge effects on river DO. (Author abstract) 27 refs.

Cooper, A. Bryce. *J Water Pollut Control Fed* v 58 n 8 Aug 1986 p 845-852.

**090493 BENTHIC CHAMBER FOR USE IN RIVERS: TESTING AGAINST OXYGEN MASS BAL-**

ANCES. An in situ benthic chamber has been developed in order to measure rates of respiration and photosynthesis in rivers. Oxygen mass balances for three rivers show satisfactory agreement between chamber and calculated net benthic oxygen uptake rates (BUR) by matching chamber and river boundary velocities (each measured 0.05 m above bed). The BUR is a function of the flow velocity of the overlying water, with both sewage fungus biofilms and pumice sediments each showing a large positive response and approximately linear relationship to velocity over the range studied. Measurements of the oxygen mass transfer coefficient for the air-water interface of an inverted chamber showed that the response to flow velocity was not significantly different from that predicted using the D.J. O'Connor-W.E. Dobbins formula. (Edited author abstract). 53 Refs.

Hickey, Christopher W. (Ministry of Works & Development, Hamilton, NZ). *J Environ Eng* v 114 n 4 Aug 1988 p 828-845.

**090494 RELATIONSHIP BETWEEN GLACIAL GEOLOGY AND STREAMWATER CHEMISTRY IN AN AREA RECEIVING ACID DEPOSITION.** Seventy streams in southwestern New York State were sampled in June and again in December. Streamwater chemistry proved to be closely associated with glacial geology. Streams in glaciated area watersheds had higher pH, alkalinity, calcium, and conductivity values than streams in unglaciated area watersheds. Within the glaciated area, streams of the Kent Drift Sheet had higher alkalinity, calcium, and conductivity values than streams of the Olean Drift Sheet. Streamwater sulfates were also analyzed in December, and were found to be highest in the Kent Drift Sheet. Glacial geology of a watershed is well predicted by discriminant analysis of streamwater chemistry data. Additional buffering capacity provided by glacial till appears to override sulfate adsorption considerations in making the glaciated area streams less susceptible to atmospheric acid deposition. (Author abstract). 17 Refs.

Phillips, Roberts A. (State Univ of New York at Buffalo, Buffalo, NY, USA). *J Hydrol* v 101 n 1-4 Jun 30 1988 p 263-273.

**Erosion** See BRIDGE PIERS—Scour; INLAND WATERWAYS—Erosion.

**Estuaries** See Also CHLOROPHYLL—Remote Sensing; COASTAL ZONES—Sedimentation; FISHERIES—Equipment; FLOW OF WATER—Turbulent; MARINE BIOLOGY; TIN COMPOUNDS—Environmental Impact; WATER POLLUTION—Analysis; WATER POLLUTION—Oil Spills; WATER POLLUTION—Pesticide Effects; WATER POLLUTION—Radioactive Materials; WATER RESOURCES—Salt Water Intrusion.

**090495 SINK OR DRAIN: A SIMULATION STUDY OF FACTORS AFFECTING THE ROLE OF AN ESTUARY SUBJECT TO TOXIC INPUTS.** In response to a shift in its mean influx, the concentrations of a refractory substance in an estuary will tend from some initial steady state (subject to environmentally induced variation) to a new level. In the 32 km Tamar Estuary, a partly-mixed estuary in southwest England, the timescale of this transition appears to be <10-20 years. The present paper describes the use of a published numerical model of pollutant dispersal in the estuary to investigate the dependence of this evolution on the mean levels and variation in space and time of the physical and chemical determinants of the system. (Author abstract) 6 refs.

Harris, J.R.W. (Inst for Marine Environmental Research, Plymouth, Engl). *Water Res* v 21 n 8 Aug 1987 p 975-981.

**090496 PLUTONIUM AND CESIUM RADIONUCLIDES IN SEDIMENTS OF THE SAVANNAH RIVER ESTUARY.** A study was made of the <sup>239</sup>Pu, <sup>240</sup>Pu, <sup>238</sup>Pu and <sup>137</sup>Cs concentration in tidal marsh sediments of the Savannah River estuary. Tidal marshes are identified as special locations for plutonium deposition because of the high biological productivity and relative stability of sediments as compared to channel sediments.



The  $^{239,240}\text{Pu}$  deposition averaged  $3.2 \text{ mCi km}^{-2}$ , which is higher than land-based fallout value of about  $2 \text{ mCi km}^{-2}$ . The  $^{239,240}\text{Pu}$  to  $^{137}\text{Cs}$  ratio was about three times higher than fallout deposition estimates, indicating a more rapid desorption of  $^{137}\text{Cs}$  from sediment in the saline waters of the area. (Author abstract) 8 refs.

Hayes, David W. (DuPont, Aiken, SC, USA); Sackett, William M. *Estuarine Coastal Shelf Sci* v 25 n 2 Aug 1987 p 169-174.

**090497 TURBULENT PERTURBATIONS OF VELOCITY IN THE CONWY ESTUARY.** Field measurements of the vertical and horizontal components of fluid velocity  $0.43 \text{ m}$  above the bed have been made with an electromagnetic flowmeter in a partially mixed reach of the Conwy estuary for parts of a flood and an ebb tide. The turbulent mean velocity and density fields showed different effects for flood and ebb tides caused by the interaction of shear and the longitudinal density gradient. The turbulent velocity parameters were generally dominated by bed-generated turbulence effects, but significant longer period contributions attributed to the shear-density interactions showed good agreement. (Edited author abstract) 24 refs.

Shiono, K. (Univ of Birmingham, Birmingham, Engl); West, J.R. *Estuarine Coastal Shelf Sci* v 25 n 5 Nov 1987 p 533-553.

**090498 HEPATITIS A VIRUS AND POLIOVIRUS 1 INACTIVATION IN ESTUARINE WATER.** The present report deals with experiments on the stability of hepatitis A virus and poliovirus 1 under different conditions in water from the estuary of Rio Martino which is a canal receiving municipal and industrial waste. The hepatitis A virus (HAV) and poliovirus 1 were added to estuarine water samples and their stability in maintenance medium was compared to that in water samples untreated and treated by heat and filtration. The inactivation curves show that the inactivating factor is biological in nature. (Edited author abstract) 15 refs.

Patti, A.M. (II Univ Tor Vergata, Rome, Italy); Santi, A.L.; Gabrieli, R.; Fiamma, S.; Cauletti, M.; Pana, A. *Water Res* v 21 n 11 Nov 1987 p 1335-1338.

**090499 ANALYSIS OF THE COASTLINE SHIFTING AROUND THE ESTUARY OF THE YELLOW RIVER.** Based on observed data, a map of high-tide coastline shifts is made for the area around the estuary of the Yellow River, from which the shifting of coastline in the delta area, the land formation through sedimentation, the extension of spits and the coastline retreats are studied. With regard to macroscopic aspects, the effect of extension on the lower reaches of the river has been discussed, and some suggestions are presented with respect to the improvement of the area around the Yellow River Estuary. (Edited author abstract) 1 ref.

Hong, Shangchi (Yellow River Conservancy Commission, Zhengzhou, China); Wu, Zhiyao. *China Ocean Eng* v 1 n 2 May 1987 p 55-66.

**090500 COMPUTATION OF SEDIMENT CONCENTRATION IN THE QIANTANG ESTUARY WITH CONSIDERATION OF SEDIMENT TRANSPORT IN TIDAL FLAT.** The authors discuss a wide tidal flat in the Qiantang Estuary. In this article the sediment concentrations in the mainstream and on the tidal flat are computed separately, taking into account the transverse exchange of sediment between them. The ratio of the bottom sediment concentration to the vertical average is not taken as the same to the ratio of sediment transport capacity. The ratio of sediment concentration can be determined by the computational results of a simple model and checked by the field data. The formula of the sediment transport capacity for tidal flow can be obtained by statistical analysis directly using the measured values of sediment concentration. The verification of sediment concentration has been carried out with two sections both in the mainstream and on the tidal flat during twelve successive tidal cycles. The average discrepancy between the calculated and the measured is less than

20%. (Edited author abstract) 6 refs.

Han, Zengcui (Zhejiang Provincial Inst of Estuarine & Coastal Engineering Research, Hangzhou, China); Hangping, Chen. *China Ocean Eng* v 1 n 2 May 1987 p 76-90.

**090501 POTENTIAL EFFECTS OF DREDGING ACTIVITIES AND INCREASED SILT LOAD ON THE ST. LUCIA SYSTEM, WITH SPECIAL REFERENCE TO TURBIDITY AND THE ESTUARINE FAUNA.** Turbidity regimes within the St. Lucia Estuary were investigated over a period of three and a half years. At the same time the potential effects, in terms of increased turbidity and silt load, of the Umfolozi River/St. Lucia Estuary Link Canal were assessed. The possible effects on the fauna of the system are further emphasized by comparison with the effects of dredging on estuarine faunas in other parts of the world. Recommendations are put forward suggesting that impact studies be undertaken before the Link Canal is fully inaugurated. Impact studies should also be carried out to determine the effects of continued dredging on the estuary. (Author abstract) 25 refs.

Cyrus, D.P. (Univ of Zululand, Natal, S Afr); Blaber, S.J.M. *Water SA* v 14 n 1 Jan 1988 p 43-47.

**090502 JOINT PROBABILITY DISTRIBUTION OF STREAMFLOWS AND TIDES IN ESTUARIES.** A procedure for estimating the joint probability of occurrence of correlated extreme tides and corresponding freshwater flows in estuaries is presented. The method uses the G.E.P. Box-D.R. Cox transformation to transform the original data to near normality, and therefore the search for a parent distribution is avoided. It is also shown that the traditional assumption of statistical independence for the jointly distributed random variables may lead to the underestimation of flows and tidal heights. The methodology is applied to the Rappahannock River in Virginia which flows into the Chesapeake Bay. (Author abstract) 12 refs.

Loganathan, G.V. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Kuo, C.Y.; Yannaccone, J. *Nord Hydrol* v 18 n 4-5 1987 p 237-246.

**090503 DEVELOPMENT OF MANUALLY USEABLE COMPOSITE MATERIALS FOR RIVER TRAINING WORKS IN HOOGHLY ESTUARY.** The training works in the Hooghly estuary required construction of spur walls in limited working season in a year with constraints regarding labour, materials and machinery and achieving stabilization of construction against onslaught of high current and wind. This paper describes some of the composite materials that have been evolved based on standpoints of local availability, economy, feasibility and rapidity of construction in time-bound working period with local labour and equipment. (Author abstract)

Mukherjee, M.K. (Calcutta Port Trust, Calcutta, India); Chaudhury, T.K. *J Inst Eng India Part CI* v 68 Jan 1988 p 167-171.

**090504 HYDROLOGY AND HYDRODYNAMICS OF THE ODRA ESTUARY WITH SPECIAL REFERENCE TO THE INFLUENCE OF WIND.** The article presents the factors which constitute the hydrology and hydromechanics of river mouths with special attention paid to the effect of wind, this being of great importance for the estuary of the Odra. Analysis of this phenomenon enabled to form a mathematical model of a tachoid with the influence of wind taken into account and to introduce it into the mathematical model of the Odra estuary in order to define the phenomenon of wind backwater. Technical aspects of wind backwater have been presented with special attention paid to the safety of navigation, protection of aquatic environment and flood protection. (Author abstract) In English and French. 10 refs.

Meyer, Zygmunt (Technical Univ of Szczecin, Pol); Buchholz, Wladyslaw. *Bull Perm Int Assoc Navig Congr* n 60 Jan-Mar 1988 p 64-76.

**090505 HYDRODYNAMIC CONDITIONS AND**

**SALINITY OF THE SWINA STRAIT AND THE SZCZECIN BAY.** The article describes certain characteristics of the Odra estuary and presents the various phases and the results of research carried out in this region during the last 40 years. In a more detailed manner, it presents the conditions and results of the expeditions performed in the years 1983 and 1985. The data obtained therefrom have made it possible to determine the prevailing hydrodynamic conditions and the salinity character of waters in the Swina Strait and the Szczecin Bay. The article also gives the results of theoretical analyses performed on the basis of ground surveys. Lastly, the authors describe the unsettled character of the velocity distribution in the Swina Strait, a fact which impedes navigation. (Author abstract) In English and French. 9 refs.

Jasinska, Ewa (Polish Acad of Sciences, Gdansk, Pol); Robakiewicz, Wojciech. *Bull Perm Int Assoc Navig Congr* n 60 Jan-Mar 1988 p 77-94.

**090506 MATHEMATIC MODEL OF THE RIVER ODRA ESTUARY.** A mathematical model of the Odra estuary, the aim of which is simulation of determined and undetermined processes in hydrodynamics of this estuary is presented. The dynamic phenomena at the mouth of the Odra being of importance in the economic human activity and the necessity of building such a model are discussed. Then the general idea of an aggregate model aimed at is described. In subsequent parts descriptions are given of the actual state - the construction and operation of the model of determined and undetermined motion in the river part of the Odra estuary and of the base of hydrological and meteorological information 'HIMOS'. The article is completed by examples of results obtained for the actual swells and by conclusions and suggestions regarding the further development of work in this field. (Edited author abstract) In English and French. 26 refs.

Ewertowski, Ryszard (Maritime Research Inst, Szczecin, Pol). *Bull Perm Int Assoc Navig Congr* n 60 Jan-Mar 1988 p 95-114.

**090507 LOWER JAMES RIVER CIRCULATION STUDY, VIRGINIA, EVALUATION OF CRANEY ISLAND ENLARGEMENT ALTERNATIVES.** This report presents results from the numerical model investigation whose primary objective was to assess general changes in circulation, currents, and sedimentation associated with six proposed alternative expansion geometries of the Craney Island confined disposal facility. An additional objective of the study was to assess the effects of each of the six alternative geometries on the reported estuarine circulation cell (flow convergence) off Hampton Flats and Newport News Point. This numerical model investigation used the TABS-2 finite element numerical models RMA-2V for hydrodynamics and STUDH for sedimentation with a modified version of an existing numerical mesh of the Lower James River. Other information presently available regarding the estuarine circulation and flow convergence observed off Newport News Point and Hampton Flats was reviewed. Results from the numerical sedimentation modeling showed that plan to base shoaling index values (plan-predicted sedimentation divided by base-predicted sedimentation) were all within 90 to 110 percent at the critical areas of interest. (Edited author abstract) 14 refs.

Heltzel, Samuel B. (USAEWES Hydraulics Lab, Vicksburg, MS, USA); Granat, Mitchell A. *Tech Rep US Army Eng Waterw Exp Stn* HL-88-8 Apr 1988 72p.

**090508 POTENTIAL EFFECTS OF DREDGING ACTIVITIES AND INCREASED SILT LOAD ON THE ST. LUCIA SYSTEM, WITH SPECIAL REFERENCE TO TURBIDITY AND THE ESTUARINE FAUNA.** Turbidity regimes within the St. Lucia Estuary were investigated over a period of three and a half years. At the same time the potential effects, in terms of increased turbidity and silt load, of the Umfolozi River/St. Lucia Estuary Link Canal were assessed. The possible effects on the fauna of the system are further emphasised by comparison with the effects of dredging on



estuarine faunas in other parts of the world. Recommendations are put forward suggesting that impact studies be undertaken before the Link Canal is fully inaugurated. Impact studies should also be carried out to determine the effects of continued dredging on the estuary. (Author abstract). 25 Refs.

Cyrus, D.P. (Univ of Zululand, Natal, S Afr); Blaber, S.J.M. *Water SA* v 14 n 1 Jan 1988 p 43-47.

**090509 INVENTORY OF TRAINING STRUCTURES IN ESTUARIES.** This report inventories training structures in estuaries. The ultimate goal of the research is to improve design guidance for the effective use of training structures in estuaries. This inventory is the result of literature and map surveys to determine what structures exist in the estuaries and is the first of three planned stages of research. Several structures will be selected for further detailed data retrieval. The structures will then be modeled in both a physical model (flume) and a numerical model. The resulting product will be a numerical method verified by prototype and physical model data to assist during the design stage for estuarine training structures. The method will also aid engineers in determining the effectiveness of existing structures. (Author abstract). 17 Refs.

Pankow, Walter (US Army Engineer Waterways Experiment Station, Vicksburg, MS, USA); Trawle, Michael J. *Tech Rep US Army Eng Waterw Exp Stn* v HL-88 n 20 Aug 1988 108p.

**090510 TEJO 1 - AN INTERACTIVE PROGRAM FOR THE DIVISION OF ESTUARIES INTO HOMOGENEOUS AREAS.** The division of an estuary into homogeneous areas from both hydrodynamic and ecological standpoints is essential to any estuarine basin management model. This paper presents an approach based on a heuristic algorithm to achieve such a division. The methodology implemented through an interactive computer program named Tejo 1 applies morphological, water quality and management criteria in order to achieve the disaggregation. The approach is equally applicable to river or lake basins, with only minor adaptations. An application of Tejo 1 to the Tejo estuary is included for illustrative purposes, which resulted in the final division of the estuary into 11 homogeneous areas. (Author abstract) 6 refs.

Camara, A.S. (New Univ of Lisbon, Monte da Caparica, Port); Cardoso da Silva, M.; Ramos, L.; Gomes Ferreira, J. *Water Sci Technol* v 19 n 9 1987, Dev in River Basin Manage, Proc of an IAWPRC Conf, Sao Paulo, Braz, Aug 13-15 1986 p 43-51.

**090511 TOWARDS CONTROL OF AN ESTUARY.** The Delta Project is in its final stage. In 1974 it was subjected to political reconsideration, but it is scheduled now for completion in 1987. This article focuses on the area with reduced tide and compares present day and expected characteristics. In this reduced tidal part salt marshes will extend by 30-70%; intertidal flats will erode to a lower level and at their edges, and the area of shallow water will increase by 47%. Biomass production on the intertidal flats will decrease, with consequences for crustaceans, fishes and birds. The operation of the storm-surge barrier and the closure strategy chosen are very important for the ecosystem. Two optional closure strategies can be followed without any additional environmental consequences. It was essential to determine a clearly defined plan of action for the whole area, and to make land-use choices from the outset. How this was done is briefly described. (Edited author abstract) 25 refs.

Saeijs, Henk L.F. (Ministry of Transport & Public Works, The Hague, Neth). *Water Sci Technol* v 19 n 9 1987, Dev in River Basin Manage, Proc of an IAWPRC Conf, Sao Paulo, Braz, Aug 13-15 1986 p 155-174.

Federal Republic of Germany See WATER SUPPLY—Water Quality.

Fluid Dynamics See FLOODS—Japan.

## France

**090512 EVOLUTION OF THE CHEMICAL COMPOSITION OF THE GARONNE RIVER WATER DURING THE PERIOD 1971-1984.** The evolution of the chemical composition of the Garonne River water was studied for the period 1971-1984. The large increases of  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{Cl}^-$  and  $\text{K}^+$  in the river water are related to a marked increase in fertilizer applications.  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  and  $\text{HCO}_3^-$  increases are not so evident. The coefficient of calcite saturation is too low to explain this change but rather it can be attributed to an increase in carbonate dissolution resulting from the nitrification of N fertilizers in the basin. A decrease in pH, more particularly during low flows, is attributed to oxidation of organic matter which is reflected by an increase in COD. (Edited author abstract) 22 refs.

Etchanchu, D. (Lab de Mineralogie et de Cristallographie, Toulouse, Fr); Probst, J.L. *Hydrol Sci J* v 33 n 3 Jun 1988 p 243-256.

## Friction

**090513 FRICTION FACTOR EVALUATION IN GRAVEL-BED RIVERS.** Field data gathered from 43 river reaches of Calabria (southern Italy) were employed to develop a theoretically based equation for predicting the f-friction factor that takes into account both the Froude number and the sediment mobility parameter. The river reaches investigated have: (1) reasonably uniform and relatively low flow; (2) no appreciable vegetation in the channel bed and banks; (3) a fully developed turbulent flow; (4) a friction slope greater than 0.2 percent; (5) small and intermediate scale roughness; (6) a mobility parameter greater than the critical value in more than 50 percent of the cases; and (7) a Froude number between 0.20-1.30. Statistical techniques were used to derive an equation for estimating f that takes into account the physical processes controlling flow resistance beyond the range of the collected data. (Author abstract). 40 Refs.

Colosimo, Carlo (Univ della Calabria, Italy); Copertino, Vito A.; Veltri, Massimo. *J Hydraul Eng* v 114 n 8 Aug 1988 p 861-876.

## Ganga River

**090514 MONITORING OF HEAVY METALS IN THE WATER AND SEDIMENTS OF THE GANGA RIVER, INDIA.** The concentrations of cadmium, cobalt, chromium, copper, iron, manganese, nickel, lead and zinc in the water and sediments of the Ganges river were determined by Atomic Absorption Spectrophotometry in the year 1981. The respective ranges of concentration of cadmium, cobalt, chromium, copper, iron, manganese, nickel, lead and zinc found in the water were ND-0.53, ND-4.89, 3.20-56.6, ND-27.57, 22.0-133.8, 35.0-93.0, ND-2.22, 2.0-5.6 and 7.37-67.36  $\mu\text{g/l}$  and in the sediments were ND-3.48, 2.35-14.4, 9.0-83.16, 11.27-95.0, 2168.0-11624.8, 110.5-470.0, 3.45-28.80, 0.55-21.8 and 72.0-418.6  $\mu\text{g/g}$ . The data showed that there was considerable variation in the elements from one sampling station to the other. The sediments collected from different sampling stations were also analyzed for pH, calcium carbonate, organic matter, potassium and phosphorus. (Author abstract) 36 refs.

Ajmal, Mohammad (Aligarh Muslim Univ, Aligarh, India); Khan, Mujahid A.; Nomani, Azhar A. *Water Sci Technol* v 19 n 9 1987, Dev in River Basin Manage, Proc of an IAWPRC Conf, Sao Paulo, Braz, Aug 13-15 1986 p 107-117.

Ganges River See WATER POLLUTION—India.

## Haut-Rhone, France

**090515 LE HAUT-RHONE FRANCAIS: GEOGRAPHIE HISTORIQUE ET GESTION D'UN FLEUVE.** [The French Haut-Rhone: Historical Geography and Management of a River]. This historical geographical

study concerns the River Rhone between Geneva and Lyon. Human relations with the fluvial environment and that part of human factors as regards the dynamics of fluvial change are studied. This study, this article merely being a summary, was awarded the Henri Milon's second prize in 1987 from the Societe hydrotechnique de France. (Author abstract) In French. 4 refs.

Bravard, J.P. (Univ Jean Moulin, Fr). *Houille Blanche* v 43 n 1 1988 p 45-52.

## Hungary

**090516 ZALA-VIZGYUJTO FAJLAGOS LEFOLYASIS VIZSZONYAINAK VIZSGALATA.** [Investigation of the Conditions of Specific Runoff in the Catchment of the Zala River]. With regard on existing gauging stations with longer observation periods, the catchment of the Zala river was divided into 6 sub-catchments. On the basis of multiannual average precipitation data the precipitation-runoff relationship was determined for each sub-catchment. The sub-catchments were then subdivided again and the values of specific average low-flow runoff were calculated based on low-flow measurements and estimates, and on the 'individual behaviour' of existing brooks. Finally, the runoff values - obtained by the different methods - were compared to each other and the following result could be drawn down: the error in the value of specific multiannual average runoff was 5 percent in case of the catchments with high runoff, and 15 percent with a small one, respectively. (Edited author abstract) 5 refs. In Hungarian.

Szilagy, Endre (NyDT VIZIG, Szombathely, Hung). *Vizgyi Kozl* v 69 n 1 1987 p 108-118.

Hydrology See Also WATER RESOURCES—Extraction.

**090517 REPRESENTATION OF FLOWS TO PARTIALLY PENETRATING RIVERS FROM LAYERED AND ANISOTROPIC AQUIFERS.** It has previously been shown that it is possible to represent the flow of water from a homogeneous, isotropic aquifer to a river or drain by using a Dupuit-Forchheimer groundwater flow model coupled with equations to calculate the magnitude of the flow to the river. This work has now been extended to include anisotropic and layered aquifers. Results obtained from two-dimensional free surface seepage models are used to assess the accuracy of the results from the Dupuit-Forchheimer models. It is shown that such models can be used to accurately estimate the flow to a river for a wide variety of situations. (Author abstract) 11 refs.

Miles, J.C. (Univ Coll, Cardiff, Wales). *J Hydrol* v 95 n 1-2 Nov 15 1987 p 113-129.

## Ice Formation

**090518 CHARACTERISTICS OF ICING OF THE WESTERN ZONE OF BAM DEVELOPMENT ACCORDING TO AERIAL AND SATELLITE DATA.** Discussed in the variation of icing of river basins in orographically identified regions of the Stanovoi highlands, the Vitim tablelands, and the Olekminskii Stanovik. Principles are identified in the variation of icing characteristics for various areas of river basins, on slopes of ranges of different exposure. The icing of basins of the Vitim and Olekma Rivers and the northern area of Lake Baikal. A map of water reserves in the ice (in mm) has been compiled from results from processing remote sounding materials. (Author abstract) 3 refs.

Abakumenko, A.E. *Sov Meteorol Hydrol* n 2 1987 p 72-76.

**090519 PERTURBATION BASED MODEL OF HEAT-INDUCED SUPPRESSION OF RIVER-ICE.** The discharge of tributary thermal effluents into cold region rivers may alter the thermal and hydrodynamic conditions of ice cover progression and create reaches of open water in the ice throughout the winter season. An analytical approach, based on perturbation techniques,



has been developed and tested concerning the suppression of ice cover and the migration of its fronts. The upstream and the downstream ice edges are determined for two cases of steady non-uniform flow. Conditions for the suppression of the ice cover are also obtained based on the relative positions of the upstream and downstream ice edges. Comparison with field data shows a good agreement with the formulation incorporating the thermal effluent velocity. (Edited author abstract) 12 refs.

Sarrafi, S. (Concordia Univ, Montreal, Que, Can); Saleh, W. *Nord Hydrol* v 18 n 4-5 1987 p 221-236.

## Improvement

**090520 RESTORATION OF HEAVILY POLLUTED BRANCHES OF THE SHATT AL-ARAB RIVER, IRAQ.** In view of the desire to improve the water quality of the heavily polluted branches of the Shatt al-Arab river at the City of Basrah, it was proposed to maintain effective flushing as well as contracting sewerage system. The present study was conducted in order to examine the water quality of these branches in an attempt to evaluate the effectiveness of the proposed flushing system. It has been found that their waters contained very low levels of dissolved oxygen and relatively high amounts of both COD and BOD<sub>5</sub>. Based on our calculations, it has been concluded that the proposed system is effective, thus within a flushing cycle all of the above mentioned parameters will become within the acceptable values of the Shatt al-Arab water quality. Moreover, this system has no appreciable effect upon the water quality characteristics of the Shatt al-Arab River due to the fact that it discharges a high volume of water annually. It has been recommended to dredge the deposited sludge to a minimum depth of 50 cm. (Edited author abstract) 8 refs.

DouAbul, Ali A.Z. (Univ of Basrah, Basrah, Iraq); Abaychi, Jamal K.; Al-Asadi, Manal K.; Al-Awadi, Haytham. *Water Res* v 21 n 8 Aug 1987 p 955-960.

## India

**090521 MEASUREMENT OF ADVENTITIOUS STREAMS IN YAMUNA-PAISUNI INTER-STREAM REGIONS (U.P. & M.P.), INDIA.** An attempt has been made to measure the adventitious streams of 20 drainage models of Yamuna-Paisuni inter-stream regions. These streams are caused by topographical and lithological variations as well as structural peculiarities of the region. The measurement has been done on the basis of the topographical sheet and the nature and characteristics of the stream are checked by field observation. (Edited author abstract) 1 ref.

Prasad, Govind (SGR Post-Graduate Coll, UP, India). *Modell Simul Control C* v 8 n 4 1987 p 61-64.

**090522 TEMPORAL, SPATIAL AND SIZE VARIATION IN THE SEDIMENT TRANSPORT IN THE KRISHNA RIVER BASIN, INDIA.** The total sediment transport of the Krishna River to the Bay of Bengal is estimated to be  $4.11 \times 10^6$  ton  $\text{yr}^{-1}$ . The sediment load decreases sharply from  $67.72 \times 10^6$  ton  $\text{yr}^{-1}$  from the upstream region (Morvakonda) to  $4.11 \times 10^6$  ton  $\text{yr}^{-1}$  at the river mouth (Vijayawada). The depletion of sediment supply in the river mouth and lack of uniformity in sediment transport within the basin is mainly due to several human activities. One of the tributaries of the Krishna, the Bhima River is the main sediment contributor to the Krishna. Erosion rate shows no systematic relationship either spatially or temporally. The total sediment erosion of the Krishna is estimated to be  $16 \text{ ton km}^{-2} \text{ yr}^{-1}$ . The particle size distribution of the suspended sediments were correlated with the mean monthly sediment transportation to evaluate the downstream and temporal variation of grain size with sediment transport. Additional study results are discussed. (Edited author abstract) 18 refs.

Ramesh, R. (Jawaharlal Nehru Univ, New Delhi, India); Subramanian, V. *J Hydrol* v 98 n 1-2 Mar 15 1988 p 53-65.

**090523 SEDIMENT TRANSPORT OF THE GODAVARI RIVER BASIN AND ITS CONTROLLING FACTORS.** The mean annual water flow and sediment transport of the Godavari River are estimated to be  $92 \text{ km}^3$  and  $170 \times 10^6$  ton (t), respectively. In terms of sediment transport and the rate of physical erosion ( $555 \text{ t km}^{-2} \text{ yr}^{-1}$ ), the position of the Godavari would be ninth and fifth respectively among the world rivers. Geology of the basin is the main controlling factor of the sediment transport. The sedimentary rocks located in the lower part of the basin and constituting 77 percent of the total basin area are responsible for 33 percent of the sediment load. More than 67 percent of sediment load is silt and clay. Annual, monthly and daily variations in sediment transport indicate that a few selected days in the hydrological year control the annual sediment budget. Our latest estimates are nearly twice that of our earlier values. The presently available global estimates on sediment transport need to be re-evaluated. (Author abstract) 35 Refs.

Biksham, G. (Jawaharlal Nehru Univ, New Delhi, India); Subramanian, V. *J Hydrol* v 101 n 1-4 Jun 30 1988 p 275-290.

## Italy

**090524 OSSERVAZIONI SULLA DINAMICA DI UN CORSO D'ACQUA TORRENTIZIO SUSEGUENTE UN EVENTO ALLUVIONALE.** [Observations on the Dynamics of Torrential Water Flow after a Flood Event]. After the flood of August 7, 1978 which took place in the Vigizzo Valley, situated in the most north-eastern part of Piedmont, the Melezzo Orientale river has undergone both transversal and longitudinal intervention to re-lay its bed. Work was carried out on the river's median section over a distance of about 3 kilometers. This summary reports on the river's behaviour after re-laying was completed and how it has responded to floods which have reached maximum levels comparable to the one in 1978. The influence that the environment has on the river's dynamics provides useful information for planning similar re-laying interventions of hydro-geological nature. (Edited author abstract) 19 refs. In Italian.

Quaglia, M. (Politecnico di Torino, Italy); Teslesca, P.; Fadda, M. *G Genio Civ* v 125 n 4-6 Apr-Jun 1987 p 97-111.

## James River

**090525 UPPER JAMES ESTUARY - A STUDY IN WATER QUALITY MANAGEMENT.** The major factors contributing to water quality problems below the City of Richmond stem from the intermittent discharge from combined sewer overflows (CSOs) coupled with the continuous discharge from the City's sewage treatment plant. The CSOs contribute a large quantity of soluble BOD, suspended solids, settleable solids, and fecal coliforms to the estuary. The City's sewage treatment plant continuously discharges large quantities of ammonia-nitrogen and phosphorus, in addition to BOD and suspended solids. Rational Management and use of the waters of the upper James estuary appear to be critical. The objectives of this paper are the discussion of the present water quality and the wastewater discharge reductions required in order to meet certain water quality and water use objectives. (Edited author abstract) 10 refs.

Das, K.C. (State Water Control Board, Richmond, VA, USA). *Water Sci Technol* v 19 n 9 1987, Dev in River Basin Manage, Proc of an IAWPRC Conf, Sao Paulo, Braz, Aug 13-15 1986 p 1-7.

## Japan See INLAND WATERWAYS—Ice Formation.

## Locks

**090526 GALLIPOLIS LOCK INTAKE VORTEX STUDY OHIO RIVER.** The existing Gallipolis Locks are located on the Ohio River at mile 279.2. Because of their location on an inside bend, the orientation for approach channels, velocity currents in the river, and the design of the approach walls, entry of downbound tows

into the lock is hazardous and time consuming during periods of high flow. As a result of increasing traffic and tow sizes, these locks will be constructed in the near future to alleviate these problems. Tests were conducted on a 1:25-scale model that reproduced 2,500 ft of the Ohio River beginning 188 ft upstream of the existing lock guide wall. This model was used to evaluate the performance of the intake structures for the new locks. (Edited author abstract)

Davidson, Robert A. (US Army Corps of Engineers, Vicksburg, MS, USA). *Tech Rep US Army Eng Waterw Exp Stn HL-87-17 Dec 1987 var pagings.*

## Management

**090527 MANAGEMENT OF THE RIVER RHINE.** The Rhine is an international river, which is being used for many different purposes such as drinking water supply, navigation, discharge of wastewater, fishing and recreation. Above all it is an important aquatic ecosystem and part of the environment and landscape. The question was how to manage such a river related to so many different interests and flowing through so many different countries? As in every management case, first of all the aim or goal should be set. The aim is to get the river clean and to maintain it that way, free from persistent toxic substances and generally of a quality which will allow healthy fish life (salmon) and recreation. The quality should be such that it allows for the preparation of healthy drinking water by natural processes, such as rapid and slow sand filtration. The water should not be heated by thermal pollution. This aim should be laid down in specific requirements valid for the whole Rhine catchment area and accepted by the riparian states.

Vander Veen, Cornelis (WRK Co, Neth). *Eur Water Sewage* v 91 n 1097 Jul 1987 p 286-289.

**090528 MANAGING AND ENGINEERING RIVERS FOR THE BENEFIT OF MAN.** From earliest times flood, famine and drought have been scourges of mankind. River engineers alleviate floods, drain the land for agriculture, and conserve water resources. They construct engineering works, guide planners and developers, and provide warnings to minimize damage caused by storms over catchments and coasts. As the country becomes more developed, problems of reconciling conflicting interests require a flexible approach. This paper examines ways of providing the basic services in a climate of increasing public clamour for wildlife and landscape protection, and recreation. (Author abstract) 15 refs.

Hockin, D.L. (North West Water, Engl); Whittle, I.R.; Bailey, R.A. *J Int Water Environ Manage* v 2 n 2 Apr 1988 p 151-158.

**Mathematical Models** See Also HYDRAULIC STRUCTURES—Computer Aided Design; WATER POLLUTION—Water Quality.

**090529 USE OF CURRENT METERS FOR CONTINUOUS MEASUREMENT OF FLOWS IN LARGE RIVERS.** Flows in the unregulated Great Lakes connecting channels, the St. Clair and Detroit Rivers, are normally determined using mathematical flow models with calibration based on periodic discharge measurements taken during the open-water seasons. Consequently, the calculated flows normally exhibit good accuracy during ice-free periods, but may contain large errors during winter months with extensive ice cover. The St. Clair River is particularly prone to large ice jams because of practically unlimited ice flow supply provided by Lake Huron and an extensive river delta that retards the passage of these ice flows. This study describes the experimental results of continuous flow measurements using electromagnetic (EM) current meters and an acoustic Doppler current profiler (ADCP) meter during 1983-1985 period. A record ice jam in the St. Clair River occurred in April 1984 and provided an excellent opportunity for testing the current meter program. Verification of current meter results was provided by flows transferred



from the Detroit River, which was ice-free and permitted accurate flow simulation. (Edited author abstract) 5 refs.

Derecki, Jan A. (NOAA, Ann Arbor, MI, USA); Quinn, Frank H. *Water Resour Res* v 23 n 9 Sep 1987 p 1751-1756.

**090530 IL MODELLO PARABOLICO DELL'EVOLUZIONE DEL FONDO DI UN CORSO D'ACQUA NATURALE. STUDIO DELL'EQUAZIONE DIFFERENZIALE A COEFFICIENTE COSTANTE. PARTE I.** [Parabolic Model of Evolution of a Natural Stream Bed. Study of a Differential Equation with a Constant Coefficient - I]. Evolution of the natural stream bed, formulated schematically to reflect a complex physical reality, is governed, as is well known, by a partial differential equation, similar to the heat transfer equation. The coefficient which is effectively constant in the latter equation has been retained constant also for the stream flow phenomenon by many researchers to make possible integration of the equation analytically. By using an analytical and numerical approach, it is shown that this coefficient can be considered constant with optimal approximation, and that its value, initial conditions being equal, depends on the final configuration attained by the water course which is the object of the altimetric evolution. Expressions for its evaluation are examined and orders of approximation are identified. (Edited author abstract). 11 Refs. In Italian.

Bianco, Gennaro (Politecnico di Torino, Turin, Italy). *Energ Elettr* v 65 n 4 Apr 1988 p 141-148.

**090531 IL MODELLO PARABOLICO DELL'EVOLUZIONE DEL FONDO DI UN CORSO D'ACQUA NATURALE. STUDIO DELL'EQUAZIONE DIFFERENZIALE A COEFFICIENTE COSTANTE. PARTE II.** [Parabolic Model of Evolution of a Natural Stream Bed. Study of a Differential Equation with a Constant Coefficient - II.]. In this second part of the study, giving up the hypothesis of  $\chi = \text{cost}$ , a new and very simple expression to calculate the coefficient K is derived. In addition, the relationship between the error made in calculating the bottom level and that relating the evaluation of the above mentioned coefficient is determined. (Edited author abstract). 21 Refs. In Italian.

Bianco, Gennaro (Politecnico di Torino, Turin, Italy). *Energ Elettr* v 65 n 4 Apr 1988 p 149-155.

**Measurements** See HYDROLOGY—Measurements.

**Mekong River** See FLOODS—Analysis.

**Mississippi River** See NATURAL GAS PIPELINES—Construction.

**Models** See FLOW OF FLUIDS—Sediment Transport.

**Monitoring** See COOLING WATER.

**Niagara River** See WATER POLLUTION—Analysis.

**Niger River** See Also PETROLEUM GEOLOGY—Sedimentology.

**090532 SOLUTE CONCENTRATIONS IN THE LOWER NIGER RIVER AND THE SOURCE ROCK CONTRIBUTION.** Water quality analyses for the Niger River for the 1980/81 hydrological year are presented. The samples were collected from the main river at Lokoja, and from two main tributaries, the Kaduna and the Benue Rivers. Different water types were distinguished by the concentrations of major ions. Distinct patterns of seasonal variation in the ion concentrations were observed, particularly for the samples collected at Lokoja. Low ion concentrations were prominent during periods of high discharge, while low flow periods coincided with high dissolved ion concentrations. Geochemical weathering calculations involving reactions of the four major minerals of granitic rocks - anorthite, biotite, albite, and K-feldspar - with carbon dioxide and water, can account for the average water composition of the Lower Niger. The proportion of the ionic components was also related to the

occurrence of the respective element in the minerals. (Edited author abstract) 17 refs.

Martins, O. (Ogun State Univ, Ago-Iwoye, Nigeria). *Hydrological Processes* v 2 n 1 Jan 1988 p 19-29.

## Norway

**090533 NORWEGIAN RIVER PROTECTION SCHEME: A REMARKABLE ACHIEVEMENT OF ENVIRONMENTAL CONSERVATION.** A dominant feature in the history of nature conservation in Norway has been the struggle to protect some of the most scenic and scientifically valuable river catchments from being exploited for hydropower development. The hydropower-producing potential of these rivers represents one of the most valuable economic resources of the nation, and has been a key factor in the transition of Norway from an agricultural to an industrial society. Viewed against this background of conflicting values, the efforts to set aside a number of representative river systems for purposes other than hydropower development have been one of the dominating environmental issues for the past few decades. 10 refs.

Huse, Sigmund (Agricultural Univ of Norway, Norw). *Ambio* v 16 n 5 1987 p 304-308.

**Odra, Poland** See Also INLAND WATERWAYS—Odra, Poland.

**090534 RIVER ODRA - ITS IMPORTANCE FOR THE NATIONAL ECONOMY.** The article deals with problems of the river Odra as an economic axis, and analyses various aspects such as the needs of water consumption, commercial and pleasure navigation of this region. Because of their particular interest, the author has mainly stressed the transport needs, specially related to the Odra waterway. The length of the waterway from Kozle to the Baltic Sea is 755.2 km and its particular sectors fit into different classes of navigable waters. Canalized in its upper part (187 km), it is regulated over its whole length. The article also gives the actual state of development, the achievements which enabled to reach this state and the prospects aimed at obtaining class IV status of navigable water on its whole length. In brief it also refers to the region's favorable conditions for the development of tourist and recreation activities. (Author abstract) In English and French.

Kwapiszewski, Andrzej (Water Management Office, Pol). *Bull Perm Int Assoc Navig Congr* n 60 Jan-Mar 1988 p 10-16.

**090535 REGION OF THE ODRA ESTUARY AND ITS CONNECTIONS WITH THE HINTERLAND.** The system and parameters of fairways of the Odra estuarine region have a direct effect on the volume of port transshipments, both in sea - and in inland navigation. In the years 1945-1987 a considerable development of port infrastructure took place in the region. This is partly because the size of vessels in operation in the region of the Odra estuary has increased. This in turn, has brought about the need to enlarge the fairway parameters. The increased activity of small ports and the development of inland navigation in this region have been determining factors for deciding the layout of new fairways and the most adequate markings to ensure the safety of navigation. (Author abstract) In English and French. 5 refs.

Jagniszczak, Igor (Maritime Coll of Szczecin, Pol). *Bull Perm Int Assoc Navig Congr* n 60 Jan-Mar 1988 p 46-55.

**090536 MODERNISATION DE LA RIVIERE ODRA EN TANT QUE VOIE NAVIGABLE.** [Modernization of River Odra as a Navigable Waterway]. Due to the important regulation works realized between 1874 and 1885, that period is considered as the first significant stage in the adaptation of the Odra River for navigation purposes. Since then, various sections of that river have gradually been regulated. Nowadays, reconstruction works are carried out on that waterway: new sector barrages have been built in place of the dams with frames and needles and most of the small locks have already been

transformed into big sluices for tows of barges. The realization of such a program - although carried out with a certain delay because of the economic crisis - will guarantee a continuity and better conditions of navigation on the Odra. Examples of reconstruction of weirs are presented at the end of the article. (Author abstract).

Banach, Wladyslaw (Hydroprojekt, Wroclaw, Pol). *Bull Perm Int Assoc Navig Congr* v 61 1988 p 105-110.

**Peoples Republic of China** See FLOOD CONTROL; HYDROLOGY—Computer Applications; HYDROLOGY—Peoples Republic of China.

## PO River

**090537 RECENT DEPOSITS AND SUSPENDED SEDIMENTS OFF THE PO DELLA PILA (PO RIVER, MAIN MOUTH), ITALY.** Present sedimentary conditions in the prodeltaic marine area immediately in front of the Po della Pila (Po River main mouth) are characterized by a maximum thickness of Holocene muds of 10-12 m at a depth of 20-25 m and by two different sedimentary cycles, with the more recent lens-shaped unit (2.5-4.0 m thick) probably deposited in the last 300 yrs. The nearshore prodelta area is characterized by rapidly accumulating deposits (2-4 cm/yr) enriched in smectite, gas, organic material (1-2%) and trace metals. The water system presented well marked vertical stratification during the summer of 1985, revealing three distinct water bodies: (1) riverine and diluted waters (average depth of 3 m), (2) middle depth waters (10-20 m) and (3) bottom waters. (Edited author abstract) 37 refs.

Boldrin, A. (CNR, Venice, Italy); Bortoluzzi, G.; Frascari, F.; Guerzoni, S.; Rabitti, S. *Mar Geol* v 79 n 3-4 Mar 1988 p 159-170.

## Remote Sensing

**090538 LANDSAT-MSS RADIANCE AS A MEASURE OF SUSPENDED SEDIMENT IN THE LOWER YELLOW RIVER (HWANG HO).** A method of converting the Landsat-MSS radiance to an estimate of suspended sediment concentration is presented. The CCT data for the Lower Yellow River (Hwang Ho) were used in the study. The data were first corrected for instrumental error due to a drift in the sensor response and then converted to the absolute radiance received by the sensor. In order to understand the detected radiance and its variability, radiative transfer in the earth's atmosphere and natural waters are discussed. The radiative transfer equation has been simplified, so that a highly accurate atmospheric correction algorithm for diffuse sky radiance may be developed. (Edited author abstract). 27 Refs.

Aranuvachapun, S. (Univ of Exeter, Exeter, Engl); Walling, D.E. *Remote Sens Environ* v 25 n 2 Jul 1988 p 145-165.

## Rhine River

**090539 DIE IAWR UND IHR ZWEITES RHEIN-MEMORANDUM 1986.** [IAWR and the Second Memorandum on the River Rhine in 1986]. The river Rhine traverses an industrialized densely populated region of Central Europe and carries a burden of multiple uses and pollutions. By cooperation of the water distribution companies in the IAWR (International Working Party of the Waterworks in the River Rhine Basin) since 1969, guidelines for rehabilitation of the Rhinewater quality were worked out, published in the first 'Memorandum of the IAWR' in 1973. Since about 1980, the conditions have improved in general, but the characteristics of pollution have changed. The second 'memorandum', published in 1986, summarizes the topical requirements of the waterworks on Rhine protection policy. (Author abstract) In German.

Naber, Gerhard (Int Arbeitsgemeinschaft Der Wasserwerke Im Rheineinzugsgebiet, Stuttgart, West Ger). *GWF Gas Wasserfach Wasser Abwasser* v 128 n 10 Oct 1987 p 522-524.



**090540 DIE TRINKWASSERVERSORGUNG AM RHEIN NACH DEM SANDOZ-UNFALL.** [Drinking Water Supply from the River Rhine After the Sandoz-Accident]. The Sandoz accident of November 1st, 1986 did not cause significant damage to the infiltration paths where bank infiltrated water seeps to the wells of the water works. In some cases operational measures undertaken by the water works in an early stage provided an effective protection against the pollution wave in the river Rhine. Investigations proved moreover that underground passage and the filtration of the withdrawn water through activated carbon guaranteed a sufficient protection against a nuisance of drinking water supply. Despite this positive review there have to be drawn far-reaching conclusions from the Sandoz accident concerning the water protection policy and improved measures of hazard defence in the view of public drinking water supply. (Author abstract) In German. 7 refs.

Winter, Hansgeorg (GEW-Werke Koeln AG, Cologne, West Ger); Lindner, Klaus. *GWF Gas Wasserfach Wasser Abwasser* v 128 n 10 Oct 1987 p 525-532.

Rhone, France See INLAND WATERWAYS—France.

Rhone River See CADMIUM COMPOUNDS—Environmental Impact.

Ruhr River See Also SEWAGE TREATMENT—Sludge Disposal.

**090541 ANFORDERUNGEN AN DIE RUHR AUS DER SICHT DER TRINKWASSERVERSORGUNG.** [Ruhr Water Quality Requirements from the Point of View of Drinking Water Supply]. The water resource Ruhr is run by the Ruhr River Association and the Ruhr Reservoirs Association. The water-works on the Ruhr cover the needs of drinking water of approx. 5 mill. people. Therefore there is no need to part from the principle of self-administration supervised by government. However, action should be taken with respect to the raw water quality. Facing the crucial importance of river Ruhr to the drinking water supply, further steps should be taken to improve the raw water quality. Deficits in raw water quality are described. (Edited author abstract) 15 refs. In German.

Scherer, Peter (Gelsenwasser AG). *GWF Gas Wasserfach Wasser Abwasser* v 129 n 4 Apr 1988 p 232-235.

**090542 MINIMIERUNG DER SCHADSTOFF-BELASTUNG DER RUHR.** [Minimizing of the Pollutant Load on the River Ruhr]. The river Ruhr has to serve as recipient for the (purified) wastewaters of a densely populated industrial area. So it is loaded with a variety of pollutants (organic matter, nutrients, toxic and noxious substances). As the small river has to serve as purveyor for the drinking water supply as well, the loading has to be reduced as far as possible. To achieve this the different sources of pollutants have to be traced. The success and the future problems of water quality management are demonstrated exemplarily for the different types of pollutants. Especially in the case of trace constituents legislative measures are needed, e.g. for the production and application of pesticides. (Author abstract) In German.

Koppe, Paul. *GWF Gas Wasserfach Wasser Abwasser* v 129 n 4 Apr 1988 p 256-261.

**Sedimentation** See Also CESIUM COMPOUNDS—Environmental Testing; FLOW OF WATER—Open Channels; INLAND WATERWAYS—Bank Erosion; SEDIMENTATION—Sampling; WATER POLLUTION—Analysis.

**090543 SOME SORPTION PROPERTIES OF NILE SILT.** The sorption properties of heat-treated Nile silt were investigated using thermoanalytical, X-ray diffraction, and spectroscopic techniques. After heat treatment at 650°C, the silt shows remarkable sorption properties for both organic, e.g. 3,6-bis-dimethyl-amino acridine hydrochloride, and inorganic, e.g. Cu<sup>2+</sup> cations. The cation uptake from chloroform and dichloromethane solvents is highly efficient but from protic solvents such as methanol or water it is insignificant. There is also a slight uptake of crude oil by the silt, a fact which may be useful in the fight

against oil pollution. The purity of the chloroform and dichloromethane was improved enormously after passing through columns of the heat-treated silt and this could be of industrial significance. This work is also pertinent to solvent purification and water treatment. (Edited author abstract) 7 refs.

Ebeid, El-Zeiny M. (Tanta Univ, Tanta, Egypt); Salem, Mohamed A.; Habib, Abdel-Fattah M. *Colloids Surf* v 27 n 4 Nov 1 1987 p 341-344.

**090544 SEDIMENT TRANSPORT, EROSION AND DEPOSITION IN RIVERS DUE TO OVERLOADING.** The paper presents a depth-averaged model for the sediment transport in natural flows based on 2-D diffusion equation, which is discretized following the solid matter transfer due to liquid exchange. The model is applied for the alluvial transport close to the equilibrium state of the 100 km segment of the Danube river upstream the 'Iron Gates I' dam and compared to a modified version of the Toffaleti model. Then the model is applied for the same segment in the case of heavy overloading with artificial sediments. (Edited author abstract) 9 refs.

Roman, P. (Polytechnical Inst, Bucharest, Rom); Carsteanu, A.; Hlevca, B. *Rev Roum Sci Tech Ser Mec Appl* v 32 n 5 Sep-Oct 1987 p 533-545.

**090545 EFFECTS OF HYDROLOGICAL FACTORS ON RIVER SUSPENDED SOLIDS CONTAMINATION FROM A COLLIERY IN SOUTH WALES.** Field studies over a 16 month period found that concentrations below the colliery ranged from 4 to 8028 mg l<sup>-1</sup>. Simple correlation and linear regression analysis of spot and storm event samples taken below the colliery gave a correlation coefficient of 0.39 between flow and suspended solids concentration. Because of the lack of explained variance, a multiple linear regression model of within-storm concentrations was derived using four selected independent variables. X<sub>1</sub> the time relation of the sample to the storm peak; log X<sub>2</sub> the stormflow at the time of sampling; log X<sub>3</sub> the baseflow at the time of sampling; and log X<sub>4</sub> an index of the storm intensity. Analysis of the entire dataset gave an R<sup>2</sup> of 0.34. When the results from three atypical events were excluded, however, the R<sup>2</sup> value improved to 0.65. Additional study results are discussed. (Edited author abstract) 51 refs.

Bird, S.C. (Univ Coll Swansea, Swansea, Wales). *Hydrol Processes* v 1 n 4 Nov 1987 p 321-338.

**090546 BOAT TRAFFIC, SEDIMENT RESUSPENSION AND TURBIDITY IN A BROADLAND RIVER.** Increasing levels of turbidity reported for parts of the Norfolk Broads over the last century have been attributed to algal growth. This paper demonstrates how the resuspension of bed sediments by a single moving boat is possible, and how the diurnal variation of boat traffic movement has distinct effects on patterns of suspended sediment concentration and hence turbidity. Control of boat speed and frequency thus has important implications for the management of turbidity levels in Broadland. (Author abstract) 22 refs.

Garrad, P.N. (Univ of East Anglia, Norwich, Engl); Hey, R.D. *J Hydrol* v 95 n 3-4 Nov 30 1987 p 289-297.

**090547 NON-EQUILIBRIUM SEDIMENT TRANSPORT PROCESS: GENERAL IDEAS.** The characteristics of alluvial phenomena, appearing in a strongly interrelating system among flow, sediment transport and geometry of streams and beds, are investigated. Some general ideas and techniques to treat them are refined so as to apply to sediment transport problems easily. After the arguments about the general ideas, non-equilibrium bed material load transport law is proposed as one of the results of this paper. (Edited author abstract) 7 refs.

Tsujimoto, Tetsuro (Kanazawa Univ, Kanazawa, Jpn). *Mem Fac Technol Kanazawa Univ* v 20 n 1 Mar 1987 p 1-10.

**090548 THREE-DIMENSIONAL ANALYSIS OF BED DEFORMATION AND ITS APPLICATION TO**

**LOWER PART OF YODO RIVER.** During floods, scourings are often observed near levees and revetments, and they are grave menace to the safety of rivers. In order to forecast scouring, a three-dimensional analysis of bed deformation is investigated here with particular reference to the transverse sediment transport. The derived method is applied to the lower part of Yodo River. The present method cannot only explain the bed deformation during flood in 1982 but also give an instructive suggestion to design of phased river improvement. (Edited author abstract) 5 refs.

Tsujimoto, Tetsuro (Kanazawa Univ, Kanazawa, Jpn); Murakami, Shogo; Murayama, Kazuhiro. *Mem Fac Technol Kanazawa Univ* v 20 n 1 Mar 1987 p 23-33.

**090549 GESCHIEBEANALYSEN IN GEBIRGSFLUEESSEN: UMRECHNUNG UND VERGLEICH VON VERSCHIEDENEN ANALYSEVERFAHREN.** [Analysis of Sedimentary Bed Material in Mountain Rivers. Conversion and Comparison of Various Analytical Methods]. This report deals mainly with the problem of comparing and combining grain size distribution curves for the surface and lower layers of mountain river bed. A method is presented for converting the results of different analysis procedures to make them directly comparable with one another. Conversion coefficients determined in the laboratory, which account for the coarsening of the surface layer, are included in this method. Further, various procedures are presented for combining the results of different analyses, each of which covers only a part of the whole range of grain sizes. It is shown that line-by-number analysis, together with conversion and correction procedures and the prediction of the finer fractions from a Fuller distribution, gives an economical and reliable grain size distribution which also accurately represents the coarse components. (Edited author abstract) In German. 20 refs.

Fehr, Rene (ETH, Zurich, Switz). *Mitt Versuchsanst Wasserbau Hydrol Glaziol Eidg Tech Hochsch Zurich* n 92 1987 139p.

**090550 PROCESS-ORIENTED ESTIMATION OF SUSPENDED SEDIMENT CONCENTRATION.** Least squares regression and ARIMA models were developed from suspended sediment data for the Ausable River, Southern Ontario, Canada. A poor correlation between discharge and suspended sediment concentration results from the dynamics of the physical system, including seasonality, antecedent conditions, and hysteresis. Regression model results were significantly improved by the division of the data set into seasons and the addition of simple, but physically meaningful variables. Misleading improvements obtained from the regression of sediment load and discharge are discussed. ARIMA models provided accurate forecasts of sediment concentration on a real-time basis, but the rigorous data requirements limit their use in modeling suspended sediment concentrations in Canadian rivers. (Author abstract) 35 refs.

Irvine, Kim Neil (McMaster Univ, Hamilton, Ont, Can); Drake, John J. *Water Resour Bull* v 23 n 6 Dec 1987 p 1017-1025.

**090551 SEDIMENT NUTRIENT FLUXES IN A TIDAL FRESHWATER EMBAYMENT.** Sediment-water exchanges of ammonium, nitrate, and phosphate are incorporated into a eutrophication model of Gunston Cove, Virginia. The exchange rates are obtained from laboratory measurements and are modeled as empirical functions of temperature, concentration, and pH. Simulation of the period from June 1 to September 30, 1983, indicates nitrogen, phosphorus, and chlorophyll 'a' are correctly modeled only when the sediment-water nutrient exchanges are taken into account. (Author abstract) 10 refs.

Cerco, Carl F. (US Army Waterways Experiment Station, Vicksburg, MS, USA). *Water Resour Bull* v 24 n 2 Apr 1988 p 255-260.



**090552 DETERMINATION AND SPECIATION OF COPPER AND LEAD IN SEDIMENTS OF A MEDITERRANEAN RIVER (RIVER TENES, CATALONIA, SPAIN).** Total concentrations of Cu and Pb and the speciation of these metals in sediments of the River Tenes are studied in order to establish the extent to which they are polluted and their capacity of remobilization. A standard reference material area (1556 mg kg<sup>-1</sup> Cu and 1555 mg kg<sup>-1</sup> Pb) in the last sampling site analyzed. For metal speciation, the sequential scheme of Tessier et al. was used. From the results obtained, it can be concluded that Cu content in non-residual fraction is bonded mainly to organic matter, whereas non-residual Pb is mainly associated to iron and manganese oxides. (Edited author abstract) 15 refs.

Rauret, G. (Barcelona Univ, Barcelona, Spain); Rubio, R.; Lopez-Sanchez, J.F.; Casassas, E. *Water Res* v 22 n 4 Apr 1988 p 449-455.

**090553 HEAVY METALS IN SEDIMENTS OF THE RIVER ECCLESBOURNE, DERBYSHIRE.** Sediments in the River Ecclesbourne are naturally contaminated with lead, zinc and cadmium from mineral veins at the head of the valley. Three riffles (shallow areas), near the mouth and source of the river and approximately midway between them, were examined in detail, with samples taken from upstream and downstream transects at each riffle. The median diameter of particles that passed through a sieve of 3.35 mm mesh was smaller in downstream transects, and the quartile skewness of particle size differed with both site and transect, although all samples had similar quartile deviations. Most particles were —light—, and the proportions of particles of three different ranges of densities varied with site, transect and size of particle. Metal concentrations decreased downstream and within sites concentrations varied with particle size and density by up to two orders of magnitude. Additional aspects of the study are discussed. (Edited author abstract) 12 refs.

Moriarty, F. (Nat'l Environment Research Council, Huntingdon, Engl); Hanson, H.M. *Water Res* v 22 n 4 Apr 1988 p 475-480.

**090554 RED RIVER WATERWAY SEDIMENTATION STUDY DOWNSTREAM FROM LOCK AND DAM NO. 1; NUMERICAL MODEL INVESTIGATION.** The effect of recently constructed and proposed channel improvements on sedimentation in the Red River downstream from Lock and Dam No. 1 were investigated. A one-dimensional numerical model (HEC-6) was used to evaluate the effect of contraction works on dredging requirements in the navigation channel. A two-dimensional numerical model (TABS-2) was used to evaluate proposals to reduce deposition in the downstream lock approach channel at Lock and Dam No. 1. Recommendations were made to reduce sediment problems in the study reach. (Author abstract). 11 Refs.

Copeland, Ronald, R. (US Army Engineers, Vicksburg, MS, USA); William, Thomas, A. *Tech Rep US Army Eng Waterw Exp Stn* v HL-88 n 15 Jun 1988 66p.

**090555 RADIONUCLIDE LEVELS IN RIVER SEDIMENT NEAR TO A TREATED EFFLUENT OUTFALL.** Analysis of river sediment near to a long established outfall of a treated radioactive effluent from a nuclear establishment into the River Thames has indicated enhanced, but very low and negligible levels of certain radioactive materials. The highest levels over a small area of the riverbed at its centre stream and very close to the outfall; levels of radioactivity only a few metres downstream were considerably lower. These higher levels were only very small fractions of the appropriate Generalised Derived Limits for the particular radionuclides. (Edited author abstract) 2 refs.

Gallop, R.G.C. (AWRE, Reading, Engl); Lawrenson, W.N.; Lockyer, J.F.; Warren, B.B. *Sci Total Environ* v 70 Mar 1988, Environ Radiochem Anal, Proc of the Fifth Symp, Harwell, Engl, Oct 1-3 1986 p 237-251.

Shanghai, Peoples Republic of China See WATER SUPPLY—Water Quality.

## Sri Lanka

**090556 STUDY OF SOME PHYSICO-CHEMICAL PROPERTIES OF NILWALA RIVER WATERS IN SOUTHERN SRI LANKA WITH SPECIAL REFERENCE TO EFFLUENTS RESULTING FROM ANTHROPOGENIC ACTIVITIES.** This paper describes the water quality of Nilwala Ganga river in Southern Sri Lanka in terms of variations of the following parameters with seasons and length of river: Acidity, Chloride, Ammonia, Nitrite, Biological Oxygen Demand, Dissolved Oxygen, and Conductivity. The influence of rainy season and agricultural activity in the catchment area of Nilwala is clearly demonstrated. The need for systematic monitoring and waste water treatment of waters of tropical rivers is evident, in particular where impacts from industrial-agricultural projects are to be expected. (Author abstract) 4 refs.

de Silva, M.P. (Univ of Ruhuna, Matara, Sri Lanka); Karunatilaka, R.; Thiemann, W. *J Environ Sci Health Part A* v A23 n 4 May 1988 p 381-398.

St. Lawrence River See MERCURY COMPOUNDS—Environmental Testing.

Tombigbee, United States See INLAND WATERWAYS—United States.

United Kingdom See WATER POLLUTION—Analysis.

United States See WATER POLLUTION—Water Quality.

## USSR

**090557 ESTIMATE OF LOSSES OF WATER RESOURCES TO EVAPORATION AND TRANSPIRATION IN THE ILI RIVER DELTA.** Based on existing calculation schemes and a summary of experimental investigations we have estimated the magnitudes of evaporation from an open water surface and different species of hydrophilous plants. The areas of bodies of water and wetlands are determined from aerial and satellite data obtained in 1958-1984. Annual losses in the delta to evaporation and transpiration are 3.3-4.0 km<sup>3</sup>. The decrease in losses because of the drying out of the delta as a result of construction of the Kapchagai HPP dam occurred after 1981, when the phase of replacement of superwetted areas by dry ones began. (Author abstract) 14 refs.

Sumarokova, V.V.; Chugunov, V.A.; Babkina, L.P. *Sov Meteorol Hydrol* n 2 1987 p 64-71.

Uttar Pradesh, India See DRAINAGE—Models.

## Volga River

**090558 PRESENT REGIME OF FLOW TO THE VOLGA DELTA AND ITS POSSIBLE CHANGES.** In the present work an attempt is made on the basis of the data of observations during a 26-year period (1960-1985) to characterize the present flow of the Volga to the delta head, to compare the actual regime of Volga streamflow regulation with the design, to estimate its possible changes, and to plan ways of further investigations and measures for solving certain problems of the Lower Volga. 14 refs.

Asarin, A.E. (All-Union Planning, Surveying & Scientific-Research Inst, USSR). *Water Resour* v 14 n 3 May-Jun 1987 p 213-219.

Water Level See WEIRS—Automation.

## Wave Effects

**090559 TYPHOON WAVES AND WAVE HEIGHTS FOR DIFFERENT RETURN PERIODS IN THE NEARSHORE WATERS OF THE ZHUJIANG RIVER MOUTH.** Based on the characteristics of

a typhoon as well as the complicated geographic and water-depth conditions in the nearshore waters of the Zhujiang River mouth, typhoon waves from every main direction in this area and wave heights for different return periods are analyzed and computed with various methods, so as to provide certain design basis for the construction of nearshore and coastal engineering works in the waters in question. (Edited author abstract) 12 refs.

Zhang, Jinghan (Acad Sinica, Guangzhou, China); Li, Shaoying. *China Ocean Eng* v 1 n 2 May 1987 p 67-75.

West Siberia, USSR See INLAND WATERWAYS—Improvement.

## Widening

**090560 PENULTIMATE FLOOD ALLEVIATION CONTRACT AT ESHER.** Contract 11 covers the 1.1km length of river between the Hersham railway viaduct and Albany Bridge, with works also being carried out upstream of the bridge. Basically the contract is for the realignment and widening of the river between these points, and for the construction of flood walls and bunds upstream. Work is being done to lower the river and control its entry into the bridge with steel sheet piling. Beyond the bridge, the river will flow into an enlarged channel and where the improved and controlled hydraulics pass beneath the structure, protection is provided with gabion mattresses.

Barfoot, Jack. *Concrete (London)* v 21 n 10 Oct 1987 p 33-35.

Yellow River See FLOODS—Peoples Republic of China.

## RIVETING

**090561 VERBINDEN DURCH RADIALNIETEN.** [Joining by Radial Riveting]. Radial machine riveting was developed at the beginning of the seventies and is based on an advancement of the tumbling principle. It is used wherever high-quality rivet connections are required. Its successful application, however, is also documented by its manifold use in nonriveting technologies. Its advantages are perfect forming of the material, a low stress of the parts to be riveted, almost soundless and vibrationless working and the efficient technique used. This article deals with the equipment, some applications and the forming of the material. (Author abstract) In German.

Burkhalter, H. *F&M Feinwerktech Messtech* v 95 n 6 Sep-Oct 1987 p S136-S138, S140.

## Electromagnetic Field Effects

**090562 ANALYSIS OF RIVET DIE DESIGN IN ELECTROMAGNETIC RIVETING.** This paper presents the findings of a numerical and experimental study of the quality of 7050-T73 aluminum rivets formed by an extremely fast electromagnetic riveting process. It is found that without careful design of the rivet forming die large strains are produced which cause crack formation in the rivet heads. By the use of finite element and experimental techniques, it is shown that control of the radial component of the flow of materials in the rivet head is essential in avoiding crack formation. A rivet die design which is effective in producing high quality, crack free, rivets is proposed. (Author abstract) 12 refs.

Reinhall, P.G. (Univ of Washington, Seattle, WA, USA); Ghassaei, S.; Choo, V. *J Vib Acoust Stress Reliab Des* v 110 n 1 Jan 1988 p 65-69.

RIVETING MACHINES See RIVETING.

RIVETS See COPPER AND ALLOYS—Fiber Reinforcement.



## ROADBUILDING MACHINERY

## Accident Prevention

**090563 SAFETY MEASURES - WHILE WORKING WITH HOT MIX PLANTS AND ALLIED EQUIPMENTS.** Various types of road construction equipment are being used in road/bridge construction. Here we shall be dealing with safety measures requiring observation while working with hot mix plant and allied equipments, i.e., paver finisher, loaders and tippers, etc. Some of the most typical causes for accidents that have taken place at construction sites are: defective equipment devices and mechanized tools; violation of normal processes of operating the machines; and inadequate or no instructions to the drivers or operators, mechanics or fitter. The safety precautions mentioned are only a few. Many more safety precautions may have to be taken according to the working conditions prevailing at a particular site.

Gulati, D.R. *Indian Highw* v 15 n 7 Jul 1987 p 23-29.

**Costs** See PAVEMENTS—Repair.

## Maintenance

**090564 GUIDELINES FOR REUSABLE SPARE PARTS IN ROAD CONSTRUCTION.** Various road-making machineries such as hot mix plants (central type and mini type), pavers, loaders and rollers are commonly used for construction work, and some of this equipment is very expensive, involving equally expensive maintenance due to the exorbitant cost of spares fixed arbitrarily by the manufacturers. Under the reconditioning process, a worn-out member is reactivated by the process of heat-treatment, turning, truing, milling, welding, machining and retempering. A discussion is given on reconditioning the central hot mix plant, the paver finisher, the cylinder head, and the crankshaft.

Duraiswamy, D. (Highways Mechanical Circle, Tamil Nadu, India). *Indian Highw* v 15 n 11 Nov 1987 p 27-33.

**090565 COLD WEATHER TIPS FOR CONSTRUCTION EQUIPMENT.** Construction equipment needs special attention in cold weather to operate at optimum productivity. Moisture can cause costly and possibly irreversible damage to equipment at freezing temperatures. Several precautions should be taken before and during the winter to help ensure that equipment will operate properly in cold weather. This article reviews these precautions.

Anon. *Public Works* v 119 n 8 Jul 1988 53p.

**Manufacture** See WELDING, ELECTRIC ARC—Robot Applications.

**Mixers** See ROADBUILDING MATERIALS—Mixing.

**Performance** See HIGHWAY ENGINEERING—Project Management.

**Rollers** See PAVEMENTS—Concrete; SOILS—Compaction.

## Testing

**090566 IT'S BITUMEN ALL THE WAY AROUND.** Reference is made to the Australian Centennial Roads Development Program. Alluding to the centenary of Australia's federation, the program will raise more than 1.2 billion dollars in its first year. The article looks at some of the major projects that have been completed under the bicentennial program. Also included are reports on a new road testing machine, the introduction of a comprehensive asphalt research program and the potential effects of the new B-double trucks on the road system.

Dixon, Susette. *J Inst Eng Aust* v 60 n 17 Aug 19 1988 p 37.

## ROADBUILDING MATERIALS See Also ASPHALT—Rheology.

**Aggregates** See Also BITUMINOUS MATERIALS—Testing; PAVEMENTS—Performance; PAVEMENTS—Testing.

**090567 SPOT SHORTAGES WILL MEAN EXPANSION.** The article describes how several states in the U.S. have dealt with the problem of aggregate shortages. Among the alternatives, using recycled concrete and asphalt pavement has been greatly favored. On a recent project in Wyoming, recycling turned out to answer another problem - that of alkali-reactive aggregates causing premature structural failure. Few major changes have taken place recently in aggregate recycling equipment. One new development that shows promise for the future is the harmonic breaker, which uses vibration rather than impact to do its work.

Anon. *Highw Heavy Constr* v 130 n 9 Sep 1987 p 66-69.

**090568 SELBSTERHAERTENDE TRAGSCHICHTEN AUS HOCHOFENSCHLACKEN.** [Self-hardening Road Base Courses of Blast-Furnace Slag]. Blast-furnace slag and metallurgical sand are industrial by-products of great value to road construction if their hardening behavior and performance are duly taken into account. A road test program with varying formulations in small trafficked segments was to reveal the best application technique. The results are commented and interpreted by conclusions which now form part of a Preliminary Code of Practice on the subject. (Author abstract) 19 refs. In German.

Motz, Heribert (Forschungsgemeinschaft Eisenhuettenschlacken). *Str Tiefbau* v 41 n 4 Apr 1987 p 24, 26, 29-33.

**090569 QUANTITY OF FINES PRODUCED DURING CRUSHING, HANDLING, AND PLACEMENT OF ROADWAY AGGREGATES.** A three part test procedure was developed to determine the quantity of fines produced during crushing, handling, and placement of aggregates used as base course in roadway construction. The first test simulates crushing at the aggregate source. It involves processing an aggregate sample of specified gradation through a small laboratory jaw crusher. The second test simulates handling by agitating an aggregate sample of specified gradation at 10% moisture content for 20 min. The modified American Association of State Highway and Transportation Officials (AASHTO) compaction test is used to simulate placement. Following the conduct of each test in the procedure, the fines are measured by washing the aggregate over a 75-µm (No. 200) sieve. At the conclusion of the three part test procedure the fines produced during crushing, handling, and placement are determined by summing the fines determined from each test in the series. Additional aspects of the subject are discussed. (Edited author abstract) 5 refs.

Pintner, Robert M. (San Diego Soils Engineering Inc, San Diego, CA, USA); Vinson, Ted S.; Johnson, Eric G. *Geotech Test J* v 10 n 4 Dec 1987 p 165-172.

**090570 DIMETHYL SULFOXIDE (DMSO) ACCELERATED WEATHERING TEST FOR AGGREGATES.** A standard accelerated weathering test using dimethyl sulfoxide (DMSO) was developed to simulate the chemical degradation of basaltic rock. The final development of the standard test involved a study of the interaction of DMSO with clay standards and an investigation of the test condition parameters affecting an existing DMSO test procedure. The weighted loss reported under the existing test procedure (similar to the sodium sulfate soundness test) was affected by the aggregate particle size, specimen mass, immersion time, and container geometry. In the recommended standard DMSO accelerated weathering test, aggregates in the particle size range of 2.4 to 4.8 mm are immersed in a container of DMSO for a period of five days. Additional study results are discussed. (Edited author abstract) 18 refs.

Szymoniak, Tom (Pavement Services Inc, Portland, OR,

USA); Vinson, Ted S.; Wilson, Jim E.; Walker, Neal. *Geotech Test J* v 10 n 4 Dec 1987 p 173-182.

**090571 DEGRADATION - UNBOUND AGGREGATES.** AGGREGATE degradation has been reported by many investigators to occur, in unbound layers of pavements, during construction and also during service life. The phenomenon of degradation has been recognised as one of the important factors affecting the performances of unbound aggregate in base, sub-base or in unpaved roads. Degradation is defined in this paper as the reduction in size of particles which occur during the process of laying and compaction and as a consequence of traffic action in association with weathering processes during pavement life. The work reported in this paper refers to a degradation study carried out in the laboratory in which different types of compaction, initial grading, material and size of compacting moulds were involved. 10 refs.

Lees, G.; Zakaria, M. *Highw Transp* v 34 n 7 Jul 1987 p 32-36.

**090572 UNE REMARQUABLE INSTALLATION DE PREPARATION D'AGREGATS EN SUEDE.** [Outstanding Facility for the Preparation of Aggregates in Sweden]. The firm Skanska AB, which is the principal Swedish construction company, has just placed into service at Onnestad, near Kristianstad in Sweden, a new preparation plant for aggregate, which is quite remarkable in its design and its automation. This plant was constructed at the site of a quarry which the firm Skanska had operated for some 30 years and which supplies high-quality material for the construction of highways and the manufacture of concrete in the entire region. Design of this new plant, as well as supply of most equipment, were provided by the firm Svedala Arbra which is affiliated with the Boliden Allis group. Automation was also investigated and perfected by Svedala Arbra. Construction of this plant started in the fall of 1986, and the production startup was in August 1987. (Edited author abstract). In French.

Anon. *Ind Miner Mines Carrieres* v 70 Jun 1988 p 26-32.

**090573 ZEMENTGEBUNDENE MV-ASCHE IM STRASSENBAU.** [Cement-based Refuse Incineration Ashes for Road Construction]. In the Federal Republic of Germany there are 24 million tons of waste per year, a third of it is burned in 47 refuse incineration plants. A further number of 20 plants will be put in operation up to the year 1995. Then 14 million tons of refuse will be burned per year. From the year 1995 onward the amount of raw ashes from these plants will amount to 4 to 5 million tons per year. Large-scale examinations have proved that refuse incineration ashes set with cement cannot be leached out and thus do not endanger the environment. They can be used in road and street building. (Author abstract). 9 Refs. In German.

Schubenz, Dieter. *Beton* v 38 n 5 May 1988 p 182-187.

**Aging** See ASPHALT—Oxidation.

**Bituminous** See Also ASPHALT; ASPHALT—Adhesion; ASPHALT—Recycling; PAVEMENTS—Asphalt.

**090574 SLURRY SEAL MIX DESIGN.** The primary objective of this study was to devise a quantitative yet simple laboratory method for designing emulsified bitumen slurry seal coats. A laboratory design procedure for slurry seal, the New California Test 355 (NCT355) was studied. Some modifications are suggested following experimentation. This paper presents the results of a laboratory evaluation of the mix design and a field verification of the laboratory design. The laboratory and field work were preceded by a thorough review of NCT355 and of other pertinent literature. During the laboratory phase, the test method was rigorously scrutinized for possible modification and simplification in order to make it more convenient without sacrificing accuracy and reliability. The field verification phase is also discussed. (Edited author abstract) 7 refs.



Bolzán, P.E. (CONICET, La Plata, Argent). *Aust Road Res* v 17 n 2 Jun 1987 p 102-110.

**090575 VERWENDUNG VON PETCHBITUMEN ALS BINDEMITELE FÜR BITUMINOSES MISCHGUT IM STRASSENBAU.** [Application of Pitch/Bitumen Mixtures as Binders for Bituminous Materials in Road Construction]. Tar and pitch have formerly been widely used as binders for road works. The decline of coal and coke consumption reduced the supply and thereby the health problems in their application. Recently a pitch/bitumen mixture reappeared on the market. This prompted the author to recall the carcinogenic hazards from polycyclic aromatic hydrocarbons in pitch and to review the safety precautions to observe in applying such binders in road construction and surface dressing. (Author abstract) 8 refs. In German.

Bandmann, Manfred (Tiefbau-Berufsgenossenschaft, West Ger). *Str Autobahn* v 41 n 6 Jun 1987 p 23-24.

**090576 TRUTH ABOUT REMIXING ASPHALT.** The remixing process is not right for every road, but where it can be used, it can account for significant cost reductions. The reduced cost stems from the fact that one machine picks up the old asphalt, recycles it, and lays the material back down on the road. The largest savings come when the process is applied to a badly rutted road where grinding and two courses are needed. On less severe projects, the savings are lower. This article discusses the remixing process and equipment, applications, and remixing work in Maryland.

Anon. *Better Roads* v 57 n 12 Dec 1987 p 18-20.

**090577 BITUMEN EMULSIONS FOR ROAD CONSTRUCTION AND MAINTENANCE.** Today, we have a range of different grades and types of emulsions, along with appropriate construction equipment, which can be used for most road construction and maintenance jobs. The series of cationic bitumen emulsifiers developed recently are significant for highway construction. When the cationic emulsion comes into contact with the aggregate, an ion-absorption occurs between the positively-ionized particles of cationic bitumen emulsion and negatively-ionized aggregates, even when the aggregates are in a damp condition. This improved cohesion between the bitumen and aggregates permit use of cationic emulsions even in wet and relatively cold weather conditions and permit the road to be opened to traffic soon after paving. The use of bitumen emulsions is also energy-saving and pollution-reducing.

Anon. *Indian Highw* v 15 n 11 Nov 1987 p 3-4.

**090578 EVAPORATION OF CUTTER FROM A BITUMEN DURING THE SPRAYING OPERATION.** Observers of the spray sealing operation when a cutback bitumen is being sprayed in cool weather are impressed by the cloud of cutter droplets which forms at the rear of the sprayer. This note describes calculation methods used to estimate this loss of cutter by evaporation during the first 1 or 2 minutes after spraying and the results obtained from the calculations. 6 refs.

Dickinson, E.J. (Australian Road Research Board). *Aust Road Res* v 17 n 4 Dec 1987 p 269-272.

**090579 BLENDED ASPHALT PROVES OUT FOR HEAVY DUTY PAVEMENT.** In 1975 the Port Authority of New York and New Jersey began to use Trinidad Lake Asphalt (TLA) to overlay an elevated roadway. TLA is a naturally occurring bitumen that comes from a pitch lake located on the Island of Trinidad. The crude asphalt is, in general, a uniform emulsion of bitumen, gas, water, sand, and clay. Other successful applications are also cited.

Grimaldi, Alfred F. (Contra Costa County, Martinez, CA, USA); Chen, Yue Sun. *Public Works* v 118 n 9 Sep 1987 p 104-106.

**090580 ADDITIVES FOR BITUMEN IN ROAD CONSTRUCTION.** In this paper an attempt has been made to document the effects of some additives on

conventional properties of bitumen. These properties are penetration value, softening point, ductility, and stripping value. The additives are derived from plants. Various tests have been conducted on a mixture of 80/100 grade bitumen and different types and percentages of additives. A detailed investigation has been carried out on five additives which have been code-named A, G, S, T, and W. The test results indicate a definite trend in the variation of the conventional physical properties of bitumen for Additives A, G, and W and a spectrum of values with finite variation in the conventional properties for Additives S and T. (Edited author abstract). 5 Refs.

Jain, J.P. (Univ of Roorkee, Roorkee, India); Gupta, A.K.; Khanna, S.K.; Jain, S.S. *J Test Eval* v 16 n 5 Sep 1988 p 481-486.

**Chemical Analysis** See ASPHALT—Rheology; GYP-SUM—Waste Utilization.

**Chromatographic Analysis** See ASPHALT—Rheology.

**Components** See ASPHALT—Mechanical Properties.

**Concrete** See PAVEMENTS—Concrete.

**Crack Propagation** See PAVEMENTS—Overlays.

**Deformation**

**090581 EVA MODIFIED BINDERS.** In the majority of road situations conventional bituminous materials give satisfactory performance. However, for certain special applications and sites where traffic is extremely heavy improved materials are required. Copolymers of Ethylene and Vinyl Acetate (EVA) offer an effective means of modifying the rheological properties of conventional penetration grade bitumens, thus enabling the production of high quality materials with in particular improved resistance to deformation and handling properties, for use on heavily trafficked roads and motorways and for difficult working conditions. 8 refs.

Choyce, Peter, W. (Sheffield City Polytechnic, Engl); Wooley, Keith G. *Highways (Croydon Engl)* v 56 n 1933 Jan 1988 p 18-19, 21, 34.

**Fly Ash**

**090582 LEACHABILITY OF LIGNITE FLY ASH ENHANCED ROAD BASE.** The abundance of fly ash along with its self-hardening properties led the Louisiana Department of Transportation and Development (LA DOTD) to use fly ash as a soil stabilizer for road bases. During this study, a total of three samples, a 30 percent lignite fly ash/soil mixture, lignite fly ash, and soil, were leached following the EPA multiple extraction procedure and analyzed by Inductively Coupled Argon Plasma spectrometry (ICAP). Results indicate that little change in leachate quality of lignite fly ash was caused by the soil stabilization process. The insignificant change is attributed to the low cation exchange capacity of the soil. ICAP analysis revealed that heavy metal concentrations were within RCRA and Public Drinking Water standards. Additional study results are discussed. (Edited author abstract) 11 refs.

Garcez, I. (James M. Montgomery Consulting Engineers Inc, New Orleans, LA, USA); Tittlebaum, M.E. *J Environ Sci Health Part A* v A22 n 7 1987 p 607-625.

**In Situ**

**090583 VALORISATION DES MATERIAUX ROUTIERS NON TRADITIONNELS: APPROCHE METHODOLOGIQUE ET BILAN DES APPLICATIONS.** [Use of Nontraditional Road Materials: Methodological Approach and Assessment of Applications]. The use of nontraditional materials, i.e. those not complying with specifications, allows savings in transport (local materials), in processing or in production (quarry residue). The article deals with the technical possibilities of using such materials. After a lengthy description of the proper-

ties of various types of sand and their utilisation constraints, the authors also look into the criteria for the use of limestone. (Author abstract) In French.

Chauvin, J.J. (Ponts et Chaussées de Bordeaux, Fr); Sabo, A. *Travaux* n 624 Sep 1987 p 1-7.

**Lime**

**090584 LEACHING OF LIME FROM LIME-STABILISED SOIL SPECIMEN.** A laboratory study was undertaken to evaluate (i) the extent of lime leached out from compacted and cured lime-stabilized soil specimens and (ii) the effect of lime content, curing and soaking periods on the leaching of lime from soil specimens. Appropriate measures to be taken at the time of using lime-stabilized soils in road construction are suggested to improve the performance of roads built with such soil types. (Edited author abstract). 4 Refs.

Dhawan, P.K. (Central Road Research Inst, New Delhi, India); Goswami, N.K.; Kumar, Ashwani. *Res Ind* v 33 n 1 Mar 1988 p 28-36.

**Mixing**

**090585 TARMAC OPENS NEW ROADSTONE PLANT.** Tarmac Roadstone-East Midlands recently unveiled its new £2m coating plant at Amphill, Bedfordshire. The plant will serve Bedfordshire, Buckinghamshire, Northamptonshire, Oxfordshire, and Hertfordshire as far as the M25. It employs six operatives and has the capacity to produce 200,000t/y of material at a rate of up to 150t/h, using granite aggregate from Tarmac's prestigious Cliffe Holl Quarry in Leicestershire. This article reports on the design and operation of the new plant. (Author abstract).

Anon. *Mine Quarry* v 17 n 6 Jun 1988 p 15-16.

**Moisture Determination** See SOILS—Bearing Capacity.

**Performance**

**090586 SPECIAL MATERIALS - THEIR USE AND APPRAISAL.** Special materials are now used in many situations in highway works. This paper shows how the properties required from these materials will vary with their usage, and the importance of defining combinations of properties in a way which will show those of greatest significance. The use of response groups for this purpose is demonstrated. Testing must be specified so that both the right test and the right test conditions are defined, as these are of greater importance when using special materials. Case histories are used to show how particular situations require specific material properties. (Author abstract) 4 refs.

Plum, David R. (Univ of Newcastle-upon-Tyne, Engl); Morton, Ronald. *Highways (Croydon Engl)* v 56 n 1936 Apr 1988 p 46, 48, 50.

**Permeability, Mechanical** See PAVEMENTS—Concrete.

**Plastics**

**090587 DEVELOPMENT OF A SECOND GENERATION OF PLASTICIZED SULFUR (SULPHLEX) BINDER.** Two second-generation plasticized sulfur formulations were identified as possessing low-temperature engineering properties that are much improved over the first-generation formulations. The J-integral, a measure of the energy required to induce crack growth, was found to be an excellent and sensitive parameter by which to evaluate the low-temperature fracture susceptibility of the plasticized sulfur binders. A strong relationship was found between the critical energy required to indicate crack growth,  $J_{IC}$  and the glass transition temperature of the plasticized sulfur binders. The second-generation binders presented are evaluated based on creep compliance, controlled stress and controlled displacement fatigue, glass transition temperature, and the  $J_{IC}$ . (Edited author abstract) 6 refs.



Little, Dallas N. (Texas A&M Univ, College Station, TX, USA). *Transp Res Rec* 1096 1986 p 52-61.

**Recycling** See Also ROADS AND STREETS.

**090588 COLD MIX RECYCLING - THE CLIENT'S VIEW.** Cold mix recycling of old roads is not a new process in the UK. Back in the 1930s some existing pavements were improved by the in situ mixing of bitumen emulsions following scarification and reshaping of the old surface. This 'Retread' process, little changed except for improvements in machinery, is still a viable alternative for roads where no overall structural improvement is required but correction of ruts, crack or pot-holes is necessary. With in situ recycling, 100% of the existing road pavement is re-used and the potential quality of this 'horizontal quarry' of material has to be assessed. Cold-mix bituminous material is about 80% as efficient as hot mix material in its load spreading capabilities. The reasons for this are partly due to the inability to fully compact materials on a yielding foundation, partly due to the difficulty of ensuring an intimate contact between bitumen an intimate contact between bitumen and cold damp materials.

Walsh, Ian D. (Kent County Council Highways Lab, Engl). *Highways (Croydon Engl)* v 56 n 1933 Jan 1988 p 46-47.

**Rubber** See ASPHALT; ASPHALT—Mechanical Properties.

**Stability** See PAVEMENTS—Asphalt.

## Standards

**090589 CONCEPTUAL FRAMEWORK FOR THE DEVELOPMENT OF PERFORMANCE-RELATED MATERIALS AND CONSTRUCTION SPECIFICATIONS.** It is assumed that the conceptual framework for specifications development includes eight sets of relationships among the process variables and nine sets of inputs or outputs for the relationships. Independent variables are selected that have predictable effects on performance-related output variables. From these independent variables, variables (EPF) appearing explicitly in prediction functions are selected and subdivided into traffic factors, environmental factors, and pavement structure factors. General forms of prediction equations for stress and distress, stress-load equivalence relationships, traffic prediction relationships, relationships among materials and construction (M&C) specification factors, and performance-cost relationships are presented. Pavement design criteria and M&C specification factors are added as the initial conditions for the definition of a pavement design for a given pavement requirement. (Edited author abstract). 7 refs.

Irick, Paul E. *Transp Res Rec* n 1126 1987. Publ by ISA, Washington, DC, USA, 1987 p 1-27.

**Stresses** See GRANULAR MATERIALS—Testing.

**Testing** See Also ASPHALT—Quality Assurance; ROADS AND STREETS—Maintenance.

**090590 STOFFEIGENSCHAFTEN VON HGT MIT ALTBETON UND ALTASPHALT: TEIL II.** [Material Characteristics of Base Course Layers Containing Concrete and Asphalt Rubble - 2]. In the first part of this article which was published in number 1/88 of this magazine, the situation of recycling concrete and asphalt rubble in Germany was reviewed. A test program of the Research Institute of the German Cement Industry for promotion of the so far unsatisfactory recycling practice was outlined. This second part of the article reports on the laboratory test results, mainly concerning compressive, cleavage and tensile strengths in bending, modulus of elasticity, deformation, shrinkage, and frost resistance. The evaluation of such recycling material in base course layers is positive. Advice is given on how to proceed. (Author abstract) 16 refs. In German.

Schmidt, Michael; Vogel, Paul. *Str Tiefbau* v 42 n 2 Feb 1988 p 19-25.

**090591 DEVELOPMENT OF SPRAY-REDUCING MACADAM ROAD SURFACINGS IN THE UNITED KINGDOM, 1967-1987.** The evolution of pervious macadam has been primarily the result of a number of road trials that have led to specification trials by the Department of Transport. The resulting specification for pervious macadam is included in the latest revision of British Standard 4987. The material can be expected to have effective spray-reducing properties for 3 years for a traffic flow of 7,000 commercial vehicles per day (cvd) per lane or for 6 years for 2,500 cvd. To improve the long-term durability of the material and its economic viability, a road trial was started in 1984 to study the performance of pervious macadams with polymer-modified binders. (Edited author abstract) 16 refs.

Colwill, D.M. (Transport & Road Research Lab, Crowthorne, Engl); Daines, M.E. *Transp Res Rec* 1115, Asphalt Mater and Mixtures. Publ by Transportation Research Board, Washington, DC, USA, 1987 p 196-202.

## Waste Utilization

**090592 ERFAHRUNGEN BEIM EINSATZ VON MUELLVERBRENNUNGSASCHEN IM TIEF- UND STRASSENBAU UNTER BESONDERER BE RUECKSICHTIGUNG DER VERWENDUNG IN BEREICHEN MIT UNTERIRDISCHEN VERSOR GUNGSLEITUNGEN.** [Experience with the Application of Refuse Incineration Ash in Pipeline and Road Construction, Especially in Areas with Underground Water Pipeline Networks]. About 2 Mt p.a. of solid waste are produced annually in the Federal Republic of Germany by household refuse incineration. About 70 to 80% of it, above all ash, can be utilized in a prepared and controlled state in pipeline and road construction for frost and carrier layers, soil strengthening or agricultural and forestry purposes. The road construction requirements are contained in a publication of the German Research Association for Road Construction and Transportation (FGSV) published in 1986. In the water protection zones 1-3 refuse ash is not permitted. The corrosion risk for pipelines with external insulation coatings is equal to zero. Pipelines that lay in refuse ash since 1975 have shown no damage. Pipes have to be protected from immediate contact with refuse ash by a layer of sand or soil at least 80 cm thick. (Translated author abstract) In German.

Hild, Juergen (Chemisches Untersuchungsamt der Stadt Hagen, Hagen, West Ger). *Str Autobahn* v 38 n 4 Apr 1987 p 144-147.

**ROADS AND STREETS** See Also AUTOMOBILES—Vibrations; CAST IRON—Testing; HIGHWAY SYSTEMS—Mexico; LIME—Physical Properties; URBAN PLANNING—Transportation.

**090593 PRIVATE-SECTOR INVOLVEMENT IN VIRGINIA'S NINETEENTH-CENTURY TRANSPORTATION IMPROVEMENT PROGRAM.** This paper discusses the financing of roads, and to a lesser extent other modes of transportation, in Virginia between 1816 and 1860, a period of major expansion during which a mixed system of private- and public-sector financing was used. The intent was to maximize the benefits and minimize the disadvantages of both systems. The perceived and real costs and benefits of this system are described, and parallels with the present situation are pointed out. (Author abstract) 3 refs.

Newlon, Howard Jr. (Virginia Highway & Transportation Research Council, Charlottesville, VA, USA). *Transp Res Rec* 1107 1987 p 3-13.

**090594 LANGZEITBEOBACHTUNGEN AN AUSGEWAELHTEN STRASSENABSCHNITTEN: ERGEBNISSE VON BENKELMAN-BALKEN-EINSENKUNGSMESSUNGEN.** [Longtime Observations of Selected Road Sections: Results of Settlement Tests with the Benkelman Beam]. The data collected since 1967 on 170 road observation sections with flexible construction in the Federal Republic of Germany were evaluated. Some results of settlement measurements with the Benkelman beam for the determination of the load-carrying capacity

of reinforcements are reported. The measurements envisaged settlement measurements on the face before and after drilling out cores 33 cm in diameter from 450 boreholes. The purpose was to study bituminous top pavements on gravel layers and frost protection layers. The study shows that even after 18 years of traffic loading with thin bituminous layers, substantial settlements may not occur. (Translated author abstract) In German. 7 refs.

Schulte, Wolfgang (Bundesanstalt fuer Strassenwesen, Bergisch Gladbach, West Ger). *Str Autobahn* v 38 n 2 Feb 1987 p 45-47.

**090595 STOFFEIGENSCHAFTEN VON HGT MIT ALTBETON UND ALTASPHALT.** [Material Characteristics of Base Course Layers Containing Concrete and Asphalt Rubble]. The amount of concrete and asphalt rubble accruing from demolition of decrepit pavements is far greater than what is used for the present as recycled construction materials. This unsatisfactory situation gave rise to tests by the Research Institute of the German Cement Industry to examine the behavior of such aggregate in test cores in the laboratory. Since this kind of recycling is practiced to a greater extent already abroad, some findings are derived from literature. Open points are outlined. A report is then presented on the test conditions, sample ingredients, and results. (Author abstract) In German. 16 refs.

Schmidt, Michael; Vogel, Paul. *Str Tiefbau* v 42 n 1 Jan 1988 p 5-6, 8-10.

**090596 LOCAL ROADS AND STREETS INTO THE NEXT CENTURY.** In examining the role of roads and streets into the next century, it is not enough to merely study the likely changes in road and street technology. A wider view is needed as roads and streets supply a means that the community uses to service a set of broader needs - the need to travel, to trade, to socialise, to produce and to consume. It is only after exploring these more basic needs that we will be able to make sensible statements about the future of roads and streets. In addition to needs, the paper discusses motor transportation in general, roads and streets, and safety. 20 refs.

Lay, M.G. (Australian Road Research Board, Aust). *Aust Road Res* v 18 n 1 Mar 1988 p 34-37.

**Accident Prevention** See Also URBAN PLANNING—Transportation.

**090597 ROAD SAFETY - SUCCESS AND FAILURE IN JAPAN.** The Japanese success in the 1970s in reducing its traffic accidents by 50% was brought about mainly by traffic engineering measures to improve the road and roadside environment. In the 1980s, however, those measures that were effective in the decade before are approaching their saturation levels in terms of both the number of installations and the extent to which they could prevent accidents; hence they become less and less effective. Stress should now be placed on a new policy to improve driver quality. To realize this purpose revision of driver education, traffic regulations, and the way in which traffic regulations are enforced is inevitable. In particular, reformation of pre-license driver education is important. Special attention should be paid to the education of young drivers because the majority of new drivers are young drivers and they have a remarkably high accident rate. 8 refs.

Koshi, M. *ITE J* v 57 n 9 Sep 1987 p 33-41.

**090598 TRAINING CHILDREN IN ROAD CROSSING SKILLS USING A ROADSIDE SIMULATION.** Five-year-old children were trained in road-crossing skill using a new method which allows them to act safely in relation to vehicles on a normal road. The children learned to time their crossings of a 'pretend road' as if the vehicles were on this, rather than on the adjacent road. A previous study, using a single lane of traffic, showed that many children performed well in this simulation with minimal instruction, but that five-year-olds were generally less



proficient than older children. In the present study, the method was extended to the more realistic case of two-way traffic, and training programs for five-year-olds were assessed. In addition, the performances of adults in the two-way pretend task and in actual crossing the road were compared; the results confirmed the validity of the simulation. After a few sessions of guided practice, the children's efficiency in making use of gaps by setting off promptly after a vehicle had passed improved markedly; in single-lane crossing they reached almost adult standard. (Edited author abstract) 16 refs.

Young, David S. (Univ of Edinburgh, Edinburgh, Scotl); Lee, David N. *Accid Anal Prev* v 19 n 5 Oct 1987 p 327-341.

**090599 CURRENT STATE OF ROAD SAFETY EDUCATION IN PRIMARY AND MIDDLE SCHOOLS.** In June 1984 a survey was conducted to provide information about the current state of road safety education in primary and middle schools. Over 90 per cent of the schools claimed to have been teaching some form of road safety education. Outside specialists (mostly the police and road safety officers) had made a substantial contribution to the subject by giving talks in 83 per cent of the schools. The input from teachers was, however, largely incidental. The limited use made by teachers of road safety curriculum materials, their limited preparation to teach road safety education and the lack of a well developed organization structure for road safety education within primary and middle schools were identified as factors requiring immediate attention if the provision of road safety is to be further improved for schoolchildren aged 5-13. (Edited author abstract) 13 refs.

Spear, Margaret G. (Univ of Reading, Engl); Singh, Amarjit; Downing, Charles. *Res Rep Transp Road Res Lab* 101 1987 25p.

**090600 EASING THE IMPACT OF ROADSIDE CRASHES.** A priority of the Federal Highway Administration (FHWA) has long been to improve road-building technology and the safety of highway users. Because full-scale crash tests can reliably duplicate actual collisions, they are the traditional standard for developing and evaluating roadside safety hardware. However, in order to reduce costs and improve the repeatability of test results, alternative test methods have been developed over the years. This paper discusses tests conducted at the Federal Outdoor Impact Laboratory, where a reusable test vehicle and small cars are being run head-on and sideways into sign posts, light poles, and guard rails in an effort to make roadsides safer.

Hargrave, Martin W. (Federal Highway Administration, McLean, VA, USA); Hansen, Allen G. *Mech Eng* v 110 n 2 Feb 1988 p 58-63.

**090601 OVERHEIGHT-VEHICLE DETECTOR SYSTEM.** Lothian Region's Transportation Committee instructed their Department of Highways to investigate the possibility of installing a system to reduce the incidence of overheight vehicles colliding with bridges at two sites. Despite the demanding requirements, a company was discovered with the necessary optical, electronic and mechanical expertise to construct and install the equipment. The system is based on the use of two solid-state light sources transmitting invisible beams of infrared light from a pole on one side of the road to two detectors mounted on a pole on the opposite side of the road. When the system detects the passage of an overheight vehicle, it promptly activates a fiber-optic vehicle diversion sign. 3 refs.

McCann, Vincent (Lothian Regional Council). *Traffic Eng Control* v 29 n 4 Apr 1988 p 210, 215.

**090602 ENGINEERING ANSWERS.** Cambridge-shire County Council aims, by the year 2000, to achieve a reduction in casualties of 10% by giving higher priority to major road schemes which will cut accidents, and by increasing the money spent on low-cost accident remedial schemes. An outline of the main remedial engineering techniques includes: a black site will be identified on a

slightly different basis by each county in the light of the severity of accidents in the county and the resources available; route action is the application of accident prevention measures along a particular route; area action usually attacks the accident problems of part of a town or city by a combination of engineering measures, education and enforcement. There have been spectacular results in many counties using these techniques. Cambridgeshire, over the last five years, has achieved more than a 200% return on total capital investment and the cut in the number of accidents on most sites is significant.

Oldridge, Brian (Cambridgeshire CC, Engl). *Surveyor (Sutton Engl)* v 169 n 4978 Jan 21 1988 p 16.

**090603 EDUCATION, ENFORCEMENT, ENGINEERING.** Road Safety. The Next Steps summarizes the findings of an interdepartmental review of road safety policy. It also promotes the redirection of resources to be concentrated on the most cost-effective policies in value for money terms, at the expense of policies of questionable value in economic terms. The report proposes the concentration of resources on three prime policies, namely curriculum studies, low cost engineering schemes and research, with little value being placed on road user education/training, campaigns or enforcement. The author discusses the report and suggests three ways that the government can improve its road safety: education; enforcement; engineering.

Aylott, Roy (City of London Corp, Engl). *Surveyor (Sutton Engl)* v 169 n 4978 Jan 21 1988 p 18-19.

**090604 RIDE SAFETY OF ROADS VEHICLES.** As vehicles ride over rough roads, they respond dynamically and inadequate road holding may arise. This paper examines the ride safety of an articulated vehicle over irregular roads through an analytical study. The vehicle's responses to road surface undulations are studied using (a) spectral density approach, and (b) statistical linearization approach. The first approach is reviewed and applied to a linearized vehicle model to obtain the dynamic wheel loads. The second approach is presented and used to deal with the various nonlinearities in vehicle suspension systems. The results of the classically linearized system are presented and conclusions are drawn as to the applicability of both approaches. (Edited author abstract). 15 Refs.

El-Madany, M.M. (King Saud Univ, Riyadh, Saudi Arabia). *J Eng Sci King Saud Univ* v 14 n 1 1988 p 95-113.

**Accidents** See Also TRAFFIC SIGNS, SIGNALS AND MARKINGS.

**090605 ERGONOMICS SOCIETY. THE SOCIETY'S LECTURE 1985. PROSPECTS FOR IMPROVING ROAD SAFETY.** The main aim of the lecture is to emphasize the acknowledged fact that the present level of road casualties represents a major public health problem. It also suggests that this whole problem area needs and deserves the skilled attention of ergonomists. The author demonstrates that the ergonomics issues in this field are varied and interesting, both theoretically and practically. 38 refs.

Brown, Ivan D. (Medical Research Council, Cambridge, Engl). *Ergonomics* v 29 n 12 Dec 1986 p 1495-1505.

**090606 ANALYSIS OF THE HAZARD INVOLVED IN TURNING OFF FROM THE OUTSIDE OF LARGE RADIUS CURVED ROADS ACROSS THE PATH OF ON-COMING TRAFFIC.** One of the most common types of traffic accidents involves vehicles turning right from a major road across the path of on-coming traffic. They usually result from misjudgement by the turning driver of the available time gap. The situation is particularly hazardous if the turn-off is located on a large radius curved section of the major road, when the turning driver is on the outer side of the curvature. This situation is analysed in this note. The derivation of a formula for the calculation of the distortion in the estimated speed of the on-coming traffic is also presented. 2 refs.

Generowicz, B. *Aust Road Res* v 18 n 1 Mar 1988 p

31-33.

**Australia** See ROADBUILDING MACHINERY—Testing.

**Austria** See PAVEMENTS—Asphalt.

**Belgium** See PAVEMENTS—Concrete.

**Bituminous** See BITUMINOUS MATERIALS—Evaporation; GAS PIPELINES—Leak Detection; PAVEMENTS—Asphalt.

**Canberra, Australia**

**090607 NEW PARLIAMENT HOUSE ACCESS ROADS.** Provision of appropriate access to New Parliament House involved the resolution of sometimes conflicting requirements, including consideration of the existing topography and road networks, observance of good traffic engineering practice, requirements of existing and projected traffic and the existing infrastructure. The ceremonial approach to the House is provided by the Land Axis which links the Parliamentary Triangle with the Forecourt of the new Parliament House. This link is both visual and physical and is provided by two roads and a continuity of landscape between the two buildings. The Parliament House Access Road structures have been designed to provide the initial welcoming gesture to all visitors. They are complementary in both principle and detail to the architecture and landscape of Parliament House. Concrete is the predominant material and the structures exhibit high quality in situ and precast concrete finishes.

Anon. *Constr Rev* v 61 n 2 May 1988 p 32-37.

**Computer Aided Design**

**090608 CORPS OF ENGINEERS LOW-VOLUME ROAD DESIGN.** The U.S. Army Corps of Engineers' pavement design procedures are particularly appropriate for low-volume road applications because they were developed from traffic tests using relatively low traffic volumes and thin pavement sections on low-strength subgrades. The flexible pavement criteria are most appropriate for thin asphalt concrete pavements in granular base courses and subbases. However, development of roller-compacted concrete pavement construction has made rigid low-volume pavements feasible in many situations, and the corps design method is capable of addressing roller-compacted concrete pavement characteristics. These design procedures, published in Army technical manuals, have also been computerized. (Edited author abstract). 4 Refs.

Potter, John, C. (US Army Corps of Engineers, Vicksburg, MS, USA); Rollings, Raymond, S.; Barker, Walter, R. *Transp Res Rec* n 1128 1987 p 90-94.

**Construction** See Also ASPHALT—Recycling; COKE PLANTS—Transportation; EMBANKMENTS—Materials; GEOTEXTILES—Applications; HIGHWAY SYSTEMS—Australia; HIGHWAY SYSTEMS—Interchanges; LOGGING—Transportation; PAVEMENTS—Concrete; ROADBUILDING MATERIALS—Testing; ROCK—Stabilization.

**090609 ARTERIAL ROAD FUNDING FOR SOUTHEASTERN JEFFERSON COUNTY: EQUITY BASED ON TRAFFIC IMPACT.** Rapid development has resulted in a sudden deterioration of traffic conditions in southeastern Jefferson County, Colorado. This has led to an intensive effort to develop a funding and construction program to alleviate the deficiencies and provide for future needs. Traffic projections were used to size the needed roadway system and derive improvement costs, which were apportioned to each land use category on the basis of traffic generation. This apportionment became the main parameter for establishing a 20-year funding plan



made up of three revenue sources: property tax, sales tax, and traffic impact fees on a 1/3, 1/3, 1/3 basis. (Edited author abstract) 1 ref.

Zebauers, Valdis (Jefferson County Dep of Highways & Transportation, Golden, CO, USA); Zeikus, Al. *Transp Res Res* 1107 1987 p 93-96.

**090610 STRASSENUMBAU- QUALITAET VOR QUANTITAET.** [Road Construction - Quality before Quantity]. Although the traffic volume is increasing constantly and rapidly on the roads, the motorists' riding behavior is far from being adapted to the worsening traffic conditions. Some improvement towards more safety, quality of life and a quieter traffic flow can be imposed by local road reconstructions which should be seen as an interdisciplinary planning task. To exemplify what can be done, some cases are outlined and supported by photos and graphs. (Author abstract) In German. 4 refs.

von Moerner, Joerg. *Str Tiefbau* v 41 n 10 Oct 1987 p 5, 8-12.

**090611 PRE-PLANNING PAYS.** With the latest phase of construction of the Birmingham Middle Ring Road getting under way, the author looks back at the long process of preparation which the scheme required - including a diversion of a stretch of the Grand Union Canal and the exhumation and clearance of a churchyard. (Edited author abstract)

Rose, Maureen. *Surveyor (Sutton Engl)* v 168 n 4973 Dec 3 1987 p 12-15.

**090612 IMPRESSIONS OF A STUDY TOUR TO THE USSR ON ROAD CONSTRUCTION AND MAINTENANCE.** A two-week seminar on construction and maintenance of roads in wet, marshy and arid areas in the USSR was organized in August 1987 by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). It was attended by the author as a delegate from India along with 13 other delegates from 13 other Asian and Pacific countries like China, Japan, Thailand, Malaysia, Afghanistan, Burma, Sri Lanka, Bangladesh, Philippines and a few delegates from USSR. Some of the general impressions formed on the basis of information gathered during the Seminar are given. Subjects covered include roads in wet and marshy areas, embankments on soft soils, roads in arid and desert areas, soil stabilization, practices in other countries, drainage, and others.

Merani, Shri N.V. (Government of Maharashtra, Public Works Dep, India). *Indian Highw* v 15 n 12 Dec 1987 p 15-26.

**090613 THOMAS ROY AND HIS 'REMARKS ON ROAD-MAKING' (1841).** Thomas Roy was a civil engineer and geologist who lived in Toronto from 1834 to 1842; he was probably Canada's first geotechnical engineer. In 1835 he carried out the survey for what would have been Canada's first railway if it had then been constructed. He acted as City Engineer for the fledgling city. Nothing is yet known of his life before 1834 but the search continues. In 1837 he presented to the Geological Society of London a paper on the former, raised water levels of the Great Lakes, based on his field observations while surveying. In 1841 he wrote and had published a remarkable little book on road making, in some ways far ahead of its time; significant extracts are presented. (Author abstract) 10 refs.

Legget, Robert F. *Can Geotech J* v 25 n 1 Feb 1988 p 1-12.

**090614 METHODS THAT CAN REDUCE WORK ZONE FATALITIES.** Flaggers and construction workers, as well as the driving public, are endangered in highway work zones. Studies show that accident rates climb during construction. Four techniques to improve the effectiveness of speed zoning in construction areas on multi-lane freeways were recently studied. The procedures studied included: Flagging using procedures of the Manual on Uniform Traffic Control Devices (MUTCD). Use of the MUTCD flagging procedure, plus the flagger using

a free hand to point at a nearby speed-limit sign. Use of a marked police car with cruiser lights and radar active. Use of a uniformed police officer standing to control traffic. This article discusses the study and its results.

Anon. *Better Roads* v 58 n 4 Apr 1988 p 33-34, 38, 40.

**090615 OPTIMIZATION OF ENGINEERING PREPARATION IN THE ROAD CONSTRUCTION PROCESS.** Results are presented of the development of economic-mathematical models, methods, and algorithms for the solution of optimization problems in the distribution of soil masses and in the outline of the design profile of a longitudinal roadbed. These developments are based on the principles of system optimization. They ensure the automation of the technology of the process of making design decisions by adapting the problem to the requirements of the person making the decision. Such an approach allows one, when correcting projects, to take into account production, social, economic and other factors, to evaluate alternatives under conditions of indeterminacy, as well as to increase the timeliness of design decision-making. 4 Refs.

Zaytsev, R.V. (Ukrainian SSR Acad of Sciences, Kiev, USSR); Sibirko, A.I.; Biletskiy, V.I.; Vasilevskiy, I.A.; Matviychuk, L.A. *Sov J Autom Inf Sci* v 20 n 3 May-Jun 1987 p 26-31.

## Database Systems

**090616 INROADS: A NEW DATABASE FOR ROADS AND TRANSPORT.** A computer-based library catalog, called ROAD, using the same format as Australian Road Research Documentation or ARRD, was developed to handle new additions to the ARRB library from January 1984. The catalog was not publicly available; however, State Road Authority libraries were provided with passwords for this file. In response to the comments of ARRB library users, the feasibility of combining the ARRD and ROAD databases was explored, with the result that a new combined database called INROADS has just been mounted on CSIRO's AUSTRALIS network. The new file is available publicly to all users of AUSTRALIS and it should prove a boon to anyone interested in roads information in Australia.

Price, R. (Australian Road Research Board). *Aust Road Res* v 17 n 2 Jun 1987 p 137-140.

**Degradation** See Also HIGHWAY SYSTEMS—Evaluation.

**090617 MANHOLE COVER DETERIORATION DIAGNOSIS TECHNIQUE.** This paper describes a technique for diagnosing manhole cover deterioration. Manhole covers installed on road surfaces suffer damage such as internal cracking and enlargement due to the repeated buffeting of vehicular traffic. The deterioration process in cast iron was investigated and the speed of crack growth was determined theoretically. The extent of cover damage was evaluated quantitatively by analyzing the free vibration characteristics after striking the cover with a hammer. These investigations have led to the development of a handy tester which is capable of measuring the life span of a cover in about 5 minutes. (Author abstract) 10 refs.

Honjoh, Katsuhiko (NTT, Jpn); Sudoh, Yoshikazu; Masuda, Jun-ichi. *Rev Electr Commun Lab (Tokyo)* v 35 n 6 Nov 1987 p 695-700.

**Design** See Also HIGHWAY ENGINEERING—Research; REGIONAL PLANNING—Transportation.

**090618 ZUR METHODIK DER STRABEN-BAUFORSCHUNG.** [Methodology of Road Design Research]. Road research aims at optimization of road design in a technical and economical respects. The approach to data and findings for implementation of these objectives can be subdivided into four fields of action: empirical observation of the performance of existing roads, test roads, laboratory, and theoretical design rules. Comments are made on all of them and on their relative merits. The success of road research is regarded as a

reasonable ensemble and harmonization of findings from all of the engaged fields. (Edited author abstract) In German.

Schmidt, Michael (Forschungsinstitut der Zementindustrie, Duesseldorf, West Ger). *Str Tiefbau* v 41 n 4 Apr 1987 p 46 between p 6 and 18.

**090619 WAY FORWARD FOR DESIGN?** With the publication of the IHT/DTp guide on design for Roads and Traffic in Urban Areas the two existing manuals on the subject have been updated. The author looks at the handbook. (Edited author abstract)

Henderson, Arthur. *Surveyor (Sutton Engl)* v 168 n 4973 Dec 3 1987 p 16-17.

**090620 CROSS SECTION DESIGN OF RESIDENTIAL STREETS BASED ON MEETINGS BETWEEN MOTOR VEHICLES.** The traffic volume and the number of trips, the factors that affect them, the daily and hourly variations, the percentages of vehicle types, the turning behavior and the number of meetings between motor vehicles of different type driving in opposite directions were examined during 208 count days on 113 residential streets in selected areas of low-rise housing in 33 Finnish municipalities. A method is created for cross section design of residential streets based on time intervals between meetings of motor vehicles of different type. Models to estimate the number of trips and the daily traffic are also presented in this report. (Author abstract) 30 refs.

Saarnivaara, Veli-Pekka (Helsinki Univ of Technology, Helsinki, Finl). *Acta Polytech Scand Civ Eng Build Constr Ser* n 87 1988 53p.

**090621 NEED FOR ADEQUATE INTERSECTION SIGHT DISTANCE IN ROADWAY DESIGN.** The design of roadway improvements or new facilities normally focuses much attention on the selection of design speed, which controls the horizontal and vertical alignment. Design speed is one of the main criteria used to attempt to achieve uniform speeds with minimum variations and to realize consistent and safe operations on roadways. Design speed establishes maximum degree of curvature or minimum radius for horizontal curves and suitable length of vertical curves to provide safe stopping sight distance in the case of emergencies. Thus it is important that adequate sight distance be provided at intersections of streets and driveways with major roadways. Proper sight distance would improve safety and result in better operating conditions. 2 Refs.

Bhesania, Russi P. (Transportation Dep of the City of Kansas City, Kansas City, MO, USA). *ITE J* v 58 n 8 Aug 1988 p 43-45.

## Developing Countries

**090622 VIEW OF ROAD MAINTENANCE ECONOMICS, POLICY AND MANAGEMENT IN DEVELOPING COUNTRIES.** Work that has been carried out at the Transport and Road Research Laboratory of the United Kingdom in the field of road maintenance in developing countries is reviewed under the headings of economics and policy, project implementation, and management. Numerical examples are given to illustrate the economic benefits of road maintenance, and some of the reasons for the poor conditions of road networks in developing countries are discussed. Different approaches to carrying out maintenance are described, including a discussion of equipment and labor-based methods, and of using contractors. Recommendations are made on priorities for budgeting. Maintenance management systems are described in terms of their objectives and their component steps, and the recommendation is made that maintenance frequencies should be determined on an economic basis using whole-life costs. Examples of the use of such methodology in the management of unpaved roads are given. The need for condition measurement surveys to determine maintenance needs for paved roads is described and different methods of rapid assessment are discussed. 62 refs.



Robinson, R. (Transport & Road Research Lab, Crowthorne, Engl). *Res Rep Transp Road Res Lab* n 145 1988 32p.

**Drainage** See Also BRIDGES—Drainage; FLOWMETERS; ROADBUILDING MATERIALS—Testing.

**090623 STORM DRAINS REQUIRE CORROSION-RESISTANT MATERIALS.** A recently completed 4.8 million dollar project contracted by the State Highway Administration of Maryland involved constructing a 17,500-ft-long median strip to divide the six lanes of State Route 528 in Ocean City. This article discusses the storm drain installation for the highway. Selection of corrosion-resistant materials is reviewed.

Anon. *Public Works* v 119 n 8 Jul 1988 76p.

## Economics

**090624 ECONOMIC ARGUMENTS ON TOLL ROADS.** From the economic point of view, tolling is an instrument that can be uniquely suited to the collection of efficient road use prices. It is important to ensure that effects on the economy at large, not only on the toll agency, are included in toll road analysis. This is not generally done and is the reason for this paper. There are, however, a number of conditions under which tolling may be appropriate (i.e., not worsen resource allocation or even improve it over untolled roads despite higher costs inevitably entailed in tolling with current technologies). Examples of results from tolling in two developing countries are provided. Only tolling of interurban roads is discussed. (Edited author abstract)

Johansen, Frida (World Bank, Washington, DC, USA). *Transp Res Rec* 1107 1987 p 80-84.

**Embankments** See Also EMBANKMENTS—Protection; LAND RECLAMATION—Revegetation; RAILROAD PLANT AND STRUCTURES—Track.

**090625 WESTBOUND EMBANKMENT PRELOAD ON RAINIER AVENUE, SEATTLE, WASHINGTON.** Fifty-foot-high approach embankments recently completed for a bridge crossing of Rainier Avenue in downtown Seattle required preloading of compressible lacustrine clay sediments as much as 50 ft thick below the abutment areas. This paper presents the results of engineering analyses and recommendations for very complex surcharge fill requirements. Vertical prefabricated drains were used in the preload to accelerate settlement and an unprecedented 55-ft-high soil-reinforced wall was used to limit the extent of the fill and thereby prevent damage to existing utilities and adjacent structures. The instrumentation program used to measure the settlement response is discussed, and the variation in magnitude and time rate of settlement measured across the site is summarized. (Edited author abstract) 6 refs.

Cotton, David M. (D.M. Cotton Associates Inc, Redmond, WA, USA); Kilian, Alan P.; Allen, Tony. *Transp Res Rec* 1119 1987 p 61-75.

**090626 USE OF WOOD FIBER IN LIGHT-WEIGHT EMBANKMENTS FOR NORTHERN APPLICATIONS.** The application of wood fibers to road-way embankments may provide a convenient solution to the most perplexing problem northern engineers face. Prior case studies have yielded excellent results in the State of Washington when used for soft soil conditions. Much work needs to be done in the areas of further defining both wood fiber and permafrost engineering properties. Important values need to be established for the viscoelastic properties of permafrost as well as engineering properties of the wood fibers, such as compressibility values as in clays, and reliable values for the modulus of elasticities of various fiber sizes and species. 6 refs.

McMahon, Robert J. (Univ of Utah, Salt Lake City, UT, USA). *North Eng* v 19 n 3-4 Fall-Winter 1987 p 35-39.

## Environmental Impact

**090627 ENVIRONMENTAL HAZARDS AND IMBALANCE OF ECO-SYSTEM DUE TO ROAD DEVELOPMENT.** The theme of this article represents the environmental and ecological changes that a region will experience due to construction of new road. The specific region (in India) discussed has already undergone environmental degradation by construction of several major projects close to the alignment of the new road. These projects have not only contributed to environmental degradation and imbalance in ecosystems but displaced local population causing them to shift laterally towards the new alignment thereby overcrowding the area and effecting drastic changes in the land use pattern.

Panda, Jagdish (N.H. & Project Circle, Angul, India). *Indian Highw* v 15 n 6 Jun 1987 p 26-33.

**090628 STUDY ON IMPACT OF ROADS ON VARIOUS SECTORS OF DEVELOPMENT IN TAMIL NADU.** In this paper, the impact analysis has been carried out through the use of factor analysis and regression analysis techniques. A host of development indicators relating to different sectors of the economy has been developed and measured for each district in Tamil Nadu. The values of development indicators have been used in factor analysis and then the values of factors are used in regression analysis. The analysis has clearly established that roads have a wide ranging impact on all the sectors of economy. (Author abstract)

Srinivasan, N.S. (Natl Transportation Planning & Research Cent, Trivandrum, India); Herur, Arun; Chand, Mahesh. *J Inst Eng India Part CI* v 68 n 2 Sep 1987 p 102-109.

**090629 EVALUATION TECHNIQUE FOR SOCIAL AND ENVIRONMENTAL ASSESSMENT OF ROADING PROPOSALS.** This paper describes the form of analyses used recently in Christchurch to assess the merits of proposed road works. In particular, it describes the method developed to assess the social and environmental effects of traffic planning. The results of the environmental and social assessment are discussed and some modification of the approach is suggested. In the past, more deterministic methods of assessment such as improvement in traffic systems measures and/or benefit cost analysis have alone been used to justify road works. With relatively less road expenditure being used to add to the urban network, wider examination of the effects of such expenditure is to be encouraged. (Author abstract)

Wood, D. Ritchie (Canterbury United Council). *Trans Inst Prof Eng NZ Civ Eng Sect* v 14 n 3 Nov 1987 p 141-146.

## Evaluation

**090630 RATING UNSURFACED ROADS.** About two-thirds of all highways in the United States are unsurfaced or lightly surfaced low-volume roads. To help local highway agencies manage the maintenance of these roads, a system for rating each section of road has been developed to indicate how badly that section needs repair and to identify problem areas. An unsurfaced road is any road that does not have portland cement concrete, asphalt concrete, or other surface treatment. Some agencies consider gravel to be a surfacing material; for the purposes of this article a gravel road is an unsurfaced road. The method for rating the condition of unsurfaced roads has three steps: 1) dividing the road network into sections; 2) inspecting the sections and identifying problems; and 3) calculating ratings that indicate the condition for each section.

Eaton, Robert A. (US Army Cold Regions Research & Engineering Lab, USA). *Public Works* v 119 n 3 Mar 1988 p 66-69.

**Failure** See Also FLOOD CONTROL; MOTOR TRUCKS—Australia.

**090631 SEALING OF CRACKS IN BITUMINOUS**

**SURFACE WITH RUBBERIZED BITUMEN.** All kinds of failure of roads render the riding quality of the road poorer and also reduce its future life and load carrying capacity. The riding quality of a cracked bituminous surface is much poorer as compared to its original quality without any cracks when laid. Besides, the cracks make the surface ugly. Cracks may range from simple hair cracks appearing on the surface which may not affect the riding quality of the road much, too wide cracks penetrating through the bituminous layer, and if not taken care, may spoil the surfacing and the road completely in due course of time. Sealing of cracks in bituminous surface by rubberized bitumen before laying fresh layers of bituminous macadam and/or dense asphaltic concrete, gives satisfactory results. This article is based on a practical example where rubberized bitumen for sealing cracks in bituminous surface, has actually been used and is behaving satisfactorily. 3 refs.

Sinha, B.N. (PWD Delhi Admn, New Delhi, India). *J Indian Roads Congr* v 48 n 1 Aug 1987 p 177-185.

**090632 THEORETICAL ROAD DAMAGE DUE TO DYNAMIC TYRE FORCES OF HEAVY VEHICLES. PART 2: SIMULATED DAMAGE CAUSED BY A TANDEM-AXLE VEHICLE.** The literature relating to road surface failure and design is briefly reviewed and the conventional methods for assessing the road damaging effects of dynamic tire forces are examined. A new time domain technique for analyzing dynamic tire forces and four associated road damage criteria are presented. The force criteria are used to examine the road damaging characteristics of a simple tandem-axle vehicle model for a range of speed and road roughness conditions. It is concluded that for the proposed criteria, the theoretical service life of road surfaces that are prone to fatigue failure may be reduced significantly by the dynamic component of wheel forces. The damage done to approximately five per cent of the road surface area during the passage of a theoretical model vehicle at typical highway speeds may be increased by as much as four times. (Edited author abstract) 32 refs.

Cebon, D. (Univ of Cambridge, Engl). *Proc Inst Mech Eng Part C* v 202 n C2 1988 p 109-117.

**Federal Republic of Germany** See MOTOR TRANSPORTATION—Europe.

## Foundations

**090633 IMPROVED ROADBASE MACADAMS: ROAD TRIALS AND DESIGN CONSIDERATIONS.** Previous pilot-scale investigations have shown that improved macadams with a larger grade of binder and more filler than normal dense bitumen macadam have considerable potential and full-scale trials should take place. These materials for use in roadbase construction have now been evaluated in five motorway and other trunk road contracts. Analysis of the production process showed that it might cost up to 10 percent more, but its superior load spreading ability allows a thinner depth of construction to be specified and the overall cost saving is likely to be at least 12 percent. There are situations where additional filler is not readily available or where its use leads to longer mixing times and a significant reduction in productivity of the mixing plant: the additional filler may then be omitted and the resultant material will still be more cost effective than normal dense bitumen macadam. Analysis of the structural properties of material taken from the five reconstruction sites provided a basis for design curves relating thickness of construction to cumulative traffic loading over the design life of the pavement. (Author abstract) 7 refs.

Nunn, M.E.; Rant, C.J.; Schoepe, B. *Res Rep Transp Road Res Lab* 132 1987 15p.

**090634 PROOF TESTING OF ROAD FOUNDATIONS.** Publication of TRRL LR 1132 in 1984 introduced into the UK design methods the concept of relating pavement structural design to the resilient properties of



road foundation constituent materials. Using these methods the road foundation itself is designed to meet construction haul road requirements with the provision that the support to the overlying pavement layers is at least equivalent to 225 mm Type 1 sub-base above a subgrade of 5% CBR. The report stated the desirability of proof-testing the road foundation to establish, prior to placing road bases, that the required level of support was available. This support has been defined in terms of dynamic or resilient moduli of the layers forming the pavement foundation. For granular materials in particular, the dynamic moduli and the static moduli are stress-dependent. 18 refs.

Cobbe, Mike I. (Geotechnics Ltd, Coventry, Engl). *Highways (Croydon Engl)* v 56 n 1933 Jan 1988 p 12, 15, 30.

**Frost Effect** See Also CONCRETE—Disintegration; PAVEMENTS—Testing.

**090635 POLYSTYRENE FORM AS A FROST PROTECTION MEASURE ON NATIONAL ROADS IN SWEDEN.** In the specifications of the National Road Administration in 1976, the extruded polystyrene skin-board, type HI 50 from the Dow Chemical Company, was recommended for use in an insulated road base. For skid resistance, the depth of insulation was changed from 50 cm, according to the 1976 specifications, to 40 cm below road surface in the specifications of 1984. This change was based on experience from the Swedish Road and Traffic Research Institute test field. A new procedure is being developed making it possible to calculate the frost heave when the frost penetrates below the base into underlying frost-susceptible soils. The procedure is based on determination of the frost heave properties of soils by a direct freezing test. This make it possible to optimize the frost-protective base construction in relation to local climatic, geological, and hydrological conditions at the site. (Edited author abstract). 5 Refs.

Gandahl, Rune (Swedish Road & Traffic Research Inst, Linköping, Swed). *Transp Res Rec* n 1146 1987 p 1-9.

## Guard Rails

**090636 PERFORMANCE OF LONGITUDINAL TRAFFIC BARRIERS.** This report presents findings and conclusions from the evaluation of an array of longitudinal traffic barriers. The barriers were evaluated according to the NCHRP Report 230 criteria. Special emphasis was given to barrier systems currently in use in large numbers. Existing crash test performance of longitudinal barrier systems was reviewed for compliance with NCHRP Report 230. Based on this review a matrix of five guardrail, two median barrier, and four bridge rail systems was evaluated with full-scale crash tests for occupant risk with 1,800-lb (820-kg) sedans (test 12 in Table 3 of NCHRP Report 230). The results were evaluated using the recommended values of NCHRP Report 230 to which all systems were essentially in compliance. Further evaluation of five guardrail and one median barrier systems was performed with an 1,800-lb (820-kg) sedan impacting at 60 mph (95 km/h) and a 20-deg angle (test S13 of NCHRP Report 230). The purpose of these tests was to provide further insight into the performance of the barrier systems. (Edited author abstract) 20 refs.

Bronstad, M.E. (Southwest Research Inst, San Antonio, TX, USA); Michie, J.D.; Mayer, J.D. Jr. *Natl Coop Highw Res Program Rep* 289 Jun 1987 175 p.

**090637 CUSHIONING THE BLOW BRUMMIE STYLE.** The guard rail energy absorbing terminal (GREAT) crash cushion system in Birmingham has saved lives by protecting occupants in collisions with rigid objects. The crash cushion solves the problem of protecting narrow rigid objects by a series of unique design features. The corrugated side panels and backups form a torsionally stiff box which resists lifting and twisting under impact. Penetration of the vehicle's passenger cell by the side panels is prevented by backup systems, and in some cases a steel cable anchors the system to the ground. Redirection in side impacts is provided by the inherently

stiff structure, and by chains attached to the ground.

Proctor, Steve (Birmingham City Engineer's Dep, Birmingham, Engl); Greaves, Des; Beresford, Tony; Bowling, John. *Surveyor (Sutton Engl)* v 169 n 4978 Jan 21 1988 p 20-22.

## Ice Problems

**090638 CHEMISTRY OF DEICING ROADS: PENETRATING ICE.** Experimental measurements of the rates at which sodium chloride, calcium chloride, urea, and calcium magnesium acetate (CMA) penetrate ice are consistent with a theory developed to predict this rate. These measurements and theory complement earlier studies of the rate at which ice can be deboned from road pavement. The mass transfer coefficients found from the penetration measurements are similar to those found from spinning ice disks, but are much less than those found for debonding. Possible reasons for this discrepancy and the steps that limit road deicing are discussed. (Author abstract) 15 refs.

Trost, Susan E. (Univ of Minnesota, Minneapolis, MN, USA); Heng, Frank J.; Cussler, E.L. *J Transp Eng* v 114 n 2 Mar 1988 p 221-231.

## India

**090639 NEW THINKING ON PRIVATE-SECTOR TOLL ROADS IN INDIA: RATIONALE AND ISSUES.** India has the fourth longest road network (1.7 million km) in the world (Table 1), about 0.8 million km of which are paved, but the unfinished tasks are stupendous: merely to connect by road all villages of 500 or more people by the year 2001 and to raise road density to 0.82 km/km<sup>2</sup> from the present 0.46 km/km<sup>2</sup>, the length of the road network would have to be increased to 2.7 million km. India's effort to involve the private sector in the provision of tolled roadways is outlined. Relevant provisions of the Seventh Five-Year Plan (1985-1990) and concerns of the private sector are discussed, and questions that remain to be resolved are summarized.

Pendse, D.P. (Tasa Industries, Bombay, India). *Transp Res Rec* 1107 1987 p 38-41.

**090640 ROADS—CAN WE NEGLECT THEM ANY FURTHER?** While only a subsidiary role was played by road transport in the past, it has now emerged as a major and essential infrastructure for growth and development of national economy. Road transport system has both flexibility and reliability, besides speed, door-to-door services, accessibility to remote areas and the highest employment generation potential as well. The article reviews three road development plans prepared for the country: the Nagpur Plan in 1943, the Bombay plan from 1961-81 and the 1981 to 2001 road plan.

Malhotra, J.M. (Indian Roads Congress, India). *Indian Highw* v 16 n 5 May 1988 p 5-8.

**090641 ROAD DEVELOPMENT IN THE STATE OF ASSAM: ACHIEVEMENTS AND FUTURE STRATEGIES.** The main achievements under the road development plans (Nagpur Plan and Bombay Plan) include the addition of roads; development of National Highways and removal of their deficiencies; building of road bridges and embankments. The task ahead calls for utmost sincerity and all out efforts from the engineering community. Technological innovations with the objective of making optimum use of locally available resources, tact and humility for obtaining complete co-operation and participation of the people, augmentation of fleet of plant and equipment to ensure maximum mechanised construction and judicious utilization of available financial resources are essential to achieve the objectives and targets laid down in the draft Master Plan of 1981-2001.

Gogoi, B.N. *Indian Highw* v 16 n 5 May 1988 p 15-21.

**Intersections** See Also HIGHWAY SIGNS, SIGNALS AND MARKINGS; STREET TRAFFIC CONTROL; STREET TRAFFIC CONTROL—Computer Applications; STREET TRAFFIC CONTROL—Management; STREET TRAFFIC CONTROL—Pedestrian Safety; TRAFFIC SIGNS, SIGNALS AND MARKINGS; TRAFFIC SIGNS, SIGNALS AND MARKINGS—Standards.

**090642 LAPTOP COMPUTERS MEASURE INTERSECTION PERFORMANCE.** Intersection level of service is defined in the 1985 Highway Capacity Manual as a function of the average delay per stopped vehicle on each approach. One solution to the problem of measuring intersection performance would thus be a computer program that calculates average stopped delay per vehicle and that runs on a small, laptop computer that could be used in the field. Intersection Delay (ISDELAY) is a straightforward program, written in a universal subset of BASIC, designed to measure stopped delay. This program should run with little or no modification on any laptop, or for that matter, any desktop computer with a BASIC interpreter. 2 refs.

Henry, R. David. *ITE J* v 57 n 6 Jun 1987 p 39-42.

**090643 DEVELOPMENT OF PASSENGER CAR EQUIVALENCIES FOR LARGE TRUCKS AT SIGNALIZED INTERSECTIONS.** The research reported in this article attempted to quantitatively measure the difference in operating characteristics between passenger cars and trucks traveling straight through a level, signalized intersection. The data collected were used to develop PCE (passenger car equivalent) values for trucks based on truck type and position in queue. Increasing the capacity of the intersection can be realized through signal timing optimization and improving the progression between intersections. 10 refs.

Molina, Cesar J. Jr. *ITE J* v 57 n 11 Nov 1987 p 33-37.

**090644 CAPACITY FACTOR OR CYCLE TIME OPTIMIZATION FOR SIGNALIZED JUNCTIONS: A GRAPH THEORY APPROACH.** In this paper a method for setting traffic signals of individual signalized junctions is presented. Capacity factor maximization and cycle time minimization are considered as objective functions. The correspondence between cycle time and capacity factor is discussed. The influence of minimum green and maximum red constraints is analyzed. Once this correspondence is known, an efficient problem-oriented algorithm, based on a PERT-like technique, is proposed for the solution of the problem. (Author abstract) 25 refs.

Cantarella, G.E. (Univ di Napoli, Naples, Italy); Improta, G. *Transp Res Part B* v 22B n 1 Feb 1988 p 1-23.

**090645 DELAY MODELS FOR MIXED PLATOON AND SECONDARY FLOWS.** A mathematical model is described for estimating approach delays at pretimed, signalized, coordinated intersections. The delay models incorporate the size of and flow rate within the progression bandwidth. Platoon dispersion and secondary flows are considered via a simplified platoon-dispersion algorithm calibrated from the TRANSYT-7F model. The basic premise in this study is that traffic is assumed to arrive at the progressed approach in two average flow rates one within the progression bandwidth, and another outside of it. This modeling concept represents a middle ground between bandwidth models that assume a constant flow rate in the dispersed platoon and TRANSYT-like techniques where arrival flow rates vary in each time slice of the cycle length. The delay models are evaluated with Webster's delay formula for random arrivals and with simulated data in NETSIM; in both cases the results compare very favorably. (Edited author abstract) 17 refs.

Rouphail, Nagui M. (Univ of Illinois, Chicago, IL, USA). *J Transp Eng* v 114 n 2 Mar 1988 p 131-152.

**090646 RODEL - AN ALTERNATIVE APPROACH TO ROUNDABOUT DESIGN.** Roundabout design has been traditionally evaluated against geometric and safety standards and by comparing forecast traffic flows with



capacity estimates. Designs that fulfil these criteria are normally considered satisfactory. However, the recent development of better equations for estimating capacities, queues and delays, together with the increased availability of computers, now enables the design and evaluation of roundabout layouts to be made in a manner not previously possible. To take advantage of these developments 'RODEL', a computer program for aiding roundabout design, has been developed. The program is fully interactive with simultaneous display of input and output. This enables the design engineer to experiment rapidly with changes in geometry while viewing the immediately displayed changes in queues, delays and delay cost. 4 refs.

Crown, R.B. *Highw Transp* v 34 n 10 Oct 1987 p 12-19.

**090647 MODELING CONFLICTS AT INTERSECTIONS HIDDEN BY VERTICAL CURVES.** A model that estimates the relative hazard to passenger cars stopping to turn left at an intersection hidden by a vertical curve is described. Monte Carlo methods are used to estimate the relative frequency of such hazardous incidents are serious conflict situations in which an accident could not be avoided by braking alone. Left-turn gap acceptance and headway distributions in opposing traffic are used in the model to determine the random delay experienced by left-turning passenger cars. Other random variables addressed in the model are traffic speeds, headways of cars following the left-turning car, and the perception reaction time of following car drivers. The results indicate that the conflict rates increase rapidly with decreasing sight distance. (Edited author abstract) 15 refs.

Farber, Eugene I. (Ford Motor Co, Dearborn, MI, USA). *Transp Res Rec* 1122 1987 p 57-67.

Joints See STREET TRAFFIC CONTROL.

**Maintenance** See Also HIGHWAY ADMINISTRATION—Financing; HIGHWAY SIGNS, SIGNALS AND MARKINGS—Defects; HIGHWAY SYSTEMS—Service Areas; MUNICIPAL ENGINEERING; PAVEMENTS—Asphalt; PAVEMENTS—Concrete; PAVEMENTS—Evaluation.

**090648 HOW DOTS IMPROVE EQUIPMENT MANAGEMENT AND MAINTENANCE.** The top equipment management and maintenance problems are people problems, according to results of a recent Better Roads' survey. Nearly half - 48.3% - of the equipment managers responding cited the difficulties in finding and keeping competent workers, dealing with top departmental management, and training personnel as their most critical problems. The need for more or better operator training was cited as the most important equipment maintenance problem. Equipment management systems are the solution to some of the problems, according to many maintenance engineers who are using them. Additional survey results are discussed.

Anon. *Better Roads* v 57 n 10 Oct 1987 p 22-31.

**090649 SOFT WEAR FOR ROADS.** Since documented justification for allocating scarce financial resources usually is demanded, a comprehensive pavement-management system can help ensure wise budget expenditure and increase the life of existing roads. According to the American Public Works Association (APWA), local agencies are adopting pavement-maintenance management systems for a variety of reasons: to inventory existing facilities, such as pavement structure, light poles and inlets; justify maintenance budget increases; prioritize maintenance needs; and provide better roads for less money. APWA initiated a research project called PAYER through its Research Foundation in 1979. The program was developed by the U.S. Army Corps of Engineers at its Construction Engineering Research Laboratory, Campaign, Ill., for pavement management at military bases.

Buchholz, John D. *Am City Cty* v 102 n 9 Sep 1987 p 76-78, 80, 84-85.

**090650 CLOSER LOOK AT IMPACT FEES.** Localities in five states use impact fees (charges collected during approval of land development) to support public facilities

to serve proposed development. Such fees are especially useful for funding improvements in suburban and fringe areas where development pressures are particularly strong and land is readily available. In this paper the emphasis is on impact fees for roadway improvements; some of the topics addressed are developers' concerns, determining traffic impacts, attracting development, and planning considerations. (Author abstract) 11 refs.

Draper, Robert W. (US DOT, Washington, DC, USA). *Transp Res Rec* 1107 1987 p 68-73.

**090651 IMPACT FEE ASSESSMENT USING HIGHWAY COST ALLOCATION METHODS.** Impact fees have been assessed as flat fees based on the size of the development; variable fees depending on the type and location of the development; and negotiated fees determined by the required investments, the interests of the local communities, and the resources of the developer. Variable fees are analogous to roadway user taxes in that roadway costs vary with traffic and a desired revenue target is to be met. Techniques used in highway cost allocation studies can be directly applied to the design of equitable variable impact fees. Because highway cost allocation studies have received considerable attention and have been widely applied, these allocation methods might be usefully adopted for impact fee assessment. (Edited author abstract) 24 refs.

McNeil, Sue (MIT, Cambridge, MA, USA); Rossi, Thomas; Hendrickson, Chris. *Transp Res Rec* 1107 1987 p 75-80.

**090652 ZUSAMMENHÄNGE ZWISCHEN DEM STRASSENZUSTAND UND DEM UNFALLGESCHEHEN, DEM ENERGIEBEDARF SOWIE DEM ZEITAUFWAND.** [Relation Between Road Conditions and Accidents, Energy Demand and Time Required]. Evaluation of suitable methods for road maintenance and an economic use of limited finances require reliable knowledge about the relations between road conditions and accidents, transportation energy demand and the time spent by traffic participants for travel. Based on an evaluation of literature, a survey of this subject is presented. Causes of accidents are analyzed and related to insufficient road roughness and slippery conditions. The energy demand depends on the routing. Unpaved roads have a high energy demand. Rolling resistance influences the energy consumption. Unevennesses require more fuel and time. Speed measurements of different road surfaces show that the difference between mean speeds lies within the range from 1 to 5 km/h. Further research is still required. (Translated author abstract) In German. 15 refs.

Hiersche, Ernst-Ulrich (Univ Karlsruhe, Karlsruhe, West Ger); Tenzinger, Bernhard. *Str Autobahn* v 38 n 2 Feb 1987 p 39-45.

**090653 ROAD REHABILITATION IN NOVA SCOTIA.** Various rehabilitation methods have been experimented with in Nova Scotia over the years to adapt maintenance processes to climatic conditions. Three specific maintenance methods will be discussed: sand sealing, crack sealing, and seal coating. For each method, material acceptance, placement, and evaluation of the end result will be examined. Special emphasis will be placed on Nova Scotia's experience and modifications that have made an efficient rehabilitation program. (Author abstract) 2 refs.

Gervais, F.A. (Nova Scotia DOT, Windsor Junction, NS, Can); Arsenault, P.J.; Lee, G.J. *Transp Res Rec* 1096 1986 p 128-134.

**090654 CITY PUTS THE BRAKES ON PAVEMENT AGING.** The article discusses a technique employed for some 20 years in Abilene, Texas to overcome the problem of new pavement deterioration. The technique relies on an asphalt rejuvenating agent, Reclamite preservative seal, manufactured by Witco Corporation's Golden Bear Division, Los Angeles. Cores showed that the agent has a compatibility with asphalt that makes it virtually a 'partner' in delaying deterioration. Today the city is getting six to eight years before any surface maintenance is required. Pavements were tested in the

field to determine the amount of material that would penetrate in one hour. Subjects covered include test methods and the application process.

White, C. L. Jr. *Public Works* v 118 n 12 Dec 1987 p 44-45.

**090655 MAINTENANCE OF ROADS IN HIGH ALTITUDE AREAS.** Motor roads and bridle roads at high altitudes less than 3000 meters in sub-Himalayan terrain are used to serve the scattered population, but their special utility is in guarding the borders at higher altitudes. These bridle roads at higher altitudes are termed border tracks. Maintenance of such bridle roads and tracks is very difficult. There are special problems associated with it, which the paper discusses, based on the author's experience of working for about 6 years in such areas and the problems that have been experienced.

Bhakuni, H.S. (PWD, Askoye, India). *Indian Highw* v 16 n 1 Jan 1988 p 5-7.

**090656 MANAGEMENT DER STRASSENERHALTUNG: EIN INTERDISZIPLINÄRER ARBEITS- UND FORSCHUNGSBEREICH.** [Management of Road Maintenance - An Interdisciplinary Work and Research Field]. Highway engineering, street traffic control, management and economic considerations as well as mathematical statistics and data processing have to be combined as aids in optimizing road maintenance. The development of a corresponding system which takes into account both the costs of the road construction burden and of the user is outlined. Models are developed for the behavior of the pavement and of the traffic at the construction sites. (Translated author abstract) 18 refs. In German.

Schmuck, Alfred (Univ der Bundeswehr Muenchen, Neubiberg, West Ger). *Bitumen* v 49 n 1 First Quarter 1987 p 3-12.

**090657 KONZEPT FÜR DIE ZUSTANDSERFASSUNG UND -BEWERTUNG IM INNERORTSBEREICH.** [Concept for the Recording and Evaluation of Pavement Conditions in Inner City Areas]. Within the framework of road maintenance management, a considerable importance is allotted to the recording and evaluation of the road surface conditions by means of the proposed systematic recording of partial aspects (damages, defects) and their evaluation, not only an objective priority ranking of the necessary works is made possible but also recommendations can be made regarding the expedient maintenance measures. An outline of the procedure is presented and some details, evaluation possibilities and costs are explained. (Translated author abstract) 3 refs. In German.

Maerschalk, Guenther (Univ Bundeswehr Muenchen, Neubiberg, West Ger). *Bitumen* v 49 n 1 First Quarter 1987 p 13-18.

**090658 ROADWAY REBUILT WITHOUT OFFENDING MOTHER NATURE.** A unique solution was required to rehabilitate Grand Tour - a narrow, 80-year old rural New Jersey roadway located on the edge of a 20-ft high bluff overlooking a large pond. Soil borings and an analysis of slope conditions confirmed a stability failure and provided the basis for a series of recommended solutions for stabilization. The unique solution featured lowering the top of the bluff about six feet to create an acceptable rate of grade down the slope. The solution, stepping the grade, was accomplished by lowering the roadway approximately three feet, using a 3-ft high brick face reinforced concrete wall along the in-land side of the road. In addition, a 3-ft high gabion retaining wall was constructed on the cliff side of the road. This design enabled the improvements to be built immediately and adjacent to the existing road.

Farrell, William P. Jr. (T&M Associates, Middletown, NJ, USA); Metz, Brad. *Public Works* v 119 n 6 May 1988 p 72-75.



**090659 BESEITIGUNG VON WINTERSCHADEN.** [Repair of Damaged Concrete Pavement as a Result of Wintry Weather Effects]. The causes of concrete pavement damage due to severe winter conditions are considered. Some answers are given generally and in some cases exemplified by pictures. The most frequently used repair material is a mixture of epoxy resin and dry quartz sand. It is to be applied with a deep sealing solution. Its application is described. (Edited author abstract) In German.

Grunau, Edvard B. *Str Tiefbau* v 42 n 5 May 1988 p 21-26.

**090660 LOCAL TRAFFIC ENGINEERING: WHERE ARE WE?** Most local governments in the United States manage and maintain streets and roads as part of their everyday duties. How well are local governments handling their responsibilities with respect to nationally accepted traffic engineering procedures and standards? To find out how local agencies in Tennessee were doing, a survey of every city and county in the state was conducted during the fall of 1987. Local governments that maintain roads need to understand the importance of following nationally accepted standards. It is clear from this survey that not all governments are following these standards. This paper analyzes the basic objectives of the survey: decision making on traffic control; signing and striping responsibilities; accident recording systems; usage of traffic control devices. 9 refs.

Hanchey, Craig M. (Neel-Schaffer Inc, Jackson, MS, USA); Meyer, Stephen E. *ITE J* v 58 n 5 May 1988 p 27-31.

**090661 GOOD REASONS TO USE HERBICIDES IN THE FALL.** Fall spraying is less likely to result in complaints from the public. About 53 percent of vegetation management supervisors recently surveyed by Better Roads' editors report receiving fewer complaints about fall herbicide use. Study results are discussed in terms of herbicide use frequency, reasons for fall spraying, dealing with public reactions, types of herbicides used in the fall, and other related subjects.

Anon. *Better Roads* v 58 n 8 Aug 1988 p 44-45.

## Management

**090662 RESIDENTIAL STREET MANAGEMENT IN SOUTH AUSTRALIA.** From the early 1900s to the late 1940s, road networks in South Australia were developed on the rectangular grid system as an extension to the original planning of early towns and villages. In the late 1940s to the late 1970s curvilinear road systems with offset intersections and an imposed hierarchy became the norm for development in residential subdivisions. Major road standards were applied to the planning, design, and construction of all streets and roads, and allowances were built in the pavement widths and depths to provide for continuing traffic growth. Current practice generally tends to follow the preceding principles with some modifications to achieve more cost-effective designs and to minimize some of the operating problems evident with such systems. 13 refs.

Hagan, W. Barry (B.C. Tonkin & Associates); Amamoo, Sam E. *ITE J* v 58 n 3 Mar 1988 p 35-41.

**Morphology** See URBAN PLANNING—Transportation.

**New Zealand** See STREET TRAFFIC CONTROL.

**Noise Abatement** See Also SOUND INSULATING MATERIALS—Wooden Construction.

**090663 MONTE CARLO TECHNIQUE TO DETERMINE THE EFFECTIVENESS OF ROADSIDE TREES FOR CONTAINING TRAFFIC NOISE.** A computer-generated simulation of noise attenuation by foliage of trees lining urban roads has been carried out. For the simulation of foliage the program uses experimentally measured leaf parameters as input variables. A geometrical reflection model is assumed for the noise

trapped by the tall building facades parallel to the road. The results show that belts of trees do not significantly attenuate traffic noise at ground level but, for elevated levels, effective attenuation of the traffic noise occurs, especially at the higher-frequency end. (Author abstract) 9 refs.

Tang, S.H. (Natl Univ of Singapore, Singapore); Ong, P.P. *Appl Acoust* v 23 n 4 1988 p 263-271.

**090664 TRAFFIC ASSIGNMENT MODEL TO REDUCE NOISE ANNOYANCE IN URBAN NETWORKS.** The possibilities of reducing traffic noise annoyance in urban networks without reducing the total amount of automobile traffic are investigated. The basic idea is to reduce noise levels by influencing drivers' route choice. Possibilities to influence this choice were investigated by modifying an equilibrium assignment algorithm. (Author abstract). 11 refs.

Houtman, Jan, Willem (Delft Univ of Technology, Neth); Immers, Ben, H. *Transp Res Rec* n 1143 1987 p 17-21.

**090665 AKTIVER LAERMSCHUTZ MIT BETON.** [Active Noise Insulation with the Aid of Concrete]. It is a commonly known fact that in the long run noise causes damage to people's health. Therefore it is necessary to reduce the nuisance to a minimum for the people living close to noisy roads. In case it is not possible to reach that aim by structural or planning measures next to the streets there are earth walls and noise insulation walls to protect people from traffic noise. The requirements and design principles of concrete noise insulation walls are the subject of this contribution. (Edited author abstract). In German.

Kommer, Eleonore. *Beton* v 38 n 5 May 1988 p 178-181.

**Noise, Acoustic** See Also AUTOMOBILES—Noise.

**090666 TRAFFIC NOISE SPECTRA IN DRY AND WET STREET CONDITIONS.** The traffic noise surveys reported in the literature traditionally have been done in dry weather conditions. Studies concerning the influence of weather factors, such as rain, on the overall level produced by vehicles have been restricted to studies on the tire noise of single vehicles where increases as high as 10 db(A) have been observed. Few studies have undertaken the measurement of traffic noise spectra of levels produced by urban traffic in rainy conditions. During the course of some studies on urban noise undertaken in certain areas of Mexico City, there was an opportunity to make some recordings on rainy days and some on dry days, and to compare the spectra recorded under these conditions. Some measurements of noise levels were made and compared under these conditions but, due to the variability of traffic flows, it was difficult to make enough recordings in which the conditions were similar, or to take a statistical sample representative enough to make the comparisons. This note primarily refers to the spectra, but some comments on findings with respect to noise levels are made. (Edited author abstract) 4 refs.

Boullosa, R.R. (UNAM, Mexico City, Mex); Lopez, A.P. *Noise Control Eng J* v 29 n 2 Sep-Oct 1987 p 54-56.

**090667 OPTIMAL STRATEGY ON TRAFFIC CONTROL TO REGULATE STREET NOISE OVER A WIDE CITY AREA FROM TWO METHODOLOGICAL VIEWPOINTS OF DYNAMIC PROGRAMMING AND MAXIMUM PRINCIPLE.** The resultant fluctuation patterns of environmental road traffic noise can be principally described by many factors concerning traffic flow and sound propagation. From this point of view, in this paper a new criterion index to evaluate the street noise over a wide city area is initially introduced in a functional form related to the  $L_{eq}$  evaluation, in close connection with physical parameters of traffic flow and sound propagation characteristics. Then, the optimal control strategies on traffic flow to regulate the street noise over a wide area are generally determined from two methodological viewpoints by use of dynamic programming and maximum principle. Finally, the validity and effectiveness of the proposed method are confirmed, especially by means of digital simulation. (Author ab-

stract) 3 refs.

Ohta, M. (Hiroshima Univ, Hiroshima, Jpn); Hatakeyama, K.; Ikuta, A.; Takaki, N. *Int J Veh Des* v 8 n 4-6 1987 p 598-608.

**090668 LES ECRANS ANTI-BRUIT ENTRE LA PORTE DES LILAS ET LA PORTE DE PANTIN, BOULEVARD PERIPHERIQUE DE PARIS.** [Noise Barriers Between the Porte Des Lilas and the Porte De Pantin on the Paris Ring Road]. The authors describe an operation which is geographically limited, but which involved the use of several acoustic protection techniques. After examining the choice of the acoustic design based upon the particular sections, the authors show how the project was worked out, describing the architectural factors and the types of barriers used. The bidding procedure, somewhat special, is covered in the next chapter which precedes the description of the work. (Edited author abstract) In French. 4 refs.

Benoist, A. (Magat et Delescluse, Fr); Lebre, R.; Mikaelian, B.; Gourlet, J. *Travaux* n 628 Jan 1988 p 38-45.

**090669 BOULEVARD PERIPHERIQUE DE PARIS TRAVAUX D'ISOLATION PHONIQUE.** [Paris Ring Road, Acoustic Insulation Work]. Noise levels on the facades of buildings along the Paris ring road often reach levels of 80 db (A) and even a record-breaking 82 db (A). A noise protection program was initiated in 1983 by the Regional Directorate of Equipment. About 30,000 windows are to be treated. The article uses the example of the Hauts-de-Seine region and more particularly of a project completed in Vanves. The authors, describing the procedures applied, go into the details of the project. They provide information on results obtained and include the testimony of a tenant who remained in his apartment while the work was being carried out. (Author abstract) In French.

Ollivier, S. (DESRET, Fr); Leichtnam, M.; Boulain, M.; Scheffer, P. *Travaux* n 628 Jan 1988 p 46-50.

**090670 LE PROJET D'ACOUSTIQUE DANS L'ENVIRONNEMENT DU BOULEVARD DE FIVES, LE POINT DE VUE DE L'INGENIEUR.** [Acoustic Design in the Environment of Boulevard De Fives. The Viewpoint of the Engineer. The Architect and Acoustic Design]. The Lille-Roubaix-Tourcoing expressway goes through one of Lille's oldest districts: Fives, built on old marshlands, symbol of the industrial revolution of the nineteenth century, shared by the Lille-Calais and Lille-Belgium railways. Low-cost housing, special cases, numerous expropriations: the DDE (French Departmental Directorate of Equipment) who enlisted the services of an architect, had to solve many complex problems calling for extensive cooperation. The rehabilitation of Fives and of the urban expressway were combined in a single project. The author reviews the setup of this project, stressing the first advanced operations. The architect participates in this article, with many photographs showing clearly his viewpoint. (Author abstract) In French.

De Ronne, B. (Direction Dep de l'Equipeement du Nord, Fr). *Travaux* n 628 Jan 1988 p 51-54.

**Nondestructive Examination** See PAVEMENTS—Degradation.

## Norway

**090671 THE TOLL RING IN BERGEN, NORWAY.** On January 2, 1986, the city of Bergen implemented a toll ring around the central business district (CBD). The Bergen toll ring and the Area License Scheme in Singapore are the only examples known to this author of vehicles being charged a toll for entering the CBD. This paper is about the recently opened toll ring around Bergen, Norway. The physical characteristics of the toll ring - toll stations, methods of payment, reserved lanes, and control system - are described. The toll ring is successful because it was introduced to raise funds for badly needed major improvements to the road system not to restrain traffic. 2 refs.



Larsen, Odd I. (Inst of Transport Economics, Oslo, Norw). *Transp Res Rec* 1107 1987 p 41-45.

## Performance

**090672 URBAN ROADS - SOME CURRENT AND FUTURE ISSUES.** This paper summarizes past and likely future trends in population, motor vehicle ownership and urban road travel. It refers to a comprehensive study of urban arterial roads, of their traffic performance in 1981, and of projections of their traffic performance in 1991. It then discusses some current issues relating to, and expenditure on urban roads. Finally, the paper comments on the future outlook for urban roads. It concludes that finance will continue to be of major concern in the future, and suggests some alternative means of financing urban arterial road works. (Author abstract) 23 refs.

Underwood, R.T. *Inst Eng Aust Civ Eng Trans* v 29 n 4 Nov 1987 p 233-238.

## Permeability, Mechanical

**090673 ZERSTÖRUNGSFREIE KONTROLLE VON FLÄCHENABDICHTUNGEN.** [Non-Destructive Tests for the Control of Watertightness of Road Surfaces]. It is difficult to determine the watertightness of built-in road sealings. When water seeps under the surface, this is usually not noticed until wet patches can be seen underneath bridges or until the road surface shows cracks. By this time it is often too late for repairs within reasonable costs. The described system, based on measuring electric resistance, facilitates the detection of sealing damages at an early stage. (Edited author abstract) In German.

Luber, W.J. (Abteilung Brückenbau des Strassenbauamtes, Schondorf, West Ger). *Bauingenieur* v 62 n 11 Nov 1987 p 519-522.

## Planning See Also TRANSPORTATION—Traffic Control; URBAN PLANNING—Transportation.

**090674 GEODAETISCHE ARBEITEN DER OERTLICHEN VORPLANUNG VON STRASSEN.** [Geodetic Works in Local Street Planning]. In our days the modernization of the network of roads is effected in each country partly by the construction of superhighways but mostly by the improvement of the existing network. This paper deals with the necessary surveying of the stabilization of the roads and of the local planning of tracing. A new technology has been elaborated and its computerization discussed. (Author abstract) In German. 6 refs.

Dede, K. (Technische Univ, Budapest, Hung). *Period Polytech Civ Eng* v 30 n 1-2 1986 p 83-97.

**090675 KOMMUNALE ERSCHLIESSUNG VON INDUSTRIEOBJEKTEN - BEISPIEL BOSCH-SALZGITTER.** [Municipal Planning of Road Access for Industrial Plants - Example of Bosch-Salzgitter]. The fiscal well-being of municipalities is strongly dependent on the revenues from industrial taxpayers within their confines. This is why it is so important for them to provide for all the facilities needed by industrial newcomers. The successful establishment of a firm in need of a plant area is outlined in a case history, comprising planning agreement on commitments to fulfill by the municipal administration and their implementation in detail. Further, aspects of town planning are considered. The project has been honored with a Federal award within the framework of a competition about the subject of Harmonization of Industry, Trade and Craftsmanship in Town Planning. In German.

Gossow, Klaus. *Str Tiefbau* v 41 n 10 Oct 1987 8p between p 18 and 34.

## Reliability

**090676 BEWERTUNG DER BEANSPRUCHUNGSSTREUUNG AUS GEMESSENEN KOLLEKTIVEN.** [Valuation of the Intensity of Measured Load Spectra]. Measured load spectra, for example on a specific road

driven by several drivers, show different distributions. The question is how to determine the scatter of loading if the spectra differ in size and frequency of load cycles. The investigation shows that the scatter of loading can be expressed as the scatter of the calculated damage sum. In this way, for a reliability analysis, the mean value and the (logarithmic) standard deviation can be taken into account. (Author abstract) In German. 8 refs.

Guethé, Heinz-Peter; Petersen, Juergen; Vogler, Josef; Zenner, Harald. *Automobiltech Z* v 89 n 12 Dec 1987 p 679-680, 684.

**090677 EFFICIENT CALCULATION METHOD TO OBTAIN UPPER AND LOWER BOUNDS OF TERMINAL RELIABILITY OF ROAD NETWORKS USING BOOLEAN ALGEBRA.** This paper proposes a new method to estimate upper and lower bounds of reliability between node pairs in road networks. The conventional calculation methods using all the minimal path sets and cut sets are impractical for a large system since the path sets and cut sets include a large number of elements. The proposed method is quite useful since it requires only partial minimal path sets and cut sets. An efficient way of selection of the paths and cuts is investigated, and an algorithm for a Boolean manipulation is developed. Also a numerical example of small size network is executed to examine the validity of the method. (Author abstract). 16 Refs. In Japanese.

Iida, Yasunori; Wakabayashi, Hiroshi. *Doboku Gakkai Rombun Hokokushu* v 9 n 7 Jul 1988 p 75-84.

## Repair See Also PAVEMENTS—Maintenance; PAVEMENTS—Repair.

**090678 DEMONSTRATION SHOWS VALUE OF ASPHALT REHABILITATION.** In Ohio, Richland County and the city of Mansfield were recently on the receiving end of a demonstration project, aimed at providing the value of rehabilitating and asphalt road. The contractor, Kokosing Construction, used a Bomag MPH-100 recycler for the work. There were three test areas completed on Cairns Road. The first is a full-width section 1,000-ft. long by an average of 25-ft. wide. The second and third test areas were on an 800-ft. long section of road with an average width of 22 ft. Use of the Bomag machine and method to rehabilitate a road saved 47% over other rehab methods.

Anon. *Better Roads* v 58 n 3 Mar 1988 p 44-45.

**090679 DUENNE SCHICHTEN IM KALTEINBAU.** [Cold-laid Thin Courses]. The general aim of road rehabilitation and maintenance is to restore a long-lasting good in-service performance at low costs. The German Road and Traffic Research Society (FGSV) is studying the relevant methods for elaboration of recommendations and rules to guide the road authorities. Its studies comprise among others the technique of cold laying of thin rubber-modified asphalt courses, excelling in high wear resistance and durability. Subjects of the paper are composition of such cold mixes, equipment for mixing and applying them, and further particular features of the technology. (Edited author abstract) In German. 3 refs.

Neis, Heinz (Raschig AG, Ludwigshafen/Rhein, West Ger). *Str Tiefbau* v 42 n 1 Jan 1988 p 21-22.

**090680 RESTORING UTILITY CUTS IN CONCRETE STREETS.** Concrete streets are especially forgiving of utility cuts. A new concrete section is either aggregate interlock or dowel bars. The replacement concrete can be struck off even with the surrounding pavement, leaving no lip or depression. Concrete's structural strength means that the repair section can bridge at least some future settlement of the backfill. A long-lasting utility cut repair involves more than 'shovelling in a little hot mix'. Considerations include the size and shape of the cut, proper removal of the concrete, backfilling materials and compaction, and concrete replacement. Each of these points is discussed in the article.

Anon. *Public Works* v 119 n 6 May 1988 p 90-91.

**090681 DYNAMIC ANALYSIS OF LANE CLOSURE STRATEGIES.** A dynamic simulation model is extended to represent traffic system disruptions in the form of lane closures. The model has two components: a macroparticle traffic simulator, and a user decision component which comprises behavioral mechanisms governing the daily departure time decisions of commuters. The model is applied to the analysis of six alternative lane closure strategies associated with planned repair activities. Examples of model results are described, highlighting the tradeoffs between the performance of the system during the perturbation period and the final equilibrium state, as well as the trade-off between the schedule delay and the travel time experienced by system users during those periods. (Author abstract) 26 refs.

Mahmassani, Hani S. (Univ of Texas, Austin, TX, USA); Jayakrishnan, R. *J Transp Eng* v 114 n 4 Jul 1988 p 476-496.

**090682 OPTIMIZATION: THE KEY TO ROADWAY IMPROVEMENTS.** Commercial and residential development in many parts of the US has caused a significant increase in traffic volume on existing roads. By resurfacing, restoring, rehabilitating, and reconstructing existing roads, transportation authorities can increase capacity and traffic safety and improve operating conditions without causing major public or environmental impacts. Because there is less community and regulatory resistance to roadway improvements than to new construction, they can be carried out in a relatively short time frame. They can also be implemented in stages, if necessary, to accommodate budget restrictions.

Urban, John (Edwards & Kelcey, Livingston, NJ, USA). *Public Works* v 119 n 8 Jul 1988 p 59-60.

## Roughness Measurement

**090683 EXTERNAL METHODS FOR EVALUATING SHOCK ABSORBERS FOR ROAD ROUGHNESS MEASUREMENTS.** Two new experimental methods are described for the selection of shock absorbers for response-type road roughness meters. The methods allow for verification of the acceptability of the shock absorbers before they are mounted in the road roughness measuring vehicle. In the first method, a programmable shaker table is used to obtain the time response of the shock absorber. In the second method, a simple scotch yoke mechanism is used to produce the frequency response of the shock absorber. In both methods, the test results are compared with the corresponding time domain or frequency domain acceptability limits, which are determined from computer simulation and based on the relevant ASTM standards. (Author abstract) 5 refs.

Wambold, James C. (Pennsylvania State Univ, University Park, PA, USA); Chapman, Daniel J.; Kulakowski, Bohdan T. *Transp Res Rec* 1117 1987 p 121-124.

## Rural See Also HIGHWAY ENGINEERING; HIGHWAY ENGINEERING—Design Aids; HIGHWAY SYSTEMS—Intersections; MOTOR TRANSPORTATION—Accidents; REGIONAL PLANNING—Land Use; STREET TRAFFIC CONTROL.

**090684 PLANNING AND IMPLEMENTING PEDESTRIAN FACILITIES IN SUBURBAN AND DEVELOPING RURAL AREAS.** The research conducted under NCHRP Project 20-19 has resulted in the publication of two reports: NCHRP Report 294A and NCHRP Report 294B. This report (Report 294B) provides detailed supporting information on all aspects of the research effort. The areas covered include study procedures; case studies; walk trip characteristics and pedestrian accident statistics; and pedestrian-related development guidelines. The reader of this report will also want to consult the companion document, NCHRP Report 294A, 'Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas - Research Report', which contains the main findings of the research. Report 294A



should serve as a basic reference on the planning, design, and implementation of pedestrian facilities in suburban and developing areas. (Edited author abstract) 9 refs.

Smith, S.A. (JHK & Associates, Alexandria, VA, USA); Opiela, K.S.; Impett, L.L.; Pietrucha, M.T.; Knoblauch, R.; Kubat, C. *Natl Coop Highw Res Program Rep* 294B Jun 1987 165p.

**090685 PLANNING AND IMPLEMENTING PEDESTRIAN FACILITIES IN SUBURBAN AND DEVELOPING RURAL AREAS - RESEARCH REPORT.** The research conducted under NCHRP Project 20-19 has resulted in the publication of two reports: NCHRP Report 294A and NCHRP Report 294B. The general topics addressed are pedestrian travel behavior and accident characteristics, commonly occurring problems with suburban pedestrian facilities, pedestrian planning within the context of the overall planning and development process, pedestrian-sensitive site planning, planning for pedestrian facilities within the highway right-of-way, and implementation of pedestrian facilities. (Edited author abstract) 62 refs.

Smith, S.A. (JHK & Associates, Alexandria, VA, USA); Opiela, K.S.; Impett, L.L.; Pietrucha, M.T.; Knoblauch, R.; Kubat, C. *Natl Coop Highw Res Program Rep* 294A Jun 1987 92p.

**090686 ROAD MAINTENANCE: MODIFIED RECYCLER MASTERS FOAMED BITUMEN IN LOCAL ROADS RENEWAL.** The recent re-emergence in the UK of structural mix-in-place recycling for the maintenance of failed or failing residential and unclassified rural roads gained a new dimension with the commissioning of the first UK plant purpose-built to perform foamed bitumen stabilization. The process, which expands hot pen grade bitumen from ten to fifteen times its original volume, will provide highway engineers with an alternative to cement and bitumen emulsion when they consider stabilization for the structural rehabilitation of their roads. The main advantages of mix-in-place recycling using foamed bitumen, as with cement and bitumen emulsion, are cost-savings and speed.

Anon. *Highways (Croydon Engl)* v 55 n 1927 Jul 1987 p 11, 24.

**090687 FINANCING, PRIVATE-SECTOR INVOLVEMENT, AND MARKET PROCESSES IN THE PROVISION OF NATIONAL ROADS IN SOUTH AFRICA.** This paper describes the changing basis of the provision of rural roads in South Africa that led to the introduction of toll roads and, in the process, to an increasing degree of privatization in the provision of roads. The background financial and administrative arrangements for the provision of rural roads is discussed and national policy that influences the financing of roads are described. With the increasing shortage of funds for roads during the past decade, the need for better economic justification of specific road projects and the search for new sources of funds combined with the policy of user charging and of supporting the free market system has had a significant effect on the development of the rural road system. (Edited author abstract) 1 ref.

Mitchell, M.F. (Dep of Transport, Pretoria, S Afr); Botha, J.L. *Transp Res Rec* 1107 1987 p 30-38.

**090688 PLANNING AND DEVELOPMENT OF RURAL ROAD NETWORKS IN DEVELOPING COUNTRIES.** Rural road planning in developing countries is defined and differentiated from other types of road investments. Various approaches to the problem are assessed; a new network modelling approach is proposed and a combinatorial tree design problem is formulated as the basic decision model; solution techniques of mathematical programming, exact enumerative and heuristic methods are presented. Experience with test problems indicates that the proposed heuristic performs satisfactorily. Attention is given to the use of solutions in the context of real world decisions. In the framework of developing countries, the new approach seems to be more practicable than any conventional method. (Author ab-

stract) 27 refs.

Van Oudheusden, Dirk L. (Asian Inst of Technology, Bangkok, Thai); Khan, Lutfar Rahman. *Eur J Oper Res* v 32 n 3 Dec 1987 p 353-362.

**090689 OPTIMIZING RURAL ROAD CONSERVATION EXPENDITURES.** A methodology of optimizing expenditures for rural road maintenance and rehabilitation is presented. The optimum schedule for pavement overlay and rehabilitation is determined resulting in minimal costs during the road's economic horizon. In developing countries, the economic horizon usually varies between 10 and 20 years; in Ecuador, it was established at 17 years. During this period most of the road's socioeconomic benefits are obtained. The economic residual value is small relative to other transportation expenditures. Total expenditures during the service lifetime include construction, maintenance, pavement overlay or rehabilitation, and vehicle-operating costs. An optimal programming methodology is presented for pavement overlay as a function of road type, traffic volume, type of terrain, and maintenance level. (Edited author abstract) 14 refs.

Greenstein, Jacob (Louis Berger Int Inc, East Orange, NJ, USA). *J Transp Eng* v 114 n 1 Jan 1988 p 40-56.

**090690 MAINTENANCE OF ROADS IN HIGH ALTITUDE AREAS.** Motor roads and bridle roads at high altitudes less than 3000 meter (10,000 ft) in sub-Himalayan terrain may be used to serve the scattered population but their special utility is in guarding the borders at higher altitudes. These bridle roads at higher altitudes are termed as border tracks. Maintenance of such bridle roads and tracks is very difficult and there are special problems associated with it. These special problems cannot be guessed unless someone works at higher altitude. In this article, experience of working for about 6 years in such areas and the problems that have been experienced are highlighted.

Bhakuni, H.S. (PWD, Askote, India). *Indian Highw* v 16 n 1 Jan 1988 p 5-7.

## Scotland

**090691 KILLIECRANKIE PASS, SCOTLAND.** An area of great scenic beauty, the narrow steep-sided valley of the Killiecrankie Pass in Scotland is invested with concrete viaducts and retaining walls of excellent workmanship. Simple but pleasing in appearance, the new A9 trunk road hugs the hillside while the structures are endowed with unity of concept, fineness of purpose, economy, ease of maintenance and durability - prime factors in their design and construction. Despite their grand scale the structures have blended admirably with the surrounding countryside, with the minimum of disruption to a region of historical and scenic importance. This article discusses the design concept of the road, and design and construction of the retaining walls and viaducts.

Anon. *Indian Concr J* v 62 n 2 Feb 1988 p 62-63.

**Service Life** See PAVEMENTS—Bituminous.

**Shoulders** See HIGHWAY ENGINEERING.

**Skid Resistance** See Also PAVEMENTS—Brick Construction; PAVEMENTS—Concrete; TIRES—Performance.

**090692 SKID RESISTANT BY DESIGN.** This paper introduces the principal factors affecting microtexture and macrotexture which create the skid resistance of a road pavement. These are related to the special factors of the non-homogeneous surface of a concrete block pavement. The performance of concrete block pavements in service is described and related to the minimum requirements for skid resistance measured by the SCRIM machine and pendulum test. In the case of concrete block pavers, the microtexture will be affected by the method of manufacture, i.e. the extent to which the upper surface of the paver contains a mixture of coarse and fine aggregate, or merely a mortar paste. In this case a test called Polished Paver

Value (BSI/DD 155)<sup>2</sup> has been developed to simulate in-service polishing. 12 refs.

Walsh, Ian (Kent County Council, Engl). *Highways (Croydon Engl)* v 56 n 1935 Mar 1988 p 27, 29.

**Slope Stability** See LANDSLIDES; TUNNELS AND TUNNELING—Blasting.

**Snow and Ice Control** See Also BRIDGES, CONCRETE—Repair; HIGHWAY SYSTEMS—Maintenance; PAVEMENTS—Concrete; SNOW PLOWS; WATER POLLUTION.

**090693 PREWETTING AIDS CANADIAN SNOW CONTROL.** Prewetting sand and salt with calcium chloride is helping two Alberta cities deal with winter. Even in -20-degree C weather, the treated mixture of sand and sodium chloride did its job in storms experienced by Calgary. In Lethbridge, a city by-law restricts the use of salt to the hills and underpasses of major roads. Other roads use sand alone or a mix of 95% sand and 5% salt. On urban roads, pre-wetting with calcium chloride has cut the amount of sand required by 40%. Even without salt, some melting action takes place down to around -5 degrees C.

Anon. *Better Roads* v 57 n 11 Nov 1987 p 34, 36.

**090694 CORROSIVITY TESTS PIT ROAD SALT vs. CMA.** The article reports on an experimental study to compare the corrosive effect of a 1.0 percent aqueous solution with a 0.60 percent aqueous road salt solution, and with water on a type of steel reinforcing bar commonly used in Milwaukee. Three rebars each were tested in aerated and unaerated CMA, road salt, and water. In all, 18 rebars were used. The CMA used in this experiment was manufactured by Gancy Chemical Corporation, Syracuse, New York and furnished by the Federal Highway Administration, McLean, Virginia. The road salt tested is the type used by Milwaukee for deicing streets. Study materials, methods and results are discussed. Refs.

Salcedo, Rodolfo N. (Dep of City Development, Milwaukee, WI, USA); Jensen, William N. *Public Works* v 118 n 11 Nov 1987 p 58-61, 90-91.

**090695 GEDANKEN ZU EINER GESAMTWIRTSCHAFTLICHEN BEURTEILUNG DES WINTERDIENSTES.** [Thoughts on an Overall Economic Evaluation of the Winter Road Service]. To maintain the viability of roads in winter when road traffic is being hampered by snow and ice, the road service authorities have the choice of spreading de-icing salts or mineral aggregate. Pros and cons of both methods are compared and assessed, mainly from general economics points of view. The ecological effects of de-icing salts on vegetation are to the author's findings by no means prohibitive, rather negligible. 4 refs. In German.

Pichler, Walter (Strassenbauamt Spittal/Drau, Austria). *Str Tiefbau* v 41 n 12 Dec 1987 p 5-6, 8.

**090696 MASCHINEN UND FAHRZEUGE ZUR WINTERWARTUNG VON WEGEN, PLATZEN UND STRASSEN.** [Equipment and Vehicles for Snow Clearing from Ways, Places and Streets]. Snow has to be cleared under the most varied circumstances: on footpaths, on small or broad lanes, over short or long distances, in various consistencies, such as from powder-like to nearly ice, by private estate owners, municipalities or regional road service institutions. Suitable varieties of equipment are available for nearly any snow clearing task. Attachments for small performances are made for Unimog or other wheeled carriers, even for hand-operated lawn mowers and fork trucks. Their limitations are outlined. Six basic versions of sophisticated design have been developed for meeting all reasonable demands. Their features and performance characteristics are set forth in detail. (Author abstract) In German.

Kotte, Gernot. *Str Tiefbau* v 41 n 12 Dec 1987 p 9-11, 14.



**090697 SALT - A GUIDE TO REGULATING ITS USE.** Calcium magnesium acetate (CMA) is the leading candidate for replacement, but only rock salt reduces the amount of salt's corrosion and is quite expensive with costs ranging from \$450 to \$500/t. compared to \$24 to \$40/t. for salt. The more important functional properties of rock salt in a winter maintenance operation are: the ability to form a brine that coats the snow particles to prevent packing and bonding of snow to the pavement; the ability of salt particles to dissolve slowly from their solid state; the ability of salt to melt snow and ice easily with temperatures of 20 degrees F and above; salt's low hygroscopic property; easy storage and treatment to resist caking. This article discusses techniques employed by the Michigan Department of Transportation to use salt effectively, efficiently and economically.

O'Toole, Martin L. (Michigan DOT, USA). *Better Roads* v 58 n 2 Feb 1988 p 41-42.

**090698 EFFECT OF ROADWAY SALTING ON SAFETY AND MOBILITY.** The research detailed in this report represents a preliminary effort to develop an understanding of the effects of roadway salting on road safety and mobility. Analyses included an assessment of available literature, the review of accident data from a number of sources, and the development of a study procedure for assessing the effects of winter conditions and maintenance activities on vehicle operations. The procedure developed was based on vehicle headway observations. Field trails of the study procedure in six different jurisdictions confirmed it to be sensitive to roadway conditions, and to be capable of reflecting the effects of maintenance activities. Results of the studies showed little variation for mean headways under dry, wet, and slushy road conditions. Mean headways under snow or icy road conditions were much larger. Limited study of the effects of maintenance activities suggested that different roadway salting strategies had little differential effect on vehicle headways. Finally a variety of study refinements were identified. Additional aspects of the study are discussed. (Edited author abstract) 3 refs.

Braaksma, John P. (Carleton Univ, Ottawa, Ont, Can); Ridley, Robert C.; Jones, Philip H. *Can J Civ Eng* v 14 n 4 Aug 1987 p 527-533.

**090699 EINFLUSS DES TAUSALZES AUF OBERFLAECHE- UND GRUNDWASSER.** [Effect of Thawing Salt on Surface and Ground Water]. Between 1965-1974 the annual consumption of salt on the roads of the Federal Republic of Germany amounted to 892,900 t, i.e. 1996 t/km. In Great Britain it was 2.97 t, in the Netherlands 5.76 t, in Belgium 0.36 t/km. In the 1979-1984 period, the greatest use of salt was in 1979, namely 3.0 Mt, in the year 1983 the lowest, namely 878,000 t. The dissolved salts are distributed below surface and in groundwater depending on the type of soil. The result of measurements carried out in the area of Augsburg, Munich and Kaufbeuren in 1976-1979 are reported. Some measures to minimize the effect of the salt on groundwater are recommended. (Edited author abstract) In German. 2 refs.

Bischofsberger, Wolfgang (TU Muenchen, Garching, West Ger). *Str Autobahn* v 38 n 5 May 1987 p 192-197.

**090700 COMPARING CHEMICAL DEICERS.** Ice penetration and melting characteristics of deicers were studied recently. It was found that calcium chloride initially penetrates ice - at all temperatures - at a rate about twice that of other deicers. Sodium chloride penetrates initially at a lower rate than calcium chloride; it performs similarly to calcium chloride over a 45- to 60-minute period at 15 to 25 degrees F. Urea and potassium chloride are substantially less active than sodium and calcium chloride. From the standpoint of undercutting and ice disbondment, the order of preference is  $\text{CaCl}_2$ ,  $\text{NaCl}$ ,  $\text{KCl}$ , and urea. Sharp-edged crystal deicers, such as sodium chloride, tend to behave differently than spherical deicers. Calcium chloride is superior from the standpoint of ice-melting volumes and ice penetration/undercutting in the early stages of ice melting. Deicer blends tested were equal to or less effective than sodium chloride - at all test

temperatures. Additional study results are discussed.

Anon. *Better Roads* v 58 n 6 Jun 1988 p 28, 30.

**090701 CMA AND SALT MIX CUTS CORROSION.** Studies by the Michigan Department of Transportation of the corrosion performance of calcium magnesium acetate (CMA) and CMA-rock salt mixes suggests that the more economical mix may provide almost as much corrosion protection as CMA by itself. Since it appears that more rock salt than CMA can be used in such a mix, it is likely that the mix will also retain many of the beneficial deicing advantages of salt - such as a lower melting temperature. CMA and salt mixtures retain much of the corrosion protection provided by CMA alone. Current data indicate one part CMA to two parts salt result in a mixture that provides corrosion protection that almost equals CMA alone. The mixture would cost less than seven times the cost of salt by itself at current prices. These and other aspects of the subject are discussed.

McCrum, Ron L. (Michigan DOT, MI, USA). *Better Roads* v 58 n 6 Jun 1988 p 32.

**090702 QUEBEC CITY-A SNOW CITY.** Quebec City, built on a promontory 300 ft high, has many hills whose slopes vary from 10 to 22 percent and numerous narrow streets (from 3 to 6 meters wide). Obviously, snow removal and winter maintenance are complicated operations that require voluminous specifications (160 pages, 65 contractual clauses, and 132 operational clauses). This article reviews snow removal techniques, and equipment. Winter pavement repair is also discussed.

Gagnon, Roger. *Public Works* v 119 n 8 Jul 1988 p 50-51.

**090703 USING LIQUID CALCIUM CHLORIDE: THREE CASE HISTORIES.** Combining liquid calcium chloride with salt produces a cost-effective partnership for snow and ice control that extends the effective temperature range of salt to 0°F and reduces the total amount of deicer required, resulting in more miles spread per ton of salt. The benefits of using liquid calcium chloride (LCC) are detailed in the article.

Anon. *Public Works* v 119 n 8 Jul 1988 p 80-81.

## Speed Control

**090704 EUROPEAN SPEED AND TRAFFIC CONTROL DEVELOPMENTS.** Low-cost speed control measures, traffic obstacles, and speed restrictions in residential neighborhoods, have proven effective in reducing accidents within heavily built-up areas. They are used increasingly in Europe and Australia, and several are currently being tested in some U.S. jurisdictions. The article reviews some of them: road bumps; reflective lane markers; speed humps; shared traffic zones; and jaloopies.

Wynne, G.G. *ITE J* v 57 n 9 Sep 1987 p 43-44.

## Stability See PAVEMENTS—Design.

**Stabilization** See Also ROADBUILDING MATERIALS—Fly Ash.

**090705 ERFABRUGEN MIT SAND-ZEMENT-VERFESTIGUNGEN IM STRABENBAU.** [Experience with Sand-Cement Stabilization of Road Base Courses]. Sand-cement stabilization of base courses has been carried out in Hamburg with good effect, even with such sand grades as do not fulfil the demand of frost resistance. Reflexion cracks can turn up in the bituminous wearing course on top, if the stabilized base course exhibits a rather high compressive strength. This experience and others which led to a Code of Practice for Design and Laying, are communicated as well as further the results of tests with partial substitution of the sand ingredient by fly ash from pit coal combustion. (Author abstract) 7 refs. In German.

Damm, K.-W. *Str Tiefbau* v 41 n 4 Apr 1987 p 34-36, 41.

**090706 GEOTEXTILE REINFORCES MARSHY SUBGRADE.** Widening and raising the grade elevation

from an extension of President Street, in Savannah, Georgia, required stabilization of the new road subgrade. The site runs through a very wet, marshy area. Because the wet conditions made excavation and fill environmentally unappealing and impractical, geotextile was incorporated into the design to stabilize and reinforce the marshy subgrade so that it could support the roadway fill material. This article discusses design and installation of the material.

Anon. *Better Roads* v 58 n 3 Mar 1988 p 35.

## Standards See Also HIGHWAY SYSTEMS—Planning.

**090707 DIE ANWENDUNG VON TRAGSCHICHTEN MIT HYDRAULISCHEN BINDEMITTELN NACH DEN NEUEN ZTVT UND RSIO.** [Use of Base Courses with Hydraulic Binders According to the New ZTVT and RSIO Recommendations]. The German 1986 edition of 'Additional Technical Regulations and Recommendations for Base Courses in Road Construction' (ZTVT-StB86) and 'Recommendations for Standardization of Road Surface Constructions', 1986 edition (RSIO 86) give recommendations about the use of base courses with hydraulic binding materials. These are the layers between the foundation or the subsoil and the pavement. The binding materials are: cement, hydraulic base course binders or highly hydraulic lime. 16 refs. In German.

Schuster, Franz Otto (Bundesanstalt fuer Strassenwesen, Bergisch Gladbach, West Ger). *Str Autobahn* v 38 n 1 Jan 1987 p 3-9.

## Stresses

**090708 THEORETICAL ROAD DAMAGE DUE TO DYNAMIC TYRE FORCES OF HEAVY VEHICLES. PART 1: DYNAMIC ANALYSIS OF VEHICLES AND ROAD SURFACES.** Theory is presented for simulating the dynamic wheel forces generated by heavy road vehicles and the resulting dynamic response of road surfaces to these loads. Sample calculations are provided and the vehicle simulation is validated with data from full-scale tests. The methods are used in the accompanying paper to simulate the road damage done by a tandem-axle vehicle. (Author abstract) 19 refs.

Cebon, D. (Univ of Cambridge, Engl). *Proc Inst Mech Eng Part C* v 202 n C2 1988 p 103-108.

**Surfaces** See BRAKES—Valves; PAVEMENTS—Asphalt; TIRES—Mathematical Models; TIRES—Testing; TUNNELS AND TUNNELING—Electric Lighting.

**Switzerland** See TUNNELS AND TUNNELING—Waterproofing.

## Testing See Also VEHICLES—Testing.

**090709 PEAK SIDE FRICTION AND YAW RATE DURING SURVEY OF HUME HIGHWAY.** The ARRB Road Geometry Survey Vehicle was used to survey the Hume Highway, from Melbourne to Sydney and return, during the week beginning April 28, 1986. As the actual vehicle travel speed is included, it is possible to calculate back to the side friction demand and the yaw rate of the vehicle at any point during the survey trip. This has been done, and the peak values throughout the trip for each speed value have been determined. The calculations and their results are discussed. 6 refs.

Rawlinson, W.R. (Australian Road Research Board). *Aust Road Res* v 17 n 2 Jun 1987 p 129-131.

**090710 DEFORMATION OF ROAD FOUNDATIONS WITH GEOGRID REINFORCEMENT.** The deformation under traffic of crushed rock sub-bases over clay subgrades has been investigated; the experiments included an investigation of the effectiveness of a reinforcing geogrid between the sub-base and the subgrade. Sections with and without reinforcement were trafficked simultaneously by a rigid two-axle lorry with its rear axle



loaded to about 80 kN and the number of vehicle passes to cause 40 mm deformation at the sub-base surface was related to the sub-base thickness, subgrade strength and the use of geogrid. Transverse trenching revealed the accumulated deformation in the sub-base and subgrade. The results were compared with existing designs for foundation layers and the performance of the reinforcement was examined over a wide range of test conditions. (Author abstract). 10 Refs.

Chaddock, B.C.J. (Transport & Road Research Lab, Crowthorne, Engl). *Res Rep Transp Road Res Lab* n 140 1988 p 1-8.

**090711 TESTING VEHICLE HELPS EVALUATE ROAD PAVEMENTS.** A road testing vehicle was developed in Australia which measures the strength and stiffness of a pavement while traveling along the road. The vehicle is constructed on a MAN bus chassis, configured to produce a load of 8.2t on its dual-tired single rear axle. The passage of the loaded vehicle produces a deflection in the pavement and both the maximum deflection and the shape of the deflection bowl are measured. The maximum deflection relates to the pavement strength and is the parameter for pavement rutting, while the deflection bowl shape relates to the pavement stiffness and is the parameter for fine fatigue cracking in the asphalt. The vehicle is able to measure deflections at speeds from 2km/h to 8km/h with distances between measurements being in the range of 4m to 11m. The high measurement speed allows up to 50 lane-km of pavement to be tested per day.

Yates, Athol. *J Inst Eng Aust* v 60 n 17 Aug 19 1988 p 39.

## Vibrations

**090712 ON THE FORCE APPLIED TO THE ROAD BY AN AUTOMOBILE RUNNING OVER A BAR-LIKE PROJECTION ON THE ROAD.** An experimental expression of the restoring force of a tire compressed by a flat plate and a dull edge is derived. Using this expression, equations of motion of a light truck that runs over a low bar-like projection placed normal to the direction of the motion of the truck are set up. These equations are solved by a numerical method in the situation that the left-hand wheels of the truck run over the projection. Based on the solution, the force applied to the road by the truck in this situation is calculated. Experiments are made to measure the force applied. A force-measuring device equipped with a force-receiving flat top plate is settled in the road with the top plate flush with the road surface, and a bar-like projection is attached to the top plate. The force is measured when the left-hand wheels of the truck run over the device. It is concluded that the results of calculation show good agreement with those of experiment. (Author abstract) In Japanese. 8 refs.

Ohno, Shinichi; Itakura, Hiroshi; Takita, Toshiyuki; Suzuki, Tsuneo. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 498 Feb 1988 p 432-438.

**Visibility** See TRAFFIC SIGNS, SIGNALS AND MARKINGS; TUNNELS AND TUNNELING—Electric Lighting.

**Widening** See HIGHWAY SYSTEMS—Construction; HIGHWAY SYSTEMS—Repair.

**ROBOT APPLICATIONS** See Also COKE OVENS—Repair; PUMPS—Manufacture.

**090713 ROBOTS FOR AUTOMATIC FEEDING OF FLEXIBLE WORKSTATIONS.** The material handling segment of the robotics industry has experienced a steady growth rate over the previous several years of 20-30%. In the following application, productivity was improved with the introduction of robotics to a manual nine-press line which manufactured door frame reinforcements for mid-size cars. In retrofitting the line to incorporate ten robots, eight positioning fixtures and special sensors, line output was cut from 290 parts/h to 275 parts/h to accommodate robot speed limitations.

Jackson, Glenn A. (GMF Robotics, Auburn Heights, MI, USA). *Ind Robot* v 15 n 1 Mar 1988 p 23-25.

**090714 COLLOQUIUM ON ROBOT CONTROL IN PRACTICE.** This colloquium contains 6 articles on robot control. Among the topics covered are: technical and economic aspects of robot applications; robot simulation and off-line programming; automotive assembly applications; robots in flexible electronic assembly; adaptable machines for automatic assembly; and total production process control. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 07220 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Computing & Control Div, London, Engl). *IEE Colloq Dig* n 1985/12, Colloq on Rob Control in Pract, London, Engl, Feb 4 1985. Publ by IEE, London, Engl, 1985 24p.

## Japan

**090715 PRESENT STATUS OF JAPAN'S ADVANCED ROBOT PROJECT.** For realizing advanced robots, numerous state-of-the-art technologies including electronics, communications, measurement, control, mechanics and material science have to be developed and combined. Advanced robotics R&D in Japan has been selected as a national project 'Advanced Robot Technology' under the National Research and Development Program. The project has been directed towards establishing the technologies for advanced robots to carry out inspection, maintenance, rescue operations and other complex tasks under dangerous environments that do not allow direct human labor. Specifically, R&D activity in the project has concentrated on robots which meet the needs in the fields of nuclear power plants, undersea and fire fighting (i.e., nuclear power plant robot, undersea robot and fire fighting robot). R&D activities have been assigned for the general technologies required for these three fields of advanced robots.

Okada, Yasushi (MITI, Tokyo, Jpn). *Ind Robot* v 15 n 1 Mar 1988 p 35-38.

**Remote Control** See SPACECRAFT—Robot Applications.

**ROBOTIC ASSEMBLY** See Also ASSEMBLY MACHINES—Automation; AUTOMOBILE ENGINE MANUFACTURE—Robot Applications; PLASTICS PRODUCTS—Assembly; PRINTED CIRCUITS—Assembly; ROBOTICS—Planning; ROBOTS, INDUSTRIAL—Electric Drive; ROBOTS, INDUSTRIAL—Sensors.

**090716 ADEPT AIDS ADEC'S PRECISION IN INDUSTRY.** Adec is a Swiss distributor of the AdeptOne direct-drive robot, which is central to the turnkey systems and applications engineering divisions. The key division is turnkey systems, which are concentrated into four areas: mechanical part assembly, clean-room applications, PCB assembly and packaging systems. All systems are robotic-based and now only Adept robots are used - in the early days of the company it did install one or two systems with Unimation PUMA robots. Using only Adept products is not a rigid policy and other types could be incorporated if necessary.

Rooks, Brian. *Assem Autom* v 7 n 3 Aug 1987 p 127-129.

**090717 CURRENT HARDWARE CONFIGURATIONS IN ASSEMBLY AUTOMATION.** The author emphasizes the importance of considering sub-system components of assembly automation systems; feeder and presentation systems. Apart from the as-designed features, the engineer should also anticipate foreseeable changes in the system environment, and plan for them. The use of case studies very well illustrate these points. These included the design of an automatic system to assemble electric-socket elements and three-pin plugs.

McClelland, Stephen. *Assem Autom* v 7 n 3 Aug 1987 p 145-146.

**090718 ASSEMBLY SYSTEM OF A HEAVY WORKS SUSPENDED BY A WIRE USING A SMALL-SIZE ROBOT.** This research deals with a

control system to handle heavy works with a small-size robot. The heavy work is suspended by a wire and the robot inserts it into a square shaped hole. To avoid an impulse force resulting from the collision of the work and the hole, a parallel spring beam is installed at the tip of the end-effector. Since the spring causes vibration of the work during positioning, a bang-bang control is introduced to decrease its amplitude. The residual amplitude is 2 mm, much smaller than its original 30 mm. (Edited author abstract) In Japanese. 2 refs.

Arai, Tamio (Univ of Tokyo, Jpn); Osumi, Hisashi. *J Fac Eng Univ Tokyo Ser A* n 24 1986 p 18-19.

**090719 ROBOTS AND MECHANICAL ASSEMBLY.** Robot industry participants and observers have long predicted the rapid growth of robots for use in assembly tasks. In the past two years, their predictions have begun to materialize as the use of robots for assembly has grown from a \$35 million market in the US in 1983 to a projected \$100 million in 1985. Mechanical product assembly represents a significant portion of the assembly tasks being performed by assembly robots today. The automotive and disk drive industries have moved decisively to employ robots for assembly of product components and final products. The paper describes how a new generation of fast, integrated robot systems will speed the penetration of robots in mechanical assembly applications.

Wood, Elaine Ide. *Rob Today* v 7 n 3 Jun 1985 p 53-55.

**090720 LOCKHEED ELECTRONICS CENTER LINKS DESIGN AND PRODUCTION: AUTOMATED FACILITY PRODUCES PRINTED CIRCUIT BOARD ASSEMBLIES.** Lockheed's \$40 million Automated Center for Electronics in Sunnyvale, Calif., links all phases of electronic circuit design, development, assembly and test to produce high-quality printed circuit board assemblies for ground and flight applications. The 213, 000-square-foot Lockheed Missiles & Space Co. center unites 200 computer-aided work stations for design and engineering with an assembly line of robotic and automated insertion equipment, and test and process controls. The center combined electronic circuit design development with automated assembly, testing and process control.

Anon. *Rob World* v 5 n 12 Nov 1987 p 26-27.

**090721 ROBOT ASSEMBLY OF PRECISION PARTS USING TACTILE SENSORS.** If the positioning control type robot is to be used for part fitting work, it is necessary to describe the loci of the parts accurately with respect to the robot's coordinates and to control the business end of the robot according to those loci. Mechanical error in the robot itself and control error cannot be eliminated completely. However, it is extremely difficult to improve absolute positional accuracy. Therefore, in assembly work a tactile sensor and a compliance device must be used which can compensate for or absorb the relative positional error between the robot and workpieces. (Edited author abstract) 7 refs.

Asakawa, Kazuo (Fujitsu Lab Ltd, Kawasaki, Jpn). *Adv Rob* v 1 n 1 1986 p 59-69.

**090722 AUTOMATION A MUST FOR HYBRID SYSTEMS.** Within the past several years, many electronics manufacturers have been experiencing both increased competition and demands to reduce overall manufacturing time. A changeover to automated production can be expensive and time consuming in terms of system development and implementation. It can also be a factor in personnel realignment or reduction, an item important to both management and labor. Major considerations such as these should be thoroughly explored before investing thousands of dollars in development and implementation of an automated Surface Mounted Component (SMC)



System. A description is given of the development of a Surface Mounted Component (SMC) system to be used in the assembly operations of Northern Telecom.

Anon. *Rob World* v 4 n 9 Aug 1986 p 24-25.

**090723 DEVELOPMENT OF ROBOTS FOR AUTOMATIC ASSEMBLY OF BOLTED SEGMENTS.** In order to conserve labor, to complete shield tunnel excavation work in a shorter period, and to improve safety, an automatic assembly robot system has been developed. An experimental assembly system for ordinary bolted concrete segments (3.55 m in diameter) has been thoroughly tested to confirm that these segments can be fed and assembled automatically. To align the bolt holes of the segments, the position of the already assembled segment is sensed by means of various position sensors incorporated in the robot, and IHI-made hydraulic stepping cylinders are employed for position control. The segments can be assembled automatically at a rate of one ring every 25 minutes. (Edited author abstract)

Yanagi, Yoshio (IHI, Tokyo, Jpn); Takayama, Seiji; Ohtsuka, Ryuzaburo. *IHI Eng Rev (Engl Ed)* v 19 n 4 Oct 1986 p 158-163.

**090724 FLEXIBILITY HELPS TO MEET EUROPEAN MARKET DEMANDS.** The Italian company Axis has built a robotic line for a domestic appliance manufacturer, OEP. The motor assembly line has been built for use in a domestic vacuum cleaner. It takes armatures and stators manufactured on Axis machines and builds them into a complete electric motor of two basic types - A41 and A42. The line is divided into two sections: the first assembling the motor and the second building on the cooling fan. Both sections use the Bosch pallet transport system to carry components on standard pallets. Insertion is carried out either by pick-and-place units or Bosch SCARA SR 800 robots. Each working station operates independently under its own micro-processor control.

Rooks, Brian. *Assem Autom* v 8 n 1 Feb 1988 p 17-21.

**090725 PRECISION, FORCE AND FLEXIBILITY - THE SECRETS OF ROBOTIC ASSEMBLY.** From their first venture, an industrial consultancy service known as COD Inter Techniques, Georges Martin and Laslo Horvath now own a group of five companies, one of which markets their own design of robot, and another which designs and markets flexible assembly systems. In 1984, the two men set up Cybro, the company which would market the robots. The following year, they set up the Sysmo company to take care of flexible assembly systems. Sysmo developed its own flexible transfer system, Sysmove, which is an integral part of the flexible assembly solutions. As well as COD, Cybro and Sysmo, the group also includes Sitelec for industrial electronics and vision systems, and Hormar Holding for management, innovation and industrial computerization. These systems are briefly described.

Kochan, Anna. *Assem Autom* v 8 n 1 Feb 1988 p 23-25.

**090726 TRANSMISSION BELT PRODUCTION BREAKS SOME NEW GROUND.** Van Doorne Transmissie (VDT) in Holland has lifted the lid on the production facility for the steel belt of its continuously-variable transmission (CVT) where robots have a critical role. Portal-type machines of VDT's own design and make are used at an exacting stage of a unique manufacturing process that breaks new ground in computerized metal-forming and assembly operations. The belt consists of an endless train of 300 individual vee-blocks aligned and supported by a parallel pair of laminated loops. It is hydraulically clamped between the input and output pulleys, and works in compression rather than tension to transmit power. Each of the twin loops forming the VDT belt comprises 10 rings of steel sheet fitted together concentrically. Like a multi-strand cable, this assembly combines flexibility and strength with durability.

Scott, David. *Assem Autom* v 8 n 1 Feb 1988 p 26-28.

**090727 DESIGN SPECIFICATION OF PARTS DIMENSIONAL TOLERANCE FOR ROBOTIC ASSEMBLY.** Success of robotic assembly can be limited by parts dimensional tolerances as well as robot repeatability. This paper examines the effects of these limitations on the success (or failure) of parts assembly. A Positioning Design Factor for Assembly (PDFA) is defined to represent the percentage of all cases where the combination of parts dimensional tolerances and parts positioning errors result in positive effective clearance, which is one of the conditions leading to successful assembly. Mathematical derivations have been applied to the classical peg-in-hole problem. A Monte Carlo analysis was used to predict the probability of favourable positioning conditions for successful insertions. The simulation also incorporated several common assembly situations such as the effect of chamfers on the mating parts and the ANSI Standard fit classes. (Edited author abstract) 10 refs.

ElMaraghy, Hoda A. (McMaster Univ, Hamilton, Ont, Can); ElMaraghy, Waguih H.; Knoll, Larry. *Comput Ind* v 10 n 1 Mar 1988 p 47-59.

**090728 ENGINE PARTS ASSEMBLY LINE ADOPTS ROBOTS WITH 6 DEGREES OF FREEDOM.** Kawasaki Heavy Industries has established a comprehensive organization for promoting system automation that goes far beyond the robots themselves. The automated line built by Kawasaki Heavy Industries is not completely unmanned; the capabilities of the robots are fully exploited in an arrangement that maintains a suitable harmony between them and the human workers. The article introduces the major features of the assembly lines that the company has set up for compact engine parts. These are: flywheel attachment station; fixed-quantity lubrication and labeling station; system for applying anticorrosive coating to transmission parts.

Anon. *Trade Times* 424 Mar 1 1988 p 12-13.

**090729 FITTING OF CRIMP CONTACTS TO CONNECTORS USING INDUSTRIAL ROBOTS SUPPORTED BY VIBRATING TOOLS.** When fitting contacts to connectors, the flexibility of the wires and the irregularity of the contact shapes have proved to be the greatest obstacles in developing automation. Within the framework of the present project, two methods for fitting irregular and flexible parts have been developed, both using industrial robots supported by vibrating tools. For theoretical analysis the irregular, flexible part is mathematically idealized. The tests are carried out with these idealized parts and crimp contacts. These tests proved that the vibration method is suitable for fitting irregular, flexible parts. (Author abstract) 2 refs.

Warnecke, H.J. (Fraunhofer-Inst fuer Produktionstechnik & Automatisierung, Stuttgart, West Ger); Frankenhauser, B.; Gweon, D.G.; Cho, H.S. *Robotica* v 6 pt 2 Apr-Jun 1988 p 123-129.

**090730 UNTERSUCHUNGEN UEBER DIE AUTOMATISCHE MONTAGE VON SCHLAEUCHEN MIT INDUSTRIEROBOTTERN.** [Studies of the Automatic Assembly of Hoses by Industrial Robots]. As a result of certain obstacles to automation, such as the lack of rigidity and the large tolerances of the workpieces, assembly of hoses has so far proved impossible. Fundamental tests were carried out on both the assembly process and the grip process, as well as quantitative and qualitative tests on the chosen assembly parameters. In addition, methods and the influence parameters acting on them as tolerance compensation are described. Examples are given of designs of the base parts and joining parts which are suitable for assembly. For the assembly of a chosen combination of joining parts and base parts a pilot assembly cell was set up with industrial robots and its feasibility was established. (Author abstract). 3 Refs. In German.

Warnecke, H.J. (Fraunhofer Inst fuer Produktionstechnik und Automatisierung, Stuttgart, West Ger); Frankenhauser, B. *Robotersysteme* v 4 n 2 1988 p 93-105.

**090731 DEVELOPMENT OF WORKING AND**

**MOVING CONTROL FUNCTIONS.** Introducing robots to production lines requires making a system configuration based on the precise knowledge of the robot capabilities. The robot makers must provide system technologies to satisfy the requirement. This paper introduces some examples of Yaskawa's assembly lines for office automation equipment and several examples of user applications. (Author abstract).

Anon. *Certif Eng* v 61 n 3 Apr-May 1988 p 3-4,6.

Applications See BUSINESS MACHINES—Cash Registers.

## Computer Aided Design

**090732 FRAMEWORK FOR CAD-BASED GEOMETRIC REASONING FOR ROBOT ASSEMBLY LANGUAGE.** In this paper, we present a framework for reasoning about objects based on their shapes and features and the representation of such objects for robotic assembly planning when the modelling is done on a computer aided design (CAD) system. We show the importance of AI languages in the communication of constructive solid geometry (CSG) based information from modellers. Finally, we present the schematic for a formalism, based on Prolog, for expressing object properties and assembly situations. (Edited author abstract) 38 refs.

Nnaji, Bartholomew, O (Univ of Massachusetts, Amherst, MA, USA). *Int J Prod Res* v 26 n 5 May 1988 p 735-764.

**090733 FORMAL APPROACH TO SPECIFYING ASSEMBLY OPERATIONS.** Experience has proved that exploiting robots for assembly tasks is much more difficult than manufacturing engineers had expected and many attempts at implementing robotic assembly have failed. The authors research has led them to believe that a formal approach to specifying the steps required for assembly would be of great benefit in developing the required software for a specific task, and in adaptively controlling and monitoring the execution of robotic assembly steps. The US National Bureau of Standards has developed a formal system, called ABC (for Assembly By Constraints) for specifying the steps required for assembly. The system is based on the reduction in the degrees of freedom of objects as they are assembled. Using this basic concept, the authors have developed 14 primitive operations which can be used to completely specify assembly steps for a large class of problems. This paper initially outlines the historical development of the system, then describes two pieces of software developed to allow easy definition of assembly tasks using the ABC system, and finally presents two practical examples. (Edited author abstract). 27 Refs.

Haynes, Leonard S. (NBS, Gaithersburg, MD, USA); Morris, Graham H. *Int J Mach Tools Manuf* v 28 n 3 1988 p 281-298.

**090734 SCHEMA FOR CAD-BASED ROBOT ASSEMBLY TASK PLANNING FOR CSG-MODELED OBJECTS.** This paper describes a robot assembly task planner that processes the knowledge of the working environment and generates a sequence of general or robot independent commands. By means of acquiring the world knowledge from the CAD systems and generating these commands, a robot should be able to automatically perform the task. The reasoning behind the decomposition from task level to mid level, and from the mid level to the general robot level planning is developed. The mathematical expressions which allow for the relating of assembly situations to the individually generated subtasks and consequent proofs of the effect of such statements are discussed. (Edited author abstract). 22 Refs.

Nnaji, Bartholomew O. (Univ of Massachusetts, Amherst, MA, USA); Chu, Jau-Yen; Akrep, Michael. *J Manuf Syst* v 7 n 2 1988 p 131-145.



**090735 SIMPLIFIED GENERATION OF ALL MECHANICAL ASSEMBLY SEQUENCES.** A modification of A. Bourjault's method (1984) for generating all valid assembly sequences for the set of parts that constitute an assembly is presented which makes practical the applications of this technique of assembly analysis to assemblies with greatly increased part count. The difference between the two methods is in the form and number of the questions whose answers yield the relations that allow algorithmic generation of assembly sequences. Bourjault's method requires  $2l^2$  questions plus an often larger number of subsequent questions whose existence depends on answers to part of the former question set; all have yes or no answers. (Here  $l$  is the number of relations between parts). The modified method requires  $2l$  questions that are answered in a precedence-logical form. The questions are similar to those asked by an engineer contemplating assembly of a set of parts. Applications and techniques for use are presented, and examples are shown for  $l$  as great as 18. 7 refs.

De Fazio, Thomas L. (Charles Stark Draper Lab Inc, Cambridge, MA, USA); Whitney, Daniel E. *IEEE J Rob Autom* v RA-3 n 6 Dec 1987 p 640-658.

## Computer Interfaces

**090736 ONE FOR THE HEART.** Data-driven robotic assembly at Hewlett-Packard's plant is presented that produces five circuit board models, four of which are double-sided, for a total of nine different images. These nine images require over 550 discrete component placements. Further, work in the plant is based on demand-pull (JIT) production. One robotic assembler accurately accommodates a variety of placement demands without requiring constant reprogramming and system setup. The host-computer program contains a database file comprising CAD data for each component and the assembly sequence for each circuit board image. The robot controller in turn contains the feeder locations and tool change locations, enabling it to respond accurately and quickly to the information sent from the host.

Burkhalter, Art (Hewlett-Packard Co, McMinnville, OR, USA). *Circuits Manuf* v 27 n 11 Nov 1987 p 59-60, 62.

**Control** See Also ELECTRONICS ENGINEERING—Education; PRINTED CIRCUITS—Robotic Assembly; ROBOTS, INDUSTRIAL—Control.

**090737 FRAMEWORK FOR INTELLIGENT ASSEMBLY IN INDUSTRY.** A special tool for using robots in intelligent industrial assembly is presented. The semantic network is the model for knowledge base organization. Planning is done by means of a special kind of production rules named demons. A dedicated NON-VON machine GRAM (GRAM Machine) stands at the basis of intelligent robot programming. Finally an example of using GRAM in industrial assembly is discussed. (Author abstract) 6 refs.

Mandutianu, Dan (Inst for Computer Technique & Informatic, Bucharest, Rom); Voinea, Serban. *Int J Prod Res* v 26 n 4 Apr 1988 p 599-611.

## Costs

**090738 NEXT STAGE IN THE USE OF ROBOTS FOR ASSEMBLY.** For single-station robot assembly, steps are already being taken to address the need for fast reconfigurability, low operator involvement and minimal equipment dedicated to specific parts or products. With standard serial assembly, however, the special equipment costs are still often too high to allow the economic assembly of products with total production volumes of less than 50,000 units and unfortunately many products are manufactured with volumes smaller than this. It becomes necessary therefore to reduce the effective cost of the re-usable equipment. Ways of doing this are discussed in this paper. (Edited author abstract). 6 Refs.

Redford, A.H. (Univ of Salford, Salford, Engl). *Int J Mach Tools Manuf* v 28 n 3 1988 p 273-279.

## Education

**090739 LABORATORY EXPERIMENT TO TEACH SOME CONCEPTS ON SENSOR-BASED ROBOT ASSEMBLY SYSTEMS.** A laboratory experiment is described that can be performed by electrical engineering graduate students and senior undergraduates. The experiment involves the assembly of a diesel-engine oil pump with an IBM RS-1 robot. The robot is instrumented with a force-sensing gripper and an optical binary sensor to detect parts in the gripper. A GE Optimation binary vision system is also used to monitor the manipulator workspace through a charge-coupled device (CCD) camera mounted on the robot arm. The students are required to program the manipulator and to process the information from the various sensors, which are used to recognize assembly components and to verify assembly operations in real-time. This assembly experiment is designed to familiarize electrical engineering students with the problems which dominate robot-based assembly systems and to demonstrate a number of practical sensor-based motion strategies which can overcome part and robot positional uncertainty found in typical manufacturing environments. These sensor-based motion strategies improve the reliability of a robot assembly system. The sensor-based assembly experiment, the laboratory setup, and the sensor-based motion strategies are discussed in detail. 33 refs.

Ahmad, Shaheen (Purdue Univ, West Lafayette, IN, USA). *IEEE Trans Educ* v 31 n 2 May 1988 p 74-84.

France See ASSEMBLY MACHINES—Automation.

## Industrial Applications

**090740 APPLICATION OF ROBOTS IN ASSEMBLY AUTOMATION.** The development of flexible assembly is closely related to the introduction of robots in assembly automation. It has long been recognized that automatic parts assembly by robots is one of the most delicate and most difficult tasks in industrial robotics. This task involves two control problems: trajectory planning for the whole automatic assembly process and reduction of the reaction forces appearing between the parts being assembled. This paper addresses both aspects of this control task. The strategical control level for the manipulation of robots and various approaches to trajectory planning tasks in assembly processes are discussed. A new approach to the determination of the strategical control level, including various models (geometric, kinematic and dynamic) for manipulation robots, is briefly described. The last and most delicate phase of the assembly process is parts mating, which is rather like inserting a peg in a hole. The experimental results of the industrial robot insertion process with force feedback are also presented in the paper. (Edited author abstract) 20 refs.

Vukobratovic, M. (Inst 'Mihajlo Pupin', Belgrade, Yugoslavia); Stokic, D. *Rob Comput Integr Manuf* v 4 n 1-2 1988, Manuf Sci, Technol and Syst of the Future, Ljubljana, Yugosl, Sep 12-14 1985 p 175-180.

## Laser Applications

**090741 LASER APPLICATIONS FOR SMALL PART ASSEMBLY.** With the development of the fiber-glass-based laser light-cable technology it is now possible to use one source of radiation for integrating several welding places in an assembly machine. Also with the small-sized focusing optics, from 25mm in diameter and 150mm long, now coming into use, it is easier, as compared with the integration of a complete source of radiation, to use laser welding also in the limited confined space of stations in an automatic assembly machine. Another problem in automatic assembly can be the marking of products and the inscription of running numbers of products or the date of manufacture. This problem can be solved by microprocessor-controlled solid-state laser units. The possibility of contactless welding, inscribing or processing can widen the scope of automation in electro- and small parts assembly. 2 refs.

Lotter, Bruno (EGO Elektro-Geraetebau GmbH, Sulz-

feld, West Ger). *Assem Autom* v 7 n 3 Aug 1987 p 133-136.

**Mathematical Models** See Also PROBABILITY—Queueing Theory.

**090742 OPERATIONS CHOICE FOR THE ROBOT IN ASSEMBLY SYSTEMS.** The problem of the choice of operations for a robot in an assembly system was formulated mathematically as the discrete stochastic system control problem. Decomposed algorithms which have been considered recognized first the current state of the assembly process and basing on it they chose the assembly operation. To control such assembly processes several state recognition algorithms were proposed and applied. The situation where a priori knowledge about the process is lacking was considered and estimates assuring the convergence of appropriate algorithms were proposed. Simulations results based on different algorithms of the choice of operations for a robot have been compared. (Author abstract) 15 refs.

Reyman, Grzegorz (Technical Univ of Wroclaw, Pol). *Syst Sci* v 11 n 2 1985 p 75-87.

**Planning** See ARTIFICIAL INTELLIGENCE—Expert Systems.

## Productivity

**090743 MAXIMIZING ROBOT PRODUCTION RATES FOR SIMPLE INSERTION OPERATIONS.** In the application of a robot to any process requiring component insertions, one must consider the ability of the robot to attain consistent part insertions given its inherent variability and the dimensional tolerances of the mating components. For some combinations of robot repeatability and component tolerances, failure at insertion is expected to occur with frequencies that can be determined analytically. Given this condition, it is important to be able to determine the point at which the robot should cease attempting to insert a particular component or set of components, given a prior sequence of failed attempts. In this paper the structure of the problem is analyzed and formulas for determining stopping rules are derived. We focus on the case of chamferless insertions, where there are no lead-ins to assist in centering the part. (Author abstract) 19 refs.

Boucher, Thomas O. (Rutgers Univ, Piscataway, NJ, USA). *IIE Trans* v 19 n 4 Dec 1987 p 385-394.

**Synthesis** See ROBOTS, INDUSTRIAL—Grippers.

**ROBOTICS** See Also AEROSPACE ENGINEERING—Federal Republic of Germany; COMPUTER AIDED MANUFACTURING; COMPUTER INTEGRATED MANUFACTURING; COMPUTER PROGRAMMING—Algorithms; COMPUTER PROGRAMMING LANGUAGES; CONTROL SYSTEMS; MECHANISMS—Control Systems; MECHANISMS—Synthesis; NUCLEAR POWER PLANTS—Robot Applications; PRINTED CIRCUITS—Computer Aided Design; ROBOTS, INDUSTRIAL—Control Systems; ROBOTS, INDUSTRIAL—Manipulators; ROBOTS, INDUSTRIAL—Mobile; ROBOTS, INDUSTRIAL—Performance; SYSTEMS ENGINEERING; SYSTEMS SCIENCE AND CYBERNETICS; SYSTEMS SCIENCE AND CYBERNETICS—Mathematical Models; TECHNOLOGY—Economic and Sociological Effects; VEHICLES—Remote Control.

**090744 ROBOTS - HOW THEY BECOME INTELLIGENT.** Some topics discussed by this paper are the following: a brief history of the concept of a robot; automation versus robots; what a robot is; basic robot elements; robot classification; intelligent robots; applications; and socio-economic aspects.

Lahiri, B.N. (Jadavpur Univ, Calcutta, India). *J Inst Eng India Part I* v 66 n 4 Mar 1986 p 67-68.

**090745 OVERVIEW OF ROBOTICS.** This paper discusses the fundamentals of robotics, including robot geometry, the problems associated with knowing and controlling the position of end effectors, and the advan-



tages to be gained from interfacing with sensors. Emphasis is placed on the computer and what it must do to make a set of sensors, actuators, and links into a robot.

Snyder, W.E. (North Carolina State Univ). *Autom and Rob in the Textile and Apparel Ind* Publ by Noyes Publ, Park Ridge, NJ, USA, 1986 p 1-22.

**090746 ENTWURF ROBUSTER REGELUNGEN FÜR ROBOTER. TEIL 1: DARSTELLUNG DER THEORETISCHEN GRUNDLAGEN.** [Design of Robust Controls for Robots. Part 1: Description of the Theoretical Foundations. A method for the design of robust controllers for robots is presented. For this purpose first of all the generally valid stability conditions for complex nonlinear time-varying systems are derived and then applied to rigid robots. The design method includes conventional linear controllers as well as a nonlinear system coupling subject to modelling errors. It is found that under very mild assumptions a robust control is possible even with the frequently used P-PI cascades and PI-P state controllers. (Author abstract) 22 refs. In German.

Becker, N.; Grimm, W.M. *Automatisierungstechnik* v 36 n 3 1988 p 101-108.

**090747 KINEMATIC EQUATIONS AND SOLUTIONS OF A HUMAN-ARM-LIKE ROBOT MANIPULATOR.** For prosthetic arms and also for the next generation of robots, mechanical manipulators consisting of links articulated in a way that better duplicate a human arm structure will be used. To control such an arm, the inverse kinematic equations, necessarily, have to be solved. There is no general formula efficient enough to solve these non-linear equations, and for each particular arm-wrist combination, a specific solution has to be sought according to the arrangement of the arm links and the type of wrist. This paper presents solutions for a human-arm-like manipulator with 6 degrees of freedom. The approach is mainly an analytic geometry method and proposes a new way of tackling the inverse kinematic problem. (Author abstract) 19 refs.

Hemami, Ahmad (Concordia Univ, Montreal, Que, Can); Labonville, Rejean. *Robotics* v 4 n 1 Mar 1988 p 65-72.

**090748 CALIBRATION OF ROBOT WRIST FORCE SENSOR.** Force feedback is one of the important feedbacks in robot control. The wrist force sensor located between the gripper and the arm is considered to be the most important force sensor. The calibration of the wrist force sensor is the same as finding its C matrix. The authors suggest a method for finding the C matrix and point out that the calibration methods of B.E. Shimino and RTI are mathematically wrong. The authors design an experiment to verify their idea. The experiment shows that the authors' result is close to the applied load and RTI's result is quite different from the applied load. The authors offer another simplified method to find  $6 \times 6$  C matrix. The result from the  $6 \times 8$  C matrix. (Edited author abstract) 7 refs.

Li, Yunming; Lee, C.S. George. *J China Test Univ* n 2 1986 p 121-128.

**090749 BASIC STUDY ON A WALL CLIMBING ROBOT (I) -MOVING METHOD AND SAFETY.** There is a great need for the development of a robot which can perform dangerous tasks such as the painting and cleaning of high rise buildings, tanks and so on. A wall climbing robot (MEL-SPIDER) which can move on vertical walls, has been developed. The robot has two parts, a mobile SPIDER which walks on the walls, and a power/control unit which is situated on the ground. The unit supplies power and control signals to the SPIDER through pneumatic tubes and electric cables. The SPIDER has eight legs and each leg is terminated with a vacuum suction cup. We have investigated the walking capabilities of the SPIDER, and have shown that it is capable of moving stably and reliably up and down, as well as sideways, on vertical walls. We have also discussed ways of improving the safety of the SPIDER. (Edited author abstract). 9 Refs. In Japanese.

Ikeda, Kiichi; Nozaki, Taketoshi; Shimada, Saburo; Tajima, Yoshio. *Kikai Gijutsu Kenkyusho Shoho* v 42 n 3 May 1988 p 117-125.

**090750 LINGUAGGI E ARCHITETTURE PER LA ROBOTICA.** [Languages and Architectures for Robotics]. The most widely used robot programming languages are reviewed and classified and architectures of the processing systems governing them are described. In view of the integration of the manufacturing processes, some graphic tools that can provide a useful support in the phase of development of application programs are described. (Translated author abstract). 9 Refs. In Italian.

Damiani, E. (Univ di Milano, Milan, Italy); D'Antona, O. *Alta Freq* v 57 n 3 Apr 1988 p 43-53.

**090751 FAST PROCEDURE FOR COMPUTING THE DISTANCE BETWEEN COMPLEX OBJECTS IN THREE-DIMENSIONAL SPACE.** An algorithm for computing the Euclidean distance between a pair of convex sets in  $R^m$  is described. Extensive numerical experience with a broad family of polytopes in  $R^3$  shows that the computational cost is approximately linear in the total number of vertices specifying the two polytopes. The algorithm has special features which makes its application in a variety of robotics problems attractive. These features are discussed and an example of collision detection is given. 29 refs.

Gilbert, Elmer G. (Univ of Michigan, Ann Arbor, MI, USA); Johnson, Daniel W.; Keerthi, S. Sathiy. *IEEE J Rob Autom* v 4 n 2 Apr 1988 p 193-203.

**090752 PROCEEDINGS OF ROBEXS '87 THIRD ANNUAL WORKSHOP ON ROBOTICS AND EXPERT SYSTEMS.** This conference proceedings contains 43 papers discussing recent advances in the field of robotics and artificial intelligence. The robotics sessions focus on modeling and planning, AI methods in robotics, system aspects of robotics, and robotic control. The expert systems sessions cover methodology, practices, goals, medical applications, automation planning, and systems dealing with real-time problems. The key theme sessions include CIM and flexible manufacturing methods, robotics and manufacturing applications, CAD/CAM and integration, AI design automation and stochastic and simulation methods. One session deals with computer algebra and S/W automation. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10945 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (ISA, Robotics & Expert Systems Div, Research Triangle Park, NC, USA). *Proc of ROBEXS '87 Third Annu Workshop on Rob and Expert Syst, Pittsburgh, PA, USA, Jun 4-5 1987* Publ by ISA (Rob and Expert Syst v 3), Research Triangle Park, NC, USA, 1987 324p.

**090753 CYCLE DE CONFERENCES D'ETUDE ET D'INFORMATION DE LA SOCIETE FRANCAISE DES MECANICIENS SUR LES ROBOTS INDUSTRIELS.** [Special Issue: Industrial Robots]. This collection of papers contains 16 papers covering the following topics: present trends in robotics; mechanical, kinematic, and dynamic design of robots; computer-aided design in robotics; programming systems for robotics; use of quaternion matrices to solve kinematics of robots; second generation robotics; robotics in automobile manufacture; standardization of industrial robots; robotic hydraulic turbine repair; inspection and maintenance robots in nuclear power plants and other hostile environments; and robotic submersibles. All papers are indexed and abstracted separately. All papers are in French. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11204 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Soc Francaise des Mecaniciens, Paris, Fr). *RFM Rev Fr Mec* n 4 1987, Cycle de Conf d'Etude et d'Inf de la Soc Fr des Mec sur les Rob Ind, Mar 25-26 1987 p 199-327.

**090754 COMMENT ABORDER UN PROJET ROBOTIQUE.** [How to Approach a Project of Robotics]. After having defined the main families of robots, the article defines the various stages of the robotization of industrial plants. It emphasizes the gains in productivity to be expected from the operation. (Edited author abstract) In French.

Germain, J.F. (ASEA, Persan, Fr). *RFM Rev Fr Mec* n 4 1987, Cycle de Conf d'Etude et d'Inf de la Soc Fr des Mec sur les Rob Ind, Mar 25-26 1987 p 253-256.

**090755 PROCEEDINGS - IEEE MICRO ROBOTS AND TELEOPERATORS WORKSHOP: AN INVESTIGATION OF MICROMECHANICAL STRUCTURES, ACTUATORS AND SENSORS.** This workshop proceedings contains 26 papers. The following topics are dealt with: microstructural fabrication technology; design, fabrication, and performance of microelectromechanical systems; and applications of micromechanical systems. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11221 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEEE, Robotics & Automation Council, New York, NY, USA). *Proc - IEEE Micro Rob and Teleoper Workshop. An Invest of Micromech Struct, Actuators and Sens, Hyannis, MA, USA, Nov 9-11 1987* Publ by IEEE, New York, NY, USA, 1987. Available from IEEE Service Cent (Cat n 87TH0204-8), Piscataway, NJ, USA 148p.

**090756 ROBOTICS RESEARCH: THIRD INTERNATIONAL SYMPOSIUM (MIT PRESS SERIES IN ARTIFICIAL INTELLIGENCE).** This symposium proceedings contains 48 papers on various aspects of robotics research. The papers are grouped into four main sections: Perception, Decision, Action, and Systems. The Perception section is divided into two chapters, the first on stereo and motion and the second on object identification and modeling. The first chapter of the section on Decision is on the topic of planning and reasoning and emphasizes the general aspects of intelligent decision making; the second chapter, entitled Task Level, is concerned with more specific aspects. The Action section has three chapters. The first is on kinematics and dynamics, the second on control, and the third on design and mechanisms. Making up the final section, on Systems, are, first, a chapter on the strongly emerging field of mobile robots and, second, a chapter on integrated systems. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11592 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Faugeras, O.D. (Ed.) (INRIA, Rocquencourt, Fr); Giral, Georges (Ed.). *Rob Res: Third Int Symp, Gouviex, Fr, Oct 7-11 1985* Publ by MIT Press, Cambridge, MA, USA, 1986 404p.

## Analysis

**090757 EFFECT OF JOINT MOTION CONSTRAINTS ON THE WORKSPACE AND NUMBER OF CONFIGURATIONS OF MANIPULATORS.** A method for the investigation of the effect of joint motion constraints on the workspace and its subspaces with different number of configuration is developed. The method is also helpful in choosing the location and extent of the applied limitations to the motion at the joints, and in the design of manipulators with desired workspace and number of configurations. As examples, the effect of constraints on the workspace, subspaces, and number of configurations of a 3 R and 3 RPR manipulators are studied. (Author abstract) 18 refs.

Rastegar, J. (Iranian Research Organization for Science & Technology, Iran); Deravi, P. *Mech Mach Theory* v 22 n 5 1987 p 401-409.



**090758 INVESTIGATION INTO THE COMPLIANCE OF SCARA ROBOTS. PART I: ANALYTICAL MODEL.** A special class of robots suited for assembly tasks called SCARA (Selective Compliance Assembly Robot Arm) provides a degree of built-in flexibility due to robot structure. In such robots there are three revolute joints and a prismatic joint. They offer four degrees of freedom consisting of rotation about two vertical and parallel axes at the revolute joints, and translation and rotation about the tool axis. A mathematical model which expresses the end effector deflection as a function of the robot Jacobian and the drive compliance parameters in Cartesian coordinates has been developed. The modified generalized assembly force model developed for the Selective Compliance Assembly Robot Arms (SCARA), used in this investigation, is described. Constraints required to prevent jamming and wedging of parts during assembly are outlined. (Edited author abstract) 13 refs.

ElMaraghy, H.A. (McMaster Univ, Hamilton, Ont, Can); Johns, B. *J Dyn Syst Meas Control Trans ASME* v 110 n 1 Mar 1988 p 18-22.

**090759 INVESTIGATION INTO THE COMPLIANCE OF SCARA ROBOTS. PART II: EXPERIMENTAL AND NUMERICAL VALIDATION.** A model of inherent elastic compliance was developed for general position-controlled SCARA, with conventional joint feedback control, for both rotational and prismatic part insertion (Part I). The developed model was applied to the SKILAM and ADEPT I robots for validation. Experimental procedures and numerical solution methods are described. It was found that the ADEPT I robot employs a coupled control strategy between joints one and two which produces a constant, decoupled end effector compliance. The applicable compliance matrix, in this case, is presented and the experimental results are discussed. The model may be used to develop compliance maps that define the amount of end effector compliance, as a function of the joints compliance, as well as its variation for different robot configurations. This is illustrated using data for the SKILAM SCARA robot. Results are plotted and discussed. (Edited author abstract) 10 refs.

ElMaraghy, H.A. (McMaster Univ, Hamilton, Ont, Can); Johns, B. *J Dyn Syst Meas Control Trans ASME* v 110 n 1 Mar 1988 p 23-30.

**090760 METHOD FOR DETERMINING AND CORRECTING ROBOT POSITION AND ORIENTATION ERRORS DUE TO MANUFACTURING.** A method is presented for calibration of a robot to correct position and orientation errors due to manufacturing. The method is based on the shape matrix robot kinematic description. Each joint is individually and successively moved in order to explicitly calculate the shape matrix of each link. In addition, methods to correct for the errors in both the forward and inverse kinematic solutions are presented. The modification of the forward solution is a simple task. The modification of the inverse kinematic solution is a difficult problem and is achieved by an iterative technique which supplements the closed-form solution. An example of the calibration and inverse solution is presented to show the improvement in the accuracy of the robot. (Author abstract) 16 refs.

Broderick, P.L. (Purdue Univ, West Lafayette, IN, USA); Cipra, R.J. *J Mech Transm Autom Des* v 110 n 1 Mar 1988 p 3-10.

**090761 ON-LINE ROBOT TRAJECTORY CONTROL IN JOIN COORDINATES BY MEANS OF IMPOSED ACCELERATION PROFILES.** A method for trajectory control in the joint space is presented. An acceleration profile is proposed for each segment of the trajectory. After a twofold integration a position trajectory is obtained with advantageous characteristics. The position trajectory is completely dynamically balanced; it exhibits continuity up to the third derivative of the position. This way, minimum requirements are imposed on the actuators. The technique delivers predictable results since the trajectory deviates only slightly from a straight line connection between successive joint coordi-

nates. Very limited computational effort is required. (Author abstract). 10 Refs.

Van Aken, Ir. L. (Katholieke Univ Leuven, Leuven, Belg); Van Brussel, H. *Robotica* v 6 n 3 Jul-Sep 1988 p 185-195.

**090762 DYNAMIC ANALYSIS OF A THREE-DEGREES-OF-FREEDOM IN-PARALLEL ACTUATED MANIPULATOR.** The dynamic analysis of a three-degrees-of-freedom in-parallel actuated manipulator is presented. The equations of motion have been formulated in joint-space using the Lagrangian approach. The analysis provides the solution to predict the forces required to actuate the links so that the manipulator follows a predetermined trajectory. A dynamic simulation program illustrates the influence of the link dynamics on the actuating force required. An example of tracing a helical path is chosen to illustrate the dynamic simulation and to show that the Cartesian position of the moving platform may be controlled at a sacrifice of orientation freedoms. The dynamic analysis provides a basis for future theoretical research to develop the control scheme, for experimental research to estimate the inertia parameters, and for design optimization of the prototype manipulator. 18 refs.

Lee, Kok-Meng (Georgia Inst of Technology, Atlanta, GA, USA); Shah, Dharman K. *IEEE J Rob Autom* v 4 n 3 Jun 1988 p 361-367.

**Applications** See Also IRON AND STEEL INDUSTRY—Robot Applications; PIPELINES—Maintenance; ROBOTS, INDUSTRIAL; ROBOTS, INDUSTRIAL—Applications; ROBOTS, INDUSTRIAL—Research.

**090763 FEASIBILITY STUDY OF A ROBOT MANIPULATOR FOR THE DISABLED.** A robotic manipulator system appears to offer much potential for a severely handicapped person who has little or no hand function. Existing environmental control systems fulfil an important role, but are limited to preselected tasks. The robotic system described here aims to overcome such limitations by providing a user-controlled manipulative device, which is not restricted to preselected tasks. The paper describes the development of a system based on a relatively cheap desk-top mounted robotic device controlled by a microcomputer, in order to investigate the feasibility of such a system. The problems which have been encountered are the provision of user input commands from a person with limited control function, and also the progression from general control of the robot to the performing of useful domestic tasks. The paper also describes and discusses the results of a user survey and user trials. (Author abstract) 5 refs.

Hillman, Michael R. (Bath Inst of Medical Engineering Ltd, Bath, Engl). *J Med Eng Technol* v 11 n 4 Jul-Aug 1987 p 160-165.

**090764 SOLVING DISK CERTIFICATION PROBLEMS WITH A ROBOTIC WORKCELL.** Testing is typically the last process performed on a rigid disk before it is installed in a disk drive. Defects and errors introduced during the testing process are usually detected only after the disk is installed; the cost of mistakes is therefore many times that of the disk itself. Simple timing studies sometimes indicate that automated disk certification does not increase overall throughput. The DC Series disk certification workcell was developed for automated burnishing, glide testing, and certifying of 5-1/4 in. and 3-1/2 in. rigid disks. Cell components are an Intellex Model 605 or IBM Model 7545-800S robot with an Applied Robotic Technologies end effector, Fluoroware cassettes, and an IBM/PC XT or AT controller. Some manufacturers have gone offshore to reduce labor costs only to find that increased inventory and additional freight costs and duty plus the labor and current stability in a foreign country can offset anticipated savings. Robotics addresses the problem of high labor costs and offer the additional advantages of rapid local response to technical issues and potentially greater savings through improved quality and yield. The benefits of using the DC Series Disk Certification workcell are discussed. (Edited author abstract)

Lane, Ted (Applied Robotic Technologies Inc, Concord,

MA, USA); Brumberger, Neil. *Rob Eng* v 8 n 5 May 1986 p 6-9.

**090765 EXPANDING FUTURE APPLICATIONS GOAL OF NEW DEVELOPMENTS.** As the robotics industry looks ahead to a new year, researchers at universities and robotic equipment companies are at work on a variety of projects ranging from advanced sensing techniques to robotic systems able to work in a vacuum. Enhancing robotic capabilities through research centered on applications helps expand the market for robotics. This article describes some projects at many companies and universities that will help determine future applications.

Conversano, Jill (Robotics World, Atlanta, GA, USA). *Rob World* v 6 n 1 Jan 1988 p 26, 28-29.

**090766 COLLOQUIUM ON PERSONAL AND DOMESTIC ROBOTS.** This colloquium proceedings contains 7 papers. The topics covered include: uses of personal robots; mobile robots; marketing of robots; and the potential of personal robots. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 07250 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Computing & Control Div, London, Engl). *IEE Colloq Dig* n 1985/48, Colloq on Pers and Domestic Rob, London, Engl, May 1 1985. Publ by IEE, London, Engl, 1985 var pagings.

**Arms** See SPACECRAFT.

**Components** See Also MECHANICAL VARIABLES MEASUREMENT—Forces.

**090767 COMPUTER-ASSISTED CHOICE OF ELECTROHYDRAULIC SERVOSYSTEMS FOR MANIPULATION ROBOTS USING COMPLETE MATHEMATICAL MODELS.** In this paper, a computer procedure for the choice of electrohydraulic servosystems of manipulation robots is described. Mathematical models based on this procedure represent complete dynamic models of manipulation robots where all dynamic effects are included. Two types of mathematical model of electrohydraulic servosystems are considered: a linearized mathematical model with fixed parameters (time-invariant model) and a linearized mathematical model with variable parameters (time-varying model). Based on exact dynamic analysis, interactive procedures for optimal choice of electrohydraulic actuators, using both types of mathematical models are derived. A criterion is based on the minimum energy consumption for trajectory realization. Selection procedures are given on a typical example of manipulation robot. Also, programmed control calculated using both types of linearized models is compared with programmed control using exact nonlinear models of servosystems. It is shown that the linearized model with variable parameters represents qualitative dynamic behavior of manipulation robots. (Author abstract) 6 refs.

Vukobratovic, M. ('Mihailo Pupin' Inst, Belgrade, Yugoslavia); Katic, D.; Potkonjak, V. *Mech Mach Theory* v 22 n 5 1987 p 431-439.

**Computer Aided Design** See Also ROBOTS, INDUSTRIAL—Materials Handling Applications.

**090768 ORGANIZING CUSTOMIZED ROBOT DYNAMICS ALGORITHMS FOR EFFICIENT NUMERICAL EVALUATION.** In 1983, the computer program called algebraic robot modeler (ARM) was implemented to generate symbolically complete closed-form and recursive dynamic robot models. To enhance computational efficiency for dynamic simulation and real-time control, the systematic organization of these symbolic models was introduced in 1985 to remove repetitive calculations within and across equations and thereby generate customized robot dynamics algorithms. The systematic organization procedure of ARM is detailed and its performance compared with documented organizations. It is pointed out that the systematic



organization procedure, and the exploitation of kinematic and dynamic manipulator structures through symbolic modeling, make ARM-generated customized algorithms the most computationally efficient manipulator dynamics algorithms of those compared. 32 refs.

Murray, John J. (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Neuman, Charles P. *IEEE Trans Syst Man Cybern* v 18 n 1 1988 p 115-125.

**090769 CONCEPTION ASSISTEE PAR ORDINATEUR EN ROBOTIQUE.** [Computer Aided Design in Robotics]. This paper presents a survey of Computer Aided Design (C.A.D.) systems dedicated to robotics. A C.A.D. system in robotics should help the engineer to design and to program workcells: for these purposes, different tools may be used to simulate and to optimize robot motions, cycle times, workcell layouts, etc. The performance of these tools is analysed and current research trends are explored. A list of commercially available systems is given. (Edited author abstract) 48 refs. In French.

Dombre, E. (Lab d'Automatique et de Microelectronique de Montpellier, Montpellier, Fr); Fournier, A. *RFM Rev Fr Mec* n 4 1987, Cycle de Conf d'Etude et d'Int de la Soc Fr des Mec sur les Rob Ind, Mar 25-26 1987 p 213-221.

**Computer Applications** See ROBOTS, INDUSTRIAL—Mobile.

**Computer Interfaces** See CONTROL SYSTEMS—Robot Applications.

**Computer Simulation** See Also ROBOTS, INDUSTRIAL—Arms; ROBOTS, INDUSTRIAL—Computer Simulation.

**090770 MAXIMAL DISTANCE RESULT OF INTEREST IN ROBOTIC SIMULATION.** Given two hyper-rectangles in  $E^n$  with sides having surface normals in the directions of the axes, and given a connected set in each that touches all  $2n$  sides of its containing hyper-rectangle, it is important to have an easily calculated upper bound on the distance between the two connected sets. A result giving such a bound, necessary in branch-and-bound algorithms used for collision avoidance in robotic simulation, is stated and proved here. (Author abstract) 2 refs.

Andersson, L.-E. (Univ of Linköping, Linköping, Sweden); Hurteau, G.; Stewart, N.F. *Appl Math Optim* v 16 n 3 Nov 1987 p 217-226.

**090771 IN POSITION: SIMULATING ROBOTIC WORKCELLS ON A MICRO.** Many commercial programs are available for modeling industrial robots. These often use state-of-the-art graphics hardware and software and can therefore offer sophisticated, complete models. The paper explains how color graphics simulation of different manufacturer robots makes it easier to choose the right one. This package for a PC/AT lets an engineer preview the candidates. Later, the purchased system can be modeled and programmed with the same software.

Derby, Stephen (Rensselaer Polytechnic Inst, Troy, NY, USA). *Comput Mech Eng* v 5 n 2 Sep 1986 p 34-37.

**090772 3-DIMENSIONAL COMPUTER ANIMATION SYSTEM WITH ROBOTIC APPLICATIONS.** The paper describes a newly developed three-dimensional computer animation system to be used for creating motion programs for a set of actors. The animation package includes a language for describing spatial motion of bodies, as well as an interactive tool to be used for assigning geometrical attributes to them and for guiding and visualizing the play-back of motion programs. One of the main uses of the package is robot programming and motion simulation. A geometrical modeler, which is an aid in creating the models of animated bodies, is also described. (Author abstract) 4 refs.

Siegler, Andras (Computer & Automation Inst, Budapest, Hungary); Bathor, Miklos; Deri, Gabor. *Robotica* v 5 pt 4 Oct-Dec 1987 p 281-290.

**090773 INTERACTIVE ROBOT SIMULATOR FOR HIGH-LEVEL TASKS.** A robot simulator is developed that enables a robot operator to make plans of high-level tasks easily without knowing the details of the robot, before its off line teaching and programming. The simulator is based on the structural model developed in the CAD system Himades-1, which was devised for general assembly units with rotating and prismatic pairs. First, some unique basic functions that use the structural model are introduced. Then the general method, independent of the type of robot, is reported, which provides the consistent and intelligent algorithm to extract the necessary transformation matrices systematically from the structural model, to set up automatically the formulas for backward motion analysis and to solve them. (Edited author abstract) 9 refs.

Kitajima, K. (Tokyo Univ of Agriculture & Technology, Koganei, Jpn). *Comput Aided Des* v 20 n 2 Mar 1988 p 93-99.

**090774 MAXIMAL DISTANCE FOR ROBOTIC SIMULATION: THE CONVEX CASE.** Given two hyper-rectangles in  $E^n$  with sides having surface normals in the directions of the axes, each containing a set that touches all  $2n$  sides of its containing hyper-rectangle, it is important to have an easily calculated upper bound on the distance between the sets, for use in a branch and bound algorithm applicable in collision avoidance in robotic simulation. In a previous paper, such a bound was given under the hypothesis that the sets are connected. Here, the authors consider the case where the sets are convex. (Author abstract) 4 refs.

Andersson, L.E. (Univ of Linköping, Linköping, Sweden); Stewart, N.F. *J Optim Theory Appl* v 57 n 2 May 1988 p 215-222.

**090775 PHYSICALLY BASED SIMULATION MODEL FOR ACOUSTIC SENSOR ROBOT NAVIGATION.** A computer model is described that combines concepts from the fields of acoustics, linear system theory, and digital signal processing to simulate an acoustic sensor navigation system using time-of-flight ranging. By separating the transmitter/receiver into separate components and assuming mirror-like reflectors, closed-form solutions for the reflection from corners, edges, and walls are determined as a function of transducer size, location, and orientation. A floor plan consisting of corners, walls, and edges is efficiently encoded to indicate which of these elements contribute to a particular pulse-echo response. Sonar maps produced by transducers having different resonant frequencies and transmitted pulse waveforms can then be simulated efficiently. Examples of simulated sonar maps of two floor plans illustrate the performance of the model. Actual sonar maps are presented to verify the simulation results. 9 refs.

Kuc, Roman (Yale Univ, New Haven, CT, USA); Siegel, M.W. *IEEE Trans Pattern Anal Mach Intell* v PAMI-9 n 6 Nov 1987 p 766-778.

**090776 COMBINED OBSERVER-CONTROLLER SYNTHESIS FOR UNCERTAIN DYNAMICAL SYSTEMS WITH APPLICATIONS.** Control of a class of nonlinear/uncertain systems is discussed using a variable-structure systems (VSS) approach. Observations of the states of such systems is also considered. The natural extension to an observer-controller design is illustrated using a computer simulation example of a  $\theta$ - $r$  manipulator. Next, the problem of path planning is addressed using a combined observer-controller strategy. The aspects of hardware implementation of the proposed observer-controller are then analyzed. 34 refs.

Walcott, Bruce L. (Univ of Kentucky, Lexington, KY, USA); Zak, Stanislaw H. *IEEE Trans Syst Man Cybern* v 18 n 1 1988 p 88-104.

**Control** See Also CONTROL SYSTEMS—Robustness.

**090777 NONLINEAR ADAPTIVE CONTROL OF AN N-LINK ROBOT WITH UNKNOWN LOAD.** An N-link planar robot holding an unknown load and driving

its end-effector along a prespecified trajectory is studied. The effect of the unknown load is discussed, and the nonlinear dynamic equation with the unknown load is derived. A non-linear model-reference adaptive control algorithm is developed for tracking of a trajectory that is a piecewise continuous function of time. The tracking error dynamics represent a linear stable system with persistent disturbances, and the Germaidze-Krasovskii theorem in the Lyapunov second method is applied to show the error stability. Digital computer simulations show the effectiveness of the adaptive control algorithm for the unknown load with mass 2 kg, 5 kg, and 10 kg. The effect of the computation time delay on the system dynamics is also addressed. (Author abstract) 22 refs.

Han, J.-Y. (Southern Illinois Univ, Carbondale, IL, USA); Hemami, H.; Yurkovich, S. *Int J Rob Res* v 6 n 3 Fall 1987 p 71-86.

**090778 ALGORITHMS FOR CONTROLLING POWER OPERATIONS OF HANDLING ROBOTS.** Methods for synthesizing control algorithms for drive systems with feedback relating to the forces being developed are presented. Synthesis procedures are developed for linear and nonlinear mathematical models of processes being controlled. Recommendations for calculating the algorithm parameters are given. (Author abstract) 10 refs.

Krut'ko, P.D. *Sov J Comput Syst Sci* v 25 n 5 Sep-Oct 1987 p 151-157.

**090779 MULTIPROCESSOR SYSTEM FOR REAL-TIME ROBOTIC CONTROL.** SIERA (System for Implementing and Evaluating Robotic Algorithms) is a multiprocessor system that incorporates a tightly coupled bus-based system (the Real Time Servo System, or RTSS) and a loosely coupled link-oriented network (the Armstrong Multiprocessor System). SIERA is capable of controlling many types of commercially available robots because the modular construction of its hardware and software has minimized robot dependencies. Support routines have been created to yield a powerful robotic algorithm development system. This includes a custom real-time operating system for the RTSS and special processes for the Armstrong system. These facilities allow a researcher to interactively modify or replace any algorithm related to the operation of the robot. A compliant control example is used to illustrate SIERA's capabilities. The algorithm presented in this example may be applied to unconstrained motion as well as compliant motion, and is the topic of further research. (Edited author abstract) 18 refs.

Kazanzides, Peter (Brown Univ, Providence, RI, USA); Wasti, Hamid A.; Wolovich, William A. *Inf Sci* v 44 n 3 Apr 1988 p 225-247.

**090780 EXPERIMENTS WITH THE USE OF A RULE-BASED SELF-ORGANISING CONTROLLER FOR ROBOTICS APPLICATIONS.** The Rule-Based Self-Organising Controller (SOC) has as one of its main advantages the fact that there is no need to have a mathematical description of the system to be controlled. In this controller, the rules are linguistic statements expressed mathematically through the concepts of Fuzzy Sets and correspond to the actions a human operator would take when controlling a given process. This paper describes several experiments which were performed with SOC. The control was considered of both simulated linear and non-linear processes. The performance of the controller was investigated for step inputs as well as for waveforms which the process output had to track; the effect of process noise was also considered. It was shown that SOC had a performance slightly superior to that of a PID controller when noise was present and the process had time varying coefficients as well as pronounced non-linear characteristics. This paper also reviews some of



the successful initial work carried out in connection with the application of SOC to a revolute joint robot arm. (Edited author abstract) 19 refs.

Tanscheit, R. (Univ of London, London, Engl); Scharf, E.M. *Fuzzy Sets Syst* v 26 n 2 May 1988 p 195-214.

**090781 ROBOTERSTEUERUNG IRS 713 (TEIL 1).** [Robot Control IRS 713: Part 1]. The authors present the charging robot control IRS 713. After having explained the construction and the periphery they treat the structure of the 4-computer-system as well as the hardware and the functions of the individual modules, such as position control and operating part. The operation and application programming form the essential points of the remaining contribution, the operation modes as well as NC programming and generation being particularly dealt with. (Author abstract) In German.

Barth, W.; Mueller, K.-J.; Reichel, F.; Zeun, G. *MSR Mes Steuern Regeln* v 31 n 3 Mar 1988 p 121-125.

**090782 ROBOT CONTROL USING ADAPTIVE TRANSFORMATIONS.** A control strategy is presented for robots that do not have accurately known mechanical structures or have inaccuracies caused by bending, slip, or backlash. In the system, the manipulator's endpoint is monitored in a servo loop, so that inaccuracies in the structure can be compensated. An adaptive transformation from task to robot-oriented coordinates has been used online, without prior modeling or calculation. The strategy developed has been simulated for a two-degree-of-freedom robot. Results are compared with those obtained using the inverse Jacobian as part of the control system. 14 refs.

Lobbezoo, Arnold J. (Univ of British Columbia, Vancouver, BC, Can); Bruijn, P.M.; Davies, M.S.; Dunford, William G.; Lawrence, Peter D.; van Nauta Lemke, H.R. *IEEE J Rob Autom* v 4 n 1 Feb 1988 p 104-106.

**090783 ROBOT CONTROL IN THE NEIGHBORHOOD OF SINGULAR POINTS.** An alternative method is proposed for designing a robot-controller in Cartesian coordinates using a time-scale transformation. The proposed controller achieves slow poles in the area of poor manipulative ability and fast poles in the area of good manipulative ability. Therefore, the robot can be properly controlled in the neighborhood of singular points without reducing the performance outside the neighborhood of these points. 14 refs.

Sampei, Mitsui (Tokyo Inst of Technology, Tokyo, Jpn); Furuta, Katsuhisa. *IEEE J Rob Autom* v 4 n 3 Jun 1988 p 303-309.

**Control Systems** See Also CONTROL SYSTEMS—Mathematical Models; PIPELINES—Maintenance; ROBOTS, INDUSTRIAL—Arms; ROBOTS, INDUSTRIAL—Control Systems; ROBOTS, INDUSTRIAL—Mathematical Models; ROBOTS, INDUSTRIAL—Mobile; SYSTEMS SCIENCE AND CYBERNETICS—Neural Nets.

**090784 PLANNING OF STRAIGHT LINE TRAJECTORY IN ROBOTICS USING INTERACTIVE COMPUTER GRAPHICS.** The planning of straight line trajectory using the interactive computer graphics simulation of robot manipulator movement is discussed. This new approach to straight line motion planning improves the 'bound deviation joint paths' developed by R.M. Taylor (1979). The new approach has three characteristics: (1) linear interpolation in joint space; (2) unequal intervals for interpolating knot points; (3) using interactive computer graphics to assure that the maximum deviation in the whole segment is less than the pre-specified values. The structure and mathematical basis of a computer program developed for this purpose are presented. (Author abstract) 10 refs.

Wang, Kesheng (SINTEF-NTH, Trondheim, Norw); Lien, Terje K. *Model Ident Control* v 8 n 3 1987 p 125-135.

**090785 CARTESIAN TRAJECTORY TRACKING FOR MANIPULATORS USING OPTIMAL CONTROL THEORY.** A Cartesian trajectory tracking system

for manipulators is developed using optimal control theory. By including the Cartesian position in the state vector, transformation of the trajectory from Cartesian space to manipulator joint space is avoided, and the Jacobian matrix need not be inverted. The tracking system may also be applied to kinematically redundant manipulators. For this type of manipulator, singularities are avoided by choosing a suitable performance index in the optimal control problem. Simulation using a simple kinematically redundant manipulator shows that a small tracking error can be achieved with low motor torques. (Author abstract) 11 refs.

Egeland, Olav (Norwegian Inst of Technology, Trondheim-NTH, Norw). *Model Ident Control* v 8 n 3 1987 p 137-147.

**090786 DYNAMIC CONTROL OF KINEMATICALLY REDUNDANT ROBOTIC MANIPULATORS.** We propose a control algorithm in which we are especially concerned with the manipulator dynamics. The algorithm is particularly well suited for the class of redundant manipulators consisting of a relatively small manipulator mounted on a larger positioning part. The main idea behind the algorithm is to augment the task space position vector by a set of generalized coordinates for the positioning part, so that the augmented task space position vector constitutes a set of generalized coordinates for the manipulator. In a simulation experiment, this control algorithm performed significantly better than controllers using generalized inverses of the manipulator Jacobian. (Edited author abstract) 15 refs.

Lunde, Erling (Norwegian Inst of Technology, Trondheim, Norw); Egeland, Olav; Balchen, Jens G. *Model Ident Control* v 8 n 3 1987 p 159-174.

**090787 COORDINATING CONTROL OF A SPECIAL JOINT STRUCTURE WITH MORE SERVOS THAN DEGREES OF FREEDOM.** A joint mechanism for use as a general building block in manipulators with a very high number of degrees of freedom is introduced. It consists of 3 servos driving a 2 d.o.f. universal joint by means of wire. A coordinate transformation set is developed, which includes positional, velocity and force transformations. Both direct and inverse transformations are presented. Special attention is given to the inverse force transformation which is obtained using linear optimization. The solution in this case is also shown to be valid for a more general class of constrained non-linear optimization problems. An example is given of the use of the coordinate transformation set; a joint control system including servos under internal force control. (Author abstract)

Dessen, Fredrik (Norwegian Inst of Technology, Trondheim-NTH, Norw). *Model Ident Control* v 8 n 3 1987 p 175-184.

**090788 GAIT CONTROL SYSTEM OF A QUADRUPEL WALKING VEHICLE.** A walking vehicle has potential capability to be developed to an off-road machine with high mobility and adaptivity by using the coordination control of its multi-degrees of freedom. This paper discusses the gait control system based on a quadruped walking vehicle developed by the authors. The total structure of the control system, consisting of three levels named A, B and C, is clarified. The control algorithm of each level is studied in detail, particularly the three sub-systems belonging to level B, i.e. gait control in xy coordinates, the same in z coordinate and trajectory control of legs taking account up/down swinging. The control algorithm at level C, which regulates the basic reflex motions, is specifically discussed. Finally, these discussions are verified by walking experiments of a model TITAN III. The joystick control of omnidirectional motions and adaptive locomotion over irregular surfaces are successfully demonstrated. (Edited author abstract) 7 refs.

Hirose, Shigeo (Tokyo Inst of Technology, Tokyo, Jpn); Fukuda, Yasushi; Kikuchi, Hidekazu. *Adv Rob* v 1 n 4 1986 p 289-323.

**090789 ROBOT CONTROL SYSTEM BASED ON FORTH.** For over 10 years, the National Bureau of Standards has conducted research in robotics. NBS has developed a Real-Time Control System (RCS) that uses the sensory-interactive hierarchical control model. RCS has been implemented by a small team of programmers and can control a variety of robots. Suggestions and theories detailing the needs of a fourth-generation robot controller have evolved from the implementation of RCS. The RCS software has been implemented with FORTH as its base coordinating and development system. Any number of programming languages can be used to solve the wide variety of problems associated with robotics, but some are better suited than others for certain tasks. The paper describes the RCS system reliability, and discusses RCS support tools. 7 refs.

Michalowski, John L. (NBS, Gaithersburg, MD, USA); Warsaw, Barry A. *Rob Eng* v 8 n 5 May 1986 p 22-26.

**090790 NEW METHOD FOR THE ROBOT CONTROLLER DESIGN.** A new method to derive systematically control algorithms given exact linearization and decoupled controls of robots for manipulators is applied to simple examples. In particular, because this method does not require dynamical equations of mechanisms, its application to physical systems is a very simple operation. (Edited author abstract) 10 refs.

Cotsafitis, M. (INSTN Saclay, Fr); Vibet, C. *Robotics* v 4 n 1 Mar 1988 p 57-63.

**090791 ROBOT-ARM-SYSTEM PLAYING 2 DIMENSIONAL PING-PONG GAME USING IMAGE PROCESSING TECHNIQUE.** A robot arm system equipped with a CCD camera and able to play a two-dimensional ping-pong game has been built. The system is able to play in the form of both robot versus robot and robot versus man. In the robot control part, 25 fuzzy production rules are used. Ambiguous instructions in terms of membership functions are generated by the robot itself using imagery data from a CCD camera. Each of these instructions consists of three fuzzy items. Two of them are input (ambiguous) information concerning the fuzzy point, that is, where the ball was hit, and the fuzzy angle, that is, from which direction the ball is coming, and the other is output information which shows how far the ball will reach. This output information, which also indicates the point the robot should move to, is calculated based on the fuzzy inference method. The whole system is controlled by only one 16-bit personal computer and works in real time. (Edited author abstract). 7 Refs. In Japanese.

Hirota, Kaoru; Arai, Yoshinori; Hachisu, Shiroh. *Bull Coll Eng Hosei Univ* n 24 Mar 1988 p 57-67.

**090792 COMPLIANT ROBOT MOTION I. A FORMALISM FOR SPECIFYING COMPLIANT MOTION TASKS.** A formalism is developed for specifying compliant motion tasks. It is based on the hybrid control functional specification method described by Mason. However, some new concepts are introduced: tracking directions, end-effector and task-frame motion constraints, feedforward velocity data, and task termination conditions. This formalism synthesizes all the information required in order to allow a completely automatic execution of the task. As a result, it achieves strict separation between programming and control, which is of primary importance for the integration of compliant motion into a robot programming language. Several examples show that the formalism applies to a broad class of compliant motion tasks. The newly defined tracking directions contribute to the autonomy of the robot control system in case only partial geometric information about the environment is available. (Author abstract). 24 Refs.

De Schutter, J. (Katholieke Univ Leuven, Louvain, Belg); Van Brussel, H. *Int J Rob Res* v 7 n 4 Aug 1988 p 3-17.



**090793 COMPLIANT ROBOT MOTION II. A CONTROL APPROACH BASED ON EXTERNAL CONTROL LOOPS.** A control approach for the execution of robot tasks in contact with the environment is worked out. The input to the controller consists of the task specification described in another paper. The control approach is based on external force and tracking loops, which are closed around the robot positioning system. The position control loops tend to decouple and linearize the complex robot dynamics, and therefore they present to the external controller a system which is easy to model and easy to control. Design and properties of external control loops are discussed in great detail. In particular, the role of a passive compliance with respect to task execution speed and disturbance rejection is analyzed both qualitatively and quantitatively. The resulting compliant motion controller has been tested experimentally, and proved to be very robust and to yield the theoretically expected performance. (Author abstract). 17 refs.

De Schutter, J. (Katholieke Univ Leuven, Heverlee, Belg); Van Brussel, H. *Int J Rob Res* v 7 n 4 Aug 1988 p 18-33.

**090794 TASK-SPACE TRACKING WITH REDUNDANT MANIPULATORS.** A controller for redundant manipulators with a small fast manipulator mounted on a positioning part has been developed. The controller distributes the fast motion to the small fast manipulator and the slow gross motion to the positioning part. A position reference is generated online to the positioning part to avoid singularities and the loss of degrees of freedom. The task-space position vector is augmented by the generalized coordinates of the positioning part. Feedback linearization and decoupling are then applied in the augmented task space to obtain a model consisting of decoupled double integrators. These integrators are controlled by linear quadratic optimal control. In the optimal control problem, the performance index is chosen so that the task-space position reference is tracked with a high bandwidth, while the reference to the positioning part is tracked with a low bandwidth. The controller has been applied to a simple planar redundant manipulator and an eight-link spray painting robot in simulation experiments. These simulations showed that a high bandwidth was possible with moderate actuator torques. 14 refs.

Egeland, Olav (Norwegian Inst of Technology, Trondheim, Norw). *IEEE J Rob Autom* v RA-3 n 5 Oct 1987 p 471-475.

**090795 LANGUAGE-AIDED ROBOTIC TELEOPERATION SYSTEM (LARTS) FOR ADVANCED TELEOPERATION.** A language-aided robotic teleoperation system is described that incorporates two sets of teleoperational languages with a master-slave manipulator. One language offers flexible means, called software jigs, to specify motion constraints superimposed on operational motion, simplifying task motion. The other offers an easy method of teaching elementary tasks which frequently appear in teleoperation. Reexecution of the thus-taught program is effectively utilized. 7 refs.

Sato, Tomomasa (Electrotechnical Lab, Tsukuba, Jpn); Hirai, Shigeoki. *IEEE J Rob Autom* v RA-3 n 5 Oct 1987 p 476-481.

**090796 MODEL PREDICTIVE HEURISTIC CONTROL OF A POSITION SERVO SYSTEM IN ROBOTICS APPLICATION.** A recently proposed method of control, namely model algorithmic control (MAC) or, equivalently, model predictive heuristic control (MPHC) is analyzed with a view to its implementation for the position control system. The formulation of the MPHC strategy to positional servo systems is presented. Both the regulator and the tracking problems are studied. The simulation and experimental results obtained indicate that the MPHC results in good performance, even under conditions of large time-varying changes in the parameters of the system. 3 refs.

Kaynak, Okay (Bogazici Univ, Istanbul, Turk); Melancon, Pierre; Rajagopalan, Venkatachari. *IEEE J Rob Autom* v RA-3 n 5 Oct 1987 p 481-485.

**090797 CLASSICAL CONTROL DESIGN FOR A FLEXIBLE MANIPULATOR: MODELING AND CONTROL SYSTEM DESIGN.** A Lagrangian dynamics approach is used to model the planar motion of a manipulator consisting of two flexible links and two rotary joints. The equations are linearized and represented by a transfer function matrix. In addition, a multivariable control system is designed by a technique based on classical methods. 14 refs.

Ower, J.C. (Univ of Toronto, Ont, Can); Van de Vegte, J. *IEEE J Rob Autom* v RA-3 n 5 Oct 1987 p 485-489.

**090798 INTERPROCESS COMMUNICATION FOR DISTRIBUTED ROBOTICS.** Because of the complex nature of the tasks performed by multiple robots cooperating in three-dimensional dynamic environments, centralized control is no longer practical; workcells have become centers of distributed computing. This motivates the need for an interprocess communication (IPC) facility which would integrate the individual elements both within and between workcells. A survey of IPC is presented in the context of distributed robotics. General approaches to communication within a distributed computing environment are discussed as an introduction to the overview of IPC. A discussion of the main IPC design issues for distributed robotics is included. 90 refs.

Gauthier, David (McGill Univ, Montreal, Que, Can); Freedman, Paul; Carayannis, Gregory; Malowany, Alfred S. *IEEE J Rob Autom* v RA-3 n 6 Dec 1987 p 493-504.

**090799 COORDINATION OF TWO PLANAR ROBOTS IN LIFTING.** The dynamic equations for a two-robot system with and without load are formulated. For control purposes, the constraint forces are derived as functions of input and state. The inverse plant method and computation of the constraint forces are used to coordinate the control of the system. No pressure or force sensors are considered, and no force feedback is used. The effectiveness of the control strategy for point-to-point motion of the coordinated robots performing a lifting task is checked by digital computer simulations. 27 refs.

Laroussi, Kader (Ohio State Univ, Columbus, OH, USA); Hemami, Hooshang; Goddard, Ralph E. *IEEE J Rob Autom* v 4 n 1 Feb 1988 p 77-85.

**090800 CONTROL AND STABILIZATION OF NONLINEAR UNCERTAIN ELASTIC ROBOTIC ARM.** An approach is presented to the control of an uncertain nonlinear flexible robot arm (PUMA-type) with three rotational joints. The third link is assumed to be elastic. A torque control law, which is a function of the trajectory error, is derived for controlling the joint angles. The knowledge of the system dynamics is not required for the derivation of the controller. This controller includes a reference model to generate command joint angle trajectories, and a dynamic system in the feedback path which requires only joint angle and rate for feedback. The torque controller asymptotically decouples the elastic dynamics into two subsystems, representing the transverse vibration of the elastic link in two orthogonal planes. For the damping of the elastic vibration, a force control law using modal velocity feedback is synthesized. Simulation results are presented to show that the combination of the torque and force control law accomplishes reference joint angle trajectory tracking and elastic mode stabilization despite the uncertainty in the system. 25 refs.

Singh, Sahendra N. (Univ of Nevada, Las Vegas, NV, USA). *IEEE Trans Aerosp Electron Syst* v 24 n 2 Mar 1988 p 148-155.

## Design

**090801 OPTIMAL DESIGN OF ROTARY DYNAMIC ABSORBER FOR ROBOT.** The optimal design of a rotary dynamic absorber which is attached to an elastic robot is carried out in this paper. Based on the band-limited white noise base excitation, the optimal tuning and damping ratios of the absorber are determined by minimizing the variance of elastic robot response. The variable metric method used to determine those optimal

parameters for the variance cannot be calculated directly by integrating the transfer function over the band-limited frequency range. The effect of material damping of robot is small enough that it can be ignored. To have a small variance, the absorber must be installed away from the base and have the moment ratio  $\mu$  (defined as the ratio of mass moment of inertia of absorber to robot) greater than 0.03. (Author abstract) 10 refs.

Wang, Y.Z. (Nat'l Central Univ, Chungli, Taiwan); Cheng, S.H. *Chung-Kuo Chi Hsueh Kung Ch'eng Hsueh Pao* v 8 n 6 Dec 1987 p 373-382.

**090802 BUILDING FAST, INTELLIGENT ROBOT SYSTEMS.** Conventional robot systems operate slowly and methodically, often playing back a pretaught sequence of positions. To investigate the construction of fast, intelligent robot systems, we have built a robot ping-pong player. We will examine the techniques required to cope with a dynamic environment, from the vision system to the robot's low-level control algorithms. We also describe an 'expert controller', which executes loosely specified strategies in real time in spite of constraints imposed by the robot and by task geometry. (Author abstract) 5 refs.

Andersson, Russell L. (AT&T Bell Lab, Holmdel, NJ, USA). *AT&T Tech J* v 67 n 2 Mar-Apr 1988 p 73-86.

**Economics** See Also ROBOTS, INDUSTRIAL—Modification.

**090803 COLLOQUIUM ON PERSONAL ROBOTICS IN THE HOME.** This conference proceedings contains 3 papers on the topic of personal robotics in the home. Specific papers address the questions of the financial condition of the personal robot industry; the technical feasibility and cost-effectiveness of mobile, 'seeing' personal robots; and the development and increasing complexity of robotics within the Euromouse maze-contest, culminating in ROBAT, robot ping-pong. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 09358 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Computing & Control Div, London, Engl). *IEE Colloq Dig* n 1986/92, Colloq on Pers Rob in the Home, London, Engl, Jul 16 1986. Publ by IEE, London, Engl, 1986 var pagings.

**Education** See Also COMPUTER INTEGRATED MANUFACTURING—Education; ROBOTICS—Vision Systems.

**090804 BUILD BERT, THE BASIC EDUCATIONAL ROBOT TRAINER, PART 1.** The amount of training required in the applications of very simple robots, even commercially available ones is considered. A menu-driven, interactive control language is written that is intended to be simple enough to program a robot. A talking robot, called BERT, is designed that can be easily built with only commonly used electronics tools: a fine-tip soldering iron, wire cutters, pliers, and so on. To program the robot a device is needed capable of transmitting ASCII code at 300 baud, with 7 data bits, no parity, and 1 stop bit. In other words, almost any computer with a serial port, or a serial terminal itself, can be used.

Brown, Karl (Vancouver Community Coll, Vancouver, BC, Can). *Byte* v 12 n 4 Apr 1987 p 113-118, 120-122.

**090805 GRAPHICAL SIMULATION OF PUMA ROBOT.** For students taking an introductory course in robotics it is at times difficult to visualize a robot in its different configurations. It would be helpful to them in the absence of a real robot, to be able to see and manipulate these positions on a computer screen. A software code using the DI3000 graphics package was developed for this purpose. The UNIMATION PUMA robot with three degrees of freedom (DOF) was modeled graphically in three dimensions so that given the co-ordinates of any



point in its work envelope the robot will be seen in a configuration necessary for reaching that point. (Author abstract) 3 refs.

Agrawal, Chandramuuli (Duke Univ, Durham, NC, USA); Aziz, Nadim M. *Adv Eng Software* v 9 n 4 Oct 1987 p 218-221.

**090806 INTRODUCING INDUSTRIAL ROBOTICS INTO AN UNDERGRADUATE AND POSTGRADUATE CURRICULUM.** The addition of the robot has caused several spin-offs to occur in the Mechanical Engineering department. Within the guidelines of the undergraduate curriculum a variety of experiments have been conducted on parts of the robot. The experiment is named 'the design of an experiment' and the ground rules are that we assign a set of students and they are supposed to design and implement an experiment to complete the task. This has been applied successfully to the robot and the results of some of the experiments involving the robot are reported. A brief description of a new robotics course, which has evolved because of the robot, is also given. Part of the research efforts that are a consequence of the new robot are also discussed. (Edited author abstract). 11 Refs.

Jeswiet, J. (Queen's Univ, Kingston, Ont, Can); Moore, T.N. *Int J Appl Eng Educ* v 3 n 6 1987 p 539-545.

## Elasticity

**090807 NONLINEAR OBSERVER FOR ELASTIC ROBOTS.** Robot manipulators in which the joints exhibit a certain amount of elasticity are discussed. The model of such robots is highly nonlinear, and available techniques to build nonlinear observers generally do not apply. A procedure to construct approximate nonlinear observers is proposed that uses a recent approach to deriving observers based on geometric nonlinear control theory together with an approximation technique. The conditions under which an exact observer exists are derived. Some examples are given for which simulation tests assure a good performance even when the observer is connected to a control system. 10 refs.

Nicosia, Salvatore (Seconda Univ di Roma, Italy); Tomei, Patrizio; Tornambe, Antonio. *IEEE J Rob Autom* v 6 n 2 Feb 1988 p 45-52.

## Evaluation

**090808 ROBOTS 9: PRESENTING THE INDUSTRY'S NEWEST AND BEST.** The paper presents results of a conference discussing the latest in robotic technology. The theme of the Robots 9 event, 'Implementing Manufacturing Technologies,' reflects the seriousness of purpose with which the robotics industry is advancing. A discussion is given of this year's hottest robotics products to meet a multitude of industrial and manufacturing needs.

Kehoe, Ellen J. (Robotics Today, Dearborn, MI, USA). *Rob Today* v 7 n 3 Jun 1985 p 33-41.

**090809 MAKING ROBOTS PAY OFF.** Rational evaluation is necessary in justifying robot applications in the plant. The article discusses four strategic factors that the evaluation should include. These are: basic applications fit; economic justification, both obvious and strategic; non-economic justification; and organizational environment check.

Brooks, Jake (Peat Marwick Main & Co, NY, USA). *Rob World* v 6 n 6 Aug 1988 p 13,14,16.

**090810 ROBOTICS: WHAT EVERY MANAGER SHOULD KNOW.** All manufacturing managers and executives should understand the basics of robotics before implementation takes place. When examining actual or proposed equipment in the plant, three aspects are addressed: its programmability; ability to operate unattended; the variety of tasks it can handle. Robots can be justified through four approaches: manufacturing necessity; economic payback; intangible benefits and future benefits. The group investigating robot applications should consider: the effect on workers displaced by robots; whether an adequate knowledge base exists to select,

design, install a robotic solution to a manufacturing problem; whether to choose a small pilot project for testing; who the working members of the robotic team will be; who would review the final recommendations.

Singer, Larry M. (Manufacturing Systems, Wheaton, IL, USA). *Manuf Syst* v 6 n 9 Sep 1988 p 40-42, 44-46.

**Imaging Techniques** See ROBOTICS, INDUSTRIAL—Vision Systems.

## Israel

**090811 ROBOTICS IN ISRAEL.** It's generally accepted that Israel's continued success in industrial development will necessitate the widespread implementation of robots. This robotization has been slow in coming. A discussion is given of the need of implementing the use of robots in the Israeli industry. Research and Development activities, as well as, the activities of the Israeli Center for Industrial robots are discussed.

Schreiber, Rita R. (Robotics Today, Dearborn, MI, USA). *Rob Today* v 7 n 3 Jun 1985 p 65-68.

## Japan

**090812 ROBOTICS DEPARTMENT, PRODUCT DEVELOPMENT LABORATORY, MITSUBISHI ELECTRIC CORPORATION (MELCO).** Half a century has passed since the Research Department was first founded at MELCO. Now there are more than 2000 researchers working in nine laboratories. Robotics research has been carried out in the Central Research Laboratory (CRL), the Manufacturing Development Laboratory (MDL) and the Product Development Laboratory (PDL). Robotics research and development at MELCO is performed eagerly with the cooperation of many departments. The Robotics Department is responsible not only for basic research but also for responding to market demand and rapid technology transfer to the Product Department. 9 refs.

Tsuda, Eiichi. *Adv Rob* v 1 n 3 1986 p 281-284.

**090813 TAKANO LABORATORY, DEPARTMENT OF PRECISION MACHINERY ENGINEERING, FACULTY OF ENGINEERING, UNIVERSITY OF TOKYO.** The main areas of research on robotics in our laboratory are the study of robot mechanisms, dynamics and speed-up of robot motion. Because the robot mechanism can be considered as a kind of multi-degree-of-freedom linkage mechanism, the transition to the research of robot mechanism has been inevitable. The techniques of speed-up of the motion and the method of treatment of non-linearity of the mechanism and its vibrations can be adapted to robotics. 8 refs.

Takano, Masaharu. *Adv Rob* v 1 n 3 1986 p 285-288.

**090814 MATSUSHIMA AND OHTA LABORATORIES, INSTITUTE OF ENGINEERING MECHANICS, UNIVERSITY OF TSUKUBA.** Matsushima and Ohta's Laboratories belong to the Institute of Engineering Mechanics, which was a new addition to the research institutional structure of the University of Tsukuba in Tsukuba Science City in 1978. The institute has 38 faculty members, and nine technical staff members and covers a broad research field of mechanics which may be classified into four areas: solid mechanics and structural engineering, fluid mechanics and hydraulic engineering, energy conversion and heat transfer, and system and control engineering. In the fourth research area, Matsushima's Laboratory is concerned mainly with micromanipulator and man-machine systems and Ohta's Laboratory with medical engineering and biomechanics.

Matsushima, Kozo (Univ of Tsukuba, Tsukuba, Jpn). *Adv Rob* v 1 n 2 1986 p 187-189.

**Mathematical Models** See Also CONTROL, MECHANICAL VARIABLES—Position; MACHINE VIBRATIONS; ROBOTS, INDUSTRIAL—Arms; ROBOTS, INDUSTRIAL—Computer Simulation; ROBOTS, INDUSTRIAL—Design; ROBOTS, INDUSTRIAL—Optimization.

**090815 STUDY ON THE CONSTRUCTION OF DYNAMIC EQUATIONS OF GENERAL ROBOTS BY KANE'S METHOD.** This paper presents a method of constructing mathematical models of robot dynamics by Kane's dynamics. The advantages of Newtonian algorithm remain in the kinematic analysis of this method. Dynamic equations can be used to solve the direct and inverse problems of robot dynamics and can be readily converted into computer programs for numerical calculation. (Author abstract) In Chinese. 5 refs.

Peng Shangxian (Tianjin Univ, China); Wang Kang. *Tianjin Daxue Xuebao* n 3 1987 p 22-30.

**090816 DUAL-NUMBER TRANSFORMATION AND ITS APPLICATIONS TO ROBOTICS.** The dual-number line transformation (originally proposed by W.K. Clifford in 1873) is chosen for line representation in 3-D space. Lemmas and theorems indicating relevant properties of the dual number, dual vector, and dual matrix are proposed. This is followed by the transformation and manipulation of dual numbers for robotic applications. This transformation procedure offers an algorithm which deals with the symbolic analysis for both rotation and translation. In particular, it can effectively be used for direct determination of Jacobian matrices and their derivatives. It is shown that the proposed procedure simplifies the formulation of the robotic kinematics, dynamics, and control system modeling. 14 refs.

Gu, You-Liang (Oakland Univ, Rochester, MI, USA); Luh, J.Y.S. *IEEE J Rob Autom* v RA-3 n 6 Dec 1987 p 615-623.

**090817 UNCERTAIN GEOMETRY IN ROBOTICS.** The author suggests that to operate efficiently, a robot system must be able to represent, account for, and reason about the effects of uncertainty in areas in which geometric analysis also plays an important part. He proposes that uncertainty be represented as an intrinsic part of all geometric descriptions. Toward this goal he develops a description of uncertain geometric features as families of parameterized functions together with a distribution function defined on the associated parameter vector. Uncertain points, curves, and surfaces are considered, and it is shown how they can be manipulated and transformed between coordinate frames in an efficient and consistent manner. The effectiveness of these techniques is demonstrated by application to the problem of developing maximal-information sensing strategies. 19 refs.

Durrant-Whyte, Hugh F. (Univ of Pennsylvania, Philadelphia, PA, USA). *IEEE J Rob Autom* v 6 n 2 Feb 1988 p 23-31.

**090818 FEEDBACK STABILIZATION AND TRACKING OF CONSTRAINED ROBOTS.** Mathematical models for constrained robot dynamics, incorporating the effects of constraint forces required to maintain satisfaction of the constraints, are used to develop explicit conditions for stabilization and tracking using feedback. The control structure allows feedback of generalized robot displacements, velocities, and the constraint forces. Global conditions for tracking, based on a modified computed-torque controller and local conditions for feedback stabilization, using a linear controller, are presented. The framework is also used to investigate the closed-loop properties if there are force disturbances, dynamics in the force feedback loops, or uncertainty in the constraint functions. 31 refs.

McClamroch, N. Harris (Univ of Michigan, Ann Arbor, MI, USA). *IEEE Trans Autom Control* v 33 n 5 May 1988 p 419-426.

**Medical Applications** See Also BIOMEDICAL ENGINEERING—Japan; BIOMEDICAL ENGINEERING—Neurosurgery; BIOMEDICAL EQUIPMENT—Catheters; HUMAN REHABILITATION ENGINEERING—Physical Therapy.



**090819 DEVELOPMENT OF A FOUR-WHEELED MOBILE ROBOT SYSTEM FOR BEDRIDDEN PATIENTS.** With the aim of reducing the difficulties faced by handicapped people and those responsible for their care and nursing, we have undertaken research on the development of a four-wheeled mobile robot system to provide assistance in the daily activities of the bedridden and handicapped. The characteristics of this system are (1) front-wheel power steering and independently directly driven rear wheels, (2) one pair of manipulators which have nine degrees of freedom mounted on the four-wheeled mobile device, and (3) a hierarchical control system with one 16 bit and several 8 bit microcomputers. We utilize a teaching-playback method to develop control programs for specific activities. As a result of our research and development, we have succeeded in establishing fundamental techniques for mobile robot systems for bedridden patients. (Edited author abstract) 2 refs.

Funakubo, Hiroyasu (Univ of Tokyo, Tokyo, Jpn); Isomura, Tsuneshi; Komeda, Takashi; Inuzuka, Yukio. *Adv Rob v 1 n 4 1986 p 371-378.*

**090820 LOOKING A ROBOT IN THE EYE.** Anyone used to industrial robots with flinch when they hear the most significant characteristic of robots in medicine: medical robots interact with people. Worse still, the interact with people in very intimate ways such as teeth brushing and surgery. This article, based on a survey, discusses the robot's place in health care and concludes, that despite all the difficulties, there are a number of applications where robots could be of very real use in the near future. (Edited author abstract)

Finlay, Patrick A. (Fulmer Systems Ltd, Stoke Poges, Engl). *CME Chart Mech Eng v 34 n 12 Dec 1987 p 21-23.*

**090821 ADVANCED ROBOT SYSTEM FOR AUTOMATED DIAGNOSTIC TASKS THROUGH PALPATION.** An approach to the design of a robot system capable of executing complex sensory-motor sequences aimed at gathering data useful for diagnostic purposes is presented. The main features of such a robot system are discussed, and its possible integration in an advanced, interactive expert system for medical diagnosis is considered. As an example of implementation of the concept of a robot system for automated diagnostic tasks, the design characteristics of a tendon-actuated, anthropomorphic finger, incorporating force and position sensors for low-level compliant motion control and skin-like sensors for tactile perception, are outlined. The hierarchical control architecture devised for managing some different diagnostic sensory-motor sequences (subroutines) is also presented. The diagnostic subroutine PULSE, which detects pulse rate and optimizes pressure pulse waveform in peripheral blood vessels by noninvasive palpation procedures, is described in detail and then experimentally evaluated in the simplified robot testbed. Preliminary results indicate that the proposed approach may lead to the development of robot systems eventually capable of collaborating with or even substituting for medical or auxiliary personnel in some simple diagnostic and therapeutic tasks. 21 refs.

Dario, Paolo (Univ of Pisa, Italy); Bergamasco, Massimo. *IEEE Trans Biomed Eng v 35 n 2 Feb 1988 p 118-126.*

**Military Applications** See RADIO NAVIGATION—Robot Applications; ROBOTS, INDUSTRIAL—Mobile.

**Optimization** See ROBOTS, INDUSTRIAL—Manipulators.

**Planning** See Also ROBOTS, INDUSTRIAL—Control Systems; ROBOTS, INDUSTRIAL—Intelligent.

**090822 AUTOMATIC GRASP PLANNING IN THE PRESENCE OF UNCERTAINTY.** This paper presents an algorithm for automatic planning of robot grasping motions that are insensitive to bounded uncertainties in the object's location. The algorithm plans parallel-jaw grasping motions for arbitrary two-dimensional polygonal objects, which need not be of uniform density. Grasping motions are viewed as parameterized operations, where

the parameter values that describe an individual operation define an operation space of all possible operations. By combining an analysis of object geometry and the physics of friction, the planning algorithm divides the operation space into regions, where all operations within a given region produce the same final grasping configuration. Task uncertainties are then included by shrinking these regions by the amount of uncertainty present. The smaller regions that remain after shrinking indicate all those operations that will successfully result in a given grasping configuration, even if the worst-case combination of errors occurs. The grasping operations presented intrinsically reduce task uncertainty. It is shown that simple squeeze-grasp operations are not sufficient for grasping all possible objects, and offset-grasp and push-grasp operations are added to increase the scope of the planner. (Edited author abstract) 24 refs.

Brost, Randy C. (Carnegie Mellon Univ, Pittsburgh, PA, USA). *Int J Rob Res v 7 n 1 Feb 1988 p 3-17.*

**090823 MULTIROBOT PLAN GENERATION IN A CONTINUOUS DOMAIN: PLANNING BY USE OF PLAN GRAPH AND AVOIDING COLLISIONS AMONG ROBOTS.** A robot plan-generation system is described that treats continuous state changes over time for multiple robots. A model for a continuous domain is represented, and a parallel plan-generation system, based on production rules for multiple robots in this domain, is proposed. The system consists of a fundamental planning subsystem for multiple robots and a subsystem for detecting and avoiding mutual collisions of cylindrical-type robots, called PLAMAT and SYDAMUC, respectively. In addition to examples for each subsystem, an assembly problem is solved as an example for the total plan-generation system, and the usefulness of the system is confirmed. 14 refs.

Nagata, Tadashi (Kyushu Univ, Fukuoka, Jpn); Honda, Kunihiko; Teramoto, Yoshiaki. *IEEE J Rob Autom v 6 n 2 Feb 1988 p 2-13.*

**Research** See Also ROBOTS, INDUSTRIAL—Research.

**090824 TOKYO INSTITUTE OF TECHNOLOGY, DEPARTMENT OF CONTROL ENGINEERING, HASEGAWA LABORATORY.** The laboratory located on Oh-okayama campus of Tokyo Institute of Technology is described. It consists of twelve members including a professor, a research assistant, and graduate and undergraduate students. Its work is concentrated on: development and application of robot sensors, for example, a visual, a tactile and a proximity sensor; development of a driving mechanism using a differential gear mechanism for an arm, a wrist and a finger of the manipulator; development of an autonomous trajectory generating servomechanism as a trajectory control method for manipulators; and development of a method [called mark flow graph (MFG)] to design, analyze and control the discrete systems such as sequential control systems or discrete manufacturing systems. 12 refs.

Hasegawa, Kensuke (Tokyo Inst of Technology, Tokyo, Jpn); Mizutani, Takashi. *Adv Rob v 1 n 1 1986 p 87-90.*

**090825 LEAST COMMON ROBOT PROJECT.** This paper describes the first stages of a Forth User Group project to develop a Least Common Robot, a simple and affordable design easily interfaced with common microcomputers. Design trade-offs are aimed at providing easy availability of such robots for school and hobby use, for easy programming in standard Forth. (Author abstract)

Meyers, Donald (Miller Microcomputer Services, Natick, MA, USA); Miller, A. Richard. *J Forth Appl Res v 5 n 1 1987, 1987 Rochester Forth Conf on Comp Comput Archit, Rochester, NY, USA, 1987 p 175-181.*

**090826 COLLOQUIUM ON THE WORLD SCENE IN ROBOTICS AND FACTORY AUTOMATION.** This conference contains 8 papers, and deals with automated manufacturing and robotics research in several countries. The use of advanced and flexible manufacturing

technology is discussed with regard to modernization of computer and robotic systems. Interaction between manufacturing facilities and academia is discussed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 09370 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Computing & Control Div, London, Engl). *IEE Colloq Dig n 1986/103, Colloq on the World Scene in Robot and Fact Autom, London, Engl, Oct 17 1986.* Publ by IEE, London, Engl, 1986 var pagings.

## Reviews

**090827 TENDANCES ACTUELLES ET INTERROGATIONS EN ROBOTIQUE. [Present Trends and Pending Questions in Robotics].** After having defined the various classes of robots: articulated arms, telemanipulators, mobile robots, the article describes summarily the current themes of research: geometric kinematics, kinematics of motion, statics, dynamics, control. A few remarks on the state of research and developments in the United States, in Japan, and at Electricite de France complement the article. (Edited author abstract) In French.

Delbos, M. (Electricite de France, Chatou, Fr). *RFM Rev Fr Mec n 4 1987, Cycle de Conf d'Etude d'Inf de la Soc Fr des Mec sur les Rob Ind, Mar 25-26 1987 p 201-204.*

**090828 ROBOTIQUE DE DEUXIEME GENERATION. [Second Generation Robotics].** Robotics, originally starting from mechanical concepts, took advantage of all recent progress in pattern recognition, computation, and computer-assisted design. The second-generation robots will involve the concept of integrated automation including the design of a whole production line, stock management, handling, machining, and even assembling. (Edited author abstract) In French.

Le Maitre, J. (IIRIAM, Marseilles, Fr). *RFM Rev Fr Mec n 4 1987, Cycle de Conf d'Etude et d'Inf de la Soc Fr des Mec sur les Rob Ind, Mar 25-26 1987 p 243-252.*

**Sensors** See Also BIOSENSORS; ROBOTS, INDUSTRIAL—Control Systems.

**090829 OPTICAL TACTILE SENSOR USING THE CT RECONSTRUCTION METHOD.** The tactile sensors used for robotics and electrical artificial hands are designed to provide force information. This paper proposes a two-dimensional tactile sensor based on the pressure-optical transmission conversion system and the principle of computer tomography. The sensor consists of a three-layered silicon rubber sheet and an array of opto-electrical elements embedded in the edge of the sheet. The pressure distribution is detected as an optical transmission pattern. The transmission pattern is reconstructed to a two-dimensional distribution using the algorithm of the computer tomography (CT) pattern reconstruction. (Edited author abstract) 13 refs.

Kawashima, Toshio (Hokkaido Univ, Sapporo, Jpn); Aoki, Yoshinao. *Electron Commun Jpn Part 2 v 70 n 10 Oct 1987 p 35-43.*

**090830 CONSISTENT INTEGRATION AND PROPAGATION OF DISPARATE SENSOR OBSERVATIONS.** The author describes a method for integrating partial, uncertain, geometric sensor observations into a robust, consistent estimate of the state of the environment. The integration process uses a Bayes procedure for comparing disparate observations of geometric features, rejecting spurious measurements, and providing partial updates of object locations to a world model. This integration mechanism can combine any number of observations from sensors that provide measurements of different geometric features. The invariant topology of



relations between uncertain geometric features is used to develop a method for propagating observations through the world model. (Edited author abstract) 14 refs.

Durrant-Whyte, Hugh F. (Univ of Oxford, Oxford, Engl). *Int J Rob Res* v 6 n 3 Fall 1987 p 3-24.

**090831 ANTHROPOMORPHIC ROBOT FINGER FOR INVESTIGATING ARTIFICIAL TACTILE PERCEPTION.** The design, implementation, and testing of an artificial tactile sensing system incorporating an articulated robot finger are presented. It was our primary aim in this work to set up the hardware and software tools necessary for investigating basic issues in artificial tactile perception. The criteria followed in the design of the robot finger and of its motor and sensory components are outlined. The authors also deal with the problem of defining a hierarchical architecture for the control of the exploratory finger. Experimental results that demonstrate the capability of the robotic system of executing the previously defined tactile subroutines and of extracting specific object features are presented. This work is of interest to prosthetics. (Edited author abstract) 41 refs.

Dario, Paolo (Univ of Pisa, Pisa, Italy); Buttazzo, Giorgio. *Int J Rob Res* v 6 n 3 Fall 1987 p 25-48.

**Space Applications** See Also ROBOTS, INDUSTRIAL—Military Purposes; SPACE PLATFORMS—Automation; SPACE RESEARCH—Automation.

**090832 SATELLITE-MOUNTED ROBOT MANIPULATORS - NEW KINEMATICS AND REACTION MOMENT COMPENSATION.** When a robot arm is mounted on a satellite, the commanded arm motions produce motion of the satellite and therefore of the robot base. As a result, the robot joint angles that would normally be commanded to produce a prescribed robot end-effector position and orientation will cause the end-effector to miss the target. We have developed a new kind of robot kinematics that adjusts the joint angle commands to account for base motion. Methods are also developed to compute the satellite attitude disturbances resulting from robot motion for use in a reaction wheel compensation system or in feedforward control. (Author abstract) 3 refs.

Longman, Richard W. (US Naval Research Lab, Washington, DC, USA); Lindberg, Robert E.; Zedd, Michael F. *Int J Rob Res* v 6 n 3 Fall 1987 p 87-103.

**090833 CONTROL DEVICE EFFECTS ON TELEROBOTIC MANIPULATOR OPERATIONS.** A series of simulation tests were performed to evaluate control input devices for the Remote Manipulator System (RMS). Six subjects operated the simulated RMS in the manual end effector mode using two three-degrees-of-freedom (DOF) hand controllers and one six-DOF hand controller. Two mission scenarios were used to vary operator workload. A task requiring docking to a stationary target from a six-DOF tracking task was used to provide a high-workload condition. Performance using the two types of controllers was compared in terms of task time, measures of position error, and operator ratings of two controller types. (Edited author abstract) 4 refs.

O'Hara, John M. (Grumman Space Systems, Bethpage, NY, USA); Olsen, Roy E. *Robotics* v 4 n 1 Mar 1988 p 5-18.

**090834 ROBOTIC SYSTEMS FOR NASA GROUND-BASED RESEARCH.** The laboratory Telerobotic Manipulator (LTM) is being developed at ORNL under the direction of NASA Langley Research Center to provide telerobotic hardware for use in NASA ground-based laboratory research. A significant technical limitation is the lack of available telerobotic hardware that can function well as a real-time teleoperator and can also provide a sound hardware basis for intelligent robotic operations. The LTM is being developed to merge these technical domains in common hardware to further NASA's research investigations. This article summarizes the mechanical and controls approach being utilized to realize these goals. (Author abstract) 4 refs.

Herndon, Joseph N. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Hamel, William R.; Meintel, Alfred J. *Robotics* v 4 n 1 Mar 1988 p 19-25.

**090835 TELEOPERATION AND AUTONOMY FOR SPACE ROBOTS.** A logical enhancement to manned space flight includes the use of robots in space. To achieve this goal, there must be a phased program where the capabilities of the robot can evolve as technology advances. This paper will review some of the ways in which robots can be used in space. Then, a system architecture standard will be suggested which supports the evolution of robot control from teleoperation to autonomy. Finally, some areas of technology transfer will be discussed which are relevant to land-based robot operation. (Author abstract) 5 refs.

Lumia, Ronald (NBS, Gaithersburg, MD, USA); Albus, James S. *Robotics* v 4 n 1 Mar 1988 p 27-33.

**Standardization** See ROBOTS, INDUSTRIAL—Standardization.

**Theory** See Also COMPUTER PROGRAMMING—Algorithms; ROBOTS, INDUSTRIAL—Grippers.

**090836 GENERALIZED UNFOLDINGS FOR SHORTEST PATHS.** We consider the problem of determining shortest paths in the presence of polyhedral obstacles between two points in Euclidean three-space. For the special case when paths are constrained to the surfaces of three-dimensional objects, simple planar unfoldings are used to obtain the shortest path. For the general case when paths are not constrained to lie on any surface, we describe generalized unfoldings wherein the shortest path in the three-space again becomes a straight line. These unfoldings consist of multiple rotations about the edges of the polyhedral obstacles. (Author abstract) 11 refs.

Bajaj, Chanderjit (Purdue Univ, West Lafayette, IN, USA); Moh, T.T. *Int J Rob Res* v 7 n 1 Feb 1988 p 71-76.

**090837 SINGULAR CONFIGURATIONS AND WORKSPACE OF ROBOTS.** The purpose of this paper is to explain the set-up of a general method for finding the singular configurations of a robot. Open and closed chain manipulators made out of links with single degree of freedom joints are considered. The manipulator singular configurations corresponding to inner and outer limits of workspace are found by the study of analytical relations between the end effector location and the joint coordinates using the Jacobian matrix. (Author abstract) 4 refs.

Becquet, M. (Univ of Brussels, Brussels, Belg). *Robotics* v 4 n 1 Mar 1988 p 73-83.

**090838 FUZZINESS IN KNOWLEDGE-BASED ROBOTICS SYSTEMS.** This paper addresses how fuzziness is employed in a robotics system, for the purposes of object representation, object or feature location and as a means of representing actions performed on objects. It describes a robotic system which would use a multimodal representation knowledge base (KB). The focus is on the use of fuzziness in this robotic system. Keyboard entered natural language phrases would be used by a human user of the robot. The robot system would, in practice, translate these phrases into executable commands and coordinates. There are several points of departure that would be employed and the first of these is the use of 'fuzzy descriptors' rather than the conventional binary distinctive feature matrix. A fuzzy descriptor is a generalization of a geometric description of an object from the system's geometric data base. How the fuzzy descriptor works is described. (Edited author abstract) 21 refs.

Dodds, David R. (Bell-Northern Research, Ottawa, Ont, Can). *Fuzzy Sets Syst* v 26 n 2 May 1988 p 179-193.

**Vibrations**

**090839 DYNAMISCHE PROBLEME AN ROBOTERN.** [Dynamic Problems in Robots]. This paper concerns different dynamic problems of robots. Dynamic

quantities and characteristics of the quality are shown. Vibration and oscillation are discussed with mathematical methods. Models, methods for the solution of these problems and the numerical computation are given for the cases of 8 robots with 3 elements. (Author abstract) In German. 7 refs.

Just, E. (Technische Hochschule Ilmenau, East Ger). *Period Polytech Mech Eng* v 31 n 2-3 1987 p 165-174.

**Vision Systems** See Also CAMERAS—Calibration; ELECTRONICS ENGINEERING—Education; IMAGE PROCESSING—Image Analysis; IMAGE PROCESSING—Mathematical Models; IMAGE SENSORS—Research; MAIL HANDLING—Robot Applications; OPTICAL COMMUNICATION EQUIPMENT—Computer Integrated Manufacturing; PATTERN RECOGNITION—Computer Simulation; ROBOTS, INDUSTRIAL—Applications; ROBOTS, INDUSTRIAL—Control; ROBOTS, INDUSTRIAL—Sensors; ROBOTS, INDUSTRIAL—Vision Systems; SUBMERSIBLES—Imaging Techniques; VISION—Artificial; VISION—Binocular Effect; WELDING—Robot Applications.

**090840 MACHINE VISION FOR ROBOTICS AND AUTOMATED INSPECTION.** Volume I of this publication deals with fundamentals in 13 chapters. Some of the topics dealt with are these: the need for vision in industry; cameras, pixels, and lighting; computer approaches to vision understanding; model machine vision systems; general methods to enable robots with vision to acquire, orient, and transport workpieces; and the future of machine vision. Volume II deals with applications in 10 chapters. The topics dealt with are these: automated inspection; alphanumeric character recognition; vision for robots; part handling, orientation, and sorting; assembly; bin picking; semiconductor manufacturing and inspection; printed circuit board inspection; spray painting; and welding. Volume III deals with manufacturers/systems. It consists of product literature with as many details as possible of machine vision systems from manufacturers identified by a multi-faceted effort. The information provided by the manufacturers has not been evaluated, edited, or summarized.

Miller, Richard K. *Mach Vision for Rob and Autom Inspect* Publ by SEAI Inst, Madison, GA, USA, 1983 3 vol, 528p.

**090841 MACHINE VISION SYSTEM FOR ROBOTIC ASSEMBLY: A SYSTEM OVERVIEW.** The development of a machine vision system is described. The system can acquire an image, identify a desired candidate for the object, and calculate robot goal coordinates. The system consists of a binary vision assembly with both hardware and software subsystems, the hardware consists of a camera, lens controller and lighting. The software consists of a high-level robot control language for multi-tasking and image processing and a menu-driven program for ease of application. The paper presents a concise review of the design goals, system, functions, vision calibration, teach process, application program and capabilities of the assembly. (Author abstract) 5 refs.

Colson, J.C. (IBM, Austin, TX, USA); Henry, J.C. *Int J Appl Eng Educ* v 1 n 6 1985 p 397-404.

**090842 MICROCOMPUTER-BASED BINARY VISION SYSTEM.** This paper describes the development of a microcomputer-based, low-cost binary vision system to be used in automatic applications such as the control of an industrial robot. The vision system processes binary images and recognizes objects based on geometric features such as the number of holes and the moments of invariant. The system is trained by showing it the different stable positions. The image processing software is written in 8088 Assembly code and can recognize up to 40 parts per minute. (Author abstract) 14 refs.

Petersen, V. (Iowa State Univ of Science & Technology, Ames, IA, USA); Even, J. *Int J Appl Eng Educ* v 1 n 6 1985 p 405-413.



**090843 CAD-INTEGRATED VISION AND ROBOTICS.** A data-driven automated SMT board assembly is described that can handle production runs as short as five PCBs per model number. The system relies on integrated CAD information downloaded to an IBM AT master cell controller that is integrated with a dual Xenotech vision system, a Seiko RT3000 robot and a high-speed database management system. All of these run on a multi-user, multi-tasking operating system. The system automatically verifies pad locations, calculates ideal assembly sequencing, determines ideal parts feeding locations, and inspects and adjusts leaded component placement positions to compensate for lead bend variations.

Myers, Greg (Delco Systems Operations, Santa Barbara, CA, USA). *Circuits Manuf* v 28 n 2 Feb 1988 p 30, 32, 37.

**090844 VISUAL DETECTION OF DIFFERENTIAL MOVEMENT: APPLICATIONS TO ROBOTICS.** A method has been developed for accurately determining the differential movement of known objects from multiple camera views. The method has been applied to a robot system to find the repeatability and accuracy of the robot in both rotational and translational terms and also for tracking an object using visual feedback. (Author abstract) 12 refs.

Bowman, M.E. (Imperial Coll, London, Engl). *Robotica* v 6 pt 1 Jan-Mar 1988 p 7-12.

**090845 SOME LOCATION PROBLEMS FOR ROBOT NAVIGATION USING A SINGLE CAMERA.** One of the most fundamental problems for a mobile robot is to find its location and posture with respect to the outside world. The paper considers two classes of point location problems found in visual navigation of a mobile robot. The problems we consider are finding the location of a robot using a map of the room where the robot moves and an image taken by a camera carried by the robot. (Edited author abstract) 13 refs.

Sugihara, Kokichi (Univ of Tokyo, Tokyo, Jpn). *Comput Vision Graphics Image Process* v 42 n 1 Apr 1988 p 112-129.

**090846 DYNAMIC SCENE ANALYSIS FOR A MOBILE ROBOT IN A MAN-MACHINE ENVIRONMENT.** This paper describes a method by which a moving robot with vision can recognize the environment and behave in a proper way by analyzing the consecutive images taken during movement in an artificial environment such as a building or plant. The environment is assumed to be a corridor in a building. Two general features of the corridor are used as the premises for the image analysis: (1) the wall of the corridor is planar and is perpendicular to the floor; (2) the floor is flat. Since it is difficult to determine simultaneously the five three-dimensional motion parameters, a method is proposed to determine successively the parameters by partitioning them into the rotation and translation components. The rotation is determined based on such points in the image as vanishing based on such points in the image as vanishing point and infinity point, which are not affected by determined from the optical flow and the rotation. The position information in the corridor is determined further. The method is versatile since it does not employ the geometrical model represented by numerical values, utilizing only the properties valid in most of the artificial environment. An experiment is made in the corridor of a building. (Edited author abstract) 11 refs.

Yagi, Yasushi (Osaka Univ, Toyonaka, Jpn); Asada, Minoru; Yachida, Masahiko; Tsuji, Saburo. *Syst Comput Jpn* v 19 n 2 Feb 1988 p 1-9.

**090847 ROBOT VISION SYSTEM IMPLEMENTED BY A MINICOMPUTER.** A robot vision system has been introduced. The system consists of an image contour sensor and a minicomputer model PDP-11/23. The image contour sensor contains an image-dissector-camera. The processing of the image information has been carried out by this computer so as to

recognize and understand the image contour. The relevant information for image analysis and classification is contained in image contours. The image-dissector-camera is suitable for the randomly-controlled scanning of optical signal. Controlled by a minicomputer, the scanning generator can produce a 'scanning star' for contour detection. The automatic contour tracking is carried out by Kalman-Bucy-filter algorithm. Thus the data processed by the computer are reduced. It can realize a syntactic graph structure based on the structure element of 'node-relation-node' as well as an associative syntactic pattern recognition. (Edited author abstract) 3 refs. In Chinese.

Li, Yalong (Dep of Automatic Control Engineering, China). *Zhongnan Kuangye Xueyuan Xuebao* v 18 n 6 Dec 1987 p 667-672.

**090848 DESIGNER'S HANDBOOK: SPATIAL RESOLUTION. A KEY TO MACHINE VISION SUCCESS.** When integrating machine vision capabilities into any system, a number of factors need to be considered. The author will define and clarify these factors, discuss their interaction and provide a systematic approach to determining spatial resolution requirements and selecting a system with the most appropriate spatial resolution. The article will focus on alignment applications; the methodology for determining resolution in flaw detection or inspection applications is somewhat different, and will not be addressed.

Schatz, David (Cognex Corp, Needham, MA, USA). *Photonics Spectra* v 22 n 6 Jun 1988 p 71-72, 74, 76.

**090849 HITCHHIKER'S GUIDE TO VISION SYSTEMS.** This article offers criteria for choosing a vision system. Three tasks were defined as representative of generic areas of application. These were biscuit inspection which has always been a favorite of vision suppliers (or perhaps just the engineers who work for them); date and lot code inspection on pharmaceutical or food products and dimensional checks on a cassette tape assembly. In addition to technological constraints the author also imposed financial limits on the application of the system.

Loughlin, Clive. *Sens Rev* v 8 n 2 Apr 1988 p 93-99.

**090850 LOOK FORWARD TO NON-CONTACT TASKS.** This article traces the latest developments in machine vision systems. The reasons why engineers should keep abreast of the technology's potential for non-contact inspection tasks, for example, are highlighted.

Astrop, Arthur. *Mach Prod Eng* v 146 n 3738 May 6 1988 p 56-57.

**090851 EYES OF THE FACTORY - ROBOTS WITH VISION.** Vision systems applications include handling discrete materials (traveling on a conveyor, or stored in a bin) for the purpose of sorting, packaging, palletizing, or machine feeding, guiding materials through such processes as finishing, deburring, cutting, and sealing, and directing the fitting and fastening motions required for assembly. Vision works best when applied to stable products in a well controlled environment. The benefits of such systems include: increased productivity; increased throughput; better manufacturing control; increased robotic cell flexibility; and decreased sophistication in presenting materials to robots.

Krepchin, Ira P. *Mod Mater Handl* v 43 n 6 May 1988 p 89-91.

**090852 OPTIMIZING INSPECTION LOCATION.** Automated inspection systems provide a powerful tool for quality control as well as process control in a wide variety of industries. Such systems pay for themselves in a short time by providing real-time information - identifying problems on the production line as they occur - thus minimizing the manufacture of 'off-spec' product. Data from a computerized inspection system can be used for trend analysis, quality assurance, and production management. Optimizing the benefits of automated inspection now is possible with new technology that allows manufacturers to inspect at both the serial and parallel stages of

the production line. Both stages offer paybacks which can work together to bring well-defined savings. Author describes the advantages of optimizing inspection location and its effect on statistical process control.

Sawyer, William H. (Computer Based Imaging Technologies, Malvern, PA, USA). *Rob World* v 6 n 3 Mar 1988 p 20-23.

**090853 LIGHTING AND OPTICS: SOME EXPERT ADVICE.** The Lighting Advisor expert system, developed by Penn Video, was created to help solve lighting and optics problems mainly for small parts assembly verification. The Lighting Advisor uses a personal computer as its work station. The software is menu-driven with help available at all times. The user tells the Lighting Advisor about the application by answering a series of questions and making choices from the menus. The questions pertain to the nature of the application, the feature and background surface qualities, whether the object is moving or stationary during the inspection, etc. The expert system reviews the answers given and returns a set of conclusions, including: the lighting technique; the light source; the camera lens; and possible color or polarized filtration or special optics requirements.

Novini, Amir (Penn Video, Akron, OH, USA). *Rob World* v 6 n 6 Aug 1988 p 34-35.

**090854 PRECISION HIGH-SPEED RANGE SENSOR AND PROCESSOR.** A 3-D camera that measures 180,000 points per second with 25 microns range accuracy has been developed. This camera is applied to inspection of electronic assemblies, especially printed wire boards (PWB). A second important application is the more traditional problem of measurement and inspection of mechanical parts and assemblies with significant three-dimensionality. This paper provides range camera description, discusses vision computer and workstation and describes two examples of camera application: lead through hole (LTH) inspection in PWB and top of board inspection.

Corby, N.R. Jr. (GE, Schenectady, NY, USA). *Sens Rev* v 8 n 3 Jul 1988 p 155-160.

**090855 AUTONOMOUS NAVIGATION, EXPLO- RATION, AND RECOGNITION USING THE HER- MIES-IIB ROBOT.** The authors describe a research experiment in which an autonomous robot, the HER- MIES-IIB, placed in an arbitrary indoor location without prior specification of the room's contents, successfully discovers and navigates among both stationary and occasionally moving obstacles, picks up and moves small obstacles, searches for and locates a control panel, and reads meters found on that panel. All computation is done onboard the robot, which contains an eight-node NCUBE parallel processor. Available sensors include an array of sonar transducers and two cameras. The robot uses an expert system for real-time navigation, implementing machine vision algorithms that run in parallel on the nodes for panel recognition and meter reading. The authors discuss dynamic replanning, rapid decision-making under uncertainty, and computational capability within the context of an indoor laboratory environment. 19 refs.

Burks, Barry L. (Oak Ridge Natl Lab, TN, USA); de Saussure, Gerard; Weisbin, Charles R.; Jones, Judson P.; Hamel, William R. *IEEE Expert* v 2 n 4 Winter 1988 p 18-23, 26-27.

**090856 DETERMINING OBJECT MOTION IN A SEQUENCE OF STEREO IMAGES.** The motion of a three-dimensional object is determined from a sequence of stereo images by extracting three-dimensional features, establishing correspondences between these features, and computing the rigid-motion parameters. Three-dimensional features are extracted from the depth map of a scene. A two-pass relaxation method is developed for matching features extracted from successive depth maps. In each iteration, geometrical relationships between a



feature and its neighbor in one map are compared to those between a candidate in the other map and its neighbors to update the matching probability of the candidate. The comparison of the geometrical relationship is based on the principle of conservation of distance and angle between features during rigid motion. The use of three-dimensional features allows the rotation and translation components of motion to be found separately by via solving linear equations. Experimental results using several sets of real data are presented. 34 refs.

Kim, Yeon C. (Univ of Texas, Austin, TX, USA); Aggarwal, J.K. *IEEE J Rob Autom* v RA-3 n 6 Dec 1987 p 599-614.

**090857 ROBOT VISION TRACKING SYSTEM.** A system designed to test a tracking theory for finding the position of an object in a scene, even when it is entering or exiting, is described. The design of a servo system used to move the camera while tracking the object is proposed. The technique involves the fundamental frequency of the Fourier transform of the vertical and horizontal projections of the image. This technique will work with stationary or moving objects as well as with a stationary or moving camera. The objective is to apply this technique to find the line between the camera and the object, such that the robot arm could follow that line until it encountered the object, and then seize it. This technique may also be useful in performing camera calibration. 10 refs.

Kabuka, Mansur (Univ of Miami, Coral Gables, FL, USA); Desoto, J.; Miranda, J. *IEEE Trans Ind Electron* v 35 n 1 Feb 1988 p 40-51.

**090858 VISION AND NAVIGATION FOR THE CARNEGIE-MELLON NAVLAB.** A distributed architecture articulated around the CODGER (communication database with geometric reasoning) knowledge database is described for a mobile robot system that includes both perception and navigation tools. Results are described for vision and navigation tests using a mobile testbed that integrates perception and navigation capabilities that are based on two types of vision algorithms: color vision for road following, and 3-D vision for obstacle detection and avoidance. The perception modules are integrated into a system that allows the vehicle to drive continuously in an actual outdoor environment. The resulting system is able to navigate continuously on roads while avoiding obstacles. 15 refs.

Thorpe, Charles (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Hebert, Martial H.; Kanade, Takeo; Shafer, Steven A. *IEEE Trans Pattern Anal Mach Intell* v 10 n 3 May 1988 p 362-373.

**ROBOTS, INDUSTRIAL** See Also ARTIFICIAL INTELLIGENCE—Expert Systems; BLAST FURNACE PRACTICE—Robot Applications; COMPOSITE MATERIALS—Fabrication; COMPOSITE STRUCTURES—Manufacture; COMPUTER INTEGRATED MANUFACTURING—Japan; COMPUTER PERIPHERAL EQUIPMENT—Printers; COMPUTERS, MICROCOMPUTER; ELECTRIC MOTORS, INDUCTION—Analysis; INDUSTRIAL PLANTS—Automation; INDUSTRIAL PLANTS—Flexible Manufacturing Systems; LASERS—Industrial Applications; MECHANICAL ENGINEERING; OPTICAL FIBERS—Robotic Assembly; PROCESS CONTROL—Robot Applications; ROBOTICS; TELEPHONE APPARATUS—Coin Operation; WELDING, ELECTRIC—Robot Applications; WELDING, ELECTRIC ARC—Automation; WELDING, ELECTRIC ARC—Personnel Training; WELDING, ELECTRIC ARC—Robot Applications.

**090859 INTERACTIVE PROGRAMMING SYSTEM FOR THE IBM 7545 ROBOT.** Industrial robots may be programmed using teach methods, off-line programming languages or by using interactive robot programming systems. This paper briefly explains each method, describes the advantages of developing interactive robot programming systems, and then describes an interactive robot programming system developed for the IBM 7545 robot. The approach used in the development process, the interactive execution and user options, and a demonstration of the operation of this interactive robot programming system are also presented. (Author abstract) 9 refs.

Jayaraman, Radhakrishnan (ERCI/SIMCO, Roanoke, VA, USA); Deisenroth, Michael P. *Comput Ind Eng* v 12 n 4 1987 p 275-282.

**090860 PRODUCTION AND USE OF INDUSTRIAL ROBOTS.** The program of work of the Economic Commission for Europe (ECE) Working Party on Engineering Industries and Automation in the field of automation since 1982 is reviewed and the studies on the production and use of industrial robots as well as the diffusion of robots, are presented in an updated form. Apart from an introduction, the work contains chapters on the scope of the study; robot definition and classification; main areas of robot application; world-wide diffusion of robots; diffusion of robots in the ECE region; the world robot industry - characteristics, structure and trends; some general technical, economic and social implications relating to the introduction of robots, the approach used in collecting information for the study, and some closing remarks on costs and benefits of the application of robots. Nine annexes provide various statistical information about the distribution of robots as well as a glossary of terms in industrial robotics (ISO) and a classification of industrial robots (ISO). Refs.

Anon. *Prod and Use of Ind Rob* Publ by UN, New York, NY, USA, 1985 173p.

**090861 WHERE ARE THE ROBOTS?** Japan has more robots than any other country in the world; even Europe is ahead of the United States. Robot technology has the potential to be the most human-felt ingredient of the computer age. Why is it, then, that U.S. industry is lagging in installing robots? The answer put forth by the author is that the Japanese are totally committed to manufacturing. Also, they have pursued a national goal of quality in manufactured goods for the past 30 years - the same period during which the United States was losing interest in manufacturing.

Reeve, Ronald C. Jr. *CHEMTECH* v 17 n 2 Feb 1987 p 72-75.

**090862 GEOMETRIC TOOLS FOR THE OFF-LINE PROGRAMMING OF ROBOTS.** Off-line programming of robots has a number of clear advantages over traditional 'teach' methods which require the robot to be taken out of production. However, off-line programming techniques require extensive geometric facilities which are ideally provided by a geometric modeling system. The use of modeling covers the planning of the robot workcell, as well as the detailed planning of the robot operations. Assembly, in particular, requires detailed geometric information concerning geometric features and solid properties. (Author abstract) 9 refs.

Stobart, R.K. (Cambridge Consultants Ltd, Cambridge, Engl). *Robotica* v 5 pt 4 Oct-Dec 1987 p 273-280.

**090863 ADVENT OF THE ANDROID.** A man-like robot or android has been a common idea in science fiction for many decades. To be universally useful, the android must be agile, dextrous and intelligent. The article traces technological achievements of recent time allowing one to commence defining the techniques needed to make such a machine reality. 4 refs.

Duggan, Matthew. *Electron Power* v 33 n 3 Mar 1987 p 199-202.

**090864 SMT ROBOTS - A USER REPORT.** Some requirements for the robotic system for assembly lines are summarized in this report based on the study of small volume aerospace and military electronics companies. Problems associated with the automation of the surface mount assembly operation are investigated and reported. In particular, the bottleneck in the placement of leadless chip carriers (LCCs) onto the screened solder paste on boards to be assembled is outlined.

Sloat, David E. (Honeywell Inc, Everett, WA, USA). *Surf Mount Technol* v 1 n 3 Jun 1987 p 16-20.

**090865 PLAN GENERATION IN ROBOTICS.** We present the state of the art of automatic plan generation,

with emphasis on its application to robotics, as well as some personal perspectives on the topics covered. We begin presenting a panoramic view of the first attempts at plan generation, but as yet, not connected with robotics. A survey was made of the main problems to be met when it is intended to plan for a real executor in a real world. Next, the case of distributed robotic systems and its implications on plan generation is examined. The question of time and its explicit representation is also looked upon. A view of learning and specialized plan generators is given. (Author abstract) 74 refs.

Camarinha-Matos, L.M. (Univ Nova de Lisboa, Monte Caparica, Port). *Robotics* v 3 n 3-4 Sep-Dec 1987 p 291-328.

**090866 DYNAMIKUNTERSUCHUNGEN VON INDUSTRIEROBOTERN MIT DEM PROGRAMMPAKET CAE-IR.** [Studies of Dynamics of Industrial Robots by Means of the Program Packet of CAE-IR]. The program CAE-IR is a result of research cooperation of institutes and universities in Leningrad, Irkutsk and Riga as well as in Berlin and Mittweida within the governmental agreement between USSR and GDR. It allows modeling basic units for robots as variable and simulation of their dynamic performance. Its performance is demonstrated in an example of the positioning control system of the paint spray robot IFA-TR 10. (Edited author abstract) In German. 9 refs.

Heimann, B. (AdW der DDR, Berlin, East Ger); Kulakow, F.M.; Loose, H.; Nollau, R. *Maschinenbautechnik* v 36 n 11 Nov 1987 p 485-489.

**090867 THEORY OF KINEMATIC PARAMETER IDENTIFICATION FOR INDUSTRIAL ROBOTS.** This paper presents the concept of completeness for kinematic identification of robot manipulators. Completeness is defined as the ability to map joint positions into tool positions for all arbitrary manipulators. It is suggested that complete models must contain a certain number of independent parameters. Furthermore it is suggested (and shown by practical examples) that the required number of independent kinematic parameters is easy to determine a-priori. This enables one to check a model for completeness. Although the basic idea behind kinematic identification may have been considered well known, several identification algorithms in the recent literature are incomplete. Two examples are included in this paper. For this reason, this paper presents the topic and includes the conditions for a complete and viable identification algorithm. (Author abstract) 19 refs.

Everett, L.J. (Texas A&M Univ, College Station, TX, USA); Hsu, Tsing-Wong. *J Dyn Syst Meas Control Trans ASME* v 110 n 1 Mar 1988 p 96-100.

**090868 WORKSPACE ANALYSIS OF 4R MANIPULATORS WITH VARIOUS DEGREES OF DEXTERITY.** For 4R manipulators and their various configurations, workspaces with full, partial, and zero dexterity are defined, and a procedure to determine them is developed. As examples, two 4R manipulators are analyzed. Subspaces with 2, 4, 6, and 8 configurations and various degrees of dexterity are found. Several points on the effect of geometrical parameters on the shape and extent of the boundary surfaces, subspaces, and number of configurations are discussed. An index for the evaluation of the degree of accessibility of the workspace of a manipulator is also proposed. (Author abstract) 23 refs.

Rastegar, J. (Manhattan Coll, Riverdale, NY, USA). *J Mech Transm Autom Des* v 110 n 1 Mar 1988 p 42-47.

**090869 KINEMATICS AND INVERSE KINEMATICS OF A PARALLEL-ACTUATED ROBOT.** This paper presents a theoretical investigation into a different type of robot manipulator, the parallel topology robot, where all the joints are effectively in parallel. Basic kinematic equations are derived. Geometric constraints



and the working volume are analysed. The inverse kinematic problem, which is useful for control purposes, is presented. (Author abstract) 5 refs.

Ali, A.M. (Jordan Univ of Science & Technology, Irbid, Jordan); Hmaid, Y. *Modell Simul Control B* v 14 n 1 1988 p 53-64.

**090870 'SNEAKY SNAKE' REACHES THE PARTS OTHER VEHICLES CANNOT.** The University of Florida and Odetics Inc are collaborating on a programme sponsored by the US Department of Energy to develop and deploy an advanced semi-autonomous robotic system for use in nuclear power plants. The 'Articulated Transporter/Manipulator System' (ATMS) will ultimately be used for surveillance, inspection, maintenance and even emergency tasks. The new multi-segmented, semi-autonomous transporter will be able to negotiate complex, obstructed strewn environments not reachable by legged, wheeled or tracked vehicles.

Anon. *Nucl Eng Int* v 33 n 405 Apr 1988 p 35-36.

**090871. ROBOTICS MACHINING SECTION BASED ON TWO PUMA-560 FA ROBOTS.** For processing of components of the body-of-revolution type the 'Elektrosila' Leningrad-Pskov Electric Equipment Combine has developed, fabricated, and introduced the 'Val-2' ('Shaft-2') robotics section (IS), based on two Puma 560-FA electromechanical robots produced by the Nokia Company, Finland. The section is intended for cutting of ends and centering of workpieces, lathework, trimming of ends, application of measurement markers, knurling, and packing of parts in containers.

Gruzintsev, R.M.; Danilov, E.G.; Levin, V.D.; Farbman, A.G. *Sov Electr Eng* v 58 n 10 1987 p 110-111.

**090872 ON THE ELIMINATION OF BRANCHING IN THE SYNTHESIS OF SPATIAL SINGLE-LOOP MECHANISMS WITH LOWER PAIRS.** A single-loop spatial mechanism kinematically becomes an open robot, if we separate the grounded joint of the input link which may then be considered as the end effector of the robot. Any position of the end-effector within the workspace of such an open robot can be reached via a number of different configurations of the links. These configurations are called 'branches' of the open robot for that particular position of the end effector. If the open robot is now stretched to a limiting position by a force exerted on the end effector, all the possible branches of the mechanism approach each other. When they become coincident, they form the 'limiting configuration'. Any two related branches are at opposite sides of the limiting configuration. From the relationship between the links in the limiting configuration and in related branches, conditions for avoidance of branching of the original closed-loop mechanism can be obtained. (Edited author abstract) 13 refs.

Sandor, George N. (Univ of Florida, Gainesville, FL, USA); Xu, Yongxian; Weng, Tzu-Chen. *Robotica* v 6 pt 2 Apr-Jun 1988 p 149-154.

**090873 BEITRAG ZUR KINEMATIK STARRER SYSTEME, INSBESONDERE UEBER DIE WINDUNG DER BAHNEN DER SYSTEMPUNKTE.** [Contribution to the Kinematics of Rigid Systems, Particularly Concerning the Turning of the System Point Trajectories]. The properties of torsion for the points in trajectory by space movement advance constructively and also are given the determination of the curvature axis and the centre of the osculating sphere in this point. (Author abstract). 4 Refs. In German.

Dizioglu, Bekir (Technische Univ Braunschweig, Braunschweig, West Ger). *Robotersysteme* v 4 n 2 1988 p 116-118.

**090874 INTRODUCTION A L'EMPLOI DES QUATERNIONS POUR LE CALCUL DE L'INVERSION DES COORDONNEES DES ROBOTS.** [Use of Quaternion Matrices to Solve Inverse Kinematics of Robots: an Introduction]. This paper introduces the quaternion algebra in the inverse coordinate transformation problem.

A five-degrees-of-freedom revolute robot is presented as an illustrative example. (Edited author abstract) 12 refs. In French.

Vibet, C. (Univ Paris XII-IUT, Evry, Fr). *RFM Rev Fr Mec* n 4 1987, Cycle de Conf d'Etude et d'Inf de la Soc Fr des Mec sur les Rob Ind, Mar 25-26 1987 p 237-242.

**090875 PROCEEDINGS OF '85 INTERNATIONAL CONFERENCE ON ADVANCED ROBOTICS.** The proceedings contains 72 papers. The papers are grouped under the following session headings: trends in robotic research; intelligence; sensory systems; manipulation; teleoperation; application in nuclear plant; locomotion; integrated system' large-scale national R&D project 'advanced robot technology'; and overviews on advanced robotics. Some of the specific topics discussed are: collision avoidance; a robot slide sense control system; computing of robot's workspace; a computer aided manipulation system for multijoint inspection robot; kinematics of six-legged vehicle on irregular terrain; speech conversion system of the musician robot; and the mechanics of mobile robots. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11307 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Robotics Soc of Japan, Jpn). *Proc of '85 Int Conf on Adv Rob, Tokyo, Jpn, Sep 9-10 1985* Publ by Japan Industrial Robot Assoc, Tokyo, Jpn, 1985. Available from IFS Publ Ltd, Engl 603p.

**090876 PROCEEDINGS - 16TH INTERNATIONAL SYMPOSIUM ON INDUSTRIAL ROBOTS; 8TH INTERNATIONAL CONFERENCE ON INDUSTRIAL ROBOT TECHNOLOGY.** Proceedings incorporates 108 papers that are grouped according to the following subjects: actuators, compliant systems, end effectors, control of multirobot systems, kinematics, dynamics, advanced control strategies, sensor-based control, integrated production systems, sensor systems, nontraditional applications, industrial applications, programming, simulation, performance testing, monitoring reliability, economic and strategic considerations, robotics education, and human factors. Topics considered include: workplaces, decoupled control, flexible manufacturing systems, industrial management and economics, robot manipulators, fire protection and safety hazards, productivity enhancement, cost effectiveness, automobile manufacture, welding, plasma-arc cutting, water jet cutting, computer software and hardware, feedback and adaptive control, programming, robotic assembly, tactile sensors, computer architecture, production planning, robotic arms and grippers. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11640 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Van Brussel, H. (Ed.) (Katholieke Univ Leuven, Belg). *Proc-16th Int Symp on Ind Rob, 8th Int Conf on Ind Rob Technol, Brussels, Belg, Sep 30-Oct 2 1986* Publ by IFS Publ Ltd, Kempston, Engl, & Springer-Verlag, Heidelberg, West Ger & New York, NY, USA, 1986 1194p.

## Accidents

**090877 HAZARD IDENTIFICATION AND SAFETY ASSESSMENT OF HUMAN-ROBOT SYSTEMS.** The purpose of this paper is to develop a systematic methodology for safety improvements of human-robot systems at present and for the future. Various types of robots are briefly summarized together with safety aspects specific to robots. Historical reviews are given of typical industrial incidents caused by robots. The paper outlines safety assessment procedures which are consistent with the probabilistic risk assessment procedures typically used for systems in the nuclear, chemical, and aerospace industries. Character analyses and hazard causation mechanisms are analyzed for a general human-machine system. The authors consider the human-robot system, and enumerates possible hazards. 7 refs.

Kumamoto, Hiromitsu (Kyoto Univ, Kyoto, Jpn); Sato, Yoshinobu; Inoue, Koichi. *Eng Risk and Hazard Assessment* v 1 p 61-80.

**090878 SAFETY OF CNC AND ROBOT TECHNOLOGY.** The incidence of robot and CNC related accidents has not been considered a significant occupational safety issue. It is suggested that this is partly due to a process of denial arising from the belief that accidents involving such machines cannot occur except in cases of gross negligence. It is argued that control processes founded on advances in information technology redistribute the risk of injury rather than eliminate that risk. This is likely to lead to the replacement of 'traditional' accidents, about which we know quite a lot, with information technology accidents, about which we know relatively little. (Author abstract). 23 Refs.

Sheehy, N.P. (Univ of Leeds, Leeds, Engl); Chapman, A.J. *J Occup Accid* v 10 n 1 Jun 1988 p 21-28.

## Analysis

**090879 ROBOT-MOTION PATH-PLANNING ALGORITHM WITH DYNAMIC PROPERTIES OF ACTUATOR MODELS.** A general planning algorithm for robot paths based on the intrinsic motions of a dynamic model of the final unit that pass it through the initial and target positions is validated and described. The boundary-value problem is solved by differentiation with respect to a parameter, and the values for the parameters of the final-unit dynamic model. (Author abstract) 10 refs.

Tyves, L.I.; Markevich, S.V. *Sov Mach Sci* n 4 1987 p 23-29.

**090880 CLOSED-LOOP DYNAMICS ANALYSIS BY APPEL'S METHOD.** Dynamics analysis of industrial robots with a constrained (closed-loop) dynamic system is often needed under operating conditions such as insertion, deburring, etc. The authors have been developing dynamic simulation programs for an open-loop dynamic system with arbitrary construction of robots. Appel's method is used for the description of the equation of motion in these programs. Since industrial robots are often used under various constraint conditions, it is preferable to simulate robot motions under various operating conditions if the direction and degree of freedom of the constraint can be selected arbitrarily in the programs. In this respect, this paper first refers to an analytical method of closed-loop dynamics by Appel's method using Lagrange multipliers, which can be easily extended from analysis of open-loop dynamics to that of closed-loop dynamics. Then numerical analysis of the robot motion under constrained condition is carried out and the validity of this method is shown. (Author abstract). 9 Refs.

Masuda, Takahiro (Mitsubishi Electric Corp, Amagasaki, Jpn); Futakawa, Akemi; Arimoto, Suguru; Miyazaki, Fumio. *Adv Rob* v 2 n 3 1987 p 227-240.

## Anthropomorphic

**090881 ROBOT MUSICIAN 'WABOT-2' (WASEDA ROBOT-2).** The WABOT-2 is an anthropomorphic robot playing keyboard instruments, developed at Waseda University. The WABOT-2 is equipped with hands tapping softly on keys, with legs handling bass keys and expression pedal, with eyes reading a score, and with a mouth and ears to converse with humans. Based on Wabot-2, WASUBOT has been developed by Sumitomo Electric Industries Ltd. Its artistic skill has been demonstrated in performing music at the Japanese Government Pavilion in Expo '85. The paper summarizes the WABOT-2's motion, visual and vocal subsystems as well as its supervisory system and singing voice-tracking subsystem. (Edited author abstract)

Kato, Ichiro (Waseda Univ, Jpn); Ohteru, Sadamu; Shirai, Katsuhiko; Narita, Seinosuke; Sugano, Shigeki; Matsushima, Toshiaki; Kobayashi, Tetsunori; Fujisawa, Eizo. *Robotics* v 3 n 2 Jun 1987 p 143-155.



**090882 RAUMLICHES KOPPELGETRIEBE FÜR ROBOTERHANDGELENK.** [Three-Dimensional Coupling Mechanism for a Robot Wrist]. This article presents a three-dimensional mechanism for robot wrists with a flexibility similar to a trunk and which needs only two drives. One point of the driven member is conducted on a screen-like surface. (Edited author abstract). 4 Refs. In German.

Muglitz, J. (Technische Univ Karl-Marx-Stadt, East Ger). *Maschinenbautechnik* v 37 n 7 1988 p 296-298.

**090883 STUDY OF THE RANGE OF MOTION OF HUMAN FINGERS WITH APPLICATION TO ANTHROPOMORPHIC DESIGNS.** The multifingered human hand serves as a model for anthropomorphic manipulators and prosthetic devices. In order to better guide the design of these devices, a study of the range of motion of human fingers is presented. The role of tendons in the actions of human fingers is modeled and results of experimental studies on the range of motion of fingers in normal humans are presented. Further study of disabled hands illustrates constraints imposed by deficient tendon mechanisms. The basic investigations of normal and disabled hands guide the design of tendon-based actuators for mechanized fingers. The design of a prototype finger actuated by a shape-memory alloy material serving as a tendon is discussed. 18 refs.

Becker, Jeff C. (Advanced Systems Technology Inc, Englewood, NJ, USA); Thakor, Nitish V. *IEEE Trans Biomed Eng* v 35 n 2 Feb 1988 p 110-117.

**Applications** See Also AUTOMOBILE MANUFACTURE—Automation; AUTOMOBILE MANUFACTURE—Computer Aided Manufacturing; AUTOMOBILE MANUFACTURE—Japan; AUTOMOBILE MANUFACTURE—Painting; AUTOMOBILE MANUFACTURE—Robot Applications; CHEMICAL ANALYSIS—Robot Applications; CHROMATOGRAPHIC ANALYSIS—Liquid; COAL MINES AND MINING—Automation; COMPUTER PERIPHERAL EQUIPMENT—Keyboards; CONTROL SYSTEMS—Design; DATA STORAGE UNITS—Robotic Assembly; DIE CASTING—Automation; DRUG PRODUCTION—Manufacture; ELECTRIC CONTACTORS—Computer Aided Manufacturing; ELECTRIC MOTORS—Accessories; ELECTRIC RECTIFIERS, SOLID STATE—Robotic Assembly; FOUNDRY PRACTICE—Cleaning; HOSE—Assembly; INDUSTRIAL PLANTS—Automation; INDUSTRIAL PLANTS—Flexible Manufacturing Systems; INDUSTRIAL PLANTS—Robot Applications; LATHES—Automation; LAWN MOWERS—Productivity; MACHINE TOOLS—Optimization; METAL FINISHING—Deburring; NUCLEAR POWER PLANTS—Robot Applications; NUCLEAR REACTORS—Repair; OPTICAL FIBERS—Connectors; PAINT SPRAYING; PAINT SPRAYING—Automation; ROBOTIC ASSEMBLY; ROBOTICS—Israel; TEXTILE INDUSTRY—Robot Applications; WELDING—Automation; WELDING, ELECTRIC ARC—Robot Applications.

**090884 ROBOT COMPLEX FOR MECHANICAL TREATMENT OF EXCAVATOR PARTS.** One of the main trends in automation and mechanization of production is the creation of robot complexes (RC) based on industrial robots (IR). RC for mechanical treatment represent a processing system based on one or several metal cutting stands served by one or several IR. The authors consider the organization of a robot complex using as example the creation of RC for manufacturing fastening parts for EKG-8, EKG-10, and EKG-12 excavators. According to the existing processing scheme a bar forging with a head serves as blank. Blank transport into the treatment zone, clamping in the cartridge, startup of the stand, transport of the part to the finished production container are all carried out manually.

Pyrkov, N.P. *Sov Energy Technol* n 1 1987 p 59-63.

**090885 CONTRIBUTION TO SOLVING DYNAMIC ROBOT CONTROL IN A MACHINING PROCESS.** In this paper, the possibility for dynamic control of robots in a machining process is presented. On the basis of closed chain theory, the nominal dynamics are calculated and the dynamic control ensuring desired reaction force during the machining process is synthesized. The numerical example of grinding process with a six degree-of-freedom manipulator is presented. (Author abstract) 6 refs.

Vukobratovic, M. ('Mihailo Pupin' Inst, Belgrade, Yu-

gos); Vujic, D. *Mech Mach Theory* v 22 n 5 1987 p 421-429.

**090886 ASSEMBLY WITH ROBOTS.** The general and specific implications of performing an assembly task robotically are discussed, the majority of which are not specific to any one sector of the manufacturing industry, nor to any particular size of product being manufactured. First, the purpose of the use of robots is discussed, their availability, purchase and viability, and the robot market is assessed. The choice of robot configuration, capability, programming method, specifications, methods for calculating the cycle time, and assessing workload are discussed. Descriptions of grippers, assembly techniques, product compatibility and process design for assembly, workstations, material feeders, sensing and vision are presented. Problems of the interaction between man and machine, safety procedures and devices are discussed. Methods of evaluation of a robot system, economics of alternative systems; economics of robots and grippers, and the outlook for the future is considered. An appendix lists the assembly robots available in the USA and the UK. 27 refs.

Owen, Tony. *Assembly with Rob*. Publ by Prentice-Hall, Englewood Cliffs, NJ, USA, 1985 206p.

**090887 ROBOTICS COMPLEX FOR STAMPING OF CABLE TERMINALS.** The robotics complex (RC) consists of the following: the model MP-98 robot, the cycle control system (type ETsPU-6030), eccentric press, two-position die, a device for piece-by-piece loading of blanks into the die, the lubrication mechanism, the device for removing terminals to the container, and the enclosure. The complex provides for fabrication of cable terminals in six sizes with minimum readjustment from one size to another.

Ginzburg, Yu.M. *Sov Electr Eng* v 57 n 7 1986 p 108-109.

**090888 PRAKTISCHER EINSATZ SENSOR-GEFUEHRTER SCHWEISSROBOTS.** [Application of Sensor-Guided Welding Robots]. Automation of manufacturing processes by means of industrial robots has been gaining in importance because this technology permits higher productivity at increased flexibility. Substantial growth rates are recorded in particular for industrial robots for spot and seam welding. In spite of this situation, the latest Frost & Sullivan study about the state of welding technology in Europe witnesses that welding by means of industrial robots is handicapped by a lack of appropriate sensors. In the 1986 annual survey of welding and flame cutting, the essential weaknesses of sensor use are quoted to be lack of availability, excessive investment costs, frequently insufficient flexibility and lack of interface standardization. These statements were confirmed by own experience in the application of welding sensors in the German automotive industry. This report is intended as a study of the requirements to be considered as representative for users, of the range of sensor principles available in industrial configuration, and of how the problems handicapping sensor use should be solved from the viewpoint of users. (Edited author abstract) 10 refs. In German.

Rogos, J. *Werkstatt Betr* v 120 n 9 Sep 1987 p 727-732.

**090889 INDUSTRIEROBOTER UND SICHERHEIT BERICHT VON DER VDI-FACHTAGUNG AM 12. MAERZ 1987, BAD SODEN/TS.** [Industrial Robots and Safety Report on the VDI Conference at Bad Soden on March 12, 1987]. 'Safety first' was the central motto of a forum held by Verein Deutscher Ingenieure (VDI). Within the overall complex of 'industrial robots in safety concepts for automatic manufacturing facilities', representatives of big and small users gave their views about reasonable procedures for planning facilities with industrial robots. Reports from practical application and transfer of experience were in the foreground for conceiving this forum which was primarily intended for managers and experts from the sector of planning, production, safety and maintenance. Implementation of existing accident prevention requirements and the results of the VDI committee on working safety of assembly and handling equipment were the central points of the subjects dis-

cussed. (Author abstract) In German.

Fluehr, Peter. *Werkstatt Betr* v 120 n 9 Sep 1987 p 733-734.

**090890 DER MESSROBOTER ZUR STEUERUNG DER FLEXIBLEN FERTIGUNG.** [Process Control Robot for Flexible Manufacture]. An automated, flexible manufacturing system requires direct acquisition and feedback of the measurement data for process monitoring. For this purpose, what are called process control robots (PCRs) have been developed and their features and control system are described. The application in industrial practice is demonstrated by way of an example of an American printing press manufacturer. (Author abstract) In German.

Jenzer, P. *F&M Feinwerktech Messtech* v 95 n 6 Sep-Oct 1987 p S154-S156, S158.

**090891 AUTOMATION OF CORRECTIVE OPERATIONS ON COMPLEX STRUCTURAL ELEMENTS WITH INDUSTRIAL ROBOTS.** Mechanical correction is the selective partial deformation of structural elements in usually small steps. Multidimensional corrective operations that were hitherto performed manually were experimentally automated with the aid of an industrial robot and a workpiece-specific experimental setup. The corrective steps are repeated until the specified dimension is reached. The required number of steps was minimized by implementing an adaptive system with variable step-width control. The experimental results demonstrate the superior performance of the automated process. (Author abstract) 9 refs.

Dalluhn, H. (Siemens AG, Munich, West Ger). *Siemens Forsch Entwicklungsber* v 16 n 6 1987 p 223-228.

**090892 ROBOT FOR FULLY AUTOMATED PRODUCTION OF A GEAR HOUSING WITH INSERTS.** A robot is described which operates in conjunction with an injection molding machine to achieve fully automated production of a plastics component designed for high service stresses. This component - a gear housing for a hammer drill - is fitted with six metal parts which are placed in the two mold halves by the robot. (Author abstract)

Meyer, D. *IPE Int Ind Prod Eng* v 11 n 3 Oct 1987 p 118, 120-121.

**090893 INDUSTRIEROBOTER MIT BREITEM ANWENDUNGSSPEKTRUM.** [Industrial Robots for a Wide Range of Applications]. Industrial robots as well as assembly and handling technologies were rather under-represented at this year's EMO in Milan if the significance of these technologies in the present environment of industrial automation is taken as a standard. Interlinked handling systems, in particular in conjunction with forming machines or with flexible manufacturing systems, were to be seen in rare instances only or even not at all. (Author abstract) In German. 2 refs.

Muecke, Konrad. *Werkstatt Betr* v 120 n 12 Dec 1987 p 1011-1015.

**090894 USING ROBOTS IN PREPARATORY PRODUCTION OPERATIONS.** Problems pertaining to conversion of preparatory stamping operations to utilization of robots are considered; models PRP-5 and MP-9S robots form the basis for the complexes. The most characteristic robotics-complex arrangements are cited. Operation of lines based on industrial robots is described. Data are given on introduction of robots at various plants of four industry. (Author abstract)

Petrov, V.V.; Nogin, V.S. *Sov Electr Eng* v 58 n 7 1987 p 26-29.



**090895 TYPICAL ROBOTIC MANUFACTURING SYSTEMS FOR THE MANUFACTURE OF THERMOSETTING PLASTIC ELEMENTS IN THE ELECTRICAL INDUSTRY.** In the Institute for Development of Manufacturing Processes in the Electrical Industry (VPIelektro) two types of robotic manufacturing systems for thermosetting plastic molding (RMSTPM) were developed: with single- and double-press operation on the basis of stationary robots. In 1985 a department consisting of six RMSTPM of the first type was put into operation at the LPEO 'Elektrosila' and at present at the Leningrad 'Elektropult' Factory three RMSTPM of the second type are being implemented. (Author abstract) 5 refs.

Saprykin, I.A.; Nogin, V.S.; Galenko, V.G.; Onichkin, Yu.E.; Rastorguev, O.F.; Stepanova, V.G.; Khalimova, E.N. *Sov Electr Eng* v 58 n 9 1987 p 105-106.

**090896 TURNKEY PROJECT WELDS CHASSIS SIDE FRAMES.** A flexible welding workcell at John Deere and Co.'s Dubuque construction equipment plant produces four different side frame chassis components for backhoe loaders. The author describes the flexible welding workcell.

Alderson, Craig E. (Genesis Systems Group Ltd, Davenport, IA, USA). *Rob World* v 5 n 8 Aug 1987 p 19-20.

**090897 CLEAN ROOM PRODUCES DISK DRIVE MEMORIES.** Speed, reliability and increased productivity are important factors in the automated assembly of component hard disk drives in a clean room environment. The author describes the importance of clean rooms in the production of disk drive memories and discusses a robotic assembly system.

Anon. *Rob World* v 5 n 8 Aug 1987 p 22-23.

**090898 SMALL PLANT AUTOMATES ONE STEP AT A TIME.** A&M Ludwig, a small manufacturer, has installed a Mitsubishi robot for the tedious task of loading a rotary transfer machine. The author describes the robot and its operation.

Anon. *Rob World* v 5 n 8 Aug 1987 p 24-25.

**090899 FLEXIBLE WORKCELL INSPECTS PARTS.** Full spectrum machine vision teams with software-based motion control in an inspection workcell which upgrades quality verification and achieves productivity requirements. The authors describe how motion control combines with machine vision to optimize flexibility.

Yoder, Stanley (Shaum Manufacturing Inc, Elkhart, IN, USA); Landa, Michelle. *Rob World* v 5 n 8 Aug 1987 p 38-40.

**090900 SENSORGESTUETZTE PROGRAMMIERUNG UND STEUERUNG VON INDUSTRIEROBOTERN.** [Sensor Based Shape Scanning and Trajectory Planning by Industrial Robots]. An important application of sensor-equipped IR is the automatic scanning of a priori unknown contours and shapes of workpieces. During the sensor-based scanning different manufacturing operations requiring moderate path velocities (< 100 mm/s) can be performed simultaneously. Typical applications are deburring or seam welding. In this paper a modularly structured system of algorithms both for sensor based contour tracking and automatic generation of fast and accurate reference trajectories (IR programs) will be introduced. Practical experiences concerning the coupling of optical and tactile sensors with an IR-control hardware are reported on. (Edited author abstract) 16 refs. In German.

Kuntze, H.-B.; Jacobasch, A.; Franke, H.; Moser, M.; Salaba, M.; Becker, P.-J. *Robotersysteme* v 4 n 1 1988 p 43-52.

**090901 ROBOTS ANSWER CHALLENGE AT NORTHERN TELECOM FACTORY.** Offshore competition left the management of the Northern Telecom plant in London, Ontario, with two alternatives: reduce product cost substantially or relocate the plant to an area with

lower labor costs. Management and labor agreed to develop a new telephone product, designed for automated manufacturing. The design changes were dramatic. The old product had 380 components (mostly mechanical), 44 fasteners, and 24 free leads. The new telephone uses 120 components (mostly electronic), seven fasteners, and only two free leads. Using existing resources and facilities, Northern initially made its 'new' phone by hand to meet introduction schedules. Automation for circuit board assembly was limited to stand-alone equipment such as radial and axial insertion machines by Universal Instruments Corp., Binghamton, N.Y. These islands of automation provided the initial step for Northern's automation efforts. Seeking product flexibility, Northern Telecom decided to integrate existing equipment in its circuit board population department with robotics for odd-form component insertion and machine loading.

Woerner, Klaus (Automation Tooling Systems Inc, Kitchener, Ont, Can). *Rob World* v 6 n 1 Jan 1988 p 15-16, 19.

**090902 EXPERIENCE IN INTRODUCING THE PUMA-560 FA INDUSTRIAL ROBOT INTO THE PRODUCTION OF PLASTICS.** Experience in the joint efforts of specialists from the Leningrad-Pskov Electric Equipment Combine 'Elektrosila' and the Finnish Nokia Company in development and introduction of a robotics production complex (RPC) for removal of seams from plastic components, realized on the basis of the Puma-560 FA industrial robot is generalized. (Author abstract)

Gruzintsev, R.M.; Danilov, E.G.; Levin, V.D.; Fomin, A.B. *Sov Electr Eng* v 58 n 10 1987 p 64-66.

**090903 ROBOTIQUE ET DEMANTELEMENT.** [Robotics and Dismantlement]. The dismantling of nuclear power plants which are not in use is going to develop in the coming years and will have to use the latest technologies in robotics. In particular, C.A.T. technologies will be indispensable to solve the safety and productivity problems which will arise. (Edited author abstract) In French.

Parent, Michel (CYBERG, Fr). *Rev Energ* v 38 n 395 Sep 1987 p 439-440.

**090904 3-D SYSTEM LOCATES CARS FOR ROBOTIC SEALING.** Inaccuracies cannot be tolerated in automobile seam sealing because of the expensive material used. Author describes a 3-D vision system that locates the car position and adjusts the robot's path to that position.

Baker, Paul D. (Robotic Vision Systems Inc, Hauppauge, NY, USA). *Rob World* v 6 n 3 Mar 1988 p 28-29.

**090905 THREE-ROBOT WORKCELL INSTALLS CONTACTS INTO PLASTIC BLOCKS.** Author describes a robotic workcell designed and developed by Vanguard Automation Inc. which installs contacts into plastic connector blocks using 3 Seiko robots working in conjunction with a rotary index table. The system is capable of installing contacts into five different styles of connectors varying from 28 to 82 contacts per connector.

Anon. *Rob World* v 6 n 3 Mar 1988 p 34.

**090906 GLUE DISPENSING STATIONS REDUCE LABOR NEEDS BY HALF.** Author describes a robotic system which automatically applies water deflectors to car door panels. The benefits of this robotic system are the material savings and increased productivity.

Anon. *Rob World* v 6 n 3 Mar 1988 p 37.

**090907 ROBOTS IN THE SHEARING SHED: AUTOMATED SHEARING OF SHEEP USING ROBOTS.** The Australian wool industry has sponsored a long-term program to find alternative ways of harvesting wool from sheep. Research into automated shearing started in 1975 and by 1977 automatic shearing of wool from sheep had been demonstrated. In that year, the University of Western Australia commenced a research program which has led to the development of specialized

sheep-shearing robots. Practically all of the technical problems have been successfully solved and present research work is directed towards small-scale demonstrations of automated shearing to promote acceptance of the idea. The Australian Wool Corporation, which is responsible for administering the research funding, has not yet decided to proceed with commercial development. (Edited author abstract).

Trevelyan, James P. (Univ of Western Australia, Nedlands, Aust). *Adv Rob* v 2 n 1 1987 p 3-8.

**090908 DEVILBISS UNVEILS NEW ROBOTIC MACHINE FOR CAR INDUSTRY.** New high standards of quality paint finishing of motor cars are being achieved by an automatic system currently being unveiled by the DeVilbiss company to potential customers from all over Europe and America as well as the UK. DeVilbiss E, as the robotic machine is called, is a long stroke, four-axis unit designed specifically for car body external surface top and side coating - a market deliberately avoided by DeVilbiss to date. This article presents a design overview of the robotic machine.

Anon. *Finishing* v 12 n 7 Jul 1988 p 38, 43.

**090909 VEHICULES DES MILIEUX HOSTILES ET ROBOTS DE SERVICE.** [Vehicles for Hostile Environments and Service Robots]. The article is concerned with the research and development activities of the French Atomic Energy Commission (C.E.A.) during the last few years. The vehicles already in operation or still under study are described, such as: VIRGULE, a wheeled vehicle of great mobility; CENTAURE and OSCAR, smaller tracked vehicles; VERI, devised from a commercial vehicle; MERITE, MIR, and MAM, devised for the inspection of central parts of powerplants; PLA (Autonomous free pick-up) for collecting nodules in the bottom of oceans, autonomous cleaners for the tunnels, platforms and cars of underground railroads. (Edited author abstract) In French.

Marchal, P. (CEN, Fontenay-aux-Roses, Fr); Villedieu, E. *RFM Rev Fr Mec* n 4 1987, Cycle de Conf d'Etude et d'Inf de la Soc Fr des Mec sur les Rob Ind, Mar 25-26 1987 p 307-318.

**Arms** See Also PROSTHETICS—Artificial Limbs; ROBOTIC ASSEMBLY; ROBOTICS—Control Systems; WELDING—Robot Applications.

**090910 ROBOT MOTION AND TASK PLANNING: SIMULATION AND PROGRAMMING OF A ROBOT ARM.** A robot simulation system has been developed to assist in robot task planning and control data programming. The system allows simulation of the robot manipulator on the CRT by taking into consideration the kinematics and dynamics of the robot arm. The architecture of the robot simulation system is presented. Description of robot positional kinematics is given by the use of geometrical model and its extension to homogeneous transformation. Several simulated robot arm positions are shown to illustrate the kinematic model. (Author abstract) 23 refs.

Tabani, Iqbal (George Washington Univ, Washington, DC, USA); Montaser, Akbar. *Anal Instrum (New York)* v 16 n 3 Sep 1987 p 385-398.

**090911 MODELING AND CONTROL CHARACTERISTICS FOR A TWO-DEGREES-OF-FREEDOM COUPLING SYSTEM OF FLEXIBLE ROBOTIC ARMS.** The dynamic characteristics of flexible robotic arms with two-degrees-of-freedom are modeled with consideration of the coupling between the first and the second arms under the assumption that each arm vibrates only due to the bending moments. In order to suppress vibration in positioning control such basic characteristics of the flexible robotic arms must be employed for the decoupling control. A decoupling control method is proposed by the feedback control method to compensate for the coupling effects between the flexible robotic arms. Experiments are then demonstrated to show the effective-



ness of the proposed method. Finally, a method of collision control is also shown as one of applications. (Author abstract) 10 refs.

Fukuda, Toshio (Science Univ of Tokyo, Tokyo, Jpn); Arakawa, Atsushi. *JSME Int J* v 30 n 267 Sep 1987 p 1458-1464.

**090912 MICROCOMPUTER-BASED CONTROL OF A ROBOTIC ARM WITH ACOUSTIC SENSOR.** The integration of an ultrasonic sensor into a simple, playback-type robotic arm is described. The implemented system is capable of searching and grasping objects within its operating range. The system has proved to be a useful tool for introducing students to the area of robotics. The work also confirms the simplicity of using acoustic sensor in low resolution applications. (Author abstract) 5 refs.

Lam, F.K. (Univ of Hong Kong, Hong Kong). *Int J Electr Eng Educ* v 24 n 4 Oct 1987 p 347-356.

**090913 DYNAMIC PATH PLANNING FOR A PLANAR ARTICULATED ROBOT ARM MOVING AMIDST UNKNOWN OBSTACLES.** This work is concerned with planning collision-free paths for a robot arm moving in an environment filled with unknown obstacles, where any point of the robot body is subject to collision. To compensate for the uncertainty, the system is provided with sensory feedback information about its immediate surroundings. In such a setting, which presents significant practical and theoretical interest, human intuition is of little help, and designing algorithms with proven convergence thus becomes important. We show that, given the target position, local feedback information is sufficient to guarantee reaching a global objective (the target position) and present a nonheuristic algorithm which generates reasonable collision-free paths. In this approach, the path is being planned continuously (dynamically), based on the arm's current position and on the sensory feedback. A case of a planar arm with two revolute joints is studied. No constraints on the shape of the robot links or the obstacles are imposed. The general idea is to reduce the problem of motion planning to an analysis of simple closed curves on the surface of an appropriate two-dimensional manifold. (Edited author abstract) 28 refs.

Lumelsky, Vladimir J. (Yale Univ, New Haven, CT, USA). *Automatica* v 23 n 5 Sep 1987 p 551-570.

**090914 NUMERICAL SOLUTION OF ROBOT ARM INVERSE KINEMATICS AND DYNAMICS.** A new method of a numerical solution of robot arm inverse kinematics and dynamics for a desired trajectory expressed in the task coordinates is proposed. In this method, a desired acceleration expressed in the task coordinates is obtained by differentiating a given desired trajectory of the top of hand with respect to time. Then the desired acceleration is transformed into the acceleration of each joint using kinematic relations. Numerical solution of the inverse kinematics can be realized by numerical integration of each joint acceleration. The method is verified by a numerical example. The advantages of the method are: (1) Inverse kinematics can be solved for any construction of robot having six degrees of freedom. (2) Not only inverse kinematics but also each joint acceleration forces can be obtained. (Author abstract) 10 refs.

Masuda, Takahiro (Mitsubishi Electric Corp, Amagasaki, Jpn); Hagihara, Shiro. *Adv Rob* v 1 n 1 1986 p 21-31.

**090915 CONTROL OF A FLEXIBLE ROBOT ARM: EXPERIMENTAL AND THEORETICAL RESULTS.** The operation of high precision robots is severely limited by their manipulator dynamic deflection, which persists for a period of time after a move is completed. These unwanted vibrations deteriorate the end effector positional accuracy and reduce significantly the robot arm production rate. A 'rigid and flexible motion controller' is derived to introduce additional damping into the flexible motion. The important issue of control and observation spillover is examined and found to present no significant practical problems. Partial evaluation of this approach is

performed experimentally by testing two controllers, a 'rigid body controller' and a 'rigid and flexible motion controller', on a single joint of a spherical coordinate, laboratory robot arm. The experimental results show a significant reduction in the end effector dynamic deflection; thus partially validating the results of the digital simulation studies. (Edited author abstract) 34 refs.

Chalhoub, N.G. (Univ of Nevada-Reno, Reno, NV, USA); Ulsoy, A.G. *J Dyn Syst Meas Control Trans ASME* v 109 n 4 Dec 1987 p 299-309.

**090916 PARAMETRIC STUDY OF ROBOT ARM VIBRATION BY SIMULATION ANALYSIS.** Most industrial robots are controlled with a semi-closed loop for controlling the movement of a robot arm by detecting the rotational angle and/or angular velocity of a driving motor. A robot system with such a structure is comprehensively analyzed by a computer simulation, considering not only an arm-dynamics system, but also a control system, driving system, and transmission system. Robot arm vibrations, and methods for their reduction are investigated by a parametric study. (Edited author abstract) 8 refs.

Masuda, Takahiro (Mitsubishi Electric Co, Amagasaki, Jpn); Futakawa, Akemi; Koga, Eiji; Inoue, Kenji. *Adv Rob* v 1 n 4 1986 p 325-342.

**090917 DECENTRALIZED CONTROL OF NON-LINEAR ROBOT MANIPULATORS.** Robot manipulators have highly nonlinear dynamics. Therefore the control of multi-link robot arms is a challenging and difficult problem. A nonlinear dynamic model is for an n-axis robot arm and a linearized model is obtained for it. The linearized model is considered as an n-controller large-scale system. The notion of decentralized stabilization has been introduced and applied to the robot arm. Controllers considered are PD, PID and PD plus a feedforward (inverse dynamics). Numerical simulation for decentralized control of a 3-axis PUMA arm are included. (Edited author abstract) 8 refs.

Jamshidi, Mohammad (Univ of New Mexico, Albuquerque, NM, USA); Seraji, Homayoun; Kim, Y.T. *Robotics* v 3 n 3-4 Sep-Dec 1987 p 361-370.

**090918 MOBILIZING A ROBOTIC ARM FOR IC PRODUCTION.** A major drive is currently under way within the semiconductor industry to optimize yields and product performance in a highly competitive market. Many market leaders have been the innovators in robotic automation, and part of their motivation to implement this automation is a result of the general technological progression in IC production and the geometries of the higher complexity devices. The paper describes the use of the V3 mobile robot which is used in the manufacture of integrated circuits which requires extremely clean environments. The V3 led to a reduction of particulates from 20,000 generated per minute to fewer than 10.

Bain, Robert M. (Veeco Integrated Automation Inc, Dallas, TX, USA). *Rob Eng* v 8 n 5 May 1986 p 27, 30-31.

**090919 FREE VIBRATIONS OF A FLEXIBLE ARM ATTACHED TO A COMPLIANT FINITE HUB.** A single-joint flexible robot arm consisting of one link and carrying an end effector is modeled by a continuous, uniform, clamped-free beam having a concentrated mass at the free end and being clamped at the other end to a compliant finite hub. The first six natural frequencies are given for various ratios of physical parameters. The modal shapes are also presented along with their orthogonality relationship. The limiting cases of some of the physical parameters are discussed. (Author abstract) 6 refs.

Mitchell, T.P. (Univ of California, Santa Barbara, CA, USA); Bruch, J.C. Jr. *J Vib Acoust Stress Reliab Des* v 110 n 1 Jan 1988 p 118-120.

**090920 STANDARDIZATION AND UNIFICATION OF GRASPING ARMS FOR INDUSTRIAL ROBOTS.** The principles of standardization of various

types of grasping arms for Industrial Robots (IR) are presented as well as the principles of creating their type and dimension series, unification of graphical and technological solutions for grasping arms and their parts. (Author abstract) 3 refs. In Russian.

Kolpashnikov, S.N.; Makarov, A.B.; Figurin, A.V.; Chelpanov, I.B. *Tr Leningradskii Politekh Inst im M I Kalinina* n 419 1986 p 35-42.

**090921 NEW METHOD FOR PATH PLANNING THE MOTION OF ROBOT ARMS.** A new method for path planning the motion of robot arms is here presented. The desired end effector motion along a prescribed path is found together with the corresponding laws governing the displacement in the joints. This method generalizes the existing methods for planning the robot arm motion subject to a preplanned linear and angular displacement of the end effector. Besides, the motions of both non-redundant and redundant robot arms are uniformly treated by the proposed method, while the constraints of the joint variables and the joint rates are simultaneously and explicitly considered. The results obtained by the implementation of this technique in path planning the motion of industrial robots show that it can be successfully applied in achieving the specific quality characteristics needed in a manipulation task performance. 6 refs.

Krusev, E.; Lilov, L. *Z Angew Math Mech* v 67 n 4 1987 p 99-101.

**090922 OPTIMAL CONTROL OF ELASTIC STRUCTURE SYSTEMS TAKING ACCOUNT OF SPILLOVER (APPLICATION TO A POSITION CONTROL OF ELASTIC ROTATING ARM).** A digital controller for an elastic structure system suffers from spillover of residual modes. In this study, this problem is formulated as a control structure constraint for the elastic system. A sub-optimization technique is applied to the optimal control problem with a control structure constraint and a suboptimal control law is derived taking account of the spillover. This method is very simple, since it needs only a solution of the Riccati equation and matrix operations. This method is applied to the optimal positioning control of a rotating elastic arm. In the numerical calculation, it is indicated that the controller system synthesized by this method remains stable and has good control performance, while the one synthesized by the optimal control theory within the reduced order system becomes unstable. Furthermore, the usefulness of this method is demonstrated in the simulation and control experiment. (Author abstract) In Japanese. 12 refs.

Yoshida, Kazuo; Shimogo, Taro; Inose, Jun. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 497 Jan 1988 p 201-208.

**090923 VIBRATION ABSORPTION CONTROL OF ROBOT ARM BY SOFTWARE SERVOMECHANISM (2ND REPORT).** The prevention of robot arm vibration caused by resonance vibration which arises from the torque variation of a harmonic drive reduction gear has become a problem for fast robot drive. The paper presented a model of robot arm vibration, and demonstrated an effective full speed range vibration absorption control method by applying the theory of the dynamic damper. Vibration energy was adsorbed by the feed forward control of power input. A flexible vibration absorption control system was established by the use of a software servomechanism. (Author abstract) In Japanese. 4 refs.

Sakuta, Hiroshi; Yoshitani, Yutaka; Yonezawa, Takahiro. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 497 Jan 1988 p 217-220.

**090924 CLOSED-LOOP DISPLACEMENT CONTROL OF A ONE-LINK FLEXIBLE ARM WITH A TIP MASS.** A theoretical and experimental study is presented for the displacement control of a one-link flexible arm with an end-point payload. The tip displacement of the arm is sensed by the gap-sensor fixed in space



and controlled by a D.C. motor located at the other end of the arm, where the motor is driven by a feedback signal composed of the tip displacement and velocity. As an example, the problem of shifting the end-point of the arm from its initial position to the desired position by the amount of  $w_d^*$  is considered. Theoretical results are obtained by applying the method of the Laplace transform to the governing equation, and the solution is obtained by the method of numerical Laplace inversion. Experimental results are obtained and compared with the theoretical ones, from which it is shown that both results are in good agreement for a wide range of parameters. (Author abstract) In Japanese. 8 refs.

Tahara, Motoaki; Chonan, Seiji. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 498 Feb 1988 p 363-370.

**090925 HISPANO-SUIZA DEVELOPS ISIS 2 FOR STEAM GENERATOR WORK.** Following the success of the ISIS robotic arm in repairing the Chinon A3 magnox unit, EdF has asked Hispano-Suiza to develop the ISIS concept for use in steam generator channel heads. The robot will have a capacity of 1000N, will be able to position itself to an accuracy of 0.1mm, and will be able to repeat its position to an accuracy of 0.2mm. The complete ISIS 2 system will incorporate: the arm; the arm-holder 'compass'; the hydraulic power generation system; the control system; and the initiating system.

Thirion, Alain (Hispano-Suiza, Bois-Colombes, Fr). *Nucl Eng Int* v 33 n 405 Apr 1988 p 36, 38.

**090926 STUDY ON VIBRATION OF FLEXIBLE ROBOT ARM - USE OF VISCOUS DAMPERS AND STRUCTURAL DAMPING TO CONTROL THE VIBRATION OF A 5-BAR LINKAGE ROBOT.** This paper deals with the vibration and vibration reduction of a closed loop 5-bar linkage robot with flexible arms in order to obtain the rapid positioning of PTP motion. Natural frequencies and natural modes of vibration of the robot are obtained by numerical analysis and checked by experiment. The effect of visous dampers attached on joints on vibration reduction is studied. The optimal damping coefficients of the dampers are calculated and compared with the experimental results. (Edited author abstract) 11 refs.

Yan, Zhong Cheng; Guo, Du Xin; Takagami, Teruo; Takano, Masaharu. *J Fac Eng Univ Tokyo Ser B* v 39 n 2 Sep 1987 p 111-132.

**090927 FUNDAMENTAL RESEARCH ON JOINT CONFIGURATION OF INDUSTRIAL ROBOT.** The main parameters for designing kinematic mechanisms of a robot are degrees of freedom, types of joints, length of links and the presence of offset. Although the length of links and offset can be expressed as quantitative evaluation functions, the combination and sequence of the joint types cannot be quantitatively evaluated. The purpose of this paper is to tabulate the arm and wrist joint configuration of a robot with six degrees of freedom. The authors establish rules to exclude duplicate or ineffective combinations of the joint configurations. The results are utilized to design the kinematic geometry of a robot manipulator. (Edited author abstract) In Japanese 10 refs.

Tamaki, Kinya (Waseda Univ, Tokyo, Jpn); Hasegawa, Yukio; Ishidate, Tatsuji. *Waseda Daigaku Rikogaku Kenkyusho Hokoku* n 119 1987 p 32-41.

**090928 ADMISSIBLE TRAJECTORY DETERMINATION FOR TWO COOPERATING ROBOT ARMS.** The problem of finding an allowable object trajectory for a cooperating two-robot system is investigated. The purpose is to move an object from one point to another by firmly grasping it at two different points using two robotic hands. The major difficulty is caused by the fact that, unless the robots have true six degrees of freedom, the trajectories the object can follow are severely limited and, in general, are difficult to find. The method proposed in the paper is based on reformulating the problem as a nonlinear optimization problem with equality constraints in terms of the joint variables. The optimization problem is then solved numerically on a

computer. The solution automatically gives the corresponding joint variable trajectories as well, thus eliminating the need for solving the inverse kinematic problem. The method has been successfully applied to a real experimental system. (Author abstract) 10 refs.

Lim, Joonhong (Univ of Iowa, Iowa City, IA, USA); Chyung, Dong H. *Robotica* v 6 pt 2 Apr-Jun 1988 p 107-113.

**090929 OPTIMAL CONTROL OF A FLEXIBLE ROBOT ARM.** This work is a computer simulation of the control of a flexible robot arm. The dynamic equations for a single-link flexible robot arm have been derived rigorously. This arm has two degrees of freedom in rotation and one in translation so that the workspace is three-dimensional. The payload is simulated by attaching additional mass to the arm at a specified location. The governing equations of the plant and the measurements are nonlinear. The process of control is divided into two stages: coarse control and fine control. Based on the optimal control theory, a linear observer is constructed for fine control. The numerical results are presented here. (Author abstract). 11 Refs.

Lee, James D. (NBS, Gaithersburg, MD, USA); Wang, Ben-Li. *Comput Struct* v 29 n 3 1988 p 459-467.

**090930 DYNAMIC EQUATIONS FOR A TWO-LINK FLEXIBLE ROBOT ARM.** The dynamic equations for a two-link flexible robot arm have been derived rigorously. The arm is moving in the vertical plane. The payload is simulated by attaching additional masses to the arm at any specific locations. Although the governing equations of the system and the measurements are nonlinear, they are explicitly obtained. The control strategy and the general procedures to construct a linear observer and to formulate a control law are discussed. (Author abstract). 15 Refs.

Lee, James D. (NBS, Gaithersburg, MD, USA); Wang, Ben-Li. *Comput Struct* v 29 n 3 1988 p 469-477.

**090931 DEVELOPMENT OF A SIX-DEGREE-OF-FREEDOM VIBRATORY DEVICE FOR LOCATING OBJECTS.** This paper describes a sensor for determining the location of rigid objects. The device can be mounted on the end of a robot arm to enable it to sense the position and orientation of an object it has picked up from a stack or tray. Since the initial location of the object only has to be approximately known, say to  $\pm 25\text{mm}$  and  $\pm 45^\circ$ , this 'stack-picking' (or 'tray-picking') technique has the advantage of not requiring a rigidly ordered environment. Also, because it still makes use of a certain amount of structure in the environment, it is less demanding on the sensing system than vision-based 'bin-picking' systems and therefore is less costly and more practical, in the short term at least. The device consists of an elastic column built-in at one end to the wrist of the robot and a small rigid platform fixed at the other end of the column. The object whose exact position and orientation are to be determined is held on the platform. Static deflections and frequencies of the natural six-degree-of-freedom vibrations of the system are used, respectively, to determine the position of the centre of mass and orientation of the principal axes of inertia of the part. (Edited author abstract). 9 Refs.

Pham, D.T. (Univ of Birmingham, Birmingham, Engl); Menendez, J. *Int J Mach Tools Manuf* v 28 n 3 1988 p 197-205.

**090932 PATH CONTROL OF A ROBOT ARM USING THE LINEARIZED CONSTRAINT CONTROL METHOD.** In present manufacturing systems path control of robots is performed by the teaching/playback method. But this method is not feasible once the job specification of the robot is altered, since the control is based on repeated trial and error to make the motion satisfy a specific performance. For this problem, there are many approaches to establish the off-line teaching method. In this paper the authors propose path control of robots based on linearized constraint control, which has been brought up by the authors in the past. A simulation

confirms that the method produces a good performance and that it can be regarded directly applicable to production robot systems in today's industry. (Author abstract). 15 Refs.

Oaki, Junji (Toshiba Corp, Kawasaki, Jpn); Mita, Tsutomu. *Adv Rob* v 2 n 3 1987 p 205-225.

**090933 DYNAMIC CONTROL OF A FLEXIBLE ROBOT ARM BY USING EXPERIMENTAL MODAL ANALYSIS.** A new control method for a flexible robot arm has been developed. First, two methods for piecewise linearized representation of the input-output relation between a control command and the resulting end effector motion have been proposed such that they include the effect of arm flexibility through the use of measured transfer function data of the input-output relation. These methods are then used for predicting a vibratory motion of the end effector which is commanded by a trapezoidal velocity pattern to obtain a good correspondence with the actual motion. Finally, based on the results obtained above, a method to compute the control command which realizes a desired smooth motion has been developed as the inverse method of the above motion prediction. Experimental results show considerable suppression of flexibility-induced vibration of the robot arm. (Author abstract). 5 Refs. In Japanese.

Inamura, Toyoshiro; Morimoto, Yoshitaka; Mizoguchi, Kenji. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 501 May 1988 p 1096-1101.

**090934 CONTROL OF MOTION OF A MANIPULATOR ALONG A CONSTRAINT.** Use of force-moment adaptation systems has expanded the capabilities of manipulation robots. This paper considers the problem of maintaining contact with a fixed object (solved on the basis of force information) as the robot grip moves along the contour of the object (i.e., along a constraint). This type of motion may be employed to determine the contour of objects, to follow a weld in automatic welding, or for abrasive cleaning or grinding. The experimental studies employed a two-handed gantry-type robot. The problem under consideration employs two horizontal degrees of mobility of one arm and the two corresponding force components. 11 Refs.

Lenskii, A.V.; Lizunov, A.B.; Mozhzhevelov, S.B.; Formalskii, A.M.; Shneider, A. Yu. *Mech Solids* v 22 n 5 1987 p 37-45.

**090935 THREE-DIMENSIONAL FLEXURAL-JOINT STIFFNESS ANALYSIS OF FLEXIBLE MANIPULATOR ARMS.** This paper presents a complete derivation of the combined flexural-joint stiffness matrix and the elastic deformation field of flexible manipulator arms treated in a three-dimensional fashion. The stiffness properties are derived directly from the differential equations used in the engineering beam theory. The expressions developed here can readily be used in the modeling, control and design of light weight flexible robot manipulators. A two-link arm is used to formulate these expressions and the results can be generalized to n-link manipulators. The stiffness matrix for a robotic link element in 3-D is of the order of  $12 \times 12$ , and for an n-link robotic arm the total elemental and system stiffness matrices will be of the order of  $(12n \times 12n)$  and  $6(n+1) \times 6(n+1)$ , respectively. (Author abstract). 16 Refs.

Meghdari, A. (Univ of New Mexico, Albuquerque, NM, USA); Shahinpoor, M. *Robotica* v 6 n 3 Jul-Sep 1988 p 203-212.

**090936 SIMPLE AND ROBUST NON-LINEAR CONTROLLER FOR A ROBOTIC ARM.** The dynamics of a robotic arm are investigated. A simple noninteractive controller is proposed. It is of two modes, velocity and position modes, and requires constant feedback gains



only. Neither the speed nor the position accuracy is sacrificed by using this controller. Simulation results are presented. (Author abstract). 3 Refs.

Ali, Ala'a Majeed (Jordan Univ of Science & Technology, Irbid, Jordan). *Modell Simul Control B* v 16 n 1 1988 p 55-63.

**090937 KALMAN FILTERING, SMOOTHING, AND RECURSIVE ROBOT ARM FORWARD AND INVERSE DYNAMICS.** The author points out the equivalence between recursive robot dynamics methods and filtering and smoothing techniques from state estimation theory. The key step is to cast the system dynamics and kinematics as a two-point boundary-value problem whose solution leads to filtering and smoothing techniques similar to the equations of Kalman filtering and Bryson-Frazier fixed-time-interval smoothing. The solutions prescribe an inward filtering recursion followed by an outward recursion. The recursive solutions are of the order  $O(N)$ , in the sense that the number of required computations only grows linearly with the number of links,  $N$ . A technique is provided to compute the relative angular accelerations at all of the joints from the applied external joint moments (and vice versa). It also provides an approach to evaluate recursively the composite multilink-system inertia matrix and its inverse. While the focus is not on exploring computational efficiency, some initial results in that direction are obtained by comparing performance with other recursive methods for a planar chain example. The analytical foundation is laid for the potential use of filtering and smoothing techniques in robot dynamics and control. 20 refs.

Rodriguez, Guillermo (JPL, Pasadena, CA, USA). *IEEE J Rob Autom* v RA-3 n 6 Dec 1987 p 624-639.

**090938 CONTROL OF ARTICULATED ROBOT ARM WITH SENSORY FEEDBACK: LASER BEAM TRACKING SYSTEM.** A method for the trajectory tracking control of an articulated robot arm using sensory feedback is presented. First, a general control algorithm for such a problem is presented. To implement sensory feedback effectively, the dynamics of a robot arm is described in the task coordinate system. Then the dynamics of the robot arm in the task coordinate system are linearized using nonlinear feedback. Because the linearization cannot be done completely because of variations and identification errors of the physical parameters of a robot arm, a robust controller is designed so that the effect of parameter variations and errors can be lessened. The control law is shown to be simplified by the use of high-gain feedback. The simplification can make the implementation of the control law very easy. The proposed algorithm is applied to the trajectory-tracking control of an articulated robot arm using a laser beam. The experiments show that the proposed algorithm works well for such a sensory feedback system. 12 refs.

Furuta, Katsuhisa (Tokyo Inst of Technology, Tokyo, Jpn); Kosuge, Kazuhiro; Mukai, Nobuhiko. *IEEE Trans Ind Electron* v 35 n 1 Feb 1988 p 31-39.

**090939 TRACKING CONTROL OF A FLEXIBLE ROBOT LINK.** The formulation of an appropriate hybrid lumped/distributed model of a flexible robot link makes it possible to formulate and study tracking problems without the necessity for a priori approximations in the flexibility model for the link. The use of secondary support beam and active tip control provides perfect tracking with hypothetical exact measurements, and tracking to arbitrary accuracy with use of a variant of the acceleration feedback technique. 17 refs.

Davis, Jon H. (Queen's Univ, Kingston, Ont, Can); Hirschorn, Ronald M. *IEEE Trans Autom Control* v 33 n 3 Mar 1988 p 238-248.

**090940 ANALYSIS OF ROBOT DRIVE TRAIN ERRORS, THEIR STATIC EFFECTS, AND THEIR COMPENSATIONS.** A mathematical model of the kinematic nonlinear drive-train errors, which reduce the absolute static positioning accuracy of robot arms, is presented. This kinematic inaccuracy renders robot ma-

nipulators less effective when programmed offline, though they might be programmed to successfully perform the same task by teach playback schemes. The kinematic drive-train inaccuracy model presented can be used to predict and compensate for these nonlinear effects online, without resorting to sensor-based programming techniques, which are often expensive and may be difficult to implement in an industrial environment. The drive-train error model presented is based on gear backlash, eccentricity, and drive-shaft compliance. That the effects of these nonlinearities severely impact the robot's repeatability and absolute positioning accuracy is mathematically proven. 9 refs.

Ahmad, Shaheen (Purdue Univ, West Lafayette, IN, USA). *IEEE J Rob Autom* v 4 n 2 Apr 1988 p 117-128.

**090941 CRIPPLED MOTION IN ROBOTS.** The feasibility of harnessing redundant degrees of freedom in a robotic arm in order to keep it in service, pending repair, after it has lost mobility in one of its joints, is examined. The concept of critical crippling is introduced, and three familiar robots are investigated as case studies. Guidelines on how one might enhance a manipulator's ability to continue operating productively even with a crippled joint are suggested. 7 refs.

Pradeep, A.K. (Univ of California, Berkeley, CA, USA); Yoder, Paul J.; Mukundan, Rangaswamy; Schilling, Robert J. *IEEE Trans Aerosp Electron Syst* v 24 n 1 Jan 1988 p 2-13.

**090942 MICROCONTROLLER-BASED ARCHITECTURE FOR CONTROL OF A SIX JOINTS ROBOT ARM.** A robot arm controller has been developed with a dual emphasis on performance and flexibility. It includes a general-purpose interface for a host microcomputer, and can be configured with up to two floating-point signal processors. The controller responds to high-level control commands from the host, computes the arm trajectory, and corrects motion errors in real-time using Newton-Euler equations. By relieving the host computer of all computational requirements, this controller design permits one host to control multiple robot arms while maintaining maximum performance. 5 refs.

Kabuka, Mansur R. (Univ of Miami, Coral Gables, FL, USA); Glaskowsky, Peter N.; Miranda, Juan. *IEEE Trans Ind Electron* v 35 n 2 May 1988 p 217-221.

**090943 COOPERATIVE CONTROL OF TWO ARMS IN THE TRANSPORT OF AN INERTIAL LOAD IN ZERO GRAVITY.** In designing a robot control system for dual arm configurations, the control engineer is faced with two challenges: to derive the equations of motion for a given situation, and to meet certain desired control requirements (for instance, minimum energy). The former may involve closed kinematic chains, such as the case when the two arms are grasping a common object. The latter usually involves nonlinear optimization. These issues are considered in the context of transporting an inertial load using two planar three-link arms. A generalized 'reduction transformation' is applied to the dynamics to remove the singularity in the system equations. A suboptimal minimum energy method is presented to reduce a difficult 12-state, six-control nonlinear optimization to two independent, nonconflicting suboptimizations. A simulation example is provided to illustrate the degree of energy reduction possible using the optimal arm torque distribution that was developed. 9 refs.

Carignan, Craig R. (MIT, Cambridge, MA, USA); Akin, David L. *IEEE J Rob Autom* v 4 n 4 Aug 1988 p 414-419.

**090944 INDEPENDENTLY WORKING COMPUTER PERIPHERAL GENERATING ROBOT ARM TRAJECTORIES.** An application specific peripheral processor is described, which independently carries out the task of generating the path for the desired motion of a manipulator. The trajectories are planned by the central computer in form of low order polynomial spline functions, whose parameters are transferred to the peripheral. The position, velocity, and acceleration values are

constantly computed to be fed into the manipulator's control system. The algorithms employed by the peripheral and detailed below exploit various intrinsic properties of polynomials to minimize the arithmetic complexity. This distributed logic approach unburdens the central processor and utilizes application specific inherent parallelism. Although a system's internal data transmission expense is reduced, the concept allows higher path update rates. The functional unit can be frequently applied and is thus easily standardizable. (Edited author abstract) 4 refs.

Halang, Wolfgang A. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA). *Microprocess Microprogram* v 23 n 1-5 Mar 1988 p 129-134.

## Assembly

**090945 REQUIREMENTS ON SCREWS FOR AUTOMATIC ASSEMBLY.** In the automatic assembly of screws rationalization effects can be attained only when jointing elements of high quality are guaranteed. During the mass production of screws faults in setting up, sudden and creep-type errors and accidental defects may occur. Sorting by mechanical selection equipment operating with ultrasonics or eddy current induction is faster and more reliable than manual visual checks. (Edited author abstract) 8 refs.

Grossberndt, Hermann. *Wire World Int* v 29 n 5 Sep-Oct 1987 p 118-122.

## Balancing

**090946 RESSORTS ET MECANISMES: UNE SOLUTION AUX PROBLEMES D'EQUILIBRAGE.** [Springs and Mechanisms: A Solution to Balancing Problems]. Balancing may be accomplished through the addition of inertia counterweights and restrictions on arm configurations. Irreversible transmission such as screw nut type are also used. To reduce loading characteristics, which can significantly enhance machine process, a new method to balance manipulators by springs is presented. The potential energy storage capabilities of linear springs are integrated with the nonlinear motion of manipulator to provide an exact value of the desired counter loading functions. This is performed by introducing simple mechanism between the spring and the structure to be balanced. Synthesis techniques based on torque balancing and energy method are developed to design the characteristics of mechanism and spring capable of balancing a given structure. Examples are given to demonstrate applications of these procedure and to illustrate the industrial potential of spring balancing. (Edited author abstract) In French. 24 refs.

Minotti, P. (CNRS, Besancon, Fr); Pracht, P. *Mech Mach Theory* v 23 n 2 1988 p 157-168.

**090947 MASSENAUSGLEICHSMCHANISMUS FUER INDUSTRIEROBOTER.** [System of Balancing for Industrial Robots]. Balancing of weight forces in industrial robots caused by forces of gravity has a special importance for increasing working speed and improving mass-power ratio, as well as cost reduction of driving energy. In practice, a series of balancing systems have been introduced which work according to different principles. Utilizing energy of a compressed spring in connection with a special crank is the fundamental of a mechanically working balancing system, which has been tested in the industrial robot ZIM 10-A. This article deals with the fundamentals of developing this mechanism. (Edited author abstract) In German. 3 refs.

Leistner, F. (Technische Univ 'Otto von Guericke', Magdeburg, East Ger); Baetge, J.; Soldatkin, E.P.; Novikov, W. *Maschinenbautechnik* v 37 n 5 May 1988 p 196-198.

## Calibration

**090948 OVERVIEW OF ROBOT CALIBRATION.** An overview is given of the existing work on robot calibration, and some of the basic issues are identified in calibration and improvement of robot precision. Model-



ing, measurement, identification, and correction issues in robot calibration are discussed, and some of the unresolved questions are identified. 26 refs.

Roth, Zvi S. (Florida Atlantic Univ, Boca Raton, FL, USA); Mooring, Benjamin W.; Ravani, Bahram. *IEEE J Rob Autom* v RA-3 n 5 Oct 1987 p 377-385.

**Cleaning** See SERVOMECHANISMS—Failure.

**Components** See GEARS—Research.

**Computer Aided Design** See Also ASSEMBLY MACHINES—Automation; ROBOTICS—Computer Aided Design.

**090949 DEVELOPMENT OF CAD CODES FOR THE JOB INTEGRATION OF INDUSTRIAL ROBOTS.** Reasons for developing special-purpose CAD codes are noted, together with a discussion of the approach that has been utilized. An example procedure concerning the selection of the controlling strategies is presented, with typical output results. The integration of the robotic devices into manufacturing lines is discussed with an indication of the computational codes presently under development. (Edited author abstract) 17 refs.

Acaccia, Gabriella M. (Univ of Genoa, Genoa, Italy); Michelini, Rinaldo C.; Molino, Rezia M. *Robotics* v 3 n 3-4 Sep-Dec 1987 p 371-387.

**090950 COMPUTER-AIDED ROBOT MODELING, PROGRAMMING AND SIMULATION.** The use of interactive computer graphics for simulation and off line programming provides a powerful tool in implementing robots. This capability essentially became available with the CAD/CAM system. This paper presents the theory of robot modeling and simulation techniques. An overview of CAD/CAM system in robotic application, such as robot off-line programming, simulation and workcell layout is represented. (Author abstract) 13 refs.

Lee, Jay (Robotic Vision Systems Inc, Hauppauge, NY, USA). *Robotics* v 3 n 3-4 Sep-Dec 1987 p 399-408.

**090951 LETTING THE INDUSTRIAL ROBOT TAKE THE GRIND.** Bula & Fils produces a varied range of automatic machines for deburring, polishing, buffing, brushing and satin finishing. In addition to its standard series of equipment, it manufactures numerous custom-built models, created and developed in answer to specific technical requirements. The MR250-2 houses an ASEA IRB 1000 six-axis robot and up to three heads to allow for brushing application such as belt grinding. This machine is a multi-purpose surface treatment center for robot handling of complex parts for small-to-medium-size components. Off-line simulation was used to design, test and program robot motion for this new process. This minimized machine downtime and production loss.

Daniels, Glynne (McDonnell Douglas Information Systems, Woking, Engl). *Ind Robot* v 15 n 1 Mar 1988 p 15-18.

**Computer Applications** See Also POWDER METALLURGY—Compacting.

**090952 PROZESSRECHNER KOORDINIERT VERSCHIEDENE ROBOTER MITTELS SENSORINFORMATIONEN.** [Process Computer Coordinates Different Robot Types Referencing Sensory Information]. A method is presented which allows synchron arc welding with multiple different type robots. The system is supported with visual sensory information. (Author abstract) 3 refs. In German.

Dreus, P.; Fuchs, K.; Wagner, R.; Willms, K. *Roboter-systeme* v 3 n 3 1987 p 161-166.

**Computer Integrated Manufacturing**

**090953 AUTOMATION WITH ROBOT SYSTEMS.** Sulzer has been developing robot systems for applications in handling, welding, protective coating deposition and assembly (also high precision assembly) for some years.

An example is given by CIW - Computer Integrated Weaving. This interdisciplinary concept provides improved productivity flexibility and increased rationalization. The cloth beam handling and transport system presented here constitutes an initial component in the Sulzer CIW. (Author abstract)

Schneider, P.; Zund, M. *Sulzer Tech Rev* v 70 1 1988 p 11-15.

**Computer Interfaces**

**090954 ROBOTIC INTERFACE PERMITTING ERROR RECOVERY.** Flexible manufacturing system involving a large number of independent control computers require convenient interfaces between the computers, and if the system is to be largely or entirely under computer control, it is necessary to include facilities for automatic error recovery. The paper describes the logical organization of a robotic interface, implemented in our laboratory, that supports automatic error recovery in a convenient way. This organization was inspired by, but is different from, the approach to error condition handling implemented in a widely used computer operating system. (Author abstract) 15 refs.

Foisy, A. (Univ de Montreal, Montreal, Que, Can); Jacques, P.; Stewart, N.F. *Robotics* v 3 n 3-4 Sep-Dec 1987 p 353-359.

**Computer Simulation** See Also ROBOT APPLICATIONS.

**090955 COMPUTER SIMULATION OF SENSOR-BASED ROBOT COLLISION AVOIDANCE IN AN UNKNOWN ENVIRONMENT.** Computer simulation is a major tool in validation of robot motion planning system. This is especially true when the motion planning system in question is based on sensor feedback and the generated trajectory is, therefore, unpredictable. This paper describes a simulation system ROPAS (for Robot Path Simulation) for testing one approach - called Dynamic Path Planning (DPP) - to sensor-based robot collision avoidance in an environment with unknown obstacles. Using real time graphics animation of the motion planning system, the user can simulate the behavior of an autonomous vehicle or a robot arm manipulator with a fixed base. The overall structure of the system is described, and examples are presented. (Author abstract) 15 refs.

Sun, K. (Yale Univ, New Haven, CT, USA); Lumelsky, V. *Robotica* v 5 pt 4 Oct-Dec 1987 p 291-302.

**090956 ROBOT SIMULATOR IN TIPS/GEOMETRIC SIMULATOR.** With the growth of factory automation, the need for off-line robot programming is increasing rapidly. Off-line programming requires a robot simulator. This is the reason for the development of a TIPS/GS (Geometric Simulator), accompanied by a robot simulator. TIPS/GS has been developed as a project in the TIPS Research Association. The goal of this project is to extend the functions and applications of the solid modeler TIPS-1. Four simulators (i.e. the assembly simulator, engineering simulator, NC simulator and robot simulator) have been developed for these extended applications. This paper is a report on the development of the robot simulator. (Author abstract) 6 refs.

Okino, Norio (Kyoto Univ, Kyoto, Jpn); Shono, Manabu. *Rob Comput Integr Manuf* v 3 n 4 1987 p 429-437.

**090957 DECISION OF ROBOT MOVEMENT BY MEANS OF A POTENTIAL FIELD.** This paper deals with a method of deciding robot movement by means of a potential field and simple simulations using it. In particular, two new concepts, 'state space for a robot' and 'oval potential', are proposed. On the basis of the proposed method, the robot has a potential field in which to store information about its environment. The field is defined on a space that represents the robot's state (state space). By using this field, the robot determines by itself how to move to a goal. The principal concepts of this method are: use of the potential field on a state space in

which the state of the robot is represented by a point enables the decision of movement to be made simply; by using the oval potential for potential distribution, objects are memorized using little information and calculation of the potential values is fast. 3 refs.

Okutomi, Masatoshi (Tokyo Inst of Technology, Meguro, Jpn); Mori, Masahiro. *Adv Rob* v 1 n 2 1986 p 131-141.

**090958 SIMULATION MODEL FOR AN INDIVIDUAL ROBOTIC MANUFACTURING CELL.** This research develops a data-driven computer simulator to evaluate the performance of an individual robotic manufacturing cell by analyzing the interactions between the robot and the machines in the cell. The model has been written in FORTRAN IV, utilizes the SLAM simulation language, and executes on an IBM 3033 computer. To validate the model, the simulation results were compared to the results of a mathematical queueing model. Finally, the analysis of a system wherein a deadlocked situation is expected has been provided as an example. (Edited author abstract) 6 refs.

Noh, Yong Deok (Auburn Univ, Auburn, AL, USA); Herring, Bruce. *Int J Prod Res* v 26 n 1 Jan 1988 p 63-79.

**090959 GROSS - GRAPHISCHES ROBOTER-SIMULATIONSPROGRAMM.** [Graphical Robot Simulation Program]. The interactive robot simulation system GROSS is presented that enables the definition and the calculation of robot movements. It supports the simple, fast and sure programming of industrial robots and reduces the necessary time for the development of the control software. The simulation is based on a mechanical model. For a special class of robots (tree structure) any geometrical dimensions can be defined as well as any kinetic and kinematic constraints. The representation of the robot simulation with all essential functions is possible by integration into a 3 D-graphics user interface. The system provides facilities like calculation and control of the working space, collision check with predefined obstacles, storing of all successful actions, estimation of the time for the robot's movements and graphical representation of its movements in real time. (Edited author abstract) In German. 15 refs.

Bullinger, H.-J.; Menges, R.; Warschat, J. *Automatisierungstechnik* v 35 n 12 1987 p 476-482.

**090960 DISTANCE CALCULATION FOR IMMINENT COLLISION INDICATION IN A ROBOT SYSTEM SIMULATION.** Minimum distance algorithms may be used in robotic simulation programs to provide the user with the distances of approach of the manipulator to obstacles in the work environment; this is important for task planning using graphical simulation of configuration maps, and for the implementation of automatic detection of (imminent) collision in robot task development systems that are based on a graphical simulation facility. In this paper we present algorithms that may be used for the calculation of distances between objects, not necessarily convex, that are made up of unions of convex polyhedra and cylindrically shaped objects (where the cross-section of the cylinder may be ellipsoidal, rather than circular). (Author abstract) 16 refs.

Hurteau, G. (Univ of Montreal, Montreal, Que, Can); Stewart, N.F. *Robotica* v 6 Pt 1 Jan-Mar 1988 p 47-51.

**090961 BEST ROBOT FOR THE JOB: SIMULATION CAN HELP DECIDE.** This paper outlines the design of the new ARG/Computervision software package for robotic simulation, known as Robographix, and describes some of the applications for which it has been used at ARG. Poor specifications, time constraints and inadequate knowledge of robot types are just a few of the problems that interfere with the proper selection of industrial robots in industry. Simulation properly used can eliminate many of the pitfalls.

Mattis, P.A. (Austin Rover Group, Engl); Gill, K.D. *Ind Robot* v 15 n 1 Mar 1988 p 32-34.



**090962** **HARDWARE-BASED SIMULATION SYSTEM FOR AUTOMATED INVESTIGATION AND GRAPHIC PROGRAMMING OF ROBOT MOTIONS.** A system intended for comprehensive simulation of robot dynamics is described. The interaction of analog and digital computers, as well as the wide use of graphic information are an essential feature of this system. Data about the structure of the entire modeling installation and its parts are presented. Calculation schemes for the modeling of individual subsystems of the robot are discussed. (Author abstract). 7 refs.

Gorbachev, V.S.; Kuleshov, V.S.; Talygin, A.K. *Sov J Comput Syst Sci* v 26 n 2 Mar-Apr 1988 p 10-19.

**Control Sensors** See Also **BIOMEDICAL ENGINEERING—Bioelectric Potentials; PROSTHETICS—Artificial Limbs; WELDING—Robot Applications.**

**090963** **TACTILE SENSING IN FLEXIBLE MANUFACTURING CELLS.** Tactile sensing in a flexible manufacturing environment is considered in relation to other developing robot-compatible sensing systems. The versatility of tactile sensing is illustrated and examples of given of the development and application of systems with which the author has been involved. These systems include component capacitance measurement; also component identification and sorting by machining a copy component. As in the use of coordinate measuring machines, a stumbling block is identified in that there is no simple tolerancing system based on generalized variational geometry, combining with geometric model data bases. A step towards zero-defect quality control and reduction in the capital and running costs of flexible manufacturing is through the application of generalized variational geometry. (Edited author abstract) 38 refs.

Spencer, R.M. (New South Wales Inst of Technology, Aust). *Mech Eng Trans Inst Eng Aust* v ME 10 n 3 Sep 1985 p 213-217.

**090964** **IMAGING FORCE SENSOR FOR ROBOTICS APPLICATIONS.** An improved design for an imaging force sensor is described based on a conductive elastomer force sensitive element. The sensor which has been designed to be mounted on a robot gripper contains 100 force sensitive elements spaced 3mm apart. Details are given of a computer program which analyses force images from the sensor to determine the location and orientation of the gripped object. Results are given of tests to determine how accurately object position and orientation can be determined using the sensor. (Author abstract) 8 refs.

Russell, R.A. (Univ of Wollongong, Aust). *Mech Eng Trans Inst Eng Aust* v ME 10 n 3 Sep 1985 p 223-227.

**090965** **DESIGN OF TACTILE SENSING SYSTEMS FOR DEXTROUS MANIPULATORS.** Preliminary work aimed at understanding the general issues and tradeoffs governing the design of extended tactile sensing systems is reviewed. General methods for estimating the bandwidths of line-addressed and matrix-addressed systems are presented. The proposed tactile sensing system incorporates four subsystems that permit the high-speed access of tactile data: (1) a transduction scheme, which initially will provide binary contact force and location information, but which later will be updated to yield graded force vector data; (2) a preprocessing scheme, which will prepare the data for transmission; (3) a multiplexing and transmission subsystem, which is designed to access the sensory data at speeds proportional to a specified number of sensors; and (4) tactile data selection techniques, which increase the system bandwidth by using a number of user-specified scanning methods. Designs for implementation at each of these levels are presented. The designs emphasize practical necessities such as simplicity, reliability, and economy, along with plans to incorporate a tactile system into the Utah/MIT Dextrous Hand. 29 refs.

Jacobsen, Stephen C. (Univ of Utah, Salt Lake City, UT, USA); McCammon, Ian D.; Biggers, Klaus B.; Phillips, Richard P. *IEEE Control Syst Mag* v 8 n 1 Feb 1988 p 3-13.

**090966** **DIFFERENTIAL SURFACE MODELS FOR TACTILE PERCEPTION OF SHAPE AND ON-LINE TRACKING OF FEATURES.** The online kinematic problem for gliding or rolling on an unknown surface is addressed, treating it as a simple two-rigid-body problem. A planar rigid-body end effector is considered that maintains contact with a rigid body of unknown shape by gliding or rolling on it. The smooth surface of the end effector is assumed to be known implicitly or parametrically in its own coordinate system. The authors present the main results both in equation form and diagrammatically. The figure given implies that if the parameters of the robot are known as well as its state, the forces of contact can be computed. However, due to the extensive amount of data required for this condition to be met, the required sensory and computational machinery may be exorbitant. Moreover, the presence of noise and the cost of removing it sufficiently make this approach impractical at present. 16 refs.

Hemami, H. (Ohio State Univ, Columbus, OH, USA). *IEEE Trans Syst Man Cybern* v 18 n 2 1988 p 312-316.

**Control** See Also **COMPUTER INTEGRATED MANUFACTURING—Computer Interfaces; COMPUTER SOFTWARE—Design; CONTROL, MECHANICAL VARIABLES—Laser Applications; ELECTRIC MOTORS—Applications; ROBOTIC ASSEMBLY—Industrial Applications; ROBOTICS—Vision Systems; WELDING, ELECTRIC ARC—Robot Applications.**

**090967** **SIMATIC INTERFACE ENHANCES SIROTEC ROBOT CONTROL PERFORMANCE.** The U Range of powerful SIMATIC S5 programmable controllers can be used to adapt robots quickly to new technologies and employ them in integrated production systems and manufacturing cells. Interfacing these programmable controllers with the SIROTEC RCM robot control enables rapid data exchange to be achieved in both directions and enhances the performance capability of the system. (Author abstract) 1 ref.

Foerster, Hansjoerg (Siemens AG, Nuremberg, West Ger); Zinnow, Uwe. *Energy Autom* v 9 n 2 Mar-Apr 1987 p 21-23.

**090968** **DEVELOPMENT OF ROBOT CONTROLLER.** A new robot controller designed especially for use in assembly for use in assembly and inspection workshops in NEC factories has been developed. This paper describes some features and the configuration of the new robot controller. It controls a multi-articulated robot with six degrees of freedom and supports an efficient programming environment. It consists of three parts: a process control unit, a motion control unit and a servo control unit. The servo control unit is a digital software servo system, in which all servo loops are performed by digital signal processors. (Author abstract) 1 ref.

Konishi, Yukihiko (NEC Corp, Jpn); Inoue, Suminori; Sawamura, Harumichi; Watanabe, Yuko; Tsukibayashi, Yuzuru; Kakimoto, Emi; Ohtsuki, Nobuo; Kawata, Kouichi. *NEC Res Dev* n 86 Jul 1987 p 53-61.

**090969** **RESEARCHING TOMORROW'S ROBOTS.** The more than 25,000 robots used in the U.S. in all kinds of manufacturing/non-manufacturing operations will be followed by thousands more in the future. Research and development programs are being conducted in government, university and private facilities. The projects described in this article include: knowledge resource/database systems; human-system interfaces; robot control; supervisory control of flexible manufacturing systems; articulated manipulator/transporter system; direct-drive robots; generic manipulation; laser articulated robot system; robot perception/planning; light weight robotic structures; and robotic assembly. 3 refs.

Stauffer, Robert N. (Robotics Today, Dearborn, MI, USA). *Rob Today* v 9 n 5 Oct 1987 p 27-28, 31-35.

**090970** **GUIDE TO CHOOSING THE SAMPLING RATE IN COMPUTERISED CONTROLLERS.** A criterion useful for choosing the sampling rate of computerized controllers is given. The proposed rule is applied to usual electric and hydraulic robot controllers. (Edited

author abstract) 7 refs.

Vibet, C. (Univ de Paris XII, Evry, Fr). *Electron Lett* v 23 n 19 Sep 10 1987 p 1002-1004.

**090971** **ANWENDUNG EINES NEUEN VERFAHRENS ZUR SCHNELLEN UND ROBUSTEN POSITIONIERUNG VON INDUSTRIEROBOTERN.** [Application of a New Concept of Fast and Robust Position Control of Industrial Robots]. There are numerous sophisticated control algorithms for industrial robots (IR) providing perfect results under academic laboratory conditions. The vast majority of IR-control systems on the market prefer rather simple conservative concepts. The main reasons for non-acceptance in practice are the high set-up costs, expensive hardware requirements and poor robustness with respect to parameter variations and model uncertainties. However, sophisticated manufacturing problems of the future (CIM) require more and more a better control performance, a high robustness within a crude industrial environment, more straightforward design and implementation procedures with PC assistance and implementation even on low-price conventional micro hardware. Predictive Functional Control (PFC) represents a new alternative concept for IR-control which can meet the above requirements. In this paper will be reported about the practical application of PFC for the position control of a conventional IR (KUKA 160). The excellent control behavior and robustness will be demonstrated by experimental results and a benchmark test. (Author abstract) 15 refs. In German.

Jacobasch, A.; Kuntze, H.B.; Arber, Ch.; Richalet, J. *Robotersysteme* v 3 n 3 1987 p 129-138.

**090972** **CONSTRAINED RELATIONS BETWEEN TWO COORDINATED INDUSTRIAL ROBOTS FOR MOTION CONTROL.** Tasks for two coordinated industrial robots always bring the robots in contact with the same object. Physically the three form a closed kinematic chain mechanism. When the chain is in motion, the positions and orientations of the two robots must satisfy a set of holonomic equality constraints for every time instant. To eliminate motion errors between them, we assign one of them to carry the major part of the task. Its motion is planned accordingly. The motion of the second robot is to follow that of the first robot, as specified by the relations of the joint velocities derived from the constraint conditions. Thus if any modification of the motion is needed in real time, only the motion of the first robot is modified. (Edited author abstract) 9 refs.

Luh, J.Y.S. (Clemson Univ, Clemson, SC, USA); Zheng, Y.F. *Int J Rob Res* v 6 n 3 Fall 1987 p 60-70.

**090973** **ROBOTS AND MACHINE TOOL CONTROL - DIGITAL SERVO-LOOPS.** Outwardly, both analogue and digital integrated circuits have similar physical appearances. Their use, however, reflects two entirely differing philosophies. A robot servo-loop has been developed within the Department of Mechanical Engineering at Monash University, where the philosophy and hardware have remained digital throughout. Such a system can be much cheaper than its analogue counterpart and lend itself directly to microprocessor joint control. The paper describes the system devised, with emphasis on components comprising the system. 4 refs.

La Brooy, R. (Monash Univ, Aust). *Mech Eng Trans Inst Eng Aust* v ME 10 n 3 Sep 1985 p 192-195.

**090974** **ROBOT CONTROL SYSTEMS: A SURVEY.** Robot manipulators have attracted considerable interest from researchers both in universities and industry during recent years. This interest covers a broad spectrum from task planning, robot language and artificial intelligence to mechanics, sensing and control. This paper



addresses the area of robot position control and gives an overview of the basic problems involved and some existing solutions. (Author abstract) 20 refs.

Moya, Mary M. (Sandia Natl Lab, Albuquerque, NM, USA); Seraji, Homayoun. *Robotics* v 3 n 3-4 Sep-Dec 1987 p 329-351.

**090975 REAL-TIME PATHFINDING IN MULTI-ROBOT SYSTEMS INCLUDING OBSTACLE AVOIDANCE.** The paper describes an approach to the solution of the find-path problem including obstacle avoidance in multirobot systems. The structure of these systems is based here on the nonlinear control approach. The method for real-time pathfinding uses a systematic design procedure which includes a hierarchical coordinator is designed for real-time collision avoidance. The collision avoidance strategy is based on an analytically described avoidance trajectory that serves for collision detection as well as avoidance. The efficiency of the approach is demonstrated for several cases of practical interest, such as collision avoidance between three robots, interaction of three stationary robots and a stationary obstacle, and interaction of mobile robots and moving obstacles. (Edited author abstract) 24 refs.

Freund, E. (Univ of Dortmund, Dortmund, West Ger); Hoyer, H. *Int J Rob Res* v 7 n 1 Feb 1988 p 42-70.

**090976 CONTRIBUTION TO THE DYNAMICS AND CONTROL OF ROBOTS HAVING ELASTIC TRANSMISSIONS.** This paper discusses one problem of robot dynamics rarely mentioned in papers relevant to this field. It is the problem of torsional effects in torque transmissions (reducers, shafts, transmission chains, etc.). The problem is significant since oscillations can appear to be due to these effects. The complete dynamic model, which includes these effects, is derived and the possible simplifications considered. The position of feedback transducers is discussed since it appears as an important problem when it is intended to minimize the influence of these elastic vibrations. The discussion is based on eigenvalues and simulation results. (Author abstract) 8 refs.

Potkonjak, V. (Univ of Belgrade, Belgrade, Yugosl). *Robotica* v 6 Pt 1 Jan-Mar 1988 p 63-69.

**090977 PREDICTING THE COMPLEXITY OF CONTROL OF A MINING ROBOT.** The efficiency of robots in mines depends on the social and economic need and on the feasibility of using robots to perform operations in a particular industrial environment. Quantitative estimates of the degree of disorganization of the environment and complexity of control at an early stage when the objects of robotization are analyzed make it possible to pinpoint the most effective potential robot applications and to restructure the industrial processes in an efficient way, redistributing the functions between man and robot. A technique for predicting the control complexity of a mining robot is discussed. 6 refs.

Konyukh, V.L. (Acad of Sciences of the USSR, Kemerovo, USSR). *Sov Min Sci* v 23 n 2 Mar-Apr 1987 p 139-143.

**090978 APPROACH TO PARALLEL PROCESSING OF DYNAMIC ROBOT MODELS.** A new parallel-processing scheme for robot dynamics computation on a multiprocessor system is described. The model to be processed is the customized numeric-symbolic dynamic model developed in our previous works, where each element of the dynamic model matrices is computed by an independent procedure (subtask). This feature is very convenient for multiprocessing since the precedence relations are reduced to a minimum. The parallel-processing scheme employs the distribution of subtasks among CPUs according to a modified branch-and-bound method combined with the largest-processing-time-first algorithm. Further, this method is extended to cover the parallel computation of driving torques, once the dynamic model matrices have been computed. The method is illustrated by two examples. (Edited author abstract) 11 refs.

Vukobratovic, M. (Inst Mihailo Pupin, Belgrade, Yugosl);

Kircanski, N.; Li, S.G. *Int J Rob Res* v 7 n 2 Mar-Apr 1988 p 64-71.

**090979 DIGITALE LAGEREGLUNG VON INDUSTRIEROBOTER-BEWEGUNGSACHSEN.** [Digital Laser Control of Industrial Robot Axes of Motion]. By using conventional procedures for position control, industrial robots often show an unfavourable dynamic behaviour due to their oscillatory mechanical structure; for this reason exact manufacturing and assembly tasks can often be fulfilled only in an unsatisfying way. It is true that there is a great number of control procedures to improve the dynamic properties of systems with an elastic structure; but there are still problems as far as the practical industrial applicability is concerned. By the example of the main movement axis of an industrial robot, this contribution shows how to realize an efficient position control with low expenditure. (Author abstract). 11 Refs. In German.

Pritschow, G. (Univ Stuttgart, Stuttgart, West Ger); Swoboda, W. *Robotersysteme* v 4 n 2 1988 p 65-72.

**090980 ERFAHRUNGEN BEI DER REALISIERUNG EINES NEUARTIGEN PRADIKTIVEN REGELUNGSKONZEPTE FÜR INDUSTRIEROBOTER.** [Experiences with the Realization of a Novel Predictive Control Scheme for Industrial Robots.]. The future tasks of flexible manufacturing automation (CIM) set new standards for the control of industrial robots which can no longer be met by the control concepts used to the present. In a joint project between IITB and the French research institute... ADERSA, a new form of control concept for industrial robots has been developed which optimally meets the increased demands regarding both quality and costs. The control concept has been realized on a normally marketed controller for an industrial robot of the type KUKA 160 and its efficiency has been experimentally tested under practical conditions. In this paper some representative results of the development will be shown which have been practically demonstrated at the HTB. (Author abstract). 10 Refs. In German.

Kuntze, H.B. (Fraunhofer-Inst IITB, Karlsruhe, West Ger); Jacobasch, A.; Salaba, M.; Hirsch, U.; Mitschke, H.; Munser, R.; Richalet, J. *Automatisierungstechnik* v 36 n 6 1988 p 208-214.

**090981 ROBOTOK MODELLREFERENCIAS ADAPTIV-IRANYITASA.** [Model Reference Adaptive Control of Robots]. It is proved that a model reference adaptive control structure can be used for robot axes that enables excellent system transition processes without knowing the parameters of the system and the elimination of the effect of disturbances (loading) on the accuracy. The same task can be solved in case of multidimensional robot arms. Through the moments working on the individual drives, the movement of arms is in complex, non-linear interrelation. The proposed robust model reference adaptive control structures have been designed by applying Lyapunov's second method. (Edited author abstract). 10 Refs. In Hungarian.

Janos, Somlo (BME, Budapest, Hung); Cat, Pham Tuong. *Meres Autom* v 36 n 6 1988 p 176-176-181.

**090982 VARIATIONAL DYNAMIC PROGRAMMING APPROACH TO ROBOT-PATH PLANNING WITH A DISTANCE-SAFETY CRITERION.** An approach to robot-path planning is developed by considering both the traveling distance and the safety of the robot. A computationally-efficient algorithm is developed to find a near-optimal path with a weighted distance-safety criterion by using a variational calculus and dynamic programming (VCDP) method. The algorithm is readily applicable to any factory environment by representing the free workspace as channels. A method for deriving these channels is also proposed. Although it is developed mainly for two-dimensional problems, this method can be easily extended to a class of three-dimensional problems. Numerical examples are presented to demonstrate the utility and power of this method. 13 refs.

Sub, Suk-Hwan (POSTECH, Pohang, South Korea); Shin, Kang G. *IEEE J Rob Autom* v 4 n 3 Jun 1988 p 334-349.

**Control Systems** See Also ARTIFICIAL INTELLIGENCE—Expert Systems; COMPUTER PROGRAMMING LANGUAGES—LISP; ROBOTIC ASSEMBLY—Mathematical Models.

**090983 STUDY ON CONCURRENT TASK CONTROL SYSTEM FOR ROBOTS.** The Concurrency Oriented Language COL for robot control and its system are described. In order to construct a Systemized-Robot with high ability by connecting separately developed functions, one has to systematically combine not only the hardware but also the software. On this background, COL has the power and flexibility to describe the following functions: concurrent processing, event control, priority control, shared variable management, real time operation, I/O handling, interrupt handling, and task state control. (Edited author abstract) In Japanese. 1 ref.

Mitsubishi, Mamoru (Univ of Tokyo, Jpn). *J Fac Eng Univ Tokyo Ser A* n 24 1986 p 16-17.

**090984 ARC ROBOT PROGRAMMING AND CONTROL SYSTEM.** Programming and control of industrial robots in a flexible manufacturing environment is a problem of increasing complexity. The paper deals with a software system, which is as much as possible independent of the real robot and suitable for different microprocessor configurations. It contains, furthermore, some components for off-line programming. (Author abstract) 4 refs.

Huebener, J. (Acad of Sciences of the GDR, Berlin, East Ger); Zecha, M. *Robotica* v 5 pt 4 Oct-Dec 1987 p 303-307.

**090985 ON THE PLANNING OF COLLISION-FREE MOVEMENTS OF MANIPULATORS.** Up to now, various methods for planning collision-free movements have been proposed. The first half of this paper discusses some of these interesting methods and briefly explains the procedures. Most of these methods are only useful when dealing with limited problems; it is difficult to apply these methods to generalized ones. The second half of the paper deals with the method that generally formalizes the problem of planning collision-free movements and explains it in detail. 31 refs.

Ozaki, H. (Kyushu Univ, Fukuoka, Jpn). *Adv Rob* v 1 n 3 1986 p 261-272.

**090986 PORT MANIPULATOR FOR THE DISTRIBUTED REALIZATION OF AN INTEGRATED MANUFACTURING SYSTEM.** A new concept, called an integrated multi-robot system (IMRS), for the decentralized control of integrated manufacturing systems was introduced previously. An IMRS is composed of robots, sensors, computers, and other real-time devices. Distributed computing systems are a natural candidate for the production of an IMRS because of their potential for meeting the high performance and reliability requirements. Since inter-communications and real-time performance are crucial to any IMRS, a dedicated function for these, called a port manipulator, is separated from applications. This separation remedies the usual limitation of communication models based on message passing. Implementation of those IMRS communication primitives proposed previously is discussed first, based on ports with various options. A hierarchical structure of the port manipulator is then presented which is suitable for supporting both intramode and intermode communications in the IMRS. The port options enable the IMRS to handle timing constraints in message passing and provide the flexibility of one-to-many, many-to-one and many-to-many mode of communications. (Edited author abstract) 20 refs.

Shin, Kang G. (Korea Inst of Technology, Taeduk, South Korea); Lee, Heungkyu. *Comput Syst Sci Eng* v 3 n 1 Jan 1988 p 21-31.

**090987 ANALYSIS AND CONTROL OF BIPED LOCOMOTION SUBJECT TO CONSTRAINTS.** In biped locomotion, the double support phase and the single



support phase appear alternately. Thus the form of the system equations frequently switch back and forth between systems of different dimensionality. Therefore the constrained dynamical system plays an important role in the control of the biped robot. The constrained system is analyzed and the control of this system is considered with application to biped locomotion. 15 refs.

Ito, Masami (Nagoya Univ, Nagoya, Jpn); Nariakiyo, Tatsuo. *Adv Rob* v 1 n 2 1986 p 165-176.

**090988 INDUSTRIAL ROBOT WITH MICROCOMPUTER CONTROL.** This paper describes the operating principle, characteristics, mechanical structure, drive system, hardware and software of the control system, critical components, test etc, of a microcomputer controlled robot. It discusses briefly the development and prospects of industrial robots in China and abroad. (Edited author abstract) In Chinese.

Fang, J.; Huang, J. *Jichuang Yu Yeya* n 2 1986 p 10-22.

**090989 SUBOPTIMAL TRAJECTORY PLANNING ALGORITHM FOR ROBOTIC MANIPULATORS.** This paper presents a Fourier-based suboptimal control approach for the trajectory planning of robotic manipulators modeled as coupled rigid bodies. The basic idea of the method is to convert a standard optimal control problem of infinite dimensionality (in time) into an optimization problem of finite dimensionality by approximating the manipulator trajectories by the sum of a polynomial and a set of appropriate eigenfunctions. The optimal control problem can then be solved via a nonlinear programming numerical algorithm given a performance index which is a continuous function to time. This method can be applied to a large class of problems with different performance indices and requires no model simplification. Manipulator control problems with free time and states and with inequality constraints can be handled effectively. The method is demonstrated in two examples of trajectory planning for a planar robotic manipulator model. (Author abstract) 16 refs.

Yen, V. (Carnegie-Mellon Univ, USA); Nagurka, M.L. *ISA Trans* v 27 n 1 1988 p 51-59.

**090990 MULTISENSORIK FUER EIN ROBOTER-SYSTEM.** [Multisensory System for a Robot System]. Sensors are very important components of advanced robot systems. However, they are difficult to incorporate into robots. For this reason we find only very simple applications in industry. They are usually analog or binary sensors as part of classical control loops. In this paper an architecture for the interpretation of multi sensor data with the help of a knowledge based system is described. The results of the sensor interpretation are the input of the planning process. Thereby, it is possible for the robot to respond to changing working conditions. (Author abstract) 32 refs. In German.

Raczekowsky, J. *Robotersysteme* v 4 n 1 1988 p 53-62.

**090991 TRIAL ON A 6-AXIS FORCE SENSOR FOR ROBOTS.** When automatic working processes such as parts assembling, deburring and grinding, are made by robots, force control must be adapted for their precise work. In such a case, a 6-axis force sensor is indispensable, and it must have the following three characteristics: (i) Compact size and light weight, (ii) High rigidity, (iii) High accuracy and resolution. In order to satisfy these requirements parallel plates structures and radial plates structures are adapted in newly designed 6-axis force sensors. After the investigations, it became clear that they satisfy the above requirements. For example, in case of a B-type detecting block where the rated force is 100 N, rated moment is 10 N·m, it is small (50 mm outer diameter, 44 mm height), light (116 g weight) and rigid (over 1.5 kHz natural frequency) enough. Its final error is smaller than 3% F.S. Its performances are confirmed in several kinds of actual works. (Author abstract) In Japanese. 9 refs.

Hatamura, Yotaro; Iino, Kenji; Ono, Kozo; Takada, Ryuji. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 497 Jan 1988 p 241-246.

**090992 APPLICATION OF DISCRETE-TIME MODEL REFERENCE ADAPTIVE CONTROL TO INDUSTRIAL ROBOTS: A COMPUTER SIMULATION.** In this paper a direct approach to discrete-time model reference adaptive control (MRAC) based on hyperstability theory is proposed to control industrial robotic manipulators. For industrial robots and manipulators which usually have highly nonlinear and complex dynamic behaviors and often unknown inertia characteristics, it is very difficult to achieve high performance with conventional control strategies. This high performance in terms of speed and accuracy can be obtained by adaptive control techniques. Considering the effects of gravity, process noise, and payload uncertainty, this approach is investigated using simulation for a three degree of freedom industrial robot. These simulation results show that adaptive control techniques can provide robust properties in spite of poor a priori information regarding the robot dynamics and circumstances. (Author abstract) 15 refs.

Yuh, J. (Univ of Hawaii, Honolulu, HI, USA); Holley, W.E. *J Manuf Syst* v 7 n 1 1988 p 47-56.

**090993 INTEGRATED PLANNING AND EXECUTION CONTROL FOR AN AUTONOMOUS MOBILE ROBOT.** We present a distributed hierarchical planning and execution monitoring system and its implementation on an actual mobile robot. The planning system is a distributed hierarchical domain independent system called FPS for Flexible Planning System. It is a rule based plan generation system with planning specific and domain specific rules. A planning solution to the 'Boxes and Wedge' Problem is presented. The Robot Control System (RCS) operates and monitors the robot in the real world. In order to allow real-time responses to asynchronous events (both internal and external), RCS consists of a rule-based decision kernel and a distributed set of sensor/effector monitors. RCS contains an execution model and may authorize local corrective action, e.g., unexpected obstacle avoidance during execution of a trajectory. RCS also generates status and failure reports through which the PMs inform the different decision subsystems as to the robot's state and current capacities. The failure reports help the RCS and planners in correcting/replanning a plan that has aborted. (Edited author abstract). 34 Refs.

Sobek, Ralph P. (CNRS, Toulouse, Fr); Chatila, Raja G. *Int J Artif Intell Eng* v 3 n 2 Apr 1988 p 103-113.

**090994 MINIMUM OPERATIONS AND MINIMUM PARAMETERS OF THE DYNAMIC MODELS OF TREE STRUCTURE ROBOTS.** An efficient method for the calculation of the inverse dynamic models of tree-structure robots is presented. The method significantly reduces the computational burden such that the inverse dynamics can be computed in real time at servo rate and leads almost directly to models with a minimum number of arithmetic operations. The method is based on a Newton-Euler formulation that is linear in the inertial parameters, on an iterative symbolic procedure, and on condensing the inertial parameters by regrouping and eliminating some of them. The description of the robot is carried out by a new notation inspired from J. Denavit and R.S. Hartenberg's (1955) notation. Results of a Fortran program developed to generate automatically the dynamic models of tree-structure robots are discussed. 26 refs.

Khalil, Wisama (Ecole Natl Supérieure du Mécanique, Nantes, Fr); Kleinfinger, Jean-François. *IEEE J Rob Autom* v RA-3 n 6 Dec 1987 p 517-526.

**090995 INTEGRATED SENSOR-BASED INTELLIGENT ROBOT SYSTEM.** A description is given of the work of the European Economic Community ESPRIT 278 project, which is concerned with the development of an integrated sensor-based (tactile plus vision) robot system capable of intelligent action within the area of workpiece positioning and orientation. A vision system is used to provide an initial estimate of workpiece position and orientation, allowing the robot to grasp the object. During the grasping phase, the tactile sensor confirms, modifies, or improves the initial information provided by the vision system. The project is now at the final phase, and the integrated components show satisfactory perfor-

mance. 29 refs.

Tzafestas, Spyros G. (Natl Technical Univ, Athens, Greece). *IEEE Control Syst Mag* v 8 n 2 Apr 1988 p 61-72.

**090996 COLLOQUIUM ON RECENT ADVANCES IN ROBOT CONTROL.** This colloquium proceedings contains 6 papers. The topics covered were robot control with flexible transmission elements; multivariable robot control; nonlinear robot control; sensor based intelligent robot control; self-tuning control of a robot manipulator and control of flexible robots. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11337 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Computing & Control Div, London, Engl). *IEE Colloq Dig* n 1987/22, Colloq on Recent Adv in Rob Control, London, Engl, Feb 16 1987. Publ by IEE, London, Engl, 1987 var pagings.

## Costs

**090997 FINANCIAL EVALUATION OF ROBOTICS INSTALLATIONS.** An important topic in capital equipment acquisition is the analysis of robots in the manufacturing environment. Due to the unique characteristics of robots, it is important to recognize all the costs and benefits of a robotic installation in evaluating the feasibility of including this new piece of equipment in the production process. What makes analyzing the proposed robotic acquisition different from the usual capital equipment purchase is dealing with secondary and tertiary benefits and costs afforded by robotic systems. The chief difficulty is estimating the cost benefits due to the flexibility of the robot installation. Three important and essential steps in the determination of the value of a robotic installation are considered. (Edited author abstract) 5 refs.

Jenkins, Kenneth (ELDEC Corp, Lynnwood, WA, USA); Smith, Philip; Raedels, Alan. *Robotics* v 3 n 2 Jun 1987 p 213-219.

**Design** See Also MECHANICAL DRIVE; ROBOTIC ASSEMBLY—Costs; WELDING—Robot Applications.

**090998 DETERMINATION OF THE PARAMETERS OF THE BALANCING MECHANISM FOR STATIC LOADS ON THE ELBOW OF THE HINGED MANIPULATOR OF INDUSTRIAL ROBOTS.** A mechanism for balancing the static moments at the elbow, with the use of a compression spring, has been developed for any manipulator used in quantity produced industrial robots. The criterion for choosing the optimum parameters of the balancing mechanism for static loads in the elbow is determined by the need to maintain a constant balancing force over the entire range of elbow displacements in a vertical plane. 4 refs.

Kondrin, A.T. *Sov Eng Res* v 7 n 1 Jan 1987 p 2-4.

**090999 DESIGN STRATEGIES FOR HIGH-SPEED LIGHTWEIGHT ROBOTS.** Industrial robots today can lift objects no heavier than about five percent of their own weight. Imagine a robotic weight lifter competing against the current Olympic human record of 750 lb. By today's standards, that robot would have to weigh about 15,000 lb, is opposed to its human competitor, who would weigh 165 lb (and who is 'rated' at 450 percent of body weight). The paper explains how weight loss in the design of a robot brings benefits such as faster and more accurate motion but the hazards could lead to lower performance. The paper describes how this problem can be approached with four design options and shows how each one addressed an important requirement. 9 refs.

Book, Wayne J. (Georgia Inst of Technology, Atlanta, GA, USA); Alberts, Thomas E.; Hastings, Gordon G. *Comput Mech Eng* v 5 n 2 Sep 1986 p 26-33.



**091000 USING EXPERT SYSTEM TO FIND ROBOTIC PATH WITH COLLISION AVOIDANCE.** A rule-based expert system has been developed and applied to a robotic planning system with collision avoidance. The model is represented as knowledge data and stored in the knowledge base with rules. The expert system can find collision-avoidance path. Several examples for different objects to pass through the different channels and to find collision-avoidance paths have been tested. The simulation results give the planning sequence or blocked section(s). The output information is useful for making decision about robot motion and for modifying the technological parameters. (Edited author abstract). In Chinese.

Cai, Zixing (Central South Univ of Technology, China). *Zhongnan Kuangye Xueyuan Xuebao* v 19 n 2 1988 p 204-211.

**091001 CONCEPTION MECANIQUE, CINEMATIQUE ET DYNAMIQUE DES ROBOTS.** [Mechanical, Kinematic, and Dynamic Design of Robots]. In this paper, we describe the different models that must be used, from the mechanical point of view, to account for the complex behavior of robots. The model consists of sub-models, each one describing a partial aspect of the global behavior. The main sub-models are respectively concerned on one hand with the geometrical kinematic and dynamic aspects, and on the other hand with actuators dynamics and control laws. Each sub-model is briefly described while the unresolved problems are enumerated. Some examples are shown that give a general overview of what can presently be achieved. (Edited author abstract) 15 refs. In French.

Barraco, A. (ENSAM, Paris, Fr); Cuny, B.; Hoffmann, A.; Jamet, P.; Lepareux, M.; Bung, H. *RFM Rev Fr Mec* n 4 1987, Cycle de Conf d'Etude et d'Inf de la Soc Fr des Mec sur les Rob Ind, Mar 25-26 1987 p 205-211.

#### Economics See Also ROBOTICS—Evaluation.

**091002 ECONOMIC ANALYSIS OF ROBOTIC ARC WELDING OPERATIONS.** The emphasis of the approaches which have been made to economic justification of robots has been toward their initial acquisition and in large batch and mass production environments. This paper examines the effect that alternative methods of operating a robot cell will have on its economic performance in small batch manufacture. Particular attention is given to the investment in tooling and fixtures and to the cost per piece produced by the cell. (Author abstract) 20 refs.

Knott, K. (Pennsylvania State Univ, University Park, PA, USA); Bidanda, B.; Pennebaker, D. *Int J Prod Res* v 26 n 1 Jan 1988 p 107-117.

#### Efficiency

**091003 EFFICIENCY OF M GROUPS OF N MACHINES SERVED BY A TRAVELLING ROBOT: COMPARISON OF TWO MODELS.** This paper solves the problem of calculating the efficiency of M groups of N machines under the care of one operative (robot), whose way of working is to patrol the groups either uni-directionally or bi-directionally, depending on whether they are located on a circle or on a line. Each group of machines is situated on a rotating circular disk (carousel). This work extends the earlier works for the uni-directional and the bi-directional patrolling problems. The problem arises in the practical context of a textile winding process and has some other industrial applications. Results are of value in maintaining controls and monitoring the process. (Edited author abstract) 5 refs.

Bunday, B.D. (Univ of Bradford, Bradford, Engl); El-Badri, W.K. *Int J Prod Res* v 26 n 2 Feb 1988 p 299-308.

#### Electric Drive See Also MACHINE TOOLS—Electric Drive.

**091004 DIRECT DRIVE AND WELD SENSORS**

**EMERGE IN TOKYO.** Direct drive (DD) robots, promised by the Japanese for a couple of years, were once again the dominant theme at the International Robots Show in Tokyo, but this time they are starting to go into production. Seiko I&E introduced a cartesian co-ordinate machine which it claims is faster over the standard assembly cycle than any DD robot. NEC, Matsushita and Sankyo Seiki introduced very cheap robots for assembly, while one or two companies are switching to the emphasis of systems rather than individual robots. Laser sensors for arc welding are also coming into vogue, now that Fanuc has succeeded in integrating the Meta Machines device.

Hartley, John. *Ind Robot* v 14 n 4 Dec 1987 p 231-238.

#### Ergonomics

**091005 NEW CONTROL METHOD FOR MOTOR VEHICLES FOR THE SEVERELY HANDICAPPED.** This report deals with the development of new control vehicles for the bedridden, physically handicapped person who needs a help-system for carrying things to the bedside from the stock in the room. This new control method is characterized by a unit loop system on the drive track. This unit loop system was constructed to execute three actions; stop, backward and right forward movement, under the control of a on-board microcomputer. This control method is used in small rooms. It also enables one to increase the driving area of a vehicle without reprogramming and adjusting the control mechanism. (Author abstract) 5 refs.

Suzuki, Yoshitaka (Rehabilitation Engineering Cent for Employment Injuries, Nagoya, Jpn); Niinomi, Sigeru; Saitoh, Yoshiyuki; Hatakeyama, Takuroh; Tsuchiya, Kazuo. *Robotica* v 6 pt 2 Apr-Jun 1988 p 131-139.

#### Evaluation

**091006 EVALUATION METHODOLOGY FOR PERFORMANCE AND SYSTEM ECONOMICS FOR ROBOTIC DEVICES.** This paper presents a mathematical model for the selection and evaluation of robots, which consists of critical factors such as maximum return on investment, objective factors such as payback value to give a more complete cost perspective, and subjective factors including hardware/software, vendor performance, and internal adaptation. This evaluation procedure can be used for the selection of robots for any robot implementations, such as CAD/CAM, CIM and military applications. (Author abstract) 8 refs.

Nnaji, Bartholomew O. (Univ of Massachusetts, Amherst, MA, USA). *Comput Ind Eng* v 14 n 1 1988 p 27-39.

**091007 WHAT'S NEXT FOR ROBOTS?** A robot is a programmable, general-purpose tool. Looking at the history of another programmable, general-purpose tool - the computer - can offer insight into the future of the robotics industry. The computer industry has already passed through four market development cycles. The robot industry has tracked the computer through the first two development cycles and appears to be following in lock step. This article looks at the market trends in the computer industry and offers some clues about the future of the robotic industry.

Johnson, Ken (Robosoft Corp, Apple Valley, MN, USA). *Rob World* v 6 n 1 Jan 1988 p 24-25.

#### Glossaries

**091008 ROBOTICS - TERMINOLOGY AND DEFINITIONS.** For many engineers, and laymen, on the periphery of electro-mechanical aids to industry, the terminology of the robotics buff seems, at times, to be out of this world. This article attempts to explain some of the terms commonly used. End effectors are discussed. 4 refs.

Virani, H. *Electron Technol (London)* v 21 n 9 Oct 1987 p 174-176.

**Grippers See Also BIOMEDICAL ENGINEERING—Computer Aided Analysis; ELECTRONIC EQUIPMENT MANUFACTURE—Robotic Assembly; INSTRUMENTS—Errors; ROBOTS, INDUSTRIAL—Sensors.**

**091009 GOALS OF ROBOT GRIPPER MECHANICS.** This paper is devoted to the methods of computation and analysis of equilibrium positions of the object in the robot gripping device, assuming that the contact between the object and gripper is maintained in a finite number of points. Problems of construction of computation models which make it possible to determine the reliability of holding an object in the gripper of an industrial robot in operation are considered. To compute the gripper carrying capacity, the authors developed a procedure involving a system of seven equilibrium equations for the 'object-gripper' mechanical system when the equations are solved, the carrying capacity of the gripper can be estimated and its exhaustive characteristic plotted, which is the area of rigid fixation within the space of acting forces and moments. The results of the present study can be used when developing the robot gripping devices, optimizing their parameters, or estimating the reliability of object holding in auxiliary transfer devices, feeders and positioners (such as spools, dispensers, special holders, etc.). (Author abstract) 3 refs.

Kolpashnikov, S.N. (Leningrad M.I. Kalinin Polytechnic Inst, Leningrad, USSR); Chelpanov, I.B. *Mech Mach Theory* v 22 n 5 1987 p 481-487.

**091010 KINEMATICS AND FRICTION IN GRASPING BY ROBOTIC HANDS.** Using the extended screw theory, grasping is analyzed in terms of the complete and partial constraint of a rigid body. The underlying kinematic theory is first reviewed and illustrated. The extended screw theory is then used to determine the disturbing and nondisturbing external wrenches, and resulting disturbances for a grasped object. This is a new application of the concept of total freedom based on the idea of component motions and the wrenches that can cause them. Determining the disturbing and nondisturbing wrenches is tantamount to determining the stability of the grasp in regard to total freedom. Finally, a novel method of incorporating friction in the kinematic analysis of grasping using screw theory is also developed using the concepts of apparent normals and apparent motions. (Author abstract) 11 refs.

Ohwovoriole, E.N. (Univ of Benin, Benin City, Nigeria). *J Mech Transm Autom Des* v 109 n 3 Sep 1987 p 398-404.

**091011 ENTWICKLUNG EINER ROBOTHERHAND FUER DIE FEINMANIPULATION VON OBJEKTEN.** [Development of a Robot Hand for the Dextrous Manipulation of Objects]. We describe the development of a modular multifingered robot hand. We discuss the problems of grasp planning and programming of multifingered robot hands, show the possibilities of a graphical hand programming system and present an iterative procedure to control the manipulation of an object in the case of curved fingertips. Also shown is the mechanical design of the finger and the related inverse coordinate transformation. (Author abstract) 17 refs. In German.

Doll, T.J. *Robotersysteme* v 3 n 3 1987 p 167-174.

**091012 STUDY ON CONTROL OF A MICRO-MANIPULATOR (1ST REPORT, BASIC CHARACTERISTICS OF A MICRO-GRIPPER AND A METHOD OF BILATERAL CONTROL).** A method of the master-slave type of bilateral control as one of the teleoperators is proposed in this paper to improve the operability of a micro-manipulator system for applications to genetic manipulation, micro surgery and others, which require contractive position and force. Conventional bilateral control methods can be classified from the viewpoint of a unified approach and a more general method is proposed here as the impedance reflective control method under some assumptions that the master slave dynamics are both linear. Then the stability problem



is also described in the vein of the model reference adaptive system. The slave of the micro-gripper, as one of micro-manipulators is made of a PMN ceramic actuator and the double link mechanism, while the master is made of a DC motor and an operating lever. (Edited author abstract) In Japanese. 15 refs.

Fukuda, Toshio; Tanie, Kazuo; Mitsuoka, Toyokazu. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 493 Sep 1987 p 1950-1956.

**091013 DESIGN AND DEVELOPMENT OF A FLEXIBLE ROBOT HAND.** This paper reviews the design and development of a flexible (articulated and programmable) robot gripper. The mechanical design is described together with some planned control schematics. Some sample tasks planned for the hand are also described. This is an on-going research program and the paper is essentially a progress report. (Author abstract) 7 refs.

Samuel, A.E. (Univ of Melbourne, Aust); Ridley, P. *Mech Eng Trans Inst Eng Aust* v ME 10 n 3 Sep 1985 p 208-212.

**091014 CONTROLLING IMPACT FORCES IN PNEUMATIC ROBOT HAND DESIGNS.** Robot hands capable of applying controllable forces to a wide variety of objects would increase the number of robotic applications in manufacturing. One frequently overlooked part of the force control problem is the initial impact between the robot hand 'finger' and the object. Experimentally determined impact forces for a variety of hand fingertip and object surface stiffnesses are presented. Experimental and numerical optimal control results for a pneumatically actuated finger are presented. A proof-of-concept robot hand which implements a 'near-optimal' control strategy for grasping objects at imprecisely known locations is presented and discussed with experimental results. (Edited author abstract) 13 refs.

Parker, J.K. (Univ of Alabama, Tuscaloosa, AL, USA); Paul, F.W. *J Dyn Syst Meas Control Trans ASME* v 109 n 4 Dec 1987 p 328-334.

**091015 MODELLING OF METHODS OF CONTROL FOR PNEUMATIC-MECHANICAL HINGE-BALANCED MANIPULATORS WITH MANUAL CONTROL.** Pneumatic-mechanical hinge-balanced manipulators (PMHBM) with manual control envisaged for local mechanization of loading and unloading operations of production or storage equipment are widely used. The mathematical model of the dynamic method of manipulation for a displacement upwards, is described by the equations of displacement of the cylinder rod and dependence of the path, velocity and acceleration of the load on the path, velocity and acceleration of the rod. The investigations were carried out by a numerical integration method for loads with a mass of 30, 60 and 90 kg. 2 refs.

Petukhov, P.Z.; Tikhomenkov, S.M. *Sov Eng Res* v 7 n 3 Mar 1987 p 4-5.

**091016 ALGORITHM FOR STABILIZATION OF THE MOTION OF THE WORKING ELEMENT OF A MANIPULATOR WITH THE USE OF A FORCE TRANSDUCER.** Industrial robots controlled by computers find wider and wider use in production processes. As a rule, the motion of the working element of mechanical manipulators along a required trajectory is planned and programmed for certain values of the load torque on the shaft of drive motors corresponding to a particular size of load to be displaced. Various methods for determining the load torques during motion of the operating elements of the manipulator, and organization of control that stabilizes the motion of the working element are proposed. 3 refs.

Anishchenko, N.V.; Safonov, A.I. *Sov Eng Res* v 7 n 3 Mar 1987 p 6-8.

**091017 GRIPS OF INDUSTRIAL ROBOTS FOR THE TRANSFER OF TIRE BEADS.** Proceedings from the requirements that grips have to fulfill, we find that the

basic criteria for choosing the optimal variant are: reliable gripping of the tire bead, ensuring mechanical integrity of the tire bead when gripped, rapid action of the grips, convenient gripping and transfer of the bead, minimal weight of the grip. The selected criteria are most satisfactorily met by mechanical grips where the clamping of the bead is effected with the aid of expanding levers. Since beads are not sufficiently rigid along the outer circumference, they have to be gripped along the inner circumference. This ensures mechanical integrity of the beads when they are gripped. The necessary gripping force on the tire bead by the grip is determined by proceeding from the condition of ensuring removal of the beads from special container cassettes intended for their storage and transport, and holding them in the grip during transfer. A calculation diagram for determining the gripping force applied to the tire bead is presented. The method of calculating the gripping force exerted on beads was used in designing grips for industrial robots used in the transfer of tire bead rings and beads in a complex (system) of machines for making components and assembling car tires. 9 refs.

Bubnov, V.E.; Kol'man-Ivanov, E.E. *Chem Pet Eng* v 22 n 11-12 Nov-Dec 1986 p 555-557.

**091018 RESTRAINT ANALYSIS OF A RIGID BODY USING FRICTIONAL ELASTIC CONTACTS.** This paper presents the analysis of restraint of a rigid body in contact with any arrangement of point contacts having known frictional properties. A necessary condition for the solution of this problem is that the elastic properties of the contacts are also known. The relationship between externally applied loads and contact forces in the presence of limiting friction is established, as is the means for evaluating the resulting bodily motion, with or without slip at the contacts. An example is given to illustrate the application of the theoretical basis to a device such as a robot gripper that relies on friction for restraint. (Author abstract) 15 refs.

Kerr, D.R. (Univ of Salford, Salford, Engl); Sanger, D.J. *J Mech Transm Autom Des* v 109 n 4 Dec 1987 p 450-454.

**091019 STEPPER MOTOR DRIVEN ROBOT GRIPPER.** A microprocessor-controlled, half-stepper motor and ball screw assembly are described. They provide precise movement of a robot arm gripper.

Coon, William (Warner Electric); Powell, Rick. *Power-convers Intell Motion* v 14 n 2 Feb 1988 p 36-37.

**091020 SYNTHESIS OF A PARALLELOGRAM GRIPPER FOR A ROBOT FROM A PERMISSIBLE POSITIONING ERROR.** The gripping devices of industrial robots and manipulators are intended for gripping and holding objects for manipulation to a defined position. The design of production lines, both for machining, stamping and for assembly, is at present the major trend in the development of robotic technology. As part of this, standardization of gripping devices is advisable. This paper presents a synthesis of gripping devices from their constituent elements, based on the permissible error when the thickness of the blank to be gripped varies. 4 refs.

Soldatkin, E.P. *Sov Eng Res* v 7 n 4 Apr 1987 p 2-4.

**091021 SYSTEMY AUTOMATYCZNEJ WYMIANY CHWY TAKOW ROBOTOW PRZEMYSLOWYCH.** [Automatic Gripper Exchange Systems for Industrial Robots]. The characteristics of automatic clamping devices for exchangeable grippers of industrial robots are outlined. Examples of design solutions are cited. The advantages and drawbacks of shape-aided and force-aided connections are indicated. Diagrams of various shape-aided connections are presented, as well as a structural diagram of a force-aided connection. In Polish. 3 refs.

Barczyk, Jan (Politechniki Warszawskiej, Pol). *Przegł Mech* v 46 n 7 Apr 1987 p 10-12.

**091022 SYNTHESIS OF A SELF-CENTRING ROBOT GRIPPER FROM A PERMISSIBLE BASIC**

**ERROR.** The objective of this paper is synthesis of the gripper mechanism from the permissible basic error. Since the gripper is self-centring, zero is taken as the nominal value of the dimension relative to which the deviations are sought, i.e. relative to points lying on the diameter of the component which is to be clamped. A deviation relative to zero is taken both with a plus sign and with a minus sign. This is necessary in the calculation method described. 2 refs.

Kukovins, V.N. *Sov Eng Res* v 7 n 5 May 1987 p 7-8.

**091023 LOW COST TACTILE GRIPPER USING SILICONE RUBBER SENSOR ARRAY.** A low cost tactile sensor using commercially available conductive silicone rubber has been developed. It comprises a two dimensional array arranged in 3 mm centre-to-centre distance. Each sensor element has a zero-force resistance of about 0.3 kohm and it has a logarithmic characteristic curve of resistance versus force. An 8 × 8 prototype tactile sensor array over an area of 3 cm × 3 cm has been fabricated and mounted on the gripper of a robot for testing and evaluation. The associated software has also been developed. The limitations of the sensor are also discussed. (Author abstract) 14 refs.

Lim, Kah-Bin (Natl Univ of Singapore, Singapore); Chong, Yoon-Song. *Robotica* v 6 pt 1 Jan-Mar 1988 p 23-30.

**091024 GREIFERTECHNIK IN DER GERA-ETECHNISCHEN INDUSTRIE.** [Gripper Technique in the Instrumental Industry]. The gripper technique plays the greatest role in the adapting of manipulators to the manufacturing process beside the software. Derived from typical instrumental and technological requirements, different gripper principles and the motion behaviour of the gripper components are explained. Furthermore the design of the drive technique resulting from this and of the form elements is described. (Author abstract) 12 refs. In German.

Braunschweig, A. (Technische Hochschule Ilmenau, East Ger). *Feingeratetechnik* v 36 n 6 1987 p 251-254.

**091025 SENSORIZED ROBOT GRIPPER.** This paper describes the design, fabrication, and preliminary testing of a tactile sensing array which is the core of a gripper intended for industrial applications. The tactile sensor, consisting of a matrix of 128 sensing elements, is based on the technology of the piezoelectric polymer PVF2. The system comprises a purposely developed electronic unit designed to scan and amplify the signals generated by the tactile matrix. Preliminary experiments demonstrate the ability of the sensorized gripper systems to detect binary tactile images of several different objects. (Edited author abstract) 10 refs.

Fiorillo, A.S. (Univ of Pisa, Pisa, Italy); Dario, P.; Bergamasco, M. *Robotica* v 4 n 1 Mar 1988 p 49-55.

**091026 OPTIMIZING THE HANDLING OF OBJECTS WITH MULTI-FINGER GRIPPERS.** Considerable effort has been devoted in recent years to the development of effective multiple prehension end effectors for both robotics applications and prosthetic devices. The evaluation of the contact forces between the fingers and the object is the fundamental parameter in designing and controlling end effectors; this is particularly important in handling delicate objects. This article introduces a generalized program which optimizes the grasp action of objects with known geometries by grippers with any number of fingers. The technique is particularly useful in designing end effectors for handling delicate objects. 8 refs.

Badreldin, Ashraf (Univ of Wisconsin, Madison, WI, USA); Seireg, Ali A. *Comput Mech Eng* v 6 n 5 Mar-Apr 1988 p 47-57.

**091027 CONSTRUCTING FORCE-CLOSURE GRASPS.** This paper presents fast and simple algorithms for directly constructing force-closure grasps based on the



shape of the grasped object. The synthesis of force-closure grasps finds independent regions of contact for the fingertips, such that the motion of the grasped object is totally constrained. A force-closure grasp implies equilibrium grasps exist. In the reverse direction, we show that most nonmarginal equilibrium grasps are force-closure grasps. (Author abstract) 17 refs.

Nguyen, Van-Duc (GE, Schenectady, NY, USA). *Int J Rob Res* v 7 n 3 Jun 1988 p 3-16.

**091028 KINEMATICS OF CONTACT AND GRASP.** The kinematics of contact describe the motion of a point of contact over the surfaces of two contacting objects in response to a relative motion of these objects. Using concepts from differential geometry, the author derives a set of equations, called the contact equations, that embody this relationship. He employs the contact equations to design the following applications to be executed by an end-effector with tactile sensing capability: determining the curvature form of an unknown object at a point of contact; and following the surface of an unknown object. The contact equations also serve as a basis for an investigation of the kinematics of grasp. The relationship between the relative motion of two fingers grasping an object and the motion of the points of contact over the object surface is derived. (Edited author abstract) 15 refs.

Montana, David J. (BBN Lab Inc, Cambridge, MA, USA). *Int J Rob Res* v 7 n 3 Jun 1988 p 17-32.

**091029 INVESTIGATION OF FRICTIONLESS ENVELOPING GRASPING IN THE PLANE.** Grasping by a two-dimensional hand composed of a palm and two hinged fingers is studied. The mathematics of frictionless grasping is presented and used in the development of a planner/simulator. The simulator computes the motion of the object using an active constraint set method and assuming exact knowledge of the physical properties of the polygonal object, hand, and support. Grasping is divided into three phases. During the first phase, the initial grasping configuration is found. In the second phase, the object is manipulated away from the support, bringing it into contact with the palm. In the last phase, the grip is adjusted to minimize the contact forces acting on the object. (Author abstract) 28 refs.

Trinkle, Jeffrey C. (Univ of Pennsylvania, Philadelphia, PA, USA); Abel, Jacob M.; Paul, Richard P. *Int J Rob Res* v 7 n 3 Jun 1988 p 33-51.

**091030 PROGRAMMIERBARE, SENSORGEFUEHRTE GREIFER FUER INDUSTRIEROBOTER.** [Programmable, Sensor-Controlled Gripper for Industrial Robot]. A survey of the grippers in current use for materials handling and assembly operations is given. The emphasis is placed upon programmable grippers controlled by adequate sensors. In German.

Schweizer, M.; Frankenhauser, B. *Konstruktion (Berlin)* v 40 n 6 Jun 1988 p 213-216.

**091031 FLEXIBLE FINGERS CAN SOLVE GRIPPER SENSITIVITY PROBLEMS.** The integrated servo/tactile gripper has been developed to assembly small mechanical devices and odd form or standard electronic components. Yet, it has been designed with features that promote flexibility and are cost effective. The interchangeable finger sets not only provide the needed flexibility in handling a variety of component designs but are inexpensive and easy to fabricate. The integration of two independently controlled parallel movement fingers with six-degrees of force sensing capabilities provide the degree of intelligence necessary to assembly a broad range of devices. Utilising force information to grasp and release allows the gripper to adapt to the component and not vice versa. Components can be inserted with a new level of confidence due to its lead 'jamming' sensing. The gripper system allows the user to relax the requirements for the precise fixturing of components, thus reducing costs. These features allow the user to design flexibility into a robot-based assembly station. 1 refs.

Irwin, C.T. (Lord Corp, Cary, NC, USA). *Assem Autom*

v 8 n 2 May 1988 p 87-90.

**091032 APPLICATION OF ACOUSTIC EMISSION SENSING TO SLIP DETECTION IN ROBOT GRIPPERS.** This paper discusses the application of acoustic emission signal analysis as a sensing tool for the detection of contact and slip related motion between a workpiece and an end effector. Some results from past work in this area are first reviewed. Different modes of slip motion (rotational and translational) are then discussed. The ability to distinguish between these slip modes is important, since it enables the robot to assess the gripping stability and recover positional control of the workpiece. Experimental results are presented to demonstrate the sensitivity of the detected acoustic emission signal to these different modes of slip motion. The effect of the gripping force on the detected acoustic emission is also discussed. (Author abstract). 17 Refs.

Rangwala, S. (Univ of California, Berkeley, CA, USA); Forouhar, F.; Dornfeld, D. *Int J Mach Tools Manuf* v 28 n 3 1988 p 207-215.

**091033 PLANNING FOR THREE-FINGER TIP-PREHENSION GRASPS.** This paper discusses the planning of grasp configurations for three-fingered tip-prehension grasps. Geometric reasoning is incorporated into the selection process so that the task requirements, together with constraints on compatibility between the task's and the object's geometry, can be used to find feasible grasp configurations. A classification of objects is made, whereby they are divided into groups based on their geometric characteristics. Task requirements are then used for developing selection rules for each group of objects. In addition, methods for reaching a grasp in the existence of uncertainty are suggested. (Author abstract). 16 Refs.

Ji, Z. (Nanjing Inst of Technology, Nanjing, China); Roth, B. *Int J Mach Tools Manuf* v 28 n 3 1988 p 251-262.

**091034 ROBOT GRIPPERS IN SULZER ROBOT SYSTEMS PROJECTS.** Sulzer Robot Systems designs and supplies complete robot cells and larger systems for the areas of handling, welding, deburring and associated applications, as well as weaving automation. Concentration on the provision of systems is the key to successful flexible automation: the robot or the peripheral components alone cannot perform the task required by the customer. Only the careful integration of robot, gripper or tooling (end-effectors), peripheral hardware and software enables the problem to be mastered. (Edited author abstract).

Schneider, P. (Sulzer Robot Systems); Servis, W. *Sulzer Tech Rev* v 70 n 2 1988 p 12-16.

**091035 AUTOMATISCHES FUEGEN VON DICH-TRINGEN.** [Manipulation of Lenses with Vacuum Grippers]. For the manipulation and joining of lenses in mountings newly developed vacuums are presented. The grippers are for manual and automated mounting. The design and performance of the grippers are described, and important parameters for their use in mounting are given. (Edited author abstract). 7 Refs. In German.

Denzin, K. (Technische Hochschule Ilmenau, East Ger); Boeswetter, G.; Hennecke, D. *Feingeraetetechnik* v 37 n 6 1988 p 253-254.

**091036 ROBOTIC ASSEMBLY SYSTEM IN SEMI-CONDUCTOR INDUSTRY.** A sensor-based robotic production system for the assembly of rectifier bridges is described. Assembly tasks in the semiconductor industry require a robot with good positional accuracy and the capability for high velocities and accelerations in all degrees of freedom. The measurement of diode properties is considered. The robot is equipped with a specially designed vacuum gripper serving also as a test electrode of the measuring system. The trajectory of the manipulator end-effector is determined by the results of the measurements. The robotic language DARL is used to control the assembly process. 11 refs.

Cibej, Ivan (Edvard Kardelj Univ, Ljubljana, Yugosl);

Solar, Borut; Bajd, Tadej; Rudel, Drago; Kralj, Alojz R.; Zdravko, Balorda; Verdenik, Ivan. *IEEE Trans Ind Electron* v IE-34 n 4 Nov 1987 p 413-416.

**091037 AUTOMATIC EVALUATION OF TWO-FINGERED GRIPS.** Grip determination is essential to any task-level planning process. The complete force/moment equations are presented for grasping by a rigid two-fingered gripper with a thin elastic layer on the contacting surface. The surface contact is modeled as a linear pressure variation. The quality measure of a grip is taken to be the coefficient of friction needed to keep the held object from slipping between the fingers under applied forces and moments. The lower the coefficient of friction, the better the grip. Incorporation of this evaluation into general grip selection strategy is discussed, and several examples are given. 22 refs.

Barber, James (Univ of Michigan, Ann Arbor, MI, USA); Volz, Richard A.; Desai, Rajiv; Rubinfeld, Ronitt; Schipper, Brian D.; Wolter, Jan. *IEEE J Rob Autom* v RA-3 n 4 Aug 1987 p 356-361.

**091038 TASK-ORIENTED OPTIMAL GRASPING BY MULTIFINGERED ROBOT HANDS.** The problem of optimal grasping of an object by a multifingered robot hand is discussed. Using screw theory and elementary differential geometry, the concept of a grasp is axiomatized and its stability characterized. Three quality measures for evaluating a grasp are then proposed. The last quality measure is task-oriented and needs the development of a procedure for modeling tasks as ellipsoids in the wrench space of the object. Numerical computations of these quality measures and the selection of an optimal grasp are addressed in detail. Several examples are given using these quality measures to show that they are consistent with measurements yielded by the authors' experiments on grasping. 32 refs.

Li, Zexiang (Univ of California, Berkeley, CA, USA); Sastry, S. Shankar. *IEEE J Rob Autom* v 6 n 2 Feb 1988 p 32-44.

**091039 ANALYSIS OF EQUILATERAL GRIP OF A PRISMATIC AND CONVEX WORKPIECE.** Certain facets of the gripping problem in robotics are discussed. A gripper with a single degree of freedom is considered, which consists of three equal-length fingers. The set of workpieces under consideration are modeled by prismatic and convex polyhedra. This leads to a planar-geometric formulation. The computational geometric problem of inscribing, in a given convex polygon, an equilateral triangle that is locally minimal, is addressed. Feasibility and the (computational) geometric construction of the solution are emphasized. 3 refs.

Orlowski, M. (CSIR, Pretoria, S Afr); Pachter, M. *IEEE J Rob Autom* v 4 n 2 Apr 1988 p 218-223.

## Hydraulic Drive

**091040 REGELUNGSKONZEPTE FUER SCHWACH GEDAEMPFT ANTRIEBE IN HANDHABUNGSSYSTEMEN.** [Control Concepts for Weakly Damped Drives in Industrial Robots]. Higher demands on control response of weakly damped drives can hardly be accomplished by applying conventional control concepts. The state feedback control is a more efficient alternative, where the unknown state variables are estimated. This paper describes the design of partly modified and further developed feedback control of an estimated state vector, which takes into account the constraints of real drives such as elasticities, friction, nonlinearities etc. The presented concepts are tested on the example of an hydraulic drive by means of hybrid simulations. (Author abstract) 15 refs. In German.

Faulhaber, S. *Robotersysteme* v 3 n 3 1987 p 149-160.

**Imaging Techniques See MECHANICAL VARIABLES MEASUREMENT—Distance.**



India See WELDING—Automation.

## Industrial Applications

**091041 RATIONALISIERUNGSRESERVEN IM SCHWEISSBEREICH.** [Potential for Rationalization in the Field of Welding. Selecting the Right Workpieces for Robotic Welding]. The two methods presented here are part of a comprehensive planning scheme for robotic welding systems in industry. The method for analyzing weak points in welding production may be used for the determination of errors with regard to processing of orders, pre-fabrication of parts, design, or welding facilities. The method for analyzing the suitability of industrial robots makes it possible to establish exactly which welding workpieces are likely to produce the most significant rationalization effect. (Author abstract) 7 refs. In German.

Gzik, H. *Robotersysteme* v 3 n 3 1987 p 175-181.

Intelligent See Also ARTIFICIAL INTELLIGENCE; WELDING, ELECTRIC ARC—Robot Applications.

**091042 MOTION CONTROL ALGORITHMS FOR SENSOR-EQUIPPED ROBOTS.** This paper deals with the development of kinematic algorithms for the control of sensor-equipped robots. The kinematics is solved in the sensor coordinate system, which reduces the computation efforts, and allows the elimination of the first joint encoder. Simplification of the algorithms can be obtained when approximations are used to solve the inverse kinematics. Three control algorithms based on approximations are presented. However, with these algorithms, convergence to the target is not always guaranteed. A Theorem which specifies the sufficient conditions required for a trajectory to converge to a target point is proved. Based on this Theorem robot parameters can be selected in the design stage of the manipulator. This is illustrated for several types of manipulators. (Author abstract) 14 refs.

Shoham, M. (Columbia Univ, New York, NY, USA); Kohen, Y. *J Dyn Syst Meas Control Trans ASME* v 109 n 4 Dec 1987 p 335-344.

**091043 DETERMINING OBJECT ATTITUDE AND POSITION FOR BIN-PICKING TASKS GUIDED BY AN INTERPRETATION TREE DERIVED FROM A GEOMETRICAL MODELER.** A method is presented in which the position and the attitude of the object can be determined by interpreting the depth map, needle map, and the edge map, following the interpretation tree. Before a matching is tried, the interpretation tree is derived based on the attitude group. The attitude group classifies the attitudes based on the labels of the observable regions. The branch in the interpretation tree is determined based on the dependence of the label on the set of regions. At each stage, the most favorable feature is utilized for the matching at the branch. The matching feature for each attitude group is employed in the precise determination of the attitude in the attitude group. This information is also registered in the interpretation tree. The input information for matching is the edge map obtained by differentiating the density map, the needle map obtained by the density-difference stereo, and the depth map obtained by the two pairs of density-difference stereo. The matching is made following the interpretation tree and using the most favorable feature at each stage. The description of the determined position, attitude and the background is stored in the world of geometrical model. Using the stored description, safe-grip attitude of the gripper is determined. (Author abstract) 18 refs.

Ikeuchi, Katsushi (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Koshikawa, Kazutada. *Syst Comput Jpn* v 18 n 12 Dec 1987 p 29-41.

**091044 PLANNING OF ACTIVITY OF ROBOTS IN QUASI-DYNAMIC ENVIRONMENTS.** Three models for organization of purposeful activity of an intelligent robot are considered. In the framework of the first model, the activity of the robot is organized in the presence of complete and accurate information about the

environment. Mechanisms of solution search, representation and use of knowledge to control the search are described. The second model allows functioning of the robot to be organized in an environment about which it has no complete and accurate information. Mechanisms are considered for analysis and identification of states of the environment, correction of knowledge, planning and replanning the activity of the robot. The third model is directed toward organization of joint functioning of a team of robots under conditions where they have common components of the environment. Mechanisms of coordination of activity of the robots with access to common resources are considered. (Author abstract) 3 refs.

Sudeykin, M.I. *Sov J Comput Syst Sci* v 25 n 5 Sep-Oct 1987 p 127-139.

**091045 INTEGRIERTES SENSORGESTUETZTES ROBOTERSYSTEM.** [Integrated Sensor Based Robot System]. This paper describes the work of the ESPRIT project 278 which is concerned with the development of an integrated sensor based (tactile and vision) robot system capable of intelligent action within the area of workpiece positioning and orientation, an important class of manufacturing problems. A vision system is used to provide an initial estimate of workpiece position and orientation which allows the robot to grasp the object. During the grasping phase, the tactile sensor confirms, modifies or improves the initial information provided by the vision system. (Author abstract) 5 refs. In German.

Warnecke, H.J.; Lindner, H.; Glaess, W. *Robotersysteme* v 4 n 1 1988 p 1-8.

**091046 KNOWLEDGE-BASED ROBOTICS.** Even if we use techniques such as geometric modelling for representing objects in the robot world, we are still lacking in methods for linking such representations with sensory feedback. In this paper, we have proposed the use of intermediate representations—we call them sensor-tuned representations—for linking constructive solid geometry (CSG) based solid modelling with sensory information. We also discuss how sensor-tuned representations are constructed from range data and how object recognition can be done with sensor-tuned representations. Finally, we show results of manipulation experiments produced by the current implementation of the system. (Edited author abstract) 22 refs.

Kak, A.C. (Purdue Univ, West Lafayette, IN, USA); Vayda, A.J.; Cromwell, R.L.; Kim, W.Y.; Chen, C.H. *Int J Prod Res* v 26 n 5 May 1988 p 707-734.

**091047 ROBOTICS RESEARCH AND DEVELOPMENT CONTINUE TO ADVANCE, ACHIEVING HIGHER LEVELS OF APPLICATION.** The article focuses on the details of industrial robot development in Japan and on trends in production, research, progress and future prospects. Research and development of third generation robots is now under way centering on the most advanced technological efforts. Traditionally, teaching/playback method has always existed between man and robots. In the future, however, although man will retain total control, the robots themselves will be able to process sophisticated environmental information and act according to their own judgment. At that time, only when the robot itself becomes incapable of effecting such judgment, the operator will be asked to judge how best to act in under the circumstances. This will be characterized as a robot-man system.

Maeda, Yuji (Mechanical Engineering Lab). *Trade Times* 424 Mar 1 1988 p 6-10.

**091048 INCREASING THE INDUSTRIAL ROBOT'S IQ.** High-level control in which the computer determines the motion path required to accomplish a task (known as intelligent control) is considered. The concepts of artificial intelligence and of a universal machine are examined in this context. Robot programming is then discussed. 2 refs.

Hall, Ernest L. (Georgia Technical Research Inst, Atlanta, GA, USA). *IEEE Potentials* v 6 n 4 p 38-40.

**091049 DYNAMIC MULTI-SENSOR DATA FUSION SYSTEM FOR INTELLIGENT ROBOTS.** The objective of the authors is to develop an intelligent robot workstation capable of integrating data from multiple sensors. The investigation is based on a Unimation PUMA 560 robot and various external sensors. These include overhead vision, eye-in-hand vision, proximity, tactile array, position, force/torque, cross-fire, overload, and slipsensing devices. The efficient fusion of data from different sources will enable the machine to respond promptly in dealing with the 'real world.' Towards this goal, the general paradigm of a sensor data fusion system has been developed, and some simulation results, as well as results from the actual implementation of certain concepts of sensor data fusion, have been demonstrated. 24 refs.

Luo, Ren C. (North Carolina State Univ, Raleigh, NC, USA); Lin, Min-Hsiung; Scherp, Ralph S. *IEEE J Rob Autom* v 4 n 4 Aug 1988 p 386-396.

## Japan

**091050 PRODUCTION ENGINEERING LABORATORY, DEPARTMENT OF MECHANICAL ENGINEERING, KYUSHU INSTITUTE OF TECHNOLOGY.** The current state of research at PEL/KIT covering automation and highly accurate production machining technology, especially for robots, has been briefly introduced. In the production field, R&D activities are positively conducted on the basis of the concepts of CAD/CAM and FA in order to rationalize production systems completely, together with the rapid progress in microelectronics and mechatronics technologies. The deburring robot DR-1 has been developed to release operators from work in ill-conditioned environments surrounded by vibration, noise, and dust, where deburring operations of castings are conducted. The measuring robot MR aims at automatically measuring the dimensions of machined workpieces set at an arbitrary position. To recognize the kind of workpiece, MR takes a picture of the workpiece by means of an ITV camera and processes it to obtain the contour. A simplified algorithm allows identification of the workpiece shape which is transferred to the robot. 2 Refs.

Takeuchi, Yoshimi (Kyushu Inst of Technology, Kitakyushu, Jpn). *Adv Rob* v 2 n 1 1987 p 99-102.

Laser Applications See WELDING, ELECTRIC ARC—Robot Applications.

## Learning

**091051 ON THE ITERATIVE LEARNING CONTROL THEORY FOR ROBOTIC MANIPULATORS.** An iterative learning technique is applied to robot manipulators, using an inherently nonlinear analysis of the learning procedure. In particular, a 'high-gain feedback' point of view is utilized to prove the possibility of setting up uniform upper bounds to the trajectory errors occurring at each trial. The subsequent analysis of convergence shows that apart from minor conditions, the existence of a finite (but not necessarily narrow) bound on the trajectory deviations can substantially suffice to guarantee the zeroing of the errors after a sufficient number of trials. This in turn leaves open the possibility of obtaining the exact tracking of the desired motion, even in the presence of moderate values assigned to the feedback gains. 16 refs.

Bondi, Paola (Univ di Naples, Italy); Casalino, Giuseppe; Gambardella, Lucia. *IEEE J Rob Autom* v 6 n 2 Feb 1988 p 14-22.

**091052 REALIZATION OF ROBOT MOTION BASED ON A LEARNING METHOD.** To make a robot track a given desired motion trajectory, a learning control scheme is proposed which is based on the repeatability of robot motion. In this scheme the robot obtains a desired motion by repeating trials (test motion). A merit of this control scheme is that the input torque



pattern that generates the desired motion can be formed without estimating the physical parameters of robot dynamics. In practice, to allow the robot motion to approach the desired one in each trial, the input torque given to the robot at the present trial is modified only by the velocity signal of the real robot motion at the previous trial and the desired one. The convergence to the desired motion is theoretically proved for a linear time-varying mechanical system, which is an approximate representation of nonlinear robot dynamics in the vicinity of the desired motion. The effectiveness of this control scheme is demonstrated through actual experiments in which a revolute-type manipulator with three degrees of freedom is used, and the desired motion trajectory is given not only in terms of joint-angle coordinates but also in terms of task-oriented coordinates. 7 refs.

Kawamura, Sadao (Ritsumeikan Univ, Kyoto, Jpn); Miyazaki, Fumio; Arimoto, Suguru. *IEEE Trans Syst Man Cybern* v 18 n 1 1988 p 126-134.

**Maintenance** See ARTIFICIAL INTELLIGENCE—Expert Systems.

**Manipulators** See Also ACTUATORS—Balancing; COMPUTER PROGRAMMING LANGUAGES—Applications; CONTROL, MECHANICAL VARIABLES—Position; CONTROL SYSTEMS—Applications; CONTROL SYSTEMS—Mathematical Models; CONTROL SYSTEMS—Robustness; CONTROL SYSTEMS, ADAPTIVE—Mathematical Models; CONTROL SYSTEMS, LINEAR; CONTROL SYSTEMS, LINEAR—Robustness; ELECTRIC LINES—Repair; EQUATIONS OF MOTION; FORGING—Automation; GARMENT MANUFACTURE—Robot Applications; INDUSTRIAL PLANTS—Flexible Manufacturing Systems; INTEGRATED CIRCUITS, VLSI—Applications; MECHANICAL ENGINEERING—Research; MECHANICAL VARIABLES MEASUREMENT—Acceleration; MECHANISMS—Control; METAL FINISHING—Deburring; NUCLEAR REACTORS—Inspection; REMOTE CONTROL—Mathematical Models; ROBOTICS—Analysis; ROBOTICS—Computer Aided Design; ROBOTICS—Control Systems; ROBOTICS—Elasticity; ROBOTICS—Space Applications; SENSORS—Applications; SPACE SHUTTLES—Robot Applications.

**091053 STATIC PROPERTIES OF BILATERAL ROBOTS.** This letter deals with the behavior of master-slave systems in equilibrium. Nonlinear properties of similar or dissimilar tele-manipulators are found by introducing a differential reciprocity concept. (Author abstract) 6 refs.

Vibet, C. (Univ Paris XII, Evry, Fr); Cotsaftis, M. *Robotics* v 3 n 2 Jun 1987 p 235-239.

**091054 STUDY ON DESIGN AND CONTROL OF TORQUE-CONTROLLED MANIPULATORS.** Force related tasks are analyzed and robot motions for executing these tasks are studied. Servoing methods are, then, developed for realizing the robot motions in rigorous and general way, considering the dynamic properties of the controlled system. (Edited author abstract) In Japanese. 75 refs.

Takase, Kunikatsu. *Denshi Gijutsu Sogo Kenkyusho Kenkyu Hokoku* n 876 Dec 1986 1-134.

**091055 KINEMATIC ACCURACY OF SPATIAL MECHANISMS AND ROBOT MANIPULATORS.** The theory of the kinematic accuracy of spatial mechanisms (position, velocity, acceleration) is described. Both the exact and linearized theory is presented based on the basic matrices approach. The method is described to determine the tolerance space of the output motion from the tolerance spaces of dimensions and driving joint variables as well as the solution of the inverse problem. The application of the theory is illustrated by the solution of the analytical and synthetic problem of the kinematic accuracy for the robot manipulator. (Edited author abstract) 6 refs.

Valasek, Michael; Stejskal, Vladimir. *Acta Tech CSAV* v 32 n 4 1987 p 453-478.

**091056 SPECIFIC FEATURES OF KINEMATICS OF MANIPULATORS BASED ON PLANE CLOSED-TYPE MECHANISMS.** Results of a comparative investigation for a fast response of plane open-type

and closed-type manipulators with two degrees of mobility are presented. It is based on a solution of direct and inverse problems of kinematics for the positions and velocities of the operating points of these mechanisms. It is shown that a closed kinematic chain using a second-class Assur mechanism ensures an almost tenfold increase in fast response at some points of the serving zone, in addition to increasing by several times the accuracy of positioning. The simplicity of the driving link drive system and of the manipulator closed mechanism control system is noted. (Translated author abstract) In Russian. 7 refs.

Dzholdasbekov, U.A.; Slutskii, L.I.; Izmambetov, M.B.; Safontsev, E.A. *Izv Vyssh Uchebn Zaved Mashinostr* n 3 1987 p 45-49.

**091057 ON THE ADAPTIVE CONTROL OF ROBOT MANIPULATORS.** A new adaptive robot control algorithm is derived, which consists of a PD feedback part and a full dynamics feedforward compensation part, with the unknown manipulator and payload parameters being estimated online. The algorithm is computationally simple, because of an effective exploitation of the structure of manipulator dynamics. In particular, it requires neither feedback of joint accelerations nor inversion of the estimated inertia matrix. The algorithm can also be applied directly in Cartesian space. (Author abstract) 21 refs.

Slotine, Jean-Jacques E. (MIT, Cambridge, MA, USA); Li, Weiping. *Int J Rob Res* v 6 n 3 Fall 1987 p 49-59.

**091058 DESIGN OF FLEXIBLE ROBOTIC MANIPULATORS WITH OPTIMAL ARM GEOMETRIES FABRICATED FROM COMPOSITE LAMINATES WITH OPTIMAL MATERIAL PROPERTIES.** The authors develop a method for optimally configuring the geometry and the material fabrication parameters of hollow box members for robotic manipulators constructed with composite laminates. We do it by integrating a formulation for laminated beams with a recent approach for predicting the damping characteristics of laminates before incorporating this general theory into an optimization algorithm, which permits general constraint conditions to be imposed on the solution procedure. To illustrate the proposed design methodology, we give an example of an industrial manipulator with flexible links that describes three-dimensional motion. (Edited author abstract) 28 refs.

Liao, D.X. (Michigan State Univ, East Lansing, MI, USA); Sung, C.K.; Thompson, B.S. *Int J Rob Res* v 6 n 3 Fall 1987 p 116-130.

**091059 POLE ASSIGNMENT SELF-TUNING CONTROLLER FOR ROBOTIC MANIPULATORS.** This paper presents an effective adaptive controller for robotic manipulators. A perturbation difference model of the manipulator is established based on which a modified pole assignment self-tuning control algorithm is developed. The controller is designed such that the variance of a generalized cost function is minimized and the controller parameters are estimated directly. Closed-loop pole assignment is achieved by adjusting on-line the weighting factors in the cost function. Simulations to a manipulator with three degrees of freedom are given to demonstrate the effectiveness of this self-tuning controller. (Edited author abstract) 9 refs.

Liu, Mei-Hua (Changsha Inst of Technology, China); Lin, Wei. *Int J Control* v 46 n 4 Oct 1987 p 1307-1317.

**091060 SYMBOLIC MATRIX MANIPULATION PACKAGE FOR THE KINEMATIC ANALYSIS OF ROBOT MANIPULATORS.** Symbolic matrix manipulations, repetitious and time-consuming, generate many chances for mistakes. A set of computer programs to handle and then review these tasks could be a valuable tool for the engineer.

Driels, Morris R. (Texas A&M Univ, College Station, TX, USA). *Comput Mech Eng* v 5 n 2 Sep 1986 p 38-46.

**091061 NEW GENERAL ALGORITHM FOR DE-**

**SCRIBING MANIPULATOR KINEMATICS.** A new algorithm for representing the kinematic problem of robot arms is presented, and its advantages discussed. It is shown that manipulator links and joints can be described using generalized cascaded 'robot joint descriptors'. Such a description provides a theoretical basis for the development of a kinematic controller applicable to most manipulator geometries. (Author abstract) 3 refs.

Cook, C.D. (Univ of Wollongong, Aust); Vu-Dinh, T. *Mech Eng Trans Inst Eng Aust* v ME 10 n 3 Sep 1985 p 169-174.

**091062 FORCE COMPLIANT MOTION IN A POSITION CONTROLLED MANIPULATOR.** Control of robot manipulators is reviewed with special emphasis on the requirements during fine motion with contact forces. Various approaches to force based control systems are discussed. An approach to force control which can be added on to existing commercial position controllers is presented and an implementation of this scheme is described. The limitations of the approach are pointed out and suggestions for further enhancements made. (Author abstract) 10 refs.

Hendy, B.G. (RMIT, Aust); Holzer, A.J. *Mech Eng Trans Inst Eng Aust* v ME 10 n 3 Sep 1985 p 183-186.

**091063 MANIPULATOR CONTROL USING A DATA-DRIVEN MULTI-PROCESSOR COMPUTER SYSTEM.** A number of schemes employing several conventional computational elements or a conventional processor augmented with special purpose transform processors to control manipulator systems have been used. The computational model underlying conventional computing architectures is itself inadequate and not very useful. Certainly the data communication mechanism in systems using several conventional computational elements is difficult to integrate with the sequential computing model. The study described in this paper applies a computing system based on the Data-flow model of computation to the task of manipulator control. Subjects covered include data flow, computation, task decomposition, and others. 22 refs.

Egan, G.K. (RMIT, Aust); Richardson, C.P. *Mech Eng Trans Inst Eng Aust* v ME 10 n 3 Sep 1985 p 218-222.

**091064 ON MULTIPLE MOVING OBJECTS.** This paper explores the motion-planning problem for multiple moving objects. The approach taken consists of assigning priorities to the objects, then planning motions one object at a time. For each moving object, the planner constructs a configuration space-time that represents the time-varying constraints imposed on the moving object by the other moving and stationary objects. The planner represents this space-time approximately, using two-dimensional slices. The space-time is then searched for a collision-free path. The paper demonstrates this approach in two domains. One domain consists of two-link planar articulated arms. (Author abstract) 26 refs.

Erdmann, Michael (MIT, Cambridge, MA, USA); Lozano-Perez, Tomas. *Algorithmica (New York)* v 2 n 4 1987 p 477-521.

**091065 ON THE EXISTENCE AND SYNTHESIS OF MULTIFINGER POSITIVE GRIPS.** We study the criteria under which an object can be gripped by a multifingered dexterous hand, assuming no static friction between the object and the fingers; such grips are called positive grips. We study three cases in detail: (i) the body is at equilibrium, (ii) the body is under some constant external force/torque, and (iii) the body is under a varying external force/torque. In each case we obtain tight bounds on the number of fingers needed to obtain grip. We also present efficient algorithms to synthesize such positive grips for bounded polyhedral/polygonal objects; the number of fingers employed in the grips synthesized by



our algorithms match the above bounds. The algorithms run in time linear in the number of faces/sides. (Edited author abstract) 25 refs.

Mishra, B. (New York Univ, New York, NY, USA); Schwartz, J.T.; Sharir, M. *Algorithmica* (New York) v 2 n 4 1987 p 541-558.

**091066 APPROACH TO THE DESIGN OF IDEAL ROBOTIC MANIPULATORS HAVING SIMPLE DYNAMIC CHARACTERISTICS.** The dynamic characteristics of currently used, multi-degrees-of-freedom robots are too complex to analyze and thus, it is not possible to design an implementable control algorithm. This paper proposes the guidelines to use in designing an ideal robot whose dynamics are much simpler than those of the conventional robot. It is shown that, even if the proposed design criteria are fulfilled with respect to the wrist only, the dynamic complexity can be drastically removed so that the conventional robot approaches very close to an ideal robot having simple dynamic characteristics. This paper further shows that the ideally designed robot dynamics can be very easily derived from Lagrangian formulation. (Edited author abstract) 13 refs.

Park, H.S. (Korea Advanced Inst of Science and Technology, Seoul, South Korea); Cho, H.S. *Proc Inst Mech Eng Part B* v 201 n 4 1987 p 221-228.

**091067 EXPERIENCE AND OUTLOOKS ON OUR STUDIES ON ROBOTS.** There are many kinds of robots - from a manual manipulator to an intelligent robot - which may be classified by various levels of autonomy. Since a robot is a machine used by human beings, it is essential to make the robot easy to handle. Therefore, it is necessary to adapt the robot to human characteristics. To be able to develop more intelligent robots, we need to study the man-robot interface in more detail. The paper discusses remote control manipulation; computer control of manipulators of a robot arm; introduction of the method of virtual reference; dynamic control; other research concerning the control of manipulators; use of visual information; and locomotion and its combination with vision. 19 refs.

Fujii, Sumiji (Univ of Tokyo, Tokyo, Jpn); Yoshimoto, Kenichi. *Adv Rob* v 1 n 1 1986 p 71-82.

**091068 MICROCOMPUTER CONTROL OF AN EXPERIMENTAL FIVE-AXIS ROBOT MANIPULATOR.** This paper outlines the development of a five-axis robot manipulator which was undertaken by project students in the Department of Mechanical and Marine Engineering of the Hong Kong Polytechnic. The design and construction of the manipulator itself, the associated microprocessor-based control system and interfaces together with the writing of assembly-language software are described. Experimental determination of the controller settings for the first three axes is also mentioned at the end of the paper. (Author abstract) 7 refs.

Leung, T.P. (Hong Kong Polytechnic); Fung, H.K. *Hong Kong Eng* v 14 n 5 May 1986 p 5-12.

**091069 MODELING AND CONTROL OF ELASTIC JOINT ROBOTS.** In this paper, the author will study the modeling and control of robot manipulators with elastic joints. A simple model to represent the dynamics of elastic joint manipulators is derived under two assumptions regarding dynamic coupling between the actuators and the links, and is useful for cases where the elasticity in the joints is of greater significance than gyroscopic interactions between the motors and links. In the limit as the joint stiffness tends to infinity, our model reduces to the usual rigid model found in the literature, showing the reasonableness of our modeling assumptions. It is shown that our model is significantly more tractable with regard to controller design than previous nonlinear models that have been used to model elastic joint manipulators. (Edited author abstract) 36 refs.

Spong, M.W. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA). *J Dyn Syst Meas Control Trans ASME* v 109 n 4 Dec 1987 p 310-319.

**091070 DIGITAL ALGORITHM FOR NEAR-MINIMUM-TIME CONTROL OF ROBOT MANIPULATORS.** A digital state feedback control algorithm has been developed to obtain the near-minimum-time trajectory for the end-effector of a robot manipulator. In this algorithm, the poles of the linearized closed loop system are judiciously placed in the Z-plane to permit near-minimum-time response without violating the constraints on the actuator torques. The validity of this algorithm has been established using numerical simulations. A three-link manipulator is chosen for this purpose and the results are discussed for three different combinations of initial and final states. (Author abstract) 15 refs.

Kao, C.K. (Pennsylvania State Univ, University Park, PA, USA); Sinha, A.; Mahalanabis, A.K. *J Dyn Syst Meas Control Trans ASME* v 109 n 4 Dec 1987 p 320-327.

**091071 PATH GENERATION BY RATE CONTROL OF MANIPULATORS.** This paper proposes a real-time control algorithm, in which both the actual errors of position and of orientation are fed back to the control value calculated for each sampling time. This paper also defines the distance between two orientations, and presents a set of formulas for orientational error using quaternions. An algorithm using screw algebra is developed for the real-time computation of joint velocities. Finally, the accuracy of trajectory control using this algorithm is studied experimentally. (Author abstract) 4 refs.

Sakaue, Shiyuki (Hitachi Ltd, Yokohama, Jpn); Sugimoto, Koichi. *Rob Comput Integr Manuf* v 3 n 4 1987 p 381-387.

**091072 3D AUTONOMOUS TRAJECTORY CONTROL OF ROBOT MANIPULATORS.** The structure of the three-dimensional autonomous trajectory control system is analyzed as a control system driven by the feedback of the proximity sensory information between the end effector and a spatial curve. The Jacobian matrix of the autonomous trajectory control system is then defined, which includes the information on the spatial curve to be traced. Based on the analysis, a three-dimensional autonomous trajectory control system is synthesized. Simulation results show its effectiveness for improving performance, and also prove that the orientational error does not disappear because of the lack of information on the curvature of the spatial curve. Finally, to improve the orientational characteristics in autonomous trajectory control, a special wrist mechanism is proposed. 17 refs.

Nakamura, Yoshihiko (Kyoto Univ, Uji, Jpn); Hanafusa, Hideo. *Rob Comput Integr Manuf* v 3 n 4 1987 p 395-408.

**091073 CONTROL OF MOTION OF MANIPULATOR WITH PROXIMITY SENSOR ALONG PROFILE OF OBJECT.** A gantry-type manipulator is considered that is equipped with an optical proximity sensor (OPRS). The two-dimensional motion of the manipulator is studied along the profile of an object whose shape is not known a priori. A control technique is described that yields this motion. An analytic study is made of motion along a straight line and a circle. Stationary motions along these curves are sought and their stability is analyzed. Experiment shows that by such a control technique it is possible to move the manipulator along the profile of objects of complex shape. (Author abstract) 15 refs.

Lizunov, A.B.; Formal'skii, A.M.; Schneider, A.Yu. *Autom Remote Control* v 48 n 5 pt 1 May 1987 p 607-615.

**091074 GENERALIZED INVERSES FOR ROBOTIC MANIPULATORS.** Jacobians are used in robotics for motion planning and control. They are also used in algorithms that determine linkage parameter errors of robots and in algorithms that determine pair variable corrections for accurate motion. Most applications require that the inverse of the Jacobian be obtained. The causes of singularities in Jacobians and a procedure to detect their presence are given. Appropriate inverse solution techniques and their implementation for robots with

various types of singularities is outlined. The solutions are applicable to robots with less than, equal to, or greater than six degrees of freedom. For each case, the implementation of both the complete Moore-Penrose inverse and a robot specific pseudo inverse are included. Although it is not necessary to use the Moore-Penrose inverse on any particular robot, the Moore-Penrose inverse can be used to obtain generic inverses for general purpose applications. (Author abstract) 20 refs.

Tucker, Michael (Lehigh Univ, Bethlehem, PA, USA); Ferreira, N. Duke. *Mech Mach Theory* v 22 n 6 1987 p 507-514.

**091075 ERROR ANALYSIS OF POSITION AND ORIENTATION IN ROBOT MANIPULATORS.** The error analysis of position and orientation in a robot hand is presented in this paper. The paper deals mainly with developing all the partial derivatives which are the error transmission functions. They are present in unified as well as quite simple form. In Section 5 of this paper a compensation of errors is also discussed and the equations of error compensation are developed. (Author abstract) 6 refs.

Huang, Z. (Northeast Heavy Machinery Inst, Fulaerji, China). *Mech Mach Theory* v 22 n 6 1987 p 577-581.

**091076 EIN SYSTEMATISCHES VERFAHREN FUER DIE RUECKWAERTSTRANSFORMATION BEI INDUSTRIEROBOTERN.** [Systematic Approach for Solving the Inverse Kinematic Problem of Robot Manipulators]. The inverse kinematic problem of robot manipulators requires the computation of the joint coordinates to execute prescribed trajectories. It implies the determination of six dependent joint coordinates in a kinematical multibody loop via six nonlinear algebraic constraint equations. The approach presented in this paper yields a non-redundant system of constraint equations which is always partitioned into an implicit core system and explicitly solvable equations. General rules have been derived for the generation of these equations. For numerous classes of manipulator designs even the complete system of equations can be solved in closed form. The method is applied to the inverse coordinate transformation of a robot with non-orthogonal revolute axes. (Author abstract) In German. 10 refs.

Woernle, C. *Robotersysteme* v 3 n 4 1987 p 219-228.

**091077 MANIPULATOREN FUER DEN TUNNEL-UND STRECKENAUSBAU IM UNTERTAGEBETRIEB.** [Manipulators for Tunnel and Mine Roadway Support in Underground Operation]. In tunneling and mining different mechanized lining drive systems are used. Inherent to all lining drive systems is a common need to shield the tunnels and mine roadways against rock pressure by setting lining supports. In this paper different typical manipulators for erecting lining segments and mine roadway supports are presented. For each manipulator type an overview is given in regard to machine design, main characteristics and application possibilities. Also an outlook for future developments is presented. (Author abstract) In German. 11 refs.

Wanner, M.-C.; Hofmann, R. *Robotersysteme* v 3 n 4 1987 p 237-245.

**091078 CARTESIAN CONTROL OF A SPRAY-PAINTING ROBOT WITH REDUNDANT DEGREES OF FREEDOM.** A controller for redundant manipulators with a small, fast manipulator mounted on a positioning part has been developed. The controller distributes the fast motion to the small, fast manipulator and the slow, gross motion to the positioning part. A position reference is generated on-line to the positioning part to avoid singularities and the loss of degrees of freedom. This reference is selected according to an ad hoc procedure which makes the small, fast manipulator work around the centre of its working range. In the control system, the task space position vector is augmented with the generalized coordinates of the positioning part. The



experiments showed that a high bandwidth and a large working range were possible with moderate motor torques, and that the end effector had a higher bandwidth than the positioning part. (Edited author abstract) 21 refs.

Egeland, Olav; Balchen, Jens G. *Model Ident Control* v 8 n 4 Oct 1987 p 185-199.

**091079 MODELING OF MANIPULATOR DYNAMICS IN THE CASE OF A VIBRATING BASE.** We investigate the dynamics of a manipulation robot with a vibrational stimulus that is transmitted via the base or foundation of the supporting structure of the manipulator. The manipulator is treated as a chain of rigid bodies that are connected in series by rotational or translational pairs, rigidly connected to a base that executes translational and angular vibrations. Control of the robot is constructed with feedback with respect to departures from nominal motion. Numerical and asymptotic methods of calculating the departures of the manipulator motion from the nominal trajectory are proposed. Results of computer modeling of manipulator dynamics are given. (Author abstract) 11 refs.

Aksel'rod, B.V.; Vujic, D.; Vukobratovic, M.; Gradet'skii, V.G.; Chernous'ko, F.L. *Mech Solids* v 22 n 2 1987 p 55-61.

**091080 ON THE THEORY OF MANIPULATION SYSTEMS WITH FORCE SENSITIZATION.** Force-moment sensitization of robotic systems constitutes a promising line of development in robotics. This paper considers a general mathematical model of a manipulation robot with a force-moment adaptation system. Structural compliance of the manipulator (in the joints and elements) is disregarded. It is assumed that compliance is concentrated only in the force sensors. No constraints whatever are imposed on the kinematic scheme of the structure. We investigate the situation, which arises, e.g., in mechanical-treatment and assembly operations, in which mechanical constraints are imposed on the object of manipulation. We describe a method of control such that the object of manipulation moves along the constraints. This method utilizes information regarding the forces. As an example we consider the problem of assembly of a thread joint. (Edited author abstract) 13 refs.

Osipov, S.N.; Formal'skii, A.M. *Mech Solids* v 22 n 2 1987 p 62-70.

**091081 INVESTIGATION OF THE DYNAMIC CHARACTERISTICS OF A ONE-DIMENSIONAL MANIPULATOR BY THE ROOT TRAJECTORY METHOD.** We consider a linear model of a manipulator with positional and velocity feedback. By using the trajectory method, we investigate the position of the roots of the characteristic determinant in relation to the relationships between the feedback coefficients. We propose a method of constructing the root trajectories for a particular system with allowance for all possible situations. We also consider some limiting cases. (Edited author abstract) 4 refs.

Borovoi, A.V. *Mech Solids* v 22 n 2 1987 p 71-74.

**091082 DSP BASED NUMERICAL CALCULATION ENGINE FOR MANIPULATOR CONTROL.** A general purpose vector/matrix calculation engine based on a 13.4MFLOPS single chip floating point digital signal processor (DSP  $\mu$ PD77230 has been developed. This engine has been proposed to simplify DSP programming without degrading its high performance computation capabilities. Basic vector/matrix functions and general functions for scalar value computation have been developed and their performance has been measured. To measure actual effectiveness in applications, algorithms for kinematics and control in robotics computation have been implemented on the engine, and their execution time has been estimated. Inverse dynamics for 6 rotational joint manipulators, based on the recursive Newton-Euler equation and with no customization for specific manipulators, has been calculated in under 0.9 msec. An efficient computation algorithm for the Jacobi matrix for the same type manipulators has been derived in under 0.3 msec. An

active stiffness control algorithm has also been computed in under 0.7 msec. This engine can be applied to high-sample-rate real time robot control as a numerical calculation accelerator. (Edited author abstract) 12 refs.

Takanashi, Nobuaki (NEC, Jpn). *NEC Res Dev* n 87 Oct 1987 p 26-33.

**091083 ADAPTIVE COMPUTED TORQUE CONTROL FOR RIGID LINK MANIPULATIONS.** We examine the adaptive control of rigid link manipulator systems. Linear estimation techniques together with a computed torque control law are shown to give a globally convergent adaptive system which does not require measurements of accelerations. (Edited author abstract) 18 refs.

Middleton, R.H. (Univ of Newcastle, Aust); Goodwin, G.C. *Syst Control Lett* v 10 n 1 Jan 1988 p 9-16.

**091084 MULTIVARIABLE SELF-TUNING CONTROL WITH DECOUPLING FOR ROBOTIC MANIPULATORS.** The paper presents two self-tuning control schemes for robotic manipulators, based on two canonical multivariable difference models. The controllers are designed such that the variances of generalized cost functions are minimized and the controller parameters are directly estimated. The weighting factors in the cost function can be prespecified in such a form that the manipulator system is decoupled and closed-loop pole assignment is achieved. Simulation results on a robotic manipulator with three degrees of freedom are presented to demonstrate the effectiveness of, and to make a performance comparison between, these two schemes. (Author abstract) 22 refs.

Liu, Mei-Hau (Changsha Inst of Technology, Changsha, China); Lin, Wei. *IEE Proc Part D* v 135 n 1 Jan 1988 p 43-48.

**091085 GLOBALLY STABLE COMPLIANT MOTION CONTROL FOR ROBOTIC ASSEMBLY.** Compliant control has been proposed as a means of avoiding the expense of highly accurate robots, fixtures and tooling. The Artificial Potential approach is an approach to compliant control which guarantees asymptotic stability but yields little insight into how one might design a controller to meet specific transient behavior specifications. The Robust Compliant Motion approach yields a controller which causes the manipulator to behave like a specified mechanical impedance in a small region of the workspace, but does not ensure stability outside this region. We present design criteria which yield a globally stable controller meeting a target impedance specification in a region about a specified operating point. Our criteria consist of three matrix equations which must be satisfied by position, velocity and feedforward gain matrices. We propose three methods of solving these equations, illustrating one of the methods with an example. We show how the design approach may be extended to redundant manipulators. (Edited author abstract) 14 refs.

Hamilton, William E. Jr. (GM, Warren, MI, USA). *Res Publ Gen Mot Res Lab GMR-6105* Jan 12 1988 25p.

**091086 EXPERIMENTAL EVALUATION OF NONLINEAR FEEDBACK AND FEEDFORWARD CONTROL SCHEMES FOR MANIPULATORS.** The manipulator trajectory tracking control problem revolves around computing the torques to be applied to achieve accurate tracking. We present the experimental results of the real-time performance of model-based control algorithms. We compare the computed-torque control scheme with the feedforward dynamics compensation scheme. The feedforward scheme compensates for the manipulator dynamics in the feedforward path, whereas the computed-torque scheme uses the dynamics in the feedback loop for linearization and decoupling. The parameters in the dynamics model for the computed-torque and feedforward schemes were estimated by using an identification algorithm. Our experiments underscore the importance of including the off-diagonal terms of the manipulator inertia matrix in the torque computation. The manipulator control schemes have been implemented on the CMU DD

arm II. (Edited author abstract) 20 refs.

Khosla, Pradeep K. (Carnegie Mellon Univ, Pittsburgh, PA, USA); Kanade, Takeo. *Int J Rob Res* v 7 n 1 Feb 1988 p 18-28.

**091087 STABILIZATION OF DESIRED MANIPULATOR ROBOT MOTIONS ON THE BASIS OF A RECURSIVE FORM OF MOTION EQUATIONS.** For manipulators with a complex kinematic behavior the operation speed of the algorithms forming the controls to stabilize a desired motion can be improved by means of recurrence algorithms. Of great interest is the method of analysis of a system of solids that allows viewing the system as a set of independent interacting physical pendulums with variable suspension points. The equations of motion of a manipulator are written in a recursive form. The equations are used to construct an effective stabilization algorithm for desired manipulator motions. 5 refs.

Arefin, I.G. *Leningrad Univ Mech Bull* n 2 1987 p 49-51.

**091088 PROGETTAZIONE DI UNA MANO AD ELEVATA DESTREZZA PER ROBOT INDUSTRIALI.** [Design of a High Dexterity Hand for Industrial Robots]. The article illustrates the goals and the progress made by a research program aimed at designing an extremity organ for industrial robots capable of performing complex operations of gripping and manipulating objects of different nature and shape. The principal design themes and solutions adopted relative to the mechanical configuration of the organ, the actuation system and sensors employed, control strategies and architecture of the system are presented. Emphasis is placed on the architectural and control aspects. Experimental results obtained so far and future lines of development of the project are illustrated. (Translated author abstract) In Italian. 28 refs.

Bonivento, C. (Univ di Bologna, Italy); Caselli, S.; Faldella, E.; Laschi, R.; Melchiorri, C.; Tonielli, A. *Alta Freq* v 56 n 7 Sep 1987 p 181-189.

**091089 APPLICATIONS OF DAMPED LEAST-SQUARES METHODS TO RESOLVED-RATE AND RESOLVED-ACCELERATION CONTROL OF MANIPULATORS.** Resolved-rate and resolved-acceleration controllers have been proposed for manipulators whose trajectories are determined by real-time sensory feedback. For redundant manipulators, these controllers have been generalized using the pseudoinverse of the manipulator Jacobian. However, near singular configurations, these controllers fail in that they require infeasibly large joint speeds. A damped least-squares reformation of the problem gives approximate inverse kinematic solutions that are free of singularities. This paper defines the new controllers and proves their stability. Some aspects of the behavior of the new resolved-rate controller are illustrated in simulations. (Edited author abstract) 21 refs.

Wampler, C.W. II (GM Research Lab, Warren, MI, USA); Leifer, L.J. *J Dyn Syst Meas Control Trans ASME* v 110 n 1 Mar 1988 p 31-38.

**091090 TRACKING CONTROLLERS FOR ROBOT MANIPULATORS: A HIGH GAIN PERSPECTIVE.** We propose a controller for the path tracking problem of robotic manipulators. The proposed controller structure is similar to that of the computed-torque scheme widely known in the literature. Unlike the computed-torque scheme, this controller is robust with respect to parameter uncertainty and disturbances. The robustness is given by a high gain mechanism that works in conjunction with a nonlinear precompensator in the control loop. The fundamental action of the high gain is to minimize the effective uncertainty that remains, subsequent to any cancellation by the precompensator. Comparison of the performance of



this controller with two other schemes reported in the literature suggests that it performs as effectively. (Edited author abstract) 13 refs.

Jayasuriya, Suhada (Texas A&M Univ, College Station, TX, USA); Cheng, Neng Hwang. *J Dyn Syst Meas Control Trans ASME* v 110 n 1 Mar 1988 p 39-45.

**091091 DYNAMIC LOAD CARRYING CAPACITY OF MECHANICAL MANIPULATORS - PART I: PROBLEM FORMULATION.** Two types of problems associated with load carrying capacity of robot manipulators are studied. The first type of problem involves determining the maximum load carrying capacity of a robot manipulator given a dynamic robot trajectory. The second problem involves synthesizing point-to-point dynamic robot motions with optimum load carrying capacities. In this Part I of the paper, the first type problem and the formulation of the second type problem are presented. A computational procedure for obtaining numerical solutions to the second type problem together with the application of the results to advanced trajectory synthesis and classification of multi-degree-of-freedom robot manipulators are given in the companion Part II of the paper. (Author abstract) 6 refs.

Wang, L.T. (Univ of Wisconsin-Madison, Madison, WI, USA); Ravani, B. *J Dyn Syst Meas Control Trans ASME* v 110 n 1 Mar 1988 p 46-52.

**091092 DYNAMIC LOAD CARRYING CAPACITY OF MECHANICAL MANIPULATORS - PART II: COMPUTATIONAL PROCEDURE AND APPLICATIONS.** A computational procedure is presented for obtaining numerical solutions to the trajectory optimization problem associated with synthesizing robot dynamic trajectories with maximum load carrying capacities. The applications of the procedure and the problem formulations given in Part I of this paper to synthesizing time-optimal robot motions and classification of multi-degree-of-freedom robot manipulators are also investigated. (Author abstract) 25 refs.

Wang, L.T. (Univ of Wisconsin-Madison, Madison, WI, USA); Ravani, B. *J Dyn Syst Meas Control Trans ASME* v 110 n 1 Mar 1988 p 53-61.

**091093 IMPLEMENTATION OF ADAPTIVE TECHNIQUES FOR MOTION CONTROL OF ROBOTIC MANIPULATORS.** This paper is concerned with the digital implementation and experimental evaluation of two adaptive controllers for robotic manipulators. The first is a continuous time model reference adaptive controller, and the second is a discrete time adaptive controller. The primary purpose of these adaptive controllers is to compensate for inertial variations due to changes in configuration and payload, as well as disturbances, such as Coulomb friction and/or gravitational forces. Experimental results are obtained from a laboratory test stand, which emulates a one-axis direct drive robot arm with variable inertia, as well as a Toshiba TSR-500V industrial robot. Experimental results from the test stand indicate that these adaptive control schemes are promising for the control of direct drive robot arms. (Edited author abstract) 23 refs.

Tomizuka, M. (Univ of California, Berkeley, CA, USA); Horowitz, R.; Anwar, G.; Jia, Y.L. *J Dyn Syst Meas Control Trans ASME* v 110 n 1 Mar 1988 p 62-69.

**091094 ROBUST CONTROLLER DESIGN FOR ROBOT MANIPULATORS.** In this paper we give a control method for robot manipulators which takes account of both the command response and the robustness in a systematic way by utilizing two-degree-of-freedom controller configuration. A simulation result is given to show the validity of our method. (Author abstract) 12 refs.

Sugie, T. (Univ of Osaka Prefecture, Sakai, Jpn); Yoshikawa, T.; Ono, T. *J Dyn Syst Meas Control Trans ASME* v 110 n 1 Mar 1988 p 94-96.

**091095 PROCEDURE FOR CONSTRUCTION OF MANIPULATOR MOTIONS FROM A GIVEN LOCAL GRIP PATH IN THE PRESENCE OF OBSTA-**

**CLES.** The proposed procedure determines the variations of the generalized coordinates of a plane four-link manipulator as the grip moves along local paths in the presence of obstacles. The procedure is based on analysis of instantaneous states of the kinematic chain and analysis of the relative positions of maps of instantaneous velocity curves and obstacles. (Author abstract) 5 refs.

Pritykin, F.N.; Tevlin, A.M. *Sov Mach Sci* n 4 1987 p 30-33.

**091096 SYNTHESIS OF A MINIMUM-TIME MANIPULATOR TRAJECTORIES WITH GEOMETRIC PATH CONSTRAINTS USING TIME SCALING.** The minimum-time and subminimum-time joint trajectories of manipulators with geometric path constraints are planned in consideration of physical constraints based on kinematics and dynamics. The idea of time scaling is introduced, i.e. a time scale factor  $K(t)$  and a set of joint trajectories, called reference trajectories, are used to describe all the sets of trajectories tracing the specified geometric path. The desirable factor  $K(t)$  which makes the travelling time as short as possible is obtained by two proposed methods: the first one is an iteratively improving method using B spline, and the second one is a directly minimizing method. These two methods are preferably applied to a geometric collision-free path of a manipulator. (Author abstract) 8 refs.

Ozaki, H. (Kyushu Univ, Fukuoka, Jpn); Mohri, A. *Robotica* v 6 Pt 1 Jan-Mar 1988 p 41-46.

**091097 SENSITIVITY ANALYSIS OF BALANCED ROBOTIC MANIPULATORS.** The payload variation has been one of the principal reasons in reducing path tracking accuracy and complicating controller design. In this paper, the trajectory and input sensitivities for the payload variation are investigated for three different robot configurations which include unbalanced, inaccurately balanced and balanced configurations. Based upon the sensitivity theory, simulation studies were made to evaluate the sensitivities of these configurations with respect to payload variations. The simulation results are discussed in detail and compared for the three configurations. (Author abstract) 6 refs.

Chung, W.K. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Cho, H.S. *Robotica* v 6 Pt 1 Jan-Mar 1988 p 53-62.

**091098 OPTIMUM KINEMATIC DESIGN OF A PLANAR THREE-DEGREE-OF-FREEDOM PARALLEL MANIPULATOR.** In this paper, the design of a planar three-degree-of-freedom parallel manipulator is considered from a kinematic viewpoint. Four different design criteria are established and used to produce designs having optimum characteristics. These criteria are (a) symmetry (b) the existence of a nonvanishing workspace for every orientation of the gripper (c) the maximization of the global workspace, and (d) the isotropy of the Jacobian of the manipulator. The four associated problems are formulated and their solutions are derived. Two of these require to resort to numerical methods for nonlinear algebraic systems. Results of optimum designs are also included. (Author abstract) 14 refs.

Gosselin, C. (McGill Univ, Montreal, Que, Can); Angeles, J. *J Mech Transm Autom Des* v 110 n 1 Mar 1988 p 35-41.

**091099 SOLUTION ALGORITHM FOR AN INVERSE PROBLEM OF MULTILINK MANIPULATOR KINEMATICS.** In a solution algorithm proposed for an inverse problem of multilink manipulator kinematics, the motion of the characteristic point along its path and the orientation of the grip are presented on the basis of equations of consistent form that make it possible to give a general solution unrelated to the form of the structural diagram or the number of moving links. (Author abstract) 12 refs.

Krasil'nikov, A.Z.; Kistochkin, E.S. *Sov Mach Sci* n 6 1987 p 48-53.

**091100 SIMULATION OF ANTHROPOMOR-**

**PHIC MANIPULATOR DYNAMICS.** This paper presents the simulation of the direct problem of anthropomorphic manipulator dynamics. The simulation of robot dynamics is concerned with the trajectory programming, the solution of inverse problems of kinematics and the dynamic equations of robot. For a six-d.o.f. manipulator with a spherical wrist, we use the method of parting system to solve the inverse problems of kinematics. Besides, we present the procedure for obtaining dynamic equations of a general robot by using Kane's dynamic equation. (Edited author abstract) In Chinese. 7 refs.

Peng, Shangxian (Research Inst of Intelligent Machine, China); Wang, Kang. *Tianjin Daxue Xuebao* n 4 1987 p 11-20.

**091101 CO-ORDINATE DETERMINATION AND PERFORMANCE ANALYSIS FOR ROBOT MANIPULATORS AND GUIDED VEHICLES.** The paper describes a technique to determine and to track the three-dimensional 'world' coordinates of a point in space, relative to some defined datum. The work was initiated in order to track the location of a robot manipulator end effector, but has relevance to automatic guided vehicles and other applications. A prototype system has been built and evaluated, and has been used successfully to track the tip of a robot manipulator arm moving at velocities of up to 2 m/s within a working envelope consisting of a cube of side 2 m. Measurement resolution of 0.5 mm was obtained, and a sampling rate of 300 Hz was achieved, by the use of real-time software within the measurement system. The coordinates and the velocity outputs are computed in only 1.2 ms. The technique provides accurate tracking of end-effector position, which can be used both for evaluating the dynamic performance of existing controllers and for the synthesis of new forms of control. (Edited author abstract) 7 refs.

Dickinson, M. (Sheffield City Polytechnic, Sheffield, Engl); Morris, A.S. *IEE Proc Part A* v 135 n 2 Feb 1988 p 95-98.

**091102 ON VELOCITY AND ACCELERATION OF MANIPULATOR CHAINS.** Quaternions have been successfully used for describing orientation of a rigid body, for attitude transformation and control as well as for investigation into general characteristics of the angular motion of a rigid body. Among all kinds of kinematical equations, the kind of equations in terms of quaternions appears to be the most advantageous one. This paper presents a method using the  $3 \times 4$  short form quaternion matrix for analysis of the angular motion of a rigid body, which is then proved to be superior to the others. In the second part, two transformation algorithms are proposed for deriving the transformation relationships of a body vector. This method is an extension of the passive transformation and active transformation for a space vector introduced by H. Goldstein. Such an extension appears to be very efficient and satisfactory for calculating the velocity and acceleration of rigid body points. Finally, the two above mentioned algorithms are applied to analyze the velocity and acceleration of manipulator chains. (Edited author abstract) In Chinese. 7 refs.

Xiao, Shangbin. *Xilei Gongye Daxue Xuebao* v 6 n 2 Apr 1988 p 129-138.

**091103 AUTONOMOUS TRAJECTORY GENERATING SERVOMECHANISM WITH ORIENTATION CONTROL OF END-EFFECTOR.** As a high accuracy trajectory control technique for manipulators, the Autonomous Trajectory Generating Servomechanism (ATGS) has been proposed. Since the function of ATGS in the algorithm is to recover trajectories when they deviate from the specified paths, and the rate-servomechanism in the ATGS is inherently capable of restraining the influence of disturbances by the effect of feedback, the path drawn by the trajectory is robust against the effects due to the dynamics of manipulators and/or parameter changes of systems. The ATGS is extended to the spatial curve case. A trajectory-generating method including the orientation control of end-effector is presented. The



trajectory control method is implemented and tested in a real articulated manipulator. The experimental results have confirmed the effectiveness of the method proposed in this research. (Edited author abstract) 2 refs.

Hasegawa, Kensuke (Tokyo Inst of Technology, Jpn); Mizutani, Takashi; Zhang, Yu-Wu. *Syst Sci* v 12 n 4 1986 p 67-77.

**091104 MULTIVARIABLE CONTROL OF ROBOT MANIPULATORS.** Since manipulators are highly nonlinear, coupled multivariable systems, multivariable control approach is necessary in principle for high speed and accurate operation of manipulators. Multivariable control approaches to robot manipulators are outlined. Then decoupling control, which is one of the multivariable control approaches, of hydraulically driven robots is described. A construction method of an autonomous contouring control system is explained for a two-joint hydraulic robot. (Author abstract) 18 refs.

Yoshikawa, Tsuneo. *Adv Rob* v 2 n 2 1987 p 181-191.

**091105 VOICE CONTROL FOR A ROBOT - AN EXAMPLE OF A MANIPULATOR FOR THE DISABLED.** Most of the present voice recognition systems adopt a speaker-dependent method which expects the speaker's voice to be preregistered in its memory. And they use a contacting type microphone to cut out background noise. They are not 'good' man-machine interfaces, since they apply some kind of restriction upon the user to cover their technological limitations. In such a way, we must consider both the robots' needs and the limitations of voice recognition in constructing the man-machine interface. This paper, through an example of a voice-controlled manipulator for the upper-limb disabled, discusses the problems that have to be solved before a voice input and output system can be applied to the human-robot system. 6 refs.

Ifukube, Tohru. *Adv Rob* v 2 n 2 1987 p 193-200.

**091106 ON THE INVERSE KINEMATICS OF REDUNDANT MANIPULATORS.** Many conventional nonredundant manipulators have singular configurations, near which some small motions of the end-effector require excessive and physically unrealizable joint speeds. Consequently, the usable workspace of the manipulator is effectively reduced. It has been proposed that high joint speeds could be avoided by introducing redundant joints and using an appropriate kinematic inversion algorithm. For a very general class of kinematic inversion algorithms, the theorems of this paper state some fundamental relations between the properties of the algorithm and its ability to resolve such problems. These results have practical implications in the design of controllers for redundant manipulators, especially when real-time sensory input is used to modify the manipulator's trajectory. (Author abstract) 23 refs.

Baker, Daniel R. (GM Research Lab, Warren, MI, USA); Wampler, Charles W. II. *Int J Rob Res* v 7 n 2 Mar-Apr 1988 p 3-21.

**091107 NEW APPROACH FOR KINEMATIC RESOLUTION OF REDUNDANCY.** This paper deals with the trajectories of points embedded in a moving rigid body being guided by a linkage having extra or 'redundant' motion parameters. A new method for the kinematic use of redundancy is presented. The method is based on the concept of a metric and differs from the typically used pseudo-inverse formulation. It is shown how the redundancy can be used to alter first-order properties such as the shape of the velocity ellipse (or the ellipsoid) and a scalar measure of transmission ratio or effectiveness. It is shown how such local use of the redundancy leads to some global results such as determining the alterable regions and the boundaries of the trajectories. An example of a planar 3R manipulator illustrates these new techniques. (Author abstract) 26 refs.

Ghosal, Ashitava (Carnegie Mellon Univ, Pittsburgh, PA, USA); Roth, Bernard. *Int J Rob Res* v 7 n 2 Mar-Apr 1988 p 22-35.

**091108 OPTIMAL KINEMATIC DESIGN OF 6R MANIPULATORS.** A fundamental theorem for the kinematic design of robot manipulators is formulated and proved. Roughly speaking, the theorem states that a manipulator having six revolute joints is optimal if and only if the manipulator or its kinematic inverse is an elbow manipulator. By 'optimal' we mean a manipulator that has the properties of (i) maximal work-volume subject to a constraint on its length and (ii) well-connected workspace - that is, the ability to reach all positions in its workspace in each configuration. The notion of work-volume we use is that derived from the translation-invariant volume form on the group of rigid motions. This notion of volume is intermediate between those of 'reachable' and 'dextrous' workspace and appears to be more natural in that it leads to simple analytical results. (Author abstract) 18 refs.

Paden, Brad (Univ of California, Santa Barbara, CA, USA); Sastry, Shankar. *Int J Rob Res* v 7 n 2 Mar-Apr 1988 p 43-61.

**091109 COORDINATE SYSTEMS AND THE INVERSE VELOCITY PROBLEM OF MANIPULATORS WITH SPHERICAL WRISTS.** We show that in order to obtain a canonical (simplest) form of the solution to inverse velocity problem of a six-axis manipulator with a spherical wrist, the simultaneous use of two distinct coordinate systems is required. One coordinate system will yield a canonical solution for the joint rates of the arm subassembly, and the other coordinate system will yield a canonical solution for the joint rates of the wrist subassembly. (Author abstract) 16 refs.

Stanisic, Michael M. (Univ of Illinois at Chicago, Chicago, IL, USA). *Int J Rob Res* v 7 n 2 Mar-Apr 1988 p 62-64.

**091110 MATHEMATICAL MODEL OF ROBOT MANIPULATION SYSTEMS.** The object of developing a mathematical model of robot manipulation systems is to obtain equations describing the equilibrium and motion of a mechanical rod system consisting of deformable straight or curved links. With the use of the mathematical model described, one can effect the choice of simple cyclic industrial robots for automatic assembly of complex products, proceeding from specified requirements for the accuracy of reproduction of motions when displacing and joining components. An assembly system developed on the basis of these robots successfully performs the required operations. It is distinguished by simplicity of the construction, low cost and functional reliability. 5 refs.

Karetnikov, V.N.; Nuzhdikhin, V.G. *Sov Eng Res* v 7 n 7 Jul 1987 p 6-8.

**091111 PRINCIPLES AND DESIGN OF MODEL-BASED ROBOT CONTROLLERS.** Model-based control algorithms for industrial manipulators require the on-line evaluation of robot dynamics are particularly sensitive to modeling errors. The development of a unifying framework for the analysis and design of model-based robot control strategies is the theme of this paper. In this framework, the practical problems associated with real-time implementation are highlighted and methods to improve the robustness of the closed-loop system are suggested. (Author abstract) 10 refs.

Tourassis, Vassilios D. (Univ of Rochester, Rochester, NY, USA). *Int J Control* v 47 n 5 May 1988 p 1267-1275.

**091112 NEW CLASS OF CONTROL LAWS FOR ROBOTIC MANIPULATORS. PART 1. NON-ADAPTIVE CASE.** A new class of exponentially stabilizing control laws for joint level control of robot arms is introduced. It has recently been recognized that the nonlinear dynamics associated with robotic manipulators have certain inherent passivity properties. More specifically, the derivation of the robotic dynamic equations from Hamilton's principle gives rise to natural Lyapunov functions for control design based on total energy considerations. Through a slight modifications of the energy Lyapunov function and the use of a convenient lemma to handle third-order terms in the Lyapunov function derivatives, closed-loop exponential stability for both the set point and tracking control problem is demonstrated. In

general, the new class of control laws offers alternatives to the more conventional computed torque method, providing trade-offs between computation and convergence properties. Furthermore, these control laws have the unique feature that they can be adapted in a very simple fashion to achieve asymptotically stable adaptive control. (Edited author abstract) 21 refs.

Wen, John T. (JPL, Pasadena, CA, USA); Bayard, David S. *Int J Control* v 47 n 5 May 1988 p 1361-1385.

**091113 NEW CLASS OF CONTROL LAWS FOR ROBOTIC MANIPULATORS. PART 2. ADAPTIVE CASE.** A new class of asymptotically stable adaptive control laws is introduced for application to the robotic manipulator. Unlike most applications of adaptive control theory to robotic manipulators, this analysis addresses the nonlinear dynamics directly without approximation, linearization, or ad hoc assumptions, and utilizes a parameterization based on physical (time-invariant) quantities. This approach is made possible by using energy-like Lyapunov functions that retain the nonlinear character and structure of the dynamics, rather than simple quadratic forms, ubiquitous in adaptive control literature, which have bound the theory tightly to linear systems with unknown parameters. It is a unique feature of these results that the adaptive forms arise by straightforward certainty equivalence adaptation of their non-adaptive counterparts found in Wen and Bayard (1988) - i.e. by replacing unknown quantities by their estimates - and that this simple approach leads to asymptotically stable closed-loop adaptive systems. (Edited author abstract) 19 refs.

Bayard, David S. (JPL, Pasadena, CA, USA); Wen, John T. *Int J Control* v 47 n 5 May 1988 p 1387-1406.

**091114 INVERSE DYNAMICS PROBLEMS METHOD IN THE THEORY OF CONSTRUCTING ALGORITHMS FOR THE CONTROL OF MANIPULATOR ROBOTS. THE STABILIZATION PROBLEM.** The problems of constructing algorithms for stabilizing the spatial position of the executing mechanisms of manipulator robots are examined. Kinematic and dynamic algorithms which realize the required dynamic properties of the stabilization loops are synthesized. The concepts of inverse dynamics problems of controlled systems are the methodological basis of the developed theory. (Author abstract) 11 refs.

Krut'ko, P.D.; Lakota, N.A. *Sov J Comput Syst Sci* v 25 n 6 Nov-Dec 1987 p 73-81.

**091115 SYNTHESIS OF THE CONTROL OF MANIPULATOR ROBOTS BASED ON THE DECOMPOSITION PRINCIPLE.** The paper provides a basis for the use of the decomposition principle for synthesizing control systems for manipulator robots. The essence of the decomposition principle is to use the control to eliminate completely the dynamic interaction among the manipulator links and then to select this control (which eliminates the interaction) so that the manipulator robot will execute motions in accordance with the control goal. The paper establishes that the effect of the decomposition is attained by introducing relay feedbacks. As a result, one obtains a two-level hierarchical control system. The lower-level subsystem ensures the steering of the manipulator toward motion in the decomposition mode, while the upper-level subsystem realizes the coordination of the motions of the links in accordance with the control goal. The structure and parameters of the system do not depend on the properties of the environment nor on the parameters of the manipulator and, in particular, on the mass of the transported load. (Author abstract) 9 refs.

Pyatnitskiy, Ye.S. *Sov J Comput Syst Sci* v 25 n 6 Nov-Dec 1987 p 82-89.

**091116 OPTIMIZATION OF CONTROL MODES IN MANIPULATOR ROBOTS WITH ENERGY EXPENDITURES TAKEN INTO ACCOUNT.** Controls that are optimal with respect to combined functionals and



take into account the energy expenditures of the drive, the time of execution of transport operations and (or) the accuracy of positioning are constructed for a manipulator with electromechanical drives. These controls are designed on the basis of a simplified model which does not take into account the dynamic interaction of the different degrees of freedom. Numerical modeling on the basis of a complete model shows that, for electromechanical manipulators the drives of which contain gear boxes with high gear ratios, the constructed controls ensure high accuracy of steering from an arbitrary initial state to the specified final state. (Author abstract) 17 refs.

Avetisyan, V.V.; Akulenko, L.D.; Boltin, N.N. *Sov J Comput Syst Sci* v 25 n 6 Nov-Dec 1987 p 90-97.

**091117 CONTROL OF RESONANT MANIPULATORS THAT MINIMIZES ENERGY EXPENDITURES.** The problem of controlling a resonant manipulator system with a single degree of freedom with the properties of the motor taken into account is studied. An optimal control which implements the required response time of the executing element with minimal expenditures of drive energy is constructed. The assumption of resonant motion allows one to consider the system as a weakly controlled one. The solution is sought by the perturbations method. (Author abstract) 11 refs.

Babitskiy, V.I.; Kovaleva, A.S. *Sov J Comput Syst Sci* v 25 n 6 Nov-Dec 1987 p 98-103.

**091118 PROBLEMS OF OPTIMIZING THE STRUCTURES AND LAWS OF CONTROL OF THE MOTION OF ELECTROMECHANICAL MANIPULATORS.** A number of problems of optimizing the structural parameters and control laws aimed at minimizing the manipulator mass, the energy expenditures, and the maximum power of the electric motors, are formulated and solved within the framework of a mathematical model of an electromechanical manipulator that takes into account the distributed elasticity of an extended link. A formalization method is developed and an algorithm for solving the problem of the mathematical design of an optimal manipulator is proposed. The effect of the values of the moment of the electromagnetic forces at the initial and final instants of the control process on the kinematic and dynamic characteristics of the controlled motions of an elastic electromechanical manipulator is investigated. (Author abstract) 13 refs.

Berbyuk, V.Ye.; Demidyuk, M.V.; Ivakh, G.F. *Sov J Comput Syst Sci* v 25 n 6 Nov-Dec 1987 p 103-112.

**091119 ENGINEERING METHOD OF CONTROLLING A MANIPULATION ROBOT.** General principles are presented for simulation and for optimal and adaptive control. The MODUL interactive system is described, which has been implemented with an SM-4 computer and is used in robotics design systems and in developing software for manipulation robots. (Author abstract) 8 refs.

Drogovoz, A.M. *Cybern Comput Technol* n 73 1987 p 128-132.

**091120 ROBOT SIMULATION, CONTROL, AND ADAPTATION.** General principles are presented for simulation, optimum control, and adaptive control for manipulating robots. A description is given of the interactive MODUL system, which has been implemented with an SM-4 computer and is intended for use in robotics CAM and in developing software for robot control. (Author abstract) 6 refs.

Kirichenko, N.F.; Krak, Yu.V.; Soroka, R.A. *Cybern Comput Technol* n 73 1987 p 133-138.

**091121 ACTUATORS FOR ROBOTIC APPLICATIONS.** This article reviews actuators which are used for robot drive. Pneumatic, hydraulic, and electric motor actuators are discussed. 6 refs.

Biscoe, G.I. (ERA Technology Ltd, Leatherhead, Engl); Mills, A.S. *Meas Control* v 21 n 3 Apr 1988 p 76-79.

**091122 USE OF FUZZY LOGIC IN ROBOTICS.** An investigation is described that attempts to demonstrate the benefits that can be gained by the use of a fuzzy logic control law. Employing such an algorithm avoids the need for a detailed mathematical description of a manipulator link and the algorithm is inherently more robust than a conventional controller. By adopting a multi-valued parameter mode of operation it is shown that good dynamic and steady state response for a wide range of input demands can be achieved. (Author abstract) 19 refs.

Wakileh, B.A.M. (Univ of Leeds, Leeds, Engl); Gill, K.F. *Comput Ind* v 10 n 1 Mar 1988 p 35-46.

**091123 ADAPTIVE FORCE CONTROL OF ROBOT MANIPULATION WITH CONSIDERATION OF CHARACTERISTICS OF OBJECTS (2ND REPORT, CONTROL OF ONE DEGREE-OF-FREEDOM MANIPULATOR BY THE ADAPTIVE HYBRID FORCE CONTROL).** In this paper, a force control method for manipulators is presented with consideration given to object dynamics based on the adaptive control. This method for the manipulator system is an extension of the previously proposed method for gripper systems, with additional consideration given to the mass effect at the tip of the manipulator. Since present industrial robotic manipulators commonly employ the input/output position servo control system, one of the purposes of this study is to use the proposed control system to simultaneously control the position of the manipulator, the forces on the manipulator and the forces against given objects. However, it is not easy to control the manipulator, without knowledge of the objects, because the dynamics of the object inevitably comes into the overall feedback control system. Then, it is necessary to adjust the control gains, depending on handling of the objects. (Edited author abstract) 10 refs. In Japanese.

Fukuda, Toshio; Kitamura, Naoyuki; Tanie, Kazuo. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 496 Dec 1987 p 2577-2583.

**091124 HYDRAULIC MANIPULATORS OFFER RELIABILITY AND EASY MAINTENANCE.** Extensive active and non-active trials have demonstrated that a hydraulic powered manipulator can provide reliable manipulation of 30kg loads in process areas in the nuclear industry. Reliability and ease of maintenance are essential in reducing life cycle costs and minimizing radiation exposure to operational and maintenance staff. This article discusses the development and its advantages, performance characteristics, manipulator control, and other aspects of the subject.

Cole, G.V. (UKAEA, Didcot, Engl); McPherson, G. *Nucl Eng Int* v 33 n 405 Apr 1988 p 39, 41-42.

**091125 DEVELOPMENT OF A PNEUMATIC CONTROL SERVO MANIPULATOR (1ST REPORT, DESIGN AND EVALUATION OF THE DIRECT FLOW-CONTROL VALVE).** For many assembly operations, a robot hand is required to have dexterity, achieved by position, force and compliance control of high degrees of freedom, as well as tactile sensing. The pneumatic servo control, which was used by the authors to control the force and compliance of artificial fingers and an elbow, did not result in a sophisticated movement with a high response. This problem comes from the lack of airflow control in the conventional pneumatic servo valve. A new type of pneumatic servo system, developed in this study, comprises two analog airflow valves with an electromagnetically driven plunger. Analysis and evaluation of the system are conducted, and examples are given to show how to design an electro-pressure transformer using the system, and to show the force and compliance control of the manipulator-joints. (Author abstract) In Japanese. 9 refs.

Sugimoto, Noboru. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 495 Nov 1987 p 2318-2324.

**091126 ANALIZA WLASNOSCI MANIPULATORA ROBOTA RIMP-1000 I ADAPTACYJNE ALGORYTMY STEROWANIA JEGO RU-**

**CHEM.** [Analysis of Properties of Robot Manipulator RIMP-1000 and Adaptive Algorithms for Continuous Path Control]. In the paper, models of the mechanical arm and of the hydraulic actuators of robot RIMP-1000 are presented. Identification of these models was carried out on the basis of results of a series of experiments. The static and the dynamic properties of this manipulator are investigated. Under the working conditions (sampling period, trajectories to follow) one can assume static dependence of the velocity of movement of each joint upon the input current of a servo-valve. The parameters of this relation are not constant. They depend upon the manipulator load, oil pressure and other variables. However, the form of this dependence is complex and not easy to identify. On the basis of the above property three simple decentralized adaptive control algorithms for continuous path control (CPC) are formulated. (Edited author abstract) In Polish. 10 refs.

Kuzan, Pawel; Pilat, Zbigniew; Malinowski, Krzysztof. *Arch Automat Telemek* v 32 n 1-2 1987 p 3-20.

**091127 MODELING OF DYNAMICS OF MANIPULATORS WITH ELASTIC JOINTS.** The aim of this paper is to develop an algorithm for automatic generation of a mathematical model of a three-dimensional manipulator, this model then being used to solve problems of dynamic and kinematic manipulator control. A number of studies have developed algorithms of this type under the assumption that the manipulator is a system of rigid bodies (rigid model). Current precision requirements for manipulation robots make it necessary to allow for effects stemming from elastic compliance of their structure. On this basis, we consider a model of a manipulator with absolutely rigid elements and elastic couplings. The resultant semianalytic method of investigation makes possible a complete analysis of manipulator dynamics and requires fewer computational resources as compared to the approach based on the finite-element method. (Edited author abstract) 10 refs.

Zak, V.L.; Pirumov, G.U.; Rogov, N.N. *Mech Solids* v 22 n 3 1987 p 31-37.

**091128 ON MODELING OF THE DYNAMICS OF AN ELASTIC MANIPULATOR.** In investigating the dynamics of anthropomorphic manipulation robots, the effect of elasticity of the structure on the accuracy of performance is taken into account. In this paper, we consider a six-element manipulation robot that is mounted, in the general case, on a moving base. We take account of bending and torsional elastic strains of two elements (the remaining elements are assumed to be rigid rods), and compliance of the joints. We obtain a mathematical model of the manipulator involving representation of the solution as a series in eigenfunctions. We give equations for investigating a closed system, with allowance for the dynamic properties of the control motors. (Edited author abstract) 7 refs.

Chernyavskaya, S.S. *Mech Solids* v 22 n 3 1987 p 38-44.

**091129 SYNTHESIS OF CONTROLS FOR A MANIPULATION ROBOT USING LYAPUNOV'S DIRECT METHOD.** Lyapunov's direct method is employed to solve the problem of synthesizing controls and of investigating the stability of a manipulator with drives at a point of the programmed trajectory. The results we present are oriented toward solution of the problem of compensation of external stimuli. For the sake of being definite, we consider a manipulator with electric drives and armature control; however, this does not limit the possibilities for considering some other type of drive. The theoretical results enable us to investigate the dynamics of the complete mathematical model of a manipulation robot, and to set up control laws that implement programmed motion with the requisite accuracy. Construction of a dynamic model in tensor form makes it possible to avoid the technical difficulties that are usually encountered.



tered when Lyapunov's direct method is applied directly to the investigation of multiply connected systems. 5 refs.

Bragina, A.A.; Chernorutskii, G.S.; Shtakan, V.F. *Mech Solids* v 22 n 4 1987 p 74-79.

**091130 LAGRANGIAN FORMULATION OF THE DYNAMIC MODEL FOR FLEXIBLE MANIPULATOR SYSTEMS.** This paper presents a procedure for deriving dynamic equations for manipulators containing both rigid and flexible links. The equations are derived using Hamilton's principle, and are nonlinear integro-differential equations. The formulation is based on expressing the kinetic and potential energies of the manipulator system in terms of generalized coordinates. In the case of flexible links, the mass distribution and flexibility are taken into account. The approach is a natural extension of the well-known Lagrangian method for rigid manipulators. Properties of the dynamic matrices, which lead to a less computation, are shown. Boundary-value problems of continuous systems are briefly described. A two-link manipulator with one rigid link and one flexible link is analyzed to illustrate the procedure. (Author abstract) 19 refs.

Low, K.H. (Univ of Waterloo, Waterloo, Ont, Can); Vidyasagar, M. *J Dyn Syst Meas Control Trans ASME* v 110 n 2 Jun 1988 p 175-181.

**091131 POINTWISE-OPTIMAL CONTROL OF ROBOTIC MANIPULATORS.** A method is presented for the pointwise-optimal control of robotic manipulators along a desired trajectory. An approximate expression for the manipulator response is used to minimize a quadratic performance index with a linear regulator and tracking criterion, during each sampling period. The delay associated with implementation of the control action is analyzed, and its adverse effects are eliminated by estimation of the joint angles and torques one time step ahead. (Author abstract) 10 refs.

Tadikonda, S. (Rutgers Univ, New Brunswick, NJ, USA); Baruh, H. *J Dyn Syst Meas Control Trans ASME* v 110 n 2 Jun 1988 p 210-213.

**091132 DESIGN AND IMPLEMENTATION OF A FIVE AXIS ROBOTIC MICROMANIPULATOR FOR INSERTING PARTS INTO PRECISION COLLETS.** The design, construction, and testing of a five-axis micromanipulator for attachment to the wrist of a large industrial robot is described. The micromanipulator is capable of inserting a part into a collet which is only 0.1-0.2 mm (0.004-0.008 in) larger in diameter than the part, thus compensating for robot positioning errors. Hydraulic actuators, operated at 6.9 MPa (1000 lbf/in<sup>2</sup>), provide 2700 N (600 lbf) of force along the linear axes, and 68 N-m (600 in-lbf) of torque about angular axes. Repeatability of the device is 0.025 mm (0.001 in). (Edited author abstract) 12 refs.

Slocum, Alexander H. (MIT, Cambridge, MA, USA); Greenspan, Lewis; Peris, James P. *Int J Mach Tools Manuf* v 28 n 2 1988 p 131-139.

**091133 FAST ALGORITHM FOR INVERSE KINEMATIC ANALYSIS OF ROBOT MANIPULATORS.** To solve the inverse kinematics problem, the authors obtain with little effort a reduce and complete set of equations by a convenient choice of end-effector frame and application of rotation orthogonality. This approach does not require computation of the forward kinematics and can be used with manipulators of any geometry, although it is most efficient when applied to orthogonal manipulators, a class of robot arms defined in this paper. For manipulators requiring numerical techniques, but for which knowledge of one joint variable allows closed-form solutions of the remaining joint variables, an iterative inverse kinematic method, simple and fast enough to be suitable for real-time manipulator control, has been developed. (Edited author abstract) 15 refs.

Manseur, Rachid (Univ of Florida, Gainesville, FL, USA); Doty, Keith L. *Int J Rob Res* v 7 n 3 Jun 1988 p 52-63.

**091134 PLANNING OF MANIPULATOR JOINT TRAJECTORIES BY AN ITERATIVE METHOD.** Manipulator joint trajectories are planned to make an arbitrary cost function as good as possible in consideration of physical constraints based on kinematics and dynamics of a manipulator system. An algorithm presented in this paper is an iteratively improving method using the local controllability of B spline. It can be also applied to the case that some points are specified and joint trajectories must pass through those points. This algorithm is applied to an example of trajectory planning of a manipulator with two links and two degrees of freedom. (Author abstract) 6 refs.

Yamamoto, M. (Kyushu Univ, Fukuoka, Jpn); Ozaki, H.; Mohri, A. *Robotica* v 6 pt 2 Apr-Jun 1988 p 101-105.

**091135 DYNAMIC BEHAVIOUR OF A SCARA ROBOT WITH LINKS SUBJECTED TO DIFFERENT VELOCITY TRAJECTORIES.** The dynamics of a mechanical manipulator have the inherent characteristics of being highly non-linear and strongly coupled due to the interaction of the inertial, centripetal, coriolis and gravitational forces. These characteristics produce difficulties in predicting the dynamic behavior of a given manipulators' structure. These interactive forces depend largely on the geometrical configuration and operational conditions of a manipulator. Therefore, it is essential to investigate the dynamics behavior under different conditions in order to obtain an optimal design. This paper presents a study of the dynamics behavior of a robot's arm with particular reference to the mechanical manipulator being designed by the AEAC. A computer software package has been developed to facilitate the investigation of the potential dynamics behavior of a robot's arm and provides the designer with useful information for the real time control of high performance robots. (Edited author abstract) 10 refs.

Ibrahim, M.Y. (GIAE, Churchill, Aust); Cook, C.; Tieu, K. *Robotica* v 6 pt 2 Apr-Jun 1988 p 115-121.

**091136 GLOBALLY ASYMPTOTICALLY STABLE 'PD+' CONTROLLER FOR ROBOT MANIPULATORS.** We describe a globally stable tracking controller for robot manipulators. The controller is an extension of Takegaki and Arimoto's position controller to the tracking case where a theorem of Matrosov is used to prove its stability. A feature of this controller is its resemblance to the computed torque controller with the inertia matrix outside the position and velocity feedback loops. Thus, our controller is decomposed into an inner PD loop and an outer dynamic compensation loop. This structure allows simple PD computations to be run at a higher speed than the dynamic compensation loop in digital implementations. (Edited author abstract) 12 refs.

Paden, Brad (Univ of California, Santa Barbara, CA, USA); Panja, Ravi. *Int J Control* v 47 n 6 Jun 1988 p 1697-1712.

**091137 HYBRID TWIST AND WRENCH CONTROL FOR A ROBOTIC MANIPULATOR.** Three necessary conditions derived from classical geometry are proposed to evaluate formulations for the simultaneous twist and wrench control of rigid bodies, and for any theory to be meaningful it must be invariant with respect to (1) Euclidean collineations, (2) change of (Euclidean) unit length, and (3) change of basis. It is demonstrated in this paper that a previously established theory of hybrid control for robot manipulators is in fact based on the metric of elliptic geometry and is thus noninvariant with respect to (1) and (2). A new alternative invariant formulation based on the metric of Euclidean geometry and an induced metric of projective geometry is presented in terms of screw theory. An example of insertion illustrates both the invariant and noninvariant methods. (Author abstract). 16 Refs.

Lipkin, H. (Georgia Inst of Technology, Atlanta, GA, USA); Duffy, J. *J Mech Transm Autom Des* v 110 n 2 Jun 1988 p 138-144.

**091138 RELIABILITY ANALYSIS OF ROBOT**

**MANIPULATORS.** A probabilistic approach to robot kinematics is presented and the concept of manipulator reliability is introduced to obtain a better evaluation of the performance of manipulators. Techniques are presented to compute this reliability and its relationship to the geometric parameters such as tolerances and arm configuration is discussed. The aspects of accuracy and repeatability of manipulators are explained in terms of manipulator reliability. The reliability of a two-link planar manipulator and the Stanford arm are considered for numerical illustration. (Author abstract). 19 Refs.

Bhatti, P.K. (Purdue Univ, West Lafayette, IN, USA); Rao, S.S. *J Mech Transm Autom Des* v 110 n 2 Jun 1988 p 175-181.

**091139 OCCLUSION AVOIDANCE OF VISUAL SENSORS BASED ON A HAND-EYE ACTION SIMULATOR SYSTEM: HEAVEN.** We have developed a hand-eye action simulator system called HEAVEN. This system provides model-based functions to assist the hand-eye system in visual recognition and monitoring the robot environment. This paper describes a function of assisting cameras in occlusion avoidance to input adequate image data without occlusion. The problem to select the best viewpoint for a camera is defined as to evaluate the viewpoints on a geodesic dome generated around a target object model. Occlusion-free space is obtained as regions on the geodesic dome by using a depth buffer algorithm. Then distance transformation of the occlusion-free regions gives candidates of the best occlusion-free viewpoint. Experimental results using a camera-in-hand system demonstrate the usefulness of the HEAVEN system in planning occlusion avoidance. (Edited author abstract). 18 Refs.

Sakane, Shigeyuki (Electrotechnical Lab, Ibaraki, Jpn); Ishii, Masaru; Kakikura, Masayoshi. *Adv Rob* v 2 n 2 1987 p 149-165.

**091140 MULTI-VARIABLE CONTROL OF ROBOT MANIPULATORS.** Since manipulators are highly nonlinear, coupled multivariable systems, multivariable control approach is necessary in principle for high speed and accurate operation of manipulators. Multivariable control approaches to robot manipulators are outlined. Then decoupling control, which is one of the multivariable control approaches of hydraulically driven robots, is described. A construction method of an autonomous contouring control system is explained for a two-joint hydraulic robot. (Author abstract). 18 Refs.

Yoshikawa, Tsuneo (Kyoto Univ, Jpn). *Adv Rob* v 2 n 2 1987 p 181-191.

**091141 VOICE CONTROL FOR A ROBOT-AN EXAMPLE OF A MANIPULATOR FOR THE DISABLED.** This paper, through an example of a voice-controlled manipulator for the upper-limb disabled, discusses the problems that have to be solved before a voice input and output system can be applied to the human-robot system. At JPL (Jet Propulsion Laboratory), supported by NASA, and VA (Veterans Administration), a voice-controlled manipulator and wheelchair are being developed. The number of voice commands is about 50 and these are used to control the motion of the manipulator and the wheelchair. At VA, the main emphasis is on voice controls at this moment, but they are also using signals produced from head, chin, and eye movements. 6 Refs.

Ifukube, Tohru (Hokkaido Univ, Sapporo, Jpn). *Adv Rob* v 2 n 2 1987 p 193-200.

**091142 FORCE DETECTION AND ACTIVE POWER ASSISTANCE OF A DIRECT-DRIVE MANIPULATOR.** When a manipulator is handled manually, it is necessary to reduce the reaction force caused by inertia, friction, gravity, etc. This paper describes an active power assistance system for a direct-drive manipulator, which assists the handling force with a motor, and a force detection system for that purpose. This method detects the



handling force by a combination of motor torque detection with a motor current and rotation detection with internal sensors (tachogenerator, etc.). It does not need special force sensors. Some configurations of the power assistance system are also shown. The effectiveness of the proposed method is demonstrated by feasibility experiments. (Author abstract). 11 Refs.

Arai, Hirohiko (MITI, Tsukuba Science City, Jpn); Tachi, Susumu. *Adv Rob v 2 n 3* 1987 p 241-257.

**091143 ROPE HANDLING BY A ROBOT WITH VISUAL FEEDBACK.** Visual information is necessary for a robot to be able to manipulate flexible objects such as a rope because flexible objects change their shape during motion. Actually direct visual feedback and verification in three-dimensional space are the keys to performing successful manipulation of such flexible objects. In this paper, important problems in hand-eye coordination are discussed and a rope handling experiment is described. The hand-eye system consists of a robot vision system, a general purpose manipulator and a Lisp system. The main visual functions adopted in the experiment are local image processing along a linear region and stereo vision. The experiment involves the performance of tasks such as inserting a rope into a ring and tying a rope. By coordinating the general purpose arm with stereo vision, our robot succeeds in manipulating a flexible rope. (Author abstract). 10 Refs.

Inaba, Masayuki (Univ of Tokyo, Tokyo, Jpn); Inoue, Hirochika. *Adv Rob v 2 n 1* 1987 p 39-54.

**091144 ELECTRIC MOTOR DRIVE MULTILINK MANIPULATOR FOR CORE INTERNAL INSPECTION.** Fuji Electric has developed a large electric motor-drive multilink manipulator system. This system makes it possible to inspect in detail structures in a reactor. This system is composed of a power manipulator, a monitoring manipulator, inspection device and a control system. With simple and easy operation, the system can automatically access the in-reactor structures to be inspected through the narrow space, avoiding the interceptive structures. This report describes an outline of the Manipulator. (Edited author abstract). In Japanese.

Shimazu, Akira; Akisada, Toshihiro; Kato, Koji; Tanaka, Shoichi; Tanaka, Koichi. *FAPIG n 118* 1988 p 8-17.

**091145 ALGORITHMS FOR OPTIMAL CONTROL OF AN ELASTIC MANIPULATION SYSTEM WHEN PERFORMING TECHNOLOGICAL POWER OPERATIONS.** The problem of finding an optimal control algorithm for an industrial robot which performs a power operation of surface machining is considered. A criterion which takes into account the deviations of the manipulator end point from the programmed displacements as well as the power indices serves as the selection criterion of the optimal control. The optimal control is found by the maximum principle. The methodology proposed for finding optimal control algorithms is examined on an example of a two-stage manipulator which performs a power operation. (Author abstract). 16 Refs.

Afonin, V.L.; Pozharinskiy, A.A.; Chinayev, P.I. *Sov J Comput Syst Sci v 26 n 2* Mar-Apr 1988 p 1-9.

**091146 MATHEMATICAL MODELING OF THE MECHANICS AND OF THE CONTROL PROCESSES OF MANIPULATION ROBOTS.** Methods for modeling the geometric, kinematic and dynamic interconnections to which manipulation robots (MRs) are subjected and the processes of identification and adaptive control are presented. The concepts of attainability and controllability of MR states are introduced and theorems which yield constructive algorithms for the construction of regions of attainability and controllability and for investigating the control capabilities of MRs are obtained. A algorithm for finding the direction of descent in the solution of the inverse problem of kinematics and trajectory planning is constructed. Its computing complexity is linear in the degrees of freedom. Various algorithms for constructing the equations of MR motion on the basis of

d'Alembert's principle are presented, their computing complexity is investigated, and special transformations for its reduction are introduced. Algorithms for the adaptive control of MR motion which uses both position and force-moment feedback are developed. (Edited author abstract). 18 Refs.

Kirichenko, N.F.; Krak, Yu.V.; Soroka, R.A. *Sov J Comput Syst Sci v 26 n 2* Mar-Apr 1988 p 30-38.

**091147 MODELING OF THE DYNAMICS OF AN ELASTIC MANIPULATOR WITH ELECTROMECHANICAL DRIVES.** The present paper is devoted to constructing mathematical techniques for modeling the dynamics of the manipulators with the elastic joints. An algorithm for automatic generation of the dynamic equations is proposed. With the aid of this algorithm are constructive characteristics of a manipulator and motors (the kinematic scheme, the moments of inertia, the gear ratios, etc.). 9 Refs.

Zak, V.L.; Pirumov, G.U. *Sov J Comput Syst Sci v 26 n 2* Mar-Apr 1988 p 39-45.

**091148 SERVOCOMPENSATION OF DISTURBANCES IN ROBOTIC SYSTEMS.** Robot manipulators are susceptible to external disturbances that may alter their behaviour so significantly that certain specifications cannot be maintained. Additive signals that satisfy a linear differential equation with constant coefficients are the type of disturbance that may enter a manipulator and corrupt its behaviour. From linear servocompensator theory one knows that linear disturbances can be asymptotically rejected if the linear plant satisfies certain criteria. However, for robot manipulators, which are extremely non-linear, the former criteria cannot be applied. It is shown that linear disturbances can be asymptotically rejected by employing a standard linear servocompensator. In linear system theory the proof that the error  $e \rightarrow 0$  as  $t \rightarrow \infty$  is shown via the Laplace transform. The Volterra series is utilized to verify the asymptotic convergence of the error. Digital computer simulations are carried out on a two-link planar robot to demonstrate the effectiveness of the linear servocompensator. (Edited author abstract). 16 Refs.

Buchner, H.J. (Siemens Central Research & Development, Munich, West Ger); Hemami, H. *Int J Control v 48 n 1* Jul 1988 p 273-288.

**091149 APPLICATION OF DISCRETE-TIME MODEL REFERENCE ADAPTIVE CONTROL TO INDUSTRIAL ROBOTS: A COMPUTER SIMULATION.** A direct approach to discrete-time model reference adaptive control (MRAC) based on hyperstability theory is proposed to control industrial robotic manipulators. For industrial robots and manipulators which usually have highly nonlinear and complex dynamic behaviors and often unknown inertia characteristics, it is difficult to achieve high performance with conventional control strategies. This high performance in terms of speed and accuracy can be obtained by adaptive control techniques. Considering the effects of gravity, process noise, and payload uncertainty, this approach is investigated using simulation for a three degree of freedom industrial robot. These simulation results show that adaptive control techniques can provide robust properties in spite of a poor a priori information regarding the robot dynamics and circumstances. (Edited author abstract). 15 Refs.

Yuh, J. (Univ of Hawaii, Honolulu, HI, USA); Holley, W.E. *J Manuf Syst v 7 n 1* 1988 p 47-56.

**091150 COMBINATION PARAMETRIC RESONANCE LEAD TO PERIODIC AND CHAOTIC RESPONSE IN TWO-DEGREE-OF-FREEDOM SYSTEMS WITH QUADRATIC NON-LINEARITIES.** The dynamic response of a parametrically excited non-linear system with two degrees of freedom is studied. The system of equations, which describes the compliant motion of a robotic manipulator, exhibits internal resonance and is excited at a frequency near a primary resonance. The effect of coupling is studied in detail. Non-zero periodic motions are observed to co-exist with a stable equilibrium state over a range of detuning near the

resonant frequency. Loss of stability of the periodic response is observed at points of vertical tangency (corresponding to a jump in the response), while for some of the cases, Hopf bifurcation in the response corresponding to amplitude-modulated motions is observed. In the latter case, period-doubling of the amplitude of response is observed with a monotonic change in detuning, eventually leading to chaotic motion in the system. (Edited author abstract). 13 Refs.

Streit, D.A. (Pennsylvania State Univ, University Park, PA, USA); Bajaj, A.K.; Krousgrill, C.M. *J Sound Vib v 124 n 2* Jul 22 1988 p 297-314.

**091151 ADAPTIVE HIERARCHICAL CONTROL FOR ROBOTIC MANIPULATORS.** This paper presents a new method of robot manipulator hierarchical control based upon on-line trajectory generation and decentralized pole-placement feedback deduced from the computed torque method. An anticipatory action is included in the controller by insuring subsequent desired joint positions, velocities and accelerations in the Newton-Euler equations of motion. The gains of the decentralized regulators are approximated by simple laws and when found inadequate (i.e. when the difference between desired and real trajectories is measured positions and velocities. New joint reference trajectories are calculated to be more adapted to the situation detected by the sensors. This robot system enables the manipulator to move in a non-predefined way. The adaptive feature of the algorithm improves the robustness of the controller with respect to errors in the dynamic model of the manipulators. (Edited author abstract). 20 Refs.

Bestaoui, Yasmina (Cent Univ de Tlemcen, Algeria). *Robotics v 4 n 2* Jun 1988 p 145-155.

**091152 KINEMATICS OF COMMON INDUSTRIAL ROBOTS.** An approach to finding the solution equations for simple manipulators is described which enhances the method of Paul, Renaud, and Stevenson, by making use of known decouplings in the manipulator kinematics. This reduces the set of acceptable equations from which we obtain relationships for the joint variables. For analyzing the Jacobian, such decoupling is also useful since it manifests itself as a block of zeros, which makes inversion easier. This zero lock can be used to obtain a concise representation for the forward and inverse Jacobian computations. The decoupling also simplifies the calculations sufficiently to allow us to make good use of a symbolic algebra program (MACSYMA) in obtaining our results. Techniques for using MACSYMA are described. Examples are given for several industrial manipulators. (Edited author abstract). 14 Refs.

Lloyd, John (McGill Univ, Montreal, Que, Can); Hayward, Vincent. *Robotics v 4 n 2* Jun 1988 p 169-191.

**091153 FEEDBACK-ERROR-LEARNING NEURAL NETWORK FOR TRAJECTORY CONTROL OF A ROBOTIC MANIPULATOR.** A neural network model for generation of motor command was proposed in our earlier paper. This model contains a feedback loop (transcortical loop), an internal neural model of motor system (spinocerebellum and magnocellular part of the red nucleus) and an internal neural model of inverse dynamics of the motor system (cerebro-cerebellum and parvocellular part of the red nucleus). The inverse-dynamics model is acquired by heterosynaptic plasticity using feedback motor command (torque) as an error signal. In this paper, we apply hierarchical arrangement of the transcortical loop and the inverse-dynamics model for learning trajectory control of an industrial robotic manipulator. Although neither strict modeling of the manipulator nor precise parameter estimation was required, the control performance by the neural-network model improved gradually during 30 minutes of learning. Once the neural-network model learned to control some movement, it could control quite different and faster movements. That is, the neural-network model has capability to



generalize learned movements. Advantages of the neural-network control over conventional control methods are discussed. (Author abstract). 29 Refs.

Miyamoto, Hiroyuki (Sumitomo Electric Ind Ltd, Osaka, Jpn); Kawato, Mitsuo; Setoyama, Tooru; Suzuki, Ryoji. *Neural Networks* v 1 n 3 1988 p 251-265.

**091154 NEW FOUR-LINK MANIPULATOR MECHANISM DESIGNS OFFER ENHANCED LOAD-CARRYING CAPACITY.** Actuators of heavy-duty manipulators (heavy and extra-heavy classes, GOST Standard 25685-83) must satisfy not only general requirements, such as providing the required number of degrees of freedom, avoiding 'dead zones' in the entire range of travels and rotation angles, and having a stiff transmission, with minimum weight and a sealed construction, but also an important specific requirement: a long travel with heavy loads. In meeting this requirement, it is not easy to achieve the requisite stiffness. The best solution is to provide the manipulator with an actuator device having a closed-loop transmission based, for example, on a hinged parallelogram (four-link mechanisms), which in its major plane is largely relieved of bending moments from the weight of the load. 5 Refs.

Gvozdev, Yu. F. *Sov Eng Res* v 7 n 8 Aug 1987 p 6-7.

**091155 LOADING/UNLOADING ATTACHMENT FOR AN INDUSTRIAL ROBOT.** Using industrial robots can help to increase the coefficient of utilization of process equipment, especially by virtue of reduced loading and unloading times. In order to increase productivity, the Heavy Engineering Research Institute (Kharkov) developed a robot attachment which reduces equipment idle times in periods when the robot is performing loading and unloading operations by up to 30 percent. The attachment is designed for the Brig-10 robot, but can be used with other models. This article reviews design features of the attachment and operation of the robot when fitted with such.

Kormanova, L.D. *Sov Eng Res* v 7 n 8 Aug 1987 p 11-12.

**091156 TRAJECTORY CONTROL OF MANIPULATORS WITH TIME VARYING INERTIA LINKS.** One way to increase the flexibility (or versatility) of manipulators is to use links with time varying inertia. One can then control both the joint torques and the inertias of the links therefore more pliancy in the practical utilization of the arm. The paper deals with the Lagrangian formulation of the corresponding inertia control problem which can be considered either in open loop or in closed loop form. The general equations are derived and it is shown that one so obtains a set of uncoupled Riccati differential equations which define the dynamics of the structural inertias. Problems related to stabilization and to structural parameter uncertainty are also considered. (Author abstract). 7 Refs.

Jumarie, Guy (Univ du Quebec in Montreal, Montreal, Que, Can). *Robotica* v 6 n 3 Jul-Sep 1988 p 197-202.

**091157 DETERMINATION OF ELASTRODYNAMIC ERRORS IN JOINTS OF INDUSTRIAL ROBOTS.** This paper presents a method for automatic forming and solving dynamic equations of motion of manipulator with elastic joints and rigid segments. For the minimal configuration of a cylindrical manipulator the numerical integration of these equations is performed, and vibrations in the joints are obtained as dynamic errors with respect to the prescribed trajectory. (Author abstract). 11 Refs.

Nikolic, Ilija (Harvard Univ, Cambridge, MA, USA). *Robotica* v 6 n 3 Jul-Sep 1988 p 213-219.

**091158 B-SPLINES JOIN TRAJECTORY PLANING.** This paper describes how B-splines can be used to construct joint trajectories for robot manipulators. The motion is specified by a sequence of Cartesian knots, i.e., positions and orientations of the end effector of a robot manipulator. For a six joint robot manipulator, these Cartesian knots are transformed into six sets of joint variables, with each set corresponding to a joint. Splines,

represented as linear combinations of B-splines, are used to fit the sequence of joint variables for each of the six joints. A computationally simple recurrence formula is used to generate the B-splines. This approach is used to establish the mathematical model of trajectory generation for robot manipulators, and offers flexibility, computational efficiency, and a compact representation. (Edited author abstract). 19 Refs.

Wang, Kesheng (NTH-SINTEF, Trondheim, Norw). *Comput Ind* v 10 n 2 Jul 1988 p 113-122.

**091159 REDUNDANCY RESOLUTION OF SERIAL MANIPULATORS BASED ON ROBOT DYNAMICS.** Based on the minimization of the joint driving forces/torques, the classical Lagrangian technique is used to develop the governing equations for the computation of the joint accelerations in an N degree of freedom serial manipulator. Explicit equations for the computation of the joint accelerations are developed and used instead of numerical based solutions for pseudo inverses (e.g. singular value decomposition method). The developed solution is computationally three times more efficient than the comparable solutions in the literature. The problems of reliability and stability are discussed. Several modifications are introduced to make the algorithm reliable and stable. An eleven degrees of freedom, three-dimensional robotic manipulator is used in a numerical example to test the developed algorithms. (Author abstract). 22 Refs.

Kazerounian, Kazem (Univ of Connecticut, Storrs, CT, USA); Nedungadi, Ashok. *Mech Mach Theory* v 23 n 4 1988 p 295-303.

**091160 STATIC AND DYNAMIC LOAD CONTOURS FOR ROBOT LIMIT DESIGN.** Ever since its rapid growth in the industries, there has been a lack of understanding of robot specification. Terms such as payload, accuracy and repeatability are well used by robot manufacturers and practitioners alike but there is no uniformity of conditions under which these terms are defined. This paper deals with static and dynamic load contours within a given workspace, for specifying and designing an all-revolute robot's application. Algorithms to compute repeatability/accuracy contours in workspaces of all-revolute robots will also be introduced. 25 Refs.

Yap, K.T. (Nanyang Technological Inst, Singapore). *Eng J Singapore* v 14 n 1 1987 p 10-21.

**091161 SINGULAR PERTURBATION APPROACH TO CONTROL OF LIGHTWEIGHT FLEXIBLE MANIPULATORS.** The control lightweight flexible manipulators is the focus of this work. The flexible manipulator dynamics is derived on the basis of a Lagrangian-assumed modes method. The full-order flexible dynamic system does not allow the determination of a nonlinear feedback control as for rigid manipulators, since there are not as many control inputs as output variables. This drawback is overcome by a model order reduction, based on a singular perturbation strategy, where the fast state variables are the elastic forces and their time derivatives. (Edited author abstract). 53 Refs.

Siciliano, Bruno (Univ di Napoli, Naples, Italy); Book, Wayne J. *Int J Rob Res* v 7 n 4 Aug 1988 p 79-90.

**091162 HANDHABEN VON LINSSEN MIT VAKUUMGREIFERN.** [Automated Assembly of a Precision-Engineering Component with the Aid of the IRB 95 Industrial Robot]. This paper describes a number of mechanical periphery devices which supplement freely programmable robotics with high joining accuracy. The accurate mode of operation of this robotic equipment is illustrated in the case of the assembly of an electromagnetic teletype component. 1 Ref. In German.

Bosewetter, G. (Technische Hochschule Ilmenau, East Ger); Denzin, K.; Hennecke, D. *Feingeraetetechnik* v 37 n 6 1988 p 248-251.

**091163 EXPERIMENTS IN LOAD-ADAPTIVE CONTROL OF A VERY FLEXIBLE ONE-LINK MANIPULATOR.** An adaptive control algorithm based

on the self-tuning regulator concept has been experimentally demonstrated on a very flexible one-link robotic manipulator. The lightly-damped structural resonances of the manipulator coupled with the use of a primary sensor separated from the actuator by flexible structure (non-collocated sensor and actuator) to give good accuracy in tip positioning make high-performance controllers sensitive to modeling error. The adaptive controller is able to maintain precise tip position control despite wide variations in end effector load. An identification algorithm is employed which estimates the mass of the tip load. It makes use of a simple parameterization of system transfer functions which is a linear-fractional expression in the mass of the load. The linear quadratic gaussian synthesis procedure is used for control design, a polynomial interpolation to a precalculated table of controller gains is made on-line to implement a controller appropriate to the identified value of load mass. Rate of convergence of the identification algorithm is such that the system is able to adapt to a 40% change in moment of inertia during a single commanded step change in position. (Edited author abstract). 10 Refs.

Rovner, Daniel M. (Orbital Science Corp, Fairfax, VA, USA); Franklin, G.F. *Automatica* v 24 n 4 Jul 1988 p 541-548.

**091164 DYNAMIC ANALYSIS AND COMPUTER IMPLEMENTATION OF MANIPULATORS BASED ON GENERALIZED D'ALEMBERT'S PRINCIPLE.** The dynamic methods of multi-rigid-body manipulators have become more and more developed. One category derives dynamic equations using vector mechanics or analytical mechanics, such as the T.R. Kane method and Roberson-Wittenburg method. Another category, such as the Popov method searches the constrained extremum of the system using variational principles. It is found that to date no one has attempted to deal with the two categories with an unified approach. The author applies the Gauss principle, the principle on which the Popov method is established, to deduce the dynamic equations of the Kane and RW methods. It is shown that these three methods are all based on the generalized D'Alembert's principle. (Edited author abstract). 8 Refs. In Chinese.

Qiu, Yuaning (Northwestern Polytechnical Univ, China); Xiao, Shangbin. *Xibei Gongye Daxue Xuebao* v 6 n 4 Oct 1988 p 457-468.

**091165 COMMENTS, WITH REPLY, ON 'SELECTION OF NEAR-MINIMUM TIME GEOMETRIC PATHS FOR ROBOTIC MANIPULATORS' BY K.G. SHIN AND N.D. MCKAY.** The commenter states that some interesting results on the selection of near-minimum time geometric paths for robotic manipulators were presented by K.G. Shin and N.D. McKay but that there are certain parts which need to be clarified. In replying, McKay argues that Y.C. Chen correctly points out that geodesics are not always curves of minimum length; indeed, there may be more than one geodesic connecting any two given points, and the shortest one must be chosen. 1 ref.

Chen, Y.C. (Univ of Waterloo, Ont, Can). *IEEE Trans Autom Control* v AC-32 n 11 Nov 1987 p 1027-1028.

**091166 ROBOTIC MANIPULATORS AND THE GEOMETRY OF REAL SEMIALGEBRAIC SETS.** Some techniques from real semialgebraic geometry are applied to the robotic manipulator problem i.e., the manipulation of rigid bodies by manipulators that are motor-driven kinematic chains. Using the notion of metric entropy, the complexity of maneuvering the manipulator from state to state is discussed. 25 refs.

Tannenbaum, Allen (Ben-Gurion Univ, Beer Sheva, Isr); Yomdin, Joseph. *IEEE J Rob Autom* v RA-3 n 4 Aug 1987 p 301-307.



**091167 REDUNDANCY RESOLUTION OF MANIPULATORS THROUGH TORQUE OPTIMIZATION.** Methods for resolving kinematic redundancies of manipulators by the effect on joint torque are examined. When the generalized inverse is formulated in terms of accelerations and incorporated into the dynamics, the effect of redundancy resolution on joint torque can be directly reflected. One method chooses the joint acceleration null-space vector to minimize joint torque in a least squares sense; when the least-squares value is weighted by allowable torque range, the joint torques tend to be kept within their limits. Methods using only the pseudoinverse with and without weighting by the inertia matrix are presented. The results show an unexpected stability problem during long trajectories for the null-space methods and for the inertia-weighted pseudoinverse method, but more seldom for the unweighted pseudoinverse method. Evidently, a whiplash action develops over time that thrusts the endpoint off the intended path, and extremely high torques are required to overcome these natural movement dynamics. 32 refs.

Hollerbach, John M. (MIT, Cambridge, MA, USA); Suh, Ki C. *IEEE J Rob Autom* v RA-3 n 4 Aug 1987 p 308-316.

**091168 FEATURE-BASED TACTILE OBJECT RECOGNITION.** The use of array force sensors can provide precisely located surface information about objects in the workspace wherever the robot arm can reach. To identify objects and their placement, it is suggested that the interpretation processes use proprioceptive information and should use tactile image features that reflect object characteristics. A technique is described for the generation of constraints on object identity and placement so that information from multiple sensor contacts can cooperate in the task of interpretation. 20 refs.

Browse, Roger A. (Queen's Univ, Kingston, Ont, Can). *IEEE Trans Pattern Anal Mach Intell* v PAMI-9 n 6 Nov 1987 p 779-786.

**091169 AUTOMATIC GRASPING: AN OPTIMIZATION APPROACH.** A method is introduced for locating stable grasps with articulated mechanical hands. A metric called the grasp goal function represents the 'distance' to an unstable grasp for a given position, external load, and set of joint torques of the gripper. The process of locating a stable grasp is treated as an optimization problem for which the most stable grasp is found by maximizing the grasp goal function. Physical constraints, such as torque or motion limitations, are accounted for by the incorporation of potential functions in the objective function. Two-dimensional and three-dimensional simulations were undertaken for which objects were represented as polygons/polyhedral and gripper elements as ellipses/ellipsoids. Results indicate that the method is particularly useful for estimating stable grasps when the initial estimate is close to being stable, but that it also can often perform adequately when this is not the case. In some instances, inadequate grasps are obtained due to the presence of local optima which represent unstable grasps, but it is still felt that the method will have application in future automated systems as a low-level component. 14 refs.

Jameson, John W. (Stanford Univ, CA, USA); Leifer, Larry J. *IEEE Trans Syst Man Cybern* v SMC-17 n 5 1987 p 806-814.

**091170 ROBUST TRAJECTORY PLANNING FOR ROBOTIC MANIPULATORS UNDER PAYLOAD UNCERTAINTIES.** Bounds on joint torque uncertainties for a robotic manipulator are derived in terms of payload uncertainties. Using these bounds, a trajectory planner is developed to incorporate payload uncertainties such that all the trajectories generated can be realized with given joint torques. The trajectory planner is applied to the first three joints of the Bendix PACS arm, a cylindrical robot, to demonstrate its use and power. 7 refs.

Shin, Kang G. (Univ of Michigan, Ann Arbor, MI, USA); McKay, Neil D. *IEEE Trans Autom Control* v AC-32 n 12 Dec 1987 p 1044-1054.

**091171 STATE AND PARAMETER ESTIMATION FOR ROBOTIC MANIPULATORS USING FORCE MEASUREMENTS.** A general framework is proposed for incorporating both a priori task geometry information and online observations, including force measurements, into an optimal estimation algorithm. The output of the algorithm is state and parameter estimates that serve to disambiguate the task geometry and can be used to dynamically adapt subsequent motions. The problem is formulated as a nonlinear constrained dynamical system, including Coulomb friction between the system and the constraints. The constraint surface is described with respect to some unknown parameters representing the geometric uncertainty. The noisy online state and force observations are expressed as functions of the state and surface parameters. The extended Kalman filter is then used to produce optimal estimates of the state and surface parameters. 15 refs.

Blauer, Michael (Bell Northern Research, Verdun, Que, Can); Belanger, Pierre R. *IEEE Trans Autom Control* v AC-32 n 12 Dec 1987 p 1055-1066.

**091172 DYNAMIC HYBRID POSITION/FORCE CONTROL OF ROBOT MANIPULATORS - DESCRIPTION OF HAND CONSTRAINTS AND CALCULATION OF JOINT DRIVING FORCE.** For the application of robot manipulators to complex tasks, it is often necessary to control not only the position of a manipulator but also the force exerted by the hand on an object. For this purpose, M. H. Raibert and J. J. Craig proposed the hybrid position/force control method (1981). In this method, however, the manipulator dynamics are taken into account rigorously. The dynamic hybrid control method, which takes the manipulator dynamics into consideration, is proposed. Constraints on the end effector are described by a set of constraint hypersurfaces, and the basic equations for dynamic hybrid control are derived. It is shown that if the manipulator is not in a singular configuration, the desired position and force at the end effector can be simultaneously realized. A basic structure of the dynamic hybrid control system with a servo compensator is given. 11 refs.

Yoshikawa, Tsuneo (Kyoto Univ, Jpn). *IEEE J Rob Autom* v RA-3 n 5 Oct 1987 p 386-392.

**091173 CLOSED-FORM SOLUTION FOR INVERSE KINEMATICS OF ROBOT MANIPULATORS WITH REDUNDANCY.** A closed-form solution formula for inverse kinematics of manipulators with redundancy is derived using the Lagrangian multiplier method. The proposed method is proved to provide the exact equilibrium state for the resolved-motion method. The repeatability problem in the resolved-motion method does not exist in the proposed method. The method is demonstrated to give more accurate trajectories than the resolved-motion method. 17 refs.

Chang, Pyung H. (MIT, Cambridge, MA, USA). *IEEE J Rob Autom* v RA-3 n 5 Oct 1987 p 393-403.

**091174 COORDINATING THE MOTIONS OF ROBOT ARMS IN A COMMON WORKSPACE.** A time/space planning system to coordinate the actions of two robot manipulators for transfer movements in a 'sparse' environment is reported. The collision avoidance reasoning guarantees that arms will arrive safely at their destination by temporally delaying or by altering the path of one arm. End effectors are constrained to follow elliptical motions. The performance of the system is sufficient in normal circumstances to drive an execution module in real time with tool tip speeds of about 3 in./s. 17 refs.

Roach, John W. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Boaz, Michael N. *IEEE J Rob Autom* v RA-3 n 5 Oct 1987 p 437-444.

**091175 COST-EFFICIENT HIGH-PERFORMANCE BIT-SERIAL ARCHITECTURE FOR ROBOT INVERSE DYNAMICS COMPUTATION.** A novel cost-efficient parallel and pipelined bit-serial array architecture is proposed for its computation that achieves

a certain bit-serial execution-time lower bound. The core of the system consists of two arrays of multifunctional bit-serial cells. One of the arrays computes the forward iterations, and the other one evaluates the backward recursions of the Newton-Euler dynamics algorithm. At the current state of technology, the resulting high-performance system may be realized in only two custom VLSI chips and a minimum number of first-in-first-out register files. The organization, operation, and performance of the proposed array structure is discussed. The architecture and functionality of an individual multifunctional bit-serial cell used as the building block of the array structure is described.

Rahman, Mahibur (Purdue Univ, West Lafayette, IN, USA); Meyer, David G. *IEEE Trans Syst Man Cybern* v SMC-17 n 6 1987 p 1050-1058.

**091176 LANGRANGIAN DYNAMICS OF FLEXIBLE MANIPULATORS USING ANGULAR VELOCITIES INSTEAD OF TRANSFORMATION MATRICES.** An approach that uses angular velocities and  $3 \times 3$  rotation matrices to represent link kinematics efficiently is presented. A truncated method expansion is used to model link deflection. A recursive computational procedure is presented that is similar to the Newton-Euler dynamics formulation for rigid manipulators. The full nonlinear inverse dynamic equations are calculated in recursive form for manipulators with an arbitrary number of flexible links. Kinematics are computed recursively from the base to the tip, and torques are computed on the return recursion. On the basis of this formulation, a fast and accurate simulation algorithm is presented. It is shown that this method offers significant improvement in computational speed without degrading numerical accuracy. The modeling accuracy of the method and some practical implementation problems are discussed.

King, J.O. (Univ of Alberta, Edmonton, Alberta, Can); Gourishankar, V.G.; Rink, R.E. *IEEE Trans Syst Man Cybern* v SMC-17 n 6 1987 p 1059-1068.

**091177 POSITIONING ERROR ANALYSIS FOR ROBOT MANIPULATORS WITH ALL ROTARY JOINTS.** Industrial robots can be commanded to accomplish different tasks with program sequences that are executed in digital computers. The operating software within these computers can provide users with information on positions and orientations of the end effectors by computing them as functions of the joint variables. However, these functions are generally not exact enough with the result that differences between the computed and the actual positions can be significant. Error sources that contribute to these differences for robots with rotary joints are examined. The effects of these errors are parameterized, and measurement data are fitted to obtain the values of these parameters. It is concluded that with sufficient but not exhaustive detail in the error modeling the differences can be reduced significantly from 5.9-mm mean error with nominal model down to 0.28-mm mean error after error compensation. 11 refs.

Chen, Jigien (Univ of Maryland, College Park, MD, USA); Chao, Lih-Ming. *IEEE J Rob Autom* v RA-3 n 6 Dec 1987 p 539-545.

**091178 PIPELINED COMPUTATION OF MANIPULATOR MODELING MATRICES.** The authors describe a characterization of the inertia content in the control formulation for the nonlinear, time-varying system of a robotic manipulator. The characterization is in the form of a pipelined modeling software which is implemented on a medium-sized array processor to run in real time. The time-varying inertia content of the manipulator is expressed in terms of kinematic influence coefficients which are represented by explicit functions of only the generalized coordinates. Properties of these influence coefficients are used to reduce the computation effort necessary to generate the modeling coefficients. The resulting algorithm requires a large number of small vector and matrix operations. To efficiently pipeline this algorithm, the structure inherent in the problem is



exploited to allow extensive use of data-dependent addressing which is used to compute multiple 'small' operations within a single pipeline. The resulting software consists of two portions—an offline portion generates integer offset vectors to direct the addressing of the online portion in computing the modeling coefficients. 40 refs.

Wander, John P. (Univ of Texas, Austin, TX, USA); Tesar, Delbert. *IEEE J Rob Autom* v RA-3 n 6 Dec 1987 p 556-566.

**091179 NEW CONTROLLER DESIGN FOR MANIPULATORS USING THE THEORY OF VARIABLE STRUCTURE SYSTEMS.** A controller design for manipulators using the theory of variable-structure systems (VSS) is presented to deal with the set-point regulation problem. The major obstacle of VSS vector control with strong dynamic coupling is overcome for a class of systems with positive symmetric inertia matrices. Parameter variations can easily be considered in the design methodology, which is readily extendable to a higher number of links. The problem of chattering is solved by the introduction of sliding sectors. 9 refs.

Yeung, Kai S. (Univ of Texas, Arlington, TX, USA); Chen, Yon P. *IEEE Trans Autom Control* v 33 n 2 Feb 1988 p 200-206.

**091180 OPTIMAL PARAMETRIZATION OF CURVES FOR ROBOT TRAJECTORY DESIGN.** A numerical method is presented for the offline determination of the minimum-time parameterization of a fixed path in robot joint space, assuming start and end at rest conditions and subject to constraints on manipulator joint torques. A numerical method for solving the problem is discussed in which the derivative of the change of variables is approximated by a cubic spline. Numerical results for a three-axis manipulator are presented. 14 refs.

Marin, Samuel P. (GM, Warren, MI, USA). *IEEE Trans Autom Control* v 33 n 2 Feb 1988 p 209-214.

**091181 UNIVERSAL SIX-JOINT ROBOT CONTROLLER.** The authors describe the specifications, design, and implementation of a general-purpose six-axis robotic manipulator controller developed to serve as a research tool for investigating practical and theoretical aspects of control strategies in robotics. The 80286-based Intel System 310 was used for running the XENIX operating servo software as well as higher-level software that implements kinematics and path planning. A Multibus-compatible interface board was designed and constructed to handle input/output signals from the joint motors of the robot manipulator. The universal controller is capable of driving robot manipulators equipped with electric joint motors and position optical encoders. To test functionality, the controller was connected to the joint motor DC power amplifier of a Unimate PUMA 560 arm, bypassing completely the manufacturer-supplied Unimate controller; proportional-integral-derivative (PID) control laws were installed into the XENIX operating system. Additional software drivers were implemented to allow application programs access to the interface board. All software was written in the language C. 9 refs.

Bihn, Daniel G. (Hewlett-Packard Co, Cupertino, CA, USA); Hsia, T.C. Steve. *IEEE Control Syst Mag* v 8 n 1 Feb 1988 p 31-36.

**091182 DEXTEROUS WORKSPACE OF SIMPLE MANIPULATORS.** A theoretical study on the dexterous workspace of robotic manipulators is presented. For a robot with wrists that can generate a full range of orientations, the boundary of the robot's dexterous workspace is governed by the boundary of  $W_1(4)$ , where  $W_1(4)$  is the reachable space of joint 4 when joints 1-3 are free to rotate. A method is developed on this basis. Three examples are given to illustrate this concept and method. They show that for simple robots, analytical expressions for the dexterous workspace can be obtained. 18 refs.

Lai, Zone-Chang (GMF Robotics Corp, Troy, MI, USA); Menq, Chia-Hsiang. *IEEE J Rob Autom* v 4 n 1 Feb 1988 p 99-103.

**091183 NEW METHOD OF DYNAMICS FOR ROBOT MANIPULATORS.** A novel method of dynamics for robot manipulators has been developed from Lagrangian mechanics. This method can solve the problem in which the number of computations is numerous when the Lagrange-Euler method is used for deriving a set of closed and explicit-form differential or state equations for robot manipulators. The method can be applied to the design of control systems, the dynamic simulation, and the computation of generalized forces or torques of robot manipulators. The number of computations of using this method is small enough to allow real-time computation on a minicomputer or microcomputer. The whole computational process for deriving the complete dynamic equations of a robot manipulator with  $n$  degrees of freedom requires at most  $(3n^3/2 + 14n^2 + 79n/2 - 4)$  multiplications and  $7n^3/6 + 10n^2 + 115n/3 - 10$  additions. 14 refs.

Li, Chang-Jin (Beijing Inst of Technology, China). *IEEE Trans Syst Man Cybern* v 18 n 1 1988 p 105-114.

**091184 SYNTHESIS OF SMOOTH TRAJECTORIES FOR PICK-AND-PLACE OPERATIONS.** A spline-based method of programming smooth trajectories for pick-and-place operations is introduced. Unlike continuous-path operations, which impose a unique Cartesian trajectory, an infinite number of smooth trajectories can be described between any given pick and its corresponding place configuration. The method begins with the mapping of the pick and the place configuration in Cartesian space into joint-coordinate space, using a general-purpose inverse kinematics package that handles singularities and redundancies. Next, a trajectory, composed of a  $C^2$ -continuous, periodic cubic spline segment, is defined between the pick and the place configurations in the joint-coordinate space. It is demonstrated that  $C^2$ -continuity will prevail in Cartesian space as well. The software implementing this method includes a graphics package as well as an interface to an offline programming system to realize the synthesis of the actual robot motion. Details of the procedure are illustrated with a numerical example applied to a commercial industrial robot. 21 refs.

Angeles, Jorge (McGill Univ, Montreal, Que, Can); Alivizatos, Andreas; Zsombor-Murray, Paul J. *IEEE Trans Syst Man Cybern* v 18 n 1 1988 p 173-178.

**091185 TIME-OPTIMAL CONTROL FOR A ROBOTIC CONTOUR FOLLOWING PROBLEM.** A mathematical formulation for the time-optimal contour following problem, defined by a unilaterally constrained manipulator, is presented. The formulation includes a careful development of the manipulator dynamics and of conditions for avoidance of impact between the end effector and the constraint surface. By a priori specification of the paths for the unconstrained motion segments, a parameterization approach is used to simplify the optimal control formulation, so that solution procedures can be identified. The methodology is applied to a simple contour-following problem for a planar Cartesian manipulator. 9 refs.

Huang, Han-Pang (Nat'l Taiwan Univ, Taipei, Taiwan); McClamroch, N. Harris. *IEEE J Rob Autom* v 4 n 2 Apr 1988 p 140-149.

**091186 KINEMATICS OF SPATIAL ROBOTIC BEVEL-GEAR TRAINS.** A systematic approach is developed for the kinematic analysis of multi-degree-of-freedom robotic bevel-gear trains. The approach is based on the idea that the motion of a bevel-gear-type end effector can be described by an equivalent open-loop chain and that the relative rotation between every two adjacent links in the equivalent open-loop chain can be derived from a set of fundamental circuit equations and coaxial conditions. The theory is demonstrated by the kinematic analysis of two robotic wrists. 17 refs.

Tsai, Lung-Wen (Univ of Maryland, College Park, MD, USA). *IEEE J Rob Autom* v 4 n 2 Apr 1988 p 150-156.

**091187 ANALOG MATRIX INVERSION.** The enhancement of robot dynamic performance can be aided by high-speed and, in some cases, low-accuracy calculation of

matrices and their inverses. Analog techniques for the calculation of robot kinematics are reviewed and a method for fast matrix inversion is proposed. Tradeoffs in speed and accuracy in such computations are also examined. 12 refs.

Sturges, Robert H. Jr. (Carnegie-Mellon Univ, Pittsburgh, PA, USA). *IEEE J Rob Autom* v 4 n 2 Apr 1988 p 157-162.

**091188 DYNAMICS AND SIMULATION OF COMPLIANT MOTION OF A MANIPULATOR.** A rigid body model for compliant motion of a manipulator is derived. The model is formulated in the joint coordinate frame, and then transformed into the constraint frame to reduce the dimensionality of the model. The proposed model is useful in the simulation of force-controlled manipulators. Examples considering the tasks of a 'peg in a hole' and 'turning a crank' are given. The basic structure of the model is represented in a general framework applicable to many other constrained mechanical systems. A control architecture is suggested, which according to the model leads to exact decoupling of force and position-controlled directions. 27 refs.

Kankaanranta, Raimo K. (Tampere Univ of Technology, Finl); Koivo, Heikki N. *IEEE J Rob Autom* v 4 n 2 Apr 1988 p 163-173.

**091189 MINIMUM TIME TRAJECTORY PLANNER FOR THE DISCRETE DYNAMIC ROBOT MODEL WITH DYNAMIC CONSTRAINTS.** A minimum-time trajectory-planner is proposed for a manipulator arm. A totally discrete approach is adopted, in contrast to other models which use continuous-time but resort to discretization in the computation. The Neuman and Tourassis discrete-dynamic robot model is used to model the robot dynamics. The proposed trajectory planner includes joint-torque constraints to fully utilize the joint actuators. Realistic constraints such as the joint-jerk and joint-velocity constraints are incorporated into the model. The nonlinear optimization problem associated with the planner is partially linearized, which enables the iterative method of approximate programming to be used in solving the problem. Numerical examples for a two-link revolute arm are presented to demonstrate the use of the proposed trajectory planner. It is numerically verified that the convergence of the iterative algorithm is quadratic, and the trajectory planner therefore is computationally efficient. The use of a near-minimum time-cost function is also shown to yield a solution close to that obtained with the true minimum time-cost function. 13 refs.

Tan, H.H. (Univ of Adelaide, Aust); Potts, R.B. *IEEE J Rob Autom* v 4 n 2 Apr 1988 p 174-185.

**091190 MANIPULATOR KINEMATICS AND THE EPSILON ALGEBRA.** An algebra is defined for use in problems of manipulator kinematics. With this algebra, one can program the solution to the kinematics in position problems, and use this same program to solve the kinematics problems in velocity and acceleration. The inverse kinematics part of the program can be used to obtain any order time-derivative of the joint positions. Some of the properties of the algebra are shown and functions of the elements of the algebra are defined. The solution to the forward and inverse kinematics problem is presented, and the use of the Ada programming language is discussed. 15 refs.

Walker, Michael W. (Univ of Michigan, Ann Arbor, MI, USA). *IEEE J Rob Autom* v 4 n 2 Apr 1988 p 186-192.

**091191 AUTOMATIC GENERATION AND SYNTHESIS OF C-FRAMES FOR MECHANICAL PARTS IN AN INSERTION TASK.** An approach that utilizes the geometric information about the mating parts in generating and synthesizing the C-frame and the compliance-selection vector which are needed at every sampling instant for hybrid position/force control scheme in an insertion task, is presented. A geometric modeling



system is used to model the mating objects involved in the insertion task. From the geometric model of the objects and the nominal position-trajectory of the task, a set of cut-planes of the mating objects perpendicular to the insertion direction can be obtained. Each individual cut-plane provides the freedom direction and the rotation freedom information of the peg on that plane. By combining the freedom directions and rotation freedom information, the orientation of the C-frame and the compliance-selection vector needed to control the manipulator to complete the insertion task can be determined. Due to the uncertainties inherent in working with real-world objects, and the limited position accuracy of the manipulator, an uncertainty model is incorporated into the cut-planes to reflect the position and orientation uncertainties of the C-frame. This approach reduces a difficult three-dimensional problem into a set of two-dimensional problems and will successfully complete the task even in the presence of position and orientation uncertainties. 11 refs.

Lee, C.S. George (Purdue Univ, West Lafayette, IN, USA); Hou, Edwin S.H. *IEEE J Rob Autom* v 4 n 3 Jun 1988 p 287-293.

**091192 DIRECT-DRIVE ACTIVE COMPLIANT END EFFECTOR (ACTIVE RCC).** A fast, lightweight, active end-effector, which can be attached to the endpoint of a commercial robot manipulator, has been designed and built using an impedance-control method. This control method causes the end-effector to behave dynamically as a two-dimensional remote center compliance (RCC). The compliance in this active end-effector is electronic and can be modulated by an online computer. The device is planar and five-bar linkage, and is driven by two direct-drive, brushless DC motors. A two-dimensional, piezoelectric force cell on the endpoint of the device, two 12-bit encoders, and two tachometers on the motors form the measurement system. The high structural stiffness and light weight of the material used in the system allow for a 15-Hz-bandwidth impedance control. 21 refs.

Kazerooni, H. (Univ of Minnesota, Minneapolis, MN, USA). *IEEE J Rob Autom* v 4 n 3 Jun 1988 p 324-333.

**091193 SUBTASK PERFORMANCE BY REDUNDANCY RESOLUTION FOR REDUNDANT ROBOT MANIPULATORS.** The problem of selecting joint space trajectories for redundant manipulators is considered. Solutions which allow secondary tasks to be performed by the arm simultaneously with end-effector motions may be selected in a number of ways. An algorithm to accomplish this, by means of conditions on a scalar function of the joint variables, is introduced and analyzed. Problems inherent in schemes involving constraints in configuration space are considered. 15 refs.

Walker, Ian D. (Univ of Texas, Austin, TX, USA); Marcus, Steven I. *IEEE J Rob Autom* v 4 n 3 Jun 1988 p 350-354.

**091194 KINEMATIC ANALYSIS OF A THREE-DEGREES-OF-FREEDOM IN-PARALLEL ACTUATED MANIPULATOR.** An alternative design of a three-degrees-of-freedom manipulator based on the concept of an in-parallel actuated mechanism is presented. The manipulator has two degrees of orientation freedom and one degree of translatory freedom. The basic kinematic equations for use of the manipulator are derived and the influences of the physical constraints on the range of motion in the practical design are discussed. Several possible applications which include the in-parallel mechanism as part of the manipulation system are suggested. 21 refs.

Lee, Kok-Meng (Georgia Inst of Technology, Atlanta, GA, USA); Shah, Dharman K. *IEEE J Rob Autom* v 4 n 3 Jun 1988 p 354-360.

**091195 ON THE DYNAMIC CHARACTERISTICS OF A BALANCED PUMA-760 ROBOT.** To reduce complexities in robot dynamics, a mechanical counter-balancing concept based on the theory of adding balancing masses to unbalanced conventional manipula-

tors is introduced. The effects of balancing on the dynamic characteristics of the PUMA-760 robot when the designed counter-balancing mechanism is applied to the robot are examined. Through theoretical and experimental study many distinct advantages such as simplicity in the dynamic equation and significant reduction in the total required input torques are demonstrated for various manipulator speeds and payload conditions. Based on these results, the dynamic characteristics of the balanced PUMA-760 robot are discussed in detail. 20 refs.

Chung, Wan-Kyun (Pohang Inst of Science & Technology, South Korea); Cho, Hyung Suck. *IEEE Trans Ind Electron* v 35 n 2 May 1988 p 222-230.

**091196 EFFICIENT PARALLEL ALGORITHMS FOR ROBOT FORWARD DYNAMICS COMPUTATION.** Two efficient parallel algorithms for computing the forward dynamics for real-time simulation were developed for implementation on a single-instruction multiple-data-stream (SIMD) computer with  $n$  processors, where  $n$  is the number of degrees of freedom of the manipulator. The first parallel algorithm, based on the composite rigid-body method, generates the inertia matrix using the parallel Newton-Euler algorithm, the parallel linear recurrence algorithm, and the modified row-sweep algorithm, and then inverts the inertia matrix to obtain the joint acceleration vector at time  $t$ . The time complexity of this parallel algorithm is of the order  $O(n^2)$  with  $O(n)$  processors. Further reduction of the order of time complexity can be achieved by implementing the Cholesky's factorization procedure on very-large-scale-integrated (VLSI) array processors to invert the symmetric, positive-definite, inertia matrix. The second parallel algorithm, based on the conjugate gradient method, computes the joint acceleration with a time complexity of  $O(n)$  for multiplication operation and  $O(n \log_2 n)$  for addition operation. The interprocessor communication problem for the implementation of the proposed parallel algorithms on SIMD machines is also discussed and analyzed. 17 refs.

Lee, C.S.G. (Purdue Univ, West Lafayette, IN, USA); Chang, Po Rong. *IEEE Trans Syst Man Cybern* v 18 n 2 1988 p 238-251.

**091197 EXPLORATION OF SENSORLESS MANIPULATION.** The use of motion strategies to eliminate uncertainty, without the use of sensors, is considered. The approach is demonstrated within the context of a simple method to orient planar objects. A randomly oriented object is dropped into a tray. When the tray is tilted, the object can slide into walls, along walls, and into corners, sometimes with the effect of reducing the number of possible orientations. For some objects a sequence of tilting operations exists that leaves the object's orientation completely determined. An automatic planner is described that constructs such a tilting program, using a simple model of the mechanics of sliding. The planner has been implemented, the resulting programs have been executed using a tray attached to an industrial manipulator, and sometimes the programs work. The authors explore the issue of sensorless manipulation, tray tilting in particular, within the context of a formal framework described by T. Lozano-Perez, M. T. Mason, and Rolf Taylor (1984). It is observed that sensorless motion strategies perform conditional actions using mechanical decisions in place of environmental inquiries. 12 refs.

Erdmann, Michael A. (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Mason, Matthew T. *IEEE J Rob Autom* v 4 n 4 Aug 1988 p 369-379.

**091198 SOLUTION ALGORITHM TO THE INVERSE KINEMATIC PROBLEM FOR REDUNDANT MANIPULATORS.** Based on a recently proposed algorithmic solution technique, the inverse kinematic problem for redundant manipulators is solved. The kinematics of the manipulator is appropriately augmented to include mentioned constraints; the result is an efficient, fast, closed-loop algorithm which only makes use of the direct kinematics of the manipulator. Simulation results illustrate the tracking performance for a given trajectory in the Cartesian space, while guaranteeing a collision-free trajectory and/or not violating a mechanical joint limit.

29 refs.

Sciavicco, Lorenzo (Univ of Naples, Naples, Italy); Siciliano, Bruno. *IEEE J Rob Autom* v 4 n 4 Aug 1988 p 403-410.

**091199 CLOSED-LOOP MANIPULATOR CONTROL USING QUATERNION FEEDBACK.** Euler parameters, a form of normalized quaternions, are used to model the hand-orientation errors in resolved-rate and resolved-acceleration control of manipulators. The quaternion formulation simplifies the stability analysis of the orientation error dynamics. Two types of quaternion feedback have been considered. The first type uses only the vector portion of the quaternion error, while the second is based on a Euler rotation representation. The quaternion vector approach leads to a linear feedback control law for which the global asymptotic convergence of the orientation error is readily established. The Euler rotation approach also results in asymptotic error convergence in the large except for a singularity where the hand orientation differs from its desired orientation by a rotation of  $180^\circ$ . 22 refs.

Yuan, Joseph S.-C. (Spar Aerospace Ltd, Weston, Ont, Can). *IEEE J Rob Autom* v 4 n 4 Aug 1988 p 434-440.

**091200 OPTIMAL ROBOT PATH PLANNING USING THE MINIMUM-TIME CRITERION.** A path planning technique is presented which produces time-optimal manipulator motions in a workspace containing obstacles. The full nonlinear equations of motion are used in conjunction with the actuator limitations to produce optimal trajectories. The Cartesian path of the manipulator is represented with B-spline polynomials, and the shape of this path is varied in a manner that minimizes the traversal time. Obstacle avoidance constraints are included in the problem through the use of distance functions. In addition to computing the optimal path, the time-optimal open-loop joint forces and corresponding joint displacements are obtained as functions of time. The examples presented show a reduction in the time required for typical motions. 19 refs.

Bobrow, James E. (Univ of California, Irvine, CA, USA). *IEEE J Rob Autom* v 4 n 4 Aug 1988 p 443-450.

**091201 MODELING AND CONTROL OF ROBOTIC MANIPULATORS AND MANUFACTURING PROCESSES (PRESENTED AT THE WINTER ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS).** This conference proceedings contains 50 papers discussing aspects related to the automation of manufacturing processes. Increased interests in automation dictates the need for better understanding of the physics involved in these processes and development of new control techniques for manufacturing automation. Modeling, feedback control and sensory information are three crucial elements in both organizing the automated factory as a whole, and in controlling unit processes. The conference papers include the following topics: Manufacturing Processes, Light metal removal with robots, Robotic manipulators, Force and compliance control, control of flexible manipulator arms, and micromechanical structures. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10833 in the Engineering Meetings (TM) database produced by Engineering Information, Inc.

Shoureshi, R. (Ed.) (Purdue Univ, USA); Youcef-Toumi, K. (Ed.); Kazerooni, H. (Ed.). *ASME Dyn Syst Control Div Publ DSC* v 6, Model and Control of Rob Manipulators and Manuf Processes, Boston, MA, USA, Dec 13-18 1987. Publ by ASME, New York, NY, USA, 1987 422p.

**091202 DESIGN OF ROBOT MANIPULATORS BASED ON KINEMATIC ANALYSES.** Kinematic analysis represents an important tool for the functional design of robot applications. It facilitates the determination of layout arrangements for the production cell, the selection of suitable machines and equipment, the design



of task specifications and robot paths and the performance of all the tasks required by new robot manipulators. This paper describes an advanced approach for the mathematical modelling and simulation of robot kinematics and examines the following problems: 1. How to set up kinematic equations for robot manipulators. 2. How to solve the inverse kinematics for robot manipulators. 3. How to develop a simulator for robot manipulators based on kinematical models, and to incorporate it in a CAD system. (Author abstract) 25 refs.

Lenarcic, Jadran (Inst 'Jozef Stefan' Ljubljana, Yugosl); Nemec, Bojan; Stanic, Uros; Oblak, Pavel. *Rob Comput Integr Manuf* v 4 n 1-2 1988, Manuf Sci, Technol and Syst of the Future, Ljubljana, Yugosl, Sep 12-14 1985 p 203-209.

## Manufacture

**091203 COMPUTER MODELING HELPS CHOICE OF DC SERVO MOTORS.** EG&G Torque Systems teamed up with CRS Plus Inc. to select the optimum DC servo motors to drive a new five-axis robot. Servomotors and their applications are described.

Friedrich, Seth D. (EG&G Torque Systems, Watertown, MA, USA). *Rob World* v 5 n 8 Aug 1987 p 28-29.

**Materials Handling Applications.** See Also AUTOMOBILE MANUFACTURE—Finishing; DRUG PRODUCTS PLANTS—Automation; MACHINE SHOPS—Flexible Manufacturing Systems; MATERIALS HANDLING—Assembly; MATERIALS HANDLING—Optimization; MATERIALS HANDLING—Pallets; PLASTICS PLANTS—Robot Applications; PRODUCTION CONTROL—Robot Applications; RADIOACTIVE MATERIALS—Safe Handling; ROBOTICS—Vision Systems; TRACTORS—Manufacture.

**091204 REVAMPED ROBOTIC PROCESS CUTS SCRAP RATE BY 300%.** The Pratt & Whitney Automated Casting Facility (ACF) at Middletown, CT, billed as the only investment casting facility of its kind in the world, uses computers to monitor some 4000 operational functions simultaneously to ensure consistent high quality in the gas turbine blades it produces for F100 military aircraft engines. Robotic handling has been the only way to ensure consistent preparation of shell molds for the investment casting process. In late 1986, plant and engineering managements concluded that after more than seven years of around-the-clock duty in an abrasive dust environment, the robots were worn out and should be replaced. The replacement decision provided Pratt & Whitney the opportunity to, on the one hand, eliminate a persistent maintenance problem and, on the other hand, boost line productivity.

Nagler, Ben. *Rob Today* v 9 n 5 Oct 1987 p 25-26.

**091205 GANTRY DEMANDS FLEXIBLE CONTROL.** Flexibility plays a critical role in the cost-efficiency and application effectiveness of a robotic system. Without adequate flexibility, a manufacturer can get caught in an expensive and frustrating cycle of modifying and reprogramming systems in the field as application requirements evolve and change. Texas-based C&D Machine and Engineering Co. found a way to break that cycle through the use of the modular, microprocessor-based Motion Plus controller from MTS Systems Corporation. The Motion Plus system added the necessary flexibility and easy programmability to C&D's System II material handling robot, so that customers could program the Cartesian coordinate, three and four axis gantry-style system themselves according to their changing needs.

Anon. *Rob World* v 4 n 11 Oct 1986 p 30-31.

**091206 MATERIALS HANDLING ROBOTICS AND SYSTEMS.** Much of the recent interest in automation has been directed towards stationary robots, although their mobile equivalents have been in widespread use for many years. This paper reviews the main types of robot vehicles, their control features, and includes typical applications in both manufacturing, storage and warehousing. (Author abstract)

Munns, M.G. (Lansing Australia Pty Ltd, Aust). *Mech*

*Eng Trans Inst Eng Aust* v ME 10 n 3 Sep 1985 p 196-202.

**091207 USE OF COMPUTER-AIDED DESIGN METHODS IN ROBOTICS.** The author discusses the structure of CAD-integrated robot programming systems. He deals with three-dimensional modelling in the robot programming environment, with the definition of the manufacturing task and planning, with the generation of the manufacturing program and its simulation, and with integration into computer-aided planning of manufacture. Special importance attaches to data management because all items of data must be made accessible to the programmer via a user interface. (Author abstract) 25 refs. In German and English.

Dillmann, Ruediger (Karlsruhe Univ, Karlsruhe, West Ger). *Schweissen Schneiden* v 39 n 4 Apr 1987 p E63-E66.

**091208 AUTOMATION BOOSTS PRODUCTIVITY IN MELROE MACHINE SHOP.** Melroe Division of Clark Equipment, Fargo, N.D., manufactures the Bobcat skid steer loader used in construction, industrial and agricultural applications for excavating and material handling. The Melroe organization has maintained a dominant market share while continuing to develop new products and integrate advanced manufacturing technology into its facilities. Experienced with arc welding robots, Melroe Division of Clark Equipment Co. called on Automated Concepts (Auto Con) for help integrating robots into the company's machine shop.

Burg, John (Automated Concepts Inc, Omaha, NE, USA). *Rob World* v 6 n 1 Jan 1988 p 20-23.

**091209 ROBOTS, PARTS HANDLERS & FEEDERS.** Parts feeding and handling equipment must be well engineered, precise, and predictable. The feeder is the heart of the automation project. A typical programmable system has a parts feeder, recognition device, vision controller, orienting mechanism, and conveyor. This article suggests that users must consider more than price when evaluating products. Another viable method of handling parts in assembly operations is the industrial robot. Yet there are problems in the industry, which the article also discusses.

Schwartz, Walter H. (Assembly Engineering, Wheaton, IL, USA); Schuch, Linda K. *Assem Eng* v 31 n 9 Sep 1988 p 66-69.

**Mathematical Models.** See Also KINEMATICS—Mathematical Models; PAINT SPRAYING—Automation.

**091210 COMPUTATION OF THE DIRECT AND INVERSE GEOMETRIC MODELS OF THE DELTA 4 PARALLEL ROBOT.** This is a description of the geometric model of the robot Delta 4, which was developed at the Institute of Microengineering at the Swiss Federal Institute of Technology in Lausanne. An explanation of the kinematic structure of the machine will serve as a brief introduction to the descriptions of the direct and inverse geometric models. A few preliminary results obtained from computer simulations have been included. (Author abstract) 8 refs.

Sternheim, F. *Robotersysteme* v 3 n 4 1987 p 199-203.

**091211 BASIC CONSIDERATIONS OF THE DEGREES OF FREEDOM OF MULTI-LEGGED LOCOMOTION MACHINES.** All multi-legged locomotion machines that do not need any dynamic balance control can be classified functionally into several levels. We define the minimum walking functions of multi-legged locomotion machines as follows: (i) two-dimensional walking; (ii) keeping the body horizontal on irregular terrains; (iii) keeping the absolute height of main body constant. Our main interest is in how many active degrees of freedom are necessary and sufficient to realize the above functions. The active degrees of freedom are examined in this paper using a four-legged machine which offers the minimum number of legs necessary to maintain static stability. It is shown that six active degrees of freedom are necessary and sufficient to realize the above functions. (Edited author

abstract) 18 refs.

Kaneko, M. (Tsukuba Science City, Ibaraki, Jpn); Abe, M.; Tachi, S. *Adv Rob* v 1 n 2 1986 p 101-116.

**091212 MODELLING ROBOT ELASTIC LINKS.** Robot elastic links are modelled as supplements. This modelling is adapted to the measuring of robot elastic features in situ. Open- and closed-loop linkages are examined. In closed-loop mechanisms, the beam-links and the rod-links are defined; the supplements modelling beam-link has three nodal points and eleven nodal values. In open-loop linkages, all the links are beam-links and are modeled as supplements with two nodal points and twelve nodal values. The rigid-body degrees of freedom are separated and the rigid-body transfer matrix is calculated. This separation leads to the displacements which represent the elastic deformation of the link, and makes it possible to calculate its flexibility matrix from the displacements measured at the nodal points. (Author abstract)

Kiedrzyński, Andre (Univ of Brussels, Brussels, Belg). *Robotics* v 4 n 1 Mar 1988 p 85-91.

**091213 REPREZENTAREA SISTEMICA A (FUNCTIONALITATI DYNAMIC A) ROBOTILOR INDUSTRIALI.** [Dynamical System Modelling of Industrial Robots]. The paper presents the representation of an industrial robot as a dynamical system, the first step for the formulation of a control problem. The particularities of the obtained dynamical system which determine the features of the control structure and control algorithms are also presented. (Author abstract) 5 refs. In Romanian.

Serban, S. (Inst Politehnic, Bucharest, Rom); Coraci, I.C. *Bul Inst Politeh Bucuresti Ser Autom Calc* v 49 1987 p 29-38.

**091214 ANALYSIS OF DISCRETE DYNAMIC ROBOT MODELS.** The discrete shift-transformation matrix of general orthogonal polynomials is introduced. The discrete shift-transformation matrix is used to transform the difference equations which describe the discrete dynamic robot model into algebraic equations. Several lemmas are introduced which, together with the discrete shift-transformation matrix, solve for the joint positions and velocities of discrete dynamic robot models using discrete orthogonal polynomials approximations. The initial numerical experiment with a cylindrical coordinate robot shows the feasibility and applicability of discrete orthogonal polynomials approximations. 13 refs.

Lee, Tsu-Tian (Univ of Kentucky, Lexington, KY, USA); Tsay, Yuh-Feng. *IEEE J Rob Autom* v RA-3 n 6 Dec 1987 p 583-590.

## Measurements

**091215 NON-CONTACTING, THREE DIMENSIONAL MEASUREMENT USING AN INDUSTRIAL ROBOT.** This paper describes the development and the methodology of a non-contacting, three dimensional measurement system using an industrial robot, a CCD camera together with a laser analogue sensor, and some results obtained by applying it to the measurement of objects. A frame image of an object in the working area of the robot is firstly taken by the camera mounted on the upper stand over the robot. Then its pattern, position and dimensions are recognized by a personal computer. Using these recognized data, robot operating instructions are made automatically on the computer. Successively the robot approaches the object and begins to measure the distance between it and the laser sensor according to the principle of the triangulation. By this measurement system, workpieces and houseware having fairly complicated contours can be measured precisely and reconstituted as three dimensional data in the computer memory cells. (Edited author abstract) In Japanese. 3 refs.

Tokui, Takaaki; Yamafuji, Kazuo. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 492 Aug 1987 p 1795-1799.



Medical Applications See DRUG PRODUCTS—Manufacture.

### Military Purposes

**091216 ROBOTS REACH OUT TO TOUCH NONINDUSTRIAL APPLICATIONS.** In general, the robotic systems being developed for use in these newer surroundings are more intelligent and versatile than their industrial counterparts. Mobility, for example, is a particularly important asset in many applications now being investigated, and in some situations it is a prerequisite. Nuclear installations, mining, and military reconnaissance are examples where the ability to move in an unstructured environment makes sensor-equipped mobile robots attractive. Applications of robotic equipment in the military, space stations, sentry duty, health care/human services, agriculture are described.

Stauffer, Robert N. (Robotics Today, Dearborn, MI, USA). *Rob Today* v 9 n 5 Oct 1987 p 19-22.

**Mobile** See Also ARTIFICIAL INTELLIGENCE—Applications; BIOMECHANICS—Biped Locomotion; CONTROL SYSTEMS—Mathematical Models; MACHINE DESIGN—Analysis; MAGNETS—Robot Applications; MATHEMATICAL TECHNIQUES—Fuzzy Sets; PIPELINES—Automatic Testing; ROBOTICS—Computer Simulation; ROBOTICS—Vision Systems; SUBMERSIBLES; VEHICLES—Control.

**091217 LONG X-TABLE UNLEASHES ROBOT.** Fixed-base manufacturing robots can inhibit a process, particularly when the product must move along a conveyor. The author describes and X-Y-Z table big enough to hold the robot, and versatile enough to follow the product - or even the operator. Two types of designs set the pattern. One, a robot table drive directly by a hydraulic cylinder. The other is a ball screw, turned with an electrohydraulic servomotor.

Yeaple, Frank (Design News, Newton, MA, USA). *Des News (Boston)* v 42 n 23 Dec 1 1986 p 76-77.

**091218 MOBILE ROBOTS FOR INDUSTRIAL AND COMMERCIAL APPLICATIONS - A REVIEW OF POSSIBILITIES AND DESIGN REQUIREMENTS.** Mobility will be a common feature in future generations of industrial robots, and robot-carts are likely to play a significant role in various industrial and commercial situations. Particular applications for such machines are examined, and a range of design and operational requirements are reviewed in the context of existing and near-term technology. (Author abstract) 7 refs.

Gascoigne, A.E. (Anthony E. Gascoigne & Associates, Black Rock, Aust). *Mech Eng Trans Inst Eng Aust* v ME 10 n 3 Sep 1985 p 175-182.

**091219 COLLISION-FREE TRAJECTORY PLANNING USING DISTANCE TRANSFORMS.** This paper describes a new approach to shortest collision-free path finding for robotic application. Both 2D and 3D solutions follow naturally from the development of distance transforms propagated through unoccupied space from single or multiple goal points. Steepest descent tracking from any specified starting point in unoccupied space traces out the shortest collision-free path to the nearest goal. The obstacles are 'grown to take account of the physical extent of the robotic vehicle, which itself is then represented by a reference point (initially at the start point but to be moved to the nearest goal point). Preliminary examples processed in the Computer Vision and Robotics Laboratory at the Australian National University are presented for evaluation. (Author abstract) 8 refs.

Jarvis, R.A. (Australian Natl Univ, Aust). *Mech Eng Trans Inst Eng Aust* v ME 10 n 3 Sep 1985 p 187-191.

**091220 SURFACE PREDICTION AND ADAPTATION IN A ROBOT'S WORKPLACE.** Oracle is the sheep shearing robot designed and built in the Department of Mechanical Engineering at the University of Western Australia. Oracle's task is to shear the fleeced off

Merino ewes and wethers. Oracle works jointly with ARAMP, the Automated Restraint and Manipulating Platform. ARAMP is capable of holding the sheep in certain pre-defined positions, of turning it over, of registering specific points on the sheep surface, and can feed back information about global features of the surface position. This paper discusses surface prediction, adaptation and learning with reference to Oracle and ARAMP. These techniques, however, are general in nature and can be used whenever a robot is required to react intelligently with an uncertain environment. Some possible examples of intelligent robot reaction to surfaces are given. 5 refs.

Owens, R.A. (Univ of Western Australia, Aust). *Mech Eng Trans Inst Eng Aust* v ME 10 n 3 Sep 1985 p 203-207.

**091221 NEW EFFICIENT MOTION-PLANNING ALGORITHM FOR A ROD IN TWO-DIMENSIONAL POLYGONAL SPACE.** We present here a new and efficient algorithm for planning collision-free motion of a line segment (a rod or a 'ladder') in two-dimensional space amidst polygonal obstacles. The algorithm calculates the boundary of the (three-dimensional) space of free positions of the ladder, uses this boundary for determining the existence of required motions, and plans such motions whenever possible. The algorithm runs in time  $O(K \log n) = O(n^2 \log n)$  where  $n$  is the number of obstacle corners and where  $K$  is the total number of pairs of obstacle walls or corners of distance less than or equal to the length of the ladder. The algorithm also serves as an initial demonstration of the viability of the technique it uses, which we expect to be useful in obtaining efficient motion-planning algorithms for other more complex robot systems. (Edited author abstract) 18 refs.

Sifrony, S. (Tel Aviv Univ, Tel Aviv, Isr); Sharir, M. *Algorithmica (New York)* v 2 n 4 1987 p 367-402.

**091222 PATH-PLANNING STRATEGIES FOR A POINT MOBILE AUTOMATON MOVING AMIDST UNKNOWN OBSTACLES OF ARBITRARY SHAPE.** The problem of path planning for an automaton moving in a two-dimensional scene filled with unknown obstacles is considered. The automaton is presented as a point; obstacles can be of an arbitrary shape, with continuous boundaries and is of finite size; no restriction on the size of the scene is imposed. The information available to the automaton is limited to its own current coordinates and those of the target position. When the automaton hits an obstacle, this fact is detected by the automaton's 'tactile sensor.' This information is shown to be sufficient for reaching the target or concluding in finite time that the target cannot be reached. A worst-case lower bound on the length of paths generated by any algorithm operating within the framework of the accepted model is developed. Algorithms that guarantee reaching the target (if the target is reachable), and tests for target reachability are presented. (Edited author abstract) 24 refs.

Lumelsky, Vladimir J. (Yale Univ, New Haven, CT, USA); Stepanov, Alexander A. *Algorithmica (New York)* v 2 n 4 1987 p 403-430.

**091223 MOTION PLANNING WITH INERTIAL CONSTRAINTS.** A body  $B$  must move from a placement  $Z_0$  to a placement  $Z_1$  while avoiding collision with a set  $S$  of moving obstacles. The motion must satisfy an inertial constraint: the acceleration cannot exceed a given bound  $M$ . The problem is analyzed, and polynomial-time motion-planning algorithms are given for the case of a particle moving in one dimension. (Author abstract) 3 refs.

O'Dunlaing, Colm (Courant Inst of Mathematical Sciences, New York, NY, USA). *Algorithmica (New York)* v 2 n 4 1987 p 431-475.

**091224 OPTIMAL PIECEWISE LINEAR MOTION OF AN OBJECT AMONG OBSTACLES.** We present an algorithm for determining the shortest restricted path motion of a polygonal object amidst polygonal obstacles. The class of motions which are allowed can be described as follows: a designated vertex,  $P$ , of the polygonal object

traverses a piecewise linear path, whose breakpoints are restricted to the vertices of the obstacles. The distance measure being minimized is the length of the path traversed by  $P$ . Our algorithm runs in time  $O(n^4 \log n)$ . We also discuss a variation of this algorithm which minimizes any positive linear combination of length traversed by  $P$  and angular rotation of the ladder about  $P$ . This variation requires  $O(n^5)$  time. (Author abstract) 22 refs.

Papadimitriou, Christos H. (Stanford Univ, Stanford, CA, USA); Silverberg, Ellen B. *Algorithmica (New York)* v 2 n 4 1987 p 523-539.

**091225 METHOD OF AUTONOMOUS LOCOMOTION FOR MOBILE ROBOTS.** A navigation method is presented which enables a mobile robot to perform autonomous locomotion. The feasibility of this method was demonstrated using experimental hardware - a prototype robot with ultrasonic sensors. This method uses objects of simple shape, such as poles and flat surfaces of walls selected from the environment, as landmarks and a map which indicates the relations of these landmarks. The robot moves from a given point to another along a designated path using its sensors. At each point it measures the positions of the objects selected as landmarks and corrects its path. The following basic problems encountered in realizing this method are discussed: (a) path design connecting two points in the environment; (b) the control of the robot's path; (c) measurement of the objects' positions using an ultrasonic sensor; and (d) correction of error from the designated path. (Edited author abstract) 7 refs.

Komoriya, Kiyoshi (Ministry of Int Trade & Industry, Tsukuba, Jpn); Tachi, Susumu; Tanie, Kazuo. *Adv Rob* v 1 n 1 1986 p 3-19.

**091226 DESIGN OF A ROBOT CAPABLE OF MOVING ON A VERTICAL WALL.** The development of a mobile robot which can work on the vertical walls of tall buildings, the side walls of large ships, etc. has been expected for a long time. A magnetic force or vacuum pressure is available to sustain the robot on a vertical wall, and wheels, crawlers and some other walking mechanisms can be used as the methods of moving. Many combinations of these mechanisms will be developed for various applications. Two kinds of robot model were built and tested. The air was sucked from the peripheral nozzle of the suction cup to the fan and crawlers were used as the moving system. There are two dangerous situations - slipping and falling, and their limits are determined. The aerodynamic matching between the fan and suction cup is also important to understand the safety conditions and to design an active controller to avoid dangerous situations. It is investigated using the above models. (Edited author abstract) 1 ref.

Nishi, Akira (Miyazaki Univ, Miyazaki, Jpn); Wakasugi, Yasuo; Watanabe, Kazuya. *Adv Rob* v 1 n 1 1986 p 33-45.

**091227 DEVELOPMENT OF VEHICLES WITH LEGS AND WHEELS.** The creeping mode locomotion on uneven ground is considered, proposing a vehicle which has legs with two joints and wheels. As a result of the experiment and examination, it was judged that the optimum locomotion vehicle is one which has four legs with two joints and six wheels (two driving wheels and four drive supporting wheels). This vehicle has various kinds of potential performance because of its multiple degrees of freedom. 7 refs.

Oomichi, Takeo (Mitsubishi Heavy Industries Ltd, Takasago, Jpn); Ibe, Tomoyoshi. *Adv Rob* v 1 n 1 1986 p 343-356.



**091228 INTEGRIERTE SENSORAKTIONS-PLANUNG ALS NEUARTIGE SENSOR- UND STEUERUNGSSARCHITEKTUR FUER DEN MOBILEN AUTONOMEN ROBOTER IPAMAR.** [Integrated Sensor Action Planning - a New Control Architecture for the Mobile Autonomous Robot IPAMAR]. Mobile autonomous robots have become a main research interest in robotics. At present, restrictions in real world understanding and computational time consumption are the technological limits of the sensor- and control structure. This paper presents a new control architecture for mobile autonomous robots named Integrated Sensor Action Planning and implemented on the research vehicle IPAMAR. For demonstration of feasibility, transportation tasks are performed by the autonomous vehicle. (Author abstract) In German. 16 refs.

Warnecke, H.-J.; Drunk, G. *Robotersysteme* v 3 n 4 1987 p 209-217.

**091229 COMPUTER COORDINATION OF MOTION FOR OMNI-DIRECTIONAL HEXAPOD WALKING MACHINES.** The design and construction of a large man-carrying hexapod called the Adaptive Suspension Vehicle (ASV) are discussed. The first steps by the ASV were taken in 1985. Further refinement of hardware and software is currently under way in an indoor test facility. Extensive outdoor testing of the ASV is presently scheduled to begin in August, 1986. 9 refs.

McGhee, Robert B. (Ohio State Univ, Columbus, OH, USA). *Adv Rob* v 1 n 2 1986 p 91-99.

**091230 MOBILE ROBOT WITH A DEVELOPED SENSE OF SECURITY.** The Sandia Interior Robot (SIR) system was originally designed as a test instrument for evaluating various types of sensors and to help in developing robot navigation algorithms but the ultimate goal was to develop an effective mechanical sentry. Two main elements comprise the current system - the SIR mobile robot platform and a remote computer that uses navigational software developed at Sandia. The mobile platform contains an onboard central processing unit (CPU) that handles data transmission via a radio link to and from the computer, and also controls the motors and sensors on the robot. Functions performed by the personal-sized computer (PC) can be grouped into one of two categories - high-level decision-making or man/machine interfacing.

Anon. *Ind Robot* v 14 n 4 Dec 1987 p 217-218.

**091231 ROBUST ESTIMATOR FOR WALL FOLLOWING.** An early goal in autonomous navigation research is to build a research vehicle which can travel through office areas and factories. A simple strategy for directing the robot's movement in a hallway is to maintain a fixed distance from the wall. The problem is complicated by the fact that there are many factors in the environment, such as opened doors, pillars or other temporary objects, that can introduce 'noise' into the distance measure. To maintain a proper path with minimum interruption, the robot should have the ability to make decisions, based on measurements, and adjust its course only when it is deemed necessary. This report describes a new algorithm which enables the robot to move along and maintain a fixed distance from a reference object. The method, based on a robust estimator of the location, combines information from earlier measurements with current observations from range sensors to effectively produce an estimate of the distance between the robot and the object. A simulation study, showing the trajectories generated using this algorithm with different parameters for different environments, is presented. (Author abstract) 10 refs.

Wang, Chih-Ming (GM, Warren, MI, USA). *Res Publ Gen Mot Res Lab* GMR-6087 Dec 9 1987 9p.

**091232 WORLD REPRESENTATION AND PATH PLANNING FOR A MOBILE ROBOT.** This paper is related to the problem of navigation of a mobile robot amidst obstacles. In order to easily take into account any modification of the environment, we propose a very simple representation of the obstacles, based on the use of

rectangles, as well as a matrix description of the spatial relationships between the obstacles. We also present a path planner based on a  $A^*$  algorithm, the features of which are specifically designed for our world of rectangles. The cost function takes into account both the length of the path and the number of turns. Some experimental results and implementation details are also given in this paper. (Author abstract) 21 refs.

Dauchez, P. (Univ of California, Santa Barbara, CA, USA). *Robotica* v 6 pt 1 Jan-Mar 1988 p 35-40.

**091233 DYNAMIC REGIMES OF THE MOTION OF MULTILEGGED WALKING ROBOTS.** An equation is derived to define the forced acceleration of the body depending on the margin of longitudinal static stability during the motion of the center of mass of a robot along an arbitrary plane curve, where the property of static stability is not provided. Expressions are derived to evaluate the margin of initial kinetic energy of such a motion sufficient for traversing a path in the presence of a forced acceleration. (Author abstract) 2 refs.

Golubev, Yu.F.; Degtyareva, E.V.; Tsar'kova, T.A. *Moscow Univ Mech Bull* v 42 n 5 1987 p 1-6.

**091234 COMPLEXITY OF FINE MOTION PLANNING.** This paper concerns the problem of motion planning for robots with uncertainty in sensing and control. Although this problem has been studied before, this is the first attempt at its inherent complexity. To compensate for the uncertainties in sensing and control, our robot model includes damping - a limited capacity for compliance. In this setting, we show that motion planning for point objects is PSPACE-hard by a direct reduction from polynomial-space bounded Turing machine computations. We also present a restricted version of the problem that is PSPACE-complete. (Author abstract) 6 refs.

Natarajan, B.K. (Cornell Univ, Ithaca, NY, USA). *Int J Rob Res* v 7 n 2 Mar-Apr 1988 p 36-42.

**091235 MODEL FOR A CONTROL AND MONITORING SYSTEM FOR AN AUTONOMOUS MOBILE ROBOT.** This paper presents a model for a robot control system that is under development. The Karlsruhe autonomous mobile robot (KAMRO) will be used in a manufacturing cell, which consists of various assembly stations and a material storage system. KAMRO will be able to analyze failures and to recover in an intelligent manner. (Edited author abstract) 7 refs.

Turau, Volker (Gesellschaft fuer Mathematik und Datenverarbeitung, Darmstadt, West Ger). *Robotics* v 4 n 1 Mar 1988 p 41-47.

**091236 AUTONOME MOBILE ROBOTS.** [Autonomous Mobile Robots]. In this paper the function and structure of an autonomous mobile robot are presented. For the automatic control of such a system a knowledge based planner module, executive module and supervisor module are necessary. All modules are to be supported by a complex perception system. The functionality of such a complex device is discussed by means of the Karlsruhe autonomous mobile robot (KAMRO) developed at the University of Karlsruhe. The project is focusing on the design and the realization of a navigation module, a docking module and an assembly module. Navigation is performed with the aid of a map (map of the institute building) and sensors. Docking is controlled with the aid of tactile and visual sensors. The assembly operation sequence is generated by a planner and is executed by a hierarchy of sensors and two manipulators. Autonomy is supported by several expert systems. (Author abstract) 6 refs. In German.

Rembold, U. *Robotersysteme* v 4 n 1 1988 p 17-26.

**091237 REMOTEC'S NEW VEHICLE USES THE ANDROS BASE.** The Remote Technology Corporation (REMOTEC) of the United States has developed a product line of mobile robots to replace workers in performing surveillance, inspection, and maintenance work tasks within hazardous environments. The registered trade name of SURBOT has been applied to each of the

different robot models produced by REMOTEC, which currently includes: SURBOT-W: A wheeled surveillance robot system; SURBOT-T: An all-terrain (tracked) surveillance robot system. The SURBOT-T system includes a remote vehicle, a portable control console, a variety of optional surveillance sensors and cabling, and a contamination containment enclosure.

Cruikshank, Andrew. *Nucl Eng Int* v 33 n 405 Apr 1988 p 38-39.

**091238 ONLINE COMPUTATION OF FEATURE SENSITIVITY MATRIX FOR VISUAL SERVO CONTROL OF ROBOTS.** For image-based visual servoing of a robot, it is necessary to determine a feature sensitivity matrix  $G$  indicating the relation between small feature changes and differential motion of the camera mounted on the robot. A new scheme for online computation of the  $G$  matrix is proposed. The proposed scheme, which requires no knowledge of relative object position, is simple, owing to a coaxially-aligned dual camera set, and would be effective for vision-based control of manipulators or mobile robots. (Edited author abstract) 4 refs.

Kim, K. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Jang, W.; Bien, Z. *Electron Lett* v 24 n 9 Apr 28 1988 p 555-556.

**091239 ANALYSIS OF COLLISION AVOIDANCE IN MULTIROBOT CELLS USING PETRI NETS.** The analysis of cycle times in multirobot assembly cells involves the representation, specification and modelling of the cell activities. Since such activities are concurrent and asynchronous in nature, Petri nets may be used as an expedient analysis tool. The cell operations in actual cells are of a stochastic nature and involve real time control strategies. Thus analytical approaches cannot be used to analyse the resulting Petri nets. We use a generalised Petri net simulator called ROBSIM to simulate Petri net models of the multirobot cell. This paper outlines a generalised procedure for addressing the collision aspect in evaluating the cycle times using ROBSIM. We believe that the procedure can also be used for other aspects of synchronization in multirobot applications. (Author abstract). 15 Refs.

Wadhwa, Subhash (Univ Coll Galway, Galway, Irel); Browne, Jim. *Robotersysteme* v 4 n 2 1988 p 107-115.

**091240 FREE RANGING AGV.** A new sensor and control structure for free-ranging operation of automated guided vehicles (AGV) has been developed and implemented. Based on the analysis of control architectures for mobile autonomous robots a control structure of Integrated Sensor Action Planning is derived. The mobile robot IPAMAR equipped with ultrasonic and optical sensors has been built for demonstration of feasibility. The vehicle navigates without landmarks. Test results of an experimental AGV course prove the control system to be robust and efficient. (Author abstract). 16 Refs.

Drunk, G. (Fraunhofer Inst for Manufacturing, West Ger). *Int J Mach Tools Manuf* v 28 n 3 1988 p 263-272.

**091241 NEW METHOD OF VEHICLE POSITION MEASUREMENT BY USE OF LASER BEAM TRACKING.** This paper describes a new method of position measurement for a vehicle travelling in two-dimensional space using laser and optical detectors. If two points set on the vehicle and a reference point form an isosceles triangle, the vehicle position relative to the reference point can be calculated by a simple relation. Then we propose a system consisting of a laser beacon at the reference point and two photo-detectors set such that they are able to rotate on the vehicle. The bearing angles of the two detectors relative to the reference point can be measured by the laser beacon. The direction of the two photo-detectors is controlled so that the difference of the two bearing angles is maximum. In order to demonstrate the above method, an experimental system is made up and used for a vehicle position measurement. The results of the



experiment show that the measurement system is effective for determining the position of the vehicle near the reference point. (Author abstract). 8 Refs.

Tsumura, Toshihiro (Univ of Osaka Prefecture, Osaka, Jpn); Fujiwara, Naofumi; Hashimoto, Masafumi; Tang, Teng. *Adv Rob v 2 n 2* 1987 p 121-135.

**091242 SIGNAL PROCESSING OF A RANGE-FINDER MAP-REALIZATION SYSTEM.** This research discusses some of the basic problems of the signal processing of the range-finder, especially when it is used to reproduce a terrain map for mobile robots. The following results were obtained: (1) The reflecting points of the laser beam on the ground surface are radially distributed and, therefore, a specialized method (Radial B-spline Interpolation) can be introduced for interpolating the beam points. By separating and applying special processing methods to shadow regions, better results of the interpolation can be produced. (2) An interpolation method in association with the memorized information is shown to be feasible for signal processing of terrain. The method of memorizing terrain, and the associative application of the memory to new terrain is proven appropriate based on a computer simulation, and further improvement of the estimation is demonstrated. (Edited author abstract). 8 Refs.

Hirose, Shigeo (Tokyo Inst of Technology, Tokyo, Jpn); Maekawa, Kazunobu; Umetani, Yoji. *Adv Rob v 2 n 2* 1987 p 167-180.

**091243 STUDY OF A MAP REALIZATION SYSTEM (CANCELLATION OF AMBIENT LIGHT AND SWAYING MOTION OF A ROBOT).** For better terrain adaptability, a walking robot should be equipped with a visual sensor. This paper defines the visual sensor for a walking robot as a map realization system, abbreviated MARS, and investigates the way to realize a practical 3-D range-finder which forms the major part of a MARS. First, the improvement in the range-finder's performance to separate and extract a projected laser slit ray in ambient light is investigated. Second, structural and algorithmic considerations are made to realize real-time compensation of the swinging motion of a walking robot and to generate a terrain map while walking. As a result, it is shown that the position measurement is executed within 240  $\mu$ m per point to generate a map in real time. The experimental MARS range-finder weighs 1.8 kg and is compact. This paper shows the feasibility of producing a practical visual system for walking robots. (Edited author abstract). 9 Refs.

Hirose, Shigeo (Tokyo Inst of Technology, Tokyo, Jpn); Yoshida, Kazuhiro; Taguchi, Kan. *Adv Rob v 2 n 3* 1987 p 259-276.

**091244 MANEUVERING TACTICS FOR A TRANSPORT ROBOT ON THE BASIS OF RANGE-FINDER INFORMATION. PART 2. TAKING INTO ACCOUNT THE OWN DIMENSIONS OF AN AUTONOMOUS TRANSPORT ROBOT.** Algorithms by which the motion control system of an autonomous mobile robot takes into account the dimensions of the robot body in the process of steering it around obstacles are described. Distances to the obstacles measured by a range finder and signals from sensors for close-range detection of obstacles serve as the initial data. The robot takes into account continuously the dimensions of its body and the steering features of its chassis. 8 Refs.

Gol'tsev, A.D. (Ukrainian SSR Acad of Sciences, Kiev, USSR); Kussul, E.M. *Sov J Autom Inf Sci v 20 n 4* Jul-Aug 1987 p 65-68.

**091245 PATH FINDING MOBILE ROBOT.** A path-finding mobile robot, controlled by one 8-bit microprocessor (MC 6808) and one ultrasonic sensor, has been constructed and demonstrated. All the robot (ETW-/ETS-18 HERO 1) has to do is to find a correct path according to the instruction given by an operator. A corridor in the university building is used as the experimental course. There exist several crossing points. The instruction to the mobile robot is a finite combination of

fuzzy distance, shape of the crossing point, and the direction to go ahead. The robot finds the correct way based on a fuzzy matching between the instructed fuzzy information and the observed fuzzy data. The maximum total distance from the starting point to the goal is about 1 kilometer (because of the battery limitation). (Edited author abstract). 6 Refs. In Japanese.

Hirota, Kaoru; Ariizumi, Yoshihiro. *Bull Coll Eng Hosei Univ n 24* Mar 1988 p 69-78.

**091246 MOBILE ROBOTS: REAL-TIME INTELLIGENT CONTROL.** A large system intended for military applications is described. Its architecture and associated Lisp-like plan-generation language allow the simultaneous execution of actions as diverse as road following and obstacle avoidance. The system uses off-board computation because of the quantity, size, and power requirements anticipated for the computers. A description is given of a demonstration dealing with autonomous navigation that includes path planning and execution from a map database, with concurrent obstacle detection and avoidance, over a 2-km open-terrain route at 8 km/hr by a full-sized vehicle in a natural outdoor environment. Subsequent efforts successfully achieved more rapid speeds for road following; the vehicle attained speeds of 24 km/hr and 21 km/hr on straight and curved sections, respectively, of a San Jose, California, test track. Current efforts focus on multiple-vehicle control and advanced autonomous capabilities such as dynamic re-planning, terrain typing, and landmark-based recognition. 8 refs.

McTamoney, Louis S. (FMC, Santa Clara, CA, USA). *IEEE Expert v 2 n 4* Winter 1988 p 55-68.

**091247 POSITION VERIFICATION OF A MOBILE ROBOT USING STANDARD PATTERN.** The authors describe a system by which the critical geometric dimensions of a standard pattern are used to locate the relative position of a mobile robot with respect to the pattern. By doing so, the method does not depend on values of any intrinsic camera parameters, except the focal length. In addition, this method has the advantages of simplicity and flexibility. This standard pattern is also provided with a unique identification code, using bar codes, that enables the system to find the absolute location of the pattern. These bar codes also assist in the scanning algorithms to locate the pattern in the environment. A thorough error analysis and experimental results obtained through software simulation are presented, as well as the current direction of the work. 10 refs.

Kabuka, Mansur R. (Univ of Miami, Coral Gables, FL, USA); Arenas, Alvaro E. *IEEE J Rob Autom v RA-3 n 6* Dec 1987 p 505-516.

**091248 MOGRER: A VEHICLE STUDY AND REALIZATION FOR IN-PIPE INSPECTION TASKS.** A three-wheeled vehicle for in-pipe monitoring tasks is described. The vehicle moves automatically by action of a driving wheel in the direction in which the pipe extends. The relation between the stretch force and the configuration of the vehicle is analyzed to optimize the lengths of the levers and the direction in which the levers should be attached for force generation. The geometric and kinematic conditions of the vehicle for stable motion are investigated. Results of a simulation of locomotion proved the capability of self-adjustment of the vehicle to different pipe shapes and sizes. The resulting vehicle mechanism, called MOGRER, was built to carry a CCD video camera attached to its body for in-pipe monitoring tasks. Experimental results show that MOGRER can monitor while moving in an inclined pipe with a heavy angle, overcoming the effects of gravity and changes in pipe size and shape. 7 refs.

Okada, Tokuji (Ministry of Int Trade & Industry, Jpn); Sanemori, Tsuyoshi. *IEEE J Rob Autom v RA-3 n 6* Dec 1987 p 573-582.

**091249 ON-LINE COMPENSATION OF MOBILE ROBOT DOCKING ERRORS.** A method to compensate for the docking inaccuracy of mobile robots is

proposed. The method is based on modifying the task of the robot arm according to the docking error, i.e., the offset between the desired and actual docking locations of the mobile robot. The docking error is sensed by a sensor mounted on the robot arm: the sensor can be either a vision system or a touch trigger probe. The algorithms for calculating the spatial docking error for each sensor and how the robot's task is modified accordingly are presented. The need for a statistical approach that will obtain results even in the presence of perturbed data is discussed and one is presented. The calculations of the spatial offset between the actual and the desired locations of the mobile robot using a vision system was implemented; results of some experiments are presented and discussed. 12 refs.

Mandel, Kostia (AT&T Bell Lab, Columbus, OH, USA); Duffie, Neil A. *IEEE J Rob Autom v RA-3 n 6* Dec 1987 p 591-598.

**091250 ROBOT NAVIGATION IN UNKNOWN TERRAINS USING LEARNED VISIBILITY GRAPHS - I: THE DISJOINT CONVEX OBSTACLE CASE.** The problem of navigating an autonomous mobile robot through an unexplored terrain of obstacles is discussed. Completely unexplored obstacle terrain is considered wherein the process of navigation involves both learning the information about the obstacle terrain and path planning. An algorithm is presented to navigate a robot in an unexplored terrain that is arbitrarily populated with disjoint convex polygonal obstacles in the plane. The navigation process is constituted by a number of transversals; each from an arbitrary source point to an arbitrary destination point. The proposed algorithm is proven to yield a convergent solution to each path of traversal. The visibility graph that models the obstacle terrain is incrementally constructed by integrating the information about the paths traversed so far. At any stage of learning, the partially learned terrain model is represented as a learned visibility graph, and it is updated after each traversal. It is proven that the learned visibility graph coverages to the visibility graph with probability one when the source and destination points are chosen randomly. Ultimately, the availability of the complete visibility graph enables the robot to plan globally optimal paths and also obviates the further usage of sensors. 26 refs.

Coommen, B. John (Carleton Univ, Ottawa, Ont, Can); Sitharama Iyengar, S.; Rao, Nageswara S.V.; Kashyap, R.L. *IEEE J Rob Autom v RA-3 n 6* Dec 1987 p 672-680.

**091251 PILOT LEVEL OF A HIERARCHICAL CONTROLLER FOR AN UNMANNED MOBILE ROBOT.** The controller for an intelligent mobile autonomous system (IMAS), equipped with vision and low-level sensors to cope with unknown obstacles, is modeled as a hierarchy of decision-making for planning and control. One of the levels (pilot) deals with a distorted 'windshield' view of the world and provides the actuator controller with real-time decisions. This level of IMAS controller is treated as a linguistic controller with fuzzy variables that assume values from possible intervals. The decision-making processes at this level of control are presented as a production system with a fuzzy database. The rules in the production system are derived from an analytical system model for minimum-time control. The choice of optimal motion execution commands is performed using fuzzy set operators. Also included is a temporal decision-making mechanism (reporter), which recognizes the persisting conflicts between successive levels of the hierarchy by observing the motion trajectory. 31 refs.

Isik, Can (Syracuse Univ, NY, USA); Meystel, Alexander M. *IEEE J Rob Autom v 4 n 3* Jun 1988 p 241-255.

**091252 ON TERRAIN MODEL ACQUISITION BY A POINT ROBOT AMIDST POLYHEDRAL OBSTACLES.** The authors consider the problem of terrain model acquisition by a roving point placed in an unknown terrain populated by stationary polyhedral obstacles in two/three dimensions. The motivation for this problem is that after the terrain model is completely acquired, navigation from a source point to a destination point can be achieved along



the collision-free paths. This can be done without the usage of sensors by applying the existing techniques for the find-path problem. In this communication, the point robot autonomous machine (PRAM) is used as a simplified abstract model for real-life roving robots. An algorithm is presented that enables PRAM to autonomously acquire the model of an unexplored obstacle terrain composed of an unknown number of polyhedral obstacles in two/three dimensions. In this method, PRAM undertakes a systematic exploration of the obstacle terrain with its sensor that detects all the edges and vertices visible from the present location, and builds the complete obstacle terrain model. 11 refs.

Rao, Nageswara S.V. (Old Dominion Univ, Norfolk, VA, USA); Iyengar, S.S.; Oommen, B. John; Kashyap, R.L. *IEEE J Rob Autom* v 4 n 4 Aug 1988 p 450-455.

**091253 MOBILE ROBOTS.** This conference proceedings contains 39 papers. The tying together of autonomous capability with a supervising human appears to be the engineering compromise that will provide a framework for future applications of mobile robots. To be effective, the supervising human will require sophisticated interfaces with the mobile robot that allow the human to diagnose problems and teach new procedures as well as direct operations and define goals. Many of the articles address this issue from a wide variety of perspective. This volume on mobile robots provides a concise series of articles that describe current progress in path planning, obstacle avoidance, control strategies, navigation, vision systems, ranging systems, and various application of mobile robots. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11063 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Wolfe, William J. (Ed.) (Martin Marietta Denver Aerospace, Denver, CO, USA); Marquina, Nelson (Ed.). *Proc SPIE Int Soc Opt Eng* v 727, Mobile Rob, Cambridge, MA, USA, Oct 30-31 1986. Publ by SPIE, Bellingham, WA, USA, 1987 363p.

**091254 LOW-LEVEL-VISION IN AN AUTONOMOUS MOBILE ROBOT.** This paper points out the sensor system of a small mobile robot (a so-called Micro Mouse), which consists of three CCD line scan cameras. The problem of the maze robot is to find the goal in the center of a maze. In contrast to the existing developments a maze robot with three CCD cameras was designed, which calculates the distance to the walls by the detection of the intensity change from the black floor to the white walls. The whole signal processing is done onboard in the small robot. This development was the base for the later construction of small laser rangefinders and a laser scanner, which is used in our autonomous mobile robot (MOBOT-III). (Edited author abstract) 2 refs.

Hinkel, Ralf (Univ of Kaiserslautern, Kaiserslautern, West Ger). *Microprocess Microprogram* v 23 n 1-5 Mar 1988 p 135-140.

## Modification

**091255 LOWER PRICES ATTRACT USERS TO REBUILT ROBOTS.** One sign the robotics industry is maturing is a growing sector of the market devoted to rebuilding these used industrial robots for another generation of duty. Proving again the flexibility of industrial robots, some of these models are being rebuilt for new applications. The lower cost of rebuilt robots is making it possible for more and more small companies to discover the benefits of industrial robots. The article discusses the robot rebuilding activities of six robot manufacturers.

Anderson, Larry. *Rob World* v 6 n 6 Aug 1988 5p.

**Modular** See Also WELDING, ELECTRIC ARC—Robot Applications.

**091256 DER EINSATZ VON FASERVERBUNDWERKSTOFFEN IM RAHMEN EINES ROBOTERBAUKASTENSYSTEM.** [Use of Fiber-Reinforced Composites within the Context of a Modular Robotic System].

A modular robot system permits the user to build up industrial robots of links and joint drives according to the intended kinematics. In this case, the links often determine the dynamic behaviour of the industrial robot by their mass and rigidity. The use of composite materials together with the modular structure makes it possible without the conception of a special robot to do lightweight constructions. Material-specific qualities determine the design with composite materials, which, when applied correctly, lead to considerable advantages for the users. (Author abstract). 15 Refs. In German.

Arendts, F.J. (Univ Stuttgart, Stuttgart, West Ger); Pritschow, G.; Nohr, M.; Wurst, K.-H. *Robotersysteme* v 4 n 2 1988 p 73-86.

## Optimization

**091257 OPTIMIERUNG DER KINEMATISCHEN ABMESSUNGEN VON HANDHABUNGSGERÄTEN.** [Optimization of the Kinematical Dimensions of Industrial Robots]. The economical use of industrial robots becomes more and more important. In this paper a computer-aided method is presented to design the kinematic structure of an industrial robot so that its workspace fits the work task in an optimal way. (Author abstract) In German. 13 refs.

Dittrich, G.; Meyer, G. *Robotersysteme* v 3 n 4 1987 p 205-208.

**091258 STANDARD CIRCULAR GAIT OF A QUADRUPED WALKING VEHICLE.** This paper introduces a more generalized gait, namely, a circular gait around an arbitrarily located turn center, and discusses a standard circular gait. The standard circular gait is the one which maximizes the speed of walking and the rotational angle in a circular walk, and this consideration forms the basis of the discussion on advanced gait control problems. This paper formalizes the problems and analyzes them by using mathematical optimization methods such as nonlinear programming. Computations are carried out on a TITAN III, the quadruped walking vehicle model constructed by the authors. Several characteristics of the optimum gait and the final gait selection chart are derived. The validity of these conditions was verified by a circular walking experiment using the TITAN III. (Edited author abstract) 8 refs.

Hirose, Shigeo (Tokyo Inst of Technology, Tokyo, Jpn); Kikuchi, Hidekazu; Umetani, Yoji. *Adv Rob* v 1 n 2 1986 p 143-164.

**Performance** See Also KINEMATICS—Applications; PLASTICS PLANTS—Robot Applications.

**091259 STATIC AND DYNAMIC PERFORMANCE MEASUREMENTS OF INDUSTRIAL ROBOTS.** A static and dynamic performance test bench is presented in this paper. Static performances consist of resolution, of repeatability and of accuracy. Dynamic performances consist of comparison between three-dimensional real measured trajectories and prescribed straight line motions, together with their acceleration, joints velocities and torque or force developed by each actuator. Trajectory measurements is contactless. Torques or forces are measured by joint actuator. Influence of control system, drive mechanism, joint efficiency and link flexibility on the path accuracy of an industrial robot can be checked. (Author abstract) 1 ref.

Bequet, M. (Univ of Brussels, Belg); D'Hamers, B. *Rev M Mec* v 32 n 1-2 Feb 1988 p 33-37.

**091260 COMPUTER-AIDED JOINT ERROR ANALYSIS OF ROBOTS.** Various definitions of task-space tolerances, using geometric pseudoenvelopes, are introduced, and novel approaches to direct and inverse joint-error analysis of robots are formulated. These error analyses lead to the development of a feasible joint-tolerance domain concept for use in computer-aided design of robots. 7 refs.

Benhabib, Bensiyon (Univ of Toronto, Ont, Can); Fenton, Robert G.; Goldenberg, Andrew A. *IEEE J Rob Autom*

v RA-3 n 4 Aug 1987 p 317-322.

## Personnel

**091261 SAFETY PROBLEMS RELATED TO ROBOTS.** The continuously growing rate of production and use of industrial robots has proved that, in parallel with other implementation aspects, due attention should be paid to problems related to their operational safety. Safety has to be planned and built in at the level of robot workplace. Although safety problems are encountered by various groups of personnel, it is mainly the programmer and the trouble-shooter who are at risk. There are gaps in the safety provisions which could be bridged by developing more appropriate safety equipment and by imposing minimal safety requirements upon all robots as well as by giving examples for a safety design of robot workplaces. (Edited author abstract) 6 refs.

Nicolaisen, P. (Fraunhofer Inst for Production Techniques & Automation (IPA), Stuttgart, West Ger). *Robotics* v 3 n 2 Jun 1987 p 205-211.

**Planning** See ARTIFICIAL INTELLIGENCE.

## Pneumatic Drive

**091262 PROSPECTS FOR THE DEVELOPMENT OF MODULAR INDUSTRIAL-ROBOT PNEUMATIC DRIVES.** The present status of application of pneumatic drives in industrial robots is briefly analyzed. Possibilities are indicated for significant improvements to various characteristics of the drives, with ways to make them more competitive with the electric drive in solution of various robotics problems. A sample design of a pneumatic telescoping module with polymer-composite components is presented. (Author abstract) 3 refs.

Krein, G.V.; Ivlev, V.I.; Chistyakov, A.B. *Sov Mach Sci* n 3 1987 p 65-69.

**Programmable** See Also COMPUTER PROGRAMMING LANGUAGES; PLASTICS MACHINERY—Molding Machines; ROBOTIC ASSEMBLY—Computer Aided Design; WELDING—Robot Applications; WELDING, ELECTRIC ARC—Robot Applications.

**091263 CONCEPTUAL STRUCTURE FOR A ROBOT STATION PROGRAMMING SYSTEM.** Task level programming systems previously proposed by several authors are discussed and another approach is offered. The possibilities of integration of components such as vision and tactile modules, CAD systems, robot simulators, specialized planners, etc., are analyzed. This should help us to understand their interrelations and limitations when their integration in a system is attempted. The usual limitations of an off-line approach are analyzed and a more active role of simulation of the whole station is suggested, specially in what concerns a comprehensive sensorial simulation allowing moving to this phase most verifications, previously mandatory on the on-line phase. This should allow a more realistic plan generation, and, eventually, interactive planning with better debugging tool. In the on-line stage, emphasis is placed on the relationship between execution supervision and sensorial feedback. One suggestion of automatic plan repair, valid for any of the phases is presented. (Edited author abstract) 8 refs.

Steiger-Garcia, A. (Univ Nova de Lisboa, Monte Caparica, Port); Camarinha-Matos, L.M. *Robotics* v 3 n 2 Jun 1987 p 195-204.

**091264 EXPERT SYSTEM FACILITATES ROBOTIC CELL PROGRAMMING.** The development and implementation of an expert system for on-line programming gets a large share of the credit for the operational and economic success of a robotic assembly cell. The cell hardware consists of a gantry robot, a Drivmatic riveting machine, end effector tooling, flexible tooling fixture, and a MV4000 cell controller. To make the cell compatible with a production environment and to increase the economic return an expert system was



developed capable of programming and managing operations of the cell. The task was to incorporate all the knowledge needed in creating a cell program into software and adding it to the existing cell control system, enhanced with knowledge about operating the cell. This knowledge came from experience gained from the original approach of off-line programming the cell, from operator manuals on the devices, and from the input of shop floor personnel involved with the original project. 2 refs.

Molz, Ronald J. *Rob Today* v 9 n 5 Oct 1987 p 15-17.

**091265 PASRO. PASCAL FOR ROBOTS.** The origin of the PASRO (Pascal for Robots) programming system was a set of procedures for performing arithmetic on geometric data types and for coordinate transformation for study and teaching purposes, developed as a base for high level robot programming. After improvements, PASRO is at present state of the implementation a programming system for teaching, studying, and experimenting and not for industrial use, although it could easily be extended for that purpose. This book deals with this programming system in detail. 11 refs.

Blume, C.; Jakob, W. 1985 128p.

**091266 USE OF CAD-DATA FOR THE OFF-LINE PROGRAMMING OF INDUSTRIAL ROBOTS.** Important components of IR-application programs are geometric data which are partly available from CAD-systems. The derivation and transformation of CAD-data into the required representation for IR-application programs is discussed. For the description of the geometric part of the robots task a frame concept with homogeneous coordinates is used. For the production task spot welding the determination of frames out of the geometric data from the CAD-system is shown. The use of CAD-data for simulation purposes is pointed out. (Author abstract) 7 refs.

Duelsen, Gerard (Fraunhoferinstitut fuer Produktionsanlagen und Konstruktionstechnik, Berlin, West Ger); Bernhardt, Rolf; Schreck, Gerhard. *Robotics* v 3 n 3-4 Sep-Dec 1987 p 389-397.

**091267 OFF-LINE ROBOT PROGRAMMING: THE STATE-OF-THE-ART.** Alternative approaches to robot programming are discussed. One of the major users of this type of system is the automotive industry, especially in Europe and the US. The system is also used in the aerospace and electronics industries. The current applications include: welding, especially of complex paths and spot welding; assembly; materials handling and palletizing. The future of off-line programming systems lies with the graphical systems described. 6 refs.

Carter, Scott (CRAG, Cranfield, Engl). *Ind Robot* v 14 n 4 Dec 1987 p 213-215.

**091268 MODULA-2 AS A LANGUAGE FOR ROBOTIC APPLICATIONS.** A primary factor in the development of intelligent robotic systems is the supporting software. Intelligent software development includes both the intelligent development of software and the development of intelligent software. Modula-2 offers tools and features that enhance both these areas. (Author abstract) 3 refs.

Pinson, Lewis J. (SMR Associates, Colorado Springs, CO, USA). *Rob Eng* v 8 n 5 May 1986 p 10-15.

**091269 KOLLISIONSKONTROLLE FUEHRT OFF-LINE ERSTELLTE INDUSTRIEROBOTER-PROGRAMME.** [Collision Control for Off-Line Produced Industrial Robot Programs]. An important prerequisite for cost-efficient application of industrial robots are effective programming methods. This applies primarily to new applications, and, in particular, where small batch production is involved. A step in this direction are off-line programming systems which permit program preparation in the job preparation phase. However, these systems offer at present only insufficient test possibilities, in particular with regard to a complete check of the programs for a collision-free timing of robot motions. A few first steps in this direction have been done; however, these steps are still

based on more or less specific requirements. This paper describes an approach which permits a complete check of previously designed programs by a combination of various methods and accuracy steps. Both mathematical test algorithms and the support by CAD are used for this purpose. (Edited author abstract) In German. 20 refs.

Eversheim, Walter (RWTH Aachen, West Ger); Schuetz, Peter; Luszek, Gerd. *VDI Z* v 130 n 1 Jan 1988 p 63-68.

**091270 TECHNOLOGICAL FUNCTIONS FACILITATE PROGRAMMING OF ROBOTS.** New areas of application are being found all the time for industrial robots. The Siemens SIROTEC RCM3 is a multi-processor control whose technology-oriented functions enable it to be adapted easily to specific tasks. The sophisticated functions, the speed of the position control and the flexibility of the SIROTEC RCM3 control present opportunities not only for industrial robots but also for special-purpose machines in new and complex manufacturing technologies such as the application of adhesive, water-jet cutting, laser welding or assembly on a small and large scale. (Edited author abstract) 1 ref.

Becker, Horst (Siemens AG, Nuremberg, West Ger); Remberg, Reinhard. *Energy Autom* v 9 n 6 Nov-Dec 1987 p 12-14.

**091271 PROGRAMMING INDUSTRIAL ROBOTS FOR FLEXIBLE PALLETIZING.** This paper presents three different approaches to dealing with variations in the operations desired in a palletizing robot. The first method involves the automatic generation, compilation and downloading of the control program. Next, the use of an intelligent workcell host computer and a robot controller/host communication program are discussed. Finally, the pallet pattern generation algorithm is imbedded directly in the robot control language and an interactive dialogue is used to provide dynamic system input. While the application is specific to robot palletizing operations, the techniques discussed are appropriate for a variety of different robot tasks. (Edited author abstract) 10 refs.

Mertens, P.; Deisenroth, M.P. *Robotersysteme* v 4 n 1 1988 p 9-16.

**091272 LES APPORTS RESPECTIFS DES LANGAGES SYMBOLIQUES ET DE LA CAO EN PROGRAMMATION DES ROBOTS.** [Respective Contributions of Symbolic Languages and Computer Aided Design in Programming of Robots.]. A high-level robot programming language constitutes a general purpose interface for accessing the basic functional capabilities of a robot. On the other hand, CAD facilities give the possibility of using a subset of these capabilities in an easier fashion. In this paper, we show how a robot programming language and CAD facilities can be combined to obtain a robot programming system satisfying the need for generality, and allowing an easy connection with the basic robot programming functions. Such a connection is based on a 'complete' simulator providing facilities for executing robot control programs on a graphic display, for describing manipulation tasks using interactive graphic tools, for simulating the physical world and its perception through sensors, and for displaying three-dimensional scenes as shaded pictures. (Author abstract). 33 Refs. In French.

Laugier, C. (Lab LIFIA, St. Martin d'Heres, Fr). *Robotica* v 6 n 3 Jul-Sep 1988 p 243-253.

**091273 SYSTEMES DE PROGRAMMATION POUR LA ROBOTIQUE.** [Programming Systems for Robotics]. Information theory constitutes an essential element for robot control. It gives a primary role to programming systems, which make it possible to take full advantage of the flexibility possibilities of robots. The data structure on which these systems rest is organized around the concept of a programming language specific to robotics. The article deals with two aspects of robot software. The first concerns programming system, while the other aspect concerns the automatic production of programs for robot control, based on C.A.D. (Edited author abstract) 67 refs. In French.

Latombe, J.C. (ITMI SA, Meylan, Fr); Laugier, C. *RFM*

*Rev Fr Mec* n 4 1987, Cycle de Conf d'Etude et d'Inf de la Soc Fr des Mec sur les Rob Ind, Mar 25-26 1987 p 223-235.

**Proximity Sensors** See Also NUCLEAR REACTORS—Maintenance; ULTRASONIC TRANSDUCERS—Performance.

**091274 IMPLEMENTATION OF A SCHEME TO IMPROVE THE POSITIONING ACCURACY OF AN ARTICULATE ROBOT BY USING LASER DISTANCE-MEASURING INTERFEROMETRY.** The accurate positioning of an articulate robot depends on the correctness of the robot kinematic linkage mechanism. The desired or nominal linkage mechanism is never achieved, because of errors in manufacturing and assembly processes. The flexibility and backlash within the linkage mechanism are included in modeling the robot end-point position error. An auxiliary photosensing device using a beam splitter has been designed to provide 3-D robot end-point position measurement. (Edited author abstract) 7 refs.

Chao, L.M. (Univ of Maryland, College Park, MD, USA); Yang, J.C.S. *Precis Eng* v 9 n 4 Oct 1987 p 210-217.

**091275 MODEL-BASED RECOGNITION OF GLOSSY OBJECTS USING THEIR POLARIMETRIC PROPERTIES.** A model-based approach to recognition of glossy objects is presented. Normals of surface patches are obtained by analyzing the polarization state of the observed rays under illumination of light sources of circular polarization. The object is assumed to lie alone in its stable pose on the floor. Solid models are examined to find the one that matches the observed normals. First, a candidate model based on the relative angles between known surface normals is found. Then the translation so that the observed positions of surface normals coincide with those of models in the image is found. Some examples are also presented. (Author abstract) 4 refs.

Koshikawa, Kazutada (Electrotechnical Lab, Sakura-mura, Jpn); Shirai, Yoshiaki. *Adv Rob* v 2 n 2 1987 p 137-147.

**091276 MECHATRONIKAI ES ROBOTTECHNIKAI ALKALMAZHATOSAGU ELFOORDULAS ES ELMOZDULASERZEKELO ES KIERTKELO ELEMKE.** [Rotation and Displacement Sensing and Evaluating Units in Mechatronics and Robotics]. Numeric measuring systems for rotation, or displacement are used in production automation. In practice, several physical principles are suitable for this purpose, the inductive, capacitive, laser and optoelectronic solutions are the most frequent ones. The author deals with the latter in detail. According to their kinetics optoelectronic transmitters can measure straight displacement, or rotation. The code system can be absolute or incremental. Both systems have advantages and disadvantages, they are applied accordingly. The incremental system is used in practice in numerically controlled machine tools. The resolution can be directly increased using the physical optical principle, indirectly with the geometric physical principle and analog interpolation. Resolution is, in principle, limited by the division accuracy achievable, but this causes no problem in industrial applications. (Author abstract). 7 Refs. In Hungarian.

Istvan, Lantos (MIKI Meresteknikai Fejlesztő Vállalat, Budapest, Hung). *Meres Autom* v 36 n 5 1988 p 125-127.

**091277 OBSTACLE AVOIDANCE WITH ULTRASONIC SENSORS.** A mobile robot system, capable of performing various tasks for the physically disabled, has been developed. To avoid collision with unexpected obstacles, the mobile robot uses ultrasonic range finders for detection and mapping. The obstacle-avoidance strategy used for this robot is described. Since this strategy depends heavily on the performance of the ultrasonic



range finders, these sensors and the effect of their limitations on the obstacle avoidance algorithm are discussed in detail. 31 refs.

Borenstein, Johann (Univ of Michigan, Ann Arbor, MI, USA); Koren, Yoram. *IEEE J Rob Autom* v 4 n 2 Apr 1988 p 213-218.

## Redundancy

**091278 ANALYTICAL TRAJECTORY OPTIMIZATION OF SEVEN DEGREES OF FREEDOM REDUNDANT ROBOTS.** The basic characteristic of kinematically redundant robots is that non-unique joint solutions may exist for a specified end effector location. Thus, trajectory planning for a kinematically redundant robot requires an optimization procedure to determine the joint displacements when solving the inverse kinematics relations. In this paper an analytical solution is developed for the trajectory optimization problem of redundant robots based on the classical Lagrange's method. A detailed formulation is provided for seven degree of freedom robots, which minimizes the Euclidean norm of joint displacements for point-to-point motion trajectory planning. (Author abstract) 7 refs.

Benhabib, B. (Univ of Toronto, Toronto, Ont, Can); Fenton, R.G.; Goldenberg, A.A. *Trans Can Soc Mech Eng* v 11 n 4 1987 p 197-200.

## Reliability

**091279 EFFECT OF ROBOTS WITH OVERLAPPING ENVELOPES ON THE PERFORMANCE OF FLEXIBLE TRANSFER LINES.** The overlapping envelopes of flexible transfer line robots allow continued processing of the products in case of robot failures. Markovian and simulation models are developed to estimate the effects of the different types of failure and repair processes on the performance of such lines. The results of simulation experiments for flexible transfer lines (FTLs) with non-Markovian failure and repair process are presented. These experiments are done to show the validity of the Markovian assumption in determining the efficiency and production rate of FTLs. (Edited author abstract). 19 Refs.

Abdel-Malek, Layek L. (New Jersey Inst of Technology, Newark, NJ, USA). *IEE Trans* v 20 n 2 Jun 1988 p 213-222.

## Remote Control See Also ROBOTICS—Control Systems.

**091280 REMOTE MAINTENANCE ROBOT SYSTEM FOR A PULSED NUCLEAR REACTOR.** A remote maintenance robot system for use in a hazardous environment is presented. The system consists of a programmable turntable, as robot, and hoist subsystems, which operate under the control of a supervisory computer to perform coordinated programmed maintenance operations on a pulsed nuclear reactor. (Author abstract) 1 refs.

Davidson, William M. (Sandia Natl Lab, Albuquerque, NM, USA); Morimoto, Alan K.; Moya, Mary M.; Schoeneman, J. Lee; Thunborg, Siegfried; Starr, Gregory P. *Nucl Technol* v 79 n 3 Dec 1987 p 249-259.

## Research See Also ROBOTICS—Japan; ROBOTICS—Reviews.

**091281 IMPACT DE LA RECHERCHE SUR LES ROBOTS INDUSTRIELS DE DEMAIN.** [Consequences of Research for Industrial Robots of Tomorrow]. Some of the most significant results in robotics research which will be capable of important industrial developments are presented. The object of this paper is to estimate the possibilities in advanced robotics and the consequences that could result in industrial applications. (Author abstract) In French. 22 refs.

Dufaut, Michel (CNRS, Fr); Husson, Rene. *RGE Rev Gen Electr* n 1 Jan 1988 p 9-18.

**091282 IMPACT DE LA RECHERCHE SUR LES**

**ROBOTS INDUSTRIELS DE DEMAIN.** [Impact of the Research of the Industrial Robots of the Future]. The authors submit here some of the most significant results in robotics research which will be capable of important industrial developments. The object of this paper is to estimate the possibilities in advanced robotics and consequences that could result in industrial applications. (Author abstract). In French.

Dufaut, Michel (CNRS, Fr); Husson, Rene. *RGE Rev Gen Electr* n 1 Jan 1988 p 9-18.

## Reviews See ROBOTICS; ROBOTICS—Reviews.

## Selection See Also WELDING—Robot Applications.

**091283 SELECTION AND DESIGN OF AUXILIARY INDUSTRIAL ROBOTS FOR FAP.** The requirements for industrial robots (IR) operating within FAP are formulated. Methods of adaptation of robots are discussed. The ways of increasing specific hoisting capacity of IR were studied. The analysis of timely replacement of manipulatory equipment and its parts by means of unification, aggregate and module designing and respective implementation of joints was carried out. The issues of IR adaptation to the changes in configuration and dimensions of the parts to be gripped are discussed and requirements are determined for multipurpose and convertible grasping arms of IR. (Author abstract) 3 refs. In Russian.

Timofeev, A.N.; Chelpanov, I.B.; Maslov, V.I. *Tr Leningradskii Politekh Inst im M I Kalinina* n 419 1986 p 26-35.

**091284 ROBOT'S ECONOMIC REPEATABILITY.** One of the most important robot specifications in assembly is its repeatability. In the same class of robots, those with smaller repeatability range are usually more expensive to operate. In this paper a mathematical model is introduced to aid the practicing engineers in choosing the most economical robot for the considered assembly processes. The model relates the interaction between the random nature of the dimensions of the parts presented for assembly, the clearance between the mating surfaces and the robot's repeatability and its operational cost, and determines their effect on the probability of successful assembly. The results of the model are tabulated showing the acceptable clearance range of the assembled parts and the optimum robot's repeatability range for the process under consideration. 18 refs.

Abdel-Malek, Layek (New Jersey Inst of Technology, Newark, NJ, USA). *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 93-97.

## Sensors See Also ROBOTICS—Sensors; SENSORS—Industrial Applications.

**091285 DETECTING METHODS FOR THE POSITION/DIRECTION OF A ROBOT HAND USING PSD AND ITS APPLICATIONS.** Detecting methods of the position/direction of a robot hand and non-linear simulation of a visual feedback control system are dealt with. While various studies have been reported on detecting methods of position/posture of a robot hand using PSD (position sensor diode), this paper proposes a new method to minimize the errors caused by the detecting computation or/and time delay which occurs when the technique is applied to on-line visual feedback control. A simulation has confirmed the effectiveness of the proposed method to construct the robot visual sensor feedback control of a manipulator. (Author abstract) 10 refs.

Adachi, Tadashi (NEC, Tokyo, Jpn); Mita, Tsutomu. *Adv Rob* v 1 n 4 1986 p 357-370.

**091286 SENSOREN IM MHI-BEREICH - ENTWICKLUNGSSTAND UND TRENDS.** [Sensors for Assembly and Materials Handling Operations - Current Status and Future Trends]. Sensors, beginning with simple proximity switches down to complex three-dimensional pick-up systems and pattern detecting systems are

increasingly gaining in importance for the modern production technology and, in particular, for the application of industrial robots in the assembly field. The paper provides a general survey of sensors used for assembly and handling, storage, and transport, and discusses later the sensors for flexible application of industrial robots for workpiece detection. Primarily radar-based sensors will play an important role in the future in this field. (Edited author abstract) In German. 80 refs.

Kompa, Guenter (Univ (GHS) Kassel, West Ger). *VDI Z* v 130 n 2 Feb 1988 p 42-54.

**091287 TACTILE SENSING FOR ROBOTS.** In addition to visual sensing, tactile sensing has been developed to the point where commercial devices designed for robot feedback and control have become available. This paper explains the fundamental principles behind tactile sensing, the several classes of sensors that are available, and potential applications to which this new technology may be addressed. (Edited author abstract) 3 refs.

Rebman, Jack (Lord Corp). *Autom and Rob in the Textile and Apparel Ind Publ* by Noyes Publ, Park Ridge, NJ, USA, 1986 p 59-95.

**091288 SENSORFUEHRUNG FUER DEN SCHWEISSROBOTER ZIS 13-54.** [Sensor Control for the ZIS 13-54 Welding Robot]. The ZIS 13-54 welding robot is a four-axis modular robot which is used for the welding of thin-to-thick materials using TE-3 inductive distance sensors for welding torch control. This article describes its design and its inductive distance sensor for welding torch control. It also describes experimental results with the application of this robot for welding of thin sections to thick plates. (Translated author abstract) 5 refs. In German.

Fiedler, Otto (Wilhelm-Pieck-Univ, Rostock, East Ger); Lushtinetz, Thomas; Prinz, Siegfried; Kruse, Karsten. *Schweisstechnik (Berlin)* v 38 n 2 1988 p 65-68.

**091289 SENSORIZATION OF ROBOTS FOR THE ADAPTATION AND CONTROL OF AUTOMATIC ASSEMBLY.** Some problems of robot sensorization are considered. They arise in the solution of problems of component mating and of control of an automated assembly process. Sensorization is a means for analyzing situations which arise in the execution of assembly operations and altering, if necessary, the course of the operation by using spare branches in its program, which improves substantially the reliability of the assembly process. Examples of the application of a machine vision system in a visual inspection mode, and of the application of state and course of operation execution control modes by using the readings of position sensors are presented. (Author abstract) 5 refs.

Okhotsimskiy, D.Ye. *Sov J Comput Syst Sci* v 25 n 6 Nov-Dec 1987 p 46-52.

**091290 TACTILE SENSORS FOR INDUSTRIAL ROBOTS.** This article assesses how tactile sensors, particularly in the form of tactile sensor arrays, will play an important part in the optimization of robot adaptivity. Requirements for the design of tactile sensors for industrial robot applications are given. The following techniques for manufacture of tactile sensor arrays are summarized: the electromechanical type, the fibre-optic type, the piezoelectric type and the piezoresistive type. 13 refs.

Lauber, Alexander (Linkoping Inst of Technology, Linkoping, Sweden); Sandell, Bengt; Holmbom, Per; Pedersen, Ole. *Sens Rev* v 8 n 2 Apr 1988 p 84-88.

**091291 HIGH-FREQUENCY ACOUSTIC SYSTEMS.** Using averaging and also temperature compensating the velocity, an air-coupled ultrasonic system operating at 500 kHz can make ranging measurements to an accuracy with  $\pm 0.004$  in. (0.010 cm) at distances up to about 10 in. (25 cm). Tests show the system resolution to



be better than 0.001 in. (0.002 cm). Averaging a number of individual readings significantly improves the accuracy of reading. By using short focal lengths and high frequency, ultrasonic beam diameters smaller than 0.050 in. (0.127 cm) can be achieved. Localized air turbulence that is not measured by the calibration transducer causes a negative shift in the reading, making the reflector appear closer than it is. The negative shift is small and should not be a problem for many applications. 1 Ref.

Smith, Richard W. (Xactex, Kennewick, WA, USA); Walter, Rex; Carlson, John; Harris, Robert. *Mater Eval* v 46 n 10 Sep 1988 p 1262-1266.

**091292 DYNAMIC SENSOR-BASED CONTROL OF ROBOTS WITH VISUAL FEEDBACK.** Sensor-based robot control may be viewed as a hierarchical structure with multiple observers. Actuator, feature-based, and recognition observers provide the basis for multilevel feedback control at the actuator, sensor, and world coordinate frame levels, respectively. The analysis and design of feature-based control strategies to achieve consistent dynamic performance is addressed. For vision sensors, such an image-based visual servo control is shown to provide stable and consistent dynamic control within local regimes of the recognition observer. Simulation studies of two- and three-degree-of-freedom systems show the application of an adaptive control algorithm to overcome unknown and nonlinear relations in the feature to world space mapping. 34 refs.

Weiss, Lee E. (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Sanderson, Arthur C.; Neuman, Charles P. *IEEE J Rob Autom* v RA-3 n 5 Oct 1987 p 404-417.

## Socioeconomic Aspects

**091293 ANALYSIS OF ROBOT GROWTH AND APPLICATION ACTIVITY IN SAN DIEGO, CALIFORNIA.** A robot activity study was conducted for the US Bureau of the Census in 1985 to provide a picture of the current and planned use of robotics in San Diego County, California. The results indicate an increasing usage rate, expectations of decreasing costs, and minimal employment effect to date, but perceptions of an increased impact. The current and future use of robotics in 65 companies is presented as a series of charts. (Edited author abstract) 5 refs.

Schlesinger, Robert J. (San Diego State Univ, San Diego, CA, USA). *Robotics* v 3 n 2 Jun 1987 p 221-228.

**091294 FORECASTING THE DIFFUSION OF INDUSTRIAL ROBOTS.** A mathematical diffusion model has been used in order to forecast industrial robots in West Germany. The calculations were done in 1985. Therefore, a comparison could be made between the forecast and the actual figures for 1985 and 1986. As the differences between forecast and actual figures are negligible the proposed model approach seems to be applicable to real world problems. It would be interesting to apply this method to other countries and other technical innovations. A main problem of the approach is data-provision. 13 refs.

Bruns, T. (Univ of Hamburg, Hamburg, West Ger); Schuenemann, T.M. *Ind Robot* v 14 n 4 Dec 1987 p 219-228.

**Software** See Also WELDING, ELECTRIC ARC—Robot Applications.

**091295 DISTRIBUTED CONTROL OF A ROBOT-BASED ASSEMBLY CELL.** A major problem in developing highly automated manufacturing facilities is the effort required to produce and test the complex software required to coordinate the actions of robots and vision systems and then integrate them into a manufacturing system. To address this problem, we present a distributed approach to assembly cell control where the individual sensing and manipulation systems run as separate processes in parallel under the supervision of a cell controller. The individual sensing and manipulation modules communicate with the cell controller using a

standard interface which simplifies system integration. Associated with the controller is a cell programming language that uses symbolic references to objects and features that are defined in terms of three dimensional object models. We can reprogram the assembly system to account for design changes by simply changing the object models. This will significantly reduce the incremental costs for reprogramming and retooling an assembly system to accommodate minor design changes in the components. (Author abstract) 9 refs.

Stevenson, Charles N. (GM, Warren, MI, USA). *Res Publ Gen Mot Res Lab* 5956 Sep 3 1987 11p.

**091296 REAL-TIME SOFTWARE FOR ROBOTS.** ICS. This paper describes two components of real-time software for robotics: real-time operating systems and the systems programming language. In particular, the design issues related to real-time operating systems are discussed and our own system, derived from the UNIX operating system, is described. No single real-time operating system is appropriate under all circumstances. However, it is shown that at least some continuity in the development environment can be provided. We have chosen to use a general-purpose programming language, C++, which has several advantages for real-time robot programming. In particular, it is shown how facilities within C++ can be used to guarantee initialization and proper termination of hardware subsystems. Support for concurrency is considered important, especially as robot systems become more complex. Proper support for concurrency can simplify communication and synchronization within a robot system. Two methods of providing concurrency within C++ are discussed. (Author abstract) 25 refs.

Cox, Ingemar J. (AT&T Bell Lab, Murray Hill, NJ, USA); Kapilow, David A.; Kropfl, Walter J.; Shopiro, Jonathan E. *AT&T Tech J* v 67 n 2 Mar-Apr 1988 p 61-72.

## Space Applications

**091297 USE OF COMPUTER GRAPHIC SIMULATION IN THE DEVELOPMENT OF ROBOTIC SYSTEMS.** This paper describes the use of computer graphic simulation techniques to resolve critical design and operational issues for robotic systems. Use of this technology will result in greatly improved systems and reduced development costs. The major design issues in developing effective robotic systems are discussed and the use of ROBOSIM, a NASA developed simulation tool, to address these issues is presented. Three representative simulation case studies are reviewed: off-line programming of the robotic welding development cell for the Space Shuttle Main Engine (SSME); the integration of a sensor to control the robot used for removing the Thermal Protection System (TPS) from the Solid Rocket Booster (SRB); and the development of a teleoperator/robot mechanism for the Orbital Maneuvering Vehicle (OMV). (Author abstract) 11 refs.

Fernandez, Ken (NASA, Huntsville, AL, USA). *Acta Astronaut* v 17 n 1 Jan 1988 p 115-122.

## Standardization

**091298 INDUSTRIAL ROBOT STANDARDIZATION AT ISO.** This paper gives a framework of the industrial robot standardization activity at ISO. It reviews the organization and current state of the standardizing work. (Author abstract)

Chabrol, Jean (AFRL, Fr). *Robotics* v 3 n 2 Jun 1987 p 299-233.

**091299 POINT SUR LA NORMALISATION NATIONALE ET INTERNATIONALE SUR LES ROBOTS INDUSTRIELS.** [National and International Standardization of Industrial Robots]. The article reports an standardization studies concerning industrial robots, undertaken at the international level (within ISO/TC 184/SC 2), as well as at the French level. These studies deal with the following subjects: terminology, graphical representation, characterisation, performance criteria and testing methods, safety, programming languages, and

mechanical interfaces. The list of standards, dealing directly or indirectly with robots, is given in the appendix. (Edited author abstract) In French.

Koplewicz, Danielle (Union de Normalisation de la Mecanique, Paris, Fr). *RFM Rev Fr Mec* n 4 1987, Cycle de Conf d'Etude et d'Inf de la Soc Fr des Mec sur les Rob Ind, Mar 25-26 1987 p 259-264.

**Teach Programming** See COMPUTER PROGRAMMING LANGUAGES—Robot Applications.

## Testing

**091300 OPTISCHES MESSSYSTEM ZUR GENAUIGKEITSPRUEFUNG VON INDUSTRIEROBOTERN.** [Optical Accuracy-Test-System for Industrial Robots]. This paper describes a method for the accuracy measurement of industrial robots, which is able to measure path- and position-misalignment in six degrees of freedom. Two laser beams from a laser unit with an integrated interferometer define a straight path within the working area of the robot. The tested robot moves an optical sensor head, the main component of the measurement system, along the laser beams. Analog signals from the sensor head and digital data from the interferometer are used to compute position and orientation as well as velocity and acceleration of the robot. Following a short review of the state of the art, the function of the measuring system is described in principle and an evaluation of its performance is given by some test results. (Author abstract) In German. 22 refs.

Weule, H.; Reichling, B. *Robotersysteme* v 3 n 4 1987 p 189-198.

**091301 EXPERIMENTS WITH A COGNITIVE INDUSTRIAL ROBOT.** Input-expectation discrepancy reduction is a ubiquitous mechanism; it permeates the human nervous system. This mechanism thus appears to be a generic strategy underlying many aspects of intelligent behavior. The authors have applied this paradigm to the domain of industrial robotics. In addition, they have explored some applications of human perceptual mechanisms in the visual system of the robot; the general strategy employed yielded a trade-off between efficient, intelligent decisions and errors. The result is a cognitive industrial robot that exemplifies a novel view of the industrial robotics field and serves to cast some fundamental problems, of artificial intelligence (AI) as well as of robotics, in a new light. In particular, the authors describe a concrete application of their ideas which can be contrasted with most AI projects, functioning as they do in purely abstract domains. (Edited author abstract) 15 refs.

Partridge, Derek (Univ of Exeter, Exeter, Engl); Johnston, Victor; Lopez, Patricia. *Int J Man Mach Stud* v 27 n 4 Oct 1987 p 435-448.

## Theory

**091302 INVERSE VELOCITY AND ACCELERATION SOLUTIONS OF SERIAL ROBOT ARM SUBASSEMBLIES USING THE CANONICAL COORDINATE SYSTEM.** The Taylor series expansion of a rigid body with three degrees of freedom is used to define and locate the canonical coordinate system for the arm subassembly of a six-axis robot with a spherical wrist. The canonical coordinate system yields the canonical form of the instantaneous kinematic equations of motion of the terminal link and the canonical form of the Jacobian matrix for the arm assembly. This form of the Jacobian matrix gives the canonical inverse velocity and acceleration solutions of the arm subassembly. As examples, the canonical inverse velocity and acceleration solutions of the spherical arm subassembly and the articulated arm subassembly are presented in the paper. A numerical example of the articulated arm subassembly is also included. (Author abstract) 23 refs.

Stanisic, M.M. (Univ of Illinois at Chicago, Chicago, IL, USA); Penneck, G.R.; Krougrill, C.M. *Int J Rob Res* v 7 n 1 Feb 1988 p 29-41.



## Vibrations

**091303 INVESTIGATION OF VIBRATIONS IN THE HAND OF AN INDUSTRIAL ROBOT EQUIPPED WITH AN IMPACT-TYPE VIBRATION DAMPER.** The problem is solved of determining the optimum parameters of an impact-type vibration damper designed to suppress vibrations in the hand of an industrial robot after it strikes the stop block. The suppression of vibrations is looked at after the hand has turned and when the column has been lowered. The effectiveness of using this type of vibration suppression in a hand is compared with that of using a dynamic vibration damper. The results are also shown of experimental investigations of the damping of vibrations caused by internal resistance. (Author abstract) 4 refs.

Vernigor, V.N.; Zelenkov, Yu.A. *Sov Mach Sci* n 2 1987 p 12-17.

**Vision Systems** See Also ARTIFICIAL INTELLIGENCE—Expert Systems; ARTIFICIAL INTELLIGENCE—Industrial Applications; AUTOMOBILE MANUFACTURE—Robot Applications; AUTOMOBILE PLANTS—Flexible Manufacturing Systems; CONTAINERS—Inspection; CONTROL SYSTEMS—Industrial Applications; CONVEYORS—Belt; ELECTRIC MOTORS—Manufacture; IMAGE PROCESSING; INTEGRATED CIRCUIT MANUFACTURE—Robot Applications; MATERIALS HANDLING—Robot Applications; OPTICAL DATA PROCESSING; PATTERN RECOGNITION—Automation; PRINTED CIRCUITS—Computer Aided Manufacturing; ROBOTIC ASSEMBLY; ROBOTICS—Economics; ROBOTS—Vision Systems; SEMICONDUCTOR DEVICES, CHARGE COUPLED—Applications; SENSORS—Performance; SHOE MANUFACTURE—Automation; VISION—Artificial; WELDING—Robot Applications; WELDING, ELECTRIC ARC—Inert Gas.

**091304 ECONOMY VISION.** Part manipulation by a robot is practicable provided the orientation of the presented part is known. Traditionally, a multi-part feeder will consist of either a number of dedicated feeders or else of plain feeders equipped with sophisticated electronics. The development of an inexpensive feeder with an uncomplicated recognizing device might be a good alternative. Two recognizing devices of this kind are described. One device includes a moving belt, 3 sensors and a programmable logic controller, but the device is dedicated to one particular part. The other device consists of a moving belt, 16 sensors, and a microcomputer. This device has self-learning capability. Both devices are able to offer information about the orientation of the part that will be presented to a robot. (Author abstract) 2 refs.

Smals, Anton T.J.M. (Eindhoven Univ of Technology, Eindhoven, Neth). *Robotics* v 3 n 2 Jun 1987 p 175-180.

**091305 GENERATING OCTREE MODELS OF 3D OBJECTS FROM THEIR SILHOUETTES IN A SEQUENCE OF IMAGES.** An important computer vision task in robotics is modeling of 3D objects in a robot's workspace. This paper presents a method for generating octree models of 3D solid objects from their silhouettes obtained in a sequence of images. The silhouettes of objects which are projected into an image and the center of projection of the image generate 3D conic volumes. A 3D model of the objects is iteratively constructed by intersecting such conic volumes obtained from a sequence of images. Hierarchical octree structures are used to represent and to process 3D volume data efficiently. The volumes of individual objects are labeled by a connectivity-labeling algorithm, and surface-normal vectors are added to their surface volume elements. (Edited author abstract) 28 refs.

Potmesil, Michael (AT&T Bell Lab, Holmdel, NY, USA). *Comput Vision Graphics Image Process* v 40 n 1 Oct 1987 p 1-29.

**091306 CAN MACHINE VISION DO THE JOB FOR YOU?** New systems and technology, combined with applications experience, are putting the benefits of machine vision within reach. But the fundamental question remains: How to measure the potential worth of machine vision in a manufacturing process? Determining whether machine vision can be applied successfully in a plant requires an evaluation of each specific application,

whether it be inspection, gauging, or robot guidance. This article reviews proven requirements for success and identifies some useful applications. Subjects covered include costs, advantages, specifying a system, and others.

Murphy, F. Patrick (Foxboro/Octek Inc, Burlington, MA, USA). *Chilton's I&CS* v 60 n 10 Oct 1987 p 53-56.

**091307 THREE-DIMENSIONAL MEASUREMENTS OF TERMINALS OF LINE-LIKE OBJECTS FROM SHADOW INFORMATION.** A new vision system has been developed to measure the 3-D positions of wire terminals. Distance information of any visible point on the wires can be obtained from the images of the wires and from their shadows on a working table projected from a point light source. A theory is presented to determine the 3-D geometry of the wires from a picture taken by a television camera with prior knowledge of the arrangement of the environment, i.e. the camera, the working table and the light source. The 3-D positions of the wires can be determined from the geometry of the environment. A vertically mounted camera and a horizontal table are used in the experiments. The position error for fine wires was less than 1% of the size of sight. The principle, procedure and calculations of the measurement are described. Experimental results and discussions are presented. (Edited author abstract) 3 refs.

Guo, Heng-Li (Osaka Univ, Toyonaka, Jpn); Yachida, Masahiko; Tsuji, Saburo. *Adv Rob* v 1 n 1 1986 p 47-58.

**091308 DESIGN OF A LARGE DEPTH OF VIEW THREE-DIMENSIONAL CAMERA FOR ROBOT VISION.** The design of a compact laser scanner for robot vision is presented. The design is based on synchronized scanners. It is shown that the Scheimpflug condition of focusing coupled with the low divergence of a laser beam provides an ideal arrangement for large depth of view. A geometrical analysis and a prototype description are presented. (Author abstract) 13 refs.

Rioux, Marc (Nat'l Research Council Canada, Ottawa, Ont); Bechthold, G.; Taylor, D.; Duggan, M. *Opt Eng* v 26 n 12 Dec 1987 p 1245-1250.

**091309 THREE-DIMENSIONAL MEASUREMENT OF MANY LINE-LIKE OBJECTS.** A method that uses two point light sources has been developed. In this method, the system operates independently of the line-like sources. Correspondences between each terminal and its shadow can then be determined uniquely. The accuracy of measurement is also improved in this new method because the position of the terminal is calculated as the intersection point of three straight lines, not two as in the previous method. Calculations of the positions of all points and orientations of all line segments are presented in this paper. Experimental results and comparisons with the previous method are also given. (Edited author abstract) 5 refs.

Guo, Heng-Li (Osaka Univ, Toyonaka, Jpn); Yachida, Masahiko; Tsuji, Saburo. *Adv Rob* v 1 n 2 1986 p 117-130.

**091310 MACHINE VISION SYSTEM OF INDUSTRIAL ROBOT MODEL ELEKTRONIKA NTs TM-01.** The paper describes the machine vision system (MVS) of the industrial robot model Elektronika NTs TM-01 intended for loading blanks and unloading machined components on NC metal-cutting machine tools. Problems connected with the choice of the arrangement of the MVS, with the construction of its hardware and software, as well as with its functioning, are considered. The basic characteristics of MVS are presented. (Author abstract)

Kuleshov, V.S. *Sov Eng Res* v 7 n 5 May 1987 p 55-57.

**091311 INTRODUCTION TO MACHINE VISION.** This paper presents the fundamentals of machine vision - the use of computer hardware and software to capture images and to extract information from them. In particular, it discusses the importance of obtaining the best possible image, the fundamental operations with which an image can be altered to allow its analysis, and strategies

of obtaining information from these images. (Edited author abstract)

Giloi, W. (Int Robomation/Intelligence Inc); Solinsky, J.C. *Autom and Rob in the Textile and Apparel Ind* Publ by Noyes Publ, Park Ridge, NJ, USA, 1986 p 23-58.

**091312 ROBOTS LEARN TO SEE.** Flexible manufacturing systems, such as robots, can recognize the type, size and orientation of workpieces with the aid of 'intelligent' optical sensors. The VIDEOMAT PS now makes available a system offering a sophisticated range of functions combined with easy programming. (Author abstract)

Brauer, Reinhard (Siemens AG, Karlsruhe, West Ger); Dunemann, Klaus; Rastetter, Thomas. *Energy Autom* v 9 n 6 Nov-Dec 1987 p 18-21.

**091313 OCCLUSION AVOIDANCE OF VISUAL SENSORS BASED ON A HAND-EYE ACTION SIMULATOR SYSTEM: HEAVEN.** We have developed a hand-eye action simulator system called HEAVEN. This system provides model-based functions to assist the hand-eye system in visual recognition and monitoring the robot environment. This paper describes a function of assisting cameras in occlusion avoidance to input adequate image data without occlusion. The problem to select the best viewpoint for a camera is defined as to evaluate the viewpoints on a geodesic dome generated around a target object model. Occlusion-free space is obtained as regions on the geodesic dome by using a depth buffer algorithm. Then distance transformation of the occlusion-free regions gives candidates of the best occlusion-free viewpoint. Experimental results using a camera-in-hand system demonstrate the usefulness of the HEAVEN system in planning occlusion avoidance. (Author abstract) 18 refs.

Sakane, Shigeyuki (Electrotechnical Lab, Sakura-mura, Jpn); Ishii, Masaru; Kakikura, Masayoshi. *Adv Rob* v 2 n 2 1987 p 149-165.

**091314 SIGNAL PROCESSING OF A RANGE-FINDER MAP-REALIZATION SYSTEM.** The function to acquire three-dimensional information of the environment is crucial for the robots, especially mobile ones, and a range-finder which directly measures the range information with an active scan of a laser beam will be extensively used in the future. Based on the outlook that such range-finders will be manufactured in the near future, this research discusses some of the basic problems of the signal processing of the range-finder, especially when it is used to reproduce a terrain map for mobile robots. The following results were obtained: (1) The reflecting points of the laser beam on the ground surface are radially distributed and, therefore, a specialized method (Radial B-spline Interpolation) can be introduced for interpolating the beam points. (2) An interpolation method in association with the memorized information is shown to be feasible for signal processing of terrain. (Edited author abstract) 8 refs.

Hirose, Shigeo (Tokyo Inst of Technology, Tokyo, Jpn); Maekawa, Kazunobu; Umetani, Yoji. *Adv Rob* v 2 n 2 1987 p 167-180.

**091315 DIE HOUGH-TRANSFORMATION: EIN VERFAHREN ZUR KLASSIFIZIERUNG BELIEBIGER KONTUREN.** [Hough-Transformation: A Method for the Classification of Any Given Contour]. The paper describes procedures which are not only well suited to find lines but also to detect analytical curves as well as arbitrary curves in pictures. They are based on the algorithms proposed by Hough for finding lines in pictures. The improvement to these algorithms done by Duda and Hart are discussed thoroughly. A generalisation of this method leads to Hough-like transformations for detection of curves of higher order. Examples of finding circles and ellipses are described. In addition, a more



general method points out an algorithm for detecting curves of any shape and orientation. (Author abstract) 6 refs. In German.

Hesse, H.; Goser, K. *Robotersysteme* v 4 n 1 1988 p 27-32.

**091316 INDUSTRIAL APPLICATIONS OF COMPUTER VISION SINCE 1982.** During the past six years, the use of computer vision systems for industrial applications has become increasingly widespread. The application of vision in this context is surveyed and reviewed, according to the principal current application areas of automated visual inspection and visually guided robotic manipulation. Recently published research and development work for the identification and location of industrial components is discussed, as this forms the basis for improving the existing highly constrained application of machine vision. The survey is restricted to the period since 1982 in order to complement existing publications at or around that time. (Edited author abstract) 263 refs.

Wallace, A.M. (Heriot-Watt Univ, Edinburgh, Scotl). *IEE Proc Part E* v 135 n 3 May 1988 p 117-136.

**091317 OBJECT RECOGNITION OPENS THE EYES OF MACHINE-VISION SYSTEMS.** Innovative architectures and sophisticated image-processing techniques - particularly those of object recognition - strive to satisfy machine-vision systems' seemingly insatiable demand for processing power. The complexity of object recognition and mathematical morphology in image processing are discussed.

Williams, Tom (Computer Design, Littleton, MA, USA). *Comput Des* v 27 n 9 May 1 1988 p 69-72, 77-79, 82-84.

**091318 THREE-DIMENSIONAL DATA ACQUISITION SYSTEM FOR ROBOTS.** Robots execute various tasks in the real three-dimensional world. Three-dimensional position data are important for world modeling systems to describe 3-D working environments and for 3-D object recognition systems. Three-dimensional laser measurements based on the triangulation principle are widely used because they are simple and reliable. This research describes a new deflection angle sensor for a laser scanner developed to improve the accuracy of 3-D measurements. A data acquisition system constructed with this sensor is also described. 5 refs.

Hasegawa, Tsutomu (Electrotechnical Lab, Jpn). *Electr Eng Jpn* v 107 n 6 Nov-Dec 1987 p 42-49.

**091319 TINA: A 3D VISION SYSTEM FOR PICK AND PLACE.** The paper describes the Sheffield AIVRU 3D vision system for robotics. The system currently supports model-based object recognition and location; its potential for robotics applications is demonstrated by its guidance of a UMI robot arm in a pick-and-place task. The system comprises: recovery of a sparse depth map using edge-based passive stereo triangulation; grouping, description and segmentation of edge segments to recover a 3D description of the scene geometry in terms of straight lines and circular arcs; statistical combination of 3D descriptions for the purpose of object model creation from multiple stereo views, and the propagation of constraints for within-view refinement; and matching 3D wireframe models to 3D scene descriptions to recover an initial estimate of their position and orientation. (Author abstract) 27 refs.

Porritt, J. (Sheffield Univ, Sheffield, Engl); Pollard, S.B.; Pridmore, T.P.; Bowen, J.B.; Mayhew, J.E.W.; Frisby, J.P. *Image Vision Comput* v 6 n 2 May 1988 p 91-99.

**091320 THREE-DIMENSIONAL MACHINE VISION.** In 3-D machine vision, the height (or depth or range - these three terms are used synonymously) of an object, or objects, is obtained as a function of the X and Y position. For many applications, three-dimensional machine vision may be the only viable option; for others, it is far more effective than two-dimensional. Three-dimensional machine vision systems that produce height information for an entire area of interest (usually a rectangular area) are referred to as full-field systems. An

example of data produced by a full-field system is seen in isometric plot. The focus of this article will be full-field machine vision and how to apply it. 13 refs.

Bieman, Leonard H. (Industrial Technology Inst, Ann Arbor, MI, USA). *Photonics Spectra* v 22 n 5 May 1988 7p between p 81 and 92.

**091321 IMPLEMENTING MACHINE VISION: AN IBM CASE STUDY.** This article outlines a case study by IBM of machine vision implementation in the robotic assembly area of the Automated Logistic Production System used in manufacturing computers. The ALPS process receives incoming component parts from the dock and processes these parts into completed products, packages them and prepares them for shipment, all in a totally automated environment. The major areas of the process are: receiving and parts staging, depalletizing, material distribution, robotic assembly, test, and packaging. The binary vision system integrated with the assembly robots is also described. The primary components of the hardware subsystem are a camera, interface electronics and lighting system. The software subsystem consists of AML/V and RAPID. AML/V is a high-level robot control language which has multi-tasking and image processing capabilities. RAPID is a user friendly, menu-driven program written in AML/V used for generating applications. 8 refs.

Henry, J. (IBM, Austin, TX, USA); Preston, C. *Sens Rev* v 8 n 2 Apr 1988 p 73-78.

**091322 TARGET TRACKING ALGORITHM USING A SENSOR WITH BIOLOGICAL VISION FEATURES.** One of the most difficult problems in a video tracking system is the speed required for real-time operation. In this paper, a fast tracking algorithm to determine displacements of points (pixels) on object surfaces between successive frames, a sequence of image frames representing a time-varying scene, is described. The displacement is represented by a four-dimensional vector whose elements are two-dimensional translation, rotational angle on the x-y plane, and scaling factor (zoom parameter). The algorithm was developed in conjunction with research on sensors for machine vision with biological vision features. The algorithm developed is called a one-dimensional correlation algorithm and has recursive, spatio-temporal, correlation characteristics. It also possesses simplicity and separability properties. These properties make it easy to design and implement it in a highly parallel fashion. A speed comparison analysis shows that this algorithm can save 40 percent of computation time, or more, over the conventional correlation algorithm if implemented in a general purpose serial processor. Furthermore, the simulation results on a real image demonstrate that this algorithm possesses a good noise immunity property, i.e., it can be applied directly to a predefined moving area without segmentation. The properties and capabilities of the algorithm make it especially suited for robotics application with the camera mounted at the end effector. (Edited author abstract). 19 refs.

Narathong, C. (Univ of Virginia, Charlottesville, VA, USA); Inigo, R.M.; Doner, J.F.; McVey, E.S. *Int J Mach Tools Manuf* v 28 n 3 1988 p 217-233.

**091323 KNOWLEDGE-BASED VISUAL PART IDENTIFICATION AND LOCATION IN A ROBOT WORKCELL.** This paper presents a method for identifying and precisely locating parts visible in the workspace of a robot workcell through analysis of single or multiple perspective images. Automatic integration of any number of arbitrary viewpoints permits detection of objects occluded from certain views, as well as providing varying image resolution and wider coverage of the visible workspace. Analysis is possible in the presence of image noise such as glare or shadow from poor lighting conditions, or structural errors such as missing or obscured object features. Automated visual detection of camera locations avoids precise camera positioning or setup time and permits use of a movable or roving camera. The system is capable of processing multiple camera input in a few seconds on a SUN 3/160 workstation, without the use of additional image processing hardware and can be easily

ported to various computer systems. (Author abstract). 12 Refs.

Rueb, K.D. (Univ of Waterloo, Waterloo, Ont, Can); Wong, A.K.C. *Int J Mach Tools Manuf* v 28 n 3 1988 p 235-249.

**091324 NBS VISION SYSTEM IN THE AMRF.** A description is presented of the NBS Vision System. The authors discuss the objectives of the Vision System and its application in the factory environment. Since the Vision System is a multi-processor system, each process is described according to its position in the vision hierarchy as well as to its particular logical and computational functions. The interfaces between the individual processes of the Vision System and the interfaces between the Vision System and other AMRF systems are described. (Edited author abstract). 7 Refs.

Nashman, Marilyn (NBS, Gaithersburg, MD, USA); Chaconas, Karen J. *J Res Natl Bur Stand (US)* v 93 n 4 Jul-Aug 1988 p 539-544.

**091325 MODEL-BASED 3-D VISION SYSTEM FOR BIN-PICKING.** A vision system to recognize 3-D objects in a scene and to evaluate their attitude is presented. This system uses a model-based approach to determine the attitude of 3-D industrial parts in the context of bin packing. It is based on the matching of the extended Gaussian image (EGI) extracted from the surface normal map (needle map) of an observed object with the EGI generated from a 3-D model using geometric modeling. It is shown that geometric modeling can be used to provide an object description (visible surface orientation referred to as a needle map) suited to the problem of 3-D object recognition and attitude evaluation. 17 refs.

Distante, Arcangelo (Istituto di Elaborazione Segnali ed Immagini, Bari, Italy); Ancona, Nicola; Attolico, Giovanni; Caponetti, Laura; Chiaradia, Maria; Stella, Ettore. *IEEE Trans Circuits Syst* v 35 n 5 May 1988 p 545-553.

## Wear

**091326 EFFECT OF THE NON-UNIFORMITY OF THE STRUCTURE OF FRICTION SURFACES ON THEIR WEAR RESISTANCE.** Study of the fatigue wear processes of the surfaces of parts of industrial robots under conditions of steady state wear by a method of continuous photography has revealed non-uniform separation of the products of wear from the friction surface in its various parts. It was also noticed that even in cases where the indices of dislocation saturation of the surface layer of samples after a machining operation were approximately identical, the rates of wear of the samples differed considerably from each other under the same friction conditions. This justified the assumption that the quality indices of the surface layer subjected to the machining operation have been non-uniform. To check this assumption, statistical methods were used to investigate the quality indices of the surface layer of parts. 4 Refs.

Butenko, V.I. *Sov Eng Res* v 7 n 8 Aug 1987 p 22-23.

**ROCK** See Also FLOW OF FLUIDS—Porous Materials; SEWAGE TREATMENT—Filtration.

**091327 REVIEW OF CONSOLIDATION GROUTING OF ROCK MASSES AND METHODS FOR EVALUATION.** Factors involved in the successful consolidation grouting of rock masses by cementitious grouting are reviewed. Properties of cementitious grouts, rock mass properties, grouting techniques, and methods to evaluate and to monitor the grouting job are discussed. Three case histories of consolidation grouting performed on a rock mass for remedial purposes are presented. (Author abstract). 66 Refs.

Dickson, R. Morgan (Geotechnical Lab, Vicksburg, MS, USA). *Tech Rep US Army Eng Waterw Exp Stn* v REMR n GT-8 Jul 1988 90p.



**Acoustic Emission Testing** See FOUNDATIONS—Grouting; ROCK MECHANICS.

**Acoustic Properties** See ULTRASONIC WAVES—Propagation.

**Analysis** See Also GEOLOGY—Tectonics; GEOLOGY—United States; NATURAL GAS—Geochemistry; OIL SHALE—New Brunswick; PETROLEUM GEOLOGY.

**091328 X-RAY FLUORESCENCE ANALYSIS OF SILICATE ROCKS.** Calibration curves for the analysis of 12 trace elements Zr, Sr, Rb, Th, Pb, Zn, Cu, Ni, Co, Mn, Cr and Cl in silicate rocks were obtained using the X-ray fluorescence spectrometer, JEOL JSX-60PX with eight standard rocks JB-1a, JB-2, JB-3, JGB-1, JA-1, JA-2, JG-1a, JR-1 and JR-2 provided by Geological Survey of Japan. A pressed powder method was employed for the measurement. Background, matrix and standardization corrections were carried out for the measured intensities of characteristic X-rays. The errors of analysis for JB-1a are within 5% for Sr, Ni, Mn and Cr, 5 to 10% for Zr, Zn and Rb, and more than 10% for Th, Pb, Cu, Cl and Co. (Author abstract) 11 refs. In Japanese.

Uchida, Etsuo (Waseda Univ, Tokyo, Jpn); Watanabe, Yoshihide; Nakamura, Tadaharu; Imai, Naoya. *Waseda Daigaku Rikogaku Kenkyusho Hokoku* n 118 1987 p 45-52.

## Anisotropy

**091329 EFFECTS OF ROCK LAMINATION ANISOTROPY ON DRILLING PENETRATION AND DEVIATION.** Borehole deviation is caused, in part, by the mechanical behavior of the drillstring as it buckles, causing the resultant thrust on the drill bit to deviate from the axis of the wellbore. This paper looks at some theories of anisotropic rock strength and at the possible effect of these anisotropies on the rate of penetration and hole deviation. These theories are reviewed in light of limited experimental data, and a new model is suggested to predict chip volumes and direction deviation forces based upon a combination of variable cohesive strength and single plane of weakness theories. 7 refs.

Karfakis, M.G. (Univ of Wyoming, Laramie, WY, USA); Evers, J.F. *Int J Rock Mech Min Sci Geomech Abstr* v 24 n 6 Dec 1987 p 371-374.

**091330 COMPRESSIVE STRENGTH CRITERION FOR ANISOTROPIC ROCK MATERIALS.** This paper proposes a general compressive strength criterion for anisotropic rock materials under multiaxial states of stress. The proposed criterion is a generalization of the Von Mises' criterion for yielding of ductile metals, which has also been used previously as a strength criterion for brittle fracture in the spirit of both being limits of linear elastic behavior. The presently proposed criterion takes into consideration the effects of the confining pressure, the various stress components, and the material anisotropy on rock material failure in a multiaxial stress state. To verify the applicability of the proposed criterion, it has been used to construct the failure envelopes for several types of rock materials. Consequently, the constructed failure envelopes and the corresponding experimental results have been compared. (Edited author abstract) 22 Refs.

Ashour, Hamdy A. (Qatar Univ, Doha, Qatar). *Can Geotech J* v 25 n 2 May 1988 p 233-237.

## Biodegradation

**091331 BIOTRANSFORMATIONS IN MONUMENTS - A SOCIOBIOLOGICAL STUDY.** Rapid and increasing deterioration and biodeterioration of facades of stone buildings, monuments and sites has been reported in many countries and cities over the past 3000 years. Biological factors in the fields of air pollution and conservation are multiple. An integrated view of material transfer and material transport is briefly presented. Biodeterioration is defined as a socio-cultural term while biotransfer, biotransport and biodegradation describe the response of materials in contact with atmosphere, hydro-

sphere and biosphere. The processes of biotransfer and biotransport need not necessarily be regarded as biodeterioration in the context of conservation. Examples are given in which biological factors lead to momentary equilibria which are socio-culturally positive (patina). Weathering and material destruction are described in terms of the reduction of materials to less complex or different constituents. (Edited author abstract) 25 refs.

Krumbein, Wolfgang E. (Univ of Oldenburg, Oldenburg, West Ger). *Durability Build Mater* v 5 n 3 & 4 Apr 1988 p 359-382.

**Blasting** See Also TUNNELS AND TUNNELING; TUNNELS AND TUNNELING—Construction; TUNNELS AND TUNNELING—Mechanization.

**091332 STUDY OF PHOTO-IMAGE ANALYSIS METHOD OF ROCK FRAGMENTATION BY BLASTING.** The method of photo-image analysis for measuring the rock fragmentation distribution after blasting is one of the forefront projects of the rock blasting science and technique in the world. This paper illustrates some important progress achieved through both laboratory and in-situ experiments: The strong linear relationship has been confirmed between the geometric parameter distributions of rock fragment plane figures on photos and the volume distribution of rock fragments in the blasted pile; Fragment distribution on the photos deflects towards the smaller grades; A software of photofilm-image analysis of rock fragmentation by blasting employing the artificial intelligence technique for shape analysis and shape correction has been worked out successfully; And relative errors in the calculated distribution of rock fragments did not exceed 15 percent. (Edited author abstract). In Chinese.

Dingxiang, Zou (Maanshan Inst of Mining Research, China). *Yu Se Chin Shu* v 40 n 2 May 1988 p 22-29.

## Chemical Analysis

**091333 SULPHATE ANALYSIS ON BLACK MUDSTONES.** During a survey of England and Wales, the Soil Survey was faced with the problem of screening several thousand soil samples for potential acidity caused by the formation of sulphuric acid from the oxidation of pyrite. pH change was utilized before and after slow, moist oxidation. The technique was very simple, and the procedure is given in this discussion. In addition, the writer questions the authors' recommendation to 'provide adequate drainage to remove newly formed sulphates and to prevent onset of acidic conditions'. The author's reply is included. 4 Refs.

Hawkins, A.B.; Pinches, G.M. *Geotechnique* v 38 n 2 Jun 1988 p 322-323.

**Chemical Reactions** See MASONRY MATERIALS—Degradation.

## Classification

**091334 PROPOSED GEOTECHNICAL CLASSIFICATION OF CARBONATE ROCKS BASED ON PORTUGUESE AND ALGERIAN EXAMPLES.** Carbonate rocks are common and widely dispersed materials. They include pure limestones and dolostones as well as a large variety of composites differentiated by the relative occurrence of accessory quartz, clay minerals and other components. Geotechnical properties reflect this wide variation of composition and a classification scheme would be helpful for consistent communication. References and data obtained for this study substantiated the proposed geotechnical classification based on porosity and swelling strain of the rocks. The relevance of these parameters for the explanation of the geotechnical behavior of carbonate rocks as well as their simplicity render them very suitable for this purpose. The field behavior of some Portuguese rocks is employed to demonstrate correlation with the proposed classification. (Author abstract) 6 refs.

Delgado Rodrigues, Jose (Nat'l Lab of Civil Engineering, Lisbon, Port). *Eng Geol* v 25 n 1 Feb 1988 p 33-43.

**Crack Propagation** See Also ROCK MECHANICS—Pore Pressure.

**091335 EXPERIMENTAL STUDY OF ANISOTROPY OF STRESS CORROSION CRACKING IN ROCKS BY DOUBLE-TORSION METHOD.** A subcritical crack growth due to stress corrosion has been identified as a source of time-dependent fracture of rocks in brittle fields. The stress corrosion cracking was investigated in humid air by using the double-torsion technique for three rocks of different origin, Murata basalt, Oshima granite and Ogino tuff. The subcritical crack growth was found to be strongly dependent on the directions of crack opening and crack propagation. The maximum growth rate was higher by several orders of magnitude than the minimum one for the same rock. The anisotropy in the crack propagation was controlled by microcracks for Oshima granite and by the fabric for other rocks. (Author abstract) 39 refs. In Japanese.

Sano, Osam (Yamaguchi Univ, Ube, Jpn). *Zairyo* v 37 n 413 Feb 1988 p 152-158.

**091336 THEORETICAL STUDY OF ANISOTROPY OF STRESS CORROSION CRACKING IN ROCKS BY THE DOUBLE-TORSION METHOD.** Subcritical crack growth has a strong dependence on the directions of crack opening and crack propagation. The maximum growth rate was higher by several orders of magnitude than the minimum one for Oshima granite. From the theoretical consideration on the torsion of two thin orthotropic plates, a way for analyzing the data of the double-torsion technique for anisotropic materials was established. Based on the Christoffel's equation, nine elastic stiffness constants of Oshima granite were determined from the sound velocities,  $V_p$  and  $V_s$ , propagating in various directions. The results of the anisotropic analysis showed that the observed difference in crack velocity of different directions was not an error due to the isotropic analysis but the intrinsic nature of the granite. A theory based on the microcrack growth model showed that the difference in crack velocity by several orders of magnitude brings in a difference of only several times in dilatancy and that of only several percents in the uniaxial compressive strength. (Author abstract) 28 refs. In Japanese.

Sano, Osam (Yamaguchi Univ, Ube, Jpn). *Zairyo* v 37 n 413 Feb 1988 p 159-165.

**Creep** See TUNNELS AND TUNNELING—Ground Supports.

**Crushing and Grinding** See Also CONCRETE AGGREGATES—Selection; PILES—Testing.

**091337 USE OF SIMULATION MODELING FOR A PROBABILISTIC ESTIMATE OF THE SPATIAL ORIENTATION OF THE DISCHARGE CHANNEL IN THE INTERELECTRODE SPACE.** The expediency of using simulation modeling on a computer for investigating the effectiveness of functioning of electrospray technological devices was substantiated qualitatively. It is shown that an algorithm for simulation modeling of the spatial orientation of discharge in the working space of the technological device should be one of the required elements of generalized algorithms for such modeling. Such an algorithm is given for the case when the spatial orientation of an individual discharge is assigned in a polar coordinate system by the relationship of the vertical and horizontal discharge angles. (Edited author abstract) 5 refs.

Tonkonogov, M.P.; Boguslavskii, V.Ya.; Kopbaev, S.T.; Kurochkina, T.N. *Sov Surf Eng Appl Electrochem* n 4 1987 p 60-62.

## Crystalline

**091338 3-D KINEMATIC MODEL OF FABRIC DEVELOPMENT IN POLYCRYSTALLINE AGGREGATES: COMPARISONS WITH EXPERIMENTAL AND NATURAL EXAMPLES.** A 3-D generalization of the approach previously developed by Etchecopar for the



simulation of fabrics in polycrystalline aggregates is presented. The model is based on a geometric minimization of gaps, overlaps and boundary displacements between deformed neighboring cells; each cell may deform using a small number ( $<5$ ) of independent slip systems. The model is applied to experimentally flattened peridotites and sheared ice as well as to naturally sheared peridotites and quartzites. For weak deformations, the simulation matches the natural and experimental observations but, for large deformations, major discrepancies are observed; in particular the model cannot explain the obliquity of Lattice Preferred Orientation with respect to the schistosity, which is commonly observed in shear deformations. However, when taking into account a 'dynamic recrystallization' process, these discrepancies are strongly reduced and the obliquity clearly appears in simple-shear models. (Author abstract) 34 refs.

Etchecopar, A. (Lab de Geologie Structurale, Montpellier, Fr); Vasseur, G. *J Struct Geol* v 9 n 5-6 1987 p 705-717.

**091339 K-FELDSPAR BRECCIA FROM THE Mo-Cu STOCKWORK DEPOSIT IN THE GALWAY GRANITE, WEST OF IRELAND.** A K-feldspar breccia, spatially associated with the Mo-Cu mineralization of a stockwork in the Late Caledonian Galway Granite at Mace Head, is described for the first time. Detailed mapping reveals a network of breccia pods and veins over an area of approximately 6000 m<sup>2</sup>. The breccia is clast-supported and is composed of sub-angular fragments of perthitic K-feldspar megacrysts, granite and microgranodiorite clasts set in a matrix of quartz, biotite and apatite. Field and textural studies indicated that the feldspar megacrysts and granite clasts were brecciated and silicified as they were carried by hydrous K- and SiO<sub>2</sub>-rich fluids. The breccia formation is genetically related to ore-forming processes in the Galway Granite. (Edited author abstract). 13 Refs.

Derham, J.M. (Univ Coll, Galway, Irel); Feely, M. *J Geol Soc London* v 145 Jul 1988 p 661-667.

## Crystallization

**091340 PETROGENESIS AND CONDITIONS OF CRYSTALLIZATION OF SPANISH LAMPROITIC ROCKS.** The lamproitic rocks of southeast Spain (8.6-6 Ma) occur mainly as dykes and plugs in the provinces of Murcia, Almeria and Albacete. Phlogopite, olivine, apatite, spinel, sanidine and glass are ubiquitous. Clinopyroxene, orthopyroxene, K-rich amphibole, biotite, ilmenite, pseudobrookite, leucite, analcime and carbonates may be additional phases. The magmas crystallized at temperatures below ca. 1200°C. The distribution of the high-valency ( $>3$ ) elements was largely influenced by the heterogeneous distribution of accessory phases in the source and by the melt structure. The magmas were generated from an enriched mantle source containing phlogopite, orthopyroxene, olivine and accessory plates (e.g., apatite). (Edited author abstract) 48 refs.

Venturelli, Gianpiero (Univ di Parma, Parma, Italy); Mariani, Emma Salvio; Foley, Stephen F.; Capedri, Silvio; Crawford, Antony. *Can Mineral* v 26 pt 1 Mar 1988 p 67-79.

Cutting See MINING MACHINERY—Testing.

Decomposition See GRANITE—Testing.

Deformation See Also GEOLOGY—Geomorphology; GEOLOGY—Tectonics; QUARTZ—Microstructure; ROCK MECHANICS; SANDSTONE—Testing; SOILS—Testing; TUNNELS AND TUNNELING—Pressure Measurement.

**091341 PREDICTED AND MEASURED ROCK MASS MODULI.** Plate bearing and rock bolt jacking tests were used to measure the in situ deformational response of four jointed rock masses, namely sandstone, limestone, shale and coal. The predicted values of the rock mass moduli were evaluated using composite theory and laboratory-determined joint stiffness and intact rock moduli. Joint shear stiffness is an order that is 10 times less

than the joint normal stiffness and this has the effect of disproportionately increasing the deformational response. Good correlation is obtained when the lower values of joint stiffnesses are used in the lower bound deformational formulations. (Edited author abstract) 7 refs.

Chappell, B.A. (Bur of Mineral Resources, Canberra, Aust). *Min Sci Technol* v 6 n 1 Nov 1987 p 89-104.

**091342 DEFORMATION PHENOMENA IN JOINTED ROCK.** The role of rock joints in rock mass deformation phenomena is described. Individually, joints display concave-shaped stress-closure curves under normal loading and convex-shaped stress-displacement curves under shear, usually accompanied by dilation. The deformation behavior of rock masses depends on the relative magnitudes of these components of closure, shear and dilation. The deformation of a rock mass may result in dramatic changes in the joint apertures and conductivities. Conversely, changes in joint water pressure cause changes in joint aperture which affect the overall deformation of the rock mass. Examples of compaction in jointed reservoirs and leakage phenomena in pressure tunnels are cited, each of which may be caused by changes in effective stress. The Paper concludes by analyzing the role of joint dilation in stress transformations and in the behavior of underground openings. (Edited author abstract) 34 refs.

Barton, N.R. (Norwegian Geotechnical Inst, Oslo, Norw). *Publ Nor Geotek Inst* n 168 1987 21p.

**091343 EN ECHELON VEIN ARRAY DEVELOPMENT IN EXTENSION AND SHEAR.** A subdivision of en echelon vein arrays is proposed, based on the geometry of sets of transcurent arrays from the Lower Carboniferous rocks in the SE midlands of Ireland. The parameters  $\delta$  (vein-zone angle) is proportional to the array orientation ( $\phi$ ) for arrays developed through secondary failure in shear zones (shear arrays). For arrays developed during propagation of an extension vein (extension arrays)  $\delta$  is proportional to the overlap of veins in the array  $P(\phi)$ . Criteria of field distinction, together with the different methods of kinematic interpretation that are required for the two types of arrays, are described. For shear arrays, the average trends of the two members of the conjugate set are calculated and the axis of principal shortening strain ( $Z$ ) bisects these. The average trend of extension arrays is parallel to that of extension veins and is therefore normal to the maximum extensional strain axis ( $X$ ). (Author abstract) 19 refs.

Rothery, Eoin. *J Struct Geol* v 10 n 1 1988 p 63-71.

**091344 SHEAR CRITERIA IN ROCKS: AN INTRODUCTORY REVIEW.** Over the last decade or so, there has been an increasing interest in the use of kinematic indicators, in other words, geological structures (often microstructures) that reveal certain aspects of the deformation history of a rock at a given scale. Amongst these are indicators of the sense or the amount of shear (or slip), in situations where the deformation history has been dominantly one of progressive simple shear (or slip). This paper discusses the subject in terms of kinematic indicators, shear zones and faults, slip system distributions, and related topics. 14 refs.

Cobbold, P.R. (Univ de Rennes, Rennes, Fr); Gapais, D. *J Struct Geol* v 9 n 5-6 1987 p 521-523.

**091345 SHEAR CRITERIA AND STRUCTURAL SYMMETRY.** During the last decade, it has been shown that most relevant shear criteria within ductile rocks are asymmetric structures (e.g. pressure shadows, shear bands, C-S structures, fabrics, tension gashes, folds, veins). The correspondence between coaxial or non-coaxial deformation, and symmetric or asymmetric particle velocity fields, respectively accounts for the use of structural symmetry as an indicator of strain history. The application of this symmetry concept to various field examples emphasizes that: (i) the degree of symmetry of a given structural pattern reflects the bulk strain regime irrespective of the size and the mechanical behavior of the considered system; and (ii) the strain regime can also be inferred from the order of appearance and dominance of

structures which contribute to the total deformation pattern, even where the progressive deformation results in a complex pattern which cannot be directly interpreted. (Author abstract) 54 refs.

Choukroune, P. (Univ de Rennes, Rennes, Fr); Gapais, D.; Merle, O. *J Struct Geol* v 9 n 5-6 1987 p 525-530.

**091346 SHEAR CRITERIA IN THE GRENVILLE PROVINCE, ONTARIO, CANADA.** The Grenville Province of Canada is a major Proterozoic orogenic belt. Mapping and structural analysis shows that the central Ontario segment of this belt is composed of a stack of imbricated thrust nappes separated by mylonite zones. The mylonite zones were generated at high metamorphic grades and contain a distinctive assemblage of mesoscopic and microscopic asymmetric structures. These structures include rotated tectonic inclusions, rotated boudins and pinch-and-swell structures, sheath folds, rotated single-crystal porphyroclasts, single crystal 'fish', and shear band foliation. The shear asymmetry indicated by these structures is highly consistent between members of the assemblage, and over a large area of the Grenville province, and shows that the thrust nappes were transported to the northwest. The consistency of the structures is thought to be due to cyclical dynamic recrystallization leading to steady-state foliations in the mylonites. (Author abstract) 40 refs.

Mawer, C.K. (Univ of New Mexico, Albuquerque, NM, USA). *J Struct Geol* v 9 n 5-6 1987 p 531-539.

**091347 KINEMATICS OF COMPRESSIONAL AND EXTENSIONAL DUCTILE SHEARING DEFORMATION IN A METAMORPHIC CORE COMPLEX OF THE NORTHEASTERN BASIN AND RANGE.** Analysis of shear criteria enables the kinematics of two main ductile-shearing events ( $D_1$  and  $D_2$ ) to be established in the Raft River, Grouse Creek and Albion 'metamorphic core complex'. The first event ( $D_1$ ) is a NNE-thrusting and corresponds to Mesozoic shortening. A well developed non-coaxial ductile deformation ( $D_2$ ), of Cenozoic age, is marked by the occurrence of opposing eastward (in Raft River) and westward shear criteria (in Albion-Grouse Creek). These characterize an arch structure where the shear strain increases outwards. In the axial zone of the complex,  $D_2$  seems coaxial. Cenozoic extension is considered to be related to gravitational instability induced by mesozoic overthickening of the crust (involving uplift, erosion and abnormal heating). Brittle extension is transformed laterally above undeformed basement towards stretched domains of the middle and lower crust through the ductile shear zones localized at the Precambrian-Paleozoic interface. (Edited author abstract) 140 refs.

Malavielle, Jacques (Lab de Geologie Structurale, Montpellier, Fr). *J Struct Geol* v 9 n 5-6 1987 p 541-554.

**091348 SHEAR STRUCTURES IN ANHYDRITE AT THE BASE OF THRUST SHEETS (ANTALYA, SOUTHERN TURKEY).** Minor-scale structures in anhydrite layers and pods within one thrust contact of the Antalya Thrust System are described. Folds whose size range from some centimeters to several meters display a wide variety of attitudes. Their axes are curvilinear and vary from orthogonal to subparallel to the stretching lineation, leading to sheath folds and eyed type sections. Shear bands are frequent. Normal and reverse fault type shear bands are self-exclusive, and both indicate a sense of shear toward the south at the scale of thrust system. A model of progressive deformation of the anhydrite layers is presented. Anhydrite layers which have undergone a strong unstable shearing deformation along a thrust have been boudinaged and now form elongate asymmetric pods. Additional aspects of the subject are discussed. 20 refs.

Marcoux, J. (Univ Paris 7, Paris, Fr); Brun, J.-P.; Burg, J.-P.; Ricou, L.E. *J Struct Geol* v 9 n 5-6 1987 p 555-561.



**091349 BULK KINEMATICS FROM SHEAR ZONE PATTERNS: SOME FIELD EXAMPLES.** This paper shows that shear zone patterns can be used to estimate both a bulk finite strain ellipsoid and aspects of the bulk deformation history. The authors describe examples of heterogeneously deformed granitic rocks which reveal the following features: (1) Shear zones show preferred orientations. (2) There are correlations between shear zone orientations and directions and senses on shear. (3) For areas that have undergone coaxial deformation histories, shear zone patterns have orthorhombic symmetries directly related to strain ellipsoid shape. (4) For areas that have undergone non-coaxial deformation histories, shear zone patterns have a lower symmetry. (5) For areas that have undergone bulk simple shear, shear senses on shear zones are consistent with the bulk shear sense. Results are compared with predictions of kinematic models involving slip along inextensible fibres and sheets. (Edited author abstract) 37 refs.

Gapais, Denis (CNRS, Rennes, Fr); Bale, Pascal; Choukroune, Pierre; Cobbold, Peter R.; Mahjoub, Yamina; Marquer, Didier. *J Struct Geol* v 9 n 5-6 1987 p 635-646.

**091350 EXAMPLE OF THREE-DIMENSIONAL ANALYSIS OF THRUST-RELATED TECTONITES.** A spaced pressure-solution cleavage related to Alpine thrusts in Mallorca (Balearic Isles) is deformed by several sets of shear planes and minor folds. All these structures formed synchronously, related to the thrust sheet movement. Shear plane sets show different orientations irrespective of the cleavage disposition. Slip along these shear planes shows that deformation did not result in plane strain. Minor fold axes show a wide range of orientations. Neither folds nor shear planes enable us to directly deduce the sense of thrust motion, indicating that these criteria must be used with care. Previous strain characterization is required for definite conclusions to be reached. (Author abstract) 35 refs.

Casas, J.M. (Univ de Barcelona, Barcelona, Spain); Sabat, F. *J Struct Geol* v 9 n 5-6 1987 p 647-657.

**091351 PRECAUTIONARY NOTE ON SHEAR BANDS AS KINEMATIC INDICATORS.** The orientation of shear bands relative to foliations defined by elongated mineral aggregates is often used to determine the large-scale sense of displacement in ductile faults. Data from contact strain zones at the bases of large overthrust complexes in the Eastern Alps and the Betic Cordilleras demonstrate that there is not always a simple geometrical relation between shear band orientation and sense of vorticity in bulk non-coaxial flow. In addition to single shear band sets that show displacements synthetic with the large-scale displacement, there are single sets with antithetic displacements, and conjugate sets. The last two observations are at variance with published data and interpretations, and cast doubts on the general applicability of shear bands as indicators of large scale flow kinematics. (Author abstract) 36 refs.

Behrmann, J.H. (Univ Giessen, Giessen, West Ger). *J Struct Geol* v 9 n 5-6 1987 p 659-666.

**091352 ROLLING STRUCTURES AT LARGE SHEAR STRAIN.** At large shear strain, shear criteria are often obliterated or become ambiguous. From examination of both natural examples and experimental models we describe a new criterion called 'rolling structure', widely represented in sheared rocks. A typical rolling structure is composed of a rigid or competent object (e.g. porphyroblast, boudin, fossil, etc.) with two tails asymmetrically disposed around it. In most cases tails are of the same material as that of the rotating object, and result from strain softening and grain-size reduction at the object periphery, forming a mantle. Z and S asymmetries of rolling structures represent dextral and sinistral senses of shearing, respectively. Tails must not be confused with pressure shadows which usually present an opposite asymmetry for a given shear sense. Besides the determination of the sense of shear, the occurrence of these structures allows a minimum estimate of the strain intensity in strongly sheared rocks, since rolling structure length is proportional to shear strain. (Author abstract) 23

refs.

Van Den Driessche, Jean (Univ Paris 7, Paris, Fr); Brun, J.-P. *J Struct Geol* v 9 n 5-6 1987 p 691-704.

**091353 PURE SHEAR AND SIMPLE SHEAR CALCITE TEXTURES. COMPARISON OF EXPERIMENTAL, THEORETICAL AND NATURAL DATA.** The authors have been investigating differences between pure shear and simple shear deformation in carbonate rocks and have found considerable agreement between textures produced in plane strain experiments and predictions based on the Taylor model. They were able to simulate the observed changes with strain history (coaxial vs non-coaxial) and the profound texture transition which occurs with increasing temperature. Two natural calcite textures were then selected and interpreted by comparing them with the experimental and theoretical results. A marble from the Santa Rosa mylonite zone in southern California displays orthorhombic pole figures with patterns consistent with low temperature deformation in pure shear. A limestone from the Tanque Verde detachment fault in Arizona has a monoclinic fabric from which it can be interpreted that 60% of the deformation occurred by simple shear. (Edited author abstract) 45 refs.

Wenk, H.-R. (Univ of California, Berkeley, CA, USA); Takeshita, T.; Bechler, E.; Erskine, B.G.; Matthies, S. *J Struct Geol* v 9 n 5-6 1987 p 731-745.

**091354 SIMPLE SHEAR EXPERIMENTS ON CALCITE ROCKS: RHEOLOGY AND MICROFABRIC.** The principal aims of this study are: (1) to compare rheological behavior and microfabric development in simple shear with earlier results obtained by coaxial testing of the same starting material; (2) to improve our understanding of the microfabric development under conditions of simple shear, both in terms of the development of grain shapes (microstructure) and the mechanisms of the development of a crystallographic preferred orientation (referred to as 'texture' in this study); and (3) to provide useful criteria for detecting rotational deformation, including information on the shear sense, for microfabric studies on naturally deformed rocks. The two calcite rocks (Solnhofen limestone and Carrara marble) were chosen because a great number of data are already available from coaxial testing of the same or similar materials, and because the flow strength of calcite is low enough to permit simple shearing with the experimental procedure chosen for this study. Many of the results are of general interest in regard to other rock-forming minerals, especially in regard to texture development under conditions of simple shear. 42 refs.

Schmid, S.M. (ETH-Zentrum, Zurich, Switz); Panozzo, R.; Bauer, S. *J Struct Geol* v 9 n 5-6 1987 p 747-788.

**091355 MODEL OF A PLASTIC BODY WITH INTERNAL FRICTION AND DILATANCY.** A broad class of materials (massive rock, soft soils, cast iron, composite materials, etc.) exhibit internal friction and dilatancy during deformation. At this time there exist several models of the theory of plasticity that describe these material properties together or individually. A new model of the theory of plasticity is proposed in this paper within whose framework a dependence of the dilatancy of the kind of stress state is successfully demonstrated. The computations based on the proposed model correlated well with experimental data from the deformation of mountain rock specimens. 12 refs.

Babakov, V.A. (Acad of Sciences of the USSR, Novosibirsk, USSR). *Sov Min Sci* v 23 n 3 May-Jun 1987 p 191-198.

**091356 'BONE-SHAPED' BOUDINS IN PROGRESSIVE SHEARING.** Some peculiar 'bone-shaped' boudins are observed in two areas of progressive shearing. They are characterized by large quartz-filled gashes that separate thinner boudins. These gashes often have a consistent obliquity, suggesting a rotation synthetic to the shear sense. These may be formed by rigid material that crystallizes in tension gashes between the boudins; during further ongoing deformation these behaved as rigid

inclusions in a more ductile matrix and show systematic rotations. The sense of rotation of the gashes constitutes a shear criterion. (Author abstract). 24 Refs.

Malavielle, J. (Univ des Sciences et Techniques du Languedoc, Montpellier, Fr); Lacassin, R. *J Struct Geol* v 10 n 4 1988 p 335-345.

**091357 THICKNESS-DISPLACEMENT RELATIONSHIPS FOR DEFORMATION ZONES.** Empirical relationships between thickness and displacement for different types of deformation zones in quartzofeldspathic rocks are presented. Faults exhibit a linear correlation of thickness with displacement and an average displacement/thickness ratio of 63; mylonite zones may show a similar correlation (with an average ratio of 2), though the data are problematic. The thickness-displacement relationships provide information on the growth of deformation zones with time and the role of strain softening and hardening during progressive displacement. (Author abstract). 49 Refs.

Hull, Joseph (Univ of Rochester, Rochester, NY, USA). *J Struct Geol* v 10 n 4 1988 p 431-435.

**091358 MECHANISM OF DEFORMATION AND FRACTURE IN POTASH ROCK.** Specimens of potash rock from the Rocanville mine of the Potash Corporation of Saskatchewan were subjected to uniaxial compression tests and to time-dependent creep tests under static, uniaxial loading. During the first cycle of loading, the main sources of the measured strain are compaction and dilation at grain boundaries and consolidation of the clay phase. The crystals of halite and sylvite deform elastically at low stress and in a brittle manner at high stress. There is little, if any, evidence for constant-volume plastic deformation at any level of uniaxial stress. The stress-strain curve can be divided into three parts, each representing a different dominant deformational process: a low-stress quasi-elastic, an intermediate-stress ductile, and a high-stress brittle mechanism. The deformation of potash rock is strongly time dependent. (Edited author abstract). 13 Refs.

Lajtai, Emery Z. (Univ of Manitoba, Winnipeg, Manit, Can); Duncan, E.J. Scott. *Can Geotech J* v 25 n 2 May 1988 p 262-278.

**Dimensional Stability** See TUNNELS AND TUNNELING—Design.

**Elasticity** See Also COAL MINES AND MINING—Rock Mechanics.

**091359 EXPERIMENTAL STUDY OF THE ELASTICITY OF MYLONITE ROCK WITH RANDOM CRACKS.** An elastic compliance tensor for discontinuous rock masses is formulated by treating each crack with an elastic equivalent, which consists of parallel plates connected by two springs. The complex geometry of cracks, which is commonly observed in actual rock masses, is explicitly taken into account in the formulation, by means of a crack tensor. Uniaxial compression tests on eight mylonite samples were carried out to verify the utility of the elastic compliance tensor with the following conclusions: the elasticity of the samples, which have completely different appearances in terms of their crack geometry, can be compared in a general manner by the help of the crack tensor concept. Experimental results on Young's moduli of the mylonite samples are in accord with the theoretical prediction, although the strength cannot be easily related to the overall characteristics of crack geometry. (Edited author abstract) 21 refs.

Oda, M. (Saitama Univ, Urawa, Jpn). *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 2 Apr 1988 p 59-69.

**Electric Conductivity** See Also GEOPHYSICS—Electrical.

**091360 INTERLAYER CONDUCTIVITY OF ROCKS - A FRACTAL MODEL OF INTERFACE IRREGULARITIES FOR CALCULATING INTERLAYER CONDUCTIVITY OF NATURAL POROUS MINERAL SYSTEMS.** A theory has been developed for



calculating interlayer conductivity for natural porous systems, such as sedimentary rocks. As the materials investigated are mainly made up of silica and alumina minerals, an electrical double layer can be presumed, which carries the physical process. A new approach has been attempted by modeling the geometrical conditions. A self-similarity model has been established for describing the porous medium, the parameters of which can be derived from physical measurements. The considerations are based on the fact that the pore wall surface is structured in all orders of magnitude in such a way that the theory of fractal dimensions is applicable. (Edited author abstract) 34 refs.

Pape, Hansgeorg (Technical Univ of Clausthal, Clausthal-Zellerfeld, West Ger); Riepe, Lutz; Schopper, Jürgen R. *Colloids Surf* v 27 n 1-3 Oct 1987 p 97-122.

## Electric Properties

**091361 CHARACTERISTICS OF THE MULTIPLE EFFECT OF PULSED VOLTAGES ON ROCKS.** The purpose of this paper was to study the multiple effect of voltage pulses in decimeter spaces. The investigations were conducted on naturally frozen water-saturated sand (frozen ground) and alkaline granite of the Sorsk deposit. Experimental results showing the multiple-pulse strength of frozen ground and granite as a function of the number of pulses  $n$  are given as well as those of the single-pulse and multiple-pulse strength of frozen ground as a function of the length of the interelectrode space. 5 refs.

Levchenko, B.S.; Podpletnev, V.I.; Semkin, B.V. *Sov Surf Eng Appl Electrochem* n 1 1987 p 71-74.

**091362 RESIDUAL WATER SATURATION, ELECTRICAL CONDUCTIVITY, AND ROUGH ROCK/PORE INTERFACES.** In this paper, we model the roughness of the pore/rock interface in terms of a random surface; we construct the surface by assigning random heights to the vertices of a triangular lattice. A completely wetting fluid preferentially lies along the concave creases of the surface and forms connected pathways that span the surface. A wetting fluid with finite contact angle does not necessarily form continuous pathways in this model. Electrical conductivity for the completely wetting case is simply proportional to the wetting-fluid saturation at very low saturations; this result agrees with recent experimental studies. (Author abstract) 11 refs.

Katz, A.J. (Exxon Production Research Co, Houston, TX, USA); Trugman, S.A. *J Colloid Interface Sci* v 123 n 1 May 1988 p 8-13.

## Energy Resources

**091363 PIONEERING WORK IN HOT ROCKS HEAT RECOVERY.** The exploration of ways to tap a new energy source that may contribute significantly to power supplies in the next century - the heat which is contained in rocks many thousands of meters deep in the earth - is being pushed forward. Research being carried out in a quarry near Falmouth, Cornwall, Southwest England, where conditions are particularly favorable is reported, along with steps taken toward improving present techniques.

Owen, John (Western Morning News, Plymouth, Engl). *Electr India* v 27 n 13 Jul 15 1987 p 19-21.

**091364 PIONEERING WORK IN HOT ROCKS HEAT RECOVERY.** The exploration of ways to tap a new energy source that may contribute significantly to power supplies in the next century - the heat which is contained in rocks many thousands of meters deep in the earth - is being pushed forward. Government research activities and economic aspects are discussed. (Edited author abstract)

Owen, John (Western Morning News, Plymouth, Engl). *Elektron (Johannesburg)* v 4 n 11-12 Nov-Dec 1987 p 21, 23.

**Energy Storage** See HEATING—Heat Storage.

## Erosion

**091365 ROCK EROSION.** This study is based on the assumptions that the rock has cracks in several directions and that water can propagate into the cracks causing pressure to build up within them. These pressure forces in the cracks act on the side and bottom of a rock block while the pressure from the flowing water acts on the top surface of the fragment. If the resulting uplift force is not balanced by the weight of the block and no other forces in the joints impede movement, the block will be lifted and carried away by the water. This paper considers the erosion of rock that is caused by water flowing parallel to its surface. This often occurs: downstream of spillways, in spillway chutes, in stilling pools and in diversion tunnels and canals. (Edited author abstract) 3 refs.

Reinius, Erling (Royal Inst of Technology, Stockholm, Swed). *Bull K Tek Högsk Inst Vattenbyggnad* n 134 1986 6p.

**Explosions** See ROCK MECHANICS.

**Failure** See Also BOREHOLES—Stability; BOREHOLES—Testing; ROCK MECHANICS; SANDSTONE—Testing; SOILS—Failure.

**091366 EXPERIMENTAL METHOD TO STUDY THE DYNAMIC TENSILE FAILURE OF BRITTLE GEOLOGIC MATERIALS.** An experimental method was developed to study the tensile failure of brittle geologic materials at strain rates of approximately 10 to 20/s. In these experiments, a cylindrical rod specimen is first loaded in static triaxial compression, then the axial pressure is released from each end simultaneously and very rapidly. The resulting rarefaction waves interact in the center of the rod to produce a dynamic tensile stress equal in magnitude to the original static compression. The pressure acting on the radial surface is approximately constant during the experiment. As an application of this method, several experiments were performed on concrete. Transient measurements were made of the axial load at each end, the confining pressure, and axial and circumferential surface strains at several locations along the length of the rod. Additional aspects of the subject are discussed. (Edited author abstract) 11 refs.

Gran, J.K. (SRI Int, Menlo Park, CA, USA); Gupta, Y.M.; Florence, A.L. *Mech Mater* v 6 n 2 Jun 1987 p 113-125.

**091367 SIMILARITY OF DISPLACEMENT-TIME RELATIONSHIPS BETWEEN LABORATORY AND FIELD MEASUREMENTS OF PROGRESSIVE SLOPE FAILURES.** Behavior patterns for movement of blocks with a rock slope, prior to the eventual failure, were studied using rigid physical models and employing a specially designed base-friction table with an inclinable base. Results indicate that a power law exists between elapsed time and the resultant cumulative horizontal displacement of the slope blocks, in the form of  $\log U = m \log (t/t_1)$  or  $U = (t/t_1)^m$ , where  $U$  = cumulative horizontal displacement of the slope blocks,  $t$  = elapsed time since measurement commenced,  $t_1$  = time intercept value and  $m$  = time exponent (i.e. slope of the straight line obtained). Additional results from the laboratory model studies are discussed. The influence of different slope block configurations on the behavior patterns for progressive movements of slope blocks is also discussed with respect to their resultant failure modes. (Edited author abstract) 15 refs.

Teme, S. Clifford (Univ of Ibadan, Ibadan, Nigeria). *Eng Geol* v 25 n 1 Feb 1988 p 83-99.

**091368 CONTROL PERFORMANCE OF SERVO-CONTROLLED TESTING MACHINES.** Optimizing the control of failure process of rock under uniaxial compression testing using a linear combination of stress and strain as the control variable model analysis of servo-controlled testing machine was conducted in this study. At first stage, supposing a linear rock model, the

characteristic polynomial of the machine-rock system was obtained and examined to reduce; The control performance is influenced by the relaxation time of rock, the slope of stress-strain curve and the response time (natural frequency) of testing machine. The relaxation time is found to be a function of control speed so that the control performance is greatly influenced by the control speed. The computer simulation was conducted using a non-linear visco-elastic rock model which was recently proposed by authors. The calculated results were compared with the experimental results. It was found that the non-linear simulation model is suitable, and main results of simulation are summarized in a diagram for quick reference. (Author abstract) 9 refs. In Japanese.

Okubo, Seisuke (Univ of Tokyo, Jpn); Fukui, Katsunori; Nishimatsu, Yuichi. *Nippon Kogyo Kaishi* v 104 n 1200 Feb 1988 p 63-67.

**091369 BURST ENERGY RELEASE INDEX.** The rockburst is a sudden manifestation of the release of strain energy stored in the rock mass. Three possible sources for the liberated energy are: stored strain energy in the surrounding mass; change in the potential energy of the rock mass; and minor slippage along rock contacts. This paper reports on a study that focuses on the rock's capacity to store and release elastic strain energy. The purpose of this study was to search for a parameter, which represents the energy released at the time of rock fracture and which can be used as a relative measure of the burst proneness of rocks. The study was conducted on rocks from 'Sudbury Nickel Belt' in Canada. The parameter that was found, the 'Burst Energy Release Index', is described. (Author abstract). 9 refs.

Singh, S.P. (Laurentian Univ, Sudbury, Ont, Can). *Rock Mech Rock Eng* v 21 n 2 Apr-Jun 1988 p 149-155.

**Filters** See SEWAGE TREATMENT—Trickling Filtration.

**Fracture** See Also FLOW OF FLUIDS—Simulation; FLOW OF WATER—Mathematical Models; GAS DYNAMICS; GEOLOGY—Engineering; GEOLOGY—Tectonics; GEOPHYSICS—Bibliographies; GEOPHYSICS—Rock Properties; LEAD ZINC DEPOSITS; PETROLEUM GEOLOGY; POROUS MATERIALS—Permeability, Mechanical; RADIOACTIVE WASTES—Disposal; ROCK DRILLING; ROCK MECHANICS—In Situ.

**091370 KINETIC APPROACH TO THE FRACTURING OF ROCKS.** There are grounds to believe that the properties of rocks observed in quasistatic loading also characterize the behavior of rocks under dynamic loads. In this case, however, additional hypotheses have to be introduced based on an intuitive notion of the process of fracturing. Two approaches to the theory of fracturing of rocks during dynamic loading have been suggested: in one the transition of the medium from intact to fractured state occurs as a jump on the failure front (instantaneous brittle failure); in the other, the behavior of the medium during fracturing is described by a model of a hardening elastoplastic body ('gradual' failure). The present paper suggests a different approach to the description of the fracturing process. (Author abstract) 15 refs.

Glushko, A.I.; Neshcheretov, I.I. *Mech Solids* v 21 n 6 1986 p 133-139.

**091371 ON THE MODEL OF BRITTLE FRACTURE OF ROCK.** We analyze the instantaneous-fracture model with a 'force' fracture criterion in the complex stressed state under conditions of plane strain. We demonstrate that, within the confines of this model, the problem of disintegration of an arbitrary discontinuity is incorrectly posed, and therefore the model cannot be employed to solve the problem of fracture in the complex stressed state. Models of gradual fracture will not be considered. (Author abstract) 10 refs.

Glushko, A.I. *Mech Solids* v 22 n 2 1987 p 154-158.



**091372 SUBSURFACE FRACTURE SURVEYS USING A BOREHOLE TELEVISION CAMERA AND ACOUSTIC TELEVIEWER.** In the television survey, a camera probe is used to inspect the borehole walls. Measurements of location, orientation, infilling width, and aperture of fractures are made on the television screen and recorded on computer data record sheets. All observations are recorded on video cassette tapes. With the acoustic televiewer, oriented images of fractures in the borehole walls are recorded on a strip-chart log and also on video cassette tapes. The images are displayed as if the walls were split vertically along magnetic north and spread out horizontally. Measurements of fracture characteristics are made on the strip-chart log, using a digitizing table and a microcomputer, and the data recorded on floppy diskettes. Computer analysis of the fracture data, provides a rapid assessment of fracture occurrence, fracture aperture, and statistically significant concentrations of fracture orientations. (Edited author abstract) 15 refs.

Lau, J.S.O. (AECL, Pinawa, Manit, Can); Auger, L.F.; Bisson, J.G. *Can Geotech J* v 24 n 4 Nov 1987 p 499-508.

**091373 FRACTOGRAPHIC DETERMINATION OF JOINT LENGTH DISTRIBUTION IN CHALK.** Measurements of fracture joint distribution combined with determination of plume length and orientation on a vertical section of a single chalk layer near Beer Sheva, Israel, reveal that joints marked by unilateral and circular plumes are skewed towards the shorter sizes while joints decorated by bilateral plumes are skewed towards the longer sizes. The mean lengths of the unilateral and bilateral joints are 66.5 cm and 155.6 cm, with standard deviations of 30 cm and 60.6 cm, respectively. These results as well as joint length observations from other areas seem to suggest a bimodal length distribution. However, since the minor maximum is generally very weak, and due to some additional uncertainties, further confirmation of the present observations is needed. (Author abstract) 18 refs.

Bahat, Dov (Ben Gurion Univ of the Negev, Beer Sheva, Isr). *Rock Mech Rock Eng* v 21 n 1 Jan-Mar 1988 p 79-94.

**091374 LEACHING OF ROCK FRACTURES: LABORATORY AND FIELD TESTS FOR BOREHOLE HEAT STORES.** The aim of the project was to increase the hydraulic conductivity of fractured rock by pumping a leaching fluid (NaOH) through rock fractures. This field test was carried out in a borehole heat store, consisting of 19 vertical boreholes to a depth of 15 m in gneissic rock. The leaching process was studied simultaneously in a laboratory test where rock samples from core drillings of the test site were used. The idea of the project, that a NaOH-solution would leach and thereby widen the fractures, was not fulfilled. On the contrary the fractures were sealed as the leaching test went on. The explanation to this is that the leaching rate was higher than expected, the leaching fluid was saturated and the dissolved minerals precipitated. The results of this project has demonstrated a way of sealing rock fractures which probably has many more applications in engineering geology. (Edited author abstract)

Nordell, Bo (Swedish Research Council for Building Research, Swed); Hallberg, Rolf O.; Sjöberg, Lennart. *Doc Swed Counc Build Res* D4 1988 43p.

**091375 ARTIFICIAL SUBSURFACE CRACKS AND GEOTHERMAL ENERGY.** Papers relating to artificial subsurface cracks are reviewed, with special attention given to the fracture mechanics approach to the design of the artificial subsurface heat-exchange systems used in geothermal heat extraction. This approach is compared with the classical approaches which have been employed in oil and/or gas well stimulation. A variety of methods for mapping the artificial, subsurface cracks are also reviewed since the development of the methods is one of the key themes involved in the design of subsurface cracks. The demonstrative field experiments of extracting heat from hot dry rocks are also surveyed, since they are the best practical examples. Finally, the basic concept for the design of artificial subsurface cracks is briefly de-

scribed following the successful results of the T-project at Tohoku University on geothermal heat extraction. (Author abstract) 183 refs.

Abe, Hiroyuki (Tohoku Univ, Sendai, Jpn); Hayashi, Kazuo. *JSME Int J Ser 1* v 31 n 1 Jan 1988 p 1-12.

**091376 DISCUSSION OF THE LENGTH LIMIT OF AN ARTIFICIAL GEOTHERMAL CRACK IN A HOT DRY ROCK ON THE BASIS OF THE TWO-DIMENSIONAL THEORY OF THERMOELASTICITY.** The theoretical analysis of propagation and closure of two-dimensional hydraulic fractures subject to the compressive tectonic stress of a linear gradient has been made by Secor and Pollard. They have found the existence of a length limit for these hydraulic fractures. In their model, however, the rock in the earth's crust is assumed to be in an isothermal state. By developing Secor and Pollard's work, the present paper is concerned with the discussion of the length limit of an artificial geothermal crack in a hot dry rock with a linear temperature gradient. The rock is assumed to be homogeneous and isotropic with respect to thermal and elastic constants. By use of the singular point method, a set of nonlinear singular integral equations is derived. The results suggest that a very artificial geothermal crack could be created in a hot dry rock with a large temperature gradient. (Author abstract) 9 refs.

Sekine, Hideki (Tohoku Univ, Sendai, Jpn). *JSME Int J Ser 1* v 31 n 1 Jan 1988 p 27-31.

**091377 TECHNICAL NOTE MICROFRACTURE BENEATH BLUNT DISC CUTTERS IN ROCK.** A large number of investigations have been undertaken with both sharp and blunt disc cutters in order to determine optimum S/P (spacing/penetration) ratios. In this study a blunt disc cutter, based on a commercially available design, was tested in simulated array. Significant subsurface crack interaction and crater development were observed to occur up to a maximum S/P ratio of 40. 25 refs.

Howarth, D.F. (Univ of Queensland, St. Lucia, Aust); Bridge, E.J. *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 1 Feb 1988 p 35-38.

**091378 SUGGESTED METHODS FOR DETERMINING THE FRACTURE TOUGHNESS OF ROCK.** Two Suggested Methods for determining the fracture toughness of rock material in the form of core specimens are described. Method 1 uses a bend specimen with a notch cut perpendicular to the core axis. The specimen rests on two support rollers and a compressive load is applied to press apart the notch sides. This causes transverse splitting of the specimen by crack growth in the ligament. Method 2 uses a specimen, called the short rod, which has a notch cut parallel to the core axis. A tensile load is applied to the specimen to pull apart the notch sides. This causes lengthwise splitting of it by crack growth in the ligament of the notched section during the test. Sampling, test apparatus, procedures, measuring equipment, and other aspects of the subject are discussed. 71 refs.

Franklin, J.A. (Int Soc for Rock Mechanics, Lisbon, Port); Zongqi, Sun; Atkinson, B.K.; Meredith, P.G.; Rummel, F.; Mueller, W.; Nishimatsu, Y.; Takahashi, H.; Costin, L.S.; Ingraffea, A.R.; Bobrov, G.F. *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 2 Apr 1988 p 71-96.

## Freezing

**091379 SIMULTANEOUS MODELLING OF ROCK FREEZING AND WATER SEEPAGE AND ITS PRACTICAL APPLICATIONS.** A new integrated finite difference simulation technique has been developed to model rock freezing and water seepage simultaneously. The mathematical model, the base of numerical algorithm, the input and output data, the verification of the model using analytical solutions and a rather sophisticated practical case history are discussed in the paper. Finally, the system of freezing and on the proper combination with depressurization of water bearing layers is presented as well. (Edited author abstract) 8 refs.

Kesseru, Zsolt (Central Inst for Mining & Development, Budapest, Hung); Dusza, L.; Widder, A.; Mate, Cs. Kiss. *Int J Mine Water* v 6 n 1 Mar 1987 p 1-32.

## Heat Transfer

**091380 SELF-SIMILAR SOLUTION OF THE PROBLEM OF HEAT AND MOISTURE TRANSFER DURING THE THAWING OF FROZEN ROCKS.** A self-similar solution is obtained in the problem of thawing of frozen soils, account being taken of moisture migration in both the thawed and the frozen zones. A comparison is made between this solution and the results of numerical modeling of this problem in a formulation without a front, as well as experimental data regarding the distribution of the total moisture content in a specimen after its one-sided thawing. (Translated author abstract). In Russian. 5 refs.

Yanitskii, P.A. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 15 Aug 1987 p 116-122.

Heat Treatment See KILNS—Design.

## Heating

**091381 PLASMA METHOD OF ROCK BODY THAWING.** A new plasma method of thawing rock bodies is described. Results of experimental and analytical investigations of the propagation of heat during the thawing of rock bodies are presented. An electrical comparison between the currently used and the proposed methods for the thawing of soils under pile foundations is considered. (Translated author abstract) In Russian. 6 refs.

Zadvornev, G.A.; Yakunin, V.N.; Prokhorov, Yu.B. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 15 Aug 1987 p 112-115.

## Hydrology

**091382 METHODE HYDROCHIMIQUE POUR LOCALISER ET MESURER LES ECOULEMENTS NATURELS EN MILIEU FISSURE PEU PERMEABLE.** [Hydrochemical Method for Localizing and Measuring Natural Flows in a Fissured Medium Having Low Permeability]. The study of the variations of the chemical composition of water with depth and time in an uncased borehole in a fissured medium gives valuable information on the circulation between the borehole and the fissures it intersects. Some chemical substances may even be regarded as tracers and the rate of flow can be determined from singular points on the concentration/depth graphs at a given date. Assuming that solute transfer in the borehole column obeys an equation containing a dispersive and a convective term, the speed of forced convection in the borehole can be calculated from the series of concentration profiles, and the yields in the various fissures can be determined. This dual qualitative and quantitative aspect is examined in various types of terrain (granite, karst, orthogneiss). (Edited author abstract) 1 ref. In French.

Bidaux, P. (CNRS, Montpellier, Fr). *Hydrogeologie* n 3 1987 p 169-176.

**Igneous** See Also GEOLOGY—Nevada; GEOLOGY—Stratigraphy; GOLD DEPOSITS—Exploration; ORE DEPOSITS—Australia; RADIOACTIVE WASTES—Geological Repositories.

**091383 LONG-TERM STRENGTH OF PLUTONIC ROCK.** Models have been formulated to assess the extent of microcrack extension in a rock mass, in response to mechanical or thermal perturbations. These models require slow crack-extension data in the form:  $V = AK_1^n$  where  $V$  is slow crack-extension velocity,  $A$  and  $n$  are constants and  $K_1$  is the stress intensity factor in tensile-opening mode at the microcrack tip. The purpose of this note is to record pairs of  $A$ - and  $n$ -values for several plutonic rocks from the Canadian Shield. The  $A$  and  $n$  pairs were derived from time-to-failure data of rock beams



loaded in four-point bending. The A-values were derived from the n-values and from values of critical stress intensity for the rocks in question. 7 refs.

Wilkins, B.J.S. (AECL, Pinawa, Manit, Can). *Int J Rock Mech Min Sci Geomech Abstr* v 24 n 6 Dec 1987 p 379-380.

**091384 MIDDLE JURASSIC TO EARLY CRETACEOUS IGNEOUS ROCKS ALONG EASTERN NORTH AMERICAN CONTINENTAL MARGIN.** Late Middle Jurassic and Early Cretaceous mafic dikes, sills, flows, and local volcanoclastic sediments are intercalated within continental shelf sediments from the Baltimore Canyon Trough northward to the Grand Banks of Newfoundland. The igneous rocks on the eastern North American margin are mainly alkali basalts of intraplate affinity. The major phases of igneous activity are synchronous with major regional tectonic events, namely the initiation of rifting in the Labrador-Greenland region (140 Ma), separation of continental plates between Iberia and the Grand Banks (115 Ma), and separation of Labrador and Greenland continental plates (83-92 Ma). Most of the igneous activity occurred along old fracture zones. The co-occurrence of Middle Jurassic and Early Cretaceous volcanic activity on the continental slope off Georges Bank is evidence that a hot-spot process alone cannot explain the linear character and age trends within the New England Seamounts. Propagation of a fracture zone into oceanic crust more satisfactorily accounts for the age and distribution of the volcanism. With regard to oil exploration on the continental margin, care must be taken to properly identify igneous and volcanoclastic rocks on mechanical logs, drill cuttings and cores. (Edited author abstract) 80 refs.

Jansa, Lubomir F. (Geological Survey of Canada, Dartmouth, NS, Can); Pe-Piper, Georgia. *AAPG Bull* v 73 n 3 Mar 1988 p 347-366.

**Imaging Techniques** See PETROLEUM RESERVOIR ENGINEERING—Core Analysis.

**Magnetic Properties** See Also GEOLOGY—Coal.

**091385 MAGNETIC SUSCEPTIBILITY OF THE ROCK MATRIX RELATED TO MAGNETIC FABRIC STUDIES.** Non-ferromagnetic minerals constitute what is called the rock matrix, whose susceptibility ( $K_1$ ) is directly accessible using only high magnetic fields. Measurements on minerals and a wide range of rock types show that  $K_1$  is mainly due to paramagnetism and hardly exceeds  $10^{-3}$  SI, with an anisotropy degree (P) less than 1.35. Different methods to estimate the role of the matrix component in low-field susceptibility (K) and its anisotropy include petrological and chemical analysis, evolution of P vs K, low temperature studies and comparison of K with remanent magnetizations. (Author abstract) 32 refs.

Rochette, Pierre (Observatoire de Grenoble, St. Martin d'Heres, Fr). *J Struct Geol* v 9 n 8 1987 p 1015-1020.

**Mechanical Properties** See Also COAL DEPOSITS—Analysis; CONCRETE—Fracture; RADIOACTIVE WASTES—Geological Repositories.

**091386 ELASTIC/VISCOPLASTIC CONSTITUTIVE EQUATIONS FOR ROCK.** The experimental data needed for the formulation of a constitutive equation to describe the creep of rocks in uniaxial or triaxial tests are reviewed and the influence of loading rate on dilatancy is pointed out. The assumptions which have to be made in obtaining a constitutive equation from these experimental data are specified. A general constitutive equation is then formulated for rocks, which can describe their elastic and viscoplastic properties for any triaxial compressive stress state. Dilatancy and volumetric compressibility of rocks are defined in mathematical terms and so are the concepts of the compressibility/dilatancy boundary and that of damage. Various time-dependent effects which can be modeled with such a constitutive equation are illustrated. The peculiarities of the creep phenomenon as described by the model are discussed. (Edited author abstract) 46 refs.

Cristescu, N. (Univ of Bucharest, Bucharest, Rom). *Int J*

*Rock Mech Min Sci Geomech Abstr* v 24 n 5 Oct 1987 p 271-282.

**091387 CONSTITUTIVE MODEL AND ASSOCIATED TESTING FOR SOFT ROCK.** A general yet simplified constitutive model is proposed to characterize stress-deformation behavior of rocks. It is based on the theory of elastoplasticity and allows for factors such as hardening, volume changes, stress paths, cohesive and tensile strengths and variation of yield behavior with mean pressure. It is applied to characterize behavior of a soft rock, soapstone. The constants for the model are determined from a comprehensive series of laboratory tests under different initial confinements and stress paths by using a multiaxial testing device. The model is verified with respect to laboratory tests used for finding the constants and complex stress path tests are not used for finding the constants. (Edited author abstract) 32 refs.

Desai, C.S. (Univ of Arizona, Tucson, AZ, USA); Salami, M.R. *Int J Rock Mech Min Sci Geomech Abstr* v 24 n 5 Oct 1987 p 299-307.

**091388 FIELD METHOD FOR THE DETERMINATION OF ROCK-MASS MODULUS.** A field test for measuring rock modulus was developed and performed at the site of Darlington Generating Station in shaly limestone. The new method yields a value consistent with the rock-mass modulus evaluated from extensometer measurements in the tunnels. A complementary laboratory program to study the effect of specimen size on the elastic parameter was also performed by using compressional and shear wave velocity measurements. It was shown that beyond a threshold value of size, the Poisson's ratio increases, whereas both dynamic shear modulus and Young's modulus decrease with increasing volume of specimen towards the field value of static modulus. (Author abstract) 7 refs.

Lo, K.Y. (Univ of Western Ontario, London, Ont, Can); Yung, T.C.B.; Lukajic, B. *Can Geotech J* v 24 n 3 Aug 1987 p 406-413.

**091389 GENERAL RELATIONS BETWEEN STATIC AND DYNAMIC MODULI OF ROCKS.** The main objective of the present study was to establish the relation between static and dynamic moduli of a range of rock materials for stress levels up to 40 MPa using a reliable method to measure compressional and shear wave velocities. The methods used and the results obtained are presented and discussed in this paper. 10 refs.

van Heerden, W.L. (Nat'l Mechanical Engineering Research Inst, Pretoria, South Afr). *Int J Rock Mech Min Sci Geomech Abstr* v 24 n 6 Dec 1987 p 381-385.

**091390 DEFORMATION AND FRACTURING BEHAVIOR OF DISCONTINUOUS ROCK MASS AND DAMAGE MECHANICS THEORY.** The mechanical behavior of a rock mass is strongly affected by discontinuities such as faults and joints. In this paper, a damage mechanics theory is proposed which deals with some sets of discontinuities distributed in a rock mass, for example, joint systems. In this theory, the distributed discontinuities are characterized by a second-order symmetric tensor, called the damage tensor. By introducing the damage concept, the deformation and fracturing behavior of the rock mass can be treated in a framework of continuum mechanics. A numerical procedure is developed in order to implement the damage mechanics model by using the finite element method. The theory and numerical analysis are applied to several laboratory tests and a practical underground opening problem. Numerical results are compared with measured data. (Author abstract) 23 refs.

Kawamoto, Toshikazu (Nagoya Univ, Nagoya, Jpn); Ichikawa, Yasuaki; Kyoya, Takashi. *Int J Numer Anal Methods Geomech* v 12 n 1 Jan-Feb 1988 p 1-30.

**091391 EXPERIMENTAL STUDY OF STRESS WAVE TRANSMISSION AT A METALLIC-ROCK INTERFACE AND DYNAMIC TENSILE FAILURE OF SANDSTONE, LIMESTONE, AND GRANITE.** An experimental technique is described for determination

of dynamic tensile fracture strength of brittle solids. This technique has been used to determine the dynamic tensile fracture strength of several types of rock. The rocks studied were granite, limestone, and sandstone; the specimens were cored perpendicular to the bedding plane for these rocks. The quasi-static fracture strengths of the same solids were also determined for comparison with the dynamic strengths. The dynamic strengths have been found to be several times the quasi-static strengths, thus showing a strong dependence of fracture strength on strain rate. (Author abstract) 17 refs.

Khan, Akhtar S. (Univ of Oklahoma, Norman, OK, USA); Irani, Fersheed K. *Mech Mater* v 6 n 4 Dec 1987 p 285-292.

**091392 STRENGTH OF A REGULARLY JOINTED ROCK MASS UNDER BIAXIAL AND AXISYMMETRIC LOADING CONDITIONS.** The strength of a regularly jointed rock mass is directional. This character depends on the orientation of the joints with respect to the loading directions and the nature and anisotropy of the applied state of stress. Analytical solutions are proposed in this paper to describe the strength of a regularly jointed rock mass under the full range of states of stress that are likely to be encountered in situ with one or several stress components being tensile. The intact rock strength is described by E. Hoek and E.T. Brown criterion. The joints have no tensile strength and a shear strength described by a Coulomb criterion. Existing analytical models fail to fully take into account the influence of the intermediate stress and the orientation of the joints on the strength of a regularly jointed rock mass. The influence of these parameters is analyzed in this paper for a jointed rock mass under biaxial and axisymmetric loading conditions. 13 refs.

Amadei, B. (Univ of Colorado, Boulder, CO, USA). *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 1 Feb 1988 p 3-13.

**091393 ESTIMATION OF THE ENVELOPE OF MAXIMUM MOHR'S CIRCLES PREPARING THE STRENGTH TEST CERTIFICATE OF ROCKS.** Strength test certificates are the principal documents characterizing the strength properties of rocks. Essentially, these are reports of experimental tests of a specific strength theory. In estimating the strength of rocks, Mohr's theory and its modification are commonly used. There is a large number of equations for the envelopes of the maximum Mohr's circles derived mostly from experimental data by fitting of a curve (which is usually algebraic). The requirements for the envelopes are specified. Some of the envelopes covered include Coulomb-Mohr envelope, Ruppenet's envelope, and parabolic envelopes. 18 refs.

Manev, G.D. (Mining & Geological Inst, Sofia, Bulg); Andreev, G.E. *Sov Min Sci* v 23 n 1 Jan-Feb 1987 p 28-36.

**Metamorphic** See Also GEOCHEMISTRY—Natural Waters; GEOLOGY—Tectonics; SAND AND GRAVEL—Deformation.

**091394 ARCuate HINGE CLEAVAGE ASSOCIATED WITH WELDED CONTACTS: AN EXAMPLE.** Arcuate hinge cleavage (a.h.c.) shows a near bedding-parallel, concentric, arcuate development within the inner arcs of hinge zones. It is favored by alternating layers of marked viscosity contrasts with little layer-parallel shortening prior to parallel folding. A field example of a.h.c. from a greywacke/pelite sequence of the Variscan of Central Europe is presented. The a.h.c. is developed as a slaty cleavage in the inner-arc hinge zone of pelite beds close to and welded to the outer arc of greywacke layers. Microscopically it is defined by the alignment of platy minerals and oblate quartz grains. The a.h.c. ( $S_2$ ) is cut by a divergently fanning crenulation cleavage ( $S_3$ ) which, in turn, is cut by slip surfaces parallel to bedding. The slip surfaces are cut by a fracture cleavage which is the macroscopically observed axial surface cleavage ( $S_4$ ). This sequence of deformational increments implies the onset of



bedding slip after the formation of a.h.c. ( $S_2$  and  $S_3$ ). We therefore suspect inhibited bedding slip by welded contacts to favor the development of a.h.c. (Author abstract) 21 refs.

Eichentopf, H. (Ruhr-Univ Bochum, Bochum, West Ger); Greiling, R.O. *J Struct Geol* v 9 n 7 1987 p 905-910.

**091395 DEFORMATION VOLUME AND CLEAVAGE DEVELOPMENT IN METASEDIMENTARY ROCKS FROM THE BALLARAT SLATE-BELT.** Pssammites from the Ballarat slate belt in SE Australia exhibit well-developed differentiated or spaced cleavage defined by alternating phyllosilicate- and quartz-rich domains (termed P- and Q-domains, respectively). Strain estimates derived from independent microstructural and chemical observations suggest that the P-Q fabrics developed in response to plane-strain deformation dominated by solution transfer with the principle finite shortening in the P-domains approximately twice that in the adjacent Q-domains. Significant finite extensions are indicated by ubiquitous quartz-albite-chlorite overgrowths in both P- and Q-domains, while pressure-shadow development around syntectonic pyrite porphyroblasts suggest finite extension of at least 100%. This estimate is comparable with the extension predicted for constant-volume deformation and consequently there appears to have been no significant bulk materials loss or gain on the hand-specimen scale. Additional aspect of the subject are discussed. (Edited author abstract) 40 refs.

Waldron, Helen M. (Univ of Melbourne, Parkville, Aust); Sandiford, Michael. *J Struct Geol* v 10 n 1 1988 p 53-62.

**091396 SHEAR CRITERIA IN GRANITE AND MIGMATITE DEFORMED IN THE MAGMATIC AND SOLID STATES.** This study is a by-product of the detailed structural and microstructural investigation of a high-grade metamorphic rock pile (Variscan Vosges Massif, France) which underwent subhorizontal shearing during partial melting and further solidification. Depending on the rock chemistry, on the position in the pile and the relative timing of progressive deformation, layered migmatites and homogeneous granites were variously deformed in the partially melted and solid states. The sense of shear obtained from these rock types, using the criteria presented here, consistently gives a top to SW direction. (Edited author abstract) 37 refs.

Blumenfeld, Philippe (CNRS, Vandoeuvre les Nancy, Fr); Bouchez, Jean-Luc. *J Struct Geol* v 10 n 4 1988 p 361-372.

**Microscopic Examination** See PETROLEUM RESERVOIR ENGINEERING—Core Analysis.

**Microstructure** See Also SOLIDS—Degradation.

**091397 ANTITAXIAL CRACK-SEAL VEIN MICROSTRUCTURES AND THEIR RELATIONSHIP TO DISPLACEMENT PATHS.** The microstructures developed in an example of a syntectonic crack-seal vein indicate that antitaxial fibers do not necessarily track the incremental opening history during crack-seal vein growth. This observation serves as a caution against the uncritical use of fibrous microstructures to make inferences about displacement histories during fiber formation. It is demonstrated that crack-seal processes can lead to the development of both irregular and laminated vein microstructures, as well as fibrous microstructures. The types of microstructures which develop in crack-seal veins, and the extent to which they reflect the opening paths of veins depend on a range of factors. The most important of these include the nucleation and growth kinetics of phases precipitated from fluids in opening fractures, and the location of sites of material accretion during successive crack-seal increments. (Author abstract) 21 refs.

Cox, Stephen F. (Australian Natl Univ, Canberra, Aust). *J Struct Geol* v 9 n 7 1987 p 779-787.

**091398 PREFERRED ORIENTATION OF PHYLLOSILICATES IN PHYLLOMITES AND ULTRAMylonites.** X-ray texture goniometry operated in the transmission mode has been applied to fine-grained,

phyllosilicate-rich SC-mylonites. Basal planes (001) phyllosilicate pole-figures depart in two respects from orthorhombic symmetry. Optical microscopy reveals S- and C-surfaces and sets of shear bands (SB) characteristic of non-coaxial deformation. The pole figures are used for two purposes. (a) The first is strain estimation after the March model by imposing orthorhombic symmetry. The resulting March strains are more or less the same in all Californian samples. This is interpreted as evidence for a 'steady state foliation'. (b) The second is shear sense determination. It is demonstrated that consistently asymmetric preferred orientations reflect structures which are typical of non-coaxial deformation. Study conclusions are discussed. (Edited author abstract) 35 refs.

O'Brien, David K. (Univ of California, Berkeley, CA, USA); Wenk, H.-R.; Ratschbacher, Lothar; You, Zhen-dong. *J Struct Geol* v 9 n 5-6 1987 p 719-730.

**Models** See MATERIALS TESTING APPARATUS—Automation.

**Permeability**

**091399 TIME AND FREQUENCY RESPONSE OF TRACER EXPERIMENTS.** Two distinctly different approaches to the interpretation of advective and dispersive transport characteristics of an intermediate scale (0-6 m) tracer experiment are examined and compared. The first, or time domain method, is based on a direct analysis of the tracer breakthrough via the widely used moment method. The second, or frequency domain method, is based on a comparison of the Fourier transform of the tracer breakthrough and its theoretical counterpart, the frequency response function. Both methods provide satisfactory estimates of the mean advective transport component of the experiment for both conservative and nonconservative tracers. For the sampling ports closest to the source (0-2 m), the moment method produces much larger estimates of the dispersivity than the frequency response method. This difference is attributed to a buildup of errors in the estimation of higher moments, resulting from local variations in the tracer and fluid migration rates within this zone. The frequency domain approach is less sensitive to random variations in the breakthrough response. This idea is illustrated with an example from optimal filtering theory. (Edited author abstract) 15 refs.

Duffy, Christopher J. (Utah State Univ, Logan, UT, USA); Al-Hassan, Sumani. *J Hydrol* v 97 n 1-2 Jan 15 1988 p 59-73.

**091400 FIELD STUDY OF SEEPAGE AND MIGRATION PROCESSES IN FISSURED-POROUS ROCKS.** Problems of parametric substantiation of seepage and migration (mass transfer) models for heterogeneous fissured-porous rocks are considered. Principles of diagnosing the experimental curves of pumping tests are discussed and the role of factors distorting the results of their interpretation within the framework of simplified asymptotic schemes is assessed. Emphasis is placed upon the possibility of manifestation of nonlinear effects and on the specific features characterizing propagation of a hydrodynamic wave in semipervious clay strata with heterogeneous storage capacity and permeability. Practical recommendations for planning and interpreting tracer tests are given. The substantiation of tests is shown to require, in particular, exclusion of hydrochemical lag in hydrodispersion in fissures and the influence of regional flow. Since only a limited number of migration parameters can be studied by means of such tests, specialized regime observations are proposed as an alternative approach. (Edited author abstract) 12 refs.

Mironenko, V.A. (Mining Inst, Leningrad, USSR); Rumynin, V.G. *J Hydrol* v 97 n 1-2 Jan 15 1988 p 149-160.

**091401 EXPERIMENTAL MEASUREMENTS OF THE DIFFUSION PARAMETERS OF LIGHT HYDROCARBONS IN WATER-SATURATED SEDIMENTARY ROCKS - II. RESULTS AND GEOCHEMICAL SIGNIFICANCE.** Diffusion parameters (diffusion coefficient, diffusion permeability, solubility coefficient) for methane, ethane, propane, n-butane, me-

thylpropane and 2,2-dimethylpropane were measured on 21 samples of water-saturated sedimentary rocks at different temperatures (30, 50, and 70°C). The rock samples include sandstones, siltstones, and claystones with porosities ranging from 0.4 to 16.5 percent and permeabilities from < 0.005 to 33.4 millidarcy. Diffusion coefficients decrease with increasing molecular weight of the hydrocarbon compound, the decrease depending on the petrophysical properties and the mineralogy of the rocks and being most drastic in shales. None of the petrophysical parameters examined in this study (porosity, permeability, formation resistivity factor) gave a good correlation with the nonsteady-state diffusion coefficient, D. An excellent correlation was found between the formation resistivity factor, F, and the steady-state diffusion permeability, P. A possibly useful - though less significant - relation bearing some resemblance with Archie's law appears to exist between the porosity and the diffusion permeability. (Edited author abstract) 35 Refs.

Krooss, B.M. (Inst of Petroleum & Organic Geochemistry, Juelich, West Ger); Leythaeuser, D. *Org Geochem* v 12 n 2 1988 p 91-108.

**Permeability, Mechanical** See Also SOILS—Permeability, Mechanical.

**091402 USE OF PERMEABILITY AS AN INDEX TO CHARACTERIZE INTERNAL STRUCTURAL CHANGES AND FRACTURE MECHANISM.** This study investigated the possibility of using variation in the permeability as an index to characterize internal structural changes and fracture mechanism of a soft rock under triaxial loadings. Extensive triaxial tests were carried out on soft rock specimens to examine this idea. These tests include (1) triaxial compression tests with low and high confining pressures, (2) triaxial tests with relaxations, and (3) cyclic triaxial tests. The results of the study confirm that observation of change in the permeability provides an excellent way of characterizing the internal structural changes and fracture mechanism of the soft rock under triaxial loadings. (Author abstract) 8 refs.

Lee, Der H. (Nat'l Cheng Kung Univ, Tainan, China); Juang, C. Hsein. *Geotech Test J* v 11 n 1 Mar 1988 p 63-67.

**Phase Diagrams**

**091403 GEO-CALC: SOFTWARE PACKAGE FOR CALCULATION AND DISPLAY OF PRESSURE-TEMPERATURE-COMPOSITION PHASE DIAGRAMS USING AN IBM OR COMPATIBLE PERSONAL COMPUTER.** Geo-Calc's general program flow consists of calculation of reaction coefficients among phases in the selected chemical systems, computation of the equilibrium position for each reaction curve whereas each point on the curve is tested for metastability against all other phases, elimination of metastable extensions and of reactions that involve metastable assemblages, and plotting of all resulting curves with labels identifying the stable assemblages. Other programs in the Geo-Calc package display the phase diagram on the screen (CGA, EGA, or HERCULES graphics adapters), print it on an Epson or compatible dot-matrix printer at the resolution of the printer and improve diagram legibility by moving the labels or replacing them automatically with numbers so reaction identifiers do not overlap. Geo-Calc is distributed with a recommended thermodynamic database, but a variety of equations of state are provided so that the programs can be used with different data sets. Run time options include selecting the type of diagram, selecting the chemical system, setting the P-T-X limits of the diagram, selecting ideal or nonideal H<sub>2</sub>O-CO<sub>2</sub> mixing and specifying whether phases are to be projected from, included in all reactions, or have a fixed activity other than unity. (Edited author abstract) 16 Refs.

Brown, Thomas H. (Univ of British Columbia, Vancouver, BC, Can); Berman, Robert G.; Perkins, Ernest H. *Comput Geosci* v 14 n 3 1988 p 279-289.



**Physical Properties** See Also EMBANKMENTS—Deformation; GEOPHYSICS—Instruments; OIL WELL DRILLING—Stresses.

**091404 SYNTHESIS OF HYDRAULIC PROPERTIES OF ROCKS WITH REFERENCE TO THE BASIN AND RANGE PROVINCE, SOUTHWESTERN UNITED STATES.** Hydraulic properties of rock types common in the Basin and Range province were synthesized. For material that is granular and well sorted consisting of particles of approximately the same size and uniformly packed, the intrinsic permeability is a function of the square of the median grain size. For granular well-sorted material with a broad range of grain sizes and argillaceous material, permeability may be an exponential function of the porosity. For fracture unweathered crystalline rock, the permeability is an exponential function of the porosity if the fracture density and geometry is uniform. Beneath the zone of weathering, the average bulk-rock intrinsic permeability decreases as depth increases, owing to overburden pressure. The most permeable rocks include fractured karstic carbonate rocks that have hydraulic-conductivity values ranging from  $10^{-1}$  to  $10^5$  meters per day, coarse-grained basin fill that has hydraulic conductivities from  $10^{-1}$  to  $10^3$  meters per day, and fractured basalt that has hydraulic-conductivity values as great as  $10^3$  meters per day. Additional study results are discussed. (Edited author abstract) 60 refs.

Bedinger, Marion S.; Langer, William H.; Reed, Joe E. *Geol Surv Water Supply Pap (US)* 2310 Dec 1986 p 35-43.

**091405 RESULTS OF PREDICTING THE PRODUCTION PROPERTIES OF STRIPPED ROCK FROM THE 'BEREZOVSKI-1' COAL PIT.** The problem of estimating the correspondence between assigned parameters for mining operations and the physico-mechanical properties of the stripped rock from individual sections of the first working of the pit has been addressed in studies conducted at the KATEK Scientific-Research Coal Institute. The angle of internal friction and the moisture content of the stripped rock, which determine the shear characteristics of the rock during bench excavation and terrace formation were assigned as basic estimable indicators. A regression analysis performed made it possible to ascertain the relationship between the moisture content of the rock, and the results of gamma-gamma core sampling. 1 ref.

Kavyrshin, A.V. (KATEK Scientific-Research Coal Inst, Krasnoyarsk, USSR); Chermenev, V.S. *Sov Min Sci* v 23 n 3 May-Jun 1987 p 242-244.

## Pore Pressure

**091406 EFFECT OF PORE PRESSURE ON THE CYCLIC FATIGUE CHARACTERISTICS OF WATER SATURATED ROCKS UNDER CONFINING PRESSURE.** In order to clarify the effect of pore pressure on cyclic fatigue characteristics of water saturated rocks under confining pressure, cyclic fatigue tests using 1 Hz sinusoidal wave of pulsating compressive stress were carried out under both confining pressure and pore pressure for Kimachi sandstone and Hirono sandy mudstone laying emphasis on endurance limit and the change of volumetric strain in cyclic fatigue process. Under the condition of constant pore pressure and constant confining pressure, endurance limit exists for both rocks. Pore pressure remarkably decreases both number of cycles to failure and endurance limit. Stress ratio corresponding to endurance limit increases with b value in equation (1), which means that the lower the stress ratio corresponding to endurance limit is, the more number of cycles is required to reach the endurance limit. Pore pressure promotes dilatancy in fatigue process of water saturated rocks, and lowers endurance limit and the number of cycles to failure. (Author abstract) 4 refs. In Japanese.

Kudo, Hiroyuki (Tohoku Univ, Jpn); Matsuki, Koji. *Nippon Gogyo Kaishi* v 104 n 1201 Mar 1988 p 157-161.

**Porosity** See Also FILTRATION—Theory; OIL WELL LOGGING; PETROLEUM RESERVOIR ENGINEERING; PHOSPHATES—Microstructure; SANDSTONE—Compaction.

**091407 PORE-THROAT SIZE CORRELATION FROM CAPILLARY PRESSURE CURVES.** Void spaces in porous media can be considered as three-dimensional networks consisting of bulges (pores) connected by constriction (throats). Computer simulations of drainage-imbibition processes show that the critical end points of wetting-phase and nonwetting-phase saturation, in drainage and imbibition respectively, and the form of simulated relative permeability curves all were significantly different for uncorrelated and correlated pore-throat models. Since these models were identical except for the arrangement of throats in relation to pores, the degree of pore-throat size correlation appears to be an important property influencing flow and fluid displacement. Examples of uncorrelated and correlated pore-throat structures in rocks are presented and it is shown that this property, although difficult to quantify by direct observation, can be evaluated from capillary pressure curves. (Author abstract) 19 refs.

Wardlaw, N.C. (Univ of Calgary, Calgary, Alberta, Can); Li, Y.; Forbes, D. *Transp Porous Media* v 2 n 6 Dec 1987 p 597-614.

**091408 SCALE EFFECT ON ROCK FISSURATION POROSITY.** The scale effect on rock fissuration porosity is analyzed by means of a structural conceptual schematic diagram designed for a reservoir of cubical blocks separated by clefts with constant openings. Two cases are considered: (1) either the blocks are compact (simple porosity due to clefts) or (2) the blocks are affected by fissuration porosity (in which case the system has double fissural porosity). This hexahedral schematization is consistent with what is often noted in tectonic fissuration. Porosities are calculated for increasing volumes whether they be spherical or cubic, and these porosities are expressed in relation to the average effective porosity of the aggregate. Representative porosities can probably be reached only for volumes in excess of  $10^6 \text{ m}^3$ , even in the best circumstances. (This is the representative elementary volume). For such volumes, an experimental approach seems difficult. The author concludes that research into this type of porosity should be carried out by statistical methods. 26 refs.

Drogue, C. (Univ des Sciences et Techniques, Montpellier, Fr). *Environ Geol Water Sci* v 11 n 2 Apr 1988 p 135-140.

**091409 STUDY ON THE ANALYSIS OF GROUND WITH DOUBLE POROSITY MODEL.** An idealized double porosity model is developed for the purpose of studying the coupled-effects of flow in porous blocks and fractures as well as solid displacement in saturated-unsaturated medium. Subsequently, Galerkin formulation is used for the finite element method to develop a new technique to investigate coupled hydraulic-mechanical behavior in the double porosity model reservoir. The verifications are performed in comparison with an analytical solution of one-dimensional consolidation problem and experimental results of unsteady flow in the sand box. Finally, a secondary compression is examined with this model, the environment of rock mass in Lugeon test is simulated, and two-dimensional consolidation problems in a saturated and saturated-unsaturated media are investigated with comparison with the single porosity model. (Author abstract). 19 Refs. In Japanese.

Ohnishi, Yuzo; Kobayashi, Akira; Shiota, Takuo. *Doboku Gakkai Rombun Hokokushu* v 9 n 6 Jun 1988 p 61-70.

## Pressure Effects

**091410 COMPUTER MODELS OF PRESSURE SHADOWS: A METHOD FOR STRAIN MEASUREMENT AND SHEAR-SENSE DETERMINATION.** In this paper a computer model of pressure-shadow growth is presented based on a principle of geometrical best fit between a rigid object and a deformable matrix. By

varying the parameters in the simulation, pressure shadows of different shapes can be generated and matched by trial-and-error with specific natural examples. Thus the method is able to give estimates of crystallization laws, finite strain and deformation path. Simulations carried out for a number of natural examples show that: (1) the pressure-shadow infilling material can be rigid or deformable and the direction of growth appears to be mostly 'displacement controlled'; (2) the finite strain is larger than what appears from the shape of the pressure shadow; and (3) the deformation path may be 'replayed' by the simulation. From the results of the simulations we emphasize the morphological characteristics of pressure-shadows which can be reliably used for shear-sense determination. (Author abstract) 38 refs.

Etchecopar, A. (Univ des Sciences et Techniques du Languedoc, Montpellier, Fr); Malavieille, J. *J Struct Geol* v 9 n 5-6 1987 p 667-677.

**Processing** See MINING MACHINERY—Performance.

**Pyrolysis** See Also PETROLEUM CHEMISTRY—Geochemistry.

**091411 HETEROATOMIC COMPOUNDS PRODUCED BY PYROLYSIS OF ASPHALTENES, COALS, AND SOURCE ROCKS.** In this paper it is proposed to expand our discussion on the organosulfur compounds as well as early results pertaining to the nature of nitrogen compounds produced from pyrolysis of various asphaltenes, coals, and kerogens and variations in the distributions of these compounds resulting from source and maturity differences. The major sulfur compounds produced by microscale pyrolysis include thiophene, benzothiophene, dibenzothiophene, benzonaphthothiophene, and various alkylated analogues. Major nitrogen-containing compounds have been tentatively identified as pyridine, quinoline, benzoquinoline, and alkylated analogues. (Edited author abstract) 16 refs.

Philp, R.P. (Univ of Oklahoma, Norman, OK, USA); Bakel, A. *Energy Fuels* v 2 n 1 Jan-Feb 1988 p 59-64.

## Radioactivation Analysis

**091412 ALPHA-PARTICLE ACTIVATION ANALYSIS OF TRACES OF NIOBIUM IN GEOLOGICAL MATERIALS.** The effectiveness of alpha activation for the analysis of traces of niobium in geological material, namely, phosphate rocks, has been demonstrated. The niobium was first pre-concentrated in a solid matrix,  $\text{Al}_2\text{O}_3$  and then irradiated with a 40 MeV alpha beam having an intensity in the range of approximately  $1-3 \mu\text{A}$  at the Variable Energy Cyclotron, Calcutta, under specific experimental conditions. Radionuclides formed by the nuclear reactions ( $\alpha, n$ ), ( $\alpha, 2n$ ), ( $\alpha, 3n$ ) and also ( $\alpha, \alpha n$ ) on niobium were detected. Niobium contents in the experimental phosphate rock samples vary from approximately 6-15 ppm. (Author abstract) 15 refs.

Das, N.R. (Saha Inst of Nuclear Physics, Calcutta, India); Basu, D.; Bhattacharyya, S.N. *Appl Radiat Isot* v 38 n 11 1987 p 939-942.

**Radioactivity** See GEOLOGY—Dating.

**Sampling** See Also MASONRY MATERIALS—Corrosion.

**091413 METHOD FOR EVALUATING THE REPRESENTATIVE ELEMENTARY VOLUME BASED ON JOINT SURVEY OF ROCK MASSES.** The representative elementary volume of a statistically homogeneous rock mass is defined as the minimum volume beyond which any submass behaves essentially like the whole rock mass. A simple, but still general, method for the determination of the minimum volume is given on the basis of the crack tensor concept; it is concluded that the size must be at least three times larger than a typical length of joint trace. (Author abstract). 19 Refs.

Oda, Masanobu (Saitama Univ, Urawa, Jpn). *Can Geotech J* v 25 n 3 Aug 1988 p 440-447.



**Sedimentary** See Also COAL—Petrography; EARTH BORING MACHINES; GEOLOGY—Tectonics; LEAD ZINC DEPOSITS—Ireland; MINERALOGY—Analytical Methods; PETROLEUM GEOLOGY; PETROLEUM GEOLOGY—Sedimentology.

**091414 MICROGEOMETRY AND TRANSPORT PROPERTIES OF SEDIMENTARY ROCK.** This monograph describes recent progress in modelling the transport properties of sedimentary rock. Statistical descriptions are applied to the pore-space geometry and to the transport processes involving pore fluids. Fractals are used to quantify the pore geometry at length scales shorter than grain size. Percolation theory is applied to fluid flow. The permeability can be expressed in terms of a single effective pore diameter measured from mercury injection capillary pressure. This permeability relation is valid for essentially all porous rock and for a broad class of porous media. Mercury injection provides a powerful caliper of the geometry of a percolation cluster in a pore-space and supplies new information about pore space correlations and dynamics of fluid displacements. The statistical description of fluid transport in porous media has analogues in disordered electronic and magnetic materials. Future work may make substantial use of such analogues to solve more complex problems of direct relevance to petroleum exploration and production. (Author abstract) 150 refs.

Thompson, A.H. (Exxon Production Research Co, Houston, TX, USA); Katz, A.J.; Krohn, C.E. *Adv Phys* v 36 n 5 Sep-Oct 1987 p 625-694.

**091415 QUANTITATIVE DETERMINATION OF CALCIUM CARBONATE IN SEDIMENTS.** A simple method to determine the calcium carbonate content of sediments by direct weight losses due to releases of carbon dioxide during the reaction between samples and diluted hydrochloric acid (HCl) was adopted in the petrographic laboratory of the Bureau of Reclamation in Sacramento, CA. Because Mg-carbonate is poorly soluble in old HCl, and other carbonates in sediments are relatively rare, the loss of CO<sub>2</sub> will be caused by the decomposition of Ca-carbonate. Reproducibility of results was very good as well as the comparison of the results with more sophisticated testing, including Atomic Absorption determinations of calcium. 1 ref.

Prokopovich, Nikola P. (Bur of Reclamation, Sacramento, CA, USA). *Bull Assoc Eng Geol* v 24 n 4 Nov 1987 p 562-563.

**091416 SWELLING BEHAVIOUR OF PELITIC ROCKS - EXPERIMENTAL INVESTIGATIONS FOR ASSESSING THE INFLUENCE OF MINERALOGICAL AND SEDIMENTOLOGICAL FACTORS.** Numerous swelling-pressure measurements have been carried out on pelitic rocks of different composition over the past years. Mineralogical composition, grain size distribution and Atterberg values were established simultaneously. The results obtained indicated varying degrees of interdependence. It was noticed that specific mineralogical and geotechnical factors could be correlated in different ways with the swelling pressure established. The time element in the formation of expansion stresses also reflected previous loads to which the rock had been subjected in its geological past. Artificially produced rock cubes made of homogenized sample material were investigated too in order to permit the determination of swelling pressure with sediments not suitable for the production of standard cubes. The expansion stresses obtained by this method were all low ones. Study results are discussed. (Edited author abstract) 20 refs.

Schwaighofer, B. (Vienna Univ of Agriculture, Vienna, Austria); Mueller, H.W. *Appl Clay Sci* v 3 n 1 Jan 1988 p 85-98.

**091417 SEDIMENTARY PHOSPHATE ROCK IN ALBERTA AND SOUTHEASTERN BRITISH COLUMBIA: RESOURCE POTENTIAL, THE INDUSTRY, TECHNOLOGY AND RESEARCH NEEDS.** Approximately 2.0 million tonnes of phosphate rock is imported from the U.S. to Alberta annually and is used in the production of agricultural fertilizers. No phosphate rock is presently mined in Canada, although sources of

igneous phosphate have been mined in the past. Sedimentary phosphate rock is found in nine geological units within the Cordilleran Foothills and Front Ranges region of Alberta. The Devonian-Mississippian Exshaw Formation, Permo-Pennsylvanian Rocky Mountain Supergroup, and the Jurassic Fernie Formation have the best potential for future development. Most of the phosphate rock in Alberta is of low grade and lies within restricted land use areas. The best over-all resource potential lies in the Fernie basin area of southeastern British Columbia, in the Fernie Formation. The possibility of deep phosphate rock deposits in the plains region should be examined. U.S. supplies of phosphate rock are secure until the year 2000; however, by this time, the richer deposits in the U.S. may be exhausted. Alternate deposits, such as the ones in Alberta and British Columbia, might then be considered. (Edited author abstract)

MacDonald, D.E. (Alberta Research Council, Can). *CIM Bull* v 81 n 913 May 1988 p 46-52.

**091418 UTILIZAREA SPECTROSCOPIEI RES LA DETECTAREA SI CARACTERIZAREA KEROGENULUI D'N DETRITUS.** [Utilization of RES Spectroscopy for Detecting and Characterization of Kerogen In Detritus, J. The possibility for the evaluation of oil potential of sedimentary rocks by detecting the kerogen in the electronic resonance spectrum, directly registered on detritus samples, is analysed. The existent paramagnetic species in the mineral matrix as well as those resulting from the contamination of the equipment and drilling fluid are emphasized. (Edited author abstract) 29 refs. In Romanian.

Meghea, A. (Inst Politehnic, Bucharest, Rom). *Mine Pet Gaze* v 39 n 3 Mar 1988 p 148-156.

**091419 GEOCHEMISTRY OF MAIN STRUCTURAL BONDS BETWEEN MINERALS IN ARGILLACEOUS ROCKS OF THE LOWER CRETACEOUS.** Pelitic sediments of the Lower Cretaceous in northwest Germany with a wide spread range in the contents of various clay minerals and carbonates were tested by using water and certain solutions. The aim was to investigate the kind and stability of the main structural bonds between minerals. Common investigations show the physicochemical properties of rocks to depend mainly on their grain size distribution, their mineralogical composition, texture and microtexture, their contents of finely dispersed humic material and their natural water contents. More detailed investigations carried out here proved that also other parameters are necessary to describe the geochemistry of the structural bonds in a better way. The stability of clayey to marly rocks against the disaggregation by water and certain solutions depends mainly on the total cation exchange capacity. Additional study results are discussed. 8 refs.

Mederer, Joseph (Niedersaechsisches Landesamt fuer Bodenforschung, Hannover, West Ger). *Appl Clay Sci* v 3 n 2 May 1988 p 135-144.

**091420 CHARACTERISTICS AND ORIGIN OF FRACTURE-HOSTED IMPSONITE, QUEBEC CITY AREA, CANADA.** Allochthonous Cambro-Ordovician sedimentary strata from the Quebec City area contain fracture-coatings and fracture-fillings of solid organic matter, ranging up to several centimeters in thickness. This material was apparently emplaced epigenetically as a viscous fluid but now occurs as soft, black solid having a brittle, conchoidal fracture. Small euhedral quartz crystals, generally less than 10 mm in length, occur in open fractures throughout the study area and commonly contain angular solid inclusions of impsonite. Doubly terminated crystals have been found completely encased in impsonite, suggesting that both materials formed simultaneously. The evidence suggests that the fracture-filling impsonite is the solid residue of a petroleum mixture that was at one time comprised of a number of immiscible phases, including at least two aromatic-rich liquids, a gas or supercritical vapor, tiny dispersed fragments of proto-impsonite, various other solid organic phases, and an aqueous phase containing dissolved silica. Crystallines of impsonite agglomerated to form a coherent mass, with

concomitant loss of the fluid phases. 4 refs.

Levine, Jeffrey Ross (Univ of Alabama, Tuscaloosa, AL, USA). *Org Geochem* v 11 n 5 1987, Sel of Pap from the 2nd Annu Meet of the Soc for Org Petrol, Houston, TX, USA, Nov 7-9 1985 p 425-426.

**Spectroscopic Analysis** See Also RARE EARTH ELEMENTS—X-Ray Analysis.

**091421 THERMOGRAVIMETRIC FOURIER TRANSFORM INFRARED SPECTROSCOPY (TG-FTIR) OF PETROLEUM SOURCE ROCKS. INITIAL RESULTS.** The first results of thermogravimetric Fourier transform infrared analysis (TG-FTIR), as applied to petroleum source rocks, are reported. Sample preparation and running time, roughly equivalent to those used for Rock Eval source rock pyrolysis analyses, are described. Initial results show that the TG-FTIR technique provides considerable additional geochemical information including the following: (a) Simultaneous T<sub>max</sub> values for thermal evolution of a number of constituents are obtained. (b) Data required for calculation of material balances of organic and inorganic sedimentary carbon, nitrogen, and sulfur are obtained. (c) Data for classification of sedimentary organic matter into kerogen types I, II, and III as well as data for classification according to depositional environment are obtained. (Edited author abstract) 28 refs.

Whelan, Jean K. (Woods Hole Oceanographic Inst, Woods Hole, MA, USA); Solomon, Peter R.; Deshpande, Girish V.; Carangelo, Robert M. *Energy Fuels* v 2 n 1 Jan-Feb 1988 p 65-73.

**Stability** See Also BLASTING—Control; ROCK MECHANICS.

**091422 APPLICATION OF THE DISTINCT ELEMENT METHOD FOR ANALYSIS OF TOPPLING OBSERVED ON A FISSURED ROCK SLOPE.** The Distinct Element Method (DEM) is one of the most suitable analytical methods for examining the stability of fissured rock slopes which are separated into many blocks with open joints. Although P.A. Cundall et al., G. Hocking and M.D. Voegele suggested with the results of their numerical analyses that DEM can be applied to the analysis of toppling of fissured rock slopes, the application of DEM to an actual case has not yet been reported. In this note, the authors describe observed toppling of a fissured rock slope and compare this to the results of DEM analysis on the phenomenon. 9 refs.

Ishida, T. (Central Research Inst of Electric Power Industry, Abiko, Jpn); Chigira, M.; Hibino, S. *Rock Mech Rock Eng* v 20 n 4 Oct-Dec 1987 p 277-283.

**091423 STABILITY ANALYSIS AND DESIGN FOR VERTICAL ROCK, SURFACE REINFORCED BY SHOTCRETE.** A principle is presented in this paper to construct a vertical rock surface bearing system reinforced by shotcrete technique. Mohr-Coulomb criterion is utilized to develop the method for analyzing the stability of vertical rock surface under loading. According to the models of sliding wedge, formulas and design procedure for vertical rock surface reinforced by shotcrete are mentioned here. (Edited author abstract) In Chinese. 4 refs.

Lu, Menglue (Guangxi Metallurgical Design Inst, China). *Tumu Gongcheng Xuebao* v 21 n 1 Feb 1988 p 64-74.

**091424 STABILIZATION WITH ROCK ANCHORS OF TWO CUTTINGS ON NATIONAL ROUTE N13.** During the construction of a section of National Route N13 (Johannesburg Southern Bypass) two large cuttings were excavated. The first, in andesite lava, was adjacent to a Rand Water Board pipeline and the second, in quartzites, adjoined private dwellings. The cuttings were restrained with stressed anchors and unstressed dowels and the exposed faces were protected by concrete panels. The geotechnical design of the lateral support in the andesite was problematic, owing to the



unpredictable variations in rock weathering. By contrast, the quartzite cutting was uniformly weathered, with consistent patterns of jointing, and design problems were concerned mainly with the overlying transported soil. (Author abstract) 4 refs.

Brackley, I.J.A. (Steffen, Robertson & Kirsten); Williams, D.; Terbrugge, P.J. *Civ Eng S Afr* v 29 n 11 Nov 1987 p 434-450.

**Strain** See Also GEOLOGY—Sedimentology; GEOLOGY—Tectonics; PETROLEUM GEOLOGY—United States; ROCK MECHANICS.

**091425  $R_p/\phi_p$  STRAIN ANALYSIS USING AN ORIENTATION NET.** Since the classical work of E. Cloos, deformed distributions of elliptical objects such as ooids or pebbles have been recognized as an extremely important category of geological strain marker. However, elliptical objects are not easily analyzed, especially where primary sedimentary fabrics are tectonically imbricated. This paper demonstrates that previously published analytical techniques generally address only specific aspects of deformed ellipse distributions; as research tools, they are like a stereonet with great circles only or small circles only. All of the above methods can be combined with the aid of a new orientation net which is as convenient to use in the field as a standard stereonet. Uniform and imbricate fabrics are evaluated with equal ease and assumptions are subjected to statistical testing. (Author abstract). 59 Refs.

DePaor, Declan G. (Johns Hopkins Univ, Baltimore, MD, USA). *J Struct Geol* v 10 n 4 1988 p 323-333.

**091426 STRAIN ANALYSIS IN ROCKS WITH PRETECTONIC FABRICS: DISCUSSION.** J. Wheeler presents an algebraic solution to the determination of strain in rocks with a pre-tectonic fabric. The discussion authors feel that Wheeler's contribution could be clarified by some further observations. Their purpose is to illustrate the problem plaguing two- vs three-dimensional fabric data. To do this, the analysis goes back to the basic assumptions behind fabric analysis to study deformation paths, pebble fabrics, envelope surfaces, and other aspects of the subject.

De Paor, D.G. (Johns Hopkins Univ, Baltimore, MD, USA); Kusky, T.M. *J Struct Geol* v 10 n 5 1988 p 529-530.

**091427 STRAIN ANALYSIS IN ROCKS WITH PRETECTONIC FABRICS: REPLY.** The reply addresses the comments of D.G. De Paor and T.M. Kusky in this issue of the journal. In the first part of the discussion they emphasize correctly the 'path independence' of ellipse fabrics undergoing homogeneous strain, which is entirely in accord with the approach used by Wheeler. The subsequent discussion involves a misunderstanding of the physical meaning of the 'fabric ellipse/ellipsoid', which Wheeler discusses. 10 Refs.

Wheeler, John (Midland Valley Exploration, Glasgow, Scotl). *J Struct Geol* v 10 n 5 1988 p 531-532.

**Stresses** See Also COAL MINES AND MINING—Blasting; COAL MINES AND MINING—Stresses; GEOLOGY—Tectonics; ROCK MECHANICS.

**091428 ROCK STRESS MEASUREMENTS BY MEANS OF HYDRAULIC TESTS ON PRE-EXISTING FRACTURES AT GIDEA TEST SITE, SWEDEN.** This paper presents a summary of the theory, technique and the results from these measurements. Hydraulic tests on pre-existing fractures were conducted in a vertical borehole, in which hydraulic fracturing rock stress measurements had been conducted earlier, and the state of stress was determined at depths from 90 to 270 m. Two- and three-dimensional solutions of stress vs depth are presented, giving similar results, both in the magnitude and orientation of stresses. At depths between 100 and 150 m, the stress state is almost isotropic in a plane perpendicular to the borehole axis. A rotation of the maximum horizontal stress with depth was found. (Edited author abstract) 8 refs.

Ljunggren, C. (Lulea Univ of Technology, Lulea, Swed);

Raillard, G. *Int J Rock Mech Min Sci Geomech Abstr* v 24 n 6 Dec 1987 p 339-345.

**091429 GRAVITY-INDUCED STRESSES IN STRATIFIED ROCK MASSES.** This paper presents closed-form solutions for the stress field induced by gravity in anisotropic and stratified rock masses. These rocks are assumed to be laterally restrained. The rock mass consists of finite mechanical units, each unit being modeled as a homogeneous, transversely isotropic or isotropic linearly elastic material. The following results are found. The nature of the gravity induced stress field in a stratified rock mass depends on the elastic properties of each rock unit and how these properties vary with depth. It is thermodynamically admissible for the induced horizontal stress component in a given stratified rock mass to exceed the vertical stress component in certain units and to be smaller in other units; this is not possible for the classical unstratified isotropic solution. Examples are presented to explore the nature of the gravity induced stress field in stratified rock masses. (Edited author abstract) 20 refs.

Amadei, Bernard (Univ of Colorado, Boulder, CO, USA); Swolfs, Henri S.; Savage, William Z. *Rock Mech Rock Eng* v 21 n 1 Jan-Mar 1988 p 1-20.

**091430 MICROSTRUCTURAL SHEAR CRITERIA ASSOCIATED WITH GRAIN-BOUNDARY SLIDING DURING DUCTILE DEFORMATION.** Experimental studies on rock analogies are described which establish that certain microstructures (diamond grain structures, tabular grain structures and asymmetric grain-boundary bulges) can be used to determine (i) if deformation was coaxial or non-coaxial and (ii) the sense of shear in zones of non-coaxial deformation. Mechanisms for the development of the structures are described which involve the linked operation of grain-boundary sliding and migration. (Author abstract) 29 refs.

Drury, M.R. (Rijksuniversiteit Utrecht, Utrecht, Neth); Humphreys, F.J. *J Struct Geol* v 10 n 1 1988 p 83-89.

**091431 INFLUENCE OF NEARBY FRACTURES ON STRESS MEASUREMENTS BY HYDRAULIC FRACTURING.** The interaction between a vertical borehole and a nearby vertical fracture is modeled by an infinite plane containing a circular hole and a crack. Analytical expressions for the stress field are obtained in terms of integral equations. Numerical results show how the stress distribution at the borehole is affected by fracture length (L), fracture-borehole separation (d), and the offset (l) of the crack centre from the minimum distance to the borehole. The crack offset can have a much stronger effect on the locations of the local minimum tangential stress at the hole boundary than the crack length and the fracture-borehole separation. The model is applied to stress measurements in a deep borehole in Northern Illinois granite. (Edited author abstract) 19 refs.

Wu, M. (Univ of Wisconsin-Madison, Madison, WI, USA); Wang, H.F. *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 1 Feb 1988 p 15-23.

**091432 USE OF ASYMMETRIC PRESSURE SHADOWS IN MYLONITES TO DETERMINE THE SENSE OF SHEAR.** Asymmetric pressure shadows (APS) on both sides of a rigid porphyroclast are commonly observed in mylonites along the Median Tectonic Line (MTL) in Japan. Based on the shape analysis of APS in XZ section (parallel to the mylonitic lineation and normal to the mylonitic foliation), the following results were obtained: (1) the relative position of the APS with respect to a porphyroclast is not a reliable criterion for deducing the sense of shear; and (2) the drag angle ( $\beta$ ) of the shadow boundaries with respect to the mylonitic foliation in each quartered domain is diagnostic of the sense of shear; when the shearing is sinistral,  $\beta$  in upper right- and lower left-hand side of a porphyroclast is larger than  $\beta$  in upper left- and lower right-hand side, and vice versa for dextral shearing. These results demonstrate that the drag patterns of APS around porphyroclasts in mylonites are highly reliable indicators for the determination of the sense of shear. (Edited author abstract). 24

Refs.

Tagaki, Hideo (Waseda Univ, Tokyo, Jpn); Ito, Mayumi. *J Struct Geol* v 10 n 4 1988 p 347-360.

**Structure** See PETROLEUM GEOLOGY; SANDSTONE—Mechanical Properties.

**Temperature Measurement** See GEOLOGY—Computer Aided Analysis.

**Testing** See Also AQUIFERS—Measurements; RAILROAD PLANT AND STRUCTURES—Track; ROCK MECHANICS; SALTS—Creep; SHALE—Deformation; SOILS—Testing.

**091433 FRACTURE TOUGHNESS DETERMINATION OF LAYERED MATERIALS.** Layered materials, such as sedimentary rocks, are ubiquitous. A newly developed fracture toughness test specimen, which is semi-circular in shape and contains an edge-crack, is subjected to three-point-bend loading. The fracture load and the fracture energy of a layered rock are then measured with static tests, and the fracture toughness is determined using a stress intensity factor method, a compliance method and a J-integral based method. The results of all three methods agree satisfactorily showing that the fracture toughness determination using linear elastic fracture mechanics is valid for anisotropic rock materials. Specifically, the static fracture toughness of oil shale, which is a typical layered rock containing fossil fuel, was measured. (Edited author abstract) 39 refs.

Chong, Ken P. (Univ of Wyoming, USA); Kuruppu, Mahinda D.; Kuszmals, Joel S. *Eng Fract Mech* v 28 n 1 1987 p 43-54.

**091434 BLIND ZONES IN THE ACQUISITION OF DISCONTINUITY ORIENTATION DATA.** In practice, discontinuity orientations are measured in rock core samples or they are mapped from rock exposures. The resulting data are biased because of the blind zones associated with each borehole or mapping surface. Although this concept of bias has been recognized in geologic mapping for a number of years, a procedure is still needed for calculating the size of a blind zone. This technical note shows how to quantitatively define the sizes of blind zones from the expected precision of orientation measurements so that their effects on site exploration data can be anticipated. 5 refs.

Yow, J.L. Jr. (Lawrence Livermore Natl Lab, Livermore, CA, USA). *Int J Rock Mech Min Sci Geomech Abstr* v 24 n 5 Oct 1987 p 317-318.

**091435 EMPFEHLUNG NR. 12 DES ARBEITSKREISES 19 - VERSUCHSTECHNIK FELS - DER DEUTSCHEN GESELLSCHAFT FUER ERD- UND GRUNDBAU e.V. MEHRSTUFENTECHNIK BEI DREIAXIALEN DRUCKVERSUCHEN UND DIREKTEN SCHERVERSUCHEN.** [Recommendation No. 12 of Committee 19 - Rock Testing Technique - of the German Geotechnical Society. Multi-stage Technique for Triaxial Compression Tests and Direct Shear Tests]. The recommendation describes the multi-stage testing technique. This technique allows up to four single failure states to be obtained on only one specimen by changing the test boundary conditions after reaching a failure state. The technique is described for carrying out direct shear tests in situ and triaxial tests on large rock specimens. (Author abstract) In German.

Wichter, Lutz (Otto-Graf-Inst, Stuttgart, West Ger). *Bautechnik* v 64 n 11 Nov 1987 p 382-385.

**091436 GAUGED SLEEVE FOR CONTROLLED TESTING OF ROCK.** Electrical resistance strain gages, each 5 cm in length, were embedded at a depth of 1 mm, inside a Cil Monothane sleeve of thickness 2 mm. Cil Monothane A80 is a single component and non-toxic, heat-cure-pour polyurethane elastomer. It has sound elasto-plastic properties when cured. It was supplied by Compounding Ingredients Ltd, England. The strain gages



cover about 95% of the circumference of the sleeve. The position of the strain gages corresponds to the mid-height of the rock sample. 13 refs.

Hakami, H. (Lulea Univ of Technology, Lulea, Swed); Alm, O.; Stephansson, O. *Int J Rock Mech Min Sci Geomech Abstr* v 24 n 6 Dec 1987 p 375-378.

**091437 MONTE CARLO INVESTIGATION OF A PROPOSED SCREEN FOR NX-BOREHOLE JACK DATA.** F.E. Heuze has submitted a draft standard guide to the ASTM Subcommittee D18.12 on Rocks and Soils for using the NX-borehole ('Goodman') jack and calculating the in-situ deformation modulus of rock masses. One aspect of the proposed standard is a 'data screen' based on a full platen seating criterion. This article describes a computer simulation study that was performed to test the effect of the screen on the modulus estimate. The study demonstrates that the screen can actually degrade the quality of the estimate. It is concluded that the section of the proposed standard guide that deals with the screening of data should not be adopted. (Author abstract) 9 refs.

Axelrod, Michael C. (Lawrence Livermore Natl Lab, Livermore, CA, USA); Verrill, Steven P.; Patrick, Wes C.; Yow, Jesse L. Jr. *Geotech Test J* v 11 n 1 Mar 1988 p 20-29.

**091438 USE OF A ROTARY SHEAR BOX FOR TESTING THE SHEAR STRENGTH OF ROCK JOINTS.** This note describes a rotary shear machine, similar to those designed by A.W. Bishop, G.E. Green, K. Garga, A. Andresen & J.D. Brown and E.N. Bromhead, but suitable for testing rock surfaces, especially the shear strength of rock surfaces separated by an infilling of weaker material. The machine was constructed in 1986 and has recently been used to complete a series of trial tests on clean, flat rock surfaces and similar surfaces separated by clean rock gouge. It was specifically designed to accurately measure shear parameters up to peak failure and to follow these parameters beyond failure to their residual or basic angle of friction. (Edited author abstract) 4 Refs.

Xu, S. (Imperial Coll, London, Engl); Freitas, M.H. de. *Geotechnique* v 38 n 2 Jun 1988 p 301-309.

**091439 DESIGN AND CONSTRUCTION OF A NEW ROTARY MACHINE FOR ROCK JOINTS.** A ring shear machine in principle similar to the ring shear apparatus for testing rocks designed by H. Kutter (1974) and that for testing soils designed by E.N. Bromhead (1970) has been constructed for testing rock joints. This paper describes the main features of the design of this machine whose principle attributes are: the ability to achieve continuous displacement of rock surfaces over distances much greater than any equipment available to date; a stiffness that allows post-peak behavior of the rock surfaces to be studied, and an unchanging apparent area of contact between the two halves of the specimen being tested. 5 Refs.

Xu, Shulin (Imperial Coll, London, Engl); Rogers, E.A.; de Freitas, M.H. *Ground Eng* v 22 n 4 May 1988 p 18-19.

**091440 EMPFEHLUNG Nr.13 DES ARBEITSKREISES 19-VERSUCHSTECHNIK FELS DER DEUTSCHEN GESELLSCHAFT FUER ERD-UND GRUNDBAU e.V. % LABORSCHERVERSUCH UND FELSTRENNFLAECHEN.** [Rock Testing Techniques of the German Geotechnical Society. Direct Shear Tests on Rock Joints.]. In direct shear tests, material parameters can be determined which describe the shear behavior of rock joints. The recommendation defines important concepts for the shear behavior of these joints. It describes force and path parameters which can be measured in tests and shows a suitable testing device. Moreover, sample removal, execution of the test and evaluation of the results are described and explained with the aid of an example. (Author abstract). In German.

Leichnitz, Wolfhard (Deutschen Bundesbahn, Frankfurt am Main, West Ger). *Bautechnik* v 65 n 9 Sep 1988 p 301-305.

## Thermal Effects

**091441 STEADY STATE RESPONSE OF AN ELASTIC HALF SPACE CONTAINING A POINT SOURCE OF HEAT.** Closed form solutions are presented for the steady state distributions of temperature, displacement and stress around a point source of heat embedded in a homogeneous, isotropic elastic half space. These solutions have been evaluated for a typical case of a heat source buried in rock and quantities such as the heave of the ground surface and the maximum horizontal tensile stress at the surface have been estimated. (Author abstract) 5 refs.

Booker, J.R.; Carter, J.P. *Res Rep Univ Sydney Sch Civ Min Eng* n R497 Aug 1985 32p.

**Thermoanalysis** See RADIOACTIVE WASTES—Geological Repositories.

## Ultrasonic Effects

**091442 INVERSION OF ULTRASONIC WAVE VELOCITY MEASUREMENTS TO OBTAIN THE MICROCRACK ORIENTATION DISTRIBUTION FUNCTION IN ROCKS.** Ultrasonic wave velocities in rock are reduced significantly by the presence of microcracks. In general, these microcracks are not randomly orientated and the rock displays an elastic anisotropy determined by the shape and content of the cracks and by the crack orientation distribution function. This function gives the probability of a crack having a given orientation with respect to a set of axes fixed in the rock, and is used to calculate the variation of elastic wave velocity with propagation direction. The coefficients,  $W_{lmn}$ , of a series expansion of the crack orientation distribution function in generalized spherical harmonics can be obtained in order  $l=4$  from the angular variation of the ultrasonic wave velocity. This allows construction of microfracture pole figures which may be compared with those obtained by petrofabric examination. The theory is applied to the measurements of Thill, Willard and Bur on Salsbury granite. (Edited author abstract) 20 refs.

Sayers, C.M. (Kominklijke/Shell Exploratie en Productie Lab, Rijswijk, Neth). *Ultrasonics* v 26 n 2 Mar 1988 p 73-77.

## Vibrations

**091443 FINITE ELEMENT ANALYSIS OF VIBRATIONS INDUCED BY PROPAGATING WAVES GENERATED BY TUNNEL BLASTING.** An example of a new tunnel excavated below an existing tunnel has been studied. Even though this problem is three dimensional in nature, due to the large computational efforts involved in three dimensional dynamic analysis, a two dimensional finite element analysis has been adopted. A pseudo-plane strain concept has been used since it has been found that the results obtained using such an approach are more realistic than the conventional plane strain analysis. It is concluded that results from such a numerical analysis could complement the field investigations to produce guidelines for safe and controlled blasting. (Edited author abstract) 29 refs.

Valliappan, S. (Univ of New South Wales, Aust); Ang, K.K. *Rock Mech Rock Eng* v 21 n 1 Jan-Mar 1988 p 53-78.

**Viscoplasticity** See SAND AND GRAVEL—Viscoplasticity.

## Wave Effects

**091444 WAVE PROPAGATION THROUGH FLUID SATURATED POROUS ROCKS.** A sedimentary rock is modeled by a random packing of identical spherical particles. The connected pore space is filled with an inviscid, compressible fluid. A low-frequency expansion technique is used to calculate the effective wave speeds explicitly in terms of the microstructural properties of the rock considered. The effect of both the pore fluid and the initial confining pressure to which the rock is

subjected can be included in the calculations. (Author abstract) 6 refs.

Walton, K. (Univ of Bath, Bath, Engl); Digby, P.J. *J Appl Mech Trans ASME* v 54 n 4 Dec 1987 p 788-793.

## Wear

**091445 ABRASION TESTING AND ARMOUR-STONE DEGRADATION.** A cylindrical tumbling mill apparatus is used to provide weight loss and shape change data on rock fragment abrasion from four experiments. Weight loss data for the four limestone samples confirm the reproducibility of the test conditions and of the abrasion resistance index value which had been reported previously for this rock type. Progressive shape changes of subsamples are analyzed using recently developed automated image analysis techniques and computer methods based on Fourier and Fractal shape descriptors. A theoretical relationship between weight loss, revolutions in the mill and surface roughness is developed. Weight loss-time, and asperity roughness-time relationships are determined and their application to armourstone rounding is discussed. Examples from a hard and a soft limestone are given to illustrate the use of the tumbling mill aggregate abrasion test in the prediction of wear or armourstone after a certain number of years in service. (Edited author abstract) 20 Refs.

Latham, John-Paul (Queen Mary College, London, Engl); Poole, Alan B. *Coastal Eng* v 12 n 3 Sep 1988 p 233-255.

**Wetting** See PETROLEUM RESERVOIR ENGINEERING.

## X-Ray Analysis

**091446 DETERMINATION OF RARE ELEMENTS IN WEATHERED CRUST OF BASIC ROCKS USING SRXFA.** The technique of SRXFA for the determination of Rb-Mo group of elements in rock samples is described. The ability of indicator ratios Nb/Ta and Zr/Hf determination in different rock samples by means of modern nuclear-physical methods is shown. The results of analysis on Nb, Ta, Zr and Hf in samples of weathered crust of basic rocks are listed and the relative mobility of these elements is estimated. (Author abstract) 4 refs.

Shypitsyn, Yu.G.; Tsybulchik, V.M. *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 286-289.

**091447 MEASUREMENT OF RARE-EARTH ELEMENT CONTENT IN ROCK STANDARDS BY XFA METHOD WITH USE OF SYNCHROTRON RADIATION FROM THE STORAGE RING VEPP-4.** X-ray fluorescence analysis with the use of synchrotron radiation was applied to determine the rare-earth element content in some rock standards. The method of processing of the complex X-ray fluorescence spectra is described. The results obtained are in good agreement with reference data. The limit of detection by this method was estimated as 0.1-0.3 ppm for light REE and 0.5-1.0 ppm for middle and heavy REE. (Author abstract) 3 refs.

Daryin, A.V. (Inst of Geology & Geophysics, Novosibirsk, USSR); Bobrov, V.A. *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 292-294.

**ROCK DRILLING** See Also BOREHOLES—Drilling; COAL MINES AND MINING—Drilling; GEOTHERMAL WELLS; MINES AND MINING—Productivity.

**091448 WATER-JET-ASSISTED DRAG BIT CUTTING IN MEDIUM-STRENGTH ROCK.** This Bureau of Mines report reviews hypotheses for the mechanism by which water jets reduce the specific energy of cutting for drag bits. Several of these hypotheses are shown to be inconsistent with published evidence and new observations. The notion of a limiting cutting speed, above which



water jets would be incapable of rendering assistance, is shown to be improbable. The hypothesis that seems most plausible is that specific energy reductions are mainly due to the erosion of crushed materials from in front of the bit. This hypothesis leads to a prediction that, for a given rock type and jet-bit configuration at a constant depth of cut, the reduction in bit forces should be a function of  $dW/dx$ , the jet energy spent per unit length of cut. This dependence upon  $dW/dx$  is shown to be consistent with other workers' results. (Author abstract) 18 refs.

Geier, J.E. (Univ of California, Berkeley, CA, USA); Hood, M.; Thimons, E.D. *Inf Circ US Bur Mines* 9164 1987 14p.

**091449 ELECTROCHEMICAL EFFECTS ON ROCK DRILLING.** Drilling tests were conducted on Sioux quartzite with  $AlCl_3$ ,  $ZrCl_4$ ,  $CaCl_2$ , and  $NaCl$  solution concentrations and on Westerly granite with  $AlCl_3$  solution concentrations below, at, and above their respective ZPC concentrations using a 16-mm diamond impregnated coring bit. Results show that surface tension reducers are efficient in chemical crack propagation. However, when drilling is regarded as activated cracking that involves the catastrophic growth of microcracks into more destructive ones, it is then possible that the interfacial tension, or surface energy, must first go up to a critical tension before a rock fragment separates with a lowering of interfacial tension. This distinction between the kinetic process of drilling and the thermodynamic state of crack formation can explain why an increase in interfacial tension can facilitate drilling rate by lowering the energy barrier for rock fragmentation. 2 refs.

Engelmann, W.H. (US Dep of Interior, Minneapolis, MN, USA); Watson, P.J.; Tuzinski, P.A.; Pahlman, J.E.; Khalafalla, S.E. *J Electrochem Soc* v 135 n 4 Apr 1988 p 1043-1044.

**091450 OBSERVATION OF CRACKS AT THE BOTTOM OF PERCUSSION AND DIAMOND DRILL HOLES.** The study described in this paper demonstrates that indentation fracture development beneath a commonly used percussive chisel bit is more complex than has been previously described. Observed crack systems resemble those due to a combination of Hertzian (spherical indenter) and sharp indenter stress fields. Work described in this paper shows that diamond core drilling does not produce an extensive fractured zone around the active cutting elements. The zone of fracture is very localized and can only be observed with the aid of a microscope. These results are in agreement with the findings of Graham. 19 refs.

Howarth, D.F. (Univ of Queensland, St. Lucia, Aust); Bridge, E.J. *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 1 Feb 1988 p 39-43.

**Circulating Media** See Also GEOTHERMAL ENERGY—Japan; GEOTHERMAL WELLS—Drilling; GEOTHERMAL WELLS—Fluid Dynamics.

**091451 ZETA POTENTIAL CONTROL FOR SIMULTANEOUS ENHANCEMENT OF PENETRATION RATES AND BIT LIFE IN ROCK DRILLING.** In pursuit of innovative methods to improve mining productivity, the Bureau of Mines is investigating the use of inorganic salts as drilling fluid additives for penetration enhancement. Laboratory diamond drilling tests were performed on Westerly Granite with aluminum chloride solutions and on Sioux Quartzite with aluminum nitrate and aluminum, calcium, sodium, and zirconium chloride solutions as drilling fluid additives. These drilling results were compared with the average drilling performance using distilled, deionized water on Sioux Quartzite (12 replicate tests) and Westerly Granite (3 replicate tests). Maximum increases in penetration per given time and bit life were obtained when drilling with zero point of charge (ZPC) concentration solutions of each additive. For Sioux Quartzite, maximum increases in penetration and bit life ranged from 96 to 115 pct and 64 to 99 pct, respectively. For Westerly Granite, maximum increases in penetration of 155 and 165 pct and bit life of 109 and 136 pct were obtained at or near ZPC aluminum chloride concentra-

tions of quartz ( $7.3 \times 10^{-7}$  mol/L  $AlCl_3$ ) and alkali feldspars ( $1.1$  to  $1.5 \times 10^{-6}$  mol/L  $AlCl_3$ ), respectively. This simultaneous increase in penetration per time together with extended bit life should result in increased productivity and reduced bit costs. (Author abstract) 17 refs.

Engelmann, William H.; Watson, Pamela J.; Tuzinski, Patrick A.; Pahlman, John E. *Rep Invest US Bur Mines* 9103 1987 22p.

## Computer Aided Analysis

**091452 APPLICATION OF THE FINITE ELEMENT METHOD TO PROBLEMS OF PENETRATION OF A TOOL INTO ROCK TO FRACTURE IT.** Two finite-element procedures of numerical simulation of the rock failure during penetration of a tool into it are considered and compared. The process of the chipped-out hole formation under the penetrating tool is studied. Numerical results are compared with experimental data. (Edited author abstract). In Russian. 6 refs.

Gnuchin, Yu.B.; Sveshnikov, I.A.; Borisenko, V.V.; Podoroga, V.A. *Probl Prochn* n 8 1987 p 106-110.

**Costs** See OIL WELL DRILLING—Bits; TUNNELS AND TUNNELING.

## Efficiency

**091453 DRILLING FOR HOT DRY ROCK RESERVOIRS.** A drilling group evaluated techniques suitable for drilling inclined boreholes, of controlled geometry, to reach temperature of 200 to 250 degrees C in crystalline rock. They concluded that there is no fundamental reason why holes for Hot Dry Rock (HDR) projects cannot be drilled and completed successfully using techniques already available, and that further development work should aim at risk and cost reduction rather than new techniques. They stressed the need for meticulous planning and careful engineering in any HDR drilling operation. (Edited author abstract) 7 refs.

Beswick, A.J.; Baron, G.; Garnish, J.D. *Geothermics* v 16 n 4 1987, Proc of the First EEC/US Workshop on Geotherm Hot Dry Rock Technol, Brussels, Belg, May 28-30 1986 p 429-432.

**Explosive** See COAL MINES AND MINING—Rock Mechanics.

## Measurements

**091454 BOREHOLE MEASUREMENTS IN THE FIELD OF HOT DRY ROCK EXPERIMENTS.** The authors examined the value of different types of borehole logging in the context of Hot Dry Rock developments and considered the limitations of current techniques and the scope for further development. They recommended that the main development effort should concentrate on methods of fracture detection, both at the borehole wall and in the far field. They further recommended that such work would best be done as part of a collaborative international effort. (Edited author abstract) 8 refs.

Haelen, R.; Pearson, R.A.; Pine, R.J. *Geothermics* v 16 n 4 1987, Proc of the First EEC/US Workshop on Geotherm Hot Dry Rock Technol, Brussels, Belg, May 28-30 1986 p 433-439.

## Remote Sensing

**091455 ELECTROMAGNETIC LOCATING TECHNOLOGY ENHANCES NO-DIG OPERATIONS.** Trenchless or no-dig operations are often conducted 'in the dark', where knowledge of progress or problems is only available by measurement or by feel. Some light has, however, been brought to bear on the subject by the development of sonde technology. Signal emitting sondes can transmit signals through rock or soil from depths down to 20m, which are then detected by a receiver. Because of the compact size of sondes, as small as  $13 \times 64$ mm, users of horizontal boring tools have found they can fit them directly to or just behind their equipment.

Consequently, in the event of failure underground, the position of the tool can be fixed exactly and arrangements made to retrieve it.

Garnet, Andy (Radiodetection Ltd). *Civ Eng (London)* Oct 1987 p 53.

## Stresses

**091456 ROTARY PERCUSSION FORCES AFFECTING A DRILLING RATE OF BIT FOR ROCK MASS.** The drilling rate of a rotary percussion drill bit depends on the revolving energy and the impact energy of the drifter, as well as the characteristics of rock mass. The rotary percussion drill tests were executed in-situ for 13 kinds of rock mass using 12 actual drill machines to clarify the interrelations between them. The drilling rate has been expressed as a function of the revolving energy, the impact energy, the bit diameter, the coefficient of crack of rock mass and the shore hardness or the amount of Los Angeles abrasion or the radial compressive strength of rock specimen. On the other hand, the rock mass properties could be determined by measuring the drilling rate of a standard rotary percussion drill machine. (Author abstract) 8 refs.

Muro, Tatsuro (Ehime Univ, Matsuyama, Jpn); Fukagawa, Yoichi; Watanabe, Masahiro. *Doboku Gak-kai Rombun Hokokushu* v 8 n 391 Mar 1988 p 206-213.

**Underwater** See GEOLOGY—Research.

**ROCK DRILLS** See Also MINES AND MINING—Drills; OIL WELL DRILLING—Control; ROCK—Anisotropy; ROCK—Fracture.

**Bits and Holders** See Also OIL WELL DRILLING; OIL WELL DRILLING—Bits; ROCK DRILLING—Stresses.

**091457 INVESTIGATION OF THE STRESS-STRAINED STATE AND STRENGTH OF ROCK CUTTING TOOLS.** The stress-strained state and strength of hard alloy inserts are calculated by the method of finite elements depending on their orientation during cutting. Calculated fields of displacements, deformations and stresses in the inserts from the action of the concentrated load applied to the angle vertex of cutting edges are obtained for different angles of orientation. Zones of dangerous tensile stresses are determined in this case. Calculations for hard alloy inserts are analyzed. Structural and technological parameters of inserts are evaluated for their effect of the stress-strained state and strength. Recommendations are made to improve the structure of inserts and selection of the angle of their fixation in the holder. Basic requirements regarding the optimal insert are formulated. (Edited author abstract) In Russian. 3 refs.

Gnuchy, Y.B.; Sveshnikov, I.A.; Podoroga, V.A. *Probl Prochn* n 9 1987 p 104-109.

**091458 WAYS TO IMPROVE THE DRILLING EFFECTIVENESS OF ROCK BITS BY A TRIBOLOGICAL METHOD.** Wear tests on the main bearings of 8.5 inch XHP 3 rock bits were performed, from which it is concluded that the way to improve the drilling effectiveness for the rock bits is to set drilling pressure and rotary speed properly, and to develop a new type of grease for rock bits which can bear a higher temperature than conventional grease. In addition, it is also shown that an inexpensive copper alloy can take the place of expensive Ag85Mn15 as an anti-wear material in the bearing, so that the production cost for the rock bits can be reduced. (Author abstract) 3 refs.

Wang, Yi-Ling (Shanghai Jiao Tong Univ, Shanghai, China); Luo, Hong. *J Tribol Trans ASME* v 110 n 2 Apr 1988 p 212-216.

**091459 LABORATORY DRILLING PERFORMANCE OF PDC BITS.** A laboratory study of polycrystalline diamond compact (PDC) bit designs has generated data that give an insight into PDC-bit performance in the



field. The tests reviewed in this paper include those for rate of penetration (ROP), torque response, hydraulic energy sensitivity, balling tendency, dull-bit performance, and bit performance after the removal of selected cutters. A total of four bit designs was tested. The designs included flat-faced profiles and parabolic profiles. (Author abstract). 2 Refs.

Warren, T.M. (Amoco Production Co); Armagost, W.K. *SPE Drill Eng* v 3 n 2 Jun 1988 p 125-135.

## Brazing

**091460 ADVANCES IN THE BRAZING OF SYN-DRILL.** The use of high temperature brazes for the production of polycrystalline diamond (PCD) studcutters can have serious deleterious effects on the components of the studcutters. The development of a lower temperature, high strength braze, as well as a more thermally stable polycrystalline diamond element, are shown to have major advantages for such brazing operations. (Author abstract)

Anon (De Beers Diamond Research Lab). *Ind Diamond Rev* v 47 n 523 1987 p 254-257.

## Computer Applications

**091461 COMPUTERIZED DRILLING IN DEEP MINING.** One should remember that even though computerized drill rigs may work quite independently after the button is pushed, someone is still required to push the button. In this respect, aspects such as work motivation and remuneration have to be given new and close consideration. A DATA-driller should be aware of why the various work phases are carried out, what is required to ensure the excavation quality we referred to earlier, and what the following phase in the work cycle is.

Hulkkonen, Kaj (Tampella Tampella Ltd). *Glueckauf Transl* v 123 n 10 May 21 1987 p 306-308.

## Control See TUNNELING MACHINES—Control.

## Design

**091462 STUDIES ON THE DESIGN OF OIL HYDRAULIC ROCK DRILL (2ND REPORT).** Oil hydraulic rock drills have been used in the field of mining and public works. This paper treats the percussion type rock drill which is driven by the interaction of a piston and valve. Sensitivity analysis is applied to an investigation of the influence of design parameters on the performance of the drill. It is demonstrated that the effect of leakage from the rear chamber of the piston is more sensitive to the performance. For the purpose of optimum design the influence of the construction of the drill is also indicated using dimensions of the piston as a variable. (Edited author abstract) In Japanese. 1 ref.

Takahashi, Yoshio (Akita Univ, Jpn); Shibuya, Yotsugi; Obinata, Goro; Nagata, Haruhisa; Nagasaku, Kiyoshi. *Nippon Kogyo Kaishi* v 103 n 1192 Jun 1987 p 377-381.

## Diamond See Also MINES AND MINING—Drills; ROCK DRILLING—Circulating Media.

**091463 SYNDRILL BREAKS WORLD RECORD.** The Boulby mine of Cleveland Potash Ltd. is the sole source of potash in the UK. Since its formation in 1968, the company has successfully overcome numerous mining engineering problems. This is typified by a switch to SYNDRILL PCD bits for exploratory long hole drilling - a switch which brought the unexpected bonus of a world drilling record. (Author abstract)

Jennings, Martin. *Ind Diamond Rev* v 47 n 521 1987 p 150-153.

**091464 CORE DRILLING WITH SYNDAX 3 PCD.** SYNDAX 3 thermally stable PCD cutting elements were launched three years ago, and the main applications to date have been in the petroleum industry. Core drilling for mineral exploration is also a potentially important area for SYNDAX 3, and some recent drilling results are reported by the authors. (Edited author abstract)

Clark, I.E. (De Beers Industrial Diamond Div); Shafto, G.R. *Ind Diamond Rev* v 47 n 521 1987 p 169-171, 172-173.

## Hydraulic

**091465 DESIGN AND STUDY OF HYDRAULIC DRILL.** A series of basic equations describing relations between the performance and various parameters of the hydraulic drill have been derived. The equations are applicable under conditions in which the oil pressure is not changeable. These basic equations can be used in the design and study of the hydraulic drill. Predictions by these equations agree with experimental results. (Edited author abstract). In Chinese.

He, Qinghua (Central South Univ of Technology, China). *Zhongnan Kuangye Xueyuan Xuebao* v 19 n 2 1988 p 195-203.

## Materials See Also TUNGSTEN CARBIDE—Mechanical Properties.

**091466 ESTIMATION OF SERVICE LIFE OF 55SiMnMo DRILLING ROD FOR YYG80-1 HYDRAULIC ROCK DRILL.** A stress analysis of drill rod for an hydraulic rock drill was carried out. The fatigue life of 55SiMnMo steel rod is estimated for three S-N curves obtained under three typical heat treatment conditions. The performance and adaptability of the steel are discussed. Measures of improving fatigue life are suggested. (Edited author abstract) In Chinese. 6 refs.

Shouzhi, Song (Northeast Univ of Technology, China); Xiaohe, Xu; Runlong, Li. *Kang T'ieh* v 23 n 1 Jan 1988 p 34-37.

## ROCK MECHANICS See Also ASBESTOS MINES AND MINING—Zimbabwe; BOREHOLES—Blasting; BOREHOLES—Pressure Effects; BOREHOLES—Stability; COAL MINES AND MINING—Roadway Supports; COAL MINES AND MINING—Rock Bolting; COAL MINES AND MINING—Roof Control; COAL MINES AND MINING—Roof Supports; EMBANKMENTS—Stability; FLOW OF FLUIDS—Porous Materials; GAS STORAGE—Underground; GEOPHYSICS—Rock Properties; GEOPHYSICS—Seismic; GLACIERS—Mathematical Models; HIGHWAY SYSTEMS—Blasting; IMAGE PROCESSING; MINES AND MINING; MINES AND MINING—Blasting; MINES AND MINING—Concrete Construction; MINES AND MINING—Design; MINES AND MINING—Open Pit; MINES AND MINING—Research; MINES AND MINING—Rock Bolting; MINES AND MINING—Rock Bursts; MINES AND MINING—Rock Pressure; MINES AND MINING—Roof Supports; MINES AND MINING—Stability; MINES AND MINING—Stowage; MINES AND MINING—Stresses; OIL WELL DRILLING—Mathematical Models; PERMEAMETERS, MECHANICAL PERMEABILITY; POROUS MATERIALS; ROCK—Anisotropy; ROCK—Elasticity; ROCK—Failure; ROCK—Fracture; ROCK—Porosity; SOIL MECHANICS; TUNNELS AND TUNNELING; TUNNELS AND TUNNELING—Design; TUNNELS AND TUNNELING—Lining; TUNNELS AND TUNNELING—Stresses; TUNNELS AND TUNNELING—Vibrations.

**091467 EFFECT OF GROUNDWATER CONDITIONS ON PLANER WEDGE STABILITY.** Generalized solutions are developed for determining factors of safety assuming planer wedge failure for a variety of groundwater conditions. These solutions are useful for first order slope stability analysis and performing parametric studies to investigate the effect of groundwater conditions on slope stability. Solutions are programmable on personal computers. (Author abstract) 3 refs.

Valsangkar, A.J. (Univ of New Brunswick, Fredericton, NB, Can); Marston, S. *Min Sci Technol* v 5 n 3 Sep 1987 p 283-286.

**091468 VARIATION OF PORE WATER WITH DEFORMATION BEHAVIOUR OF ROCKS UNDER VARIOUS EFFECTIVE CONFINING PRESSURES.** The triaxial compression test for some kinds of rocks was carried out, monitoring variation of pore water with deformation behaviour by use of a hydraulic testing machine equipped with a servo-control system for triaxial loading. Differential stress and variation of pore water-strain curves for rock samples were determined at the range within 10% of a value of sample deformation under the condition of confining pressure and pore pressure

extending up to 80MPa. The experiment showed that it was possible to monitor variation of pore water following the deformation behaviour of samples, and these phenomena were divided into two types depending on the deformation behaviour. One type obtained primarily under the brittle deformation behaviour, possessed a turning point between outflow and inflow of pore water which existed before a point of maximum differential stress on stress-strain curves. This turning point approximately agreed with the position occurring dilatancy of volumetric strain. In regard to the other type obtained under the ductile deformation behaviour, there was no the turning point in the majority of cases, although dilatancy occurred on volumetric strain. It is presumed that this discrepancy is largely concerned with fracture mode in a rock specimen. (Author abstract) 7 refs. In Japanese.

Goto, Tatsuhiro (Muroran Inst of Technology, Jpn); Sato, Tateki. *Nippon Kogyo Kaishi* v 103 n 1194 Aug 1987 p 485-491.

**091469 BACK ANALYSIS PROCEDURES FOR THE INTERPRETATION OF FIELD MEASUREMENTS IN GEOMECHANICS.** A survey is presented of some recent developments of the numerical techniques for back analysis in the field of geomechanics, with particular reference to tunneling problems. In the spirit of Terzaghi's observational design method, these techniques are seen as practical tools for interpreting the available field measurements, in order to reduce the uncertainties that in many instances affect the parameters governing the solution of complex geomechanics problems. Both deterministic and probabilistic viewpoints are considered and some significant applications to practical problems are illustrated. (Author abstract) 63 refs.

Gioda, Giancarlo (Technical Univ of Milan, Milan, Italy); Sakurai, Shunsuke. *Int J Numer Anal Methods Geomech* v 11 n 6 Nov-Dec 1987 p 555-583.

**091470 BEHAVIOUR SIMILARITY OF MOHR'S ROCK STRENGTH DIAGRAMS.** On the basis of comprehensive analysis of a number of triaxial test data, we find: 1) There exists a remarkable similarity among strength curves obtained from tests when rock samples with different origins and structures are tested under different loading conditions and loading modes; 2) there exists a high correlation between the shear strength coefficient (A) and the normal compressive strength coefficient (B), and between the internal friction coefficient (f) and the cohesion coefficient (K), on the failure surfaces of rocks; and 3) in logarithmic coordinates the rock strength diagrams are represented by parallel straight lines. Empirical formulae have been obtained by exponential regression. If the uniaxial compressive strength,  $R_c$ , is measured, the values of shear strength at any given normal compressive strength can be obtained, and the rock strength diagrams can be easily determined. Test work for determining rock strength diagrams is greatly simplified, and the amount of calculation has been reduced for determining cohesive force (C), and the angle of internal friction ( $\phi$ ). (Edited author abstract) 2 refs. In Chinese.

Gong, Benyi (Central Coal Mining Research Inst, China). *Meitan Xuebao* n 1 1987 p 1-11.

**091471 NEW METHOD FOR MEASURING TWO-DIMENSIONAL CHANGE OF IN-SITU STRESSES DURING EXCAVATIONS: A STUDY ON THE METHOD FOR MEASURING IN-SITU STRESS CHANGES WITH PRESSURE CELL (1ST REPORT).** The method uses a cylindrical pressure cell with eight strain gages glued to the inner wall of the cell which is inserted in a borehole with non-contraction type grouting material. A special merit of this method lies in the internal pressure test which is carried out, using the measuring instrument itself in order to know the mechanical interaction between the measuring system and the rock mass. Utilizing the information on the deformation modulus of the rock mass obtained in the internal pressure test, two-dimensional changes of in-situ stresses are measured with the least squares method on the circumfer-



ential strain distribution around the inner wall of the pressure cell. Results of laboratory tests in uniaxial and biaxial compression are summarized. (Edited author abstract) In Japanese. 4 refs.

Matsuki, Koji (Tohoku Univ, Jpn). *Nippon Kogyo Kaishi* v 103 n 1195 Sep 1987 p 543-547.

**091472 STUDY OF ACOUSTIC EMISSION DURING DEFORMATION OF ROCKS UNDER CONDITIONS OF A COMPLEX AXISYMMETRIC STRESSED STATE.** The authors carried out studies of rock specimens during their deformation under complex stressed conditions with simultaneous recording of mechanical properties, and ultrasonic and AE signal propagation rates. This will make it possible to reveal the laws governing microcrack formation in the high strain region. A study of the laws for acoustic emission (AE) behavior with a complex stressed state has shown that the nature of the dependence for the number of AE signals depends markedly on the ratio of stressed state components for the specimen. The existence of a range for the maximum AE intensity is due to formation of cracks of tensile origin. The range of minimum AE intensity corresponds to the shear mechanism of deformation with a growing residual increase in material volume (quasiplastic deformation). 7 refs.

Stavrogin, A.N.; Zaretskii-Feoktistov, G.G.; Tanov, G.N. *Sov Min Sci* v 22 n 5 Sep-Oct 1986 p 341-350.

**091473 GEOMETRICAL IDENTIFICATION OF THREE-DIMENSIONAL ROCK BLOCK SYSTEMS USING TOPOLOGICAL TECHNIQUES.** This paper describes a new approach to the problem of defining geometrically polyhedral rock blocks created by the intersection of planar discontinuities in a rock mass. The approach represents an extension of the combinatorial topology concepts to solid geometry, which, when implemented computationally, results in a procedure for the systematic identification of the spatial arrangement of rock blocks. The principle of simplicial homology is reviewed and a specific application of block geometry analysis is presented. (Edited author abstract) 8 refs.

Lin, D. (Univ of Minnesota, Minneapolis, MN, USA); Fairhurst, C.; Starfield, A.M. *Int J Rock Mech Min Sci Geomech Abstr* v 24 n 6 Dec 1987 p 331-338.

**091474 CREEP BENDING OF ROCK PLATES.** Creep bending of a rock plate under constant loading has been analysed. Non-equal elastic and viscosity constants under compressive and tensile loading of rock have been incorporated in Burger's model. Results are presented in terms of non-dimensionalised parameters whose influence has been studied over a wide range. The influence of some of these parameters appears dominating. (Author abstract) 4 refs.

Singh, J.G. (Banaras Hindu Univ, Varanasi, India); Upadhyay, P.C. *Min Sci Technol* v 6 n 2 Jan 1988 p 163-169.

**091475 FRACTURE TOUGHNESS OF SOME BRITISH ROCKS BY DIAMETRAL LOADING OF DISCS.** Results of fracture toughness tests on five types of rock as determined by diametral loading of discs are presented. Results indicate that the fracture toughness  $K_{Ic}$  is independent of crack length and dimensionless crack length but depends upon the width to diameter ratio of the specimens. The effect of the width to diameter ratio on fracture toughness was examined in detail and a minimum ratio of 0.8 is recommended. (Author abstract) 2 refs.

Singh, R.N. (Univ of Nottingham, Nottingham, Engli); Pathan, A.G. *Min Sci Technol* v 6 n 2 Jan 1988 p 179-190.

**091476 PARAMETER IDENTIFICATION IN A DAMAGE MODEL FOR ROCK MECHANICS.** Attention is focused on the mechanical behavior of rock-like materials. Developments and applications of a constitutive model based on damage theory are presented. The internal damage model is calibrated for a hard brittle rock, Bushveld Norite, and through this process the identification of the material parameters is carried out. Emphasis is

placed on the identification of the material parameters in the damage evolution law. The uniqueness of solutions in the softening regime is investigated through finite element mesh sensitivity studies of non-uniform deformation triaxial compression tests. (Author abstract) 10 refs.

Resende, L. (Univ of Cape Town, Rondebosch, S Afr); Martin, J.B. *Int J Numer Anal Methods Geomech* v 12 n 1 Jan-Feb 1988 p 79-97.

**091477 PLASMA METHOD OF REINFORCEMENT OF SOFT ROCKS AND CALCULATIONS FOR THE RESULTING STRUCTURES.** Thermal reinforcement of soft rocks is employed for strengthening embankments, support walls, foundations, and other supporting and containment systems in underground construction. Rocks around boreholes are heated by supplying a heat carrier through the hole. A wider application of thermal reinforcement of rocks has been limited by the long time (several days) of the baking process, as well as the insufficient strength of the resulting structural components. The main cause of this is the practically low (not more than 1000°C) temperatures of the heat carrier. With the plasma method of thermal reinforcement, this shortcoming can be overcome because the mean mass temperature of the heat carrier can be raised to 10,000° C. 4 refs.

Zadvornev, G.A. (Military Engineering Acad, Togliatti, USSR); Novikov, V.F. *Sov Min Sci* v 22 n 6 Nov-Dec 1986 p 434-440.

**091478 DISTINCT ELEMENT METHOD - APPLICATION TO ANALYSE SLIDING AND TOPPLING FAILURES.** The distinct element method proposed by Cundall in 1971 has been applied to simulate the process of sliding and toppling failures. To check the accuracy of the computer simulation, a series of physical experiments as well as analytical calculations have also been carried out. Two problems are treated in this paper: one is the sliding and/or toppling behaviors of jointed pillars; the other is the behavior of plane sliding of a quadrangle block in relation to the force required to arrest its movement. Excellent agreements between the simulated results and the physical test results indicate that the distinct element method is effective to solve the problems concerning discontinuous rock mass. (Edited author abstract) 8 refs.

Zhang Yu (Beijing Univ of Iron & Steel Technology, Beijing, China); Ishijima Yoji; Sato Masaru. *Yu Se Chin Shu* v 39 n 4 Nov 1987 p 1-11.

**091479 METHOD OF INTEGRATED EVALUATION OF ROCK CRACK RESISTANCE AT THE STAGE OF PRECRITICAL CRACK GROWTH.** A procedure for a complex estimation of the rock crack resistance at the stage of precritical crack growth is reported. The procedure permits determining alongside with crack resistance characteristics also elastoplastic constants of the tested materials of the compact specimens loaded according to the patterns of eccentric tension and transversal compression. Experimental results are presented for marble, sandstone and quartzite. Their reliability is confirmed by a correspondence of elastic characteristic determined according to the above procedure and those obtained when testing the same materials for uniaxial compression and pure bending. (Author abstract) In Russian. 11 refs.

Volkov, G.S.; Sopenko, S.I. *Probl Prochn* n 10 Oct 1987 p 26-31.

**091480 INFLUENCE OF OUT-OF-PLANE STRESS ON A PLANE STRAIN PROBLEM IN ROCK MECHANICS.** This paper considers the excavation of a cylindrical cavity in a uniformly prestressed mass of brittle Mohr-Coulomb rock. Previous plane strain displacement solutions have assumed that the out-of-plane stress remains the intermediate principal stress at all points. It is here shown that when this assumption breaks down, an inner plastic zone is created in which  $\sigma_r < \sigma_z = \sigma_\theta$ . A displacement solution is given for this case, using a variable-dilation plastic flow rule, and results are compared with the previous solution for specific problems. A

significant difference is observed only for problems involving a large drop in strength upon yield. (Author abstract) 7 refs.

Reed, M.B. (Brunel Univ, Uxbridge, Engli). *Int J Numer Anal Methods Geomech* v 12 n 2 Mar-Apr 1988 p 173-181.

**091481 CHARACTERIZING ROCK JOINT GEOMETRY WITH JOINT SYSTEM MODELS.** Two major approaches have emerged to describe the assemblage of geometric joint characteristics in a rock mass: the traditional disaggregate characterization and the more recent aggregate characterization. In the former, each joint characteristic is described separately. In the latter the independence of joint characteristics is captured through the formulation joint system models. A particular joint system model represents a typical geometry. The individual characteristics are still stochastically described but their interdependence is specified. The joint system models which represent the newest developments and to which the authors and their co-workers at MIT have made significant contributions will be presented in greater detail. 70 refs.

Dershowitz, W.S. (Golder Associates, Redmond, WA, USA); Einstein, H.H. *Rock Mech Rock Eng* v 21 n 1 Jan-Mar 1988 p 21-51.

**091482 CASAGRANDE RESISTANCE ENVELOPES FOR ROCK AND ROCKFILL SLOPES HAVING CIRCULAR SLIP SURFACES.** A series of Casagrande resistance envelopes are presented for use in the preliminary design and evaluation of uniform rock and rockfill slopes. The influence of tension cracks on the safety factors for such slopes is examined. A comparison is also made between the safety factors obtained using the resistance envelope method and those obtained using published stability charts for rockfill slopes having nonlinear shear strength envelopes. (Author abstract) 11 refs.

Baikie, L.D. (Technical Univ of Nova Scotia, Halifax, NS, Can). *Can Geotech J* v 25 n 1 Feb 1988 p 42-49.

**091483 INFLUENCE OF THIN LOW-VELOCITY LAYER ON ELASTIC WAVES.** It is important for in-site rock mass estimation and fractured zone exploration with seismic method to clarify the elastic wave propagation in rock mass including thin low-velocity layer such as water-saturated cracks and thin fractured zone. In-site P wave velocity is commonly used for estimation of rock mass including cracks, because P wave velocity decreases as the thickness of cracks and the number of them increase. But the time average formula is not applicable to in-site rock mass including cracks. The reason is as follows. The wave length of P wave used for rock mass estimation is much longer than the thickness of the cracks. Therefore, transmitted wave is formed by the superposition of many waves. The one is the wave which transmits without any reflection at the contact plane between rock and the material in the cracks, and the others are the waves which have multiple reflections within the cracks in their wave paths. (Edited author abstract) In Japanese. 1 ref.

Sassa, Koichi (Kyoto Univ, Jpn); Watanabe, Toshiki. *Nippon Kogyo Kaishi* v 104 n 1199 Jan 1988 p 7-10.

**091484 CHARACTERISTICS OF THE FORMATION OF A REGION OF INFLUENCE AROUND AN EXCAVATION IN COMPACTED AND BROKEN ROCKS.** In recent years, in Don Basin mines, a method of preserving preparatory excavations has been widely used, which involves excavating along compacted and broken rock at the floor level of a coal seam being worked. This method has a number of advantages in such excavations, compared with stratal and field excavations, such advantages flowing from the structural features of



the broken rock bed. This article discusses the characteristics of the formation of a region of influence around an excavation in compacted and broken rocks. 5 refs.

Zborshchik, M.P. (Donetsk Polytechnic Inst, USSR); Morozov, A.F.; Pilyugin, V.I. *Sov Min Sci* v 23 n 2 Mar-Apr 1987 p 101-105.

**091485 SEISMIC-ACOUSTIC STUDIES OF DYNAMIC PHENOMENA IN THE PRODUCTION UNIT 'MECHEKUGOL'.** Seismic-acoustic studies for predicting failure of rocks at the Production Unit 'Mechekugol' in the mine make it possible to obtain information about the condition of the intact rock mass using active methods, i.e., the excitation and recording of elastic waves from an 'artificial source' and passive methods, i.e., observation of seismic-acoustic emissions occurring spontaneously during failure of rocks. Artificially excited and spontaneously occurring elastic waves carry all the information about material properties and about the failure process itself. Recording of acoustic signal parameters and their range is possible depending upon which instruments are used. In studying dynamic phenomena and sudden outbursts in the research center of the 'Mechekugol' enterprise use is made of the Danish seismic-acoustic instrument system of the firm Bruel and Kjaer, which makes it possible to carry out various studies. 4 refs.

Szucz, I. *Sov Min Sci* v 23 n 2 Mar-Apr 1987 p 120-125.

**091486 BREAKING EFFECT OF AN EXPLOSION DURING PREPARATION OF FACING STONE BLOCKS.** Use of explosive energy of a detonating fuse (DF) during preparation of facing stone blocks under certain conditions leads to formation in the rock mass of different types of irreversible strains. They are basically cracks normal to breaking, occurring in the vicinity of the blast-hole during propagation of rarefaction waves in the rock mass, and fatigue cracks connected with development of micro- and macrostructural defects with each cycle of explosive loading. This article considers the effect of an intense load on the radius of the zone of disturbed continuity for the space around the blast-hole (R) in different rocks with explosion of single ( $n=1$ ) and double ( $n=2$ ) lengths of DF in blast-holes 25, 32m and 44 mm in diameter. 4 refs.

Mikhel'son, R.V. (G.A. Tsulukidze Inst of Mine Mechanics, Tbilisi, USSR). *Sov Min Sci* v 23 n 2 Mar-Apr 1987 p 135-138.

**091487 GENERAL SLIP MODEL FOR ROCK MECHANICS.** In situ testing of rock to obtain its deformation modulus is a recognized procedure in the geomechanical investigation of dam sites and of the bedrock formation for other large structures. In such tests the deformation response to loading is found to be reasonably linear, but during unloading the response is often strongly curved. On reloading, the load-deformation curve may rejoin the original loading line, but it may also join at the point where unloading was started. The strong hysteresis effect shows that a considerable amount of energy is dissipated and it is generally agreed that this is due to the presence of joints or cracks. In the present study, the rock is modelled using springs and slip models both in parallel and in series. In the first part a slip model is described which is similar to but more general than a model described by B.H.G. Brady et al. In the second part, models are combined to produce a more realistic picture of practical behaviour of a rock mass. 2 refs.

Vreede, F.A. (CSIR, Pretoria, S Afr). *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 1 Feb 1988 p 53-56.

**091488 DEVELOPMENTS IN ROCK MECHANICS: A PERSPECTIVE OF 25 YEARS.** In this Lecture rock mechanics is regarded as the study of all effects on the surrounding rock mass of creating cavities through the removal of rock. In this context the main problems in rock mechanics are (1) those related to the medium in which the excavation is made and (2) those which are related to the complexity and progressively changing nature of the openings created. The author comments on the basis of evaluating the efficacy of rock mechanics when applied to

the prediction of ground displacement by theoretical analysis. 50 refs.

Salamon, M.D.G. (Colorado Sch of Mines, Golden, CO, USA). *Trans Inst Min Metall Sect A* v 97 Apr 1988 p A57-A68.

**091489 ANALYSIS OF ROCK REINFORCEMENT USING FINITE DIFFERENCE METHODS.** Large-scale rock reinforcement offers the prospect of flexible and effective control of rock displacement around large open mine excavations. Although the technology of rock reinforcement is well developed, reinforcement analysis and design methods are not. Analysis is presented here for the mechanics of two models of rock reinforcement, one based on local action of a reinforcing element at a slipping joint, the other on spatially-extensive action in rock subject to diffuse deformation. The principles of some finite difference methods of analysis of stress and displacement are outlined. The performance of a code modeling spatially-extensive reinforcement is examined in a parameter study of slope hangingwall reinforcement using long grouted cables. (Author abstract) 18 refs.

Brady, B. (Itasca Consulting Group Inc, Minneapolis, MN, USA); Lorig, L. *Comput Geotech* v 5 n 2 1988 p 123-149.

**091490 PALEOSTRESS DETERMINATION IN A ROCK BY A FRACTOGRAPHIC METHOD.** A fractographic technique hitherto used in ceramics for the evaluation of fracture stress is adapted to calculate fracture paleostresses in rocks. An example from a granite in East Sinai is analyzed. The results obtained for the ranges of local paleofracture stress, severest flaw size and initial stress intensity factor agree reasonably well with previous evaluations of fracture stresses in granite and with direct observations of the rock's grain size. (Author abstract) 33 refs.

Bahat, Dov (Ben Gurion Univ of the Negev, Beer Sheva, Isr); Rabinovitch, A. *J Struct Geol* v 10 n 2 1988 p 193-199.

**091491 FULLY DEFORMABLE DISCRETE ELEMENT ANALYSIS USING A FINITE ELEMENT APPROACH.** A method of analysis is presented for problems in which the deformation of the individual blocks play a significant role. The blocks are modeled as single quadrilateral elements and a constitutive model has been presented for computing the contact forces. In order to illustrate the influence of the deformation of the individual blocks two examples have been presented. The results of the analysis with deformable blocks and with rigid blocks are compared. These examples clearly demonstrate the importance of the deformation of blocks in the class of problems represented by these two examples. (Author abstract). 13 Refs.

Ghaboussi, ZJamshid (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA). *Comput Geotech* v 5 n 3 1988 p 175-195.

**091492 ROCK ENGINEERING AND EXCAVATION IN AN URBAN ENVIRONMENT.** The volume contains 38 papers presented at the meeting. Subjects covered include blasting control, subsurface investigations, tunnel design and construction, landslide analysis and control, rock excavations, rock slopes, slope stabilization rock bolting geotechnical engineering, subway station excavations, building foundations, seismic refraction surveying, blasting analysis and control, vibration control, rockfall protection, subsidence, and others. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10957 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Inst of Mining & Metallurgy, London, Engl). *Rock Eng and Excavation in an Urban Environ, Hong Kong, Feb 24-27 1986* Publ by Inst of Mining & Metallurgy, London, Engl, 1986 552p.

**Analysis** See TUNNELS AND TUNNELING—Ground Supports.

**Anisotropy** See ROCK—Crack Propagation.

**Computer Aided Analysis**

**091493 COMPUTERIZED POLE CONCENTRATION GRAPHS USING THE WULF STEREOGRAPHIC PROJECTION.** With the development of computer techniques, it is possible to draw contours of pole concentration with computers. However, those programs are coded by using the principle of traditional hemisphere projection with manual drawing methods. When a counting circle is across the boundary, compensation counting is necessary from its corresponding circle, which provides complication both in counting and calculation. If an approximate calculation is used, certain errors may occur. By full utilization of the property of the Wulff projection, a large hemisphere is adopted to eliminate the counting of the corresponding circle and to provide a clear in concept, simple in formula, accurate in counting and fast in calculating method. 2 refs.

Zhang, Shixiong (Univ of Iron & Steel Technology, Beijing, China); Tong, Guangxu. *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 1 Feb 1988 p 45-51.

**Computer Applications**

**091494 ROCK ENGINEERING SOFTWARE.** The Commission on Computer Programs of the International Society for Rock Mechanics has attempted to produce a list of programs by sending questionnaires worldwide, and asking for short descriptions of the programs in question. The response has been very warm, and a large number of program descriptions have been received. The list should give an overview of the current state of development and application of computer programs in universities, research institutions and companies. Furthermore, the list should help towards information exchange between the various institutions, and encourage the further use of numerical methods. Commercial aspects have not been taken into account in producing the list. Program descriptions are given, and program abstracts in each section are ordered alphabetically according to country of origin. Programs for a given country are ordered by their code names.

Plischke, B. *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 4 Aug 1988 p 183-251.

**Elasticity**

**091495 TWO-DIMENSIONAL DIRECT BOUNDARY INTEGRAL METHOD FOR ELASTODYNAMICS.** This paper presents the mathematical and numerical development of a two-dimensional boundary element model for elastodynamics problems in rock mechanics. The model is based on a time-domain formulation of the direct boundary integral method, and is capable of computing the transient response of an underground excavation to dynamic loading conditions. All boundary contours are approximated by straight line segments, joined end to end, and the displacements and tractions within a time step are assumed to vary quadratically over each segment. Two example problems for a suddenly pressurized circular hole in an infinite plate are used to illustrate the numerical procedures described in the paper. (Edited author abstract). 19 Refs.

Crouch, S.L. (Univ of Minnesota, Minneapolis, MN, USA); Tian, Y. *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 3 Jun 1988 p 149-158.

**Failure** See ROCK—Testing.

**Fracture** See ROCK—Permeability, Mechanical.

**In Situ**

**091496 IN-SITU TESTS USING CRACK-DETECTOR WITH ROTATING PROBES FOR MEASURING SONIC VELOCITY (2ND REPORT) - STUDIES ON CRACK DISTRIBUTION AND SONIC VELOC-**



**ITY CHANGE IN ROCKS (3RD REPORT).** A crack detector has been developed for measuring the distribution of open cracks and the change in sonic velocity in rock masses. In-site measurements have been performed in a tunnel and a quarry. In order to confirm what part of a retaining wall was damaged by an earthquake, the distribution of open cracks and the change in sonic velocity were measured in a borehole drilled in the retaining wall. From the results of measurement, it was clear that the crack zone in the retaining wall lies on the extension of the boundary between the natural ground and the bank. These findings show that use of the crack detector is practical when the distribution of open cracks corresponds to the undetectable area of measurements for the design of rock and concrete structures. (Edited author abstract) In Japanese.

Sugimoto, Fumio (Tohoku Univ, Jpn); Furuzumi, Mitsumasa. *Nippon Kogyo Kaishi* v 103 n 1198 Dec 1987 p 829-834.

**Mathematical Models** See Also COAL MINES AND MINING—Subsidence; GEOLOGY—Structural; ROCK—Fracture.

**091497 IMPULSIVE PROPERTIES OF FALLING ROCKS ON SAND-LAYERS BY MEANS OF CUNDALL'S DISCRETE BLOCK METHOD.** In this study, the transmission mechanism of impulsive force of a falling rock on a sand layer was investigated by means of Cundall's discrete block method. At first, a falling rock and a sand layer were modelled by elements assembled of rigid cylinders, springs and dashpots, then effects of basic parameters such as spring and damping constants on the impulsive force were discussed under the numerical analysis as a two dimensional problem. Secondly, to explain the real behavior better, the discrete block model was extended to a three dimensional problem using the character of the sand based on experimental results. Finally, it was shown that the transmission mechanism of impulsive force by a falling rock in this method agrees with that in experimental results on various conditions. (Author abstract) In Japanese. 12 refs.

Yoshida, Hiroshi; Masuya, Hiroshi; Imai, Kazuaki. *Doboku Gakkai Rombun-hokokushu* v 9 n 4 Apr 1988 p 297-306.

**091498 TOWARDS A METHODOLOGY FOR ROCK MECHANICS MODELLING.** Rock mechanics models fall into the class of "data-limited problems"; one seldom knows enough about a rock mass to model it unambiguously. Modellers are beginning to realize that data-limited problems require a very different modelling approach from that developed in, for example, electrical or aerospace engineering. It follows that one cannot use models in rock mechanics in a conventional way, and that there is a need to adopt a distinctive and appropriate methodology for rock mechanics modelling. Some guidelines and heuristics, which may be considered as the first steps towards developing such a methodology, are presented. Three case studies are then used to illustrate the application, in practice, of these ideas. (Author abstract). 8 Refs.

Starfield, A.M. (Univ of Minnesota, Minneapolis, MN, USA); Cundall, P.A. *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 3 Jun 1988 p 99-106.

**091499 FORMULATION OF A THREE-DIMENSIONAL DISTINCT ELEMENT MODEL - PART I. A SCHEME TO DETECT AND REPRESENT CONTACTS IN A SYSTEM COMPOSED OF MANY POLYHEDRAL BLOCKS.** The distinct element method has advanced to a stage where the complex mechanical interactions of a discontinuous system can be modelled in three dimensions. An important component is the formulation of a robust and rapid technique to detect and categorize contacts between three-dimensional particles. The technique, described in Part I of this paper, can detect the contact between blocks of any arbitrary shape (convex or concave) and represent the geometrical and physical characteristics prescribed for the contact (e.g. three-dimensional rock joint behaviour). The method utilizes an

efficient data structure which permits the rapid calculation on a personal computer of systems involving several hundred particles. (Author abstract). 4 Refs.

Cundall, P.A. (Univ of Minnesota, Minneapolis, MN, USA). *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 3 Jun 1988 p 107-116.

**091500 FORMULATION OF A THREE-DIMENSIONAL DISTINCT ELEMENT MODEL-PART II. MECHANICAL CALCULATIONS FOR MOTION AND INTERACTION OF A SYSTEM COMPOSED OF MANY POLYHEDRAL BLOCKS.** A three-dimensional formulation of the distinct element method is embodied in computer program 3DEC, which has been adopted to run on a personal computer. This formulation is based on a dynamic (time domain) solution algorithm which solves the equations of motion of a three-dimensional block system by an explicit finite-difference scheme. The scheme is well suited in rock mechanics studies to determine if a discontinuous rock mass will fail under a given set of applied loads. Part II of this paper describes the mechanical calculations of rigid body motion and block interaction. Part II also presents the technique used in 3DEC to generate a three-dimensional model for rock mechanics analysis. Several examples are provided which demonstrate the capabilities of 3DEC and the size of problem that can be analyzed on a personal computer. The examples emphasize the use of microcomputer graphics to assess model results. (Author abstract). 13 Refs.

Hart, R. (Itasca Consulting Group Inc, Minneapolis, MN, USA); Cundall, P.A.; Lemos, J. *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 3 Jun 1988 p 117-125.

**091501 GENERATING A BLOCKY ROCK MASS.** A block generator has been developed to reconstruct the three-dimensional block structure around excavations in rock. The blocky rock mass defined by the generator is an essential input to study of the stability of the jointed rock masses in the vicinity of excavations, using either single block stability analysis techniques, or block model codes. The generation method enables us to include knowledge of the tectonic history of the rock mass in order to make maximum use of the usually limited data on the fracture sets. A computer language BGL (Block Generation Language) has been developed to facilitate application of the method. The main features of BGL are outlined and a tutorial example is presented. Finally, the problem of graphically displaying the joint systems of three-dimensional blocky rock masses is discussed, and a novel graphical display method is presented. (Edited author abstract). 37 Refs.

Heliot, D. (Ecole des Mines, Nancy, Fr). *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 3 Jun 1988 p 127-138.

**Mechanical Properties** See ROCK—Igneous.

#### Permafrost

**091502 DYNAMICS OF THAWING PERMAFROST ROCKS FOR MINING EXCAVATIONS.** Effective operation and evaluation of support systems of mine workings in permafrost require predictions of the dynamics of wall thawing by warm air. Several investigations have been done in this area, but all have the same shortcoming: The studies were done for a constant positive temperature of air in the mine. In practice, however, variable temperatures should be considered, since the workings of all underground mines in the northeastern USSR operate all year round in sign-variable temperature conditions. The present study addresses the problem by algorithmic computer simulation. 8 refs.

Izakson, V.Yu. (Yakutsk State Univ, USSR); Petrov, E.E. *Sov Min Sci* v 23 n 2 Mar-Apr 1987 p 105-110.

#### Plasticity

**091503 FINITE STRAIN ROCK PLASTICITY: STRESS TRIAXIALITY, PRESSURE, AND TEMPERATURE EFFECTS.** An elasto-plasticity theory is used to model the deformation of geological materials

under various confining pressures and moderate temperatures. Based on this theory, dilatancy (i.e., inelastic volumetric expansion) of an intact granite is studied under conventional triaxial stress states. The effect of pressure and temperature on the magnitude of dilation and on the stress (measured relative to the peak stress) at the onset of dilatancy is investigated. It is found that, consistent with experimental data, the theory predicts this stress to be about 50% of the peak stress, but its specific value depends on pressure and temperature. As an illustration, stress-strain curves for intact granite at relatively shallow crustal depths are predicted for application to the study of crustal deformation and the prediction of fault behavior. (Edited author abstract) 61 refs.

Rowshandel, B. (Northwestern Univ, Evanston, IL, USA); Nemat-Nasser, S. *Soil Dyn Earthquake Eng* v 6 n 4 Oct 1987 p 203-219.

#### Pore Pressure

**091504 MESURE DE L'INFLUENCE DE LA PRESSION SUR LA PROPAGATION DE FISSURE DANS LES ROCHES.** [Measuring the Influence of Pressure on Crack Propagation in Rocks]. The influence of pressure on fissure propagation by opening (mode I) in a compact fine-grained rock (Comblanchian limestone) and by plane shearing (mode II) in a stratified rock (slaty shale) has been revealed and measured. In both cases, a linear relation was found between the critical-stress intensity factor and pressure. This relation is illustrated for mode II by applying solid friction effects. (Author abstract) In French. 34 refs.

Biret, F. (CNRS, Talence, Fr); Valentin, G. *Rev Inst Fr Pet* v 42 n 6 Nov-Dec 1987 p 807-825.

#### Porosity

**091505 COMPLIANCE EFFECTS ON PORE PRESSURE DISTRIBUTION.** Initially the rock mass considered has directional attributes caused by joint sets. This means that the discontinuous material is anisotropic to deformation response. If the joints are aligned either parallel or perpendicular to the applied loads, the modes of stress distribution are different and the compliances are lower or upper bound values respectively. For a specific model representing either parallel or perpendicular pore alignment, the relation between applied load and induced pore pressure for each model is different. Terzaghi's effective stress law is a compatibility model, while Bishop and Skempton's induced pore pressure relations are equilibrium models. The difference between stress transfer and stress redistribution is examined. The structural compliance of the soil or rock mass frame is more important than that of the intact material when the porosity is greater than 10%. When porosity is less than 5%, the intact rock material compliance relative to fluid compliance controls the stress distribution between the fluid and intact rock material. (Author abstract) 9 refs.

Chappell, B.A. (Bureau of Mineral Resources, Canberra, Aust). *Min Sci Technol* v 6 n 2 Jan 1988 p 191-204.

**Pressure Effects** See Also COAL MINES AND MINING—Gas Bursts.

**091506 GENERAL TENDENCY OF INITIAL STRESS STATE IN JAPAN WITH THE DATA OF IN-SITU MEASUREMENTS.** An initial stress state considerably affects the stability of an underground opening. In this paper, the authors collect and arrange the data measured at 41 points in Japan by stress relief methods, and discuss the general tendency of initial stress state in Japan. The results exhibit that the magnitude of the vertical stress is close to the overlying rock weight in the most cases, however, the horizontal stress varies with directions and the magnitude of minimum horizontal stress often exceeds that of the vertical stress. The directions of minimum horizontal stresses seem to be consistent with those implied by the geodetic strains. Therefore, the large horizontal compressive stresses in Japan can be affected greatly by crustal movements. (Author abstract). 26 Refs. In Japanese.



Saito, Toshiaki; Ishida, Tsuyoshi; Terada, Makoto; Tanaka, Yutaka. *Doboku Gakkai Rombun Hokokushu* v 9 n 6 Jun 1988 p 71-78.

**Shear Strength** See Also ROCK—Testing.

**091507 ELASTOPLASTIC MODEL WITH DAMAGE FOR STRAIN SOFTENING GEOMATERIALS.** The paper examines certain important aspects of a rate independent model that accounts for distributed damage due to microcrack growth. Material behavior is considered as a mixture of two elastic-plastic interacting components, one termed topical, and the other termed damaged. The mechanisms of failure are considered and discussed with respect to multiaxial stress paths. An explanation of failure, at the microlevel, is given. A series of laboratory tests on a concrete are used to illustrate the development of failure. (Edited author abstract) 46 refs.

Frantziskonis, G.; Desai, C.S. *Acta Mech* v 68 n 3-4 Sep 1987 p 151-170.

**Slope Stability** See MINES AND MINING—Rock Mechanics.

**Stability**

**091508 STATIC ANALYSIS OF THE STABILITY OF THREE-DIMENSIONAL BLOCKY SYSTEMS AROUND EXCAVATIONS IN ROCK.** This paper describes the development of a procedure for three-dimensional analysis of the static stability of an assembly of polyhedral rock blocks around an underground excavation. The method is based on graph theory, and involves systematic analysis of the spatial arrangement of the blocks. The relationship between a structured graph and block system topology is investigated in order to identify removable blocks, i.e. blocks that are geometrically and kinematically free to become detached from the remaining system of blocks. Algorithms to construct paths of removable blocks from a given block system are described, together with post-processing procedures for creating graphic computer displays of the blocky system, and of the stable and unstable blocks. (Author abstract) 20 Refs.

Lin, D. (Univ of Minnesota, Minneapolis, MN, USA); Fairhurst, C. *Int J Rock Mech Min Sci Geomech Abstr* v 25 n 3 Jun 1988 p 139-147.

**Stresses** See Also BAUXITE MINES AND MINING—Rock Mechanics; COAL MINES AND MINING—Stresses; MINES AND MINING—Rock Mechanics; TUNNELS AND TUNNELING—Ground Supports.

**091509 COMPLETE ELASTIC MODEL FOR FLUID-INDUCED AND IN-SITU GENERATED STRESSES WITH THE PRESENCE OF A BOREHOLE.** This paper develops a complete linear elastic model of a square plate with a circular hole in the middle. The model takes into account two horizontal in-situ stresses, the axial stress and stresses due to fluid flow in the borehole and inside the porous plate. The model contains solutions for both plane strain and plane stress conditions. The model has many applications in applied mechanics. In rock mechanics, it gives the total stress field, including the effects to the fluid pressure inside the rock. It may also be used to model the mechanical response of chemical absorption processes like clay swelling or thermal effects. One particular application of the model is in wellbore stability problems as applied to the petroleum and mining industry. Here, the knowledge of the stress fields is of utmost importance for a safe and economical operation. (Edited author abstract) 11 refs.

Sigve Aadnoy, Bernt (Univ of Texas at Austin, Austin, TX, USA). *Energy Sources* v 9 n 4 1987 p 239-259.

**091510 COMPLIANCE EFFECTS ON PORE PRESSURE DISTRIBUTION.** Initially the rock mass considered has directional attributes caused by joint sets. This means that the discontinuous material is anisotropic to deformational response. If the joints are aligned either parallel or perpendicular to the applied loads, the modes of stress distribution are different and the compliances are lower or upper bound values, respectively. For a specific

model representing either parallel or perpendicular pore alignment, the relation between applied load and induced pore pressure for each model is different. Terzaghi's effect stress law is a compatibility model, while Bishop and Skempton's induced pore pressure relations are equilibrium models. The difference between stress transfer and stress redistribution is examined. The structural compliance of the soil or rock mass frame is more important than that of the intact material when the porosity is greater than 10%. When porosity is less than 5%, compliance controls the stress distribution between the fluid and intact rock material. (Author abstract) 9 refs.

Chappell, B.A. (Bureau of Mineral Resources, Canberra, Aust). *Min Sci Technol* v 6 n 3 Mar 1988 p 233-246.

**091511 THREE-DIMENSIONAL STRESS ANALYSIS: A FORMULATION FOR MINING PROBLEMS.** Mathematical and computational aspects of a three-dimensional boundary element formulation designed specifically for application to mining rock mechanics problems are described. Stress analysis of mining geometries differs in many respects from equivalent analyses of civil or mechanical engineering. These differences are highlighted and the manner in which these differences are accommodated by the formulation is described. The formulation has been implemented into a program BEAP (Boundary Element Analysis Package). A test problem is presented and compared with other formulations. Design goals for the program are discussed. A practical mining example is presented. (Edited author abstract) 18 refs.

Diering, J.A.C. (Steffen, Robertson & Kirsten, Johannesburg, S Afr); Yu, Y.S. *Comput Geotech* v 5 n 2 1988 p 151-170.

**Structural Analysis** See GEOPHYSICS—Rock Properties.

**Viscoplasticity**

**091512 VISCOPLASTIC MODEL FOR SOFT ROCK.** The aim of the model is to represent the main features of soft or brittle rock strata, using a small number of physically-meaningful material parameters. The yield surface is based on either the Mohr-Coulomb or Hoek-Brown criterion, and a simple small-dilation flow rule allows the implicit algorithm of elasto-viscoplasticity to be used. Elastic-brittle plastic behaviour is modelled, resulting in stress discontinuities across the interface between intact and failed rock. The effects of lamination and jointing are taken into account. Results are presented for a tunnelling problem with axial symmetry. (Author abstract) 13 refs.

Reed, M.B. (Brunel Univ, Uxbridge, Engl). *Eng Comput (Swansea Wales)* v 5 n 1 Mar 1988 p 65-70.

**ROCK PRODUCTS**

**Inclusions** See CONCRETE AGGREGATES—Chemical Reactions.

**Shaping**

**091513 MECHANICAL DESIGN OF A MEDIUM DUTY STONE SLICING MACHINE.** The article presented here deals with the design of a medium duty stone slicing machine. It is claimed to be an original work in the field of stone slicing. The machine is essentially a compound slider crank mechanism with two degrees of freedom. It incorporates an ingenious blade tensioning and holding device. Power required for machine is 40 HP, with the production capacity being a maximum of 16 slices of 40×40×2 cm per two hours. The design is optimized for processing granite and marble slabs. However, suitable sized slabs of other types can also be processed. (Edited author abstract) 4 refs.

Mathur, Amitabh (Visvesvaraya Regional Coll of Engineering, Nagpur, India); George, C.J.; Suri, Rohit; Thombre, S.B.; Modak, J.P. *Modell Simul Control B* v 10 n 3 1987 p 39-50.

**091514 CONTROLLED FRACTURE IN A FINITE GEOMETRY BODY AS A STONE SHAPING TOOL.** A stone cutting technique capable of manufacturing curved shell sections from rectangular stone slabs has been recently proposed. Initially the rectangular slab of stone is prestressed by means of metal stamp pads which are rubber lined to prevent damage to the stone. Knife edges are then applied to the prestressed system at some fixed distance from the pads. As the load on the knives reaches a critical value, the stone fractures underneath the knife edges. The resulting crack propagation is curved and symmetric. Experiments with a limited number of different stones have shown that the initial angle of crack propagation is practically independent of the type of stone being cut. The purpose of this paper is to perform a preliminary analysis of this fracture process and to quantify such values as the initial angle of crack propagation and the critical knife-to-stamp load ratios producing fracture. (Edited author abstract) 6 refs.

Levy, C. (Florida Int Univ, Miami, FL, USA); Perl, M. *Eng Fract Mech* v 29 n 3 1988 p 263-273.

**ROCK PRODUCTS PLANTS**

**Mechanization**

**091515 PENDELBODENFOERDERER - EIN NEUES FOERDER- UND LAGERSYSTEM FUER SCHUETT- UND STUECKGUT.** [Shuttle Floor Conveyor - A New Conveyor and Storage System for Bulk Material and Unit Goods]. With the introduction of a hydraulically powered shuttle floor conveyor the rock and mineral products industry has at its disposal a new and efficient method for the storage and conveying of unit loads and bulk materials. Thousands of shuttle floor installations are already in use worldwide. The limits of application can be further extended quite considerably, especially in stationary systems. This conveying method offers ample scope for research and development. (Author abstract) In German. 3 refs.

Rappen, A. *ZKG Int Engl Transl* v 41 n 2 Feb 1988 p 95-98.

**ROCKET ENGINES**

**091516 SPACE STATION PROPULSION SYSTEM TECHNOLOGY.** Two propulsion systems have been selected for the space station: O/H rockets for high thrust applications and the multipropellant resistojets for low thrust needs. These thruster systems integrate very well with the fluid systems on the station. Both thrusters will utilize waste fluids as their source of propellant. The O/H rocket will be fueled by electrolyzed water and the resistojets will use stored waste gases from the environmental control system and the various laboratories. This paper presents the results of experimental efforts with O/H and resistojet thrusters to determine their performance and life capability. (Author abstract) 18 refs.

Jones, Robert E. (NASA, Cleveland, OH, USA); Meng, Phillip R.; Schneider, Steven J.; Sovey, James S.; Tacina, Robert R. *NASA Tech Memo* 100108 1987 16p.

**091517 CONCEPTUAL DESIGN AND INTEGRATION OF A SPACE STATION RESISTOJET PROPULSION ASSEMBLY.** The resistojets propulsion module is designed as a simple, long life, low risk system that offers operational flexibility to the Space Station Program. It can dispose of a wide variety of typical Space Station waste fluids by using them as propellants for orbital maintenance. A high-temperature mode offers relatively high specific impulse with long life while a low-temperature mode can propulsively dispose of mixtures that contain oxygen or hydrocarbons without reducing thruster life or generating particulates in the plume. A low-duty cycle and a plume that is confined to a small aft



region minimizes the impacts on the users. Simple interfaces with other Space Station systems facilitate integration. (Edited author abstract)

Tacina, Robert R. (NASA, Cleveland, OH, USA). *NASA Tech Memo* 89847 1987 17p.

**091518 NEW GENERATION OF SPACE ENGINES.** A primary method of launching future spacecraft will be the Space Transportation System (STS). Studies have identified minimum length stages capable of lifting heavy and deployed payloads from the STS low-Earth orbit to geosynchronous Earth orbit using storage or cryogenic propulsion systems. Aerojet TechSystems is presently developing two engines suitable for these stages, a storage engine in the few thousand pound thrust range, and a cryogenic engine with a thrust of only a few hundred pounds. The storage engine breadboard testing has been accomplished, and the flightweight development program will be complete by the end of this decade. A qualified engine is anticipated for service in the early 1990 time frame. The low-thrust cryogenic engine lags this storage engine by approximately three years in development and availability. This paper discusses the technical issues, their solutions, and the development status of these two engines. (Edited author abstract)

Siebenhaar, Adam (Aerojet TechSystems Co, Sacramento, CA, USA). *Acta Astronaut* v 15 n 12 Dec 1987 p 1001-1008.

**091519 OPERATIONAL LIFE IMPROVEMENT OF SSME HIGH-PRESSURE TURBOPUMPS.** The history of the SSME Phase I engine and the design and results of the SSME Phase II Program are presented. Operational life limits and high-maintenance areas of the high-pressure turbopumps are identified. The Phase II design improvements, supporting analyses, and test results are described. The formal certification test program is discussed. Modifications have been made to the high-pressure fuel turbopump to reduce turbine operating temperature, to extend the life of the first- and second-stage turbine blades, and to reduce sheet metal maintenance. Modifications have been made to the high-pressure oxidizer turbopump to improve bearing life and to eliminate subsynchronous whirl. These are discussed in detail. (Edited author abstract)

Hale, James R. (Rockwell Int, Canoga Park, CA, USA); Wood, Byron K. *Acta Astronaut* v 15 n 12 Dec 1987 p 1009-1018.

**091520 HYBRID BOOSTERS FOR ARIANE 5.** Results of a systems analysis are presented which investigates replacing Ariane 5's solid rocket boosters by LOX/polyethylene hybrids. Their advantages and disadvantages are discussed. A performance and mass breakdown is presented. (Author abstract)

Lo, R.E. (DFVLR, Hardhausen-Lampoldshausen, West Ger); Dargies, E. *Acta Astronaut* v 15 n 12 Dec 1987 p 1059-1061.

**091521 ASSESSMENT OF EXISTING AND FUTURE LAUNCH VEHICLE LIQUID ENGINE DEVELOPMENT.** Existing liquid propellant engines for large launch vehicles are described in terms of pertinent engine and propellant parameters and their launch vehicle application. The development approach and the maturity of engine technology which prevailed prior to and early in specific engine development programs are discussed including lessons learned. New engines, including improved conventional and new concepts that could support the next generation launch vehicle, are delineated with emphasis on technology. The technology maturity and development needed to alleviate the potential development risk are presented along with projected gains in performance, operability, reusability, reliability and producibility. A technology ranking methodology which incorporates a relative transportation system life cycle cost (LCC) as the payoff function is developed. The methodology is useful for establishing preliminary but timely cost effectiveness rankings of various technologies. (Edited author abstract) 5 refs.

Stampf, E. (Aerospace Corp, El Segundo, CA, USA); Meyer, L. *Acta Astronaut* v 17 n 1 Jan 1988 p 11-22.

**091522 SPACE STATION PROPULSION.** Two propulsion systems have been selected for the Space Station: gaseous H/O rockets for high thrust applications and the multipropellant resistojets for low thrust needs. These two thruster systems integrate very well with the fluid systems on the space station, utilizing waste fluids as their source of propellant. The H/O rocket will be fueled by electrolyzed water and the resistojets will use waste gases collected from the environmental control system and the various laboratories. This paper presents the results of experimental efforts with H/O and resistojets thrusters to determine their performance and life capability. (Edited author abstract) 23 refs.

Jones, Robert E. (NASA, Cleveland, OH, USA); Morren, W. Earl; Sovey, James S.; Tacina, Robert R. *NASA Tech Memo* 100216 1987 17p.

**091523 AUXILIARY PROPULSION TECHNOLOGY FOR ADVANCED EARTH-TO-ORBIT VEHICLES.** This paper is concerned with the auxiliary propulsion subsystem and the impetus for the current hydrogen/oxygen technology program. A review of the auxiliary propulsion requirements of advanced Earth-to-Orbit (E-T-O) vehicles and their proposed missions is given first. Then the performance benefits of hydrogen/oxygen auxiliary propulsion are illustrated using current shuttle data. The proposed auxiliary propulsion subsystem implementation includes liquid hydrogen/liquid oxygen (LH<sub>2</sub>/LO<sub>2</sub>) primary Reaction Control System (RCS) engines and gaseous hydrogen/gaseous oxygen (GH<sub>2</sub>/GO<sub>2</sub>) vernier RCS engines. A distribution system for the liquid cryogenics to the engines is outlined. The possibility of providing one 'dual-phase' engine that can operate on either liquid or gaseous propellants is being explored. (Edited author abstract) 14 refs.

Schneider, S.J. (NASA, Cleveland, OH, USA). *NASA Tech Memo* 100237 1987 15p.

## Bearings

**091524 SELF-LUBRICATING PERFORMANCE OF HIGH-SPEED BALL BEARING FOR LIQUID HYDROGEN. 2. SELF-LUBRICATING PERFORMANCE IMPROVEMENTS.** This report presents the test results on the self-lubricating performance improvements of a high-speed ball bearing used in the liquid hydrogen turbopump of a liquid oxygen/liquid hydrogen engine (LF-5) in a Japanese H-I rocket. The modified bearing is an rf-sputtered PTFE-film-coated bearing attached to a retainer chemically etched with hydrofluoric acid. (Edited author abstract) In Japanese. 20 refs.

Nosaka, Masataka (Nat'l Aerospace Lab, Kakuda, Jpn). *J Jpn Soc Lubr Eng* v 32 n 12 1987 p 833-838.

## Boosters

**091525 SOVIET TYPE G BOOSTER - A SKEPTICAL VIEW.** This paper examines the available sources of information in an attempt to determine if the Lenin booster ever existed, concentrating on seven aspects of the supposed booster's mission: 1) the mission profile, 2) the Soyuz spacecraft, 3) the Type G engines 4) the Proton booster, 5) the Lunar landing vehicle, 6) the alleged launch date, and 7) the available evidence of the explosion that allegedly occurred upon liftoff of the booster during its first test of July 4, 1969. (Author abstract) 41 refs.

Anderman, D. *J Br Interplanet Soc* v 40 n 5 May 1987 p 223-229.

## Combustion See Also PROPELLANTS—Solid.

**091526 PRESSURE-CONTROLLABLE BURNER.** A modified test burner device called the pressure-controllable burner, based on the conventional T-burner and T-motor, has been constructed for measuring the response function of solid propellant combustion. On this device is mounted a controller system which can modulate the

mean pressure in the burner's chamber according to test needs, and maintain the same pressure level after burnout as before. It can be seen from the test traces that the frequency shifts of acoustic pressure oscillations during the growth period and decay period are slight (less than 5% and 10%, respectively), and the difference between these frequencies is slight. Therefore, the response functions measured by the pressure-controllable burner have higher accuracy and better repeatability as compared with those obtainable from conventional burners. (Edited author abstract) 4 refs. In Chinese.

Sun, Weishen; Fang, Jiming; Zhang, Xunwen; Sui, Ying; Hu, Jingyan. *Bingong Xuebao* v 2 n 3 Aug 1987 p 57-65.

**091527 NUMERICAL ANALYSIS OF SSME PRE-BURNER INJECTOR ATOMIZATION AND COMBUSTION PROCESSES.** The coaxial spray injection and combustion flowfields of a Space Shuttle Main Engine preburner injector element have been analyzed using a three-phase numerical code, with the objective of defining the flame characteristics and obtaining the temperature profiles at various locations downstream. The former is crucial for delineating the factors that control combustion instability and efficiency, whereas the latter is important for ensuring that temperature nonuniformities are within the design limits as the hot gas enters the turbine nozzles. The model is unique in its comprehensiveness of the physics that are incorporated, which include the processes of atomization, evaporation, secondary droplet breakup, multispecies chemistry, and turbulent diffusion. The model produced realistic results of the complex flowfield, yielding information on the liquid jet length, spray shape, flame zone size and characteristics, and droplet properties. The temperature levels are generally in agreement with the available test data. An external group combustion-type of flame is predicted. Salient combustion and mixture features are discussed, and sources of uncertainty are pointed out for future studies. (Author abstract) 18 refs.

Liang, P.Y. (Rockwell Int, Canoga Park, CA, USA); Jensen, R.J.; Chang, Y.M. *J Propul Power* v 3 n 6 Nov-Dec 1987 p 508-514.

## Combustion Chambers

**091528 ADVANCES IN HIGH CHAMBER PRESSURE PROPULSION.** The space shuttle main engine (SSME), a liquid oxygen, liquid hydrogen-fueled rocket engine capable of 512,000 lbf vacuum thrust represented the solution to system requirements of high performance, reusability, and long life. Solutions that NASA/Marshall Space Flight Center (MSFC) pursued to accomplish the high performance, long life goals set for SSME are discussed. In addition, currently projected requirements for liquid rocket engines have identified liquid oxygen/hydrocarbon-fueled engines for booster application in the near future. These advanced hydrocarbon-fueled engines will require improvements in performance and life to be suitable for their projected missions. Raising chamber pressure to increase performance and reduce engine envelope are the key objectives in hydrocarbon-fueled engine technology. (Edited author abstract)

McCool, Alexander A. (NASA, Huntsville, AL, USA); Richmond, Robert J. *Space Technol (Oxford)* v 7 n 4 1987 p 281-285.

**091529 FLOWFIELD IN A DUAL-INLET SIDE-DUMP COMBUSTOR.** The cold flowfield of a side-dump combustor, which consisted of a plexiglass, circular duct with two 60-deg curved inlets located radially at an angle of 180 deg, is measured quantitatively using laser-Doppler velocimetry. Air was used as a flow medium. The Reynolds number, based on the combustor diameter and bulk velocity, was  $2.6 \times 10^4$ . Detailed profiles of mean velocities and turbulence intensities are reported. The impinging stagnation point of the inlet jets, the lengths needed to reach both one-way flow and fully developed mean-velocity profile, and the primary combustor flow regions are determined. In addition, the homogeneity and isotropy of the turbulence are documented.



Furthermore, the results also identify the part of fluid dynamic characteristics unable to be predicted by two-dimensional models. This information will be useful to test and develop combustor modeling in this area. (Author abstract) 17 refs.

Liou, T.-M. (Nat'l Tsing Hua Univ, Taiwan); Wu, S.-M. *J Propul Power* v 4 n 1 Jan-Feb 1988 p 53-60.

## Control

**091530 RESISTOJET CONTROL AND POWER FOR HIGH FREQUENCY AC BUSES.** Resistojets are operational on many geosynchronous communication satellites which all use dc power buses. Multipropellant resistojets were selected for the Initial Operating Capability (IOC) Space Station which will supply 208 V, 20 kHz power. This paper discusses resistojets heater temperature controllers and passive power regulation methods for ac power systems. A simple passive power regulation method suitable for use with regulated sinusoidal or square wave power was designed and tested using the Space Station multipropellant resistojets. The breadboard delivered 20 kHz power to the resistojets heater. (Edited author abstract) 26 refs.

Gruber, Robert P. (NASA, Cleveland, OH, USA). *NASA Tech Memo* 89860 1987 32p.

## Cooling

**091531 UNTERSUCHUNGEN VON FLUESSIGKEITS-FILMSTROMUNGEN BEI HOHEN VERDAMPFUNGSRATEN IM HINBLICK AUF FILMKUEHLUNG.** [Investigation of Annular Flow at High Evaporation Rates with Respect to Liquid Film Cooling]. The process of liquid film cooling of combustion chamber walls subjected to extremely high heat rates is investigated. A theoretical model has been developed for a reliable prediction of the film cooling length. The mass transfer at the liquid-gas interface results from evaporated liquid and entrained liquid droplets. The film cooling length analysis, which includes the physical effects in detail, is separated into two regions: heating the liquid and evaporating the liquid. The theoretical results were experimentally verified at high pressures and temperatures using a modified  $H_2/O_2$ -rocket motor. (Edited author abstract) 71 refs. In German.

Nahtoll, Juergen. *Forschungsber Dtsch Forsch Versuchsanst Luft Raumfahrt* FB 88-08 1988 119p.

## Costs

**091532 LIFE-CYCLE-COST CONSIDERATIONS FOR LAUNCH VEHICLE LIQUID PROPELLANT ROCKET ENGINE.** This paper discusses the engine cost contribution to the life cycle cost of launch vehicles and what cost differences exist between engines designed for expendable and reusable vehicles. The cost drivers in the engine development and production phases, and during vehicle flight operation, are delineated. Analysis of historical cost data and parametric cost modeling were used as a basis for the cost observations. Several measures for potential engine cost reduction are discussed. (Edited author abstract) 11 refs.

Meisl, Claus J. (Rockwell Int, Canoga Park, CA, USA). *J Propul Power* v 4 n 2 Mar-Apr 1988 p 118-126.

## Design See Also SPACE SHUTTLES—Launching.

**091533 DESIGN AND PERFORMANCE TESTS OF A LOW POWER DC ARCJET THRUSTER.** This paper describes a quasi-one-dimensional flow model which can be used for the design of an arcjet thruster. Owing to the simplicity of the model, the performance characteristics of the thruster can be calculated easily to find an optimum configuration suitable for various missions. In order to verify the adequacy of the model, a thruster was fabricated and its performance characteristics were measured. The experimental results were compared with the calculations performed with the model. Both are in satisfactory agreement, and it is concluded that this flow model is a

useful tool for the design of an arcjet thruster. (Edited author abstract) 2 refs.

Nishida, Michio (Kyoto Univ, Jpn); Kaita, Keiji; Tanaka, Ken-ichi. *Mem Fac Eng Kyoto Univ* v 49 pt 4 Oct 1987 p 358-369.

**091534 DUAL-INTERRUPTED-THRUST PULSE MOTOR.** This paper presents the design and testing of a new pulse motor concept designated dual-interrupted-thrust (DIT). The DIT motor incorporates two tandem propellant grains, separated by an interstage bulkhead having a central opening or port. During operation of the first stage, the port, which is substantially larger than the nozzle throat, is closed by a frangible ceramic cover. At a later time, when the second stage is ignited, the port cover shatters into small harmless fragments and the combustion gases flow without significant pressure losses into the empty first-stage chamber and out the nozzle. Static firings conducted to date indicate that DIT is a viable and attractive pulse motor concept. 4 refs.

Carrier, J.L.C. (Defence Research Establishment Valcartier, Que, Can); Constantinou, T.; Harris, P.G.; Smith, D.L. *J Propul Power* v 3 n 4 Jul-Aug 1987 p 308-312.

**091535 DESIGN METHODS IN SOLID ROCKET MOTORS.** This collection of papers contains 10 papers summarizing the state-of-the-art in designing solid rocket motors and their components. The scope is to collect the experience of several countries in using new technologies and new methods which have been developed over the past ten years. Specifically, the papers deal with propellant grain, motor cases, nozzles, internal thermal inhibitions, and general optimization of solid rocket engines. Six papers are in English, four are in French. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10760 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (AGARD, Neuilly-sur-Seine, Fr). *AGARD Lect Ser* n 150, Des Methods in Solid Rocket Mot, Rijswijk, Neth, Athens, Greece, Ankara, Turk and Lancaster, CA, USA, Apr 1987. Publ by AGARD, Neuilly-sur-Seine, Fr, 1987. 244p.

**Electric Propulsion** See Also PLASMAS—Heating; PROPULSION—Electric Energy.

**091536 ARCJET STARTING RELIABILITY: A MULTISTART TEST ON HYDROGEN/NITROGEN MIXTURES.** An arcjet starting reliability test was performed to investigate one feasibility issue in the use of arcjets on board a satellite for north-south stationkeeping. A 1 kW arcjet was run on hydrogen/nitrogen gas mixtures simulating decomposed hydrazine. A pulse width modulated power supply with an integral high voltage starting pulser was used for arc ignition and steady-state operation. The test was performed in four phases in order to determine if starting characteristics was performed in four phases in order to determine if starting characteristics changed as a result of long term thruster operation. More than 300 successful starts were accumulated over an operating time of 18 hr. Overall results indicate that there is a link between starting characteristics and long term thruster operation. (Edited author abstract) 9 refs.

Haag, Thomas W. (NASA, Cleveland, OH, USA); Curran, Frank M. *NASA Tech Memo* 89867 May 11-13 1987 14p.

**091537 LOW POWER dc ARCJET OPERATION WITH HYDROGEN/NITROGEN/AMMONIA MIXTURES.** An experimental investigation was conducted to determine the effect of gas composition and ambient pressure on arcjet operation. Arcjet operation in different facilities was also compared to determine the validity of tests in small facilities. Volt-ampere characteristics were determined for an arcjet using hydrogen/nitrogen mixtures (simulating both ammonia and hydrazine), hydrogen/nitrogen/ammonia mixtures, and pure ammonia as propellants at various flow rates. The arcjet had a typical performance of 450 sec specific impulse at 1 kW with

hydrogen/nitrogen mixtures. It was determined that the amount of ammonia present in the gas stream had a significant effect on the arcjet volt-ampere characteristics. Also, hydrogen/nitrogen mixtures simulating ammonia gave arc characteristics approximately the same as those of pure ammonia. (Edited author abstract) 21 refs.

Hardy, Terry L. (NASA, Cleveland, OH, USA); Curran, Francis M. *NASA Tech Memo* 89876 1987 24p.

**091538 LOW POWER ARCJET THRUSTER PULSE IGNITION.** An investigation of the pulse ignition characteristics of a 1 kW class arcjet using an inductive energy storage pulse generator integral with a pulse width modulated power converter identified several thruster and pulse generator parameters that influence breakdown voltage including pulse generator rate of voltage rise. This work was conducted with an arcjet tested on hydrogen-nitrogen gas mixtures to simulate fully decomposed hydrazine. Over all ranges of thruster and pulser parameters investigated, the mean breakdown voltages varied from 1.4 to 2.7 kV. Ignition tests at elevated thruster temperatures under certain conditions revealed occasional breakdowns to thruster voltages higher than the power converter output voltage. (Edited author abstract) 15 refs.

Sarmiento, Charles J. (NASA, Cleveland, OH, USA); Gruber, Robert P. *NASA Tech Memo* 100123 1987 27p.

**091539 ELECTROMAGNETIC EMISSION EXPERIENCES USING ELECTRIC PROPULSION SYSTEMS - A SURVEY.** As electric propulsion systems become ready to integrate with spacecraft systems, the impact of propulsion system radiated emissions are of significant interest. Radiated emissions from electromagnetic, electrostatic, and electrothermal systems have been characterized and results synopsized from the literature describing 21 space flight programs. Electromagnetic radiated emission results from ground tests and flight experiences are presented with particular attention paid to the performance of spacecraft subsystems and payloads during thruster operations. The impacts to transmission of radio frequency signals through plasma plumes are also reviewed. (Author abstract) 70 refs.

Sovey, James S. (NASA, Cleveland, OH, USA); Zana, Lynnette M.; Knowles, Steven C. *NASA Tech Memo* 100120 1987 35p.

**091540 ARCJET COMPONENT CONDITIONS THROUGH A MULTISTART TEST.** A low-power, dc arcjet thruster was tested for starting reliability using hydrogen-nitrogen mixtures simulating the decomposition products of hydrazine. More than 300 starts were accumulated in phases with extended burn-in periods interlaced. A high degree of flow stabilization was built into the arcjet and the power supply incorporated both rapid current regulation and a high voltage, pulsed starting circuit. A nominal current level of 10 A was maintained throughout the test. Photomicrographs of the cathode tip showed a rapid recession to a steady-state operating geometry. A target of 300 starts was selected, as this represents significantly more than anticipated (150-240), in missions of 10 yr or less duration. Weighings showed no apparent mass loss. Some anode erosion was observed, particularly at the entrance to the constrictor. (Edited author abstract) 18 refs.

Curran, Frank M. (NASA, Cleveland, OH, USA); Haag, Thomas W. *NASA Tech Memo* 89857 May 1987 19p.

**091541 NASA ELECTRIC PROPULSION PROGRAM.** NASA supports electric propulsion for a broad class of missions. Concepts with potential to significantly benefit or enable space exploration and exploitation are identified and advanced toward applications in the near to far term. This paper summarizes recent program progress



in mission/system analyses and in electrothermal, ion, and electromagnetic technologies. (Edited author abstract) 52 refs.

Byers, David C. (NASA, Cleveland, OH, USA); Wasel, Robert A. *NASA Tech Memo* 89856 May 1987 20p.

**091542 2000-HOUR CYCLIC ENDURANCE TEST OF A LABORATORY MODEL MULTIPROPELLANT RESISTOJET.** This paper presents some results of an effort to demonstrate the technological readiness of a long-life multipropellant resistojet for Space Station auxiliary propulsion. A laboratory model resistojet made from grain-stabilized platinum served as a test bed to evaluate the design characteristics, fabrication methods, and operating strategies for an engineering model multipropellant resistojet developed under contract. The laboratory model thruster was subjected to a 2000-hr, 2400-thermal-cycle endurance test using carbon dioxide propellant. Maximum thruster temperatures were approximately 1400°C. The post-test analyses of the laboratory model thruster included an investigation of component microstructures. (Edited author abstract) 12 refs.

Morren, W. Earl (NASA, Cleveland, OH, USA); Sovey, James S. *NASA Tech Memo* 89854 May 1987 22p.

**091543 LOW-POWER ARCJET CYCLIC LIFTEST.** A cyclic lifetest of a low power dc arcjet thruster using a hydrogen/nitrogen propellant mixture simulating hydrazine is currently in progress. Over 300 hr of operation have been accumulated to date in 2 hr duty cycles at a power level of about 1.15 kw, approximating that available on commercial communications satellites. A burn-in period was carried out before consistent operation was attained. After this period, the arcjet operated in a very stable fashion from cycle to cycle. At the beginning of each cycle, there was a brief starting transient followed by a rapid rise to a steady-state voltage. The steady state voltage increased by about 5 v over the first 95 cycles. After this, it increased by only 1 v through the remainder of the test. Thrust measurements taken before the life test and again after the completion of the 144th cycle showed that both thrust, specific impulse, and arc voltage had increased over this period of operation. (Edited author abstract) 24 refs.

Curran, Francis M. (NASA, Cleveland, OH, USA); Hardy, Terry L.; Haag, Thomas W. *NASA Tech Memo* 100233 1987 14p.

**091544 COMPUTATIONAL FLUID DYNAMICS STUDY OF AN MPD THRUSTER.** An unsteady two-dimensional analysis of an MPD accelerator is performed, taking the Hall effect into consideration. Starting from a purely gas-dynamic flow, the MHD equations are numerically integrated both inside and outside a thruster using argon as the propellant. The calculated flow properties, e.g., the current distribution, the specific impulse and the thrust, agree well with available experimental observations. (Edited author abstract) 10 refs.

Yamada, Hiroyuki (Nagoya Univ, Nagoya, Jpn); Fujiwara, Toshi. *Mem Fac Eng Nagoya Univ* v 38 n 2 1986 p 261-278.

**Electromagnetic Propulsion** See Also PROPULSION—Aerospace Applications.

**091545 FAST ACTING VALVE FOR MPD ARCJET.** The article reports on the development of a quasi-steady MPD (Magneto-Plasma-Dynamic) arcjet, which is a typical electric thruster device. Since the quasi-steady MPD arcjet is operated in a pulse mode with a very short time interval between pulses (about 1/1,000 s), it requires a propellant valve having high response characteristics. We have developed a fast acting valve (FAV) as a propellant valve for the MPD arcjet, and found that our FAV is of practical use.

Manago, Masata (IHI, Tokyo, Jpn); Suzuki, Hiroshi; Morimoto, Shinji; Uematsu, Kazuo. *IHI Eng Rev (Engl Ed)* v 19 n 2 Apr 1986 p 99-100.

**Exhausts** See Also SPACE SHUTTLES—Launching.

**091546 LANGMUIR PROBE SURVEYS OF AN ARCJET EXHAUST.** Electrostatic (Langmuir) probes of both spherical and cylindrical geometry have been used to obtain electron number density and temperature in the exhaust of a laboratory arcjet. The arcjet thruster operated on nitrogen and hydrogen mixtures to simulate fully decomposed hydrazine in a vacuum environment with background pressures less than 0.05 Pa. The exhaust appears to be only slightly ionized (less than 1 percent) with local plasma potentials near facility ground. The current-voltage characteristics of the probes indicate a Maxwellian temperature distribution. Plume data are presented as a function of arcjet operating conditions and also position in the exhaust. (Author abstract) 20 refs.

Zana, Lynnette M. (NASA, Cleveland, OH, USA). *NASA Tech Memo* 89924 1987 28p.

**091547 EVALUATION OF ROCKET PLUME SIGNATURE UNCERTAINTIES.** In this study, a method is developed that systematically accounts for and evaluates the uncertainties involved in predicting infrared radiation and emitted from aluminized rocket plumes. The approach consists of identifying the important parameters for plume infrared radiation calculations and then perturbing these parameters individually about a set of nominal values to establish their influence on the emitted radiation. Finally, all of the individual uncertainties are combined using an appropriate statistical method to obtain the uncertainty factor for the infrared plume signature. 26 refs.

Nelson, H.F. (Univ of Missouri-Rolla, Rolla, MO, USA). *J Spacecr Rockets* v 24 n 6 Nov-Dec 1987 p 546-551.

## Fuel Pumps

**091548 THERMAL FINITE-ELEMENT ANALYSIS OF SPACE SHUTTLE MAIN ENGINE TURBINE BLADE.** Finite-element, transient heat transfer analyses were performed for the first-stage blades of the space shuttle main engine (SSME) high-pressure fuel turbopump. Heat transfer coefficients were predicted by performing a boundary-layer analysis at steady-state conditions with the STAN5 boundary-layer code. Two different peak-temperature overshoots were evaluated for the startup transient. Cutoff transient conditions were also analyzed. A reduced gas temperature profile based on actual thermocouple data was also considered. Transient heat transfer analyses were conducted with the MARC finite-element computer code. (Edited author abstract) 11 refs.

Abdul-Aziz, Ali (NASA, Cleveland, OH, USA); Tong, Michael T.; Kaufman, Albert. *NASA Tech Memo* 100117 1987 9p.

## Heat Transfer

**091549 ROTATION EFFECTS ON INHOMOGENEOUS MIXING IN AXISYMMETRIC SUDDEN-EXPANSION FLOWS.** Rotation effects on variable-density co-axial jet mixing in an axisymmetric sudden-expansion geometry are investigated experimentally. A central air jet surrounded by an annular helium/air jet is injected into a circular tube with an enlarged cross-sectional area. Two cases are examined in detail; one stationary and another with a constant speed of rotation of 840 r.p.m. about the tube axis. Results show that mixing between helium and air is greatly enhanced by rotation. (Edited author abstract) 15 refs.

So, R.M.C. (Arizona State Univ, Tempe, AZ, USA); Yu, M.H.; Otugen, M.V.; Zhu, J.Y. *Int J Heat Mass Transfer* v 30 n 11 Nov 1987 p 2411-2421.

**Ignition** See Also PROPELLANTS—Combustion.

**091550 NUMERICAL MODEL FOR PELLET-DISPERSION IGNITER SYSTEMS.** A fairly comprehensive practical numerical method for the description of ignition transient flow behavior of pellet-dispersion igniter

systems is presented. The model was specifically developed for the study of conventional bag and cartridge igniters employed for small-diameter, composite-propellant rocket motors, but the model in its general form may be adapted for the study of a multitude of ignition transient problems. An extensively modified algorithm based on the random-choice method is applied to obtain the solution of the one-dimensional hydrodynamic equations governing the two-phase core flow behavior within the motor chamber and nozzle, in conjunction with pressure-dependent and crossflow-dependent burning rate equations for the solid propellant and igniter pellets. Good agreement is obtained between experimental firing data and predictions from the model for head-end pressure-time profiles. (Author abstract) 16 refs.

Greatrix, D.R. (Univ of Toronto, Toronto, Ont, Can); Gottlieb, J.J.; Constantinou, T. *J Propul Power* v 4 n 5 Sep-Oct 1988 p 412-420.

**Ion Propulsion** See Also PROPULSION—Electric Energy; PROPULSION—Ion Energy.

**091551 EXPLOSIVE PLASMA INJECTORS IN THE STUDY OF CIRCUMTERRESTRIAL SPACE.** Among current active experiments performed in space, important results have been obtained with the help of experiments involving the injection of different chemical substances. Experiments with injection are employed for tracing chemical or physical processes, enabling diagnostics of the natural state of the space medium. With the help of injection it is possible to create a disturbance in the medium and to stimulate natural or artificial processes of a geophysical character. 29 refs.

Ruzhin, Yu.Ya.; Skomarovskii, V.S.; Stadnichenko, I.A.; Titov, V.M.; Shvetsov, G.A. *Combust Explos Shock Waves* v 23 n 3 May-Jun 1987 p 350-357.

**091552 HIGH POWER ION THRUSTER PERFORMANCE.** The ion thruster is one of several forms of space electric propulsion being considered for use on future SP-100-based missions. One possible major mission ground rule is the use of a single Space Shuttle launch. Thus, the mass in orbit at the reactor activation altitude would be limited by the Shuttle mass constraints. When the spacecraft subsystem masses are subtracted from this 'available mass' limit, a maximum propellant mass may be calculated. Knowing the characteristics of each type of electric thruster allows maximum values of total impulse, mission velocity increment, and thrusting time to be calculated. Because ion thrusters easily operate at high values of efficiency (60 to 70 percent) and specific impulse (3000 to 5000 sec), they can impart large values of total impulse to a spacecraft. (Edited author abstract) 24 refs.

Rawlin, Vincent K. (NASA, Cleveland, OH, USA); Patterson, Michael J. *NASA Tech Memo* 100127 1987 14p.

## Manufacture

**091553 PIONEERING COMMERCIAL ROCK-ETRY IN THE UNITED STATES OF AMERICA: THIOKOL'S REACTION MOTORS DIVISION, 1958-1972, PART 3: RMD OPERATIONAL HISTORY.** This article is the continuation of the history of Reaction Motors. Parts 1 and 2 on Reaction Motors, Inc. appeared in the December 1983 and April 1985 issues of this journal, and covered the corporate and project history of the firm up to its merger with the Thiokol Chemical Corporation at midnight, 30 April 1958. Here in Part 3, we trace the operational history of the Reaction Motors Division within Thiokol's Aerospace Group from May 1958 to the demise of the Division 14 years later. (Author abstract) 7 refs.

Ordway, Frederick I. III (Reaction Motors Inc). *J Br Interplanet Soc* v 40 n 9 Sep 1987 p 389-404.



**091554 PIONEERING COMMERCIAL ROCK-ETRY IN THE UNITED STATES OF AMERICA: THIOL'S REACTION MOTORS DIVISION, 1958-1972. PART 4: RMD PROJECT HISTORY.** This article concludes the history of Reaction Motors. Part 3 dealt with the administrative history of Reaction Motors Division of the Thiokol Chemical Corp. and summarized major and minor projects undertaken during the life of the Division, from 1958 to 1972. This concluding part focuses upon the major projects in more detail. These are the Sparrow III, Bullpup, Corvus, Condor, X-15 powerplant, XLR-II engines in Lifting Bodies, and the Surveyor verner, TD-339. (Author abstract) 55 refs.

Winter, Frank H. (Smithsonian Inst, Washington, DC, USA). *J Br Interplanet Soc* v 40 n 9 Sep 1987 p 405-416.

**091555 ENGINE PRODUCTION SOARS WITH BLEND OF CAD/CAM & ROBOTICS.** The article discusses how programming and simulating robots with CAD/CAM streamlines Space Shuttle engine production. Since 1983, NASA and the Rocketdyne Div., Rockwell International have applied robotic technology to produce the Space Shuttle Main Engines (SSME). At the Productivity Enhancement Facility at Marshall Space Flight Center (MSFC), Huntsville, Ala., engineers develop automated welding processes and tooling for robotic work-cells. The engines are produced and assembled at the Rocketdyne production facility in Canoga Park, Calif. A technology transfer program provides a structured communication link between the two centers.

Stiles, Dan (Intergraph Corp). *Prod Eng (Cleveland)* v 34 n 9 Sep 1987 p 54-55, 58-59.

## Materials

**091556 ULTRASONIC NDE OF STRUCTURAL CERAMICS FOR POWER AND PROPULSION SYSTEMS.** A review is presented on research investigations of several ultrasonic evaluation techniques applicable to structural ceramics for advanced heat engines. This review highlights recent work conducted under the sponsorship of and at the Lewis Research Center. Results obtained with scanning acoustic microscopy, scanning laser acoustic microscopy, photo-acoustic microscopy, and scanning electron acoustic microscopy are compared. In addition to these flaw imaging techniques, microstructure characterization by analytical ultrasonics is described. The techniques were evaluated by application to research samples of monolithic silicon nitride and silicon carbide in the form of discs and bars containing naturally occurring and deliberately-introduced flaws and microstructural anomalies. Strengths and limitations of the techniques are discussed. (Author abstract) 13 refs.

Vary, Alex (NASA, Cleveland, OH, USA); Generazio, Edward R.; Roth, Don J.; Baaklini, George Y. *NASA Tech Memo* 100147 1987 11p.

## Mathematical Models

**091557 STUDY OF COMBUSTION AND FLOW BEHAVIOR IN SOLID-PROPELLANT ROCKET MOTORS.** A comprehensive study of several important aspects of the internal ballistics of solid-propellant rocket motors (SRMs) has been undertaken. Numerical models have been developed for the solution of the quasi-steady and unsteady, one-dimensional, hydrodynamic equations of motion governing the two-phase core flow behavior within the motor chamber and nozzle. A new phenomenological model of erosive burning has been developed and incorporated into an overall solid-propellant combustion model, which in turn is solved in conjunction with the equations of motion for the SRM. The quasi-steady internal ballistics predictions based on the phenomenological combustion model are consistent with experimental observation. In concurrence with the quasi-steady flow analysis, a new phenomenological model was also developed for the description of normal acceleration effects on the combustion process, for the parametric study of spinning, composite-propellant SRMs. (Edited author abstract) 15 refs.

Greatrix, D.R. (Univ of Toronto, Can). *UTIAS Rep* 20 Dec 1987 var pagings.

**091558 TWO-DIMENSIONAL MODEL OF THE PLASMA THRUSTER.** Given the condition that the flow generated by a self-induced magnetic field is two-dimensional and steady, a model for the arc region of the plasma thruster is formulated based on magnetohydrodynamic (MHD) descriptions. Use is made of a generalized Ohm's law that includes the Hall and ion slip terms. Characteristics of the arc region are investigated as functions of system parameters. The study shows that the Hall effect causes the current to concentrate severely at the trailing edge of the anode, and it is suggested that if the plasma thruster is a coaxial type, it is better to have the cathode inside. (Author abstract) 7 refs.

Park, Won-Taek (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Choi, Duk-In. *J Propul Power* v 4 n 2 Mar-Apr 1988 p 127-132.

## Nondestructive Examination

**091559 DYNAMIC REAL-TIME RADIOGRAPHY OF SOLID-PROPELLANT ROCKET MOTORS DURING STATIC FIRING.** A radiographic testing setup that allows better understanding of internal-component behavior of solid-propellant rocket motors during static firing has been developed by the Naval Weapons Center (NWC), China Lake, CA. The radiographic systems used are rugged and capable of withstanding rocket motor malfunctions, usually with little or no damage. The testing method, used for both high-energy and low-energy systems, offers several benefits: reasonable cost, probability, protection of equipment, and valuable data. This paper discusses the radiographic systems in use at NWC by describing their capabilities and the functions of their various components and outlines the safety considerations in using each system. High-energy as well as low-energy systems and applications are discussed. (Author abstract) 2 refs.

Rogerson, D.J. *Mater Eval* v 45 n 11 Nov 1987 p 1330-1333.

## Nozzles See Also FLOW OF FLUIDS—Nozzles; HEAT TRANSFER—Nozzles.

**091560 EXPERIMENTAL STUDY OF LOW REYNOLDS NUMBER NOZZLES.** High-performance electrothermal thrusters operate in a low nozzle-throat Reynolds number regime. Under these conditions, the flow boundary layer occupies a large volume inside the nozzle, contributing to large viscous losses. Four nozzles (a conical, bell, trumpet, and modified trumpet) and a sharp-edged orifice were evaluated over a Reynolds number range of 500 to 9000 with unheated nitrogen and hydrogen. The nozzles showed significant decreases in specific impulse efficiency with decreasing Reynolds number. At Reynolds numbers less than 1000, all four nozzles were probably filled with a large boundary layer. The discharge coefficient decreased with Reynolds number in the same manner as the specific impulse efficiency. The bell and modified trumpet nozzles had discharge coefficients 4 to 8 percent higher than those of the cone or trumpet nozzles. (Edited author abstract) 14 refs.

Grisnik, Stanley P. (NASA, Cleveland, OH, USA); Smith, Tamara A.; Saltz, Larry E. *NASA Tech Memo* 89858 1987 12p.

**091561 COMPARISON OF TWO PROCEDURES FOR PREDICTING ROCKET ENGINE NOZZLE PERFORMANCE.** Two nozzle performance prediction procedures which are based on the standardized JANAF methodology are presented and compared for four rocket engine nozzles. The first procedure required operator intercedence to transfer data between the individual performance programs. The second procedure is more automated in that all necessary programs are collected into a single computer code, thereby eliminating the need for data reformatting. Results from both procedures show similar trends but quantitative differences. Agreement was best in the predictions of specific impulse and local skin

friction coefficient. Other compared quantities include characteristic velocity, thrust coefficient, thrust decrement, boundary layer displacement thickness, momentum thickness, and heat loss rate to the wall. (Edited author abstract) 8 refs.

Davidian, Kenneth J. (NASA, Lewis Research Cent, Cleveland, OH, USA). *NASA Tech Memo* 89814 1987 14p.

**091562 DETAILED DESCRIPTION OF THE UNCERTAINTY ANALYSIS FOR HIGH AREA RATIO ROCKET NOZZLE TESTS AT THE NASA LEWIS RESEARCH CENTER.** A preliminary uncertainty analysis has been performed for the High Area Ratio Rocket Nozzle test program which took place at an altitude test capsule. Results from the study establish the uncertainty of measured and calculated parameters required for the calculation of rocket engine specific impulse. A generalized description of the uncertainty methodology employed is provided. Specific equations used and a detailed description of the analysis are presented. Verification of the uncertainty analysis model was performed by comparison with results from the experimental program's data reduction code. (Edited author abstract) 30 refs.

Davidian, Kenneth J. (NASA, Cleveland, OH, USA); Dieck, Ronald H.; Chuang, Isaac. *NASA Tech Memo* 100203 1987 28p.

**091563 PERFORMANCE OF HIGH-AREA-RATIO NOZZLE FOR A SMALL ROCKET THRUSTER.** Theoretical estimates of supersonic nozzle performance were compared to experimental test data on nozzles with area ratios of 100:1 (conical) and 300:1 (optimum contour) and on 300:1 nozzles cut off at 200:1 and 100:1. These tests were performed on a 5 lbf monopropellant hydrazine thruster with chamber pressures of 25-135 psia. The analytic method used was the conventional inviscid method of characteristic with a correction for laminar boundary-layer displacement and drag. (Edited author abstract) 4 refs.

Kushida, Raymond (Hughes Aircraft Co, El Segundo, CA, USA); Hermel, Jerry; Apfel, Steve; Zydowicz, Michael. *J Propul Power* v 3 n 4 Jul-Aug 1987 p 329-333.

## Nuclear Energy See Also SPACECRAFT—Interplanetary.

**091564 STUDY OF SCHWARZ CONVERTERS FOR NUCLEAR POWERED SPACECRAFT.** High power space systems which use low dc voltage, high current sources such as thermoelectric generators, will most likely require high voltage conversion for transmission purposes. This study considers the use of the Schwarz resonant converter for use as the basic building block to accomplish this low-to-high voltage conversion for either a dc or an ac spacecraft bus. The Schwarz converter has the important assets of both inherent fault tolerance and resonant operation and parallel operation in modular form is possible. A regulated dc spacecraft bus requires only a single stage converter while a constant frequency ac bus requires a cascaded Schwarz converter configuration. If the power system requires constant output power from the dc generator, then a second converter is required to route unneeded power to a ballast load. (Author abstract) 15 refs.

Stuart, Thomas A. (Univ of Toledo, Toledo, OH, USA); Schwarze, Gene E. *NASA Tech Memo* 89911 1987.

**091565 STUDY OF SCHWARZ CONVERTERS FOR NUCLEAR POWERED SPACECRAFT.** High-power space systems which use low dc voltage, high current sources such as thermoelectric generators, will most likely require high voltage conversion for transmission purposes. This study considers the use of the Schwarz resonant converter for use as the basic building block to accomplish this low-to-high voltage conversion for either a dc or an ac spacecraft bus. The Schwarz converter has the important assets of both inherent fault tolerance and



resonant operation and parallel operation in modular form is possible. A regulated dc spacecraft bus requires only a single stage converter while a constant frequency ac bus requires a cascaded Schwarz converter configuration. If the power system requires constant output power from the dc generator, then a second converter is required to route unneeded power to a ballast load. (Author abstract) 15 refs.

Stuart, Thomas A. (Univ of Toledo, Toledo, OH, USA); Schwarze, Gene E. *NASA Tech Memo* 89893 1987 11p.

**091566 NUCLEAR FERRY - Cislunar Space Transportation Option of the Future.** This paper summarizes the results of a study concerning the use of solid Core Nuclear Rocket Engines in future commercial space transportation systems. Tungsten-water moderated reactors were chosen to be the most desirable reactor type due to high specific impulse, lowest weight and longest life time. A Life Cycle Cost analysis for a 50 year life-time demonstrated that nearly 50% of the total LCC are consumed by Earth-to-LEO transportation cost. Orbital burden cost due to ferry maintenance and repair were found to be the second important cost driving factor. Increased vehicle size reduced the specific transportation cost only slightly while smaller vehicles increase cost significantly. (Author abstract) 9 refs.

Thomas, Ulrich (Technical Univ of Berlin, Berlin, West Ger). *Space Technol (Oxford)* v 7 n 3 1987 p 227-234.

**Optimization** See ROCKETS AND MISSILES—Orbits and Trajectories.

**Performance** See Also PROPULSION—Electric; PROPULSION—Electric Energy.

**091567 THRUST MODULATION IN HYBRID ROCKET ENGINES.** An experimental investigation of hybrid rocket engines (HRE) is performed to study the throttling performance within a thrust range of 10:1. Controllable, stable, and reproducible throttling properties were demonstrated down to 10% of thrust. The performance with gasification demonstrated the general feasibility of wide-range throttling with fixed-injection geometry. The paper outlines a method for calculating the ballistic behavior of hybrid propellant combinations that is based upon the regression characteristic and the effects of gasification. (Edited author abstract) 11 refs.

Waldmann, W. (DFVLR, Lampoldshausen, West Ger). *J Propul Power* v 4 n 5 Sep-Oct 1988 p 421-427.

**Propellants** See Also PROPELLANTS—Combustion; PROPELLANTS—Liquid; PROPELLANTS—Solid; PROPELLANTS—Aerospace Applications.

**091568 LIQUID ROCKET ENGINE PROPELLANT FLOW PATH OPTIMIZATION METHODS.** One of the basic questions arising in liquid rocket engine propellant flow path design is selection of the flow areas in the various segments. We propose methods for calculating the flow section area of a propellant flowpath segment with account for the influence of the other segments, the turbopumps, and the final flight speed and altitude. 2 refs.

Astakhov, B.A.; Sokolov, N.S. *Sov Aeronaut* v 30 n 2 1987 p 12-16.

**091569 DIRECT MEASUREMENT OF HIGH FREQUENCY, SOLID PROPELLANT, PRESSURE-COUPLED ADMITTANCES.** This paper presents an experimental method that is capable of directly measuring solid propellant pressure-coupled responses at the high frequencies associated with tangential mode instabilities inside solid propellant rocket motors. The method utilizes a magnetic flowmeter to measure the velocity oscillation above a burning propellant surface simultaneously with a pressure oscillation measurement within an externally excited combustion chamber. A magnetic flowmeter burner was designed and constructed to evaluate this method of pressure-coupled response measurement. Response measurements were obtained for two formulations of AP/HTPB composite propellant at pressure oscillation frequencies of 4000 and 8000 Hz. The measurement data

displayed repeatable trends in both the real and imaginary parts of the pressure-coupled response function. (Author abstract) 8 refs.

Wilson, J.R. (Pennsylvania State Univ, University Park, PA, USA); Micci, M.M. *J Propul Power* v 3 n 4 Jul-Aug 1987 p 296-302.

## Pumps

**091570 EXPERIMENTAL STUDY ON HIGH-PRESSURE GAS SEALS FOR A LIQUID OXYGEN TURBOPUMP.** An experimental study on high-pressure gas seals was carried out in order to investigate the feasibility of a liquid oxygen (LOX) turbopump rotating-shaft seal system for Japan's LE-7 rocket engine. Floating-ring seals 50 millimeters in diameter were successfully operated under the following conditions: a maximum rotational speed of 25,000 rpm and a maximum sealed hydrogen gas pressure of about 15 MPa. The leakage rates obtained in the experiment were in good agreement with analytical results obtained from a quasi-one-dimensional compressible flow equation. A 100-millimeter-diameter double segmented hydrodynamic circumferential seal designed for a helium gas purge system was tested in order to investigate the wear process of the carbon segmented-rings. The seal was operated for about 1.5h under the following conditions: a helium purged-gas pressure of about 0.6 MPa and a rotational speed of about 20,000 rpm. Under these conditions rubbing contact between the carbon segmented-rings and the runner occurred; however, the wear rates of carbon segmented-rings decreased with time and the maximum wear depth was less than 10µm after this test. (Edited author abstract) 5 refs.

Oike, Mamoru (Nat'l Aerospace Lab, Miyagi, Jpn); Nosaka, Masataka; Watanabe, Yoshiaki; Kikuchi, Masataka; Kamijo, Kenjiro. *Tribol Trans* v 31 n 1 Jan 1988 p 91-97.

## Reliability

**091571 PRETEST UNCERTAINTY ANALYSIS FOR CHEMICAL ROCKET ENGINE TEST.** A parametric pretest uncertainty analysis has been performed for a chemical rocket engine test at a unique 1000:1 area ratio altitude test facility. Results from the parametric study provide the error limits required in order to maintain a maximum uncertainty of 1 percent on specific impulse. Equations used in the uncertainty analysis are presented. (Author abstract)

Davidian, Kenneth J. *NASA Tech Memo* 89819 1987 15p.

**091572 CONFIDENCE LIMITS FOR STRESS-STRENGTH MODELS WITH EXPLANATORY VARIABLES.** A lower confidence bound is obtained for  $P(Y > X | z_1, z_2)$ , where  $X$  and  $Y$  are independent normal variables, with explanatory variables  $z_1$  and  $z_2$ , respectively. For equal residual variances, an exact solution is obtained, but for the unequal variance case, an approximate lower confidence bound is developed. Examples of the use of these procedures are given. One of the examples deals with the strength of a rocket motor. (Edited author abstract) 8 refs.

Guttman, I. (Univ of Toronto, Toronto, Ont, Can); Johnson, R.A.; Bhattacharyya, G.K.; Reiser, B. *Technometrics* v 30 n 2 May 1988 p 161-168.

## Repair

**091573 EXPERIENCE OF THE SALYUT-7 PROPULSION SYSTEM (PS) REPAIR OPERATIONS.** The paper describes the initiation and nature of the propulsion system contingency situation and analyzes the capabilities for its elimination. Covered are methods and program development to provide repair-restoration operations; (RRO) equipment development and manufacture (instruments, rigging, devices etc.); and ground-based repair-restoration operations on mock-ups and cosmonaut training.

Ovchinnikov, V.S. (Moscow Aviation Inst, Moscow, USSR). *Acta Astronaut* v 15 n 9 Sep 1987 p 719-723.

**Research** See PROPULSION—Aerospace Applications.

**Seals** See SPACE SHUTTLES—Design.

**Service Life** See SPACE SHUTTLES.

## Stability

**091574 ACOUSTIC MODE DETERMINATION IN SOLID ROCKET MOTOR STABILITY ANALYSIS.** It is the purpose of this work to show that the classical rigid-wall assumption used to evaluate the chamber acoustic modes does not ensure the independence of the stability integrals from the location of the aft closure plane. This point is particularly crucial when the nozzle length is not small compared to the motor length. A simple acoustic admittance boundary condition will be proposed that greatly improves the stability analyses through an improved reference acoustic mode determination. 8 refs.

Vuillot, Francois (Office Nat'l d'Etudes et de Recherches Aerospatiales, Chatillon, Fr). *J Propul Power* v 3 n 4 Jul-Aug 1987 p 381-384.

**091575 PULSED INSTABILITY IN ROCKET MOTORS: A COMPARISON BETWEEN PREDICTIONS AND EXPERIMENTS.** A series of 18 pulsed motor tests was conducted in heavy-wall solid rocket motors having an internal case diameter of 8.38 cm. The motor length was varied from 0.61 - 1.22 m. Three related reduced-smoke propellants and four different grain designs were tested. All of the motors were linearly stable and all were pulsed into nonlinear instability. The data from this test series were used to evaluate the validity of previously developed pulser models and to evaluate the ability of a previously developed nonlinear instability analysis to predict the observed trends in the data. (Edited author abstract) 17 refs.

Baum, Joseph D. (US Air Force Rocket Propulsion Lab, Edwards AFB, CA, USA); Levine, Jay N.; Lovine, Richard L. *J Propul Power* v 4 n 4 Jul-Aug 1988 p 308-316.

**Testing** See Also ENGINEERING EDUCATION—Demonstrations.

**091576 DATA-ACQUISITION AND PROCESSING SYSTEM FOR SIX-COMPONENT SOLID ROCKET MOTOR TESTING.** This paper describes a system using a DPD-11/03 microcomputer for the data acquisition and processing in six-component tests for solid rocket motors, giving the chief technical performance, structural components, functions and features of the system. Experimental data are collected and a comparison is made between those manually and computer processed. Static precision of the test system is given. (Edited author abstract) In Chinese.

Li, Zhaomin; Liu, Jing; Li, Baojiang; Xu, Zhuping. *Binggong Xuebao* v 2 n 3 Aug 1987 p 73-75.

**091577 LIFE TEST OF A 22-NEWTON (5-LBF) HYDRAZINE ROCKET.** Life tests were conducted on a 22-N (5-lb) hydrazine rocket thruster which incorporates the latest technology to obtain long life from the catalyst bed. A spring mechanism surrounding the catalyst bed continually applies compression to the catalyst bed to prevent the formation of any void channels. The thruster was tested over an operational cycle of both steady-state and pulse firing which simulated a possible Space Station duty cycle. It ran as expected for about 40 hr, or  $3.2 \times 10^6$  N-sec ( $7.2 \times 10^5$  lb-sec) total impulse. Subsequently, some thrust chamber pressure decreases were noted during long steady-state test periods. After 60.2 hr of run time, the tests had to be terminated due to a blockage in the propellant injector tube which occurred during heating of the thruster by a heat lamp. The thruster had accrued over  $4.8 \times 10^6$  N-sec ( $1.1 \times 10^6$  lb-sec) of total impulse before



the injector tube was inadvertently blocked. After disassembly and inspection of the thruster, a chemical analysis of the catalyst indicated that iron and nickel metals had poisoned some of the catalyst, thereby causing a degradation in performance. (Edited author abstract) 5 refs.

Meng, P.R. (NASA, Cleveland, OH, USA); Schneider, S.J.; Morgan, C.J.; Jones, R.E.; Pahl, D.A. *NASA Tech Memo* 100232 1987 11p.

**091578 ROCKET ALTITUDE TEST FACILITIES REGISTER.** This publication deals with testing of rocket engines under altitude simulation prior to the first flight test with the objective of precise measurement of specific impulse under vacuum conditions. The data related to altitude simulation facilities currently existing in the western world are compiled. Emphasis is placed on facilities capable of performing research and development tests. 32 refs.

Ducasse, P. (NATO, Neville sur Seine, Fr). *AGARDograph* n 297 Mar 1987 82p.

**091579 DEVELOPMENT STATUS OF LE-7.** The National Space Development Agency of Japan (NASDA) is now developing the H-II launch vehicle which can place a 2 ton payload into a geostationary orbit. The first stage of H-II uses a cryogenic engine, named LE-7, in combination with two solid rocket boosters. LE-7 is a staged combustion cycle engine with a thrust of 1180 kN and a specific impulse of 4405 Ns/kg in vacuum. The development program of LE-7 is now in a component development phase. This paper presents the results of the following tests: tests of the combustion devices (igniters, preburner, main chamber); tests of the fuel turbopump; and tests of the oxidizer turbopump. 6 refs.

Torii, Yoshihiro (Natl Space Development Agency of Japan, Tokyo, Jpn); Sogame, Eiji; Kamijo, Kenjiro; Ito, Takahiro; Suzuki, Koichi. *Acta Astronaut* v 17 n 3 Mar 1988 p 331-340.

**Theory See PROPULSION—Aerospace Applications.**

## Thermoanalysis

**091580 TWO-DIMENSIONAL FINITE DIFFERENCE PROGRAM FOR THERMAL ANALYSIS OF ROCKET THRUST CHAMBERS.** A two-dimensional finite difference computer model for thermal analysis of rocket thrust chambers has been developed. The model uses an iterative scheme for calculating the temperature distribution within the chamber wall and implements a successive overrelaxation formula for a quick convergence. The inputs of the model are the dimensions of the thrust chamber wall, types of materials used, heat transfer coefficients and temperatures of the hot gas and the coolant. The resulting output of the program consists of the nodal temperature distribution, heat transfer to the coolant, and heat transfer from the hot gas. (Author abstract)

Naraghi, Mohammad H. (NASA, Cleveland, OH, USA). *NASA Tech Memo* 100191 Sep 1987 51p.

**ROCKETS AND MISSILES** See Also AIRCRAFT—Control; MILITARY ENGINEERING—Electronic Warfare; MILITARY ENGINEERING—Operations Research; SATELLITES—Design; SHOCK WAVES; WARSHIPS—Preservation.

**091581 ON THE RELATIVISTIC THEORY OF ROCKET FLIGHT.** It is shown by macroscopic analysis that, when the entire mass of a rocket is consumed for creating thrust, objects may be obtained as a result having energy but zero mass, moving the velocity of light. It is shown that the boost process of such massless objects can be realized in finite time from the observer's point of view. The vast stellar luminosity of quasars and certain jet motions observed in remote space can be explained by the production of massless radiation with internal motions connected with the separation of large energies inside the stars. (Author abstract) 2 refs.

Sedov, L.I. *Appl Math Mech* v 50 n 6 1986 p 700-705.

**091582 ENTWICKLUNG EINES STAUANTRIEBS FUER DEN FLUGKOEPEREREINSATZ.** [Ramjet Development for Missile Propulsion]. A summary of basic aspects of the application of ramjet engines to missile propulsion is followed by a presentation of the technological studies and flight testing of an experimental missile by MBB. This work was performed in preparation for the current development of an engine to be used in a tactical missile. The status of this development is also reviewed. The existing experience in this field will be useful for the recently discussed application of ramjet propulsion to advanced space transport. (Author abstract) 8 refs. In German.

Pohl, W.-D. (Messerschmidt-Boelkow-Blohm GmbH, Munich, West Ger). *Z Flugwiss Weltraumforsch* v 12 n 2 Mar-Apr 1988 p 80-88.

**091583 COMPUTATION ON SHOCK STRUCTURES OF THE ROCKET EXHAUST PLUMES.** The physical solution of the initial and boundary problems of the rocket and missile impingement with complex shock structures in arbitrary bounded flow fields has been calculated in this paper. The formulae of Godunov's scheme on irregular grid are derived here. A body-fitted coordinates network constructed by using Thompson's Method is applied in our calculation. Some results of the interactions of the rocket exhaust plumes and strong impingement solved in second class grid have also been given. (Author abstract) 6 refs. In Chinese.

Zhang, Fuxiang; Lian, Wenyu. *Bingong Xuebao* n 2 May 1988 p 9-16.

## Accident Prevention

**091584 LABORATORY SHIELDING FOR PROJECTILES.** This paper addresses the considerations for containing missiles with different types of shielding; the blast resistance of shielding is not discussed. Missile hazards are often accompanied by blast waves. Rigid walls of steel or reinforced concrete are usually needed for blast resistance. However, if a shield is to be designed to withstand both blast and missiles, the thickness required to stop the missiles will almost always be adequate to absorb the blast wave. Preliminary cost estimates, therefore, need be based only on consideration of missiles. For detailed design, the services of a competent structural engineer with dynamic design experience are required to ensure that the supports for the walls are adequate for any blast forces. 8 refs.

Ciolek, William H. (Amoco Corp, Naperville, IL, USA). *Plant Oper Prog* v 7 n 2 Apr 1988 p 79-86.

**Aerodynamics** See Also AERODYNAMICS—Wings and Airfoils.

**091585 STROEMUNGSSICHTBARMACHUNG AN EINEM HOCHGESTELLTEN OGIVKREISZYLINDER RUMPF MIT HILFE DER LASERLICHTSCHNITT-METHODE.** [Performance Analysis and Tuning of Error Control Procedures in Communication Protocols]. In the first part of this work the performance of error control procedures in high-speed satellite channels is investigated. For this purpose a new performance measure, the tolerable bit error rate, is introduced and calculated for different throughput requirements and error control procedures. Furthermore, a new class of satellite link protocols is described and analyzed. In the second part, satellite channels are considered as incorporated in a terrestrial network. Assuming an end-to-end connection with one satellite link, the interaction of Go-Back-N and Selective Repeat protocols with the ISO - transport protocol is investigated by means of queueing network models. (Author abstract) In German. 11 refs.

Sausen, Frank (DFVLR, Goettingen, West Ger). *Forschungsber Dtsch Forsch Versuchsanst Luft Raumfahrt* 86-45 1986 57p.

**091586 VORTEX FILAMENT MODEL OF THE WAKE BEHIND A MISSILE AT HIGH ANGLE OF**

**ATTACK.** A method for calculation of the flow past a missile at high angle of attack is described in which the vortex wake is approximated by means of three-dimensional vortex filaments attached to given open separation lines. The condition of tangential flow on the body is satisfied by use of quadrilateral source panels. Each filament consists of straight-line segments, ending in a semi-infinite segment parallel to the freestream, and is made part of a system of vortices of horseshoe type by means of connecting segments inside the body. The method involves the simultaneous calculation of the rollup and circulations of the vortex filaments, using conditions that hold along the juncture of a separating vortex sheet and the body. Calculations are presented for a blunted ogive cylinder at 10-deg incidence and for a hemisphere cylinder at 19-deg incidence, starting from separation lines obtained by use of the thin-layer Navier-Stokes equations. (Author abstract) 22 refs.

Van Tuyl, Andrew H. (Naval Surface Weapons Cent, Silver Spring, MD, USA). *AIAA J* v 26 n 3 Mar 1988 p 264-270.

**091587 COMPUTER AIDED AERODYNAMIC DESIGN OF MISSILE CONFIGURATION.** Aerodynamic configurations of tactical missiles have to produce the required lateral force with minimum time lag to meet the required maneuverability and response time. The present design which is mainly based on linearized potential flow involves (a) identification of critical design points, (b) design of lifting components and their integration with mutual interference, (c) evaluation of aerodynamic characteristics, (d) checking its adequacy at other points, (e) optimization of parameters and selection of configuration, and (f) detailed evaluation including aerodynamic pressure distribution. Iterative design process is involved because of the mutual dependence between aerodynamic characteristics and the parameters of the configuration. (Edited author abstract) 5 refs.

Panneerselvam, S. (Defence R&D Lab, Hyderabad, India); Theerthamalai, P.; Sarkar, A.K. *Def Sci J* v 37 n 4 Oct 1987 p 469-481.

## Calculations

**091588 ACCURACY ESTIMATION OF MISSILE MISS DISTANCE DETERMINED BY MONTE CARLO METHOD.** The authors introduce the application of Monte Carlo method to the calculation of the missile miss distance. A new method for estimating the accuracy of missile miss distance is determined by Monte Carlo method. In this method the authors use statistical principles to define the reliable intervals of the expectation  $E(\eta)$  and the mean variance  $\sigma$ . The calculated results show that this method is very useful and convenient in practice. (Edited author abstract). 6 Refs. In Chinese.

Zhou, Fengqi (Northwestern Polytechnical Univ, China); Li, Yanjun. *Xibei Gongye Daxue Xuebao* v 6 n 3 Jul 1988 p 271-280.

**Computer Aided Design** See AERODYNAMICS—Supersonic.

## Control

**091589 EFFECT OF GIMBAL FRICTION MODELING TECHNIQUE ON CONTROL STABILITY AND PERFORMANCE FOR CENTAUR UPPER STAGE.** The powered-phase autopilot for the Centaur upper stage rocket uses an autopilot forward loop gain scheduler that decreases the proportional gain as propellant mass is depleted. Nonlinear time response simulation studies revealed that Centaur vehicles with low-gain autopilots would have large attitude error limit cycles. These limit cycles were due to the assumed presence of Coulomb friction in the engine gimbals. This situation could be corrected through the use of an harmonic 'dither,' programmed into the on-board digital computer and added to the engine command signal. Control authority was found to be restored when dither was used. It is recommended that autopilot simulation studies for future Centaur vehicles include a bend and slide engine gimbal friction



model, with a small amount of Coulomb friction, modeled as part of the actuator dynamics, for a conservative stability analysis. (Edited author abstract) 10 refs.

Graham, Ronald E. (NASA, Cleveland, OH, USA). *NASA Tech Memo* 89894 1987 9p.

**091590 CONTROLLABILITY OF MOTION OF A BALLISTIC FLIGHT VEHICLE IN THE PITCH PLANE DURING THE ACTIVE LEG OF THE TRAJECTORY.** We employ methods of the mathematical theory of controllability to establish the possibility of neutralizing the effects of perturbations (for whatever reason) of the magnitude of the apparent acceleration, of a ballistic flight vehicle, by means of correction of its orientation (correction of the calculated program of angular pitch rotation). Our study provides a theoretical substantiation of the correctness of the electromechanical methods of inertial guidance for ballistic flight vehicles that were developed earlier by the author. (Author abstract) 4 refs.

Korenevskii, D.G. *Mech Solids* v 22 n 3 1987 p 1-5.

## Costs

**091591 MISSILE PROPULSION COST MODELING.** An approach for parametric propulsion system cost modeling is presented and is illustrated by Cost Estimating Relationships (CERs) for unit production costs of solid propellant booster stages. Due to their relative simplicity, the costs obtained from the CERs represent only first order approximations of booster stage costs. They were developed from cost and technical data of historical propulsion systems available in the open literature. The approach for developing the CERs is outlined and the rationale for the selection of independent parameters is presented. The analysis of the cost data revealed several generic observations and rules of thumb. These are given since they might prove useful for back of the envelope type cost predictions. (Edited author abstract). 2 Refs.

Meisl, Claus J. (Rockwell Int, Canoga Park, CA, USA). *Eng Costs Prod Econ* v 14 n 2 Jul 1988 p 117-129.

## Cryogenic Equipment

**091592 NOVEL APPROACH TO SUPERCRITICAL HELIUM FLIGHT CRYOSTAT SUPPORT STRUCTURES.** A unique system for structural support of optical flight cryostats has been designed, constructed, fully tested and flight qualified. The principal feature is a single epoxy fiberglass cylinder which serves both as a radiation shield cooled over its entire length and as an integral part of the internal structural support. The result is a high cryogen to package ratio, with simple and reliable mechanical joints and no additional adhesive bonds required in the structural load path. Additional advantages include quicker fabrication, low cryogen usage rates, and a rigid support. (Edited author abstract) 2 refs.

Maguire, J.F. (Janis Research Co, Wilmington, MA, USA); Ramsden, J.D.; Wolman, D.E. *Cryogenics* v 28 n 2 Feb 1988 p 142-146.

## Design

**091593 H-II ROCKET: NEW JAPANESE LAUNCH VEHICLE IN THE 1990s.** In order to acquire a launch capability quickly Japan's space program initially relied heavily on US technology. Now, however, with the H-II rocket they are embarking on a launch vehicle which is domestically designed and manufactured and promises to be internationally competitive. This article describes the technical features of H-II and outlines Japan's plan for space in the twenty-first century. (Author abstract) 10 refs.

Godai, Tomifumi. *Endeavour* v 11 n 3 1987 p 116-121.

**Fuel Tanks** See SPACE SHUTTLES—Thermal Insulation.

**Guidance** See Also NAVAL WARFARE; OPTICAL FIBERS—Reliability.

**091594 FIELD TEST RESULTS ON THE USE OF TRANSLATED GPS FOR TRIDENT I.** The U.S. Navy contracted the development and construction of a demonstration translated GPS tracking system to assess the technical risk of using GPS for range safety and to demonstrate tracking accuracy. Field tests were conducted with the completed system using scheduled Trident I (C-4) test launches. This paper describes the translated GPS tracking system concept, the field tests that were performed, and the results of those field tests. (Edited author abstract) 2 refs.

Wells, Lawrence L. (Interstate Electronics Corp, Anaheim, CA, USA). *Navigation* v 34 n 2 Summer 1987 p 115-123.

**091595 OPTIMAL INTERCEPT GUIDANCE LAW WITH UNCERTAINTY FACTORS AND NORMAL CONSTRAINT.** From the point of view of a differential game, an optimal intercept guidance law with uncertainty factors and normal constraint is discussed using minimum-maximum principle. It is assumed that the kinetic characteristics of the guided object is a first order lag loop; the minimum control energy consumption is taken as the performance index; the terminal states belong to an intercept curved surface with out-off control and the terminal acceleration of the guided object equals zero; the force controlling the guided object satisfies the normal constraint and the maneuver of the target is considered as the uncertainty factor. The author has deduced an optimal intercept guidance law in a closed loop analytical form for the case where the change of direction of motion of the guided object is not large. (Edited author abstract) In Chinese. 7 refs.

Zhan, Zhixiang. *Xibei Gongye Daxue Xuebao* v 5 n 4 Oct 1987 p 447-456.

**091596 INTEGRATION OF GPS/INS FOR MAXIMUM VELOCITY ACCURACY.** It is shown that weapon delivery accuracy using GPS depends more on velocity accuracy than position accuracy if jamming occurs several minutes before reaching the target. The total accuracy deteriorates very slowly the first few minutes after jamming provided the GPS and INS are integrated for maximum velocity accuracy. Also, rate-aiding of the carrier loop with INS data is shown to be practical provided proper attention is paid to attitude motion compensation, and compensation for lags in INS data as small as a millisecond. (Author abstract) 19 refs.

Diesel, John W. (Diesel Computing Systems Inc, Woodland Hills, CA, USA). *Navigation* v 34 n 3 Fall 1987 p 190-211.

**091597 CAN A MIXED GUIDANCE STRATEGY IMPROVE MISSILE PERFORMANCE?** The terminal phase of a missile vs aircraft engagement in an uncertain, noise-corrupted environment is formulated as a partial-information differential game. The cost function of the game is the missile's single-shot kill probability. A new approach, allowing a mixed missile guidance strategy, leads to a feasible saddle-point solution and circumvents the difficulties encountered in previous investigations. A simple example demonstrates that in some cases, the implementation of optimal mixed strategies is indeed advantageous for both parties. The present paper is the first step in the search for feasible saddle-point solutions for a large class of nondeterministic pursuit-evasion games. (Author abstract) 31 refs.

Forte, I. (Technion-Israel Inst of Technology, Haifa, Isr); Shinar, J. *J Guid Control Dyn* v 11 n 1 Jan-Feb 1988 p 53-59.

**091598 DESIGN OF ADAPTIVE AUTOPILOT FOR TACTICAL MISSILES.** This paper studies the possibility of designing digital adaptive autopilot of tactical missiles, using model reference adaptive control

(MRAC) with explicit identification. The plant considered is the roll loop of the air-to-air missiles whose dynamic parameters vary within wide limits. The recursive least square (RLS) method, with a forgetting factor for the second order plant, is selected to implement the on-line parameter identification, and a P+I adaptive law is used to make the plant output follow the reference model output very closely. All the differential equations are transformed into different equations using backward difference method in order to avoid the trouble caused by the inherent one-step sampling lag. Some practical problems encountered in design are discussed. The parameter identifications for two kinds of inputs are given. It is shown that the results of using MRAC with real-time identification are in agreement with those using MRAC with real values of the plant parameters. (Edited author abstract) In Chinese. 6 refs.

Chen, Jiashi; Ou, Yangling; Wang, Jianjun. *Xilei Gongye Daxue Xuebao* v 6 n 2 Apr 1988 p 199-208.

**091599 DESIGN AND SIMULATION OF AN ADAPTIVE CONTROL SYSTEM FOR A LASER BEAM-RIDER GUIDED TRIAL-MISSILE.** In this paper, we use discrete model reference adaptive control approach to design and analyze a laser beam-rider guided trial-missile control system. When the signal magnitude is limited through the use of a limiter, a great loss of the system performance is usually incurred. But the proposed approach can assure that the system retains satisfactory performance as long as the limiting factor is selected properly. (Edited author abstract) In Chinese. 7 refs.

Bao, Pingan; Zhou, Fenggi. *Xilei Gongye Daxue Xuebao* v 6 n 2 Apr 1988 p 209-218.

**091600 INERTIAL GUIDANCE SYSTEM FOR THE H-I LAUNCH VEHICLE - NICE.** This report describes an outline of the NICE (NASDA Inertial-guidance and Control Equipment) inertial guidance system developed for the NASDA H-I launch vehicle. MHI has participated in NICE system integration support, the development of the flight program and the data interface unit. This system provides for first and second stage attitude control, navigation and guidance, second stage tank pressurization control, and vehicle sequencing functions. The functions and performance of the NICE system were perfectly certified through the first flight of the H-I launch vehicle (Test flight #1 mission) on August 13, 1986.

Nagao, Naoteru (Mitsubishi Heavy Industries Ltd, Jpn); Tani, Syozo. *Tech Rev Mitsubishi Heavy Ind* v 25 n 1 Feb 1988 p 61-67.

**Launching** See Also SPACE FLIGHT—USSR.

**091601 TESTING ICBM TRANSPORTATION PAD SEPARATION.** During horizontal transport and handling, a small ICBM is protected within the erection and firing canister by some 80 molded urethane/aluminum composite pads arranged in 10 circumferential rows at key locations along the missile's length. Each row of pads is secured to the missile by two tension cables and toggle latches. Every cable includes a tensioning device and a tension-load indicator to facilitate installation and routine inspection. At launch, each row of pads with its retaining cables must remain in place on the missile as the assembly moves upward within the canister while passing over a variety of irregularities in the canister wall. Upon exiting the mouth of the canister, each row of pads must automatically separate from the missile and fall clear. To demonstrate that the required pad separation will occur promptly, but not prematurely, a low-cost simulation test was devised that required neither a missile nor a canister.

Bockruker, Ronald W. (National Technical Systems, Saugus, CA, USA). *Test (Oakland CA)* v 50 n 3 Jun-Jul 1988 p 24-25.



**091602 'FIRST STRIKE PREVENTION': A PROPOSED ARMS-CONTROL TECHNOLOGY.** A system of tamperproof electronic black boxes is proposed to implement a technique which prevents the launching of nuclear missiles for a first strike, but which allows them to be launched for a retaliatory second strike. The proposed technology is very similar to one developed during the past ten years to provide security in retail electronic banking systems. The various elements of the system are described, and additional issues that must be resolved for it to work as intended are discussed. 5 refs.

Campbell, Carl M. Jr. *IEEE Technol Soc Mag* v 6 n 4 Dec 1987 p 17-22.

**Manufacture** See ADHESIVES—Applications; INSPECTION—Sampling; ROCKET ENGINES—Manufacture.

**Materials** See ALUMINUM SHEET—Forming.

## Military

**091603 SDI TECHNOLOGY - TOO FAR, TOO FAST?** The Strategic Defense Initiative was originally held out to be the greatest scientific challenge of the late 20th century and a technical solution to our present nuclear stalemate. Unfortunately, the politics and science of nuclear weapons are not that simple. In this article the author reports on the technology behind the USA's Strategic Defense Initiative. (Edited author abstract) 18 refs.

Clery, Dan. *Electron Power* v 33 n 7 Jul 1987 p 437-442.

**Nozzles** See FLOW OF FLUIDS—Two Phase; HEAT TRANSFER—Nozzles.

**Orbits and Trajectories** See Also COMPUTER SIMULATION LANGUAGES—Applications; ORDNANCE.

**091604 TRAJECTOIRE DE LA LIBERATION OPTIMALE DANS LE CAS DE LA 'FUSEE EXPONENTIELLE' D'ESNAULT PELTERIE.** [Optimal Escape Trajectory for the 'Exponential Rocket' of Esnault Pelterie]. Reference is made to the scheme of 'exponential rocket', or rocket with constant acceleration proposed in 1930 by Esnault Pelterie. A comparison is made of the results he obtained for access to escape velocity with vertical trajectory with those given by an optimal trajectory. (Edited author abstract) In French. 2 refs.

Contensou, Pierre. *Acta Astronaut* v 17 n 1 Jan 1988 p 137-139.

**091605 HIGH PERFORMANCE MISSILE SYNTHESIS WITH TRAJECTORY AND PROPULSION SYSTEM OPTIMIZATION.** Synthesis of a high-performance two-pulse-motor-propelled missile by simultaneous optimization of trajectory and propulsion systems in two operational scenarios is described. This work employed a quasi-Newton parameter optimization scheme with penalty functions to meet terminal and path constraints. The trajectory control variables were parameterized using piecewise linear open-loop commands and piecewise constant linear feedback gains. The pulse motor parameters optimized were pulse split, average thrust levels, neutrality factors, pulse burn times, and the interpulse delay. Optimization of the rocket motor thrust curve in addition to the trajectory increased the range by up to 11% when compared with the trajectories optimized with originally specified rocket motor propulsion data. (Author abstract) 16 refs.

Menon, P.K.A. (Integrated Systems Inc, Palo Alto, CA, USA); Cheng, V.H.L.; Lin, C.A.; Briggs, M.M. *J Spacecr Rockets* v 24 n 6 Nov-Dec 1987 p 552-557.

**Performance** See Also SATELLITES—Launching.

**091606 ANALYTICAL SOLUTIONS TO ROCKET PERFORMANCE WITH AN ARBITRARY THRUST PROGRAMME HAVING CONSTANT THRUST INCLINATION WITH RESPECT TO THE HORIZON IN VACUUM.** The investigations described in this paper pertain to rocket performance due to maneuvering in a

vacuum with an arbitrary thrust inclined at a constant angle with respect to the horizon. Considering the variable thrust either as a function of time, or mass ratio, it is established that dynamical equations projected on the horizontal and vertical directions can be solved analytically; closed-form solutions to the overall range, endurance and final or impact velocity arising out of both burning and coasting phases can be achieved depending on the nature of the thrust function. Rocket performance with an arbitrary thrust program of greater thrust function evolves greater peak altitude for a vertical path, and greater overall but shorter burnout range, for the curvilinear path. (Edited author abstract). 2 Refs.

Maitra, S.N. (Nat'l Defence Acad, Poona, India). *Sadhana* v 12 n 4 May 1988 p 339-352.

**Propellants** See Also PROPELLANTS—Measurements; PROPELLANTS—Solid.

**091607 ISRO POLYOL - THE VERSATILE BINDER FOR COMPOSITE SOLID PROPELLANTS FOR LAUNCH VEHICLES AND MISSILES.** A family of propellants based on a low cost hydroxy terminated binder has been developed and proved in large size motors. It can meet the requirements of Apogee motors as well as large boosters. The system offers advantages comparable with HTPB propellants in terms of high ballistic performance, stringent mechanical properties, ease and reliability of cure even at ambient conditions and high storage stability. The near-Newtonian flow behavior, simplicity and processing characteristics of this saturated binder propellant are particularly noteworthy. (Author abstract) 6 refs.

Krishnamurthy, V.N. (Vikram Sarabhai Space Cent, Trivandrum, India); Thomas, Solomon. *Def Sci J* v 37 n 1 Jan 1987 p 29-37.

**091608 ANALYSIS ON THE IMPULSE LOSS OF SOLID-PROPELLANT ROCKET ENGINES.** Under the condition of  $V_p/LF$  1.0, an equilibrium model is used to study the specific impulse loss in solid propellant rocket engines. Some equations of rocket nozzle properties, including the critical velocity and specific impulse, are derived. The calculated results show that the velocity at the throat of the nozzle is less than the sonic speed of the gas, and the specific impulse is lost due to the effects of solid particles. The thrust coefficient does not always decrease, and it depends on the expansion ratio and solid mass ratio. A computer program TWPH is completed. The results of computation are compared with the experimental results of Winston N. Brundige giving satisfactory coincidence. (Edited author abstract) 6 refs. In Chinese.

Wang, Nanyan. *Bingong Xuebao* v 2 n 3 Aug 1987 p 8-16.

**Re-entry** See Also AERODYNAMICS—Hypersonic.

**091609 FIXED-RANGE OPTIMAL RE-ENTRY MANEUVERS WITH BOUNDED LIFT CONTROL.** Optimal lift control for transferring a hypervelocity vehicle between fixed initial and final values of the range and flight-path angle, with a maximum bound imposed on the magnitude of the lift coefficient, is derived using Green's theorem. payoffs are either maximum final velocity, maximum final altitude, minimum time, or minimum heat input. It is shown that the optimal maneuver for either payoff consists of a max. lift/min. lift or min. lift/max. lift nonsingular path and conditions for the final state to be reachable by such a sequence are determined. Only descending or ascending trajectories are considered, for which analytical solutions are obtained and the location of switching points determined. Results of parametric studies are presented in nondimensional form. (Author abstract) 5 refs.

Beiner, L. (Tel Aviv Univ, Ramat-Aviv, Isr). *Z Flugwiss Weltraumforsch* v 11 n 3 May-Jun 1987 p 161-166.

**091610 THERMOPHYSICAL ASPECTS OF RE-ENTRY FLOWS (TECHNICAL PAPERS SE-**

**LECTED FROM THE AIAA 23RD AEROSPACE SCIENCES MEETING AND THE AIAA 20TH THERMOPHYSICS CONFERENCE).** This conference proceedings contains 24 papers. The emphasis of the conference is on research and development activities on re-entry flows. Various chapters are introduced covering: Low-density phenomena; high temperature kinetics and transport properties; aerothermodynamic ground simulations and measurements; and numerical simulations of hypersonic flows. Much of the motivation for the research concerning the thermochemical state of high temperature shock-layer gases is to enhance the capability to predict the radiative heating environment for aerossisted orbital transfer vehicle (AOTV) entry conditions. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11446 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Moss, James N. (Ed.) (NASA, Hampton, VA, USA); Scott, Carl D. (Ed.). *Prog Astronaut Aeronaut* v 103, Thermophysics Aspects of Re-Entry Flows, Reno, NV, USA & Williamsburg, VA, USA, Jan & Jun 1985. Publ by AIAA, New York, NY, USA, 1986 626p.

**Reliability** See RELIABILITY—Estimation; ROCKET ENGINES—Reliability.

**Remote Control** See AIRCRAFT, MILITARY—Flight Simulators.

## Reviews

**091611 TECHNOLOGY '88: AEROSPACE AND MILITARY.** This overview of 1987 developments focuses on missiles, which overshadowed other events. The discussion covers the performance of Cruise missiles; the development of radar-triggered missiles; and the accuracy of the US Trident II missile. Also considered are the B-1B bomber and antimissile plans for the US Strategic Defense Initiative. An expert opinion is offered by Thomas F. Curry, chief scientist at E-Systems' center for advanced planning and analysis, who discusses belt-tightening by the US Department of Defense.

Adam, John A. (IEEE, New York, NY, USA). *IEEE Spectrum* v 25 n 1 Jan 1988 p 61-64.

**Sounding** See SPACE FLIGHT—Weightlessness.

**Testing** See ROCKET ENGINES—Testing.

## Welding

**091612 AUTOMATSKO ZAVARIVANJE KOMORE RAKETNIH MOTORA TIG POSTUPKOM BEZ I SA DODATKOM MATERIJALA.** [Automated TIG welding with and without Filler Material of a Missile Motor]. The requirements of the designers for an increased reliability of weldments, high mechanical properties of the welded joint, almost at the level of the base material, making of welded joint without defects, an increased material thickness and selection of steels prone to welding cracks, have resulted in a particular interest of the process engineers in the application of the optimum welding procedure in order to achieve the stated requirements. In cases of very critical weldments which involved fabrication in heavy and complicated tools, the investigation was directed to the application of automated production by using TIG procedure in two passes: with and without filler material. This paper also presents the results of all the accompanying tests of welded joints which are essential with such rigid design requirements. (Author abstract) In Serbo-Croatian. 9 refs.

Pantelic, Ijiljana. *Zavarivanje (Zagreb)* v 30 n 5 Oct-Nov 1987 p 279-283.

**ROLLING MILL PRACTICE** See Also GAGES; IRON CHROMIUM COBALT ALLOYS—Formability; METAL FOIL—Manufacture; METALS AND ALLOYS—Deformation; RAILS—Manufacture; ROLLING MILLS—Design; ROLLING MILLS—Stresses; ROLLING MILLS—USRS; ROLLS—Design; ROLLS—Wear; SHAFTS AND SHAFTING—Manufacture; SHEET AND STRIP METAL—Forming; STEEL—Thermomechanical



Treatment: STEEL SHEET—Applications: STEELMAKING—USSR; TITANIUM AND ALLOYS—Mechanical Properties; WIRE MILLS.

**091613 BERECHNUNG DES KRAFT- UND ARBEITSBEDARFS BEIM BLOCKWALZEN.** [Computation of the Force and Work Requirements in Cogging]. The article deals with the application of a computation method for flat rolling with free spreading with additional consideration of the rolled material contact with the collars. This computation method is usually used for bloom rolling. It is assumed that the mean peripheral stress,  $t_m$ , determined for flat pass, also operates in the additional collar contact areas. Rolling force, and both deformation torque, and deformation energy are calculated. (Edited author abstract) In German. 6 refs.

Knauschner, Alfred (Bergakad Freiberg, Freiberg, East Ger). *Neue Huette* v 32 n 7 Jul 1987 p 247-252.

**091614 NEW DEVELOPMENTS IN ROD MILLS. PART I - DESIGN AND OPERATION.** Compact rolling mills have been developed for high-precision production of wire rod. Advantages include: twist-free rolling in single, 3-roll stands; quick C changing of stands; minimum temperature variation during rolling; and high yield and utilization. A finishing block produces 5.5 to 12.5-mm dia specialty steel rod to within a normal and specially controlled dimensional tolerance of  $\pm 0.15$  and  $\pm 0.08$  mm, respectively.

Blos, Ernst O. (Friedrich Kocks GmbH, Hilden, West Ger). *Iron Steel Eng* v 63 n 12 Dec 1986 p 35-41.

**091615 NEW DEVELOPMENTS IN ROD MILLS. PART II - OPERATION OF A SPECIALTY STEEL WIRE ROD FINISHING MILL AT TOYAMA WORKS.** In 1983 Nippon Koshu Steel Co., Ltd. (NKS) installed a new high-performance finishing mill for rolling high-alloy wire rod at the Toyama works. The goals were to obtain higher productivity and improved quality. This mill, a 3-roll block mill designed and built by Kocks, was selected for rolling the entire NKS product mix (bearing, tool and die, high-speed, carbon, valve, stainless, heat-resistant and other specialty steels and super alloys) in many sizes and in small lots at maximum efficiency. This article describes the new mill and its performance during the first 30 months of operation.

Saito, Makoto (Nippon Koshu Steel Co, Toyama, Jpn); Arioka, Hisashi; Ueda, Sumio. *Iron Steel Eng* v 63 n 12 Dec 1986 p 41-46.

**091616 BASIC RESEARCH ON THE PROCESS OF COMPONENTS-ROLLING (5TH REPORT, OPTIMIZATION OF THE PROCESS BY MEANS OF CHANGING THE CHARACTERISTICS AND ADJUSTABLE ROLLING PARAMETERS OF A ROLLING MACHINE).** The forming process in components-rolling is governed by many factors relating to deformation and the rolling machine. In order to provide a fundamental approach to the optimization of the process by means of changing the characteristics inherent in each rolling machine and controlling the adjustable rolling parameters, a series of theoretical simulations was carried out. A new method of simulation of the process based on an equivalent configuration model is proposed to obtain detailed information without tedious calculation. Theoretical simulation is done by changing the elastic characteristics of a machine, upper preset load, the penetration rate of die and the preset position of a die-stopper, and the preferable rolling condition becomes clear. On the basis of these analyses, design and controlling principles of machines for improving the accuracy of form are pointed out for the first time. (Author abstract) In Japanese. 6 refs.

Tsutsumi, Shigeaki; Kato, Takao; Tanaka, Shigekazu. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 492 Aug 1987 p 1860-1868.

**091617 HEATING AND ROLLING OF LIQUID-CORED 'ZF' INGOTS.** The 'ZF' process is a new process to team rimmed steel which has been investigated and developed jointly by Anshan Institute of Iron and Steel Technology and Anshan Iron and Steel Corporation.

In this paper, the deformation characteristics of the liquid core rolling of ZF 6.67t rimmed steel ingots, the percentage available for liquid core rolling and the solidification curve of the ingots were thoroughly studied by simulation in the laboratory and in situ. A new production technology has been worked out in accordance with the characteristics of the ingots which makes the average charging temperature of ZF6.67t rimmed steel ingots reach 1006.2°C, and the percentage of liquid core heating reach 82.58%, so that the capacity of the soaking pit is increased by 1/3, the iron loss during heating is decreased by 0.7%, and 46.5% of the gas is saved. It is proved that the 'ZF' process is an efficient measure ensuring liquid core heating and rolling. (Edited author abstract) In Chinese.

Tao, Jun (Anshan Inst of Iron & Steel Technology, China); Hu, Lin. *Kang T'ieh* v 22 n 6 Jun 1987 p 21-25.

**091618 SOFTENING BEHAVIOR OF TWO TI BEARING STEELS DURING TORSIONAL SIMULATION OF ROLLING.** An industrial controlled-rolling schedule was simulated in hot torsion for two Ti steels. The yield and the maximum stresses of each pass were determined from the recorded flow data. An approach resulting in a new softening parameter based on mechanical flow data is presented here. The evolution of austenite structure was determined from samples quenched after selected passes. The normalized times to 50% softening were determined from both the mechanical and metallographic data for each pass. The increase in Ti level from 0.03 to 0.12% in these steels led to austenite grain refinement in the simulated 'as rolled' material. This improvement was ascribed mainly to TiC precipitation during rolling. (Author abstract) 20 refs.

Liu, W.J. (McGill Univ, Montreal, Que, Can); Akben, M.G. *Can Metall Q* v 26 n 2 Apr-Jun 1987 p 145-153.

**091619 FERRITE FORMATION FROM DEFORMED AUSTENITE IN A Ti MODIFIED HSLA STEEL.** The effect of austenite deformation in the recrystallization, partial recrystallization and non-recrystallization temperature range on the subsequent ferrite transformation was investigated in a commercial HSLA steel with 0.076% Ti and a reference C-Mn steel of same base chemistry. The steel samples were given reductions in the range 20-60% at 850, 950 and 1050°C by single pass rolling followed by isothermal transformation to ferrite at 690°C for up to 1800 s. It was found that the austenite to ferrite transformation rate was increased both with increase in the amount of austenite deformation and lowering the finish rolling temperature. The addition of titanium resulted in decrease in the rate of ferrite formation as well as led to the formation of polygonal ferrite grains. Non-recrystallized elongated austenite grains appear to give fine ferrite structure while mixed ferrite grains resulted from partially recrystallized austenite. It was observed that not only the austenite grain boundaries, but also the twin boundaries and/or the deformation bands within elongated austenite grains were found to act as potent nucleation sites for ferrite. (Author abstract) 14 refs.

Misra, S. (Univ of Wollongong, Aust); Dunne, D.P.; Chandra, T. *Can Metall Q* v 26 n 2 Apr-Jun 1987 p 155-160.

**091620 SIMULACE PODMINEK DOVALCOVANI MIKROLEGOVANYCH OCELI.** [Simulation of Conditions for Finish Rolling of Microalloy Steels]. A new steel rolling method is proposed which takes into account the fact that during the rolling process at a constant rate with a drop of the Zener-Hollomon parameter Z takes place; this is replaced by a newly defined Z' parameter which is the function of the torsion temperature and rate. The description of the stress/strain curves utilizes this parameter. This makes the complicated computation of the activation energy which is required for evaluating the Z value unnecessary. The method was experimentally verified under conditions of finish rolling of a C-Mn-Nb-V-based microalloy steel. In Czech. 11 refs.

Schindler, Ivo; Zidek, Milan; Boruta, Josef. *Hutn Listy* v 42 n 3 Mar 1987 p 177-181.

**091621 EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF ROLLING CHANNEL SECTION BEAMS.** Where the width/height ratio of the steel slab is large, there is little lateral spread of the material during rolling. However, as the width/height ratio decreases to below unity, the lateral spread increases and its accurate prediction becomes important. In the present investigation rolling tests were performed on rolling rectangular section beams of three different initial shape factors in a three-pass rolling sequence to produce channel section beams. In the absence of theoretical analysis for rolling of shaped sections, approximate methods for determining roll load, roll torque, and lateral spread have been suggested by several authors. These are compared with the experimental results. Approximate theoretical expressions are suggested to calculate roll load, roll torque, and lateral spread during rolling. (Edited author abstract) 15 refs.

Hamid, M. (Univ of Manchester, Engl). *Ironmaking Steelmaking* v 14 n 5 1987 p 243-247.

**091622 INTENZITA DEFORMACNI RYCHLOSTI PRI VALCOVANI PLOCHYCH VYVALKU.** [Intensity of Deformation Speed in Rolling of Flats]. A new formula has been derived for computing the instantaneous deformation speed intensity in an arbitrary cross section of the deformation zone in hot rolling of flats. By integrating this relationship, expressions for calculation of the median intensity of the deformation speed have been obtained. The new expression considers real deformations and takes into account the continuity equation governing the passage of the rolled material through the gap between the walls. In Czech. 11 refs.

Kure, Frantisek (Vysoka Skola Banska, Ostrava, Czech); Schindler, Ivo; Kliber, Jiri; Mackova, Emilie. *Hutn Listy* v 42 n 1 Jan 1987 p 14-18.

**091623 LOCAL TRANSVERSE ROLLING OF POLYGONAL TUBES.** It was possible to set up functions, which separate the areas of square and pentagonal tubes, for local transverse rolling of polygonal tubes on the basis of tests and energy analyses. A likewise developed function equation describes the dependence of the initial radial cross-section reduction on the dimensions of the tubes and tools. The knowledge of this function permits rational planning of the production method, which requires only simple equipment. (Author abstract) 4 refs.

Cywinski, Marek (Silesian Technical Univ, Gliwice, Pol); Misiolek, Zbigniew. *Strips Sheets Tubes* v 4 n 2 Dec 1987 p 31-34.

**091624 HOCHREDUKTIONSMASCHINE ALS VORUMFORMSTUFE IN EINER KONTINUIERLICHEN DRAHTSTRASSE.** [High Reduction Mill as a Preforming Stage in a Continuous Rod Mill]. With the further development of round casters, the high reduction mill which allows to obtain rolling passes with cross-section reductions of more than 84% in one operation, is gaining importance as a preliminary stage in wire rod mills. It can be used separately, in combination with a shaping stand and as a roughing stand in continuous wire rod or light section rolling mills and allows the rolling both of smooth wire rods and rebars. Experience gathered with an Italian wire rolling mill, on which more than 250,000 tons have been rolled up till now, show that investment and operating cost are more favorable than in the case of conventional plant. (Author abstract) In German.

Recalcati, Camillo; Ventura, Claudio; Rensch, Wilfried. *Stahl Eisen* v 108 n 1 Jan 11 1988 p 47-52.

**091625 POTREBNA SNAGA I ENERGIJA ZA VALJANJE - PROMENA MOMENTA I ENERGETSKI BILANS.** [Power and Energy Necessary for Rolling (Moment Variations and Energy Balance)]. The process of rolling is one of the means of material treatment by plastic deformation. For such treatment it is necessary to invest a certain energy. This energy is transmitted to rolls by motors and transmitters of power. During this trans-



mittance the rolls perform the necessary deformation work. In this article, methods for the determination of the necessary torque, power and energy of deformation are shown. Their distribution (energy balance) is also discussed. (Edited author abstract) 4 refs. In Serbo-Croatian.

Tasic, N. (Metalurški kombinat, Smederevo, Yugosl.). *Metalurgija (Sisak Yugosl.)* v 26 n 4 Oct-Dec 1987 p 117-123.

**091626 GEOMETRICAL MODEL FOR ROLLING OF CUNEIFORM AND RING-SHAPED SECTIONS IN CONICAL ROLLS.** The authors present a theoretical analysis. A generalized geometric model of the contact zone was designed for the rolling of cuneiform sections in cylindrical and conical rolls with parallel or intersection axes as well as of ring-shaped sections in conical rolls with intersection axes or with parallel generatrices of the rolls to the exit plane. Numerical analysis of the effect exerted by the roll conicity angles on the main geometric relations and parameters of the contact zone was carried out for the rolling of an oval strip. 8 refs.

Kamenshchikov, Yu.I.; Barkov, L.A. *Russ Metall Met n 4* 1987 p 56-61.

**091627 INFLUENCE OF HEATING SCHEDULES BEFORE ROLLING ON PROPERTIES AND STRUCTURE OF SHKH15 STEEL.** The authors have determined a relationship between the temperature schedules used for heating SHKH15 steel before rolling and the properties and structure obtained after rolling. Heating at high temperatures must be for strictly controlled times. Reduction of the temperature to 1150-1180°C immediately before rolling improves the quality of the rolled stock. (Author abstract) 3 refs.

Gerashchenko, P.M. (Ukrainian Scientific Research Inst of Special Steels, USSR); Zhadan, V.T.; Shtrugunov, I.L.; Zaikin, V.V.; Kapsheeva, V.M. *Steel USSR* v 17 n 5 May 1987 p 224-226.

**091628 ROLLING OF CONTINUOUSLY CAST STRIPS AND THE TECHNICAL CONSEQUENCES WITH RESPECT TO THE DESIGN OF HOT STRIP PRODUCTION PARTS.** After positive experiences with a pilot plant for the casting of transfer bars, rolling tests were carried out on a reversing stand, in a hot strip mill, and in a cold mill in order to confirm the properties of the hot and cold rolled strip. This was followed by the development of process concepts for the manufacture of hot strip which, by comparison with conventional hot strip production plants, offer economic advantages for plants with lower outputs. The rolling tests showed that all steels that are castable on conventional continuous casters can also be produced on the strip caster while exhibiting good surface and mechanical properties. The article then presents the so-called CSP concept (Compact Strip Production), in which the caster is combined with a soaking furnace and a 4-stand finishing mill in one single line. (Edited author abstract) 3 refs.

Flemming, Guenter (SMS Schloemann-Siemag Aktiengesellschaft, Dueseldorf, West Ger); Kappes, Paul; Rohde, Wolfgang; Vogtmann, Lothar. *MPT Metall Plant Technol* v 11 n 1 1988 12p between p 16 and p 36.

**091629 INCREASING THE LIFE OF SLIDING PASSES.** The most efficient method of increasing the life of cast iron passes in the leader stand is electrospray alloying with titanium-cobalt alloys of the T5K12 type. The use of cemented steel passes reduce pass breakage to a minimum. The use of bronze passes with a hardness greater than HB 400 is promising for the finishing stand. The heat treatment (quenching and tempering) of gray iron passes increases their durability and reduces the tendency toward metal build-up. The resistance of passes to metal build-up is also increased by optimizing the profile of the working surface of the pass and the chemical composition of the rolled metal. The Magnitogorsk Mining-Metallurgical Institute developed a technology for machining passes of steel 20KhGSMa which makes it possible to obtain an optimum profile and roughness.

Naumenko, V.D. (Magnitogorsk Mining-Metallurgical

Inst, USSR); Isaev, N.M.; Kuznetsov, R.V.; Shulepnikova, A.G.; Svirchevskii, V.I.; Pudov, E.A.; Il'in, M.G. *Metallurgist (USSR)* v 31 n 7-8 Jul-Aug 1987 p 258-259.

**091630 TECHNOLOGY FOR END ROLLING (ORBITAL FORGING) OF THIN FLAT PARTS.** The present work analyzes the metal flow during end rolling (orbital forging). Several new technological processes are proposed, and a method of designing end-rolling technologies is developed. After analysis, the following is the conclusion. 1) Fracturing of the central zone of workpieces is caused by the additional tensile stresses developed in the workpiece center when rolling with tool inclination angles of 3° or more. 2) New technological processes of end rolling (orbital forging) have been developed which provide additional workpiece deformation for sizing disks, piercing holes, or separating rolled rings from a rod. 3) A method is proposed for designing technological processes for end rolling (orbital forging) or flat parts such as disks as rings, achieving large degrees of deformation without fracturing. 8 refs.

Kazachenok, V.I.; Nagovitsyn, V.V.; Zimin, Yu.A. *Sov Forg Sheet Met Stamping Technol n 2* 1987 p 5-10.

**091631 SIMULATION OF RING ROLLING WITH NEW WAX-BASED MODEL MATERIALS ON A FLEXIBLE EXPERIMENTAL MACHINE.** Nowadays, the practice of using model materials for the analogical simulation of most forming processes is well established; however, the practice is almost non-existent in ring rolling. Important new opportunities for ring rolling have arisen due to a remarkable development over the last five years: highly unsymmetrical thin-walled rings and weld-neck flanges are being required to an increasing extent in high-cost materials such as aluminum alloy, stainless and maraging steels, heat-resisting alloys, titanium, magnesium, nickel alloys and suchlike. The present investigation explores the applications of the analogical-simulation method in ring-rolling sequences. For these applications, a new flexible horizontal machine has been developed for the rolling of model-material rings, the outer diameters of which do not exceed 700 mm. Typical rolling examples are concerned with the prediction of rolling forces and torques, with the analysis of flow patterns, and with some operating rules for idler and edging rolls. (Edited author abstract) 26 refs.

Boucly, P. (Univ of Valenciennes, Valenciennes, Fr); Oudin, J.; Ravalard, Y. *J Mech Work Technol* v 16 n 2 Apr 1988 p 119-143.

**091632 EFFECT OF ROLLING FACTORS ON TOLERANCE OF FINISHED HOLLOW DRILL.** The production of a steel hexagonal hollow drill using a core bar in its center is a process of bimetal combination rolling in which the principle of deformation is specific and complicated. The section accuracy of finished products is thus under the influence of various factors such as pass design, deformation rate, ingot shape type to mill. Tests on the effect of these factors are described. (Edited author abstract) In Chinese. 4 refs.

Chuanxun, He (Guiyang Steel Works). *Kang T'ieh* v 23 n 2 Feb 1988 p 32-36.

**091633 TWO STRAND SHAPING TECHNOLOGY.** The authors describe the solutions found by the Pervouralsk Unintegrated Metal Structures Works to the problems entailed in the development of two- and multiple strand shaping. He discusses the possibility of organizing two or more synchronized passes on the work portion of the roll shafts; the possibility of longitudinally parting a double width starting stock to two or more strips directly on the mill; the development of roll and roll pass designs promoting the production of a quality shape in each strand without additional edging rollers, straightening guides, or other devices and the possibility of cutting two or more shapes at a time to measured lengths in final form on the mill. Assimilation of the final two-strand shaping technology and equipment developed raised the productivity of mills for symmetrically bent shapes by an average factor of 1.7. (Author abstract)

Vizgalov, V.K. (Pervouralsk Unintegrated Metal Structures Works, USSR). *Steel USSR* v 17 n 10 Oct 1987 p 459-460.

**091634 QUELQUES DEFATS SUR OU DANS LES PRODUITS LAMINES ISSUS DE COULEE CONTINUE.** [Some Defects of CC-Origin on and in Rolled Products]. This paper deals with the following three defects of CC-origin in rolled products and how to eliminate them: (1) star cracks in heavy plates; (2) skin lamination on cold rolled strip; and (3) macroinclusions near the welds in helically welded natural gas pipes. (Edited author abstract) In French.

Hintikka, S. (Rautaruukki Oy, Finl). *Cah Inf Tech Rev Metall* v 85 n 3 Mar 1988 p 231-236.

**091635 HODNOCENI KALIBRACI POUTNICKYCH STOLIC.** [Evaluating Roll Pass Design in Pilger Mills]. The paper presents an evaluation of four roll pass design systems based on rolling results at Chomutov. Individual roll pass design systems differ by optimization criterion. The evaluation considers the roll pass design effect on the quality of cold rolled tubes. (Edited author abstract) 26 refs. In Czech.

Wiesner, Hubert (Valcovny Trub a Zelezarny, n.p. Chomutov, Czech). *Hutn Listy* v 42 n 7 Jul 1987 p 474-483.

**091636 STUDIUM TVARU PASMA DEFORMACE PRI KOSEM VALCOVANI.** [Examination of Deformation Zone Shape in Skew Rolling]. The deformation zone shape affects steel formability in piercing. Through the deformation zone change the stress state in the formed rolling stock changes and the total deformation speed of skew rolling increases. Effect of compression, piercing axis height and angle of working roll axis on the deformation zone shape and biting conditions of the metal formed by working rolls were recorded. (Edited author abstract) 19 refs. In Czech.

Strakos, Martin (Vitkovica, Ostrava, Czech); Barta, Radomir; Pejcoch, Pavel. *Hutn Listy* v 43 n 3 Mar 1988 p 173-177.

**091637 SPINDLE DEVICE FOR MILL ROLLING PERIODIC SECTIONS.** A spindle device for adjusting the attitudes of roll passes when realignment of the pass periods is required during the rolling of periodic sections on a continuous light section mill is described. It can be recommended for application in that adjustment of one of its articulations in a clockwise or anticlockwise direction gives accurate alignment of the setting of the roll pass periods. Realignment takes only 5-7 min, reducing mill downtime for this operation. (Edited author abstract).

Komarov, A.N. (Dnepropetrovsk Inst of Ferrous Metallurgy, USSR); Levchenko, L.N.; Natapov, A.S.; Kostyuchenko, M.I.; Pivovarov, S.M. *Steel USSR* v 17 n 11 Nov 1987 p517.

**091638 DEFORMATION AND DISTRIBUTION OF REDUCTIONS BETWEEN ROLLS DURING ROLLING OF II-SHAPED BILLETIN CLOSED BOX PASS.** At the Metal Mechanical Working Department of the Donetsk Polytechnic Institute, a new method has been developed for rolling complex sections with T-shaped grooves. Theoretical and experimental relationships were obtained for calculating the distribution of reductions between the rolls and spread of the flanges of the strip during rolling in a closed box pass. The relationships can be used to determine optimum pass designs and reduction schedules for the production of complex shaped sections. (Edited author abstract). 4 refs.

Klimenko, V.M. (Donetsk Polytechnic Inst, USSR); Lesik, L.N.; Moiseenko, V.V.; Solod, V.S.; Kulichkov, Yu. B. *Steel USSR* v 17 n 12 Dec 1987 p 555-556.

**091639 LOADS IN THE PROCESS OF ELONGATING ROLLING IN THE ASSEL MILL.** The results of investigations of the loads accompanying the process of tube rolling in a three-wall oblique Assel rolling mill are



reported. Based on experimental data, relationships between the loads and the following parameters have been defined: tube-diameter decrease;  $\alpha$  - angle of skew of the roll axes from the axis of rolling;  $\beta$  - angle of inclination of the roll axes from the rolling axis when  $\alpha=0$ ; wall thickness and their decrease in relation to the tube diameter. The relationships have been interpreted and the dependence determined between some of them and (i) the coefficient of the axial velocity and (ii) the amount by which the contact length between the tube and the roll is increased due to local deformation of the tube at entry to the roll gap. (Author abstract).

Dobrucki, Wladyslaw (Acad Gorniczp-Hutnicza, Krakow, Pol); Pietrzykowski, Andrzej. *J Mech Work Technol* v 16 n 3 Jun 1988 p 243-255.

## Analysis

**091640 FINITE ELEMENT STUDY OF FLAT ROLLING.** Using an Eulerian formulation, a finite element solution for the flat rolling problem is presented. Calculations are performed to establish the effects of roll deformation and of the variation of the coefficient of friction in the roll gap on the predictive capabilities of the model. Comparison to data of Al-Salehi et al (1973) and Shida and Awazuhara (1973) indicates that the differences between measurements and calculations decrease when the above-mentioned effects are accounted for. (Author abstract) 28 refs.

Hwu, Yhu-Jen (China Steel Corp, Taiwan); Lenard, J.G. *J Eng Mater Technol Trans ASME* v 110 n 1 Jan 1988 p 22-27.

**091641 TRACKING SINE WAVES IN SYSTEMS WITH HIGH SLEW RATES.** In analysis of rotating equipment it is usual to employ tachometer channels to allow synchronous sampling and time domain averaging, followed by discrete Fourier transforms to provide the fundamental frequency and its harmonics. Sometimes however, the running speed changes so rapidly that this cannot be achieved. Structural Dynamics Research Corporation, USA has therefore produced I-DEAS Tdas for coping with this difficulty, based on Prony's algorithm, which only requires form data points to identify each harmonic, with the data sampled at a constant frequency. (Author abstract) 5 refs.

Anon. *Noise Vib Control Worldwide* v 19 n 4 Apr 1988 p 120-122.

**Applications See METAL FORMING MACHINES—Manufacture.**

**Automation See Also ROLLING MILLS—Design.**

**091642 AUTOMATION OF THE ROUGHING TRAIN IN A WIDE STRIP MILL.** The roughing stand in the Voest-Alpine hot strip mill at Linz has been equipped with process computer control with the aim of reducing production costs and increasing plant productivity. All the existing mechanical and electrical equipment has remained unchanged and the adaptation and expansion measures in the areas of basic automation and measuring techniques were also minimal. Commissioning took place virtually, while the mill was in operation. The project was completed at the beginning of 1986 and the experience gained since then shows that the envisaged objectives have been achieved. (Author abstract)

Langer, Rupert (Voest-Alpine AG, Linz, Austria); Pichler, Rudolf. *MPT Metall Plant Technol* v 11 n 2 1988 4p.

**Bars See Also BARS—Steel; CONCRETE REINFORCEMENTS; ROLLING MILLS—Automation; ROLLING MILLS—Components; ROLLING MILLS—Design; ROLLING MILLS—German Democratic Republic; STEELMAKING—Electric Furnace Process.**

**091643 OUTLINE OF THE RECONSTRUCTION OF THE BAR MILL IN KOKURA STEEL WORKS.** Recently, the quality requirements of the users for the sound surface condition of wire rods produced in the wire

rod mill and the dimensional accuracy of bars produced in the bar mill have been getting higher. In order to satisfy both the users' quality requirements above and to improve the quality of the products produced in the bar mill, reconstruction of the bar mill was carried out. Main items of the reconstruction are listed as follows: founding the roller type billet ejector of the reheating furnace; establishment of the 5 stands, 3-roll block mill (S.F.Mill); and increasing the capacity of the air cooling and water cooling equipment with the application of automatic control. (Author abstract) In Japanese.

Ogata, Shunji; Niibayashi, Takafumi; Kato, Yoshimitsu; Kawashima, Yoshio; Ueno, Yasunaga. *Sumitomo Met v* 39 n 3 Aug 1987 p 289-294.

**091644 EIN NEUES RECHENVERFAHREN FUER DAS WALZEN VON FEINSTAHL UND DRAHT.** [New Mathematical Model for Rolling of Light Sections and Wire]. A new mathematical model is presented for computation of material flow, rolling force, rolling moment and energy requirements in rolling steel bars and wire in straight passes. The model takes into account all relevant factors which are quantitatively represented. In German. 7 refs.

Hensel, Arno (Bergakad Freiberg, Freiberg, East Ger). *Neue Huette* v 32 n 5 May 1987 p 183-189.

**091645 IMPROVING MILL YIELD BY IN-LINE BILLET WEIGHING.** In many plants mill yield (cast billet to prime bar) is increased by adjusting billet length according to product. There is, however, significant variation in the billet weight per unit length because of differences in cross-sectional area and in the density of the as-cast steel. Yield is maximized when billet weight rather than length is controlled. This paper describes weighing equipment which has been installed immediately following caster cut-off units (torches or shears). Billet weight is controlled by adjusting cut-off length to suit prevailing conditions. The adjustment can be manual or by a 'close loop' control system. The yield improvements which are obtained provide very attractive returns on investment. (Author abstract)

Asbury, F. (Ferrex Engineering Ltd); McIntyre, E.H. *SEALSI Q* v 16 n 4 Oct 1987 p 64-69.

**091646 IN-LINE HEAT HARDENING OF REINFORCING BARS IN A ROLLING MILL.** Reinforcing steel heat hardening process and equipment including in-line cooling and hydraulic conveyance systems have been described and product property control practices illustrated. The level of reinforcing steel properties has been evaluated. Principal trends in heat hardening technology as regards reinforcing steel have been outlined. (Author abstract)

Chernenko, V.T.; Filonov, O.V.; Kazyskiy, O.L.; Ivoditov, A.N. *Sov Mater Sci Rev* v 1 n 1 1987 p 41-42.

**091647 OUTLINE OF HIGH-PRODUCTIVITY ROLLING MILL FOR STEEL BAR.** Rolling-mill equipment is now required to have high productivity, low energy and labor demands, and low installation cost. Kobe Steel has completed a new bar mill satisfying these requirements. It has a capacity of 520,000 tons per year in any product size from D10 to D25, and features the newly developed Kobe Compact Solid Mill and Kobe Split Rolling Unit. (Author abstract)

Matsumiya, Katsuyuki (Kobe Steel, Jpn); Kumagai, Kazuo; Shinomoto, Yoshiyuki. *Kobelco Technol Rev* n 2 Aug 1987 p 14-17.

**091648 MODELS FOR PREDICTING THE TEMPERATURE AND ROLLING FORCE IN SPLITTING CALIBER FOR THE CONTINUOUS ROLLING OF ANGLES.** Based on the investigation of experimental data obtained from a  $\phi 250 \times 6$  semi-continuous bar mill, mathematical models for the continuous rolling of angles have been studied. The structure of the models is identified theoretically, and the coefficients of the models are determined by statistical analysis of the experimental data. By the method of dispersing numerically and coinciding

with a function, the program of a simplified section rolling model is proposed. (Edited author abstract) 2 refs. In Chinese.

Su, Fengxi (Beijing Univ of Iron & Steel Technology, China); Xin, Ping; Jiang, Jinmei; Wang, Jin; Jiang, Shusheng; An, Jiusheng; Li, Zihao. *Kang T'ieh* v 22 n 7 Jul 1987 p 16-22.

**091649 EVALUATION OF DIMENSIONAL ACCURACY OF HOT ROLLED STEEL ROUNDS.** A method for evaluating the dimensional accuracy of steel rounds during rolls has been proposed, with the dimensional variations being considered both along the bar and between different bars. Coefficients for the effects of various geometrical characteristic components on final steel accuracy have been presented. (Author abstract)

Berkovskiy, V.S.; Tabakov, A.N.; Gorbunov, V.E.; Kiyko, G.V. *Sov Mater Sci Rev* v 1 n 2 1987 p 243-247.

**091650 HERSTELLEN VON PROFILEN AUF WALZBLOECKEN.** [Manufacture of Sections on Rolling Blocks]. Sections with sufficiently close tolerances can also be manufactured on rolling blocks under typical rolling conditions with a slight drag. It is possible to use a combination of the round/oval drawing pass sequences such as they are normal for round sections with special shaping pass sequences. Applications are possible in small section mills with the proper finishing blocks or with wire blocks for corresponding section wires. (Edited author abstract) In German. 8 refs.

Oelstoeter, Gerhard (Bergakademie, Freiberg, East Ger); Kutzsche, Karl; Flemming, Folker. *Drahtwelt* v 73 n 10 Oct 1987 p 159-163.

**091651 ROTHERHAM PLANS FOR BETTER, TIGHTER AND MORE FLEXIBLE FUTURE.** Better quality, more flexibility in the rolling schedule and tighter control on dimensions are the main aims of Rotherham Engineering Steels current investments in its bar rolling mills. Developments include upgrading mill electrics and control, installing quick change stands, improved handling and testing and fuller in-line inspection. The article reports on how the company is preparing itself for the next decade.

Anon. *Steel Times* v 215 n 12 Dec 1987 p 622, 624.

**091652 OUTLINE OF RECONSTRUCTION OF THE BAR MILL AT THE KOKURA STEEL WORKS.** Recently, users' quality requirements for the sound surface conditions of wire rods produced in the wire rod mill and the dimensional accuracy of bars produced in the bar mill are getting higher. In order to satisfy both of the users' quality requirements above and to improve the quality of the products produced in the bar mill, a reconstruction of the bar mill at the Kokura Steel Works was carried out. The main items of usage to be reconstructed were as follows: (1) Founding of a roller type billet ejector for the reheating furnace; (2) Establishment of a 5 stand, 3-roll block mill (S.F. MILL); (3) Increased capacity of the air cooling and water cooling equipment through the application of an automatic control system. (Author abstract)

Ogata, Shunji (Sumitomo Metal Industries Ltd, Jpn); Niibayashi, Takafumi; Kawashima, Yoshio; Ueno, Yasunaga; Kato, Yoshimitsu. *Sumitomo Search* n 35 Nov 1987 p 83-88.

**091653 ANALYSIS OF ROLLING OF BARS BY THE ENERGY METHOD USING FINITE ELEMENT DIVISION (ANALYSIS OF SQUARE-OVAL PASS).** In the field of bar rolling, very little theoretical research has been performed because the flow of the material in bar rolling is complicated. Recently, authors proposed a new energy method using finite element division; this method was applied to the analysis of the flow of the material for two types of bar rolling: square-diamond pass and round-oval pass. However, another important type of bar rolling exists: square-oval



pass. The flow of the material of this type differs greatly from that of the former types. In square-oval pass, the material is deformed inhomogeneously, and the degree of freedom of the velocity fields must be increased for precise simulation of the flow of the material. In this paper, authors have improved the method to lessen computation time and memory requirements. This method is then applied to the analysis of the flow of the material in square-oval pass and reasonable results are obtained for rolling properties such as width spread, strain rate distribution, folding of stress-free side surface, and others. (Edited author abstract) 7 refs.

Komori, Kazutake (Tokyo Inst of Technology, Tokyo, Jpn); Kato, Kazunori; Murota, Tadao. *JSM Int J Ser 1* v 31 n 2 Apr 1988 p 257-263.

**091654 ROZBOR NAPJATOSTI PRI KALIBRACI OBDELNIK - OVAL.** [State of Stress Analyzed in Rectangle-Oval Roll Pass Design]. The paper deals with the analysis of deformation and stress fields in shaping pass rolling. The hybrid method used is briefly described. Deformation fields are solved experimentally with the help of a photoplastic method. The stress fields are evaluated by the plasticity theory. The procedure is demonstrated on the example of a rectangular section bar. The stress intensity distribution and shear deformation intensity were evaluated as well as the contact tension and forming force. 8 refs. In Czech.

Macura, Pavel (Vyzkumny Ustav Hutnictvi Zeleza, Dobruška, Czech). *Hutn Listy* v 43 n 4 Apr 1988 p 260-264.

**091655 TRANSITION AND DECREASING OF THE MATERIAL SURFACE DEFECTS IN 3-ROLL ROLLING.** Round aluminum bars with five rectangular grooves as artificial defects on the surface were hot-rolled. Changes in the depth and shape of the surface grooves during rolling and effects of rolling conditions on the defects were investigated. Depth of grooves decreases on parts which contact the rolls. Oval and round roll are effective in reducing the defects. (Edited author abstract). 4 Refs. In Japanese.

Horiata, Masahiko (Waseda Univ, Tokyo, Jpn); Motomura, Mitsugu. *Keikinzoku* v 38 n 5 May 1988 p 270-275.

**091656 THEORETICAL ANALYSIS OF 3-ROLL ROLLING PROCESS BY THE ENERGY METHOD.** The 3-roll process is analyzed by the energy method. A simplified admissible velocity field defined by three variable parameters is introduced. The solutions are derived by minimizing the consumed energy rate. Numerical calculations are done for a hexagon flat pass and the results are compared with experiments. Results on roll torque and reduction in cross-sectional area agree satisfactorily. Pure Pb and Pb-2%Sn alloy were used as model materials (Author abstract). 2 Refs.

Horiata, Masahiko (Waseda Univ, Tokyo, Jpn); Motomura, Mitsugu. *Trans Iron Steel Inst Jpn* v 28 n 6 1988 p 434-439.

**Billet** See Also ALUMINUM FOUNDRY PRACTICE—Casting; CAST IRON—Continuous Casting; PIPE, STEEL—Manufacture; STEEL—Continuous Casting; STEELMAKING—Ladle Process; TUBES—Manufacture.

**091657 DEVELOPMENT OF SECONDARY COOLING PROCESS CONTROL SYSTEM FOR ROUND BILLET CONTINUOUS CASTING.** With the aim of optimization of secondary cooling for continuous casting, Sumitomo Metal Industries has developed a dynamic spray cooling control system and continues to apply that to other casters. This system has been applied to the round billet casting plant at Wakayama Steel Works immediately after application to slab and bloom plant. In this dynamic control system, temperature profiles of the cast material is calculated according to the heat conduction formula of cylinder, and optimum water flow rate is settled to maintain the temperature pattern using operating conditions. By the application of this system, the control accuracy of  $\pm 20^\circ\text{C}$  is obtained although the casting speed changed 0.5m/min, and achieved a decrease

of surface and internal cracks. (Author abstract) In Japanese. 3 refs.

Takawa, Takeshi; Takamoto, Tsutomu; Okuno, Keigo; Miki, Hirohisa. *Sumitomo Met* v 39 n 3 Aug 1987 p 8-15.

**091658 OPTIMISATION OF BASIC PARAMETERS OF ROLLING COMPLEX FOR PRODUCTION OF BILLETS.** The authors suggest a new integral function for optimisation of a rolling complex for the purpose of increasing its productivity. Modern methods of optimisation are used to determine the best processing conditions and parameters for the roughing mill, hot cutting shears, and continuous mill of such a complex with consideration of the interplay of these conditions and parameters. Use of the method to solve the problem of optimisation of a rolling complex for the production of billets enabled the number of passes required to be reduced from 11 to 9 and the best loading for the edging stands of the continuous billet mill and additional loading for the first two horizontal stands to be obtained with a resultant increase in productivity. (Edited author abstract) 10 refs.

Lekhov, O.S. (USSR Acad of Sciences, Sverdlovsk, USSR); Malakhov, A.V.; Bazhutin, V.V.; Zhigalin, A.G. *Steel USSR* v 17 n 2 Feb 1987 p 78-80.

**Bloom** See Also RAILS—Manufacture; STEEL—Continuous Casting; STEEL INGOTS—Manufacture.

**091659 PRODUCTION OF ROLLED SHAPES FROM LENGTHWISE-CUT CONTINUOUS-CAST SLABS.** The Magnitogorsk Metallurgical Combine conducted a study to examine the feasibility of using semifinished products obtained by lengthwise cutting of slabs to roll rounds. Flame cutting of the slabs into narrower semifinished products is accompanied by substantial losses of metal and the propagation of internal defects to the surface. This finding served as an impetus for searching for different methods of longitudinal slab cutting. Studies have shown that the rolling-cutting method can reduce metal loss and improve the metallographic characteristics of the rolled shape.

Shcherbakov, O.N. (Magnitogorsk Metallurgical Combine, USSR); Rabinovich, E.I.; Myachin, R.I.; Kornilov, V.L.; Loginov, V.G. *Metallurgist (USSR)* v 31 n 7-8 Jul-Aug 1987 p 210-211.

**Cold Rolling** See Also ALUMINUM METALLOGRAPHY—Textures; BERYLLIUM AND ALLOYS—Anisotropy; COPPER AND ALLOYS—Cladding; HEAT TREATMENT—Annealing; IRON AND STEEL METALLOGRAPHY—Textures; ROLLING MILLS; ROLLING MILLS—Design; ROLLING MILLS—Process Control; ROLLING MILLS—Tennessee; SHEET AND STRIP METAL—Computer Aided Manufacturing; SHEET AND STRIP METAL—Rolling; STAINLESS STEEL; STEEL—Continuous Casting; STEEL—Forging; STEEL—Mechanical Properties; STEEL HEAT TREATMENT—Annealing; STEEL SHEET; STEEL SHEET—Rolling; STEEL SHEET—Transportation; TITANIUM AND ALLOYS—Forming.

**091660 MAINTAINING FLATNESS IN COLD ROLLING USING NIPCO ROLLS.** The basic element of the Nipco flatness control system for rolling mills is the hydraulically controlled Nipco roll. In 4-high rolling mills it is used instead of a conventional back-up roll, while in skin-pass mills with only two rolls it is used as a work roll. The system uses hydraulic modules to control nip force at definable positions along the roll. It is suitable for 2 and 4-high stands.

Guettinger, Heinz (Sulzer-Escher Wyss Ltd, Zurich, Switz); Lehmann, Rolf; Schnyder, Eugen. *Steel Times Int* v 11 n 3 Sep 1987 p 48-49, 64.

**091661 NEW TWELVE-HIGH REVERSING COLD ROLLING MILL.** A twelve-high cold rolling mill with the blast technology has been put into operation at Metallwerke Schwarzwald, Villingen/Schwenningen, Federal Republic of Germany. A special feature of this rolling mill is the direct hydraulic screwdown system which has been developed by Josef Froehling GmbH. Extremely short reaction times, smallest adjustments and, as a result, closest thickness tolerances are obtained by

means of a separate high pressure hydraulic control loop, operating with servo valves. (Author abstract)

Froehling, Peter (Josef Froehling GmbH, Olpe, West Ger). *MPT Metall Plant Technol* v 10 n 4 1987 p 88, 90.

**091662 EQUIPMENT AND TECHNOLOGY CHARACTERISTICS OF THE NEW TYPE 6-HIGH COLD ROLLING MILL.** This paper presents the equipment, technological characteristics and operational data of the 6-high cold rolling mill with intermediate rolls shifting in axial directions. The roll dimensions are: 110/130/300 dia. 400L mm and 125/150/380 dia. 400L mm. Experimental results regarding the mill modulus curve, the relation between the shifting force of intermediate rolls and the rolling load and speed, the influence of intermediate rolls shifting on the shape change, the shape control function of the work roll bending force, the improvement of the edge drop and the existence of infinite width rigidity are given in this paper. The advantages of the 6-high mill, such as a reduction of edge drops and cracks, the tendency toward heavy reduction, a reduction of the number of passes and intermediate anneals and stability in shaping and performance are confirmed by experiments. With the application of the 6-high mills, the quality and yield of rolled strips, the productivity and the operating efficiency of the rolling mill can be improved. (Edited author abstract) 3 refs. In Chinese.

Zhang, Shutang (Central Iron & Steel Research Inst, China); Du, Meiyang; Yang, Qirui; Hou, Jin. *Kang T'ieh* v 22 n 7 Jul 1987 p 23-26, 15.

**091663 OPTIMISING THE TECHNOLOGY FOR COLD ROLLING ANISOTROPIC STEEL MELTED BY THE SULPHIDE METHOD.** The authors describe the use of regression analysis for determining the effects of tensioning during operations of cold rolling (following hot rolling) on the field strength and deformation texture during reduction and reversal of anisotropic steel. Details are given of the necessary total reduction in the first pass of rolling with reversal. Regression equations are given for thermal and deformation actions on the magnetic properties of steel of this type. (Author abstract) 3 refs.

Gustomesov, V.A. (Verkh-Isetsk Iron- & Steelworks, USSR); Khaikin, B.E.; Korobov, A.G.; Radin, F.A. *Steel USSR* v 17 n 2 Feb 1987 p 92-95.

**091664 WRITING COMPLEX PROGRAMS FOR THE MK-56 CALCULATOR.** As an example the author uses an 89 × 12 mm tube which is to be rolled to 20 × 2.5 mm on a cold reduction mill. It is known that for the given grade of steel the elongation factor per pass  $\mu_p$  should be no greater than 3.0. One needs to calculate the overall elongation factor, the number of passes, the actual elongation factor per pass and the diameter and wall thickness of the tube after each pass. Using this program as an example, the author writes the subroutines.

Dorokhov, A.I. (All-Union Scientific Research & Planning-Design Inst of the Pipe Industry, USSR). *Metallurgist (USSR)* v 31 n 4 Mar-Apr 1987 p 99-103.

**091665 ADVANCED THICKNESS CONTROL TECHNOLOGY FOR THE FULLY CONTINUOUS TANDEM COLD MILL AT KASHIMA STEEL WORKS.** The fully continuous rolling mill was built by remodeling the existing tandem cold mill at Kashima Steel Works in April 1983. Digital control system and a HYDRO-FIT type keyless oil film bearing which is mounted on the back up roll by oil injection system have been adopted in order to minimize gage deviation in the longitudinal direction. As a result, strip gage accuracy through a coil can be compensated within  $\pm 1\%$  of the strip gage. (Edited author abstract) In Japanese.

Yamamoto, Kazuya; Nishino, Takao; Nishimura, Fumio; Mori, Masaaki; Ooi, Toshiya. *Sumitomo Met* v 39 n 4 Oct 1987 p 363-374.



**091666 COLD ROLLING: THE ALTERNATIVE FOR SPLINED SHAFTS.** Many design engineers, when faced with the task of specifying splines, threadforms and similar features on shafts, still think in terms of conventional metal-cutting techniques. However, there is an important alternative in the cold rolling process which normally offers significant advantages in reducing production cost while, at the same time, enhancing the inherent mechanical properties of the component. There have been more demands placed upon both quantity and quality of the parts produced by cold rolling. As a result, it has been greatly improved over recent years, through better machine and tool design coupled with a clearer understanding of the material requirements of the components being cold formed. The very fact that the metal is made to cold flow in the production of the profile means that the structure of the material is improved in the critical areas and smaller diameter stock can be used.

Lee, Geoff (Marbaix Lapointe). *Eng Mater Des* v 32 n 3 Mar 1988 p 22, 24.

**091667 DEVICE TO MEASURE STRIP TENSION ON COLD-ROLLING MILLS.** One of the important parameters in rolling is the tension of the strip being rolled. The Special Design Office of the Chermatavtomatika Scientific Industrial Association has developed several different tension meters and introduced them on a number of mills for flat rolled products. The tension of the strip is determined by measurement of the vertical component of the tensile force on a sensor built into the bearing of the measurement roller.

Parfenov, V.V. ('Chermatavtomatika' Scientific-Industrial Assoc, USSR); Fisher, E.G.; Kritskii, Yu.M.; Ochevovskii, R.M.; Novikov, V.S. *Metallurgist (USSR)* v 31 n 5-6 May-Jun 1987 p 177-179.

**091668 EIN WEITERER MODERNISIERUNG-SABSCHNITT DES KALTBREITBANDWALZWERKS DER STAHLWERKE PEINE-SALZGITTER AG.** [Further Modernization of the Cold Wide Strip Mill of Stahlwerke Peine-Salzgitter AG]. The continuous pickling line has been equipped with three flat pickling baths and is now controlled by a computer. An automatic surface inspection system assists the detection of defects. The tandem mill has been mechanized and automated. It has been provided with a process control system, a new automatic gage control and a fifth 6-roll mill stand, complete with shape control and own emulsion circuit. The annealing shop is being converted at present to high-convective furnaces. One of the two temper mills has been combined with a tension leveling machine and equipped with a central control station as well as a new type of temper degree control system. In the area of the finishing shop, two wide strip coiling units have been revamped, a precision slitting plant complete with packing line and partially automated facility for the production of circular blanks have been installed. (Author abstract) In German. 21 refs.

Koehler, Gerhart (Stahlwerke Peine-Salzgitter AG, Salzgitter, West Ger). *Stahl Eisen* v 108 n 6 Mar 21 1988 p 73-79.

**091669 KALTWALZEN GROSSFORMATIGER DUENNBLECHE AUS SONDERWERKSTOFFEN AUF EINEM 6-WALZEN-UMKEHRGERUEST.** [Cold Rolling of Large-Sized Sheets Made of Special Materials in a Six-Roll Reversing Mill]. The report discusses the development of a process technology for the production of cold-rolled, large-sized single sheets of special high-grade steels, nickel, superalloys and other nickel-basis materials. The variety of alloys and dimensions to be rolled, in conjunction with project-specific small batch sizes, requires the rolling of single sheets and does not therefore allow the production of coils. The investigation focused on the development of a cold rolling technology for the tension-free rolling of single sheets in a six roll Sendzimir mill in connection with the design of a process computer system for semi-automatic rolling. (Edited author abstract) 13 refs. In German.

Kettler, Heinrich-Wilhelm (VDM Nickel-Technologie

AG, Altena, West Ger); Jung, Herbert. *Stahl Eisen* v 108 n 7 Apr 5 1988 p 315-322.

**091670 BERECHNUNG DES SCHWINGUNGS-VERHALTENS SCHNELLAUFENDER KALTWALZ-TANDEMSTRASSEN.** [Calculation of the Vibrational Behaviour of High-Speed Cold Rolling Tandem Mills]. In order to investigate the influences of plant data and parameters of the rolling schedule on the tendency of a cold rolling tandem mill to vibration, a mathematical model describing the coupling between the vibrational characteristics of the rolling plant and the elastomechanical processes in the roll gap was developed. With a computer program, based on this model, a better understanding of the mechanisms of the vibration was achieved. A simplified method for comparing different rolling schedules in respect to their tendency to chatter was worked out. (Author abstract) 13 refs. In German.

Pawelski, Oskar (Max-Planck Inst fuer Eisenforschung GmbH, Duesseldorf, West Ger); Rasp, Wolfgang; Friedewald, Klaus. *Stahl Eisen* v 108 n 7 Apr 5 1988 p 323-328.

**091671 ELIMINATION OF DISTORTION NEAR THE CUT-OFF EDGES OF COLD ROLL-FORMED LARGE THICK CHANNELS.** Methods for eliminating the distortion of the cut-off flange edges of a steel channel-section of 4.5 mm wall thickness and 75 mm flange height are experimentally researched, using a punch-die apparatus or press-rolls. The principle of the methods is to compress the flange edge and cause new plastic deformation there, so that the residual stress which occurred during the cold roll-forming process re-distributes, with reduction of elastic recovery during the subsequent dimensional length-cutting operation. Prototype production tests have been carried out and high accuracy products have been obtained. (Author abstract) 5 refs.

Ona, Hiroshi (Takushoku Univ, Hachioji, Jpn); Jimma, Takashi; Utsunomiya, Noriji. *J Mech Work Technol* v 16 n 2 Apr 1988 p 193-202.

**091672 OPTIMISATION OF SCHEDULES FOR COOLING OF ROLLED SECTIONS DURING THERMOMECHANICAL TREATMENT WITH CONTROLLED COOLING.** An examination is made of the complex experimental-theoretical approach used at the Omutninsk Iron- and Steelworks to solve the problem of determining optimum schedules for cooling rolled stock during thermomechanical treatment with controlled rolling. This included mathematical modelling of the temperature field of the metal with account taken of the heat released during phase transformation of austenite, and an experimental investigation of austenite transformation during cooling. (Author abstract) 8 refs.

Samoilovich, Yu. A. (Moscow Steel & Alloys Inst, USSR); Voronov, A.N.; Kabakov, Z.K.; Trusov, V.A.; Distergelt, I.M.; Petrenko, A.M. *Steel USSR* v 17 n 8 Aug 1987 p 367-370.

**091673 COMPARATIVE ANALYSIS OF ROLLING PROCESS AND PROCESS OF DRAWING ROLLER DRAW PLATES.** The results of the authors' comparative analysis indicate differences between the rolling process and the process of drawing through undriven rollers. The characteristic differences between the process of rolling with tension and that of drawing through undriven rolls arise from the different methods of power transmission for rotating the deforming tools. The stress state of the billet during drawing through roller draw plates is a function of the design of the support bearings of the work rollers. The use of back tension is expedient in the case of drawing through roller draw plates with backup rollers. (Author abstract) 9 refs.

Dobrov, I.V. (Dnepropetrovsk Inst of Ferrous Metallurgy, USSR); Grudev, A.P.; Kokovikhin, Yu.I. *Steel USSR* v 17 n 10 Oct 1987 p 463-465.

**091674 NEW AUTOMATIC GAUGE CONTROL SYSTEM FOR A REVERSING COLD MILL.** The response of an AGC system depends on the dynamic characteristics of reel motor current control controlling

reel motor current or roll position. The AGC system controlling the reel motor current is better than the AGC system controlling the roll position even with a hydraulic screwdown system. A new AGC system controlling reel motor current is better than the AGC system controlling the roll position even with a hydraulic screwdown system. A new AGC system controlling reel motor current and roll position has been developed based on the results. This system has been applied to Sendzimir and 4-high reversing mills. (Edited author abstract). 6 Refs.

Kondo, Katsuya (Sumitomo Metal Industries Ltd, Amagasaki, Jpn); Misaka, Yoshisuke; Okamoto, masaki; Matsumori, Yasuo; Miyagi, Toshimitsu. *Trans Iron Steel Inst Jpn* v 28 n 6 1988 p 507-513.

**091675 LENGTH OF CONTACT ARC DURING COLD ROLLING.** A solution is put forward to the problem of determining the length of the contact arc during cold rolling based upon the Hitchcock-Tselikov equation without iterations. The expressions obtained ensure accurate calculation of the length of the contact arc in the case of elastic compression of the rolls and elastic recovery of the strip dimensions once it has left the deformation zone. The limiting values of the ratio of the contact forces of friction to the deformation resistance of the metal that ensure rolling of strip of minimum thickness are established. (Author abstract). 5 Refs.

Nikolaev, V.A. (Zaporozh'e Industrial Inst, USSR). *Steel USSR* v 17 n 11 Nov 1987 p 507-510.

**091676 DEVELOPMENT OF A COMPUTER MODEL OF FLAT ROLLING.** A computer program was developed by an engineering student for cold rolling of flat products. The software which was based on the analysis of a model of cold rolling was written to be highly interactive. The objectives of this project were to encourage student development of process models and computer programs and to use these in appropriate laboratory assignments. (Author abstract). 1 Ref.

Derek Shiu, K.H. (Univ of Regina, Regina, Sask, Can); Bhole, S.D. *CoEd J* v 8 n 3 Jul-Sep 1988 p 56-59.

Computer Aided Analysis See ROLLING MILLS—Mathematical Models.

## Computer Aided Design

**091677 ROLL PASS DESIGN FOR THE ROLLING OF SPECIAL SECTIONS.** Due to the increasing market for special sections, there is a necessity to increase the skill in section pass design. This can be done by presenting a number of good roll pass designs for different sections to get ideas for roll pass design for similar sections and by developing computer-aided roll design systems (CARD). In this paper, roll pass design for rolling of nine different sections is presented with comments on the rolling conditions. These pass designs are from the roll pass design catalogue presented by the Swedish Ironmasters Association (Jernkontoret). CARD systems are complex, but open new possibilities for automation of roll design procedure and roll turning. (Edited author abstract) 32 refs.

Lundberg, Sven-Erik (Milltek Innovation, Gavle, Swed); Sjobkvist, Lenny. *Scand J Metall* v 17 n 1 1988 p 38-45.

Computer Aided Manufacturing See IMAGE PROCESSING—Computer Applications.

Computer Applications See Also IRON AND STEEL PLANTS—Modernization.

**091678 COMPUTERIZED THERMOMECHANICAL ROLLING IN HEAVY PLATE MILLS.** The deformation of the plate in thermomechanical rolling has to take place within a specified temperature range. This temperature specification and the target parameters of conventional rolling have made it necessary to provide an appropriate automation system, which was developed by Siemens AG. This report describes the design and different functions of the system as well as the initial results achieved in operational practice. (Edited author abstract)



Soergel, Guenter (Siemens AG, Erlangen, West Ger). *MPT Metall Plant Technol* v 10 n 6 1987 6p between p 40 and 48.

## Computer Simulation

**091679 TEMPERATURE SIMULATION AND ITS APPLICATION TO STEEL QUALITY CONTROL IN BAR ROLLING.** A water-filled cooling tube was developed for controlled rolling and cooling of bar, and, based on experimentally obtained cooling characteristics of the tube, cooling ability in the water cooling process was formulated. By incorporating the present formula into a previously developed temperature model; temperature simulation of bar subject to forced water cooling in the rolling process became possible. Operational conditions for controlled rolling and cooling were determined by the simulation, and uniform finegrained structure and hardness were obtained in practical rolling. (Author abstract) In Japanese. 3 refs.

Takatsuka, Kouro; Moritaka, Mitsuru; Gumi, Kazumi; Ikeda, Tatsuo. *R&D Res Dev Kobe Steel Ltd* v 37 n 4 Oct 1987 p 19-22.

**091680 WEITERENTWICKLUNG EINES RECHENMODELLS AUF DEM GEBIET DES KONTINUIERLICHEN WALZENS IN STRECKKALIBERREIHEN.** [Further Development of a Computer Model Simulating Continuous Rolling in Roughing Pass Sequences]. Based on an efficient method to describe the geometry of the deformation zone by rolling in roughing pass series, a model for the calculation of the temperature field over the cross-section of the rolling stock as well as a method for an improved calculation of the rolling force in continuous light section and wire rod mills have been developed. A comparison of the calculated deformation parameters with those measured in a modern continuous wire mill confirmed the applicability of the methods developed. (Edited author abstract) 6 refs. In German.

Hensel, Arno (Bergakademie Freiberg, Freiberg, East Ger); Wehage, Harald; Wehage, Joerg. *Neue Huette* v 32 n 11 Nov 1987 p 406-410.

## Control See Also ROLLING MILLS—Control Systems.

**091681 MJERENJE I REGULACIJA DIMENZIJA SIPKE I ZICE KOD VALJANJA.** [Measurement and Regulation of Rod and Wire Dimensions at Rolling]. The application of modern microelectronic elements for regulation of production flow is discussed. Other applications are for control and guidance. The methods are applied to rod and wire rolling. (Edited author abstract) In Serbo-Croatian. 16 refs.

Oehlstoeter, Gerhard (Bergakademie Freiberg, Freiberg, East Ger). *Metalurgija (Sisak Yugosl)* v 26 n 2-3 Apr-Sep 1987 p 81-86.

**091682 SHAPE MEASUREMENT AND CONTROL ON HOT AND COLD MILLS.** The article briefly reviews techniques and equipment applicable to both ferrous and non-ferrous hot and cold mills. The Vidimon shapemeter is described in detail. There are now 120 of these systems installed world-wide.

Godfrey, Graham (Davy McKee, Sheffield, Engl). *S Afr Mech Eng* v 37 n 10 Oct 1987 p 493-495.

**091683 CAPTEURS DIMENSIONNELS DANS LE PROJET D'AUTOMATISATION DU TRAIN GREY DE DIFFERDANGE.** [Dimension Sensors in the Automation Project of the Grey Mill at Differdange]. In the automation project of the Grey mill at ARBED-Differdange, the dimension sensors are important for a real-time control of the roll stands. During development of the control for the beam dimensions, a two-level approach has been adopted. Level 1 is control of the essential beam dimensions at the intermediate roll stand during different milling cycles. This control is realized at hot milling temperature for the whole length of the beams. Level 2 is dimension control of the beam section and form as they

come out of the finishing stand upstream of the hot saws. For level 1 a combination of CCD cameras, radiometric and laser technics allows continuous measuring of the thickness, height and length of the flanges at a speed of 8 m/s. During level 2 the final control of the form and dimensions of the beams is realized by robotic technics. (Edited author abstract) In French.

Zenner, A. (ARBED); Panunzi, C.; Liesch, J.; Reimen, V.; Majerus, C. *Cah Inf Tech Rev Metall* v 84 n 5 May 1987 p 375-383.

**091684 RIZENE VALCOVANI MIKROLEGOVANYCH OCELI - EKONOMICKE ZVYSENÍ UZITÝCH VLASTNOSTÍ KONSTRUKČNÍCH OCELI.** [Control Rolling of Microalloyed Steels - Economic Increase of Utility Properties of Structural Steels]. The paper reviews the development and introduction of fine grain, higher strength steels as well as the development of lower-alloyed and heat treated steels. For the development of heavier and stronger supports (in mines) the technology of control rolling of microalloyed steel may be put on stream on adjusted installations in metallurgical plants. (Author abstract) 10 refs. In Czech.

Sicha, Frantisek. *Hutn Listy* v 43 n 3 Mar 1988 p 169-172.

**091685 MODEL SIMULTANNIHO RIZENI TLOUSTKY PLECHU A PASU V JEJICH PODELNEM A PRICNEM SMERU.** [Model of Simultaneous Thickness Control of Sheets and Strips in Their Longitudinal and Transverse Direction]. The article describes an automatic control system for longitudinal thickness. Excess thickness causes corrugation with higher rolling forces along the length. The model presented provides for compensation of the negative effect which on four-high mills may be ensured by simultaneous control of transverse sections of rolling stock. In Czech. 4 refs.

Hajduk, Milan (Vyzkumny Ústav Strojirensky a Metalurgicky, Ostrava, Czech); Varta, Jiri; Stehlik, Petr; Konvicny, Josef; Zidek, Milan. *Hutn Listy* v 42 n 9 Sep 1987 p 622-628.

**091686 MAITRISE DE L'EPASSISSEUREN TETE DE BANDE AU TRAIN A BANDES DE SOLMER.** [Strip Head End Thickness Control at Sollac Fos Hot Strip Mill]. As a result of customer requests work has been carried out to improve the head end thickness performances in hot strip mills. This paper describes the method used at Sollac Fos Hot Strip Mill and the evolution of some ratios relative to thickness performance. From 1982 to 1986, the percentage of head end thickness in the range  $\pm 50$  microns has increased from 67 percent to 80 percent. In French.

de Lamberterie, B.; Roux, G. *Cah Inf Tech Rev Metall* v 85 n 5 May 1988 p 399-405.

**091687 THICKNESS CONTROL OF ROLLING MILLS USING THE ROLL BALANCING FORCE.** A new thickness control method of rolling mills using the roll balancing force (Roll Balancing Force AGC) has been developed. The features of Roll Balancing Force AGC are as follows. The delay of measurement is minimized by using the roll force feedback. The advanced thickness control can be obtained without using an expensive hydraulic roll positioning device. Roll Balancing Force AGC is useful for the improvement of thickness control in the rolling mill with an electrical roll positioning device. In Japanese.

Hoshino, Ikuya; Kimura, Hiroshi; Kokubo, Syunji; Abe, Teichi; Nakagawa, Kiyoshi. *Sumitomo Keikinzoku Gihō* v 29 n 2 Apr 1988 p 1-7.

## Control Systems See Also ROLLING MILLS—Modernization.

**091688 APPLICATION OF THE PROCESS DIAGNOSIS TECHNIQUE FOR THE DOWN COILER.** Down coilers at the No. 2 Hot Strip Mill in NKK's Fukuyama Works have been equipped with the latest

devices in order to obtain high quality and high yield ratio products. The process diagnosis system detects abnormalities of the equipment and studies the causal relationship between quality of products and equipment condition by monitoring the down coilers. Its main functions are described.

OGAWA, Sadaoyoshi (Nippon Kokan KK, Fukuyama, Jpn); Okitu, Hiroto; Kuboyama, Kiyoshi; Yoshimoto, Matuo. *Trans Iron Steel Inst Jpn* v 27 n 11 1987, Pap Presented at the 113th Iron and Steel Inst of Jpn Meet, Tokyo, Jpn, Apr 2 1987 p B.279.

## Cooling See Also ROLLING MILLS—Cooling.

**091689 IMPROVEMENT OF METAL COOLING SYSTEMS ON SHEET AND PLATE MILLS.** The design of a laminar cooling container with slit discharge of coolant across the width of the sheet or plate has been developed and tested in industrial conditions. It ensures a sufficiently high uniformity of the cooling flow across the width of the metal with high stability with respect to impurities in the coolant. The procedure for determining the thermotechnical parameters of laminar cooling systems has been revised, with account taken of the specific consumption of water, its temperature, the thickness of the rolled metal, and the speed of the strip through the cooling device. 4 refs.

Gertsev, A.I. (All-Union Scientific Research Inst of Metallurgical Engineering, USSR); Pavlenko, V.V.; Maksimenko, G.A. *Steel USSR* v 17 n 4 Apr 1987 p 197-199.

## Energy Conservation

**091690 ENERGIEOPTIMALE MODELLGES-TUETZTE FUEHRUNG EINER WALZWERK-SOFENGRUPPE.** [Energy Optimal Model-Aided Control of a Group of Rolling Mill Furnaces]. Model-aided process control of rolling mill furnaces leads to a more efficient utilization of the energy input. The following report describes the design, installation and testing of the system for a group of rolling mill furnaces. The description covers the furnace equipment, the adaptation of the furnace instrumentation, the hardware and software involved as well as the process model strategies and data flow for the supply of the model. The operating results of the acceptance tests and the initial experience are discussed and evaluated both in technical and economic terms. In German with English abstract.

Evers, Wilhelm (Stahlwerke Peine-Salzgitter AG, Salzgitter, West Ger); Klima, Rolf; Krause, Artur; Kuck, Arno; Plottke, Anton. *Stahl Eisen* v 108 n 10 May 16 1988 p 43-51.

## Heat Transfer See Also STEEL—Cooling.

**091691 CHARACTERISTICS OF HEAT TRANSFER OF MULTI SPRAY NOZZLE.** In order to examine the characteristics of heat transfer at high water flux and high temperature, the water flux, spray distance and depth of water were varied. By arranging small nozzles between each roller, a high water flux and a large impinged space will be realized. Thus the cooling capacity and cooling uniformity will be improved. 2 refs.

Ohnishi, Akira (Sumitomo Metal Industries Ltd, Hasaki-machi, Jpn); Takashima, Hiroyuki; Hariki, Michiharu. *Trans Iron Steel Inst Jpn* v 27 n 12 1987, Prepr for the 113th ISI Meet, Part VI, Tokyo, Jpn, Apr 1-3 1987 p B.299.

**Hot Rolling See Also ALUMINUM CALCIUM ZINC ALLOYS—Superplasticity; CARBON STEEL—Thermomechanical Treatment; COPPER AND ALLOYS—Defects; FLOW OF SOLIDS—Testing; IRON AND STEEL METALLOGRAPHY—Textures; IRON AND STEEL PLANTS—Computer Aided Manufacturing; ROLLING MILLS—Control; ROLLING MILLS—Cooling Systems; ROLLING MILLS—Japan; ROLLING MILLS—Modernization; ROLLING MILLS—Process Control; SILICON STEEL—Microstructure; STAINLESS STEEL—Formability; STEEL—Continuous Casting; STEEL—Deformation; STEEL—Formability; STEEL—Mechanical Properties; STEEL—Pickling; STEEL SHEET; STEEL SHEET—Fracture; STEEL SHEET—Rolling; WIRE—Manufacture.**



**091692 UTJECAJ DUZINE VLACNE SILE I NJENA UPOTREBA ZA INTENZIFIKACIJU TOPLOG VALJANJA SIPKASTOG MATERIJALA.** [Influence of Longitudinal Drawing Stress and its Application at the Intensification of Hot Rolled Rod Material]. In this paper the influence of longitudinal drawing stress in rod hot rolling is presented. This problem has been studied for several years at Bergakademie Freiberg and at the factory for rolling equipment SKET in Magdeburg. Test results are given. (Edited author abstract) In Serbo-Croatian. 8 refs.

Oehlstoeter, Gerhard (Bergakademie Freiberg, Freiberg, East Ger). *Metallurgija (Sisak Yugosl)* v 26 n 2-3 Apr-Sep 1987 p 77-80.

**091693 ROLE OF CONSTITUTIVE FORMULATION IN THE ANALYSIS OF HOT ROLLING.** The effect of constitutive modelling of material behavior on the predictive abilities of two models of flat rolling is studied. Comparison of calculated roll forces and powers to those measured on a commercial steel mill indicates that the Orowan model is sufficiently accurate when supplied with carefully determined flow strength data. The manner of representation of that data is found to be significant. The results show that a multidimensional databank, which stores values of strength for specific strains, rates of strain and temperatures is very useful in modelling the process. (Author abstract) 32 refs.

Lenard, J.G. (Univ of New Brunswick, Fredericton, NB, Can); Wang, F.; Nadkarni, G. *J Eng Mater Technol Trans ASME* v 109 n 4 Oct 1987 p 343-349.

**091694 COOLING CONDITIONS OF HOT ROLLED STEEL COILS.** It is established that the effect of the onset of a steady-state temperature field is of a universal nature and can be used for analysis of the cooling processes in hot rolled coils after rolling. The increase in the cooling rate of a coil owing to blowing with a steam of air is attributable to redistribution of the heat flows in the metal and increase in the proportion of heat transfer by convection as cooling progresses. Control of the steady-state cooling condition in the high temperature range (800-700°C) provides the possibility of additional heat treatment of strip wound into a coil, utilisation of the heat in the strip, and a reduction of cooling time in the low temperature range (350°C). (Edited author abstract) 4 refs.

Gasho, E.G. (Moscow Engineering Inst, USSR); Prokhorov, V.I.; Moroz, A.T.; Frantsenyuk, L.I. *Steel USSR* v 17 n 2 Feb 1987 p 86-87.

**091695 PRODUCTION OF ROLLED PRODUCTS OF LOW-CARBON STEELS FOR FINISH STAMPING.** Based on the equipment at the Magnitogorsk Metallurgical Combine for rolling, heat treatment, and finishing and the requirements for the production of hot-rolled products to be subjected to finish stamping, the authors chose a scheme which includes rolling on a continuous hot strip mill, accelerated cooling, cutting of the strip, heat treatment, strengthening, pickling and oiling. The main problem in realizing this scheme was developing a heat treatment regime which would ensure a fully spheroidized structure and low tensile strength. In connection with the absence of an annealability interval for granular pearlite in the case of hypoeutectoid steels, only a subcritical anneal can be employed in bell-type furnaces for sheets of steels 08kp and 20.

Kovalenko, L.V. (Ukrainian Scientific-Research Inst of Metals, USSR); Krasnopol'skii, V.M.; Legeida, N.F.; Podpovetnaya, T.A. *Metallurgist (USSR)* v 31 n 3-4 Mar-Apr 1987 p 63-64.

**091696 RECHNERISCHE ANALYSE VON WALZEIGENSPANNUNGEN.** [Numerical Analysis of Residual Rolling Stresses]. A numerical method is presented with the aid of which the formation of residual stresses in hot-rolled sections during cooling after the rolling process can be simulated on a computer. The bases of the theoretical assumptions are explained. The temperature dependent thermal and mechanical properties of structural steel are given as a basis for the calculation

procedure. The processes in a hot-rolled I-beam during cooling are illustrated and explained by a numerical analysis. For the first time, the distribution of residual stresses in a bar with a square cross section, which has been known by measurement on the surface only, could be determined by calculation. (Edited author abstract) In German. 21 refs.

Hamme, U. (Bergische Univ Wuppertal, Wuppertal, West Ger); Schaumann, P. *Stahlbau* v 56 n 11 Nov 1987 p 328-334.

**091697 INVESTIGATION OF TEMPERATURE FIELDS IN BEARING STEEL BAR COILS DURING COOLING AFTER HOT ROLLING.** Unevenness in the temperature distribution within coils during cooling after hot rolling has a marked influence on the microstructure and mechanical properties of the metal. Study of the temperature conditions during cooling of coils is therefore important for determining accurate process parameters in the hot rolling of steel. In this project the authors experimentally and theoretically determined the temperature distribution over the cross-section of bearing steel rod coils during cooling after hot rolling to different schedules. The thermal conductivity equation for a cooling coil in a cylindrical coordinate system can be written in the following form. The authors theoretically and experimentally determined the temperature fields and changes in this field over the cross-section of bearing steel ShKh15 rods during cooling as a function of coil weight and dimensions, cooling start temperature, and cooling conditions. (Edited author abstract) 3 refs.

Zhadan, V.T. (Ukrainian Scientific Research Inst of Special Steels, Alloys & Ferroalloys, USSR); Yatsenko, V.A.; Gerashchenko, P.M.; Shtrugunov, I.L. *Steel USSR* v 17 n 3 Mar 1987 p 135-136.

**091698 TEMPERATURE DISTRIBUTION IN A SLAB DURING HOT ROLLING.** The dependence of the temperature distribution during hot rolling of a steel slab on the speed of rolling, reduction and initial temperature is investigated. It is observed that while the center of the slab cools, the surface loses heat at a much higher rate following which significant reheating occurs. Because of that different parts of the slab receive significantly different thermal-mechanical treatments, possibly resulting in a nonhomogeneous product. (Author abstract) 49 refs.

Karagiozis, A.N. (Univ of Waterloo, Waterloo, Ont, Can); Lenard, J.G. *J Eng Mater Technol Trans ASME* v 110 n 1 Jan 1988 p 17-21.

**091699 FRICTION AND FORWARD SLIP IN HOT ROLLING.** Relations between forward slip and the coefficient of friction in flat rolling were determined by a computer program Friction-Hill. This program gives a numerical solution to von Karman's equation. The relation between forward slip and the coefficient of friction is dependent on the model of friction, geometry of rolling, deformation of the rolls, elastic entrance and exit regions, and model of yield stress of the material in the bar. The conclusion is that to evaluate coefficients of friction from measurements of forward slip in hot rolling by application of a simple equation is unreliable. (Author abstract) 14 refs.

Jarl, Magnus. *Scand J Metall* v 17 n 1 1988 p 2-7.

**091700 MODELING OF THE ROLLING OF UNEVENLY HEATED SLABS.** The work is an experimental investigation of the effect which the temperature field of the metal in rolling has on the nonsteady state shaping of the end regions of wide ingots and slabs under rolling conditions in universal stands of slabbing as well as in thick and thin sheet hot rolling mills. The method of thermomechanical modeling of hot plastic deformation processes of continuously heated bodies was developed. Deformation rate fields were obtained in the longitudinal-horizontal symmetry plane of the specimens which model slab rolling in vertical rollers. 10 refs.

Dylyuk, A.G.; Trubitsyn, A.A. *Russ Metall Met* n 4 1987 p 51-55.

**091701 BEEINFLUSSUNG DES WALZENPROFILS DURCH DIFFERENTIELLE ERWAERMMUNG DES WALZENKERNS.** [Control of Roll Profile by Differential Heating of Roll Core]. Laboratory investigations have shown that thermal heat-up of the back-up roll core leads to an increase of roll crown and allows one to compensate in this way roll wear. Initial results of measurements in operation confirm this result: in two accordingly prepared back-up rolls, which had been repeatedly used as bottom rolls in the finishing mill, it was possible to compensate the wear to an extent ensuring that the rolls would maintain their original cylindrical shape throughout the rolling campaign. (Author abstract) In German. 7 refs.

Fabian, Wolfgang (Hoesch Stahl AG Werk Westfalenhuette, Dortmund, West Ger); Fischer, Friedrich-Wilhelm; Kopineck, Hermann-Josef; Tappe, Wilhelm; Wladika, Hans. *Stahl Eisen* v 108 n 3 Feb 8 1988 p 36-40.

**091702 CHANGES OF SHAPES NEAR TWO EDGES DURING ROLLING OF STEEL FLATS.** The shape of the edges of a metal after flat rolling was studied by experiments. It is shown that the shape of the edges changes into single convex from double convex as the degree of deformation increases. There is a degree of deformation at which the shape is not convex. The formula obtained can be used for hot rolling. (Edited author abstract) In Chinese. 3 refs.

Han Baoyun (Central Iron & Steel Research Inst, China); Tang Weilin. *Kang T'ieh* v 22 n 11 Nov 1987 p 17-20.

**091703 DEVELOPMENT OF TECHNOLOGY AND EQUIPMENT FOR THERMOPLASTIC HARDENING OF ROLLED METAL - PROSPECTS FOR IMPROVING THE QUALITY AND SAVING METAL.** A new method is proposed for rolled metal hardening by means of high-speed sign-variable plastic bending, i.e. thermoplastic treatment. This process makes it possible to do without bulky and complex equipment. The effect of the sign-variable bending on the metal structure results in an increase of its uniformity over the entire cross section, refinement of all the elements of the structure. It brings about orientation of martensite crystals with respect to the deformation axis. Thermoplastic treatment stably improves the strength characteristics of carbon and low-alloyed steels by 15-20% and impact toughness by a factor of 1.5-2 in comparison with conventional hardening. (Translated author abstract) In Russian.

Golovanenko, S.A.; Krylov, N.I.; Vasilevskii, M.S. *Izv Vyssh Uchebn Zaved Mashinost* n 10 1987 p 126-129.

**091704 FERRITE GRAIN REFINEMENT THROUGH ACCELERATED COOLING AFTER CONTROLLED ROLLING IN LOW CARBON STEELS.** The authors studied the transformation behavior and ferrite nucleation in continuous and isothermal transformation. A combination of strain imposed in the uncrystallized region and an increase in supercooling by accelerated cooling caused an increase in intragranular nucleation which resulted in ferrite grain refinement. The number of intragranular nuclei decreased as recovery and recrystallization progressed before transformation. It is suggested that intragranular nucleation sites were dislocations, the sub-grain boundary and inclusions which could not act as nucleation sites under conditions of controlled rolling. Accelerated cooling brought about ferrite grain refinement by promotion of intragranular nucleation on the proper sites and suppression of grain growth. (Edited author abstract) 17 refs. In Japanese.

Abe, Takashi (Nippon Kokan KK, Kawasaki, Jpn); Tsukada, Koshiro; Kozasu, Isao. *Tetsu To Hagane* v 74 n 3 Mar 1988 p 505-512.

**091705 MODERNISIERUNG VON WARMBANDSTRASSEN.** [Modernization of Hot Strip Mills]. The article concerns itself with all the important modernization measures. These include the installation of walking



beam furnaces with a lower hearth loading, reduction of the slab reheating temperature, installation of a new 4-high reversing stand in the roughing train with greater rigidity and high capacity drives, installation of an edger with a high width reduction and automatic width control, installation of insulation hoods between the roughing and finishing trains or the incorporation of a coilbox, conversion to a larger transfer bar thickness by the installation of a correspondingly heavy crop shear, expansion of the rolling programme through increasing the capacity of the finishing train, installation of hydraulic screwdown as well as of profile and flatness control in the finishing train, laminar cooling between finishing train and coiler, new downcoiler with hydraulically controlled wrapper roll retraction for greater coil weights and strip thicknesses, process automation, hot charring and direct rolling. (Author abstract) 7 refs. In German.

Fricke, Helmut (Mannesmann Demag Sack GmbH, Duesseeldorf, West Ger); Lederer, Andreas. *Stahl Eisen* v 108 n 7 Apr 5 1988 p 305-314.

**091706 SIMULACE VALCOVANI PLOCHYCH VYVALKU KRUTOVYMI ZKOUSKAMI.** [Simulation of Hot Flat Rolling by Torsion Tests]. The advantages and disadvantages of torsion test are briefly evaluated. The number of twists  $N$  and the equivalent strain are in nonlinear relationship, and the same nonlinearity between the twist rate  $N$  and the strain rate makes the calculations difficult. Some formula currently applied to determine the equivalent strain and the mean equivalent strain rate are tabulated. Finally, some recommendations are given to simulate the rolling by torsion tests, and the required  $N$ - and  $N$ -values as a function of the rolling parameters are summarized. 12 refs. In Czech.

Kliber, Jiri; Petlachova, Michela. *Sb Ved Pr Vys Sk Banske Ostrave Rada Hutn* v 33 n 1 1987 p 235-251.

**091707 OPTIMALIZACE PODMINEK VALCOVANI KOROZIVZDORNÝCH Cr-NiTi OCELI ZA TEPLA.** [Optimization of Hot Rolling Conditions for Corrosion Resisting Cr-NiTi-Steels]. Chromium and nickel equivalents are defined more precisely on the basis of nitrogen, aluminum and carbon balances. The effect of heating conditions on the occurrences of ferrite, and derivation of mathematical relations for the description of the ferrite occurrence curve as a function of the temperature and heating time carbon determination for various initial ferrite contents. Plasticity of cast Cr-NiTi-steels has been improved by modifying the chemical composition and heating conditions. (Edited author abstract) 8 refs. In Czech.

Zidek, Milan; Liska, Miroslav. *Sb Ved Pr Vys Sk Banske Ostrave Rada Hutn* v 33 n 1 1987 p 277-297.

**091708 ON THE STRAIN RESISTANCE OF STEEL DURING HOT ROLLING.** The static softening of steel during the pauses between deformation stages can be described by an expression covering the effects of temperature, strain rate, and degree of previous deformation. The proposed procedure is capable of determining the strain resistance of steels during hot rolling, allowing for failure to soften completely between passes. The calculated results agree closely with experimental data. 9 refs.

Levchenko, G.V.; Vorobei, S.A. *Russ Metall Met* n 3 1987 p 82-86.

**091709 PREVENTION OF WARPING OF WEB OF HOT ROLLED H-SECTIONS.** Modification of the rolling practice to accommodate recommendations based on the results of the authors' investigations make it possible to produce H-beams with web thicknesses in the 'minus tolerance field' and halve the yield of seconds and amount of reject for 'web waviness' on the wide flange beam rolling mill in the Nizhnii Tagil Iron and Steel Combine. For the changeover to the production of hot rolled beams to GOST 26020-23 introduction of the results of the investigation made it possible to roll to dimensions lower than nominal without the formation of web waviness. (Author abstract) 4 refs.

Davydov, M.G. (Perm Polytechnic Inst, USSR); Trusov, P.V.; Zudov, E.G.; Kirichkov, A.A.; Petrenko, Yu. P. *Steel USSR* v 17 n 8 Aug 1987 p 365-366.

**091710 STANOVENIE KRITICKEJ TEPLoty FAZOVEJ PREMENY GAMA - ALFA PRI RIADENOM VALCOVANI.** [Critical Temperature of Gamma-Alpha Phase Transformation in Controlled Rolling]. The paper analyses the reasons for establishing the gamma-alpha phase transformation temperature in plastic deformation according to the texture perfection which develops in alpha phase deformed during the rolling process. The phase transformation temperature is affected by a dynamic rolling effect. The  $A_{r3}$  point is situated in the 720-740°C temperature range. (Edited author abstract) 22 refs. In Czech.

Chon, Kim (Vysoka Skola Technicka, Kosice, Czech); Ulicny, Stefan; Vlado, Martin. *Hutn Listy* v 42 n 7 Jul 1987 p 470-473.

**091711 ACCELERATED COOLING: A PHYSICAL METALLURGY PERSPECTIVE.** In the 25 years that accelerated cooling has been used in the production of steel, its role has undergone drastic changes. In 1962-1970, it was used exclusively on hot strip mills, mainly to reduce the length of run-out tables otherwise required for low temperature coiling. The unexpected benefits spawned research and development which has continued to the present. There have been significant advances made as a result of this interest. Among the first was the appreciation of the importance of the condition of austenite prior to cooling. Later work on alloy design and process variations led to improvements in ferrite-pearlite steels and the development of multiphase steels for strip and plate applications. The dual-phase (as-rolled) strip steels and ferrite-bainite plate steels are examples of important developments. These steels offer final properties which were not available in earlier times. The purpose of this paper is to discuss accelerated cooling from the viewpoint of how cooling rates and continuous cooling transformation (CCT) diagrams can determine the sequence of phases which form and how physical metallurgy principles govern their amounts and distributions. Of principal interest are (i) the factors which control the hot rolled microstructure of austenite, (ii) the influence of austenite microstructure and composition on the CCT diagram, and (iii) the influence of cooling path on microstructure evolution for a given CCT diagram. (Edited author abstract). 80 Refs.

DeArdo, A.J. (Univ of Pittsburgh, Pittsburgh, PA, USA). *Can Metall Q* v 27 n 2 Apr-Jun 1988 p 141-154.

**091712 ASSIMILATION OF TECHNOLOGY FOR PRODUCTION OF FEEDSTOCK FOR HIGH PRECISION SHAPED SECTIONS ON 300 MILL WITH FOUR ROLL PASS.** An examination is made of technology for the production of high precision shaped sections developed on the basis of experimental investigations of temperature and deformation schedules for rolling rounds in a four roll pass. The use of a rolling stand with a universal four roll pass enables rectangular and square sections to be produced with identical edge radii. Implementation of the technology has made it possible to dispense with a number of drawing conversions, reduce the number of anneals and surface preparation operations, lower metal consumption, and simplify the manufacture of high precision steel shaped sections. (Author abstract). 4 Refs.

Nikiforov, B.A. (Magnitogorsk Inst of Mining & Metallurgy, USSR); Shchegolev, G.A.; Garasimiyuk, E.I.; Litichevskii, V.M.; Batalov, A.G. *Steel USSR* v 17 n 12 Dec 1987 p 552-553.

**091713 FORMATION OF ACCURACY OF HOT SIZED STEEL ON 350 MILL.** A study was made of the dimensional accuracy of hot sized, 46 mm diameter stock 20KhGNM steel from an industrial 360 t batch. The maximum and minimum diameters and ovality of bars after the rolling mill, sizing unit, and needle milling unit were analyzed. Computer aided calculations enabled confidence intervals and variances to be determined and

spectral density graphs to be plotted. (Author abstract). 5 Refs.

Vorob'ev, Yu. P. (Leningrad Polytechnic Inst, USSR); Lunev, V.A.; Kozko, A.V.; Gorobets, V.A.; Dyachenko, F.V.; Volovats, D. Ya. *Steel USSR* v 17 n 12 Dec 1987 p 554-555.

**091714 PROFILE AND SHAPE CONTROL IN HOT STRIP MILL.** A profile and shape control system has been developed for use in hot strip mills at Wakayama Steel Works and Kashima Steel Works. The control system consists of variable crown (VC) rolls, work roll benders and work roll shifting devices on the last three stands of the finishing train. These devices can be preset so that the desired strip profile can be obtained. To achieve this, mathematical models were developed which could be used to calculate the thermal roll crown, roll wear, VC roll profile and strip profile. These models are suitable for online calculations. (Edited author abstract). 11 Refs. In Japanese.

Takahashi, Ryoichi (Sumitomo Metal Industries Ltd, Amagasaki, Jpn); Nunokawa, Tsuyoshi; Takeda, Ei. *Tetsu To Hagane* v 74 n 7 Jul 1988 p 206-213.

**091715 SLAB SIZING MILL AND ITS TENSION CONTROL SYSTEM.** In 1980 a slab sizing mill was constructed at Oita Works, Nippon Steel Corporation. The mill has V-H-V stands. (V: Vertical, H: Horizontal). The 3 stand tandem mill controls the width of continuous casting slabs. The products of this mill are sent to the hot strip mill and plate mill. This paper describes the interstand tension control. (Edited author abstract). 7 Refs. In Japanese.

Kosuge, Hiroshi (Nippon Steel Corp, Jpn); Yanai, Toshio; Takeda, Koukichi; Anbe, Yoshiharu; Tanaka, Akihiro; Sumihama, Takahiro; Sekiguchi, Kunio; Miyashita, Makoto. *Tetsu To Hagane* v 74 n 7 Jul 1988 p 214-221.

**091716 IMPROVEMENT OF ECONOMICS AND PRODUCT QUALITY IN STRIP MILLS THROUGH HIGH-TECH ROLLING-PART 1: HOT STRIP MILLS.** During 1987 SMS Schloemann-Siemag introduced a new technology for the economical manufacture of hot strip. The technology is known as compact strip production. It is based on a continuous caster which produces 40 to 50 mm thick strip at a production capacity equivalent to that of a modern slab caster. The quality of these strips enables their direct entry into a hot strip finishing train. The new technology marks the end of the use of the complete roughing train in hot strip production plants. It will also remove a technical problem which is a determining factor for the current hot strip roughing train, namely, matching the transfer bar width to that of the strip. 5 Refs.

Rohde, Wolfgang (SMS Schloemann-Siemag AG, Duesseeldorf, West Ger). *MPT Metall Plant Technol* v 11 n 3 1988 8p.

**091717 EFFECTS OF HOT ROLLING TEMPERATURE AND SOLUTE CARBON ON DRAWABILITY OF HOT ROLLED IN FERRITE REGION AND ANNEALED SHEET STEEL.** The effects of the solute carbon content during hot rolling and the hot rolling temperature in ferrite region on the recrystallization texture and Lankford value of extra low carbon sheet steels were studied. The conclusions are: 1) With the addition of Ti or Nb effective in raising the recrystallization temperature of the extra low carbon steel, the hot rolled texture becomes nearly the same as the cold rolled one even though the rolling temperature is 700-800°C. The effects of hot rolling temperature in ferrite region on the hot rolled and hot rolled-annealed textures of interstitial free sheet are small. 2) Solute carbon content during hot rolling is one of the most important factors that affect the recrystallization texture. When decreased the solute carbon content during hot rolling by carbide (TiC, NbC) precipitation, recrystallization texture of {554} <225>



orientation is developed after annealing. That is nearly the same as the cold rolled and annealed texture. (Edited author abstract). 15 Refs. In Japanese.

Hashimoto, Shunichi (Kobe Steel Ltd, Kobe, Jpn); Yakushiji, Terutoshi. *Tetsu To Hagane* v 74 n 8 Aug 1988 p 1617-1624.

**091718 SCALE-BREAKING OF HOT-ROLLED STRIP WITH RUBBER ROLL.** Hot rolled strip at high coiling temperatures for continuous annealing can be effectively pickled if the scale formed on the surface is cracked beforehand. Such cracking is commonly achieved by tension leveling or skinpass rolling. A rubber roll rolling method in which bending strain is applied to steel strip by passing it between a rubber roll and steel roll has proved effective in enhancing pickling efficiency. 2 refs.

Matoba, Tetsu (Nippon Steel Corp, Tokai, Jpn); Mizuyama, Yaichiro; Ataka, Matsuo. *Trans Iron Steel Inst Jpn* v 27 n 12 1987, Prepr for the 113th ISIJ Meet, Part VI, Tokyo, Jpn, Apr 1-3 1987 p B.300.

**091719 EFFECTS OF FINISH-ROLLING TEMPERATURE AND CARBON CONTENT ON MICROSTRUCTURE AND MECHANICAL ANISOTROPY OF 0.04 - 0.13% C STEELS.** Steels with carbon content from 0.13 to 0.04% were rolled in the temperature range 1 220 to 750°C and air cooled. The grain size gradually decreased with lowering rolling temperature and then increased with further lowering of rolling temperature down to the ferrite range. Rolling in the ferrite range produces a strong anisotropy in tensile ductility. (Edited author abstract) 7 refs.

Vodopivec, Franc (Inst of Metallurgy, Ljubljana, Yugoslavia); Gabrovsek, Marin; Zvokelj, Janez. *Trans Iron Steel Inst Jpn* v 28 n 2 1988, Prepr for the 114th ISIJ Meet, Kumamoto, Jpn, Oct 9-11 1987 p 117-124.

**Light Metals** See ALUMINUM SHEET—Mathematical Models.

**Lubricants** See ALUMINUM SHEET—Contamination; METALS AND ALLOYS—Wear.

**Lubrication** See Also ALUMINUM SHEET—Finishing.

**091720 RECYCLING OF USED LUBRICANTS IN A CARBON-TAPE SHOP.** Waste water from cold rolling is contaminated by oil. Unit oil consumption during cold rolling can be 3.5-4.5 kg/ton rolled metal. The two methods of recycling process lubricants are chemical and mechanical purification. Recycled oils can be used as lubricants for minor elements of mechanisms or as a secondary energy resource. One scheme for reclaiming used lubricants has been devised by the VNIPIChermetenergootchistka Institute and is being used in the carbon tape shop at the Magnitogorsk combine.

Spiridonova, S.I. (VNIPIChermetenergootchistka Inst, USSR); Mel'nikov, Yu.N.; Petrina, L.S.; Batuev, A.Ya. *Metallurgist (USSR)* v 31 n 3-4 Mar-Apr 1987 p 65-66.

**091721 DEVELOPMENT OF A SIMULATION TESTING MACHINE FOR EVALUATING THE LUBRICITY OF LUBRICANT IN COLD SHEET ROLLING.** In a new type of simulating test, it is necessary to deform the workpiece material plastically which is different from the Timken test. The contact behavior between rolls and workpiece is closer to that in rolling practice. The roll can be rotated at a high relative speed and the normal force and tangential force can be measured individually. The simulation testing machine developed is sufficient for these conditions. (Edited author abstract) In Japanese. 17 refs.

Azushima, Akira (Yokohama Natl Univ, Yokohama, Jpn). *Tetsu To Hagane* v 74 n 4 Apr 1988 p 696-702.

**Mathematical Models** See Also STEEL—High Temperature Properties; STEEL SHEET—Rolling.

**091722 JEDNODIMENZIONALNI MATEMATICKI MODEL HLADENJA SLABA ILI DEBELE**

**TRAKE. [One-Dimensional Mathematical Model of Slab or Thick Strip Cooling].** This work presents a one-dimensional mathematical model for determination of the inside slab or thick strip temperature in the course of cooling. Differential equations representing the model are solved. The finite difference method was used. (Edited author abstract) In Serbo-Croatian. 7 refs

Crnko, Josip (Metalurška Fakultet, Sisak, Yugoslavia); Lazic, Ladislav. *Metalurgija (Sisak Yugosl)* v 26 n 2-3 Apr-Sep 1987 p 45-51.

**091723 MATEMATSKI MODEL ZA VALJANJE SITNIH PROFILA I ZICE.** [Mathematical Model for Rolling of Small Profiles and Wires]. A new mathematical procedure is presented as the basis for a mathematical model. The input values have been collected through testing on modern continuous mills. The article gives theoretical and experimental results based on rolling mill trials. (Edited author abstract) In Serbo-Croatian. 7 refs.

Hensel, Arno (Bergakademie Freiberg, Freiberg, East Ger). *Metalurgija (Sisak Yugosl)* v 26 n 2-3 Apr-Sep 1987 p 69-75.

**Measurements** See Also ELECTROMAGNETIC FIELDS—Computer Aided Analysis.

**091724 DAS PLANHEITMESSVERFAHREN DER THYSEN STAHL AG BEIM HERSTELLEN KALTGEWALTZTER BAENDER.** [Thyssen Stahl AG Flatness Measuring Technique]. Thyssen Stahl AG has developed apparatus to continually measure the flatness of cold-rolled strip. Apparatus has been developed which, by contactless means measures the distance (waviness) of 50 mm-wide tracks of the cold-rolled strip from a straight reference line during rolling. The distance measurement procedure is based on the eddy-current principle. A minicomputer processes the measured values. With the aid of video equipment it has been possible to make a comparison between the waviness reading on the tandem mill and the waviness of an uncoiled strip. In German.

Bellen, Franz Josef (Thyssen Stahl AG, Duisburg, West Ger); Meuters, Friedrich; Buechel, Ernst. *Thyssen Tech Ber* v 19 n 2 1987 p 237-242.

**091725 CASTING LIGHT ON SECTION MEASUREMENT.** On-line measurement of sections rolled at high speeds enables quality assurance to be improved. Automatic feedback to the rolling stands results in consistent dimensions being achieved. The application of optical systems of position measurement has resulted in practical methods of computing dimensions. At a recent seminar held by The Institute of Metals in London, the progress achieved by this technology was discussed. (Author abstract)

Anon. *Steel Times* v 216 n 2 Feb 1988 p 98.

**Nondestructive Examination**

**091726 ZERSTÖRUNGSFREIE VERFAHREN ZUR PRÜFUNG VON ERZEUGNISSEN UND HOCHBEANSPRUCHTEN ANLAGENBAUTEILEN DER EISEN- UND STAHLINDUSTRIE.** [Non-Destructive Methods Applied to Products and Highly Stressed Plant Components in the Iron and Steel Industry]. The article outlines the methods used for detecting surface and internal defects - ultrasonic, eddy current, magnetic stray flux, dye penetrant, electrical potential, and optical tests, as well as spectrometric methods permitting analyses and identity checks without sampling. Their possibilities and limits are pointed out. Test methods used at Thyssen Stahl AG are presented as examples of applications. In German. 35 refs.

Thoma, Christian (Thyssen Stahl AG, Duisburg, West Ger); Buechel, Ernst. *Thyssen Tech Ser* p 195-207.

**Optimization** See STEEL SHEET—Rolling.

**Pipe** See Also PIPE, STEEL—Manufacture.

**091727 THIN-WALLED PIPE ROLLING ON A SMOOTH FORMER IN ELLIPTIC PASSES.** The present paper applies the flow theory of A.A. Ilyushin to the process of lengthwise rolling of thin-walled pipes. The distinctive features of this process are the presence of priorly unknown loads at the boundaries of the flow region and the variability of the circular liner velocity of the points of the roll surface with respect to the pass width. Equations can be derived to describe lengthwise rolling of pipes under the assumption of a smooth former. Based on a solution of the equations that have been derived, the conditions are formulated providing the absence of adhesion areas in the deformation focus; analytical expressions are given for estimating the stresses on the front and back of the deformation focus inaccessible to direct measurement through measurable quantities, such as the speed of the rolled pipe at the entry and exit of the pass. For the area adjacent to the pass apex, the results can be used to establish a correlation with the data on the rolling of thin sheets, corrected for tension. (Edited author abstract) 6 refs.

Fomin, L.F. *Mech Solids* v 22 n 1 1987 p 174-180.

**091728 PROCESS CONTROL SYSTEM OF SUMITOMO'S HOT WELDED STEEL PIPE MAKING MILL (SW METHOD).** A new pipe-making process named the 'SW method' developed for the continuous butt-welding pipe mill was put into operation at the Kashima Steel Works in 1985. The special features of the new pipe-making system are its ability to carry out welding at high temperature conditions by using a high frequency induction welder and to remove the weld bead by a cut-off device just after welding. The pipe is then continuously reheated in the furnace to get a circumferentially uniform temperature for the following stretch reducing process. In this paper, the electric and computer control systems of the SW method are introduced. The major computer control systems are as follows: (1) Automatic pipe wall thickness control. (2) Automatic welding heat input control. (3) Automatic furnace combustion control. (Author abstracts) 8 refs.

Nagashima, M. (Sumitomo Metal Industries Ltd, Jpn); Yamashita, A.; Hamada, M.; Arai, O.; Matada, T. *Sumitomo Search* n 35 Nov 1987 p 67-76.

**091729 PRESSURE OF METAL ON ROLLERS IN LENGTHWISE ROLLING OF PIPE.** On the basis of a generalization of the theory of flows of thin layers of plastic substances over surfaces to the case of arbitrary boundary loads, we investigate the contact pressure distribution in the case of lengthwise rolling of thin-walled pipe on a smooth mandrel. The solution of the equations of the first fundamental problem of flow theory is determined by the successive-approximation method. We introduce the concept of critical number, whose value characterizes the presence or absence of sticking zones at a deformation site. We investigate the effect of the rolling parameters on the position of the point of application of the maximum contact pressure. We give the distributions of the normal contact stresses and formulas for the total pressure of the metal on the roller in one particular case of distribution of the boundary loads. (Edited author abstract) 4 refs.

Fomin, L.F. *Mech Solids* v 22 n 3 1987 p 129-133.

**091730 GREATER EFFICIENCY OF PIERCING PROCESS ON PLANT WITH PILGER MILLS.** A method developed from a design study of some of the work stand components on the two high mill of the plant equipped with Pilger mills in the Zhdanov Iron and Steel Combine is described. The method, employing eccentric sets of inserts for the roll bearings and giving an increase in feed angle from the existing 4°15 ft to 5°12 ft, makes it possible to improve the quality of the resultant pipes and improve the speed and power parameters of the bottom



end first and upsetting end first piercing. The practice applies to casing pipes, general purpose pipes, and gas cylinder billets. (Author abstract) 2 refs.

Getiya, I.G. (All-Union Correspondence Mechanical Engineering Inst, USSR); Leont'eva, I.N.; Ermakov, V.V.; Shumilin, V.K. *Steel USSR* v 17 n 7 Jul 1987 p 323-325.

**091731 CHOICE OF RATIONAL METHODS OF STRAIGHTENING PIPES ON MACHINES WITH SKEWED ROLLS.** An analysis is made of pipe straightening machines developed by research organizations and pipemaking works. The authors discuss the advantages and disadvantages of the principles on which these design are based with respect to straightening and the elimination of out-of-roundness along the entire length of the pipe. Rational use of the methods on appropriate equipment makes it possible to raise the level of service properties along with improvement of the geometric parameters of the pipes. (Author abstract) 6 refs.

Starushkin, N.I. (All-Union Scientific Research Inst for the Tube Industry, USSR); Palkin, Yu.A.; Letkin, A.M. *Steel USSR* v 17 n 10 Oct 1987 p 461-462.

**091732 RATIO OF DEFORMATIONS BETWEEN MILLS OF PLANT WITH THREE ROLL REELING MILL.** One of the ways of increasing the output of pipe rolling plants is to optimise the distribution of deformation between the mills of the plant. An examination is made of the results of investigating the distribution of the relative degree of utilisation between the various mills as a function of pipe size as well as the possibilities of increasing the output of the plant by optimising the distribution of deformations between the mills. A program has been developed for calculating the rolling cycles of the piercing and reeling mills of a 50-200 pipe rolling plant with different ridge heights of the reeling mill rolls. (Edited author abstract). 2 Refs.

Podkustov, V.P. (Moscow Steel & Alloys Inst, USSR); Potapov, I.N.; Rodin, N.M.; Akhmedshin, R.I.; Zimovets, V.G.; Ryabov, V.F.; Frolochin, V.V.; Ulanov, O.D. *Steel USSR* v 17 n 9 Sep 1987 p 413-415.

**091733 PARAMETERS OF ROLLING DRIVE PIPES ON PILGER MILLS.** Various investigations have been carried out to study the influence of deformation parameters in Pilger and sizing mills on the accuracy of rolling drive pipes. The influence of the coefficient of polishing on the wall thickness accuracy of pipes was established. Data were obtained on the accuracy of the external diameter of drive pipes rolled on different sizing mills. Implementation of developed recommendations has enabled technology for rolling of type A drive pipes to be improved at a cost benefit. (Author abstract).

Pavlovskii, B.G. (All-Union Scientific Research & Design Inst for the Tube Industry, USSR); Il'Nitskii, A.A.; Dovgal, A.I.; Men'shchikov, A.M.; Zelenyi, N.I. *Steel USSR* v 17 n 9 Sep 1987 p 424-426.

**091734 HOT AND COLD REDUCED SEAMLESS AND WELDED PIPES.** An account is given of developments by the All-Union Research and Design Institute for the Tube Industry (VNITI) in the field of cold reduction of seamless and welded pipes. The developments cover cold continuous rolling in the absence of a mandrel (reduction and sizing), reduction, reduction-elongation, reduction-sizing, and sizing mills, differential group roll drives for multistand mills, procedures for calculating the processing and power-force parameters required of these mills, and elimination of the thickened ends of pipes by reduction with tensioning. All of these developments have resulted in improvement of the quality and accuracy of the pipes. (Author abstract). 12 Refs.

Gulyaev, G.I.; Yurgenas, V.A.; Erokhin, I.N.; Njchiporenko, A.I. *Steel USSR* v 17 n 12 Dec 1987 p 559-561.

**091735 DRIVE ROLLER SHOES IN HELICAL ROLLING MILL FOR SEAMLESS STEEL PIPES.** Manufacture of alloy steel pipes by a helical rolling mill provided with fixed guide shoes sometimes involves

problems due to galling between the shoes and pipes. This results in pipe defects, a lower operating rate and a decrease in shoe life. Kawasaki Steel Corp. has developed a drive roller shoe to solve these problems. The outer surface defects are minimized and tool cost and productivity are improved.

Anon. *Trans Iron Steel Inst Jpn* v 28 n 2 1988, Prepr for the 114th ISIJ Meet, Kumamoto, Jpn, Oct 9-11 1987 p 148.

Plate See Also FURNACES, HEAT TREATING—Control Systems; PLATES—Steel; ROLLING MILLS; ROLLING MILLS—Equipment; ROLLING MILLS—Vibrations; STAINLESS STEEL; STEEL—Low Temperature Properties; STEEL—Mechanical Properties.

**091736 DEVELOPMENT OF HIGH SHAPE FACTOR ROLLING TECHNOLOGY AND ITS APPLICATION TO MANUFACTURING THICK STEEL PLATES WITH 50 kgf/mm<sup>2</sup> GRADE HIGH TENSILE STRENGTH FOR ARCTIC SERVICE.** Improvement of toughness in thick rolled steel plate and a manufacturing procedure for getting uniform properties over the whole thickness were studied. High shape factor rolling (large roll diameter and large reduction per pass) brought about excellent toughness at the mid-thickness. Simulation experiment and rigid plastic finite element method (FEM) analysis showed that high shape factor rolling increased the rolling effect and resulted in fine ferrite grain size. The thick steel plate with 50 kgf/mm<sup>2</sup> tensile strength can be used for arctic service. (Edited author abstract) In Japanese. 23 refs.

Yamaba, Ryota (Nippon Steel Corp, Tokai, Jpn); Tsuzuki, Takeshi; Tomita, Yukio; Oyama, Noboru; Itoh, Kametaro. *Tetsu To Hagane* v 73 n 14 Oct 1987 p 1714-1721.

**091737 EFFECTS OF CONTROLLED ROLLING AND CONTROLLED COOLING ON THE MICROSTRUCTURE AND PROPERTIES OF 16Mn STEEL.** The influence of a combined process of controlled rolling and controlled cooling on the microstructure and properties of Ti-treated C-Mn (16Mn) steel plates has been investigated. The results indicate that the ferrite grain and transformation structures can be refined in existing rolling mills of China when controlled rolling and cooling conditions are properly combined. It is expected to enhance Charpy V impact toughness at -40°C with the expected strength and ductility. (Edited author abstract) 6 refs. In Chinese.

Wu, Boqun (Central Iron & Steel Research Inst, China); Xi, Xiurong; Zhao, Pingshun; Zhang, Kelan. *Kang Tieh* v 22 n 7 Jul 1987 p 27-33.

**091738 INVESTIGATION OF ROUND INGOT END DEFORMATION DURING LONGITUDINAL ROLLING.** The effect of round ingot end shape on end crops in a rolling mill has been investigated. Use of scarf type bevels in round ingots has led to a 1.7-2.3% yield increase. This study looks into the effect of ingot end bevel geometry on the size of plate end crops. Rolling tests were performed on bench-scale two-high mills: a 150 mm mill ( $D_r=140$ mm) and a 190 mm mill ( $D_r=260$  mm). The pass reduction was 10-15%. The test materials were a PT-ZV titanium alloy and plasticine.

Gridnev, I.M.; Titlyanov, A.E.; Belokopytov, N.P. *Sov Mater Sci Rev* v 1 n 2 1987 p 239-241.

**091739 TECHNICAL FEATURES OF PLATE-ROLLING ON THE 3000 MILL.** The 3000 mill at the Il'ich Zhdanov Metallurgical Combine is used to make plates 8-25-mm thick, 1500-2700-mm wide, and 12.1-24.2-m long. The plates are made of low-alloy structural steels of the 09G2FB type and are rolled in a controlled regime. The mill is also used to make plates of ordinary and low-alloy steels which are rolled in the standard regime. The article identifies shortcomings of the mill and gives recommendations for improvements.

Kononov, Yu.V. (Il'ich Zhdanov Metallurgical Combine, USSR); Popov, N.N.; Nalcha, G.I.; Vinnik, M.V.; Zarya, A.V. *Metallurgist (USSR)* v 31 n 3-4 Mar-Apr

1987 p 57-58.

**091740 STARTUP OF THE PRODUCTION OF TWO-LAYER PLATES AT THE COMBINE.** The Kommunarsk Metallurgical Combine began to master the production of bimetallic plates in 1959. Packets of bimetallic plates weighing 0.5-1.4 tons and measuring 8-24 × 1400-1600 × 4000-7500 mm are rolled on the two-stand 2800 plate mill at the combine. The grades of steel used for the base layer are steels VSt3sp, 20K, 16GS, and 09G2S. The steels used for the cladding layer are steels 12Kh18N10T, 08Kh18N10T, 08Kh13, 10Kh17N13M2T, 10Kh17N13M3T, 06KhN28MDT, 08Kh17N15M3T, and other steels. To improve the mechanical properties of plates with base layers of steels 16GS and 09G2S, quenching and tempering is used in place of normalizing.

Khoroshilov, N.M. (Kommunarsk Mining-Metallurgical Inst, USSR); Barbashev, B.M.; Musikevich, V.F.; Ostapenko, V.M.; Lutsenko, V.A.; Yakimenko, S.G. *Metallurgist (USSR)* v 31 n 3-4 Mar-Apr 1987 p 92-93.

**091741 SPECIAL FEATURES AND OPERATIONS OF THE FUKUYAMA PLATE MILL.** The new Work Roll Shift (WRS) Mill was installed at the Fukuyama Steel Plate Mill in November 1985 in order to improve quality, yield, and productivity. It was the first time that the WRS mill was used in plate rolling. The remarkable feature of this mill is its ability to control the plate crown and shape with work roll shifting (1000 mm stroke) and powerful work roll bending. Then we achieved perfect Schedule-Free Rolling and succeeded in reducing the plate crown. After careful investigation for the design, we achieved low stress and a sufficient level of safety in spite of a large pressure load and a high torque rate. This paper describes the technology for the design, specification, control system, and operation of the mill. (Author abstract) 2 refs.

Yako, Kazunori (Nippon Kokan KK, Fukuyama, Jpn); Ishihara, Yoshiaki; Murakami, Shitoshi; Yamawaki, Mitsuru; Sugimoto, Tadao; Suemura, Youtarou. *Nippon Kokan Tech Rep Overseas* v 50 Sept 1987 p 18-26.

**091742 THROUGH-THICKNESS PROPERTIES OF PLATE ROLLED FROM CONTINUOUSLY CAST SLAB.** The need to provide guaranteed properties in the through-thickness direction of rolled plate prompted the authors to investigate factors affecting these properties. The authors studied the causes of lamination cracks in fractures in full section plate specimens and attribute these to concentrations of manganese sulfide inclusions in the axial zone of the slab which are elongated in rolling to plate and also to hydrogen accumulation in the axial zone. Suitable measures for countering these phenomena are described. (Edited author abstract) 6 refs.

Pemov, I.F. (Central Scientific Research Inst of Ferrous Metallurgy, USSR); Gotsulyak, A.A.; Tolokin, L.I.; Nosochenko, O.V.; Peredeev, B.M. *Steel USSR* v 17 n 3 Mar 1987 p 137-139.

**091743 OPTIMIERUNGSSTRATEGIE UND MODELLEBILDUNG FÜR DAS GROBBLECHWALZEN.** [Optimization Strategy and Model Structure for Heavy Plate Rolling]. The optimization of a heavy plate mill is designed to ensure extremely exacting thickness, width, flatness and shape tolerances, and accurate tensile strength, yield point and notched bar test toughness values. Further aims are the minimization of energy consumption, the maximization of steel yield, and the reduction of the load on the plant. The report describes the structure of a process control model, which allows to control the forming process and temperature variation in regard of the above mentioned variables. In German. 4 refs.

Czapinski, Witold (AEG Aktiengesellschaft, Berlin, West Ger). *Stahl Eisen* v 108 n 1 Jan 11 1988 p 41-46.



**091744 SAVING METAL BY EFFICIENT MANUFACTURE ON PLATE MILLS.** An examination is made of a procedure for calculating optimum parameters for the manufacture of carbon and low alloy steel plate on a 3000 mill. The efficient size and weight of slabs for production of plates and skelp are determined. The proposed means of efficient manufacture enables finished stock to be obtained without additional cropping in the range of plates rolled in the minus tolerance field and thereby makes it possible to achieve a saving in metal and production costs. (Author abstract) 3 refs.

Kononov, Yu.V. (Donetsk Scientific Research Inst of Ferrous Metallurgy, USSR); Furman, Yu.V.; Nosov, V.G.; Shebanits, E.N.; Shcherbak, V.M.; Dmitriev, V.D. *Steel USSR* v 17 n 10 Oct 1987 p 455-457.

**091745 STANOVENI INTENZITY DEFORMACE PRI VALCOVANI TLUSTYCH PLECHU S UVAZOVANIM SMYKOVE SLOZKY DEFORMACE.** [Establishing Deformation Intensity in Plate Rolling Considering Shear Component of Deformation]. Flat steel test specimens with the width ten times higher than the height were rolled as sheared specimens. After rolling they were longitudinally sheared in the axial direction and the contact line course was recorded. The mean intensity value of deformation was established by the surface transformation under a derivation curve. 22 Refs. In Czech.

Schindler, Ivo (Hutnicka Fakulta Vysoke Skoly Banske, Ostrava, Czech); Kure, Frantisek; Holy, Hynek. *Hutn Listy* v 43 n 5 May 1988 p 221-226.

**091746 DEVELOPMENT OF A PROCESS FOR MANUFACTURING TRIMMING FREE PLATES.** This paper reports a method for manufacturing trimming-free plates on the basis of analysis of edging characteristics in lead model tests, the features of a commercial edger and its control system and squaring characteristics of the edge in production rolling. Width reducing efficiency is small in V rolling. A small amount of width screw-down improves the efficiency. Width loss can be reduced by a combination of chamfer rolling with finish edging. Automatic width control is necessary for accuracy. (Edited author abstract) 11 Refs.

Inoue, Masotoshi (Kawasaki Steel Corp, Jpn); Ohmori, Kazuo; Orita, Tomoyuki; Okamura, Isamu; Isoyama, Shiegeru; Tarui, Masaaki. *Trans Iron Steel Inst Jpn* v 28 n 6 1988 p 448-455.

**091747 TRENDS IN PLATE QUALITY IMPROVEMENT.** A rolling method has been developed based on a nonuniform deformation over the width due to the use of rolls with annular grooves in the roughing stands. This method improves mechanical properties of final products, stabilizes the width, raises yield, leads to better scale removal conditions, and increases mill capacity. Testing of the plate and strip rolling method demonstrated that the rectangular shape of the products was improved and 1-1.5% of material was saved because of a lower scrap rate. The effect of rolling method on impact energy was evaluated using a 09G2 steel slab. (Edited author abstract) 6 Refs.

Dolzhenkov, F.E.; Ostapenko, A.L.; Orobtshev, V.V.; Novik, V.I.; Sunyaev, A.V. *Sov Mater Sci Rev* v 1 n 4 1987 p 401-405.

**091748 METAL FLOW IN THE DEFORMATION ZONE DURING ROLLING IN ANNULAR-GROOVED ROLLS.** The plate rolling process in annular grooved rolls has the following stages (1) working of a smooth surface slab in grooved rolls and (2) working of a variable thickness slab in the transverse direction using grooved rolls. The first process stage was investigated by physical simulation using a laboratory mill. Lead specimens were used. A set of differential equations is solved to derive analytical relations for calculating velocity field components which describe the kinematic state of a slab in the deformation zone during rolling in annular grooved rolls. (Edited author abstract) 6 Refs.

Kononov, Yu. V.; Litvinova, T.S.; Neustroev, S.L.;

Makarenko, S.N. *Sov Mater Sci Rev* v 1 n 4 1987 p 407-411.

**091749 EFFECTIVENESS OF ANNULAR-GROOVED ROLLS IN PLATE PRODUCTION.** Investigation of mechanical properties of 17GS steel and rolling parameters during rolling in a two-high stand of the 2800 mm mill in Cherepovets using annular-grooved rolls is reported. The use of annular grooved rolls improves the impact toughness and reduces the frequency of substandard plates. The use of the rolls also raises the total electric power required for the rolling process. (Author abstract) 3 Refs.

Nabatov, G.I.; Ridner, V.Z.; Malova, R.P.; Kononova, I. Yu. *Sov Mater Sci Rev* v 1 n 4 1987 p 413-416.

**091750 EFFECT OF WORK ROLL DIAMETER ON THE DEFORMATION OF A FOUR-HIGH ROLL ASSEMBLY.** The effect of the work roll diameter on deformation of a four-high roll assembly has been analyzed using mathematical simulation. A relation between roll diameter and deflection has been revealed for noncylindrical roll contact. In addition to the backup roll effect, the rigidity of the roll assembly is influenced by the roll diameter. (Edited author abstract) 2 Refs.

Budakva, A.A.; Kachalka, Z.G.; Manshilin, G.I.; Zavrazhnyy, A.N. *Sov Mater Sci Rev* v 1 n 4 1987 p 417-419.

**091751 ENERGY AND FORCE PARAMETERS DURING ROLLING WITH BENDING.** A kinematically permissible velocity field for rolling with bending has been plotted in order to calculate the upper rolling power limit. The field includes two rigid zones separated by the arc of a circle. A field of characteristics for determining the lower power limit has also been plotted. Rolling power and torque have been computed. The results make it possible to predict where rolling with bending requires a lower power than conventional rolling involving straight motion of rectilinear outer zones. (Author abstract) 2 Refs.

Brovman, M. Ya. *Sov Mater Sci Rev* v 1 n 4 1987 p 421-424.

**091752 EFFICIENT COMBINATION OF SLAB DEFORMATION IN THE VERTICAL AND HORIZONTAL STANDS OF A PLATE MILL.** In a plate mill, the dimensional accuracy of the final plate width is governed by slab deformation on the vertical stand. The effects of single and total reductions of slab sides in the edging rolls on the final plate shape have been investigated experimentally. Efficient reduction ranges have been identified. The limits within which the reduction of slab sides or edges can be used have been determined as a function of slab lengthening in horizontal rolls. (Edited author abstract) 5 Refs.

Klimenko, V.M.; Filippov, E.L.; Yurchenko, Yu. I.; Smirnov, E.N. *Sov Mater Sci Rev* v 1 n 4 1987 p 437-441.

**091753 IMPROVED EFFICIENCY OF AUTOMATED PLATE MILLS.** All plate mill products are shipped to order according to size specifications. For this reason, the selection of optimal size and weight of initial slabs has an important effect on metal consumption. The potential for improving yield in various plate rolling operations of reversing plate mills has been considered. Metal savings of up to 15% can result from semifinished plate shape improvement as well as the use of tighter side and end allowances, uniform slab size, and minus allowance ranges. (Edited author abstract) 6 Refs.

Furman, Yu. V. *Sov Mater Sci Rev* v 1 n 4 1987 p 443-445.

**091754 ENGINEERING METHOD OF CALCULATING BULK TEMPERATURE OF PLATES.** Simplified expressions for bulk temperature of plates have been derived on the basis of a numerical solution of the differential heat conduction equation. The approximation error is low thus the relations can be recommended for engineering calculations. The model was verified using production conditions of the 3600 mm mill of the Azovstal

plant and the 2300 mm mill of the Donetsk plant. (Edited author abstract) 5 Refs.

Goncharov, N.V.; Artsybashev, V.A. *Sov Mater Sci Rev* v 1 n 4 1987 p 447-449.

**091755 DEVELOPMENT AND VERIFICATION OF A RECURRENT MATHEMATICAL MODEL FOR PREDICTING ROLLING FORCES.** Algorithms incorporating the manual operation strategies of thickness distribution between the passes have been developed for the finishing stand of the 3600 mm plate mill at Azovstal. In this work a mathematical model for predicting rolling forces is discussed. This model is used in the algorithms of automatic control of reduction based on mill operator strategies. Test data illustrating the accuracy of rolling force predictions achieved by the model are presented. (Edited author abstract) 3 Refs.

Tvardovskiy, V.P.; Ganchich, G.G.; Ievlev, N.G.; Poleshchuk, V.V. *Sov Mater Sci Rev* v 1 n 4 1987 p 495-497.

**091756 IMPROVED INDIRECT PLATE GAUGE CONTROL.** Use of thickness readings from a thickness gauge positioned downstream of the finishing stand for automatic adjustment of a Simms-Golovin controller has been considered. Inaccurate initial information on mill compliance has an effect on the quality of the first three programmed plates. The availability of controller automatic adjustment and roll misalignment adjustment results in rolled plates having a standard deviation of 0.035 mm over the length of each plate. (Edited author abstract) 3 Refs.

Gagarin, P.P. *Sov Mater Sci Rev* v 1 n 4 1987 p 499-501.

**Powder Metals** See Also POWDER METALLURGY—Copper; ROLLING MILLS—Design.

**091757 POWDER ROLLED STRIP - A SUCCESS STORY AT MIXALLOY.** Over the past five years Mixalloy Ltd. in Mold, North Wales, has succeeded in commercializing the production of powder rolled strip using the slurry process from a number of alloys including nickel, cobalt and copper based compositions. MPR recently visited the company and Amanda Weaver reports on the latest production developments and new product innovations. (Author abstract)

Weaver, Amanda. *Met Powder Rep* v 42 n 9 Sep 1987 p 598-599, 602-603.

**091758 CHARACTER OF DENSIFICATION ZONE FORMATION IN THE ROLL-CLADDING OF A BASE WITH A POWDER.** Changing the curvature of the working surface of one of the rolls in the rolling of metal powders affects the thickness and density of the resultant strip. In this connection, it is proposed that the following four variants of powder rolling should be distinguished: between rolls of the same diameter, between rolls of different diameters, between a roll and a flat plate, and between a roll and the inside surface of a ring. A common application of the third variant is roll cladding of one or both sides of a base with a powder. In this work, the results obtained are evidence that the third variant of rolling gives scope for increasing the thickness of rolled powder strip and productivity of mills. Use of a base enables the productivity of powder rolling mills to be increased three to four times and strip 1.5-1.8 times thicker to be obtained with rolls of the same diameter as in rolling by the first variant. 4 refs.

Katashinskii, V.P. (Acad of Sciences of the Ukrainian SSR, USSR). *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 701-704.

**091759 DEFORMATION AND COMPACTING OF POWDER BILLETS IN INITIAL STAGES OF ROLLING OF SECTIONS.** Rolling in grooves of capsules containing sprayed steel powders is characterized by special features. The rate of hardening the powder mass in rolling in the first groove is determined by the strain and angle of inclination of the walls of the groove. The



hypothesis of the equality of the perimeters of the powder billet prior to and after rolling has been confirmed for single-pass rolling cylindrical capsules with the powder in various grooves. The maximum compacting of the powder without overfilling the groove is obtained using an oval groove with an axes ratio higher than 3. 7 refs.

Panovko, V.M. (Acad of Sciences of the USSR, USSR); Yusupov, V.S. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 773-775.

**Quality Control** See Also ROLLING MILLS—Modernization.

**091760 MANUELLE PRUEFSYSTEME ZUR DETEKTION VON OBERFLAECHENFEEHLERN AN GROEBLECHEN UNTER WALZWERKBEDINGUNGEN.** [Manual Systems Used to Detect Surface Flaws in Plate Under Rolling Mill Conditions]. Different type of surface cracks can occur on plates due to various causes. In many cases, these cracks are invisible and can only be detected by the magnetic powder inspection method. Attempts were made to examine the usability and efficiency of alternative manual testing systems under the rough conditions in a production shop, to adapt and optimize the systems, and to select the best inspection method. Manual testing devices based on ultrasonic (prototype) and eddy-current methods have been developed which, in comparison with the magnetic powder inspection method, make it possible to drastically reduce the testing time. In German.

Klein, Axel (Thyssen Stahl AG, Duisburg, West Ger); Smit, Hans; Lorenz, Joachim; Kuepper, Dieter; Buechel, Ernst. *Thyssen Tech Ber* v 19 n 2 1987 p 215-220.

**091761 OPERATION SIGMA: VERS LA QUALITE TOTALE A SOLLAC.** [Sigma Operation: Towards Total Quality at Sollac]. Increasing quality requirements from customers have involved Sollac in a broad-ranging operation named Sigma which is designed to restore the financial results and maintain the firm's status on the market. The Sigma operation integrates the quality assurance program, quality circles and progress groups. New actions are being undertaken, especially the Juran program (improvement in relationships within the firm) and SPC program (statistical process control) aimed at developing control of quality. (Edited author abstract) In French.

Serin, B. (Sollac, Fr). *Cah Inf Tech Rev Metall* v 84 n 5 May 1987 p 385-391.

**Sheet and Strip** See Also IRON AND STEEL METALLOGRAPHY—Textures; METAL FORMING—Stresses; ROLLING MILLS—Computer Aided Manufacturing; SHEET AND STRIP METAL—Rolling; SHEET AND STRIP METAL—Thickness Measurement; STEEL SHEET—Mechanical Properties.

**091762 AUTOMATIC SLAB HEATING CONTROL AT INLAND'S 80-IN. HOT STRIP MILL.** A long-term program to study the design, operation and control of slab reheating furnaces is being carried out at Inland Steel Co. A mathematical model of the dynamic thermal phenomena that exist in the furnaces has been developed and verified. This model has been used to study the slab heating process under steady-state and transient conditions. The automatic heating control system has reduced product temperature variability during slab rolling by 40% with energy savings of 6.4%. 2 refs.

Veslocki, Timothy A. (Inland Steel Co, East Chicago, IN, USA); Smith, Clifford C.; Kelly, Christopher D. *Iron Steel Eng* v 63 n 12 Dec 1986 p 47-54.

**091763 INCREASE IN WORK CAPACITY OF ROLL MOUNTINGS OF WIDE STRIP MILLS.** The authors conclude from analysis of the design and functional parameters of three types of work roll and back-up roll mountings used on the roughing and finishing trains of 1700 and 2000 continuous wide strip mills for hot rolling, that the version employing coupled but independently mounted upper and lower work roll and back-up roll sets has the greatest advantages. Preliminary skewing of the work rolls relative to the stand center line in the

same direction, is recommended for ensuring that the center lines of the work and back-up rolls coincide during rolling (after the bite). This reduces the dynamic axial and radial loads on the mountings and their bearings, thus increasing the work capacities of the latter. (Edited author abstract) 3 refs.

Lipukhin, Yu.V. (All-Union Correspondence Polytechnic Inst, USSR); Danilov, L.I.; Plakhtin, V.D.; Ivanov, D.Yu.; Sorokin, A.M. *Steel USSR* v 17 n 1 Jan 1987 p 35-39.

**091764 TEMPERATURE VARIATION ACROSS WIDTH OF STRIP DURING COLD ROLLING.** The nature of the temperature distribution over the width of strips rolled on twenty-roll and four-high 450 mills (corrosion resistant steel in four stages with intermediate recrystallization annealing) was established experimentally. It is demonstrated that the transverse distribution irregularity of the temperature influences the shape of the final strip, giving rise to increase in waviness and decrease in warping. In developing the modes of deformation and roll profiling ensuring that the strips are flat after rolling, the nature of the change in the temperature irregularity across the width has to be taken into account. (Edited author abstract) 3 refs.

Ashikhmin, G.V. (Moscow Steel & Alloys Inst, USSR); Polukhin, V.P.; Aleshin, V.P.; Kuznetsov, I.V. *Steel USSR* v 17 n 1 Jan 1987 p 39-40.

**091765 INCREASE IN EFFECTIVENESS OF STRIP FLATNESS CONTROL ON 2030 MILL.** The authors' theoretical and statistical research indicates that roll bending should not be resorted to as a means of strip flatness control until full use has been made of the capacities of the cooling water distribution manifolds for control of the thermal profiling of the work rolls. Application of this concept to the strip flatness control systems on the first four stands of a 2030 mill has provided the conclusion that the suggested method of control and method of calculating the settings for the system exhibit adequate effectiveness and can be used to solve the same problems on other types of rolling mills. (Edited author abstract) 9 refs.

Kuznetsov, L.A. (Lipetsk Polytechnic Inst, USSR); Bozhkov, A.I.; Bulatnikov, E.I.; Gulyaev, N.I.; Kolpakov, S.S. *Steel USSR* v 17 n 2 Feb 1987 p 84-85.

**091766 COMPUTERSIMULATION ZUR VERFAHRENSUNTERSUCHUNG UND OPTIMIERUNG AN WARBREITBANDSTRASSEN.** [Computer Simulation for Examining and Optimizing the Operation of Hot Wide Strip Mills]. To improve the energy consumption and material economy on a hot wide strip mill, it is necessary to elucidate the basic principles of the physical and metal physical processes during hot forming. In this connection, the computer simulation has proved to be an efficient method for planning new equipment, as well as for optimizing rolling technologies and for introducing new rolling techniques. The paper presents a computer model of a wide strip mill for description of its efficiency. (Edited author abstract) In German. 8 refs.

Esser, Fred (VEB Metallurgie-Elektronik Leipzig, Leipzig, East Ger); Birnstock, Frieder; Zouhar, Gustav; Hoefgen, Heiner. *Neue Huette* v 32 n 10 Oct 1987 p 361-366.

**091767 REDUCTION IN STRIP TEARING DURING STOPPING AND STARTING OF A CONTINUOUS COLD-ROLLING MILL.** This study showed that the sections of reduced thickness are critical sections where the strip tears during startup of the mill and fluctuation of interstand tension. Tearing is particularly frequent between the last two stands, where the thickness of the strip is minimal. To avoid the formation of sections of lower than normal thickness, the authors developed an automatic system to relieve the rolling forces and moments on the mill when it is stopped with strip in the stands. The system provides for a smooth reduction.

Pimenov, A.F. (Acad of Sciences of the USSR, USSR);

Abramov, A.N.; Triano, A.I.; Efremov, N.I. *Metallurgist (USSR)* v 31 n 4 Mar-Apr 1987 p 94-95.

**091768 CONTROL OF CONTINUOUS MILLS BY MEANS OF MONITORING INTERSTAND TENSIONS.** An examination is made of the principles of construction of an automatic strip tension control system for the interstand spaces of a continuous hot rolling wide strip mill. Strip tension is measured indirectly from deviation in the ratio of rolling torque to rolling force. The main results of an experimental investigation of the accuracy with which interstand tensions are maintained in real conditions by the control method are analyzed. (Edited author abstract) 3 refs.

Druzhinin, N.N. (All-Union Scientific Research Inst of Metallurgical Engineering, USSR); Mirer, A.G. *Steel USSR* v 17 n 3 Mar 1987 p 126-129.

**091769 INFLUENCE OF TEMPERATURE AND SHAPE OF DEFORMATION ZONE ON PARAMETERS OF COLD ROLLING OF SHEET.** An investigation was made of the influence of the degree of deformation and heating of the metal and the shape of the deformation zone on the pressure and force parameters during cold rolling of thin sheet of 08 kp low carbon rimming steel on a six-stand 1400 mill. The influence of heating on the mechanical properties of cold hardened steel was examined. Results of studying the reduction in the sixth stand were used in developing a schedule for rolling 0.22-0.20×855 mm sheet from 2.30 mm thick stock. (Author abstract) 6 refs.

Skorokhodov, V.N. (Central Scientific Research Inst of Ferrous Metallurgy, USSR); Pimenov, A.F.; Vasil'ev, A.V.; Shakhov, V.L.; Chernov, P.P. *Steel USSR* v 17 n 3 Mar 1987 p 132-135.

**091770 SYSTEM REGULACE TLOUSTKY PASU NA DVACETIVALCOVEM TANDEMU SKODA 2 × C3-1200.** [Strip Thickness Control System on the Twenty-Roll Tandem Mill Skoda 2 × C3-1200]. The article describes the underlying principle of automatic strip thickness control on a two-stand twenty-roll tandem cold rolling mill. The article also presents findings concerning verification of control algorithms on technological process models and experience acquired in the implementation of a thickness control system using a control system based on a PPC-4 computers. (Translated author abstract) In Czech. 5 refs.

Oplova, Galina (VUET, Czech); Hick, Zdenek. *Automatizace* v 31 n 1 Jan 1988 p 5-10.

**091771 DYNAMIC CHARACTERISTICS OF HOT SHEET MILLS ALONG FEEDSTOCK TEMPERATURE - STRIP TEMPERATURE CHANNEL.** An examination was made of the dynamic characteristics of a hot sheet mill along the main channel 'parameters of strip at entry into finishing train - parameters of strip at exit from it'. Investigations were conducted on a 2000 mill with the use of optical pyrometers and X-ray thickness and width gages to measure the temperature, thickness, and width of strip before and after the finishing train of the mill. Reasons for variation in the given parameters are established and a method for improving the quality of rolled stock was developed. (Author abstract) 3 refs.

El'ke, I.N. (Dnepropetrovsk Inst of Ferrous Metallurgy, USSR); Kugryshev, V.D.; Zhurkovskii, A.V. *Steel USSR* v 17 n 4 Apr 1987 p 173-174.

**091772 DYNAMIC FEATURES OF ROLLING STAND-STRIP SYSTEM.** A study is made of the dynamics of the process of hot rolling of strip. The influence of the rigidity of the strip on the damping factor during rolling is examined. A mathematical model of the stand-strip system is developed. The influence of dry



friction in the stand on the amplitude-phase frequency characteristics of the dynamic rigidity of the system is established. (Author abstract) 3 refs.

Dukmasov, V.G. (Chelyabinsk Polytechnic Inst, USSR). *Steel USSR* v 17 n 4 Apr 1987 p 177-180.

**091773 DEFORMATION OF METAL IN ASYMMETRIC ROLLING OF THIN STRIPS.** The object of the study was deformation between stationary and driving work rolls (the DSDR process). Investigation of the metal's deformed state established that despite a difference in roll diameters and redistribution of the absolute reduction value, the nonuniformity level of a metal's kinematic and deformed states along the height of the deformation zone cross section does not exceed 8%. The non-monotonic characteristics of the plastic deformation process vary within a range which is also characteristic for symmetric rolling. 10 refs.

Potapkin, V.F.; Satonin, A.B.; Dobronosov, Yu.K. *Russ Metall Met* n 4 1987 p 62-66.

**091774 ANALYSIS OF THE INTERACTION BETWEEN ABRASIVE POWDER AND THE SCALE ON ROLLING STOCK SURFACES.** Design of industrial technology which includes the process of abrasive powder descaling of rolling stock (APD process) made it necessary to develop theory in order to design equipment for the descaling. Using the concept of the distribution function of abrasive powder makes it possible to generate continuous formulas suitable for differentiation for calculation of discrete forces arising during the interaction of abrasive particles with the scale and thus to create the possibility of energy force calculations for the APD process using free-flow medium mechanics. Results of the calculation method permitted reduction of energy consumption by 20-30% and improvement in the quality of descaling. 7 refs.

Garber, E.A.; Letavin, M.I.; Subbotin, A.N.; Lipukhin, Yu.V.; Pimenov, A.F.; Zhukov, Yu.K. *Russ Metall Met* n 4 1987 p 67-71.

**091775 SLIT COIL TENSIONING - PAPER STUFFING TO STRAND EXTENSIONERS.** The basic problem in producing a perfect slit coil is that the center slit strands rewind faster and tighter than the outer strands which may leave the outer coils loose and unstable. Three causes for this rewind differentials are crowned strip, wavy edges, and uneven burr or coating buildup on the strip. The strain extender slitting process provides a solution to loose and unstable outer slit strands caused by crown in the master coil together with an upgrading of end product with respect to gage surface and shape quality.

Theis, Henry E. (Herr-Voss Corp, Callery, PA, USA). *Iron Steel Eng* v 65 n 3 Mar 1988 p 45-49.

**091776 INFLUENCE OF CONCENTRATION AND DROPLET SIZE OF EMULSIONS ON THEIR EFFICIENCY IN COLD ROLLING.** The authors conducted experiments to determine the influence of the method of preparation of an oil-water emulsion on its stability and lubricating and cooling properties during trial rolling in a laboratory cold strip mill. The lubricants were prepared using propeller-type agitation and ultrasonic oscillation in distilled water at 70°C. The oils used as a base were palm oil and K-2 coriandrol. (Author abstract) 8 refs.

Pimenov, A.F. (Central Scientific Research Inst of Ferrous Metallurgy, USSR); Shakhov, V.L.; Vasil'ev, A.V.; Traino, A.I.; Bukhanov, A.N.; Safin, G.G. *Steel USSR* v 17 n 5 May 1987 p 228-229.

**091777 EXPERIENCE WITH THE NIPCO SYSTEM IN STRIP AND FOIL ROLLING.** The basic element of the Nipco system is the hydraulically controlled Nipco roll. In four-high rolling mills, it is used instead of a conventional back-up roll, while in skin-pass mill stands with only two rolls it is used as a work roll. This roll assumes the tasks of the generation of rolling forces, roll push-up, width setting, local flatness corrections, and replacement of roller bearings. The above

characteristics make the Nipco roll an ideal actuator in the rolling mill. The Nipco system integrates the individual modules of roll, roll chocks, hydraulics, controls, and software into one entity. (Author abstract)

Lehmann, Rolf (Sulzer-Escher Wyss Inc, Zurich, Switz); Schnyder, Eugen; Guetinger, Heinz. *MPT Metall Plant Technol* v 11 n 1 1988 p 64, 66, 68.

**091778 INFLUENCE OF TEMPER ROLLING CONDITIONS ON MECHANICAL PROPERTIES AND STRUCTURE OF LOW CARBON STEEL.** The authors describe a comparative assessment of the influence of different temper rolling conditions on the ferrite substructure in the surface layer and properties of 08Yu steel strip of 0.7-1.5 mm thickness. The strip was rolled without lubricants and also with oil and emulsol lubricants in the 1700 mill at the Urals Heavy Engineering Works. Changes in temper rolling conditions (by using lubricants or altering the strip thickness) reduce the amount of work hardening in the ferrite of the surface layer and also the absolute yield strength values in the temper rolled strip. (Author abstract) 7 refs.

Pargamonov, E.A. (Zaporozhstal Iron & Steel Combine, USSR); Nesterenko, A.M.; Mazur, V.L. *Steel USSR* v 17 n 6 Jun 1987 p 268-270.

**091779 MODERNIZATION OF THE HOT STRIP MILL AT BRITISH STEEL CORP.'S PORT TALBOT WORKS.** A major hot strip mill modernization that included a new reversing roughing mill, Coilbox, seventh finishing stand and new downcoilers was accomplished using organizational changes that virtually integrated the steel company and contractors' site teams. In addition to improving product quality and extending product size range, a major rebuild of the 2032-mm (80-in.) Port Talbot hot strip mill has permitted a doubling in coil weight from 9 to 18 kg/mm width. The modernization was accomplished using an organization system that virtually integrated the BSC and Davy McKee site teams.

Gronbeck, Robert W. (Davy McKee Sheffield Ltd, Sheffield, Engl); McDonald, James H. *Iron Steel Eng* v 65 n 4 Apr 1988 p 17-23.

**091780 LINEAR PROGRAMMING FOR CONTROL OF STRIP SHAPE AND ROLL GRINDING.** Control of strip shape in hot and cold continuous mills involves simultaneous consideration of the elements that interact to produce the strip's final profile and flatness. On-line control options include load shifting, roll bending and roll crown changes through roll shifting or crossing, all subject to known limits. Roll grinding must be compatible with the rolling campaign and the range of on-line control. (Author abstract) 4 refs.

Fapiano, Donald J. (GE, Salem, VA, USA). *Iron Steel Eng* v 65 n 4 Apr 1988 p 24-28.

**091781 WORLD'S WIDEST STAINLESS STRIP MILL.** A Z-high retrofit to a 4-h reversing mill has provided modern rolling mill capability. Advantages include elimination of intermediate anneals, improved strip shape and surface quality, and increased mill productivity at lower investment cost. (Author abstract)

Senzimir, Michael G. (T. Sendzimir Inc, Waterbury, CT, USA); Molin, Per; Petersson, Bo. *Iron Steel Eng* v 65 n 4 Apr 1988 p 36-38.

**091782 INSPECTION OF GROUND ROLLS - THEORY INTO PRACTICE.** Today's customers for wide steel and aluminium strip are able to shop around for the best quality at the most favourable price - a direct consequence of overcapacity. To retain their market share, producers are being forced to match the quality demands of the market and a major factor in the battle is a reputation for supplying strip with consistently good shape or flatness. This article describes a new roll inspection and designed to ensure that every roll sent forward to the mill has the specified profile. It makes use of the three probe technique. (Edited author abstract) 1 ref.

Armstrong, D.A. (Open Univ in Wales, Cardiff, Wales); Thomas, R.H.; Murray-Shelley, R. *CME Chart Mech Eng* v 34 n 11 Nov 1987 p 44-47.

**091783 INFLUENCE OF STRIP SURFACE MICROROUGHNESS ON ROLLING PARAMETERS.** The authors conducted investigations in laboratory mills with roll diameters of 100, 200m and 250 mm rolling 1.05-1.85 mm thick aluminium strip and 1.05-1.37 mm thick 08ps steel strip. During rolling with low reductions in ground rolls, some increase in the friction coefficient is observed with increasing surface microroughness. With  $R(\text{a surf.}) > 2.5 \mu\text{m}$ , however, the friction coefficient tends to decrease. An increase in the strip microroughness to  $R(\text{a surf.}) = 4.4-5.7 \mu\text{m}$  during rolling in shot blasted rolls results in a drop in the friction coefficient. 2 refs.

Nikolaev, V.A. (Zaporzh'e Industrial Inst, USSR); Volkov, I.A.; Pilipenko, S.S. *Steel USSR* v 17 n 7 Jul 1987 p 322-323.

**091784 CRITERIA FOR THE PREVENTION OF SPLIT ENDS.** A criterion for the prevention of split ends (alligatoring)  $A$  is expressed mathematically. This criteria,  $t_0/R_0 > 1.81 \times (t_0/t_f - 1)$  is derived through the extension of an earlier upper bound solution for strip rolling of a perfectly plastic mises material. The treatment is based on the division of the deformation region to a series of triangles, undergoing rigid body rotational motions. (Author abstract) 13 refs.

Zhu, Y.D. (Lehigh Univ, Bethlehem, PA, USA); Avitzur, B. *J Eng Ind Trans ASME* v 110 n 2 May 1988 p 162-172.

**091785 PREVENTION OF CENTRAL BURSTS DURING ROLLING.** An upper bound analysis has been developed to model the flat rolling of a perfectly plastic material. This field permits the possible formation of an internal void. The process conditions under which it is energetically favorable for a void to develop have been determined. It has been found that internal void formation (central burst) is more likely to occur in thick strips and sheets when small reductions are taken. Both front and back tension tend to promote the development of a central burst with the back tension reducing the safe, noncentral burst domain to a greater degree. Criteria curves for the central burst domain and the safe domain are presented for a wide range of process variables. (Author abstract) 21 refs.

Avitzur, B. (Lehigh Univ, Bethlehem, PA, USA); Van Tyne, C.J.; Turczyn, S. *J Eng Ind Trans ASME* v 110 n 2 May 1988 p 173-178.

**091786 CVC TECHNOLOGY FOR COLD ROLLING MILLS - PLANT EXAMPLES.** Continuously variable crown (CVC) is a new yardstick for quality in hot and cold rolling. Strip flatness and profile can be controlled by CVC technology that provides a continuously adjustable roll gap crown. The technology also incorporates horizontal stabilization of slim work rolls, roll bending and a closed-loop control system including thermal flatness control. Some installations in West Germany are described.

Bald, Wilfried (SMS Schoemann-Siemag AG, Dusseldorf, West Ger); Klamma, Klaus. *Iron Steel Eng* v 65 n 5 May 1988 p 24-28.

**091787 NEW AGC SYSTEM CONTROLLING MOTOR CURRENT AND ROLL POSITION FOR REVERSING COLD MILLS.** Requirements for gauge accuracy of cold rolled strip have been increasing year by year. An automatic gauge control system (AGC) with high performance is in demand for reversing cold mills. A new AGC system has been developed based on fundamental research by Sumitomo Metal Industries, Ltd.

Anon. *Trans Iron Steel Inst Jpn* v 28 n 4 1988 p 333.

**091788 CONTROLLED ROLLING OF A LOW CARBON STEEL IN WIDE STRIP MILLS.** The combined effects of initial finishing temperature and



cooling between the finishing stands of a wide strip mill on the mechanical properties of steel 3sp were investigated. It was shown that cooling between the stands and a higher initial finishing temperature have no detrimental effect on strength, ductility and impact properties of this steel. A combination of cooling in the intermediate roller table to about 900°C and cooling between the stands is necessary for improving the low temperature properties of steel. The recommended final finishing temperature for a low carbon steel with a guaranteed strength level lies at the beginning of the  $\gamma$ - $\alpha$  transformation range, i.e., at 800-780°C. (Author abstract)

Potemkin, V.K.; Peshkov, V.A.; Zakharov, I.Yu. *Sov Mater Sci Rev* v 1 n 3 1987 p 265-268.

**091789 CROWN AND SHAPE CONTROL IN HOT FINISHING MILL.** In order to meet the demands for high accuracy of strip crown and flatness, the Kakogawa hot finishing mill has been remodeled to work roll shift mill. Various new systems for computer control of strip crown and flatness in the work roll shift mill have been developed and the entire control apparatus has been renewed. As a result of these reformations, accuracy of strip crown and flatness has greatly improved. (Author abstract) 4 refs. In Japanese.

Yamamoto, Yoshitaka; Hirata, Kiyoshi; Oike, Yoshio; Sato, Junji; Honda, Sueji; Tsutsumi, Yasuhiro. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 77-80.

**091790 CVC MILL PRODUCES FLAT STRIP FOR PROGRESSION PRESSWORK.** The article describes a continuous variable crown mill at Friedr. Gustav Theis Kaltwalzwerke GmbH. The mill has been designed to meet high standards of flatness and straightness. Five components directly and jointly control any deviation from material characteristics, which in turn provides cost savings during subsequent processing of the strip by customers. Improved control of strip characteristics is of particular importance when the material is used in long progression tooling.

Anon. *Sheet Metal Ind* v 65 n 4 Apr 1988 p 174, 176.

**091791 APPLICATION OF OFF-LINE COMPUTER MODEL MILLMAX AT WEIRTON STEEL'S HOT STRIP MILL.** A variety of configurations were analyzed using an off-line computer model to establish optimum characteristics for a revamped hot strip mill. Based on the physics of rolling, the model can be calibrated using actual rolling data for a broad product range. It can also be employed for the extrapolation of rolling conditions, development of new operating practices and to accelerate the learning curve of new on-line setup computers. 30 refs.

Ginzburg, Vladimir B. (Int Rolling Mill Consultants Inc, Pittsburgh, PA, USA); Kaplan, Naum M.; James, Kenneth L.; Zickelsoose, William F. *Iron Steel Eng* v 65 n 6 1988 p 24-33.

**091792 ERFABRUNGEN BIE DER INBETRIEBNAHME EINER NEUEN PRODUKTIONS-LINIE FUER SONDERWERKSTOFFE, CuSn6-BAND UND BUNTMETALLPLATTIERTES STAHLBAND.** [Experience with the Start of a New Production Line for Special Materials, CuSn6 Strip, and Steel Strip Cladded with Non-Ferrous Metal]. The dynamic development of electric engineering and electronics and thus the increased demands on surface quality as well as on the geometrical and mechanical properties of cold-rolled strips resulted in re-equipping and extending an existing production line for strips of special alloys, bronze and non-ferrous clad materials. By utilizing a new process engineering technique, the fundamentals were provided to continuously supply microelectronics with semi-finished and finished high-grade metallurgical products. New engineering steps of production were established to improve the quality. During the start-up period, new techniques were initiated. The cooperation with the Freiberg Mining Academy and VEB Edelmetallwerk Freital resulted in a further improvement by employing high-tech equipment, and the output was also substantially increased. (Edited author abstract)

In German.

Schlosser, Gerd-Ulrich (VEB, Aue, East Ger); Havlik, Jan; Nevirva, Pavel. *Neue Huette* v 33 n Apr 1988 p 147-152.

**091793 VALCOVANI DVOUFAZOVYCH FERTICKO-MARTENZITICKYCH OCELI NA TEPLÉ SIROKOPASOVE TRATI.** [Rolling Two-Phase Ferritic-Martensitic Steel on Hot Wide Strip Mill]. The article analyzes the feasibility of obtaining a two-phase ferritic-martensitic structure of strip hot rolled in a controlled rolling process. Mathematical models were used for optimum chemical analysis and regime of rolling and cooling. Results of practical experiments are discussed. 8 refs. In Czech.

Horejs, Slavomir (Vyzkumny Ustav Hutnictvi Zeleza, Dobra, Czech); Navrat, Vlastimil; Wozniak, Jan; Parilak, Ludovit; Simon, Arpad. *Hutn Listy* v 43 n 4 Apr 1988 p 252-260.

**091794 NACIAG WEWNETRZNY PODCZAS WALCOWANIA.** [Inner Tension in the Rolling Process]. Analysis is given of stresses and deformation in the course of crushing during rolling the middle part of the band. These stresses act in the same way as back tension during the rolling process. Their range comprises not only tensile stresses but also compressive stresses. (Author abstract) 2 refs. In Polish.

Mazurkiewicz, J. (Politechnika Slaska, Katowice, Pol). *Hutnik* v 54 n 9 Sep 1987 p 243-245.

**091795 TECHNOLOGICAL CONDITIONS FOR THE PRODUCTION OF DUAL PHASE FERRITE-MARTENSITE STEEL STRIPS BY CONTROLLED ROLLING.** Fundamental aspects of the production of dual phase ferritemartensite steel strips by hot rolling are discussed. Attention is paid especially to analyses of the rolling conditions which ensure the creation of the desired dual phase structure in economically alloyed steels. The controlled rolling parameters for Mn-Si and Mn-Si-Mo steel strips under the conditions of the HSM 1700 hot strip mill at the East Slovak Ironworks, on which the full-scale experiment was based, were analyzed by means of a mathematical model. The paper summarizes the results of theoretical calculations, practical rolling experiments, and application of the strips for the cold stamping of automobile wheels. (Author abstract) 6 refs.

Wozniak, Jan (Iron & Steel Research Inst, Dobra, Czech); Horejs, Slavomir; Navrat, Vlastimil. *Arch Hutn* v 33 n 1 1988 p 67-77.

**091796 STABILITY OF STRIP IN ELONGATING PASSES OF LIGHT SECTION MILLS AND ROD MILLS.** The condition of natural stability during the rolling of an oval strip in round and edging oval passes was determined. Natural stability is observed in round passes with relatively large reductions which decrease in edging oval passes with increase in their height/width factor. From the point of view of stability and uniform loading of the adjacent stands, flat oval passes with flats equal to 0.3 to 0.4 of the width of the pass are rational for an oval-round pass system. Displacement and overflow of the grooves have the greatest influence with respect to loss of stability. (Author abstract). 3 Refs.

Utkin, G.S. (Scientific Research Inst of Ferrous Metallurgy, USSR); Rezvov, B.S. *Steel USSR* v 17 n 9 Sep 1987 p 419-421.

**091797 SHAPE STABILITY OF COILS OF HOT ROLLED STRIP.** An investigation was made into the sagging of coils of hot rolled strip conveyed in horizontal and vertical attitudes to a stock bay and stacked there in a single tier and multiple tiers on a flat surface. It is demonstrated that transferring these coils on cradles with wall inclinations of 35-40° from the coils of the hot wide strip rolling mill to the stock bay in a horizontal attitude and stacking them 1-3 high in a horizontal attitude on these cradles is the best method of preventing their sagging during cooling with resultant difficulties during

subsequent processing. The coils cool more rapidly and almost uniformly when stacked horizontally. (Author abstract). 8 Refs.

Mazur, V.L. (Inst of Ferrous Metallurgy, USSR); Melishko, V.I.; Kostyakov, V.V.; Karetnyi, Z.P. *Steel USSR* v 17 n 9 Sep 1987 p 421-424.

**091798 LOOPER OPTIMAL MULTIVARIABLE CONTROL FOR HOT STRIP FINISHING MILL.** The goal of controlling the hot strip finishing mill loopers is to stabilize rolling operations and maintain product quality by controlling the tension applied to the strip and the looper angle within their reference values. In this paper, a looper optimal multivariable control based on the optimal regulator theory employing a looper drive system with a speed control loop is proposed. Other topics discussed includes the results of simplifying the control system by the use of a programmable controller. (Edited author abstract). 4 Refs.

Fukushima, Kenya (Nippon Steel Corp, Hirohata, Jpn); Tsuji, Yuichi; Ueno, Shinji; Anbe, Yoshiharu; Sekiguchi, Kunio; Seki, Yoshiro. *Trans Iron Steel Inst Jpn* v 28 n 6 1988 p 463-469.

**091799 FUNDAMENTAL STUDY ON SNAKING IN STRIP ROLLING.** Three-dimensional analysis for strip rolling, in which elastic deformation of rolls and plastic deformation of a strip are treated as one system, is expanded to calculate the nonsymmetric deformation of both rolls and strip. The analysis is applied to evaluate the off-centering or cambering of a strip and the fundamental characteristics of snaking of a strip. The phenomena of nonsymmetric rolling and off-centering or cambering can be predicted accurately by the analysis. (Author abstract). 8 Refs.

Ishikawa, Takashi (Nagoya Univ, Nagoya, Jpn); Tozawa, Yasuhisa; Nishizawa, Jun. *Trans Iron Steel Inst Jpn* v 28 n 6 1988 p 485-490.

**091800 OPTIMISATION OF INTERSTAND TENSIONS DURING CONTINUOUS STRIP ROLLING.** Interstand tension regimes have a considerable influence on dimensional and geometrical accuracies of rolled strip. Rolling strips under optimum interstand tension conditions on the 2000 continuous strip mill in the Cherepovets Iron and Steel Combine enabled the thickness variation of the sheet to be lowered by an average of 0.05-0.15 mm, the width variations to be lowered by 7-8 mm, and the flatness to be increased by 5-10 mm m<sup>-1</sup>. A regime of interstand tensions giving considerable improvement in dimensional and geometrical accuracy indices of the final sheet was developed from the results of the investigation. (Edited author abstract). 3 Refs.

Zaikov, M.A. (Krasnodar Polytechnic Inst, USSR); Medenkov, A.A.; Pogorzelskii, V.I.; Kolesnikov, I.A.; Zaikov, A.M. *Steel USSR* v 17 n 11 Nov 1987 p 510-511.

**091801 INFLUENCE OF SKIN PASS ROLLING TEMPERATURE ON POWER-FORCE PARAMETERS OF PROCESS AND QUALITY OF ROLLED PRODUCT.** The authors established the influence of the temperature and amount of deformation of strip on the power-force parameters of the process and properties of 08kp, 08Yu, and 2011 steels during skin passing. To obtain minimum yield strength and hardness values in an 08Yu type steel, the amount of deformation during skin passing must be lowered with increase in temperature. Skin passing with a reduction of 5-9% is recommended in the case of 2011 electrical engineering steel. Varying the skin pass temperature in the 40-200°C range has no influence on its magnetic properties. Considering the positive influence of an increase in temperature on the



power-force parameters of the skin passing process, 2011 steel strip is ideally rolled at temperatures between 100 and 200°C. (Author abstract). 11 Refs.

Mazur, V.L. (Central Scientific Research Inst of Ferrous Metallurgy, USSR); Pargamonov, E.A.; Chernov, P.P.; Kolesnichenko, B.P.; Zaspenko, Ya. P.; Kulikov, V.I. *Steel USSR* v 17 n 11 Nov 1987 p 512-514.

**091802 GENERAL FORMULATION OF PROBLEM OF DESIGNING SHEET ROLLING TECHNOLOGY.** The general problem of developing automatic sheet rolling technology design systems is formulated. The objects used in these systems and the relations between them are given. Possible means of automating all the stages of system development and formalizing the procedure for determining optimum rolling technology are analyzed. An example of the practical use of the proposed procedure is the cold rolling technology design system introduced on a 1700 four stand mill of one of the iron and steel combines in the USSR. (Edited author abstract). 8 Refs.

Kuznetsov, L.A. (Lipetsk Polytechnic Inst, USSR). *Steel USSR* v 17 n 12 Dec 1987 p 557-558.

**091803 PRODUCTION OF DUPLEX, LOW ALLOY, FERRITIC-MARTENSITIC STEELS FROM ROLLING HEAT.** The authors investigated the feasibility of developing low cost alloying compositions for molybdenum free duplex ferritic-martensitic steels and attempted to devise a practice for producing hot rolled strip utilizing schedules available on the 2000 hot wide strip mill at Cherepovets Combine. The two steels involved were 06G2S2 and 06KhGS. The basic requirements for developing of a duplex structure were the use of accelerated cooling before coiling and a reduction in the coiling temperature to 500°C and below. (Author abstract). 7 Refs.

Medenkov, A.A. (Central Scientific Research Inst of Ferrous Metallurgy, USSR); Tishkov, V. Ya.; Pimenov, V.A.; Fonshtein, N.M. *Steel USSR* v 17 n 12 Dec 1987 p 571-573.

**091804 BENDING OF STRIPS WITH ONE-SIDE THICKNESS VARIATIONS DURING ROLLING.** Theoretical and experimental investigations of strip curvature during rolling of wide strip have been carried out. The strip had a cross section with a vertical symmetry axis and one-sided thickness variation resulting in convexity or concavity over the width. The concept of additional stresses has been used to develop expressions for the curvature of the workpiece at the roll inlet and outlet. It has been found that during rolling of strip with the cross section the workpiece bends toward the wide face at the roll inlet and outlet and that the curvature is determined by the deviations of cross section shape and area from those of a rectangular section strip. (Author abstract).

Korokhov, V.G.; Popov, N.N. *Sov Mater Sci Rev* v 1 n 4 1987 p 425-427.

**091805 CONTRACTION MECHANISM IN ROLLING OF FLUTED SHEETS.** Fluted sheet contraction during rolling has been examined using vector analysis which makes it possible to consider the three-dimensional problem. Applications of expressions invariant with respect to coordinate transformation and to various coordinate systems has been demonstrated. These expressions simplify the analysis. The contraction mechanism has been identified by simultaneously considering the vector and scalar fields for which the divergence can be negative, pointing to contraction. (Author abstract).

Meleshko, A.M.; Kuznetsov, Yu. E.; Dobroslovestnov, A.M.; Lamintsev, V.G. *Sov Mater Sci Rev* v 1 n 4 1987 p 433-436.

**091806 STUDIES OF THE ROLL CONTACT LINE IN COLD ROLLING OF STRIP.** The problem of identification of the contact line of the strip with the roll in cold rolling, taking into consideration the effect of elastic deformation of the tool and the metal and the asymmetric shape of the projection diagram of normal

contact stresses, is solved. Comparison of calculation results for the contact line with experimental data confirmed their satisfactory agreement. Distortion of the roll's cylindrical shape in the deformation zone has to be taken into consideration in calculations of energy-work parameters of cold rolling, particularly the rolling moment and forward slip. 12 Refs.

Vasilev, Ya. D.; Shuvuyakov, V.G. *Russ Metall Met* n 5 1987 p 107-115.

**091807 EFFECTIVE COOLING OF WORK ROLLS IN STRIP ROLLING.** An examination has been made of the effectiveness of roll cooling as applied to strip rolling, taking into account practical considerations such as the spray location and positioning, coolant flowrate, and rolling temperature. It is indicated by the results that, for cold rolling, the most effective cooling can be achieved by commencing spray cooling at the exit side of the roll gap and by providing a large spray contact angle. However, for hot rolling, cooling should commence at least 45° from the roll gap exit and a high spray flux density with relatively small spray contact angle is more appropriate. (Author abstract). 30 Refs.

Yuen, W.Y.D. *Mater Sci Technol* v 4 n 7 Jul 1988 p 628-634.

**091808 SYNCHRONIZED OPERATION SYSTEM BETWEEN STEELMAKING AND HOT ROLLING AT MIZUSHIMA WORKS. RATIONALIZATION OF HOT STRIP MANUFACTURING PROCESS AT MIZUSHIMA WORKS - I.** Mizushima Works has started a synchronized operation between steelmaking and hot rolling operations (which is named the P2 system). Aims of this system are improvement in lead time, stock reduction, hot charge rolling, manpower, production yield and quality. This paper outlines and characteristics of the system. 2 refs.

Takizawa, Syouchi (Kawasaki Steel Corp, Jpn); Fujiwara, Kozo; Hirayama, Katsuhisa; Harimoto, Akira; Kuzuhara, Tamio; Nakanishi, Masao. *Trans Iron Steel Inst Jpn* v 27 n 10 1987, Prepr for the 113th ISIJ Meet, Part IV, Tokyo, Jpn, Apr 1-3 1987 p B.252.

**091809 DEVELOPMENT OF AN ON-LINE CC OPERATION AND QUALITY ASSURANCE SYSTEM. RATIONALIZATION OF HOT STRIP MANUFACTURING PROCESS AT MIZUSHIMA WORKS - II.** The paper describes synchronization of steelmaking and hot rolling (P2 system) aimed at a sheet steel manufacture rationalization at Mizushima Works. On-line automation was achieved at the continuous casting plant in terms of operations and quality assurance by refurbishing the instrumentation unit and equipment remodeling. This paper gives a brief outline. 2 refs.

Nariishi, Masaaki (Kawasaki, Steel Corp, Jpn); Hirayama, Katsuhisa; Hina, Hideshi; Tanaka, Hideyuki; Iwamura, Tadaaki; Takizawa, Syouchi. *Trans Iron Steel Inst Jpn* v 27 n 10 1987, Prepr for the 113th ISIJ Meet, Part IV, Tokyo, Jpn, Apr 1-3 1987 p B.253.

**091810 ROLLING CHANCE FREE OPERATION BY WORK ROLL SHIFT IN HOT STRIP MILL. RATIONALIZATION OF HOT STRIP MANUFACTURING PROCESS AT MIZUSHIMA WORKS - III.** In a system recently started at Mizushima Works for synchronization of steelmaking and hot rolling operations, a technique for defect free operation is essential. To meet this aim, a work roll shifting mechanism was introduced. This report briefly describes the system.

Ito, Sumihiko (Kawasaki Steel Corp, Jpn); Kasuga, Hiroo; Fujiwara, Kozo; Takeya, Akihiko; Uehara, Atunori; Takizawa, Syouchi. *Trans Iron Steel Inst Jpn* v 27 n 10 1987, Prepr for the 113th ISIJ Meet, Part IV, Tokyo, Jpn, Apr 1-3 1987 p B.254.

**091811 NEW ROLL FORCE AWC SYSTEM FOR ROUGHING TRAIN IN HOT STRIP MILL.** For minimization of both the mill margin in width of a strip and the head and tail cut off loss and restrictions on slab width, rougher automatic width control (RAWC) system

was developed and applied to the hot strip mill at Kakogawa Works of Kobe Steel, Ltd. It is important for the RAWC system to reduce the fluctuations in width caused by skid marks as well as to eliminate subsequent shape irregularities. The fluctuations in width are reduced by a force-AWC (RF-AWC) system including a modified edger mill and a control model.

Anon. *Trans Iron Steel Inst Jpn* v 27 n 12 1987 p 993.

**091812 DEVELOPMENT OF A HOT SIZING PRESS - RATIONALIZATION OF HOT STRIP MANUFACTURING PROCESS AT MIZUSHIMA WORKS-IV.** Mizushima Works has developed a steel-making - hot rolling synchronization system (Mizushima P2 system) to rationalize hot strip rolling. As the hardware for this system, a hot sizing press was developed and installed in the hot rolling plant. This report presents features of the hot sizing press. 2 refs.

Kondo, Toru (Kawasaki Steel Corp, Kurashiki, Jpn); Fujiwara, Kozo; Naoi, Takayuki; Abe, Hideo; Kimura, Tomoaki; Nihei, Mituo. *Trans Iron Steel Inst Jpn* v 28 n 1 1988, Prepr for the 114th ISIJ Meet, Part I, Kumamoto, Jpn, Oct 9-11 1987 p B.18.

**091813 DEFORMATION PROPERTIES OF HOT SIZING PRESS MATERIALS - RATIONALIZATION OF HOT STRIP MANUFACTURING PROCESS AT MIZUSHIMA WORKS-V.** With the aim of rationalizing CC slab rolling for strip manufacture, a steelmaking - hot rolling synchronization system (Mizushima P2 system) was launched at Mizushima Works. As the key hardware, a hot sizing press was developed. This report outlines the deformation property of slabs rolled on the sizing press. 3 refs.

Ueki, Shigeru (Kawasaki Steel Corp, Kurashiki, Jpn); Fujiwara, Kozo; Naoi, Takayuki; Nikaido, Hideyuki; Isobe, Kunio; Hira, Takaaki. *Trans Iron Steel Inst Jpn* v 28 n 1 1988, Prepr for the 114th ISIJ Meet, Part I, Kumamoto, Jpn, Oct 9-11 1987 p B.19.

**091814 QUALITY CONTROL SYSTEM IN THE STEELMAKING-HOT ROLLING SYNCHRONIZED OPERATION - RATIONALIZATION OF HOT STRIP MANUFACTURING PROCESS AT MIZUSHIMA WORKS-VI.** This paper reports the quality control improvements made in planning and raw materials sectors to meet the requirements of the steelmaking-hot rolling system (P2 system) which was started up at Mizushima Works in 1986 for the rationalization of strip manufacturing. A checking function of manufacture and hot rolling specification items has been improved. A simulation function has been installed for optimization of slab dimensions. 2 refs.

Yamada, Nobuo (Kawasaki Steel Corp, Kurashiki, Jpn); Takizawa, Syouchi; Kibayashi, Takashi; Maeda, Kikuo; Nakai, Kazuyoshi; Miyahara, Kazuaki. *Trans Iron Steel Inst Jpn* v 28 n 1 1988, Prepr for the 114th ISIJ Meet, Part I, Kumamoto, Jpn, Oct 9-11 1987 p B.20.

**Slab** See Also ROLLING MILLS—Modernization; STEEL—Continuous Casting; STEEL—Inclusions; STEEL FOUNDRY PRACTICE—Casting.

**091815 EINFLUSS DER SEKUNDAERKUEHLUNG BEIM STRANGGIESEN AUF DAS AUSBRECHEN UND DIE INNERE QUALITAET VON BRAMMEN.** [Effect of Secondary Cooling on the Bulging and Internal Quality of Slabs]. The deformation of two rolls and the bulging of the slab surface between these rolls have been determined with the aid of a special measuring system developed by CRM, during the casting process in a slab continuous casting plant. This report discusses the results of the measurements in terms of slab deflection and deformation of the rolls, which were



obtained during several hundred casts, carried out under varying operating conditions. (Edited author abstract) In German. 12 refs.

Etienne, Arlette (CRM, Liege, Belg); Franssen, Roger; Pirlot, Robert. *Stahl Eisen* v 107 n 20 Oct 5 1987 p 53-60.

**091816 IMPROVING THE RELIABILITY OF UNIVERSAL SPINDLES.** Statistical studies of the performance of the universal spindles on the 1150 slabbing mill and the roughing stands of the 1700 hot strip mill at the Karaganda Metallurgical Combine established that the main reason for spindle failure is wear of the contact surfaces of the bronze bushings and spindle heads. This wear changes the service conditions of elements of the hinge, leads to shock loads, facilitates the deposition of scale and water on the friction surface, and diminishes the reliability of the spindles. Experience shows that the bronze bushings usually begin to wear from the peripheral sections. To alleviate the concentration of contact stresses during the initial stage of the run-in period, it was suggested that the bushings be provided with chamfers. The design change improved the service life of the spindles.

Eidel'man, V.M. (Karaganda Metallurgical Combine, USSR); Khlopomin, V.N.; Shumakher, E.A.; Chichenev, N.A. *Metallurgist (USSR)* v 31 n 7-8 Jul-Aug 1987 p 215-217.

**091817 NEW METHOD FOR UNIVERSAL ROLLING OF LARGE H-BEAMS FROM CONTINUOUSLY CAST SLABS.** In the structural shape mill at Kashima Steel Works of Sumitomo Metal Industries, Ltd., all large H-beams ranging up to H900×300 and H500×500 have been produced by rolling 250-mm thick continuously cast slabs in one heat with a new split rolling method. Compared with the conventional rolling method which starts from ingots, the rolling yield has been raised by 10%. Energy consumption has been significantly improved. (Author abstract). 6 Refs.

Hayashi, Chihiro (Sumitomo Metal Industries Ltd, Amagasaki, Jpn); Kusaba, Yoshiaki; Nakayama, Katsuichi. *Trans Iron Steel Inst Jpn* v 28 n 6 1988 p 428-433.

**091818 PREVENTION OF BUCKLING IN HEAVY WIDTH REDUCTION WITH LONGITUDINALLY INCLINED EDGING ROLLS.** Heavy width reduction has become increasingly important in the production of hot steel strip. When a thick slab is subjected to heavy width reduction, the rolling force is too great, therefore the edge must be larger. On the other hand, when a wide slab is subjected to heavy width reduction, most slabs buckle convexly upwards along the transverse direction. It was an objective of this study to develop an improved method to reduce heavily the width of thin materials without transverse buckling. A new edger rolling method with a pair of edging rolls tilted in the entry direction was developed. When the edging rolls are tilted in the entry direction, the vertical force is applied upward to the edges of the slab. The resultant vertical force and transverse force of edge rolling bends the slab convexly downwards. When heavy reduction is applied to a slab bent in this manner, slab bending is constrained by the table rollers and buckling does not take place. (Edited author abstract). 2 Refs.

Kitazawa, Jitsuo (Kobe Steel Ltd, Kanazawa, Jpn); Mizuta, Atsuo; Korida, Kazuhiko; Takizawa, Kenzaburo; Kokubo, Ichiro. *Trans Iron Steel Inst Jpn* v 28 n 6 1988 p 456-462.

## Soaking Pits

**091819 NEUE SCHEITRECHTE TIEFOFEN-DECKEL MIT GROSSFORMATIGEN HAENGEDECKELELEMENTEN AUS HITZEBESTÄNDIGEM STAHLBETON.** [New Flat Soaking Pit Cover with Large-Size Suspended Roof Elements from Reinforced Refractory Concrete]. A six-chamber soaking pit for ingot preheating up to 900°C as well as for homogenizing up to 1,350°C, which has previously been equipped with slidable arch covers, has recently been reset with

plane horizontal covers to be lifted by the charging crane of the pit. These covers consist of large-size suspended roof elements made of heat-resistant reinforced concrete. Three-years experience with the behavior and handling of this new cover design is reported in this paper. It is shown that in addition to a number of technological advantages, substantial savings in energy, repairs, and operating cost have been achieved. (Edited author abstract) In German 4 refs.

Herrmann, Peter (Brennstoffinstitut Freiberg, Freiberg, East Ger); Wempe, Harald; Schlueter, Herbert; Langer, Berthold. *Neue Huette* v 33 n 2 Feb 1988 p 49-51.

**091820 METHODS FOR HEATING INGOTS WITH LIQUID CENTRES IN SOAKING PITS.** Tightening of works schedules for the transfer of steel ingots from the melting shop to the soakers involves the charging and heating of ingots with liquid centers. The authors describe how this problem has been tackled in the USA and Japan (patents). Two Soviet techniques which are being used in production with improved pit throughputs are described. (Author abstract). 3 Refs.

Roi, N.S. (Dnepropetrovsk Inst of Ferrous Metallurgy, USSR); Svinolobov, N.P.; Minaev, A.N.; Borborts, Yu. S.; Gorbunov, A.D.; Ryzhov, A.F. *Steel USSR* v 17 n 11 Nov 1987 p 534-536.

## Stresses

**091821 MEASUREMENT OF THE INTERFACIAL STRESSES IN ROLLING USING THE ELASTIC DEFORMATION OF THE ROLL.** A new method to measure the frictional stresses and normal pressure in the roll gap during cold rolling, and experimental verification of this new method, are presented. The method overcomes many of the shortcomings of pin-type sensors. The elastic deformation of the roll itself is measured with strain gages, and is used to calculate the stresses between the sheet and the roll. Since no modification of the roll is necessary, the deformation process is undisturbed by the measurement. Mechanical isolation of the sensor is unnecessary. The mathematical procedure used to calculate the normal pressure and frictional stresses from the measured strains explicitly acknowledges that these strains are the result of the entire distribution of pressures and shears in the roll gap. (Edited author abstract) 34 refs.

Meierhofer, D.J. (Univ of Minnesota, Minneapolis, MN, USA); Stelson, K.A. *J Eng Ind Trans ASME* v 109 n 4 Nov 1987 p 362-369.

**091822 ANALYZA NAPETOVEHO POLE PRI USTALENEM PROCESU VALCOVANI.** [Analysis of Stress Field in Stabilized Rolling Process]. The article concerns the stress state in the rolling stock when using plain rolls. Plastic deformation, tensile and pressure stresses and stress distribution were studied under thermodynamic rolling conditions. A case is analyzed under various geometric rolling conditions. In Czech. 8 refs.

Macura, Pavel (Vyzkumny Ustav Hutnictvi Zeleza, Dobruha, Czech). *Huta Listy* v 42 n 9 Sep 1987 p 629-633.

**091823 NAPETOVOY STAV V PROVALKU PRI NEUSTALENEM PROCESU VALCOVANI.** [Stress State in Rolling Stock in Unsteady Rolling Process]. The paper describes the analysis of deformation and stress fields in the area before the entry of the rolls during the bite of the rolls. For the analysis computation method was used where the deformation states were experimentally evaluated on the basis of a photoplastic method. The stress field was solved with plasticity theory. (Author abstract) 5 refs. In Czech.

Macura, Pavel (Vyzkumny Ustav Hutnictvi Zeleza, Dobruha, Czech). *Huta Listy* v 43 n 1 Jan 1988 p 14-18.

**Thickness Measurement** See Also ALUMINUM ROLLING MILLS—Control Systems.

**091824 DICKEN- UND DICKENQUERPROFILMESSUNG BEI DER WARMBANDPRODUKTION.** [Thickness- and Thickness Cross Profile Measurement in

Hot Rolled Strip Production]. Thyssen Stahl AG has been studying the development of continuous and contactless longitudinal and transverse thickness profile measuring equipment on hot strip mills. Both designs are based on the principle of absorption of radioactive radiation when passing through to material to be measured, depending on its properties and dimensions. The equipment described is a result of partly new measuring methods using microcomputers. In German.

Harz, Kurt (Thyssen Stahl AG, Duisburg, West Ger); Henkemeyer, Harald; Meurers, Friedrich; Remberg, Eckhard; Weyen, Hans-Gerd; Buechel, Ernst. *Thyssen Tech Ber* v 19 n 2 1987 p 229-235.

**Tube** See Also POWDER METALLURGY—Stainless Steel; ROLLING MILLS; ROLLS—Design; STEEL—Continuous Casting; TUBES—Manufacture; TUBES—Surfaces.

**091825 ALGOMA'S NEW NO. 2 SEAMLESS MILL: THE PROCESS AND ITS CAPABILITY.** Algoma's new No. 2 seamless mill represents the latest in tubemaking technology. Main components include: a rotary hearth furnace; a hot mill consisting of a pierce, retained mandrel mill and stretch reducing mill; as well as extensive finishing and inspection facilities. There is a fully integrated computerized control system which includes the individual tracking of each piece of pipe during manufacture. Algoma's No. 2 seamless tube mill, conceived in 1979 to provide a broader range of pipe products from 1.9 to 123/4 in., was placed in operation in 1986. Preliminary results during start-up have confirmed that performance is well within API specifications with further improvements achievable as practices and procedures are refined. (Edited author abstract) 1 ref.

Code, J. Bryan (Algoma Steel Corp Ltd, Sault Ste. Marie, Ont, Can). *Iron Steel Eng* v 64 n 10 Oct 1987 p 26-30.

**091826 NEW STRETCH REDUCING MILL AT ALGOMA.** A 22-stand stretch reducing mill installed as part of Algoma's new No. 2, 303,000-tonne/year seamless tube mill produces 1.9 to 7.0-in. tube from a single shell size. A wall thickness control system is installed that increases product yield by 4 to 5% as well as a heavy end control system that reduces crop losses by approximately 15%. Other features include a variable group drive through differential drives, a 2-motor drive with one motor only influencing elongation and an automated quick stand change system. (Author abstract)

Wermuth, Ralf M. (Friedrich Kocks GmbH, Hilden, West Ger); Code, J. Bryan. *Iron Steel Eng* v 64 n 10 Oct 1987 p 31-36.

**091827 CROSS-ROLLING MILL AS A PIERCING UNIT - DEVELOPMENTS DURING THE LAST 15 YEARS.** In the hot manufacture of seamless tubes the piercing of the billets is carried out mainly on cross-rolling mills. Up to about 1970 the Stiefel-type mill with guide shoes was the most important of the cross-roll piercing mills. In 1972 the Diescher-type piercing mill was introduced, the main feature of which is the vertical arrangement of the rolls with horizontally arranged guide discs. This mill set new standards in respect of piercing performance. At the beginning of the eighties, the cone-type piercing mill with horizontally arranged rolls experienced a renaissance. The technological advantages of the cone-type piercing mill are the high elongating capability, the size flexibility and the capability of piercing high-alloy steels. In order to combine the technological possibilities of the cone-type piercing mill with the design advantages of the Diescher-type, a new cone-type piercing mill, one employing a vertical roll arrangement, has been developed. (Author abstract)

Oberem, Karl (Geschaftsgruppe MEER, Moenchengladbach, West Ger). *MPT Metall Plant Technol* v 10 n 4 1987 p 80, 82, 84-85.



**091828 PROFILOGRAPH TO MEASURE WEAR OF THE TUBE-PIERCING MANDRELS.** The ability of tube production equipment - particularly tube piercing mandrels - to retain their shape for a long period of time determines the quality of the inside surface of the pierced shell, the productivity of the mill, and the cost of the product. The profilograph normally used to copy the mandrel profile and compare the copy with the original profile to determine the degree of wear requires the mandrel to be removed from the mill. This shortcoming is eliminated in the profilograph developed by the Gruzinsk Polytechnic Institute. This profilograph can be used directly on the mill during brief stoppages.

Mogil'ner, I.Yu. (Gruzinsk Polytechnic Inst, USSR); Berishvili, T.K.; Khundadze, E.N. *Metallurgist (USSR)* v 31 n 3-4 Mar-Apr 1987 p 67-68.

**091829 MODERNIZATION OF THE FEED MECHANISM OF A PILGER MILL.** The quality of tubes rolled on a Pilger mill and the productivity of the mill itself depend directly on the absolute value and stability of the angle of inclination of the shell during rolling, which in turn depend to a large extent on the design of the tilting mechanism. To eliminate wear problems, the authors designed a new manipulator. This design of manipulator precludes generation of an axial component of pressure from the air compressed in the piston chamber and acting on the thrust element of the drill. The design also prevents wedging of the drill in the nut. This reduces wear of the nut and drill and enhances the speed and performance of the air cylinder.

Shubik, M.A. (Severskii Pipe Plant, USSR); Zelenyi, N.I.; Slivin, V.A.; Sedov, A.A. *Metallurgist (USSR)* v 31 n 4 Mar-Apr 1987 p 98-99.

**091830 RASPODJELA BRZINA U ZONI DEFORMACIJE I PRORACUN BROJA OKRETAJA PRI KONTINUIRANOM TOPLOM VALJANJU CIJEVI NA IZVLACNO-REDUCIRNOM STANU.** [Speed Distribution in the Deformation Zone and Calculation of Number of Revolutions at Continuous Hot Rolling of Tube on SRM]. The speed calculation and distribution in the deformation zone at seamless tube rolling on a stretch-reducing mill (SRM) have been elaborated. By regulating the rolling speed the required reductions of cross-sectional surface and tube wall thickness are obtained. On the basis of the calculated speeds, rolling has been performed. The analysis of the results shows that there are small deviations which can be corrected by changing the position of the radius of rolls. (Edited author abstract) 7 refs. In Serbo-Croatian.

Krizanic, R. (Metalurski fakultet, Sisak, Yugosl). *Metallurgija (Sisak Yugosl)* v 26 n 4 Oct-Dec 1987 p 109-115.

**091831 IMPROVING THE ACCURACY OF CASING ON A TUBE-PRODUCTION UNIT WITH PILGER MILLS.** During the XI Five-Year Plan, the Ural Scientific Research Institute of the Tube Industry collaborated with the Severskii Pipe Plant to develop a set of control and measurement procedures designed to increase the accuracy of casing made on model 168-325 tube production units with Pilger mills. The work was done to increase the accuracy of tube wall thickness and increase the straightness of the generatrix. The problem of increasing tube accuracy was solved by optimizing the deformation regimes and by developing and introducing new roll passes and methods of pass adjustment on the Pilger mill, sizing mill, and straightening machine. To increase wall thickness and tube diameter accuracy a pass system which reduces the longitudinal variation of wall thickness was developed.

Fridman, D.S. (Ural Scientific-Research Inst of the Tube Industry, USSR); Khaidukov, I.F.; Zelenyi, N.I.; Ivakhnenko, A.S.; Starostin, Yu.A. *Metallurgist (USSR)* v 31 n 5-6 May-Jun 1987 p 137-138.

**091832 AUTOMATIC TUBE-LENGTH GAUGE.** The Central Automation and Mechanization Laboratory of the Chelyabinsk Pipe Plant has developed an automatic tube length gauge and installed in on the entry roller

conveyor of the finishing section. Data on tube length is provided to the control post by means of an alphanumeric printer. Using a control block and control panel, the operator can monitor the functioning of the gauge. Indicators are provided to indicate the condition of the measuring sensors and tracking block.

Borisov, V.I. (Chelyabinsk Pipe Plant, USSR); Musatov, V.V. *Metallurgist (USSR)* v 31 n 5-6 May-Jun 1987 p 179-181.

**091833 METHOD OF DESIGNING ROLL GROOVES FOR A NONCONTINUOUS COLD TUBE ROLLING MILL.** Tube rolling conditions have been analyzed and the desirability of using lower-cost heavy-walled blanks has been demonstrated. The effect of blank size on process productivity and finished product quality has been shown. Recommendations for selecting faster rolling routes for AMG-2 aluminum alloy tubing have been provided. Commercial applications based on results of the present analysis are described. (Author abstract) 4 refs.

Filimonov, G.V.; Kucheryayev, B.V.; Borisenko, V.P.; Baranov, A.A. *Sov Mater Sci Rev* v 1 n 3 1987 p 299-302.

**091834 DETERMINATION OF TUBE DIAMETER VARIATIONS DURING REELING IN A TWO-HIGH HELICAL MILL.** Tube diameter variation during reeling in a two-high mill has been studied as a function of tube diameter/wall thickness ratio, reeling wall reduction and tube ID expansion. The results are presented as nomographs for finding tube OD growth and plug sizes vs. tube wall reduction for different tube sizes. (Author abstract)

Zelentsov, A.N.; Vysokosov, A.G.; Savel'yev, D.N. *Sov Mater Sci Rev* v 1 n 3 1987 p 303-304.

**091835 WIRTSCHAFTLICHKEITSUNTERSUCHUNG VON ZENTRAL- UND ZAHNKRANZENTRIEBEN FÜR ROHRMUEHLEN.** [Investigation of the Economy of Central Drives and Girth Gear Drives for Tube Mills]. Highly reliable drives are needed for grinding plants in the cement industry. Dependability and economy are major criteria of assessment in this context. A comparison is made between the dual-pinion girth gear drive and the central drive with planetary gearing. The difference in operating expenses is examined in relation to running time. A profitability calculation with reference to the capital cost is carried out. The comparison shows that, despite its higher capital cost, the modern, central drive with planetary gearing is superior to the dual-pinion girth gear drive. (Edited author abstract) In German. 3 refs.

Schroebl, W. *ZKG Int* v 40 n 7 Jul 1987 p 366-369.

**091836 AMELIORATION OF THE EFFECTS OF REDUNDANT SHEARING IN 3-ROLL OBLIQUE TUBE ELONGATION BY MEANS OF CRHS-DESIGNED PASSES.** In rotary tube-making operations, the presence of strains is reflected in a differential axial wall shearing (longitudinal), circumferential tendency to lap forming, wall caviting, and distortion of structure due to tube twisting when it is compensating for slip between the rolls. Tubular wax and lead specimens were elongated in a 3-roll oblique system to estimate the incidence of unnecessary macroshear strain, and the correlation between force and torque parameters and the redundancy of the system. The effect of pass geometry on the material response was tested against the conditions created by theoretical roll profiles designed in accordance with the CRHS concept and those produced by standard industrial passes. (Edited author abstract) 9 refs.

Blazynski, T.Z. *Materialwiss Werkstofftech* v 19 n 2 Feb 1988 p 61-66.

**091837 THEORETICAL ANALYSIS OF SHAPE OF POLYGONAL TUBE FORMED BY FORM ROLLING.** Theoretical study has been made to confirm shapes of polygonal tubes formed by the form rolling in which a round tube is rotated between some rollers. A geometrical shape that can rotate touching with all rollers without deformation was analyzed. The relation between the number of rollers  $m$  and the number of sides  $n$  of a

rotatable polygonal shape was derived to be  $n = mp \pm 1$ . The shape was described by a simulation of movement of rollers around a fixed imaginary polygon. The simulation gave a shape very similar to that of a tube formed practically. (Author abstract) 3 refs.

Asakura, Kenji; Tsuda, Hiroshi; Kohzu, Masahide; Ozaki, Shinji. *Bull Univ Osaka Prefect Ser A* v 36 n 1 1987 p 11-20.

**091838 EFFECT OF FORM ROLLING CONDITION ON THEORETICAL SHAPE OF FORMED POLYGONAL TUBE.** A study has been made to clarify the effect of working condition on the theoretical shape of polygonal tube formed by the form rolling in which a round tube is rotated between some rollers. The equation of a closed curve was derived, which represent a rotatable polygonal shape when calculative conditions are suitable. Then, the calculative conditions were analyzed and transformed into the practical working conditions: pre-deformation ratio  $\delta$ , tube diameter  $R_t$  and roller diameter  $R_r$ . The working conditions were represented as  $\delta-R_t/R_r$  diagram, which indicates polygonal shapes rotatable theoretically. The working conditions to obtain the theoretical shape similar to the shape of formed tube agree well with the working conditions in the practical forming. (Author abstract)

Kohzu, Masahide; Tsuda, Hiroshi; Ozaki, Shinji; Asakura, Kenji. *Bull Univ Osaka Prefect Ser A* v 36 n 2 1987 p 157-167.

**091839 SNIZENI PRICNE RUZNOSTENOSTI TRUBEK ZAVEDENIM NOVE KALIBRACE VALCU NA AUTOMATIKU.** [Reduction of Tube Wall Thickness Variety through New Roll Pass Design in Piercing Mill]. The paper deals with the computation and practical check of a new roll pass design in the piercing mill. The proposed a mill pass shape provides for a more uniform deformation distribution along the pass circumference as well as a decrease in wall thickness difference along the tube circumference. The decrease of wall thickness nonuniformity results in more advantageous deformation distribution. (Edited author abstract) 12 refs. In Czech.

Kotrбаты, Jiri (Vyzkumny Ustav Hutnictvi Zeleza, Dobra, Czech); Bar, Josef. *Huta Listy* v 42 n 4 Apr 1987 p 239-244.

**091840 MANDREL MILL HYDRAULIC SCREW-DOWN CONTROL.** Mandrel mill hydraulic screwdown control was installed at the Kainan Steel Tube Works of Sumitomo Metal Industries, Ltd. in July, 1985. The purpose of the control is to preform tube ends in a thin tapered form. By preforming the tube ends, it is possible to cancel the end thickening in the reducer and reduce the length of crop losses. The analysis of variations in inter-stand tensions when end thinning control is carried out and the methods of roll speed control to prevent these variations are discussed. The causes of wall eccentricity in end thinning control and its countermeasures are described. The computer control system installed at the Kainan Steel Tube Works is presented. (Author abstract). 5 Refs.

Hayashi, Chihito (Sumitomo Metal Industries Ltd, Amagasaki, Jpn); Utakoji, Masaru; Yamada, Tateo; Watanabe, Masaki; Nakanishi, Renpei. *Trans Iron Steel Inst Jpn* v 28 n 6 1988 p 440-447.

**091841 INCREASE IN PROCESSING PLASTICITY OF DEFORMED METAL AFTER COLD PERIODIC ROLLING OF TUBES.** A description is given of the two-array and roll-roller methods developed in the All-Union Research Institute for the Tube Industry (VNITI) for the periodic rolling of tubes which enable the processing plasticity of deformed steels (corrosion resistant and alloy steels) to be increased by factors of 2-2.5. Use of these methods makes it possible to practically halve the production cycle time for smaller than 10 mm dia. cold deformed tubes in corrosion resistant and alloy steels and



alloys. This presents the possibility of raising pipe production by 40-50 percent for the same work areas. (Author abstract). 2 Refs.

Popov, M.V. *Steel USSR* v 17 n 12 Dec 1987 p 561-563.

## USSR

**091842 IMPROVEMENT OF ROLLED PRODUCT SHAPES.** Research in the Petrovsk Iron and Steelworks established the possibility of lowering the metal consumption of various rolled structural shapes (H-beams, channels, trough shaped sections, Z-sections, etc.) by 12-20% without lowering their bearing capacities. This is achieved by redesigning the shapes in such a way that parts of the volumes of the lightly loaded elements of the shape are transferred to those elements requiring reinforcement. A number of lightened rolled product shapes have also been assimilated on the section rolling mill. (Edited author abstract) 3 refs.

Katsnel'son, G.N. (Donetsk Scientific Research Inst of Ferrous Metallurgy, USSR); Fulagin, G.F.; Kokin, V.M. *Steel USSR* v 17 n 5 May 1987 p 221-223.

**091843 INTRODUCTION OF PRODUCTION TECHNOLOGY FOR AND EFFICIENCY OF USE OF CONTINUOUS-CAST BLOOMS 300×(1650-1850) MM IN CROSS SECTION.** In connection with the task of improving the structure and quality of metal products which confronts the ferrous metallurgical sector in the USSR it is important to expand the available range of rolled products obtained from continuously cast semi-finished products. Such an expansion presumes optimization of the dimensions of the cast products. The article describes such efforts in the rolling mills at the Azovstal' and Il'ich Zhdanov combine.

Bulyanda, A.A. (Central Scientific-Research Inst of Ferrous Metallurgy, USSR); Nosochenko, O.V.; Gotsulyak, A.A.; Kornienko, A.I. *Metallurgist (USSR)* v 31 n 5-6 May-Jun 1987 p 130-132.

## Welding

**091844 NEW COMPACT ACCUMULATOR SYSTEM FOR STRIP MILLS.** As the steel industry increasingly moves toward integrated strip processing that couples rolling mills and treatment lines, it has generated a growing demand for a new, compact accumulator system. The new 'drum accumulator' offers a space-saving and competitively priced solution. In its most basic form, the feed-in welding accumulator, the drum accumulator reduces mill costs by approximately one-half over the conventional loop accumulator, in addition to saving workshop and foundation costs. (Author abstract)

Angerer, Klaus (Siemens AG, Erlangen, West Ger). *MPT Metall Plant Technol* v 11 n 2 1988 p 72, 76-77.

**ROLLING MILLS** See Also FURNACES, HEATING; METAL FORMING; RINGS—Manufacture; ROLLING MILL PRACTICE—Bars; ROLLING MILL PRACTICE—Computer Applications.

**091845 3-ROLL MILL FOR COLD ROLLING WIRE.** The characteristics of a three-roll mill are briefly introduced. The article concentrates on analyzing and discussing the technology of such a mill for cold rolling wire. This mill is modern equipment with high deformation efficiency and low consumption of energy, and can achieve high total reductions (>90 percent) in one operation without intermediate annealing and pickling. Therefore, it has better economic efficiency. (Edited author abstract)

Zhong, Hong-Ru (Beijing Univ of Iron and Steel Technology, Beijing, China); Li, Xiao-Hong. *Wire Ind* v 54 n 645 Sep 1987 p 568, 570.

**091846 PLATE ROLLING MILL EXPANSION AT DILLINGER HUETTENWERKE.** The present article describes the design of the rolling mill at Dillinger Huette put into operation in 1973 as well as special features of erection, commissioning and past operating experience.

The new 5.5 m stand can be used both as a roughing and finishing stand. When being used as a roughing stand, longer and heavier concast slabs may be utilized. When being operated as a finishing stand, plates up to 5.2 m wide can be rolled as well as 64 in. large tube plates. With these facilities the mill is the only rolling mill outside Japan affording such great potential. (Edited author abstract)

Weber, Friedrich (Aktiengesellschaft der Dillinger Huettenwerke, Dillingen, West Ger); Oswald, Werner; Engel, Manfred; Kopf, Gerhard. *MPT Metall Plant Technol* v 10 n 5 1987 7p between 44 and 53.

**091847 NEW 20" SEAMLESS TUBE MILL.** In the course of the past years the Bromford Tube Works of the British Steel Corporation has been completely modernized. The elongator has been replaced by a Mannesmann rotary piercer. Two new cutting-off machines have also been installed. The most challenging part of the modernization project was the replacement of the pilger mill stand, pinion gearbox, hot saw, sizing mill, cooling bed, and straightening press. The installation of a completely new designed pilger mill overcame the disadvantages of the conventional pilgering process. Especially the introduction of continuously cast round material with direct piercing will result in a new breakthrough for the hot pilger mill. (Author abstract)

Wakeman, Michael James (British Steel Corp, Birmingham, Eng); Haessler, Karl Heinz. *MPT Metall Plant Technol* v 10 n 6 1987 6p between p 49 and 57.

**091848 MITTELSTAHLSTRASSEN DER ZUNKUNFT.** [Medium-Section Rolling Mills of the Future]. The rolling mills installed at Huta Katowice and Chaparral Steel exemplarily demonstrate that different markets result in different plant designs. It should be noted that medium-section mills can be operated economically already at yearly production rates of 200,000 to 250,000 t. A special importance in mills designed to safely meet the demands of the future has to be attached to the finishing facilities. The provision of universal mills can be appropriate. (Author abstract) In German.

Feldmann, Hugo (SMS Schloeman-Siemag AG, Dusseldorf, West Ger); Mueller, Hubert. *Stahl Eisen* v 108 n 6 Mar 21 1988 p 83-88.

**091849 L'USINE SIDERURGIQUE A PRODUITS PLATS AU XXIEME SIECLE.** [Manufacture of Flat Products for the 21st Century]. A picture of the flat product steel plant of the 21st century is presented. On the one hand, integrated plants working continuously with such features as direct rolling and schedule-free rolling but making the best use of today's technology are likely to produce a large part of the world's steel. On the other hand new technologies are emerging, especially in the field of thin product, casting and rolling on compact mills. These developments may result in more compact plants, either mini-mills or integrated mills. (Edited author abstract) 41 refs.

Birat, J.P. (IRSID). *Cah Inf Tech Rev Metall* v 84 n 11 Nov 1987 p 773-788.

**091850 MEDIUM-SECTION MILLS FOR FUTURE DEMANDS.** This paper deals with the production process and optimization in rolling mills. Some of the topics discussed include high-capacity mills, steel mills, and small-scale production mills. Other topics covered include continuous finish-rolling and the effect of market conditions on production.

Feldmann, Hugo (SMS Schloemann-Siemag Aktiengesellschaft, Dusseldorf, West Ger); Mueller, Hubert. *MPT Metall Plant Technol* v 11 n 1988 6p.

**091851 FUNDAMENTAL STUDIES FOR APPLICATION OF NEW COMPACT MULTI-REDUCTION MILL.** A new compact multi-reduction mill (NCM) which can substitute one stand for two or three stands in a cold tandem mill has been developed. This mill is based on three-pass rolling in one stand and enables a 70% reduction in thickness in the cold rolling of mild carbon steel. The rolling experiments and numerical calculations

showed that strip-pulling-out type rolling was more suitable than strip-enveloping type rolling and gave excellent characteristics in rolling lubrication, roll cooling and heat scratch prevention. (Edited author abstract). 7 Refs.

Yamamoto, Hiroyasu (Nippon Steel Corp, Kitakyushu, Jpn); Shiraishi, Toshiyuki; Kawanami, Takao; Shinya, Sadahiko; Goto, Takeo; Koyama, Toshihiro; Mineura, Toshimi. *Trans Iron Steel Inst Jpn* v 28 n 6 1988 p 491-497.

**091852 ROLLING CHARACTERISTICS OF NEW COMPACT MULTI-REDUCTION MILL.** In order to achieve reduction over 70 percent in one cold rolling stand, the three-gap rolling method has been investigated. The new compact multi-reduction mill (NCM) consists of four work rolls arranged vertically in one housing and the strip is threaded through three roll gaps. A stable rolling condition has been accomplished by regulating the tension, roll speed difference and rolling force. The number of work rolls to be driven, conditions to realize the optimum inter-gap tensions, and the position of the neutral points have been investigated theoretically. The rolling force, torque, tensions, forward slip, rolling energy, and optimum rolling conditions have been investigated experimentally. Practical applications for tandem cold mills and reversing cold mills are discussed. (Edited author abstract). 5 Refs.

Miyasaka, Kiyoto (Ishikawajima-Harima Heavy Industries Co, Yokohama, Jpn); Koide, Seiji; Shiozaki, Hiroyuki; Yamamoto, Hiroyasu; Iura, Teruo; Kawanami, Takao; Tanaka, Akihiro. *Trans Iron Steel Inst Jpn* v 28 n 6 1988 p 498-506.

**Automation** See Also ROLLING MILL PRACTICE—Plate; ROLLING MILL PRACTICE—Sheet and Strip.

**091853 MODERNIZATION OF A MERCHANT BAR MILL.** The report describes the modernization of a German merchant bar mill built in 1961 with the task to also produce high-grade steels. Main points of the modernization were the installation of a crop shear and of a rotary 4-crank shear behind the last mill stand, the prolongation of the cooling bed run-in roller table and the installation of a travelling type abrasive cut-off machine with length measuring stop. Especially this machine has proven its value as it allows the hot and cold abrasive cutting of steel and can also be used as a saw without alterations. (Author abstract) 1 ref.

Mundanjohi, Theo (Hoestemberge & Kluetsch GmbH, Saarlouis, West Ger). *MPT Metall Plant Technol* v 10 n 4 1987 p 14, 16.

**091854 AUTOMATISIERUNG DER VORSTRASSE EINER BREITBANDSTRASSE.** [Automation of the Roughing Train of a Wide Strip Mill]. A process computer for the control of the roughing mill has been installed at Voest-Alpine AG in Linz. All the existing mechanical and electrical equipment has remained unchanged, and the adaptation and expansion steps taken in terms of automation and measuring technique were also reduced to a minimum. Commissioning took place virtually under running operating conditions of the mill. The project was completed at the beginning of 1986, and the initial operating results show that the envisaged objectives have been achieved. (Author abstract) In German.

Langer, Rupert (Voest-Alpine AG, Linz, West Ger); Pichler, Rudolf. *Stahl Eisen* v 107 n 22 Nov 2 1987 p 67-70.

**Bearings** See Also LUBRICATING OILS—Testing.

**091855 SPHERICAL ROLLER BEARINGS WITH-STAND OPERATING DEMANDS AT QUANEX MILL.** Spherical roller bearing pillow blocks are meeting performance demands under rigorous operating conditions at the 2-year old Quanex MacSteel mini mill at Fort Smith, Ark. Installed on eight Birdsboro roller conveyor tables that move hot steel billets from a rotary-type continuous caster to a cooling bed or through a reheating



furnace, the heavy-duty bearings have performed well around the clock on a 5 and 6-day weekly schedule, despite scale and high temperatures. Qualex MacSteel produces two types of high-quality specialty steel products at the Fort Smith mill.

Anon. *Iron Steel Eng* v 65 n 1 Jan 1988 p 60.

**091856 LOAD DISTRIBUTION IN ROLLING BEARINGS AND STRESSING IN THE ROLL CHOCK OF A ROLLING MILL.** A study was made of the effect of preloaded chocks in rolling mills on the load distribution in the bearings. According to the results obtained by finite-element calculation and the FAGT240 program, no unreasonably high additional loads are generated in the rolling bearings of preloaded chocks. The stresses generated in the chock are permissible. The chock deformations were measured. The measured results coincide to a large extent with the calculated results. 6 refs.

Schlereth, Werner (FAG Schweinfurt, West Ger). *Ball Roller Bear Eng* 1985 p 28-32.

**091857 REDUCED COST AND MAINTENANCE FOR ROLLING MILL DRIVE SHAFTS - SPLIT CYLINDRICAL ROLLER BEARINGS INSTEAD OF SLIDING BEARINGS.** The work rolls of large four-high rolling stands are driven via universal joint drive shafts. Originally the drive shafts were carried in greased split sliding bearings. The service life of which was found to be very short, in spite of an excessive application of lubricating grease. It was therefore decided to convert from sliding bearings to cylindrical roller bearings, also of split design. The split cylindrical roller bearings have about the same dimensions as the sliding bearings so that the old housings can be re-used after some reconditioning work. The new bearings operate reliably; problems have not yet occurred. Maintenance cost and work and above all the grease consumption could be reduced to an acceptable level.

Engisch, Hans (FAG Wuppertal, West Ger); Rudloff, George. *Ball Roller Bear Eng* 1985 p 34-35.

## Belgium

**091858 INVESTMENT AT SIDMAR TACKLES FINISHING QUALITY.** Investment in finishing has been the priority at Belgian steelmaker Sidmar. The company has approved a five-year plan to meet the increasing quality requirements in the market for strip. In its hot strip mill several projects are being undertaken to improve customer service and to move towards schedule-free rolling. A new walking beam furnace will enable the mill to roll stainless grades for which its present furnaces are not suited.

Verstraeten, P. (Sidmar, Ghent, Belg). *Steel Times Int* v 12 n 2 May 1988 p 50-51.

## Components

**091859 DESIGN OF A MINIMUM TENSION ROLLING PROCESS IN A REVERSIBLE BAR MILL.** ACEC belonged to the Belgo-German consortium which equipped the Maxhütte works in the G.D.R. with a reversible bar mill and was responsible for the installation's electrical, automation and data processing aspects. Within this framework, ACEC installed an automatic system which, during the rolling process, monitors the tension in the bar being rolled by the tandem and finishing stands and stores the corrections necessary for improving the blanks' entry conditions. This article reviews salient features of the system. (Edited author abstract).

Mariame, P. *ACEC Rev* v 1 n 1 1988 p 7-10.

**Computer Aided Design** See Also ROLLING MILL PRACTICE—Cold Rolling; ROLLS—Design.

**091860 PARAMETRY ENERGOSILOWE WALCOWANIA CEOWNIKOW W WALCARKACH NAWROTNYCH.** [Energy-Force Parameters of U-Section Rolling in Reversing Mills]. A program for calculating and selecting the basic process parameters of U-Section rolling in reversing mills is presented. The program makes

it possible to calculate the force and energy parameters, the temperature distribution over the strip width, the minimum initial and final temperature of rolling, the additional time necessary for cooling U-Section flanges with given temperature differences and to select the rolling speed. The program has been implemented on a Sinclair Spectrum microcomputer and can be used by process engineers and mill operators. (Edited author abstract) 8 refs. In Polish.

Okon, Ryszard (Akad Gornicz-Hutnicza, Cracow, Pol); Glowacki, Mirosław; Pietrzyk, Maciej; Nowakowski, Andrzej. *Hutnik* v 54 n 2 Feb 1987 p 31-36.

## Computer Aided Manufacturing

**091861 RECHNERGESTUETZTE STICH-PLANOPTIMIERUNG FUER EIN 130/390 X 400 SCHWERMETALLQUARTO.** [Computer Aided Optimization of the Roll Pass Schedule for a 130/390 X 400 Heavy Metal Four High Stand]. A program system for computing and optimizing pass sequences for two-high and four-high cold strip rolling mills is presented (initialized BOSFEKUG). Handling and practice-relatedness of the software package is illustrated at a 130/390 X 400 four-high cold rolling non-ferrous heavy metals stand. The qualitative and quantitative effects achieved are worked out and underlined by selected data. (Author abstract) 8 refs. In German.

Roettger, Juergen (Technische Univ, Magdeburg, East Ger); Becker, Hans; Richter, Roger; Kretschmann, Manfred. *Neue Huette* v 33 n Apr 1988 p 141-146.

**Computer Applications** See Also ROLLING MILL PRACTICE—Sheet and Strip.

**091862 RECHNERGEFUEHRTES THERMOMECHANISCHES WALZEN IN GROBBLECHSTRASSEN.** [Computerized Thermomechanical Rolling in Heavy Plate Mills]. In order to maintain a specified temperature range in thermomechanical rolling the rolling process has to be interrupted once or several times for the cooling of the rolled piece. The intervals between passes are used to roll further plates, i.e. multipiece rolling process. For the control of the forming and waiting phases resulting from the temperature and acceptance specification Siemens AG has developed an automation system, which determines the optimum number of passes within the rolling phases with the aid of the function rolling schedule computation. The waiting times between the forming phases are calculated by means of a temperature model. The program block image establishes a mapping of the mill assignment within the automation range. Only in this way is it possible for the computer to ensure an optimized control of the rolling process. (Edited author abstract) In German.

Soergel, Guenter (Siemens AG, Erlangen, West Ger). *Stahl Eisen* v 107 n 20 Oct 5 1987 p 29-34.

**091863 LAN REDUCES CABLING COSTS IN A ROLLING MILL.** Until now the control and monitoring of starting processes in a rolling mill always involved high cabling costs. Recently LAN was used for signal transmission which saves cabling and allows flexible expansion. As only non-time-critical signals were involved, the SINEC L1 LAN represented a cost-effective solution. (Edited author abstract)

Becker, Manfred (Siemens AG, Nuremberg, West Ger); Eberl, Gerhard; Klopsch, Achim. *Energy Autom* v 10 n 1 Jan-Feb 1988 p 34-37.

## Computer Simulation

**091864 SIMULATION PROGRAM FOR MILL SETTING OF HOT TANDEM MILLS.** A simulation program for hot tandem mill threading has been developed to estimate the mill setting system. Inputs to the program are the entry thickness, temperature of rolled stock, and mill setting values at each stand. Outputs are the strip thickness, the rolling force, strip temperature of each stand, and inter-stand strip loops. The calculated

threading conditions are displayed on a graphics display terminal. (Author abstract) In Japanese. 3 refs.

Konishi, Masami; Nose, Kazuo; Nakayama, Makishi; Imamura, Hiroshi. *R&D Res Dev Kobe Steel Ltd* v 37 n 4 Oct 1987 p 11-14.

**Control** See Also METAL FORMING—Bending; ROLLING MILL PRACTICE—Bars; ROLLING MILL PRACTICE—Tube.

**091865 PROFILE CONTROL OF HOT ROLLED STRIP BY WORKING ROLL SHIFTING (K-WRS) MILL.** A new type of rolling mill has been developed that improves transverse gage profile and flatness of hot rolled strip as well as permitting schedule-free rolling. The concept, which has been applied to a number of hot strip mills, involves the side shifting of work rolls that are tapered at one end only. A mathematical model for predicting strip profile has been developed and optimum operation and automatic profile control have been established. 12 refs.

Kitahama, Masanori (Kawasaki Steel Corp, Chiba, Jpn); Yaritha, Ikuo; Abe, Hideo; Awazuhara, Hiroshi. *Iron Steel Eng* v 64 n 11 Nov 1987 p 34-43.

**091866 MINIMUM TENSION CONTROL IN FINISHING TRAIN OF HOT STRIP MILLS.** A minimum tension control (MTC) system has been installed on a 2000-mm wide hot strip mill to reduce maintenance and operating cost associated with interstand loopers. Superimposed on the main electrical drive control system, it generates the correct cascade speed setpoints to control interstand material flow based on tension-dependent changes in rolling torque. The technology required to implement MTC is reviewed in this article together with the results of measurements obtained during operation.

Bass, Gordon V. (Siemens Energy & Automation Inc, Roswell, GA, USA); Hartmann, Rudolf. *Iron Steel Eng* v 64 n 11 Nov 1987 p 48-53.

**091867 SCORECARD APPROACH TO STATISTICAL PROCESS CONTROL AT KAISER'S TRENTWOOD WORKS.** Quality production and decreased costs were the incentives for the modernization of Kaiser Aluminum's Trentwood sheet and plate mill in the Pacific Northwest. The 5-stand cold rolling mill provides a typical example of the application of the scorecard approach at Trentwood. Key variables for each coil are graphically presented and summary graphs are automatically produced for each day.

Sheppard, John (Kaiser Aluminum & Chemical Corp); Shogen, Robert. *Light Met Age* v 45 n 5-6 Jun 1987 p 12-14, 16.

**091868 AGC SYSTEM FOR COLD STRIP MILL WITH A.C. MOTOR DRIVEN SCREWING DOWN INSTALLATION.** This paper presents a method of using an AGC system with an adaptive gaugometer. Based on rolling pressure data sampled in line, this new system estimates the parameter of presaging pressure-model by recursive least square identification algorithm, forecasts the pressure of the stand itself, and determines the magnitude of screwdown control according to minimum variance control law. This paper also presents methods used to realize AGC in unfavorable conditions by using A.C. motor driven screwing down equipment as actuator of the controller. These methods were studied by digital stimulation on cold strip mills to overcome the gauge disturbance caused by skid marks and entry thickness difference, and have been used in the 350mm three-stand tandem cold mill in Shanghai No.10 steel works. (Edited author abstract) In Chinese. 6 refs.

Jie, Yang (Wuhan Iron & Steel Univ); Hetie, Chen; Jiarong, Zhao; Yunfan, Fang; Chaonan, Tong; Qi, Wang. *Kang Tieh* v 23 n 2 Feb 1988 p 27-31.

**Control Systems** See Also ROLLING MILL PRACTICE—Hot Rolling; ROLLING MILL PRACTICE—Pipe; ROLLING MILL PRACTICE—Sheet and Strip; ROLLING MILL PRACTICE—Tube; STEEL SHEET.



**091869 NEW COMPUTER CONTROL SYSEM FOR ARMCO'S MIDDLETOWN WORKS 86-IN. HOT STRIP MILL.** A new computer control system has been installed at Armco's Middletown works 86-in. hot strip mill, replacing the original computer control system which was installed when the mill was built in 1967. The new system consists of one host computer and four satellite computers, one each in the furnace, roughing, finishing and coiler areas. Improvements have been realized in gage performance and runout table spray control due to increased computer power, I/O throughput and flexibility.

Boesherz, Kenneth B. (Armco Inc, Middletown, OH, USA); Johnson, Lloyd. *Iron Steel Eng* v 63 n 12 Dec 1986 p 29-34.

**091870 DIGITAL CONTROL OF AN EXISTING 5-STAND TANDEM COLD MILL.** Computerization of a tandem cold mill provides two main functions: process control and a supervisory role. Process control functions include interstand tension, screwdown operation and automatic gage control using delivery and entry stand x-ray gage deviations. Supervisory functions are orders and schedules, tracking through the mill and production information. The mill described is Ashland's 5-stand, 4-h tandem cold mill.

Lewis, Charles O. (Armco Inc, Ashland, KY, USA); Sturgill, Michael L. *Iron Steel Eng* v 64 n 11 Nov 1987 p 20-24.

**091871 ANALYSIS AND CONTROL SYSTEMS FOR SHAFT VIBRATION IN STEEL ROLLING PROCESSES.** In recent years, the authors have been endeavoring to revamp steel rolling processes by realizing continuous and synchronized production between two processes in order to achieve higher quality of products. In cold and hot tandem mills or continuous annealing process lines, which required high response and high accuracy to the motor control system, the authors encountered troubles with shaft vibrations caused by interaction between mechanical and electrical control systems, and developed a new power drive technique which was effective in solving the problems. And authors were able to understand the influence of all the digital thyristor motor drive system and the cross current type cycloconverter drive system on the shaft vibration problem through computer simulation analyses and experiments. As a result, the following were found effective in suppressing shaft vibrations: (1) to apply a digital filtering method to speed feedback, (2) to control a speed control loop in high speed sampling time and high accuracy calculation, and (3) to apply the modern control theory. (Author abstract) 3 refs.

Doi, Katsuhiko (Kawasaki Steel Corp, Jpn); Ishikawa, Kozo; Tsukuda, Hifumi; Yamamoto, Kazuki; Suganuma, Namio; Naito, Tadashi. *Kawasaki Steel Tech Rep* n 17 Oct 1987 p 73-80.

**091872 SENSOR-TYPE AUTOMATIC STEERING CONTROL SYSTEM FOR ROLLING MILL - 1ST REPORT THEORETICAL ANALYSIS AND EXPERIMENTAL RESULTS.** During rolling operation, the rolled strip is often driven rapidly to one side and, as result, the strip breaks on the work rolls are damaged. This unstable behavior is caused by horizontally asymmetrical factors of rolling conditions. To control this lateral instability, IHI has developed a new type of automatic steering control (ASC) system, the major feature of which is the installation of a sensor detecting the lateral movement of the rolled strip. This paper gives a theoretical analysis and experimental results of the new ASC system which clarifies the system far more effective than the conventional ASC system. (Edited author abstract) 3 refs.

Kuwano, Hiroaki (IHI, Tokyo, Jpn); Takahashi, Norio. *IHI Eng Rev (Engl Ed)* v 19 n 4 Oct 1986 p 152-157.

**091873 SENSOR-TYPE AUTOMATIC STEERING CONTROL SYSTEM FOR ROLLING MILL - 2ND REPORT: DEVELOPMENT OF HOT STRIP STEERING SENSOR.** Reference is made to a previous

paper in which a new type of automatic steering control system was proposed, the major feature of which is the installation of a (referred to as 'steering sensor') detecting lateral movements of the rolled strip. This paper gives a brief description of the newly developed hot strip steering sensor. Field experiments have confirmed that the sensor can detect movements of the hot rolled strip rapidly and precisely. (Edited author abstract) 5 refs.

Kubota, Sadao (IHI, Tokyo, Jpn); Kato, Heiji; Takeda, Ei; Sato, Kun-ichi; Taniguchi, Shin-ichiro; Fujishima, Ikuo; Miura, Hiroaki; Kuwano, Hiroaki. *IHI Eng Rev (Engl Ed)* v 20 n 1 Jan 1987 p 21-25.

**091874 MICROPROCESSOR-BASED DISTRIBUTED CONTROL SYSTEM INSTALLED AT RAVENSCRAIG.** British Steel's Ravenscraig plant, near Glasgow, Scotland, has recently undergone an extensive modernization program. A key element of the program was major modifications on two of three reheating furnaces and installation of a sophisticated MAX 1 distributed control system at the hot strip mill. Ravenscraig is moving rapidly into information technology - revamping the hot mill control system is just part of an overall plan. It was important that the system be fully and effectively operational from the outset.

Anon. *Iron Steel Eng* v 65 n 4 Apr 1988 p 52-53.

**091875 COMPUTER AIDED STUDY OF SYSTEM FOR COMBINED CONTROL OF THICKNESS AND PROFILE OF ROLLED STOCK BY MULTIPOLAR METHOD.** The multipole method has made it possible to conduct a computer aided study of a multichannel system for combined control of the thickness and profile of rolled stock directly in digital form. Longitudinal and transverse thickness variations of rolled metal have been examined, and frequency characteristics of the multichannel system have been established. (Author abstract) 11 refs.

Kuznetsov, B.I. (Ukrainian Correspondence Polytechnic Inst, USSR). *Steel USSR* v 17 n 8 Aug 1987 p 375-378.

**091876 WESTINGHOUSE TO MODERNIZE CONTROL SYSTEM AT SIDMED.** Sideruluz Del Mediterraneo (SIDMED) is planning a multimillion dollar modernization of the cold finishing complex at Sagunto, Spain. The modernization plans include installation of a digital process control system for the 80-in. Tandem mill. This system, designed and built by Westinghouse Electric Corp., will replace existing automation and regulator control equipment that has been in use since the plant's opening in 1976. Additionally, existing automation equipment in SIDMED's pickle line will be upgraded.

Anon. *Iron Steel Eng* v 65 n 5 May 1988 p 47-48.

## Cooling

**091877 GESTEUERTE RINGABKUEHLUNG IN FEINSTAHLWALZWERKEN.** [Controlled Ring Cooling in Light Section Rolling Mills]. The article deals with a new technology of cooling fine iron rings by means of moistened compressed air. In its technical realization as a step-by-step-conveyor equipment with a ventilation system, this process yields fine iron rings with improved service properties and results in a more efficient overall performance of the mill units. Heat treatment of the fine iron rings directly from the rolling heat is possible within wide limits. (Author abstract) In German.

Pechau, Gerhard (VEB Schwermaschinenbau-Kombinat 'Ernst Thaelmann', Magdeburg, East Ger). *Neue Huette* v 33 n 2 Feb 1988 p 58-59.

**Cooling Systems** See Also ROLLING MILL PRACTICE—Bars; ROLLING MILL PRACTICE—Computer Simulation; SEPARATORS—Magnetic.

**091878 MATHEMATICAL MODEL AND CONTROL SYSTEM OF COOLING PROCESS.** In the slab casting and hot rolling processes, steel quality greatly depends on cooling conditions. Therefore, it is important to carefully control the temperature in the cooling process to regulate the quality of the steel. To realize high

temperature accuracy, computer control systems have been installed. In this article, the basic concept of the cooling process control is described. In addition, secondary cooling process control in continuous casting, hot strip coiling temperature control and dynamic accelerated cooling control at the plate mill are also described. (Author abstract) 9 refs.

Takawa, Takeshi (Sumitomo Metal Industries Ltd, Jpn); Takahashi, Ryoichi; Tatsuwaki, Masao. *Sumitomo Search* n 34 May 1987 p 79-87.

**091879 CALCULATION OF STEADY STATE TEMPERATURE AT THE WORK ROLL SURFACE.** Formula for estimating steady state work roll surface temperature are presented. The predicted and experimental data were compared to show a rather good agreement. Estimations demonstrated that use of cooling as close to the contact zone as possible substantially improves cooling efficiency and reduces the roll surface temperature rise. (Author abstract)

Khloponin, V.N.; Kosyrev, M.V.; Burlakov, S.A. *Sov Mater Sci Rev* v 1 n 2 1987 p 223-228.

**Defects** See ROLLING MILL PRACTICE—Sheet and Strip.

**Design** See Also ROLLING MILL PRACTICE—Bars.

**091880 EXPERIENCE WITH THE PRODUCTION OF THIN FLAT BLANKS BY ROLLING.** To meet a demand for thin flat blanks of complex configuration up to 60 mm in size, a new two-stand reversing mill, the SPPD-10, has been designed and constructed. In the designing of the mill, previous experience with the operation of the SPP-4 and SPPD-6 mills was taken into account. The technical specifications of the SPPD-10 mill are given. 4 refs.

Lozhechnikov, E.B. (Belorussian Polytechnic Inst, USSR); Gromov, V.B.; Maksimov, N.N.; Prosyanyuk, V.V.; Trush, F.F.; Yurkov, S.V. *Sov Powder Metall Met Ceram* v 26 n 3 Mar 1987 p 190-193.

**091881 CONTINUOUS PROCESS LINE SHOWS PROMISE FOR MEDIUM-SIZE MILLS.** In July 1987 Nippon Steel Corporation and Inland Steel Industries of the United States signed a contract for a joint venture called I/N Tek to build a fully integrated processing line for cold rolled sheet. The line, which is continuous from descaling to inspection, allows a medium sized mill the flexibility to process different steel grades and sheet sizes economically. The venture will be based on NSC's Hirohata line and will have similar operating parameters.

Iida, Hiroshi (Nippon Steel Corp, Jpn). *Steel Times* v 215 n 9 Sep 1987 p 446, 452.

**091882 RECENT TECHNOLOGY AND DEVELOPMENT OF MULTI-HIGH ROLLING MILLS.** Since 1970, Kobe Steel has produced 21 high-performance KST (20-high) rolling mills and KT (12-high) rolling mills for copper, specialty metals, and stainless-steel rolling. Kobe Steel's multihigh rolling mills, with their advanced shape control mechanisms, unique and highly accurate wedge-type hydraulic roll-gap control device, and high performance gage-control systems, have established a worldwide reputation for advanced technology among users requiring thin-rolled products of extremely high quality. Kobe Steel has been a pioneer in flatness control technology manufacturing the Shapematic roller (flatness measuring roller) and developing the sophisticated Automatic Flatness Control System. (Author abstract) 1 ref.

Sakamaki, Hirokichi (Kobe Steel, Jpn); Kitagawa, Soichi. *Kobelco Technol Rev* n 2 Aug 1987 p 9-13.



**091883 INGENIEURAUFGABEN BEIM BAU UND IM BETRIEB NEUZEITLICHER AUTOMATISIERTER WALZANLAGENTECHNIK.** [Tasks for the Engineer for the Construction and Operation of Modern Automated Rolling Mill Technique]. Modern rolling plants are characterized by a high degree of automation. There are high demands upon throughput capacity, quality and reliability. During design of such plants, process and system analyses have to be carried out. The interaction between electrical systems and mechanics and the technical process are to be determined and the structural design is to be optimized by simulation. To achieve high operational safety and reliability, a determination of stresses, deformations and service life parameters of the structural elements is of utmost importance. (Author abstract) 14 refs. In German.

Guericke, Wilhelm (Technische Univ, Magdeburg, East Ger); Becker, Hans. *Neue Huette* v 33 n 4 Apr 1988 p 128-132.

**091884 HOCHEFFEKTIVES FEIN- UND MITTELSTAHLWALZWERK FUER QUALITAETSTAEHLE.** [High Efficient Small and Medium Section Rolling Mill for Quality Steels]. The largest rolling mill ever supplied by SKET is described in this article. Involved in the metallurgical complex recently built at Oskol (USSR), the small-and-medium-section mill for the manufacture of high-grade steels represents the final process stage of a closed metallurgical cycle. The mill's designed capacity amounts to one million metric tons of finished material, the share of small and medium section steels being approximately equal. Owing to the great variety of processes and equipment solutions used, the plant represents the latest rolling mill standards. Thus, the hot charging of feedstock, low-temperature rolling, almost continuous rolling at maximum furnace capacity and an immediately following annealing process utilizing the rolling heat will among other hightech standards result in good economic effects as far as the prospective user is concerned. Further distinct characteristics are the mill's electrical equipment based upon memory-programmable controls as well as a comprehensive automation system. (Author abstract) 7 refs. In German.

Tietge, Heinz (VEB, Magdeburg, East Ger); Popien, Adalbert; Scharf, Joerg. *Neue Huette* v 33 n Apr 1988 p 133-140.

**091885 LES CAGES MULTICYLINDRES.** [Multi-Roll Mills]. In the conventional 1-2-3-4 type Sendzimir mill, each type of roll has a particular function in order to control profile and shape of the strip: rapid work roll change (small diameter) to have the most adapted crown; tapered intermediate rolls with shift capability to control edge drop; self adjusted segmented rolls allowing local crown variation; and eccentric screwdown system to adjust the roll gap. (Edited author abstract) 29 refs. In French.

Guilleraut, Jean-Phillipe (IRSID, Fr). *Cah Inf Tech Rev Metall* v 85 n 2 Feb 1988 p 141-152.

**091886 APPLICATION OF 3-ROLL TECHNOLOGY FOR ROLLING SPECIALTY ROD AND BAR PRODUCTS.** Increasing quality demands to be met by specialty steel rod and bar products can be economically achieved with 3-roll mill stands. In addition to improved surface quality, closer dimensional tolerances and a homogeneous structure, operating advantages reported include higher yields, higher mill availability and lower energy consumption. The use of 3-roll technology for the production of quality and specialty steels avoids many of the problems that are typically encountered in a 2-high rolling operation. Also the processing costs are lower. The layouts of several mills are shown.

Ammerling, W.-Jurgen (Friedrich Kocks GmbH, Hilden, West Ger); Brauer, Hans. *Iron Steel Eng* v 65 n 9 Sep 1988 p 22-27.

## Developing Countries

**091887 TECHNOLOGY FOR A BASIC INDUSTRY IN A DEVELOPING NATION.** This article describes a universal small scale plant for the manufacture of aluminum sections, bars, tubes, wire and electrical cable. It is based on the findings of an investigation dealing with the manufacture of aluminum semi-finished products in West Africa. In order to arrive at a reasonable forecast of the consumption of extruded products by the year 2000, three alternative hypotheses for the period 1986 to 2000 have been drawn up. (Edited author abstract)

Weber, R.D. (AB Process-Metallurgi, Vasteras, Swed). *Wire Ind* v 55 n 4 Apr 1988 p 321-328.

**Economics** See ROLLING MILL PRACTICE—Hot Rolling.

**Electric Drive** See Also ROLLING MILL PRACTICE—Sheet and Strip.

**091888 ZUR ANTRIEBSDYNAMIK EINES KALTWALZWERKES.** [Drive Dynamics of a Cold Rolling Mill]. A theoretical study is made of the drive dynamics of a six-high cold rolling stand of Sendzimir type. The design of the driving mechanism and of the spring and mass system is considered. The types of vibrations that can occur are indicated, and calculations are made of the roll-force and roll-momentum variations. In German.

Schwenzeier, W. (Inst fuer Verformungskunde und Huttenmaschinen, Leoben, Austria); Herzog, A.; Pfeffer, H. *Berg Huetttenmaenn Monatsh* v 132 n 7 Jul 1987 p 241-244.

**091889 CARDAN CROSS-PIN SPINDLES APPLIED TO LARGE HORIZONTAL ROUGHERS.** In 1984, Kaiser Aluminum installed the equipment required to complete the Trentwood modernization program. To overcome frequent failures of slipper-type coupling on a 132-in. breakdown mill rolling aluminum, a drive shaft system was designed that incorporates an ultrahigh capacity universal joint coupling. Power to the mill was also increased by 60%. The calculated maximum torque amplification value approximately 1.1, agrees with measured values and is lower than that obtained with slippers which was 4.0. 3 refs.

Stone, Leslie E. Jr. (Kaiser Aluminum & Chemical Corp, Spokane, WA, USA); Simmons, Thomas E. *Iron Steel Eng* v 64 n 11 Nov 1987 p 44-47.

**091890 MODERNIZATION OF A SKIN PASS MILL.** Bochum steelworks decided on a systems engineering approach to the modernization of their skin pass mill in Germany. The chosen drive concept has symmetrically arranged, cycloconverter-fed induction motors which, combined with a system for measuring and controlling strip flatness and VDU-supported operations control, considerably improve plant production and strip quality. Use of packaged control-gear stations assembled and largely test-operated by Brown Boveri in their factories, reduced loss of production during the mill conversion and lowered capital costs. (Author abstract) 1 ref.

Leder, H.-W. (Brown Boveri, Mannheim, West Ger). *Brown Boveri Rev* v 74 n 11 Nov 1987 p 604-612.

**091891 DEVELOPMENT AND INTRODUCTION OF THYRISTOR AND UNCONTROLLED CONVERTERS FOR MAIN ELECTRIC DRIVES OF NON-REVERSING ROLLING MILLS.** Thyristor and uncontrolled converters installed on the main drive of some Soviet non-reversing rolling mills and their performance are described. The Yuvenergohermet Production and Technical Enterprise has developed and, jointly with the Taganrog, Donetsk, and Sulino iron- and steelworks, and the K. Liebknecht and Azerbaidzhan tube rolling works, introduced thyristor (2000-7200 kw, 3 sets) and uncontrolled (550-5150 kw, 12 sets) converters with a total installed capacity of 59.5 Mw. Their special features are compared. (Edited author abstract)

Osadchii, V.G. (Yuvenergohermet Production & Technical Enterprise, USSR); Alekseevich, V.A. *Steel USSR* v 17 n 7 Jul 1987 p 337-338.

**091892 EXPERIENCE WITH a-c CYCLOCONVERTERS FOR HIGH-HORSEPOWER MILL DRIVES.** Rolling mill stands require extremely high drive powers. At the same time, high demands are placed on the control dynamics and peak load capability of these drives. By using a static cycloconverter with the Siemens Transvektor control, excellent performance characteristics can be obtained while insuring economic operations. The ac cycloconverter drives provide reductions in operating costs due to higher efficiency (approximately 4%) compared with dc drives and insignificant inspection and maintenance requirements. Applications have been made in blooming, plate, hot strip and cold mills. The discussion covers power factor, harmonics and typical installations. 6 refs.

Hauck, Oliver O. (Siemens Energy & Automation Inc, Roswell, GA, USA). *Iron Steel Eng* v 65 n 9 Sep 1988 p 35-40.

**Energy Utilization** See FURNACES, METALLURGICAL—Energy Utilization; TUBES—Forming.

## England

**091893 AUTOMATIC TUBE MILL FOR BRASWAY.** Brasway plc, one of Europe's leading producers of welded steel tube, recently completed the installation of a high productivity tube mill from Oto Mills of Italy. The mill is installed in the new tube producing complex, which is said to be one of the most modern and technically equipped tube producing facilities in Europe. From this complex Brasway plans to expand its sales of welded steel tube throughout the UK and Europe. The article describes the equipment.

Anon. *Sheet Met Ind* v 64 n 10 Oct 1987 p 510, 512.

**Equipment** See Also ROLLING MILL PRACTICE—Control Systems.

**091894 MEANS OF MECHANIZATION IN ROLLING-MILL PRACTICE.** Fork-type manipulators, positioned between the roller conveyors, are used on intermediate and section mills to tilt the semifinished product or section as it moves from one stand to the next. However, the manipulator cannot handle pieces that are bent lengthwise or twisted; the piece must contact the manipulator at a certain spot, with its front end first. The article describes a design of manipulator which eliminates these problems and a roller conveyor which places the rolled product into containers.

Gevlich, G.I. (Makeevka Metallurgical Combine, USSR). *Metallurgist (USSR)* v 31 n 7-8 Jul-Aug 1987 p 260-262.

**091895 MANIPULATOR FOR A SQUARE SEMIFINISHED PRODUCT.** A manipulator for handling square semifinished products was installed in front of a 550 roughing stand. Installation of the manipulator has improved the gripping of the square in the rolls of the mill stand. The thrust blocks and their stationary supports were set at a 120° angle in the manipulator relative to the base. The surface of the supports in contact with the square was made in the form of an arc. The article describes how the square is handled.

Goncharov, V.I. (Chelyabinsk Metallurgical Combine, USSR); Sidash, A.I. *Metallurgist (USSR)* v 31 n 7-8 Jul-Aug 1987 p 263.

**091896 NEW COMBINATION HOT LEVELLER FOR THIN AND THICK PLATE.** Recent development in thermomechanical control process (TMCP) in plate mills has made it possible to produce steel plates with higher strength and toughness. However, the problem of poor shapes which cannot be flattened by the conventional



hot leveller has arisen. In order to cope with this problem, Sumitomo Metal Industries, Ltd. has developed a combination hot leveller in Kashima Steel Works.

Anon (Sumitomo Metal Industries Ltd, Ibaraki, Jpn). *Trans Iron Steel Inst Jpn* v 28 n 1 1988 p 76.

**Federal Republic of Germany** See ROLLING MILL PRACTICE—Sheet and Strip.

**Flexible Manufacturing Systems** See SHEET AND STRIP METAL—Manufacture.

## France

**091897 CONTINUOUS COUPLED TANDEM MILLS AND PICKLE LINES AT USINOR, SOLLAC AND COCKERILL SAMBRE.** The Usinor, Montataire mill is an example of a step by step upgrading; the Sollac, Ste. Agathe mill is the first greenfield coupled mill and the Cockerill Sambre, Ferlatil facility represents a new, fully continuous mill that is currently being installed. Tests of the coupled pickle line/tandem mill operation are described leading to novel equipment designs such as strip turning devices and elevated accumulators. Improvements are reported in productivity (over 40%), hot band yield, roll life, rolling oil consumption and workforce reduction.

Quehen, Andre (Clecim SA, Courbevoie, Fr); Christoffel, Joseph C.; Cabaret, Pierre. *Iron Steel Eng* v 64 n 11 Nov 1987 p 26-33.

## German Democratic Republic

**091898 V.E.B. MAXHUETTE MERCHANT BAR MILL AT UNTERWELLENBORN (SAAFFELD - G.D.R.).** Within the framework of its participation in a Belgo-German consortium, ACEC equipped and commissioned a merchant bar mill of the VEB MAXHUETTE company in the GDR. The ACEC supplies were concerned with electrotechnical, electronic and data processing equipment. This equipment included the 6 kV distribution, the transformer/rectifier/motor sets of the rolling mill, auxiliary controls, the relay and contractor control cubicles, the regulation and sequencing automation of the rolling, tandem and finishing mills and of the finishing zone, together with the integrated control consoles and the central control room. (Author abstract)

Mariame, Ph. *ACEC Rev* n 4 1987 p 3-9.

## Guides See ROLLING MILL PRACTICE—Tube.

**Japan** See Also ROLLING MILL PRACTICE; ROLLING MILL PRACTICE—Sheet and Strip; ROLLING MILL PRACTICE—Slab.

**091899 FULLY CONTINUOUS DESCALING AND COLD ROLLING MILL.** Mizushima Works remodeled are the existing pickling line and batch type cold tandem mill into a fully continuous line in 1985. Some technologies for combining a pickling line with a cold tandem mill descaling with a tension leveller and mechanical descaler, continuous width changeable trimmer, and flying gauge changing technology. Improvement in product quality and material yield, increase in productivity, shortened production time, and labor saving have been obtained. The mill can produce cold rolled strip using only two processes, KM-CAL installed in 1984 and the fully continuous descaling and cold rolling mill. (Edited author abstract) 7 refs.

Yuasa, Hiroyasu (Kawasaki Steel Corp, Kurashiki, Jpn); Nakanishi, Toshinobu; Takeno, Tadayoshi; Tabuti, Mamoru; Yamamoto, Kazuaki; Komatsu, Tomio. *Tetsu To Hagane* v 74 n 3 Mar 1988 p 473-480.

**091900 DEVELOPMENT OF HIGH-ACCURACY THICKNESS AND CROWN CONTROL IN HOT STRIP MILL.** Construction of a new hot strip mill 1 840 mm in width was started in June, 1982 and was completed on August 1, 1984 at Nippon Steel's Hirohata Works. The computer control systems of the mill have enabled high accuracy quality control. An absolute mode AGC system gives high accuracy of strip thickness. The system is

composed of quick response AGC with hydraulic screw down system; compensating control for mass flow balance; decoupling control of bender and screw down systems for gauge, crown and shape of strip; and a set up function for control parameters. The crown and shape control system has a pre-set function of roll cross angles corresponding to a crown schedule for each strip and feedback crown and shape control of the work roll bender system within each strip. (Edited author abstract) 8 refs. In Japanese.

Tsuji, Yuichi (Nippon Steel Corp, Himeji, Jpn); Shimazu, Satoshi; Hiraishi, Yuichi; Fukushima, Kenya; Kato, Kat-suhiro; Hirase, Kazuo. *Tetsu To Hagane* v 74 n 3 Mar 1988 p 481-488.

**091901 APPLICATION OF CROWN AND SHAPE CONTROL SYSTEM TO HOT STRIP MILL IN KASHIMA STEEL WORKS, SUMITOMO METAL INDUSTRIES, LTD. (DEVELOPMENT OF CROWN AND SHAPE CONTROL SYSTEM IN HOT STRIP MILL - I).** In September 1986 Kashima hot strip mill installed shape (crown, profile and flatness) control equipment on three finishing stands. This equipment, known as the VC back up roll, the work roll shift and the roll bender was installed to improve crown accuracy and achieve schedule-free rolling. This report gives the main specifications of the shape control equipment. 1 ref.

Nunokawa, Tsuyoshi (Sumitomo Metal Industries Ltd, Jpn); Yagisawa, Shigeru; Hatoko, Hisaki; Yamamoto, Akio; Yamaguchi, Koki; Takahashi, Ryoichi; Ebukuro, Tadao. *Trans Iron Steel Inst Jpn* v 27 n 9 1987, Prepr for the 113th ISIJ Meet, Part III, Tokyo, Jpn, Apr 1-3 1987 p B.228.

**091902 OUTLINE OF REMODELLING AT FINISHING STAND FOR HOT STRIP MILL IN KASHIMA STEEL WORKS, SUMITOMO METAL INDUSTRIES, LTD.** This report gives the design for remodeling the hot strip mill finishing stand in Kashima Works. It outlines the stress of the mill housing, surge pressure of work roll bending hydraulic system, Sumitomo VC roll and work roll changing system. This remodeling was carried out from January 1984 to July 1986.

Hashizume, Fujihiko (Sumitomo Metal Industries Ltd, Jpn); Ebukuro, Tadao; Uemura, Masanobu; Morita, Kenji; Tanaka, Keiji; Nunokawa, Tsuyoshi; Kishimoto, Ichiro. *Trans Iron Steel Inst Jpn* v 27 n 9 1987, Prepr for the 113th ISIJ Meet, Part III, Tokyo, Jpn, Apr 1-3 1987 p B.229.

**091903 WORK ROLL SHIFT MILL FOR HOT ROLLING.** Recent progress in hot strip and plate rolling for energy saving and improved product quality and yield includes hot charge rolling and hot direct rolling. New work roll shift mills by Hitachi have roll bending and shifting mechanisms which are controllable according to rolling methods. The work roll shift mill provides high accuracy of crown control and minimization of edge drop.

Anon. *Trans Iron Steel Inst Jpn* v 27 n 9 1987 p 758.

## Lubrication See Also STEEL SHEET—Rolling.

**091904 ROLLING LUBRICANTS IN TODAY'S ENVIRONMENT.** The demands for improved quality and performance from the steel industry have increased in recent years. New technology for rolling lubricants and ancillary process fluids has been developed. These developments enable higher speeds, bigger reductions and cleaner strip to be produced. They also reduce the problems encountered when rolling concast strip and allow the use of chrome/alloy rolls. Theory and practical results are presented. Controlled particle size emulsification is discussed. 3 refs.

Turner, C.H. (Croda Application Chemicals Ltd); O'driddle, K. *Steel Times* v 215 n 9 Sep 1987 p 462, 464, 466.

## Machinery

**091905 CALCULATION OF DYNAMIC TORQUE AND LOSS OF STRETCHING FORCE FOR COILERS.** The dynamic torque and the loss of stretching force for coilers have been considered by the designer in order to satisfy coiling constant-stretching force. It must be calculated exactly, especially when put under the use of computer control. In this paper, the formula of calculation of dynamic torque and loss of stretching force for coilers is established by using two examples. (Author abstract). 3 Refs. In Chinese.

Wenzu, Fu (Shanghai Design & Research Inst of Metallurgy, China). *Chi Hsieh Kung Ch'eng Hsueh Pao* v 24 n 1 Mar 1988 p 88-91.

## Maintenance See Also ROLLS—Spalling.

**091906 SAW SETUP SURFACES CONTINUOUS CASTER ROLLS.** An exacting and precise specialty, the repair and maintenance of continuous caster rolls for steel mills has become an integral part of Millcraft Products' operations. The operational condition of these rolls is extremely critical to the final shape of the product. To withstand the high temperature and corrosive environment of the water used to cool the steel slabs, the continuous casting rolls typically are made from a high-chromium alloy steel. These alloy steel rolls provide excellent corrosion and oxidation resistance, superior metal-to-metal wear resistance and good thermal fatigue property values. Periodic maintenance of caster rolls is required to ensure a high-quality finished product from the steel mill. The worn rolls are preheated to prevent excessive buildup of internal stresses, which may cause cracking during welding. The company uses Lincoln Electric's Tiny Twinarc submerged arc welding system to buildup and hardface the rolls.

Anon. *Weld J (Miami Fla)* v 67 n 8 Aug 1988 p 41-43.

**Mathematical Models** See Also ROLLING MILL PRACTICE—Bars; ROLLING MILL PRACTICE—Cold Rolling; SHEET AND STRIP METAL—Rolling.

**091907 MATHEMATICAL MODELS FOR COMPUTER CONTROL OF HOT ROUGHING MILL OF ALUMINUM.** Mathematical models to estimate the rolling force P and the rolling torque G of hot roughing mill of aluminum were developed. These models consist of equations to calculate the rolling force function  $Q_p$ , the torque arm coefficient  $\lambda$  and the mean flow stress  $K_{fm}$ . The equation of  $Q_p$  and  $\lambda$  are derived empirically by analyzing the rolling data. The equation of  $K_{fm}$  is based on the empirical expression of the experimental data by complastometer. Almost satisfactory accuracy is achieved in estimating P and G. The calculating method to obtain the pass schedule in the restrictions of rolling force, rolling torque, angle of biting etc. was developed. The total number of passes reduces and the productivity of roughing mill for aluminum alloys increases by using this new pass schedule. (Author abstract) In Japanese. 10 refs.

Kimura, Hiroshi (Sumitomo Light Metal Industries Ltd, Nagoya, Jpn). *Keikinzoku* v 38 n 1 Jan 1988 p 40-46.

## Mexico See IRON AND STEEL PLANTS—Mexico.

**Modernization** See Also ROLLING MILL PRACTICE—Cold Rolling.

**091908 MODERNIZATION OF A TANDEM COLD MILL WITH DISTRIBUTED DIGITAL CONTROL.** A 4-stand tandem mill modernization includes repowering, automatic controls, and automatic tension and gage control. The mill setup system and dynamic speed analysis procedure are described. The mill modernization described is designed to improve productivity and product quality with a minimum of mill downtime.

Smith, Andrew W. (Westinghouse Electric Corp, Pittsburgh, PA, USA). *Iron Steel Eng* v 64 n 10 Oct 1987 p 45-49.



**091909 USE OF UNDERGROUND CONSTRUCTION METHODS DURING THE RECONSTRUCTION OF METALLURGICAL SHOPS.** Chelyabinsk Specialized Shaft Construction Administration No. 6 of the Vostokshakhtoprokhodka Trust of the Soyuzshakhtoprokhodka Industrial Association was created in 1978 to conduct work on reconstruction in existing plants. It has recently completed several projects involving the construction of underground facilities at the Chelyabinsk, Magnitogorsk, and Nizhny Tagil metallurgical combines. The article describes the reconstruction of the hot strip mills and associated structures.

Baranov, L.P. ('Vostokshakhtoprokhodka' Trust, USSR); Severinov, I.A.; Dolinin, P.S. *Metallurgist (USSR)* v 31 n 5-6 May-Jun 1987 p 141-143.

**091910 MODERNIZATION OF A HEAVY SECTION MILL AT THE EGYPTIAN IRON & STEEL CO.** The Egyptian Iron & Steel Co. placed an order with Krupp to supply services and equipment to modernize the blooming and section mills at the Helwan works. Installation of combination universal/2-h roughing and finishing stands with movable housings permits efficient production of a wide range of sections (parallel flange beams, rails, angles, channels and bars). Universal or 2-h roll sets installed in a spare stand minimize mill downtime and optimize productivity.

El Sherbini, Ziad (Egyptian Iron & Steel Co, Cairo, Egypt); El Dahab, Hassan Abou; Madersbach, Wolfgang; Rekos, Werner. *Iron Steel Eng* v 65 n 4 Apr 1988 p 29-35.

**091911 FURTHER MODERNIZATION OF THE COLD WIDE STRIP MILL AT STAHLWERKE PEINE-SALZGITTER AG.** In order to improve the product quality and reduce the energy consumption the company undertook an extensive modernization project embracing the areas of pickling, the tandem mill, batch annealing, the temper mill and the finishing shop in their cold wide strip mill. The article describes the conversion measures and their operational effects. The continuous pickling plant was equipped with 3 flat pickling baths and is now computer controlled. Detection of defects is assisted by automatic surface inspection. The tandem mill was mechanized and automated, being provided with a process control system, a new gauge control system and, as the fifth stand, a 6-high stand with flatness control and its own emulsion circuit. The annealing plant is at the moment being converted to high-convection furnaces. (Edited author abstract)

Koehler, Gerhart (Stahlwerke Peine-Salzgitter AG, Salzgitter, West Ger). *MPT Metall Plant Technol* v 11 n 2 1988 7p.

**091912 MODERNIZATION OF INLAND STEEL'S 56-IN., 4-STAND TANDEM MILL.** Modernization of a 1958 tandem mill has resulted in a facility with significant quality and productivity improvements. In-body gage deviation, for example, has improved from  $\pm 3\%$ , to less than  $\pm 1\%$ . Components of the program include conversion to hydraulic AGC on all stands; closed-loop shape control; roll bending; side-shift roll changers; and entry end modifications.

Ryba, Thomas C.; Hennes, James M.; Mills, Dennis R. *Iron Steel Eng* v 65 n 6 1988 p 17-23.

**091913 MODERNIZATION OF A SECTION MILL FOR THE EGYPTIAN IRON AND STEEL COMPANY.** The Egyptian Iron and Steel Company, Hadisob, contracted Krupp Industrietechnik to modernize the blooming, section and plate mills in its Helwan works. The report describes the work involved in modernizing the section mill, highlighting the approach selected and special technical features and requirements. (Author abstract)

Buch, E. (Krupp Industrietechnik GmbH, Duisburg, West Ger); Klute, F.; Rekos, W. *Tech Mitt Krupp (Engl Ed)* n 1 Apr 1987 p 35-44.

**091914 MODERNIZATION OF HOT STRIP MILLS.** After a pause of several years, hot strip mills

worldwide are beginning to pay renewed attention to project activities. The article concerns itself with the important modernization measures. These include the installation of walking beam furnaces with a lower hearth loading, reduction of the temperature to which the slab is heated, installation of a 4-high reversing stand in the roughing train with greater rigidity and high capacity drives, installation of an edger with a high width reduction and automatic width control, installation of insulation hoods between the roughing and finishing trains or the incorporation of a coilbox, conversion to a larger transfer bar thickness by the installation of a heavy crop shear, expansion of the rolling program through increasing the efficiency of the finishing train, installation of hydraulic screwdown as well as of profile and flatness control in the finishing train, laminar cooling between finishing train and coiler, downcoilers with hydraulically controlled wrapper roll retraction for greater coil weights and strip thicknesses, process automation, hot charging and direct rolling. (Edited author abstract). 7 Refs.

Fricke, Helmut (MDS Mannesmann Demag Sack GmbH, Duesseldorf, West Ger); Lederer, Andreas. *MPT Metall Plant Technol* v 11 n 3 1988 10p.

**091915 REMODELING OF HOT FINISHING MILL FOR WORK ROLL SHIFT MILL. (MODIFICATION OF HOT FINISHING TRAIN IN KAKOGAWA WORKS, KOBE STEEL, LTD. - I).** The demands for improved quality of hot strip such as gauge, width, crown and flatness have increased. In order to meet these demands, remodeling of the hot finishing mill for a work roll shift mill was completed in March 1987. In this paper, the remodeling details are briefly described.

Tokushige, Keiji (Kobe Steel Ltd, Kakogawa, Jpn); Yamamoto, Yoshitaka; Maekawa, Hirohiko; Honda, Sueji; Nakata, Takamasu; Miyamoto, Hiromi. *Trans Iron Steel Inst Jpn* v 28 n 2 1988, Prepr for the 114th ISIJ Meet, Kumamoto, Jpn, Oct 9-11 1987 B.59.

**091916 NEW CONTROL SYSTEM AND ITS EFFECTS IN HOT FINISHING MILL. (MODIFICATION OF HOT FINISHING TRAIN IN KAKOGAWA WORKS, KOBE STEEL, LTD. - II).** The control system of the hot finishing mill in Kakogawa Works was renewed during the mill remodeling. In this paper, the configuration of the system and its benefits are presented. The automatic gauge control system is composed of a gauge meter AGC, a monitor and an X-ray system. The flatness control system is a feed-back control that adjusts the roll bending force of the last stand based on shape meter measurements. 3 refs.

Hirata, Kiyoshi (Kobe Steel Ltd, Kakogawa, Jpn); Yamamoto, Yoshitaka; Tsutsumi, Yasuhiro; Nakajima, Shigeki; Shiraishi, Toshikazu; Ohike, Yoshio. *Trans Iron Steel Inst Jpn* v 28 n 2 1988, Prepr for the 114th ISIJ Meet, Kumamoto, Jpn, Oct 9-11 1987 p B.60.

**091917 DEVELOPMENT OF CROWN AND SHAPE CONTROL SYSTEM IN HOT FINISHING MILL (MODIFICATION OF HOT FINISHING TRAIN IN KAKOGAWA WORKS, KOBE STEEL, LTD.-III).** Accompanying modification of the hot finishing train in Kakogawa Works, a crown and shape control system suitable for a work roll shift mill was developed. The system started in March 1987. The paper outlines the system and its benefits. 2 refs.

Satoh, Junji (Kobe Steel Ltd, Kakogawa, Jpn); Ohike, Yoshio; Hirata, Kiyoshi; Miyamoto, Yoshikazu; Honda, Sueji; Kataura, Yoshikazu. *Trans Iron Steel Inst Jpn* v 28 n 2 1988, Prepr for the 114th ISIJ Meet, Kumamoto, Jpn, Oct 9-11 1987 p B.61.

## Noise Abatement

**091918 KOERPERSCHALLDAEMMUNG UND IMMISSIONSSCHUTZ BEI FERTIGUNGSANLAGEN MIT ELASTISCH GELAGERTEN GROSSFUNDAMENTEN.** [Structure Borne Sound Insulation and Protection Against Immission in Industrial Plants by Elastically Embedded Large Block-Type Foundations.],

The paper refers about the design and the construction of the elastic bedding of a foundation for a rolling mill for Molybdenum sheets. Due to dynamic measurements at a smaller, but similar-type rolling mill and within an established mechanical model it is possible, to predict the expected loading conditions on the foundation. Thus it is shown, that an elastically embedded foundation is necessary to protect adjacent facilities against vibrations. Due to conceptional reasons elastic Polyurethane mats are used as vibration isolator. The layout of the foundation-isolation system is described in detail. Finally the results from field measurements, after completion of the foundation, are compared with calculated values from the design stage. (Author abstract). 17 Refs. In German.

Schmid, H.J. *Bauingenieur* v 63 n 8 Aug 1988 p 349-355.

## Ohio

**091919 LTV'S 84-IN. HOT STRIP MILL AT CLEVELAND WORKS.** Cleveland works is LTV Steel's largest steelmaking operation and the largest flat rolled complex in the U.S., based on hot rolled capacity. The mill is a combination of the former Jones & Laughlin plant on the west side of the river and the former Republic Steel facility on the east side. In addition to two coke plants on the east side, there are six blast furnaces (three operating); two 2-vessel BOF shops; one 2-vessel electric furnace shop; two slabbing mills; one continuous twin-strand slab caster; two hot strip mills, two tandem mills and three finishing mills. Some of the products include hot rolled bands and sheets, strip mill plate, cold rolled sheets, electrogalvanized sheets, preprinted sheets and cold rolled motor lamination steel produced in a variety of grades including high-strength low-alloy (HSLA), alloy and high carbon.

Anon. *Iron Steel Eng* v 65 n 9 Sep 1988 P CI-76-CI-77.

**Optimization See ROLLING MILL PRACTICE; ROLLING MILL PRACTICE—Billet; ROLLING MILL PRACTICE—Pipe.**

**Performance See ROLLING MILL PRACTICE—Plate.**

**Process Control See Also ROLLING MILL PRACTICE—Cold Rolling; ROLLING MILL PRACTICE—Energy Conservation.**

**091920 INTRODUCTION DU SPC (STATISTICAL PROCESS CONTROL) SUR LE TRAIN A BANDES DE SOLLAC FLORANGE.** [Application of the SPC Method on a Hot Strip Mill]. The use of SPC Statistic Process Control is being developed as a part of the total quality operation called Sigma. This study will show its application to width control on the hot strip mill. The aims are: (a) to use the statistical methods, which are a common language and which allow the engineer or the on-line operator to analyse the process in accurate and identical ways; (b) to increase knowledge about the processes and their possibilities; and (c) to use a preventive strategy rather than a detection method. In French.

Feuillet, D. (Sollac, Fr); Amet, J.P. *Cah Inf Tech Rev Metall* v 85 n 4 Apr 1988 p 325-330.

**091921 APPLYING SPC SYSTEMS TO A COLD ROLLING MILL.** This article describes how a cold rolling mill in the West Midlands, UK, introduced statistical process control techniques into its cold rolling process. First phase of a two-phased implementation strategy has been completed successfully and each of the four rolling mills at British Rolling Mills (BRM) have been equipped with continuous gauge monitoring systems. (Author abstract).

Anon. *Steel Times Int* v 12 n 3 Jun 1988 p 42-43.

**Production See ROLLING MILL PRACTICE—Plate.**

## Quality Control

**091922 QUALITAETSUEBERWACHUNG IN WALZWERKEN.** [Quality Control in Rolling Mills]. Modern rolling mills for hot and cold strip are largely



automated, being equipped with complex instrumentation to determine product parameters. Process control and quality surveillance are interlinked via measurement and test systems. So far only a few of the event-describing and process-connected variables have been continuously measured during the process. Developments in this field are underway. (Edited author abstract) 32 refs. In German.

Keck, Roland (BFI Betriebsforschungs-institut GmbH, Dusseldorf, West Ger). *Baender Bleche Rohre* v 28 n 10 Oct 1987 p 185-192.

**Retrofitting** See ROLLING MILL PRACTICE—Sheet and Strip.

## Scheduling

**091923 TASK SCHEDULING ALGORITHMS FOR MULTIPROCESSOR REAL-TIME CONTROL SYSTEMS.** The computing load for the control of a steel rolling mill plant may be regarded as a group of tasks (each task is an individual program) such as setting of controlled variables and operation monitoring. The task group can be represented by a task graph, an acyclic finite directed graph because precedence relations exist among the tasks. Dynamic scheduling methods are proposed which are extensions of the developed static scheduling algorithms. Their efficiency in comparison with the deadline driven scheduling algorithm developed by Liu and others is shown. 8 refs.

Kai, Munenori (Waseda Univ, Tokyo, Jpn); Kasahara, Hironori; Narita, Seinosuke; Ukaji, Hitoshi. *Electr Eng Jpn* v 107 n 2 Mar-Apr 1987 p 120-130.

## Stresses

**091924 ZUM ZEITLICHEN BELASTUNGSVERLAUF IN DEN GERUESTEN DER VORSTRABE EINES KONTINUIERLICHEN FEINSTAHLWALZWERKS UNTER BESONDERER BERUECKSICHTIGUNG DER SPINDELMOMENTE.** [Temporal Load Variation in the Stands of the Roughing Train of a Continuous Light Section Rolling Mill with Special Regard to the Spindle Moments]. The rolling parameters in the roughing group of a continuous light section mill were measured. Major emphasis in this study was put on temporal load variations in the rolling stands. From the results conclusions may be drawn for an optimization of the rolling technique in the rolling mill in question as well as for the planning and design of new rolling mills. (Edited author abstract) 2 refs. In German.

Kuhne, Reinhard (VEB Schwermaschinenbau-Kombinat 'Ernst Thaelmann', Magdeburg, East Ger); Kutzsche, Karl; Ennulat, Volker; Seifert, Volker. *Neue Huette* v 32 n 11 Nov 1987 p 401-405.

## Temperature Control

**091925 AUTOMATIC TEMPERATURE CONTROL OF METAL ON HOT ROLLING REVERSING MILL.** The software, hardware, and formulae entailed in the automatic system used to monitor the temperature of the metal on the hot rolling reversing mill in the Azerbaidzhan Tube Rolling Works are described. Photoelectric pyrometers measure the temperature distributions and irregularities of the four faces of the semi as it is manipulated for the passes. It was found suitable to use the average temperature measurement results for all the passes in the first pass groove of the mill to calculate the temperature irregularity and distribution in the semi. (Edited author abstract) 2 refs.

Mugarab-Samed, K.G. (Azerbaidzhan Polytechnic Inst, USSR); Agaev, Kh.A.; Akperov, N.M.; Badalov, F.A.; Leus, I.A. *Steel USSR* v 17 n 3 Mar 1987 p 130-132.

## Tennessee

**091926 MIGHTY MILL TO DEFEND ALCOA'S CANSTOCK SHARE.** Alcoa wanted to fortify a leadership position in the booming canstock market, but needed more capacity as the demand for aluminum beer and

soft-drink cans accelerated during the late 1970s. For this reason the company upgraded a mill in Tennessee. Some major elements of the program include: a \$100 million modernization of the hot line, an automated materials handling system employing automatic guided vehicles (AGV), an electromagnetic ingot casting facility, computer-automated roll grinders, a new scalper, and two of the world's fastest aluminum strip shears.

Church, Fred L. (Modern Metals, Chicago, IL, USA). *Mod Met* v 43 n 11 Dec 1987 6p between p 10 and 24.

**091927 'WORLD'S MOST MODERN ALUMINUM CONTINUOUS ROLLING MILL'.** What Alcoa calls the world's most modern aluminum continuous rolling mill has gone on line at their Tennessee Operations near Knoxville. The \$150 million multi-stand, fully continuous cold mill is the keystone of a four-year, \$400 million effort to completely modernize Alcoa's 75 year old East Tennessee manufacturing complex. Tennessee Operations is dedicated to the manufacture of aluminum beverage can body sheet for can makers. The most modern features of the mill are the roll stock technology on the three-stand rolling mill and the instrumentation, computerization and predictive diagnostic capabilities of the 4 computers.

Anon. *Light Met Age* v 45 n 11-12 Dec 1987 p 5-6.

## Tools, Jigs and Fixtures

**091928 LOW-WASTE PROCESS FOR MANUFACTURING A PRECISION STAMPING TOOL.** The All-Union Correspondence Institute of Mechanical Engineering is developing a process for producing tools for tube rolling mills by precision hot stamping. The use of precision hot stamping of tube-milling tools permitted an increase in labor output by a factor of 9 and during mechanical treatment by a factor of 2-3 and reduced metal consumption 2- to 3-fold. During manufacture of bolts by stamping, owing to the increase in impact and fatigue characteristics of the metal, steel OKhN2F was replaced with the cheaper 30KhGSA. The cost of the stamped parts declined by a factor of 2-3. The economic effect from introducing the new process amounts to about 90 thousand rubles per year.

Kopyskii, B.D.; Dmitriev, V.D.; Ivanov, I.P.; Brodskii, V.M. *Sov Forg Sheet Met Stamping Technol* n 5 1987 p 81-85.

## USSR

**091929 WAYS OF RAISING PRODUCTIVITY OF 2-8X100-600 SECTION BENDING LINE.** On the 2-8X100-600 section bending line in the Magnitogorsk Iron and Steel Combine the flying shears are mounted downstream of the profiling mill, i.e. the metal is profiled from a continuously prepared strip before cutting to length. A comparative analysis is made of this process and the alternative process of profiling the metal before cutting to measured lengths. The latter is found to be superior. The envisaged reconstruction of this line incorporates the profiling mill being followed by the flying shears followed by three finish profiling work stands. (Edited author abstract)

Trishevskii, I.S. (Ukrainian Scientific Research Inst of Metallurgy, USSR); Mar'in, V.S.; Yurchenko, A.B.; Khmel', V.A.; Kochubeev, V.N. *Steel USSR* v 17 n 4 Apr 1987 p 182-184.

## Vibrations

**091930 EBENHEITSREGELUNG FUER EINE UMKEHRWALZANLAGE IN TWIN-DRIVE-AUSFUEHRUNG.** [Flatness Control for a Reversing Rolling Mill with a Twin Drive]. Torsional vibrations of the lower and upper driving strand under certain conditions may lead to transverse unevenness of plates during rolling. After an analysis and modeling of the dynamic behavior based on the interaction of the rolling process and the mechanical and electrical design of the drive, improvements of the control system are proposed. In German. 5 refs.

Riefenstahl, Ulrich (Technische Univ 'Otto von Guericke' Magdeburg, East Ger); Guericke, Wilhelm. *Neue Huette* v 32 n 10 Oct 1987 p 372-376.

## Waste Disposal

**091931 SORPTION PROPERTIES OF AUXILIARY SORPTION MATERIAL WASTES OF METALLURGICAL PLANTS.** Mill scale, limestone, granulated cupola slag, dewatered sludge of waste water from converter gas purification and the etching division, and type AR-3 activated carbon (1 g/liter) are studied for their sorption properties for oils (0.2-4.0 g/liter): type 40 and 50 industrial oils, MS-20 aviation oil, and oil wastes from sumps. Their sorption properties permit use of the materials as components of auxiliary filters in the mechanical dewatering of scale- and oil-containing sludges of rolling mill waste water. (Author abstract) 8 refs.

Bereznyuk, V.G.; Galkin, Yu. A.; Etyukhova, O.V.; Aksenov, V.I.; Ilyushina, T.V. *Sov J Water Chem Technol* v 9 n 4 1987 p 47-50.

**ROLLS** See Also PAPERMAKING MACHINERY—Design; PAPERMAKING MACHINERY—Rolls; ROLLING MILL PRACTICE; ROLLING MILL PRACTICE—Cold Rolling; ROLLING MILL PRACTICE—Control; ROLLING MILL PRACTICE—Plate; STEEL—Continuous Casting.

**091932 CORRUGATIONS IN ROLLING CONTACT PROBLEMS.** The rolling contact problem is formulated for large strain of elastic-plastic material with isotropic hardening and Coulomb's friction law between the rotating rigid roller and the material surface. The basic equations are given for the updated Lagrangian approach which is described and discussed in a number of papers. 7 refs.

Bogacz, R.; Ronda, J.; Brzozowski, M. *Z Angew Math Mech* v 67 n 11 1987 p 567-568.

**Cast Iron** See Also PAPERMAKING MACHINERY—Rolls.

**091933 OPTIMUM IN-MOLD TREATMENT CONDITIONS FOR ROLLING-MILL ROLLS.** The treatment parameters and optimum conditions for the production of rolling mill rolls have been investigated. The in-mold treatment parameters were optimized by a series of experiments based on a Box-Wilson plan. The selected optimization parameters were the additive size analysis pouring temperature and the dissolution factor FR (the ratio between the pouring rate by weight and the cross-sectional area of the reaction chamber). The proposed parameters have been corroborated by trials at the Dnepropetrovsk Roll Foundry.

Skoblo, T.S.; Maslov, A.A.; Doluda, A.A.; Novikova, S.K. *Sov Cast Technol* n 6 1987 p 31-33.

**091934 METHOD FOR INSTALLING THERMOCOUPLES IN A MOLD.** The quality of cast rolls depends on the design and heat resistance of the mold components, the pouring conditions, and the metal cooling rate. This created a need for experimental studies of hardening of cast iron rolls cast in combined (shell-sand-clay) molds. The cast iron was poured at 1280-1320°C depending on the chemical composition and required hardness of the working layer. Production of individual heat-protected blocks for each thermocouple proved to be the most suitable method for conditions of a rolling mill. 1 ref.

Khrychikov, V.E.; Koteshev, N.P.; Efimenko, I.A. *Sov Cast Technol* n 9 1987 p 65-66.

**091935 CENTRIFUGAL CASTING OF ROLLS FOR WIDESTRIP MILLS.** An experimental batch of rolls for the 1680 mill has been produced at the Lutugino Roll Foundry. Preliminary trials have shown that centrifugally cast rolls weighing up to 10 tons can be made in the proposed machine with a variable axis of rotation using existing technology. The major difference between this



and other machines is the provision of radial thrust bearings in the mold supports. The design provides constant axial compression, and the mold is rotated by a system with conical mating surfaces.

Patser, A.I.; Klimkovskii, B.M. *Sov Cast Technol* v 11-12 1987 P9.

**Computer Aided Design** See Also ROLLING MILL PRACTICE—Computer Aided Design.

**091936 DESIGN OF VARI-FLEX MID-FASTENED ROLLS.** The discussion centers mainly on the construction of design characteristics of Vari-flex Roll of Kleinfewers Co. of the Federal Republic of Germany. Two design schemes, i.e. the design schemes of vari-flex mid-fastened roll coupled with ordinary mid-fastened roll and common roll are presented with examples calculated by microcomputer. (Author abstract). 2 Refs. In Chinese.

Fei, Junwang (Shanghai Univ of Engineering Science, China). *Zhongguo Fangzhi Daxue Xuebao* v 14 n 4 1988 p 69-77.

**Cooling** See ROLLING MILL PRACTICE—Sheet and Strip.

## Corrosion

**091937 CORROSION FATIGUE TESTING OF SUCTION ROLL ALLOYS.** A broad correlation between crack growth rate and service performance has been found in the regime where the crack growth rates are low, provided the fatigue tests are performed in simulated white waters and large mean stresses are present. (Author abstract) 12 refs.

Yeske, Ronald A. (Inst of Paper Chemistry, Appleton, WI, USA). *Tappi J* v 71 n 3 Mar 1988 p 47-54.

**Defects** See Also ROLLING MILL PRACTICE—Bars.

**091938 SELECTING OPTIMUM INTERFERENCES FOR LARGE PRESS-FIT JOINTS TO SUIT THE PRODUCTION TECHNOLOGY.** With very large press-fit joints, the problem of choosing a suitable interference is especially difficult because of restrictions imposed by the production technologies employed. In particular, heat-treatment of very large parts can cause significant stresses. If the stresses caused by the interference fit are sufficiently high and the defects sufficiently serious, the sleeves can crack. Experience shows that brittle fracture of the sleeves occurs along the generating-line, i.e. in planes perpendicular to the maximum tensile stress. Consequently, it can be assumed that damage occurs as a result of normal fracturing. 8 refs.

Firsov, V.T. *Sov Eng Res* v 7 n 3 Mar 1987 p 25-27.

**091939 AUTOMATIC ULTRASONIC FLAW DETECTOR FOR ROLL SURFACE CRACKS (KARCS).** Recent demands for higher quality and productivity of rolled sheets have brought severe conditions in both hot and cold rolling, and troubles due to cracks on the roll surface often arise. To prevent such cracks from growing, early detection and removal of the flaws are necessary. An automatic crack detection system (KARCS) developed by Kanto Special Steel Works will meet these requirements. It is based on surface wave ultrasonic testing techniques.

Anon. *Trans Iron Steel Inst Jpn* v 28 n 6 1988 p515.

**Deformation** See Also ROLLING MILL PRACTICE—Sheet and Strip.

**091940 ROZKLAD ODKSZTALCEN NA KRZYWCE ATAKU WALCA PIELGRZYMOwego.** [Deformation Distribution upon the Cam of Pilger Roll]. The process of pilger rolling is where at different angles of roll rotation the geometrical parameters of the roll and its pass change. The application value is the basic rolling parameter significantly effecting the technical and energetic parameters for example, deformation distribution on the pilger roll cone. This parameter defines unitary volume of the metal application between the rolls transported

along the length of the cam in consecutive cycles of pilger rolling. (Edited author abstract) 12 refs. In Polish.

Kajtoch, Jerzy (Akad Gornicz-Hutnicza, Cracow, Pol). *Hutnik* v 54 n 6 Jun 1987 p 174-177.

**Design** See Also ROLLING MILL PRACTICE; ROLLING MILL PRACTICE—Tube.

**091941 METHOD FOR EVALUATION OF ROUGHING MILL ROLL DESIGN.** A method for the evaluation of the efficiency parameters of mill roll designs and rolling conditions in roughing mills has been proposed. The evaluation has been based on mill equipment utilization efficiency in terms of roll nip, equipment strength and drive rating. An algorithm and associate computer program have been developed for calculating the efficiencies. Method applications have been illustrated using comparative analysis of mill roll designs and rolling conditions for several roughing mills. (Author abstract)

Zhadan, V.T.; Berkovskiy, V.S.; Shturgunov, I.L.; Osadchii, V.A. *Sov Mater Sci Rev* v 1 n 2 1987 p 233-238.

**091942 IMPROVED DESIGN OF ROLLS FOR THE PIERCING MILL OF A PILGER UNIT.** There are certain features to the process of producing large diameter (up to 575 mm) tubes on the Pilger unit at the Chelyabinsk Pipe Plant. One such characteristic is the formation of triangles defects on the sides of the pipe during rolling. Investigations showed that the main shortcoming of the existing design for the work rolls is the fact that it is difficult for the shell to move away from the mandrel at the end of piercing. The formation of triangles associated with this problem was eliminated by a new roll design.

Getiya, I.G. (All-Union Correspondence Inst of Mechanical Engineering, USSR); Osadchii, V.Ya.; Shumilin, V.K.; Saf'yanov, A.V.; Lapin, L.I.; Logovikov, V.A.; Aver'yanov, L.A.; Leont'eva, I.N. *Metallurgist (USSR)* v 31 n 3-4 Mar-Apr 1987 p 59-62.

**091943 IMPROVED ROLL DESIGN ON A CONTINUOUS INTERMEDIATE MILL.** The continuous intermediate mill at the Chelyabinsk combine has 14 stands jointed into three continuous groups. The odd stands (5th through 13th) are vertical, while the remaining stands are horizontal. Rectangular (box) passes are used in the first eight stands, while diagonal (diamond - square) passes are used in the finishing group. The transition from box passes to passes with diagonal symmetry is accompanied by an increase in the tendency of the bloom to twist at the outlet of the first diamond pass and to buckle in subsequent stands. This problem was eliminated by improved roll design.

Utkin, G.S. (Chelyabinsk Metallurgical Combine, USSR); Talalaikin, G.E.; Sharapov, V.E.; Kut'yavin, A.I. *Metallurgist (USSR)* v 31 n 7-8 Jul-Aug 1987 p 250-252.

**Fabrication** See ROLLING MILL PRACTICE—Tube.

**Failure** See Also STEEL CORROSION—Pitting.

**091944 FRACTURE ANALYSIS OF THE SMALL-SIZED COLD MILL ROLL MADE OF GCr15 STEEL.** This paper deals with a systematic analysis of fractured GCr15 steel cold mill rolls with metallography. It is considered that most of the fractures of the rolls in this lot after machining and treatment, belong to the brittle fracture type at low cycle fatigue. The main cause of the fracture was that the root of the shaft shoulder is coarse in machining, and stress concentration existed in the right angular cutting corner, in which microcracks may be produced during quenching, and these become the fatigue sources. Secondly, due to an improper heat treating process, the carbide network still remained in the structure of products, which not only decreases fatigue resistance but also increases brittleness. By means of an advanced process, a lot of forging was machined and heat treated. As a result, the service life of rolls is increased by 10 times. (Edited author abstract) In Chinese.

Wei-dong, Qian. *Jinshu Rechuli* n 6 Jun 1987 p 39-42.

**091945 STRESS ANALYSIS OF GROOVED ROLLS HAVING CLOSED PASSES AND DISCUSSION ON THEIR GROOVE SHAPES BY PHOTO-ELASTIC METHODS.** The stresses were analyzed by a three-dimensional photoelastic method and the cause of the breakage was studied. The effect of groove shapes on the stress distribution of the grooved roll was investigated by a two-dimensional photoelastic method. The breakage was caused by large mechanical working stresses. To prevent breaking of the grooved roll at a groove fillet, it is effective to make the diameter of the groove and collar as large as possible. (Edited author abstract) In Japanese. 12 refs.

Miyazawa, Kenji (Kanto Special Steel Works Ltd, Fujisawa, Jpn). *Tetsu To Hagane* v 74 n 4 Apr 1988 p 688-695.

**091946 SURVEY OF ROLL COVER FAILURES.** A survey is reported on roll cover failures in the Canadian pulp and paper industry. Statistics are presented on 225 rollcovers which failed prematurely between 1980 and 1985. These data are based on reports from 50 newsprint, pulp, board and fine paper mills. Most of the failures occurred on press rolls, and the most common mode of failure was covered disbonding. Some of the reasons for disbonding are briefly reviewed. (Author abstract) 6 refs.

Garner, A. (PAPRICAN, Pointe Claire, Que, Can). *Pulp Pap Can* v 89 n 5 May 1988 p 47-52.

## Fatigue

**091947 ESTIMATION OF THERMAL PLASTIC STRAIN FATIGUE LIFE OF ROLLS.** Thermal plastic strain fatigue life of rolls has been approximately estimated by using Neuber's plastic stress-strain concentration theory. A path-independent nature integral as defined by Rice and cyclic strain growth rate were also employed in the analysis. (Author abstract) 4 refs. In Chinese.

Li, Zhenzi (Central South Univ of Technology, Changsha, China). *Chin Shu Hsueh Pao* v 24 n 1 Feb 1988 p A58 - A59.

## Grinding

**091948 ANTRIEBSMOTOREN FUER GUT-BETT-WALZENMUEHLEN.** [Drive Motors for Grinding Rolls]. Since 1985 high-pressure grinding rolls have been used for coarse and fine grinding of material with the intention to considerably reduce the power required for the grinding process. There are described the characteristic data and influences to be taken into accounts for dimensioning the drive motors. The typical fluctuations in operation are explained by means of measured values. Generally, squirrelcage motors of a rating inferior to 1,000 kw are used for driving unit. (Author abstract) In German. 3 refs.

Adrian, F.J.; Ranze, W. *ZKG Int* v 40 n 7 Jul 1987 p 360-365.

**091949 ROLL SUPERFINISHING WITH COATED ABRASIVES.** For the past several years, the Industrial Abrasives Division/3M Company has been researching an alternative for roll refinishing called 'Coated Abrasive Superfinishing.' Prior to this article, a group of researchers at 3M studied the effects of superfinishing parameters with selected abrasive sizes on selected roll materials with a one inch wide, lab prototype unit. This report thoroughly investigates and evaluates the superfinishing parameters on several different roll materials in an effort to develop the most efficient method of producing a uniform surface finish on these rolls with a 4 in. wide production model. (Author abstract)

Dimberg, Alan P. (3M Co). *Carbide Tool J* v 20 n 2 Mar-Apr 1988 p 4-8.



## Heat Treatment

**091950 TRATAMENTO TERMICO DE ROLOS DE LINGOTAMENTO CONTINUO RECUPERADOS POR SOLDA.** [Heat Treatment of Continuous Casting Rolls Recovered by Welding]. The performance of the continuous casting rolls depends on their relative position in the continuous casting machine. Different mechanical stresses generate cracks and warpings, which adversely affect product quality. The substitution of weld surfacing by submerged arc cladding using stainless steel wire for a new low grade steel followed by a specially developed heat treatment procedure is shown in this paper, resulting in excellent roll performance and low cost. (Edited author abstract). In Portuguese. 5 refs.

Soares, David; Larangeiras, Jose Carlos; Almeida, Joaquim Nunes. *Metal ABM* v 43 n 356 Jul 1987 p 420-422, 424-425.

**091951 ELECTROCONTACT QUENCHING OF CAST-IRON ROLLS.** Studies were conducted on 500-mm-diameter rounds cut from cast iron (grade SPKHN-45) rolls. Analysis of the results makes it possible to recommend electrocontact quenching for surface strengthening of rolls. It increases the hardness of the working surface to HFC 45-50 to depths of up to 1.5-2.0 mm.

Reznitskii, A.M. (Donetsk Scientific-Research Inst of Ferrous Metallurgy USSR); Shekhter, S.Ya.; Kolesnikov, M.V.; Dritova, T.L.; Livshits, S.L. *Metallurgist (USSR)* v 31 n 3-4 Mar-Apr 1987 p 64-65.

**091952 DEVELOPMENT OF SURFACE TREATMENT TECHNIQUES FOR PROCESS ROLLS IN STEELWORKS.** Studies on surface treatment techniques of process rolls, except for working rolls in iron and steel works, were carried out by taking account of the operating conditions. Welding materials of rolls used in the continuous casting process and hot rolling process were developed, which would particularly satisfy such properties as adhesion resistance, heat-check resistance and wet-corrosion resistance. It was found out that CrC cermet with a superior wear-resistance property at high temperature and the CoCrAlY alloy with a build-up resistance property were suitable for hearth rolls. Furthermore, it was found out that WC containing Ni self-fusing alloys were suitable for conductor rolls and WC thermal spray materials were suitable for rolls used in the cold rolling process. Reliability and long-life of various process rolls were improved by these new techniques. (Author abstract) 14 refs.

Kasai, Satoshi (Kawasaki Steel Corp, Jpn); Sato, Yuji; Yanagisawa, Akihiro; Ichihara, Akira; Onishi, Hiromu. *Kawasaki Steel Tech Rep* n 17 Oct 1987 p 81-90.

**Inspection** See ROLLING MILL PRACTICE—Sheet and Strip.

**Manufacture** See Also INGOT MOLDS—Iron Construction.

**091953 CASTING CLAD ROLLING-MILL ROLLS ON A STEEL CORE.** Two novel techniques have been developed and tested for the production of rolling mill with a hard wear-resisting outer layer on a ductile core. The shrinkage of the cast outer layer is provided for by (1) flattening tubular metal inserts or (2) by preheating a steel layer-separating tube which remains as the inner layer of a two-layer cladding. By supplying rolling mills with sets comprising a single core and 3-4 cladding units, it is possible to reduce alloy iron consumption by 60%, guarantee a specified working layer thickness and prolong roll lives by 30-40%. 3 refs.

Khrychikov, V.E.; Koteshev, N.P.; Mushenkov, Yu.A. *Sov Cast Technol* n 4 1987 p 22-24.

**Mathematical Models** See COATING TECHNIQUES—Mathematical Models.

**Measurements** See CYLINDERS—Measurements.

**Plastics Applications** See PAPERMAKING MACHINERY—Rolls.

**Process Control** See GLASS MANUFACTURE—Annealing.

## Protective Coatings

**091954 CHROME PLATING WORK ROLL OF COLD MILL.** After joint research with Nomura Mekki (Nomura Plating) Co. Ltd. and tests with actual equipment, NKK installed continuous chrome plating equipment for work rolls. Operation of this equipment has been continuing satisfactorily since start-up. This report outlines the equipment and the results achieved.

Uebayashi, Takeo; Kamase, Toshihide. *Nippon Kokan Tech Rep Overseas* n 51 Dec 1987 p 67-69.

**Repair** See ROLLING MILLS—Maintenance.

**Spalling** See Also HEAT TREATMENT—Nitriding.

**091955 CAUSE AND PREVENTION OF SPALLING OF BACKUP ROLLS FOR HOT STRIP MILL.** The spalling on the surfaces of backup rolls is classified into two categories: excess rolling contact fatigue resulting from local wear and propagation of surface cracks generated by thermal shock in mill accidents such as squeezing and roll slip and incomplete removal of cracks in roll dressing. Factors for preventing the spalling phenomena are studied from experiments. The spalling tendencies are correlated with the carbon and chromium contents, areal fractions of carbides, and fracture toughness values of roll materials. To prevent spalling, it is necessary to control and improve the properties of roll materials and procedures of roll maintenance. (Edited author abstract) 7 refs.

Ohkomori, Yoshihiro (Japan Casting & Forging Corp, Kitakyushu, Jpn); Kitagawa, Ikujiro; Shinozuka, Keigo; Miyamoto, Ritsuzo; Yazaki, Seiichi; Inoue, Mutsuhiko. *Trans Iron Steel Inst Jpn* v 28 n 1 1988 p 68-74.

**Steel** See Also ROLLING MILL PRACTICE.

**091956 EFFECTS OF DIFFERENCE IN ROLLER HARDNESS ON ROLLING CONTACT FATIGUE.** Rollers made from 0.45% carbon steel with hardnesses in the range of 190 to 500 HB were used as test pieces. The rollers were rotated under rolling with sliding conditions. The sum of the initial surface hardnesses of the rollers was made greater than the theoretical oil film thickness, in most cases. By measuring the duration of full EHL conditions, the friction coefficients, etc., it was clearly shown that the reason why an unexpectedly small hardness difference can cause pitting failure is attributed to the insufficient running-in which occurs when the hardness difference is greater than a certain limit. (Edited author abstract) 12 refs.

Ishibashi, Akira (Saga Univ, Saga, Jpn); Hoyashita, Shigeru. *JSME Int J* v 30 n 269 Nov 1987 p 1826-1832.

**091957 EXPERIENCE IN PRODUCTION AND USE OF ROLLING MILL ROLLS OF HIGH CHROMIUM IRON.** The authors investigated carbide formation, alloy distribution in the matrix, and carbide transformation in relation to alloying additions and heat treatment in chromium irons for rolling mill rolls. A new composition has been developed for high chromium rolls for the sizing stands of rolling mills and trials with this in production conditions are reported. The new type of roll has better mechanical properties and wear resistance than chromium-nickel iron rolls. (Author abstract) 10 refs.

Vishnyakova, E.N. (Ukrainian Scientific Research Inst of Metallurgy, USSR); Skoblo, T.S.; Mozharova, N.M.; Bondin, R.D.; Ovchinnikov, N.N.; Komlyakov, V.I. *Steel USSR* v 17 n 8 Aug 1987 p 386-389.

**091958 EFFECT OF HIGH TEMPERATURE THERMOMECHANICAL SURFACE TREATMENT**

## ON RESIDUAL STRESSES IN 9Kh STEEL ROLLS.

The selection of the method for determining residual stresses is confined to a narrow choice because of high hardness and small diameter of specimens. The Sachs method can be used only for a study of the stressed state in solid or hollow thick-walled cylinders with large diameters. The Heine-Bauer method used in this study may be recommended for determining axial residual stresses in thin rods. The distribution and level of residual stresses in 20 mm diameter 9Kh steel work rolls quenched following HF heating and hardening by high temperature thermomechanical surface treatment have been investigated. Residual stresses resulting from quenching in oil are presented for comparison, the contact fatigue limit varies within broad ranges during surface treatment. (Edited author abstract). 4 Refs.

Nikolaev, V.A.; Polukhin, V.P.; Pimenov, A.F.; Layko, M. Yu.; Zobnin, A.D. *Sov Mater Sci Rev* v 1 n 4 1987 p 503-506.

## Stresses

**091959 MEASUREMENT OF ACTUAL STRESS AND TEMPERATURE ON THE ROLL SURFACE IN ROLLING (1ST REPORT, DEVELOPMENT OF A SENSOR FOR DETECTING PRESSURE AND FRICTIONAL STRESS).** A stress sensor for detecting pressure and frictional stress acting on the roll surface in rolling has been developed. Using this sensor, not only pressure but also frictional stress in the rolling direction and frictional stress in the width direction can be detected at the same time. The measuring performance of this sensor is investigated and an example of the measurement in rolling is shown. The accuracy of the measured data is confirmed. (Author abstract) In Japanese. 5 refs.

Hatamura, Yotaro; Yoneyama, Takeshi. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 495 Nov 1987 p 2392-2395.

**Surfaces** See SURFACES—Processing.

**Textures** See STEEL SHEET—Rolling.

**Vibrations** See ROLLING MILL PRACTICE—Cold Rolling.

**Wear** See Also PAPERMAKING MACHINERY—Rolls; ROLLING MILL PRACTICE—Hot Rolling; WEAR OF MATERIALS.

**091960 WEAR AND DETERIORATION OF ROLLING ROLL AND PROCEDURE OF ANTI-WEAR.** Roll wear and surface deterioration generally depend on the rolling load and roll surface temperature at the contact arc. Cast steel and adamite rolls should preferably be used under conditions that will bring the roll surface temperature to 600°C at which there will be formed a strong black scale film on the roll surface. Grain cast iron rolls on which a black scale film hardly develops should be used at surface temperatures around 700°C. So, to minimize temperature rise on the roll surface at the contact arc, it is clarified that reduction of friction coefficient is an excellent expedient. When roll lubricants are used in rolling process, the friction coefficient at the contact arc decreases largely and the anti-wear durability of the roll is strengthened. Roll surface roughening damage is influenced by the thermal fatigue of the surface layer in a hot strip mill. (Edited author abstract) In Japanese. 9 refs.

Ohnuki, Akira (Takasago Tekko Corp, Tokyo, Jpn). *J Jpn Soc Lubr Eng* v 32 n 9 1987 p 621-626.

**091961 SIMULATION OF ROLLER GUIDE WEAR IN A HIGH TEMPERATURE TEST RIG.** Surface studies and the observed linear increase in wear vs. number of tests cycles together with the linear increase in wear rate with normal force clearly show that abrasion by disc oxides is the dominant wear mechanism at elevated temperatures. The influence of disc temperature on the operating wear mechanisms as well as the resulting wear



are also evaluated. A quantitative classification of four guide roller materials, a high chromium tool steel, two grades of high chromium cast iron and a cermet, has also been made. The hard cermet, containing about 50 vol.% titanium carbides, proved to be the outstanding material in roller guide applications. (Edited author abstract) 14 refs.

Hammarsten, Asa; Hogmark, Sture. *Wear* v 120 n 1 Nov 16 1987 p 81-99.

**091962 DEVELOPMENT OF STRUCTURE AND CONSTRUCTION OF REGRESSION MODEL OF WEAR OF SHEET MILL WORK ROLLS.** On the basis of an investigation on a continuous 2000 hot wide strip mill, a mathematical model describing wear of sheet mill work rolls was developed. Adaptable regression models make it possible to monitor the rolling process reliably and to obtain information on the parameters entering the model directly during roll operation on the mill. Roll wear can be predicted at the stage of development of rolling schedules. (Author abstract). 5 Refs.

Shatalov, R.L. (All-Union Correspondence Polytechnic Inst, USSR); Grigoryan, G.G.; Sharov, A.A.; Savin, V.A. *Steel USSR* v 17 n 9 Sep 1987 p 416-419.

**091963 HARDNESS AND WEAR RESISTANCE OF ADAMITE FOR WORK ROLLS IN HOT ROLLING MILL.** The hardness of adamite roll materials for hot work rolls depends on the amount of hardness of coarse carbides and the hardness of the matrix. The high-hardened adamite roll materials have excellent wear resistance when the amount of coarse carbides is about 8 percent, but resistance deteriorates when the amount exceeds a critical level. As the volume of coarse carbides increases, the spacing between them decreases. The area of coarse carbides in contact with hot strip surfaces also increases to induce a partial disintegration of brittle carbides. The rolls with about 8 percent of coarse carbides have a hardness from Hs 65 to 70. (Edited author abstract). 7 Refs.

Noguchi, Hiroshi (Kawasaki Steel Corp, Kawasaki, Jpn); Hiraoka, Hisashi; Watanabe, Yasuo; Sayama, Yasuhiro. *Trans Iron Steel Inst Jpn* v 28 n 6 1988 p 478-484.

**091964 STRUCTURE AND WEAR RESISTANCE OF ADAMITE ROLL MATERIALS FOR HOT WORKING ROLLS.** The adamite roll materials used for hot working rolls are duplex materials with coarse carbides and matrix. It is desirable that the matrix structure consists of optimum volume fraction and distribution of carbides in order to keep high hardness for better wear resistance. It is concluded that the wear resistance of Adamite is based on its microstructure. 2 refs.

Noguchi, Hiroshi (Kawasaki Steel Corp, Handa, Jpn); Hiraoka, Hisashi; Watanabe, Yasuo. *Trans Iron Steel Inst Jpn* v 27 n 12 1987, Prepr for the 113th ISIJ Meet, Part VI, Tokyo, Jpn, Apr 1-3 1987 p B.309.

**Romanian** See CAST IRON—Nodular; ELECTRIC BREAKDOWN; ELECTRIC TRANSFORMERS—Calculations.

**ROOFS** See Also BUILDINGS—Climate Control.

**091965 PERIMETER FLASHING - WILL YOURS HOLD?** Incorporating 'can't strips' or 'gravel stops' the flashing assembly is intended to provide a water-tight seal between the roof edge and building wall. Flashing assemblies are used on roofs that are generally flat or slightly sloped, made up of various components, and surfaced with built-up or single-ply membranes. The flashing assembly consists of heavy sheet metal (generally preformed galvanized iron, cold-rolled copper or aluminum), wood nailers and cant strips. Improper installation or maintenance of these components can lead to failure of the flashing assembly, thus providing a starting point for wind uplift followed by failure of the associated built-up roof components. This article discusses loss history, design and construction considerations, and existing installations.

Anon (Kemper Group, New York, NY, USA). *Build Stand* v 57 n 1 Jan-Feb 1988 p 8-9.

**091966 SNOW LOADS ON SLOPED ROOFS.** The author proposes design recommendations using the results from a field investigation, wherein the effects of slope and thermal environment are measured independently of other snow accumulation factors. Data from instrumented sloped roofs are combined with observations from a group of similar structures. A flat-roof building with four different thermal conditions is monitored as a control for the sloped roofs. Results are widely applicable since the field site has significant snow accumulation during the years of study. Regression analysis is used to formulate new sloped roof coefficient; the coefficient errors are normally distributed. (Edited author abstract) 18 refs.

Sack, R.L. (Univ of Idaho, Moscow, ID, USA). *J Struct Eng* v 114 n 3 Mar 1988 p 501-517.

## Analysis

**091967 SHAPES, SAGS AND TENSIONS OF THE HANGING ROOFS WITH HORIZONTAL BOUNDARIES.** The author derives the equations for surfaces of hanging roofs with horizontal boundaries and formulas for their sags, tensions, horizontal stretches and reactions. The paper contains solutions for the roofs with circular, elliptical, triangular, square, hexagonal and rectangular boundaries. Circular and elliptical roofs with central holes as well as roofs over the sectoral plans and halls bounded by two circular cylinders are also considered. The derived relations and formulas apply to orthotropic membranes and rectangular cable networks with two perpendicular horizontal components of tension forces. The presented solutions are based on Poisson's differential equation. The maximum sag of the hanging roofs with horizontal boundaries occurs in the place with the horizontal tangent plane where the roof is acted on by the horizontal tension components only. The maximum tension which is equal to the maximum resultant reaction acts in the place and direction of the maximum slope which is at the horizontal boundary. (Edited author abstract) 13 refs.

Sobotka, Zdenek (CSAV, Prague, Czech). *Acta Tech CSAV* v 33 n 2 1988 p 233-268.

**Cable Supported** See AUDITORIUMS—Construction; BUILDINGS—Hong Kong; EXHIBITION BUILDINGS—Computer Aided Design; GYMNASIUMS—Earthquake Resistance; RECREATION CENTERS—Riyadh, Saudi Arabia.

## Cable Suspended

**091968 VARIOUS SHAPES OF CABLES AND CYLINDRICAL SUSPENSION ROOFS WITH COMPLEX VERTICAL LOADS.** The author derives the equations of the cable curves and surfaces of the cylindrical suspension roofs under various kinds of vertical loads. The loads distributed across the horizontal span are expressed by an algebraic series and polynomials as well as by trigonometric sine and cosine series. Accordingly, the algebraic or transcendental cable curves are obtained. The vertical loads distributed along the cable or on the surface of a cylindrical suspension roof are expressed by the algebraic series and polynomials. The corresponding relations represent the coordinates of the cable curve in the parametric form depending on the angle of inclination. The author derives relations for the curves formed by the cables acted on simultaneously by the loads uniformly distributed across the horizontal span and along the cable curve. It is shown how the shape of the cable curve and the surface of a cylindrical suspension roof depend on the kind of loading and that the catenary and parabola are special cases of the derived general relationships. (Edited author abstract) 16 refs.

Sobotka, Zdenek. *Acta Tech CSAV* v 32 n 4 1987 p 479-510.

## Components

**091969 ROOFING: MORE THAN THE SUM OF ITS PARTS.** Selecting a roofing system neither starts nor ends with the membrane. With that in mind, this issue is devoted to some of those other major considerations involved in roofing selection: decks, vapor barriers, insulation, penetrations, perimeters, wind uplift and fire resistance, warranties and guarantees, testing and inspection, and specifications. The intent is to look at the roofing system from a variety of viewpoints and consider components, in addition to the membrane, that play an integral role in a roof's success. What goes under the roof continues to be a primary concern in the selection of roofing membranes. Specific concerns for the type of deck under a particular membrane are best left to the manufacturer of the membrane.

Raeber, John A. *Constr Specifier* v 40 n 11 Nov 1987 p 34-35.

**091970 NUTS AND BOLTS OF PERIPHERAL ROOFING COMPONENTS.** When it comes to roofing for new projects or renovation work, designers and specifiers are primarily concerned with selecting either built-up roofing or single ply membranes. Preoccupied with the selection of these membrane systems, they may inadvertently neglect the peripheral components. Although roofing membranes are critical in accommodating the various criteria for each project, they constitute only one component of the overall roofing system. Careful consideration must be given to selecting individual peripheral components. These peripheral components are required to support, attach, terminate, seal, vent, protect, isolate, drain, accommodate movement, or provide access. 1 ref.

Israel, Sheldon B. (Construction Specifications Inst, Fort Lauderdale, FL, USA). *Constr Specifier* v 40 n 11 Nov 1987 p 44-49.

## Concrete

**091971 DURABILITY OF NATURAL FIBERS IN CEMENT-BASED ROOFING SHEETS.** Natural fibres such as sisal, jute, ramie and coir can be used as reinforcement in cement-based roofing sheets. Natural fibre concrete is a low-cost material. With time the natural fibres decompose producing a brittle composite. Studies reported here shows that this embrittlement can be prevented by replacing a part of the ordinary Portland cement by highly active pozzolanic materials, like silica fume or rice husk ash. (Author abstract) 5 refs.

Gram, H.E. (Swedish Cement & Concrete Research Inst, Sweden); Nimityongskul, P. *J Ferrocem* v 17 n 4 Oct 1987 p 321-327.

**091972 TIPS ON ROOFING CONCRETE ROOF DECKS.** If properly designed and constructed, almost any roofing system will work on a concrete roof deck. But because not all concrete roofs are the same, determining which roofing system will perform best requires the answers to many questions: How long must the roof last? Must it endure constant sun or severe winters? Must it withstand high winds? Is there usually a lot of traffic on the roof? Is the concrete roof deck dead level or sloped? Is it precast or cast in place? A complete roofing system for a low-slope roof consists of a vapor retarder (if required), insulation (if desired), and a roof membrane and flashing system. This paper summarizes numerous combinations of roofing materials and installation methods.

Koziol, Richard (Wiss, Janney, Elstner Associates Inc, Northbrook, IL, USA). *Concr Constr* v 33 n 2 Feb 1988 p 4p.

**091973 PRECAST CONCRETE ROOF STRUCTURE: FAILURE AND REPAIR.** Heavy concrete fragments crashing into the floor of a huge warehouse building, from an overhead precast structure, calls for an investigation to determine the cause of this phenomenon



and stop it. Field observations show that the roof double-tees are bearing on the edge of improperly reinforced concrete flanges of precast I-griders. This causes cracking and eventual fallout of fragments of the girder flange. As a result, bearing of some of the double-tees is reduced to 1.5 in., an unacceptable amount. Such precarious support could cause sudden and catastrophic failure. The shortcomings of the original design are identified, and a correct design that would have prevented failure is presented. Additional aspects of the subject are discussed. (Edited author abstract). 7 Refs.

Gurfinkel, German (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA). *J Perform Constr Facil* v 2 n 3 Aug 1988 p 144-158.

**Concrete Construction** See SKATING RINKS—Structural Design.

**Concrete Shell** See Also AUDITORIUMS—Restoration.

**091974 ADVANTAGES OF PERLITE CONCRETE ROOF DECK SYSTEMS.** Insulating concrete roof deck systems have proven their worth on millions of square feet of major buildings from coast to coast. In the past 15 years the most widely used insulating concrete has been one prepared from perlite aggregate. 'Perlite' is not a brand name but a petrographic term for a naturally occurring, asbestos free, siliceous rock defined in the dictionary as 'volcanic glass with concentric shelly structure'. The feature that distinguishes perlite from other volcanic glasses is that when heated to a suitable temperature it expands, like popcorn, to four to 20 times its original volume. The glassy, closed cellular structure of expanded perlite resists water penetration and results in concrete mixes requiring about 30 percent less water than vermiculite and other open celled aggregates.

Pruter, Walter F. *Constr Specifier* v 40 n 11 Nov 1987 p 52-55.

**Construction** See Also STADIUMS—Roofs.

**091975 AIR FORCE BUILT-UP ROOF TOLERANCES.** The need to control workmanship has been identified as important in obtaining a built-up roof which will perform adequately. The use of tolerances to evaluate workmanship has various degrees of acceptance. If it is determined that variances are to be used in the contract specifications, the designer is faced with a wide range of recommendations. An investigation of past variances from specified quantities does not alleviate the problem. There appear to be no clearly identified allowable variances that a contractor should be able to attain, given current construction and quality assurance procedures; at least not as evidenced by a frequency analysis of variances occurring in Air Force roofing projects. Selecting realistic tolerances is difficult because of the many factors and variables involved in construction. In addition, a built-up roof is a complex system with interacting components.

Lavigne, Dale R. (US Air Force, USA). *Mil Eng* v 79 n 517 Sep-Oct 1987 p 492-495.

**Cooling**

**091976 HEAT TRANSPORT MODEL FOR ROOF MIST SPRAY SYSTEMS.** The Roof Mist Spray System (RMSS) employs evaporative cooling for heat removal. A light water mist is periodically sprayed on the roof of a building during warm days. The water evaporates between applications, causing a cooling of the roof surface. This reduces the temperature gradient between the roof surface and the building interior, thus reducing the load on the building's air conditioning system. According to commercial vendors, such a system can be installed at less than one-fifth of the insulation costs for the same effect. Additionally, the roof life can be doubled due to lower surface temperatures. The purpose of this study was to develop a heat transport model to predict the cooling load on buildings. 6 refs.

White, Charles R.; Hanley, Thomas R.; Mathiasmeier, Kenneth J. *ASHRAE J* v 29 n 10 Oct 1987 p 39-41.

**091977 ROOF SPRAY COOLING SYSTEMS.** Evaporative roof spraying systems are most effective when the plant has a large roof area in proportion to exposed walls and sensible-to-total heat ratios are high. Water consumption seldom average more than 10 oz/100 sq ft of roof surface in a 6-min period, but the roof temperature is typically reduced 40 to 60°. This article discusses the evaporative cooling process, applications, roof protection, and economics.

Abernethy, Dick (Fan-Jet Roof Cooling Systems, Carrollton, TX, USA). *Plant Eng (Barrington Ill)* v 42 n 3 Mar 10 1988 p 178-180.

**Coverings**

**091978 EVALUATION OF THE CRACK-BRIDGING ABILITY OF EXPOSED ROOF COATINGS.** A major problem with single-layer in situ applied or prefabricated roofing membranes, exposed to intensive solar radiation in subtropical climates, is their long-time ability to bridge over working cracks. A performance test, suitable for accelerated testing and evaluation of the crack-bridging ability of roofing membranes, exposed to real climatic conditions and experience gained with its use are described. The testing device consists of a reinforced concrete slab measuring 100 cm x 50 cm x 5 cm on free-moving horizontal supports. A transverse crack of controlled width is induced at mid-length. The membrane under test can be applied before or after inducing the crack. Typical temperature variations, and resulting crack widths recorded during the calibration period, are discussed. Included also are results of comparative tests performed with the device on different roofing materials. (Edited author abstract) 3 refs.

Jaegermann, C. (Technion-Israel Inst of Technology, Haifa, Isr); Puterman, M. *Mater Struct* v 20 n 120 Nov 1987 p 403-407.

**091979 COPING WITH MEMBRANE ROOF PENETRATIONS.** Flashings are more often the point of entry for water than the roof membrane. One study of 163 roofs indicated five times as many flashing leaks as leaks in the roof surface. Guides to flashing usually start with the customary edge flashing and base flashing conditions, which indeed account for the bulk of the material and labor in flashing a typical roof. In flat roofs the base and edge flashings are the outer boundary of the plane we call the roof surface, which is often more like a pan: turned up at the edges. This article concentrates on the interruptions that occur within that plane or pan, broadly called penetrations, whether they are curved holes, joints, or small holes made for pipes and posts.

Heineman, Paul (Barretta & Associates, Boca Raton, FL, USA). *Constr Specifier* v 40 n 11 Nov 1987 p 36-43.

**Deformation** See GARAGES—Concrete.

**Design** See TANKS—Roofs.

**Drainage**

**091980 DESIGNERS' NOTEBOOK: THE ROOF TOP DRAIN.** In order to provide a receptacle to drain cooling towers, coil drains, etc., located on the building roof, a roof top fixture such as a 'Roofceptor,' floor sink, or open site drain must be installed. The article presents 4 possible fixture designs. The fourth solution suggests that a fixture is not needed but rather an open waste line through roof, or perhaps an adequate or oversized vent for the equipment drain. As long as this open waste line meets all minimum termination requirements of a vent through the roof, it should not only be a safe and sanitary method of receiving an indirect equipment drain but a logical one as well. The proposed solution to this problem would eliminate the added cost of the fixture, the extra roof penetration, and the need for frost protection for the fixture trap.

Smith, Larry E. (Systems Design, Carlsbad, CA, USA). *Plumbing Eng* v 15 n 9 Nov-Dec 1987 p 11-12.

**Failure**

**091981 TESTING SINGLE PLY'S WEATHERABILITY.** Wind, rain, pollution, and other natural elements all contribute to single ply roofing system failures. But without a doubt, the sun's powerful ultraviolet (UV) rays are responsible for causing more damage to single ply roofing systems than any other weather-related element. Destructive UV rays (those in the 290 to 350 nanometer range) are responsible for the failure of thousands of roofs each year. Once these powerful UV rays begin to break down the chemical bonds in the polymer chains that make up many single ply roofing membranes, the other natural elements ultimately finish the job of destroying the integrity of the roofing membrane. Six common tests are widely used to evaluate the long-term weatherability characteristics of single ply roofing materials: real-time testing; enclosed carbon arc testing; sunshine carbon arc testing; xenon arc testing; QUV testing; and EMMAQUA concentrated sunlight testing.

Peterson, Arnold (J.P. Stevens & Co, North Hampton, MA, USA). *Constr Specifier* v 40 n 11 Nov 1987 p 21, 23, 25.

**091982 ROOF COLLAPSE UNDER SNOWDRIFT LOADING AND SNOWDRIFT DESIGN CRITERIA.** This paper summarizes an investigation of the roof collapse that occurred at Waterville Junior High School in Waterville, Maine, on February 9, 1978, after a heavy snowstorm. The primary cause of the collapse is found to be that load from drifting snow was not considered in the design; the physical cause is found to be severe overloading of open web joists. Had the designer followed accepted engineering practice standards for drifting snow existing at the time of design, the collapse would not have occurred. The paper also compares the snowdrifts observed at Waterville Junior High School to accepted engineering practice at the time of design, to other observations of snowdrifts, and to recent code criteria for snow drifts. The proper character of drift loads is found not to have been recognized by the structural engineering profession at the time of the collapse, and presently, the ability of the profession to predict snowdrifts and their loads is limited. Recommendations for improving predictions of snowdrift loads using recent code criteria are presented. (Author abstract) 16 refs.

Zallen, Rubin M. *J Perform Constr Facil* v 2 n 2 May 1988 p 80-98.

**091983 INTRODUCTION OF THE TRUSSED ROOF RAFTER IN BRITAIN.** The author describes the situation in Britain when trussed rafters for roofs were introduced in Britain from America and explains why it resulted in a number of roof failures. Contributory factors to the failures are listed. 16 Refs.

Yeomans, D.T. (Univ of Liverpool, Liverpool, Engl). *Struct Saf* v 5 n 2 Jun 1988 p 149-153.

**Fire Protection** See Also TRUSSES—Fire Resistance.

**091984 BRANDSCHUTZ F 90 FUER TRAPEZBLECHDAECHER.** [F 90 Fire Protection Board for Trapezoidal Sheet Roofs]. Trapezoidal sheeting is being used to an increasing extent for roofs and ceilings. The thinness of such building components necessitates a special method of fire protection. With their Thermax M fire protection board Isovolta can offer a solution which, apart from being highly economical, offers F 90 fire protection. (Author abstract) In German.

Anon (Isovolta, Wiener Neudorf, Austria). *Stahlbau Rundsch* n 68 Apr 1987 p 9.

**Fire Resistance**

**091985 WIND UPLIFT ON ROOFS.** This article represents a perspective on wind uplift as it pertains to roof systems. It will attempt to review the relationship of wind uplift to fire, describe the Underwriters Laboratories, Inc., (UL) and Factory Mutual Research Corporation (FMRC)



tests, and recommend the best design for a built-up roof (BUR) or single ply roof system today. Is there a relationship between wind uplift and the fire resistance of a roof system? From the author's viewpoint, there is. This risk comes not from external fire sources - where, for instance, burning brands are blown onto a roof deck - but from internal fire sources.

Hoover, Stephen R. *Constr Specifier* v 40 n 11 Nov 1987 p 76-79.

## Fires

**091986 ROOFS AND FIRE.** Roof constructions have to satisfy a number of structural fire protection requirements which take into account the following: possible ignition and extensive flame spread over the external surface caused by heat radiated by a fire in an adjacent building (or another part of the same building) and by flying burning brands; and the risk that once a roof had been ignited on the outside the fire will penetrate to the inside of the building; the need, in some circumstances, to prevent a fire inside a building spreading to a nearby building or an upper part of the same building; and the possible effects of the roof on the fire spread within the building. The author describes how roofs are tested and examines some case studies. Fire experience suggests that there are shortcomings in current legislation. 13 refs.

Day, Terry. *Fire Prev* n 201 Jul-Aug 1987 p 18-23.

## Insulation

**091987 BEWERTUNG DES DIFFUSIONSVERHALTENS BEI DER ZUSATZDAEMMUNG VON WARMDAECHERN.** [Evaluation of the Diffusion Behavior in Additional Insulation of Thermally Insulated Roofs]. In order to improve the energy conservation quality of insulated roofs in existing single-floor industrial buildings, it is possible to add additional insulation. In the case of 80 mm thick mineral wool, laminated strips under a new roof skin, there arise normally no problems. In the case of relative inferior air moisture levels of 65%, two condensation planes arise in additionally insulated roofs, which is not permissible. The possibilities of avoiding the condensation plane by means of perforation of the old roof skin or overdimensioning of the additional insulation are investigated. Perforation is not an appropriate solution. Overdimensioning leads to a permissible solution from the diffusion technical point of view, but requires excessive use of the insulating material. In German. 1 ref.

Schwarz, Frieder (Bauakademie der DDR, East Ger). *Bauplanung Bautech* v 41 n 2 Feb 1987 p 54-55.

**091988 UEBER DIE LUFTDURCHLAESSIGKEIT GENEIGTER DAECHER.** [Air Tightness of Sloped Roofs]. The effects of different types of material for roofing on the heat losses and condensation of ceilings have been studied by measurements. Guidelines for proper insulation are given for particular roofing materials and insulating materials. In German.

Knublauch, Erwin (Fachhochschule Hagen, Hagen, West Ger); Schaefer, Hubertus; Sidon, Stefan. *Gesund Ing Haustechnik Bauphysik Umwelttech* p 108 n 1 Feb 1987 p 23-26, 35-36.

**091989 WETTING OF POLYSTYRENE AND URETHANE ROOF INSULATIONS IN THE LABORATORY AND ON A PROTECTED MEMBRANE ROOF.** When subjected to a sustained temperature gradient in the presence of moisture in laboratory wetting tests, urethane and expanded polystyrene roof insulations accumulate enough moisture to significantly reduce their insulating ability. Extruded polystyrene is quite resistant to moisture in such tests. But the vapor drive is not as great in actual roofs and it may reverse direction, thereby seasonally drying the insulation. To determine how well the laboratory tests could predict the wetting rate of insulation in actual protected membrane roofs, extruded and expanded polystyrene and urethane insulations were installed in a protected membrane roof in Hanover, NH. (Edited author abstract) 13 refs.

Tobiasson, Wayne (US Army Corp of Engineers, Hanover, NH, USA); Greatorex, Alan; Van Pelt, Doris. *J Therm Insul* v 11 Oct 1987 p 108-119.

**091990 VERMICULITE ROOF INSULATION SYSTEMS.** Vermiculite concrete offers fire protection for the roof system because it is non-combustible. In addition, it can easily be sloped to drain water, has a monolithic surface, and bonds securely to the structural substrate, providing a high degree of wind-uplift resistance. Polystyrene continues to be the most cost effective insulation that is both dimensionally stable and minimally affected by moisture. The inclusion of polystyrene board in vermiculite roof insulation allows the system to provide more than 34" R insulation.

Dudley, Hubert T. (W.F. Grace & Co, Cambridge, MA, USA). *Constr Specifier* v 40 n 11 Nov 1987 p 62-65.

**091991 FOAMED PLASTIC ROOF INSULATION.** Foamed plastic insulation is widely used in the commercial low-slope roofing market, with total 1986 use estimated at 2.3 billion board feet. A variety of types are available, each having different properties and benefits. Some considerations include compatibility with other roofing system components, type of substrate, fire performance of the overall system, in-service durability of the product, needs for creating slope, method of attachment, resistance to moisture (e.g., internal moisture drive/condensation, moisture in event of leak, or moisture when placed above membrane in PMR applications), and long term R-value retention. This article summarizes the differences between the four basic generic types of rigid foam plastic insulation: extruded expanded polystyrene (XEPS), molded bead polystyrene (MEPS), polyurethane/polyisocyanurate (PUR/PIR), and phenolic.

Petersen, Wayne (Dow Chemical Co, Midland, MI, USA). *Constr Specifier* v 40 n 11 Nov 1987 p 66-69, 71, 73-74.

**091992 VENTS AND VAPOR RETARDERS FOR ROOFS.** Vents and vapor retarders are features incorporated into roofing systems to prevent moisture from condensing within the roof. Their need in building envelopes depends on the local climate, the temperature and moisture conditions within the building, and the type of materials and systems used for the envelope. Condensation problems in roofs are usually caused by moisture in indoor air that moves upward into the roofing system in cold weather. However, problems can also occur in hot, humid regions when moisture in outdoor air condenses within a roof, particularly above air-conditioned spaces. This article is primarily concerned with condensation in cold weather, but the warm weather problem will also be addressed. 22 refs.

Tobiasson, Wayne (US Army Corp of Engineers, Hanover, NH, USA). *Constr Specifier* v 40 n 11 Nov 1987 p 80-84, 87-88, 90.

## Maintenance

**091993 WHEN IS IT SAFE TO RE-COVER AN EXISTING ROOF?** The reason roof replacement is under consideration is because the existing system leaks. Almost never is a roof considered for major work simply because it has exceeded its projected life span. More likely, it has leaked and been patched on many occasions over a long period of time. This means that water has entered the existing system and is probably being retained in the insulation. Unless the existing roof is removed, there is virtually no way of knowing the condition of the deck underneath it. Simply looking at the deck from below may not uncover the hazards - decks deteriorate from water coming in from above, not below.

Warseck, Karen (Hoffmann Architects, Atlanta, GA, USA). *Natl Eng* v 92 n 3 Mar 1988 p 8-9.

## Materials

**091994 EXPLORING THE OPTIONS: SINGLE PLY ROOFING.** Today, single ply is an accepted alternative to built-up roofing (BUR) and is no longer

marketed primarily as a reroofing product to be used over intact BUR. It may be installed loose laid and ballasted, or it may be fully adhered, partly adhered, or mechanically fastened. The single ply system does not vary a great deal from the BUR system in that they both use a structural deck, vapor retarder, and insulation, or a form topped by a poured-in-place insulating fill as a substrate. The difference is in the single ply membrane: a single sheet of rubber, plastic, or modified bitumen taking the place of three or four plies of tar- or asphalt-saturated felt laminated with asphalt or coal tar pitch. This article discusses single-ply roofing materials, applications, installation procedures, and other aspects of the subject.

Hoover, Stephen R. *Constr Specifier* v 40 n 12 Dec 1987 p 92-100, 102-103.

**091995 ROOFING: COATED COIL'S NEXT GROWTH MARKET?** Roofing may challenge food cans as the next big growth market for coil coated steel. Construction is already steel's third largest market. There are two main roofing targets for the coil coating industry to aim at: the nonresidential, low-slope market, which is principally commercial and light industrial construction, and the residential market.

Church, Fred L. (Modern Metals, Chicago, IL, USA). *Mod Met* v 43 n 11 Dec 1987 5p between p 28 and 36.

**091996 STUDY OF SOME VARIABLES AFFECTING THE PROPERTIES OF SULFUR-REINFORCED SUGARCANE RESIDUE-BASED BOARDS.** Low density boards made with sugar-cane residue (bagasse) fiber, were later post-treated with either sulfur or sulfur modified with Escopol (a drying type of oil). Beating time, pre-treatment (addition of phenolic resin or wax to slurry before board formation) and post-treatment were the manufacturing variables employed in the study. The effects of the variables on the physical and mechanical properties (dry and after 48 h water soaking) of the products were investigated, using analysis of variance technique and basing significance on 10%, 5% and 1% probability levels. Although the boards were affected by all the variables, the deterministic factor was the amount of sulfur or sulfur/Escopol picked-up during post-treatment. (Edited author abstract) 8 refs.

Nnabuife, Elias L.C. (Anambra State Univ of Technology, Awka, Nigeria). *Indian J Technol* v 25 n 8 Aug 1987 p 363-367.

**091997 PROCESS TECHNOLOGY OF CERAMIC ROOFING TILES FROM RED IRAQI CLAY.** A study on the utilization of red Iraqi clay for the production of ceramic tiles, to be used as protective wearing cover for flat roofs, has been carried out. Local quartz sands have been added in varying proportions to the clay to overcome the drying and firing cracks. The optimal laboratory results were adapted on pilot scale. The characteristics of the manufactured tiles were compared with those of the concrete tiles currently used in Iraq. (Edited author abstract) 8 refs.

Girgis, Lamey G. (Nat'l Research Cent, Cairo, Egypt); El-Rawi, S. *Sprechsaal* v 121 n 1 1988 p 56-61.

**091998 GRANULE EMBEDMENT ON SHINGLES AND ROOFING MEMBRANES.** Samples of shingles and modified bituminous membranes covered with stone, slag or slate granules were tested for the amount of granules applied and the coverage provided to the bitumen. The granule embedment in the as-received condition and after wetting was measured by scrubbing the samples with 50 strokes of a steel wire brush. Five representative samples out of the thirteen were also subjected to an extended scrub test, where the number of scrub strokes was increased to 150 (in intervals) to evaluate the retention. The results showed significant variations between samples. The requirement of a fixed amount of granule loss exists in most standards. Although this is adequate for quality control, the loss should be proportional to the quantity of granules applied, rather than a



fixed amount. Proper assessment of granule adhesion requires testing for wet granule loss, for the initial granule coverage and for the tendency for granules to detach under extended scrubbing. (Author abstract) 5 refs.

Dutt, O. (Nat'l Research Council of Canada, Ottawa, Ont., Can.). *J Test Eval* v 16 n 3 May 1988 p 322-327.

**Plastics Applications** See Also ELASTOMERS—Applications; POLYVINYL CHLORIDE—Applications.

**091999 NEW LABORATORY PROCEDURES TO EVALUATE THE DURABILITY OF ROOFING MEMBRANES.** Demand continues to increase rapidly for a method to test the durability of new generation roofing membranes. New generation membranes mean thermoplastic, thermoset and modified bituminous membranes. Current laboratory procedures used to evaluate the durability of roofing membranes use artificial weathering devices which attempt to simulate the primary weathering agents. Although this is probably a valid method for evaluating a specific product, a problem arises when one wants to evaluate several different types of roofing materials in the same test. In this article the author describes the features and advantages of using thermal analysis or thermo-analytical techniques to bridge the gap between test procedures for different polymeric membranes.

Farling, Michael S. (Carlisle SynTec Systems). *Rubber World* v 197 n 4 Jan 1988 p 20-23, 48.

## Protective Coatings

**092000 COATINGS FOR ROOFS AND DECKS DON'T HAVE TO BE UGLY.** Several types of coating systems for roofs and decks are described. Special high-strength polyurethane solvent-based coatings, one- and two-component systems, have performed excellently as topcoats. Single-component, moisture-curing polyurethanes which are fluid-applied and provide multi-layered, monolithic-textured waterproof toppings for both plywood and concrete substrates are easy to apply, economical and functional. Epoxy has good properties as a base coat in many applications on concrete and metal. In polyurethane-hypalon coating systems, the polyurethane provides the usual excellent physical properties and ease of application, while the hypalon topcoat ensures maximum weatherability. Butyl as a topcoat is of definite interest because of its low price and outstanding weatherability. 5 Refs.

Gamero, Robert. *Elastomerics* v 120 n 9 Sep 1988 p 28-29.

## Repair

**092001 MEMBRANE AND FLASHING CONDITION INDEXES FOR BUILT-UP ROOFS, VOLUME II: INSPECTION AND DISTRESS MANUAL.** As part of the system for built-up roofs, this volume presents the standardized information needed to conduct the visual inspection survey, including names, descriptions, severity levels, measurement criteria, causes and photographs of membrane and flashing distresses. Procedures for distress density calculations are also provided. Roof inspectors can use this information to objectively determine the indexes that reflect the (1) ability of the membrane and flashing to perform their functions, (2) needed level of maintenance, and (3) waterproof integrity. (Edited author abstract)

Shahin, Mohamed Y. (US Army Construction Engr Research Lab, Champaign, IL, USA); Bailey, David M.; Brotherson, Donald E. *Tech Rep US Army Corps Eng Constr Eng Res Lab* M-87/13 v 1-2 Sep 1987 98p.

**092002 MEMBRANE AND FLASHING CONDITION INDEXES FOR BUILT-UP ROOFS, VOLUME I: DEVELOPMENT OF THE PROCEDURE (UNCLASSIFIED).** Because no systematic procedure exists to determine priorities and select repair strategies for low-slope roofs, the U.S. Army Construction Engineering Research Laboratory (USA-CERL) is developing a roof

maintenance management system that will provide a practical decisionmaking procedure to identify cost-effective repairs. This volume describes part of the overall system; the development and verification of roof condition indexes for rating built-up roofs, based on a visual distress survey. Separate indexes were developed for the membrane and flashing components. Each index is expressed as a numerical rating ranging from 0 to 100, and provides a measure of the component's ability to perform its function, needed level of maintenance, and leak potential. The roof condition indexes have been field tested and validated through the assistance of several roof experts from both the military and private sectors. (Edited author abstract)

Shahin, Mohamed Y. (US Army Construction Engr Research Lab, Champaign, IL, USA); Bailey, David M.; Brotherson, Donald E. *Tech Rep US Army Corps Eng Constr Eng Res Lab* M-87/13 v 1-2 Sep 1987 33p.

## Service Life

**092003 NONDESTRUCTIVE METHODS FOR INSPECTING SINGLE PLY ROOFING MEMBRANE SEAMS.** Durable, single ply roofing membranes are characterized, among other factors, as having seams that remain watertight over the intended service life of the roofing. Failure of a seam can result in water penetration of the roofing system causing damage to itself, other building components, and building contents, and also loss of thermal efficiency of the roof insulation. Two nondestructive evaluation methods show promise for detecting voids and delaminations in adhesive-bonded, single ply membrane seams. 12 refs.

Rossiter, Walter J. Jr. (Cent for Building Technology, USA). *Constr Specifier* v 40 n 11 Nov 1987 p 92-96, 98, 100.

## Standards

**092004 SPECIFYING MEMBRANE ROOFING. A SYSTEMATIC APPROACH.** Today, writing roofing specifications is complex. First, there are bewildering numbers of membranes and insulations. The latest NRCA Roofing Materials Guide lists over 475 roofing systems and 200 insulations currently marketed in the United States. The specifier must decide how to install the system - by hot hopping, self-adhering, adhering with cold adhesive, torching, mechanically fastening, welding with solvents, welding with heat, or by loose laying and ballasting. He must contend with compatibility of materials, complicated flashing systems, and shorter term guarantees, as well as Underwriters' Laboratories' and Factory Mutual's requirements for fire and wind uplift. This article is arranged in accordance with the CSI Standard Three-Part Section Format. It is desirable to limit the types of membranes on a single project to simplify future maintenance.

Henshell, Justin. *Constr Specifier* v 40 n 11 Nov 1987 p 102-108.

**Steel** See Also STADIUMS—Roofs; STADIUMS—Vienna, Austria.

**092005 DACHAUFBAUTEN IN STAHL.** [Steel Roofings]. For roof storey construction, as necessary when renovating old apartment houses, steel has proved the best solution. The reasons are: slender and thus lightweight sections, easy handling in cramped space, and short construction times. (Author abstract) In German.

Pelikan, E. *Stahlbau Rundsch* n 70 Apr 1988 p 14-15.

## Stresses

**092006 STRESSES IN SIMPLY SUPPORTED FOUR-PITCH SQUARE ROOF.** This paper is an extension of the paper entitled 'Internal Stresses of Combined H.P. Shells'. In this paper, the equation of surface of a Four-Pitch Square Roof is developed. By using the method presented, the stress formulas in the Four-Pitch Square Roof are obtained based on elastic shell

theory. An example is calculated by microcomputer for illustration. (Edited author abstract) 2 refs. In Chinese.

Jiang, Qingfeng (South China Inst of Technology, China). *Tumu Gongcheng Xuebao* v 20 n 2 May 1987 p 28-34.

**Structural Analysis** See Also DOMES AND SHELLS—Structural Analysis; SILOS—Wind Effects; STRUCTURAL FRAMES—Steel.

**092007 SHAPES, SAGS AND TENSIONS OF THE HANGING ROOFS WITH HORIZONTAL BOUNDARIES.** The author derives the equations for surfaces of the hanging roofs with horizontal boundaries and formulae for their sags, tensions, horizontal stretches and reactions. The paper contains the solutions for the roofs with the circular, elliptical, triangular, square, hexagonal and rectangular boundaries, the circular and elliptical roofs with central holes as well as for the roofs over the sectoral plans and halls bounded by two circular cylinders. The derived relations and formulae apply for the orthotropic membranes and rectangular cable networks with two perpendicular horizontal components of tension forces. The presented solutions are based on the Poisson's differential equation. The maximum sag of the hanging roofs with horizontal boundaries occurs in the place with the horizontal tangent plane where the roof is acted on by the horizontal tension components only. The maximum tension which is equal to the maximum resultant reaction acts in the place and direction of the maximum slope which is at the horizontal boundary. (Author abstract). 13 Refs.

Sobotka, Zdenek (CSAV, Prague, Czech). *Acta Tech CSAV* v 33 n 2 1988 p 233-268.

**Structural Design** See Also TRUSSES—Computer Aided Design.

**092008 ROOF CONNECTIONS IN HOUSES: KEY TO WIND RESISTANCE.** The meteorological facts behind severe winds are examined. Windspeeds are translated into structural loads, and these loads are compared with strengths of some common and upgraded roof connections. It is shown that the strength of common connections may intersect various wind-speed probability curves in the steepest part of these curves. This implies that slight changes in connection strength can provide large changes in the structural reliability of the connections. (Edited author abstract) 25 refs.

Conner, Harold W. (Univ of Oklahoma, Norman, OK, USA); Gromala, David S.; Burgess, Donald W. *J Struct Eng* v 113 n 12 Dec 1987 p 2459-2474.

**092009 DESIGN METHOD FOR 1986 CANADA PLAN SERVICE ROOF TRUSSES.** The new approach used by the Canada Plan Service to optimize the roof truss design is given in detail. This paper describes the analog model used to represent more closely the real structure and covers the design procedure for sizing the plywood gussets and nailing patterns to resist shear, tension and flexural forces developed in the joints. (Author abstract). 9 Refs.

Masse, D.I. (Agriculture Canada, Ottawa, Ont, Can); Turnbull, J.E.; Jackson, H.A. *Can Agric Eng* v 30 n 2 Jul 1988 p 277-281.

## Testing

**092010 FURTHER INVESTIGATION OF THE EFFECT OF APPLICATION PARAMETERS ON ADHESIVE-BONDED SEAMS OF SINGLE-PLY ROOF MEMBRANES.** A laboratory study was conducted to determine if a T-peel test was sensitive to differences in initial (7 days) bond strength for adhesive-bonded seams of EPDM (ethylene propylene diene terpolymer) rubber membranes made under different application conditions. The main categories of application parameters investigated were: surface condition (cleanness, moisture) of the rubber; pressure applied; temperature during seam formation; open time. The T-peel test was found to be sensitive to changes in bond resulting from variation of some of the application parameters. Seams prepared using uncleaned



sheets (without removing the talc or other contaminants from their surfaces), or using long open times, had lower average peel strengths than those of the control specimens. Light pressure or high temperature during bond formation produced seams with average peel strengths higher than those of the controls. (Edited author abstract). 17 Refs.

Rossiter, Walter J. Jr. (NBS, Gaithersburg, MD, USA). *Mater Struct* v 21 n 124 Jul 1988 p 243-249.

## Thermal Effects

**092011 ROOF TEMPERATURE VARIATIONS AND THEIR EFFECTS ON ROOF NOISE.** This paper predicts the temperature variations of metal roofs and discusses their implications on thermally induced roof noise. The noise burst characteristics generated by both fast and slow temperature variations are studied for various commonly used roof profiles. Remedial actions aimed at reducing or eliminating thermally induced noise on roofs are suggested. (Author abstract) 14 refs.

Tu, C.V. (BHP, Steel Int Group, Aust); Yuen, W.Y.D.; Ellen, C.H. *Mech Eng Trans Inst Eng Aust* v ME 11 n 3 Sep 1986 p 146-157.

## Thermal Insulation

**092012 SEASONAL VARIATIONS IN THE MODES OF HEAT TRANSFER IN A MOIST POROUS THERMAL INSULATION IN A FLAT ROOF.** Glass fiber insulation specimens 60 mm thick, with moisture contents ranging up to 15% by volume, were placed on the roof of the Outdoor Test Building of the Institute for Research in Construction, National Research Council of Canada in Saskatoon, Saskatchewan. The specimens were sealed in polyethylene to prevent the loss of moisture. Thermal conductances were calculated using transfer functions. The results showed an increase in thermal conductance when the weather was warm enough to produce daily reversals in temperature gradient across the wet specimens. In winter, the moisture was deposited in the upper, colder part of the insulation. It was apparently distributed through the upper part of the insulation and not deposited as a solid layer at the top surface, since its effect on thermal conductance indicated by the interior temperature gradient, extended well down in the insulation. (Edited author abstract) 8 refs.

Hedlin, C.P. (Nat'l Research Council of Canada, Saskatoon, Sask, Can). *J Therm Insul* v 11 Jul 1987 p 54-66.

## Wind Effects

**092013 WIND RESISTANCE TESTING FOR ROOF ASSEMBLIES.** Testing standards have been established for rating roofsystem wind resistances. Tests performed by Underwriters' Laboratories (UL) and Factory Mutual (FM) result in product labeling and classifications that affect every roof system installation. Manufacturers wishing to display the UL or FM marking on their products must first submit product samples to the organization for testing and evaluation. Upon satisfactory completion of the test or tests, the manufacturer is given permission to print the appropriate label on its products, provided the material being labeled is the same material as that originally tested by the organization. This article discusses the standards of both organizations.

Coursey, Richard (J.P. Stevens & Co). *Plant Eng (Barrington Ill)* v 42 n 3 Mar 10 1988 p 174-176.

## Wood See ARCHES—Wood.

## Wooden Construction

**092014 FIRE-RESISTANT COATINGS FOR ROOF/CEILING DECK TIMBERS.** Laboratory tests demonstrated that the intumescent resulting from application of some proprietary flame-retardant paint and coating systems to timber planks could reduce char formation in the planks by as much as 70% during the first 30 min of exposure to ASTM E119 fire conditions. Application of these coating systems to the exposed

surfaces of plank used in construction of heavy timber building assemblies should increase the fire resistance of these components by at least 30 min. This would represent a significant increase in the fire resistance of heavy timber roof systems and could extend the use of this type of construction system to many of the non-residential buildings for which building code authorities presently require fire resistance ratings greater than 1 h. (Author abstract) 9 refs.

Richardson, L.R. (Forintek Canada Corp, Ottawa, Ont, Can); Cornelissen, A.A. *Fire Mater* v 11 n 4 Dec 1987 p 191-194.

## ROPE

**092015 ROPES IN EQUILIBRIUM.** The mechanical equilibrium of a rope wrapped around a solid body or around another rope is investigated, with friction and tension being taken into account. Various examples are treated to illustrate the theory. Its application to knots and hitches is indicated. (Author abstract) 3 refs.

Maddocks, John H. (Univ of Maryland, College Park, MD, USA); Keller, Joseph B. *SIAM J Appl Math* v 47 n 6 Dec 1987 p 1185-1200.

## Testing

**092016 DESIGN OF HALL-EFFECT SENSORS FOR MAGNETIC TESTING OF STEEL ROPES.** The design and operating principles of four new Hall-effect sensors for magnetic testing of steel ropes are presented. The radial or tangential component of the magnetic leakage flux can be measured efficiently depending on the shape of the concentrators (rings or sleeves). The output signal can be modified by using multiple constructions of the basic sensors. Different sensors can be used depending on the predominant character of the wear of the rope. (Author abstract) 10 refs.

Kalwa, E.; Piekarski, K. *NDT Int* v 20 n 5 Nov 1987 p 295-301.

## Wear See CABLEWAYS.

**ROTORS** See Also AGRICULTURAL MACHINERY—Design; CENTRIFUGES—Design; COMPRESSORS—Efficiency; CONTROL SYSTEMS, OPTIMAL—Design; ELECTRIC MACHINERY—Analysis; ELECTRIC MACHINERY, SYNCHRONOUS—Stators; ELECTRIC MOTORS, ELECTRIC MOTORS, INDUCTION—Mathematical Models; HELICOPTERS—Rotors; OIL WELL DRILLING—Bits; REFRIGERATING MACHINERY—Compressors; TURBOMACHINERY—Blades; TURBOMACHINERY—Efficiency; TURBOMACHINERY—Vibrations; WIND TURBINES—Rotors; WIND TURBINES—Wind Effects.

**092017 ANALYSIS OF DYNAMIC BEHAVIOR OF ROTORS WITH NONLINEAR ELASTODAMPER SUPPORTS. II.** We present the results of analysis of a three-disc rotor with two nonlinear hydrodynamic dampers. The results are compared with the experimental data. We evaluate the accuracy of the modal analysis method and also compare various methods of numerical integration of the equations of motion. (Author abstract) 3 refs.

Borzdzyko, E.V.; Leont'ev, M.K.; Zvonarev, S.L. *Sov Aeronaut* v 30 n 4 1987 p 7-11.

**092018 COMPUTER SIMULATION AND PARAMETER ESTIMATION OF UNCAVITATED SQUEEZE-FILM BEARINGS.** Development of analytical expressions for the oil-film forces of an uncavitated squeeze-film bearing and linearization of these forces are discussed. The linearization provides theoretical expressions for the damping coefficients. An alternative approach is adapted to obtain optimum coefficient values by using a least square estimator together with the oil-film forces generated by a non-linear simulation program. Comparison of the theoretical and optimum values highlights the need to identify the parameters from experimental data. A simple frequency domain estimation method, which requires the measurement of displacements only, is adopted to identify the bearing parameters from simulated out-of-balance response. (Edited author abstract). 10

Refs.

Sahinkaya, M. Necip (Univ of Strathclyde, Glasgow, Scotl); Kucuk, Noy C. *Bull Tech Univ Istanbul* v 39 n 3 pt 4 1986 p 529-542.

## Accident Prevention See SEPARATORS—Components.

## Acoustic Emission Testing

**092019 RECHERCHE D'UNE METHODE DE DETECTION PRECOCE DE FISSURATION DE ROTOR PAR EMISSION ACOUSTIQUE.** [Development of an Incipient Rotor Crack Detection Method by Acoustic Emission Technique.]. The objective of the program presented is to develop a method of detection and monitoring of crack growth in machine rotor by application of acoustic emission techniques. This program is performed by R and D Division of Electricite de France, jointly with INSA de Lyon. The first task of the program is relative to the characterization of acoustic emission during a progressive tensile test performed on a NCT specimen. The second task of the program deals with the experimentation of acoustic emission techniques for the monitoring of a specimen during cycling bending tests. The last task of the program is relative to evaluation of application of acoustic emission techniques for a small rotor integrity monitoring during fatigue rotation tests. (Author abstract). 9 Refs. In French.

Le Reverend, D. (Service Ensembles de Production, Italy); Massouri, M. H.; Fleishmann, P. *Electr Fr Bull Dir Etud Rech Ser A* n 2 1988 p 21-34.

## Aerodynamics

**092020 FLOW VISUALIZATION AND ANALYSIS OF AERODYNAMICALLY DETUNED SUPERSONIC ROTORS.** The effect of aerodynamic detuning on the supersonic steady and unsteady blade passage flow field is experimentally investigated on a free surface water table by means of color Schlieren and shadowgraph flow visualization techniques. Two aerodynamic detuning mechanisms are considered: (1) alternate circumferential spacing of adjacent airfoils; (2) the replacement of alternate airfoils with splitters. The steady flow visualization demonstrates the significant effect of aerodynamic detuning on the passage flow field and, in particular, the shock wave-airfoil surface intersection locations. The unsteady flow visualization studies show the importance of the interblade phase angle. A mathematical model is also described and utilized to demonstrate the enhanced aeroelastic stability associated with the altered cascade passage shock wave structure due to these aerodynamic detuning mechanisms. (Author abstract) 8 refs.

Farmer, C.S. (Purdue Univ, West Lafayette, IN, USA); Fleeter, S. *Exp Fluids* v 6 n 3 1988 p 145-155.

**092021 AERODYNAMIC INDICIAL RESPONSE AND STABILITY DERIVATIVES OF A ROTOR ANNULUS.** The key to finding the aerodynamic forces acting on a rotor in arbitrary rigid-body motion is its response to indicial input of its individual degrees of freedom. A theory is developed to find such indicial responses for an unloaded rotor annulus moving in its own plane. New rational approximations in the complex-frequency domain are used to find the corresponding transient cascade forces for incompressible flow. The indicial response consists of an initial impulse and an oscillatory decaying part for force components parallel and perpendicular to the applied motion. The harmonic response is also found and is expressed in terms of complex 'rotor-stability-derivatives,' which are essentially the direct- and cross-coupled frequency dependent damping or stiffness force coefficients. Both responses are obtained explicitly in terms of the unsteady cascade characteristics and reduced frequency or time. Parametric studies indicate lowered damping, aerodynamic spring-softening and cross-stiffness whirling forces depen-



dent on the upstream dynamic pressure for perturbation frequencies near the rotor speed. (Author abstract) Refs.

Mengle, V.G. (Univ of California, Los Angeles, CA, USA). *J Vib Acoust Stress Reliab Des* v 110 n 2 Apr 1988 p 178-184.

## Analysis

**092022 WHIRLING OF UNSYMMETRICAL ROTORS: A FINITE ELEMENT APPROACH BASED ON COMPLEX CO-ORDINATES.** The equations of motion for the study of the flexural dynamic behavior of a general rotating system, based on the finite method and on the use of complex coordinates, are described. The model can take into account the presence of the nonrotating parts of the machine and can include damping, both of 'viscous' and 'hysteretic' type. If either the rotor or the non-rotating parts of the machine possess axial symmetry, the whirl-spin map of the system and the response to any given unbalance distribution or fixed force system can be directly obtained. In the more general case of an unsymmetric rotor running on an unsymmetric supporting structure, a series solution is sought for the equation of motion. An example shows that a good precision is obtained when using only the first few terms of this series. (Edited author abstract). 26 Refs.

Genta, G. (Politecnico di Torino, Turin, Italy). *J Sound Vib* v 124 n 1 Jul 8 1988 p 27-53.

**092023 ON DYNAMIC BOUNDARY CONDITIONS IN THE METHOD OF COMPONENT MODE SYNTHESIS.** To the author's knowledge, no research paper has been published on the dynamic boundary conditions of the CMS (Component Mode Synthesis) method in the nonlinear rotor system. In this paper, the dynamic boundary conditions are considered. According to Routh's equation with non-holonomic constraints, the equations of motions for the nonlinear rotor-bearing systems are derived by CMS method, satisfying all the geometric and dynamic boundary conditions. If the dynamic boundary condition contains derivative terms, the condition will have a significant influence on the behaviour of the solution. If the dynamic boundary condition does not contain derivative terms, the effect of the condition on the behaviour of the solution may seem weak. The condition in this case, however, may be used to reduce the degree-of-freedom of the system. (Edited author abstract). 6 Refs. In Chinese.

Gao, Jianmin (Northwestern Polytechnical Univ, China); Cheng, Songqi. *Xibei Gongye Daxue Xuebao* v 6 n 3 Jul 1988 p 343-350.

**092024 APPROXIMATE METHOD FOR SOLVING THE OFFSET SYNCHRONOUS RESPONSES OF FLEXIBLE ROTOR-SQUEEZE FILM DAMPER BEARING SYSTEM.** In order to simplify the response analyses of flexible rotor-uncentrally SFDB (Squeeze Film Damper Bearing) system, the Equivalent Linearizing Method is used for solving the offset synchronous response of the system; the nonlinear fluid film forces are linearized with offset synchronous response and a set of nonlinear algebraic equations for solving the offset response is obtained. In this set of equations, the motion of rotor disk can be represented by the motion of bearing journal, so that the system's degrees of freedom are decreased. Besides, as the problem of solving differential equations is replaced by solving algebraic equations, the computing time can be saved obviously and the analyses are simplified. Numerical results show that the equivalent solution is very near the real solution in the first harmonic approximation, and that the equivalent linearizing method can save computing time greatly compared with direct integrating method. (Edited author abstract). 10 Refs. In Chinese.

Meng, Guang (Northwestern Polytechnical Univ, China); Xu, Jiankang; Xue, Zhongqing. *Xibei Gongye Daxue Xuebao* v 6 n 3 Jul 1988 p 351-360.

**092025 NATURAL FREQUENCIES AND BIPLANAR RESPONSE OF GENERALIZED ROTATING**

**SPINDLE SYSTEMS.** A method of spatial discretization is given here which utilizes a sequence of comparison functions as obtained from associated beam characteristic functions. A varied form of beam characteristic function is utilized which exhibits excellent numerical behavior. A family of program has been developed so as to maximize computational efficiency. The resulting programs require only geometrical, inertia and bearing stiffness parameters and output complete dynamic - and static - performance characteristics. (Author abstract) 13 refs.

Gartner, Joseph R. (Univ of Connecticut, Storrs, CT, USA); Cobb, Eben C. *Rob Comput Integr Manuf* v 4 n 1-2 1988, Manuf Sci, Technol and Syst of the Future, Ljubljana, Yugosl, Sep 12-14 1985 p 165-174.

**Applications** See ELECTRIC MOTORS, RELUCTANCE TYPE—Design.

**Balancing** See Also STEAM TURBINES—Rotors; TURBOMACHINERY—Balancing; TURBOMACHINERY—Computer Aided Design.

**092026 INFLUENCE OF GYROSCOPIC EFFECT ON RESONANCE AVOIDANCE DURING ACCELERATION OF UNBALANCED FLEXIBLE ROTORS.** Vibration of machines with rotors in critical speed zone has been recently extensively studied. Previous papers have dealt with passage of a rotor through the resonance zone disregarding the gyroscopic effect of the rotor. The condition of a safe passage of the resonance zone for the rotor system without damping is derived. The condition for a safe passage through the zone of critical rotational frequency by a flexible Laval shaft is obtained as a function of magnitude of external damping, critical rotational frequency, disbalance, and mass/inertia parameters. In this paper conditions of rotor safe passage through the resonance are analyzed as a function of zone magnitude of external damping; anisotropy of elastic supports; mass and inertia of the rotor; magnitude of disbalance. Also, a formula is derived to determine maximum vibration amplitude in the resonance zone for a given magnitude of the constant torque of the drive motor; and it is shown, that for large external damping the rotor motion can be considered as quasi steady for study of the rotor passage through the resonance zone. i.e., rotation frequency variation can be neglected. 13 refs.

Zobnin, A.P.; Kelzon, A.S.; Neigebauer, I.I. *Vib Eng* v 1 n 1-4 1987 p 269-281.

**092027 MODAL BALANCING OF FLEXIBLE ROTORS DURING OPERATION: DESIGN AND MANUAL OPERATION OF BALANCING HEAD.** Modal balancing experiments are performed with a rotor bearing system by using a single wireless, manually controlled precision balancing head. The balancing head designed is proven to be accurately functioning, effective in modal balancing and reliable well over the first critical speed. In this work, a precision balancing and constructed with much consideration of high gravity fields. Actual experiments are performed and the results are discussed to verify the feasibility of a single plane balancing head for overcoming the first flexible critical speed. (Edited author abstract) 6 refs.

Lee, C.-W. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Kim, Y.-D. *Proc Inst Mech Eng Part C* v 201 n C5 1987 p 349-355.

**092028 UCA BALANCING DEMONSTRATED ON GAS TURBINE ROTOR.** The Unified Constrained Approach (UCA), a tool for the high-speed balancing of flexible rotors, has long been a subject of research of MTI. The value of this technique was recently demonstrated on a gas turbine rotor. During testing, it has been found that large orbits at the dampers tend to cause heating of the damper oil, changing damper performance and consequently the behavior of the rotor. This test illustrates the viability of the UCA in tailoring a balancing approach to the unique requirements of an individual rotor-bearing system. It demonstrates that it is possible to satisfy the criteria necessary for orbit control on this rotor system.

Zorz, E.S. (Mechanical Technology Inc); Martin, M.

*Turbomach Int* v 28 n 6 Sep-Oct 1987 p 8.

**092029 POSITION ERROR OCCURRENCE IN SELF BALANCERS USED ON RIGID ROTORS OF ROTATING MACHINERY.** A self-balancing method is presented which utilizes freely moving balancing bodies rotating in unison with a rotor to be balanced. Because of resistance to motion, eccentricity of race over which the balancing bodies are moving and the influence of external vibrations, it is impossible to attain a complete balance. Each one of these three factors has been analyzed and its influence on the magnitude of balancing body position errors determined. As a result of some inaccuracy in positioning the balancing bodies, certain residual unbalance always remains. (Author abstract) 9 refs.

Tadeusz, Majewski (Warsaw Univ of Technology, Warsaw, Pol). *Mech Mach Theory* v 23 n 1 1988 p 71-78.

**092030 ON A NEW 'DESTABILIZATION' PHENOMENON: EFFECT OF ROTARY DAMPING.** In this note we consider the effect of rotary damping on the instability of Beck's column - almost entirely overlooked in the field of nonconservative problems of elastic stability. Despite the fact that the classical Bernoulli-Euler theory neglects rotary inertia, damping due to this type of motion of the beam cannot always be neglected. 27 refs.

Lottati, I.; Elishakoff, I. *Ing Arch* v 57 n 6 1987 p 413-419.

**092031 OPTIMIZATION OF THE LOW-FREQUENCY BALANCING OF FLEXIBLE ROTORS.** An optimization problem is solved for low-frequency static-dynamic balancing of a flexible rotor. The coordinates of the correction plans and values of the balancing coefficients that deliver the smallest statistical-mean values of the dynamic deflections or rotor-bearing reactions are determined as a result of optimization. The optimization problem is solved by the LP-search method. (Author abstract) 4 refs.

Glizer, A.I. *Sov Mach Sci* n 3 1987 p 75-78.

**092032 SOME PRACTICAL ASPECTS OF BALANCING AN ULTRA-CENTRIFUGE ROTOR.** In this paper the method of balancing centrifuge rotors for three modes based on practical experience is presented. The object is to provide useful and practical information, as technical information on balancing of centrifuge rotors is not available. (Edited author abstract) 7 refs.

Khan, Zubair M. (Dr A.Q. Khan Research Lab, Kahuta, Pak); Suleman, M.; Ashraf, M.; Khan, A.Q. *J Nucl Sci Technol* v 24 n 11 Nov 1987 p 951-959.

**092033 BALANCING DOUBLE-OVERHUNG ROTORS IN THREE CORRECTION PLANES.** Double-overhung rotors, where the main mass is not between the bearings, are now widely used. These rotors are traditionally balanced in two correction planes in the vicinity of the bearings. With overhung rotors, and especially double-overhung rotors, the elastic deflection is affected by the imbalance of the rotor section between the bearings to a greater extent than in the case of end-bearing rotors. Because the initial imbalance is equal to the imbalance to be eliminated, the elastic deflection of the shaft will be proportional to double the initial unbalanced mass between the bearings.

Bulychev, N.Ya. *Sov Eng Res* v 7 n 6 Jun 1987 p 27-28.

**092034 COMPLEX MODAL BALANCING OF FLEXIBLE ROTORS INCLUDING RESIDUAL BOW.** A balancing procedure utilizing the Complex Modal Method is presented for linear flexible rotor dynamic systems including the effect of residual shaft bow. The method does not require trial runs; however, a valid mathematical model of the system dynamics is required to obtain the system's modal parameters, which are used to relate the balance corrections to measured responses. Several balancing strategies based on the extension of previous work are suggested for single-speed



balancing. Two applications are presented: 1) a gas turbine system with computer-generated response data, and 2) an operating steam turbine-generator system. (Author abstract). 9 Refs.

Meacham, W.L. (Allied Signal Aerospace Co, Phoenix, AZ, USA); Talbot, P.B.; Nelson, H.D.; Cooperider, N.K. *J Propul Power* v 4 n 3 May-Jun 1988 p 245-251.

**Bearings** See Also BEARINGS—Gas Lubrication; BEARINGS—Stability; VIBRATIONS—Damping.

**092035 STABILITY OF A RIGID ROTOR SUPPORTED ON FLEXIBLE OIL JOURNAL BEARINGS.** This investigation deals with the stability characteristics of oil journal bearings, including the effect of elastic distortions in the bearing liner. Graphical results are presented for steady-state load, stiffness and damping coefficients, and the stability. These results are given for various slenderness ratios, eccentricity ratios, and elasticity parameters. The lubricant is first assumed to be isoviscous. The analysis is then extended to the case of a pressure-dependent viscosity. It has been found that stability decreases with increase of the elasticity parameter of the bearing liner for heavily loaded bearings. (Author abstract) 16 refs.

Majumdar, Bankim C. (NASA, Cleveland, OH, USA); Brew, David E.; Khonsari, Michael M. *NASA Tech Memo* 89899 1987 28p.

**092036 STUDY OF THE DYNAMIC BEHAVIOR OF ROTOR-BEARING SYSTEMS BY THE FINITE ELEMENT METHOD.** The study of the problems given in this paper is of practical importance in the design of turbomachinery today. Natural characteristics of the rotor-bearing systems were investigated. On the basis of Jeffcott's flexible rotor theory and the finite element method, equations of motion for the rotor-bearing systems with respect to either the fixed frame or the rotary frame were present. Illustration included a single, uniform rotor with bearing supports, a stepped rotor with bearings and rigid disks, and a dual rotor system. Numerical results contained with the whirl modes and whirl speeds. Physical meanings concerning the dynamic behavior of the rotor-bearing systems were detailedly discussed in which the critical speeds related to the excitations were introduced. The computational procedures and results shown in this paper are significant for the understanding of the dynamic behavior of the rotor-bearing systems and helpful for the design of a turbine engine. (Author abstract) 10 refs.

Wu, Shih-Shyn J. (Natl Chung-Hsing Univ, Taichung, Taiwan). *Chung-Kuo Chi Hsueh Kung Ch'eng Hsueh Pao* v 8 n 4 Aug 1987 p 239-250.

**092037 TRANSIENT DYNAMIC ANALYSIS OF ROTORS USING THE COMBINED METHODOLOGIES OF FINITE ELEMENTS AND TRANSFER MATRIX.** A new approach is proposed to predict the dynamic behavior of rotor-bearing systems in time domain using the combined methodologies of finite elements and transfer matrices. This approach makes use of the finite element method to model symmetric shafts and then transforms the system properties to transfer matrix mode. The formulation provides flexibility to include both linear and nonlinear system models, often encountered in rotor dynamic applications. Few example rotor cases had been studied and the results were compared with those obtained using finite element method. This establishes that considerable savings in computational effort can be achieved without losing any accuracy. (Author abstract). 16 Refs.

Subbiah, R. (Stress Technology Inc, Rochester, NY, USA); Kumar, A.S.; Sankar, T.S. *J Appl Mech Trans ASME* v 55 n 2 Jun 1988 p 448-452.

**092038 INSTABILITY AND UNBALANCE RESPONSE OF DISSYMMETRIC ROTOR-BEARING SYSTEMS.** The study deals with the instability and unbalance response of dissymmetric rotors, when periodic differential equations are impossible to avoid. The method which yields motion instability is based on an extension of

the well-known Floquet theory. A transfer matrix over one period of the motion is obtained, and the stability of the system can be tested with the eigenvalues of the matrix. To find the instability and the unbalance response, the Newmark formulation is used. Here, the dissymmetry comes either from the rotor or from the bearings in such a way that it is possible to solve a regular differential system without periodic coefficients, either in the stationary coordinate system or in the rotating one. (Edited author abstract). 18 Refs.

Guilhen, P.M. (CNRS, Villeurbanne, Fr); Berthier, P.; Ferraris, G.; Lalanne, M. *J Vib Acoust Stress Reliab Des* v 110 n 3 Jul 1988 p 288-294.

## Calculations

**092039 CALCULATING THE OPTIMAL GEOMETRIC RELATIONSHIPS FOR A CONICAL ROTOR WITH ALLOWANCE FOR THE EDDY-CURRENT FIELD REACTION.** Expressions are given for determining the optimal relationships in the conical rotor of an electromagnetic damper (brake) that will maximize the ratio of electromagnetic torque to rotor moment of inertia when the damper operates in the linear and nonlinear regions of the mechanical characteristic. (Author abstract) 5 refs.

Khairullin, I.Kh.; Ismagilov, F.R.; Nurmukhametov, M.N. *Sov Electr Eng* v 57 n 8 1986 p 37-40.

**Compressors** See MECHANISMS—Mathematical Models.

## Computer Aided Design

**092040 APPLICATION OF ADVANCED COMPUTATIONAL CODES IN THE DESIGN OF AN EXPERIMENT FOR A SUPERSONIC THROUGH-FLOW FAN ROTOR.** Increased emphasis on sustained supersonic or hypersonic cruise has revived interest in the supersonic throughflow fan as a possible component in advanced propulsion systems. Use of a fan that can operate with a supersonic inlet axial Mach number is attractive from the standpoint of reducing the inlet losses incurred in diffusing the flow from a supersonic flight Mach number to a subsonic one at the fan face. The data base for components of this type is practically nonexistent; therefore, in order to furnish the required information for assessment of this type fan, a program has been initiated at the NASA Lewis Research Center to design, build, and test a fan rotor that operates with supersonic axial velocities from inlet to exit. This paper describes the design of the experiment using advanced computational codes to calculate the unique components required. (Edited author abstract) 24 refs.

Wood, J.R. (NASA, Cleveland, OH, USA); Schmidt, J.F.; Steinke, R.J.; Chima, R.V.; Kunik, W.G. *J Turbomach* v 110 n 2 Apr 1988 p 270-279.

**Construction** See ELECTRIC MOTORS, INDUCTION—Rotors.

## Deformation

**092041 INVESTIGATING THE STRESSED-DEFORMED STATE OF ROTORS ON A STANDARD SERIES OF MILL EXHAUSTERS.** The Syzransk Turbine Construction Works and the Central Boiler-Turbine Institute (NPO TsKTI) have developed a series of mill exhausters designed for grinding brown coals. In order to draw up a reliable engineering method for calculating the stressed-deformed state of the impeller as the key assembly of the exhauster, strength tests were carried out on prototype specimens of mill exhausters on a test rig in the factory. The stress at individual points on the casing of the impeller was measured experimentally using 2PKB-10-200 tensoresistors which were first stuck (adhesive BF-2) onto plates made of cold-rolled foil 2Kh18N9T 0.1 mm in thickness, then processed in a thermostat. The tensoresistors were installed on the rotor by spot welding using special equipment. 4 refs.

Abrosov, A.N.; Trifskii, M.L.; Chernov, V.A.; Zotov, Yu.

*V. Sov Energy Technol* n 7 1987 p 29-32.

**Design** See Also HYDRAULIC TURBINES—Blades; HYDRAULIC TURBINES—Models.

**092042 KRUCHE PEKANIE WIRNIKOW. [Brittle Fracture of Rotors].** Machine rotors must be made out of steels which ensure a ratio of the nominal plasticity limit to the tensile strength of less than 0.7. For other steels the threshold and critical crack length must be calculated. By comparing them with the length of the largest fault allowed by the forging manufacturer, a rotor design with or without an axial hole may be selected. In the case of high-speed rotors the safer design is the one with an axial hole. In Polish. 13 refs.

Laczowski, Ryszard. *Przegl Mech* v 46 n 10 May 1987 p 8-11.

## Electromagnetic Field Effects

**092043 ELECTROMAGNETIC CONTROL OF OIL-FILM SUPPORTED ROTORS USING SPARSE MEASUREMENTS.** An electromagnetic controller is applied to a flexible rotor supported by two oil-film bearings. The synchronous vibration is controlled by using a combined estimation and optimization algorithm. This requires no a priori knowledge of the system model. The effect of using a limited number of measurement sites on the controller performance is assessed. Optimum measurement sites are defined. The results of both computer simulations and experimental studies are presented. It is shown that the strategy developed by the authors can reduce the synchronous vibration to less than 10 percent of the uncontrolled response. The open-loop adaptive strategy can be applied to reduce the time required for in-situ tuning of magnetic controllers. (Author abstract). 12 Refs.

Burrows, C.R. (Univ of Strathclyde, Glasgow, Scotl); Sahinkaya, M.N.; Clements, S. *J Vib Acoust Stress Reliab Des* v 110 n 3 Jul 1988 p 295-299.

**Fatigue** See Also ELECTRIC GENERATORS—Rotors; STEAM TURBINES; STEAM TURBINES—Rotors; STEEL—Strain.

**092044 INFLUENCE OF RELATIVE SLIP RANGE AND CONTACT MATERIAL ON THE FRETTING FATIGUE PROPERTIES OF 3.5NiCrMoV ROTOR STEEL.** The influence of relative slip range and contact material on the fretting fatigue properties of 3.5NiCrMoV rotor steel has been investigated. Two generator rotor slot wedge materials, 1CrMo steel and 2014A aluminum alloy, were employed as contact materials. The results indicate that the observed relationships between both relative slip range and contact material and the fretting fatigue strength of 3.5NiCrMoV steel can be fully rationalized in terms of surface fretting contact stresses. Relative slip range and contact material are themselves of secondary importance. Fretting fatigue tests have been interrupted and specimens broken open, demonstrating that small cracks can initiate by fretting at stresses considerably below the fretting fatigue limit. The size of these nonpropagating cracks is related to the frictional and normal forces at the fretting contact and is independent of externally applied stresses and relative slip range, at least over the range of conditions investigated. (Edited author abstract). 14 Refs.

Nix, K.H. (Central Electricity Research Lab, Leatherhead, Engl); Lindley, T.C. *Wear* v 125 n 1-2 Jul 1988 p 147-162.

**Fluid Dynamics** See Also FLOW OF FLUIDS—Wakes; TURBOMACHINERY—Blades.

**092045 INVESTIGATION ON THE FLOW FIELDS AND POWER MECHANISM OF A SAVONIUS ROTOR. (FLOW VISUALIZATION BY A SMOKE-WIRE METHOD).** Unsteady flow fields around a Savonius rotor and its power mechanism are studied by a flow visualization experiment for various rotor angles and tip-speed ratios. For small tip-speed ratios, the rotor receives a corotating torque mainly due



to the difference of the drag on both the blades. As the tip-speed ratio increases a Coanda-like flow pattern is formed on the convex side of an advancing blade, and the corotating torque is expected by the induced lift, though the torque due to the difference of the drag decreases. The power performance of a Savonius rotor can be explained reasonably by the flow visualization results. (Author abstract) In Japanese. 16 refs.

Fujisawa, Nobuyuki (Shirai, Hiroyuki); Saikawa, Yuji. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 496 Dec 1987 p 3716-3721.

**Forging** See FORGING—Simulation; STEAM TURBINES—Rotors.

## Forming

**092046 PROPERTIES OF LARGE A286 ALLOY ROTOR FORGING.** This paper describes the preliminary investigation, manufacture, and properties of a trial A286 rotor forging, to establish the manufacturing process of large A286 alloy forging planned to be applied to rotor material used at temperatures above 593°C for ultra-supercritical steam turbines. First, Ti contents and heat treatment conditions were investigated to improve the creep rupture ductility. Subsequently, a large trial A286 alloy rotor forging of 850mm barrel diameter, weighing 8.9 tons, was manufactured from a 16 ton electro slag remelted ingot, and its properties were tested. Chemical composition of the trial A286 alloy rotor forging shows little variation, and its grains are fine and uniform (2.5-3.5 in ASTM G.S.No.). Its mechanical properties are comparable to those of small forgings with a conventional Ti content, reported previously. The good mechanical properties are caused by relatively lower Ti content and application of three-step aging treatment. (Author abstract) 7 refs.

Kohno, Masayoshi (Kobe Steel, Jpn); Honjo, Takemitsu; Kinoshita, Shushi; Suzuki, Akira. *Kobelco Technol Rev* n 2 Aug 1987 p 41-44.

**Grinding** See Also AIRCRAFT ENGINES, JET AND TURBINE—Rotors.

**092047 SCHLEIFEN VON ROTOREN FUER STRAHLTRIEBWERKE.** [Grinding of Rotors for Jet Engines]. Jet engines of civil aircraft are required to operate at optimum fuel utilization and minimum noise level. This results in the necessity for their regular overhauling involving maintenance work on the blades which are subject to wear. Final machining of the blade tips on the assembled and fully equipped rotor is done by grinding. The newly developed high-speed rotor grinding machine constitutes substantial progress and even represents a new technology. (Edited author abstract) In German.

Gohritz, Armin; Kuhfuss, Bernd; Havenith, Hubert. *Werkstatt Betr* v 120 n 10 Oct 1987 p 797-800.

**Heat Transfer** See GAS TURBINES—Blades.

## High Temperature Effects

**092048 ADVANCED 12Cr STEEL ROTOR APPLICABLE TO ELEVATED STEAM TEMPERATURE 593°C.** The upper limit of steam temperature which 12Cr steel rotors can withstand has been considered to be 566°C, but the recent projects on the advanced steam turbine of large capacity demand to raise it. The key factor in upgrading the creep rupture strength of the existing 12Cr steel rotors is to adjust 'Equivalent Molybdenum Content' to the optimum, which is 1.5 percent in case no tungsten is contained. A HP-IP rotor, of 11 tons in final machined weight, for EPDC's Wakamatsu high-temperature turbine to be operated with 593/593°C steam, Mn 0.51, P 0.013, S 0.001, Ni 0.60, Cr 10.23 Mo 1.48, V 0.17, Nb 0.056, N 0.045, and Al 0.002 percent, respectively, through ESR process. Its creep rupture strength after heat treatment is 122 MPa for 593°C and 10<sup>5</sup> hr. The paper reports the concept of this material and the actual achievement in Wakamatsu forging, referring to the

working condition expected on the rotors for 1000 MW-class advanced steam turbine. (Author abstract) 8 refs.

Hizume, A. (Mitsubishi Heavy Industries Ltd, Tokyo, Jpn); Takeda, Y.; Takano, Y.; Suzuki, A.; Kinoshita, S.; Kono, M.; Tsuchiyama, T. *J Eng Mater Technol Trans ASME* v 109 n 4 Oct 1987 p 319-325.

## Inspection

**092049 TURBINES MISSILES ASSESSMENT.** In a study commissioned by the U.S. Nuclear Regulatory Commission (NRC), Pacific Northwest Laboratory evaluated the costs and benefits of modifying regulatory requirements in the area of the turbine rotor design reviews and inspections. The basis for the analysis was presented in the Regulatory Analysis Guidelines and in the Handbook for Value-Impact Assessment. The effects of selected modifications to regulations were evaluated in terms of public risk and costs to industry and the NRC. The results indicate that substantial savings in operating costs may be realized by changing the interval of turbine rotor inspections. (Author abstract) 19 refs.

Vo, Truong V. (Pacific Northwest Lab, Richland, WA, USA). *Nucl Technol* v 82 n 1 Jul 1988 p 21-35.

## Magnetic Field Effects

**092050 SYNTHESIS OF A LINEAR OPTIMUM CONTROL SYSTEM FOR THE MAGNETIC SUSPENSION OF A RIGID ROTOR.** A procedure is developed for synthesis of a linear optimum multidimensional system for control of the active magnetic suspension of a rigid rotor with minimum integral rms control error in transients. Calculations and tests are reported for a rotor magnetic suspension control system for an experimental high-speed motorized spinle. (Author abstract) 12 refs.

Zhuravlev, Yu.N. *Sov Mach Sci* n 4 1987 p 44-51.

**Manufacture** See ELECTRIC MOTORS—Manufacture.

**Materials** See STEAM TURBINES—Design; STEEL—Hydrogen Embrittlement; TITANIUM AND ALLOYS—Fracture.

## Mathematical Models

**092051 CONICAL ELEMENT FOR FINITE ELEMENT ROTOR DYNAMICS.** A conical beam element for rotor dynamic analysis is proposed. The element, with circular or annular cross-section, is based on the Timoshenko beam theory. It has two complex degrees of freedom at each node. The procedure for the computation of the stiffness, mass, gyroscopic damping matrices and of the unbalance vector is fully described. (Author abstract) 8 refs.

Genta, G. (Politecnico di Torino, Turin, Italy); Gugliotta, A. *J Sound Vib* v 120 n 1 Jan 8 1988 p 175-182.

**092052 DYNAMICS OF VISCOELASTIC ROTORS.** The stability of two mathematical models of a viscoelastic rotor - a 2-parameter solid model and a 3-parameter solid model - is investigated by means of a complex Routh-Hurwitz analysis. While the 2-parameter model possesses a certain well-known stability limit for the angular velocity, it is shown that the 3-parameter model has two stable regions for the angular velocity, separated by an unstable one, if the coefficient of external damping is less than a special value  $d_c^*$ . For external damping coefficients greater than  $d_c^*$ , the rotor is stable for all angular velocities. It is interesting that the stabilizing value  $d_c^*$  does not depend on the coefficient of internal damping. Moreover, the general result for the 3-parameter model is shown to include the following special cases: small external and internal damping coefficients, and very large internal damping coefficient. (Author abstract) 11 refs.

Kliem, W. (Engineering Acad of Denmark, Lyngby, Den). *Dyn Stab of Syst* v 2 n 2 1987 p 113-123.

**092053 SYSTEME DE REFERENCE D'UN OBJET MESURE ROTATIF.** [Frame of Reference of Rotating Measured Object]. The article describes three types of frames of reference used in the study of electrodynamic problems of rotating bodies. The reduction of complexity of the mathematical description of these problems needs introduction of simplifying assumptions, through which the possibility of quantitative expression of the relativistic second-order effects is lost and single types of the description are consequently of formal similarity. (Edited author abstract) 12 refs. In Czech.

Kubikova, Marta (Vyzkumny Ustav Merici Techniky, Brno, Czech). *Elektrotech Obz* v 76 n 7 Jul 1987 p 361-364.

**Mechanical Properties** See AIRCRAFT—Wings.

**Noise, Acoustic** See Also TEXTILE MACHINERY—Vibrations.

**092054 ANALYSIS OF THE ACOUSTIC PLANFORM METHOD FOR ROTOR NOISE PREDICTION.** This study analyzes the acoustic planform method as an alternative to using the equation of Ffowkes Williams and Hawkings for predicting transonic and supersonic rotor noise. The studied method avoids the singularity encountered when the noise source travels towards the observer at sonic velocity. It introduces the necessity for computing acoustic planforms and integrating over them. Results are presented for a rotating, rectangular, monopole surface with supersonic tip velocity. These computations show a decrease in peak acoustic pressure as the tip speed increases beyond a critical supersonic Mach number. The results provide an explanation for some experimental data and some guidelines for proceeding on to the prediction of actual rotor noise. (Author abstract) 6 refs.

Wells, Valana L. (Arizona State Univ, Tempe, AS, USA). *AIAA J* v 26 n 5 May 1988 p 522-523.

## Optimization

**092055 OPTIMAL DESIGN OF SQUEEZE FILM DAMPERS FOR FLEXIBLE ROTOR SYSTEMS.** Optimization techniques are employed to design squeeze film dampers for minimum transmitted load to the bearing and foundation in the operational speed range. The rotor systems are modeled by finite element formulation. The maximum transmitted load in the operational speed range is the objective function that is minimized using mathematical nonlinear programming (NLP) techniques. The damper design parameters are the radius, length, and radial clearance. Stability of the equilibrium solutions are investigated in the design procedure. Design derivatives have been determined in closed form expression without resolution of the inherently nonlinear problem. A parametric study of the transmitted force is carried out to show the influence of damper parameters on the response and to demonstrate the merits of applying optimization techniques in damper design. Two numerical examples are presented that illustrate the effectiveness of optimizing squeeze film damper designs for reducing transmitted load. (Author abstract) 33 Refs.

Chen, W.J. (Arizona State Univ, Tempe, AZ, USA); Rajan, M.; Rajan, S.D.; Nelson, H.D. *J Mech Transm Autom Des* v 110 n 2 Jun 1988 p 166-174.

**Performance** See Also HELICOPTERS—Man Powered; WIND TURBINES—Rotors.

**092056 INFLUENCE OF REYNOLDS NUMBER ON PERFORMANCE MODELING OF HORIZONTAL AXIS WIND ROTORS.** This paper investigates the influence of Reynolds number on performance modeling of horizontal axis wind rotors. A procedure for accounting for Reynolds number effects on airfoil section models was developed and implemented for NACA 0012 and NACA 4415 profiles. For symmetrical airfoils, this effect on performance was only significant for low tip-speed ratios, while cambered airfoils were affected more uniformly at all operating conditions. Changes in performance were induced by parametric variations of wind speed, rotor scale,



and rotor generating mode using the Reynolds number dependent section models. Results show that wind speed variations are more significant for smaller rotors at lower wind-speeds, and section models represented at only a single Reynolds number are more suitable for the analysis of constant RPM rotors. (Edited author abstract) 11 refs.

Musial, W.D. (Univ of Massachusetts, Amherst, MA, USA); Cromack, D.E. *J Sol Energy Eng Trans ASME* v 110 n 2 May 1988 p 139-144.

## Seals

**092057 THEORY VERSUS EXPERIMENT FOR THE ROTORDYNAMIC COEFFICIENTS OF LABYRINTH GAS SEALS. PART I: A TWO CONTROL VOLUME MODEL.** The basic equations are derived for a two-control-volume model for compressible flow in a labyrinth seal. The recirculation velocity in the cavity is incorporated into the model for the first time. The flow is assumed to be completely turbulent and isoenergetic. The wall friction factors are determined using the Blasius formula. Jet flow theory is used for the calculation of the recirculation velocity in the cavity. Linearized zeroth and first-order perturbation equations are developed for small motion about a centered position by an expansion in the eccentricity ratio. The zeroth-order pressure distribution is found by satisfying the leakage equation while the circumferential velocity distribution is determined by satisfying the momentum equations. (Edited author abstract). 23 Refs.

Scharrer, Joseph K. (Texas A&M Univ, College Station, TX, USA). *J Vib Acoust Stress Reliab Des* v 110 n 3 Jul 1988 p 270-280.

**092058 THEORY VERSUS EXPERIMENT FOR THE ROTORDYNAMIC COEFFICIENT OF LABYRINTH GAS SEALS. PART II: A COMPARISON TO EXPERIMENT.** An experimental test facility is used to measure the leakage and rotordynamic coefficients of teeth-on-stator labyrinth gas seals. The test results are presented along with the theoretically predicted values for the two seal configurations at three different radial clearances and shaft speeds to 16,000 cpm. The test results show that the theory accurately predicts the cross-coupled stiffness for both seal configurations and shows improvement in the prediction of the direct damping for the teeth-on-rotor seal. The theory fails to predict a decrease in the direct damping coefficient for an increase in the radial clearance for the teeth-on-stator seal. (Author abstract). 15 Refs.

Childs, D.W. (Texas A&M Univ, College Station, TX, USA); Scharrer J.K. *J Vib Acoust Stress Reliab Des* v 110 n 3 Jul 1988 p 281-287.

**Stability** See Also BEARINGS—Journal; COMPRESSORS—Rotors; DYNAMICS; TEXTILE MACHINERY—Stability; WIND TURBINES—Rotors.

**092059 STABILITY LIMITS OF FLEXIBLE ROTOR SUPPORTED BY JOURNAL BEARINGS WITH PRESSURE DIFFERENCE BETWEEN BOTH ENDS (2ND REPORT, THEORETICAL ANALYSIS - PART 2).** The effects of mean radial clearance and bearing length on the stability threshold speed are investigated. The dynamic Reynolds equation is applied to the system, and numerically solved with the pressure drop mainly due to the axial acceleration of the oil at the inlet end of journal bearing being taken into account. The stability threshold speed is obtained by linearizing the equation of motion about the equilibrium and applying the Birstow-Hitchcock method to solve the characteristic equation. The stability threshold speed increases with pressure difference except for the range of low pressure difference regardless of the dimensions of mean radial clearance and bearing length. (Edited author abstract) In Japanese. 1 ref.

Kaneko, Satoru. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 492 Aug 1987 p 1691-1696.

**092060 STABILITY OF A RIGID ROTOR SUPPORTED ON FLEXIBLE OIL JOURNAL BEARINGS.** This investigation deals with the stability charac-

teristics of oil journal bearings, including the effect of elastic distortions in the bearing liner. Graphical results are presented for (1) steady-state load, (2) stiffness and damping coefficients, and (3) the stability. These results are given for various slenderness ratios, eccentricity ratios, and elasticity parameters. The lubricant is first assumed to be isoviscous. The analysis is then extended to the case of a pressure-dependent viscosity. It has been found that stability decreases with increase of the elasticity parameter of the bearing liner for heavily loaded bearings. (Author abstract) 16 refs.

Majumdar, B.C. (NASA, Cleveland, OH, USA); Brewe, D.E.; Khonsari, M.M. *J Tribol Trans ASME* v 110 n 1 Jan 1988 p 181-187.

**092061 STABILITY ANALYSIS OF A LOADED RIGID ROTOR IN HERRINGBONE GASDYNAMIC BEARINGS.** A stability analysis is performed for a rigid symmetric rotor in herringbone-grooved gasdynamic bearings in the case of loading by a transverse force. Whipple's equation is used with small compressibility numbers to obtain analytic expressions for the dynamic reactions of the lubricant film in the form of series in the relative eccentricity. The stability of the off-center equilibrium position is investigated. (Author abstract) 3 refs.

Kremer, M.I.; Fridman, V.M. *Sov Mach Sci* n 4 1987 p 98-102.

**092062 STABILITY OF A RIGID ROTOR SUPPORTED BY AEROSTATIC JOURNAL BEARINGS WITH CIRCULAR SLOT RESTRICTORS (ON THE DOUBLE-ROW ADMISSION BEARING).** This paper discusses the stability of a rigid rotor supported by double-row admission journal bearings with circular slot restrictors. In the theoretical analysis, the energy loss at the outlet of the slot is taken into account because the gas flow is subject to a rapid change in direction, and here, the energy loss coefficient is determined experimentally. It is found that a better agreement between the theoretical and experimental results for the threshold of instability can be obtained by considering the energy loss. Furthermore, in this paper, it is shown experimentally that an aerostatic journal bearing with circular slot restrictors has higher stiffness and higher stability than a conventional point source bearing with inherently compensated feeding holes. (Author abstract) 5 refs.

Yoshimoto, S. (Science Univ of Tokyo, Tokyo, Jpn); Anno, Y.; Ohashi, T. *J Tribol Trans ASME* v 110 n 2 Apr 1988 p 228-234.

**092063 ANALISI DELLA STABILITÀ DI UN ROTORE RIGIDO SU CUSCINETTI POROSI LUBRIFICATI.** [Analysis of Stability of a Rigid Rotor on Lubricated Porous Bearings]. An investigation of the dynamic behavior of a rigid and balanced rotor, rotating at constant speed in porous bearings, has been carried out. In order to evaluate the dynamic stiffness and damping coefficients and the critical stability parameter, the short bearing model for porous bearings was used. These parameters, in a dimensionless form, are reported in graphs and tables for various permeability coefficients. (Author abstract). 16 Refs. In Italian.

Capone, G. (Univ di Napoli, Naples, Italy); D'Agostino, V. *Energ Elettr* v 65 n 5 May 1988 p 229-236.

**092064 STABILITY OF ROTORS IN COMPRESSIBLE FLUID-FILM BEARINGS.** A power-shaped multipad hydrodynamic journal bearing working in compressible fluid is described here that is suitable for high-speed turbomachines. This type of bearing is much simpler than tilting pad or foil journal bearings and will provide satisfactory results for machines intended to operate under relatively constant environmental and operating conditions. The work presented here is mostly analytical. Load capacity and the phase angle are calculated for the steady-state condition by numerically solving the nonlinear Reynolds equation. (Edited author abstract). 12 Refs.

Agrawal, G.L. (United Technologies Corp, Windsor Locks, CT, USA). *J Propul Power* v 4 n 5 Sep-Oct 1988

p 437-444.

**Stresses** See Also CENTRIFUGES—Rotors; COMPRESSORS—Calculations; HYDRAULIC TURBINES—Rotors; STEAM TURBINES—Analysis; TURBOGENERATORS—Deformation.

**092065 STRESS-STRAIN STATE AND BEARING STRENGTH OF A SEPARATOR ROTOR MADE OF HARDENED COMPONENTS.** The authors study the stress-strain state and the bearing strength of a self-discharging separator rotor having a diameter of 500 mm, made of components which have gone through a hardening cycle. We investigated three variants of the rotor of identical design, differing in the materials used for the body components, which were austenitic-class steels 06Kh17N13M3-VD and ALIII-23-43-02 and austenitic-ferritic class steels. The stress-strain state of a rotor was studied by the numerical method of finite elements for an axisymmetric problem. As a result of the calculations, we obtained the components of displacements and stresses, and also the main stresses at the nodal points. Strength was evaluated by analyzing the equivalent stresses determined by the fourth theory of strength. The highest stresses act on nodes 148 and 336 and amount to 195 and 160.7 MPa, respectively. 8 refs.

Rachkov, V.I.; Gusakov, B.F.; Balandin, V.A.; Kutepov, S.M. *Chem Pet Eng* v 22 n 5-6 May-Jun 1986 p 262-265.

**092066 EXPERIMENTAL STUDY OF STRESS-STRAIN STATE OF MODELS OF BIPLANE HYDRAULIC SEAL ROTORS.** Hydraulic seals of the pressure lines are one of the most important components in the hydromechanical equipment of hydroelectric power plants and pump-houses. Disk ( $H \leq 230$  m) and spherical ( $H > 200$  m) seals are installed in domestic hydrounits. The stress-strain state of a series of model hydraulic seal rotors of the biplane type was investigated for operation at different heads  $H = 160-270$  m. The models were made of steel, intended for manufacture of the full-scale steel rotors. 3 refs.

Sin'ko, S.N.; Shilov, V.P.; Gushinskaya, B.Kh. *Sov Energy Technol* n 6 1987 p 7-10.

## Structural Analysis

**092067 DYNAMICS OF THE ROTOR SYSTEM WITH A TORSIONAL CRACK (A QUALITATIVE ANALYSIS USING A SIMPLE ROTOR MODEL).** In this study, a qualitative analysis of the dynamics of a rotor system with a torsional crack that grows at an angle of 45 degrees toward the axis of the shaft is presented. On the assumption that the bending stiffness of the shaft changes synchronously with the open-close behavior of the crack caused by the torsional vibration of the shaft, the equation of motion of the simple rotor with a torsional crack is represented by a differential equation with parametric excitation on the coordinate system rotating at the operation speed of the rotor. The solution of the equation shows that the steady-state response of the rotor system with the torsional crack contains the frequencies represented by  $m\Omega + n\Omega_T$ ;  $m = 1, 2$ , and  $N = 0, 1, 2, \dots$ , where  $\Omega$  is the operation speed of the rotor, and  $\Omega_0$  is the frequency of torsional vibration of the shaft. (Author abstract). 6 Refs. In Japanese.

Ichimonji, Masayuki; Watanabe, Shunzo. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 501 May 1988 p 1054-1061.

**Testing** See COMPRESSORS—Testing.

**Thermal Effects** See TURBOGENERATORS—Rotors.

**Vibrations** See Also BEARINGS—Roller; BEARINGS—Testing; DISKS—Rotating; SHAFTS AND SHAFTING—Speed Control; SHAFTS AND SHAFTING—Vibrations.



**092068 AMPLITUDE-FREQUENCY ANALYSIS OF THE MOTION OF MULTIPLE-IMPELLER ROTORS WITH A VIEW TO THE EFFECT OF THE LUBRICANT LAYER OF THE BEARINGS.** To determine the amplitude-frequency response of rotors, a mathematical model was suggested previously. Using this as a basis, a computer program was developed. An example is used to illustrate the program's capabilities. It is shown that this program can be used for analyzing the dissipative system consisting of a rotor and supports; it increases the accuracy of the calculation of the critical angular velocities, and provides the designer with much wider possibilities for a comprehensive analysis of the dynamics of the rotor. The program KS-ID may also be used for the theoretical analysis of flexible rotors of pumps, centrifuges and other machines. 3 refs.

Shnepp, V.B.; Khamidullin, I.V.; Yagafarov, I.M.; Gimadeeva, V.A. *Chem Pet Eng* v 22 n 7-8 Jul-Aug 1986 p 319-322.

**092069 HOLOGRAPHIC RAPID CONTROL OF VIBRATION FREQUENCIES OF ROTORS OF COMPRESSED-GAS AGGREGATES.** The rotors of turbo-compressed-gas aggregates operate under dynamic loads; this places strict requirements as to the precision of the determination of vibration frequencies. To overcome the shortcomings of current techniques, the authors used contact-free optical approaches, based on the inversion of the contrast of the interference bands and reduction in visibility of vibrating sections. The stand for the determination of the frequencies of natural vibrations of the rotor includes a module for the excitation of the rotor and an optical module for the recording and reconstruction of the holograms. The fact that the sensitivity of holographic interferometry can be adjusted by changing the angle  $\beta$  and consequently the number of interference lines on the object and that the vibrations can be observed visually, gives high reproducibility and precision to the test. The time required for a rapid test of the rotor is less than two hours. The tests based on the rapid holographic control of the vibration frequency characteristics lead to the development of a rotor design which gives the required efficiency and long life to the machine. The use of the turbo-compressed-gas aggregates in air liquefaction plants has confirmed the validity of the design solutions. 5 refs.

Dvorkin, B.M. *Chem Pet Eng* v 22 n 5-6 May-Jun 1986 p 175-177.

**092070 BERECHNUNG DER BIEGESCHWINGUNGEN VON TURBOMASCHINENROTOREN MIT DEM PROGRAMM ANISO.** [Calculation of Bending Vibrations of Turbine Rotors by Means of the Program ANISO]. With the electronic data processing program ANISO including the associated programs LAPARA, AEROK, and FUPARA, an important means is available to design turbines, by means of which the plant can be protected from dangerous bending vibrations of the rotor and a high smooth running can be obtained. Possibilities of programs are presented, influence coefficients are discussed and a calculation example is stated. (Author abstract) In German. 10 refs.

Schubert, K.-H. (VEB Bergmann Borsig, East Ger). *Maschinenbautechnik* v 36 n 7 Jul 1987 p 305-309.

**092071 BIFURCATING SELF-EXCITED VIBRATIONS OF A HORIZONTALLY ROTATING VISCO-ELASTIC SHAFT.** Self-excited postcritical vibrations of a rotating geometrically non-linear shaft caused by internal friction are analyzed in this paper using the Hopf bifurcation theory. Stable periodic vibrations bifurcate from the non-trivial equilibrium which becomes unstable itself. Ordinary differential equations of motion are obtained by means of Galerkin's method. Bifurcating periodic solution is constructed in a parametric form due to Iooss and Joseph. (Author abstract) 4 refs.

Kurnik, W. *Ing Arch* v 57 n 6 1987 p 467-476.

**092072 DYNAMICS OF THE UNBALANCED ROTOR IN MULTICENTER SLIDING JOURNAL BEARINGS WITH NONISOTHERMAL LUBRICA-**

**TION.** An algorithm is proposed for solution of a nonlinear, nonstationary hydrodynamic problem of lubricant flow in multicenter sliding bearings with allowance for thermal processes. The reliability of the mathematical model used and its implementation procedure are confirmed experimentally. It is found that the linear theory of small perturbations is not accurate enough for calculation of the vibrations of rotors in multicenter bearings of high-speed turbomachines. Allowance for nonisothermal lubricant flow makes it possible to improve the path traced by the center of the journal and the minimum lubricant-film thickness, and to determine maximum lubricant temperature. (Author abstract) 7 refs.

Maksimov, V.A.; Mozhanov, V.V. *Sov Mach Sci* n 3 1987 p 87-91.

**092073 ROTATION OF A ROTOR BY MEANS OF AN ELASTIC ROD UNDER THE ACTION OF VIBRATIONS DURING SHIPMENT.** During shipment of machines with rotors mounted in antifriction bearings, these bearings are often damaged by fretting corrosion. This phenomenon develops under conditions such that the force acting on the bearing is quite high and the relative displacements of the rolling bodies and races are limited. Devices that rotate the rotor during shipment and provide for a supply of lubricant to the contact zone between the rolling bodies and the races are used to prevent bearing damage. One of the simplest and most effective protective devices is the elastic-rod system. In this paper the authors determine the regions of existence of various rotation regimes in parameter space and the shaft rotation frequency  $\Omega$ , when rotation occurs without separation from the rod and investigate this frequency as a function of the parameters of the device. Since the rotation frequency has little influence on the effectiveness of protection, the authors concentrate their attention on the conditions under which rotation occurs. (Edited author abstract) 5 refs.

Doroshko, A.D.; Iofin, L.E.; Presler, K.Kh. *Sov Mach Sci* n 3 1987 p 92-94.

**092074 HIGH ORDER SUBHARMONIC RESPONSE OF HIGH SPEED ROTORS IN BEARING CLEARANCE.** Subharmonic vibration refers to the response of a dynamic system to excitation at a whole-number multiple ( $n$ ) of its natural frequency by vibrating asynchronously at its natural frequency, that is, at  $(1/n)$  of the excitation. The phenomenon is generally associated with asymmetry in the stiffness vs. deflection characteristic of the system. It may be characterized as the 'bouncing' of the rotor on the surface of the stiff support, energized by every  $n$ th unbalance impulse prior to contact. Second, observed in high speed rotating machinery with such an asymmetry in the bearing supports. An incident is reported where 8th and 9th order subharmonic vibration responses have been observed in a high speed rotor. A simple but exact computer model of the phenomenon has been evolved based on the numerical integration of a finite difference formulation. (Edited author abstract) 6 refs.

Ehrich, F.F. (GE, Lynn, MA, USA). *J Vib Acoust Stress Reliab Des* v 110 n 1 Jan 1988 p 9-16.

**092075 SPECIAL CASE OF CRITICAL SPEED OF RIGID ROTORS WITH ANISOTROPIC SUPPORTS.** The critical speed of vertical rigid rotors, elasticity supported at both ends and having an angular difference between the principal axes of elasticity at the lower support and that at the upper, has been investigated. Such a rotor system is found in machinery in which the support stiffness is much softer than that of the shaft, such as a centrifugal separator. The critical speed generally depends on the angular difference, but it is found that the critical speed becomes independent of the angular difference when the rigid rotors satisfy a special condition. The physical explanation for this special case is given. Finally, such a special condition for overhung rotors is also considered. (Author abstract) 3 refs.

Iwata, Y. (Kanazawa Univ, Kanazawa, Jpn); Sato, H.; Tamura, A. *J Sound Vib* v 121 n 1 Feb 22 1988 p 161-168.

**092076 VIBRATION AMPLITUDES OF MISTUNED BLADES.** Due to the mistuning effect, the nominally identical blades on a rotor are forced to vibrate with greatly unequal amplitudes under certain circumstances. It is, therefore, desirable to have the capability of predicting the highest responding blades so that such blades may be instrumented during engine tests. Good agreement is obtained when the results of this study, which is based on a model with structural coupling, are compared with those of other investigators utilizing models with aerodynamic and structural coupling. It is concluded that if the primary resonance being excited is not in a 'crossover' zone, the highest responding blades are most likely to be those with extreme mistuning. (Edited author abstract) 21 refs.

Afolabi, D. (Purdue Univ, Indianapolis, IN, USA). *J Turbomach* v 110 n 2 Apr 1988 p 251-257.

**092077 TRANSIENT RESPONSE OF SINGLE-DISK ROTOR ON ANISOTROPIC SUPPORTS PASSING THROUGH CRITICAL POINT.** This paper clarifies the nonlinear and non-stationary characteristics of transient vibrations of a single-disk rotor system on anisotropic supports passing through a critical point under a limited energy supply using analytical dynamics and the Bogoliubov-Mitropolskii asymptotic method. The governing equations for the motion of the system are reduced to a first order differential equation system capable of numerical integral solution. The influences of gyroscopic effect of the rotor, external and internal damping as well as the initial phase angle of static unbalance on the transient response are discussed. (Edited author abstract) 6 refs. In Chinese.

Fang, Zhichu (Shanghai Jiaotong Univ, China); Luo, Zhenhuang. *Ku Ti Li Hsueh Hsueh Pao* n 4 Dec 1987 p 321-330.

**092078 STABILIZATION BY ELECTROMAGNETIC DAMPER FOR CONTAINED LIQUID INDUCED ROTOR VIBRATION.** It is a well-known phenomenon that unstable rotor vibration occurs when rotors, partially filled with liquid, are rotated through a certain range of rotational speeds. This type of self-excited vibration appears in large-scale continuous flow ultracentrifuges, due to heavier liquid forming laminations with greater weight density. The unstable vibration results from a forward whirl rotor motion. An electromagnetic bearing control, reacting to detection of the rotor displacement, can produce particular damping force characteristics as are required for stabilization. Our control technique features an additional cross coupling network between  $x$  and  $y$  directional channels. This is equivalent to the damping effect generated by the cross stiffness of the bearing reaction:  $K_{xy}$  and  $K_{yx}$ . The sign of the cross stiffness especially depends upon the whirl direction. This optional control strategy using the cross effect is successfully experienced by combating unstable flow induced forward rotor vibration. (Author abstract) 8 refs. In Japanese.

Matsushita, Osami; Takagi, Mitiyuki; Yoneyama, Mitsubu; Saitou, Ikuhiro; Nagata, Akio; Aizawa, Masaharu. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 496 Dec 1987 p 2453-2458.

**092079 ROTOR ACTIVE 'ANTI-SWIRL' CONTROL.** Rotor self-excited vibrations due to solid/liquid interaction, such as occurring in seals, can easily be reduced or eliminated by controlling fluid circumferential velocity. This is known as 'anti-swirl' technique. An active 'anti-swirl' control system for rotating machines is described in the paper. While mainly controlling rotor self-excited vibrations, this active control system reduces also rotor lateral vibrations caused by other factors (such as unbalance), by increasing the system effective damping. (Author abstract) 23 refs.

Muszynska, A. (Bently Rotor Dynamics Research Corp, Minden, NV, USA); Franklin, W.D.; Bently, D.E. *J Vib Acoust Stress Reliab Des* v 110 n 2 Apr 1988 p 143-150.



**092080 DATA DEPENDENT SYSTEMS APPROACH TO MODAL ANALYSIS. PART II: APPLICATION TO STRUCTURAL MODIFICATION OF A DISC-BRAKE ROTOR.** The Data Dependent Systems (DDS) methodology is used to determine the modal parameters of a disc-brake rotor. The rotor, due to its symmetry, causes the vibration induced disc-brake squeal phenomenon. This paper presents results from an experimental investigation to show how structural modification can be used to change the modal parameters of the rotor. The modal parameters from both the DDS method and from a Fourier analyzer based modal analysis package are presented. Each rotor was modeled with 60 points on three equally spaced diameters. For an unmodified free-free rotor (resting on packing foam) the DDS results indicate that a 60th order model was required, whereas a structurally modified disc-brake rotor required a 76th order model. The results indicate how the disc-brake rotor can be modified to reduce the squeal propensity in selected frequency ranges. (Author abstract) 12 refs.

Pandit, S.M. (Michigan Technological Univ, Houghton, MI, USA); Jacobson, E.N. *J Sound Vib* v 122 n 3 May 8 1988 p 423-432.

**092081 USE OF SMOOTH BENDING MOMENT MODES IN HELICOPTER ROTOR BLADE VIBRATION STUDIES.** The application of a special type of assumed mode in problems of helicopter rotor blade vibration is described. These assumed modes thus have a smoothly varying bending moment distribution, as actually occurs on the rotor blade. Similar types of assumed mode are used to represent twisting motion. Natural frequencies and normal mode shapes for a rotating helicopter rotor blade are evaluated by using these special assumed modes. The results are seen to compare favorably with results obtained more conventionally and with a more detailed mathematical model. (Edited author abstract) 7 refs.

Done, G.T.S. (City Univ, London, Engl); Patel, M.H. *J Sound Vib* v 123 n 1 May 22 1988 p 71-80.

**092082 COUPLED LATERAL-TORSIONAL VIBRATION OF A ROTAR SYSTEM TRAINED BY GEARS (8TH REPORT: THE RELATION BETWEEN VIBRATIONS AND GEAR NOISE).** There are many papers dealing with the vibrations of a geared-rotor system. Recently, the dynamic behavior of the geared system has been analyzed. However many of them have studied only the dynamic load on the tooth, or have left the tooth rigidity and the flexural rigidity of the shaft out of consideration. But it is important to consider the effect of coupled lateral and torsional vibration. This study presents the experimental results of the vibrations and the noise of the geared-rotor system with a journal bearing. The following results are obtained. In response to angular acceleration in the gears, there are some resonant peaks caused by the excitation relating to the mesh frequency. And some other resonances appear in response to the lateral vibration and the torsional vibration caused by the mesh frequency excitation. The gear noise is concerned mainly with the vibration of the tooth. (Author abstract) 4 refs. In Japanese.

Iwatsubo, Takuzo; Ohi, Takao. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 500 Apr 1988 p 834-841.

**092083 ANALYSIS OF THE DYNAMIC BEHAVIOR OF ROTORS WITH NONLINEAR ELASTICALLY DAMPED SUPPORTS. I.** A method of modal analysis of the dynamic behavior of elastic multimass rotors on nonlinear elastically damped supports is described. By using a limited set of forms of natural vibrations, the dimensionality of the problem can be reduced substantially. The system of nonlinear model equations of motion is solved numerically by step-by-step integration with respect to time. (Author abstract) 2 refs.

Borzdzyko, E.V.; Leont'ev, M.K.; Khronin, D.V. *Sov Aeronaut* v 30 n 3 1987 p 22-25.

**092084 FEMROT - EIN BAUSTEIN FUER BE-RECHNUNGEN ZUR ROTORDYNAMIK. [FEM-**

**ROT - a Module for Calculations about Dynamics of Rotor].** FEMROT is a program of finite elements for static and dynamic calculations at rotor structures of machining and processing machine building. A survey is given about model generation and solvable calculation problems. By connection with the program TANDYS further essential problems of rotor dynamics can be solved. As examples for using FEMROT types of vibration of two rotor systems are stated. (Author abstract) In German. 5 refs.

Waldeck, D. (Technische Univ Karl-Marx-Stadt, East Ger). *Maschinenbautechnik* v 37 n 5 May 1988 p 238-240.

**092085 ACTIVE VIBRATION CONTROL OF FLEXIBLE ROTOR SUPPORTED BY ACTIVE CONTROL BEARINGS (2ND REPORT, QUASI-MODAL CONTROL BASED ON EXPERIMENTAL MODAL ANALYSIS).** Vibration of a flexible rotor is reduced by a quasi-modal control method with only velocity feedback. If a mathematical model includes much error of parameter identification, much cumulated error in feedback gains result from an incorrect equation of motion. In these cases, the responses with control are not improved as we expected, or the control system becomes unstable for the worst case. Therefore, in this paper, the control system is designed based on an experimental modal analysis instead of a mathematical model. The first mode to the fifth mode of the flexible rotor supported by linear actuators through bearing housings are controlled by only two sensors and two actuators in the experiments. The maximum amplitudes of unbalance responses are reduced, and the self-excited vibrations caused by dry friction are prevented by the quasi-modal control. (Author abstract). 5 Refs. In Japanese.

Nonami, Kenzou; Kawamata, Satoru; Hoodate, Masami. *Nippon Kikai Gakkai Ronbunshu C Hen* v 54 n 501 May 1988 p 1073-1078.

**092086 STABILITY OF CRACKED ROTORS IN THE COUPLED VIBRATION MODE.** A transverse surface crack is known to add to a shaft a local flexibility due to the stress-strain singularity in the vicinity of the crack tip. This flexibility can be represented, in the general case by way of a 6x6 compliance matrix describing the local flexibility in a short shaft element which includes the crack. This matrix has off-diagonal terms which cause coupling along the directions which are indicated by the off-diagonal terms. In addition, when the shaft rotates the crack opens and closes. Then the differential equations of motion have periodically varying stiffness coefficients and the solution can be expressed as a sum of harmonic functions of time. A method for the determination of the intervals of instability of the first and of second kind is developed. The results have been presented in stability charts in the frequency vs. depth of the crack domain. (Edited author abstract). 10 Refs.

Papadopoulos, C.A. (Washington Univ, St. Louis, MO, USA); Dimarogonas, A.D. *J Vib Acoust Stress Reliab Des* v 110 n 3 Jul 1988 p 356-359.

**092087 CONTROL OF ROTOR AERODYNAMICALLY FORCED VIBRATIONS BY SPLITTERS.** A mathematical model is developed to demonstrate the potential benefit of splitter blades as a passive control mechanism for the flow-induced forced response of supersonic turbomachine rotors. The splitters introduce both aerodynamic and structural detuning and also provide a large measure of control of the location of the Mach wave full-chord airfoil and splitter intersections. The level of aerodynamic detuning is associated with the relative locations of the splitters in the full-chord airfoil passages, with the level of structural detuning a function of the ratio of the natural frequencies of the splitters to that of the full-chord airfoils. (Edited author abstract). 11 Refs.

Fleeter, Sanford (Purdue Univ, West Lafayette, IN, USA); Hoyniak, Daniel; Topp, David A. *J Propul Power* v 4 n 5 Sep-Oct 1988 p 445-451.

## Wear Resisting

**092088 EFFECT OF THE STRUCTURE OF SURFACING MATERIALS OF ROTOR COUPLINGS ON WEAR OF PUMP-COMPRESSOR PIPES.** An investigation was conducted into the effect of the structure of hard alloys on the wear of the surface of a pipe in order to select efficient surfacing materials and their deposition technology. Microscopic analysis showed that the friction surfaces of the pump-compressor pipes in contact with rods hard faced with sormite No. 1 and VZK satellite contain deep grooves and scratches, in contrast to the smooth and flat friction surface of pipes with no visible damage tested in pairs with the rods hard faced with S-6 satellite and Az-4 alloy. Experimental results show that rod couplings should be hardfaced with hard alloys with a homogeneous fine-dispersed structure where the hardness of the matrix differs only slightly from that of the inclusions. 3 refs.

Dzhabarov, R.D. *Chem Pet Eng* v 23 n 1-2 Jan-Feb 1987 p 13-15.

**RUBBER** See Also ELASTOMERS—Applications; EP-OXY RESINS—Modification; NYLON POLYMERS—Modification; POLYVINYL CHLORIDE—Additives; PRESSES—Corrosion Resistance.

**092089 RIGIDITIES OF SPHERICAL AND CONICAL THIN-LAYER RUBBER-AND-METAL ELEMENTS.** Approximate solutions are obtained by a variational method and simple expressions are written for the rigidity coefficients of spherical and conical elements in the form of a thin layer of low-compressibility rubber secured at the faces to rigid metallic casings. The rigidities of single- and multilayer rubber-metal elements of these configurations are calculated under the action of all components of the principal vector and principal moment of the external forces under wide variation of geometric and mechanical parameters and for a specific example. (Author abstract) 4 refs.

Kruglyakova, V.I. *Sov Mach Sci* n 6 1987 p 60-64.

**092090 VLIV KVALITY DISPERGACE SAZI NA VLASTNOSTI KAUCUKOVYCH SMESI A PRYZI. [Effect of Carbon Black Dispersion on Properties of Rubber Compounds and Vulcanizates].** Based on data published in literature, the article discusses the effect of the degree of carbon black dispersion in rubber on rubber properties. The degree of carbon dispersion is to serve as one of the principal criteria used in optimizing the rubber mixing process. (Translated author abstract) 9 refs. In Czech.

Pokluda, Ivo (Vyzkumny Ustav Gumarenske a Plastikarske Technologie, Gottwaldov, Czech); Polaskova, Marie. *Plasty Kauc* v 25 n 3 1988 p 74-79.

**092091 PROCEEDINGS FROM THE INTERNATIONAL RUBBER CONFERENCE: IRC 86.** This conference proceedings contains 126 papers in three volumes. Of these 37 papers are short papers, and 28 are in the abstract form only. Topics covered include: rubber chemistry; mixing and blending; rubber physics; rubber processing; dynamic properties; advances in tire manufacturing and properties of tires; testing and control equipment for rubber manufacture and processing; reinforcements to rubber and rubber products and properties of these composites; economy and strategy for the future rubber industry; rubber components for machinery; raw materials and compounding; study of chemical reactions and kinetics of these reactions during rubber compounding and processing and effects of various chemicals and operating parameters on properties of rubber and rubber compounds; and calculation and mathematical techniques for determining properties and behavior of rubber products. Technical and professional papers from this confer-



ence are indexed and abstracted with the conference code no. 11133 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *Proc from the Int Rubber Conf. IRC 86, Goteborg, Swed, 1986* Publ by Swedish Inst of Rubber Technology, Swed, 1986. Available from PGI Service Lab, Varnamo, Swed 3 vol, 806p.

## Acoustic Emission Testing

**092092 KOERPERSCHALL IN GUMMIFEDERN - EINE UNTERSUCHUNG.** [Structure Born Noise Radiating from Rubber - Springs An Analysis]. When considering the moduli of compression and of elasticity in shear as well as their frequency and temperature characteristics, elastomers give rise, at room temperature and at acoustic frequencies, to expect sound velocities permitting the formation of standing waves. In this test, it is shown that for shear and compressional waves, the typical resonance phenomena can be detected by the formation of standing waves. When frequency and amplitude characteristics of the elastomer used for the spring are known, the frequencies of standing waves can be rated for vibrational excitations as known. From this, it is derived that for nondirectional excitations of vibration, the shear waves of all springs are to be considered. (Edited author abstract) 8 refs. In German.

Hinsch, P. *Kautsch Gummi Kunstst* v 41 n 4 Apr 1988 p 366-369.

## Additives See Also ADHESIVES; RUBBER, SYNTHETIC—Mechanical Properties.

**092093 DISTILLATE EXTRACTS AS THE BASE FOR TIRE RUBBER SOFTENING AGENTS.** Softening agents for tire rubbers are usually aromatic oils. The aromatic softening agent used in the USSR - PN-6sh oil - is a residual extract obtained in the solvent extraction of deasphalted oil. The authors have investigated the composition and properties of extracts obtained in solvent treatment of lube distillates, which are available in considerably larger quantities than the residual extracts. The results obtained in an investigation of extracts from lube distillates obtained at the Industrial Association 'Gorknefteorgsintez' are presented. 3 refs.

Eyseev, V.S. (All-Union Scientific Research & Design Engineering Inst of Petrochemical & Petroleum Refining Equipment, USSR); Zavidov, V.I.; Gureev, A.A.; Popova, N.N. *Chem Technol Fuels Oils* v 23 n 1-2 Jan-Feb 1987 p 72-74.

**092094 METODY HODNOCENI STUPNE DISPERSACE PRISAD V KAUCUKOVYCH SMESICH.** [Methods Used in Evaluating Dispersion of Ingredients in Rubber Stocks]. Methods employed to evaluate the dispersion of additives in rubber compounds are surveyed. Also reliability and suitability of the methods for routine quality checks of mixed stocks and for studying mixing processes are assessed. (Author abstract) In Czech. 21 refs.

Pokluda, Ivo (Vyzkumny ustav Gumarenske a Plastikarske Technologie, Gottwaldov, Czech). *Plasty Kauc* v 24 n 12 1987 p 365-371.

**092095 RUBBER ADDITIVES DERIVED FROM GUAYULE RESIN.** The commercial viability of natural rubber from the desert shrub guayule will depend on production of high-value byproducts to offset farming and processing costs. Guayule resin, the nonrubber extractables, can be chemically modified to produce solid derivatives which enhance the physical and chemical properties of rubber compositions. These derivatives affect sulfur vulcanization in a manner related to the nature of the modifying agent. Sulfurized guayule resin reduces vulcanization hysteresis. Guayule resin condensed with polyamines or amine-terminated polyethers improves green strength and vulcanizate tear strength. (Author abstract) 17 refs.

Schloman, William W. Jr. (Firestone Tire & Rubber Co, Akron, OH, USA). *Ind Eng Chem Res* v 27 n 4 Apr 1988 p 712-716.

**092096 NEUES KAUSCHUKADDITIV FÜR DIE NACHVULKANISATIONSTABILISIERUNG UND VERBESSERTE GUMMI/MESSING-HAFTUNG.** [New Rubber Additive for Post-Vulcanization Stabilization and Improved Rubber-Brass Bonding]. The new additive Duralink HTS, hexamethylene bis thiosulfate disodium dihydrate, creates hybrid crosslinks containing a hexamethylene group when present during the vulcanization of sulfur based rubber compounds. The hybrid crosslink produces improved stability of compounds when subjected to overcure or high temperature cure as measured by the retention of physical properties in NR and SBR vulcanizates. This additive can also be used as an adhesion promoter to give high resistance to attack by corrosive environments such as steam and salt on rubber to brass-plated steel cord bonds. (Author abstract) 5 refs. In German.

Lloyd, D.G. (Monsanto Europe S.A., Belg). *Gummi Fasern Kunstst* v 41 n 6 Jun 1988 4p.

## Adhesion See TIRES—Cords.

## Aging

**092097 STARNUTI SIRNYCH VULKANIZATU A MOZNOSTI JEHO ZPOMALENI.** [Aging of Sulfur Vulcanizates and Possibilities of Its Retardation]. Rubber aging problems and aging retardation techniques are dealt with. Quantitative data are presented showing the effect of aging temperature, environment, accelerator/sulfur ratio, and antioxidant level on scission and additional crosslinking. In Czech. 18 refs.

Meissner, Bohumil (Katedra Polymeru Vysoke Skoly Chemicko-Technologicke, Prague, Czech). *Plasty Kauc* v 24 n 1 Jan 1987 p 5-11.

**092098 STARNUTI SIRNYCH VULKANIZATU A MOZNOSTI JEHO ZPOMALENI.** [Aging of Sulphur Rubber Vulcanizates and Possibilities of Its Retarding]. Quantitative data on the effect of aging temperature, environment, accelerator/sulfur ratio, and antioxidant content on scission and additional crosslinking are presented. The data were obtained by analyzing aging data of sulfur-cured unsaturated rubbers. (Edited author abstract) In Czech. 18 refs.

Meissner, Bohumil (Vysoke Skoly Chemicko-Technologicke, Prague, Czech). *Plasty Kauc* v 24 n 6 Jun 1987 p 181-186.

**092099 AGING OF EPDM RUBBER.** The effect of oxidative and thermal aging of EPDM raw rubber and rubber vulcanizate on gelation, network structure, and technical properties has been studied over a wide range of temperatures and times of aging. Three grades of EPDM having different types of diene have been considered. The kinetics of aging of both raw rubber and vulcanizates has also been reported. Different network structures have been produced due to different reactivity of termonomers. Cross-link density, cross-link efficiency, polysulfidic linkage, zinc sulfide sulfur, combined sulfur, free sulfur, and sulfur inefficiency change with aging time and temperature. The number of polysulfidic cross-links decreases continuously with increase in time or temperature of aging. There is no definite trend in other structural features. (Edited author abstract) 22 refs.

Saha Deuri, A. (Indian Inst of Technology, Kharagpur, India); Bhowmick, Anil K. *J Appl Polym Sci* v 34 n 6 Nov 5 1987 p 2205-2222.

**092100 EFFECT OF AGEING ON CRITICAL CUT LENGTH AND MORPHOLOGY OF FRACTURE SURFACE IN TENSILE RUPTURE OF NATURAL RUBBER.** Variation of tensile strength with flaw sizes has been studied both for unaged and aged natural rubber (NR) gum vulcanizates (aged up to 150°C). A precut of varying lengths is given at the center of the tensile specimens. The morphology of the fracture surfaces has also been reported. A critical cut length is observed for NR vulcanizates. There is an increase in the critical cut length ( $l_c$ ) on ageing. The sharp fall of tensile strength at

the critical cut length, however, gradually diminishes. On prolonged ageing, no critical cut length is observed. A mathematical model has been made to explain the behavior of the critical cut length of NR that there is a change in the mechanism of rupture above the  $l_c$ . Below the  $l_c$ , it is a cut growth process and fracture is originated from natural flaws/nicks and proceeds towards the precut at the center. However, for samples with precut greater than the  $l_c$ , the fracture is mainly a tearing phenomena initiating from the given precut. A quantitative correlation between the tensile strength and the distance between crack lines/tear lines has been found. (Author abstract) 11 refs.

Deuri, A. Saha (Indian Inst of Technology, Kharagpur, India); Bhowmick, Anil K. *J Mater Sci* v 22 n 12 Dec 1987 4299-4306.

## Amorphous

**092101 X-RAY CDF STUDY ON THE BEHAVIOUR OF THE AMORPHOUS CHAIN UNDER EXTENSION.** The behavior of the amorphous chain in vulcanized natural rubber (NR) and styrene-butadiene rubber (SBR) under extension is studied by means of the cylindrical distribution function (CDF) derived from wide angle X-ray scattering (WAXS). In the case of the highly stretched vulcanized NR where the orientation-induced crystallization took place, the observed WAXS intensity was separated into a crystalline peak component and a broad amorphous one from which the CDF was obtained. The CDF calculated from the broad component shows that some of the amorphous segments of the highly stretched vulcanized NR are extended as fully as the crystalline chains and that the fraction of the segments increases with increasing extension. In the case of SBR, such fully stretched segments as in the case of the vulcanized NR show higher degree of an interchain packing order than those in the vulcanized NR. (Author abstract) 15 refs.

Miyadera, Nobuo (Tokyo Inst of Technology, Tokyo, Jpn); Yokoyama, Yutaka; Miyasaka, Keizo. *J Mater Sci* v 22 n 11 Nov 1987 p 3924-3930.

## Antioxidants

**092102 ACTIVITY OF PHENOLIC ANTIOXIDANTS IN RUBBER APPLICATIONS - THEORY AND PRACTICE.** A large number of phenolic antioxidants are presently available, from the low cost monophenols to the highly expensive polyphenols. The selection of an antioxidant from this range is not always easy. The purpose of this paper is to give some rational grounds for this selection. This will be achieved in two different and complementary ways: (1) theoretically by examining the relationship between the activity of phenolic antioxidants and their chemical structure and hence predicting their performance; and (2) practically by comparing phenolic antioxidants in typical rubber applications. This approach shows the value of the theory, but also its limits due to the nature of the media in which the products are used. (Edited author abstract) 15 refs.

Levy, M. *Kautsch Gummi Kunstst* v 40 n 11 Nov 1987 p 1043-1052.

**092103 UMWANDLUNG VON ANTIDEGRADANTEN IN NATURKAUSCHUKMISCHUNGEN.** [Transformation of Antidegradation Agents in Natural Rubber Mixtures]. The reaction products of N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine (6PPD) formed in a rubber compound by air aging at an elevated temperature have been isolated. It is found that two classes of molecules are generated during the aging showing different antioxidant activity. (Author abstract) 11 refs. In German.

De Coninck, D. (Monsanto Technical Cent, Louvain-la-Neuve, Belg); Aarts, A.J.; Burhin, H.; Orband, A. *Gummi Fasern Kunstst* v 41 n 9 Sep 1988 5p.



**Applications** See ELASTOMERS—Physical Properties; ELECTRIC CABLES—Insulation; POLYAMIDES—Synthesis; RINGS—Materials.

**Blending** See Also EPOXY RESINS—Dielectric Properties; NITRILE RESINS—Blending; RUBBER, SYNTHETIC—Vulcanization.

**092104 DYNAMIC MECHANICAL PROPERTIES OF NR-HDPE BLENDS.** A study of the dynamic mechanical properties of natural rubber (NR)-high-density polyethylene (HDPE) blends is reported in the present paper. The effects of blend ratio, dynamic crosslinking, and carbon black filler on the storage, loss moduli, and  $\tan \delta$  are examined. The dynamic mechanical properties of pure HDPE are reported for comparison. 27 refs.

Akhtar, S. (Indian Inst of Technology, Kharagpur, India); Bhagawan, S.S. *Rubber Chem Technol* v 60 n 4 Sep-Oct 1987 p 591-599.

**092105 CO-VULCANIZATION IN NR/EPDM BLENDS.** A novel cure system made of sulfur and peroxide curatives catalyzed by MBTS (mercaptobenzothiazole disulfide) and DPG (diphenylguanidine) was found to improve co-vulcanization of EPDM (ethylene propylene diene monomer) dispersion in NR (natural rubber). This cure system showed a two fold improvement in tensile strength of NR/EPDM vulcanizate over that of a conventional sulfur cure system, excellent heat aging resistance static ozone resistance. The presence of peroxide in the cure system did not show any detrimental effect on NR/EPDM vulcanizate cured in hot air autoclave when a proper level and type of peroxide and other cure constituents were used. (Author abstract) 15 refs.

Tobing, Singa D. (Servus Rubber Co). *Rubber World* v 197 n 5 Feb 1988 p 33-37.

**092106 RHEOLOGICAL BEHAVIOUR OF 1,2 POLYBUTADIENE-NATURAL RUBBER BLENDS.** The rheological behavior of thermoplastic 1,2 polybutadiene-natural rubber (1,2 PBD-NR) blends has been investigated in terms of effects of blend ratio, filler loading and temperature on viscosity, die swell and flow behavior index ( $n'$ ). The viscosities of the blends were found to obey a logarithmic additivity rule up to a shear stress of  $1 \times 10^5$  Pa. At a given shear stress, HAF black imparts higher viscosity to the blends than clay does. The viscosities of the 50/50 blend at different loadings of clay merge into a single curve when corrected on the basis of volume fraction of polymer. The activation energies of flow indicate that the clay-filled blend (50/50) is more temperature sensitive than the carbon black-filled blend. Die swell was found to increase with shear rate and decrease on addition of filler. The die swell data exhibit maxima/minima at certain blend ratios, and have been explained on the basis of extrudate morphology. (Edited author abstract) 13 refs.

Bhagawan, S.S. (Indian Inst of Technology, Kharagpur, India); De, S.K. *Plast Rubber Process Appl* v 9 n 1 1988 p 37-45.

**092107 UNTERSUCHUNGEN ZUM WANDGLEITVERHALTEN VON KAUSCHUK-MISCHUNGEN AN EINEM HOCHDRUCK-KAPILLAR-VISKOSIMETER.** [Investigation into the Wall Slip Behavior of Rubber Blends with a High Pressure Capillary Viscometer]. To predict the processing of rubber for better process control the knowledge of the flow properties is necessary. The rheological behavior includes anomalous flow such as wall slip. An investigation of the wall slippage of rubber compounds based on ethylene-propylene-diene-rubber (EPDM) is presented. The effect of filler and softener is particularly taken into account. The wall slippage is estimated by a method suggested by M. Mooney. As a result can be mentioned, that wall slipping EPDM blends at low pressure slide like a solid on the capillary wall with a friction behavior close to Coulombs law. At high pressure the rubber blends behave like a liquid with a pressure independent wall slip. (Edited author abstract) 25 refs. In German.

Jepsen, C.; Raebiger, N. *Kautsch Gummi Kunstst* v 41

n 4 Apr 1988 p 342-352.

**092108 BLENDS OF DISSIMILAR RUBBERS - CURE-RATE INCOMPATIBILITY.** The mechanical properties of a vulcanizate of a blend which comprises both a high-diene rubber such as NR and an ozone-resisting concentration (at least 30 to 40 wt.% of the polymers) of EPDM can be greatly improved if the EPDM is chemically modified by the action of maleic anhydride. The effect of the EPDM modification of the vulcanizate properties is to give increased tensile strength, improved fatigue resistance, and reduced hysteresis and set. The excellent ozone resistance which results from the presence of about 30 to 40% unmodified EPDM is also obtained when the modified EPDM is used. Good results are obtained when only 1 to 2% (as a wt.% of EPDM) of maleic anhydride is used in the modification of the EPDM. Good results are obtained when only part of the EPDM is modified by the action of maleic anhydride. However, best results are obtained when all of the EPDM is treated with maleic anhydride. 21 refs.

Coran, A.Y. (Monsanto Chemical Co, Akron, OH, USA). *Rubber Chem Technol* v 61 n 2 May-Jun 1988 p 281-292.

**092109 TECHNIQUE FOR MEASURING THE CROSSLINK DENSITIES IN BOTH PHASES OF A VULCANIZATE BLEND.** This paper reports on the use of freezing point depressions used in conjunction with swelling experiments to examine the crosslink densities in vulcanizate blends. Natural rubber (SMR 20) (NR) and polybutadiene Buna-CB11 (BR) were cured with BDH dicumyl peroxide (DCP) and various accelerated sulfur formulations using tetramethyl thiuram disulphide (TMTD) as accelerator. Vulcanizates were swollen in cyclohexane and the gel solvent frozen by cooling the swollen vulcanizate in a Du Pont differential scanning calorimeter (DSC) at 5°C/min. The magnitude of the depression of the freezing point of a solvent in a swollen vulcanizate is dependent on the crosslink density. It is shown that use of such measurements, coupled with the conventional swelling technique, allows the crosslink density in both phases of a vulcanized blend to be determined. (Edited author abstract). 20 Refs.

Honiball, D. (Univ of Port Elizabeth, Port Elizabeth, S Afr); McGill, W.J. *J Polym Sci Part B* v 26 n 7 Jul 1988 p 1529-1537.

## Bonding

**092110 BIDEN VON GUMMI AUF SUBSTRATE.** [Bonding Between Rubber and Substrate]. This paper demonstrates the dependence of the bond quality between elastomers and materials with high elasticity moduli on physical and chemical factors. They form the basis for production specifications which guarantee reproducible manufacture of high-grade articles if applied with high precision and discipline. (Edited author abstract). 21 Refs. In German.

Haertel, Volker (Metzeler GmbH, Munich, West Ger). *Gummi Fasern Kunstst* v 41 n 6 Jun 1988 8p.

## Chemical Analysis

**092111 DETERMINATION OF CARBON BLACK IN RUBBER VULCANIZATES BY METATHESIS DEGRADATION.** The amount of fillers such as carbon black occurring in rubber vulcanizates can be determined in various ways. In the present paper, the authors investigate whether metathesis degradation of rubbers (e.g., 1,4-polybutadiene crosslinked by sulfur or dicumyl peroxide) is also suited to determine carbon black fillers. The crosslinked matrix is degraded to low molecular weight products with an excess of a low molecular weight olefin. Metathesis degradation is carried out with the catalyst  $WCl_6/(CH_3)_2Sn$  at only slightly elevated temperatures (40 or 60°C). The low molecular weight olefin used is the relatively cheap 1-octene, whose boiling point allows working at normal pressure. 7 refs.

Stelzer, F. (Technische Univ Graz, Graz, Austria); Hummel, K.; Sommer, F.; Baumegger, A.E.; Ch Lesiak, M.

*Rubber Chem Technol* v 60 n 4 Sep-Oct 1987 p 600-605.

**092112 HPLC PROCEDURE FOR THE DETERMINATION OF FREE SULFUR IN NATURAL RUBBER FORMULATIONS.** The conventional ASTM method for the determination of the percent of free sulfur is a time-consuming method. Additionally, because of the many steps involved and the necessity of subjective endpoint determination, the data would vary from operator to operator. This lack of precision is detrimental in a quality-control type environment, and a retest can literally hold up production. The HPLC method described is almost totally automated. Sample preparation involves no exposure to such toxic chemicals as formaldehyde, cadmium salts, or glacial acetic acid. Quantitation is a computer operation negating operator to operator variations which can cause up to 20% relative standard deviation. 1 ref.

King, R.J. (West Co, Phoenixville, PA, USA); Mondimore, D.M. *Rubber Chem Technol* v 60 n 4 Sep-Oct 1987 p 716-720.

**092113 OZONOLYSIS OF EPOXIDIZED NATURAL RUBBER.** The epoxidized natural rubber was fragmented by ozonolysis and the ozonolyzed mixture was analyzed by gas chromatography/mass spectroscopy. The peak areas of the analyzed partial chromatograph were used to calculate the ratio of CC, CEC, and CEEC (dyad, triad, and tetrad) compared with the theoretical value calculated assuming random epoxidation of the latex. In this manner the epoxidation reaction was proved to be random. (Author abstract) 15 refs.

Perera, M.C.S. (Australian Natl Univ, Aust); Elix, J.A.; Bradbury, J.H. *J Appl Polym Sci* v 36 n 1 Jun 20 1988 p 105-116.

## Chemical Resistance

**092114 EFFECT OF FRESH WATER AND SEA WATER ON DIFFERENT GRADES OF CREPE RUBBER.** The tendency to absorb moisture and the metal ion concentration in natural rubber vary with the amount of proteins present. Yellow fraction rubber, containing the highest protein content, rapidly absorbs moisture if exposed to water, causing mold contamination and deterioration of the tensile properties of vulcanizates. White crepe rubber, which is made by removing the yellow fraction, contains the least amount of non-rubber constituents and is least affected by sea water or fresh water. (Edited author abstract) 7 refs.

Tillekeratne, L.M.K. (Rubber Research Inst, Ratmalana, Sri Lanka); Perera, M.C.S.; Rodrigo, H.V. *Plast Rubber Process Appl* v 8 n 4 1987 p 245-251.

## Chlorination

**092115 STRUCTURE OF PRODUCTS OF THE INITIAL STATE OF CHLORINATION OF NATURAL RUBBER.** The structure of the products of the initial stage of chlorination of natural rubber was studied by ozonolysis and IR spectroscopy. Specimens of uniform composition containing up to one atom of chlorine per monomer unit were obtained in a stop-flow setup. On the basis of data on unsaturation and the contents of methyl and vinylidene groups in the specimens under study it was concluded that cyclization occurs during the initial stage of chlorination and the probable paths involving the formation of cyclic structures are considered. (Author abstract). 10 Refs.

Kofman, V.L. (USSR Acad of Sciences, USSR); Podmashterev, V.V.; Razumovskii, S.D.; Krentsel, L.B.; Litmanovich, A.D. *Polym Sci USSR* v 29 n 5 1987 p 1224-1230.

**Chromatographic Analysis** See Also CARCINOGENS—Chromatographic Analysis.

**092116 GPC ANALYSIS OF RUBBER IN GUAYULE AND FIVE SPECIES OF PARTHENIUM (ASTERACEAE).** The genus Parthenium includes one spe-



cies, guayule (*P. argentatum* Gray), that produces large amounts of good quality rubber. In this study, the molecular weights of guayule and five species of *Parthenium* are reported. The  $F_1$  hybrids between guayule and one of these species, *P. alpinum* were also examined to determine the size of the polymers that characterize these hybrids. The molecular weight determinations were carried out with the aid of a high performance liquid chromatography system. 12 refs.

West, Jan (Texas A&M Univ, College Station, TX, USA); Rodriguez, Eloy. *Rubber Chem Technol* v 60 n 5 Nov-Dec 1987 p 888-892.

**092117 ENTWICKLUNGSTENDENZEN UND PROBLEME BEI DER ANALYSE VON KAUTSCHUK UND GUMMI.** [Development Trends and Problems in Rubber Analysis]. A selection of results from instrumental analysis is discussed. The various constituents of rubber compounds are considered in the sequence of elastomers, curing agents/crosslinking, fillers and additives. An appreciation of current instrumental techniques with the greatest potential as, e.g., integral multi-component methods is given. (Author abstract) In German. 33 refs.

Schnecko, H.; Angerer, G. *Kautsch Gummi Kunstst* v 41 n 2 Feb 1988 p 149-153.

**Composition Effects** See Also CARBON BLACK—Mixing.

**092118 CHARACTERIZATION OF NATURAL RUBBER FOR GREATER CONSISTENCY.** Characterization of the rubber hydrocarbon in terms of molecular weight, molecular weight distribution and gel component in association with an understanding of the contribution of the lipids, proteins and inorganic constituents of the non-rubbers has laid the foundation for the preparation of uniform natural rubber. Technological tests, devised under the SMR scheme that correlate with the basic molecular parameters and non-rubbers have resulted in more uniform NR. Processability indicators being investigated are aimed towards more uniform processing and consistent product performance. 14 Refs.

Nair, Sekaran (Rubber Research Inst of Malaysia, Malaysia). *Rubber World* v 198 n 4 Jul 1988 p 27-30,88.

## Crack Propagation

**092119 COMPARISON OF THE LOCUS AND THE EXTRAPOLATION METHODS THAT DETERMINE THE CRITICAL J-INTEGRAL IN THE PRESENCE OF REMOTE ENERGY DISSIPATION.** The locus method of partitioning the energy for crack propagation from the total deformation energy is based on energy release rate interpretation of J-integral. The extrapolation method is based on an assumption that the total energy absorbed can be thought of as the sum of the energies absorbed in the crack tip region and the region away from it, and thus the effect of remote energy dissipation on the critical J-integral value can be eliminated by evaluating the value using the crack tip energy only. A comparison of these two methods is attempted based on the same load-displacement records of a highly deformable thermoplastic rubber, and advantages of the locus method are presented. (Edited author abstract). 12 Refs.

Kim, B.H. (Univ of Massachusetts, Amherst, MA, USA); Joe, C.R. *Eng Fract Mech* v 30 n 4 1988 p 493-503.

## Crosslinking

**092120 PEROXIDE CROSSLINKING: A STRENGTH/WEAKNESS ANALYSIS VS SULPHUR VULCANIZATION.** The basic mechanisms of peroxide and sulfur crosslinking are described. The kinetics of peroxide crosslinking, decomposition mechanism and products, and choice of proper peroxide are discussed. There are a few limiting factors to peroxide crosslinking, which are mainly related to the fact that the highly reactive free radicals generated are prone to side reactions; the far less aggressive radicals generated in sulphur

vulcanization in general do not give rise to this type of side reaction. 16 refs.

van Drumpt, J.D. (Akzo Chemie America). *Rubber World* v 197 n 6 Mar 1988 p 33-34, 36-41.

**092121 APPLICATION OF STATIC SIMS TO THE STUDY OF RUBBER CROSS-LINKING.** Static SIMS has been used to analyze the sulfur cross-links at the surface of compounded polyisoprene rubbers. Linear relationships were found between the normalized intensities of  $S_1^-$  ions and the total cross-link densities and between the intensities of the  $S_4^-$  clusters and the percentages of the polysulfidic cross-links. (Author abstract). 6 Refs.

van Ooij, W. (Colorado Sch of Mines, Golden, CO, USA); Nahmias, M.; Brown, A. *Surf Interface Anal* v 11 n 10 Jul 1988 p 539-541.

## Crystallization

**092122 RHEO-OPTICAL STUDY OF THE INFLUENCE OF ADDITIVES ON CRYSTALLIZATION RATES IN CIS-1,4 POLYISOPRENE.** A rheo-optical study of the influence of additives on crystallization rates in synthetic cis-1,4 polyisoprene (IR2200) at room temperature is presented. Nine different additives at a 1% concentration were examined. This study has found many additives which seem to be effective in enhancing the rate of stress-induced crystallization in IR2200. There is a good relation between enhancement of green strength and fraction of stress-induced crystallinity in IR2200 caused by additives. 20 refs.

Chen, Yun-Jin (Univ of Akron, Akron, OH, USA); White, James L.; Min, Kyonsuku; Nakajima, Nobuyuki; Weisert, Frederick C. *Rubber Chem Technol* v 61 n 2 May-Jun 1988 p 324-339.

**Curing** See Also THERMOPLASTIC ELASTOMERS—Blending.

**092123 CURING RUBBER.** The author discusses the vulcanization of specific elastomers and the influence that the variety and density of cross-links can have on mechanical properties. It is shown that considering the cross-links as mechanical junctures uniting two polymer chains, the effect of their number and their flexibility becomes apparent in a mechanical sense. As an example, tire tread is subject to a range of mechanical abuse and dictates the use of polysulfidic cross-links at a minimum density. Seals, especially O-rings, are usually under compression over a broad range of temperatures. Service conditions dictate thermally stable cross-links (carbon-carbon or carbon-sulfur-carbon) at a high density. Bonded-rubber motor mounts require a density somewhere between that needed for tire treads and O-rings to allow a balance between mechanical life and strain relaxation. 13 refs.

Hertz, Daniel L. Jr. *CHEMTECH* v 16 n 7 Jul 1986 p 444-447.

**092124 COMPARISONS OF METHODS OF STATE-OF-CURE DETERMINATION.** The DSC method of relative state-of-cure determination is preferred due to the ability to use a small irregular sample and because of the short time required to run a test. This method is limited, however, to materials with a sufficiently high heat of vulcanization. The time required to reach 80% conversion at 142°C for Y156B-2 as measured by DSC is 19 minutes. This time to 80% conversion is for reference in comparing test methods only. The Mooney-Rivlin method of relative state-of-cure determination is a useful method for those elastomers which do not lend themselves to the DSC method. The small strain modulus ( $C_1 + C_2$ ) should be used instead of the more rigorous  $C_1$  measurement. The two-solvent technique of the solvent swell method of relative state-of-cure determination is a good procedure for determining X for a solvent-polymer pair. The solvent swell method in general is not recommended for this type of state-of-cure measurement due to poor resolution at higher states-of-cure.

Warley, R.L. (Lord Corp); Del Vecchio, R.J. *Rubber World* v 196 n 6 Sep 1987 p 30-32, 34-36, 38.

**092125 STUDIES ON THE CURE CHARACTERISTICS AND VULCANIZATE PROPERTIES OF 50/50 NR/SBR BLEND.** Blends of 50/50 natural rubber (NR) and styrene-butadiene rubber (SBR) are vulcanized using several conventional and semi-EV systems. The cure characteristics and vulcanizate properties are compared. The quantity and quality of crosslinks in each case are deciphered by chemical probes to correlate them with the vulcanizate properties. (Author abstract) 14 refs.

Joseph, Rani (Cochin Univ of Science & Technology, Cochin, India); George, K.E.; Francis, D. *J Appl Polym Sci* v 35 n 4 Mar 1988 p 1003-1017.

**092126 CHANGES IN THE VISCOSITY AND CURE BEHAVIOUR OF NATURAL RUBBER COMPOUNDS DURING STORAGE AT 20-40°C. PART 2: EFFECTS OF MIXING TEMPERATURE FOR CONVENTIONAL THIAZOLE- AND SULPHENAMIDE-ACCELERATED SYSTEMS.** The effects of mixing temperature on changes in the viscosity and cure behavior of natural rubber compounds during storage at 20-40°C have been studied for compounds containing conventional thiazole- and sulphenamide-accelerated systems. Mill finalization temperature over the range 60-100°C was found to have little effect on scorch and cure performance. The storage-related decrease in state of cure measured by Rheometer torque rise was, however, found to be greater in hot-mixed compound stored at 40°C. (Edited author abstract) 3 refs.

Bristow, G.M. *NR Technol* v 18 Pt 4 1987 p 75-80.

**092127 CURE MODIFICATION OF NR EFFECTED BY THIOAMINES IN THE PRESENCE OF DIBENZOTHAZYL DISULFIDE.** The activating as well as retarding effect of some thioamines, namely, bis(N-oxidiethylene) monosulphide, bis(N-cyclopentamethylene) monosulphide and N-cyclopentamethylene-N'-oxidiethylene monosulphide has been studied in MBTS-accelerated vulcanization in NR. The accelerators formed in the medium from the reaction of thioamine with MBTS bring about cure synergism. The vulcanizates obtained exhibit good age resistance behavior. The thioamine-MBTS combinations also improve the heat resistance of the resulting vulcanizates. (Author abstract) 11 refs.

Das, P.K.; Datta, R.N.; Basu, D.K. *Kautsch Gummi Kunstst* v 41 n 1 Jan 1988 p 59-62.

**092128 STABILIZED CURATIVE BLENDS FOR RUBBER.** Blending of curatives offers several advantages. These include a sharply reduced number of weightings of curative ingredients, reduced weighing costs, reduced dusting and improved cleanliness. These advantages might not be realized with some curative blends. For example, diphenyl guanidine (DPG) could not be blended with sulfenamide accelerators because it reacted chemically with the sulfenamides. This paper shows that aging of curative blends (like S and DPT) sharply reduces the scorch resistance of rubber compounds containing the aged blends. Selected additives will stabilize the blends. Blends were aged at 40°C under dry (28% RH) or humid (92% RH) conditions. Relative humidity (RH) was established with dry- and wet-bulb thermometers. 10 refs.

Sommer, J.G. (GenCorp Research Div, Akron, OH, USA). *Rubber Chem Technol* v 61 n 1 Mar-Apr 1988 p 149-155.

## Cutting

**092129 TRIM-LOSS MINIMIZATION IN A CREPE-RUBBER MILL; OPTIMAL SOLUTION VERSUS HEURISTIC IN THE 2 (3)-DIMENSIONAL CASE.** The efficiency - waste minimization - of a production planning system (PPS), solving the 3-dimensional cutting problem in a crepe rubber mill, has had to be proved. The authors point out the problem caused by material and production. An algorithm solving these



problems optimally but with comparatively high CPU-time is present. It is shown how a good heuristic for the same problem works. A comparison is made with the heuristic with the optimal solution. Another comparison is made of the presently employed system with the heuristic. (Edited author abstract) 3 refs.

Schneider, W. (Univ Linz, Auhof, Austria). *Eur J Oper Res* v 34 n 3 Mar 1988 p 273-281.

**Deformation** See Also MATERIALS—Deformation; POLYMERS—Mathematical Models; TIRES—Testing.

**092130 VOLUME CHANGE AND GAS TRANSPORT AT UNIAXIAL DEFORMATION OF FILLED NATURAL RUBBER.** The volume dilation of differently filled specimens of natural rubber has been measured using a deformation dilatometer. If the matrix detaches from the filler particles, hollow spaces form. The volume dilatation caused by this effect can be measured and calculated if the material is submerged in a liquid medium. The measured volume dilatation reflects the interaction between filler and matrix. The volume contraction caused by stress-induced crystallization can be recorded clearly only if one uses a liquid as the measurement medium. Due to gas exchange between the sample and its environment and the different gas solubilities in the amorphous and crystalline material no stress-induced crystallization can be detected. At the same time, a possibility opens up of determining gas solubilities in crystalline material. (Edited author abstract) 15 refs.

Reichert, W.F. (Univ Regensburg, Regensburg, West Ger); Hopfenmueller, M.K.; Goeritz, D. *J Mater Sci* v 22 n 10 Oct 1987 p 3470-3476.

**092131 NONLINEAR COMPUTATION OF AXISYMMETRIC SOLID RUBBER DEFORMATION.** This paper is devoted essentially to the detailed derivation of the element gradient vector and stiffness matrix for the nonlinear finite element analysis of axisymmetric rubber. The technique, which is based on the discrete sampling of the total potential energy of the deformed solid, is a natural extension of one employed previously in the nonlinear analysis of rubber membranes. However, in contrast with the thin membrane case exact incompressibility is avoided here and an extra energy term is added for the change of volume work. 14 refs.

Fried, Isaac (Boston Univ, Boston, MA, USA); Johnson, Arthur R. *Comput Methods Appl Mech Eng* v 67 n 2 Mar 1988 p 241-253.

**092132 NOTE ON ELASTIC ENERGY DENSITY FUNCTIONS FOR LARGELY DEFORMED COMPRESSIBLE RUBBER SOLIDS.** A successful finite element program for near-incompressible solids needs a good positive-definitive variational principle, and a mechanism to balance the physical and computational modeling requirements. This study has three points to make in this respect. One is to provide an elementary explicit proof to the theorem stating that an elastic energy density expression that is a function of the principal stretch ratios represents an isotropic material - a material with such a constitutive equation that the stress and strain matrices have colinear principal axes. Secondly, to show how the arithmetic-geometric-mean inequality theorem rationally leads to most of the elastic energy density functions in use for the large displacements analysis of nearly incompressible solids, and to possible new ones as well. Thirdly, to estimate, on a uniaxial stretching problem, the upper limit for the bulk modulus needed to reproduce the observed residual compressibility of rubberlike solids. 13 Refs.

Fried, Isaac (Boston Univ, Boston, MA, USA); Johnson, Arthur R. *Comput Methods Appl Mech Eng* v 69 n 1 Jul 1988 p 53-64.

**Elasticity** See Also POLYMERS—Swelling.

**092133 MATHEMATICAL MODEL FOR THE ELASTICITY OF RUBBER.** The Gaussian molecular theory of rubber networks shows good agreement with the experimental data for only small strains and deviates from

it for moderately large deformations. This deviation is associated with the assumption of affine deformation. In this study, a mathematical model is developed without changing the principals of molecular theory. The predictions by this model is found to be in good agreement with experimental data. (Author abstract) 10 refs.

Akyuz, Saim (Istanbul Technical Univ, Istanbul, Turk). *Bull Tech Univ Istanbul* v 39 n 1 1986 p 19-31.

**092134 ELASTIC STABILITY OF RUBBER PRODUCTS.** The problem of a sheet of Mooney-Rivlin type material, subject to general biaxial loading, is studied both analytically and by the finite element method. An energy approach to the problem is first presented. This problem represents the biaxial loading of rubber sheets or combined extension and inflation of rubber tubes, which are often used in experimental work for characterization of rubber materials. It is shown that the problem has multiple solutions for a certain domain of loading. The equilibrium state actually attained is dependent on the manner of quasistatic loading. Various stable solutions are obtained by the finite element method. 5 refs.

Tabaddor, Farhad (Uniroyal Goodrich Tire Co, Akron, OH, USA). *Rubber Chem Technol* v 60 n 5 Nov-Dec 1987 p 957-965.

**092135 ORIGINS OF ENTANGLEMENT EFFECTS IN RUBBER ELASTICITY.** The effects of entanglements on a network chain with fixed ends are modeled as hoops through which the chain must pass. This model differs from the tube models which allow no 'chain leakage' from the tube and from the slip-link models which do not conserve monomer along the chain. The strain-dependent portion of the free energy as the chain ends are displaced is shown to arise from three factors: the entropy of the strained unentangled subchains spanning the hoops, the distortion of the hoops with strain, and the narrowing of the distribution of segments required to reach a hoop with increasing extension ratio. An analytical expression for the free energy of the chain can be derived that takes the  $M - 1$  hoops per chain to be of infinitesimal diameter thereby neglecting this second factor. (Edited author abstract) 13 refs.

Adolf, Douglas (Sandia Natl Lab, Albuquerque, NM, USA). *Macromolecules* v 21 n 1 Jan 1988 p 228-230.

**092136 EXCLUDED-VOLUME EFFECTS IN RUBBER ELASTICITY. 3. SEGMENT ORIENTATION.** The effect of excluded volume on segment orientation in rubber elasticity is studied by molecular dynamics simulation of model systems of freely jointed chains with a truncated Lennard-Jones repulsive potential acting between all atoms. In a single chain with fixed end-to-end distance  $L$  and periodic boundary conditions, it is found that excluded volume causes negative orientation for sufficiently small  $L$ . This effect has been observed previously for a tie molecule and suggests an analogy between the confining effect of the crystalline lamellae on the tie molecule and that of excluded volume on the chain with periodic boundary conditions. In a system of three chains, corresponding to the three-chain model of rubber elasticity, it is found that intrachain excluded-volume interactions alone cause a decrease in orientation in the tensile region, but inter- and intrachain interactions together cause an increase in orientation beyond the ideal chain case. (Edited author abstract) 28 refs.

Gao, J. (Brown Univ, Providence, RI, USA); Weiner, J.H. *Macromolecules* v 21 n 3 Mar 1988 p 773-778.

**092137 RUBBER ELASTICITY AND FRACTURE.** Rubber is an amorphous elastomer of high entropy that is normally treated by statistical thermodynamics instead of molecular modeling. A pseudo-amorphous model is introduced that is useful in extending true stress-true strain uniaxial tensile results to other more complex states of stressing. While the statistical thermodynamic approach is still needed to deal with thermal aspects of rubber elasticity, the new approach represents a simpler, more accurate method of dealing with mechanical properties. Fracture of rubber follows a criterion of constant

engineering strain (or constant extension ratio) in the resultant principal stress direction which is consistent with the proposed model and the experimental results presented. (Author abstract). 9 Refs.

Shaw, M.C. (Arizona State Univ, Tempe, AZ, USA); Young, E. *J Eng Mater Technol Trans ASME* v 110 n 3 Jul 1988 p 258-265.

**092138 JUNCTION FLUCTUATIONS IN CONFINED CHAIN MODELS OF RUBBER ELASTICITY.** The junction fluctuations in a microneutral network of entangled chains are examined and compared to the assumptions made by the constrained junction theories. The entanglements acting on the microneutral network chains are pictured as hoops of infinitesimal diameter through which a chain must pass. Over a limited range of the uniaxial extension ratio, the calculated fluctuations qualitatively agree with the constrained junction theories. Quantitative agreement is improved by allowing the hoops to have finite size. However, junction fluctuations are seen to have little effect on the uniaxial force of the microneutral network. The force is dominated by the strain dependence of the chain entropy. This implies that agreement in the junction fluctuations is not sufficient to infer that the constrained junction theories correctly model the primary effects of entanglements on network chains. (Author abstract). 15 Refs.

Adolf, Douglas (Sandia Natl Lab, Albuquerque, NM, USA). *Macromolecules* v 21 n 7 Jul 1988 p 2249-2253.

## Electric Conductivity

**092139 ELECTRICAL CONDUCTIVITY AND ESR STUDIES OF CARBON-BLACK-LOADED NATURAL RUBBER.** The results of electrical conductivity and electron spin resonance (ESR) measurements on NR with four types of carbon black filler were reported. Two forms of space charge limited current (SCLC) were identified, indicative of different electron trap energies, depending on the type of carbon black filler. Such SCLC behavior, with steep trap-filling regions on the current-voltage curves, is indicative of trap-dominated transport in the polymer regions of carbon-black-NR composites. Discrete shallow traps are evident for two of the compositions; deep, exponentially distributed traps for two others. ESR spectra of the composites are very pronounced, with lineshape also depending on the type of carbon black used. Observed g-values are close to that of the free electron, and don't vary with carbon black type or temperature. Linewidths narrow and increase in intensity with increasing amounts of carbon black, with no detectable g-value shift. 12 refs.

Siswanto, Muliawati G. (Univ of Indonesia, Jakarta, Indonesia); Na Peng Bo; Parangtopo; Neubacher, H.; Burton, L.C. *Rubber Chem Technol* v 61 n 2 May-Jun 1988 p 269-280.

## Evaluation

**092140 COMPARISON OF NATURAL RUBBER AND SYNTHETIC RUBBERS.** This technical note discusses the strengths and weaknesses of natural rubber in comparison with synthetic rubbers. The article outlines the important role played by compounding ingredients added to the base rubber; particularly influential are the vulcanizing system, type and level of filler and the chemical added to raise resistance to degradation. 5 refs.

Anon. *NR Technol* v 19 pt 1 1988 p 14-18.

## Extrusion

**092141 NONISOTHERMAL FLOW OF A GENERALIZED POWER-LAW FLUID IN CONVERGING SECTIONS FOR RUBBER EXTRUSION.** A method for predicting pressure drop and temperature distribution in convergent sections is proposed. The generalized power-law rheological equation of state is used. Only the shear component of the converging flow is considered in order to estimate its contribution to total flow in such sections. A finite-difference scheme was used to simulate



the flow. The method was applied to an ethylene-propylene terpolymer compound using different angles of approach for which the pressure drop and the extrudate temperature had been measured experimentally. Comparison with theoretically predicted data showed excellent agreement for small angles, while for large angles the inclusion of extensional effects was found to be necessary. (Edited author abstract) 32 refs.

Kakouris, A.P. (Loughborough Univ of Technology, Eng); Freakey, P.K. *Polym Eng Sci* v 27 n 18 Mid-Oct 1987 p 1371-1379.

**092142 EXTRUSION DU CAOUTCHOUC AVEC UNE VIS A DEUX ETAGES.** [Study of Rubber Extrusion with a Two-Stage Screw]. The authors have studied the extrusion of an EPDM based compound in a two stage extruder. This extruder is equipped with pressure-temperature sensors at the end of each stage. Output, pressure and temperature were studied as a function of different working parameters (speed or rotation of the screw, thermal regulation). Dismounting of the screw has shown it to be incompletely filled. The rheology of the compound was measured with a capillary rheometer and an oscillating cone plane rheometer, for temperatures varying from 60 to 100°C and shearing rates between  $10^{-1}$  and  $10^3$  s<sup>-1</sup>. (Edited author abstract) In French. 17 refs.

Bennani, N. (CNRS, Valbonne, Fr); Vergnes, B.; Guichard, C. *Rev Gen Caoutch Plast* v 64 n 671 Aug-Sep 1987 p 103-106, 115-117.

**092143 MELT BLENDER FILLS THE GAP.** A high-performance, cold-feed extruder has been developed for the tire industry. By incorporating Sulzer AG's SSM-HV bolt-on melt blender into a standard cold-feed extruder, many of the drawbacks of such unmodified units may be overcome. The idea is not new - it has been used for many years in the chemical and plastics industries. What is new, however, is its use for the highly viscous melts found in rubber processing. The melt blender is suitable for applications where a high throughput, close tolerances and a homogeneous mix are needed. 1 ref.

Schiesser, Walter H. (Interplast SA). *Eur Rubber J* v 169 n 10 Nov 1987 p 42, 44.

**Fatigue** See Also AUTOMOBILE MATERIALS—Fatigue; TIRES—Rolling Resistance.

**092144 TAHOVA UNAVA PRYZE.** [Tensile Fatigue of Rubber]. The paper presents a brief survey of test results concerning tensile fatigue of rubber, one of the principal properties characterizing rubber durability. Various durability test methods were compared using selected rubber composition. It has been concluded that the simplest and most realistic procedure consists of determining the median of the values obtained and their range. (Edited author abstract) In Czech. 18 refs.

Brezik, Rudolf (Vyzkumny Ustav Gumarske a Plastikarske Technologie, Gottwaldov, Czech); Vaculikova, Kvetoslava. *Plasty Kauc* v 24 n 5 May 1987 p 141-145.

**Fillers** See Also CARBON FIBER—Physical Properties; RUBBER PRODUCTS—Modification; RUBBER TESTING—Tensile Tests; RUBBER TESTING—Wear.

**092145 MAGNESIUM SILICATE FILLER IN RUBBER TREAD COMPOUNDS.** Carbon blacks keep their dominant role among the rubber fillers and account for about 60% of total filler consumption. Since the energy crisis and due to its negative effect on carbon black manufacturing cost, greater interest has been put into the search for alternative fillers and particularly in cheaper inorganic materials, either natural or synthetic, that after suitable treatments can reach reinforcement levels very close to those of carbon black. Along this line, in the present work the mineral, sepiolite, a magnesium silicate with microfibrillar morphology, as a filler for rubber compounds is studied. The properties of two conventional compounds for passenger and truck tire treads are compared with similar formulations in which sepiolite is substituted for part (30% maximum) of the carbon black. 6 refs.

Gonzalez Henandez, Luis (Inst de Plasticos y Caucho, Madrid, Spain); Ma Ibarra Rueda, Luis; Chamorro Anton, Celia. *Rubber Chem Technol* v 60 n 4 Sep-Oct 1987 p 606-617.

**092146 TRANSIENT ELECTROMECHANICAL BEHAVIOR OF CARBON-BLACK-FILLED RUBBER.** This work shows the sensitivity and uniqueness of conductivity and dielectric constant transient response to compressional stress for natural rubber filled with specific types of carbon black. The strong correlation between conductivity and capacitance (both steady-state magnitudes and transients) is attributed to the polymer itself. A qualitative model for these effects is based on changes of conductive and resistive microelements due to fracture of the carbon black matrix. 16 refs.

Parris, Donald R. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Burton, Larry C.; Siswanto, Muliawati G. *Rubber Chem Technol* v 60 n 4 Sep-Oct 1987 p 705-716.

**092147 EFFECT OF INORGANIC PEROXIDE ON NATURAL RUBBER-CARBON BLACK SYSTEM.** The chemical used for enhancing the polymer-filler interaction prior to or during mixing results in improved green strength and thus yield vulcanizates with better physical properties. In this paper the authors report the results of studies on the effect of inorganic peroxide on carbon black-rubber interaction during mixing. Both hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) and solid zinc peroxide were used in HAF-black (N330) and GPF-black (N660) in natural rubber systems. The effect of peroxide on steel cord-rubber adhesion has also been studied. 8 refs.

Chakraborty, S.K. (JK Industries Ltd, Udaipur, India); Mukherjee, D.P. *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2623-2629.

**092148 SEPIOLITE - A NEW INORGANIC ACTIVE FILLER FOR THE RUBBER INDUSTRY.** The use of sepiolite, a natural silicate, as a filler for rubber compounds is studied. Due to its marked adsorptive nature the sepiolite delays the vulcanization, and therefore the addition of an activator is needed. Tri-ethanolamine and di-ethyleneglycol, added during the mixing in the roll mill, have been studied for this purpose. Normal or even higher cure rates are obtained. The use of a silane coupling agent improves markedly the properties of the vulcanizates filled with sepiolite, which reach the level normally obtained with a fine particle precipitated silica. (Edited author abstract) 5 refs.

Gonzalez, H.L.; Ibarra, R.L.; Royo, M.J.; Rodriguez, D.A.; Chamorro, A.C. *Kautsch Gummi Kunstst* v 40 n 11 Nov 1987 p 1053-1057.

**092149 KOHLEN ALS FUELLSTOFFE FUER KAUTSCHUKE - VERSUCHE ZUR BEEINFLUSSUNG DER EIGENSCHAFTEN.** [Coal as Filler for Rubber - Experiments to Change Properties]. The properties of finely ground coal as filler for technical rubbers were investigated by way of two rubbers as examples and compared with the properties of thermal black. Comminution without access of oxygen and addition of stearates, resins, and fatty alcohols do not change the properties considerably. Because coal has a substantially smaller density than carbon black, the parts of filler in rubber were varied, and a comparison between coal and thermal black on the basis of equal parts by volume was performed. (Edited author abstract) In German. 3 refs.

Baumann, H.; Ambroz, F.-J.; Klein, J.; Juentgen, H. *Kautsch Gummi Kunstst* v 41 n 2 Feb 1988 p 154-156.

**092150 PRODUCT MODIFICATIONS IMPORTANT IN FILLERS.** Carbon black usage by the U.S. rubber industry is over double that of the inorganic fillers. About 90 percent of non-carbon fillers are clays, calcium carbonates, silicas, and silicates. More than 100 grades of these products are available, many developed for specific product applications. Filler characteristics such as the size and shape of particles and aggregates, the chemical nature and extent of surface dispersibility, and the tendency to

agglomerate and form secondary filler networks, determine rubber properties. A variety of surface treatments and 'coupling' agents have been developed for the inorganic fillers, which give better dispersion, increased surface activity, and improved rubber properties. 5 refs.

Dannenberg, Eli M. *Elastomerics* v 119 n 12 Dec 1987 p 22-25.

**092151 OPTIMUM LOADING OF CARBON BLACK IN RUBBER BY MONSANTO OSCILLATING DISC RHEOMETER.** Evaluation of different carbon blacks by the measurements of rubber properties is an accepted industrial practice. Very often carbon blacks are compared at the same weight percent loading. The present work suggests that carbon blacks should be compared at the 'optimum loading' which is different for different blacks. A procedure for determination of optimum loading from Monsanto rheometer curves is suggested. The method is based on the different hydrodynamic effect of carbon black aggregate reinforcement on viscosity (uncured stock) and modulus (cured stock). A parameter  $L$ , defined as  $L = \eta_r - Mr$  ( $\eta_r$  = relative viscosity,  $Mr$  = relative modulus), is determined from the rheometer curves at different carbon black concentrations. As the concentration exceeds the 'optimum loading',  $L$  rises sharply showing a preponderance of undispersed carbon black agglomerates. This value has been determined for a number of carbon blacks and has been correlated with carbon black parameters and rubber properties. 15 refs.

Sircar, Anil K. (J.M. Huber Corp). *Rubber World* v 197 n 2 Nov 1987 p 30-35, 44.

**092152 PROCESSING EASE AND RUBBER-CARBON BLACK INTERACTION.** Two samples of poly(ethyl acrylate) rubber, different in their mill processability and their manner of accepting carbon black were examined. This is a case history of how the authors differentiated rheological behavior of gum elastomers and how the authors characterized the rubber-carbon black interaction in the compound. The dynamic mechanical properties were measured over the temperature range of interest. This information was used to interpret the difference in mill processability. Several carbon blacks in different particle size and structure were compounded with these samples. The effect of the different carbon blacks on these elastomers was examined with tensile stress-strain measurements. At least a part of the differences in behavior could be interpreted as the differences in the interaction between rubber and carbon black. 24 refs.

Nakajima, N. (Univ of Akron, Akron, OH, USA); Miller, R.A. *Rubber Chem Technol* v 61 n 2 May-Jun 1988 p 362-376.

**092153 FILLER REINFORCEMENT IN RUBBER.** A general introduction of reinforcement of rubbers by particulate fillers has been discussed, with major emphasis on the common factors which affect reinforcement levels of fillers in rubbers. Mechanism of reinforcement, some of which are not clearly discernible, and the role of hysteresis in reinforcement have not been discussed. A discussion is also presented of the ability of any filler to reinforce rubber, which is determined by three main characteristics. These are: particle size, structure or state of aggregation of filler particles, and the physical and chemical nature of the filler surface. 20 refs.

Ogunniyi, David S. (Univ of Ilorin, Nigeria). *Elastomerics* v 120 n 8 Aug 1988 p 24-27.

## Fire Resistance

**092154 EFFECTS OF BROMINATED FLAME RETARDANTS AND CROSSLINKING AGENTS ON THE FLAME RETARDANCY OF RUBBERS.** Tetra-bromo-p-cresol (TBPC), pentabromophenol (PBP), and their allyl ether derivatives - tetra-bromo-p-cresol allyl ether (TBPC-AE) and pentabromophenol allyl ether (PBP-AE) - were used in the study of flame retardancy of ethylene-vinyl acetate (EVA) copolymer and styrene-butadiene rubber (SBR), which were cured by dicumyl peroxide (DCP) and sulfur, respectively. The depen-



dence of the flammability of crosslinking polymers on the polymer matrix, its additives, and the degree of crosslinking was investigated. The empirical equations of flame retardancy were established for these rubbers and compared with the measured values. It was found that the oxygen index of SBR-S system was in accordance with the empirical equations, while the EVA-DCP system, affected by the decomposed residue of DCP, showed a slight deviation. (Edited author abstract) 17 refs.

Yang, Chin-Ping (Tatung Inst of Technology, Taipei, Taiwan); Chen, Wen-Tung. *J Appl Polym Sci* v 36 n 4 Aug 5 1988 p 963-978.

## Fracture

**092155 J-INTEGRAL AND CRACK OPENING DISPLACEMENT AS CRACK INITIATION CRITERIA IN NATURAL RUBBER IN PURE SHEAR AND TENSILE SPECIMENS.** The purpose of this study was to determine, based on the concepts of J-integral and crack opening displacement, the failure criterion of carbon-black-filled NR in pure-shear specimens and to compare the results with those in SEN specimens and with the tearing energy. 9 refs.

Lee, R.F. (Univ of Massachusetts, Amherst, MA, USA); Donovan, J.A. *Rubber Chem Technol* v 60 n 4 Sep-Oct 1987 p 674-688.

## Friction

**092156 IMPORTANCE OF STRUCTURAL INHOMOGENEITY IN THE FAILURE OF RUBBER SURFACES IN FRICTION AGAINST METALS.** The influence of the structural inhomogeneity of filled elastomers on their failure in friction against metals is indicated. Attention is concentrated on the variable capacity of the rubber for deformation under the physical and mechanical interactions at the solid filler/rubber matrix interface under sign-alternating loads. Microinhomogeneous deformation of filled elastomers is attained by replacing homogeneously deformed elastomers with equivalents having a certain effective length. The thickness of the layer around the filler is calculated and experiments are performed to determine it. (Edited author abstract) 17 refs.

Polyakov, P.V.; Antsupov, Yu. A. *Sov Mach Sci* n 6 1987 p 34-37.

**092157 EFFECT OF HIGH-FREQUENCY GLOW-DISCHARGE TREATMENT ON RUBBER PROPERTIES.** The change in the physical and mechanical indices and friction coefficient of rubbers subjected to a high-frequency glow discharge with the use of various gas media (argon, oxygen, Freon) is described. It is shown that such treatment improves the friction properties of rubbers under conditions of low-speed axial friction. (Author abstract) 3 refs.

Krylova, S.N.; Ural'skii, M.L.; Slovetskii, D.I.; Gorelik, R.A.; Kornev, A.E.; Vinogradov, G.K.; Meilakhs, L.A. *Sov Surf Eng Appl Electrochem* n 3 1987 p 82-84.

## Grafting

**092158 STUDIES ON GRAFT COPOLYMERIZATION OF METHYL METHACRYLATE IN NATURAL RUBBER LATEX INDUCED BY GAMMA RADIATION.** Methyl methacrylate graft natural rubber was prepared by initiating the polymerization of methyl methacrylate in natural rubber field latex using  $\gamma$  rays. The combined effect of radiation and chemical initiation was also studied. Properties of these graft rubbers were compared with those prepared using only redox catalysts. (Author abstract) 5 refs.

George, K. Mariamma (Rubber Research Inst of India, Kottayam, India); Claramma, N.M.; Thomas, E.V. *Radiat Phys Chem* v 30 n 3 1987 p 189-192.

**Injection Molding** See Also THERMOSETS—Injection Molding.

**092159 TOOLS FOR INJECTION MOULDING OF RUBBER.** This report describes the present state of technology in injection molding tools for rubber processing. Topics covered are the design and construction of tools, including computer-aided methods, and different injection molding systems, with particular emphasis on cold channel tools. The requirements for tools used in automated injection molding of rubber are described with the help of practical examples. (Edited author abstract)

Hofmann, W. *Kunstst Ger Plast* v 77 n 12 Dec 1987 p 3-12.

## Isomerization

**092160 COMPARISON OF METHODS OF CALCULATION OF  $^{13}\text{C}$ -NMR CHEMICAL SHIFTS OF DIENE POLYMERS WITH APPLICATIONS TO ISOMERIZED NATURAL RUBBER.** Natural rubber was isomerized by two methods that involved either dehydrobromination of hydrobrominated natural rubber or heating natural rubber with butadiene sulfone. The  $^{13}\text{C}$ -NMR spectra of the methylene region of isomerized natural rubber was interpreted in terms of dyad arrangements for which assignments were made by calculating chemical shifts according to three different published methods. Contrary to literature reports, it was found that the sulphur dioxide catalyzed isomerization of natural rubber was accompanied by a significant amount of double bond migration; a possible reaction scheme was proposed. (Edited author abstract) 35 refs.

Bradbury, J.H. (Australian Natl Univ, Canberra, Aust); Elix, J.A.; Perera, M.C.S. *J Polym Sci Part A* v 26 n 2 Feb 1988 p 615-626.

**Latex** See Also MICROSTRIP DEVICES.

**092161 PRODUCTION OF ACID FROM COCOA SWEATINGS AND ITS USE FOR COAGULATION OF NATURAL RUBBER LATEX.** Cocoa sweating drain off during the fermentation of cocoa beans and are normally a waste. These sweatings were converted to ethanol and then to a mixture of acids by successive fermentation by yeast and bacteria. Of the acid formed, 25 to 50% was non-volatile and was unidentified. The acid was used to coagulate rubber latex to form RSS No. 1 smoked sheet rubber which was similar to rubber from latex coagulated with formic acid. The advantages are that many estates grow both cocoa and rubber, lower production costs of rubber, and an environmental benefit, cocoa sweatings normally being a pollutant. (Author abstract) 11 refs.

Sarath-Kumara, Subaddarage J. (Ceylon Inst of Scientific & Industrial Research, Colombo, Sri Lanka); Jansz, Errol R.; Tillekeratne, L.M. Kirithi; Wickremasinghe, L. Kirithi G.; Mendis, Leslie P. *J Chem Technol Biotechnol* v 39 n 1 1987 p 11-18.

**092162 STUDY OF THE MECHANISM OF ACTION OF AROMATIC THIOLS ON CAROTENOID PIGMENTS.** Aromatic thiols are used widely to bleach carotenoid plant pigments present in natural rubber latex in trace quantities, in the manufacture of white latex crepe rubber. If this is not done these pigments impart a yellow color to the crepe, thereby lowering its grade. The bleaching reaction between carotenoid pigments and aromatic thiols is known to occur in the presence of at least diffuse daylight. In this mechanistic study it was observed that the aromatic thiols have no action on unoxidized carotene. (Edited author abstract) 10 refs.

Tillekeratne, L.M.K. (Rubber Research Inst, Sri Lanka); Tillekeratne, L.M.V.; Vimalasiri, P.A.D.T. *Polym Degradation Stab* v 19 n 3 1987 p 213-219.

**092163 FURANIZED RUBBER STUDIED BY NMR SPECTROSCOPY.** The double bonds of natural rubber latex (stabilized by a nonionic surfactant) were reacted with an approximately equimolar amount of

performic acid at room temperature with a limited amount of formic acid present. Product analysis by  $^1\text{H}$ -NMR during the course of the reaction showed that 69-90% epoxidation occurred before the advent of ring opening and ring expansion to produce furanized rubber; hence the rate of epoxidation was greater than the rate of furanization. By  $^1\text{H}$ - and  $^{13}\text{C}$ -NMR, it was found that the furanized rubber probably consisted of tetrahydrofuran rings linked together by C-C bonds at positions adjacent to the hetero atom and contained a terminal hydroxy group. (Edited author abstract) 28 refs.

Perera, M.C.S. (Australian Natl Univ, Canberra, Aust); Elix, J.A.; Bradbury, J.H. *J Polym Sci Part A* v 26 n 2 Feb 1988 p 637-651.

**092164 DRYING EFFECTS IN NATURAL RUBBER LATEX FILMS.** Drying rates of natural rubber latex films have been studied using control of drying conditions such as temperature and humidity. The effect of compound modification on drying has also been assessed. Improved drying rates can be obtained by physical variation of drying conditions: such improvements are likely to be specific to a particular oven and how it is loaded. The overall drying rate may be usefully increased by certain compound modifications such as prevulcanization or the addition of low levels of hard polymers, particularly polystyrene, which has little effect on physical properties. (Author abstract) 8 refs.

Gazeley, K.F.; Swinyard, P.E. *NR Technol* v 18 Pt 4 1987 p 81-87.

**092165 EFFECT OF METALLIC CATIONS ON THE ELECTROPHORETIC PROPERTIES OF A PRETREATED HEVEA LATEX.** High-ammonia latex concentrate prepared from doubly-centrifuged field Hevea latex was exhaustively dialysed to remove any residual water-soluble non-rubber constituents. The electrophoretic mobilities of the dialysed latex in the presence of various metallic cations were investigated as a function of electrolyte concentration. It is believed that strong adsorption of hydrolysed species from the metallic ions was responsible for reversing the charge of the originally negative latex particles. The number of cation binding sites on the latex particle surface and the chemical free energies of cation adsorption were calculated. It was found that the interaction of the latex particle with the hydrolysable metallic cations was much more stronger than that with the simple divalent cations and that this interaction was comparable to that of biological surfaces. (Edited author abstract) 28 refs.

Ho, C.C. (Univ of Malaya, Kuala Lumpur, Malays). *Colloid Polym Sci* v 266 n 1 Jan 1988 p 70-76.

**Low Temperature Effects** See SEALS—Materials.

## Manufacture

**092166 DER WIRTSCHAFTLICHE MISCHBETRIEB DES GUMMIFORMTEILHERSTELLERS.** [Economic Mixing Plant for the Manufacture of Molded Rubber Parts]. The main requirements of an economic mixing plant are shown in detail from a diagram of the equipment, the heart of which is the rubber mixer. Possibilities of improving quality and increasing output are shown in case a new investment is to be made and the best mixing system can be chosen. In addition, possibilities of optimizing existing machines are shown for customers with their own mixing plant. Improvements in quality stability are dealt with. The mixing cycle can be optimally controlled and regulated and the entire production better supervised by using micro-computer systems. (Edited author abstract) In German. 2 refs.

Schmid, H.-M. *Kautsch Gummi Kunstst* v 40 n 9 Sep 1987 p 820-825.

**092167 NATURKAUTSCHUK IM JAHR 2000.** [Natural Rubber in the Year 2000]. On basis of statistical evaluations forecasts are presented for a worldwide



increase of the NR production reaching 7 to 8.8 mill tons/a by means of a complex of scientific and socio-economic measures, which would mean a doubling of NR production during the next 13 years. The prognosis considers an important increase in the yield per hectare, an enlargement of the planting area, and an economically viable balance of the total rubber consumption of 40% NR, 40% SR, and 20% of speciality rubbers. Finally, an energy balance is discussed from the economic aspects. (Edited author abstract) In German.

Heinsch, K.F. *Kautsch Gummi Kunstst* v 41 n 3 Mar 1988 p 233-235.

**092168 RUBBER-SOFT - EIN PROGRAMMSYSTEM FUER ELASTOMERVERARBEITER.** [RUBBER-SOFT - A Program for Elastomer Molders]. The program RUBBER-SOFT calculates the process parameters, which are important for producing elastomer moldings (pressure drop, material temperature, scorch-index and cure rate). The program also does calculations for mold design and optimizing process conditions. The software uses modules for the preparation of material data (RUBBER-D), for calculation of pressure drop (RUBBER-P) and for calculation of vulcanization (RUBBER-V). Ease of handling and short calculation times are characteristic of the program. Different examples show typical applications of the program. (Edited author abstract). 4 Refs. In German.

Krehwinkel, Th. (Ingenieurbüros Krehwinkel & Schneider, Cologne, West Ger); Schneider, Ch. *Kautsch Gummi Kunstst* v 41 n 6 Jun 1988 p 564-568.

## Marketing

**092169 ORIENTATION DU MARCHÉ DU CAOUTCHOUC NATUREL.** [Natural Rubber Market Trends]. The world consumption of natural rubber has increased by 26% over the last ten years, from 3,500,000 tons in 1976 to 4,425,000 tons in 1986 (the present increase being more than 100,000 tons per year). At the same time, the consumption of synthetic rubber has increased from 8,100,000 tons to 9,160,000 tons, i.e., an increase of 13%. The share of natural rubber has increased from 30.7% to 32.6% of the total rubber consumption and this percentage has remained stable for about 5 years. The three main producers (Malaya, Indonesia and Thailand) have modified production and other countries, more recent cultivators of hevea, such as Liberia, the Ivory Coast and Cameroon now produce specified rubbers. (Edited author abstract) In French. 2 refs.

Loyen, Gerard (Alcan Italia SpA, Milan, Italy). *Rev Gen Caoutch Plast* v 64 n 670 Jun-Jul 1987 p 53-58.

## Materials See SILICA.

## Mechanical Properties See Also ELASTOMERS —Mechanical Properties; POLYMERS—Fillers.

**092170 STUDY OF NATURAL RUBBER IN COMPRESSION.** The non-linear kinetic-statistical theory of rubber elasticity is applied to the case of natural rubber blocks loaded in compression through steel platens bonded to the rubber. The rubber elasticity equations are modified for the bonded ends conditions by a theoretically derived shape parameter function which enhances the value of the shear modulus term. These equations form the basis for analyzing experimental data for compression tests on rubber specimens bonded to steel platens. From this analysis the applicability of the modified rubber elasticity equations are then assessed by comparisons between test results and theory. (Author abstract) 11 refs.

Betz, E. (Univ of Newcastle, Aust); Bennett, D.J. *Mech Eng Trans Inst Eng Aust* v ME 10 n 2 July 1985 p 113-119.

**092171 GENERALIZED CRITERION FOR RUBBER TOUGHENING: THE CRITICAL MATRIX LIGAMENT THICKNESS.** The thickness of matrix ligament is shown to be the single parameter determining whether a polymer/rubber blend will be tough or brittle.

The matrix ligament is defined as the region of the matrix between two neighboring rubber particles. Specifically, the ligament thickness is the surface-to-surface interparticle distance. When the average ligament thickness is smaller than a critical value, a blend will be tough; when greater, it will be brittle. In other words, a sharp brittle-tough transition occurs at the critical ligament thickness. This critical parameter is independent of rubber volume fraction and particle size, and is characteristic of the matrix for a given mode, temperature and rate of deformation. What is important is the matrix ligament, not rubber particles. The single matrix parameter explains the effects of phase morphology, rubber volume fraction, particle size, particle-size polydispersity, and particle flocculation on toughness. (Author abstract) 14 refs.

Wu, Souheng (DuPont, Wilmington, DE, USA). *J Appl Polym Sci* v 35 n 2 Feb 5 1988 p 549-561.

**092172 DESIGN BASICS: STRESS-STRAIN RELATIONSHIPS.** Designers of rubber articles need to be aware of the basic stress-strain relationships in rubber. Likewise, rubber technologists need to be aware of the problems that the product designer is trying to overcome. As the part becomes more complex, this problem is magnified. As a rule, the stress-strain properties measured by the rubber technologist will be orders of magnitude greater than the product designer is concerned with. Likewise, typical rubber properties are measured in tension while most rubber articles are used in compression. Being able to relate these two points of view is critical to being able to correctly identify and specify properties in a material to be used.

Menough, Jon (R.M. Engineered Products, North Charleston, SC, USA). *Rubber World* v 197 n 2 Nov 1987 p 8-9.

**092173 NATURAL RUBBER IN ENGINEERING.** The purpose of this paper has been to draw the attention of engineers and designers to the enormous potential for using natural rubber as an engineering material. Its versatility awaits further exploitation by the innovator. Extensive data are available to assist in the designing of natural rubber components completely reliable in function. Some of the topics covered include vulcanization, compounding temperature effect on properties, weathering resistance, swelling phenomena, and recent development in rubber utilization. 36 refs.

Lindley, P.B.; Leaver, A.D.W. *NR Background* n 2 9p.

**092174 DESIGN BASICS - RUBBER IN SHEAR.** In previous papers two basic methods of applying load to rubber articles were reviewed - tension and compression. In this paper applying load through shear is reviewed. In moving from tension and compression to shear, the understanding of how a rubber product reacts to the forces applied becomes significantly more complex. As previously noted, shear is a combination of both tensile and compressive forces acting at right angles to each other. However, having a basic feel for the effects of shear is very important in having a basic understanding of rubber and the products made from it. While we often consider isolated forces and their effect on a given product, there are very few products that are, in the real world, acted upon by solely one force. And often, that additional force will have a dramatic effect on the performance and life of the product.

Menough, Jon (Rubber World, Akron, OH, USA). *Rubber World* v 198 n 2 May 1988 p 12-13.

**092175 MODELLING AND ANALYSIS OF RUBBERLIKE MATERIALS.** A numerical scheme for strictly and nearly incompressible rubberlike materials is described. A Total Lagrange description is adopted to describe the large deformations that occur. A separate interpolation for the displacements and the pressures is used to model the (near) incompressibility. The employed constitutive model can be classified as hyperelastic with the strain energy function being composed of a deviatoric and a volumetric contribution. Thus, the volumetric deformations can be controlled in a physically realistic

manner, which is important since experimental evidence indicates that, although the ratio of bulk modulus over shear modulus is very large for rubbers, volumetric strains cannot be neglected. The second part of the paper is devoted to a number of practical examples. (Edited author abstract). 25 Refs.

de Borst, R. (Delft Univ of Technology, Delft, Neth); van den Bogert, P.A.J.; Zeilmaker, J. *Heron* v 33 n 1 1988 p 2-57.

## Microstructure

**092176 POLYMERSTRUKTUR UND REVERSION.** [Polymer Structure and Reversion]. Reversion phenomena are caused by subsidiary reactions of sulphur. The course of sulphur reaction, however, is to no small extent a matter of polymer structure. Correlations between the microstructure and reversion are shown using a series of models based on butadiene, styrene and isoprene. By number and type of double bonds and side groups the appearance of the rheometer curves can be enhanced. An attempt to give a theoretical interpretation is made. Ways of overcoming reversion problems by tailor made polymer structures are offered. (Edited author abstract) 12 refs. In German.

Nordsiek, K.H. *Kautsch Gummi Kunstst* v 41 n 4 Apr 1988 p 327-333.

## Mixing See Also RUBBER MACHINERY—Extruders; RUBBER MACHINERY—Mixers.

**092177 INTERNAL MIXING: A PRACTICAL INVESTIGATION OF THE INFLUENCE OF INTERMESHING ROTOR CONFIGURATION AND OPERATING VARIABLES ON MIXING CHARACTERISTICS AND FLOW DYNAMICS.** This paper deals with the measurement and interpretation of pressures and temperatures produced by the mixing of a rubber compound in the chamber of an internal mixer equipped with interlocking rotors. Pressure transducers and infrared/fiber optic temperature sensors were sited flush with the inner surface of the mixing chamber of a Francis Shaw KO Intermix of 2 L chamber volume. The variation of pressure with transducer position in the chamber wall and with rotor position was measured for selected fill factors and rotor speeds at 'equilibrium' conditions (quasi-static power requirement for the mixer) and at intervals during a complete mixing cycle. Two rotor designs were studied. Interpretation of the results was carried out with reference to biconical rotor rheometer measurements on the mixed rubber compounds and by reference to four regimes of viscoelastic behavior identified for two-roll mill mixing. (Edited author abstract) 26 refs.

Frakley, P.K. (Loughborough Univ of Technology, Engl); Patel, S.R. *Polym Eng Sci* v 27 n 18 Mid-Oct 1987 p 1358-1370.

**092178 BUEMATIC - MIKROPROZESSORSYSTEM FUER EINE KAUSCHUKMISCHLINIE.** [BUEMATIC - Microprocessor System for a Rubber Mixing Line]. In the rubber industry with consumers' quality expectations constantly increasing, a general automatic control of raw material dosing, mixing and, in case necessary, re-treatment is required in any production line. Besides the strategy of the control goals achievable of the automatic control system itself shall be explained. A description is given of the hardware, especial characteristics, the range of action, efficiency and the advantages of applying the BUEMATIC. The system presented is distinguished by safe and user friendly operation as well as transparent presentation and documentation of its process. (Edited author abstract) In German.

Goehler, D. v 41 n 2 Feb 1988 p 160-163.

**092179 IMPROVED DISPERSIVE MIXING THROUGH REDUCTION IN FLOW FIELD VORTICITY.** Dispersive mixing is most efficiently accomplished with pure straining flow. Vorticity in the flow field



inhibits this extending action; accordingly, the presence of shearing flow will decrease the overall effectiveness of dispersive mixing processes. A method to reduce the vorticity by inducing lubricated flow through development of a nonuniform distribution of the components of a polymer blend is described. (Author abstract) 24 refs.

Roland, C.M. (US Naval Research Lab, Washington, DC, USA); Nguyen, M. *J Appl Polym Sci* v 35 n 8 Jun 1988 p 2141-2154.

**092180 ANALYSIS OF APPEARANCE MECHANISM OF FINE PARTICLES IN INITIAL PERIOD OF NR MIXING.** Various solid behaviors of NR in an initial period of mixing and their properties as upgraded by control are described. A block of NR charged into a mixer was initially broken under the breaking condition in tensile strength and then transformed into many fine particles due to nonuniform elasticity in melt fracture occurring in NR film. These behaviors influenced the reduction rate of Mooney viscosity and the effective dispersion of carbon black mixed into the NR. (Author abstract) 6 refs. In Japanese.

Hashizume, Shinji. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 50-53.

**092181 COMPUTER INTEGRATED MANUFACTURING APPLIED TO AN INTERNAL MIXER.** The demand for tire quality is increasing. The uniformity of tire components can be improved by a staged approach to mixed rubber quality. The three major players - equipment, raw materials and controls - all have roles to play in an improvement program. A planned approach should include improvements in: process visibility, process consistency, and process control. A system is needed which includes: a data base that makes information available at any time, anywhere; an effective interface between the operator and the process; easily modified displays and reports for MIS and SPC; flexibility to change when the requirements change; and controls which can expand with the process.

Wolf, Craig A. (Measurex Corp). *Rubber World* v 198 n 3 Jun 1988 p 18-20.

**092182 COMPUTER PROGRAMS FOR COMPOUND DEVELOPMENT, MILLROOM RECORD SYSTEMS.** Chase Elastomer Corporation wrote its own software to manage its own rubber formulations, inventory, and production control. The software is named Millroom Record System, or MRS, developed to run on IBM-PC or compatible personal computers. Unlike earlier computer systems, the MRS software was designed for ease of use, even by those not familiar with computers. The operator is guided through each step with a prompt, or set of instructions or questions whereby all that is required is to supply the requested data or information.

Chase, Tom (Chase Technologies Inc). *Rubber World* v 198 n 3 Jun 1988 p 21-23, 25.

## Moisture Determination

**092183 APPLICATION OF MICROSTRIP SENSORS FOR DETERMINATION OF MOISTURE CONTENT IN HEVEA RUBBER LATEX.** The application of microstrip sensors for determination of moisture content or total solid content (t.s.c) in hevea rubber content is described. The sensors with characteristic impedances 93- $\Omega$  (on polyguide substrate), 50- $\Omega$  (on polyguide) and 50- $\Omega$  (on RT-Duroid) have been tested. The accuracy and reproducibility of 93- $\Omega$  sensor are at a level of 0.5 percent (compared with Standard Gravimetric Method) and 0.7 percent moisture content (wet basis) respectively. This performance is better than the previous technique using twin-horn antennas. With this accuracy, rapidity, ease of operation and compactness, this method has been found to be satisfactory for use in the field where t.s.c. determination is a prime factor in payment to the rubber tapper. (Author abstract). 10 Refs.

Khalid, K. (Univ of Agriculture Malaysia, Malays). *J Microwave Power Electromagn Energy* v 23 n 1 1988 p 45-51.

**Molding** See Also ELASTOMERS—Mold Release Agents.

**092184 NEW COMPUTER-AIDED DESIGN SYSTEM FOR RUBBER MOULDERS.** A computer-aided design system, FILLCALC, which allows moulders to simulate the flow and cure of elastomers during injection moulding, has recently been introduced. This paper describes the system, gives a summary of the mathematical models used by the program in making its predictions. A description is also given of the results of an experimental validation of the software. (Edited author abstract) 3 refs.

Bowers, S.; Dickinson, P.; Simpson, R. *Kautsch Gummi Kunstst* v 40 n 10 Oct 1987 p 953-956.

**092185 INJECTION MOULDING MACHINES FOR RUBBER PROCESSING.** A discussion is presented of the Oro series of molding machines. Criteria for microprocessor selection are presented. A four-nozzle injection molding machine for elastomer processing is described. Automatic demoulding is outlined. In English and German.

Bernhardt, I. *Kunstst Ger Plast* v 78 n 3 Mar 1988 p 11-12.

## Molecular Structure

**092186 VIBRATIONAL SPECTROSCOPIC ANALYSIS OF THE STRUCTURE OF NATURAL RUBBER.** The authors have obtained a series of well-defined raw rubber samples of both gel and sol fractions by well-established separation techniques. In this study, the authors have used infrared spectroscopy to better understand the structural aspects of the two fractions by identifying and interpreting different infrared spectroscopic features found in each fraction. Main emphasis was given to assess the number, magnitude, and the functional groups associated with hydrogen bonding. These data are useful in the characterization of intermolecular interactions and their effects on raw-rubber mechanical properties. 19 refs.

Lu, F.J. (Univ of Massachusetts, Amherst, MA, USA); Hsu, S.L. *Rubber Chem Technol* v 60 n 4 Sep-Oct 1987 p 647-658.

**Molecular Weight** See Also POLYPROPYLENE—Freezing.

**092187 VARIATION IN THE MOLECULAR WEIGHT DISTRIBUTION OF RUBBER FROM CULTIVATED GUAYULE.** The molecular weight (MW) and the molecular weight distribution (MWD) of natural rubber (NR) are directly related to rubber quality. Guayule, *Plathium argentatum* Gray, can synthesize high MW rubber similar to Hevea and is actively being developed as a new source of NR for the arid regions of the world especially in the United States. The purpose of this study was to examine the MW and MWD of guayule rubber obtained from cultivated plants to see whether agronomic management affects rubber quality. Analyses were made on different varieties of guayule grown under different irrigation regimes and harvested at different times of the year. In addition, plants treated with bioregulators, shown previously by others to increase rubber production, were tested for their effects on rubber MW and MWD. 15 refs.

Backhaus, R. A. (Arizona State Univ, Tempe, AZ, USA); Nakayama, F.S. *Rubber Chem Technol* v 61 n 1 Mar-Apr 1988 p 78-85.

## Oxidation

**092188 ALTERNATING CURRENT VOLTAMMETRY AS A MEANS OF INVESTIGATING TRANSFER OF METALS IN ISOPRENE RUBBER OXIDIZED ON ALLOYS.** The transport of metals in isoprene rubber oxidized in the presence of alloys (brass and Kovar) has been investigated by means of ac voltammetry. Contact oxidation occurring in the volume of the rubber is accompanied simultaneously by the accumulation of catalytically active alloy components in

the rubber. Oxidation of the SKI-3 on a metal substrate is accompanied by degradation and by crosslinking of the macromolecules. The degradation appears as a reduction in the specific viscosity of the SKI-3 (Polyisoprene Rubber) solution at the stage of the induction period in the oxidation process. The rate of degradation of the films depends on the nature of the substrate. For instance, SKI-3, films on a copper substrate degrade more rapidly than on an aluminum one. (Edited author abstract) 6 refs.

Yeliseyeva, I.M. (Gomelsk State Univ, USSR); Sviridenko, V.G.; Lin, D.G. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1731-1733.

## Ozone Resistance

**092189 ZUR OZONBESTÄNDIGKEIT VON CM-VULKANISATEN.** [Ozone Resistance of CM-Vulcanizates]. The resistance of CM-vulcanizates against moist ozone attack was studied. Thiadiazole-cured CM-vulcanizates turned out to be resistant, whilst peroxide-cured CM-vulcanizates require adequate compounding to guarantee resistance under extreme conditions. Among other things the antioxidant AFS, a product proved for CR-compounds, is suitable for this purpose. (Author abstract) 8 refs. In German.

Schaefer, K.; Dickmann, R. *Kautsch Gummi Kunstst* v 40 n 11 Nov 1987 p 1038-1039.

**Performance** See GAGES—Pressure Measurement.

## Phase Transitions

**092190 ON THE DIFFERENCES BETWEEN THE GLASS TRANSITION TEMPERATURE OF NATURAL RUBBER AND ITS SYNTHETIC ANALOGUES AS MEASURED BY D.S.C. ANALYSIS.** The glass transition temperature of natural rubber and high cis synthetic polyisoprenes have been compared by careful d.s.c (differential scanning calorimetry) analysis. Natural rubber is found to have a glass transition temperature some 0.7-0.9 K lower than the synthetic analogues. The small difference is shown to be the result of plasticization by non-rubber impurities in the natural material, and not due to presence of trace 3,4-units in the synthetic analogues. (Author abstract) 6 refs.

Burfield, David R. (Univ of Malaya, Kuala Lumpur, Malays). *Polym Commun (Guildford Engl)* v 29 n 1 Jan 1988 p 19-20.

**Physical Properties** See Also THERMOPLASTICS—Additives.

**092191 COMPARATIVE PROPERTIES OF NATURAL RUBBER AND SYNTHETIC ISOPRENE RUBBERS.** The properties of engineering vulcanizates of isoprene rubbers (IRs) and natural rubber have been compared using compounds reinforced with N550 (FEF) black, and containing various vulcanizing systems. In most physical properties synthetic IRs were found to be similar to natural rubber, but differences occurred at high temperatures and in nonrelaxing fatigue resistance. Here natural rubber (100% cis-1,4 IR) exhibited superior strength to 96-98% cis-1,4 IRs, which in turn were superior to 92-94% cis-1,4 IRs. The low compression set and creep of synthetic IRs may be beneficial in some applications, but these properties are offset by their inferior fatigue life and hot strength compared to natural rubber. (Author abstract) 8 refs.

Elliott, D.J. *NR Technol* v 18 Pt 4 1987 p 69-74.

**092192 DETERMINATION OF SEQUENCE DISTRIBUTION OF STYRENE UNITS IN CURED SBR.** The sequence distribution of styrene units is known to be one of the most important structural factors governing the physical properties of cured styrene-butadiene rubber (SBR). The authors have proposed a new method for the analysis of the sequence distribution of styrene and 1,2-butadiene units in SBR by a combination of ozonolysis



and high-resolution GPC measurements. This ozonolysis-GPC method provides quantitative information about the distribution of styrene units for short to long styrene sequences in random, partially blocked, and triblock copolymers; and also about the arrangement and tacticity of styrene and 1,2 units. The ozonolysis-GPC method was applied to the analysis of the sequence distribution of styrene units in cured SBR. 7 refs.

Tanaka, Yasuyuki (Tokyo Univ of Agriculture & Technology, Koganei, Jpn); Nunogaki, Kazuki; Adachi, Junichi. *Rubber Chem Technol* v 61 n 1 Mar-Apr 1988 p 36-41.

#### Polymerization See POLYETHERS—Forming.

#### Processing See Also RUBBER MACHINERY—Testing; TIRES—Recycling.

**092193 SURFACE MODIFICATION OF NATURAL RUBBER LACES.** Epoxidation has been applied to modify the surface of natural rubber laces. When very thin laces of fractionated bleached rubber are used, about 6% of the double bonds could be modified. Using <sup>1</sup>H nuclear magnetic resonance (NMR) and infrared (IR) analysis the best condition for the reaction was worked out. Both <sup>13</sup>C NMR and differential scanning calorimetry (DSC) results indicate that the 6% epoxide groups are placed in a predominantly block manner. Modification in yellow fraction rubber however gives lower epoxy contents. Increase in glass transition temperature by epoxidation results in more damping and better abrasion resistance. The resultant polymer acts very similarly to a 90/10 natural rubber/50% epoxidized natural rubber (NR/ENR-50) blend. (Author abstract) 20 refs.

Perera, M.C.S. (Rubber Research Inst of Sri Lanka, Ratmalana, Sri Lanka). *J Appl Polym Sci* v 34 n 7 Nov 20 1987 p 2591-2600.

**092194 LABORATORY METHOD OF ASSESSMENT OF MOULD RELEASE OF CURED RUBBER USING A TMS RHEOMETER.** Mold release in rubber processing is a frequently encountered problem. Difficulties in quantitatively measuring the low levels of adhesion involved have hindered research work on the topic. This paper describes the use of the TMS rheometer to obtain a measure of mold release. A blank of uncured rubber is molded around a stationary bioconical rotor, representing the mold surface. After curing the rubber in situ, an electric motor starts the rotor and the peak stress at its surface as the rubber breaks free is taken as the 'mold sticking index'. The preconditioning of the rotor necessary for obtaining reproducible results is described. (Edited author abstract) 5 refs.

Champaneria, R.K. (Univ of Bath, Bath, Engl); Harris, B.; Lotfiour, M.; Packham, D.E.; Turner, D.M. *Plast Rubber Process Appl* v 8 n 3 1987 p 185-188.

**092195 EIN KONZEPT ZUR DIREKTVERARBEITUNG VON PULVERKAUTSCHUK AUF SPRITZGIESSMASCHINEN.** [Conception for Direct Processing of Powder Rubber on Injection Molding Machines]. This report summarizes theoretical and practical results of research activities. Experimental studies for the description of plastification behavior of an injection molding plastification unit were made. Especially the resulting mixing homogeneity was investigated dependent on variation of screw geometry and processing parameters. The best results were obtained by using a screw with a short and strong compression and shearing and mixing elements in the metering zone, which are necessary for dispersion and distribution of carbon black. (Edited author abstract) In German. 25 refs.

Menges, G.; Weyer, G.; Speuser, G. *Kautsch Gummi Kunstst* v 41 n 1 Jan 1988 p 63-70.

**092196 SRC85 - PROCEEDINGS - THE 8TH SCANDINAVIAN RUBBER CONFERENCE: NEW TECHNOLOGY FOR IMPROVED DESIGN WITH RUBBER.** This Conference proceedings contains 43 papers, eight of which are in the German Language. The main topics covered are engineering design with rubber, rub-

ber-fiber composites, textile adhesion and processing for quality. Consistency of quality has been stressed because of the automation of rubber products manufacturing processes. Ways and means of improvement in the process economics and reduction in environmental pollution are analyzed. Product diversification based on modifications of polymerization to yield different polymer structure is discussed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10204 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *SGF Publ* 65, SRC85 - Proc - The 8th Scand Rubber Conf: New Technol for Improv Des with Rubber, Copenhagen, Den, Jun 10-12 1985. Publ by AF Danmarks Gummiteknologiske Forening, Den, 1985 891p.

#### Production See Also RUBBER INDUSTRY—Plantations.

**092197 PRODUCTION OF HYDROXYL-TERMINATED LIQUID NATURAL RUBBER-MECHANISM OF PHOTOCHEMICAL DEPOLYMERIZATION AND HYDROXYLATION.** Photochemical degradation of natural rubber yielded hydroxyl-terminated liquid natural rubber (HTNR) when carried out in solution in presence of H<sub>2</sub>O<sub>2</sub>. Ultraviolet radiation from a medium pressure mercury vapor lamp and sunlight were found to be almost equally effective in bringing about the depolymerization and hydroxylation of natural rubber. The variations in the composition of the reagents and exposure time on the extent of depolymerization was conducted, and a suitable procedure for the large scale preparation of HTNR was described. A probable mechanism leading to the formation of HTNR as well as the side products is discussed based on the analytical data. (Author abstract) 38 refs.

Ravindran, T. (Cochin Univ of Science & Technology, Cochin, India); Nayar, M.R. Gopinathan; Francis, D. *Joseph. J Appl Polym Sci* v 35 n 5 Apr 1988 p 1227-1239.

**092198 PRIMENA DOMACIH PROCESNIH ULJA U KABLOVSKIM IZOLACIONIM SMESAMA NA BAZI EPDM-KAUCUKA.** [Application of Domestic Processing Oils in EPDM-Based Insulation Compounds for Cables]. The application of domestically produced rubber process oils in the production of EPDM insulating rubber has been investigated. Detailed investigations of rheological, physical and dielectric characteristics of EPDM insulating compounds and vulcanized rubbers have been made using rubber process oils with different types of structural content. A review is presented of the effects of physical and chemical properties of rubber process oils on rubber compound characteristics. (Edited author abstract) 5 refs. In Serbo-croatian.

Nedic, Radosav (Novi Sad Cable Factory, Novi Sad, Yugosl); Sokolovic, Slobodan; Nikolic, Dragoljub. *Polimeri (Zagreb)* v 8 n 12 Dec 1987 p 353-356.

**092199 RUBBER PRODUCTION OF SALT-STRESSED GUAYULE AT VARIOUS PLANT POPULATIONS.** The hypothesis that increasing the plant population of guayule (*Parthenium argentatum*) to compensate for the reduced plant canopy size caused by soil salinity coupled with an anticipated enhancement of rubber production under the moderate environmental stress imposed by salinity was tested in a field plot experiment in the Imperial Valley of California. Irrigation waters having electrical conductivities of 1.2, 3.2, 6.5, and 9.4 dS/m were applied for 4 years to plots having plant populations of 28,000, 56,000, and 84,000 plants per hectare. The influence of salinity on rubber and resin production was independent of plant population. The salt tolerance threshold, maximum average salinity level of the root zone measured as the electrical conductivity of saturated soil extracts without yield reduction, was 7.5 dS/m; beyond this threshold, rubber production was reduced 6.1 percent per unit increase of soil salinity. The hypothesis tested was proven to be false because neither increased salinity nor increased plant population increased rubber production. (Edited author abstract). 19 Refs.

Hoffman, G.J. (USDA, Fresno, CA, USA); Shannon, M.C.; Maas, E.V.; Grass, L. *Irrig Sci* v 9 n 3 1988 p 213-226.

#### Radiation Effects See Also BIOMEDICAL ENGINEERING—Radiotherapy; POLYBUTADIENES—Radiation Effects.

**092200 UNEVEN SURFACE ABSORBED DOSE DISTRIBUTION IN ELECTRON-ACCELERATOR IRRADIATION OF RUBBER ITEMS.** Electron accelerators for industrial use are equipped with scanning devices, where the scan frequency or linear velocity along the window may vary. For example, the ELV accelerators (Institute of Nuclear Physics, Siberian Branch, Academy of Sciences of the USSR) have a scan frequency of 50 Hz, while the LUE accelerators (Electrophysical Apparatus Research Institute) have values from 0.5 to 2 Hz. In a flow technology, where the items are transported to the irradiation zone at a set rate, the speed of an item may be comparable with the scan speed, so there is substantial nonuniformity in the absorbed dose, which adversely affects the quality. The authors have examined the dose nonuniformity for long rubber items during vulcanization by means of LUE-8-SRV and ELV-2 accelerators. Results of the investigation are presented in this article. 2 refs.

Gorbunov, I.F.; Pashinin, V.I.; Vanyushkin, B.M. *Sov At Energy* v 63 n 2 Aug 1987 p 626-629.

#### Reinforcing

**092201 BONDING OF UNTREATED CELLULOSE FIBERS TO NATURAL RUBBER.** Sulfur- and peroxide-cured Natural rubbers reinforced with short fibers of cellulose and carbon black have been studied with respect to water absorption, crosslink density, tensile strength, and the dependence of the dynamic storage modulus on strain amplitude. The results indicate that there is bonding between fiber and matrix even in the absence of a specific bonding system. (Author abstract) 6 refs.

Flink, Per (Royal Inst of Technology Stockholm, Swed); Westerlind, Bo; Rigdahl, Mikael; Stenberg, Bengt. *J Appl Polym Sci* v 35 n 8 Jun 1988 p 2155-2164.

#### Research

**092202 ENGINEERING WITH RUBBER.** The author shows how the buildup of basic knowledge of the behavior of rubber has evolved into an understanding of how to achieve particular properties that lead to performance required for industrial applications. A discussion is presented of the behavior of rubber which shows that nonlinear stress-strain curves, creep, and hysteresis, and its properties are influenced not only by the method of fabrication but also by its previous history. This results not only in less precision in design compared with metals but also in less consistency in properties. Factors relative to strain amplification, elastic behavior and, strength and fatigue behavior are examined. The engineering applications of rubber are also discussed. 17 refs.

Mullins, Leonard (Malaysian Rubber Producers' Research Assoc, Welwyn Garden City, Engl). *CHEMTECH* v 17 n 12 Dec 1987 p 720-727.

**092203 STATISTICAL METHODS IN RUBBER RESEARCH AND DEVELOPMENT.** The areas covered in this review are 1) statistical experimental design, 2) response surface methodology, 3) multiresponse optimization, 4) empirical and mechanistic modeling, 5) characterization of rubber property distributions, and 6) a brief review of Taguchi methods. There is some overlapping among these areas, but this classification is useful in order to cover the material in a coherent manner. Statistical methods have considerable utility in rubber research and development. Such methods are cost effective and perhaps more importantly, help the user to formulate questions in such a way as to make research programs more productive. The use of statistical methods in formulation development has been particularly fruitful.



Statistical methods help the practitioner make sound decisions in the light of often extreme variability in the data. This is especially the case when the data is fatigue, tensile strength, or some other fracture property of rubber. 125 Refs.

Derringer, George C. (Battelle Columbus Div, Columbus, OH, USA). *Rubber Chem Technol* v 61 n 3 Jul-Aug 1988 p 377-420.

## Rheology

**092204 USE OF NOVEL PARAMETERS IN THE ASSESSMENT OF NATURAL RUBBER PROCESSABILITY.** A number of parameters related to rheological behavior of natural rubber may be obtained from unconventional measurements using the Mooney viscometer. These parameters have been measured on commercial samples of the major available grades of SMR. Discrimination between grades was found to be better than for more conventional parameters. The significance of the measurements in terms of consistent processability of natural rubber is discussed. (Author abstract) 5 refs.

Bristow, G.M.; Sears, A.G. *NR Technol* v 18 pt 3 1987 p 49-60.

**092205 RHEOLOGISCHES VERHALTEN GEFUELLTER KAUSCHUKMISCHUNGEN: TEIL 2. DYNAMISCHES FLEISSVERHALTEN.** [Rheological Behavior of Filled Rubber Compounds: Part 2. Dynamic Flow Behavior]. A rheological equation of state for filled rubber compounds is presented under the condition of isothermal dynamic shear. A reversible and non-reversible part of deformation is considered as a function of time. A Weissenberg-Rheogoniometer R18 is used, the material functions are quantified and the regression coefficients are discussed as a function of typical filler parameters. (Author abstract) In German. 2 refs.

Poltersdorf, B.; Schwambach, D. *Kautsch Gummi Kunstst* v 41 n 1 Jan 1988 p 40-43.

## Shock Waves

**092206 ON TENSILE SHOCK WAVES IN RUBBER-LIKE MATERIALS.** The problem of generation of one-dimensional tensile shock waves in rubber-like materials is studied numerically and compared to the exact elastic nonlinear solution and the steady wave solution. It is shown that a rate-type semilinear visco-elastic model can describe the steepening of the wave during its propagation and a 'thickness' of the wave is naturally incorporated. An energetic criterion for the numerical stability is discussed. The numerical results point out the uncertainty (difficulty) one may encounter in measuring the dynamic Young's modulus and Maxwell-type viscosity coefficient. (Author abstract) 11 refs.

Mihalescu-Suliciu, M. (Inst of Mathematics, Bucharest, Rom); Suliciu, I. *J Appl Mech Trans ASME* v 54 n 3 Sep 1987 p 498-502.

## Solubility See POLYETHYLENES—Blending.

## Solvent Extraction

**092207 BATCH PROCESS FOR SOLVENT EXTRACTION OF NATURAL RUBBER FROM GUAYULE.** Quantities of high-quality rubber gumstock, well below the permissible contaminant levels established by the Federal Emergency Management Agency (FEMA) and the American Society for Testing Materials (ASTM), have been prepared in the Food Protein Research and Development Center's Industrial Crops Solvent Extraction Pilot Plant using a batch-processing approach. Different combinations of solvents and alcohols for rubber precipitation, antioxidants, extraction temperatures, shrub sources, storage conditions, and preparation methods were investigated; and their effects on rubber material properties were evaluated. Compounding studies and physical testing have shown that the center's guayule rubber is comparable to both have a rubber and Mexican guayule rubber prepared by an aqueous extraction

method. These results confirm the overall adequacy of the process. However, a number of processing steps require initial evaluation or further 'fine tuning' to ensure development of a fully optimized processing scheme. (Edited author abstract) 10 refs.

Wagner, J.P. (Texas A&M Univ, College Station, TX, USA); Engler, C.R.; Parma, D.G.; Lusas, E.W. *Polym Plast Technol Eng* v 27 n 2 Jun 1988 p 155-171.

## Strain

**092208 FILLER-LOADED VULCANISATES AND ITS INTERPRETATION IN TERMS OF THE VAN DER WAALS NETWORK.** In the first stretch filler-loaded vulcanizates suffer in general heterogeneous and irreversible deformation even under quasi-static conditions. A full understanding of these phenomena is still not yet available. It is shown that an understanding of the Mullins softening is possible by defining strain-dependent 'one-way hidden variables'. With the aid of the van der Waals model of real networks the description is then made quantitative if modes of cooperation were defined. Light is shed onto the role of the type of filler-to-rubber contacts made up, for example, by chemical bonds or by adhesion. Exceptional high degrees of universality in the deformation behavior is, nevertheless, typical for filler-loaded vulcanizates. (Edited author abstract) 36 Refs.

Kilian, H.G. (Univ of Ulm, Ulm, West Ger). *Kautsch Gummi Kunstst* v 41 n 6 Jun 1988 p 529-537.

## Stresses

**092209 EFFECTS OF AIR AND OIL ON STRESS RELAXATION OF NITRILE RUBBER, SILICONE RUBBER AND FLUOROCARBON RUBBER.** Stress relaxation properties of nitrile rubber, silicone rubber and fluorocarbon rubber surrounded by oil (oil 2 according to ASTM 471) and air have been studied. Measurements were also made on specimens of the three materials and immersion in water. It is found that the silicone rubber degraded faster in oil than in air, whereas nitrile rubber degraded faster in air than in oil. Under compression, the restoring force relaxes most slowly for fluorocarbon rubber, and more rapidly for nitrile rubber than for silicone rubber. Treatment with water had no influence on silicone rubber, but caused a deterioration of the stress relaxation properties of the other two materials. (Author abstract) Refs.

Bjoerk, F.; Stenberg, B. *Kautsch Gummi Kunstst* v 41 n 1 Jan 1988 p 44-47.

## Structure

**092210 NATURE OF MICROCRYSTALLINE FORMATIONS AND THEIR CORRELATION WITH THE PROPERTIES OF ETHYLENE-PROPYLENE RUBBERS.** The existence of several microcrystalline zones in ethylene-propylene rubber with melting points in the 285-365°K range has been demonstrated, using DTA, calorimetry and wide angle X-ray methods. The influence of thermal prehistory on the behavior of the low temperature crystalline modifications has been studied. After annealing, the more stable ones are microcrystallites with melting points in the 308-315°K range. The presence of microcrystallites has a substantial effect on the thermo-oxidative and relaxation properties of the olefin rubbers. (Author abstract) 22 refs.

Aliguliyev, R.M. (All-Soviet Technological Inst for Olefin Production & Processing, USSR); Ovanesova, G.S.; Khiteyeva, D.M.; Oganyan, V.A. *Polym Sci USSR* v 28 n 7 Jul 1987 p 1616-1621.

## Surface Properties See ELASTOMERS—Adhesion.

## Surfaces

**092211 EFFECT OF TREATMENT IN PLASMA ON SURFACE PROPERTIES OF SILOXANE RUBBER.** Treatment with a glow discharge was carried out in a flow of argon or oxygen at P = Pa and discharge current

of 3 mA. The surface tension was found by measuring the wetting angles of the rubber surface by various liquids and plotting the curve of the cosines of the wetting angle as a function of the value of the surface tension of the corresponding liquids. The surface tension of the polymer was found by extrapolating the curves obtained to  $\cos \theta = 1$ . (Edited author abstract)

Bogonosov, A.I.; Krotova, G.D.; Maksimov, A.I. *Sov Surf Eng Appl Electrochem* n 4 1987 p 52-54.

## Swelling See Also TUBES—Rubber.

**092212 SOME COMMENTS ON THE SWELLING MECHANISM OF RUBBER VULCANIZATES.** The relationship between network structure and mechanical properties for rubber vulcanizates has been widely investigated. The authors prepared ordinary natural rubber (NR) vulcanizates and an endlinked polydimethylsiloxane (PDMS) model network. In this paper the authors compare the values of  $M_c$  for both types of samples calculated by using the conventional Flory-Rehner equation with those estimated from the new approach and discuss the swelling mechanism of crosslinked rubber. 27 refs.

Oikawa, Hidetoshi (Tohoku Univ, Sendai, Jpn); Murakami, Kenkichi. *Rubber Chem Technol* v 60 n 4 Sep-Oct 1987 p 579-590.

**092213 KINETICS OF ABSORPTION AND DESORPTION OF LIQUID BY A RUBBER ANNULUS USING A MODEL AND SHORT-TERM TESTS.** When rubber is in contact with a liquid, the liquid may be absorbed, provoking swelling. Absorption of liquid by rubber is controlled by diffusion under transient conditions; and desorption by diffusion and evaporation. A model based on an explicit numerical analysis is described for calculating the kinetics of absorption and desorption. This model takes into account the diffusion of the liquid through the rubber in the absorption process; and the diffusion of the liquid and its evaporation from the surface during the desorption process. It has been applied with good agreement with experiments on annulus samples of rubber of various thicknesses. The relevant parameters, the coefficient of diffusion and the rate of evaporation, were previously determined by using short-term tests with thin sheets of the same rubber. (Author abstract) 10 refs.

Khatir, Y. (Univ of St.-Etienne, St.-Etienne, Fr); Bouzon, J.; Vergnaud, J.M. *Plast Rubber Process Appl* v 9 n 1 1988 p 53-58.

## Testing See POLYMERS—Testing.

## Thermal Effects

**092214 THERMAL ANALYSIS OF SILICONE CAOUTCHOUC POLYMERS AND SILICONE RUBBERS, II.** It was proved experimentally that isotherms obtained from the results of isothermal thermogravimetric analysis are suitable for the characterization of silicone rubbers used in industry. The experimental results provide a possibility for the calculation of overall (apparent) reaction rate constants, characteristic of the thermal decomposition process, and for the calculation of half-life values in conjunction with the service life. Comparisons of the isotherms and of the characteristic calculated values demonstrated the effects of the parameters of silicone rubber preparation and of the conditions of application on the thermal stability. (Author abstract) 4 refs.

Liptay, G. (Technical Univ of Budapest, Budapest, Hung); Nagy, J.; Borbely-Kusznann, A.; Weis, J.Ch. *J Therm Anal* v 32 n 6 Nov-Dec 1987 p 1683-1691.

## Viscoelasticity See Also TIRES—Friction.

**092215 NONLINEAR VISCOELASTIC MODEL FOR REPRESENTING NONFACTORIZABLE TIME-DEPENDENT BEHAVIOR IN CURED RUBBER.** A nonlinear constitutive equation is advanced for cured rubber where the elastic and relaxation contributions to the overall response have separate generalized



deformational dependences. Predictions of viscoelastic behavior based on this theory are then compared to transient and dynamic data acquired in two strain fields on a natural rubber gum vulcanizate. It is shown that the model successfully predicts the nonfactorizability of time and strain effects observed for the large strain and the incremental strain, stress relaxation functions, and for the incremental storage modulus. However, in the case of the incremental loss modulus, these effects are observed to be factorizable, a behavior also predicted by the model. Further, the observed deformational dependence of the incremental loss tangent is well characterized by the theory. (Edited author abstract) 19 refs.

Sullivan, J.L. (Ford Motor Co, Dearborn, MI, USA). *J Rheol* v 31 n 3 Apr 1987 p 271-295.

**092216 VISCOELASTIC ANALYSIS OF LABORATORY- AND FIELD-AGED RUBBER FROM SYNTHETIC POWERLINE INSULATOR WEATHER-SHEDS.** The present investigation illustrates that viscoelasticity measurements are sensitive to modifications in the morphology of filled rubbers brought about by multi-factor aging. Tests to measure elongation at break are among the most popular to monitor degradation in rubbers; this study has shown that  $\tan \delta$  measurements of glass transition temperature can be correlated fairly well with elongation at break values of aged EPM. Therefore, viscoelastic analysis could eventually replace other conventional destructive tests. The present testing method can be considered nondestructive since only small cubes are needed. 6 refs.

Lamarre, L. (Inst de Recherche d'Hydro-Quebec, Varennes, Que, Can); de Tourreil, C. *Elastomerics* v 119 n 11 Nov 1987 p 17-20.

Viscosity See RHEOMETERS.

**Vulcanization** See Also ELASTOMERS—Swelling; RUBBER PRODUCTS—Extrusion; VULCANIZATION—Equipment.

**092217 SCHWEFELFREIE VULKANISATIONSSYSTEME FUER DIENKALKSCHUHE - EINE UEBERSICHT.** [Sulfur-Free Vulcanization Systems for Diene Rubber - A Review]. A systematic survey is given for the most important vulcanization systems for General Purpose Rubbers (i.e. except special elastomers like EPDM, CSM and the like). The following vulcanization processes are described: Vulcanization by sulfur donors; by chemicals with reactive chlorine atoms; by resins; by products with reactive nitrogen-containing groups (which is a big and diversified sector); by olefinic groups including so-called cyclization; by peroxides and finally by ionic groups (salt vulcanization). The author also considered the question, why sulfur vulcanization is still the predominant technology despite its well known disadvantages; there were a number of attempts to replace it by other methods; but with very limited success. (Edited author abstract) In German. 115 refs.

Kempermann, Th. *Kautsch Gummi Kunstst* v 40 n 8 Aug 1987 p 741-751.

**092218 NEW ACCELERATORS FOR VULCANIZATION OF RUBBER: PART 5. POLYMERIC THIOCARBAMOYL SULFENAMIDES.** Four polymeric thiocarbamoyl sulfenamides based on hexamethylene diamine (HMDA), 1,3-diamino propane (DAP), 1,3-di-4-piperidyl propane (DPP) and 4,4'-diamino diphenyl methane (DADPM) have been evaluated as sulfur vulcanization accelerators for NR both in the gum and the black filled stocks. Only the HMDA based polymeric thiocarbamoyl sulfenamide (PTS) appeared to offer the best activity. The efficiencies of the PTSs have been found to be significantly controlled by the level of dispersion in the rubber matrix. A correlation has been established between the relative efficiencies of the PTSs and such properties like polymer segment mass, polarity of the polyaccelerators, their melting points, etc. (Edited author abstract) 7 refs.

Khamrai, A.K.; Adhikari, B.; Maiti, S.; Maiti, M.M. *Kautsch Gummi Kunstst* v 40 n 8 Aug 1987 p 752-755.

**092219 RETARDING AND ANTIOXIDANT ACTIVITY OF 1-CYCLOHEXYLTHIO-2-MERCAPTOBENZIMIDAZOLE IN THE VULCANIZATION OF NR ACCELERATED BY THIOCARBAMYL SULFENAMIDE.** The effect of 1-cyclohexylthio-2-mercaptobenzimidazole (CMB) on the vulcanization of NR accelerated by N-oxydiethylene thiocarbamyl-N'-oxydiethylene sulfenamide (OTOS) has been studied. It is found that CMB delays the onset of cure and generates 2-mercaptobenzimidazole during vulcanization. The results indicate the retarding as well as antioxidant activity of CMB. (Author abstract) 12 refs.

Das, Prasanta Kumar (Indian Assoc for the Cultivation of Science, Calcutta, India); Datta, Rabindra Nath; Basu, Dipak Kumar. *J Appl Polym Sci* v 34 n 5 Oct 1987 p 1977-1983.

**092220 NEW VULCANISING SYSTEMS - A REVIEW.** Although well understood for a long time now, the vulcanization of rubbers continues to be the subject of many investigations. This review of work published in this field covers the period since that compiled by M.C. Kirkham. Many studies have been published covering both new vulcanising chemicals - accelerators and activators, retarders and other agents - and also the vulcanising process itself, particular processes for high temperature curing. The two approaches are in any case associated. Many authors who have studied for example the effects of high temperature curing have done so in order to find a vulcanisation system better adapted to today's conditions. The first part of this review covers high temperature vulcanisation and its consequences. Next follows a review of products for conventional sulphur cures (accelerators, activators and retarders), then sulphurless systems and finally the vulcanisation of specialty elastomers. (Author abstract) 50 refs.

Bertrand, G. (Vulnax Int Ltd, Vitry-Sur-Seine, Fr); Olivier, J.-J. *Progr Rubber Plast Technol* v 3 n 2 1987 p 1-10.

**092221 DIPENTAMETHYLENE THIURAM TETRASULFIDE (DPTS) VULCANIZATION OF NATURAL RUBBER AT ELEVATED TEMPERATURE.** The dependences of the first order reaction rate constant, the scorch, and optimum (90% conversion) cure time from the dosage of DPTS, ZnO, stearic acid, and sulfur in a NR-Dipentamethylene thiuram tetrasulfide system has been studied. The DPTS vulcanization seems to proceed in a similar manner as the crosslinking with thiuram disulfide with the exception that the polysulfidic component is likely to contain more S-atoms than the corresponding sulfuring transition complex from thiuram disulfide. (Author abstract) 14 refs.

Das, C.K. *Kautsch Gummi Kunstst* v 40 n 9 Sep 1987 p 826-828.

**092222 CURE MODIFICATION EFFECTED BY 2-IMINOTHIOPHthalIMIDES IN THE VULCANIZATION OF NR ACCELERATED BY THIOCARBAMYL SULFENAMIDES AND DIBENZOTHIATZYL DISULFIDE.** To moderate the scorchy behavior of the binary combinations of accelerators comprising thiocarbamyl sulfenamide and dibenzothiazyl disulfide (MBTS), N-clohexylthio phthalimide (CTP) was earlier used as a retarder. Although CTP could prolong the scorch time of the recipes, at the same time it reduced the torque developed during vulcanization of NR as recorded by a Monsanto Rheometer (R-100). Obviously, the vulcanizates obtained from these retarded systems possessed poor modulus, tensile strength, torque, etc. The present investigation is an effort to improve the physical properties of the NR vulcanizates obtained with other retarders and to explore the various reactions so as to understand the mechanism of cure retardation as applicable to these systems. With this in mind, N-oxydiethylene-thiophthalimide (ODTP) and N-cyclopentamethylene thiophthalimide (CPTP) have been employed as retarders in the present investigation. 18 refs.

Das, Prasanta Kumar (Indian Assoc for the Cultivation of Science, Calcutta, India); Datta, Rabindra Nath; Basu,

Dipak Kumar. *Rubber Chem Technol* v 60 n 5 Nov-Dec 1987 p 803-821.

**092223 STUDIES ON THE REACTION OF BIS-(DIISOPROPYL) THIOPHOSPHORYL DISULFIDE WITH SILICA IN THE VULCANIZATION OF NR.** The reaction between bis(diisopropyl) thiophosphoryl disulfide (DIPDIS) and silica has been investigated. The study reveals that DIPDIS can be used as a coupling agent for silica. The chemical bond between the silanol groups of silica and DIPDIS has been established through the isolation and characterization of isopropyl alcohol that is eliminated from the reaction. The chemical nature of the bond is also supported by the IR analysis of the reaction products of silica and DIPDIS obtained both in the presence and absence of rubber. From the exploratory studies it is indicated that DIPDIS can also react with NR even during mixing of ingredients. (Edited author abstract) 14 refs.

Mandal, Swapna Kumar (Indian Assoc for the Cultivation of Science, Calcutta, India); Datta, Rabindra Nath; Das, Prasanta Kumar; Basu, Dipak Kumar. *J Appl Polym Sci* v 35 n 4 Mar 1988 p 987-994.

**092224 STUDIES ON THE REACTION OF BIS-(3-TRITHOXY Silyl PROPYL) TETRASULFIDE WITH SILICA FILLER, ACCELERATOR AND NR.** Investigations have been carried out on the effect of silane coupling agent in vulcanization of NR. Bis-(3-trithoxy silyl propyl) tetrasulfide (TESPT), a representative silane compound having two reactive end groups, was used to determine its role during compounding as well as vulcanization. The studies reveal that TESPT is reactive towards NR, silica and accelerators like 2-mercapto benzothiazole and N-oxydiethylene-2-benzothiazole sulfenamide and thus throws additional light on the coupling reactions, especially in the early part of vulcanization. (Author abstract) 7 refs.

Datta, R.N.; Das, P.K.; Mandal, S.K.; Basu, K. *Kautsch Gummi Kunstst* v 41 n 2 Feb 1988 p 157-159.

**092225 STRUCTURAL ELUCIDATION OF NR VULCANIZATES CONTAINING THIOAMINES AND THIOPHTHALIMIDES AS CURE MODIFIERS.** This investigation deals with the modification of curing effected by cyclohexylthioamines and alkylthiophthalimides in the vulcanization of NR accelerated by the dual system of accelerators comprising thiocarbamyl sulfenamides and dibenzothiazyl disulfide. There exists a correlation between the various sulfidic linkages and the physical properties of the vulcanizates, e.g. torque, modulus and tensile strength. It is apparent from the investigation that thioamines greatly modify curing and improve the heat and age resistance behavior of the vulcanizates and are better than thiophthalimides in this respect. (Edited author abstract) 11 refs.

Das, P.K.; Datta, R.N.; Basu, D.K. *Kautsch Gummi Kunstst* v 41 n 3 Mar 1988 p 236-238.

**092226 FROM VULCANIZATION MODEL TO PROCESS CONTROL.** The simulation of the vulcanization process is leading to increased insight into process behavior in terms of temperature, time, and degree of cure. A model is presented which has been built with the minimum of compromise to the physics of this process. The ultimate goal is to develop a quantitative prediction of the vulcanization process with an accuracy of  $\pm 5\%$  in the degree of cure, which will lead to optimal process control in the near future. 18 refs.

Veltman, B. (Nederlandse Philips Bedrijven BV, Eindhoven, Neth); van Hastenberg, C. *Rubber Chem Technol* v 61 n 1 Mar-Apr 1988 p 64-77.

**092227 PRACTICAL CONSIDERATIONS OF ACCELERATION BASED ON THEORY.** Various practical considerations related to the selection and use of accelerators have been discussed. These include the effect of accelerator type, loading, cure temperature, activators,



retarders, postcrosslinking agents, dispersion and solubility on vulcanizate properties. Many of these effects have been linked to the theoretical view of accelerated sulfur vulcanization in an effort to make these concepts more generally applicable. (Edited author abstract) 21 refs.

Lay, Robert W. (BF Goodrich Co, Brecksville, OH, USA). *Elastomerics* v 120 n 5 May 1988 p 21-26.

**092228 SULFUR VULCANIZATION WITH TWO PLATEAUS - FORMATION OF AN INHIBITOR DURING VULCANIZATION?** Efficient sulfur vulcanizing systems based on thiazolesulfenamide accelerators derived from secondary amines show unusual and complex vulcanization kinetics in NR. This feature does not appear to have been reported previously. Depending on the nature and purity of the accelerator, the ratio of accelerator to sulfur, the cure temperature, the type of rubber being used, and the presence of other additives, two distinct periods of crosslinking may be evident, separated by a more or less well-defined plateau. This plateau is longer and more distinct if the accelerator is pure, its ratio to sulfur is high, the cure temperature is low, and there are no other additives present. Sulfenamide accelerators derived from both primary and secondary amines may give rise to this behavior in rubbers other than NR. The observed behavior has been shown to be due to the formation, during the first cure period, of an extractable crosslinking inhibitor. 15 refs.

Loo, C.T. (Rubber Research Inst of Malaysia, Kuala Lumpur, Malays); Porter, M.; Tidd, B.K. *Rubber Chem Technol* v 61 n 2 May-Jun 1988 p 173-185.

**092229 NONISOTHERMAL VULCANIZATION OF RUBBER COMPOUNDS.** The present work is devoted to theoretical and experimental investigations of the isothermal and nonisothermal vulcanization of rubber compounds. A nonisothermal vulcanization kinetic model has been proposed. In particular, this model can easily be implemented in the analysis of the injection molding process of rubber compounds. The model has been verified in nonisothermal experiments including both homogenous and nonhomogenous vulcanization of rubber compounds, and can be applied to any nonisothermal processing operations, including vulcanization of tires. 22 refs.

Isayev, A.I. (Univ of Akron, Akron, OH, USA); Deng, J.S. *Rubber Chem Technol* v 61 n 2 May-Jun 1988 p 340-361.

**092230 SULFUR-FREE VULCANIZATION SYSTEMS FOR DIENE RUBBER.** The sulfurless crosslinking of natural and synthetic rubber to form vulcanizates is an extensive field which even a survey cannot treat exhaustively. This paper will, therefore, be confined to diene rubbers important in tire production (NR, IR, SBR, BR), except for occasional references to polychloroprene (CR). As will be shown, even this restriction leaves an exceptionally large number of fundamental possibilities; to some extent, therefore, a bibliography will have to suffice. Various vulcanization systems have been discussed. Some of the vulcanization agents covered include thiourea, bis-mercapto compounds, reactive chlorine compounds, thiuram, reactive nitrogen compounds, and peroxides. 115 Refs.

Kempermann, Th. (Bayer AG, Leverkusen, West Ger). *Rubber Chem Technol* v 61 n 3 Jul-Aug 1988 p 422-447.

**092231 CONTINUOUS VULCANIZATION PROCESSES.** In order to increase the output of extruded rubber parts usually vulcanized in a second stage, let us say the batch process cycle, various continuous vulcanization systems have been developed. In the most recent period of development, the continuous vulcanization process has gained in importance. The following continuous systems are known: vulcanization in a steam pipe, vulcanization in a hot air tunnel, vulcanization in a salt bath, vulcanization in a fluid bed, UHF (microwave) vulcanization, shear head extrusion, and radiation vulcanization. The author briefly reviews each one of these processes.

Herlaut, Elisabeth (France Elastomerics). *Rubber World*

v 198 n 4 Jul 1988 p 20-22.

**092232 UNIFORMITY BY MICROWAVE.** Microwave heating offers an efficient, clean and rapid way to bring even the most awkwardly shaped extrusion up to cure temperature on a continuous basis. It offers particular benefits in terms of cure uniformity as most rubber compounds can be formulated to optimize microwave penetration/absorption. Microwave penetration depends on the power of the microwave source and on the absorption properties of the material. Microwaves can totally penetrate extruded components made from polar rubber compounds, so that all of such extrusions is subjected to their effects. The process' principal disadvantage is that microwave is a pre-heating technique and not a full vulcanization system. Capital investment is rather higher with microwaves than with alternative systems, but this outlay is justified by the large energy savings possible with this method.

Tedesko, Peter (Cim d'Or SA, Spain). *Eur Rubber J* v 170 n 7 Jul-Aug 1988 p 27.

**092233 MICROWAVE VULCANIZATION FOR GOOD, CONSTANT AND RELIABLE PRODUCTION RESULTS.** It is argued that to produce good microwave-vulcanized rubber extrusions it is necessary to pass them through a microwave tunnel, thus bringing the product up to the vulcanizing temperature, and then through a hot-air tunnel to reach the proper degree of vulcanization. The article deals first with the problem of determining the power requirements of the UHF tunnel and the length of the hot air tunnel.

Tedesko, Peter (CIM-DOR Corp, Spain). *Rubber World* v 198 n 6 Sep 1988 p 27-30.

## Wear

**092234 FRACTAL ANALYSIS OF RUBBER WEAR SURFACES AND DEBRIS.** The wear surface and debris of three rubber compounds (NR, PBD and NR/PBD/SBR), worn on a modified blade abrader, were fractal. The fractal dimension of the wear surface was: (1) limited to a finite range, and if the wear mechanism remained the same; (2) independent of the wear load; and (3) the basis for creating a master fractal plot by a shift factor that (4) decreased linearly with wear load. The fractal dimension of wear was determined on the basis of profilometer traces and showed that the wear load affected the scale of the wear process. The fractal dimension of the debris also increased with the wear load and is thought to be a function of the agglomeration mechanism during wear. (Author abstract). 18 Refs.

Stupak, P.R. (Univ of Massachusetts, Amherst, MA, USA); Donovan, J.A. *J Mater Sci* v 23 n 6 Jun 1988 p 2230-2242.

**RUBBER COMPOUNDING** See Also ELASTOMERS—Mechanical Properties; RUBBER; RUBBER—Additives; RUBBER—Crosslinking; RUBBER—Curing; RUBBER—Fillers; RUBBER—Ozone Resistance; RUBBER—Solvent Extraction; TIRES—Materials.

**092235 COMPOUNDING NATURAL RUBBER FOR LOW ROLLING RESISTANCE IN INDUSTRIAL SOLID TYRE APPLICATIONS.** Vulcanizates for industrial solid tires with low rolling resistance require low hysteresis, high modulus and good wear properties, together with a high degree of reversion resistance in order to minimize the adverse influence of long vulcanizing times. The progressive compounding stages to achieve these properties are demonstrated. Further improvements in rolling resistance characteristics can be achieved through alternative compounding techniques, though at the expense of wear and tear properties. The ideal tire construction would be a dual compound comprising a reversion-resistant tread cap with good wear performance and low hysteresis, and a high modulus base compound to enhance the low rolling resistance. (Author abstract) 2 refs.

Wallace, I.R. *NR Technol* v 18 pt 3 1987 p 61-66.

**092236 PREPARATION AND EVALUATION OF MULTIFUNCTIONAL RUBBER INGREDIENTS.** Modified epoxidized linseed oil compound with aniline and phenylhydrazine were prepared. These compounds are macromolecules and have the advantages that they are nonvolatile, do not bloom to the surface of rubber and can be homogeneously distributed in rubber mixes. The prepared compounds behave as multifunctional rubber ingredients. The results reveal that they have showed in NR a good accelerating efficiency compared with MBT, as plasticizer compared with processing oil and as antioxidant compared with PBN. The extended study for these compounds in SBR mixes showed that they behave as a good antioxidants and plasticizers, but as weak accelerators. (Author abstract) 8 refs.

Yehia, A.A. (Nat'l Research Cent, Cairo, Egypt); Badran, B.M.; Ismail, M.N. *Rubber World* v 197 n 1 Oct 1987 p 37-39.

**092237 DEVELOPMENT OF A REAL-TIME CONTROL SYSTEM FOR INTERNAL MIXERS.** In this paper, the development and evaluation of a real-time computer-control system for the internal mixing of elastomer compounds are described and results from small-scale evaluation trials presented and discussed. Although the control system has been developed for the mixing of elastomer compounds, it has features which are relevant to the melt-mixing of thermoplastics and of elastomer-thermoplastic blends. 13 refs.

Freakley, P.K. (Loughborough Univ of Technology, Loughborough, Engl); Matthews, B.R. *Rubber Chem Technol* v 60 n 4 Sep-Oct 1987 p 618-635.

## Additives

**092238 POLYMER-BOUND ANTIDEGRADANTS: A BETTER WAY TO LOCK IN HIGH PERFORMANCE.** This article will review: (a) reasons that polymer-bound antidegradants were first developed; (b) selected advances in the field during the last five years; and (c) special compounding considerations in their use. Polymer-bound antioxidants can be grouped according to the methods used to build the antidegradant into the polymer network. Methods include: (a) copolymerization, (b) reaction with a pendant active group and (c) reaction of a highly active group on the antidegradant with standard polymer functionality. Current work in the field is focused primarily on three areas: 1) copolymerization, 2) attachment of radicals to diene polymers and 3) reactions of antidegradants with epoxidized polyisoprene. The reaction of sulfur radicals is discussed and epoxidized polymer and rubber compounding are outlined. 21 Refs.

Gillick, James G. (Goodyear Tire & Rubber Co). *Elastomerics* v 120 n 8 Aug 1988 p 17-19.

**Materials** See ZIRCONIUM COMPOUNDS—Applications.

## Moisture

**092239 METHODE ZUR SCHNELLEN BESTIMMUNG DES FEUCHTIGKEITSGEHALTES BEI HILFSTOFFEN FUER DIE GUMMIINDUSTRIE.** [Method for the Quick Estimation of the Humidity Content of Compounding Ingredients for the Rubber Industry.] A new method for the determination of the humidity content of different powder-like compounding ingredients for the rubber industry is reported that is based upon the heat of reaction of water and Karl-Fischer-Reagent. Mineral fillers as well as thermosensitive organic compounds like accelerators and antioxidants can be investigated. Test method and some test results are described. (Author abstract). 4 Refs. In German.

Soos, I. (Taurus Ungarische Gummiwerke, Budapest, Hung); Marik-Korda, P. *Kautsch Gummi Kunstst* v 41 n 6 Jun 1988 p 572-574.



## Process Control

**092240 RHEOLOGIC SOFTWARE - A TOOL TO ASSIST IN THE SPC OF RUBBER MIXING.** A trend has emerged in the rubber industry toward the implementation of statistical process control (SPC). Customers are no longer content with the knowledge that a product meets specification. They are demanding that the product be as free from variation as the intended use demands. The authors discuss how the addition of a RheoLogic package to the Monsanto oscillating disc rheometer has enabled Veray Laboratories to move from having a piece of test equipment into having a valuable tool. 1 ref.

Russo, Stephen (Vernay Lab); Di-Mauro, Patrick J.; Braver, John I. *Rubber World* v 197 n 4 Jan 1988 p 14-17.

Research See RUBBER—Research.

## Rheology

**092241 RHEOLOGICAL BEHAVIOR OF RUBBER CARBON BLACK COMPOUNDS IN VARIOUS SHEAR FLOW HISTORIES.** The rheological properties of rubber carbon black compounds are studied in various shear flow histories. In particular we studied (i) stress relaxation, (ii) transient and steady state shear flow, (iii) stress relaxation after steady flow, (iv) sequential shear flow history, (v) storage effects, (vi) programmed step shear histories. At low carbon black concentrations, the rheological response is similar in character to that of unfilled elastomers. For carbon black concentrations of 20 percent by volume and above, the compounds exhibit yield values which increase with carbon black concentration and decreasing particle size. The rubber carbon black compounds exhibit 'hysteresis loops' in programmed step shear histories and rheological property growth in storage experiments. (Author abstract), 26 Refs.

Montes, Sergio (Univ of Akron, Akron, OH, USA); White, James L.; Nakajima, Nobuyuki. *J Non Newtonian Fluid Mech* v 28 n 2 Jun 1988 p 183-212.

## RUBBER FACTORIES

**092242 USE OF FLUIDIZING TECHNIQUES IN PNEUMATIC HANDLING OF PROCESS MATERIALS.** Mention fluidization in the rubber and plastics industry and the mind almost instantly connects it with the Rapra designed fluid bath. Fluidization of carbon blacks and processing powders to make them handle is an entirely different matter. Basically, it is the passage of low pressure air through a permeable membrane. When the membrane is set at an angle (min 3°) with black or powder on it, passage of air through the membrane breaks down the frictional resistance between membrane and powder, causing it to flow like water in the down slope direction. At this point, a practical demonstration of fluidization techniques on a model airslide may help to give a better understanding of this article.

Hardy, H. *Rubber World* v 198 n 4 Jul 1988 p 23-26.

Computer Applications See RUBBER—Manufacture.

Process Control See Also RUBBER MACHINERY—Molding Machines.

**092243 PROCESS CONTROL EVALUATION IN ACCORDANCE WITH AUTOMOTIVE INDUSTRY REQUIREMENTS.** The elements of process control are after-pressure regulation: via the work input for injection curing time regulation. The objective of these controls is to make sure that the quality of the article is the same shot after shot. In addition the state-of-the-art in process control is: regulation of the screw speed - which is standard in extruder technology - and regulation of the back pressure. 6 refs.

Graf, Hans-Joachim (Kloekner Ferromatik Desma); Tarka, S. *Rubber World* v 197 n 6 Mar 1988 p 25-26, 28-30.

## RUBBER, FOAMED

## Drying

**092244 ELECTROMAGNETIC ENERGY FOR DRYING RUBBER FOAM.** High frequencies and microwaves can be applied in the production of rubber foam for foaming, curing and drying. An investigation has revealed that high frequency drying of the final 20% moisture content is feasible on an industrial scale. (Author abstract)

Van Look, W. (State Univ Ghent, Belg). *J Microwave Power Electromagn* v 22 n 3 1987, Radio Freq Ind Appl, 1987 p 178.

Manufacture See WASTEWATER—Environmental Impact.

RUBBER INDUSTRY See Also RUBBER—Manufacture.

## Chemical Analysis

**092245 MODERN ANALYTICAL METHODS USED IN THE RUBBER INDUSTRY - THE POLYSAR EXPERIENCE.** Many new analytical techniques, invariably faster and more powerful than the old ones, have been developed. A brief description of the regularly used techniques, including modern spectroscopic, chromatographic, and microscopic methods are given, with some examples of application. Also included is a discussion about the logical approach in problem solving situations. (Edited author abstract)

Chu, C.Y. *Kautsch Gummi Kunstst* v 41 n 1 Jan 1988 p 33-39.

Computer Applications See RUBBER—Manufacture.

## Europe

**092246 INCREASING IMPORTANCE OF SPECIALTY ELASTOMERS IN WESTERN EUROPE.** The increasing use of special rubbers is determined less by completely new applications than by their role as substitutes for the elastomers that can no longer meet more stringent demands. The discussion is restricted to the West European market, which is typical of other industrialized regions in development and applications of special elastomers. In some of the technologically demanding areas of elastomer application, especially the automobile sector, Western Europe is often a trend setter. 6 refs.

Casper, R. (Bayer AG, West Ger); Rhode, E. *Elastomerics* v 120 n 4 Apr 1988 p 11-16.

**092247 ZUNEHMENDE BEDEUTUNG DER SPEZIALKAUTSCHUKE IN WESTEUROPA.** [Increasing Importance of Special Rubbers in Western Europe]. A review of the present situation on the Western European market is followed by a prediction of the future development of special rubbers - which in the last ten years have accounted for most of the growth in the elastomer field. The prospects of the various special rubbers, expressed as the relation between a performance number and price, are estimated. The increasing importance of this group of rubbers results from the substitution of materials that are no longer adequate, either because the technical demands made on them have become too severe or because more stringent safety requirements have been introduced. The substitution processes and their causes are discussed more fully with reference to applications in motor vehicle under-the-hood applications and in cables. (Edited author abstract). 6 Refs. In German.

Casper, R. (Bayer AG, Leverkusen, Czech); Rohde, E. *Kautsch Gummi Kunstst* v 41 n 6 Jun 1988 p 541-548.

Plantations See Also RUBBER—Molecular Weight; RUBBER—Production.

**092248 SEASONAL CHANGES IN RUBBER AND RESIN CONTENTS IN CHRYSOTHAMNUS**

**NAUSEOSUS SSP. HOLOLEUCUS AND SSP. TURBINATES.** *Chrysanthamnus nauseosus* (rubber rabbit-brush) is a desert shrub that grows in high density in large populations over a wide range of environmental conditions in the western United States and contains natural rubber that has potential commercial value. Individual plants of two sympatric subspecies (*turbinatus* and *hololeucus*) were analyzed to determine the distribution of rubber and resin within the plant. The highest rubber and the lowest resin contents were in the stems near the soil level whereas the highest resin and lowest rubber were in the top of the plants. Negative correlation between rubber and resin from top to bottom of the plants was significant for ssp. *turbinatus*. During the growing season, the highest rubber and lowest resin contents occurred during the summer for both subspecies. In contrast the highest resin and lowest rubber contents occurred in the spring for both subspecies. Negative correlation between rubber and resin for one year old tissue in ssp. *turbinatus* was very significant. (Edited author abstract). 12 Refs.

Hegerhorst, D.F. (Brigham Young Univ, Provo, UT, USA); Weber, D.J.; Bhat, R.B.; Davis, T.D.; Sanderson, S.C.; McArthur, E.D. *Biomass* v 15 n 3 1988 p 133-142.

**092249 SALT TOLERANCE OF IRRIGATED GUAYULE.** The salt tolerance of guayule (*Parthenium argentatum* Gray cv. N565-II) was tested in small field plots (silty clay soil) in the Imperial Valley of California. Seedlings were transplanted in October 1981. Differential salination was begun in March 1982 and continued for 4 years by irrigating with waters salinized with NaCl and CaCl<sub>2</sub> (1:1 by wt.) to obtain electrical conductivities of 0.8, 1.4, 3, 6, 9, and 12 dS/m. Dry matter, rubber, and resin yields were determined from pollarded plants in February 1984 and uprooted plants in February 1985 and 1986. Rubber concentrations in the woody branches in 1984 and 1985 averaged 6.1 and 7.3 percent, respectively on a dry weight basis and were not significantly affected by soil salinity. Resin concentrations averaged 8.6 percent and 7.3 percent for the two years. In 1986, both rubber and resin concentrations decreased with increased salinity. Plant mortality rather than growth reduction at high levels of salinity appears to be the limiting factor for rubber production from irrigated guayule. (Edited author abstract). 15 Refs.

Maas, E.V. (USDA, Riverside, CA, USA); Donovan, T.J.; Francois, L.E. *Irrig Sci* v 9 n 3 1988 p 199-211.

## Waste Utilization

**092250 EQUIPMENT FOR SHREDDING RUBBER SCRAP.** A range of machines has been developed for shredding rubber scrap and discarded rubber articles into crumbs. These machines are intended for shredding vulcanized pressure-rubber parts, used rubber articles, and scrap from the shoe industry. The machine has a knife-type shredder which converts scrap into crumbs of 6-8 mm size, and a disk mill which converts the large crumbs to a particle size not exceeding 2 mm. If necessary, the scrap can be processed in the knife-type shredder alone to get crumbs of 6-8 mm size. The production line for rubber crumbs consists of a magnetic separator, shredding unit, vibratory separator, two magnetic separators, hopper, packing unit, and four pneumatic transport systems. Another important project was the development of equipment for reclaiming worn tires with metallic and textile cords. A machine (type 142.041) has been developed and successfully tested for cutting tires with metallic cord. It consists of two cutter shafts (rotating towards each other) mounted in housings which are connected by a common frame. 1 ref.

Rozhkov, V.F.; Golikov, V.N.; Kurglov, V.I.; Cherepkova, R.V. *Chem Pet Eng* v 22 n 11-12 Nov-Dec 1986 p 545-547.



**RUBBER MACHINERY** See Also RUBBER INDUSTRY—Waste Utilization; RUBBER PRODUCTS—Manufacture.

**092251 EQUIPMENT FOR PROCESSING POLYMERIC MATERIALS AND PAPER AND PULP PRODUCTS EQUIPMENT FOR THE MANUFACTURE OF RUBBER SCREENS.** Equipment for the production of rubber screens with mesh size  $40 \times 40$  mm has been developed. The equipment comprises a machine for making rubber screens MIRS-40, No. 442.031 and a machine for cutting flash MVO-40, No. 642.041. The machine for the manufacture of rubber screens MIRS-40 consists of a shaping drum fixed in bearing blocks on a bed, which contains two side walls, fastened with braces, from clamping and deflection drums covered by a steel band. A shield is installed to protect the rubber mixture being fed in from prevulcanization. The machine is equipped with a system of electric heating, which supplies the necessary heat for warming the machine, setting it to a given temperature schedule, and maintaining a working temperature during operation.

Tarasov, V.I.; Bragin, A.N.; Shcherbakov, I.F.; Cherepkova, R.V. *Chem Pet Eng* v 23 n 7-8 Jul-Aug 1987 p 391-392.

**092252 NEW DESIGNS, MACHINES AND MATERIALS STRETCH THE APPLICATIONS FOR RUBBER HOSE.** Innovative manufacturing methods, including continuous curing equipment, have contributed to improved economics with much better process control and quality. This paper reviews products that contain reinforcement. Some indication is of the technical progress in the hose industry. Rubber compound preparation, manufacturing methods, process control and materials are discussed.

Johnson, James. *Elastomerics* v 120 n 6 Jun 1988 p 38-42.

**Control** See PLASTICS MACHINERY—Molding Machines.

**Control Systems** See TIRES—Manufacture.

## Design

**092253 TRENDS IN TIRE AND RUBBER MANUFACTURING EQUIPMENT.** Various studies, improvements and developments have been made in tire and rubber manufacturing equipment in compliance with the tire and rubber industry's needs for reliable performance, higher productivity, energy conservation, and introduction of factory automation. In this paper, Kobe Steel's technical trends in major tire manufacturing equipment are discussed. (Author abstract) In Japanese.

Nakagawa, Kazuhiko. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 6-8.

**Extruders** See Also RUBBER, SYNTHETIC—Extrusion.

**092254 EXTRUSION UND VULKANISATION VON PROFILEN.** [Extrusion and Vulcanization of Profiles]. Ultramodern lines for manufacturing complex single component- and composite profiles are described. The author indicates that the automobile industry compels profile manufacturers to improve their products with regard to dimensional constancy and physical characteristics. Experience has shown that these requirements can only be fulfilled by optimization of the machines, as well as by a precise analysis of the production technology on the basis of the key parameters and effects of all disturbances, and by increasing application of process control units. (Edited author abstract) In German.

Capelle, G. *Kautsch Gummi Kunstst* v 40 n 11 Nov 1987 p 1058-1066.

**092255 IKR MIXING MECHANISM AND PERFORMANCE OF COLD FEED EXTRUDER FOR RUBBER.** This paper describes the latest inclined-cavity cold-feed extruder, the 'IKR,' the screw of which has three rows of inclined rectangular cavities at the end section of the rotor and barrel. This inclined-cavity cold-feed ex-

truder has a capacity of over 700 kg/h and has shown remarkable improvement not only in distribution and dispersion performance but also in time reduction of material change over time and remainders. The application of the IKR is expected to expand such fields as extrusion and the warming of rubber, and blending of polymers, additives and chemicals. (Author abstract) 5 refs. In Japanese.

Shirai, Toshio. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 32-34.

**Manufacture** See PLASTICS MACHINERY—Design.

**Mixers** See Also RUBBER—Mixing.

**092256 SELECTION OF OPTIMAL DESIGN OF SCREW MIXER FOR PRODUCTION AND CONVERTING RUBBER MIXTURES.** The process of producing rubber mixtures from powder composites and the simultaneous molding of semiproductions in screw mixers is the most promising process for converting rubber mixtures. The authors carried out comparative investigations of six types of screw mixers with screws with diameter  $D = 80$  mm and length  $L = 9-10 D$  (with the exception of the extended screw with a three-start eccentric thread for which  $L = 16 D$ ). To compare and evaluate the machines, the authors adopted four parameters of the process as criteria: output of the machine  $G$ , final temperature of the mixtures  $T$ , specific energy expenditure on conversion of the mixtures  $q$ , and also the quality of the processing of the mixtures. Results show that the best quality of conversion is ensured by the machine with an elongated three-start screw when fed with compacted and powdered composite. Investigational results were used to design screw mixers. 8 refs.

Bagno, A.I.; Bastrygin, V.V.; Zoroastrova, M.A.; Damov, A.S. *Chem Pet Eng* v 22 n 11-12 Nov-Dec 1986 p 533-535.

**092257 MIXING PERFORMANCE OF MIXER FOR RUBBER.** New technology has been developed for improving the mixing performance of an internal batch mixer, using a 16 l-size mixer equipped with a new type of 4WH rotor operated in a mode of optimum orientation even-speed mixing at a higher rotation speed. Further modifications and improvements regarding rubber-mixing technology are also reviewed, including: (a) precise production of rotors with CAD and CAM, and modification of rotor material; (b) application of a micro-processor to a new automatic mixing controller; and (c) energy-saving devices (mechanical floating weight and mini-oil dust stop). (Author abstract) 1 ref. In Japanese.

Hagiwara, Katsunobu; Hamada, Yoshihiro; Asai, Toshihiro. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 28-31.

**092258 ACQUISITION AND APPLICATION OF DATA OBTAINED DURING THE MIXING CYCLE OF AN INTERNAL BATCH MIXER.** The emphasis in polymer processing and fabrication has been placed upon product uniformity and consistency in the pursuit of improved quality. To accomplish this goal we first must understand the implication of these parameters to the actual process. To define any processing operation there are two components, a fixed mechanical configuration of equipment and a set of variable operating conditions for this equipment. The data which are obtained from the batch mixer provide a dual function: a) to record the processing conditions for documentation, and b) on line indication and control of the operating conditions for the batch mixer. The control systems for batch mixers can benefit from advancements in data acquisition as these parameters are utilized in complex reactive feedback control logic. The better equipped we are to obtain, interpret and apply the data from the batch mixer, the easier it will be to increase processing uniformity.

Flaherty, William F. (Farrel Corp). *Rubber World* v 198 n 4 Jul 1988 p 14-18.

**Molding Machines** See Also RUBBER PRODUCTS—Molding.

**092259 FROM TRANSFER TO INJECTION MOLDING: HOW ONE COMPANY DID IT.** Monarch Rubber recently recognized the need for new manufacturing technology that could help: improve product performance and durability; assure continued product quality through statistical process control aided by micro-processor technology; and improve productivity and reduce costs. Monarch believed all three areas should be attacked simultaneously to maintain their competitive market position. The company launched a major expansion project, enlisting the help of equipment supplier French Oil Mill Machinery. The two companies explored a total systems approach through research and development of alternative molding processes for Monarch's line of vibration control devices. The result was an improved ability to provide customers with the highest-quality parts at good value.

Anon. *Elastomerics* v 120 n 6 Jun 1988 p 28-32.

**092260 BLASTING BY METAL BEADS.** In general terms, using Metalbead and a manually operated, suction feed rubber mould cleaner, a typical  $1 \text{ m}^2$  multicavity segmented mould can be cleaned in less than ten minutes with no change in crucial dimensions. This compares with six hours with acid or chemical methods. Metalbead, unlike glass bead, will not become trapped in vent holes. It therefore will not be brought back to the press and risk contaminating raw stock. The grade of Metalbead will be selected according to the type of rubber mould cleaner specified and the feed method. Suction and pressure feed cabinets are capable of handling moulds up to about  $1 \text{ m}^2$ . Because some moulds are very heavy, a side-loading turntable trolley is used to ease loading and manipulation inside the cabinet.

Lee, Ken (Guyson Int Ltd). *Eur Rubber J* v 170 n 7 Jul-Aug 1988 p 26.

**Reviews** See RUBBER PRODUCTS—Molding.

## Testing

**092261 STRENGTH OF AN IMPROVED STAND FOR RUBBER-PROCESSING ROLLERS.** The improvement of the traditional construction of the roller stand with the aim of improving its life and at the same time reducing its metal content and dimensions represents one of the acute problems of polymer engineering. With the aim of determining the most strongly stressed element, the stressed-deformed state of the improved stand was investigated by the photoelasticity method on a plane model 9.8 mm thick, built at the scale 1:10 from optically sensitive material based on ED-16M epoxy resin, as well as by tensometry on a full-scale unit. 2 refs.

Bondarenko, V.N.; Golovan', S.N.; Korolenko, M.P.; Parfenyuk, A.I.; Linyuk, E.V. *Chem Pet Eng* v 23 n 3-4 Mar-Apr 1987 p 113-115.

**RUBBER PRODUCTS** See Also LAMINATED PRODUCTS; RUBBER—Mechanical Properties; SEALS—Hydrodynamics; SEALS—Reliability; TIRES—Materials.

## Aging

**092262 SCHUTZMITTEL FUER LANGZEITWIRKUNG IN KAUSCHUK.** [Long-lasting Protective Agents for Rubber Products]. An outline is given of the present methods for manufacturing rubber parts used in aggressive atmospheres and exposed to high temperatures, such as in automobile engine compartments. Engine parts must also withstand oil attack and gasoline fumes. A survey of vulcanization agents and additives to rubber is given. In German. 26 refs.

Fries, Hermann (Bayer AG). *Gummi Fasern Kunstst* v 40 n 5 May 1987 12p between p 238 and 258.



**Bonding** See ADHESIVES—Mechanical Properties; TIRES—Cords.

**Components** See SULFUR—Applications.

**Crack Propagation** See AUTOMOBILE MATERIALS—Rubber.

**Curing** See Also RUBBER—Vulcanization.

**092263 THERMODYNAMISCHE ASPEKTE BEI DER VULKANISATION VON GUMMIFORM-TEILEN.** [Thermodynamic Aspects of Curing Molded Rubber Parts]. The vulcanisation of molded rubber parts - their manufacture from the physical standpoint - is a thermodynamic process. Assuming that a complete cross-link is always wanted, then time is a dependent value and assuming that the composition remains constant, then the values pressure and temperature determine the process. The influence exerted by both values on the make-up of molded rubber parts is illustrated separately by two examples. Calculation results are discussed, using an example for thermic interpretation. These results are achieved by employing the Finite Element Method, have specific characteristics and give indications of general importance to the process engineer. In addition, they show which possibilities are offered by employing these calculation methods. (Edited author abstract) 8 refs. In German.

Masberg, U. *Kautsch Gummi Kunstst* v 41 n 4 Apr 1988 p 353-358.

**092264 INCREASE IN THE STATE OF CURE IN VULCANIZATES AFTER REMOVAL FROM THE MOLD.** The progress of cure reactions was observed for rubber sheets during the cooling period after their extraction from the mold. The study was performed by considering either motionless air at 125°C and water at 12°C for cooling the rubber previously cured in a mold kept at 160°C. A significant increase in the state of cure was calculated with the help of a numerical model for the vulcanizates, especially in the case of air at 125°C. An improvement in physical properties such as the swelling in toluene, and mechanical properties measured either under static or dynamic conditions, was determined. (Edited author abstract). 22 Refs.

Khouider, A. (Univ of St. Etienne, St. Etienne, Fr); Vergnaud, J.M. *J Polym Eng* v 8 n 1-2 Jan-Jun 1988 p 19-37.

**092265 INCREASE IN THE STATE OF CURE IN RUBBER SHEETS DURING THE COOLING PERIOD IN WATER.** This paper shows that an increase in the state of cure is obtained within the material during the cooling period in water. Although the progress in the cure is not so large as that occurring when the material was cooled in motionless air, it is still significant especially for large samples. As the state of cure is increased at the midplane of the material or in the surrounding part of the midplane, this fact could reduce the steepness of the gradients of state of cure, making the rubber more homogeneous as far as the state of cure was concerned. Various factors were found to be of importance, and especially the thickness of the material, the motion of the water, and the value of the state of cure when the rubber was extracted from the mold. (Edited author abstract). 14 Refs.

Khouider, A. (Univ of St. Etienne, St. Etienne, Fr); Turin, J.; Vergnaud, J.M. *J Polym Eng* v 8 n 1-2 Jan-Jun 1988 p 55-71.

**Degradation** See POLYISOPRENE—Aging.

**Design** See RUBBER—Mechanical Properties.

**Extrusion** See Also RUBBER MACHINERY—Extruders.

**092266 PROFILE EXTRUSION AND VULCANIZATION.** A complete line for extruding and vulcanizing rubber profiles (300-400 kg/h) is presented. The product's specification, dictated by the profile's build-up and properties, is the main factor determining overall technical

expenditure for a continuously operating production line. Considering the actual market trend, especially in the automotive industry, profile manufacturers are urged to improve their products with regard to constancy of their dimensions and physical properties. A long-term realization of these requirements is only possible by developing a well aimed machine optimization, by analyzing parameters and their effects, and by concentrating on the application of process control systems. Each machine unit was systematically checked and determined optimal parameters applied to the complete line; on this basis an appropriate overall control system concept was developed.

Capelle, Gerd (Hermann Berstorff GmbH); Hunziker, Peter. *Rubber World* v 197 n 6 Mar 1988 p 16-17, 19-20, 22-23.

## Fire Protection

**092267 UNIQUE FIRE PROTECTION USING RUBBER-BASED MATERIALS.** Fire protective elastomeric materials are used in construction for a wide range of applications. These uniquely engineered materials can be used to meet fire codes and to comply with current and proposed fire test standards. Applications include fire protection of penetration seals in fire rated floors and walls, electrical and telephone poke-through devices and electrical raceways in the nuclear and petrochemical industry. The use of a unique rubber compound based on chloroprene and intumescent technology is presented.

Licht, Richard R. (3M Co). *Rubber World* v 198 n 2 May 1988 p 29-31.

**Manufacture** See Also ELASTOMERS—Testing; RUBBER MACHINERY; THERMOPLASTIC ELASTOMERS.

**092268 PRESSES FOR VULCANIZING INDUSTRIAL RUBBER PRODUCTS.** A new type of pressing equipment has been developed. This equipment is intended for shaping and vulcanizing joints in rubber-fabric blanks. Data has also been generated for selecting the optimum operating parameters and for designing hydro-mechanical vulcanizing presses to suit joint lengths of 2 to 40 m. The main operating parameters which affect the working of the press are the unit molding pressure, temperature, and vulcanizing duration. The presses consist of a base, stationary, and movable heating platens, link-lever mechanism for moving the upper platen, mechanism for feeding the workpiece into the operating zone, hydraulic power pack, and control cabinet. The presses can work either in automatic, or in manual modes. 5 refs.

Sakolishch, M.R.; Rusakov, V.A.; Popov, A.V. *Chem Pet Eng* v 23 n 5-6 May-Jun 1987 p 270-273.

**Mechanical Properties** See POLYMERS—Low Temperature Properties.

## Modification

**092269 MECHANIZING THE DIFFUSIVE MODIFICATION OF INDUSTRIAL RUBBER ARTICLES.** Diffusive saturation of industrial rubber articles (IRA) with inhibitors greatly enhance their resistance to various types of aging and helps economize the consumption of deficient components. One of the promising directions of diffusive modification is the use of compositions based on organosilicon polymers which make for favorable redistribution of inhibitors between the saturating shell and the IRA. To overcome the deficiencies and mechanize the process, equipment was designed and built for the dynamic modification of the IRA. The process duration for attaining the given inhibitor concentration in the vulcanizers is primarily determined by kinetic equations of diffusive saturation of the given IRA. 3 refs.

Gerashchenko, E.I.; Prokazova, E.V. *Chem Pet Eng* v 23 n 3-4 Mar-Apr 1987 p 116-118.

**Molding** See Also RUBBER—Processing.

**092270 AUSTRIEBFREIE HERSTELLUNG VON GUMMIFORMTEILEN AUF SPRITZGIESSMASCHINEN.** [Flashless Production of Rubber Molded Parts on Injection Molding Machines]. The author examines the causes of flashes in rubber product manufacture. In addition, he outlines methods for selecting mold dimensions; controlling the injection process; examines the Dwell pressure phase and the flexion of the clamping platens. Transfer molding and flash-free transfer molding are discussed. Flash-free injection molding and mold design are outlined. Methods governing the selection of injection molding machines are given along with precision requirements. The IRN process model is also discussed. In German. 15 refs.

Graf, H.-J. *Kautsch Gummi Kunstst* v 40 n 9 Sep 1987 p 829-836.

**092271 SPRITZTRANSFER FUER DIE FERTIGUNG VON GUMMI/METALL-ARTIKELN.** [Injection Transfer Molding of Rubber/Metal Components]. A survey of the current manufacturing techniques used to bond rubber to components exposed to vibrations is given. Main emphasis is on the parts used in the automobile industry. These parts are attached to metal in order to dampen the excessive vibrations in clutches bearings and mountings by so-called transfer moldings that distribute impact to larger areas. In German.

Cottancin, G. (REP, Corbas, Fr). *Gummi Fasern Kunstst* v 40 n 3 Mar 1987 7p between p 124 and 134.

**092272 PRIMER ON CUSTOM MIXING AND MOLDING: THE QUALITY EQUATION.** In the custom mixing and molding field the two principal manufacturing operations and the areas of technical input and responsibility usually accepted are: 1) mixing of the rubber compound and testing for vulcanization characteristics; and 2) molding of the rubber product and examination for visual faults along with testing for specific mechanical properties such as hardness, deformation and stiffness. A discussion is presented of custom mixing methods along with the pros and cons of three basic processes for molding rubber products. The three processes are: compression molding, transfer molding and injection molding. 3 Refs.

Hepburn, Claude (Loughborough Univ, Engl). *Elastomerics* v 120 n 7 Jul 1988 p 26-29.

**Nondestructive Examination** See ELASTOMERS—Nondestructive Examination.

## Physical Properties

**092273 CHANGES IN THE FINE STRUCTURE OF RUBBER VULCANIZATES FATIGUED BY REPEATED FORCE.** This author investigated the changes in the fine structure of NR vulcanizates fatigued by repeated compression force in relation to the delamination chipping in heavy-duty tires by using small-angle X-ray scattering, low temperature X-ray diffractions and solid pulsed NMR, and reported the formation of the anisotropic structure and the changes in the movement of rubber molecules. The benzene crystallization method has been developed to detect the molecular orientation of SBR and has been applied to the investigation of the changes in the fine structure of SBR vulcanizates fatigued by repeated force. 11 refs.

Udagawa, Y. (Yokohama Rubber Co, Hiratsuka, Jpn). *Rubber Chem Technol* v 61 n 1 Mar-Apr 1988 p 1-13.

**Stresses** See SHOCK WAVES.

**Structural Analysis** See AUTOMOBILE MATERIALS—Rubber.

**Surface Properties** See RUBBER—Processing.



Testing See RUBBER, SYNTHETIC—Abrasion Resistance; TIRES—Cords; TIRES—Reviews.

## Vibrations

**092274 ON THE ROLE OF NON-LINEARITY IN THE DYNAMIC BEHAVIOUR OF RUBBER COMPONENTS.** Rubber components are frequently used in automotive applications as isolators, bushes, mounts or springs, usually bonded to steel end pieces and usually where very specific dynamic behavior is required for anti-vibration purposes. The force/deflection behavior of rubber is in general non-linear. Design of rubber engineering components conventionally seeks to suppress or avoid the effects of nonlinearity over the operating range of the component. Alternatively if the consequences of nonlinearity for dynamic behavior are understood well enough, then it is possible to exploit its effects in novel ways to enhance the performance of rubber components. In this paper the basic features of the dynamic mechanical properties of rubber are discussed together with consideration of the way they may be influenced by nonlinear force/deflection behavior. The advantages that may be gained from nonlinearity are illustrated by the performance of a recently developed automotive suspension system. (Author abstract) 5 refs.

Harris, J. (MRPRA, Brickendonbury, Engl); Stevenson, A. *Int J Veh Des* v 8 n 4-6 1987 p 553-577.

## Viscoelasticity

**092275 VISCOELASTIC PROPERTIES OF STRUCTURAL SILICONE RUBBER SEALANTS.** This paper presents a theoretical approach used to predict the behavior of silicone rubber under uniaxial stress fields. The model is based on the concept of the classical Maxwell treatment of viscoelasticity and stress relaxation behavior. However, the Hookean spring component of the Maxwell element is replaced with an ideal elastomer component. With this substitution, the new model permits the crosslink density of the silicone elastomer to be estimated from test data and allows a stress level to be predicted as a complex function of extension, crosslink density, absolute temperature, and relaxation time. Simple uniaxial tensile tests were performed on two commercial silicone rubber sealants. Their experimental behavior was compared to the predicted performance based on the new viscoelastic model. Agreement was found to be quite good. (Edited author abstract). 13 Refs.

Tock, Richard W. (Texas Tech Univ, Lubbock, TX, USA); Dinivahi, M.V.R.N.; Chew, Choon Hoi. *Adv Polym Technol* v 8 n 3 Fall 1988 p 317-324.

## RUBBER RECLAMATION

### Granulation

**092276 KUELOENLEGES FINOMSAGU ES ELOKEZELT GUMIORLET HASZNOSITASA.** [Utilization of a Pre-treated Rubber Granulate of Special Fineness]. The general problems of utilizing rubber wastes are discussed. The applicability of secondary prime materials produced within the country for the tyre industry is reported. (Edited author abstract) 6 refs. In Hungarian.

Kulesar, Erno (Taurus Gumiipari Vallalat, Budapest, Hung). *Muanyag Gumi* v 24 n 6 1987 p 173-176.

**RUBBER, SYNTHETIC** See Also COMPOSITE MATERIALS—Fiber Reinforced; ELASTOMERS; POLYMERS—Modification; POLYMERS—Structure.

**092277 MAKING ISOPRENE FROM N-BUTENES.** Isoprene can be made by regioselective hydroformylation of 2-butenes to 2-methylbutanal followed by dehydration or, alternatively, hydroformylation of isobutene to 3-methylbutanal followed by dehydration. However, as is discussed, dehydrating aldehydes that are not branched at the 2-position is much less selective than with 2-branching. Thus, the more practical approach with respect to isoprene is to proceed via hydroformylation of 2-butenes to

2-methylbutanal. The authors show that dehydration of aldehydes and ketones of appropriate structure can be a selective route to dienes. When this chemistry can be combined with an efficient process for generation of the aldehyde or ketone such as hydroformylation, then an economically attractive route to diene can be achieved. 8 refs.

Forster, Denis; Sluka, James P.; Vavere, Atis. *CHEM-TECH* v 16 n 12 Dec 1986 p 746-751.

**092278 SORPTION AND DIFFUSION OF WATER IN ETHYLENE-PROPYLENE DIENE RUBBER IN PRESENCE OF VULCANIZATION ACCELERATORS.** The authors have studied the diffusion and sorption patterns of water vapor by the ethylene propylene diene elastomer SKEPT-40 and its composites with vulcanization accelerators in the activity interval of the vapor  $0.1 < p/p_s < 0.85$ . It is shown that the water sorbed by the polymer is in the matrix in three states: bound, clustered and free. The  $p/p_s$  intervals within which the particular states of sorbed water in the elastomer may be realized are determined. (Author abstract) 17 refs.

Chalykh, A.Ye. (USSR Acad of Sciences, USSR); Dontsov, A.A.; Petrova, T.F.; Lapshova, A.A. *Polym Sci USSR* v 28 n 6 1986 p 1348-1355.

**092279 CHARACTERIZATION OF RUBBER PARTICLE SIZE DISTRIBUTION OF HIGH-IMPACT POLYSTYRENE USING AN IMAGE ANALYSIS METHOD.** Accurate characterization of high-impact polystyrene (HIPS) rubber particle size distribution has been achieved using an automatic image analysis system. The new method involves preparation of a microscope slide consisting of a dilute suspension of HIPS particles in a polymer matrix. Images of silhouetted rubber particles of true diameter are obtained using an image processor and particle size calculations can be made with a minimum of editing of the binary image. The new method provides measurement of true rubber particle diameters because the particles in the prepared slide are not swollen by an solvent. (Author abstract). 5 Refs.

Hall, R.A. (Amoco Chemical Co, Naperville, IL, USA). *J Appl Polym Sci* v 36 n 5 Aug 20 1988 p 1151-1155.

## Abrasion Resistance

**092280 FORMATION OF ABRASION PATTERNS AND THE WEAR OF RUBBER.** Wheels of an unfilled isoprene rubber and a carbon-black natural rubber were rubbed against a cylinder or a razor blade, and the formation mechanisms of abrasion patterns and the wear mechanisms of rubber were examined. When the abrasion patterns were formed on the rubber surfaces, small particles by roll-formation were observed in the early stage of wear. They grew up to relatively large in size and adhered to the rubber surface. Then cracks were formed just beneath the front portion of the adhered particles and grew large to form a series of the abrasion patterns having saw teeth. During motion of the slider the teeth are bent backwards, thus exposing their underside to the action of the slider. (Edited author abstract) In Japanese. 38 refs.

Uchiyama, Yoshitaka; Sawai, Muneyoshi. *Mem Fac Technol Kanazawa Univ* v 20 n 2 Mar 1987 p 33-43.

## Additives See RUBBER PRODUCTS—Aging.

## Aging

**092281 ADVANCED SYSTEM FOR EPICHLOROHYDRIN RUBBER VULCANIZED WITH TRI-AZINE THIOLS.** This article describes a new type of epichlorohydrin rubber, epichlorohydrin-ethylene oxide-allyl glycidyl ether terpolymer (GECO), named Gecron 3100 series, as well as its ancillary curing agent called ZISNET-F, or 2,4,6-trimercapto-S-triazine (triazine F). This combination, compared with conventional epichlorohydrin rubber, has not only excellent heat and ozone resistance but also excellent compression set resistance. Consequently, in Japan GECO/triazine F epichlorohydrin compounds have become the major material for

the manufacture of emission control hose tubes, exhaust gas control components and diaphragms. In this article, the authors describe the improvements achieved in aging properties as a result of the combined use of this new epichlorohydrin rubber and the new vulcanizing agent, especially with regard to compression set and heat resistance. 6 refs.

Hashimoto, Kinro (Nippon Zeon of America Inc, Akron, OH, USA); Maeda, Akio; Inagami, Masaaki; Watanabe, Noboru. *Elastomerics* v 119 n 9 Sep 1987 p 12-15.

**092282 STUDIES ON THE AGEING OF EPDM BASED ROCKET INSULATOR COMPOUND BY STRESS RELAXATION AND THE EFFECT OF PROPELLANT BINDER.** The stress relaxation of unaged and aged solid propellant insulator compound based on EPDM has been investigated. The effect of a thin coating of hydroxy-terminated polybutadiene (HTPB) rubber on the insulator compound has also been studied. The results indicate that for EPDM gum vulcanizate, stress relaxation occurs due to physical flow of rubber chains and an interchange reaction of polysulfidic linkages, particularly at high temperature. However, stress relaxation data for asbestos fiber and cork filled compounds and the insulator lie on two intersecting straight lines, indicating physical relaxation processes. The first line, of greater slope ( $< 200$  s), is attributed to rearrangement/reorientation at the rubber-filler interface. On ageing, the rate of relaxation decreases for asbestos and cork filled compounds, indicating an enhancement in rubber-filler interaction. However, the coating of HTPB serves as a protective layer in the relaxation process for the insulator compound under stress. (Author abstract) 10 refs.

Deuri, A. Saha (Indian Inst of Technology, Kharagpur, India); De, P.P.; Bhowmick, Anil K.; De, S.K. *Polym Degradation Stab* v 20 n 2 1988 p 135-148.

## Amorphous See RUBBER—Amorphous.

## Antioxidants See Also ANTIOXIDANTS—Polymerization.

**092283 STABILISATION OF EPDM AT HIGH TEMPERATURES BY POLYMER-BOUND ANTIOXIDANTS: III. EVALUATION OF MASTER-BATCH CONCENTRATES.** Concentrates of two polymer-bound arylamine antioxidants (MADA-B and MPDA-B) in EPDM (2 g/100 g) were found to be rather more effective than MADA-B made by the normal treatment of the whole rubber at the same concentration. They are also shown to be considerably more effective than conventional arylamine antioxidants (Nugard 445 and Flectol H) under a range of high temperature tests designed to simulate the severe conditions to which the rubbers are exposed in seals and gaskets. A practically relevant contamination test in which the rubbers are subjected to contact with a hydraulic fluid (Skydrol) before exposure to high-temperature aging has been found to provide a means of discrimination between different antioxidants. (Author abstract) 8 refs.

Scott, Gerald (Aston Univ, Birmingham, Engl); Tavakoli, S. Mehdi. *Plast Rubber Process Appl* v 9 n 1 1988 p 59-62.

## Applications See Also AIRCRAFT—Ice Problems.

**092284 SPECIALITY APPLICATIONS OF BUTYL RUBBER.** The discussion on butyl rubber includes the following topics: the chemistry of polymerization; the production of butyl rubber, halobutyl rubber, and crosslinked butyl rubber; basic properties of regular butyl rubber, halobutyl rubber, and crosslinked butyl rubber, as well as the choice of grade/type; basic compounding of butyl rubber (curing systems); other compounding ingredients; compounding for specific vulcanizate properties (heat resistance, ozone resistance, polymer unsaturation, fillers and plasticizers, protective agents, moisture/steam resistance, chemical resistance, permeability and low-temperature properties); the basic compounding of halobutyl rubber; the basic compounding of crosslinked butyl



rubber; processing; blending with other elastomers; and applications. 10 refs.

Kumbhani, K.J. (Polysar Ltd). *Rubber World* v 198 n 3 Jun 1988 p 28-37.

**Blending** See Also NYLON POLYMERS—Blending; POLYETHYLENES—Reinforcing; RUBBER—Blending.

**092285 MORPHOLOGY AND PROPERTIES OF BLENDED NBR/PVC/BR ELASTOMERS.** Nitrile rubber (NBR) has good oil resistance, but lacks ozone resistance. Addition of polyvinyl chloride (PVC) leads to a rubber-plastic mixture which may have more desirable properties. In order to increase the elasticity of NBR/PVC elastomers the authors have developed a method of addition of butadiene rubber (BR) to compose ternary elastomers. The novel elastomer has been fabricated into oil-resistant gaskets and driving belts. It appears that the composition has a significant economical advantage over currently used materials. 4 refs.

Xiaojiang, Zheng (Univ of Science & Technology, Chengdu, China); Pu, Henry H.; Yafei, Lu. *J Polym Sci Part C* v 26 n 6 Jun 1988 p 255-258.

## Chemistry

**092286 REACTIVITIES OF SULFUR-CENTERED RADICAL TOWARD POLYISOPRENES AND POLYBUTADIENES STUDIED BY FLASH PHOTOLYSIS METHOD.** The kinetic behavior of the thiyl radical in the solution containing polyisoprenes and polybutadienes has been studied by the flash photolysis method. For benzothiazole-2-thiyl radical, the addition rate constants toward these polymers and the model compounds of the polymers were evaluated. The relative reverse rate constants and equilibrium constants were also estimated. The addition rate constants decrease with an increase in the degree of polymerization. The relative reverse rate constants for the polymers are smaller than those for 2-methyl-2-butene, suggesting a kind of polymer effects; i.e., it can be presumed that the bonded-thiyl radicals migrate very rapidly to the neighboring double bonds in the polymer. Significant differences in the rate parameters were observed between polyisoprene, and polybutadiene, between cis- and trans-polyisoprenes, and between 1,4- and 1,2-polybutadienes. (Edited author abstract) 24 refs.

Ito, Osamu (Tohoku Univ, Sendai, Jpn); Tamura, Saburo; Murakami, Kenkichi; Matsuda, Minoru. *J Polym Sci Part A* v 26 n 5 May 1988 p 1429-1438.

## Crack Propagation

**092287 CUT-GROWTH BEHAVIOUR OF EPDM-BROMOBUTYL RUBBER BLENDS UNDER REPEATED STRESSING.** Cut-growth behavior of ethylene-propylene-diene rubber (EPDM), bromobutyl rubber (BIIR) and their blends under dynamic loading has been studied over a range of temperatures. The crack-growth resistance increases with the increase of BIIR content in the gum and filled blends. The 30:70 EPDM:BIIR blend, however, gives the best fatigue resistance because of morphology and strain energy density factors. Failure surfaces have been examined both by photography and electron microscopic techniques. The crack always propagates from the precut. The rate of crack propagation is faster for EPDM gum samples. The blends show fracture features intermediate between those of fractured BIIR and EPDM rubbers. Straight flow lines, cracks and fatigue striations (10 to 15  $\mu$ m distance between two consecutive striations) are observed for gum samples. The flow lines are increased and the cracks are reduced for filled samples. The fractography of the crack front at the precut and that away from it are similar. At a higher temperature (100°C), there is a reduction of fatigue life for the blends and pure rubbers. Many cracks are observed on the fracture surface of gum and filled samples. (Author abstract) 11 refs.

Bhaumik, Tapan K. (Indian Inst of Technology, Kharagpur, India); Gupta, B.R.; Bhowmick, Anil K. *J Mater Sci*

v 22 n 12 Dec 1987 p 4336-4342.

**Crosslinking** See POLYETHYLENES—Crosslinking.

**Curing** See RUBBER—Curing.

**Deformation** See Also TIRES—Cords.

**092288 THERMOELASTIC MEASUREMENTS OF SOME ELASTOMERS UNDER EXTENSION AND TORSION.** The relative energetic contribution to the retractive force of a deformed rubber sample,  $F_e/f$ , and the corresponding  $M_e/M$  have been evaluated from thermoelastic measurements of constant pressure. A wide range of elongations  $1.25 < \alpha < 3.0$  has been studied over the temperature range 20-100°C. Thermoelastic measurements have been obtained for butyl rubber, cis-polybutadiene rubber and styrene-butadiene rubber, using two different experimental techniques, the first from measurements of  $F_e/f$  in simple extension, and the other from measurements of the internal energy contribution  $M_e$  to the restoring couple  $M$  in cylindrical rubber samples (subjected to combined torsion about the axis and extension in the axial direction). The results of this work are used to assess the principal theories of elasticity. (Edited author abstract) 23 refs.

Mohsin, Mahmood A. (Univ of Manchester, Manchester, Engl); Treloar, Leslie R.G. *Polymer* v 28 n 11 Oct 1987 p 1893-1898.

**092289 VAN DER WAALS MODEL FOR FILLED RUBBERS WITH MODIFIED INTERFACIAL CONTACTS.** It is shown how the global deformation mechanism in filler-loaded vulcanizates was modified by additional filler-to-matrix bonds. A quantitative description is given in terms of an extended van der Waals treatment including the formulation of a reduced mechanical equation of state. An interpretation of the Mullins softening is presented. (Author abstract) 30 refs.

Kilian, H.G. (Univ ULM, Oberer Eselsberg, West Ger); Schenk, H. *J Appl Polym Sci* v 35 n 2 Feb 5 1988 p 345-362.

## Degradation

**092290 THERMOCATALYTIC DEGRADATION OF ISOBUTYLENE POLYMERS IN PRESENCE OF MAGNESIUM CHLORIDES.** The thermal degradation of polyisobutylene and butyl rubber in presence of magnesium chloride is activated by chemically bound water as is confirmed by the experimental results and quantumchemical calculations. A feature of the thermocatalytic degradation is the combination of the processes of initiation by the 'law of chance' and the 'law of end groups'. Analysis of the experimental data and the quantum chemical calculations shows that the activity of the magnesium chloride crystallohydrates in the thermal degradation of PIB is due to the presence in the catalysts of chemically bound water. (Edited author abstract) 9 refs.

Ivanova, S.R. (Bashkir 40th October Revolution State Univ, USSR); Ponedel'kina, I.Yu.; Romanko, T.V.; Karpasas, M.M.; Minsker, K.S. *Polym Sci USSR* v 28 n 6 1986 p 1356-1360.

**092291 KINETICS AND MECHANISM OF THE OZONE DEGRADATION OF NITRILE RUBBERS IN SOLUTION.** The kinetics of the decrease in the molecular mass of three nitrile rubber samples, containing, respectively, 20, 28 and 39 mol% of acrylonitrile, has been studied viscosymetrically during their ozonization in solution. By comparing the functional groups obtained during ozonolysis of the C=C bonds with the amount of the ozone consumed, it has been found that approximately 1 mole of ozonides or 2 moles of aldehydes are formed from 1 mole of reacted ozone. An attempt has been made to prove the authors' suggestion that the intensity of the ozone degradation in solution of polybutadiene elastomers with predominantly 1,4-trans bonded butadiene, is considerably higher than that of the 1,4-cis-polybutadiene rubbers. (Edited author abstract) 19 refs.

Anachkov, M.P. (Inst of Kinetics & Catalysis, Sofia, Bulg); Rakovsky, S.K.; Stefanova, R.V.; Shopov, D.M. *Polym Degradation Stab* v 19 n 4 1987 p 293-305.

## Dielectric Properties

**092292 DIELECTRIC PROPERTIES OF PERBUNAN RUBBER:  $\gamma$ -IRRADIATION EFFECTS.** A systematic dielectric study over a frequency range extending from 200 Hz to 100 KHz and temperature ranging from 20° to 60°C has been carried out on perbunan rubber. The acrylonitrile content of the rubber samples was 28% and 38%. The effect of 15 MR  $\gamma$ -irradiation on the dielectric properties of both samples was studied and the results are interpreted. The study revealed that NBR-38 is better than NBR-28 for insulating purposes. (Author abstract) 5 refs.

Abd El-Nour, K.N. (Nat'l Research Cent, Cairo, Egypt); Fouda, I.M.; Migahed, M.D. *Polym Degradation Stab* v 19 n 3 1987 p 207-211.

**092293 EFFECT OF THERMAL AGING ON XANTHAN SOLUTIONS.** Few investigations have been carried out to study the mechanical and electrical properties of this type of rubber. The effect of the stepwise addition of conventional rubber ingredients to raw butyl rubber on its dielectric properties was previously carried out at low frequency region. Systematic studies of the dielectric properties of butyl rubber is not yet available over a wide range of frequency. In this note, the dielectric properties are studied at a wide range of frequencies extending from  $10^6$  to  $10^{10}$  Hz. The values obtained for  $\epsilon'$  and  $\epsilon''$  for the different samples are shown graphically. The values of  $\epsilon'$  and  $\epsilon''$  increase with increase of filler content. From these figures it is clear that pure there is a region of anomalous absorption with a maximum at about  $10^7$  Hz, which corresponds to pure Debye losses. The position of the maximum is nearly the same for the filler-free sample and the filled ones, indicating that there is no chemical interaction between any of the fillers and butyl rubber. 8 refs.

Hakim, I.K. (Nat'l Research Cent, Cairo, Egypt); Bishai, A.M.; Saad, A.L. *J Appl Polym Sci* v 35 n 4 Mar 1988 p 1123-1125.

## Elasticity

**092294 EXPERIMENTAL ANALYSIS OF THE MOLECULAR THEORY OF RUBBER ELASTICITY.** Stress-strain and birefringence-strain experiments, on polybutadiene and poly(methyl-3,3,3-trifluoropropyl siloxane) elastomeric networks of various degrees of crosslinking have been carried out in order to evaluate the molecular theory of rubber elasticity, which is based on the idea of constraints imposed by entangled network chains on crosslink fluctuations. Previously published results on polyoxypropylene and poly(dimethylsiloxane) networks have also been analyzed. In general, the theory describes the elastic behavior of all these systems satisfactorily. Stress-strain and birefringence data can be interpreted using the same set of parameters. (Edited author abstract) 18 refs.

Sanjuan, J. (Univ a Distancia, Madrid, Spain); Llorente, M.A. *J Polym Sci Part B* v 26 n 2 Feb 1988 p 235-244.

**Evaluation** See RUBBER—Evaluation.

## Extrusion

**092295 COMPARISON OF SCREW EXTRUSION OF RUBBER COMPOUNDS WITH DIFFERENT EXTRUDER/SCREW COMBINATIONS.** The authors describe a fundamental study of flow mechanisms in screw extruders for rubber compounds. They expand their earlier studies based on the Maddock screw-pulling procedure, with rubber strips containing markers in a comparison of three different screw extruders. The placement of the rubber is recorded and the rubber sections examined for their flow patterns. This work also extends their earlier market experiments on flow of rubber compounds through dies. Their results on screw extruders



exhibited both transverse flow patterns and sometimes showed a starved, partially filled screw. Their efforts in this paper seek to generalize these results. They also describe a theoretical model for the flow of rubber compounds in a screw extruder and compare it with their experiments. 28 refs.

Kubota, Kazuhisa (Univ of Akron, Akron, OH, USA); Brzowski, Ryszard; White, James L.; Weissert, Frederick C.; Nakajima, Nobuyuki; Min, Kyonsuku. *Rubber Chem Technol* v 60 n 5 Nov-Dec 1987 p 924-944.

**092296 AIR-LUBRICATED DIE FOR EXTRUSION OF RUBBER COMPOUNDS.** In many cases, the output of a rubber extruder is limited by the resistance of flow in the die. It is shown that the resistance of flow of rubber compound through the die can be greatly reduced while retaining good product appearance, by using a die with a porous wall and injecting air so as to separate the extruding rubber from the wall. This method seems to be especially suitable for extrudates of circular and annular cross sections, where the same extrudate swelling develops in all directions. 6 refs.

Brzowski, Ryszard (Univ of Akron, Akron, OH, USA); White, James L.; Szydlowski, Witold; Weissert, Frederick C.; Nakajima, Nobuyuki; Min, Kyonsuku. *Rubber Chem Technol* v 60 n 5 Nov-Dec 1987 p 945-956.

## Fillers

**092297 EFFECT OF SILANE COUPLING AGENT ON VULCANIZATION, NETWORK STRUCTURE, POLYMER-FILLER INTERACTION, PHYSICAL PROPERTIES AND FAILURE MODE OF MICA-FILLED STYRENE-BUTADIENE RUBBER.** Physical properties of composites from mica and styrene-butadiene rubber (SBR) have been studied with special reference to the effect of silane coupling agent (A-174) in the compound. Tensile and tear properties increase with the addition of mica. The increase of tensile properties is more pronounced in the case of silane-treated mica. Silane treatment also raises the volume fraction of rubber in solvent-swollen rubber vulcanizate. Attempts have been made to correlate the changes in properties with the network structure of rubber. In order to understand the mechanism of failure, tensile fracture surfaces have been examined by scanning electron microscopy (SEM). The fractographs have been correlated with the strength and type of failure of these composites. The observed values of viscosity (rheometric) corresponds to the calculated values from existing theory based on the hydrodynamic model of dispersed particles in a fluid medium. (Author abstract) 26 refs.

Debnath, S. (Indian Inst of Technology, Kharagpur, India); De, S.K.; Khastgir, D. *J Mater Sci* v 22 n 12 Dec 1987 p 4453-4459.

## Heat Resistance

**092298 HEAT RESISTANCE EVALUATION FOR RUBBER COMPOUNDS.** The method used for calculating heat resistance index (HRI) by studying the kinetics of elongation loss, has been shown to be a more thorough method of comparing rubber materials for hardening upon aging under accelerated conditions. The HRI analysis describes in this paper gives a more comprehensive technique for developing heat resistant materials based on different polymer systems are demonstrated by the excellent correlation between elastomeric shaft seal life and HRI. HRI may be a valuable technique for estimating service life of rubber components where heat hardening is the primary contributor to rubber failure. 12 refs.

Dinzburg, Boris N. (CR Industries); Keller, Robert W.; Bond, Robert. *Rubber World* v 197 n 5 Feb 1988 p 28-32.

## Injection Molding

**092299 INJECTION MOULDING OF LIQUID SILICON RUBBER.** With liquid silicone rubber (LSR) one differentiates between single and double component systems, which can be processed on injection moulding

machines with or without the addition of colour pastes. Single component systems crosslink with peroxides, in the same way as with the conventional production of mouldings in solid silicone rubber. The speed of vulcanisation is mainly determined by the peroxide used. With the two-component system the advantages of addition crosslinkage are utilised. The two-component liquid silicones differ from conventional elastomers, in that they are ready-to-use blends of paste-like consistency. That also is a reason, why the processing of liquid silicone rubbers is gaining entrance into shops specialising in thermoplastics injection moulding. Liquid silicon rubbers excel through good low-temperature flexibility, superb ageing characteristics (particularly under the influence of ozone) and distinguished dielectrical performance over a wide temperature range. 6 refs.

Steinbichler, G. *Kunstst Ger Plast* v 77 n 10 Oct 1987 p 3-5.

**Manufacture** See Also EMULSIONS—Polymerization.

**092300 ANTIOXIDANTS IN THE PREVENTION OF ACRYLONITRILE TOXICITY.** Long-term 5-year application of antioxidants by means of adding alpha-tocopherol or ionole to the gravy of the ready-made meat dish used for dietotherapy in workers engaged in the production of acrylonitrile synthetic rubbers assisted in decreasing disease incidence among workers of major occupations by 35.5%. Disability day loss was decreased by 37.8%, and among all those working at the plant by 17% and 14%, respectively. (Edited author abstract) In Russian. 5 refs.

Ivanov, V.V.; Klimatskaya, L.G. *Gig Tr Prof Zabol* n 8 Aug 1987 p 20-22.

**Marketing** See RUBBER—Marketing.

**Mechanical Properties** See Also ANTIOXIDANTS—Performance; EPOXY RESINS—Fracture; POLYBUTADIENES—Aging.

**092301 COMPARISON OF TENSILE AND SHEAR BEHAVIOR OF CARBON-BLACK-FILLED ELASTOMERS.** When the carbon black is compounded into rubber on a two-roll mill, an experienced operator sometimes stretches the compound by hand to see if a satisfactory dispersion of carbon black is achieved. This demonstrates that the elongational behavior is one of the important characteristics of the compound. Comparison of elongational and shear behavior is expected to yield information on the difference in behavior of the gum and the filled compound. This paper presents the results of these measurements, a systematic treatment of the data, and an interpretation based on a possible mechanism concerning the role played by carbon black on the deformation of the compound. 22 refs.

Nakajima, N. (Univ of Akron, Akron, OH, USA); Scobbo, J.J. Jr.; Harrell, E.R. *Rubber Chem Technol* v 60 n 4 Sep-Oct 1987 p 761-780.

**092302 EFFECTS OF MIXING PROCEDURE ON DYNAMIC MECHANICAL PROPERTIES OF AN ETHYLENE-PROPYLENE-DIENE RUBBER/BROMOBUTYL RUBBER BLEND.** Ethylene-propylene-diene rubber (EPDM) and bromobutyl rubber (BIIR) are widely used in automotive suspension applications. In this work, the effects of mixing procedure on the dynamic mechanical properties of the EPDM/BIIR blends have been investigated using a Du Pont 1090/982 Dynamic Mechanical Analyzer. These properties include storage modulus and damping coefficient. Experimental data show that the low temperature dynamic mechanical properties of the blend compositions mixed using a constant temperature procedure are better than those mixed by a conventional method. (Edited author abstract) 7 refs.

Trexler, H.E.; Lee, M.C.H. *Kautsch Gummi Kunstst* v 40 n 10 Oct 1987 p 945-949.

**092303 EFFECTS OF TRANS-POLYOCTENYLENE ON THE MECHANICAL PROPERTIES OF**

**NBR.** Trans-polyoctenylene (TOR), a high-polymer polymerization product of cyclooctene, has found use as a processing aid in high-viscosity rubber stocks. The authors have compared some physical and mechanical properties of a NBR-compound with TOR with those of the same compound without TOR. Mooney viscosity was lower for the compound with TOR. Cylinders with a height and diameter of 20 mm were molded. It was found that stress-relaxation measured in the common static way was almost the same for the two compounds. Dynamic stress-relaxation occurred much more rapidly for the compound with TOR. The compound with TOR increased in hardness more rapidly when aged in air, and showed a higher swelling in oil. The DSC results imply that TOR is incorporated as a separate phase in the parent rubber. The sealing properties are affected detrimentally when TOR is used as a processing aid in NBR. (Edited author abstract) 6 refs.

Bjork, Folke (Royal Inst of Technology, Stockholm, Sweden); Stenberg, Bengt. *J Appl Polym Sci* v 34 n 8 Dec 1987 p 2649-2655.

**092304 EFFECT OF FLAW SIZE ON TENSILE RUPTURE AND MORPHOLOGY OF FRACTURE SURFACE OF SYNTHETIC RUBBERS WITH SPECIAL REFERENCE TO ROCKET INSULATOR COMPOUND.** Studies on tensile strength of polybutadiene (RR) and ethylene-propylene diene rubber (EPDM) having a wide range of flaw sizes have been carried out under both normal and aging conditions. A similar study has been done for a solid propellant rocket insulator compound, based on EPDM. The morphology of tensile fracture surface has also been reported in each case in order to understand the mechanism of rupture. Unlike NR, EPDM, and BR gum vulcanizates, both unaged and aged, show no critical cut length ( $l_c$ ). Scanning electron microscopic studies show that the mechanism of rupture EPDM and BR gum vulcanizates are similar throughout the whole range of precuts. It occurs through a tearing process originated from the given precut at the center of the samples. A quantitative relation between tensile strength and distance between crack lines/tear lines has also been found. Though insulator compound shows a definite  $l_c$ , similar fracture surface has been observed over the entire range of flaw sizes. (Edited author abstract) 6 refs.

Deuri, A. Saha (Indian Inst of Technology, Kharagpur, India); Bhowmick, Anil K. *J Appl Polym Sci* v 35 n 2 Feb 1988 p 327-343.

**092305 TENSILE IMPACT AND FLEX FATIGUE FAILURE OF EPDM/XLPE BLENDS.** The impact strength increases with the weight per cent of XLPE and reaches a maximum at 70 percent XLPE. The tensile strength increases at lower proportions of XLPE and tends to level off at higher ( $\geq 70$  percent) proportions. The impact behaviour can be correlated with the increase in tensile strength which increases the force required to rupture the specimen and prevents the crazes from developing into a crack. As the proportion of XLPE increases, the flex resistance decreases and the rate of decrease is sharper at lower proportions of XLPE ( $< 50$  percent). The decrease of fatigue resistance with increase of XLPE is associated with the high stiffness of the XLPE compared to EPDM. 12 Refs.

Thomas, Sabu (Indian Inst of Technology, Kharagpur, India); Nando, Golok B. *J Mater Sci Lett* v 7 n 6 Jun 1988 p 557-559.

## Microstructure

**092306 STRUCTURE AND PROPERTIES OF A NEW SYNTHETIC TIRE RUBBER: HIGH-TRANS SBR.** In 1978, the authors described a Ba-Li catalyst system capable of producing butadiene homopolymer and butadiene-styrene copolymers with trans-1,4 sequences long enough to cause crystallization and correspondingly good green strength. The present paper focuses on further development, at the author's laboratory, leading to styrene-butadiene rubbers which possess excellent green strength and tack strength. Their black vulcanizates



display outstanding abrasion resistance, are resistant to oxidation and crack initiation, and, in blends with NR, show a remarkably low rate of crack growth. 23 refs.

Fabris, H.J. (GenCorp, Akron, OH, USA); Hargis, I.G.; Livigni, R.A.; Aggarwal, S.L. *Rubber Chem Technol* v 60 n 4 Sep-Oct 1987 p 721-741.

## Molecular Structure

**092307 DETERMINATION OF THE STRUCTURE OF CHLOROBUTYL AND BROMOBUTYL RUBBER BY NMR SPECTROSCOPY.** Chlorobutyl and bromobutyl rubbers are manufactured by adding molecular chlorine or bromine to a solution of butyl rubber in a hydrocarbon solvent. The chemical structures of the halobutyl rubbers have not been fully characterized, because the isoprenyl content, the site of the halogenation reaction, is very low (less than 3%). This paper reports the detailed  $^1\text{H}$  and  $^{13}\text{C}$  NMR spectra of both chlorobutyl and bromobutyl rubbers and assigns the observed signals to the exomethylene structure. Attempts are also made to assign minor signals in the  $^1\text{H}$  spectra to other possible structural variants. 12 refs.

Chu, Chia Yeh (Polysar Ltd, Sarnia, Ont, Can); Watson, Kenneth Norman; Vukov, Rastko. *Rubber Chem Technol* v 60 n 4 Sep-Oct 1987 p 636-646.

## Oxidation

**092308 PHOTO-OXIDATION OF EPDM RUBBER: PART 1 - KINETICS OF OXYGEN CONSUMPTION.** In this paper we describe the kinetics of oxygen consumption of films of nonvulcanised EPDM rubber irradiated with UV light. Purified rubber shows a lower consumption rate compared with crude rubber. Also, a strong lowering of the rate is observed on irradiating at 365 nm compared with 313 nm. Introduction of benzophenone as initiator increases the rate on irradiating at 365 nm. These results are interpreted in terms of impurity initiated photo-degradation. Use of a hindered amine additive decreases the overall rate of oxygen consumption in proportion to its concentration in the films, thus acting as a stabiliser for this rubber. This stabilising effect is also observed when benzophenone is present in the film. (Author abstract). 12 Refs.

De Paoli, Marco-A. (Univ Estadual de Campinas, Brazil). *Polym Degradation Stab* v 21 n 3 1988 p 277-283.

## Performance

**092309 VERHALTEN VON EPDM BEI TIEFEN TEMPERATUREN.** [Low-Temperature Behavior of EPDM]. The low-temperature performance of technical rubber goods is increasingly being specified with respect to compression set, hardness and torsion modulus. Using ethylene-propylene rubber, the author investigates to what degree molecular structure, molecular weight and tercomponent influence the behavior of vulcanisates at low temperature. Beside the rubber, lubricants and plasticisers affect the flexibility as well, as demonstrated by comparing a mineral oil that has a solidification point above the glass transition temperature of the rubber with an ester plasticiser whose solidification point lies below the  $T_g$  of the rubber. (Edited author abstract) In German.

Mahlke, D. *Kautsch Gummi Kunstst* v 40 n 10 Oct 1987 p 931-934.

## Physical Properties See Also LIGNIN; RUBBER—Physical Properties.

**092310 ETHYLEN-ACRYLATAUTSCHUK - EIN KOSTENGUNSTIGER DICHTUNGSWERKSTOFF FUER HOHE BEANSPRUCHUNGEN.** [Ethylene-Acrylate Rubber - a Cost-Profitable Temperature Resistant Sealing Material]. This paper describes the development of ethylene-acrylate rubber Vamac (Du Pont) and its use as temperature resistant sealing material. The compound is explained and the physical properties of respective vulcanisates, especially after long term aging at 120 and 140°C, are presented. Furthermore this work shows the

technical possibilities and the significance of this new inexpensive polymer for the manufacture of rocker cover seals, inner axle boots for the automotive industry and oil hose covers in comparison with conventional sealing materials, like NBR and ACM. (Edited author abstract) In German.

Huebsch, D. *Kautsch Gummi Kunstst* v 41 n 3 Mar 1988 p 239-241.

## Polymerization

**092311 EFFECT OF CHEMICAL MODIFICATION OF SOLUTION-POLYMERIZED RUBBER ON DYNAMIC MECHANICAL PROPERTIES IN CARBON-BLACK-FILLED VULCANIZATES.** The above-mentioned chemical modification has been developed by slightly modifying the chain-ends using a lithium catalyst system without changing the main chain structure. The chemical modification involves an addition reaction of some polar compounds such as EAB [4,4'-bis-(diethyl amino)benzophenone]. The chemical modification has been applied to both high-vinyl polybutadiene (Nipol BR 1245) and solution-polymerized SBR (Nipol SBR NS 110's). Characteristics of the modified rubbers as compared with unmodified rubbers are the improved rebound resilience (hence low rolling resistance) without sacrificing wet-skid resistance. The purpose of this paper is to clarify the mechanism of the improvement by the chemical modification. 15 refs.

Nagata, Nobuo (Nippon Zeon Co, Tokyo, Jpn); Kobatake, Takushi; Watanabe, Hiroyuki; Ueda, Akio; Yoshiooka, Akira. *Rubber Chem Technol* v 60 n 5 Nov-Dec 1987 p 837-855.

## Processing See Also RUBBER.

**092312 EFFECT OF MOULDING PRESSURE, COOLING RATE AND CURING TEMPERATURE ON THE PROPERTIES OF ROCKET INSULATOR.** A new solid propellant rocket insulator compound based on ethylene-propylene diene rubber (EPDM) meets all the technical properties needed for the purpose. In order to have a field trial of the compound, the effect of molding pressure, cooling rate and curing temperature on the technical and swelling properties has been investigated and the results are reported. Molding of the insulator compound at high pressure, low cure temperature and slow cooling rate gives the maximum values of physical properties and the minimum swelling. The density of the compound, however, increases. All the changes in properties are explained on the basis of rubber-filler interaction. 4 refs.

Deuri, A. Saha (India Inst of Technology, Kharagpur, India); Bhownick, Anil K.; John, B.; Ram, T.S. *J Mater Sci Lett* v 6 n 10 Oct 1987 p 1117-1122.

**092313 PROCESSABILITY OF EPDM RUBBERS IN INTERNAL MIXERS - DEPENDENCE ON MOLECULAR STRUCTURE.** For a number of EPDM grades differing in molecular structure and molar mass distribution, the authors investigated the carbon black dispersion rate during mixing in a three-liter internal mixer. They used an average EPDM compound composition with 70 phr FEF black, 40 phr SRF black and 70 phr naphthenic oil. Depending on the instantaneous temperature of the compound, the mixing process in an internal mixer can be divided into several stages, using the analogy of the different regimes in the behavior of pure rubber on a two-roll mill. (Edited author abstract). 14 Refs.

Noordermeer, J.W.M. (DSM Kunststoffen bv, Geleen, Neth); Wilms, M.J.M. *Kautsch Gummi Kunstst* v 41 n 6 Jun 1988 p 558-563.

**092314 FOAMING CHARACTERISTICS OF FILLED SOLUTIONS OF NITRILE BUTADIENE RUBBER.** During the development of nitrile-butadiene-rubber-based coatings, persistent foaming - a grave obstacle in such applications - was encountered. An investigation was undertaken to study the behavior of foams in order to prevent their formation. Both the

apparent viscosity and the foam stability were found to attain their minimum values at the same filler level. It is plausible that the observed phenomenon is due to the binding of polymer chains to filler particles, which takes place most effectively at a certain proportion of filler and polymer. (Author abstract). 9 Refs.

Hoontrakul, P. (Western Illinois Univ, Macomb, IL, USA); Szamosi, Janos; Tobing, S.D. *Polym Eng Sci* v 28 n 15 mid-august 1988 p 1009-1011.

## Research

**092315 SILICONE RUBBER, ITS DEVELOPMENT AND TECHNOLOGY PROGRESS.** This paper discusses the development and technological progress of silicone rubber since it first became commercially available within the U.S. in 1944 from both the Dow Corning Corporation and the General Electric Company. Advances in silicone rubber have been brought about by the need to satisfy practical market place requirements not fulfilled by other elastomers, and certainly not least in importance, by the scientific challenge to improve technology. Fundamentally involved in the use of silicone rubber in fulfillment of market needs is the combination of the performance properties that silicone rubbers exhibit. These properties include excellent weather and thermal stability, ozone and oxidation resistance, good electrical properties, extreme low-temperature flexibility, low activation energy for viscous flow, high gas permeability, good release from organic materials, good solvent and oil resistance, physiological inertness (compatible with body tissue), and being curable by a variety of methods at both elevated and ambient temperatures. 33 Refs.

Polmanteer, Keith E. (Dow Corning Corp, Midland, MI, USA). *Rubber Chem Technol* v 61 n 3 Jul-Aug 1988 p 470-502.

## Rheology

**092316 TEMPERATURE-PRESSURE INDUCED RUBBER-CARBON BLACK INTERACTION IN UNCURED RUBBER COMPOUNDS.** When assessing the viscosity of rubber-carbon black masterbatches versus temperature, peculiar variations with heat input were observed, using either capillary or rotational rheometers. These anomalies can be explained by the formation of a pseudo-structure induced by the temperature and the bulk pressure conditions within the instrument cavity. Extensive tests were carried out on NR and SBR compounds containing carbon blacks with various structures and particle sizes; the results obtained show that the pseudo-structure formation is enhanced by the surface activity of the filler. Experimental results support the hypothesis that variations in the amount of occluded rubber rather than in the volume of bound rubber are involved in these effects. (Edited author abstract) 6 refs.

Leblanc, J.L.; Swiderski, Z. *Kautsch Gummi Kunstst* v 40 n 9 Sep 1987 p 815-819.

## Spectroscopic Analysis

**092317 ANALYSIS OF NITRILIC RUBBER VULCANIZATES.** Analysis of the acrylonitrile content (AN) in NBR vulcanizates faces the difficulties encountered with elastomers with a heteroatom in their molecule. In this investigation, identification and quantitative analysis of NBR vulcanizates and NBR/PVC composites were done applying TG, DTG and IR techniques. Glass transition temperature ( $T_g$ ) was determined from loss factor ( $\tan \delta$ )/temperature graphs. Glass transition temperature was found to increase the AN content in NBR. (Author abstract) 7 refs.

Gonzalez Hernandez, L.; Ibarra Rueda, L. *Kautsch Gummi Kunstst* v 41 n 1 Jan 1988 p 50-53.

## Stabilizers

**092318 METAL SALTS OF 2(2,4-DIHYDROXYBENZOYL)BENZOIC ACID AS A NEW CLASS OF EFFECTIVE PHOTOSTABILIZERS.** For the stabil-



zation to ultraviolet light of polydienes (rubbers), several different types of stabilizers are used. One of the intensively examined groups was different metallo-organic compounds. In this work, results on a new class of metal salts of 2(2,4-dihydroxybenzoyl)benzoic acid are presented and an attempt is made to gain some insight into the role of metal cations in the stabilizing mechanism. Cls-1,4-polybutadiene was used in the photostabilization experiments. 17 refs.

Liu, R.X. (Acad Sinica, Beijing, China); Lin, F.; Wu, S.K. *J Polym Sci Part C* v 26 n 1 Jan 1988 p 17-24.

#### Stresses See Also RUBBER—Stresses.

**092319 EFFECT OF CROSS-LINKS WHICH OCCUR DURING CONTINUOUS CHEMICAL STRESS-RELAXATION.** Large radiation-induced stress increases observed during the continuous stress-relaxation of a nitrile rubber aged in an inert,  $\gamma$ -radiation environment are analyzed using a simple (no adjustable parameters) shrinkage model derived from linear viscoelasticity. Stress-relaxation experiments based on the model in conjunction with determination of the time-dependence of the material's modulus and linear shrinkage show that the observed increases in stress can be quantitatively accounted for by shrinkage effects caused by new cross-links. In contrast to typical assumption, the results therefore show that new chemical cross-links formed during continuous stress-relaxation studies can have a large impact on the relaxation results. By using the model in conjunction with stress-relaxation conducted as a function of initial sample strain, estimates can be made of the importance of shrinkage effects for any elastomer. (Author abstract) 9 refs.

Gillen, Kenneth T. (Sandia Natl Lab, Albuquerque, NM, USA). *Macromolecules* v 21 n 2 Feb 1988 p 442-446.

#### Synthesis

**092320 USE OF THE UNIFAC METHOD FOR EQUILIBRIUM CALCULATIONS IN SYSTEMS WITH HETEROCYCLIC OXYGEN-CONTAINING COMPOUNDS.** The authors used the UNIFAC method for calculation of liquid-vapor equilibria in systems studied previously, containing 4,4-dimethyl-1,3-dioxane (DMD), MDHP, and MTHP. Owing to absence of literature data on group-interaction parameters of the  $-CH_2O-$  group in the pyran and dioxane rings, the calculations were performed in two variants, with parameters of the  $-CH_2O-$  ether group, and with parameters of this group in the tetrahydrofuran series. The results of calculations relating to systems studied in the literature are given. It is shown that the use of the  $-CH_2O-$  group in the tetrahydrofuran series raises the accuracy of prediction both of the composition and of the boiling points of the mixture. In view of the practical importance of systems with heterocyclic compounds, it was necessary to obtain corrected parameters of group interaction for groups in the molecules of the heterocyclic compounds. Accordingly, we calculated group-interaction parameters for the  $-CH_2O-$  group in the dioxane and pyran rings from available literature data, using the UNIEX program. The averaged results of these calculations are given. This work is pertinent to synthetic rubber synthesis. 8 refs.

Evshtegneev, A.Yu. ('Lennetfchim' Scientific & Production Assoc, USSR); Lesteva, T.M.; Budantseva, L.S. *J Appl Chem USSR* v 59 n 11 pt 2 Nov 1986 p 2381-2383.

#### Testing See TUBES—Mechanical Properties.

#### Thermal Effects

**092321 SPECTROSCOPIC STUDIES ON THE INITIAL STAGES OF THERMAL DEGRADATION OF POLYCHLOROPRENE.** Thermal degradation of polychloroprene under nitrogen, especially at the initial stages, has been studied by using  $^1H$ -NMR,  $^{13}C$ -NMR and FT-IR spectroscopy. A model polymer of low molecular weight was prepared to avoid gelation during degradation. None of isomerized 1,2 unit has been found in the original polymer. Allylic rearrangement of 1,2 unit was the

first-stage reaction, which was finished within 30 min at 150°C. The extent of HCL loss was proportional to the decrease of isomerized 1,2 unit. It has been suggested that the next-stage reaction is dehydrochlorination of the isomerized 1,2 unit. (Edited author abstract) 16 Refs.

Miyata, Yoshiaki (Denki Kagaku Kogyo Co, Niigata, Jpn); Atsumi, Masao. *J Polym Sci Part A* v 26 n 9 Aug 20 1988 p 2561-2572.

#### Thermodynamic Properties

**092322 VISCOSITY AND SOME THERMODYNAMIC PROPERTIES OF BUTYL RUBBER SOLUTIONS IN VARIOUS SOLVENTS AT LOW TEMPERATURES.** Generalized dependences of effective viscosity on shear rate and of maximum newtonian viscosity on concentration were obtained for moderately concentrated solutions of butyl rubber in various solvents and their mixtures with the monomer at temperatures from 50 to -90°. The dependences of the rheological Martin constant and of intrinsic viscosity on the composition of the solvent-monomer mixture, on temperature and on molecular mass of the rubber were obtained. Values of the thermodynamic parameters characterizing intermolecular polymer-solvent interactions were calculated, and the  $\theta$ -temperature values of the solutions and their dependence on the composition of the solvent-monomer mixture were predicted. (Author abstract) 20 refs.

Vladykin, L.N. (Research Inst of Monomers for Synthetic Rubbers, USSR); Budtov, V.P.; Kopylov, Ye.P.; Pautov, P.G. *Polym Sci USSR* v 29 n 2 Feb 1987 p 354-363.

#### Viscoelasticity See Also SILICA—Textures.

**092323 VISCOELASTIC CHARACTERIZATION OF LONG BRANCHING AND GEL IN ELASTOMERS BY COMPARISON OF LARGE AND SMALL DEFORMATIONAL BEHAVIOR.** Ten different raw elastomers of varied chemical structure and Mooney viscosity were characterized with both tensile stress-strain behavior and dynamic shear behavior. The room temperature tensile stress-strain behavior was determined at strain rates of 0.239, 0.0892, and 0.00653 sec<sup>-1</sup>. These stress-strain data were reduced with a use of strain-time correspondence principle. The dynamic-shear behavior was observed over the frequency range from 10<sup>-2</sup> to 10<sup>2</sup> rad/s. Double logarithmic Cole-Cole plots were used to characterize a relative degree of long branching and gel content. 22 refs.

Nakajima, N. (Univ of Akron, Akron, OH, USA); Scobbo, J.J. Jr.; Harrell, E.R. *Rubber Chem Technol* v 60 n 4 Sep-Oct 1987 p 742-760.

#### Vulcanization See Also RUBBER—Aging.

**092324 VULCANIZACE CHLOROPRENOVEHO KAUCUKU OXIDY KOVU.** [Vulcanization of Chloroprene Rubber with Metallic Oxides]. Vulcanization of chloroprene rubber with metallic oxides is described by a set of three exponential equations. Using the experimental design technique, the effects of various vulcanization system components on the vulcanization reaction kinetics are examined. (Edited author abstract) In Czech. 8 refs.

Behal, Miroslav (Vyzkumny ustav Gumarenske a Plastikarske Technologie, Gottwaldov, Czech); Duchacek, Vratislav. *Plasty Kauc* v 24 n 3 Mar 1987 p 70-73.

**092325 EFFECTS OF SILANE COUPLING AGENT ON NETWORK STRUCTURE AND KINETICS OF VULCANISATION OF MICA FILLED STYRENE-BUTADIENE RUBBER.** The kinetics of sulfur vulcanisation of SBR filled with mica in the presence of a silane coupling agent was investigated. Coran's model was used to evaluate the rate constants and delay factors. The network structure has been explained in the light of these kinetic parameters. (Edited author abstract) 18 refs.

Debnath, S.; Bhattacharya, A.K.; Khashtgir, D.; De, S.K. *Kautsch Gummi Kunstst* v 40 n 10 Oct 1987 p 938-940.

**092326 KINETICS OF VULCANIZATION OF NI-**

**TRILE-BUTADIENE RUBBER.** The reaction rate constant and the cure rate index are measured by an oscillating disc rheometer as a function of temperature for the vulcanization process of several copolymers of acrylonitrile with butadiene. The crosslinking agents were tetramethylthiuramdisulfide and sulphur. The sol fraction and the swelling ratio was investigated as a function of cure time. Dielectric measurements during vulcanization at 353 K are reported. (Author abstract) 10 refs.

Yehia, A.A.; Stoll, B. *Kautsch Gummi Kunstst* v 40 n 10 Oct 1987 p 950-952.

**092327 CURE ADHESION IN THE INTERFACE OF FLUORINATED AND NITRILE RUBBERS.** Recently there has been a great deal of interest in new composite rubbery materials. Good properties require the reinforcement of the interfacial region which is formed between different rubbers. This work indicates newly developed vulcanization systems which are very effective in producing fluorinated and nitrile butadiene composite materials with very good properties, because they induce interpolymer interactions. The new systems are distinguished by the presence of common vulcanizing agents and accelerators. 27 refs.

Mori, Kunio (Iwate Univ, Morioka, Jpn). *Rubber Chem Technol* v 60 n 5 Nov-Dec 1987 p 822-836.

**092328 THERMOVULCANIZATION OF POLYCHLOROPRENE RUBBER AND ITS BLENDS WITH POLY(VINYL CHLORIDE).** Heat and mechanical stressing at higher temperature effect changes in polychloroprene rubber leading to network formation. During thermovulcanization of polychloroprene rubber in the temperature range of 150-200°C, two reactions have been observed and their kinetic parameters determined. When the rubber is stressed by shearing forces, the rate of degradation crosslinking is fairly high even at relatively low temperatures (90-150°C). Thermovulcanization of polychloroprene rubber/poly(vinyl chloride) blends has been investigated in the entire concentration range at 180°C. Maxima have been observed on the dependences of some kinetic parameters of the thermovulcanization reaction on polymer blend composition. (Author abstract) 13 refs.

Behal, Miroslav (Research Inst of Rubber & Plastics Technology, Gottwaldov, Czech); Duchacek, Vratislav. *J Appl Polym Sci* v 35 n 2 Feb 5 1988 p 508-515.

**RUBBER TESTING** See Also RUBBER—Aging; RUBBER—Chemical Resistance; RUBBER, SYNTHETIC—Heat Resistance.

#### Compression Tests

**092329 STUDY OF SPONTANEOUS RUBBER/METAL ADHESION. I. THE ROLLING CYLINDER TEST.** The spontaneous adhesion of vulcanized filled elastomers to steel has been studied using a rolling cylinder test. Owing to the relatively high degree of crosslinking, heavy cylinders are required to ensure good contact with the hard rubber track. This in turn invokes compression within the bulk of the rubber. A consequence is that hysteresis losses are associated not only with the adhesion phenomenon but also with the compression deformation of the system. Theoretical and experimental analyses have led to the conclusion that the two effects may be treated as additive. Both hysteresis losses can be related to the WLF superposition principle. (Author abstract) 13 refs.

Zaghzi, N. (Cent de Recherches sur la Physico-Chimie des Surfaces Solides, Mulhouse, Fr); Carre, A.; Shanahan, M.E.R.; Papirer, E.; Schultz, J. *J Polym Sci Part B* v 25 n 11 Nov 1987 p 2393-2402.

#### Elasticity

**092330 RUBBER TESTING WITH THE DEFO-ELASTOMER.** Rheology measurements allow to characterize rubber polymers or provide reliable quality control tests of rubber compounds. Specimens tested in a



two-plate-plastometer flow when compressed, elastically recover part of their height when the compression load has been removed. The test results provide information on viscosity, elasticity, shear rate dependency of viscosity, and fatigue. Special emphasis is placed on the method to provide perfect specimens using vacuum compaction. The Defo-Elastomer is backed by modern computerization to allow easy handling of tests, to store data and to provide the results in tabulated and graphical form. (Edited author abstract) 1 ref.

Schramm, G. *Kautsch Gummi Kunstst* v 40 n 8 Aug 1987 p 756-765.

**Fatigue** See ELASTOMERS—Mechanical Properties; RUBBER—Fatigue.

## Fracture

**092331 RUBBER FRACTURE CHARACTERIZATION USING J-INTEGRAL.** The use of the J-integral to investigate fracture characterization in a carbon black reinforced natural rubber is described. Three applications to crack initiation are included: two based on the use of a hypothetical zero specimen length and one on conventional testing procedures for metals. While the validity of the zero-length methods is questionable, the conventional method yielded a consistent  $J_c$  value of 1.01 N/mm for a typical tire compound. This value was obtained from 24 combinations of varying specimen geometries and pre-crack lengths. The J-integral is revealed as a valid fracture parameter that is applicable not only for material evaluation but also for designing tire structures to resist premature failure. (Edited author abstract) 22 refs.

Chow, C.L. (Univ of Hong Kong, Hong Kong); Wang, J.; Tse, P.N. *Tire Sci Technol* v 16 n 1 Jan-Mar 1988 p 44-60.

## Friction

**092332 DETERMINATION OF THE COEFFICIENT OF FRICTION OF RUBBER AT REALISTIC TIRE CONTACT PRESSURES.** To obtain a value of the coefficient of friction corresponding to a given pressure, as uniform a contact pressure distribution as possible should be maintained, and mechanical interference due to extraneous edges should be eliminated. An axially symmetric rotational test using an annular specimen eliminates the frictional lift phenomenon responsible for the high pressure gradients in conventional tests. This basic concept, used by Gent and Henry (1982), was modified to emphasize a uniform contact pressure distribution and high pressure applications. Therefore, a test apparatus was built to implement this concept, and the results obtained are considered to represent pointwise values of the coefficient of friction at the given normal pressure. 5 refs.

Lazeration, J.J. (Goodyear Tire & Rubber Co, Akron, OH, USA). *Rubber Chem Technol* v 60 n 5 Nov-Dec 1987 p 966-974.

**Impact** See POLYURETHANES—Mechanical Properties.

**Mechanical Properties** See RUBBER, SYNTHETIC—Aging.

**Tensile Tests** See Also MATERIALS TESTING APPARATUS; RUBBER—Aging.

**092333 EFFECT OF CARBON BLACK ON THE J-INTEGRAL AND STRAIN ENERGY IN THE CRACK TIP REGION IN A VULCANIZED NATURAL RUBBER.** It is shown that carbon black increases the size and the energy density of the process zone, but not the local crack-tip strain at which crack initiation occurs. Thus it appears that the critical condition for crack initiation at the crack tip is strain-controlled, and CB increases the energy required to achieve this. Related studies by X-ray diffraction and differential scanning calorimetry show that CB increases the strain-induced crystallization of natural rubber in general and at the crack tip, and this is a significant sink for energy and a source of fracture resistance. 22 refs.

Liu, H. (Univ of Massachusetts at Amherst, Amherst, MA, USA); Lee, R.F.; Donovan, J.A. *Rubber Chem Technol* v 60 n 5 Nov-Dec 1987 p 893-909.

**092334 MICROSTRUCTURAL CHANGES IN THE CRACK TIP REGION OF CARBON-BLACK-FILLED NATURAL RUBBER.** This study shows that carbon black increases the amount of strain-induced crystallization (SIC) in the crack tip region, and suggests that in natural rubber this contributes significantly to crack growth resistance. It is suggested that an apparently over-looked effect of CB on the extent of crystallization, originally reported by Gehman and Field in 1941, makes a major contribution to crack initiation and rupture resistance by increasing the extent of crystallinity and increasing the size of the crystallized zone at comparable crack driving forces. SIC absorbs deformation energy in proportion to the amount of transformation; therefore CB allows more energy to be dissipated through the transformation. Hence, CB-filled rubber requires more energy to establish the critical conditions in the crack tip. 14 refs.

Lee, D.J. (Univ of Massachusetts, Amherst, MA, USA); Donovan, J.A. *Rubber Chem Technol* v 60 n 5 Nov-Dec 1987 p 910-923.

## Wear

**092335 SCANNING ELECTRON MICROSCOPY STUDIES ON WEAR OF HDPE-FILLED NATURAL RUBBER VULCANIZATES.** The wear properties of natural rubber (NR) vulcanizates filled with high density polyethylene (HDPE) have been studied. The mechanism of wear was explained on the basis of abraded surface morphology. It was found that incorporation of HDPE increases the abrasion resistance of NR vulcanizates and the abrasion mechanism changes from frictional wear to abrasive wear with increasing HDPE loading. (Edited author abstract) 28 refs.

Kurian, Josit (Indian Inst of Technology, Kharagpur, India); Nando, G.B. *Wear* v 127 n 2 Oct 15 1988 p 139-147.

## RUBIDIUM See Also LASERS, DYE—Performance.

**092336 CROSS SECTION OF THE REACTION  $^{85}\text{Rb}(\gamma, n)^{84\text{m}}\text{Rb}$ .** The cross section for the formation of isomeric states  $^{84\text{m}}\text{Rb}$  in the photoneutron reaction on the  $^{85}\text{Rb}$  nucleus was measured for the first time in this work by the method of induced activity. In previous works the isomeric ratios of the cross sections  $\sigma_m/\sigma_g$  or the yields  $Y_m/Y_g$  of this reaction were measured for energies above the energy of the gigantic dipole resonance. In this work the energy dependence of  $Y_m/Y_g$  is obtained for  $E_\gamma = 25$  MeV, with a step of  $E_\gamma = 0.5$  MeV. 11 refs.

Davydov, M.G.; Khamraev, F.Sh.; Shomurov, E.M. *Sov At Energy* v 62 n 3 Mar 1987 p 243-245.

## Isotopes

**092337 PRODUCTION OF EFFICIENT  $^{81}\text{Rb}/^{81\text{m}}\text{Kr}$  GENERATORS USING ZIRCONIUM PHOSPHATE.** Rubidium-81 is produced by bombardment of a NaBr target. The target is dissolved in water and  $^{81}\text{Rb}$  is efficiently sorbed on zirconium phosphate. Na is selectively eluted with HCl. About 80% of the  $^{81\text{m}}\text{Kr}$  can be eluted from the generator with moist air. Recoil effects and/or the relative sizes of  $\text{Rb}^+$  and  $^{81\text{m}}\text{Kr}$  may play a role in the  $^{81\text{m}}\text{Kr}$  elution efficiency. (Author abstract) 12 refs.

Brits, R.J.N. (CSIR, Pretoria, S Afr); Haasbroek, F.J. *Appl Radiat Isot* v 38 n 8 1987 p 623-627.

## Optical Pumping

**092338 SIGNAL INTENSITY VERSUS TEMPERATURE CHARACTERISTICS OF A MIXED  $^{87}\text{Rb}/^{85}\text{Rb}$  RESONANCE CELL FOR USE IN A RUBIDIUM FREQUENCY STANDARD.** The dependence of the signal intensity of the  $^{87}\text{Rb}$  microwave resonance ( $f = 6834$  MHz) on the  $^{85}\text{Rb}$  atoms included in a resonance cell

is examined about a mixed  $^{87}\text{Rb}/^{85}\text{Rb}$  cell used in an optically pumped Rb frequency standard. The temperature that gives the maximum resonance intensity in the signal intensity versus temperature characteristic curves, shifts toward higher temperatures with increasing mass ratio  $m (= ^{85}\text{Rb}/^{87}\text{Rb})$  of Rb in the cell. 17 refs.

Kuramochi, Naimu (Tokyo Inst of Technology, Yokohama, Jpn); Oura, Nobunori; Miyoshi, Hiroshi; Tannaka, Yoshinao. *IEEE Trans Ultrason Ferroelectr Freq Control* v UFFC-34 n 6 p 619-621.

## Radiation Effects

**092339 LIGHT-INDUCED DRIFT IN RUBIDIUM: SPECTRAL DEPENDENCE AND ISOTOPE SEPARATION.** We report on the frequency dependence of the light-induced drift velocity of rubidium in argon buffer gas. The sign of the drift velocity is found to closely follow the sign of the derivative of the low-intensity absorption spectrum. This is in disagreement with previous predictions and is qualitatively different from the sodium case. Numerical studies agree with our observations, and point to the importance of the ratio of the ground-state hyperfine splitting to the Doppler width. These observations imply that the two naturally occurring isotopes  $^{85}\text{Rb}$  and  $^{87}\text{Rb}$  can be easily separated using light-induced drift, and this is experimentally demonstrated. (Author abstract) 11 refs.

Streeter, A.D. (Univ of Leiden, Leiden, Neth); Mooibroek, J.; Woerdman, J.P. *Opt Commun* v 64 n 2 Oct 15 1987 p 137-143.

**Spectroscopic Analysis** See Also ALKALI METALS—Spectroscopic Analysis.

**092340 LOW TEMPERATURE NON-THERMALISED LUMINESCENCE OF  $\text{Ru}(\text{bpy})_3^{2+}$  DOPED IN  $\text{Cd}(\text{bpy})_3(\text{PF}_6)_2$  SINGLE CRYSTALS.** The polarised luminescence spectrum of  $\text{Ru}(\text{bpy})_3^{2+}$  doped in single crystal  $\text{Cd}(\text{bpy})_3(\text{PF}_6)_2$  shows a smaller Stokes shift than that observed in the isomorphous Zn host, although absorption spectra are almost identical. Polarised, temperature dependent and time resolved luminescence spectra demonstrate the extent of non-thermalisation in the luminophore below 10 K. (Author abstract) 5 refs.

Krausz, Elmars (Australian Natl Univ, Canberra, Aust); Moran, Grainne. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 272-273.

**Spectrum Analysis** See LASERS, SEMICONDUCTOR.

## X-Ray Analysis

**092341 PECULIARITIES OF DIRECT X-RAY DETERMINATION OF Ru, Rh AND Pd USING VEPP-4 SYNCHROTRON RADIATION.** The first results are presented of an analysis of light platinumoids (Ru, Rh, Pd) in silicate rocks, ores and references by the SRXFA technique. To improve the reproducibility of the analysis results, the sample has been scanned with a SR beam and the data obtained averaged over a large area. The influence of combinatorial lines in the SRXFA spectra, caused by the pulse nature of the radiation, has been observed. The detection limits for Ru, Rh and Pd were 0.017-0.07 ppm at a  $10^3$  s in the absence of conflicting spectral lines. (Author abstract) 5 refs.

Khvostova, V.P. (Giredmet, Moscow, USSR); Maximov, V.N.; Yaroshevsky, A.A.; Baryshev, V.B.; Kulipanov, G.N. *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 283-285.

**RUBIDIUM COMPOUNDS** See Also CRYSTALS—Electron States; GRAPHITE—Testing.



**Electric Conductivity** See Also GLASS—Ionic Conduction.

**092342 SOME ASPECTS OF THE ELECTRICAL CONDUCTIVITY OF FERROELECTRIC RUBIDIUM HYDROGEN TARTRATE SINGLE CRYSTALS.** In this letter authors report on the growth of single crystals of RHT from solution and measurements of their electrical conductivities at different temperatures. An attempt has been made to understand the mechanism of charge transport. The following conclusions may be drawn from this study. RHT single crystals up to  $16 \text{ mm} \times 5 \text{ mm} \times 4 \text{ mm}$  in size were grown using the gel technique. They belong to the orthorhombic system and having space group  $P2_12_1$ . The variation in d.c. conductivity of single crystal and pellet samples was studied in the temperature range between 300 to 470 K. The electrical conductivity of the crystalline sample is larger than that of pellet samples. The electrical conductivity in the case of RHT crystals is intrinsic above 393 K and extrinsic below 393 K. The extrinsic conductivity is dominated by  $(\text{Rb})^+$  and  $(\text{HCOOH})_2^-$  ion impurities while the intrinsic conductivity is due to Frenkel defects. The activation energy for the electrical conduction process is estimated. The activation energy for crystals is higher than that of pellet samples. 8 refs.

Desai, C.C. (Sardar Patel Univ, Vallabh Vidyanagar, India); Patel, A.H. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1066-1068.

**092343 POLARITY STUDY OF RUBIDIUM ACID PHTHALATE (RAP) SINGLE CRYSTALS.** The pyroelectric properties related to the polarity including pyroelectric effect, dielectric property and DC-conductivities of rubidium acid phthalate (RAP) crystal have been studied in this paper. By using differential temperature analysis (DTA) and weight loss analysis, a qualitative explanation has been given on the temperature dependence of high-temperature thermoelectricity. The positron annihilation technique (PAT) is used to determine successfully the negative single vacancy distribution in the positive and negative directions of polar axis. Our experiment verifies that the DC-conductivities of RAP crystals are caused by the thermal-defect in the crystal. (Author abstract) 8 refs. In Chinese.

Shi, Zikang (Fujian Inst of Research on the Structure of Matter, China); Liang, Guijing. *Hongwai Yanjiu A-ji* v 7A n 1 1988 p 39-46.

## Impurities

**092344 HOST-SPIN LATTICE RELAXATION NARROWING IN  $\text{Rb}_2\text{Co}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}:\text{Mn}^{2+}$  SINGLE CRYSTALS.** EPR of  $\text{Mn}^{2+}$  in  $\text{Rb}_2\text{Co}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$  single crystals has been studied at various temperatures from 292 to 77 K using a  $\approx 9.45 \text{ GHz}$  EPR spectrometer. The observation of resolved  $\text{Mn}^{2+}$  spectra at room temperature is interpreted in terms of a random modulation of the interaction between the  $\text{Mn}^{2+}$  and the host  $\text{Co}^{2+}$  ions by the rapid spin-lattice relaxation of  $\text{Co}^{2+}$ . It is found that the effective spin-lattice relaxation time  $T_1 \propto T^{-n}$  where  $n=1.75$  for B || Z axis if  $103 < T < 292 \text{ K}$ . (Author abstract) 13 refs.

Jain, V.K. (Maharshi Dayanand Univ, Rohtak, India); Yadav, V.S.; Singh, Jitender. *Solid State Commun* v 64 n 6 Nov 1987 p 929-931.

**Ionic Conduction** See Also POTASSIUM COMPOUNDS—Ionic Conduction.

**092345 ELECTRICAL RESPONSE OF  $\text{RbAg}_4\text{I}_5$  /GRAPHITE INHOMOGENEOUS INTERFACES.** The ac impedance of the cell graphite/graphite+ $\text{RbAg}_4\text{I}_5$ / $\text{RbAg}_4\text{I}_5$ /graphite+ $\text{RbAg}_4\text{I}_5$ /graphite was investigated in the frequency range from  $10^{-4}$  to  $3 \times 10^5 \text{ Hz}$ . A model assuming the graphite+ $\text{RbAg}_4\text{I}_5$  mixture to represent a porous interface could explain the observed dependences in nearly the whole frequency range with the exception of the lowest frequencies. Attempts to improve the agreement presuming adsorption, discharge of charge carriers or diffusion of neutral species failed. An excellent

fit could be achieved assuming a frequency dependent ac conductivity of the interface, approximately proportional to the frequency, as in the bulk of many solids with low conductivity, such as amorphous semiconductors or dielectrics. (Author abstract) 30 refs.

Lanyi, S. (Slovak Acad of Sciences, Bratislava, Czech); Tucek, J. *Solid State Ionics* v 24 n 4 Sep 1987 p 273-280.

## Magnetic Properties

**092346 ELECTRON SPIN RESONANCE IN HYDROGENATED  $\text{RbFeSe}_2$ .**  $\text{RbFeSe}_2$  is a member of the alkali dithioferate series of compounds. A magnetic phase transition was observed at  $T_c=185 \text{ K}$ . In this letter we report ESR measurements in hydrogenated  $\text{RbFeSe}_2$  between 160 and 360 K. From the difference between two curves in the temperature range 160 to 200 K and the value of the transition temperature in non-hydrogenated  $\text{RbFeSe}_2$ , the transition temperature of hydrogenated  $\text{RbFeSe}_2$  is estimated to be approximately 245 K. Hydrogenation thus increases the transition temperature of  $\text{RbFeSe}_2$  by about 60 K. 9 refs.

de Biasi, R.S. (Inst Militar de Engenharia, Rio de Janeiro, Brazil); Taft, C.A.; Furtado, N.C. *J Mater Sci Lett* v 6 n 10 Oct 1987 p 1185-1186.

**Microscopic Examination** See FERROELECTRIC MATERIALS—Microscopic Examination.

## Optical Properties

**092347 OPTICAL ABSORPTION SPECTRUM OF CHROMIUM DOPED RUBIDIUM ALUMINIUM SULPHATE DODECAHYDRATE.** Optical absorption spectrum of chromium doped rubidium aluminum sulfate dodecahydrate single crystal is investigated. The electronic spectrum in the UV-VIS region is characteristic of  $\text{Cr}^{3+}$  in trigonal symmetry and vibrational spectrum in the i.r. region is ascribed to the  $\text{SO}_4^{2-}$  and  $\text{H}_2\text{O}$  groups. A number of crystal field parameters are evaluated for  $\text{Cr}^{3+}$  in trigonal symmetry. (Edited author abstract) 19 refs.

Ramesh, K. (S.V. Univ, Tirupati, India); Reddy, Y.P. *Solid State Commun* v 62 n 12 Jun 1987 p 837-840.

**Phase Transitions** See Also CRYSTALS—Pressure Effects.

**092348 EPR STUDY OF PHASE TRANSITIONS IN THE LANGBEINITE  $\text{Rb}_2\text{Cd}_2(\text{SO}_4)_3$ .** Two reversible phase transitions in the langbeinite  $\text{Rb}_2\text{Cd}_2(\text{SO}_4)_3$  have been observed by EPR, to occur at  $129 \pm 2 \text{ K}$  and at  $102 \pm 2 \text{ K}$ . The  $\text{Mn}^{2+}$  spin-Hamiltonian parameters in this host, at room temperature, have been evaluated by the use of a rigorous least-squares fitting procedure, numerically, diagnosing the spin-Hamiltonian matrix, and fitting a large number of resonant line positions simultaneously, observed for several orientations of the external magnetic field. (Author abstract) 16 refs.

Misra, S.K. (Concordia Univ, Montreal, Que, Can); Korczak, S.Z. *Solid State Commun* v 61 n 10 Mar 1987 p 665-670.

**Physical Properties** See BRONZE—Physical Properties; MAGNETIC MATERIALS—Magnetic Properties; POTASSIUM AND ALLOYS—Electric Properties.

## Pressure Effects

**092349 HYDROSTATIC PRESSURE DEPENDENCE ON THE TUNNELING SPLITTING IN  $\text{RbCl}:\text{Ag}^+$ .** We present measurements of the pressure dependence of the tunneling splitting in  $\text{RbCl}:\text{Ag}^+$  for hydrostatic pressures from 950 to 1850 bar. The dependence is linear above 1100 bar and appears to have a break in the curve between 1000 and 1100 bar. This data suggests that a configurational change may take place near 1000 bar. (Author abstract) 9 refs.

Morgan, Michael (Univ of California at Santa Cruz, Santa Cruz, CA, USA); Bridges, Frank. *Solid State Commun* v 61 n 6 Feb 1987 p 355-356.

## Radiation Effects

**092350 ELECTRON-INDUCED DECOMPOSITION OF RUBIDIUM CHROMIUM FLUORIDE.** The decomposition of  $\text{Rb}_x\text{CrF}_3$  hexagonal tungsten bronzes (HTB) with  $x=0.20$  and  $0.30$  have been followed by high resolution electron microscopy (HREM). In the electron beam of the microscope, Rb is depleted from the tunnels of the bronze structure leading to the formation of  $\text{CrF}_3$  which crystallizes in a distorted  $\text{ReO}_3$ -type structure. An amorphous phase is frequently intermediate to this transformation. A qualitative comparison of the rate of reaction, depending upon the energy and direction of the electrons, of the compounds of different composition is made. These observations suggest a mechanism for the reaction. (Author abstract) 9 refs.

Sharma, Renu (Arizona State Univ, Tempe, AZ, USA); Barry, John; Eyring, LeRoy. *Ultramicroscopy* v 23 n 3-4 1987 p 453-461.

**Spectroscopic Analysis** See Also POTASSIUM COMPOUNDS—Spectroscopic Analysis.

**092351 MOESSBAUER SPECTROSCOPY OF  $^{57}\text{Fe}$  IN  $\text{Rb}_2\text{ZnCl}_4$ .** Moessbauer spectra of  $^{57}\text{Fe}$  substituted for Zn are observed in  $\text{Rb}_2\text{ZnCl}_4$  in its normal, incommensurate, and ferroelectric phases. The spectra are analyzed to derive isomer shifts, Moessbauer fractions, quadrupole coupling constants, and crystal-field splittings. Distinct sites are discerned below the lock-in transition. (Author abstract) 17 refs.

Horikx, J.J.L. (Rijksuniversiteit Utrecht, Utrecht, Netherlands); Arts, A.F.M.; de Wijn, H.W. *Solid State Commun* v 65 n 12 Mar 1988 p 1597-1600.

**092352 CONFIGURATION OF  $F_A$  (II) CENTERS IN  $\text{RbCl}:\text{Li}^+$  DERIVED FROM LUMINESCENCE EXPERIMENTS.** The off-axis configuration of  $F_A$  centers in  $\text{RbCl}:\text{Li}^+$  has been investigated by means of luminescence measurements. A first quantitative evaluation of the off-axis angle has been obtained. The technique we used is the same applied in the case of  $\text{KCl}:\text{Li}^+$ , i.e. the study of the reorientation of the  $F_A$  centers under polarized optical pumping. 9 refs.

Baldacchini, G. (ENEA, Frascati, Italy); De Matteis, F.; Grassano, U.M.; Scacco, A.; Somma, F. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 351-352.

**Spectrum Analysis** See LITHIUM COMPOUNDS—Spectrum Analysis.

**Structure** See Also POTASSIUM COMPOUNDS—Structure.

**092353 PREPARATION AND CRYSTAL STRUCTURES OF PLUTONIUM (IV) HEXACHLORO COMPLEXES,  $\text{Rb}_2\text{PuCl}_6$  AND  $\text{K}_2\text{PuCl}_6$ .**  $\text{Rb}_2\text{PuCl}_6$  and  $\text{K}_2\text{PuCl}_6$  were prepared by heating mixtures of anhydrous  $\text{PuCl}_3$  and the respective alkali metal chlorides under high  $\text{Cl}_2$  pressures. Their crystal structures were determined by powder X-ray crystallography. The variable atom parameters were obtained by means of electrostatic calculation to have the maximum Madelung constant. Raman spectra showed two lines corresponding to  $\nu_1(\text{A}_g)$  and  $\nu_3(\text{F}_g)$  for both compounds. The difference of stability in  $\text{M}_2\text{PuCl}_6$  ( $\text{M}=\text{K}, \text{Rb}, \text{Cs}$ ) is discussed. (Edited author abstract) 30 refs.

Morris, Lester R. (Argonne Natl Lab, Argonne, IL, USA); Fujino, Takeo. *J Solid State Chem* v 72 n 2 Feb 1988 p 338-352.

**092354 PREPARATION AND CRYSTAL STRUCTURES OF PLUTONIUM(III) PENTACHLORO COMPLEXES,  $\text{K}_2\text{PuCl}_5$  AND  $\text{Rb}_2\text{PuCl}_5$ .**  $\text{K}_2\text{PuCl}_5$  and  $\text{Rb}_2\text{PuCl}_5$  were prepared by heating mixtures of anhydrous  $\text{PuCl}_3$  and respective alkali metal chlorides in vacuum-sealed quartz ampoules at  $400-500^\circ\text{C}$ . Their crys-



tal structures are both orthorhombic with  $K_2PrCl_5$ -type structure. Fourteen variable atom parameters of these complexes were obtained by electrostatic calculation with a program which maximizes the Madelung constant under the condition that the ion-ion separations in the crystal are all larger than respective critical distances. The measured Raman lines of  $Rb_2PuCl_5$  are very close to those of hexachloride complexes. The bond lengths and stability of  $M_2PuCl_5$  ( $M=K, Rb$ ) are discussed. (Edited author abstract) 21 refs.

Morss, Lester R. (Argonne Natl Lab, Argonne, IL, USA); Fujino, Takeo. *J Solid State Chem* v 72 n 2 Feb 1988 p 353-362.

**Surfaces** See SILVER AND ALLOYS—Electrodeposition.

## Toxicity

**092355 COMPARATIVE TOXICITY OF SOLUBLE RUBIDIUM COMPOUNDS.** Rubidium compounds are widely used in electronics, optics and chemicals industries. The air of the working environment contains aerosols of rubidium compounds. Comparative toxicity and industrial hygienic evaluation of rubidium containing aerosols are the topics of this investigation. 1 ref. In Russian.

Khamidulina, Kh.Kh. *Gig Tr Prof Zabol* n 9 1987 p 55-57.

**RUBY** See Also ALUMINA—Electronic Properties; FLUORESCENCE—Materials.

## High Pressure Effects

**092356 X-RAY DIFFRACTION OF RUBY ( $Al_2O_3$ ;  $Cr^{3+}$ ) TO 175 GPa.** Compression data for ruby ( $Al_2O_3$ ,  $\approx 0.05\% Cr^{3+}$ ) have been obtained by energy-dispersive X-ray scattering in a diamond-anvil cell to 175 GPa (1.75 Mbar) at room temperature. Ruby does not undergo any reconstructive structural transition to at least 175 GPa at room temperature, although there is comparatively large uncertainty in pressure due to the weakening and broadening of  $R_1-R_2$  luminescence under nonhydrostatic compression. The unit-cell volume measured at the highest pressure (where  $V/V_0 = 0.71$ ) is consistent with the predictions of a Birch-Murnaghan equation of state with parameters obtained from low-pressure ultrasonic and single-crystal compression measurements. (Edited author abstract) 27 refs.

Jephcoat, A.P. (Carnegie Inst of Washington, Washington, DC, USA); Hemley, R.J.; Mao, H.K. *Physica B & C* v 150 n 1-2 May 1988, Proc of the Int Conf on Electr Struct and Phase Stab in Adv Ceram, Argonne, IL, USA, Aug 17-19 1987 p 115-121.

## Impurities

**092357 CHROMIUM-GALLIUM COMPLEXES IN  $Al_2O_3$ : I. LUMINESCENCE.** The shift and broadening of the R lines in chromium-doped ruby are studied of the gallium impurity content ( $<2\%$ ). A great number of well-resolved emission lines are assigned to gallium-chromium pairs; their first and second excited states are identified by excitation spectroscopy. Weaker lines are assigned to triads formed by one chromium ion and two gallium ions. For most of these triads the shifts of the R lines due to each of the two gallium ions add linearly. A triad formed by two chromium ions (4th NN) and one gallium ion (1st NN to one chromium ion) is also identified and studied. Time-resolved fluorescence line narrowing measurements allow the determination of the energy level scheme of a pair of loosely bound chromium ions. (Author abstract) 17 refs.

Wasiela, A. (CNRS, St. Martin d'Heres, Fr); Merle D'Aubigne, Y.; Block, D. *J Lumin* v 36 n 1 Oct 1987 p 11-22.

**092358 CHROMIUM-GALLIUM COMPLEXES IN  $Al_2O_3$ : II. ENERGY TRANSFER.** In gallium-doped ruby the spectral dependence of the transfer efficiency

from isolated chromium ions to chromium-chromium pairs is very similar to that observed in gallium-free ruby, and shows no evidence for a mobility edge. The efficiency of the transfer to gallium-chromium pairs exhibits two maxima for excitation in the wings of the  $R_1$  line, an effect attributed to a non-uniform distribution of the donor-acceptor distances for such an excitation. The single-ion to gallium-chromium pair transfer is analyzed assuming a direct transfer, slightly enhanced by radiation trapping and donor-donor transfer in the samples with the largest donor concentrations. The dipole-dipole interaction deduced from the oscillator strength of the  $R_1$  line cannot account for the observed transfer efficiency. The dynamics of the acceptor emission and the transfer efficiency can be accounted for assuming either a multipolar interaction of higher order or an exchange interaction. The comparison of the observed transfer efficiency with values calculated using theoretical estimates of the quadrupole-quadrupole and exchange interactions are in favor of the latter. (Author abstract) 21 refs.

Wasiela, A. (CNRS, St. Martin d'Heres, Fr); Block, D.; Merle D'Aubigne, Y. *J Lumin* v 36 n 1 Oct 1987 p 23-37.

## Magnetic Field Effects

**092359 INVERSION CHARACTERISTICS OF RUBY AT THE CENTER OF THE MILLIMETER BAND.** The probabilities of spin-lattice relaxation transition in ruby for  $\theta=90^\circ$  in the range of magnetic fields 1.5-2.2 T and in the temperature range 1-5°K are calculated based on the Kroenig-Van Vleck mechanism. Different schemes for obtaining inversion are analyzed. The inversion coefficients for three and four-level pumping schemes in the frequency range 40-60 GHz are calculated. The results of experimental studies of the inversion coefficients at a frequency of 43 GHz are presented. The advantages of schemes with two-level pumping over the symmetric scheme are shown. (Author abstract) 4 refs.

Blinov, A.K. (Acad of Sciences of the Ukrainian SSR, USSR); Peskovskii, S.A. *Radiophys Quantum Electron* v 30 n 6 Jun 1987 p 587-590.

## Microscopic Examination

**092360 SURFACE FACETTING AND POLARITY OF ALUMINA.** Atomic-resolution electron microscopic images of ruby show (0001) polar surface facets developing under electron irradiation. Attempts to understand the 'dark-line' contrasts associated with the surface atom profiles, following comparison of the experimental images with computer modeling, leads to the realization that aluminum atom and oxygen atom surface terminations may be distinguished. Hence surface polarity, as well as details of surface step structure and mobility, may be determined. Positive surface polarity is preferred. (Author abstract) 16 refs.

Bursill, L.A. (Univ of Melbourne, Parkville, Aust); Lin, Peng Ju; Smith, David J. *Ultramicroscopy* v 23 n 2 1987 p 223-227.

## Optical Properties

**092361 SPECTROSCOPIC STUDIES OF LUMINESCENT PROPERTIES OF INSULATORS. A HISTORICAL PERSPECTIVE.** We present a historical survey of the evolution of our understanding of optical properties of insulators achieved through the study of their luminescent or emissive behavior. We will focus on developments involving ruby; this material has played a central role in the maturation of the field of luminescence and has served as the test material for much of the methodology currently employed in these studies. (Author abstract) 7 refs.

Yen, William M. (Univ of Georgia, Athens, GA, USA). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 9-11.

**Phase Transitions** See LASER BEAMS—Effects.

## Pressure Effects

**092362 PRESSURE CALIBRATION WITH ARGON AND THE EQUATION OF STATE FOR RUBY TO 600 KBAR.** Pressure calibration with argon is proposed. It can be employed in high-pressure x-ray diffraction experiments in which argon is used as the pressure medium. The calibration has been used to obtain the equation of state for ruby to 600 kbar. (Author abstract). 11 refs.

Xu, Ji-an (Norton Christensen Inc, Salt Lake City, UT, USA). *High Temp High Pressures* v 19 n 6 1987 p 661-664.

## Spectroscopic Analysis

**092363 STUDY OF TIME-DELAYED FOUR-WAVE MIXING WITH INCOHERENT LIGHT IN THE ABSORPTION BAND OF RUBY.** Time-delayed four-wave mixing with incoherent light in the absorption band  $^4T_2$  of ruby has been studied experimentally. Dephasing times have been obtained formally by analyzing the experimental data on the basis of two-level theory at different conditions. Two-level theory fails in the interpretation of the results, and a theory based on a multi-level model has been developed and applied to explain the results successfully. It is shown that  $T_2$  determined on the basis of two-level theory is not the ordinary dephasing time of individual transition but an effective one which reflects the behavior of the total absorption spectrum of the band. (Author abstract). 9 refs.

Zhang, Ruihua (Chinese Acad of Sciences, Beijing, China); Mi, Xin; Zhou, Haitian; Ye, Peixian. *Opt Commun* v 67 n 6 Aug 15 1988 p 446-450.

**RUNOFF** See Also COTTON—Growing; IRRIGATION—Analysis; SOILS—Erosion; WATER POLLUTION; WATERSHEDS.

**092364 SUSPENDED SEDIMENT AND METALS REMOVAL FROM URBAN RUNOFF BY A SMALL LAKE.** A small lake in the Chicago Metropolitan Area was from 91 to 95 percent efficient in removing suspended sediment and from 76 to 94 percent efficient in removing copper, iron, lead, and zinc from urban runoff. Sediments accumulated in the lake in the form of an organic-rich mud at an average rate of 20 millimeters per year; this reduced lake storage and covered potential habitat for aquatic organisms. Copper, lead, and zinc concentrations were closely associated with suspended-sediment concentrations and with silt- and clay-sized fractions of lake sediment. Although concentrations of mercury and cadmium were near detection limits in runoff, measurable concentrations of these metals accumulated in the lake sediments. (Author abstract) 21 refs.

Striegl, Robert G. (US Geological Survey, Lakewood, CO, USA). *Water Resour Bull* v 23 n 6 Dec 1987 p 985-996.

**092365 EFFECTS OF PRECIPITATION AND LAND USE ON STORM RUNOFF.** Storm-runoff quantity and quality were studied in three watersheds located near St. Paul in Ramsey County, Minnesota, from April 15 through September 15 of 1984, 1985, and 1986 to qualitatively determine the effects of precipitation and selected land uses on storm runoff. In respect to precipitation effects, differences in storm-runoff quantity between years in an urban watershed that lacks wetlands appear to be related to the average storm size (amount of precipitation) during the study period of each year. In contrast, the differences in storm-runoff quantity from watersheds that contain wetlands appear to be related to total precipitation during study period of each year. In respect to land use, the differences in storm-runoff quantity appear to be related to the amounts of impervious and wetland area. The watershed that contains the largest amount of



impervious area and smallest amount of wetland area has the largest amount of storm runoff. (Edited author abstract) 18 refs.

Brown, R.G. (US Geological Survey, Lansing, MI, USA). *Water Resour Bull* v 24 n 2 Apr 1988 p 421-426.

**092366 SNOWMELT RUNOFF IN SUBURBAN ENVIRONMENTS.** The runoff responses of two subcatchments of a small drainage basin in Peterborough, Ontario were investigated for the spring snowmelts of 1984 and 1985. One of the catchments has undergone substantial suburbanization, while the other is largely in rural land use. Suburban development appears to have produced substantial increases in spring quickflow yields from the entire basin. A comparison of the responses of the two subcatchments reveals that the suburban catchment reacts more rapidly to snowmelt and rain-on-snow inputs and generates larger initial quickflow response ratios than the rural basin as a result of the microclimatic, pedologic and hydraulic characteristics of build-up areas. However, the dynamic behavior of the runoff contributing area of the rural catchment results in a marked increase in its quickflow yield as melt progresses. (Edited author abstract) 34 refs.

Buttle, J.M. (Trent Univ, Peterborough, Ont, Can); Xu, F. *Nord Hydrol* v 19 n 1 1988 p 19-40.

**092367 RUNOFF GENERATION IN A PLOUGH-DRAINED PEAT BOG IN SOUTHERN SCOTLAND.** This paper reports on a study, using runoff plots and other equipment, of runoff generation in a peat bog in Scotland four years after it had been plough-drained for afforestation. In generally dry periods runoff responses were dominated by flow generated by rain falling directly onto the ditches. Only during very wet periods was this source of runoff less important than water draining into the ditches from the strips on either side. Flow from the strips to the ditches consisted entirely of groundwater. This occurred at a very low rate unless the water table was within 6-7 cm of the surface; then it could become as rapid as the rate at which rain landed on the area. The results emphasize the need to consider the ditches and the strips between them separately when seeking an understanding of runoff generation in densely plough-drained peatlands. (Author abstract) 22 refs.

David, J.S. (Univ of Edinburgh, Edinburgh, Scot); Ledger, D.C. *J Hydrol* v 99 n 3-4 May 30 1988 p 187-199.

**092368 NACHWEISE ZUR REGENWASSER-BEHANDLUNG.** [Analysis of the Treatment of Stormwater Runoff]. The analysis of the impact of stormwater runoff in combined systems is mostly limited to the evaluation of the over-flowing portion of the water. Accounting the frequency and the duration of discharges the effect of stormwater outlets may be calculated more correctly. However a general evaluation is only reasonable if also the operation and construction of the outlet and the quality of the receiving water as well as economics are considered. (Author abstract) 9 refs. In German.

Willems, Gilbert. *GWF Gas Wasserfach Wasser Abwasser* v 129 n 4 Apr 1988 p 269-274.

**092369 MODIFIED FICKIAN MODEL FOR SOLUTE UPTAKE BY RUNOFF.** A one-dimensional Fickian diffusion model for entrainment of interstitial soil water by overland flow is modified to account for early non-Fickian mass transfer observed during laboratory runoff experiments. Results show that this asymptotic diffusion coefficient varies with the square of the quantity  $V_0/\sqrt{k}$ , where  $V_0$  is shear velocity and  $k$  is media permeability. Modifying the model entails the development of type curves for a range of convective time scales, or times of non-Fickian mass transfer. The entrainment, or mass transfer, coefficient is estimated as a function of the convective time scale. This procedure shows that the entrainment coefficient varies linearly with  $V_0/\sqrt{k}$ . Reasonable prediction of mass loss results using the asymptotic diffusion coefficients, an empirical relationship for the entrainment coefficient, and a convective time scale of 5 min as model input. (Edited author abstract). 20 Refs.

Richardson, C.P. (New Mexico Inst of Mining & Technology, Socorro, NM, USA); Parr, A.D. *J Environ Eng* v 114 n 4 Aug 1988 p 792-809.

**092370 ENHANCEMENT OF RUNOFF FROM A SMALL WATERSHED BY CLOUD SEEDING.** Daily volumes of runoff, from a small watershed, are compared, with respect to daily depths of precipitation, under randomly allocated cloud seeding. Enhancement is found with respect to rainfalls at the control and at the target area. The effect is evident by doubling the number of runoff days, by doubling the ratio to the volume of the precipitation, and by heightening the regression line for nonleading days in runoff sequences. With respect to the rainfall at the control, this heightening is about 40% of the mean volume per runoff day. The generation of the runoff is governed by the abstractions which consume 98% of the precipitated waters. High rates of enhancement are found for the intense fraction of the rainfall, for the Eastern sector of the watershed and for the later portion of the rainy season. (Edited author abstract). 8 Refs.

Ben-Zvi, Arie (Israel Hydrological Service, Jerusalem, Isr). *J Hydrol* v 101 n 1-4 Jun 30 1988 p 291-303.

**Analysis.** See Also FLOODS; HYDROLOGY; ORE TREATMENT—Tailings Disposal; RAIN AND RAINFALL—Arizona; RAIN AND RAINFALL—Canada; WATERSHEDS—Hydrology.

**092371 SNOWMELT RUNOFF PATHWAYS IN A BOREAL FOREST HILLSLOPE, THE ROLE OF PIPE THROUGHFLOW.** On an instrumented slope of the Lac Laflamme basin, it was observed that, during snowmelt season: (1) the unsaturated matrix flow seems to be a negligible component of the downslope flow through the soil horizons; (2) the groundwater flow from an aquifer in till, a few meters thick, is the major pathway for rain-melt inputs; and (3) when groundwater levels are high, a turbulent pipe throughflow occurs at the mineral and organic soils interface. Gauging one of the subsurface streams showed that, although its discharge is correlated and synchronized with nearby groundwater levels, its hydrograph often reflected that of rain-melt input. Pipe throughflow does not carry more than one fifth of the seasonal rain-melt input. The water delivered by pipe throughflow forms a distinct 0.5-1 m thick acidic layer that invades the lake just beneath the lake ice cover and is susceptible to affect the fish spawning ground. (Edited author abstract) 36 refs.

Roberge, Jean (Laval Univ, Sainte-Foy, Que, Can); Plamondon, Andre P. *J Hydrol* v 95 n 1-2 Nov 15 1987 p 39-54.

**092372 FREQUENCY ANALYSIS OF ANNUAL RUNOFF FOR SMALL WATERSHEDS IN UPPER DAMODAR VALLEY.** Attempts have been made in this paper to apply the theory of probability functions to carry out the frequency analysis of the annual runoff data for twenty small watersheds in upper Damodar valley. Five probability distributions have been compared, making use of chi-square methods of goodness of fit and the magnitudes of runoff have been estimated using the best fit probability distribution for each of the watersheds at different probability levels. (Author abstract) 5 refs.

Singh, R. (IIT, Kharagpur, India); Misra, N.; Satyanarayana, T. *J Inst Eng India Part AG* v 68 n 1 Aug 1987 p 14-17.

**092373 PATTERNS OF WATERSHED MONTHLY RUNOFF.** Two dimensional sliding polynomials were adapted to pattern analysis of watershed monthly rainfall and runoff. Contours of runoff in the two-dimensional space of time and rainfall are constructed on a grid of 16 nodes whose values are determined by least squares. This method is form free, hence derived patterns are not biased to selected functional forms, but can directly represent the smoothed data. Values of the nodes are localized averages of the data constrained by required mathematical continuity across the grid of values. An advantage of the method is that the standard deviation can be calculated for each node, thus producing patterns of uncertainty of the

deterministic component revealed by the data. (Author abstract) 16 refs.

Snyder, W.M.; Thomas, A.W. *Water Resour Bull* v 23 n 6 Dec 1987 p 1133-1140.

**092374 RUNOFF GENERATION IN A LOW ARCTIC DRAINAGE BASIN.** The production of runoff from a small drainage basin in the continuous permafrost area of continental Canada was studied for two years. The basin comprises two main land types (dry tundra slopes and valley bottom wetlands) and several lakes. In spring, meltwater from most parts of the basin contributed to total runoff but the magnitude and timing of slope and wetland runoff differed. In summer this difference in runoff production was more marked. In both seasons the base of the slopes initiated runoff, which increased significantly once the wetlands began to discharge. The combined runoff mechanisms of the two land types and the linkages between them provide a general framework for an understanding of runoff generation in low Arctic basins. (Author abstract). 18 Refs.

Roulet, Nigel T. (York Univ, North York, Ont, Can); Woo, Ming-Ko. *J Hydrol* v 101 n 1-4 Jun 30 1988 p 213-226.

**092375 ESTIMATION OF THE TIME OF CONCENTRATION FOR DIVERGING SURFACES.** A solution is obtained for estimating the time of concentration for a diverging watershed. A comparison of concentration times for diverging and plane surface is made to examine the influence of the degree of divergence for a diverging watershed on the time of concentration. Assuming that the physical characteristics such as watershed length, slope, roughness and rainfall excess are the same, an expression of the ratio of the time of concentration for a diverging surface to that for a plane surface is derived. The expression is solved numerically, and evaluated graphically. (Edited author abstract). 9 Refs.

Agiralioglu, Necati (Technical Univ of Istanbul, Istanbul, Turk). *Hydrol Sci J* v 33 n 2 Apr 1988 p 173-179.

**092376 DRAINAGE BASIN PEAK DISCHARGE RATING CURVE.** The stream gauge rating curve for a drainage basin can be transformed into a drainage basin peak discharge rating curve that is more stable than the rating curve from which it is derived. The resulting drainage basin peak discharge rating curve can be used to predict peak discharge, identify anomalous discharges caused by channel obstructions or other causes, evaluate the effect of flood retarding structures, and evaluate historical records. The drainage basin peak discharge rating curve is valid for drainage basins of any size, for any discharge up to the time of concentration, and for snowmelt. (Author abstract). 6 Refs.

Rogers, Wilbur F.; Singh, Vijay P. *Hydrol Processes* v 2 n 3 Jul-Sep 1988 p 245-253.

**092377 HILLSLOPE RUNOFF PROCESSES AND MODELS.** Hillslope hydrology is concerned with the partition of precipitation as it passes through the vegetation and soil between overland flow and subsurface flow. In the 1960s and 1970s, hillslope hydrology developed as a distinct topic through the application of new field observations to develop a generation of physically based forecasting models. Some recent models have generally attempted to simplify the processes acting, for example including only vertical unsaturated flow and lateral saturated flows. Others explicitly forecast partial or contributing areas. With hindsight, the most complete and distributed models have generally shown little forecasting advantage over simpler approaches, perhaps trending towards reliable models which can run on desk top microcomputers. The variety now being recognised in hillslope hydrological response should also lead to models which take account of more complex interactions. (Edited author abstract). 60 Refs.

Kirkby, Mike (Leeds Univ, Leeds, Engl). *J Hydrol* v 100 n 1-3 Jul 30 1988 p 315-339.



## Calculations

**092378 COMPOSITION METHOD OF CALCULATING PROBABILITY DISTRIBUTION OF THE VOLUME OF SPRING FLOOD RUNOFF.** Proposed is a method of calculating the volume of the spring flood runoff based on the use of the composition of probability distributions of the major runoff factors, with consideration of the completeness and quality of hydrometeorological data, which is most efficient when used in the case of hydrometeorologically unstudied drainage basins. (Author abstract) 8 refs.

Rozhdestvenskii, A.V.; Tikhomirova, A.A. *Sov Meteorol Hydrol* n 4 1987 p 76-81.

## Chemical Analysis See Also GEOCHEMISTRY—Groundwater.

**092379 CONTRIBUTIONS OF RAINFALL TO CONSTITUENT LOADS IN STORM RUNOFF FROM URBAN CATCHMENTS.** Rainfall is a significant source of some constituents, particularly nitrogen species, in storm runoff from urban catchments. Median contributions of rainfall to storm runoff loads of 12 constituents from 31 urban catchments, representing eight geographic locations within the United States, ranged from 2 percent for suspended solids to 74 percent for total nitrite plus nitrate nitrogen. The median contribution of total nitrogen in rainfall to runoff loads was 41 percent. Median contributions of total-recoverable lead in rainfall to runoff loads varied by as much as an order of magnitude between catchments in the same geographic location. This indicates that average estimates of rainfall contributions to constituent loading in storm runoff may not be suitable in studies requiring accurate constituent mass-balance computations. (Author abstract) 3 refs.

Ebbert, J.C. (US Geological Survey, Tacoma, WA, USA); Wagner, R.J. *Water Resour Bull* v 23 n 5 Oct 1987 p 867-871.

**092380 TOXICITY AND CHEMICAL COMPOSITION OF URBAN STORMWATER RUNOFF.** The effects of land use on the chemical composition of urban stormwater runoff and its subsequent acute toxicity to the aquatic invertebrate *Daphnia pulex* have been investigated in the Brunette drainage basin of Burnaby, British Columbia. Both land use and interval between rainfall events influenced the chemical composition and toxicity of the stormwater. The industrial and commercial land use sites were the major source of those trace metals most often considered toxic to aquatic invertebrates, with runoff from the commercial sites proving most frequently toxic to the test organism. Toxicity followed the sequence commercial > industrial > residential > open space. A detailed study of a single storm event indicated that while the 'first-flush' of the storm contributed to toxicity - through the physical scouring of insoluble pollutants - some soluble pollutants, which were washed out of the watershed later in the storm event, also proved to be toxic. Additional aspects of the subject are discussed. (Edited author abstract) 40 refs.

Hall, Ken J. (Univ of British Columbia, Vancouver, BC, Can); Anderson, Bruce C. *Can J Civ Eng* v 15 n 1 Feb 1988 p 98-106.

**092381 STREAM NITRATE LEVELS IN A SMALL CATCHMENT IN SOUTH WEST ENGLAND OVER A PERIOD OF 15 YEARS (1970-1985).** Stream nitrate levels in a small catchment of mixed land use (the Slapton Wood catchment) have been studied since September 1970; a record of this length is possibly unique in the United Kingdom for such a small basin (94 ha). A sustained increase in nitrate concentration has been observed during the study period. In addition to this long-term trend, short-term changes in nitrate concentrations relate to stream discharge levels and to seasonal variations. Multivariate statistical analysis has been used to quantify these trends and to identify those factors controlling the production and loss of nitrate from the catchment system. The main period of nitrate removal occurs in winter when high concentrations coincide with

the main period of throughflow generation. The influence of climatic variability is illustrated by reference to the 1975/76 drought and post-drought period. (Author abstract). 27 Refs.

Burt, T.P. (Univ of Oxford, Oxford, Engl); Arkell, B.P.; Trudgill, S.T.; Walling, D.E. *Hydrol Processes* v 2 n 3 Jul-Sep 1988 p 267-284.

## Components

**092382 ANALYSIS OF RUNOFF BY FREQUENCY RESPONSE METHOD.** The existence of dead time and delay time is recognized in one-component input-output system response. These two effects should not be regarded as identical. Various reports have been given on delay time over a long time as an important concept of dead time, and of runoff component separations by means of the frequency response method. The proposed method is of practical use to clarify the runoff properties. The effectiveness of the model is verified using simulated data as well as actual flood events. (Author abstract) In Japanese. 13 refs.

Saga, Hiroshi. *Doboku Gakkai Rombun-Hokokushu* v 9 n 5 May 1988 p 77-86.

## Computer Simulation See Also HYDROLOGY—Mathematical Models; MILITARY ENGINEERING.

**092383 STORM WATER SIMULATION: MODELING AND ANALYSIS OF A THREE-DIMENSIONAL CLOUD.** A simulation of storm water is presented for developing a physical understanding of storm runoff from urban basins. A new three-dimensional cloud model simulates storm rainfall. The model contains nine prognostic equations: three momentum equations, pressure and thermodynamic equations, three moisture and water equations, and a subgrid kinetic energy equation. A particular coordinate transformation is used. It maps a simulation domain with an irregular lower boundary onto a rectangular domain. A finite difference scheme which conserves heat, moisture, water substances, and subgrid-scale motion solves the transformed equations. The rainfall is averaged in space and time for a basin to obtain the hyetograph. We use the Road Research Laboratory Hydrograph method (the RRL method) to compute the storm runoff hydrograph for the basin from the hyetograph. A simulation result for a simplified atmospheric condition is presented. (Author abstract) 10 refs.

Horibata, Yasuyoshi (Toshiba Corp, Kawasaki, Jpn); Kodate, Hidemi. *Simulation* v 50 n 2 Feb 1987 p 66-76.

**092384 TWO PACKAGES FOR METEOROLOGICAL DATA PROCESSING AND RUNOFF SIMULATION FOR PERSONAL COMPUTERS.** This paper presents two packages designed to solve some of the most common problems involved in the analysis of a river catchment on a personal computer. The main operations performed concern preprocessing of raw meteorological data (to obtain time series of rainfall, snowfall and daily mean temperatures at different elevations), and simulation of the daily runoff from the catchment. Both packages have been developed at the Laboratorio di Informatica Ambientale e Territoriale (LITA) of the Politecnico di Milano, Italy. (Author abstract) 10 refs.

Gandolfi, C. (Politecnico di Milano, Milan, Italy); Pirovano, G.; Soncini-Sessa, R. *Environ Software* v 2 n 4 Dec 1987 p 192-198.

**092385 SIMULATION OF RUNOFF AND NITRATE LEACHING FROM AN AGRICULTURAL DISTRICT IN SWEDEN.** A twenty-year series of runoff and nitrogen leaching measurements from a cereal-dominated agricultural watershed in southern Sweden indicated a trend towards increased leaching. To investigate causal factors associated with the trend, two simulation models were used. Water and heat conditions were simulated with a physically based model. Simulated values agreed well with observed water flows, and no significant change in the water balance as a result of alterations in

land use were detected. Based on the simulated soil climate and data on land use, soil nitrogen dynamics were simulated with a nitrogen model. Model predictions were tested against leaching measurements. Alternative assumptions of 'fast' or 'slow' turnover of nitrogen in crop residues were tested. Model simulations of leaching agreed best with measured trends when a fast turnover rate of crop residues was assumed (i.e., < 50% of crop residue N was stabilized in humus). (Edited author abstract) 20 refs.

Jansson, Per-Erik (Swedish Univ of Agricultural Sciences, Uppsala, Swed); Andersson, Rune. *J Hydrol* v 99 n 1-2 May 15 1988 p 33-47.

**092386 URBAN RUNOFF SIMULATION MODEL.** Several rainfall-runoff simulations were conducted in order to determine the hydrologic response of the unit hydrograph to the impact of urbanization. A hydrologic model was formulated for an urban catchment located at Houston, Texas, using the kinematic wave model developed by the Hydrologic Engineering Center (HEC). The model was used to simulate various degrees of urbanization by allowing the percentage of watershed imperviousness and the channel roughness coefficient to vary from simulation to simulation. A system of regression equations was developed to quantify the impact of urbanization on the unit hydrograph. The equations were incorporated into the A&M Watershed Model and verified by modeling three test watersheds. (Edited author abstract) 20 refs.

Garcia, Alfred Jr. (Texas A&M Univ, College Station, TX, USA); James, Wesley P. *J Water Resour Plann Manage* v 114 n 4 Jul 1988 p 399-413.

**092387 URBAN STORMWATER FLOWRATE AND QUALITY PREDICTION. THE FLUPOL MODEL.** [Urban Stormwater Flowrate and Quality Prediction: The Flupol Model]. Urban stormwater runoff has gradually become an important source of stream pollution. The use of stormwater simulation and river water quality models helps to emphasize the impact of urban stormwater runoff on the receiving streams. FLUPOL was precisely developed to simulate the quantity and quality response of urban sewer networks with the smallest possible number of data. The model presentation is followed by a validation from measurements carried out in a large size storm sewer of a large urban area located south of Paris. (Edited author abstract). 10 Refs. In French.

Bujon, G. (Agence de Bassin, Siene-Normandie, Fr). *Houille Blanche* n 1 Jan 1988 p 11-23.

## Control See Also AGRICULTURAL WASTES—Management; DRAINAGE—Design; RAIN AND RAINFALL—Mathematical Models; SOILS—Conservation; WATER RESOURCES—Management.

**092388 EVALUATION OF PERMEABILITY OF PERMEABLE PAVEMENT FOR CONTROLLING STORM RUNOFF IN URBAN AREA.** One of the problems with which the urban storm runoff is confronted is the increase of the runoff water flowing into the rivers in the urban area. This increase of runoff water is caused by the development and urbanization around the river basin. This phenomenon in the increase of runoff water produces many problems in the storm water drainage. The permeable facilities for the storm water control are effective countermeasures for these problems. The values of permeability of the permeable pavement for controlling the storm runoff are evaluated on the basis of the research and studies in this paper. (Edited author abstract) 11 refs.

Wada, Yasuhiko (Kansai Univ, Osaka, Jpn); Miura, Hiroyuki. *Technol Rep Kansai Univ* n 29 Mar 1987 p 193-202.

**092389 REGULATION OF STORM WATER POINT SOURCE DISCHARGES.** The National Pollutant Discharge Elimination System (NPDES) regulatory program is administered by the Environmental Protection Agency (EPA) to control point source wastewater discharges to waters of the U.S. Structuring regulations to



effectively deal with storm water has thus far been the subject of a 14 year controversy. The Water Quality Act of 1987 has been a two-edged sword for EPA's storm water program. Of primary importance is the notion that EPA is dealing with an infant program, and must, therefore, move cautiously towards the goal of effectively controlling storm water point sources. To that end, EPA should focus on qualitative information as a first step towards addressing the storm water problem in a practical and cost-effective, yet environmentally sound manner.

Korpcics, J. Joseph (US EPA, Dallas, TX, USA). *J Water Pollut Control Fed* v 60 n 1 Jan 1988 p 50-56.

**092390 MULTICRITERION STORMWATER MANAGEMENT METHODS.** While detention basins designed to control peak discharge are effective in controlling peak rates, the basins are ineffective in controlling the degradation of erodible channels downstream of the basin. A relationship for making planning estimates of the volume of detention storage required to control channel erosion is provided. A procedure that can be used for design is also provided. Planning and design methods for water quality control through detention time control are also provided. The importance of adopting multicriterion stormwater management policies is emphasized, with the policy recommending control of flooding, channel erosion, and detention time for water quality enhancement. (Edited author abstract) 11 refs.

McCuen, Richard H. (Univ of Maryland, College Park, MD, USA); Moglen, Glenn E. *J Water Resour Plann Manage* v 114 n 4 Jul 1988 p 414-431.

**092391 EFFECTIVENESS OF AN URBAN RUN-OFF DETENTION POND-WETLANDS SYSTEM.** The effectiveness of an urban detention system, composed of a detention pond and wetlands in series, in reducing constituent loads carried in runoff was determined. The detention pond was effective in reducing loads of suspended solids and suspended metals. Nutrient efficiencies were variable, ranging for all species and phases, from less than 0 to 72 percent. The wetlands generally was effective in reducing both suspended and dissolved loads of solids and metals. The system, by combining the treatment of the pond and wetlands, was very effective in reducing loads of most constituents. (Edited author abstract). 11 Refs.

Martin, Edward H. (US Geological Survey, Altamonte Springs, FL, USA). *J Environ Eng* v 114 n 4 Aug 1988 p 810-827.

**092392 ALTERNATIVE STRATEGIES FOR STORMWATER DETENTION.** In a simulation experiment, stormwater flows are partially diverted, at various levels, to a detention basin in order to compare the recombined (i.e., undiverted flows and basin discharges) hydrograph to the response of the traditional, in-line design. The use of off-line detention basins is shown to be an effective technique for reducing peak flows from developed watersheds to pre-development levels with lower storage requirements. In addition, the discharge hydrographs produced by off-line detention are significantly different from those produced by the traditional design and may be more suited to certain stormwater management situations. (Author abstract). 14 Refs.

Nix, Stephan J. (Syracuse Univ, Syracuse, NY, USA); Tsay, Ting-Kuei. *Water Resour Bull* v 24 n 3 Jun 1988 p 609-614.

## Estimation

**092393 ESTIMATING RUNOFF VOLUMES FROM FLAT, HIGH-WATER-TABLE WATERSHEDS.** Four methods of estimating stormwater runoff total volume are evaluated as to their performance on watersheds of Florida's flatwoods resource area. Three additional techniques representing modifications and extensions of existing methods are developed and their performance evaluated. Characteristics of flatwoods watersheds include extremely flat relief, sandy soils, dynamic shallow water tables, and scattered wetlands. Data collected by the U.S. Geological Survey (USGS) and South

Florida Water Management District (SFWMD) from the five small (8-1450 ha) agricultural watersheds (improved and unimproved pasture) served as the basis of evaluation. All total volume estimation techniques examined rely upon the SCS (Soil Conservation Service) runoff equation. Best results were achieved with methods which included antecedent depth to the water table as a measure of watershed storage potential. (Author abstract) 15 refs.

Capece, J.C. (Univ of Florida, Gainesville, FL, USA); Campbell, K.L.; Baldwin, L.B.; Konyha, K.D. *Trans ASAE* v 30 n 5 Sep-Oct 1987 p 1397-1402.

**092394 DETERMINISTIC APPROACH TO INFLOW DESIGN RAINFLOOD DEVELOPMENT AS APPLIED BY THE U.S. BUREAU OF RECLAMATION.** A brief introductory discussion is provided relative to the historical development of the deterministic approach used in the analysis of extraordinary flood events, namely the probable maximum flood, by the Bureau of Reclamation. The paper then proceeds from the brief historical treatment to a more detailed discussion emphasizing the current hydraulically based adaptation of the traditional unit hydrograph approach for modeling the conversion of rainfall to runoff. Among the properties identified and discussed are the geometric configuration of the drainage network as developed by geological processes and the hydraulic characteristics of the drainage network in terms of the system's hydraulic efficiency in conveying extreme magnitude flood discharges to points of runoff concentration. The generation of unit hydrographs for ungaged basins using the approach is discussed in some detail. Additional aspects of the subject are discussed. (Edited author abstract) 13 refs.

Cudworth, Arthur G. Jr. (US Bur of Reclamation, Denver, CO, USA). *J Hydrol* v 96 n 1-4 Dec 15 1987 p 293-304.

**092395 ESTIMATING RUNOFF PEAK RATES FROM FLAT, HIGH-WATER-TABLE WATERSHEDS.** Six methods of estimating stormwater runoff peak discharge are evaluated as to their performance on watersheds of Florida's flatwoods resource area. Characteristics of flatwoods watersheds include extremely flat relief, sandy soils, dynamic shallow water tables, and scattered wetlands. Data collected by the U.S. Geological Survey and South Florida Water Management District from five small (8 to 1450 ha) agricultural watersheds (improved and unimproved pasture) served as the basis of evaluation. Runoff peak rate estimation techniques ranged in approach from empirical formulas to an overland flow simulation model. Among the established methods examined, best results were achieved using the overland flow technique. Three of the six peak rate estimation methods (the SCS graphical method, the CREAMS hydrologic model equation, and the SCS triangular hydrograph method) were modified to improve their performance on flatwoods watersheds. (Author abstract) 18 refs.

Capece, J.C. (Univ of Florida, Gainesville, FL, USA); Campbell, K.L.; Baldwin, L.B. *Trans ASAE* v 31 n 1 Jan-Feb 1988 p 74-81.

**092396 FRACTALS AND THE RIVER-LENGTH CATCHMENT-AREA RATIO.** The fractal nature of stream-length and catchment-area measurement is investigated using eight rivers in Missouri. The fractal dimension for the length measurement was found to average 1.158 and for area to average 1.0105. These values are close to those hypothesized by Mandelbrot (1983). (Author abstract) 6 refs.

Hjelmfelt, Allen T. Jr. (Univ of Missouri-Columbia, Columbia, MO, USA). *Water Resour Bull* v 24 n 2 Apr 1988 p 455-459.

**092397 METODO PER LA STIMA DELLE PORTATE AL COLMO DI BACINI ITALIANI CON AREA MINORE DI 100 KM<sup>2</sup> ATTRAVERSO LE PORTATE GIORNALIERE.** [Method, Based on Daily Discharges, for Estimating the Peak Discharge of Italian Basins with an Area not Exceeding 100 km<sup>2</sup>.] Considering the ratio  $\lambda$  between the yearly maxima of peak

discharge  $Q$  and daily discharge  $q$  as a random variable, two formulae are given, by means of which the mean and standard deviation of  $\lambda$  can be derived from some geomorphological and hydrological characteristics of the basin. A method, based on these formulae, is also given to estimate the peak discharge with an assigned return period  $T$  from the yearly maxima of the daily discharge. The results, obtained from an analysis carried out on 72 Italian basins, are proposed for basins with an area not exceeding 100 km<sup>2</sup>. (Author abstract). 9 Refs. In Italian.

Ciaconi, C. (Facolta di Ingegneria di Udine, Italy); Moisello, U. *Energ Elettr* v 65 n 5 May 1988 p 189-195.

**092398 SIMPLE MODEL FOR RUNOFF ESTIMATION.** A simple model for runoff estimation is presented, with particular reference to Athens basin. The method is based on assumptions of a symmetrical exponential storm profile and a linear cumulative area - time relation, while a power law is postulated for correlating the storm peak factor with rainfall duration. A general expression is derived for the peak flow and discussed in comparison with the rational formula. Further, the outflow hydrograph from subcatchments of uniform characteristics is approximated by a triangular form. The model parameters for the Athens area are estimated from local rainfall data. Specific applications in Athens basin indicate good agreement with results of established techniques or observations, implying that the present method may constitute a useful tool in design practice. (Author abstract). 6 Refs.

Christodoulou, G.C. (Nat'l Technical Univ of Athens, Greece); Memos, C.D. *Int J Water Resour Dev* v 3 n 3 Sep 1987 p 207-215.

**092399 JOINT PROBABILITY ESTIMATES OF RETURN PERIOD FLOWS.** A methodology for combining rainfall probabilities and the probabilities of various antecedent conditions for estimating return period flows is presented. The methodology is based on the principles of derived distributions to combine the probability distributions of rainfall and runoff equation parameters to derive the distribution of flow. To date the majority of the authors' work has used the Extreme Value Type I distribution to describe rainfall probabilities and the lognormal distribution to describe the probability distribution of  $S$  in the SCS runoff equation. The method is not dependent on the form of the parent distributions that are used. Results from applying the method to watersheds near Stillwater, OK; Coshocot, OH; Hastings, NE; and Safford, AZ are presented. (Edited author abstract). 12 refs.

Haan, C.T. (Oklahoma State Univ, Stillwater, OK, USA); Edwards, D.R. *Trans ASAE* v 31 n 4 Jul-Aug 1988 p 1115-1119.

Hydrodynamics See SOILS—Surfaces.

## Hydrology

**092400 PROJECTION OF URBANIZATION EFFECTS ON RUNOFF USING CLARK INSTANTANEOUS UNIT HYDROGRAPH PARAMETERS.** In order to predict flood conditions in 1990 for the Beargrass Creek watershed, Louisville, Kentucky, trends in the Clark Instantaneous Unit Hydrograph (Clark IUH) parameters were utilized to determine the 1990 unit hydrograph and flood conditions. Based on the results from this flood study, this paper demonstrates the applicability of using projected Clark IUH parameters for modeling future runoff conditions in an urbanizing watershed. Values of these parameters, as estimated from maximum annual historical flood data, are used to develop regression models for predicting future Clark IUH parameters. Using the projected parameters, selected annual flood events since 1973 are simulated in order to verify the accuracy of these projections. (Edited author abstract) 12 refs.

Bhaskar, Nageshwar Rao (Univ of Louisville, Louisville, KY, USA). *Water Resour Bull* v 24 n 1 Feb 1988 p 113-124.



**Management** See PETROLEUM REFINERIES—Effluent Treatment.

**Mathematical Models** See Also IRRIGATION; RAIN AND RAINFALL—Mathematical Models; RIVERS—Discharge; URBAN PLANNING—Hydrology; WATER-SHEDS—Hydrology.

**092401 RECURSIVE ESTIMATION OF KERNELS OF NONLINEAR RAINFALL-RUNOFF MODELS.** Two algorithms, one for estimating the kernels of nonlinear functional series models of the rainfall-runoff process using a fixed length of rainfall-runoff data, and the other for updating the kernel estimates as additional data become available are proposed. These recursive algorithms are based on the steepest gradient method and are useful for on-line prediction of runoff. The estimation schemes are applied to model the daily rainfall-runoff process in the Rough river basin in Kentucky and the prediction results of both the linear and nonlinear models are compared. Improvement in prediction results brought about by fitting ARMA type models to residual sequences is discussed. (Author abstract) 19 refs.

Rao, Srinivas G. (Dames & Moore, Tampa, FL, USA); Ramachandra Rao, A. *J Hydrol* v 95 n 3-4 Nov 30 1987 p 341-364.

**092402 ON HYDROLOGIC SIMILARITY: 2. A SCALED MODEL OF STORM RUNOFF PRODUCTION.** The paper describes a simple physically based conceptual model of runoff production based on catchment topography and the spatial variability of rainfall and soil properties. Both infiltration excess and saturation excess runoff production mechanisms are considered. The interaction between the two mechanisms of runoff production and the effect of a finite water table on the infiltration excess mechanism are explicitly considered. Dimensionless formulation has led to the identification of five similarity parameters and three dimensionless variables representing initial conditions and storm characteristics. Finally, a number of experiments were performed to study the sensitivity of the runoff production response to some of these similarity parameters. (Edited author abstract) 21 refs.

Sivapalan, M. (Princeton Univ, Princeton, NJ, USA); Beven, Keith; Wood, Eric F. *Water Resour Res* v 23 n 12 Dec 1987 p 2266-2278.

**092403 ANALYSIS OF OBJECTIVE FUNCTIONS USED IN URBAN RUNOFF MODELS.** The objective functions used in parameter estimation in urban runoff models are compared by using a method proposed by M.H. Diskin and E. A. Simon and the urban runoff model ILLUDAS. Two sets of objective functions, the first one used by Diskin and Simon in their study and a second one which includes other objective functions are used. Rainfall-runoff data from urban watersheds in the US are used in the study. The results indicate that the least squares criterion is the best among those studied. (Author abstract) 21 refs.

Rao, A. Ramachandra (Purdue Univ, West Lafayette, IN, USA); Han, Ji. *Adv Water Resour* v 10 n 4 Dec 1987 p 205-211.

**092404 DETERMINATION OF RUNOFF FREQUENCIES FOR UNGAUGED URBAN CATCHMENTS.** A method is described for generating flood frequency information for a catchment for a design situation. The technique comprises a combination of deterministic and stochastic components. This involves deterministically modelling the response of the catchment together with the use of a stochastic element to derive the conditional probability vector of the outlet hydrograph peaks. The advantage of the method is that the infiltration is modelled using a range of values that is described statistically. (Author abstract) 25 refs.

Lambourne, J.J. (Univ of the Witwatersrand, S Afr). *Water SA* v 14 n 1 Jan 1988 p 1-6.

**092405 MODELING PHOSPHORUS TRANSPORT IN SURFACE RUNOFF.** A submodel for esti-

imating phosphorus loss from agricultural watersheds has been developed and incorporated into the ANSWERS watershed model. Model validation was accomplished using data from field plots. The model's usefulness as a planning tool was demonstrated on a watershed in Virginia. The model uses ANSWER's extended sediment transport option to describe the transport of individual particle size classes. A nonequilibrium desorption equation is used to account for the desorption of phosphorus from the soil to surface runoff. Sediment-bound phosphorus is modeled as a function of the specific surface area of the soil and sediment. The equilibrium between soluble and sediment-bound phosphorus is modeled using a Langmuir isotherm. (Author abstract) 41 refs.

Storm, D.E. (Univ of Kentucky, Lexington, KY, USA); Dillaha, T.A. III; Mostaghimi, S.; Shanholtz, V.O. *Trans ASAE* v 31 n 1 Jan-Feb 1988 p 117-127.

**092406 MODIFIED CREAMS NUTRIENT MODEL FOR COASTAL PLAIN WATERSHEDS.** In evaluating the suitability of the CREAMS model for simulating nutrient yield from Coastal Plain — flatwoods — watersheds in South Florida, it was determined that assumptions made in developing the model were not valid for the sandy soils prevalent in this region. Conceptual changes to the model led to the development of the CREAMS-WT version which better represents the low phosphorus buffering capacity of these sandy soils. For verification, two watersheds were simulated without calibration: a beef pasture with low nutrient loading, and a dairy watershed with very high nutrient loading. Predicted annual flow-weighted concentrations of total-N and total-P compare closely with observed values for both sites, correctly reflecting the response of these extreme cases of nutrient loading. A sensitivity analysis of new and modified parameters is presented along with comments on estimating parameters. (Author abstract) 20 refs.

Heatwole, C.D. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Campbell, K.L.; Bottcher, A.B. *Trans ASAE* v 31 n 1 Jan-Feb 1988 p 154-160.

**092407 STORAGE-EFFECTIVE DRAINAGE (SED) RUNOFF MODEL.** The storage-effective drainage (SED) runoff model was developed to assist in the research objectives of Alberta Environment's Spring Creek Experimental Watershed Project. The project's primary mandate was to identify the effects of large scale deforestation in a pristine boreal forest on the hydrologic cycle. During the research pretreatment phase it was observed that: (1) during two consecutive water years the basin had a 50% difference in annual input but displayed a 700% difference in annual output; and (2) two storms, with the same magnitude and intensity, generated output responses that differed by a multiple of 500. Recognizing the wide range of watershed responses to a given input it is impossible to distinguish the effects of deforestation using the established investigative tools of regression and statistical analyses particularly when dealing with small data samples. For this reason the SED model, which uses changes in basin storage conditions as a means of accurate runoff modelling and hydrograph reconstitution, was developed. (Author abstract) 2 refs.

Holecck, George (Alberta Dep of Environment, Edmonton, Alberta, Can). *J Hydrol* v 98 n 3-4 Apr 15 1988 p 295-314.

**092408 RATIONAL FORMULA INTERPRETED USING A PHYSICALLY-BASED MATHEMATICAL MODEL.** A new interpretation is given for the rational formula in view of a mathematical model founded on the kinematic overland flow and Green and Ampt infiltration equations. The potential variability of the runoff coefficient with various rainfall and basin characteristics is demonstrated. However, using the concept of hydrologic similarity, it is possible to predict the runoff coefficient in terms of several physically-based non dimensional parameters for homogeneous planar, rectangular basins. (Author abstract) 19 refs.

Akan, A. Osman (Old Dominion Univ, Norfolk, VA, USA); Al-Turbak, Abdulaziz A. *Nord Hydrol* v 19 n 1

1988 p 41-52.

**092409 WATERSHED RUNOFF MODELLING - A CASE STUDY.** In this paper an attempt has been made to study the interrelationships among some selected geomorphic parameters. The geomorphic parameters are further grouped into different characteristic groups and used for development of regression models for prediction of mean annual runoff. In all, about 24 models are developed and the best fit model is identified which can be conveniently used for prediction of runoff of an ungauged watershed in any region having similar physiographic features as that of Upper Damodar Valley. (Author abstract) 26 refs.

Misra, N. (IIT, Kharagpur, India). *J Inst Eng India Part AG* v 68 Jan 1988 p 91-95.

**092410 DETERMINATION OF THE SPRING RUNOFF FOR A BASIN WITH ABUNDANT LAKES USING A STEPWISE LINEAR STORAGE MODEL.** Humid regions contain areas in which the storage capacity of lakes is a very important factor in determining the yearly distribution of runoff. The purpose of this paper is to show first that a stepwise linear storage model may be used for estimating spring runoff, and second that runoff data from small lakeless basins can be used as input in a model for large basins with several lakes. The model has two parameters that must be determined by calibration. The first is associated with the number of sub-basins draining into the lakes, and the second indicates the time delay of snow melt in the larger basin as compared with that of the small basin. The model may be used for forecasting purposes and for estimating runoff in cases in which runoff data are lacking. (Edited author abstract) 10 refs.

Virta, Juhani (Dep of Geophysics, Helsinki, Finl). *Aqua Fenn* v 17 n 2 1987 p 115-121.

**092411 REGRESSION ESTIMATES FOR TOPOLOGICAL-HYDROGRAPH INPUT.** Physiographic, hydrologic, and rainfall data from 18 small drainage basins in semiarid, central Wyoming were used to calibrate topological, unit-hydrograph models for celerity, the average rate of travel of a flood wave through the basin. The data set consisted of basin characteristics and hydrologic data for the 18 basins and rainfall data for 68 storms. Calibrated values of celerity and peak discharges subsequently were regressed as a function of the basin characteristics and excess rainfall volume. Predicted values obtained in this way can be used as input for estimating hydrographs in ungauged basins. The regression models included ordinary least-squares and seemingly unrelated regression. This latter regression model jointly estimated the celerity and peak discharge. (Edited author abstract) 13 refs.

Karliringer, Michael R. (US Geological Survey, Denver, CO, USA); Guertin, D. Phillip; Troutman, Brent M. *J Water Resour Plann Manage* v 114 n 4 Jul 1988 p 446-456.

**092412 UNCERTAINTY ESTIMATES FOR SURFACE RUNOFF MODELS.** A lower bound for variance in surface runoff modelling estimates is advanced. The bound is derived using a linear unit hydrograph approach which utilizes a discretization of the catchment into an arbitrary number of subareas, a linear routing technique for channel flow effects, a variable effective rainfall distribution over the catchment, and calibration parameter distributions developed in correlating rainfall-runoff data by the model. The uncertainty bound reflects the dominating influence of the unknown rainfall distribution over the catchment and is expressed as a distribution function that can be reduced only by supplying additional rainfall-runoff data. It is recommended that this uncertainty distribution in modelling results be included in



flood control design studies in order to incorporate a prescribed level of confidence in flood protection facilities. (Author abstract). 8 Refs.

Hromadka, T.V. II (Williamson & Schmid, Irvine, USA); McCuen, R.H. *Adv Water Resour* v 11 n 1 Mar 1988 p 2-14.

**092413 PROGRESS IN DEVELOPING AN OPERATIONAL SNOWMELT-RUNOFF FORECAST MODEL WITH REMOTE SENSING INPUT.** In order to apply to snowmelt-runoff model (SRM) or any snowmelt model operationally, a logical progression is required from utilization in the pure simulation mode when all data are known to the pure forecasting mode when no future data are known. Significant progress has been made and results are presented which include pure simulation, simulation when the actual output data are unknown, simulation when estimated or forecasted snow cover input data are employed, simulations or forecasts with updating using observed streamflow, and first attempts at true forecasts. Based on these results, an objective method for forecasting with SRM is being developed. (Author abstract). 10 Refs.

Rango, A. (USDA, Beltsville, MD, USA). *Nord Hydrol* v 19 n 2 1988 p 65-76.

**092414 DETERMINATION OF RUNOFF FREQUENCIES FOR UNGAUGED URBAN CATCHMENTS.** Engineers often intuitively use the recurrence interval of a design storm for runoff recurrence interval. It is suggested that this assumption is not soundly based, as the antecedent moisture content (AMC) or catchment wetness has a significant effect on the storm runoff recurrence interval. A method is described for generating flood frequency information for a catchment for a design situation. The technique comprises a combination of deterministic and stochastic components. This involves deterministically modelling the response of the catchment together with the use of a stochastic element to derive the conditional probability vector of the outlet hydrograph peaks. The advantage of the method is that the infiltration is modelled using a range of values that is described statistically. (Author abstract). 25 Refs.

Lambourne, J.J. (Univ of the Witwatersrand, Johannesburg, S Afr). *Water SA* v 14 n 1 Jan 1988 p 1-6.

**092415 RAINFALL-RUNOFF MODELING—PAST, PRESENT AND FUTURE.** A brief review of the historical development of mathematical methods used in rainfall-runoff modeling is presented. A simple classification of the current available models based upon both a priori knowledge and problem requirements is proposed in order to assess the state of the art. Finally an analysis of emerging problems in hydrology is used to ascertain possible future developments and trends. 51 Refs.

Todini, E. (Univ of Bologna, Italy). *J Hydrol* v 100 n 1-3 Jul 30 1988 p 341-352.

**092416 APPROXIMATE CONFIDENCE INTERVALS FOR VERIFICATION CRITERIA OF THE WMO INTERCOMPARISON OF SNOWMELT RUNOFF MODELS.** The comparison of the performances of hydrological models is usually based on the values of criteria which are functions of the differences between estimated and observed flows. In comparing models we have to consider whether the differences between performance criterion values may be due to sampling variation. To deal with this problem, the comparison of approximate confidence intervals of criterion values using the jackknife statistic is proposed. The method is applied to the results of the recent WMO project for the intercomparison of conceptual models of snowmelt runoff. (Author abstract). 21 Refs.

Cavadas, G. (McGill Univ, Montreal, Que, Can); Morin, G. *Hydrol Sci J* v 33 n 4 Aug 1988 p 369-377.

**092417 PROBLEMS OF RAINFALL-RUNOFF MODELLING IN ARID AND SEMIARID REGIONS.** The distinctive features of arid and semiarid regions affect rainfall-runoff modeling on both a discrete event basis and

a continuous basis. The general characteristics of arid zone hydrological processes and the problems they present in runoff modeling are discussed. Both sloping lands with integrated stream networks and flatlands with repetitive micro-hydrology are considered. The wide diversity in some characteristics may require different parameter values and possibly different approaches in different regions. Lack of observed data provides the major problem for runoff modeling in arid regions. Some comments are given on appropriate approaches to modeling for sloping regions. (Author abstract). 69 Refs.

Pilgrim, D.H. (Univ of New South Wales, Kensington, Aust); Chapman, T.G.; Doran, D.G. *Hydrol Sci J* v 33 n 4 Aug 1988 p 379-400.

**092418 MODALP: A DETERMINISTIC RAINFALL-RUNOFF MODEL FOR LARGE KARSTIC AREAS.** A model has been developed for fractured-fissured and karstic aquifers and it consists of two main systems, one of which represents the surface drainage area and simulates the peak flows of the hydrograph while the other simulates the inflows from the adjacent closed basins that contribute to the baseflow. Each of the two systems consists of two reservoirs. The first reservoir represents the soil cover and the unsaturated zone. Its main function is to deliver the effective precipitation to the second reservoir. The second reservoir represents the saturated zone of the karst system. Since the intensity of karstification decreases with depth, a variable discharge coefficient is considered in the model. The model has been applied successfully to the Manavgat River basin in Turkey, a highly karstified area. (Author abstract). 10 Refs.

Arikan, Alparslan (Hacettepe Univ, Ankara, Turk). *Hydrol Sci J* v 33 n 4 Aug 1988 p 401-414.

**092419 STOCHASTIC MODELLING OF RUNOFF FROM AN AGRICULTURAL WATERSHED IN SOUTHERN SASKATCHEWAN.** Analyses of hydrologic information collected from a small agricultural watershed near Swift Current in southern Saskatchewan from the past 35 yr revealed marked variations in the runoff behavior from year to year. Two simple stochastic models have been proposed, one for synthesizing monthly runoff flow and the other for snowmelt runoff simulation. Bayesian statistics have been utilized for estimating different conditional probabilities of runoff events for subunits within the watershed. When combined with historical runoff records, synthesized runoff flow may improve hydrologic design criteria for engineering structures. Frequency values of annual runoff and maximum one day runoff have also been computed on the basis of extreme value distribution. (Author abstract). 13 Refs.

Sharma, Shri Niwas (Agriculture Canada, Can); McConkey, B.; Steppuhn, H. *Can Agric Eng* v 30 n 2 Jul 1988 p 203-208.

**Measurements** See Also RAIN AND RAINFALL—Drainage; RIVERS—Hungary; SEWERS—Flow; SOILS—Erosion.

**092420 QUANTITY OF STORMWATER RUNOFF FROM TEN STRETCHES OF ROAD, A CAR PARK AND EIGHT ROOFS IN HERTFORDSHIRE, ENGLAND DURING 1983.** Rainfall and runoff were monitored simultaneously for one year from a residential road, a car park, nine sections of road draining to individual gullies, two house roofs, two garage roofs, and three types of factory roof. The sites, included an automatic weather station in Redbourn, Hertfordshire. The percentage runoff averaged 11.4 per cent for roads and 56.9 per cent for roofs. Percentage runoff from the roads was cyclic with a peak during the summer months but there was a marked variation in monthly percentage runoff within and between sites. Regression analysis to explain percentage runoff was undertaken with various subsets of data for: each site; roads; and roofs. 'Seasonal' variables had a positive relationship for loads which shows that the percentage runoff from roads is higher in summer than winter. The antecedent variables showed that percentage runoff from roads and roofs is increased by antecedent

rainfall. Depression storage, assessed by examining rainfalls that did and did not produce runoff, showed a diversity of monthly values. Peak runoff from the results showed an attenuation to 12.8 per cent for 1 minute rainfall intensities and 24.2 per cent for 5 minute intensities. For roofs the attenuation averaged 36.8 per cent for 1 minute intensities and 92.6 for 5 minute intensities. Additional aspects of the study are discussed. (Edited author abstract). 3 Refs.

Hollis, G.E. (Univ Coll London, London, Engl); Owendon, J.C. *Hydrol Processes* v 2 n 3 Jul-Sep 1988 p 227-243.

## Models

**092421 APPLICATION OF THE PRECIPITATION-RUNOFF MODEL IN THE WARRIOR COAL FIELD, ALABAMA.** A deterministic precipitation-runoff model, the Precipitation-Runoff Modeling System, was applied in two small basins located in the Warrior coal field, Alabama. Each basin has distinct geologic, hydrologic and land-use characteristics. Preliminary daily and storm calibrations were developed for each basin. Initial parameter and variable values were determined according to techniques recommended in the user's manual for the modeling system and through field reconnaissance. Parameters with meaningful sensitivity were identified and adjusted to match hydrograph shapes and to compute realistic water year budgets. When the developed calibrations were applied to data exclusive of the calibration period as a verification exercise, results were comparable to those for the calibration period. The model calibrations included preliminary parameter values for the various categories of geology and land use in each basin. The parameter values for areas underlain by the Pottsville Formation in the Bear Creek basin were transferred directly to similar areas in the Turkey Creek basin, and these parameter values were held constant throughout the model calibration. Parameter values for all geologic and land-use categories addressed in the two calibrations can probably be used in ungauged basins where similar conditions exist. The parameter transfer worked well, as a good calibration was obtained for Turkey Creek basin. (Edited author abstract) 41 refs.

Kidd, Robert E. (US Bur of Land Management); Bossong, C.R. *Geol Surv Water Supply Pap (US)* 2306 1987 42p.

**Prediction** See Also FORESTRY—Hydrology; RAIN AND RAINFALL—Analysis.

**092422 PREVISION DES DEBITS ET DES FLUX POLLUANTS TRANSITES PAR LES RESEAUX D'EGOUTS PAR TEMPS DE PLUIE. LE MODELE FLUPOL [Urban Stormwater Flowrate and Quality Prediction. The FLUPOL Model].** Urban stormwater runoff has become gradually an important source of stream pollution. The use of stormwater simulation and river water quality models helps to appreciate the impact of urban stormwater runoff on the receiving streams. FLUPOL was precisely developed to simulate the quantity and quality response of urban sewer networks with the smallest possible number of data. The Model presentation is followed by a validation from measurements carried out in a big size storm sewer of a large urban area located south of Paris. (Author abstract) In French. 10 refs.

Bujon, G. (Compagnie Generale Des Eaux, Paris, Fr). *Houille Blanche* v 43 n 1 1988 p 11-23.

**Remote Sensing** See Also DRAINAGE—Computer Aided Analysis.

**092423 TOWARD SNOWMELT RUNOFF FORECAST BASED ON MULTISENSOR REMOTE-SENSING INFORMATION.** Snow-cover mapping is a prerequisite for deriving the main input variable for a deterministic snowmelt runoff model (SRM). Operational forecasting of snowmelt runoff has to rely on guaranteed snow-cover information for a specific area and time. Remote sensing can provide the necessary data, especially when different sensor systems are available for combined interpretations. It has been shown already how



remote-sensing information from Landsat-MSS and NOAA-AVHRR supplement each other. It is important, though, that when using coarse spatial sensor resolution, special attention to the area, its topography, and the amount of snow coverage be taken. 7 refs.

Baumgartner, Michael F. (USDA, Beltsville, MD, USA); Seidel, Klaus; Martinec, Jaroslav. *IEEE Trans Geosci Remote Sens* v GE-25 n 6 Nov 1987, 1986 Int Geosci and Remote Sens Symp (IGARSS'86) - Remote Sens - Today's Solutions for Tomorrow's Inf Needs, Zurich, Switz, Sep 8-11 1986 p 746-750.

## Sedimentation

**092424 CONCEPTUAL CATCHMENT MODEL FOR ESTIMATING SUSPENDED SEDIMENT FLOW.** A conceptual catchment model of the instantaneous unit sediment graph was developed for sediment graph prediction and to determine the effect of soil conservation measures on sediment flow for a mountainous watershed by routing mobilized sediment through a series of linear reservoirs. The sediment graphs generated by convolution of the instantaneous unit sediment graph with mobilized sediment were compared with the natural observed ones on the Chaukhutia watershed comprising an area of 452 km<sup>2</sup> of the Ramganga reservoir catchment. The mobilized sediment during a storm was related to rainfall excess and the parameters of the model were estimated utilizing fourteen sediment events observed during the years 1976-84. (Author abstract) 12 refs.

Kumar, Swantosh (G.B. Pant Univ of Agriculture & Technology, Pantnagar, India); Rastogi, R.A. *J Hydrol* v 95 n 1-2 Nov 15 1987 p 155-163.

**092425 SIZE DISTRIBUTION OF SEDIMENT AS AFFECTED BY SURFACE RESIDUE AND SLOPE LENGTH.** Runoff samples for determination of size distribution of sediment were collected under simulated rainfall conditions at selected downslope distances on plots covered with sorghum and soybean residue at rates ranging from 0.00 to 6.73 t/ha. The effects of surface residue and slope length on size distribution of sediment were evaluated. Substantial movement of sediment in the form of aggregates was found for each of the residue treatments. Significant differences in size distribution of sediment occurred between residue treatments. For a given residue rate, differences in sediment size distribution were found between sorghum and soybean residue. Size distribution of sediment was also determined to be significantly different at selected downslope distances. (Author abstract) 19 refs.

Gilley, J.E. (ISDA-ARS, Lincoln, NE, USA); Finkner, S.C.; Varvel, G.E. *Trans ASAE* v 30 n 5 Sep-Oct 1987 p 1419-1424.

**092426 SIZE AND SURFACE TEXTURE OF SEDIMENT IN AN URBAN CATCHMENT.** The size and surface texture of sediment collected in stormwater runoff from an urban catchment of 420 hectares in NW London were examined. The area comprised mixed urban land uses drained by a separate sewer system; seven land use classes were recognized as sediment sources. Sediment was examined using an electronic particle counter and scanning electron microscopy. A Fuzzy Classification Technique was used to analyze the micrographs. Sediment composition varied, but that reaching the sewer system was predominantly quartz particles, <100µm, and of abraded appearance. Early stages of silica precipitation on particles were noted. (Author abstract) 46 refs.

Roberts, A.H. (Univ of Exeter, Devon, Engl); Ellis, J.B.; Whalley, W.B. *Sci Total Environ* v 72 Jun 15 1988 p 11-27.

**Simulation** See WATERSHEDS—Sampling.

## Testing

**092427 SIMULATION OF SURFACE RUNOFF AND PIPE DISCHARGE FROM AN AGRICULTURAL SOIL IN NORTHERN SWEDEN.** In order to

test the ability of a physically based water and heat model to predict surface runoff and pipe discharge, adaptations were made to an agricultural field in the north of Sweden. A five-year period was selected, including observations of meteorological data, frost in the soil and discharge. Surface runoff was the dominating part of the total runoff, especially during conditions of frozen soil. The simulated discharge agreed well with the general partitioning between surface runoff and pipe discharge but discrepancies occurred in their temporal patterns. A probable explanation of these discrepancies was that the model did not account for the enhanced spatial heterogeneity in water flow through snow and in partially frozen soil. (Edited author abstract) 22 refs.

Jansson, Per-Erik (Swedish Univ of Agricultural Sciences, Uppsala, Swed); Gustafson, Arne. *Nord Hydrol* v 18 n 3 1987 p 151-166.

**092428 INFLUENCE OF TILLAGE SYSTEMS AND RESIDUE LEVELS ON RUNOFF, SEDIMENT, AND PHOSPHORUS LOSSES.** A rainfall simulator was used to study the effects of conventional tillage and no-till on the losses of runoff, sediment, and phosphorus (P) from agricultural lands. No-till was found to be effective in reducing runoff and sediment losses. Runoff and sediment losses decreased as residue level increased, regardless of the tillage system. Increasing crop residue level from 0 to 750 kg/ha caused a decrease in average orthophosphorus (PO<sub>4</sub>) concentration for both tillage systems. However, as the crop residue level increased, from 750 to 1,500 kg/ha, the PO<sub>4</sub> concentrations increased. Both PO<sub>4</sub> and total-P (P<sub>T</sub>) losses were greatest with the 0 kg/ha residue treatment, intermediate with 1,500 kg/ha residue, and least with 750 kg/ha residue. Additional study results are discussed. (Edited author abstract) 24 refs.

Mostaghimi, S. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Dillaha, T.A.; Shanholtz, V.O. *Trans ASAE* v 31 n 1 Jan-Feb 1988 p 128-132.

**Transport Properties** See PHOSPHORUS COMPOUNDS—Environmental Impact.

**RUPTURE DISKS** See NUCLEAR REACTORS, PRESSURIZED WATER—Accident Prevention; EXPLOSIVES—Accident Prevention.

**RUTHENIUM AND ALLOYS** See Also CRYSTALS—Growing.

## Morphology

**092429 AN EXAFS STUDY ON THE MORPHOLOGY CHANGE OF Ru CATALYST BY CO ADSORPTION.** In this communication we present another example of the morphology change upon adsorption for Ru supported on γ-O<sub>2</sub> and show this phenomenon is not limited to Rh. The following conclusions can be drawn from the present study. First, ultradispersed Ru clusters are formed on alumina support from Ru<sub>3</sub>(CO)<sub>12</sub>. Second, Ru-Ru bonds in the very tiny Ru clusters are disrupted by CO adsorption, leading to the formation of a new species like Ru(CO)<sub>n</sub>. Third, the tiny Ru clusters are recovered by CO desorption. 12 refs.

Mizushima, Takanori (Inst for Molecular Science, Okazaki, Jpn); Tohji, Kazuyuki; Udagawa, Yasuo. *J Am Chem Soc* v 110 n 13 Jun 22 1988 p 4459-4460.

## Spectroscopic Analysis

**092430 LUMINESCENCE DECAY CHARACTERISTICS OF Ru(bpy)<sub>3</sub><sup>2+</sup> IN DILUTE SINGLE CRYSTALS AND POLYMER HOSTS.** Luminescence decay characteristics for Ru(bpy)<sub>3</sub> doped in dilute single-crystals and polymer hosts have been measured in the temperature range 1.5 to 77 K using 1 ms square-pulse excitation from an acousto-optically modulated Ar<sup>PLU</sup> laser. Previously observed deviations from single-exponential decay behavior in experiments using higher-power, short (3 ns) pulse excitation, are shown to be mainly due to sample heating effects. The temperature dependence of the decay times is

consistent with luminescence from three states of equal degeneracy, separated by (8±0.5) and (60±5) cm<sup>-1</sup> respectively. (Author abstract). 22 Refs.

Krausz, Elmar (Australian Natl Univ, Canberra, Aust); Moran, Grainne. *J Lumin* v 42 n 1 Jun-Jul 1988 p 21-27.

## Structure

**092431 ON THE TOPOLOGIES OF (M<sub>13</sub>)<sub>13</sub> SUPERCLUSTERS OF RUTHENIUM, RHODIUM AND GOLD.** A mechanism is proposed for the building of (M<sub>13</sub>)<sub>13</sub> superclusters and their transition to the normal structure, which has been observed experimentally by G. Schmid and N. Klein for M=Rh, Ru and Au. The cluster energies are determined for this purpose as a topologically approximated sum of pair potentials. A discussion is presented of two simple criteria for estimating the most stable cluster for a given number N of atoms: (i) the maximum A<sub>max</sub> of the total adjacency and (ii) the minimum W<sub>min</sub> of the Wiener index. (Edited author abstract). 10 Refs.

Fritsche, H.G. (Freidrich-Schiller-Univ, Jena, East Ger); Bonchev, D.; Mekenyan, O. *J Less Common Met* v 141 n 1 Jul 1988 p 137-143.

**Surface Properties** See ALKALI METAL COMPOUNDS—Adsorption.

## Surfaces

**092432 INTERACTION OF ALUMINUM WITH THE Ru(0001) SURFACE AND ITS INFLUENCE UPON CO CHEMISORPTION.** The interaction of vapor-deposited Al with Ru(0001) surface and its influence upon CO chemisorption has been studied in ultrahigh vacuum by use of Auger electron spectroscopy, thermal desorption mass spectroscopy, and low-energy electron diffraction (LEED). Below 670 K, the Al grows as an overlayer in (111) oriented islands. By 1170 K, Al penetrates the surface to form intermetallic compounds with the Ru, and a (√3 × √3)R30° LEED pattern dominates the surface structure. A new CO desorption state at 850-1050 K appears at submonolayer Al coverages, which is attributed to strong, direct, interaction between adsorbed CO and Al probably involving C-O bond cleavage. (Edited author abstract) 25 refs.

Campbell, Charles T. (Indiana Univ, Bloomington, IN, USA); Goodman, D.W. *J Phys Chem* v 92 n 9 May 5 1988 p 2569-2573.

## Thin Films

**092433 PHOTODEPOSITION OF Ru ON InP AND GaInPAs. CATALYTIC AND ELECTRONIC PROPERTIES.** The authors restrict this investigation to Ru/InP and Ru/GaInPAs contacts. The large grain polycrystalline quaternary semiconductor has been chosen because of differences in surface chemistry. Experimental data show that the typical current enhancement upon metallization is found. The increase in catalytic activity is larger for InP. A somewhat lower overall photoactivity is noted for GaInPAs. 36 refs.

Lewerenz, H.J. (Hahn-Meitner-Inst Berlin, Berlin, West Ger); Michaelis, R. *J Electrochem Soc* v 135 n 4 Apr 1988 p 913-916.

**RUTHENIUM COMPOUNDS** See Also CATHODES—Materials; COBALT COMPOUNDS—Processing; ORGANIC COMPOUNDS—Synthesis; POLYELECTROLYTES.

**092434 CONSTITUTION OF THE Mo-Ru SYSTEM.** The constitution of the Mo-Ru system was reinvestigated between 900 and 2000°C using metallography, X-ray diffraction, X-ray microanalysis, differential thermal analysis and dilatometry. The system is of the eutectic type with a eutectic temperature of 1955°C and a eutectic composition of about 42 at.% ruthenium. The maximum solubility of ruthenium in molybdenum is 32.4 at.%



ruthenium and of molybdenum in ruthenium is 51.5 at.% molybdenum at 1935°C. The only intermediate phase,  $\text{Mo}_2\text{Ru}_3$ , present between 36.7 and 39.4 at.% ruthenium is formed by a peritectoid reaction at 1915°C and is decomposed by a eutectoid reaction at 1143°C. The lattice parameters and the c/a ratio of the hexagonal ruthenium (molybdenum) solid solution increase with increasing molybdenum content. (Edited author abstract) 6 refs.

Kleykamp, H. (Kernforschungszentrum Karlsruhe, Karlsruhe, West Ger). *J Less Common Met* v 136 n 2 Jan 1988 p 271-275.

**092435 LUMINESCENT CHARGE-TRANSFER STATE OF RUTHENIUM-BIPYRAZINE COMPLEXES.** Using laser flash photolysis, excited-state absorption measurements on  $\text{Ru}(\text{bpy})_3^{2+}$  and  $[\text{Ru}(\text{bpy})_2(\text{bpz})]^{2+}$  were carried out in methanol (bpy is bipyridine; bpz is bipyrazine). Pulse radiolysis was used to produce spectra of one-electron-reduced forms of bpz which were compared with the excited-state spectra found in the laser flash photolysis experiments. A strong indication of the localization of the electron on one bpz ligand was observed, thus confirming a lower  $\pi^*$  level in bpz compared to the case of bpy. Decay rate constants and  $\text{O}_2$  quenching rate constants are also reported in water, methanol, and acetonitrile. This work is pertinent to solar energy conversion. (Edited author abstract) 52 refs.

Barqawi, K.R. (Yarmouk Univ, Irbid, Jordan); Akasheh, T.S.; Beaumont, P.C.; Parsons, B.J.; Phillips, G.O. *J Phys Chem* v 92 n 2 Jan 28 1988 p 291-294.

**092436 EFFECT OF  $\text{RuO}_2$  ON THE BEHAVIOR OF SILVER AT THICK-FILM TERMINATIONS.** In an attempt to understand the silver-glass interactions at the electrode/resistor terminations in hybrid integrated circuits, the behavior of silver in binary  $75\text{PbO}-25\text{SiO}_2$  glass containing up to 20 wt.%  $\text{RuO}_2$  particles was studied between 650 and 850°C. It is shown that the dissolution of silver into glass increases with increasing amount of  $\text{RuO}_2$  particles. A different temperature dependence of dissolution was observed for  $\text{RuO}_2$ -free and  $\text{RuO}_2$ -doped glasses. Silver-ion- $\text{RuO}_2$  interactions have been proposed as a possible mechanism responsible for the increased dissolution of silver in glass. 6 refs.

Yamaguchi, Takashi (Keio Univ, Yokohama, Jpn); Kageyama, Makiko. *IEEE Trans Compon Hybrids Manuf Technol* v 11 n 1 Mar 1988, Chicago, IL, USA, Sep 21-23 1987 p 134-136.

## Chemical Reactions

**092437 INTERACTION OF  $\text{TRIS}(2,2\text{'-BIPYRAZINE})\text{RUTHENIUM}(2+)$  ION WITH RADIOLYTICALLY-GENERATED RADICALS IN AQUEOUS SOLUTION. REACTIVITY OF  $\text{Ru}(\text{bpz})_3^{2+}$  TOWARD ELECTRON RELAYS.** In this study, the authors have used the techniques of pulse and continuous radiolysis to examine the reactions of the primary radiolytic products, OH and H, with  $\text{Ru}(\text{bpz})_3^{2+}$ ; an attempt to oxidize  $\text{Ru}(\text{bpz})_3^{2+}$  with  $\text{Cl}_2^-$  was unsuccessful. We have also examined the reaction of  $\text{Ru}(\text{bpz})_3^{2+}$  with  $\text{Co}(\text{sep})^{3+}$  (sep=sepulchrate=1, 3, 6, 8, 10, 13, 16, 19-octazabicyclo[6.6.6]icosane) and  $\text{Cr}(\text{bpy})_3^{3+}$ , electron relays that have been employed in photochemical model systems. 39 refs.

Mulazzani, Quinto G. (CNR, Bologna, Italy); Venturi, Margherita; Hoffman, Morton Z. *Radiat Phys Chem* v 32 n 1 1988 p 71-78.

**092438 FORMATION RATE AND GAS-LIQUID EQUILIBRIUM OF  $\text{RuO}_4$ .** The formation rate of ruthenium tetroxide ( $\text{RuO}_4$ ) from nitrosyl ruthenium trinitrate ( $\text{RuNO}(\text{NO}_3)_3$ ) was measured at temperatures of 70-115°C in 3-9 mol. $\text{dm}^{-3}$  nitric acid solutions. The gas-liquid equilibrium ratio was measured at temperatures at 40-80°C in 0.1-9 mol. $\text{dm}^{-3}$  nitric acid solutions. The gas-liquid equilibrium ratio of  $\text{RuO}_4$  ranged about 60-260 under the experimental conditions. The reaction rate increased greatly with acid concentrations above 6 mol. $\text{dm}^{-3}$ . The activation energy of the reaction was about

130 kJ. $\text{mol}^{-1}$  in 9 mol. $\text{dm}^{-3}$  nitric acid solution. It was concluded that the rate of  $\text{RuO}_4$  formation dominated the distill-out phenomena of Ru in an evaporator as used in nuclear fuel reprocessing plants. (Author abstract) 16 Refs.

Sasahira, Akira (Hitachi Ltd, Hitachi, Jpn); Kawamura, Fumio. *J Nucl Sci Technol* v 25 n 5 May 1988 p 472-478.

Concentration See HYDROGEN—Production.

## Electric Conductivity

**092439 ELECTRICAL PROPERTIES OF  $\text{A}_2[\text{Ru}_{2-x}\text{A}_x]\text{O}_{7-y}$  (A = Pb OR Bi) PYROCHLORES AS A FUNCTION OF COMPOSITION AND TEMPERATURE.** The variable stoichiometry pyrochlore compounds exhibit high electrical conductivity with room temperature values ranging from 10 to 1000 ( $\text{ohm}\cdot\text{cm}$ ) $^{-1}$ , dependent upon composition. For the lead-containing series, resistivity vs temperature data show that there is a smooth variation from a positive to a negative temperature coefficient of resistivity (TCR) as a function of increasing lead content. Substitution of approximately 20% of the ruthenium by lead results in a material with essentially temperature-independent resistivity. (Edited author abstract) 21 refs.

Beyerlein, R.A. (Exxon Research & Engineering Co, Annandale, NJ, USA); Horowitz, H.S.; Longo, J.M. *J Solid State Chem* v 72 n 1 Jan 1988 p 2-13.

## Electric Properties

**092440 ELECTROPHYSICAL PROPERTIES OF COMPOSITES BASED ON SOME RUTHENIUM COMPOUNDS.** The authors investigated resistivity at normal temperature and the temperature dependence of resistivity of  $\text{RuO}_2$  and  $\text{Bi}_2\text{Ru}_2\text{O}_7$  containing admixtures able to change the electrical properties (e.g., Cu, Ti, Mn, Fe with mass content not exceeding 10-2-10-3%). An analysis of the experimental data permits the conclusion that thick film resistive elements with resistivity of less than 5  $\Omega/\text{sq}$ . formed on ceramic VK 94-1 cannot be obtained from powdered  $\text{Bi}_2\text{Ru}_2\text{O}_7$  with specific surface of 10,000-12,000  $\text{cm}^2/\text{g}$ . Resistive elements with a resistance on the order of single ohms per square can be made on the basis of powdered  $\text{RuO}_2$ , but the problem of compensating the high positive temperature coefficient of electrical resistance arises. 9 refs.

Smolin, M.D. (Acad of Sciences of the Ukrainian SSR, USSR); Fedorov, V.N.; Grebenkina, V.G. *Sov Powder Metall Met Ceram* v 26 n 9 Sep 1987 p 733-735.

## Electrochemistry

**092441 ELECTRICAL DOUBLE LAYER ON OXIDES: SPECIFIC ADSORPTION OF CHLORIDE AND METHYLVIOLGEN ON RUTHENIUM DIOXIDE.** The main purpose of this study is to gain insight into the electrochemical properties of the  $\text{RuO}_2$ -electrolyte interface and the interaction between  $\text{RuO}_2$  and  $\text{MV}^{2+}$  ions. It is demonstrated how quantitative data on specific adsorption can be obtained from  $\sigma_0$  and  $\zeta$ -potential measurements without introducing an inner-layer model, like the ones based on surface complexation or site binding. Our analysis is based on purely thermodynamic arguments combined with diffuse double-layer theory, and therefore has a general validity. In addition, we hope to contribute to the discussion about the common features of the double layer on oxide. 33 refs.

Kleijn, J.M. (Agricultural Univ, Wageningen, Neth); Lyklema, J. *J Colloid Interface Sci* v 120 n 2 Dec 1987 p 511-522.

## Forming

**092442 COMPLEXES OF  $\text{Ru(III)}$  WITH AMINOPOLYCARBOXYLIC ACIDS AND THEIR INTERACTION WITH MOLECULAR OXYGEN TO FORM  $\text{Ru(IV)}-\mu\text{-PEROXO}$  COMPLEXES.** The interaction of  $\text{Ru(III)}$  with IMDA, HEDTA, EDTA, PDTA,

CDTA and DTPA was studied by potentiometric and spectrophotometric methods at 25°C and 0.10 M ionic strength. Experiments were carried out under nitrogen and oxygen atmospheres. Evidence for the formation of dioxygen complexes in these systems is presented. Stability constants for the different species existing in each of the systems were calculated using a computer program. (Edited author abstract) 18 refs.

Taqi Khan, M.M. (Central Salt & Marine Chemicals Research Inst, Bhavnagar, India); Hussain, Amjad; Venkatasubramanian, K.; Ramachandrabhaiah, G.; Oomen, V. *J Mol Catal* v 44 n 1 Feb 15 1988 p 117-127.

## Ion Implantation

**092443 DSA  $\text{RuO}_2/\text{TiO}_2$  ELECTRODE MODELED BY ION IMPLANTATION: AN IN SITU CHARACTERIZATION BY PHOTOACOUSTIC AND PHOTOCURRENT SPECTROSCOPY.** Ion implantation of ruthenium into titanium was used to produce near-surface alloys of controllable surface composition. The thin oxide layer that was formed in situ at the surface of the implanted alloy was taken as a model for  $\text{Ru}_x\text{Ti}_{1-x}\text{O}_2$  (DSA) electrodes. The time dependence of the surface ruthenium/titanium ratio in the mixed oxide was correlated to the original implant profile, measured by Rutherford backscattering, with the assumption of no preferential dissolution. The experimental results are interpreted in terms of a transition from a semiconducting layer to a metallic-like layer when the ruthenium/titanium ratio reaches a value of about 0.10. (Edited author abstract) 56 refs.

Vallet, C.E. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); Borns, S.E.; Hendrickson, J.S.; White, C.W. *J Electrochem Soc* v 135 n 2 Feb 1988 p 387-395.

## Magnetic Properties

**092444 PHYSICAL PROPERTIES OF METAL CLUSTER COMPOUNDS V: MAGNETIC MEASUREMENTS ON LOW-NUCLEARITY (RUTHENIUM CARBONYL CLUSTERS).** We present magnetic susceptibility and magnetization measurements on a series of low-nuclearity ( $n=6$ ) ruthenium carbonyl clusters. It is shown that even these very small metal cluster have a fraction of unpaired spin density leading to a low-temperature divergent susceptibility and a magnetization that is far from saturated in fields up to 5 tesla. The effect of CO adsorption on the magnetic properties of a bare cluster is discussed. (Author abstract) 18 refs.

de Aguiar, J. Albino O. (Fijksuniv te Leiden, Leiden, Neth); Mees, A.; Darriet, J.; de Jong, L.J.; Drake, S.R.; Edwards, P.P.; Johnson, B.F.G.; Lewis, J. *Solid State Commun* v 66 n 9 Jun 1988 p 913-916.

Microstructure See SEMICONDUCTING SILICON COMPOUNDS—Diffusion.

## Optical Properties

**092445 OPTICAL PROPERTIES OF  $\text{RuO}_2$  THIN FILM.** In this letter authors report the first transmission spectra of  $\text{RuO}_2$  thin film and our assigned optical transitions are compared with those of the theoretical works Mattheiss. In summary, the first transmission spectra of  $\text{RuO}_2$  thin film were obtained and P-d and d-d transitions were assigned which showed good agreement with the theoretical calculations of Mattheiss. 18 refs.

Park, H.L. (Yonsei Univ, Seoul, South Korea); Chung, C.H.; Kim, C.H.; Kim, H.S. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1093-1094.

Phase Equilibria See RESISTORS—Thick Films.

## Reduction

**092446 COMPARATIVE STUDY OF ELECTROCHEMICAL REDUCTION OF RUTHENIUM COMPLEXES.** It was found that a complex with a binuclear structure which differs from the specially synthesized



complex  $K_3[Ru_2N(H_2O)_2Cl_8]$  with respect to the structure of the internal sphere is formed in an electrolyte. Hydrolysis and activation of the starting form of the complex, accelerated due to the necessity of conducting electrolysis at 70°C, is the cause of the instability of the electrolyte prepared from the binuclear complex  $K_3[Ru_2N(H_2O)_2Cl_8]$ . Electrolyte (I), in which equilibrium is rapidly established and the state of the ruthenium ions does not subsequently change, is preferred for prolonged electrolysis with stable characteristics of the cathode process. 13 refs.

Beletskii, V.M. (Acad of Sciences of the Ukrainian SSR, USSR); Nechaeva, N.E.; Khar'kova, L.B.; Sosnovskaya, G.N. *J Appl Chem USSR* v 60 n 4 pt 1 Apr 1987 p 724-728.

## Spectroscopic Analysis

**092447 ENERGY TRANSFER AND HIGHLY RESOLVED EMISSION OF  $[Ru_{1-x}Os_x(bpy)_3](PF_6)_2$ .** The emission properties of the title compound are investigated at  $T = 2$  K and high magnetic fields. The radiationless energy transfer from the [Ru]-host to the [Os]-guest is governed by a fast process and a slow one, which indicates a relatively ineffective transfer in the host material. Moreover, the guest emission is found to be highly resolved and is assigned to result from a superposition of vibronic components emitted from three different sites. (Author abstract) 8 refs.

Yersin, Hartmut (Univ Regensburg, Regensburg, West Ger); Hensler, Gerold; Gallhuber, Erich. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 676-677.

**Structure** See ORGANOMETALLICS—Structure.

**Surfaces** See HYDROGEN—Adsorption.

## Synthesis

**092448 SYNTHESIS, OXYGENATION AND CATALYTIC PROPERTIES OF RUTHENIUM(III) SALOPH COMPLEXES.** Synthesis and dioxygen affinities of ruthenium(III)-Schiff base complexes with various appended axial base ligands are reported. A mechanism is proposed for the conversion of cyclohexene to the epoxide, and a subsequent rate law derived with the help of which were determined the values of the rate and equilibrium constants. (Edited author abstract) 19 refs.

Taqvi Khan, M.M. (Central Salt & Marine Chemicals Research Inst, Bhavnagar, India); Mirza, Shaikat A.; Prakash Rao, A.; Sreelatha, C. *J Mol Catal* v 44 n 1 Feb 15 1988, Int Workshop on Homogen Catal: Act of Mol Oxygen and Catal Oxid by Dioxygen Compd, Bhavnagar, India, Oct 3-6 1986 p 107-115.

**Thin Films** See Also ANODES—Materials.

**092449 INFRARED AND X-RAY PHOTOELECTRON SPECTRA OF RUTHENIUM OXIDE FILMS AND RUTHENIUM HYDROXIDE.** The IR and x-ray photoelectron spectra of ruthenium hydroxide and of ruthenium oxide films produced by ruthenium chloride hydroxide decomposition at 300, 400, 500, and 600°C were examined in order to obtain information concerning the effect of hydration on the structure and electronic properties of the surface of ruthenium oxide (RO) electrodes. It was shown that Ru hydroxide and RO films contain, both water molecules and hydroxyl groups; the latter are retained up to higher temperatures (600°C) in the RO films than in Ru hydroxide. It was found that water makes the materials studied amorphous, and it also was found that hydration influences their electronic structure (valence band and the electronic core levels of Ru and O). (Author abstract) 33 refs.

Belova, I.D. (L.Ya. Karpov Physicochemical Scientific-Research Inst, Moscow, USSR); Shifrina, R.R.; Roginskaya, Yu.E.; Popov, A.V.; Varlamova, T.V. *Sov Electrochem* v 23 n 9 Sep 1987 p 1138-1144.

## RUTHENIUM IRON BORON ALLOYS

### Amorphous

**092450 MAGNETISM IN AMORPHOUS  $Ru_xFe_{80-x}B_{20}$  ALLOYS: MAGNETIZATION AND MOSSBAUER STUDY.** Amorphous alloys of  $Ru_xFe_{80-x}B_{20}$ ,  $0 \leq x \leq 22$  have been investigated using low field ac susceptibility, dc magnetization and  $^{57}Fe$  Mossbauer spectroscopy. The magnetic phase diagram of  $Ru_xFe_{80-x}B_{20}$  is confirmed. Mossbauer measurements reveal a low temperature transition in  $Ru_{18}Fe_{62}B_{20}$  magnetization measurements indicate a noncollinear magnetic structure. The effect of substitution of Ru on distribution in exchange is discussed. (Author abstract) 13 refs.

Paulose, P.L. (Tata Inst of Fundamental Research, Bombay, India); Nagarajan, V.; Nagarajan, R.; Vijayaraghavan, R. *Solid State Commun* v 61 n 3 Jan 1987 p 151-155.

### Electric Conductivity

**092451 ELECTRICAL RESISTIVITY OF AMORPHOUS  $Ru_xFe_{80-x}B_{20}$  ALLOYS.** Amorphous  $Ru_xFe_{80-x}B_{20}$ ,  $0 < x < 22$  shows interesting changes in magnetic behavior with Ru concentration and temperature. In the course of our study of these alloys using a variety of techniques we have undertaken electrical resistivity measurements which probe the zero field ( $H=0$ ) state. For  $Ru_{18}Fe_{62}B_{20}$ , the electrical resistivity,  $\rho$ , as a function of temperature has a minimum around 106 K. In magnetic fields up to 1.8 Tesla the change in the  $\rho$  of  $Ru_{20}Fe_{60}B_{20}$  is small and within experimental errors. (Edited author abstract) 1 refs.

Paulose, P.L. (Tata Inst of Fundamental Research, Bombay, India); Nagarajan, V.; Vijayaraghavan, R. *Key Eng Mater* v 13 pt 2 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 543.

## RUTHENIUM VANADIUM ALLOYS

### Phase Diagrams

**092452 RUTHENIUM-VANADIUM SYSTEM.** There are disparities in the reports of the compositions associated with Ru-rich solvus and the V-rich solvus. There is uncertainty as to the phase relationship between CsCl structure and the bcc V-rich terminal solution and there is a question whether or not a tetragonal phase that has been observed at lower temperatures in the central portion of the system is an equilibrium feature of the system. The discussion indicates the source of these uncertainties and reviews the currently available data. 15 refs.

Smith, J.F. (Iowa State Univ, Ames, IA, USA). *J Alloy Phase Diagrams* v 3 n 3 Sep 1987 p 133-138.

## S

## SAFETY VALVES See Also VALVES AND VALVE GEAR.

**092453 CALCULATING DISCHARGE OF GAS OR STEAM THROUGH SAFETY-VALVES.** The author presents a formula for calculating the flow-rate of gas or steam through a safety-valve. Solving the formula by conventional methods is somewhat time-consuming, so he has formulated a nomogram which allows the problem to be considerably simplified and to be solved with the aid of a ruler. SI (metric) units are used in the calculations, but the system is equally valid for English units, for which a corresponding formula and nomograph are also included.

Zanker, Adam. *World Pumps* Oct 1987 p 327-328.

**092454 VENT HEIGHTS FOR EMERGENCY RELEASE OF HEAVY GASES.** The safe disposal of releases to atmosphere via safety relief valves and Emer-

gency Relief Systems (ERS) requires adequate vent heights to produce tolerable concentrations of contaminants. Such releases occur generally upon pressure relief; they may be from liquified or, simply, gaseous systems. This paper describes a method developed to estimate vent heights for emergency releases of heavy gases to prevent flammability at exposed locations. 34 refs.

Bodurtha, Frank T. Jr. (Frank T. Bodurtha Inc, Newark, DE, USA). *Plant Oper Prog* v 7 n 2 Apr 1988 p 122-126.

## Design

**092455 EFFECT OF THE RATE OF SEAL MOVEMENT IN THE POWER CHARACTERISTICS OF THE SAFETY VALVE.** To develop a reliable method of designing the safety valve, a study of the effect of the rate of seal movement on its power characteristics was made. Experiments were carried out in a safety valve model of  $D_u = 50$  mm. The model consists of a body with inlet and outlet nipples, and a seat on which the seal is pressed down by spring. The seal is fixed on a mobile stem. A special system was devised to record the locational coordinates of the seal relative to the seat and the rate of its displacement during the functioning of the valve. Using the derived dependence  $h(t)$ ,  $d^2h/dt^2$  was calculated by the numerical method. The calculations were made in a uniform grid in the high-accuracy nodes using the simplest (single member) equations and improved by the Runge-Romberg method. The results of  $f(h)$  calculations obtained by the method described above are given. It is shown that no significant differences of  $f(h)$  were noticed within the range of experimental errors ( $\pm 10\%$ ) at seal displacement rates  $h \leq 1$  m/sec. 5 refs.

Borzov, B.A.; Kozlov, V.M.; Kuznetsov, O.V. *Chem Pet Eng* v 22 n 7-8 Jul-Aug 1986 p 313-315.

**092456 RESISTANCE TO GAS/VAPOR-LIQUID FLOW IN SAFETY VALVES.** As a result of systematic statistical investigations of the reliability and general validity of expressions for calculation of the resistance to the flow of mixtures of air and water through full-stroke safety valves, the semiempirical check-valve equations of D. Chisholm with a coefficient of  $B=1.5$ , and P.E. Tremblay, stand out as the most accurate. They are also to be preferred for design calculations for other two-phase flows, since reliable knowledge does not exist for these. (Edited author abstract). 30 Refs.

Friedel, L. (Hoechst AG, Frankfurt, West Ger). *Int Chem Eng* v 28 n 3 Jul 1988 p 406-423.

## Noise Abatement

**092457 REVIEW OF THE DEVELOPMENT OF SAFETY AND RELIEF VALVE SILENCERS FOR STEAM DISCHARGE.** The paper outlines the progress made by the Central Electricity Generating Board (CEGB) in the development of silencers for the control of boiler safety valve and relief valve noise. System noise sources and the formulation of environmental noise criteria are discussed; the silencer design philosophy adopted by the CEGB is described and the progressive improvements are charted to demonstrate the advances made over earlier practices. The results of this work are design concepts which provide silencers which are suitable for application to any of the CEGB's steam valve vent systems and are capable of meeting stringent neighborhood noise criteria. (Author abstract) 7 refs.

Crawford, C.J. (CEGB, Barnwood, Engl). *Proc Inst Mech Eng Part A* v 202 n A2 1988 p 89-96.

## Pressure Control

**092458 DETERMINING THE CRITICAL PRESSURE RATIO IN THE FLOW SECTION OF A SAFETY VALVE.** When new types of safety fittings are developed and improvements made to existing ones, the main problems which arise are the optimization of the throughput capacity of the safety device and the development of effective methods of controlling such operating parameters as operating cycle pressure (pressure of com-



plete opening and closing), length of operating cycle, speed with which shut-off device moves into position. An analysis carried out showed that the parameters are determined by two integral characteristics - flowrate and force characteristics, which are taken here to mean the dependence of the flowrate of the working medium and the force on the slide valve from the flow side on the lift of the slide valve. 3 refs.

Borзов, B.A.; Kozlov, V.M. *Sov Energy Technol* n 7 1987 p 39-42.

## Reliability

**092459 QUALITY AND RELIABILITY OF SAFETY RELIEF VALVES.** The leading particulars of safety relief valve testing facilities, judged by the ISPESL Italian Control Authorities as being suitable and reliable, were singled out. These facilities enabled a whole cycle of experimental tests to be conducted in free blowdown and variable back pressure conditions, which led to the evaluation of the leading performance characteristics of a new series of safety relief valves in accordance with real working conditions. The protective function of these devices justifies the interest in any possible further improvement of their performance, quality and reliability.

Filidoro, R. (Nuovo Pignone, Florence, Italy); Mummolo, G. *Pipe Line Ind* v 67 n 6 Dec 1987 p 27-29.

**Wear** See PIPELINES—Computer Simulation.

**SAILING VESSELS** See Also AERODYNAMICS—Wings and Airfoils; YACHTS—Design; YACHTS—Resistance.

**092460 JAPANESE ADVANCES IN TRANSPORT TECHNOLOGY.** Modern sail-assisted ships are designed to make use of natural wind power in order to improve fuel consumption. More than seven years ago, September 1980, the world's first sail-assisted commercial ship, the 699 G/T tanker Shin-Aitoku Maru, was completed. This fuel-efficient vessel was notable in that sail control was totally automated, requiring no extra crew. This article reviews the sail-assisted concept, and select design features of vessels that employ them.

Hamada, Noboru (Japan Marine Machinery Development Assoc). *Sea Technol* v 29 n 2 Feb 1988 p 25-29.

**Accident Prevention** See YACHTS—Accident Prevention.

## Aerodynamics

**092461 SIMPLE MULTILAYER PANEL METHOD FOR PARTIALLY SEPARATED FLOWS AROUND TWO-DIMENSIONAL MASTS AND SAILS.** A new multilayer panel method has been developed using superimposed combinations of vortex doublet and source/sink elements to predict the static pressure distributions found over two-dimensional mast/sail geometries. The method takes into account all the partially separated regions present, and all the computations are performed without any need for iteration. The only inputs required are: mast/sail geometry, aerodynamic incidence angle, freestream Reynolds number, and empirically determined separation and reattachment locations. All of the base pressures involved are obtained as part of the solution. Comparison between experimental and theoretical results showed excellent agreement. (Author abstract). 1 Ref.

Wilkinson, Stuart (Univ of South Florida, Tampa, FL, USA). *AIAA J* v 26 n 4 Apr 1988 p 394-395.

## Design

**092462 TECHNOLOGY AND DESIGN FOR STARS & STRIPES.** The February 4, 1987 victory of STARS & STRIPES in the America's Cup races off Perth, Western Australia, was a culmination of a three-year project of broad scope and great intensity. The design/technology team approach used to develop the 12-meter yacht STARS & STRIPES is presented. The effort

includes three separate yacht-design firms, advanced computational tools, forty 1/3 scale model tests, and a very sophisticated full-scale yacht evaluation procedure. The total performance evaluation system, which integrates the myriad details of yacht designs and race tactics within the flow-code results into a single figure of merit, the relative speed of 12-meter yachts around the race course, is discussed. (Edited author abstract) 5 refs.

Salvesen, Nils (Science Applications Int Corp, Annapolis, MD, USA); Fritts, Martin; Meinhold, Michael. *Finite Elem Anal Des* v 4 n 1 Jun 1988 p 79-82.

**092463 KANKO MARU.** The newly built Kanko Maru, completed for the Nagasaki Holland Village Association of Japan, is a replica of the steamer Soembing, built in 1853 and presented to the Shogun of Japan in 1855 by King William II of Orange. This article reviews select design features of the vessel.

Anon. *HSB International* v 36 n 12 1988 5p.

**092464 ANCIENT INTERFACE XVII: PROCEEDINGS OF THE SEVENTEENTH AIAA SYMPOSIUM ON THE AERO/HYDRONAUTICS ON SAILING.** The proceedings contains ten papers. The main topics were computational fluid dynamics, sailing vessel design, keelless twin wing yacht design, flow about windsurfing sails, and racing yacht design. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11563 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Feiereisen, William (Ed.) (AIAA, San Francisco Section, CA, USA). *AIAA Monogr* v 34, Anc Interface XVII: Proc of the Seventeenth AIAA Symp on the Aero/Hydro-naut on Sail, Stanford, CA, USA, Oct 31 - Nov 1 1987. Publ by Western Periodicals Co, Northern Hollywood, CA, USA, 1987 120p.

## Masts

**092465 WELDED MASTS MEAN SMOOTH SAILING AHEAD.** The article briefly outlines a GTA welding process for aluminum masts for sailing boats. The setup was designed to handle a variety of unique situations. The mast is clamped together for welding, but since the V-groove is cut with a circular saw, there can be variations in fitup, requiring torch adjustments. To compensate for distortion, the mast is pre-bent in the opposite direction of the weld.

Anon (Miller Electric Manufacturing Co, Appleton, WI, USA). *Weld J (Miami Fla)* v 67 n 1 Jan 1988 p 47-48.

## Materials

**092466 MAKING ALUMINUM SAILBOAT SPARS - THE AUTOMATED WAY.** Masts of sailing vessels contain, within their hollow centers, pulleys, ropes, cables, and electrical wiring for the radio and lighting system. The aluminum mast is a long extrusion with a tapered upper end and fittings attached at its sides. The article describes the operations of a mast manufacturer that uses plasma cutting and welding and computer aided manufacturing for its anodized aluminum masts.

Cassidy, Victor M. (Modern Metals, Chicago, IL, USA). *Mod Met* v 43 n 10 Nov 1987 p 50-53.

## Reviews

**092467 WIND STAR BRINGS A BREATH OF FRESH AIR TO CRUISING.** This article reports on the revolutionary concepts incorporated in the newest computer-controlled sailing ship to enter service. Wind Star leads a quartet of mini cruise liners aimed at the de luxe market. The computer-controlled sail system is discussed, and a design review of the craft is presented.

Payne, Stephen. *Nav Archit* Feb 1987 p 77-78.

**Stability** See HYDROFOILS—Stability.

**SALT DEPOSITS** See RADIOACTIVE WASTES—Geological Repositories; PETROLEUM GEOLOGY—Technics; RADIOACTIVE WASTES—Disposal.

## SALT MINES AND MINING

### England

**092468 TUNNELLING IN SALT: A MAJOR DEVELOPMENT PROJECT AT THE WINSFORD SALT MINE.** Winsford salt mine in Cheshire currently supplies some 80% of Britain's rock salt requirements for de-icing roads. This year the mine operators, ICI Mond Division, plan to produce 2.25 Mt rock salt, up from 1.85 Mt in 1986, in response to a growing demand from local authorities throughout the country. To meet this target, the company contracted out a major development project to extend underground room and pillar workings to the north east of reserves.

Anon. *Mine Quarry* v 16 n 10 Oct 1987 p 9-10.

**Gas Bursts** See COAL MINES AND MINING—Gas Bursts.

**Rock Mechanics** See MINES AND MINING—Rock Mechanics.

**Waste Disposal** See BOREHOLES—Diamond Drilling.

**SALTS** See Also ALCOHOLS—Solubility; CATALYSIS; COMPRESSED AIR—Energy Storage; CRYSTALLIZATION—Magnetic Field Effects; ELECTROLYTES—Composition Effects; ENERGY STORAGE; IONS—Reduction; METALS AND ALLOYS—Corrosion; ORGANIC COMPOUNDS—Electric Properties; ORGANIC COMPOUNDS—Reaction Kinetics; ORGANIC COMPOUNDS—Synthesis; PAVEMENTS—Concrete; PHYSICS—Solid State; POLYAMIDES—Crazing; POLYMERS—Electric Conductivity; POLYURETHANES—Structure; ROADS AND STREETS—Snow and Ice Control; SOLAR RADIATION—Collectors; STEEL HEAT TREATMENT—Boriding; SURFACE ACTIVE AGENTS; THERMAL DIFFUSION—Measurements.

**092469 ELECTROACTIVE LANGMUIR-BLODGETT FILMS OF N-OCTADECYLPYRIDINIUM-TCNQ CHARGE-TRANSFER SALT.** Langmuir-Blodgett films of the 1:1 charge-transfer salt N-octadecylpyridinium-TCNQ have been deposited onto glass substrates. The layers exhibit significant bulk lateral conductivity without doping. The value obtained at room temperature is  $(2.0 \pm 0.2) \times 10^{-2} \text{ S cm}^{-1}$ ; over the temperature range 100 - 300 K, the films show typical semiconductor behaviour with an activation energy of  $0.13 \pm 0.005 \text{ eV}$ . Infrared and u.v.-visible transmission spectra of the films are characteristic of an organic conductor. (Author abstract) 9 refs.

Dhindsa, A.S. (Univ of Durham, Durham, Engl); Bryce, M.R.; Lloyd, J.P.; Petty, M.C. *Synth Met* v 22 n 2 Dec 1987 p 185-189.

**092470 POLYMORPHISM IN DIALKYLAMMONIUM CHLORIDES. AN ADIABATIC CALORIMETRY STUDY.** The heat capacities of four di-n-alkylammonium chlorides (di-n-pentylammonium chloride, di-n-hexylammonium chloride, di-n-octylammonium chloride, and di-n-decylammonium chloride) were measured from T=25 K to 350 K using adiabatic calorimetry. All of the compounds investigated were observed to undergo solid-solid phase transitions in the temperature region examined. The thermodynamic properties obtained for these compounds were compared with those of the layered perovskites (alkylammonium metal halides) and the mono-n-alkylammonium chlorides. 45 refs.

Van Oort, Michiel J.M. (Dalhousie Univ, Halifax, NS, Can); White, Mary Anne. *Ber Bunsenges Phys Chem* v 92 n 2 Feb 1988 p 168-176.



**092471 SALT HYDRATES USED FOR LATENT HEAT STORAGE: CORROSION OF METALS AND RELIABILITY OF THERMAL PERFORMANCE.** Data are presented on the corrosion resistance of metallic alloys to hydrated salts, which may be utilized as phase change materials (PCM) for heat storage. With the same experimental apparatus, tests on the thermal performance reliability of PCM after repeated thermal cycling were carried out. Commercially available latent heat storage components containing the following salt hydrates with melting points between 15°C and 32°C have been considered:  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ ,  $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$ ,  $\text{Na}_2\text{SO}_4 \cdot 1/2\text{NaCl} \cdot 10\text{H}_2\text{O}$ ,  $\text{NaOH} \cdot 3.5\text{H}_2\text{O}$ . The containment materials tested were stainless steel, carbon steel, Al alloys, and Cu. As many as 5650 thermal cycles involving repeated melting and freezing of the phase change materials were carried out. The most corrosion-resistant alloy to all the hydrated salts tested was stainless steel. Only the two commercial  $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$  tested showed good thermal stability after repeated thermal cycling. (Author abstract). 10 Refs.

Porisini, Frenadad Coen (Commission of the European Communities, Ispra, Italy). *Sol Energy* v 41 n 2 1988 p 193-197.

**Adhesion** See ALKALI METAL COMPOUNDS—Research.

**Adsorption** See Also WATER TREATMENT—Ion Exchange.

**092472 INTERFACIAL BEHAVIOR OF TETRAALKYLAMMONIUM IONS AT THE Hg ELECTRODE IN GLYCOLS.** The adsorption behavior of tetramethyl-, tetraethyl-, and tetrabutylammonium cations on Hg from glycol solutions has been investigated by capacitance measurements both in the presence and absence of a supporting electrolyte. The surface activity is governed by both electrostatic and lyophobic factors. The former are important for small negative charges and low ionic strengths. Lyophobic factors become progressively predominant as the ionic size increases. A preliminary comparison has been made of tetraalkylammonium ions in ethylene glycol, 1,2- and 1,3-propylene glycol. (Author abstract) 28 refs.

Japaridze, J.I. (Acad of Sciences of the GSSR, Tbilisi, USSR); Chagelishvili, V.A.; Khutzhishvili, Z.A.; De Batistati, A.; Trasatti, S. *Colloids Surf* v 28 n 2-4 Dec 1987 p 135-146.

**092473 MULTIPLE EQUILIBRIA MODEL OF THE ADSORPTION OF OLEATE AQUEOUS SPECIES AT THE GOETHITE-WATER INTERFACE.** The interaction between monomers and dimeric aqueous oleate species and ionizing groups at the goethite-water interface has been constructed to analyze experimental surface change titration and oleate adsorption isotherms. The binding constants that emerge and the pH-concentration distribution of surface oleate complexes support the concept of anion-neutral molecule coadsorption or acid soap dimer adsorption in the region where precipitation of oleic acid and/or ferric oleate is precluded. 19 refs.

Jung, R.F. (Univ of Melbourne, Parkville, Aust); James, R.O.; Healy, T.W. *J Colloid Interface Sci* v 122 n 2 Apr 1988 p 544-549.

**092474 EFFECT OF INORGANIC SALT ON ADSORPTION OF SODIUM ALKYL SULFATES AND FATTY ACID SODIUM SALTS FROM AQUEOUS SOLUTION ONTO ION EXCHANGE RESINS.** The adsorption isotherms of sodium salts of alkyl sulfonic acid and fatty acid with various carbon numbers onto ion exchange resins were measured in the absence and in the presence of sodium chloride in aqueous solutions. In the absence of the inorganic salt, the amount of adsorption remarkably increased with an increase in the length of alkyl groups in the adsorbates. Furthermore, the amount of adsorption apparently decreased with addition of sodium chloride into the solutions and almost reached a constant value at high concentrations of NaCl. This behavior strongly suggested that the electrostatic interac-

tion on the adsorption decreased with increasing salt concentration and that the effect of hydrophobic interaction seems to play an important role on adsorption. (Author abstract). 9 Refs.

Ihara, Yasuji (Yamaguchi Women's Univ, Yamaguchi, Jpn). *J Appl Polym Sci* v 36 n 4 Aug 5 1988 p 891-897.

**092475 ADSORPTION MODEL OF PYRIDINIUM SALTS ON QUARTZ.** On the basis of adsorption and flotation measurements using a new flotation apparatus an adsorption model of pyridinium salts on quartz is presented. Depending on the character of the counterions the maximum amount of surfactant adsorbed is a bilayer or a tetralayer. Measurements of the flotation rate at various electrolyte concentrations show sharp maxima at surfactant concentrations near critical micelle concentration (CMC)/2. If the flotation rate is a function of the surface hydrophobicity, then the first adsorption layer is completed at this surfactant concentration. The dependence of the flotation rate on phosphate concentration shows three sharp flotation maxima that do not correspond to those measured in the presence of sulfate ions. The shift of the first two maxima is explained as a chemical change of the quartz surface induced by the phosphate ions. The small third maximum may be caused by a further adsorption layer that is weakly bound to the surface. (Edited author abstract). 18 Refs.

Schwarz, Reinhard (Univ of Regensburg, Regensburg, West Ger); Heckmann, Klaus; Strnad, Jiri. *J Colloid Interface Sci* v 124 n 1 Jul 1988 p 50-56.

## Analysis

**092476 GAS CONTENT DETERMINATIONS OF SALT SAMPLES USING ACOUSTIC RESPONSES.** The Bureau of Mines has developed a practical methodology for determining occluded gas contents of domal rock salt samples. The method, which is portable and field-worthy, provides results in 5 min or less and does not require a laboratory environment or specially trained personnel to obtain meaningful results. The results can be used to identify gas-enriched zones, and thus may aid mine operators in production planning or ventilation design. The test method is based on the relationship between gas content and the acoustic response of salt samples as they are dissolved in water. The relationship is defined by an equation, and the results are repeatable. The equation was derived by testing a series of rock salt samples collected from domal salt mines in Louisiana. (Author abstract) 14 refs.

Marshall, Thomas E. (US Bur of Mines, Pittsburgh, PA, USA); Finfinger, Gerald L. *Rep Invest US Bur Mines* n 9113 1987 10p.

**Applications** See ROADS AND STREETS—Snow and Ice Control.

**Chemical Reactions** See SILVER AND ALLOYS—Chemical Reactions.

## Chemical Vapor Deposition

**092477 LABORATORY STUDIES OF BINARY SALT CVD IN COMBUSTION GAS ENVIRONMENTS.** A flash-evaporation technique is used to obtain vapor deposition characteristics for the binary alkali sulfates  $\text{K}_2\text{SO}_4$  +  $\text{Na}_2\text{SO}_4$  at 1 atm above 1,100 K. This technique gives results of immediate engineering interest, such as dewpoint temperatures, condensate composition and rates of vapor deposition as well as useful data on the system's thermodynamic characteristics. It is concluded that alkali sulfate deposition and vaporization in combustion environments are inevitably influenced by chemical reactions such as hydroxide formation. It is also concluded that solution nonideality is important even for homologous alkali-salt mixtures. (Edited author abstract) 34 refs.

Liang, Baishen (Yale Univ, New Haven, CT, USA); Rosner, D.E. *AIChE J* v 33 n 12 Dec 1987 p 1937-1948.

## Chromatographic Analysis

**092478 DIRECT SEPARATION OF D- AND L-SOTALOL MANDELATE AND HYDROCHLORIDE SALTS BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY.** A method was developed specifically to determine the purity of d- and l-sotalol mandelate salts during resolution of the racemic mixture. This procedure provides a useful means of monitoring directly the purity of the salt and the composition of the mother liquors at each step of purification. (Author abstract) 5 refs.

Le Garrec, L. (Recherche Syntax France, Monthery, Fr); Delee, E.; Pascal, J.-C.; Jullien, I. *J Liq Chromatogr* v 10 n 13 1987 p 3015-3023.

**092479 SEPARATION OF SULPHONIUM SALTS BY ION CHROMATOGRAPHY: FIVE- AND SIX-MEMBERED CYCLIC SULPHONIUM SALTS.** Several cyclic 5- and 6-membered sulphonium compounds were separated by ion pair chromatography on an opti-dbb ion pair column. The salts show specific retention behavior when using different mixtures of acetonitrile and aqueous sodium perchlorate solutions as eluents. The increase of retention times with extending chain length of the alkyl group R and with ring size is due to an increase of the solute molecular surface areas which were also calculated. The obtained retention parameters give additional information for structural determination. (Author abstract) 12 refs.

Aced, Gaby (Hann-Meiner-Inst Berlin GmGh, Berlin, West Ger); Anklam, Elke; Mockel, Hermann J. *J Liq Chromatogr* v 10 n 15 Nov 1987 p 3321-3327.

**092480 SOLUTE-SOLVENT INTERACTIONS IN LIQUID TETRABUTYLAMMONIUM SULFONATE SALTS STUDIED BY GAS CHROMATOGRAPHY.** The gas chromatographic properties of 11 tetrabutylammonium sulfonate salts containing proton donor/acceptor substituents incorporated into the sulfonate anion are described. Several of these salts are liquid at room temperature and can be used as stationary phases at temperatures up to 160-200°C. These salts retained polar solutes largely by gas-liquid partitioning although interfacial adsorption was significant for the n-alkanes, particularly for the anions containing hydroxyl and acetamide substituents. (Edited author abstract) 19 refs.

Pomaville, Rena M. (Wayne State Univ, Detroit, MI, USA); Poole, Colin F. *Anal Chem* v 60 n 11 Jun 1 1988 p 1103-1108.

**Components** See ORGANIC COMPOUNDS—Separation; TITANIUM AND ALLOYS.

**Concentration** See AMMONIUM COMPOUNDS—Crystallization; FLOW OF FLUIDS—Porous Materials; OIL WELL DRILLING—Drill Pipe; PROTEINS—Extraction.

**Corrosive Effects** See CONCRETE—Chemical Attack.

## Creep

**092481 EFFECT OF SIMULATED SAMPLING DISTURBANCE ON CREEP BEHAVIOUR OF ROCK SALT.** This article presents the results of an experimental study of creep behaviour of a rock salt under uniaxial compression as a function of prestrain, simulating sampling disturbance. The prestrain was produced by radial compressive loading of the specimens prior to creep testing. The tests were conducted on an artificial salt to avoid excessive scattering of the results. The results obtained from several series of single-stage creep tests show that, at short-term, the creep response of salt is strongly affected by the preloading history of samples. The nature of this effect depends upon the intensity of radial compressive preloading, and its magnitude is a function of the creep stress level. The effect, however, decreases with increasing plastic deformation, indicating that large creep strains may eventually lead to a complete loss of preloading memory. (Author abstract) 34 refs.

Guessous, Z. (Ecole Polytechnique, Montreal, Que, Can);



Gill, D.E.; Ladanyi, B. *Rock Mech Rock Eng* v 20 n 4 Oct-Dec 1987 p 261-275.

## Crystal Lattices

**092482 ON THE  $\text{Eu}^{2+}$  -  $\text{Mn}^{2+}$  ENERGY TRANSFER IN  $\text{BaMgF}_4$ .** Energy transfer from  $\text{Eu}^{2+}$  to  $\text{Mn}^{2+}$  ions is shown to occur in  $\text{BaMgF}_4$ : Eu, Mn crystals. The efficiency of this transfer is moderate. This is attributed to the fact that  $\text{Eu}^{2+}$  and  $\text{Mn}^{2+}$  ions are distributed randomly in the host lattice. Quantitative evaluation leads to the suggestion that the transfer is restricted to only seven neighbors at 4.0 Å and is thus exchange mediated. (Author abstract) 9 refs.

Srivastava, A.M. (Polytechnic Univ, Brooklyn, NY, USA); Sobieraj, M.T.; Ruan, S.K.; Banks, E. *Mater Chem Phys* v 19 n 3 Apr 1988 p 199-204.

## Crystallization

**092483 KINETICS OF MASS CRYSTALLIZATION OF SALTS FROM SOLUTIONS IN IDEAL MIXERS.** Experiments were conducted in an experimental crystallizer with a dual circulation circuit. In conducting the experiments, the consumption of the starting feed solution saturated with potassium chloride at the temperature of 50-55°C was  $0.3 \cdot 10^{-5} \text{ m}^3/\text{sec}$ , the efficiency of the installation with respect to the solid state was  $2.7 \cdot 10^{-2} \text{ kg}/(\text{m}^3 \cdot \text{sec})$ , and the temperature in the apparatus was 16-20°C. A comparison of the scattering of the experimental points with the width of the confidence interval confirms the fluctuational character of the dependence of the average size of the crystals on time. The method for calculating the supersaturation, which arises in ideal mixing apparatus as a function of the available supersaturation  $x_p$ , is the ratio of the characteristic times of creation to elimination of supersaturation  $\mu$  and the time of creation of supersaturation  $\tau_c$  to the average time of residence of the crystals in the apparatus  $t$  permits selecting the required geometric dimensions of the apparatus. 5 refs.

Zel'manov, G.Z. *J Appl Chem USSR* v 60 n 6 pt 1 Jun 1987 p 1222-1225.

**092484 METHOD OF CALCULATING SALT CRYSTALLIZATION FROM SOLUTION INVOLVING RECIRCULATION.** To obtain coarse-grained dust-free salts by mass crystallization from solution, it is desirable to recirculate a fraction of the finished crystals. In this connection, considerable interest attaches to a recirculation model for the stationary and transient states, as well as results on the effects of grain size and amount of the returned crystals on the nucleation kinetics and crystal growth. The authors have analyzed the transient response in recirculation crystallization of salts from solution. The experiments were performed with an experimental crystallization system including a horizontal crystallizer containing a frame stirrer of capacity 0.01 m<sup>3</sup>, tanks for the initial saturated solution and suspension, together with the necessary auxiliary equipment and measuring instruments. The flow rate for the potassium chloride feed solution was 48 liter/h, temperature 67-70°, density  $1.205 \cdot 1.207 \times 10^3 \text{ kg}/\text{m}^3$ , temperature of suspension in apparatus 53-55°, and density of mother liquor  $1.198 \cdot 1.200 \times 10^3 \text{ kg}/\text{m}^3$ . The results show that the time required to reach the stationary state was virtually the same under all conditions and was determined only by  $k$  (2.5, 5, or  $10 \text{ h}^{-1}$ ). 7 refs.

Zel'manov, G.Z. (All-Union Halurgy Research & Development Inst, USSR); Shchusser, M.B.; Seballo, V.A. *J Appl Chem USSR* v 59 n 6 1 Jun 1986 p 1154-1157.

**Decomposition** See Also POLYMERIZATION—Catalysts; SEMICONDUCTOR MATERIALS—Drying.

**092485 KINETICS OF THE HYDROLYTIC DECOMPOSITION OF PERXENATE IONS IN ACIDIC SOLUTIONS.** The hydrolytic decomposition of perxenate ions in acidic solutions has been investigated by kinetic fluorimetry. It is shown that perxenate ions are effective quenchers of excited  $\text{Tb(III)}$  ions. The rate

constant for the quenching of excited  $\text{Tb(III)}$  ions and the bimolecular rate constant for the deactivation of  $\text{Tb(III)}$  by perxenate ions are determined from the Stern-Volmer equation. The deactivation process is attributed to the oxidation of the excited  $\text{Tb(III)}$  ions by perxenate ions. The rate constant for the hydrolytic decomposition of perxenate ions is determined. (Author abstract) 9 refs.

Khamidullina, L.A. (Acad of Sciences of the USSR, Ufa, USSR); Rykova, V.V.; Afonichev, D.D.; Kazakov, V.P. *Kinet Catal* v 28 n 4 pt 2 Jul-Aug 1987 p 865-867.

**092486 THERMODYNAMIC BASIS OF THE SPECTRUM OF THERMAL DECOMPOSITION PRODUCTS OF METAL OXALATES.** A previous study has shown that a thermochemical approach provides a successful avenue for the interpretation of the thermal decomposition and gas-phase reduction behavior of metal sulphates. The purpose of the letter is to report that a similar analysis also yields a logical basis for understanding the spectrum of thermal decomposition behavior for metal oxalates. The materials under consideration are the metal salts of oxalic acid,  $(\text{COOH})_2$ . The thermodynamic stability as reflected in the  $-\Delta H_c$  values provides a plausible basis for the three classes of products observed. 4 refs.

Vijh, Ashok K. (Inst de Recherche d'Hydro-Quebec, Varennes, Que, Can). *J Mater Sci Lett* v 7 n 5 May 1988 p 513-514.

**Density Measurement** See ALUMINUM COMPOUNDS—Thermodynamic Properties.

## Differential Thermal Analysis

**092487 DTA DETERMINATION OF THE ANHYDRITE CONTENT IN ROCK SALTS.** The DTA method was used to determine the phase diagram of the  $\text{NaCl-CaSO}_4$  system over the range 0.55 wt.% of  $\text{CaSO}_4$  in air atmosphere. The effects of  $\text{SiO}_2$ ,  $\text{CaCO}_3$  and  $\text{Fe}_2\text{O}_3$  on the melting temperatures of pure  $\text{NaCl}$  and the eutectic were determined. On the basis of the above temperatures, a method of quantitative determination of the anhydrite content in rock salts has been developed. (Author abstract) 2 refs.

Swiatek, A. (Acad of Mining & Metallurgy, Cracow, Pol); Wacławski, I. *J Therm Anal* v 32 n 6 Nov-Dec 1987 p 1715-1718.

**Electric Conductivity** See Also SILICATES—Electric Conductivity.

**092488 (BEDT-TTF) $_2\text{CuCl}_2$ , A NEW CONDUCTING CHARGE TRANSFER SALT.** (BEDT-TTF) $_2\text{CuCl}_2$ , synthesized by oxidation and by electrocrystallization, has been characterized by single crystal X-ray diffraction, four-probe electrical conductivity, EPR and magnetic susceptibility, and shown to be semiconducting with  $\sigma \approx 4 \times 10^{-2} \text{ S cm}^{-1}$  at 290 K and  $E_g = 0.3 \text{ eV}$ . Static magnetic susceptibility and EPR measurements suggest strongly that the material is magnetic, consisting of strongly localized spins ( $S = \frac{1}{2}$  per BEDT-TTF dimer) with one-dimensional antiferromagnetic exchange. (Edited author abstract) 16 refs.

Kurmo, Mohammedally (Oxford Univ, Oxford, Engl); Talham, Daniel R.; Day, Peter; Howard, Judith A.K.; Stringer, Andrew M.; Obertelli, David S.; Friend, Richard H. *Synth Met* v 22 n 4 Feb 1988 p 415-418.

**092489 ELECTRICAL CONDUCTIVITY OF MOL-TEN  $\text{B}_2\text{O}_3\text{-Na}_2\text{O}$  MIXTURES.** The conductivity of mixtures of boron oxide and sodium oxide was measured in concentration and temperature ranges extending respectively from 0 to 33 mole%  $\text{Na}_2\text{O}$  and from 1023 to 1273 K. Different conductimetric cells were used in order to fit the cell factor to the electrolyte concentration. Equivalent conductance isotherms were determined assuming that  $\text{B}_2\text{O}_3$  acts as a solvent; the equivalent conductance of the melts increases with the  $\text{Na}_2\text{O}$  content. The temperature dependence is correctly described by an Arrhenius equation at all compositions. The preexponen-

tial factor does not significantly change with the basicity of the melt; the concentration dependence of the equivalent conductance is thus entirely brought about by the changes of the activation energy. (Author abstract) 7 refs.

Claes, P. (Catholic Univ of Louvain, Louvain-la-Neuve, Belg); Coq, J.L.; Glibert, J. *Electrochim Acta* v 33 n 3 Mar 1988 p 347-352.

**092490 ELECTRICAL CONDUCTIVITY OF ACID CRYSTALLOHYDRATE  $\text{MgHPO}_4 \cdot 3\text{H}_2\text{O}$  AND ITS STRUCTURAL TRANSFORMATIONS.** Electrical and thermal characteristics of solid  $\text{MgHPO}_4 \cdot 3\text{H}_2\text{O}$  have been investigated in a temperature interval from 20-400°C, and correlated with data of X-ray diffraction analysis. It is noted that in the temperature interval from 20-140°C, despite the presence of considerable hydrogen concentrations, the sample shows very small electrical conductivity. This is a consequence of crystal structure, where the strongest hydrogen bond exists between acid proton and oxygen of  $\text{PO}_4^{3-}$  group. The strong hydrogen bond decreases the number of potential electric carriers and prevents rotation of the  $\text{PO}_4^{3-}$  acceptor group, which causes crystallohydrate to show poor conductivity. With the breakage of crystal structure, caused by dehydration, amorphous  $\text{MgHPO}_4$  salt is formed and conductivity abruptly increases. At about 550°C crystallization starts and the newly formed phase  $\text{Mg}_2\text{P}_2\text{O}_7$  again shows poorer conductivity. (Author abstract) 15 refs.

Minic, D.M. (Belgrade Univ, Belgrade, Yugosl); Susic, M.V.; Petranovic, N.A.; Dimitrijevic, R.Z. *Mater Chem Phys* v 19 n 6 Jul 1988 p 579-588.

**Electric Properties** See Also ORGANOMETALLICS—Electric Properties.

**092491 REACTION OF TETRAMETHYLTETRASELENAFULVALENE (TMTSF) WITH COPPER (II) HALIDES AND THE ELECTRICAL PROPERTIES OF THE PRODUCTS.** The semiconductive compounds  $[(\text{TMTSF})_{1/2}]_2$  (room-temperature powder conductivity  $\sigma_{\text{RT}} = 9 \times 10^{-2} \text{ S cm}^{-1}$  and activation energy  $E = 0.07 \text{ eV}$ ) and  $(\text{TMTSF})_2\text{Br}_2$  ( $\sigma_{\text{RT}} = 7 \times 10^{-4} \text{ S cm}^{-1}$  and  $E = 0.18 \text{ eV}$ ) were obtained by redox reactions between TMTSF and copper (II) halides. These compounds were characterized with the aid of infrared, electron spin resonance and X-ray photoelectron spectroscopies, and thermoelectric power and magnetic susceptibility measurements. In contrast with common TMTSF and TTF conductors,  $(\text{TMTSF})_2\text{CuBr}_2$  had a large negative thermoelectric power. This property can be explained on the basis of the excess electrons produced on TMTSF by the transfer of electrons from  $\text{Cu}^2+$  to TMTSF (Author abstract) 17 refs.

Inoue, Michiko B. (Univ de Sonora, Sonora, Mex); Cruz-Vazquez, Catalina; Inoue, Motomichi. *Synth Met* v 22 n 3 Jan 1988 p 231-237.

**092492 MICROWAVE CONDUCTIVITY IN THE PURE AND IODINE-DOPED ORGANIC CONDUCTOR  $\alpha$ -(BEDT-TTF) $_2\text{I}_3$ .** The microwave conductivity in dependence of temperature was measured on pure and iodine doped crystals of  $\alpha$ -(BEDT-TTF) $_2\text{I}_3$  along the stack direction [100] and perpendicular to it [010]. The exposure times to iodine were varied in many steps between 2 min and 360 min. The contactless microwave technique enables to keep the same crystal in each case throughout all measurements. The results show that the microwave conductivity vs. temperature is not influenced distinctly by iodine doping. Only at the onset of the plateau range immediately below the metal-insulator transition at 135 K a small enhancement of the conductivity is found for exposure times larger than 60 min. In no case a transition to a superconducting state is observed. Therefore recently reported superconductivity may be due to surface effects. (Author abstract) 7 refs.

Kremer, W. (Univ Goettingen, Goettingen, West Ger); Helberg, H.W.; Gogu, E.; Schweitzer, D.; Keller, H.J. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem, of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 896-899.



## Electronic Properties

**092493 ELECTRONIC EXCITATIONS IN (BEDT-TTF)-SALTS.** The indicatrix orientation, the birefringence, and the transmission spectra were measured in small crystals of the organic conductors  $\alpha$ -(BEDT-TTF) $_2$ I $_3$  and  $\alpha$ -(BEDT-TTF) $_3$ (NO $_3$ ) $_2$  in the near infrared (NIR) and the visible (VIS) spectral range. The results are discussed with regard to the orientation of the BEDT-TTF molecule axes and the arrangement of the intermolecular contact directions. The principal polarizabilities are calculated by composing the polarizabilities along the BEDT-TTF molecule axes and along the several contact directions. At high energies ( $\geq 2$  eV) in the VIS the orientation of the polarizability tensor is governed by the orientation of the stack forming molecules due to the intramolecular excitations. In the NIR the intermolecular excitations become dominant. The transmission spectra are compared with calculations of the dipole interactions. 4 refs.

Helberg, H.W. (Univ Goettingen, Goettingen, West Ger). *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem, of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 899-901.

**092494 NEW ASPECTS OF THE INFRARED STUDY OF ELECTRON-PHONON COUPLING.** The temperature dependence of the spectral properties of dimerized TCNQ salts is explained in terms of an isolated dimer model. The cases of one and two electrons per dimer are considered separately, because the electron-electron interaction should be treated in an explicit way in these solids. An important new observation is that the changes in electronic interactions depend both on frequency and temperature. Hence, the thermal changes in the spectral properties manifest themselves by the variations of molecular band intensities and by the shift of their positions. The analysis of the Re  $(1/\rho(\omega))$  function, which can be calculated from reflectivity data, is claimed to allow the temperature dependence of the electron-molecular vibration coupling parameters to be determined unambiguously. (Author abstract) 5 refs.

Yartsev, V.M. (Chelyabinsk State Univ, Chelyabinsk, USSR); Graja, A. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 151-155.

**092495 ORIGIN OF THE ANOMALY IN THE D.C. CONDUCTIVITY IN (BEDT-TTF) $_x$ TCNQ $_x$  SALT.** The electronic properties of monocrystalline (BEDT-TTF) $_x$ TCNQ $_x$  salt have been investigated by measuring the dc conductivity, spin susceptibility and radiopospectroscopic g factor and linewidth for various crystal orientations, from 370 K to 130 K. It is suggested that the behavior of the compound is determined both by the BEDT-TTF layers and TCNQ chains. (Author abstract) 4 refs.

Firlej, L. (Polish Acad of Sciences, Poznan, Pol); Graja, A.; Wolak, J.; Eremenko, O.N. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 157-160.

**Energy Utilization** See STEAM GENERATORS—Design.

**Environmental Impact** See ROADS AND STREETS—Snow and Ice Control.

## Extraction

**092496 EQUIPMENT FOR CYCLIC BATCH MOLTEN SALT EXTRACTION.** A device which makes practical the cyclic contact of different molten metal phases and a molten salt phase, without freezing the salt phase between contacts, was designed, fabricated, and tested. (Author abstract) 6 refs.

Long, Jack L. (Rockwell Int, Golden, CO, USA). *Solvent Extr Ion Exch* v 5 n 5 1987 p 989-996.

**Fused** See Also ELECTRIC BATTERIES, SECONDARY; ELECTRODES—Materials; METALLIC COMPOUNDS—Forming; METALS AND ALLOYS—Cooling; NICKEL CHROMIUM TUNGSTEN MOLYBDENUM ALLOYS—Protective Coatings; OPTICAL MATERIALS—Synthesis; PLASTICS FILMS—Electrochemistry; POTASSIUM COMPOUNDS; SLAGS—Phase Diagrams; SODIUM COMPOUNDS—Solutions; THERMAL CONDUCTIVITY—Measurements.

**092497 CONFORMAL IONIC SOLUTION MODEL AND ITS APPLICATION FOR THE CALCULATION OF MOLTEN SALT PHASE DIAGRAMS.** The conformal ionic solution model (C.I.S.) based on statistical mechanical perturbation theory is reviewed. The calculation of the excess relative integral molar Gibbs energies and the phase diagrams of a ternary additive system which is one either containing three different kinds of cations and one kind of anion or three different kinds of anions and one kind of cation is discussed. The ternary reciprocal system containing two cations and two anions is also covered. (Edited author abstract) In Chinese. 20 refs.

Qiao, Zhi-yu (Beijing Univ of Iron & Steel Technology, China). *Xi You Jin Shu* v 6 n 2 May 1987 p 111-116.

**092498 COMPUTER MODELLING OF MOLTEN SALT AND SLAGS FOR PHASE DIAGRAM CALCULATIONS (SEQUEL).** The thermodynamics of molten salts and slags is reviewed with particular attention given to models which permit the thermodynamic properties to be represented, interpolated and extrapolated for purposes of phase diagram calculations. Topics discussed include the Temkin sublattice model, methods of estimating multicomponent phase diagrams from binary data and the accuracy of such methods, reciprocal ternary salt solutions, structural ordering in molten salts and slags, an extended quasichemical model for treating such ordering and calculation of multicomponent silicate slag systems. A list of salt and slag systems which have been evaluated to date is presented. (Author abstract) In Chinese. 43 refs.

Pelton, Arthur D. (Ecole Polytechnique de Montreal, Can). *Xi You Jin Shu* v 6 n 2 May 1987 p 117-123.

**092499 MEASUREMENT OF SOME PHYSICO-CHEMICAL PROPERTIES OF THE NaCl-CaCl $_2$ -BaCl $_2$  TERNARY MOLTEN SALT SYSTEM.** The NaCl-CaCl $_2$ -BaCl $_2$  ternary eutectic system can be used as a low temperature electrolyte for electrowinning and electroplating of refractory metals. This paper is a study on the relationship between the properties and temperature of this system in the temperature range of electrolysis, including the measurement of density, conductivity, viscosity, surface tension and anode critical current density of the eutectic melt at 480-689°C. The authors also studied the relationship between properties and composition at 600°C with composition in the neighborhood of eutectic point. (Edited author abstract) In Chinese. 5 refs.

Li, Guo-xun (General Research Inst of Nonferrous Metals, Beijing, China); Guo, Ai-jun; Zhang, Shu-ling; Ma, Shu-lan. *Xi You Jin Shu* v 6 n 3 Aug 1987 p 177-180.

**092500 STRUCTURAL INVESTIGATION OF THE MOLTEN SYSTEM LiCl-CaCl $_2$  BY X-RAY DIFFRACTION METHODS.** The structures of the molten system (LiCl) $_x$ (CaCl $_2$ ) $_{1-x}$ , with  $x = 1, 2/3, 1/2$ , and 0, were investigated by X-ray diffraction analysis. The coordination number obtained for the nearest-neighbor pair LiCl,  $N_{Li/Cl}$ , in molten LiCl was interpreted by the volume expansion  $\Delta V_f/V_s = (26.2\%)$  on melting. In molten CaCl $_2$ , the obtained bond-lengths and coordination numbers obtained for the nearest neighbor ionic pairs were close to those found in the crystalline form, which are consistent with the abnormally small  $\Delta V_f/V_s = (0.9\%)$ . The values of  $N_{Li/Cl}$  and  $N_{Ca/Cl}$  in molten LiCaCl $_3$  and Li $_2$ CaCl $_4$  are similar to those found in molten LiCl and CaCl $_2$ , respectively. In addition, over the whole range of concentration in this molten system, the nearest-neighbor bond length  $l_{Li-Cl}$  showed a linear dependence on molar fraction. The behavior in this system can be considered to be a result of the strongly Coulombic attractions between Li $^+$  or Ca $^{2+}$  and Cl $^-$ , which implies the formation of certain ionic groups. Experimental results by X-ray

structural analysis have directly given evidence for ionic groups. (Edited author abstract) 34 refs.

Iwamoto, Nobuya (Osaka Univ, Ibaraki, Jpn); Umesaki, Norimasa; Asahina, Tadashi; Kosaka, Mineo. *High Temp Sci* v 23 n 1 Feb 1987 p 1-15.

**092501 PHASE EQUILIBRIA AND STRUCTURAL SPECIES IN MgF $_2$ -MgO, MgF $_2$ -CaO, AND MgF $_2$ -Al $_2$ O $_3$  SYSTEMS.** Phase diagrams of the halide systems of the alkali and alkaline-earth metals, and the alkaline-earth metal halide-oxide systems are useful in selecting the right type of salt mixtures. Some of the light-metal fluorides and oxides have relatively high heats of fusion per unit mass and hence may find application in thermal energy storage systems. Cryoscopic studies also provide a method for elucidating the structural species in the molten salt mixtures. 18 refs.

Sharma, Ram A. (GM, Warren, MI, USA). *J Am Ceram Soc* v 71 n 4 Apr 1988 p 272-276.

**092502 DATABASE AND SUBLATTICE MODEL FOR MOLTEN SALTS.** A thermodynamic database for molten salt solutions is being developed through the systematic optimization of binary and ternary data. Over 200 systems have been evaluated. Parameters for the subsystems of the Li, Na, K / F, Cl, OH, CO $_3$ , SO $_4$  system are tabulated. For calculating activities in multicomponent solutions, a sublattice model is used. Equations for integral and partial properties are given in full. For each sublattice it is shown how a consistent 'Kohler-Toop' (or 'Muggianu-Toop') formalism can be devised for multicomponent systems. The practical significance and importance of the various terms in the sublattice model as applied to molten salts are discussed. An example of automatic accessing of the multicomponent salt database for equilibrium calculations with a particular system is presented. (Edited author abstract) 32 refs.

Pelton, Arthur D. (Ecole Polytechnique de Montreal, Montreal, Que, Can). *Calphad* v 12 n 2 Apr-Jun 1988 p 127-142.

**092503 SHAPE OF RAMAN SPECTRA OF MOLTEN KNO $_3$ -NaNO $_2$  SOLUTION.** The Raman spectra of molten KNO $_3$ -NaNO $_2$  at 473-623 K have been measured. The regularity of the shape was investigated. The symmetrical stretching frequency peak  $\nu_1$  of NO $_3^-$  or NO $_2^-$  becomes broader as the temperature increases or the concentration decreases. The results are discussed based on the view point of a theoretical model obtained in previous work. (Edited author abstract) 4 refs. In Chinese.

Yan, Licheng (Shanghai Inst of Metallurgy, China); Wang, Yinting; Yang, Jinxiu; Li, Yu; Ma, Guang; Chen, Nianyi. *Chin Shu Hsueh Pao* v 24 n 1 Feb 1988 p B63-B64.

## Geochemistry

**092504 EXTRACTION OF ELECTROLYTES-FORM UNCONSOLIDATED SEDIMENTS USING SATURATED PASTE AND FREEZING.** The determinations of the total amount and composition of soluble electrolytes (usually defined as position of soluble electrolytes (usually defined as 'soluble salts') is the first basic step in engineering geochemical investigations. In the author's initial studies in California and Nevada, the standard, generally accepted pedological method for the preparation of saturated soil pastes and their extraction was originally used for determinations of the amount and composition of salts. A new method requiring less personnel attention and more suitable for geologic purposes was developed, however, during the last decade and successfully used in this study. This note briefly describes and critically evaluates both methods. 6 refs.

Prokopovich, Nikola P. (US Bur of Reclamation, Sacramento, CA, USA). *Bull Assoc Eng Geol* v 24 n 4 Nov 1987 p 564-569.



**Granulation** See POTASSIUM COMPOUNDS—Granulation.

## Hydrogenation

**092505 HYDROGENATION AND STRUCTURAL CHANGES IN POTASSIUM DITHIOFERRATE UNDER HEAT TREATMENT.** Polycrystalline potassium dithioferrate ( $KFeS_2$ ) was studied using X-ray diffraction to detect structural changes occurring in the compound when submitted to heat treatment at a temperature of 500°C under vacuum and in a hydrogen atmosphere. The changes observed in samples treated under vacuum and in a hydrogen atmosphere were similar, suggesting the presence of a new unstable phase coexisting with that of the untreated sample, and that the structural transformation observed is supposed to be primarily induced by the high-temperature treatment. (Edited author abstract) 29 refs.

Torriani, I.L. (Univ Estadual de Campinas, Campinas, Brazil); Arguello, Z.P.; Filho, A.R. Freira; Suassuna, J.P.; Taft, C.A. *J Mater Sci* v 23 n 3 Mar 1988 p 1068-1070.

## Ionic Conduction

**092506 ELECTRICAL CONDUCTIVITY AND PHASE DIAGRAM OF THE  $Na_2SO_4$ - $CaSO_4$  SYSTEM.** Very high vacancy concentrations may be obtained in solid solutions of the high temperature phase of  $Na_2SO_4$ . In this paper the  $Na_2SO_4$ - $CaSO_4$  system has been studied using differential scanning calorimetry (DSC) impedance spectroscopy and X-ray powder diffraction. The phase diagram, especially the stability range of the solid solution of the high temperature  $Na_2SO_4$  phase, has been redetermined. The electrical conductivity of this solid solution increases rapidly with increasing  $CaSO_4$  content and reaches a maximum for about 5 mol%  $CaSO_4$ ; the conductivity at e.g. 300°C,  $3.5 \times 10^{-3} (\Omega \text{ cm})^{-1}$ , is almost three orders of magnitude higher than that of pure  $Na_2SO_4$ . (Author abstract) 33 refs.

Bandaranayake, P.W.S.K. (Chalmers Univ of Technology, Goteborg, Sweden); Mellander, B.-E. *Solid State Ionics* v 26 n 1 Jan 1988 p 33-36.

## Magnetic Properties

**092507 RADICAL ANION SALTS OF  $N,N'$ -DICYANOQUINONEDIMINE (DCNQ): CONDUCTIVITY AND MAGNETIC PROPERTIES.** DC-conductivity ( $\sigma$ ), static susceptibility ( $\chi$ ), ESR-intensity, resonance position and linewidth of ( $R_1$ ,  $R_2$ - $N,N'$ -DCNQI) $_2$ Me ( $R_1 = CH_3$ ;  $R_2 = CH_3$ , Cl, Br; Me = Ag, Cu) between 300 K and 1.2 K are reported. All copper salts have a high  $\chi$  of about  $5.6 \cdot 10^{-4}$  emu/mole in the conducting temperature range. This can be explained by strong electron-electron repulsion. In two salts, a CDW driven phase transition is seen and antiferromagnetic resonance (AFMR) is found below 10 K. The lack of any ESR signal in the conducting state is due to strong spin-orbit coupling (SOC) given by the nitrogen(p)-Cu(d) admixture which implies some electronic transport across the stacks. The silver salts do not exhibit these features. They behave as quasi-one dimensional conductors with reduced SOC effects. The conductivity is limited solely to the anion stack. Consequently, 1D-localization effects dominate the temperature dependence of the conductivity. (Author abstract) 16 refs.

Werner, H.-P. (Univ Stuttgart, Stuttgart, West Germany); von Schuetz, J.U.; Wolf, H.C.; Kremer, R.; Gehrke, M.; Aumüller, A.; Erk, P.; Huenig, S. *Solid State Commun* v 65 n 8 Feb 1988 p 809-813.

**092508 ANGULAR DEPENDENCE OF FIELD INDUCED TRANSITIONS AND RAPID OSCILLATIONS IN  $(TMTSF)_2ClO_4$ .** We report studies of the angular dependence of the transition fields for the magnetic field induced spin density wave (FISDW) states and of the frequency of the rapid magnetic oscillations in the Bechgaard salt  $(TMTSF)_2ClO_4$ . As H is rotated away from  $c^*$ , the transition field positions and the oscillation frequency increase, exhibiting the conventional inverse

cosine behavior expected for an anisotropic electronic system. The results verify that both effects are orbital and two dimensional in nature. We find no evidence for a nonmonotonic behavior of the threshold field with angle that has been predicted by a recent theory. (Author abstract) 22 refs.

Yan, X. (Univ of Pennsylvania, Philadelphia, PA, USA); Naughton, M.J.; Cheema, O.S.; Chamberlin, R.V.; Hsu, S.Y.; Chiang, L.Y.; Chaikin, P.M. *Solid State Commun* v 66 n 9 Jun 1988 p 905-908.

**Measurements** See AMMONIUM COMPOUNDS—Measurements.

**Molten** See Also ALUMINUM AND ALLOYS—Electrodeposition; ELECTRODES—Testing; ION EXCHANGE—Phase Equilibria; PLASTICS—Waste Utilization; SOLAR ENERGY—Energy Storage; STEEL HEAT TREATMENT—Carburizing; TOOL STEEL—Heat Treatment.

**092509 CONSTRUCTION OF MOLTEN SALT PHASE DIAGRAMS BY COMBINATION OF CALCULATION WITH MEASUREMENT.** The principle and methods of calculation of phase diagram, especially the geometric models for determination of excess molar Gibbs energy and excess partial molar Gibbs energy in all phases have been reviewed. Considering the significance and the limitation of calculation of phase diagram, it is pointed out that the combination of calculation with measurement is the best method for construction of molten salt phase diagrams. The procedure of this method is also described. In Chinese. 18 refs.

Qiao Zhiyu (Beijing Univ of Iron & Steel Technology, China); Duan Shuzhen; Gui Weizhen; Sun Minsheng. *Chin Shu Hsueh Pao* v 23 n 4 Aug 1987 p B179-B184.

**092510 PHASE DIAGRAM OF  $NaF$ - $CaCl_2$ - $LiCl$  SYSTEM.** The phase diagram of  $NaF$ - $CaCl_2$ - $LiCl$  system was studied by X-ray phase analysis. It was found that the  $NaF$  forms negative deviation molten salt solution with  $CaCl_2$ - $LiCl$  system. This result was discussed based on some conclusion obtained from the Monte Carlo simulation of molten salt mixture. (Author abstract) In Chinese. 7 refs.

Yan Licheng (Shanghai Univ of Science & Technology, China); Yang Jinxiu; Zhu Yingying. *Chin Shu Hsueh Pao* v 23 n 4 Aug 1987 p B204-B206.

**092511 SPECIFIC ELECTRIC CONDUCTIVITY OF MOLTEN  $CaF_2$ - $CaCl_2$ ,  $SrF_2$ - $SrCl_2$  AND  $BaF_2$ - $BaCl_2$  MIXTURES.** The specific electric conductivity of  $CaF_2$ - $CaCl_2$ ,  $SrF_2$ - $SrCl_2$  and  $BaF_2$ - $BaCl_2$  binary salt melts was studied in the complete concentration range up to temperatures of the order of 1500°C. It was established that conductivity, measured for individual chlorides and certain fluoride-chloride mixtures in a broad temperature range, differs significantly from Arrhenius behavior. Specific electric conductivity isotherms at 1500°C in all three systems are characterized by significant negative deviations from additivity. Experimental results of the temperature dependence of specific electric conductivity were analyzed by the method of least squares and were tabulated. (Author abstract) 11 refs.

Voronin, B.M.; Prisyazhnyi, V.D.; Khizhnyak, K.K.; Zamkov, V.N.; Novikov, Yu.K. *Sov Prog Chem* v 53 n 6 1987 p 47-51.

## Morphology

**092512 MORPHOLOGY AND CRYSTALLINE NATURE OF A LANGMUIR-BLODGETT FILM OF A TCNQ CHARGE TRANSFER SALT.** In order to obtain an ultrathin conductor as a two-dimensional (2D) layered arrangement of organic molecules, we have built up Langmuir-Blodgett (LB) films from N-docosylpyridinium $^+$ -TCNQ charge transfer salt. The morphology of these films is closely investigated by means of three interrelated methods. (Edited author abstract) 19 refs.

Barraud, A. (CEA, Gif Sur Yvette, France); Floersheimer, M.; Moehwald, H.; Richard, J.; Ruauel-Teixier, A.; Vandevyver, M. *J Colloid Interface Sci* v 121 n 2 Feb 1988

p 491-507.

## Optical Properties

**092513 PHOTOCROMIC BEHAVIOR OF VI-LOGENS AND POLYVILOGENS IN POLYMER MATRICES.** The photochromic behavior of viologens ( $V^{2+}$ ) and polyviologens ( $PV^{2+}$ ) was investigated using poly(N-vinyl pyrrolidone) (PVP) and poly(vinyl alcohol) (PVA) as matrices. In the PVP matrix the coloration rate of butylviologen bromide increases with decreasing humidity, but no influence of humidity on coloration rate was observed in the PVA matrix. The coloration rate in the PVA matrix follows a second-order plot while in the PVP matrix it does not. These results imply that, for the coloration process of viologens in polymer matrices, the effect of the matrix polymer as an electron donor must be considered. (Edited author abstract) 9 refs.

Chen, Y.L. (Zhongshan Univ, Guangzhou, China); Guan, Y.J.; Mai, Y.L.; Li, W.; Liang, Zh.X. *J Macromol Sci Chem* v A25 n 2 1988 p 201-210.

**092514 OPTICAL STUDY ON BIS-PROPYLENEDITHIOTETRATHIAFULVALENIUM (BPDT-TTF) SALTS.** Polarized reflectance spectra of semiconductive  $(BPDT-TTF)_3(PF_6)_2$  and  $(BPDT-TTF)_3I_3$  were measured at room temperature over the spectral region from 720  $\text{cm}^{-1}$  to 25,000  $\text{cm}^{-1}$ . Both of these salts exhibited one-dimensional behavior in contrast to the BEDT-TTF (bis-(ethylenedithio)tetrathiafulvalenium) salts. The transfer integrals and the on-site Coulomb energy of these materials were estimated by analyzing the optical spectra, and the on-site Coulomb energy of  $(BPDT-TTF)_3(PF_6)_2$  was found to be significantly larger than that of TCNQ salts. (Author abstract) 23 refs.

Yakushi, K. (Univ of Tokyo, Tokyo, Japan); Tajima, H.; Ida, T.; Tamura, M.; Hayashi, H.; Kuroda, H.; Kobayashi, A. *Synth Met* v 24 n 4 Jun 1988 p 301-309.

**092515 OPTICAL ABSORPTION OF SELENITE SINGLE CRYSTALS SUBJECTED TO HIGH ELECTRIC FIELDS AND IRRADIATED WITH X-RAYS OR  $\gamma$ -RAYS.** Owing to the utility of some divalent metal sulphates (e.g. barytes and selenites) doped with rare earths for dosimetry work, some interest has been developed recently, in the investigation of their physical properties. It is the aim of this letter to present measurements on the optical absorption of selenite single crystals together with its thermal bleaching properties in the region of 200 to 700 nm before and after X-ray or  $\gamma$ -ray irradiation under high a.c. or d.c. electric fields. From the present investigation of the optical absorption of selenite single crystals the two peaks lying at 236 and 400 nm, which disappear around bleaching temperatures of 140 and 330°C, respectively, may be ascribed to the weaker and stronger bonds of the water of crystallization present in selenite single crystals. 8 Refs.

Mishra, Sakuntala (Indian Inst of Technology, Kharagpur, India); Rao, Krishna A.V.; Rao, K.V. *J Mater Sci Lett* v 7 n 9 Sep 1988 p 936-939.

## Phase Transitions

**092516 COUPLING OF CATION AND ANION ROTATIONAL MODES AT PHASE TRANSITIONS IN GUANIDINIUM SALTS.** An analysis of proton and fluorine cross-relaxation in guanidinium salts results in a determination of activation parameters of cation and anion reorientations. A convergence of respective rotational correlation frequencies discovered at first-order phase transitions seems to present a new type of coupling between rotational modes of two sublattices. (Author abstract) 24 refs.

Pajak, Z. (A. Mickiewicz Univ, Poznan, Poland); Kozak, A.; Grottel, M. *Solid State Commun* v 65 n 7 Feb 1988 p 671-673.



**Physical Properties** See Also LITHIUM COMPOUNDS—Thin Films.

**092517 STRUCTURE AND PROPERTIES OF A NEW CONDUCTING ORGANIC CHARGE-TRANSFER SALT  $\beta$ -(BEDT-TTF) $_2$ AuBr $_2$ .** A new conducting organic charge-transfer salt,  $\beta$ -(BED-TTF) $_2$ AuBr $_2$  has been synthesized and its crystal structure determined. Single crystal four-probe conductivity has been measured at ambient and applied pressures from 300-1.4K and EPR spectroscopy from 300-4.2K.  $\beta$ -(BED-TTF) $_2$ AuBr $_2$  crystallizes in PI (Z=1) with  $a = 9.020(1)$ ,  $b = 5.707(9)$ ,  $c = 16.320(1)$  Å;  $\alpha = 97.60(1)$ ,  $\beta = 92.12(1)$ ,  $\gamma = 102.89(1)$ ;  $V = 811.8(2)$  Å $^3$ . While the electronic properties are two-dimensional, the molecular packing of the BEDT-TTF molecules is slightly different from that found in other  $\beta$ -phase BEDT-TTF salts with triatomic counterions.  $\beta$ -(BEDT-TTF) $_2$ AuBr $_2$  is metallic to 1.4K at pressures up to 5.6 kbar although at all pressures studied there is appreciable hysteresis in the cooling and warming cycles of the conductivity between 6 and 14K. Abrupt transitions in the temperature dependence of both the peak-to-peak EPR linewidth and integrated signal intensity occur near 20K. The possibility of a low temperature structural modification is discussed. (Author abstract) 28 refs.

Kurmoo, M. (Inorganic Chemistry Lab, Oxford, Engl); Talham, D.R.; Day, P.; Parker, I.D.; Friend, R.H.; Stringer, A.M.; Howard, J.A.K. *Solid State Commun* v 61 n 3 Feb 1987 p 459-464.

**Production** See PIPE, COPPER—Corrosion.

**Recovery** See POTASSIUM COMPOUNDS—Recovery.

**Removal** See ION EXCHANGE RESINS—Solutions.

#### Research

**092518 PROTON POSITIONS AND THE HYDROGEN BONDING SCHEME IN SOME DIAMAGNETIC TUTTON'S SALTS—SINGLE CRYSTAL PMR STUDY.** Single crystal proton magnetic resonance (PMR) studies of three diamagnetic Tutton's salts, K $_2$ M(SO $_4$ ) $_2$ ·6H $_2$ O, M=Cd, Mg and Zn, are reported. The proton positions in these salts are determined using El Saffar's empirical procedure. The hydrogens participate in bonding with the oxygens of the sulfate groups. The H-bonding is estimated to be very strong since the H...O $_s$  length is smaller than 2.6 Å. the O $_w$ ...H...O $_s$  hydrogen bond is non-linear (approximately 173°), and plays a dominant role in determining the crystal packing. (Author abstract) 7 refs.

Srinivas, D. (Indian Inst of Technology, Madras, India); Subramanian, S. *J Phys Chem Solids* v 48 n 9 1987 p 837-840.

**Solubility** See Also SURFACE ACTIVE AGENTS—Solubility.

**092519 PHASE EQUILIBRIA IN THE SYSTEM Na $_2$ NH $_4$  | SO $_4$ , H $_2$ PO $_4$ ·H $_2$ O AT 25°C.** The purpose of this work was to construct a diagram for solubility and for activity of water in saturated solutions of the quaternary reciprocal system Na $_2$ NH $_4$  | H $_2$ PO $_4$ , SO $_4$ ·H $_2$ O at 25° from data on phase equilibria in the ternary subsystems, and to study experimentally the solubility diagram in order to verify the calculated results. It can be seen that the solubility diagram of the system Na $_2$ NH $_4$  | SO $_4$ , H $_2$ PO $_4$ ·H $_2$ O at 25° includes six crystallization fields of solid phases, eight lines of three-phase equilibrium, and four invariant points, corresponding to equilibrium of the solution with three solid phases. 11 refs.

Filippov, V.K. (A.A. Zhdanov State Univ, Leningrad, USSR); Charykova, M.V.; Trofimov, Yu.M. *J Appl Chem USSR* v 60 n 6 pt 1 Jun 1987 p 1160-1165.

**Solutions** See Also ACIDS—Extraction; ELECTROLYTES—Solutions; GELS—Shrinkage; POLYETHYLENES—Solutions; TITANIUM AND ALLOYS—Dissolution.

**092520 PVTX DATA FOR THE SYSTEM KCl-H $_2$ O IN THE TEMPERATURE RANGE 298.15-573.15 K AND AT PRESSURES FROM EQUILIBRIUM TO 1000 BAR.** Experimentally obtained, precise values for the specific volumes of aqueous salt systems are difficult to employ directly. Difficulties arise because the data are generally obtained using different ranges of the parameters of state, and are reported for particular temperatures, pressures, and compositions that do not permit linear interpolation of the property of interest. These limitations do not apply when there is an equation of state describing the thermodynamic properties. This work attempted to find an equation of state that describes the thermodynamic property with an error relative to the result of experimental precise studies not lower than the requirements of the areas of application indicated above. The requirements can be satisfied by a mathematical description that provides for a deviation from the values of known studies no worse than the experimental error they show. Some of the results are presented in this article. 7 refs.

Gilyarov, V.N. (Lensovet Leningrad Technological Inst, USSR); Tsai, S.V.; Puchkov, L.V.; Zarembo, V.I. *J Appl Chem USSR* v 60 n 1 pt 1 Jan 1987 p 37-40.

**092521 SELF-ORGANIZATION OF THE SUPERMOLECULAR STRUCTURE OF CARBOXYMETHYLCELLULOSE IN HIGHLY PURIFIED AQUEOUS SOLUTIONS.** Processes of the spontaneous formation of secondary supermolecular aggregates (equilibrium with the medium of the particles) and anisotropic supermolecular structures of a fluctuation nature which take place in time are observed in highly purified aqueous solutions of CMC in the concentration of 1.2-1.8%. Based on the character of the supermolecular organization of solutions of CMC with a change in the concentration, the liquid crystalline state is not attained due to transition of the solution in the concentration of approximately 7% to the gel state. It is also found that the x-ray structural analysis of solutions in CMC does not reveal any changes in the x-rays in concentration of the solutions up to a concentration of 25%, where the solution is a completely formed film, and confirms the absence of structural changes in the gel with an increase in the concentration of CMC. 8 refs.

Petrovavlovskii, G.A.; Vasil'eva, G.G.; Kallistov, O.V.; Sidorovich, A.V.; Vokova, L.A. *J Appl Chem USSR* v 60 n 8 pt 2 Aug 1987 p 1736-1739.

**092522 STUDY OF THE KINETICS OF POLYCONDENSATION OF THE SALTS OF DICARBOXYLIC ACIDS AND DIAMINES IN SOLUTION.** The kinetics of the reaction of high temperature polycondensation of the salts of bifunctional alicyclic derivatives in solution has been investigated for the first time by the method of reaction microaquametry. The kinetic and thermodynamic characteristics of the process have been determined. It is established that the reactivity of the salts of the adamantane derivatives are at the level or somewhat below that of the salt of adipic acid and hexamethylene diamine. (Author abstract) 9 refs.

Khardin, A.P. (Volgograd Polytechnical Inst, USSR); Novakov, I.A.; Radchenko, S.S.; Kulev, I.A.; Orlinson, B.S.; Sherman, F.B.; Voskresenskaya, I.A.; Birznieys, K.A. *Polym Sci USSR* v 29 n 4 1987 p 823-828.

**Spectroscopic Analysis** See Also AMMONIUM COMPOUNDS.

**092523 ASSESSMENT OF JORDANIAN SALT USING NUCLEAR TECHNIQUES.** Elemental study and concentration determinations have been conducted on Jordanian crude salt using Rutherford Back-Scattering (RBS) and X-ray Fluorescence (XRF) spectrometry techniques. Analyses have also been carried out on different purified salt samples available in the local market. Results reveal relatively high traces of elemental concentrations in crude salt. It is suggested that refining crude salt may result in a reduction of bromide concentration and other traces considerably, thus making it feasible for human consumption. (Edited author abstract) 14 refs.

Al-Saleh, K.A. (Univ of Jordan, Amman, Jordan); Arafah, D.-E.; Jabr, I.J.; Saleh, N.S. *Appl Phys Commun* v 7 n 3 Sep 1987 p 195-208.

**092524 PHOTODISSOCIATION AND COLLISIONALLY ACTIVATED DISSOCIATION STUDIES OF N-ALKYLPYRIDINIUM CATIONS FORMED BY LASER DESORPTION.** A series of N-alkylpyridinium salts was studied by laser desorption mass spectrometry. Laser desorption was shown to produce gaseous N-alkylpyridinium cations quite easily from the relatively nonvolatile salts. Gas-phase dissociation studies revealed that these cations dissociate by two different mechanisms involving either a direct C-N bond cleavage or a more complicated cleavage involving proton transfer. (Author abstract) 25 refs.

Watson, C.H. (Univ of Florida, Gainesville, FL, USA); Baykut, G.; Mowafy, Z.; Katritzky, A.R.; Eyley, J.R. *Anal Instrum (New York)* v 17 n 1-2 Mar-Jun 1988 p 155-172.

**092525 LASER EFFECT OF A SERIES OF VARIOUSLY SUBSTITUTED PYRYLIUM AND THIOPYRYLIUM SALTS.** The laser effect of 47 pyrylium salts and 6 thiopyrylium salts has been investigated by excitation with a pulsed (5 Hz) nitrogen laser (337 nm) and compared to that of rhodamine 6G. The thiopyrylium derivatives as well as the pyrylium salts which contain nitro substituents show a rather poor effect if any. Out of the pyrylium series, 19 compounds have an important response as laser dyes. For most of them, the lasing range is larger than that of rhodamine 6G and for several of them (19, 20, 21, 32, 35, 39, 47 and 46) this range covers more than 80 nm. The behavior of 35 and 47 is particularly striking. (Author abstract) 20 refs.

Tripathi, Sadhana (CNRS, Thiais, Fr); Wintgens, Veronique; Valat, Pierre; Toscano, Vincente; Kossanyi, Jean; Bos, Francis. *J Lumin* v 37 n 3 Jun-Jul 1988 p 149-157.

#### Structure

**092526 CONDUCTIVE TETRAMETHYLTETRASELENAFULVALENIUM SALT BASED ON A DIVALENT OXALATO-BRIDGED BIS-(TETRAFLUOROMETALLATE) COMPLEX: (TMTSF) $_3$ (Ti $_2$ F $_8$ (C $_2$ O $_4$ )).** Single crystals of the salt exhibit a mixed-valence stack with a cylindrical divalent inorganic anion about twice as large as those that typically fit in the classical (TMTSF) $_2$ X structure. The centrosymmetrical unit cell is triclinic. Electrical conductivity measurements show a semiconducting behavior ( $\sigma_{298K} = 0.8 \Omega^{-1} \text{cm}^{-1}$ ). In addition, this is the first report of an X-ray structure determination for the anion Ti $_2$ F $_8$ (C $_2$ O $_4$ ) $^{2-}$ . (Edited author abstract) 14 refs.

Penicaud, A. (CNRS, Orsay, Fr); Batail, P.; Bechgaard, K.; Sala-Pala, J. *Synth Met* v 22 n 3 Jan 1988 p 201-207.

**092527 CRYSTAL STRUCTURES OF AuCl $_2$  SALTS OF BIS(ETHYLENEDITHIO)-TETRATHIAFULVALENE(BEDT-TTF). EXISTENCE OF DIVALENT GOLD, Au(II).** The organic donor BEDT-TTF forms 2:1 and 1:1 salts with AuCl $_2^-$ . The 2:1 salt is the  $\beta'$ -type which is isostructural with the ICl $_2^-$  and IBrCl $^-$  salts, and has one-dimensional electronic structure. In the 1:1 salt, half of AuCl $_2^-$ , which are incorporated in the sheets of BEDT-TTF, are likely to be formally neutral and to include anomalous divalent gold, Au(II). (Author abstract) 17 refs.

Mori, Takehiko (Inst for Molecular Science, Okazaki, Jpn); Inokuchi, Hiroo. *Solid State Commun* v 62 n 8 May 1987 p 525-529.

**092528 STRUCTURE AND PROPERTIES OF SALTS OF CELLULOSE XANTHIC ACID.** The effect of the structure of salts of cellulose xanthic acid on their properties has been examined. It has been shown that the character of the bond between the metal and the dithiocarbonate group in CXA (Cellulose Xanthic Acid) salts



varies gradually as the electronegativity of the metal increases, going from ionic to covalent or coordinate. The degree of ionicity of the metal-sulfur bond exerts a decisive effect of the solubility of metal cellulose xanthates in water or dilute alkali solutions. The heat resistance of CXS salts, and also the rate of acid hydrolysis of the thiocarbonate groups, depend on the degree of ionicity of the sulfur-metal bond, the xanthates of the heavy metals which have a complex structure (copper, silver, cadmium, cobalt, bismuth, and lead) being the most stable. 34 refs.

Malyshevskaya, K.A.; Mazur, N.A. *Fibre Chem* v 19 n 3 May-Jun 1987 p 192-198.

**092529 4 K CRYSTALLOGRAPHIC AND ELECTRONIC STRUCTURES OF (TMTTF)<sub>x</sub>X SALTS (X<sup>-</sup>:PF<sub>6</sub><sup>-</sup>, AsF<sub>6</sub><sup>-</sup>). The 4 K crystallographic and electronic structures of (TMTTF)<sub>x</sub>PF<sub>6</sub> and (TMTTF)<sub>x</sub>AsF<sub>6</sub> are presented. The structural investigation was performed by neutron diffraction. Thermal expansion and structural data are compared to those of the Se analogs. The tight-binding band electronic structures are based on calculations of the transfer integrals within the dimer splitting approximation. The results are discussed and compared to the room-temperature values. The transfer integrals of the two salts, which are very similar at 300 K, tend to differ markedly at low temperature. The observed differences in the transfer integrals are related to the changes of the orientation of two neighboring organic chains. The variations of the electronic parameters appear to depend on the anion. (Author abstract) 31 refs.**

Granier, T. (CNRS, Talence, Fr); Gallois, B.; Ducas, L.; Fritsch, A.; Filhol, A. *Synth Met* v 24 n 4 Jun 1988 p 343-356.

**092530 ELECTROCHEMICALLY PREPARED RADICAL SALTS OF BEDT-TTF: MOLECULAR METALS AND SUPERCONDUCTORS.** The structural, electronic and superconducting properties of several electrochemically prepared BEDT-TTF radical salts are discussed. It is found that bulk superconductivity at 8 K and ambient pressure exists in β-(BEDT-TTF)<sub>2</sub>I<sub>3</sub> and α<sub>1</sub>-(BEDT-TTF)<sub>2</sub>I<sub>3</sub> crystals. While in the β-crystals the superconducting state has to be prepared under special conditions (temperature-pressure cycling procedure) and is only metastable, in α<sub>1</sub>-(BEDT-TTF)<sub>2</sub>I<sub>3</sub> this superconducting state at 8 K is stable and entirely reproducible for many temperature cycles up to 380 K. 41 refs.

Schweitzer, D. (MPI fuer Med Forschung, Heidelberg, West Ger); Gogu, E.; Hennig, I.; Klutz, T.; Keller, H.J. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem, of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 890-896.

**092531 STRUCTURE AND PHASE TRANSITIONS OF AROMATIC RADICAL CATION SALTS - A NEW CLASS OF ORGANIC METALS.** Stable radical cation salts of a variety of simple arenes can be prepared by anodic oxidation. These highly conducting crystals are deposited on the anode during the electrocrystallization. They can be considered as a new family of organic conductors built up from simple, easily obtainable building blocks. The packing found between the aromatic rings can be regarded as a model for the interchain interactions in conducting polymers, e.g., doped poly-p-phenylene. The crystal structures of most radical cation salts can be characterized as columnar structures. The molecular overlap plays an important role in the electrical and magnetic properties. (Edited author abstract) 25 refs.

Enkelmann, V. (Max-Planck-Inst fuer Polymerforschung, Mainz, West Ger); Goeckelmann, K. *Ber Bunsenges Phys Chem* v 91 n 9 Sep 1987, Discuss Meet: Phys and Chem, of Unconv Org Mater, Wiesbaden-Naurod, West Ger, Apr 29-May 1 1987 p 950-957.

## Synthesis

**092532 SYNTHESIS, CRYSTAL STRUCTURES AND PHYSICAL PROPERTIES OF CONDUCTING SALTS (BEDT-TTF)<sub>x</sub>X (X = CF<sub>3</sub>SO<sub>3</sub> OR p-CH<sub>3</sub>C<sub>6</sub>H<sub>4</sub>**

SO<sub>3</sub>). Two new conducting BEDT-TTF salts with organic anions, (BEDT-TTF)<sub>x</sub>X, where X = CF<sub>3</sub>SO<sub>3</sub> (1) or p-CH<sub>3</sub>C<sub>6</sub>H<sub>4</sub>SO<sub>3</sub> (2), are described. Crystal data: (1), monoclinic, space group P2<sub>1</sub>/n, a = 6.649(1), b = 33.050(3), c = 15.018(1) Å, β = 90.98(1)°, V = 3299.8 Å<sup>3</sup> and Z = 4; (2), monoclinic, space group P2<sub>1</sub>, a = 7.785(1), b = 6.697(2), c = 34.402(8) Å, β = 91.10(2)°, V = 1793.2 Å<sup>3</sup> and Z = 2. The conductivity of (1) shows two phase transitions at 218 and 306 K and exhibits a temperature-dependent activation energy at all temperatures from 150-400 K. The conductivity of (1) between 220 and 400 K suggests an analogy with the inorganic quasi-one-dimensional material K<sub>2</sub>[Pt(CN)<sub>4</sub>B<sub>2</sub>O<sub>3</sub>·3H<sub>2</sub>O. (2) is semiconducting in the temperature range 150-300 K, σ<sub>300K</sub> = 10<sup>-3</sup> S cm<sup>-1</sup> and E<sub>g</sub> = 0.26 eV. (Author abstract) 8 refs.

Chasseau, D. (Chemical Crystallography, Oxford, Engl); Watkin, D.; Rosseinsky, M.J.; Kurmoo, M.; Talham, D.R.; Day, P. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 117-125.

## Thermal Conductivity

**092533 THERMAL CONDUCTIVITY OF LiKSO<sub>4</sub> NEAR ITS HIGH-TEMPERATURE PHASE TRANSITION.** The thermal conductivity of LiKSO<sub>4</sub> ferroelastic crystals was measured along the three principal crystallographic axes in the vicinity of its high-temperature phase transition at 705 K. The data showed an anomalous behaviour in the temperature dependence of the thermal conductivity in the transition region of width about 25 K. The anomaly in the phonon contribution to the conductivity was referred to the freezing-in of either optic and/or acoustic modes of lattice vibrations in the near vicinity of the phase transition. The results are discussed in terms of the scattering mechanisms of energy carriers. (Author abstract) 18 refs.

Okaz, A.M. (Alexandria Univ, Alexandria, Egypt); Mahmoud, S.M.; Kassem, M.E. *J Mater Sci* v 23 n 3 Mar 1988 p 998-1001.

## Thermal Effects

**092534 THERMAL STABILITY OF SALTS OF HIGHER QUATERNARY ALKYLAMMONIUM BASES.** The thermal stability of salts of higher quaternary alkylammonium (QAS) bases used as extracting agents for metals in hydrometallurgy was studied by complex thermal analysis and by different chemical methods of determining the degree of decomposition of QAS on heating. The study of the composition of the products of decomposition of QAS at different temperatures revealed that 100°C is the limit temperature for heating the reaction mass in quaternization of higher amines, since the relative thermal decomposition of the salts of higher alkylammonium bases attains 1.5% of the product per h at this temperature. Heating of higher QAS in air at 120-150°C results in irreversible decomposition of QAS, primarily with the formation of unsaturated compounds and amine salts. 7 refs.

Sokal'skaya, L.I.; Semenov, V.A.; Osipova, E.S.; Zhukova, N.G. *J Appl Chem USSR* v 60 n 5 pt 2 May 1987 p 1063-1066.

**Thermal Properties See HEAT PUMP SYSTEMS—Chemical Reactions.**

## Thermodynamic Properties

**092535 HEATS OF FORMATION OF QUATERNARY HYDRAZINIUM SALTS.** For industrial production of N,N-dimethyl-N-benzyl-hydrazinium (I) and N,N-dimethyl-N-(2-chloroethyl)hydrazinium (II) chlorides, data on their heats of formation by given reactions are required. The heat effects ΔH<sub>R</sub><sup>o<sub>1</sub> and ΔH<sub>R</sub><sup>o<sub>2</sub> of two reactions were calculated from literature values of the enthalpies of formation of the original reactants and from the authors' experimental values for the enthalpies of formation of compounds (I) and (II). The final reaction products were analyzed for As<sub>2</sub>O<sub>3</sub>, H<sub>2</sub>PtCl<sub>6</sub>, HCl, and</sup></sup>

HNO<sub>3</sub> contents in order to determine the quantity of heat evolved in side reactions. The standard enthalpies of formation ΔH<sub>f</sub><sup>o of the test compounds were calculated from the values obtained for the enthalpies of combustion and standard enthalpies of formation. The values obtained for the molar enthalpies of combustion ΔH<sub>c</sub><sup>o and enthalpies of formation ΔH<sub>f</sub><sup>o are given. 12 refs.</sup></sup></sup>

Kuznetsova, V.P. (State Inst of Applied Chemistry, USSR); Polyakova, L.P.; Masalitina, T.N.; Koshkova, A.V.; Ovchinnikov, P.N. *J Appl Chem USSR* v 60 n 2 pt 2 Feb 1987 p 404-406.

## Thermodynamics

**092536 THERMODYNAMICS OF Ca-CaF<sub>2</sub> AND Ca-CaCl<sub>2</sub> SYSTEMS FOR THE DEPHOSPHORIZATION OF STEEL.** Calcium is soluble in halide salts which can be used to remove phosphorus from steel as a phosphide ion. The activity and activity coefficient of calcium phosphide and the equilibrium phosphorus distribution ratio between Ca-CaF<sub>2</sub> and Ca-CaCl<sub>2</sub> fluxes and pure solid iron were measured as a function of the Ca composition in the flux at 1350°C, 1400°C, and 1450°C. The Ca-Ca halide fluxes were equilibrated with pure solid iron and a Ag-Ca alloy under an Ar atmosphere. The Ag-Ca alloy was used to maintain a constant chemical potential of calcium. Phosphorus distribution between these fluxes and solid pure iron increased with increasing calcium activity and decreasing temperature. The activity coefficient of γCa<sub>15</sub>P was 36.6 at 1350°C and 11.0 at 1450°C for a calcium activity of 0.2 (wt pct Ca = 2.5) in the Ca-CaF<sub>2</sub>; the activity coefficient increases with increasing Ca in the flux. In addition, the activity of Ca in the Ca-Ca halide fluxes was determined. The equilibrium phosphorus distribution ratio between Ca-Ca halide systems and molten chromium steel was calculated as functions of Cr and C contents of the metal and calcium activity in the flux at 1600°C. This ratio was about 20 for 18 pct Cr stainless steel at 1600°C. (Edited author abstract). 23 Refs.

Masumitsu, N. (Nippon Steel Corp, Jpn); Ito, K.; Fruhan, R.J. *Metall Trans B* v 19 n 4 Aug 1988 p 643-648.

**Thin Films See NICKEL AND ALLOYS—Corrosion.**

## Transport Properties

**092537 COMPLEXATION AND TRANSPORT PROPERTIES IN BINARY GLASS-FORMING MOLTEN CHLORIDE SYSTEMS.** Following a recent study of the contrasting effects of FeCl<sub>4</sub><sup>-</sup> versus CrCl<sub>6</sub><sup>3-</sup> complex anion formation on the transport properties of solutions containing them, we report a study of the intermediate cases of MCl<sub>4</sub><sup>2-</sup> complex formation (M = Co<sup>2+</sup>, Ni<sup>2+</sup>, and Cd<sup>2+</sup>). In these cases an intermediate and unspectacular response is observed, and secondary factors intercede to produce an apparent contradiction between composition-dependent behavior close to, and far from, the glass transition. The contradictions are resolved by recognizing that, in these intermediate cases, the predominant effect of complexation is to produce a decrease in liquid 'fragility'. (Author abstract) 12 refs.

Elias, Anselmo (Univ of Lisbon, Lisbon, Port); Angell, C. Austen. *J Chem Eng Data* v 33 n 1 Jan 1988 p 1-5.

**092538 CORRESPONDING STATES CORRELATION OF TRANSPORT PROPERTIES OF UNIVALENT MOLTEN SALTS.** A law of corresponding states was developed for the transport properties of univalent molten salts with the use of four potential parameters and a characteristic mass. The characteristic mass was defined as m<sub>R</sub> = 2m<sub>A</sub>m<sub>C</sub>/(m<sub>A</sub> + m<sub>C</sub>) or m<sub>S</sub> = {2m<sub>A</sub><sup>1/2</sup>m<sub>C</sub><sup>1/2</sup>}/(m<sub>A</sub><sup>1/2</sup> + m<sub>C</sub><sup>1/2</sup>)<sup>2</sup>, where m<sub>A</sub> and m<sub>C</sub> are anion and cation masses, respectively. The corresponding states correlations were obtained by expanding the autocorrelation functions of the dynamical quantities for the transport properties with the mass difference between the anion and cation. The four-poten-



tial-parameter correlation was applied to the electrical conductivity, viscosity, and self-diffusion coefficient. (Edited author abstract) 17 refs.

Tada, Yutaka (Nagoya Inst of Technology, Nagoya, Jpn); Hiraoka, Setsuro; Uemura, Tomokazu; Harada, Makoto. *Ind Eng Chem Res* v 27 n 6 Jun 1988 p 1042-1049.

Ultrafiltration See MEMBRANES—Applications.

## X-Ray Analysis

**092539 X-RAY STUDY OF THE TRIIODIDE CHAIN DISORDER IN SOME IODIDE ORGANIC SALTS.** One-dimensional iodide organic salts often present a similar organization of triiodide chains embedded in an organic matrix. At room temperature, these chains may present an important structural disorder characterized by the absence of long-range order in the chain direction. As the temperature is lowered, order generally develops, leading to an order-disorder phase transition of an original type. It is illustrated on some compounds by x-ray scattering techniques. (Author abstract) 14 refs.

Albouy, P.A. (Univ Paris Sud, Orsay, Fr); Pouget, J.P.; Strzelecka, H. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 127-136.

**SAMARIUM AND ALLOYS** See Also NEODYMIUM AND ALLOYS—Magnetic Properties; SUPERCONDUCTING MATERIALS—Thermal Properties.

## Amorphous

**092540 PROPERTIES OF AMORPHOUS  $\text{Sm}_x\text{Fe}_{80-x}\text{B}_{20}$  RIBBONS.** Properties of amorphous  $\text{Sm}_x\text{Fe}_{80-x}\text{B}_{20}$  ribbons are investigated. Saturation magnetization and Curie temperature decrease whereas the crystallization temperature increases with increasing samarium content. Saturation magnetostriction varies from  $37 \times 10^{-6}$  for  $x=1$  to  $12 \times 10^{-6}$  for  $x=9$ . The coercivity decreases with decreasing magnetostriction. The domain structure is also studied. (Author abstract) 7 refs.

Idzikowski, B. (Polish Acad of Sciences, Poznan, Pol); Wrzeczono, A. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 375-380.

## Electrodeposition

**092541 ELECTRODEPOSITION OF SAMARIUM.** The electrodeposition of samarium from an aqueous acidic bath onto copper, brass, stainless steel, titanium and tin oxide coated glass substrates is reported. In this study, complexing agents were used to shift the deposition potential to the positive side and stabilize the bath. The complexing agents used were oxalic acid, ammonium thiocyanate, sodium citrate and EDTA. Of these complexing agents, oxalic acid was selected as suitable, since it showed the maximum positive potential shift. 12 refs.

Lokhande, C.D. (Shivaji Univ, Kolhapur, India); Madhale, R.D.; Pawar, S.H. *Met Finish* v 86 n 8 Aug 1988 p 23-25.

**Magnetic Properties** See Also MAGNETIC MATERIALS—Additives.

**092542 INVESTIGATIONS OF THE MAGNETIC PROPERTIES AND DEMAGNETIZATION PROCESSES OF AN EXTREMELY HIGH COERCIVE  $\text{Sm}(\text{Co}, \text{Cu}, \text{Fe}, \text{Zr})_{7.6}$  PERMANENT MAGNET. I. DETERMINATION OF INTRINSIC MAGNETIC MATERIAL PARAMETERS.** The intrinsic magnetic material parameters of the 2:17 type matrix phase and the 1:5 type precipitation phase in sintered multiphase  $\text{Sm}(\text{Co}_{0.68}\text{Fe}_{0.22}\text{Zr}_{0.02})_{7.6}$  permanent magnet was determined in the whole ferromagnetic temperature regime between 10 K and  $T_C = 1070$  K. Magnetization curves measured parallel and perpendicular to the alignment axis are analyzed taking into account the volume fractions of ferromagnetic phases, their magnetostatic interactions, and the angular distribution of grain axes. The influence

of annealing treatments on the intrinsic magnetic properties of the relevant ferromagnetic phases are investigated. (Author abstract) 45 Refs.

Durst, K.-D. (Max-Planck-Institut fuer Metallforschung, Stuttgart, West Ger); Kronmueller, H.; Ervens, W. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 403-416.

## Physical Properties

**092543 NONLINEAR FARADAY AND VOIGT EFFECT IN A  $J=1$  TO  $J'=0$  TRANSITION IN ATOMIC SAMARIUM VAPOR.** Nonlinear modifications of the Faraday- and Voigt effect are observed in the atomic  $^{152}\text{Sm}$   $\gamma=570.68$  nm  $^7F_1-^7F_0$  line due to optically induced Zeeman coherence and optical pumping effects in the  $^7F_1$  Sm ground state. The magneto-optical signals display narrow spectral structures when the external longitudinal or transverse magnetic field is scanned through zero; over a wide angle the amplitudes of the magneto-optical signals show a cubic dependence on laser intensity. Our observations agree with a simple model based on a perturbation treatment for an atomic  $J=1$  to  $J'=0$  transition. (Edited author abstract) 15 refs.

Drake, K.H. (Univ of Hannover, Hannover, West Ger); Lange, W.; Mlynec, J. *Opt Commun* v 66 n 5-6 May 15 1988 p 315-320.

## Radiation Effects

**092544 DESCRIPTION AND ANALYSIS OF AN ACCELERATOR-BASED PRODUCTION METHOD OF THE BRACHYTHERAPY SOURCE  $^{145}\text{Sm}$ .** This paper describes an accelerator-based  $^{145}\text{Sm}$  production method and calculational comparison of the advantages and disadvantages of this method versus a reactor-based method. In particular, the  $^{145}\text{Sm}$  yield and purity will be calculated for the accelerator-based production method and compared with the  $^{145}\text{Sm}$  yield and purity for the reactor-based production method. 9 Refs.

Bluc, Thomas E. (Ohio State Univ, Columbus, OH, USA). *Nucl Technol* v 82 n 3 Sep 1988 p 304-310.

**Spectroscopic Analysis** See Also FLUORESCENCE.

**092545 DISCRIMINATION OF  $\text{Sm}$  CENTERS IN  $\text{ZnS}$  BY SITE SELECTIVE LASER SPECTROSCOPY.** Evidence of seven Sm centers in a  $\text{ZnS:Sm}$ , Li crystal has been found. The relative emission intensities due to different centers depend on exciting laser power. The coupling of the excited states of the rare earth ions to the quasi-continuum of states of the whole complex, where DA pairs may be a part of it, is responsible for the different excitation probabilities observed. 3 refs.

Hommel, D. (AdW der DDR, Berlin, East Ger); Busse, W.; Gumlich, H.-E.; Suisky, D. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 391-392.

**092546 INTERACTION OF  $\text{Sm}^{3+}$  IONS IN BORATE GLASS.** The interaction of  $\text{Sm}^{3+}$  ions in borate glasses doped with different concentration has been investigated. The decay curves become nonexponential when the  $\text{Sm}^{3+}$  concentration is larger than 1 mol%. It can be explained by cross relaxation between  $\text{Sm}^{3+}$  ions. By fitting the experimental data to the model of Inokuti and Hirayama, the cross relaxation has been assigned to be of electric dipole-dipole character (EDD). According to Dexter's theory, the transfer probabilities for four pairs of possible cross relaxation were estimated. The intensity parameters of  $\text{Sm}^{3+}$  in borate glass, which are used in the estimation of transfer probabilities, were calculated by the use of emission spectra. (Author abstract) 5 refs.

Zhang, Zhilin (Shanghai Univ of Science & Technology, Shanghai, China); Jiang, Xueyin; Li, Zhuoting; Wu, Peifang; Xu, Shaohong. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 657-658.

**SAMARIUM COBALT ALLOYS** See Also MAGNETS—Powder Metal.

**Amorphous** See Also MAGNETIC MATERIALS—Thin Films.

**092547 GALVANOMAGNETIC EFFECTS IN  $\text{Sm-Co}$  AMORPHOUS MAGNETIC FILMS.** Galvanomagnetic effects in  $\text{Sm-Co}$  amorphous magnetic films are discussed. In films with in-plane magnetization, resistivity rose gradually with the Sm concentration, while the Hall resistivity, Hall sensitivity, and Hall voltage peaked around 15 atm% Sm and gradually declined. In perpendicular magnetization films, both the Hall resistivity and Hall sensitivity decreased as the Sm content increased. In both perpendicular and in-plane magnetization film, the Kerr rotation angle decreased as the Sm concentration increased. 3 refs.

Li, Z.Y. (Huazhong Univ of Science & Technology, China); Zhang, L.J.; Sakurai, Y. *IEEE Transl J Magn Jpn* v TJMJ-2 n 5 May 1987, Contrib from the 9th Annu Conf on Magn in Jpn, Jpn, Nov 26-29 1985 p 467-468.

**Magnetic Properties** See MAGNETIC MATERIALS—Thermal Effects; MAGNETS—Materials.

**Phase Transitions** See RARE EARTH ELEMENTS—Microstructure.

## Synthesis

**092548 STRUCTURE FORMATION IN ALLOYS OF THE SAMARIUM-COBALT SYSTEM OBTAINED BY THE DIRECT-REDUCTION METHOD.** The existence of  $\text{Sm}_2\text{Co}_{19}$  phases in powders obtained by both the direct-reduction method and by crushing ingots of an alloy of the pure components is reliably established. It is shown that during the diffusion of samarium into the cobalt particles the formation of  $\text{Sm}_2\text{Co}_7$  and  $\text{Sm}_2\text{Co}_{19}$  phases is preceded by a state of short-range ordering of the shear planes. It is ascertained that the radial crystalline texture in the outer layers of the powder obtained by direct reduction coincides with the 001 direction of the lattice, and an assumption is made concerning the mechanism of formation of this texture. On the basis of a comparative phase analysis of the compositions of the powders obtained by the two methods, it is established that alloys obtained by reduction are closer to a two-phase state than ingots of alloys of the pure components. In Russian. 5 refs.

Lebedev, G.A.; Livshits, B.G.; Taranov, O.G.; Agreev, A.V. *Izv Vyssh Uchebn Zaved Chern Metall* n 5 1987 p 95-100.

**SAMARIUM COBALT IRON BORON ALLOYS**

## Magnetic Properties

**092549 HARD MAGNETIC PROPERTIES OF THE RAPIDLY QUENCHED  $\text{Sm}(\text{Co-Fe-B})_5$  ALLOY RIBBONS.** The structure and hard magnetic properties of the rapidly quenched  $\text{SmCo}_{5-x}\text{B}_x$  ( $0 \leq x \leq 1$ ) and  $\text{Sm}(\text{Co}_{1-x}\text{Fe}_x)_2\text{B}$  ( $0 \leq x \leq 0.74$ ) alloy ribbons fabricated under various quenching rates were systematically examined. Metastable states, such as  $\text{CaCu}_2$  type disordered structure and amorphous state were found in a wide composition range,  $0.6 \leq x \leq 1.0$  for  $\text{SmCo}_{5-x}\text{B}_x$  and  $0 \leq x \leq 0.5$  for  $\text{Sm}(\text{Co}_{1-x}\text{Fe}_x)_2\text{B}$  in the ribbons fabricated under high quenching rate. The maximum value of  $H_c$  ( $> 18 \text{ kOe}$ ) was obtained for ribbons which consist of the  $\text{CaCu}_2$  disordered structure as a single phase. It was concluded that the formation of  $\text{CaCu}_2$  type disordered  $\text{Sm}(\text{Co-Fe-O})_5$  compound with high Fe and low B content was considered to be effective to improve the hard magnetic properties of  $\text{Sm-Co}$  based alloys. (Edited author abstract) 5 refs.

Saito, H. (Tohoku Univ, Sendai, Jpn); Takahashi, M.; Wakiyama, T. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2725-2727.



## SAMARIUM COBALT IRON COPPER ALLOYS

## Magnetic Properties

**092550 EFFECTS OF Zr CONTENT ON PHASE TRANSFORMATION AND MAGNETIC PROPERTIES OF  $\text{Sm}(\text{Co}, \text{Cu}, \text{Fe}, \text{Zr})_{7-9}$  MAGNET ALLOYS.** Sm-Co-7.0 at%Cu-22.0 at%Fe- (0.1, 4.2, 0 and 3.0 at%) Zr sections of the phase diagram were determined in the Sm content range from 6 to 16 at% above 1073 K. Addition of Zr by 1.4 or 2.0 at% expands the Sm solubility in the 2/17 phase towards both the richer and poorer side and changes the crystal structure to  $\text{TbCu}_7$  and/or  $\text{Th}_2\text{Ni}_{17}$  type at high temperature. Addition of Zr by 3.0 at% expands the (2/17+2/7) phase region which has the  $\text{TbCu}_7$  and/or  $\text{Th}_2\text{Ni}_{17}$  type structure(s).  $\text{Sm}(\text{Co}, \text{Cu}, \text{Fe}, \text{Zr})_2$  alloys possess high coercivity when homogenized with  $\text{TbCu}_7$  (Zr 1.4 and 2.0%) at high temperature and decompose into the 2/17 phase with  $\text{Th}_2\text{Ni}_{17}$  type structure and 1/5 phase with  $\text{CaCu}_5$  type structure by aging treatment. (Edited author abstract) 15 refs. In Japanese.

Morita, Yoshio (Univ of Tokyo, Tokyo, Jpn); Umeda, Takateru; Kimura, Yasuo. *Nippon Kinzoku Gakkaishi* v 52 n 2 Feb 1988 p 243-250.

## SAMARIUM COBALT ZIRCONIUM ALLOYS

**092551 CELLULAR MICROSTRUCTURE DEVELOPMENT IN  $\text{Sm}(\text{Co}, \text{Fe}, \text{Cu}, \text{Zr})_{8.35}$  ALLOYS.** TEM studies of Zr-containing 2:17-type permanent magnet alloys show that the cellular microstructure develops from a high temperature 2:17R phase, first by the precipitation of Sm-depleted, Zr-rich '2:17H' platelet phase, then by the precipitation of Cu-rich, Fe- and Zr-depleted '1:5' boundary phase. These results are supportive of, but also suggest refinements to, a model proposed earlier for the metallurgical behavior of these alloys. (Author abstract) 14 refs.

Ray, A.E. (Univ of Dayton, OH, USA); Soffa, W.A.; Blachere, J.R.; Zhang, B. *IEEE Trans Magn* v MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 2711-2713.

## Magnetic Properties

**092552 EFFECT OF ZIRCONIUM ON STABILIZATION FOR THE 1-7 PHASE IN 2-17 TYPE Sm-Co PERMANENT MAGNET.** The 2-17 type rare earth permanent magnets show high coercivity only when they are subjected to aging after solution treatment. It is necessary for obtaining high coercivity that they are in a single 1-7 phase region at the solution temperature. In the present study, an isothermal phase diagram in the Sm-Zr-Co ternary system at 1473 K close to the solution temperature was constructed in order to investigate the extent of composition ranges stable for the 1-7 phase due to Zr addition. The behavior of the Zr atom in the 1-7 phase was investigated. The Zr addition may extend the stable 1-7 phase region to a higher Co content. Zr atom dissolved in the 1-7 phase seems to substitute either a pair of Co atoms occupying a dumbbell site or a single Sm atom involved in the 1-7 phase. (Edited author abstract). 14 Refs. In Japanese.

Nishio, Takayuki (Nagoya Univ, Nagoya, Jpn); Fukui, Yasuji; Iwama, Yoshiro. *Nippon Kinzoku Gakkaishi* v 52 n 5 May 1988 p 502-507.

## SAMARIUM COMPOUNDS See Also INTERMETALLICS; INTERMETALLICS—Microstructure; RARE EARTH COMPOUNDS; SUPERCONDUCTING MATERIALS.

**092553 INFLUENCE OF ZIRCONIUM ON  $\text{Sm}(\text{Co}, \text{Fe}, \text{Cu}, \text{Zr})_{7.2}$  ALLOYS FOR PERMANENT MAGNETS. II: COMPOSITION AND LATTICE CONSTANTS OF THE PHASES IN HEAT-TREATED MATERIALS.** Specimens of composition  $\text{Sm}(\text{Co}_{0.69}\text{Fe}_{0.22}\text{Cu}_{0.06}\text{Zr}_{0.03})_{7.2}$  were submitted to either long

annealing at 1160-850°C or heat treatments similar to those applied to magnetic materials. The composition and lattice constants of the phases in the specimens were determined by electron-probe analysis and X-ray diffraction. Under equilibrium conditions, a mixture of 2:17R, 2:17H, 2:7 is stable at 1160-1000°C. At 850°C, a mixture of 2:17R, 2:7R, 5:19 is found. Apart from these phases, a 1:3 phase is present in specimens treated like permanent magnetic alloys. Iron is mainly distributed in 2:17, copper replaces cobalt in 2:7, zirconium replaces samarium and induces the precipitation of phases of the series  $\text{Sm}_{n+1}\text{Co}_{5n-1}$ , at the expense of 1:5. The higher the zirconium content, the lower the n of the phase precipitated. (Edited author abstract) 21 refs.

Derkaoui, S. (CNRS, St. Martin d'Heres, Fr); Allibert, C.H.; Delannay, F.; Laforest, J. *J Less Common Met* v 136 n 1 Dec 1987 p 75-86.

## Amorphous See GLASS—Elasticity.

## Dielectric Properties

**092554 TEMPERATURE DEPENDENCE OF THE DIELECTRIC CONSTANT IN SAMARIUM NITRATE CRYSTALS.** Automatic measurement is reported of the temperature dependence of ac impedance of the crystal at 1 kHz by using a digital two-phase lock-in amplifier (NF Electronic Instrum., 5610) and a  $\mu$  computer (NEC PC9801 E) at an applied voltage of 300 mV. The single crystals of samarium nitrate were grown from a saturated solution by evaporation at 26°C for 14 days. Specimens were prepared by cutting the crystal parallel to the (001) plane. 8 Refs.

Kawashima, R. (Inst of Technology, Muroran, Jpn); Matsuda, T. *Phys Status Solidi A* v 108 n 1 Jul 1988 p K73-K75.

## Magnetic Properties

**092555 MAGNETIC PROPERTIES OF  $\text{SmMn}_2\text{Ge}_2$  COMPOUNDS.** The magnetic characteristics of  $\text{SmMn}_2\text{Ge}_2$  compounds have been studied by measurements of ac susceptibility, magnetization, electrical resistivity and X-ray diffraction; the p-T diagram has also been determined. With decreasing temperature the phase transitions occur in the following sequence, ferromagnetism is observed in the temperature region of 153 K < T < 341 K, antiferromagnetism becomes stable for 106.5 K < T < 153 K and re-entrant ferromagnetism appears below 106.5 K. The observed magnetic phase transitions correspond with the change of the lattice parameters. In the antiferromagnetic phase the magnetic field  $H \approx 6$  kOe induces the transition into the ferromagnetic phase. The pressure dependence of the phase transition temperatures was also observed. (Author abstract). 12 Refs.

Duraj, M. (Technical Univ of Cracow, Cracow, Pol); Duraj, R.; Szytula, A.; Tomkowicz, Z. *J Magn Magn Mater* v 73 n 2 Jun 1988 p 240-246.

**092556 CRYSTAL STRUCTURE AND MAGNETIC PROPERTIES OF  $\text{Sm}_3\text{Fe}_{20}\text{C}_x$  INTERMETALLIC COMPOUNDS.** When  $x < 1.0$ , the main phase of  $\text{Sm}_3\text{Fe}_{20}\text{C}_x$  compounds is rhombohedral, which is very close to  $\text{Sm}_2\text{Fe}_{17}$  and it becomes tetragonal when  $x < 1.0$ . The carbon atoms preferentially occupy the empty 3a sites of  $\text{Sm}_2\text{Fe}_{17}$  leading to the increase in the lattice constants and Curie temperature. (Author abstract) 4 refs.

Luo, Sheng (Beijing Univ of Iron & Steel Technology, Beijing, China); Zhang, Guowei; Liu, Zhihui; Pei, Xiedi; Jiang, Wei; Ho, Wenwang. *J Magn Magn Mater* v 70 n 1-3 Dec 1 1987, Proc of the Int Symp on Magn of Internet Compd, Kyoto, Jpn, Apr 20-22 1987 p 311-312.

## Phase Transitions See NEODYMIUM COMPOUND—Phase Transitions.

## Structure

**092557 INFLUENCE OF THE STRUCTURAL NATURE OF SAMARIA ON ITS BEHAVIOUR**

AGAINST ATMOSPHERIC  $\text{CO}_2$  AND  $\text{H}_2\text{O}$ . This work reports on the behavior in air of a monoclinic sample of samaria, prepared in our laboratory. The results, which support the existence of a close relationship between the structural nature of the samarium sesquioxides and their evolution in air, allow us to interpret the strong differences of behavior found by us between two commercial samples of  $\text{Sm}_2\text{O}_3$  from different suppliers. (Author abstract) 17 refs.

Bernal, S. (Facultad de Ciencias, Cadiz, Spain); Botana, F.J.; Garcia, R.; Rodriguez-Izquierdo, J.M. *Mater Lett* v 6 n 3 Dec 1987 p 71-74.

## Synthesis

**092558 SYNTHESIS AND STRUCTURAL STUDY OF SAMARIUM HEXACYANOFERRATE (III) TETRAHYDRATE,  $\text{SmFe}(\text{CN})_6 \cdot 4\text{H}_2\text{O}$ .** Single crystals of  $\text{SmFe}(\text{CN})_6 \cdot 4\text{H}_2\text{O}$  prepared from an aqueous solution under ambient conditions have been used for single-crystal diffraction, thermal gravimetric analysis, and infrared spectrometric studies. This characterized compound is compared to previously reported  $\text{LnT}(\text{CN})_6$  (T = Cr, Fe, Co) structures. Samarium hexacyanoferrate (III) tetrahydrate is found to be monoclinic, not hexagonal or orthorhombic as presupposed.  $\text{SmFe}(\text{CN})_6 \cdot 4\text{H}_2\text{O}$  crystallizes in space group  $\text{P2}_1/\text{m}$  (No. 11),  $a = 7.431(1)$ ,  $b = 13.724(3)$ ,  $c = 7.429(2)$  Angstrom,  $\beta = 119.95(1)^\circ$ ,  $Z = 2$ . Full-matrix least-squares refinement has yielded the final values of  $R = 0.0292$  and  $R_w = 0.0296$  for 1028 unique reflections. The observed and calculated densities are 2.198(3) and 2.197  $\text{Mg m}^{-3}$ , respectively. (Edited author abstract) 20 refs.

Mullica, D.F. (Baylor Univ, Waco, TX, USA); Perkins, Herbert O.; Sappenfield, E.L.; Grossie, David A. *J Solid State Chem* v 74 n 1 May 1988 p 9-15.

## Thermal Properties

**092559 STRUCTURAL AND THERMAL PROPERTIES OF  $(\text{Sm}_{1-x}\text{Nd}_x)_2(\text{Z})_3$ .** The authors carried out studies of structural, thermal, and electrical properties of a series of mixed rare earth molybdates with varying compositions. The present communication on  $(\text{Sm}_{1-x}\text{Nd}_x)_2(\text{MoO}_4)_3$  is part of the study. X-ray structural studies, differential thermal analysis (DTA) and thermogravimetric analysis were carried out. The X-ray diffraction powder patterns of pure and Nd-substituted  $\text{Sm}_2(\text{MoO}_4)_3$  are shown. 16 Refs.

Roy, M. (Indian Inst of Technology, Kharagpur, India); Chowdhury, R.N.P.; Acharya, H.N. *Phys Status Solidi A* v 107 n 1 May 1988 p K1-K5.

**092560 X-RAY AND THERMAL PROPERTIES OF  $(\text{Sm}_{1-x}\text{Gd}_x)_2(\text{MOO}_4)_3$ .** The authors have carried out systematic studies of the structural, electrical and thermal properties of ferroelectric-ferroelastic  $(\text{Sm}_{1-x}\text{Gd}_x)_2(\text{MoO}_4)_3$  with varying concentration x. The present letter is part of these studies. X-ray powder diffractograms were recorded with  $\text{Cu-K}\alpha$  radiation. The peak positions and diffraction angles were determined for calculating the interplanar spacings (d-values) and lattice parameters. To study the reaction kinetics and phase transition mechanism of the pure  $\text{Sm}_2(\text{MoO}_4)_3$  and mixed  $(\text{Sm}_{1-x}\text{Gd}_x)_2(\text{MoO}_4)_3$  with various gadolinium concentrations levels. Differential thermal analysis (DTA) and thermogravimetric analysis (TGA) were carried out. 11 Refs.

Roy, M. (Indian Inst of Technology, Kharagpur, India); Choudhary, R.N.P.; Acharya, H.N. *J Mater Sci Lett* v 7 n 7 Jul 1988 p 769-771.

## Vaporization

**092561 THERMODYNAMICS OF VAPORIZATION OF SAMARIUM(II) TELLURIDE AND YTTERBIUM(II) TELLURIDE: A DISCUSSION OF THE THERMOCHEMISTRY OF THE DIVALENT LANTHANOID AND ALKALINE EARTH TELLURIDES.** The congruent vaporization of the solid monotellurides of ytterbium and samarium, both of practically



stoichiometric composition, was studied over the temperature ranges 1606-1764 and 1732-1922 K, respectively, by the Knudsen effusion weight-loss technique. Using enthalpy and entropy data from the literature for gaseous  $\text{LnTe}$ ,  $\text{Ln}$ ,  $\text{Te}_2$ , and  $\text{Te}$ , and estimated data for solid  $\text{LnTe}$  ( $\text{Ln}=\text{Yb}, \text{Sm}$ ) it could be concluded from thermodynamic calculations that within the given temperature ranges  $\text{Ln}$  and  $\text{Te}$  are the principal vapor species and that  $\leq 2.8$  and  $\leq 0.9$  mol percent of the vapor is present as  $\text{YbTe}$  and  $\text{SmTe}$ , respectively. (Edited author abstract) 18 Refs.

Petzelt, T. (Univ der Bundeswehr Hamburg, Hamburg, West Ger); Ludwigs, J. *High Temp Sci* v 24 n 2 Oct 1987 p 79-91.

## SAMARIUM IRON NICKEL BORON ALLOYS See MAGNETS.

## SAMARIUM NEODYMIUM CERIUM ALLOYS See MAGNETIC MATERIALS.

## SAMARIUM TITANIUM IRON ALLOYS See RARE EARTH ELEMENTS—Magnetic Properties.

**SAMPLING** See Also AIR POLLUTION—Air Quality; CONTROL SYSTEMS, SAMPLED DATA—Estimation; DATA CONVERSION, ANALOG TO DIGITAL; DATA CONVERSION, ANALOG TO DIGITAL—Testing; DIESEL ENGINES—Valves; DIGITAL COMMUNICATION SYSTEMS—Computer Simulation; DIGITAL COMMUNICATION SYSTEMS—Voice Data Integrated Services; FOSIL FUELS—Testing; GEOLOGY—Dating; HOUSES—Energy Utilization; ION BEAMS—Applications; LOGIC CIRCUITS—Analysis; MATHEMATICAL STATISTICS—Estimation; MATHEMATICAL TECHNIQUES—Estimation; MATHEMATICAL TECHNIQUES—Sampling; MEASUREMENT ERRORS, NITROGEN COMPOUNDS—Environmental Testing; PAPERMAKING—Quality Control; RELIABILITY THEORY; SOILS—Classification; STATISTICAL METHODS; STATISTICAL METHODS—Time Series Analysis; STRUCTURAL ANALYSIS.

**092562 COMPOSITE OPERATING CHARACTERISTICS OF SAMPLING SYSTEMS WITH RULES OF SEVERITY ADJUSTMENT AND DISCONTINUING INSPECTION.** A key to the analysis of composite operating characteristics of sampling systems having normal, tightened, and reduced plans together with an entire switching procedure involving discontinuing inspection lies in determining the expected proportion of the lots inspected under the various plans. Traditional means employed in such cases are the methods of Markov chain or computer simulation. In this paper, an expression of the expected proportion of lots inspected under various plans is developed by using the method of a uni-variable generating function, a departure from the traditional methods mentioned above. As the discontinuing inspection can be switched to other objects of inspection, the composite operating characteristics of the sampling system are studied with rules of severity adjustment and discontinuing inspection. (Edited author abstract) 5 refs. In Chinese.

Tang, Guoqing; Zhang, Weiji. *Bingong Xuebao* v 2 n 3 Aug 1987 p 66-72.

**092563 RAPID GENERATION OF FREQUENCY TABLES.** This paper is concerned with situations where random samples of size  $n$ , from a discrete distribution, are required in the form of frequency tables rather than as streams of  $n$  individual variables. Instead of constructing each table by generating  $n$  observations and collecting them together, each table is generated directly by regarding it as a single sample from a multinomial distribution whose index is  $n$  and whose probabilities are those of the target distribution placed in decreasing order of magnitude. Sampling is achieved by a series of conditional binomial generations using a fast 'variable-parameter' algorithm. Results are presented which show that the new direct procedure is generally far faster than the standard indirect procedure using the very fast alias method to generate individual observations. Extensions to bivariate discrete distributions and to continuous distributions are noted. (Edited author abstract) 13 refs.

Kemp, C.D. (Univ of St. Andrews, Scotl); Kemp,

Adrienne W. *Appl Stat* v 36 n 3 1987 p 277-282.

**092564 MUTUAL INFORMATION, ESTIMATION IN THE SAMPLING WITHOUT REPLACEMENT.** The aim of the present paper is to approach the value of the mutual information of order  $\beta=2$  in a large population on the basis of a sample drawn at random and without replacement from it. This purpose is achieved by obtaining an unbiased estimator of that value and estimating its mean square error. In addition, a contrast between samplings with and without replacement shows that the second one entails an improvement in the estimation precision with respect to the first one. Finally, we discuss the suitability of adopting the measure of order  $\beta=2$ . (Edited author abstract) 39 refs.

Gil, Maria Angeles; Perez, Rigoberto; Gil, Pedro. *Kybernetika* v 23 n 5 1987 p 407-419.

**092565 ZERO ACCEPTANCE SAMPLING PLANS: EXPECTED COST INCREASES.** The cost of sampling has led practitioners and researchers to search for sampling procedures that require small sample sizes, but still afford adequate consumer and producer protection. The zero acceptance number single sampling plans proposed by N.L. Squeglia were meant to provide equal or greater consumer protection with less inspection than the corresponding MIL-STD-105D sampling plans. Practitioners who are being pressured to use  $C=0$  acceptance sampling plans to leave the impression of total conformance to product specifications should exercise extreme caution. If one were to use the Squeglia  $C=0$  plans, unless the true process percent defective is substantially better than the specified AQL, total inspection cost will be significantly higher. 7 refs.

Baker, R.C. (Univ of Texas, Arlington, TX, USA). *Qual Prog* v 21 n 1 Jan 1988 p 43-46.

**092566 SAMPLING PLAN.** A computer program is developed to construct sampling plans based on the binomial distribution. The paper assumes prior knowledge of acceptance sampling concepts and presents a computer program written in BASIC on IBM PCXT for this purpose.

Alborzi, M. (Abadan Inst of Technology, Abadan, Iran). *Comput Math Appl* v 15 n 2 1988 p 153-157.

**092567 SAMPLING THEOREM AND WINTNER'S RESULTS ON FOURIER COEFFICIENTS.** The present paper arises from the reconsideration, aimed towards a sampling theorem, of a book on Fourier series by A. Wintner. The idea of this book was to obtain precise formulae for the Fourier coefficients of a function from a countable set of its values on the unit circle. 9 Refs.

Schiff, J.L. (Univ of Auckland, Auckland, NZ); Walker, W.J. *J Math Anal Appl* v 133 n 2 Aug 1 1988 p 466-471.

**092568 ANTI-THETIC-VARIATE SPLITTING FOR STEADY-STATE SIMULATIONS.** Obtaining precise estimates of parameters of infinite-horizon or steady-state simulations can be expensive because of the need to discard initial outputs to mitigate the effects of initial condition. We consider splitting independent replications at the point of output truncation into dependent replications to reduce point estimator variance and/or simulation cost. The results indicate that antithetic-variate splitting can be more effective than the classical antithetic-variate estimator in steady-state simulations where antithetic sampling is effective. It is essential to design the simulation experiment so that negative correlation induced between processes is preserved in the output processes. Three key factors in the design are: method of input process generation; synchronization of random number streams; and monotonicity of the input-output transformations. (Edited author abstract) 14 Refs.

Nelson, Barry L. (Ohio State Univ, Columbus, OH, USA). *Eur J Oper Res* v 36 n 3 Sep 1988 p 360-370.

**092569 COMETARY DUST SIZING: COMPARISON BETWEEN OPTICAL AND IN-SITU SAMPLING TECHNIQUES.** We try to evaluate the level of

confidence that can be placed in the optical methods available for sizing cometary dust (and, at the same time, deriving all its other characteristics). We use for this purpose the new informations provided by the in-situ sampling of Comet Halley dust. We try to determine whether data from this origin are compatible with visible and I.R. spectra of this comet acquired from the Earth, and with earlier interpretations of such spectra. We find that, as happens frequently when remote sensing and local sampling techniques data can be compared, none of these techniques can claim to be fully satisfactory. In the case of cometary dust, current estimates based on optical sizing only may be much less accurate than previously assumed. Improvements in the observational approaches appear needed, as well as new laboratory investigations and theoretical developments to improve the capabilities of the optical studies of cometary dust. (Author abstract) 40 Refs.

Crifo, Jean Francois (CNRS, Fr). *Part Part Syst Charact* v 5 n 1 Mar 1988 p 38-46.

**092570 SELECTIVE SAMPLING METHOD MADE EASY.** While in the usual form of the selective sampling method a speed converter is required, we propose here a version, called blind sampling, which involves only time delays, gates and scalars. Apart from its simplicity, it also allows us to use shorter measuring times. An intermediate arrangement (one-eyed sampling), which shares the advantages of both the lucid and the blind versions, is also explained. A detailed description of the necessary electronic arrangements can be found in Rapport BIPM-85/14, and we plan to publish some recent developments in an appropriate journal. (Author abstract)

Mueller, Joerg W. (Bur Int des Poids et Mesures, Sevres, Fr). *Appl Radiat Isot* v 38 n 10 1987, Tech in Radionuclide Metrol, Proc of an ICRM Semin, Rome, Italy, Jun 15-16 1987 p 885.

**092571 RISK-WEIGHTED STRATEGY OF STATISTICAL SAMPLING.** Traditionally, sampling plans have been based either on randomized sampling or have relied on best engineering judgment. Here, a new strategy is proposed using differences in the risks associated with different units of the sampling set (e.g., a waste barrel, a unit surface at a work or contamination site) to influence the frequency of sampling. This results in a sampling plan which, unlike conventional random sampling, can form the basis for tests involving risk considerations. Sampling rates are higher for units which pose a higher risk, while maintaining a sufficient rate for units with a much smaller risk. This strategy is presented here in a general form and examples are given in the area of transport and disposal of nuclear waste. (Author abstract) 6 refs.

Seiler, Fritz A. (Lovelace Biomedical and Environmental Research Inst, Albuquerque, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 129-133.

**Analysis** See Also CLAY—Consolidation.

**092572 SAMPLING VARIANCE: BIAS AND REPRODUCIBILITY.** Product quality necessitates the collection of a representative sample for analysis. The representativeness of a sample is measured by its accuracy or variance. Sampling variance is discussed in two parts, bias and reproducibility. Bias is an error that consistently results in either high or low analysis. Test methods for bias are described in detail. Reproducibility is a measure of expected fluctuation around the true result. Reproducibility can be reduced by additional increments, analysis, or both. (Author abstract)

Savage, K.I. (Commercial Testing & Engineering Co, Lombard, IL, USA). *J Test Eval* v 16 n 1 Jan 1988 p 94-104.



**Applications** See AEROSOLS—Atmospheric; CONTROL SYSTEMS, NONLINEAR—Robustness.

### Computer Applications

**092573 EFFICIENT ALGORITHM FOR DRAWING A SIMPLE RANDOM SAMPLE.** A procedure is described which allows the selection of a simple random sample of size  $n$  from a list of  $N$  items, where  $N$  is unknown, and only  $2n$  independent, uniform deviates are required. (Author abstract) 2 refs.

Pinkham, R.S. (Stevens Inst of Technology, Hoboken, NJ, USA). *Appl Stat* v 36 n 3 1987 p 370-372.

**Efficiency** See AEROSOLS—Atmospheric.

**Equipment** See CEMENT PLANTS—Pilot Plants; COAL—Sampling.

**Grain Size and Shape** See SOILS—Denitrification.

**Instruments** See AEROSOLS—Sampling; AIR POLLUTION—Indoor; METEOROLOGY—Fog; ORGANIC COMPOUNDS—Environmental Testing; SOILS—Deformation.

### Mathematical Models

**092574 IMPLEMENTATION OF STRATIFIED SAMPLING FOR MONTE CARLO APPLICATIONS.** Stratified sampling is a method used in Monte Carlo calculations to take advantage of certain known aspects of probability distributions. The sampling region is subdivided into discrete subregions, and each of these is sampled a preassigned number of times. A form of stratified sampling has been implemented into a major Monte Carlo particle transport computer code with very encouraging results. (Author abstract) 12 refs.

Brown, Robert S. Jr. (Univ of Arizona, Tucson, AZ, USA); Hendricks, John S. *Nucl Sci Eng* v 97 n 3 Nov 1987 p 245-248.

**Optimization** See Also WATER RESOURCES—Management.

**092575 OPTIMUM SAMPLING PLANS BASED ON POST-QUALITY CONTROL RELIABILITY.** The effect of variables sampling quality control (QC) on the probability distributions of controlled variables is considered. The resultant filtration effect is shown to be a factor in the determination of post-QC reliability for components, etc., defined by the above variables. A cost optimization procedure is suggested, balancing extra cost of sampling and rejection against reduced cost of failure or defect, leading to the possibility of determining an optimum sampling plan for a given application. (Author abstract) 17 refs.

Parkinson, D.B. (Univ of Liverpool, Liverpool, Engl). *Reliab Eng Syst Saf* v 21 n 1 1988 p 59-75.

### Planning

**092576 OPTIMAL BAYESIAN SINGLE-SAMPLING ATTRIBUTE PLANS WITH MODIFIED BETA PRIOR DISTRIBUTION.** In this article we study the properties of the optimal Bayesian single-sampling plans when the prior distribution of the lot fraction defective is modified Beta, which has been found useful in the analysis of inspection schemes for complex production systems. These properties are used to devise an improved and more efficient algorithm for the determination of the optimal sampling plans. Numerical examples are presented to illustrate the potential computational savings of the algorithm. (Author abstract) 23 refs.

Tagaras, George (Univ of Pennsylvania, Philadelphia, PA, USA); Lee, Hau L. *Nav Res Logist* v 34 n 6 Dec 1987 p 789-801.

**Protection** See SAND AND GRAVEL—Testing.

**Stability** See CONTROL SYSTEMS, DIGITAL—Transients.

**Theory** See Also INFORMATION THEORY—Data Compression; SIGNAL PROCESSING.

**092577 IRREGULAR SAMPLING THEOREM FOR FUNCTIONS BANDLIMITED IN A GENERALIZED SENSE.** It is shown that a well-known irregular sampling formula for ordinary bandlimited functions is also valid for functions bandlimited in a generalized sense, except for some necessary modifications. (Author abstract) 5 refs.

Seip, Kristian (Univ of Trondheim, Trondheim, Norw). *SIAM J Appl Math* v 47 n 5 Oct 1987 p 1112-1116.

**092578 ON THE APPLICATION OF AN OPTIMAL SPLINE SAMPLING THEOREM.** In this article, linear combinations of B-spline are presented which are a suitable substitute of the sinc-function in the classical sampling theorem. The advantage is that in practical applications no truncation error occurs; further, the number of samples needed is extremely small, and the signal need not be assumed to be bandlimited. Finally, this method is illustrated graphically and numerically for some testfunctions. (Author abstract) 34 refs.

Engels, W. (Technische Hochschule Aachen, Aachen, West Ger); Stark, E.L.; Vogt, L. *Signal Process* v 14 n 3 Apr 1988 p 225-236.

**SAND AND GRAVEL** See Also EMBANKMENTS—Foundations; FLOW OF FLUIDS—Transport Properties; FLOW OF WATER—Suspensions; FOUNDATIONS—Piles; FOUNDATIONS—Settlement; ICE—Friction; MORTAR—Physical Properties; OFFSHORE STRUCTURES—Protection; PILES; PILES—Structural Analysis; PILES—Testing; RIVERS—Friction; SEWAGE TREATMENT—Septic Tanks.

**092579 COUNTERMEASURE FOR SAND LIQUEFACTION: 'GRAVEL DRAINS METHOD'.** The gravel drain method aims to prevent sandy soil from liquefying by constructing gravel piles in the ground to disperse pore water pressure caused when an earthquake occurs. In designing gravel drains, adequate evaluation of the soil constant and the selection of a highly permeable, choke free gravel are important. The authors propose a selection standard after having made experimental studies. A compaction rod type machine for the construction of gravel drain piles causes low levels of vibration and noise and will not disturb the peripheral ground during its use. 14 refs.

Saito, Akira (Nippon Kokan KK, Jpn); Tagawa, Kengo; Tamura, Toru; Oishi, Hiroshi; Nagayama, Hideaki; Shimaoka, Hisatoshi. *Nippon Kokan Tech Rep Overseas* n 51 Dec 1987 p 46-52.

**092580 PROCESSES PRODUCING NORTH AMERICA'S EAST COAST SAND AND GRAVEL RESOURCES: A REVIEW.** Requirements for large volumes of aggregate exist and are expected to expand. Marine deposits of sand and gravel are one such source. The Continental Shelf off the east coast of North America is largely covered by subthoquartzitic to arkosic sands with a few isolated gravel deposits. Coastal processes, which are largely responsible for the form and character of granular sediments in this region are discussed. 160 refs.

Stubblefield, W.L. (Nat'l Sea Grant Coll Program, Rockville, MD, USA); Duane, D.B. *Mar Min* v 7 n 2 1988 p 89-122.

**092581 ANALYTICAL AND MODEL STUDIES OF REINFORCEMENT OF A LAYER OF GRANULAR FILL ON A SOFT CLAY SUBGRADE.** The effectiveness of geogrid reinforcement, placed at the base of a layer of granular fill on the surface of soft clay, has been studied by small-scale model tests in the laboratory. In the tests, monotonic loading was applied by a rigid footing, under plane strain conditions, to the surface of reinforced and unreinforced systems, using a range of fill thicknesses and

subgrade strengths. Continuous measurements were made of footing load and footing displacement, and deformations of the subgrade and of the geogrid reinforcement were measured from photographs. From these measurements the different mechanisms of failure in the unreinforced and reinforced system were established. A finite element computer program has been specially formulated to allow inclusion of a thin reinforcing layer, and to handle correctly the large deformations and strains induced in the physical models. (Edited author abstract) 16 refs.

Love, J.P. (Oxford Univ, Oxford, Engl); Burd, H.J.; Milligan, G.W.E.; Houlsby, G.T. *Can Geotech J* v 24 n 4 Nov 1987 p 611-622.

**092582 EFFECTS OF REINFORCING ELEMENTS ON THE BEHAVIOR OF WEAKLY CEMENTED SANDS.** Plane strain test results from weakly cemented sand samples with various types of reinforcement inclusions are reported. Mesh and anchored fibre types of reinforcements are shown to more than double the plane strain shear strength of a 33:1 sand-cement mixture. Other types of inclusions were not as effective, with some actually producing a strength decrease. All inclusions increased the ductility of this weakly cemented sand, allowing the material to absorb strains of 4-6 percent rather than the 0.5-1 percent of failure strain in the unreinforced material. The application of reinforcements to cemented tailings used for mine backfill is briefly discussed. (Author abstract) 3 refs.

Li, Loretta (Queen's Univ, Kingston, Ont, Can); Mitchell, Robert. *Can Geotech J* v 25 n 2 May 1988 p 389-395.

### Anisotropy

**092583 EFFECTS OF INITIAL ANISOTROPIC FABRIC AND  $\sigma_2$  ON STRENGTH AND DEFORMATION CHARACTERISTICS OF SAND.** A laboratory investigation has been carried out into the effects of initial anisotropic fabric and  $b = (\sigma'_2 - \sigma'_3) / (\sigma'_1 - \sigma'_3)$  on the strength and deformation characteristics of air-pluviated Toyoura sand. Drained tests in triaxial compression ( $b = 0.0$ ), in plane strain compression ( $b = 0.2$  approximately) and in triaxial extension ( $b = 1.0$ ) were performed at different directions of principal stresses with respect to the deposition direction. The strength in triaxial extension was found to be strongly influenced by failure modes. The inherent anisotropy in strength and the effects of both the parameter  $b$  and the failure mode on strength are portrayed in the form of a three dimensional surface. (Edited author abstract) 28 refs.

Lam, Woon-Kwan (Univ of Tokyo, Jpn); Tatsuoaka, Fumio. *Soils Found* v 28 n 1 Mar 1988 p 89-106.

**Applications** See OIL WELL PRODUCTION—Filtration; ROADS AND STREETS—Stabilization.

**Classification** See ROADBUILDING MATERIALS—In Situ; SAND AND GRAVEL PLANTS—Water Recycling.

### Cleaning

**092584 OPERATING EXPERIENCE ON THE ALLJIG AIR-PULSE GRAVEL JIG FOR SEPARATION OF ORGANIC IMPURITIES IN GRAVEL AND SAND.** Increasing requirements of quality demanded by customers and a worsening of raw-material properties have led to an increased demand for high-performance, economical sorting equipment for gravel and sand processing. The Alljig jigs, which have previously been predominantly used for cleaning coal and other mineral raw materials have also proved reliable for separating organic impurities from gravel and sand. The operating results presented in this paper show that the use of these air-pulsed jigs enables gravel and sand to be produced virtually free of wood and coal at high specific throughputs over the entire grain range 0-32 mm. The utilization of this technique results in significant simplification of processing and plant engineering at gravel preparation plants, so that the economy of using Alljig gravel jigs is achieved extremely rapidly. 4 Refs.

Breuer, H.; Jungmann, A. *Aufbereit Tech* v 29 n 6 Jun



1988 p 324-330.

**Compaction** See Also PILES—Design.

**092585 LIQUEFACTION-INDUCED COMPACTION AND SETTLEMENT OF SAND DURING EARTHQUAKES.** By employing a dozen of irregular time histories of motions obtained during the recent major earthquakes, two series of simple shear tests, one in uni-directional and the other in multi-directional loading conditions, were carried out on saturated loose, medium dense and dense samples of Fuji river sand. Following the undrained application of irregular loads, the generated pore water pressures were made to dissipate and the volumetric strains measured. The amount of reconsolidation volumetric strains thus determined is regarded as representing the settlement characteristics of sand which takes place in-situ deposits following the liquefaction during earthquakes. The test results indicated that the magnitude of maximum shear strain induced during the irregular loading is uniquely correlated with the volumetric strains during the reconsolidation. (Edited author abstract) 15 refs.

Nagase, Hideo (Gunma Univ, Kiryu, Jpn); Ishihara, Kenji. *Soils Found* v 28 n 1 Mar 1988 p 65-76.

**Consolidation** See Also AIRPORTS—Construction.

**092586 LIQUEFACTION STRENGTH OF SANDS SUBJECTED TO SUSTAINED PRESSURE.** Using two kinds of sands, a series of cyclic undrained triaxial tests was performed on loose and dense specimens subjected to different periods between 0.1 hour and 68 days of sustained pressure. At the same time, tests on specimens over-consolidated with an OCR of two or four were performed in order to compare the effects of long-term consolidation and over-consolidation. For each sand, the strength increase after 68 days under sustained pressure was found to be equivalent to that due to over-consolidation with an OCR of about two. It was further found that for each sand the strength increase due to long-term consolidation and over-consolidation was found to be a similar function of the plastic axial strain which had occurred during each consolidation history. This result suggests that strength increase by these different consolidation histories is due to a similar mechanism. (Edited author abstract) 10 refs.

Tatsuoka, Fumio (Univ of Tokyo, Tokyo, Jpn); Kato, Hiroyuki; Kimura, Masaru. *Soils Found* v 28 n 1 Mar 1988 p 119-131.

**Creep** See ICE—Creep.**Crushing and Grinding**

**092587 MORE RECENT DEVELOPMENTS IN THE FIELD OF GRAVEL CRUSHING.** Reduction is an almost imperative procedure during extraction and treatment of mineral raw materials. The layout of any reduction equipment has to take duly into account the unseverable nexus between raw material, reactor, and operational conditions. Another requirement to be met is market demands. Furthermore energy expenditure and wear behaviour are critical factors for the selection of reduction equipment. Suitable machines to comminute gravel are in the first line cone crushers and impact crushers where some remarkable improvements have been achieved in the recent past. (Author abstract) 6 refs.

Leininger, D. *Aufbereit Tech* v 29 n 4 Apr 1988 p 197-202.

**Deformation**

**092588 SOIL PARAMETERS FOR DEFORMATION ANALYSIS OF SAND MASSES.** Meaningful stress and deformation analysis of soil structures requires an adequate stress-strain law. Herein are presented guidelines for selection of parameters for a simple incremental hyperbolic stress-strain law for sand based upon a tangent stiffness that varies with stress level. The parameters are obtained from an examination of laboratory and field

measurements available in the literature, and are presented in terms of both penetration value and relative density. The laboratory results indicate the importance of first-time or primary loading versus repeated loading on modulus values. Back analysis of field observations for monotonic loading conditions indicates that primary loading modulus values obtained from triaxial tests are appropriate at low relative density, whereas perhaps higher values, in the repeated loading range, are appropriate at high relative densities. (Author abstract) 23 refs.

Byrne, P.M. (Univ of British Columbia, Vancouver, BC, Can); Cheung, H.; Yan, L. *Can Geotech J* v 24 n 3 Aug 1987 p 366-376.

**092589 SYMMETRY OF PEBBLE-DEFORMATION INVOLVING SOLUTION PITS AND SLIP-LINEATIONS IN THE NORTHERN ALPINE MOLASSE BASIN.** Deformation features on pebbles of the Alpine Molasse Basin are most clearly developed in carbonate components. Ductile distortion is small; most of the pebbles moved against each other to produce solution pits and slip-lineations on the pebble surfaces. The complete lineation field has a triaxial geometry. From a compressional axis of divergence with maximum solution, fields of diverging lineations extend to meet at a plane of convergence. Their ends bend away from an intermediate axis towards an (extensional) axis of convergence. The strain-symmetry is pure shear for orthogonal lineation-field axes, uniaxial compression and extension representing special cases. The angle  $\alpha$  between the divergent and the convergent axes decreases from 90 to 0° with the transition from pure to simple shear. Additional aspects of the subject are discussed. (Edited author abstract) 45 refs.

Schrader, Frank (Univ Bonn, Bonn, West Ger). *J Struct Geol* v 10 n 1 1988 p 41-52.

**Density** See FOUNDATIONS—Bearing Capacity.

**Dredging** See Also DREDGES—Applications; DREDGING—Management; MINES AND MINING—Legislation; SAND AND GRAVEL PLANTS—Productivity.

**092590 BIOLOGICAL EFFECTS OF MARINE SAND MINING AND FILL PLACEMENT FOR BEACH REPLENISHMENT: LESSONS FOR OTHER USES.** The U.S. Army Corps of Engineers and others have monitored and evaluated the disruption and recovery of the physical and biological environment during beach replenishment operations. While primary focus has been on beach areas where the material is deposited, borrow areas from which the material has been taken have also been examined. Currently, replenishment material is obtained from new channel construction, dredging operations, nearshore and inshore borrowing. Based on what is known about the biological impacts of beach nourishment and nearshore borrow areas, nearshore and offshore mining operations should not create long-term adverse impacts on organisms and physical characteristics in the area if appropriate site selection, timing, techniques, and monitoring are carefully performed. (Edited author abstract) 9 refs.

Hurme, Arthur K. (US Army Corps of Engineers, Fort Belvoir, VA, USA); Pullen, Edward J. *Mar Min* v 7 n 2 1988 p 123-136.

**092591 MARINE SAND AND GRAVEL MINING AND PROCESSING TECHNOLOGIES.** This paper outlines the important factors that need to be considered in the selection of appropriate engineering systems for mining and processing of marine sands and gravel. There are several basic steps required to optimize the system to obtain the best product at the lowest cost. First is the definition of the product, then the characterization of the resources available including the deposit, the equipment, and the people, and the measure of the constraints upon each of these. 40 refs.

Cruickshank, Michael J. (US Geological Survey, Reston, VA). *Mar Min* v 7 n 2 1988 p 149-163.

**092592 MARINE AGGREGATES.** Marine dredged sand and gravel is making an ever increasing contribution

to British and North European demand for aggregates as land based resources continue to decline. The leading company in the UK/North Europe marine aggregates industry is ARC Marine Ltd, with an annual production of over 7 Mt. The company is expecting the third of a new class of ships, the Arco Adur, to be delivered in May this year from the North Devon yard of Appledore-Ferguson Shipbuilders, part of a £30 million new building programme. The fourth dredger of this class was ordered from Appledore-Ferguson in March, on the day the Arco Adur was named and floated out from the shipyard.

Anon. *Mine Quarry* v 17 n 4 Apr 1988 p 12-14.

**Drying**

**092593 TECHNOLOGICAL SAND DRYING, COOLING, AND PNEUMATIC TRANSPORTATION LINE.** Production trials have been carried out at the Parkhomenko Engineering Works in Voroshilovgrad on an automated technological line for the fluidized-bed drying and cooling of quartz sand, based on the Polish Model Sch5A equipment. The line units comprise equipment for receiving, drying and cooling the sand and a pneumatic transport system which takes the dried sand to supply bunkers in the sand preparation shops, which include a section for the preparation of liquid sand suspensions (ZhSS). The line throughput is 8 tonnes/hr. The paper concludes by emphasizing how the introduction of the technological sand drying, cooling and pneumatic transportation line has eliminated arduous manual labor, improved the health and hygiene aspects of the working conditions, reduced dust pollution in the plant, stabilized the molding and coremaking processes and enhanced the quality of the castings.

Rek, M.L.; Nekrytyi, M.I. *Sov Cast Technol* n 1 1986 p 54-55.

**092594 LOW PRESSURE FILTER FOR DEWATERING OF SAND.** This article presents in a clear and concise manner the numerous structural and economic advantages of the low-pressure filter. This filter operates at pressure below atmospheric and has proven itself even under such difficult conditions as dewatering of sand feeds from marine deposits which are practically free of finest-size grains. The engineer who is engaged in sand dewatering problems will be pleased to see that the cited developments of the low-pressure filter are derived as logical advances from previous trends. (Edited author abstract). German, English.

Blankmeister, W. (Haus der Technik, Essen, West Ger). *Aufbereit Tech* v 29 n 6 Jun 1988 p 341-344.

**England**

**092595 RAIL-AND SEA-BORNE AGGREGATES FOR THE SOUTH-EAST.** The South East Economic Planning Region is made up of the counties that surround Greater London. In 1986 this region consumed 58 million tonnes of aggregate and is forecast to have a demand of 68.9 million tonnes of aggregate in the year 2001. Four major sources of supply go to satisfy the region's current demand. There is the indigenous land-won sand and gravel that until the mid-sixties represented the major part of the region's supply. There is marine aggregate which has increased its contribution since the early fifties. Rail-borne material has also increased its contribution since the early 1970s. Finally, sea-borne material has made a small but steady contribution to the region over the years and is likely to make an increasing contribution in the future.

Tidmarsh, David (Foster Yeoman Ltd). *Quarry Manage* v 15 n 2 Feb 1988 p 31-33.

**Erosion**

**092596 LABORATORY INVESTIGATION OF DUNE EROSION.** A set of laboratory experiments have been conducted to study the relationship between the swash hydrodynamics, height, and velocity, and the quantity of dune eroded due to a single swash. The erosion



at the toe of the dune has been correlated with the force exerted on the dune by the uprush. This erosion-versus-force relationship is based on laboratory tests for a simple sand distribution and moisture content. The test results presented here, as well as recent field experiments, suggest that it is possible to estimate dune erosion by an analysis of the wave swash characteristics. 9 refs.

Overton, M.F. (North Carolina State Univ, Raleigh, NC, USA); Fisher, J.S.; Young, M.A. *J Waterw Port Coastal Ocean Eng* v 114 n 3 May 1988 p 367-373.

## Failure

**092597 FAILURE STATE OF A SAND IN SIMPLE SHEAR.** In this article, results of tests on loose and dense Leighton Buzzard sand from two specially instrumented simple shear devices - Cambridge University's device and a Norwegian Geotechnical Institute type - are used to interpret the failure mode and the failure stress state. The data were obtained from the centre of the samples, a region removed from stress concentrations. Failure was observed to be initiated on vertical planes and occurred very soon after shear displacement was applied. However, neither these vertical planes nor the horizontal planes were the planes of maximum stress obliquity mobilized during the tests. (Edited author abstract) 16 Refs.

Budhu, Muniram (State Univ of New York at Buffalo, Buffalo, NY, USA). *Can Geotech J* v 25 n 2 May 1988 p 395-400.

## Freezing

**092598 FROST PENETRATION AND THERMAL REGIME IN DRY GRAVEL.** The depth of frost and ground temperatures were monitored on a regular basis between 1983 and 1985 at 12 locations in Tumbler Ridge, British Columbia. The soil is dry gravel which has a moisture content of 1.5 to 4 percent. The maximum depth of frost recorded was 3.98 m for a winter having 1,430° C-days. Back calculation using the Stefan equation yielded  $n$  factors relating air and ground freezing indices to be generally within the range of those quoted in the literature. However, in heavily traveled cleared roadways, the value of  $n$  was higher than that reported in the literature. Values of unfrozen thermal diffusivity were calculated from both the temperature dissipation with depth and the time lag that the maximum temperature was recorded with depth. The results of these analyses compare well with typical values quoted in the literature for dry gravel. (Author abstract) 3 Refs.

McKeown, S. (Golder Associates, Atlanta, GA, USA); Clark, J.I.; Matheson, D. *J Cold Reg Eng* v 2 n 3 Sep 1988 p 111-123.

## Friction See PILES—Friction.

## Grain Size and Shape See SOILS—Physical Properties.

## Heat Transfer

**092599 ANALYSIS OF THE HEAT STORAGE PROCESS IN WET SOIL SOLVED AS A COUPLED PROBLEM.** A quantitative analysis of the heat storage process is tried in wet sand, based on the simultaneous heat and moisture transfer equations. And the effects of moisture on heat transfer are calculated according to the various moisture contents and mean temperatures of the storage media. The results show that moisture content in soil has considerable effects on heat transfer. The effects depend mainly on the direct effect on thermal conductivity. The contribution of moisture flow to heat diffusion is not so large. It is shown that governing equations can be solved with the linearized approximation except for the case of a high heating temperature or a very low moisture content. (Edited author abstract) 12 refs.

Matsumoto, Mamoru (Kobe Univ, Kobe, Jpn); Kotera, Norihiko. *Energy Build* v 11 n 1-3 Mar 22 1988, Proc of the Third Int Symp on Clim-Build-Hous, Karlsruhe, West Ger, Sep 22-26 1986 p 239-247.

**Measurements See TELECOMMUNICATION LINKS, MICROWAVE—Attenuation.**

## Mechanical Properties See Also OIL WELL DRILLING.

**092600 ELASTOPLASTIC CONSTITUTIVE MODEL FOR CYCLIC BEHAVIOR OF SANDS.** The constitutive model of sands is proposed to describe the characteristics of plastic behavior for cyclic loadings. A non-associated flow rule is used and both yield function and plastic potential are generalized forms of the Modified Cam clay model. The hardening parameter is represented by the plastic work related to different portions of volumetric and deviatoric changes. The boundary surface is employed to describe the plastic strain within the yield surface. The directional independency of yield condition in triaxial compression and extension tests is extended to that in general stress states. Several drained and undrained cyclic tests are predicted and the comparison is made with experimental results. (Edited author abstract) 23 refs.

Hirai, Hiroyoshi (Kumamoto Univ, Kumamoto, Jpn). *Int J Numer Anal Methods Geomech* v 11 n 5 Sep-Oct 1987 p 503-520.

**092601 MODELING GROUTED SAND UNDER TORSIONAL LOADING.** Chemically grouted sand is considered a two-phase particulate composite, and the mechanical properties under pure torsional loading are examined at both the particulate and composite levels. Both the adhesive and cohesive properties of grout are believed to influence the behavior of grouted sand, and an experimental program was conducted to quantify the particular relationship for each. These data, together with the porosity of the sand, are employed to formulate strength, shear modulus, and failure strain models for predicting the behavior of grouted sand from a knowledge of the properties of the constituents. The most critical mode of failure for grout and grouted sand is tension, but comparisons are also made between the shear and compressive properties. (Edited author abstract) 9 refs.

Vipulanandan, Cumaraswamy (Univ of Houston, Houston, TX, USA); Krizek, Raymond J. *Transp Res Rec* 1104 1986 p 33-42.

**092602 USE OF CRITICAL STATE REPRESENTATIONS OF SAND IN THE METHOD OF STRESS CHARACTERISTICS.** The limitations of critical state representations of sand behavior are discussed and it is shown that stress dilatancy is an implicit part of a critical state framework. It is then argued that dilatancy leads to underestimates of bearing capacity factors in the method of characteristics. Kinematic constraints should also be considered in such calculations. Both dilatancy and kinematic constraint may be introduced into a stress characteristics approach while preserving critical state characterization of sand, using the technique known as the method of associated fields. (Author abstract) 24 refs.

Jefferies, M.G. (Gulf Canada Resources Inc, Calgary, Alberta, Can); Been, K. *Can Geotech J* v 24 n 3 Aug 1987 p 441-446.

**092603 DENSITY VARIATION IN SPECIMENS SUBJECTED TO CYCLIC AND MONOTONIC LOADS.** Control specimens are tested in the triaxial chamber, frozen under back pressure and confining pressure with the top drainage line open, and then dissected into 96 elements in a cold room. The density of each segment and, consequently, the density distribution of the specimen are determined from the ice content. Homogeneity, i.e., relative density uniformity, is quantified in terms of the standard deviation of all elements about the average relative density determined for the 96 elements. Relative density dispersion with an increase in strain level is shown at three densities, approximately 40, 60, and 70% relative density. Density redistribution as a result of cyclic and monotonic loading is demonstrated and quantified in test specimens of Banded sand. (Edited author abstract) 15 refs.

Gilbert, Paul A. (US Army Waterways Experiment Station, Vicksburg, MS, USA); Marcuson, William F. III.

*J Geotech Eng* v 114 n 1 Jan 1988 p 1-20.

**092604 ENDOCHRONIC MODEL OF SAND WITH CIRCULAR STRESS PATH.** The endochronic constitutive equations developed previously by the writers for the description of sand behavior in true triaxial tests are applied to predict the behavior of Ottawa sand with a circular stress path in the deviatoric stress plane. Predictions by other investigators on the set of data obtained from this stress path are generally poor, and do not even show a qualitative agreement between theories and experiment. It is shown here that the endochronic constitutive equations do lead to reasonable results for this stress path. (Author abstract) 4 refs.

Wu, Han C. (Univ of Iowa, Iowa City, IA, USA); Aboutorabi, M.R. *J Geotech Eng* v 114 n 1 Jan 1988 p 93-103.

**092605 MODULUS AND DAMPING DUE TO UNIFORM AND VARIABLE CYCLIC LOADING.** Laboratory tests are run on five different cohesionless soils to determine their modulus and damping characteristics. Torsional simple shear and resonant column tests are performed by the same test apparatus in order to compare results. Results indicate that the tests are interchangeable as long as there isn't a significant cycles effect. Number of loading cycles generally increases modulus in sands and decreases modulus in silts. Damping decreases with number of loading cycles for both silts and sands. Threshold strain levels are also studied with agreement between predicted and measured results. Ramberg-Osgood parameters, taken with uniform cyclic tests, are applied to irregular loading tests along with the results. (Author abstract) 14 Refs.

Ray, Richard P. (Univ of South Carolina, Columbia, SC, USA); Woods, Richard D. *J Geotech Eng* v 114 n 8 Aug 1988 p 861-876.

## Mixing

**092606 EFFECT OF LOW ELECTROLYTE CONCENTRATION ON HYDRAULIC CONDUCTIVITY OF SODIUM/CALCIUM-MONTMORILLONITE-SAND SYSTEM.** The effect of electrolyte concentration in the percolating solution on hydraulic conductivity (HC) of Na/Ca-montmorillonite-sand mixtures at exchangeable sodium percentage (ESP) 5, 10, and 20 was studied. The HC was decreased following a decrease in electrolyte concentration. The HC of the system at sodium adsorption ratio (SAR) 10 dropped to a very low value ( $4.2 \times 10^{-10} \text{ m s}^{-1}$ ) and no clay was observed in the leachate, when the  $10 \text{ mol}_c \text{ m}^{-3}$  solution was replaced with solutions of lower concentration prior to introducing distilled water. At SAR 5, an increase in HC was obtained when  $1 \text{ mol}_c \text{ m}^{-3}$  solution was replaced with distilled water. This increase was due to clay dispersion and movement out of the system because swelling is limited at SAR 5. (Edited author abstract) 11 refs.

Keren, R. (Volcani Cent ARO, Bet Dagan, Isr); Singer, M.J. *Soil Sci Soc Am J* v 52 n 2 Mar-Apr 1988 p 368-373.

## Moisture

**092607 COMPUTATIONAL MODEL FOR SATURATED SAND SUBJECTED TO CYCLIC LOADING.** The paper presents an analytical model for calculating permanent strains and accumulated pore water pressure due to cyclic loading of saturated sand. The proposed formulation is based on concepts analogous to viscoelasticity to predict strains and pore pressures at the end of one or more cycles of loading without an explicit description of the hysteretic sand behavior within each cycle. Attention is focused on developing general expressions which also partly account for soil anisotropy and the effect of principal stress rotation. The model parameters are derived empirically from the results of drained or undrained static and cyclic triaxial and simple shear tests. The proposed constitutive equations are incremental, in terms of effective stresses, so that they may be applied to predict permanent strains and accumulated pore water pressure under various drainage and boundary conditions.



(Edited author abstract) 24 refs.

Bouckovalas, George (Norwegian Geotechnical Inst., Oslo, Norw); Hoeg, Kaare. *Soils Found* v 27 n 4 Dec 1987 p 34-44.

## Moisture Determination

**092608 INFLUENCE OF WATER CONTENT ON COMPRESSIVE STRENGTH OF FROZEN SANDS.** The authors propose a new experimental equation concerning the compressive strength of frozen sands. This equation and its derivative form define the equi-dry specific gravity lines and the equi-degree of saturation lines. These lines are presented in graphical forms and it is understood that: 1) if the degree of saturation is constant, the compressive strength decreases as the water content increases; 2) the water content at which the maximum compressive strength occurs can be quantitatively determined using the dry specific gravity in the densest state. (Author abstract) 6 refs.

Enokido, Motonori (Gunma Univ, Kiryu, Jpn); Kameta, Junji. *Soils Found* v 27 n 4 Dec 1987 p 148-152.

## Pennsylvania

**092609 LONG REACH EXCAVATOR MINES SMALL DEPOSITS.** Because large deposits of approved aggregates have become scarce in the Erie, Pa. area, Hoover Sand and Gravel Co. has developed the capability to explore and develop small areas containing suitable material. Profitable operation of such a venture requires careful selection of mining and processing equipment. The article describes a long reach excavator for underwater extraction of aggregate.

Michard, Don. *Pit Quarry* v 80 n 5 Nov 1987 p 40-41.

## Pressure Effects See Also SOIL MECHANICS.

**092610 ELASTO-PLASTIC CONSTITUTIVE MODEL FOR SAND IN LOW AND HIGH PRESSURE.** An elasto-plastic constitutive model was established in order to describe the stress-strain behavior of normally and over-consolidated sand for static loading in a wide stress region. The fundamental concept herein is based on the assumption that sand can be regarded as an isotropic material. The proposed model which involves eight parameters consists of two set of the yield, plastic potential and hardening functions. These functions are expressed based on a few basic assumptions and experimental evidences obtained from the multi-step stress path tests under 0.1 MPa-10 MPa confining pressure. This model can give good qualitative prediction of shear and volumetric strains for triaxial compression tests with various stress paths on normally and over-consolidated sand in a wide stress region. (Author abstract). 30 Refs. In Japanese.

Murata, Hidekazu; Hyodo, Masayuki; Yasufuku, Noriyuki. *Doboku Gakkai Rombun Hokokushu* v 9 n 6 Jun 1988 p 11-20.

**092611 MEASUREMENT OF SHEAR WAVE VELOCITIES IN DILUVIAL GRAVEL SAMPLES UNDER TRIAXIAL CONDITIONS.** A method of measuring the shear wave velocity in a triaxial test specimen (300 mm in diameter, 600 mm in height) has been proposed. The validity of the measurement method and the characteristics of the detected waves were confirmed by conducting preliminary tests on a steel cylinder and Toyoura sand specimens. By applying this method, the velocities of the shear waves propagating in the 'undisturbed' samples which were obtained from diluvial gravel deposits by means of an in-situ freezing method were measured under various confining pressures. The results of these measurements indicated that the effect of confining pressure on shear wave velocity was more significant for diluvial gravel samples than for clean sand, and that the shear wave velocities in reconstituted gravel specimens at in-situ overburden pressure were 20 to 30 percent below those in diluvial gravel samples. The shear moduli at a strain amplitude of  $10^{-3}$  in cyclic triaxial tests were about 5

percent less than those determined from measurement of shear wave velocities. It was concluded that the disturbance of the diluvial gravel specimens at in-situ overburden pressure were 20 to 30 percent below those in diluvial gravel samples was very slight during the entire sampling procedure. (Edited author abstract). 13 Refs.

Nishio, Shin'ya (Shimizu Corp, Tokyo, Jpn); Tamaoki, Katsuyuki. *Soils Found* v 28 n 2 Jun 1988 p 35-48.

## Processing

**092612 SAND PROCESSING, PRODUCT OPTIMIZATION AND WASTE TREATMENT - PART 1. PREPARATION AND SCREENING.** Any sand preparation process begins by physically screening a feed to remove oversize. At this stage in a wet process the desire to reduce the slit content, defined as  $-75\mu\text{m}$ , must also be considered. Feed preparation should aim to scrub off or dilute adhered clay and slit particles from the sand and to break down claybound agglomerates which might otherwise occur often as small balls with the sand or coarse aggregate. The article covers washing, scrubbing and various types of screening operations.

Littler, A. (ARC Southern). *Quarry Manage* v 14 n 6 Jun 1987 p 147, 149, 151.

**092613 MODERN GRAVEL AND SAND PROCESSING IN THE NORTHERN UPPER RHINE REGION IN THE KARLSRUHE-MANNHEIM AREA.** The shortage of sand and gravel resources in some conurbations of the Federal Republic of Germany caused by the depletion of the existing deposits, but above all by administrative measures, has compelled the quarry companies to better utilize the deposits presently still available. Thus, in many places, sands and gravel which are strongly contaminated or not corresponding to the standards have to be washed and sized. Producing a premium-quality gravel sand nowadays requires great effort with regard to preparation processing technique. As high additional costs are unacceptable for bulk products such as sand and gravel, modern processing plants must primarily be oriented toward minimization of maintenance, repair and, particularly, energy costs. Besides high-performance component units, this requires above all an optimal design of the entire process. The new sand and gravel processing plant of the Pfander company at Russheim is used as an example of such a production plant oriented toward future demands. (Edited author abstract) In German and English.

Schuetze, H.J.; Stotz, A. *Aufbereit Tech* v 28 n 12 Dec 1987 p 722-726.

**092614 SAND PROCESSING, PRODUCT OPTIMIZATION AND WASTE TREATMENT: PART 5. REMOVAL OF DELETERIOUS MATERIALS AND WASTE TREATMENT.** The presence of lignite (brown coal) in concrete produces staining on a finished surface and leaves behind small cavities as the lignite is weathered out. Lignite occurs in natural sands in a variety of forms from disseminated specks to regular very thin beds and in some cases large fragments of partially fossilized wood. There are several methods of effecting its removal, all relying on the same principle, namely that lignite is intrinsically less dense than sand. Four methods of lignite removal are described, the first two being applicable to gravel, the third and fourth to sand. 12 refs.

Littler, A. (ARC Southern Ltd). *Quarry Manage* v 15 n 3 Mar 1988 p 37-38, 41-42.

## Production See QUARRIES AND QUARRYING—Loaders.

## Recovery See BEACHES—Maintenance.

## Research

**092615 BASIC RESEARCH ON CUTTING FORCES IN SATURATED SAND.** A theory for the cutting of sand under water has been developed. During the process of cutting saturated sand, the deformation rate

is very important because of the effect of dilatancy. Decreasing pore-water pressure due to dilatancy increases the effective stress. These higher effective stresses result in large cutting forces at high deformation rates. The pore-water pressure changes during the cutting process are calculated, and, subsequently, a prediction is given of the cutting forces. Calculated pore-water pressures and cutting forces are compared with the results of full-scale tests. (Author abstract) 12 refs.

van Os, A.G. (Delft Hydr, Delft, Neth); van Leussen, W. *J Geotech Eng* v 113 n 12 Dec 1987 p 1501-1516.

## Sampling See FLOW OF WATER—Sediment Transport.

## Sedimentation See RIVERS—Dredging.

## Selection See WATER FILTRATION.

## Stabilization See PAVEMENTS—Asphalt.

## Stresses See Also SOILS—Stresses.

**092616 EXPERIENCE WITH MEASUREMENT OF HORIZONTAL GEOSTATIC STRESS IN SAND DURING CONE PENETRATION TEST PROFILING.** The incorporation of an additional transducer to cone penetrometers has recently been proposed at the University of California at Berkeley. The additional transducer is used to measure the horizontal stress on the friction sleeve, this stress being related to the horizontal geostatic stress of the soil; this type of cone is referred to as a horizontal stress cone (HSC) although it also incorporates a piezometric transducer. The paper derives an algorithm for determination of horizontal geostatic stress from measurements made with an HSC in sand. Some mathematical aspects of the algorithm and how these aspects constrain cone data evaluation are discussed. (Edited author abstract) 20 refs.

Jefferies, M.G. (Gulf Canada Resources, Calgary, Alberta, Can); Jonsson, L.; Been, K. *Geotechnique* v 37 n 4 Dec 1987 p 483-498.

**092617 CALIBRATION CHAMBER TESTS OF A CONE PENETROMETER IN SAND.** The results of a series of tests using a cone penetrometer in sand in a large calibration chamber are reported. Sand at three different densities and a range of stress states was studied. The principal finding from the tests is that cone resistance in sand depends primarily on the horizontal stress and the angle of friction but is relatively unaffected by the vertical stress. A relationship between  $q_c$ ,  $\sigma'_h$  and  $\phi'_{1/2}$  is proposed and compared with previous work in calibration chambers. (Author abstract) 5 refs.

Houlsby, G.T. (Oxford Univ, Engl); Hitchman, R. *Geotechnique* v 38 n 1 Mar 1988 p 39-44.

**092618 DRAINED PRINCIPAL STRESS ROTATION IN SATURATED SAND.** An investigation into the effects of drained principal stress rotation on the behavior of a saturated medium-loose sand is described. Using a hollow cylinder apparatus the principal stress directions were rotated both at a constant shear stress and under an increasing shear stress during drained monotonic loading to failure. The experimental results are presented. The findings are used to support the notion that a bounding surface, defined by tests with fixed principal stress orientations, can be used to make a qualitative prediction of drained and undrained behavior during monotonic loading to failure which includes rotation of principal stress directions. The bounding surface conveys the importance of both anisotropy in determining strength and the direction of principal stress rotation in determining the magnitude of volumetric strains or pore pressures which develop. (Edited author abstract) 15 refs.

Symes, M.J. (Deloitte, Haskins & Sells, London, Engl); Gens, A.; Hight, D.W. *Geotechnique* v 38 n 1 Mar 1988 p 59-81.



**092619 PORE PRESSURE AND EFFECTIVE STRESS IN A HIGHLY SATURATED SAND BED UNDER WATER PRESSURE VARIATION ON ITS SURFACE.** The behavior of pore pressure and effective stress in a highly saturated sand bed under variations in the water pressure on its surface were investigated to determine the mechanism of the collapse of hydraulic structures during flooding or when attacked by storm waves. The vertical, one-dimensional model was used as a basic model to clarify the effect of water pressure variation on only to the vertical direction. The theoretical results show that a sand bed under variations of water pressure is weakened by an increase in excess pore pressure and that under certain conditions the sand bed will liquefy. Although many factors related to water pressure variation and property of the material determine this phenomenon, the most important factor seems to be the small amount of air present in the sand bed. The theoretical results reported are verified by experiments. (Author abstract) 14 refs.

Nago, Hiroshi (Okayama Univ, Okayama, Jpn); Maeno, Shiro. *Nat Disaster Sci* v 9 n 1 1987 p 23-35.

**Testing** See Also SOILS—Reinforcement; SOILS—Strain.

**092620 EXPERIMENTAL OBSERVATIONS OF ANISOTROPY IN SOME STRESS CONTROLLED TESTS ON DRY SAND.** Samples of dry Leighton Buzzard sand have been prepared by pluviation and tested in a true triaxial apparatus and a directional shear cell in order to investigate the response of the sand to series of deviatoric stress probes. True triaxial tests (without rotations of principal axes) showed that dense sand had some significant initial anisotropy as a result of the preparation by pluviation, whereas medium dense sand had negligible initial anisotropy. Sets of probes on samples of medium dense sand with identical histories were used to reveal the link between history and location and size of the current yield locus in both the true triaxial apparatus and the directional shear cell. (Author abstract) Refs.

Alawaji, H. (Univ of Colorado, Boulder, CO, USA); Alawi, M.; Ko, H.-Y.; Sture, S.; Peters, J.F.; Wood, D.M. *Cambridge Univ Eng Dep Tech Rep CUED/D-Soils* TR 198 1987 19p.

**092621 STRENGTH TESTING APPARATUS FOR RESIN-COATED SANDS.** In the production of shell molds and cores in resin-coated sand, the important mechanical property indices include strength in the hot and cooled conditions, corresponding to the operations of stripping the shells from the pattern equipment and their subsequent transportation, assembly and pouring. Test pieces must be prepared from the resin-coated sand (RCS), for testing immediately after formation at 250°C and after cooling to room temperature.

Zhuravlev, F.M.; Markov, P.A.; Radchenko, S.I.; Azhgikhina, L.S. *Sov Cast Technol* n 1 1986 p 56-57.

**092622 CONE PENETRATION TEST IN SANDS: PART II, GENERAL INFERENCE OF STATE.** The state parameter concept provides a new method of characterizing sand behavior, but the utility of the concept relies on the ability to measure the state parameter in situ. In this paper the state parameter approach is applied to data from calibration chamber tests on several sands. It is shown that this approach leads to a common relationship for all the data that includes the effects of material type, quantified by the slope of the steady state line. The state parameter for a sand can therefore be determined in situ with a reasonable precision using a general framework of interpretation which applies to all uncemented sands. (Edited author abstract) 28 refs.

Been, K. (Golder Associates, Calgary, Can); Jefferies, M.G.; Crooks, J.H.A.; Rothenburg, L. *Geotechnique* v 37 n 3 Sep 1987 p 285-299.

**092623 CROSS-HOLE SEISMIC TESTING OF SAND FILL.** In a recent project, the original specification for the soil was for a uniformly graded medium sand, with

particle size of 0.2mm to 0.6mm, and a maximum moisture content of 7 per cent. Sand of this specification is not readily available. Following discussions with the client, it was agreed that a trial embankment should be constructed using selected locally available material, and tested to determine the compressive wave velocity and the bearing capacity under conditions as near as possible to those which would be obtained when the sand was placed on the structure concerned. This paper describes the procedures used during the testing, and comments on the significance of the results.

Darracott, B.W. (Wimpey Lab Ltd, Middlesex, Engl); May, J. *Ground Eng* v 20 n 6 Sep 1987 p 33-34, 36, 38.

**092624 POTENTIAL SYSTEMATIC ERROR IN LABORATORY TESTING OF VERY LOOSE SANDS.** There is a potential error in the determination of specimen void ratio in triaxial tests on very loose sands. This error can be attributed to densification during final saturation. The result can be an error in the determination of the location of the steady state flow line in void ratio - stress space. Stress levels on the steady state flow line at a given void ratio may be in error by two orders of magnitude. If carried through to the analysis of susceptibility to liquefaction, this potential error could be extremely unconservative. Test results are presented that illustrate this potential source of error. A laboratory procedure is proposed that provides a simple calculation of final specimen void ratio and is potentially more accurate than presently used procedures. (Author abstract) 11 refs.

Sladen, J.A. (EBA Engineering Consultants Ltd, Calgary, Alberta, Can); Handford, G. *Can Geotech J* v 24 n 3 Aug 1987 P 462-466.

**092625 STRESS PATH AND PERMANENT DEFORMATIONS IN SAND SUBJECTED TO REPEATED LOAD.** Presented is a study of the effect of stress path on the development of permanent deformations in sand. Using a pneumatic servo-controlled triaxial system, the confining pressure was varied simultaneously with the axial load. Six different straight line stress paths were investigated; three under compression and three under extension conditions. Dry Ottawa sand was subjected to 100,000 sinusoidal loading cycles at a frequency of 1 Hz. Several loading intensities were used in each stress path. A linear relationship was observed between the permanent axial strain and the logarithm of the number of loading cycles, for constant repeated stress magnitude and constant stress path. Furthermore, based on the results presented here, one can utilize the conventional constant confining pressure triaxial tests to estimate the effect of stress path. Consequently, the results of the conventional tests can be generalized. (Edited author abstract) 14 refs.

Leshchinsky, Dov (Univ of Delaware, Newark, DE, USA); Rawlings, Deborah L. *Geotech Test J* v 11 n 1 Mar 1988 p 36-43.

**092626 STABILIZATION OF LIQUEFIABLE SAMPLES DURING TRANSPORT.** This technical note presents a new method to transport liquefiable soils from the investigation site to the laboratory. The development of this method resulted from research on liquefiable soils from the Imperial Valley, CA. This method is based upon the application of a slight vacuum on the pore water of the soil. The vacuum decreases the pore pressure, and therefore increases the effective confining stress. Sample recovery and integrity were compared with experiences of others. Comparisons were made in the sample quality after extrusion and sample preparation, as well as the variability of the test result. This method proved to be an improvement over previous techniques. (Author abstract) 6 refs.

Ho, Carlton L. (Washington State Univ, Pullman, WA, USA); Sarmiento, John S.; Davazanjian, Edward Jr. *Geotech Test J* v 11 n 1 Mar 1988 p 72-74.

**092627 CONE PENETRATION TEST CALIBRATION FOR ERKSACK (BEAUFORT SEA) SAND.** This paper describes a series of calibration chamber tests

carried out on a sand dredged from the Beaufort Sea for construction of artificial islands. This Erksak sand is a uniformly graded, subrounded medium-grained sand with a fines content of 3-6%. The testing chamber described is 1.4 m in diameter, and allows independent control of vertical, horizontal, and back pressures on the sand sample. The chamber test data are presented and confirm that the Erksak sand fits the general trends observed for other sands very well. A method is also described that allows the interpretation to be consistent, even in the event that nonuniform void ratios occur in the samples. Measurements of horizontal stress behind the cone tip, which is a new development in cone penetrometer testing, are also presented. (Edited author abstract) 14 refs.

Been, K. (Golder Associates, Calgary, Alberta, Can); Lingnau, B.E.; Crooks, J.H.A.; Leach, B. *Can Geotech J* v 24 n 4 Nov 1987 p 601-610.

**092628 BEHAVIOR OF SAND PARTICLES IN SAND-STEEL FRICTION.** This paper describes a method for observing the particle behavior near the interface in sand-steel friction tests. A friction testing apparatus was modified to allow the observation of sand particles. Close-up photographs were taken of the sand particles at specified timing in sand-steel friction tests. The change in particle coordinates gives the displacement of particles during the friction test. The sand-steel interface showed a small amount of sliding before the peak in the frictional resistance. The sand on a smooth steel surface slid without large shear deformation. The sand particles on a rough steel surface rolled as well as slipped along the interface. These movements caused the formation of a shear zone within the sand along a rough interface. (Edited author abstract) 16 refs.

Uesugi, Morimichi (Tokyo Inst of Technology, Yokohama, Jpn); Kishida, Hideaki; Tsubakihara, Yasunori. *Soils Found* v 28 n 1 Mar 1988 p 107-118.

**092629 THEORETICAL AND EXPERIMENTAL BOUNDS FOR SHEAR-BAND BIFURCATION STRAIN IN BIAXIAL TESTS ON DRY SAND.** A two-dimensional flow theory of plasticity for granular media is derived and the corresponding constitutive equations for the two linear comparison solids in the sense of Raniecki and Bruhns are presented. The constitutive models are calibrated by using experimental data from plane-strain rectilinear deformations on a fine-grained sand. Predictions for shear-band formation based on these constitutive models are presented and critically discussed in the light of experimental results. (Author abstract) 30 refs.

Vardoulakis, I. (Univ of Minnesota, Minneapolis, MN, USA). *Res Mech* v 23 n 2-3 1988 p 239-259.

**092630 INTERPRETATION OF FLAT PLATE DILATOMETER TESTS IN SANDS IN TERMS OF THE STATE PARAMETER.** This paper assesses the key parameters which govern the expansion stage of a flat plate dilatometer (DMT) test in cohesionless material in order to develop relevant correlations with respect to the compressibility of sands. Laboratory tests in a small calibration chamber were conducted to obtain a response from the DMT during expansion in undisturbed Ottawa sand under a given stress field. The deformation characteristics inferred from the DMT data compared well with those obtained from triaxial tests. The results from the DMT are best interpreted in terms of the state parameter which combines the influence of void ratio and stress level with reference to the steady state line of the soil. A framework based on the normalized state parameter for the interpretation of DMT test profiles in most sands is proposed. (Edited author abstract) 12 refs.

Konrad, J.M. (Univ of Waterloo, Ont, Can). *Geotechnique* v 38 n 2 Jun 1988 p 263-277.



**092631 TO OVERCOME FRICTIONAL EFFECT IN A LARGE SCALE PLANE STRAIN APPARATUS.** An economical low friction layer has been developed which is capable of maintaining the coefficient of friction for soil/container interfaces in large-scale laboratory tests at 3 percent-10 percent for a wide range of stresses. The claimed level of performance is supported by the results of two monitoring methods in a large-scale laboratory model. A comparison of the results for extensive plane strain simulation using both physical and numerical techniques yields further quantitative evidence. 3 Refs.

Matthews, R.S. (Univ of Bradford, Engl); Boot, J.C. *Geotechnique* v 38 n 2 Jun 1988 p 311-315.

**092632 SIMPLE SHEAR TESTING ON SAND IN A TORSIONAL SHEAR APPARATUS.** A method for simple shear simulation using a hollow cylindrical specimen is described. Drained tests at controlled axial stresses were performed automatically by means of a servo-system consisting of a micro-computer and a pneumatic-controlling system. For undrained tests on saturated specimens the simple shear simulation was achieved only by a mechanical means. The torsional simple shear behavior of Toyoura sand is described. It was found that the strength and deformation properties of Toyoura sand at relatively large strains in torsional simple shear are very similar to those by the plane strain compression test in which the directions of principal stresses with respect to the deposition direction and the value of  $\sigma_3'$  are similar to those at failure in the torsional simple shear test. (Edited author abstract). 35 Refs.

Pradhan, Tej B.S. (Geo-Research Inst, Jpn); Tatsuoka, Fumio; Horii, Noriyuki. *Soils Found* v 28 n 2 Jun 1988 p 95-112.

**092633 CORRELATION BETWEEN STANDARD PENETRATION TEST VALUES AND OVERBURDEN PRESSURE FOR DESERT SANDS.** The influence of the effective overburden pressure on the standard penetration test (SPT) values in calcareous desert sands is examined by field tests. A simple field testing procedure is proposed and employed in Kuwait at five sites having different relative densities for the surface soils. The correction factors for the SPT are determined from test results and compared with the most reliable correlations for clean silica sand. (Author abstract). 8 Refs.

Ismail, Nabil F. (Kuwait Univ, Safat, Kuwait); Jeragh, A.M.; Khalidi, O.A.; Mollah, M.A. *Can Geotech J* v 25 n 3 Aug 1988 p 590-594.

## Thermal Conductivity

**092634 MEASUREMENTS OF THE EFFECTIVE THERMAL CONDUCTIVITY OF DISPERSED MATERIALS.** The transient hot wire method was used to measure the effective thermal conductivity,  $\lambda_e$ , of several sands under various conditions. The method has been found to be well suited and appears advantageous for its quickness. The effective thermal conductivity of dispersed materials was found to depend strongly on porosity, water content, and thermal conductivity of the moistening liquid; and to depend weakly on grain size and grain geometry. There is an effect of temperature on  $\lambda_e$  for temperatures between 20 and 70°C which seems to be due to the temperature dependence on the thermal conductivity of the gas or liquid involved. (Author abstract) 14 refs.

Song, You Wang (Univ Stuttgart, West Ger); Hahne, Erich. *High Temp High Pressures* v 19 n 1 1987 p 57-64.

## Transportation

**092635 STATISTICAL PREDICTION OF SEDIMENT TRANSPORT.** Based on the longshore sediment transport calculated by the Bijker formula, this paper discusses the long-term distribution of sediment transport and presents formula to statistically predict probable and most disadvantageous total quantity of sediment transport in multiple years blocked by a littoral barrier. These formula are useful for planning and designing various types of coastal structures. (Author abstract) 2 refs.

Liu, Defu (Tianjin Univ, Tianjin, China). *China Ocean Eng* v 1 n 2 May 1987 p 91-93.

## Vibrations

**092636 LEVEL GROUND SOIL-LIQUEFACTION ANALYSIS USING IN SITU PROPERTIES: I.** A fundamental approach utilizing the electrical properties of soils to characterize their grain (particle shape) and aggregate (porosity and fabric anisotropy) characteristics is presented. Correlations between mechanical properties relevant to the analysis of soil liquefaction and electrical indices defining the structure of a soil are given, and the influence of fabric anisotropy on mechanical behavior of soils is demonstrated. The nondestructive nature of the proposed method provides a means to predict in situ properties and thus overcome the difficulty of retrieving undisturbed samples. (Edited author abstract) 30 refs.

Arulanandan, Kandiah (Univ of California, Davis, CA, USA); Muralletharan, Kanthasamy K. *J Geotech Eng* v 114 n 7 Jul 1988 p 753-770.

**092637 LEVEL GROUND SOIL-LIQUEFACTION ANALYSIS USING IN SITU PROPERTIES: II.** A method is presented for level ground soil-liquefaction analysis, which is treated as a boundary value problem. This method uses a semiempirical, one-dimensional, elastoplastic constitutive model and finite difference method to solve the governing differential equation for the prediction of pore pressure generation, dissipation, and settlement characteristics during and after dynamic excitation. A compressibility function incorporating effects at low effective stresses is included in this method, which is verified by centrifuge model tests. This procedure utilizes input properties representative of field conditions determined by a nondestructive electrical method. The proposed method for analyzing the generation and redistribution of pore pressure, therefore, provides a means for predicting liquefaction of level ground sites - a boundary value problem - based on the results of in situ testing. (Edited author abstract) 30 refs.

Arulanandan, Kandiah (Univ of California, Davis, CA, USA); Muralletharan, Kanthasamy K. *J Geotech Eng* v 114 n 7 Jul 1988 p 771-790.

**092638 CENTRIFUGE LIQUEFACTION TESTS IN A LAMINAR BOX.** The difficulties associated with instrumenting earthquake sites in order to record pore pressure changes in a future event led to the use of scaled model tests performed in a centrifuge. Both dry and saturated sands were employed, contained in a box constructed of aluminium laminae designed to move freely on each other. This would result in shearing distortions developing in the soil unimpeded by the container. Accelerometers, displacement transducers and pore pressure sensors were attached to the box and embedded in the soil at various elevations so as to record the response of the soil to an earthquake-like excitation supplied to the base of the container. A special apparatus was constructed to imitate earthquake motion. In some tests on saturated sand, the soil profile was liquefied. Study results are discussed. (Edited author abstract). 20 Refs.

Hushmand, B. (Earth Technology Corp, Long Beach, CA, USA); Scott, R.F.; Crouse, C.B. *Geotechnique* v 38 n 2 Jun 1988 p 253-262.

**092639 DYNAMIC MODULI AND DAMPING RATIOS FOR CEMENTED SANDS AT LOW STRAINS.** This paper advances the present understanding of the beneficial effects of cementation of sands on their dynamic behavior at low strain amplitudes. The influence of important parameters such as cement content, effective confining pressure, density, and curing period is discussed in detail on the basis of extensive resonant column test results. A newly proposed relationship for maximum dynamic shear modulus is compared with reported relationships. Empirical relations for maximum dynamic Young's modulus, dynamic shear damping, and dynamic longitudinal damping are developed for the first time. All the relations developed are nondimensional and adaptable to any system of units. Correlations between dynamic

moduli and static strength from triaxial (drained) tests are developed for an effective confining pressure equal to 49 kPa. (Author abstract). 21 Refs.

Saxena, Surendra (Illinois Inst of Technology, Chicago, IL, USA); Avramidis, Anestis S.; Reddy, Krishna R. *Can Geotech J* v 25 n 2 May 1988 p 353-368.

**092640 COHESIONLESS SOIL BEHAVIOR UNDER RANDOM EXCITATION CONDITIONS.** A testing program was undertaken in which dry sand at different confining pressures was tested in a resonant column device using random torsional excitation in addition to conventional sinusoidal loading. The concept of the root-mean-square (rms) strain, as well as the use of the extreme value theory to determine the peak shearing strain under random excitation, is presented. The transfer function method was used for the first time in soil testing. Evaluation of the dynamic soil properties for sinusoidal vibration followed conventional procedures. During random loading, the damping values are higher and the shear moduli lower than the values obtained from sinusoidal loading at the same rms strain. Formulas were developed to correct the damping and shear moduli obtained from routine sinusoidal testing. (Edited author abstract). 28 Refs.

Amini, F. (Soil Consultant Inc, Chantilly, VA, USA); Tawfiq, K.S.; Aggour, M.S. *J Geotech Eng* v 114 n 8 Aug 1988 p 896-914.

## Viscoplasticity

**092641 VISCOPLASTIC MODEL FOR GEOLOGIC MATERIALS WITH GENERALIZED FLOW RULE.** The general yield function in the hierarchical approach for constitutive modeling of materials is used with P. Perzyna's theory to characterize viscoplastic behavior of geologic materials: a sand and rock salt. Particular attention is given to determination of the constants from laboratory quasistatic or short term, and creep tests. The proposed model is verified with respect to observed laboratory response of the sand and salt. It is implemented in a non-linear finite element procedure and applied to analyze time-dependent behavior of a cavity in the rock salt. (Author abstract) 26 refs.

Desai, C.S. (Univ of Arizona, Tucson, AZ, USA); Zhang, D. *Int J Numer Anal Methods Geomech* v 11 n 6 Nov-Dec 1987 p 603-620.

## Wave Effects

**092642 PROPERTIES OF IRREGULAR STANDING WAVES AND THEIR ACTION ON A SAND BOTTOM.** According to the results of a model test in a wave channel, some properties of irregular waves reflected by a vertical wall and the scouring patterns of the sand bottom in front of the wall are discussed. The main conclusions of the action of regular standing waves on sand beds in front of a vertical wall are also mentioned briefly for comparison. It has been shown by analysis that the ultimate scouring depth could be on the safe side if the significant wave height is taken as the equivalent wave height in the regular wave test. (Edited author abstract) 7 refs.

Xie Shileng (Ministry of Communications, Tianjin, China). *China Ocean Eng* v 1 n 1 Feb 1987 p 83-97.

## SAND AND GRAVEL PLANTS See Also ORE TREATMENT—Classifiers; QUARRIES AND QUARRYING—France.

### Alabama

**092643 BUCKET WHEEL TURNS UP PRODUCTION FOR FRIESE.** Two years ago, the Friese Materials Corp.'s Atmore, Ala. sand and gravel plant became the first North American facility to incorporate a Fuchs/Stichweh bucket wheel into its operation. The wheel has proven to be a money saver, eliminating the need for one wheel loader and its operator. The machine keeps maintenance at a minimum while producing a low moisture



product.

Constantino, Darren. *Pit Quarry* v 80 n 11 May 1988 p 41-42.

## California

**092644 SAND DIEGO SAND AND GRAVEL OPERATION MOVES MOUNTAINS.** In keeping with its portable company status, Dave Martin Supplies does not own a permanent crushing facility. A limited amount of crushing is performed for them by a local company. The company owns Read RD-90 and RD-150 portable screening units. They are moved around the company's main yard, located northeast of San Diego, or transported to specific job sites for use in a variety of projects. One such project was the removal of 500,000 st of material from the side of a local hill to make a place for a 20-ft-high by 200-ft-diameter water tank.

Kuhar, Mark S. *Pit Quarry* v 81 n 2 Aug 1988 p 117-119.

## Construction

**092645 CONSTRUCTION OF A NEW GRAVEL PLANT ON THE NORTHERN PERIMETER OF THE HARZ MOUNTAINS.** In 1985, Messrs. Oker, Kies and Splitt GmbH & Co, Kieswerk KG, Schladen, West Germany placed an order for a new gravel preparation plant stipulating that it should be designed to meet the changed demands of the building trade and be operated with a minimum of manpower. The task of the new plant was to prepare graywacke gravel with a grain size of 0-150 mm won by dredging. The order specified a 0.09/0.25 fine sand fraction of 12-20% in 0/2 sand. Since the fine sand fraction was not high anyway, wastage during the preparation process had to be avoided as much as possible. However, in view of the high power requirements, a pump-cyclone system for desilting was not allowed. In German and English.

Wittwer, G. *Aufbereit Tech* v 28 n 6 Jun 1987 p 331-335.

## England

**092646 RAIL-FED COATING DEPOT UPRATED BARDON HILL'S LONDON TERMINAL FULLY OPERATIONAL.** A little over a year ago the Bardon Hill Group opened their new rail off-loading and aggregate storage facility at West Drayton in Middlesex. Phase two of the development of Bardon's London terminal, which included the modernization of on-site coating plants, began afterwards and is now reaching completion. The result is a twin-plant operation with a combined capacity of some 700 tonnes/h.

Anon. *Quarry Manage* v 14 n 12 Dec 1987 p 11-12, 15-16.

## Equipment See Also SCREENS AND SIEVES—Performance.

**092647 KOMPAKTANLAGE ZUR TROCKENAUFBEREITUNG VON FEINSAND MIT MOGENSEN-SIZERN UNTER NUTZUNG VON DEPONIEGAS.** [Compact Unit for Dry Processing of Fine Sand with Mogensen Sizers Using Gas from Disposal Sites]. Dry quartz sands yield significantly higher profits than wet sands; they can also be sized at a higher separation efficiency. This is why dry sizing is used in a new unit at a quartz works near Stade in northern Germany for producing five commercial grain sizes. In order to reduce the high energy costs for drying the feed material, energy from waste (gas from disposal sites) obtained from a rubbish tip located near the plant is used. The unit is laid out for 20 tph dry sand; it operates free of clogging, is enclosed to seal in dust and is of particularly compact design. By placing three Mogensen sizers above the block of five silos, no further conveyors are required for filling them. The compact design and the low weight of the screening station permit an economical supporting structure. The utilization of cheap gas from disposal sites and the intelligent, but simple plant concept lead to exceedingly economical production of commercial products. (Edited author abstract) In German and English.

Kindt, H.-J.; Eggerstedt, R. *Aufbereit Tech* v 28 n 11 Nov 1987 p 657-664.

**092648 SAND PROCESSING, PRODUCT OPTIMIZATION AND WASTE TREATMENT - PART 4. DE-SLIMING AND DEWATERING.** De-sliming/dewatering can be carried out by any of four basic machine types. The physical process involved, along with a description of the machine type and a discussion of their suitability to the application, are considered. The equipment covered is hydrocyclones, hindered-settling classifiers, mechanical types, and dewatering screens. 7 refs.

Littler, A. (ARC Southern Ltd, Engl). *Quarry Manage* v 15 n 1 Jan 1988 p 21-26.

**092649 SYSTEMIZED LUBRICATION MEANS AUTOMATIC MAINTENANCE.** Pin and bushing life should be the same as the life of the machine. Scheduled lubrication eliminates the need to replace pins and bushings that might sustain damage due to lubrication starvation and the resulting wear. This saves the machine operator hours of downtime, mechanic's time, parts cost and lost production. One company that believes in preventive maintenance offered by systemized lubrication is J.F. Shea, a California-based construction firm. The article describes lubrication practice at Shea's Redding Sand and Gravel facilities.

Kuhar, Mark S. *Pit Quarry* v 80 n 1 Jul 1988 p 28-30.

## Federal Republic of Germany See SAND AND GRAVEL—Processing.

## Illinois

**092650 CHICAGO QUARRIES ADAPT TO CHANGING MARKETS.** Among production leaders for many years, two Chicago area plants, Vulcan Materials Company's McCook Quarry and Material Service Corporation's Thornton Quarry, have continued high output and profitable operations as they adapt to changing market needs. Each plant recently installed a specialized production facility to increase output of high-demand products. Vulcan's McCook installed a processing plant for shore protection rip-rap, while Material Service put in a crushing/screening auxiliary facility for increased production of - 1 in material.

Anon. *Quarry Manage* v 15 n 2 Feb 1988 p 35-36.

## Modernization

**092651 RETROFIT PROGRAM REVITALIZES OLDER SAND & GRAVEL PLANT.** The plant of Elam Sand & Gravel, Inc., Victor, NY, has been revamped to produce 300 t/h of what is claimed to be the cleanest sand product in the state. A major capital investment in new processing equipment, coupled with an accelerated maintenance program, have expanded production capabilities by 8 products. The process of transforming the 1960-vintage plant into a high-efficiency facility capable of meeting current sand specifications required two months, and more than \$30,000 in parts alone, including new pulleys, rollers, shafts, bearings, and conveyor belts, according to Leo Spezio. In addition to sand processing equipment, new purchases included 3 Caterpillar front end loaders and five new Mack tri-axle trucks.

Michard, Don. *Pit Quarry* v 80 n 8 Feb 1988 p 46-48.

**092652 J.L. SHIELY CO. UPDATES VETERAN SAND/GRAVEL PLANT.** In a program to optimize the productivity of its 900-acre Nelson Plant in the Twin Cities metropolitan area, management of J.L. Shiely Company has been conducting a long term program of processing system improvement and site reclamation. Conversion to urethane screening media and modern crushers has raised production while extending life of the deposit. Most of the production is barged to the St. Paul/Minneapolis downtown area.

Michard, Don. *Pit Quarry* v 80 n 9 Mar 1988 p 42-44.

## Ohio See Also SCREENS AND SIEVES—Plastics Applications.

**092653 DEWATERING A SAND-RICH GRAVEL DEPOSIT.** American Aggregates installed a bucket wheel at its sand-rich Newark, Ohio, facility for efficient sand dewatering. The wheel rotates one revolution every 50 seconds, handling 200 tons of sand per hour. As a result, this dredging operation has cut maintenance costs and increased production while producing a drier product.

Adams, Bruce. *Pit Quarry* v 80 n 2 Aug 1987 p 28-29.

## Productivity See Also EARTHMOVING MACHINERY—Mechanical Drive.

**092654 GETTING OUT OF A STICKY SITUATION.** A Michigan sand and gravel producer changed processing methods and significantly decreased clay problems. The new plant, incorporating a portable Universal ImpactMaster II, has eliminated the need to remove clay balls and, in this application, can out-produce both jaw crushers, according to Miller. After dredging material, wheel loads feed the crushing/screening plant. A hopper with underlying feeder belt is charged using one or two of the firm's Hough loaders. Material is conveyed to the Universal ImpactMaster II, equipped with a double-deck Allis-Chalmers vibrating screen. Top deck overs are crushed; bottom deck overs can either be crushed or stockpiled; bottom deck throughs can be entirely stockpiled or partially mixed with coarser material from the bottom deck.

Drake, Bob. *Pit Quarry* v 80 n 8 Feb 1988 p 38-40.

## Tennessee See DREDGES—Design.

## Waste Disposal See SAND AND GRAVEL—Processing.

## Water Recycling

**092655 KLAERUNG UND FEINSCHLAMMBEHANDLUNG IN SAND- UND KIESAUFBEREITUNGSANLAGEN.** [Clarification and Treatment of Fine Slurries in Sand and Gravel Preparation]. Washery and circuit water from sand and gravel treatment plants may be clarified successfully with polymeric flocculants. The clarified water can be reused in the washery circuit or discharged without problems. There are well-proven clarifying systems available with integrated dissolving and dosing equipment for polymeric synthetic flocculants. If required, the sedimentated and thickened slurries can be dewatered at low cost by application of polymeric flocculants with decanter centrifuges, sieve belt presses or chamber filter presses. (Edited author abstract) In German and English.

Reuter, J.M. *Aufbereit Tech* v 28 n 3 Mar 1987 p 148-155.

**092656 DEWATERING OF SLUDGE IN GRAVEL WORKS WITH BELT FILTER PRESSES AND CHAMBER FILTER PRESSES USING RECYCLING OF WASH WATER.** For wet processing, the recycling of wash water is necessary with respect to political aspects and thus has an economical purpose. The economy of this process is explained by using an example from gravel processing. The contaminated wash water is cleaned in a clarification reactor and re-used as wash water in the gravel preparation plant. The sludge which is formed can be dewatered with belt filter presses and chamber filter presses. The process scheme of the complete unit, the clarification reactor, the belt filter presses and the chamber filter presses are described. Operating results and technical data are listed. (Author abstract)

Hoffmann, E. *Aufbereit Tech* v 29 n 4 Apr 1988 p 212-217.



## SAND, FOUNDRY

**092657 POLYCYCLISCHE AROMATISCHE KOHLENWASSERSTOFFE IM FORMSAND.** [Polycyclic Aromatic Hydrocarbons in Molding Sands]. Polycyclic aromatic hydrocarbons as a materials group of organic compounds which occur both in nature and are produced during incomplete combustion of organic materials. Some of these materials are carcinogenic. This article deals with the hazards generated by these hydrocarbons present in foundry sands. Results of examinations of samples of used sands from 10 foundries are presented and evaluated. In German. 26 refs.

Kleinheyer, Ulrich (VDG, Duesseldorf, West Ger); Schmittner, Hartwig; Staufenbiel, Richard; Wolf, Dieter; Zindler, Guenter. *Giesserei* v 74 n 21 Oct 12 1987 p 640-643.

**092658 NEW CONCEPTS OF GREEN SAND TECHNOLOGY - PART II.** As Part I of this two-part article emphasized, molding sand tolerances have become tighter since use of compaction by vibration has declined. Significant changes in sand properties and molding problems are caused by increase core sand inflow, condensate accumulation, decreased temperature moisture, faster sand recycling, reduced preparation times, and higher compaction. This concluding article addressed those problems, assesses production risks, and advises about better foundry practice. (Author abstract)

Boenisch, Dietmar (Univ Aachen, West Ger); Ruhland, Norbert. *Foundry Manage Technol* v 116 n 3 Mar 1988 5p between p 38 and 49.

**092659 SELF MOULDING CHEMICALLY BONDED SANDS.** Since most jobbing foundries have had to tackle more cost effective production and higher demands for quality against a reduced demand for castings and selective skills shortages, effort has been put into semi-mechanised systems. In mouldmaking the parallel developments in chemically bonded sands have continued to achieve the foundryman's goal supplying the right quality at the right price. The implementation of machines for moulding chemically bonded sands has helped Hawthorth Castings achieve consistent quality competitively by the elimination of much core setting and reduced fettling.

Anon. *Foundry Trade J* v 162 n 3363 Feb 11 1988 p 86, 88.

**092660 STATISTICAL EVALUATION OF THE PROPERTIES OF MOLDING SANDS IN CHENGDU AND SYNTHETIC ANALYSIS OF THE PROPERTIES AND THE CASTING QUALITIES.** The author analyzed green molding sands from 44 different iron foundry shops in Chengdu. Ten properties of the molding sands were tested. The test data was processed by computer. In this area of Chengdu two thirds of the casting defects are caused by blowholes, sand inclusions and crushes. The clay contents are too high and the moisture contents are excessive. The paper presents reference targets for suitable properties of molding sands. (Edited author abstract) 3 refs. In Chinese.

Jiang, Yixiang (Sichuan Inst of Technology, China). *Zhuzao* n 12 Dec 1987 p 12-16.

**092661 RAPID MONITORING OF ACTIVE CLAY CONSTITUENT CONCENTRATIONS.** In the USSR molding problems are responsible for 70% of reject castings. The flaws produced by defective molding sand arise from the amount of clay constituent in the sand, the degree of wetting (the bentonite/water ratio) and the quality of the clay constituent. A rapid monitoring test has been developed on the basis of the release of basic exchange ions ( $K^+$ ,  $Na^+$ ,  $Ca^{2+}$ ,  $Mg^{2+}$ ) by interaction with water which characterizes the binding capacity. The same test can be used to determine the degree of bentonite activation obtained by adding soda ash. 2 refs.

Lysochenko, V.V.; Tkachenko, Yu.K.; Krasil'nikov, Yu.K.; Lesnov, V.N. *Sov Cast Technol* n 8 1987 p 12-14.

**092662 ENHANCING THE FLOWABILITY OF CLAY SUSPENSIONS.** The strength of baked molds can be enhanced by introducing the clay in the form of a suspension (slip) prepared from lump material. The authors investigated the possibility of enhancing the flowability of low-grade clay slips by adding fluidizers such as sulfite yeast lye (SYL), sodium hexametaphosphate (SHMP) or sodium bentonite. The use of high-flowability slip eliminates the fouling of distribution pipelines and gives a 30-40% increase in permeability, a 30-50% increase in sand strength, and a 10-15% reduction in water content. SYL, SHMP, and bentonite can be used in this way to adjust molding sand properties over a wide range.

Kuz'min, N.N.; Komissarov, V.A.; Rodin, V.A. *Sov Cast Technol* n 7 1987 p 20-22.

**092663 PHENOL DESTRUCTION IN FOUNDRY WASTEWATER.** Phenols and phenolic compounds are toxic materials generated in foundries by some sand binders and by the combustion of coke. Phenolic compounds appear in foundry wastewater streams in varying concentrations. Local and state limitations on the discharge of phenolics have been in effect for a number of years. However, stricter regulations for the foundry industry were promulgated by the U.S. Environmental Protection Agency (EPA) in 1985. Full compliance with these regulations is mandated by Oct 31, 1988. This examination of current technology for the destruction of phenolics in foundry wastewater streams includes a presentation of new technology using chlorine dioxide to destroy phenolic compounds. Biological digesters, potassium permanganate and hydrogen peroxide are also discussed. 4 refs.

Fuller, Ross K. (Ashland Chemical Co, Boonton, NJ, USA); Tomlin, John L. *Mod Cast* v 78 n 6 Jun 1988 p 25-27.

## Additives

**092664 STRUCTURE AND PROPERTIES OF ANTI-BURN-ON DRESSING FOR COLD-SETTING RESIN-BONDED SANDS.** Tests have been carried out on an anti-burn-on dressing containing 65 wt.% zircon flour and 35 wt.% resin KO-0168 for large molds and cores made from cold setting resin-bonded sands. This mixture has a low resistance to sedimentation and the dressings are liable to craze when heated to high temperatures. Inorganic stabilizers (aerosils with different specific surface areas) were examined with a view to stabilizing the dressing mixture and strengthening the coatings at 900-1500°C. Statistical analysis confirmed a reduction in burn-on and surface flaws when using dressings with superior properties.

Gulyaeva, T.B.; Velikanov, G.F.; Brechko, A.A. *Sov Cast Technol* n 1 1987 p 19-21.

**092665 INVESTIGATION ON THE PREGELATINIZED STARCH ADDITIVES FOR GREEN MOLDING SAND.** Pregelatinized starch (a starch) additive is used in foundries of western countries but less in China. Effects of several pregelatinized starch products on properties of moulding materials were studied. The results show that pregelatinized starch improves the stripping property, anti-friability, anti-erosion and anti-scabbing properties of molding sand and improves the quality of green sand castings. (Edited author abstract) 5 refs. In Chinese.

Yu, Zhenzong (Qinghua Univ, China); Zheng, Dianjun; Wang, Zhigang; Wang, Yafeng. *Zhuzao* n 1 1988 p 7-12.

**092666 ENHANCING THE PLIANCY OF RESIN-BONDED SANDS.** Pliancy tests have been carried out in the Kupyansk foundry on sands containing oxidizing and mineral additives. Stress analyses on the castings showed that the residual stress levels are lowered by 10-15% in the presence of 0.2% of oxidizer and by 30-35% in the presence of 1% expanded vermiculite. Hydrated silicates are preferable in wet-mixed resin-bonded sands and oxidizers in the resin-coated sand type of mixture. 1 ref.

Sinchugov, A.Yu.; Chernenko, N.G.; Voronin, Yu.F.; Kolotilo, D.M. *Sov Cast Technol* n 8 1987 p 15-17.

**092667 USE OF STARCH PRODUCTS TO COMBAT SCALING.** Various additives can be used in molding sands to combat the formation of scabs and scales. They include starch products made by the heat treatment of starch/albumen suspensions or the extrusion treatment of corn grain wastes. The authors investigated the effects on the tensile strength of molding sands in the water condensation zone of a number of starch products, i.e., krakhmalit, extruded starch reagent and starch products modified by extrusion. The addition of starch products is only effective in molding sands bonded with unactivated bentonite.

Gordeev, G.D.; Kiselev, V.L.; Lysochenko, V.V. *Sov Cast Technol* n 8 1987 p 64-65.

**092668 INFLUENCE OF PHOSPHATES ON PROPERTIES OF SOLUBLE SILICATE AND MOLDING SANDS.** The knock-out properties of silicate-bonded sands are usually improved by lowering the soluble silicate content and adding a variety of organic and inorganic additives, singly or in combinations. The basic sodium salts of phosphoric acid meet the technical requirements. The best among them is sodium triphosphate (STPP). This work compared STPP with trisodium phosphate. 4 refs.

Sychev, I.S.; Vishnyakov, K.I.; Skazhennik, V.A. *Sov Cast Technol* n 7 1987 p 27-30.

## Adhesion

**092669 ELIMINATING THE ADHESION OF LIQUID SELF-SETTING SANDS TO PATTERNS AND PATTERN PLATES.** A study has been made of the composition of expendable parting agents used to prevent liquid self-setting (LSS) sands from sticking on wooden and more particularly metallic equipment. However, these parting agents have failed to suppress sand adhesion to an adequate extent; the useful life of the semi-permanent coating only averages 8-10 cycles. As the coating of semi-permanent parting agent is attacked by the kerosene, the prepared surfaces become rougher; much more LSS sand sticks on and eventually the surface finish of the halfmolds, cores, and castings deteriorates. The problems can be overcome by adopting a novel parting agent (USSR Author's Certificate No. 755408), consisting of 75-85% diesel fuel as the vehicle and 15-25% added paraffin wax. The use of diesel fuel has substantially prolonged the useful life of pattern equipment and eliminated the adhesion of LSS sands to wooden patterns.

Guba, A.I.; Maksimenko, G.U. *Sov Cast Technol* n 3 1986 p 76-77.

**Binders** See Also FOUNDRY PRACTICE—Coremaking; FOUNDRY PRACTICE—Molding; IRON FOUNDRY PRACTICE—Coremaking; STEEL CORROSION—Electrochemical.

**092670 SILICATE-BONDED HOLDING SANDS WITH IMPROVED PROPERTIES.** The analysis of the two-dimensional model sections showed that the optimum proportions, which give the required strength, life and knockout quality ( $W \leq 3$  J) are within the range: soluble silicate 4.5-5%, remainder ferrochromium slag and sodium sulfite. The sodium silicate content must be  $\geq 4.5\%$ , otherwise the sand is lacking in strength, but above 6-8% soluble silicate the knockout quality is impaired. The useful life, denoting the time interval between bringing the sand into contact with the hardener and making the core or mold, must satisfy the requirements for making medium-size and large cores. Beyond this period, the sand becomes less compactable, and more friable, i.e., its useful life has expired. A table compares the compressive strength and friability data on specimens compacted after increasing delays. 3 refs.

Vasin, Yu.P.; Bortnikov, M.M.; Gurlev, V.G.; Kasatkina, V.I. *Sov Cast Technol* n 4 1986 p 19-22.



**092671 COMPOSITION/DENSITY RELATIONSHIP IN SODIUM SILICATE.** The allied sectors that produce ZhS do not supply a product with the density and silicate module values required for castings production. The problem has arisen of organizing the production of sodium silicate in lump or possibly dissolved form (as ZhS) so that foundries can be supplied with ready-made silicate binders. This requires accurate data on the influence of ZhS composition on its density. An additional composition characteristic is the water content W, found by difference from the above characteristics ( $\%W = 100 - \%SiO_2 - \%Na_2O$ ). The total insoluble impurities content (covering Al, Fe, and Ca oxides plus  $SO_3$ ) must be below 0.6% for sodium silicate (according to GOST 13078-81) and can be ignored for the purposes of calculation. The above characteristics are interrelated: given any two, the others can be found and are invariant.

Afanaseva, R.S.; Teplyakov, S.D. *Sov Cast Technol* n 4 1986 p 23-25.

**092672 STRENGTH OF MOLDING SANDS.** Petrographic sections of typical sands were examined in areas of grain-boundary failure and on contact faces, using binocular mineralogical and biological microscopes (POLAM-II and MBI-15U). Examinations in ordinary and polarized light and by the phase-contrast clay-bonded sands with a cohesive strength mechanism. Examinations in ordinary and polarized light and by the phase-contrast procedure failed to reveal any areas devoid of a binder film on the sand grain surfaces. The mode of failure was by direct loss of adhesion or a combination of adhesive and cohesive breakdown in all the molding sands examined. Maximum strength is obviously exhibited by sands in which the adhesion and cohesion forces are equally balanced. If either force predominates, the system loses its equilibrium; its overall strength is reduced and in some cases the sand can collapse spontaneously. Since molding sands constitute dissipative systems, in which the binder structuring process is unstable and progresses in the direction of reduces degrees of freedom for individual elements of the supramolecular structure, the vital factor is the selection of a composition which has near-equilibrium properties over the period required for practical use. 6 refs.

Velikanov, G.F.; Primak, I.N.; Brechko, A.A. *Sov Cast Technol* n 3 1986 p 16-19.

**092673 MODIFIED PHENOL-UREA-FORMALDEHYDE BINDER FOR CORE SANDS.** Hot-box coremaking in foundries has been largely based for some years on resins KF-90, BS-40, and SF-411. The phenol-urea-formaldehyde resin SF-411 is the most economical, since it does not contain expensive furanols. It provides good setting rates and high strength properties in resin-bonded sand specimens (comparable with carbamide-furan resins). The high reactivity of resin SF-411 is explained by the presence of up to 8% free formaldehyde and 25% methylol groups, which participate actively in the resin structuring processes at elevated temperatures. The major drawbacks are the high free phenol content (up to 7%) of the resin and its short shelf life. The Kemerovo Chemical Industry Research Institute has developed a resin grade FML, of higher reactivity and lower toxicity than grade SF-411. 2 refs.

Kozlova, G.I.; Dubikovskaya, L.V.; Kvasha, F.S.; Lamasov, A.A. *Sov Cast Technol* n 3 1986 p 30-31.

**092674 LOW-TOXICITY COLD-SETTING BINDER 'FURITOL-30'.** It was established that Furitol-30 has superior reactivity and binding capacity than the popular binders for CS sands (OF-1, FS-40, etc.). There is no irritant odor. The volatile contents of the air remained below the PDK limits at all points in the sand preparation, molding and coremaking and pouring bays. The surface finish and general strength of the molds and cores remained satisfactory at catalyst contents from 25 to 65% by weight of binder. The coresand is capable of hardening at relatively low temperatures (5 K above the shop temperature). Pilot commercial trials have shown that binder Furitol-30 meets all the technological and industrial health requirements for castings production and

can be used for molding and coremaking in foundries making steel or iron castings of any weight.

Antonov, M.M.; Pechennikova, T.I.; Bekbulatov, I.A.; Vidyakina, L.M.; Skobelina, Yu.P. *Sov Cast Technol* n 3 1986 p 34-35.

**092675 IMPROVING THE KNOCKOUT BEHAVIOR OF SILICATE-BONDED SANDS.** The coresands used in the foundries at the Elektrotvazhmash, LEZ (Elektrosila) and REZ (Riga Electrical Engineering) Works contain up to 8% of soluble silicate, and are difficult to knock out. The easiest way of improving their knockout properties under these foundry conditions is to introduce additives which will aid the disintegration of the cores and molds at the knockout stage. The purpose of the additives is to form refractory multi-component compounds with the soluble silicate, which will melt in this case at temperatures well above the second peak on the curve of knocking-out energy. The labor costs of knocking out and fettling can be halved by using the proposed mixture. The greatest improvement is attained when the cores and faced molds reach the temperature of kaolin phase transformation (1000-1100°C), which is usually the case when the core is surrounded by metal on all sides except for the print. Thus, the most acceptable method at present available to the Elektrotvazhmash, LEZ LPEO Elektrosila and PO REZ foundries for improving the knockout behavior of silicate-bonded sands is to introduce weakening additives, and the most effective of these is kaoline. 2 refs.

Boguslavskii, A.M.; Sereda, L.O.; Khasin, A.V. *Sov Cast Technol* n 3 1986 p 36-38.

**092676 LIQUID SELF-SETTING SANDS BASED ON SULFITE-YEAST LIQUOR.** The mechanism of the setting of LSS sands based on sulfite-yeast liquor and chromic anhydride or sodium persulfate has been analyzed. The entire range of possible variants should be studied, to ascertain the optimum conditions for the formation of strong gels by the treatment of SYL with plentiful and cheap materials with a high oxidizing potential.

Ektova, V.N.; Kozuseva, T.I. *Sov Cast Technol* n 3 1986 p 39-40.

**092677 BINDER FOR MAKING FOUNDRY CORES AND MOLDS FINISHED BY BAKING.** The possibility of using the oil-grease residue from black cotton oil, lacquer grade gasoline and a sicative as a binder mixture has been investigated with a view to enhancing the strength of baked cores and molds, shortening the baking period of the molding sand, replacing raw materials in short supply, and reducing atmospheric pollution. The oil-grease residue from black cotton oil was mixed with white spirit for 20-40 min without heating, and the calculated amount of sicative was added when the mixture became uniform. The residue in question is a mixture of saturated and unsaturated fatty acids in the range  $C_{12}-C_{22}$  and polyphenolic gossypol derivatives (iodine number  $\geq 100$ , and acid number  $\leq 90$  mg KOH per gram of residue). The sicatives used were both technical products, NF-1 or 64b. The binder preparation by the new technology utilizes more plentiful and less costly raw materials. The use of the new binder for molding and coremaking has led to higher strength after a (25%) shorter baking period. The proposed binder contains less volatile materials and is less toxic.

Moshoshina, M.N. *Sov Cast Technol* n 3 1986 p 78.

**092678 GAS-FORMING CAPACITY DURING POURING OF SANDS WITH SYNTHETIC BINDERS.** Hungarian foundries use sands based on synthetic resins. On occasion they encounter gas-produced defects, particularly when using sands of Hungarian origin. The most widely used resins are DORFIX-A and THERMOFIX FFK. The gas formation dynamics in cores can be determined by a described procedure. The article includes some of the results and their bearing on the prevention of defect formation.

Tot, L.; Nandori, D. *Sov Cast Technol* n 12 1986 p 34-37.

**092679 RESEARCH ON A SUSPENSION AGENT OF ALCOHOL BASED COATINGS.** The article describes an inorganic ion exchanged Li-bentonite as the suspension agent for alcohol based coatings. This suspension agent uses an auxiliary agent which can improve the suspension stability over 90% within 8 hours. Compared with organic bentonite, the suspension agent is less expensive and is beneficial in foundry practice. In Chinese.

Ye, Kongrong (Taiyuan Univ of Technology, China). *Zhuzao* n 5 May 1987 p 10-12.

**092680 STUDY ON  $SO_2$  PROCESS AND ITS APPLICATION.** The  $SO_2$  process, characteristics of resin TTY-1 and properties of  $SO_2$  resin bound sand have been studied. The application of the  $SO_2$  process in the manufacture of cores of submerged pumps is described briefly. (Edited author abstract) In Chinese.

Shen, Yan (Tianjin Inst of Machinery Research & Design, China). *Zhuzao* n 5 May 1987 p 13-15.

**092681 STRENGTH AND KNOCKOUT PROPERTIES OF SILICATE-BONDED SANDS.** Standard methods of investigation were applied to finding the structural characteristics of silica gels prepared by treating an aqueous solution of sodium silicate with carbon dioxide. The structural characteristics were modified by adding strengtheners to the sodium silicate solution. The additives included aliphatic amines and multi-component commercial mixtures of aromatic alcohols and their simple esters. The most effective way of improving the knockout properties of silicate bonded sands is to use additives which simultaneously strengthen the sand before pouring, weaken it after heating, and lower the necessary binder content. 3 refs.

Zhukovskii, S.S.; Ivanov, A.A. *Sov Cast Technol* n 1 1987 p 14-18.

**092682 USE OF MODIFIED SOLUBLE SILICATE BINDERS TO IMPROVE FETTLING-SHOP WORKING CONDITIONS.** Ways of improving the knockout properties of silicate bonded sands and the working conditions in fettling shops can contribute towards higher labor productivity. The authors carried out a planned study of the problem and derived regression models which characterize the influence of production factors on employee performance. Using the modifying additives ( $NH_4$ ) $_2$  $SO_4$  and  $Na_2SO_3$  improves the initial strength properties of silicate-bonded sands and makes them easier to knock out after heating in the poured molds. This reduces the labor costs of knocking out and the dust content of the workplace. 5 refs.

Vasin, Yu.P.; Bortnikov, M.E.; Kryukova, I.V.; Gurlev, V.G. *Sov Cast Technol* n 1 1987 p 58-62.

**092683 PREPARATION OF SOLUBLE SILICATE CONTAINING SODIUM TRIPOLYPHOSPHATE.** The addition of sodium tripolyposphate (STPP) to soluble silicates both increases the initial strength of silicate-based molding sands and makes the used sand easier to knock out after heating to high temperatures. The additions can be made either during soluble silicate production, at the autoclave digestion stage, or later. Both methods have been investigated. They give different results arising from the properties of alkaline aqueous STPP solutions at room temperature and during heating to 190°C. 2 refs.

Sychev, I.S.; Skazhennik, V.A. *Sov Cast Technol* n 1 1987 p 63-64.

**092684 INVESTIGATION AND APPLICATION OF ALCOHOL BASED COATINGS FOR CAST IRON AND STEEL IN HIGH PRESSURE MOULDING LINE.** In a high pressure moulding line green sand moulds are used for cast iron and steel. In order to guarantee the surface quality of castings and eliminate defects of the adhering sand, spraying of alcohol based coatings is adopted. The authors have developed three types of alcohol based coatings. Their refractory fillers are



graphite, alumina and zircon. The application of lithium ion exchanged bentonite and an auxiliary agent can produce a suspension stability of over 90% within 8 hours. (Edited author abstract) In Chinese.

Ye, Kongrong (Taiyuan Univ of Technology, China); Wang, Boyin; Xie, Fanqun; Chang, Jinshan. *Zhuzao* n 9 Sep 1987 p 26-30.

**092685 PROPERTY CHANGES IN CLAY-BONDED MOLDING SANDS DURING POURING.** After pouring a mold, the binder (clay, bentonite) in the sand layers immediately outside the casting loses its strength virtually completely. With increasing distance from the casting, the temperature reached by the sand becomes lower and the degree of weakening steadily decreases. It has been established that sand heated to 180-200°C undergoes no significant changes in properties, whereas at 550-620°C the bentonite entirely loses its binding capacity. These temperatures mark the boundaries between three distinct layers of sand in the poured mold: completely degraded, partially weakened, and still retaining the initial strength. If used sand is repeatedly recycled, fresh clay must be added to it in order to restore its strength to the standardized level.

Kartashov, V.T.; Medvedev, Ya.I.; Ivanov, N.Kh. *Sov Cast Technol* n 3 1987 p 35-36.

**092686 PHOSPHATE-BONDED COLD-SETTING SANDS FOR STEEL AND IRON CASTINGS PRODUCTION.** From the point of view of foundry technology requirements, a system must set in air over a short interval of time (1-5 min). This setting rate is ensured by using oxides containing a cation with an ionic potential (ratio between charge and radius) of between 2.5 and 5.5. Suitable oxides include FeO, Fe<sub>2</sub>O<sub>3</sub>, NiO, MgO, and CuO. On the grounds of technology and economy, investigations were carried out on systems of orthophosphoric acid (H<sub>3</sub>PO<sub>4</sub>) and the oxides of iron and magnesium. The materials for iron-phosphate binders can include mill scale (from forges or rolling mills), iron ore concentrates, and ferruginous powder. The use of phosphate-bonded sands for the production of large carbon and alloy steel castings has reduced coremaking labor costs, cut the volume of knocking out and fettling operations and improved the dimensional accuracy of the castings. Phosphate-bonded core sands may also be adopted for the production of massive iron castings instead of cold setting sands with synthetic resin or soluble silicate binders. In this case, it should be possible to use either magnesium or iron oxides.

Zhukovskii, S.S.; Yunovich, Yu.M.; Nevskaya, O.E. *Sov Cast Technol* n 4 1987 p 44-47.

**092687 UNIFIED MOLDING SANDS FOR SMALL FOUNDRY MOLDS.** Trials were organized in the Verkhnedneprovsk Foundry to explore the scope for using clay-bonded molding sands with optimum physicochemical properties for machine molding. The mixtures have a minimum of constituents but include binders based on bentonite clays with agrimus additions. Agrimus is a waste product from the food industry arising from the pentose hydrolysis of corn stalks and consists largely of cellulose. The use of agrimus additions lowers the energy consumption in the molding shops and enhances the quality of the castings.

Bondarenko, V.I.; Kartashov, V.T.; Medvedev, Ya.I. *Sov Cast Technol* n 4 1987 p 48-49.

**092688 AQUEOUS WAX DISPERSIONS FOR RESIN-COATED SANDS.** In order to minimize the binder contents required to attain the specified mechanical and technological properties, the laws governing the spreading of resin over the sand grain surfaces were investigated. The resin flow kinetics were examined under a microscope (MNO-2). Granules of resin SF-015, in the form of spheres weighing 3 mg each, were dripped onto a preheated quartz sand substrate. As the resin touched the substrate, a motion picture camera was switched on to record its spread at a rate of 8 frames per minute. The droplet geometry was measured under a microscope (UIM-23), recording its linear and angular dimensions.

Radchenko, S.I. *Sov Cast Technol* n 5 1987 p 57-59.

**092689 RECYCLED COLD-SETTING MOLDING SANDS BASED ON FURITOL-30 BINDER.** Model tests have been carried out on the thermal and mechanical reclamation of cold-setting sands with furitol-30 binder. The furitol-30 is a silanized phenol-furane type resin. The thermal reclamation neutralizes the product (to pH=7.28) and brings the loss on ignition back to its original level.

Antonov, M.M.; Pechennikova, T.I.; Treiber, O.Yu.; Zheldakova, L.E. *Sov Cast Technol* n 8 1987 p 18-19.

**092690 LOW-TOXICITY COMPLEX BINDER.** The binder used to make hot-box cores is usually a 20% solution of urea in phenol spirit. Consequently, toxic fumes are given off and the low reactivity of phenol spirits prevent the equipment from being operated at maximum output rates. One way of improving working conditions and increasing equipment productivity is the development of complex binders with catalytic additives. The authors tested a range of catalytic additives for core sands based on complex hot-setting resins, which contain carbamide resin. The proposed core sands based on complex binders are used at the Khar'kov Tractor Works. The air in the working zones contains less phenol (2.5-fold reduction) and formaldehyde (2-fold reduction) and is free from cyanides and acrolein.

Sandalov, A.V.; Gumantsov, A.I.; Skobelina, Yu.P.; Temereva, V.V. *Sov Cast Technol* n 8 1987 p 20-22.

**092691 PHENOL-UREA-FORMALDEHYDE BINDER TOL-2 FOR HIGH-REACTIVITY CORE-SANDS.** Binders for use in the hot-box coremaking process should harden at moderate temperatures, have a high thermal durability comparable with phenol-formaldehyde resins and a high hardening rate comparable with urea-formaldehyde resins. The Kemerovo Chemical Research Institute has developed a new phenol-urea-formaldehyde resin grade TOL-2, a product of the two-stage condensation of formaldehyde, urea and phenol in an alkaline medium. The physicochemical properties of the new resin and the existing foundry-grade phenol-urea-formaldehyde resin SF-411 are compared.

Voroin, Yu.F.; Sincugov, Yu.D.; Koshelev, V.I.; Parfenov, Yu.A.; Kozlova, G.I. *Sov Cast Technol* n 8 1987 p 23-26.

**092692 GAS EMISSION FROM HOT SETTING BINDERS.** The VNIITmash Institute has collaborated with the VNIOT VTSPS Institute (Sverdlovsk) in an investigation of the quantitative aspects of gas emission during the preparation, baking and thermal degradation of core binders. The nature of the toxic substances associated with the use of binders USK-1 and KO is determined by the chemical constitution and structure of these products (petroleum still bottoms). During baking, core sands emit significant amounts of saturated aldehydes (formaldehyde), alcohols (methanol) and unsaturated aldehydes (acrolein). Binders SKT-11 and LST pollute the atmosphere with furfuryl spirit, furfural and formaldehyde. 4 refs.

Sincugov, Yu.D.; Sandalov, A.V.; Ogloblina, R.I.; Karavaeva, E.S. *Sov Cast Technol* n 8 1987 p 59-61.

**092693 ACOUSTIC EQUIPMENT FOR THE PREPARATION OF COMPLEX MOLDING SAND BINDERS.** Acoustic equipment produces uniform and stable binder suspensions which are of high quality and virtually immune to sedimentation. Molding sands with the requisite physicochemical and handling properties are produced at minimum consumption rates for bentonite and organic binders. The reductions are 20-30% on bentonite and up to 40% on binder USK-1. This leads to lower gas-forming capacity in the molding sands and lower mold and castings scrap rates.

Kiselev, V.K.; Burdenko, Yu.V.; Murkhortov, V.I. *Sov Cast Technol* n 8 1987 p 66-67.

**092694 INFLUENCE OF AIR HUMIDITY AND**

**TEMPERATURE ON THE SETTING OF COLD-HARDENING SANDS.** A study has been made of the strength-time relationships for cold-hardening sands and the effects of the humidity and temperature of the ambient atmosphere. The binder used was grade FF-1F resin, together with a 78% aqueous solution of acid hardener in amounts of 10-20% by weight of resin. Similar tests were carried out on sands bonded with soluble silicate and siloxanes. In order to harden cores and molds made from self-hardening sands at low ambient temperature, the binders and fillers should be preheated. A certain minimum binder and filler temperature is essential to the production of cold-hardening sands with a reduced binder/catalyst content (1.5-2 wt%). 4 refs.

Romashkin, V.N. *Sov Cast Technol* n 7 1987 p 23-26.

**092695 MOLD & CORE BINDERS KEEP PACE WITH INDUSTRY DEMANDS.** There are more than 20 different foundry resin binder systems currently used in the foundry industry. Total binder and individual system usage in North America are given. New process developments and refinements are directed at lowering emissions and improving casting dimensions, binder processing and reclamation. 3 refs.

Burditt, Michael F. (Modern Casting, Des Plaines, IL, USA); Carey, Paul R. *Mod Cast* v 78 n 6 Jun 1988 p 20-24.

## Compaction

**092696 MOLD DEFORMATION AND ACCURACY.** The behavior under load of molding sands in use can be described with the aid of the well-known elastoviscous model for the volume which deforms as it absorbs the external forces and the elastic potential model for the absorption of residual energy. The deformation conditions usually considered in molding sand investigations assume that the strains are independent of the time factor  $\tau$ . However, the elastoviscous bodies characteristically exhibit transient dynamic strain behavior. Authors have examined the results of tests on moist fluid sands under transient strain conditions, i.e., constant stress application with periodic deformation of the loading-load release type. The investigation has shown that sand control tests based on the ultimate strength alone do not meet the requirements of mold design. The working conditions applied to the sand must be covered by control tests on rigidity, which more truly reflects the real stress-strain conditions. This enables the mold design to be calculated rationally without unnecessary safety margins on strength and stability. 3 refs.

Plotnikov, N.R.; Vasenichev, V.P. *Sov Cast Technol* n 4 1986 p 26-28.

**092697 MECHANISM AND CONDITIONS OF SAND DEFORMATION DURING IMPULSE MOLDING PROCESSES.** There are two ways whereby molding sand is compacted in the impulse molding processes: under the action of static gas pressure with no expansion or acceleration, and under the action of the inertia of gas molecules following the explosive expansion of a gas/air mixture. Compaction by the second method is carried out with the aid of a device consisting of a special chamber or nozzle, a gas chamber, and a valve. The process can thus be accepted as effective and promising by virtue of its many advantages: self-accommodation to various casting configurations and mold dimensions; low sensitivity to variations in molding sand quality; high-quality mold production, and so on.

Vasil'kovskii, L.F. *Sov Cast Technol* n 3 1987 p 20-24.

## Cooling

**092698 CONTINUOUS COOLING OF WET FOUNDRY SAND USING A FLUIDIZED BED.** In order to establish the optimum cooling system for hot returned sand in metal casting processes, a mathematical model including simultaneous heat and mass transfer has been constructed. The study is especially directed towards clarifying the dynamical behavior of sand cooling in a



one-pass fluidized bed. Characteristics of both transient and steady-state bed temperature are explained by the model. A proposal is given on optimal operation which raises heat exchange efficiency in fluidization cooling of hot molding sand. (Edited author abstract) 13 refs.

Nomura, Hiroyuki (Toyoashi Univ of Technology, Toyohashi, Jpn); Terashima, Kazuhiko; Banno, Takeo. *Part Sci Technol* v 5 n 2 1987 p 207-218.

**092699 COOLING RETURN SAND WITH THREE-STAGE PROCESS.** Hot sand problems can be eliminated by evaporating water from the return sand. Such evaporative cooling is achieved by passing a counterflow of high-volume, low-velocity air through a curtain of damp, hot sand. Three-stage cooling is effective and efficient when flash cooling and premixing are accomplished on a belt conveyor and final cooling is performed in a rotary drum.

Didion, Michael S. (Didion Manufacturing Co, St. Peters, MO, USA). *Foundry Manage Technol* v 115 n 10 Oct 1987 p 44-45.

**Drying** See Also FOUNDRY PRACTICE—Molding.

**092700 DRY PNEUMATIC BENEFICIATION OF MOLDING SANDS.** The pneumatic method of beneficiating clay-bearing molding sands (without calcining) can be used for small quantities of sand when the organization of expensive hydraulic beneficiation facilities would be irrational, i.e., primarily in regions remote from the beneficiation plants (Siberia, the Far East). If the foundry already has the means for used sand reclamation, the introduction of pneumatic beneficiation can be much easier.

Osipov, M.A.; Stakhorski, A.V. *Sov Cast Technol* n 3 1986 p 42-43.

## Economics

**092701 ECONOMIC ROUTE MEEHANITE CASTINGS FROM POLYSTYRENE PATTERNS.** The polystyrene pattern manufacturing route is undoubtedly cheaper than conventional foundry techniques. Its use in the foundry can be divided into two distinct areas. First, the manufacture of relatively large castings on a one-off, or several-off, basis, using manually produced patterns, and secondly the production of repetition castings where the patterns are mass produced on specially developed machinery. The expanded polystyrene route for the production of castings, whether large one-offs, short or long series castings, offers significant economic benefits to castings buyers and users. The process also has considerable technical advantages compared with conventional sand casting, and offers engineering designers increased degrees of freedom.

Donaldson, E.G. (Int Meehanite Metal Co). *Cast World* v 20 n 2 Jul 1988 p 30-36.

**Hardening** See Also FOUNDRY PRACTICE—Carbon Dioxide Process.

**092702 USE OF SURFACTANTS TO ENHANCE THE PROPERTIES OF SOLUBLE SILICATE.** One promising method of improving the physicochemical properties of SS is by modification with surfactants. Authors have studied the effects of surfactant modification on surface tension, the wetting angle  $\theta$  and the viscosity of soluble silicates, since these variables determine the binder distribution in the sand. Surface tension measurements were taken by the maximum bubble pressure method in apparatus designed in conformity with the Rebind principle;  $\theta$  measurements on quartz were made by projecting the images of binder droplets on a quartz plate on to a screen; viscosity measurements were made in the VPZh-2 viscometer. Sands based on surfactant-modified soluble silicate have better physicochemical properties than those based on unmodified SS at the same binder content. If the sand properties are kept unchanged, modification reduces the knockout energy to 50-67% of the level for sands made with unmodified SS.

Morozov, I.V.; Chernyavskaya, M.G.; Kazakov, O.G. *Sov Cast Technol* n 3 1986 p 32-33.

## Mathematical Models

**092703 INFLUENCE OF SAND PREPARATION SYSTEM FACTORS ON CONSUMPTION OF MOLDING MATERIALS.** The influence of sand preparation system factors on the consumption of molding materials can be determined from a mathematical model which can predict the behavior of the system and its individual parameters. This article gives an evaluation of the scope for cost reductions in the preparation of unified sands for iron castings. It is based on a model of the molding sand balance. 2 refs.

Kvasha, F.S. *Sov Cast Technol* n 2 1987 p 60-64.

## Mechanical Properties

**092704 SAND TESTING ON SPECIMENS MADE IN HOT BOXES.** According to GOST 23409.7-78, sand specimens made in hot boxes for tensile testing must be prepared in a corebox on a sandblower rig under the conditions laid down in the technical norms for specific binders and sands. The corebox must be designed to produce figure-of-eight specimens 25 mm thick. The NIILitavtoprom Institute has developed a laboratory unit for the production of specimens by blowing into hot boxes. It has been found that identical specimens made in two units operating in parallel can give different tensile strength values for the same batch of sand. The authors therefore investigated the effects on tensile strength of varying the dwell time in the hot box, the cooling rate and the time lapse before testing. The specimens contained 100 parts sand and either 3.5% resin SF-480 and 0.5% catalyst M1 or 2.62% resin SFP-011L and 0.97% acetone.

Bekerman, F.A.; Morozov, I.V.; Sergeev, P.S. *Sov Cast Technol* v 11-12 1987 p 36-38.

## Mixing

**092705 APERCU SUR LES MOYENS DE DOSAGE A LA SABLIERIE: VERIFICATION ET CONTROLE.** [Sand Shop Proportioning Resources: Verification and Control]. Checks of sands prepared in the foundry by continuous mixers reveal large variations in the mechanical properties of these sands. In this article, simple ways of checking and monitoring the proportions are proposed. (Edited author abstract) In French.

Lahalle, J.P. (Cent Technique des Industries de la Fonderie, Fr). *Fonderie Fondeur Aujourd'hui* n 68 Oct 1987 p 19-21.

## Permeability, Mechanical

**092706 PERMEABILITY MEASUREMENTS ON MOLDING AND CORE SANDS.** Permeability measurement is one of the most widely used methods of testing molding and core sands in the laboratory. There are both standard and accelerated methods available. In both cases, permeability is defined by the formula  $r = Ql/\Delta pS$ , in which  $Q$  is the air flow rate ( $\text{cm}^3/\text{min}$ ),  $\Delta p$  the pressure drop across the specimen,  $\text{gf}/\text{cm}^2$  ( $1 \text{ gf}/\text{cm}^2 = 100$ ),  $l$  the length of the specimen ( $\text{cm}$ ) and  $S$  its cross-sectional area ( $\text{cm}^2$ ). An instrument with error correction has been developed by the Kharkov Branch of VNIIITmash and tested at the Usman Foundry Equipment Works. The instrument, Model 04314, has a measuring range of 30-300 units and an effective error limit of  $\pm 4\%$ . It is equipped with a 3-range digital indicator. It requires a 220-V mains supply but uses neither a bell nor a nipple.

Gomel'skii, Yu.S. *Sov Cast Technol* n 3 1986 p 41.

**Reclamation** See Also STEEL FOUNDRY PRACTICE—Molding.

**092707 CORESANDS CONTAINING RECYCLED SAND.** A pilot commercial unit for the pneumatic reclamation of used sands at 12 tons/hr has been set up in the Minsk Tractor Works. The quality of the reclaimed

sand is evaluated from its clay content ( $\leq 0.5\%$ ) and its loss on ignition ( $\leq 1\%$ ). The reclaimed sand is used for coremaking in the iron foundry. The following composition is specified for coresand with the mechanical properties:  $\sigma_{\text{comp}} = 12-14 \text{ kPa}$ ;  $\sigma_{\text{tensile}} = 1.2-1.4 \text{ MPa}$ ; water content 2.2-2.5%; gas permeability  $\leq 90$  units. A similar method to the above has been used to determine the relationship between the wettability of reclaimed sand and mixtures with fresh sand, and the quality of the reclaimed sand. Thus, by determining the wettability of the mixture of fresh and reclaimed sand (a point on the vertical axis) and that of the reclaimed sand alone, one can maintain in-process control over the proportion of reclaimed sand to be used.

Zhukovskii, A.S.; Suris, V.A. *Sov Cast Technol* n 3 1986 p 73-74.

**092708 WHEN CONSIDERING SAND RECLAMATION, PLAN FOR WASTE DISPOSAL.** Environmental restrictions on mining and preparation of new sand for foundries are increasing its cost. This and other factors thus make sand reclamation more attractive than ever for the typical foundry. The article outlines the steps involved in waste characterization and analysis including a materials balance evaluation.

Zayko, Robert E. (RMT Inc, Madison, WI, USA). *Foundry Manage Technol* v 115 n 9 Sep 1987 p 54, 56.

**092709 ECONOMIC PROBLEMS OF SAND RECLAMATION.** It is urgently necessary to draw up an All-Union standard procedure (or amend the existing procedure) with clearly defined rules for calculating the cost-effectiveness of sand reclamation in foundries, reflecting every cost factor. The relevant issues are: the actual costs of handling fresh sand, including, for example, the need for manual labor in winter, turn-around times for freight wagons, maintaining sand disposal dumps and possible extra charges for handling wastes which can harm the environment; the reduction in 'irrecoverable metal losses' when used sand is reclaimed rather than dumped; and the reduction or elimination of delays arising from interruptions in sand supply deliveries compared with the year before sand reclamation was introduced. 4 refs.

Fomin, V.N. *Sov Cast Technol* n 5 1987 p 20-22.

**092710 DRY MECHANICAL RECLAMATION IN MINTYAZHMASH PLANTS.** One major trend in the supply of foundry molding sands is the reclamation of used molding and core sands, with the basic purposes of restoring their grain structure and properties after use. The importance of reclamation in relation to the economic consumption of natural quartz sands is reflected in documents regulating the installation of sand reclamation facilities and a recycling policy. Accordingly, the TsNIIM Institute has developed the technology of dry mechanical sand reclamation from used silicate-bonded mixes and the range of equipment needed for its adoption.

Boichenko, A.S.; Gorfinkel, V.M.; Pyshmintsev, Yu.P. *Sov Cast Technol* n 5 1987 p 23-24.

**092711 INITIAL OPERATING EXPERIENCE IN DRY MECHANICAL RECLAMATION UNITS.** Production trials of the dry mechanical sand reclamation system and equipment have shown that it is a highly efficient system for the recycling of used molding sand mixtures after reclamation.

Mikheenkova, M.A.; Galibov, Yu.V.; Boichenko, A.S.; Menaker, M.N. *Sov Cast Technol* n 5 1987 p 25-29.

**092712 PNEUMATIC RECLAMATION OF USED SILICATE-BONDED SANDS.** The line operates under automatic control. The equipment is switched on before starting to knock out the castings, while the pneumatic regenerators and extraction system are switched on when



sufficient prepared material is available in the hopper. The technical characteristics of the line, with one and two regeneration systems in operation, are reported.

Fomin, V.N.; Zinchenko, Yu.A.; Kutovoi, N.L.; Gordeev, A.N. *Sov Cast Technol* n 5 1987 p 30-33.

**092713 RECLAMATION - THE MOST IMPORTANT MEANS OF REDUCING MOLDING SAND CONSUMPTION.** This report details the recommendations on optimum sand reclamation systems (I and II relating to molding and core sands, respectively), and shows that virtually every type of used sand can be reclaimed and recycled to the required property specifications. For instance, a bentonite-bonded sand can contain up to 20% of used resin-bonded core sand. Either mechanical or thermomechanical methods can be used. Reclaimed sand after mechanical stripping can be used in unified molding sands or special facing sands. After thermomechanical reclamation, the product can be used to make molds and cores of every type, as a substitute of identical quality to fresh sand. Minavtoprom undertakings have developed and introduced a technology and equipment for dry sand reclamation, which can handle virtually any type of used molding or core sand. 7 refs.

Poroshin, Yu. E.; Vodenikov, Yu. A. *Sov Cast Technol* n 5 1987 p 34-38.

**092714 ELECTROHYDRAULIC SAND RECLAMATION FROM USED SILICATE-BONDED MOLDING SANDS.** Electrohydraulic sand reclamation under conditions similar to those encountered in production plants was investigated in a specially developed laboratory rig in which the parameters of the discharge circuit could be varied widely. The ranges were: capacitor charging voltage 20-50 kV; capacitance 0.1-5  $\mu$ F; recurrence frequency 1.0-20 Hz; sand-water pulp volume 1-75 l. The rig was equipped with a two-beam recording oscillograph (S8-11) and an electrostatic kilovoltmeter (S-100). The number of discharge pulses was recorded in a PS-100 counter. The reclaimed sands retain no silicate reaction-products, and confirm the results of derivatographic, mineralogical, X-ray structural and electron microscope investigations. They furthermore confirm that after electrohydraulic regeneration, the reclaimed sands are substantially similar in composition to the original (clay content and water absorption capacity). The results demonstrate that aqueous pulps containing used silicate-bonded sands can be treated electrohydraulically to obtain high-quality reclaimed sands of similar physicochemical properties to the original basic sand. 2 refs.

Kukui, D.M.; Odinochko, V.F. *Sov Cast Technol* n 5 1987 p 43-45.

**092715 USED SAND RECLAMATION IN A NON-FERROUS METALS FOUNDRY.** The wet reclamation technology described yields high grade reclaimed sands from the used sands from nonferrous metals foundries, including clay-bonded molding sand mixes and resin-bonded coresand mixes. The final stage of treatment in electrostatic corona-discharge drum separators completely eliminates residual nonmagnetic metallic impurities. The technology is designed for the use of equipment already in commercial production.

Bulygin, I.F.; Gabdulkaev, R.L.; Krysova, L.P. *Sov Cast Technol* n 5 1987 p 62.

**092716 REGENERATION OF WASTE MOLD SAND.** Two reclamation methods - a dry method and a wet method - are available which make it possible to reuse waste sand discharged from foundries in large quantities. Japan has widely adopted the dry method, in which secondarily generated wastes are easily treated and the recovered sand has a higher purity. Our Yokohama Plant, however, completed a water-washing type reclamation facility, which is equivalent to the wet method, because of the small area of land available and to minimize the initial investment. The facility reclaims the entire amount of waste sand generated in the plant, which is then reused as raw sand material for core and main molds. It has been proved that the sand recovered by the wet method, when

applied to a cold box, (becoming popular in recent years), is higher in strength than new sand, although the purity of the sand recovered by this wet method is lower than that of sand recovered by a dry method. (Author abstract)

Tanaka, Toshihide (Nissan Motor Co, Yokohama, Jpn). *Conserv Recycling* v 10 n 4 1987 p 253-263.

**092717 MODEL L495/24,008 PNEUMATIC SAND RECLAMATION UNIT.** At the request of the agricultural machinery ministry, the VNIITmash Institute has finalized the technical documentation for a prototype production unit based on the experimental unit for used molding sand reclamation installed at the Minsk Tractor Works (MTZ). The unit consists of a supply bunker, an acceleration pipeline, upper and lower cleaning sections, and a suction manifold with drum screens. The drum screens discharge reclaimed sand and screenings separately and are linked to an air extraction system.

Berezhnoi, S.V.; Demenkov, G.G.; Kuznetsov, V.V.; Shmorgun, Ya.Sh. *Sov Cast Technol* n 8 1987 p 51-52.

## Recycling

**092718 THERMAL AND MECHANICAL RECYCLING OF USED FOUNDRY SANDS.** A dry process for recycling used foundry sand has been developed. This process can be used for treating many kinds of binding materials such as, for example, clay, synthetic resins and cement. It consists of a versatile, economical and nonpolluting recycling technique for foundry sands which can be applied to all foundries which have casting molds based on sand. The significant processing stages are magnetic separation, fluid bed treatment and counterflow baffling. The recycling sand has the quality of new sand; an extensive reuse of by-products in other fields of industry appears to have good prospects, so that only extremely low quantities have to be disposed of. Another important factor of using this process is the recovery of about 50% of the heat used. (Edited author abstract) In German and English.

Bauer, H. *Aufbereit Tech* v 8 Aug 1987 p 456-462.

## Rheology

**092719 SIMULATING THE RHEOLOGICAL PROPERTIES OF MOLDING SANDS.** The basic data for synthesizing a rheological model of molding sands can be derived from stress-strain curves recorded in simple shear. The author used a plastometer operating on the principle of axial shear between coaxial cylinders. Tests can be carried out at different shearing rates in sands compacted to different degrees, and complex stress distributions can be set up in the specimens during testing. The stress-strain curves are automatically recorded on the chart of a two-coordinate potentiometer. The key to rheological simulation is the selection of a combination of elementary models compatible with the postulated adequacy conditions in respect of the description of experimental data. Having found the rheological model for a molding sand, the computer can be used to select optimum compaction conditions or sand compositions for a given molding process. 5 refs.

Avdokushin, V.P.; Doroshenko, S.P.; Surguchev, E.A.; Akhonin, S.V. *Sov Cast Technol* n 3 1986 p 23-25.

**092720 AUTOMATED PLANNING OF OPTIMUM MOLDING SAND COMPOSITIONS.** There is an urgent need nowadays to adopt a unified procedure for the twin problems of automated planning, i.e., to optimize the composition and properties of the molding sand and the molding conditions to suit the operating characteristics of a given molding machine, and conversely to optimize the molding machine characteristics to suit molding sand of a given composition and properties. The proposed procedure in conjunction with the use of computers to interpret the oscillograms, the calculation of optimum sand compositions, and continuous composition correction under production conditions, is a key link in automatic production control (ASU TP) systems for foundries.

Matveenko, I.V.; Komarov, L.E.; Sheklein, N.S. *Sov Cast*

*Technol* n 3 1986 p 66-67.

## Structure

**092721 ON THE SPHEROIDAL MODEL OF MOLDING SAND STRUCTURE.** Discussions of the strengthening mechanism in cores and molds, and solutions to practical technical problems, are usually based on the spheroidal model. This describes molding sand as a system of spheres of identical diameter bonded together at contact faces. The size and shape of the contact zones depend on the capillary forces which draw the liquid mixture into the contact areas. The spheroidal model has been used to derive formulas for calculating sand strength. It is applied whenever the strengthening and weakening of molds and cores is studied theoretically or experimentally. It follows from the general views on the strength of disperse systems that the strength of molding sands is actually influenced by the basic characteristics of the spheroidal model such as the number of contact areas in unit volume, the size of the contact zones and their strength, regarded as a combination of adhesion and cohesion. 4 refs.

Zhukovskii, S.S.; Romashkin, V.N. *Sov Cast Technol* n 3 1986 p 20-22.

## Testing

**092722 STUDY OF THE LIFESPAN OF COLD-SETTING AND PLASTIC SELF-SETTING SANDS.** The newly developed test and testing instrument can be used in the laboratory and production shops, not only to monitor the lifespan and investigate the properties of CS and PSS sands but also for the quality control of raw materials. The scientific uses of the instrument embrace the entire kinetics of sand behavior from the moment of preparation. PRS instruments are already in use at the Nevskii Zavod, KhTZ (S. Ordzhonikidze) and Stankolit. 2 refs.

Volkov, A.V.; Borsuk, P.A. *Sov Cast Technol* n 3 1986 p 26-29.

**092723 NEW CONCEPTS OF GREEN SAND TECHNOLOGY - PART I.** Technology advances in green sand molding machines are outpacing the sophistication of conventional sand testing practices. For instance, green strength alone is an inadequate measure of mold quality and can lead to interpretation errors. Molding sands need to be monitored differently today than in the past. Innovative green sand testing technology is available to match the capabilities of today's state of the art molding equipment.

Boenisch, Dietmar (Univ Aachen, West Ger); Ruhland, Norbert. *Foundry Manage Technol* v 116 n 2 Feb 1988 p 21-27.

**Thermodynamic Properties See STEEL FOUNDRY PRACTICE—Molding.**

**SAND, SILICA See Also METAL FORMING—Explosive; SAND, FOUNDRY—Reclamation.**

## Drying

**092724 DEWATERING OF QUARTZ SAND ON STEAM-HEATED HORIZONTAL SAND FILTERS.** Thermal drying and mechanical dewatering with dewatering silos or vacuum filters to 5-15 wt% residual moisture content, depending on grain size, the economical dewatering of sand to constant values 3 wt% water content is of great interest. The Dorr-Oliver horizontal sand filter with steam heating has proved to be excellently suited for this task. (Edited author abstract) In German and English.

Schaper, E. *Aufbereit Tech* v 28 n 6 Jun 1987 p 340-344.

**Marketing See GLASS INDUSTRY—Materials.**



## Mathematical Models

**092725 COMPUTER MODEL FOR BARCHAN-DUNE MOVEMENT.** Barchan sand dunes are one of the most recognizable desert landforms. They have been the subject of considerable mathematical and physical research. Research for this paper set out to take these previous results, and formalize them into a computer model. The model simulates the movement of a barchan dune of any morphology under a variety of wind regimes, and produces graphic and textual output. Limited testing suggests the model produces rates of movement comparable with those observed in the field. The program is written in Turbo Pascal to run on IBM PCs and compatibles. It is believed that the program will be at its most useful as a contribution to geomorphology laboratory classes. (Author abstract) 11 refs.

Fisher, Peter F. (Kent State Univ, Kent, OH, USA); Galdies, Peter. *Comput Geosci* v 14 n 2 1988 p 229-253.

**Moisture Control** See GLASS INDUSTRY—Quality Control.

**Optical Properties** See REMOTE SENSING.

**Piles** See OFFSHORE STRUCTURES—Foundations.

## Sampling

**092726 AUTOMATIC DRY SAND SAMPLING.** Quality Environment Ltd, manufacturers of automatic samplers and systems, has developed an automatic dry sand sampler based on earlier designs of gas and water samplers. The instrument is installed on a silica sand plant. This article discusses the need for sampling and the development of the sand sampler.

Jenkins, Roy (Quality Environment Ltd). *Mine Quarry* v 16 n 9 Sep 1987 p 17, 19.

**Separation** See CLASSIFIERS—Design.

**Size Separation** See SAND AND GRAVEL PLANT—S—Equipment.

## Surfaces

**092727 ACTIVATION OF QUARTZ AGGREGATE BY NITRIC ACID AND ITS INFLUENCE ON THE HARDENING PROCESS AND THE STRENGTH OF CEMENT-SAND CONCRETE.** A study was made of the activation of the quartz sand by solutions of nitric acid and the effect of this activation on the hardening kinetics and the strength of the cement-sand concrete. Experimental evidence shows that activation of the surface of the quartz sand by nitric acid leads to a significant increase in the exchange capacity relative to calcium ions and the partial hydrophobization of the surface. It is established that the significant influence of the surface of the quartz sand on the kinetics of the hardening and the strength of the cement-sand composite, and the linear dependence of the strength of this composite on the exchange capacity of the aggregate. 14 refs.

Gladkikh, Yu.P. (I.A. Grishmanov Belgorod Technological Inst, USSR); Yadykina, V.V.; Zavrzhina, V.I. *J Appl Chem USSR* v 60 n 2 pt 1 Feb 1987 p 314-318.

**SANDSTONE** See Also AQUIFERS—Geochemistry; FLOW OF FLUIDS—Porous Materials; NATURAL GAS DEPOSITS—Texas; OIL FIELDS—Reservoir Evaluation; PETROLEUM GEOLOGY; PETROLEUM GEOLOGY—Alabama; SURFACE ACTIVE AGENTS—Adsorption; URANIUM DEPOSITS.

**092728 ASUPRA INTERACIUNII APEL MARINE SI DE INJECTIE CU UNELE GRESIL ALBIENE.** [On the Interaction Between Sea and Injection Water with Certain Albion Sandstones]. By simulating in the laboratory the filtration of sea and injection water, in deposit conditions, a significant drop in the respectivity index of the collector is pointed out. The explanation is given for the drop of the receptivity index. (Edited author abstract) 17 refs. In Romanian.

Parcalabescu, I.D. (Inst de Petrol si Gaze Ploiesti, Rom); Manea, F.; Nistor, I. *Mine Pet Gaze* v 38 n 5 May 1987 p 234-244.

## Analysis

**092729 SEISMIC STRATIGRAPHY OF EARLY PENNSYLVANIAN MORROWAN SANDSTONES, MINNEOLA COMPLEX, FORD AND CLARK COUNTIES, KANSAS.** The oil fields of the Minneola complex in southwest Kansas produce from north-west-southeast-trending marine sandstones of Morrowan age. Reservoir quality stratigraphic traps developed at the intersection of sandstone trends and topographic lows or channels on the underlying eroded Mississippian surface. Electric logs in the Ladd-8 Norton discovery well revealed that an expanded Morrow section consisting of sandstone and shale had been deposited in lows on the underlying eroded Mississippian surface. Modeling indicated that the addition of this low-velocity elastic material within these channels caused a variety of seismic anomalies, the distribution of which guided subsequent exploration and development drilling. These seismic anomalies are associated with topographic lows on the Mississippian unconformity surface rather than the productive sandstones. These anomalies vary according to the thickness of sediment deposited within the erosionally low areas, the varying geometry and lithologies of these deposits, variations in overlying sediments, and the angle at which the seismic line is shot across the lows. (Edited author abstract) 18 refs.

Clark, Stacy L. (Ladd Petroleum Corp, Tulsa, OK, USA). *AAPG Bull* v 71 n 11 Nov 1987 p 1329-1341.

**092730 TECTONIC, SEDIMENTARY, AND SEISMIC MODELS FOR D SANDSTONE, ZENITH FIELD AREA, DENVER BASIN, COLORADO.** The Zenith field is a recently developed area that contains significant reserves in the D sandstone, with minor production from the J sandstone, with minor production from the J sandstone. The productive D sandstone in the Zenith field has previously been interpreted as a distributary channel deposit. A new depositional environment for the D sandstone is proposed based on detailed mapping that suggests the D productive sandstones are of channel origin within a valley-fill complex. Analysis of seven stratigraphic intervals clearly show that paleostructure influenced D depositional patterns. Seismic models were constructed and seismic data were examined in the Zenith field area to determine if thick D valley-fill deposits are detectable. An analysis of the Dakota interval on the model and seismic data shows an amplitude anomaly present in the position of the D valley-fill deposits. (Edited author abstract) 13 refs.

Sonnenberg, Stephen A. (Bass Enterprises Production Co, Denver, CO, USA). *AAPG Bull* v 71 n 11 Nov 1987 p 1366-1377.

**092731 SEQUENCE STRATIGRAPHY AND DEPOSITIONAL CONTROLS IN LATE PROTEROZOIC-EARLY CAMBRIAN SEDIMENTS OF AMADEUS BASIN, CENTRAL AUSTRALIA.** The Amadeus basin is an isolated intracratonic basin at the center of the Australian continent which, because of its location and geometry, provides an ideal opportunity to investigate depositional controls. The Arumbera sandstone was deposited as two major depositional sequences in a shallow marine and deltaic or coastal-plain setting, similar to that of the Devonian Catskill delta of North America. Sediment was supplied from the southwest by heavily laden, braided streams. In the deep subbasins, the Arumbera Sandstone forms a continuous depositional unit across the Proterozoic-Cambrian boundary. The final geometry of the Arumbera Sandstone and the nature of its sediments were determined largely by local subsidence rates. Other variables, such as climate, the lack of vascular plants, and the uplifts of the source area were also factors in controlling deposition. (Edited author abstract) 30 refs.

Lindsay, John F. (Bur of Mineral Resources, Canberra, Aust). *AAPG Bull* v 71 n 11 Nov 1987 p 1387-1403.

**092732 REGIONAL SEDIMENTOLOGY AND PETROLEUM GEOLOGY OF MARINE, LATE BATHONIAN-VALANGINIAN SANDSTONE IN THE NORTH SEA.** A large number of marine, late Bathonian-Valanginian sandstone units have been identified in the North Sea, north of the Mid North Sea High. This paper discusses their complex areal distribution and outlines sedimentological models. The sandstone formations are interpreted as shallow marine, transgressive and regressive units interbedded with beach, lagoonal and coastal plain deposits. Coarse grained scarp fed fans occur along fault-controlled rift margins. The total proven recoverable reserves in these sandstone reservoirs are  $2.3 \times 10^9$  ton oil equivalent, of which approximately one third is oil. (Edited author abstract) 20 refs.

Faereth, Roald B. (Norsk Hydro AS, Stabekk, Norw); Pederstad, Knut. *Mar Pet Geol* v 5 n 1 Feb 1988 p 17-33.

**Applications** See FLOW OF FLUIDS—Porous Materials.

## Compaction

**092733 COMPACTION AND POROSITY EVOLUTION OF PLIOCENE SANDSTONES, VENTURA BASIN, CALIFORNIA.** Sandstones of the Pico and Repetto formations were studied to quantify the processes involved in compaction and to determine the porosity evolution of the beds during burial. Stratigraphic studies and graphic porosity-depth plots suggest that the sample's maximum burial depths were approximately 10000 ft deeper than the present-day depths of 850-13000 ft. Assuming sands had 40 percent initial porosity, the sandstones that are at present most deeply buried lost a total absolute porosity of 26 percent by all compactional processes, which includes 14 percent by grain rearrangement and 6 percent each by pressure solution and ductile grain deformation. Compaction was almost entirely the result of overburden pressure and was not noticeably retarded in overpressured zones, suggesting that overpressures developed after maximum burial was achieved. Secondary porosity averages 20-40 percent of the total thin-section porosity. (Edited author abstract). 47 Refs.

Wilson, John C. (Univ of Texas at Austin, Austin, TX, USA); McBridge, Earle F. *AAPG Bull* v 72 n 6 Jun 1988 p 664-681.

## Composition Effects

**092734 EFFECT OF SALT COMPOSITION ON CLAY RELEASE IN BERECA SANDSTONES.** The effect of salt composition of fluid injected into clay-bearing Bereca sandstones on the water-sensitivity phenomenon has been studied. Experiments were carried out with solutions of sodium and/or calcium ions, which are the ions commonly found in the formation. Freshwater flooding of sandstones previously exposed to sodium salt solutions results in the release of clay particles and a drastic reduction in permeability. The permeability reduction is lessened, however, when calcium ions are also present in the salt solution. Formation damage is virtually eliminated when the solution composition is adjusted to give calcium surface coverages greater than a critical value of 75%. (Edited author abstract) 29 refs.

Kia, S.F. (Univ of Michigan, MI, USA); Fogler, H. Scott; Reed, M.G.; Vaidya, R.N. *SPE Prod Eng* v 2 n 4 Nov 1987 SPE 15318, p 277-283.

**Deformation** See GEOLOGY—Newfoundland; ROCK—Deformation.

**Fatigue** See ROCK—Pore Pressure.

**Mechanical Properties** See Also ROCK—Mechanical Properties.

**092735 EXPERIMENTAL AND THEORETICAL STUDIES ON STRAIN SOFTENING BEHAVIOR OF ROCKS.** In order to reinvestigate the strain softening behavior of rocks, firstly, conventional triaxial tests for Ainoura sandstone were performed by using the stiff



testing machine. It is an interesting test result that the strain softening behavior could not be controlled stably because of brittleness when confining pressure exceeds 30MPa rather than in uniaxial. The comparison between the local strains with the strain gauges and the apparent strain with the displacement transducer in the strain softening and residual regions manifests that the latter strain reflects the plastic shear deformation along the fracture plane formed in the specimen. It means that the strain softening behavior is not an intrinsic property of material but depends on the structure of the specimen. Secondly, a model for the strain softening behavior was based on the test results and expressed by equation. The present experimental result that softening stress increased with confining pressure reasonably explains the unstable strain softening behavior under high confining pressure. In Japanese. 19 refs.

Kimura, Tsuyoshi (Kyushu Univ, Jpn); Esaki, Tetsuro; Aoki, Kazuo; Nishida, Tadashi. *Nippon Kogyo Kaishi* v 104 n 1199 Jan 1988 p 11-16.

Michigan See PETROLEUM GEOLOGY—Stratigraphy.

Permeability, Mechanical See NATURAL GAS DEPOSITS—Pressure Effects.

## Porosity

**092736 MICROPOROSITY STUDY OF VILLAMAYOR SANDSTONE (SALAMANCA, SPAIN).** In the clay fraction of the Villamayor Sandstone (Salamanca, Spain), pores with a diameter close to 3 nm are predominant. These pores are in the mesoporosity range and micropores are absent. On heating in vacuo at 470 K no significant change in the pore size distribution was observed, but the specific surface area decreased by ca. 10%, probably due to sintering of the particles on loss of water and surface hydroxyl groups. Treatment with humid nitric oxide for 20 h at this same temperature decreased the contribution by these pores but increased that from pores in the range 5-15 nm diameter. No change was observed, however, in the X-ray diffraction diagram, indicating that changes upon nitric oxide treatment affect isolated, non-periodical portions of the crystals. (Edited author abstract) 16 refs.

Del Arco, Margarita (Univ de Salamanca, Salamanca, Spain); Carballo, Ana M.; Holgado, Maria J.; Martin, Cristina; Rives, V. *Appl Clay Sci* v 2 n 4 Sep 1987 p 375-383.

**092737 GENERATION OF WATER-SOLUBLE ORGANIC ACIDS FROM KEROGEN DURING HYDROUS PYROLYSIS: IMPLICATIONS FOR POROSITY DEVELOPMENT.** Concentrations of organic acids ranging up to several thousand parts per million have previously been found in oil-field waters. These acids are of interest because of their potential to enhance porosity by the dissolution of carbonates and aluminosilicates. They are believed to be generated from organic geopolymers (kerogen) in the late-diagenetic-early-catagenetic stage of thermal maturation. During the course of artificial maturation experiments in which kerogens of varying type were heated in the presence of water (so-called 'hydrous pyrolysis') and different minerals, the distribution and abundance of low molecular weight water-soluble acids were determined by gas chromatography and gas chromatography-mass spectrometry. Preliminary results suggest that significant quantities of mono- and di-carboxylic acids are produced during hydrous pyrolysis. The amounts and types of acid appear to vary as a function of kerogen type, maturity and mineralogy. Implications of these findings regarding the development of secondary porosity are discussed. (Author abstract) 18 refs.

Eglinton, T.I. (Univ of Newcastle upon Tyne, Newcastle, Engl); Curtis, C.D.; Rowland, S.J. *Mineral Mag* v 51 pt 4 Oct 1987 p 495-503.

**092738 REPLACEMENT OF SANDSTONES BY URANIFEROUS HYDROCARBONS: SIGNIFICANCE FOR PETROLEUM MIGRATION.** Hydro-

carbons (bitumens sensu lato) in sandstones have been recorded in several instances to have partially replaced their host rock, including quartz grains. Many replacive hydrocarbons are uranium-rich: associated non-uraniferous hydrocarbons are not replacive. Uranium is transported as carbonate complexes, which may be decomposed by organic acids to yield  $UO_2^{2+}$  ions and  $CO_2$ . The  $UO_2^{2+}$  will be absorbed onto hydrocarbons before reduction to a mineral phase, generally uraninite; and the  $CO_2$  may be aggressive towards the silicate grains of the host sandstone. Accretionary nodules of replacive uraniferous hydrocarbon in red beds (e.g. at the cores of reduction spots) can provide valuable information about petroleum migration. They occur particularly in the vicinity of faults, and may record the interactions between metal-rich groundwaters and hydrocarbons leaking along a fault from an underlying reservoir. A trial study in Devonian sandstones of Easter Ross successfully traced a hydrocarbon-bearing sandstone reservoir from an occurrence of uraniferous hydrocarbon nodules. (Author abstract) 55 refs.

Parnell, John (Queen's Univ, Belfast, North Irel); Eakin, Paul. *Mineral Mag* v 51 pt 4 Oct 1987 p 505-515.

**092739 FRACTAL POROUS MEDIA. II: GEOMETRY OF POROUS GEOLOGICAL STRUCTURES.** Some geological structures are analyzed and found to be fractal. An interesting feature is the very large range of scales involved. The spreading dimension is also measured for some of them. The consequences of these measurements on the analysis of transport processes in porous media are presented. The existence of fractal structures multiplies the variety of actual porous media. (Edited author abstract) 21 refs.

Jacquin, C.G. (Inst Francais du Petrole, Rueil Malmaison, Fr); Adler, P.M. *Transp Porous Media* v 2 n 6 Dec 1987 p 571-596.

## Quebec

**092740 DIVERSE OCCURRENCES OF GALENA-CEMENTED SANDSTONES IN THE PALEOZOIC, NORTHERN APPALACHIANS, QUEBEC.** Four occurrences of galena-cemented sandstones in the Lower St. Lawrence - Gaspésie area are described. They constitute a new, insufficiently explored type of deposit in Quebec. One mineralized body, a minor occurrence, is hosted in Lower Devonian rocks deposited in an estuarine, intertidal river channel during a marine regression. Major cements are dolomite and sulfides. Another occurrence, a drilled prospect, is hosted in upper Silurian rocks deposited unconformably on Cambro-Ordovician basement during a marine transgression. With galena and quartz as main cementing minerals, it is similar to some economic sandstone-lead deposits. A third and fourth, a drilled prospect and a minor occurrence, are hosted in Upper Cambrian rocks deposited on continental slopes. (Edited author abstract) 22 refs.

Schrijver, Kees (INRS-Georesources, Ste.-Foy, Que, Can); Beaudoin, Georges. *CIM Bull* v 80 n 908 Dec 1987 p 54-62.

Repair See CHURCHES—Restoration.

## Testing

**092741 TRIAXIAL TESTING OF BRITTLE SANDSTONE USING A MULTIPLE FAILURE STATE METHOD.** The first phase of a recent research program undertaken to investigate sandstone/methane outbursts in coal bearing rocks required the use of a sandstone reference material in the development and trial of the testing procedures to be used. The International Society for Rock Mechanics (ISRM) multiple failure state method is attractive because an approximate strength envelope can be determined from a single specimen. In this test program however the brittle nature of the reference material made control of failure by monitoring axial strain (the ISRM method) impossible; specimens always failed at the first, low or zero confinement, stage. An alternative method of detecting imminent failure in the specimen was developed

and applied, yielding results almost identical to those obtained by conventional single state testing. (Edited author abstract) 3 refs.

Cain, Peter (CANMET, Sydney, NS, Can); Yuen, Clement M.K.; Le Bel, Guy R.; Crawford, Adrian M.; Lau, Donald H.C. *Geotech Test J* v 10 n 4 Dec 1987 p 213-217.

**092742 STRENGTH AND DEFORMATION BEHAVIOUR OF SANDSTONES.** Triaxial test results up to 125 kg/cm<sup>2</sup> on four Indian sandstones have been presented in this paper. The deformation characteristics in terms of modulus of elasticity and Poisson's ratio and their variation with confining pressure have been discussed. The modulus parameters K and n have been evaluated for predictions at high confining pressures. Further, the strength criterion proposed by the authors is also discussed and used in the strength predictions for these sandstones. (Author abstract) 13 refs.

Rao, K.S. (Indian Inst of Technology, New Delhi, India); Venkatappa Rao, G.; Ramamurthy, T. *J Inst Eng India Part CI* v 68 Jan 1988 p 181-186.

## Texas

**092743 CEMENTATION AND BURIAL HISTORY OF A LOW-PERMEABILITY QUARTZARENITE, LOWER CRETACEOUS TRAVIS PEAK FORMATION, EAST TEXAS.** One problem in interpreting diagenetic conditions in older basins is identifying the timing of diagenetic events except in relative terms. In this study of the Lower Cretaceous Travis Peak Formation in East Texas, the authors used a combination of standard petrography and stable-isotope geochemistry, and knowledge of the burial and thermal history of the formation to identify the authigenic cements in the formation, interpret the timing of their formation, and infer the conditions under which the cements precipitated. Results suggest that much of the cementation occurred in deeply circulating hot meteoric water. 43 refs.

Dutton, Shirley P. (Univ of Texas, Austin, TX, USA); Land, Lynton S. *Geol Soc Am Bull* v 100 n 8 Aug 1988 p 1271-1282.

**SANDWICH STRUCTURES** See Also BEAMS AND GIRDERS—Vibrations; BUILDINGS—Walls; DOMES AND SHELLS—Stability; PLATES—Composite; PLATES—Deflection; STRUCTURAL PANELS—Design.

**092744 AL/PVC COMPOSITE EMI SHIELDING MATERIALS: PART 2. MANUFACTURING PROCESS AND PROPERTIES.** AL/PVC laminated shielding material is formed of 270 µm aluminum sheet and 100 µm PVC sheet. The properties are: peel strength: 3.5kgf/25mm width, 180° peel; flame resistance: approved by UL-94V0; dielectric resistance: more than 5 kV; moisture resistance: 40°C×95%RH×500hr, no peeling; and heat resistance: 60°C×500hr, no peeling. The attenuation of noise by this shielding is more than 30db at a noise frequency of 30-1,000MHz. (Edited author abstract) In Japanese. 3 refs.

Hasegawa, Yoshifumi (Sumitomo Light Metal Industries Ltd, Jpn); Nishino, Masao. *Sumitomo Keikinzoku Gihō* v 28 n 4 Oct 1987 p 214-218.

Aluminum See AUTOMOBILE MATERIALS—Light Metals.

Analogies See PLATES—Deflection.

## Analysis

**092745 FINITE ELEMENT PACKAGE FOR THE ANALYSIS OF SANDWICH CONSTRUCTIONS.** An approach to the finite element analysis of sandwich constructions is proposed which is based on a built up element technique. Finite element models are formulated from an assemblage of simple plane elasticity and special beam elements. Such independent specification of core and facings provides a versatile means of defining sandwich properties and response, allowing the analysis of diverse structural forms with a single computer package. The



program is particularly suitable for the examination of sandwich beams with transversely soft cores. Such properties are common in cladding panels which use plastic foams as insulation. (Edited author abstract) 13 refs.

O'Connor, D.J. (Univ of Ulster, Antrim, North Irel). *Compos Struct* v 8 n 2 1987 p 143-161.

## Bonding

**092746 STUDY OF THE TRANSIENT LIQUID PHASE BONDING PROCESS APPLIED TO A Ag/Cu/Ag SANDWICH JOINT.** Transient liquid phase (TLP) bonding involves the formation of a liquid layer between two adjoining pieces and the formation of a solid bond as the liquid disappears during annealing at a constant temperature. In this study, a model Ag/Cu/Ag sandwich joint associated with a simple eutectic phase diagram was used to study the different stages of this process. The results confirm that the TLP bonding is a diffusional process occurring in distinctive stages. The two most important stages are the widening and homogenization of the previously dissolved liquid interlayer, and the subsequent solidification and shrinking of the interlayer. Whereas the former stage involves diffusional processes in the solid phase. A modeling approach has been explored which shows that in most eutectic systems there exists an optimal bonding temperature corresponding to the shortest time needed for complete solidification. The use of an alloy close to the eutectic composition as an interlayer material shortens the TLP process. (Edited author abstract) 13 refs.

Tuah-Poku, Isaac (AT&T Engineering Research Cent, Princeton, NJ, USA); Dollar, M.; Massalski, T.B. *Metal Trans A* v 19A n 3 Mar 1988 p 675-686.

## Crack Propagation

**092747 SANDWICHED LAYER CONTAINING AN INTERFACE CRACK.** Stresses around an interface crack in the elastic layer sandwiched between two elastic half-planes are determined. The crack surfaces are loaded by an equal and opposite normal stress. It is assumed that no contacting regions exist near the crack tips. Application of the Fourier transform technique reduces the problem to that of solving a pair of dual integral equations. To solve the integral equations, the crack surface displacements are expanded in trigonometrical functions accompanied with the unknown coefficients. To solve these unknowns, the Schmidt method is used. The stress intensity factors are calculated numerically for some combinations of Young's modulus ratio of the composite materials and the crack length. (Author abstract) 7 refs.

Itou, S. (Kanagawa Univ, Yokohama, Jpn). *Eng Fract Mech* v 29 n 5 1988 p 549-555.

**Deformation** See DOMES AND SHELLS—Elastoplasticity; PLATES—Buckling.

## Design

**092748 OPTIMAL SANDWICH BEAM DESIGN FOR MAXIMUM VISCOELASTIC DAMPING.** Three-layer sandwich beams, made of two elastic outer layers and a viscoelastic layer sandwiched between them, are considered as damping structural elements. A sixth-order equation of motion with complex coefficients of a sandwich beam in free vibrations is reviewed and solved numerically for a large variety of boundary conditions. The solution is used later as part of an optimal design program. An equality constrained minimization algorithm is modified and used to obtain optimal design of damping sandwich beams subjected to inequality design constraints. The use of the program is demonstrated by solving two design problems. (Author abstract) 13 refs.

Lifshitz, J.M. (Technion, Haifa, Isr); Leibowitz, M. *Int J Solids Struct* v 23 n 7 1987 p 1027-1034.

## Heat Transfer

**092749 SANDWICH PLATE UNDER THERMAL IMPACT.** The extensive application of laminated structure elements in industry arouses interest in determining the temperature fields therein and in describing their dynamic behavior under thermal force action. An expression is obtained for the temperature field and the fluctuations excited by a thermal impact are investigated. (Edited author abstract) 9 refs.

Kharitonov, V.V. (Belorussian Inst of Railroad Transport Engineers, Gomel, USSR); Starovoitova, T.A.; Starovoi-tov, E.I. *J Eng Phys* v 52 n 6 Jun 1987 p 734-740.

**Mathematical Models** See Also BEAMS AND GIRDERS—Vibrations.

**092750 COUPLING BETWEEN SYMMETRIC AND ANTISYMMETRIC MODES IN SHELLS OF REVOLUTION.** An analytical-numerical procedure is applied for composite laminated shells of revolution in investigating the coupling effect between symmetric and antisymmetric modes and its overall influence. The numerical solution is based on separating the variables in Fourier series in the circumferential direction and conical finite elements in the meridional direction. The contribution of the coupling effect is examined by means of parametric analysis. (Author abstract) 11 refs.

Sheinman, Izhak (Technion-Israel Inst of Technology, Isr); Weissman, Shmuel. *J Compos Mater* v 21 n 11 Nov 1987 p 988-1007.

## Mechanical Properties

**092751 TENSILE PROPERTIES OF STAINLESS STEEL-CLAD ALUMINIUM SANDWICH SHEET METALS.** The yield strength, tensile strength, strength coefficient, uniform elongation, strain hardening exponent and strain rate sensitivities have been analyzed on the basis of the fact that the flow stresses of the sandwich sheets follow the rule of mixtures, an average of component properties weighted by the volume fractions. The rule of mixtures can be applied to the tensile strengths and strength coefficients whereas the yield strengths do not follow the rule. The force weighted average rule, an average of component properties weighted by volume fractions and forces, can be applied to uniform elongations, strain hardening exponents and strain rate sensitivities of the sheets. (Edited author abstract) 5 refs.

Lee, Dong Nyung (Seoul Natl Univ, Seoul, South Korea); Kim, Yoon Keun. *J Mater Sci* v 23 n 4 Apr 1988 p 1436-1442.

**092752 HIGH PERFORMANCE SANDWICH PANELS MADE FROM BRAIDED TUBES.** A light-weight, high performance sandwich panel has been developed using thin walled braided tubes as the core material. The panels have certain specific advantages over conventional honeycomb sandwich panels including superior skin-core bonding, integral conduit systems and self-draining thereby avoiding moisture accumulation. A short manufacturing process leads to a cost effective product. The technology of the tube production is not material specific so any reinforcing fiber can be used in conjunction with a large number of resin systems including thermoplastic resins. The braided tubes used as the core can be produced in a wide variety of cross-sectional shapes and sizes so the panels can be designed to meet various specific functions. (Author abstract).

Williams, Dennis J. (Courtaulds Research, Coventry, Engl); Ajibade, Funsho. *SAMPE Q* v 19 n 4 Jul 1988 p 35-39.

## Nondestructive Examination

**092753 CHECK OF BOND QUALITY OF METAL HONEYCOMB BY NONDESTRUCTIVE TESTING.** Described in the paper are the sensitivity and reliability for detecting unbonded fault in the metal honeycomb structure of single skin with the bond strength checker type

QJ-75, the check of the honeycomb structure with back-up plate and the make of the simulated fault in a bonded sample. (Author abstract) In Chinese.

Hu Shaohai (Nanchang Aircraft Manufacturing Co, China). *Wusun Jiance* v 10 n 3 Mar 1988 p 66-68.

## Pressure Effects

**092754 EFFECT OF CONTACT AREA SHAPE AND PRESSURE DISTRIBUTION ON MULTI-LAYER SYSTEMS RESPONSE.** Numerical analysis of stresses, strains, and displacements in multilayer systems for any shape of contact area and pressure distribution is presented. The scheme developed for microcomputers is made of two programs: one for evaluating the stresses and deformations under a point load and the second for performing the numerical integration of the point load solution. Results obtained by using the scheme for the uniformly distributed pressure, Boussinesq, and three-layer system cases were compared to those of analytical and other numerical solutions. Results for a rectangular contact area and nonuniform pressure distribution are presented. The effect of the contact area and pressure distribution shapes on the design strains is illustrated and discussed. The scheme presented is preferable to the 3-D finite element analyses. It dispenses with the use of mainframe computers and is highly accurate. (Edited author abstract) 7 refs.

Uzan, Jacob (Technion, Israel Inst of Technology, Haifa, Isr); Sides, Arie. *Trans Res Rec* 1117 1987 p 21-24.

## Stability

**092755 STABILITY OF ORTHOTROPIC SANDWICH SHELLS OF REVOLUTION UNDER NONAXISYMMETRIC TEMPERATURE-FORCE LOADING.** The stability problem of sandwich shells of revolution subjected to nonaxisymmetric temperature-force loads is solved in this paper. The presence of nonaxisymmetric components of the temperature-force loading complicates the structure stability investigation substantially. A variation of nonlinear thin shell theory in a quadratic approximation is used in this paper for small elongations and shears in the projections on the axes related to the undeformed coordinate surface. 9 refs.

Fomichev, Yu.I.; Perevozchikova, V.M.; Bakulin, V.N. *Sov Appl Mech* v 22 n 12 Dec 1986 p 1155-1160.

## Stresses

**092756 ANALIZA STATECZNOSCI TROJWARSTWOWEJ POWLOKI WALCOWEJ PRZY OBCIAZENIACH ZLOZONYCH.** [Stability of Sandwich Cylindrical Panel under Combined Load]. The paper presents the analysis of stability loss for the open sandwich cylindrical shell with light weight core, and free-supported at all edges. Using the nonlinear solution the upper and the lower critical load values are obtained for panel loaded simultaneously by compression forces acting along shell generated by shear forces uniformly distributed at the shell edges, and also by uniform radial external pressure. The stability equilibrium regions, as load parameters, of the considered shell in three-dimensional coordinate system are elaborated. The influence of some geometrical and physical parameters on critical load values at the stated combined load is also investigated. The results of calculations are presented on graphs. (Author abstract) 11 refs. In Polish.

Sekulski, Zygmunt. *Arch Budowy Masz* v 33 n 4 1986 p 427-442.

**092757 BUCKLING ANALYSIS OF COUPLED SHEAR WALLS BY THE MULTI-LAYER SANDWICH MODEL.** It is well known that the continuum model of a shear wall is a sandwich beam which consists of 'stiff' and 'soft' layers. The paper presents the differential equation system of the multi-layer sandwich beam, and gives a method and closed formulas to determine the



critical load in case of a concentrated force acting on the top of the beam. The paper also shows that the critical load of a multi-layer sandwich cantilever is - to a close approximation - equal to the critical load of a triple-layer sandwich beam, i.e. a sandwich with thick faces. (Author abstract) 9 refs.

Kollar, Laszlo P. *Acta Tech (Budapest)* v 99 n 3-4 1986 p 317-332.

**092758 ON THE RULE OF MIXTURES FOR FLOW STRESSES IN STAINLESS-STEEL-CLAD ALUMINIUM SANDWICH SHEET METALS.** Sandwich sheets of (304 stainless steel)-aluminum-(304 stainless steel) were fabricated by rolling. The flow stresses followed the mixture rule which is an average of component properties weighted by volume fractions, even when transverse stresses were calculated to develop in the component layers due to their different anisotropic plastic behaviour. Such flow stresses are attributed not to negligibly small transverse stresses compared with longitudinal stresses but to the compensation effects of increased and decreased longitudinal stresses due to tensile and compressive transverse stresses which developed in the different component layers. (Edited author abstract) 13 refs.

Lee, Dong Nyung (Seoul Natl Univ, Seoul, South Korea); Kim, Yoon Keun. *J Mater Sci* v 23 n 2 Feb 1988 p 558-564.

**092759 STRESS CONCENTRATIONS OF A SANDWICH PLATE WITH A HOLE OR NOTCH.** This paper presents the characteristics and some example data of the stress concentrations of a sandwich plate in a wide sphere of dimensions in order to determine the optimum design of a sandwich plate with a hole or notch. In analyzing the structural sandwich plate, we apply two bending theories, of which we name one the simple bending theory and the other the advanced bending theory. By using FEM analysis, which is based on these two bending theories, we determine stress concentrations of a sandwich plate, taking into account both the accuracy and cost efficiency of the calculations. We also examine the stress concentrations and reveal the characteristics of the stress concentrations under two types of bending loads: anticlastic bending load and cylindrical bending load. To show examples of stress concentrations of a sandwich plate, we use the simple bending theory under the anticlastic bending load. (Edited author abstract) 4 refs.

Kim, Yeonseung (KAERI, South Korea); Nagao, Hiroshi. *JSMI Int J Ser 1* v 31 n 1 Jan 1988 p 42-49.

**092760 POINT CONCENTRATIONS IN THICK-FACED SANDWICH BEAMS.** The analysis of thick-faced sandwich beams is reviewed with particular emphasis on responses within the region of point loading. Examination of solution equations for three- and four-point loading cases shows that point effects are highly localized, dissipating fully with a critical span away from the point load. The critical span length is constant, and stress concentrations and displacement distortions have constant magnitude when presented in terms relating to sandwich cross-sectional geometry and material properties. Facing stress is magnified below the landing with an associated complementary reduction in core shear stress. Local face bending promotes reduction in overall displacement. Point effects are shown to be the major source of errors in the determination of sandwich properties by flexural testing methods. An alternative approach to such tests is suggested. A conjugate point method, which uses displacement positions outside the influence of the point effects, is shown to be much more accurate. (Author abstract) 13 refs.

O'Connor, David J. (Univ of Ulster, Antrim, North Irel). *J Eng Mech* v 114 n 5 May 1988 p 733-752.

## Structural Analysis

**092761 ULTIMATE STRENGTH OF COMPOSITE STEEL-CONCRETE STRUCTURE OF SANDWICH**

**SYSTEM.** Recently, various kinds of Arctic offshore structures have been constructed. In designing such structures, designers have to pay particular attention to how to overcome ice loads acting on the structures. The use of the composite steel-concrete structure of a sandwich system appears to be a viable solution for offshore structures in the Arctic. In this paper, theoretical and experimental studies were carried out to study elastic-plastic behavior and ultimate strength composite steel-concrete structure of sandwich system where concrete was placed in between steel plates. The theoretical analysis was performed using the finite element method which was newly developed to incorporate nonlinear characteristics of concrete and interaction between steel and concrete. (Edited author abstract) 2 refs.

Matsuishi, Masakasa (Hitachi Zosen Technical Research Lab Inc, Jpn); Hattori, Yoichi; Iwata, Setsuo; Ishihama, Takaaki; Yamamoto, Takao; Kitazono, Masumi. *Nav Archit Ocean Eng* v 24 1986 p 233-240.

**092762 RECTANGULAR HYBRID ELEMENTS FOR THE ANALYSIS OF SANDWICH PLATE STRUCTURES.** The structural behavior of sandwich plate structures are characterized by transverse shear deformations in the core. The assumed stress hybrid finite element technique is particularly suitable for developing sandwich plate bending elements. In the present study, rectangular three-layer sandwich plate elements have been formulated using simple assumed stress functions. Numerical test problems have been solved to examine the convergence property and suitability of these elements. The results are compared with that of a complete quadratic stress mode element and with analytical solutions. Six degrees of freedom per node shell elements are formulated by combining the plate bending elements with membrane elements. A folded plate sandwich panel roof has been analyzed using these elements and the results are compared with the experimental values. The use of simple stress function gives satisfactory results and reduces the size of the matrices to be used, the length of the program, and the computation time for the formulation of element stiffness matrices. (Author abstract) 11 refs.

Fazio, P. (Concordia Univ, Montreal, Que, Can); Gowri, K.; Ha, K.H. *Can J Civ Eng* v 14 n 4 Aug 1987 p 455-460.

**092763 STRUCTURE AND MECHANICS OF THE IRIS LEAF.** The structure of the iris leaf resembles that of a sandwich beam with fiber composite faces separated by a low-density foam core. Such structures have a high specific stiffness because the separation of the faces by the lightweight core increases the moment of inertia of the section with little increase in weight. This paper examines the structure of the leaf of the bearded iris and shows that its flexural stiffness can be explained in terms of the mechanics of sandwich beams. (Author abstract). 17 Refs.

Gibson, L.J. (MIT, Cambridge, MA, USA); Ashby, M.F.; Easterling, K.E. *J Mater Sci* v 23 n 9 Sep 1988 p 3041-3048.

## Structural Design

**092764 USE OF MODAL ENERGY DISTRIBUTION IN THE DESIGN OF HONEYCOMB SANDWICH DECKS.** Through the example of a spacecraft equipment deck, which is generally made of honeycomb sandwich construction, it is shown that modal energy distribution can be used as an effective guideline in improving the deck's frequencies to meet the restrictions imposed upon it. The kinetic energy distribution is employed as a basis for redistributing various packages on the deck. Strain energy distribution is used to identify areas which can be stiffened by bonding 'doubblers' on the face sheets and the doubler thickness is obtained from a sensitivity analysis. (Author abstract) 5 refs.

Sambasiva Rao, M. (ISRO Satellite Cent, Bangalore, India); Nair, P.S.; Durvasula, S. *Comput Struct* v 28 n 6 1988 p 737-743.

**092765 INTERACTIVE BUCKLING IN SANDWICH STRUCTURES.** A progressive destabilization in

compressed elastic structures of sandwich construction is identified. The analytical model allows for the independent variation of bending and shear in the section, components that are found in significantly different combinations in the overall and local forms of buckling that make up the interaction. An optimum wavelength for local buckling is identified, which maximizes the interactive effect by bringing the primary and secondary bifurcations together. Examples of sandwich sections drawn from the literature are tested. (Edited author abstract) 25 refs.

Hunt, G.W. (Imperial Coll of Science & Technology, London, Engl); Da Silva, L.S.; Manzocchi, G.M.E. *Proc R Soc London Ser A* v 417 n 1852 May 9 1988 p 155-177.

## Wave Effects

**092766 LONGITUDINAL IMPACT ON A SANDWICH STRUCTURE BAR (A METHOD OF ESTIMATING THE MODULUS OF RIGIDITY OF THE BOND LAYER).** This paper is concerned with the wave propagation in a sandwich structure bar, the free end of which is struck in the direction of the length by a rigid hammer. The bond layer is subjected to a dynamic shearing strain by the resulting elastic waves, which are generated in both the facing and the core by the longitudinal impact. In taking note of the fact that the magnitudes of the axial strains in the facing and the core as well as the shearing strain in the bond layer depend greatly on the modulus of rigidity of the bond layer, the modulus of rigidity of the bond layer was estimated by comparing the calculated values of the ratio of the axial strain in the core to that in the facing with experimental values. (Edited author abstract) 4 refs. In Japanese.

Fukatsu, Kouji; Nagayama, Yoshitaka; Hayakawa, Kouichi. *Nippon Kikai Gakkai Ronbunshu A Hen* v 54 n 498 Feb 1988 p 268-272.

**SANITARY ENGINEERING** See Also REFUSE DISPOSAL; REFUSE DISPOSAL—Land Fill; SEWAGE TREATMENT; SEWAGE TREATMENT—In Situ; SEWAGE TREATMENT—Stabilization Ponds; SEWAGE TREATMENT PLANTS—Phoenix, Arizona.

## Australia

**092767 STRATEGY FOR BLUE MOUNTAINS SEWERAGE SYSTEM UNDER FIRE.** A \$125 million strategy to upgrade the Blue Mountains sewerage system has come under fire from environmentalists who claim that it is based on scientifically unsound studies. The existing facilities are inadequate and rundown despite upgrading work carried out by the Board since 1980, with only 3 of the 12 sewage plants providing tertiary treatment. The Board has decided on an effluent management plan involving the upgrading of 6 of the existing secondary treatment plants to tertiary standard and the addition of disinfection facilities to all plants. The plan also allows for nutrient removal at some plants. However, the Blue Mountains Environmental Council disputes the study, claiming it involved a large degree of questionable extrapolation.

Jones, Cheryl. *J Inst Eng Aust* v 59 n 24 Dec 11 1987 p 39.

**Bibliographies** See CHEMICAL PLANTS—Effluent Treatment; DAIRIES—Wastes; FOOD PRODUCTS PLANTS—Effluent Treatment; SEWAGE ANALYSIS; SEWAGE TREATMENT—Activated Sludge; SEWAGE TREATMENT—Bibliographies; TEXTILE MILLS—Effluent Treatment.

**Brazil** See SEWAGE TREATMENT—Stabilization Ponds.

**Computer Simulation** See SEWAGE TREATMENT—Activated Sludge.

**Costs** See SEWAGE TREATMENT—Sludge Digestion.

**Developing Countries** See SEWAGE TREATMENT—Stabilization Ponds.



**Economics** See SEWAGE TREATMENT PLANTS—Costs.

**Europe** See REFUSE DISPOSAL—Composting; SEWAGE TREATMENT—Stabilization Ponds.

**Federal Republic of Germany** See SEWAGE TREATMENT—Stabilization Ponds.

**France** See SEWAGE TREATMENT—Lagoons; SEWAGE TREATMENT—Stabilization Ponds.

**Israel** See SEWAGE TREATMENT—Stabilization Ponds.

**Jordan** See SEWAGE TREATMENT—Stabilization Ponds.

## Management

**092768 MULTICRITERION SELECTION OF WASTEWATER MANAGEMENT ALTERNATIVES.** Multicriterion decision-making (MCDM) techniques are used to analyze a multiobjective wastewater management problem in order to select an appropriate management scheme. A specific case study consisting of 15 alternative management schemes is evaluated with respect to 12 noncommensurable, discrete criteria, using three different MCDM techniques: compromise programming (CP), cooperative game theory (CGT), and ELECTRE I. The case study is the Nogales International Wastewater Management Project, which treats wastewater coming from the twin cities of Nogales, Arizona and Nogales, Sonora, Mexico. Analyses of matrix using the MCDM techniques result in selecting the most satisfying alternative in the case of CP and CGT and narrowing the choice to a few non-dominated alternatives (here, two) in the case of ELECTRE I. (Edited author abstract) 23 refs.

Tecle, Aregai (Univ of Arizona, Tucson, AZ, USA); Fogel, Martin; Duckstein, Lucien. *J Water Resour Plann Manage* v 114 n 4 Jul 1988 p 383-398.

**Mathematical Models** See SEWAGE TREATMENT—Activated Sludge; SEWAGE TREATMENT—Stabilization Ponds; SEWAGE TREATMENT—Trickling Filtration; WASTEWATER—Lagoons.

**Peoples Republic of China** See REFUSE DISPOSAL—Peoples Republic of China.

**Peru** See SEWAGE TREATMENT—Stabilization Ponds.

**Planning** See URBAN PLANNING.

**Portugal** See SEWAGE TREATMENT—Lagoons; SEWAGE TREATMENT—Stabilization Ponds.

**Prediction** See WASTEWATER—Biological Treatment.

**Project Management** See REGIONAL PLANNING—Water Supply; SEWERS—Tunnels; WATER TREATMENT PLANTS—Contracts.

**Research** See FOOD PRODUCTS PLANTS—Effluent Treatment; SEWAGE TREATMENT—Activated Sludge; SEWAGE TREATMENT—Stabilization Ponds; SEWAGE TREATMENT—Water Reclamation.

**Safety Codes** See INDUSTRIAL HYGIENE—Research.

**Standards** See CHEMICALS—Health Hazards.

**Switzerland** See REFUSE DISPOSAL—Composting.

**United States** See SEWAGE TREATMENT—Stabilization Ponds.

**Venezuela** See SEWAGE TREATMENT—Lagoons.

**SAPPHIRE** See Also ELECTRIC LAMPS, ARC—Materials; OPTICAL FIBERS—Spectroscopic Analysis; ORE DEPOSITS—Nonmetallic.

**Bonding** See WINDOWS—Space Applications.

## Crystallization

**092769 SAPPHIRE WHISKERS FROM BOEHMITE GEL SEEDED WITH  $\alpha$ -ALUMINA.** Sapphire whiskers were grown in thin films of boehmite (AlOOH) gel seeded with  $\alpha$ -alumina seeds at temperatures from 900 to 1200°C. The whiskers were 20-60 nm in diameter and had lengths up to 10  $\mu$ m. The diameter was found to increase with temperature. The crystallographic growth direction of the whiskers was at 46° to the co-axis of  $\alpha$ -alumina. The sides of the whiskers were faceted, exposing the pyramidal planes. A special technique used, to prepare the films allowed us to characterize them directly by transmission electron microscopy. Details of the technique are described. (Author abstract) 27 refs.

Jagota, S. (Cornell Univ, Ithaca, NY, USA); Raj, R. *J Cryst Growth* v 85 n 3 Nov II 1987 p 527-534.

**Impurities** See RESONATORS, CAVITY—Performance.

**Ion Implantation** See Also ZIRCONIUM AND ALLOYS—Ion Implantation.

**092770 SIALON FORMATION BY  $Si^+$  AND  $N_2^+$  ION IMPLANTATION INTO SAPPHIRE.** Single-crystal alumina was implanted firstly with 400 keV  $Si^+$  and subsequently with  $N_2^+$  ions and then annealed at 1673 K in an  $N_2$  atmosphere. The implanted layers were characterized by means of x-ray diffraction, Rutherford backscattering-channeling of 2 mev  $He^+$  ions, and the resonance nuclear reaction  $^{15}N(p,\gamma)^{12}C$ . The annealing of sapphire implanted at ambient temperature resulted in the formation of  $\beta$ -sialon, a solid solution of  $\beta$ -silicon nitride and alumina in the subsurface layer, while implantation at ca. 100 K resulted in the formation of aluminum oxynitride in the surface layer. In the latter case, the implanted silicon atoms were believed not to react with the implanted nitrogen atoms but with the substrate oxygen atoms. These crystalline precipitates were found to have epitaxial relations with the sapphire substrate. (Author abstract) 25 refs.

Noda, Shoji (Toyota Central Research & Development Lab Inc, Aichi-gun, Jpn); Doi, Haruo; Hioki, Tatsumi; Kawamoto, Jun-Ichi; Kamigaito, Osami. *J Mater Sci* v 22 n 12 Dec 1987 4267-4273.

**092771 SEGREGATION OF MAGNESIUM AND CALCIUM TO THE (101 $\bar{0}$ ) PRISMATIC SURFACE OF MAGNESIUM-IMPLANTED SAPPHIRE.** Auger electron spectroscopy was used to study the segregation of magnesium and calcium to the prismatic plane of sapphire doped with Mg by ion implantation. Segregation behavior depended strongly upon the annealing atmosphere. Air annealing showed Mg segregation to the free surface whereas vacuum annealing resulted in no observable Mg segregation above the detectability limit of our instrument. This is attributed to excessive vaporization of MgO at low oxygen pressures. In the absence of Mg on the surface, strong Ca segregation was observed although the bulk concentration of Ca was below 40 ppm, the total impurity level. The effective heat of segregation of Mg in air was found to be about -1.4 eV in the temperature range 1300° to 1550°C. (Edited author abstract) 24 refs.

Mukhopadhyay, S.M. (Cornell Univ, Ithaca, NY, USA); Jardine, A.P.; Blakely, J.M.; Baik, S. *J Am Ceram Soc* v 71 n 5 May 1988 p 358-362.

**092772 MORPHOLOGY OF SMALL GOLD CRYSTALS FORMED INSIDE SAPPHIRE BY ION IMPLANTATION.** The shape of gold crystals inside sapphire has been studied by transmission electron microscopy. 400 keV gold ions were implanted into sapphire ( $\alpha$ - $Al_2O_3$ ) at a substrate temperature of 1200°C. The gold ions precipitate as small crystals, which have an ordinary f.c.c. structure and dimensions less than 60 nm. The small gold crystals clearly have faceted outlines. The sides of the outlines are parallel to low-index crystal-planes of sapphire. It has therefore been concluded that the shape of the gold crystals is characterized by the foreign crystal (i.e., sapphire), and that the shape should be a tetradecahedron which consists of two {0001} and twelve {21 $\bar{1}$ 3} planes of sapphire. (Author abstract) 6 refs.

Ohkubo, Masataka (Toyota Central Research & Development Lab Inc, Aichi-gun, Jpn); Suzuki, Noritomo. *Phil Mag Lett* v 57 n 5 May 1988 p 261-265.

## Mechanical Properties

**092773 CHARACTERIZING THE HARDNESS AND MODULUS OF THIN FILMS USING A MECHANICAL PROPERTIES MICROPROBE.** A new ultralow load microindentation has been acquired by the Metals and Ceramics Division of Oak Ridge National Laboratory. The system's spatial resolution and its data acquisition capabilities allow the determination of several mechanical properties from submicrometre volumes of materials, hence the term mechanical properties microprobe. In this paper we demonstrate the ability of such a system to measure the modulus and hardness of an ion-implanted sapphire specimen. The implantation process results in an amorphous surface layer 155 nm thick. The hardness and modulus of the amorphous  $Al_2O_3$  are 10 GPa and 200 GPa respectively. This represents a 60% reduction in hardness and a 50% reduction in modulus compared with the unimplanted material. (Author abstract) 8 refs.

Oliver, W.C. (Oak Ridge Natl Lab, Oak Ridge, TN, USA); McHargue, C.J. *Thin Solid Films* v 161 Jul 1988 p 117-122.

## Melting

**092774 EVAPORATION AND ENERGY TRANSFER FOR A PARTIALLY MOLTEN, LASER-HEATED SAPPHIRE FILAMENT.** Molten regions were formed on 0.025-cm-diameter sapphire filaments that were heated from one side with a continuous-wave  $CO_2$  laser beam in a low-pressure flow reactor. As the laser intensity was increased the liquid/solid interface moved from the laser-heated edge to the opposite edge of the filament, the apparent temperature measured in the molten region with an optical pyrometer increased from 1470  $\pm$  25 to 2040  $\pm$  30 K, and the filament evaporation rate increased by a factor of 1.6. Optical and energy-transfer properties of sapphire and liquid  $Al_2O_3$  were calculated from optical pyrometry, energy-balance measurements, and spectral absorption coefficient data for sapphire. (Edited author abstract) 21 refs.

Abrevaya, Hayim (Yale Univ, New Haven, CT, USA); Nordine, Paul C. *J Am Ceram Soc* v 71 n 7 Jul 1988 p 546-553.

**Radiation Effects** See Also ZIRCONIUM AND ALLOYS—Radiation Effects.

**092775 MODEL FOR LATTICE DEFECTS IN SAPPHIRE.** A model is proposed to account for the changes under ultraviolet illumination of several of the prominent optical absorption bands in neutron-irradiated crystalline sapphire. This model, based on observed photobleaching and predicted optical anisotropic properties of single- and paired-anion vacancies, assigns absorption and luminescent bands to specific charge states of anion divacancies. 23 refs.

Pogatschnik, G.J. (Oak Ridge Natl Lab, TN, USA); Chen, Y.; Evans, B.D. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1709-1712.

**Substrates** See CRYSTALS—Epitaxial Growth.

**SATELLITES** See Also ANTENNAS—Radar; DOMES AND SHELLS—Optimization; MAPS AND MAPPING; RADIO ASTRONOMY; REMOTE SENSING; SPACE FLIGHT—Human Factors; SPACE PLATFORMS; SPACE PLATFORMS—USSR; SPACECRAFT.

**092776 POLAR BEAR SPACECRAFT.** The Polar BEAR spacecraft was developed to measure auroral and ionospheric parameters and their effects on rf wave



propagation. It provides coverage of the auroral oval in an area different from that covered from previous spacecraft, and the data gathered will complement the research being carried out by earlier programs. This article provides a technical description of the spacecraft and its initial in-orbit performance. (Author abstract) 4 refs.

Peterson, Max R.; Grant, David G. *Johns Hopkins APL Tech Dig* v 8 n 3 Jul-Sep 1987 p 295-302.

**092777 FLIGHT OF POLAR BEAR: A SUCCESSFUL SATELLITE PROGRAM GROWS FROM PARTS AND DETAILS.** The Polar BEAR - Polar Beacon Experiment and Auroral Research - satellite had been developed by APL and sponsored by the Defense Nuclear Agency and the U.S. Air Force's Space Division. It carried several experiments designed to improve communications over the earth's polar regions. At high latitudes, solar flares and auroras routinely disrupt the transmissions from a multitude of satellites orbiting overhead for purposes of communications, navigation, and meteorology. They interfere as well with some ground communications and radar signals. The Polar BEAR satellite is expected, during one year of mission time, to provide data that will lead to several new techniques for alleviating the disruptions. The article describes the Polar BEAR experiments, steps in building the satellite, launcher malfunctions and final launching.

McCloskey, William. *Johns Hopkins APL Tech Dig* v 8 n 3 Jul-Sep 1987 p 329-339.

**092778 APPLICATION OF ADVANCED TECHNOLOGY TO A PERMANENTLY MANNED SPACE STATION.** Over the last three years, it has been the objective of NASA's Space Station Advanced Development Program (ADP) to provide funds to accelerate promising technologies in generic areas in order to bring them forward as timely application options for the Space Station initial design. New advanced technologies from the NASA funded ADP and the independent research conducted by the United States aerospace industry. Technologies are being tested and matured today in order to provide the Space Station Program Manager the latest options for consideration in the initial design of a Space Station. The ADP covered a span of 14 different disciplines involving some 70 application areas. This article briefly summarizes the most outstanding contributions from selected discipline and presents typical current test data that shows promising applications in four of those areas; namely, Environmental Control and Life Support, Extravehicular Activities, Electrical Power, and Thermal Subsystem Design. (Edited author abstract)

Carlisle, Richard F. (NASA, Washington, DC, USA); Nolan, Mark. *Space Technol (Oxford)* v 7 n 4 1987 p 327-336.

**092779 FAMILY OF PERIODIC SOLUTIONS TO THE PROBLEM OF ROTATION OF A SOLID BODY AT A TRIANGULAR LIBRATION POINT IN THE RESTRICTED THREE-BODY PROBLEM.** Families of spatially periodic solutions to the problem of rotation of an axially symmetric solid body and a body with a triaxial central inertia ellipsoid around the libration point  $L_4$  (circular and elliptical) are obtained and studied in the restricted three-body problem. It is assumed that the inertia ellipsoid is nearly spherical. The investigation is conducted using the Poincaré theory of periodic solutions for degenerate Hamiltonian systems. The obtained solutions are numerically investigated. (Author abstract) 6 refs.

Lelyavin, S.N. *Cosmic Res* v 25 n 3 May-Jun 1987 p 276-282.

**092780 EVOLUTION OF THE ROTATION OF A DYNAMICALLY SYMMETRIC GYROSTAT WITH INTERNAL FRICTION.** The author considers the problem of rotation of a dynamically symmetric rigid body with a small free momentum wheel. There is energy dissipation due to viscous friction between the momentum wheel and the body. In the first approximation it is shown by the method of averaging that the problem of rotation

of a rigid body is integrable. An analytical dependence is obtained between the nutation angle and time. An optimal viscosity is found that achieves the quickest decrease of nutation angle. (Author abstract) 9 refs.

Pivovarov, M.L. *Cosmic Res* v 25 n 3 May-Jun 1987 p 282-285.

**092781 UNIAXIAL MAGNETIC ORIENTATION OF ARTIFICIAL SATELLITES.** We consider motion relative to the center of mass of an axisymmetric artificial Earth satellite with a permanent magnet. It is assumed that the mechanical moment acting on the satellite from the geomagnetic field is large, and that the equations of motion contain a large parameter. Using the existence theorems for periodic solutions of ordinary differential equations with a large parameter, we investigate periodic motions of the axis of symmetry of the satellite, in which this axis makes a small angle with the field-strength vector of the geomagnetic field. Such motions can be employed to realize a uniaxial magnetic orientation mode of the satellite. The findings can provide an exhaustive interpretation of the results of numerical calculations. (Author abstract) 3 refs.

Sazonov, V.V. *Mech Solids* v 22 n 2 1987 p 24-29.

**092782 DYNAMICS OF EARTH-ORBITING FLEXIBLE SATELLITES WITH MULTIBODY COMPONENTS.** A novel approach to the dynamics of satellites with flexible multibody components is proposed. The property of invariance under superposed rigid-body motions of geometrically-exact structural theories is employed to refer the dynamics of motion directly to the inertial frame. To avoid numerical ill conditioning, the dynamics of the far field and the near field are treated separately by introducing a rationally-fixed floating frame, which is a parallel translate of the inertial frame. Constraint conditions to determine the orientation of floating frames proposed in the past are thus entirely bypassed. The proposed formulation can accommodate an unrestricted class of maneuvers under the action of follower forces and gravitational force, and is particularly suited for the dynamics of flexible multibody systems undergoing a broad range of deformations. (Author abstract) 26 refs.

Vu-Quoc, L. (Stanford Univ, Stanford, CA, USA); Simo, J.C. *J Guid Control Dyn* v 10 n 6 Nov-Dec 1987 p 549-558.

**092783 CANADIAN SATELLITE USER CONFERENCE, 1987 - CONFERENCE PROCEEDINGS.** This conference proceedings contains 71 papers eight of which are in abstract form only, and one written in French. The conference covers a wide range of topics of concern to Canadian satellite users and the satellite user community in general. The topics discussed include: corporate satellite networks, entertainment networks, technological advances in satellite communications, telecommunication policy, issues and trends, satellites in the 1990s, satellite links with remote communities, satellite learning systems, innovation aspects, private networks, mobile applications, satellite systems management, teleconferencing, future broadcast opportunities, business communications, system design, costs, and performance. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10615 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Olsen, Brian L. (Compiler) (Telesat Canada, Broadcast Services, Ottawa, Ont, Can); Bigras, A.E. (Compiler); McGuire, C. (Compiler). *Can Satell User Conf, 1987 - Conf Proc, Ottawa, Ont, Can, May 25-28 1987* Publ by Telesat, Ottawa, Ont, Can, 1987 409p.

Applications See ATMOSPHERIC MOVEMENTS—Remote Sensing; WATERSHEDS—Remote Sensing.

Astronomical See Also SOLAR RADIATION—Spectrum Analysis; SUN; TELESCOPES—Space Applications.

**092784 'MIRRABOOKA' X-RAY DETECTOR AND**

**SPACECRAFT DESIGN STUDY.** The Mirrabooka Wide Band Width X-Ray Astronomy satellite is being developed by a consortium comprising the University of Tasmania, ADFA Physics Department and the ANU. The spacecraft is based on the SPARTAN free flying bus developed by NASA. This paper describes a design study being conducted by Hawker de Havilland, in collaboration with the above consortium, which addresses two major tasks: The High Energy Detector; the design integration of the science payload into the SPARTAN bus. The output from the study is the Preliminary Design Review Data Pack, which is an essential step in the NASA review process. (Author abstract)

Raju, J.A.S. *Trans Inst Eng Aust Multi Discip Eng* v GE11 n 1 Apr 1987 p 15-20.

**092785 HIPPARCOS MAIN MISSION ACCURACY SIMULATION.** The Hipparcos satellite is the European Space Agency's (ESA) first mission dedicated to global astrometry. Scheduled for launch by Ariane in 1989, in its 2.5 year nominal lifetime its main mission accuracy goal is to measure the positions and parallaxes of stars brighter than 9th B magnitude with errors of 2 milliarcseconds and proper motions with rms errors of 2 milliarcseconds per year. A study of the main mission accuracy is reported. The work involved early analytical studies followed by the development of simulation programs. Besides allowing an analysis of the effects on the eventual accuracy of satellite design changes, an important side effect was that the programs, by implementing the data reduction on simulated data, enabled us to propose improvements in that reduction and assess their benefits, and to show where no improvement was possible. (Edited author abstract). 2 Refs.

Davies, P.E. (Logica Space & Defence Systems Ltd, London, Engl); Burrows, C.J. *J Br Interplanet Soc* v 41 n 10 Oct 1988 p 435-440.

## Australia

**092786 AUSSAT - INITIAL ORBIT OPERATIONS.** Initial Orbital Operations for the first two AUSSAT satellites are described up to, and including, the commencement of on station operations. Relevant planning and operational considerations are outlined and a description of geostationary perturbations and their corrections given. In particular the problems associated with an unscheduled early deployment from the STS and the constraints imposed on performing a station change on a dual spin spacecraft during the eclipse season are discussed together with details of the actual manoeuvre sequence implemented. 1 ref.

Hope, W. (Edwards, A.F.); Poynton, B.R.; Hope, D. *Trans Inst Eng Aust Multi Discip Eng* v GE11 n 1 Apr 1987 p 1-10.

**092787 LYMAN LAUNCHES AUSTRALIA INTO SPACE.** LYMAN is a joint Australian, USA and European scientific satellite which will enable Australian industry to rapidly come up to speed with space technology. This will enable Australian industry to prime contract all future Australian space endeavors. The LYMAN mission will make the first spectroscopic observations of faint sources in the vital Far Ultraviolet band (90-120 nm) and of any sources in the Extreme Ultraviolet band (10-90 nm). The Far Ultraviolet region is important because molecular hydrogen, a major constituent of the interstellar gas, and deuterium, a crucial cosmological probe, can only be studied in detail in this wavelength region. LYMAN will measure simultaneously the amount of cold, warm, and hot plasma in objects ranging from planets to quasars at temperatures ranging from a few thousand to many millions of degrees.

Stapinski, T.E. *Trans Inst Eng Aust Multi Discip Eng* v GE11 n 1 Apr 1987 p 41-44.

Communication Systems See Also AEROSPACE GROUND SUPPORT—Equipment; ANTENNAS—Control; NATURAL GAS PIPELINES; NATURAL GAS PIPELINES—Control.



**092788 PERFORMANCE OF A KA-BAND SATELLITE SYSTEM UNDER VARIABLE TRANSMITTED SIGNAL POWER CONDITIONS.** A laboratory hardware-based satellite communication system simulator has been used to measure the effects of transmitted signal power changes on the performance of a Ka-band system. Such power changes can be used to compensate for signal fade due to rain attenuation. This paper presents and discusses the results of these measurements. 6 refs.

Fujikawa, Gene (NASA, Cleveland, OH, USA); Kerczewski, Robert J. *NASA Tech Memo* 88984 1987 9p.

**092789 IMPACT OF MODULATION ON OPTIMIZATION OF GROUND TERMINAL AND MOBILE SATELLITE PAYLOAD.** The optimization of the satellite communications payload and ground mobile terminals is applied here to evaluate the impact of the ground modulation technique and required voice quality on the performance and cost of a mobile satellite system. Different analogue and digital modulation techniques are considered, each with different unfaded (C/N<sub>0</sub>) values for the satellite uplink and a given fade margin. Some typical results are given for the ground mobile antenna gain and transmitter amplifier power for different modulations, with the satellite uplink parameters such as the antenna diameter, pointing error and number of beams. They illustrate how such optimization of the total space and ground segments of the Mobile Satellite System is essential to arrive at the total cost given a set of required performance and projected number of users. (Author abstract) 9 refs.

Sultan, Nizar (Canadian Astronautics Ltd, Ottawa, Ont, Can); Paynes, W.F.; Carter, D. *Randolph. Acta Astronaut* v 15 n 11 Nov 1987 p 955-958.

**092790 PROPAGATION EFFECTS ON SATELLITE SYSTEMS AT FREQUENCIES BELOW 10 GHz. A HANDBOOK FOR SATELLITES SYSTEMS DESIGN.** Frequencies below 10 GHz continue to be used for a large fraction of satellite service, and new applications, including mobile satellite service and the global positioning system, use frequencies below 10 GHz. As frequency decreases below 10 GHz, attenuation due to precipitation and gases decreases and ionospheric effects increase. Thus the ionosphere, which can be largely neglected above 10 GHz, receives major attention in this handbook. Although attenuation and depolarization due to rain are less severe below 10 GHz than above, they are nevertheless still important and constitute another major topic. The handbook emphasizes the propagation effects on satellite communications but material that is pertinent to radio navigation and positioning systems and deep-space telecommunications is included as well. (Edited author abstract) Refs.

Flock, Warren L. (Univ of Colorado, Boulder, CO, USA). *NASA Ref Publ* 1108(02) Dec 1987 506p.

**092791 COMMUNICATIONS PAYLOAD CONCEPTS FOR GEOSTATIONARY FACILITIES.** This report summarizes and compares the major results of two NASA sponsored studies that defined potential communications payload concepts to meet the satellite traffic forecast for the turn of the century for the continental United States and Region 2 of the International Telecommunications Union. Future scenarios of aggregations of communications services are presented. Payload concepts are developed and defined in detail for nine of the scenarios. Payload costs and critical technologies per payload are also presented. Finally, the payload concepts are compared and the findings of the reports are discussed. (Edited author abstract) 15 refs.

Poley, William A. (NASA, Cleveland, OH, USA); Lekan, Jack. *NASA Tech Memo* 100154 Dec 1987 94p.

**092792 SATELLITE GROUND-TERMINAL USER SIMULATION.** Realistic simulation of satellite communication systems and evaluation of satellite networking schemes require emulation of the system's users. A laboratory model of a Ka-band satellite-to-ground time-division multiple-access (SS-TDMA) communica-

tion network, referred to as the System Integration, Test, and Evaluation (SITE) Project, is presently under development at NASA Lewis Research Center. The SITE Project uses special bit-error-rate (BER) test sets to simulate the transmitting and receiving users of a communication network. The bit-error-rate test sets contain circuit boards that can be modified to create a variety of interfaces to satellite system ground terminals. (Author abstract) 2 refs.

Shalkhauser, Mary Jo W. (NASA, Cleveland, OH, USA). *NASA Tech Memo* 100234 Jan 1988 14p.

**092793 DIGITAL GROUP DEMODULATION SYSTEM FOR MULTIPLE PSK CARRIERS.** A digital group demodulator has been implemented by employing a transmultiplexer (TMUX) that simultaneously translates multiple SCPC carrier signals into the original baseband form. Since the operation rate for the TMUX is determined by the channel spacing and not by the baud rate, an adaptive interpolation function is required for each channel following the TMUX operation, so that the baseband signals can be obtained at the correct decision timing. For this purpose, an adaptive rate conversion (ARC) filter has been introduced. Using the ARC filters, excellent demodulation performance is always obtained for any relation between the channel spacing and the baud rate in an SCPC system. 6 refs.

Ohsawa, Tomoki (NEC Corp, Jpn); Namiki, Junji. *J Spacecr Rockets* v 24 n 6 Nov-Dec 1987 p 558-564.

**092794 USE OF SPREAD-SPECTRUM CODING AS A FADING COUNTERMEASURE AT 20/30 Hz.** The Direct Interestablishment Communications Experiment (DICE) will involve direct business communications (data, voice and video) between geographically separated divisions of a large company by satellite at 30/20 GHz. In order to reduce the effects of fading, the information flow through the system will be reduced in faded conditions to maintain high quality data and voice communications at the expense of some slowing down of the video information. A method of matching variable throughput to the transmission system by means of spread-spectrum techniques is described. This method maintains stable conditions in the satellite and avoids large excursions in link performance, even under severe fading conditions. (Author abstract) 5 refs.

Hughes, C.D. (ESTEC, Noordwijk, Neth); Tomlinson, M. *ESA J* v 11-12 n 4-1 1987-1988 p 73-81.

**092795 LOW-COST RECEPTION OF METEOSAT AND OTHER SATELLITE IMAGES USING TERRESTRIAL METEOROLOGICAL BROADCASTS.** This article describes an inexpensive means of receiving and displaying satellite images from terrestrial meteorological broadcasts. The simple radio receiver described, when interfaced to a home computer and a printer, delivers products of a quality sufficient for a great many meteorological purposes. This article describes the types of terrestrial meteorological transmissions available and compares them with the direct-satellite-broadcast products. Examples of images that have been received with the simple low-cost system are presented. (Author abstract) 16 refs.

Sanderson, T.R. (ESTEC, Noordwijk, Neth). *ESA J* v 11-12 n 4-1 1987-1988 p 91-102.

## Control

**092796 APPROXIMATE ANALYSIS OF THE SOLUTIONS OF AN AVERAGED BOUNDARY PROBLEM OF OPTIMAL STABILIZATION.** The problem of optimal stabilization of the rotational motion of a controlled solid on a finite time interval is investigated with averaging over the fast variable. (Author abstract) 6 refs.

Boitsova, I.A.; Marchenko, V.P. *Mech Solids* v 22 n 1 1987 p 39-44.

**092797 ANOMALOUS ATTITUDE MOTION OF THE POLAR BEAR SATELLITE.** After an initial

three-month period of nominal performance, the Polar BEAR satellite underwent large attitude excursions that finally resulted in its tumbling and restabilizing upside down. This article describes the attitude motion leading up to the anomaly and the subsequent reinversion effort. (Author abstract) 8 refs.

Hunt, John W. Jr.; Williams, Charles E. *Johns Hopkins APL Tech Dig* v 8 n 3 Jul-Sep 1987 p 324-328.

**092798 DYNAMICS AND CONTROL OF THE TETHERED SATELLITE SYSTEM IN THE PRESENCE OF OFFSETS.** A mathematical model for studying the dynamics of the Tethered Satellite System (TSS) is proposed that accounts for a three-dimensional offset of the point of attachment. The system chosen consists of a plate-type space station from which a tether-supported subsatellite is deployed or retrieved. The mass of the tether as well as the rigid body dynamics of the tether, subsatellite and space station are considered. Controllability of the linearized equations is established numerically and the control is achieved through simple velocity feedback using thrusters and momentum wheels. (Author abstract) 13 refs.

Lakshmanan, P.K. (Univ of British Columbia, Vancouver, BC, Can); Modi, V.J.; Misra, A.K. *Acta Astronaut* v 15 n 12 Dec 1987 p 1053-1057.

**092799 SPACE ATTITUDE DETERMINATION USING A SECOND-ORDER NONLINEAR FILTER.** The stringent attitude determination accuracy and faster slew maneuver requirements demanded by present-day spacecraft control systems motivate the development of recursive nonlinear filters for attitude estimation. This paper presents the second-order filter development for the estimation of attitude quaternion using three-axis gyro and star tracker measurement data. Performance comparisons have been made by computer simulation of system models and filter mechanization. It is shown that the second-order filter consistently performs better than the extended Kalman filter when the performance index of the root sum square estimation error of the quaternion vector is compared. The second-order filter identifies the gyro drift rates faster than the extended Kalman filter. The uniqueness of this algorithm is the online generation of the time-varying process and measurement noise covariance matrices, derived as a function of the process and measurement nonlinearity, respectively. (Author abstract) 35 refs.

Vathsal, S. (NASA, Goddard Space Flight Cent, Greenbelt, MD, USA). *J Guid Control Dyn* v 10 n 6 Nov-Dec 1987 p 559-566.

Control Equipment See ACTUATORS—Automatic Testing.

## Control Systems

**092800 CCD STAR TRACKER FOR SCIENTIFIC SATELLITES.** A microprocessor controlled star-tracker (STT) using a charge coupled device (CCD) as a detector has been developed for the purpose of being applied to attitude determination and control of a scientific satellite. The STT, with the field of view (FOV) of 8 deg × 6 deg can detect and track a star as dim as 5.7th magnitude with accuracy of better than half an arc-minute. A pair of the STTs are aboard the X-ray astronomy satellite ASTRO-C that was launched on February 5, 1987. In this paper, the STT design, and its sensitivity and accuracy analysis are described. Preliminary in-flight results are also presented. (Author abstract) 8 refs.

Ninomiya, Keiken; Hirokawa, Eiji; Murata, Kiyoshi; Muranaka, Noboru; Yokota, Toyohachi; Hamada, Akihiko. *NEC Res Dev* n 89 Apr 1988 p 63-71.

**092801 ISRO SPACECRAFT TECHNOLOGY EVOLUTION.** Evolutionary trends in the technologies related to Indian Space Research Organization (ISRO) satellites, both past and present, are outlined. The issues



related to the developmental complexities of different spacecraft subsystems are discussed in the context of the needs of the current generation operational spacecraft like the Indian Remote Sensing Satellite (IRS) and the Indian National Satellite (INSAT) II. Considerations pertinent to reliability and long-life requirements, crucial to operational satellites, are also highlighted. (Author abstract) 13 refs.

Kasturirangan, K. (ISRO, Bangalore, India); Sridharamurthy, K.R. *Sadhana* v 12 n 3 Mar 1988 p 251-288.

## Cryogenic Equipment

**092802 ANALYTICAL STUDY OF He II FLOW CHARACTERISTICS IN THE SHOOT TRANSFER LINE.** Pressure and temperature profiles for He II flow in the transfer line for the Superfluid Helium On-Orbit Transfer (SHOOT) experiment are determined using a finite difference method to solve the one-dimensional two-fluid conservation equations. For practical purposes, forced flow of He II can be treated as a classical turbulent flow. (Edited author abstract) 15 refs.

Lee, J.H. (NASA, Moffett Field, CA, USA); Ng, Y.S.; Brooks, W.F. *Cryogenics* v 28 n 2 Feb 1988 p 81-85.

**092803 DEWAR TO DEWAR MODEL FOR SUPERFLUID HELIUM TRANSFER.** A model has been developed to predict the flow of He II between a source and a receiving dewar. The model uses a finite difference approximation to integrate the describing equations. The transfer path may contain porous plugs or mechanical pumps, heater sections, heat leaks, constrictions due to valves, and bends. These line elements may occur in any order and in any quantity. The line elements are easily reconfigured by changing the input data. (Edited author abstract) 8 refs.

Snyder, H.A. (Univ of Colorado, Boulder, CO, USA). *Cryogenics* v 28 n 2 Feb 1988 p 86-89.

**092804 MECHANICAL PUMPS FOR SUPERFLUID HELIUM TRANSFER IN SPACE.** Two alternate mechanical pump concepts have been identified for the transfer of superfluid helium in space. Both pumps provide flow at sufficient head and have operating characteristics suitable for the Space Infrared Telescope Facility (SIRTF) refill mission. One pump operates at a relatively low speed and utilizes mechanical roller bearings, while the other operates at a higher rotational speed using either electromagnetic or tilting pad gas-dynamic bearings. The use of gas bearings requires transfer of normal helium so that the gas pressure within the pump casing is high enough to operate the bearings. (Edited author abstract) 14 refs.

Izenzon, M.G. (Creare Inc, Hanover, NH, USA); Swift, W.L. *Cryogenics* v 28 n 2 Feb 1988 p 90-95.

**092805 CAVITATION CHARACTERISTICS OF A SMALL CENTRIFUGAL PUMP IN He I AND He II.** The cavitation characteristics of a small pre-induced centrifugal pump operating in He I and He II over the temperature range 1.8-4.2 K are presented. The pump and close-coupled induction motor operate immersed in liquid helium. A six-blade propeller inducer and a three-blade screw inducer were both tested. With this pump configuration using either inducer, there is a tremendous difference between the cavitation characteristics of He I and He II. (Edited author abstract) 6 refs.

Ludtke, P.R. (NBS, Boulder, CO, USA); Daney, D.E. *Cryogenics* v 28 n 2 Feb 1988 p 96-100.

**092806 TURBULENT FLOW PRESSURE DROP IN VARIOUS He II TRANSFER SYSTEM COMPONENTS.** Pressure drop experiments in highly turbulent He II flow were performed in flow loops driven by either a centrifugal pump or a single-stroke bellows pump. Pressure drops in straight tubing, coiled tubing, bellows sections, valves and Venturi flow meters were measured over a range of flow rates and temperatures. Cavitation and, in some cases, metastable superheating were observed in pressure drop measurements with Venturis in both

centrifugal and bellows pump flow circuits. (Edited author abstract) 10 refs.

Walstrom, P.L. (Univ of Wisconsin, Madison, WI, USA); Weisend J.G.; Maddocks, J.R.; Van Sciver, S.W. *Cryogenics* v 28 n 2 Feb 1988 p 101-109.

**092807 SLIP EFFECTS ASSOCIATED WITH KNUDSEN TRANSPORT PHENOMENA IN POROUS MEDIA.** Porous media used in phase separators and thermomechanical pumps have been the subject of characterization efforts based on the Darcy permeability of laminar continuum flow. The present experimental and theoretical studies address questions of slip effects associated with long mean free paths of gas flow at room temperature. Data obtained are in good agreement, within data uncertainty, with a simplified asymptotic Knudsen equation proposed for porous plugs on the basis of Knudsen's classical flow equation for long mean free paths. (Edited author abstract) 14 refs.

Frederking, T.H.K. (Univ of California, Los Angeles, CA, USA); Hepler, W.A.; Khandhar, P.K. *Cryogenics* v 28 n 2 Feb 1988 p 110-114.

**092808 INTEGRATED FOUNTAIN EFFECT PUMP DEVICE FOR FLUID MANAGEMENT AT LOW GRAVITY.** To transfer He II in space, the supply tank must be drained at low gravity. Conventional capillary devices such as the gallery system make use of the capillary retention capability of the screens for fluid management. Liquid helium is collected into gallery channels and then conveyed to the downstream fountain effect pump (FEP) or mechanical pump. In this paper, a new fluid management device is proposed. The screens along the gallery channels are replaced by porous plugs which are responsible for both the fluid retention and pumping (by mechanical effect) of He II. No downstream pump is needed. (Edited author abstract) 5 refs.

Yuan, S.W.K. (Lockheed Missiles & Space Co, Palo Alto, CA, USA); Frank, D.J. *Cryogenics* v 28 n 2 Feb 1988 p 115-119.

**092809 LIQUID/VAPOUR PHASE SEPARATION IN <sup>4</sup>He USING ELECTRIC FIELDS.** In space, a replacement must be found for gravity to physically control and, in certain instances, contain cryogenic liquids. A program has been started at the Jet Propulsion Laboratory to study the use of electric field generated forces to establish the required orienting effects. We present measurements which show that it is possible to apply strong enough electric fields to a liquid/vapor interface of <sup>4</sup>He to obtain an orienting force comparable to gravity. Some advantages of the electric field separator as opposed to passive surface tension devices are identified. (Edited author abstract) 9 refs.

Israelsson, U.E. (JPL, Pasadena, CA, USA); Jackson, H.W.; Petrac, D. *Cryogenics* v 28 n 2 Feb 1988 p 120-125.

**092810 ENCLOSED CAPILLARY DEVICE FOR LOW GRAVITY MANAGEMENT OF He II.** To transfer He II in space, a large tank must be drained at low gravity. This paper describes and analyses an enclosed gallery device designed for collecting and delivering He II to a pump. The device allows most of the liquid to move about in the tank while it maintains a liquid flow to the pump. Only the liquid in the screen-covered gallery channels and in the upper and lower receivers is contained. The device operates by providing surface tension dominated liquid paths from all locations within the tank to the lower receiver, which houses the pump. (Edited author abstract) 13 refs.

Frank, D.J. (Lockheed Missiles & Space Co, Palo Alto, CA, USA); Yuan, S.W.K. *Cryogenics* v 28 n 2 Feb 1988 p 126-131.

**092811 CAVITATION IN FLOWING SUPERFLUID HELIUM.** Flowing superfluid helium cavitates much more readily than normal liquid helium, and there is a marked difference in the cavitation behaviour of the two fluids as the lambda point is traversed. Examples of cavitation in a turbine meter and centrifugal pump are

given together with measurements of the cavitation strength of flowing superfluid helium. We attribute the unusual cavitation behaviour of superfluid helium to its immense thermal conductivity. (Author abstract) 15 refs.

Daney, D.E. (NBS, Boulder, CO, USA). *Cryogenics* v 28 n 2 Feb 1988 p 132-136.

**Design** See Also SPACE FLIGHT—Human Factors; SPACE PLATFORMS—Design; SPACECRAFT—Design.

**092812 ORBITING VEHICLE SERIES OF SATELLITES.** From 1965 to 1971 the majority of US military space experiments were conducted aboard the Orbiting Vehicle (OV) family of satellites. The authors describe the five OV variants and the diversified program of research that was conducted. (Author abstract) 12 refs.

Powell, Joel W.; Richards, G.R. *J Br Interplanet Soc* v 40 n 9 Sep 1987 p 417-426.

**092813 AI APPLICATIONS FOR THE SPACE STATION.** NASA is currently developing a Space Station for long term usages of space. This Space Station presents NASA with numerous problems which may be best handled by effective use of expert systems. This paper outlines some of the benefits expert systems will provide, some of the issues involved in choosing appropriate applications, and the impact expert systems will have on the design of the Space Station. (Author abstract) 7 refs.

Culbert, Chris (NASA, Houston, TX, USA); Boarnet, Marlon; Savely, Robert T. *Robotics* v 4 n 1 Mar 1988 p 35-40.

**092814 NICHE FOR LIGHTWEIGHT SATELLITES.** Lightweight satellites (lightsats) can be cost effective for missions of 90 days or less. Such low altitude orbits increase ground resolution and reduce telemetry power and antenna size. Sounding rockets, rather than scaled-down satellites, are the best model for lightsat design, fabrication, and operation. Economical ways to launch lightweight payloads are critical to the future of lightsats. Making available several options depends on the establishment of standards for the vehicle/payload interface. Several proposals for small launch vehicles have appeared, but right now progress is impeded because launch-vehicle designers do not know which satellite their vehicle will handle, and satellite designers do not know what accommodations to make for the launch vehicle.

Fuhs, Allen E. (Orbital Sciences Corp); Mosier, Marty R. *Aerospace* v 26 n 4 Apr 1988 p 14-16.

**092815 ASSESSMENT OF SPACE STATION DESIGN AND OPERATION THROUGH BIOASTRONAUTICS.** The paper reviews the main elements and major issues affecting the productivity of crew members during long-term missions on board an Earth-orbiting Space Station. The paper further discusses some selected factors which might not be sufficiently identified and/or considered from the bioastronautics point of view at the present stage of planning Space Station design and operation. (Edited author abstract) 23 refs.

Klein, K.E. (DFVLR, Cologne, West Ger); Bluth, B.J.; Wegmann, H.M. *Acta Astronaut* v 17 n 2 Feb 1988, Space Life Sci: Hum, Acta and Plant, Innsbruck, Austria, Oct 4 1986 p 207-212.

**Detection** See MINERAL EXPLORATION—Remote Sensing.

**Electric Power Supplies** See ELECTRIC POWER GENERATION—Space Applications.

**Electronic Equipment** See Also ANTENNAS—Arrays; ANTENNAS, SCANNING—Feed Systems; TAPE RECORDERS—Space Applications.

**092816 UoSAT-2 DIGITAL COMMUNICATIONS EXPERIMENT.** The Digital Communications Experiment (DCE) in orbit on the UoSAT-2 satellite was designed to gain flight experience with the hardware and



software necessary to operate a store-and-forward communications service from a satellite in low-Earth orbit. Since its commissioning in early 1986, the DCE has been used to relay up to 30 pages of information per day among groundstations in the USA and the UK; the Amateur Radio Service uses the DCE to relay messages among Local Area Packet-radio Networks. The DCE is also running an electronic mail system designed to interact with one user at a time. (Author abstract) 7 refs.

Ward, J.W. (Univ of Surrey, Guildford, Engl); Price, H.E. *J Inst Electron Radio Eng* v 57 n 5 Sep-Oct 1987 Suppl p 163-173.

**092817 DEVELOPMENT OF THE RADARSAT SAR ANTENNA.** The Canadian RADARSAT Remote Sensing Satellite will employ a Synthetic Aperture Radar (SAR) as the primary instrument. This SAR instrument will be able to alter its beam-pointing angle to anywhere within a 500 km Earth ground track, with either a wide or narrow swath, at ground incidence angles from 20 to 49 degrees. This ability to alter the ground track is unique, and neither existing nor planned remote sensing satellites can provide such complete ground access. A major factor that allows this flexibility is the electronically steerable SAR antenna. The SAR antenna represents the single most important technology development for the RADARSAT program, being critical to the performance of the switchable radar. The baseline design is a 15 m by 1.5 m slotted waveguide planar array that extends from a folded launch configuration, which requires the use of RF as well as mechanical joints in the hardware implementation. The ability to reconfigure the ground coverage is provided by electronic beam switching in the SAR Antenna using ferrite variable phase shifters in the elevation (across track) beam forming network. In order to fulfil the performance specifications of the radar system, the SAR antenna must meet stringent electrical and mechanical requirements. Accordingly, an electrical breadboard model was fabricated and tested in order to confirm the viability of the baseline concept. (Edited author abstract) 3 refs.

Zimcik, D.G. (Communications Research Cent, Ottawa, Ont, Can); Martins-Camelo, L.; Cowles, P.R. *Can Aeronaut Space J* v 34 n 2 Jun 1988 p 102-106.

**Energy Storage** See FLYWHEELS—Space Applications.

**Equipment** See ALTIMETERS—Applications; ANTENNAS—Space Applications; SPECTROMETERS—Space Applications.

**Fire Protection** See SPACECRAFT—Fire Protection.

## Fuel Cells

**092818 REGENERATIVE FUEL CELL STUDY FOR SATELLITES IN GEO ORBIT.** This paper summarizes the results of a 12-month study to identify high-performance regenerative hydrogen-oxygen fuel cell concepts for geosynchronous satellite application. Emphasis was placed on concepts with the potential for high energy density (watt-hours/lb) and passive means for water and heat management to maximize system reliability. Both polymer membrane and alkaline electrolyte fuel cells were considered, with emphasis on the alkaline cell because of its high performance, advanced state of development and proven ability to operate in a launch and space environment. Three alkaline system concepts were studied. (Edited author abstract).

Van Dine, Leslie (Int Fuel Cells, South Windsor, CT, USA); Gonzalez-Sanabria, Olga; Levy, Alexander. *NASA Tech Memo* 89914 1987 6p.

**Geodetic** See Also ALTIMETERS—Laser Applications; MAPS AND MAPPING—Imaging Techniques; SURVEYING—Costs; SURVEYING INSTRUMENTS—Computer Applications.

**092819 GLOBAL TRACKING NETWORKS FOR CRUSTAL DYNAMICS.** Highly accurate Satellite Laser Ranging (SLR) and Very-Long-Baseline Interferometry

(VLBI) have been implemented by the NASA Crustal Dynamics Project and many cooperating groups in many countries to form global SLR and VLBI networks for geodetic measurements of global plate motion, plate deformation, regional deformations in areas of high earthquake activity, and accurate measurements of the Earth's polar motion and changes in rotation rate. These systems are measuring vector baselines between stations to an accuracy of 2-5 cm. New improvements being implemented will improve the accuracy to about 1 cm. (Author abstract) 10 refs.

Coates, Robert J. (Goddard Space Flight Cent, Greenbelt, MD, USA). *Acta Astronaut* v 17 n 1 Jan 1988 p 53-60.

**092820 SENSING BY SATELLITE.** Among the many satellites orbiting the earth several times each day are Landsat and SPOT, commercial ventures that collect image data to order for paying customers. These images are rapidly changing the way civil engineers look at the world. Equally impressive is the growing availability of software for small computers that allows sophisticated processing of the satellite data. Such processing can reveal a wealth of data about the landscape. Land usage, the geologic and hydrologic character of an area, and the extent of events such as floods, landslides, crop diseases and snowfall are just a few of the applications. This paper reviews the satellite imagery separation for different surveying tasks.

Link, Lewis E. (US Army Corps of Engineers, Hanover, NH, USA). *Civ Eng (New York)* v 58 n 1 Jan 1988 p 64-67.

**092821 LAUNCH AND OBSERVATION PROGRAM OF THE EXPERIMENTAL GEODETIC SATELLITE OF JAPAN.** The functions, specifications, and observation equipment of Japan's Experimental Geodetic Satellite (EGS) are described along with the nature of observations made since its August, 1986 launch. The functions of the EGS are 1) to reflect input laser light back toward the ground for precise ranging and 2) to reflect solar light to determine the direction to the satellite from an observation site. The satellite is a hollow sphere, 2.15 m in diameter, and weighs 685 kg. The surface is covered with corner cube reflectors and separate solar light reflectors. The launch orbit is circular with an inclination of 50° and altitude of 1500 km. Tracking observation was started by Japanese and cooperative international organizations using satellite laser ranging (SLR) systems and optical cameras just after the launch. The range precision given by some NASA SLR systems reached 1 cm. Observations in isolated islands also will be made using a transportable laser ranging station with a range accuracy of 5 cm. The Hydrographic Department of Japan will obtain and use positioning data in construction of a marine geodetic control network. 11 refs.

Sasaki, Minoru (Maritime Safety Agency, Tokyo, Jpn); Hashimoto, Hidekazu. *IEEE Trans Geosci Remote Sens* v GE-25 n 5 Sep 1987 p 526-533.

**Imaging Techniques** See IMAGE PROCESSING—Image Analysis.

**Instruments** See Also ALTIMETERS—Space Applications; REMOTE SENSING—Agricultural Applications; TELESCOPES—Ultraviolet.

**092822 UPDATE ON VISIBLE AND NEAR INFRARED CALIBRATION OF SATELLITE INSTRUMENTS.** Additions, corrections and general updates are provided to complement J.C. Price on calibration of visible-near infrared satellite instruments. Data relative to the Landsat Multispectral Scanner and the Landsat Thematic Mapper and their correction are discussed. Corrected calibration data for NOAA AVHRR and SPOT are presented. (Edited author abstract) 8 refs.

Price, John C. (USDA, Beltsville, MD, USA). *Remote Sens Environ* v 24 n 3 Apr 1988 p 419-422.

**Japan** See REMOTE SENSING—Multispectral Scanners.

**Laser Applications** See TELECOMMUNICATION LINKS, SATELLITE—Laser Applications.

**Launching** See Also AERODYNAMICS—Jets; AEROSPACE VEHICLES—Navigation Systems; ROCKETS AND MISSILES—Design.

**092823 ARIANE LAUNCHER IN OPERATION.** The directors of ArianeSpace, the world's first industrial and commercial space transport company, have every reason to be confident about the future. So far in 1987 another four satellites have been registered for launch by Ariane, making a total of 63 satellites, 14 of which have already been placed successfully in orbit. Mission V19, the first since last May's failure, is now scheduled for the middle of this month (September), although ArianeSpace remains understandably cautious and will postpone the launch should any major problems arise.

Anon. *Spaceflight* V 29 n 9 Sep 1987 p 312-317.

**092824 INTELSAT'S FUTURE SATELLITES.** The author reports on Intelsat's forthcoming generation of satellites, including the INTELSAT VI and INTELSAT VII. He places special emphasis on the topics of launch vehicle and communications payload.

Thompson, P.T. (British Telecom Intl, Engl). *Electron Wireless World* v 94 n 1623 Jan 1988 p 23-27.

## Magnetic Field Effects

**092825 INFLUENCE OF GEOMAGNETIC FIELD INHOMOGENEITIES ON THE DYNAMICS OF A SCREENED SATELLITE.** The influence of inhomogeneities of the Earth's magnetic field is studied as it affects the stability of the relative equilibrium positions of an Earth satellite which has a cylindrical screen for electrostatic protection and moves on a circular equatorial orbit. The necessary and sufficient stability conditions are derived. The regions of admissible values of satellite parameters are constructed. The type and degree of influence are described for each of the components of the principal moment of Lorentz forces, introduced by the inclusion of the geomagnetic field inhomogeneity in the screen volume as it influences the dimensions of the regions and the vibration frequencies of the satellite. (Author abstract) 8 refs.

Tikhonov, A.A. *Leningrad Univ Mech Bull* n 2 1987 p 35-42.

## Maintenance

**092826 REPPRE - REPSIM - REPSTA: PROGRAMS FOR EVALUATING THE AVAILABILITY AND MAINTENANCE OF SPACE SYSTEMS.** A computer simulation sequence consisting of the REPPRE preprocessing program, the REPSIM simulation program and the REPSTA postprocessing program, has been developed at ESTEC to enable the solution of a class of problems relating to the availability and maintenance of communications and other application satellite systems. Current conventional systems can be modeled, as can the most advanced systems envisaged, such as clusters and repairable assemblies. The result is a tool that has applications in planning, design and risk analysis. (Edited author abstract) 2 refs.

Debruyne, J.C. (ESTEC, Noordwijk, Neth); Jenks, C.S. *ESA J* v 11 n 3 1987 p 297-315.

## Marketing

**092827 DO'S AND DON'TS OF SATELLITE PROCUREMENT.** 12 guidelines are suggested which, coupled with common sense and flexibility, can produce significant savings and advantages for a procuring agency compared to a fixed and intransigent approach. It is argued that a flexible approach is more rewarding than a rigid tender containing strict 'design specifications', and difficult stiff penalties. Cooperative efforts to achieve economies also help the manufacturer understand the buyer's particular



constraints and lead to better working relationships. (Edited author abstract). 1 ref.

Sion, Elío. *Space Commun Broadcast* v 6 n 3 Jul 1988 p 165-171.

**Measurements** See ARTIFICIAL INTELLIGENCE—Expert Systems.

**Monitoring** See OCEANOGRAPHY—Remote Sensing.

**Navigation Aids Application** See Also AIR NAVIGATION: CLOCKS, ELECTRIC—Calibration; HYDROGRAPHIC SURVEYING; NAVIGATION; RADIO NAVIGATION: RADIO NAVIGATION—Reliability; RADIO RECEIVERS—Design; ROCKETS AND MISSILES—Guidance.

**092828 STANDARD-C AND POSITIONING.** The International Maritime Satellite Organization (INMARSAT) began operations in February 1982. It took over the MARISAT system. In the navigation and positioning field INMARSAT will demonstrate the capability and benefits of relaying position information through the INMARSAT system for both the maritime and aeronautical communities. As a natural extension, a series of ranging tests and demonstrations will be conducted and a feasibility study related to the provision of a passive navigation capability and an integrity channel for other navigation systems will be undertaken.

Bell, J.C. (INMARSAT, London, Engl). *Navigation* v 34 n 2 Summer 1987 p 124-139.

**092829 INTEGRATION OF GPS AND STRAPDOWN INERTIAL SUBSYSTEMS INTO A SINGLE UNIT.** Direct design at the outset of a tightly integrated GPS and strapdown INS allows optimization of both for performance and cost. Using this approach, a properly designed slow-sequencing, single-channel receiver, married to a low-cost strapdown inertial unit, provides satellite tracking during 10-g acceleration, very high jamming suppression, improved strapdown inertial outputs, and improved GPS navigation accuracy. Packaging this 'GPS/I' in a single unit reduces software and hardware redundancies, and results in a very low-cost design. (Edited author abstract) 9 refs.

Buechler, David (Northrop Corp, Norwood, MA, USA); Foss, Michael. *Navigation* v 34 n 2 Summer 1987 p 140-159.

**092830 COMNAV-COMMUNICATION/NAVIGATION FOR GLOBAL APPLICATIONS.** A short description of existing and proposed satellite navigation systems is given, followed by a discussion of requirements and chances for the realization of such a worldwide system for civil application. To avoid the extremely high cost of a dedicated satellite system for navigation tasks only, a different and less expensive approach is presented in this paper. It combines communication with navigation by utilizing conventional geostationary and additional high eccentric (LOOPUS) orbit spacecraft. Special attention is given to the orbital configuration of COMNAV, especially the LOOPUS orbit. It can be shown that such an integrated system can fulfill all user demands while simultaneously reducing establishment cost and increasing the chances of early introduction into service. (Author abstract)

Nauck, J. (MBB/ERNO, Bremen, West Ger); Reb, R.; Bischof, B. *Space Technol (Oxford)* v 7 n 4 1987 p 305-308.

**092831 GRAPHIC DEPICTION OF DYNAMIC SATELLITE CONSTELLATION ACCURACY/COVERAGE OVER TIME.** The Global Positioning System (NAVSTAR/GPS) should reach full 3D capability in mid-1990. The constellation is expected to consist of 18 basic satellites and three active spares deployed in six orbital planes. The proposed constellation yields occasional geometric configurations that result in poor navigation solutions, of importance to both the civilian and military aircraft communities. Analyses were undertaken to determine if placing the three active spares in an equatorial orbit at the same altitude as the other satellites

would improve the situation. The analyses demonstrate the equatorial concept of sparing provides certain advantages over the 6 orbit, 21 satellite constellation currently proposed, provided certain new constraints are acceptable and the true mask angle is within the expected range. (Edited author abstract) 6 refs.

Stein, Barry A. (Science Applications Int Corp, McLean, VA, USA); Wheaton, Eric. *Navigation* v 34 n 3 Fall 1987 p 260-274.

**092832 OPTIMAL LOCATIONS OF PSEUDOLITES FOR DIFFERENTIAL GPS.** Because of the announced DOD policy to degrade GPS accuracy, Differential GPS has assumed increasing importance. Furthermore, the delay in operational deployment of the NAVSTAR satellites has focused increased attention on the use of pseudo-satellites (pseudolites or PLs) to enhance accuracy and provide earlier operational capability. This paper examines the following problem: What is the best location for a PL when one considers the worst possible satellite outage in twenty-four hours? What is the resulting worst case GDOP (Geometric Dilution of Precision)? Both single and dual PL systems are considered, and the results are extrapolated to expected user receiver performance (horizontal and vertical errors). The results indicate that a dual PL system will outperform the satellite-only GPS system, even with a worst case satellite outage. In addition, there should be negligible degradation during periods when the military intentionally reduces ephemeris or clock accuracy. Furthermore, the accuracy of such a system would provide aircraft positioning very close to Category I FAA landing requirements. (Edited author abstract) 15 refs.

Parkinson, Bradford W. (Stanford Univ, Palo Alto, CA, USA); Fitzgibbon, Kevin T. *Navigation* v 33 n 4 Winter 1986-1987 p 259-283.

**092833 DIFFSTAR: A CONCEPT FOR DIFFERENTIAL GPS IN NORTHERN NORWAY.** During the Fall of 1984 A/S Kongsberg Vaapenfabrikk (Kongsberg) started a project to investigate the improvement which could be obtained if GPS was used in differential mode. One of the main elements of the project was a field test employing two GPS receivers collecting data for post-processing. Based upon the results of the feasibility study, a project was started. The aim was to develop a real time differential GPS system by the Spring of 1986, based on a GPS receiver developed by Kongsberg. The carrier of the differential message is the Consol navigation system. Consol has been closed down as a navigation system in Northern Norway. The frequency (320 KHz) and the transmitter will be used for the differential GPS-system. The Consol system has a range capability of approximately 1000 km from the reference station. (Edited author abstract)

Fjereide, Hermod (A/S Kongsberg Vaapenfabrikk, Kongsberg, Norw). *Navigation* v 33 n 4 Winter 1986-1987 p 284-294.

**092834 MEASUREMENT ERRORS IN GPS OBSERVABLES.** Airborne users of GPS may benefit from differential (relative) navigation to the extent that the errors in their measurements of pseudorange and/or delta range to each satellite are correlated with observation errors for the same satellite signals received at a reference site. This paper describes some results of an experiment to characterize the measurement errors of one airborne GPS user equipment. The results suggest that pseudorange errors are dominated by slowly varying systematic processes that are likely to be highly correlated from user to user, whereas delta-range errors appear to be zero-mean processes that are dominated by user generated noises, especially clock jitter and tracking errors. (Author abstract) 3 refs.

Greenspan, Richard L. (Charles Stark Draper Lab Inc, Cambridge, MA, USA); Donna, James I. *Navigation* v 33 n 4 Winter 1986-1987 p 319-334.

**092835 GPS FAILURE DETECTION BY AUTONOMOUS MEANS WITHIN THE COCKPIT.** In civil

aviation, it is desirable to be able to detect navigation system failures quickly and alert the pilot and crew accordingly. Also, while not absolutely necessary, it certainly would be simpler in the GPS case if the detection could be done autonomously within the cockpit rather than via a communication link with a network of monitoring stations on the ground. The scheme used for failure detection in this investigation is the Magill adaptive filter, which is also known as the Multiple Model Estimation Algorithm (MMEA) in control theory. Preliminary results indicate that soft ramp-type satellite clock failures can be detected and identified in a relatively short time for the low dynamic environment that might be encountered in the high-altitude enroute situation. Failure detection is more difficult in the low-altitude nonprecision approach scenario, but preliminary results indicate that this can also be done. (Edited author abstract) 10 refs.

Brown, Grover (Iowa State Univ, Ames, IA, USA); Hwang, Patrick Y.C. *Navigation* v 33 n 4 Winter 1986-1987 p 335-353.

**092836 SELF-CONTAINED GPS INTEGRITY CHECK USING MAXIMUM SOLUTION SEPARATION.** Previous approaches to the self-contained GPS (Global Positioning System) integrity problem have been in a hypothesis testing setting where the two hypotheses are: (1) a single satellite has failed, or (2) there is no failure. In this setting, selective availability is the major source of noise that impedes the detection scheme's ability to detect failures and, at the same time, have a low false alarm rate. This paper poses the problem in a different setting where the basic questions posed are: (1) is the radial position error less than some present bound? or (2) is it greater than that bound? This is a more fundamental approach, because the pilot does not really care where the error comes from; rather, he is only concerned that the radial position error does not exceed a certain specified level. Results of Monte Carlo simulations using a 24-satellite constellation and maximum separation of redundant solutions as the test statistic are presented. These results indicate that this scheme could provide radial error protection of about 250 m with acceptably low alarm and miss rates. (Edited author abstract) 8 refs.

Brown, R. Grover (Iowa State Univ, Ames, IA, USA); McBurney, Paul W. *Navigation* v 35 n 1 Spring 1988 p 41-53.

**092837 U.S. COAST GUARD DIFFERENTIAL GPS NAVIGATION FIELD TEST FINDINGS.** The U.S. Coast Guard has a research program to investigate the capability of C/A-code GPS (Global Positioning System) and methods to improve its accuracy and integrity. A differential GPS demonstration system is being assembled and tested at the U.S. Coast Guard Research and Development Center in Groton, Connecticut. Analysis of static and dynamic testing is discussed. Details of instrumentation supporting the test program are also presented. (Edited author abstract) 3 refs.

Pietraszewski, D. (US Coast Guard R&D Cent, Groton, CT, USA); Spalding, J.; Viehweg, C.; Luft, L. *Navigation* v 35 n 1 Spring 1988 p 55-72.

**092838 GLOBAL POSITIONING SYSTEM (GPS) AUTONOMOUS USER SYSTEM.** A GPS autonomous navigation system will be operational with the GPS Block IIR satellites in the first decade of the twenty-first century. This system will provide the user with full navigation accuracy for 180 days even if the GPS Operational Control Segment (OCS) is inoperable. Until such a system is operational, GPS navigation accuracy depends on a functioning OCS. If the OCS fails, the navigation accuracy degrades rapidly. To provide interim full-system accuracy in the event of loss of the OCS, an Autonomous User System (AUS), requiring user segment modification only, has been designed, implemented, and field tested. In this paper, the AUS is described, and test results are presented. These results indicate that, in the 180-day period, the autonomous user can achieve a navigation accuracy of the



same order of magnitude as is obtained when the OCS is functioning. The AUS concepts are also applicable to other navigation systems. (Author abstract). 8 Refs.

Ananda, M.P. (Aerospace Corp, Los Angeles, CA, USA); Bernstein, H.; Feess, W.A.; Paugstat, T.C. *Navigation* v 35 n 2 Summer 1988 p 197-216.

**092839 CHOOSING THE BEST SOLUTION TO THE GPS INTEGRITY AND COVERAGE ISSUES.** The FAA has stated that use of the GPS as a sole means civil aviation radionavigation system requires that a user be quickly notified of out-of-tolerance conditions (the 'integrity' issue), and that the system provide adequate coverage even with satellite failures (the 'coverage' issue). These FAA concerns have prompted numerous research studies aimed at warning GPS users of anomalous conditions and improving satellite coverage. Approaches to the integrity issue include implementation of ground-based monitor stations to evaluate GPS signals (combined with various techniques for disseminating warnings to users), and processing of redundant data within the GPS receiver to detect anomalies and autonomously provide warning. Approaches to the coverage issue include expansion of the Department of Defense (DoD) constellation to 24 semisynchronous satellites, augmentation by dedicated geosynchronous GPS satellites, and addition of a civil GPS payload on existing geosynchronous civil weather satellites. (Edited author abstract). 25 Refs.

Damiani, T.R. (Rockwell Int, Seal Beach, CA, USA); Hemesath, N.B. *Navigation* v 35 n 2 Summer 1988 p 217-237.

**092840 NEW CONCEPT FOR INDEPENDENT % > GPS% INTEGRITY MONITORING.** Monitoring of the GPS signals-in-space status for integrity, with a fast response time, is essential if the system is to be used by civil aviation for nonprecision approach guidance. One alternative for providing such a monitoring function is to employ an independent monitoring system with a few ground-based signal monitors to cover a region and a satellite-based integrity broadcast channel to provide real-time GPS signal status. This paper introduces a new decision concept for accepting or rejecting a GPS signal for navigation in the independent monitoring system. Performance of the new concept is evaluated in terms of the probability of alarms against position error protection level, which are two important parameters for any integrity method. (Author abstract). 9 Refs.

Lee, Young C. (MITRE Corp, McLean, VA, USA). *Navigation* v 35 n 2 Summer 1988 p 238-254.

**092841 AUTONOMOUS GPS INTEGRITY MONITORING USING THE PSEUDORANGE RESIDUAL.** The use of GPS for navigation-critical applications such as aircraft nonprecision approach or harbor and river crossings requires the navigation data to be both extremely accurate and extremely reliable. This paper describes a method for autonomous GPS satellite failure detection and isolation (D/I). The test statistic for the D/I algorithm is the range residual parameter for six or more satellites in view. Based on experiments conducted at Stanford, nominal carrier-aided pseudorange measurement errors are modeled as Gaussian random variables with mean in the range from -5 m to +5 m and standard deviation of 0.4 m. The theoretical statistical distribution of the range residual is given. Monte Carlo simulations present results of applying the algorithm to measurement sets containing a biased measurement. With a 100 m biased measurement present, successful detection is achieved 99.9 percent of the time, and successful D/I is achieved 72.2 percent of the time. (Edited author abstract). 20 Refs.

Parkinson, Bradford W. (Stanford Univ, Stanford, CA, USA); Axelrad, Penina. *Navigation* v 35 n 2 Summer 1988 p 255-274.

**092842 HIGH-ACCURACY KINEMATIC POSITIONING BY GPS-INS.** Recent results achieved with relative GPS positioning techniques indicate that accu-

cies at the meter level are possible in land vehicle mode if the cycle slip problem can be minimized. One of the possible solutions to the problem is the integration of GPS and inertial data. Results from inertial surveys show that, with regular, accurate coordinate or range updates, an INS will give velocity estimates at the cm/s level. By integrating differential GPS measurements with an INS, the effect of cycle slips over short intervals may be eliminated from the positioning results. A Kalman filter-smoother to handle this problem has been developed. It integrates differential range and phase measurements with data from an inertial navigation system. The optimal backward smoother improves the filter estimates for periods of poor geometry and multiple cycle slips. Results of the test show that sub-meter kinematic positioning accuracies and cm/s velocity accuracies are achievable with an integrated GPS-INS. (Edited author abstract). 13 Refs.

Wong, R.V.C. (Univ of Calgary, Calgary, Alberta, Can); Schwarz, K.P.; Cannon, M.E. *Navigation* v 35 n 2 Summer 1988 p 275-287.

**092843 INDEPENDENT GROUND MONITOR COVERAGE OF GPS SATELLITES.** The Federal Aviation Administration plans to monitor independently signals in space from the Global Positioning System (GPS) for the purpose of providing immediate awareness to civil aviation users of the operational status of GPS when it is used in the National Airspace System. The operational status will be disseminated to air traffic control and will possibly be broadcast from ground monitoring stations to GPS aviation users via a dedicated integrity channel. An algorithm is described that measures the coverage of a configuration of ground monitoring station locations, and it is applied to several different configurations of ground monitoring stations to compare the coverage provided. Also included are the resulting ground monitoring station configurations that give the best coverage of GPS signals for several specific geographical areas, the conterminous United States (CONUS), Canada, and Alaska. 5 refs.

Viets, Karen J. (Mitre Corp, McLean, VA, USA). *IEEE Trans Aerosp Electron Syst* v AES-23 n 5 Sep 1987 p 678-685.

**092844 NAVSAT: A GLOBAL SATELLITE BASED NAVIGATION SYSTEM.** A description is given of the NAVSAT concept, developed by the European Space Agency to fulfill the civilian user requirements for a better navigation capability and mobile communication needs in the future. In selecting the NAVSAT architecture, special care has been devoted to different satellite constellation alternatives in order to identify the most promising solution in terms of navigation performance and system cost. The present NAVSAT baseline, while offering precise navigation performance comparable or better than the Global Positioning System (GPS), cuts significantly the overall cost of a satellite navigation system. The particular constellation selected is also easing the set up of the integrated navigation-communication-search-and-rescue service.

Rosetti, C. (ESA, Paris, Fr); Carnebianca, C. *IEEE Aerosp Electron Syst Mag* v 2 n 12 Dec 1987 p 15-21.

**092845 HIGH-CAPACITY AERONAUTICAL MOBILE SATELLITE SYSTEM.** A conceptual system design is described for a satellite-based aeronautical safety communications system capable of serving both general aviation (GA) aircraft and commercial aviation (CA) aircraft in the contiguous US (CONUS) in the mid-1990s. It is shown how the large system capacity that is required can be obtained using a 15-m deployable antenna onboard a high-power commercial communications satellite expected to be available in the mid-1990s. 6 refs.

Sue, M.K. (JPL, Pasadena, CA, USA). *IEEE Aerosp Electron Syst Mag* v 3 n 1 Jan 1988 p 11-20.

**092846 ON PRECISION OF GPS C/A CODE.** The accuracy of clear acquisition (C/A) code for civilian users of the Global Positioning System, in comparison with precise (P) code, is discussed. Different design techniques

for GPS receivers are presented. The 1-ms range ambiguity of C/A code is discussed, and a solution is given. Intentional degradation of GPS signals and denial of accuracy is discussed, and some predictions are presented. The issue of government support and protection of domestic GPS industry against possible unfair international competition is briefly discussed. 12 refs.

Ashjaee, Javad. *IEEE Aerosp Electron Syst Mag* v 3 n 6 Jun 1988 p 7-10.

**092847 PROCEEDINGS OF THE SATELLITE DIVISION FIRST TECHNICAL.** This conference proceedings contains 38 papers on navigation satellites. The main topics discussed include the Global Positioning System (GPS), which is a satellite-based navigation system for measuring position, velocity and time anywhere in the world, the integration of GPS with inertial navigation systems, satellite constellations, GPS receiver performance and design, Kalman filtering applications, GPS accuracy issues, satellite failure detection, and aircraft and ship navigation systems. Technical and professional papers from this conference are indexed and abstracted with the conferencing code no. 11198 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Inst of Navigation, Satellite Div, Washington, DC, USA). *Proc of the Satell Div First Tech Meet, Colorado Springs, CO, USA, Sep 21-25 1987* Publ by Inst of Navigation, Washington, DC, USA, 1988 316p.

## Observatories

**092848 EARTH OBSERVATION FROM THE SPACE STATION.** The Polar Platform as an element of the international Space Station programme offers real opportunities to provide remotely sensed data in a routine way to meet the operational needs of the Earth Observation science and applications community. The paper identifies application priorities for the Polar Platform and the associated measurement requirements. The importance of data handling is stressed and proposals made to involve user based data centres in the Polar Platform ground segment. An adequately funded national Polar Platform Preparatory Programme is recommended to develop applications and to prepare the user community. Suggestions are made for a UK sensor development programme that complements instruments provided through ESA. (Edited author abstract)

Plevin, John (Natl Environment Research Council, Swindon, Engl); Lynn, David. *J Br Interplanet Soc* v 40 n 11 Nov 1987 p 505-512.

**092849 IRAS KNOWN ASTEROID PREDICTION AND ASSOCIATION.** IRAS (Infrared Astronomical Satellite) was launched on January 25, 1983, with the primary purpose of performing a survey of the entire celestial sphere in four infrared wavelength bands. To strive for completeness and reliability for the fixed point sources, 95% of the sky was covered with at least four scans of the telescope field of view. This type of coverage detects moving objects, such as asteroids, at more than one location. To identify each moving object, all of the detections from a single source must be extracted and then linked together. This paper describes the techniques and procedures used to obtain data concerning the known asteroids from the set of observations produced by the IRAS satellite. (Author abstract) 7 refs.

Kia, Tooraj (JPL, Pasadena, CA, USA); Fowler, John W. *J Astronaut Sci* v 35 n 3 Jul-Sep 1987 p 287-299.

**092850 PROMISE OF THE HUBBLE SPACE TELESCOPE.** No other NASA scientific spacecraft has attracted so much attention during its development than the Hubble Space Telescope (HST). This is in large part due to the enormity of the technical challenges but also due to the series of delays generated both within the program and by the hiatus in flights of the Space Shuttle. This attention should not detract from the paramount



scientific role that we expect the HST to play. It will present a leap in orders of magnitude in observational capability in optical astronomy, opening up new areas of investigation. Experience in its operation will also determine the wisdom of the 'great observatories' approach that NASA has assumed for the major astronomy and astrophysics disciplines. (Author abstract) 14 refs.

O'Dell, C.R. (Rice Univ, Houston, TX, USA). *J Br Interplanet Soc* v 41 n 1-2 Jan-Feb 1988 35-40.

**092851 RADARSAT - CANADA'S FIRST EARTH OBSERVATION SATELLITE.** RADARSAT is a Canadian-led co-operative program with the UK and USA to launch and operate a remote sensing satellite with a Synthetic Aperture Radar (SAR) as the principal sensor. Other instruments may include a Radar Altimeter (RA) and an Along-Track Scanning Radiometer (ASTR). The spacecraft is scheduled for launch into a sun-synchronous polar orbit in 1994 on an expendable launch vehicle for a five-year mission. The right-looking SAR, with the unique ability to shape and steer the radar beam over an 800 km accessibility swath, will provide daily Arctic coverage, three-day coverage of the Canadian land mass, and 16-day coverage of the globe. The RA is expected to have a 25 km swath along the spacecraft nadir track, and will also provide global coverage every 16 days. The objective of the RADARSAT program is to generate data of both applications and research value related to global ice, oceans, renewable resources and nonrenewable resources. The spacecraft platform will be a low-earth orbit derivative from the ESA Olympus geostationary orbit spacecraft. The expendable launch vehicle will probably be a Titan IV. The spacecraft will have an ability to store the instrument data which can later be transmitted to an appropriate data acquisition station, thus ensuring global coverage by the sensor complement. (Edited author abstract) 15 refs.

Ahmed, S. (Communications Research Cent, Ottawa, Ont, Can); Warren, H.R.; Langham, E.J. *Can Aeronaut Space J* v 34 n 1 Mar 1988 p 4-12.

**092852 GROUND SYSTEM FOR THE XUV WIDE FIELD CAMERA ON ROSAT.** In addition to its large X-ray telescope, the W. German ROSAT satellite will carry an XUV telescope (the Wide Field Camera, WFC) provided by the United Kingdom, and covering the wavelength range from 60 to about 600 Å. The primary scientific objective of the mission is to perform all-sky surveys in the X-ray (6-80 Å) and XUV (60-200 Å) wavebands. The subsequent pointing phase will be used for detailed studies of selected sources. I describe the Ground System which will be responsible for WFC mission operations and data handling, and discuss some of the scientific results expected from the instrument. (Author abstract). 10 Refs.

Pye, J.P. (Leicester Univ, Leicester, Engl). *J Br Interplanet Soc* v 41 n 8 Aug 1988 p 337-343.

**092853 ROSAT WIDE FIELD CAMERA XUV TELESCOPE.** If all goes to plan early 1990 will see NASA launch the West German X-ray astronomy satellite ROSAT. On-board will be the main X-ray telescope designed to view the energy range 0.15 to 2.0 KeV while alongside will be the XUV Wide Field Camera built by the United Kingdom to cover the lower energy band 0.062 to 2.21 KeV. The prime objective of the mission is to perform an all-sky survey of soft X-ray sources with a sensitivity much better than has previously been possible and an energy band extending to the extreme ultraviolet, a region of the electromagnetic spectrum which has so far remained largely unexplored. (Author abstract). 21 Refs.

Barstow, M.A. (Univ of Leicester, Leicester, Engl); Willingale, R. *J Br Interplanet Soc* v 41 n 8 Aug 1988 p 345-351.

**092854 QUICK-LOOK FACILITY FOR THE XUV WIDE FIELD CAMERA ON ROSAT.** The British XUV Wide Field Camera (WFC) will form part of the ROSAT X-ray astronomy satellite due to be launched in 1990. Since commanding of the satellite and data reception will

take place in Germany, project staff in the UK will not have immediate access to telemetry data and thus will be unable to carry out near real-time monitoring of the functioning of the instrument and the quality of the scientific data returned. This will be the primary responsibility of the WFC Quick-Look Facility (OLF). Attached to the ROSAT Science Data Centre (RSDC) at the Max Planck Institute for Extraterrestrial Physics (MPE) near Munich, the OLF will serve as the front-end of the WFC ground system. The planned tasks and operation of the OLF and its interface with the UK and German ground systems are outlined. (Author abstract). 2 Refs.

Harris, A.W. (Rutherford Appleton Lab, Oxford, Engl). *J Br Interplanet Soc* v 41 n 8 Aug 1988 p 353-356.

**Operations Research** See SPACE PLATFORMS—Operations Research.

**Orbital Laboratories** See Also ATMOSPHERIC COMPOSITION—Spectroscopic Analysis; SPACE PLATFORMS—Design.

**092855 LIFE SCIENCES SPACE STATION PLANNING DOCUMENT: A REFERENCE PAYLOAD FOR THE EXOBIOLOGY RESEARCH FACILITIES.** The Cosmic Dust Collection and Gas Grain Simulation Facilities represent collaborative efforts between the Life Sciences and Solar System Exploration Divisions designed to strengthen a natural Exobiology/Planetary Sciences connection. The Cosmic Dust Collection Facility is a Planetary Science facility, with Exobiology a primary user. Conversely, the Gas Grain Facility is an Exobiology facility, with Planetary Science a primary user. Requirements for the construction and operation of the two facilities, contained herein, were developed through joint workshops between the two disciplines, as were representative experiments comprising the reference payloads. (Edited author abstract) 3 refs.

Anon (NASA, Washington, DC, USA). *NASA Tech Memo* 89606 Feb 1987 66p.

**Orbital Transfer** See SPACECRAFT—Orbital Transfer.

**Orbits and Trajectories** See Also ELECTROMAGNETIC WAVES—Propagation in Troposphere; MATHEMATICAL TECHNIQUES—Boundary Value Problems; PROBABILITY—Game Theory; SPACECRAFT—Control; SPACECRAFT—Orbital Transfer; SPACECRAFT— rendezvous.

**092856 AUSTRALIA AND THE REGULATION OF THE GEOSTATIONARY-SATELLITE ORBIT.** Australia was deeply involved in the first session of the World Administrative Radio Conference on the use of the geostationary-satellite orbit and the planning of the space services utilising it. This paper discusses the historical background to the Conference, Australia's preparations for it and the matters dealt with at the Conference, with particular reference to the Fixed-Satellite Service. It outlines those issues which remain to be resolved before the second session of the Conference in 1988 with particular reference to Australia's interests. (Author abstract) 7 refs.

Andrews, F.B. *Trans Inst Eng Aust Multi Discip Eng v* GE11 n 1 Apr 1987 p 11-14.

**092857 PRELIMINARY ORBIT DETERMINATION USING SATELLITE-TO-SATELLITE LIMITED RANGE AND RANGE-RATE DATA.** A method is presented for the problem of preliminary orbit determination by use of limited range and/or range-rate data with random initial guesses. This method, based on observation function minimization techniques, is essentially a deterministic process. The problem considered consists of an unknown geocentric satellite observed by either one or two tracking satellites using minimum measurement data sets for the determination of the unknown satellite's orbital elements. Additional data, in excess of the minimum data, are used to identify spurious solutions. (Edited author abstract) 8 refs.

Culp, Robert D. (Univ of Colorado, Boulder, CO, USA); Jin, Lin-Sheng. *Acta Astronaut* v 15 n 11 Nov 1987 p

807-811.

**092858 MACRO-MEASUREMENTS CONCEPT: A TOOL FOR SPECIFICATION OF RADIO-LOCALIZATION SYSTEMS.** Within the scope of problems concerning orbit computation, our study is based on information obtained from the set of measurements performed during one satellite pass within visibility of a tracking station. At best, this information is restricted to a number of geometrical components which are studied and interpreted. It is the aggregate of the set of geometrical components obtained during the set of passes which allow orbit computation to be performed. The quality of this information is then examined, i.e. the precision of geometric components obtained and factors liable to have a negative effect. Signature errors of elementary measurements performed during each pass and which may seriously impair orbit computation are finally considered. (Edited author abstract)

Zarrouati, O. (CNES, Toulouse, Fr). *Acta Astronaut* v 15 n 11 Nov 1987 p 813-821.

**092859 ORBIT AND ATTITUDE CONTROL OF A GEOSTATIONARY INERTIALLY ORIENTED LARGE FLEXIBLE PLATE-LIKE SPACECRAFT.** The paper presents design of a near optimal orbit and attitude control system for a very large flexible rectangular flat plate-like spacecraft in geostationary orbit, with its normal kept in the orbital plane in an inertial orientation. First, assuming the plate to be rigid, an optimal control system is designed. Two control systems are needed: one to balance the gravity gradient torque and the other to control the plate's orbit and attitude against disturbances. The interaction of the structural dynamics with control system is investigated next. It is shown that the structural dynamics destabilizes the control system. The control design is modified to reduce the interactions, by including just a couple of flexural modes into the control logic and by optimally locating the thrusters a little away from the corners. An approach to find an optimal location of actuators and a concept of 'associated modes' are also proposed. (Edited author abstract) 14 refs.

Rajasingh, C.K. (DFVLR, Oberpfaffenhofen, West Ger); Shrivastava, Shashi K. *Acta Astronaut* v 15 n 11 Nov 1987 p 823-832.

**092860 PREFERRED COORDINATE SYSTEM AND THE ASSOCIATED ORIENTATION REPRESENTATION IN ATTITUDE DYNAMICS.** Librational equations of motion when expressed in terms of local coordinates presented in this paper yield a set of rational differential equations devoid of planes of singularity. For a specified level of accuracy in numerical integration, a rational set requires less CPU time than an equivalent transcendental set. To interpret the results of the integration, the time evolution of orientation is presented as a curve in the three dimensional topological space RP3. The above new local coordinates is an example of a globally defined nonsingular rational parametrization of space of rotations suitable for problems of dynamics involving general rotations. (Author abstract) 8 refs.

Marandi, S.R. (Univ of British Columbia, Vancouver, BC, Can); Modi, V.J. *Acta Astronaut* v 15 n 11 Nov 1987 p 833-843.

**092861 LAUNCH VEHICLE TRAJECTORY OPTIMIZATION.** A launch vehicle trajectory optimization software is developed using diagonalized multiplier approach. A new modification, in which the Kuhn-Tucker vector norm is minimized along the multiplier update direction, avoids violent initial multiplier corrections. The optimality of the solutions is established, and robustness of the package demonstrated. This package is presently employed as a standard tool for mission design studies at the Indian Space Research Organisation. 12 refs.

Adimurthy, V. *Acta Astronaut* v 15 n 11 Nov 1987 p 845-850.



**092862 SEMIANALYTIC SATELLITE THEORY FOR ORBITAL DECAY PREDICTIONS.** An extended form of the method of averaging, which uses the true anomaly as the fast variable, is applied to the long-term prediction of near-Earth orbits perturbed by an oblate geopotential and atmospheric drag. This paper proposes the analytical averaging of the drag perturbation as an efficient alternative to the usual numerical procedure. Similarly, an analytic version of a well-known numerical atmospheric model provides accurate reference density data on a global scale. A local representation of this model generates the density profile along the orbit in a form suitable for analytical averaging. The design of the local density model includes a theoretical determination of its order of approximation, similar to the order of quadrature in numerical averaging. The problem of accurately modeling the density profile along a highly-eccentric orbit is successfully resolved by an analytic technique that leads to a substantial reduction in the number of costly density evaluations. The analytics are completely independent of the global density model, they allow the inclusion of the dominant gravity-drag coupling effects, and they resolve earlier convergence difficulties caused by series expansions in powers of the orbital eccentricity. (Edited author abstract) 60 refs.

de Lafontaine, J. (Univ of Toronto, Toronto, Ont, Can); Hughes, P.C. *J Astronaut Sci* v 35 n 3 Jul-Sep 1987 p 245-286.

**092863 EVOLUTION OF THE ORBITS OF DISANTARTIFICIAL SATELLITES.** The main features of the evolution of the orbits of artificial earth satellites with semimajor axes from 100,000 to 200,000 km are investigated over time intervals on the order of 5-10 years. A variant of the numerical analytical method published previously by the author has been used for the investigation. The results obtained by this method adapted to the conditions of the satellite problem are compared with the result of the numerical integration of the rigorous equations of motion of artificial earth satellites with allowance for lunar and solar perturbations. The ranges of change of the eccentricities and inclinations for almost circular initial orbits of artificial earth satellites with semimajor axes of 125,000 and 160,000 km have been determined over an interval of 10 years. (Author abstract) 8 refs.

Vashkov'yak, M.A. *Cosmic Res* v 25 n 3 May-Jun 1987 p 257-270.

**092864 TWO-DIMENSIONAL PERIODIC MOTION OF A SATELLITE RELATIVE TO ITS CENTER OF MASS NEAR A COLLINEAR LIBRATION POINT.** Periodic motions of a satellite relative to its center of mass are studied in the vicinity of point  $L_2$  of a periodic circular orbit in the restricted three-body problem. The satellite is represented as a solid body with an arbitrary central inertial ellipsoid. The existence and stability of periodic motions generated by two-dimensional rotation and oscillation of arbitrary amplitude are considered. (Author abstract) 7 refs.

Churkina, N.I. *Cosmic Res* v 25 n 3 May-Jun 1987 p 271-276.

**092865 CONTRACTION OF SATELLITE ORBITS UNDER THE INFLUENCE OF AIR DRAG. VIII. ORBITAL LIFETIME IN AN OBLATE ATMOSPHERE, WHEN PERIGEE DISTANCE IS PERTURBED BY ODD ZONAL HARMONICS IN THE GEOPOTENTIAL.** This paper is devoted to developing the necessary orbital theory for predicting the lifetimes of satellites moving in an oblate atmosphere and subjected to the perturbations due to odd zonal harmonics in the geopotential. The effects of odd zonal harmonics and atmospheric oblateness are expressed as multiplying factors,  $F(\alpha_z)$  and  $F(\alpha_o)$ , to be applied to the lifetime predictions calculated in the absence of the perturbations. The results are valid for the great majority of orbits about the Earth, and in particular for all orbital eccentricities between 0 and 1; but the limits set for the controlling parameters exclude near-polar orbits with perigee heights lower than about 180 km, and orbits having inclinations within a narrow band centered on 63.4°. (Edited author

abstract) Refs.

King-Hele, D.G. (Royal Aircraft Establishment, Farnborough, Engl); Walker, Doreen M.C. *Proc R Soc London Ser A* v 414 n 1847 Dec 8 1987 p 271-295.

**092866 PREDICTED SOLAR CYCLE TWENTY-TWO 10.7 cm FLUX AND SATELLITE ORBIT DECAY.** This study develops an empirical model of the 10.7 cm solar flux ( $F_{10.7}$ ) through solar cycle twenty-two as it relates to the problem of a low-Earth orbiting satellite and its orbit decay. A comparison between the predicted orbit decay using the model and the first thirty-seven months of actual altitude of the Solar Mesosphere Explorer (SME) satellite is conducted. The predicted orbit semimajor axis is solved as a function of atmospheric density using a modified Jacchia 1971 atmospheric model (J71). J71 densities vary based on the empirically modeled  $F_{10.7}$  of solar cycle twenty-two. The derivation of the orbit radius,  $r$ , related to atmospheric mass density,  $\rho$ , is outlined, as are the simplifications made in this study for atmospheric density modeling. The  $F_{10.7}$  model for solar cycle twenty-two is then detailed with a comparison to one other model. Finally, the results of the predicted SME orbit decay are evaluated against the actual orbit decay. (Author abstract) 27 refs.

Tobiska, W. Kent (Univ of Colorado, Boulder, CO, USA); Culp, Robert D.; Barth, Charles A. *J Astronaut Sci* v 35 n 4 Oct-Dec 1987 p 419-433.

**092867 ON THE COLLISION HAZARD OF COLLOCATED GEOSTATIONARY SATELLITES.** The collision hazard of 2 collocated geostationary satellites within a  $\pm 0.1^\circ$  tolerance window is investigated by computer simulation of the controlled motion including the error effects of modeling, orbit determination and maneuver execution. Several modifications of the basic station-keeping strategy are introduced in order to separate the two satellites, even in the presence of errors. The latter are simulated by a multivariate normal random generator and superimposed on the controlled motion. Roughly 500 years of station-keeping are simulated for each separation policy. The statistical evaluation indicates that identical control strategies for both satellites lead to a high collision risk, and only some of the tested separation policies reduce the hazard to an acceptable level at the cost of a small increase in fuel consumption. (Edited author abstract) 23 refs.

Haerting, Alexander (DFVLR, Oberpfaffenhofen, West Ger); Eckstein, Martin C.; Leibold, Alois; Murthy, Kanduru N. Srinivasa. *Forschungsber Dtsch Forsch Versuchsanst Luft Raumfahrt* 88-02 1988 62p.

**092868 ECONOMICAL SEMI-ANALYTICAL ORBIT THEORY FOR MICRO-COMPUTER APPLICATIONS.** An economical algorithm is presented for predicting the position of a satellite perturbed by drag and zonal harmonics  $J_2$  through  $J_4$ . Simplicity being of the essence, drag is modeled as a secular decay rate in the semi-major axis (retarded motion); with the zonal perturbations modeled from a modified version of the Brouwers formulas. The algorithm is developed as: an alternative on-board orbit predictor; a back up propagator requiring low energy consumption; or a ground based propagator for microcomputer applications. (e.g., at the foot of an antenna). An  $O(J_2)$  secular retarded state partial matrix (matrizant) is also given to employ with state estimation. The theory has been implemented in BASIC on a inexpensive microcomputer, the program occupying under 8K bytes of memory. Simulated trajectory data and real tracking data are employed to illustrate the theory's ability to accurately accommodate oblateness and drag effects. (Author abstract) 13 refs.

Gordon, R.A. (NASA, Greenbelt, MD, USA). *NASA Tech Pap* 2811 Mar 1988 56p.

**092869 MOTIONS OF A SATELLITE THAT ARE ASYMPTOTIC TO ITS ECCENTRICITY OSCILLATIONS.** We consider plane motions of a rigid-body satellite relative to the center of mass in a central Newtonian gravitational field in an elliptic orbit. We

demonstrate that existence of motions that are asymptotic to stable (in linear approximation) periodic oscillations of the satellite in a low-eccentricity orbit. Our investigation is based on a general analysis of the problem of asymptotic solutions of a conical system of second-order differential equations, whose Hamiltonian is periodic relative to the independent variable. 17 refs.

Markev, A.P.; Shcherbina, G.A. *Mech Solids* v 22 n 4 1987 p 1-9.

**092870 GEOSTATIONARY TETHER SATELLITE SYSTEM AND ITS APPLICATION TO COMMUNICATION SYSTEMS.** The geostationary tether satellite system expands the geostationary orbit resource from a one-dimensional arc into a two-dimensional disk. The tethered satellites, each several thousand kilometers apart and aligned along the local vertical, are stabilized at the altitude of the geosynchronous orbital speed. When this system is applied to communications systems, it is estimated that the number of satellites can be increased as much as thirteenfold and the communication capacity can be increased more than seventeenfold, compared with a conventional geostationary satellite orbit system. 11 refs.

Yasaka, Tetsuo (NTT, Yokosuka, Jpn); Hatsuda, Takeshi. *IEEE Trans Aerosp Electron Syst* v 24 n 1 Jan 1988 p 68-75.

**Photography** See CAMERAS; REMOTE SENSING—Agricultural Applications.

**Power Supply** See Also ELECTRIC BATTERIES—Space Applications; ELECTRIC BATTERIES, SECONDARY—Space Applications; ELECTRIC BATTERIES, SECONDARY—Testing; SOLAR CELLS—Aerospace Applications; SPACECRAFT—Power Supply.

**092871 SPACE STATION ELECTRIC POWER SYSTEM REQUIREMENTS AND DESIGN.** This paper gives an overview of the conceptual definition and design of the Space Station electric power system (EPS). Responsibilities for design and development of the EPS are defined. The EPS requirements are listed and discussed, including average and peak power requirements, contingency requirements, and fault tolerance. The most significant Phase B trade study results are summarized, and the design selections and rationale are given. Finally, the power management and distribution system architecture is presented. (Author abstract)

Teren, Fred (NASA, Lewis Research Cent, Cleveland, OH, USA). *NASA Tech Memo* 89889 1987 15p.

**092872 SPECULATIONS ON FUTURE OPPORTUNITIES TO EVOLVE BRAYTON POWERPLANTS ABOARD THE SPACE STATION.** Although both Rankine and Brayton cycles, two concepts for solar-dynamic power generation, now compete to power the Space Station, this paper confines its attention to the Brayton cycle using a mixture of He and Xe as its working fluid. Such a Brayton powerplant to supply the Station's increasing demands for both electric power and heat has the potential to gradually evolve higher and higher performance by exploiting already-evolved materials (ASTAR-81C and molten-Li heat storage), its peak cycle temperature rising ultimately to 1500 K. Adapting the Station to exploit long tethers (200 to 300 km long) could yield large increases in payloads to LEO, to GEO, and to distant destinations in the solar system. (Edited author abstract) 27 refs.

English, Robert E. (NASA, Cleveland, OH, USA). *NASA Tech Memo* 89863 1987 28p.

**092873 SOLAR DYNAMIC POWER SUPPLY FOR ORBITING SYSTEMS WITH FREE-PISTON STIRLING ENGINE.** The Stirling cycle has been extensively developed and tested for various terrestrial applications. It is therefore believed that a free piston Stirling engine with integrated linear alternator will have sufficient potential for space power applications. A solar dynamic power system for approx. 1 kW<sub>e</sub> has been proposed for the



second German Spacelab Mission (D2) in 1990 and is further being considered as candidate for similar flight opportunities. This might be the very first in-orbit operation of a free piston Stirling engine. The actual power system configuration and operating characteristics will mainly be determined by the particular mission constraints. This paper is focussed on the concept of the proposed flight-demonstration-experiment and related areas of technological concern. General issues like overall efficiency, pointing accuracy, erosion/degradation, maintenance, replaceability, etc., are addressed as well. (Edited author abstract)

Kuczera, H. (MBB/ERNO, Ottobrunn, West Ger). *Space Technol (Oxford)* v 7 n 4 1987 p 345-350.

**092874 ADVANCED POWER SUPPLY AND DISTRIBUTION SYSTEMS FOR COLUMBUS.** The paper describes power supply and distribution systems to be used on unmanned/man-tended Columbus elements, capable of supplying 10 kW to 30 kW to a variety of users in low earth orbits (LEOs). For the definition of the Electrical Power System (EPS) challenging requirements as the provision of high power levels under hard LEO conditions, maintainability, commonality etc. are to be taken into account. These requirements are to be seen in conjunction with the Columbus IOC (initial operational capability) scenario stipulating that EPS hardware shall be used on the Polar Platform, the Pressurized Module attached to the U.S. Space Station and the Man-Tended Free Flier. According to the availability of the European technologies, the baseline in the power generation area is a photovoltaic system which provides three regulated main buses (150 V d.c.) to the users. In order to maintain power supply during eclipse phases, nickel hydrogen batteries will be used for energy storage purposes with nickel cadmium as back-up solution. (Edited author abstract) 2 refs.

Eggers, Gert (AEG Aktiengesellschaft, Wedel, West Ger). *Acta Astronaut* v 17 n 1 Jan 1988 p 99-114.

**092875 PHOTOVOLTAIC POWER MODULES FOR NASA'S MANNED SPACE STATION.** Two similar space power systems able to survive the low-earth orbit environment, are being considered for NASA's Manned Space Station (SS), scheduled to begin operation in the mid 1990's. The Space Station Electric Power System (EPS) is composed of Photovoltaic (PV) Power Modules, Solar Solar Dynamic (SD) Power Modules, and the Power Management and Distribution (PMAD) System. One EPS configuration will deliver 37.5 kW of PV-based, utility-grade, ac power to SS users. A second 75 kwe PV-based EPS option is also being considered for SS deployment. The two EPS options utilize common modules and differ only in the total number of PV Power Modules used. Each PV Power Module supplies 18.75 kwe of ac power and incorporates its own energy storage and thermal control. The focus of this paper is on the general requirements and the current preliminary design configuration of the Space Station PV Power Modules. (Edited author abstract) 9 refs.

Tatro, Charles A. (NASA, Cleveland, OH, USA). *NASA Tech Memo* 100229 1988 12p.

**092876 LOW EARTH ORBIT ENVIRONMENTAL EFFECTS ON THE SPACE STATION PHOTOVOLTAIC POWER GENERATION SYSTEMS.** A summary of the Low Earth Orbital Environment, its impact on the Photovoltaic Power systems of Space Station and the solutions implemented to resolve the environmental concerns or issues are described in this paper. Low Earth Orbital Environment (LEO) presents several concerns to the Photovoltaic power systems of the Space Station. These concerns include atomic oxygen interaction with the polymeric substrate of the solar arrays, ionized environment effects on the array operating voltage, the effects of the meteoroids and debris impacts and penetration through the different layers of the solar cells and their circuits, and the high energy particle and radiation effects on the overall solar array performance. (Edited author abstract) 22 refs.

Nahra, Henry K. (NASA, Cleveland, OH, USA). *NASA Tech Memo* 100230 1988 19p.

**Propellants** See ROCKET ENGINES.

**Radiation Effects** See Also LOGIC CIRCUITS—Radiation Effects; SPACECRAFT—Radiation Effects.

**092877 THICK DIELECTRIC CHARGING ON HIGH-ALTITUDE SPACECRAFT.** Thick dielectric charging, in which energetic electrons embed within bulk dielectrics, building up to potentials in excess of the breakdown potential of the dielectric, is shown to be a causative factor in anomalous operation of high-altitude satellites. A table of maximum expected electron fluxes in various altitude orbits is presented. Consideration of these maximum fluxes and the fact that the energy associated with a bulk dielectric breakdown is small demonstrate that bulk charging can be eliminated as a spacecraft problem through minimal shielding (400 mg/cm<sup>2</sup>) of all cables and circuit boards otherwise exposed to the environment, and through desensitizing digital logic inputs which are serviced by cables. (Author abstract) 25 refs.

Vampola, A.L. (Aerospace Corp, Los Angeles, CA, USA). *J Electrostatics* v 20 n 1 Oct 1987, Spacecr Charging: Sel Pap Presented at the AGARD Symp on the Aerosp Environ at High Alt and Its Implic for Spacecr Charging and Commun, Hague, Neth, Jun 1986 p 21-30.

**092878 ELECTRON BEAM EXPERIMENTS AT HIGH ALTITUDES.** Experiments with the electron gun on the SCATHA satellite produced evidence of beam-plasma interactions, and heating of the low-energy electrons around the satellite. These experiments were conducted near geosynchronous orbit, in the dusk bulge, and plasma sheet, with one short operation in the lobe regions, providing a range of ambient plasma densities. Data from electrostatic analyzers and the dc electric field experiment show that the satellite charged to near the beam energy in sunlight, at sufficiently high beam currents. The electrostatic analyzers showed distribution functions which had peaks or plateaus at energies greater than the satellite potential. These measurements indicate heating of the ambient plasma, at several Debye lengths from the satellite (several tens of meters), with the heated plasma then accelerated into the satellite. It is likely that at times the 'ambient' cold plasma is in fact the photoelectron sheath generated by the satellite. (Edited author abstract) 16 refs.

Olsen, R.C. (Univ of Alabama in Huntsville, Huntsville, AL, USA). *J Electrostatics* v 20 n 1 Oct 1987, Spacecr Charging: Sel Pap Presented at the AGARD Symp on the Aerosp Environ at High Alt and Its Implic for Spacecr Charging and Commun, Hague, Neth, Jun 1986 p 43-57.

**092879 EVIDENCE FOR DIFFERENTIAL CHARGING ON METEOSAT-2.** Operational problems with Meteosat-1 led to a collaborative effort to furnish subsequent spacecraft with simple charging monitors and to study the geosynchronous environment in an attempt to better understand the charging process. The electron spectrometer on Meteosat-2 has yielded a continuous data set since 1982 which has clarified the role of plasmasheet electrons in the detailed current balance which controls spacecraft potentials. Continual observation of eclipse and partial shadowing features has illuminated the dominant role of photoelectrons and demonstrated that a safe clamping of differential voltages can be attained. An electron albedo index has been developed as an aid to assessing spacecraft liability to charging. The majority of anomalies experienced by Meteosat-2 are not directly caused by charging. (Edited author abstract) 20 refs.

Wrenn, G.L. (Royal Aircraft Establishment, Farnborough, Engl); Johnstone, A.D. *J Electrostatics* v 20 n 1 Oct 1987, Spacecr Charging: Sel Pap Presented at the AGARD Symp on the Aerosp Environ at High Alt and Its Implic for Spacecr Charging and Commun, Hague, Neth, Jun 1986 p 59-84.

**092880 AUTOMATIC CHARGE CONTROL SYS-**

**TEM FOR GEOSYNCHRONOUS SATELLITES.** An autonomous system to detect both absolute and differential spacecraft charging aboard high-altitude satellites, and to reduce those potentials before hazardous arcing levels are reached, is now being developed. The system will utilize a xenon-based plasma source that can be ignited without any warm-up, and that will produce a plasma capable of furnishing a neutralizing ion current greater than 1 mA. The spacecraft charging level will be detected by sensors similar to those that operated aboard SCATHA. Satellite frame potential (relative to the ambient space plasma) will be determined by an electrostatic analyzer. The flight system will be completed by mid-1988, and could be flight-tested at geosynchronous orbit in the 1989-1992 time period. (Edited author abstract) 8 refs.

Shuman, B.M. (US Air Force Geophysics Lab, Hanscom AFB, MA, USA); Cohen, H.A.; Hyman, J.; Robson, R.R.; Santoru, J.; Williamson, W.S. *J Electrostatics* v 20 n 1 Oct 1987, Spacecr Charging: Sel Pap Presented at the AGARD Symp on the Aerosp Environ at High Alt and Its Implic for Spacecr Charging and Commun, Hague, Neth, Jun 1986 p 141-154.

**Radiation Protection**

**092881 RADIATION PROBLEMS IN MANNED SPACEFLIGHT WITH A VIEW TOWARDS THE SPACE STATION.** With the advent of a permanently manned Space Station, the longstanding problems of radiation protection in manned spaceflight have acquired an immediacy. This paper endeavors to emphasize the gaps of our knowledge which must be closed for effective radiation protection. The information that is required includes the accurate determination of the exposure inside the space station to the various components of the ionizing radiation, the evaluation of the biological importance of the different radiation qualities and the depth-dose distribution of the less penetrating component. There is also the possibility of an interaction with weightlessness. (Edited author abstract) 28 refs.

Buecker, H. (DFVLR, Cologne, West Ger); Facius, R. *Acta Astronaut* v 17 n 2 Feb 1988, Space Life Sci: Hum, Anim and Plant, Innsbruck, Austria, Oct 4 1986 p 243-248.

**Radiation Shielding**

**092882 RADIATION DOSE AND SHIELDING FOR THE SPACE STATION.** Significant differences in dose prediction for Space Station arise depending on whether or not the magnetic field model is extrapolated into the future. The basis for these calculations is examined in detail, and the importance of the residual atmospheric layer at altitudes below 1000 km with respect to radiation attenuation is emphasized. Dosimetry results from Shuttle flights are presented and compared with the computed results. It is recommended that, at this stage, no extrapolation of the magnetic field into the future be included in the calculations. A model adjustment, to replace this arbitrary procedure, is presented. Dose predictions indicate that, at altitudes below 500 km and at low inclination, and with nominal module wall thickness (0.125 in. aluminum), orbit stay times of 90 days in Space Station would result in quarterly radiation doses to the crew. (Edited author abstract) 12 refs.

McCormack, Percival D. (NASA, Washington, DC, USA). *Acta Astronaut* v 17 n 2 Feb 1988, Space Life Sci: Hum, Anim and Plant, Innsbruck, Austria, Oct 4 1986 p 231-241.

**Radio Equipment** See Also ANTENNAS—Space Applications; EVAPORATION—Remote Sensing; NATURAL GAS PIPELINES—Control Systems.

**092883 CNES S-BAND NETWORK AND THE INTERNATIONAL COOPERATION.** Running a national S-band network since 1984, CNES has successfully put several satellites in orbit with an adequate support of



foreign agencies like NASA, SSC, NASDA and ESAs. This experiment pleads for an actual international S-Band network, capable of positioning satellites until the end of the 90s when space relay systems are able to provide by themselves this kind of service. (Author abstract)

Bescond, P. (Cent Natl d'Etudes Spatiales, Toulouse, Fr); Jeambrun, G. *Acta Astronaut* v 17 n 1 Jan 1988 p 143-145.

## Re-entry

**092884 RE-ENTRY OF SPACE DEBRIS, PROCEEDINGS OF AN ESA WORKSHOP.** The workshop materials contain eleven papers dealing with re-entry of space debris into the Earth atmosphere. Current status of re-entry prediction methods, computations of satellite orbits, satellite observations with radar tracking stations, satellite lifetime predictions, orbit decays and anomalies are discussed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10752 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

ESA, Paris, Fr (Anon). *Eur Space Agency Spec Publ ESA SP 246*, Re-entry of Space Debris, Proc of an ESA Workshop, Darmstadt, West Ger, Sep 24-25 1985. Publ by ESA, Paris, Fr 85p.

## Reliability See SPACECRAFT—Fracture.

**Remote Sensing** See Also AEROSOLS—Atmospheric; ATMOSPHERIC MOVEMENTS—Remote Sensing; ATMOSPHERIC RADIATION; BIOMASS—Remote Sensing; EARTH ATMOSPHERE—Magnetosphere; LAKES—Finland; RADAR—Synthetic Aperture; REMOTE SENSING—Environmental Applications; REMOTE SENSING—Multispectral Scanners; SOLAR RADIATION—Argentina.

**092885 UNTERSUCHUNGEN ZUM EINSATZ VON WELTRAUMLUFTBILDERN (SPACELAB-RMK-AUFNAHMEN) FUER ROUTINEMAESSIGE GROSSRAUMINVENTUREN EXTENSIV BEWIRTSCHAFTETER WAELDER.** [Investigations on the Application of Space Photographs (Metric Camera) for Routine Inventories of Extensively Managed Forest Areas]. The application of Landsat MSS data for far range inventories increased during the last years. Since summer 1984 pictures are available taken with a metric camera in space. These are comparable with Landsat data in many respects. The applicability of these photos for forest inventories are shown in this paper comparing the content of information, the different possibilities of processing, and the availability of the data. (Author abstract) In German.

Forstreuter, Wolf (Univ Freiburg, Freiburg, West Ger). *Forschungsber Dtsch Forsch Versuchsanst Luft Raumfahrt* 87-22 1987 247p.

**092886 REFLEXIONS SUR L'UTILISATION A DES FINS THEMATIQUES DE L'IMAGERIE SATELLITAIRE.** [Considerations on the Use of Satellite Imagery for Thematic Purposes]. This study is concerned with a general model of satellite data interpretation. For this interpretation, the user has to abstract a particular dimension from the landscape considered as a system. The review of some applications in remote sensing has revealed that all the algorithms used in image processing for land surveys consist of operations on three kinds of information extracted from satellite data. In cartographic applications and in land use inventories, the emphasis is laid on the spectral information. When the aim of the study is to model the geographical properties of the landscape, the analysis of spectral information is combined with analysis of the spatial information. Finally, when evolutionary studies are conducted, the temporal information is introduced. (Author abstract) In French. 57 refs.

De Keersmaecker, M.L. (Univ Catholique de Louvain, Louvain-la-Neuve, Belg); Lambin, E. *Int J Remote Sens* v 8 n 9 Sep 1987 p 1277-1287.

**092887 VARIABILITY OF LANDSAT MSS SPECTRAL RESPONSES OF FORESTS IN RELATION**

**TO STAND AND SITE CHARACTERISTICS.** The use of field measures of slope angle, slope aspect, cover type, crown size and crown density is evaluated in appraising the variability of Landsat Multispectral Scanner (MSS) spectral responses for 182 sample sites within Crater Lake National Park, Oregon. Multiple linear regression models indicate that 73, 72, 71 and 57 percent of the variation in the mean response of MSS bands 4, 5, 6 and 7, respectively, was explained by the environmental variables entered into the models. In general, crown size and crown density are less important in altering spectral response than terrain orientation. (Edited author abstract) 15 refs.

Walsh, Stephen J. (Univ of North Carolina, Chapel Hill, NC, USA). *Int J Remote Sens* v 8 n 9 Sep 1987 p 1289-1299.

**092888 VEGETATION SPATIAL VARIABILITY AND ITS EFFECTS ON VEGETATION INDICES.** Landsat MSS data were used to simulate low resolution satellite data, such as NOAA AVHRR, to quantify the fractional vegetation cover within a pixel and relate the fractional cover to the normalized difference vegetation index (NDVI) and the simple ratio (SR). The MSS data were converted to radiances from which the NDVI and SR values for the simulated pixels were determined. Each simulated pixel was divided into clusters using an unsupervised classification programme. Spatial and spectral analysis provided a means of combining clusters representing similar surface characteristics into vegetated and non-vegetated areas. (Edited author abstract) 23 refs.

Ormsby, J.P. (NASA, Goddard Space Flight Cent, Greenbelt, MD, USA); Choudhury, B.J.; Owe, M. *Int J Remote Sens* v 8 n 9 Sep 1987 p 1301-1306.

**092889 SOIL AND SUN ANGLE INTERACTIONS ON PARTIAL CANOPY SPECTRA.** The spectral behavior of an incomplete cotton canopy was analyzed in relation to solar zenith angle and soil background variations. Soil and vegetation spectral contributions towards canopy response were separated using a first-order interactive model and consequently used to compare the relative sensitivity of canopy spectra to soil background and solar angle differences. Canopy reflectance behavior with solar angle increased, decreased or remained invariant depending on the reflectance properties of the underlying soil. Sunlit and shaded soil contributions were found to alter vegetation index behavior significantly over different Sun angles. (Author abstract) 18 refs.

Huete, Alfredo R. (Univ of Arizona, Tucson, AZ, USA). *Int J Remote Sens* v 8 n 9 Sep 1987 p 1307-1317.

**092890 CARACTERISATION DE FORMATIONS VEGETALES MEDITERRANEEENNES A PARTIR DE DONNEES 'THEMATIC MAPPER'. UNE ETUDE DE CAS EN ANDALOUSIE (ESPAGNE).** [Characteristics of Mediterranean Vegetation Formations on the Basis of the Thematic Mapper Data. A Case Study in Andalusia (Spain)]. The study is focused on the characterization of vegetation formations in a Mediterranean area (943 km<sup>2</sup>) located in southern Spain: herbaceous canopies (rangelands), shrubby vegetation and complex woody/herbaceous formations. Vegetation formations (physiognomical units) have been characterized by their spectral responses in the six reflective TM channels and by vegetation indices. From the ratio index TM4/TM3 there has been derived a map displaying seven classes (water, bare soil and five biomass levels reflecting the hierarchy of vegetation formations). Channels TM3, TM4 and TM5 have been considered for a supervised classification into nine land-cover categories (seven vegetation formations, bare soil and water). The proportion of correct classification of vegetation formations is about 78 percent when considering test areas. In French. 20 refs.

Lacaze, Bernard (CNRS, Montpellier, Fr); Joffre, Richard. *Int J Remote Sens* v 8 n 9 Sep 1987 p 1319-1333.

**092891 TERRAIN RESOURCES SURVEYS BY VISUAL MONOSCOPIC AND STEREOSCOPIC INTERPRETATION OF FGEOs IMAGES.** Monoscopic and stereoscopic interpretation of FGEOs (First Genera-

tion Earth Observation Satellites) images were applied comparatively in order to divide the region of Central Peloponnesos (Greece) into physiographic units for thematic mapping concerning geomorphology, soils and land use. A stereo pair of Landsat-1 black and white prints and a false-color print at 1:250,000 scale were used in order to construct a reconnaissance physiographic map, to construct a land use map, and to reconsider the monoscopic interpretation techniques, because of the newly-developed SPOT stereo capability and 10×10 m ground resolution. (Edited author abstract) 25 refs.

Silleos, Nikolaos (Faculty of Agriculture, Thessaloniki, Greece); Astaras, Theodoros. *Int J Remote Sens* v 8 n 9 Sep 1987 p 1335-1348.

**092892 RADIOMETRIC CORRECTION OF VISIBLE AND INFRARED REMOTE SENSING DATA AT THE CANADA CENTRE FOR REMOTE SENSING.** This article reviews experience in radiometric corrections of satellite and airborne remote sensing data at the Canada Centre for Remote Sensing (CCRS) during the period 1972 to 1986. It also describes current research areas and recommends areas of future research where high priority is important for global change monitoring and for the derivation of quantitative information from remotely-sensed data in the solar reflective spectral regions. The emphasis has been on routine application of accurate correction techniques in a production environment and the progression has been from relative calibration to absolute calibration to the current work towards routine atmospheric corrections. (Edited author abstract) 70 refs.

Ahern, F.J. (Canada Cent for Remote Sensing, Ottawa, Ont, Can); Brown, R.J.; Cihlar, J.; Gauthier, R.; Murphy, J.; Neville, R.A.; Teillet, P.M. *Int J Remote Sens* v 8 n 9 Sep 1987 p 1349-1376.

**092893 DISCRIMINATION PROBLEMS FOR SATELLITE IMAGES.** This paper discusses the pitfalls of classifying satellite images using automatic classifiers. The discussion is illustrated by application of quadratic and linear discrimination to high resolution data produced for the National Remote Sensing Centre campaign. Within the training set there is good discrimination between most land uses, but the lack of agreement between overall results of discrimination for the two discriminators shows that measures of accuracy based on accuracy within the training set can be misleading. Cross-validation of the quadratic discriminator and calculation of between and within site measures of spectral variability also illustrate how the usual calculations may give over-optimistic measures of discrimination accuracy and spectral variability. (Author abstract) 3 refs.

Kershaw, C.D. (Univ of Edinburgh, Edinburgh, Scotl). *Int J Remote Sens* v 8 n 9 Sep 1987 p 1377-1383.

**092894 LANDSAT SENSORS; EOSAT'S PLANS FOR LANDSATS 6 AND 7.** This paper describes the design configuration of the Enhanced Thematic Mapper (ETM) sensors that are presently under construction for Landsats 6 and 7. It presents an overview description of the Thematic Mappers that are currently flying on Landsats 4 and 5. The enhancements to the Landsats 6 and 7 Thematic Mappers are then described in some detail, including the implementation of a panchromatic band of detectors providing 15 m spatial resolution for both ETM sensors. The Landsat-7 ETM may include as many as five bands of thermal detectors with 120/60 m spatial resolution; the implementation and performance of this option will be discussed. The paper also provides a brief description of two new sensors that are being considered for Landsats 6 and/or 7: a low-resolution (500 m), wide-field sensor (a regional Mapper) with the Thematic Mapper's spectral-coverage, and a high-resolu-



tion (10/20 m), narrow-field, pointable Advanced Landsat Sensor (ALS) utilizing multispectral linear array technology. (Edited author abstract)

Engel, Jack L. (Santa Barbara Research Cent, Goleta, CA, USA). *Acta Astronaut* v 15 n 11 Nov 1987 p 879-885.

**092895 SATELLITE REMOTE SENSING IMAGERY IN PUBLIC HEALTH.** The purpose of this paper is to give a brief overview of the existing fields of the application of satellite imagery and to draw the attention of the scientific community to a new outlook for the future of public health. This outlook is based on new capacities of the space remote sensing technology, which allows us to focus its application on a new field. Further, this paper discusses the methodology for the operational application and specifies public health activities which can use this methodology. Necessary actions for establishing present capacities and limitations as a formulation of the development of new techniques are proposed. (Edited author abstract) 23 refs.

Jovanovic, Petar (Assoc of Scientific Unions of Yugoslavia, Belgrade, Yugosl). *Acta Astronaut* v 15 n 11 Nov 1987 p 951-953.

**092896 EARTH OBSERVING SYSTEM: CONCEPTS AND IMPLEMENTATION STRATEGY.** Concepts have been developed for an Earth Observing System (Eos), a fifteen year mission planned to begin in the 1990s. Diverging from previous practices, Eos is conceived as an Earth science information system where orbiting remote sensing instruments, in situ measurement devices and a data and information system are to be fused into a highly capable research tool. The Eos data and information system will have distributed elements, providing the users with remote electronic access to data services without constraining the location of the elements of the system. The implementation strategy assumes that Eos instruments are to fly on polar platforms developed as part of the Space Station complex. The global nature of Earth system science naturally implies the need for international involvement. Three Eos platforms are planned to be launched into low, polar, sun-synchronous orbits during the Space Station's Initial Operating Configuration, one to be provided by the European Space Agency and two by the United States. (Edited author abstract) 6 refs.

Hartle, R.E. (NASA, Greenbelt, MD, USA). *Space Technol (Oxford)* v 7 n 4 1987 p 337-344.

**092897 ERFASSUNG DER LANDNUTZUNGS-STRUKTUREN NORDWESTLICH WUERZBURG ANHAND DIGITALER, MULTISPEKTRALER LANDSAT-5-THEMATIC-MAPPER-DATEN.** [Land-Use Classification in a Region North-West of Wuerzburg Using Digital, Multispectral LANDSAT 5 Thematic Mapper Data]. Using a Landsat TM scene of July 7, 1984 the land-use of a predominantly rural area is recorded by means of digital image processing techniques. In order to distinguish a maximum of land cover types, possibilities of interactive separation of different classes, with almost similar spectral reflection, are shown. The results of the supervised Maximum-Likelihood classification as well as a color composite are superimposed with selected topographical information. Furthermore, methods of visual interpretation are presented. (Author abstract) In German. 84 refs.

Dech, Stefan W. (DFVLR, Oberpfaffenhofen, West Ger). *Forschungsber Dtsch Forsch Versuchsanst Luft Raumfahrt* 87-37 1987 180p.

**092898 INFLUENCE OF TOPOGRAPHY ON FOREST REFLECTANCE USING LANDSAT THEMATIC MAPPER AND DIGITAL TERRAIN DATA.** The relationship between forestry variables and the response of Thematic Mapper bands is analyzed over selected mountainous forest sites with a view to improving current models. Forestry stand species and age information was collected for 250 sites in a region with slopes up to 35 degrees and a variety of aspects. Spring and summer

Thematic Mapper imagery over the area were used; these data contain a wealth of information related to species and age, and topography. A digital elevation model was compiled with a resolution of 30 metres in order to study the relationship between reflectance, the variable of interest, and the local sun/surface/sensor geometry. The influence of the age on the apparent reflectance distribution is analyzed: reflectance globally decreases with stand age, especially for TM4, TM5, and TM7. (Edited author abstract) 12 refs.

Leprieux, C.E. (Lab d'Etudes et de Recherches en Teledetection Spatiale, Toulouse, Fr); Durand, J.M.; Peyron, J.L. *Photogramm Eng Remote Sens* v 54 n 4 Apr 1988 p 491-496.

**092899 ALTERNATIVES FOR MAPPING FROM SATELLITE IMAGERY.** The paper reviews what can be done with remote sensing satellite imagery with MSS and TM images. It shows where we stand today with space cartography and tries to clarify in which direction remote sensing and cartographic systems will compete in the next decade. (Edited author abstract)

Konecny, G. (Inst fuer Photogrammetrie, Hanover, West Ger). *Acta Astronaut* v 17 n 3 Mar 1988 p 355-358.

**092900 FUTURE ROLE OF SATELLITES.** Remote sensing of the sea surface, and hence oil slicks, can be carried out from any height: ground level (either on shore or from a ship), from an aircraft or from space. Each of these options possesses distinct advantages and disadvantages and any comprehensive monitoring system will in all probability involve elements of all three. This paper is concerned with the role of remote sensing satellites in any such system. It has been shown that polar orbiting spacecraft do not have a role in response to an oil spill but that they do have a possible use in routine monitoring. A system of two satellites (similar to the proposed polar platform) has been proposed which would enable such monitoring to be done in UK waters. The instrument needed would be similar to the SAR-C proposed for the ESA polar platform, for which both resolution/swath and incidence angle can be varied. 5 refs.

Challenger, P.G. (Inst of Oceanographic Sciences, Wormley, Engl). *Q J Tech Pap Inst Pet* Jan-Mar 1988 p 31-40.

**Repair** See ROCKET ENGINES—Repair; SPACE PLATFORMS—Repair.

## Robot Applications

**092901 CONTINUOUS PATH CONTROL OF SPACE MANIPULATORS MOUNTED ON OMV.** Theoretical analysis of the formulation of kinematics for a manipulator mounted on a satellite is presented. To solve the inverse kinematics, the authors define a new generalized Jacobian matrix, and utilizing this generalized matrix, the problem can be treated analytically. The authors then verify the method proposed here in the simulation study. Finally, they also discuss the several points which are indispensable for further investigations. (Edited author abstract) 3 refs.

Umetani, Yoji (Tokyo Inst of Technology, Tokyo, Jpn); Yoshida, Kazuya. *Acta Astronaut* v 15 n 12 Dec 1987 p 981-986.

## Scheduling

**092902 SCHEDULING EXPERIMENTS ON THE SPACE STATION.** The objective of this research is to schedule laboratory experiments on the space station in a power starved environment. Experiments on the space station will compete for electric power and other scarce resources. A principal investigator for an experiment may submit numerical preferences for different periods in which his/her experiment can be started. Weighted preferences are computed by multiplying these preferences by a numerical priority assigned to the experiment by a space station management committee. The scheduling problem is formulated as an integer programming problem with 0/1 variables. (Edited author abstract) 10 refs.

Sheskin, Theodore J. (Cleveland State Univ, Cleveland, OH, USA). *Comput Ind Eng* v 14 n 3 1988 p 315-323.

**Sensors** See SEMICONDUCTOR DEVICES, CHARGE COUPLED.

## Simulators

**092903 GOULD ES1000 RECORDER IS OUT OF THIS WORLD.** A Gould ES1000 recorder is playing a vital role in reproducing the dynamic parameters generated by a satellite simulator belonging to the MATRA ESPACE Data Processing and Ground Division in Toulouse, France. The Gould ES1000 was the perfect choice, not only because it could easily fulfill the basic requirements but also because it offered additional ones as well: it executes multi-channel recording in analog format; its digital inputs permit full control by a computer via a standard IEEE 488 bus; and it has an IT164 four-channel digital input, IT488 remote control and M200 alphanumeric printing.

Anon. *Aircr Eng* v 60 n 1 Jan 1988 p 14-15.

**Sounding** See EARTH ATMOSPHERE—Upper Atmosphere.

## Stability

**092904 STABILITY OF A SATELLITE WITH AN AEROGYROSCOPIC ORIENTATION SYSTEM IN A CIRCULAR ORBIT.** We consider the problem of uniqueness of stable equilibrium orientation of a satellite moving in a circular orbit, that is equipped with an areostabilizer and two single-degree-of-freedom gyroscopes, mounted in a certain fashion and attached to the housing of the satellite by an elastic coupling. We obtain sufficient conditions imposed on the system parameters, such that only the so-called zero position of the satellite is stable, while other positions are either impossible or unstable. (Author abstract) 2 refs.

Biryukova, M.P. *Mech Solids* v 22 n 2 1987 p 9-16.

**092905 STABILITY OF STATIONARY MOTIONS OF AN ELASTIC RING IN THE PLANE OF A CIRCULAR ORBIT.** The stability of the stationary motions of a satellite in the form of an elastic rod bent into a ring is studied in the linear approximation taking into account the deformability of the system. Gravitational and aerodynamic forces are taken into account. If there is no aerodynamic resistance, then from the Jacobi integral it may be concluded that the motion is stable in the sense of Lyapunov. In the general case the partial differential equations can be reduced to ordinary differential equations by Galerkin's method, after which the stability of the corresponding trivial solution can be studied in the standard manner. It turns out that the aerodynamic forces cause the stationary motion to be unstable, and this instability cannot, for all practical purposes, be eliminated by damping owing to dissipation of energy in the rod material. (Author abstract) 10 refs.

Sidorenko, V.V. *Cosmic Res* v 25 n 4 Jul-Aug 1987 p 361-367.

**Telemetry** See Also PLASMAS—Acceleration; RAIN AND RAINFALL—Telemetry.

**092906 EXAMINATION OF POSSIBLE SOLAR WIND SOURCES FOR A SUDDEN BRIGHTENING OF COMET IRAS-ARAKI-ALCOCK.** Possible solar wind sources for a sudden global brightening of Comet IRAS-Araki-Alcock are examined. No increases in solar wind momentum flux, solar energetic particles or solar activity occurred coincident with these brightenings. The only change in the solar wind coincident with the brightenings was a rotation of the interplanetary magnetic field to a more flow-aligned state. If this rotation did not lead to the cometary brightening, the brightening must have been intrinsic to the comet. (Author abstract) 11 refs.

Russell, C.T. (Univ of California, Los Angeles, CA, USA); Luhmann, J.G. *Geophys Res Lett* v 14 n 10 Oct 1987 p 991-994.



**092907 ATMOSPHERIC EFFECTS ON LANDSAT TM THERMAL IR DATA.** The components of atmospherically attenuated target radiance and the path radiance emitted by the atmosphere are calculated to explain the fact that for certain meteorological conditions, properly calibrated thermal IR (infrared) data gathered from aircraft and spacecraft altitudes provide accurate temperature measurements of surface water bodies even when atmospheric corrections are not applied. Results show that although the 8-14- $\mu$ m atmospheric window is far from being transparent (< 50% transmission), the amount of atmospheric path radiance may be equal to the amount of attenuated target radiance. Errors in remotely sensed temperatures introduced by atmospheric effects are shown to be smaller than or of the same order of magnitude as those errors caused by sensor noise and the effects of applying a cubic convolution during the process of converting the TM (Thematic Mapper) data from A-type to geometrically corrected P-type data format. 28 refs.

Bartolucci, Luis A. (Murray State Univ, KY, USA); Chang, Mao; Anuta, Paul E.; Graves, Mark R. *IEEE Trans Geosci Remote Sens* v 26 n 2 Mar 1988 p 171-176.

**Tracking** See Also ANTENNAS, SCANNING—Control; TELEMETERING SYSTEMS—Aerospace Applications.

**092908 NOISE-RESISTANT UNIT AUTOMATICALLY TRACKS GEOSYNCH SATELLITES.** Earth stations used for tracking geosynchronous satellites must be highly accurate, noise-resistant, and reliable, yet still be cost-effective. Conventional stations, using step-track algorithms, have limited accuracy because of demands for low-cost, simplified hardware. Monopulse systems, although more accurate, are more costly. However, a new tracking algorithm not only improves the accuracy, but also saves money by using similar cost-effective, step-track hardware. 3 refs.

Richharia, Madhavendra (Surrey Univ, Guildford, Engl). *Microwaves RF* v 26 n 12 Nov 1987 p 119-120, 122, 124.

**092909 KETTERING GROUP.** The origins and gradual evolution of the Kettering Group of amateur satellite observers is described. The Group's major achievements are noted. (Author abstract) 5 refs.

Perry, G.E. (Kettering Group, Kettering, Engl). *Space Commun Broadcast* v 5 n 5 Nov 1987 p 405-407.

**092910 KEEPING TRACK OF MIR.** The Soviet Mir Satellite cannot be treated as an ordinary satellite, because it is constantly using its engines to alter its orbit. No sooner are new Keplerian Orbital Elements put into a computer, than Mir shifts orbit and all subsequent computations are invalid. In this paper, the author describes a simple two-step tracking method which allows the observer to stay in touch with this moving target. (Edited author abstract)

Branegan, John. *Spaceflight* v 30 n 4 Apr 1988 p 156-160.

**Wave Effects** See TRUSSES—Structural Analysis.

**Weather** See Also AEROSPACE GROUND SUPPORT—Australia; RADAR IMAGING; RAIN AND RAINFALL—Estimation.

**092911 IMPROVED METHOD FOR DETECTING CLEAR SKY AND CLOUDY RADIANCES FROM AVHRR DATA.** To obtain accurate estimates of surface and cloud parameters from satellite radiance data a scheme has to be devised which identifies cloud-free and cloud-filled pixels (i.e. fields of view). Such a scheme has been developed for application on high resolution (1.1 km pixel) images recorded over Western Europe and the North Atlantic by the AVHRR on the TIROS-N/NOAA polar orbiters. The scheme consists of five daytime or five night-time tests applied to each individual pixel to determine whether that pixel is cloud-free, partly cloudy or cloud-filled. The scheme has been successfully applied to data for all seasons, including images with unusually cold or warm surface temperatures. To assess the method both daytime and night-time NOAA-9 passes over the U.K. were obtained for a week in April 1985 and some

results from this data set are presented here. (Edited author abstract) 46 refs.

Saunders, R.W. (Hooke Inst for Atmospheric Research, Oxford, Engl); Kriebel, K.T. *Int J Remote Sens* v 9 n 1 Jan 1988 p 123-150.

**092912 APPLICATIONS OF METEOROLOGICAL SATELLITE IMAGERY TO WEATHER ANALYSIS AND FORECASTING IN CHINA.** A survey of the applications of satellite imagery to weather analysis and prediction in China is presented. The principal topics considered include their use in analyzing and forecasting the weather systems over the Qinghai-Xizang plateau, typhoons, subtropical anticyclones and mesoscale cloud clusters. From 18 years' experience we conclude that satellite imagery is a new and useful tool for watching severe storms and studying weather systems over China. (Author abstract) 8 refs.

Dang, Renqing (Nanjing Univ, Nanjing, China); Fang, Zongyi. *Int J Remote Sens* v 9 n 1 Jan 1988 p 151-158.

**092913 TANDEM SATELLITE CONCEPT FOR CLOUD STEREOSCOPY AND WIND VECTOR DERIVATION.** Stereoscopic line scanners in a tandem configuration of two satellites in the same low Earth orbit are used to generate synchronous and non-synchronous stereoscopic cloud distribution image pairs. Cloud displacement vectors from these images are used to determine the wind vectors and their true heights. The technical requirements for the satellites are briefly described. (Author abstract) 9 refs.

Drescher, A. (DFVLR, Oberpfaffenhofen, West Ger). *Z Flugwiss Weltraumforsch* v 12 n 2 Mar-Apr 1988 p 127-128.

**092914 LOW COST CAPTURE OF DATA FROM METEOSAT.** The Meteosat satellite is parked in a geostationary position over the equator at zero meridian and views a world disc comprising, mainly, Africa and Europe. The author describes a reliable capture of data from satellites using inexpensive hardware and its distribution around a laboratory of independently operating data collection/image processing workstations. In this article discussion is limited to data capture from Meteosat although we are also involved in collecting data from the NOAA series of orbiting satellites.

Stephenson, John (Univ of Bradford, Engl). *Comput Bull (London 1986)* v 4 pt 2 Jun 1988 p 22-23.

**092915 USE OF SATELLITE AND RADAR IMAGES IN OPERATIONAL PRECIPITATION NOWCASTING.** Remote sensing provides spatial and temporal resolution data. Within meteorology, these two qualities have simulated the development of a new approach to short range forecasting termed 'nowcasting' FRONTIERS is one example of a real time precipitation nowcasting system, based on METEOSAT and ground based weather radar imagery. (Edited author abstract). 7 Refs.

Howes, S. (Logica Space & Defence Systems Ltd, London, Engl). *J Br Interplanet Soc* v 41 n 10 Oct 1988 p 455-460.

**092916 APT ON THE POLAR ORBITING WEATHER SATELLITES.** The author recounts the historical development of meteorological satellites to describe the need for automatic picture transmission (APT). The idea for weather observations from a satellite originated with a small group of meteorologists of the U.S. Army Signal Corps Research and Development Lab. at Ft. Monmouth, N.J., and resulted in the design of Vanguard II. The Tiros and TOS series of satellites, and the design of Nimbus, are briefly reviewed. A faster picture dissemination than was available at that time was needed, sparking the development of APT. All three systems, existing polar orbiting weather satellites, APT, and geosynchronous weather satellites, are discussed. It is noted that while the idea of APT and the polar orbiters was stimulated by the need for immediate data access, a companion goal was to produce a ground station at the lowest possible cost. Descriptions are given of the APT

system, its evolution, and the subsequent benefits desired.

Stampf, Rudolf A. *IEEE Trans Aerosp Electron Syst* v AES-23 n 6 Nov 1987 p 820-830.

**Zero Gravity Materials Processing** See Also MATERIALS SCIENCE; POWDER METALLURGY—Tungsten; SPACE FLIGHT—Weightlessness.

**092917 G-300, THE FIRST FRENCH GETAWAY SPECIAL MICROGRAVITY MEASUREMENTS OF FLUID THERMAL CONDUCTIVITY.** On Earth thermal conductivity measurements on liquids are difficult to perform because of thermal motions due to convection. In microgravity the convection due to buoyancy is evanescent and we expect a strong lowering of Rayleigh and Nusselt numbers. Three low viscosity liquids were selected to carry out the measurements: distilled water (standard), and two silicone oils. We use a modified 'hot plate' method with a simplified guard ring. Comparisons between Earth and orbit results may help to understand the convection occurrence in our cells. G-300 payload is cantilevered from the experiment mounting plate (EMP) and it includes: four struts, an intermediate plate, a bottom plate with four bumpers, a battery box, an electronic rack and six experimental cells assembled in twin-packs thermally coupled with the EMP. (Edited author abstract) 5 refs.

Perron, J.C. (ESE, Gif-sur-Yvette, Fr); Chretien, P.; Garnier, C.; Lecaude, N. *Acta Astronaut* v 15 n 12 Dec 1987 p 1029-1034.

**092918 EVOLUTION OF A SERVICEABLE EURECA.** Within the European space platform program, the EURECA is being established as a ground-based platform for short microgravity missions. The development towards a serviceable platform for longer, scientific missions is described. The plan of an advanced space-based platform for increasing payload demands is outlined. The platform design and the adaptation to scientific missions and servicing operations are investigated. The cost-effective utilization of the different platform types using new operational concepts is analyzed in parametric life cycle cost calculations for different payloads and mission scenarios. (Author abstract) 10 refs.

Weydandt, J. (MBB-ERNO, Bremen, West Ger); Richarz, H.P.; Wartenberg, H.; Kerstein, L. *Acta Astronaut* v 15 n 12 Dec 1987 p 1035-1049.

**092919 MARANGONI INSTABILITY WITH NON-UNIFORM VOLUMETRIC ENERGY SOURCES DUE TO INCIDENT RADIATION.** The effects of non-uniform volumetric energy sources, temperature-dependent viscosity and surface-tension on Marangoni convection in an incompressible fluid layer are studied. The nonlinear temperature profile arises from external incident radiation. The critical conditions for the onset of Marangoni instability in a microgravity environment ( $10^{-6}$ - $10^{-3}$  g) are determined numerically after a normal mode-type linear stability analysis. The perturbation equations are solved as an optimal control problem in the calculus of variations using Miele's sequential gradient-restoration algorithm (SGRA). The results indicate that viscosity plays a significant role in Marangoni convection relative to surface-tension. (Edited author abstract) 23 refs.

Lam, T.T. (Rice Univ, Houston, TX, USA); Bayazitoglu, Y. *Acta Astronaut* v 17 n 1 Jan 1988 p 31-38.

**092920 MASS TRANSPORT PHENOMENA BETWEEN BUBBLES AND DISSOLVED GASES IN LIQUIDS UNDER REDUCED GRAVITY CONDITIONS.** This paper describes the experimental and analytical work that has been done to establish justification and feasibility for a shuttle mid-deck experiment involving mass transfer between a gas bubble and a liquid. The experiment involves the observation and measurement of the dissolution of an isolated, immobile gas bubble of specified size and composition in a thermostated solvent liquid of known concentration in the reduced gravity environment of earth orbit. The primary objective



of the experiment is the elimination of convective effects that occur in normal gravity. The results will yield information on transport under conditions of pure diffusion. (Edited author abstract) 36 refs.

DeWitt, Kenneth J. (NASA, Cleveland, OH, USA); Brockwell, Jonathan L.; Yung, Chain-Nan; Chai, An-Ti; McQuillen, John B.; Sotos, Raymond G.; Neumann, Eric S. *NASA Tech Memo* v 100273 Jan 11-14 1988 p 1-9.

**092921 SIXTH EUROPEAN SYMPOSIUM ON MATERIAL SCIENCES UNDER MICROGRAVITY CONDITIONS, PROCEEDINGS OF AN INTERNATIONAL SYMPOSIUM.** This conference proceedings contains 85 papers, 14 of which are in French. The papers are arranged in the following groups: Invited papers; Critical phenomena; Fluid physics; Glass; Industrial perspectives; Melt growth; Solution growth; Space instrumentation; Transport phenomena; and Vapor growth. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11195 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (ESA, Paris, Fr). *Eur Space Agency Spec Publ ESA SP 256*, Sixth Eur Symp on Mater Sci under Microgravity Cond, Bordeaux, Fr, Dec 2-5 1986. Publ by ESA, Paris, Fr, 1987 597p.

## SAWMILLS

### Design

**092922 TESTING DESIM FOR DESIGNING AND SIMULATING THE OPERATION OF HARDWOOD SAWMILLS.** The DESIM system was tested to determine how realistically it could simulate the operation of a hardwood sawmill. We compared the individual values for a number of test variables from one 10-hour operating shift with the corresponding frequency distributions for 100 simulated 10-hour shifts. The actual values for all of the test variables fell within two standard deviations of the mean simulated values. Since the actual values and the mean simulated values are reasonably close, the DESIM system did realistically simulate the operation of the test mill. (Author abstract). 8 Refs.

Adams, Edward L. (USDA, Princeton, WV, USA). *For Prod J* v 38 n 7 pt 8 Jul 8 1988 p 41-45.

### Economics

**092923 CAPITAL BUDGETING PRACTICES OF SMALL- TO MEDIUM-SIZED SAWMILLS AND PALLET MILLS.** Sawmills and pallet mills in the eastern and southeastern United States were surveyed to determine their capital budgeting practices. It was found that discounted cash flow techniques have not been extensively adopted as primary methods of investment analysis. Nondiscounted payback period was the most extensively used quantitative method of analysis. For investments requiring less than \$50,000, 47.5 percent of the firms used no quantitative method. The majority of firms compared the expected return on an investment to a minimum rate of return, but this minimum was often determined nonquantitatively. Firms most often account for the risk of an investment by subjective means. Firms with less than \$50 million in annual sales were tested for a relationship between investment decisionmaking or risk accounting technique and firm size, location, and type. No statistically significant relationships were found. (Author abstract) 26 refs.

Bush, Robert J. (Southern Illinois Univ, Carbondale, IL, USA); Sinclair, Steven A. *For Prod J* v 37 n 10 Oct 1987 p 68-71.

**092924 MODELING SAWMILL PRODUCTION, COSTS, AND PROFITABILITY AS A GUIDE TO PREPARING BIDS FOR TIMBER.** An empirically based sawmill simulation model was developed to assist buyers in determining bids for specific tracts of timber. The model is deterministic and incorporates physical production functions and cost and product price data important

in sawmill operations. The model was used in a study of competitive bidding for a sample of timber sales and sawmills in southern New England. Results show that log size has an important effect on sawing production and costs. Competition for high quality timber was keen and profit margins estimated for individual mills were considered acceptable to both buyer and seller, and were closely grouped. (Edited author abstract) 12 refs.

Howard, Andrew F. (Univ of British Columbia, Vancouver, BC, Can). *For Prod J* v 38 n 3 Mar 1988 p 29-34.

### Efficiency

**092925 COMPARISON OF SAWING VARIABLES BY REGION OF THE UNITED STATES.** Sawing variables obtained from 650 studies of softwood sawmills were compared by region of the United States. The term sawing variable is used here to describe certain factors of the sawmilling process that determine the efficiency with which wood fiber is converted to lumber. Variables were headrig kerf, resaw kerf, total sawing variation, oversizing/undersizing, fixed-head planer allowance, and rough green size. Comparison-of-means tests were used to compare regional values of these sawing variables. Significant differences among regions were found for all sawing variables. It was also found that total sawing variation for 8/4 lumber was significantly lower than for 4/4 lumber at the same study sawmills. 13 refs.

Steele, Philip H. (Mississippi State Univ, Mississippi State, MS, USA); Wagner, Francis G.; Seale, R. Dan. *For Prod J* v 38 n 4 Apr 1988 p 19-24.

**Machinery** See HINGES—Friction.

**Performance** See WOOD PRODUCTS—Manufacture.

### United States

**092926 RELATIVE SOFTWOOD SAWMILL CONVERSION EFFICIENCY BY REGION OF THE UNITED STATES.** Accurate assessment of future trends in the supply of forest products depends, in part, on knowledge of regional softwood sawmill conversion efficiency. Data from 650 sawmill studies carried out in the years 1973 through 1983 were analyzed to obtain estimates of regional conversion efficiency. Statistical tests, both adjusted and unadjusted for log size, showed that significant regional differences existed. The fact that conversion efficiency adjusted for log size differed among regions indicates that processing technologies, in the form of improved processing methods, fibersaving machinery, and/or improved quality control programs, also differed among some regions. (Author abstract) 21 refs.

Steel, Philip H. (Mississippi State Univ, Mississippi State, MS, USA); Wagner, Francis G.; Taylor, Fred W. *For Prod J* v 38 n 2 Feb 1988 p 33-37.

**SAWS** See Also METAL CUTTING.

**092927 STUDY ON THE HEAT TREATMENT OF HAND-SAW BLADES MADE OF DUAL-METALS.** On the basis of the CCT-diagrams of W6Mo5Cr4V2 and 50CrNiMoVA steels, by adopting different heat treating processes, comparative tests on hardness, microstructure and machinability were carried out. It is found feasible to employ through heating for the saw blades in the salt bath, but if the hardness of the teeth is higher than HRC 67, they easily break, and if it is lower than HRC 62, their wear resistance is poor. When hardened saw blades are tempered or nitrocarburized, the procedure is beneficial for increasing mechanical property and cutting life. (Edited author abstract) In Chinese. 5 refs.

Yang, Ke-fu; Qin, Heng-wu. *Jinshu Rechuli* n 6 Jun 1987 p 29-32.

**092928 MULTIWIRE SAW FOR THE PRODUCTION OF ULTRASOUND TRANSDUCERS.** Ultrasound echography is now an important tool in medical diagnostics, e.g. in cardiology, gynaecology and radiology. In this paper a multiwire saw is described which is

capable of separating up to 600 acoustic elements over a 120 mm range. The saw itself automatically controls all kinds of sawing parameters such as wire tension, wire speed, etc. in order to minimise wire breakage and to optimise sawing results. With this saw the production costs are low, small forces are exercised on the product, hardly any heat is produced, the sawing groove is very smooth and no limitation exists as to the sawing depth. (Edited author abstract) 2 refs.

den Ouden, A. (Erasmus Univ, Rotterdam, Neth); Brinkman, J.F.; Niesing, R.; Lancee, C.T.; Bom, N. *J Phys E* v 20 n 12 Dec 1987 p 1457-1461.

**092929 DIE CHANCE DES KREISSAEGENS: TRENNEN UND FERTIGEN.** [Chance of Circular Sawing: Severing and Manufacturing]. Based on a statement an expert in severing techniques made 10 years ago, it is intended to investigate here the development of severing techniques since then. In the midst of a substantial change that forced the circulatory severing techniques into the background by preferring translatory techniques, it is highly justified to raise the question for a new position of circular sawing within the severing technologies in general. The statement was: 'Sawing is in most cases a preparatory operation and in rare cases only a finishing operation. Sawing errors can be corrected during subsequent operations. The objective in preparatory machining by sawing is to prevent the subsequent operations of turning or milling to become more costly due to sawing ...'. Consequent application of circular sawing can now minimize or even eliminate subsequent machining needs. One of the chances involved with circular sawing appears to be that it can combine severing and manufacturing in the cut-off process. If appropriately conceived, this cut-off process can thus also perform a machining operation which would have to be made subsequently by means of another machining method if a different severing technique was used. (Edited author abstract) 18 refs. In German.

Goettel, Heinz G. *Werkstatt Betr* v 121 n 4 Apr 1988 p 305-309.

**Applications** See INTEGRATED CIRCUIT MANUFACTURE—Equipment.

### Design

**092930 GUIDED SAW HUNTING.** A new design factor affecting the accuracy of lateral positioning of a guided circular saw is identified. Conventional guide configurations lead to a 'hunting' behavior, where the sawblade does not remain perpendicular to the drive shaft, but always drifts to one side or the other. This behavior is explained using a simple geometrical model, and methods of preventing or minimizing the effect are described. (Author abstract)

Schajer, Gary S. (Weyerhaeuser Technology Cent, Tacoma, WA, USA). *For Prod J* v 38 n 4 Apr 1988 p 47-50.

**Diamond** See Also CONCRETE—Cutting; CONCRETE—Sawing; CUTTING TOOLS—Diamond; GLASS—Machining; ORDINANCE—Materials.

**092931 BUILDING OWNER SAVES MONEY.** Diamond wire was first used in the quarry and for block squaring on soft rock types, mainly marbles, travertine and the like. With further advances it proved possible to perfect the technique to the point where it can now be economically applied to hard rock. Potential applications for the diamond wire saw are also to be found in the construction industry, especially where reinforced concrete walls over 500 mm thick have to be removed - an operation which previously required diamond stitch drilling or wall sawing with the blade penetrating from both sides. Diamond wire sawing can offer significant advantages over stitch drilling and conventional wall sawing for



reinforced concrete over 500 mm thick. The owner of a building in Lucerne, Switzerland, opted for the new technique to cut an opening of  $7.02 \times 4.45$  m.

Schaffner, J.; Blaser, E. *Ind Diamond Rev* v 47 n 521 1987 p 163-164.

**092932 CHAIN SAWING FOR HOUSES.** Mining below ground can affect dwellings on the surface. A new sawing method for creating expansion and contraction joints in the walls of terraced houses, to reduce the effects of soil movement, has been tried in Germany. People who live in mining areas generally appreciate the risks, but in view of the high costs and general inconvenience, often for a lengthy period, new techniques are constantly sought to enable the tensions to be released in house structures in a way which is both simpler and causes minimum inconvenience. The use of diamond sawing techniques to make a parting line has been discussed for a long time now in Germany, but so far practical tests have not produced satisfactory results.

Weber, U. (Ruhrkohle AG); Zilm, F. *Ind Diamond Rev* v 47 n 522 1987 p 214-215.

**092933 CENTRALIZATION AT BURLINGTON.** Prior to 1984, Burlington Slate operated separate processing facilities at each of its seven quarries, spread over an eighteen mile radius. The company then invested in a £1 million scheme to centralize all slate processing at its headquarters at Kirkby-in-Furness, the first phase of which was reported in IDR in 1985. The move by Burlington to centralized processing appears to be paying dividends. Turnover for 1986 was over \$5 million, an increase on the \$4.2 million the previous year. Over 60% of production is exported and it is interesting to note that in most years, the turnover figure is boosted by a single major project such as the \$2.2 million Heinz Centre. The facilities at Kirkby are now more than capable of maintaining the present production figures. Architectural products account for around 70% of turnover and as long as the demand for slate continues, Burlington is confident it can continue to meet that demand. 3 refs.

Jennings, Martin. *Ind Diamond Rev* v 47 n 522 1987 p 216-218.

**092934 BACK TO THE STONE AGE.** Almost a hundred years ago, the founder of the Halifax, UK company Marshalls Mono Ltd started production of natural York stone paving from a local quarry. This set in motion a process which eventually led to the establishment of one of Britain's largest suppliers of precast concrete paving, a material which became so popular that it led to the shutdown of natural stone quarrying ten years ago. Recent changes in market trends, however, prompted a rethink. The author reports on how the discovery of extra reserves of stone, coupled with advantages brought about by diamond sawing, have led to Marshalls Mono getting back into the natural stone business. (Author abstract) 2 refs.

Jennings, Martin. *Ind Diamond Rev* v 47 n 522 1987 p 221-222.

**092935 STUDY ON MACHINING CHARACTERISTICS OF DIAMOND ABRASIVE WIRE.** The basic characteristics of diamond abrasive wire in the case of constant pressure plane cutting-off operation with a reciprocation type wire saw are experimentally studied. The cutting-off tests for some selected workmaterials are carried with and without coolant at various wire-speeds, wire-tensions and normal forces. The abrasive wire of 200µm in nominal diameter which has one layer of copper bonded diamond grains around high-strength steel core of 3.1 GPa is used for the experiments. Major experimental results are as follows, (1) The ratio of tangential force to normal force is decided by material of workpiece and wear of abrasive wire, while it slightly depends upon wire running speed, wire tension and normal force. (2) The area cut off by same wire-running-length is proportional to normal force. (3) Machining without coolant shows much lower cutting ability than that with coolant. (Edited author abstract) In Japanese. 8 refs.

Ito, Satoshi; Murata, Ryoji. *Kikai Gijutsu Kenkyusho Shoho* v 41 n 5 Sep 1987 p 236-244.

**092936 RAPID, STRESS-FREE CUTTING.** Two machine designs have been developed for the rapid and stress-free sectioning of a range of engineering materials, including molybdenum coated steel, Inconel, honeycomb composites, glass and ceramics. The first type is fitted with a finite wire that operates with a reciprocating cutting motion at speeds of up to 1000 m/min. The second type is fitted with an endless wire capable of running at speeds up to 10,000 m/min. 3 refs.

Vogel, Matthias. *Ind Diamond Rev* v 46 n 513 Feb 1986 p 61-63.

**092937 NEW PARTNER SAW RINGS THE CHANGES.** A new power saw, the Partner K3500, incorporates a unique off-center drive, which enables a 260 mm depth of cut to be achieved from its 350 mm diameter sawblade. This lightweight unit can therefore be hand-held by a single operator to cut door and window openings in most standard walls, a job previously requiring a track-mounted, center-driven saw with a 700 mm diameter sawblade. 2 refs.

Jennings, Martin. *Ind Diamond Rev* v 48 n 524 1988 p 1-3.

## Foundations

**092938 AUFSCHUETTKISSENGRUENDUNG VON SAELEGATTERFUNDAMENTEN.** [Gang Saw Foundations on Sand Paths]. The paper discusses the problem of the discrepancy between the calculated and the measured values in the case of gang saw foundations placed on sand pads. The author points out that the universally used calculation model for block foundations under non-percussive working machines frequently requires a thorough analysis of the elastic properties of the subsoil. In such cases it is advisable to carry out on-site examinations of the subsoil. (Author abstract) In German. 6 refs.

Falkowski, Jozef (Technischen Hochschule, Koszalin, Pol). *Bautechnik* v 65 n 2 Feb 1988 p 66-68.

**092939 EINFLUSS DER TRAEGERKRAEFTE HOEHERER ORDNUNG.** [Influence of Higher-Order Inertia Forces on the Oscillation Amplitudes of Gang Saw Foundations]. The paper deals with the problem encountered when taking higher-order exciting forces into consideration in the design of foundations to be placed under gang saws and other low-speed crank-operated machines. The theoretical analysis and experimental measures indicate that it is useful to consider only first-order and second-order exciting forces. This simplifies the computation process while maintaining a level of accuracy which is sufficient for engineering practice. (Author abstract) 4 refs. In German.

Falkowski, Jozef (Technische Hochschule, Koszalin, Pol). *Bautechnik* v 65 n 5 May 1988 p 164-167.

**Heat Treatment** See STEEL HEAT TREATMENT—Carburizing.

## Manufacture

**092940 PLCS SPEED CHAIN SAW TESTING, INCREASE PRODUCTION EIGHTFOLD.** Stihl, Inc., a manufacturer of gasoline-operated chain saws, has changed the control of its saw testing from manual to programmable controller (PLC) based operation. As a result, they have cut 3¼ minutes from the test cycle and boosted the productivity of their in-line test standards from 15 units/hr to 120 units/hr. Quality control has also improved because test results and adjustments are now more accurate, consistent, and traceable. The 3.5 min. labor saving in testing represents about a 10% productivity gain in the overall assembly operation.

Mueller, Peter K. (Stihl Inc, Virginia Beach, VA, USA); Gosnell, Rodney. *Chilton's I&CS* v 61 n 3 Mar 1988 p 81-82.

**092941 DAS SAEGBAND: VOM WEGWERF-ARTIKEL ZUM PRAEZISIONSWERKZEUG.** [Sawband: from a Throwaway Article to a Precision Tool]. Band sawing has become a competitor for previously leading serving techniques. This would be unimaginable without the sawband as a tool. A decision change from a simple throwaway article to a precision tool has commenced here. Important expectations are held of the sawband of the future. Basic studies to date have been dealing mostly with geometry and mechanics of machine, process and tool, but the material technology of the tool usually was treated with neglect. However, it is exactly this technology that will make the development progress. (Author abstract). 13 Refs. In German.

Goettel, Heinz G. *Werkstatt Betr* v 121 n 7 Jul 1988 5p.

## Metal Working

**092942 BASIC STUDY ON VIBRATORY MULTI-WIRE SAWING.** This paper deals specifically with vibratory multi-wire sawing from among the various vibratory methods of applied mechanical vibration energy. The vibratory multi-wire saw designed for use in this study makes possible the slicing of larger works when compared to the present technological level. 3 refs.

Ishikawa, Ken-ichi (Kanazawa Inst of Technology, Kanazawa, Jpn); Suwabe, Hitoshi. *Bull Jpn Soc Precis Eng* v 21 n 4 Dec 1987 p 293-295.

**092943 PRODUKTIVITÄTSORIENTIERTES KREISSAGEN VON ALUMINIUM-KNET-LEGIERUNGEN.** [Productivity-Oriented Circular Sawing of Wrought Aluminium Alloys]. Currently available machine tools are rarely capable of making full use of the great potential offered in aluminium working. Among the few exceptions are cold circular saws and in particular a series of such machines specially adapted to aluminium materials. Specific examples are used to describe how wrought aluminium alloys can be sawed efficiently on heavy-duty circular saws. (Edited author abstract). 6 Refs. In German.

Henning, Klaus; Bleher, Siegfried. *Werkstatt Betr* v 121 n 6 Jun 1988 p 503-507.

## Thickness Measurement

**092944 ERRORS IN ESTIMATING THICKNESS PARAMETERS FOR SAW MATERIALS FROM A RESTRICTED NUMBER OF BLADE MEASUREMENTS.** This paper examines the errors for three methods of determining the thickness parameters for saw materials. These include: (1) direct parameter estimation from a restricted number N of measurements made at equally separated points along the blade (2) direct estimation from an indefinitely large number of measurements made on a restricted length L near the root or crest and (3) statistical estimation from a restricted number N of measurements made at equally separated points along the blade. 4 refs.

Kovzun, N.I. *Meas Tech* v 30 n 3 Mar 1987 p 211-214.

## Vibrations

**092945 BASIC STUDY ON VIBRATION MULTI-WIRE SAWING USING WIRE FIXED DIAMOND GRAINS.** A vibration multiwire sawing machine using wire-fixed diamond grains was developed for cutting hard and brittle materials. The underlying operational principle of the machine and some experimental results are described. 2 refs.

Ishikawa, Ken-ichi (Kanazawa Inst of Technology, Kanazawa, Jpn); Suwabe, Hitoshi. *Bull Jpn Soc Precis Eng* v 21 n 3 Sep 1987 p 214-216.

**092946 VIBRATION COMPARISON OF TWIN-CYLINDER AND SINGLE-CYLINDER CHAINSAWS.** A twin-cylinder chainsaw was evaluated to determine the vibration levels transmitted to the



operator. The saw vibration was compared with two different types of single-cylinder saws in a static bench test and in a dynamic buckling test. The tests showed a significant reduction in vibration at the handles of the twin-cylinder saw model as compared to the single-cylinder saws. (Author abstract) 8 refs.

Stokes, Bryce J. (US Forest Service, Auburn, AL, USA). *Trans ASAE* v 30 n 6 Nov-Dec 1987 p 1619-1623.

**092947 SELF-EXCITATION IN GUIDED CIRCULAR SAWS.** The paper presents the results of an experimental and analytical study into the vibrational characteristics of guided rotating saw blades that are not perfectly flat. Experimental results are presented that show the nature of the vibrations induced by the interaction between the guides and the blade. An analytical model is developed that includes the effect of the interaction between the guide and the blade, and this model may be used as a design tool in avoiding the self-excited resonances that exist in the coupled blade/guide system. (Author abstract). 8 Refs.

Lehmann, B.F. (Univ of British Columbia, Vancouver, BC, Can); Hutton, S.G. *J Vib Acoust Stress Reliab Des* v 110 n 3 Jul 1988 p 338-344.

**092948 CONTROL OF CHAIN SAW VIBRATION.** Vibration transmitted to the hands when using hand tools such as chain saws is a major health hazard in the forest industry. Several factors such as the type of chain saw, speed, and type of wood were found to be relevant in evaluating the vibration level and are included in an ISO standard. This article describes the effects of the sharpness parameters, horizontal angle, vertical angle and depth gauge, on the vibration level based on data obtained in our laboratories. (Author abstract). 10 Refs.

Dessureault, Pierre C. (Univ du Quebec, Trois-Rivieres, Que, Can); Laperriere, Andre; Vincent, Jean-Yves. *S V Sound Vib* v 22 n 7 Jul 1988 p 32-34.

## Woodworking

**092949 HYGIENIC EVALUATION OF VIBRATION PARAMETERS OF GAS SAWS MP-5, 'URAL-2'.** Gas-powered saws MP-5 are used in tree logging. Vibration and noise measurement methods are described. Hygienic occupational characteristics of vibration and noise effects are evaluated with the aid of spectrum analysis. Mechanically unsound saws are the source of high level hazardous noise and vibration effects. In Russian. 3 refs.

Kravchenko, O.K. *Gig Tr Prof Zabol* 10 Oct 1987 p 49-50.

**SCAFFOLDS** See Also BRIDGES, RAILROAD—Construction.

## Applications

**092950 TRAGGERUESTE - TECHNISCHE ANFORDERUNGEN UND MOEGLICHKEITEN.** [Supporting Scaffolds - Technical Requirements and Scope of Application]. Supporting scaffolds are to serve as temporary platforms for concrete structures while the concrete is setting. A round-up is presented on their application, the demands on functional performance and safety. Further, design concepts and their main features are dealt with. A special version, a form traveler for segmental bridge construction and its functional features are set forth. (Author abstract) In German.

Moser, Egon. *Str Tiefbau* v 41 n 7-8 Jul-Aug 1987 p 16-18, 23-24.

**Modular Construction** See CONCRETE CONSTRUCTION—Forms.

## Structural Analysis

**092951 ERGAENZENDE UNTERSUCHUNGEN ZU KUPPLUNGEN FUER GERUESTROHRE.** [Supplementary Studies of Couplers for Scaffolding Tubes].

The correlation between the tightening torque and the normal force in the screw of screw couplers is treated especially for repeated tightening. In addition, the decrease in the pretensioning force as a function of time is shown for coupler tubes made of steel and aluminum. A numerical approximation is introduced which treats the coupler as a double-shear friction connection. Regarding the torsional stiffness of right angle couplers the correlation between moment and angle is given as hysteresis loops for the range of positive and negative bending moments. In conclusion, the interaction between the different forces and the bending moment a right-angle coupler can transmit is discussed. (Edited author abstract) In German. 18 refs.

Voelkel, G. (FMPA Baden-Wuerttemberg, Stuttgart, West Ger); Zimmermann, W. *Stahlbau* v 56 n 11 Nov 1987 p 335-342.

**092952 ZUR SCHUBTRAGFAEHIGKEIT DES CRUCIANI-LEHRGERUESTES.** [Shear Capacity of Cruciani-Scaffolding]. The paper discusses the shear capacity of the Cruciani-Scaffolding. Shear capacity and deformation behavior of the scaffolding determine the sequence and the size of the individual concrete casting sections as well as the site organisation - especially if large casting sections are projected. A simplified analysis is presented to analyze the shear capacity and to calculate the deformations and the stress strain behavior. (Edited author abstract). 9 Refs. In German.

Ewald, Gert (Univ der Bundeswehr Muenchen, Munich, West Ger). *Bauingenieur* v 63 n 6 Jun 1988 p 267-272.

## Testing

**092953 TESTING AND EVALUATION OF SCAFFOLDING TUBES.** This paper describes the testing and evaluation of test results of cold-formed scaffolding tubes. A column design curve based on the test measurement in proposed. Despite being primarily relevant to scaffolding tubes, the findings of this study also have significance for other cold-formed shapes that are at present designed to somewhat conservative local specifications. (Author abstract) 10 refs.

Allen, A. (Univ of the Witwatersrand, Johannesburg, S Afr); Scholz, H. *Civ Eng S Afr* v 29 n 6 Jun 1987 p 209-213.

**SCALES AND WEIGHING** See Also FLOW OF SOLIDS—Measurements; OIL WELL DRILLING; ROLLING MILL PRACTICE—Bars; SEMICONDUCTING GALLIUM ARSENIDE—Growth; STRAIN GAGES.

**092954 STANDARD BALANCES WITH UPPER SCALE LIMITS UP TO 10 kg.** The Czechoslovak Metrological Institute has set up a standard balance employing the substitution principle to determine the mass of the working standard and to check and certify first-class substandard weights of mass from 1 to 10 kg. The balance has upper and lower ends joined by three rods. Between the rods is a guide column for the weight displacement mechanism. The bearing plate is mounted on the upper end, on which the middle prism in the balance arm rests during the weighing. The balance employs a two-prism duralumin arm with adjustable counterweights. A major condition for obtaining high accuracy and sensitivity is correct and careful adjustment of the main units: prisms, supports, clamping bearings, mobile section of suspension, rotating table, etc. The balance has been used in the simultaneous calibration for two sets of weights of mass 1, 2, 5, and 10 kg made of nonmagnetic stainless steel. The results were processed by least squares. The standard deviation of the values calculated from the differences between the measured values and those given by the equation was  $\pm 0.15$  mg.

Spurny, R. *Meas Tech* v 29 n 2 Feb 1986 p 90-92.

**092955 MASS MEASURING ON CONVEYOR BELTS.** The article presents an overview of mass measuring on conveyor belts. It deals with the basic weighing equation and the various components of a mass-measuring system. The regulations pertaining to payment massme-

ters by the Department of Trade and Metrology are explained, and the importance of weighing accuracy is highlighted by a typical example from within Eskom. A general overview of mechanical, electro-mechanical, hybrid and nuclear massmeters is given, and the article concludes by emphasizing the importance of the correct maintenance of conveyor massmeters. (Edited author abstract) 5 refs.

Fraser, Max. *S Afr Mech Eng* v 38 n 1 Jan 1988 p 43, 45, 47-48.

**092956 HIGH ACCURACY WEIGHING AND HANDLING SYSTEM FOR BISCUIT MANUFACTURE.** The article describes a recently designed and installed automated multi-ingredient weighing and handling system, the Neu system which features high throughput with very high weighing accuracies of both solid and liquid materials. It feeds seven weighed ingredients into a new Vicars mixer, one of a series of mixing units which prepare dough for biscuit manufacture. The weighing system comprises a load cell lever assembly, fitted to the high speed mixer. The process is controlled automatically by a programmable logic controller (PLC), equipped with visual display screen. The controller supplies all operator information and monitors the total weight of ingredients in the mixer, as well as the net weight of each ingredient as it is fed into the unit.

Giles, A.C. (Neu Engineering Ltd, Woking, Engl). *Bulk Solid Handl* v 8 n 1 Feb 1988 p 61.

**092957 SAMPLING AND WEIGHING OF MINERAL CONCENTRATES.** While the variance is the most basic measure for precision, more transparent measures such as coefficients of variation, and confidence intervals and ranges, are frequently applied. Statistical tests differentiate between random variations that are intrinsic to a measurement process, and systematic errors that should be avoided if at all possible. Loss prevention and control is a logical approach to assessing the risk to lose due to systematic errors that should be eliminated, and due to random variations that can be reduced at a cost. The accuracy and precision characteristics of wet weights, moisture contents and metal grades for consignments of mineral concentrates are discussed, and their impact on the risk to lose are addressed. (Edited author abstract) 1 ref.

Merks, Jan W. (Matrix Consultants Ltd, Vancouver, BC, Can). *Bulk Solid Handl* v 8 n 2 Apr 1988 p 179-185.

**092958 ACCURACY AND TOLERANCES OF WEIGH-IN-MOTION SYSTEMS.** Tolerances for a 95 percent confidence level were derived after the system had been calibrated to yield a zero mean of differences in the weigh-in-motion wheel weight estimates and the corresponding static wheel weights. The concept of use tolerances, which allow for the probable error in both the static weight measurement and the weigh-in-motion weight estimate, is presented. Tolerances for high-speed weigh-in-motion, intermediate-speed weigh-in motion, and low-speed weigh-in-motion scales at the experimental site are tabulated. (Edited author abstract) 8 refs.

Izadmehr, Bahman (Univ of Texas at Austin, Austin, TX, USA); Lee, Clyde E. *Transp Res Rec* 1123 1987 p 127-135.

**092959 PRACTICAL UNCERTAINTY LIMITS TO THE MASS DETERMINATION OF A PISTON-GAGE WEIGHT.** The mass of a 590-g piston-gage weight was determined with a standard error of 0.057 mg (0.1 ppm). The sources of error are carefully examined. These include air-buoyancy corrections, physically adsorbed surface moisture, and air-convection within the weighing chamber. The authors conclude that significant



improvement cannot be realized with the conventional weighing techniques available to most piston-gage users. (Edited author abstract). 12 Refs.

Davis, R.S. (NBS, Gaithersburg, MD, USA); Welch, B.E. *J Res Natl Bur Stand (US)* v 93 n 4 Jul-Aug 1988 p 565-571.

**092960 DEVELOPMENT OF A 20-TON-CAPACITY LOAD-CELL-BASED WEIGHING SYSTEM FOR IAEA FIELD USE.** Based on results of an International Atomic Energy Agency (IAEA) field test of the prototype 20-ton-capacity Load-Cell-Based Weighing System (LCBWS), a modified LCBWS is being configured for routine IAEA field use in verifying the masses of 10- and 14-ton UF<sub>6</sub> cylinders. The modified system is being designed to meet IAEA objectives for accuracy and portability as well as to meet facility operating safety conditions. To best meet these design requirements, a comprehensive survey of commercially available weighing equipment was conducted. Detailed equipment specifications for 25 load cells from 15 manufacturers, for 5 digital crane scales from 3 manufacturers, and for 7 digital weight indicators from 5 manufacturers were compared. (Edited author abstract) 3 refs.

Cooley, J.N. (Oak Ridge Gaseous Diffusion Plant, Oak Ridge, TN, USA); Huxford, T.J. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 730-734.

**Automation** See Also IRON ORE TREATMENT—Sintering.

**092961 DRY INGREDIENT WEIGHING.** Computerization has certainly played the single most important role in the automation of micro and minor ingredients followed closely by the advances in scale and feeder equipment design. There are numerous electronic companies presently selling dedicated industrial grade batching controllers. These controllers are multi-industry adaptable, reliable and able to provide greater control of your batching operation. Numerous variations in scale hopper design configurations can be found as well as variety of feeder designs.

Anderson, Carl E. (Agra Products Int Inc, Minneapolis, MN, USA). *Bulk Solid Handl* v 8 n 1 Feb 1988 p 60.

## Calibration

**092962 CALIBRATION AND ACCURACY TESTING OF WEIGH-IN-MOTION SYSTEMS.** Recent calibration techniques are outlined and a different approach is advocated, based on random vehicles. A statistical appraisal of the approach is discussed. A new technique is described for self-calibration of weigh-in-motion systems, based on the fact that loads on certain axles of particular truck classes show relatively little variation. The questions of weigh-in-motion accuracy appraisal and weigh-in-motion performance standards are addressed. An accuracy 'funnel' for the assessment of weigh-in-motion performance is proposed. (Edited author abstract) 9 refs.

Davies, Peter (Castle Rock Consultants, Phoenix, AZ, USA); Sommerville, Fraser. *Transp Res Rec* 1123 1987 p 122-126.

**092963 ON-SITE CALIBRATION OF WEIGH-IN-MOTION SYSTEMS.** A pronounced improvement in the accuracy with which weights were estimated by the high and intermediate systems was achieved when six loaded five-axle tractor-trailer trucks, chosen randomly from the traffic stream, were used as the basis for calibration compared with multiple runs of the same loaded two-axle, single-unit test truck. The variability in weigh-in-motion weight estimates was not affected appreciably by the type of moving-vehicle loading that was used as the basis for calibration. Static-weight loading is recommended for low speeds of weigh-in-motion calibration, and moving-vehicle loading is recommended for practicable on-site calibration of higher-speed

weigh-in-motion systems. (Edited author abstract) 5 refs.

Izadmeh, Bahman (Univ of Texas at Austin, Austin, TX, USA); Lee, Clyde E. *Transp Res Rec* 1123 1987 p 136-144.

**Computer Applications** See Also FLOW OF WATER—Nozzles; SILOS—Inventory Control.

**092964 BATCHING SYSTEM FOR GLASS/CHEMICALS.** The heart of the weighing and batching system is a Philips Microcomputer Batching Controller (MBC) which controls the weighing and batching of the raw ingredients - various cullets (scrap and bottle glass), chemicals and water - in their correct weights and proportions. Various products require various recipes, while also the recipes will change due to the quantity of the raw materials. This was one of the main reasons (simple recipe storage and change of recipes), for choosing the Philips MBC. Another reason was the facility of providing detailed printouts and totalising of material consumption. The MBC is a Microcomputer Batching System with well proven standard software designed for industrial use, and made to be used under industrial conditions, especially in the glass industry, where reliability is important and consistency of the batches is a must. Operation is simple and performed from the keyboard and a mimic panel. The MBC with its Weighing Point Modules and its input and outputs is placed in a panel and does not form part of the operator controls.

Anon. *Bulk Solid Handl* v 8 n 1 Feb 1988 p 65-66.

## Control

**092965 NEW WEIGHING SYSTEMS BY MOTHERWELL CONTROL SYSTEMS LTD.** The Motherwell InFlo Division of Motherwell Control Systems continues to break new ground in the application of continuous weighing systems, as evidenced by some recent contracts which are described. These include: weighing/blending system to a coal washing facility; lorry load-out scheme to speed up load/dispatch operations; belt scale units for trans-shipment terminals. Motherwell is meeting these and other challenging applications such as the new tube conveyor designs, with courage based on its proven experience with world class clients, and is at the same time extending its activities to cover an increasingly comprehensive range of products and services, particularly the control systems associated with weighing installations.

Kelly, John P. (Motherwell Control Systems Ltd, Orpington, Engl). *Bulk Solid Handl* v 8 n 1 Feb 1988 p 59.

**092966 STEVENS CHECKWEIGHER FOR BAKERIES.** Their Average Weight systems have already been installed at nearly 100 bakeries in the U.K. and the latest Model 280 uses microprocessor based electronics designed specifically for the bakery industry. The unit is dust and splash proof sealed to IP65 standards and incorporates a printer to provide all the data recording required by Average Weight Legislation. Information from the printer includes time and shift number, product identification (from a memory of up to 22 individual lines) and weight of each product. The weigh unit provides tare input to delete the packaging weight and an indication of tolerance performance on two levels.

Anon. *Bulk Solid Handl* v 8 n 1 Feb 1988 p 62.

**092967 LOSS-IN-WEIGHT FEEDERS FIT IN TIGHT QUARTERS.** The heart of the Loss-in-Weight Feeder is the time-and-test-proven AccuRate feeder, with its unique agitation features. This feeder rests upon a counterbalanced scale that weighs only the material in the feeder, not the feeder itself, for maximum resolution. The third component is a state-of-the-art control that incorporates a CRT monitor for instant display of functions, commands, current situations and operations. This easy-to-use control displays mode of operation, feeding parameters, operations information, alarm parameters and more.

Anon. *Bulk Solid Handl* v 8 n 1 Feb 1988 p 63.

**092968 ENHANCING THE POWER OF PROCESS WEIGHING.** Weighing ingredients as a method of providing for batch process control, instead of measuring flow or level, has grown in popularity over the last few years, particularly where mixture additions involving solids and powders, or variable density fluids, are concerned. Process weighing for batch monitoring and control has advanced slowly, but now the techniques are broadening their appeal.

Tinham, Brian. *Control Instrum* v 19 n 9 Sep 1987 p 81, 85, 87.

## Control Systems

**092969 MAGNETIC SCALES FOR LINEAR ENCODING.** Experienced control designers know that feedback encoders must be located close to the controlled axis. This practice minimizes error sources that can degrade position measurements and cause problems. However, it is often difficult to get such optimum positioning, particularly when using linear encoders. The glass scales frequently employed in these devices must be kept away from sources of contamination such as smoke, fumes, oil, coolant, or metal chips. One way to avoid such difficulties is to use magnetic scales as feedback encoders. The paper describes how magnetic encoders are a worthwhile alternative to glass scales in harsh conditions where dirt and grime can foul position measuring instruments.

Billingsley, John (Natl Machine Systems Inc, Orange, CA, USA). *Mach Des* v 58 n 28 Nov 20 1986 p 142-145.

**Design** See GRANULAR MATERIALS—Weighing.

## Display Systems

**092970 IMPROVING A SAND BLENDING PROCESS BY CONTINUOUSLY DISPLAYING INGREDIENT WEIGHT AND FLOW RATIOS.** Demand for rigidly specified aggregate products has led to a new system for controlling the manufacturing of blended sand products at Northwest Aggregates Company, USA. A personal computer-based product provides the operator with a continually updated display for adjusting the blending process. During the first month of operation, operators have decreased the Fineness Modulus range to 0.15 for all products and to 0.05 for specific product runs. Additionally, final weight of each of four ingredients typically deviates from target by one percentage point. (Edited author abstract) 4 refs.

Nachtigal, Chester L. (Kistler-Morse Corp, Redmont, WA, USA); Mann, William H.; Inwards, Richard W. *Bulk Solid Handl* v 8 n 2 Apr 1988 p 189-193.

## Electronic

**092971 GERAETEBAU-PROBLEMLÖSUNG FUER EINE SELBSTBEDIENUNGSWAAGE.** [Instrument Engineering Solution for a Self-Service Balance]. The idea of a self-service balance comes from the U.S.A. where for many years now shoppers have been able to preweigh their purchases, especially of fruit and vegetables. Later at the cash-desk the definitive weight and purchase price are established with a check-out balance. It was this idea that gave rise to the wish for a self-service balance as a complete solution for Finland, Sweden and Norway. Finish products were already available on the market, so a solution had to be developed and delivered quickly. A first step was taken with an interim solution consisting of familiar components with certain modifications. This article describes how the self-service balance was developed from the interim solution into a special-purpose product and how it is built up of mechanical, optical, electronic and software components. (Author abstract) In German. 1 ref.

Balingen, Horst Kraft. *F&M Feinwerktech Messtech* v 95 n 6 Sep-Oct 1987 p 353-357.



**092972 ELECTRONIC SCALES: THE BALANCE TIPS TO MORE SYSTEMS.** Computer interfaces from bar code options such as hand-held scanners and label printers to radio telemetry make electronic scales more productive in weighing and counting. As a result, scales now perform more functions and are easily integrated into other handling systems. They produce productivity gains in inventory accuracy, parts kitting, parcel shipment throughput and other areas.

Feare, Tom. *Mod Mater Handl* v 42 n 10 Sep 1987 p 63-66.

**092973 WEIGHT FORWARD.** Improved and cheaper electronics have furthered the development of highly accurate multiple loadcell weighing systems. It is in this area, particularly those applications using lower capacity those applications using lower capacity bending beams, where the single-point or 'center-cell' loadcell has been making progress. The availability of higher capacity single-point designs means that units are no longer restricted to the retail, postal and bench-scale markets. The article describes some available equipment.

Proctor, Andrew. *Process Eng (London)* v 68 n 9 Sep 1987 p 69, 71-72.

**092974 ADVANCEMENT OF LOAD CELL WEIGHING TECHNIQUES FOR HIGH SPEED NETT WEIGHERS WORKING IN HARSH ENVIRONMENTS.** To provide greater control with higher speed and accuracy, a new generation of weighers has been developed, employing a single load cell. Initial designs used a bending beam load cell, and a parallelogram flexure linkage system that catered for uneven loading in the weighpan and eliminated the need for anti-sway links. A design to eliminate side forces but still retain the direct load cell concept has now been achieved by means of a cantilever support system incorporating a single tension load cell. The cell is of unit construction and can be accurately machined and set up on the bench before being inserted into the weigher. The life of the load cell is also extended as the unit has overload protection stops capable of withstanding 500% overload.

Ford, Derek (Richard Simon & Sons Ltd, Nottingham, Engl); Smith, David. *Bulk Solid Handl* v 8 n 1 Feb 1988 p 43-46.

**092975 ELECTRONIC BELT WEIGHERS FOR RUMANIAN BEET SUGAR INDUSTRY.** Electronic Belt Weighers Series 1200 supplied by Adequate Services were chosen and installed by the Rumanian Beet Sugar Industry to improve the monitoring of product and consequential efficiency of sugar extraction. The machines are now in their factories providing precise measurement of throughput and control of the extraction process. The machines give digital readout of Total Weight. Flow Rate in tons per hour and kilograms per metre, with computer compatible signals. Also a comprehensive diagnostic programme monitoring both weigher and conveyor performance.

Anon. *Bulk Solid Handl* v 8 n 1 Feb 1988 p 62.

**092976 HIGHLY ACCURATE LOAD CELL FOR USE IN HOSTILE ENVIRONMENTS.** A compact bending beam load cell that combines high accuracy with a water proof, stainless steel package has been introduced. Designated the SHB, the new load cell is available for quantity dry batch or liquid weighing applications in hostile environments, including industrial floor scales, tank and hopper scales, and filling machines. The SHB is rated by the West German PTB at the high accuracy level of C3 (3000 Divisions) for use in Class III scales.

Anon. *Bulk Solid Handl* v 8 n 1 Feb 1988 p 64.

**092977 OPTICAL LOAD CELL TRANSDUCER.** The technology produces a very low profile, low physical weight load cell with no temperature or hysteresis effect. An 8,000 kg transducer is 50 mm<sup>2</sup> by approximately 12 mm thick and only grams in weight. The intensity of the output beam is determined by a Pin Diode, which converts light intensity to voltage in an opamp feed back arrange-

ment. With the Pin Diode in reverse bias the diode leakage current is linearly dependent on light and the output voltage is also a linear function of the light intensity.

Anon. *Bulk Solid Handl* v 8 n 1 Feb 1988 p 65.

**092978 PROCESS WEIGHING EQUIPMENT.** Negretti Automation manufactures a wide range of load cells and associated measuring and control instrumentation designed to meet the requirement of industrial weighing processes. Prominent among these is a range of Shear Beam Load Cells for compressive and tensile loads. The Digital Weightfinder is available on a 3½ or 4½ digit indication and has two fully adjustable trip points. The unit is ideal for precision low cost weight indication and control applications. The Weightcontroller is a versatile instrument available as either a precision weight indicator with 8 operator adjustable trip points or as a batch controller with 10 protected pre-set recipes. The MPC84 is a programmable process controller that accepts direct load cell input as well as other analogue and digital process I/O.

Anon. *Bulk Solid Handl* v 8 n 1 Feb 1988 p 68.

**092979 NEW LOAD CELLS FROM HUNTLEIGH TECHNOLOGY.** The HSB load cell, a new low profile shearbeam load cell, is now available in a stainless steel version with a capacity up to 5 tons. It is designed for single and multiple heavy industrial and process weighing applications where environmental conditions could be harmful to the standard steel bodied cell. The DC6 load cell is available in capacities ranging from 20 kg to 200 kg with the same accuracy specification as given above. The load cell is hermetically sealed to protect its strain gauge and internal circuitry and of low profile.

Anon. *Bulk Solid Handl* v 8 n 1 Feb 1988 p 66.

**092980 BELT SCALE TECHNOLOGY UTILIZES PARALLELOGRAM PRINCIPLE.** Millitronics has developed a single idler belt scale which gives instantaneous readings to variations in product loading. This innovation has been achieved with the use of a floating suspension consisting of two load cells. Utilizing the parallelogram principle, the load cells react only to the vertical force of the mass transmitted through the weighing idler, and never to idler friction, sideforces and off-center loading. As a consequence of the patent-protected design, the Millitronics single idler belt scale (MSI) provides greater than usual accuracy for standard single idler cost. It has proven reliable on previously inappropriate single idler scale applications, such as those with faster moving belts and uneven loading.

Closs, Ralph (Millitronics, Peterborough, Ont, Can). *Bulk Solid Handl* v 8 n 2 Apr 1988 p 194.

**092981 WEIGHTING UNITS CONTROL MATERIAL AND PROCESSES.** Electromechanical scales, which have been integrated into material flow, are now an important element for quality control, optimization, control and regulation, classification, marking, invoicing, maintaining ledgers for materials and costs. They must be able to be configured in compact or decentralized form, and to be integrated into or adapted to other systems. This involves the development of evaluation and display equipment such as terminals/monitors and software for standardized modules, supplemented by tasks specified by users. Examples of application, taken from a variety of process-engineering fields, demonstrate the variability and the ability of weighing systems to be adapted to and integrated into automated production processes with the ability to be partially standardized for data recording and processing. (Edited author abstract). 3 Refs.

Weinberg, H. *Aufbereit Tech* v 29 n 5 May 1988 p 282-290.

## Errors

**092982 CALCULATION AND MINIMIZATION OF THE ERROR OF BEAM BALANCES CAUSED BY NONPARALLELISM OF THE KNIFE-EDGES.** Nonparallelism of the working edges of the input and

output knife-edges of the weighing beam relative to the working edge of the bearing knife-edge is a source of error in balances. The qualitative aspect of this phenomenon was discovered and separate elements of the theory have been presented. In this paper the authors analyze the error due to nonparallelism of the working edges for a beam mechanism of a general type with the basic factors taken into account. 4 refs.

Ishkhanov, I.A. *Meas Tech* v 30 n 6 Jun 1987 p 523-526.

**092983 ACCURACY AND SPEED OF INTRACYCLIC ALGORITHMS FOR WEIGHT-SPACE DISPENSING.** Weight-space methods (WSM) of dispensing are being increasingly used for constructing high-accuracy dispensers of small masses of bulk materials. Different algorithms for WSM, in particular, intracyclic algorithms, in which the dose formed is divided into a series of sequential subdoses, whose masses are measured and subsequent subdoses are formed from the results of these measurements, are used to reduce measurement error. The fact that an analysis of the accuracy and speed of such algorithms is not contained in the literature prevents evaluating their applicability when the dispensers are being designed. In this paper the authors attempt to fill this omission. 6 refs.

Polunov, Yu.L. *Meas Tech* v 30 n 6 Jun 1987 p 527-529.

**Industrial Applications See IRON AND STEEL PLANTS—Measurements.**

## Magnetic

**092984 NOVEL WEIGHING METHOD USING MAGNETIC COUPLING OF BALANCE AND SAMPLE BY A PERMANENT MAGNET.** A weighing method is described which uses coupling of an electromagnetic balance and the sample with permanent magnets. One magnet is fixed to the balance and attracts a second induced or permanent counter magnet which is attached to the sample and can move freely between two supports in a sealed nonferromagnetic sample cell. At the critical floating distance  $r_c$  of the two magnets, the effective mass  $m(r_c)$  indicated by the balance is equal to the desired apparent mass  $m$  of the counter magnet. This unstable state of mass equality can be observed precisely by the balance itself, because the counter magnet moves from its support and either rises or falls very rapidly to the other support. The result of these events is an effective mass change from  $m(r_c)$  to  $m(r_c \pm d)$  indicated by the balance (where  $d$  is the distance moved by the counter magnet). (Edited author abstract) 14 refs.

Kerl, K. (Technische Univ Braunschweig, Braunschweig, West Ger). *J Phys E* v 20 n 11 Nov 1987 p 1326-1330.

**Precision Balances See ALSO FLOW OF FLUIDS—Channel Flow; PLASTICS FILMS; SEMICONDUCTING SILICON—Mechanical Properties.**

**092985 METHOD OF DETERMINING THE INSTRUMENTAL ERROR IN A REMOTE-READING SYSTEM FOR TAKING READINGS FROM A PRECISION BALANCE.** Tests have been made during metrological certification on precision balances which showed that deviation in any element of the readout system (RS) from the optimum position produced a component in the instrumental error. The most difficult task in measurement accuracy estimation is observing the error components; one tends to eliminate factors that cause them or to reduce the effects to a minimum by adjustment. For this purpose, we propose a method of determining the instrumental error component arising from mismatch between the RS components. 3 refs.

Afanas'ev, S.N.; Biryuzov, S.V. *Meas Tech* v 30 n 2 Feb 1987 p 135-137.

**092986 ESTIMATING THE METROLOGICAL CHARACTERISTICS OF PRECISION BALANCES.** The balance consists of the following systems: for taking the readings (automatic and visual), for weighing proper,



for remote control, and for processing the data. The weighing system proper is used in balancing the measures in transferring the unit of mass. The automatic reading system (RS) produces an electrical signal proportional to the limiting deviation  $\epsilon_1$  of the pointer from the zero position. The balance were tested by a special method that took account of their design features. We determined the value of a scale division and the standard deviation SD in the observations with automatic and visual readout. The calculations were made from results on comparing two weights A and B of mass 1 kg each. These studies showed that the RS scale division remains virtually unaltered during a single observation period (about two weeks), so it should be determined once before or after the comparison of the weights. The results also show that automating the readings reduced the RS scale division by a factor 4-5. 3 refs.

Afanas'ev, S.N.; Biryuzov, S.V.; Malysheva, T.A.; Pavlov, I.V.; Sidel'nikov, A.I. *Meas Tech* v 29 n 2 Feb 1986 p 88-90.

**092987 EASY-TO-BUILD BALANCE FOR AUTOMATIC MEASUREMENT.** The design and construction of a continuously recording precision balance resistant to varying pressure and temperature conditions and suitable for data acquisition systems is described. A horizontal beam is suspended at both ends by a pair of wires yielding a trapezoidal configuration. The horizontal displacement of the beam due to the difference of a probe mass acting on one beam end compared with a reference mass attached to the other end is tracked by an inductive displacement transducer. The prototype achieved an overall accuracy better than 50 mg in the range 30-50 g at temperatures ranging from 20 to 100°C. The temperature coefficient of the offset was found to be initially 10 mg K<sup>-1</sup> and was reduced to a total residual error of 50 mg over the entire range by temperature compensation. (Edited author abstract) 4 refs.

Spirkl, W. (Univ of Muenchen, Munich, West Ger); Laevemann, E.; Ries, H. *J Phys E* v 20 n 12 Dec 1987 p 1452-1454.

## Process Control

**092988 PROCESS WEIGHT INDICATOR COMMUNICATES ON DATA NETWORK.** Kistler-Morse introduces the 1020 Weight Indicator, which displays the weight of material stored in bins, tanks, silos, and other industrial vessels, on a bright digital readout. An RS422 serial interface allows networking of many indicators with process control computers or management data files. The 1020 is compatible for use with most PCs and serial input printers. Net and gross weight displays, push-button tare, programmable setpoints, isolated current transmitter, and many other advanced features offer tremendous versatility. The rugged NEMA-4 enclosure and unique sensor design ensure years of reliable operation, even in harsh process environments.

Anon. *Bulk Solid Handl* v 8 n 1 Feb 1988 p 63.

Readout Systems See COAL—Sampling.

## Reliability

**092989 DERZEITIGE GENAUIGKEITSGRENZEN BEI 1-KG-KOMPARATORWAAGEN.** [Historical Accuracy Limits of 1 Kg Comparator Scales]. By means of the most accurate prototype balances (beam scales with knife-edges and pans) the quantities influencing the scale, the mass standard and the weighing are described. The resulting requirements for the improvement of the relative standard deviation to  $s_{rel} < 5 \cdot 10^{-10}$  have led to three new developments: balance according to the principle of electrodynamic force compensation; beam scale with flexure strip suspensions; balance according to the hydrostatic weighing principle. The measuring principles are presented and the results hitherto obtained described. (Author abstract) 11 refs.

Kochsiek, M. *PTB Mitt* v 97 n 3 Jun 1987 p 179-186.

## Stability

**092990 STABILITY ANALYSIS OF THE ELECTRONIC BALANCE BY ROOT-LOCUS TECHNIQUE.** In this study a TG 528B damping analysis balance is reformed into an electronic balance with LED digital display. The stability analysis of the electronic balance is conducted by root-locus technique and put into practice with satisfaction. The maximum capacity, sensitivity, linearity and stable time of the electronic balance reaches up to 199.9 g, 0.001 g, 0.05% and 0.5 second, respectively. (Author abstract) In Chinese. 6 refs.

Xu Guohua. *Huadong Huagong Xueyuan Xuebao* v 14 n 1 1988 p 121-126.

## Standards

**092991 PORTABLE AUTOMATED, INEXPENSIVE MASS AND BALANCE CALIBRATION SYSTEM.** Reliable mass measurements are essential for a nuclear production facility or process control laboratory. DOE Order 5630.2 requires that traceable standards be used to calibrate and monitor equipment used for nuclear material measurements. To ensure the reliability of mass measurements and to comply with DOE traceability requirements, a portable, automated mass and balance calibration system is used at the Savannah River Plant. Automation is achieved using an EPSON HX-20 notebook computer, which can be operated via RS232C interfacing to electronic balances or function with manual data entry if computer interfacing is not feasible. This economical, comprehensive, user-friendly system has three main functions in a mass measurement control program (MMCP): balance certification, calibration of mass standards, and daily measurement of traceable standards. The balance certification program tests for accuracy, precision, sensitivity, linearity, and cornerloading versus specific requirements. The mass calibration program allows rapid calibration of inexpensive mass standards traceable to certified Class S standards. (Edited author abstract)

Maxwell, S.L. III (DuPont, Aiken, SC, USA); Clark, J.P. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 670-677.

## Weigh Stations

**092992 NEW WEIGHING CONCEPT ENABLES ACCURATE INVENTORY CONTROL IN CONTINUOUS MATERIAL THROUGHPUT APPLICATIONS WITH HIGH ACCURACY STATIC WEIGHING.** A trend in today's marketplace is to use high accuracy static scale systems in continuous material flow operations. This trend is due to an increased awareness and understanding of the economic advantages of using systems which provide high weighing accuracy. Front end costs are substantially higher than such systems as conveyor belt scales, but many operations are looking further ahead in their weighing systems selection than the initial system cost. System paybacks and return on investment concerns have proven that the economic advantages of static weighing systems may well be justifiable. Again, the main concern in weighing a product with the highest degree of accuracy is not just to know how much material came into or went out of an operation, but to obtain the greatest control. Gaining this control of product gives you the control of your money. (Edited author abstract)

Freeman, James R. (Kanawha Scales & Systems, Poca, WV, USA). *Bulk Solid Handl* v 8 n 1 Feb 1988 p 49-51.

## SCANDIUM AND ALLOYS

### Analysis

**092993 STUDY ON THE DETERMINATION OF RE IN SCANDIUM OXIDE USING THE DUAL-SYSTEM AND DOUBLE-WAVELENGTH METHOD.** The dual system and double wavelength spectrophotometry has been applied to the determination of RE impurities in scandium oxide. The procedure is accomplished as follows: Select 682 nm, the absorbance maximum of RE-CPA-PI absorption spectrum, as the analytical wavelength. Determine 596 nm (or 614.5 nm) on the Sc-CAS absorption spectrum by the isosbestic points method as the reference wavelength. (Edited author abstract) In Chinese. 5 refs.

Lin, Jin-he (Nankai Univ, China); Han, Chao; Shi, Hui-ming. *Xi You Jin Shu* v 6 n 3 Aug 1987 p 217-221.

## Oxidation

**092994 INVESTIGATION OF AIR-GROWN SCANDIUM OXIDE AND EXPERIMENTAL DETERMINATION OF THE INELASTIC MEAN-FREE-PATH IN SCANDIUM AND IN SCANDIUM OXIDE.** The thickness of the passivation layers formed in air on scandium at room temperature was measured by XPS, using the inelastic mean-free-path (IMFP) of the Sc 2p photoelectrons as well as an extrapolation of layer-thickness measurements at oxygen exposures  $\leq 10^6$  L. The IMFP of scandium and scandium oxide was determined experimentally by the 'overlayer' technique. The XPS standard spectra of metallic scandium and of scandium oxide were recorded. The line parameters of the Sc 2p and of the O 1s spectra were determined by a convolution program. (Author abstract) 20 refs.

Reichl, R. (Univ of Tuebingen, West Ger); Gaukler, K.H. *Appl Surf Sci* (1985) v 31 n 4 May 1988 p 460-470.

**092995 STUDIES OF THE OXIDATION OF SCANDIUM AND YTTRIUM USING THERMOGRAVIMETRY AND ELLIPSOmetry.** High-temperature air oxidation of powder and compact specimens of Y and Sc was studied. Values of the effective activation energy of the oxidation process were measured. It is shown that the kinetic curves for Y oxidation under isothermal conditions have an inflection related to oxygen dissolution in the metal matrix. 11 refs.

Shevchenko, V.G.; Akashev, L.A.; Konoenko, V.I. *Russ Metall Met* n 5 1987 p 69-72.

## Photochemical Reactions

**092996 STUDY OF THE EFFECT OF SOLVATION, MIXED MICELLA AND NEGATIVE ION ON THE COLOUR REACTION OF Sc-CAS SYSTEM.** In this paper the effect of solvation, mixed micella and negative ion on the colour reaction of the Sc-CAS-CTMAB system has been investigated. Experimental results show that the addition of ethyl alcohol, emulsifier OP or negative nitrogen ion has a similar effect on photochemical properties. These additions speed up the reaction rate, improve operating conditions and enlarge the workable range of pH values. The authors also determined the effect of more than twenty materials on the microanalysis of Sc. (Edited author abstract) 12 refs. In Chinese.

Zhang Gui-zhu (Nankai Univ, China); Shi Hui-ming. *Xi You Jin Shu* v 5 n 2 May 1986 p 114-121.

## Processing

**092997 INVESTIGATIONS IN THE SCANDIUM-NITROGEN SYSTEM.** Single-phase samples of  $\delta$ -ScN<sub>1-x</sub> and two-phase Sc/ScN alloys were prepared by direct nitridation of Sc metal and by arc-melting of ScN + Sc, respectively. The lattice parameters of  $\delta$ -ScN<sub>1-x</sub> prepared at 1370-1770 K were measured. Microprobe Sc profiles across diffusion layers of  $\delta$ -ScN<sub>1-x</sub> on Sc metal prepared at 1380 and 1770 K indicate that in this temperature range ScN<sub>1-x</sub> has a homogeneity range of ScN<sub>0.87</sub>-ScN<sub>1.00</sub>. In the diffusion 1 the dark blue color of ScN on the nitrogen-rich surface takes on a clearly visible violet tinge near the Sc/ScN boundary. Nitridation of solid Sc metal results in a porous or hollow nitride sample. This is probably due to the preferential diffusion of Sc<sup>3+</sup> ions through the originally formed ScN layer. (Edited author abstract). 9 refs.



Lengauer, Walter (Technical Univ of Vienna, Vienna, Austria). *J Solid State Chem* v 76 n 2 Oct 1988 p 412-415.

## Solvent Extraction

**092998 SOLVENT EXTRACTION OF SCANDIUM FROM WOLFRAMITE RESIDUE.** The particular properties of scandium make it an attractive candidate for recovery by solvent extraction - one of the most important processes in hydrometallurgy for the separation, purification and concentration of metal ions. Toward this end, an acid leaching and solvent extraction system has been developed and optimized to extract scandium from wolframite residue. With the technique, the scandium oxide content in the resultant scandium hydroxide can reach 70-78 percent. Further, the concentration coefficient and total recovery of scandium oxide from the residue to the product has amounted to  $(1.9-3.9) \times 10^3$  and 76-89 percent, respectively. (Edited author abstract). 4 refs.

Gongyi, Guo; Yuli, Chen; Yu, Li. *J Met* v 40 n 7 Jul 1988 p 28-31.

## Specific Heat

**092999 SPECIFIC HEAT MEASUREMENTS IN SCANDIUM-RARE EARTH ANISOTROPIC SPIN GLASSES.** We report on specific heat measurements at low temperatures of the anisotropic spin glass alloys ScDy 3 at%, ScEr 4.25 at% and ScEr 10 at%. We find that at the lowest temperature range the data indicate the occurrence of an anisotropy induced gap around zero frequency in the density of states of the magnetic excitations. Moreover, some of our specific heat curves present a maximum coinciding with  $T_g$ , raising thus the question of thermal signs for a spin glass phase transition in anisotropic systems. (Author abstract) 21 refs.

Pureur, P. (UFRGS, Porto Alegre, Brazil); Fraga, G.L.; Brandao, D.E.; Caudron, R.; Safa, H.; Nieva, G. *J Magn Magn Mater* v 68 n 2 Aug 2 1987 p 213-217.

**Spectroscopic Analysis** See RARE EARTH ELEMENTS—Spectroscopic Analysis.

## SCANDIUM COMPOUNDS

### Physical Properties

**093000 INTERBAND TRANSITIONS IN ScPd<sub>3</sub> AND YPd<sub>3</sub>.** A theoretical ab-initio study of optical properties of ScPd<sub>3</sub> and YPd<sub>3</sub> is presented. Agreement with experimental data for YPd<sub>3</sub> in the high energy range is excellent. In the low energy range a sharp narrow peak in YPd<sub>3</sub> is obtained which is not observed experimentally due to Drude's correction. In the case of ScPd<sub>3</sub> this low energy is shifted somewhat towards higher energy and it is very intense, hence more probable to be observed. (Edited author abstract) 12 refs.

Alouani, M. (Max-Planck-Institut fuer Festkoerperforschung, Stuttgart, West Ger); Koenig, C.; Khan, M.A. *Solid State Commun* v 65 n 5 Feb 1988 p 327-330.

**SCANDIUM TANTALUM ALLOYS** See NITRIDES—Structure.

## SCANDIUM TUNGSTEN ALLOYS

### Phase Diagrams

**093001 RARE EARTH - TUNGSTEN SYSTEMS.** The review is the result of a literature search through 1985. The systems covered include alloys of tungsten with scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium. Crystal structure, lattice parameters, thermodynamic properties and solubility are also given. 21 Refs.

Pandian, S. (Defence Metallurgical Research Lab, Hyderabad, India); Naidu, S.V. Nagender; Rao, P. Rama. *J Alloy Phase Diagrams* v 4 n 2 May 1988 p 73-116.

**SCHEDULING** See Also ARTIFICIAL INTELLIGENCE—Expert Systems; CHEMICAL PLANTS—Production Control; COMPUTER OPERATING SYSTEMS—Program Processors; COMPUTER PROGRAMMING—Algorithms; COMPUTER SYSTEMS, DIGITAL—Multiprocessing; COMPUTER SYSTEMS, DIGITAL—Parallel Processing; CONSTRUCTION INDUSTRY—Costs; CONSTRUCTION INDUSTRY—Management; DATABASE SYSTEMS; ELECTRIC POWER SYSTEMS—Interconnection; ENGINEERING—Project Management; ENGINEERING RESEARCH—Planning; INFORMATION SCIENCE—Information Retrieval; INVENTORY CONTROL—Mathematical Models; MANAGEMENT SCIENCE; MATHEMATICAL PROGRAMMING, DYNAMIC; MATHEMATICAL PROGRAMMING, LINEAR; OPERATIONS RESEARCH; PRODUCTION CONTROL; PRODUCTION CONTROL—Computer Applications; PRODUCTION ENGINEERING—Management.

**093002 ROUTING AND SCHEDULING OF WARDENS FOR PUBLIC CAR PARK INSPECTION.** This paper presents a case study on the inspection operations of public car parks which employ a 'coupon parking' system with checking by wardens. The problem is to determine an optimal staffing level for the wardens as well as an optimal schedule for their deployment. A framework is laid out in the paper for modeling the car park inspection policy, and some heuristic procedures are developed for the determination of number of wardens required in a zone. The proposed model has been tested against some field data, leading to results that provide a more rational and systematic basis for the scheduling of inspection operations. (Author abstract) 4 refs.

Ong, H.L. (Natl Univ of Singapore, Singapore); Goh, T.N. *Comput Ind Eng* v 12 n 4 1987 p 239-248.

**093003 FINITE SCHEDULING: IT WORKS IF... SCHEDULING JOBS AND MACHINES TO MEET CUSTOMER DELIVERY DATES IS MORE SCIENCE THAN ART AND IS PRONE TO FAILURE.** Computer-based scheduling systems are only marginally successful. There are many reasons why some finite-scheduling approaches have not worked in make-to-order job-shop manufacturing operations. One primary reason is because it lacks a machine-job sequencing function. Sequencing places operations on machines in a chronological time-sequence, along with the operations from thousands of other jobs competing for the same machine resources. Not only is it necessary to come up with a sequence for each machine, but those sequences must be coordinated so that operations from each job can move feasibly from one machine to another, and, at the same time, be sure that the jobs are completed by their respective due dates or delivery schedules.

Connor, Jon L. (Heuristica Corp, Seattle, WA, USA). *Manuf Syst* v 5 n 8 Aug 1987 p 39-40.

**093004 MULTI-JOB CYCLIC SCHEDULING FOR AN AUTOMATED FLOW-TYPE MANUFACTURING SYSTEM (RELATIONSHIP BETWEEN JOB OUTPUT INTERVAL AND BUFFER CAPACITY).** A multi-job cyclic scheduling problem for an automated flow-type manufacturing system was analyzed. Flow of jobs in the system was represented as a network. Using the network representation, the job output interval in a steady state was obtained. In the cyclic scheduling problem, an optimum schedule is a non-idle schedule, where a bottleneck machine produces jobs without idle time in a steady state. A lower bound on the buffer capacity and a scheduling method were obtained to construct a non-idle schedule. (Author abstract) In Japanese. 7 refs.

Yura, Kenji. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 493 Sep 1987 p 2054-2059.

**093005 OPTIMAL TOTAL-WORK-CONTENT-POWER DUE-DATE DETERMINATION AND SEQUENCING.** This paper considers sequencing of  $n$  jobs on a single machine. The total-work-content-power (TWK-P) due-date assignment method is used to assign due-dates to jobs. The objective is to determine the optimal due-date multiple factor so as to minimize a cost function based on the due-date multiple and job earliness, and tardiness values. A linear programming (LP) formulation of the problem is proposed and the optimal solution is determined via considering the LP dual problem.

Cheng, T.C.E. (Univ of Manitoba, Winnipeg, Manit, Can). *Comput Math Appl* v 14 n 8 1987 p 579-582.

**093006 EVALUATING PROJECT SCHEDULING AND DUE DATE ASSIGNMENT PROCEDURES: AN EXPERIMENTAL ANALYSIS.** This study presents a number of important results for managers interested in scheduling projects and setting due dates. First, using more information concerning the current work in progress, available resources, and activity precedent relationships provides a better due date estimate for a new project. Second, a finite scheduling procedure (called SFT) consistently gives better due date estimates than simpler aggregate procedures. Third, when some project due dates are set externally, due date performance deteriorates. Fourth, the effort, measured by CPU time, for SFT to estimate a good due date depends upon the ratio of activity resources required to total resources available, rather than the number of activities across all projects. And fifth, similarities and differences between the results observed in this study and past due date job shop scheduling research are reviewed. (Edited author abstract) 30 refs.

Dumond, John (US Air Force Inst of Technology, Wright-Patterson AFB, Dayton, OH, USA); Mabert, Vincent A. *Manage Sci* v 34 n 1 Jan 1988 p 101-118.

**093007 SUITABILITY OF THE WEIGHTED  $l_p$ -NORM IN ESTIMATING ACTUAL ROAD DISTANCES.** This paper evaluates whether, on the basis of easy-to-obtain data characterizing the road network of a particular area, one can predict the extent of the improvement in estimate accuracy. Such an ability to predetermine estimate accuracy would help researchers decide when to use the expensive  $l_p$ -norm. The investigation shows, however, that no such relationship can be proven. The extent of the improvement in estimate accuracy offered by the weighted  $l_p$ -norm cannot be predicted. (Edited author abstract) 12 refs.

Berens, Wolfgang (Univ Muenster, Muenster, West Ger). *Eur J Oper Res* v 34 n 1 Feb 1988 p 39-43.

**093008 TWO-MACHINE FLOW SHOP SCHEDULING PROBLEM WITH CONTROLLABLE JOB PROCESSING TIMES.** The paper deals with a two-machine flow shop scheduling problem in which both the sequence of jobs and their processing times are decision variables. It is assumed that the cost of performing a job is a linear function of its processing time, and the schedule cost to be minimized is the total processing cost plus maximum completion time cost. It is shown that the decision form of this problem is NP-complete, even when the processing times on one machine only are controllable and all the processing cost units are identical. Two heuristic methods for solving the problem are proposed and their worst-case analysis is presented. (Author abstract) 8 refs.

Nowicki, Eugeniusz (Technical Univ of Wroclaw, Wroclaw, Pol); Zdrzalka, Stanislaw. *Eur J Oper Res* v 34 n 2 Mar 1988 p 208-220.

**093009 SINGLE MACHINE SCHEDULING TO MINIMIZE WEIGHTED EARLINES SUBJECT TO NO TARDY JOBS.** This paper considers the single machine scheduling problem where the objective is to minimize the total weighted earliness subject to no tardy jobs. Known results for a well researched single machine scheduling problem where the objective is to minimize the weighted completion time subject to no tardy jobs have been used in analyzing this problem. Several important results are proved and both exact and approximate methods are developed to solve this problem. (Author abstract) 10 refs.

Chand, Suresh (Purdue Univ, West Lafayette, IN, USA); Schneeberger, Hans. *Eur J Oper Res* v 34 n 2 Mar 1988 p 221-230.



**093010 HEURISTIC SCHEDULING POLICY FOR MULTI-ITEM, SINGLE-MACHINE PRODUCTION SYSTEMS WITH TIME-VARYING, STOCHASTIC DEMANDS.** A heuristic scheduling policy is introduced for multi-item, single-machine production systems facing stochastic, time-varying demands. The policy, which we term the dynamic cycle lengths heuristic, integrates feedback control based on the monitoring of inventory levels with the maintenance of economic production cycles. The policy is applied time period by time period to make decisions concerning which items to produce in what quantities during the next time period. (Edited author abstract) 17 refs.

Leachman, Robert C. (Univ of California, Berkeley, CA, USA); Gascon, Andre. *Manage Sci* v 34 n 3 Mar 1988 p 377-390.

**093011 SHIFTING BOTTLENECK PROCEDURE FOR JOB SHOP SCHEDULING.** We describe an approximation method for solving the minimum makespan problem of job shop scheduling. It sequences the machines one by one, successively, taking each time the machine identified as a bottleneck among the machines not yet sequenced. Every time after a new machine is sequenced, all previously established sequences are locally reoptimized. Both the bottleneck identification and the local reoptimization procedures are based on repeatedly solving certain one-machine scheduling problems. Besides this straight version of the Shifting Bottleneck Procedure, we have also implemented a version that applies the procedure to the nodes of a partial search tree. Computational testing shows that our approach yields consistently better results than other procedures discussed in the literature. (Edited author abstract) 13 refs.

Adams, Joseph (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Balas, Egon; Zawack, Daniel. *Manage Sci* v 34 n 3 Mar 1988 p 391-401.

**093012 SIMULATION STUDY OF JOB SHOP SCHEDULING WITH DUE DATES.** This paper presents a study of a hypothetical job shop by computer simulation. The purpose is to investigate the main and interaction effects of three shop decision variables: (a) the job dispatching rule, (b) the due-date assignment method, and (c) the shopload ratio, on a shop performance measure defined as the percentage of jobs late. The multiple regression analysis technique is employed to estimate the functional relationship between the performance measure and shop decision variables. Two potential applications of the regression model are explored and discussed. (Author abstract) 10 refs.

Cheng, T.C.E. (Univ of Manitoba, Winnipeg, Manit, Can). *Int J Syst Sci* v 19 n 3 Mar 1988 p 383-390.

**093013 PROJECT SCHEDULING WITH MULTIPLE, DOUBLY CONSTRAINED RESOURCES.** This paper deals with a project scheduling problem in which project activities can be divided into mutually disjoint subsets of those activities which require the same resource. Mathematical models of activities are given in the form of performing speed - resource amount functions and binary conditions imposed on initial and final states of activities. The problem of finding optimal resource allocation is stated as an optimal control problem and then transformed into nonlinear programming problem, for which we propose a special computational procedure based on Wolfe's generalized linear programming method. We also present necessary and sufficient conditions for the existence of an optimal resource allocation. (Edited author abstract) 15 refs.

Nowicki, Eugeniusz; Zdrzalka, Stanislaw. *Arch Automat Telemek* v 32 n 1-2 1987 p 63-78.

**093014 ON THE INTEGER PROPERTIES OF SCHEDULING SET PARTITIONING MODELS.** The approach discussed in this paper not only reduces the size of the feasible region by reducing the number of valid variables, but also lessens the potential for fractionality. We impose additional problem structure not already implicit in the mathematical model. This structure ensures

that many of the basic feasible solutions of the reduced LP are integer, or near-integer in the sense that fractional values can easily be resolved. In this paper, we discuss the theoretical basis for the natural integer properties of the reduced set partitioning linear program. 24 refs.

Ryan, D.M. (Univ of Auckland, Auckland, NZ); Falkner, J.C. *Eur J Oper Res* v 35 n 3 Jun 1988 p 442-456.

**093015 ONE-PROCESSOR SCHEDULING WITH SYMMETRIC EARLINESS AND TARDINESS PENALTIES.** We consider one-processor scheduling problems having the following form: Tasks  $T_1, T_2, \dots, T_N$  are given, with each  $T_i$  having a specified length  $l_i$  and a preferred starting time  $a_i$  (or, equivalently, a preferred completion time  $b_i$ ). The tasks are to be scheduled nonpreemptively (i.e., a task cannot be split) on a single processor to begin as close to their preferred starting times as possible. We examine two different cost measures for such schedules. For the first of these, we show that the problem of finding minimum cost schedules is NP-complete; however, we give an efficient algorithm that finds minimum cost schedules whenever the tasks either all have the same length or are required to be executed in a given fixed sequence. For the second cost measure, we give an efficient algorithm that finds minimum cost schedules in general, with no constraints on the ordering or lengths of the task. (Edited author abstract) 12 refs.

Garey, Michael R. (AT&T Bell Lab); Tarjan, Robert E.; Wilfong, Gordon T. *Math Oper Res* v 13 n 2 May 1988 p 330-348.

**093016 MORE EFFICIENT FORMULATION OF THE SINGLE MACHINE, STATIC DEMAND, LOT SCHEDULING PROBLEM.** The classical assumptions of the economic lot scheduling problem have two main drawbacks. They lead to false cost calculations and the solutions developed under them are often difficult to implement. In this paper, more realistic assumptions are suggested and it is shown that these new assumptions allow a more efficient formulation of the problem. The characteristics of this formulation are studied and it is shown that, for a given production sequence, the model reduces to a continuous linear program with a totally unimodular constraint matrix. (Author abstract) 9 refs.

Boctor, Fayez Fouad (Univ Laval, Que, Can). *Eng Costs Prod Econ* v 14 n 1 May 1988 p 3-10.

**093017 MULTI-PRODUCT FLOWSHOP SCHEDULING WITH ORDERED PROCESSING TIMES.** The problem of scheduling  $n$  jobs on  $m$  machines has received considerable research attention over the last 30 years or so. As a result, several optimization and heuristic algorithms are now available. This paper presents a single-pass heuristic scheduling procedure, to yield optimum solution, when the processing times of the jobs are ordered. (Author abstract) 6 refs.

Mishra, R.C. (Univ of Roorkee, Roorkee, India); Pandey, P.C.; Gaindhar, J.L. *Comput Ind Eng* v 14 n 3 1988 p 361-364.

**093018 OPTIMAL CONSTANT DUE-DATE ASSIGNMENT AND SEQUENCING.** The paper considers the sequencing of  $n$  jobs in a single-machine shop in which each job is assigned a constant flow allowance. The objective is to determine the optimal value of the flow allowance and the optimal job sequence to minimize a cost function based on the flow allowance and the job earliness and tardiness values. We first propose a linear programming (LP) formulation of the problem. We then derive that it is independent of the job sequence. After the theoretical treatment, a numerical example is presented for discussion. (Author abstract). 9 Refs.

Cheng, T.C.E. (Univ of Manitoba, Winnipeg, Manit, Can). *Int J Syst Sci* v 19 n 7 Jul 1988 p 1351-1354.

**093019 ONE-PROCESSOR SCHEDULING WITH SYMMETRIC EARLINESS AND TARDINESS PENALTIES.** We consider one-processor scheduling problems having the following form: Tasks  $T_1, T_2, \dots, T_N$  are given, with each  $T_i$  having a specified length  $l_i$  and a preferred

starting time  $a_i$  (or, equivalently, a preferred completion time  $b_i$ ). The tasks are to be scheduled nonpreemptively (i.e., a task cannot be split) on a single processor to begin as close to their preferred starting times as possible. The authors examine two different cost measures for such schedules, the sum of the absolute discrepancies from the preferred starting times and the maximum such discrepancy. (Edited author abstract). 12 Refs.

Garey, Michael R. (Princeton Univ, Princeton, NJ, USA); Tarjan, Robert E.; Wilfong, Gordon T. *Math Oper Res* v 13 n 2 May 1988 p 330-348.

**093020 TOWARDS THE STANDARDIZATION OF PERFORMANCE MEASURES FOR PROJECT SCHEDULING HEURISTICS.** Performance measures that can be used to compare project-scheduling heuristics are presented. Quantitative measures relative to the project duration are proposed for the diagnostic analysis of activity-sequencing heuristics in PERT networks with precedence and resource constraints. The aim is to establish a basis for the standardization of performance measures for the heuristics. A project analyst can use the evaluation techniques presented in deciding which of the many available scheduling heuristics is most appropriate for a given project scenario. A comparative experiment indicates that heuristics perform almost equally well for small projects, while their performances vary considerably for large projects. Thus, small projects with mediocre complexity are not accurate performance-measurement agents for scheduling heuristics. 27 refs.

Badiru, Adedeji B. (Univ of Oklahoma, Norman, OK, USA). *IEEE Trans Eng Manage* v 35 n 2 May 1988 p 82-89.

**093021 INORGA SCHEDULING SYSTEM.** Many systems have been developed for the scheduling of piece and small batch production, one of them at Inorga Institute in Prague. This system consists of three relatively independent levels, each of which can be used separately. The orders for final products are planned in Rough Scheduling, which represents the highest level in our scheduling hierarchy. The most important condition for a feasible schedule is to accept all due-dates, the optimality criterion is to minimize differences between capacity needs and requirements for all products, capacities and time periods. A similar approach is used for the lower scheduling level, i.e. for Fine Scheduling. Batches of parts are planned here for groups of machines on workshop levels. The lowest scheduling level, Dynamic Rescheduling, is concerned with single machines and single operations. (Edited author abstract) 3 refs.

Safka, Zdenek (Inorga Inst, Prague, Czech). *Eng Costs Prod Econ* v 12 n 1-4 Jul 1987, Proc of the Fourth Int Work Semin on Prod Econ, Innsbruck, Austria, Feb 17-21 1986 p 137-142.

**Computer Applications** See Also ARTIFICIAL INTELLIGENCE—Expert Systems; COMPUTER AIDED DESIGN; CONSTRUCTION INDUSTRY—Scheduling; DATA PROCESSING—Critical Path Analysis; MACHINE SHOP PRACTICE—Scheduling; PRODUCTION CONTROL—Computer Applications; PRODUCTION CONTROL—Scheduling; TRANSPORTATION—Operations Research.

**093022 SIMPLE AND INTEGRATED HEURISTIC ALGORITHMS FOR SCHEDULING TASKS WITH TIME AND RESOURCE CONSTRAINTS.** We consider the problem of scheduling a set of  $n$  tasks in a system having  $r$  resources. Each task has an arbitrary, but known, processing time and a deadline, and may request use of a number of resources. A resource can be used either in shared mode or exclusive mode. In this article, we study algorithms used for determining whether or not a set of tasks is schedulable in such a system, and if so, determining a schedule for it. This scheduling problem is known to be NP-complete and hence we methodically study a set of heuristics that can be used by such an algorithm. Due to the complexity of the problem, simple heuristics do not perform satisfactorily. However, an algorithm that uses



combinations of these simple heuristics works very well compared to an optimal algorithm that takes exponential time complexity. For the combination that performs the best, we also determine the scheduling costs as a function of the size of the task set scheduled. (Author abstract) 14 refs.

Zhao, Wei (Univ of Massachusetts, Amherst, MA); Ramamritham, Kriithi. *J Syst Software* v 7 n 3 Sep 1987 p 195-205.

**093023 EXPERT SCHEDULING SYSTEMS: SURVEY AND PRELIMINARY DESIGN CONCEPTS.** This paper addresses expert systems used for scheduling problems. It focuses first on a survey of NASA-related and other expert systems for scheduling. Then a case study of developing scheduling requests of NASA Goddard principal investigators (i.e., satellite experimenters) is presented. Components of this scheduling domain are discussed, and then suggestions for requirements and preliminary design concepts for a generalized expert system scheduler are explained. (Author abstract) 27 refs.

Liebowitz, Jay (George Washington Univ, Washington, DC, USA); Lightfoot, Patricia. *Appl Artif Intell* v 1 n 3 1987 p 261-283.

**093024 COMPUTERIZED SHOP FLOOR SCHEDULING.** Computerized shop floor scheduling is probably one of the most glaring examples of an area in which the tremendous efforts and investments of a large number of companies have produced at best only a partial solution. One of the more successful attempts is known as OPT<sup>®</sup> (optimized production technology). This article describes its evolutionary process from basically a computerized Kanban to an attempted computerization of the Drum-Buffer-Rope technique. The major emphasis will be on the reasoning - gained from the experience of implementing this package - that brought this evolution so quickly to its ultimate conclusion. The real key lies mainly in the conceptual framework under which we run our organizations. (Edited author abstract) 11 refs.

Goldratt, Eliyahu M. (Avraham Y. Goldratt Inst, New Haven, CT, USA). *Int J Prod Res* v 26 n 3 Mar 1988 p 443-455.

**093025 LOOKAHEAD HEURISTIC FOR MULTI-ITEM SINGLE MACHINE PRODUCTION SCHEDULING WITH DYNAMIC, STOCHASTIC DEMANDS.** This paper presents a simple heuristic for scheduling the production of many items on a single machine when demands are both dynamic and stochastic. The heuristic is based on (s,S) type policies and relies principally on simulations of the upcoming production days (the Lookahead function) to decide if the production facility should be shut down or not on a given working shift. Comparative simulation test results show that, under varying production conditions, the Lookahead heuristic provides low total inventory and changeover costs while maintaining high service level. (Author abstract) 13 refs.

Gascon, Andre (Univ Laval, Que, Can). *Infor* v 26 n May 1988 p 114-126.

**Computer Simulation** See MOTOR BUS TRANSPORTATION—Route Analysis; PRODUCTION CONTROL—Scheduling.

**Management** See Also ENGINEERING—Project Management.

**093026 EXPERT SYSTEM APPROACH AND THE FLEXIBILITY-COMPLEXITY PROBLEM IN SCHEDULING PRODUCTION SYSTEMS.** Operations research (OR) is in an excellent position to take advantage of the new techniques provided by expert systems technology to tackle the complex production scheduling problems arising in actual flexible production systems. The description of two real life projects will point out these similarities and show that this flexibility-complexity problem can be mastered by a pragmatic OR-approach, advantageously enforced and enlarged by expert system (ES)-techniques. 8 refs.

Muller-(Malek), H. (Rijksuniversiteit te Gent, Ghent, Belg); De Samblancx, S.; Matthys, D. *Int J Prod Res* v 25 n 11 Nov 1987 p 1659-1670.

**093027 THROUGHPUT TIME CONTROL.** Accelerating rates of change in product design and process technologies, coupled with more rapid market fluctuations and shorter product life cycles have spelled doom for many manufacturing companies unable to react promptly. A principal fallacy limiting the success of many companies, even those with fine modern computer-based planning and control systems, has been the strong belief that such systems can work well with any lead times. This paper presents the beneficial effects of better control (meaning reduction) of throughput times in all phases of planning, execution and control of manufacturing and shows how well-run companies are achieving such reductions. (Edited author abstract)

Plossl, G.W. (G.W. Plossl & Co, Marietta, GA, USA). *Int J Prod Res* v 26 n 3 Mar 1988 p 493-499.

**093028 EXPERIMENTAL STUDY OF HUMAN DECISION-MAKING IN COMPUTER-BASED SCHEDULING OF FLEXIBLE MANUFACTURING SYSTEM.** This paper describes a study which explores human decision-making abilities in scheduling and dispatching decisions using a real-time interactive computer-simulation based system. The experimental results demonstrate that human decision-making is superior to general dispatching rules. An explanation of these results and an analysis of subjects' behavior is presented in the light of information obtained from verbal protocol data. (Author abstract) 12 refs.

Nakamura, Nobuto (Hiroshima Univ, Higashi-Hiroshima, Jpn); Salvendy, Gavriel. *Int J Prod Res* v 26 n 4 Apr 1988 p 567-583.

**Mathematical Models** See Also ACCIDENT PREVENTION—Management; AIR TRANSPORTATION—Scheduling; DECISION THEORY AND ANALYSIS; INVENTORY CONTROL—Scheduling; IRON AND STEEL PLANTS—Scheduling; MOTOR BUS TRANSPORTATION—Route Analysis; MOTOR BUS TRANSPORTATION—Scheduling; PERSONNEL—Scheduling; PROBABILITY—Queueing Theory; TRANSPORTATION—Route Analysis; TRANSPORTATION—Scheduling.

**093029 SIMULATION OF SCHEDULING RULES HELPS DECISION-MAKING ON VARIOUS OBJECTIVES IN MANUFACTURING PLANT.** A company embarked upon a major computerization project called the Plant Loading System (PLS). This system linked most major functions from order entry and plant scheduling to bill of landings and invoicing. This was done through a series of separate but inter-related modules using a common data base. The question of which optimal decision rule to use in scheduling is addressed. A simulation model which could be run in house to establish the effectiveness of various decision rules.

Siegel, S.L. (Teledyne Allvac, Monroe, NC, USA). *Ind Eng* v 19 n 10 Oct 1987 p 40-44, 46.

**093030 SCHEDULING TASKS WITH DUE DATES IN A FABRICATION/ASSEMBLY PROCESS.** In fabrication and assembly processes, end-product due dates play a significant role in scheduling tasks to minimize earliness and lateness penalties. We develop a heuristic technique for this problem that solves a sequence of maximum flow problems to identify improved schedules. This method compares favorably with finite loading, another scheduling heuristic. Our computational results include the solution of a problem involving 26,100 tasks scheduled on 52 work centers. (Author abstract) 25 refs.

Faaland, Bruce (Univ of Washington, Seattle, WA, USA); Schmitt, Tom. *Oper Res* v 35 n 3 May-Jun 1987 p 378-388.

**093031 NOTE ON THE WEIGHTED TARDINESS PROBLEM.** We identify a condition characterizing adjacent jobs in an optimal sequence for the weighted tardiness problem. This condition can be used as an effective pruning device in enumerative methods. Further,

we show that the Modified Due Date Rule is a special case of this condition. We identify a set of circumstances under which the first job in an optimal sequence can be determined without fully solving the problem. (Edited author abstract) 8 refs.

Rachamadugu, Ram Mohan V. (Univ of Michigan, Ann Arbor, MI, USA). *Oper Res* v 35 n 3 May-Jun 1987 p 450-452.

**093032 MULTIOBJECTIVE, MULTI-LEVEL HEURISTIC FOR DYNAMIC RESOURCE CONSTRAINED SCHEDULING PROBLEMS.** The Resource Constrained Scheduling Problem (RCSP) as it is often referred to, is known to be NP-complete which necessitates the creation of heuristics. In this paper, a multi-level, multi-priority schema is presented which enables the user to deal with static environments but places special emphasis on quasi-dynamic scheduling environments. The polynomial time and space complexity of the heuristic together with the computational experience demonstrate the effectiveness of the quasi-dynamic heuristic. (Edited author abstract) 22 refs.

Norbis, Mario I. (Univ of Massachusetts, Amherst, MA, USA); MacGregor Smith, J. *Eur J Oper Res* v 33 n 1 Jan 1988 p 30-41.

**093033 ON THE SUPERIORITY OF A BACKWARD APPROACH IN LIST SCHEDULING ALGORITHMS FOR MULTI-MACHINE MAKESPAN PROBLEMS.** List scheduling algorithms are commonly used for the makespan problems of job shops and of identical processors with precedence constraints. These algorithms list operations in some order and then assign them in this order to the machines as they become available. Existing list scheduling algorithms schedule the operations forward. We suggest and test a backward approach, in which the operations are scheduled backward. When the precedence constraints are in-tree like, i.e., when each operation has at most one immediate successor, the backward approach gives better solutions than the forward approach. (Edited author abstract) 16 refs.

Kim, Yeong-Dae (Univ of Michigan, Ann Arbor, MI, USA). *Int J Prod Res* v 25 n 12 Dec 1987 p 1751-1759.

**093034 EFFECTS OF SETUP TIME ON OUTPUT CAPACITY IN CELLULAR MANUFACTURING.** When the average setup time is shorter, machines are available for processing relatively more time, leading to an increase in shop output capacity. In this simulation experiment, setup times are lowered, both by implementation family grouping and through the use of a sequence dependent setup time based scheduling procedure. The results clearly showed that reduced setup times led to greater output capacity. The higher input rate in the models with increased capacity, however, had a detrimental effect on many other performance variables in the shop. Some of this detrimental effect was alleviated by the use of a scheduling procedure which was designed to capitalize on the sequence dependent nature of setup times. (Edited author abstract) 28 refs.

Flynn, Barbara B. (Iowa State Univ, Ames, IA, USA). *Int J Prod Res* v 25 n 12 Dec 1987 p 1761-1772.

**093035 MINIMIZING WEIGHTED ABSOLUTE DEVIATION IN SINGLE MACHINE SCHEDULING.** This paper presents a procedure to minimize the total penalty when jobs are scheduled on a single machine subject to earliness and tardiness penalties. This performance criterion has been shown to be non-regular thus, requiring a search among schedules with inserted machine idle time to find a solution. A procedure to optimally insert idle time is also presented. (Author abstract) 12 refs.

Fry, Timothy D. (Univ of South Carolina, USA); Armstrong, Ronald D.; Blackstone, John H. *IIE Trans* v 19 n 4 Dec 1987 p 445-450.



**093036 FILTERED BEAM SEARCH IN SCHEDULING.** The technique involves systematically developing a small number of solutions in parallel so as to attempt to maximize the probability of finding a good solution with minimal search effort. We systematically study the performance behavior of beam search with other heuristic methods for scheduling, and the effects of using different evaluation functions to guide the search. We also develop a new variation of beam search, called filtered beam search which is computationally simple yet produces high quality solutions. (Edited author abstract) 26 refs.

Ow, Peng Si (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Morton, Thomas E. *Int J Prod Res* v 26 n 1 Jan 1988 p 35-62.

**093037 ECONOMIC LOT-SCHEDULING PROBLEM: ACHIEVING FEASIBILITY USING TIME-VARYING LOT SIZES.** This paper considers the Economic Lot Scheduling Problem; that is, the problem of scheduling several products on a single facility so as to minimize holding and setup costs. We develop a formulation that provides feasible schedules by allowing the lot sizes and thus the cycle times for each product to vary over time and by explicitly taking into account setup times. Our main results characterize when feasible schedules exist, quantify the insensitivity of the schedules; costs to minor adjustments, and thus show how close the schedules will be to ones with optimal equal cycle times. We also present a heuristic for finding good feasible schedules. (Author abstract) 30 refs.

Dobson, Gregory (Univ of Rochester, Rochester, NY, USA). *Oper Res* v 35 n 5 Sep-Oct 1987 p 764-771.

**093038 QUASI ON-LINE SCHEDULING PROCEDURES FOR FLEXIBLE MANUFACTURING SYSTEMS.** This paper presents three quasi on-line scheduling procedures for flexible manufacturing systems (FMSs) consisting of work stations, transport devices, and operators. In the scheduling, different types of decisions are taken to perform a particular operation, i.e. the selection of a work station, a transport device and an operator. Further, the scheduling sequence of the operations has to be determined. The three developed procedures differ in the way these four decision problems are solved hierarchically. Several dispatching rules (SPT, SPT/TOT, SPT/TOT and EFTA) are available to solve the last mentioned decision problem. The scheduling procedures involve a buffer handling method to avoid deadlock. Based on simulation tests, some conclusions are drawn about the performance of the scheduling procedures and the various dispatching rules. (Edited author abstract) 8 refs.

Slomp, J. (Twente Univ of Technology, Enschede, Neth); Gaalman, G.J.C.; Nawijn, W.M. *Int J Prod Res* v 26 n 4 Apr 1988 p 585-598.

**093039 MODEL FOR LOT SIZING AND SEQUENCING IN PROCESS INDUSTRIES.** This paper presents a mixed integer linear programming model for scheduling production in process industries that embodies the economic trade-offs encompassed in three avenues of research: capacitated lot sizing, flowshop scheduling and sequencing with sequence-dependent setup times. The model is used to schedule production for a problem representative of those found in the food processing industry. The corresponding schedule is then compared with approaches that consider lot sizing and sequencing as independent decisions and it is shown that decomposing the scheduling problem into smaller subproblems can result in the generation of infeasible production schedules. (Edited author abstract) 42 refs.

Smith-Daniels, V.L. (Arizona State Univ, AZ, USA); Ritzman, Larry P. *Int J Prod Res* v 26 n 4 Apr 1988 p 647-674.

**093040 FIXED JOB SCHEDULE PROBLEM WITH SPREAD-TIME CONSTRAINTS.** We consider a generalization of the fixed job schedule problem in which each processor is available only for a prefixed time interval from the release time of the earliest task assigned to it. The

problem can arise in bus driver scheduling. We show that the problem is NP-hard, and introduce polynomial procedures to determine lower bounds, dominance criteria and reductions. We also develop a branch-and-bound algorithm for obtaining the optimal solution of the problem and analyze the algorithm's average performance in a series of computational experiments. Finally, we investigate the preemptive case and other polynomial special cases. (Author abstract) 8 refs.

Fischetti, Matteo (Univ of Bologna, Bologna, Italy); Martello, Silvano; Toth, Paolo. *Oper Res* v 35 n 6 Nov-Dec 1987 p 849-858.

**093041 'LARGEST VARIANCE FIRST' POLICY IN SOME STOCHASTIC SCHEDULING PROBLEMS.** We consider a situation in which  $n$  jobs, requiring random amounts of processing, all with the same mean, are to be scheduled on  $m$  parallel machines with respect to one of two objectives: expected flowtime and expected makespan. We discuss optimality of the rule that says to schedule the jobs with the largest variance first (LVF). We show that for some very simple job length distributions, LVF minimizes both the expected flowtime and the expected makespan. (Author abstract) 10 refs.

Pinedo, Michael (Columbia Univ, New York, NY, USA); Weiss, Gideon. *Oper Res* v 35 n 6 Nov-Dec 1987 p 884-891.

**093042 SCHEDULING INDEPENDENT TASKS WITH DEADLINES ON SEMI-IDENTICAL PROCESSORS.** Given  $m$  semi-identical processors which are parallel processors all working with the same speed but in different time intervals of availability and  $n$  independent tasks with deadlines, the problem of constructing a feasible pre-emptive schedule is examined. We present an  $O(m \log n)$  time algorithm to construct such a schedule whenever one exists. We show that the number of induced pre-emptions is proportional to the total number of processing intervals and deadlines. (Author abstract) 4 refs.

Schmidt, Gunter (Technical Univ of Berlin, West Ger). *J Oper Res Soc* v 39 n 3 Mar 1988 p 271-277.

**093043 PLANNING AND SCHEDULING FOR EPITAXIAL WAFER PRODUCTION FACILITIES.** We propose and test several heuristics for scheduling jobs in a multiproduct parallel reactor (machine) shop with different criteria. We introduce a set of indices to measure the degree of homogeneity in the product set. Based on the results of the computational experiments, we recommend that the choice of the heuristic should be guided by the homogeneity of the product set and the chosen objective criterion. We examine two variants of the planning model and briefly comment on their application to the design and layout of the facility. Since one of the variants of the problem is difficult to solve, we present a method to obtain an approximate solution. We provide bounds on the performance of this approximate solution and demonstrate that it is asymptotically optimal. (Edited author abstract) 19 refs.

Bitran, Gabriel R. (MIT, Cambridge, MA, USA); Tirupati, Devanath. *Oper Res* v 36 n 1 Jan-Feb 1988 p 34-49.

**093044 DYNAMIC PROGRAMMING SOLUTION TO THE DYNAMIC, MULTI-ITEM, SINGLE-MACHINE SCHEDULING PROBLEM.** Our algorithm, which we developed using an approach similar to C.R. Glassey's that minimizes the total number of changeovers, casts the optimal schedule as a shortest path through a network embedded in a state space. It generates optimal schedules under two assumptions. First, we assume that in each time period within the planning horizon, the machine must either be shut down or be producing some one item for the entire time period. Second, we assume that inventory holding costs are representable as a nondecreasing function of aggregate inventory. We provide a number of numerical examples that we solved using the algorithm. (Edited author abstract) 7 refs.

Gascon, Andre (Univ Laval, Que, Can); Leachman,

Robert C. *Oper Res* v 36 n 1 Jan-Feb 1988 p 50-56.

**093045 TWO-STAGE, HYBRID FLOWSHOP SCHEDULING PROBLEM.** This paper describes the two-stage flowshop problem when there are identical multiple machines at each stage, and shows that the problem is NP-complete. An efficient heuristic algorithm is developed for finding an approximate solution of a special case when there is only one machine at stage 2. The effectiveness of the proposed heuristic algorithm in finding a minimum makespan schedule is empirically evaluated and found to increase with the increase in the number of jobs. (Author abstract) 8 refs.

Gupta, Jatinder N.D. (Ball State Univ, IN, USA). *J Oper Res Soc* v 39 n 4 Apr 1988 p 359-364.

**093046 ECONOMIC LOT-SCHEDULING PROBLEM: A SIMPLE APPROACH.** A simple approach that selects good feasible solutions to the economic lot-scheduling problem (ELSP) has been presented. It is based on identifying the smallest subgroup of items to be manufactured in every production cycle. The procedure iterates starting with the first item and enlarging the subgroup of items until the fundamental period so obtained is feasible. The solution obtained satisfies some reasonable properties: the smaller the economic time of an item, the more often it is manufactured; the fundamental period is (almost) equivalent to the economic time of the subgroup of items manufactured every cycle. The subgroup of items manufactured every cycle is the smallest subgroup feasible, once previous properties have been satisfied. 7 refs.

Larraneta, J. (Univ of Seville, Spain); Onieva, L. *J Oper Res Soc* v 39 n 4 Apr 1988 p 373-379.

**093047 GENERAL FLOW-SHOP SCHEDULING WITH RESOURCE CONSTRAINTS.** The paper deals with a version of the general non-permutation flow-shop scheduling problem in which the duration of each operation on certain machines is a linear function of the allotted part of a constrained resource. The objective is to determine both a sequence of the operations on each machine and an allocation of resource to each operation in order to minimize the over-all completion time. The algorithm for solving this problem is based on the disjunctive graph theory and branch and bound technique. Due to the present elimination properties, the search tree is strongly restricted. (Edited author abstract) 9 refs.

Janiak, Adam (Technical Univ of Wroclaw, Wroclaw, Pol). *Int J Prod Res* v 26 n 6 Jun 1988 p 1089-1103.

**093048 EXTENSION OF PALMER'S HEURISTIC FOR THE FLOW SHOP SCHEDULING PROBLEM.** We describe a simple modification of Palmer's heuristic for scheduling jobs in a flow shop. The additional computation required is relatively small. The performance of the algorithm compares very well with that of the more sophisticated and better algorithm of Campbell, et al. (1970) at a fraction of the effort required by the latter. (Edited author abstract) 10 refs.

Hundal, Tejpal S. (Univ of Pittsburgh, Pittsburgh, PA, USA); Rajgopal, Jayant. *Int J Prod Res* v 26 n 6 Jun 1988 p 1119-1124.

**093049 NETWORK SCHEDULING LIMITED BY SPECIAL CONSTRAINT AS A FUNCTION OF TIME COST.** The paper deals with the application of mathematical programming techniques to network analysis and network management in general. The authors show the application of linear programming to network scheduling when the problem is to minimize the total crashing cost and the required completion time is given. Finally the application of goal programming is presented in network scheduling in the case, when all kinds of constraints (time, resource, etc.) are introduced into the problem and the manager has to deal with multiple objectives which may



be in conflict. All kinds of network scheduling problems mentioned are illustrated through a detailed numerical example. (Edited author abstract) 3 refs.

Jandy, G. (Technical Univ, Budapest, Hung); Tanczos, K. *Period Polytech Transp Eng* v 15 n 2 1987 p 111-123.

**093050 IMPROVED BRANCHING SCHEME FOR THE BRANCH AND BOUND PROCEDURE OF SCHEDULING  $n$  JOBS ON  $m$  PARALLEL MACHINES TO MINIMIZE TOTAL WEIGHTED FLOWTIME.** All jobs and machines are assumed to be available at time zero. Machines work on jobs one at a time a pre-emption is not allowed. Setup times are included in the processing times which are sequence-independent, deterministic and known in advance. Some new and simple results are presented which are easy to implement to obtain an efficient branch-and-bound algorithm. A new and improved lower bound is developed which is easy to compute. (Edited author abstract) 14 refs.

Sarin, Subhash C. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Ahn, Seokyo; Bishop, Albert B. *Int J Prod Res* v 26 n 7 Jul 1988 p 1183-1191.

**093051 DISPATCHING IN A MULTISTAGE JOB SHOP WHERE MACHINE CAPACITIES ARE UNBALANCED.** A realistic assumption is one in which machine capacities are not balanced such that one machine can be identified as a bottleneck. In this paper, the performance of selected dispatching rules in an unbalanced multistage job shop is evaluated to determine whether the performance is consistent for jobs which are routed through the bottleneck and for jobs which by-pass the bottleneck. This research identifies which type of sequencing rule performs best in a multistage job shop where capacities are not balanced (i.e. such that one work center can be identified as a 'bottleneck'). (Edited author abstract) 20 refs.

Fry, Timothy D. (Univ of South Carolina, Columbia, SC, USA); Philipoom, Patrick R.; Markland, Robert E. *Int J Prod Res* v 26 n 7 Jul 1988 p 1193-1223.

**093052 NOTE ON LPT SCHEDULING.** A bound is given for the worst case performance of a variant of the longest processing time (LPT) scheduling algorithm for independent jobs on a uniform set of non-identical processors. We show that if the jobs are selected by a processor as it becomes free then the ratio of this finish time to the optimal finish time is bounded by one half the relative speed of the fastest processor. (Edited author abstract) 4 refs.

Morrison, John F. (Towson State Univ, Baltimore, MD, USA). *Oper Res Lett* v 7 n 2 Apr 1988 p 77-79.

**093053 APPROXIMATIONS FOR THE TIME SPENT IN A DYNAMIC JOB SHOP WITH APPLICATIONS TO DUE-DATE ASSIGNMENT.** Using an exponential limit theorem and a heuristic decomposition of open queueing networks, we show that for a large class of dynamic job shops, the total time spent in a dynamic job shop can be approximated by an exponential random variable with an appropriate mean. Approximations for job shops that do not belong to this class are also developed. Numerical results show that the proposed approximations are in general very good. Application of these approximations in the assignment of due-dates is also illustrated. (Edited author abstract). 20 Refs.

Shanthikumar, J. George (Univ of California, Berkeley, CA, USA); Sumita, Ushio. *Int J Prod Res* v 26 n 8 Aug 1988 p 1329-1352.

**093054 DISCRETE TIME AVERAGE COST FLEXIBLE MANUFACTURING AND OPERATOR SCHEDULING MODEL SOLVED BY DECONVEXIFICATION OVER TIME.** The principal concern is to schedule operators over time to various activities of a manufacturing system for the purpose of optimizing some steady-state criteria. In mathematical terms, the problem is modeled as a deterministic, infinite horizon, discrete dynamic program. Our solution procedure is to convexify the problem to obtain a linear program, and then to

deconvexify the solution of the linear program over time to arrive at an optimal solution. Apparent loss in objective value due to the deconvexifications is circumvented with buffer inventories. The procedure is reduced to solving a sequence of linear programs and the complexity is stated in these terms. (Edited author abstract). 10 Refs.

Eaves, B. Curtis (Stanford Univ, Stanford, CA, USA); Rothblum, Uriel G. *Oper Res* v 36 n 2 Mar-Apr 1988 p 242-257.

**093055 DYNAMIC SCHEDULING AND ROUTING FOR FLEXIBLE MANUFACTURING SYSTEMS THAT HAVE UNRELIABLE MACHINES.** This paper presents a method for real-time scheduling and routing of material in a Flexible Manufacturing System (FMS). It extends the earlier scheduling work of Kimemia and Gershwin in which the FMS model includes machines that fail at random times and stay down for random lengths of time. The new element is the capability of different machines to perform some of the same operations. The times that different machines require to perform the same operation may differ. This paper includes a model, its analysis, a real-time algorithm, and examples. (Author abstract). 24 Refs.

Maimon, Oded Z. (Tel Aviv Univ, Tel Aviv, Isr); Gershwin, Stanley B. *Oper Res* v 36 n 2 Mar-Apr 1988 p 279-292.

**093056 WEIGHTED TOTAL TARDINESS PROBLEM WITH FIXED SHIPPING TIMES AND OVER-TIME UTILIZATION.** Shipping times are assumed to occur at fixed and specified points in time, and their number is much smaller than the number of jobs. The goal is to find an overtime utilization level and job sequence that yields a 'good' tradeoff between overtime cost and tardiness penalties. We begin by showing that the problem in its simplest form is NP-hard. We then present an approximate algorithm based on a capacitated transshipment formulation. This approximation provides a feasible solution along with its error bound. The algorithm is refined by incorporating the dominance relations of jobs. Extensive computational experience indicates that the algorithm is implementable in terms of both speed and accuracy. (Edited author abstract). 25 Refs.

Matsuo, Hirofumi (Univ of Texas at Austin, Austin, TX, USA). *Oper Res* v 36 n 2 Mar-Apr 1988 p 293-307.

**093057 MULTIPROCESSOR SCHEDULING WITH INTERPROCESSOR COMMUNICATION DELAYS.** We consider the problem of scheduling a set of  $n$  partially ordered tasks on  $m$  identical processors in order to minimize the makespan, where there is a communication delay between any pair of distinct processors. This problem is NP-hard. We provide a heuristic algorithm, called Earliest Ready Task (ERT) algorithm, to solve the problem. Among all tasks whose parent tasks have been assigned, an ERT algorithm is one that always chooses one task that can be processed earliest. We show that the makespan  $M$  generated by ERT algorithm always satisfies a given equation where  $M'$  the optimal makespan without considering communication delay and  $C_{comm}$  is the maximum communication delay in one chain. We also provide an algorithm to find this chain. The time complexity of implementing the ERT algorithm is  $O(mn^2)$ . (Edited author abstract). 12 Refs.

Lee, Chung-Yee (Univ of Florida, Gainesville, FL, USA); Hwang, Jing-Jang; Chow, Yuan-Chieh; Anger, Frank D. *Oper Res Lett* v 7 n 3 Jun 1988 p 141-147.

**093058 OPTIMIZATION BASED HEURISTIC FOR SCHEDULING PARALLEL PROJECT NETWORKS WITH CONSTRAINED RENEWABLE RESOURCES.** We present a model for the simultaneous planning of many individual project networks. We formulate the problem as an integer program that is similar to models found in the inventory/production scheduling literature. A Dantzig-Wolfe decomposition is used to obtain solutions to the linear programming relaxation of the problem. The algorithm selects a subset of these solutions to form a final schedule. Computational results

are presented. Extensions of the algorithm, including non-identical projects, alternative objective functions and implementation on a rolling horizon are also discussed. (Edited author abstract). 11 Refs.

Weiss, Elliott N. (Univ of Virginia, Charlottesville, VA, USA). *IIE Trans* v 20 n 2 Jun 1988 p 137-143.

**093059 HOIST SCHEDULING FOR A PCB ELECTROPLATING FACILITY.** This paper describes a model and associated algorithm for generating maximum throughput cyclic schedules for the movements of a hoist in a PCB electroplating facility. The algorithm is enumerative in nature and involves the solution of linear programming subproblems. Computational experience with schedules for real systems is presented. (Author abstract). 8 Refs.

Sharpiro, Gerald W. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Nuttle, Henry L. *IIE Trans* v 20 n 2 Jun 1988 p 157-167.

**093060 MEAN VALUE ANALYSIS OF THE TRAVELLING REPAIRMAN PROBLEM.** We consider the machine repairman problem where the machines are spatially distributed and repaired by a travelling serviceman. We assume identical machines with exponential up times and general repair times. We also assume that the travel times between pairs of locations have identical, but arbitrary distributions. Assuming a work-conserving, non-preemptive service discipline, a semi-Markov model is developed and various performance measures are evaluated. Some applications of the model are discussed. The model developed here, is used elsewhere to develop approximations for a more realistic situation where machines are non-identical and travel time distributions between pairs of locations are also non-identical. (Author abstract). 22 Refs.

Agnihotri, Saligrama R. (State Univ of New York, Binghamton, NY, USA). *IIE Trans* v 20 n 2 Jun 1988 p 223-229.

**093061 OPTIMAL PLANNING AND SCHEDULING OF ASSEMBLY LINES.** This paper explores the economic conditions under which single-model assembly lines are operated in a batch mode (through intermittent manufacture at higher production rates) rather than by the traditional method of continuous production at the demand rate. A model for optimizing the 'cycle time, station number' combination is developed through consideration of five factors: the learning, inventory, setup, balancing and facility costs. Economic justification for operating in a batch mode was found for total demands ranging from 20 to 4000 assembled products which is expected to include a sizable percentage of the total products manufactured in industrialized countries each year. Greatest savings occur for total demands in the order of 1000 products. (Author abstract). 26 Refs.

Dar-el, E.M. (Industrial Engineering & Management, Haifa, Isr); Rabinovitch, M. *Int J Prod Res* v 26 n 9 Sep 1988 p 1433-1450.

**093062 LOOK-AHEAD SCHEDULING FOR MINIMIZING MACHINE INTERFERENCE.** This paper presents a simple look-ahead rule for scheduling two or more parallel semi-automatic machines sharing the same server. The rule increases machine utilization in situations where machines and servers are highly utilized. Production is lost because of interference time. The amount of interference, as well as the output from a system depend on: (a) The distribution of loading-unloading times and processing times; (b) the priority rule used to select the next job to be processed; and (c) the number of machines assigned to the operator. (Edited author abstract). 8 Refs.

Koulamas, Christos P. (East Carolina Univ, Greenville, NC, USA); Smith, Milton L. *Int J Prod Res* v 26 n 9 Sep 1988 p 1523-1533.



**093063 IMPROVED BOUNDS FOR THE RANGE OF LATENESS ON A SINGLE MACHINE.** In a recent article, Gupta and Sen have developed an algorithm to minimize the range of lateness on a single machine. The algorithm is based on the branch-and-bound approach suggested by Townsend for single-machine problems with quadratic penalty functions of completion times. A simple general result for regular composition of cost functions is presented, application of which improves the Gupta and Sen procedure. (Author abstract). 4 Refs.

Tegze, M. (Charles Univ, Prague, Czech); Vlach, M. *J Oper Res Soc* v 39 n 7 Jul 1988 p 675-680.

**093064 EVALUATING PROJECT SCHEDULING AND DUE DATE ASSIGNMENT PROCEDURES: AN EXPERIMENTAL ANALYSIS.** This study presents a number of important results for managers interested in scheduling projects and setting due dates. Using more information concerning the current work in progress, available resources, and activity precedent relationships provides a better due date estimate for a new project. A finite scheduling procedure (called SFT) consistently gives better due date estimates than simpler aggregate procedures. When some project due dates are set externally, due date performance deteriorates. The effort, measured by CPU time, for SFT to estimate a good due date depends upon the ratio of activity resources required to total resources available, rather than the number of activities across all projects. Similarities and differences between the results observed in this study and past due date job shop scheduling research are reviewed. (Edited author abstract). 30 Refs.

Dumond, John (Indiana Univ, Bloomington, IN, USA); Mabert, Vincent A. *Manage Sci* v 34 n 1 Jan 1988 p 101-118.

**093065 OPTIMALLY BALANCING LARGE ASSEMBLY LINES WITH FABLE.** A new algorithm named 'FABLE', obtains proven optimal solutions for ten 1000 task lines, which each possess the computationally favorable conditions of an average of at least 6 tasks per work station and a small number of between-task precedence requirements, in less than 20 seconds of IBM 3033U CPU time for each problem. A total of 549 problems of various characteristics are solved to determine conditions under which FABLE performs most and least favorably. Performance is sensitive to average number of tasks per work station, number of between-task precedence requirements (measured by 'order strength'), and the total number of tasks per problem. A heuristic variant of FABLE is also described. (Edited author abstract). 10 Refs.

Johnson, Roger V. (Univ of Michigan, Ann Arbor, MI, USA). *Manage Sci* v 34 n 2 Feb 1988 p 240-253.

**093066 SHIFTING BOTTLENECK PROCEDURE FOR JOB SHOP SCHEDULING.** We describe an approximation method for solving the minimum makespan problem of job shop scheduling. It sequences the machines one by one, successively, taking each time the machine identified as a bottleneck among the machines not yet sequenced. Every time after a new machine is sequenced, all previously established sequences are locally reoptimized. Both the bottleneck identification and the local reoptimization procedures are based on repeatedly solving certain one-machine scheduling problems. Besides this straight version of the Shifting Bottleneck Procedure, we have also implemented a version that applies the procedure to the nodes of a partial search tree. (Edited author abstract). 13 Refs.

Adams, Joseph (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Balas, Egon; Zawack, Daniel. *Manage Sci* v 34 n 3 Mar 1988 p 391-401.

**093067 DEVELOPMENT AND IMPLEMENTATION OF A SCHEDULING SYSTEM FOR A WAFER FABRICATION FACILITY.** We discuss implementation issues and describe the algorithms that form the basis of the scheduling system. We present computational results with representative data, and illustrate that sched-

uling procedures can be simplified considerably when they are preceded by a planning stage. The authors learned this fact through interaction with managers of the firm, and this changed the preconceived direction of the work in this application. The result is a formalization of the planning and scheduling problems. (Edited author abstract). 7 Refs.

Bitran, Gabriel R. (MIT, Cambridge, MA, USA); Tirupati, Devanath. *Oper Res* v 36 n 3 May-Jun 1988 p 377-395.

**093068 ADAPTABLE SCHEDULING ALGORITHM FOR FLEXIBLE FLOW LINES.** Consider a manufacturing line that produces parts of several types. Each part must be processed by at most one machine in each of several banks of machines. This paper presents an algorithm that schedules the loading of parts into such a line. The objective is primarily to minimize the makespan and secondarily to minimize queuing. The problem is decomposed into three subproblems and each of these is solved using a fast heuristic. The most challenging subproblem is that of finding a good loading sequence, and this is addressed using workload concepts and an approximation to dynamic programming. We make several extensions to the algorithm in order to handle limited storage capacity, expediting, and reactions to system dynamics. The algorithm was tested by computing schedules for a real production line, and the results are discussed. (Author abstract). 7 Refs.

Wittrock, Robert J. (IBM, Yorktown Heights, NY, USA). *Oper Res* v 36 n 3 May-Jun 1988 p 445-453.

**Military Purposes** See MILITARY ENGINEERING—Operations Research.

## Monitoring

**093069 SCHEDULE MONITORING OF ENGINEERING PROJECTS.** A tool for monitoring, reporting, and controlling the progress of time-critical projects called progress plotting is presented. It helps distinguish between minor schedule slips and problems that call for serious management intervention. It also serves to evaluate planning accuracy on previous projects. Progress is shown by plotting the actual time used on a project against the completed percentage of the critical path. Control lines in the plotting space indicate probabilities of completing the project on schedule. If the progress line crosses a low-probability control line, managers may want to intervene and bring the project back on schedule. Crossing a high-probability control line means an early finish may be anticipated with confidence. The progress plot is comparable to the process-control chart used in manufacturing settings. 10 refs.

Schmidt, M.J. (Digital Equipment Corp, Marlborough, MA, USA). *IEEE Trans Eng Manage* v 35 n 2 May 1988 p 108-114.

**Optimization** See Also COMPUTER SYSTEMS, DIGITAL—Parallel Processing; DECISION THEORY AND ANALYSIS; ELECTRIC POWER SYSTEMS—Load Dispatching; ELECTRIC POWER SYSTEMS—Scheduling; WATERWAY TRANSPORTATION—Scheduling.

**093070 WEIGHTING FUNCTION FOR PRE-EMPTIVE MULTICRITERIA ASSIGNMENT PROBLEMS.** This paper presents a weighting function for aggregating pre-emptive criteria into a representative composite in multicriteria assignment problems. The result is based on taking advantage of the bipartite graph structure of such problems. An application is presented which involves assigning faculty and personnel to parking lots at a large university. (Author abstract) 20 refs.

Phillips, Nancy V. (Univ of Texas, Austin, TX, USA). *J Oper Res Soc* v 38 n 9 Sep 1987 p 797-802.

**093071 SIMPLE ALGORITHM FOR FLOWSHOP SCHEDULING BASED ON TOTAL PROCESSING TIME CRITERION.** Several computer based algorithms are available for the solution of  $n \times M$  flowshop scheduling problems, normally based on a single optimization crite-

rior. The algorithms proposed by Campbell, et al and Gupta are claimed to be efficient and yield near optimal solutions based on the minimization of makespan (throughput time) as the objective functions. Majority of the available algorithms are sometimes incapable of dealing with complex situations and become computationally infeasible. Keeping this in view, a simple algorithms has been proposed, based on total processing time criterion and multiple objective functions, for  $n \times M$  flowshop scheduling. The results thus obtained have been compared with those of Gupta. (Edited author abstract) 11 refs.

Mishra, R.C. (Indian Sch of Mines, Dhanbad, India); Pandey, P.C.; Gaidhar, J.L. *J Inst Eng India Part PR* v 68 pt 2 Nov 1987 p 41-43.

**093072 JOB-SHOP DECISION SUPPORT WITH A MICROCOMPUTER SPREADSHEET.** A simple microcomputer-based decision aid supports the production manager in evaluating alternative schedules by quickly displaying finished times and lateness. This simple tool is intended to assist an experienced scheduler do the job more quickly. There is no attempt to optimize, but merely to demonstrate the impact of alternative schedules. The main attraction of such a system is its simplicity: it takes advantage of the scheduler's experience, can be built with only moderate effort, and can be operated by even a relatively naive computer user. It is also relevant to the organizational realities of the situation. 5 refs.

Pendergraft, Norman (Univ of Idaho, Moscow, ID, USA). *Prod Invent Manage J* v 28 n 4 1987 p 11-14.

**093073 OPTIMAL COMMON DUE-DATE WITH LIMITED COMPLETION TIME DEVIATION.** Given a set of  $n$  jobs with deterministic processing times and the same ready times, the problem is to find the optimal common flow allowance  $k^*$  for the common due-date assignment method, and the optimal job sequence  $\sigma^*$  to minimize a penalty function of missing due-dates. It is assumed that penalty will not occur if the deviation of job completion from the due-date is sufficiently small. Three lemmas are presented and a numerical example is provided to illustrate the use of the results to determine the optimal solution to the due-date determination and sequencing problem. (Author abstract) 16 refs.

Cheng, T.C.E. (Univ of Manitoba, Winnipeg, Manit, Can). *Comput Oper Res* v 15 n 2 1988 p 91-96.

**093074 DETERMINATION OF AN OPTIMAL COMMON DUE DATE AND OPTIMAL SEQUENCE IN A SINGLE MACHINE JOB SHOP.** We consider  $n$  jobs on a machine sequencing problems in which all jobs have a common due date and a deviation in its completion time occurs when a job is completed before or after the common due date. Starting with an arbitrary sequence we relate the problem to generalized linear goal program from which some basic results are proved using elementary properties of linear equations and a linear programming problem. Using these results and the idea of sensitivity analysis in linear programming, an algorithm is developed that determines the optimal due date and the corresponding optimal sequence yielding the global minimum value of the mean absolute deviation of the completion times of the jobs in the optimal sequence from the corresponding optimal common due date. In the end a numerical example to explain the algorithm is provided. (Edited author abstract) 17 refs.

Bector, C.R. (Univ of Manitoba, Winnipeg, Manit, Can); Gupta, Y.P.; Gupta, M.C. *Int J Prod Res* v 26 n 4 Apr 1988 p 613-628.

## Testing

**093075 FEASIBILITY TEST FOR MULTI-PRODUCT LOT SIZE SCHEDULING ON ONE FACILITY.** Venuganti's necessary and sufficient condition for the feasibility of scheduling two products is extended to that of scheduling multi-products. Using this extended condition, this paper presents a succinct approach to test feasibility of a given set of schedule parameters (basic



period and multipliers) in an economic lot scheduling problem (ELSP). This is achieved by partitioning the integer linear programming (ILP) model originally given by Haessler and Hogue into smaller independent models by an efficient approach based on the Chinese Remainder Theorem. The present approach reduces the number of necessary variables and constraints of the ILP model drastically. For a small problem involving ten products or so, the test can be carried out very simply by hand. An example is given to illustrate the approach. (Author abstract) 17 refs.

Park, Kyung S. (Korea Advanced Inst of Science & Technology, South Korea); Yun, Deok K. *Int J Policy Inf v 11 n 1 Jun 15 1987 p 101-108.*

## SCHOOL BUILDINGS See Also ASBESTOS—Health Hazards.

### Climate Control

**093076 SYSTEM UPGRADE.** Cave Spring High School was designed and built in the late 1960s. The original design consisted of a central heat pump plant using a cooling tower to either reject heat in the cooling season or to absorb heat during the heating season. A few years after construction of the original building, a new wing (18,000 sq ft) was added and is conditioned by all electric rooftop multi-zone units. In addition to the unit based control changes, a microprocessor-based facility management system now controls all major energy consuming HVAC equipment. Electronic zone temperature sensors, located strategically throughout the facility, feed environmental data back to the central control which performs logic functions to achieve efficient and economical control and maintain comfortable space conditions.

Crutchfield, Walter I. III (Cii Engineered Systems Inc, Richmond, VA, USA); Wash, Ronald L. *ASHRAE J v 30 n 6 Jun 1988 p 40-42.*

**093077 HVAC SYSTEMS REPLACEMENT.** Lumen Christi High School, located in Jackson, Michigan, was constructed in 1967. The gross building area is 155,000 sq ft. The classroom, cafeteria, administration portion of the building was heated and air conditioned using rooftop multizone, gas-fired air handling units. Based on the HVAC systems analysis, a closed loop water source heat pump system was recommended to replace the current rooftop multizone units. A microprocessor-based energy management system was installed to control the individual heat pumps and ancillary equipment. The system is also utilized to limit the building electrical demand peak by shedding various mechanical loads in a prioritized sequence to maintain a comfortable facility.

Partridge, A. James (James Partridge Associates Inc, Birmingham, MI, USA). *ASHRAE J v 30 n 6 Jun 1988 p 47-49.*

### Construction

**093078 LOW COST SCHOOL BUILT WITH INDIGENOUS MATERIAL AND TECHNIQUES AT HUB, BALUCHISTAN, PAKISTAN.** An experimental and demonstration low cost school has been built at Village Baroot, Hub, Baluchistan. The foundation and base course of the floor are made of soil cement stabilized material. The load bearing walls of the school have also been made of soil cement stabilized blocks. The roof has been precast and consists of battens, tiles and screed. In these portland cement has been replaced by finely grained granular slag up to 30 percent. A cement concrete floor has been provided in the school. Precast concrete arches have been fixed in the veranda for architectural purposes. The school is structurally sound and functionally very efficient. (Author abstract). 5 Refs.

Sulainam, M. (Natl Building Research Inst, Karachi, Pak); Mansoor, Nadir; Khan, Khalida; Waliuddin, A.M. *Int J Hous Sci Appl v 12 n 3 1988 p 219-229.*

### Energy Conservation

**093079 SOLAR-ASSISTED HEAT PUMP SYSTEM AND IN-GROUND ENERGY STORAGE IN A SCHOOL BUILDING.** An experimental solar-assisted heat pump system with a hybrid ground-coupled storage at the F.U.L. in Arlon, Belgium, is described. It includes a 382 m<sup>2</sup> solar roof, two types of water storages, heat storage in earth by horizontal exchangers, and heat pumps. One operating period (1984-1985) is analyzed. The data processed has shown that each of the subsystems has apparently performed adequately: annual collector efficiency is 0.41, heat pump C.O.P. range around 4. Despite important energy losses from the underground storage, the storage efficiency reaches 0.7. This effectiveness is mainly due to heat recovery below natural soil temperature and also to the use of buried tanks of short-term storage. The main difficulties are controlling the flow between these subsystems and developing an operating strategy that matches both the building's heat requirements and a good solar fraction. (Author abstract) 8 refs.

Nicholas, J. (Fondation Univ Luxembourgeoise, Arlon, Belg); Poncelet, J.-P. *Sol Energy v 40 n 2 1988 p 117-125.*

### Foundations

**093080 CONSTRUCTION OF GROUT COLUMNS IN CAVITIES IN THE EDWARDS LIMESTONE.** In 1985, Trinity Engineering Testing Corporation contracted with the Round Rock Independent School District to investigate the subsurface conditions at a new high school site located on McNeil Road southwest of Round Rock, Texas. The building was planned as a single and two-story structure. The school site is located on the geologic formation known as Edwards Limestone prone to solution cavities. At this site, the extent of the cavities precluded the use of deep drilled piers due to the excessive cost for drilling, casing and concrete. The evidence of recent collapse at the surface, and the very near surface cavities encountered in the core borings, made the use of shallow footings without grouting a high-risk solution. This left grouting as the only apparent workable solution.

Gunter, John A. (Trinity Engineering Testing Corp, Austin, TX, USA). *Tex Civ Eng v 58 n 2 Feb 1988 p 18-21.*

### Health Hazards

**093081 ASBESTOS IN SCHOOLS.** The containment or removal of asbestos from 733,000 buildings in the U.S. will cost an estimated \$100 billion over the 15-20 years. Recently, a boiler furnace explosion in a school located in an eastern state set in motion a series of events that is unusual for this type of occurrence. The explosion caused the insulation on the boiler, boiler breeching and connected piping to disintegrate and come to rest on the boiler room floor and other horizontal surfaces. The cleanup and removal was completed the next day and the air sampling results were within the Environmental Protection Agency's (EPA's) recommended standards. (Edited author abstract)

Scott, Timothy A. *Natl Eng v 92 n 3 Mar 1988 p 14-16.*

### Planning

**093082 SCHOOL COMPLEX IN THE GALLARATESE DISTRICT OF MILAN.** The various scholastic activities carried out in the teaching facility are all held in buildings which also leave ample space for the sports facilities and garden premises. All the blocks have a reinforced concrete loadbearing structure: beams and columns supported by strip foundations or r.c. footings. The floor decks are formed by a brick and r.c. composite structure, with the exception of the tower block, where precast T beams were used. The roof of the gymnasiums, swimming pools and workshops are ribbed prestressed concrete, whereas the precast panels are characterized by the exposed, pigmented surfaces which were bushhammered for finish. (Edited author abstract) In Italian and English.

Cavallotti, Carlo. *Ind Ital Cem v 57 n 11 Nov 1987 p 688-699.*

**093083 SAXA RUBRA HIGH SCHOOL ON THE VIA FLAMINIA IN ROME.** The architectural concept of the design resulted from the relation between volume and the particular site, the intended unity of the structure and its large structural grid. The compact monolithic two-floor structure rises from pilot is under which all the common facilities of the school are located. The reinforced concrete structure consists of in-situ cast columns and precast concrete beams and floors. Industrially produced 28 cm thick prestressed floor slabs were employed, enabling all spans up to 12 m in length to be covered. Precast cladding component panels, commonly marketed, were adapted to the required lengths and to the circular openings. (Author abstract) In Italian and English.

Gatti, Alberto; de Sanctis, Diambra; Michetti, Antonio; Tiberi, Michele. *Ind Ital Cem v 58 n 1 Jan 1988 p 34-51.*

### Solar, Passive

**093084 PASSIVE SOLAR HEATED SCHOOL IN WALLASEY. VIII A STUDY OF THE LIGHTING.** The Wallasey School is recognized as an important building in the development of passive solar gain technology. This work reports an analysis of the lighting of the solar block of the school. A comprehensive photometric survey describes the visual environment of the school in both quantitative and qualitative terms. The results are compared with both statutory legislation and predictions using tools available to the original designers. Some general conclusions are drawn which emphasize the importance of visual aspects within the total design of passive solar technology buildings. (Author abstract) 18 refs.

Carter, D.J. (Univ of Liverpool, Liverpool, Engl). *Int J Energy Res v 11 n 4 Oct-Dec 1987 p 433-444.*

### Space Heating

**093085 ENERGY STORAGE IN A CENTRAL HEATING SYSTEM: SPA SCHOOL FIELD TRIAL.** Cranfield Institute of Technology and British Gas plc have undertaken a collaborative programme of tests of a system which interposes a heat store between a boiler and a distributive central heating network. This has culminated in a field trial at Spa School in London. A thermally insulated 3235 l hot water store was installed in the circuit between the existing modular boiler set and the hydronic 'radiator' network. The pipework was arranged so that the heating system could be operated either as configured originally or in the storage mode, in which case two of the five modular boilers were valved off. The two configurations were operated alternately (for four week periods), and their performances were carefully monitored over the 1985/86 heating season. The storage system performed successfully with a 40% lower installed boiler capacity. Boiler cycling was reduced by a factor of 15 and the mean boiler load factor rose from 37 to 70%. Analysis of the results are given. (Edited author abstract) 10 refs.

Cohen, R.R. (Cranfield Inst of Technology, Engl); O'Callaghan, P.W.; Probert, S.D.; Gibson, N.M.; Nevrala, D.J.; Wright, G.F. *Build Serv Eng Res Technol v 8 n 4 1987 p 79-84.*

### Ventilation

**093086 NATUERLICH UND MECHANISCH BELUEFTETE KLASSENRAEUME - VERGLEICH VON LUFTQUALITAET UND ENERGIEVERBRAUCH.** [Natural and Mechanical Ventilation of Classrooms, Compared in Terms of Air Quality and Energy Consumption]. Rooms with a high occupation density, e.g. classrooms, have high air change requirements which in view of the occurring draught cannot always be covered by opening windows. Especially in the winter season, windows can only be opened for short periods of time. The problem may be solved by installing decentralized ventilation systems. Combined with heat recovery units, these systems ensure lower heat consump-



tion than in naturally ventilated rooms. In German.

Rigos, Elstratios; Amonn, Wido. *Ki Klima Kaelte Heiz* v 16 n 5 May 1988 p 232-235.

**093087 BE UND ENTLUEFTUNG MIT WAER-MERUECKGEWINNUNG VON KLASSENRAEUMEN-EIN VERGLEICH VON LUTQUALITAET UND ENERGIVERBRAUCH.** [Forced Ventilation with Heat Recovery in Classrooms: A Comparison of Air Quality and Energy Utilization]. Rooms in which many persons are compelled to stay together at the same time, as e.g. classrooms, have a high demand for outside air. It can not always be guaranteed by opening the windows owing to the draft phenomena that take place. Especially, in low outdoor air temperature conditions, the windows can be opened only for short periods of time. As this is insufficient to improve air quality in the long run, a solution is proposed involving the use of decentralized ventilation devices equipped with heat recovery installations for each classroom. This can even lead to a lower demand for ventilation heat compared with naturally ventilated classrooms. (Translated author abstract). In German.

Rigos, E.; Amonn, W. *ETA Elektrowaerme Tech Ausbau* v 46 n 4 Jun 1988 p A104-A107.

**SCINTILLATION** See Also ARGON—Scintillation; GASES, INERT—Radiation Effects.

**093088 MEASUREMENT OF SUBNANOSECOND SCINTILLATION DECAY TIMES BY TIME-CORRELATED SINGLE PHOTON COUNTING.** A time-correlated single photon counting system for measuring scintillation decay times is described in which the system time response function has a FWHM less than 220 ps. This is a two-scintillator system in which a time-to-amplitude converter (TAC) is started by gamma-induced flashes from a bright 500-ps FWHM scintillator closely coupled to a 14-stage photomultiplier. The TAC is stopped by single-photon pulses from an amplified high-gain microchannel-plate photomultiplier viewing the sample. A  $^{60}\text{Co}$  source is sandwiched between the start scintillator and the sample to be measured. The time correlation depends on the coincident excitation of both scintillators by the two  $\gamma$  rays from each nuclear disintegration. (Author abstract) 5 refs.

Fluornoy, J.M. (EG&G Energy Measurements Inc, Goleta, CA, USA). *Radiat Phys Chem* v 32 n 2 1988 p 265-268.

**093089 SCINTILLATION PROCESS IN THREE-COMPONENT SYSTEMS: THE LUMINESCENCE MINIMUM REVISITED.** The scintillation yield from the three-component system  $C+B+T$ , where  $T$  is the scintillation solute, is studied as a function of the electron fraction of component  $B$  for both  $\beta^-$ -particle excitation and for optical excitation of  $C$  both below and above its ionization threshold. When  $C$ =cyclohexane and  $T$ = $N,N,N'$ -tetramethylphenylenediamine, deep minima (20-40%) are observed when  $B$ =benzene under all excitation conditions, and much shallower minima (approximately 5%) are observed when  $B$ =toluene and then only for  $\beta^-$ -particle excitation and excitation above the ionization threshold of  $C$ . Analysis of these results indicates that the production of  $S_1$  state of  $B$  (i.e.  $B^*$ ) via either energy transfer from electronically excited  $C$  or via charge transfer from  $C^+$  followed by  $B^+e^-$ — $B$  is intrinsically inefficient in dilute cyclohexane solution. The analysis of the results illustrates the inadequacy of previous theories of the luminescence minima. 31 Refs.

Yoshida, Yoichi (Univ of Minnesota, Minneapolis, MN, USA); Walter, Lee; Lipsky, Sanford. *Radiat Phys Chem* v 32 n 3 1988 p 449-456.

**Measurements** See SCINTILLATION COUNTERS—Materials.

**Radiation Effects** See CRYSTALS—Scintillation.

**SCINTILLATION COUNTERS** See Also ACCELERATORS—Targets; BARIUM COMPOUNDS—Scintillation; BIOMEDICAL EQUIPMENT—Radionuclides; BISMUTH COMPOUNDS—Scintillation; CALORIMETERS—Testing; CARBON—Radioactivity; CESIUM COMPOUNDS—Scintillation; CHARGED PARTICLES—Spectrum Analysis; ELECTRON TUBES, PHOTOMULTIPLIER; ELECTRON TUBES, PHOTOMULTIPLIER—Spectrum Analysis; NEUTRONS—Detection; NEUTRONS—Detectors; NEUTRONS—Emission; NUCLEAR INSTRUMENTATION—Design; PARTICLE DETECTORS; PHOTOCATHODES—Applications; POLARIMETERS; RADIOACTIVITY MEASUREMENT; SCINTILLATION; SPECTROMETERS; SPECTROMETERS—Design; SPECTROSCOPY, MOSSBAUER; X-RAYS—Measurements.

**093090 PERFORMANCE COMPARISON OF SELECT ALKYL BENZENE AND DETERGENT BASED LIQUID SCINTILLATION COCKTAILS.** Tritium was employed in the evaluation of performance characteristics for six commercially available cocktails represented by the manufacturers to possess favorable disposal characteristics. Unidentified alkylbenzene organic solvents and/or triton-like detergents form the basis for these cocktails, which were evaluated in large (20 mL) and mini (7 mL) glass and polyethylene vials. The cocktails showed higher backgrounds, lower unquenched efficiencies, and greater quench resistance to nitromethane than a reference toluene based preparation. Detergent based cocktails were difficult to dispense accurately, and resisted sample incorporation. One cocktail lacked stability in polyethylene vials. (Author abstract) 9 refs.

Elliott, John C. (California State Univ, Fullerton, CA, USA); van Mourik, Bradley. *Appl Radiat Isot* v 38 n 8 1987 p 629-633.

**093091 PHOTODIODE READOUT AND PULSE SHAPE ANALYSIS OF CsI(Tl) SCINTILLATOR SIGNALS.** The light output performance of CsI(Tl) scintillators coupled directly or via wavelength shifters to a photodiode is investigated. Using a photodiode readout system, the zero-crossing technique of pulse shape analysis has been employed to identify gammas, neutrons and charged particles. (p,d,t, $\alpha$ ) with a low energy threshold. (Author abstract) 13 refs.

Kreutz, P. (Inst fuer Kernphysik, Frankfurt, West Ger); Kuehnel, A.; Pinkenburg, C.; Pochodzalla, J.; Guo, Z.Y.; Lynen, U.; Sann, H.; Trautmann, W.; Trockel, R. *Nucl Instrum Methods Phys Res Sect A* v A260 n 1 Oct 1 1987 p 120-123.

**093092 DEVELOPMENT OF LOW COST LIQUID SCINTILLATOR COUNTERS FOR COSMIC RAY EXPERIMENTS.** Large area scintillation counters for use in an extensive air shower array have been developed. These detectors are based on liquid scintillator contained in vacuum-formed acrylic dishes and exhibit good spatial uniformity and timing resolution. (Author abstract) 4 refs.

Bultena, Sandra (McGill Univ, Montreal, Que, Can); Hanna, David; Murthy, Kavita. *Nucl Instrum Methods Phys Res Sect A* v A260 n 1 Oct 1 1987 p 247-253.

**093093 GAS SCINTILLATOR FOR CONVERSION ELECTRON DETECTION.** One of the simplest and most efficient detectors used for ionizing particles detection is the gas scintillation detector (GSD). This article discusses a GSD for low-energy electron detection suitable for studies of surface layers and thin films using Moessbauer's conversion electron spectroscopy, and provides the results of the study of the used in the detector gas mixture light output dependence on the detector admixture composition, concentration, and mixture pressure. 11 refs.

Vartanov, V.S.; Zemskov, B.G. *Meas Tech* v 30 n 3 May 1987 p 293-296.

**093094 LARGE POSITION SENSITIVE PLASTIC SCINTILLATION DETECTORS.** Two large plastic scintillators are described, a 1 m square detector with 2 dimensional position sensitivity and a  $1.8 \times 0.2$  m detector with position sensitivity along its length. Both scintillators

are 0.1 m thick. Measurements of pulse height, timing and position resolution, performed using cosmic rays, are presented and the experimental pulse height response is compared with the predictions of Monte Carlo calculations. (Author abstract) 13 refs.

Annand, J.R.M. (Univ of Glasgow, Scotl); Crawford, G.I.; Owens, R.O. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 329-339.

**093095 ANALYSIS OF HEAVY ION INDUCED LIGHT SIGNALS DERIVED FROM A GAS SCINTILLATION DRIFT CHAMBER.** A study of the pulse shapes of heavy ion signals was performed with a gas scintillation drift chamber (GSDC). The scintillation light of  $^{56}\text{Fe}$  and  $^{197}\text{Au}$  ions was recorded with a 100 MHz flash ADC. The dependence of the pulse shapes on impact position and inclination is displayed and discussed. Furthermore we report on the charge resolution of the GSDC, which was  $\sigma = 0.22 \pm 0.04$  charge units for  $^{56}\text{Fe}$  ions of 900 MeV/nucleon. (Author abstract) 6 refs.

Mathis, K.D. (Univ of Siegen, Siegen, West Ger); Isbert, J.; Simon, M. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 403-407.

**093096 64-ELEMENT SCINTILLATOR HODOSCOPE FOR THE DETERMINATION OF THE PION MOMENTUM OF THE  $\pi$ M1 BEAM AT SIN.** A 64-element scintillator hodoscope with an active area of  $280 \times 38$  mm<sup>2</sup> is described. It has been developed to determine the momentum of the pions in the  $\pi$ M1 channel at the Swiss Institut for Nuclear Research (SIN) with high resolution and high efficiency. (Author abstract) 5 refs.

Baran, R. (Univ Erlangen-Nuernberg, Erlangen, West Ger); Fiedler, K.; Hofmann, A.; Olszewski, R.; Ortner, H.W.; Patzelt, C. *Nucl Instrum Methods Phys Res Sect A* v A262 n 2-3 Dec 15 1987 p 541-543.

**093097 HIGH RESOLUTION SCINTILLATING FIBRE (SCIF) TRACKING DEVICE WITH CCD READOUT.** We present our initial test beam measurements of a high resolution scintillating fibre (SCIF) detector with charge coupled device (CCD) readout. We discuss the analysis procedure and evaluate the performance of the detector and its readout assembly. We find a detected photon density along minimum ionizing tracks of  $2.0 \text{ mm}^{-1}$ , with a straight-line rms residual of  $(19.3 \pm 2.9) \mu\text{m}$ , giving rise to a track impact parameter precision of  $(8.8 \pm 2.0) \mu\text{m}$ . The two-track resolution is found to be  $52 \mu\text{m}$ . (Author abstract) 11 refs.

Atkinson, M.N. (Rutherford Appleton Lab, Chilton, Engl); Crennell, D.J.; Fisher, C.M.; Hughes, P.T.; Kirkby, J.; Fent, J.; Freund, P.; Osthoff, A.; Pretzl, K. *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 333-342.

**093098 IMAGE OF A RADIATION FIELD BY A DIRECTIONAL DETECTOR WITH A FLAT DIRECTIVITY DIAGRAM.** The work deals with a composite directional scintillation detector of a slab form. The detector, exhibiting an axially asymmetric directivity diagram, enables one to scan the radiation field with two variously sharp diagrams of the directional efficiency. Mathematical expressions describing the image of the scanned field are derived and an example of a three-dimensional radiation field image is presented for illustration. (Author abstract) 7 refs.

Petr, I. (Technical Univ of Prague, Prague, Czech). *Nucl Instrum Methods Phys Res Sect A* v A263 n 2-3 Jan 15 1988 p 487-492.

**093099 STATISTICAL LIMITATIONS IN THE DIRECTIONAL DETECTION OF  $\gamma$ -RAYS USING A COMBINED SCINTILLATION DETECTOR.** Fluctuations in the output count rates and errors due to the finite dead time of the processing apparatus appropriate to a combined directional scintillation detector are analyzed. Two situations, namely a monodirectional radiation field



and a superposition of a monodirectional field with an isotropic background field are considered. (Author abstract) 4 refs.

Petr, I. (Prague Technical Univ, Prague, Czech). *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 415-418.

**093100 LOW BACKGROUND GAS SCINTILLATION PROPORTIONAL COUNTER.** A gas scintillation proportional counter with veto region inside the wall is described. With the rise time discrimination of the pulse and the veto region, the rejection efficiency of the room spurious background was 82%. (Author abstract) 11 refs.

Miyamoto, Sigenori (Osaka Univ, Toyonaka, Jpn); Saito, Makoto; Kimura, Kazuhiro; Tsunemi, Hiroshi; Kitamoto, Shunji. *Nucl Instrum Methods Phys Res Sect A* v A264 n 2-3 Feb 15 1988 p 528-530.

**093101 STROBED MULTICHANNEL PHOTON COUNTER.** A strobed multichannel photon counter that operates in the visible region is built on the basis of a luminance amplifier with a microchannel plate and an Li-706 supervidicon. A pulse overvoltage supply mode for the microchannel plate provides the gain required for a counter plateau and permits strobing of the photodetector in the nanosecond (140 nsec) range. The counter noise is practically completely determined by the photocathode noise of the luminance amplifier. The multichannel counter has long-term stability, a simple electronic system, and a photodetector of small size. (Author abstract) 8 refs.

Ganichev, V.A. (Acad of Sciences of the USSR, Troitsk, USSR); Elkin, O.K.; Zaidel, I.N.; Kozlov, V.A.; Lyapunov, G.M.; Malinovskii, A.L.; Ryabov, E.A.; Sil'kis, E.G. *Instrum Exp Tech* v 30 n 5 pt 2 Sep-Oct 1987 p 1186-1189.

**093102 GAMMA SPECTROMETRY AND PLASTIC-SCINTILLATOR INHERENT BACKGROUND.** Plastic scintillators (PS) are widely used because they are fast, very transparent, cheap, and comparatively simple to make and machine. Detectors based on them provide time resolution down to 80 psec. The authors measured the energy resolution for a linear dependence of light yield on  $\gamma$ -ray energy. This article presents results of the investigation. 18 refs.

Pomerantsev, V.V.; Gagauz, I.B.; Mitsai, L.I.; Pilipenko, V.S.; Solomonov, V.M.; Chernikov, V.V.; Tsirlin, Yu.A. *Sov At Energy* v 63 n 2 Aug 1987 p 618-623.

**093103 RADIOASSAY OF ALPHA- AND BETA-EMITTERS BY SEQUENTIAL CHERENKOV AND LIQUID SCINTILLATION COUNTINGS.** Alpha- and beta-activities in a sample can be determined by using Cherenkov counting and liquid scintillation efficiency tracing technique. This method does not require any modification of a conventional liquid scintillation counter, and analytical procedure is very simple. All that is required is one set of Cherenkov color quenched standard samples and a liquid scintillation reference sample. This technique has been applied to a  $^{32}\text{P}$ - $^{241}\text{Am}$  pair, and found to be practicable for routine radioassay with the aid of computerized data processing. (Author abstract) 16 refs.

Fujii, Haruo (Tokyo Medical & Dental Univ, Tokyo, Jpn); Takiue, Makoto. *Appl Radiat Isot* v 39 n 4 1988 p 327-330.

**093104 MODEL FOR THE OPTICAL RESPONSE OF PLASTIC SCINTILLATOR.** We describe a model we have developed to understand the measured attenuation lengths of a new plastic scintillator made by Polivar, Pomezia (Italy). The model may be useful to companies and scientists developing new types of two-wavelength scintillators. (Author abstract) 8 refs.

Introzzi, G. (Univ e Sezione INFN, Pavia, Italy); Ratti, S.P.; Coteus, P.W.; Culy, S.; Cumalat, J.P. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 161-166.

**093105 RESPONSE OF A SMALL LIQUID SCINTILLATION COUNTER FOR LOW ENERGY ( $\gamma$ ,p) EXPERIMENTS.** In this paper we present the experimental details and the performance of a small NE213 counter operating at high pressure used in low energy ( $\gamma$ ,p) experiments. The p/ $\gamma$  discrimination techniques used to select a low event rate of protons in a high photon background are described. (Author abstract) 13 refs.

Bernabei, R. (Univ di Roma, 'Tor Vergata', Rome, Italy); D'Angelo, S.; De Pascale, M.P.; Picozza, P.; Belli, P.; Incicchiti, A.; Proserpi, D.; Girolami, B. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 167-170.

**093106 BaF<sub>2</sub> SCINTILLATOR: A STAND-ALONE DETECTOR FOR  $\gamma$ -RAYS AND LIGHT CHARGED PARTICLES.** The performance of thick ( $\geq 10$  cm) BaF<sub>2</sub> crystals as detector for  $\gamma$ -rays and light charged particles have been tested. The capability of BaF<sub>2</sub> of identifying  $Z=1$  particles by itself alone is shown. A new method to perform  $\gamma$ -particle and particle mass discrimination to be used in multiple coincidence experiments with highly segmented detection system is presented. (Author abstract) 9 refs.

Agodi, G. (Univ di Catania, Catania, Italy); Alba, R.; Bellia, G.; Coniglione, R.; Del Zoppo, A.; Maiolino, C.; Migneco, E.; Piattelli, P.; Sapienza, P.; Chen, Yan. *Nucl Instrum Methods Phys Res Sect A* v A269 n 3 Jun 20 1988 p 595-598.

**093107 INFLUENCE OF PHOTON PEAK ARRIVAL IN THE TIMING OF PLASTIC SCINTILLATORS BY MEANS OF PULSED LASER AND OPTICAL FIBERS.** The influence of photon peak arrival in the laser-optical fibers timing system of a large array of plastic scintillators has been studied for different types of photomultipliers. The obtained results, helpful in properly designing the system are presented and discussed. The behavior of four types of photomultipliers to a short laser light pulse, injected in the scintillator they were coupled to, has been investigated. For EMI9964B, Philips XP2020 and Hamamatsu R2083 we have found that when the number of photoelectrons leaving the photocathode is larger than 15-20 and up to 60, the time resolution does not improve significantly and its behavior versus  $N_e$  is similar in all the PMTs. (Edited author abstract). 10 Refs.

Benetti, Pietro (Univ di Pavia, Pavia, Italy); Genoni, Massimo; Tomaselli, Alessandra. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 411-415.

**093108 DEVELOPMENT OF A NaI(Tl) DETECTOR WITH SUPERIOR PHOTON ENERGY RESOLUTION FOR USE ABOVE 100 MeV.** We have designed and tested a new high resolution NaI(Tl) total absorption scintillation counter. The detector has a measured resolution of 1.3% and 1.7% FWHM for 130 MeV photons and 330 MeV electrons, respectively. Computer simulations to account for loss of resolution due to pileup and energy spread of the beam indicate that the ultimate experimental resolutions at these energies are  $1.2 \pm 0.1\%$  and  $1.3 \pm 0.1\%$ . The resolutions at these two energies are at least a factor of 2 better than that of any other total absorption scintillation counter available today. Based on shower simulations, the detector is expected to have a resolution of approximately 130-200 MeV photons. (Edited author abstract). 9 Refs.

Miller, J.P. (Boston Univ, Boston, MA, USA); Austin, E.J.; Booth, E.C.; Gall, K.P.; McIntyre, E.K.; Whitehouse, D.A. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 431-436.

**093109 RESPONSE OF SCINTILLATORS TO HEAVY IONS - I: PLASTICS.** The response of various scintillator detectors to ions of  $A = 1-84$  and energies  $E/A = 5-30$  MeV has been measured and found to be linear above an energy of 100 MeV. Results are presented for a typical organic plastic scintillator including parameterizations of the data as a function of  $Z$ ,  $A$ , and energy. These results are applicable to the use of scintillators as heavy-ion detectors, with one calibration point giving a

normalization that allows use of the whole set of curves. The response functions are compared to previous parameterizations at lower energies and discussed in terms of the theory of  $\delta$ -ray formation in the scintillator. 18 refs.

McMahan, M.A. (Lawrence Berkeley Lab, Berkeley, CA, USA). *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 42-46.

**093110 CONDENSED XENON SCINTILLATORS.** Liquid and solid xenon were investigated as scintillator media for the detection of charged particles. The LET dependence of the integral light output was studied over a wide range of ionization densities using alpha and beta particles and heavy ions of 1.4 MeV/amu. For solid xenon, scintillation decay times were measured by the delayed single-photon method. For liquid xenon, a compact transportable detector unit coupled to a liquid-nitrogen cryostat was designed as a detector for medium-energy heavy ions. With an integrated solid-state detector this unit can be applied as detector telescope for particle identification. 12 refs.

Baum, W. (Tech Hochschule Darmstadt, West Ger); Gotz, S.; Heckwolf, H.; Heeg, P.; Mutterer, M.; Theobald, J.P. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 102-104.

**093111 HIGH-EFFICIENCY SCINTILLATION DETECTOR FOR THERMAL AND HIGH-ENERGY NEUTRONS AND GAMMA RADIATION.** Subcriticality experiments require high-efficiency radiation detectors that are sensitive to neutrons (thermal and fast) over a wide energy range and to gamma radiation. A scintillation detector design that meets these criteria is described. It consists of two scintillators assembled on a single photomultiplier tube. One scintillator is a glass, loaded with lithium enriched in  $^6\text{Li}$ , and has high efficiency for low-energy neutrons. The second scintillator is a plastic having very good efficiency for higher-energy neutrons. Efficiency values are reported for various neutron energy ranges and for gamma radiation.

Chiles, M. (Oak Ridge Natl Lab, TN, USA); Mihalczko, J.; Blakeman, E.D. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 110-113.

**093112 NEUTRON DETECTION EFFICIENCY OF A LARGE SCINTILLATION CALORIMETER.** The efficiency of a mineral-oil-based scintillation detector, with 0.1% by weight of Gd within the walls of a modular substructure, was measured and calculated. From these measurements a detection efficiency of 28.6% can be deduced, for neutrons produced by a neutrino-proton reaction in the 56-t neutrino detector KARMEN, that neutrons from the inverse  $\beta$ -decay reaction in KARMEN can be detected with high probability via the  $\text{Gd}(n, \gamma)$ -reaction. A neutron efficiency of about 30% is thus possible, which means that high-efficiency neutrino detection is possible in KARMEN. 9 refs.

Gemmeke, H. (Kernforschungszentrum und Univ Karlsruhe, West Ger); Grandegger, W.; Maschuw, R.; Plischke, P.; Zeitnitz, B. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 360-364.

**093113 GAS SCINTILLATION DRIFT CHAMBERS WITH WAVE SHIFTER FIBER READOUT.** Results for a prototype xenon gas scintillation drift chamber are presented. Its operation is discussed using two types of light detection schemes: one based on an



Anger camera geometry and one based on an array of wave-shifting light fibers. The results are judged to demonstrate the instrument's potential. 5 refs.

Sadoullet, Bernard (Univ of California, Berkeley, CA, USA); Weiss, Steven; Parsons, Ann; Lin, Robert P.; Smith, Garth. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 543-549.

**093114 SCINTILLATING FIBRE DETECTOR IN THE UA2 UPGRADE PROGRAMME.** A study of a compact and cylindrical tracking detector based on the use of scintillating fibers is presented. A prototype has been built and tested with 40 GeV/c electrons and hadrons. (Author abstract) 3 refs.

Merkel, B. (Lab de l'Accelérateur Lineaire, Orsay, Fr). *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 31-34.

## Accessories

**093115 TIME-REFERENCING DEVICE FOR LARGE SCINTILLATION COUNTERS.** A device is described for time referencing of the output signal to the moment of entry of a charged particle into a large (> 100 mm) scintillation counter viewed on both sides by photomultipliers. The device, which employs 11 integrated circuits of series K500, contains two shapers, which are locked onto the constant part of the pulse leading edge, a coincidence circuit, and a circuit for locking onto the center of the time interval between photomultiplier signals. The device is compact and simple to adjust. The time resolution of a time-of-flight measurement system equipped with these devices is 300 nsec. The dead time of the device is 50 nsec. (Author abstract) 18 refs.

Boreiko, V.F. (Joint Inst for Nuclear Research, Dubna, USSR); Grebenyuk, V.M.; Zinov, V.G.; Ivanov, V.V.; Kozhevnikov, Yu.A.; Stoletov, G.D. *Instrum Exp Tech* v 30 n 5 Pt 1 Sep-Oct 1987 p 1109-1112.

## Applications

**093116 STANDARDIZATION OF PURE BETA EMITTERS BY LIQUID-SCINTILLATION COUNTING.** A precise instrument and method of standardization of beta emitter radioactive solutions by liquid-scintillation counting is described. The instrument includes a triple-scintillation-coincidence detector and a double-output-coincidence electronic unit. The method is based on the extrapolation of counting rate to a value achieved when the triple to double ratio (TDCR) approaches unity. Examples of measurements are given and advantages of the method are discussed. (Author abstract) 9 refs.

Pochwalski, Krzysztof (Inst of Atomic Energy, Swierk, Pol); Radoszewski, Tomasz; Broda, Ryszard. *Appl Radiat Isot* v 39 n 2 1988 p 165-172.

**093117 NEUTRON-GAMMA DISCRIMINATION BASED ON LEADING EDGE SHAPE MEASUREMENT.** A neutron-gamma discriminator using a NE213 scintillator and an amplitude independent pulse risetime measurement technique is presented. A separation index S has been proposed in place of the figure of merit M to evaluate the performance. Performance of the n-γ discriminator has been studied with a 30 mCi Am-Be source in the light of S and other possible performance indices. A good performance in an in-beam experiment has been obtained for a dynamic range of 20 keV to 10 MeV electron equivalent energy. (Author abstract). 15 Refs.

Bose, Suvendu (Saha Inst for Nuclear Physics, Calcutta, India); Chatterjee, Mihir Baran; Sinha, Bedanta Kumar; Bhattacharyya, Rangalal. *Nucl Instrum Methods Phys Res Sect A* v A270 n 2-3 Jul 15 1988 p 487-491.

**093118 APPLICATION OF LARGE BARIUM FLUORIDE SCINTILLATORS TO IN-BEAM GAMMA-RAY SPECTROSCOPY.** Properties of large-volume BaF<sub>2</sub> of scintillators have been studied and first

experiences of applications to in-beam γ-ray spectroscopy are reported. Energy resolutions of 9.1 percent at 662 keV and 6.3% at 1332 keV γ-ray energies were obtained. A time resolution of 375 ps FWHM was measured using a <sup>60</sup>Co source. Gain variations of the phototubes from changes in count rate could be limited to a 2 percent level. Lifetimes have been measured for the first 2+ state of <sup>152</sup>Sm using a <sup>152</sup>Eu source and the 5<sub>1</sub>− state of <sup>40</sup>Ca at 4.49 MeV populated in the (α, α') reaction. (Author abstract). 18 Refs.

Karle, W. (Technische Univ Muenchen, Garching, West Ger); Knopp, M.; Speidel, K.H. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 507-511.

Calibration See NEUTRONS—Detectors.

Computer Applications See NEUTRONS—Detectors.

## Design

**093119 BACKGROUND SUPPRESSION IN A GAS-SCINTILLATION PROPORTIONAL DETECTOR FOR EXOTIC-ATOM X-RAYS.** This is an update of report on a gas-scintillation detector with a 7-cm-diameter Be window for the detection of the K X-ray lines of exotic atoms such as p&amp, p&amD and K<sup>−</sup> p. Additional insulation eliminated breakdown at 9 kV to allow an improvement in background suppression. Timing markers from two scintillation regions combined with energy information, signals from guard detectors, and offline analysis resulted in a background reduction factor of ≈300. Time and amplitude spectra are shown. 5 refs.

Okx, W.J.C. (Delft Univ of Technology, Neth); van Eijk, C.W.E.; Hollander, R.W.; Zoutendijk, A. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1818-1821.

## Efficiency

**093120 CALCULATION OF LIQUID-SCINTILLATION DETECTOR EFFICIENCY.** Definitions of basic notions are given and dependence of counting probabilities of different kinds of scintillation pulses upon energy of beta particles interacting with scintillator are derived. Efficiency of beta-particle counting in liquid-scintillation coincidence detectors is determined. Calculated and experimental counting efficiencies are compared for double and triple detectors. (Author abstract) 9 refs.

Broda, Ryszard (Inst of Atomic Energy, Swierk, Pol); Pochwalski, Krzysztof; Radoszewski, Tomasz. *Appl Radiat Isot* v 39 n 2 1988 p 159-164.

**093121 EBEGA-THE COUNTING EFFICIENCY OF A BETA-GAMMA EMITTER IN LIQUID SCINTILLATORS.** A program is described which computes the counting efficiency of a beta-gamma ray emitter as a function of the figure of merit in liquid scintillation systems. A Monte Carlo scheme is used to simulate the gamma-ray interaction with a toluene-based scintillator. The results are valid for systems with two photomultipliers working in coincidence. (Author abstract). 15 Refs.

Garcia-Torano, E. (CIEMAT, Madrid, Spain); Grau Malonda, A.; Los Arcos, J.M. *Comput Phys Commun* v 50 n 3 Aug 1988 p 313-319.

## Electronic Equipment

**093122 PERFORMANCES OF A PREAMPLIFIER-SILICON PHOTODIODE READOUT SYSTEM ASSOCIATED WITH LARGE BGO CRYSTAL SCINTILLATORS.** The characteristics of a hybridized low noise preamplifier are described. Performances of the preamplifier in combination with silicon photodiodes are discussed and results from laboratory tests and test runs with an assembly of large BGO crystals are presented. (Author abstract) 16 refs.

Goyot, M. (Univ Claude Bernard Lyon-1, Villeurbanne, Fr); Ille, B.; Lebrun, P.; Martin, J.P. *Nucl Instrum*

*Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 180-187.

## High Temperature Effects

**093123 PERFORMANCE RESULTS FOR SCINTILLATION DETECTORS FOR HIGH TEMPERATURE ENVIRONMENTS INCLUDING MWD.** Sheet reflectors and elastomeric potting materials have become available for packaging NaI(Tl) scintillation detectors. The problem of compatibility of these materials with NaI(Tl) in the high-temperatures encountered in oil well applications is discussed. Specially treated systems that are compatible with NaI(Tl) to at least 200°C are described. Their performance is as good as that of traditional packed-powder systems, with only a 5 to 10% pulse height drop during initial exposure to 180°C. Additional data to 200°C show similar stable results, indicating potential application in the harsh MWD (measurement-while-drilling) environment.

Dayton, R. (Bicron Corp, Newbury, OH, USA); Mayhugh, M.; Papp, M.; Parkhurst, P.; Schreiner, R. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 879-881.

Materials See Also PLASTICS—Scintillation.

**093124 CHARACTERISTICS OF THE SCINTILLATION RESPONSES OF SMALL LITHIUM GLASS DETECTORS TO ELECTRON EXCITATION.** The response characteristics of lithium glass scintillators to electron excitation have been determined for a range of electron energies, lithium concentrations and lithium enrichments. The characteristics determined were the absolute scintillation efficiency and intrinsic resolution. These measurements form part of a study of the possible use of such glasses for the determination of the tritium breeding in fusion reactor blanket experiments. The measurements were undertaken to investigate the effects of the gamma background on the signals arising from the tritium production reactions induced with the glass scintillators. Criteria for the selection of glasses most suitable for tritium breeding are discussed in terms of their measured characteristics. (Author abstract) 16 refs.

Dalton, A.W. (Australian Atomic Energy Commission, Menai, Aust). *Nucl Instrum Methods Phys Res Sect A* v A259 n 3 Sep 15 1987 p 545-549.

**093125 NEW POLYVINYLTOLUENE-BASED, RADIATION-RESISTANT PLASTIC SCINTILLATOR.** With the proposed Superconducting Super Collider (SSC) in the active planning stage and other particle physics accelerator facilities being upgraded to higher center-of-mass energies, it has become evident that the radiation levels (particularly gamma and neutron) will seriously degrade the performance of current detector systems. Specifically, the SSC is expected to produce (in the forward region) an annual dose of ten megarad. At the University of Florida, an ongoing effort is being made to produce a radiation resistant plastic scintillation. The plastic scintillator, doped with p-terphenyl and 3-hydroxyflavone fluors in a polyvinyltoluene base, and heated in an argon atmosphere to accelerate recovery, has significant radiation resistance. 3 Refs.

Zorn, Carl (Univ of Florida, Gainesville, FL, USA); Bowen, Margaret; Majewski, Stan; Walker, James; Wojcik, Randolph; Hurlbut, Charles; Moser, Wayne. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 701-703.

**093126 MEASUREMENT OF THE LIGHT YIELD OF COMMON INORGANIC SCINTILLATORS.** The light yield in photons per magaelectronvolt of some common inorganic scintillating crystals has been measured with silicon photodiodes. Incident particles are gammas in the 1-MeV region. The light signal was



calibrated against 60-keV gammas converted directly in the photodiode depletion layer. Among the tested materials CsI(Tl) gave the highest light yield of 52,000 photons/MeV deposited energy. 9 refs.

Holl, I. (Max Planck Inst fuer Physik und Astrophysik, Munich, West Ger); Lorenz, E.; Mageras, G. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 105-109.

**093127 NEW SCINTILLATING GLASS FOR HIGH ENERGY PHYSICS APPLICATIONS.** A scintillating glass has been developed containing cerium (3+) oxide in an aluminate host glass. In this material the scintillation emission spectrum is red-shifted relative to that observed for  $Ce^{3+}$  in silicate glasses. Emission and absorption spectra are more widely separated in the aluminate composition, suggesting that such glasses might have improved light-transmission properties. The refractive index is high, making it a potentially interesting material for use in fiber-optic tracking detectors. 3 refs.

Puselje, D. (Univ of Notre Dame, IN, USA); Baumbaugh, B.; Bishop, J.; Busenitz, J.; Cason, N.; Cunningham, J.; Gardner, R.; Kennedy, C.; Mannel, E.; Mountain, R.J.; Ruchti, R.; Shephard, W.; Zanabria, M.; Baumbaugh, A.; Knickerbocker, K.; Rogers, A. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 475-476.

## Medical Applications

**093128 GATED THALLIUM SCINTIGRAPHY IN PATIENTS WITH CORONARY ARTERY DISEASE: AN IMPROVED PLANAR IMAGING TECHNIQUE.** The use of thallium scanning in the assessment of myocardial perfusion is well established. However, myocardial contraction leads to significant blurring of standard static images. By using electrocardiographic gating and a high sensitivity collimator, multiple view gated scans can be acquired prior to thallium redistribution. Reporting of these images on cine loop display in 100 consecutive patients undergoing coronary arteriography and 14 volunteers results in improved visual assessment of regional myocardial perfusion and, in information on left ventricular function. Predictive accuracy improves from 85% to 94% with gated imaging. Gated thallium scanning could be readily applied in most centers using thallium at no extra cost and with improved predictive accuracy in the non-invasive detection of significant coronary disease. (Edited author abstract) 20 refs.

Martin, W. (Royal Infirmary, Glasgow, Scotl); Tweddel, A.C.; McGhie, A.I.; Hutton, I. *Clin Phys Physiol Meas* v 8 n 4 Nov 1987 p 343-354.

## Performance

**093129 DETERMINATION OF THE LIGHT RESPONSE OF BC-404 PLASTIC SCINTILLATOR FOR PROTONS AND DEUTERONS WITH ENERGIES BETWEEN 1 AND 11 MeV.** The response of BC-404 plastic scintillator is measured up to 11 MeV for protons and up to 8 MeV for deuterons using a time-of-flight spectrometer. It is shown that the response is nonlinear in this energy range and can be described very well using a four-term polynomial in energy. Earlier response curves which were extrapolated from high energy data and from interpolation of low energy data at widely separated energies are nearly linear in the low energy region. A comparison has been made between our new measured data and the existing curves. (Author abstract) 12 refs.

Saraf, S.K. (Ohio Univ, Athens, OH, USA); Brient, C.E.; Egun, P.M.; Grimes, S.M.; Mishra, V.; Pedroni, R.S. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 200-203.

## Stability

**093130 STABILIZATION OF PHOTOMULTIPLIER GAIN OF LIQUID SCINTILLATION COUNTER.** A system for stabilization of photomultiplier

gain is described in which reference signals are provided by an AL102V light-emitting diode. The noise level and neutron registration efficiency of the scintillation counter remained unchanged over 10 days of measurements. (Author abstract) 1 ref.

Alkhazov, I.D.; Dmitriev, V.D.; Kuznetsov, A.V.; Malkin, L.Z.; Petrov, B.F.; Sheremet'ev, A.K.; Shpakov, V.I. *Instrum Exp Tech* v 30 n 5 Pt 1 Sep-Oct 1987 p 1108-1109.

**Standards** See RADIOACTIVITY MEASUREMENT—Standardization.

## Testing

**093131 RESOLUTION TESTS OF CsI(Tl) SCINTILLATORS READ OUT BY PIN DIODES.** Cylindrical CsI(Tl) scintillators of 38 mm diameter and 100 mm length read out with PIN diodes of 400 mm<sup>2</sup> area were tested with respect to their response to medium energy light particles (p, d, t,  $\alpha$ ). Resolutions of better than 1% were achieved for 50 MeV protons and 90 MeV  $\alpha$ -particles. For many crystals the resolution was found to be limited to 2-3% by local crystal nonuniformities which caused variations of the light output efficiency of several percent. A bench test is described which allows the detection of inhomogeneities to better than 0.5% accuracy. The quality of particle identification obtained with  $\Delta E-E$  and pulse shape discrimination techniques are investigated as a function of count rate. (Author abstract) 11 refs.

Gong, W.G. (Michigan State Univ, East Lansing, MI, USA); Kim, Y.D.; Poggi, G.; Chen, Z.; Gelbke, C.K.; Lynch, W.G.; Maier, M.R.; Murakami, T.; Tsang, M.B.; Xu, H.M. *Nucl Instrum Methods Phys Res Sect A* v A268 n 1 May 10 1988 p 190-199.

## SCRAP METAL

### Costs

**093132 HOW MUCH DOES SCRAP REALLY COST.** There are several methods used to determine the unit product cost of scrap in manufacturing, and some of these methods do not give correct answers. Scrap costs are usually higher than expected, and the methodology presented in this article gives a consistent and accurate method for determining correct scrap costs. Scrap calculations are often based upon a percent scrap rate, but they can also be evaluated on an actual unit basis. To compare the various methods, an illustrative example using the scrap percentage basis is presented. 2 Refs.

Creese, Robert C. *Cost Eng (Morgantown WVa)* v 30 n 7 Jul 1988 p 15-19.

### Processing

**093133 GRUNDLAGEN DER BERECHNUNG UND KONSTRUKTION VON SHREDDERN SOWIE BETRIEBSERGEBNISSE.** [Basic Principles of the Design and Construction of Shredders and Their Operational Results]. Based on the analysis of the technological state-of-the-art in shredder construction, this report deals first with the principles underlying scrap processing in shredders with horizontally pivoted rotor. It then discusses the determination and evaluation of variants for structural design of the individual machine components and their assembly. A method of computing the nominal driving power of shredders is presented. Results obtained with the operation of a shredder with a nominal driving power of 1600 kw are described. (Translated author abstract) In German. 73 refs.

Schaefer, Siegmar; Hoeffel, Karl. *Freiburg Forschungsh Reihe A* 752 1988 104p.

**093134 POMIESZANIE GATUNKOW WYROBOW HUTNICZYCH JAKO ZBIOR PROBLEMOW ZWIĄZANYCH Z TECHNOLOGIA WYTWARZANIA ORAZ DYSTRYBUCJA.** [Mixing of Metallurgical articles as a Set of Problems Connected with Production Technology and Distribution]. The article

discusses the mixing of various types of metallurgical articles. It underlines the necessity of work organization rationalization in steelworks and scrap yards. Other factors which eliminate mixing such as fast marking due to technical means have been analysed. (Author abstract) In Polish.

Czyżewski J. *Hutnik* v 54 n 9 Sep 1987 p 263-265.

**Recovery** See ZIRCONIUM AND ALLOYS—Recovery.

**Recycling** See ALUMINUM AND ALLOYS—Recycling.

**Reprocessing** See Also ALUMINUM CASTINGS—Scrap; FURNACES, ELECTRIC—Computer Simulation; LEAD AND ALLOYS—Recovery; NUCLEAR REACTORS; BOILING WATER—Decommissioning; ORE TREATMENT—Waste Utilization; STEELMAKING—Energy Conservation; TUNGSTEN AND ALLOYS—Scrap.

**093135 EFFECT OF THE THICKNESS OF THE FERROMAGNETIC FLUID LAYER IN A MAGNETOHYDROSTATIC SEPARATOR ON THE EFFICIENCY OF THE CONCENTRATION OF CRUSHED COPPER-LEAD SCRAP.** The effect of the thickness of the ferromagnetic fluid layer in the working chamber of a magneto-hydrostatic separator on the concentration efficiency is shown. On the basis of experimental studies, analytic expressions for the variation of the layer thickness are obtained for ferromagnetic fluid layers with magnetization of 9, 13 and 25 kA/m. It is shown that at an optimal ferromagnetic fluid layer thickness mutual contamination of the separation products is minimal. The concentration efficiency in this case is 98.1%. 4 refs. In Russian.

Kravchenko, N.D.; Bondarev, N.A.; Chuprina, Yu.V. *Izv Vyssh Uchebn Zaved Tsvetn Metall* n 4 1987 p 2-4.

**093136 RECLAMATION OF TUNGSTEN CONTAINING SCRAP MATERIALS: ECONOMIC AND TECHNICAL ASPECTS.** The authors discuss some of the technical and economic aspects of recycling tungsten scraps, its availability, recycling methods, and some of the benefits that have been obtained in using the 'Zinc Process' over the past 12 years. In recent years the sorting of feed material for the 'Zinc Process' has become more complicated and technically challenging because of the increasing use of cermets, ceramics, coated inserts, and Ni- and NiCr-binder carbides. (Author abstract).

Kieffer, Bernhard F.; Lassner, Erik. *Int J Refract Hard Met* v 7 n 2 Jun 1988 p 63-65.

## Separation

**093137 VIBRATIONSSORTIEREN VON SHREDDER-SCHROTT.** [Vibratory Sorting of Shredder Scrap]. Using a relatively simply constructed vibratory unit enables a screen cut for the nonferrous components in vibratory sorting shredder scrap to be achieved which succeeds in reclaiming virtually 98% of this component. The other component - in this case rubber - is still present at about 20% in the valuable component. The results apply for a material feed composition of 50% nonferrous scrap metal to 50% rubber; the bulk weight is about 800 kg per ton of nonferrous scrap metal. (Edited author abstract) In German and English.

Ghosh, S.; Coxon, M.; Schmidt, P. *Aufbereit Tech* v 29 n 1 Jan 1988 p 22-25.

**093138 KONTINUIERLICHE COMPUTERGE-STEuerte METALL-LEGIERUNGS-SORTIERUNG.** [Continuous Computer-Controlled Metal-Alloy Sorting]. While at present all processes for sorting and selecting of metal scraps are based on physical qualities, the patented computer-controlled sorting process provides a continuous sorting based on chemical composition. By combination of different machine modules it is possible to select pieces of ferromagnetic- and non-metals before passing the analytical station. Depending on the sorting-program, the selection of alloys follows with mechanical ejectors. The



process is applicable to all continuous automatic sorting and selecting of nonferrous and ferrous alloy pieces. (Edited author abstract) In German and English.

Sczmarowsky, K. *Aufbereit Tech* v 29 n 1 Jan 1988 p 32-35.

**SCREENS AND SIEVES** See Also AGRICULTURAL WASTES—Separation; COAL PREPARATION—Screening; CRUSHED STONE PLANTS—Indiana; FLOW OF FLUIDS—Screens; IRON ORE TREATMENT—Pelletizing; PAPERMAKING MACHINERY; PULP MANUFACTURE—Screening; SAND AND GRAVEL PLANTS—California.

**093139 TEST SIEVING METHODS.** In spite of the considerable standardization work that has been done, there are hundreds of granular materials for which sieve analysis data are desired but for which standard test procedures have not been established or published. One of the objectives of this manual is to meet this need for supplementary procedures for specific materials by summarizing the most accepted general procedures for making sieve tests and also by providing guidelines for developing new standard sieve analysis procedures when none are available. The manual describes wire cloth sieves, perforated plate sieves, precision electroformed sieves, center-line sieves, samples and sampling, general test sieving procedure, hand sieving method, mechanical sieve shaker method, wet testing, combined wet and dry testing, weighing, calculation, graphic presentation of test results, care and cleaning of test sieves, and offers miscellaneous suggestions. Eight appendices list U.S. standard sieve series, and offer standards for sieve analysis procedures. A glossary is also presented. 20 refs.

Anon. *ASTM Spec Tech Publ* 447B 1985 46p.

**093140 COMPACT SIZING SCREEN DISPELS TEXAS-SIZE DOUBTS.** The article describes the operations of Royer/Mogensens's test center in Kingston, Pa. The center uses a full-size 1/2 meter Sizer measuring about 8 feet deep by 3 feet wide by 5 feet deep. The Sizer is able to produce very clean material.

Anon. *Powder Bulk Eng* v 1 n 11 Nov 1987 p 52-55.

## Calculations

**093141 APERTURE SIZE IN A SCREEN OF PLAIN DUTCH WEAVE.** In an investigation into the aperture of the effective size in a screen of plain Dutch weave, it was found that a spherical particle is obliged to pass through two areas: the space between two wefts on the surface of the screen and an inner triangular space surrounded by a warp and two wefts. The size of the triangular area was estimated geometrically and compared with the results of screening experiments using glass beads and silica sand. The experimental results were related to the original size distribution of the material, the number distribution of screened oversize and undersize, and the curve for the efficiency of separation of particles. (Edited author abstract). 7 Refs.

Yamamoto, H. (Government Industrial Research Inst, Nagoya, Jpn); Utsumi, R.; Kushida, A. *Int Chem Eng* v 28 n 3 Jul 1988 p 455-460.

**Design** See COAL PREPARATION—Screening; CRUSHERS—Design; ORE TREATMENT—Screening.

## Materials

**093142 POLYURETHANE AND RUBBER SCREEN DECKS, I.** A concise description of rubber and polyurethane vibrating screen decks is provided followed by the problems relating to screen aperture size selection. The latest techniques of manufacture and assembly of ready-to-fit screening systems is described. The operational characteristics of these systems are described, and the results of several successful applications are discussed. Well-proved methods of screening difficult ores with near-mesh or wet characteristics are discussed. The success of these systems will ensure their steady growth in various applications. (Edited author abstract) In German and English. 5 refs.

Wolff, K. *Aufbereit Tech* v 28 n 6 Jun 1987 p 322-330.

## Performance

**093143 SIEBBODEN AUS POLYURETHAN UND GUMMI - TEIL 2.** [Polyurethane and Rubber Screen Decks, II]. Rubber and polyurethane screen panels have been developed against a background of decades of screening experience and have proved worldwide for over fifteen years to be excellent in use. They are the result of a well balanced combination of steel, synthetics or rubber and have found a secure place in all processing plants. Modular screen panels of the type resting and held down only on two opposite sides lead to a simple and cost effective support structure offering additional advantages. The ease of handling of the relatively small modules with low weight as well as optimal stackability, low maintenance and ease of exchange, reduce the running costs of plants. Continuing growth in the use of modular screen panels can be expected refs 8. In German and English.

Wolff, K. *Aufbereit Tech* v 28 n 7 Jul 1987 p 383-391.

**093144 SCHARFE KLASSIERUNG VON KUNSTSTOFFEN MIT NASSSIEBEN** [Sharp Classification of Plastics on Wet Screens]. On a continuously operating wet screen about 10 per cent undersize of plastics pearl material have to be screened out at 400. Rotating water nozzles are used to clean the screen apertures. Three problems were investigated, theoretically and by making use of a test-model: jammed grains were pushed out of the screen meshes by cleaning water ejected from the nozzles; the transport of the coarse material was dealt with as a function of the nozzle parameters; and the quasi-completeness of separation of the feed sizes was found to be attainable, as a function of the geometry of the screen and its mode of operation. If accurately tuned the stream-type wet screen is able to satisfactorily master difficult tasks. (Edited author abstract) 1 ref. In German and English.

Baecker, J. *Aufbereit Tech* v 28 n 7 Jul 1987 p 392-396.

**093145 HOHERE DURCHSATZRATEN BEI DER NABSIEBKlassierung IM FEINBEREICH MIT 'BANANEN' - UND UNTERWASSERSIEBMASCHINEN.** [Higher Feed Rates for Wet Screening in Fines Ranges with 'Banana' and Underwater Screening Machines]. Wet screening is finding increasing application in fines ranges. The construction of larger screening units for higher feed rates and the continuous development of improved synthetic screen decks have made a significant contribution to this. Two special kinds of screening machines for wet screening, the banana screen, a high-speed screen with up to 30 m<sup>2</sup> screening area, and the underwater screening machine, with up to 10 m<sup>2</sup> screening area, can be applied to cut-points down to 0.3 mm. Depending on the sizing work, the specific feed rate is between 10 and 30 metric t/m<sup>2</sup> h, even, with high product-quality requirements, and this occurs with low water consumption. Due to the precise cut-point and long operating life of synthetic screen decks, the machines have been frequently used with success for extremely abrasive raw materials, such as glass sand, milled quartz, etc. (Edited author abstract). In German and English.

Singh, B.K. *Aufbereit Tech* v 28 n 7 Jul 1987 p 397-403.

**093146 EINSATZ VON GUMMISIEBELAEGEN IN DER KIESAUFBEREITUNG AUF SIEBMASCHINEN UND RUNDSORTIERERN.** [Use of Rubber Screen Mats on Screening Machines and Circular Sorting Units in Gravel Processing]. In the case of a gravel plant in Denmark it is shown that 112 out of a possible 142 screen mats are made of rubber. By means of special aperture shapes, certain types and thicknesses of rubber adapted to screening machine characteristics and screening problems, long-term, trouble-free, no-maintenance operation can be achieved. In spite of higher initial investment costs for rubber screen mats, their long operating life and the cost/utilization ratio favors the use of rubber screen mats. In German and English.

Bendzko, J. *Aufbereit Tech* v 28 n 7 Jul 1987 p 410-414.

## Plastics Applications

**093147 SCREENING OUT NOISE, DUST PROBLEMS.** A New England producer, seeking a solution to the noise/dust problem, started switching to urethane screening media about two years ago. The change has reduced plant noise - and complaints - and reduced blinding caused by water-mist dust control. Operating costs - based on longer wear life and fewer blinding problems - are also lower. The greatest benefit according to Balf Co., Newington, Conn. is that finer material will not build up on the urethane screens under moisture conditions necessary to effectively control dust.

Drake, Robert (Pit & Quarry, Cleveland, OH, USA). *Pit Quarry* v 80 n 11 May 1988 p 24-26.

**093148 URETHANE SCREENS PROVE DURABLE FOR DRAVO.** One of the challenges facing older aggregate processing plants is updating equipment to remain cost competitive. Positive changes in the wear characteristics of modern screening media can be accommodated by simple retrofits. Dravo Basic Material Co.'s Camp Dennison, Ohio facility - originally built in the 1940s - has cut screening costs by switching to urethane and rubber-coated products.

Kuhar, Mark S. (Pit & Quarry, Cleveland, OH, USA). *Pit Quarry* v 80 n 11 May 1988 p 38-39.

**Vibrating** See Also BLAST FURNACES—Charging Equipment; SCRAP METAL—Separation; VIBRATIONS—Measurements.

**093149 SELECTING THE RIGHT VIBRATING SCALPER: DETERMINATION OF SIZE, DECKING AND FRAME DESIGN.** Vibrating scalpers perform important functions in aggregate mining and mineral plants and can be the key to a smooth running and profitable operation. It is important to select the correct size unit and to specify the optimum decking and live-frame features to meet requirements. A scalper can be described as an extra heavy duty vibrating screen, typically designed with grizzly bars or heavy-duty plate separating at large openings and handling larger material (typically +10in). The function of scalping is the separation of oversize from predominantly finer feed.

Luadzers, Leon (Hewitt-Robins, Columbia, SC, USA). *Quarry Manage* v 14 n 10 Oct 1987 p 43-45.

**093150 SCREENING EFFICIENCY FOR PLANAR AND SPATIAL DRIVE MECHANISMS.** Screen oscillation with a crank pitman, spatial crank slider, bent shaft, and a quick return drive mechanism for separating over and under sized particulates was simulated. An index was used for evaluating the effect of the different drives. It was based on the velocity of the particulate relative to the screen and on the opportunity the particulate had to penetrate the screen. The index indicated that the crank pitman drive was better for the screening of particulates than the other three. (Author abstract) 3 refs.

Tan, Jingalu (Univ of Minnesota, St. Paul, MN, USA); Harrison, H. Page. *Trans ASAE* v 30 n 5 Sep-Oct 1987 p 1242-1245.

**093151 SKUTECZNA WYDAJNOSC PRZESIEWANIA WIBRACYJNEGO.** [Effective Output of Vibration Screening]. Based on a mathematical model of screening the real probability of single grain passing through a sieve cloth aperture as a function of changing process parameters was investigated. The results of experiments obtained proved the correctness of the previously developed model of sieve classification and were the base for the new developed equations for determination of an effective screening output, its efficiency and surface area of the screen needed. The formulas have a universal



application and may be employed for different materials and conditions of screening process. (Author abstract) 8 refs. In Polish.

Blasinski, Henryk (Politechnika Lodzka, Lodz, Pol); Krakowiak, Tadeusz. *Inz Chem Procesowa* v 8 n 3 1987 p 447-464.

**093152 NEUE PNEUMATISCHE MAGNETSIEB-MASCHINE DER FIRMA RHEWUM.** [New Pneumatic Magnetic-Screening Machines of the Rhewum Firm]. Studies were made of the screening of ultrafine bulk materials on Rhewum's high-performance screening machine, in which the screen cloth is subjected to direct excitation. Given the good results achieved in fine and medium screening (in the range 0.1 to 6 mm) with the tried and tested principle of direct excitation of the screen cloth, and given the latest knowledge of air-assisted extremely fine grading, pilot-scale separation trials were carried out at a particle size below the critical size for purely mechanical screening (0.1-0.2 mm). Using a combination of both direct vibration of the screen cloth by means of electro-magnetic vibrators and pneumatic screening, a high feed rate and the throughput performance is achieved for products having specific properties and particle size distribution such as to make successful continuous screening extremely difficult. (Edited author abstract). 3 Refs.

Landsmann, R. (Rheum GmbH, Remscheid, West Ger); Scholz, N. *Aufbereit Tech* v 29 n 5 May 1988 p 265-272.

## Wear Resisting

**093153 WECHSELSIEBBOEDEN AUS POLYURETHAN UND GUMMI IN EINEM SYSTEM.** [Clamp-on Screen Decks of Polyurethane and Rubber Together in One System]. The Gummi Kueper company supplies a system for wear-resistant clamp-on screen decks known as V 100, its special feature being the variety of different materials used in one system with 100% compatibility. On the basis of operational experience, it is shown that virtually all bulk materials can be sized (graded) in a pegging or clamp-on system. (Edited author abstract) In German and English.

Dietz, G. *Aufbereit Tech* v 28 n 11 Nov 1987 p 665-669.

## SCREW THREADS See Also FASTENERS—Design.

### Analysis See BOLTS AND NUTS—Analysis.

### Cutting See SCREWS—Thread Cutting.

## Fatigue

**093154 FATIGUE STRENGTH OF MACHINED SCREW THREAD (EFFECTS OF LOADING MODES IN FATIGUE TEST).** The effects of various kinds of factors on the fatigue strength of machined screw thread connection generally used as the fastener of machine components are examined. Effects of materials (i.e. heat-treatment), fastening force, yielding pre-tension or pre-compression before the oscillating loading test and lubrication between the connecting surfaces are chosen as the factors. Fatigue tests are performed for both types of screw thread, and bolt-nut connections made of normalized or tempered S 45 C, and obtained results are investigated in detail. Consequently, the effects on the fatigue strength are clarified. Furthermore, the strain hardening caused at each step of the machining and loading process is discussed. (Author abstract) 6 refs. In Japanese.

Isogimi, Kiyoshi; Kurita, Hajime. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 496 Dec 1987 p 2640-2644.

## Finishing

**093155 DISC TOOL FOR BURNISHING WORM THREADS.** A disc tool was designed for burnishing the worm used in the power reduction box of the SMR-026/1 ore extraction machine. The proposed disc tool design and basic parameter calculation method can be used for

hardening other types of helical surfaces. The tool is simple both to use and to produce, and can be used widely in production.

Sogoyan, M.T. *Sov Eng Res* v 7 n 2 Feb 1987 p 47-48.

## Grinding

**093156 PRODUCTION ENGINEERING TECHNOLOGY.** It is essential to ensure during the screw grinding process not only a low degree of heat conduction into the workpiece (which is attained by reduction of finish grinding conditions) but also rapid heat elimination from the workpiece. In grinding of reversing screws oil coolants (oil grades I-12A and I-20A) are in predominant use and they facilitate production of the requisite surface layer qualities and of the screw profile accuracy. This article gives the results of comparative efficiency investigations of oil grade I-12A and of 6 percent 'Aquemus' emulsion, both of which are delivered into the cutting area by spraying during the rough thread grinding operations on a reversing leadscrew of a typical 50 × 10mm size, made from hardened steel grade 8KhF (HRC 59-63), using wheels grade 44A16M38K5. The essential advantage of coolant delivery by spraying lies in the simplicity of the method and in efficient washing of the workpiece, which results in its effective cooling. 4 Refs.

Mukhortov, V.N.; Grigoryan, G.D. *Sov Eng Res* v 7 n 9 Sep 1987 p 39-41.

## Manufacture See GEARS—Worm.

## Measurements

**093157 AUTOMATIC MEASUREMENT OF SCREW PITCH ERROR BY THERMOPLASTIC HOLOGRAM.** A non-contact measuring method is proposed for the screw pitch error utilizing thermoplastic hologram instead of silver-halide plate hologram, and then the possibility to realize this method is experimentally investigated. The pitch signal is obtained by illuminating the hologram with both signal and reference beam, and the positional pulse is obtained through the electric circuits. (Edited author abstract) 5 refs.

Mariyama, Kazuo (Tokyo Inst of Technology, Yokohama, Jpn); Nakano, Kiyomi. *Bull Res Lab Precis Mach Electron Tokyo Inst Technol* n 59 Mar 1987 p 11-18.

## rolling See Also AIRCRAFT LANDING GEAR—Manufacture.

**093158 DURABILITY OF TITANIUM ALLOY COMPONENTS WITH ROLLED THREADS UNDER CYCLIC LOADING.** Weakening of threaded joints, as a result of stress relaxation under the effect of cyclic loads, is one of the prevalent forms of operational failures in various machines and structures. The objective of the investigation was to carry out comparative tests for relaxation resistance and fatigue strength of free and working threads produced by two methods: cutting and rolling. Testpieces of two types made of titanium alloys type VT16 and VT9 were subjected to stress relaxation tests under cyclic loading. The results are evaluated for both methods. 6 refs.

Savkin, A.N.; Kondrat'ev, O.V. *Sov Eng Res* v 7 n 6 Jun 1987 p 5-7.

## Tapping

**093159 NON-CUTTING TAP WITH AN ALTERNATING SCHEME OF THREAD FORMING.** Described is the design of a non-cutting tap forming the thread profile alternately by thread turns on the engaging and sizing portions. This threading process brings with it a substantial reduction of radial forces and contact stresses (as compared with the standard tapping method) and this provides thread production on the closed contour principle not only in non-ferrous materials but also in steel and in other materials, which are difficult to machine. Calculation recommendations are made for practicable sizes of taps; test results are also given. (Author abstract)

3 refs.

Ryzhov, E.V. *Sov Eng Res* v 7 n 3 Mar 1987 p 61-62.

**093160 VIBRATORY METHOD FOR TIGHTENING THREADED JOINTS.** The advantages offered by vibratory tightening of nuts are pointed out. They are: high productivity and accuracy, large reduction of the twisting moment (in comparison with the tightening moment), reduction of the stresses in the body of the bolt, improved self locking properties of the threaded joint in a number of cases and, finally, absence of appreciable vibration and noise. 14 refs.

Reshetov, D.N. *Sov Eng Res* v 7 n 6 Jun 1987 p 2-4.

## SCREWS See Also BEARINGS—Ball; BOLTS AND NUTS; PLASTICISERS.

## Design

**093161 DESIGN RELIABILITY IN FASTENING.** Superior strength, safety and reliability have ensured the place of the socket screw as a fastener for high technology hydraulic requirements. A simple manufacturing 'tool' by many standards, the socket screw has a diversity of applications unmatched by any other form of fastening. It is now viewed in many hydraulic related industries as the production and design tool, combining the ability to fit exactly and be aesthetically acceptable while coping with the tensile loads required. The production of 'special' socket screws in small quantities, with diameters and often long lengths is applied to hydraulic production problems. (Edited author abstract)

White, A. (Non Standard Socket Screws Ltd). *Power Int* v 33 n 389 1987 p 165.

## Hardening

**093162 SELECTION OF ALLOYS FOR HARD-FACING SCREWS OF EXTRUDERS.** The authors examined three groups of hardfacing alloys with different alloying systems. The alloys examined were deposited on the specimens by the plasma method. The filler material for hardfacing was represented by industrial and experimental powders of the alloys produced by dispersing liquid metal with nitrogen. The first group included the chrome-nickel alloys Nos. 1-3 with boron and silicon. The second group consists of the alloys Nos. 4-7 based on cobalt and alloyed to various degrees with tungsten, chrome, and carbon. The third group includes the wear-resistant alloys Nos. 8-11 based on iron and differing in the alloying system and the type of structural hardening. The test results show that almost all the alloys tested, with the exception of alloys Nos. 1 and 11, form mainly cold cracks in the deposited layer. A large number of cracks distributed at the edges of the bead in the form of fine tears formed in deposition of the alloys Nos. 4, 5, and 7. 7 refs.

Som, A.I.; Gladkii, P.V.; Perepletchikov, E.F.; Gladchenko, A.N. *Chem Pet Eng* v 23 n 5-6 May-Jun 1987 p 310-313.

## Heat Treatment See STEEL HEAT TREATMENT.

## Manufacture

**093163 CHANGES IN SCREW MANUFACTURING.** The demands made on screws have been increasing considerably in recent years. For instance, in mass production screws are no longer screwed in by hand but are fastened automatically by screw-in devices. One condition for trouble-free production of screws and screw fastening corresponding to tightening requirements must be first-class screw products of constant quality. The article discusses trends in the improvement of quality by manufacturing processes.

Anon. *Wire* v 38 n 1 Jan 1988 p 51-56.

## Mechanical Properties

**093164 WITHDRAWAL STRENGTH OF SCREWS FROM A COMMERCIALLY AVAILABLE ME-**



**DIUM DENSITY FIBERBOARD.** Tests carried out to determine the holding strengths of various sizes of sheet metal type screws in the face of a commercially available medium density fiberboard (MDF) indicated that withdrawal strength could be predicted by means of an expression, given in the paper, that relates withdrawal strength (lb), internal bond strength (psi), diameter of the screw (in.), and depth of embedment of the screw (in.). Similarly, tests carried out to determine holding strength in the edge of the MDF included in the tests indicated that withdrawal strength could be predicted by another expression relating the same variables. Withdrawal strengths were about 13 percent higher when optimum pilot holes were used than when pilot holes were not used. (Edited author abstract) 7 refs.

Eckelman, Carl A. (Purdue Univ, West Lafayette, IN, USA). *For Prod J* v 38 n 5 May 1988 p 21-24.

**Performance** See PLASTICS MACHINERY—Extruders.

**Production** See ZINC PLATING—Automation.

**Reliability** See STEEL STRUCTURES—Connections.

**Stainless Steel**

**093165 GALVANO-MECHANICAL TIN PLATING OF 300 SERIES STAINLESS STEEL SELF-TAPPING SCREWS.** A galvano-mechanical tin plating process is described. After a pretreatment cycle in a tumbling mill and rinsing, the glass tumbling media is added to the mill along with an adequate amount of ambient fresh water to just cover mass of parts and media. The plating mill is rotated at approximately 150 surface feet per minute and, in sequence, mild acid compounds and surface preparation concentrates are added, along with a copper coating chemical and the proprietary stainless steel tin finishing compound. In approximately 20-25 minutes, a combination of chemical displacement or galvanic reactions and the mechanical burnishing of the glass media, produce a thin, bright, lubricious coating of tin metal of about 2-3 microns in thickness. 6 refs.

Satow, A. (McGean Tru-Plate Inc). *Fastener Age* v 1 n 1 Sep-Oct 1987 p 15-16, 19.

**Stresses**

**093166 STIFFNESS OF A PRE-LOADED BALL SCREW.** The stiffness of a pre-loaded ball screw is investigated as the stiffness of the spacing disc between the nut halves ranges from infinity to a small value. The stiffness equation is derived on the basis of Hertzian contact between the balls and the guiding grooves. The stiffness of the ball screw rises as the spacing disc stiffness is increased and the high stiffness is maintained until the pre-load is lost. The calculated stiffness approximately agrees with the experimental one with a small externally-applied load but the values deviate as the externally-applied load is increased. When the spacing disc stiffness becomes larger, the agreeable range between experimental and calculated values extends to that of a wider externally-applied load. (Author abstract) In Japanese. 7 refs.

Nakashima, Katuhiro; Takafuji, Kazuki. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 492 Aug 1987 p 1898-1904.

**Thread Cutting**

**093167 OPTIMIZATION OF A PROGRAMMED MULTIPASS METHOD OF CUTTING SCREW THREADS ON LATHES.** The authors developed an alternative pass program that accounts for the thickness limitations on the layer being cut. The new program is based on the same generator pass program, equal areas of cut on each successive pass. It differs in that the trajectory of the cutting edge of the tool from pass to pass is not parallel to the generatrix of the thread's profile but is at a definite angle to it. In program, this angle is 3° on the first four passes and is increased by 3° after every fourth subsequent pass. A test of this pass program indicated

that the shavings were coiled and broken up in all the preliminary thread-cutting passes and were rinsed away easily by the cutting fluid without the operator's intervention. These pass programs have enabled us to create optimal conditions for the use of hard alloy cutting tool bits. This change has produced an increase in their durability by several factors (with wear-resistant coatings) under stable chip-breakup conditions.

Abasov, Ya.A.; Gatamov, S.B. *Chem Pet Eng* v 22 n 7-8 Jul-Aug 1986 p 402-403.

**093168 GEWINDEREHEN MIT HARTMETALL-WENDESCHNEIDPLATTEN.** [Thread Cutting by Turning with Indexable Carbide Inserts]. According to DIN 8589, thread cutting is screw cutting for generating a thread by means of a single-profile turning tool. Thread cutting is substantially different from plain turning: The various parameters can be varied in plain turning regardless of each other to adapt to the cutting process going on. In thread cutting, however, geometry and profile are determined by the feed rate and cannot be adapted to the individual metal cutting process. The operation can be performed on both conventional and special thread cutting lathes and permits the production of accurate threads with good surface finish by means of simple low-cost tools. (Author abstract). 3 Refs. In German.

Altmeier, Manfred. *Werkstatt Betr* v 121 n 6 Jun 1988 p 480-482.

**SCRUBBERS** See Also CUPOLAS—Dust Abatement; FLUE GASES—Desulfurization; GASES—Purification.

**093169 USE OF A CONICAL SCRUBBER TO REMOVE SULFUR DIOXIDE FROM SINTERING-MACHINE WASTE GASES.** An increase in the productivity of the sintering machines at the Magnitogorsk Metallurgical Combine has been accompanied by an increase in the volume of sulfur dioxide-bearing waste gases which are generated. The technology proposed by the institute VNIIchermetenergochistka for removing SO<sub>2</sub> from the gas with a conical scrubber ensures the cleaning of a large amount of gas due to a reduction in downtime and the amount of limestone suspension necessary. Use of the new scrubber also lowers electric power costs and the cost of gas cleaning.

Kanenko, G.M.; Kostin, M.P.; Ol'khovskaya, L.N.; Orlova, E.A.; Chapala, I.D. *Metallurgist (USSR)* v 31 n 5-6 May-Jun 1987 p 144-145.

**093170 SCRUBBER PUTS AN END TO PIGMENT MANUFACTURER'S COLORFUL PROBLEM.** In 1982 BASF Wyandotte, a high-volume producer of nonsoluble pigments used by the paint and printing industries, applied a scrubber modification in its operation. The modified scrubber solved difficulties BASF experienced scrubbing particulates from process tanks at its facility in Holland, Michigan. The scrubber lowers maintenance costs and eliminates excessive foam.

Anon. *Powder Bulk Eng* v 2 n 5 May 1988 p 29-31.

**093171 EXPERIMENTAL RESULTS FROM A PLATE-COLUMN WET SCRUBBER WITH GAS-ATOMIZED SPRAY.** A pilot wet scrubber was examined experimentally. It is constructed like a plate column. Its plates are designed to set the gas into a whirling motion with tangential velocities of up to 25 m/s and to ensure a uniform distribution of the liquid throughout the gas flow. Particles suspended in the waste gas are collected by gas-atomized droplets to yield cut diameters between one and two microns. Energy consumption is lower than in the case of other scrubbers. The scrubbing mechanisms are analyzed by examining the measured pressure drops. Finally, methods of determining the collection efficiency are discussed and an empirical approach to its calculation is presented. (Author abstract) 10 refs.

Fan, Xiaolun (Ministry of Chemical Industry, Xian, China); Schultz, Tilman; Muschelknautz, Edgar. *Chem Eng Technol* v 11 n 2 Apr 1988 p 73-79.

**093172 LOW PRESSURE LOSS BLAST FURNACE GAS SCRUBBER.** Top pressure recovery turbines (TRT) for blast furnace gas have come into use in high pressure blast furnaces to recover the pressure energy. To enhance the TRT recovery, Nippon Steel Corp. has developed a low pressure loss combined gas cleaning system, the Venturi Scrubber-Electrostatic Space Cleaner Super (VS-ESCS). The VS-ESCS is a combined system of scrubbers and a wet electrostatic precipitator.

Anon. *Trans Iron Steel Inst Jpn* v 27 n 11 1987 p 910.

**Analysis**

**093173 PECULIARITIES OF INSTALLATION OF VENTURI SCRUBBERS IN SUCCESSION.** It was found that the efficiency of dust collection in Venturi scrubbers (in the case of single-stage battery or group assembly of Venturi tubes) depends strictly on the energy consumption by them. A mathematical analysis showed that in the low-pressure mode of operation of the Venturi scrubbers, successive multistage installation of the latter is preferable to the single-stage one for equal hydraulic resistance. The authors assessed the efficiency of dust collection experimentally in one, two, and three successively placed diffuserless Venturi scrubbers. The investigations were conducted on real gases leaving the drying drum of the rock phosphate meal plant. The concentration of the dust of the rock phosphate meal in the gas before the Venturi scrubber varied within 0.4-4.5 g/m<sup>3</sup> (under normal conditions). The experiments performed reiterate the conclusion that the largest particles are collected selectively only in the first section (in the direction of the gas flow) of the apparatus where the median particle diameter diminishes on the average from 5.13 to 1.48 μm. 9 refs.

Dubinskaya, F.E. *Chem Pet Eng* v 22 n 9-10 Sep-Oct 1986 p 506-510.

**Corrosion** See Also FLUE GASES—Desulfurization.

**093174 CONTINUOUS MONITORING OF FGD WET SCRUBBER CORROSION.** This article describes an electrochemical corrosion monitoring system developed in England that offers utilities the capability of continuously measuring power plant corrosion activity for a wide range of operating conditions. (Author abstract)

Anon. *JAPCA* v 37 n 11 Nov 1987 p 1369-1372.

**093175 MULTITECHNIQUE CORROSION MONITORING IN FLUE GAS DESULFURIZATION SYSTEMS: PHASE 1.** The capabilities of a multitechnique electrochemical monitoring system for monitoring corrosion in the aggressive flue gas condensate that forms as thin films on the surface of scrubber outlet duct walls have been evaluated. The system employs a corrosion probe incorporating several discrete elements made of the Type 316L stainless steel used in the ductwork under study. The system monitored corrosion behavior using four techniques simultaneously, based on electrochemical impedance, electrochemical potential noise, galvanic coupling current using zero resistance ammetry, and electrochemical current noise. The corrosion monitor operated successfully at two test sites. The system distinguished between periods of pit initiation, pit propagation, passivity, and uniform corrosion and demonstrated direct relationships between these corrosion responses and changes in operating conditions.

Anon. *Electr Power Res Inst Coal Combust Syst Div Rep EPRI CS 5605* Jan 1988 164p.

**Costs**

**093176 CAPITAL AND OPERATING COSTS OF WET SCRUBBERS INSTALLED ON COAL-FIRED UTILITIES IMPACTING THE EAST COAST.** A computer program has been written to determine the cost of building and operating wet scrubbers on individual coal fired utilities in the states where emissions are likely to affect the acid rain problem in the eastern United States. The program differs from many other estimates since it



calculates the cost for each of 831 individual sites. The capital costs for installing scrubbers on the top fifty sulfur oxide emitting plants will be about \$20 billion. This will result in an increase in the cost of electricity on an average of 0.88 cents/kWh and a reduction of sulfur oxide emissions from 1980 of 7,100,000 tons per year. An additional reduction of at least 1,000,000 tons per year can be obtained by requiring all plants burning oil to burn low sulfur oil. The SO<sub>2</sub> reductions will be continued for at least the next thirteen years and have a very significant effect through the year 2010. (Edited author abstract) 9 refs.

Baasel, William D. (Ohio Univ, Athens, OH, USA). *JAPCA* v 38 n 3 Mar 1988 p 327-332.

## Diffusion

**093177 NUMERICAL SOLUTION FOR MASS TRANSPORT IN MEMBRANE-BASED DIFFUSION SCRUBBERS.** The Galerkin finite element method was used to develop a numerical model for the design of porous-wall diffusion scrubbers, devices which may be used as alternatives to diffusion denuders, and to selectively separate dissolved components from a liquid stream. It was found that the analytical P. Gormley-M. Kennedy solution for a tube with an ideally absorbing interior wall is appropriate for scrubbers characterized by a gas-liquid interface at the wall. However, the major conclusion of this work is that the Gormley-Kennedy solution is often inappropriate for application to diffusion scrubbers based upon a liquid-liquid interface at the wall. For such scrubbers, the unknown concentration boundary condition at the interior wall can be accounted for with the numerical solution, thus providing a design tool that has not been previously available. A set of penetration curves was generated for design purposes, and example applications are provided. (Author abstract) 25 refs.

Corsi, Richard L. (Univ of California, Davis, CA, USA); Chang, Daniel P.Y.; Larock, Bruce E. *Environ Sci Technol* v 22 n 5 May 1988 p 561-565.

## Evaluation

**093178 EVALUATION OF FINE PARTICLE WET SCRUBBERS.** A study was undertaken to reduce emissions for a calciner stack. Tests were conducted to characterize the particle size distribution, effluent loading, and chemical composition. Several methods for reducing emissions were evaluated. The source of the effluent was found to be due to some combination of: excessive mist carryover from a spraytower, flashing of high solids concentration quench liquid, poor flow patterns, a large quantity of fine particles, condensation of metal vapors, or gas phase reaction which formed fine particles. A series of studies were conducted to improve the operation of the spray tower. As only limited success was achieved with these methods several other control devices were evaluated. This article discusses (1) the methodology used to evaluate the cause of the effluent problem, (2) the principles followed in obtaining a representative slipstream, and (3) the performance of the three devices tested, along with parameters which affect performance. (Author abstract)

Blackwood, T.R. (Monsanto Co, St. Louis, MO, USA). *Environ Prog* v 7 n 1 Feb 1988 p 71-75.

## Foundations

**093179 GRUENDUNG DER WAESCHER-STRASSE EINER RAUCHGASENTSCHWEFELUNGSANLAGE.** [Foundations for the Scrubber Line of a Flue Gas Desulfurization Plant]. German power generation companies are currently doing a great deal to prevent air pollution. A total of approx. 15 billion Deutschmarks has been invested in measures aimed at reducing SO<sub>2</sub> emissions from coal-fired power stations. Using the example of a lignite-fired power generation plant, this paper outlines the extensive structural measures required for this, in particular the foundations for the scrubber line. (Author abstract) In German.

Keitel, Helmut (Wayss & Freytag AG, Frankfurt am

Main, West Ger). *Bautechnik* v 65 n 1 Jan 1988 p 2-4.

## Industrial Applications

**093180 ENHANCEMENT IN INTERFACIAL AREA THROUGH PACKED VENTURI SCRUBBER.** Venturi scrubbers have gained greater importance as an equipment for air pollution control measures. The efficient contact of gases can be observed through high contact time and high interfacial area. To increase these parameters a H.D.P.E. wire noted packing of 96.8% porosity was inserted in a conical form in the diffuser section. A four fold increase in the interfacial area was obtained. (Author abstract) 11 refs.

Manthapurwar, N.S. (Natl Environmental Engineering Research Inst, Nagpur, India); Sonolikar, R.L.; Agarwal, A.L. *Indian J Environ Health* v 29 n 3 Jul 1987 p 242-246.

**Materials** See Also ELASTOMERS—Corrosion; FLUE GASES—Desulfurization.

**093181 TITANIUM...THE SOLUTION TO THE CORROSION PROBLEM IN FGD SCRUBBER SYSTEMS.** As pollution control equipment has become more sophisticated and the process streams closed to minimize effluents, the conditions that the materials of construction must withstand have become more severe. Environments that can be encountered in wet electrostatic precipitators and scrubbers include wet/dry conditions with high chloride levels at low pH and variable, often high, temperatures. Titanium and titanium alloys can meet the demands for a corrosion resistant material for construction of scrubber systems. Titanium has a history of excellent performance in acid chloride environments similar to those in a scrubber system and is cost competitive with other candidate materials of construction.

Anon. *Sel of Mater for Serv Environ (Source Book Series)* Publ by ASM Int, Metals Park, OH, USA, 1987 p 374-379.

## Performance

**093182 PERFORMANCE OF A HYDRO-FILTER - MASS TRANSFER COEFFICIENT AND GAS-LIQUID INTERFACIAL AREA.** An experimental study of the effect of operating conditions on the performance of a hydro-filter (marble-bed scrubber) has been conducted. The overall volumetric mass transfer coefficient, K<sub>GA</sub>, remains constant while the gas flow rate changes in the stable operating regions but increases sharply in the region above the loading point, corresponding to a sharp increase in the total pressure drop of the hydro-filter. Since the gas flow is turbulent and the liquid flow is laminar under the present experimental conditions, the value of K<sub>GA</sub> is strongly dependent on the flow conditions of the liquid and its properties, while those of the gas have less effect. The performance of a hydro-filter as a mass transfer device is shown to be superior to other types of scrubbers although its main drawback is large pressure drop. (Author abstract). 18 Refs.

Uchida, S. (Shizuoka Univ, Hamamatsu, Jpn); Sumiyama, M.; Kamo, H. *Can J Chem Eng* v 66 n 4 Aug 1988 p 681-685.

## Protective Coatings

**093183 ORGANIC COATINGS IN SIMULATED FLUE GAS DESULFURIZATION ENVIRONMENTS.** Tests in simulated scrubber outlet duct environments show that the precise formulation of the coating as well as environment chemistry affect coating performance. In addition, entrapped air bubbles in the coating degrade coating reliability. The coatings included nine combinations of epoxy resins and amine hardeners, three vinyl esters, a polyester, a fluoropolymer, a urethane/asphalt, and an electrostatically sprayed, fusion-bonded epoxy. The testing demonstrated that chemical attack of the coating and corrosion of the substrate often depend on the pH and ionic makeup of the test solution. However, no single solution was consistently damaging to all coatings.

A correlation exists between ac conductance or dc resistance and the extent of substrate corrosion. The type of hardener affected the performance of epoxy resins - novolac and bisphenol A resins hardened with an aliphatic or cycloaliphatic amine provided the best protection.

Anon. *Electr Power Res Inst Coal Combust Syst Div Rep EPRI CS* n 5449 Oct 1987 120p.

## Pumps

**093184 SLURRY PUMPS FOR FLUE GAS DESULFURIZATION PLANTS.** Acid rain is a political issue. The evidence that damage is caused to the environment by sulfur dioxide deposition is significant. Slurry pumps operating in flue gas desulfurization plants have to be able to withstand some of the most hostile working conditions known. This article presents an insight into the demands on pumping equipment, materials and pump life and details a number of interesting applications.

De Ruijter, A. (Warman Int, Neth). *World Pumps* Jun 1987 p 172-174.

## Waste Disposal

**093185 SPRAY DRYER WASTE MANAGEMENT.** EPRI has conducted a number of studies to provide utilities with cost information on waste management for conventional wet scrubbing. Studies have characterized waste products; developed engineering designs for effective waste handling, disposal, and/or utilization; and estimated waste management costs. A study, completed in late 1986 evaluated spray dryer wastes. On a dollar-per-ton-disposed basis, spray dryer waste management costs were found to be higher than those for either conventional fly ash or scrubber sludge alone. Cost estimates for new and retrofit spray dryer applications must be revised upward from those produced earlier by EPRI. (Author abstract)

Golden, Dean (EPRI, Palo Alto, CA, USA). *JAPCA* v 38 n 3 Mar 1988 p 292-293.

**SEALS** See Also AIR ENGINES; BEARINGS—Gas Lubrication; COAL MINES AND MINING—Continuous Miners; COMPRESSORS; COMPRESSORS—Seals; JOINTS—Sealants; NUCLEAR REACTORS, GAS COOLED—Cores; PISTONS—High Pressure Effects; PUMPS—Vacuum Applications; PUMPS, GEAR—Lubrication; PUMPS, ROTARY—Design; SPECTROMETERS—Components.

**093186 MODELS OF LABYRINTH SEALINGS FOR TURBOMACHINERY - PART I. FORMULATION OF THE PROBLEM AND STUDY OF GEOMETRICAL EFFECTS.** The nature of the flow in labyrinth seals is studied for the case where the flow is steady laminar and incompressible. The flow patterns and the pressure distributions within the labyrinths are obtained for different models of labyrinth in the absence of an imposed axial leakage velocity. Nine models were considered, the first three where the labyrinth casing or gland was grooved circumferentially with height-to-pitch ratios of 0.5, 1, and 2. The second family was studied when the shaft had grooves machined on its circumference with different values of height-to-pitch ratios, a third group of labyrinths with shafts stepped with the same height-to-pitch ratios was considered as above. The effect of geometrical configuration on the performance of the labyrinth sealing forms the starting point of the study of the problem in general. (Edited author abstract) 5 refs.

El-Gamal, Hassan (Alexandria Univ, Egypt); Awad, Taher; Saber, El-Sayed. *Modell Simul Control B* v 10 n 4 1987 p 41-52.

**093187 MODELS OF LABYRINTH SEALINGS FOR TURBOMACHINERY - PART II. THE LEAKAGE PROBLEM.** The effect of geometrical shape of models of labyrinth sealings on the amount of leakage losses through turbomachines has been investigated thoroughly in this work. Combinations of labyrinth models of practical importance have been considered here theoretically.



cally in great detail. It has been concluded that there exist some combinations of labyrinth models which give the optimum performance, that is, the minimum leakage for given pressure gradients. The choice of a specific model has been found to depend on the range of pressure gradient applied, whether small or relatively large. (Author abstract) 6 refs.

El-Gamal, Hassan (Alexandria Univ, Egypt); Awad, Taher; Saber, El-Sayed. *Modell Simul Control B* v 10 n 4 1987 p 53-64.

**093188 VACOSS-S: THE SERIES PRODUCTION MODEL OF THE VARIABLE CODING SEAL SYSTEM.** The development of the series production model of the electronic seal system VACOSS is being carried out in the frame of the Program of the Federal Republic of Germany in Support of the International Atomic Energy Agency. The paper describes the concept of and specifications for the Variable Coding Seal System VACOSS-S. (Author abstract) 1 ref.

Guenzel, R. (Dornier-System GmbH, Friedrichshafen, West Ger); Richter, B.; Stein, G.; Gaertner, K.J. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 318-319.

Acoustic Emission Testing See PUMPS.

## Analysis

**093189 ANALYSIS OF AN UNPRESSURIZED, LATERALLY RESTRAINED, ELASTOMERIC O-RING SEAL.** An unpressurized, elastomeric O-ring seal inserted into a rectangular groove is analyzed numerically and experimentally. The salient parameters characterizing the seal deformed geometry and stress field are investigated. The results gathered are compared with those holding for a laterally unrestrained toroidal seal. Based on such a comparison, an analytical model is developed which accounts for the lateral restraining effects. (Author abstract) 45 refs.

Dragoni, E. (Univ of Bologna, Bologna, Italy); Strozzi, A. *J Tribol Trans ASME* v 110 n 2 Apr 1988 p 193-200.

**093190 ANALYSIS OF ECCENTRIC ANNULAR INCOMPRESSIBLE SEALS: PART 1 - A NEW SOLUTION USING FAST FOURIER TRANSFORMS FOR DETERMINING HYDRODYNAMIC FORCE.** A new analysis procedure is presented which solves for the flow variables of an incompressible-flow annular pressure seal in which the rotor has a large static displacement from the centered position. The analysis begins with a set of governing equations based on a turbulent bulk-flow model and Moody's friction equation. No simplification of these bulk-flow equations are required for the solution procedure. Perturbation of the flow variables yields a set of zeroth and first-order equations. The zeroth-order equations (which model the large static displacement) are integrated by means of an efficient new method which employs Fast Fourier Transforms. (Edited author abstract) 19 refs.

Nelson, C.C. (Texas A&M Univ, College Station, TX, USA); Nguyen, D.T. *J Tribol Trans ASME* v 110 n 2 Apr 1988 p 354-359.

**093191 ANALYSIS OF ECCENTRIC ANNULAR INCOMPRESSIBLE SEALS: PART 2 - EFFECTS OF ECCENTRICITY ON ROTORDYNAMIC COEFFICIENTS.** In a previous paper, a new analysis procedure was presented which solves for the flow variables of an annular pressure seal in which the rotor has a large static displacement (eccentricity) from the centered position. This paper (Part 2) incorporates the solutions from Part 1 to investigate the effect of eccentricity on the rotordynamic coefficients. The analysis begins with a set of governing equations based on a turbulent bulk-flow model and Moody's friction factor equation. Perturbations of the flow variables yields a set of zeroth- and first-order equations. After integration of the zeroth-order equations by means of the method described in Part 1, the resulting

zeroth-order flow variables are used as input in the solution of the first-order equations. (Edited author abstract) 2 refs.

Nelson, C.C. (Texas A&M Univ, College Station, TX, USA); Nguyen, D.T. *J Tribol Trans ASME* v 110 n 2 Apr 1988 p 361-366.

## Bonding

**093192 EFFECT OF INTERFACIAL MICROSTRUCTURE ON QUALITY OF  $Al_2O_3/Nb$  SEAL.** Through a study of Na corrosion of an  $Al_2O_3/Nb$  seal interface, it is shown that the main factor influencing the seal and the lifetime of a high pressure sodium lamp is the interface bonding between the glass seal and Nb. The microstructure of the interface has been studied by means of TEM. Based on a thermodynamic analysis and the J.A. Pask theory of metal/ceramic interface bonding, the physicochemical process of glass seal/Nb interfaces and the bonding mechanism during sealing is discussed. (Edited author abstract) 8 refs. In Chinese.

Wen, Lishi (Acad Sinica, Shenyang, China); Wu, Shengjin; Si, Chongyao. *Chin Shu Hsueh Pao* v 24 n 1 Feb 1988 p B27-B33.

**093193 TECHNOLOGY OF GLASS, CERAMIC, OR GLASS-CERAMIC TO METAL SEALING (PRESENTED AT THE WINTER ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS).** This conference proceedings contains 11 papers on the current technology of bonding metals to glass, ceramics or glass ceramics. Some of the subjects covered are the microstructural features of bonding, mechanical interactions that occur between materials with dissimilar mechanical and thermal properties, chemical bonding, interfaces, stresses and mechanical testing. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10982 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Moddeman, W.E. (Ed.) (Monsanto Research Corp); Merten, C.W. (Ed.); Kramer, D.P. (Ed.). *ASME Mater Div Publ MD* v 4, Technol of Glass, Ceram, or Glass-Ceram to Met Sealing, Boston, MA, USA, Dec 13-18 1987. Publ by ASME, New York, NY, USA, 1987 98p.

Ceramic See CERAMIC PRODUCTS—Bonding.

Chemical Attack See LUBRICANTS—Additives.

Deformation See Also BEARINGS—Air Lubricated; VALVES AND VALVE GEAR—Testing.

**093194 STRESS FIELDS IN A COMPRESSED UNCONSTRAINED ELASTOMERIC O-RING SEAL AND A COMPARISON OF COMPUTER PREDICTIONS AND EXPERIMENTAL RESULTS.** A finite element stress analysis computer program, FEMALES (an acronym for Finite Element Mechanical Analysis of Large Elastic Strain), has been developed specifically for the analysis of large deformations in elastomeric materials. In this paper, the program is reviewed for use in elastomeric sealing applications. The principle of operation of the program is described, and its performance is compared with experimental and analytical results for the case of an O-ring compressed between flat plates. Two main methods for specifying elastic material properties are considered: firstly, an elaborate method which involves a range of measurements from elastomer specimens, and, secondly, another known as the neo-Hookean model, which only requires estimates of Young's modulus and the bulk modulus. In this particular application it was found that the two models gave similar results. This supports the use of the simpler model, since the materials data can be very readily obtained. The overall conclusion drawn from the work was that FEMALES is a workable system that produces results in good agreement with experiment. (Edited author abstract) 24 refs.

George, A.F. (CEGB, Berkeley, Engl); Strozzi, A.; Rich,

J.I. *Tribol Int* v 20 n 5 Oct 1987 p 237-247.

Design See Also AUTOMOBILE ENGINES—Components; BIOREACTORS—Seals; STEAM TURBINES—Seals.

**093195 CONTACT PAIR SEALING MECHANISM IN AN END SEAL.** Efficient sealing and long life are the two main requirements which determine the design of end seals. These requirements together ensure minimum leakage through the end clearance and minimum wear of the contact pair over a long period of operation. To reduce leakage it is necessary to ensure that the reduction in fluid film thickness as a result of the load applied to the friction pair is such that boundary friction occurs. For certain friction conditions equations are available for assessing the fluid leakage. Research shows that with increasing specific loading of the friction pairs, leakage is reduced. 10 refs.

Golub, M.V. *Sov Eng Res* v 7 n 3 Mar 1987 p 19-21.

**093196 CONTACTING MECHANICAL SEAL DESIGN USING A SIMPLIFIED HYDROSTATIC MODEL.** While hydrostatic theory of mechanical face seal operation is well understood, there has always been some difficulty in applying this idea to the design of seals that contact. In this paper, a simple mixed friction model of seal load support is formulated. Surface roughness is an essential parameter. Mechanical contact load support and hydrostatic load support are both considered. Local support equilibrium is always satisfied. The minimum film thickness and leakage are found. Considering both fluid and mechanical contact friction, the total power consumption is found. The model works equally well for convergent or divergent films. This model is combined with both thermally - caused and pressure - caused radial taper effects using a simple relationship. Using very few algebraic equations, one can solve for the equilibrium operating conditions for practical seals. (Edited author abstract) 13 refs.

Lebeck, A.O. (Univ of New Mexico, Albuquerque, NM, USA). *Tribol Int* v 21 n 1 Feb 1988 p 2-14.

**093197 RADIAL STRESS DISTRIBUTION AND FRICTION FORCES IN A SOFT-PACKED STUFFING-BOX SEAL.** This paper presents a theoretical analysis and experimental results concerning the distribution of radial (contact) stresses at the packing-stem and packing-housing interfaces, deformation of the packing in the mounted condition, and friction forces in the operating condition (the reciprocating stem, with pressure of the medium) in a soft-packed stuffing-box seal. The formulas derived and the experimentally determined material parameters for plaited PTFE-impregnated asbestos packing can be used in the design of soft gland packings, particularly industrial fittings such as valves and gate valves. (Edited author abstract) 12 refs.

Ochonski, W. (Technical Univ of Mining & Metallurgy, Cracow, Pol). *Tribol Int* v 21 n 1 Feb 1988 p 31-38.

**093198 ALGEBRAISCHE BERECHNUNG VON INTEGRALEN KENNGROSSEN FUER DIE INKOMPRESSIBLE STROMUNG IN EINER LABYRINTHDICHTUNG.** [Algebraic Calculation of Integral Values for the Incompressible Flow in a Labyrinth Seal]. In an earlier work finite-difference computations and measurements had been performed in the model of a labyrinth seal. The Reynolds number of the shaft was  $Re = 5.04 \cdot 10^4$  and the Taylor number  $Ta = Re(s/R_1)^{1/2} = 1.77 \cdot 10^4$ , shaft was  $Re = 5.04 \cdot 10^4$ . For engineering applications pressure, mean circumferential velocity, kinetic energy of its fluctuations and its dissipation are estimated algebraically in the present contribution. This is done by means of the classical relations for the fully turbulent flow around a shrouded rotating shaft and a shrouded rotating disk. Additional measurements in the



range of  $1.3 \cdot 10^4 < Re < 10^5$ , i.e.  $4.4 \cdot 10^3 < Ta < 3.5 \cdot 10^4$ , confirm the validity of the algebraic formulae. In German. 19 refs.

Stoff, Horst (EPF, Lausanne, Switz). *Forsch Ingenieurwes* v 54 n 1 Jan 1988 p 19-23.

**093199 SECONDARY SEALING.** While double and tandem seals provide the secondary containment needed for critical sealing applications, cheaper and less cumbersome alternatives are sought by many plant operators. A number of the major seal manufacturers have focused in recent years on developing both dry running and non-contact, or 'fully abeyant', standby arrangements. The Flexibox company's SBOP standby seal running on dry air has been developed with careful attention given to reducing the friction of sliding packings which has enabled low spring loads to be used. This, combined with wider faces and silicon carbide versus carbon faces, has allowed the necessary low wear rates to be attained. Tests, he says, have indicated lifetimes in the standby mode of over 16 000 hours. Other dry and non-contacting standby seals are also described.

Royse, Susan. *Process Eng (London)* v 69 n 6 Jun 1988 p 67-68.

**093200 EFFECTIVE USE OF BUFFER GAS SLEEVE-TYPE SEALS IN CENTRIFUGAL COMPRESSORS.** In this paper, the behavior of a buffer gas sleeve-type seal is explained on the basis of statistical physics. This is related to measurements made in an actual application with normal runout and vibration. Optimum utilization of this kind of seal in centrifugal compressors is discussed. It is concluded that a straight sleeve seal can be made more effective and efficient than the labyrinth seals that are usually used in such buffer seal applications. (Author abstract). 3 Refs.

Wang, Yu-Ming (Tianjin Mechanical Seal Research Inst, China); Chen, Zhen-Qing. *Tribol Trans* v 31 n 3 Jul 1988 p 376-381.

**093201 TRANSIENT RESPONSE OF FLOATING RING LIQUID SEALS.** The design and analysis of pressure balanced seals are important to the designers and users of turbomachinery which require floating element seals. The design objective for compressor seals differs from that of the engineered pump seal but the common factor includes the ability to predict the dynamic response of the floating ring seal relative to the rotor shaft. Steady-state calculations can be used to study possible operating conditions for compressor designs, but they do not include accurate account of rotor shaft response and ring spin torque. In addition, engineered pump seal applications are such that the ring is expected to track shaft movement during start-up and shut-down transients when reduced pressures and leakage produce laminar flow sealing conditions. (Edited author abstract). 10 Refs.

Kirk, R.G. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA). *J Tribol Trans ASME* v 110 n 3 Jul 1988 p 572-578.

**093202 DEVELOPMENT OF SEALANT SELF CIRCULATION 'VISCOSSEAL'.** When vapor is sealed with a liquid sealant of the same substance, gas ingestion takes place at the liquid-gas interface on one side (atmospheric side) of a pair of viscosseals. This ingested gas flows into the central cavity between the two viscosseals, and then a part of the ingested gas leaks into the sealed chamber through the viscosseal on the other side (turbine side). As one of the countermeasures for this type of gas leakage, a modified viscosseal with a self-circulating sealant loop has been proposed. The characteristics of the modified viscosseal are described in this paper. (Edited author abstract). 11 Refs.

Imai, Hiroyuki (Electrotechnical Lab, Tsukuba, Jpn); Korenaga, Sada-yoshi; Takata, Hiroshi; Koga, Tadashi. *J JSLE Int Ed* n 9 1988 p 115-120.

## Fluid Dynamics

**093203 STUDY OF FACE SEALS WITH ECCENTRIC ROTATION.** We present the results of a theoretical study of the dynamics and flow of fluid in face seals. The expression for the leakage, obtained by solving the viscous fluid equations with account for the variable clearance in the face seal, shows that the centripetal fluid flow depends in considerable measure on the skew angle and the magnitude of the eccentricity in the friction pair. The obtained results are of significant importance for face seals of downhole electrical equipment. (Author abstract) 1 ref.

Griskin, E.N. *Sov J Frict Wear* v 8 n 2 1987 p 14-21.

**093204 SEALING MECHANISM OF ROTARY SHAFT LIP-TYPE SEALS.** In order to clarify the sealing mechanism of rotary shaft lip-type seals, the dynamic behaviors of the microasperities on the sealing surfaces and the triple interlines among air, oil and solid surfaces were observed through a hollow glass shaft with the aid of a microscope, an imaging television camera, and video tape recording. The recorded original pictures of the microasperity contacts were statistically analyzed after a digital image processing method was applied. As a result, several characteristic values were introduced which express the configuration of the contacting surfaces in terms of the distribution of the microasperities existing at the contacting surfaces of rotary shaft lip-type seals under dynamic conditions. Through the measurement of these characteristic values, models of sealing surfaces were proposed to characterize real microgeometries under nonleaking and leaking conditions of rotary shaft lip-type seals. In addition, it was confirmed that the theoretical sealing condition expressed by the models agreed well with the experimental one for real rotary shaft lip-type seals. (Edited author abstract) 5 Refs. In Japanese.

Nakamura, Kenya (NOK Corp, Fujisawa, Jpn). *J Jpn Soc Lubr Eng* v 32 n 10 1987 p 696-701.

**093205 EFFECTS OF ELASTIC DEFORMATION ON SEAL DYNAMICS.** The dynamic characteristics and stability of the annular pressure seal employed in pumps have been theoretically deduced with consideration of the effects of elastic deformation due to the high pressure difference. Turbulent flow is assumed in both circumferential and axial direction, and the deformation of the seal and the shaft is governed by the linear theory of elasticity. The results derived herein considering the elastic deformation are compared with the previously published author's results in the stiffness, damping, and add mass coefficients. (Author abstract) 7 refs.

Iwatsubo, T. (Kobe Univ, Kobe, Jpn); Yang, B.S. *J Vib Acoust Stress Reliab Des* v 110 n 1 Jan 1988 p 59-64.

**093206 NUMERICAL AND ANALYTICAL STUDY OF FLUID DYNAMIC FORCES IN SEALS AND BEARING.** A numerical model based on a transformed, conservative form of the three-dimensional Navier-Stokes equations and an analytical model based on 'lumped' fluid parameters are presented and compared with studies of modeled rotor/bearing/seal systems. The rotor destabilizing factors are related to the rotative character of the flow field. It is shown that these destabilizing factors can be reduced through a decrease in the fluid average circumferential velocity. However, the rotative character of the flow field is a complex three-dimensional system with bifurcated secondary flow patterns that significantly alter the fluid circumferential velocity. By transforming the Navier-Stokes equations to those for a rotating observer and using the numerical code PHOENICS-84 with a nonorthogonal body fitted grid, several numerical experiments were carried out to demonstrate the character of this complex flow field. (Edited author abstract). 26 Refs.

Tam, L.T. (Cham of North America Inc, Huntsville, AL, USA); Przekwas, A.J.; Muszynska, A.; Hendricks, R.C.; Braun, M.J.; Mullen, R.L. *J Vib Acoust Stress Reliab Des* v 110 n 3 Jul 1988 p 315-325.

Friction See HYDRAULIC ACCUMULATORS—Seals.

Glass See GLASS—Seals.

## Hydrodynamics

**093207 HYDRODYNAMICS OF RUBBER SEALS FOR RECIPROCATING MOTION, LUBRICATING FILM THICKNESS, AND OUT-LEAKAGE OF O-SEALS.** This paper gives the fundamentals of the hydrodynamics of rubber seals for reciprocating motion, introducing certain modifications that are aimed at availability of engineering practice and conformity with experiment. The inverse problem in the theory of hydrodynamic lubrication of a rubber seal has been related with the contemporary achievements in elastohydrodynamic lubrication of the contact with a roll made of a low elasticity modulus material. The experimental verification of the relationship which conditions height of the slot (lubricating film thickness) between the sealing ring and surface of the sealed element on material, geometrical, and exploitation parameters of the O-ring is a significant result of this research work. This dependence solves the problem of lubrication and leakage in the case of O-rings during the outstroke of the sealed element. (Author abstract) 8 refs.

Karaszewicz, Artur (Technical Univ of Warsaw, Warsaw, Pol). *Ind Eng Chem Res* v 26 n 11 Nov 1987 p 2180-2185.

**093208 HYDRODYNAMICS OF RUBBER SEALS FOR RECIPROCATING MOTION.** The author found that the techniques involved in determining the design of O-ring seals and their suitability for a particular purpose has been a somewhat inexact science. He gives an experimentally verified formula relating to the height of the lubricating film thickness between the O-ring and the sealed element, with the material of the O-ring, its geometrical parameters and the required operating conditions, which he considers may become the basis for designing O-ring seals. (Edited author abstract) 6 refs.

Karaszewicz, Artur (Technical Univ of Warsaw, Pol). *Power Int* v 33 n 389 1987 p 169-172.

Inspection See VISION—Artificial.

## Leak Detection

**093209 MEASURING SEAL LEAKAGE.** To address the need for accurate seal flow data a new tracer gas injection technique is under development for on-line seal leakage measurement. When developed, such a system would eliminate the difficulties of measuring seal clearance. Initial testing of such a system suggests that plus-or-minus 10 percent accuracy is possible, compared to 30% uncertainty in calculated methods. 5 refs.

McGreehan, William F. (Air Systems Design); Haaser, Fred G.; Sherwood, Laurence T. *Leading Edge (Evendale OH) Spring* 1987 p 30-35.

**093210 LEAKAGE CHARACTERISTICS OF STEPPED LABYRINTH SEALS (A CONTINUED REPORT, EFFECTS OF SHAPE FACTORS ON LEAKAGE RATE).** In this study, the effects on the leakage rate shape factors, such as relative position  $a_D/l$ , number of fin  $n$ , height of step  $h_2$ , depth of groove  $h_1$  and pitch  $l$ , thickness  $\delta$  and clearance of fin  $\epsilon$  are investigated in detail for stepped labyrinth seals (downward stepped type), which have a higher efficiency from the practical viewpoint, and their optimum shapes at both the stationary and rotating states are determined. The geometrical values for their optimum shapes are in those cases when  $h_2/l$ ,  $a_D/l$ ,  $h_1/l$ ,  $\delta/l$ , and  $l/\epsilon$  take the values around 0.2, 0.4 to approximately 0.5, 0.5 to approximately 0.6, 0.4 and 15, respectively. On the basis of these results, a method of predicting the leakage rate and the plan procedure are described. On the other hand, the present experimental



result is obtained by using a comparatively larger rotor to increase the peripheral velocity. (Edited author abstract) 5 refs. In Japanese.

Miyake, Kunihiko; Ariga, Ichiro. *Nippon Kikai Gakkai Ronbunshu B Hen* v 53 n 495 Nov 1987 p 3285-3290.

**093211 SEMICONDUCTOR SEAL TESTING.** All international specifications agree that the sensitivities of fine and gross leak test methods must overlap. This is because many of the leaks that occur in semiconductor packages occur beyond the detection range of commonly used test methods. Up to 40 per cent of leak test failures may escape detection. The article describes several methods: gross leak test method; weight gain method; two step fluorocarbon leak detection; vapor detection systems; fine leak testing.

Gillespie, Terence (Trio-Tech, Deansgrange, Irel). *J Soc Environ Eng* v 26-4 n 115 Dec 1987 p 25-27.

## Lubricants

**093212 LUBRICANTS AND THEIR EFFECTS ON SEALS.** Cooperation among component, sealing systems, and lubricant manufacturers is crucial to providing consumers the best seal-lubricant-component systems. Selection of a particular elastomer system for a sealing application is generally made as a balance of several factors: over all cost, operating temperature ranges, and anticipated lubricant types. Field failures due to use of replacement lubricants in a component which aggressively attach or swell the seal's critical elastomer element, are familiar to seal manufacturers. (Edited author abstract)

Anon. *Automot Eng (Warrendale Pa)* v 95 n 11 Nov 1987 p 79-83.

## Lubrication

**093213 FACE SEAL WITH CIRCUMFERENTIAL PUMPING GROOVES AND RAYLEIGH-STEPS.** This paper presents an analysis of a new noncontacting face seal with circumferential pumping grooves and shrouded Rayleigh-steps. The hydrodynamic lubricating film is maintained under rotation due to the Rayleigh-steps. If the low pressure side of the seal is filled with a fluid, the fluid can be pumped into the high pressure side through the circumferential pumping grooves until the shaft speed reaches a limit value. The experimental result confirms the theoretical prediction for the lubricating and sealing performances. Due to the high pumping ability in addition to the high stiffness of its hydrodynamic film, the seal can operate without wear and leakage for a high pressure fluid. (Author abstract) In Japanese. 7 refs.

Ikeuchi, Ken; Mori, Haruo; Nishida, Tohru. *Nippon Kikai Gakkai Ronbunshu C Hen* v 53 n 493 Sep 1987 p 2017-2024.

**Manufacture** See Also HYDROELECTRIC POWER PLANTS—Seals.

**093214 CMMs RIDE HERD ON RAWHIDE'S QUALITY DRIVE.** Chicago Rawhide makes transmission seals, main-bearing seals and frontwheel seals to prevent loss and contamination of lubricants in autos, trucks, farm equipment and other vehicles. The seals range from simple, one-piece components multipart assemblies of metal and rubber. The company uses coordinate measuring machines (CMM) to provide the inspection capabilities for statistical process control.

Rakowski, Leo R. (Machine & Tool Blue Book, Wheaton, IL, USA). *Mach Tool Blue Book* v 82 n 12 Dec 1987 p 30-34.

**093215 SEALS FOR BIOREACTORS.** Vessels used for reactions involving biological changes and materials place special demands on mechanical seals; for example, preventing leakage into a bioreactor can be just as important as eliminating product escape. Careful design and a keen awareness of the consequences of inadequate performance are the keys to the effective sealing of a rotating shaft that penetrates the shell of a bioreactor. There

are several special considerations that the seal manufacturer has to take into account in such cases.

Cameron, Bill (Flexibox Ltd, Manchester, Engl). *Engineering (London)* v 227 n 12 Dec 1987 p 718-719.

**093216 LIFE CYCLE EXPERT.** This case study illustrates the quality professional's role in knowing the product's entire life cycle, from raw materials to end user with regard to the functioning of a pharmaceutical seal manufacturing plant in Clearwater, Florida. The plant is highly automated, with each worker tending from one to ten machines. The three primary materials used to make seals are here examined as to how they are released to production and how this might be done in the future. In addition, the role of traditional inspectors is examined in two manufacturing departments. The general role of quality professionals, along with that of the hourly quality work force, is reassessed. Product life cycle is evaluated relating to new products, changing current product, and raw materials. 3 refs.

Nelson, Earl E. (West Co, Phoenixville, PA, USA). *Qual Prog* v 20 n 11 Nov 1987 p 41-43.

**Materials** See Also ADHESIVES—Applications; PIPELINES—Packing; VALVES AND VALVE GEAR; WATER PIPELINES—Seals.

**093217 FLEXIBLE GRAPHITE AND ALUMINIUM-IMPREGNATED GRAPHITE FOR LIQUID AMMONIA PUMPS SEALING.** This paper introduces the novel sealing materials, flexible graphite and aluminium-impregnated graphite. The materials succeed in the application to liquid ammonia pumps in urea plants for a long time. (Edited author abstract) 4 refs. In Chinese.

Xu, J. (Zigong Research Inst of Carbon Products of Mechanical Devices, China). *Huagong Xixie* v 14 n 1 1987 p 14-18.

**093218 MATERIAL PERFORMANCE FOR SEALS AND PACKAGINGS.** The day of asbestos cord and simple packings to provide a seal in pumps and other machinery is almost past. This article shows how the demand of designers for glands and packings to withstand high temperatures, aggressive fluids and higher performance, have been met by the use of composite and sometimes exotic materials, together with sophisticated designs employing fillers and reinforcement of various kinds. He makes the important point that co-operation between the mechanical designer and the seal specialist is essential at an early stage if satisfactory performance is to be achieved.

Bayliss, Neil (Mercia Rubber Ltd). *World Pumps* Jul 1987 p 195-196.

**093219 FLUID SEALING WITHOUT ASBESTOS.** The hazardous effect of the use of blue asbestos is now well known and strenuous efforts are being made in many different fields to develop suitable alternatives. This article shows how this trend has affected the manufacturers of gaskets and packings, for which no one substitute has proved satisfactory for all occasions.

McClure, Bill (TBA Industrial Products Ltd). *World Pumps* Jul 1987 p 198-199.

**093220 STATUS OF RECENT MECHANICAL SEALS.** The application of SiC as the material of seal faces is opening new pages in mechanical seal technology. In this paper, various types of SiC and their characteristics are described, and two successful examples of SiC application at ultrahigh PV values are reported. These two examples indicate that progress in mechanical seal technology is rapidly extending its application possibilities. (Edited author abstract) In Japanese. 3 refs.

Fujita, Takuya (Eagle Industry Co, Sakado, Jpn). *J Jpn Soc Lubr Eng* v 32 n 12 1987 p 850-855.

**093221 RAYLEIGH-STEP FACE SEAL WITH REVERSE STEPS.** This paper presents a new hydrodynamic seal, in which the pressure drops caused by the reverse steps reduce the hydrodynamic film force, while

they scarcely affect the film stiffness if the step recesses are deep enough. Thus, the clearance is controlled at high-speed operation. The numerical analysis clarifies that the leakage flow rate of the seal is less than a critical value over the entire range of rotating velocities. The critical leakage flow rate which corresponds to a zero hydrodynamic film force condition is determined by the seal face design, and it is independent of the balance ratio. If the seal operates at a relatively low balance ratio, a hydrodynamic lubricating film is formed at a low velocity. In addition, leakage is limited at a high velocity. The experimental results confirm that a seal with reverse steps shows excellent performance over a wide range of rotating velocities. (Author abstract) 3 refs.

Ikeuchi, Ken (Kyoto Univ, Kyoto, Jpn); Mori, Haruo; Nishida, Tohru. *JSME Int J* v 30 n 270 Dec 1987 p 2027-2033.

**093222 POLYURETHANE ELASTOMERS AS HYDRAULIC SEAL MATERIAL.** The availability of the diisocyanate paraphenylene diisocyanate (PPDI) and cyclohexyl diisocyanate (CHDI) has made possible the synthesis of thermoplastic polyurethanes (TPU's) which have greater thermal stability than previously obtainable as predicted from their DMTA thermograms. The ability to combine elevated temperature service with the unique strength and wear resistant properties of polyurethane, together with the automation made possible by the thermoplastic injection molding is considered to represent an advance in current seal materials. This paper describes the special synthesis and formulation of TPU's based on PPDI and CHDI together with a spectrum of the strength properties used to judge them as potential seal elastomers. Some of these TPU elastomers possess tensile strengths of 50 MPa and compression set values of <25% obtained by using special post-curing techniques. DMTA data is used to predict these TPU's responses to elevated temperatures. (Author abstract) 2 refs.

Hepburn, C. (Loughborough Univ of Technology, Loughborough, Engl). *Cell Polym* v 6 n 5 1987 p 51-66.

**093223 GRAPHITE AND CARBON FIBERS FOR COMPRESSION PACKINGS.** Graphite exhibits better thermal and electrical conductivity, greater resistance to mechanical wear, and lower thermal expansion. On the other hand, carbon is superior to graphite in resistance to fracture and abrasion from suspended particles. Fibers and yarns of carbon and graphite are available in various strengths ranging from 20×10<sup>6</sup> psi to greater than 50×10<sup>6</sup> psi modulus. Carbon and graphite fibers and yarns have gained wide acceptance in the packings and seals industry because of their thermal and chemical resistance. Manufacturers of mechanical packings provide carbon and graphite in various forms which include braided yarns, twisted yarns, and rovings. The constructions are normally impregnated or coated with lubricants to enhance fluid blocking and extend chemical resistance.

Heilhecker, Eugene C. (Robco Inc, Pittsburg, PA, USA). *Mater Eng (Cleveland)* v 105 n 3 Mar 1988 p 59.

**093224 CORRELATION BETWEEN LABORATORY TEST AND SERVICE PERFORMANCE OF ELASTOMERIC SEALS AT LOW TEMPERATURE.** Simple and inexpensive methods can provide the necessary information needed for selecting the seal material for low temperature applications. The measurement of hardness, compression set and rebound resilience over a range of temperature and plotting the data versus temperature are sufficient to fully characterize the material. In order to make sure of the suitability of the selected material functional tests should be carried out under the working conditions, because there are other factors that can favor or impair the service performance of seal at low temperature. (Edited author abstract). 15 Refs.

Nagdi, K. (Parker-Praedifa GmbH, West Ger); Bissingen-Bietigheim. *Kautsch Gummi Kunstst* v 41 n 7 Jul 1988 p 717-722.



**093225 SUBMARINE PROPELLER SHAFT SEALS. SIX COMPOSITE MATERIALS EXAMINED.** A test program has been carried out to determine the effect of prolonged exposure to high-pressure seawater on the properties of carbon-carbon composite seal face materials and to assess their performance when run in a seal test rig against a variety of countersurfaces. The effects of composite anisotropy and graphitization were examined using specimen rings with the direction of fiber lay-up either in, or normal to, the rubbing plane, and in the graphitized or nongraphitized condition. It was found that the carbon-carbon composites are stable in water and perform well as a seal face material; however, current high procurement cost will probably restrict their use to the more exacting applications. 5 Refs.

Green, G.A. (Ministry of Defence, Poole, Engl); Tribe, F.J. *Ind Lubr Tribol* v 40 n 3 May-Jun 1988 p 4-10.

**Mathematical Models** See GASKETS—Reliability.

## Measurements

**093226 EXPERIMENTS ON DYNAMIC STIFFNESS AND DAMPING OF TAPERED BORE SEALS.** Stiffness and damping were measured in tapered bore ring seals with air as the sealed fluid. Excitation was provided by a known unbalance in the shaft which rotated in the test seals. Results were obtained for various seal supply pressures, clearances, unbalance amounts, and shaft speeds. Stiffness and damping varied little with unbalance level, indicating linearity of the seal. Greater variation was observed with speed and particularly supply pressure. A one-dimensional analysis predicted stiffness fairly well, but considerably overestimated damping. (Author abstract) 11 refs.

Fleming, David P. (NASA, Cleveland, OH, USA). *NASA Tech Memo* 89895 1987 12p.

**Mechanical Properties** See VACUUM TECHNOLOGY—Seals.

**Noise, Acoustic** See Also PUMPS—Seals.

**093227 RINGING PHENOMENA OF MECHANICAL SEALS.** Ringing phenomena in mechanical seals of automotive water pumps are divided into two types, according to the mechanism of their occurrence. One is caused by sealed liquid boiling between, or near, the sliding surfaces. The ringing is observed only when sealing conditions cause the sliding surfaces to reach a higher temperature than the boiling point of the sealed liquid and can be prevented by improving the heat-transfer capacity of the seal. The other is caused by stick-slip between the sealing surfaces. In general, the stick-slip motion is generated by the interaction between vibration and lubrication characteristics. From the viewpoint of the vibration characteristics, increasing the stiffness is effective in preventing the ringing. On the other hand, as to the lubrication characteristics, the negative slope of the torque-speed curve should be as weak as possible in low speed ranges. (Edited author abstract). 12 Refs. In Japanese.

Kiryu, Kenji (Eagle Industry Co, Takahashi, Jpn); Hirabayashi, Hiroshi. *J Jpn Soc Lubr Eng* v 33 n 6 1988 p 431-436.

**Performance** See ALSO GLASS—Seals; PNEUMATICS; PUMPS, CENTRIFUGAL—Seals.

**093228 STUDY ON PERFORMANCE OF HYDRODYNAMIC SEAL RING WITH CIRCULATION GROOVES.** This paper examines the influence of hydrodynamic effect of mechanical seals used in high pressurized reactors upon the seal characteristics. The experimental results show that the hydrodynamic seal ring with circulation grooves is of good lubricating condition. The relation of leakage, load coefficient and differential pressure is obtained experimentally. The relation shows that the larger the load coefficient, the smoother the operation and the smaller the leakage rate and the erosion of the contact faces. (Author abstract) 4 refs. In Chinese.

Li, S. (Beijing Inst of Chemical Technology, Beijing, China); Guan, Y. *Huagong Jixie* v 14 n 1 1987 p 19-21.

**093229 NEW EQUATION FOR SEAL USERS.** The development of newer and more efficient techniques for sealing mechanical equipment against a variety of liquid, gaseous and granular media, has been rapid and continuous. For many years the standard materials available to users of packed glands were asbestos and various types of common organic fibers, such as ramie, flax, jute and cotton. The last twenty years have been very productive in the development of new materials. A survey of new materials used for Seals is given.

Cheetham, E.J. (Henry Crossley Ltd, Bolton, Engl). *World Pumps* n 11 Nov 1987 p 360-361.

**Plastics** See ELECTRIC BATTERIES, SECONDARY—Electrodes.

**Plastics Applications** See ELASTOMERS—Testing.

**Pneumatic Drive** See AIR CUSHION VEHICLES—Vibrations.

**Pressure Effects** See COMPRESSORS—Seals.

## Quality Control

**093230 SYSTEMS ASSURANCE OF THE QUALITY OF SHUT-OFF EQUIPMENT IN CHEMICAL INSTALLATIONS.** For the purpose of realizing a program of systems quality assurance of shut-off equipment, engineering methods of calculating hermeticity and reliability indices of equipment seals for a given purpose have been developed. They embrace calculations functional hermeticity and the breakdown-freedom of seals of stand-by sealing equipment for flammable media; functional hermeticity and optimum lifetime of seals in repair along shut-off equipment for toxic media; and functional freedom from breakdowns and optimum hermeticity of seals in controlling shut-off equipment for aggressive media. To realize a method for systems evaluation of the serviceability of seals for a given purpose, original means lifetime testing of the seals have been worked out and studies are being made of equipment for oxygen pipelines, acid pipelines, and alkali pipelines in chemical manufacturing. 6 refs.

Goshko, A.I. *Chem Pet Eng* v 22 n 11-12 Nov-Dec 1986 p 572-575.

**Reliability** See Also SPRINGS—Mechanical Properties.

**093231 IMPROVING THE RELIABILITY OF CUFF-TYPE SEALS.** We present the results of experimental studies made to improve seal reliability and reduce leakages of the sealed medium. We examine two different cuff constructions and techniques that make it possible to markedly reduce the contact friction torque with simultaneous reduction of the sealed medium leakage. The studies are performed using the same technique, which makes it possible to obtain comparable results and present recommendations on the application of these seals. (Author abstract) 6 refs.

Snegovskii, F.P.; Serbin, A.N. *Sov J Frict Wear* v 8 n 5 1987 p 129-133.

**Rubber** See VALVES AND VALVE GEAR—Calculations.

**Selection** See Also PLASTICS MACHINERY—Molding Machines.

**093232 SELECTION OF SEAL CONSTRUCTION FOR CLOSURES OF VESSELS WHICH OPERATE UNDER CONDITIONS OF CYCLIC VARIATION IN PRESSURE AND TEMPERATURE.** The object of this work was to show how, on the basis of classification and analysis of existing sealing units, a promising construction is selected, and to examine the directions of studies which are necessary to introduce it. The classification suggested includes nine groups of criteria which characterize methods of ensuring hermeticity, mechanism of operation, and

constructional make-up sealing elements. Using the proposed classification, advanced construction characteristics have been selected, and an analysis of the operation of existing sealing unit constructions and auxiliary devices has been performed for conditions of cyclic loading by pressure or temperature. 9 refs.

Shvets, Yu.I.; Pogodin, V.K. *Chem Pet Eng* v 23 n 7-8 Jul-Aug 1987 p 317-321.

**093233 SAFEGUARDS SEALS ACTIVITIES UPDATE.** Ongoing commercial developments, some Department of Energy (DOE) contractor-initiated developments, and the desire to standardize seals and procedures stimulated the establishment of a seals task force to assess the current seals situation, develop reference material to assist in standardization, and recommend appropriate long-term activities. This paper summarizes the results of the task force effort and briefly discusses some of the more recent domestic seals developments. (Author abstract) 3 refs.

Waddoups, Ivan G. (Sandia Natl Lab, Albuquerque, NM, USA); Rao, Magal. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 192-196.

**Surfaces** See Also VALVES AND VALVE GEAR—Calculations.

**093234 FACE WAVINESS OF SPLIT SEALS.** Face waviness influences solid-to-solid contact and fluid pressure distribution, and controls fluid leakage of mechanical seals. Using Fourier series, the effects of misalignment on waviness can be studied. Analytical results show that the third cosine harmonic is the lowest-order harmonic not affected by misalignment. Three face height traces of a split seal ring were taken and analyzed. They were taken along the same waviness measurement track, but at different degrees of misalignment. Though their 'peak-to-valley' magnitudes change significantly, the third-harmonic cosine coefficients remain constant, which substantiates the analytical finding. (Edited author abstract). 1 Ref.

Lai, Tom W. (John-Crane-Houdaille, Morton Grove, IL, USA). *Tribol Trans* v 31 n 3 Jul 1988 p 335-338.

**Testing** See BIOMEDICAL ENGINEERING—Surgical Implants; NUCLEAR POWER PLANTS—Testing; PUMPS—Seals; RINGS—Testing; SAFETY VALVES—Design.

## Ultrasonic Applications

**093235 ULTRASONIC IDENTITY DATA STORAGE AND ARCHIVAL SYSTEM.** Ultrasonic seals are being used to determine if an underwater stored spent fuel container has been compromised and can be used to determine if a nuclear material container has been compromised. This paper has described a system designed to conveniently handle ultrasonic seal signature information. The concept centers on a main data base being located at IAEA headquarters, with the necessary interface to allow for the transfer of data using the SPAR bubble cassette. This system was installed at the IAEA in November, 1986, and is presently undergoing evaluation. (Edited author abstract) 5 refs.

McKenzie, J.M. (Sandia Natl Lab, Albuquerque, NM, USA); Self, B.G.; Walker, J.E. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 316-317.

## Vibrations

**093236 EFFECT OF TORSIONAL VIBRATIONS ON THE LEAKAGE FROM MODELS OF LABYRINTH SEALS.** The theoretical treatment of the oscillatory fluid motion resulting from the torsional vibration of a rotating shaft having labyrinth seals models of several geometrical configurations and for different values of the axial leakage velocity is considered here. Solutions for the so-called steady streaming components to order  $S^{-2}$



(S=the Strouhal or the frequency number) are presented in some detail. It was found here that the torsional vibrations may improve the performance of the labyrinth seal, have no effect and may worsen the performance depending on the model of the labyrinth seal selected. (Author abstract) 9 refs.

El-Gamal, Hassan (Alexandria Univ, Alexandria, Egypt); Awad, Taher; Saber, El-Sayed. *Modell Simul Control B* v 14 n 4 1988 p 11-22.

## Wear

**093237 MECHANISM OF HYDROGEN WEAR OF AUTOMOTIVE AND TRACTOR ENGINE WATER PUMP FACE SEALS.** We present the results of spectral, durametric, electron-microscope, and roentgenographic studies of water pump bearing face specimen microvolumes in contact with the sealing washer. It is shown that the process of destruction of the near-surface layers of the bearing face material is associated with the onset of tensile stresses due to significant increase of the hydrogen content in the hydridophylic zone. We identify the periodic nature of the change of the hydrogen concentration and the wear rate in time. We construct a mathematical model of the water pump bearing face hydrogen wear process; this model satisfactorily describes the experimental data. (Author abstract) 9 refs.

Madaminov, B.A.; Polyakov, S.A.; Burumkulov, F.Kh.; Andreeva, A.G. *Sov J Frict Wear* v 8 n 5 1987 p 85-92.

## SEAPLANES

### Design

**093238 SOME THOUGHTS ON POWER-AUGMENTED-RAM WING-IN-GROUND (PAR-WIG) EFFECT VEHICLE.** The PAR (power-augmented-ram) WIG (wing-in-ground) effect vehicle is highly promising as an overwater commuter transport vehicle. Three important requirements, the PAR effect, the ability of OGE (off ground effect) flight, and the ability of automatic IGE (in ground effect) flight, are described. Many useful materials for designing WIG effect vehicles are presented. New concepts are proposed which contain some new devices. The ability of "stick-free" IGE flight is especially desirable, and hence the phugoid mode should be suppressed sufficiently. (Edited author abstract). 13 Refs.

Ando, Shigenori (Nagoya Univ, Nagoya, Jpn). *Trans Jpn Soc Aeronaut Space Sci* v 31 n 91 May 1988 p 29-47.

**SEAWATER** See Also AEROSOLS—Atmospheric; CAST IRON—Stress Corrosion Cracking; COPPER COMPOUNDS—Oxidation; COPPER NICKEL ALLOYS—Corrosion; FLUE GASES—Desulfurization; GASES—Solubility; OCEANOGRAPHY—Remote Sensing; SEWAGE—Sedimentation; STAINLESS STEEL—Corrosion Resistance; STEEL—Corrosion; STEEL—Crack Propagation; STEEL CORROSION; STEEL CORROSION—Computer Aided Analysis; TUNGSTEN AND ALLOYS—Corrosion; WOOD—Environmental Testing.

**093239 BUBBLE MOTIONS IN SEA WATER.** This paper considers one aspect of the problems associated with bubbles in the wake of a surface ship. A method which has been developed for calculating the evolution and transport of bubbles is described. Results which were obtained with this method are presented and are compared with the limited experimental data which are available. Generally good agreement was found between the numerical and experimental results. Several areas are noted where further research is indicated. (Author abstract) 11 refs.

Miner, E.W. (US Naval Research Lab, Washington, DC, USA); Griffin, O.M.; Skop, R.A. *Ocean Phys Eng* v 12 n 1 1987 p 25-46.

**093240 KINETICS AND MECHANISM OF HYDROGEN SULFIDE OXIDATION IN SEA WATER.** Oxidation of hydrogen sulfide in sea water occurs mainly at the boundary of the aerobic and anaerobic zones, in the layer of coexistence of hydrogen sulfide and oxygen (C

layer). Hydrogen sulfide zones have begun to form as a result of anthropogenic influences on the shelf of the Black Sea. A prediction of the dynamics of the C layer has become an extremely urgent problem in connection with the threat to fisheries, development of agriculture, and recreational value of the Black Sea coast. The key problem when constructing appropriate predictive models for calculating the dynamics of the C layer is knowledge of the kinetics and mechanism of hydrogen sulfide oxidation in sea water and the dynamics of the mass transport of oxygen and hydrogen sulfide. This paper discusses oxidation agents and products, mathematical models and conditions of applicability, and other aspects of the subject. 42 refs.

Leonov, A.V. (Acad of Sciences of the USSR, USSR); Aizatullin, T.A. *Water Resour* v 14 n 1 Jan-Feb 1987 p 59-72.

**093241 ONE-DIMENSIONAL MODEL OF GAS EXCHANGE BETWEEN THE OCEAN AND ATMOSPHERE.** Discussed are the main processes which condition gas transfer through the boundary layer of water. With the aid of the equation of balance of turbulent energy we estimated the profile of the coefficient of turbulent diffusion in the viscous sublayer. We obtained a one-dimensional equation of orbital motion in a system of rest of the free surface for a flat wave with small curvature. A conclusion is formed about the independence of the amplitude of this movement from wavelength for gravity waves. Within the framework of the one-dimensional model of advective-diffusion transfer we studied the contribution of wave movement to gas exchange. It is shown that with a windspeed of 2-7 m/sec the dependence of gas exchange velocity on wind speed is close to linear. (Author abstract) 17 refs.

Degterev, A.Kh. *Sov Meteorol Hydrol* n 3 1987 p 99-102.

**093242 STABILITY AND DECAY OF FOAM IN SEA WATER.** Surface foam is produced by the entrainment of air in the form of small bubbles at and just beneath the water surface during white-capping, when steep waves break, and when a displacement ship moves through the water. The residence time of a single- or multi-layer foam at the surface depends on the stability of the bubbles in that layer. This paper presents the results of a study which examined the influence of salt content on the foaming ability of water and on the stability of a three-dimensional foam produced by blowing air through controlled laboratory samples of simulated sea water and a sample of sea water obtained from an Atlantic coastal site. The results clearly show that varying the salt content of a clean water sample between 0 and 16 ppt significantly influences its foaming ability and the corresponding stability of a layer of surface foam. (Edited author abstract) 32 refs.

Peltzer, Rodney D. (US Naval Research Lab, Washington, DC, USA); Criffin, Owen M. *Ocean Phys Eng* v 12 n 2 1987-1988 p 101-126.

**Analysis** See Also AIR POLLUTION—Environmental Impact; COASTAL ZONES—France; OCEANOGRAPHY—Caspian Sea; ORGANIC COMPOUNDS—Chemical Analysis; SEWAGE ANALYSIS; SEWAGE TREATMENT—Sludge Disposal; WATER POLLUTION—Marine Pollution; WATER POLLUTION—Oil Spills.

**093243 PRECONCENTRATION OF TRACE METALS FROM SEAWATER WITH 7-DODECENYL-8-QUINOLINOL IMPREGNATED MACROPOROUS RESIN.** 7-Dodeceny-8-quinolinol (DDQ) impregnated XAD-4 resin (DDQ resin) was prepared, and its extraction behavior was studied and compared with solvent extraction with DDQ for Ag, Al, Bi, Cd, Cu, Fe, Ga, Mn, Ni, Pb, and Ti. The results demonstrate that the DDQ resin is effective in the preconcentration of those metals from seawater. The column extraction method using the DDQ resin was applied to seawater analysis with satisfactory results being obtained. (Author abstract) 25 refs.

Isshiki, Kenji (Kyoto Univ, Kyoto, Jpn); Tsuji, Fujimio; Kuwamoto, Tooru; Nakayama, Eiichiro. *Anal Chem* v 59

n 20 Oct 15 1987 p 2491-2495.

**093244 ORGANIC COMPOUNDS IN THE WATER COLUMN OF THE EASTERN BALTIC.** This article presents data on the content and composition of organic compounds (OCs) extractable by organic solvents from sea water and suspended material of eastern regions of the Baltic Sea (region adjacent to Klaipeda port, the Gulfs of Finland and Riga, and Kaliningrad and Kurisches Lagoons). The isolated OCs are a complex mixture of components arriving with allochthonous organic matter (OM) from technogenic sources and products of the synthesis of marine organisms. Study materials, methods and results are discussed. 6 refs.

Nemirovskaya, I.A. (Acad of Sciences of the USSR, USSR); Nesterova, M.P.; Pustel'nikov, O.S. *Water Resour* v 14 n 1 Jan-Feb 1987 p 79-86.

**093245 KADMIUMIN, LYLJYN JA KUPARIN PITOISUDET JA SITOUTUMINEN ORGAANISEEN MATERIAALIIN ITAMEREN MERIVEDESSA JA SEDIMENTISSA.** [Concentrations of Cadmium, Lead and Copper and Binding to Organic Matter in Water and Sediments of the Baltic Sea]. Anodic stripping voltammetry (ASV) is particularly suitable for trace metal analyses of sea water. In addition to total metal concentrations, the method allows the degree of complexation of trace metals to natural organic material to be determined. In the Gulf of Bothnia and the Gulf of Finland, the concentrations of cadmium and copper are similar to those in oceanic surface water, while the concentration of lead is somewhat higher. About half of the copper is bound to dissolved organic matter. (Edited author abstract) 37 refs. In Finnish.

Perttälä, Matti (Merentutkimuslaitos, Helsinki, Finl); Scheinin, Helvi; Halkkonen, Petri; Revitzer, Hannu; Bordin, Guy. *Kem Kem* v 14 n 9 1987 p 741-745.

**093246 INVESTIGATION OF THE MODIFIED FOULING INDEX AS A TEST FOR PLUGGING POTENTIAL OF PRETREATED SEAWATER.** The pretreatment of raw seawater is necessary to reduce the fouling of reverse osmosis membranes and increase run length. To measure the plugging potential of pretreated feedwater, the modified fouling index was tested using both control suspensions and pretreated seawater. The defining equation was found to adequately describe the process. By distinguishing between the various filtration mechanisms, the modified fouling index was found to be more precise than other plugging indexes. A scheme is presented for the in situ, computer controlled measurement of the modified fouling index. (Author abstract) 16 refs.

van der Vaart, D.R. (NC State Univ, Raleigh, NC, USA); Stahel, E.P. *Desalination* v 68 n 1 Jan 1988 p 45-56.

**093247 HYDROTHERMAL CH<sub>4</sub> BETWEEN 12°N AND 15°N OVER THE MID-ATLANTIC RIDGE.** Hydrothermal effluents enriched in gases such as helium, hydrogen and methane have been found outgassing from mid-ocean ridge zones, crustal rifts, volcanoes and other areas of tectonic activity. Although methane is not conservative in seawater, its analysis on board ship can be used qualitatively or semi-quantitatively to locate hydrothermal fields as a cruise progresses. Between 12° and 15°N over the Mid-Atlantic Ridge, CH<sub>4</sub> anomalies (up to 44 nl l<sup>-1</sup>) in the water column reveal the presence of plumes originating from hydrothermal discharge. The large amplitude of the CH<sub>4</sub> anomaly at one station (Hy-36) integrated over more than 1000 m, reflects a large CH<sub>4</sub> input and thus extensive hydrothermal activity in this slow spreading section similar to inputs from fast spreading sites like the East Pacific Rise. (Author abstract) 50 refs.

Charlou, Jean Luc (IFREMER/Cent de Brest, Brest, Fr); Dmitriev, Leonid; Bougault, Henri; Needham, Hubert David. *Izv Akad Nauk SSSR Fiz Atmos Okeana* v 23 n 9 Sep 1987 p 121-131.



**093248 pH OF THE WATER OF THE BLACK SEA.** Materials of five expeditions were used to study the spatial distribution of pH in the water of the Black Sea. Anomalies of the vertical distribution of pH, not described in the literature, and the major factors determining the structure of the vertical distribution of pH in the 0-300 m water layer are established. A mathematical model of the development of the vertical structure of the pH in the layer of coexistence of  $O_2$  and  $H_2S$  is constructed which considers hydrodynamic factors and the process of oxidation of hydrogen sulfide. (Author abstract) 10 refs.

Kononov, S.K.; Ryabinin, A.I. *Sov Meteorol Hydrol* n 10 1987 p 59-64.

**093249 COULOMETRIC DETERMINATION OF HYDROPEROXIDES IN SEA WATER.** A method is proposed for coulometric determination of hydroperoxides in sea water on the basis of an investigation of the conditions of extraction of petroleum products (hydrocarbon hydroperoxides) from sea water, their reaction with iodide ions in a chloride-ethanol-acetonitrile solution, and the conditions of electrogeneration of tin (II) titrant in an alcohol hydrochloric acid solution. (Author abstract) 7 refs.

Radaev, E.F.; Shamsutdinova, L.G. *Sov J Water Chem Technol* v 9 n 5 1987 p 61-64.

**093250 TRITIUM CONTENT IN THE WHITE, BARENTS, KARA, AND JAPAN SEAS.** The degree of tritium pollution of the White, Barents, Kara, and Japan Seas is estimated. The ratio of the water of the Barents Sea proper entering the White Sea basin and the return water of the White Sea proper is roughly 1:3.5. With the values used in this work for the water constituents of the balance and concentrations of tritium in them the main contributor (on the order of 75%) to the input and (on the order of 89%) to the output portions of the tritium reserve in the White Sea basin is the water exchange with the Barents Sea through the throat and funnel. (Author abstract) 11 refs.

Vakulovskii, S.M. (Inst of Experimental Meteorology, USSR); Katrich, I. Yu.; Roslyi, E.I. *Sov Meteorol Hydrol* n 12 1987 p 59-64.

**Applications** See BIOGAS—Synthesis; OIL WELL PRODUCTION—Thermal.

## Beryllium Determination

**093251 DISTRIBUTION OF  $^{10}Be$  AND  $^9Be$  IN OCEAN WATER.** The vertical distributions of  $^{10}Be$  and  $^9Be$  have been measured at several locations in the Pacific and the North Atlantic. The results from the Pacific show that both isotopes exhibit nutrientlike profiles resulting from participation in the cycling of marine particulates. The  $^{10}Be/^9Be$  ratios from the different stations vary from  $1$  to  $3 \times 10^{-7}$  in the mixed layer but tend towards a value close to  $1.1 \times 10^{-7}$  in the deep ocean. Profiles from North Atlantic stations show a lower deep-water  $^{10}Be/^9Be$  ratio of about  $6 \times 10^{-8}$ . (Author abstract) 16 refs.

Kusakabe, M. (Univ of Southern California, Los Angeles, CA, USA); Ku, T.L.; Southon, J.R.; Vogel, J.S.; Nelson, D.E.; Measures, C.I.; Nozaki, Y. *Nucl Instrum Methods Phys Res Sect B* v B29 n 1-2 Nov II 1987, Accel Mass Spectrom, Proc of the Fourth Int Symp, Niagara-on-the-Lake, Ont, Can, Apr 27-30 1987 p 306-310.

**Bubble Formation** See OCEANOGRAPHY.

## Carbon Determination

**093252 AMS  $^{14}C$  MEASUREMENT OF SMALL VOLUME OCEANIC WATER SAMPLES: EXPERIMENTAL PROCEDURE AND COMPARISON WITH LOW-LEVEL COUNTING TECHNIQUE.** The technique for small volume oceanic AMS  $^{14}C$  measurement is described. The procedure includes sampling,  $CO_2$  extraction from the water samples; target preparation and measurement at the ETH/SIN AMS facility. AMS  $^{14}C$  data from a station in the southern Weddell Sea with an accuracy of  $\pm 5\%$  are presented. The data are in good

agreement with large volume  $^{14}C$  measurements done by conventional low-level counting techniques with an accuracy of  $\pm 2\%$ . (Author abstract) 8 refs.

Kromer, B. (Univ Heidelberg, Heidelberg, West Ger); Pfeleiderer, C.; Schlosser, P.; Levin, I.; Muennich, K.O.; Bonani, G.; Suter, M.; Woelfli, W. *Nucl Instrum Methods Phys Res Sect B* v B29 n 1-2 Nov II 1987, Accel Mass Spectrom, Proc of the Fourth Int Symp, Niagara-on-the-Lake, Ont, Can, Apr 27-30 1987 p 302-305.

**Chemistry** See ATMOSPHERIC COMPOSITION.

## Composition Effects

**093253 INFLUENCE DES ACIDES FAIBLES DISSOUS DANS L'EAU DE MER SUR LA VALEUR DU COEFFICIENT D'ABSORPTION DES ONDES ACOUSTIQUES AUX BASSES FREQUENCES.** [Influence of Weak Acids Dissolved in Seawater on the Absorption Coefficient of Low Frequency Acoustic Waves]. Measurements of relaxation in aqueous solutions of boric acid with different weak acids added were carried out using the temperature jump method. The measurements indicate a modification of the relaxation role of boric acid. In French. 3 refs.

Watson, G. (CNRS, Strasbourg, Fr); Mallo, P. *Acustica* v 64 n 4 Oct 1987 p 219-220.

**Corrosive Effects** See Also PAINT; STAINLESS STEEL—Corrosion Resistance.

**093254 SOCIETY OF CHEMICAL INDUSTRY MATERIALS PRESERVATION GROUP, PAPERS PRESENTED AT THE CONFERENCE ON CHLORINATION OF SEAWATER SYSTEMS AND ITS EFFECT ON CORROSION.** This conference proceedings contains 6 papers on chlorination of seawater systems and its effect on corrosion of the water supply systems for production platforms and the seawater desalination plants. The results of some research on fouling organisms and chlorination as fouling prevention is discussed. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10728 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Society of Chemical Industry, Materials Preservation Group, London, Engl). *Soc of Chem Ind Mat Pres Group, Pap Presented at the Conf on Chlorination of Seawater Syst and Its Eff on Corros, Birmingham, Engl, Mar 4 1986* Publ by Society of Chemical Industry, London, Engl, 1986 var pagings.

**Decontamination** See WATER POLLUTION—Oil Spills.

## Distillation

**093255 SEAWATER DISTILLATION UTILISING SALT-GRADIENT SOLAR POND ENERGY SYSTEMS - A REVIEW PAPER.** The concept of salt-gradient solar pond energy systems is outlined. The technology of solar ponds with regard to site selection, construction, establishment, maintenance, stability, heat extraction, efficiency, fouling, leakages, environmental aspects, and cost considerations are briefly reviewed. Design requirements for solar distillation plants are discussed. Different types of distillation plants are considered. Plants which match best with solar pond energy systems are identified. These plants are mainly designed to operate in remote and arid regions of the world. (Author abstract) 104 refs.

Al-Zubaidi, A.A.J. *IDA Mag* v 1 n 5 Jun 1987 p 17-30.

## Electrolysis

**093256 EFFECT OF ANION COMPOSITION OF THE ELECTROLYTE ON ACTIVE CHLORINE CURRENT YIELD IN THE ELECTROLYSIS OF SEA AND BRACKISH WATERS.** The goal of the present investigation was to study the effect of the main ions present in natural waters on the current yield of active chlorine during electrolysis of the water using the promis-

ing anode materials ruthenium oxide-titanium anodes (ROTA), magnetite-titanium anodes (MTA), and platinum-titanium anodes (PTA). As a comparison, a graphite anode was used in a number of experiments. The results obtained may be used to design plants for production of AC by direct electrolysis of sea and brackish waters. 5 refs.

Slipchenko, A.V. (Dumanskii Inst of Colloidal Chemistry & Water Chemistry, Kiev, USSR); Savluk, O.S.; Borisov, Yu.S. *Sov J Water Chem Technol* v 9 n 2 1987 p 74-77.

## Environmental Testing

**093257 MULTI-SEDIMENT-TRAP STUDY ON THE TEMPORAL AND SPATIAL VARIABILITY OF POLYCYCLIC AROMATIC HYDROCARBONS AND LEAD IN AN ANTHROPOGENIC INFLUENCED ARCHIPELAGO.** Sixteen sediment traps have been used to collect seston for more than 8 months to study the spatial and temporal distribution of 18 PAH compounds and lead in the Stockholm archipelago (Baltic Proper). Concentrations and especially fluxes exhibit a steep logarithmic decline with distance from urban areas. PAH concentrations and fluxes are higher during the winter-spring period than during the summer due to increased emissions, more extensive washout of land-deposited PAH during snow melting, and resuspension caused by nonstratified water conditions and mixing zone effects. Results indicate that air-transported black carbon particles from a variety of 'nonpoint' pollution sources are the probable main carriers of PAH in combination with particles from direct runoff for the stations in the immediate surroundings of the urban area. (Edited author abstract). 76 Refs.

Broman, Dag (Univ of Stockholm, Stockholm, Sweden); Colmsjo, Anders; Ganning, Bjorn; Naf, Carina; Zebuhr, Yngve. *Environ Sci Technol* v 22 n 10 Oct 1988 p 1219-1228.

**Filtration** See Also SANDSTONE.

**093258 CROSS-FLOW MEMBRANE FILTRATION OF SEA WATER.** Large tubular membranes, developed for the continuous treatment of hazardous liquid wastes, particularly those containing heavy metals, at rates up to  $100m^3/h$ , have been evaluated over the past two years for use with sea water, large volumes of which are required for injection into offshore oil reservoirs. Required quality of water is typically 95-98% removal of particles greater than  $2\mu m$ , with volumes of water up to  $2,600m^3/h$ . Although the 'dead-end' separation efficiency of the coarsest membranes was probably adequate for this sea water application, in the cross-flow mode the active filtration surface is believed to be 'dynamic membrane' formed by deposition of solids on the membrane surface. Under these conditions, the separation efficiency of even the coarsest membranes was very high. (Edited author abstract) 5 refs.

Abdel-Ghani, M.S. (Imperial Coll, London, Engl); Jones, R.E.; Wilson, F.G. *Filtr Sep* v 25 n 2 Mar-Apr 1988 p 105-109.

**Heat Capacity** See WATER—Specific Heat.

## Heat Transfer

**093259 MODELLING SEA SURFACE TEMPERATURE RISE RESULTING FROM INCREASING ATMOSPHERIC CARBON DIOXIDE CONCENTRATIONS.** Concern over the role of the oceans in a warming world, likely to result from increasing atmospheric carbon dioxide, has prompted analysis using simple models. Results from two recent, independent studies using a simple box-diffusion model suggest that over the last 130 years, observations and models are not in disagreement. Although a diffusive deep ocean was indeed included in this simplistic model, it is suggested here that the resulting ocean model offers an oversimplistic view of the oceanic contribution to the overall global atmosphere-ocean climate system and that it is necessary to add a convective capability to the water column. Using this approach it is suggested that, on a timescale of a century, the sea surface



temperature increase is likely to be less by a factor of at least 3 than that previously forecast. (Author abstract) 26 refs.

Henderson-Sellers, B. (Univ of Salford, Salford, Engl). *Clim Change* v 11 n 3 Dec 1987 p 349-359.

**Industrial Applications** See **ELECTRIC POWER PLANTS—Cooling Water.**

## Ion Exchange

**093260 THOROUGH SOFTENING OF SEA WATER BY STAGED-COUNTERCURRENT Na-CATION TREATMENT.** The possibility is investigated of thorough softening of Caspian Sea water by staged-countercurrent (s-c) Na-cation treatment. A method is developed for evaluating the feasibility of regeneration of the second stages of s-c filters with the spent regeneration solution of the preceding regeneration. Empirical formulas and regression equations are derived to describe the effect of the principal factors on the technological indices of secondary softening. The optimal ratio is determined for volumes of media of s-c filter stages, providing placement of 10-15% of the total media in the second stage. (Author abstract) 5 refs.

Abdullaev, K.M.; Agamaliyev, M.M.; Krikun, M.M.; Davydov, G.M. *Sov J Water Chem Technol* v 9 n 6 1987 p 83-87.

## Mass Transfer

**093261 CONCERNING A MECHANISM OF SALT TRANSFER IN A STRATIFIED FLUID.** A two-phase model of unsteady salt transfer is considered for a fluid consisting of turbulent spots and laminar interlayers. A relation is proposed for the dependence of the turbulent flow on the difference between the salt content in the spots and the interlayers. Estimates of the value of the proportionality coefficient are obtained for the salt transfer intensity and the salt boundary motion velocity for typical conditions of existence of the salt-water and fresh-water lenses in the ocean. (Edited author abstract) In Russian. 10 refs.

Gavrilin, B.L.; Domanov, M.M. *Izv Akad Nauk SSSR Fiz Atmos Okeana* v 23 n 11 Nov 1987 p 1174-1178.

## Optical Properties

**093262 INTENSITY OF LIGHT REFLECTED FROM A SEA SURFACE.** A study is made of the reflection of light from a rough sea surface with allowance for single and double reflection. Detailed consideration is given to the brightness distribution in the vicinity of a caustic, i.e., in a domain where the geometric-optic approximation can not be applied. An explicit expression is found for the parameter that determines the reflected light distribution in the caustic zone. The total energy flux within the caustic zone is estimated. Concrete evaluations are presented for a sinusoidal surface. (Edited author abstract) In Russian. 8 refs.

Shifrin, K.S.; Gardashov, R.G. *Izv Akad Nauk SSSR Fiz Atmos Okeana* v 23 n 4 Apr 1987 p 415-422.

**093263 FLUCTUATIONS OF THE INFRARED RADIATION OF A ROUGH SEA.** On the basis of a stochastic facet model of a rough sea surface, a general expression for the variance of the infrared sea brightness is obtained. Convenient formulas are presented for applied calculations. Examples of calculations for the 10- $\mu$ m wavelength are presented. A physical interpretation of the results obtained is given. (Edited author abstract) In Russian. 14 refs.

Demidov, E.F.; Lukina, E.V. *Izv Akad Nauk SSSR Fiz Atmos Okeana* v 23 n 4 Apr 1987 p 423-429.

**093264 RELATION BETWEEN OPTICAL TRANSFER FUNCTION AND NATURAL LIGHT FIELD IN THE SEA OR ATMOSPHERE.** In this paper relationship between the optical transfer function of sea water and the distribution of natural radiance field in the sea is

simply and directly determined based on the transform model of the sea-radiance transfer. The variance of the angle spectrum of the sea radiance field is analysed. A new simple method of estimating the distribution of the sea radiance field and measuring the optical transfer function of the sea water is proposed. The method is perfectly suitable for the atmospheric circumstances. (Author abstract) 11 refs. In Chinese.

Liu, Zhishen (Shandong Coll of Oceanography, China); Huang, Xiaosheng; He, Mingxia; Zhang, Zhiming. *Guangxue Xuebao* v 7 n 8 Aug 1987 p 707-713.

**093265 ZOOPLANKTON GRAZERS AS TRANSFORMERS OF OCEAN OPTICS: A DYNAMIC MODEL.** A model was developed, based on data collected in the Southern California Bight region, to assess the effect of zooplankton grazing on the attenuation of light due to suspended particles. Diel vertical distribution and grazing activity of the principal zooplankton grazers in the coastal waters of southern California were studied during mid-March, 1986. Model parameters are temperature, particle doubling rate, particle size-frequency distribution, zooplankton grazing efficiency and zooplankton size-frequency distribution. With parameters at their standard values, the diffuse attenuation coefficient,  $K_d$ , remains approximately constant, decreasing by only 3.5% in one 24-h cycle. The model is most sensitive to changes in temperature and, secondly, to changes in the abundance of grazers. Additional aspects of the subject are discussed. (Edited author abstract) 82 refs.

Huntley, Mark E. (Scripps Inst of Oceanography, LaJolla, CA, USA); Marin, Victor; Escritor, Florence. *J Mar Res* v 45 n 4 Nov 1987 p 911-945.

**093266 EMISSIVITY OF PURE AND SEA WATERS FOR THE MODEL SEA SURFACE IN THE INFRARED WINDOW REGIONS.** Emissivity of pure and sea waters for the model sea surface is tabulated as a function of the zenith angle of observed radiation ( $\theta$ ) and the surface wind speed in the infrared window regions, 3.5-4.1  $\mu$ m and 8-13  $\mu$ m. The sea surface is simulated by many facets whose slopes are changed according to the isotropic Gaussian distribution with respect to surface wind. Emissivity is also computed for the plane surface condition. Computational results show that 1) emissivity decreases slowly with the increase of  $\theta$ , 2) little effect of the surface wind is noted on emissivity for  $\theta \leq 30^\circ$ , whereas this effect greatly appear for  $\theta \geq 70^\circ$ , and 3) relative difference of emissivities between pure water and sea water is less than 0.1% within  $\theta = 50^\circ$  for wind speed less than 15 m/s. Finally, the corresponding apparent temperatures are also examined. (Author abstract) 10 refs.

Masuda, K. (Meteorological Research Inst, Tsukuba, Jpn); Takashima, T.; Takayama, Y. *Remote Sens Environ* v 24 n 2 Mar 1988 p 313-329.

## Phase Equilibria

**093267 PHASE EQUILIBRIA IN THE Na, K, Mg, Ca/SO<sub>4</sub>, Cl-H<sub>2</sub>O SYSTEM AT 25°C.** The structure of the diagram of phase equilibria in the Na, K, Mg, Ca/SO<sub>4</sub>, Cl-H<sub>2</sub>O six-component system at 25°C was investigated by the translation method. The presence of 41 sixfold nonvariant points was established, of which 33 are formed by straight-through translation and one is formed by unidirectional translation. Seven nonvariant points were established for the outlined trisaturation fields of solid phase in the region of the sixfold composition. A schematic structure of the acranite fragment of the investigated system is presented. (Author abstract) 12 refs.

Soliev, L.; Goroshchenko, Ya.G. *Sov Prog Chem* v 53 n 5 1987 p 12-16.

**Processing** See **LITHIUM AND ALLOYS—Recovery; URANIUM AND ALLOYS—Recovery.**

## Radioactivity

**093268 INFLUENCE OF THE ARRIVAL OF RADIOACTIVE INDUSTRIALLY CONTAMINATED NORTH SEA WATER UPON THE RADIATION CONDITIONS IN THE BALTIC SEA.** The present work is a continuation of the author's preceding research on the radiation influence which North Sea waters contaminated by the effluents of the West European radiochemical plants have upon the conditions in the Baltic Sea. It was established by these investigations that practically the entire water area of the Baltic Sea is covered by industrial radioactive contamination to various extents. As in the past years, the highest levels of the industrial contamination are observed in the Southwestern part of the Baltic Sea. It follows that the <sup>134</sup>Cs which is missing in the global source is a much better radioactive indicator of industrial radioactive contamination than <sup>137</sup>Cs which enters into the sea water as precipitant from the atmosphere as well as via river water. 12 refs.

Vakulovskii, S.M.; Nikitin, A.I.; Chumichev, V.B. *Sov At Energy* v 62 n 2 Feb 1987 p 126-130.

**093269 ARTIFICIAL RADIONUCLIDES IN THE SURFACE WATERS OF THE BALTIC SEA AND THE NORTH SEA IN THE FALL OF 1984.** Regular observations of the radioactivity of the surface waters of the Baltic Sea helped to establish the laws governing the appearance and the change in the concentration fields of a number of artificial radionuclides. The author compares in this paper data obtained in the fall of 1984 with the results reported in the literature. 9 refs.

Kadzhene, G.I.; Kortokov, V.P.; Mironov, V.K.; Kleiza, I.V.; Lukinskene, M.V.; Styro, D.B. *Sov At Energy* v 62 n 4 Apr 1987 p 292-296.

**093270 SOURCES OF RADIOACTIVITY IN THE OCEAN ENVIRONMENT: FROM LOW LEVEL WASTE TO NUCLEAR POWERED SUBMARINES.** This paper summarizes both natural and man-made radioactivity in the marine environment. Radioactivity occurs naturally in both the sea water and in the ocean sediment. Radioactivity in the sea water is fairly uniform geographically and is dominated by the naturally occurring isotope K (potassium-40). Unlike sea water, sediment radiation levels vary with sediment type and location. The primary source of natural radiation in the sediment results from deposition of insoluble thorium isotopes formed by the decay of water-soluble uranium. Man-made sources of radioactivity arise from, in descending order of importance: sinking of two U.S. and two Soviet nuclear submarines; fallout from nuclear weapons testing; dumping of primarily British and American low-level nuclear waste; and dumping of reprocessing plant radiated effluents from the British Windscale facility and other European and Indian reprocessing facilities. (Author abstract). 6 refs.

Solomon, Kenneth Alvin (Rand Corp, Santa Monica, CA, USA). *J Hazard Mater* v 18 n 3 Jun 1988 p 255-262.

**Remote Sensing** See Also **OCEANOGRAPHY—Currents.**

**093271 COVER: CIRCULATION PATTERNS IN AVHRR IMAGERY.** AVHRR data have been used to study sea surface temperatures (SSTs) in the north east Atlantic and around the eastern coast of Scotland in an attempt to examine the development of circulation patterns in these waters. It is shown that within the Rockall Trough mesoscale eddies appear to dominate the mixing process allowing the transfer of heat, salt and nutrients between respective water bodies. Cyclonic eddies are most prevalent, as is to be expected in the Northern Hemisphere, but some anti-cyclonic activity is also evident. Differences between satellite-derived and buoy temperatures were of the order of 1.0 deg C and this error is thought to be due to a combination of the positional accuracy of the rectification algorithms, possible surface skin and wind effects, and the global nature of MCSST (Multi-Channel Split Window) algorithms together with the inherent problem of identifying a point buoy measure-



ment with an average satellite value. 5 refs.

Vaughan, R.A. (Univ of Dundee, Dundee, Scotl); Downey, I.D. *Int J Remote Sens* v 9 n 4 Apr 1988 p 597-600.

**093272 EFFECT OF DISSOLVED 'YELLOW SUBSTANCE' ON THE QUANTITATIVE RETRIEVAL OF CHLOROPHYLL AND TOTAL SUSPENDED SEDIMENT CONCENTRATIONS FROM REMOTE MEASUREMENTS OF WATER COLOUR.** The effect of the dissolved 'yellow substance' on the quantitative retrieval of chlorophyll and suspended sediment concentrations from remote measurements of water color, has been investigated through a sensitivity analysis applied to theoretical simulations. Two different models for yellow substance absorption, derived from experimental observations, have been used in the computation. The results obtained showed important effects, leading to the conclusions that the presence of yellow substance must be taken into careful account in the process of inferring water composition for its color signature. (Author abstract) 21 refs.

Tassan, S. (Commission of European Communities, Ispra, Italy). *Int J Remote Sens* v 9 n 4 Apr 1988 p 787-797.

**Salt Removal** See Also DESALINATION: DISTILLATION EQUIPMENT—Testing; EVAPORATORS—Mathematical Models; STEAM POWER PLANTS—Dubai; United Arab Emirates; WIND TURBINES—Applications.

**093273 DESIGN AND FIELD TESTS OF A MEMBRANE DISTILLATION SYSTEM FOR SEAWATER DESALINATION.** The design of the cassettes, the units forming a desalination module, is described in some detail. The stacking of the cassettes in a module is illustrated. A description is given of the field-test system. The measuring equipment and the test arrangements are described. Comparisons between the theoretically calculated and the actual performance are made, and an imperfection factor is introduced. The variation of this factor as a function of various operation parameters is shown. Graphic illustrations of the theoretical influence on performance of main system parameters are presented. (Author abstract) 1 ref.

Kjellander, Nils (Swedish Natl Development Co, Stockholm, Swed). *Desalination* v 61 n 3 Oct 1987 p 237-243.

**093274 NEW REVERSE OSMOSIS PLANT AT GLEN ROCKY, GIBRALTAR.** For very many years, the water supply in Gibraltar for domestic and military purposes has depended upon some form of desalination. Until recent times this demand was met by various types of distillation plants exploiting improvements in distillation technology to enhance performance and reduce energy consumption. The need to meet water demand and at the same time, minimize consumption of energy has led to the installation of reverse osmosis systems. This paper reports the recent installation set to work at Glen Rocky for the Property Services Agency on behalf of the Ministry of Defence.

Turner, A.G. (Weir Westgarth Ltd); Querns, W.R. *IDA Mag* v 1 n 10 Feb 1988 p 23-29.

**093275 EXPERIMENTS ON SEAWATER DESALINATION BY MEMBRANE DISTILLATION.** Application of membrane technology in the sugar industry as a result of the development of new membrane materials is discussed. (Edited author abstract).

Kubota, Shoji (Water Re-Use Promotion Cent, Tokyo, Jpn); Ohta, Keichi; Hayano, Ichiro; Hirai, Mitsuyoshi; Kikuchi, Kunio; Murayama, Yoshio. *Desalination* v 69 n 1 Jun 1988 p 19-26.

## Sampling

**093276 UPTAKE OF CALCIUM AND MAGNESIUM FROM THE ARABIAN GULF WATER ON PLASTIC AND GLASS SURFACES.** The uptake of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  from the Arabian Gulf water on walls of plastic and glass bottles was followed at room temperature for contact times up to 360 h. Both ions are physically

adsorbed in two distinct species, which can be leached out by water and acid elution, successively. The amounts adsorbed are too little to be of practical interest. Both plastic and glass bottles can be safely used to collect and store seawater samples. (Author abstract) 7 refs.

Shams El Din, A.M. (Material Testing Lab, Abu Dhabi, United Arab Emirates); Mohammed, Rizk A. *Desalination* v 61 n 3 Oct 1987 p 245-248.

**093277 INCIDENCE OF YEASTS IN COASTAL SEA WATER OF THE ATTICA PENINSULA, GREECE.** Coastal sea water from 15 locations around the Attica peninsula, Greece, were collected and analyzed for the presence of yeasts on three occasions during 1984. Yeast cell densities ranged from 30 to 1020 CFU 50 ml<sup>-1</sup>. There was a marked increase in yeast cell densities during the summer months. A total of 30 yeast species were recorded, single sampling stations yielding from 8 to 27 species. Qualitative differences between sites were consistent throughout the sampling period. Potentially pathogenic species, often in high numbers, were recorded from many stations, the most common being *Rhodotorula* spp, *Candida* spp, and *Torulopsis glabrata*. (Edited author abstract) 23 refs.

Velegraki-Abel, A. (Athens Sch of Hygiene, Athens, Greece); Marselou-Kinti, U.; Richardson, C. *Water Res* v 21 n 11 Nov 1987 p 1363-1369.

## Surfaces

**093278 MODELING OF THE SEA SURFACE FOR DAYLIGHT IMAGERY STUDIES.** Plastic-coated paper is shown to possess reflectivity characteristics quite similar to those of the surface of water. This correspondence has been used with a conversion factor to model a sea surface by means of plastic-coated paper. Such a paper model is then suitably illuminated and photographed, yielding physically simulated daylight imagery of the sea surface under controlled conditions. A simple example of sinusoidal surface simulation is described. 5 refs.

Naidu, P.S. (Indian Inst of Technology, Bangalore, India); Reddy, Y.V. *IEEE J Oceanic Eng* v 13 n 3 Apr 1988 p 81-83.

**093279 LASER SEA SURFACE SENSING FROM AN AIRCRAFT.** One can use the statistics of the flashes produced by a narrow laser beam scanning over the sea in sensing the characteristics of the small-scale waves and determining the wave spectrum. Theoretical studies on the statistical characteristics of this random sequence have taken the sea surface as frozen, which is justified if the speed is  $v_c \gg c$ , where  $c$  is the characteristic speed of the surface waves. Here the authors give a method of calculating these characteristics with allowance for the wave motion, where experiments on that basis are analyzed. 5 refs.

Shevchenko, T.B.; Shugan, I.V. *Bull Acad Sci USSR Phys Ser* v 51 n 8 1987, Proc of the Fifth All-Union Conf on Laser Opt, Leningrad, USSR, Jan 1987 p 28-31.

**Temperature Measurement** See Also RADAR IMAGING.

**093280 METHODOLOGY FOR AN OPERATIONAL MONITORING OF REMOTELY-SENSED SEA SURFACE TEMPERATURES IN INDONESIA.** Operational sea surface temperature (SST) monitoring was tested with the study of large-scale SST features in Indonesia from July 1981 to June 1985. Digital data were provided by digitizing 208 weekly SST charts of NOAA-NESS. The pixel size corresponded to 1°15' longitude and latitude. These data displayed a 0.5 deg K r.m.s. error compared with 1985 in situ measurements. Iterative interactive factorial analyses combined with a parallelepiped classifier as a clustering technique enhanced the SST spatio-temporal features. The study area was divided into zones in which pixels had similar SST profiles and dates of occurrence of thermal anomalies were pointed out. Sea fronts and upwellings were mapped through spatio-temporal analyses of thermal gradients.

This study stresses the possibility of operational SST monitoring for Indonesia, allowing simple data manipulation with hardware easily maintained locally. (Author abstract) 20 refs.

Gastellu-Etchegorry, J.P. (Gadjah Mada Univ, Yogyakarta, Indonesia); Boely, T. *Int J Remote Sens* v 9 n 3 Mar 1988 p 423-438.

## Thermodynamics

**093281 ESTIMATION OF ION PRODUCT OF WATER IN SEA WATER.** The equations of Sweeton, Mesmer, and Baes, of Marshall and Mesmer, and of Marshall and Franck, which were found useful in estimating the ion product of pure water at different temperatures and pressures, have now been applied for predicting the ion product of water in sea water at 0 and 25°C and up to 1000 bar pressure. By introduction of the density of sea water at a given pressure, the equation of Marshall and Franck describes some reliably calculated values for the ion product of water in sea water. The equation of Sweeton, Mesmer, and Baes with an added density relationship based on the equation of Marshall and Franck also provides these values. (Author abstract) 8 refs.

Kumar, Anil (Univ of Karlsruhe, Karlsruhe, West Ger). *J Chem Eng Data* v 33 n 1 Jan 1988 p 48-49.

## Trace Analysis

**093282 DIRECT DETERMINATION OF DISSOLVED COBALT AND NICKEL IN SEAWATER BY DIFFERENTIAL PULSE CATHODIC STRIPPING VOLTAMMETRY PRECEDED BY ADSORPTIVE COLLECTION OF CYCLOHEXANE-1,2-DIONE DIOXIME COMPLEXES.** A highly sensitive voltammetric technique was developed for the direct determination of cobalt and nickel in seawater at picomolar and nanomolar concentrations, respectively. Detailed experiments were conducted to determine the optimal ligand type and concentration, buffer type and concentration, pH, and desorption potential. Replicate analyses of seawater reference materials yielded excellent agreement with certified values. Analytical precision for Co and Ni at coastal and open ocean concentrations was approximately  $\pm 5\%$  relative standard deviation. (Edited author abstract) 20 refs.

Donat, John R. (Univ of California, Santa Cruz, CA, USA); Bruland, Kenneth W. *Anal Chem* v 60 n 3 Feb 1988 p 240-244.

**093283 DETERMINATION OF TRACE METALS IN SEAWATER BY GRAPHITE FURNACE ATOMIC ABSORPTION SPECTROMETRY AFTER PRECONCENTRATION USING SYNERGISTIC EXTRACTION.** Trace Cd, Mn, Pb, Co, Ni, and Cu have been quantitatively separated and concentrated from seawater matrices with a low concentration (mmol dm<sup>-3</sup> level) of 1,1,1-trifluoro-4-mercapto-4-(2-thienyl)-3-buten-2-one and triethylphosphine oxide cyclohexane solution. The synergistic extract was directly injected into the furnace and a reproducible signal with little memory effect was obtained. The extracted adduct enhanced the AAS sensitivity during thermal decomposition processes, and simultaneously resulted in depression of the interferences. The detection limits of the analytes ranged from several ng dm<sup>-3</sup> to 100 ng dm<sup>-3</sup>. The proposed technique provides both the preconcentration and determination for trace analysis by a single extraction using a small volume of sample. Coastal seawater samples were analyzed by the method. (Author abstract). 16 refs.

Ueda, Kazumasa (Kanazawa Univ, Kanazawa, Jpn); Kubo, Katsutoshi; Yoshimura, Osamu; Yamamoto, Yoshikazu. *Bull Chem Soc Jpn* v 61 n 8 Aug 1988 p 2791-2795.



## SEAWEED

## Analysis

**093284 ACCUMULATION DES METAUX LOURDS PAR CYSTOSEIRA BARBATA FORMA REPENS. APPLICATIONS BIOTECHNOLOGIQUES.** [Accumulation of Heavy Metals by *Cystoseira Barbata Forma Repens*: Biotechnological Applications]. The ability of *Cystoseira barbata* f. *Repens*, a brown seaweed, to accumulate heavy metals was studied for possible applications in marine or lagoon decontamination. Weed was sampled in its natural environment and cultivated in filtered seawater containing Cd, Cu, Pb or Zn. The effects of the kind of metal and of concentration on growth and morphogenesis were studied. The effect on these two features varied from one pollutant to another. However, *C. barbata* f. *repens* took up heavy metals in all cases with fairly high concentration factors: approximately 1300 for copper, 300 to 400 for the other metals. Concentrations of Cu, Cd, Pb and Zn in the weed reached 50, 1, 5.6 and 50 mg g<sup>-1</sup> dry weight respectively. This species could therefore be used for the decontamination of certain marine environments. (Author abstract) In French. 22 refs.

Rochilly, C. (Univ de Provence, Marseille, Fr); Beraïl, G.; Pellegrini, M.; Galea, J.; Massiani, C. *J Fr Hydrol* v 18 n 2-3 1987 p 103-115.

## Drying

**093285 PRESERVATION OF SARGASSUM TENNERIMUM J. AG. WITH FORMALIN AND OPEN-AIR DRYING AND ITS EFFECT ON QUALITY AND QUANTITY OF ALGINATE.** Sargassum *Tennerimum* J. Ag. can be effectively preserved by pretreatment with formalin followed by open-air drying on ground or horizontally suspended ropes. More than 90 percent of moisture can be removed within 20 to 36 hr on rope while on grid it requires 52 to 108 hr and on ground more than 100 to 108 hr. The plants treated with 2% formalin and dried at 23 cm thick beds on ground or at 5 kg.m<sup>-1</sup> beds on rope had high concentration of extractable alginic acid. Significant increase in viscosity was observed when *S. tenerimum* was treated with 5% formalin and dried on rope or ground. However drying on grid, even after pretreatment with formalin, tremendously reduced the viscosity of alginate. Plants treated with 5% formalin for 1 hr and dried at 23 cm thick beds on ground showed the highest viscosity. (Edited author abstract) 25 refs.

Tewari, A. (Central Salt & Marine Chemicals Research Inst, Bhavnagar, India); Joshi, H.V.; Ramaval, B.K. *Res Ind* v 32 n 3 Sep 1987 p 199-207.

**Extraction** See POLYSACCHARIDES—Testing.

**Fractionation** See POLYSACCHARIDES—Molecular Structure.

**SECURITY SYSTEMS** See Also HYDRAULIC GATES; NUCLEAR POWER PLANTS—Safeguard Systems; NUCLEAR REACTORS—Safeguard Systems; REFUSE DISPOSAL—Land Fill; SEMICONDUCTOR DEVICES—Protection; VIDEO RECORDING.

**093286 FINDING SECURITY THROUGH TECHNOLOGY.** Many American cities and counties are examining and experimenting with a wide range of security and access-control systems, public-warning systems, and better lighting fixtures to alert and protect the public. Safety-conscious local governments are experimenting with a wide range of security applications, from well-lit parking garages to outdoor siren systems.

Anon. *Am City Cty* v 103 n 3 Mar 1988 5p between p 52 and 62.

**093287 ACCESS CONTROL.** This paper addresses the broad spectrum of access control. It relates it to the varied and ever-changing needs of the user and outlines the benefits it offers management. Current products are outlined, highlighting the concept of distributed intelli-

gence control. (Author abstract)

Child, Colin (Philips Communications & Security). *Electron Technol (London)* v 22 n 5 May 1988 p 83-85.

**093288 NO LOCK, SAFE OR BURGLAR ALARM CAN STOP A THIEF WITH A KEY.** Last year, bank employees stole nine times more money than bank robbers. That's not unusual. It happens every year in every industry. Employee theft cost US business over \$1 billion in 1984. The only way you can stop the rise in employee theft is to stop hiring applicants who pose a risk. You can do that by developing a stringent pre-employment screening process. (Author abstract) 5 refs.

O'Kelly, June P. (Equifax Services Inc, Atlanta, GA, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 181-184.

**093289 WATCH - A LOW-COST, SECURE-ITEM MONITORING SYSTEM.** Sandia National Laboratories has developed a remote sensor package that provides a low-cost, convenient way of monitoring item movement. Originally, the package was intended for use in valve monitoring, but it is now possible to use it in any sensor application where hardware installation is impractical or uneconomical. Full system implementation includes a receiver/controller which correlates the arrival time of RF signals generated by item-monitoring transmitters to increase communication security. Wireless Alarm Transmission of Container Handling (WATCH) is such a system. One important application of WATCH is in storage vaults where there are a number of material containers. Applying WATCH to inventory control reduces inventory workload and employee exposure rates; the system also provides quick access to inventory information by interfacing the system with plant site computer systems. (Author abstract)

Sanderson, S.N. (Sandia Natl Lab, Albuquerque, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 310-315.

**093290 INTELLIGENT CARD ACCESS KEYS.** A newly developed access control technology allows information about users to be stored on key-like EEPROM devices. The keys store encrypted information about the user and his or her authorized access activity. Specially developed key readers scan, decrypt, and process the key data, and make the decision whether entry should be granted or denied. The key readers can function as complete, stand-alone facility management systems, incorporating access control security monitoring, and remote control. Key readers can also be interconnected with an MCM-1000 Multiplex Monitoring System to form a distributed processing local area network. (Edited author abstract)

Tennefoss, Michael R. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 430-437.

**093291 ELECTRONICALLY ENHANCED SECURITY SYSTEM USING PLASTIC SCINTILLATORS FOR SPECIAL NUCLEAR MATERIAL DETECTION.** The Electronically Enhanced Security System at the Department of Energy Rocky Flats Plant (RFP), operated by Rockwell International, in Golden, Colorado, includes a Special Nuclear Material (SNM) monitoring system. The Enhanced Security System has numerous areas or posts that are each monitored by the following equipment for alarm detection: plastic scintillators, solid-state color cameras, microwave occupancy detectors, and audio and visual alarmed condition indicators. At centralized guard posts, assessment of an alarm is accomplished by using time-lapse color video cassette recorders, alarm annunciators, an intercom system, dedicated color monitors, and an alarm color monitor. As a pilot program, the Enhanced Security System accomplished a considerable yearly cost savings. (Edited author abstract) 2 refs.

Jasper, Peter P. Jr. (Rockwell Int, Golden, CO, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 461-466.

**093292 PERSONNEL PROTECTION USING INTERIOR ACTIVATED BARRIERS.** This paper addresses equipment that will protect personnel and classified information in sensitive locations. The protection is afforded by a new type delay system called an Interior Activated Barrier (IAB). The interior activated barrier may be deployed with or in tandem with conventional hardline barriers. The total delay time afforded to protect personnel and information is measured in hours uniformly against attacks utilizing hand tools, power tools, and small explosives (less than four pounds). (Edited author abstract) 2 refs.

Timm, Ronald E. (R.E. Timm & Associates Inc, Hinsdale, IL, USA); Miranda, James E.; Cook, Billy G. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 608-614.

**093293 DEVELOPMENT OF REAL TIME ALARM/SURVEILLANCE SYSTEM.** PNC has carried out real time alarm/surveillance system as part of its R&D programs on the physical protection systems for its nuclear facilities from 1984 to 1986. The guard operates a closed circuit television (CCTV) camera to see whether the alarms are caused by intruders or by accidents in the existing physical protection systems. But it is very difficult to assess rapidly moving objects using such a TV system. Monitor images are used to be continuously recorded by VTR, but this does not seem to be very suitable for it takes quite a long time to play back. Aiming at more effective and reliable physical protection systems, a new alarm/surveillance system was developed; the system detects persons entering into the surveillance zone and provides effective means to confirm. (Edited author abstract)

Kajiyoshi, M. (Power Reactor & Nuclear Fuel Development Corp, Tokyo, Jpn); Uchida, S.; Suenaga, S.; Iwabuchi, M.; Fujimoto, T.; Yoshimura, A. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 651-653.

## Computer Aided Analysis

**093294 USE OF COMPUTER PROGRAMS TO EVALUATE EFFECTIVENESS OF SECURITY SYSTEMS.** Thirty or more computer programs for security vulnerability analysis were developed from 1975 through 1980. Most of these programs are intended for evaluating security system effectiveness against outsider threats, but at least six programs are primarily oriented to insider threats. Some strengths and weaknesses of these programs are described. Six of these programs, four for outsider threats and two for insider threats, have been revised and adapted for use with IBM personal computers. (Edited author abstract) 29 refs.

Harris, L. Jr. (Science Applications Int Corp, San Diego, CA, USA); Goldman, L.A.; McDaniel, T.L.; James, J.W.; Rajczak, W.M. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 37-43.

## Computer Interfaces

**093295 MICROPROCESSOR INTERFACE FOR AN ELECTRONIC SEAL/VIDEO SURVEILLANCE SYSTEM.** In international nuclear materials safeguards a need for advanced containment/surveillance equipment is anticipated which uses electronic sealing and closed circuit television in a coupled system approach. The paper describes a microprocessor interface for a seal/TV surveillance system, which is being developed within the framework of the bilateral exchange program between the USA and the Federal Republic of Germany. In its basic form, this interface would provide recorded video data of the application and/or removal of the electronic seal, together with annotated video frames containing pertinent seal



data. Possible applications are discussed. (Author abstract) 6 refs.

Richter, B. (KFA, Juelich, West Ger); Stein, G.; Johnson, C.S.; Sonnier, C.S. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 592-594.

**Czechoslovakia** See NUCLEAR POWER PLANTS—Safeguard Systems.

## Design

**093296 SECURITY ENGINEERING.** Effective security design requires a detailed analysis of assets, threats, vulnerabilities, and protective measures. This analysis is called security engineering. The US, like most other nations, has much experience in security engineering for wartime; however, there is a great lack of experience in engineering against terrorist threats. A new Army guide entitled *The Security Engineering Manual* attempts to fill this void by expanding the scope of security engineering to include terrorist and other 'peacetime' threats. Security engineering design is a step-by-step process that requires team input. It begins at the initial facility planning stage and continues through final design. There are six steps in the process.

Trout, John E. (Corps of Engineers' Protective Design Cent, Omaha, NE, USA); Betts, Curt P. *Mil Eng* v 80 n 522 Jul 1988 p 368-371.

## Equipment

**093297 EVOLUTION OF INTERIOR INTRUSION DETECTION TECHNOLOGY AT SANDIA NATIONAL LABORATORIES.** Interior Intrusion Detection Technology began at Sandia National Laboratories (SNL) in 1975 as part of the Fixed Facilities Physical Protection Research and Development program sponsored by the US Department of Energy in connection with their nuclear safeguards effort. This paper describes the evolution of Interior Intrusion Detection Technology at Sandia National Laboratories from the beginning of the Interior Sensor Laboratory to the present. (Edited author abstract) 8 refs.

Graham, R.H. (Sandia Natl Lab, Albuquerque, NM, USA); Workhoven, R.M. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 595-601.

## Evaluation

**093298 USE OF INFORMATION RESOURCE MANAGEMENT (IRM) IN SUPPORT OF THE INSPECTION AND EVALUATION PROGRAM FOR DOE/OSE.** The Department of Energy, Office of Security Evaluations (DOE/OSE) is in the process of enhancing its inspection and evaluation programs in order to improve their effectiveness. The overall goal is to enhance the ability of OSE to make positive and gradual impacts on DOE's efforts to maintain and improve security at its nuclear facilities. This goal will be met by developing inspection and evaluation procedures that provide thorough, realistic, and unbiased judgements during inspections; produce reliable and rational inspection and evaluation results; are acceptable throughout DOE; and are defensible to criticism. These inspection and evaluation procedures will eventually result in inspections that will more realistically stress the safeguards and physical security at a site based on the accepted standards for that site. (Edited author abstract)

Gubiotti, R.A. (Battelle Columbus Div, Columbus, OH, USA); Spencer, C. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 697-703.

**Imaging Techniques** See Also IMAGE PROCESSING; IMAGE PROCESSING—Reconstruction; PATTERN RECOGNITION SYSTEMS.

**093299 IMAGE-BASED SURVEILLANCE AND SECURITY SYSTEMS USING PERSONAL COMPUTERS FOR DEVICE AIMING AND DIGITAL IMAGE COMPARISON.** Image-based security systems should not be considered a total replacement for security personnel. The use of data links for positioner control means that imagers can be placed in very remote locations. This may reduce manpower requirements because fewer field observers will be required. However, a basic staff capable of responding quickly to any design-parameter security threat must still be maintained. In a well designed system, imagers and computers should work in conjunction with required manpower, not as a separate entity. This will provide the earliest detection of potential security threats thereby affording maximum time for adequate response.

Quiett, Steve (Security Software Systems, El Cajon, CA, USA); Axtell, L.H. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 645-650.

**Inspection** See Also DATA PROCESSING—Security of Data; INSPECTION; NUCLEAR POWER PLANTS—Safeguard Systems.

**093300 CONDUCTING AN INSPECTION OF PROTECTION PROGRAM OPERATIONS.** Protection Program Operations (PPO) encompasses the entire physical security program at a facility, including security construction and equipment, procedures, forces, management and supervision, and the integration of these elements into a total system. PPO subtopics are Physical Security Systems (PSS), Protection Forces (PF), and System Performance Tests (SPT). PSS assesses those security elements designed to protect security interests, and includes sensors, surveillance devices, systems for transmission and integration of alarm and assessment information, barriers, lighting, etc. PF assesses the management, training, equipment and facilities, and skills and knowledge of the protective force. SPT includes Force-on-Force, Emergency Management Performance Test, and Limited Scope Performance Tests. (Author abstract)

Brown, Steven (DOE, USA); Howell, Jerry. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 538-541.

**093301 OSE INSPECTION OF PROTECTION PROGRAM OPERATIONS: FIELD PERSPECTIVE OF INSPECTIONS.** Protection Program Operation includes three functional areas: Physical Protection Systems, Protective Forces, and System Performance Testing. The Office of Security Evaluations (OSE) inspects field offices in these areas by evaluating programs relative to Standards and Criteria and by performing a variety of exercises and other types of tests to assure protective systems are effective and maintained at a proper level to meet the defined threat. Our perception of the OSE inspection has been positive. The approach taken by ID, with key areas/activities emphasized, during each phase of the field inspection process is described in this report. (Edited author abstract)

Brown, R.W. (DOE Idaho Operations Office, Idaho Falls, ID, USA); Martin, H.R. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 542-543.

**093302 OSE INSPECTION OF COMPUTER SECURITY: REVIEW.** The inspection process within the Department of Energy (DOE) serves the function of analyzing and reporting on the performance of security measures and controls in specific areas at sites throughout DOE. Three aspects of this process are discussed based on experience in computer security: Policy basis of performance inspections; Role and form of standards and

criteria in inspections; and Conducting an inspection using the standards and criteria. (Edited author abstract)

Jaehne, Edwin M. (Jaehne Associates Ltd, Rockville, MD, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 544-547.

**Japan** See NUCLEAR POWER PLANTS—Safeguard Systems.

**Performance** See NUCLEAR POWER PLANTS—Safeguard Systems.

## Personnel Training

**093303 SECURITY PERSONNEL TRAINING USING A COMPUTER-BASED GAME.** Security personnel training is an integral part of a total physical security program, and is essential in enabling security personnel to perform their function effectively. Several training tools are currently available for use by security supervisors, including: textbook study, classroom instruction, and live simulations. However, due to shortcomings inherent in each of these tools, a need exists for the development of low-cost alternative training methods. This paper discusses one such alternative: a computer-based, game-type security training system. This system would be based on a personal computer with high-resolution graphics. Key features of this system include: a high degree of realism; flexibility in use and maintenance; high trainee motivation; and low cost. (Author abstract) 4 refs.

Ralph, J. (Booz, Allen & Hamilton Inc, Seabrook, MD, USA); Bickner, L. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 71-76.

**093304 PRELIMINARY DESIGN FOR AN INSTITUTIONAL NEEDS ASSESSMENT PROCESS TO GUIDE THE DEVELOPMENT OF TRAINING PROGRAMS AT THE DEPARTMENT OF ENERGY CENTRAL TRAINING ACADEMY.** In order to provide and maintain a high level of nuclear security at DOE installations, the Office of Safeguards and Security (OSS) is charged with the deployment of highly trained security staff at each DOE site. Faced with this mission, OSS must ensure that both Safeguards and Security personnel are adequately trained to meet present as well as potential future insider and outside threats. A major step toward meeting this goal was to begin to standardize training, and create a central training facility to implement training for safeguards and security personnel. (Edited author abstract) 2 refs.

Golder, Thomas (DOE Central Training Acad, Albuquerque, NM, USA); Laktasic, Stanley. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 324-329.

## Planning

**093305 MASTER PLANNING FOR SUCCESSFUL SAFEGUARD/SECURITY SYSTEMS ENGINEERING.** The development and phased implementation of an overall master plan for weapons systems and facilities engaged in the complexities of high technology provides a logical road map for system accomplishment. An essential factor in such a comprehensive plan is development of an integrated systems security engineering plan. Some DOD programs use new military regulations and policy directives to mandate consideration of the safeguard/security disciplines be considered for weapons systems and facilities during the entire life cycle of the program. The emphasis is to make certain the weapon system and applicable facilities have complementary security features. Together they must meet the needs of the operational mission and, at the same time, provide the security forces practical solutions to their requirements. This paper discusses the process of meshing the safe-guards/security requirements with an overall master plan and the challenges attendant to this activity. (Author abstract)

Bruckner, Donald G. (Holmes & Narver Inc, Albuquerque,



que, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 65-67.

**093306 VULNERABILITY ASSESSMENT: DETERMINING PROBABILITIES OF NEUTRALIZATION OF ADVERSARIES.** The Security Manager charged with the responsibility of designing Safeguards and Security Systems at Department of Energy facilities must take many factors into consideration. There must be a clear understanding, supported by documented guidance, of the level of threat to be addressed, the nature of the facility to be protected, and the funds available to design, implement, and maintain the Safeguards and Security System. In order to successfully assess the security system the security manager must have in depth working knowledge of all facility and security system characteristics, and how the characteristics impact on the ability to defeat adversaries. Each tactic of a potential adversary strategy must be considered, and each tactic of the security forces strategies must be measured against the adversary tactics and strategy.

Graves, Bert R. (DOE Central Training Acad, Albuquerque, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 330-332.

## Research

**093307 LABORATORY TOOL FOR THE DEVELOPMENT OF INTRUSION DETECTION SYSTEMS.** Learning systems present an attractive solution to the intrusion detection problem in situations where scenarios change, and where false alarms are costly. General Research Corporation (GRC) has developed a system for perimeter intrusion detection, and in comparison tests demonstrated false alarm reductions from 2.4 to 8.5 over single-sensor fixed processing systems. From this work, the concept of the Prototyping System has evolved. The Prototyping System is a laboratory tool for rapid and inexpensive layout of sensors and processing for physical security systems. Waveshapes can be measured and then tested for capability of discrimination between nuisances and intruders. The system facilitates performance comparisons between individual sensors and sensor groups, and rapid optimization of processing parameters. (Author abstract) 6 refs.

Bartek, Richard J. (General Research Corp, Santa Barbara, CA, USA); Sanders, Ann H. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 68-70.

**093308 R&D/OPERATIONAL MC&A INTER-FACE.** Improvements in our ability to do materials control and accounting (MC&A) have been steady since the beginning of the nuclear age and the appearance of processes and facilities for handling nuclear materials. The motivation for these improvements has not been just safeguards: the desire for better process control also has played a major role, and the emergence of technology focused on the problems of MC&A has made it possible to pursue such improvements. However, it is a continuing challenge to match the needs of the operational MC&A elements with the capabilities and resources of the R&D community. (Edited author abstract) 5 refs.

Shipley, J.P. (Los Alamos Natl Lab, Los Alamos, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 216-220.

## Sensors

**093309 MOVEMENT DETECTION.** This paper considers the three major detection technologies currently employed in intruder detection: passive infra-red; ultrasonic; microwave. The theory and application of each technology is discussed separately. The benefits of advanced and dual technology sensors are outlined. Selection criteria are proposed based on risk assessment and environmental suitability. (Author abstract)

Owers, I.A. (Racal-Guardall Ltd, Scotl). *Electron Technol (London)* v 22 n 5 May 1988 p 95-97.

Spain See NUCLEAR POWER PLANTS—Safeguard Systems.

Standards See Also CRYPTOGRAPHY—Reviews.

**093310 DEVELOPMENT AND SIGNIFICANCE OF THE DOE SAFEGUARDS AND SECURITY STANDARDS AND CRITERIA.** In October 1985, the DOE Assistant Secretary for Defense Programs created a task force to develop inspection standards and criteria for Safeguards and Security. These standards and criteria (S/C) would provide the DOE Inspection and Evaluation (I&E) teams with the guidance needed to assess the security posture of DOE's nuclear and other important facilities. This paper discusses the process used to achieve the desired end result and the significance of the Task Force's accomplishments. (Edited author abstract)

Toman, John (Lawrence Livermore Natl Lab, Livermore, CA, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 707-715.

**093311 WHAT ARE THE ATTRIBUTES OF A GOOD STANDARD AND ASSOCIATED CRITERIA?** The Department of Energy (DOE) Standards and Criteria (S&C) provide the framework upon which Office of Security Evaluations (OSE) inspections of safeguards and security at DOE facilities are conducted. The S&C were created to assure that inspections are comprehensive, standardized to the extent possible and accurately reported in meaningful terms, and that assessments are objective. With these goals in mind, the desirable attributes of a standard and its associated criteria are relevance, inspectability, and limited need for inspector judgement. (Author abstract)

Allentuck, Jack (Brookhaven Natl Lab, Upton, NY, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 716-720.

Sweden See NUCLEAR POWER PLANTS—Safeguard Systems.

United States See NUCLEAR POWER PLANTS—Safeguard Systems.

Video Recording See Also NUCLEAR FUELS—Safeguards; TELEVISION EQUIPMENT—Cameras.

**093312 PROTOTYPE TV-LINK FOR AUTHENTICATION OF VIDEO INFORMATION.** In the frame of the Program of the Federal Republic of Germany in Support of the International Atomic Energy Agency a prototype TV-link with high tamper resistance has been developed. The paper describes the technical realization of the authentication method for the transmission of video information. (Author abstract) 1 ref.

Richter, B. (KFA, Juelich, West Ger); Stein, G.; Neumann, G.; Gartner, K.J. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 320-323.

**093313 LOGISTICAL AND SAFEGUARDS ASPECTS RELATED TO THE INTRODUCTION AND IMPLEMENTATION OF VIDEO SURVEILLANCE EQUIPMENT BY EURATOM.** With the growing availability of reliable video equipment for surveillance applications in safeguards and the disappearance of the Super 8 mm cameras, there will be a period of transition from film camera to video surveillance, a process which started two years ago. This gradual transition, as the film cameras come to the end of their useful lives, will afford the safeguards authorities the opportunity to examine in detail the logistical and procedural changes necessary. This paper examines, on the basis of existing video equipment in use or under development, the differences and problems to be encountered in the approach to surveillance. (Edited author abstract) 3 refs.

Chare, P.J. (Commission of the European Communities, Luxemb); Wagner, H.G.; Otto, P.; Schenkel, R. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 553-559.

**093314 MODULAR INTEGRATED VIDEO SYSTEM (MIVS).** The Modular Integrated Video System (MIVS) is being developed for the International Atomic Energy Agency (IAEA) for use in facilities where mains power is available and the separation of the Camera and Recording Control Unit is desirable. The system is being developed under the US Program for Technical Assistance to the IAEA Safeguards (POTAS). The MIVS is designed to be a user-friendly system, allowing operation with minimal effort and training. The system software, through the use of a Liquid Crystal Display (LCD) and four soft keys, leads the inspector through the setup procedures to accomplish the intended surveillance or maintenance task. Review of surveillance data is accomplished with the use of a Portable Review Station. This Review Station will aid the inspector in the review process and determine the number of missed video scenes during a surveillance period. (Author abstract)

Schneider, Sigfried L. (Sandia Natl Lab, Albuquerque, NM, USA); Sonnier, Cecil S. *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 565-566.

**093315 VIDEO AUTHENTICATION TECHNIQUE.** Unattended video surveillance systems are particularly vulnerable to the substitution of false video images into the cable that connects the camera to the video recorder. New technology has made it practical to insert a solid state video memory into the video cable, freeze a video image from the camera, and hold this image as long as desired. Various techniques, such as line supervision and sync detection, have been used to detect video cable tampering. The video authentication technique described in this paper uses the actual video image from the camera as the basis for detecting any image substitution made during the transmission of the video image to the recorder. The technique, designed for unattended video systems, can be used for any video transmission system where a two-way digital data link can be established. (Edited author abstract)

Johnson, Charles S. (Sandia Natl Lab, Albuquerque, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 567-569.

**093316 VIDEO IMAGING SYSTEM FOR DETECTION, TRACKING, AND ASSESSMENT (VISDTA).** Automatic scene scanning and digital video processing are combined in a sensor/assessment system called VISDTA. In fixed-site or mobile security applications, the operator can initiate automatic scene scanning. While scanning, detection algorithms process video from a thermal imager or low-light camera. An additional detection algorithm operates on single fixed scenes. Video is displayed with graphics on a monitor next to the operator's touch-panel display. Assessment by the operator is aided by zoom/-focus control, pan/tilt control, and range measurements. Detection ranges can be kilometers. In this paper, the system design is described, along with highlights of the user interface, and performance estimates are made. (Author abstract)

Pritchard, Daniel A. (Sandia Natl Lab, Albuquerque, NM, USA). *Nucl Mater Manage* v 16 1987, INMM 28th Annu Meet: 'Safeguards - A Mature Technol?', Newport Beach, CA, USA, Jul 12-15 1987 p 640-644.

**SEDIMENTATION** See Also BEACHES—Construction; BEACHES—Erosion; COPPER ORE TREATMENT—Tailings Disposal; DREDGING; FLOW OF FLUIDS—Suspensions; GEOLOGY—Subaqueous; OIL WELL DRILLING—Drilling Fluids; PARTICLE SIZE ANALYSIS; POLYCHLORINATED BIPHENYLS—Sorption; POLYMETHYL METHACRYLATE—Solutions; SEWAGE TREATMENT—Stabilization Ponds; SOILS—Erosion; WASTEWATER—Treatment; WATER POLLUTION—Agricultural Runoffs; WATER POLLUTION—Analysis.



**093317 EFFECT OF SEDIMENTATION FEED FLUX ON THE SOLIDS FLUX CURVES.** The solids flux curve was determined using an experimental procedure based on measuring the concentration at various heights of a bed of settled solids formed during a semicontinuous sedimentation test. The flux curve was found to be dependent on the system feed flux. This dependence is due to inertial forces near the surface of the bed which should depend on the feed flux. At a given feed flux, there was good agreement between the solids flux curve determined by the new method and continuous sedimentation results. (Edited author abstract) 7 refs.

Galvin, K.P. (BHP, Shortland, Aust); Waters, A.G. *Powder Technol* v 53 n 2 Dec 1 1987 p 113-120.

**093318 COLLISION EFFICIENCY AND COLLOIDAL STABILITY OF UNEQUAL SIZE SPHERICAL PARTICLES MOVING THROUGH QUIESCENT VISCOUS LIQUID.** Collision efficiencies have been computed for unequal-size spherical particles settling in quiescent viscous liquids, taking into account the hydrodynamic interaction, interparticle attraction and electrostatic repulsion. The results are closely related to the mechanism of coagulation of colloidal particles in a sedimentation field. If the interparticle attraction and electrostatic repulsion are both negligibly small as compared to viscous drag, the collision efficiency  $\eta$  is very small, i.e. about 0.003. However, a relatively large Van der Waals force makes  $\eta$  greater than unity. As the ratio of the radii of the two particles (smaller divided by larger) decreases the collision efficiency also decreases. (Edited author abstract) 13 refs.

Yuu, Shinichi (Kyushu Inst of Technology, Kitakyushu, Jpn); Nakagawa, Fuyuhiko; Mihara, Hiroshi; Fukui, Yoshihiro. *J Chem Eng Jpn* v 20 n 5 Oct 1987 p 518-525.

**Analysis** See Also DREDGING—Waste Disposal; OCEANOGRAPHY—Caspian Sea; SUSPENSIONS—Separation; WATER POLLUTION—Marine Pollution.

**093319 CASCADE-SIEVE SHAKER FOR RAPID PARTICLE SIZE ANALYSIS OF COARSE SEDIMENT.** A new sieving apparatus and an analytical method have been developed and used for rapidly defining the particle-size distribution of sediment coarser than 0 millimeter. The apparatus consists of inner and outer support frames, a series of rectangular sieve screens that are arranged in an alternating cascade fashion, and a mechanism for vibrating the inner frame and screens vertically at a frequency of 3.7 Hertz. Sediment introduced on the topmost sieve is vibrated through the system. Particles that pass through a sieve are directed to the next finer sieve, whereas particles that are retained are shunted off into a collection container. Size separates in the collection containers are weighed cumulatively on an electronic balance, and the particle-size distribution is calculated automatically by computer. (Edited author abstract) 3 refs.

Hubbell, David W.; Stevens, Herbert H. Jr. *Geol Surv Water Supply Pap (US)* 2310 Dec 1986 p 73-85.

**093320 TREATMENT OF SEDIMENTATION CURVES BY COMPUTATIONAL MATHEMATICS METHODS.** We propose an analytical expression for determining the granulometric composition of a Stokes' suspension from the experimental sediment accumulation curve during sedimentation. We propose an algorithm for solving this problem by computational mathematics methods. For the specific example of sedimentation of one fraction of the commercial phosphor KTTs-540 in an aqueous silicate suspension, we compare the proposed analytical method with the graphical analysis method of tangents. (Author abstract) 9 refs.

Borodenko, V.I.; Shecheglov, A.Yu. *Colloid J USSR* v 49 n 2 Mar-Apr 1987 p 284-287.

**Calculations** See FLOW OF WATER—Sediment Transport.

**Centrifugation** See SOIL POLLUTION—Sampling.

**Chemical Analysis** See RIVERS—Sedimentation; WATER POLLUTION—Analysis.

**Chemistry** See LAKES—Water Level.

## Classification

**093321 BASAL MIXING ZONES IN LOESSES OF LOUISIANA AND IDAHO: I. IDENTIFICATION AND CHARACTERIZATION.** The thickness and character of basal mixing zones in loess with different underlying materials and in different climates were studied in Louisiana and Idaho. Peoria loess in Louisiana is underlain by sandy braided stream deposits, clayey alluvium, and an older Sicily Island loess. In Idaho, materials underlying loess deposits include glacial till, basalt, Pliocene sediments, and a paleosol developed in loess. Multiple criteria, divided into primary and secondary indicators, were used in the identification of basal mixing zones. The primary indicators of basal mixing zones were field morphology and particle-size distribution. Secondary indicators include total elemental analyses, clay mineralogy,  $\text{CaCO}_3$  equivalence, exchangeable cations and soil reaction listed in order of decreasing sensitivity. (Edited author abstract) 23 refs.

Schumacher, B.A. (Lockheed EMSCO, Las Vegas, NV, USA); Lewis, G.C.; Miller, B.J.; Day, W.J. *Soil Sci Soc Am J* v 52 n 3 May-Jun 1988 p 753-758.

**Computation** See RIVERS—Estuaries.

**Computer Aided Analysis** See COMPUTER SOFTWARE—Applications.

## Computer Applications

**093322 SEDIAT: A BASIC PROGRAM FOR THE COLLECTION AND STATISTICAL ANALYSIS OF PARTICLE SETTLING VELOCITY DATA.** SEDIAT is a series of compiled IBM-BASIC (version 2.0) programs that direct the collection, statistical calculation, and graphic presentation of particle settling velocity and equivalent spherical diameter for samples analyzed using the settling tube technique. The programs follow a menu-driven format that is understood easily by students and scientists with little previous computer experience. Settling velocity is measured directly (cm/sec) and also converted into Chi units. Equivalent spherical diameter (reported in Phi units) is calculated using a modified Gibbs equation for different particle densities. Input parameters, such as water temperature, settling distance, particle density, run time, and Phi/Chi interval are changed easily at operator discretion. Optional output to a dot-matrix printer includes a summary of moment and graphic statistical parameters, a tabulation of individual and cumulative weight percents, a listing of major distribution modes, and cumulative and histogram plots of a raw time, settling velocity, Chi and Phi data. (Author abstract) 15 refs.

Wright, Robyn (Univ of New Mexico, Albuquerque, NM, USA); Thornberg, Steven M. *Comput Geosci* v 14 n 1 1988 p 55-81.

**093323 COMPUTER PROGRAMME FOR CALCULATING FREE SETTLING TERMINAL VELOCITIES.** The underlying principles and the algorithm for developing a computer programme for estimation of free settling terminal velocities of particles have been discussed. The programme, written in BASIC language, selects the appropriate equation for estimation of terminal velocity depending on a particular combination of properties of particles (size and density) and the medium of suspension (density and viscosity). Possible modifications of the programme to suit a variety of conditions are also discussed. (Edited author abstract) 7 refs.

Chakrabarti, D.M. (Natl Metallurgical Lab, Jamshedpur, India). *NML Tech J* v 28 n 1-4 Feb-Nov 1986 p 3-9.

## Computer Simulation

**093324 DEPOSIM: A MACINTOSH COMPUTER MODEL FOR TWO-DIMENSIONAL SIMULATION OF TRANSPORT, DEPOSITION, EROSION, AND COMPACTION OF CLASTIC SEDIMENTS.** DEPOSIM is a dynamic deterministic two-dimensional simulation model implemented on an Apple Macintosh 512 kbyte computer that represents the interaction between transport, deposition, erosion, and compaction of clastic sediments. Sediment particles, transported within a fluid medium, are represented in a cross section through a sedimentary basin. The cross section is separated into discrete columns. The behavior of particles depends on velocity of the fluid in each column of the cross section, as well as on the basin's configuration, particularly on the steepness of slope of the seafloor. Fluid velocity depends on the velocity of the fluid newly supplied to the basin in each time increment, and on the depth of water in each column. Input parameters were taken from actual sedimentological and oceanographic literature that is concerned with clastic sediments. DEPOSIM takes into account up to three different particle sizes. Graphics subroutines display the cross sections and frequency distributions of particle sizes on a column-by-column basis.

Bitzer, Klaus (Albert Ludwigs Univ Freiburg, Freiburg, West Ger); Harbaugh, John W. *Comput Geosci* v 13 n 6 1987 p 611-637.

**093325 SIMULATING SEDIMENT DEPOSITION TO ESTABLISH A CHRONOLOGY FOR AN URBAN LAKE.** The sediment of Lake Paramatta, Sydney, contains complex laminations interspersed between massive sediment layers of known age. This paper describes a simulation of sedimentary process, based on climatic data, that allows the accurate dating of these laminated sediments. Detailed chronologies of this type are essential to monitoring environmental change through the study of fossils and chemistry of lake sediments. (Author abstract) 14 refs.

Dolman, G.S. (Australian Natl Univ, Canberra, Aust). *Math Comput Simul* v 30 n 1-2 1988, Simul Soc of Aust 1987 Conf, Melbourne, Aust, May 11-13 1987 p 139-144.

**Concentration** See FLOW OF WATER—Sediment Transport.

**Contamination** See DREDGING—Materials.

## Electric Field Effects

**093326 ELECTROFORCED SEDIMENTATION OF THICK SLURRIES IN CONSOLIDATION REGION.** It is shown that the settling rates of thickened slurries can be greatly enhanced by application of D.C. voltages. It is demonstrated that the settling rates increase remarkably with increasing electric field intensity. The basic differential equation for gravitational settling of thick slurries is derived and this is extended to electroforced sedimentation. The theoretical settling rates and the porosity distributions in settling sediments of both gravitational and electroforced settling compare favorably with experimental observations. In addition, it is shown that the compression-permeability characteristics in the low compressive pressure region can be closely determined analytically by using batch sedimentation data. (Author abstract) 11 refs.

Murase, T. (Nagoya Univ, Nagoya, Jpn); Iwata, M.; Aragaki, T.; Shirato, M. *Drying Technol* v 6 n 3 1988 p 361-388.

**Environmental Impact** See MARINE BIOLOGY.

**Environmental Testing** See WATER POLLUTION—Analysis; WATER POLLUTION—Water Quality.

## Equipment

**093327 LAMELLA SETTLERS: MATERIAL BALANCES AND CLARIFICATION RATES.** We show



that material balances and clarification rates of a lamella settler can be obtained from the particle size distribution and density of the solid, the density and viscosity of the liquid, the desired concentration of solids in the overhead product, and the concentration of solids in the feed and underflow, using an algorithm based on a simple geometric model. The method was validated using concentrated suspensions (up to 20 vol% solids) of four different feed-particle size distributions of hydrargillite (aluminum hydroxide) in water. Most of the data were obtained in a 60-cm-long settler with 1-cm plate separation inclined at 60° to the horizontal in 'open bottom' and 'normal' configurations. The algorithm is not applicable to tube settlers, whose hydrodynamics are more complex. (Author abstract) 16 refs.

Maimoni, Arturo (Lawrence Livermore Natl Lab, Livermore, CA, USA). *Environ Prog* v 7 n 2 May 1988 p 93-98.

**Grain Size and Shape** See FLOW OF WATER—Channel Flow.

**Lead Determination** See GAMMA RAYS—Absorption.

**Mathematical Models** See Also RESERVOIRS—Management.

**093328 COMPRESSION ZONE EFFECT IN BATCH SEDIMENTATION.** Theories of batch sedimentation, taking into account the compression zone effect, are reinterpreted and modified. According to the discussion presented and the experimental results shown, characteristics - which are the loci of points representative of layers with the same settling rate and the same solids concentration in the settling zone - rise tangentially to the sediment curve on a height vs. time plot. Mathematical expressions that relate the solids concentration to the variations of the pulp-supernatant interface height and of the sediment height are presented. In addition, the model presented is proposed for use when it is not possible to measure the sediment height. A procedure for calculating the concentration at the top of the sediment is also indicated. Calcium carbonate suspensions in water were selected for testing the equations deduced. The relation between the continuous thickener unit area and the underflow solids concentration was obtained from the batch tests, and is compared with that calculated by the graphic methods. (Edited author abstract) 14 refs.

Font, R. (Univ de Alicante, Alicante, Spain). *AIChE J* v 34 n 2 Feb 1988 p 229-238.

## Measurements

**093329 INFLUENCE OF THE CONCENTRATION OF THE DISPERSE PHASE (OCHER) ON THE FLOCCULATING ACTION OF HYDROLYZED POLYACRYLAMIDE.** The authors estimate the influence of the concentration of particles of the disperse phase on the sedimentation rate, as this is one of the most important characteristics of sedimentation processes in real systems. Experimental results show that the accelerated sedimentation of ochre due to addition of HPAA is especially pronounced in the region of low  $C_d$ ; the effect is strongest at  $C_d = 5 \cdot 10^{-4}$  mass %, and it weakens with increase of  $C_d$ . It is shown that the initial clarification rates (and therefore the rates of sedimentation of the ochre particles) depend strongly on  $C_d$ , and they cannot be used for strict quantitative assessment of the flocculating action of the polymeric flocculant. 10 refs.

Nagel', M.A. (S.M. Kirov Kazan' Inst of Chemical Technology, USSR); Valiulina, F.I.; Kurenkov, V.F.; Myagchenkov, V.A. *J Appl Chem USSR* v 60 n 1 pt 2 Jan 1987 p 145-148.

**093330 INFLUENCE OF SEDIMENTOMETER PARAMETERS ON ACCURACY OF ANALYZING SEDIMENT COMPOSITION.** Sources of errors in determining hydraulic grain size by sedimentometers are investigated. A differential equation of motion of the balance pan of the instrument is proposed. By solving this equation we calculate the measurement error caused by

oscillations of the balance pan. By comparing measurement results with standards we show the influence of the method of sample introduction on the accuracy of sedimentometric analysis. Recommendations are made for sedimentometer design. (Author abstract) 13 refs.

Onishchenko, E.L. *Sov Meteorol Hydrol* n 3 1987 p 103-108.

**093331 DEGREE AND STABILITY OF MAGNETIC DISPERSIONS: SEDIMENTATION, RHEOLOGICAL, AND MAGNETIC PROPERTIES.** There is a distinct correlation between the dispersion qualities of magnetic acicular particles as measured by slush grind rheology, sedimentation test, and coating magnetic properties. Sedimentation time measurement is a very sensitive tool to evaluate the degree of dispersion and dispersion stability. Sedimentation, rheology, and coating magnetic properties show that 'steric stability' is essential to maintain the excellence of magnetic particle dispersion. Some surface active agents provide excellent pigment dispersion but poor stability with time, whereas other chemical compounds adsorbed on a particle surface can provide a very high degree of dispersion with excellent dispersion stability. Results of particle size evaluation from sedimentation measurements show five to six times improvement in the degree of dispersion due to suitable surface active agents. (Author abstract) 10 refs.

Dasgupta, Sunil (Hercules Inc, Wilmington, DE, USA). *J Colloid Interface Sci* v 121 n 1 Jan 1988 p 208-213.

**Phase Equilibria** See POLYMERS—Molecular Weight.

**Radioactivity** See RIVERS—Estuaries.

**Remote Sensing** See RIVERS—Remote Sensing.

## Sampling

**093332 SAMPLING TECHNIQUES FOR GRAVEL SIZED SEDIMENTS.** The methods commonly used for sampling the coarser surface layers of gravel-bed streams are reviewed. It is found that while an areal sample is biased toward the coarser grains compared with a volumetric sample of the same material, the conversion formula suggested by a voidless cube model overcompensates for this effect. A modified version of the cube model that accounts for porosity is proposed. The modified cube model and tests conducted with a real sampling using wax indicate that area-by-weight analyses can be converted successfully to the equivalent bulk sieve analyses. The average depth of the wax samples ranged from  $D_{65-91}$ , increasing with median grain size. The equivalence of the grid by number and bulk sieve analyses is reaffirmed. (Author abstract) 17 refs.

Diplas, Panayiotis (Univ of Iowa, Iowa City, IA, USA); Sutherland, Alex J. *J Hydraul Eng* v 114 n 5 May 1988 p 484-501.

## Structure

**093333 BASAL MIXING ZONES IN LOESSES OF LOUISIANA AND IDAHO: II. FORMATION, SPATIAL DISTRIBUTION, AND STRATIGRAPHIC IMPLICATIONS.** Basal mixing zones of loess with different underlying materials in Louisiana and Idaho have been identified. Formation of basal mixed zones occurs when loess is deposited on a pedogenically active surface and becomes incorporated into the underlying stratigraphic unit through bioturbation and pedoturbation processes. Factors influencing basal mixed zone formation include climate, nature of stratigraphic materials underlying the loess deposits, and rate of loess deposition. The warm, humid climate in Louisiana is more conducive to the formation of thicker basal mixed zones than the cool, semiarid climate of Idaho. In Louisiana, thicker basal mixing zones were found where loess was underlain by coarse textured, unconsolidated materials than where underlain by unconsolidated materials with similar or finer textures. (Edited author abstract) 21 refs.

Miller, B.J. (Louisiana State Univ, Baton Rouge, LA,

USA); Schumacher, B.A.; Lewis, G.C.; Rehage, J.A.; Spicer, B.E. *Soil Sci Soc Am J* v 52 n 3 May-Jun 1988 p 759-764.

## Suspensions

**093334 SEDIMENT DESORPTION OF PCB CONGENERS AND THEIR BIO-UPTAKE BY DIP-TERAN LARVAE.** Sediment desorption of PCB congeners and their bio-uptake by Chironomus tentans Fabricus were investigated in a continuous flow system. The desorption of 71 congeners (in Aroclors 1221, 1016, 1254 and 1260) determined by glass capillary gas chromatography could be described by a first order function. The release rate of the individual congeners was inversely related to their octanol/water partition coefficients ( $K_{ow}$ ). The depth of mobilization generally decreased with the number of chlorine substitutions and was inversely related to  $K_{ow}$ . Bio-uptake of the congeners by Chironomus tentans Fabricus was selective with the bio-uptake factor being highest for those with 2-4 chlorines. There was no correlation between the factor and either  $K_{ow}$  or desorption rate from the sediments. (Author abstract) 38 refs.

Wood, L.W. (New York State Dep of Health, Albany, NY, USA); Rhee, G.-Y.; Bush, B.; Barnard, E. *Water Res* v 21 n 8 Aug 1987 p 875-884.

**Theory** See SUSPENSIONS—Sedimentation.

**Toxicity** See WATER POLLUTION—Analysis.

**Traps** See BEACHES—Recovery; RESERVOIRS—Sedimentation.

**Ultrasonic Applications** See SUSPENSIONS—Flocculation.

**Velocity Measurement** See POLYMERS—Solutions; SURFACE ACTIVE AGENTS—Additives.

**Wave Effects** See Also SEISMIC WAVES—Refraction.

**093335 WAVE-INDUCED INSTABILITY IN SANDY SUBMARINE SEDIMENTS.** The influences of the effective stress change induced by harmonic ocean waves on the stability of sandy submarine sediments in very gently sloped seafloors are examined. The general solution of the problem of flow through poro-elastic media and their deformation is represented by a linear combination of the solution of the Laplace equation and the diffusion equation (consolidation equation). The solution for horizontal seafloors is assumed to be approximately applicable to a very gently sloped planar seafloor. All possible arc failures are found by trial, using the slice method. The geometry of the possible instability is represented by the envelope of all the possible slides. The effective stress changes under the troughs towards the still water level of the storm waves in the direction of wave propagation can cause circular arc failures in sediments with Skempton's pore pressure coefficient,  $B$ , of less than 0.8, in water depths down to about 100m. The length of the largest failure arc is of the order of 1/9 approx. 2/9 of the wavelength, and the length of the composite failure zone can be about 3/4 of the half wavelength. The depths of the slip circle penetration can be of the order of the wave amplitude. (Author abstract) 12 refs.

Okusa, Shigeyasu (Tokai Univ, Orido, Jpn); Yoshimura, Mitsugu. *Soils Found* v 27 n 4 Dec 1987 p 62-72.

**SEISMIC WAVES** See Also COAL MINES AND MINING; COAL MINES AND MINING—Longwall; COAL MINES AND MINING—Rock Bursts; CONCRETE—Earthquake Resistance; COPPER MINES AND MINING—Rock Bursts; FOUNDATIONS—Earthquake Resistance; GEOPHYSICS—Seismic; PIPELINES—Earthquake Resistance; PIPELINES—Shock Waves; RESERVOIRS—Environmental Impact; SAND AND GRAVEL—Compaction; SOILS—Vibrations; VIBRATIONS—Mathematical Models.



**093336 SPATIALLY DISTRIBUTED RECEPTION OF SEISMIC WAVES.** The possibility of implementing, a selective (as regards the direction and distance) reception of seismic waves by recording the amplitudes of the natural forms of a body immersed in the ground, is considered. It is shown that, with the growth in the number of the observed shapes, the signal-to-noise ratio on the reception side can attain the same level as at the radiation point. Methods of recording the amplitudes of natural forms, and the errors connected with the finality of the number of the observed forms are discussed. (Translated author abstract) 2 refs. In Russian.

Merkulov, V.I. *Izv Sib Otd Akad Nauk SSSR Ser Tekh Nauk* n 7 pt 2 Apr 1987 p 64-67.

**093337 UNIFORM HALF-PLANE ELASTODYNAMIC PROBLEMS BY AN APPROXIMATE BOUNDARY ELEMENT METHOD.** The applicability of an approximate boundary element method to uniform half-plane elastodynamic problems is investigated. This method employs the concept of images to construct approximate fundamental solutions for the half-plane and does not require any half-plane surface discretization. The method is formulated in the frequency domain for the case of harmonic disturbances or the Laplace transform domain for the case of transient disturbances. Two numerical examples are used to illustrate the proposed method and study its advantages and disadvantages. (Edited author abstract) 52 refs.

Kontoni, Dionysia-Pinelopi N. (Univ of Patras, Patras, Greece); Beskos, Dimitri E. *Soil Dyn Earthquake Eng* v 6 n 4 Oct 1987 p 227-238.

**093338 ZASTOSOWANIE TEORII SPLINE OW DO WYZNACZANIA POL PREDKOSCI FAL SEJS-MICZNYCH.** [Application of the Spline Theory to the Determination of the Velocity Field of Seismic Waves]. An algorithm was constructed for the determination of the velocity field of seismic waves on the basis of their measured travel times. This general approximation problem has been solved with the aid of the spline functions technique. Such an approach enables a continuous velocity field to be obtained. An algorithm in this form can be used to investigate the seismic velocity field with only limited alterations such as, for example, in a confined rock massif including a coal mine. (Edited author abstract) In Czech. 4 refs.

Garus, Adam (Politechnika Slaska, Gliwice, Pol). *Acta Mont* n 75 Mar 1987 p 83-89.

**093339 VZTAH SEISMICKEHO NEKLIDU U STRUKTURY PROSTREDI.** [Interrelationship between Seismic Noise and Structure of the Environment]. The paper is devoted to the seismic noise in the frequency band approx. several Hz to several tens of Hz. The noise is assumed to be created mainly by surface waves. Assuming a regular distribution of the noise sources along Earth's surface, the ratios of the seismic noise amplitude spectra in known structures were estimated using the matrix method. The estimated spectral ratios principally differed from the measured ones. The discrepancy between estimates and measurements seems to be caused at least by an irregular distribution of the noise sources, which strongly influence the spectral ratios. Moreover, the seismic noise sources in the frequency band considered appeared to be nonstationary. (Edited author abstract) In Czech. 6 refs.

Ruzek, Bohuslav (CSAV, Prague, Czech); Mohapl, Petr; Klimes, Ludek. *Acta Mont* n 75 Mar 1987 p 193-203.

**093340 WAVES CAUSED BY MOVING LOADS IN AN ISOTROPIC LAYER INHOMOGENEOUS THROUGH THE THICKNESS.** Problems on motion with a constant subseismic velocity of an oscillating load on the boundary of an isotropic elastic layer inhomogeneous over the thickness are studied in a three-dimensional formulation. Quantitative estimates are given for the upper limits on the magnitudes of the velocity of motion and the load vibration frequency for which a unique solution exists for the problem in energy classes. In cases

when no energy solution exists, principles are formulated to extract the unique solution and a solution is given in the far field. Results are presented of numerical computations of the waves field characteristics in the cases of the motion of a normal concentrated load in a homogeneous layer. Situations are noted in which a different number of waves propagates in different layer domains. The problems considered are of interest for seismology and in designing aerodrome coverings. (Author abstract) 9 refs.

Belokon, A.V.; Nasedkin, A.V. *Appl Math Mech* v 51 n 2 1987 p 237-243.

**Analysis** See Also EARTHQUAKES—Mathematical Models; STRUCTURAL DESIGN—Earthquake Resistance.

**093341 FAULT LENGTH OF SMALL-SIZED EARTHQUAKES AS ESTIMATED FROM THE PULSE WIDTH OF INITIAL P WAVE.** The pulse width of the initial P wave was measured for about 300 aftershocks of the western Nagano, Japan earthquake of September 14, 1984. Based on the data set, the statistical relationship between the fault length L (km) and earthquake magnitude determined by the Japan Meteorological Agency  $M_j$ ,  $\log L = 0.58 M_j - a$  was established for the magnitude range of  $M_j = 3-5$ . The constant a takes the value of 2.48-2.64 depending on the fault type assumed. It appears that this formula may give a good estimate of the fault length even for larger earthquakes of  $M_j$  up to 8. The L- $M_j$  relation is converted to  $M_0 = b \times 10^{2.2 L^{2.3}}$  where  $M_0$  is the seismic moment (dyn-cm), and b is a constant taking the value of 4.9-11.4 corresponding to a. This relation predicts that the stress drop associated with fault rupture increases with the seismic moment of an earthquake. (Author abstract) 18 refs.

Ohtake, Masakazu (Nat'l Research Cent for Disaster Prevention, Ibaraki, Jpn). *J Phys Earth* v 34 n 5 1986 p 397-406.

**093342 NUMERICAL STUDY OF CAUSTICS AND POLARIZATIONS OF SEISMIC WAVES INTERACTING WITH THE THREE-DIMENSIONAL GEOLOGICAL STRUCTURES.** Ray tracing in three-dimensional, piecewise continuous models of near-surface geological structures is used to study the geometry of caustics and wave polarizations induced by refracted and multiply reflected high frequency seismic waves. The geological structures modeled are sediment-filled basins and curved reflectors. We show that multiply reflected seismic P-waves may easily induce localized intensification of both vertical and horizontal motions at the ground's surface. The results may be of importance to the prediction of earthquake hazards in urban areas. Additionally, we suggest applications to the study of the excitation of free oscillations of sedimentary and to the seismic detection of subsurface reflectors. (Author abstract) 10 refs.

Sorauf, C.M. (Univ of North Carolina, Chapel Hill, NC, USA); Rial, J.A. *Appl Numer Math* v 4 n 1 Mar 1988 p 71-81.

**Applications** See COMPOSITE MATERIALS—Testing.

**Attenuation** See Also EARTHQUAKES—Japan; GEOPHYSICS—Geothermal.

**093343 LABORATORY MEASUREMENTS OF ELASTIC WAVE ATTENUATION BY SCATTERING DUE TO RANDOM HETEROGENEITIES.** Scattering attenuation and spatial fluctuation of P waves traveling through a scattering medium were examined experimentally by using an ultrasonic technique. 2-D models of random media used in laboratory experiments are characterized by a triangular correlation function and a 2.4 percent standard deviation in velocity and density. The range of wave length covered in the experiments corresponds to  $2 + LS/ka < 33$ , where k is the wave number and a is the correlation distance of the heterogeneities, i.e., the heterogeneity size. The results obtained lead to the conclusion that forward scattered energy should not be counted as lost energy when the scattering attenuation of seismic waves traveling through a scattering medium is

calculated. It is suggested that initial motions as well as the subsequent phase of direct P or S wavelets are strongly contaminated by nonuniform forward-scattered energy; Fourier amplitudes for entire parts of the wavelets should be used to determine the attenuation of the waves as a function of frequency. 29 refs.

Mjatsunami, Koji (Kyoto Univ, Jpn). *Bull Disaster Prev Res Inst Kyoto Univ* v 38 pt 1 Mar 1988 p 1-16.

## Computation

**093344 LINE SOURCES FOR SEISMIC MODELING BY FINITE DIFFERENCES IN INHOMOGENEOUS MEDIA.** Initial (source) conditions for second-order finite-difference seismic-wave equation computations are usually implemented by inserting an analytic solution of the wave equation into the finite difference grid at two successive time steps. This approach is difficult to use in an arbitrarily inhomogeneous model and when free-surface boundary conditions are a required component due to proximity of the source to that surface. These problems can be overcome by noting that a small aperture behaves as a point source. In this algorithm, an aperture placed at the free-surface admits energy to the inhomogeneous structure from a small portion (a 'line') of a wavefront propagating in an auxiliary homogeneous medium defined above the free-surface. (Edited author abstract) 21 refs.

Sun, Robert (Univ of Texas at Dallas, Richardson, TX, USA); McMechan, George A. *Geoexploration* v 24 n 3 Oct 1987 p 183-196.

**Computer Aided Analysis** See PETROLEUM PROSPECTING—Seismic Survey.

## Computer Simulation

**093345 LARGE-SCALE, EXPLICIT WAVE SIMULATIONS ON THE CRAY-2.** Most time-domain, wave modeling problems in geophysics are intractable by classical analysis methods, due principally to nonseparability and to a lesser extent material nonlinearity. Therefore discrete numerical solutions are often necessary for the simulation of realistic models. Applications in 2-D and 3-D geophysical modeling are the subject of this paper, particularly as solved on a CRAY-2 supercomputer. Implementation and performance differences between earlier CRAYs and CRAY-2 are described, including the discrepancy between scalar fetch and vector processing speeds. Explicit finite element solvers are applied to applications involving 2-D simulation of a seismic refraction experiment across the state of Maine, 3-D simulation of near-source scattering experiments, and both linear and nonlinear axisymmetric source simulation. Results show that the CRAY-2 allows cost-effective 2-D simulations of truly large-scale models, but only begins to be effective in 3-D for models of interest in geophysics. (Edited author abstract) 9 refs.

Wojcik, G.L. (Weidinger Associates, Palo Alto, CA, USA); Vaughan, D.K.; Barenberg, M.; Mould, J. *Appl Numer Math* v 4 n 1 Mar 1988 p 47-70.

**Diffraction** See GEOPHYSICS—Seismic.

## Estimation

**093346 BAYESIAN ESTIMATION IN SEISMIC MIGRATION.** Seismic migration is a technique widely used in seismic oil exploration for wavefield reconstruction and for imaging the geometrical distribution of the reflection surfaces within the earth from the seismic data recorded on the earth surface. These data are usually corrupted by noise (white noise, surface waves, multiple reflections, etc.) that degrades the result of the migration. Another factor which influences the migration is the inadequate knowledge of the distribution of the acoustic-wave propagation velocity in the subsurface of the earth. The authors use estimation theory techniques to find the MAP (maximum a posteriori) estimate of the wave propagation velocity and of the geometrical distribution of the subsurface reflector points. 13 refs.



Pitas, Ioannis (Univ of Thessaloniki, Greece); Venetianopoulos, Anastasios. *IEEE Trans Acoust Speech Signal Process* v 36 n 2 Feb 1988 p 252-264.

**Mathematical Models** See Also SOILS—Vibrations.

**093347 ONE-DIMENSIONAL SEISMIC INVERSION USING ADAPTIVE DECONVOLUTION.** This paper presents an adaptive deconvolution approach to one-dimensional normal incidence inversion of noisy seismic data. A layered system is considered, which is characterized by reflection coefficients and travel-times. The reflector model is assumed to be random, while the seismic source signature wavelet, which travels into the earth, is unknown and time-varying. A recursive instrumental variable algorithm is appropriately combined with a fixed-lag deconvolution and detection technique for adaptive estimation of the wavelet, reflection coefficients and travel-times. The proposed procedure includes a multiples suppression method, which is fed with the above estimates, constructs and removes from the given signal the part containing all significant multiple, transmission and absorption effects. Examples are given, which illustrate the derived results. (Author abstract) 16 refs.

Kollias, Stefanos (Natl Technical Univ of Athens, Greece); Fodopoulos, Panayotis; Halkias, Christos. *Signal Process* v 14 n 3 Apr 1988 p 269-285.

**093348 ANALYSIS OF THE CHARACTERISTICS-INTEGRATION METHOD FOR ONE-DIMENSIONAL WAVE INVERSION.** Basing our work on the one-dimensional (1-D) wave equation, we present an inverse method which we call the characteristics-integration method. The method is derived from integration along characteristic families of straight lines of the wave equation in the time domain. With the source function known and reflection data recorded on the surface, the characteristics-integration method can efficiently and economically recover the subsurface impedance profile, provided that the structure is inhomogeneous only in the depth direction. (Edited author abstract) 18 refs.

Chen, Nei-Mao (Columbia Univ, New York, NY, USA); Chu, Yu-Hua; Kuo, John T. *Geophysics* v 53 n 8 Aug 1988 p 1034-1044.

**Measurements** See EARTHQUAKES—Prediction.

**Models** See NUCLEAR REACTORS—Earthquake Resistance.

**Monitoring** See RESERVOIRS—Environmental Impact.

**Noise, Spurious Signal** See GEOPHYSICS—Seismic.

**Propagation** See Also BOREHOLES—Explosions; FOUNDATIONS—Soil Structure Interaction; GEOPHYSICS—Seismic; PIPELINES—Earthquake Resistance; SOILS—Vibrations.

**093349 ON CAUSALITY IN DYNAMIC RESPONSE ANALYSIS BY TIME-DEPENDENT BOUNDARY ELEMENT METHODS.** The ramifications of a particular type of causality constraint, namely so-called shadow-zones, are explored in the context of time-dependent boundary element methods. In particular, wave propagation problems in 2-D elastic soil media with a non-convex shape are analysed. (Author abstract) 12 refs.

Antes, Heinz (Ruhr-Univ Bochum, Bochum, West Ger); Von Estorff, Otto. *Earthquake Eng Struct Dyn* v 15 n 7 Oct 1987 p 865-870.

**093350 PROPAGATION OF COMPLEX DISCONTINUITIES WITH PIECEWISE CONSTANT AND VARIABLE VELOCITIES ALONG CURVILINEAR AND BRANCHING TRAJECTORIES.** The method of functionally invariant solutions of wave equations utilizing the principle of superposition is used to construct exact solutions for a system of complex discontinuities propagating with piecewise constant velocities along curvilinear and branching trajectories. A passage to the limit is shown

in the course of which the solution constructed yields velocities along smooth curvilinear trajectories. It is shown that if the propagation of a major discontinuity (crack) begins with the formation of a pure shear element, then as the velocity increases, dislocation components of the displacement vector will appear at the discontinuity; if on the other hand the propagation of a major crack begins with the formation of a pure dislocation element, then as the velocity of propagation of the crack increases, it will branch and considerable shear components of the displacement vector will form on the branched segments of the crack. The minimum values of the branching angles are determined. Theoretical seismograms are given to illustrate the results. (Edited author abstract) 26 refs.

Bykovtsev, A.S. *Appl Math Mech* v 50 n 5 1986 p 620-628.

**093351 EFFECTS OF CANYON TOPOGRAPHY AND GEOLOGICAL CONDITIONS ON STRONG GROUND MOTION.** The finite and infinite element coupling system is used to study the effects of canyon topography and geological conditions on strong ground motion. The system is first applied to a semi-cylindrical shaped canyon using SH wave propagation to verify its accuracy. It is concluded that different topography conditions may have important effects on the ground motions along the canyon. The geological conditions, by which we mean different softening of weathered strata of the canyon surface, will have significantly amplified effects on the free field motions. This fact suggests that a deep weathered rock excavation of arch dam abutments for stability purposes will also benefit earthquake resistance of the dam due to the reduction of ground motions of the sound rock. (Author abstract) 11 refs.

Chuhan, Zhang (Tsinghua Univ, Beijing, China); Chongbin, Zhao. *Earthquake Eng Struct Dyn* v 16 n 1 Jan 1988 p 81 + 87.

**093352 ONE-DIMENSIONAL WAVE PROPAGATION IN A HIGHLY DISCONTINUOUS MEDIUM.** A pulse propagates through a one-dimensional medium consisting of a large number N of homogeneous layers. As it propagates the pulse, which consists of multiply scattered energy, is broadened and slightly delayed compared with the first arrival, which travels at the characteristic speed. R.F. O'Doherty and N.A. Anstey first studied this phenomenon in 1971 and gave an incomplete theory predicting the pulse shape and spectrum essentially by summing a diagram. We corroborate their results with a rigorous theory giving the limiting pulse shape as N approaches  $\infty$  while the reflection coefficients go to zero like  $1/\sqrt{N}$ . This work is novel in that: (a) a rigorous theory is given, (b) the development is in the time domain, and (c) probabilistic concepts, such as ensemble averages, are not used; spatial averages suffice. (Edited author abstract) 20 refs.

Burridge, Robert (Schlumberger-Doll Research, Ridgefield, CT, USA); Papanicolaou, George S.; White, Benjamin S. *Wave Motion* v 10 n 1 Jan 1988 p 19-44.

**093353 SOURCE WAVELET ESTIMATION BY UPWARD EXTRAPOLATION.** In this paper an extension of the theory of source wavelet estimation is proposed. As in previous publications, this method is based on extrapolation of the wave field measured at depth, upward to the free surface. The extrapolation is performed by using the finite difference approximation to the full inhomogeneous wave equation. The extrapolation results in a wavelet which generally includes ghosts and can be used for source signature deconvolution and deghosting. The method needs two closely spaced receivers and is applicable for arbitrary locations of the source and the receivers in one-dimensional multilayered models, provided the source is above the receivers; furthermore, it can be applied to both marine and land data. Application of the proposed method to a number of synthetic models shows that it gives a good estimate of the source wavelet. (Edited author abstract)

Shtivelman, V. (Inst for Petroleum Research & Geophysics, Holon, Isr); Loewenthal, D. *Geophysics* v 53 n 2 Feb 1988 p 186-191.

1988 p 158-166.

**093354 NEW ALGORITHM FOR FINITE-DIFFERENCE MIGRATION OF STEEP DIPS.** One-way wave propagation is formulated in the (x, t) domain as an integrodifferential equation and is applied to the migration of stacked data. A key step is to replace the phase-shift square root in the frequency-domain representation by an integral of a rational function; the resulting expression is interpreted in the space-time domain. Approximating the integral by a finite sum leads to a number of practical approximations, the lowest order being Claerbout's 15 degree equation and others being various high-order equations in the literature. Optimal mth-order quadrature formulas based upon Chebyshev criteria suggest a second-order approximation which takes 20 percent more time than the 15 degree equation but is accurate to over 50 degrees. (Author abstract)

Zhang Guan-quan (Acad Sinica, China); Zhang Shu-lun; Wang Ying-xiang; Liu Chau-ying. *Geophysics* v 53 n Feb 1988 p 167-175.

**Reflection** See Also AQUIFERS—Testing; COAL MINES AND MINING—Subsidence; GEOPHYSICS—Seismic; SEISMOLOGY—Mathematical Models.

**093355 THREE-DIMENSIONAL IMAGING OF STEEPLY DIPPING STRUCTURE NEAR THE SAN ANDREAS FAULT, PARKFIELD, CALIFORNIA.** Shot gathers from the Parkfield, California, deep crustal seismic reflection line, recorded in 1977 by COCORP, reveal coherent events having horizontal to reverse move-outs. These events were migrated using a multioffset three-dimensional Kirchhoff summation method. This method is a ray-equation back projection inversion of the acoustic wave field, which is valid under the Born, WKB, and far-field assumptions. Migration of full-wave acoustic synthetics, having the same limitations in geometric coverage as the COCORP survey, demonstrates the utility of the imaging process. The images obtained from back projection of the survey data suggest that the Gold Hill fault carries ultramafic rocks from the surface to 3 km depth at a dip greater than 45 degrees, where it joins the San Andreas fault. (Edited author abstract)

Louie, John N. (California Inst of Technology, Pasadena, CA, USA); Clayton, Robert W.; LeBras, Ronan J. *Geophysics* v 53 n 2 Feb 1988 p 176-185.

**093356 ROBUST DECONVOLUTION BY MODIFIED WIENER FILTERING.** To design a modified Wiener filter for deconvolution in the presence of additive noise, it is necessary to know the frequency characteristics of the wavelet precisely, plus the spectra of the input and additive noise. Typically, some appropriate estimate of the frequency function of the wavelet is taken, and the modified Wiener filter is designed from that estimate. A more realistic practical viewpoint is to think of the estimated wavelet response as one of a set of possible frequency response functions. By using statistical information obtained during wavelet estimation, a modified Wiener filter equivalent to a statistically robust deconvolution filter can be constructed. In this case 'robust' means that the error criterion which defines the deconvolution filter allows for the set of possible wavelet frequency functions. Two different error criteria are considered: (1) the minimization of the average mean-squared error, and (2) the minimization of the maximum mean-squared error. Deconvolution using an estimated wavelet can thus be made robust to wavelet uncertainties in an easily followed technique. (Edited author abstract)

Walden, A.T. (BP Exploration Co, London, Engl). *Geophysics* v 53 n 2 Feb 1988 p 186-191.

**Refraction**

**093357 SIMPLE APPROACH TO THE MASKED-LAYER PROBLEM IN SEISMIC REFRACTION WORK.** The effect of a masked layer (either due to velocity inversion or hidden layer condition) on seismic refraction interpretation is determined in a simple way using the delay-time concept and it is shown that the



error in the computed depth to the refractor below can be corrected easily, provided the velocity of the masked layer and its thickness or the thickness of the overlying layer are known. It is seen, extending the concept, that the depth to an interface obtained from the corresponding intercept time and average velocity of the multilayer overburden is always less than the true depth. Hence, large errors due to the presence of masked layers can be avoided by calculating depths using the average velocity or else the effective velocity estimated from the T-D graph, in refraction work. A multilayer field example is presented for illustration. (Author abstract) 5 refs.

Pant, P.R.; Vijaya Raghava, M.S. *Geoexploration* v 24 n 6 Dec 1987 p 549-556.

**093358 REPORT 15. THE SEISMIC REFRACTION COMPRESSION-SHEAR WAVE VELOCITY RATIO AS AN INDICATOR OF SHALLOW WATER TABLES: A FIELD TEST.** To test the assumption that the velocity of shear waves increases much less than the velocity of compressional waves at a water table, a seismic refraction survey was performed over a shallow water table in alluvial sediment. Using a sledge hammer and a partially buried steel cylinder as a source, a maximum shot-to-receiver distance of 330 ft and depth of investigation of 60 ft were achieved. The ratio of  $V_p$  to  $V_s$  (compressional/shear wave velocity) at the water table was found to be 2.48. In the four nonsaturated layers above the water table,  $V_p/V_s$  ratios ranged from 1.54 to 1.55. As predicted by the theoretical models considered, shear wave velocity did not increase measurably at the water table. In an area in which a shallow water table was not likely to exist, shear wave velocity increased by at least as much as the increase in compressional velocity at each refractor. Results indicate that the comparison of S- and P-wave velocity profiles is a promising technique for water table detection. (Edited author abstract) 13 refs.

Schuyler-Rossie, Christine (US Army Corps of Engineers, Vicksburg, MS, USA). *Misc Pap US Army Eng Waterw Exp Stn* EL-79-6 Nov 1987 var pgs.

**Scattering** See Also GEOPHYSICS—Seismic.

**093359 LABORATORY TESTS OF THE SINGLE- AND MULTIPLE-SCATTERING MODELS FOR THE GENERATION OF SEISMIC CODA WAVES.** To investigate the scattering property of the earth's crust using seismic coda waves, scattering models for coda generation were first tested using an ultrasonic technique and sufficiently large 2-D models of scattering media. Next, short-period coda waves from local small earthquakes that occurred in the central Kinki district of southwest Japan were analyzed with the multiple-scattering model for coda generation given by Gao et al. It was concluded that the multiple-scattering model of Gao et al. for coda generation explains the time decay of the amplitude of coda consisting of waves scattered by small-scale crack-like heterogeneities in the earth's crust very well. Also, when the lithosphere is assumed to be a scattering medium with randomly distributed heterogeneities, the isotropic scattering coefficient,  $g$ , of the earth's crust in the central Kinki district is nearly proportional to  $f^{1.0}$  in the frequency range of  $2 < f < 16$  Hz. It is suggested that the heterogeneities responsible for short-period coda generation may be numerous cracks in the crust that have lengths of less than about 100 m. 40 Refs.

Matsunami, Koji. *Bull Disaster Prev Res Inst Kyoto Univ* v 37 pt 4 Dec 1987 p 147-168.

**Spectrum Analysis** See Also EARTHQUAKES—Mexico; EARTHQUAKES—New Zealand; EARTHQUAKES—Prediction; EXPLOSIONS—Underground; SIGNAL PROCESSING—Spectrum Analysis; STRUCTURAL ANALYSIS—Dynamic Response; STRUCTURAL DESIGN—Earthquake Resistance.

**093360 WAVEFORM INVERSION USING SECONDARY OBSERVABLES.** A new method is proposed for inverting single-station surface-wave seismograms. Instead of inverting directly the time-signal, use is made of secondary observables built up from a set of time-frequency images. This allows us to enhance the sig-

nal-to-noise ratio and to make more linear the relationship between the model parameters and the inverted observables. The feasibility of the method is checked on multimode synthetics prior to present the inversion of a long-period multimode seismogram related to the Pacific Ocean. (Author abstract) 9 refs.

Cara, M. (Inst de Physique du Globe de Strasbourg, Fr); Leveque, J.J. *Geophys Res Lett* v 14 n 10 Oct 1987 p 1046-1049.

**093361 SEISMIC SPECTRA ON SOIL WITH UNCERTAIN PROPERTIES.** Expected spectral ordinates and their standard deviations are computed for ground motions produced by SH waves at the surface of a homogeneous soil formation resting on a half-space of rock. Wave transmission is idealized as linear and one-dimensional. Uncertainties about soil properties are taken into account using various approximations: a Taylor series expansion of the Fourier spectrum magnification factors with different numbers of terms and different intervals for numerical differentiation; discretization of the joint probability density function of the soil properties so as to match its moments up to those of third order including the crossed moments; a discretization that matches up to some fifth-order moments; and a fine numerical integration for the marginal density function of the modulus of rigidity, discretizing the rest of the density function. The latter approach gives sufficiently accurate results for practical purposes. (Edited author abstract) 13 refs.

Hong, Han Ping (Univ Nacional Autonoma de Mexico, Mexico City, Mex); Rosenbluth, Emilio. *Earthquake Eng Struct Dyn* v 15 n 7 Oct 1987 p 911-920.

**093362 SEISMIC SPECTRA ON SOIL WITH UNCERTAIN PROPERTIES.** Expected spectral ordinates and their standard deviations are computed for ground motions produced by SH waves at the surface of a homogeneous soil formation resting on a half-space of rock. Wave transmission is idealized as linear and one-dimensional. Uncertainties about soil properties are taken into account using various approximations: a Taylor series expansion of the Fourier spectrum magnification factors with different numbers of terms and different intervals for numerical differentiation; discretization of the joint probability density function of the soil properties so as to match its moments up to those of third order including the crossed moments; a discretization that matches up to some fifth-order moments; and a fine numerical integration for the marginal density function of the modulus of rigidity, discretizing the rest of the density function. The latter approach gives sufficiently accurate results for practical purposes. Effects of even moderate uncertainty about soil properties on the statistics of spectral ordinates are found to be decisive. (Author abstract) 13 refs.

Hong, Han Ping (Univ Nacional Autonoma de Mexico, Mexico City, Mex); Rosenbluth, Emilio. *Earthquake Eng Struct Dyn* v 15 n 7 Oct 1987 p 911-920.

**093363 SPECTRAL ESTIMATES OF TELESEISMIC P-WAVE ATTENUATION TO 15 HZ.** NORESS recordings of nuclear explosions in central Asia ( $\Delta = 38^\circ$ ) provide new spectral attenuation estimates for frequencies from about 3 to 15 Hz. Two path spectra, representing propagation losses from the Shagan River and Degelen test sites to southern Norway, are calculated using the double-averaging technique of Bache et al. (1985, 1986). Both paths exhibit less attenuation than previously documented for explosions recorded teleseismically at the UKAEA arrays over the 1- to 8-Hz frequency range. The Shagan and Degelen spectra have somewhat different decay rates, perhaps reflecting variations in average source properties. Since the NORESS data extend to higher frequencies than previously available for attenuation measurements, we compare the NORESS spectral data to published models derived from NORSAR data (1 to 8 Hz) for the same path. The NORESS data support frequency-dependent  $t$  in the 3- to 15-Hz frequency range. The results also demonstrate that extrapolation of attenuation models obtained from longer period data to shorter

periods may not predict the correct spectral levels. Actual high-frequency measurements are needed in order to characterize attenuation behavior at high frequencies. (Edited author abstract) 21 refs.

Walck, Marianne C. *Bull Seismol Soc Am* v 78 n 2 Apr 1988 p 726-740.

**093364 MODELING TELESEISMIC SV WAVES FROM UNDERGROUND EXPLOSIONS WITH TECTONIC RELEASE: RESULTS FOR SOUTHERN NOVAYA ZEMLYA.** Detailed forward modeling of long-period shear waves for two large underground explosions at the Southern Novaya Zemlya test site indicates that the appropriate equivalent double-couple orientation for the tectonic release radiation is vertical strike-slip. Incorporating realistic Green's functions using Baag and Langston's (1985b) WKBJ spectral method allows complete modeling of the SV signals. Due to differences in frequency content between the explosion and double-couple SV waveforms, constructive interference occurs more efficiently than destructive interference when the two signals are linearly superimposed. As a result, using tectonic release moments determined from the SH waves and the optimum F factors required to match the SV amplitude patterns, the waveforms produced by the strike-slip and thrust orientations differ substantially at some azimuths. Complete waveform modeling of SV signals can provide improved constraints on tectonic release radiation and explosion source strength. (Edited author abstract) 42 refs.

Cohée, Brian P. (Univ of Michigan, Ann Arbor, MI, USA); Lay, Thorne. *Bull Seismol Soc Am* v 78 n 3 Jun 1988 p 1158-1178.

**093365 P-WAVE AND S-WAVE SEPARATION IN THIN BEDS.** Compressional (P) and shear (S) waves can be separated in vector vertical-seismic profile recordings through the use of multichannel multidimensional filters. These filters have impulse responses that are spatially and temporally infinite, and their application to recordings of finite spatial extent, such as those made in thin beds, results in a truncation error. The use of constrained shift-varying filters helps to minimize this error. The constrained filters are derived under the assumption that most of the energy in the recording is concentrated around a few apparent (vertical) velocities. Implementation of these shift-varying filters requires little additional computation beyond that required by simpler shift-invariant filters. The reduction of truncation error accomplished by this processing scheme is demonstrated with several synthetic data sets. 8 refs.

Lang, Stephen W. (Schlumberger-Doll Research, Ridgefield, CT, USA); Oristaglio, Michael L. *IEEE Trans Geosci Remote Sens* v 26 n 2 Mar 1988 p 177-186.

**Velocity** See Also GEOPHYSICS—Rock Properties; GEOPHYSICS—Seismic; SOILS—Permafrost.

**093366 NORMAL MOVEOUT REVISITED: INHOMOGENEOUS MEDIA AND CURVED INTERFACES.** The equation of normal moveout is valid for a reflection from the base of a single homogeneous and isotropic bed, but is only an approximation in the real world of multilayered, inhomogeneous media and curved interfaces. Using the theory of geometrical optics. It is possible to find another second-order equation which represents hyperbolas that are also symmetrical about the time axis. However, the centers of these hyperbolas do not coincide with the center of the coordinates, but are shifted along the time axis. This equation is not only more accurate than the usual normal moveout, but its use is more economical on a vector computer because the traditional dynamic correction is a static correction in the Analysis of the focusing depth time. This procedure makes it possible to compute velocities for all the samples of all the stacked traces and produces a velocity section. (Edited author abstract).

de Bazelaire, Eric (Soc Natl Elf Aquitaine, Pau, Fr). *Geophysics* v 53 n 2 Feb 1988 p 143-157.



**093367 RAY BENDING DUE TO STRONG VELOCITY ANOMALIES.** Tomographic methods may be useful in determining localized changes in rock masses if accurate methods of inverting the data can be found. However, in the presence of strong localized anomalies, the underlying assumptions of many tomographic inversion methods break down. In fact, velocity contrasts as low as 15 percent can produce quite distorted raypaths. Even though the raypaths are distorted, the traveltimes on these paths are quite close to those which would arise from the straight-ray assumption. The longer path length is compensated for by higher velocity. As a consequence, blind application of tomographic inversion to data obtained in the presence of strong anomalies can result in an incorrect and distorted but consistent solution. (Author abstract)

Singh, R.P. (Indian Inst of Technology, Kanpur, India); Nyland, E. *Geophysics* v 53 n 2 Feb 1988 p 201-205.

**Velocity Measurement** See GEOPHYSICS—Subaqueous; SAND AND GRAVEL—Pressure Effects.

**SEISMOGRAPHS** See Also OIL WELLS—Hydraulic Fracturing.

**093368 NOTE ON THE NOISE AMPLITUDES IN SOME STRONG MOTION ACCELEROGRAPHS.** The amplitudes of digitization and processing noise in strong motion digital and analog accelerographs are discussed and compared with those for hand and automatic digitization. By finding the period bands for which the signal-to-noise ratio in recorded accelerograms is greater than one, the value for the pass-band cutoff periods for data processing are presented. The Empirical scalings for amplitudes in terms of: (1) earthquake magnitude and epicentral distance and, (2) Modified Mercalli Intensity at the recording site have been employed. (Author abstract) 26 refs.

Amini, A. (Univ of Southern California, Los Angeles, CA, USA); Trifunac, M.D.; Nigbor, R.L. *Soil Dyn Earthquake Eng* v 6 n 3 Jul 1987 p 180-187.

**093369 SYNTHESIS SEISMOGRAMS FOR MARINE SEDIMENTS AND DETERMINATION OF POROSITY AND PERMEABILITY.** We present numerical simulations of vertical seismic profiles (VSPs) of marine sediments. The theoretical seismograms, which are computed for vertically incident waves in flat layered poroelastic media, include the effects of dispersion and attenuation predicted by Biot theory. According to Biot theory, fast and slow compressional waves are excited and there is mode conversion at the interfaces. We include this effect in the calculation of reflection and transmission coefficients as an energy-loss mechanism through the slow compressional waves. (Edited author abstract). 15 Refs.

Turgut, Altan (Univ of Miami, Miami, FL, USA); Yamamoto, Tokuo. *Geophysics* v 53 n 8 Aug 1988 p 1056-1067.

## Analysis

**093370 SYNTHETIC SEISMOGRAMS IN REALISTIC MEDIA: A WAVE-THEORETICAL APPROACH.** In order to interpret seismograms, we should separate the effects of source and medium, which are strongly coupled. The medium effect is usually estimated by computing synthetic seismograms for a model of the Earth. Of course, a three-dimensionally heterogeneous, arbitrarily anisotropic and attenuative medium is the most realistic model, but it requires a great deal of theoretical and numerical effort. At present one- or two-dimensionally layered, isotropic and attenuative media consisting of homogeneous layers are the most productive models for precise waveform analyses of seismograms. A new approach based on the reflectivity method is presented here to compute complete synthetic seismograms in these models. (Edited author abstract) 62 refs.

Kohketsu, Kazuki (Univ of Tokyo, Jpn). *Bull Earthquake Res Inst Univ Tokyo* v 62 pt 3 1987 p 201-245.

**Digital Devices** See GEOPHYSICS—Seismic.

## Processing

**093371 APPLICATION OF FREQUENCY VARIABLE FILTERS TO SURFACE-WAVE AMPLITUDE ANALYSIS.** The problem of spectral biasing due to frequency domain filtering of surface-wave seismograms is investigated, and the method of frequency variable filters (FVF) is developed to compensate for this bias. As a result, the FVF can significantly improve signal to noise in the filtering process, except at points which require increased frequency domain resolution due to biasing. A detailed comparison of some currently accepted surface-wave filters is made in order to clarify the development of the FVF algorithm. Three long-period, surface-wave seismograms are tested with FVF and compared to two other methods, the multiple filter technique and the phase-matched filter (PMF). Emphasis is placed on finding limitations in all the methods, not on routine processing. Results of the tests show that the FVF and PMF are an improvement over multiple filter technique, in that the results of processing can be diagnosed in both the time and frequency domains. (Edited author abstract) 15 refs.

Russel, David R.; Herrmann, Robert B.; Hwang, Horng-Jye. *Bull Seismol Soc Am* v 78 n 1 Feb 1988 p 339-354.

**Recording** See EARTHQUAKES—Evaluation.

**SEISMOLOGY** See Also ACCELEROMETERS—Reliability; COMPUTER SOFTWARE—Portability; NUCLEAR REACTORS—Earthquake Effect; NUCLEAR REACTORS—Earthquake Effects; SEISMIC WAVES; STRUCTURAL DESIGN—Earthquake Resistance.

**093372 SEISMIC LOADS ON INDUSTRIAL AND POWER PLANT EQUIPMENT.** A method is proposed for the determination of seismic loads acting on the industrial and power plant equipment structures. They comprise a high frequency spectrum of eigenfrequencies, different from characteristic frequencies of the seismic effect. (Translated author abstract) 4 refs. In Russian.

Chukaev, A.G.; Rossikhin, N.A. *Izv Vyssh Uchebn Zaved Mashinost* 2 1987 p 26-30.

**093373 FREQUENCY DOMAIN COHERENT PROCESSING OF REGIONAL SEISMIC SIGNALS AT SMALL ARRAYS.** It can be shown that most currently-used methods for enhancing regional signals at small arrays are special cases of a more general frequency domain processing scheme designed to optimize the signal/noise power gain for the processor once the signal and noise power spectral matrices are given. The optimum processor makes use of the coherence structures of the signal and noise, and can be simply derived by simultaneous diagonalization of these power spectral matrices. Curiously enough, the optimum processors are not weighted beams but include phase-shifting different from the array beam steers. Such processing schemes can be programmed quite efficiently in the frequency domain and may, in some cases, be more efficient than weighted array beams. (Author abstract) 17 refs.

Der, Zoltan A.; Shumway, Robert H.; Lees, Alison C. *Bull Seismol Soc Am* v 78 n 1 Feb 1988 p 326-338.

**093374 INTRODUCTION AU GENIE PARASISMIQUE.** [Introduction to Earthquake Engineering]. The article presents a digest of all the factors an engineer must know in the field of earthquake engineering before approaching the specific problems: basic concepts of seismology (origin of earthquakes, frequency, means of measuring and recording), dynamic analysis of structures, design of earthquake-resistant engineering structures...). The author concludes by underlining the real problem of protecting buildings against earthquakes, which is the absorption and dissipation without failure or unacceptable deformations of the energy exerted on a building during an earth tremor. (Author abstract) In French. 4 refs.

Absi, Elie (Ecole Centrale de Paris, Fr). *Ann Inst Tech*

*Batim Trav Publics* v 40 n 453 Mar-Apr 1987 p 45-64.

**093375 MICROZONATION OF A METROPOLITAN AREA.** A method for seismic microzonation of a large metropolitan area (approximately 90×90 km) is examined. It utilizes information on the location of active faults and their relative levels of seismicity, the three-dimensional geometry of the source to station and frequency dependent attenuation, the effects of local amplification of wave amplitudes in terms of the depth of sedimentary deposits beneath the site, and two different scaling procedures in terms of earthquake magnitude and the epicentral intensity. It is shown that these two methods of scaling are consistent, and that both can lead to reliable estimates of uniform risk spectra. The method presented here does not require any new or difficult steps to gather data when compared to other microzonation procedures employed in the United States or abroad. The advantage of the method, however, lies in its ability to properly balance different contributing factors to the seismic risk at a point, in time, space and frequency of strong ground shaking. (Author abstract) 38 refs.

Lee, V.W.; Trifunac, M.D. *Rep Univ South Calif Dep Civ Eng* n 87-02 May 1987 143p.

**093376 ON SITE SPECIFIC DESIGN RESPONSE SPECTRA.** From an analysis of 59 horizontal and 30 vertical response spectra of accelerograms recorded on soil sites, simple functional relationships for spectral values have been derived. The coefficients of the fit and comparisons between predicted and observed response spectra for both horizontal and vertical motions are presented in this paper. (Author abstract) 15 refs.

Ghosh, A.K. (BARC, Bombay, India). *Nucl Eng Des* v 106 n 2 Feb (II) 1988 p 275-287.

**093377 DRAFT EUROCODE 8-SAMPLE SEISMIC FORCE CALCULATIONS FOR DISCUSSION PURPOSES.** Draft Eurocode 8 (Common Unified Rules for Structures in Seismic Regions) is open for study and comment until the latter part of 1989. This paper presents sample seismic force calculations for an idealized building, to illustrate the differing forces which result from the alternative calculation methods allowed. It is tentatively suggested that part of the Draft be revised as a result of the above. (Author abstract). 6 Refs.

Hayhurst, C.J. (W.S. Atkins Engineering Sciences, Surrey, Engl); Maguire, J.R. *Earthquake Eng Struct Dyn* v 16 n 5 Jul 1988 p 775-779.

**093378 ENGINEERING SEISMOLOGY.** With the spread of urban civilization and investment in large engineering projects in seismic regions, the toll to be taken by future earthquakes, and particularly the extent of the damage, are likely to increase. Engineering Seismology emerges, therefore, as an inter-disciplinary branch of engineering, a link between earth sciences and civil engineering, that aims primarily at the minimization, not the elimination, of earthquake risk. Engineering Seismology, in general, provides the data required for proper earthquake risk management, the criteria needed for the selection of safer sites for engineering projects, and in particular provides the engineer with the basic earthquake design ground motions and deformations that structures must survive with economically acceptable damage. The author's central topic is the importance of field observations and measurements in advancing our knowledge of Engineering Seismology. 367 Refs.

Ambraseys, N.N. (Imperial Coll of Science & Technology, London, Engl). *Earthquake Eng Struct Dyn* v 17 n 1 Sep 1988 p 1-105.

**093379 SEISMIC MICROZONING ON SOIL LIQUEFACTION POTENTIAL BASED ON GEOMORPHOLOGICAL LAND CLASSIFICATION.** A simplified procedure without using boring data is proposed for the seismic microzoning on soil liquefaction potential. The geomorphological land classification is adopted as the



index for liquefaction susceptibility, because the classification data are easily available for an area of interest. For each geomorphological unit, the critical peak ground velocity which separates liquefiable from non-liquefiable conditions is investigated based on case histories at about 250 sites during 19 Japanese earthquakes. The critical peak ground velocities at the sites with the same geomorphological unit are almost the same. These critical velocities vary depending on the geomorphological unit. Combining the land classification map and the isoseismal map of an earthquake which represents the distribution of peak ground velocity, the seismic microzoning on liquefaction potential during an earthquake can be readily made. (Edited author abstract). 77 refs.

Kotoda, Kikuo (Waseda Univ, Tokyo, Jpn); Wakamatsu, Kazue; Midorikawa, Saburoh. *Soils Found* v 28 n 2 Jun 1988 p 127-143.

**093380 ATTENUATION OF SEISMIC INTENSITY IN THE BALKAN COUNTRIES.** The parameters of the Gaussian distribution functions (average and standard deviation) of hypocentral distances to selected isoseisms, are presented for Albania, Greece, Bulgaria, Romania, Turkey and Yugoslavia. The results apply for the Medvedev-Karnik-Sponheuer (MKS) intensity, provided that all data is corrected to a unified MKS equivalent intensity as defined by Shebalin et al. (1974). The results should be of general value in macroseismic studies in the Balkan countries, but are essential for the development of microzonation maps when the seismicity is described in terms of the locally available intensity catalogues. Except for the Vrancea region in Romania and south-west Turkey, the observed attenuation of the intensities versus the hypocentral distance is similar to the attenuation of the Modified Mercalli Intensity (MMI) in the western United States of America. This finding should facilitate the use of other empirical scaling relations, developed in California, for various predictions of the characteristics of strong earthquake shaking in the Balkan countries. (Author abstract). 30 refs.

Trifunac, M.D.; Lee, V.W.; Cao, H.; Todorovska, M.I. *Rep Univ South Calif Dep Civ Eng* n 88-01 Apr 1988 53p.

**Analysis** See GEOLOGY—Tectonics.

## Australia

**093381 ASSESSMENT OF SEISMIC RISK IN NORTH EASTERN AUSTRALIA.** Research over the last few years has delineated the earthquake history and quantitatively assessed the seismic risk for northeastern Australia. Contrary to common beliefs, the level of seismic activity and consequent seismic risk for this region is comparable with the risk for other well recognized earthquake provinces in Australia. The scene is now set to promote an awareness to the engineering community as to the potential for earthquake damage and to provide seismological information that may be considered relevant to engineering designs. This paper discusses the situation pertaining to a continental (or intra-plate) regime, determines various earthquake parameters (with the emphasis on Richter magnitudes) and relationships between such parameters, and summarises the method of computations for the seismic risk. The research embodies a multidisciplinary approach integrating seismology with geology, tectonics and engineering based on a 118 year history of earthquakes in northeastern Australia. (Author abstract). 36 refs.

Rynn, J.M.W. (Univ of Queensland, Aust). *Trans Inst Eng Aust Civ Eng* v CE30 n 2 Jul 1988 p 45-56.

## Automation

**093382 TOWARDS A KNOWLEDGE-BASED SYSTEM FOR AUTOMATED GEOPHYSICAL INTERPRETATION OF SEISMIC DATA (AGIS).** Geophysical seismic interpretation is part of geophysical oil prospecting. It evaluates and analyzes seismic reflection data aiming at the detection of the position of hydrocarbon reservoirs. This work requires considerable experience and knowledge and must be done by skillful interpreters.

The aim of our research is to develop an expert system, which incorporates some of this geophysical knowledge and which can partly perform a knowledge-based automated geophysical interpretation. In its present state, the system developed can recognize various patterns useful in interpretation. It can also work interactively with an interpreter for improved performance. (Author abstract) 35 refs.

Pitas, I. (Univ of Thessaloniki, Thessaloniki, Greece); Venetsanopoulos, A.N. *Signal Process* v 13 n 3 Oct 1987 p 229-253.

## Instruments

**093383 OPTIMUM DESIGN OF OCEAN BOTTOM SEISMOMETERS.** This paper continues to develop the theory of coupling of ocean bottom seismometers (OBS) to soft sediments and arrive at results suggesting that OBS packages should be designed with: (1) the minimum mass possible, (2) radius of area in contact with the sediment proportional to the cube root of the mass, and the maximum radius less than 1/4 of the shear wavelength, (3) density of the OBS approximately that of the sediment, (4) a low profile and a small vertical cross section with water, and (5) low density gradients, and maximum symmetry about the vertical axis. Agreement of the theory with test data is good; most deviations are reasonable, given limitations of the theory and experiments. The theory also suggests that the coupling frequency, the frequency above which the OBS does not follow the motion of the sediment, is directly proportional to the sediment shear velocity. (Edited author abstract) 23 refs.

Sutton, George H. (Rondout Associates Inc, Stone Ridge, NY, USA); Duennieber, Frederick K. *Mar Geophys Res* v 9 n 1 1988 p 47-65.

**Japan** See BUILDINGS—Earthquake Resistance.

**Mathematical Models** See Also GEOPHYSICS—Seismic; STRUCTURAL ANALYSIS—Dynamic Response.

**093384 RECONSTRUCTION OF BLOCKY IMPEDANCE PROFILES FROM NORMAL-INCIDENCE REFLECTION SEISMOGRAMS WHICH ARE BAND-LIMITED AND MISCALIBRATED.** We study the inverse problem of determining the impedance of a one-dimensional medium from reflection data which are band-limited and uncalibrated. The problem arises in seismic exploration data processing. We give a brief review of the subject and explain why there is a need to model the data more realistically. We show that if we are given, in addition to the reflection data, some a priori information about the impedance, we can in principle determine the desired unknown. The method incorporates the a priori information about the impedance profile in an optimization problem involving  $L^1$ - and  $L^2$ -norms. From the character of the optima of the minimization, we are able to assess the possibility of absolute calibration of the data, and of estimating the absolute impedance of the medium. Our findings are illustrated with numerous simulations. (Author abstract) 32 refs.

Santosa, Fadil (Univ of Maryland, College Park, MD, USA); Symes, William W. *Wave Motion* v 10 n 3 Jun 1988 p 209-230.

**Research** See EARTHQUAKES—Research; SURFACE WAVES—Velocity.

**Safety Codes** See STRUCTURAL DESIGN—Earthquake Resistance.

**Spectrum Analysis** See SEISMIC WAVES—Spectrum Analysis.

**Theory** See Also GEOPHYSICS—Subcrustal; MATHEMATICAL TECHNIQUES—Estimation.

**093385 REFLECTION SEISMOLOGY OVER AZIMUTHALLY ANISOTROPIC MEDIA.** Recent surveys have shown that azimuthal anisotropy (due most plausibly

to aligned fractures) has an important effect on seismic shear waves. The anisotropic effects on different polarization components of vertically traveling shear waves permit the recognition and estimation of very small degrees of azimuthal anisotropy (of order  $\geq 1$  percent), as in an interferometer. Anisotropic effects on traveltime yield estimates of anisotropy which are averages over large depth intervals. Often, raw field data must be corrected for these effects before the reflectors may be imaged; two variations of a rotational algorithm to determine the 'principal time series' are derived. Anisotropic effects on moveout lead to abnormal moveout unless the survey line is parallel to the fractures. Anisotropic effects on reflection amplitude permit the recognition and estimation of anisotropy (hence fracture intensity) differences at the reflecting horizon, i.e., with high vertical resolution. (Edited author abstract) Refs.

Thomsen, Leon (Amoco Production Co, Tulsa, OK, USA). *Geophysics* v 53 n 3 Mar 1988 p 304-313.

**SELENIUM** See Also SEMICONDUCTING GALLIUM ARSENIDE—Ion Implantation; TANTALUM COMPOUNDS—Structure.

**093386 DISTRIBUTION OF SELENIUM IN HIGH-TEMPERATURE HYDROTHERMAL SULFIDE DEPOSITS AT 13° NORTH, EAST PACIFIC RISE.** 'Black smoker' chimneys and Fe-Cu-rich massive sulfides are found on the axial graben and off-axis seamounts, respectively, of the East Pacific Rise at 13°N. The trace element selenium substitutes for sulfur in solid solution in all sulfide minerals. Electron-microprobe analyses were performed under optimal conditions to obtain a minimum detection-limit (MDL) of 30 ppm for selenium in chalcopyrite, with a calculated precision of 30 ppm. The Se content of the sulfides depends on the physicochemical parameters of the ore solutions during precipitation. High Se values occur in high-temperature mineral assemblages. The highest selenium contents are found in chalcopyrite ( $\approx 2500$  ppm) and in euhedral pyrite ( $\approx 1500$  ppm). For selected samples, the lowest mean concentration of Se in chalcopyrite is 645 ppm. (Edited author abstract) 42 refs.

Auclair, Gilles (IFREMER, Brest, Fr); Fouquet, Yves. *Can Mineral* v 25 pt 4 Dec 1987 p 577-587.

## Adsorption

**093387 SELENIUM ADSORPTION BY GOETHITE.** For the well-being of human beings and animals, it is necessary to understand the processes that control the mobility and transport of toxic elements in the environment. The behavior of toxic elements is influenced by the redox and pH of the system and by processes such as precipitation and coprecipitation, the formation of organic or inorganic complexes, biological interactions, and adsorption. This paper is concerned with the process of adsorption and how it may influence the mobility of the toxic element, selenium. The adsorption of Se by goethite was studied as a function of time (10 min-24 h), temperature (295.5 and 303.5 K), pH (4-11), particle concentration (3-300 mg/L), total Se concentration ( $0.02-5 \times 10^{-5}$  M), oxidation state [Se(IV) and Se(VI)], and competing anion concentration [anion]/[Se(IV)]=0.25 to 50,000 in order to assess the influence of these factors on Se mobility. 54 refs.

Balistreri, Laurie S. (US Geological Survey, Denver, CO, USA); Chao, T.T. *Soil Sci Soc Am J* v 51 n 5 Sep-Oct 1987 p 1145-1151.

**093388 SORPTION OF SELENIUM(IV) AND SELENIUM(VI) FROM ACID SOLUTIONS BY ORGANO-SILICON ION-EXCHANGERS.** The purpose of this work was to study the possibility of sorption of trace amounts of selenium(IV) and selenium(VI) from acid solutions by organosilicon ion-exchangers. These organosilicon ion-exchangers have higher thermal and chemical stability than organic sulfonated cation-exchangers and ion-exchangers containing sulfhydryl groups (KSG), and



are very effective in relation to a number of precious (Ag, Pt, Pd) and heavy ( $Hg$ ) metals, and also to rare earth elements. It is found that the ion-exchangers studied are most effective with respect to selenium(IV); the ion-exchangers PMMS-2 and PSSK-3 have the highest sorption activity. The optimal conditions for sorption of selenium(IV) were found. 12 refs.

Vlasova, N.N. (Acad of Sciences of the USSR, USSR); Stanevich, L.M.; Bol'shakova, S.A.; Voronkov, M.G. *J Appl Chem USSR* v 60 n 7 pt 1 Jul 1987 p 1394-1397.

**Amorphous** See Also SEMICONDUCTING SELENIUM—Electric Properties.

**093389 STUDY OF THE ELECTRICAL CONDUCTIVITY OF AMORPHOUS - CRYSTALLINE SELENIUM MIXTURES.** A series of compressed powder samples of a double-phase selenium mixture were prepared with various fractional volumes of amorphous (a) and crystalline (c) phases. The direct current properties of the samples were measured and are discussed. The activation energy was found to decrease from 1.8 eV (for the 90% amorphous-10% crystalline sample) to 0.67 eV (for the 100% crystalline sample). For the same range of fractional volumes, the conductivity  $\sigma_m$  of the mixture at room temperature was found to increase from  $5.5 \times 10^{-13} \Omega^{-1} \text{cm}^{-1}$  to  $5.25 \times 10^{-7} \Omega^{-1} \text{cm}^{-1}$ , and the pre-exponential factor  $\sigma_0$  increased from  $5 \times 10^{-4} \Omega^{-1} \text{cm}^{-1}$  to  $2.75 \Omega^{-1} \text{cm}^{-1}$ . An empirical formula to fit the measured conductivity data over the entire range of the double-phase mixture is proposed. This formula was also tested for massive selenium samples of different degrees of crystallinity (defined from X-ray measurements) and very satisfactory results were obtained. (Author abstract) 17 refs.

Kotkata, M.F. (Ain Shams Univ, Cairo, Egypt); Kandil, K.M. *Mater Sci Eng* v 95 n 1-2 Nov 1987 p 287-293.

**093390 PHENOMENOLOGICAL MODEL OF PHOTOPRECIPITATION IN A-SE COLLOID SOLUTIONS.** An attempt has been made in this study to develop a physical model for the photoprecipitation and photoaggregation effects in amorphous Se(a-Se) colloids. The theory explains in basic terms the experimental time dependence of the precipitated elemental Se concentration. Several kinetic parameters were evaluated by correlating the experiment to theory, subject to strong light intensity and narrow beam approximations. The results were used to quantify and clarify several further features of photoprecipitation in a phenomenological way. (Author abstract) 5 refs.

Peled, A. (Tel-Aviv Univ, Tel-Aviv, Isr); Naot, D. *Colloid Polym Sci* v 265 n 11 Nov 1987 p 986-992.

**093391 INVESTIGATION OF THE PRESSURE DEPENDENCE OF THE ELASTIC CONSTANTS OF AMORPHOUS SELENIUM IN THE VICINITY OF THE GLASS-TRANSITION.** The hydrostatic pressure dependences of the velocities of longitudinal and shear ultrasonic waves propagated in amorphous selenium have been measured as a function of temperature through the glass-transition region. Both  $\partial C_{11}/\partial P$  and  $\partial C_{44}/\partial P$  increase rapidly as temperature is increased, a finding attributed to a combination of increasing vibrational anharmonicity as  $T_g$  is approached from below and to free-volume effects. At room temperature, substantially below  $T_g$ , the thermal Grueneisen parameter is only 1.05 whereas the mean long-wavelength acoustic parameter is 3.0. This arises because the intermolecular volume is much more compressible than the intramolecular volume: the Grueneisen parameters for purely internal modes of vibration are small whereas those for the external modes are larger. (Author abstract) 12 refs.

Ford, P.J. (Univ of Bath, Bath, Engl); Saunders, G.A.; Lambson, E.F.; Carini, G. *Phil Mag Lett* v 57 n 3 Mar 1988 p 201-207.

**Estimation** See SOILS—Microbiology.

**Ionization** See SPECTROSCOPY.

### Spectroscopic Analysis

**093392 TOTAL REFLECTION ENERGY-DISPERSIVE X-RAY FLUORESCENCE SPECTROMETRY USING MONOCHROMATIC SYNCHROTRON RADIATION: APPLICATION TO SELENIUM IN BLOOD SERUM.** Monochromatic synchrotron X-radiation at The National Synchrotron Light Source (NSLS) has been investigated as an excitation source for the direct energy-dispersion X-ray fluorescence (EDXRF) spectrometric analysis of metals in solution at parts per billion (ppb) levels in the total reflection geometry. A minimum detection limit (mdl) of 8 ppb was determined for selenium in human blood serum and in proposed NBS-SRM 1598 bovine serum. The results show that this method is sufficiently sensitive for analysis of Se in blood serum. (Edited author abstract) 15 refs.

Pella, P.A. (NBS, Gaithersburg, MD, USA); Dobbryn, R.C. *Anal Chem* v 60 n 7 Apr 1 1988 p 684-687.

### Structure

**093393 PHASE RELATIONS AND EQUILIBRIUM COPOLYMERIZATION IN THE Se-S SYSTEM.** The phase relations in the Se-S system were investigated by the appearance of phase method, differential thermal analysis, and differential scanning calorimetry. High purity selenium melts at  $216 \pm 2^\circ\text{C}$ . A peritectic exists at  $85 \text{ at.}\% \text{ Se}$  and  $168 \pm 2^\circ\text{C}$ ; the peritectic isotherm extends from  $92$  to  $73.5 \text{ at.}\% \text{ Se}$ . A temperature minimum of  $102 \pm 1^\circ\text{C}$  exists at a composition of  $35 \pm 1 \text{ at.}\% \text{ Se}$ . High purity sulfur melts at  $114 \pm 1^\circ\text{C}$  and polymerizes at  $160 \pm 2^\circ\text{C}$ . Addition of  $10 \text{ at.}\% \text{ Se}$  lowers the polymerization temperature to  $118 \pm 3^\circ\text{C}$ . The Se-S system shows complete liquid miscibility and in this respect it differs from the majority of selenide type systems that generally show one or more fields of liquid immiscibility. (Edited author abstract) 25 refs.

Boctor, N.Z. (Purdue Univ, West Lafayette, IN, USA); Kullerud, G. *CHEMTECH* v 17 n 8 Aug 1987 p 513-521.

### Thin Films

**093394 STRUCTURAL, MORPHOLOGICAL, AND OPTICAL RECORDING CHARACTERIZATION OF SELENIUM FILMS.** Selenium films obtained by vacuum deposition and hot-wall epitaxy (HWE) were investigated for structural, morphological, and holographic characteristics. Vacuum-deposited Se films, which are generally amorphous, were found to crystallize under an intense beam of an electron microscope. The transmission electron diffraction results indicated that the crystallized phase was  $\beta$ -monoclinic. These films have high transmittance in the visible spectrum and exhibit good exposure characteristics for recording holograms. Parameters such as diffraction efficiency, modulation transfer function, and spatial frequency, determining the exposure characteristics, were evaluated. Films grown by hot-wall epitaxy, however, have different properties. The surface morphology showed growth to needlelike single crystals  $5 \mu\text{m}$  in size, with preferred growth in the (100) direction. These films were gray and exhibited poor transmittance and scattering centers, thus losing their recording properties. X-ray diffraction results of Se films grown by HWE indicated that the crystallized phase was hexagonal in structure. (Edited author abstract) 14 refs.

Singh, Amarjit (Univ Laval, Que, Can); Song, Li; Lessard, Roger A. *Opt Eng* v 26 n 9 Sep 1987 p 944-948.

**093395 ON THE THEORY OF PHOTOADSORPTION KINETICS OF a-SE COLLOIDS: A SIMPLE MODEL FOR THE KINETIC PARAMETERS.** Amorphous selenium (a-Se) films have been deposited from colloid solutions by irradiation with light and the kinetic parameters have been recorded for a wide range of operating conditions. Surface photodeposition (SP) is an adsorption effect by which colloid particles adhere onto

irradiated substrates at the solution interface, to create thin films of continuous composition. Attempt is made to obtain a physical picture of the SP process. For this end, the experimental kinetic law of film growth is used and through a simple but sufficiently realistic model connection to the fundamental physical parameters of the SP mechanisms is made. 11 refs.

Peled, A. (Cent for Technological Education Holon, Holon, Isr); Perakh, M. *J Colloid Interface Sci* v 122 n 1 Mar 1988 p 193-200.

**093396 ETUDE DES PROPRIETES DE COUCHES MINCES DE SELENIUM HEXAGONAL DOPEES AU CHLORE.** [Properties of Thin Chlorine-Doped Hexagonal Selenium Films]. Thin films of chlorine-doped selenium were characterized using X-rays, scanning electron microscopy and secondary ion mass spectrometry (SIMS) studies. The conductivity, Hall effect and thermoelectric power variations were measured vs. temperature. A new device for measurements of the thermoelectric power of resistive samples is described. SIMS analysis showed that chlorine was not uniformly distributed in the films. The crystallite size was found to increase when the chlorine concentration decreased and/or when the substrate temperature during deposition increased. The films being polycrystalline, electrical measurements show that only a small fraction of chlorine enters the crystallite and increases the acceptor concentration, while the excess chlorine remains at the grain boundaries. (Author abstract) 23 refs. In French.

Napo, K. (Univ de Nantes, Nantes, Fr); Bernede, J.C.; Safoula, G.; Burgaud, P.; Ameziane, A. *Thin Solid Films* v 157 n 2 Feb 29 1988 p 291-306.

**093397 EFFECT OF ULTRATHIN SELENIUM OVERCOAT ON THE STABILITY OF TELLURIUM-BASED OPTICAL RECORDING MEDIA.** An ultrathin selenium overcoat about  $20\text{-}40 \text{ \AA}$  thick was found to be quite effective in retarding both the uniform and the localized degradation rate of tellurium-based optical recording media in room ambient and high humidity and temperature accelerated testing environments. Results from x-ray photoelectron spectroscopy analyses of selenium-overcoated tellurium films and Te-Se alloy films suggested the formation of a high selenium concentration Te-Se alloy for the selenium-overcoated film. The effect of the selenium overcoat is interpreted in terms of the presence of this Te-Se alloy which is capable of retarding both the oxidation and weight loss degradation mechanisms reported previously for thin tellurium films. This interpretation is consistent with the results from the electrochemical studies made on these films in that the open-circuit potential of the selenium-overcoated films corresponds to those for Te-Se alloy films having about 90% Se. (Author abstract) 14 refs.

Lee, W.Y. (IBM, San Jose, CA, USA). *Thin Solid Films* v 154 n 1-2 Nov 12 1987, Pap Presented at the Int Conf on Metall Coat - Part II, San Diego, CA, USA, Mar 23-27 1987 p 447-458.

**X-Ray Analysis** See BIOLOGICAL MATERIALS—Chemical Analysis.

## SELENIUM BISMUTH ALLOYS

### Thin Films

**093398 THERMAL BEHAVIOUR OF  $\text{Se}_{0.995}\text{Bi}_{0.005}$  THIN FILMS.**  $\text{Se}_{0.995}\text{Bi}_{0.005}$  deposited on aluminum (SeBi/Al) and kapton (SeBi/kapton) has been characterized by means of differential thermal analysis. The thermal phenomena such as glass transition temperature, crystallization and melting have been studied. The nature of the substrate on the one hand and the presence of bismuth in selenium on the other hand seem to modify these phenomena. The temperature  $T_g$  corresponding to the binary SeBi alloy is very slightly higher than that of pure selenium. While the nature of the substrate does not modify in such a manner the value of  $T_g$ . The activation energy associated with crystallization for SeBi/Al is higher than the activation energy of SeBi/kapton. A



sharper peak of crystallization occurs in the case of SeBi/kapton reflecting the small size of the crystals. Finally, melting of two phases has been observed in the case of SeBi/Al and a difficult melting in the case of SeBi/kapton. (Edited author abstract) 10 refs.

Atmani, H. (Lab d'Etude des Couches Minces Amorphes et Polycristallines, Mont-St.-Aignan, Fr); Vautier, C. *Mater Chem Phys* v 18 n 1-2 Oct 1987 p 129-137.

## SELENIUM COMPOUNDS

**Adsorption** See SOILS—Composition Effects;  
SOILS—pH Effects.

**Amorphous** See GLASS—Thermal Properties.

## Chemistry

**093399 AQUATIC CHEMISTRY OF SELENIUM: EVIDENCE OF BIOMETHYLATION.** The chemical species of dissolved selenium were examined in surface waters from three sites in the San Joaquin and Imperial Valleys of California. Six dissolved selenium species were identified: the inorganic species selenate and selenite; nonvolatile organic selenides, including seleno amino acids and a dimethylselenium ion; and the volatile methylated forms dimethyl selenide and dimethyl diselenide. Laboratory studies indicate that the nonvolatile dimethylselenium ion can be transformed into volatile dimethyl selenide at neutral pH, providing a pathway for the in situ production of dimethyl selenide in natural waters. Geochemical flux calculations indicate that outgassing of dimethyl selenide may be an important removal mechanism for dissolved selenium from aqueous systems. (Edited author abstract) 22 refs.

Cooke, Terence D. (Univ of California, Santa Cruz, CA, USA); Bruland, Kenneth W. *Environ Sci Technol* v 21 n 12 Dec 1987 p 1214-1219.

## Electrodeposition

**093400 NATURE OF THE SITES OF ELECTRON GENERATION ON SELENIUM SURFACES DURING ELECTRODEPOSITION FROM STRONGLY ACIDIC ELECTROLYTES.** The nature of the sites of electron generation was studied on selenium surfaces in strongly acidic electrolytes. It is shown that in strongly acidic electrolytes, adsorbed oxides of selenium are the SEG (Sites of Electron Generation) on the electrode surface. They are stable only in strongly acidic media (pH < 0.7) when there is a large excess of SeO<sub>2</sub> present in the solution. In electrolytes with a lower concentration of hydrogen ions, the adsorbed surface oxides dissolve, the sites of electron generation disappear, and the rate of the electrochemical reaction decreases drastically. (Edited author abstract) 9 refs.

Bigelis, V.M. (Acad of Sciences of the Uzbek SSR, Ulugbek, USSR); Mukhopadaya, O.Ya.; Rakhmanov, A. *Sov Electrochem* v 23 n 5 May 1987 p 540-543.

## Environmental Impact

**093401 ACCUMULATION OF SELENIUM IN CROPS GROWN ON SLUDGE-TREATED SOIL.** Uptake by barley, Swiss chard and radish of Se from composted Los Angeles County sewage sludge applied to land was studied in a long-term field study. Sludge was applied at 0, 225.5, 45, 90, and 180 Mg/ha per year for 8 to 10 yr and the data reported here are for the last year of the study. Total surface soil Se increased with the highest rate of sludge addition from < 0.1 mg/kg in the control soil to 1.2 mg/kg. Only 13 to 25% of the sludge-applied Se could be accounted for in the 0- to 15-cm depth of incorporation and there was no measurable Se in the subsoil to 150 cm. There was little or no measurable uptake of Se by barley leaf and grain at the level of detection of this study, and there were also no significant increases in chard or radish Se concentrations with sludge addition. Selenium concentrations in chard (0.05-0.11 mg/kg) were severalfold lower than those in radish. (Edited author abstract) 18 refs.

Logan, T.J. (Ohio State Univ, OH, USA); Chang, A.C.; Page, A.L.; Ganje, T.J. *J Environ Qual* v 16 n 4 Oct-Dec 1987 p 349-352.

**093402 BIOGEOCHEMICAL CYCLING OF SELENIUM IN THE SAN JOAQUIN VALLEY, CALIFORNIA, USA.** Subsurface agricultural drainage waters from western San Joaquin Valley, California, were found to contain elevated concentrations of the element selenium in the form of selenate. In 1978, these drainage waters began to replace previous input to Kesterson Reservoir. In the 1983 nesting season, unusual rates of deformity and death in embryos and hatchlings of wild aquatic birds occurred at the refuge and were attributed to selenium toxicosis. Features necessary for contamination to have taken place included geologic setting, climate, soil type, availability of imported irrigation water, type of irrigation, and the unique chemical properties of selenium. (Edited author abstract) 103 refs.

Presser, Theresa S. (US Geological Survey, Menlo Park, CA, USA); Ohlendorf, Harry M. *Environ Manage* v 11 n 6 Nov 1987 p 805-821.

**093403 SELENIUM UPTAKE BY SOME AGRICULTURAL CROPS FROM CENTRAL CALIFORNIA SOILS.** Greenhouse experiments were conducted to study Se uptake and partitioning by crops grown in five California soils of differing physical and chemical properties. Alfalfa (*Medicago sativa* L.), barley (*Hordeum vulgare* L.), beet (*Beta vulgaris* L.), and tomato (*Lycopersicon esculentum* Mill.) were grown in soil to which 0, 0.5, and 1.5 mg Se(VI) kg<sup>-1</sup> was added. Alfalfa was also grown in four additional soils to which 0, 0.5, 1.5, and 3.0 mg Se(VI) kg<sup>-1</sup> had been added. Plants were grown to maturity, separated into plant parts and analyzed for yield and tissue Se. For the barley, beet, and tomato, the edible portion of the plant contained much less total Se than the generally inedible plant parts. The presence of soluble SO<sub>4</sub><sup>2-</sup> in the soil was the major soil factor in determining Se accumulation by plants. Alfalfa grown in low-SO<sub>4</sub><sup>2-</sup> soil accumulated Se to a concentration 10 to 20 times greater (> 1000 mg Se kg<sup>-1</sup>) than plants growing in high-SO<sub>4</sub><sup>2-</sup> soil (< 100 mg Se kg<sup>-1</sup>). When exposed to Se(VI) in the root zone, all plants tested were capable of accumulating Se to concentrations potentially harmful to animals. (Author abstract) 22 refs.

Wan, H.F. (Acad Sinica, Nanjing, China); Mikkelsen, R.L.; Page, A.L. *J Environ Qual* v 17 n 2 Apr-Jun 1988 p 269-272.

**093404 GROWTH AND UPTAKE OF SELENIUM BY SWISS CHARD IN ACID AND NEUTRAL SOILS.** The absorption of Se by plants in acid and neutral soils in relation to the concentration and chemical form of Se added was studied. Selenate-Se added to an acid in amounts equal to or greater than 1.0 mg kg<sup>-1</sup> significantly reduced yields of Swiss chard (*Beta vulgaris* L. var. cicla). Selenite-Se, however, added to the acid soil at levels up to 2 mg kg<sup>-1</sup> did not affect yields. Likewise, yields were also unaffected when selenite or selenate was added alone or in combination to a neutral soil at levels up to 2 mg Se kg<sup>-1</sup>. Amounts of Se absorbed by plants from soils where selenate was added were greater than where selenite was added. Selenate added to the soils was, in part, reduced to selenite during the growth period. (Author abstract) 12 refs.

Zhang, Penchu (Univ of California, Riverside, CA, USA); Ganje, T.J.; Page, A.L.; Chang, A.C. *J Environ Qual* v 17 n 2 Apr-Jun 1988 p 314-316.

**093405 DISTRIBUTION AND MOBILITY OF SELENIUM AND OTHER TRACE ELEMENTS IN SHALLOW GROUNDWATER OF THE WESTERN SAN JOAQUIN VALLEY, CALIFORNIA.** Samples of shallow groundwater that underlies much of the irrigated area in the western San Joaquin Valley, CA, were analyzed for various major ions and trace elements, including selenium. Concentrations of the major ions generally were similar for groundwater collected in the two primary geologic zones - the alluvial fan and basin trough. Selenium concentrations are significantly higher in the

groundwater of the alluvial-fan zone than in that of the basin-trough zone. The concentrations of oxyanion trace elements were significantly correlated with groundwater salinity, but the correlations between selenium and salinity and between molybdenum and salinity were significantly different in the alluvial-fan geologic zone. Study conclusions are discussed. (Edited author abstract) 33 refs.

Deverel, Steven J. (US Geological Survey, Sacramento, CA, USA); Millard, Steven P. *Environ Sci Technol* v 22 n 6 Jun 1988 p 697-702.

**Magnetic Properties** See MAGNETIC MATERIALS—Research.

**Optical Properties** See SOLAR ENERGY—Materials.

**Order-Disorder** See MAGNETIC MATERIALS—Synthesis.

## Phase Transitions

**093406 CONTROL OF PHASE TRANSITION IN TaSe<sub>3</sub>.** Stabilization factors of the high and low temperature phases of TaSe<sub>3</sub> are investigated. The low temperature phase is stabilized by zirconium or titanium impurity. The high temperature phase is stabilized by oxygen impurity. Without oxygen impurity, the low temperature phase is stable up to decomposition temperature and the phase transition is completely suppressed by zirconium impurity. (Author abstract) 8 refs.

Hayashi, K. (Okayama Univ of Science, Okayama, Jpn); Kawamura, A.; Komai, K. *Mater Res Bull* v 23 n 10 Oct 1987 p 1341-1345.

## Synthesis

**093407 NEW TRANSITION METAL SILICOSELENIDES POSSESSING CdI<sub>2</sub>-TYPE STRUCTURES.** Three different kinds of first-row transition metal silicoselenides having CdI<sub>2</sub>-related structures have been synthesized. Vanadium and chromium form VSiSe<sub>3</sub> and Cr<sub>1+x</sub>SiSe<sub>3</sub> which are similar to MPSe<sub>3</sub>, crystallizing in a hexagonal structure. Manganese forms Mn<sub>3/2</sub>SiSe<sub>3</sub>, which is isostructural with Mn<sub>3/2</sub>SiTe<sub>3</sub>. With Fe, Co and Ni, a new type of silicoselenide with the formula MSi<sub>2</sub>Se<sub>4</sub> (M = Fe, Co or Ni) is obtained. These solids crystallize in the CdI<sub>2</sub>/Cr<sub>3</sub>S<sub>4</sub> structure, where M atoms and Si-Si pairs occupy the cation positions. (Author abstract) 12 refs.

Gopalakrishnan, J. (Indian Inst of Science, Bangalore, India); Nanjundaswamy, K.S. *Mater Res Bull* v 23 n 1 Jan 1988 p 107-112.

## Toxicity

**093408 ACUTE TOXICITY OF INORGANIC SELENIUM TO DAPHNIA MAGNA (STRAUS) AND THE EFFECT OF SUB-ACUTE EXPOSURE UPON GROWTH AND REPRODUCTION.** The acute toxicities of sodium selenite (Na<sub>2</sub>SeO<sub>3</sub>) and sodium selenate (Na<sub>2</sub>SeO<sub>4</sub>) to *Daphnia magna* were determined in defined culture at 22°C. For adults, the 48-h LC<sub>50</sub> values were 0.68 ppm selenium as selenite and 0.75 ppm selenium as selenate. Juveniles were more sensitive, with a 48-h LC<sub>50</sub> of 0.55 ppm selenium as selenate. Eggs and embryos were found to be much less sensitive, with a 72-h LC<sub>50</sub> of 1.4 ppm selenium as selenate. Sub-acute exposure of *D. magna* to sodium selenate caused suppression of growth over instars 1-5 and reduced egg production in instar 9 when adults were exposed to test solutions from instar 6 onwards. These sublethal effects were found at concentrations in the range proposed as suitable for the use of selenium in the amelioration of mercury contamination. (Author abstract) 25 refs.

Johnston, P.A. (Queen Mary Coll, London, Engl). *Aquat Toxicol* v 10 n 5-6 Aug 1987 p 335-352.



## X-Ray Analysis

**093409 X-RAY DIFFRACTION STUDY OF  $\text{NH}_4\text{HSeO}_4$  AND  $\text{ND}_4\text{DSeO}_4$ .** This paper reports results obtained from an x-ray diffraction study of  $\text{NH}_4\text{HSeO}_4$  and  $\text{ND}_4\text{DSeO}_4$  single crystals in their various phases. In connection with incommensurability: a) a 3c-superstructure phase has been found both in  $\text{AHSe}$  and in  $\text{ADSe}$ , b) a 2c-superstructure has been discovered in  $\text{ADSe}$ . The non-equilibrium processes have been identified clarifying the situation about the phase diagram. (Author abstract) 14 refs.

Rozycki, A. (CNRS, Orsay, Fr); Denoyer, F.; Novak, A. *J Phys (Paris)* v 48 n 9 Sep 1987 p 1553-1558.

**SELENIUM GERMANIUM ALLOYS** See GLASS, METALLIC—Crystallization.

## SELENIUM INDIUM ANTIMONY ALLOYS

## Thin Films

**093410 SELENIUM-INDIUM-ANTIMONY ALLOY FILM FOR ERASABLE OPTICAL DISKS.** A new type of crystal phase change was found in selenum-indium-antimony alloy film, which is a unique material. The phase change occurs reversibly between two different crystal states when the film is irradiated with laser pulses, resulting in different optical reflectivities. An erasable optical disk using this film has good carrier-to-noise-ratio of 45 db, moderate recording sensitivity and long media life, but erasable cycles still vary from between  $10^3$  and  $10^6$  times at present. Though there remain some problems to be solved, the disk is nearly ready for practical use, and as such is promising. A proposed model of the phase-change mechanism is discussed. (Edited author abstract) 9 refs.

Koshino, Naga-aki (Fujitsu Lab, Atsugi, Jpn); Utsumi, Ken-ichi; Goto, Yasuyuki. *Fujitsu Sci Tech J* v 24 n 1 Mar 1988 p 60-69.

## SELENIUM TELLURIUM ALLOYS

**Electric Properties** See PHOTOGRAPHIC REPRODUCTION—Xerography.

## Thermodynamics

**093411 THERMODYNAMIC ASSESSMENT OF THE Se-Te SYSTEM.** An optimized set of data for the Se-Te system has been obtained by the least squares method. The excess Gibbs energy functions of both the liquid and solid phases were expressed by Redlich-Kister polynomials. The thermodynamic functions and the phase diagram, calculated by the resulting analytical description, are in reasonably good agreement with the experimental data. (Author abstract). 18 Refs.

Ghosh, G. (Katholieke Univ Leuven, Heverlee, Belg); Lukas, H.L.; Delaey, L. *Calphad* v 12 n 3 Jul-Sep 1988 p 295-299.

**SEMICONDUCTING ALUMINUM COMPOUNDS** See Also INTEGRATED CIRCUITS, VLSI—Manufacture; LASERS, SEMICONDUCTOR—Efficiency; LASERS, SEMICONDUCTOR—Electric Properties; LASERS, SEMICONDUCTOR—Fabrication; LASERS, SEMICONDUCTOR—Manufacture; LASERS, SEMICONDUCTOR—Performance; SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers; SEMICONDUCTING GALLIUM ARSENIDE—Growth; SEMICONDUCTING GALLIUM ARSENIDE—Thin Films; SEMICONDUCTOR DEVICES—Contacts; SEMICONDUCTOR DEVICES, MISFET—Heterojunctions; TRANSISTORS, BIPOLAR—Fabrication; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, FIELD EFFECT—Mathematical Models; TRANSISTORS, FIELD EFFECT—Millimeter Waves; TRANSISTORS, FIELD EFFECT—Modeling; TRANSISTORS, FIELD EFFECT—Modulation; TRANSISTORS, FIELD EFFECT—Performance; TRANSISTORS, FIELD EFFECT—Simulation.

## Analysis

**093412 QUASIPARTICLE CALCULATION OF VALENCE BAND OFFSET OF  $\text{AlAs-GaAs}$  (001).** A

first principles quasiparticle theory for band offsets of heterojunctions is developed and used to compute the valence band offset  $\Delta E_v$  for the prototypical  $\text{AlAs-GaAs}$  (001) interface. The result  $\Delta E_v = 0.53 \pm 0.05$  eV is in good agreement with recent experimental values and in particular with the most recent photoluminescence data  $\Delta E_v = 0.56 \pm 0.03$  eV for an MBE grown sample. We show that there is a substantial many-body correction of 0.12 eV to the value of the valence band offset calculated using local density functional theory. (Author abstract) 32 refs.

Zhang, S.B. (Univ of California, Berkeley, CA, USA); Tomanek, D.; Louie, Steven G.; Cohen, Marvin L.; Hybertsen, Mark S. *Solid State Commun* v 66 n 6 May 1988 p 585-588.

**Applications** See LASERS, SEMICONDUCTOR—Reliability; SOLAR CELLS—Research.

**Charge Carriers** See Also SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers.

**093413 DEEP ELECTRON TRAPS IN  $\text{AlAs-GaAs}$  SUPERLATTICES AS STUDIED BY DEEP-LEVEL TRANSIENT SPECTROSCOPY.** Deep electron traps in Si-doped  $\text{AlAs-GaAs}$  superlattices (SLs) grown by MBE have been investigated using deep-level transient spectroscopy (DLTS). The concentration of the characteristic electron trap (E2 trap) in the SLs increases upon decreasing the period of SL and increasing the Si doping concentration. The E2 trap concentration for uniformly Si-doped SLs is more than one order higher than that for SLs doped selectively at the middle part of each  $\text{AlAs}$  and  $\text{GaAs}$  layer. The E2 traps have properties similar to the so-called DX centers in  $\text{Al}_x\text{Ga}_{1-x}\text{As}$ , and they exist only in the  $\text{AlAs-GaAs}$  interfaces. The different activation energies of the traps in SLs and  $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As}$  can be explained in terms of carrier emission from the E2 trap to the mini-band levels of the SLs and to the conduction band minimum of the alloys, respectively. (Author abstract) 11 refs.

Kobayashi, Kikuo (NHK, Tokyo, Jpn); Morita, Masahiko; Kamata, Norihiko; Suzuki, Takeo. *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 192-195.

**093414 ENERGY AND SPIN POLARIZATION ANALYSIS OF NEAR BAND GAP PHOTOEMISSION IN  $\text{AlGaAs/GaAs}$  HETEROSTRUCTURES.** Analysis of electron energy and spin allows a determination of the characteristics parameters for thermalization and spin relaxation for electrons in the conduction band. The use of a  $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As}$  sample covered by a thin  $\text{GaAs}$  overlayer as a convenient source of polarized electrons under He-Ne laser excitation is suggested. (Author abstract). 10 refs.

Ciccacci, F. (Univ di Roma 'Tor Vergata', Rome, Italy); Drouhin, H.-J.; Hermann, C.; Houdre, R.; Lampel, G.; Alexandre, F. *Phys Scr* v 38 n 3 Sep 1988 p 458-461.

**Chemical Vapor Deposition** See INTEGRATED CIRCUITS, LSI—Processing; LASERS, SEMICONDUCTOR—Fabrication.

**Composition Effects** See LASERS, SEMICONDUCTOR—Analysis; TRANSISTORS, BIPOLAR—Heterojunctions.

**Crystal Lattices** See SEMICONDUCTING GALLIUM ARSENIDE—Crystal Lattices.

## Defects

**093415 CONTRIBUTION A L'ETUDE DES FAUTS DE CROISSANCE PAR EJM A L'AIDE DE LA PHOTOLUMINESCENCE ET LA MICROSCOPIE AUGER.** [Contribution to Study of Growth Defects in Molecular Beam Epitaxy Aided by Photoluminescence and Auger Microscopy]. Morphological growth defects, so-called oval defects, are investigated in MBE Si doped  $\text{Al}_x\text{Ga}_{1-x}\text{As}$   $x = 0.30$  layers by photoluminescence topography (PLT) and by Auger electron spectroscopy (AES). The photoluminescence emission peak of these

defects lies between 0.78 and 0.90  $\mu\text{m}$  corresponding to an Al concentration between 0 and 15%. The intensity of this emission is anomalously high which could possibly be explained by a local confinement. Most oval defects present essentially the same behavior when analyzed by PLT, while scanning Auger microscopy reveals morphological and compositional differences. A variation in the Al and Ga concentration as well as the presence of certain impurities (O-In) are observed. These results give further support to the fact that gallium oxides play a major role in the formation of some oval defects and that some others may contain different impurities. (Author abstract) 6 refs. In French.

Ossart, P. (CNET, Bagneux, Fr); Souza, P. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 295-296.

**Doping** See Also SEMICONDUCTING GALLIUM ARSENIDE—Doping; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, FIELD EFFECT—Tunneling.

**093416 ELECTRICAL PROPERTIES OF CADMIUM AND ZINC DOPED  $\text{CuAlS}_2$ .** The aim of this note is to study the electrical properties of cadmium and zinc doped  $\text{CuAlS}_2$  single crystals. Copper (99.999 percent), aluminium and sulfur (99.999 percent) were used as starting materials for obtaining the  $\text{CuAlS}_2$  ternary compound. The stoichiometric quantities of the starting elements were sealed under high vacuum (up to  $10^{-3}$  Pa) in a Nb crucible held in quartz ampoule. The synthesis was carried out by the direct melting method in a vertical furnace with vibration. To achieve equilibrium the compound obtained was homogenized by subsequent annealing. X-ray diffraction studies showed that the resulting material was of single phase. 5 Refs.

Aksenov, I.A. (Acad of Sciences of the Byelorussian SSR, Minsk, USSR); Makovetskaya, L.A.; Savchuk, V.A. *Phys Status Solidi A* v 108 n 1 Jul 1988 p K63-K65.

**093417 HOT ELECTRON DISTRIBUTION AND TRANSPORT IN  $\text{AlGaAs/GaAs/AlGaAs}$  QUANTUM WELLS.** We report experimental studies of hot electron distributions and energy relaxations in modulation doped  $\text{AlGaAs/GaAs/AlGaAs}$  multiple quantum wells. We have measured high field-dependent photoluminescence spectra with different MQWs. We discuss two-dimensional electron distributions and hot electron-phonon interactions, i.e. electron temperatures depending on two-dimensional electron density and quantum well structures. In the highly doped MQW, the electron temperature increased significantly from low electric fields. These experimental results are discussed from the aspect of two-dimensional electron-phonon interactions. (Author abstract) 7 refs.

Makiyama, K. (Osaka Inst of Technology, Osaka, Jpn); Inoue, M.; Ashida, M.; Cho, Y.; Iwai, Y.; Sasa, S.; Hiyanizumi, S. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 371-374.

**Electric Field Effects** See Also SEMICONDUCTING GALLIUM ARSENIDE—Electric Field Effects.

**093418 ELECTRON VELOCITY AT HIGH ELECTRON FIELDS IN  $\text{AlGaAs/GaAs}$  MODULATION-DOPED HETEROSTRUCTURES.** We have measured the electron velocity in low-doped  $\text{GaAs}$  and in  $\text{AlGaAs/GaAs}$  modulation-doped heterostructures at electric fields up to 8000 V/cm at both 300 and 77 K. In order to avoid the charge domain formation which occurs in dc measurements at these fields, this measurement uses 35 GHz radiation to supply the electric field. These measurements indicate that the peak velocity for electrons in the heterostructures is lower than electrons in bulk low-doped  $\text{GaAs}$ . This result is explained in terms of modified intervalley transfer, real space transfer, and an enhanced scattering with polar optical phonons. (Author abstract) 20 refs.

Masselink, W.T. (IBM, Yorktown Heights, NY, USA); Braslau, N.; LaTulipe, D.; Wang, W.I.; Wright, S.L. *Solid*



State Electron v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 337-340.

**093419 HIGH FIELD HOT ELECTRON TRANSPORT THROUGH  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  MULTIQUANTUM WELL SUPERLATTICES.** We report the measurement of the high electric field hot electron mean free path  $L$  for transport through  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  multiquantum well superlattices by fabricating a novel detector whose  $\gamma = 10\mu\text{m}$  infrared sensitivity critically depends on hot electron transport. We find  $L$  to be  $L = 4500$  Angstrom for a 50 period superlattice composed of 72 Angstrom GaAs quantum wells separated by 133 Angstrom  $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As}$  tunneling barriers (i.e.,  $L = 22$  periods). We have achieved an avalanche gain of 300% at  $10\mu\text{m}$  in these quantum well superlattices. The electrons are generated by resonant intersubband tunneling and then avalanche by hot electron impact ionization of carriers out of the quantum wells. By analyzing these measurements we find a highly nonthermal peaked electron distribution with a relatively narrow energy width of 60 meV. (Edited author abstract) 19 refs.

Levine, B.F. (AT&T Bell Lab, Murray Hill, NJ, USA); Choi, K.K.; Bethea, C.G.; Walker, J.; Malik, R.J. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 583-587.

**Electric Properties** See Also SEMICONDUCTING GALLIUM ARSENIDE—Physical Properties; SEMICONDUCTOR DEVICES—Heterojunctions.

**093420 MAGNETORESISTANCE EFFECT IN  $\text{AlGaAs/GaAs}$  TWO-DIMENSIONAL ELECTRON GAS STRUCTURES AT ROOM TEMPERATURE.** Room temperature magnetoresistance measurements have been made on a number of  $\text{AlGaAs/GaAs}$  two-dimensional electron gas structures in fields of up to 7 Tesla. These wafers exhibit varying degrees of conduction in the  $\text{AlGaAs}$  in parallel with the 2-D electron gas which is formed at the heterojunction. By making the assumption of a single, energy-independent scattering time for each conducting channel, the magnetoresistance data are well fitted by the two band model, giving values of the sheet electron density in the 2-D electron gas at 300 K in with the results of Shubnikov-de Haas measurements at 4.2 K, even in the presence of significant parallel conduction. An upper limit on the error associated with this assumption in the case of the 2-D electron gas can be estimated by studying samples with minimal parallel conduction. (Edited author abstract) 13 refs.

Battersby, S.J. (Philips Research Lab, Redhill, Engl); Selten, F.M.; Harris, J.J.; Foxon, C.T. *Solid State Electron* v 31 n 6 Jun 1988 p 1083-1088.

**093421 CHARGE TRAPPING IN  $n\text{-Al}_x\text{Ga}_{1-x}\text{As}$  'INSULATORS' AND RELATED DEVICE INSTABILITIES.** In some devices based on  $\text{GaAs/Al}_x\text{Ga}_{1-x}\text{As}$  heterostructures, the  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  plays the role of a wide band gap 'insulator'. These devices are therefore excellent systems for studying charge trapping in  $\text{Al}_x\text{Ga}_{1-x}\text{As}$ . It is poorly understood property of  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  that incorporation of any n-type dopant results in the formation of a deep electron trap, the DX center. Recent experiments on heterostructure devices have probed both thermal and athermal (hot electron) capture and emission by the DX center. By observing the trapping behavior as the composition (Al mole fraction) of the alloy is varied, the relationship between the trap level and the band structure of the host material has been clarified. A remarkable result is the observation of electron trapping at alloy compositions where the trap state is resonant with the conduction band. (Author abstract) 37 refs.

Theis, T.N. (IBM, Yorktown Heights, NY, USA); Parker, B.D. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 52-63.

## Electronic Properties

**093422 MEASUREMENT OF 'MATERIAL' PARAMETERS IN MULTI-QUANTUM-WELL STRUCTURES.** Multi-quantum-well (MQW) structures can be

regarded as new materials whose properties are determined by the well and barrier thicknesses  $L_z$  and  $L_b$  and the well depth (which is composition dependent). Measurements of  $L_z$ ,  $L_b$  and  $x$  are reported for 16 MQW samples grown by molecular beam epitaxy in the  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  system. Results from x-ray diffraction, photoluminescence excitation spectroscopy and transmission electron microscopy are found to compare well with each other and with values predicted from MBE growth conditions. (Author abstract) 45 refs.

Orton, J.W. (Philips Research Lab, Redhill, Engl); Fewster, P.F.; Gowers, J.P.; Dawson, P.; Moore, K.J.; Dobson, P.J.; Curling, C.J.; Foxon, C.T.; Woodbridge, K.; Duggan, G.; Ralph, H.I. *Semicond Sci Technol* v 2 n 9 Sep 1987 p 597-606.

**093423 CALCULATIONS OF BOUND STATES IN THE VALENCE BAND OF  $\text{AlAs/GaAs/AlAs}$  AND  $\text{AlGaAs/GaAs/AlGaAs}$  QUANTUM WELLS.** A realistic pseudopotential complex-band-structure approach to the calculation of bound states in semiconductor quantum wells is described. The method is applied to the determination of bound-state energies and charge densities in the valence band of (100)  $\text{AlAs/GaAs/AlAs}$  and  $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As/GaAs/Al}_{0.3}\text{Ga}_{0.7}\text{As}$  isolated quantum wells as functions of well width. Our results suggest the existence of additional structure in the optical spectra of quantum wells at widths corresponding to regions in which there is substantial hybridization of light- and heavy-hole bound states. (Author abstract) 25 refs.

Brand, S. (Univ of Durham Science Lab, Durham, Engl); Hughes, D.T. *Semicond Sci Technol* v 2 n 9 Sep 1987 p 607-614.

**093424 ENERGY RELAXATION OF 2D ELECTRONS AT AN  $\text{AlGaAs/GaAs}$  HETEROJUNCTION AT HELIUM TEMPERATURES.** The peculiarities of 2D electron gas heating are derived from the comparison of temperature and field dependences of galvanomagnetic effects for one or two occupied size-quantized subbands. The main energy relaxation mechanism at helium temperatures is shown to be the scattering by piezoelectric potential of acoustic phonons. Experimental data and theory show that while the carrier density increases, the temperature dependence of energy loss rate changes due to contribution of electrons in second subband to the energy relaxation processes. (Author abstract) 8 refs.

Kreschuk, A.M. (Acad of Sciences of the USSR, Leningrad, USSR); Martisov, M.Yu.; Polyanskaya, T.A.; Savelyev, I.G.; Saidashev, I.I.; Shik, A.Ya.; Shmartsev, Yu.V. *Solid State Commun* v 65 n 10 Mar 1988 p 1189-1192.

**093425 RELAXATION OF THE NON-POLAR (1010) SURFACES OF WURTZITE  $\text{AlN}$  AND  $\text{ZnS}$ .** Using the pseudo-function method and local density theory, we minimize the total energy of the (10 $\bar{1}$ 0) surfaces of  $\text{AlN}$  and  $\text{ZnS}$ , within the context of a Rigid Rotation Model. We predict that the surface anions rotate inward toward the bulk through very small angles (in contrast to the anions of the (110) surface of GaAs, which rotate outward through large angles,  $\omega \approx 29^\circ$ ). Thus, to an adequate approximation, the (10 $\bar{1}$ 0) surfaces of these relatively ionic wurtzite semiconductors do not relax. (Author abstract) 11 refs.

Tsai, M.-H. (Univ of Notre Dame, Notre Dame, IN, USA); Kasowski, R.V.; Dow, John D. *Solid State Commun* v 64 n 2 Oct 1987 p 231-233.

**093426 NEW PHENOMENA OBSERVED ON AN ELECTRON TRAP RELATED TO OXYGEN IN  $\text{Al}_x\text{Ga}_{1-x}\text{As/GaAs}$  DH LED.** An electron trap of 0.29 eV in  $\text{Al}_x\text{Ga}_{1-x}\text{As/GaAs}$  DH LED has been studied and tentatively identified to be related to oxygen, it is noticed that the emission or capture DLTS peak of this trap will shift to lower temperature when filling or evacuating pulse duration increases. (Author abstract) 1 ref.

Wu, Z. (Acad Sinica, Shanghai, China); Zhou, B.L.; Zhang, G.C. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 369-370.

**Etching** See SEMICONDUCTING GALLIUM ARSENIDE—Etching.

**Growth** See Also LASERS, SEMICONDUCTOR—Fabrication; LASERS, SEMICONDUCTOR—Modes; LASERS, SEMICONDUCTOR—Performance; SEMICONDUCTING GALLIUM ARSENIDE—Growth; SEMICONDUCTOR DIODES—Heterojunctions; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, FIELD EFFECT—Heterojunctions.

**093427 GROWTH PROPERTIES OF  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  GROWN BY MOVPE USING TEG AND TMA.** Correlations of metalorganic gas flow rate ratio with solid phase composition and the growth rate of MOVPE-grown  $\text{AlGaAs}$  using TEG and TMA are investigated. The  $\text{AlGaAs}$  growth rate is low compared to the sum of individually grown GaAs and AlAs growth rates, and solid phase composition differs from that calculated from their growth rate ratios. These characteristics result from variations in GaAs and AlAs growth rates with vapor phased composition. The correlations among growth properties can be explained by considering the reaction between metalorganic gas sources which reduces the amount of metalorganics contributing to the growth. (Author abstract) 7 refs.

Shinohara, Masanori (NTT LSI Lab, Atsugi, Jpn); Imamura, Yoshihiro; Yanagawa, Fumihiko. *Jpn J Appl Phys Part 2* v 26 n 9 Sep 1987 p 1459-1461.

**093428 ARSENIC PRESSURE DEPENDENCE OF COMPOSITION  $x$  IN  $\text{Al}_x\text{In}_{1-x}\text{As}$  GROWN BY MOLECULAR BEAM EPITAXY.** The dependence of the composition  $x$  of  $\text{Al}_x\text{In}_{1-x}\text{As}$  on the arsenic pressure and substrate temperature in molecular beam epitaxy is investigated. At a growth temperature of  $540^\circ\text{C}$ , the composition scarcely depends on the arsenic pressure, but at  $580^\circ\text{C}$  the Al composition decreases with increasing arsenic pressure under a constant flux ratio of group III elements. The dependence of composition  $x$  on the arsenic pressure and substrate temperature can be explained semiquantitatively using a modified thermodynamical model. (Author abstract) 9 refs.

Nakagawa, Tsuyoshi (Osaka Univ, Ibaraki, Jpn); Gonda, Shun-ichi; Emura, Shuichi; Shimizu, Saburo. *J Cryst Growth* v 87 n 2-3 Feb 1988 p 276-280.

**093429 CHARACTERIZATION OF  $\text{AlGaAs/GaAs}$  HETEROSTRUCTURES GROWN IN A MULTI-CHAMBER OMVPE APPARATUS.** Organometallic vapor phase epitaxial (OMVPE) growth of compound semiconductor is carried out in a multichamber apparatus under reduced hydrogen pressure. Provided the transit times of the reactant fluxes through the reaction cell are small compared to time required for their fluxes to broaden spatially by diffusion, a condition achievable at low pressure, each reactant may be localized to a portion of reaction cell. By positioning substrates by rotation in these localized growth zones with the appropriate combination of the sources; trimethylgallium, trimethylaluminum, and arsine, abrupt  $\text{AlGaAs/GaAs}$  heterostructures are formed. With this technique  $\text{AlAs/GaAs}$  superlattices of 12 Å period are observed with transmission electron microscopy (TEM). Also Raman spectroscopy and photoluminescence are used to characterize the effects of rotation speed and the growth rate on the resulting heterostructures. By combining these superlattices into separate confining laser structures high efficiency, low threshold injection lasers are demonstrated. 14 refs.

Shealy, J.R. (GE, Syracuse, NY, USA). *J Cryst Growth* v 87 n 2-3 Feb 1988 p 350-356.

**093430 CRITICAL MISORIENTATION MORPHOLOGY IN  $\text{AlGaAs}$  AND  $\text{GaAs}$  GROWN BY ATMOSPHERIC-PRESSURE MOCVD ON MIS-ORIENTED SUBSTRATES.** This work describes a study of misorientation effects in the growth of  $\text{AlGaAs}$  and  $\text{GaAs}$  by atmospheric-pressure MOCVD. The pronounced rough morphology reported here was observed at  $700^\circ\text{C}$  using misoriented (100) GaAs substrates with a



high density of induced nucleation flaws. Growth on these substrates was characterized by faceted defects with a well-defined angle between singular-plane trends and clustered monatomic step risers. Long-range morphology on a GaAs epitaxial layer in the form of terraces similar to those seen in LPE was also observed for growth at 700°C on a well-prepared (100) substrate. The observation of long-range surface morphology and critical misorientation effects demonstrates that near-equilibrium growth conditions have been found in atmospheric-pressure MOCVD where the step surface energy is lowered by a long-range morphology of treads and risers, for growth on slightly misoriented (100) substrates. (Edited author abstract) 24 refs.

Johnson, E.S. (Motorola Inc, Phoenix, AZ, USA); Legg, G.E. *J Cryst Growth* v 88 n 1 Apr 1988 p 53-66.

**093431 THERMODYNAMIC STABILITY AND REACTIVITY OF AISB AND THEIR RELATIONSHIP TO CRYSTAL GROWTH.** The vapor pressure, species concentration and reactivity of AISB is modeled thermodynamically using the newly-described sticky trust region technique, STRT, for free energy minimization. The conditions chosen include oxygen and hydrogen concentrations appropriate to Czochralski crystal growth in SiO<sub>2</sub>, CBN, Al<sub>2</sub>O<sub>3</sub> and BeO crucibles and growth in the absence of a crucible. Results are compared with crystal growth experiments where appropriate. At the melting point the principal vapor species is Sb<sub>2</sub> with a total vapor pressure of approx. 10<sup>-3</sup> atm, which is about 10<sup>2</sup> larger than for GaSb. The results agree with the experimental data of Sirota and Golodushko. Reaction with the crucible is predicted for SiO<sub>2</sub> and BN in agreement with crystal growth experiments and also with C, where the slow kinetics of vitreous carbon reactions make it possible to use it for crucibles. Al<sub>2</sub>O<sub>3</sub> and BeO are predicted to be inert. Preliminary crystal growth results confirm these results and these materials are recommended for further investigation. The results indicate that thermodynamic 'testing' of crucibles is an appropriate crystal growth strategy. (Author abstract) 12 refs.

McAfee, K.B. Jr. (AT&T Bell Lab, Murray Hill, NJ, USA); Gay, D.M.; Hozack, R.S.; Laudise, R.A.; Sunder, W.A. *J Cryst Growth* v 88 n 4 May II 1988 p 488-498.

**093432 GROWTH OF AlGaAs AND GaAs BY ATMOSPHERIC-PRESSURE MOCVD ON LENTICULAR SUBSTRATES.** This work describes a study of the growth by atmospheric-pressure MOCVD at 650-700°C of AlGaAs and GaAs on lens-shaped substrates which sample surface misorientations up to 22° from the (100). Only visually smooth growth and no change in the band-edge PL wavelength were observed for small misorientations from the (100) plane under these growth conditions, in contrast to readily observed rough morphology patterns and PL band-edge shifts in MBE. Patterns of rough growth due to microscopic point defects associated with specific crystalline orientations were observed for both MOCVD-grown AlGaAs and GaAs films for surface misorientations greater than 10°. (Edited author abstract) 14 refs.

Johnson, E.S. (Motorola Inc, Phoenix, AZ, USA); Legg, G.E.; Curless, J.A. *J Cryst Growth* v 85 n 1-2 Nov I 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 182-187.

## Impurities

**093433 FLUORESCENCE EXAFS STUDY OF AlGaAs DOPED WITH Se DONOR IMPURITIES.** We performed extended x-ray absorption fine structure measurements on Al<sub>0.38</sub>Ga<sub>0.62</sub>As:Se in order to investigate the lattice relaxation accompanying the existence of the deep level. The local structure of Se donor impurities was observed by monitoring the SeK<sub>α</sub> fluorescence yield. A small glancing angle arrangement was applied to suppress the effects of both Ga and As K<sub>α</sub> fluorescence x-rays. The nearest-neighbor distances around Se were not influenced by the existence of the deep level. (Author abstract) 20 refs.

Kitano, Tomohisa (NEC Corp, Kawasaki, Jpn); Mizuta, Masashi. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1806-1808.

**Ion Implantation** See Also SEMICONDUCTING GALLIUM ARSENIDE—Ion Implantation; TRANSISTORS, BIPOLAR—Heterojunctions.

**093434 COMPARISON OF LATERAL RESOLUTION OF FINE STRIPES BERYLLIUM AND BORON IMPLANTED BY FOCUSED ION BEAM IN Si-DOPED AlGaAs/GaAs MULTILAYER QUANTUM WELLS.** Using impurity controlled Al-Ga intermixing in Si-doped Multi-Quantum Wells (MQW), a highly anisotropic Be diffusion after Focused Ion Beam (FIB) implantation and thermal annealing was measured by Auger Al profiles analysis, with a Be lateral diffusion dependent on the scan speed of ion beam. Then, after the demonstration of Al-Ga intermixing suppression by Boron FIB implantation, an improved lateral resolution was obtained with boron implantation in Si-doped MQW. (Author abstract) 8 refs.

Brillouet, Francois (Optoelectronics Joint Research Lab, Kawasaki, Jpn); Ishida, Koji; Morita, Tetsuo; Miyauchi, Eizo; Takamori, Takeshi; Nakashima, Hisao. *Jpn J Appl Phys Part 1* v 26 n 8 Aug 1987 p 1320-1323.

**Ionization** See Also SEMICONDUCTING GALLIUM ARSENIDE—Ionization.

**093435 DETERMINATION OF THE PHOTOIONIZATION THRESHOLD OF THE DEEP DONOR IN Al<sub>0.33</sub>Ga<sub>0.67</sub>As:Si.** Photoionization of the DX center in Si-doped Al<sub>0.33</sub>Ga<sub>0.67</sub>As has been studied by means of photoconductivity. The optical cross-section shows a threshold at hν=200 Mev and relative maxima (shoulders) around 400, 600, 950, and 1700 Mev. The results throw doubt on the validity of the large lattice relaxation model, generally accepted for this class of centers. They can be well accounted for by the small lattice relaxation model, recently proposed by the authors. (Author abstract) 15 refs.

Henning, J.C.M. (Philips Research Lab, Eindhoven, Neth); Ansems, J.P.M. *Appl Phys A* v A 44 n 3 Nov 1987 p 245-247.

**Magnetic Field Effects** See TRANSISTORS, FIELD EFFECT—Heterojunctions.

**Measurements** See SEMICONDUCTING GALLIUM ARSENIDE—Measurements.

## Microscopic Examination

**093436 STRUCTURE OF AlGaAs/GaAs MULTILAYERS IMAGED IN SUPERLATTICE REFLECTION.** A new transmission electron microscope method is reported where plan-view samples of Al<sub>0.3</sub>Ga<sub>0.7</sub>As/GaAs multilayers in (001) orientation and with a modulation wavelength of 210 Å are imaged using superlattice reflections. The results, obtained using both a large-angle diffraction technique and direct dark-field imaging, provide an accurate measurement of the multilayer period and also suggest the occurrence of local fluctuations in period, possibly of monolayer dimensions, which differ along [110] and [11̄0] directions. The method also provides some information on the composition profile in multilayers. (Author abstract) 3 refs.

Vincent, R. (Univ of Bristol, Bristol, Engl); Cherns, D.; Bailey, S.J.; Morkoc, H. *Phil Mag Lett* v 56 n 1 Jul 1987 p 1-6.

**Microwaves** See TRANSISTORS, BIPOLAR—Heterojunctions.

**Optical Properties** See Also LASERS, SEMICONDUCTOR—Stability; SEMICONDUCTING GALLIUM ARSENIDE—Optical Properties.

**093437 DYNAMIC SWITCHING CHARACTERISTICS OF PHOTOLUMINESCENCE BY AN ELECTRIC FIELD IN AlGaAs QUANTUM WELL STRUCTURES.** Transient photoluminescence measurements for

pulsed electric field at room temperature on AlGaAs quantum well structures have been carried out to clarify the characteristics of luminescence switching by an electric field. With our method, the radiative lifetime and non-radiative lifetime can be separately evaluated. Luminescence switching by electric field shows a high speed capability that is free from lifetime limitation. Based on the relationships between radiative and nonradiative processes, the intensity modulation of luminescence under the condition of a constant carrier density is demonstrated. (Author abstract) 11 refs.

Ogura, Ichiro (Hiroshima Univ, Higashi-Hiroshima, Jpn); Yamanishi, Masamichi; Kan, Yasuo; Suemune, Ikuro. *Jpn J Appl Phys Part 2* v 26 n 8 Aug 1987 p 1313-1316.

**093438 PIEZO-RAMAN STUDIES OF PHONONS IN AISB.** We have studied the effect of a uniaxial stress on the transverse optical and longitudinal optical phonons of AISb. Raman piezospectroscopic techniques have been employed in the region of transparency, using a cw Nd:YAG laser. Phonon and effective charge deformation parameters have been obtained from the data, and also an estimate of the Faust-Henry coefficient from the integrated scattering intensities. (Author abstract) 24 refs.

Anastassakis, E. (Max-Planck-Institut fuer Festkoerperphysik, Stuttgart, West Ger); Cardona, M. *Solid State Commun* v 63 n 10 Sep 1987 p 893-897.

**093439 PERSISTENT PHOTOCONDUCTIVITY IN FREE-STANDING LAYERS OF n-AlGaAs.** Persistent photoconductivity has been observed in free-standing epitaxial layers of n-AlGaAs. Values of Hall electron mobility and concentration have been measured. The results demonstrate that the major part of persistent photoconductivity is a bulk effect, characteristic of AlGaAs, and it does not require the presence of a heterointerface with GaAs. Electron mobility is about one-fourth of the theoretically calculated value; therefore, a reassessment of alloy scattering strengths is required. (Edited author abstract) 18 refs.

Leybovich, I.S. (Washington Univ, St. Louis, MO, USA); Rode, D.L. *Solid State Electron* v 31 n 7 Jul 1988 p 1123-1125.

**Order-Disorder** See SEMICONDUCTING GALLIUM ARSENIDE—Order-Disorder.

**Physical Properties** See Also SEMICONDUCTING GALLIUM ARSENIDE—Optical Properties; SEMICONDUCTING GALLIUM ARSENIDE—Physical Properties.

**093440 ENERGY AND SPIN POLARIZATION ANALYSIS OF NEAR BAND GAP PHOTOEMISSION IN AlGaAs/GaAs HETEROSTRUCTURES.** Near band gap photoemission from AlGaAs/GaAs heterostructures located close to a GaAs surface under negative electron affinity is performed by coadsorption of cesium and oxygen. This new technique provides experimental information on the energy levels of these systems. Energy distribution curves and analysis of the spin polarization of the emitted electrons allow us to obtain a clear picture of the energy and spin relaxation processes together with an understanding of the vertical transport through the structure towards the surface. (Edited author abstract) 11 refs.

Ciccacci, F. (Univ di Roma 'Tor Vergata', Rome, Italy); Drouhin, H.-J.; Hermann, C.; Houdre, R.; Lampel, G.; Alexandre, F. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 489-492.

**093441 EFFECT OF HOT PHONONS AND COUPLED PHONON-PLASMON MODES ON SCATTERING-INDUCED NDR IN QUANTUM WELLS.** We have extended our Monte Carlo simulation of scattering-induced NDR in Al<sub>0.8</sub>Ga<sub>0.2</sub>As/GaAs quantum wells by including (a) the effect of hot phonons (b) coupled phonon-plasmon modes (c) degeneracy. Hot phonons were modeled using a phenomenological lifetime which we ranged from 3ps to 10ps. Coupled modes were



modelled in the antiscreeing approximation. Bulk-like modes were assumed in both cases. NDR is quenched if the phonon lifetime exceeds 7ps, but is little affected if the lifetime is 3ps. The effect of coupled modes is appreciable at a doping density of  $10^{18}\text{cm}^{-3}$ , virtually eliminating NDR, but at  $10^{17}\text{cm}^{-3}$  the effect is much smaller. Including degeneracy has only a small effect on the results. We conclude that NDR is still possible at electron densities around  $10^{17}\text{cm}^{-3}$ . (Author abstract) 9 refs.

Ridley, B.K. (Univ of Essex, Colchester, Engl); Al-Mudares, M. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 683-685.

## Pressure Effects

**093442 MODE GRUENEISEN PARAMETERS AND PRESSURE-INDUCED PHASE TRANSITION OF TETRAHEDRAL COMPOUNDS.** The pressure effect on the phonon frequency, i.e. the mode Grueneisen parameter of AlP, AlAs, and AlSb is studied from the electronic theory of solids. Then, a linear correlation by B.A. Weinstein between the TA-mode Grueneisen parameter at the point X and the phase transition pressure  $P_t$  is not necessarily satisfied for all of tetrahedral covalent crystals. (Author abstract) 26 refs.

Kagaya, H.-Matsuo (Akita Univ, Akita, Jpn); Soma, T. *Phys Status Solidi B* v 142 n 1 Jul 1987 p 97-103.

**Research** See SEMICONDUCTING GALLIUM ARSENIDE—Research.

**Spectroscopic Analysis** See Also SEMICONDUCTING GALLIUM ARSENIDE—Chromatographic Analysis.

**093443 PHOTOLUMINESCENCE SPECTRA AND RADIATIVE CENTERS IN  $\text{Al}_x\text{Ga}_{1-x}\text{P}$ .** Luminescence centers and radiative recombination mechanisms in  $\text{Al}_x\text{Ga}_{1-x}\text{P}$ : (N) have been investigated by means of photoluminescence measurement, performing at different excitation levels between 20K and 290K. For low excitation level measurements, the samples were excited by a cw radiation of 5145 Angstrom or 4880 Angstrom from an argon ion laser. The luminescence from the sample was analyzed by a SPEX 1403 double pass monochromator and detected by a c-31034 photomultiplier and a photon counting system. 3 refs.

Jiang, Bingxi (Xiamen Univ, Xiamen, China); Lin, Xihua; Liu, Xiao. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 125-126.

**093444 MULTISTATE MODEL FOR DX CENTERS IN  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  ALLOY.** Donor related DX centers in  $\text{AlGaAs:Sn}$  have been studied by CC-DLTS and constant-capacitance transient. A multistate model with different binding energies and electron-lattice couplings is suggested. (Edited author abstract) 3 refs.

Kang, Junyong (Xiamen Univ, Xiamen, China); Huang, Qisheng. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 365-366.

**093445 PHOTOLUMINESCENCE STUDY OF  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  HETEROJUNCTION BIPOLAR TRANSISTORS FABRICATED BY MOLECULAR BEAM EPITAXY.** Photoluminescence (PL) in  $\text{AlGaAs/GaAs}$  heterojunction bipolar transistors (HBT's) fabricated by molecular beam epitaxy (MBE) is discussed. Each PL signal is identified. A novel PL signal related to the N- $\text{AlGaAs/p}^+\text{-GaAs}$  heterojunction in the HBT was identified. This signal is thought to originate in the two dimensional electrons at the heterojunction. (Author abstract) 2 refs.

Eda, Kazuo (Matsushita Electric Industrial Co, Osaka, Jpn); Inada, Masanori. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 759-760.

**Structure** See SEMICONDUCTING GALLIUM ARSENIDE—Structure.

**Surfaces** See SEMICONDUCTING GALLIUM COMPOUNDS—Surfaces.

## Thermal Properties

**093446 THERMAL PROPERTIES OF TETRAHEDRAL COMPOUNDS.** The thermal properties of tetrahedral compounds are studied theoretically from first principle using the lattice dynamical method recently developed. Numerical calculations about the specific heat are performed for AlP, AlAs, AlSb and about the thermal expansion coefficient for AlP, AlAs, AlSb, ZnS, ZnSe, ZnTe, and CdTe. (Author abstract) 9 refs.

Kagaya, H.-Matsuo (Akita Univ, Akita, Jpn); Soma, T. *Phys Status Solidi B* v 142 n 2 Aug 1987 p 411-416.

**Thin Films** See SEMICONDUCTING GALLIUM ARSENIDE—Thin Films; SEMICONDUCTING GALLIUM COMPOUNDS—Thin Films.

**Transport Properties** See Also SEMICONDUCTING GALLIUM ARSENIDE—Electronic Properties; SEMICONDUCTING GALLIUM ARSENIDE—Transport Properties; SEMICONDUCTING INDIUM COMPOUNDS—Electronic Properties.

**093447 SIMULATIONS OF NONLINEAR TRANSPORT IN  $\text{AlGaAs/GaAs}$  SINGLE WELL HETEROSTRUCTURES.** There have been, efforts devoted to novel APD structures which take advantage of heterojunctions. Unlike bulk structures, the performance of these devices is based on nonlinear transport perpendicular to heterojunctions and involves details of band structures and band edge discontinuities. Theoretical investigations have mostly been devoted to the macroscopic quantities rather than microscopic processes. We present a numerical study of nonlinear transport across heterointerfaces in strong electric fields and concentrate on the details of the energy distribution of electrons. The specific structure under consideration is a generic  $\text{AlGaAs/GaAs}$  single well structure as shown. (Edited author abstract) 8 refs.

Kim, K. (Univ of Illinois, Urbana, IL, USA); Hess, K.; Capasso, F. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 349-350.

## Vapor Deposition

**093448 MOVPE GROWN  $\text{Al}_x\text{Ga}_{1-x}\text{As/GaAs}$  HETEROSTRUCTURES.** The factors controlling interface quality of MOVPE grown  $\text{Al}_x\text{Ga}_{1-x}\text{As/GaAs}$  double quantum wells (QW) are discussed with reference to a monolayer step propagation model for growth. To illustrate the application of MOVPE QW structures, high electron mobility transistors (HEMTs) and a multiple quantum well (MQW) device are briefly reviewed. (Author abstract) 5 refs.

Roberts, J.S. (Univ of Sheffield, Sheffield, Engl). *Chemtronics* v 2 n 2 Jun 1987 p 78-82.

**093449 CHLORIDE VPE OF  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  BY THE HYDROGEN REDUCTION METHOD USING A METAL AL SOURCE.** VPE of  $\text{AlGaAs}$  by the chloride transport method using separate Al and Ga metals has been demonstrated for the first time.  $\text{AsCl}_3$  instead of toxic  $\text{AsH}_3$  was used as the arsenic source. Mirror-like surfaces with growth rates of 1-2  $\mu\text{m/hr}$  were obtained. Background doping levels range in the order of  $10^{18}\text{cm}^{-3}$ , probably due to the reaction between  $\text{AlCl}_3$  and the quartz reactor. Band-edge emissions were observed in the photoluminescence spectra. (Author abstract) 9 refs.

Hasegawa, Fumio (Univ of Tsukuba, Tsukuba, Jpn); Katayama, Koji; Kobayashi, Ryuji; Yamaguchi, Hiromu; Nannichi, Yasuo. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 254-257.

## SEMICONDUCTING ANTIMONY

### Radiation Effects

**093450 DEFOCUSING OF ATOMIC KNOCK-ONS IN CRYSTALS LOW LOCAL SYMMETRY OF STRUCTURAL ELEMENTS.** An essential condition for the high radiation stability (RS) of semiconductors and dielectric materials is the fulfillment of the inequality  $r_0 > l_f$  for all crystallographic directions, where  $r_0$  is the radius of the instability zone of the pair vacancy interstitial atom and  $l_f$  is the path length of a dynamic crowdion. Besides structures possessing suppressed focusing of atomic knock-ons resulting from the lack of focusing lenses, there are structures whose local symmetry lowering leads to the suppression of due simple focusing due to the goffering of atomic chains as well as the suppression of additional focusing due to the asymmetric defocusing lenses. Thus the distortion of lattice structures causes a diminution of  $l_f$  and an improvement of RS in such materials when compared with undistorted ones. A higher radiation stability should also be present in those crystals where focusing is possible only in some crystallographic directions. The aim of the investigations has been the experimental test of this statement. The following single crystal semiconductor materials were investigated: SnSe having a distorted NaCl lattice and SnSe<sub>2</sub> possessing a layer lattice of the CdI<sub>2</sub> type were one half of the octahedral sites is unoccupied in the hexagonal close-packed lattice of iodine ions. 11 refs.

Dmitriev, Yu. (All-Union Scientific Research Inst of Single Crystals, Scintillation Materials & Particularly Pure Chemical Substances, Kharkov, USSR); Koshkin, V.; Ulmanis, U. *Phys Status Solidi A* v 106 n 1 Mar 1988 p K7-K11.

## SEMICONDUCTING ANTIMONY COMPOUNDS

### Defects

**093451 ANTISITE DEFECTS IN  $\text{Sb}_{2-x}\text{Bi}_x\text{Te}_3$  MIXED CRYSTALS.** In layered mixed crystals of  $\text{Sb}_{2-x}\text{Bi}_x\text{Te}_3$  two types of point defect are considered: the antisite defects  $\text{Bi}_{\text{Te}}$  and  $\text{Sb}_{\text{Te}}$ . Using previously determined free carrier concentrations in the mixed crystals and the results of quantum chemical calculations, a model has been proposed which enables one to determine the energy of formation of the antisite defects and their concentrations for various values of  $x$ . The results show that the  $\text{Sb}_{\text{Te}}$ -defect concentration decreases monotonically with increasing content of Bi atoms in the whole region  $0 < x < 2$ , while the  $\text{Bi}_{\text{Te}}$ -defect concentration goes through a maximum at  $x=0.5$ . Changes in the structural parameters are also explained in terms of the quantum chemical calculations. (Author abstract) 14 refs.

Stary, Z. (Univ of Chemical Technology, Pardubice, Czech); Horak, J.; Stordeur, M.; Stoelzer, M. *J Phys Chem Solids* v 49 n 1 1988 p 29-34.

**093452 ANTISITE DEFECTS IN  $\text{Sb}_{2-x}\text{In}_x\text{Te}_3$  MIXED CRYSTALS.** Changes in the values of the plasma resonance frequency and some transport coefficients (electrical conductivity, Hall coefficient, Seebeck coefficient) of  $\text{Sb}_{2-x}\text{In}_x\text{Te}_3$  crystal show that an increase in the content of incorporated In atoms causes a decrease in the free carrier concentration. This result is interpreted in the following way. In atoms are incorporated in the Sb-sublattice and form uncharged substitutional defects  $\text{In}_{\text{Sb}}$  which, of the higher electropositivity of In than Sb, cause an increase in bond polarity and also in crystal ionicity. This effect leads to an increase in the energy of formation of antisite defects, such that the concentration of antisite defects is decreased with increasing values of  $x$ . (Edited author abstract) 17 refs.

Horak, J. (Technical Univ of Chemical Engineering, Pardubice, Czech); Stary, Z.; Lostak, P.; Pancir, J. *J Phys Chem Solids* v 49 n 2 1988 p 191-198.



## Doping

**093453 EFFECT OF SELENIUM OF THE ELECTRIC PROPERTIES OF  $\text{Sb}_2\text{Te}_3$ .** During the doping of antimony telluride single crystals with selenium the electric conductivity decreases with an increase in the impurity concentration. This is probably related to compensation of the antimony positive charge upon introduction of the impurities and to defects in the structure of the compound itself. In Russian. 5 refs.

Sherov, P.N. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 8 Aug 1987 p 1291-1293.

## Low Temperature Properties

**093454 ELECTRICAL CONDUCTIVITY STUDY OF AN  $\text{SbSi}$  INGOT AT LOW TEMPERATURE.** A study of the temperature dependence of the electrical conductivity in the low-temperature region is made on a  $\text{SbSi}$  ingot for the first time. The ingot used in the present investigation is grown from melt by the temperature-fluctuation technique. The electrical conductivity is measured by applying a weak dc field along the c axis (needle axis) of the crystals. An anomaly is observed at 225 K in the plot of the electrical conductivity against temperature of the sample. This second-order phase-transition temperature obtained from the electrical conductivity study made on the  $\text{SbSi}$  ingot is compared with that obtained from other studies made on individual single-crystalline needles as well as inter-growths grown by other techniques and the results are discussed. (Author abstract) 10 refs.

Palaniappan, L. (Anna Univ, Madras, India); Gnanam, F.D.; Ramasamy, P. *Semicond Sci Technol* v 2 n 12 Dec 1987 p 790-792.

## Magnetic Properties

**093455 FURTHER INVESTIGATIONS ON THE TEMPERATURE-DEPENDENCE OF MAGNETIC SUSCEPTIBILITY AND THERMOGRAVIMETRY OF STOICHIOMETRIC ANTIMONY TRISELENIDE AND ANTIMONY TRITELLURIDE SEMICONDUCTORS.** Stoichiometrically adjusted antimony triselenide and antimony tritelluride semiconductors were carefully prepared for the first time. Numerous measurements were carried out, involving X-ray diffraction analysis, true density, thermogravimetric analysis and the temperature-dependence of the magnetic susceptibility. The results obtained indicated that antimony triselenide and antimony tritelluride polycrystals possess mass susceptibilities of  $-0.361 \times 10^{-6}$  and  $-0.386 \times 10^{-6}$  C.G.S., respectively. The results are discussed on the basis of electronegativity difference, partial ionicity of the bond, and bond strength. (Author abstract). 15 Refs.

Abou-Sekina, M.M. (Tanta Univ, Tanta, Egypt). *J Therm Anal* v 34 n 1 Jan-Feb 1988 p 155-159.

## Photoconductivity

**093456 STUDY OF LOCALIZED STATES IN AMORPHOUS CHALCOGENIDE  $\text{Sb}_2\text{S}_3$  FILMS.** Thin films of  $\alpha\text{-Sb}_2\text{S}_3$  were prepared by thermal evaporation. Experimental parameters usually related to electronic disorder were studied, such as the exponent of the photoconductivity and the optical absorption edge. The results suggest that the defects in this material induce a density of state with exponential band tails. (Author abstract) 20 refs.

Droichi, M.S. (Univ de Sao Paulo, Sao Paulo, Brazil); Vaillant, F.; Bustarret, E.; Jousse, D. *J Non Cryst Solids* v 101 n 2-3 May 1988 p 151-155.

## Physical Properties

**093457 CONCENTRATION DEPENDENCES OF THE PROPERTIES OF  $\text{SnTe}$ -BASED SOLID SOLUTIONS OF THE  $\text{Sn-Sb-Te}$  SYSTEM.** In  $\text{SnTe}$ -based solid solutions of the  $\text{Sn-Sb-Te}$  system the dependences of the microhardness, the Hall carrier concentration and the thermoelectric power on the Te content along the Sb

isoconcentrate were found to be of nonmonotonic nature. The results obtained are interpreted on the basis of concepts concerning a chemical reaction in the solid solution leading to the formation of  $\text{Sb}_2\text{Te}_3$  molecular complexes. In Russian.

Rogacheva, E.I.; Gorne, G.V.; Laptev, S.A.; Rusinov, N.V.; Ob'edkov, A.G. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1830-1834.

Processing See SEMICONDUCTING CADMIUM COMPOUNDS—Synthesis.

## Spectroscopic Analysis

**093458 X-RAY SPECTROSCOPIC AND THEORETICAL INVESTIGATION OF THE ENERGY BAND STRUCTURE OF  $\text{SbSi}$ .**  $\text{SbSi}$  is a representative of a very interesting class of compounds having both ferroelectric and semiconducting properties. A complex experimental and theoretical investigation of the energy band structure of  $\text{SbSi}$  is reported. Unlike earlier experiments, the X-ray spectroscopic method, which allows the distribution of the local partial density of states (DOS) in a broad energy interval is used. 17 refs.

Soldatov, A.V. (Rostov State Univ, Rostov-on-Don, USSR); Sukhetskii, Yu.V.; Khasabov, A.G.; Gusatinski, A.N. *Phys Status Solidi B* v 146 n 1 Mar 1988 p K21-K24.

## Switching

**093459 NONLINEAR I-V BEHAVIOUR & THRESHOLD SWITCHING IN DISORDERED  $\text{Sb-Se-Te}$  SYSTEM.** The nonlinear I-V behavior and threshold switching of bulk disordered  $\text{Sb}_2\text{Se}_3$  Te system have been experimentally studied. It is seen that above a certain voltage, the current through the material shoots to a very high value whereas the potential across the material drops to a very low value. The first virgin switching was observed at 98 V and stable reproducible switching at 205 V. An attempt is made to explain the nonlinear I-V behavior and the threshold switching using the charged defect states existing in the bulk material. The variation of switching voltage with number of switching cycles is also satisfactorily explained using the concept of filament formation and formation of insulating layer in between the electrode and the sample. (Author abstract) 17 refs.

Muragi, B.D. (Shivaji Univ, Kolhapur, India); Zope, J.K. *Indian J Pure Appl Phys* v 25 n 2 Feb 1987 p 77-79.

## Thin Films

**093460 ELECTRICAL CONDUCTIVITY AND THERMOELECTRIC POWER OF AMORPHOUS  $\text{Sb}_2\text{Te}_3$  THIN FILMS AND AMORPHOUS-CRYSTALLINE TRANSITION.** The results of electrical conductivity and thermoelectric studies on antimony telluride, a promising thermoelectric material, in the thin film state are reported. Films were vacuum-deposited on to clean glass substrates with thickness between 50 and 200 nm and studied in the temperature interval 300 to 470 K. On heating the as-grown films, there is a sharp fall both in the Seebeck coefficient and the electrical resistivity at around 340 to 370 K for all the films. This is attributed to an amorphous to crystalline transition, which is confirmed by X-ray diffractogram and electron diffraction patterns. (Author abstract) 9 refs.

Damodara Das, V. (Indian Inst of Technology, Madras, India); Soundararajan, N.; Pattabi, Manjunatha. *J Mater Sci* v 22 n 10 Oct 1987 p 3522-3528.

**093461 ON THE STRUCTURE AND TRANSFORMATION OF THE ORANGE FORM OF  $\text{Sb}_2\text{S}_3$  LAYERS.** In the present work we present structural studies concerning the orange modification of semiconducting antimony trisulfide. The behavior of the electrical conductivity of thin vacuum-deposited films with temperature in the range from 25 to 190°C is also considered. X-ray diffraction study showed that the orange modification of antimony trisulfide can neither be considered as amor-

phous material nor does it change into the black modification upon grinding. Thin vacuum-deposited layers, prepared by conventional thermal evaporation of the bulk material in  $5 \times 10^{-6}$  torr on an amorphous substrate at room temperature, were crystalline. The behavior of the electrical conductivity with temperature in the range 25 to 190°C indicated transition points at 80, 108, 135 and 175°C. (Edited author abstract) 18 refs.

Mady, Kh.A. (Nat'l Research Cent, Cairo, Egypt); Ham-mad, S.M.; Soliman, W.Z. *J Mater Sci* v 22 n 11 Nov 1987 p 4153-4157.

## Transport Properties

**093462 ELECTRICAL TRANSPORT PROPERTIES OF AMORPHOUS SEMICONDUCTING  $\text{Sb-Se-Te}$  SYSTEM.** Dc conductivity and thermoelectric power (TEP) studies of  $\text{Sb}_2\text{Se}_3\text{Te}$  system have been experimentally investigated. The linear relationship between thermo e.m.f. and temperature difference and p-type nature of the material have been explained on the basis of charged defect states and unsymmetric broadening of mobility edges. (Author abstract) 4 refs.

Muragi, B.D. (Shivaji Univ, Kolhapur, India); Zope, J.K. *Key Eng Mater* v 13 pt 2 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 509-513.

## SEMICONDUCTING BISMUTH COMPOUNDS

**093463 BISMUTH VALENCE ORDER-DISORDER STUDY IN  $\text{BaBiO}_3$  BY POWDER NEUTRON DIFFRACTION.** Two structural arrangements have been shown to exist for the perovskite-like compound  $\text{BaBiO}_{3.5}^{3+} \text{BiO}_{5.5}^{5+} \text{O}_3$  by powder neutron diffraction data. The first is characterized by a partial (75%) order of the  $\text{Bi}^{3+}$  and  $\text{Bi}^{5+}$  cations on the two crystallographically independent sites, while in the second arrangement the two cations are almost 100% disordered. The structure of eleven differently-prepared  $\text{BaBiO}_3$  samples showed that the deciding factor for obtaining one or the other arrangement is the temperature at which the sample is prepared or subsequently heat-treated. On the contrary, the cooling rate and the atmosphere (air or oxygen) do not seem to be important parameters. DTA measurements indicated that  $\text{BaBiO}_3$  undergoes an additional phase transition at 860°C on heating and 801°C on cooling. (Edited author abstract) 13 refs.

Chailout, C. (NBS, Gaithersburg, MD, USA); Santoro, A.; Remeika, J.P.; Cooper, A.S.; Espinosa, G.P.; Marezio, M. *Solid State Commun* v 65 n 11 Mar 1988 p 1363-1369.

## Doping

**093464 EFFECT OF A MAGNETIC FIELD ON THE THERMOELECTRIC PROPERTIES OF TIN-DOPED SOLID SOLUTIONS OF ANTIMONY (9 AT.%) IN BISMUTH.** In Tin-doped alloys of bismuth with 9 at.% antimony the effect of a magnetic field on the electric resistivity, thermoelectric power and thermal conductivity remains qualitatively the same as in the undoped alloy. However, the increase in the resistivity and thermoelectric power is intensified, and the effect of the magnetic field on the thermal conductivity is attenuated. Therefore no significant increase in the thermoelectric and magnetothermoelectric Q-factor occurs. In Russian. 8 refs.

Zemskov, V.S.; Belaya, A.D.; Zayakin, S.A.; Bulatova, N.A. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 4 Apr 1987 p 554-557.

**093465 BEHAVIOR OF Te IN PLASTICALLY DEFORMED  $\text{Bi}_2(\text{Te, Se})_3$  ALLOYS.** Plastic deformation of alloys based on  $\text{Bi}_2(\text{Te, Se})_3$  leads to the dissolution of the Te present in the second phase with an increase in pressure. Deformation and temperature accelerate the



dissolution. Primary recrystallization caused by a high degree of deformation decreases the solubility of Te in newly forming crystalline grains. 6 refs. In Russian.

Erofeev, R.S.; Scherbina, E.I. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 907-911.

**093466 MONOCRYSTALLINE STRUCTURE OF  $\text{Bi}_2\text{Te}_3\text{-Bi}_2\text{Se}_3$  WITH A p-n JUNCTION.** We describe the preparation of the  $\text{Bi}_2\text{Te}_3\text{-Bi}_2\text{Te}_{3-x}\text{Se}_x$  monocrystalline structure with a selenium concentration gradient and a p-n junction. The formation of this structure and the decrease in free-hole concentration are explained on the basis of the interaction of incorporated selenium atoms with the antistructural defects of the  $\text{Bi}_2\text{Te}_3$  lattice. Samples with a selenium concentration gradient were prepared from the p- $\text{Bi}_2\text{Te}_3$  single crystal. Evidence of the formation of a p-n junction was obtained from current-voltage characteristics of the  $\text{Bi}_2\text{Te}_3\text{-Bi}_2\text{Te}_{3-x}\text{Se}_x$  monocrystalline structure. 14 refs.

Lostak, P. (Inst of Chemical Technology Pardubice, Czech); Horak, J.; Novotny, R.; Kliorka, J. *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1469-1470.

**093467 OPTICAL PROPERTIES OF GALLIUM-DOPED  $\text{Bi}_2\text{Te}_3$  SINGLE CRYSTAL.** Reflectance and transmittance in the infrared spectral region were determined on Ga-doped  $\text{Bi}_2\text{Te}_3$  single crystal samples grown using a modified Bridgman technique the type of electrical conductivity is found from the polarity of thermopower. The plasma resonance frequency, optical relaxation time, and high-frequency dielectric constant were determined by fitting the Drude-Zener formulas to the reflectance spectra. Ga impurities act as donors. This effect is qualitatively explained by interaction of substitutional defects with anti-site defects and by the formation of interstitial ions. The dependence of the absorption coefficient on the energy of incident photons is discussed. (Edited author abstract). 15 refs.

Lostak, P. (Czechoslovak Acad of Sciences, Pardubice, Czech); Novotny, R.; Navratil, J.; Sramkova, J. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 619-625.

## Electric Conductivity

**093468 ELECTROOPTIC MEASUREMENT OF THE VOLUME RESISTIVITY OF BISMUTH SILICON OXIDE ( $\text{Bi}_{12}\text{SiO}_{20}$ ).** Single crystals of bismuth silicon oxide ( $\text{Bi}_{12}\text{SiO}_{20}$ ) and its isomorphs (including, for example, bismuth germanium oxide ( $\text{Bi}_{12}\text{GeO}_{20}$ )) have been utilized in a wide range of active electrooptic and acousto-optic devices. A key material parameter that influences device performance characteristics is the volume resistivity, which is difficult to measure accurately using standard techniques in refractory oxides like  $\text{Bi}_{12}\text{SiO}_{20}$  due to its large magnitude (typically  $> 10^{13} \Omega \text{ cm}$ ). We present here a technique for the measurement of such very high resistivities in electrooptic materials; this method utilizes the electrooptic modulation induced by a voltage placed across the (crystallographically oriented) sample as a probe of temporal voltage transients that are in turn directly related to the sample volume resistivity. The technique is described in detail, and experimental results are presented on a number of undoped and doped samples of bismuth silicon oxide grown by the Czochralski technique. (Edited author abstract) 17 refs.

Seery, David A. (Univ of Southern California, Los Angeles, CA, USA); Garrett, Mark H.; Tanguay, Armand R. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 282-289.

## Electric Properties

**093469 THERMOELECTRIC PROPERTIES OF  $\text{Bi}_{1-x}\text{Sb}_x$  FILMS WITH  $0 < x \leq 0.3$ .** The electrical conductivity, its temperature coefficient and the thermoelectric power of  $\text{Bi}_{1-x}\text{Sb}_x$  films with  $0 < x \leq 0.3$  and thicknesses from 20 to 400 nm were measured in the temperature range 80-400 K. The results are discussed in the framework of a previously proposed anisotropic

non-degenerate two-band model. (Author abstract) 31 refs.

Voelklein, F. (Akad der Wissenschaften der DDR, Jena, East Ger); Kessler, E. *Thin Solid Films* v 155 n 2 Dec 30 1987 p 197-208.

**093470 STRUCTURAL AND ELECTRICAL PROPERTIES OF BISMUTH TELLURIDE FILMS GROWN BY THE MOLECULAR BEAM TECHNIQUE.** Films of  $\text{Bi}_2\text{Te}_3$  were grown by coevaporation of its component elements. Direct evaporation of  $\text{Bi}_2\text{Te}_3$  was not suitable; it is noncongruent and results in a lack of stoichiometry. Molecular beams of bismuth and tellurium from effusion cells were condensed on silica substrates. The authors studied the composition and crystallographic properties of the films as a function of substrate temperature. They also investigated the thermoelectric properties, carrier concentration, mobility, and thermoelectric power. 7 refs.

Charles, E. (Univ des Sciences et Techniques du Languedoc, Montpellier, Fr); Groubert, E.; Boyer, A. *J Mater Sci Lett* v 7 n 6 Jun 1988 p 575-577.

## Optical Properties

**093471 EXCITONIC ABSORPTION AND URBACH'S TAIL IN BISMUTH SULFIDE SINGLE CRYSTALS.** The absorption coefficient of bismuth trisulfide single crystals has been measured through more than four orders of magnitude and in the range of energies from 1.25 to 1.70 eV. A detailed study as a function of temperature has been carried out from 29 to 300 K. An Urbach tail for low values of absorption has been found. This tail and its temperature evolution fit the expression for ionic materials. An excitonic region appears at low temperature and the shape of the exciton peak is Gaussian, which corresponds to a strong exciton-phonon coupling. The exciton binding energy is estimated ( $28 \pm 3 \text{ meV}$ ) and then the energy gap at 29 K is obtained ( $E_g = 1.523 \pm 0.003 \text{ eV}$ ). The fundamental electronic transition has been found to be a strongly anisotropic allowed direct transition. From reflectivity measurements a localized level at 1.361 eV at 29 K has been found. The change of the gap with temperature is interpreted through an electron-phonon mechanism. (Author abstract) 46 refs.

Cantarero, A. (Univ de Valencia, Valencia, Spain); Martinez-Pastor, J.; Segura, A.; Chevy, A. *Appl Phys A* v 45 n 2 Feb 1988 p 125-132.

## Phase Equilibria

**093472 VAPOUR-SOLID PHASE EQUILIBRIUM OF  $\text{Bi}_2(\text{Se}_{1-x}\text{S}_x)_3$  TERNARY CRYSTALS.** With the objective of analyzing the relations between the concentration of free carriers in  $\text{Bi}_2(\text{Se}_{1-x}\text{S}_x)_3$  ternary crystals and the vapour pressures of selenium and/or sulfur, a model describing the equilibrium between the vapour and the solid phase of a ternary crystal has been worked out by adopting the simplification that the ternary system can be taken for an ideal solid solution where the activity of  $\text{Bi}_2\text{S}_3$  is equal to its concentration. The proposed model explains well the experimentally observed variation of the concentration of free carriers in  $\text{Bi}_2(\text{Se}_{1-x}\text{S}_x)_3$  crystals with increasing value of  $x$  ( $x = 0.00-0.16$ ) under identical growth conditions. (Edited author abstract) 10 refs.

Horak, J. (Technical Univ of Chemical Engineering, Pardubice, Czech); Novotny, R.; Lostak, P.; Hoschl, P. *J Phys Chem Solids* v 48 n 12 1987 p 1227-1233.

**093473 STUDY OF HETEROGENEOUS EQUILIBRIA IN THE  $\text{BiBr}_3\text{-Bi}_2\text{Se}_3$  SYSTEM.** The p-T-x phase diagram of the  $\text{BiBr}_3\text{-Bi}_2\text{Se}_3$  system was constructed using differential thermal and x-ray phase analyses and by tensimetric vapor pressure determination. Two crystalline compounds,  $\text{BiSeBr}$  and  $\text{Bi}_2\text{Se}_3\text{Br}$ , melting incongruently at  $783 \pm 5$  and  $843 \pm 5 \text{ K}$ , respectively, and a small range of solid solutions on the bismuth selenide side are noted in this system. On the basis of the data obtained, the enthalpy and entropy variations for dissociative evaporation of the compounds are calculated, and

estimates are made of the standard thermodynamic characteristics of crystalline bismuth selenobromides. 12 refs. In Russian.

Vorob'eva, T.A.; Kolomnina, E.V.; Trifonov, V.A.; Popovkin, B.A.; Novoselova, A.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1843-1846.

## Phase Transitions

**093474 MAGNETIC FREEZE-OUT AND MAGNETIC-FIELD-INDUCED SEMICONDUCTOR-SEMIMETAL TRANSITION IN  $\text{Bi}_{1-x}\text{Sb}_x$  ALLOYS UNDER HIGH HYDROSTATIC PRESSURE.** The galvanomagnetic properties of extremely pure single-crystal  $\text{Bi}_{1-x}\text{Sb}_x$  alloys ( $x \approx 0.07$  to  $0.08$ ) are investigated under hydrostatic pressure with static magnetic fields in the range 0 to 6 T. A striking anomalous behaviour of the longitudinal magnetoresistance is observed in pure crystals as the magnetic field is increased above a certain critical value. At low magnetic fields and at high magnetic fields the electrical resistivity increases with increasing temperature in a metallic manner in contrast to the thermally activated behaviour observed at intermediate fields. A strong enhancement of the observed anomalies under hydrostatic pressure is found. The anomalous properties are associated with charge carrier freeze-out effect in the intermediate field regime and a magnetic-field-induced semiconductor-semimetal transition in high magnetic fields. (Edited author abstract). 33 refs.

Kraak, W. (Humboldt-Univ zu Berlin, Berlin, East Ger); Troppenz, U.; Herrmann, R.; Chudinov, S.M.; Kulbachinskii, V.A. *Phys Status Solidi B* v 148 n 1 Jul 1988 p 333-347.

## Spectroscopic Analysis

**093475 VOLUME AND QUASI-SURFACE EXCITONIC STATES IN LAYERED SEMICONDUCTOR.** The influence of the surface states and the intensity of the laser emission with the quantum energy  $\hbar\nu > E_g$  on the reflectance and the photoluminescence spectra of  $\text{Bi}_2\text{S}_3$  single crystals in temperature range of 4.2-77 K are studied. The quasi-surface excitons, theoretically predicted previously, were obtained experimentally. (Author abstract) 3 refs.

Lisitsa, M.P. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Motsny, F.V. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 497-498.

## Thermoelectric Effects

**093476 THERMOELECTRIC PROPERTIES OF LEAD-DOPED SINGLE CRYSTALS OF SOLID SOLUTIONS OF THE  $\text{Sb}_{1.5}\text{Bi}_{0.5}\text{Te}_3\text{-Bi}_2\text{Se}_3$  SYSTEM.** A study was made of the temperature dependences of the thermoelectric power and the electric conductivity of lead-doped single crystals of solid solutions of the  $\text{Sb}_{1.5}\text{Bi}_{0.5}\text{Te}_3\text{-Bi}_2\text{Se}_3$  system in the 100-300 K range. It is shown that doping with lead has no effect on the nature of these dependences, the slopes of which are determined mainly by the degree of deviation of the solid-solution composition from the stoichiometric. 7 refs. In Russian.

Abrikosov, N.Kh.; Ivanova, L.D.; Polikarpova, N.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1826-1829.

## Thin Films

**093477 DEPOSITION OF CHALCOGENIDE THIN FILMS BY SOLUTION GROWTH TECHNIQUE ON POLYMER SURFACES.** This letter describes the deposition of thin films of chalcogenides on polymer substrates. Thermal treatment of polymer substrates is needed because of the presence of mechanical strains during its sheet formation by a mechanical process. Non-uniform mechanical strain causes inhomogeneous oxidation of the surface which results in a non-uniform deposition of chalcogenides thin films. 12 refs.



Pramanik, P. (Indian Inst of Technology, Kharagpur, India); Bhattacharya, S. *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1105-1106.

# SEMICONDUCTING BORON See Also DOSIMETRY.

## Activation

**093478 ELECTRICAL ACTIVATION OF LOW-FLUENCE BORON IMPLANTATION IN SILICON STUDIED BY PCV IN COMBINATION WITH SIMS.** The thermally induced electrical activation of boron implanted in silicon at fluences  $\leq 10^{13} \text{ cm}^{-2}$  was studied by the combination of secondary ion mass spectroscopy (SIMS) and pulsed capacitance voltage (PCV). After annealing at 900°C for 30 min boron is completely ionized and the contribution of electrically active defects to the electrical profile is negligible. For partly annealed samples ( $T < 900^\circ\text{C}$ ) the degree of electrical activation of boron decreases with increasing boron concentration due to the presence of residual defects. The experimental data can be described qualitatively by the first-order kinetics if the influence of residual crystal defects on the electrical activation is considered. (Author abstract) 26 refs.

Kempf, J. (IBM Deutschland GmbH, Sindelfingen, West Ger). *Appl Phys A* v A45 n 1 Jan 1988 p 77-81.

## Applications See SEMICONDUCTING SILICON—Ion Implantation.

## Doping

**093479 CRYSTAL STRUCTURE OF THE PHASE  $\text{ZnB}_{0.25}$ .** On the basis of single-crystal diffractometry, a study is made of the structure of a solid solution of zinc in  $\beta$ -rhombohedral boron, and the coordinates of the  $\beta$  and Zn atoms are determined. An analysis is made of all the interatomic distances and the coordination polyhedra of the Zn atoms. A comparison is made of the structures of interstitial solid solutions of third-period transition-metal atoms in  $\beta$ -rhombohedral boron. In Russian. 8 refs.

Kuz'ma, Yu.B.; Gurin, V.N.; Korsukova, M.M.; Akselrud, L.G. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 4 Apr 1987 p 566-569.

## Laser Applications

**093480 STRUCTURE OF BORON FILMS PRODUCED BY LASER CHEMICAL REACTIONS IN THE FIELD OF THE PULSED  $\text{CO}_2$  LASER.** The method of high-resolution electron microscopy was used to examine the structure and constitution of boron films produced by laser-chemical reactions in the field of a pulsed  $\text{CO}_2$  laser. The results show that the film represents the statistically distributed structural elements, i.e., clusters of boron atoms with the icosahedral structure. It was also shown that the initial amorphous structure of boron transforms in laser heating into the  $\beta$ -rhombohedral crystal structure with the crystallographic parameters typical of  $\beta$ -boron. (Author abstract) 5 refs.

Kervailshvili, P.D.; Kuteliya, E.R.; Tkeshelashvili, G.I. *Phys Chem Mater Treat* v 21 n 3 May-Jun 1987 p 250-252.

# SEMICONDUCTING CADMIUM COMPOUNDS See Also CADMIUM AND ALLOYS—Diffusion; CADMIUM AND ALLOYS—Magnetic Properties; CRYSTALS—Dislocations; LUMINESCENCE—Analysis; MERCURY AND AMALGAMS—Heat Treatment; PHOTOCONDUCTING MATERIALS; PHOTOVOLTAIC CELLS—Manufacture; SEMICONDUCTING GALLIUM ARSENIDE—Growth; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES, MIS—Electric Properties; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Electric Properties; SEMICONDUCTOR MATERIALS—Spectroscopic Analysis; SOLAR CELLS—Contacts; SOLAR CELLS—Surfaces; SOLAR CELLS—Thin Films; TRANSISTORS, BIPOLAR—Temperature Effect; TUNGSTEN COMPOUNDS—Reduction.

**093481 TYPE CONVERSION IN  $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$  BY**

ION BEAM TREATMENT. Conversion of vacancy-doped p-type cadmium mercury telluride to n-type rapid diffusion of mercury interstitials created during ion bombardment is rate-limited by the dose and requires neither donor ions nor postannealing. (Author abstract) 3 refs.

Blackman, M.V. (Mullard Ltd, Southampton, Engl); Charlton, D.E.; Jenner, M.D.; Purdy, D.R.; Wortherspoon, J.T.M.; Elliott, C.T.; White, A.M. *Electron Lett* v 23 n 19 Sep 10 1987 p 978-979.

**093482 ELECTROCHEMICAL AND ELECTRO-OPTICAL STUDY OF THE STRAINED-LAYER SUPERLATTICE SYSTEM:  $\text{CdTe-ZnTe}$ .** The behavior of  $\text{CdTe-ZnTe}$  strained-layer superlattices has been investigated for the first time in electrolytic medium. The role of the electrochemical control of the superlattice/electrolyte interface is emphasized for gaining information on the material using the electrochemical technique. Measurements in the dark and under illumination enable avoiding spurious electrochemical reactions in further investigations, and the p-type conductivity of these superlattices is determined unambiguously. Photocurrent spectroscopy and electroreflectance measurements in electrolytic medium are coupled in order to determine the various transition energies of these complex structures. (Edited author abstract) 30 refs.

Lemasson, Philippe (CNRS, Thiais, Fr); Nguyen Van Huong, Chau; Chu, X.; Sivananthan, S.; Faurie, Jean-Pierre. *J Electrochem Soc* v 135 n 5 May 1988 p 1282-1289.

**093483 PHOTOCHEMISTRY OF COLLOIDAL SEMICONDUCTORS. 25. QUENCHING OF  $\text{CdS}$  FLUORESCENCE BY EXCESS POSITIVE HOLES.** Colloidal  $\text{CdS}$  dissolves anodically (to yield  $\text{Cd}^{2+}$ ,  $\text{SO}_3^{2-}$ , and  $\text{SO}_4^{2-}$  ions) when it is attacked by OH radicals produced by  $\gamma$ -irradiation. The fluorescence intensity of  $\text{CdS}$  slightly decreases during the first stages of this dissolution, but drastically increases in the later stages as the particles become very small. This increase is attributed to the removal of surface sites at which the radiationless recombination of charge carriers takes place. It is shown that the longer the lifetime of fluorescence the more efficient is the quenching. The holes injected by OH radicals slowly leave the particles which then become fluorescent again. The consequences of this effect in photocatalysis are pointed out. A mechanism of quenching is discussed. (Edited author abstract) 15 refs.

Kumar, Anil (Hahn-Meitner-Inst Berlin, Berlin, West Ger); Janata, Eberhard; Henglein, Armin. *J Phys Chem* v 92 n 9 May 5 1988 p 2587-2591.

**093484 MELT GROWTH OF  $\text{CdTe}$  SINGLE CRYSTALS WITH CONTROLLED DEVIATION FROM STOICHIOMETRY.**  $\text{CdTe}$  single crystals were grown by an improved vertical Bridgman method with the Cd or Te reservoir chamber at the lower part of the growth tube. The reservoir is provided for regulating the partial pressures exactly and in consequence, controlling the stoichiometry of the grown crystals. The effectiveness of the proposed method was confirmed from the electrical conductivities of the crystals which changed drastically depending on the controlled partial pressures. (Author abstract) 13 refs.

Mochizuki, K. (Tohoku Univ, Sendai, Jpn); Masumoto, K.; Miyazaki, K. *Mater Lett* v 6 n 4 Feb 1988 p 119-122.

**093485 PHOTOCARGING OF POLYNUCLEAR METAL COMPLEX AT n-CADMIUM SULFIDE PHOTOANODE STABILIZED BY COATING WITH POLYMER-PENDANT TRIS(2,2'-BIPYRIDINE)RUTHENIUM(II).** Chemical storage of visible light energy is attracting much attention both in photoenergy conversion and information memory devices. The authors have succeeded in stabilizing liquid-junction n-cadmium sulfide ( $\text{CdS}$ ) by coating it with polymer-pendant tris(2,2'-bipyridine)ruthenium(II) ( $\text{Ru}(\text{bpy})_3^{2+}$ ) complex. This stabilized n- $\text{CdS}$  is an excellent candidate for adsorbing and converting visible light energy into charges. As a

storage material, Prussian Blue (PB) which is a mixed-valent high molecular weight polynuclear iron cyanide complex ( $\text{Fe}^{3+}_4[\text{Fe}^{\text{II}}(\text{CN})_6]^{14-3}$ ) was selected. 14 refs.

Kaneko, Masao (Inst of Physical & Chemical Research, Wako, Jpn); Okada, Tokuo; Teratani, Shousuke; Taya, Kazuo. *Polym J* v 20 n 4 1988 p 361-364.

**093486 PHOTOCHEMISTRY OF COLLOIDAL SEMICONDUCTORS. 26. PHOTOELECTRON EMISSION FROM  $\text{CdS}$  PARTICLE AND RELATED CHEMICAL EFFECTS.** Laser illumination of small  $\text{CdS}$  particles in aqueous solution leads to the formation of hydrated electrons, which are detected by their strong absorption. The yield increases with decreasing particle size. The maximum quantum yield observed is 0.07 electrons emitted per photon adsorbed. At the highest laser intensities applied, five electrons are emitted from one colloidal particle. The absorption of the remaining holes is also observed. The emitted electrons react with colloidal particles in solution. During the laser flash a strong bleaching signal, attributed to the electrons generated in the particles, is recorded shortly below the onset of absorption. With knowledge of the specific absorbance, the stationary concentration of electrons on the particles during the laser flash is calculated. These effects are studied at various laser intensities. (Edited author abstract) 16 refs.

Haase, Markus (Hahn-Meitner-Inst, Berlin, West Ger); Weller, Horst; Henglein, Armin. *J Phys Chem* v 92 n 16 0811 1988 p 4706-4712.

## Amorphous

**093487 AMORPHOUS THIN FILMS OF  $\text{CdSnAs}_2$ : DEPOSITION AND CHARACTERIZATION.** The structural and optical properties of the films are compared with those of polycrystalline thin films.  $\text{CdSnAs}_2$  crystallizes in the chalcopyrite structure and has high carrier mobility. The properties were investigated by X-ray diffraction and by scanning electron microscopy (SEM). A reliable X-ray diffraction method has been developed to characterize the existence of an amorphous phase. 6 refs.

Raju, D.V.R. (Coll of Military Engineering, Pune, India); Rao, V.J. *J Mater Sci Lett* v 7 n 5 May 1988 p 527-528.

## Analysis

**093488  $E_g$  VERSUS  $x$  RELATION FROM PHOTOLUMINESCENCE AND ELECTRON MICRO-PROBE INVESTIGATIONS IN p-TYPE  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  ( $0.35 \leq x \leq 0.7$ ).** Combined photoluminescence (at  $10 \leq T \leq 300 \text{ K}$ ) and electron microprobe investigations have been carried out with  $\text{HgCdTe}$  samples grown from the melt or from solution. By exciting the samples through metallic masks with  $200 \mu\text{m}$  diameter holes fixed with respect to the sample care was taken to pick up both characteristic X-ray radiation as well as the photoluminescence from the same sample area. The  $E_g$  versus  $x$  relation determined in this way at  $T = 30 \text{ K}$  has been compared with data from the interband absorption edge by other authors. (Author abstract) 10 refs.

Gille, P. (Humboldt-Univ zu Berlin, Berlin, East Ger); Herrmann, K.H.; Puhlmann, N.; Schenk, M.; Tomm, J.W.; Werner, L. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 593-598.

## Applications See GLASS—Optical Properties; PHOTOELECTRIC CELLS; PHOTOELECTRIC CELLS—Measurements; SEMICONDUCTOR DIODES—Heterojunctions; SEMICONDUCTOR DIODES—Low Temperature Effects; SOLAR CELLS—Cadmium Sulfide.

## Charge Carriers See Also MAGNETIC SEMICONDUCTORS—Physical Properties.

**093489 ACOUSTOELECTRIC MEASUREMENTS OF MINORITY AND MAJORITY CARRIER MOBILITIES IN SEMICONDUCTORS INCLUDING  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ .** Acoustoelectric voltages versus absorbed surface acoustic wave (SAW) power measurements are



used to nondestructively determine carrier mobilities in bulk silicon, GaAs and epitaxial  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  employing a separate medium convolver structure. The longitudinal component of the acoustoelectric signals (LAV) has been used in the past to determine the carrier mobilities in semiconductor films. In the present work, it is shown that the transverse component of the acoustoelectric signals (TAV) can also be used to measure the carrier mobilities. TAV and LAV measurements yield mobilities in perpendicular directions. Hence, these measurements can be used to study the electron mobilities of a two-dimensional electron system in superlattices. A new delay line structure is introduced to invert the semiconductor surface through the field effect to measure the minority carrier mobilities. Carrier mobilities in graded epitaxial  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  are measured after subsequent etching of the surface to obtain the mobility values versus depth. The findings of the above measurements and Hall measurements are in satisfactory agreement. (Author abstract) 16 refs.

Tabib-Azar, M. (Case Western Reserve Univ, Cleveland, OH, USA); Das, P. *Appl Phys A* v 45 n 2 Feb 1988 p 119-124.

**093490 OBSERVATION OF CYCLOTRON RESONANCE IN CdSe BELOW THE METAL-INSULATOR TRANSITION.** We report the observation of electron cyclotron resonance (CR) in n-type CdSe with an average carrier density below the metal-insulator transition ( $N_d^{1/3}a^* = 0.08$ ). A plasma-shifted electron cyclotron resonance (SCR) is also observed. The number of carriers participating in cyclotron resonance, which is more than 4 orders less than  $N_d \cdot N_a$ , increases rapidly with magnetic field, in agreement with a previous calculation based on Poisson distribution of donors. This supports the picture of metallic donor clusters within doped semiconductors due to random distribution of impurities. The simultaneous appearance of both CR and SCR is interpreted in terms of the breakdown of the Maxwell Garnett theory for random-donor semiconductors. (Author abstract) 6 refs.

Lee, M.W. (Univ of Maryland, College Park, MD, USA); Drew, H.D. *Solid State Commun* v 62 n 12 Jun 1987 p 825-828.

**093491 CORRELATION BETWEEN CARRIER CONCENTRATION IN  $\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$ .** In order to use ( $\text{HgCd}$ )Te for photoconductive detector applications, material with a near-intrinsic free carrier concentration and therefore few residual impurities is required. Material with a high carrier concentration has been found to contain relatively large amounts of chlorine and there is a correlation between the Cl concentration and the carrier concentration determined using the Hall effect. The sources of Cl contamination have been found to be the Cd starting material, chemicals used to clean the starting materials as well as the silica ampules used during growth. (Author abstract) 8 refs.

Marais, M.A. (CSIR, Pretoria, S Afr); Strydom, H.J.; Basson, J.H.; Rogers, D.E.C.; Booyens, H. *J Cryst Growth* v 88 n 3 May 1988 p 391-396.

**093492 CARRIER RECOMBINATION IN  $\text{p-Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$  AND  $\text{n-Hg}_{0.7}\text{Cd}_{0.3}\text{Te}$ .** Transport and photoconductive properties of  $\text{p-Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$  and  $\text{n-Hg}_{0.7}\text{Cd}_{0.3}\text{Te}$  have been studied at temperatures between 16 and 250 K. The crystals showed different lifetimes than that observed in n-type  $\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$ , where Auger recombination was found as the dominating recombination mechanism. The minority carrier lifetime in  $\text{p-Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$  could be explained by Shockley-Read recombination involving a deep donor-like centre located about 6 meV above the valence band edge. In n-type  $\text{Hg}_{0.7}\text{Cd}_{0.3}\text{Te}$  radiative recombination was found to dominate at temperatures above 40 K. Obviously the band gap of this composition is too wide for an effective Auger mechanism. Below 40 K trapping of minority carriers occurs and one observes two life time constants. Here the recombination mechanism was identified as recombination via defects in the band gap. (Author abstract) 17 refs.

Schilz, J. (Univ zu Koeln, Cologne, West Ger); Nimtz, G.;

Geibel, C.; Ziegler, J. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 677-681.

**Chemical Vapor Deposition** See Also SOLAR CELLS—Thin Films.

**093493 THERMODYNAMIC ANALYSIS OF THE GROWTH OF  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  BY MOCVD.** The dependence of the compositional parameter  $x$  in  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  (MCT) upon the growth temperature and feed compositions has been analyzed by thermodynamic principles. The results indicate that  $x$  increases sharply from its low temperature values to unity once the growth temperature has reached a critical point, where the decomposition of  $\text{HgTe}$  becomes significant. Higher Hg/Cd ratios, as well as higher DETe concentrations in the feed can help to prevent  $\text{HgTe}$  decomposition until higher temperatures are reached and are thus more desirable growth conditions for MCT using the MOCVD method. (Author abstract) 22 refs.

Liaw, Ing-Ruey (Nat'l Tsing Hua Univ, Hsinchu, Taiwan); Chou, Kan-Sen; Lin, Ming-Shyong. *J Cryst Growth* v 87 n 4 Mar 1988 p 529-534.

**093494 ENTHALPY CHANGE IN MOVPE PREPARATION OF MERCURY CADMIUM TELLURIDE.** Heat balance calculations for the preparation of mercury cadmium telluride by the interdiffused multilayer process from the gas phase by thermal decomposition of dimethyl cadmium,  $\text{Me}_2\text{Cd}$ , or Hg vapor with diethyl telluride,  $\text{Et}_2\text{Te}$ , show that the enthalpy change for the process is due mostly to the formation of hydrocarbons from the metal alkyls, rather than to the formation of CdTe or HgTe. (Author abstract) 10 refs.

McAllister, Trevor (CSIRO, Clayton, Aust). *J Cryst Growth* v 91 n 1-2 Aug 1988 p 218-220.

**093495 PHOTO-MOCVD GROWTH OF  $\text{HgTe}$ - $\text{CdTe}$  SUPERLATTICES.**  $\text{HgTe}$ - $\text{CdTe}$  superlattices have been grown by photo-assisted metalorganic chemical vapor deposition (MOCVD). The substrate temperatures used were 182°C and 240°C. Superlattices were obtained despite low growth rates requiring long growth times, up to 12 h. Superlattice structures were verified by cross-sectional transmission electron microscope (TEM) and diffractometer X-ray diffraction patterns. The X-ray diffraction patterns showed satellite peaks up to third order. A grid-like array of dislocations at the substrate layer interface, suggesting operation of a dislocation-blocking mechanism, was observed. The electrical properties of superlattices grown at higher temperature (240°C) were improved compared with those grown at lower temperature (182°C) and had n-type conductivity as grown, with carrier concentrations approximately  $10^{16} \text{ cm}^{-3}$  and mobilities approximately  $10^4 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ . Infrared transmission/reflection measurements showed that the superlattice absorption edge was shifted to longer wavelengths compared with the homogeneous alloy of the same CdTe fraction ( $x$ -value), as expected. (Author abstract) 21 refs.

Ahlgren, William L. (Santa Barbara Research Cent, Goleta, CA, USA); Smith, E.J.; James, J.B.; James, T.W.; Ruth, R.P.; Patten, E.A.; Knox, R.D.; Staudenmann, J.-L. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 198-209.

**093496 TEMPERATURE-INDEPENDENT UNASSISTED PYROLYTIC MOCVD GROWTH OF CADMIUM TELLURIDE AT 250°C USING 2,5-DIHYDROTELUROPHENE.** The molecule 2,5-dihydrotelurophene (DHTe) was identified, synthesized and tested to determine its potential as a Te source for unassisted pyrolytic MOCVD growth of  $\text{Hg}_x\text{Cd}_{1-x}\text{Te}$  at substrate temperatures  $\approx 300^\circ\text{C}$ . Experiments were concentrated on unassisted pyrolytic growth of CdTe using DHTe and dimethylcadmium (DMCd) as a Cd source. The long-term stability of DHTe far exceeded theoretical expectations. Cadmium telluride growth rates were a linear function of the DHTe flow rate and independent of substrate temper-

ature at or above 250°C. All CdTe layers grown on high-resistivity CdTe substrates were p-type, with carrier concentrations between  $6.2 \times 10^{15}$  and  $4.2 \times 10^{16} \text{ cm}^{-3}$ . The best electrical properties were obtained at a growth temperature of 250°C, where the p-type carrier concentration was  $6.2 \times 10^{15} \text{ cm}^{-3}$  and the Hall mobility was  $80 \text{ cm}^2/\text{V}\cdot\text{s}$ . (Edited author abstract) 17 refs.

Lichtmann, L.S. (Hughes Research Lab, Malibu, CA, USA); Parsons, J.D.; Cirlin, E.-H. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 217-221.

**093497 TEMPERATURE-INDEPENDENT UNASSISTED PYROLYTIC MOCVD GROWTH OF CADMIUM TELLURIDE AT 290°C AND MERCURY TELLURIDE AT 325°C USING DIMETHYLCADMIUM, METHYLALYLTELLURIDE AND DIMETHYLMERCURY.** Methylallyltelluride (MATE) was synthesized and tested as part of a joint effort between American Cyanamid Co. and Hughes Research Laboratories to develop a Te alkyl suitable for low-temperature, high-growth-rate epitaxy of  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  (MCT) alloys by unassisted pyrolytic metalorganic chemical vapor deposition (MOCVD). Cadmium telluride and HgTe growth studies using MATE were performed at substrate temperatures between 250 and 350°C. Reproducible temperature-dependent CdTe growth rates as high as  $30 \mu\text{m/h}$  were achieved at or above 290°C. The decomposition characteristics of the Hg source, dimethylmercury (DMHg), limited the minimum temperature for temperature-independent growth of HgTe to 325°C. Between 325 and 340°C the maximum HgTe growth rates were  $15 \mu\text{m/h}$ . Room-temperature Hall measurements were performed on CdTe epitaxial layers grown on high-resistivity CdTe substrates at 300°C. These layers were p-type. (Edited author abstract) 15 refs.

Parsons, J.D. (Hughes Research Lab, Malibu, CA, USA); Lichtmann, L.S. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 222-227.

**093498 GROWTH OF  $\text{CdHgTe}$  BY MOCVD AT REDUCED TEMPERATURES.**  $\text{CdHgTe}$  has been grown by MOCVD at 350°C using IMP. The material was superior to that grown at 410°C in terms of surface morphology, decreased acceptor concentration and better interface control. The compositional uniformity was also greatly improved, and at 1% in  $x$  over  $1 \text{ cm}^2$  is the best ever reported for MOCVD grown CMT. (Author abstract) 19 refs.

Thompson, J. (GEC Research Ltd, Wembley, Engl); Mackett, P.; Smith, L.M.; Cole-Hamilton, D.J.; Shenai-Khatkate, D.V. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 233-239.

**093499 GROWTH OF  $\text{CdHgTe}$  BY METALORGANIC CHEMICAL VAPOUR DEPOSITION FOR OPTICAL COMMUNICATION DEVICES.** MOCVD has been used for the first time to grow  $\text{CdHgTe}$  by the interdiffused multilayer process for  $1.3\text{-}1.55 \mu\text{m}$  photodiodes. The growth has been optimised to give uniform material with a smooth surface morphology. The use of a HgTe layer as the p-type ohmic contact has resulted in photodiodes having a very low series resistance (30-35  $\Omega$ ). The epitaxial diodes have also exhibited good thermal stability. Other parameters are comparable with those obtained for bulk grown devices. (Author abstract) 11 refs.

Thompson, J. (GEC Research Ltd, Middlesex, Engl); Mackett, P.; Jenkin, G.T.; Nguyen Duy, T.; Gori, P. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 917-923.



**Coatings** See ELECTRODES, ELECTROCHEMICAL—Materials.

## Compaction

**093500 HOT ISOSTATIC PRESSING OF CADMIUM SULPHIDE.** Cadmium sulfide, CdS, has some potential applications as a semiconductor. For example, it has been widely used in solar batteries, photometers (exposure meters) and so on. However, cadmium sulfide is a thermally unstable material which cannot be fully densified by normal sintering, because its sintering temperature is limited to a relatively low temperature. Pressure sintering is a promising technique because a reduction of sintering temperature and also simultaneous use of the capsule is favorable in the case of volatile materials. Hot isostatic pressing is a type of pressure sintering. The present letter is concerned with fabrication of dense bodies of cadmium sulfide. 7 refs.

Hattori, T. (Univ of Chiba, Chiba, Jpn); Iwade, Y.; Tatsumoto, H. *J Mater Sci Lett* v 6 n 11 Nov 1987 p 1301-1302.

**Computation** See SEMICONDUCTING ZINC COMPOUNDS—Computation.

## Contacts

**093501 TUNNELING EFFECT ON THE METAL-CdTe CONTACT.** A theoretical analysis is made of metal/CdTe contacts by a numerical method. Factors which influence the current density and contact resistance of the M-S junction are discussed. Besides the thermionic current component, the tunneling current, treated with the WKB approximation, is incorporated into the current transport across the M-S junction. It is shown that the latter should not be neglected, especially in cases of high doping concentration and low temperature. A set of optimum process parameters for contact of CdTe related devices is proposed. (Edited author abstract) 10 refs.

Houng, Mau-Phon (Nat'l Cheng Kung Univ, Tainan, Taiwan); Jenq, Fenq-Lin. *Solid State Commun* v 66 n 1 Apr 1988 p 1-5.

## Crystalline

**093502 PHOTOLUMINESCENCE OF CdTe CRYSTALS DOPED WITH OXYGEN AND ITS COMPARISON WITH ZnTe:O.** Photoluminescence spectra of CdTe crystals doped with oxygen at low temperature (4.9-20K) are investigated and a new emission peak O and its LO phonon replicas are observed. The energy positions of these peaks do not shift with the temperature and the excitation power. The emission peak O has been identified as the recombination of the exciton bound to oxygen center. The characteristic of luminescence from the  $O_{Te}$ -bound exciton in CdTe:O is compared with that in ZnTe:O. (Author abstract) 21 refs.

Tang, Wenguo (Acad Sinica, Shanghai, China); Li, Zhongshou; Zhang, Suying; Li, Zhiyuan; Lin, Xingzhao. *Chin J Infrared Res Ser B (Engl Ed)* v 6 1987 p 15-22.

**Defects** See Also SEMICONDUCTING TELLURIUM COMPOUNDS—Defects.

**093503 PHOTOPYROELECTRIC SPECTROSCOPY (P<sup>2</sup>ES) OF ELECTRONIC DEFECT CENTERS IN CRYSTALLINE n-CdS.** Photopyroelectric spectroscopy (P<sup>2</sup>ES) of n-CdS single crystals was performed at an open circuit, and in conjunction with photocurrent spectroscopy (PCS) in the presence of an applied ac or dc transverse field. The results showed that P<sup>2</sup>ES is very sensitive to the presence of deliberately introduced subbandgap defect structures, with the P<sup>2</sup>E signal dominated by non-radiative de-excitation mechanisms at defect centers. The potential of this technique as a powerful electronic defect diagnostic tool, combined with the overall experimental simplicity, was demonstrated with mm-thick crystals used as received in an open-cell geometry. (Author abstract) 26 refs.

Mandelis, A. (Univ of Toronto, Toronto, Ont, Can); Loe,

W.; Wagner, R.E. *Appl Phys A* v A44 n 2 Oct 1987 p 123-130.

**093504 ELECTRON TRAPS IN SINGLE-CRYSTALL CdS.** Deep-level transient spectroscopy (DLTS) has been used to characterize bulk defect states in single-crystal boules of CdS grown from the vapor phase. Two centers are present in as-grown material with activation energies of 0.29 eV and 0.44 eV. However, annealing the crystals in either Cd or S appears to introduce two additional levels with activation energies of 0.61 eV and 0.74 eV. If the sample is maintained in the dark for some time, the DLTS peak disappears but can be recovered again by exposure to light. Apparently this cycle can be repeated indefinitely. Parallel observations in the scanning electron microscope have shown that the annealing process also produces a network of extended defects and subgrain boundaries. (Edited author abstract) 20 refs.

Claybourn, M. (Univ of Durham, Durham, Engl); Brinkman, A.W.; Russell, G.J.; Woods, J. *Philos Mag B* v 56 n 3 Sep 1987 p 385-395.

**093505 PHOTOCAPACITANCE STUDY OF DEFECTS IN PLASTICALLY-DEFORMED CdTe.** Deformation-induced defects have been investigated in both n- and p-type CdTe photocapacitance measurements (PCM). Two deep levels were observed in similar concentrations near the middle of the gap. The corresponding defects are supposed to be identical with those that have been found by other authors, using deep-level transient spectroscopy. From a fit of our data to models of the absorption cross-section we obtain the photo-ionization energies and can reliably estimate the activation enthalpies of the relaxed defect states, taking into account the electron-phonon interaction. The Huang-Rhys factor for the electron-phonon coupling of both states is of the order of twenty. (Author abstract) 14 refs.

Nitecki, R. (Technische Univ Clausthal, Goettingen-Clausthal, West Ger); Labusch, R. *Philos Mag B* v 58 n 3 Sep 1988 p 285-292.

**093506 DEEP LEVELS DUE TO DISLOCATIONS IN CdS.** Nonstationary capacitance spectroscopy (DLTS) is widely used in determining deep-level parameters for semiconductors. In application to dislocations, an important point in that the method in particular enables one to isolate the lines corresponding to extended defects. Also, the working volume is determined by the thickness of the depleted region in a Schottky diode and the contact area, so it can be extremely small, and therefore microindentation can be used to introduce dislocations, while one can also examine unevenly distributed growth dislocations. We have applied DLTS to cadmium sulfide and have identified signals in the spectra corresponding to certain dislocation types. 9 refs.

Vyvenko, O.F.; Bazlov, N.V.; Tul'ev, A.V. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 39-43.

**093507 DISLOCATION STRUCTURE AND MOTION IN Al<sup>III</sup>V<sup>VI</sup> SEMICONDUCTOR.** Dislocation-motion studies for Al<sup>III</sup>V<sup>VI</sup> semiconductors include determining the speeds of both types during plastic strain in CdS. Here we describe the splitting geometry and motion seen in the electron microscope separately for the  $\alpha$  and  $\beta$  dislocations in CdS, CdTe, and ZnTe as examined at an accelerating voltage of 100-400 kV, with the motion stimulated by local heating. 20 refs.

Cockayne, D.J.H.; Lu, G.; Sikorsky, A. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 87-92.

**093508 DISLOCATIONS IN HgCdTe-CdTe AND HgCdTe-CdZnTe HETEROJUNCTIONS.** Mechanisms that govern the generation and movement of dislocations in (111) heterojunctions of HgCdTe-CdTe and HgCdTe-CdZnTe grown by liquid phase epitaxy have been investigated with etch pit studies. The density and

distribution of the misfit dislocations in these heterojunctions have been measured quantitatively and analyzed to clarify the mechanisms that generated them. The origins of the dislocations threading through the epilayer are reported. (Author abstract) 13 refs.

Takigawa, H. (Fujitsu Lab Ltd, Atsugi, Jpn); Yoshikawa, M.; Maekawa, T. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 446-451.

**093509 DEFECT FORMATION DURING MBE GROWTH OF HgTe ON CdTe.** HgTe grown by MBE onto CdTe substrates under excess Hg conditions was found to lead to a columnar void-twin microstructure, with the twins nucleating from the voids. Grown under Hg-deficient conditions, the microstructure of MBE HgTe consisted of columnar polycrystals. Nucleation of the polycrystals occurred only at the commencement of growth. Possible growth and twinning mechanisms are discussed. (Author abstract) 6 refs.

Schaafe, H.F. (Texas Instruments Inc, Dallas, TX, USA); Koestner, R.J. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 452-459.

## Diffusion

**093510 INTERDIFFUSION IN MERCURY CADMIUM TELLURIDE EVALUATED FROM VAPOR PHASE GROWTH KINETICS.** A method is presented for determining interdiffusion coefficients from the kinetics of isothermal vapor phase epitaxial growth of mercury cadmium telluride ( $Hg_{1-x}Cd_xTe$ ). After an initial transient, growth is interdiffusion limited. Interdiffusion coefficients in the composition range  $x = 0.1$  to  $0.7$  and a temperature range of  $450$  to  $700^\circ C$  were determined using a simple geometric analysis of the composition profiles obtained in this interdiffusion limited regime. The technique offers advantages in simplicity and added control over the defect nature of the material during the interdiffusion process. The interdiffusion coefficients for the composition and temperature range studied are represented by the following equation:  $D_x (cm^2/s) = 300 \exp(-7.53x) \exp(-1.92 \text{ eV}/kT)$ . Comparison with other studies shows good agreement. (Author abstract) 19 refs.

Fleming, J.G. (Stanford Univ, Stanford, CA, USA); Stevenson, D.A. *Phys Status Solidi A* v 105 n 1 Jan 1988 p 77-85.

**Doping** See Also SEMICONDUCTOR DIODES, LIGHT EMITTING—Fabrication; SOLAR CELLS—Cadmium Sulfide.

**093511 SINTERING BEHAVIOUR AND ELECTRICAL PROPERTIES OF Cd<sub>1-x</sub>Zn<sub>x</sub>S FILMS CONTAINING CdCl<sub>2</sub>.** Polycrystalline Cd<sub>1-x</sub>Zn<sub>x</sub>S films were prepared by coating a slurry which consisted of CdS, CdCl<sub>2</sub>, various amounts of ZnS and propylene glycol on to glass substrates and by sintering in a nitrogen atmosphere, and their sintering behaviors and electrical properties were investigated. As the amount of ZnS increases, the enhancing effects of CdCl<sub>2</sub> on sintering and doping decrease, due primarily to the formation of ZnCl<sub>2</sub> which evaporates rapidly during sintering, resulting in poor microstructure and a sharp increase in electrical resistivity. The sharp increase in the electrical resistivity is related to a sharp decrease in electron concentration which is caused by poor doping efficiency, and by an increase in the donor ionization energy of chlorine as the zinc content increases. The trap density of grain boundaries, on the other hand, decreases with increasing zinc content in sintered Cd<sub>1-x</sub>Zn<sub>x</sub>S films. (Author abstract) 13 refs.

Seol, Y.S. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Im, H.B. *J Mater Sci* v 22 n 10 Oct 1987 p 3533-3536.

**093512 PHOTOREFLECTIVE SPECTROSCOPY OF DOPED AND UNDOPED Cd<sub>1-x</sub>Mn<sub>x</sub>Te.** We present results of photoreflectivity measurements on Cd<sub>1-x</sub>



Mn<sub>2</sub>Te. The composition dependence of the energy gap for  $0 \leq x \leq 0.5$  at room and liquid nitrogen temperatures was determined with accuracy comparable to exciton reflectivity and photoluminescence at  $T=4$  K. The line-shape change as a function of  $x$ , temperature between 80-295 K, and  $n^-$  and  $p^-$  type dopants is described. This first and simple method is used to determine the spatial quality and homogeneity of large crystal wafers. (Author abstract) 17 refs.

Misiewicz, J. (MIT, Cambridge, MA, USA); Zheng, X.-L.; Becla, P.; Heiman, D. *Solid State Commun* v 66 n 4 Apr 1988 p 351-354.

**093513 GROUP V ACCEPTOR DOPING OF Cd<sub>x</sub>/Hg<sub>1-x</sub>Te LAYERS GROWN BY METAL-ORGANIC VAPOUR PHASE EPITAXY.** Layers of Cd<sub>x</sub>Hg<sub>1-x</sub>Te have been grown by metal-organic vapor phase epitaxy and doped with arsenic and with phosphorus. This has been achieved by establishing metal-rich gas phase conditions during growth and obviates the need for high temperature 'activation' type anneals. Data from Hall measurements and secondary ion mass spectrometry on annealed samples are in close agreement. (Author abstract) 12 Refs.

Capper, P. (Philips Research Lab, Redhill, Engl); Whiffin, P.A.C.; Easton, B.C.; Maxey, C.D.; Kenworthy, I. *Material Lett* v 6 n 10 Jun 1988 p 365-368.

**093514 ISOTROPIC HYPERFINE COUPLING CONSTANT IN MANGANESE-DOPED Cd<sub>1-x</sub>Se.** An EPR study was performed on the alloy system Cd<sub>1-x</sub>Zn<sub>x</sub>Se:Mn<sup>2+</sup> using an X-band spectrometer. The isotropic hyperfine coupling constant of the material was measured both at room temperature and 77 K. The results obtained were correlated with the ionicity of the constituent semiconductors. Results of this work were also compared to those of analogous systems. (Edited author abstract) 21 Refs.

Koh, A.K. (Univ Kebagsaan Malaysia, Bangi, Malays). *J Phys Chem Solids* v 49 n 8 1988 p 993-995.

**Electric Conductivity** See Also CADMIUM COMPOUNDS—Electric Conductivity.

**093515 CONDUCTION PROCESSES IN INHOMOGENEOUS CdSe<sub>1-x</sub>Te<sub>x</sub> SEMICONDUCTORS.** The results obtained from a study of the Hall effect, conduction, thermally stimulated current and thermoelectromotive force and the potential-current and frequency characteristics of solid solution films of CdSe<sub>1-x</sub>Te<sub>x</sub> ( $0.02 \leq x \leq 0.97$ ) are reported. The films were investigated over a temperature range of 80-400 K. The samples studied have been found to be inhomogeneous semiconductors. The films of CdSe<sub>1-x</sub>Te<sub>x</sub> solid solutions have been shown to possess a highly conducting impurity zone whose amplitude of potential relief inhomogeneity is considerably lower than that of the intrinsic zones. It is found that in CdSe<sub>1-x</sub>Te<sub>x</sub> semiconductors Shklovsky's percolation non-ohmicity takes place in the impurity conduction zone, which so far has not been observed experimentally. (Author abstract) 13 refs.

Belyaev, A.P. (Leningrad Lensoviet Inst of Technology, Leningrad, USSR); Kalinkin, I.P. *Thin Solid Films* v 158 n 1 Mar 1988 p 25-36.

**093516 PHOTO-EPR AND DLTS OF CdTe:CO.** We present results from investigations on the electrical activity of substitutional Co in CdTe. Both photo-EPR and DLTS indicate a Co-related center with an energy level in the upper half of the gap, in accordance with an empirical rule for the relative energetic positions of transition-metal-impurity levels. The threshold energies for the photo-quenching and the excitation of the Co<sup>2+</sup> EPR are determined and a configuration-coordinate model is presented. (Author abstract) 18 refs.

Hendorfer, G. (Johannes Kepler Univ Linz, Linz, Austria); Brunthaler, G.; Jantsch, W.; Reisinger, J.; Sitter, H. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 497-501.

## Electric Field Effects

**093517 ELECTRIC FIELD DEPENDENCE OF THE HOT-ELECTRON DRIFT VELOCITY IN Hg<sub>0.8</sub>Cd<sub>0.2</sub>Te UNDER MAGNETIC QUANTISATION AT LOW TEMPERATURES.** The electric-field dependence of the drift velocity of hot electrons in Hg<sub>0.8</sub>Cd<sub>0.2</sub>Te at a lattice temperature of 1.5 K is studied theoretically in the extreme magnetic quantum limit considering electron scattering by acoustic phonons and ionized impurities. Band non-parabolicity, free carrier screening, non-equilibrium and non-equilibrium condition of acoustic phonons, and Landau level broadening due to electron-impurity interactions are included in the calculations. The agreement with recent experimental data is found to be satisfactory. (Author abstract) 5 refs.

Basu, Partha Pratim (Inst of Radio Physics & Electronics, Calcutta, India); Sarkar, C.K.; Chattopadhyay, D. *Solid State Commun* v 64 n 9 Dec 1987 p 1241-1242.

## Electric Properties

**093518 EFFECT OF AN ELECTRIC FIELD ON MASS TRANSFER OF SULFUR AND CADMIUM IN THIN POLYCRYSTALLINE CdS FILMS.** A study was made of the effect of an electric field in the electrophysical properties of thin cadmium sulfide films. It was found that the variation of the resistivity and photoconductivity of the films as a function of the coordinate is caused by accelerated ion displacement in the semiconductor layer above the surface and by the occurrence of quasi-chemical reactions leading to the formation of intrinsic defects in the bulk of the semiconductor. In Russian. 14 refs.

Ignatov, A.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 8 Aug 1987 p 1255-1257.

**093519 EFFECT OF COMPOSITIONAL INHOMOGENEITY ON THE ELECTRIC AND OPTICAL PROPERTIES OF Cd<sub>x</sub>Hg<sub>1-x</sub>Te SINGLE CRYSTALS ( $0.19 \leq x \leq 0.30$ ).** A study was made of the electric conductivity, the Hall effect and the Faraday effect on free charge carriers as a function of the geometrical dimensions of a Cd<sub>x</sub>Hg<sub>1-x</sub>Te sample with  $0.19 \leq x \leq 0.30$ . On the basis of this study, the electric parameters and the effective electron masses of this material were determined. The  $x$  distribution profile along the thickness of the sample and the amplitude of its fluctuations  $\Delta x$  were established experimentally. The possibility of a contactless method of determining compositional fluctuations in these crystals is shown. 9 refs. In Russian.

Abdinov, A.Sh.; Seidli, G.S.; Khydyrova, E.B.; Shukuyrov, N.M. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1835-1838.

**093520 DISLOCATIONS AND ELECTRICAL CHARACTERISTICS OF HgCdTe.** The electrical characteristics of HgCdTe samples have been experimentally examined as a function of dislocation density. MIS measurements on samples with a graded dislocation density ranging from about  $2 \times 10^5$  to  $2 \times 10^6$  cm<sup>-2</sup> showed the net doping concentration is independent of local dislocation density, but that MIS dark current varies linearly with dislocation density. No evidence for impurity segregation to dislocations was observed between the low and high dislocation density region. Deformed HgCdTe shows a larger decrease in the electron mobility after low temperature plasma hydrogenation than do undeformed samples. Dislocation density may influence the hydrogen solubility in these samples. Collectively, both the MIS and Hall results suggest dislocations themselves do not contribute to the carrier concentration in HgCdTe. (Edited author abstract) 22 refs.

Tregilgas, J.H. (Texas Instruments Inc, Dallas, TX, USA); Polgreen, T.L.; Chen, M.C. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 460-466.

## Electrochemistry

**093521 PHOTOELECTROCHEMISTRY OF CADMIUM SULFIDE. 1. REANALYSIS OF PHOTO-CORROSION AND FLAT-BAND POTENTIAL.** The photoelectrochemical behavior of cadmium sulfide depends strongly on the pretreatment of the electrodes. Sulfur, the main photocorrosion product of CdS, changes the potential drop across the Helmholtz double layer and shifts the flat-band potential of CdS in the anodic direction. Removal of sulfur from the surface is possible by prepolarizing the electrode at about  $-1.1$  V(SCE) in the presence of oxygen. The flat-band potential of the clean (0001) Cd surface has been determined to about  $-1.8$  V(SCE) in the dark. Illumination of the electrode leads to surface-state charging due to formation of S<sup>-</sup>, the intermediate in the formation of both possible photooxidation products: S<sup>0</sup> in the absence of oxygen and SO<sub>4</sub><sup>2-</sup> in the presence of oxygen. (Author abstract) 44 refs.

Meissner, Dieter (Inst fuer Solarenergieforschung, Hanover, West Ger); Memming, Ruediger; Kastening, Bertel. *J Phys Chem* v 92 n 12 Jun 16 1988 p 3476-3483.

**093522 PHOTOELECTROCHEMISTRY OF CADMIUM SULFIDE. 2. INFLUENCE OF SURFACE-STATE CHARGING.** The energy bands at the surface of clean CdS become unpinned upon illumination and are shifted in the anodic direction by several hundred millivolts. The same effect occurs in the dark after addition of the oxidized species of certain redox systems whose standard potentials are located in the bandgap of CdS. A model is presented in which the band movement is interpreted by positive charging of surface states. In the case of light excitation a hole in the valence band is captured by the surface state, in the case of a suitable oxidizing agent the surface state is charged by direct electron transfer from this state to the acceptor in the electrolyte. The potential dependence of photocurrents and dark currents can be explained semiquantitatively in terms of charge transfer via surface states. (Edited author abstract) 13 refs.

Meissner, Dieter (Inst fuer Solarenergieforschung, Hanover, West Ger); Lauermann, Iver; Memming, Ruediger; Kastening, Bertel. *J Phys Chem* v 92 n 12 Jun 16 1988 p 3484-3488.

**Electrodeposition** See Also ELECTRODES, ELECTROCHEMICAL—Photosensitivity; SOLAR CELLS—Electrodeposition.

**093523 CHARACTERIZATION OF CdS THIN FILMS ELECTRODEPOSITED BY AN ALTERNATING CURRENT ELECTROLYSIS METHOD.** Cadmium sulfide thin films have been electrodeposited by a method involving the application of a square wave potential to tin oxide electrodes immersed in an electrolyte containing cadmium sulfate and sodium thiosulfate. To elucidate the main electrochemical processes that occur during the positive and negative parts of the applied wave, a voltammetric study has been carried out. The morphology and the structural and optical properties of these films are analyzed. Electrical properties before and after annealing are reported. (Author abstract) 12 refs.

Fatas, E. (Univ Autonoma de Madrid, Madrid, Spain); Herrasti, P.; Arjona, F.; Garcia Camarero, E. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2799-2801.

**093524 PHOTOELECTROCHEMICAL DEPOSITION AND PROPERTIES OF THIN-FILM CADMIUM TELLURIDE.** Thin-film cadmium telluride has been deposited cathodically on titanium in a photoelectrochemical cell (PEC) using a propylene carbonate solution of Cd II and tri-n-butylphosphine telluride (BPT) at 100°C. Illumination of the cathode enhances the cathodic current relative to that observed during the dark process. Furthermore, the current under illumination decreases more slowly than it does for the dark process, providing thicker films in a shorter time. Under illumination, the Te:Cd ratio of the film is independent of light intensity and



applied potential in the range  $-0.8$  to  $-1.4$  V (Ag-AgCl reference electrode). This ratio and the deposition current depend on the concentration of cadmium ion relative to that for BPT. Photovoltaic cells (PVC) have been fabricated. Light-to-electric-power conversion efficiencies as high as 5.2% have been achieved thus far over small surface areas. The bandgap of the CdTe film is determined to be 1.44 eV. (Edited author abstract) 15 refs.

Von Windheim, Jesko (Univ of Guelph, Guelph, Ont, Can); Darkowski, Andrzej; Cocivera, Michael. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicon Technol Conf, Ottawa, Ont, Can p 1053-1059.

**Electronic Properties** See Also MERCURY COMPOUNDS—Electronic Properties; SEMICONDUCTING ZINC COMPOUNDS—Electronic Properties.

**093525 ON THERMALLY ACTIVATED ELECTRON MOBILITY IN N-TYPE  $\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$ .** It is shown that the assumption of a thermally activated mobility in n-type  $\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$  is not supported by the available experimental evidence. In particular, the criticism of our previous paper by Gebhardt and co-workers is shown to be unfounded. The hypothesis of magnetic freeze-out is well supported by experimental data and by the similarity to the behaviour of InSb. (Author abstract) 10 refs.

Herlach, Fritz (Katholieke Univ Leuven, Louvain, Belg); De Vos, Godelieve. *J Phys C Solid State Phys* v 20 n 34 Dec 10 1987 p 5901-5903.

**093526 BOUND STATES IN INVERSION LAYERS ON p- $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ : SELF-CONSISTENT RESULTS.** Bound states in inversion layers on p- $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  are calculated self-consistently taking the interaction of the conduction and valence bands through the surface potential and the  $\kappa$ -p interaction explicitly into account. Three different models of the band structure are compared and numerical results are presented. It is shown that the four-band spinless model, proposed by Zawadzki for InSb, is not appropriate to describe the bound states on  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  and more elaborate models, which take the spin-orbit interaction into account, have to be used. (Author abstract) 16 refs.

Nachev, I. (Inst of Microelectronics, Sofia, Bulg). *Semicond Sci Technol* v 3 n 1 Jan 1988 p 29-34.

**093527 MODIFICATION OF CdMnTe REFLECTIVITY SPECTRA BY Mn DENSITY OF STATES.** We present a simple model which interprets main features of the blurring of the CdMnTe reflectivity spectra with increasing the manganese concentration. We have made an attempt to determine the energy position of the unoccupied Mn 3d states. They are located at about 2.9 eV above the valence band maximum. (Author abstract) 15 refs.

Oleszkiewicz, J. (Univ Jagiellonski, Cracow, Pol); Kisiel, A.; Rodzik, A. *Solid State Commun* v 63 n 2 Jul 1987 p 77-80.

**093528 STUDY OF DEEP LEVELS IN NARROW-GAP SEMICONDUCTORS  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  BY ATSC METHOD.** The deep levels in narrow-gap semiconductors  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  ( $x=0.195$  approximately 0.275) are investigated using the alternating thermal stimulated current (ATSC) method. The physical properties of the deep levels in  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  are discussed. The experimental results show that the ATSC method is an effective way to investigate the deep levels in narrow gap semiconductors  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ . (Author abstract). 11 Refs. In Chinese.

Lin, He (Acad Sinica, China); Tang, Dingyuan. *Hongwai Yanjiu A-Ji* v 7A n 4 1988 p 267-273.

**093529 DEEP LEVELS IN n-TYPE  $\text{HgCdTe}$ .** Deep levels in both bulk and LPE liquid phase epitaxy n-type  $\text{Hg}_{0.685}\text{Cd}_{0.315}\text{Te}$  have been studied by deep level transient spectroscopy (DLTS) between 78 and 170 K using metal-insulator-semiconductor (MIS) capacitors. One major acceptor-like electron trap was observed in the

depletion region of the semiconductor with an energy level at  $E_c-85$  meV, or  $E_c-0.3E_g$ . The electron capture cross section was found to be independent of the temperature and has an average value of  $1 \times 10^{-16}$  cm<sup>2</sup>. The ratio of the trap concentration ( $N_t$ ) to the shallow donor concentration ( $N_d$ ) in both the bulk material and the LPE film was found to be close to 1. A general expression allowing numerical calculation of the capacitance transient due to the thermal ionization of traps in MIS capacitors with any value of  $N_t/N_d$  is also given. (Author abstract) 13 refs.

Chen, M.C. (Texas Instruments Inc, Dallas, TX, USA); Goodwin, M.W.; Polgreen, T.L. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 484-489.

**093530 DEEP LEVELS IN CdTe.** We have used a variety of complementary techniques to study electronic trapping levels that are far from either band edge in CdTe. These deep levels play an important role in determining the electrical properties of the material. We have studied and attempted to identify levels due to specific defects and those due to either intentional or unintentional dopants. These findings have been correlated with information from the literature. The methods used included both DC and AC photoconductivity, photocurrent induced transient spectroscopy (PITS), and deep level transient spectroscopy (DLTS). CdTe samples doped with aluminum, indium, tin, cesium, and phosphorus, as well as nominally undoped sample have been examined. Fifteen different levels have been identified as related to these impurities. (Author abstract) 23 refs.

Kremer, R.E. (Oregon Graduate Cent, Beaverton, OR, USA); Leigh, W.B. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 490-496.

**093531 OPTICAL NONLINEARITY OF BOUND SINGLE AND MULTIEXCITONS IN CdS.** By means of two-beam experiments, the transmission properties of highly excited CdS crystals of different thicknesses ( $6 \mu\text{m}$  to  $1 \text{ mm}$ ) have been investigated in the energy regime of the bound single and multiexcitons. Induced transmission was observed in the whole considered region for lower pump intensities. However, nonlinearly growing absorption counteracts this increase for rising excitation densities. Excitation spectroscopy of select points of the transmission spectrum and the temperature dependence of the observed phenomena show that bound single and multiexcitons as well as charge transfer processes play an important role in determining these properties of CdS samples. However, intraband transitions of free electrons and two step-processes of free single and biexciton's generation via bound exciton states have also to be discussed. (Author abstract) 7 refs.

Hoening, T. (Technische Univ Berlin, Berlin, West Ger); Gutowski, J.; Broser, I. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 576-580.

**093532 DEGENERATE AND NONDEGENERATE FOUR-WAVE MIXING AND LASER-INDUCED GRATINGS IN CdS.** In this contribution we determine for the first time the diffusion length of degenerate and non-degenerate carriers in CdS as a function of density and temperature; we observe and analyse switching processes in self-diffraction and report on nondegenerate four-wave mixing. 10 refs.

Renner, R. (Physikalisches Inst der Univ, Frankfurt am Main, West Ger); Weber, Ch.; Becker, U.; Klingshirn, C. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 581-585.

## Encapsulation

**093533 COPOLYMERIZATION OF VINYL MONOMERS ON THE SURFACE OF CdS AND PHOTOCONDUCTIVITY PROPERTIES OF RESULTING**

**COMPOSITES.** The reaction behaviour of CdS encapsulated copolymer composites, their photoconductivity, and the mechanism of their photosensitivity were investigated. The results indicated that the reactivity ratios of the monomers for the encapsulated copolymer are considerably different from those of the homopolymer during encapsulation. The photoconductivities showed a marked increase over that of CdS alone. These characteristics were explained with the distribution state of the energy levels of the traps and also with the increase of the characteristic temperature. Similar results were also observed for the light intensity index derived from the dependence of the photocurrent upon irradiation intensity. (Edited author abstract) 18 refs.

Haga, Y. (Chiba Inst of Technology, Narashino, Jpn); Inoue, S.; Nakajima, M.; Yosomiya, R. *Mater Chem Phys* v 19 n 4 May 1988 p 381-395.

## Etching

**093534 CHEMICAL INTERACTIONS AT THE INTERFACE BETWEEN CADMIUM TELLURIDE AND AQUEOUS SOLUTIONS OF  $\text{HCl-HNO}_3$  MIXTURES.** The rate of solution of CdTe in  $\text{HCl-HNO}_3\text{-H}_2\text{O}$  solutions was investigated. Experiments were carried out on high-resistance samples of p-type single crystals of cadmium telluride. A quantitative characteristic of the etching process is the rate of solution of the semiconductor. Diagrams were constructed for the etching rate of CdTe as a function of the reagent composition at 293 and 303 K. From the diagrams it is evident that the cadmium telluride solution rate rises with an increase in the nitric acid concentration. 8 refs.

Sava, A.A. (Acad of Sciences of the Ukrainian SSR, USSR); Tomashik, V.N.; Mizetskaya, I.B.; Tkach, V.N. *J Appl Chem USSR* v 60 n 1 pt 1 Jan 1987 p 29-33.

**093535 VOLUME ALLOYING CADMIUM TELLURIDE CRYSTALS WITH SILVER IN SELECTIVE ETCHING.** Selective etching of specimens of p-CdTe in silver-bearing etching agents results in the introduction of rapidly diffusing Ag<sub>i</sub> donors into the volume of the material. This leads to a large reduction of the concentration of free carriers. (Author abstract) 5 refs.

Kovalets, M.A.; Kuchman, N.I.; Nikonyuk, E.S.; Chiochan, I.P.; Shvydka, M.M. *Phys Chem Mater Treat* v 21 n 3 May-Jun 1987 p 295-296.

**093536 EFFECT OF CHEMICAL AND MECHANICAL TREATMENTS ON THE SURFACE PROPERTIES OF CADMIUM SELENIDE SINGLE CRYSTALS.** Chemical polishing of cadmium sulfide single crystals with the aid of an alcohol solution of bromine leads to the appearance of a perturbed surface layer which differs in nature from the perturbed layer formed after mechanical treatment. The composition of this layer varies in comparison with the element ratio in the bulk of the crystal. There also forms on the surface of the crystal a layer of natural oxide, which is about three times thicker on the (0001) surface than on the (0001) plane. 7 refs. In Russian.

Komisarchik, M.Sh.; Novosel'tseva, T.D.; Rummyantseva, T.Ya.; Lapushkina, L.V.; Orlov, Yu.F. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1809-1813.

## Growth

**093537 EPITAXIAL GROWTH OF CdTe ON InSb(100) BY RF SPUTTERING.** Cadmium telluride is deposited epitaxially by rf sputtering on the clean surface of InSb(100) substrate from which the surface native oxide has been etched off in advance by  $\text{H}_2$  plasma treatment. The crystalline quality of CdTe films which depends on the substrate temperature is evaluated by means of the optical reflectance, Raman scattering and RHEED pattern measurements. CdTe films prepared at temperatures of 250-300°C are deposited epitaxially, but those at 100°C are not. (Author abstract) 8 refs.

Nishibayashi, Yoshiaki (Hiroshima Univ, Higashihiroshima, Jpn); Imura, Takeshi; Osaka, Yukio. *Jpn J Appl*



Phys Part 2 v 26 n 9 Sep 1987 p 1437-1439.

**093538 GROWTH AND CHARACTERISATION OF  $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$  GROWN BY LPE USING A NOVEL SLIDING BOAT.** A significant problem in the growth of CMT by Te-solution LPE is associated with melt residues on the layers. This paper describes the development and use of a sliding boat which tilts the substrate after growth to remove these droplets. The reproducibility of the process depends on control of Hg vapor pressure and the composition of the melts. A relationship between the x-value of the layers and the Cd and Hg content in the melts has been established. Variations in x are  $\pm 0.002$ , for  $x \approx 0.22$ , over  $13 \times 13 \text{ mm}^2$  areas. Various chemical analysis techniques have been used to assess the purity of the layers. Electrical characterization of the layers has shown them to be p-type as grown, as expected, and suitable annealing in Hg vapor converts them to n-type. (Author abstract) 30 refs.

Brice, J.C. (Philips Research Lab, Redhill, Engl); Capper, P.; Easton, B.C.; Page, J.L.; Whiffin, P.A.C. *Semicond Sci Technol* v 2 n 11 Nov 1987 p 710-715.

**093539 BORON-SEGREGATION IN CZOCHRALSKI-GROWN CdTe.** Chemical analysis of CdTe ingots grown by the liquid encapsulated Czochralski technique using  $\text{B}_2\text{O}_3$  encapsulant show that the material contains up to 90 ppm boron and that the boron distribution is non-uniform. High concentrations are found at twin and grain boundaries. Boron-rich precipitation is also observed. The observation of low carrier concentrations ( $n_{77\text{K}} = 8 \times 10^{14} \text{ cm}^{-3}$ ) and high electrical mobility ( $\mu_{77\text{K}} = 4800 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ ) in this material also supports the thesis that most of the boron is not electrically active. (Author abstract) 19 refs.

Blackmore, G.W. (Royal Signals & Radar Establishment, Malvern, Engl); Courtney, S.J.; Royle, A.; Shaw, N.; Vere, A.W. *J Cryst Growth* v 85 n 3 Nov II 1987 p 335-340.

**093540 NEW EPITAXIAL RELATIONSHIPS IN THE DEPOSITION OF CdS ONTO CdTe.** The present paper reports on the epitaxial growth of CdS onto  $\{111\}\text{A}$ ,  $\{1\bar{1}1\}\text{B}$  and  $\{221\}$  oriented single crystal CdTe substrates by vacuum evaporation. These observations were made in the course of a wider investigation of the CdS/CdTe solar cell in which structural aspects were investigated along with other parameters such as contacts, electrical properties, doping, etc. The epitaxial layers were grown on highly resistive undoped CdTe substrates and were intended only as a study of the epitaxial growth of CdS onto CdTe. Clearly these structures would have had an unacceptably high series resistance and no attempt was made to fabricate device structures from them (by the evaporation of contacts, etc.) or to measure their electrical characteristics. 19 refs.

Awan, G.R. (Univ of Durham, Durham, Engl); Brinkman, A.W.; Russell, G.J.; Woods, J. *J Cryst Growth* v 85 n 3 Nov II 1987 p 477-482.

**093541 LIQUID PHASE EPITAXY OF  $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$  ( $0.5 < x < 1$ ) AND PHASE DIAGRAM DETERMINATION.** Cd-rich  $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$  layers were grown onto CdTe and  $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$  substrates by liquid phase epitaxy from a Te-rich solution in an open tube apparatus. Mercury vapor losses were carefully controlled in a specially designed sliding graphite reactor. Solid solution compositions between  $x=0.5$  and  $x=1$  were obtained. An expression for the segregation coefficient of cadmium as a function of x was obtained, viz.:  $k_{\text{Cd}} = x(1.080 - x)/0.080$ . The phase diagram of the ternary alloy in the Te corner was inspected and a method for determining the liquidus temperatures from the kinetics of epitaxial growth is presented; two isotherms  $T=460^\circ\text{C}$  and  $T=480^\circ\text{C}$  have been determined. The effect of the degree of supercooling on the layer morphology was studied. (Author abstract) 19 refs.

Lusson, A. (CNRS, Meudon Principal, Fr); Triboulet, R. *J Cryst Growth* v 85 n 3 Nov II 1987 p 503-509.

**093542 CZOCHRALSKI GROWTH OF CdTe AND**

**CdMnTe FROM LIQUID ENCAPSULATED MELTS.** CdTe and CdMnTe boules with diameters up to 50 mm and weighing up to 1 kg have been grown by liquid-encapsulated Czochralski (LEC) pulling from  $\text{B}_2\text{O}_3$ -encapsulated melts. LEC CdTe boules were always characterized by a high incidence of twinning and polycrystallinity. However, by alloying with manganese at compositions up to 0.20 mole fraction MnTe, growth proceeding by means of alternating bands or lamellae perpendicular to the  $\langle 111 \rangle$  growth axis was achieved. Preliminary attempts to control melt convection by the application of magnetic fields to LEC CdTe and CdMnTe melts indicate that field intensities much greater than 2000 G will be required. (Edited author abstract) 21 refs.

Hobgood, H.M. (Westinghouse Research & Development Cent, Pittsburgh, PA, USA); Swanson, B.W.; Thomas, R.N. *J Cryst Growth* v 85 n 3 Nov II 1987 p 510-520.

**093543 AUTOMATED SYSTEM FOR METAL ORGANIC VAPOUR-PHASE EPITAXY.** In Metal Organic Vapor Phase Epitaxy, metal-organic compounds are transported, in the vapor state, to a heated reaction site, or susceptor, where the formation of the desired material takes place. A particular application being studied in this laboratory is the growth of cadmium mercury telluride (CMT). In general, by controlling the times during which particular vapors are allowed to flow into the MOVPE reactor, one can grow alternating layers of different, carefully controlled compositions (heterostructures). In the particular example of CMT, the reaction is followed by an annealing stage which results in a homogeneous material of controlled composition; the whole method being known as the Interdiffused Multilayer Process (IMP). 2 refs.

Mills, A.D.; Whiffin, P.A.C. *Annu Rev Philips Res Lab* 1986 p 121-123.

**093544 CdTe JUNCTION PHENOMENA.** Five main areas of research on CdTe junction phenomena are reviewed: (1) the effect of surface etching and stoichiometry on the properties of Schottky barriers and heterojunctions with CdS and indium tin oxide (ITO) formed on p-type CdTe crystal; (2) the major junction transport models applicable to CdS/CdTe, CdS/ZnCdTe, ZnO/CdTe and ITO/CdTe junctions; (3) the deposition and control of the properties of p-type CdTe films using close-spaced vapor transport and the characteristics of CdS/CdTe junctions prepared with these films; (4) the successful doping of p-type CdTe films during growth by ion-beam doping methods; and (5) methods of preparing low-resistivity contacts to p-CdTe. (Edited author abstract) 72 refs.

Bube, Richard H. (Stanford Univ, Stanford, CA, USA). *Sol Cells* v 23 n 1-2 Jan-Feb 1988 p 1-17.

**093545 X-RAY DIFFRACTION STUDIES OF CdTe GROWN ON InSb.** Cadmium telluride layers, grown on InSb substrates which were  $(100) 2^\circ$  oriented towards  $(110)$ , were examined using double crystal X-ray diffraction in conjunction with secondary ion mass spectrometry and photoluminescence. The layers were grown by organometallic vapor phase epitaxy at atmospheric pressure. The crystal quality of the CdTe is shown to be related to the substrate temperature and the nature of the surface prior to growth. Growth on diethyltelluride stabilized InSb substrates resulted in epitaxial layers with a misorientation of about  $235 \text{ arc sec}$  with respect to the substrates. On the other hand, layers followed the orientation of the substrate, when dimethylcadmium stabilized InSb was used. Growth at  $350^\circ\text{C}$  resulted in the smallest X-ray rocking curve (DCRC), with a full width at half maximum (FWHM) of about  $20 \text{ arc sec}$ . Secondary ion mass spectrometry and photoluminescence data complement the results of this X-ray diffraction study. (Author abstract) 14 refs.

Bhat, Ishwara B. (Rensselaer Polytechnic Inst, Troy, NY, USA); Patel, Kshyamasil; Taskar, Nikhil R.; Ayers, John E.; Ghandhi, Sorab K. *J Cryst Growth* v 88 n 1 Apr 1988 p 23-29.

**093546 LIQUID PHASE EPITAXIAL GROWTH OF  $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$  FROM SEMI-INFINITE Hg-RICH MELT.** Semi-infinite Hg-rich melt in the vertical dipping configuration was used to grow thin layers of  $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$  onto CdTe and cadmium telluride on sapphire (COS) substrates. The experimental procedure is described in detail. The melt, weighing about 10 kg, was constantly held in the temperature range  $475\text{--}490^\circ\text{C}$ . Cooling rates of  $3.6\text{--}5.4^\circ\text{C/h}$  were employed. Surface morphology of the layers when examined by using an optical microscope revealed incidents of substrate-replicated twinnings. X-ray diffraction and back reflection Laue technique showed the layers to be monocrystalline and of good epitaxial quality. The technique EDX was used to investigate the compositional variations through the layer. All as-grown layers were n-type ( $n = 2 \times 10^{15}\text{--}1.4 \times 10^{16} \text{ cm}^{-3}$  and  $\mu_H = 3 \times 10^4\text{--}3 \times 10^5 \text{ cm}^2/\text{V.s}$  at 77 K for x in the range 0.221-0.24). Carrier mobility profiles through the layers were also studied using the successive layer removal/Hall measurements (step and etch) technique. (Author abstract) 34 refs.

Sangha, S.P.S. (GEC Research Ltd, Wembley, Engl); Rinn, L.M.; Nicholls, R.E. *J Cryst Growth* v 88 n 1 Apr 1988 p 107-117.

**093547 EFFECT OF THE SUBSTRATE MISMATCH ON THE LPE OF  $\text{HgZnTe}$  AND  $\text{CdZnTe}$  LAYERS.** The effect of the lattice mismatch is studied on the processes which occur during the contact between supersaturated Hg-Zn-Te growth solutions and the CdZnTe substrates. The influence of these processes on the characteristics of the HgZnTe layers is outlined. Similar behavior of the two Hg-rich solid solutions is demonstrated when heterostructures with the same lattice mismatch are compared. In order to find out how the presence of Hg in the layers influences the lattice mismatch phenomena, results are compared with those of another heterostructure based on II-VI solid solutions:  $\text{Cd}_{1-y}\text{Zn}_y\text{Te}/\text{Cd}_{1-z}\text{Zn}_z\text{Te}$ . 23 refs.

Sher, Ariel (Soreq Nuclear Research Cent, Yavne, Isr); Raizman, A.; Eger, D. *J Cryst Growth* v 87 n 4 Mar 1988 p 507-518.

**093548 GROWTH OF ORIENTED TELLURIUM-DOPED CADMIUM SULFIDE SINGLE CRYSTALS FROM THE VAPOR.** Single crystals of Te-doped CdS ( $\text{Te} = 0.02\text{--}0.35 \text{ wt.}\%$ ) have been grown in the form of cylinders with volumes up to  $17 \text{ cm}^3$  by the method of contactless growth on oriented CdS (0001) inoculates. The Te content along the length of the crystal decreases by a factor of 1.5 to 2. During sublimation a preferred diffusion of tellurium into the cold part of the vial is observed. The electric and optical properties of the crystals vary as a function of the tellurium content. In Russian. 7 refs.

Klinkova, L.A.; Fursova, T.N.; Bondarenko, A.I. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 12 Dec 1987 p 1976-1980.

**093549 GROWTH AND CHARACTERIZATION OF  $\text{Cd}_{1-x}\text{Mn}_x\text{Te}$  SINGLE CRYSTALS.**  $\text{Cd}_{1-x}\text{Mn}_x\text{Te}$  crystal, which is a semimagnetic semiconductor, is a new semiconductor compound receiving much attention not only for use in optical magnetic field/electric current meters but also as a substrate for the epitaxial growth of  $\text{Hg}_{1-y}\text{Cd}_y\text{Te}$ , which is used for infrared detectors. In our research, we grew  $\text{Cd}_{1-x}\text{Mn}_x\text{Te}$  crystals measuring 30 to 40 mm in diam with a composition range of 0.10 to 0.19, and evaluated the crystallinity, electrical properties, optical properties, magneto-optical properties, etc., of the resulting crystals. As a result we discovered that the Mn composition changed in the growth direction at an effective segregation coefficient ( $k_{\text{eff}}$ ) of 0.93, and that it was extremely uniform, with fluctuation on the wafer surface of only 1% or less. The average EPD (etch pit density) on the wafer surface was  $3\text{--}4 \times 10^4 \text{ cm}^{-2}$ , and excellent crystallinity was observed with no cell structures or lineages. Using double-crystal x-ray rocking curve measurements, it was confirmed that the increase in the Mn concentration reduced the full width at half maximum



(FWHM) and that the crystal perfection surpassed that of CdTe crystals. Excellent infrared transmission of 50% or more in the 2 to 25  $\mu\text{m}$  wavelength range was obtained. (Edited author abstract) 13 refs.

Kotani, Toshihiro; Nakanishi, Fumitake; Yasuo, Hiroyuki; Shibata, Masahiro; Tada, Kohji. *Sumitomo Electr Tech Rev* n 27 Jan 1988 p 166-173.

**093550 X-RAY CHARACTERIZATION OF LPE MERCURY CADMIUM TELLURIDE.** X-ray topography and double crystal diffractometry investigations have been performed on  $\text{Hg}_{0.78}\text{Cd}_{0.22}\text{Te}$  epilayers grown on substrates by liquid phase epitaxy. Topographs showed only misfit dislocations and dislocation cellular arrangements. Double crystal rocking curves exhibited considerably narrower Bragg peak half-widths than previously reported; half-widths as small as 20 arc sec were indeed observed. These results demonstrate that the present epilayers are characterized by a very good crystal quality. (Author abstract). 9 Refs.

Bernadri, S. (CSELT, Turin, Italy); Ferrari, C.; Franzosi, P. *J Cryst Growth* v 89 n 4 7(I) 1988 p 608-611.

**093551 GROWTH AND CHARACTERIZATION OF CVT GROWN  $\text{CdIn}_{25}\text{Se}_2$  SINGLE CRYSTALS.** The single crystals were grown by closed tube chemical vapour transport (CVT) using iodine as the transporting agent. X-ray analysis reveals that the crystal system is monoclinic with space group  $\text{C2/m}$ . Vickers microhardness numbers are independent of applied load. Far-IR and Auger spectroscopic analysis of these crystals are also reported. 10 Refs.

Vengatesan, B. (Anna Univ, Madras, India); Chinnakali, K.; Kanniah, N.; Ramasamy, P. *J Mater Sci Lett* v 7 n 6 Jun 1988 p 654-656.

**093552 HIGH CAPABILITY QUASI-CLOSED GROWTH SYSTEM FOR ISOTHERMAL VAPOUR PHASE EPITAXY OF  $(\text{Hg,Cd})\text{Te}$ .** A high capability open growth system for isothermal vapor phase epitaxy has been developed. The system is based on a quasi-closed quartz container with multiple growth bins. The container is placed inside a quartz tube which is filled with multiple growth bins. The container is placed inside a quartz tube which is filled with  $\text{H}_2$  or evacuated. The system enables epitaxial  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  layers from 1 to 1000  $\mu\text{m}$  in thickness to be grown on bulk CdTe,  $\text{Cd}_{1-x}\text{Zn}_x\text{Te}$  and alternative substrates such as mica, sapphire and GaAs. The layer morphology is entirely determined by the substrate quality. Several methods of layer compositional profile control are proposed. A process duration of one day (including low temperature annealing) has been developed to fabricate layers of 3-30  $\mu\text{m}$  thickness and up to about 1000  $\text{cm}^2$  in total area as a basis for manufacturing PV, PC and PEM IR detectors. (Author abstract). 11 Refs.

Piotrowski, J. (Military Acad of Technology, Warsaw, Pol); Nowak, Z.; Grudzien, M.; Galus, W.; Adamiec, K.; Djuric, Z.; Jovic, V.; Djinic, Z. *Thin Solid Films* v 161 Jul 1988 p 157-169.

**093553 MAGNETO-OPTICAL PROPERTIES OF  $\text{Cd}_{1-x}\text{Mn}_x\text{Te}$  MULTILAYERED STRUCTURE PREPARED BY IONIZED-CLUSTER BEAMS.** The film growth of  $\text{Cd}_{1-x}\text{Mn}_x\text{Te}$  with a multilayered structure was performed by ionized-cluster beam deposition technique, and their magneto-optical properties have been investigated. It was found that the films had a periodical structure from the results of Auger electron spectroscopy and x-ray diffraction measurements. In the Faraday rotation spectra of the multilayered structures, two band-edge dispersions corresponding to the well and barrier layers were observed. As the well width decreases, the dispersion peak for the well layer shifts toward higher photon energies and becomes higher, while the dispersion for the barrier layer remains unchanged. This can be explained by a quantum size effect in a superlattice. 17 refs.

Koyanagi, Tsuyoshi (Yamaguchi Univ, Ube, Jpn); Watanabe, Toshio; Matsubara, Kakuei. *IEEE Trans Magn* v

MAG-23 n 5 Sep 1987, INTERMAG '87: Int Magn Conf, Tokyo, Jpn, Apr 14-17 1987 p 3214-3216.

**093554 SUPERLATTICES OF II-VI SEMICONDUCTORS.** Superlattices and microstructures involving II-VI semiconductors have been the subject of a great deal of interest for application to optoelectronics in the infrared and visible. The techniques of material fabrication provided by molecular beam epitaxy (MBE) and metalorganic chemical vapor deposition (MOCVD) make it possible for us to conceive of a number of new structures that could have application in the optoelectronics arena. Superlattices and heterojunction structures involving some of the wide band gap II-VI compounds such as CdTe, ZnTe, and ZnSe could bring to reality the dream of making wide band gap visible light emitters. (Author abstract) 25 refs.

Miles, R.H. (California Inst of Technology, Pasadena, CA, USA); McCaldin, J.O.; McGill, T.C. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 188-193.

**093555 CRYSTAL GROWTH OF LARGE-AREA SINGLE-CRYSTAL CdTe AND CdZnTe BY THE COMPUTER-CONTROLLED VERTICAL MODIFIED-BRIDGMAN PROCESS.** Recent improvements in the growth of 5-cm diameter CdTe and  $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$  boules by the computer-controlled vertical modified-Bridgman (VMB) process are described. The most significant improvements in crystal quality are attributed to a combination of new furnace design, improved temperature-profile control, and in-situ post-growth thermal annealing of boules. In addition, thermal diffusivities of CdTe and  $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$  were measured as a function of temperature in the vicinity of the melting points. The effect of this critical parameter on the solid-liquid interface shape and position was determined with the aid of a finite-element numerical thermal model. (Author abstract) 8 refs.

Sen, S. (Santa Barbara Research Cent, Goleta, CA, USA); Konkel, W.H.; Tighe, S.J.; Bland, L.G.; Sharma, S.R.; Taylor, R.E. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 111-117.

**093556 HIGH QUALITY, SINGLE CRYSTAL CdTe GROWN BY A MODIFIED HORIZONTAL BRIDGMAN TECHNIQUE.** High quality CdTe single crystals with low etch pit densities (EPDs) and subgrain-free structure have been produced by a multizone horizontal Bridgman technique. The volume of single crystal is up to 75% of the boule. Experimental results have demonstrated that growth stress plays a critical role in the reduction of dislocation densities. X-ray topography data confirm the improvement in crystalline perfection: EPD counts as low as  $2 \times 10^4/\text{cm}^2$  are observed and double crystal X-ray rocking curves have FWHMs as low as 10 arc sec. (Author abstract) 11 refs.

Lay, K.Y. (II-VI Inc, Saxonburg, PA, USA); Nichols, D.; McDevitt, S.; Dean, B.E.; Johnson, C.J. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 118-126.

**093557 CRYSTAL GROWTH AND CHARACTERIZATION OF CdTe FROM THE MELT UNDER CONTROLLED Cd PARTIAL PRESSURE.** CdTe crystals were grown by a modified Bridgman technique with the Cd pressure kept equal to the equilibrium value. 6N purity Cd and Te were used to synthesize the CdTe. Metallographic observation of the as-grown crystals showed that no inclusions were present. The deviation of composition from stoichiometry was investigated by microprobe analysis and was found to be below the limit of detection. The Cd and Te distribution obtained by microprobe scanning was homogeneous. Microscopic observation of preferentially etched crystals showed a dislocation density of  $10^3$ – $10^5 \text{ cm}^{-2}$ . The structural perfection is good, as seen from X-ray diffraction Laue patterns. The lattice parameter determined by X-ray

diffraction is 6.4846 Angstrom. Our CdTe crystals have been used as substrates for hot wall epitaxial growth of CdTe films and for the fabrication of temperature sensors coupling with optical fibers. (Edited author abstract) 5 refs.

Song, Wen-Bin (Shanghai Univ of Science & Technology, Shanghai, China); Yu, Mei-Yun; Wu, Wen-Hai. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 127-131.

**093558 STATE OF THE ART OF LPE HgCdTe AT LIR.** LPE has become an established technique for the growth of CMT layers. In this paper we discuss in detail the LPE growth of CMT from Te-rich solutions in an open-tube horizontal-slider apparatus, based on LIR's experience. Different physical parameters (vapor pressure, surface tension), apparatus design, and experimental procedure (thermal cycle, crystallization path, growth kinetics) are described. The physical parameters of undoped-CMT layers grown by LPE are given: surface morphology, defect density, composition, thickness, electrical properties (as-grown and n-type annealed). Good uniformity and reproducibility in both 3-5  $\mu\text{m}$  and 8-12  $\mu\text{m}$  ranges has been established over more than 500 layers/year grown in our pilot line. This paper presents a new and sophisticated structure entirely grown by LPE = CMT/CZT/CZT, the advantages of which are discussed. (Author abstract) 11 refs.

Pellicciari, B. (CEA, Grenoble, Fr). *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 146-160.

**093559 PROPERTIES OF DOPED II-VI FILMS AND SUPERLATTICES GROWN BY PHOTOASSISTED MOLECULAR BEAM EPITAXY.** A new film growth technique, photoassisted molecular beam epitaxy (PAMBE), has been used to prepare substitutionally doped II-VI semiconductor compounds. This epitaxial growth technique differs from conventional MBE in that the substrate is illuminated during the entire film growth process. We have used this new technique to prepare conducting layers of CdTe and CdMnTe. In our experiments, the output from an argon ion laser is used as the source of illumination. In and Sb were employed as n-type and p-type dopants, respectively. Conducting n-type CdMnTe:In-CdTe superlattices have also been grown along with doped CdMnTe:Sb-CdTe structures. The structural, electrical, and optical properties of the conducting epilayers were investigated by means of double crystal X-ray diffraction, Van der Pauw Hall effect measurements, and low temperature photoluminescence. (Author abstract) 16 refs.

Giles, N.C. (North Carolina State Univ, Raleigh, NC, USA); Bicknell, R.N.; Harper, R.L.; Hwang, S.; Harris, K.A.; Schetzina, J.F. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 348-353.

**093560 SURFACE NUCLEATION KINETICS OF MOLECULAR BEAM EPITAXIAL DOPED (001) AND (111) CdTe.** Reflection high-energy electron diffraction desorption studies have been used to determine the reaction kinetics of (001) and (111) CdTe surfaces. The addition of Sb was found to impede epitaxy on the (111) surface, but to be compatible with epitaxy on the (001) surface. The desorption of Cd, Te and Sb from (001) CdTe were observed to follow an Arrhenius relationship with activation energies of 7.70, 1.95 and 3.69 eV, respectively. Reflection high-energy electron diffraction intensity oscillations were observed for the growth of (001) CdTe and used to study interface smoothness. The effect that



photo-assisted molecular beam epitaxy has on the reaction of Sb doping of (001) CdTe was determined. (Author abstract) 17 refs.

Benson, J.D. (Georgia Inst of Technology, Atlanta, GA, USA); Summers, C.J. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 354-361.

**093561 MBE p-TYPE  $Hg_{1-x}Cd_xTe$  GROWN ON THE (110) ORIENTATION.** Reported here for the first time is the successful MBE growth of  $Hg_{1-x}Cd_xTe$  ( $0.16 < x < 0.41$ ) on the nonpolar (110) face of CdTe substrates. (110) HgCdTe epilayers always show p-type conductivity at 77 K with high hole concentration ( $10^{16}$ – $10^{19} \text{ cm}^{-3}$ ) and good structural quality, as determined by double-crystal X-ray rocking curve (100-180 arc sec). We also report that during the MBE growth process, the rate of Hg vacancy formation on the (110) orientation is greater than on the more conventional (111)B and (100) orientations. The unique material properties of (110) HgCdTe may find application in the fabrication of photovoltaic detectors, light emitting diodes, and multiple quantum wells for nonlinear optics applications. (Author abstract) 20 refs.

Arias, J.M. (Rockwell Int Science Cent, Thousand Oaks, CA, USA); Shin, S.H.; Gertner, E.R. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 362-366.

**093562 GROWTH AND CHARACTERIZATION OF HIGH-QUALITY CdTe EPILAYERS ON GaAs SUBSTRATES BY HOT-WALL EPITAXY.** CdTe layers with a thickness of 3-15  $\mu\text{m}$  are grown on (100) oriented GaAs substrates in a hot-wall-epitaxy system. As a quality criterion, the 1.8 K near band edge photoluminescence is measured. We observe sharp bound-exciton lines. Their full width at half maximum (FWHM) is decreasing with increasing thickness of the layers, revealing a decreasing density of extended lattice defects at the surface. The FWHM of the dominating acceptor bound exciton emission from a 15  $\mu\text{m}$  thick layer is 0.18 meV. This value is close to the FWHM obtained with high purity CdTe. A small shift of 0.5 meV of the epilayer exciton line energy relative to the bulk emission is independent of the layer thickness. (Author abstract) 12 refs.

Sitter, H. (Univ Linz, Linz, Austria); Lischka, K.; Faschinger, W.; Wolfrum, J.; Pascher, H.; Pautrat, J.L. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 377-381.

**093563 GROWTH OF (111) AND (100) CdTe FILMS ON (100) GaAs SUBSTRATES BY HOT WALL EPITAXY.** Both (111) and (100) oriented CdTe films have been grown on (100) GaAs substrates by hot wall epitaxy. X-ray diffraction and photoluminescence measurements indicate that the (111) material is of superior crystal quality with typical X-ray FWHM values ranging between 60 and 80 arc sec. SIMS analysis shows gallium in these layers at a level of mid  $10^{14} \text{ atoms/cm}^3$ . (Author abstract) 13 refs.

Korenstein, R. (Raytheon Co, Lexington, MA, USA); MacLeod, B. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 382-385.

**093564 CHEMICAL STRUCTURE OF MICROCRYSTALLINE CdTe FILMS GROWN BY RF SPUTTERING.** We have applied X-ray photoemission and Auger spectroscopy techniques to the study of the stoichiometric properties of CdTe thin films grown by RF sputtering. The microcrystalline films were deposited on glass substrates held at temperatures between 50 and 200°C. They contain a mixture of the cubic (zinc-blende) and hexagonal (wurtzite) phases which are nearly stoichiometric. By using bulk and surface sensitive photoemission geometries it is shown that a tellurium oxide overlayer is

always formed after exposure to air. A simple calculation shows that this overlayer is at most 10 Angstrom thick. Cadmium seems to be insensitive to the presence of oxygen, as demonstrated by the absence of shifted Cd peaks in the X-ray spectra. It is shown that the low kinetic energy features in the Auger spectra ( $< 100 \text{ eV}$ ) are very sensitive to the oxide overlayer and contamination. (Author abstract) 11 refs.

Hernandez-Calderon, I. (IPN, Mexico City, Mex); Jimenez-Sandoval, S.; Pena, J.L.; Sailer, V. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 396-400.

**093565 TEMPERATURE DEPENDENCE OF THE HALL EFFECT OF THM-GROWN  $Hg_{1-x}Cd_xTe$  CRYSTALS.** The  $Hg_{1-x}Cd_xTe$  crystal was grown by THM and the crystal obtained was 10 mm in diameter and about 50 mm in length. The mid-portion, two-thirds of the total length, has good homogeneity as  $x = 0.20 \pm 0.02$  for the axial and  $x = 0.200 \pm 0.004$  for the radial direction. The type-conversion temperature  $T_c$  for the Hall coefficient shifted linearly to higher value as  $x$  increased, and the linearly fitted curve can be expressed as  $T_c = 1048x - 105$ . We presented  $\mu_H(300 \text{ K})/\mu_H(77 \text{ K}) \approx 19$  as the minimum value of the mobility ratio which may give a criterion to be related with the crystal quality for the as-grown p-type MCT in the temperature range. (Author abstract) 13 refs.

Kim, K.M. (Yonsei Univ, Seoul, South Korea); Hahn, S.R.; Noh, S.K.; Park, H.L.; Chung, C.H. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 673-676.

**Impurities** See Also MAGNETIC SEMICONDUCTORS—Mathematical Models; SEMICONDUCTING ZINC COMPOUNDS—Impurities.

**093566 STUDIES OF IMPURE CADMIUM OXIDE SEMICONDUCTORS USING NMR, EPR AND CONDUCTIVITY MEASUREMENTS.** Cadmium oxide semiconductors were prepared by heating CdO which also contained hydroxide and carbonate species formed on storage. Reaction of the impurities on heating, and high temperature annealing, produced an unusually wide range of electrical conductivities, EPR spectra and NMR spectra. Changes in EPR spectra were correlated with the  $^{113}\text{Cd}$  shift, which was shown to be proportional to the square root of the relaxation rate, and also proportional to the line width. This allowed the Knight shift contribution to the resonance position to be separated from the paramagnetic shielding (due to covalency). (Edited author abstract) 40 refs.

Meinhold, R.H. (DSIR, Petone, NZ). *J Phys Chem Solids* v 48 n 10 1987 p 927-934.

**093567 FERMI LEVEL PINNING IN THE MIDDLE OF THE BAND GAP IN CdTe:Cl CRYSTALS - ROLE OF DEEP LOCALIZED STATES.** The authors studied the temperature dependence of the equilibrium Hall effect and also the spectral and intensity dependence of the photo-Hall effect in CdTe:Cl. The goal was to gain an understanding of the spectrum of deep levels which are responsible for the crystal characteristics. 8 refs.

Agrinskaya, N.V. (Acad of Sciences of the USSR, Leningrad, USSR); Arkadeva, E.N. *Phys Status Solidi B* v 143 n 2 Oct 1987 p K103-K106.

**093568 PICOSECOND PHOTOLUMINESCENCE FROM BOUND EXCITONS IN  $Cd_{1-x}Zn_xTe$ .** Picosecond lifetimes of donor- and acceptor-bound excitons have been observed by time correlated single photon counting with high spectral resolution. The lifetimes increase with localized energy as expected for radiative transitions and are predicted reasonably well by both the Sanders-Chang and Rashba-Gurgenishvili theories. Lifetimes measured at the main photoluminescence peak for three other  $Cd_{1-x}Zn_xTe$  samples with  $x = 0, 0.023$  and  $0.19$  decrease with increasing  $x$ . (Author abstract) 22 refs.

Yom, S.S. (Emory Univ, Atlanta, GA, USA); Perkowski, S.; Amirtharaj, P.M.; Kennedy, J.J. *Solid State Commun* v 65 n 9 Mar 1988 p 1055-1058.

**093569 SOURCES AND BEHAVIOUR OF IMPURITIES IN LPE-GROWN (Cd,Hg)TE LAYERS ON CDTE(111) SUBSTRATES.** The sources of background impurities in LPE layers of (Cd, Hg)Te grown on CdTe(111) substrates are investigated using Spark-source mass spectrometry (SSMS) and secondary-ion mass spectrometry (SIMS). The principal sources of impurities were (i) the compounds HgTe and CdTe used in the LPE solution synthesis, (ii) the graphite sliding boat system and (iii) the CdTe substrate. The main impurities and their typical levels in the LPE layers were found to be Li(0.2 ppm), Na(0.3-1.0 ppm), Si(0.1-0.3 ppm), Cl(0.3-0.4 ppm) and K(0.03-0.06 ppm). To reduce the levels various changes in procedure were adopted such as cleaning of the graphite boat parts in aqua regia, the use of elemental starting materials (Hg, Cd, Te), substrate purification and the use of in-situ wash melts. The effect of Hg saturated isothermal annealing on the impurity concentrations and distribution has been studied, revealing rapid surface segregation of the Group IA impurities. The values of the distribution coefficients for several impurities have been calculated from the analytical results. (Edited author abstract) 27 Refs.

Astles, M.G. (Royal Signals & Radar Establishment, Malvern, Engl); Hill, H.; Blackmore, G.; Courtney, S.; Shaw, N. *J Cryst Growth* v 91 n 1-2 Aug 1988 p 1-10.

**093570 ION IMPLANTATION AND SIMS PROFILING OF IMPURITIES IN II-VI MATERIALS (HgCdTe AND CdTe).** Ions from throughout the periodic table have been implanted into HgCdTe and CdTe under a variety of conditions, and the  $\times$  atom depth distributions measured using oxygen and cesium secondary-ion mass spectrometry (SIMS). Many of these ions were implanted in the {100} crystal direction as well as in a random orientation close to {111}. Most of the HgCdTe material implanted was solid-state-recrystallized bulk  $Hg_{1-x}Cd_xTe$  ( $x = 0.19$  to  $0.35$ ) thermally processed at 350°C for 3 or 4 weeks (device-quality material) and etched prior to implantation. Ions from H to Ta were implanted at energies from 100 to 700 keV and fluences from  $10^{13}$  to  $3 \times 10^{15} \text{ cm}^{-2}$ . The SIMS technology developed for this work is discussed. SIMS sensitivity factors for HgCdTe and CdTe are shown to be the same within experimental accuracy (relative to Te). (Edited author abstract) 3 refs.

Wilson, R.G. (Hughes Research Lab, Malibu, CA, USA). *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 735-743.

**093571 NEUTRALIZATION OF ACCEPTOR AND DONOR IMPURITIES IN HYDROGENATED CdTe.** n-Type CdTe crystals were hydrogenated by annealing under hydrogen gas at 500°C. A strong reduction in donor concentration by orders of magnitude was observed and attributed to the neutralization of donor impurities by formation of complexes with hydrogen. The diffusion profiles of deuterium were measured and analysed in terms of a neutral fast diffusing species (atomic deuterium) and a charged slow species trapped on ionized acceptors. (Author abstract) 15 refs.

Svob, L. (CNRS, Meudon, Fr); Heurtel, A.; Marfaing, Y. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 815-818.

**093572 CONTROL OF IMPURITY CONCENTRATION ON CdSe SURFACES.** Photoluminescence of n-type CdSe crystals at 1.8 K and above has been used to investigate the effect of photoelectrochemical etching on the impurity distribution near the semiconductor surface. The results suggest that shallow donor states are removed from the surface preferentially and hence the surface



becomes relatively intrinsic following that surface treatment. The model of non-uniform charge flow is invoked to explain phenomenon. (Author abstract) 14 refs.

Tenne, R. (Weizmann Inst of Science, Rehovot, Isr); Mariette, H.; Levy-Clement, C.; Jaeger-Waldau, R. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 826-833.

**Ion Implantation** See Also SEMICONDUCTOR DEVICES—Junctions.

**093573 CHEMICAL CHARACTERIZATION OF THE SUPERFICIAL LAYERS OF DEUTERIUM-IMPLANTED CADMIUM TELLURIDE.** This work is a part of a general investigation of the physico-chemical behavior of hydrogen in cadmium telluride. In this letter we present results of our studies by X-ray photoelectron spectroscopy (XPS) of the influence of deuterium implantation on the surface and in the surface region of cadmium telluride. As a conclusion it can be stated that: deuterium implantation removes the superficial layers of CdTe, leaving a surface depleted in tellurium; and deuterium implantation protects this surface from further oxidation.

Svob, L. (CNRS, Meudon, Fr); Ballutaud, D.; Hage-Ali, H. *J Mater Sci Lett* v 7 n 9 Sep 1988 p 949-951.

**093574 LUMINESCENCE OF Fe<sup>+</sup>-IMPLANTED CdTe.** In the 5 K photoluminescence spectra of Fe<sup>+</sup> implanted and subsequently annealed CdTe samples two emission bands, peaked at 1.03 and 1.13 eV, respectively, appear. The intensity of these lines increases linearly with the implanted Fe<sup>+</sup> dose. By varying the wavelength of the exciting laser radiation, we find that these lines are emitted from the implanted surface region only. Time resolved photoluminescence experiments reveal the time constant of the emission process. (Author abstract) 4 refs.

Kernoecker, R. (Johannes Kepler Univ, Linz, Austria); Lischka, K.; Palmeshofer, L. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 625-628.

**093575 ELECTRICAL DOPING OF HgCdTe BY ION IMPLANTATION AND HEAT TREATMENT.** The semiconductor Hg<sub>1-x</sub>Cd<sub>x</sub>Te (CMT) is today the leading material for making infrared photodetectors. The first part of the paper is directly devoted to the general properties of junctions made by ion implantation in CMT: the structure of junctions, the effects of implantation damage, defects, annealing, and junctions made by active impurities. The second part deals with the effect of acceptor evolution in CMT after heat treatment, and a study of the kinetics is presented. In the last part of the paper it is shown that very high quality devices with very small size and large two-dimensional arrays can be achieved using an ion-implantation technique of junction formation in CMT epilayers grown by LPE. 80 refs.

Destefanis, G.L. (CEA, Grenoble, Fr). *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 700-722.

**093576 DEFECTS, DIFFUSION AND ACTIVATION IN ION IMPLANTED HgCdTe.** The current understanding in junction formation by ion implantation in HgCdTe material is discussed. Two major techniques are available for junction formation: a traditional technique that consists of an ion implantation process (usually B or Be) followed by a diffusion of the irradiation-displaced mercury atoms (I<sup>2</sup>/DMD), and a classical technique of ion implantation followed by the electrical activation of the implanted species. The activation process could be of a diffused species from the implanted source, or of the as-implanted species (I<sup>2</sup>/AD or I<sup>2</sup>/D, respectively). A variety of junctions different in nature and electrical profile have been demonstrated. The best quality devices obtained so far in Hg<sub>1-x</sub>Cd<sub>x</sub>Te material with x = 0.2 from either technique are implanted-diffused in nature.

(Edited author abstract) 37 refs.

Bubulac, L.O. (Rockwell Int Science Cent, Thousand Oaks, CA, USA). *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 723-734.

**093577 COMPARATIVE ANALYSIS OF THERMAL AND PULSE ELECTRON BEAM ANNEALING OF PHOSPHORUS IMPLANTED CADMIUM TELLURIDE.** In this paper, an analysis is extended to explain the experimental data of the different annealing processes. The profiles of implantation-induced defects as well as the temperature distribution of pulse electron beam (PEB) annealing and the phosphorus redistribution after the annealing process are calculated. The results show a strong dependence of the measured hole concentrations on the redistributed phosphorus atoms in CdTe after PEB annealing, while the implantation-induced point defects greatly affect the resultant electrical characteristics in thermally annealed samples. A logical explanation for these two cases is that the p-type conduction in the thermally annealed CdTe is compensated by cadmium vacancies, and is promoted by phosphorus interstitials, while in the PEB annealed samples phosphorus at substituted tellurium sites are easily formed due to the melting effects. (Edited author abstract) 15 refs.

Hsu, Y.J. (Nat'l Tsing Hua Univ, Hsinchu, Taiwan); Hwang, H.L.; Sun, C.Y. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 749-755.

**093578 DOSE RATE EFFECTS IN INDIUM-IMPLANTED Hg<sub>1-x</sub>Cd<sub>x</sub>Te.** In order to more clearly understand the effects of temperature and ion current on ion-implantation induced disorder in Hg<sub>0.7</sub>Cd<sub>0.3</sub>Te, we have implanted various doses of indium at 300 keV using different implant currents and heat sink conditions. Calculations of the transient temperature rise expected under the ion beam carried out for well heat sunk samples and for various heat sink conditions show acceptable values for moderate beam currents (1 μA cm<sup>-2</sup>). Experimental results indicate that considerable dynamic annealing occurs during implantation at temperatures greater than 77 K and that this annealing causes enhanced diffusion of indium during the implant. (Author abstract) 6 refs.

Magel, L.K. (Stanford Univ, Stanford, CA, USA); Simon, T.W. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 756-761.

**093579 ARSENIC ION IMPLANTATION IN Hg<sub>1-x</sub>Cd<sub>x</sub>Te.** Arsenic was implanted in Hg<sub>1-x</sub>Cd<sub>x</sub>Te (0.19 ≤ x ≤ 0.23) of n-type (electron concentrations in the range from 10<sup>14</sup> to 10<sup>15</sup> cm<sup>-3</sup> at 77 K). The implantations were carried out using fluences between 10<sup>14</sup> and 5 × 10<sup>15</sup> cm<sup>-2</sup> and ion energies of 350 keV while the samples were kept at room temperature. The charge carrier concentration at 300 K was determined by analysing the infrared reflectance in the plasma resonance regions. Thermoelectric probing was also applied for determining the conduction type and the carrier concentration. Subsequently the implanted samples were annealed in saturated Hg vapour for 30 to 45 min at temperatures of 200, 300, 400 and 500°C. It was found that the As concentration profiles analysed by SIMS were not affected by annealing. The results suggest that the majority of the implanted As forms charge-compensating complexes (presumably involving oxygen) that are electrically inactive and highly immobile in the lattice. (Edited author abstract) 15 refs.

Baars, J. (Franhofer-Inst fuer Angewandte Festkoerperphysik, Freiburg, West Ger); Seelwind, H.; Fritzsche, Ch.; Kaiser, U.; Ziegler, J. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA Jul 12-17 1987 p 762-767.

**093580 OPTICAL AND STRUCTURAL CHARAC-**

**TERIZATION OF HEAVILY BORON-IMPLANTED CdTe.** CdTe single crystals were subjected to multiple-energy boron ion implants with total doses up to 1.5 × 10<sup>16</sup> B<sup>+</sup> ions/cm<sup>2</sup>. Various diagnostic techniques were used to assess the structural and electronic properties of these crystals in their as-implanted condition and after anneals under vacuum. The degradation of crystallinity following the boron implants was clearly evident. Annealing temperatures up to 500°C were not effective to remove the damage from these heavy dose implants. The chosen boron implant conditions and annealing procedures have not produced substitutional boron donor centers. Excellent correlations were obtained for model calculations of boron projected range and implant damage profiles with the corresponding experimental parameters. (Author abstract) 26 refs.

Bowman, R.C. Jr. (Aerospace Corp, Los Angeles, CA, USA); Alt, R.L.; Adams, P.M.; Knudsen, J.F.; Jamieson, D.N.; Downing, R.G. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 768-777.

## Laser Applications

**093581 EFFECT OF INTRINSIC DEFECTS OF THE CADMIUM SULFIDE-STRUCTURE ON THE EFFICIENCY AND OPTICAL STRENGTH OF UNCOOLED LASERS.** Cadmium sulfide is used for the fabrication of electron-beam-pumped lasers operating in the visible range of the spectrum. On the basis of a study of the electrophysical, photoluminescent and structural properties of cadmium sulfide, a model is proposed according to which an improvement in the output parameters of the laser emission is caused by an increase in the concentrations of shallow donor and acceptor levels arising with the participation of sulfur and cadmium atoms (or their vacancies). In mechanically polished cadmium sulfide crystals radiation annealing of the damaged layers was observed, as a result of which the efficiency of the lasers increased two- to threefold. In Russian. 11 refs.

Bogdankevich, O.V.; Kostin, N.N.; Krasavina, E.M.; Kryukova, I.V.; Markov, E.V.; Matveenko, E.V.; Tepiltskii, V.A. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 10 Oct 1987 p 1618-1622.

## Magnetic Field Effects

**093582 QUANTUM LIMIT BEHAVIOR OF THE MAGNETORESISTANCE IN Hg<sub>1-x-y</sub>Cd<sub>x</sub>Mn<sub>y</sub>Te ALLOYS SUBJECTED TO A HIGH PULSED MAGNETIC FIELD.** The transverse magnetoresistance and the Hall effect of a quaternary alloy semimagnetic semiconductor Hg<sub>1-x-y</sub>Cd<sub>x</sub>Mn<sub>y</sub>Te were measured in high-pulsed magnetic fields up to 30 T. The investigation of the asymptotic power law (q<sub>p</sub>(B) ∝ B<sup>α</sup>) in a quantum limit regime revealed that the short-range-type scattering is enhanced with increasing Mn composition, suggesting the scattering associated with the localized magnetic moment of Mn. (Author abstract) 18 refs.

Takeyama, S. (Univ of Tokyo, Tokyo, Jpn); Yamada, N.; Miura, N. *Solid State Commun* v 63 n 3 Jul 1987 p 227-230.

**093583 LONGITUDINAL MAGNETOPHONON RESONANCE IN N-Hg<sub>1-x</sub>Cd<sub>x</sub>Te.** The longitudinal magnetophonon resonance peaks of N-Hg<sub>1-x</sub>Cd<sub>x</sub>Te (x = 0.19-0.31) are observed for ΔN ≤ 6 using magnetic field modulation and lock-in amplifier techniques. The magnetophonon spectra at various temperatures (T = 55-140 K) for a sample with x = 0.31, n approximately 1 × 10<sup>14</sup> cm<sup>-3</sup>, μ approximately 1 × 10<sup>5</sup> cm<sup>2</sup>/V.s are measured. (Author abstract) 8 refs.

Zheng, Guozhen (Acad Sinica, Shanghai, China); Guo, Shaoling; Liang, Yong; Tang, Dingyuan; Shen, Jie. *Chin J Infrared Res Ser B (Engl Ed)* v 6 1987 p 33-37.



**Magnetic Properties** See MAGNETIC SEMICONDUCTORS—Magnetic Properties.

## Measurements

**093584 INVESTIGATION OF p-CdTe AND p-Zn<sub>x</sub>Cd<sub>1-x</sub>Te SINGLE CRYSTALS BY ps-LASER-INDUCED GRATINGS AND BY PHOTOLUMINESCENCE.** From the measured erasure times of transient gratings created in the volume and on the surface of non-intentionally doped p-type CdTe and Zn<sub>x</sub>Cd<sub>1-x</sub>Te ( $x \leq 0.11$ ) single crystals the free-carrier lifetime and the surface recombination velocity at room temperature are determined, respectively. The erasure time of the surface grating in CdTe is found to be 130 ps, which is one order smaller than that of the volume grating. A lifetime shortening is observed in mixed crystal. Moreover, using CW-laser excitation the samples are characterized additionally by photoluminescence investigation at low temperatures to test the quality, to determine the mole fraction, and to identify impurities. The A<sup>0</sup>X-line observed is interpreted as due to a single acceptor on Te site. In the mixed crystals at  $x \geq 0.09$  the two-mode behavior of LO-phonons and an up to now not observed splitting of the A<sup>0</sup>X-line are found. (Author abstract) 20 refs.

Rueckmann, I. (Humboldt-Universität zu Berlin, Berlin, East Ger); Petrauskas, M.; Netikis, V.; Tamulaitis, G.; Halpap, J. *J. Phys Status Solidi B* v 142 n 2 Aug 1987 p 629-640.

## Mechanical Properties

**093585 MICROHARDNESS AND POLARITY IN Cd<sub>x</sub>Hg<sub>1-x</sub>Te.** The Vickers microhardness of Cd<sub>x</sub>Hg<sub>1-x</sub>Te alloys has been measured at room temperature as a function of composition and the nature of the {111} faces for different conduction types. The hardness-composition curve shows a maximum at about  $x = 0.75$ . On the {111} faces, the metal face (A face) is harder than the metalloid face for all studied doping types and is related to the different mobilities of the A(g) and B(g) dislocations. This behaviour is compared with a model previously developed for hardness polarity in GaAs. (Author abstract) 16 refs.

Barbot, J.F. (CNRS, Poitiers, Fr); Rivaud, G.; Desoyer, J.C. *J. Mater Sci* v 231 n 5 May 1988 p 1655-1659.

**093586 MICROHARDNESS OF (Hg, Cd)Te.** The microhardness of (Hg, Cd)Te has been investigated by means of Vickers measurements. The measured hardening effect, dependent on composition, is discussed as a function of mutual changes of the binding properties of the solid solution and, additionally, as a function of a favoured formation of (3Cd:1Hg)Te tetrahedrons. (Author abstract) 5 refs.

Schenk, M. (Humboldt-Universität zu Berlin, Berlin, East Ger); Fissel, A. *J. Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 502-505.

**093587 VICKERS HARDNESS OF Hg<sub>1-x</sub>Cd<sub>x</sub>Te EPILAYERS GROWN BY ISOTHERMAL VAPOR PHASE EPITAXY.** A novel method for preparing graded compositions of Hg<sub>1-x</sub>Cd<sub>x</sub>Te epilayers is presented. The epilayers are grown by an isothermal vapor phase epitaxial technique, which uses a CdTe substrate and either Te-rich HgTe or HgCdTe as the source. The substrate is positioned vertically to the source allowing a graded composition of HgCdTe epilayer to be deposited. Epilayer thickness of 100-200 μm were deposited, with  $x$  values ranging from 0.1 to 0.7. Vickers hardness measurements were made over the composition range with hardness values ranging from 33 to 75 kg/mm<sup>2</sup>. These values are similar to hardness values in the literature which were measured on individual bulk specimens. Our method is particularly effective since a single oriented layer of varying composition is measured rather than separately prepared samples of different orientation. (Author abstract) 37 refs.

Fleming, J.G. (Stanford Univ, Stanford, CA, USA); Farthing, L.J.; Stevenson, D.A. *J. Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf

on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 506-510.

**Optical Properties** See Also SEMICONDUCTING LEAD COMPOUNDS—Optical Properties; SEMICONDUCTOR MATERIALS—Electronic Properties.

**093588 ESTIMATE OF FREE-CARRIER ABSORPTION BY PHOTON-IONIZED IMPURITY-PLASMON PROCESSES IN N-TYPE Hg<sub>1-x</sub>Cd<sub>x</sub>Te.** The infrared absorption spectra for a sample of Hg<sub>1-x</sub>Cd<sub>x</sub>Te with  $x=0.19$  reported previously have been recalculated including both the absorption due to individual carrier transition and that due to collective excitation of carriers (plasmons), taking into account the dispersion of refractive index and the non-parabolicity of the energy band in the absence of Landau damping. The agreement between theory and experiment is good and suggests that free-carrier absorption due to collective excitation can play a noticeable role in the frequency range from  $\omega_p$  up to  $2\omega_p$  and above. The value of the concentration of ionized impurities thus obtained is believed to be more accurate than that obtained previously. (Author abstract) 18 refs.

Qian Dingrong (Acad Sinica, Shanghai, China); Szuszkiewicz, W. *Phil Mag Lett* v 55 n 3 Mar 1987 p 147-151.

**093589 OPTICAL NONLINEARITY AND PHASE COHERENCE OF EXCITON-BIEXCITON TRANSITION IN CdSe.** Picosecond time-resolved degenerate four-wave mixing has been performed in bulk crystals of CdSe. A strong nonlinear resonance is found 5 meV below the free-exciton energy and is ascribed to the induced exciton-biexciton transition. The phase coherence time of the transition is 20 ps at low excitation intensity and temperature, and decreases with increasing values of these parameters. For pump intensities above  $\approx 1 \mu\text{J}/\text{cm}^2$ , spatial and temporal instabilities are observed. (Author abstract) 10 refs.

Hvam, J.M. (Odense Univ, Odense M, Den); Balslev, I.; Honerlage, B. *Europhys Lett* v 4 n 7 Oct 1 1987 p 839-843.

**093590 DETECTION OF NEGATIVE PHOTOCONDUCTIVITY IN Cd<sub>x</sub>Fe<sub>1-x</sub>Se SYSTEM.** A photoconductivity spectrum of p type Cd<sub>x</sub>Fe<sub>1-x</sub>Se was investigated. A negative photoresponse has been observed at 1.7 eV. The origin for the negative photoconductance is attributed to the transition of the electrons from inner Fe<sup>2+</sup> level to the top of the valence band where they recombine with the holes. (Author abstract) 16 refs.

Joshi, N.V. (Univ de Los Andes, Merida, Venez); Moggilon, Leticia; Sanchez, J.; Martin, J.M. *Solid State Commun* v 65 n 2 Jan 1988 p 151-153.

**093591 LUMINESCENCE OF MIXED ZnS-CdS SEMICONDUCTOR CATALYSTS IN NAFION POLYMER FILMS.** The luminescence of CdS and mixed ZnS-CdS semiconductor particles supported in Nafion polymer films has been studied to elucidate the previously reported synergism in the ZnS-CdS system for photoredox H<sub>2</sub> production. The luminescence of these systems is complex, depending on the history of the particular sample, the intensity and wavelength of the exciting light, and the presence of ions that can quench specific emitting states (e.g. S<sup>2-</sup> or methylviologen). For the mixed ZnS-CdS system the two semiconductors do not alloy but there is intimate contact between the ZnS and CdS phases, indicated by the complete quenching of ZnS luminescence. Prolonged irradiation produces a luminescent ZnS phase. The emission features agree reasonably well with sub-bandgap states deduced from earlier photoconductivity studies on CdS crystals. These results help explain why the reported emission features of CdS are as varied as the laboratories reporting them. (Author abstract) 26 refs.

Finlayson, M.F. (Univ of Texas at Austin, Austin, TX, USA); Park, K.H.; Kakuta, N.; Bard, A.J.; Campion, A.; Fox, M.A.; Webber, S.E.; White, J.M. *J. Lumin* v 39 n 4 Mar 1988 p 205-214.

**093592 OPTICAL NONLINEARITY OF CdS.** The discovery and investigation of optically nonlinear behav-

ior of CdS is reviewed. The development is described from nonlinear anti-Stokes excitation via the characterization of inelastic light scattering processes and the identification of high-density phenomena like biexciton creation, excitonic collisions, and electron-hole plasma generation towards very recent time-resolved gain, light-induced grating, and in particular optical bistability experiments. CdS is thus shown to allow for an extremely wide variety of different optically nonlinear processes and may be regarded as a model material for this field. Possible applications show up for several of the described phenomena. (Author abstract) 117 refs.

Broser, I. (Technische Univ, Berlin, West Ger); Gutowski, J. *Appl Phys B* v B46 n 1 May 1988 p 1-17.

**093593 EXCITON-RELATED OPTICAL NONLINEARITIES IN SEMICONDUCTORS AND SEMICONDUCTOR MICROCRYSTALLITES.** We report on large optical nonlinearities due to specific many-body effects in high-density electron-hole pair systems. On bulk CdS we study the effect of free-carrier screening on the absorption and refraction in the vicinity of the band-gap at room temperature. Steady-state saturable absorption at mW-power levels and four-wave mixing with first-order efficiencies as large as 2% of the incoming light are demonstrated on a 1 μm slab. On CuBr microcrystallites embedded in glass we investigate the changes of the exciton absorption caused by many-exciton effects both at cryo and room temperature. In contrast to bulk semiconductors, we observe a blue shift of the exciton peak at resonant optical excitation. In addition, strong saturation of absorption with very large contrast shows up. We find Lorentzian saturation intensities in the 100 kW/cm<sup>2</sup> range. (Author abstract) 27 refs.

Henneberger, F. (Humboldt-Universität zu Berlin, Berlin, East Ger); Woggon, U.; Puls, J.; Spiegelberg, Ch. *Appl Phys B* v B46 n 1 May 1988 p 19-25.

**093594 BAND EDGE ABSORPTION SATURATION DYNAMICS OF SEMICONDUCTORS.** Temporal evolution of the transmission coefficient and of the output light intensity during the laser pulse is investigated for CdSe single crystals. The nonlinear bleaching observed in the Urbach region of the absorption spectrum at room temperature has a threshold character. With the increase of the laser pulse energy exceeding the threshold value  $E_1$ , the transmission coefficient at first experiences a strong rise and then reaches a saturation. A phenomenological model describing the observed features is proposed assuming an abrupt dependence of the absorption coefficient on the photoexcitation density. The sequence of dynamical relationships between the transmission and the pump level is quantitatively analyzed. From experimental data the threshold specific energy and the specific energy required for the bleaching of a 100 μm sample are deduced. They are equal to  $2.2 \times 10^{-11}$  and  $1.9 \times 10^{-10} \text{ J}/\mu\text{m}^2$ , respectively. (Author abstract) 6 refs.

Kochelap, V.A. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Kulish, N.R.; Lisitsa, M.P.; Malysb, N.I.; Sokolov, V.N. *Phys Status Solidi B* v 146 n 1 Mar 1988 p 319-327.

**093595 EXCITONS AT HIGH DENSITY IN CdS AND GaSe, AND OPTICAL BISTABILITY.** Changes in the absorption and refractive index caused by laser absorption in CdS and GaSe are investigated and used to produce absorptive resonatorless bistability in CdS and to explain dispersive optical bistability in a GaSe Fabry-Perot cavity. (Author abstract) 17 refs.

Dneprovskii, V.S. (Moscow State Univ, Moscow, USSR); Furtichev, A.I.; Klimov, V.I.; Nazvanova, E.V.; Okorokov, D.K.; Vandsheev, U.V. *Phys Status Solidi B* v 146 n 1 Mar 1988 p 341-350.

**093596 PICOSECOND TRANSIENT OPTICAL NONLINEARITIES IN CdS AND CdSe.** Nonlinear absorption of CdS and CdS<sub>0.7</sub>Se<sub>0.3</sub> crystals is studied around room temperature using an excite-and-probe



technique in the ps time region and taking Fabry-Perot interferences into account. Large nonlinear changes of the optical coefficients are obtained. The experimental spectra are in reasonable agreement with the theoretical ones assuming a heating of the excited carriers. The nonlinearities relax within about 1 ns. (Author abstract) 8 refs.

Egorov, V.D. (Acad der Wissenschaften der DDR, Berlin, East Ger); Floegel, P.; Hoang Xuan Nguyen; Kaschke, M. *Phys Status Solidi B* v 146 n 1 Mar 1988 p 351-356.

**093597 DIRECT OPTICAL TRANSITIONS IN CdGaInS<sub>4</sub>.** CdGaInS<sub>4</sub> single crystals are candidates for application as photovoltaic detectors in the ultraviolet spectral region. This note presents experimental results on the absorption edge of CdGaInS<sub>4</sub> in a wide range of the absorption coefficient at temperatures of 80, 180, and 300 K. The investigation has shown that CdGaInS<sub>4</sub> is a direct band gap semiconductor ( $E_g = 2.92$  eV at 300 K) and has an exponential density of states tail below the conduction band ( $\Delta = 60$  to 77 meV). The energy gap is close to  $E_g = 2.86$  eV. 5 Refs.

Moldovyan, N.A. (Acad of Sciences of the Moldavian SSR, Kishinev, USSR); Radautsan, S.I.; Zhitir, V.F.; Arama, E.D.; Remenko, D.S. *Phys Status Solidi A* v 106 n 2 Apr 1988 p k181-k184.

**093598 INFLUENCE OF DEFECT GENERATION PROCESS IN CdIn<sub>2</sub>S<sub>4</sub> SINGLE CRYSTALS ON THE PHOTOLUMINESCENCE AND RAMAN SCATTERING SPECTRA.** Photoluminescence (PL) and Raman scattering (RS) spectra is explained in dependence of the applied heat treatment conditions are studied. The deformation of the integral PL spectrum is explained by a model within which the local levels are due to the intrinsic defects of the semiconductor. The presence of a wide-band background in the RS spectra and the deformation of the PL spectra characteristic for samples subjected to rapid cooling after annealing at temperatures not lower than  $T_c \approx 300$  to 320 °C are the result of a phase transition of the order-disorder type. The latter occurs at  $T \approx T_c$  and causes the conversion of the crystal structure from a normal spinel ( $T < T_c$ ) into a partially inverted one ( $T > T_c \approx 320$  °C). (Edited author abstract). 18 Refs.

Kulikova, O.V. (Acad of Sciences of the Moldavian SSR, Kishinev, USSR); Kulyuk, L.L.; Radautsan, S.I.; Ratseev, S.A.; Strumban, E.E.; Tezlevan, V.E.; Tsitsanu, V.I. *Phys Status Solidi A* v 107 n 1 May 1988 p 373-377.

**093599 PLASMA REFLECTIVITY SPECTRA OF INHOMOGENEOUS Cd<sub>0.2</sub>Hg<sub>0.8</sub>Te CRYSTALS.** Results of numerical calculations and experimental studies of the influence of microinhomogeneities on plasma reflectivity spectra of ion-implanted Cd<sub>0.2</sub>Hg<sub>0.8</sub>Te crystals are presented. The calculations of plasma reflectivity spectra were performed for a model implanted crystal consisting of a uniform substrate and a disordered surface layer. Two types of microstructure of the damaged layer were considered: 1) a separate grain structure in which particles of material A are dispersed in a continuous host of material B and 2) an aggregate structure being a random mixture of two (A, B) or three (A, B, C) phases. 7 Refs.

Eidziunas, G. (Acad of Sciences of the Lithuanian SSR, Vilnius, USSR); Kavaliauskas, J.; Krivaite, G.; Sileika, A. *Phys Status Solidi A* v 107 n 1 May 1988 pK75-K78.

**093600 OPTICAL PROPERTIES OF II-VI SEMI-MAGNETIC SEMICONDUCTORS.** A short review about recent optical data pertaining to band structure and energy levels related to magnetic ions in semimagnetic semiconductors (SMSC) is presented. Then, optical effects which demonstrate the strength of exchange interaction between magnetic ions and free or weakly bound carriers are considered; they include the already well studied giant magneto-optical effects and the formation of magnetic polarons (MP). Photoluminescence in large gap materials is a good way to study different aspects: bound excitons still present a low spin concentration, donor-acceptor (D-A) pair emission to study magnetic polarons bound to acceptors, with special emphasis upon the anisotropy in wurtzite structures. At higher spin concentration, proper-

ties of localized excitons have been deduced from optical pumping (site selection) and time resolved spectroscopy, on a picosecond time-scale. A few examples in the new field of SMSC based superlattices and quantum wells are also given. (Author abstract) 36 refs.

Benoit A La Guillaume, C. (Univ Paris VII, Paris, Fr). *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 522-527.

**093601 EXCITATION WAVELENGTH AND PUMP CHOPPING FREQUENCY DEPENDENCE OF PHOTOREFLECTANCE IN Hg<sub>1-x</sub>Cd<sub>x</sub>Te.** We have measured photoreflectance (PR) at 77 K in the vicinity of the E<sub>1</sub> optical feature from Hg<sub>1-x</sub>Cd<sub>x</sub>Te (0.14 < x < 0.3) using infrared (3.39 μm) and deep blue-violet (4579 and 4067 Angstrom) pump beams; both n- and p-type materials were investigated. The spectral lineshapes were fitted using existing theories of electromodulation yielding interband energies and broadening parameters. In addition, the dependence of the PR intensity on the modulation frequency (f) was studied in order to obtain information regarding surface (interface) traps. The variation of PR intensity with f yielded characteristic trap time constants in the range 1-4 ms. (Author abstract) 20 refs.

Ksendszov, A. (Brooklyn Coll, Brooklyn, NY, USA); Pollak, Fred H.; Amirtharaj, P.M.; Wilson, J.A. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 586-592.

**093602 OPTICAL BISTABILITY IN II-VI COMPOUNDS.** This paper reviews the different types of optical bistability in II-VI semiconductor compounds with particular emphasis on experimental results obtained in CdHgTe, CdTe and ZnSe. Results of optical bistability in an entirely molecular beam deposited ZnSe filter are presented for the first time. (Author abstract) 30 refs.

Miller, A. (Royal Signals & Radar Establishment, Great Malvern, Engl); Staromlynska, J.; Muirhead, I.T.; Lewis, K.L.; Craig, D.; Steward, G. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 859-865.

**Order-Disorder** See SEMICONDUCTOR MATERIALS—Mechanical Properties.

**Oxidation** See Also CATALYSTS—Cadmium Sulfide.

**093603 MECHANISM OF PLASMA OXIDATION FOR THE SURFACE OF Cd<sub>x</sub>Hg<sub>1-x</sub>Te.** The surface condition of narrow-band solid solution of Cd<sub>x</sub>Hg<sub>1-x</sub>Te determines to a marked extent the characteristics of optoelectronic instruments fabricated from it. Therefore, the passivation of its surface by creating a thin layer of intrinsic oxide on it by various methods is the objective of numerous studies. The electrochemical method of oxidation is the most common. According to recent articles on plasma oxidation of this surface, the oxides thus obtained have better and stabler characteristics than those obtained with the electrochemical method. But no investigations have been conducted on possible mechanisms for this method. In the present article we present the results of a study on the oxidizing mechanism for the surface of Cd<sub>x</sub>Hg<sub>1-x</sub>Te in an oxygen plasma and a brief characterization of the oxide-semiconductor interface. 20 refs.

Alekperov, G.A.; Abdullaev, Ya.A.; Aleskerov, R.O.; Guseinov, E.K. *Sov Microelectron* v 16 n 3 May-Jun 1987 p 136-138.

**Phase Transitions** See Also MAGNETIC SEMICONDUCTORS—Phase Transitions.

**093604 HEAT CAPACITY OF CADMIUM DIPHOSPHIDE IN THE 6-400 K TEMPERATURE RANGE.** Measurements were made of the heat capacity of the Tetragonal modification of cadmium diphosphide in the 6-400 K temperature range. The presence in these crystals of a sequence of phase transitions related to the existence of modulated structures comprising commensu-

rate and incommensurate states is confirmed. 7 refs. In Russian.

Sheleg, A.U.; Yakubenko, T.I.; Tekhanovich, N.P. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 5 May 1987 p 714-716.

**093605 DETECTION OF 3D<sup>6</sup>5s → a<sup>5</sup>D<sup>4</sup> TRANSITION OF Fe<sup>2+</sup> IN Cd<sub>1-x</sub>Fe<sub>x</sub>Te.** The purpose of the present investigation is to examine the high-energy side of the absorption spectrum with a view to detecting the 3D<sup>6</sup>5s → a<sup>5</sup>D<sup>4</sup> transition. Optical absorption spectra in the range 530-550 nm have been investigated in diluted magnetic semiconductors Cd<sub>1-x</sub>Fe<sub>x</sub>Te for x = 0.015, 0.05 and 0.1 at 300 and 77 K. The transition corresponding to a deep level of Fe<sup>2+</sup> 3D<sup>6</sup>5s → a<sup>5</sup>D<sup>4</sup> has been detected for the first time. The crystals used for this investigation were grown by chemical transport technique. 8 refs.

Joshi, N.V. (Univ de Los Andes, Merida, Venez); Mogollon, Leticia. *Mater Lett* v 6 n 11-12 Oct 1987 p 446-448.

**093606 NEW HIGH PRESSURE PHASE OF CdTe.** The phase transition of CdTe have been studied by high pressure x-ray diffraction with a diamond anvil cell up to 39.20 GPa at room temperature. It was found that the transformation sequences of CdTe is from zinc blende phase to NaCl phase at 3.31 GPa, to β-Sn phase at 10.33 GPa and to a new phase at 12.18 GPa. The new phase appears to have a simple orthorhombic structure (S.G.Pmm2) with two atoms in the unit cell. The positions of atoms are Cd(0, ½, ¼) and Te(0, 0, 0). The lattice parameters of the orthorhombic phase at 19.30 GPa are a = 2.8102 (Å), b = 5.2580 (Å), c = 3.0265 (Å). (Author abstract) 18 refs.

Hu, Jing Zhu (Chinese Acad of Sciences, Beijing, China). *Solid State Commun* v 63 n 6 Aug 1987 p 471-474.

**093607 STRUCTURAL STUDY OF PRESSURE INDUCED PHASE TRANSITION FOR MIXED CRYSTAL Cd<sub>1-x</sub>Mn<sub>x</sub>Te.** A phase transition from zinc-blende to NaCl-type structure induced by pressure is identified for the mixed crystal Cd<sub>1-x</sub>Mn<sub>x</sub>Te by use of X-ray powder diffraction under high pressure. It is also demonstrated experimentally that the phase transition can be irreversible. (Author abstract) 10 refs.

Shan Wei (Acad Sinica, Shanghai, China); Shen Xuechu; Tang Ruming; Hu Jingzhu. *Chin J Infrared Res Ser B (Engl Ed)* v 6 1987 p 85-88.

## Photoconductivity

**093608 HOT ELECTRON EFFECTS IN FREE CARRIER PHOTOCONDUCTIVITY IN HgCdTe.** The research and observation of free electron absorption and photoconductivity in N-type Hg<sub>0.78</sub>Cd<sub>0.22</sub>Te at 100k have been made using a cw tunable CO<sub>2</sub> laser. It is found that the photoexcitation gives rise to an increase in the hot electron temperature and a change of mobility. The analysis of experimental results shows that the ionized impurity scattering dominates variation of the mobility. There is a possibility to develop a new type far infrared detector. (Author abstract) (In Chinese) 10 refs.

Wang, Weili (Peking Univ, China); Xing, Qijiang. *Hong-wai Yanjiu A-JI* v 6 n 5 1987 p 341-346.

**093609 PHOTOCONDUCTIVITY OF (CdSe, ZnS):La.** Photoconductivity of rare earth doped mixed bases of II-VI compounds has not drawn any particular attention, although formation of mixed bases is important from the point of view of extending the maximum response in the visible region. With this in mind, the photoconductivity of (CdSe,ZnS):La has been investigated. The lower values of photocurrent at lower and higher concentrations of lanthanum may be due to a release of fewer electrons from lanthanum and concentration quenching, respec-



tively. Two trap depths at 0.54 and 0.45 eV have been found and these depend on the concentration of lanthanum. 4 refs.

Bhushan, S. (Ravishankar Univ, Raipur, India); Giriya, L.C. *J Mater Sci Lett* v 7 n 5 May 1988 p 444-446.

**093610 TEMPERATURE DEPENDENT PHOTOCONDUCTIVITY AND PHOTOLUMINESCENCE OF  $\text{Cd}_{1-x}\text{Mn}_x\text{Te}$ .** Photoconductivity (PC) and Photoluminescence (PL) studies of  $\text{Cd}_{1-x}\text{Mn}_x\text{Te}$  are reported in the ranges of composition  $0.15 < x < 0.40$  and temperature  $10 < T < 300$  K. The results of this study show that p-d transitions make an important contribution to the optical properties of  $\text{Cd}_{1-x}\text{Mn}_x\text{Te}$  in the above range of compositions. Strong changes in both the PL and PC spectra are observed when the  $\Gamma_6$  conduction band edge shifts through the Mn 3d<sub>5</sub> levels. This explains the specific temperature dependence of the PC for  $x=0.32$  and the strong increase in the normalized intensity of the PL band at 2.0 eV at  $x > 0.35$ . The shift in the binding energy of the excitonic contribution to the PC with temperature agrees well with the model of Golnik on interactions of the excitons with the Mn<sup>2+</sup> spins. (Edited author abstract) 32 refs.

Neff, H. (North Carolina State Univ, Raleigh, NC, USA); Bachmann, K.J.; Lay, K.Y.; Kotz, R. *J Lumin* v 36 n 6 Mar 1987 p 347-354.

**093611 CHARACTERIZATION OF PHOTOCONDUCTING CdTe USING ACOUSTOELECTRIC METHODS.** The present paper demonstrates the possibility of the application of acoustoelectric measurements for the characterization of bipolar photoconductors. It shows the influence of charge carrier trapping on the acoustoelectric effect. The use of acoustoelectric measurements enables us to obtain information not only on densities and mobilities of carriers in bipolar semiconductors, but also on the trap parameters. 13 refs.

Rosenzweig, J. (Univ Karlsruhe, Karlsruhe, West Ger). *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987; Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 689-694.

**093612 CORRELATION OF EXCITATION SPECTROSCOPY OF EDGE LUMINESCENCE AND PERSISTENT PHOTOCONDUCTIVITY IN CDS.** Simultaneous excitation spectra of time-resolved luminescence and persistent photoconductivity are investigated in near-zero stored-charge states at temperatures 1-4 K and magnetic fields up to 4 Tesla. The sample (EP-A) is a high purity, almost fully compensated, CdS single crystal, 0.5 mm thick, etched on the front (excitation) surface and polished on the rear (luminescence detection) surface. 9 refs.

Baum, D. (Syracuse Univ, Syracuse, NY, USA); Jiang, H.X.; Honig, A. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 119-120.

**Physical Properties** See Also MAGNETIC SEMICONDUCTORS—Physical Properties.

**093613 LATTICE PARAMETERS, ENERGY GAPS, AND MAGNETIC PROPERTIES OF THE  $\text{Cd}_x\text{Hg}_y\text{Mn}_z\text{Te}$  ALLOY SYSTEM.** Polycrystalline samples of  $\text{Cd}_x\text{Hg}_y\text{Mn}_z\text{Te}$  alloys ( $x+y+z=1$ ) are prepared by the standard melt and anneal technique. Debye-Scherrer powder X-ray photographs are used to determine equilibrium conditions in the alloys, to delineate the range of single phase solid solution and to determine values of zinc blende lattice parameter  $a$ . Optical absorption measurements are made to give room temperature values of energy gap  $E_g$  for the single phase alloys. Measurements of magnetic susceptibility in the temperature range 4 to 250 K are made to give values of  $T_g$ , the spin-glass transition temperature, and  $\theta$ , the Curie-Weiss temperature. Analysis of these data shows that for samples with  $g > 1.5$  ev, the results are well explained by the superexchange mechanism previously used in the analysis of the  $\text{Cd}_x\text{Zn}_y\text{Mn}_z\text{Te}$  etc. results, but that for the cases with  $E_g \leq 1.5$  ev a

Bloembergen-Rowland type of interaction needs to be included in order to explain the experimental values of  $T_g$  and  $\theta$ . (Edited author abstract) 21 refs.

Manhas, S. (Univ of Ottawa, Ottawa, Ont, Can); Khulbe, K.C.; Beckett, D.J.S.; Lamarche, G.; Woolley, J.C. *Phys Status Solidi B* v 143 n 1 Sep 1987 p 267-274.

**093614 WAVELENGTH AND TEMPERATURE DEPENDENCE OF THE FARADAY EFFECT IN  $\text{Cd}(1-x)\text{Mn}(x)\text{Te}$ .** The wavelength dependence of the Faraday effect at fixed temperature and the temperature dependence at fixed wavelength have been measured in  $\text{Cd}(0.55)\text{Mn}(0.45)\text{Te}$ . These results can be explained using a simple exciton model and the known temperature dependence of the magnetic susceptibility and exciton energy. (Edited author abstract) 13 refs.

Butler, M.A. (Sandia Natl Lab, Albuquerque, NM, USA). *Solid State Commun* v 62 n 1 Apr 1987 p 45-47.

**093615 DAMAGE STUDY AND PHYSICAL PROPERTIES OF ION IMPLANTED  $\text{Cd}_{0.7}\text{Hg}_{0.3}\text{Te}$  PROCESSED BY FURNACE AND RAPID THERMAL ANNEALING.** Ion implantation of In, Ar and Xe was carried out on p-type  $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$  ( $x = 0.7$ ) and followed by both furnace annealing (FA) in the presence of Hg vapour and rapid thermal (RTA) on encapsulated crystals. Rutherford backscattering spectroscopy and photoluminescence experiments show that the implantation damage is removed by FA at 400°C for 1 h or RTA at 380°C for 10 s. The In-implanted profile obtained by SIMS exhibits a diffusion broadening following FA, while the In atomic distribution is very little affected by RTA. Sheet Hall-effect measurements indicate that following FA at 300 and 400°C electron conductivity appears and is associated with some activation of the In and with implantation-induced defects. RTA, which removes the defects very well, does not lead to any n-type conversion that could be related to the absence of a Hg external phase. (Author abstract) 15 refs.

Uzan, C. (CNRS, Meudon, Fr); Marfaing, Y.; Legros, R.; Kalish, R.; Richter, V. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987; Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 744-748.

## Plasmas

**093616 PICOSECOND PLASMA DYNAMICS AND ALL-OPTICAL DATA PROCESSING.** Using time resolved pulse and probe spectroscopy, the transmission modulation of CdSe platelets is investigated under excitation and generation of a dense electron-hole plasma. Induced absorption is related to exciton screening, band-gap renormalization, and energy relaxation in a high density electron-hole plasma. These investigations also are of interest from the point of view of optical signal processing because an all-optical picosecond inverter gate and more generally a many input NOR gate can be built based on the induced absorption which occurs in the presence of a dense electron-hole plasma. The operation of such a device is described and discussed in relation with the possible development of optical coprocessors (compatible with a parallel processing of data) and especially in relation with the critical problem of associating and cascading optical NOR gates. (Edited author abstract) 25 refs.

Collet, J.H. (INSA, Toulouse, Fr); Pugno, M. *Phys Status Solidi B* v 146 n 1 Mar 1988 p 393-401.

## Pressure Effects

**093617 PRESSURE DEPENDENCE OF THE BOWING PARAMETER OF DIRECT BAND GAP OF  $\text{CdSe}_x\text{Te}_{1-x}$ .** The variation of the lowest direct band gap of compounds  $\text{CdSe}_x\text{Te}_{1-x}$  with hydrostatic pressure has been measured by photoluminescence at room temperature. This allowed determination of pressure dependence of the bowing parameter. Our data compared to theoretical calculations based on the dielectric model indicates that the average ionic potential is constant with pressure.

This result has been previously assumed in the calculation of energy-band pressure coefficients and proved fundamental for the agreement with experimental values for a wide variety of semiconductors. (Author abstract) 12 refs.

Lemos, V. (Inst de Fisica 'Gleb Wataghin'-UNICAMP, Campinas, Braz); Moro, J.R.; de Souza, Q.A.G.; Motisuke, P. *Solid State Commun* v 60 n 11 Dec 1986 p 853-856.

## Pressure Measurement

**093618 OPTICAL ABSORBANCE MEASUREMENT OF EQUILIBRIUM PARTIAL PRESSURES OVER CdTe MELT.** Equilibrium partial pressures over CdTe melt at different temperatures have been determined by means of optical absorbance measurements. The authors' results at the liquidus temperature of CdTe are compared with those obtained by R.F. Brebrick. (Author abstract) In Chinese. 5 refs.

Sang Wenbin (Shanghai Univ of Science & Technology, China); Zhou Shuquan; Wu Wenhai. *Hongwai Yanjiu, A-Ji* v 6 n 6 1987 p 451-455.

## Radiation Effects

**093619 CATHODOLUMINESCENCE FROM LOW-ENERGY BOMBARDMENT OF CdS.** An enhancement of the green-edge emission in polycrystalline CdS films after low-energy electron bombardment has been observed. The opposite behavior occurred in CdS single crystals. Both thermal and athermal processes (including ejection and diffusion of species) have been accounted for in explaining the cathodoluminescence modulation under the action of electron bombardment. (Author abstract) 9 refs.

Achour, S. (Univ of Constantine, Algeria). *Phil Mag Lett* v 57 n 3 Mar 1988 p 177-182.

**093620 EFFECT OF ELECTRON IRRADIATION ON THE NEAR-SURFACE PROPERTIES OF CADMIUM SULFIDE MONOCRYSTALS.** Low-resistance cadmium sulfide monocrystals are investigated from the chip side, from an etched surface, and from a proton-implanted surface ( $E_p = 150$  keV). (Author abstract) 11 refs.

Bogdankevich, O.V.; Borisov, N.A.; Dyukov, V.G.; Mityukhlyayev, V.B.; Faifer, V.N.; Shustov, A.V. *Bull Acad Sci USSR Phys Ser* v 51 n 3 1987, Mater of the Fifth All-Uni Symp on Scanning Electron Microsc and Anal Methods for Invest Solids, Zvenigorod, USSR, May 1986 p 20-24.

## Recrystallization

**093621 ANOMALOUS HALL EFFECT FOR n-TYPE  $\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$  GROWN BY THE SOLID STATE RECRYSTALLISATION TECHNIQUE.** Curves showing the anomalous Hall coefficient versus temperature have been obtained for thick low-doped n-type  $\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$  samples grown by the solid state recrystallization technique. These curves have a lower value of the Hall coefficient at 77 K than at very low temperature, contrary to classical predictions. These results are modelled in terms of a p-type core sandwiched between two n-type surface regions and, using this, the curves are analyzed to obtain the properties of the n-type surface region. (Author abstract) 11 refs.

Basson, J.H. (CSIR, Pretoria, S Afr); Booyens, H. *Semicond Sci Technol* v 3 n 2 Feb 1988 p 150-153.

**Spectroscopic Analysis** See Also SEMICONDUCTING GALLIUM ARSENIDE—Spectroscopic Analysis.

**093622 STUDY OF THE FUNDAMENTAL ABSORPTION EDGE OF  $\text{Cd}_{1-x}\text{Mn}_x\text{Te}$ .** The measurements of the fundamental absorption edge in  $\text{Cd}_{1-x}\text{Mn}_x\text{Te}$  for  $x=0.007, 0.20, 0.30, 0.45$  in the temperature range 10 to 300 K by transmission are reported and discussed. It is shown that the variation of energy gap with temperature is linear, and the temperature coefficient of the energy gap



is negative and strongly depends on the composition of the  $\text{Cd}_{1-x}\text{Mn}_x\text{Te}$  mixed crystals. (Author abstract) In Chinese. 4 refs.

Chen, Chenjia (Peking Univ, China); Wang, Xuezhong; Liu, Jizhou; Liu, Caixia; Galazka, R.R. *Hongwai Yanjiu A-JI* v 6 n 5 1987 p 359-362.

**093623 DEEP LEVEL STRUCTURE AND COMPENSATION MECHANISM IN IN-DOPED CdTe CRYSTALS.** Deep Level Transient Spectroscopy (DLTS) and Optical Deep Level Transient Spectroscopy (ODLTS) experiments have been conducted on a series of In-doped CdTe crystals grown by the Bridgman or the travelling heater (ThM) methods using Te as the solvent. The THM samples are n-type but strongly compensated. Annealing at 700°C under high Cd vapor pressure leads to a decompensation of the crystals. The electron concentration is then a measure of the donor (In) concentration, which was in the range  $3 \times 10^{16}$ – $1.5 \times 10^{18} \text{ cm}^{-3}$ . Six and eight electron traps are, respectively detected in the non-annealed and annealed samples at a concentration level  $10^2$ – $10^3$  times below the net electron concentration. They cover the energy range 0.2–0.8 eV. Similar traps are found in both types of crystals, the concentration of which increases with In content and after annealing. (Edited author abstract) 30 refs.

Ido, T. (CNRS, Principal, Fr); Heurtel, A.; Triboulet, R.; Marfaing, Y. *J Phys Chem Solids* v 48 n 9 1987 p 781-790.

**093624 PICOSECOND TIME-RESOLVED LUMINESCENCE OF LOCALIZED EXCITONS IN  $\text{CdS}_{1-x}\text{Se}_x$ .** We present time-resolved luminescence results on  $\text{CdS}_{0.3}\text{Se}_{0.64}$  which give a new insight on the kinetics of excitons localized by alloy potential fluctuations. By exciting in the localized exciton band with detection close to the exciting wavelength we obtain the lifetime across the band. Below the exciting laser energy two processes contribute to luminescence: transfer of localized excitons by tunnel effect assisted by acoustical phonons, and luminescence (assisted by acoustical phonons) of all the states excited at time  $t=0$  either directly or through their acoustical absorption wing. The time behavior of luminescence with respect to the detuning from the exciting energy helps to discriminate between those two contributions. Furthermore it shows that intermediate long-living states are involved in the exciton relaxation process. (Author abstract) 13 refs.

Gourdon, C. (Univ Paris VII, Paris, Fr); Lavallard, P.; Permogorov, S.; Reznitsky, A.; Aaviksoo, Y.; Lippmaa, Y. *J Lumin* v 39 n 2 Dec II 1987 p 111-116.

**093625 COMPOSITIONAL DEPENDENCE OF INFRARED PHONON PARAMETERS FOR  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ .** The full set of Lorentzian oscillator parameters describing the two-mode phonon behavior in  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  is reported. A new analysis of reflectivity spectra combined with existing results gives the most accurate available values for the CdTe-like and HgTe-like transverse optical frequency, strength and (for the first time) damping constant vs CdTe fraction  $x$  at room, liquid nitrogen and liquid helium temperatures. Polynomial fits vs  $x$  for each parameter are provided for use in characterizing  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  and the HgTe-CdTe superlattice. (Author abstract) 26 refs.

Rajavel, D. (Emory Univ, Atlanta, GA, USA); Perkowitz, S. *J Electron Mater* v 17 n 1 Jan 1988 p 25-27.

**093626 MAGNETO-OPTICAL SPECTROSCOPY OF DONOR BOUND ELECTRONS IN  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ : VOIGT AND FARADAY GEOMETRY.** We report the observation of the Voigt geometry impurity transition ( $|000+\rangle \rightarrow |101+\rangle$ ) in n-type  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  ( $x=0.237$  and  $x=0.270$ ). The transition energies agree with the non-parabolic theory of hydrogenic donors when central cell effects are included. Measurements of the Faraday geometry ( $|000+\rangle \rightarrow |110+\rangle$ ) transition are also reported. This work provides evidence for the condensation of electrons onto ionized donors in magnetic fields above the Mott-Anderson metal-insulator transition in  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ . (Edited author abstract) 16 refs.

Choi, J.B. (Univ of Maryland, College Park, MD, USA); Kim, L.S.; Drew, H.D. *Solid State Commun* v 65 n 6 Feb 1988 p 547-551.

**093627 PICOSECOND LUMINESCENCE OF EXCITONS LOCALIZED BY DISORDER IN  $\text{CdS}_x\text{Se}_{1-x}$ .** We have investigated in  $\text{CdS}_x\text{Se}_{1-x}$  and in pure CdSe the temporal evolution of the excitonic luminescence with 20 ps time resolution. In CdSe and in alloys with  $x < 0.15$  the onset and decay of the luminescence can be described by time constants which are independent of the photon energy in the region of the free and bound excitons. In contrast, the time constants vary strongly over the main emission band for  $x > 0.15$ , which is attributed to the relaxation of excitons localized by compositional disorder. A simplified hopping model is presented which accounts for the experimental findings. (Author abstract) 24 refs.

Shevel, S. (Philipps-Univ Marburg, Marburg, West Ger); Fischer, R.; Goebel, E.O.; Noll, G.; Thomas, P.; Klingshirn, C. *J Lumin* v 37 n 1 Apr 1987 p 45-50.

**093628 THERMAL IONISATION AND PHOTOIONISATION PROPERTIES OF DEEP TRAPS IN N TYPE CdTe.** Physical properties of some native deep electron traps in n type CdTe have been investigated by means of capacitance techniques. Using D.L.T.S. measurements, 4 levels labelled  $E_1$  to  $E_4$  have been detected with apparent ionisation energies in the range of 0.24–0.88 eV and unusually small electron capture cross sections  $\sigma_c \approx 10^{-20} \text{ cm}^2$ . Deep Level Optical Spectroscopy (D.L.O.S.) has been used to measure the spectral dependence of the photoionisation cross section of the defects. Interpretation is made in terms of one dimensional configuration coordinate diagrams. From these, it is concluded that levels  $E_2$   $E_3$   $E_4$  are weakly relaxed while level  $E_1$  is strongly coupled to the lattice. (Edited author abstract) 10 Refs.

Debbag, F. (CNRS, Montpellier, France); Bastide, G.; Rouzeyre, M. *Solid State Commun* v 67 n 1 Jul 1988 p 1-5.

**093629 RAMAN SCATTERING IN  $\text{Cd}_{1-x}\text{Mn}_x\text{Se}$  UNDER HYDROSTATIC PRESSURE.** The behaviour of phonons in the mixed crystals  $\text{Cd}_{1-x}\text{Mn}_x\text{Se}$  ( $0 \leq x \leq 0.45$ ) in the wurtzite phase is investigated by Raman scattering under hydrostatic pressure. The measurements are reported while increasing as well as decreasing the pressure. Mixed crystals of all the compositions as well as pure CdSe undergo a phase transition to NaCl structure between 22 and 29 kbar depending on the composition. The reverse transitions occur at much lower pressures indicating hysteresis. In mixed crystals with  $x \geq 0.40$ , a new Raman peak appears under hydrostatic pressure which lies between CdSe-like longitudinal optical (LO) phonon and MnSe-like transverse optical (TO) phonon. The new mode behaves in a manner similar to other zone-center optical phonons and continues to exist even when the pressure is fully released after cycling through the phase transition. Zone-boundary acoustic phonons are found to exhibit softening. (Author abstract) 21 Refs.

Arora, Akhilesh K. (Indira Gandhi Cent for Atomic Research, Kalpakkam, India); Ramdas, A.K. *Indian J Pure Appl Phys* v 26 n 2-3 Feb-Mar 1988 p 182-187.

**093630 PHOTOACOUSTIC SPECTROSCOPY OF CdTe AND (Hg, Cd)Te.** The photoacoustic (PA) spectroscopy using a piezoelectric PZT transducer attached to the sample is shown to be successfully employable also for small gap II-VI semiconductor bulk crystals and epilayers both in the low- and high-absorption region. The PA measurements of CdTe and (Hg, Cd)Te mixed crystals carried out at room temperature yield information about the quality and composition of the samples, respectively. Especially, the PA spectroscopy can be used to study the exciton absorption region of a layer also in the case of a substrate with smaller energy gap, as demonstrated for CdTe epilayers on GaAs as an example. (Author abstract) 13 Refs.

Goede, O. (Humboldt-Univ zu Berlin, Berlin, East Ger);

Heimbrot, W.; Koepp, Th. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 443-447.

**093631 SPATIAL ORIGIN OF VARIOUS PL LINES IN CdTe AT 77 K.** We report on the spatial origin of the exciton and defect photoluminescence lines in CdTe at 77 K. A scanning electron microscope was used to obtain images of cathodoluminescence that was spectrally resolved with the help of optical filters. We observe that the exciton and the defect luminescence lines originate from different spatial locations on the sample. The exciton line itself appears to originate from two different locations, one of which is clustered dislocations. These results question the validity of the generally accepted criterion that a large ratio of exciton to defect emission in the luminescence spectrum of CdTe at 77 K implies good crystal quality. (Author abstract) 8 refs.

Bubulac, L.O. (Rockwell Int Science Cent, Thousand Oaks, CA, USA); Bajaj, J.; Tennant, W.E.; Newman, P.R.; Lo, D.S. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 536-543.

**093632 PHOTOLUMINESCENCE SPECTROSCOPY OF EXCITONS FOR EVALUATION OF HIGH-QUALITY CdTe CRYSTALS.** Near band-edge photoluminescence spectra are presented for a variety of CdTe samples. The relationship between sample quality and exciton emission spectra is discussed. Time-resolved spectroscopy, excitation spectroscopy, and power-dependence of photoluminescence are reported. The change in exciton photoluminescence power dependence with excitation wavelength indicates that the superlinear power dependence is due to the formation of excitons from photoexcited electrons and holes. (Author abstract) 13 refs.

Cooper, Donald E. (Rockwell Int Science Cent, Thousand Oaks, CA, USA); Bajaj, J.; Newman, P.R. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 544-551.

**093633 OPTICAL NONLINEARITIES AND BISTABILITIES IN HIGHLY PHOTO-EXCITED II-VI COMPOUNDS.** In this contribution we are reviewing recent results of our research group on nonlinear optical spectroscopy of semiconductors, using CdS as model substance. We are treating spectroscopy with laser-induced gratings and some pump-and-probe beam experiments in some detail and we shortly mention the application of the nonlinearities in optical bistability as well as results obtained for mixed  $\text{CdS}_{1-x}\text{Se}_x$  crystals. 13 refs.

Klingshirm, C. (Univ Frankfurt, Frankfurt am Main, West Ger); Becker, U.; Gogolin, O.; Kunz, M.; Lyssenko, V.G.; Majumder, F.A.; Oberhauser, D.; Renner, R.; Rinker, M.; Schwab, H.; Shevel, S.; Swoboda, H.-E.; Weber, C.; Wegener, M.; Witt, A. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 64-67.

**093634 RECOMBINATION CROSS SECTION-ELECTRON ENERGY RELATION OF THE  $(e_A)$  EMISSION IN CdTe:Li.** By means of the effective mass approximation, the recombination cross section-electron energy relation of the free electron-acceptor emission in CdTe:Li has been studied. This relation has been compared with the relative theory. (Author abstract) 7 refs.

Liu, Junye (Acad Sinica, Changchun, China); Xu, Xurong. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 141-142.

**093635 GROWTH AND PHOTOLUMINESCENCE OF CdTe SINGLE CRYSTALS.** High-purity CdTe single crystals with near stoichiometry and many Cd vacancies were grown using a sublimation method under controlled partial pressure of cadmium or tellurium, respectively. The very strong peaks of exciton emission for



the former and a broad emission band for the latter are observed by photoluminescence at 10K. The broad emission band is considered to arise from the formation of  $V_{Cd}$  complexes. (Author abstract) 3 refs.

Huang, Ximin (Acad Sinica, Changchun, China); Lin, Ge; Jing, Yumei. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 377-378.

**093636 ISOTOPE SHIFT OF EMISSION AND ABSORPTION LINES AT  $CdS:Ni^{2+}$ : INTERPRETATION BY A DYNAMIC JAHN-TELLER EFFECT.** Isotope effects of the emission and absorption lines of the  $3 T_1(P) \rightarrow 3 T_1(F)$  and  $3 A_2(P) \rightarrow 3 T_1(F)-Ni^{2+}$  transitions in CdS are investigated. The fine structures of these lines are interpreted by an intermediate Jahn-Teller effect at the  $3 T_1(P)$  and  $3 T_1(F)$  state. The calculated isotope shifts agree with the theory and the experiment. (Author abstract) 3 refs.

Scherz, Udo (Inst fuer Theoretische Physik, Berlin, West Ger); Hoffmann, Axel; Nestler, Bodo; Xu, Lun Biao. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 411-412.

**093637 TEMPERATURE DEPENDENT DAMPING DISPERSION OF EXCITONIC POLARITONS IN CdS.** The damping dispersion  $\Gamma(\omega)$  is determined by analysing transmission spectra of CdS at temperatures between 2 and 30 K. It is shown that the low energy side of the spectrum is governed by temperature independent impurity scattering of lower branch polaritons. For the high energy side phonon scattering is the dominant process, especially at higher temperatures. (Author abstract) 4 refs.

Pantke, Karl-Heinz (Technische Univ Berlin, Berlin, West Ger); Broser, Immanuel. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 499-500.

**093638 LUMINESCENCE OF HIGHLY EXCITED CdS.** We measure the emission spectra of single crystal CdS from  $10^6 W/cm^2$  to  $10^7 W/cm^2$  excitation intensity at 4.2K, and observe a new luminescence peaking at 4910 Angstrom after the excitation intensity increases to  $1.0 \times 10^7 W/cm^2$ . (Author abstract) 4 refs.

Liu, Xianping (Acad Sinica, Changchun, China); Bao, Qingcheng; Dai, Rensong; Xu, Xurong. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 521-522.

**093639 OPTICAL NONLINEARITY DUE TO INCREASED ABSORPTION IN CdS AT ROOM TEMPERATURE.** In this paper two types of optical nonlinearity in CdS crystal platelets due to the increased absorption with increasing incident intensity at room temperature (RT) are reported. The experiments reveal their origin. One is ascribed to the effect of lattice heating in the transmission of a laser tuned around the exciton in CdS. The other is ascribed to the absorption band of exciton-electron (Ex-EI) scattering moving towards the low energy direction under high excitation. 2 refs.

Yang, Fang (Acad Sinica, Changchun, China); Li, Duoli; Tian, Nailiang; Xiong, Guangnan; Xu, Xurong. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 527-528.

**093640 PICOSECOND COHERENT LIGHT SCATTERING IN THE EXCITON-BIEXCITON RESONANCE OF CdSe.** Time resolved degenerate four-wave mixing in CdSe shows a strong nonlinear resonance  $\approx 5 meV$  below the free exciton energy. It is ascribed to the induced exciton-biexciton transition. In the resonance, we determine the nonlinear susceptibility  $\chi(3) \approx 3 \times 10^{-9} cm^2/v^2$ . At 4.2K and low exciton densities, the phase coherence time of the transition is  $T_2 \approx 27 ps$ , decreasing with increasing density and temperature. (Author ab-

stract) 5 refs.

Hvam, J.M. (Odense Univ, Odense, Den); Balslev, I.; Dornfeld, C. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 529-530.

**093641 OPTICAL GAIN IN THE D-A LUMINESCENCE OF  $CdIn_2S_4$ .** Under high intensity extrinsic excitation, optical gains of the order of a few  $cm^{-1}$  are observed for the donor-acceptor emission band of compensated  $CdIn_2S_4$ . This is related to the onset of photoconductivity and photoluminescence saturation under the same excitation conditions. (Author abstract) 5 refs.

Fortin, E. (Univ of Ottawa, Ottawa, Ont, Can); Beauvais, J. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 531-532.

**093642 NONLINEAR REFRACTION OF GAUSSIAN LASER BEAMS IN CdS AT  $\lambda = 532 nm$ .** Self-defocusing experiments in CdS at  $\lambda = 532 nm$  are performed at temperatures just above room temperature. From the experiments we exclude that the dominant mechanism for the nonlinear refraction is of thermal origin. We estimate a nonlinear susceptibility of  $\chi(3) = 2.9 \cdot 10^{-7}$  (e.s.u.) in good agreement with a model based on generation of carriers by single-photon absorption. (Author abstract) 4 refs.

Petersen, Paul Michael (Technical Univ of Denmark, Lyngby, Den). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 533-534.

**093643 DYNAMICS AND SPATIAL DISTRIBUTION OF EDGE LUMINESCENCE GENERATORS IN CdS FROM TIME-RESOLVED EXCITATION SPECTROSCOPY.** Although donor-acceptor (D-A) recombination emission in semiconductors is reasonably well understood, the processes contributing to the photo-production of the  $D^0-A^0$  generators have not been adequately explored. We present here results of our studies at liquid helium temperatures of sub-microsecond time-resolved excitation spectroscopy of D-A emission carried out on pure, un-doped n-type CdS crystals of very different compensation, providing different electric field strengths near the surfaces. 6 refs.

Jiang, H.X. (Syracuse Univ, Syracuse, NY, USA); Baum, D.; Honig, A. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 557-558.

**093644 PICOSECOND STUDY ON THE VALENCE HOLE INTER-BAND TRANSITION IN CdS SINGLE CRYSTAL.** The photoluminescence spectra and picosecond decay dynamics of highly excited CdS crystal at different polarized states have been investigated. The valence band hole inter-band relaxation has been found, and the theoretical discussions are given. (Author abstract) 5 refs.

Qi, Jifa (Acad Sinica, Changchun, China); Shi, Ke; Xiong, Guangnan; Xu, Xurong. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 575-576.

**093645 RAMAN SCATTERING OF CdS AND  $CdS_xSe_{1-x}$  MICROCRYSTALS IN THE GLASS MEDIUM.** Two-mode behavior of  $CdS_xSe_{1-x}$ , the surface phonon mode of CdS microcrystals in the glass medium and the pressure effect of the glass medium on CdS microcrystals were observed. CdS and  $CdS_xSe_{1-x}$  microcrystals in the glass medium were grown in a multicomponent silicate glass in which the semiconductor phase of concentration of about 1% was dissolved during the synthesis. At the secondary heat treatment of the glass samples, nucleation and growth of semiconductor microcrystals occurred as a result of a diffusive phase decomposition of the super-saturated solid solution. The average size of the microcrystals enlarged as the heat treatment time increasing. The heat temperature is  $680^\circ C$ . 4 refs.

Zhou, Fangce (Acad Sinica, Changchun, China); Sun, Yunfeng; Pan, Jinsheng. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 739-740.

**093646 SPECTRAL PROPERTIES OF  $CdS(Se)$  MICROCRYSTALLITES IN AMORPHOUS MEDIA.** The absorption, excitation, and emission spectra of selenium ruby glasses the same doped but differently reheated are measured. The temperature dependences are also obtained. Some new phenomena have been observed. Comparing these results with those of CdS(Se) crystal, we put forward the mechanism of emission. (Author abstract) 6 refs.

Zhang, Jinshan (Acad Sinica, Shanghai, China); Gan, Fuxi; Qi, Changhong. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 741-742.

**Spectrum Analysis** See Also SEMICONDUCTING GERMANIUM—Spectrum Analysis; SEMICONDUCTOR DIODES, PHOTODIODE—Spectrum Analysis; SEMICONDUCTOR MATERIALS—Spectrum Analysis.

**093647 LOCAL AND QUASI-LOCAL MODES OF Zn IN CdTe.** The far infrared absorption and reflection spectra of the mixed crystals  $Zn_xCd_{1-x}Te$  with small x in the temperature range of 4.2-300K and the frequency region of  $20-350 cm^{-1}$  are reported. The local and quasi-local modes induced by Zn and ZnTe in CdTe and the CdTe-like 2TA two-phonon absorption are observed for the first time. The frequencies of the modes are estimated by use of the mass-defect model combined with Green's function method. The random element-isodisplacement (REI) model is used to calculate the two-mode-behaviors of the mixed crystals and to fit the reflection spectra. Besides, the temperature dependence of the phonon absorption is calculated and well explained. (Author abstract) 5 refs.

Lu, Wei (Acad Sinica, Shanghai, China); Ye, Hongjuan; Yu, Zhiyi; Zhang, Suying; Fu, Ying; Xu, Wenlan; Shen, Xuechu. *Chin J Infrared Res Ser B (Engl Ed)* v 6 1987 p 47-54.

**Structure** See SEMICONDUCTING SILICON—Structure; SEMICONDUCTING ZINC COMPOUNDS—Structure.

## Surfaces

**093648 STUDY ON WORK FUNCTION OF THE {0001} FACES OF CdS CRYSTAL - III. EFFECT OF THE IRRADIATION WITH RED LIGHT.** By means of a highly sensitive thermistor (sensitivity:  $10^{-3}^\circ C$ ) as well as a Kelvin electrode of NESA glass with a detection sensitivity of several mv, the contact potential difference and the temperature of a crystal were measured with respect to CdS polar surfaces. It was confirmed that when a photoconducting crystal is irradiated at room temperature by weak light with bulk excitation for a certain time and then interrupted, the temperature drop and rapid decrease in the electric conductivity of the crystal causes a pyroelectric charge on the polar surface. (Edited author abstract) 5 refs.

Sasaki, Kazuo (Hiroaki Univ, Hiroaki, Jpn). *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1467-1469.

**093649 CORRELATION OF FERMI LEVEL SHIFT WITH PHOTOVOLTAGES AT RUTHENIUM-MODIFIED CdTe SURFACES.** The effect of ruthenium surface modification is shown to considerably improve the properties of CdTe-based photoelectrochemical (PEC) solar cells. Contact potential difference (CPD) measurements on n- and p-CdTe show shifts in surface Fermi level in opposite directions corresponding to an increase in barrier height in each case. The magnitudes of



the changes in CPD are approximately equal to the increase of open-circuit voltage,  $V_{oc}$ , observed in photoelectrochemical cells. (Author abstract) 10 refs.

Mandal, K.C. (Jadavpur Univ, Calcutta, India); Basu, S.; Bose, D.N. *CHEMTECH* v 17 n 8 Aug 1987 p 559-561.

**093650 SURFACE PHOTOVOLTAGE SPECTROSCOPY FOR REAL N- AND P-TYPE (110) CdTe SURFACES IN THE VISIBLE AND NEAR INFRA-RED SPECTRAL RANGE.** Surface photovoltage spectroscopy has been carried out on real n- and p-type (110) CdTe surfaces in the wavelength range 0.36-1  $\mu$ m at room temperature (300 K), and at atmospheric pressure. The measurements show the existence of surface states at 1.3; 1.48, and 1.2; 1.46 eV within the energy gap of n- and p-type CdTe, respectively. Surface states greater than the energy gap at 2.24, 2.38, 2.68, and 3.1 eV have also been detected in n-type samples and at 1.66, 2.12, 2.69 eV in p-type samples. (Author abstract) 14 refs.

El-Dessouki, M.S. (Cairo Univ, Giza, Egypt); Attia, V.A. *Appl Phys A* v A45 n 2 Feb 1988 p 175-178.

**093651 SURFACE DERIVATIZATION AND ISOLATION OF SEMICONDUCTOR CLUSTER MOLECULES.** The authors describe a synthesis of nanometer-sized clusters of CdSe using organometallic reagents in inverse micellar solution and chemical modification of the surface of these cluster compounds. In particular we show how the clusters grow in the presence of added reagents and how the surface may be terminated and passivated by the addition of organoselenides. Passivation of the surface allows for the removal of the cluster molecules from the reaction medium and the isolation of organometallic molecules which are zinc blende CdSe clusters terminated by covalently attached organic ligands. Preliminary cluster characterization via resonance Raman, infrared, and NMR spectroscopy, X-ray diffraction, transmission electron microscopy, and size-exclusion chromatography is reported. (Author abstract) 10 refs.

Steigerwald, M.L. (AT&T Bell Lab, Murray Hill, NJ, USA); Alivisatos, A.P.; Gibson, J.M.; Harris, T.D.; Kortan, R.; Muller, A.J.; Thayer, A.M.; Duncan, T.M.; Douglass, D.C.; Brus, L.E. *J Am Chem Soc* v 110 n 10 May 11 1988 p 3046-3050.

**093652 PHASE TRANSITIONS IN SUBSURFACE LAYERS OF CdS IN MECHANICAL POLISHING AND VARIOUS ANNEALING TREATMENTS.** The structure of the surface of CdS after mechanical polishing, chemical etching, annealing and electron irradiation was examined by electron diffraction in the reflection regime. The results show that mechanical polishing is accompanied by the phase transformation  $\alpha$ -CdS  $\rightarrow$   $\beta$ -CdS phase transition in the thin subsurface layer. Annealing and electron irradiation are accompanied by the reverse transition. (Author abstract)

Koba, E.S.; Kostin, N.N.; Kryukova, I.V.; Lotsko, D.V.; Mil'man, Yu.V.; Torchun, N.M. *Phys Chem Mater Treat* v 21 n 6 Nov-Dec 1987 p 611-614.

**093653 EVIDENCE FOR ADDUCT FORMATION AT THE SEMICONDUCTOR-GAS INTERFACE, PHOTOLUMINESCENT PROPERTIES OF CADMIUM SELENIDE IN THE PRESENCE OF AIMES.** The authors demonstrate that bulk PL from etched or cleaved n-CdSe single crystals is strongly affected by exposing the crystals to a family of gaseous amines. Moreover, the magnitude of the interaction can be correlated with the intrinsic basicity of the amines, thereby evidencing adduct formation with the surface. For etched samples, the PL data are in good agreement with the dead-layer model; cleaved samples exhibit PL properties that do not fit the dead-layer model, indicating that the PL changes arise, at least in part, from changes in surface recombination velocity. We also show that PL changes can be used to construct Langmuir adsorption isotherms. It is also shown that exposure of etched n-CdSe substrates to other volatile classes of compounds can be used to probe the nature of the interactions that perturb the PL (photoluminescence) response. 16 Refs.

Meyer, Gerald J. (Univ of Wisconsin-Madison, Madison, WI, USA); Lisenky, George C.; Ellis, Arthur B. *J Am Chem Soc* v 110 n 15 Jul 20 1988 p 4914-4918.

**093654 SURFACE RECOMBINATION VELOCITY MEASUREMENTS OF CdS SINGLE CRYSTALS IMMersed IN ELECTROLYTES. A PICOSECOND PHOTOLUMINESCENCE STUDY.** The effect of solution composition and concentration on the luminescence decay profile is measured for CdS single crystals immersed in various aqueous solutions. The surface recombination velocity is strongly dependent on the ionic solution composition and concentration. The experimental data are explained in terms of the chemisorption of ions on the CdS surface. (Author abstract). 22 Refs.

Benjamin, D. (Sch of Chemistry, Ramat-Aviv, Isr); Huppert, D. *J Phys Chem* v 92 n 16 0811 1988 p 4676-4679.

**093655 PREPARATION OF STOICHIOMETRIC MERCURY CADMIUM TELLURIDE SURFACES.** A technique involving cathodization of an anodized surface has been proposed as a surface treatment of mercury cadmium telluride substrates in the fabrication of infrared-sensitive devices. The resultant surface was analyzed with X-ray photoelectron spectroscopy and compared with surfaces produced by cleavage, sputtering, and chemical etching. It was found that the cathodized surface had a surface composition close to the bulk stoichiometry. The first monolayer of the surface was enriched in mercury and depleted in cadmium. This surface was also more inert towards air oxidation than the Br-methanol treated surface, probably because of the surface enrichment of mercury. (Author abstract) 8 refs.

North, R.B. (Optotek Ltd, Kanata, Ont, Can); Lau, W.M. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 1044-1046.

**Synthesis See Also SEMICONDUCTING ZINC COMPOUNDS—Synthesis.**

**093656 SYNTHESIS AND DEFECT STRUCTURE OF TWO TYPES OF CADMIUM ANTIMONY OXIDE SEMICONDUCTING CERAMICS.** The synthesizing process and mass transport mechanism of CdO-Sb<sub>2</sub>O<sub>3</sub> ceramics are discussed. Two compounds with stable structure have been obtained and the crystal structures and microstructures are examined by XRD and SEM. A differential scanning calorimeter is used to determine the phase transformation and latent heat. The defect structure of these semiconducting ceramics are investigated by varying the atmosphere, trivalent ion doping, and Seebeck effect experiments. (Author abstract) 8 refs.

Li Biao-Rong (Huazhong Univ of Science & Technology, Wuhan, China). *J Am Ceram Soc* v 71 n 2 Feb 1988 p C.78-C.81.

**093657 SYNTHESIS OF CADMIUM SULFIDE IN SITU IN REVERSE MICELLES AND IN HYDROCARBON GELS.** The synthesis in situ of cadmium sulfide semiconductors in AOT reverse micelles produces smaller and more monodispersed particles than are obtained in Triton reverse micelles or in aqueous solution. When gelatine is added to the previous solution, the semiconductor is entrapped in a hydrocarbon gel and its size remains the same as that obtained in reverse micelles. The size of the sulfide cadmium aggregate formed in AOT hydrocarbon gels is similar to that obtained under similar conditions in AOT reverse micelles. AOT surfactant can play the role of stabilizing agent. However, a more efficient stabilization is obtained by adding to AOT reverse micelles another stabilizing agent such as sodium hexametaphosphate. (Edited author abstract) 27 refs.

Petit, C. (Lab de Structure et Reactivite aux Interfaces, Paris, Fr); Pileni, M.P. *J Phys Chem* v 92 n 8 Apr 21 1988 p 2282-2286.

**Theory See MAGNETIC SEMICONDUCTORS—Theory.**

**Thermal Effects See MAGNETIC SEMICONDUCTORS—Thermal Effects.**

**Thermodynamics**

**093658 THERMODYNAMIC MODEL OF THE GAS TRANSPORT IN A HWE SYSTEM.** A thermodynamic consideration is given of the gas transport in a hot wall epitaxy (HWE) system which involves a compound AB dissociating completely in the gas phase. Evaporation, transport, and kinetic limited regimes can occur in HWE. Only the transport limited mode is considered in this paper. HWE is a half-open epitaxy method permitting a gas flow of dissipation through a defined hole on the locus of the substrate. The results of the computations are discussed with respect to CdTe. (Edited author abstract) 11 refs.

Griesche, J. (Humboldt-Univ Berlin, Berlin, East Ger); Schikora, D. *Phys Status Solidi A* v 105 n 1 Jan 1988 p 189-195.

**Thick Films**

**093659 BURSTEIN EFFECT IN THICK FILMS OF CADMIUM ORTHOSTANNATE (Cd<sub>2</sub>SnO<sub>4</sub>).** The shift in the fundamental optical absorption edge towards higher energy accompanied by a large increase in electrical conductivity and with higher band gap in a semiconductor is termed the 'Burstein Effect'. This letter deals with the shift observed in the optical absorption edge for doped and undoped thick films of Cd<sub>2</sub>SnO<sub>4</sub>. In the case of doped films, the optical absorption edge shifts from 534 to 514 nm, the band gap increases from 2.32 to 2.41 eV and the reflectance decreases from 40 to 20% on going from highly resistive (645 k $\Omega$ ) samples. For the undoped films, the shift is from 528 to 520 nm, the band gap increases from 2.35 to 2.36 eV and the reflectance decreases from 41.5 to 39.5% as the resistance of the sample increases from 10<sup>5</sup> to 10<sup>3</sup> $\Omega$ . 12 refs.

Setty, M.S. (Nat'l Chemical Lab, Poona, India). *J Mater Sci Lett* v 6 n 8 Aug 1987 p 909-911.

**Thin Films See Also PHOTOVOLTAIC CELLS; SOLAR CELLS—Cadmium Sulfide; SOLAR CELLS—Efficiency; SOLAR CELLS—Materials; SOLAR CELLS—Research; SOLAR CELLS—Thin Films.**

**093660 CRYSTALLINE PROPERTIES OF INDOPEDED CdS THIN FILMS.** Polycrystalline indium-doped CdS thin films have been deposited onto glass by vacuum evaporation from two crucibles of CdS and indium. The influence of the indium concentration and the substrate temperature on the morphology and the crystalline properties of the films have been studied. The films crystallize in the hexagonal phase and show a columnar structure perpendicular to the substrate. The grain size increases with the substrate temperature and with the indium concentration. The interplanar spacing between the (002)H planes also increases with the indium concentration, but, when it is higher than  $7 \times 10^{19}$  cm<sup>-3</sup>, indium agglomerates appear in the films. A decrease of the grain size and (002)H interplanar spacing results with further increases in indium concentration. (Author abstract) 23 refs.

Bertran, E. (Univ de Barcelona, Barcelona, Spain); Varela, M.; Lousa, A.; Morenza, J.L. *J Cryst Growth* v 84 n 3 Sep 1987 p 483-488.

**093661 VAPOUR-DEPOSITED CdS FILMS AND THEIR DEPENDENCE ON THE SOURCE MATERIAL.** An investigation has been made of the conditions required for the formation of vapor-deposited CdS thin films with reproducible characteristics suitable for use in photovoltaic solar cells. Cathodoluminescence spectroscopy has been used to provide information on differences in composition between the deposited films and the source material from which they were produced, and particular consideration has been given to the influence of the source



material structure and stoichiometry on the electrical properties of the resultant films. Under identical deposition conditions, four different high-purity sources were shown to produce films with very different electrical characteristics, but by selecting appropriate deposition conditions (substrate temperature and deposition rate) it was found that each material was capable of generating films with the required characteristics. (Author abstract) 11 refs.

Crypt, F.J. (Univ of Hull, Hull, Engl); Hariri, A.; Scott, B.G. *J Mater Sci* v 22 n 10 Oct 1987 p 3745-3748.

**093662 PHOTOELECTRICAL PROPERTIES OF H<sup>+</sup> IMPLANTED CdS THIN FILMS.** The purpose of this work is to study the effect of ion implantation in CdS thin films. This was done from the point of view of improving control of the photoelectrical properties of this compound. Several elements, such as indium, gallium, chlorine, copper and silver, which are commonly used as dopants in CdS, were implanted and were found to have the same effects as classical doping methods. However, hydrogen produced somewhat unexpected results since drastic changes occurred in the photoelectronic properties of the treated CdS films. 9 refs.

Mahdjoubi, L. (CDM, Alger, Algeria); Hadj-Zoubir, N.; Benmalek, M. *Thin Solid Films* v 156 n 2 Jan 30 1988 p L21-L25.

**093663 IN DOPING IN CdTe FILM BY Co-EVAPORATION OF CdTe AND In.** High-dark-conductivity CdTe films have been prepared by co-evaporation of CdTe and In. The conductivity of the films prepared in this study ranged from  $10^{-8}$  to  $10^3 \text{ Scm}^{-1}$ . The film structure was of zinc-blend type with a preferential orientation of the (111) planes parallel to the substrate. Analyzing the film structure by X-ray analysis, it was found that the In atoms were doped substitutionally into the CdTe during the low-concentration doping stage and then doped interstitially during the high-concentration doping stage. The properties of a very-high-conductivity film could be explained by adopting a new periodicity concept of the doped film using a tentative model. (Author abstract) 12 refs.

Suzuki, Tatsuro (Shizuoka Univ, Hamamatsu, Jpn); Ema, Yoshinori; Hayashi, Toshiya. *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 2009-2014.

**093664 OPTO-ELECTRONIC CHARACTERISTICS OF CHEMICALLY DEPOSITED CADMIUM SULPHIDE THIN FILMS.** Cadmium sulfide thin films showing photo-to-dark conductivity ratio up to  $10^9$  and photoconductivity up to  $3 \Omega^{-1} \text{ cm}^{-1}$  for white illumination approximately  $300 \text{ W m}^{-2}$  can be prepared from chemical baths containing thiourea and triethanolamine complex of cadmium ions. The photocurrent decay time depends on the bath temperature and the duration of storage and it ranges from a few seconds to  $10^4 \text{ s}$  per decade. The optical transmission of the films also varies significantly: from about 10% to 70-80% (above the band-gap absorption), depending on the deposition conditions. The high activation energy  $\approx 1 \text{ eV}$  for dark conductivity as well as the high photosensitivity suggest the nearly stoichiometric nature of the films. The implications of these characteristics in various opto-electronic applications are discussed. (Author abstract) 48 refs.

Nair, P.K. (Univ Nacional Autonoma de Mexico, Morelos, Mex); Campos, J.; Nair, M.T.S. *Semicond Sci Technol* v 3 n 2 Feb 1988 p 134-145.

**093665 HgCdTe THIN FILMS FOR SOLAR CELLS APPLICATION PREPARED BY MULTISOURCE EVAPORATION.**  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  thin films in their cadmium-rich composition were prepared by a multisource evaporation system. In the composition range  $0.05 < 1-x < 0.15$  the films exhibit a forbidden gap between 1.4 and 1.2 eV, close to that corresponding to the theoretical maximum photovoltaic conversion efficiency. In the same composition range they are p type and exhibit a resistivity which varies between  $10^4$  and  $10 \Omega \text{ cm}$ . (Author abstract) 10 refs.

Romeo, N. (CNR, Parma, Italy); Canevari, V.; Zini, L.; Spaggiari, C. *Thin Solid Films* v 157 n 2 Feb 29 1988 p 175-180.

**093666 EFFECT OF SINTERING CONDITIONS ON THE MICROSTRUCTURE AND OPTICAL PROPERTIES OF  $\text{Cd}_{1-x}\text{Zn}_x\text{S}$  FILMS.** Polycrystalline  $\text{Cd}_{1-x}\text{Zn}_x\text{S}$  films were prepared by coating  $(1-x)\text{CdS} + x\text{ZnS}$  slurry on amorphous glass substrates and sintering in nitrogen or nitrogen atmosphere containing  $\text{ZnCl}_2$  vapor to produce films with properties suitable for fabricating all polycrystalline  $\text{Cd}_{1-x}\text{Zn}_x\text{S}/\text{CdTe}$  heterojunction solar cells. The microstructure and optical properties of these films has been correlated with composition,  $\text{CdCl}_2$  which was added as a sintering aid, sintering temperature and atmosphere. By optimizing the preparation conditions, it is possible to produce sintered  $\text{Cd}_{1-x}\text{Zn}_x\text{S}$  films on glass substrate with electrical resistivity less than  $1 \Omega \cdot \text{cm}$  and 15% higher optical transmission than CdS films. (Author abstract) 13 refs.

Park, K.C. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Im, H.B. *J Electrochem Soc* v 135 n 4 Apr 1988 p 993-997.

**093667 ON RAMAN SCATTERING IN Cd-As DISORDERED THIN FILMS.** Room temperature Raman scattering in amorphous films with various Cd:As ratios was studied. The low frequency feature ( $30\text{-}60 \text{ cm}^{-1}$ ) is attributed to Cd-As and Cd-Cd vibrations. The high frequency one ( $200\text{-}260 \text{ cm}^{-1}$ ) is assigned to As-As vibrations. (Author abstract) 6 refs.

Weska, J. (Polish Acad of Sciences, Zabrze, Pol); Burian, A.; Zwick, A.; Renucci, M. *Solid State Commun* v 63 n 2 Jul 1987 p 181-182.

**093668 EFFECT OF THERMAL TREATMENT ON SOME PROPERTIES OF ELECTRODEPOSITED CdS THIN FILMS.** Cadmium sulfide has been used as an excellent material for photoconductors, electroluminescent layers, space charge limited diodes and triodes, photovoltaic devices, etc. An analysis of the influence of the temperature of thermal treatment on the properties of electrodeposited thin films of CdS has been carried out. The transition from cubic to hexagonal phase, and the changes of grain size and resistivity are studied. (Edited author abstract) 16 refs.

Fatas, E. (VAM Madrid, Spain); Herrasti, P. *Mater Chem Phys* v 19 n 4 May 1988 p 315-325.

**093669 ELECTRODEPOSITION OF CdSe FILMS ON  $\text{SnO}_2/\text{F}$  COATED GLASS.** Thin films of CdSe were electrodeposited on transparent and conducting  $\text{SnO}_2/\text{F}$  substrates, and for comparison, on indium-tin-oxide (ITO) substrates, using an aqueous electrolyte at room temperature. The optical properties of the samples were analysed by means of transmittance, reflectance and absorbance measurements. The homogeneity of the CdSe film was found to be strictly related to the sheet resistivity of the substrate. The effect of heat treatments on the optical and structural properties of the samples is discussed. Preliminary results of backwall photoelectrochemical cells using a transparent substrate/CdSe/ $\text{S}-\text{S}^{2-}/\text{Pt}$  configuration are also given. (Author abstract) 17 refs.

Fantini, M.C.A. (UNICAMP, Campinas, Braz); Moro, J.R.; Decker, F. *Sol Energy Mater* v 17 n 4 Jun 1988 p 247-255.

**093670 LOW RESISTIVITY CdS THIN FILMS PREPARED BY SINGLE SOURCE EVAPORATION.** Low resistivity CdS thin films with a thickness of about 4 microns have been deposited on glass substrates by a single source evaporation method. The resistivity was controlled by the amounts of  $\text{In}_2\text{S}_3$  added to the CdS source material. The deposited films were examined by X-ray diffraction, electron probe micro analysis, Hall effect measurements, scanning electron microscopy and optical transmission measurements. (Edited author abstract) 4 refs.

Shih, I. (McGill Univ, Montreal, Que, Can); Qiu, C.X.;

Qiu, S.N.; Choi, W.L. *J Can Ceram Soc* v 60 n 4 Dec 1987 p 67-69.

**093671 OPTICAL AND STRUCTURAL PROPERTIES OF POLYCRYSTALLINE CdSe DEPOSITED ON TITANIUM SUBSTRATES.** We report studies of photoluminescence, Raman scattering and x-ray diffraction performed on CdSe polycrystalline films deposited on titanium substrates by two different methods: chemical deposition and electroplating. We discuss the changes observed in these films as they are subjected to heat treatments. The differences observed in the energy gap of both types of film and their evolution as a function of annealing temperature are tentatively explained in terms of quantum confinement produced by the small grain size of the films. (Author abstract) 25 refs.

Cerdeira, F. (UNICAMP, Campinas, Braz); Torriani, I.; Motisuke, P.; Lemos, V.; Decker, F. *Appl Phys A* v A46 n 2 Jun 1988 p 107-112.

**093672 EFFECT OF BATH TEMPERATURE ON THE OPTOELECTRONIC CHARACTERISTICS OF CHEMICALLY DEPOSITED CAS THIN FILMS.** The temperature of the chemical bath used in the electrodeless deposition of cadmium sulfide thin films has been found to affect the deposition rate, optical transmission T(percentage), film morphology, photoconductivity  $\sigma_{ph}$ , photoconductivity to dark conductivity ratio  $\sigma_{ph}/\sigma_d$  and photocurrent decay time  $\tau_{ph}$ . The results pertain to CdS films deposited from aqueous chemical baths containing a triethanolamine complex of  $\text{Cd}^{2+}$  ions and thiourea, in which  $\text{Cd}^{2+}$  and thiourea were mixed in 1:0.5 and 1:0.25 molar ratios. As the bath temperature was raised from 30 to 85°C, the time required to deposit a thin film, of about 0.5  $\mu\text{m}$  thickness, from the 1:0.5 bath was reduced from 480 to 18 min and that from the 1:0.25 bath was reduced from 1320 to 25 min. Systematic variations in the optoelectronic characteristics were also observed as functions of bath temperature. (Edited author abstract). 28 Refs.

Nair, M.T.S. (Univ Nacional Autonoma de Mexico, Morelos, Mex); Nair, P.K.; Campos, J. *Thin Solid Films* v 161 Jul 1988 p 21-34.

**093673 PREPARATION, ELECTRICAL PROPERTIES AND OPTICAL CHARACTERIZATION OF  $\text{Cd}_2\text{SnO}_4$  AND  $\text{CdIn}_2\text{O}_4$  THIN FILMS AS TRANSPARENT AND CONDUCTIVE COATINGS.** Transparent and conductive  $\text{Cd}_2\text{SnO}_4$  and  $\text{CdIn}_2\text{O}_4$  thin films have been prepared by reactive sputtering from Cd-Sn and Cd-In alloy targets in an  $\text{Ar}+\text{O}_2$  atmosphere. Electrical conductivities of the order of  $10^5 \Omega^{-1} \text{ m}^{-1}$  with the optical transmission as high as 90% were easily attained. Hall and thermoelectric power measurements indicate that charged point defects are responsible for the scattering of conduction indicate that charged point defects are responsible for the scattering of conduction electrons. The optical constants of the films were computed from the transmission and reflection measurements in the visible and near-IR spectral ranges using a special procedure based on a model of an inhomogeneous film with a rough surface. (Author abstract) 18 refs.

Pisarkiewicz, T. (Acad of Mining & Metallurgy, Cracow, Pol); Zakrzewska, K.; Leja, E. *Thin Solid Films* v 153 Oct 26 1987, Pap Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 479-486.

**093674 LUMINESCENCE AND PARTICLE SIZE IN MICROCRYSTALLINE CdTe THIN FILMS.** The structure of as-grown and thermally annealed microcrystalline CdTe thin films, prepared by a hot wall close-spaced vapor transport technique, has been analyzed by photoluminescence, and the results compared with those obtained with several other techniques. We found that, among all the techniques used to examine the crystalline quality of the CdTe films, photoluminescence is the most sensitive to the presence of generic defects. Heat treatment increases the average particle size from 500 Angstrom in the as-grown sample to 10000 Angstrom



after annealing at 550°C for 1 h. Nevertheless, the changes observed in the photoluminescence due to annealing can be accounted for, not in the basis of a microcrystalline particle size, but in terms of the average distance between defects. (Author abstract) 12 refs.

Mendoza-Alvarez, J.G. (Inst Politecnico Nacional, Mexico City, Mex); Gonzalez-Hernandez, J.; Sanchez-Sinencio, F.; Zelaya, O.; Chao, S.S. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 391-395.

**093675 MICROCRYSTALLINE GRAIN SIZE GROWTH IN  $\text{Cd}_{0.95}\text{Fe}_{0.05}\text{Te}$  THIN FILMS.** In this work we have studied the growth of the microcrystalline grains in  $\text{Cd}_{0.95}\text{Fe}_{0.05}\text{Te}$  thin films, with mixed phases of amorphous and polycrystalline material, as a function of isochronal thermal annealing at different temperatures. We have found that for annealing temperatures  $T_a$  near 300°C, crystallization of the film amorphous phase takes place. The dependence of the room-temperature resistivity and thermal activation energy on the annealing temperature has also been studied and explained in terms of a model that includes grain growth and crystallization of the amorphous phase. 17 refs.

Alvarez-Fregoso, Octavio (Univ Nacional Autonoma de Mexico, Mexico City, Mex); Huanosta, A.; Sanchez-Sinencio, F.; Mendoza-Alvarez, J.G. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 401-409.

**093676 HIGH MAGNETIC FIELD CHARACTERIZATION OF (Hg, Cd)Te SURFACE LAYERS.** A description is given of the use of the Shubnikov-De Haas effect, parallel-field magnetoresistance and cyclotron resonance to give a rather complete characterisation of (Hg, Cd)Te surface accumulation layers. The Shubnikov-De Haas and parallel-field magnetoresistance enable one to distinguish the separate contributions to conductivity from surface layers and bulk, the measure surface carrier densities and very accurately deduce the number of populated subbands. The structures studied are infra-red detector elements passivated with an anodic oxide. We have found that the oxide is sensitive to above band gap UV (approximately 3.3 eV) illumination, which causes a persistent discharge of the oxide surface states below 77 K. This allows us continuously to decrease the surface carrier concentration and make accurate studies of the systematic surface charge density dependence of the subband populations, effective masses and resistance. (Edited author abstract) 29 refs.

Nicholas, R.J. (Clarendon Lab, Oxford, Engl); Nasir, F.; Singleton, J. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 656-666.

**093677 POLYCRYSTALLINE CdSe FILMS FOR THIN FILM TRANSISTORS.** In this paper X-ray, ESCA, TEM and electrical measurements on evaporated CdSe films, used in thin films transistors (TFT), are reported. Special attention has been paid to semiconductor films obtained from recrystallized mixtures of CdSe and 1-2%  $\text{In}_2\text{Se}_3$ . Such films might be represented as  $(3\text{CdSe})_x(\text{In}_2\text{Se}_3)_{1-x}$ . Doping the CdSe evaporation source with In yields 20  $\mu\text{m}$  self-aligned TFTs with excellent characteristics: electron mobility in the evaporated thin films increases from 20-50  $\text{cm}^2/\text{V}\cdot\text{s}$  for undoped films to more than 100  $\text{cm}^2/\text{V}\cdot\text{s}$  for doped films. DC stability behaviour is also improved: the TFT current drop after 180 s is reduced from 30% to less than 5%. (Author abstract) 9 refs.

Van Claster, A. (Ghent State Univ, Ghent, Belg); Vervaeke, A.; De Rycke, I.; De Baets, J.; Vanfleteren, J. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 924-928.

**093678 ION-ASSISTED SPUTTER DEPOSITION OF CdTe LAYERS.** Epitaxial, single-phase CdTe layers

have been deposited on a variety of single-crystal substrates, including freshly cleaved KBr and NaCl and polished  $\text{BaF}_2$ , by ion-assisted, planar, rf magnetron sputtering. The substrate temperature and bias were used as independent, operator-controlled process parameters to greatly enhance the degree of orientation in the films and (or) modify the crystallographic form of the deposited layer. Thus, depending primarily on the substrate temperature and bias, the deposited CdTe films exhibited one of four forms. Compositional analysis revealed no impurities. However, films of all crystallographic phases contained a large density of planar defects such as twins, stacking faults, and low-angle grain boundaries. (Edited author abstract) 8 refs.

Das, S.R. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Rajan, K.; van der Meer, P.; Cook, J.G. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 864-867.

**093679 TRANSMISSION ELECTRON MICROSCOPY CHARACTERIZATION OF THE MICROSTRUCTURE OF  $\text{Cd}_3\text{As}_2$  FILMS PREPARED BY PULSED-LASER EVAPORATION.** Transmission electron microscopy with an analytical X-ray system has been used to investigate  $\text{Cd}_3\text{As}_2$  films prepared by pulsed-laser evaporation. The films were deposited on amorphous substrates at approximately 120°C. They consisted mainly of a fine polycrystalline array. The crystal structure was identified as the body-centered tetragonal form of  $\text{Cd}_3\text{As}_2$ . No other crystallographic phase of  $\text{Cd}_3\text{As}_2$  was observed. Some regions with amorphous or eutectic inclusions were also observed. These results have been correlated with the electrical properties of pulsed-laser evaporated  $\text{Cd}_3\text{As}_2$  films. (Author abstract) 9 refs.

Carpenter, G.J.C. (Canadian Cent for Mineral & Energy Technology, Ottawa, Ont, Can); Dubowski, J.J.; Williams, D.F. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 961-965.

**093680 DEVICE-ORIENTED STUDY OF CdS FILMS DEPOSITED BY A HOT-WALL TECHNIQUE.** A device-oriented study was carried out on thick CdS films (25-30  $\mu\text{m}$ ) suitable for solar-cell applications deposited on glass substrates, using a hot-wall technique at a pressure of  $1 \times 10^{-6}$  Torr (1 Torr = 133 Pa). Films were characterized using X-ray diffraction, scanning electron microscopy, and transmission electron microscopy. The degree of preferred orientation was observed using a simplified version of the Schulz method. Films grown under nominally identical conditions showed two types of growth habit. Front-wall  $\text{Cu}_2\text{S}$ -CdS heterojunctions were made using a hot CuCl dip. Current-voltage characteristics were measured at room temperature. Without optimizing the cell design, open-circuit voltages of 0.45 V and short-circuit currents of 20-30  $\text{mA}\cdot\text{cm}^{-2}$  under AM2 illuminations were observed. (Edited author abstract) 16 refs.

Haque, A. (Univ of Waterloo, Waterloo, Ont, Can); Dixon, A.E.; Brodie, D.E. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 1015-1019.

## Vapor Deposition

**093681 PHOTO-SELECTED II-VI CRYSTAL GROWTH: A STUDY OF LOW TEMPERATURE EPITAXY.** In this paper the limitations to low temperature growth rates of HgTe and CdTe will be considered and in particular the causes of low growth rates below 200°C will be discussed. Epitaxial quality is a particular concern for high performance infrared detectors and has to be carefully characterized for layers grown at low temperatures. Previous reports of photo-MOVPE layers have used single crystal diffraction and TEM (transmission electron microscopy) to assess the crystalline quality of these layers. In this paper more detailed X-ray diffraction assessment is used to examine epitaxial layer quality. 21 refs.

Irvine, S.J.C. (Royal Signals & Radar Establishment, Great Malvern, Engl); Mullin, J.B.; Hill, H.; Brown, G.T.;

Barnett, S.J. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 188-197.

**093682 OMVPE GROWTH OF CdTe-ZnTe SUPERLATTICES.** Superlattices consisting of CdTe and ZnTe have been grown using atmospheric pressure OMVPE. Structural characterization by X-ray diffraction and transmission electron microscopy along with optical characterization using photoluminescence and photoreflectance has been completed. Exceptionally bright luminescence emission compared to the corresponding alloys is observed, indicating the excellent optical quality of these layers. Similarly, in photoreflectance, we are able to observe several confined states, confirming the presence of the superlattice. Structurally, the layers exhibit a high density of defects, presumably due to the relatively large lattice and thermal expansion mismatch between CdTe, ZnTe and the GaAs substrate. (Author abstract) 19 refs.

Kisker, D.W. (AT&T Bell Lab, Holmdel, NJ, USA); Fuoss, P.H.; Krajewski, J.J.; Amiratharaj, P.M.; Nakahara, S.; Menendez, J. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 210-216.

**093683 EXTRINSIC DOPED n- AND p-TYPE CdTe LAYERS GROWN BY ORGANOMETALLIC VAPOR PHASE EPITAXY.** In this paper we report on the extrinsic n- and p-doping of CdTe layers, grown by organometallic vapor phase epitaxy. Triethylindium and arsine gas were used as n- and p-type dopants respectively, with doping levels of around  $10^{17} \text{ cm}^{-3}$  in both cases. Layers were grown on both semi-insulating CdTe and GaAs substrates. Layers grown on semi-insulating GaAs had an intervening 1-2  $\mu\text{m}$  undoped CdTe layer to relieve the strain caused by the large (14.6%) lattice mismatch of the CdTe-GaAs combination. Van der Pauw measurements were made to evaluate the quality of these layers, and mobility values as high as 3600  $\text{cm}^2/\text{V}\cdot\text{s}$  obtained at 40 K for lightly doped n-type samples. Grown junctions, made using extrinsic doped layers, have resulted in diodes with excellent electrical characteristics. (Author abstract) 11 refs.

Taskar, N.R. (Rensselaer Polytechnic Inst, Troy, NY, USA); Natarajan, V.; Bhat, I.B.; Ghandhi, S.K. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 228-232.

**093684 MATERIAL CHARACTERISTICS OF  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  GROWN BY ORGANOMETALLIC VAPOR PHASE EPITAXY.** We compare the material properties of  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  grown by conventional organometallic vapor phase epitaxy (OMVPE) with those obtained by interdiffused multilayer OMVPE. Both are compared with material properties of state-of-the-art LPE  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  grown from Te-rich solutions. The  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  layers were grown on bulk CdTe, sapphire ( $\text{Al}_2\text{O}_3$ ) and GaAs substrates. Layers were characterized by optical microscopy, IR transmission, Hall effect, double crystal X-ray diffraction, electron microprobe and secondary ion mass spectroscopy (SIMS). Better crystallinity and smoother morphologies are obtained by conventional OMVPE; interdiffused multilayer OMVPE currently results in better compositional uniformity and reproducibility. The observed differences can be interpreted on the basis of growth kinetics. Both techniques yield  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  epitaxial layers with LPE-like qualities. (Author abstract) 22 refs.

Edwall, D.D. (Rockwell Int Science Cent, Thousand Oaks, CA, USA); Gertner, E.R.; Bubulac, L.O. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 240-247.

**093685 VAPOR GROWTH OF CdTe AS SUBSTRATE MATERIAL FOR  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  EPITAXY.** A specific technique has been established to grow large



single crystal of CdTe from the vapor phase. Investigation of the crystals by X-ray topography, etching techniques and IR microscopy revealed the absence of subgrain boundaries and inclusions, although residual strains were still observed. The substrates are suitable for  $\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Te}$  epitaxy. A novel technique for producing ohmic contacts on p-CdTe is described. (Author abstract) 6 refs.

Geibel, C. (Telefunken Electronic, Heilbronn, West Ger); Maier, H.; Schmitt, R. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 386-390.

**093686 STRUCTURAL DEFECTS IN CdTe CRYSTALS GROWN BY TWO DIFFERENT VAPOUR PHASE TECHNIQUES.** The structural defects present in large single crystals of CdTe grown at the same temperature by two different vapour phase techniques have been investigated using a range of techniques including TEM, SEM, EBIC, EDX and chemical etching. The contrasting defect content of the differently grown crystals can be explained by the considerable difference in the periods taken to grow the crystals by the separate techniques. In the crystals grown by the slower method, the development of both sub-grain boundaries and precipitates reaches a much more advanced stage than in those grown by the faster technique. (Author abstract) 24 refs.

Durose, K. (Univ of Durham, Durham, Engl); Russell, G.J. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 471-476.

**093687 TEM STUDIES OF EPITAXIAL CdTe AND (Hg, Cd)Te GROWN BY MOVPE ON GaAs AND CdTe SUBSTRATES.** Epitaxial layers of [111]-oriented CdTe have been grown on [111] A CdTe, [111] B GaAs and [100] GaAs by MOVPE. Cross-sectional transmission electron microscope (TEM) studies have revealed the presence of many lamella twins lying parallel to the substrate-layer interface in all of these layers. In contrast, [100] CdTe deposited onto [100] GaAs exhibits a large number of misfit dislocations at the interface. A structural comparison of epitaxial layers of (Hg, Cd)Te deposited onto CdTe/[111] B GaAs hybrid substrates and onto bulk [111] A CdTe substrates is also reported. (Author abstract) 23 refs.

Brown, P.D. (Univ of Durham, Durham, Engl); Hails, J.E.; Russell, G.J.; Woods, J. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 511-515.

**093688 COMPARISON OF THE STRUCTURE OF CdTe AND (Hg, Cd)Te LAYERS GROWN BY MOVPE ON [111]A AND [111]B CdTe SUBSTRATES.** This paper presents a comparison of the structural properties of layers of CdTe and (Hg, Cd)Te grown onto [111]A and [111]B CdTe substrates as determined by the combined techniques of RHEED, SEM and cross-sectional TEM. The interest in the structural properties of homoepitaxial layers of CdTe arises from the fact that this material is often deposited as a buffer layer prior to the deposition of CMT when foreign substrates are employed. It may also be desirable to grow a buffer layer of CdTe before the deposition of CMT on CdTe substrates in order to eliminate the effect of surface contaminants and provide an atomically clean interface. 15 refs.

Hails, J.E. (Univ of Durham, Durham, Engl); Russell, G.J.; Brown, P.D.; Brinkman, A.W.; Woods, J. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 516-521.

**093689 AUGER ELECTRON SPECTROSCOPY STUDY OF PULSED-LASER EVAPORATED CdTe FILMS ON (100) GaAs<sup>1</sup>.** Pulsed-laser evaporated CdTe films deposited on (100) GaAs substrates have been studied by Auger electron spectroscopy (AES). The depth dependence of chemical composition has been determined from sputtering profiles. The films had a constant chemi-

cal composition within the accuracy of AES. Thermal treatment of GaAs substrate at temperatures as low as 260°C was found to be sufficient for obtaining an O- and C-free post-growth surface of GaAs. The width of the interfacial CdTe-GaAs region was  $\leq 3$  nm, and the interface was Te-rich. A possibility of forming the  $\text{As}_2\text{Te}_3$  layer at the CdTe-GaAs interface has been demonstrated. (Author abstract) 16 refs.

Dubowski, J.J. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Mitchell, D.F.; Sproule, G.I. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 972-974.

**X-Ray Analysis** See Also CRYSTALS—Epitaxial Growth.

**093690 STRUCTURAL AND STABILITY CHARACTERIZATION OF II-VI SUPERLATTICES STUDIED BY X-RAY DIFFRACTION.** Two II-VI superlattice systems are reviewed:  $\text{Hg}_{1-x}\text{X}_x\text{Te}/\text{CdTe}$  ( $\text{X}=\text{Cd}, \text{Mn}, \text{and Zn}$ ) and  $\text{ZnTe}/\text{CdTe}$  which have been grown by molecular beam epitaxy at 185 and 300°C, respectively, in a Riber 2300 growth system. The first system, of immediate technological importance, is a tunable narrow band gap semiconductor developed for infrared detection. The second is a matched strained-layer superlattice which exhibits unusual elastic properties. Significant interdiffusion is found to occur during the growth of  $\text{HgTe}/\text{CdTe}$  superlattices. This phenomenon seems not to exist to the same extent in the  $\text{ZnTe}/\text{CdTe}$  system. In addition, interdiffusion in  $\text{Hg}_{1-x}\text{X}_x\text{Te}/\text{CdTe}$  superlattices is markedly reduced when  $x < 0$ . The structural and stability aspects are studied by X-ray diffraction as a function of the incident X-ray energy, of the sample temperature during annealing or interdiffusion, and in scanning other directions than that of the growth. (Author abstract) 27 refs.

Staudenmann, J.-L. (Columbia Univ, Upton, NY, USA); Knox, R.D.; Horning, R.D. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 436-445.

## SEMICONDUCTING DIAMONDS

### Surfaces

**093691 EXPERIMENTAL EVIDENCE FOR ANTIFERROMAGNETIC SPIN ORDERING ON THE (111)-(2×1) SURFACE OF DIAMOND.** A quantitative interpretation of the C KVV Auger lineshape provides experimental evidence for antiferromagnetic spin ordering within the  $\pi$ -bonded chain model on the (111)-(2×1) surface of diamond. An initial state electron correlation model is utilized to quantitatively interpret the Auger lineshape. (Author abstract) 32 refs.

Ramaker, D.E. (US Naval Research Lab, Washington, DC, USA); Hutson, F.L. *Solid State Commun* v 63 n 4 Jul 1987 p 335-339.

### Thin Films

**093692 SYNTHESIS OF DIAMOND THIN FILMS HAVING SEMICONDUCTIVE PROPERTIES.** Semiconductive diamond films were fabricated by the thermal filament CVD method. A saturated solution of  $\text{B}_2\text{O}_3$  powder in  $\text{CH}_3\text{OH}$  mixed with acetone was used. The films deposited were identified as diamond by several methods including Raman spectroscopy. By the measurement of electrical properties, the obtained films were found to show p-type conduction. (Author abstract) 6 refs.

Okano, Ken (Tokai Univ, Hiratsuka, Jpn); Naruki, Hidetoshi; Akiba, Yukio; Kurosu, Tateki; Iida, Masamori; Hirose, Yoichi. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 173-175.

**093693 STRUCTURE AND CERTAIN PHYSICAL PROPERTIES OF SEMICONDUCTOR DIAMOND FILMS.** The structural features and electrophysical prop-

erties of films obtained by deposition of a carbon condensate in a glow discharge plasma are studied. It is shown that the film under study is a p-type semiconductor. It is shown that on the whole, diamond semiconductor films are close in electrophysical properties to amorphized silicon and germanium obtained from the gas phase. (Edited author abstract) 17 refs.

Andreev, V.D. (Inst of Superhard Materials, USSR); Semenov, V.A.; Sozin, Yu. I.; Nachal'naya, T.A.; Torishnii, V.I. *Sov J Superhard Mater* v 9 n 6 1987 p 22-28.

**093694 ACCRESCIMENTO DI FILM SEMICONDUCTORI DI DIAMANTE MEDIANTE DEPOSIZIONE PLASMA-ASSISTITA DA FASE VAPORE.** [Growth of Semiconducting Diamond Films by Plasma-Assisted Vapor Deposition.]. Diamond films of 2-20  $\mu\text{m}$  thickness were grown on silicon substrates from a gaseous mixture of methane and hydrogen. By introducing a small amount of diborane gas into the above mixture, bluish boron-doped diamond films that exhibit semiconducting properties have been deposited. The range of experimental conditions that make it possible to obtain the well-known diamond structure has been determined by means of electron diffraction, X-ray diffraction and Raman spectroscopy. (Edited author abstract) 8 Refs. In Italian.

Sato, Y. (Nat'l Inst of Research in Inorganic Materials, Ibaraki, Jpn); Kamo, M.; Setaka, N. *Ceramurgia* v 18 n 2 Mar-Apr 1988 p 84-87.

**SEMICONDUCTING FILMS** See Also FILMS—X-Ray Analysis; IRON TELLURIUM ALLOYS; SEMICONDUCTING GALLIUM ARSENIDE—Vapor Deposition; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING ZINC COMPOUNDS—Electric Conductivity; SEMICONDUCTOR DEVICES, MOSFET—Analysis; SEMICONDUCTOR MATERIALS—Thin Films; SILVER COPPER ALLOYS—Anodic Oxidation; SOLAR CELLS; SOLAR CELLS—Thin Films.

**093695 POSSIBILITY OF THE USE OF AN ELECTROLYTE-INSULATOR-SEMICONDUCTOR (EIS) SYSTEM FOR INVESTIGATING THE PROPERTIES OF  $\text{Ta}_2\text{O}_5$  IN CONTACT WITH AN ELECTROLYTE SOLUTION.** An investigation is conducted of the properties of  $\text{Ta}_2\text{O}_5$  films obtained by the anodic and thermal oxidation of tantalum on silicon surfaces when they are in contact with an electrolyte solution. The investigations carried out showed that the electrical characteristics of the  $\text{Ta}_2\text{O}_5$ -Si structures are greatly dependent on the method used to prepare the  $\text{Ta}_2\text{O}_5$  film. In the case of freshly prepared structures with anodic oxide films, there was no modulation of the differential capacitance of the space-charge region of silicon over the entire range of bias amplitudes investigated. 11 refs.

Vlasov, Yu.G.; Bratov, A.V.; Tarantov, Yu.A.; Khanin, S.D.; Pogulyaev, V.V. *J Appl Chem USSR* v 60 n 4 pt 2 Apr 1987 p 892-894.

**093696 OPTICAL SECOND-HARMONIC GENERATION OF MODULATION DOPED  $\text{Ga}_{0.8}\text{Al}_{0.2}\text{As}$  FILM GROWN BY MOLECULAR BEAM EPITAXY.** Absolute values of the second-order nonlinear susceptibility of modulation doped (1 0 0)  $\text{Ga}_{0.8}\text{Al}_{0.2}\text{As}$  are measured through a Q-switched Nd:YAG laser with self-calibrated power emanating in p-polarization. The angular variation of the reflecting second-harmonic wave agrees satisfactorily with the Bloembergen and Pershan theory. The nonlinear susceptibility of  $\text{Ga}_{0.8}\text{Al}_{0.2}\text{As}$  grown by MBE method is 20% larger than that of GaAs. A quasi-photon counting technique exploited in this experiment provides the possibility to detect the second harmonic reflecting coefficients as low as  $10^{-21} \text{ cm}^2/\text{watt}$ . (Author abstract) 11 refs.

Tzeng, Chin-Ching (Nat'l Tsing-Hua Univ, Hsinchu, Taiwan); Lue, Juh-Tzeng. *Solid State Commun* v 64 n 4 Oct 1987 p 621-624.



**093697 EFFECT OF ANNEALING TEMPERATURE ON HYDROGEN CONTENT IN a-Si:H/a-SiN<sub>x</sub>:H MULTILAYER FILMS.** The hydrogen effusion and its temperature dependence in amorphous semiconducting a-Si:H/a-SiN<sub>x</sub>:H multilayer films prepared by PCVD has been studied using IR absorption, nuclear methods, and electron microscopy. The possible interpretations of the out-diffusion of hydrogen in the films are presented. (Author abstract) 19 refs.

Wang, W.L. (Lanzhou Univ, Gansu, China); Zhang, J.J.; Liao, K.J. *Mater Lett* v 6 n 1-2 Nov 1987 p 45-48.

**093698 PLASMA DEPOSITED THIN FILMS.** This volume contains 8 chapters dealing with plasma deposited thin film technology. Topics include: Plasma deposition processes; Formation, composition and microstructure kinetics; Electronic properties of plasma-deposited semiconductor films; Carbon thin films; Silicon nitride and other insulator films; Photovoltaic structures by plasma deposition; Xerographic applications of amorphous tetrahedral materials; and Hydrogenated amorphous silicon electric devices and arrays.

Mort, Joseph (Ed.) (Xerox Corp, Webster, NY, USA); Jansen, Frank (Ed.). *Plasma Deposited Thin Films* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 235p.

**093699 LUMINESCENT AND ELECTROPHYSICAL PROPERTIES OF POLYCRYSTALLINE PbTe FILMS.** Lead halogenide films are widely used in electrooptics for creating radiation receivers and sources. Because of this development of methods for testing the parameters of films of these materials and the structures based on this is a current issue. The method of local cathode luminescence (CL), which is quite well developed in application with respect to A<sup>111</sup>BV and A<sup>111</sup>BV compounds is an effective method for investigating the properties of semiconductors. This work presents the results of investigations of local luminescent and certain electrophysical properties of polycrystalline PbTe films. (Edited author abstract) 9 refs.

Petrov, V.I.; Gareev, A.F.; Gorbachev, V.V.; Rulenko, M.P.; Shabalin, A.V. *Bull Acad Sci USSR Phys Ser* v 51 n 3 1987, Mater of the Fifth All-Union Symp on Scanning Electron Microsc and Anal Methods for Invest Solids, Zvenigorod, USSR, May 1986 p 25-28.

**Amorphous** See Also FILMS—Mechanical Properties; SEMICONDUCTING GERMANIUM COMPOUNDS—Amorphous; SEMICONDUCTING GERMANIUM COMPOUNDS—Physical Properties; SEMICONDUCTING GLASS—Radiation Effects; SEMICONDUCTING INDIUM COMPOUNDS—Amorphous; SEMICONDUCTING SELENIUM COMPOUNDS—Photoconductivity; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Chemical Vapor Deposition; SEMICONDUCTING SILICON—Growth; SEMICONDUCTING SILICON—Hydrogenation; SEMICONDUCTING SILICON—Purification; SEMICONDUCTING SILICON COMPOUNDS—Electronic Properties; SEMICONDUCTING ZINC COMPOUNDS—Physical Properties; SEMICONDUCTING ZINC COMPOUNDS—Thin Films; SEMICONDUCTOR MATERIALS—Amorphous.

**093700 HIGH-RATE DEPOSITION OF a-Si:H FILM WITH A SEPARATED PLASMA TRIODE METHOD.** The separated plasma triode (SPT) method has been developed to deposit high-quality a-Si:H films at high deposition rates. Plasma properties were measured by a probe method and an optical emission spectroscopy (OES) method. It is possible to improve the electron density in a plasma without increasing the plasma potential near the substrate by the SPT method. High-quality a-Si:H films and high-performance a-Si solar cells were obtained at high deposition rates using the SPT model. (Author abstract) 19 refs.

Tanaka, Makoto (Sanyo Electric Co, Hirakata, Jpn); Ninomiya, Kunimoto; Nakamura, Noboru; Tsuda, Shinya; Nakano, Shoichi; Ohnishi, Michitoshi; Kuwano, Yukinori. *Jpn J Appl Phys Part 1* v 27 n 1 Jan 1988 p 14-19.

**093701 PHOTO-INDUCED POTENTIAL BARRIER IN As-Se-Ge FILMS.** Photo-excited effects in As-Se-Ge and As-Se-Ge-Sn amorphous films have been

studied under illumination of different light sources. As-Se-Ge system exhibited rectifying characteristics under illumination of light with  $h\nu > E_g$ , while As-Se-Ge-Sn film did not show such phenomena. The illumination of the IR light along with the light of  $h\nu > E_g$  weakened the rectification behavior. The photovoltage and I-V characteristics results suggest the existence of "photo-induced" potential barrier in the As-Se-Ge system, which is considered to concern the creation and destruction of neutral defect states D'. (Author abstract) 12 refs.

Katyal, S.C. (Kanazawa Univ, Kanazawa, Jpn); Okano, S.; Suzuki, M.; Bando, T. *Solid State Commun* v 66 n 6 May 1988 p 581-584.

**093702 AMORPHOUS CuInSe<sub>2</sub> FILMS.** This paper describes the deposition of amorphous p-CuInSe<sub>2</sub> films by flash evaporation and for the first time by co-evaporation. The results of temperature dependence of dc conductivity on one each film of flash and co-evaporation and their energy gap (mobility edge) determination by a new technique - photoacoustic absorption spectroscopy (PAS) are also reported. At 300 K the conductivity values of flash and co-evaporated films are  $9 (\Omega\text{cm})^{-1}$  and  $10^{-3} (\Omega\text{cm})^{-1}$  respectively. Conductivity values strongly depend on Cu/In and Se/(Cu+In) ratios which in turn are preparation dependent. An energy gap of  $1.03 \pm 0.02$  eV and  $1.05 \pm 0.02$  eV are resulted from PAS measurements which are close to the band gaps of the polycrystalline material but far less than that reported in literature of the amorphous films. (Author abstract) 6 refs.

Venkataraman, S. (Univ of Hyderabad, Hyderabad, India); Bhatnagar, A.K. *Key Eng Mater* v 13 pt 2 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 519-522.

## Analysis

**093703 NONDESTRUCTIVE SURFACE ANALYSIS BY NUCLEAR SCATTERING TECHNIQUES.** An elastic-recoil detection (ERD) technique is developed and successfully applied in the simultaneous, nondestructive multielement depth-profile studies of thin films with thicknesses up to 2  $\mu\text{m}$ , used in various material technologies. In this technique, the light elements are knocked out of the target by using an energetic heavy-ion beam obtained from the Tandem Accelerator Facility of the Nuclear Physics Laboratory. A time-of-flight method is used to separate the masses and the energies of the recoiled elements as well as the Rutherford backscattering incident ions. Using 30 MeV <sup>35</sup>Cl as the beam probe, we get an observed surface resolution of better than 100 Angstrom at a 30° detection angle. Typical mass resolutions for energies < 5 MeV are 0.2 amu in the C region and 0.7 amu in the Si region. The factors related to the mass and depth resolutions, probing depth, and approximate detection limit are systematically studied using <sup>19</sup>F, <sup>35</sup>Cl, and <sup>79</sup>Br as incident beams. This newly developed ERD method, along with the already existing Rutherford backscattering (RBS) technique, makes the Nuclear Scattering Facility at the Universite de Montreal unique for surface analysis. (Author abstract) 14 refs.

Gujrathi, S.C. (Univ de Montreal, Montreal, Que, Can); Aubry, P.; Lemay, L.; Martin, J.P. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 950-955.

## Applications See HYGROMETERS.

**Charge Carriers** See SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTOR MATERIALS—Amorphous.

## Chemical Deposition

**093704 LASER DEPOSITION OF MATTER FROM THE GAS PHASE AND MASS TRANSFER IN THE BEAM FIELD.** The authors report on the deposition (induced by radiation of a CO<sub>2</sub> laser) of boron particles from the gas phase of molecules of alkenes HCIC=CBCl<sub>2</sub>H, and also on mass transfer of particles along the beam onto which the processes of isotopically

selective multiphoton dissociation and secondary chemical reactions are superimposed. The latter results in the quantitative difference: a. in the mass of the material of the film deposited on the inlet and outlet windows of the reactor; b. in the isotope composition of boron in these films. Various possible mechanics which may cause this phenomenon are discussed. (Author abstract) 14 refs.

Abdushelishvili, G.I.; Bakhtadze, A.G.; Kervalishvili, P.D.; Tkeshelashvili, G.I.; Tsinaidze, T.B. *Phys Chem Mater Treat* v 21 n 3 May-Jun 1987 p 253-255.

**Chemical Vapor Deposition** See Also FER-  
RITES—Electric Conductivity; SEMICONDUCTING  
DIAMONDS—Thin Films; SEMICONDUCTING FILMS  
—Amorphous; SEMICONDUCTING GALLIUM ARSE-  
NIDE—Defects; SEMICONDUCTING INDIUM COM-  
POUNDS—Growth; SEMICONDUCTING SILICON—  
Amorphous; SEMICONDUCTING SILICON—Chemical  
Vapor Deposition; SEMICONDUCTING SILICON—Dop-  
ing; SEMICONDUCTING SILICON—Phase Transitions;  
SEMICONDUCTING SILICON COMPOUNDS—Chemical  
Vapor Deposition; SEMICONDUCTING ZINC COM-  
POUNDS—Thin Films; SEMICONDUCTOR MATERI-  
ALS—Amorphous; SEMICONDUCTOR MATERIALS—  
Thin Films.

**093705 STUDY AND CHARACTERIZATION OF PECVD OXIDES.** Plasma enhanced chemical vapor deposited (PECVD) silicon oxide films used as final passivation layers in MOS-LSI technology are prepared by the reaction of silane and nitrous oxide in a parallel plate radial flow plasma reactor. Deposition parameters (temperature, rf power, and the reactant gas ratio) were systematically varied for finding optimum process parameters for better yields. The film composition and properties for samples deposited at different condition are characterized by measuring the IR spectra, deposition rate, etch rate, and annealing behavior and are compared with thermally grown silicon oxide films. (Author abstract) 7 refs.

Sen, S. (Indian Telephone Industries Ltd, Bangalore, India); Annamalai, S.; Acharya, P.K. *Phys Status Solidi A* v 105 n 1 Jan 1988 p 171-177.

**093706 PLASMA DEPOSITION OF HYDROGENATED AMORPHOUS SILICON FILMS.** The purpose of this paper is to summarize aspects of glow discharge relevant to the deposition of high-quality hydrogenated amorphous silicon materials and to elucidate the effects on these films and devices of various deposition parameters and other aspects of the growth process, to better understand how the films are formed. Common diagnostic measurement techniques for determining plasma composition and film properties are reviewed. Also discussed are some effects on film quality of the deposition-system design, including the electrode geometry, bias control, and plasma confinement, and the effects of the most significant deposition parameters, such as power density, substrate temperature, feed-gas concentration, pressure, and gas flow rate. Special emphasis is placed on avoiding contamination from impurities and avoiding the structural inhomogeneities that can result from microparticulates in the plasma or from ion bombardment of the growing film. (Edited author abstract) 213 refs.

Luft, Werner (Solar Energy Research Inst, Golden, CO, USA); Tsuo, Simon. *Appl Phys Commun* v 8 n 1 Mar 1988 p 1-74.

**093707 PLASMA-DEPOSITED FILMS: KINETICS OF FORMATION, COMPOSITION, AND MICROSTRUCTURE.** A number of inorganic and organic materials have been synthesized by plasma-enhanced chemical vapor deposition (PECVD) techniques, in which the precursor gases are decomposed in a glow discharge, and the thin films can be grown on substrates at temperatures below 300°C. Plasma-deposited silicon nitride and silicon dioxide are widely used as encapsulating materials for the final passivation of very large scale integrated (VLSI) circuits. In recent years, glow discharge-produced amorphous silicon has attained considerable importance as a new electronic material for fabricat-



ing thin film devices such as solar cells, transistors, sensors, and photoreceptors. Very extensive work on this material is in progress to characterize the electronic and structural properties of amorphous silicon films as well as to understand the growth kinetics. Further developments of plasma CVD techniques to prepare metal thin films or novel organic materials are expected in the near future, based upon better understanding of the deposition chemistry in the glow discharge. The author examines deposition variables, the composition and chemical bonding of the deposited flow, radial beam deposition and the silicon growth process. 39 refs.

Hirose, Masataka (Hiroshima Univ, Higashihiroshima, Jpn). *Plasma Deposited Thin Films* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 p 21-43.

**093708 PLASMA DEPOSITION OF HYDROGENATED AMORPHOUS SILICON FILMS.** Plasma-assisted chemical vapor deposition has become the most common technique used in the deposition of hydrogenated amorphous silicon films and devices for photovoltaic applications. The purpose of this paper is to summarize aspects of glow discharge relevant to the deposition of high-quality hydrogenated amorphous silicon materials and to elucidate the effects on these films and devices of various deposition parameters and other aspects of the growth process, to better understand how the films are formed. Common diagnostic measurement techniques for determining plasma composition and film properties are reviewed. Also discussed are some effects on film quality of the deposition-system design, including the electrode geometry, bias control, and plasma confinement, and the effects of the most significant deposition parameters, such as power density, substrate temperature, feed-gas concentration, pressure, and gas flow rate. (Edited author abstract) 213 Refs.

Luft, Werner (Solar Energy Research Inst, Golden, CO, USA); Tsuo, Simon. *Appl Phys Commun* v 8 n 1 Mar 1988 p 1-74.

**093709 ArF LASER PHOTOCHEMICAL VAPOR DEPOSITION OF Si FILMS WITH VARIOUS CARRIER GASES.** Amorphous 0.1  $\mu\text{m}$  to 0.3  $\mu\text{m}$  thick Si films of optical homogeneity with a photoconductivity to dark conductivity ratio of  $10^5$  were obtained at substrate temperatures of approx. 200°C. The deposition rate - influenced by light intensity, gas flow, gas pressure and substrate conditions - was approx. 1 nm/min to 5 nm/min. In-situ ion current measurements suggest that each deposition shower initiated by a short 30 ns laser pulse lasts up to 100  $\mu\text{s}$ . One of the most significant observations was the high  $\text{Si}_2\text{H}_6$  excitation selectivity of the photo-CVD process without the carrier gas, e.g. He, Ar or  $\text{N}_2$ , excessively influencing the photoconductivity of the Si films. (Author abstract) 10 Refs.

Bayer, E. (Siemens AG, Munich, West Ger); Kusian, W.; Schneider, G. *Siemens Forsch Entwicklungsber* v 17 n 4 1988 p 190-194.

**Compressibility** See SEMICONDUCTING SILICON COMPOUNDS—Pressure Effects.

**Crack Propagation** See SEMICONDUCTOR MATERIALS—Crack Propagation.

**Crystallization** See Also SEMICONDUCTING INDIUM COMPOUNDS—Crystallization; SEMICONDUCTING SILICON—Doping.

**093710 CRYSTALLIZATION OF SUPERCOOLED INSULAR FILMS OF BINARY ALLOYS OF THE Pb-Bi(Sn) AND Sn-Bi SYSTEMS.** The temperatures of the attainable supercoolings and the corresponding crystal nucleation frequencies in insular films of alloys of the Pb-Bi, Pb-Sn and Sn-Bi systems were determined experimentally. In alloys of the Pb-Bi and Sn-Bi systems, the nature of the concentration dependence of the temperature of the attainable supercoolings in the range corresponding to solid solutions is in qualitative agreement with theoretical predictions. In the Pb-Sn alloy, a more complex dependence is observed. In Russian. 13 refs.

Skokov, V.N.; Dik, A.A.; Koverda, V.P.; Skripov, V.P. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 9 Sep 1987 p 1477-1480.

**Defects** See Also SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Defects.

**093711 ELECTRICAL CONDUCTION AND OBSERVATION OF LOCAL DEFECTS IN THIN SANDWICH STRUCTURES OF  $\text{Cu-SiO}_2/\text{CeO}_2\text{-Cu}$ .** AC and DC conduction in MIM sandwich structures based on  $\text{SiO}_2/\text{CeO}_2$  as a dielectric prepared by the co-evaporation technique has been investigated before and after electroforming for different compositions. The electroformed samples show voltage-controlled negative resistance (VCNR), voltage-memory, thermal-voltage-memory and pressure-voltage-memory effects and the results are explained in terms of the filamentary model of electrical conduction. The positive electrode was investigated using a scanning electron microscope to observe the effects of electroforming and the liberation of gas as a result of the application of high electric fields. (Author abstract) 14 refs.

Al-Dhhan, Z.T. (Brunel Univ, Uxbridge, Engl); Hogarth, C.A. *Int J Electron* v 63 n 5 Nov 1987 p 707-722.

**Diffusion** See SEMICONDUCTING POLYMERS—Doping.

**Doping** See Also SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Doping; TIN COMPOUNDS—Thin Films.

**093712 BPSG FILMS DEPOSITED BY APCVD.** The recent substitution of borophosphosilicate (BPSG) glasses for phosphosilicate glass (PSG) films has significantly eased the conditions needed to reflow the planarizing glass films and to achieve the topographies required to promote continuous metal and insulator step coverage. This article examines some of the relationships between deposition conditions and film characteristics for BPSG films deposited in a continuous, atmospheric CVD reactor. The authors present observations of BPSG reflow behavior as it relates to film dopant concentration and reflow anneal conditions. 5 refs.

Hurley, Kurt H. (Watkins-Johnson Co, Scotts Valley, CA, USA); Bartholomew, Lawrence D.; Bordonaro, Donald T. *Semicond Int* v 10 n 11 Oct 1987 p 91-95.

**093713 EFFECT OF INDIUM ON THE ELECTRICAL TRANSPORT PROPERTIES OF  $\text{Pb}_{0.8}\text{Sn}_{0.2}\text{Te}$  THIN FILMS.** Hall coefficient and dc conductivity studies were made in the 77-300K temperature range on  $\text{Pb}_{0.8}\text{Sn}_{0.2}\text{Te}$  films doped with different concentrations of indium. Indium was found to give donors, and the values of the Hall coefficient and the Hall mobility were found to decrease with an increase in the doping concentration of indium. Analysis of mobility data revealed that lattice and defect scatterings are predominant in these films. (Author abstract) 17 refs.

Jagadish, C. (Univ of Delhi, Delhi, India); Dawar, A.L.; Mathur, P.C. *Mater Res Bull* v 23 n 1 Jan 1988 p 99-106.

**093714 DONOR ACTION OF INDIUM AND BISMUTH IN  $\text{Pb}_{0.8}\text{Sn}_{0.2}\text{Te}$  THIN FILMS.**  $\text{Pb}_{0.8}\text{Sn}_{0.2}\text{Te}$  films doped with different concentrations of indium and bismuth were grown by flash evaporation. D.C. conductivity and Hall coefficient studies were made on all the films in the temperature range 77-300 K. Carrier concentration is found to increase with the increase in doping concentration of indium and bismuth, whereas mobility is found to decrease. (Author abstract) 5 refs.

Jagadish, C. (Univ of Delhi, Delhi, India); Dawar, A.L.; Mathur, P.C. *Solid State Commun* v 64 n 4 Oct 1987 p 603-604.

**093715 QUENCHING OF PHOTOLUMINESCENCE IN POLY(THIOPHENE) FILMS BY ELECTROCHEMICAL DOPING.** Photoluminescence observed in undoped poly(thiophene) and poly(3-methylthiophene) films decreases in intensity with a slight blue

shift by electrochemical  $\text{ClO}_4^-$  doping. However, they persist through polaronic states until fairly heavy doping levels of ca. 0.1 per thiophene ring and are quenched by the onset of metallic state. (Author abstract) 7 refs.

Hayashi, S. (Osaka Univ, Suita, Jpn); Kaneto, K.; Yoshino, K. *Solid State Commun* v 61 n 4 Jan 1987 p 249-251.

**093716 PHOTOINDUCED ABSORPTION IN DOPED POLY(3-METHYLTHIOPHENE) FILMS.** Interactions of photoinduced polarons and dopant-induced (bi)polarons have been studied by photomodulation spectroscopy in electrochemically p-type doped poly(3-methylthiophene) films. The result indicates that the photoinduced negative polaron (or electron) trapped at dopant-induced bipolaron is predominantly observed in photoinduced absorption spectra of lightly doped films. (author abstract) 13 refs.

Kaneto, K. (Osaka Univ, Suita, Jpn); Uesugi, F.; Yoshino, K. *Solid State Commun* v 64 n 9 Dec 1987 p 1195-1198.

**093717 EFFECT OF ZINC ON THE SOLUBILITY AND DISTRIBUTION COEFFICIENTS OF BISMUTH IN INDIUM ANTIMONIDE.** Zinc has a significant effect on the solubility of bismuth in indium antimonide. The solubility also depends on the cross section over which doping is carried out. Under conditions of epitaxial growth from the liquid phase to obtain Bi- and Zn-doped InSb layers with a maximum bismuth content (1.47 at.%) and a maximum effective bismuth distribution coefficient ( $2.10^{-2}$ ), growth should be carried out from melt solutions of the InSb-InBi section. 5 refs. In Russian.

Ufimtsev, V.B.; Lapkina, I.A.; Zinov'ev, V.G.; Sorokina, O.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1784-1787.

**Electric Conductivity** See Also SEMICONDUCTING GLASS—Synthesis; SEMICONDUCTOR MATERIALS—Amorphous.

**093718 SURFACE-STATE GENERATED CURRENTS IN THIN SEMICONDUCTOR LAYERS.** The conditions for the formation of a regime of currents which are bounded by the surface states in thin layers of semiconductors are studied. It is shown that these conditions consist of a strong reduction in the near junction barrier by the heating electric field and localization of injected charge in the near-surface region owing to a developed spectrum of centers on the surface of the semiconductor. Working formulas are obtained for determining the surface charge, the near-surface conductivity and also the depth of the centers near the surface and their density in a model with a monoenergetic distribution of these centers over the current voltage characteristic. The conditions for distinguishing a given mechanism from other mechanisms of current flow are determined. (Author abstract) 13 refs.

Gusev, M.Yu.; Zyuganov, A.N.; Koren', N.N.; Smerentko, P.S. *Sov J Commun Technol Electron* v 32 n 2 Feb 1987 p 108-113.

**Electric Properties** See Also SEMICONDUCTING INTERMETALLICS—Thin Films; SEMICONDUCTING LEAD COMPOUNDS—Thin films; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING ZINC COMPOUNDS—Thick Films; SEMICONDUCTOR DEVICES, MOSFET—Thin Films.

**093719 ENHANCEMENT OF LOW TEMPERATURE THERMOPOWER IN HIGH-RESISTIVITY FILMS.** The authors present measurements and calculations of the thermopower of amorphous Ti-Te and In-Sb films. The observed thermopower (even for films near the metal-semiconductor transition) shows a temperature-dependent enhancement in agreement with the theoretical electron-phonon enhancement, which is calculated



for  $\text{Ti}_{90}\text{Te}_{10}$  and  $\text{In}_{90}\text{Sb}_{10}$  using the Eliashberg function obtained from superconductivity data. (Edited author abstract) 21 refs.

Mawdsley, A. (Victoria Univ of Wellington, Wellington, NZ); Kaiser, A.B. *Solid State Commun* v 66 n 10 Jun 1988 p 1023-1026.

**Electrodeposition** See Also SEMICONDUCTING CADMIUM COMPOUNDS—Electrodeposition; SEMICONDUCTING CADMIUM COMPOUNDS—Thin Films; SEMICONDUCTING INDIUM COMPOUNDS—Thin Films.

**093720 ELECTRODEPOSITION OF  $\text{CuInTe}_2$  FILMS.**  $\text{CuInTe}_2$  films have been deposited on a titanium substrate from acidic as well as from alkaline baths. The as-deposited films were uniform and adhered well to the substrate. Structural and compositional studies showed that the as-deposited films were amorphous or consisted of fine grains and were stoichiometric in composition. (Author abstract) 8 refs.

Lokhande, C.D. (Shivaji Univ, Kolhapur, India); Pawar, S.H. *J Phys D* v 20 n 9 Sep 14 1987 p 1213-1214.

**Electronic Properties** See Also SEMICONDUCTING CADMIUM COMPOUNDS—Thick Films.

**093721 TUNNELLING MAGNETO-PLASMONS AND ANDERSON LOCALISATION IN SEMICONDUCTOR SUPERLATTICES.** We present a theory of magneto-plasmons in tunnelling semiconductor superlattices. A new plasmon branch is predicted, which is due to the mini-band energy dispersion in the superlattice direction. This tunnelling plasmon branch is sensitive to disorder. Anderson localization (AL) of the electron states causes its frequency to decrease, scaling according to the AL length until the plasmon disappears due to Landau damping at low frequencies. Experimental implications are discussed. (Author abstract) 24 refs.

Que, Wei-ming (Simon Fraser Univ, Burnaby, BC, Can); Kirichenov, George. *J Phys C Solid State Phys* v 20 n 36 Dec 30 1987 p L989-L994.

**093722 ELECTRONIC PROPERTIES OF PLASMA-DEPOSITED AMORPHOUS SEMICONDUCTOR FILMS.** This chapter treats the basic properties of amorphous films deposited in a glow discharge. A glance at the programs of international conferences on amorphous semiconductors shows that amorphous silicon (a-Si:H) prepared by plasma decomposition of silane ( $\text{SiH}_4$ ) plays a dominant role in this field. In addition, the study of this material is expected to help in reaching a better understanding of the physics of disordered materials in general. By using glow discharge techniques, one can obtain a much lower defect density in the films, as compared to other deposition techniques, due to the incorporation of hydrogen atoms. This beneficial effect of hydrogen incorporation also leads to good semiconducting properties in a-Ge:H films deposited from germane ( $\text{GeH}_4$ ) and in amorphous alloy films such as a- $\text{Si}_{1-x}\text{Ge}_x$ :H, a- $\text{Si}_{1-x}\text{C}_x$ :H, a- $\text{Si}_x\text{N}_{1-x}$ :H, and a- $\text{SiO}_x$ :H, which are obtained from the deposition of gas mixtures of silane with  $\text{GeH}_4$ , hydrocarbons,  $\text{NH}_3$ , and  $\text{N}_2\text{O}$ , respectively. These alloy films are of great practical interest. The present chapter concentrates mainly on those electronic properties of a-Si:H films which are regarded as relevant for the various technical applications of this material. 169 refs.

Fuhs, Walter (Univ Marburg, Marburg, West Ger). *Plasma Deposited Thin Films* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 p 45-87.

**093723 ELECTRON TRANSPORT AND PHOTOELECTRIC PROPERTIES IN GLOW DISCHARGE a-Si:H FILMS PREPARED FROM DISILANE.** The electron transport and photoelectric properties in a-Si:H films prepared from disilane by an rf glow-discharge decomposition process have been measured as a function of substrate temperature and have been compared with those prepared from monosilane. The temperature dependence of the electron mobility reveals a significant difference in the tail state distribution below the conduction band between disilane and monosilane films. This

suggests the local atomic structures of a-Si:H films depend critically on source gas species, even if the room-temperature properties are apparently the same. (Edited author abstract) 17 refs.

Hattori, R. (Osaka Univ, Suita, Jpn); Shirakawa, K.; Shirafuji, J. *J Non Cryst Solids* v 104 n 1 Aug 1988 p 52-58.

**Growing** See SEMICONDUCTING GALLIUM ARSENIDE—Chemical Vapor Deposition; SEMICONDUCTOR MATERIALS—Defects.

**Growth** See Also CRYSTALS—Epitaxial Growth; MOLECULAR BEAM EPITAXY—Reviews; SEMICONDUCTING BISMUTH COMPOUNDS—Electric Properties; SEMICONDUCTING GALLIUM ARSENIDE—Defects; SEMICONDUCTING GALLIUM COMPOUNDS—Aging; SEMICONDUCTING GERMANIUM—Density; SEMICONDUCTING GLASS—Thin Films; SEMICONDUCTING INDIUM COMPOUNDS—Thin Films; SEMICONDUCTING SELENIUM—Thin Films; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Thin Films; SEMICONDUCTING TIN COMPOUNDS—Thin Films; SEMICONDUCTING ZINC COMPOUNDS—Growth; SEMICONDUCTING ZINC COMPOUNDS—Thin Films; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES—MOSFET—Materials; SEMICONDUCTOR MATERIALS—Thin Films; SILICON AND ALLOYS—Amorphous.

**093724 STRUCTURE AND ELECTROPHYSICAL PROPERTIES OF LAYERS OF  $\text{Pb}_{1-x}\text{Cd}_x\text{S}$  SOLID SOLUTIONS.** Epitaxial layers of  $\text{Pb}_{1-x}\text{Cd}_x\text{S}$  solid solutions of both n- and p-types have been grown by a 'hot wall' method. It is shown that, when a mechanical mixture of lead sulfide and cadmium sulfide is used as the source, the composition of layers of  $\text{Pb}_{1-x}\text{Cd}_x\text{S}$  solid solutions can be controlled within the range  $1 \leq x \leq 10 \text{ mol.}\%$  CdS by varying the substrate temperature. A decrease in the substrate temperature caused an increase in the CdS concentration in the layers. However, at substrate temperatures less than 673 K the structural perfection of the layers deteriorated. In the case of p-type layers the Hall coefficient did not depend on temperature, while in the case of n-type layers it decreased monotonically with an increase in temperature. With an increase in x the electron and hole mobilities decreased. 8 refs. In Russian.

Blokhin, Yu.N.; Lutskaia, O.F.; Yas'kov, D.A. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 888-891.

**093725 STUDY OF  $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$  EPITAXIAL FILMS DEPOSITED BY MBE TECHNIQUE.** Epitaxial films of  $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$  (LTT) were deposited on (100) KCl substrates at 300, 325 and 350°C using Molecular Beam Epitaxial (MBE) technique. RHEED, X-ray and Van der Pauw techniques were employed to study surface structure, single crystallinity and electrical properties of these films respectively. The resistivity of these films was found to decrease from  $10^{-2} \Omega\text{-cm}$  at 300K to  $10^{-3} \Omega\text{-cm}$  at 100 K. The mobility was found to increase with lowering of temperature in the range  $10^2 \text{ cm}^2/\text{V sec}$  at 300 K and  $10^3 \text{ cm}^2/\text{V sec}$  at 100 K. (Author abstract) 22 refs.

Ponnuraju, K. (Indian Inst of Technology, Madras, India); Vaya, P.R. *J Inst Electron Telecommun Eng* v 32 n 5 Sep-Oct 1986 p 407-410.

**093726 EPITAXIAL GROWTH OF  $\text{Pb}_{1-x}\text{Ge}_x\text{Te}$  FILMS AND OF  $\text{PbTe}/\text{Pb}_{1-x}\text{Te}$  SUPERLATTICES.**  $\text{Pb}_{1-x}\text{Ge}_x\text{Te}$  films with Ge contents up to about 10% were grown by a modified hot wall epitaxy (HWE) system using pyrolytic carbon source furnaces. Also,  $\text{PbTe}/\text{Pb}_{1-x}\text{Ge}_x\text{Te}$  ( $x \leq 0.06$ ) superlattices with periods ranging from 300-900 Å were deposited on  $\text{BaF}_2$  substrates. The growth kinetics were studied and growth rates determined. The structural properties of the films and superlattices are analyzed using X-ray diffraction. (Author abstract) 23 refs.

Clemens, H. (Montanuniv Leoben, Leoben, Austria); Ofner, P.; Krenn, H.; Bauer, G. *J Cryst Growth* v 84 n 4 Oct 1987 p 571-576.

**093727 COMPOSITION AND STRUCTURE OF CHEMICALLY DEPOSITED  $\text{CuInSe}_2$  THIN FILMS.** The composition, morphology and crystallographic structure of  $\text{CuInSe}_2$  films grown at 50°C and 90°C by the

chemical method are discussed. Characterization includes EDS, X-ray and transmission electron diffraction and optical absorption spectroscopy. Nearly stoichiometric  $\text{CuInSe}_2$  thin films are obtained with chalcopyrite structure and with thickness in the range 1-3  $\mu\text{m}$  and the grain size in the range 0.2-1.5  $\mu\text{m}$ . The effect of deposition mixture temperature on film orientation has been studied by X-ray and electron diffraction. Preferred orientation along [112] direction occurs at a deposition-mixture temperature of 90°C. (Edited author abstract) 12 refs.

Padam, G.K. (NPL, New Delhi, India). *Mater Res Bull* v 22 n 6 Jun 1987 p 789-794.

**093728 CHARACTERIZATION OF EPITAXIALLY GROWN SEMICONDUCTIVE LAYERS BY SCATTERING OF OPTICAL PSEUDO-SURFACE WAVES AND INTERFERENCE FRINGES DUE TO GUIDED WAVES WITHIN THE LAYERS.** When optical pseudo-surface waves are generated by a nearly critical transmission condition, their scattering is very useful for observation of defects, such as dislocations and microcracks near surfaces and also for detection of scratches and dust on the surfaces. Guided waves created by multiple reflections between interfaces make equal-thickness fringes by which fluctuation of their thickness is observed. (Author abstract) 3 refs.

Ogawa, Tomoya (Gakushuin Univ, Tokyo, Jpn). *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1638-1641.

**093729 DIFFUSION OF TIN IN A  $\text{PbSe}_{1-x}\text{Te}_x$  SOLID SOLUTION.** A study was made of the diffusion of tin in single crystals of a solid solution of lead selenide and lead telluride by the radioactive tracer method using the  $^{113}\text{Sn}$  isotope. It was found that the diffusion conditions correspond to the conditions of synthesis of  $\text{Pb}_{0.8}\text{Sn}_{0.2}\text{Te}$  epitaxial layers on  $\text{PbSe}_{0.08}\text{Te}_{0.92}$  by the vacuum condensation method. Various diffusion mechanisms were noted in the 350-500°C temperature range, and their activation energies were determined. It is shown that the diffusion of tin in  $\text{PbSe}_{0.08}\text{Te}_{0.92}$  may be represented within the framework of a 'dissociative mechanism' model. In Russian. 6 refs.

Simirskii, Yu.N.; Krylyuk, O.N.; Gas'kov, A.M.; Zlomanov, V.P. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 8 Aug 1987 p 1278-1281.

**093730 CHARACTERIZATION OF REACTIVELY SPUTTERED TIN FILMS.** Tin films were grown on 4 inch silicon substrates by dc magnetron sputtering from a pure Ti target in an  $\text{Ar}/\text{N}_2$  atmosphere. The influence of deposition parameters (e.g., gas composition, substrate bias, and temperature) on film properties were examined by means of x-ray diffraction, and measurement of resistivity, stress, and density. 18 refs.

Cirelli, Nadia (SGS, Agrate, Italy); Hems, John. *Solid State Technol* v 31 n 2 Feb 1988 p 75-78.

**093731 GROWTH AND CHARACTERIZATION OF GERMANIUM AND BORON DOPED SILICON EPITAXIAL FILMS.** The epitaxial growth and characterization of in-situ germanium and boron (Ge/B) doped Si epitaxial films is described. As indicated by secondary ion mass spectroscopy and spreading resistance measurements, the total and electrically activated B concentrations are essentially identical and independent of Ge incorporation. The B and Ge concentrations are uniformly distributed in these Ge/B doped films. A slight enhancement of Hall mobility is obtained, possibly due to the stress relief induced by Ge counterdoping. Electron injection reveals a different transport mechanism of the  $\text{SiO}_2$  grown on these Ge/B doped films. (Edited author abstract) 7 refs.

Ang, Simon S. (Texas Instruments Inc, Dallas, TX, USA); Garvin, James F., Jr. *J Electron Mater* v 17 n 1 Jan 1988 p 39-43.



**093732 GROWTH OF POLYANILINE FILMS: EVIDENCE FOR FRACTAL SURFACE.** During electropolymerization of aniline using cyclic potential scanning the surface area of the polyaniline films grows like a power law of their volume, with the exponent  $\alpha \approx 0.4$ . Implications of this result are discussed. (Author abstract) 5 refs.

Villeret, B. (CEN de Grenoble, Grenoble, Fr); Nechtschein, M. *Solid State Commun* v 64 n 4 Oct 1987 p 435-437.

**093733 LPE GROWTH OF InGaAsP EPITAXIAL LAYERS OF GaAs SUBSTRATES.** The effects of various growth conditions on surface morphology and compositional nonuniformity of LPE (liquid phase epitaxial) layers of  $\text{In}_x\text{Ga}_{1-x}\text{As}_y\text{P}_{1-y}$  ( $y < 0.01$ ) on (100) GaAs substrate are studied. The growth conditions for obtaining a smooth and uniform layer are found from the results of the changes in surface morphology. The interface instability occurring under undercooling conditions in the LPE process is studied by means of an analysis of the Fourier spectra of the surface morphology. Compositional nonuniformity of InGaAsP LPE layers are investigated by means of precision X-ray diffractometry. The compositional variation taking place in the initial growth stage over several seconds is found. The variation in the initial stage is analyzed theoretically from the 'growth lines' on the In-Ga phase diagram for a diffusion-limited growth model. (Edited author abstract) 24 refs.

Hirmamatsu, Kazumasa (Nagoya Univ, Nagoya, Jpn); Akasaki, Isamu; Sawaki, Nobuhiko. *Mem Fac Eng Nagoya Univ* v 38 n 2 1986 p 183-207.

**093734 THERMODYNAMIC ANALYSIS OF THE CONCENTRATION PROFILES OF EPITAXIAL LAYERS OF NONIDEAL SOLID SOLUTIONS.** On the basis of a thermodynamic analysis using the quasi-regular approach, a mathematical model of the process of equilibrium crystallization of non-ideal three-component solid solutions of compounds of  $\text{A}^{\text{III}}\text{B}^{\text{V}}$  type from a limited volume of melt solution is constructed. This model makes it possible to calculate the distribution of the components along the thickness of the epitaxial layer at low rates of cooling of the melt solution. Computer calculations of the concentration profiles of  $\text{Ga}_{1-x}\text{Al}_x\text{As}$  epitaxial layers showed good agreement with experimental data for epitaxial-layer thicknesses up to 20  $\mu\text{m}$ . At high cooling rates mass transfer processes in the bulk of the melt solution must be taken into account. In Russian. 12 refs.

Kazakov, A.I. (Kishmar, I.N.); Mokritskii, V.A.; Yakubovskii, M.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 10 Oct 1987 p 1602-1606.

**093735 CRYSTALLIZATION OF  $\text{Ga}_x\text{In}_{1-x}\text{As}_y\text{Sb}_{1-y}$  SOLID SOLUTIONS ON GaSb AND InAs SUBSTRATES.** The melt compositions and supercoolings required for the crystallization of  $\text{Ga}_x\text{In}_{1-x}\text{As}_y\text{Sb}_{1-y}$  solid solutions which are isoperiodic with GaSb and InAs substrates were determined. An estimate is made of the composition range of the solid solution ( $\delta \leq \gamma \leq 0.3$ ) which can be grown on GaSb substrates from a supercooled (supersaturated) liquid phase. It is shown that, above 820 K, films of solid solutions corresponding in composition to the central part of the isoperiodic lines cannot be obtained. In Russian. 9 refs.

Bochkarev, A.E.; Gal'gazov, V.N.; Dolginov, L.M.; Selin, A.A. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 10 Oct 1987 p 1610-1614.

**093736 DEPOSITION OF EPITAXIAL SEMICONDUCTOR LAYERS FROM THE LIQUID AND GASEOUS PHASES ONTO A MOVING SUBSTRATE.** Growth from a melt solution on a moving substrate possesses an instability related to trapping of liquid phase from the container. However, in a static regime it is possible to obtain large-block textured silicon and gallium arsenide films on graphite substrates. The conditions for temperature-gradient zone melting through the gaseous-phase or vacuum zone are determined for the growing

of single-crystal or polycrystalline Si and GaAs films on moving substrates. 4 refs. In Russian.

Popov, V.P.; Lozovskii, S.V.; Kovaler, N.M. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1769-1772.

**093737 STUDY OF InAs LAYERS GROWN BY MOLECULAR-BEAM EPITAXY ON {100} GaAs SUBSTRATES.** Smooth epitaxial layers of InAs with a thickness of 0.2-2.0  $\mu\text{m}$  have been obtained by molecular beam epitaxy on {100} GaAs substrates. A study was made of their electric properties and surface morphology. It is shown that the quality of the layers depends essentially on their thickness and the growth conditions. N-type InAs layers obtained under near-optimal conditions had a carrier concentration and mobility at 300 K of  $6.10^{17} \text{ cm}^{-3}$  and  $6600 \text{ cm}^2/(\text{V}\cdot\text{sec})$  for a thickness of approximately 0.4  $\mu\text{m}$  and a concentration and mobility of  $1.10^{17} \text{ cm}^{-3}$  and  $11,000 \text{ cm}^2/(\text{V}\cdot\text{sec})$  for a thickness of approximately 1.0  $\mu\text{m}$ . 15 refs. In Russian.

Dvoryankina, G.G.; Dvoryankin, V.F.; Petrov, A.G.; Kudryashov, A.A.; Porotnikov, A.P.; Varaksin, G.A.; Khusid, L.B. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1777-1783.

**093738 STRUCTURE OF A LEAD SULFIDE/SILICON CONTACT.** A comparative study was made of the structure and composition of vacuum condensates of lead sulfide obtained on silicon substrates by the conventional method from a molecular beam and from a gas-dynamic flow of PbS vapor. It is shown that through condensation from a gas-dynamic flow of PbS vapor and a photoactivating treatment in an oxidizing medium PbS/silicon heterostructures can be obtained in which the heterocontact region and the PbS films themselves have the same composition and structure as in the case of condensation from a molecular beam. Moreover, the homogeneity along the film thickness on large-area structures, which is characteristic of the gas-dynamic flow method, is preserved. 6 refs. In Russian.

Bakueva, L.G.; Il'in, V.I.; Karasik, N.Ya.; Musikhin, S.F.; Ozerova, L.V.; Putilovskaya, M.Yu. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1788-1791.

**093739 CONTRIBUTION TO THE UNDERSTANDING OF FILM-SUBSTRATE INTERFACIAL STRUCTURE EVOLUTION SUBSEQUENT TO FILM GROWTH.** The author analyses the present state of art of the understanding of film-substrate interfacial geometry evolution subsequent to film growth. The observed trends are discussed within the frame of a simple microscopic theory based upon the soft phonon theory of interfacial geometrical transitions in film-substrate systems. For a softer film on a stiffer substrate, the main issues are: (i) the film growth can produce an interfacial reconstruction, (ii) an increase of the interfacial bonding acts as a factor stabilizing the interfacial crystallographic structure. (iii) the stability of the interfacial geometry increases as the elastic properties of the film and of the substrate become closer. (Author abstract) 12 refs.

Masri, P. (Univ des Sciences & Techniques du Languedoc, Montpellier, Fr). *Solid State Commun* v 65 n 12 Mar 1988 p 1617-1620.

**093740 GROWTH OF GAINAS/INP BY THE VAPOR PHASE EPITAXY HYDRIDE METHOD.** The hydride method was used to study the  $\text{Ga}_x\text{In}_{1-x}\text{As}$  deposition process on <100> InP-wafers. The effects of the vapor pressures of arsenic and metal chlorides on the composition  $x$  have been investigated in order to optimize the lattice matching to InP. These studies were carried out with a reactor designed to obtain sharp interfaces and to make possible an in situ surface analysis by ellipsometry. Thin film deposition on the substrate without heteronucleation at the entry of the deposit zone was achieved by using an additional HCl line. The  $\text{Ga}_x\text{In}_{1-x}\text{As}$  layer matching to the InP substrate required a value of  $[\text{In Cl}]/[\text{Ga Cl}] \approx 20$ . (Edited author abstract). 25 Refs.

Lassalle, F. (Univ Blaise Pascal Cermont II, Aubiere, Fr); Porte, A.; Laporte, J.L.; Pariset, C.; Cadoret, M. *Mater*

*Res Bull* v 23 n 9 Sep 1988 p 1285-1297.

**093741 C-V & IR ABSORPTION STUDY OF THIN OXIDE ( $\approx 500 \text{ \AA}$ ) FILMS THERMALLY GROWN ON SILICON.** Results of C-V and IR studies on Si-SiO<sub>2</sub> systems of thin oxides thermally grown on Czochralski (CZ) and float zone (FZ) wafers are reported. The oxides were grown at 900°C in dry oxygen as well as in TCE ambient to get  $\approx 500$  angstrom thick SiO<sub>2</sub>. The oxide thickness was accurately measured by ellipsometer and capacitance methods. IR absorption spectra revealed the peaks for Si-O and O-Si-O stretching bonds at  $830 \text{ cm}^{-1}$  and  $1090 \text{ cm}^{-1}$  respectively. An extra peak at  $1250 \text{ cm}^{-1}$  was also observed, indicating the presence of SiCH<sub>3</sub> which was used for fixing the sample. The variation of interface state density  $N_{it}$  with energy showed an oscillatory behavior at the mid-gap in dry oxide samples along with an increase at the band edges, whereas in TCE oxide samples a smoother variation in  $N_{it}$  was noted. (Author abstract). 17 Refs.

Jmajhi, Prvaya (Indian Inst of Technology, Madras, India); Sadhana, M. *Indian J Pure Appl Phys* v 26 n 4 Apr 1988 p 294-296.

**093742 EPITAXIAL GROWTH OF PbTe ON (100) GaAs SUBSTRATES.** The growth of PbTe films on GaAs by molecular beam epitaxy was studied by reflection high energy electron diffraction. The strains in the films were investigated by X-ray diffraction. Despite a lattice mismatch of 14.2 percent, oriented films can be grown up to a thickness of 4000 angstrom. For thicker films the thermal strain causes cracks if the samples are cooled from growth to liquid-nitrogen temperature. (Edited author abstract). 11 Refs.

Clemens, H. (Montanuniversitaet Leoben, Leoben, Austria); Ofner, P.; Bauer, G.; Hong, J.M.; Chang, L.L. *Mater Lett* v 7 n 4 Oct 1988 p 127-130.

**Hydrogenation** See SEMICONDUCTING SILICON—Synthesis; SEMICONDUCTOR MATERIALS—Amorphous.

## Impurities

**093743 PRELIMINARY IMPURITY ANALYSIS OF  $\text{CuInSe}_2$  THIN FILMS USING THE ELASTIC RECOIL DETECTION METHOD.** Knowledge of impurities in thin films is important for fabrication and characterization of photovoltaic devices. The light-impurity distribution in electrodeposited  $\text{CuInSe}_2$  thin films has been investigated by an elastic recoil detection method using a 30 MeV <sup>35</sup>Cl beam and identifying the recoil masses using a time-of-flight technique. It was found that both oxygen and hydrogen were present and distributed uniformly throughout the thickness studied. Upper limits for carbon and nitrogen were also established. The energy spectra for oxygen and hydrogen were deconvolved to obtain the relative concentrations as a function of depth. Using the same technique, the compositional uniformity of Cu, In and Se was also determined, yielding results qualitatively consistent with those obtained by secondary ion mass spectroscopy. (Edited author abstract). 6 Refs.

Gujrathi, S.C. (Univ de Montreal, Montreal, Can); Qiu, C.X.; Lunney, M.D.N.; Shih, I. *Mater Lett* v 7 n 4 Oct 1988 p 131-133.

**Ion Implantation** See SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING TIN COMPOUNDS—Doping; SEMICONDUCTOR DEVICES—Contacts.

## Mathematical Models

**093744 ANALYTICAL MODEL OF FLOW DICHROISM IN LANGMUIR-BLODGETT FILMS.** A model of flow orientation has been developed for analyzing the dichroism in Langmuir-Blodgett (LB) films by introducing a two-dimensional fluid and a sink, which represent the monolayer and a substrate, respectively. The angular distribution function derived using the velocity gradient given by the ideal-fluid approximation satisfactorily explains the data of dichroism in the mixed LB films of a dye and a fatty acid prepared with different velocities.



The results are consistent also with those of the line-shape analysis of ESR spectrum reported previously. (Author abstract) 12 refs.

Minari, Naoto (Electrotechnical Lab, Tsukuba, Jpn); Ikegami, Keiichi; Kuroda, Shin-ichi; Saito, Kazuhiro; Saito, Mitsuyoshi; Sugi, Michio. *Solid State Commun* v 65 n 11 Mar 1988 p 1259-1262.

### Measurements

**093745 ANGULAR DISTORTIONS AND THE EXPONENTIAL ABSORPTION EDGE OF SILICON-RICH  $a\text{-Si}_x\text{N}_y\text{H}_z$  ALLOYS.** Raman Scattering, Photothermal Deflection Spectroscopy (P.D.S.) and optical transmission measurements have been performed on the same samples from two sets of Silicon-rich ( $y/x \leq 0.8$ )  $a\text{-Si}_x\text{N}_y\text{H}_z$  films prepared under widely different conditions in two glow-discharge reactors. The opening of the optical gap  $E_G$  with rising Nitrogen concentrations is linear with the increase of the reciprocal slope  $E_0$  of the Urbach edge. Because of the strong correlation observed between this last parameter and the width of the 'optic' inelastic scattering peak, the broadening of the valence band tail with Nitrogen incorporation was attributed to an increasing r.m.s. standard deviation of the Silicon-Silicon bond angle distribution. (Author abstract) 36 refs.

Bustarret, E. (CNRS, Grenoble, Fr); Morgado, E. *Solid State Commun* v 63 n 7 Aug 1987 p 581-585.

**093746 ERROR REDUCTION IN THE ELLIPSO-METRIC MEASUREMENT ON THIN FILMS.** A theoretical study on the error reduction scheme for ellipsometry in a paper by Ho et al. to measure ultra thin film ( $<200\text{\AA}$ ) is presented. The study is on a more general double-layer model which can be simplified to the single-layer model. It is shown that the errors can be reduced by at least 5 times for the double-layer structure and 2 times for the single-layer structure. A  $\phi_0$ - $T_1$  plot is devised to reduce the random errors which is useful to determine the index profile of a double-layer thin film. (Edited author abstract). 22 refs.

Jua Hwang Ho (Nat'l Chiao Tung Univ, Hsinchu, Taiwan); Chung Len Lee; Tan Fu Lei. *Solid State Electron* v 31 n 8 Aug 1988 p 1321-1326.

**Metallizing** See SEMICONDUCTOR DEVICES—Noise.

### Microscopic Examination

**093747 TRANSMISSION ELECTRON MICROSCOPIC STUDY OF THE ELECTROCHROMIC MATERIAL BIS(PHTHALOCYANINATO) YTTERBIUM.** Transmission electron microscopy has been used to characterize thin solid films of bis(phthalocyaninato) ytterbium which were prepared by subliming powder, in vacuo, onto unheated carbon-coated glass substrates. The films are found to consist of three main growth forms: (i) highly crystalline monocrystals in the form of rectangular parallelepipeds, (ii) less perfect, thinner rectangular-shaped monocrystals than type (i), and (iii) very small, finely distributed molecular clusters and strings. The crystallinity of types (i) and (ii) is degraded by electron irradiation, but the use of low-dose methods has enabled the following crystallographic parameters to be determined from the microcrystals by means of both lattice images and electron diffraction: crystal system: face-centered tetragonal, unit cell parameters:  $a=b=28.02\pm0.48$  Å,  $c=6.92\pm0.10$  Å. Variations of cell parameters outside the error limits are shown to be statistically significant and are believed to indicate the presence of a structural variant. Several forms of crystal defects have been imaged and identified. (Author abstract) 22 refs.

Song, Se Ahn (Univ of Essex, Colchester, Engl); O'Connor, M.; Barber, D.J.; Silver, J. *J Cryst Growth* v 88 n 4 May II 1988 p 477-487.

**Microstructure** See SEMICONDUCTING CADMIUM COMPOUNDS—Thin Films; SEMICONDUCTOR MATERIALS—Amorphous.

**Optical Properties** See Also SEMICONDUCTING SILICON—Amorphous; SILICON NITRIDE—Thin Films.

**093748 ENERGY GAP AND OPTICAL DIELECTRIC CONSTANT OF  $\text{Pb}_{1-x}\text{Cd}_x\text{Se}$  FILMS.** The transmission spectra of laser-deposited  $\text{Pb}_{1-x}\text{Cd}_x\text{Se}$  films ( $x=0, 0.02, 0.05, 0.08$  and  $0.12$ ) have been measured over the energy range  $0.1\text{--}0.65$  eV at two different temperatures 90 and 300 K. From these spectra the dispersion of the refractive index and the absorption coefficient-energy dependence have been obtained. Thus the dependences of the gap and the optical dielectric constant on the Cd content  $x$  have been investigated. The experimental results have been discussed in the framework of the recently developed theoretical model by Volkov and Pankratov et al. (Author abstract) 17 refs.

Baleva, M. (Univ of Sofia, Sofia, Bulg); Maksimov, M.; Sendova, M. *Infrared Phys* v 27 n 6 Nov 1987 p 389-397.

**093749 APPARATUS BASED ON KSVU-5 SYSTEM FOR STUDY OF SEMICONDUCTOR FILMS.** Apparatus for study of the optical and photoelectric properties of semiconductor films and structures is described that is based on a KSVU-5 spectral computer system. The apparatus operates interactively with an Elektronika D3-28 microcomputer for real-time interpretation of the results and selection of conditions under which the properties of films can be satisfactorily described by simple mathematical models. (Author abstract) 3 refs.

Voroshilov, S.A. (Saratov State Univ, USSR); Kisin, V.V.; Nazvanov, V.F. *Instrum Exp Tech* v 30 n 4 pt 2 Jul-Aug 1987 p 972-974.

**093750 CALCULATION OF THE INTEGRATED COEFFICIENTS OF ABSORPTION AND TRANSMISSION OF SOLAR RADIATION FOR SEMICONDUCTOR FILMS.** A method is described for calculating the absorption and transmission of solar radiation by thin semiconductor films as a function of the thickness of the films. Computational results are presented. (Author abstract) 3 refs.

Antropov, A.V. (A.A. Zhdanov Leningrad State Univ, USSR); Kirillov, S.N.; Novik, F.T.; Trofimov, O.A. *J Eng Phys* v 53 n 3 Sep 1987 p 1024-1027.

**093751 LIGHT-INDUCED EFFECTS ON THE OPTICAL ABSORPTION OF  $a\text{-Si}$ :H.** The modifications of the optical absorption of glow-discharge  $a\text{-Si}$ :H films upon light exposure and subsequent annealing are determined by spectroscopic ellipsometry, photothermal deflection spectroscopy and IR absorption measurements. The results show that illumination induces both reversible changes of the defect states density and irreversible morphological modifications involving hydrogen atoms. (Author abstract). 15 Refs.

Cabarrocas, P. Roca I. (Ecole Polytechnique, Palaiseau, Fr); Chahed, L.; Drevillon, B.; Theye, M.L. *J Non Cryst Solids* v 104 n 1 Aug 1988 p 59-61.

**093752 ELECTRICAL & OPTICAL PROPERTIES OF  $\text{CdSb}_2\text{S}_4$  FILMS & THEIR USE IN ECPV CELLS.**  $\text{CdSb}_2\text{S}_4$  films have been deposited onto conducting and nonconducting glass substrates at an optimised substrate temperature following spray pyrolysis technique. The composition of films is nearly stoichiometric and the films exhibit characteristics of a direct band gap semiconductor with n-type conductivity. From values of dynamic V-I characteristics, it is inferred that electrochemical photo-voltaic cells made up of n- $\text{CdSb}_2\text{S}_4$ , 0.5M KCl, 0.5M  $\text{Fe}^{2+}$ , 0.5M  $\text{Fe}^{3+}$  IC are good generators of electricity. The efficiency and fill factor are found to be 0.0084 percent and 33.46 percent respectively. (Author abstract). 9 Refs.

Pawar, S.H. (Shivaji Univ, Kolhapur, India); Bhosale, C.H.; Pawar, A.J. *Indian J Pure Appl Phys* v 26 n 4 Apr 1988 p 323-325.

**Order-Disorder** See SEMICONDUCTING SELENIUM COMPOUNDS—Amorphous.

**Physical Properties** See Also SEMICONDUCTING GLASS—Crystallization; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING ZINC COMPOUNDS—Doping; SEMICONDUCTOR MATERIALS—Thin Films.

**093753 INVESTIGATION ON PHYSICAL PROPERTIES AND STRUCTURE OF AMORPHOUS HYDROGENATED CARBON FILMS.** Hydrogenated amorphous carbon films were prepared by glow-discharge decomposition of pure  $\text{CH}_4$  at different gas pressure. Results of a study of optical and electrical properties and of the bonding and structure of the films are presented. The values of optical constants are close to those of dense hydrocarbons and nearly independent of gas pressure. Measurements of the temperature dependence of electrical conductivity indicate a conduction by extended states. The results of infrared spectroscopy indicate the existence of a hydrogen-rich phase with saturated groups. (Edited author abstract) 18 refs.

Demichelis, F. (Politecnico di Torino, Turin, Italy); Fanciulli, M.; Kaniadakis, G.; Tagliaferro, A.; Tresso, E.; Rava, P.; Giamello, E. *J Non Cryst Solids* v 101 n 2-3 May 1988 p 179-186.

### Plasmas

**093754 FIELD THEORETICAL TREATMENT OF PLASMA MODES IN COUPLED TWO-DIMENSIONAL SYSTEMS.** We investigate an assembly of two two-dimensional electron systems separated spatially but coupled by Coulomb interaction. The acoustic and the optical plasma modes are studied using a field theoretical method. It is found that a certain approximation in treating one class of diagrams gives an effective exchange potential equal to that calculated using the method of Kohn and Sham. For small wave-vector, expressions equivalent to Boltzmann equations are obtained. Numerical results are obtained for the dependence of the frequency on wave vector and densities of the electron systems. (Edited author abstract) 10 refs.

Sy, H.K. (Nat'l Univ of Singapore, Singapore). *Solid State Commun* v 61 n 4 Jan 1987 p 245-247.

**Preparation** See Also SEMICONDUCTING GERMANIUM COMPOUNDS—Chemical Vapor Deposition.

**093755 RESISTIVITY AND PHOTOCONDUCTIVITY OF PLASMA-SPRAYED POLYCRYSTALLINE SILICON.** Polycrystalline silicon layers of area  $8\text{ cm}^2$  and thickness  $t$  ranging from  $100\text{ }\mu\text{m}$  to  $2\text{ mm}$  were prepared on alumina substrates by plasma spraying silicon powder. For  $t > 500\text{ }\mu\text{m}$ , these layers could be detached from the substrate. The conductivity could be made n or p type by in situ doping. The microstructure, impurity content and resistivity as a function of both phosphorus and boron doping concentrations were studied. The effect of heat treatment on the resistivity, Hall mobility and the photoconductivity is reported. The data are explained qualitatively on the basis of existing models of the transport behavior of polycrystalline silicon. (Author abstract) 27 refs.

Akani, M. (CNRS, Meudon, Fr); Suryanarayanan, R.; Brun, G. *Thin Solid Films* v 151 n 3 Aug 17 1987 p 343-353.

### Quality Control

**093756 CELL FOR SEMICONDUCTOR ANODIC OXIDATION, ETCHING, AND PARAMETER MEASUREMENT.** One can recover the dopant profile and major-carrier mobility from measurements of the Hall constant and resistivity made on layerwise oxidation and etching for semiconductor films. This is necessary in devising means of making electronic components. Various types of cell, including ones described recently, are used in research and in routine measurement for these purposes. The authors describe a cell for use with GaAs films grown on seminsulating GaAs. This structure imposes require-



ments much more stringent than those for ordinary silicon and gallium arsenide ones. The cell design involves three major aspects: protecting the ohmic contacts and leads from the corrosive medium, electrolyte mixing, and illumination.

Vil'f, F.Zh. (Moscow Electronic Engineering Inst, USSR); Khrekin, A.V. *Ind Lab (USSR)* v 53 n 9 Sep 1987 p 854-856.

**Radiation Effects** See SEMICONDUCTOR MATERIALS—Phase Transitions.

**Silicon** See Also PHOTOVOLTAIC CELLS—Efficiency.

**093757 ELECTRIC PROPERTIES AND SUBMICROPOROSITY OF VACUUM-DEPOSITED FILMS OF AMORPHOUS SILICON.** A hierarchical model of the structure of the objects under investigation is suggested. It was established that the films' free space, which is localized in the form of submicropores, and surface states connected with formation of it are a characteristic defect determining the electron properties of condensates of amorphous silicon. (Author abstract) 5 refs.

Boiko, B.T.; Cheremskoi, P.G.; Lebedeva, M.V.; Usenko, M.Yu.; Rudenko, V.A.; Murovtsiev, L.G. *Appl Sol Energy* v 23 n 3 1987 p 40-44.

**Space Charge**

**093758 TRANSIENT PHOTOCONDUCTIVITY PROBING OF NEGATIVE BULK SPACE CHARGE EVOLUTION IN HALOGENATED AMORPHOUS SELENIUM FILMS.** A delayed transient photoconductivity technique was applied to probe the time evolution of a negative bulk space charge build-up in chlorine doped amorphous selenium films during the application of an electric field. It is shown that the observed negative bulk space charge density depends linearly on the delay time and can be attributed to thermal generation of holes from mid-gap localized states and their consequent sweep out leaving behind ionic centers. Other possible causes are also discussed. The photoinjected excess hole  $\tau_h$ , obtained by extrapolating to zero delay time, was found to be increased by Cl addition to a-Se whereas the hole drift mobility  $\mu_h$  was reduced by almost the same factor. (Author abstract) 7 refs.

Kasap, S.O. (Imperial Coll of Science & Technology, London, Engl); Juhasz, C. *Solid State Commun* v 63 n 6 Aug 1987 p 553-556.

**Spectroscopic Analysis** See SEMICONDUCTING GERMANIUM—Amorphous; SEMICONDUCTING SILICON—Thin Films; SEMICONDUCTING SILICON COMPOUNDS—Synthesis.

**Spectrum Analysis** See SEMICONDUCTOR MATERIALS—Charge Carriers.

**Sputtering** See WAVEGUIDES, OPTICAL—Optical Properties.

**Stability** See SEMICONDUCTOR MATERIALS—Thin Films.

**Stresses** See SEMICONDUCTING ZINC COMPOUNDS—Defects.

**Structure** See IRIIDIUM COMPOUNDS—Electronic Properties; SEMICONDUCTING ANTIMONY COMPOUNDS—Thin Films; SEMICONDUCTING BORON—Laser Applications.

**Surfaces**

**093759 SUBSTITUENT AND METAL-ION COMPLEXATION EFFECTS UPON THE GAS-SURFACE INTERACTIONS OF THIN ORGANIC FILMS.** The dark d.c. surface currents are reported for thin films of organic semiconducting compounds when exposed to dinitrogen tetroxide, hydrogen chloride and chlorine. The magnitudes of the dark currents are a function of the  $\pi$ -electron bonding of the organic framework, and can also be varied (i) by altering the peripheral substituents or

(ii) by metal-complex formation or (iii) by changing the physical characteristics of the films. The possibilities for gas-discriminatory analytical devices are discussed. (Author abstract). 17 Refs.

Honeybourne, Colin L. (Bristol Polytechnic, Bristol, Engl); Hill, Callum A.S.; Ewen, Richard J.; Collings, M.S.; Clarke, William C. *J Phys Chem Solids* v 49 n 9 1988 p 1003-1008.

**Switching** See SEMICONDUCTING SELENIUM COMPOUNDS—Switching.

**Synthesis** See Also SEMICONDUCTOR DEVICES—Heterojunctions.

**093760 PREPARATION OF p-TYPE POLYCRYSTALLINE WS<sub>2</sub> ELECTRODES.** Three different types of polycrystalline WS<sub>2</sub> electrodes have been prepared by solid-gas reaction of H<sub>2</sub>S with metallic tungsten or anodic tungsten oxide films at temperatures higher than 330°C. The electrode behavior of the specimens has been tested by means of cyclic voltammetry in the dark and under illumination. All samples obtained have shown p-type photoelectrochemical behavior. (Author abstract) 27 refs.

Di Paola, Agatino (Univ di Palermo, Palermo, Italy). *Mater Res Bull* v 22 n 5 May 1987 p 569-576.

**093761 PREPARATION OF BISMUTH IODIDE FILMS BY IODINATION OF CHEMICALLY DEPOSITED BISMUTH SULPHIDE FILMS.** c-Axis Oriented bismuth iodide thin films were prepared by iodination of chemically deposited bismuth sulfide thin films. The mechanism of iodination is discussed in the light of the results of x-ray diffraction and electrical resistivity studies with different times of iodination. The replacement of sulfur by iodine in the Bi<sub>2</sub>S<sub>3</sub> lattice is feasible in view of the favorable free energy change. The shift in the optical absorption edge of the iodized films confirms the substitution phenomenon. X-ray fluorescence studies of iodized films washed with carbon disulfide gave evidence of the isolation of sulfur on the surface of the converted BiI<sub>3</sub> film. (Author abstract) 12 refs.

Singh, S.K. (Regional Research Lab, Bhubaneswar, India); Nayak, B.B.; Acharya, B.S.; Mohanty, B.C. *React Solids* v 4 n 1-2 Oct 1987 p 173-180.

**093762 LOW TEMPERATURE CHEMICAL PREPARATION OF SEMICONDUCTING TRANSITION METAL CHALCOGENIDE FILMS FOR ENERGY CONVERSION AND STORAGE, LUBRICATION AND SURFACE PROTECTION.** A simple technique is presented for the production of films of transition metal disulfides such as MoS<sub>2</sub>, WS<sub>2</sub>, FeS<sub>2</sub>, or RuS<sub>2</sub> by the reaction of transition metal carbonyls with a sulfur source in an organic solvent benzene, toluene, xylene, mesitylene at temperatures ranging between 80 to 165°C. The quality of the materials and films has been investigated, and some applications are discussed. They include use of the chemically prepared sulfides as photoactive materials (e.g., MoS<sub>2</sub>, WS<sub>2</sub>, FeS<sub>2</sub>), as lubricating films (MoS<sub>2</sub>), as electrodes for Li-batteries (MoS<sub>2</sub>, FeS<sub>2</sub>) and for corrosion protection (RuS<sub>2</sub>). (Edited author abstract). 17 Refs.

Chatzitheodorou, G. (Hahn-Meitner-Inst, Berlin, West Ger); Fiechter, S.; Kunst, M.; Luck, J.; Tributsch, H. *Mater Res Bull* v 23 n 9 Sep 1988 p 1261-1271.

**Thermoelectric Effects** See SEMICONDUCTING ANTIMONY COMPOUNDS—Thin Films.

**Thickness Measurement** See SEMICONDUCTING GALLIUM COMPOUNDS—Growth; SEMICONDUCTING SILICON—Optical Properties.

**Thin Films** See Also PLASMAS—Magnetoplasma; SEMICONDUCTING INDIUM COMPOUNDS—Optical Properties; SEMICONDUCTING SILICON COMPOUNDS—Thin Films.

**093763 PREPARATION OF Zn<sub>x</sub>Cd<sub>1-x</sub>O THIN FILMS.** Investigation has been made on Zn<sub>x</sub>Cd<sub>1-x</sub>O thin films prepared by a sputtering technique. From X-ray diffraction, it was found that the magnitude of the

preferred (002) peak of ZnO decreased as the cadmium concentration was increased. For the rf sputtered Cd-rich films, a preferred (200) plane was observed. It was further found that the crystalline quality of the films was better for the pure materials. The absorption edge obtained from transmission measurements showed a minimum at  $x=0.6$  and an abrupt increase as the  $x$  value was increased from 0.6 to 1. Room temperature electrical measurements showed a strong positional effect for the Zn-rich samples. Good resistivity uniformity was obtained for the Cd-rich films even using the same deposition conditions. (Author abstract) 5 refs.

Qiu, S.N. (McGill Univ, Montreal, Que, Can); Qiu, C.X.; Shih, I. *Sol Energy Mater* v 16 n 6 Dec 1987 p 471-475.

**093764 ELECTROCHEMICAL SYNTHESIS OF PHOTOACTIVE In<sub>2</sub>Se<sub>3</sub> THIN FILMS.** In<sub>2</sub>Se<sub>3</sub> thin films were grown by alternate electrodeposition of selenium and indium from separate baths onto titanium substrates with subsequent thermal annealing. The influence of annealing temperature on the properties of the obtained films was examined. The results of X-ray diffraction patterns led to the conclusion that films were  $\beta$ -phase when the temperature ranged between 300 and 500°C. At 600°C the thin film loses Se and the ratio Se/In decreases. Only photoanodic response, n-type thin films, was observed when the samples were tested in a photoelectrochemical cell with a sulfite/sulfate redox couple. Values of the photocurrent on the spectra response were increased when the annealing temperature was also increased, showing the best photocurrent values at 500°C, and the films that were annealed at 600°C showed no photoactivity. Additional study results are discussed. (Edited author abstract) 21 refs.

Herrero, J. (Inst de Energias Renovables, Madrid, Spain); Ortega, J. *Sol Energy Mater* v 16 n 6 Dec 1987 p 477-485.

**Trace Analysis** See SEMICONDUCTING SILICON—Trace Analysis.

**Vapor Deposition** See SEMICONDUCTING CADMIUM COMPOUNDS—Mechanical Properties; SEMICONDUCTING DIAMONDS—Thin Films; SEMICONDUCTING GALLIUM ARSENIDE—Growing; SEMICONDUCTING GALLIUM ARSENIDE—Impurities; SEMICONDUCTING LEAD COMPOUNDS—Thin Films; SEMICONDUCTING TELLURIUM—Vapor Deposition; SEMICONDUCTING ZINC COMPOUNDS—Growth; SEMICONDUCTOR MATERIALS—Thin Films.

**SEMICONDUCTING GALLIUM** See Also SEMICONDUCTING GERMANIUM—Spectroscopic Analysis.

**Ion Implantation**

**093765 ENHANCED ACTIVATION OF Ga IMPLANTED Si THROUGH RAPID THERMAL PROCESSING.** Metastable activation of Ga implants has been achieved through rapid annealing. Carrier concentrations of  $\approx 2 \times 10^{20} \text{ cm}^{-3}$  exceed the Ga solubility limit by a factor of five and are comparable to boron doping levels. Retention of these doping levels severely limits any subsequent thermal processing. (Author abstract) 5 refs.

Davies, D. Eirug (EOARD, London, Engl). *Electron Lett* v 24 n 1 Jan 7 1988 p 35-36.

**Marketing** See SEMICONDUCTING GERMANIUM—Marketing.

**SEMICONDUCTING GALLIUM ARSENIDE** See Also AMPLIFIERS, MICROWAVE—Low Temperature Effects; AMPLIFIERS, MICROWAVE—Noise, Spurious Signal; AMPLIFIERS, OPERATIONAL—Design; CARBON—Thin Films; CRYSTALS—Electric Field Effects; DATA STORAGE, DIGITAL—Random Access; ELECTRIC FILTERS, SWITCHED—Design; ELECTRODES—Materials; ERBIUM AND ALLOYS—Spectroscopic Analysis; GALLIUM AND ALLOYS—Spectroscopic Analysis; INTEGRATED CIRCUITS—Military Applications; INTEGRATED CIRCUITS, DIGITAL—Computer Aided Design; INTEGRATED CIRCUITS, LSI—Microwaves; INTEGRATED CIRCUITS, MONOLITHIC—Millimeter Waves; INTEGRATED CIRCUITS, MONOLITHIC—Performance; INTEGRATED CIRCUITS, MONOLITHIC—Transients; INTEGRATED CIRCUITS,



VLSI—Analysis; INTEGRATED CIRCUITS, VLSI—Performance; LASERS, SEMICONDUCTOR; LASERS, SEMICONDUCTOR—Performance; LASERS, SEMICONDUCTOR—Reliability; LASERS, SEMICONDUCTOR—Theory; LOGIC CIRCUITS—Fabrication; LOGIC CIRCUITS, TRANSISTOR TRANSISTOR—Performance; MICROSTRIP DEVICES—Computer Aided Design; OPTICAL DEVICES—Switching; SEMICONDUCTING ALUMINUM COMPOUNDS—Doping; SEMICONDUCTING ALUMINUM COMPOUNDS—Electric Properties; SEMICONDUCTING ALUMINUM COMPOUNDS—Vapor Deposition; SEMICONDUCTING GALLIUM ARSENIDE; SEMICONDUCTING GALLIUM COMPOUNDS—Chemical Vapor Deposition; SEMICONDUCTING GALLIUM COMPOUNDS—Growth; SEMICONDUCTING INDIUM COMPOUNDS—Defects; SEMICONDUCTING INDIUM COMPOUNDS—Measurements; SEMICONDUCTING SELENIUM COMPOUNDS—Growth; SEMICONDUCTING SILICON—Dielectric Properties; SEMICONDUCTING SILICON—Growth; SEMICONDUCTING SILICON—Spectroscopic Analysis; SEMICONDUCTOR DEVICES—Applications; SEMICONDUCTOR DEVICES—Electronic Properties; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES, FIELD EFFECT—Fabrication; SEMICONDUCTOR DEVICES, FIELD EFFECT—Manufacture; SEMICONDUCTOR DEVICES, FIELD EFFECT—Mathematical Models; SEMICONDUCTOR DEVICES, FIELD EFFECT—Microwaves; SEMICONDUCTOR DEVICES, FIELD EFFECT—Noise; SEMICONDUCTOR DEVICES, MIS—Performance; SEMICONDUCTOR DEVICES, MOS—Semiconductor Insulator Boundaries; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Performance; SEMICONDUCTOR DIODES; SEMICONDUCTOR DIODES—Electric Properties; SEMICONDUCTOR DIODES, IMPATT—Analysis; SEMICONDUCTOR MATERIALS; SEMICONDUCTOR MATERIALS—Heterojunctions; SEMICONDUCTOR MATERIALS—Manufacture; SEMICONDUCTOR MATERIALS—Structure; SILICON GERMANIUM ALLOYS—Thin Films; SOLAR CELLS—Materials; THERMISTERS—Performance; TRANSISTORS—Electronic Properties; TRANSISTORS—Materials; TRANSISTORS—Performance; TRANSISTORS, BIPOLAR—Electric Field Effects; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, FIELD EFFECT; TRANSISTORS, FIELD EFFECT—Computer Aided Analysis; TRANSISTORS, FIELD EFFECT—Contacts; TRANSISTORS, FIELD EFFECT—Design; TRANSISTORS, FIELD EFFECT—Efficiency; TRANSISTORS, FIELD EFFECT—Electric Properties; TRANSISTORS, FIELD EFFECT—Electronic Properties; TRANSISTORS, FIELD EFFECT—Etching; TRANSISTORS, FIELD EFFECT—Fabrication; TRANSISTORS, FIELD EFFECT—Heterojunctions; TRANSISTORS, FIELD EFFECT—Mathematical Models; TRANSISTORS, FIELD EFFECT—Microwaves; TRANSISTORS, FIELD EFFECT—Millimeter Waves; TRANSISTORS, FIELD EFFECT—Modeling; TRANSISTORS, FIELD EFFECT—Performance; TRANSISTORS, FIELD EFFECT—Radiation Effects; TRANSISTORS, FIELD EFFECT—Theory; WAVEGUIDES—Mathematical Models.

**093766 GALLIUM ARSENIDE: THE 'OTHER' SEMICONDUCTOR FOR MICROCHIPS.** GaAs is one of a class called 'compound semiconductor crystals.' This means that it is formed out of more than just one element from the periodic table; it conducts electricity in a limited, controllable way like silicon; and the different atoms in it form a crystalline structure with a carefully ordered pattern: arsenic atoms alternate with gallium atoms in a precise 1-to-1 sequence. This article describes some of the challenges of bringing this electronic material into commercial production for integrated circuits.

Rogers, David W. (Cominco Ltd, Trail, BC, Can). *ASTM Stand News* v 15 n 10 Oct 1987 p 28-31.

**093767 CHARGE TRANSFER AND STABILIZATION AT ILLUMINATED n-GaAs/AQUEOUS ELECTROLYTE JUNCTIONS.** A simple model for the charge transfer process at various n-GaAs/aqueous electrolyte junctions is proposed. The assumptions made in the model are justified thanks to Electrochemical Photocapacitance Spectroscopy experiments; this technique is of great help in such a matter. As a result, the model accounts very well for the numerous aqueous electrolytes we used. It is found that (i) the more reducing the redox couple the greater the kinetics, i.e. S increases (ii) the more concentrated the redox species the more stabilized the electrode and (iii) the smaller the water concentration the greater S. All the parameters of the model are discussed and physically interpreted. The main results are: (i) the direct transfer for the redox reaction and (ii) the greater S the more pinned at the surface the band edges of the semiconductor. (Edited author abstract) 27 refs.

Allongue, P. (CNRS, Paris, Fr); Cachet, H. *Electrochim Acta* v 33 n 1 Jan 1988 p 79-87.

**093768 DYNAMICS OF ELECTRON TRANSFER BETWEEN TWO ADJACENT CHANNELS AS CALCULATED BY AN ENSEMBLE MONTE CARLO METHOD.** The dynamical characteristics of electron transfer between two channels are elucidated by using a many-particle Monte Carlo model with self-consistent electric fields. The study has been performed to assess switching speeds associated with various novel devices such as velocity modulation transistors and dual channel high electron mobility transistors. Typical time constants for a one micrometer device (0.4  $\mu\text{m}$  gate length) are 3.5 psec for the longitudinal (source-to-drain) and 0.2 psec for the transport perpendicular to the interfaces between the two channels. (Author abstract) 8 refs.

Kizilyalli, I.C. (Univ of Illinois at Urbana, Champaign-Urbana, IL, USA); Hess, K.; Iafraite, G.J.; Smith, D. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 2 Jun 1987 p 93-97.

**093769 GENERATION KINETICS OF EL2 CENTERS IN GaAs.** The generation kinetics of EL2 centers is investigated by means of the optical absorption at low temperature with GaAs in which grown-in EL2 centers have previously been eliminated by annealing at 1200°C. An analysis of the experimental results with chemical rate equations shows that an EL2 center consists of at least three defects of elementary type. The activation energy for the generation of EL2 centers is determined to be about 2.5 eV. The results favor the picture that the kernel of an EL2 center consists of one  $\text{As}_{\text{Ga}}$  antisite and two Ga vacancies. (Author abstract) 10 refs.

Suezawa, Masashi (Tohoku Univ, Sendai, Jpn); Sumino, Koji. *Jpn J Appl Phys Part 2* v 27 n 1 Jan 1988 p 18-20.

**093770 PHOTOCHEMICAL PATTERN ON p-TYPE GaAs.** A photochemical pattern on p-type GaAs has been realized with an electrodeless system. The illuminated zone appears to be above the surface whereas it is etched on n-type sample. The electrolyte is an acidic solution containing  $\text{Fe}^{3+}$  as an oxidizing agent. This solution reacts with the material and particularly with As atom under light leading to  $\text{As}_4\text{O}_6$  growth. (Author abstract) 9 refs.

Moutonnet, D. (CNET, Lannion, Fr). *Mater Lett* v 6 n 1-2 Nov 1987 p 34-36.

**093771 BAND-OFFSETS AND EFFECTIVE-MASS PARAMETERS IN QUANTUM WELLS.** The 85% rule for the conduction band-offset of GaAs quantum wells with AlGaAs barriers established by R. Dingle et al. turns out to be an artifact of using inappropriate hole mass parameters. It is shown that band parameters (for hole masses and conduction band nonparabolicity) obtained from adhering to quantum well optical data are consistent with known values for the bulk material. (Author abstract) 14 refs.

Roessler, U. (Univ Regensburg, Regensburg, West Ger). *Solid State Commun* v 65 n 11 Mar 1988 p 1279-1280.

**093772 PHOTOREFRACTIVE TWO-WAVE MIXING IN GaAs USING A DIODE-PUMPED Nd:YLF LASER AT 1.31  $\mu\text{m}$ .** Two-wave mixing has been observed in Cr-doped semi-insulating GaAs using a compact Nd:YLF diode-pumped solid-state CW laser system at 1.31  $\mu\text{m}$ . Significant enhancement of the two-wave mixing gain was achieved through application of AC electric fields. (Author abstract) 10 refs.

Walsh, K. (King's Coll, London, Engl); Hall, T.J. *Electron Lett* v 24 n 8 Apr 1988 p 477-478.

**093773 EFFECT OF HYDROSTATIC PRESSURE ON THE 0.15 eV Cu ACCEPTOR LEVEL IN GaAs.** The evolution of the characteristic photoluminescence (PL) of the 0.15 eV Cu acceptor level in GaAs has been studied as a function of hydrostatic pressure. In the pressure range up to 35 kbar, i.e. in the direct gap region, the Cu-related PL band closely tracks the near-band-edge emission. The pressure derivative of the Cu acceptor level has been determined and is found to be  $0.3 \pm 0.2$  meV/kbar. This number is only a small fraction of the

total pressure derivative of the energy gap which amounts to 10.7 meV/bar, a result similar to our previous findings for the Mn acceptor level in GaAs, for which the pressure derivative was found to be  $1.2 \pm 0.2$  meV/bar. It should be noted that the remaining difference in pressure derivative is significant and beyond the uncertainty of the experimental data. (Edited author abstract). 17 Refs.

Nilsson, S. (University of Lund, Lund, Swed); Samuelson, L. *Solid State Commun* v 67 n 1 Jul 1988 p 19-21.

**093774 BAND-GAP NARROWING DUE TO MANY-BODY EFFECTS IN n-TYPE DEGENERATE GaAs CRYSTALS.** The band-gap narrowing due to many-body effects in n-type degenerate GaAs crystals is analytically expressed in terms of the total donor concentration, principally on the basis of the integral expressions of conduction-and-valence band edge shifts, established and numerically computed by R.A. Abram et al. in the plasmon pole approximation and a self-energy approach. Here, the additional screened Coulomb hole effect is also considered. Then, the numerical results are compared with the corresponding results deduced from other works. Finally, it is suggested that, at both, very low and high concentrations, the result of band-gap narrowing is reduced to that given by the traditional Hartree-Fock exchange effect, and thus proportional to the cube root of the total donor concentration. (Edited author abstract). 8 Refs.

van Cong, H. (Univ de Perpignan, Perpignan, Fr); Charar, S.; Brunet, S. *Phys Status Solidi B* v 147 n 1 May 1988 p 253-260.

**093775 SPECTROMETRIE DE PHOTOELECTRONS X ET UV POUR LE SUIVI IN-SITU DE L'EXPOSITION DE GaAs (100) ET (110) A DES PLASMAS MULTIPOLAIRES.** [X-Ray and UV Photoelectron Spectrometry for In-Situ Followup of Exposure of GaAs (100) and (110) to Multipolar Plasmas]. The authors study the interaction of III-V compound surfaces with  $\text{H}_2$  and  $\text{N}_2$  multipolar plasmas. N- and p-doped GaAs (100) wafers underwent a series of short hydrogen deoxidation plasmas. At each of them, XPS analyses provided information about the chemical structure and the position of the Fermi level on the (100) surface. During the early deoxidation phase, the Fermi level moves from a pinning position due to residual oxides to that of a clean GaAs (100) surface covered by at least one monolayer of oxygen. For longer plasma exposures, elemental arsenic seems to yield a new pinning position. UPS analyses were also performed on GaAs (110) surfaces, freshly cleaved in UHV and exposed to  $\text{H}_2$  and  $\text{N}_2$  multipolar plasmas. Attention was paid to both surface contributions in third-core levels and surface structures in valence bands. (Author abstract) 4 refs. In French.

Mabon, R. (Lab d'Electronique et de Physique Appliquee, Limeil-Brevannes, Fr); Landesman, J.P.; Schaefer, B.J.; Bonnet, J. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 251-252.

## Adsorption

**093776 TIME-DEPENDENT CHEMISORPTION ON A SEMICONDUCTOR SURFACE.** The microscopic aspects of interfacial growth are only crudely accessible to experiment. We have therefore developed a technique for computer-experimental studies of atoms and molecules deposited on solid surfaces, in which forces are determined from the electronic structure rather than atomic potentials. Here we report simulations of Cl, O, Se, N, As, Si, Ge, Al, Ga, Zn, Hg, Cu, and Au on the (110) surface of GaAs. The results exhibit non-trivial variety in both the dynamics and final bonding sites. (Author abstract) 25 refs.

Ménon, M. (Texas A&M Univ, College Station, TX, USA); Allen, R.E. *Solid State Commun* v 64 n 3 Oct 1987 p 353-356.



## Analysis

**093777 THEORETICAL INVESTIGATION OF ENERGY SHIFTS AT THE GaAs/Au INTERFACE.** We have used an image screening model to calculate the shift of the  $Ga(3d^{-1})$  core-level distribution when a GaAs surface is covered with metal. Using the GaAs bulk dielectric constant we find a shift of 0.1 (0.18) eV with a mean free path of 25 (8) Å. These shifts are comparable to the measured ones, indicating that final-state (image) screening represents an important part of core-level shifts in the vicinity of the interface. (Author abstract).

Karlsson, K. (Chalmers Univ, Goteborg, Sweden); Nyqvist, O.; Wendin, G. *Solid State Commun* v 67 n 4 Jul 1988 p 339-342.

**093778 SEQUENTIAL ETCH ANALYSIS OF ELECTRON INJECTION IN P<sup>+</sup>-GAAS.** The influence of heavy impurity doping of electron injection currents in p<sup>+</sup>-n diodes is investigated experimentally. By extracting the  $n = 1$  diffusion current after successive etches of the p<sup>+</sup>-layer, the electron injection current is characterized. The technique is applied to a metal organic chemical vapor deposition (MOCVD) grown GaAs solar cell Zn-doped  $1.2 \times 10^{10} \text{ cm}^{-3}$  on the p-side. The results, which demonstrate that so-called bandgap narrowing effects enhance the injected electron current, have important implications for the design of GaAs solar cells and bipolar transistors. 11 refs.

Klausmeier-Brown, M.E. (Purdue Univ, West Lafayette, IN, USA); Kyono, C.S.; DeMoulin, P.D.; Tobin, S.P.; Lundstrom, M.S.; Mellich, M.R. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1159-1161.

**Anisotropy** See SEMICONDUCTOR MATERIALS—Defects.

**Applications** See Also AMPLIFIERS—Fabrication; AMPLIFIERS, MICROWAVE—Materials; DATA CONVERSION, ANALOG TO DIGITAL; ELECTRONIC CIRCUITS, COUNTING—Fabrication; ELECTRONIC CIRCUITS, FREQUENCY CONVERTER—Millimeter Waves; ELECTROOPTICAL DEVICES; INTEGRATED CIRCUIT MANUFACTURE—Materials; INTEGRATED CIRCUITS—Materials; INTEGRATED CIRCUITS, DIGITAL—Fabrication; INTEGRATED CIRCUITS, DIGITAL—Manufacture; INTEGRATED CIRCUITS, DIGITAL—Materials; INTEGRATED CIRCUITS, LSI—Marketing; INTEGRATED CIRCUITS, MONOLITHIC—Microwaves; INTEGRATED CIRCUITS, VLSI—Design; LASERS; LASERS, SEMICONDUCTOR—Electric Properties; LASERS, SEMICONDUCTOR—Modes; OPTICAL DEVICES—Switching; SEMICONDUCTOR DEVICES—Contacts; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER; SEMICONDUCTOR DIODES, IMPATT—Calculations; SEMICONDUCTOR DIODES, IMPATT—Testing; SOLAR CELLS—Measurements; SOLAR CELLS—Performance; SOLAR CELLS—Radiation Damage; SOLAR CELLS—Space Applications; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, FIELD EFFECT—Design; TRANSISTORS, FIELD EFFECT—Fabrication; TRANSISTORS, FIELD EFFECT—Heterojunctions; TRANSISTORS, FIELD EFFECT—Ion Implantation; TRANSISTORS, FIELD EFFECT—Microwaves; TRANSISTORS, FIELD EFFECT—Millimeter Waves; TRANSISTORS, FIELD EFFECT—Theory; WAVEGUIDES, OPTICAL—Fabrication.

**093779 GALLIUM ARSENIDE INTEGRATED CIRCUITS FOR TELECOMMUNICATIONS SYSTEMS.** This paper reviews the status of the GaAs technology and how it may enhance the performance and value of new systems. The higher speed performance being achieved with the first generation of GaAs ICs, now available from several commercial sources, is demanding new features of design, packaging and assessment both for the integrated circuits and for their interconnection of PCBs or hybrids. It also reports on the widening range of laboratory device structures, mostly involving complex epitaxial heterostructures, which will offer another significant improvement in systems performance. Within telecommunications, two important applications for high speed ICs are for long and short haul optical fiber systems and for low cost millimetre-wave radio systems. Variations of the basic GaAs IC device structures can be used for both these applications with much commonality in current and future technologies. For the longer term, many laboratories are developing monolithic optoelectronic ICs (OEICs) to achieve high performance at

reduced cost for increased market penetration. (Edited author abstract) 19 refs.

Mellor, P.J.T. *Br Telecom Technol J* v 5 n 4 Oct 1987 p 5-18.

**093780 TECHNOLOGY CHOICE FOR HIGH-SPEED APPLICATIONS - GaAs OR SILICON.** This paper compares gallium arsenide and silicon technologies for high-speed digital applications. The bases of comparison are physics, engineering and economics. Gallium arsenide is shown to be limited by engineering and economic considerations; true like-for-like comparisons on speed are almost impossible to obtain. Where complexity is low and performance at a premium, gallium arsenide is probably the best choice, but for even modest complexity silicon bipolar will remain dominant. (Author abstract) 4 refs.

Saul, Peter (Plessey Research Caswell Ltd, Towcester, Engl). *Microprocessors Microsyst* v 11 n 8 Oct 1987 p 438-442.

**093781 RELATIONSHIP BETWEEN SEGREGATED ARSENIC IN GaAs AND PHOTOLUMINESCENCE AND KINETICS OF ARSENIC SEGREGATION AT ROOM TEMPERATURE.** Arsenic segregation in GaAs passivation/insulation is a major problem in GaAs-based device applications. The extent of arsenic segregation is related to the intensity of photoluminescence observed when a treated GaAs surface is exposed to a laser beam. The relationship is then used to determine the kinetics of the arsenic segregation, which involves a solid-solid reaction for oxygen extraction by gallium from  $As_2O_3$ . The results are applied to literature data. The kinetics determined indicate that the solid-solid reaction could be elementary, at least with respect to the gallium atom concentration. (Author abstract) 16 refs.

Lee, Hong H. (Univ of Florida, Gainesville, FL, USA); Figueroa, Luis. *J Electrochem Soc* v 135 n 2 Feb 1988 p 496-499.

## Bonding

**093782 DIRECT ADHESION OF SINGLE-CRYSTAL GaAs WAFERS.** Bonding of two single-crystal GaAs wafers is reported. The bonding process includes a heat treatment at 850°C in flowing hydrogen ambient. High-resolution transmission microscopy observation shows that the two wafers are bonded directly. Disorder in lattice pattern was also observed instead of clear bonding seam. A simple argument on adhesion mechanism is also given. (Author abstract) 8 refs.

Yamada, A. (Sumitomo Metal Mining Co, Tokyo, Jpn); Oasa, M.; Nagabuchi, H.; Kawashima, M. *Mater Lett* v 6 n 5-6 Mar 1988 p 167-169.

**Charge Carriers** See Also ELECTRIC WIRING; HALL EFFECT DEVICES—Mathematical Models; LASER PULSES—Modulation; SEMICONDUCTING ALUMINUM COMPOUNDS—Charge Carriers; SEMICONDUCTING GALLIUM COMPOUNDS—Charge Carriers; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES—Noise; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Junctions; SEMICONDUCTOR DIODES—Electric Properties; SEMICONDUCTOR MATERIALS—Cooling; SEMICONDUCTOR MATERIALS—Doping; TRANSISTORS, BIPOLAR—Performance; TRANSISTORS, FIELD EFFECT—Computer Simulation; TRANSISTORS, FIELD EFFECT—Modeling; TRANSISTORS, FIELD EFFECT—Substrates.

**093783 HIGH-MOBILITY VERTICAL TRANSPORT IN GRADED-GAP GaAs/AlGaAs SUPERLATTICES.** In compositionally graded superlattices, grown by molecular beam epitaxy, the carrier mobilities in the direction perpendicular to the layers have been experimentally estimated in an 'all-optical' experiment. Mobilities in low-period graded-gap superlattices are estimated to be greater than those of AlGaAs graded-gap alloys. (Author abstract) 22 refs.

Lambert, B. (CNET, Lannion, Fr); Chomette, A.; Deveau, B.; Regreny, A. *Semicond Sci Technol* v 2 n 11 Nov 1987 p 705-709.

**093784 INFLUENCE OF ADSORBED IONS ON CHARGE-CARRIER RECOMBINATION AT THE n-GaAs PHOTO-ANODE SURFACE.** Photocurrent-voltage and capacitance-voltage measurements were performed at the n-GaAs/aqueous electrolyte interface before and after the pre-treatment of the surface in solutions containing  $Pb^{2+}$  or  $Ru^{3+}$ . The results confirm the model, proposed before, in which two types of surface states were assumed to participate in electron-hole recombination, i.e. non-photo-induced states as well as states associated with photodecomposition intermediates, and demonstrate that, whereas the pre-treatment enhances the rate of recombination in the former type of states, it does not significantly affect the rate of recombination in the latter, nor that of interfacial charge transfer. (Author abstract) 11 refs.

Vanmaekelbergh, D. (Rijksuniv Gent, Ghent, Belg); Gomes, W.P. *Semicond Sci Technol* v 2 n 11 Nov 1987 p 756-758.

**093785 ON THE ACCESSIBILITY OF THE BAND-GAP ON SEMICONDUCTOR INTERFACES BY NON-EQUILIBRIUM FERMI ENERGIES OF ELECTRONS AND HOLES.** Non-equilibrium surface Fermi energies of electrons and holes on semiconductor electrodes reach only a part of the bandgap. This phenomenon is proved in greater detail by calculation of Fermi energy profiles, for stationary irreversible anodic or cathodic as well as for reversible charge transfer processes, both in the dark and at illumination. The effect of limited bandgap accessibility upon surface charging is outlined briefly. Solid-state junctions are likewise taken into account. (Author abstract) 4 refs.

Lorenz, W. (Karl-Marx-Univ, Leipzig, East Ger); Sourisseau, R. *J Electroanal Chem Interfacial Electrochem* v 239 n 1-2 Jan 10 1988 p 9-16.

**093786 FREE CARRIER EFFECTS ON EXCITON SPECTRA IN p-TYPE MODULATION-DOPED GaAs-AlGaAs QUANTUM WELLS IN HIGH MAGNETIC FIELDS.** Novel properties of excitons in p-type modulation-doped GaAs-AlGaAs multi-quantum wells were investigated in high magnetic fields and in the wide temperature range. The intensity of the lowest heavy hole exciton, which is quenched by carriers at zero field, was found to increase with increasing magnetic field or temperature. The band filling effect is thought to be responsible for these phenomena. (Author abstract) 17 refs.

Iwasa, Y. (Univ of Tokyo, Tokyo, Jpn); Lee, J.S.; Miura, N. *Solid State Commun* v 64 n 4 Oct 1987 p 597-601.

**093787 CYCLOTRON MASSES IN n-GaAs/Ga<sub>1-x</sub>Al<sub>x</sub>As HETEROJUNCTIONS.** Electron cyclotron resonance is studied in single layer GaAs/Ga<sub>1-x</sub>Al<sub>x</sub>As heterostructures. The cyclotron mass is measured over a wide range of the two-dimensional electron density  $N_2$  and the magnetic field strength B to enable detailed comparison with self-consistent theoretical results that take into account the effects of band nonparabolicity. The calculations are performed using an effective  $2 \times 2$  subband Hamiltonian, which is derived from a five-level k-p-model by fourth order perturbation theory and includes remote band contributions. Close agreement between experimental and theoretical cyclotron masses is achieved and the importance of band nonparabolicity in these systems is demonstrated. (Author abstract) 12 refs.

Thiele, F. (Univ Hamburg, Hamburg, West Ger); Merkt, U.; Kotthaus, J.P.; Lommer, G.; Malcher, F.; Roessler, U.; Weimann, G. *Solid State Commun* v 62 n 12 Jun 1987 p 841-844.

**093788 PHOTOLUMINESCENCE SPECTRA OF TWO-DIMENSIONAL EXCITONS IN A GaAs SINGLE QUANTUM WELL IN A MAGNETIC FIELD.** Time-resolved photoluminescence spectra of two-dimensional excitons in a GaAs single quantum well were investigated in a magnetic field perpendicular to the hetero



interface (z-axis). The diamagnetic shift of the heavy-hole exciton and the increase of the luminescence intensity were observed. The radiative lifetime, however, was independent of the magnetic field up to 6 T. Therefore, this luminescence has the exciton-polariton nature. (Author abstract) 13 refs.

Kusano, J. (Osaka Univ, Toyonaka, Jpn); Segawa, Y.; Aoyagi, Y.; Namba, S. *Solid State Commun* v 65 n 9 Mar 1988 p 925-928.

**093789 MONTE CARLO STUDY OF NONEQUILIBRIUM PHONON EFFECTS IN GaAs.** A many-particle Monte Carlo technique for nonequilibrium phonon problems is proposed. The laser induced nonequilibrium LO phonon population in GaAs is calculated. The intervalley coupling constants of GaAs are estimated from the comparison of Monte Carlo calculation and available experimental results. (Author abstract) 9 refs.

Mickevičius, R. (Lithuanian Acad of Sciences, Vilnius, USSR); Reklaitis, A. *Solid State Commun* v 64 n 10 Dec 1987 p 1305-1308.

**093790 DONOR NATURE OF THE MAIN ELECTRON TRAPS IN ELECTRON-IRRADIATED N-TYPE GaAs.** Of all the electron (E) and hole (H) traps measured by DLTS in 1 MeV electron-irradiated GaAs, two of them, E1 and E2, have much higher production rates (approximately  $2 \text{ cm}^{-1}$ ) than any of the others. By carefully analyzing nine samples which exhibit the type-conversion phenomenon, we show that the net production rate of below-mid-gap acceptors over above-mid-gap donors in n-type samples is  $\tau_{\text{net}} \equiv \tau_A - \tau_D = 0.4 \pm 0.1 \text{ cm}^{-1}$ . This number is consistent with recent temperature-dependent Hall-effect data only if E1 is a donor. We then show that other evidence also strongly favors E2 as a donor, while E3 remains uncertain. The donor nature of E1 and E2 is much more consistent with their identification as As-vacancy related than are other proposed models. (Author abstract) 8 refs.

Look, D.C. (Wright State Univ, Dayton, OH, USA). *Solid State Commun* v 64 n 5 Nov 1987 p 805-807.

**093791 ELECTROPHYSICAL PROPERTIES OF GALLIUM ARSENIDE IN COMBINATION WITH IMPURITY-DOPED GERMANIUM AND ISOVALENT INDIUM AND ANTIMONY IMPURITIES.** The temperature dependence of the charge carrier concentration and mobility in n-type GaAs monocrystals doped jointly by Ge and isovalent In and Sb impurities is investigated. The observable charge carrier concentration and mobility changes in the GaAs:Ge:In and GaAs:Ge:Sb are compared with the corresponding characteristics in GaAs:Ge, and the change in properties along the ingots can be explained by the Ge impurity redistribution in the gallium and arsenic sublattices in the presence of an isovalent impurity. (Author abstract) 13 refs.

Krivov, M.A. (Tomsk State Univ, USSR); Malisova, E.V.; Nikiforova, M.P.; Starikov, A.N.; Khludkov, S.S.; Grigor'ev, Yu.A.; Egorova, O.L.; Osvenskii, V.B. *Sov Phys J* v 30 n 9 Sep 1987 p 721-725.

**093792 PREPARATION OF EXTRA-THIN CHANNEL WITH HIGH CARRIER CONCENTRATION IN GaAs BY SI ION IMPLANTATION THROUGH SiN FILM.** Shallow junctions with high carrier concentration are important for high speed MESFET. By using Si ion implantation through SiN film, thin junctions ( $< 1000 \text{ Å}$ ) with carrier concentrations of  $> 10^{18} \text{ cm}^{-2}$  have been prepared. High doses of Si,  $> 10^{13} \text{ cm}^{-2}$ , and mode-rate energy 80 keV, were found to be suitable. The thickness of the SiN approximately equals the displacement of the carrier concentration peak towards the surface of the wafer. (Edited author abstract) In Chinese. 2 refs.

Yan Benda (Shanghai Jiao Tong Univ, Shanghai, China); Shi Changxin; Xin Shangheng; Zhou Wenying. *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 308-311.

**093793 CHARGE STABILIZATION OF Cr AT INTERSTITIAL SITES IN GaAs.** The authors study the Cr impurity in GaAs at the anion and cation tetrahedral

interstitial sites, in several charge states. Lattice relaxation was not included. The results indicate the charge state  $2+$  is unstable: i.e., the system presents negative-U characteristics as was also proposed for the impurity in Si by Yoshida and Zunger. (Author abstract) 10 refs.

Scolfaro, Luiza M.R. (Univ de Sao Paulo, Sao Paulo, Brazil); Fazzio, A.; Mota, R. *Solid State Commun* v 66 n 10 Jun 1988 p 1031-1033.

**093794 CHARACTERIZATION OF ACTIVE LAYERS IN GaAs BY MICROWAVE ABSORPTION.** Free carrier electric microwave absorption is applied to the analysis of ion implanted and epitaxial active layers in GaAs. An improved version of a previously reported waveguide system is described. It allows a quick and nondestructive determination of the sheet resistance, carrier concentration and carrier mobility of active layers. The usefulness of the method for routine electric material characterization supporting a microelectronic device fabrication is demonstrated. Finally, some explorative microwave measurements of heterostructures and photo-induced effects are reported. (Author abstract) 13 refs.

Jantz, W. (Fraunhofer-Institut fuer Angewandte Festkoerperphysik, Freiburg, West Ger); Frey, Th.; Bachem, K.H. *Appl Phys A* v A45 n 3 Mar 1988 p 225-232.

**093795 EFFECT OF DEEP LEVELS INDUCED BY ELECTRON IRRADIATION UPON THE CHARGE TRANSPORT MECHANISM AND THE PRESSURE-DEPENDENT ELECTRICAL PROPERTIES OF FORWARD-BIASED  $p^+-n-n^+$  GaAs DIODES.** Results are presented on the effect of electron bombardment upon the charge transport mechanism and the pressure-dependent electrical properties of  $p^+-n-n^+$  GaAs diodes. It is shown that at low bias voltage the electron irradiation does not change the charge-carrier transport mechanism. A change of IVC of GaAs diodes induced by increase of the irradiation dose is due to a rise of resistance of the diode base, resulting from a compensation of the base after the bombardment and to the appearance of double injection of the charge carriers into the diode base. It is found that a sublinear section of the IVC, which appears at high irradiation dose, is a result of the formation of a near-anode stationary high-field domain. Analytical expressions are obtained which describe the experimental IVC for the irradiated diodes. The sensitivity of the irradiated diodes to the hydrostatic pressure is described by means of analytical formulas and numerical calculations, taking into account the pressure dependence of the width of the gap, energies of the gap levels induced by irradiation, and the lifetime of the charge carriers injected into the base region. (Edited author abstract) 20 refs.

Brudnyi, V.N. (Univ of Tomsk, Tomsk, USSR); Gaman, V.I.; Diamond, V.M. *Solid State Electron* v 31 n 6 Jun 1988 p 1093-1099.

**093796 ON SPACE-CHARGED-LIMITED CONDUCTION IN SEMI-INSULATING GaAs.** We have measured the temperature dependence of Cr doped semi-insulating (SI) GaAs in planar and point contact configurations at various fields ranging between  $10$  and  $10^6 \text{ V/m}$ . In a planar configuration the transport is ohmic up to approximately  $10^4 \text{ V/m}$  with an activation energy of approximately  $0.75 \text{ eV}$ . At higher fields we have observed a space-charge-limited (SCL) transport with an activation energy of about  $0.47 \text{ eV}$ . In a point contact configuration a quasi-ohmic and a transitional region have been found, both having an activation energy of approximately  $0.47 \text{ eV}$ . Such behaviour is in qualitative agreement with Lampert's theory of SCL conduction. Some deviations from this theory are accounted for by the existence of macroscopic screening length in SI-GaAs. (Author abstract) 15 refs.

Mares, J.H. (Czechoslovak Acad of Sciences, Prague, Czech); Kristofik, J.; Smid, V. *Solid State Electron* v 31 n 8 Aug 1988 p 1309-1313.

**093797 EVIDENCE FOR ACCEPTOR SURFACE STATES IN GaAs PLANAR-TYPE DEVICES.** The

nature of surface states existing on a bare surface of weakly n-doped VPE (vapor phase epitaxy) GaAs layers ( $\approx 10^{14} \text{ cm}^{-3}$ ) has been investigated. Planar-type devices with large interelectrode length ( $\approx 60 \mu\text{m}$ ), have been used. In order to identify bulk effects, previous measurements (in darkness) of channel current transients resulting from backgating effects have shown the existence of the EL2 electron trap and of a hole trap (activation energy  $\approx 0.11 \text{ eV}$ ) located at the substrate-channel interface. Photoreponse measurements under illumination in the  $0.8\text{-}2 \text{ eV}$  energy range and transient channel current measurements in darkness, after switching-off the illumination (in the same energy range) have been performed. From these measurements, the existence of acceptor surface states at an energy of  $0.4 \text{ eV}$  above the valence band is demonstrated and confirmed by studying the  $\text{EL2} \rightarrow \text{EL2}^*$  photoconversion. Thermal ionization of these surface states has been evidenced experimentally. (Author abstract) 11 refs.

Dansas, P. (CNRS, Orsay, Fr); Bouchemat, M.; Bru, C.; Pascal, D.; Laval, S. *Solid State Electron* v 31 n 8 Aug 1988 p 1327-1333.

**093798 PERPENDICULAR TRANSPORT OF OPTICALLY GENERATED CARRIERS IN GaAs/AlGaAs QUANTUM WELL STRUCTURES.** We have calculated the transport of carriers over GaAs quantum wells embedded in an AlGaAs slab of some micrometers thickness. The carriers are generated near one surface by means of a laser beam. We have solved the Boltzmann equation using the iterative technique. The quantum wells are modeled as interfaces, where the carriers can be transmitted, reflected, or captured with probabilities  $T$ ,  $R$ , and  $W$ , respectively. The capture probability is calculated for emission of optical phonons and the modification of the initial state is taken into account in order to satisfy the condition  $R+T+W=1$ . Due to the energetic position of the transmission resonances with respect to the bottom of the conduction band in the AlGaAs the time-dependent behavior of the carrier system after a picosecond laser pulse is shown to depend sensitively on parameters like quantum well width and depth. (Author abstract) 22 Refs.

Kuhn, T. (Univ Stuttgart, Stuttgart, West Ger); Mahler, G. *Phys Scr* v 38 n 2 Aug 1988 p 216-220.

**093799 DETERMINATION OF FREE CHARGE CARRIER DISTRIBUTION AND MICROSEGREGATION OF DOPANTS IN N-TYPE GaAs.** An experimental approach to the rapid determination of the micro-distribution of free charge carriers in n-type GaAs is reported. Computer based video processing techniques are used to determine the IR absorption characteristics of wafers with a spatial resolution of less than  $10 \mu\text{m}$  and to convert these data after calibration into charge carrier density. The application of this technique to microsegregation analysis of Te-doped GaAs is demonstrated. (Author abstract) 20 Refs.

Carlson, D.J. (MIT, Cambridge, MA, USA); Witt, A.F. *J Cryst Growth* v 91 n 1-2 Aug 1988 p 239-243.

**093800 CALCULATION OF BOUND EXCITONS IN  $\text{GaAs-Ga}_{1-x}\text{Al}_x\text{As}$  QUANTUM WELL STRUCTURES.** The ground state energies of an exciton bound to a neutral donor and an exciton and biexciton bound to an ionized donor have been calculated using the density functional theory. The results are compared with experimental data. (Author abstract) 12 Refs.

Haufe, A. (Karl-Marx-Univ, Leipzig, East Ger). *Solid State Commun* v 67 n 9 Sep 1988 p 899-901.

**093801 HYDRODYNAMIC CARRIER TRANSPORT IN SEMICONDUCTORS WITH MULTIPLE BAND MINIMA.** Carrier transport equations for analysis of semiconductor devices fabricated in materials with multiple band minima, such as GaAs, are presented. An approach is taken in which the carrier density is conserved and an approximation to the distribution function in terms



of quasi-Fermi potentials, carrier temperatures, and other fixed parameters is used that satisfies the particle energy and temperature distributions for each valley in the material. A model of a GaAs MESFET, which illustrates the importance of the physical effects and achieves reasonable agreement with experiment without use of adjustable parameters, is presented as an example. 22 refs.

Wilson, Charles L. (NBS, Gaithersburg, MD, USA). *IEEE Trans Electron Devices* v 35 n 2 Feb 1988 p 180-187.

**093802 ELECTRONIC RAMAN SCATTERING IN QUANTUM WELLS: COUPLED LEVELS IN TILTED MAGNETIC FIELDS.** We report on a magneto-Raman scattering investigation of free and donor-bound electrons in GaAs-Al<sub>x</sub>Ga<sub>1-x</sub>As quantum wells. For fields perpendicular to the layers, the spectra show intersubband transitions of photoexcited electrons and 1s → 1s' donor excitations. Tilted fields lead to subband-Landau level and 1s'-2p<sup>+</sup> coupling. Experimental results for the latter case agree very well with variational calculations. Data on combined intersubband-cyclotron resonances at arbitrary tilt angles are accurately described by expressions valid for parabolic wells. The parabolic approach is shown to provide a good approximation in situations where coupling to higher subbands can be neglected. (Author abstract) 16 refs.

Boroff, R. (Univ of Michigan, Ann Arbor, MI, USA); Merlin, R.; Greene, R.L.; Comas, J. *Superlattices Microstruct* v 3 n 5 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 493-496.

**093803 MAGNETIC DEPOPULATION OF SUBBANDS AND UNIVERSAL CONDUCTANCE FLUCTUATIONS IN QUASI-ONE-DIMENSIONAL GaAs-AlGaAs HETEROSTRUCTURES.** Narrow conducting channels have been fabricated in the two-dimensional electron gas in a GaAs-AlGaAs heterostructure, using a recently developed shallow mesa etch technique. Four-terminal high field magnetoresistance measurements at temperatures down to 2 K have been performed on samples with etched width between 8 μm and 0.5 μm. The Shubnikov-de Haas oscillations are studied, and clear evidence is presented for magnetic depopulation of 1-dimensional subbands. The data for the 0.5 μm wide channel are in satisfactory agreement with a simple analysis based on a parabolic confinement potential. Large sidewall depletion effects are found. We also observe irregular structure in the magnetoresistance. The dependence of the effects on the orientation of the magnetic field shows that the magnetoresistance arises from the orbital motion of the 2-dimensional electrons. (Edited author abstract) 15 refs.

van Houten, H. (Philips Research Lab, Eindhoven, Neth); van Wees, B.J.; Mooij, J.E.; Roos, G.; Berggren, K.F. *Superlattices Microstruct* v 3 n 5 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 497-501.

**093804 COMPLEX BAND STRUCTURE CALCULATIONS OF THE ELECTRIC FIELD DEPENDENCE OF THE TRANSMISSION OF HOLES THROUGH A (100) GaAs/AlGaAs/GaAs BARRIER STRUCTURE.** A pseudopotential complex band structure approach is used to investigate the transmission of heavy and light holes through a (100) GaAs/AlGaAs/GaAs barrier structure in the presence of an electric field. The results can be significantly different from those obtained using a simple effective mass model. In particular, for an incident light hole there is large barrier induced mixing with the spin-split-off states which reduces the light hole transmission and excites the transmission of spin-split off states. Transmission through a quantum well structure is also considered and significant effects are seen due to the presence of resonances. (Author abstract) 10 refs.

Monaghan, S. (Sch of Engineering & Applied Science, Durham, Engl); Brand, S. *Superlattices Microstruct* v 3 n 6 1987, Third Int Conf on Superlattices, Microstruct and

Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 697-700.

**093805 HOT CARRIER TRAPPING IN GaAs/AlGaAs SINGLE QUANTUM WELLS WITH DIFFERENT CONFINEMENT STRUCTURES.** The trapping efficiency and dynamics of hot carriers in GaAs/AlGaAs single quantum wells with different confinement structures are investigated by photoluminescence excitation spectroscopy and picosecond luminescence spectroscopy. The trapping efficiency is highest for graded confinement structures and reaches 100% for a quantum well with a linear band gap profile of the AlGaAs. The lower trapping efficiencies in single quantum wells without additional confinement and in separate confinement heterostructures is attributed to radiative and nonradiative recombination in the AlGaAs. The trapping times are shorter than 20ps for all the different structures. (Author abstract) 5 refs.

Pollard, H.J. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Leo, K.; Ploog, K.; Feldmann, J.; Peter, G.; Gobel, E.O.; Fujiwara, K.; Nakayama, T. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 341-344.

**093806 MAGNETIC FIELD-DEPENDENT HOT CARRIER RELAXATION IN GaAs QUANTUM WELLS.** Energy loss rates are calculated for electrons, confined in a GaAs quantum well and by a magnetic field perpendicular to its plane, interacting with unconfined LO phonons. Phonon emission rates calculated are compared with the temperature decay of carriers photoexcited by a picosecond laser pulse, measured by time-resolved luminescence spectroscopy. Measured energy loss rates are much less than those calculated assuming equilibrium phonon populations. A numerical calculation of the evolution of the coupled electron and phonon systems demonstrates that this is due to the generation of non-equilibrium phonons. After a few tens of picoseconds carrier cooling is governed by phonon decay. The carrier temperature decay curve depends on the volume of phonon phase space to which the carriers are coupled, the phonon lifetime and the carrier specific heat, and is relatively insensitive to the field-dependence of the carrier-phonon scattering matrix elements and carrier density of states. (Author abstract) 12 refs.

Turberfield, A.J. (Univ of Oxford, Oxford, Engl). *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 387-390.

**093807 ULTRAFAST RELAXATION OF HOT PHOTOEXCITED CARRIERS IN GaAs.** The roles of carrier-carrier interactions and nonequilibrium phonons on the ultrafast relaxation of photoexcited carriers in GaAs are examined. At low carrier concentrations, the e-h interaction is the main energy loss channel for hot electrons, while at high carrier concentrations, the e-h interaction is the primary energy loss channel. This latter result follows from the high e-h scattering rate, the screening of the e-h interaction, and the high efficiency of hole-phonon scattering through the unscreened deformation potential interaction. The electron energy-loss rates through the e-h interaction increases as the excitation energies and intensities are increased. In two-dimensional systems, the e-h interaction further complicates the problem since the transverse optical modes are driven out of equilibrium by their interaction with the holes. (Edited author abstract) 19 refs.

Ferry, D.K. (Arizona State Univ, Tempe, AZ, USA); Osman, M.A.; Joshi, R.; Kann, M.J. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 401-406.

**093808 INITIAL RELAXATION OF PHOTOEXCITED CARRIERS IN GaAs AND GaAs QUANTUM WELLS UNDER SUBPICOSECOND EXCITATION.** After excitation by a subpicosecond pulse, we observe a slow rise of the luminescence both in GaAs and in GaAs quantum wells. By comparing the results in GaAs and InP, we show that the slow rise in GaAs and GaAs quantum wells is due to the slow return of the electrons

from the L to the Γ valley. Our results show the importance of electron-electron scattering and the inadequacy of a simple phonon cascade model at densities as low as  $5 \times 10^{16} \text{ cm}^{-3}$ . (Edited author abstract) 8 refs.

Deveaud, Benoit (AT&T Bell Lab, Holmdel, NJ, USA); Shah, Jagdeep; Damen, T.C.; Gossard, A.C.; Lugli, P. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 435-438.

**093809 FEMTOSECOND RELAXATION DYNAMICS OF NONEQUILIBRIUM CARRIERS IN GaAs AND RELATED COMPOUNDS.** The initial relaxation of hot electrons in AlGaAs has been measured using optical correlation spectroscopy at temperatures from 300 to 10 K and a range of carrier densities. Comparison of the results shows that, at 300 K, of the carriers that leave the initially excited states within the first 50 fs, 65% scatter to the satellite valleys, 30% leave via carrier-carrier interactions including plasmon scattering, and approximately 5% scatter by LO phonon emission. (Author abstract) 5 refs.

Tang, C.L. (Cornell Univ, Ithaca, NY, USA); Wise, F.W.; Walmsley, I.A. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 439-442.

**093810 FEMTOSECOND HOT CARRIER ENERGY REDISTRIBUTION IN GaAs AND AlGaAs.** Excited carrier dynamics in GaAs and Al<sub>2</sub>Ga<sub>3</sub>As are investigated using femtosecond pump and continuum probe techniques. Absorption saturation measurements provide evidence for transient spectral hole burning due to split-off as well as heavy and light hole valence to conduction band transitions. The initial nonthermal carrier distribution thermalizes and assumes a broad energy distribution on a femtosecond time scale. (Author abstract) 15 refs.

Schoenlein, R.W. (MIT, Cambridge, MA, USA); Lin, W.Z.; Brorson, S.D.; Ippen, E.P.; Fujimoto, J.G. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 443-446.

**093811 NONEQUILIBRIUM PHONON EFFECTS ON THE TIME-DEPENDENT RELAXATION OF HOT CARRIERS IN GaAs MQW.** The existence of a large population of nonequilibrium hot phonons after an initial rapid carrier cooling in an undoped multiple GaAs quantum well structure excited by 500fs laser pulses is experimentally verified. An effective carrier depletion time is determined to be as short as 10ps. A mechanism which leads to such a short carrier depletion time is associated with hot phonon enhanced phonon-replica-emission. (Author abstract) 8 refs.

Shum, Kai (City Coll of New York, New York, NY, USA); Jannarkar, M.R.; Chao, H.S.; Alfano, R.R.; Morkoc, H. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 451-454.

**093812 CARRIER-CARRIER INTERACTION AND INTERVALLEY TRANSFER EFFECTS ON THE ULTRAFAST RELAXATION OF PHOTOEXCITED ELECTRONS IN GaAs.** The roles of the carrier-carrier (c-c) and intervalley deformation potential interactions on the ultrafast cooling of electrons in GaAs are examined for excitation energy of 2.0 eV and in the presence of uniform 500 v/cm applied electric field, using an Ensemble Monte Carlo (EMC) approach. It is found that immediately after excitation, a significant portion of the electrons transfer to the upper valleys where they relax primarily through the emission of LO, equivalent and nonequivalent intervalley phonons. Subsequently, the electrons return to the central valley. When the electron-hole interaction is included, 70% of the electron population to return to the central valley after 2.3 ps, compared to 3.1 ps when the e-h interaction is ignored. (Author abstract) 10 refs.

Osman, M.A. (Scientific Research Associates Inc, Glastonbury, CT, USA); Grubin, H.L. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 471-474.



**093813 HOLE-ACOUSTIC PHONON ENERGY LOSS RATES IN GaAs QUANTUM WELLS DETERMINED BY LIGHT SCATTERING.** We report a determination of energy loss rates of free holes in GaAs quantum wells. The hot hole temperatures were obtained from Stokes and anti-Stokes inelastic light scattering spectra. In the temperature range dominated by acoustic phonon interactions we find that the hole energy loss rate is proportional to the square of the hole temperature. (Author abstract) 16 refs.

Pinczuk, A. (AT&T Bell Lab, Murray Hill, NJ, USA); Shah, Jagdeep; Gossard, A.C. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 477-479.

**093814 HOT PHONONS IN GaAs REVISITED.** The importance of hot phonon effects in laser-excited GaAs is reevaluated in view of recent work that has focused on the role of carrier dynamics in the cooling process. Our calculations show that both lattice heating and the details in the carrier dynamics play an important role in the initial stage of the cooling process. (Author abstract) 8 refs.

Poetz, W. (Univ of Illinois, Chicago, IL, USA); Osman, M.A.; Ferry, D.K. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 673-676.

**093815 TRANSIENT HOT-PHONON EFFECTS ON THE VELOCITY OVERSHOOT OF GaAs: A MONTE CARLO ANALYSIS.** A novel ensemble Monte Carlo algorithm has been developed to simulate nonequilibrium phonon effects in the transient and steady-state high-field conductivity of bulk n-GaAs. The interplay of the electronic intervalley transfer with the mutual drag and heating between the carriers and longitudinal optical phonons is demonstrated over a wide range of fields, temperature and carrier densities. For the moderately high doping levels of practical interest the characteristic times for a strong phonon amplification turn out to be sufficiently long to prevent a substantial interference of phonon disturbances with the onset of valley transfer during overshoot, but modifications of up to 20 percent are found for the steady-state velocity, with a gradual change from an enhancement at low fields to a comparable decrease around the maximum and negative differential part of the velocity-field characteristics. Comparable nonequilibrium-phonon effects are found for the case of negligible (i.e. remote) ionized-impurity scattering as realized in various GaAs-based heterostructures. (Author abstract) 10 refs.

Rieger, M. (Univ Graz, Graz, Austria); Koccar, P.; Bordone, P.; Lugli, P.; Reggiani, L. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 687-690.

**093816 HOT ELECTRON RELAXATION IN POLAR SEMICONDUCTORS.** Theoretical results are obtained for the energy-loss of hot electrons to longitudinal optical phonons in three and two dimensional semiconductor (GaAs bulk and quantum well case) systems for carrier temperatures between 25K and 200K. All the relevant physical effects (quantum statistics, dynamical screening, plasmon-phonon coupling, Landau damping, hot phonon effects and quantum-well width corrections) are included in a many-body calculation. Our theory agrees with experimental results and explains quantitatively an order of magnitude discrepancy in experimental relaxation rates in GaAs quantum wells reported by different groups as arising from a partial cancellation between plasmon-phonon mode-coupling and hot phonon effects thus resolving an important controversy in the subject. (Edited author abstract) 14 refs.

Das Sarma, S. (Univ of Maryland, College Park, MD, USA); Jain, J.K.; Jalabert, R. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 695-700.

**093817 HOT ELECTRON CAPTURE IN GaAs MQW: NDR AND PERSISTENT EFFECTS.** We report the observation of negative differential resistance (N.D.R.) associated with the capture of hot carriers at low temperatures by low mobility centres in GaAs-Ga<sub>1-x</sub>Al<sub>x</sub>As multiple quantum wells. NDR occurs with threshold fields of a few hundred volts cm<sup>-1</sup>. The barrier height

over which the hot carriers are captured is directly obtained from the hot-electron PL spectra. The depth of the trapping centres are directly observed. In a p type sample, following the capture of hot carriers, a field-induced persistent conductivity state is observed. Nondestructive switching to and from this state occurs which is probably associated with the impact ionization of the captured carriers. (Author abstract) 14 refs.

Balkan, N. (Univ of Essex, Colchester, Engl); Ridley, B.K.; Roberts, J. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 799-803.

**Chemical Vapor Deposition.** See Also ORGANIC COMPOUNDS—Purification; SOLAR CELLS—Space Applications; WAVEGUIDES, OPTICAL—Optimization.

**093818 ULTRAVIOLET ABSORPTION SPECTRA OF SELECTED ORGANOMETALLIC COMPOUNDS USED IN THE CHEMICAL VAPOR DEPOSITION OF GALLIUM ARSENIDE.** Ultraviolet absorption spectra and absolute absorption cross sections of trimethylgallium (CH<sub>3</sub>)<sub>3</sub>Ga, triethylgallium (C<sub>2</sub>H<sub>5</sub>)<sub>3</sub>Ga, trimethylarsine (CH<sub>3</sub>)<sub>3</sub>As, and triethylarsine (C<sub>2</sub>H<sub>5</sub>)<sub>3</sub>As have been recorded as a function of temperature. Room temperature peak absorption cross sections of 2.6×10<sup>-17</sup>, approx. 1.7×10<sup>-17</sup>, 5.6×10<sup>-17</sup>, and 4.1×10<sup>-17</sup> cm<sup>2</sup>, respectively, were obtained for the above compounds at 195.0, approx. 190.0, 201.0, and 208.5 nm. (CH<sub>3</sub>)<sub>3</sub>As and (C<sub>2</sub>H<sub>5</sub>)<sub>3</sub>As were found to be thermally stable up to 350°C, whereas (CH<sub>3</sub>)<sub>3</sub>Ga and (C<sub>2</sub>H<sub>5</sub>)<sub>3</sub>Ga began to show decomposition at approximately 300-350°C. This study resolves previous discrepancies in the absorption cross section for (CH<sub>3</sub>)<sub>3</sub>Ga, and provides data for photo-enhanced deposition studies and optical diagnostic measurements in conventional chemical vapor deposition. (Author abstract) 22 refs.

McCrary, V.R. (AT&T Bell Lab, Murray Hill, NJ, USA); Donnelly, V.M. *J Cryst Growth* v 84 n 2 Aug 1987 p 253-258.

**093819 EVALUATION OF LARGE AREA HETEROSTRUCTURE MATERIAL FOR HIGH POWER LASER STRUCTURES.** Metal organic chemical vapor deposition (MOCVD) is now widely recognized as the most appropriate technology for adapting to the requirements of opto-electronic device production. We report on the development of MOCVD for the growth of two inch diameter multi-heterostructure (MH) laser wafers along with the establishment of material assessment techniques capable of evaluating the properties of large geometry structures. Electrical and optical characterization of single and multi-heterostructures have been made in order to evaluate and optimize alloy, thickness and doping uniformity. A cross-calibration exercise between various electro-optic techniques has been carried out and a high level of agreement found between measured parameters. An ability to maintain intact substrate geometry allows information to be acquired on epitaxial growth prior to processing. Oxide-isolated facet-coated stripe lasers have been fabricated from two-inch processed wafers producing high output power >20 W at 40 Å under pulsed conditions. Threshold current densities of 1 kA cm<sup>-2</sup> along with T<sub>0</sub> values of 155 K have been achieved. Far fields of 23° along with stable output power over a wide temperature range (25°-95°C) are reported. (Author abstract) 21 refs.

Jones, M.W. (STC Defence Systems, Paignton, Engl); Ridge, M.I.; Daniel, D.R.; Butlin, R.S. *Chemtronics* v 2 n 2 Jun 1987 p 69-77.

**093820 AlGaAs GROWTH BY OMCVD USING AN EXCIMER LASER.** AlGaAs has been grown as GaAs by laser assisted OMCVD using an excimer laser, wavelength 193 nm, and a Cambridge OMCVD reactor. Films were grown at temperatures of 450 and 500°C with the laser beam parallel to the surface and impinging onto the surface at 15° from parallel. The samples were heated by rf coils while the laser beam was perpendicular to the gas flow. Typical gas flow parameters are 12 slm of H<sub>2</sub>, 15 sccm of Ga(CH<sub>3</sub>)<sub>3</sub>, 13 sccm of Al(CH<sub>3</sub>)<sub>3</sub>, and a pressure of 250 mbar. The initial energy density of the beam at the

surface was 40 mJ/cm<sup>2</sup>, the pulse rate was 20 pps, and the growth time was 7 min. The films were analyzed by Auger electron spectroscopy for the aluminum concentration and by TEM for the surface morphology. (Author abstract) 6 refs.

Warner, Joseph D. (NASA, Lewis Research Cent, Cleveland, OH, USA); Wilt, David M.; Pouch, John J.; Aron, Paul R. *NASA Tech Memo* 88937 1986 10p.

**093821 SELECTIVE AREA GROWTH OF HIGH QUALITY GaAs BY OMCVD USING NATIVE OXIDE MASKS.** A study of selective area growth by atmospheric pressure organometallic chemical vapor deposition (OMCVD) using plasma-grown GaAs native oxide masks was conducted. Deposition experiments were carried out with different growth parameters to observe the variation of polycrystalline coverage on the oxide mask. With high growth temperatures or low V/III ratios, poly deposition on the mask was depleted, particularly in regions near the unmasked single-crystal areas. With the optimum conditions for GaAs growth, the polycrystalline growth was homogeneous to the single-crystal boundary, and the single-crystal GaAs areas exhibited liquid nitrogen mobilities up to 105,000 cm<sup>2</sup>/Vs. (Edited author abstract) 26 refs.

Jones, Stephen H. (Univ of Massachusetts, Amherst, MA, USA); Lau, Kei May. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3149-3155.

**093822 GROWTH RATE AND UNIFORMITY OF MOCVD GaAs.** The atmospheric MOCVD of GaAs using TMG, AsH<sub>3</sub> and H<sub>2</sub> in a horizontal air-cooled reactor has been discussed and a formula of the growth rate of GaAs is derived on the basis of chemical thermodynamics and kinetics. The growth rate is linearly dependent on TMG concentration within a specified temperature range and believed to be limited by the diffusion of reaction species closely related to Ga element. The comparison of numerical calculation with the experimental data shows that this formula is in agreement with experimental results. In the formula, the relations between the growth rate, the uniformity of the epitaxial layer, and process parameters such as the velocity of gas flow, the growth temperature and the TMG mole fraction in gas flow can be seen. (Edited author abstract) In Chinese. 8 refs.

Liang, Bing-wen (Acad Sinica, China); Ding, Yong-qing; Lu, Feng-zhen; Peng, Rui-wu. *Xi You Jin Shu* v 6 n 4 Nov 1987 p 263-267.

**093823 REDUCTION OF DEEP LEVEL CONCENTRATIONS IN GaAs LAYERS GROWN BY FLOW-RATE MODULATION EPITAXY.** In a modified metalorganic chemical vapor deposition, flow-rate modulation epitaxy, the growth rate of GaAs can be higher than one monolayer per cycle (0.28 nm/cycle). Ga-atoms, the number of which is up to 3 times as high as the surface site number, and arsenic are alternately supplied on the (001) GaAs substrates to grow GaAs layers. There is no surface degradation of the epitaxial layers even at a growth rate of three monolayers per cycle. In this method after Ga-atomic layers are formed, As atoms diffuse into the Ga-atomic layers to form a GaAs single crystal. In GaAs layers grown under such conditions, the concentration of the midgap level, 'EL2', is much reduced. Furthermore, photoluminescence measurement indicates that high-quality GaAs layers are grown. (Author abstract) 12 refs.

Makimoto, Toshiaki (NTT, Musashino, Jpn); Yamauchi, Yoshiharu; Horikoshi, Yoshiji. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 152-154.

**093824 CONVERGENT-BEAM ELECTRON DIFFRACTION STUDY OF STRAIN MODULATION IN GaAs/InGaAs SUPERLATTICES GROWN BY METAL-ORGANIC CHEMICAL VAPOUR DEPOSITION.** Convergent-beam electron diffraction has been used to study strain modulation in GaAs/InGaAs super-



lattices (6% In and 2% In) in plan-view. Reflections from planes inclined to the interface of the superlattice are split with sidebands, the angular separation of which is related to the modulation periodicity. It is inferred from higher-order Laue zone lines that inclined planes on opposite sides of an interface in GaAs and InGaAs layers are rotated towards and away from the interface as a result of distortion due to coherent matching and local relaxation in regions where the GaAs substrate and buffer layer have been non-milled away. (Author abstract) 12 refs.

Fung, K.K. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); York, P.K.; Fernandez, G.E.; Eades, J.A.; Coleman, J.J. *Phil Mag Lett* v 57 n 4 Apr 1988 p 221-227.

**093825 LATERAL GROWTH ON (110) GaAs SUBSTRATES BY METALORGANIC CHEMICAL VAPOR DEPOSITION.** Lateral growth was carried out on (110) GaAs substrates by metal-organic chemical vapor deposition (MOCVD). In the case of lateral layers extending over free GaAs surfaces, the lateral growth rate is highest in the  $[00\bar{1}]$  direction and lowest in the  $[001]$  direction; the dependences can be explained by the stability of the kink sites. In the case of lateral layers extending over  $\text{SiO}_2$  films, definite facets appear in  $[1\bar{1}1]A$ ,  $[1\bar{1}10]$ , and  $[1\bar{1}2]$  directions, and lateral layers extending in the  $[111]A$  direction show an extremely smooth surface and a plumb  $(1\bar{1}1)A$  plane at the front edge. The ratio of lateral length to thickness is 1.4, which coincides well with the ratio of monolayer space of the  $[111]$  surface to the  $\{110\}$  surface. (Author abstract) 7 refs.

Okamoto, Kotaro (Univ of Electro-Communications, Chofu, Jpn); Furuta, Mamoru; Yamaguchi, Ko-ichi. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 437-440.

**093826 ATOMIC LAYER EPITAXY OF GaAs USING SOLID ARSENIC AND  $\text{DEGaCl}$ .** ALE growth of GaAs was reported using solid arsenic and  $\text{DEGaCl}$ . An abrupt shutoff of arsenic vapor was successfully achieved and monolayer growth was obtained independent of  $\text{DEGaCl}$  partial pressure. Grown surfaces were mirror-like at growth temperatures of 400 approximately  $550^\circ\text{C}$ . Grown layers showed p-type conductivity. The carrier concentration of the grown layers was rather low compared with that reported in  $\text{DEGaCl-AsH}_3\text{ALE}$ . QMS measurements of the  $\text{DEGaCl}$  decomposition rate suggest that  $\text{DEGaCl}$  completely decomposes to GaCl before reaching the substrate, which is considered to result in lower carbon contamination. (Author abstract) 16 refs.

Sasaoka, Chiaki (NEC, Kawasaki, Jpn); Yoshida, Masaji; Usui, Akira. *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 490-492.

**093827 GROWTH AND CHARACTERIZATION OF GaAs LAYERS GROWN ON Ge/Si SUBSTRATES BY METALORGANIC CHEMICAL VAPOR DEPOSITION.** Epitaxial GaAs layers have been grown on (100) oriented Ge/Si substrates by metalorganic chemical vapor deposition. Double-crystal X-ray diffraction shows that the full width at half maximum of the (400) reflection obtained from 3  $\mu\text{m}$ -thick GaAs is as small as  $114$  arc seconds. The GaAs surface dislocation density estimated by a molten KOH study is  $4.9 \times 10^6 \text{ cm}^{-2}$ . Photoluminescence measurements show that an excitonic transition at  $1.4852 \text{ eV}$  dominates at  $4.2 \text{ K}$ . These results suggest that Ge/Si substrates are suitable for growing sufficiently high quality GaAs layers. (Author abstract) 25 refs.

Fukuda, Yukio (NTT, Applied Electronics Lab, Musashino, Jpn); Kadota, Yoshiaki; Ohmachi, Yoshiro. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 485-488.

**093828 COMPARISON OF ALTERNATE AS-SOURCES TO ARSINE IN THE MOCVD GROWTH OF GaAs.** We have investigated the use of methyl-, ethyl-, and butyl-based alkylarsine compounds as alternatives to arsine in the epitaxial growth of GaAs. These are all low vapor pressure liquids that can be handled more safely than arsine, which is stored as a high pressure gas. Films were deposited over a wide range of growth conditions ( $T_g$

=  $550\text{--}850^\circ\text{C}$ ,  $V/\text{III} = 2\text{--}20$ ) at atmospheric pressure in a horizontal MOCVD reactor. The quality of the films grown with the alkylarsine sources was limited by the presence of both carbon and donor impurities. Isotopic labeling studies using 50% enriched  $^{13}\text{C}$ -trimethylarsine provided direct evidence that the methyl groups from trimethylarsine were a major source of the carbon observed in the films. The effects of source purity and composition on the morphological, electrical and optical properties of the GaAs films will be presented. (Author abstract) 23 refs.

Lum, R.M. (AT&T Bell Lab, Holmdel, NJ, USA); Klingert, J.K.; Lamont, M.G. *J Cryst Growth* v 89 n 1 Jun 1988, Purif of Mater for Cryst Growth and Glass Process - Proc of the Second Workshop, Champion, PA, USA, Sept 28-Oct 1 1987 p 137-142.

## Chromatographic Analysis

**093829 G.c./m.s. ANALYSES OF TRIMETHYL GALLIUM AND TRIMETHYL ALUMINIUM.** A transfer device designed to enable sampling of metalorganic chemicals from conventional 'bubblers' employed in MOCVD applications, for analysis by capillary gas chromatography in combination with mass spectrometry (g.c./m.s.) is described. Chromatographic and mass spectra data obtained from the analysis of trimethylgallium and trimethylaluminum as examples of extremes in volatility are reported. The difficulties presented by the more reactive metalorganic,  $\text{Me}_3\text{Al}$ , to the success of the analysis by g.c./m.s. are outlined. The relevance of the findings to MOCVD is discussed in terms of the information obtained concerning the presence, amounts and identities of extrinsic organic impurities. (Author abstract) 9 refs.

Baugh, P.J. (Salford Univ, Salford, Engl); Casson, A.; Jones, M.W.; Jones, A.C. *Chemtronics* v 2 n 2 Jun 1987 p 93-97.

## Cleaning

**093830 NOUVELLE METHODE DE DECAPAGE. [New Cleaning Method].** The authors have studied the interaction of GaAs (001) surface with ammonia dissociated by U.V. radiation. With such chemical treatment, one can notice the disappearing of arsenic oxide and carbon, together with the noticeable decrease of gallium oxide as seen by X-ray Photoelectron Spectroscopy (X.P.S.). X-ray Photoelectron Diffraction (X.P.D.) indicates that the remaining chemical surface bonds, essentially GaN and GaO, have the same structural ordering as the clean GaAs (001) surface. (Edited author abstract) 3 refs. In French.

Guizot, J.L. (Thomson-CSF, Orsay, Fr); Alnot, P.; Olivier, J.; Wycsick, F. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 165-166.

## Composition Effects

**093831 CONTROL COMPOSITION OF THE MELT STOICHIOMETRY IN LEC SEMI-INSULATING GaAs.** Control of the melt stoichiometry is an essential factor to obtain undoped LEC semi-insulating GaAs. Experiments have showed that the As weight loss depends on the heat processes, heating rate, the crucible and height of the boronic oxide layer. The arsenic weight loss from crucible of pyrolytic boron nitride is greater than that from a Quartz crucible. (Edited author abstract) 7 refs. In Chinese.

Ma Bi-chun (General Research Inst of Non-ferrous Metals, Beijing, China); Wang Yong-hong; Yu Bin-cai; San-sheng; Deng Zhi-jie. *Xi You Jin Shu* v 5 n 4 Nov 1986 p 303-306.

**Computer Applications See COMPUTERS, MICRO-PROCESSOR—Design.**

## Computer Simulation

**093832 MONTE CARLO PARTICLE SIMULATION FOR NDM OF GaAs.** Monte Carlo particle simulation method has been used to study the negative differential mobility of electrons in the GaAs conduction energy band. The initial states of electrons are proposed to be located in the 64 band according to Maxwell distribution. Electrons drifted along the electric field encounter polar optical or acoustic phonon scattering among valleys or within valleys. It is supposed that the directional velocity of electrons after scattering is eliminated. (Edited author abstract) In Chinese. 6 refs.

Zhao Honglin (Tianjin Univ, Tianjin, China). *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 332-334.

**Contacts See Also ELECTRIC CONTACTS—Fabrication.**

**093833 DEGRADATION OF SCANNED-ELECTRON-BEAM ALLOYED OHMIC CONTACTS ON n-GaAs.** Degradation of scanned-electron-beam (SEB) and furnace-alloyed Au-Ge-Ni Ohmic contacts to n-type GaAs with time, above room temperature, has been studied with and without current flow through the contacts. The degradation is characterized in terms of contact resistivity, source-to-drain resistance  $R_{sd}$ , and more stable than surface-alloyed contacts when aging is performed at temperatures below  $300^\circ\text{C}$  without current flow, and the smooth surface morphology of the SEB-alloyed contacts is lost when they are aged above  $300^\circ\text{C}$ . SEB-alloyed contacts show a overall reducing contact resistivity with aging time. In the case of gradual degradation of contacts due to current flow above room temperature, for typical GaAs field-effect-transistor contact structures, the SEB-alloyed contacts do not show any performance advantage over furnace-alloyed contacts. (Author abstract) 25 refs.

Kalkur, T.S. (Univ of Western Australia, Nedlands, Aust); Nassibian, A.G. *Semicond Sci Technol* v 2 n 9 Sep 1987 p 615-620.

**Crystal Lattices See Also SEMICONDUCTING ZINC COMPOUNDS—Crystal Lattices.**

**093834 BIHOLE IN QUANTUM WELL STRUCTURES.** In  $\text{GaAs-Ga}_{1-x}\text{Al}_x\text{As}$  many quantum well structures or superlattices the top valence subband VBI of size quantization is heavy-hole-like HH1 and the effective mass  $m_1$  is positive. The second valence subband VB2 has a heavy-hole - HH2 or light-hole - LH1 character in dependence on the barrier and well layer thicknesses and the composition  $x$ . The effective mass  $m_2$  in VB2 is negative and the condition for bihole formation  $m_1 > |m_2|$  is fulfilled. The binding energy if the bihole is calculated. The bihole formation due to light absorption is studied. The oscillator strengths in the cases of inter- and intrasubband transition of holes succeeded by bihole formation are obtained. (Author abstract) 13 refs.

Bobrysheva, A.I. (Acad of Sciences of the Moldavian SSR, Kishinev, USSR); Russu, S.S.; Zaloj, V.A. *Phys Status Solidi B* v 143 n 2 Oct 1987 p 549-555.

**093835 LATTICE DYNAMICS OF GaAs/AlAs SUPERLATTICES.** We report on the results of three-dimensional shell model calculations of GaAs/AlAs superlattice phonon frequencies and eigenvectors. Their dependence on direction and magnitude of the wavevector is investigated. Among others we find the occurrence of acoustical (Lamb- and Love-like) guided and optical (Fuchs-Kliwer-like) interface phonons for wavevectors perpendicular to the layer normal; for wavevectors parallel to the normal there are folded and confined phonons. For the folded phonons the ionic displacements can be described by continuously matched sine and cosine functions. An effective wavevector can be attributed to the confined phonons. With this wavevector Raman data in



superlattices are reevaluated and compared with recent high-accuracy neutron scattering data for bulk GaAs. (Author abstract) 18 refs.

Richter, E. (Univ Regensburg, Regensburg, West Ger); Strauch, D. *Solid State Commun* v 64 n 6 Nov 1987 p 867-870.

**Defects** See Also SEMICONDUCTOR DEVICES—Junctions; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Electric Properties; SEMICONDUCTOR MATERIALS—Defects.

**093836 TRANSMISSION ELECTRON MICROSCOPY STUDY OF DEFECTS IN Sn-DOPED GaAs FILMS GROWN BY MOLECULAR BEAM EPITAXY.** Films of GaAs, heavily doped with Sn, which have been grown by molecular-beam epitaxy are found to contain single-crystal Sn particles situated in the near surface region of the epilayer GaAs. The morphology and chemical composition of the particles have been examined by using cross-section transmission electron microscopy combined with energy-dispersive X-ray spectroscopy. Different growth conditions were used to study the Sn-particle formation and high-resolution transmission electron microscopy was used to investigate microstructures. The observations are discussed in terms of several models previously proposed for these phenomena. (Author abstract) 24 refs.

Chen, S.H. (Cornell Univ, Ithaca, NY, USA); Carter, C.B.; Enquist, P. *Appl Phys A* v A44 n 2 Oct 1987 p 143-151.

**093837 DETECTION OF EL2 IN UNDOPE LEC GaAs BY A NOVEL VARIATION OF PHOTO-INDUCED TRANSIENT SPECTROSCOPY.** A variation of Photo-Induced Transient Spectroscopy (PITS) is described. By elimination of charge exchange with the surface of semi-insulating GaAs, negative peaks in PITS spectra are suppressed. This allows the transient response of bulk EL2 centers to be detected by PITS in undoped LEC GaAs for the first time. (Author abstract) 8 refs.

Blight, S.R. (GEC, Wembley, Engl); Page, A.D.; Ladbroke, P.H.; Thomas, H. *Jpn J Appl Phys Part 1* v 26 n 8 Aug 1987 p 1388-1389.

**093838 ON THE NATURE OF THE MAIN MID-GAP DONOR LEVEL EL2 IN GaAs.** In order to shed some light on the configuration of EL2 in GaAs, the authors summarize its characteristics including electrical, optical, magnetic, chemical and crystallographic properties. On the basis of this knowledge they suggest that the nomenclature EL2 be restricted to a deep donor level that can meet three important requirements simultaneously, i.e., stoichiometric relation, dislocation density dependence and photoquenching behavior. In this way, the complication arising from the presence of the EL2 may be alleviated. (Edited author abstract) In Chinese. 70 refs.

Zou, Yuan-xi (Acad Sinica, China); Wang, Gang-yu. *Xi You Jin Shu* v 6 n 2 May 1987 p 81-90.

**093839 SINGLE STACKING FAULTS IN HIGH-STRESS DEFORMED SEMI-INSULATING GaAs.** Single intrinsic stacking faults in semi-insulating undoped GaAs have been studied by transmission electron microscopy. The crystals were deformed at room temperature by uniaxial compression and under hydrostatic pressure. It is shown that the stacking faults are produced by the dissociation of  $60^\circ(\beta)$  dislocations under very high stress ( $\tau \approx 0.75$  GPa). The partial dislocations bounding the stacking faults are systematically  $30^\circ(\beta)$  in character. These observations are consistent with the classification of mobilities of partial dislocations that had been previously established when studying deformation microtwins in the same material:  $30^\circ(\beta) < 30^\circ(\alpha) < 90^\circ(\alpha$  or  $\beta)$ . (Author abstract) 12 refs.

Lefebvre, A. (CNRS, Villeneuve d'Ascq, Fr); Androussi, Y.; Vanderschaeve, G. *Phil Mag Lett* v 56 n 4 Oct 1987 p 135-141.

**093840 DISLOCATION VELOCITY MEASURE-**

**MENTS IN SEMI-INSULATING In-DOPED GaAs.** The mean velocities of  $\alpha$ ,  $\beta$  and screw dislocations in doped GaAs have been determined by X-ray topography. Although the velocities of  $\beta$  dislocations were found to be nearly equal to those measured in undoped material, the velocities of  $\alpha$  and screw dislocations were lower. The activation energies for dislocation motion were found to be approximately the same as in undoped material, except for temperatures higher than  $400^\circ\text{C}$  and values of the resolved shear stress,  $\sigma$ , less than 10 MPa. In this range, the mobilities of  $\alpha$  and screw dislocation were more severely reduced and were time-dependent. We suggest that these different effects are related to a selective interaction between the dopant (In) and  $\alpha$  partials. (Author abstract) 11 refs.

Burle-Durbec, N. (CNRS, Marseilles, Fr); Pichaud, B.; Minari, F. *Phil Mag Lett* v 56 n 5 Nov 1987 p 173-178.

**093841 ARSENIC ANTISITE DEFECTS IN GaAs AND GaP: PSEUDO JAHN-TELLER EFFECT AND TEMPERATURE DEPENDENCE OF THE HYPERFINE CONSTANT.** Electron paramagnetic resonance experiments on arsenic antisites in GaAs and GaP show that the hyperfine constant decreases sharply with temperature. It is demonstrated here that this effect can be quantitatively explained by a pseudo Jahn-Teller effect between the ground ( $A_1$ ) and excited ( $T_2$ ) electronic states of the defect. This also results in a softening of some local force constant. The relation to the case of off-center impurities is discussed. (Author abstract) 15 refs.

Mauger, A. (CNRS, Paris, Fr); von Bardeleben, H.J.; Bourgoin, J.C.; Lannoo, F.; Lannoo, M. *Europhys Lett* v 4 n 10 Nov 15 1987 p 1151-1155.

**093842 DISLOCATION REDUCTION IN GaAs ON Si BY THERMAL CYCLES AND InGaAs/GaAs STRAINED-LAYER SUPERLATTICES.** The etch-pit density of epitaxial GaAs layers grown on Si was significantly reduced by using the technique of growth interrupt and thermal cycles (in situ TC) followed by growth of  $\text{In}_{0.1}\text{Ga}_{0.9}\text{As}$ /GaAs strained-layer superlattices (SLs). The etch-pit density of  $1.4 \times 10^6 \text{ cm}^{-2}$  (density of small pits by molten KOH etching) was achieved in 3.5  $\mu\text{m}$ -thick GaAs epilayers. It was also found that the effect of SLs on dislocation reduction was more enhanced by combining with the in situ TC process than the effect when SLs were used by themselves. (Author abstract) 18 refs.

Okamoto, Hiroshi (NTT Applied Electronics Lab, Musashino, Jpn); Watanabe, Yoshio; Kadota, Yoshiaki; Ohmachi, Yoshiro. *Jpn J Appl Phys Part 2* v 26 n 12 Dec 1987 p 1950-1952.

**093843 THEORY OF DEFECT COMPLEXES AT SEMICONDUCTOR SURFACES.** We report calculations of deep levels associated with defect complexes at semiconductor surfaces. For the antistructure defect ( $\text{As}_{\text{Ga}}$ ,  $\text{Ga}_{\text{As}}$ ) at the (110) surface of GaAs, the results are qualitatively the same as the sum of those for the individual antisite defects  $\text{As}_{\text{Ga}}$  and  $\text{Ga}_{\text{As}}$  - a donor level and two acceptor levels within the band gap. (Author abstract) 26 refs.

Ren, Shang-Fen (Texas A&M Univ, College Station, TX, USA); Allen, Roland E. *Solid State Commun* v 64 n 4 Oct 1987 p 589-591.

**093844 ON THE METASTABILITY OF THE EL2 DEFECT IN PLASTICALLY DEFORMED GaAs.** DLTS spectra and transients of photocapacitance quenching under  $\lambda = 1.06 \mu\text{m}$  photoexcitation of the EL2 defect were investigated in GaAs crystals subjected to plastic deformation. The concentration of EL6 traps increased, and the quenching became slower and non-exponential, after the sample deformation. It is argued that the deformation-induced EL6 traps in the vicinity of EL2 open a new channel for the deexcitation of EL2: phonon assisted electron tunneling from EL2 to EL6, which diminishes the transformation rate of EL2 into the metastable state. EL6 is assigned to the isolated  $\text{As}_{\text{Ga}}$  antisite defect. (Author abstract) 28 refs.

Wosinski, T. (Univ Goettingen, Goettingen, West Ger); Figielski, T. *Solid State Commun* v 63 n 10 Sep 1987 p 885-888.

**093845 ANALYSIS OF THERMALLY STIMULATED CURRENT SPECTROSCOPY IN SEMI-INSULATING GaAs. I. INITIALIZATION.** The operation of improved thermally stimulated current (TSC) spectroscopy is described and analyzed. This method is suited for studying defects in semi-insulating (SI) GaAs at liquid-helium temperatures. This paper, the first in a series, presents an analysis of the first half process of TSC, that is, initialization, which consists of three stages: carrier generation, transport, and trapping. The initialization is analyzed in terms of such parameters as electrode spacing, biasing voltage and polarity, excitation light energy and dose, and temperature. The analysis leads to new methods of determining the cross section of a deep level trap. From the photocurrent transient, the cross section was estimated for the dominant trap(s) as  $5 \times 10^{-15} \text{ cm}^2$ . Another method offers an estimation for nondominant trap levels. (Author abstract) 11 refs.

Tomozane, Mamoru (Univ of Tsukuba, Tsukuba, Jpn); Nannichi, Yasuo; Onodera, Isao; Fukase, Tadashi; Hasegawa, Fumio. *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 260-268.

**093846 ON THE EXISTENCE AND ORIGIN OF ELLIPTICAL DEFECTS WITH NUCLEUS ON EPILAYERS GROWN BY MOLECULAR BEAM EPITAXY.** Macroscopic elliptical defects with a nucleus on GaAs epilayers grown by molecular-beam epitaxy were analyzed by scanning electron microscopy (SEM) and by Nomarski optical microscopy. The origin has been identified to be a macroscopic surface contamination before growth. (Author abstract) 10 refs.

Mreira, Marcus Vinicius Baeta (Federal Univ of Minas Gerais, Minas Gerais, Braz); de Oliveira, Alfredo Gontijo. *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 332-333.

**093847 INFLUENCE OF SUBSTRATE DEFECTS ON THE STRUCTURE OF EPITAXIAL GaAs GROWN BY MOCVD.** GaAs layers were grown by MOCVD under 'optimum' conditions on substrates containing structural defects which are most commonly encountered in variously doped, LEC and HB grown, bulk GaAs crystals. The structure of the homo-epitaxial samples was investigated by sequent DSL photoetching. Dislocations of various types were generally found to propagate in a one-to-one relation from the substrate into the epilayer. The same was observed for twins. Impurity inhomogeneities in the substrate, such as growth striations and extended atmospheres around grown-in dislocations, have no noticeable influence on the epilayer structure. Microdefects, both in the bulk matrix and along grown-in dislocations, can produce a multiple of epilayer dislocations. Heavily indium-doped substrates lead to the formation of networks of misfit dislocations. (Author abstract) 27 refs.

Weyher, J.L. (Katholieke Univ, Nijmegen, Neth); Van de Ven, J. *J Cryst Growth* v 88 n 2 Apr II 1988 p 221-228.

**093848 ANTISITE DEFECTS IN PLASTICALLY-DEFORMED GaAs: AN ALTERNATIVE ANALYSIS.** A revision is presented of the accepted view that the observed increase in electron paramagnetic resonance (EPR) with plastic deformation in GaAs is due to the generation of As antisite defects. It is proposed instead that only compensating deep acceptor defects are generated. The increase of the EPR signal from As antisites can then be attributed to the compensation of the neutral As antisites that were already present in the as-grown GaAs. The nonquenching extrinsic absorption can be attributed to the acceptors. The same analysis suggests that in the case of electron and neutron irradiation, both acceptors and As antisites are generated. These proposals succeed in



eliminating some recently imposed complexities in the relationship between As antisites and EL2. (Author abstract) 11 refs.

Bray, R. (Max-Planck-Institut fuer Festkoerperforschung, Stuttgart, West Ger). *Solid State Commun* v 60 n 11 Dec 1986 p 867-870.

**093849 FORMATION OF ARSENIC ANTISITE DEFECTS DURING PLASTIC DEFORMATION OF GaAs.** The electron paramagnetic resonance (EPR) signal of arsenic antisite defects increases after plastic deformation of GaAs. This has been attributed by R. Bray to the formation of only compensating acceptors rather than additional antisites. A critical discussion of this alternative model is presented, taking into account new experimental results. (Edited author abstract) 13 refs.

Weber, E.R. (Lawrence Berkeley Lab, Berkeley, CA, USA). *Solid State Commun* v 60 n 11 Dec 1986 p 871-872.

**093850 INTERFACE STUDY ON GaAs-ON-Si BY TRANSMISSION ELECTRON MICROSCOPY.** A correlation between the surface and interface defects in GaAs-on-Si structures was examined by KOH etching and transmission electron microscopy. Line-shaped etch pits revealed on the GaAs-on-Si (100) were attributed to twins produced at the interface. This twin generation was avoided by off-setting the substrate orientation. An alternative for this is the application of an additional heat treatment after the GaAs buffer layer is grown. In this case, the twin propagation ends on the buffer layer. (Author abstract) 10 refs.

Nozaki, Chiharu (Toshiba Corp, Kawasaki, Jpn); Naritaka, Shigeo; Kokubun, Yoshihiro; Yasuami, Shigeru. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 293-295.

**093851 ELECTRON PARAMAGNETIC RESONANCE OF ISOLATED  $As_{Ga}$  + ANTISITE DEFECT IN NEUTRON-TRANSMUTATION DOPED SEMI-INSULATING GaAs.** The isolated  $As_{Ga}$  antisite defect produced by the neutron-transmutation doping in semi-insulating GaAs was studied using the electron paramagnetic resonance technique. The results show that the optically induced quenching of the isolated  $As_{Ga}$  + antisite defect is quite different from that of the EL2 center. Illumination with white light seems to always reduce the electron paramagnetic resonance spectrum suggesting that depopulation of the EL2 center does not introduce a noticeable change in the  $As_{Ga}$  + antisite concentration. (Author abstract) 11 refs.

Manasreh, M.O. (Systran Corp, Dayton, OH, USA); McDonald, P.F.; Kivlighn, S.A.; Minton, J.T.; Covington, B.C. *Solid State Commun* v 65 n 11 Mar 1988 p 1267-1269.

**093852 EXPLORATION ON THE NATURE OF HOLE TRAPS A AND B IN LPE n-TYPE GaAs.** Two series of experiments have been performed on hole traps A and B in LPE GaAs grown under arsenic-deficient conditions and a comparison has been made between the concentration of A and B and the diffusion coefficient of  $V_{Ga}$  within the temperature range 770-870 degrees C. The results lead us to understand that hole traps A and B are related to  $V_{Ga}$  and  $V_{As}$  respectively and they are all related to  $V_{Ga}$ . These results are supported by our previous experiments as well as those of Prints et al., and Hasegawa and Majerfeld. Finally, the results are discussed on the basis of our thermochemical model. (Author abstract) 8 refs.

Zhou, Jicheng (Shanghai Inst of Metallurgy, Shanghai, China); Li, Liansheng; Liu, Miaoxiu; Lu, Bingfang; Zhang, Jue. *Mater Lett* v 6 n 7 Apr 1988 p 247-250.

**093853 REDISTRIBUTION OF EL2 IN UNDOPEd SEMI-INSULATING GaAs DURING ANNEALING UNDER ARSENIC OVERPRESSURE.** The variations of the EL2 concentration in undoped semi-insulating (SI) GaAs crystals with arsenic pressure,  $P(As_2)$ , during high-temperature annealing have been investigated using infrared absorption measurements at 1.1  $\mu m$ . It is found

that the variations can be divided into two types within a range of  $P(As_2) < 2$  atm, beyond which the EL2 concentration, not varying with  $P(As_2)$ , approached an apparently saturated value which is correlated with the stoichiometry of as-grown crystals. An improvement on the uniformity of EL2 distributions is achieved after annealing. These results are in agreement with an analysis proposed in a previous paper. (Author abstract) 11 refs.

Wu, Ju (Chinese Acad of Science, Shanghai, China); Mo, Peigen; Zou, Yuanxi. *Mater Lett* v 6 n 5-6 Mar 1988 p 161-163.

**093854 ROLE OF EL2 CENTRES IN INFRA RED IMAGES OF DEFECTS IN GaAs MATERIALS.** Careful measurements of the changes induced by photoquenching in the infrared transmission image of GaAs wafers at Liquid Nitrogen temperature shows an important enhancement of the mean light level and disappearance of the usual fourfold feature; but it also shows that the contrast of the pattern (cell structure) is not affected at all. The contribution of EL2 centres to the image is questioned; it is deduced from these results that photoquenchable EL2 centres are slightly more abundant in the cells than in the walls. In large cell materials an intermediate zone is found surrounding the cells and containing higher EL2 densities. This sheds new light on the role of the dislocations; these results are discussed and compared with etching and luminescence images. (Author abstract) 34 refs.

Fillard, Jp (Univ des Sciences et Techniques du Languedoc, Montpellier, Fr); Montgomery, P.; Gall, P.; Asgarinia, M.; Bonnafe, J. *Jpn J Appl Phys Part 1* v 27 n 3 Mar 1988 p 384-388.

**093855 PREDICTION OF EQUILIBRIUM DEFECT CONCENTRATIONS IN GaAs AND ZnSe.** We use the local density approximation within a self-consistent pseudopotential and pseudatomic-orbital scheme to predict equilibrium point defect concentrations in semiconductors and their dependence on stoichiometry, temperature and Fermi level. We compare and contrast the native defects expected in GaAs (III-V) with those in ZnSe (II-VI). We find in stoichiometric p-type material that the dominant defect in GaAs is the cation on anion antisite defect, whereas the interstitial cation defect is dominant in ZnSe. The prominence of interstitials in p-type ZnSe tends to self-compensate the material since  $Zn_i$  is a double donor. We also demonstrate how extrinsic impurities may affect native defect concentrations by considering as an example the Zn impurity in GaAs. (Author abstract) 10 refs.

Jansen, Robert W. (Arizona State Univ, Tempe, AZ, USA); Sankey, Otto F. *Solid State Commun* v 64 n 2 Oct 1987 p 197-201.

**093856 COMPARISON OF DEEP LEVEL DEFECTS IN OMVPE GaAs LAYERS GROWN ON VARIOUS GaAs SUBSTRATE TYPES.** In order to obtain epitaxial GaAs layers with a low enough defect concentration for an analysis of process induced impurities and defects, undoped OMVPE layers were grown on different substrate types. Deep level transient spectroscopy (DLTS) showed that the epitaxial layers grown on all substrate types contained the EL2 electron trap in concentrations of about  $1 \times 10^{14}/cm^3$ . Apart from the EL2, layers grown on semi-insulating substrates contained no electron traps in concentrations above  $10^{11}/cm^3$ , while layers grown on most n+ and p+ substrates contained electron and hole traps in concentrations of well above  $10^{13}/cm^3$ . It was therefore concluded that the choice of the proper substrate type when attempting to grow epitaxial layers with a low defect concentration is of the utmost importance. (Author abstract) 13 refs.

Auret, F.D. (Univ of Port Elizabeth, Port Elizabeth, S Afr); Nel, M.; Leitch, A.W.R. *J Cryst Growth* v 89 n 2-3 Jun II 1988 p 308-312.

**093857 POINT DEFECTS IN GaAs STUDIED BY CORRELATED POSITRON LIFETIME, OPTICAL, AND ELECTRICAL MEASUREMENTS.** Positron life-

time measurements were used in combination with optical (infrared absorption, photoluminescence, and photoreflection) and electrical (Hall and resistivity) investigations to study native point defects and their complexes in as-grown GaAs crystals. In undoped n-type GaAs which contains  $2 \times 10^{16} cm^{-3}$  EL2<sup>+</sup> centres strong positron trapping by a vacancy-type defect is detected. The point defect is discussed as a vacancy in the As sublattice appearing in a neutral or negative charge state. A specific positron trapping rate of  $6 \times 10^{10} s^{-1} cm^{-3}$   $s^{-1} MIN^{-1}$  ( $3 \times 10^{14} s^{-1} MIN^{-1}$ ) is estimated from comparison of electrical and positron lifetime parameters and by identifying the compensating centres in heavily doped n-type GaAs. The number of grown-in vacancies is discussed. Temperature dependent studies indicate a change in the nature of the dominating positron trap at low temperatures. Annealing experiments are discussed as a compensation of vacancies around 500 °C. (Edited author abstract) 54 Refs.

Dlubek, G. (Paedagogischen Hochschule, Halle, West Ger); Dlubek, A.; Krause, R.; Bruemmer, O.; Friedland, K.; Rentzsch, R. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 419-432.

**093858 EL2<sup>+</sup> DISTRIBUTION IN THE VICINITY OF DISLOCATIONS IN GaAs-In MATERIALS.** We have recently shown that, contrary to the well-reputed opinion, the EL2<sup>+</sup> centers in GaAs undoped materials are not especially concentrated on dislocations; the cell pattern, in particular, does not disappear after photoquenching at Liquid Nitrogen Temperature. In this paper we complete this study with details of the EL2<sup>+</sup> densities in the vicinity of individual dislocations in GaAs-In materials. Laser Scanning Tomography and Infra Red Transmission images are analyzed complementarily. Grown-in axial dislocations appear to be surrounded by a wide EL2-rich cylindrical zone, whereas the dislocation itself is not to be considered as a large reservoir of gettered EL2 centers. (Author abstract) 13 Refs.

Fillard, Jp. (Center D'Etudes E'lectronique de Montpellier, Montpellier, Fr); Gall, P.; Asgarinia, M.; Castagne, M.; Baroudi, M. *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 899-902.

**093859 DEEP LEVEL IN SEMI-INSULATING LIQUID ENCAPSULATED CZOCHARALSKI-GROWN GaAs.** Photo-induced transient spectroscopy (PITS) was performed on various heat-treated samples of semi-insulating liquid encapsulated Czochralski-grown GaAs. Seven deep levels at 0.57, 0.52, 0.42, 0.36, 0.27, 0.22 and 0.18 eV were observed. These levels can be identified with levels seen using other deep-level techniques and a variety of crystal growth and sample preparation techniques. The levels at 0.52, 0.42 and 0.36 eV can be annealed out by heat treatment. These levels therefore seem to be associated with structural defects rather than impurities. (Author abstract) 11 Refs.

Burd, M.R. (Univ of California, Los Angeles, CA, USA); Braunstein, R. *J Phys Chem Solids* v 49 n 7 1988 p 731-735.

**093860 ELECTRON, HOLE AND EXCITON BINDING ENERGIES ON INTERFACE DEFECTS OF SINGLE QUANTUM WELL STRUCTURES.** We report on variational calculations of binding energies of electrons, holes and excitons on quantum well interface defects. The defects are modeled by cylindrical protrusions of the well-acting material into the barrier-acting one. We have also examined the effect of adding an attractive coulombic potential to either an attractive or a repulsive interface defect. (Author abstract) 4 Refs.

Gerbier, F.; Bastard, G. *Phys Scr* v 38 n 1 Jul 1988 p 109-110.

**093861 REVEALING OF DEFECTS IN GaAs.** Defects including striation, surface damage, dislocations, twins and microdefects in bulk GaAs crystals and epilayers were studied and characterized by using AHA



etching under illumination. The etched defect patterns revealed by this method are good. In addition, helical dislocations and microdefects in heavily doped n-GaAs crystals were also revealed and are discussed. (Edited author abstract). 16 Refs. In Chinese.

Min, Hui-Fang (Acad Sinica, China); Shen, Bao-Liang; Zhao, Zhe. *Xiyou Jinshu* v 7 n 1 Feb 1988 p 37-41.

**093862 ABSORPTION SPECTRA OF DEFORMED AND ELECTRON-IRRADIATED GALLIUM ARSENIDE CRYSTALS.** Optical absorption has been used to determine the energy levels due to defects introduced by strain or by electron bombardment in gallium arsenide crystals. The gallium arsenide crystals were grown by horizontal methods (Bridgman's or Czochralski's). The crystals had high growth-defect concentrations, with energy levels in the middle of the forbidden band. These defects are known as EL2. Crystals containing these defects show optical photobleaching. It is of interest to correlate these growth defects with ones artificially introduced by strain or electron bombardment. 7 refs.

Haga, T.; Suezawa, M.; Sumino, K. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 66-69.

**093863 TIME-RESOLVED PHOTOLUMINESCENCE OF THE DEFECT LINES IN GaAs MOLECULAR-BEAM EPITAXY.** A time-resolved photoluminescence study of the defect-induced bound excitons (DIBE) observed in the energy region 1504-1511 meV in high quality molecular-beam epitaxy grown GaAs has been performed. Our results support the model that these lines consist of two distinct recombination processes. Transient resonant excitation of these DIBE demonstrate that the lines  $i$  to  $s$  can be associated with acceptor-bound exciton transitions. (Author abstract) 19 refs.

Charbonneau, S. (Simon Fraser Univ, Burnaby, BC, Can); Thewalt, M.L.W.; Steiner, T. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 838-841.

**093864 DISLOCATIONS AND ANTISTRUCTURAL DEFECTS IN GaAs.** Processes are considered that can lead to antistructural  $As_{Ga}$  defects in initial and plastically strained GaAs crystals on account of the presence of dislocations. The relationship between these defects and EL2 centers in GaAs is discussed. (Author abstract) 32 refs.

Figielski, T. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 6-12.

**093865 INTERACTION OF DISLOCATIONS AND INDIUM IN GaAs.** Selective etching and X-ray topography have been used to examine dislocation dynamics in In-doped GaAs crystals, where the comparison is made with analogous results for undoped GaAs and for crystals containing Si. (Author abstract) 27 refs.

Yonenaga, I.; Takebe, M.; Sumino, K. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 19-22.

**093866 SCANNING DLTS STUDY OF GALLIUM ARSENIDE DEFECT DISTRIBUTIONS AND ENERGY LEVELS.** Scanning deep-level transient spectroscopy (SDLTS) enables one to examine spatially separated centers containing deep levels at concentrations up to  $10^{19} m^{-3}$  with a spatial resolution of some microns. (Author abstract) 10 refs.

Breitenstein, O.; Heydenreich, J. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 44-48.

**093867 SYNCHROTRON RADIATION IN DISLOCATION OBSERVATION FOR GALLIUM ARSE-**

**NIDE NEAR THE MELTING POINT.** A study has been made on the behavior of dislocations in gallium arsenide near the melting point. Melting is simultaneous in dislocation-free regions and ones with many dislocations. The dislocations remain stable during melting. (Author abstract) 5 refs.

Sato, F.; Matsui, M.; Chikawa, J. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 99-102.

**093868 DISLOCATIONS IN TIN-DOPED GaAs GROWN BY ORGANOMETALLIC VAPOR EPITAXY.** Vapor-phase epitaxy with organometallic compounds has been used to grow GaAs films having tin concentrations up to  $2.10^{19} cm^{-3}$ . The dislocation density has been examined as a function of tin concentration and growth conditions. A model is proposed for defect formation in the films. (Author abstract) 12 refs.

Yakimova, R. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 134-138.

## Deformation

**093869 PHOTOSTIMULATED ENHANCEMENT OF DISLOCATION GLIDE IN GALLIUM ARSENIDE CRYSTALS.** The effect of illumination on the plastic properties of gallium arsenide crystals was studied experimentally. The illumination reduces the plastic flow stress. The phenomenon is referred to as the negative photoplastic effect. The NPPE and the mean velocity of dislocations were investigated as functions of temperature, stress, and strain as well as intensity and wavelength of the exciting light. Based on the analysis of experimental results a physical model is proposed. (Edited author abstract). 33 Refs.

Midivanyan, B.E. (Acad of Sciences of the USSR, Chernogolovka, USSR); Shikaidov, M.Sh. *Phys Status Solidi A* v 107 n 1 May 1988 p 131-140.

**Diffusion See SEMICONDUCTING ZINC COMPOUNDS—Chemical Vapor Deposition.**

**Doping See Also CRYSTALS—Growing; SEMICONDUCTING SILICON—Doping; SEMICONDUCTOR DIODES—Mathematical Models; SEMICONDUCTOR MATERIALS—Doping; SEMICONDUCTOR MATERIALS—Ion Implantation; SEMICONDUCTOR MATERIALS—Spectrum Analysis; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, FIELD EFFECT—Microwaves; TRANSISTORS, FIELD EFFECT—Millimeter Waves; TRANSISTORS, FIELD EFFECT—Noise; TRANSISTORS, FIELD EFFECT—Transients.**

**093870 AMPHOTERIC DOPING IN SI-IMPLANTED UNDOPED OR IN-DOPED CZOCHRALSKI GaAs.** We have studied the conditions causing amphoteric doping in Si-implanted Czochralski GaAs by photoluminescence and Hall effect measurements. Wafers of either undoped or In-doped GaAs were implanted and capped with either  $SiN_x$  or  $SiO_x$  before the activation anneal. Localized, strong amphoteric doping was observed only in  $SiN_x$  capped In-doped wafers. In all other annealed wafers only donor activity was detected. This effect is explained by the point defect reactions due to the presence of In and the interaction of the GaAs with the capping material during annealing. (Author abstract) 7 refs.

Warwick, Colin A. (NEC Corp, Kawasaki, Jpn); Ono, Haruhiko; Kuzuhara, Masaaki; Matsui, Junji. *Jpn J Appl Phys Part 2* v 26 n 8 Aug 1987 p 1398-1400.

**093871 SIMPLE OPEN-TUBE Zn-DIFFUSION TECHNIQUE FOR GaAs AND AlGaAs.** This paper will describe a simple open-tube diffusion technique of Zn into GaAs and AlGaAs in a  $N_2$  ambient using a granular solid source of ZnGaAs alloy. Resulting carrier concentration profiles for both GaAs and AlGaAs are shown and discussed. Selective area diffusion has been performed in both of these materials using plasma-enhanced chemical vapor deposited (PECVD)  $Si_3N_4$  and sputtered Si diffu-

sion masks. Enhanced lateral diffusion along the mask-semiconductor interface for the above two diffusion masks are also discussed. 12 refs.

Choudhury, A.N.M. (GTE Lab Inc, Waltham, MA, USA); Oren, M.; Rothman, M.A.; Shastri, S.K. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2631-2634.

**093872 GROWTH AND CHARACTERIZATION OF GaAs DOPING SUPERLATTICES.** The paper reports on doping superlattices and measurements of material parameters. The authors discuss the properties of the effective bandgap of GaAs doping superlattices grown by molecular beam epitaxy. The GaAs structure consists of a periodic sequence of thin n-type (Si-doped) and p-type (Be-doped) layers with uniform doping concentration and can be considered as the structure of several p-n junctions connected in series. The films were grown under As-rich conditions at 530-600°C. The photoluminescence at low temperature (4.2K) was measured for a number of NIPI structures with various layer thickness and doping concentrations. (Edited author abstract) In Chinese. 5 refs.

Liang, Ji-ben (Acad Sinica, Beijing, China); Jiang, De-sheng; Sun, Dian-zhua; Chen, Zon-gui; Huang, Yun-heng; Kong, Mei-ying. *Xi You Jin Shu* v 6 n 1 Feb 1987 p 43-48.

**093873 ENERGY LEVELS RELATED TO VANADIUM IN VPE GaAs.** A study of energy levels in V and Cr doped VPE GaAs was performed using infrared photoconductivity and photo-induced transient spectroscopy (PITS). SIMS analysis was performed on the epilayer and the substrate. V and Cr coexisted in the epilayer whereas only Cr was contained in the substrate. PITS measurements were made on the epilayer and three peaks of 0.15 eV, 0.43 eV and 0.72 eV were obtained. (Edited author abstract) In Chinese. 11 refs.

Wang, Le (Acad Sinica, China); Zhong, Jin-quan; Chen, Zheng-xiu; Zhou, Bing-lin. *Xi You Jin Shu* v 6 n 3 Aug 1987 p 192-196.

**093874 COMPLEX COMPENSATION OF Ge PULSE-DIFFUSED INTO GaAs.** The compensation of Ge pulse-diffused into high-purity epitaxial GaAs from a thin elemental source using rapid thermal processing has been investigated. A comparison of SIMS and differential Hall effect measurements shows that the resulting  $n^+$ -doped layers are highly compensated, with atomic Ge concentrations of  $10^{21}$ - $10^{22} cm^{-3}$ , but free electron concentrations of only approx.  $1 \times 10^{18} cm^{-3}$ . In contrast to the case where Ge is introduced during crystal growth or by ion implantation,  $Ge_{Ga}$  donors are not compensated by  $Ge_{As}$  acceptors when Ge is pulse-diffused into GaAs. Photoluminescence spectroscopy shows that  $Ge_{Ga}$  donors are compensated by  $V_{Ga}$  acceptors rather than  $Ge_{As}$  acceptors. At low diffusion temperatures, Ga vacancies are formed as Ga rapidly diffuses into the Ge layer. (Edited author abstract) 19 refs.

Farley, C.W. (Univ of Texas at Austin, Austin, TX, USA); Kim, T.S.; Lester, S.D.; Streetman, B.G. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2888-2892.

**093875 EXTRA DIFFUSION OF Zn INTO GaAs IN LOW CONCENTRATION RANGE: APPLICATION OF THE MODEL OF VARYING CHARGE TRANSFER.** A second diffusion of Zn has been observed in GaAs in the low-concentration range. The behavior is similar to that of double diffusion in InP. The effect of zinc activity in the vapor phase has been studied using a semi-closed-box system. The observed profiles of Zn have been explained using a model of varying charge transfer by vacancy centers during interstitial-substitutional interchanges. (Author abstract) 12 refs.

Kazmierski, K. (THOMSON-CSF, Orsay, Fr); Launay, F.; de Cremoux, B. *Jpn J Appl Phys Part 1* v 26 n 10 Oct 1987 p 1630-1633.



**093876 CALCULATION OF THE HOMOGENEITY RANGE OF TIN-DOPED GALLIUM ARSENIDE.** A calculation of the homogeneity range of tin-doped gallium arsenide is performed by the method of quasi-chemical reactions. It is shown that the introduction of tin into gallium arsenide leads to a narrowing of the low-temperature boundaries of the homogeneity range on both the Ga excess side and the As excess side. The results of the calculation are in good agreement with experimental data showing that doping gallium arsenide with tin leads to an intensification of the decomposition of a solid solution of gallium in gallium arsenide. In Russian. 17 refs.

Morozov, A.N.; Bublik, V.T.; Morozova, O.Yu. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 9 Sep 1987 p 1429-1433.

**093877 FORMATION OF HETEROGENEITIES IN NUCLEAR-DOPED SPECIMENS OF GaAs AND InAs.** Investigations were conducted into the mechanics of formation of heterogeneities in nuclear-doped specimens of GaAs and InAs. It is shown that the nuclear doping method greatly increases (2-5 times for GaAs and 4-10 times for InAs) the homogeneity of doping in the cross section of single crystals. The relatively higher heterogeneity of nuclear-doped gallium arsenide in comparison with nuclear-doped indium arsenide is caused by the higher degree of compensation determined by residual acceptor defects and can be reduced to around 1-2% if the degree of compensation is reduced to  $K \leq 0.2$ . (Author abstract) 11 refs.

Kolin, N.G.; Osvenskii, V.B.; Yurova, E.S.; Yur'eva, I.M. *Phys Chem Mater Treat* v 21 n 4 Jul-Aug 1987 p 306-312.

**093878 Sn INCORPORATION IN GaAs BY MOLECULAR BEAM EPITAXY.** The characteristics of heavily Sn-doped GaAs grown by molecular beam epitaxy are investigated. The free carrier concentration saturates at  $1 \times 10^{19} \text{ cm}^{-3}$  for a growth temperature of  $600^\circ\text{C}$  and at  $2 \times 10^{19} \text{ cm}^{-3}$  for  $400^\circ\text{C}$ . In the saturation region for  $600^\circ\text{C}$ , the concentration of incorporated Sn atoms increases with increasing doping concentration. SIMS and electrical characterizations show that the excess Sn atoms are incorporated into GaAs as neutral impurities. The formation of Sn-rich 3D islands does not occur on the GaAs surface at doping concentrations up to around  $3 \times 10^{19} \text{ cm}^{-3}$ , which is much higher than the previously reported critical doping concentration of  $1 \times 10^{19} \text{ cm}^{-3}$ . (Author abstract) 8 refs.

Ito, Hiroshi (NTT, Atsugi, Jpn); Ishibashi, Tadao. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1760-1762.

**093879 SPECTRAL SHIFT OF PHOTOLUMINESCENCE OF HIGHLY DOPED GaAs EPITAXIAL LAYERS GROWN BY MOCVD.** The photoluminescence spectra of Se-doped and Si-doped GaAs epitaxial layers grown by metalorganic chemical vapor deposition (MOCVD) were measured and compared. The spectral shift of Se-doped samples changes only with the carrier concentration, which can be explained by the Moss-Burstein shift, while that of Si-doped samples depends not only on the carrier concentration but also on growth rates and V/III mole fractions. It became apparent from x-ray diffraction that the lattice constant began to decrease in highly Si-doped layers and that the anomalous spectral shifts are caused by the lattice compression originating from a high density of  $[\text{Si}_{\text{Ga}}\text{Si}_{\text{As}}]$  pairs incorporated in highly Si-doped layers. (Author abstract) 12 refs.

Okamoto, Kotaro (Univ of Electro-Communications, Chofu, Jpn); Kurihara, Nobuaki. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1763-1766.

**093880 SYMMETRY FORBIDDEN LO-PHONON RAMAN SCATTERING IN HEAVILY DOPED  $<100>$  n-GaAs.** We have investigated symmetry forbidden longitudinal optic Raman for various polarization configurations at  $4579\text{Å}$  from the  $<100>$  surface of heavily doped n-GaAs caused by the strong surface-fields and high impurity levels. We have evaluated the magnitude and phase of the coefficient of the electric-field induced term as well as the magnitude of the coefficients

of the impurity-induced factor. (Author abstract) 13 refs.

Shen, H. (Brooklyn Coll of CUNY, Brooklyn, NY, USA); Parayanthai, P.; Pollark, F.H. *Solid State Commun* v 63 n 4 Jul 1987 p 357-359.

**093881 HEAVILY Sn-DOPED GaAs BUFFER LAYERS FOR AlGaAs/GaAs HBTs.** The Sn atom profile in MBE grown GaAs with a buried, heavily doped layer was characterized using SIMS analysis. Sn carryforward was prevented by decreasing either the growth temperature or doping concentration. Bulk resistivity of  $0.0006 \Omega \cdot \text{cm}$  with a free carrier concentration of  $1 \times 10^{19} \text{ cm}^{-3}$  and specific contact resistance of  $1.6 \times 10^{-7} \Omega \cdot \text{cm}^2$  were obtained with samples grown at  $600^\circ\text{C}$ . To confirm the feasibility of the heavily Sn-doped buffer layer, an Al-GaAs/GaAs heterojunction bipolar transistor was fabricated. A current gain of 120 and base-collector junction breakdown voltage of 16 V were obtained. (Author abstract) 16 refs.

Ito, Hiroshi (NTT, Atsugi, Jpn); Ishibashi, Tadao. *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 707-709.

**093882 MAGNETOOPTICAL STUDIES OF SHALLOW DONORS IN SELECTIVELY DOPED GaAs-GaAlAs MULTIPLE QUANTUM WELLS.** High-precision magnetotransmission measurements on shallow donors in selectively doped GaAs-GaAlAs multiple quantum wells are presented. The results are compared to the predictions of a one-impurity theory and show discrepancies which are discussed. The actual doping profile is found to be shifted away from the GaAlAs-GaAs interface with respect to the corresponding intentional location. (Edited author abstract) 12 refs.

Huant, S. (CNRS, Grenoble, Fr); Grynberg, M.; Martine, G.; Etienne, B.; Lambert, B.; Regreny, A. *Solid State Commun* v 65 n 12 Mar 1988 p 1467-1472.

**093883 INFLUENCE OF LASER FLUENCE AND DOPANT GAS PRESSURE ON PROPERTIES OF PHOTOCHEMICAL DOPING OF Si INTO GaAs USING XeCl EXCIMER LASER.** Silicon doping of GaAs has been performed with the combination of pulsed XeCl excimer laser (wavelength: 308 nm) and silane gas ( $\text{SiH}_4$ ). Sheet resistances and depth profiles of the Si-doped GaAs as the functions of laser fluence, the number of laser pulses and gas pressure have been measured in order to make clear the relation between properties of doped GaAs and irradiation conditions. The secondary ion mass spectroscopy (SIMS) has revealed that the depth of Si in GaAs is limited in such a very shallow region (30-110 nm) that might be controlled easily by irradiation conditions. The efficiency for carrier generation of Si in GaAs with laser fluence is discussed. (Author abstract) 10 refs.

Sugioka, K. (Riken, Saitama, Jpn); Toyoda, K. *Appl Phys A* v A45 n 3 Mar 1988 p 189-192.

**093884 FUNDAMENTAL STUDIES AND DEVICE APPLICATION OF  $\delta$ -DOPING IN GaAs LAYERS AND IN  $\text{Al}_x\text{Ga}_{1-x}\text{As}$ /GaAs HETEROSTRUCTURES.** The confinement of donor and acceptor impurities to an atomic plane normal to the crystal growth direction, called  $\delta$ -doping, is important for the fabrication of artificially layered semiconductor structures. The implementation of  $\delta$ -function-like doping profiles by using Si donors and Be acceptors generates V-shaped potential wells in GaAs and  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  with a quasi-two-dimensional (2D) electron (or hole) gas. In this review we consider three areas of fundamental and device aspects associated with  $\delta$ -doping: (i) the prototype structure of  $\delta$ -doping formed by a single atomic plane of Si donors in GaAs; (ii) GaAs sawtooth doping superlattices, consisting of a periodic sequence of alternating n- and p-type  $\delta$ -doping layers equally spaced by undoped regions; and (iii) the confinement of donors (or acceptors) to an atomic (001) plane in selectively doped  $\text{Al}_x\text{Ga}_{1-x}\text{As}$ /GaAs heterostructures. 27 refs.

Ploog, K. (Max-Planck-Inst Fuer Festkoerperforschung, Stuttgart, West Ger); Hauser, M.; Fischer, A. *Appl Phys A* v A45 n 3 Mar 1988 p 233-244.

**093885 MICRODEFECTS IN SULPHUR DOPED GaAs.** Doping GaAs substrate material is one means of reducing dislocation densities. In the present work, transmission electron microscopy (TEM) of substrate surfaces have been examined after etching by the diluted Sirtle etch which is enhanced by the action of light. Horizontal Bridgemen and liquid encapsulated Czochralski grown substrate material were examined. These were heavily doped with sulphur. TEM of the LEC material showed that the majority of the microdefects were decorated interstitial Frank loops. 15 refs.

Pennoek, G.M. (Delft Univ of Technology, Delft, Neth); Schapink, F.W.; Weyher, J.L. *J Mater Sci Lett* v 7 n 4 Apr 1988 p 353-354.

**093886 ERBIUM-DOPED GaAs LIGHT-EMITTING DIODE AT  $1.54 \mu\text{m}$ .** Erbium doped GaAs light-emitting diodes have been fabricated from molecular beam epitaxial GaAs layers. Electroluminescence spectra were recorded at 77 K and at 300 K. Two emission bands were observed at these temperatures: the GaAs band-edge emission centred at around  $0.9 \mu\text{m}$  and the Er related emission centred at  $1.54 \mu\text{m}$ . The variation of the electroluminescence intensities of each emission with current density is presented. (Author abstract). 7 refs.

Rolland, A. (CNET, Lannion, Fr); Le Corre, A.; Favennec, P.N.; Gaumeau, M.; Lambert, B.; Lecroisier, D.; L'Haridon, H.; Moutonnet, D.; Rochoix, C. *Electron Lett* v 24 n 15 Jul 21 1988 p 956-958.

**093887 GROWTH BY MOCVD OF LOW-DOPED P-TYPE GaAs USING A DIMETHYLZINC ADDUCT.** The use of the dimethylzinc-tetramethylethylenediamine ( $\text{Me}_2\text{Zn-TMED}$ ) adduct as a dopant for the growth of GaAs by MOCVD is reported. Using this reagent reproducible p-type doping at low levels, over the range  $10^{15}$  to  $10^{17} \text{ cm}^{-3}$ , can be achieved. The layers have good electrical properties and, despite the source being a solid, no measurable memory effect was detected within the growth apparatus. (Author abstract). 11 refs.

Wright, P.J. (Royal Signals & Radar Establishment, Malvern, Engl); Cockayne, B.; Jones, A.C.; Orrell, E.D. *J Cryst Growth* v 91 n 1-2 Aug 1988 p 63-66.

**093888 SPATIAL DISTRIBUTION OF IMPURITIES IN DELTA-DOPED n-TYPE GaAs.** Capacitance-voltage (CV) profiling measurements on delta-doped n-type GaAs reveal extremely narrow peaks with a full-width at half-maximum of 40 angstrom. Comparison of experimental with self-consistently calculated CV profiles demonstrates that Si impurities are localized on a length scale of a lattice constant in delta-doped GaAs. Diffusion and segregation are of minor importance. The basic theory of CV measurements on quantum-mechanical systems such as delta-doped semiconductors is developed and presented. (Author abstract). 14 refs.

Ullrich, B. (Max-Planck-Inst For Solid State Research, Stuttgart, West Ger); Schubert, E.F.; Stark, J.B.; Cunningham, F.E. *Appl Phys A* v 47 n 2 Oct 1988 p 123-129.

**093889 STUDY ON THE DECREASING GRADIENT DISTRIBUTION OF IMPURITIES IN GaAs EPITAXIAL LAYER.** In this paper the preparation of GaAs by a liquid phase epitaxial process is described. It is necessary that the longitudinal doping profile of the epitaxial layer for a hyperabrupt junction should be in a decreasing gradient form. The decreasing gradient is related to various forms of doping profiles and different values of  $\gamma$  can be obtained from the experimental results. In general,  $\gamma$  varies in the range of 0.6 to 2. Material produced by this method has been used to fabricate a hyperabrupt junction GaAs tuning varactor whose break-



down voltage is  $V_B=25-60V$  and ratio of capacitance variation  $C_{j0}/C_{j0(B)}$  is 10-12. (Edited author abstract). 1 Ref. In Chinese.

Shi, Yi-He (General Research Institute of Non-Ferrous Metals, Beijing, China); Ding, Mo-Yuan; Li, Shuang-Xi. *Xiyou Jinshu* v 7 n 1 Feb 1988 p 75-76.

**093890 SILICON AND INDIUM DOPING OF GaAs: MEASUREMENTS OF THE EFFECT OF DOPING ON MECHANICAL BEHAVIOR AND RELATION WITH DISLOCATION FORMATION.** The effect of indium and silicon doping on dislocation formation in GaAs single crystals has been studied experimentally using dynamic compression tests and indentation rosettes. By direct measurements of the critical resolved shear stress (CRSS) in temperature range from 400 to 1100°C using dynamic compression tests, we found that at the melting point, the critical resolved shear stress of GaAs is twice that of undoped GaAs. More recent measurements show that at high temperatures ( $T \geq 1000^\circ C$ ) the critical resolved shear stress of silicon-doped crystals is lower than that of undoped GaAs. Well-defined indentation rosettes were obtained at high temperatures from a Vickers indenter using small loads. Analysis of such rosettes confirm that the mechanical behavior of the GaAs crystals is not drastically affected by the presence of dopants. Reduction of dislocation densities in doped crystals is attributed to modifications introduced by the dopant in the equilibrium concentration of native defects at the melting point (particularly gallium and arsenic vacancies). (Author abstract) 22 refs.

Bourret, E.D. (Lawrence Berkeley Lab, Berkeley, CA, USA); Tabache, M.G.; Beeman, J.W.; Elliot, A.G.; Scott, M. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 275-281.

**093891 VACANCY COMPLEXES IN Cr-DOPED GaAs.** Cr-doped semi-insulating GaAs has been investigated by means of positron lifetime spectroscopy. In as-grown GaAs the dominant positron trap is a  $Cr_{Ga} \cdot V_{As}$  complex. Upon annealing the concentration of this complex increases around 260°C and then decreases at temperatures higher than 500°C. No vacancy agglomeration took place. In low temperature (130 K)  $e^-$ -irradiated (28 MeV) Cr-GaAs, di- and trivacancies were observed together with the gallium antisite,  $Ga_{As}$ . (Author abstract) 10 refs.

Mascher, P. (Univ of Winnipeg, Winnipeg, Manit, Can); Kerr, D.; Dannafer, S. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 295-299.

**093892 DIFFUSION OF Ge IN GaAs AT  $SiO_2$ -ENCAPSULATED Ge-GaAs INTERFACES.** The diffusion of Ge in semi-insulating GaAs was investigated for annealing temperatures in the range 650-800°C. The samples consisted of electron-beam or metalorganic chemical-vapour deposition deposited Ge-GaAs interfaces encapsulated with  $SiO_2$ . Ge diffusion profiles, measured with secondary-ion mass spectroscopy (SIMS), had a characteristic plateau and steep slope at the diffusion front, similar to those obtained for Si and Sn diffusion at  $SiO_2$ -encapsulated GaAs. A new model that eliminates the necessity for paired-Ge diffusion was introduced. It proposed that dissociation and out-diffusion of GaAs into the  $SiO_2$  produced a nonequilibrium flux of vacancies into the GaAs. Calculated profiles using a position-dependent Ge diffusion coefficient were shown to fit the SIMS data independent of the type of Ge diffusing species, whether single ions or pairs. (Edited author abstract) 13 refs.

Kavanagh, Karen L. (Cornell Univ, Ithaca, NY, USA); Magee, Charles W. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 987-990.

**093893 HIGH DENSITY FEMTOSECOND EXCITATION OF NONTHERMAL CARRIER DISTRIBUTIONS IN INTRINSIC AND MODULATION**

**DOPED GaAs QUANTUM WELLS.** We investigate the dynamics of non-thermal carrier distributions in undoped and modulation doped GaAs quantum well structures (layer thickness  $\approx 100$  Angstrom) with near band-gap-resonant intense femtosecond light pulses. We study selectively the carrier-carrier scattering process up to very high densities and carry out the optical investigation of non-thermal carrier generation in the presence of a thermalized Fermi-sea of electrons. In undoped quantum wells we find a reduction of the thermalization time from about 100 fs to about 30 fs as the photocarrier density increases from  $N_{eh} \approx 2 \times 10^{10} \text{ cm}^{-2}$  to  $\approx 10^{12} \text{ cm}^{-2}$ . The thermalization time is found to be sensitive to background doping with excess electrons in modulation doped samples. (Edited author abstract) 13 refs.

Knox, Wayne H. (AT&T Bell Lab, Holmdel, NJ, USA); Chemla, Daniel S.; Livescu, Gabriela. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 425-430.

**093894 PRESSURE-DEPENDENT STUDIES OF THE DX CENTRE IN Si- AND Sn-DOPED  $n^+$ -GaAs.** Shubnikov-de Haas and persistent photoconductivity measurements are used to study the effect of hydrostatic pressure on the free electron concentration, mobility, and the occupancy of the DX centre in MBE grown  $n^+$ -GaAs heavily doped with either Si or Sn. The results show that the DX centre produces a resonant donor level between the F- and L- conduction band minima at a concentration comparable with the doping level. The position and occupancy of the DX centre are calculated using Fermi-Dirac statistics. For the Si-doped samples comparison with local vibrational mode measurements indicate that the DX level can be identified with  $Si_{Ga}$ . (Author abstract) 20 refs.

Portal, J.C. (CNRS, Grenoble, Fr); Maude, D.K.; Foster, T.J.; Eaves, L.; Dmowski, L.; Nathan, M.; Heiblum, M.; Harris, J.J.; Beall, R.B.; Simmonds, P.E. *Superlattices Microstruct* v 4 n 1 1988, Chicago Conf, Pap, Chicago, IL, USA, 1987 p 33-38.

**093895 DOPAGE DE GaAs A L'ERBIUM EN EPITAXIE PAR JETS MOLECULAIRES.** [Erbium Doping of GaAs During Molecular Beam Epitaxy]. Erbium doping of GaAs,  $Al_{0.24}Ga_{0.76}As$  and quantum wells is achieved by Molecular Beam Epitaxy. Erbium concentrations are measured by SIMS. Observation by an etching technique and STEM have shown the existence of Erbium precipitates above  $10^{18} \text{ at.cm}^{-3}$ . Photoluminescence measurements at 4.5 K show several types of spectra with a maximum peak centered at  $1.54 \mu\text{m}$  or  $1.565 \mu\text{m}$ . At 300 K, the dominant peak is always at  $1.54 \mu\text{m}$  and the authors obtain better resolved spectra than previously published. (Author abstract) 2 refs. In French.

Charasse, M.N. (THOMSON-CSF, Orsay, Fr); Galtier, P.; Lemaire, F.; Hirtz, J.P.; Huber, A.M.; Grattapain, C.; Lagorisse, O.; Chazelas, J.; Vojdani, N.; Weisbuch, C. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composes III - V, Fr, Apr 27-28 1988 p 185-186.

**093896 ETUDE DU DOPAGE RESIDUEL DE GaAs,  $Ga_{1-x}Al_xAs$  ET  $Ga_{0.47}In_{0.53}As$  EPITAXIES PAR EJM-OM.** [Study of Residual Doping of GaAs,  $Ga_{1-x}Al_xAs$ , and  $Ga_{0.47}In_{0.53}As$  by MOMBE]. GaAs,  $Ga_{1-x}Al_xAs$  and  $Ga_{0.47}In_{0.53}As$  layers were grown by metal organic molecular beam epitaxy (MOMBE) using triethyl-III sources for group III elements and a solid arsenic source. The net carrier concentration of the undoped layers was measured by Hall effect, and its dependence on growth temperature  $T_S$ , source V/source III flux ratio R and alloy composition was investigated. Low residual doping level in the range  $10^{15} \text{ cm}^{-3}$  could be achieved in GaAs (p type) using low  $T_S$  and high flux ratio R, and in  $Ga_{0.47}In_{0.53}As$  (n type), using opposite growth conditions. For  $Ga_{1-x}Al_xAs$ , an exponential dependence of the net carrier concentration x was observed. (Author abstract) 2 refs. In French.

Benchimol, J.L. (CNET, Bagneux, Fr); Alexandre, F.; Kobayashi, N.; Alaoui, F. *Vide Couches Minces* v 43 n

241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composes III - V, Fr, Apr 27-28 1988 p 199-200.

**093897 CARACTERISATION PAR CATHODOLUMINESCENCE ET MICROSCOPIE ELECTROACOUSTIQUE DE L'INCORPORATION DES DOPANTS DANS GaAs et  $Ga_{0.28}Al_{0.19}In_{0.53}As$ .** [Characterization by Cathodoluminescence and Electroacoustic Microscopy of Dopant Incorporation in GaAs and  $Ga_{0.28}Al_{0.19}In_{0.53}As$ ]. The evolution of the near band edge and deep level cathodoluminescence emissions and of the electron acoustic signal is used to study the dopant (Be, Si) incorporation as function of growth conditions. For each material, dopant, and growth condition, a threshold doping level can be defined. Above this threshold level, the impurities are incorporated in nonelectrically active sites. All the measurements are used for a better understanding of the incorporation mechanism, especially for high doping levels. (Author abstract) 3 refs. In French.

Papadopoulos, A.C. (CNET, Bagneux, Fr); Bresse, J.F.; Alexandre, F.; Praseuth, J.P. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composes III - V, Fr, Apr 27-28 1988 p 263-264.

## Economics

**093898 GaAs: BUMPY ROAD.** Gallium arsenide facilities investments have been made by numerous firms. Some within the industry have noted that the entire foreseeable market for GaAs devices and circuits could well be supplied by one or two firms, leaving the large remainder representing so much overcapacity. The fact that most of these facilities willingly accept outside work reinforces this conclusion. This article provides a perspective gained from a sampling of GaAs firms and users, a description of the business from their viewpoints. 7 refs.

White, Joseph F. (Microwave Journal, Norwood, MA, USA). *Microwave J* v 31 n 4 Apr 1988 6p between p 42 and 50.

## Electric Conductivity

**093899 WEAK LOCALIZATION AND INTERACTION CORRECTIONS IN MICROSTRIPS OF GaAs.** In this letter we present magnetoresistance measurements obtained on microstrips of  $n^+$  GaAs. We observe a recently predicted electron scattering mechanism and directly measure the damaged layer caused by ionic etching. (Author abstract) 10 refs.

Mailly, D. (CNRS, Bagneux, Fr). *Europhys Lett* v 4 n 10 Nov 15 1987 p 1171-1176.

**093900 RESISTIVITY AND HALL-EFFECT TOPOGRAPHY ON PHOTOEXCITED SEMI-INSULATING GaAs.** A new non-destructive method is presented for obtaining true resistivity ( $\rho$ ), mobility ( $\mu$ ), and electron concentration ( $n$ ) topography on photoexcited, semi-insulating GaAs. The method is based on the use of two perpendicular light slits, which join four removable in contacts on the periphery of the wafer to form a classical Greek-cross configuration. By placing contacts all around the periphery the whole wafer can be mapped. We give results for  $1.1 \mu\text{m}$  photoexcitation on a 3 in. low-pressure, liquid-encapsulated Czochralski wafer and compare with EL2 results on the same wafer. A by-product of the analysis is the determination of electron lifetime. Finally, the possibility of nondestructive dark electrical topography is discussed. (Author abstract) 22 refs.

Pimentel, E. (Avionics Lab AADR, Wright-Patterson AFB, OH, USA); Look, D.C. *J Electron Mater* v 17 n 1 Jan 1988 p 63-66.



**093901 FREQUENCY DEPENDENCE OF THE DIAGONAL CONDUCTIVITY OF A 2DEG IN GaAs HETEROSTRUCTURE IN THE QUANTUM HALL REGIME.** We have measured directly the diagonal conductivity of a 2DEG in GaAs/AlGaAs heterostructure via a capacitively coupled structure with dc bias at magnetic fields up to 6 tesla. From the ungated region of a sample of Corbino geometry, the diagonal conductivity at the Landau gap regions was measured via capacitive coupling to a non-quantized 2DEG in the source and drain capacitors. A strong frequency dependence was observed over a range of frequencies from 100 Hz to 20 kHz at the temperature of 1.3 K. The result is compared to the calculations from the percolation theory. From the measurements of two different temperatures, 1.3 and 4.2 K, the activation energy for the conductivity was estimated to be about 10% of Landau level spacing. (Author abstract) 10 refs.

Lee, J.I. (Brown Univ, Providence, RI, USA); Goldberg, B.B.; Heiblum, M.; Stiles, P.J. *Solid State Commun* v 64 n 4 Oct 1987 p 447-450.

**Electric Field Effects** See Also TRANSISTORS, FIELD EFFECT—Mathematical Models.

**093902 ELECTRIC FIELD EFFECTS ON INTERSUBBAND TRANSITIONS IN QUANTUM WELL STRUCTURES.** We report on a Raman scattering study of the electric-field dependence of  $c_0 \rightarrow c_1$  intersubband transitions of photoexcited electrons in a 264 Å GaAs-Al<sub>0.3</sub>Ga<sub>0.7</sub>As quantum-well structure. The measured Stark shifts are in very good agreement with theoretical predictions. The intensity of the intersubband peak increases rapidly with applied field due to parity-mixing. In contrast to the enhanced broadening shown by exciton resonances, the width of  $c_0 \rightarrow c_1$  is nearly independent of the field. This feature is attributed to effects of structural disorder. (Author abstract) 23 refs.

Bajema, K. (Univ of Michigan, Ann Arbor, MI, USA); Merlin, R.; Juang, F.Y.; Hong, S.C.; Singh, J.; Bhattacharya, P.K. *Superlattices Microstruct* v 3 n 6 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 685-687.

**093903 QUANTITATIVE CHARACTERIZATION OF CHAOTIC CURRENT OSCILLATIONS IN GaAs:Cr.** Chaotic self-generated current oscillations are investigated in semi-insulating GaAs:Cr at electric fields  $\geq 3$  kV/cm. The evolution of the phase space dimension  $m_0$ , related to the fractal dimension of the strange attractor  $d: m_0 = \text{int}(d) + 1$ , is determined by means of a special electronic instrument. A physical model is proposed which includes spatial nonuniformity of the hot electron plasma. (Author abstract) 8 refs.

Pozela, J. (Acad Sci Lithuanian SSR, Vilnius, USSR); Tamasevicius, A.; Ulbikas, J. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 805-808.

**Electric Properties** See Also SEMICONDUCTOR MATERIALS—Radiation Damage.

**093904 ELECTRICAL PROPERTIES OF Ga/nGaAs(110) INTERFACES.** The electrical properties of moderately doped Ga/nGaAs(110) Schottky diodes, fabricated on both the clean cleaved and on the cleaved and air exposed GaAs(110) surface, have been studied. The current-voltage characteristic of both interfaces have an extremely large electron-hole recombination current. It is argued that this is produced by a disordered GaAs interfacial layer. Additionally, the capacitance-voltage characteristics of Ga/nGaAs(110) diodes, fabricated on the clean cleaved surface, are non-ideal and they preclude conventional analysis. The aging behavior of these interfaces has also been studied in detail. The electrical characteristics and the changes in the electrical characteristics with time are discussed in terms of the available microscopic theories of Schottky barrier formation. (Author abstract) 35 refs.

McLean, A.B. (Univ Coll Cardiff, Cardiff, Wales); Williams, R.H. *Semicond Sci Technol* v 2 n 10 Oct 1987 p 654-660.

**093905 GROWTH OF HIGH PURITY GaAs AND Al<sub>x</sub>Ga<sub>1-x</sub>As FROM ADDUCT-PURIFIED METAL-ORGANICS.** By the use of direct injection inductively coupled plasma (ICP) emission spectroscopy we have identified silicon and zinc as volatile impurities in non-purified trimethylgallium (TMGa). The effect of these impurities on the electrical properties of GaAs layers is discussed. We have been able to remove these impurities to non-detectable levels using adduct purification techniques. The use of adduct-purified TMGa enabled us to grow GaAs layers with  $n_{77} K = 1.4 \times 10^{14} \text{ cm}^{-3}$  and  $\mu_{77} K = 137,000 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ . Low temperature photoluminescence (PL) data is presented for these high purity layers. Adduct purification also proved effective in greatly lowering silicon contamination in TMAI. Al<sub>x</sub>Ga<sub>1-x</sub>As and Al<sub>x</sub>Ga<sub>1-x</sub>As 2DEG structures grown with purified TMAI exhibited significantly improved electrical characteristics. (Author abstract) 17 refs.

Jones, A.C. (Epichem Ltd, Wirral, Engl); Wales, G.; Wright, P.J.; Oliver, P.E. *Chemtronics* v 2 n 2 Jun 1987 p 83-88.

**093906 TRANSIENT THERMOELECTRIC EFFECTS IN GaAs CRYSTALS.** Dynamic measurements of thermal diffusion processes of conduction carriers and phonons in GaAs crystals have been made in the temperature range 80-300 K using a pulsed laser-induced 'transient thermoelectric (TTE)' effect. The initial stage of the decay curves of TE voltages gives the carrier recombination times  $\tau_r$ , from which capture cross sections for electrons and holes are evaluated. During the second stage, three relaxation processes with relaxation times  $\tau_1$ ,  $\tau_m$ , and  $\tau_2$  were observed in both n- and pGaAs; the fast, intermediate, and slow components are associated with electrons at the  $\Gamma$ , X, and L point conduction bands for n-GaAs, and the light, split-off band, and heavy holes for p-GaAs, respectively. The final stage yields the thermal diffusion coefficient  $D_T$  and the thermal conductivity  $k$  for phonons in these crystals. (Author abstract) 16 refs.

Sasaki, Minoru (Hiroshima Univ, Hiroshima, Jpn); Horisaka, Shuu; Inoue, Masasi. *Jpn J Appl Phys Part 1* v 26 n 10 Oct 1987 p 1704-1708.

**093907 METHOD OF MEASURING THE INHOMOGENEITIES OF THE ELECTROPHYSICAL PROPERTIES OF SEMIINSULATING GALLIUM ARSENIDE.** In connection with the extension of the domain of application of semiinsulating GaAs, a requirement to control the homogeneity of this material appeared in addition to the usual demands on its integral parameters. There are reports in the literature about the utilization of an optical method based on light absorption by deep centers and the method of resistance to spreading with bias lighting for this purpose. Because the distribution of deep centers does not determine uniquely the homogeneity of the electrophysical properties of semiinsulating GaAs, the possibilities of the second method of measuring the inhomogeneity was investigated in this paper. A description of the installation of this method and sufficiently contradictory data about the substance of the parameters being measured, the specific resistivity, and the photoconductivity signal, are contained in the literature. 8 refs.

Yurova, E.S. (State Scientific-Research & Design Inst of the Rare Metal Industry, Moscow, USSR); Kartavykh, A.V. v 53 n 5 May 1987 p 402-406.

**093908 ELECTRICAL CHARACTERIZATION OF A SUPERLATTICE.** Capacitance-voltage measurements have been performed on a periodic 20-20 Å GaAs-GaAlAs (30%Al), n-type ( $3 \times 10^{16} \text{ cm}^{-3}$ ) doped, 1.7  $\mu\text{m}$  thick structure. They show that the material is homogeneous in the growth direction. Deep traps produced by electron irradiation and detected by Deep Level Transient Spectroscopy, whose energy levels are well-known in bulk GaAs and GaAlAs, are found to emit electrons in a superlattice miniband, common to both materials, situated at 0.140 eV  $\pm$  0.02 eV above the conduction band edge of GaAs and at 0.130 eV below the conduction band edge of GaAlAs, providing a band offset of 0.27 eV. (Author abstract) 12 refs.

Bourgoin, J.C. (Univ of Paris VII, Paris, Fr); Mauger, A.; Stevenard, D.; Deveaud, B.; Regreny, A. *Solid State Commun* v 62 n 11 Jun 1987 p 757-759.

**093909 ELECTRICAL AND OPTICAL PROPERTIES OF HEAVILY DOPED Mg- AND Te-GaAs GROWN BY LIQUID-PHASE EPITAXY.** GaAs epitaxial layers doped with Mg and Te were grown on (100) GaAs substrates by liquid-phase epitaxy with a 6°C supersaturation temperature. Room-temperature carrier concentrations up to  $2 \times 10^{19} \text{ cm}^{-3}$  for p-type and  $2.6 \times 10^{19} \text{ cm}^{-3}$  for n-type dopants were obtained reproducibly. Carrier mobilities at 77 K in both n- and p-type layers showed a sharp drop at concentrations higher than  $2 \times 10^{19} \text{ cm}^{-3}$ . The full width at half maximum value and the relative intensity of the photoluminescent spectrum increased and decreased, respectively, with carrier concentration for both Mg- and Te-doped layers, and showed abrupt slope variations near a carrier concentration of  $1 \times 10^{19} \text{ cm}^{-3}$ . In Mg-doped GaAs layers, the peak wavelength of photoluminescence spectra increased with hole concentration due to band-gap shrinkage. On the other hand, the photoluminescence peak wavelength decreased with electron concentration due to a Burstein-Moss shift and to band-tailing effects in the Te-doped GaAs layers. (Author abstract) 14 refs.

Wu, M.C. (Nat'l Cheng-Kung Univ, Tainan, Taiwan); Su, Y.K.; Cheng, K.Y.; Chang, C.Y. *Solid State Electron* v 31 n 2 Feb 1988 p 251-256.

**093910 COMPENSATION MECHANISM OF UNDOPE SEMI-INSULATING GaAs.** Carbon concentrations ( $C_{AS}$ ) of eight various undoped Si-GaAs samples are measured using the method of infrared local vibrational mode (LVM). It is found that all of the obtained ( $C_{AC}$ ) are less than  $5.20 \times 10^{14} \text{ cm}^{-3}$ . Net acceptor concentrations  $N_A - N_D$  could be deduced from the measured results of 1.1  $\mu\text{m}$  infrared absorption and Hall effect at 400K. It turns out that the  $N_A - N_D$  values of all samples are always larger than ( $C_{AS}$ ). There is an order of magnitude difference for those samples cut from the lower part of ingots. Therefore, the acceptors in those samples must arise from other impurities than carbon, in which boron ( $B_{AS}$ ) may be the main impurity. (Author abstract) 8 refs. In Chinese.

Zhou, Binglin (Acad Sinica, China); Wu, Zheng; Chen, Zhengxiu; Hu, Binghua. *Hongwai Yanjiu A-Ji* v 7A n 2 1988 p 149-152.

**093911 SOME PROPERTIES OF MIS STRUCTURES PREPARED BY PLASMA OXIDATION OF Al LAYERS ON GaAs.** Metal-oxide-semiconductor structures were fabricated on an n-type GaAs substrate at room temperature by plasma anodic oxidation of aluminum films evaporated on the GaAs substrate. Current and charge transient spectroscopies and low frequency C-U measurements were applied to the MOS capacitors. The optimum processing condition for the minimum interface-state-density is related to the properties of the Al film. Three apparent activation energies of the dominant DLTS peak ( $E_c - 0.5 \text{ eV}$ ,  $E_c - 0.67 \text{ eV}$ ,  $E_c - 0.72 \text{ eV}$ ) for three concentrations of donors ( $10^{24}$ ,  $2.7 \times 10^{23}$ , and  $1.4 \times 10^{22} \text{ m}^{-3}$ ) were determined. The differences in the values of the energies can be estimated as a consequence of the Poole-Frenkel effect with an extrapolated value of the true energy  $E_c - 0.75 \text{ eV}$ . From this point of view the observed DLTS peaks are attributed to the out migration of Ga atoms through the oxide layer and forming of a high resistivity O-compensated layer between the oxide and the semiconductor. (Edited author abstract). 21 refs.

Pincik, E. (Slovak Acad of Sciences, Bratislava, Czech); Matatko, B.; Bartos, J.; Thurzo, I.; Grendel, M.; Nadzdy, V.; Zuberikova, M.; Morvic, M. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 659-667.

**093912 ELECTRON CONDUCTION IN AN ATOMIC-LAYER-DOPED GaAs PLANE.** Electronic transport characteristics in Si atomic-layer-doped GaAs are investigated using Hall measurements. In the uni-



formly Si-doped GaAs crystals, the carrier concentration varies very little throughout the whole temperature range, while the atomic-layer-doped GaAs layer exhibits a strong temperature-dependent electron concentration with a minimum value around 100 K. The temperature dependence of the sheet resistance of the Si atomic-layer-doped GaAs is quite different from that of the uniformly Si-doped GaAs. The observed characteristics are interpreted by considering parallel conduction in the Si atomic-layer-doped GaAs. We propose a hypothetical model that the electrons are confined by a local potential well structure due to the random distribution of Si atoms in the atomic-layer-doped plane. Using this model, we also discuss the discrepancy reported so far between the doped layer thickness evaluated from magnetoresistance measurements and that from C-V profiling measurements. (Author abstract) 9 refs.

Makimoto, Toshiaki (NTT, Jpn); Kobayashi, Naoki; Horikoshi, Yoshiji. *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 770-772.

**093913 PHOTONIC SWITCHING BY TUNNELING-ASSISTED ABSORPTION MODULATION IN A GaAs SAWTOOTH STRUCTURE.** We report on an electrically controlled optical modulator using a novel GaAs sawtooth structure. This structure consists of alternating n-type and p-type delta-doped GaAs. Modulation of tunnelling-assisted absorption is achieved by changing the internal electric field which in turn is controlled by external bias. Modulation of light intensity is demonstrated over a broad spectral range of  $\Delta\lambda > 100$  nm. A contrast ratio of 1:1.7 of the opaque and transparent states is obtained. Low-voltage operation ( $\Delta V > 5$  V) and potential high-speed capability make the new device an attractive candidate for future photonic switching systems. (Author abstract) 5 refs.

Schubert, E.F. (AT&T Bell Lab, Murray Hill, NJ, USA); Cunningham, J.E. *Electron Lett* v 24 n 15 Jul 21 1988 p 980-982.

**Electrodes** See ELECTROCHEMISTRY.

**Electronic Properties**

**093914 STUDY OF THE CONDUCTION BAND NON-PARABOLICITY, ANISOTROPY AND SPIN SPLITTING IN GaAs AND InP.** The conduction bands in GaAs and InP have been studied very accurately through the cyclotron resonance over a wide range of energies using the photoconductive detection technique. Pronounced band non-parabolicity has been measured in GaAs and InP and the band anisotropy has been measured in GaAs. Values for the band-edge masses of  $0.660 m_0$  respectively have been determined. A five-level K-p model of the band structure in the presence of a magnetic field has been used to describe the data where resonant and non-resonant polaron contributions to electron energies are included in the theory. The non-parabolicity and spin-doublet splitting of the cyclotron resonance are well described by the employed formalism in both materials and the theory also gives a reasonable account of the anisotropy of the band in GaAs. The fit to experimental data allowed us to determine the matrix element of momentum Q between the higher conduction and valence bands in both materials. (Edited author abstract) 44 refs.

Hopkins, M.A. (Clarendon Lab, Oxford, Engl); Nicholas, R.J.; Pfeffer, P.; Zawadzki, W.; Gauthier, D.; Portal, J.C.; DiForte-Poisson, M.A. *Semicond Sci Technol* v 2 n 9 Sep 1987 p 568-577.

**093915 RESONANCE EFFECT IN INTER-SUB-BAND TRANSITIONS OF SINGLE QUANTUM WELLS.** Inter-sub-band transitions between electronic states of a single quantum well are considered. In such a double heterostructure a longitudinal polar optical mode emitted or absorbed in any transition can belong to one of a finite number of distinct branches. The transition rate is calculated here using fully quantum mechanical methods and its variation with the width of the well is explored. It is found that besides the familiar increase with

increasing width of the well, the rate exhibits periodic peaks. These constitute a resonance effect which arises whenever the conditions of incorporating a new polar branch are satisfied. Illustrations are given specifically for GaAs/Ga<sub>0.7</sub>Al<sub>0.3</sub>As single quantum wells. 13 refs.

Babiker, M. (Univ of Essex, Colchester, Engl); Chamberlain, M.P.; Ridley, B.K. *Semicond Sci Technol* v 2 n 9 Sep 1987 p 582-586.

**093916 OBSERVATION OF THE FERMI EDGE ANOMALY IN THE ABSORPTION AND LUMINESCENCE SPECTRA OF n-TYPE MODULATION-DOPED GaAs-AlGaAs QUANTUM WELLS.** A well defined sharp peak was observed in the absorption and luminescence spectra near the absorption edge of n-type modulation-doped GaAs-Al<sub>x</sub>Ga<sub>1-x</sub>As multiple quantum wells. The peak is assigned as the Fermi edge anomaly similar to the many-body effects in the soft x-ray spectra of metals. As the temperature was raised above 10 K, the peak disappeared, but it was restored by the application of magnetic field. The magnetic field dependence of the peak indicates that it has an excitonic character. (Author abstract) 20 refs.

Lee, J.S. (Univ of Tokyo, Tokyo, Jpn); Iwasa, Y.; Miura, N. *Semicond Sci Technol* v 2 n 10 Oct 1987 p 675-678.

**093917 ELECTROPHYSICAL PROPERTIES OF NONRECTIFYING CONTACTS TO n-GALLIUM ARSENIDE BASED ON Ni-Sn.** At present there are available a large number of studies on the relationship between thermal processing conditions and the electro-physical properties of nonrectifying contacts to GaAs based on eutectics of the noble metals with group IV elements. Study of the transition layer on an (Au-Ge)/Ni-n-GaAs nonrectifying contact reveals that the boundary between the contact material and the GaAs is inhomogeneous and consists of NiAs, NiGe, Ni<sub>3</sub>GeAs, and AuGeAs phases, in the compositions of which dopant elements may also appear. The processes of physicochemical interaction of transition metal alloys with gallium arsenide during formation of physicochemical interaction of transition metal alloys with gallium arsenide during formation of the nonrectifying contact are significantly less well studied. The goal of the present study is an experimental and theoretical investigation of nonrectifying contacts to n-GaAs, formed from Ni-Sn alloys. 13 refs.

Nikolaev, I.V. (Moscow Electronic Technology Inst, USSR); Yaremchuk, A.F.; Mochalov, A.I.; Chistyakov, Yu.D. *Sov Microelectron* v 16 n 2 Mar-Apr 1987 p 98-101.

**093918 ACCEPTORLIKE ELECTRON TRAP IN GaAs RELATED TO NI.** We have investigated an emission level at  $E_c - 0.40$  eV in GaAs by DLTS. The photo cross section  $\sigma_{ph}$  reveals a resonance due to an excited state of the involved impurity center. Tentatively we identify the level as related to 3d<sup>9</sup> configuration of the isolated Ni<sub>Ga</sub> impurity. Two deep levels in the lower half of the band gap observed by ODLTS are discussed as possible candidates for the single acceptor level of Ni<sub>Ga</sub>. As an alternative model a Ni-related complex is discussed. (Author abstract) 22 refs.

Brehme, S. (Karl Marx Univ Leipzig, Leipzig, East Ger); Pickenhain, R. *Solid State Commun* v 59 n 7 Aug 1986 p 469-471.

**093919 MOMENTUM MIXING ENHANCEMENT OF BAND NON-PARABOLICITY IN GaAs-Ga<sub>1-x</sub>Al<sub>x</sub>As SUPERLATTICES.** We present pseudopotential calculations of the conduction and valence mini-band non-parabolicity in GaAs-Ga<sub>1-x</sub>Al<sub>x</sub>As superlattices of period approximately 80 Angstrom with various well widths. We find an order of magnitude difference between the non-parabolicity in structures with very narrow approximately 5 Angstrom and wider approximately 40 Angstrom wells. We relate this effect to the competition between quantum-size effects and zone-folding enhanced momentum mixing involving higher levels of X character. We show that the variation of the non-parabolicity of the electron energy with respect to its wavevector across the

small Brillouin zone takes on a complicated form which arises due to the anti-crossing behaviour of the higher conduction and lower valence mini-band states. Our results show that non-linear properties of semiconductor superlattices are a sensitive function of the form and position of the higher lying mini-bands which are normally ignored in simple models. (Author abstract) 5 refs.

Brown, L.D.L. (Newcastle-upon-Tyne Univ, Newcastle-upon-Tyne, Engl); Jaros, M. *Semicond Sci Technol* v 3 n Jan 1988 p 40-47.

**093920 ENERGY LOSS RATE OF ELECTRONS IN QUANTUM WELLS.** The Energy Loss Rate (ELR) of electrons in quantum wells, due to polar interaction with bulk longitudinal optical (LO) phonons is calculated, including the effect of dynamical screening of the electron-LO phonon interaction. The effect of a nonequilibrium distribution of LO phonons ('hot phonons') is included via a relaxation time approximation, keeping the relaxation time as a parameter. Numerical results are given for GaAs quantum wells, for the range of parameters (quantum well size, electron temperature, electron density) relevant to recent experimental determinations. The dynamical screening, which is a natural consequence of the energy-balance equations used, is shown to be relevant to the electron density dependence. (Edited author abstract) 14 refs.

Senna, J.R. (Inst de Pesquisas Espaciais-INPE, Sao Jose dos Campos, Braz); Sarma, S. Das. *Solid State Commun* v 64 n 11 Dec 1987 p 1397-1403.

**093921 QUANTUM LIMIT CYCLOTRON RESONANCE IN p-GaAs.** Electron scattering by neutral acceptors has been studied through far infrared ( $\lambda = 172 \mu\text{m}$ ) cyclotron resonance on p-GaAs at 4.2 K. It is found that (1) The inverse relaxation time is considerably smaller in the quantum limit than that predicted by dc transport theory in the absence of a magnetic field. (2) The same increases linearly with neutral acceptor concentration. (3) The electron momentum transfer cross section by neutral acceptor is by more than an order of magnitude smaller than that by neutral donor even in the quantum limit. (Author abstract) 17 refs.

Kobori, H. (Osaka Univ, Toyonaka, Jpn); Ohya, T.; Otsuka, E. *Solid State Commun* v 63 n 2 Jul 1987 p 123-126.

**093922 THEORETICAL ANALYSIS OF THE SURFACE-POLAR OPTICAL PHONON LIMITED DISTRIBUTION FUNCTION OF HOT ELECTRONS IN GaAs-QUANTUM WELLS.** The steady state nonequilibrium distribution function of quasi two-dimensional (2D) electrons confined to move in a square n-GaAs quantum well is determined from the Boltzmann integral-equation, which is solved iteratively for the interaction of the charge carriers with polar optical phonons taking into account electron-electron collisions. The carrier concentration, field and temperature dependence of the distribution function is investigated systematically for the first time. (Edited author abstract) 24 refs.

Kiener, C. (Univ of Innsbruck, Innsbruck, Austria); Zandler, G.; Vass, E. *Solid State Commun* v 65 n 10 Mar 1988 p 1241-1246.

**093923 STRUCTURED ULTRAFAST MOBILITY IN HIGHLY PHOTOEXCITED SEMICONDUCTORS.** We study the dependence of the mobility of the hot carriers of highly photoexcited plasmas in semiconductors on the irreversible evolution of their macroscopic state. We show that there are three different regimes of behavior of the ultrafast mobility transient: (i) structure (i.e. existence of maxima and minima) without overshoot at low fields, (ii) structure with overshoot at intermediate fields, (iii) normal evolution at intermediate to high fields. We name regimes (i) and (ii) hot carriers structured ultrafast mobility transients, and a criterion for their



occurrence is given. We present results of numerical calculations appropriate for electron transport in the central valley of GaAs. (Author abstract) 12 refs.

Freire, V.N. (Univ Estadual de Campinas, Campinas, Brazil); Vasconcellos, A.R.; Luzzi, R. *Solid State Commun* v 66 n 7 May 1988 p 683-687.

**093924 EFFECTS OF SHORT-RANGE AND LONG-RANGE ORDER ON THE ENERGY GAPS OF (GaAs)<sub>1-x</sub>Ge<sub>2x</sub> AND (GaSb)<sub>1-x</sub>Ge<sub>2x</sub>.** The effects of both short-range and long-range order on the energy gap of (GaX)<sub>1-x</sub>Ge<sub>2x</sub>, X = As or Sb, have been calculated by applying the Haydock recursion method to a variety of structural models for these materials. We find that realistic models for <100>-grown and <111>-grown alloys with different long-range order, but the same short-range order, have almost identical composition dependences of the energy gap. In contrast, hypothetical alloy structures with the same long-range order, but different short-range order, exhibit marked differences in energy gap. (Author abstract) 16 refs.

Davis, L.C. (Ford Motor Co, Dearborn, MI, USA); Holloway, H. *Solid State Commun* v 64 n 1 Oct 1987 p 121-124.

**093925 INDIRECT GAP RESONANT TUNNELING IN GaAs/AlAs.** A full band structure calculation of resonant tunnelling through AlAs barriers using a nearest neighbour tight binding method has been compared with experiment. We report good agreement of our calculation with measurements both qualitatively and quantitatively. The peak resonant current densities agree to within 20%, without the parameter adjustments used in other studies. The major contribution to the tunnelling current is found to result from X-like states in the AlAs barriers. This is the first rigorous theoretical confirmation of the conclusions arrived at from a number of other experimental studies. (Author abstract) 16 refs.

Cade, N.A. (GEC Research Ltd, Wembley Middlesex, Engl); Parmar, S.H.; Couch, N.R.; Kelly, M.J. *Solid State Commun* v 64 n 3 Oct 1987 p 283-286.

**093926 HIGH-FIELD ELECTRON TRANSPORT IN GaAs AND Ga(0.47)In(0.53)As RECTANGULAR QUANTUM WELLS.** Lattice-scattering limited velocity-field characteristics of GaAs and Ga(0.47)In(0.53)As quantum wells are computed by the Monte Carlo method. The velocity approaches a saturation value at 77 K for a field of about 0.2 kV/cm, while at 300 K it increases with the field as E<sup>0.5</sup>, with n around 0.8 to 0.9. Velocity run-away is produced for parabolic bands when the velocity is about (2 to 2.5) × 10<sup>7</sup> cm/s in GaAs and (3.3 to 3.8) × 10<sup>7</sup> cm/s in Ga(0.47)In(0.53)As. The run-away disappears when the effects of band non-parabolicity and inter-subband scattering are included. The velocity in GaInAs is larger by a factor of about 1.1 to 1.8. (Author abstract). 14 refs.

Bose, D. (Calcutta Univ, Calcutta, India); Nag, B.R. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 569-575.

**093927 EFFECTS OF SO AND LO PHONON ON THE BINDING ENERGY OF THE EXCITON IN GaAs-Ga<sub>1-x</sub>Al<sub>x</sub>As QUANTUM WELL.** A calculation is given for the binding energy of the light and heavy exciton in GaAs-Ga<sub>1-x</sub>Al<sub>x</sub>As quantum well, in which the interaction of the exciton with surface optical (SO) and bulk (LO) phonon taken into consideration. (Author abstract) 4 refs.

Pan, Jinsheng (Acad Sinica, Changchun, China); Ruan, Hangyu. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 725-726.

**093928 EFFECT OF ELECTRON-PHONON INTERACTION ON THE HYDROGEN IMPURITY BINDING ENERGY IN A QUANTUM WELL.** In this paper, taking account of both the interaction H<sub>e</sub>-LO and the interaction H<sub>e</sub>-SO, we use the method used by Huybrechts in the study of a bound polaron in three dimensional crystals. And we assume the walls of the quantum well to be infinitely high and choose the

variational wave function in the study of the states of shallow donor in a quantum well. We calculate the polaron effect on the quantum well donor binding energy as a function of the width of the quantum well and as a function of the donor position. 5 refs.

Shen, Mengyan (Neimenggu Univ, Huhehaote, China); Gu, Shiwei. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 735-736.

**093929 DEEP ELECTRON TRAPS AND THEIR CHANGES DURING DEGRADATION IN GaAs<sub>0.6</sub>P<sub>0.4</sub> LEDs.** In this paper we present further data on the deep electron traps in GaAs<sub>0.6</sub>P<sub>0.4</sub> LEDs. At the same time, the changes in deep levels during forward bias degradation are also presented. Standard GaAs<sub>0.6</sub>P<sub>0.4</sub> LEDs fabricated by Zn diffusion into grown n-type material have been used in present experiments. Samples were encapsulated with the epoxy. 3 refs.

Huang, Bo (South China Normal Univ, Guangzhou, China); Yuan, Qing. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 810-811.

**093930 ENSEMBLE MONTE CARLO SIMULATIONS OF FEMTOSECOND ENERGY RELAXATION OF PHOTOEXCITED ELECTRONS IN BULK GaAs.** We present results of ensemble Monte Carlo simulations of the femtosecond relaxation of photoexcited electrons in bulk GaAs. Our results are in qualitative agreement with experimental data of Rosker, Wise and Tang (1986) and show that the fast relaxation component (approximately 34 fs) is primarily due to Γ → L scattering with a minor contribution from electron-electron scattering. The intermediate relaxation component (approximately 160 fs) is a result of the energy loss of electrons in the Γ valley which occurs chiefly by polar optical phonon (POP) scattering. (Author abstract) 11 refs.

Bailey, D.W. (Univ of Illinois, Urbana, IL, USA); Stanton, C.J.; Artaki, M.A.; Hess, K.; Wise, F.W.; Tang, C.L. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 467-470.

**093931 USE OF LINEARLY GRADED COMPOSITION AlGaAs INJECTORS FOR INTERVALLEY TRANSFER IN GaAs: THEORY AND EXPERIMENT.** The use of semiconductor multilayers for hot electron injection and intervalley transfer have recently been demonstrated. In this study graded composition AlGaAs layers are used to generate a non-equilibrium distribution of electrons, in order to spatially control the transfer of electrons from the Γ to L valleys. The consequent growth of charge and field instabilities has been investigated both experimentally and by Monte-Carlo simulation. Emphasis has been placed on the exploitation of these hot electrons in transferred electron devices. Gunn diodes consisting of such graded gap layers, and transit regions of 1 μm have been fabricated by molecular beam epitaxy. They have been observed to oscillate at a frequency of GHz. Experimental results on these structures, together with their Monte-Carlo simulations, are discussed. (Edited author abstract)

Couch, N.R. (GEC, Wembley, Engl); Beton, P.H.; Kelly, M.J.; Kerr, T.M.; Knight, D.J.; Ondria, J. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 613-616.

## Etching

**093932 EFFECT OF DOPANTS CONCENTRATION ON RESOLUTION AND RATE OF LIGHT INDUCED ETCHING - PART II. APPLICATION TO n-GaAs.** This paper describes the model of light-induced etching (LIE, photoetching) including the space-charge region derived in Part I as applied to n-GaAs. Materials with high donor concentrations (from 10<sup>17</sup> to 10<sup>18</sup> cm<sup>-3</sup>) are shown to have the highest photoetching resolution. The model explains the decrease of etching rate with increased doping level in case of uniform illumination. Comparison with earlier published experiments on n-GaAs leads to a qualitative agreement. (Edited author abstract) 11 refs.

Marsik, Jaroslav (Tesla Electronics Research Inst, Prague, Czech). *Tesla Electron* v 18 n 4 1985 p 107-112.

**093933 IN SITU ELECTRICAL AND OPTICAL MEASUREMENTS ON GaAs EPITAXIAL LAYERS DURING CHEMICAL ETCHING.** For the detailed characterization of epitaxial GaAs a chemical method has been devised. This method combines carrier concentration vs depth profile measurements with in-depth photocapacitance spectroscopy regarding the deep levels involved in a sample. This method was constructed on the following base: (1) Uniform chemical-etching by suitable etchants selected in the H<sub>2</sub>SO<sub>4</sub>-H<sub>2</sub>O<sub>2</sub>-H<sub>2</sub>O system and (2) In situ capacitance and photocapacitance measurements on the etchant as well as the other electrolyte Schottky contact. In applying the method there is almost no restriction on the magnitude of both the carrier concentration and the sample-thickness. It can, therefore, be applied to various samples, including their interface regions. Here, details of the method and typical results are presented. (Author abstract) 30 refs.

Yamashita, Akiyasu (NTT, Musashino, Jpn). *Jpn J Appl Phys Part 1* v 26 n 8 Aug 1987 p 1328-1333.

**093934 STUDY OF GaAs ETCHING IN ALKALINE H<sub>2</sub>O<sub>2</sub> SOLUTIONS.** We studied the etching kinetics of GaAs in alkaline H<sub>2</sub>O<sub>2</sub> solutions. The influence of the solution composition and of complexing agents on etching and oxide formation was investigated. Current-potential measurements with a micro-electrochemical flow cell allowed us to distinguish between chemical and electrochemical etching modes. From these results, suggestions are made concerning the dissolution mechanism. The results are compared with those found for acidic H<sub>2</sub>O<sub>2</sub> systems. 24 refs.

Kelly, J.J. (Philips Research Lab, Eindhoven, Neth); Reynders, A.C. *Appl Surf Sci* (1985) v 29 n 2 Oct 1 1987 p 149-164.

**093935 CORRELATION OF THE ETCHING MORPHOLOGY WITH THE MAIN MIDGAP DONOR DISTRIBUTION IN UNDOPED, SEMI-INSULATING GaAs.** The authors report on the use of a modified AB etch to delineate electrically inhomogeneous regions in undoped material. The features exposed by this etch have been correlated with the spatial distribution of the main deep donor (normally known as EL2) in Si GaAs. Based on the results presented, we conclude that the etch rate of an AB etch with reduced HF content is extremely sensitive to the local electronic properties of the substrate. The etch rate is, in fact, so dependent on the local EL2 content that this etchant actually produces an 'etch map' of the EL2 distribution in Si GaAs wafers. Our results are fully consistent with the recent correlation between the etch rate of standard AB etchant and the position of the Fermi level. 13 refs.

Dobrilla, P. (Litton Systems, Morris Plains, NJ, USA); Miller, D.C. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3197-3199.

**093936 TEMPERATURE DEPENDENCE OF THE ETCH RATES OF GaAs, AlGaAs, InP, AND MASKING MATERIALS IN A BORON TRICHLORIDE-CHLORINE PLASMA.** The pressure, temperature, and power effects are examined independently of each other for GaAs, AlGaAs, and InP in a boron trichloride:chlorine plasma. Conditions are examined for which chemical etching and for which sputter-assisted etching occur. The variations of etch rate with change in temperature are discussed. For fixed temperatures the GaAs etch rates actually decrease with increased power in the low pressure regime. For InP the etch rates increase with increasing power at fixed temperatures. (Author abstract) 27 refs.

Contolini, Robert J. (Bell Communications Research, Red Bank, NJ, USA). *J Electrochem Soc* v 135 n 4 Apr 1988 p 929-936.



**093937 248 nm LASER ETCHING OF GaAs IN CHLORINE AND OZONE GAS ENVIRONMENTS.** KrF laser etching of GaAs in  $\text{Cl}_2$  and  $\text{O}_3$  gas ambients by direct laser illumination is reported. The etch depth per pulse in  $\text{Cl}_2$  was found to be linear versus the laser fluence on the sample in the 0.2-1.1 J/cm<sup>2</sup> range. It increased as a function of the  $\text{Cl}_2$  pressure up to 6 Torr and slightly decreased for pressures above this value. It also decreased as a function of the laser repetition rate. Very smoothly etched surfaces were obtained after irradiation using the  $\text{Cl}_2$  and  $\text{O}_3$  etching gases. Auger analysis of the etched GaAs surfaces shows almost no traces of chlorine after etching in  $\text{Cl}_2$ , whereas a thick oxide layer of about 1500 Å thickness was found after etching in ozone. (Author abstract) 13 refs.

Koren, G. (IBM, Yorktown Heights, NY, USA); Hurst, J.E. Jr. *Appl Phys A* v A45 n 4 Apr 1988 p 301-304.

**093938 IMPERFECTIONS OF GAS-PHASE EPITAXIAL GaAs, AS REVEALED IN SYRTLE'S ETCHANT.** The imperfections revealed in Syrtle's etchant in the form of dome-shaped etching figures are clusters of impurity defects in thin layers of the epitaxial film. These inhomogeneities may form as a result of gettering of impurity atoms at sinks and thus reduce the concentration of inactive contaminating impurity. It is shown that the observed imperfections are electrically active and create regions of nonradiative recombination. 4 refs. In Russian.

Sorokin, I.N.; Klebanova, N.A.; Kozeikin, B.V.; Nosikov, S.V.; Terent'eva, G.N. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1773-1776.

**093939 ETCHING OF Ga<sub>0.7</sub>Al<sub>0.3</sub>As USING KI-I<sub>2</sub>.** Results are presented to show that the etch rate of Ga<sub>0.7</sub>Al<sub>0.3</sub>As using the KI-I<sub>2</sub> etchant is proportional to the dilution of the etchant producing etch rates up to 6 µm min<sup>-1</sup>. In contrast the etch rate of GaAs using this etchant is inversely proportional to the dilution of the etchant and produces a much lower etch rate of 0.026 µm min<sup>-1</sup>. (Author abstract) 2 refs.

Wismayer, A.C. (Univ of Surrey, Guildford, Engl); Weiss, B.L. *Mater Lett* v 6 n 8-9 May 1988 p 284-286.

**093940 STUDY ON ETCHING PARAMETERS OF A REACTIVE ION BEAM ETCH FOR GaAs AND InP.** Some etching characteristics for GaAs and InP with  $\text{Cl}_2$  gas using a reactive ion beam etching (RIE) system have been studied. The employed etching gas was ionized by electron cyclotron resonance (ECR) at a gas pressure of about  $6 \times 10^{-4}$  Torr; the applied microwave power was 300 W. The etch rate was measured as a function of the substrate temperature and the applied ion extraction voltage. At low temperatures, the etch rate of InP was proportional to the five halves of the extraction voltage. This agreed well with a theoretical consideration. The maximum etch rates for InP and GaAs were 2.0 and 1.2 µm/min, respectively, both at 200°C. (Author abstract) 15 refs.

Tadokoro, Takashi (Tokyo Inst of Technology, Yokohama, Jpn); Koyama, Fumio; Iga, Kenichi. *Jpn J Appl Phys Part 1* v 27 n 3 Mar 1988 p 389-392.

**093941 DETERMINATION OF TRACE TELLURIUM IN GaAs AND InSb BY FLAMELESS ATOMIC ABSORPTION SPECTROMETRY.** Various chemical etchants have been studied in order to find a suitable rate for etching GaAs and InSb. The interference of matrixes GaAs and InSb can be eliminated by increasing the ash temperature and adding a collected factor, respectively. The method is accurate and fast, and satisfies the requirement of semiconductors material technology. (Edited author abstract) In Chinese. 4 refs.

Cui Xianhang (Acad Sinica, China); Xu Xuemin. *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 283-287.

**093942 PHOTOELECTROCHEMICAL ETCHING OF n-GaAs AND n-InP.** Laser stimulated etching offers the possibility of selective working up of semiconductors. When creating microstructures, this one-step technique is advantageous compared to classical methods. Using a

suitable optical device with light focusing, lines lower than 100 nm can be produced. In this study, He-Ne laser and oxidizing etching solution were used for etching of n-GaAs and n-InP semiconductors. The dependence of the etching rate on the laser power density, exposition time, and composition of the etching solution was investigated. 11 refs.

Svorcik, V. (Inst of Chemical Technology, Prague, Czech); Rybka, V.; Myslik, V. *Phys Status Solidi A* v 106 n 1 Mar 1988 p K35-K39.

**093943 NANOMETER STRUCTURE FABRICATED BY FIB AND ITS OBSERVATION BY STM.** Fabrication of a fine ridge pattern on single quantum well layer of GaAs/AlGaAs system is carried out by means of enhanced etching induced by bombardment of a 50-keV focused Ga-ion beam. A 50-nm wide ridge pattern can be stably obtained, though the etched profile shows a tapered or overhanged side wall depending on scanning direction in sample surface plane. A scanning tunneling microscope is utilized for evaluation of three-dimensional feature of micro-fabricated Si. It is demonstrated that a grid pattern with a periodicity of 160 nm and a groove depth of 30-50 nm can be visualized with a resolution less than 10 nm in lateral direction and less than 5 nm in depth. (Author abstract) 7 refs.

Komuro, M. (Electrotechnical Lab, Sakura-mura, Jpn); Okayama, S.; Kitamura, O.; Mizutani, W.; Tokumoto, H.; Kajimura, K. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Micro lithogr, Jouy-en-Josas, Fr, Sep 22-25 1987 p 343-348.

**093944 RAMAN SCATTERING OF REACTIVE-ION ETCHED GaAs.** We have used Raman scattering to investigate the extent and nature of the damage caused by dry etching of GaAs samples. Damage has been seen to be confined to the first few hundred angstroms and has a correlation length larger than 250 Å. A sample on which 'quantum dots' had been etched has also been studied and a new feature observed in the spectrum. This is discussed in terms of a surface phonon mode. (Author abstract) 7 refs.

Watt, M. (Univ of St. Andrews, St. Andrews, Scotl); Sotomayor-Torres, C.M.; Cheung, R.; Wilkinson, C.D.W.; Arnot, H.E.G.; Beaumont, S.P. *J Mod Opt* v 35 n 3 Mar 1988, Eighth Natl Quantum Electron Conf, St. Andrews, Scotl, Sep 21-25 1988 p 365-370.

**093945 RAMAN SCATTERING INVESTIGATIONS OF THE DAMAGE CAUSED BY REACTIVE-ION-ETCHING OF GaAs.** Reactive ion etched GaAs samples have been studied by Raman scattering measurements. Damage has been seen to be confined to the first few hundred angstroms and have a correlation length larger than 250 Å. A sample on which quantum dots had been etched has also been studied and evidence for a surface mode is discussed. (Author abstract) 6 refs.

Watt, M. (Glasgow Univ, Glasgow, Scotl); Sotomayor-Torres, C.M.; Cheung, R.; Wilkinson, C.D.W.; Arnot, H.E.G.; Beaumont, S.P. *Superlattices Microstruct* v 4 n 2 1988, Pap from the Chicago Conf, Chicago, IL, USA p 243-244.

## Fracture

**093946 FRACTURE TOUGHNESS OF PURE AND In-DOPED GaAs.** The use of GaAs for microelectronic devices is impeded by the occurrence of detrimental extended crystal defects, which appear during growth or subsequent processing. The ability of a material to resist crack extension from preexisting flaws which can be generated at several steps of device processing is conveniently expressed by  $K_{IC}$ , the critical stress intensity factor for mode I fracture. The authors report on preliminary results obtained with the accurate technique of pre-cracked profiled DCB samples. This technique is particularly well suited to crack tip plasticity and brittle-ductile transition studies. In this note, room temperature - i.e., in the fully brittle range - experiments are

reported. 19 Refs.

Michot, Gerard (CNRS, Nancy, Fr); George, Amand; Chabli-Brenac, Amal; Molva, Engin. *Scr Metall* v 22 n 7 Jul 1988 p 1043-1048.

## Growing

**093947 LOW PRESSURE OMVPE GROWTH OF GaAs USING A SOLID ELEMENTAL ARSENIC SOURCE AND TEG.** A new low pressure process for the growth of GaAs using triethylgallium (TEG) and a solid elemental arsenic source has been demonstrated. GaAs epitaxial layers with specular surface morphology have been obtained. N-type background free carrier concentrations on the order of  $5 \times 10^{16} \text{ cm}^{-3}$  with room temperature mobilities around 4500 cm<sup>2</sup>/V/s are measured in these samples. The ability to grow GaAs epi layers with good surface morphology using a solid elemental arsenic source makes it more acceptable as a relatively safe industrial production process. (Author abstract) 17 refs.

Tzeng, Y. (Auburn Univ, Auburn, AL, USA); Jeske, W.; Tong, C.C.; Langford, S. *J Electrochem Soc* v 135 n 2 Feb 1988 p 452-455.

**093948 PREPARATION OF EPITAXIAL GaAs LAYERS FOR NEGATIVE ELECTRON AFFINITY PHOTOCATHODES BY USING THE ELECTRICAL CURRENT-INDUCED LIQUID PHASE EPITAXY.** The article reports on a new method of electrical current-induced liquid phase epitaxy used to prepare epitaxial GaAs layers doped with zinc. Measurement results have proved the LPEE to be a suitable method for producing NEA photocathodes. (Author abstract) 3 refs.

Zeng, Qingke (South China Inst of Technology, Guangzhou, China); Zeng, Xianfu. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 911-912.

**Growth** See Also CRYSTALS—Dislocations; CRYSTALS—Growing; LASERS, SEMICONDUCTOR—Electric Conductivity; LASERS, SEMICONDUCTOR—Fabrication; SEMICONDUCTING SILICON—Growth; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Testing; SEMICONDUCTOR DIODES, TUNNEL—Electronic Properties; SEMICONDUCTOR MATERIALS—Thin Films; TRANSISTORS, FIELD EFFECT—Fabrication.

**093949 MATHEMATICAL MODELLING OF THE LIQUID ENCAPSULATED CZOCHRALSKI GROWTH OF GALLIUM ARSENIDE: I. HEAT FLOW MODEL.** The temperature distribution in a GaAs crystal during growth has been determined using a finite element model of the heat flow in a LEC Czochralski system. The model results which include estimated values for the boundary parameters, are shown to be in good agreement with analytical solutions to the heat flow equations, using simplified boundary conditions, and to experimental temperature measurements in a LEC Melbourn grower at 3.04 MPa pressure. (Author abstract) 21 refs.

Schvezov, C. (Univ of British Columbia, Vancouver, BC, Can); Samarasekera, I.V.; Weinberg, F. *J Cryst Growth* v 84 n 2 Aug 1987 p 212-218.

**093950 MATHEMATICAL MODELLING OF THE LIQUID ENCAPSULATED CZOCHRALSKI GROWTH OF GALLIUM ARSENIDE: II. STRESS MODEL.** The stress distribution in GaAs crystals, during growth, has been calculated with finite element numerical methods, assuming thermoelastic crystal behavior. These results are compared to analytical solutions and found to be in good agreement with axisymmetric solutions, and to a lesser extent with plane strain solutions. Based on calculated thermal stresses in the crystal, the Von Mises stresses have been determined throughout the crystal. The local effective resolved shear stress leading to dislocation generation and movement was determined by subtracting reported values of yield stress and critical resolved shear



stress from the maximum resolved shear stress. The results show high dislocation densities occur in the central region and near the outside surface of the crystal in agreement with reported observations of etch pit density distributions in GaAs. (Author abstract) 15 refs.

Schvezov, C. (Univ of British Columbia, Vancouver, BC, Can); Samarasekera, I.V.; Weinberg, F. *J Cryst Growth* v 84 n 2 Aug 1987 p 219-230.

**093951 EFFECTS OF CRUCIBLE MATERIAL ON UNDOPE LEC GaAs CRYSTALS.** We have grown undoped GaAs crystals using the LEC technique with crucibles made of new materials, namely a sintered AlN crucible, a sintered  $\text{Si}_3\text{N}_4$  crucible and a  $\text{Si}_3\text{N}_4$  coated quartz crucible, and have examined the properties of crystals grown from these crucibles. It is possible to grow single crystals in each crucible, but larger amounts of arsenic are lost from the melt by vaporization with the AlN and  $\text{Si}_3\text{N}_4$  crucibles during growth. Silicon on the order of  $10^{15}$ - $10^{16}$  atoms/cm<sup>3</sup> is detected in the crystals grown from the  $\text{Si}_3\text{N}_4$  and  $\text{Si}_3\text{N}_4$  coated quartz crucibles, and the conductivity of the crystals becomes n-type. On the other hand, for the AlN crucible, a high concentration of aluminum and carbon of the order of  $10^{17}$  atoms/cm<sup>3</sup> is detected and the crystals show p-type conductivity. The incorporation of a great deal of aluminum seems to be the main reason for the high carbon concentration. (Author abstract) 8 refs.

Fujii, Takashi (Optoelectronics Joint Research Lab, Kawasaki, Jpn); Eguchi, Minoru; Inada, Tomoki; Fukuda, Tsuguo. *J Cryst Growth* v 84 n 2 Aug 1987 p 237-240.

**093952 SOME KINETIC AND THERMODYNAMIC ASPECTS OF DOPANT INCORPORATION IN MBE GROWN InP AND GaAs.** Experimental results for S-doped InP are used to show how the basic kinetic model of Wood and Joyce provides information on the dopant incorporation and desorption mechanisms. The effects of the incident dopant flux, the growth rate and the flux of the group V element are discussed. The calculated enthalpies of equilibrium desorption reactions of chalcogens in both InP and GaAs are shown to agree with the observed activation energies of desorption. (Author abstract) 25 refs.

Airaksinen, V.M. (Univ of Glasgow, Glasgow, Scotl); Cheng, T.S.; Stanley, C.R. *J Cryst Growth* v 84 n 2 Aug 1987 p 241-246.

**093953 MAGNETIC FIELD EFFECT ON RESIDUAL IMPURITY CONCENTRATIONS FOR LEC GaAs CRYSTAL GROWTH.** A horizontal magnetic field applied LEC (MLEC) apparatus, for mass-producing large diameter undoped LEC GaAs, has been newly developed. The detailed magnetic field effect on residual impurity concentrations has been studied. The carbon and boron concentrations have been found to be decreased by the MLEC technique, related to the applied magnetic field strength. The thermochemical mechanism for impurity incorporation into GaAs single crystals has been clarified through this study. The oxidation rate of free gallium and deoxidation rate of carbon oxide are shown to be the rate limiting reactions determining the impurity incorporation rate into GaAs crystals. The obtained results suggest that applying a magnetic field to molten GaAs suppresses the chemical reaction closely related to the impurity incorporation into resultant GaAs single crystals. The experimental results show good agreement with this predicted thermochemical mechanism. (Edited author abstract) 6 refs.

Terashima, Kazutaka (Toshiba Corp, Kawasaki, Jpn); Nishio, Johji; Washizuka, Shoichi; Watanabe, Masayuki. *J Cryst Growth* v 84 n 2 Aug 1987 p 247-252.

**093954 EFFECT OF CRYSTAL ORIENTATION ON DISLOCATION FORMATION IN LEC GaAs.** The etch pit density (EPD) in  $\langle 111 \rangle$  and  $\langle 100 \rangle$  semi-slices of a twinned LEC crystal was measured and compared to the thermal stress patterns theoretically calculated. It is seen that there is a qualitative agreement between stress and dislocation distribution in the two

differently oriented portions of the slices. Evidence is given that  $\langle 100 \rangle$  oriented crystals are more sensitive to thermal stress and are more difficult to grow without dislocations indeed. The discrepancies in quantitative EPD and total stress distributions have been ascribed both to the approximation in the theory of stress model and to the presence of point defects which obviously play as dislocation source. (Author abstract) 12 refs.

Fornari, R. (MASPEC-CNR Inst, Parma, Italy); Paorici, C.; Zanotti, L.; Zecchina, L. *J Cryst Growth* v 84 n 2 Aug 1987 p 266-270.

**093955 STUDY OF DISLOCATIONS IN INDOPE LEC GaAs CRYSTALS.** Grown-in dislocations in In-doped GaAs grown by the liquid-encapsulated Czochralski (LEC) technique have been studied by X-ray transmission topography, AB etching and transmission electron microscopy. The observed dislocations have been classified into three types by their configurations. They include edge-type dislocations and helices starting from the interface between the seed and the grown crystal. The elimination procedures for these dislocations have been suggested from the observed dislocation configurations. (Author abstract) 20 refs.

Nakajima, Masato (Optoelectronics Joint Research Lab, Kawasaki, Jpn); Fujii, Takashi; Ishida, Koichi. *J Cryst Growth* v 84 n 2 Aug 1987 p 295-302.

**093956 QUANTUM CONFINED STARK SHIFTS IN MOVPE-GROWN GaAs-AlGaAs MULTIPLE QUANTUM WELLS.** We report the observation of clear quantum confined Stark shifts in GaAs-AlGaAs Quantum-well devices grown using metal-organic vapour-phase epitaxy. (Author abstract) 9 refs.

Whitehead, M. (Univ Coll London, London, Engl); Parry, G.; Roberts, J.S.; Mistry, P.; Li Kam Wa, P.; David, J.P.R. *Electron Lett* v 23 n 20 Sep 24 1987 p 1048-1050.

**093957 MOLECULAR-BEAM-EPITAXIAL GROWTH OF GaAs ON HIGH-TEMPERATURE HYDROGEN-ANNEALED (100) SILICON.** Superior-quality GaAs epitaxial layers have been grown by molecular beam epitaxy on high-temperature hydrogen-ambient annealed silicon (100) substrates. Rutherford backscattering and channelling of 2.1 MeV He<sup>+</sup> ions and transmission electron microscopy techniques have been used to characterize these layers. Comparative studies indicate that the epitaxial layers grown on hydrogen-ambient annealed substrates have a superior surface morphology and a lower interface disorder than those on chemically cleaned (100) substrates. Cross-sectional transmission electron micrographs show the presence of a high density of threading dislocations, stacking faults and twins in the GaAs layers grown on the chemically cleaned silicon (100) substrates. In contrast, a significant reduction in the density of these defects is observed in the layer grown on the preannealed substrates. (Author abstract) 16 refs.

Humphreys, T.P. (North Carolina State Univ, Raleigh, NC, USA); Das, K.; Bedair, S.M.; Wortman, J.J.; Parikh, N.; Chu, W.K.; El-Masry, N.; Tarn, J.C.L. *Electron Lett* v 23 n 20 Sep 24 1987 p 1079-1081.

**093958 EFFECT OF NATURAL CONVECTION AND THERMAL TRANSPARENCY OF LIQUID ENCAPSULANT ON THERMAL STRESSES DURING LEC GROWTH OF GaAs.** The effects of natural convection and thermal transparency of the liquid encapsulant on the temperature and elastic stress distributions in GaAs crystals grown by the low pressure liquid-encapsulated Czochralski (LP-LEC) technique are numerically investigated. The results indicate that the stresses exceed CRSS appreciably during conventional LP-LEC growth and can be significantly reduced by total encapsulation of the growing solid. (Author abstract) 13 refs.

Motakef, Shahryar (MIT, Cambridge, MA, USA). *Int J Heat Mass Transfer* v 30 n 7 Jul 1987 p 1487-1495.

**093959 HIGH PRESSURE CRYSTAL GROWTH YIELDS BETTER GaAs WAFERS.** The aim of all the

crystal growth techniques is to produce GaAs material of crystallographic perfection, of a high standard of purity, with uniform electrical properties, which shows batch-to-batch reproducibility, and can yield large surface area wafers (40mm<sup>2</sup>). Although there are a number of methods of achieving GaAs crystals, two techniques have dominated the field, horizontal Bridgman (HB) and high pressure liquid encapsulated Czochralski (HP-LEC). The article discusses technological advances in GaAs substrates manufacture.

Davis, G.E. (Cambridge Instruments). *New Electron* v 20 n 4 Feb 17 1987 p 36, 38-39.

**093960 FLUID MOTION IN THE ENCAPSULANT REGION OF THE LEC GROWTH SYSTEM.** A numerical model representing the encapsulant region of liquid encapsulating Czochralski (LEC) crystal growth is developed. The fluid flow and heat transfer processes within the encapsulant are discussed for the growth of GaAs single crystals. (Author abstract) 6 refs.

Hicks, T.W. (Univ of East Anglia, Norwich, Engl). *J Cryst Growth* v 84 n 4 Oct 1987 p 598-600.

**093961 ANALYSIS OF THE CRYSTAL WEIGHING METHOD APPLIED TO LIQUID ENCAPSULATED CZOCHRALSKI GROWTH.** We analyze theoretically the force detected by a crystal weight sensor during liquid encapsulated Czochralski (LEC) growth. Based on a realistic model for LEC pulling, an expression for the differential weight gain signal (DWGS) is derived in terms of fundamental dynamic variables. The treatment gives an exact account of the mass growth, and the effects of buoyancy and melt meniscus dynamics. The generally complex relationship is well approximated by a simple modification of the results found recently for the regular Czochralski (CZ) case. The case of GaAs growth with B<sub>2</sub>O<sub>3</sub> encapsulation provides material constants in the quantitative discussion. (Edited author abstract) 28 refs.

Johansen, Tom H. (Univ of Oslo, Oslo, Norw). *J Cryst Growth* v 84 n 4 Oct 1987 p 609-620.

**093962 EFFECTS OF CERTAIN GROWTH PARAMETERS ON HOLE AND ELECTRON TRAPS IN LPE GaAs.** The purpose of the present paper is to investigate the behavior of hole traps A and B in liquid phase epitaxial (LPE) layers of GaAs materials. The effects of growth rates and the epitaxial temperatures are reported. It is noted that hole traps A and B will be present in equal amounts only when a suitable growth rate is adopted. After which, the greater the growth rate, the greater the divergence between the concentrations of A and B. The probable mechanism of this phenomenon has been discussed on the basis of our thermochemical model. 10 refs.

Zhou, Jicheng (Acad Sinica, Shanghai, China); Lu, Yian; Li, Liansheng; Lu, Bingfang; Zhang, Jue. *Mater Lett* v 6 n 11-12 Oct 1987 p 479-483.

**093963 MICROSCALE PHENOMENA IN BULK GaAs CRYSTALS: THE EFFECT OF THERMAL GRADIENTS.** Undoped bulk crystals of gallium arsenide were grown in a unique Bridgman apparatus. The effect of the temperature gradient impressed over the melt, in conjunction with the role of the melt composition (arsenic source temperature), was investigated. Crystals were photo-etched to produce the interface striation patterns and the defect structures characteristics of the growth conditions. At low gradients the interface was found to be sharply curved, but uniform electron-beam induced current and cathodoluminescence intensities were observed. As the temperature gradient over the melt was increased the interface became flatter, and the uniformity of the EBIC and CL signals deteriorated. Growth of crystals from nonstoichiometric melts resulted in increased dislocation densities, with EBIC and CL yields unique to the



Ga:As ratio in the melt. Deep level populations were also observed to respond to variations in the melt composition. (Author abstract) 12 refs.

Parsey, J.M. Jr. (AT&T Bell Lab, Murray Hill, NJ, USA); Thiel, F.A. *J Cryst Growth* v 85 n 3 Nov II 1987 p 327-334.

**093964 LIQUID PHASE EPITAXY GROWTH OF GaAs/GaAlAs MULTI-QUANTUM WELL STRUCTURES.** Experiments in liquid phase epitaxial fabrication of thin GaAs/GaAlAs layers over a planar substrate have been carried out. Layer thicknesses smaller than 300 Å were routinely obtained, with the best result being 120 Å. Interface sharpness between the layers is approximately 10 Å, which is comparable to OMCVD results, but the layers' thicknesses are usually not uniform. Of the experimental parameters, the growth time and the cooling rate seem to have the largest effect on the obtained layer thickness, while the growth temperature and the substrate crystallographic orientation produce less noticeable effects. Quantum effects in the growth layers were observed by photoluminescence measurements. (Author abstract) 15 refs.

Cser, J. (JPL, Pasadena, CA, USA); Katz, J.; Hwang, D.M. *J Cryst Growth* v 85 n 3 Nov II 1987 p 341-344.

**093965 PRECISE MELT COMPOSITION CONTROL FOR LEC GaAs.** A precise melt composition control technique for LEC GaAs has been developed by optimizing the direct synthesis process. A linear relation has been obtained between the molar ratios for the initial melt and initial charge (Ga/As:1.02-0.92). Temperature and pressure were programmed with an automated system to minimize arsenic loss during synthesis and to maintain high reproducibility. (Author abstract) 4 refs.

Nishio, Johji (Toshiba Corp, Kawasaki, Jpn); Terashima, Kazutaka. *J Cryst Growth* v 85 n 3 Nov II 1987 p 469-471.

**093966 EFFECTS OF ARSENIC AMBIENT CONTROLLED LEC GaAs CRYSTAL GROWTH TECHNIQUE ON RESIDUAL IMPURITIES.** The influence of the arsenic ambient on the residual impurities in LEC GaAs crystals was investigated. It is noted that undoped semi-insulating GaAs crystals are obtained by the arsenic ambient controlled LEC (As-LEC) crystal growth technique even when a quartz crucible and pure polycrystalline GaAs were used. The reaction mechanisms between GaAs and the quartz crucible both with and without an arsenic ambient in the LEC GaAs crystal growth process are discussed. (Author abstract) 13 refs.

Ozawa, Shoichi (Optoelectronics Joint Research Lab, Kawasaki, Jpn); Miyai, Hiroo; Kobayashi, Junji; Fukuda, Tsuguo. *J Cryst Growth* v 85 n 3 Nov II 1987 p 553-556.

**093967 LOW-TEMPERATURE SURFACE CLEANING OF SI AND SUCCESSIVE PLASMA-ASSISTED EPITAXIAL GROWTH OF GaAs.** Removal of native oxide on Si at a temperature as low as 500°C and the successive epitaxial growth of GaAs have been achieved in hydrogen plasma. Simultaneous supply of Ga or As during hydrogen plasma treatment has been found to be more effective in getting reproducible epitaxial growth than simple hydrogen-plasma cleaning. (Author abstract) 9 refs.

Gao, Qing Zhu (Tohoku Univ, Sendai, Jpn); Hariu, Takashi; Ono, Shoichi. *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1576-1578.

**093968 SILICON MIGRATION DURING MBE GROWTH OF DOPED (Al,Ga)As FILMS.** It is well established that in MBE-grown GaAs/(Al,Ga)As selectively doped heterojunctions the electron mobility in the two-dimensional electron gas (2-DEG) is considerably lower for a GaAs grown on (Al,Ga)As (inverted) interface than for (Al,Ga)As grown on GaAs (the so-called normal structure). It has been suggested that there are two principal processes responsible for the observed difference between normal and inverted struc-

tures. One is crystallographic, and requires that the interface perfection, or more probably the smoothness, is lower than GaAs is grown on (Al,Ga)As. The second is that Si donors migrate from the doped (Al,Ga)As into the undoped GaAs in the inverted but not the normal structure. It is important to understand the migration behavior, both in the context of present devices such as HEMTs and also for the design of future devices which may be based on very thin layers of highly doped material (e.g., hot electron devices or heterojunction bipolar transistors). This understanding is the motivation for the present work, in which we present results relating to two main problems: (i) the possible concentration dependence of Si migration and (ii) the mechanism of this migration. 18 refs.

Gonzalez, Luisa; Clegg, J.B.; Hilton, D.; Gowers, J.P.; Foxon, C.T.; Joyce, B.A. *Annu Rev Philips Res Lab* 1986 p 28-32.

**093969 CHARACTERIZATION OF SURFACE FACETING ON (110)GaAs/GaAs GROWN BY MOLECULAR BEAM EPITAXY.** Commonly observed faceting of (110) GaAs grown by molecular beam epitaxy has been systematically investigated. Faceted (110) films were examined with microscopic, electrical, and optical techniques. The geometry of the facets with respect to the GaAs crystal was determined and an atomic model of facet formation was derived from experimental results. The study ultimately led to the elimination of facet formation on (110) GaAs grown by molecular beam epitaxy. (Author abstract) 12 refs.

Allen, L.T.P. (Lawrence Berkeley Lab, Berkeley, CA, USA); Weber, E.R.; Washburn, J.; Pao, Y.C.; Elliot, A.G. *J Cryst Growth* v 87 n 2-3 Feb 1988 p 193-200.

**093970 NOVEL ELECTRON-BEAM EXPOSURE EPITAXY FOR GROWING GaAs FILMS ON FLUORIDE/SI STRUCTURES.** A novel heteroepitaxial technique, which we call electron-beam exposure epitaxy (EBE-epitaxy), has been employed in growing GaAs films on  $\text{CaF}_2/\text{Si}(111)$  structures. In this method, prior to the growth of GaAs films, the surfaces of  $\text{CaF}_2$  are exposed to an electron-beam under impingement by arsenic fluxes. It has been found that thin GaAs films with excellent crystallinity and smooth surfaces can be obtained on the  $\text{CaF}_2/\text{Si}(111)$  structures. It has also been found that mixing of regular (type A) and rotationally twinned (type B) crystallites does not occur in the films, but that they show preferential and dominant type A orientation which is identical to that of the  $\text{CaF}_2$ . (Author abstract) 8 refs.

Lee, Hee Chul (Tokyo Inst of Technology, Yokohama, Jpn); Ishiwaru, Hiroshi; Kanemaru, Seigo; Furukawa, Seiji. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1834-1836.

**093971 MOLECULAR BEAM EPITAXIAL GROWTH OF GaAs ON SILICON WITH BURIED IMPLANTED OXIDES.** We report results of direct growth of GaAs by molecular beam epitaxy on nominally (100) oriented silicon with buried implanted oxides. Rutherford backscattering and transmission electron microscopy techniques have been used to characterize these layers. The formation of hillocks and a uniform layer of GaAs in the intervening regions between hillocks have been observed. Microtwins, dislocations and antiphase domain boundaries are the predominant defects observed in these layers. (Edited author abstract) 13 refs.

Das, K. (North Carolina State Univ, Raleigh, NC, USA); Humphreys, T.P.; Wortman, J.J.; Posthill, J.B.; Tarn, J.C.L.; Parikh, N. *Electron Lett* v 24 n 1 Jan 7 1988 p 67-68.

**093972 SUBSTRATE ORIENTATION AND PROCESSING EFFECTS ON GaAs/SI MISORIENTATION IN GaAs-ON-SI GROWN BY MBE.** The angular misorientation of GaAs epitaxial layers grown on silicon substrates by molecular beam epitaxy has been measured using X-ray diffraction. A significant misorientation, or tilt, between the epitaxial layer and the substrate has been observed. The magnitude of the tilt depends on the initial

substrate orientation, the silicon substrate type (float zone or Czochralski), postgrowth annealing, and epitaxial layer thickness. In almost all cases, the sense of the tilt is such that the GaAs  $\langle 001 \rangle$  lies between the surface normal and the silicon  $\langle 001 \rangle$ . While the presence of interfacial dislocations with Burgers vectors that are approximately parallel to the heterointerface does predict a tilt between the substrate and the epitaxial layer, the sense of the tilt that arises from these dislocations is opposite to that observed experimentally. A model, based on the relief of misfit by dislocations inclined approximately 45 degrees to the interface, is proposed that correctly describes the observed tilt. (Author abstract) 19 refs.

Matyi, R.J. (Texas Instruments Inc, Dallas, TX, USA); Lee, J.W.; Schaake, H.F. *J Electron Mater* v 17 n 1 Jan 1988 p 87-93.

**093973 THEORETICAL STUDY OF MODE TRANSITION BETWEEN 2d-NUCLEATION AND STEP FLOW IN MBE GROWTH OF GaAs.** The disappearance of RHEED intensity oscillation by increasing growth temperature in GaAs MBE on a stepped surface has been studied theoretically based on the 2d-nucleation and surface diffusion theories. By comparing the present and the published RHEED results, the surface diffusion length and the diffusion coefficient of Ga atoms on the (100) GaAs surface are obtained. (Edited author abstract) 13 refs.

Nishinaga, Tatsu (Univ of Tokyo, Tokyo, Jpn); Cho, Kyoungh-Ik. *Jpn J Appl Phys Part 2* v 27 n 1 Jan 1988 p 12-14.

**093974 SOURCE OF CARBON CONTAMINATION IN GaAs GROWN BY METAL-ORGANIC-CHLORIDE ( $\text{Ga}(\text{CH}_3)_3/\text{AsCl}_3/\text{H}_2$ ) VPE.** Comparative characterization of two types of GaAs was conducted using photoluminescence (PL) and Hall measurements. The first is of GaAs grown by metal organic (MO)-chloride VPE, in which system the trimethylgallium ( $\text{TMG}$ ;  $\text{Ga}(\text{CH}_3)_3$ ) vapor is substituted as the Ga metal source in the chloride ( $\text{Ga}/\text{AsCl}_3/\text{H}_2$ ) VPE system. The second type is of GaAs grown either by  $\text{CH}_4$  or by  $\text{C}_2\text{H}_6$  doped chloride VPE. MO-chloride VPE GaAs was contaminated with carbon. The possible carbon source is considered to be ethane since the  $\text{C}_2\text{H}_6$ -doped chloride VPE system produced GaAs electrically close to GaAs grown in the MO-chloride VPE system. This is demonstrated by the fact that mass spectrometric analysis of hydrocarbons produced by thermal decomposition of TMG revealed ethane along with methane. (Author abstract) 24 refs.

Yoshida, Masaji (NEC Corp, Kawasaki, Jpn). *J Cryst Growth* v 88 n 1 Apr 1988 p 16-22.

**093975 STRUCTURAL FEATURES OF MBE GROWN VERY SHORT PERIOD GaAs-AlAs SUPERLATTICES.** Very short period GaAs-AlAs superlattices (period less than 25 Å) were grown by molecular beam epitaxy. Three techniques were carried out to study these samples: transmission electron microscopy, X-ray diffraction, and photoluminescence. Diffraction techniques have proved to be particularly suitable for the analysis of this type of samples. By combining electron and X-ray diffraction, the origin of the fine structure of diffraction peaks could be explained with respect to the growth process. Owing to the high sensitivity of diffraction techniques, very small period variations (less than one monolayer) could be evidenced. The period of the three described samples was shown to be a fractional number of monolayers, which is related to the growth conditions used in this MBE set-up. Photoluminescence results give evidence of the high quality of the superlattices, and are fully consistent with those given by the diffraction techniques. (Author abstract) 19 refs.

Guenais, B. (CNET, Lannion, Fr); Poudoulec, A.; Auvray, P.; Baudet, M.; Regreny, A.; Lambert, B. *J Cryst Growth* v 88 n 1 Apr 1988 p 125-134.



**093976 MIGRATION-ENHANCED EPITAXY OF GaAs AND AlGaAs.** Surface migration is effectively enhanced by evaporating Ga or Al atoms onto a clean GaAs surface under an As-free or low As pressure atmosphere. This characteristic was utilized by alternately supplying Ga and/or Al and As to the substrate surface for growing atomically-flat GaAs-AlGaAs heterointerfaces, and also for growing high-quality GaAs and AlGaAs layers at very low substrate temperatures. The migration characteristics of surface adatoms have been investigated through reflection high-energy electron diffraction measurements. It was found that different growth mechanisms are operative in this method at both high and low temperatures. Both these mechanisms are expected to yield flat heterojunction interfaces. By applying this method, GaAs layers and GaAs-AlGaAs single quantum-well structures with excellent photoluminescence were grown at substrate temperatures of 200 and 300°C, respectively. (Author abstract) 28 refs.

Horikoshi, Yoshiji (NTT, Musashino, Jpn); Kawashima, Minoru; Yamaguchi, Hiroshi. *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 169-179.

**093977 PRECIPITATE IDENTIFICATION IN V- AND Cr-DOPED LEC GROWN GaAs.** Precipitates which form during the LEC growth of vanadium- and chromium-doped GaAs are shown to be predominantly the respective transition metal arsenides VAs and CrAs. In general, the precipitation follows closely upon the transition from single crystal to polycrystalline growth which arises primarily from factors such as constitutional supercooling and twinning. As a result, the precipitates are usually found at grain boundaries in the non-single crystal regions near the termination of growth. A scanning electron micrograph of a polished crystal section, typical of those cut from the base of V-doped crystals, is shown. (Edited author abstract) 6 refs.

Cockayne, B. (Royal Signals & Radar Establishment, Great Malvern, Engl); MacEwan, W.R.; Harris, I.R.; Smith, N.A. *J Cryst Growth* v 88 n 2 Apr II 1988 p 180-182.

**093978 ORIENTED OVERGROWTHS IN MOVPE-GROWN GaAs.** The crystallographic structure of crater-containing oriented overgrowths on GaAs epitaxial layers grown by metalorganic vapor phase epitaxy (MOVPE) has been studied by transmission electron microscopy and diffraction. The craters are the visible outward sign of polycrystalline constructions of 6 grains or more having low order twin relations with the matrix. Anisotropic development of the facets of the grains is proposed to be the growth mechanism of the hillock. Stacking fault pyramids are present but their correlation with craters and overgrowths is not systematic. (Author abstract) 57 refs.

Rudra, Alok (CNRS, Valbonne, Fr); Grenet, Jean-Claude; Gibart, Pierre; Heral, Helene; Rocher, Andre. *J Cryst Growth* v 87 n 4 Mar 1988 p 535-546.

**093979 GROWTH CELLS OF HEAVILY In-DOPED LEC GaAs CRYSTALS.** We observed the generation of growth cells in heavily In-doped LEC GaAs crystals (with an In concentration of  $1 \times 10^{21}$  atoms/cm<sup>3</sup> in the initial melt) grown under various growth conditions, and examined the generation of growth cells with respect to the growth parameters. Growth cells are generated at the top of the convex solid-liquid interface, and the angle over which the growth cells spread changes with the curvature of the solid-liquid interface. The fraction solidified at which growth cells first appears ( $g_{cell}$ ) depends on the pulling speed and the axial temperature gradient. For instance, when the axial temperature gradient is kept constant at 80°C/cm, the values of  $g_{cell}$  are around 0.22, 0.45 and 0.70 for the pulling speeds of 9, 5 and 3 mm/h, respectively. When the pulling speed is kept constant at 5 mm/h, the values of  $g_{cell}$  are 0.45 and 0.13, for axial temperature gradients of 80 to 20°C/cm. (Author abstract) 9 refs.

Fujii, Takashi (Optoelectronics Joint Research Lab, Kawasaki, Jpn); Nakajima, Mansato; Fukuda, Tsuguo. *J*

*Cryst Growth* v 87 n 4 Mar 1988 p 547-553.

**093980 GROWTH OF GaAs PLATE CRYSTAL BY THE LIQUID ENCAPSULATED STEPANOV METHOD.** We have successfully grown two sizes of GaAs plate crystals: one with a width of 36 mm, a thickness of 10 mm and a length of 100 mm, and the other with a width of 36 mm, a thickness of 4 mm and a length of 90 mm. First, the wettability of die materials, such as PBN, quartz, graphite, hBN, AlN and sapphire, with respect to the GaAs melt were examined and it was found that these materials are not wet. Then, the plate crystals were grown by LES method using the graphite growth die. The head of the grown GaAs plate was a single crystal, but the surface became polycrystalline after shape-controlling by the die. There seems to be the relationship between the generation of the polycrystals and the change in the shape of the solid-liquid interface. (Author abstract) 9 refs.

Fujii, Takashi (Optoelectronic Joint Research Lab, Kawasaki, Jpn); Eguchi, Minoru; Fukuda, Tsuguo. *J Cryst Growth* v 87 n 4 Mar 1988 p 573-577.

**093981 MECHANISM OF INFLUENCE OF RARE-EARTH ELEMENTS ON PROPERTIES OF GaAs LAYERS GROWN USING LIQUID EPITAXY.** The mechanism of the influence of lanthanides on the properties of GaAs layers grown through liquid epitaxy is studied using electro-physical methods, radioisotopic analysis, and photoluminescence at a temperature of 4.2 K. The addition of Gd and Yb to the molten solution leads to a reduction in the concentration of residual donors which is associated with the formation of chemical compounds with elements of the VI group, which are forced back into the second phase. (Author abstract) 6 refs.

Bespalov, V.A.; Elkin, A.G.; Zhurkin, B.G.; Kvit, A.V.; Oktyabrskii, S.R.; Perezhozin, G.A. *Sov Phys Lebedev Inst Rep* n 9 1987 p 41-44.

**093982 INITIAL GROWTH CONDITIONS OF GaAs ON (100) Si GROWN BY MIGRATION-ENHANCED EPITAXY.** This paper investigates the effect of initial growth conditions on the structural and optical properties of GaAs and (AlGa)As/GaAs quantum well heterostructures (QWH) on (100) Si. Samples are grown by migration-enhanced epitaxy (MEE) at 300°C. Only the growth conditions of the first GaAs monolayer on Si substrates are varied. Optimization requires: 1) no exposure of the hot Si surface to As, and 2) Ga-dominated initial growth conditions. Sharp low-temperature excitonic luminescence (8.0 meV (FWHM) for  $L_z = 2$  nm) confirms the smooth heterointerfaces of the MEE-grown layers. Samples grown by conventional MBE at 300°C show a clearly poorer crystal quality. (Author abstract) 13 refs.

Stolz, Wolfgang (NTT, Musashino, Jpn); Naganuma, Mitsuru; Horikoshi, Yoshiji. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 283-286.

**093983 ELECTRON-MICROSCOPE STUDIES OF THE SURFACE OF EPITAXIAL GaAs LAYERS IN THE PROXIMITY OF THE (111)A FACE.** Electron-microscope studies have been carried out on the relief of the growth surface of epitaxial gallium arsenide layers in the vicinity of the (111)A face. The quantitative characteristics of the elements of the relief have been determined: the density of growth centers on a singular face, the height of the steps, and the distances between steps in the vicinal planes. The parameters of the growth steps are shown to depend on the orientation of the face and the concentration of the growth components in the vapor phase. (Author abstract) 7 refs.

Ivonin, I.V. (Tomsk Univ, USSR); Toropov, S.E. *Sov Phys J* v 30 n 9 Sep 1987 p 725-729.

**093984 GROWTH OF GaAs MILLIMETER WAVE IMPATT DIODE MATERIAL USING LOW TEMPERATURE VAPOR PHASE EPITAXY.** Chloride transport vapor phase epitaxy has been one of the most widely used techniques for the epitaxial growth of GaAs

for microwave device applications. Unfortunately, this technique has been limited to the growth of relatively low frequency (<40 GHz) structures due to its inherently high growth rate at typical deposition temperatures (approx. 750°C). It is well known, however, that the growth rate is a strong function of deposition temperature and that growth in the kinetically limited low temperature regime not only allows one to achieve low growth rates but also improves both thickness and doping uniformity. It would therefore seem that low temperature chloride transport vapor phase epitaxy (LTVPE) would be well suited for the growth of GaAs device structures for mm-wave applications. We report here the use of LTVPE for the routine production of double drift Read profile IMPATT diode structures for operation at 44, 60, and 94 GHz. State-of-the-art power and efficiency results are obtained from diodes produced with this material and excellent uniformity is observed across 2 inch diameter wafers. (Author abstract) 26 refs.

Lauterwasser, B.D. (Raytheon Research Div, Lexington, MA, USA). *J Cryst Growth* v 88 n 4 May II 1988 p 527-534.

**093985 AXIAL CHANNELING STUDIES OF HETEROEPITAXIAL In<sub>0.25</sub>Ga<sub>0.75</sub>As ON GaAs.** Axial channeling results are presented for the analysis of the heteroepitaxial growth structure of In<sub>0.25</sub>Ga<sub>0.75</sub>As on <100> GaAs by MBE. The strain measurements have utilized inclined-direction axial dechanneling and angular scans. Anomalously large dechanneling along the declined <110> axis relative to the <100> growth direction indicates the presence of lattice strain due to lattice mismatch. Imperfections or lattice defects in dislocation nature in the epitaxial layer also give rise to significant dechanneling. (Author abstract) 8 refs.

Yin, Shiduan (Chinese Acad of Sciences, Beijing, China); Wu, Chunwu; Zhang, Jingping; Liu, Jiarui; Zhu, Peiran; Wang, Yu. *Solid State Commun* v 65 n 10 Mar 1988 p 1181-1183.

**093986 DEVELOPMENT OF HIGHLY UNIFORM GaAs EPITAXIAL WAFERS WITH A THREE-INCH DIAMETER.** With the demand for high frequency and high output GaAs FETs for use in transmitters and receivers in satellite communications and microwave circuits, chip sizes are becoming large. In the manufacturing processes for FETs, to decrease the number of processes and improve the yield, it is desirable to increase the diameter and improve the uniformity of GaAs epitaxial wafers. The two-inch GaAs VPE (Vapor Phase Epitaxial growth) wafer has been produced as a material for FETs, and to meet the above-mentioned requirements three-inch VPE wafers have been developed. To make the reactor large enough for the development of the three-inch wafer, the vapor phase growth techniques accumulated over the last few years were put to use, and simulation software which analyzes gas flow and thermal flow in the reactor tube to optimize the growth conditions in the newly-designed, larger reactor tube was developed. 2 refs.

Miura, Yoshiki; Takemoto, Kikuro; Kaji, Mikio; Iguchi, Shin-ichi; Hara, Daijiro; Oji, Masataka; Matsushima, Akira; Kakino, Yuji; Senda, Yasuhiko. *Sumitomo Electr Tech Rev* n 27 Jan 1988 p 155-159.

**093987 ULTRA-HIGH THROUGHPUT OF GaAs AND (AlGa)As LAYERS GROWN BY MOLECULAR BEAM EPITAXY (MBE) WITH A SPECIALLY DESIGNED MBE SYSTEM.** The ultra-high throughput of extremely uniform GaAs and (AlGa)As layers with excellent surface morphology can be realized by MBE with a new MBE system designed for both a drastic increase of the throughput and a reduction of the surface defect density. The simultaneous growth of seven 5-cm-dia. epilayers can be achieved with a thickness variation of less than 2% by optimizing the effusion cell geometry. A computer-controlled growth sequencer and a newly developed source recharging system are incorporated for automatic growth, and operated continuously day and night without venting the growth chamber even



during source recharging. The surface defect density has been reduced to less than  $50/\text{cm}^2$  by the introduction of a modified Ga cell and a face-down sample-transfer system. This system allows the growth of nearly 100 GaAs FET or HEMT wafers each day (24 hr). The devices constructed from these wafers showed excellent performance. (Author abstract) 15 refs.

Sonoda, Takuji (Mitsubishi Electric Corp, Jpn); Ito, Michihiro; Segawa, Kazuaki; Takamiya, Saburo; Mitsui, Shigeru. *Jpn J Appl Phys Part 1* v 27 n 3 Mar 1988 p 337-343.

**093988 MINIMISATION OF THERMAL STRESSES DURING THE GROWTH OF GaAs CRYSTALS.** Undesirably high dislocation densities in Czochralski growth gallium arsenide crystals are generally accepted to be due to high thermal stresses generated by temperature gradients in the crystal during growth. Detailed numerical calculations are presented, using finite element methods, for partially and fully grown crystal geometries to calculate the resulting stresses. By varying such parameters as the ambient temperature, heat transfer coefficient and crystal geometry the dislocation density can be minimized and hence optimum growth conditions predicted. It is shown that the optimum conditions during the initial stages of crystal growth are radically different to those required for the mature crystal geometry. (Author abstract) 16 refs.

Meduoye, G.O. (Univ of Liverpool, Liverpool, Engl); Bacon, D.J.; Evans, K.E. *J Cryst Growth* v 88 n 3 May 1988 p 397-410.

**093989 HETEROEPITAXIAL ZnSe ON GaAs: HIGH GROWTH RATES AT LOW TEMPERATURES BY CONVENTIONAL VPE.** Heteroepitaxial layers of AnSe have been grown on GaAs substrates in a conventional VPE system using vaporization of ZnSe powder with a hydrogen carrier gas flow. Mass transport in a temperature gradient of  $200^\circ\text{C}/\text{cm}$  results in extremely pure layers in conditions apparently suitable for p-type doping. (Author abstract) 4 refs.

Umar-Syed, M. (Univ of Manchester, Manchester, Engl); Lilley, P. *J Cryst Growth* v 88 n 3 May 1988 p 415-418.

**093990 GROWTH OF GaAs ON PREFERENTIALLY ETCHED GaAs SURFACES BY MIGRATION-ENHANCED EPITAXY.** The migration mechanism of surface adatoms during migration-enhanced epitaxy is quite different from that expected in conventional molecular beam epitaxy. This difference is clearly demonstrated in the cross-sectional views of GaAs layers grown on preferentially etched, undercut-mesa stripes. Definite crystal facets of (110) appear in the layers grown by migration-enhanced epitaxy, in contrast to the (111)B facets in the layers grown by molecular beam epitaxy. The migration mechanisms of these two growth methods are discussed in order to interpret the differences in the faceting characteristics. (Author abstract) 13 refs.

Kawashima, Minoru (NTT, Musashino, Jpn); Horikoshi, Yoshiji. *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 483-486.

**093991 APPLICATION OF RHEED INTENSITY EFFECTS TO INTERRUPTED GROWTH AND INTERFACE FORMATION DURING MBE GROWTH OF GaAs/(Al, Ga)As STRUCTURES.** There is a diffraction-induced phase effect in the RHEED intensity oscillation technique used in MBE, whereby intensity maxima only correspond to monolayer completion for very restricted conditions. In particular, the angle of incidence of the primary beam is extremely critical. The effect occurs because the total intensity at the measured position of the specular beam is always derived from at least two different diffraction processes, which do not have the same phase relation to monolayer formation. It can be accommodated either by a systematic series of measurements to establish an empirical relationship between incidence angle and phase, or by Fourier transform techniques. Unless full account is taken of this purely diffraction-induced effect, very misleading results can be obtained for the time

constants of the recovery period following cessation of growth and this is illustrated for GaAs. The effect also has important implications for the growth-interrupt technique. In addition, it is shown that for heterojunction formation in the GaAs/(Al,Ga)As system, adatom (Ga and Al) migration lengths are of greater importance than the position in the monolayer at which the composition is changed, and that RHEED can provide only limited information on the interface structure. (Author abstract) 20 refs.

Joyce, B.A. (Philips Research Lab, Surrey, Engl); Zhang, J.; Neave, J.H.; Dobson, P.J. *Appl Phys A* v 45 n 3 Mar. 1988 p 255-260.

**093992 LOW-FREQUENCY NOISE IN GaAs LAYERS GROWN BY MOLECULAR BEAM EPITAXY.** Low-frequency noise in n-GaAs layers grown by molecular beam epitaxy has been studied for various carrier concentrations and device dimensions. The noise decreases linearly with an increase in total carriers and layer thickness. The frequency dependence of the noise varies at a rate of  $f^{-1.5}$  in the devices with SnAu contacts, and at the rates of  $f^{-1.2}$  to  $f^{-2.0}$  in those with AuGe contacts. SnAu ohmic contacts have noise levels 20 db lower than those of AuGe contacts. Surface cap layers either doped to n- or p-type have little effect on the overall frequency dependence of the noise. (Edited author abstract) 14 refs.

Tacano, Muneazu (Electrotechnical Lab, Tsukuba, Jpn); Sugiyama, Yoshinobu; Taguchi, Takashi; Soga, Hajime. *Solid State Electron* v 31 n 7 Jul 1988 p 1215-1219.

**093993 DISLOCATION REACTIONS AND LINEAGE FORMATION IN LIQUID ENCAPSULATED CZOCHRALSKI GROWN GaAs CRYSTALS.** Dislocation generation and the reactions during the crystal growth in undoped and In-doped GaAs have been investigated, and the formation mechanism of lineage structures in undoped crystals is discussed. Rectangular specimens were plastically bent with the same stress directions as those expected during crystal growth. The dislocation distribution in the deformed crystals was compared with that in an as-grown In-doped crystal. By considering the slip systems acting in the crystals, it was found that different kinds of dislocation reactions occur depending on the azimuth at the wafer periphery. Slip dislocations around  $\langle 110 \rangle$  directions react to form sessile dislocations along the dislocation propagation direction. It is concluded that this is an early stage of lineage formation, which extends along  $\langle 110 \rangle$  at the  $\langle 110 \rangle$  region. (Author abstract) 19 refs.

Ono, Haruhiko (NEC, Kawasaki, Jpn). *J Cryst Growth* v 89 n 2-3 Jun II 1988 p 209-219.

**093994 A GROWTH ANALYSIS FOR METAL-ORGANIC VAPOR PHASE EPITAXY OF GaAs.** Metalorganic vapor phase epitaxy (MOVPE) of GaAs is analyzed using a new growth model. Surface reactions for trimethylgallium or triethylgallium adsorbed on the substrate surfaces are assumed to be the growth-rate-limiting steps. A catalytic effect is taken into account by assuming different decomposition rates for adsorbed alkyls on Ga- and As-terminated surfaces. The surface reactions are expressed in terms of reaction times and analyzed using a rate equation approach. Parameters in a rate equation are determined by fitting to the experimental results obtained by various methods: conventional MOVPE with and without laser irradiation, pulsed MOVPE, and laser atomic layer epitaxy. Good agreement between experiments and calculations in all growth methods shows the usefulness of the model. (Author abstract) 12 Refs.

Doi, Atsutoshi (Inst of Physical & Chemical Research, Wako, Jpn); Iwai, Sohachi; Meguro, Takashi; Namba, Susumu. *Jpn J Appl Phys Part 1* v 27 n 5 May 1988 p 795-800.

**093995 SELECTIVELY DOPED GaAs/N-Al<sub>0.3</sub>Ga<sub>0.7</sub>As HETEROSTRUCTURES GROWN BY GAS-SOURCE MBE.** Selectively doped GaAs/N-Al<sub>0.3</sub>Ga<sub>0.7</sub>As heterostructures with a 6 nm spacer layer have been grown for the first time by gas-source MBE using

triethylgallium and triethylaluminum as group III sources, and metallic arsenic. A reasonably high two-dimensional electron gas (2DEG) mobility of  $48,000 \text{ cm}^2/\text{Vs}$  (77 K) with a sheet electron concentration ( $N_s$ ) of  $6.8 \times 10^{11} \text{ cm}^{-2}$  was obtained at a substrate temperature of  $580^\circ\text{C}$  and an arsenic pressure of  $1.1 \times 10^{-4}$  Torr. (Author abstract) 13 Refs.

Ando, Hideyasu (Fujitsu Lab Ltd, Morinosato-Wakamiya, Jpn); Kondo, Kazuhiro; Ishikawa, Hideaki; Sasa, Shigehiko; Inata, Tsuguo; Hiyamizu, Satoshi. *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 896-898.

**093996 BEHAVIOR OF Ge DURING LPE GROWTH OF GaAs.** The incorporation behavior and the ratio of Ge on Ga site to Ge on As site during GaAs LPE growth have been studied in a temperature range of  $550\text{--}950^\circ\text{C}$  by means of Hall measurement, SIMS, electrochemical C-V and photoluminescence. The segregation coefficient of Ge rises as the temperature decreases and the ratio of  $\text{Ge}_{\text{Ga}}/\text{Ge}_{\text{As}}$  increases with temperature in the range of  $550\text{--}950^\circ\text{C}$ . (Edited author abstract) 14 Refs. In Chinese.

Yang, Hui (Acad Sinica, Beijing, China); Liang, Junwu. *Bandaoti Xuebao* v 9 n 4 Jul 1988 p 429-434.

**093997 EPITAXIAL METASTABLE (GASB)<sub>1-x</sub>(Ge<sub>2</sub>(1-y)Sn<sub>2</sub>)<sub>x</sub> QUATERNARY ALLOYS ON GAAS(100): CRYSTAL GROWTH, STRUCTURE, AND RAMAN SCATTERING.** Epitaxial metastable (GaSb)<sub>1-x</sub>(Ge<sub>2</sub>(1-y)Sn<sub>2</sub>)<sub>x</sub> quaternary alloys have been grown with  $0 \leq x \leq 1$  and  $y \leq 0.27$  by RF multitarget sputter deposition on GaAs(100) substrates. Films,  $\approx 1 \mu\text{m}$  thick, deposited under the same growth conditions on Corning 7059 glass substrates were polycrystalline with a strong (220) preferred orientation. A growth phase map, plotted as a function of x, y, and deposition temperature  $T_s$ , showed that the maximum growth temperature decreased rapidly with increasing Sn concentration, ranging from  $\geq 500^\circ\text{C}$  for  $0 \leq x \leq 1$  with  $y=0$  to  $\geq 150^\circ\text{C}$  for  $x=0.6$  with  $y=0.27$ . The lattice parameter  $a_0$  of the alloys decreased linearly with increasing x for a given y and increased linearly with y for a given value of x.  $a_0$  ranged from  $0.6094 \text{ nm}$  for GaSb to  $0.5775 \text{ nm}$  for (GaSb)<sub>0.2</sub>(Ge<sub>1.86</sub>Sn<sub>0.14</sub>)<sub>0.8</sub>. Analysis of fundamental and superstructure diffraction peak intensities, the zincblende-to-diamond structure phase transition was found to occur near  $x \approx 0.3$ . Raman scattering results showed a two-peak behavior over the composition range investigated. The GaSb-like longitudinal-optical peak near  $234 \text{ cm}^{-1}$  softened and broadened with increasing x for all y values. A weak 'Ge-like' mode increased in frequency from  $265 \text{ cm}^{-1}$  at  $x=0.05$  with  $y=0.07\text{--}0.27$  to  $280 \text{ cm}^{-1}$  at  $x=0.6$  and  $y=0.07$ . The reaction path for phase decomposition in these alloys was found using hot-stage transmission electron microscopy to proceed through a series of intermediate metastable phases. (Edited author abstract) 26 Refs.

Shah, S.I. (Univ of Illinois, Urbana, IL, USA); Greene, J.E.; Abels, L.L.; Raccach, P.M. *J Cryst Growth* v 91 n 1-2 Aug 1988 p 71-80.

**093998 GROWTH AND ASSESSMENT OF CDS AND CDSE LAYERS PRODUCED ON GAAS BY METALORGANIC CHEMICAL VAPOR DEPOSITION.** CdS and CdSe layers have been grown successfully on GaAs by MOCVD. The surface morphology, RHEED patterns and photoluminescence properties of the layers were studied for different substrate orientations. It was found that the CdS grew hexagonally on the (111)A substrate face, while the layers produced on (100), (110) and (111)B faces were a mixture of cubic and hexagonal phases. Layers of CdSe grown on GaAs were also a mixture of cubic and hexagonal phases for substrate faces other than (111)A, for which the layer was predominantly cubic. The change in photoluminescence with growth temperature was investigated and for CdS the best growth temperature, as measured by the width of the bound



exciton emission, was 350°C. No evidence of large scale diffusion of Ga or As from the substrate was found. (Author abstract). 14 Refs.

Halsall, M.P. (Univ of Hull, Hull, Engl); Davies, J.J.; Nicholls, J.E.; Cockayne, B.; Wright, P.J.; Russell, G.J. *J Cryst Growth* v 91 n 1-2 Aug 1988 p 135-140.

**093999 TYPES OF OVAL DEFECTS ON GAAS GROWN BY MBE.** According to the shapes of oval defects, three types are observed on the MBE grown GaAs epilayers. All of their long oval axis were along the  $\langle 110 \rangle$  direction, but their origins are attributed to different sources. The origins of each type are deduced by experiments. The composition of the oval defects is similar to that of the grown epi-layers by the analysis of EDAX. (Edited author abstract). 11 Refs.

Lee, C.T. (Chung Shan Inst of Science & Technology, Lung-Tan, Taiwan); Chou, Y.C. *J Cryst Growth* v 91 n 1-2 Aug 1988 p 169-172.

**094000 DYNAMICS AND CONTROL OF THE CZOCHRALSKI PROCESS. II. OBJECTIVES AND CONTROL STRUCTURE DESIGN.** A new control system design is proposed for the Czochralski process in order to improve crystal quality, particularly GaAs. An expanded set of formal control objectives are proposed based on a consideration of defect formation, segregation, and the process coupling. A control structure is developed that meets the control objectives and the restrictions posed by the batch related disturbances, system coupling, and the dynamic characteristics of the measurements, outputs, and inputs. (Author abstract). 42 Refs.

Gevelber, Michael A. (MIT, Cambridge, MA, USA); Stephanopoulos, George; Wargo, Michael J. *J Cryst Growth* v 91 n 1-2 Aug 1988 p 199-217.

**094001 TEMPERATURE GRADIENTS, DOPANTS, AND DISLOCATION FORMATION DURING LOW-PRESSURE LEC GROWTH OF GaAs.** In this work we will review the current status of low pressure, low thermal gradient GaAs crystal growth. Our previous studies have shown that undoped GaAs crystals grown under low pressure by the liquid encapsulated Czochralski technique from melts with axial temperature gradients of 6°C/cm at the solid/liquid interface have dislocation densities of approx.  $3 \times 10^3 \text{ cm}^{-2}$  throughout the boule. Our recent work shows that growth at an order of magnitude slower pull rate has no effect on this dislocation density, but does result in more extensive polygonization. Increased pull rates, however, increase the dislocation density. These observations together with others reported in the literature strongly support a mechanism wherein dislocations are formed as a result of microscopic stress fields (exceeding the critical resolved shear stress) that arise from inhomogeneous vacancy incorporation at the solid/liquid interface. (Edited author abstract) 36 refs.

Elliot, A. Grant (Hewlett-Packard, San Jose, CA, USA); Wei, Chia-Li; Vanderwater, David A. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 59-68.

**094002 GROWTH AND CHARACTERIZATION OF LOW DEFECT GaAs BY VERTICAL GRADIENT FREEZE.** In this paper we discuss the growth of 2 inch diameter undoped and In-alloyed GaAs by vertical gradient freeze (VGF). Through the use of low gradients, undoped material with a dislocation density of  $(2-6) \times 10^3 \text{ cm}^{-2}$  has been obtained. With the addition of 0.6 at.% InAs to the melt, this density is further reduced to 0-1000  $\text{cm}^{-2}$ . In contrast to standard LEC, GaAs grown by VGF shows low concentrations of the EL2 deep level and of the C shallow acceptor level. The material is semi-insulating,  $\rho \geq 10^7 \Omega \text{ cm}$ , and is thus suitable for device applications. From temperature dependent Hall measurements, the semi-insulating (SI) behavior is believed to be caused by Fermi level pinning at a defect with an energy level of approx. 0.5 eV. (Edited author abstract) 15 refs.

Abernathy, C.R. (AT&T Bell Lab, Murray Hill, NJ,

USA); Kinsella, A.P.; Jordan, A.S.; Caruso, R.; Pearton, S.J.; Temkin, H.; Wade, H. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 106-115.

**094003 GROWTH AND CHARACTERIZATION OF GaAs ALLOYED WITH IN AND P.** Indium- and phosphorus-alloyed GaAs crystals were grown by the liquid encapsulated Czochralski (LEC) method. Phosphorus was found to complement indium, which has relatively low concentration at the seed end, in providing the lattice hardening. The dislocation density was low even at the seed end of the crystals. Lattice-matched wafers exhibited near zero band gap shift in the crystal where the ratio of phosphorus to indium ranged from 1 to 1.3. The distribution coefficient of phosphorus was determined to be 3.  $0 \pm 0.3$  for the two crystals grown at 2 and 4 mm/h. The crystals exhibited high room-temperature electron mobility of  $> 7000 \text{ cm}^2/\text{V}\cdot\text{s}$  and resistivities ranging from low  $10^7$  to low  $10^8 \Omega \text{ cm}$ . Temperature-dependent Hall measurements revealed no extraneous levels attributable to indium or phosphorus in the band gap. (Author abstract) 17 refs.

Kimura, H. (Hughes Research Lab, Malibu, CA, USA); Hunter, A.T.; Cirlin, E.-H.; Olsen, H.M. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 116-123.

**094004 EVALUATION OF THE MELLER 'EDG' FURNACE FOR GROWTH OF LARGE DIAMETER GaAs SINGLE CRYSTALS IN A HORIZONTAL CONFIGURATION.** An extensive evaluation of the Meller 'EDG' furnace has been conducted in order to assess its performance for growth of large diameter (2 and 3 inch) GaAs crystals in the horizontal configuration. The axial and radial temperature gradients were found to influence strongly the crystal-melt interface shape and crystalline perfection of the crystals. When the axial thermal gradients are small relative to the radial thermal gradients, the shape of the crystal-melt interface fluctuates in time as growth proceeds, indicating the presence of oscillatory convective flows in the melt. The crystal-melt interface becomes stable as the axial component of the thermal gradient over the solid is increased. The crystals produced with optimized gradient conditions have a low and uniform dislocation density. (Author abstract) 11 refs.

Bourret, E.D. (Lawrence Berkeley Lab, Berkeley, CA, USA); Guirton, J.B.; Haller, E.E. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 124-129.

**094005 GROWTH AND CHARACTERIZATION OF HIGH QUALITY LPEE GaAs BULK CRYSTALS.** High purity GaAs bulk crystals were grown by liquid phase electroepitaxy (LPEE). One inch diameter more than 4 mm thick ingots were free of polycrystalline edges and Ga inclusions. Typical free carrier concentration was in the  $10^{14} \text{ cm}^{-3}$  range. Low temperature photoluminescence (PL) measurements identified the Si acceptor as the dominant residual impurity which was distributed very uniformly throughout the ingots. In addition, a correlation was established between residual impurity concentration and key growth parameters, such as temperature, baking time of the Ga-As solution, and the solution volume. (Author abstract) 17 refs.

Bryskiewicz, T. (MIT, Cambridge, MA, USA); Bugajski, M.; Lagowski, J.; Gatos, H.C. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 136-141.

**094006 EFFECT OF CRYSTAL RADIUS FLUCTUATIONS ON THE STRESS FIELD IN LEC GALLIUM ARSENIDE.** Calculations of the shear stress field in LEC Gallium Arsenide have been carried out in which the crystal radius was systematically changed during growth. Various combinations of wavelength and amplitude of fluctuations were considered both in the bulk

crystal and the seeding cone. For the bulk crystal, the maximum shear stress is shown to increase as the amplitude of the fluctuations increases and the wavelength decreases. For fluctuations with wavelengths less than 20 mm, the shear stress increases hyperbolically with decreasing wavelength. Fluctuations in radius in the seeding cone result in higher stresses in the cone, but these stresses do not reach the stresses in the bulk crystal. (Author abstract) 9 refs.

Schvezov, C.E. (Univ of British Columbia, Vancouver, BC, Can); Samarasekera, I.V.; Weinberg, F. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 142-147.

**094007 COMPLEX FLOW PHENOMENA IN VERTICAL MOCVD REACTORS: EFFECTS ON DEPOSITION UNIFORMITY AND INTERFACE ABRUPTNESS.** The structure of axisymmetric flow patterns in vertical MOCVD reactors is studied with emphasis on their effect on deposition rate uniformity and interface abruptness. Flow visualizations by illuminating  $\text{TiO}_2$  seed particles in a sheet of laser light are used to illustrate forced and mixed convection flows. Excellent agreement between experimental observations and model predictions is demonstrated. Simulations show that the film thickness uniformity is affected by susceptor edge, reactor wall and buoyancy effects. Furthermore, nonlinear interactions between transport processes lead to multiple steady flows for typical operating conditions. The deposition of GaAs and AlAs from  $\text{Ga}(\text{CH}_3)_3$ ,  $\text{Al}(\text{CH}_3)_3$  and  $\text{AsH}_3$  are used as case studies. Simulations of solid and gas phase concentration transients in the growth of AlAs/GaAs interfaces illustrate the effects flow structures have on interface abruptness. (Author abstract) 24 refs.

Fotiadis, Dimitrios I. (Univ of Minnesota, Minneapolis, MN, USA); Kremer, Anthony M.; McKenna, Donald R.; Jensen, Klavs F. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 154-164.

**094008 IN SITU MASS SPECTROSCOPY AND THERMOGRAVIMETRIC STUDIES OF GaAs MOCVD GAS PHASE AND SURFACE REACTIONS.** Two special MOCVD reactors systems designed for in situ monitoring of gas phase and surface reactions are presented. The gas phase decomposition mechanisms of  $\text{Ga}(\text{CH}_3)_3$ ,  $\text{Ga}(\text{C}_2\text{H}_5)_3$  and  $\text{As}(\text{CH}_3)_3$  in  $\text{H}_2$ , He and  $\text{D}_2$  are investigated by molecular beam sampled mass spectroscopy. The data show that the initial thermal pyrolysis reaction of  $\text{Ga}(\text{CH}_3)_3$  and  $\text{As}(\text{CH}_3)_3$  is a unimolecular reaction leading to the loss of methyl groups. A new thermogravimetric MOCVD system is used to measure surface reaction rates of  $\text{Ga}(\text{CH}_3)_3$  and  $\text{As}(\text{CH}_3)_3$  at low pressures, where mass transfer effects are absent. Data for varying total pressures and constant partial pressures of  $\text{Ga}(\text{CH}_3)_3$  and  $\text{As}(\text{CH}_3)_3$  indicate that the growth rate at reduced pressures is influenced by gas phase reactions. At low pressures surface reactions appear to dominate and at high temperatures the growth rate goes to zero and etching takes place. (Edited author abstract) 31 refs.

Lee, Peter W. (Univ of Minnesota, Minneapolis, MN, USA); Omstead, Thomas R.; McKenna, Donald R.; Jensen, Klavs F. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 165-174.

**094009 LIQUID PHASE EPITAXY OF GaAs QUANTUM WELL STRUCTURES.** Gallium arsenide quantum wells are grown by liquid phase epitaxy. The growth parameters are carefully adjusted in order to prevent any dissolution of the GaAlAs layer by the GaAs growth solution as well as to eliminate solution carryover. The interfaces between the thin GaAs layer and the GaAlAs cladding layers are therefore chemically abrupt. Due to a specific difference in the growth morphologies of GaAlAs and GaAs, the GaAlAs/GaAs and the GaAs/-



GaAlAs heterointerfaces differ considerably. The different interface morphologies cause quantum well thickness fluctuations which influence the line-widths of the quantum well related optical transitions. Photoluminescence measurements presently reveal minimum line-widths of 2.5 meV, and discrete  $n=1$  heavy-hole,  $n=1$  light-hole, and  $n=2$  heavy-hole exciton transitions are clearly detected by photoluminescence-excitation spectroscopy. (Author abstract) 13 refs.

Bantien, F. (Max-Planck-Institut fuer Festkörperforschung, Stuttgart, West Ger); Kelting, K.; Bauser, E. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 194-198.

**094010 GROWTH AND CHARACTERIZATION OF GaAs ON Si SUBSTRATES GROWN BY MOLECULAR-BEAM EPITAXY.** Single-crystal GaAs layers have been grown by molecular beam epitaxy (MBE) on (100) Si substrates. Surface morphology, defect density, and optical and electrical properties have been studied as a function of the growth parameters. The characterization techniques included photoluminescence, Hall effect, cross-sectional transmission electron microscopy, and X-ray diffraction. GaAs metal semiconductor field-effect transistors on Si exhibited transconductances of  $128 \text{ mS} \cdot \text{mm}^{-1}$  and current-gain cutoff frequencies as high as 19 GHz. Special heterostructures showed Shubnikov-de Haas oscillations at low temperature and plateaus in the Hall resistance, which confirmed the presence of two-dimensional electron gas in the heterostructure. (Author abstract) 28 refs.

Mandeville, P. (Bell-Northern Research Ltd, Ottawa, Ont, Can); SpringThorpe, A.J.; Miner, C.J.; Bruce, R.A.; Currie, J.F.; McAlister, S.P. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 897-903.

**094011 GROWTH OF GALLIUM ARSENIDE ON Si(100) BY MOLECULAR-BEAM EPITAXY.** The growth of GaAs on Si(100) directly and with Ge buffer layers has been carried out sequentially under ultra high vacuum conditions in a double-ended III-V and group IV molecular beam epitaxy system. These heterostructures were examined by cross-sectional transverse emission microscopy, Rutherford backscattering, X-ray diffraction, and photoluminescence spectroscopy. Dislocation densities were observed to be high ( $\geq 10^9 \text{ cm}^{-2}$ ) near both the GaAs-Si and the Ge-Si interfaces and to decrease to approximately  $5 \times 10^8 \text{ cm}^{-2}$  a few micrometers from these interfaces. No dislocations were observed to originate at the GaAs-Ge interface, but the threading dislocations existing in the Ge buffer layer were found to propagate across this interface without significant deviation. The crystalline quality of the GaAs grown on Ge buffer layers was comparable with that grown on Si directly. (Author abstract) 11 refs.

Moore, W.T. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Devine, R.L.S.; Maigne, P.; Houghton, D.C.; Baribeau, J.-M.; Denhoff, M.W.; Jackson, T.E.; Kornelsen, E.V.; SpringThorpe, A.J.; Mandeville, P. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 904-908.

**094012 GROWTH AND PROPERTIES OF  $\text{Ga}_{1-x}\text{In}_x\text{As}$  STRAINED LAYER SUPERLATTICES GROWN BY LOW-PRESSURE METAL-ORGANIC VAPOUR-PHASE EPITAXY.** We have analyzed the structural and optical properties of  $\text{Ga}_{1-x}\text{In}_x\text{As}$ -GaAs strained-layer superlattices (SLS) grown by low-pressure metal-organic vapour-phase epitaxy. Sample uniformity over  $2.5 \text{ cm} \times 2.5 \text{ cm}$  has been studied by X-ray diffraction and low-temperature photoluminescence. The sample composition and period are uniform in the longitudinal direction (gas-flow direction in the reactor) and in the central portion (1.5 cm) in the transverse direction. On each side, the In composition decreases slightly towards the edges, as shown by an energy shift of the photoluminescence excitonic recombinations. Comparison of experimental and calculated transition energies in a series of samples, taking into account strain and

quantization, shows clearly that SLS grown on mismatched buffer layers are under additional strain. This additional strain is not present when the layer or whole SLS thicknesses exceed a critical value beyond which the mismatch is partially accommodated by misfit dislocations. (Author abstract) 17 refs.

Roth, A.P. (Nat'l Research Council, Ottawa, Ont, Can); Masut, R.A.; Sacilotti, M.; D'Arcy, P.J.; Sproule, G.I.; Mitchell, D.F.; LePage, Y. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 909-912.

**094013 STRUCTURE OF HETEROEPITAXIAL GaAs ON Si.** We present x-ray scattering results which indicate that thin GaAs films are compressed in the film plane at room temperature, while thicker films are under tensile stress, the cross-over region being at about 1000 Å. In addition, we show that the GaAs lattice is translationally incommensurate with the Si substrate and that the in-plane [001] axes are misaligned by 3-5°. Thermal expansion measurements of the out-of-plane lattice parameters of the film and substrate indicate that the GaAs in-plane thermal expansion follows from the anharmonicity of the substrate. (Edited author abstract) 8 refs.

Zabel, H. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Lucas, N.; Feidenhans, R.; Als-Nielsen, J.; Morkoc, H. *Superlattices Microstruct* v 3 n 5 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 515-517.

## Halogenation

**094014 FLUORINATION OF GaAs.** [Fluorination of GaAs]. Coating layers were grown on GaAs (100) by oxidation under fluorine of the semiconductor. For a fluorination temperature close to 400°C and a fluorine pressure of 1 bar, Rutherford backscattering (RBS) of 2 MeV  $\alpha$  particles and infrared measurements show that the inner part of the layers is mainly constituted of the fluoride of III-B element. However XPS studies performed on very thin layers (40 Å-50 Å) reveal that arsenic as gallium is always present near the interfaces and is bound with fluorine. At room temperature for a sweep frequency down to 0.01 Hz, the 1 MHz C(V) characteristics show that an important modulation of the surface potential of the semiconductor is obtained without hysteresis. (Author abstract) 3 refs. In French.

Barriere, A.S. (Univ de Bordeaux I, Talence, Fr); Guegan, H.; Seguelong, T.; Thabti, A.; Desbat, B.; Bertault, D.; Alnot, P.; Chazelas, J. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 215-216.

**Heat Treatment** See Also SEMICONDUCTING INDIUM COMPOUNDS—Heat Treatment.

**094015 RAPID THERMAL ANNEALING OF IMPLANTED LAYERS IN SILICON NITRIDE ENCAPSULATED GALLIUM ARSENIDE.** The rapid thermal annealing (RTA) of implanted layers in semi-insulating gallium arsenide encapsulated with silicon nitride has been investigated and compared with conventional hot wall furnace annealing. The evaluation was based on comparisons of the electrical characteristics of MESFET's including channel sheet resistance, pinchoff voltage, saturation drain current, and isolation sheet resistance. The results show that a high degree of uniformity and reproducibility of device characteristics over full 2 and 3 in. wafers can be obtained using rapid thermal annealing. (Edited author abstract) 9 refs.

Wilson, M.R. (Univ of Cincinnati, Cincinnati, OH, USA); Kosel, P.B.; Shen, Y.D.; Welch, B.M. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2560-2565.

**Impurities** See Also SEMICONDUCTING GALLIUM COMPOUNDS—Impurities; SEMICONDUCTOR MATERIALS—Impurities; SEMICONDUCTOR MATERIALS—Spectrum Analysis.

**094016 MULTIPLE STRUCTURES OF TRANSITION-METAL DEEP IMPURITIES IN GaAs.** The multiplet structures of substitutional 3d transition-metal (TM) impurities Ti to Ni in GaAs have been calculated by the first-principles cluster method, which connects the calculated results of the one-electron energy levels by the LDA approach on the cluster consisting of 59 atoms with the ligand-field theory of Sugano, Tanabe and Kamimura. The present theory explains fairly well experimental results on the low-lying multiplets of various TM impurities in GaAs and also reproduces qualitatively the observed chemical trend seen in the ionization energies of TM impurity acceptors. (Author abstract) 20 refs.

Watanabe, Satoshi (Univ of Tokyo, Tokyo, Jpn); Kamimura, Hiroshi. *J Phys C Solid State Phys* v 20 n 26 Sep 20 1987 p 4145-4157.

**094017 POLARON EFFECTS ON THE BINDING ENERGY OF A HYDROGENIC IMPURITY IN A SEMICONDUCTOR QUANTUM WELL.** The polaron effect on the ground-state level of a hydrogenic impurity in a semiconductor quantum well is calculated as a function of the well thickness. The formulation is based on an extension of the strong-coupling polaron theory and covers the overall range of the electron-phonon coupling strength. It is observed that in a GaAs-based quantum structure the phonon-induced shift in the binding energy is smaller than that in the bulk case except for too narrow well sizes. (Author abstract) 10 refs.

Ercelbi, A. (Middle East Technical Univ, Ankara, Turk); Sualp, G. *J Phys C Solid State Phys* v 20 n 33 Nov 30 1987 p 5517-5526.

**094018 SEM AND EMPA ANALYSIS OF IMPURITIES RELATED TO GaAs SUBSTRATES AND MBE GROWN GaAs LAYERS.** Distribution of impurities on heat-treated GaAs substrates and layers has been investigated by SEM in conjunction with EMPA analysis. The layers were grown by MBE on both undoped and chromium doped semi-insulating substrates. Comparisons of the electron micrographs and the corresponding EMPA spectra suggest that heating causes the impurities, namely Si, Fe and Cr, to diffuse out from the substrate and redistribute themselves on the layer surface resulting in characteristic defect patterns. No effects due to arsenic over-pressure and/or presence of carbon in the growth environment were apparent, as suggested by previous studies. (Author abstract) 10 refs.

Kadhim, N.J. (Hatfield Polytechnic, Hatfield, Engl); Mukherjee, D. *Vacuum* v 38 n 1 1988 p 11-12.

**094019 SUBSTRATE-IMPURITIES EFFECTS ON GaAs MESFETs.** The effects of background impurities in LEC and HB-grown, doped and undoped GaAs substrates on electron-concentration profiles and ion-implanted MESFET threshold voltages are modeled. For realizing the most steeply falling channel electron profiles, high concentrations of either deep or shallow acceptors are required. When background acceptor impurities are absent, the electron profiles follow the slowly falling ion-implant profiles, which are strongly influenced by ion channeling. The use of buried p layers to give steeply falling profiles, and to reduce the dependence of MESFET threshold voltages on fluctuating acceptor impurities in GaAs is proposed. (Author abstract) 28 refs.

Anholt, R. (Stanford Univ, Stanford, CA, USA); Sigmon, T.W. *J Electron Mater* v 17 n 1 Jan 1988 p 5-10.

**094020 APPROXIMATE TREATMENT OF LOCALIZED VIBRATIONAL MODES.** The 'rigid-well' approximation for the local vibrational mode frequency of a light impurity in a crystal in which only the impurity itself is regarded as moving may be regarded as the leading term in an expansion in powers of the ratio of the impurity mass to the host mass or masses. It is found that the retention of only one further term provides an analytic approximation that is quantitatively useful over a much wider range of cases of interest. This approximation



assumes a particularly simple form if the contributions from the motion of second and further neighbors of the impurity are negligible. Various applications are presented. (Author abstract) 22 refs.

Leigh, R.S. (Univ of Reading, Reading, Engl); Newman, R.C. *Semicond Sci Technol* v 3 n 2 Feb 1988 p 84-89.

**094021 DETERMINATION OF THE RESIDUAL CARBON ACCEPTOR CONCENTRATION IN SEMI-INSULATING GaAs WAFERS BY IR SPECTROSCOPY: ACCURACY AND DETECTION LIMITS.** The IR absorption method is investigated in detail with respect to a routine application in semiconductor industry laboratories. The experimental and analytical procedures necessary for an accurate determination of the residual carbon acceptor ( $C_A$ ) concentration also in commercial wafers are given. A specific technique to eliminate the interference fringes arising from multiple reflections inside the wafer is presented. At a measurement temperature of 77 K the detection limit for carbon is  $6 \times 10^{13} \text{ cm}^{-3}$  in wafers of 5 mm thickness. The IR method is also applicable to commercial wafers giving a detection limit of about  $6 \times 10^{14} \text{ cm}^{-3}$ . (Author abstract) 18 refs.

Alt, H.Ch. (Siemens Research Lab, Munich, West Ger). *Semicond Sci Technol* v 3 n 2 Feb 1988 p 154-159.

**094022 DEFECT INDUCED RAMAN TRANSITION IN NON-STOICHIOMETRIC Ga-RICH GaAs: A PSEUDOLocalized VIBRATIONAL MODE OF THE GaAs ANTISITE?** Raman scattering with below band gap excitation has been used to study as grown GaAs pulled from Ga-rich melts. A vibrational pseudolocalized defect mode is observed at  $225 \text{ cm}^{-1}$  in material, which also contains the 78/203 meV double acceptor. The temperature variation of the  $225 \text{ cm}^{-1}$  Raman peak is found to depend on the charge state of the double acceptor. These findings indicate that the 78/203 meV acceptor levels and the  $225 \text{ cm}^{-1}$  vibrational mode may arise from the same defect center. Possible models for this center are discussed including the Ga-antisite defect. (Author abstract) 14 refs.

Wagner, J. (Fraunhofer-Inst fuer Angewandte Festkoerperphysik, Freiburg, West Ger); Ramsteiner, M.; Newman, R.C. *Solid State Commun* v 64 n 4 Oct 1987 p 459-463.

**094023 INTERACTION BETWEEN DISLOCATIONS AND In IN In-DOPED GaAs SINGLE CRYSTALS UNDER HIGH-TEMPERATURE PLASTIC DEFORMATION.** The interaction between dislocations and indium has been studied in In-doped GaAs under high-temperature plastic deformation. This interaction is revealed by yield drops in the stress-strain curves after stress relaxations, and by serrated yielding (the Portevin-Le Chatelier effect). Static aging can be shown to be due to elastic interactions, in agreement with the model recently proposed by M. Ehrenreich and J.P. Hirth. (Author abstract) 22 refs.

Djemel, A. (CNRS, Meudon, Fr); Castaing, J.; Duseaux, M. *Philos Mag A* v 57 n 4 Apr 1988 p 671-676.

**094024 IMPURITY BANDS IN  $\text{Ga}_{1-x}\text{Al}_x\text{As}/\text{GaAs}$  QUANTUM WELLS.** We calculate the Density-of-States (DOS) for electrons bound to impurities in a thin sheet inside a  $\text{Ga}_{1-x}\text{Al}_x\text{As}/\text{GaAs}$  quantum well. Impurities are considered at the center, midway to the interface and at the interface of the GaAs layer. It is shown that for reasonable impurity concentrations an impurity band appears separated from the lowest subband. The bandwidth is comparable with that obtained due to diagonal disorder assuming a uniform distribution inside the whole well. (Author abstract) 6 refs.

de Andrada e Silva, E.A. (Inst de Pesquisas Espaciais, Sao Jose dos Campos, Brazil); da Cunha Lima, I.C. *Solid State Commun* v 64 n 1 Oct 1987 p 113-115.

**094025 ABNORMAL Si AND Zn IMPURITY DISTRIBUTIONS AT INTERFACES IN HOMO-EPI-TAXIAL GaAs GROWN BY ATMOSPHERIC**

**PRESSURE METAL ORGANIC VAPOUR PHASE EPITAXY (MOVPE).** Anomalous impurity distributions ('spikes') of silicon and zinc at the interface of homoepitaxial gallium arsenide (GaAs) grown by atmospheric pressure metal organic vapour phase epitaxy (MOVPE) have been observed and measured by dynamic secondary ion mass spectrometry (SIMS). The magnitudes of the spikes vary with the method of heating used during growth and with the temperature and flow of arsine ( $\text{AsH}_3$ ) used during the bakeout procedure prior to epitaxial growth. (Author abstract) 17 refs.

Hunt, Neil (UMIST, Manchester, Engl); Henderson, Douglas K.; Williams, John O. *Chemtronics* v 3 n 2 Jun 1988 p 86-89.

**094026 EFFECTS OF SUBSTRATE MISORIENTATION AND GROWTH TEMPERATURE ON IMPURITY INCORPORATION IN HYDROGEN REDUCTION CHLORIDE VPE OF GaAs.** Effects of misorientation of the substrate and growth temperature on the carrier concentration were investigated for the epitaxial growth of GaAs by chloride vapor phase epitaxy (VPE) utilizing the hydrogen reduction method. Carrier concentrations of the epitaxial layers grown on  $2^\circ$  off (100) substrates are always about one half of those on exactly (100) substrates, even though the compensation ratios are the same. The carrier concentration and the total impurity incorporated increase monotonically with increase of the growth temperature, but the compensation ratio is a minimum at a growth temperature of  $750^\circ\text{C}$  and increases at higher and lower growth temperatures. These results seem to be explained by the Kossel model, i.e. by smaller segregation constants of the impurities for  $2^\circ$  off (100) substrates with many growth steps. (Author abstract) 18 refs.

Hasegawa, F. (Univ of Tsukuba, Tsukuba Science City, Jpn); Yamamoto, T.; Arima, E.; Nannichi, Y. *J Cryst Growth* v 89 n 4 7(1) 1988 p 511-518.

**094027 THEORY OF IMPURITY BAND RECOMBINATION.** Multiple scattering theory (MST) according to Klauder applied to the energy spectrum of a semiconductor enables the description of the extreme case of heavily doped as well as of slightly doped material. For doping levels of donors and acceptors below the Mott density the MST provides an impurity band state density for electrons and holes and an almost parabolic conduction and valence band state density. In the framework of this procedure we have calculated the whole luminescence spectrum of GaAs. The considered doping is of n-type ( $N_D = 5 \times 10^{14} \text{ cm}^{-3}$ ), where the degree of compensation of the material is assumed to amount to 10%. The theoretical results are compared with measured luminescence spectra. (Author abstract) 5 refs.

Haufe, A. (Karl-Marx-Univ, Leipzig, East Ger); Fieseler, H.; Schwabe, R. *Phys Scr* v 38 n 1 Jul 1988 p 111-113.

**094028 IMAGING AND ANALYSIS OF CARBON DISTRIBUTION IN GaAs USING RADIOACTIVE TRACER  $^{14}\text{C}$ .** Microscopic segregation of carbon in GaAs has been studied using autoradiography of a crystal doped with radioactive tracer  $^{14}\text{C}$ . The autoradiographs were compared to images of the wafers obtained by photoetching and by high resolution scanning photoluminescence microscopy. It was found that the carbon distribution is homogeneous within the limit of the resolution of the radiographs of about  $15 \mu\text{m}$  and that there is no correlation between the carbon distribution and the luminescence contrast. (Author abstract) 11 refs.

Bourret, E.D. (Lawrence Berkeley Lab, Berkeley, CA, USA); Guitron, J.B.; Haller, E.E. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 290-294.

**094029 PROPERTIES OF THE 78 meV ACCEPTOR IN GaAs.** An acceptor with a binding energy of 78 meV is frequently observed in LEC GaAs. As a commonly observed acceptor its identification and control are important aspects of materials development. It has recently been

shown to be a double acceptor with a second level at 203 meV. Although it is a common center its origin has not yet been conclusively determined; both the gallium antisite and boron on the arsenic site are often proposed origins. Experimental and theoretical studies of this acceptor are reviewed including the identification of the center as a double acceptor, the origins of the various photoluminescence properties, infrared absorption by the electronic levels of this impurity, Raman studies of the S-states, and experiments bearing on its identification. (Author abstract) 27 refs.

Moore, W.J. (US Naval Research Lab, Washington, DC); Hawkins, R.L.; Shanabrook, B.V. *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 65-74.

**094030 OPTICAL AND ELECTRICAL STUDIES OF LIQUID-ENCAPSULATED CZOCHRALSKI SEMI-INSULATING GaAs WITH DIFFERENT CARBON CONCENTRATIONS.** The effects of the presence of carbon over a range of approximately  $10^{14}$ - $10^{16} \text{ cm}^{-3}$ , in liquid-encapsulated Czochralski-grown semi-insulating GaAs have been studied using Fourier-transform infrared (FTIR), photoluminescence, and photo-induced transient spectroscopy (PITS), and temperature-dependent Hall-effect measurements. From photoluminescence measurements in the temperature range of 4-30 K, the decay signal was found to consist of two parts, the initial decay obeying an exponential behaviour with an activation energy of 15 meV and the subsequent decay obeying a power law of the form  $t^{-P}$  with the values of  $P$  ranging from 1.4 to 3.5. Results from PITS measurements revealed a broad peak at about 240 K which could be due to the formation of a free As vacancy or its complexes. The intensity of the EL2 family of emission peaks was directly dependent on the water content of the boric oxide encapsulant used during the growth process. Mobility and resistivity of the samples were also measured and tabulated. (Edited author abstract) 17 refs.

Teh, C.K. (Univ of Alberta, Edmonton, Alberta, Can); Tin, C.C.; Weichman, F.L. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 945-949.

**094031 INVERTED POPULATIONS OF HOT ELECTRONS IN A MAGNETIC FIELD: THE EFFECTS OF ELECTRON-ELECTRON AND IMPURITY SCATTERING IN n-GaAs.** Monte Carlo simulation of hot-electron transport in bulk n-GaAs in the presence of crossed electric and magnetic fields shows that inverted populations associated with cyclotron motion can arise at low temperatures provided charged impurity scattering is weak. Electron-electron scattering, even at electron concentrations as low as  $10^{14} \text{ cm}^{-3}$ , at 10K limits the range of electric fields over which inversion occurs. Strong negative magnetoresistance, though weakening, persists to 300K, even in the presence of an impurity and electron concentration of  $2 \times 10^{17} \text{ cm}^{-3}$ , and dynamic screening of the polar interaction. (Author abstract) 9 refs.

Abou El-El, F. (Univ of Essex, Colchester, Engl); Ridley, B.K. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 691-694.

**Ion Implantation** See Also SEMICONDUCTING ALUMINUM COMPOUNDS—Ion Implantation; SEMICONDUCTOR DEVICES, FIELD EFFECT—Thermal Effects; SEMICONDUCTOR MATERIALS—Ion Implantation; SPECTROMETERS—Calibration; TRANSISTORS, BIPOLAR—Fabrication; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, FIELD EFFECT; TRANSISTORS, FIELD EFFECT—Analysis; TRANSISTORS, FIELD EFFECT—Fabrication; TRANSISTORS, FIELD EFFECT—Materials; TRANSISTORS, FIELD EFFECT—Mathematical Models; TRANSISTORS, FIELD EFFECT—Transistors.



**094032 THERMAL DIFFUSION OF BURIED BERYLLIUM AND SILICON LAYER IN GaAs DOPED BY FOCUSED ION BEAM IMPLANTATION.** The diffusion profiles of buried Be and Si doped by focused ion beam (FIB) implantation in GaAs after annealing were investigated. The diffusion coefficients of Be and Si were determined by fitting from the results of computer calculations. The diffusion coefficient of FIB-doped Be was enhanced by excess interstitial Be. Beryllium diffusion profiles expand by annealing with a high dose of 850°C. The concentration-dependent diffusion of Si in GaAs doped using a molecular beam was observed. The diffusion coefficient of Si heavily doped by FIB, however, was undetectably small in contrast with that of Be at 850°C. (Author abstract) 12 refs.

Morita, Tetsuo (Optoelectronics Joint Research Lab, Kawasaki, Jpn); Kobayashi, Junji; Takamori, Takeshi; Takamori, Akira; Miyauchi, Eizo; Hashimoto, Hisao. *Jpn J Appl Phys Part 1* v 26 n 8 Aug 1987 p 1324-1327.

**094033 COMPOSITIONAL DISORDERING OF SI-IMPLANTED GaAs/AlGaAs SUPERLATTICES BY RAPID THERMAL ANNEALING.** Compositional disordering of Si-implanted GaAs/Al<sub>0.5</sub>Ga<sub>0.5</sub>As superlattices, followed by rapid thermal annealing (RTA), is investigated by means of sputtering Auger electron spectroscopy (AES) and Raman spectroscopy. The disordering was found to take place in the Si-implanted superlattices with a dose of  $1 \times 10^{15} \text{ cm}^{-2}$ , annealed at 1000°C for 4 to 30 seconds, resulting in an Al<sub>0.25</sub>Ga<sub>0.75</sub>As alloy. The Raman spectra showed that this alloy had a higher quality as the implanted samples were annealed for longer periods of time. (Author abstract) 12 refs.

Uematsu, Masashi (NTT, Atsugi, Jpn); Yanagawa, Fumihiko. *Jpn J Appl Phys Part 2* v 26 n 8 Aug 1987 p 1407-1409.

**094034 ELECTRICAL CHARACTERIZATION OF ION IMPLANTATION INTO GaAs: TOPOGRAPHY AND DEPTH PROFILES.** Recent advances in the characterization of ion-implanted GaAs samples have included whole wafer mapping (topography) and depth profiling techniques. We review several methods for mapping electrical parameters, including the dark-spot resistance (DSR), and the microwave photoconductance techniques. In addition, we suggest a new photo-Hall technique which would allow mobility ( $\mu$ ) and carrier-concentration ( $n$ ) mapping as well as that of resistivity ( $\rho$ ). Finally, we review methods for obtaining  $\mu$ ,  $n$  and depth profiles, with particular emphasis on the application of the magnetoresistance techniques in actual field-effect transistor structures. (Author abstract) 41 refs.

Look, D.C. (Wright State Univ, Dayton, OH, USA). *J Electrochem Soc* v 134 n 10 Oct 1987 p 2527-2533.

**094035 SUBSTRATE IMPURITY MIGRATION DURING RAPID THERMAL ANNEALING OF SI IMPLANTED GaAs.** One of the potential advantages of rapid thermal annealing (RTA) compared to conventional furnace annealing is reduced implant dopant and background impurity diffusion. In this paper, the migration of Cr and Mn during annealing of Cr-doped semi-insulating GaAs implanted with 100 Kev Si<sup>+</sup> ions at a dose of  $7 \times 10^{12} \text{ cm}^{-2}$  was measured using SIMS. We investigated uncapped RTA at 860° and 930°C for times between 1 and 60s and compared them to capless 30 min furnace anneals. During RTA, Cr migration was severe and showed a strong time-temperature dependence. Mn migration was undetectable for RTA anneals less than 60s, but dominated the 30 min furnace anneals. (Author abstract) 9 refs.

Kanber, H. (Hughes Aircraft Co, Torrance, CA, USA); Whelan, J.M. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2596-2599.

**094036 TRANSIENT ANNEALING OF HIGH DOSE Mg IMPLANTS IN GaAs.** Transient anneals of high dose ( $10^{15} \text{ cm}^{-2}$  at 150 keV) Mg implants in GaAs showed a maximum in sheet carrier density of  $2.1 \times 10^{14} \text{ cm}^{-2}$  at 750°C/5 s. Close correlation of carrier concentration vs. depth profiles with atomic concentration vs. depth

profiles strongly indicated that the electrical behavior of the implant is governed by redistribution of the implant; up to 50% of the total dose being lost to the cap after a transient anneal at 900°C/5 s. (Author abstract) 14 refs.

Szweda, R. (Plessey Research (Caswell) Ltd, Towcester, Engl); Lamb, M.S.M.; Blunt, R.T. *Chemtronics* v 2 n 2 Jun 1987 p 89-92.

**094037 SILICON NITRIDE FILM AS GaAs ANNEALING ENCAPSULANT.** Doping GaAs wafers using ion implantation is widely used in the semiconductor industry. Because of the damage caused by this procedure, the wafer must be annealed at temperatures approaching 900°C. This relieves the stress and damage in the wafer caused by the ions, and activates the implant. To avoid dissociation of the gallium and arsenic at these elevated temperatures, the wafer is enveloped in a dielectric sheath which acts as a diffusion barrier. This film must offer good adhesion to the substrate, be free of pinholes, have excellent thermal cycling properties and still act as a diffusion mask against Ga and As. Such a film offers additional physical protection during handling and subsequent photolithography. The dielectric must also be of such a quality that after all this processing it can be removed easily. Silicon dioxide, oxynitride and nitride have been used as encapsulants on III-V materials. This article concentrates on silicon nitride and investigates its behavior during annealing. 7 refs.

Kiermasz, A. (Electrotech, Bristol, Engl); McQuarrie, A.; Bhardwaj, J. *Semicond Int* v 10 n 12 Nov 1987 p 107-110.

**094038 SI IMPLANTATION IN UNDOPED Si GaAs AND ITS ANNEALING BEHAVIOR.** Undoped Si GaAs single crystals are the substrates for full ion implanted GaAs MESFET. The authors studied <sup>29</sup>Si<sup>+</sup> implantation HPDS LEC undoped Si GaAs and its annealing behavior including the effects of annealing temperature, time and As pressure on the carrier profile, electrical activation efficiency and Hall mobility. The undoped Si GaAs single crystal is superior to the Cr-doped single crystal. (Edited author abstract) In Chinese. 13 refs.

Xia, Guan-qun (Acad Sinica, China); Chen, Zi-yao; Wang, Wei-yuan; Wang, Yong-hong; Ma, Bi-chun. *Xi You Jin Shu* v 6 n 2 May 1987 p 97-100.

**094039 LASER ANNEALING OF GaAs IMPLANTED WITH LOW DOSES OF SELENIUM IONS.** GaAs samples were implanted with 100-400 keV,  $10^{12}$ - $10^{14} \text{ cm}^{-2} \text{ Se}^+$  ions and annealed using undiffused and diffused pulsed ruby-laser beams with the samples held at various temperatures. The resulting surface and structural defects as observed by various microscopic and spectroscopic methods are related to measured electrical properties of implanted GaAs, and the causes of the observed poor and lack of electrical activation of samples identified. Laser irradiation of samples ( $T \approx 516^\circ\text{C}$ ) induces surface damage in the form of regular parallel broken lines with a periodicity of about 0.69  $\mu\text{m}$ , the wavelength of the ruby laser. A diffused laser beam ( $\leq 0.5 \text{ J/cm}^2$ ) reduces surface vaporization and eliminates periodic surface structures. The measured electrical properties are still poor. (Author abstract) 20 refs.

Akintunde, J.A. (Univ of Ife, Ile-Ife, Nigeria). *Solid State Electron* v 30 n 12 Dec 1987 p 1251-1258.

**094040 DAMAGE DISTRIBUTION IN Si<sup>+</sup>-IMPLANTED GALLIUM ARSENIDE-LATTICE IMAGING.** Silicon-implanted GaAs is studied by cross-sectional high-resolution transmission electron microscopy. A diffusion zone, next to the maximum of radiation-defect clusters, distribution with an extension of 200-300 Angstrom has been observed. The changes of the contrast are interpreted as related with radiation-enhanced diffusion of As interstitials. (Author abstract) 14 refs.

Vitali, G. (Univ of Rome 'La Sapienza', Rome, Italy); Kalitzova, M.; Pashov, N.; Werner, P.; Bartsch, H. *Appl Phys A* v 45 n 2 Feb 1988 p 133-135.

**094041 TRANSIENT ANNEALING OF Sn<sup>+</sup> IM-**

**PLANTED GaAs.** High temperature ( $\geq 900^\circ\text{C}$ ) transient annealing of Sn<sup>+</sup> implants into GaAs have been studied by secondary ion mass spectroscopy, electrical measurements and transmission electron microscopy. A two-layer encapsulant ( $\text{Si}_3\text{N}_4 + \text{AlN}$ ) has been used prior to annealing using an incoherent light furnace. Secondary ion mass spectroscopy measurements show that outdiffusion of tin has occurred which depends both on the dose and annealing conditions. The as implanted atomic profiles are wider than the theoretical profiles and up to 17% further broadening occurs during annealing. Electron concentrations approach  $10^{19} \text{ cm}^{-3}$  have been measured reproducibly. Transmission electron microscopy results show both faulted and unfaulted dislocation loops and dislocation lines, all defects being decorated with precipitates which contain metallic tin. A large concentration of stacking fault tetrahedra is also produced. (Author abstract) 12 refs.

Shahid, M.A. (Univ of Surrey, Guildford, Engl); Bensalem, R.; Sealy, B.J.; Favennec, P.N.; Gauneau, M. *Nucl Instrum Methods Phys Res Sect B* v B30 n 4 Apr 1 1988 p 531-539.

**094042 MeV S IMPLANTATION INTO GaAs.** The physical and electrical characteristics of MeV S implants into GaAs have been studied. The redistribution of the ion implanted S has been investigated using secondary ion mass spectroscopy and electrochemical capacitance-voltage profiling. The redistribution of the implanted S has been greatly reduced when rapid thermal anneal, instead of furnace anneal, is employed for activation. The measured diffusion coefficient (using RTA) is  $3.7 \times 10^{-12} \text{ cm}^2/\text{s}$ , which is comparable to that measured in furnace annealed samples. Hence the reduction in the redistribution is solely from a reduction of the time at temperature. (Edited author abstract) 26 refs.

Thompson, Philip E. (US Naval Research Lab, Washington, DC, USA); Dietrich, Harry B. *J Electrochem Soc* v 135 n 5 May 1988 p 1240-1244.

**094043 COMPOSITION AND CARBON EFFECTS ON UNIFORMITY FOR IMPLANTED ACTIVE LAYERS FABRICATED IN UNDOPED LEC GaAs.** Fluctuations in carrier concentrations in implanted layers were found to depend on the carbon concentration in substrates. Real composition effects, i.e. not via carbon, were clarified, when the carbon concentration was reduced to  $\approx 3 \times 10^{14} \text{ atoms/cm}^3$ . Fluctuations in the carrier concentration were least, when a crystal was grown from raw materials with an atomic ratio (Ga/As)<sub>m</sub> around 0.95. (Author abstract) 4 refs.

Usuda, K. (Toshiba Corp, Kawasaki, Jpn); Yasuami, S. *Mater Lett* v 6 n 5-6 Mar 1988 p 164-166.

**094044 ANNEALING BEHAVIOUR OF Be- AND Mg-IMPLANTS IN GaAs.** Mg<sup>+</sup> and Be<sup>+</sup> ions were implanted into semi-insulating GaAs with doses ranging from  $10^{14}$  to  $2 \times 10^{15} \text{ cm}^{-2}$ . Both implants were annealed by furnace anneal (FA) as well as by rapid thermal anneal (RTA) with various annealing temperatures and were analyzed by Secondary Ion Mass Spectroscopy (SIMS), Hall and electrochemical carrier profile measurements. Both Mg and Be as-implanted profiles can be fitted by Pearson-IV distributions. After RTA SIMS measurements show significant diffusion only for high-temperature anneals. In this case Be exhibits large diffusion tails and distinct steps in the atomic profile, whereas Mg shows only a slight dopant redistribution. However, after FA generally strong dopant redistribution and surface peaks can be observed. Mg implants yield lower activation and higher sheet resistances than Be when identical implantation doses and annealing cycles are used. (Author abstract) 18 refs.

Humer-Hager, T. (Siemens Research Lab, Munich, West Ger); Zwicknagel, P. *Jpn J Appl Phys Part 1* v 27 n 3 Mar 1988 p 428-433.



**094045 NONDESTRUCTIVE TOPOGRAPHIC EVALUATION OF ION IMPLANTED LAYERS ON GaAs SUBSTRATES BY OPTICAL ABSORPTION.** It is demonstrated that ion implanted layers can be analyzed prior to annealing by measuring the sub-bandgap optical absorption of the damaged lattice. The absolute value and lateral homogeneity of the implantation dose can be measured. The method is fast, nondestructive and compares favorably with existing measurement techniques. (Author abstract) 8 refs.

Windscheit, J. (Fraunhofer-Institut fuer Angewandte Festkörperphysik, Freiburg, West Ger); Wetting, W.; Jantz, W. *Appl Phys A* v 47 n 2 Oct 1988 p 115-118.

**094046 FABRICATION AND PERFORMANCE OF GaAs MESFETS WITH GRADED CHANNEL DOPING USING FOCUSED ION-BEAM IMPLANTATION.** The dopant concentration in the channel region of GaAs MESFETs is tailored by focused ion-beam implantation, allowing the fabrication of devices with higher power ratings than uniformly doped devices of similar dimensions. With this technique, multiple masking steps during fabrication and avoided, and dopant concentration can be changed with great precision in both position and magnitude. The effect of dopant grading on other device parameters, such as the transconductance and the pinch-off voltage, is reported. 8 refs.

Evason, A.F. (Cambridge Univ, Engl); Cleaver, J.R.A.; Ahmed, H. *IEEE Electron Device Lett* v 9 n 6 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 281-283.

**094047 IMPLANTATION IONIQUE A HAUTE ENERGIE DU SI DANS L'AsGa. [High-Energy Implantation of Si Ions in GaAs].** We present a study of the implantations of 7 MeV Si ions into GaAs at a dose of  $10^{14}$  ions/cm<sup>2</sup>. The depth profile of the ions is measured by secondary-ion mass spectroscopy. It is found to be in good agreement with a Monte Carlo calculation based on the Lindhard, Scharff and Schiott model of ion collisions in solids. The penetration depth of the Si ions is 3.38  $\mu$ m, with a standard deviation 0.35  $\mu$ m. The samples are annealed in a rapid annealing oven. A maximal activation of dopants is obtained with a temperature of 850°C for 20 s. The resistivity and average mobility after this anneal are  $3.48 \times 10^{-3}$   $\Omega$ -cm and 2800 cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup> respectively. This suggests that the majority of ions are activated. (Author abstract) 8 refs. In French.

Azelmad, A. (Ecole Polytechnique de Montreal, Montreal, Que, Can); Currie, J.F.; Yelon, A.; Sood, P. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 979-981.

**094048 ETUDE EN XPS DE L'INTERACTION D'OXYGENE IMPLANTE A TRES FORTE DOSE AVEC UN SUBSTRAT DE GaAs. [XPS Study of the Interaction of High-Dose Oxygen Implants with a GaAs Substrate].** The authors have performed XPS studies in function of depth on GaAs samples with high implanted dose, in order to emphasize the chemical interaction of oxygen with the substrate. Successive ion argon etching was used to obtain the depth profiling. In spite of contamination formed by ion implantation or effects of ion etching, it is possible to follow the concentration of Ga3d, As3d and O1s in function of the depth. The peaks decomposed in gaussians by means of a model used before, enabling the authors to emphasize a behavior similar to an interface oxygen-GaAs, with the presence of arsenic element and gallium oxides. (Author abstract) 4 refs. In French.

Quemerais, A. (CNRS, Rennes, Fr); Agliz, D.; Tran, Q. Dang; Priol, M. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 279-280.

## Ionization

**094049 ELECTRON IONIZATION RATE IN MULTILAYERED SEMICONDUCTOR STRUCTURES.**

We present theoretical results of the electron impact ionization rate in GaAs/AlGaAs multi-quantum-well structures as a function of applied electric field for various geometries, i.e., well and barrier widths. In addition, we present preliminary measurements of the current-voltage characteristics of MBE-grown photodiodes which demonstrate very low leakage current as well as sharp breakdown behavior. It is found that the net ionization rate, determined by averaging over the constituent GaAs and AlGaAs layers, approaches the weighted average of the constituent bulk rates at high electric field strengths. (Edited author abstract) 15 refs.

Brennan, K.F. (Georgia Inst of Technology, Atlanta, GA, USA); Wang, Yang; Torabi, A.; Summers, C.J. *Superlattices Microstruct* v 3 n 6 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 673-677.

## Magnetic Field Effects

**094050 HIGH SPEED PULLING OF GaAs SINGLE CRYSTAL USING THE MAGNETIC FIELD APPLIED LEC TECHNIQUE.** The properties of high pulling rate (20-27 mm/h) LEC GaAs single crystals under a magnetic field are investigated by using the infrared absorption coefficient,  $\alpha$ , at a wavelength of 1.0  $\mu$ m, the microscopic resistivity and the Hall measurement technique. The distributions of  $\alpha$  and the microscopic resistivity in these crystals are not as homogeneous as those of the conventional 9 mm/h pulling rate crystal with or without magnetic field. After whole ingot annealing at 950°C, however, high speed pulling crystals are drastically changed to the homogeneous in the distribution of  $\alpha$  and the resistivity. This is attributed to the increase and the homogeneous distribution of the native deep donor in the crystals. (Edited author abstract) 14 refs.

Kimura, Tadashi (Optoelectronics Joint Research Lab, Kawasaki, Jpn); Obokata, Takeshi; Fukuda, Tsuguo. *J Cryst Growth* v 84 n 3 Sep 1987 p 394-398.

**094051 MAGNETIC FIELD DEPENDENCE OF GATE VOLTAGE AND CURRENT IN A GaAs-HETEROSTRUCTURE IN THE QUANTUM HALL REGIME.** The current flow at a fixed gate voltage and the floating gate voltage for fixed charge density in a gated GaAs heterostructure have been measured as a function of the magnetic field. The voltage oscillations which reflect the behavior of the chemical potential have been resolved. The experimental results are explained by a statistical model of inhomogeneities in the carrier concentration implying an effective density of states between the Landau levels. (Edited author abstract) 14 refs.

Weiss, D. (TU Muenchen, Garching, West Ger); Mosser, V.; Gudmundsson, V.; Gerhardt, R.R.; Klitzing, K.V. *Solid State Commun* v 62 n 2 Apr 1987 p 89-91.

**094052 METASTABLE SHALLOW DONOR STATES OF n-GaAs IN A MAGNETIC FIELD.** The photothermal spectrum of shallow donors in n-GaAs has been investigated at various magnetic field strengths up to 4T at different temperatures between 1.4 and 12K. Weak spectral structures observed at frequencies above the dominant  $1s \rightarrow 2p_{+1}$  line are attributed to optical excitations into metastable states which arise in a magnetic field. The final states of these transitions can be unambiguously assigned by using high field quantum numbers. (Author abstract) 10 refs.

Wagner, H.P. (Univ Regensburg, Regensburg, West Ger); Prettl, W. *Solid State Commun* v 66 n 4 Apr 1988 p 367-369.

**094053 ELECTRON-PHONON INTERACTION OF A TWO-DIMENSIONAL ELECTRON GAS IN A STRONG MAGNETIC FIELD.** The energy relaxation rate due to phonon scattering of a quasi two-dimensional electron gas is calculated for a GaAs quantum well in the presence of a strong magnetic field. Degenerate electron statistics and Gaussian broadened Landau levels are taken into account, as well as a nonequilibrium phonon distribution in case of polar optical phonon scattering. For

electron-acoustic phonon scattering it is found that the energy loss at low electron temperatures ( $kT_e < \hbar\omega_{ac}$ ) is directly proportional to the density of states at the Fermi level and is inversely proportional to well thickness. For polar optical phonon scattering magnetophonon resonances are found at high electron temperatures ( $kT_e > \hbar\omega_{ac}$ ), although the phonons are not in equilibrium with the bath. (Author abstract) 18 refs.

Reinen, H.A.J.M. (Univ of Nijmegen, Nijmegen, Neth); Berendschot, T.T.J.M.; Kappert, R.J.H.; Bluyssen, H.J.A. *Solid State Commun* v 65 n 12 Mar 1988 p 1495-1499.

**094054 HOT ELECTRON TRANSPORT PARALLEL TO STRONG MAGNETIC FIELDS IN GALLIUM ARSENIDE.** Electrical conductivity of very lightly doped n-type gallium arsenide parallel to strong magnetic fields was studied in electric fields up to 1kV/cm. At 4K, conductivity is dominated by impact ionization of shallow donor levels, which are deepened by the magnetic field. Large effects of magneto-impurity resonances are observed. Measurements near liquid nitrogen temperature indicate that parallel magnetic fields induce a transition from sublinear to superlinear conductivity. (Author abstract) 24 refs.

Hellman, E.S. (Stanford Univ, Stanford, CA, USA); Harris, J.R. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 785-788.

## Magnetic Properties

**094055 OBSERVATION OF AHARONOV-BOHM MAGNETORESISTANCE OSCILLATIONS IN SELECTIVELY DOPED GaAs-AlGaAs SUBMICRON STRUCTURES.** Aharonov-Bohm magnetoresistance oscillations are investigated in a selectively doped GaAs-AlGaAs submicron ring with a width of 0.35  $\mu$ m and a diameter of 1  $\mu$ m. The ring is fabricated from a MBE grown film making use of electron beam lithography and dry etching methods. A wire with submicron width and several micron length, which is fabricated for comparison, shows only aperiodic fluctuations with an average period much larger than  $h/e$ . However, the ring shows the MR oscillations with the period of  $h/e$  due to AB effect, superimposed on aperiodic fluctuations. (Author abstract) 12 refs.

Ishibashi, Koji (Osaka Univ, Toyonaka, Jpn); Takagaki, Yukihiko; Gamo, Kenji; Namba, Susumu; Ishida, Shuichi; Murase, Kazuo; Aoyagi, Yoshinobu; Kawabe, Mitsuo. *Solid State Commun* v 64 n 4 Oct 1987 p 573-576.

**094056 SAMPLE SIZE DEPENDENCE OF MAGNETOCONDUCTANCE FLUCTUATIONS IN NARROW n<sup>+</sup>-GaAs WIRES.** Submicron sized n<sup>+</sup>-GaAs wires are fabricated using MOCVD and electron beam lithography techniques, and effects of sample size on magnetoconductance fluctuations have been investigated. It is found that the magnitude of the fluctuation decreases by ensemble averaging with increasing sample size in wires with the width and the length larger than the inelastic scattering length. It is found that the fluctuation becomes larger than the predicted value in wires with the width narrower than the inelastic scattering length. (Author abstract) 9 refs.

Ishibashi, K. (Osaka Univ, Toyonaka, Jpn); Kawai, H.; Gamo, K.; Namba, S.; Ishida, S.; Murase, K.; Aoyagi, Y.; Kawabe, M. *Solid State Commun* v 63 n 12 Sep 1987 p 1169-1171.

## Manufacture

**094057 GALLIUM ARSENIDE - FROM MINE TO MICROCIRCUIT.** Gallium arsenide is the second most important semiconductor material for the manufacture of electronic devices. The main sources of the refined metal are in Europe - France, Germany, Switzerland and Hungary - and the Far East. There are also significant sources in North America. The only application is in the electronics industry. The annual supply of high-purity grade Ga in 1985 is estimated to have been 40-50 t (60%



to GaP, 40% to GaAs). Available resources are abundant, being tied to aluminium supply. 3 refs.

Grant, I.R. (ICI Subsidiary, Milton Keynes, Engl). *Trans Inst Min Metall Sect C* v 97 Mar 1988, Proc of the Twelfth Annu Comm Meet of the Inst of Min and Metall, London, Engl, Dec 3 1987 p 48-52.

**Marketing** See SEMICONDUCTOR MATERIALS—Marketing.

## Mathematical Models

**094058 PHYSICS FOR MODELS OF GALLIUM ARSENIDE DEVICES.** Klauder's self-energy methods (third-level and fifth-level) have been applied to calculate the effects of carrier-dopant ion interactions on parameters for modeling GaAs devices. The effects of carrier-carrier interactions have been calculated by modifications to the theory of Abram et al. The changes in the band edges and effective intrinsic carrier concentrations for both n-type and p-type GaAs are given. Significant results are that device models should include separate and distinct values for the changes in band edges and effective intrinsic carrier concentrations in n-type and p-type material and that the effects of bandgap narrowing and degeneracy are separately large but competitive. 6 refs.

Bennett, Herbert S. (NBS, Gaithersburg, MD, USA); Lowney, Jeremiah R. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 1 Mar 1987 p 31-36.

**094059 MOMENTS OF THE BOLTZMANN TRANSPORT EQUATION AS APPLIED TO THE GALLIUM ARSENIDE PERMEABLE BASE TRANSISTOR.** Solutions to the first three moments of the Boltzmann transport equation and Poisson's equation are obtained for a permeable base transistor (PBT) using linearized, block implicit (LBI) and ADI techniques. Two level electron transfer is considered. The results of the simulations are compared to results obtained from the drift and diffusion equations. The comparison indicates that nonequilibrium transport and velocity overshoot are important in the PBT. The predicted I-V characteristics of the device show substantially higher current levels and a higher cutoff frequency are obtained with the moment equations. (Author abstract) 9 refs.

Kreskovsky, J.P. (Scientific Research Associates Inc, Glastonbury, CT, USA); Meyyappan, M.; Grubin, H.L. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 2 Jun 1987 p 99-105.

## Measurements

**094060 MEASUREMENT OF PHYSICAL PARAMETERS OF GaAs EPITAXIAL STRUCTURES.** The paper gives a summary of measuring methods and techniques used for characterization and quality testing of GaAs epitaxial layers in specialized laboratory of basic physical measurements of the TESLA Electronics Research Institute (TERI). Epitaxial GaAs layers grown by chloride technique are used for the manufacture of metal-semiconductor field-effect transistors (MESFETs) and microwave monolithic integrated circuits (MMICs). (Author abstract) 9 refs.

Vesely, Miroslav (TESLA Electronics Research Inst, Prague, Czech). *Tesla Electron* v 18 n 3 Sep 1985 p 88-93.

**094061 INFLUENCE OF IN SUBSTITUTION AND PLASTIC DEFORMATION ON AS<sub>Ga</sub>-RELATED PHOTOLUMINESCENCE IN GaAs.** Low-temperature photoluminescence experiments have been carried out on semi-insulating GaAs crystals undoped or containing approximately  $5 \times 10^{19}$  In atoms cm<sup>-3</sup>. A broad band peaking around 0.8 eV is observed which is generally related to the antisite defect As<sub>Ga</sub>. The effect of In substitution or plastic deformation is to shift this band towards higher energies by 10-25 meV. This positive energy shift is quantitatively accounted for by considering the stress fields induced by the incorporation of indium or the creation of dislocations. (Author abstract) 22 refs.

Djemel, A. (CNRS, Meudon, Fr); Castaing, J.; Heurtel,

A.; Svob, L.; Marfaing, Y. *Phil Mag Lett* v 55 n 5 May 1987 p 239-245.

**094062 Ge DIFFUSION INTO GaAs BY PULSED LASER IRRADIATION.** Ge diffusion into GaAs from thin evaporated layers as sources is reported. Irradiation with a Q-switched ruby laser gives rise to n-type diffused layers of a thickness from 240 to 710 Angstrom. A strong compensation of the diffused layers, that cannot be removed by thermal annealing, was observed. From the present experimental results it can be inferred that the diffusion coefficient increases at the melting point by 5 to 6 orders of magnitude. (Author abstract). 24 refs.

Garcia, B.J. (Univ Autonoma de Madrid, Madrid, Spain); Martinez, J.; Piqueras, J.; Castano, J.L.; Munoz-Yague, A. *Appl Phys A* v 46 n 3 Jul 1988 p 191-196.

**094063 CONVERGENT-BEAM ELECTRON DIFFRACTION FROM AlGaAs/ GaAs SINGLE QUANTUM WELLS.** Relative spectroscopic measurements of the bulk modulus of GaInAsP lattice-matched to InP yield a value within 1 percent of that of InP. This surprising result is not in agreement with accepted interpolated values but is predicted by Keyes' empirical scaling rule for elastic constants. (Author abstract). 9 refs.

Cherns, D. (Univ of Bristol, Bristol, Engl). *Philos Mag Lett* v 58 n 1 Jul 1988 p 45-51.

## Melting

**094064 BEAM-INDUCED COMPOSITION CHANGES IN 'MELTED' GaAs.** Analytical electron microscopy has been used to study the melting behavior of GaAs crystal under strong illumination with an electron beam. It is found that the chemical composition has been changed to Ga:As=2:1 after being melted. The decrease of As atoms is interpreted as being due to evaporation of As into the vacuum. (Edited author abstract) 7 refs.

Wang, Z.L. (State Univ of New York at Stony Brook, Stony Brook, NY, USA). *Mater Lett* v 6 n 4 Feb 1988 p 112-115.

## Metallizing

**094065 HIGH-TEMPERATURE METALLISATION SYSTEMS FOR TRANSIENT ANNEALING OF GaAs.** The letter reports the results of rapid thermal annealing of W, Ta and TaSi<sub>x</sub> on GaAs. The results indicate that rapid thermal annealing results in contact stability to higher temperatures than is seen in conventional annealing. The stability of tantalum is greatly improved when silicon is added to the system, forming a TaSi<sub>x</sub> contact. The preliminary results of TaSi<sub>x</sub> on In-doped GaAs indicate that the process of Ga and/or As outdiffusion is inhibited up to a temperature of 1050°C. (Edited author abstract) 4 refs.

Morgan, D.V. (UWIST, Cardiff, Wales); Thomas, H.; Anderson, W.T.; Thompson, P.; Christou, A.; Diskett, D.J. *Electron Lett* v 23 n 21 Oct 8 1987 p 1154-1155.

**094066 INFLUENCE OF GALLIUM IN A METALLISATION ON GaAs.** ESCA analysis of systems composed of Ge, Ga, Au layers alloyed to GaAs is reported to elucidate the influence of gallium in a metallization scheme. The results reveal that a metal system containing gallium shows an absence of arsenic in the alloyed surface, and thus its presence precludes an early dissociation of GaAs. The metallurgical analyses are correlated to previously reported unstable performance of GaAs/Au contacts and thermally stable electrical behavior of GaAs/Au/Ga Schottky diodes. (Author abstract) 13 refs.

Gupta, R.P. (Central Electronics Engineering Research Inst, Pilani, India); Wuelfl, J.; Hartnagel, H.L.; Khokle, W.S. *IEE Proc Part I* v 135 n 2 Apr 1988 p 25-28.

**Microscopic Examination** See Also SEMICONDUCTING ALUMINUM COMPOUNDS—Microscopic Examination.

**094067 HIGH RESOLUTION ELECTRON MICROSCOPY AND ETCHING STUDY OF TWINS IN GaAs.** The combination of etching, photoetching, electron diffraction and high resolution electron microscopy technique was used to characterize twins in GaAs. These techniques were applied to study (001) oriented samples taken from Si-doped n-type horizontal Bridgman GaAs crystals containing twins. From photoetching and etching it is concluded that the intersection of the twin plane with the (001) plane is parallel to [11 $\bar{1}$ ] type. Selected area electron diffraction and high resolution electron microscopy (HREM) on chemically thinned samples, performed on matrix and twin areas, showed the twin to be a 180° rotation or a reflection twin with a (111) composition plane. The model is further confirmed by image calculations. HREM observations reveal the presence of a thin surface contamination layer of unknown composition on the twin portion of the sample. However this layer did not influence the high resolution images of the GaAs. (Edited author abstract) 18 refs.

Zandbergen, H.W. (State Univ of Leiden, Leiden, Neth); Weyher, J.; Van Landuyt, J. *J Cryst Growth* v 84 n 3 Sep 1987 p 476-482.

**094068 LATTICE IMAGING STUDY OF IN-DEPTH DISORDERING OF SI-IMPLANTED GaAs.** Cross-sectional high resolution transmission electron microscopy has been used to obtain direct information on the in-depth radiation damage distribution of weakly damaged GaAs by Si-ion implantation. A comparison is made between the experimental data and the calculated (using TRIM computer simulations) deposited energy by nuclear stopping for the same conditions. In particular a diffusion zone, with 200-300 Angstrom width, of high point defect concentration beyond the damage peak is detected. These point defects are interpreted as As interstitials. By direct observation, information concerning the damage- and radiation-enhanced diffusion in implanted III-V compound semiconductors is obtained. (Author abstract). 30 refs.

Vitali, G. (CNR, Rome, Italy); Kalitzova, M.; Pashov, N.; Werner, P.; Bartsch, H.; Karpuzov, D. *Appl Phys A* v 46 n 3 Jul 1988 p 185-190.

**094069 INVESTIGATIONS OF THE MICROHETEROGENEITY OF THE PARAMETERS OF LOCAL CENTERS IN HIGH RESISTANCE SEMICONDUCTOR MATERIALS USING SCANNING ELECTRON MICROSCOPY.** The problem of uniformity of the properties of high resistance and semiconductor materials has acquired special meaning in recent years with respect to creation of instruments with a high degree of integration. Until recently analysis of the parameters of local centers in a high resistance semiconductor has been a very complex problem, not to mention analysis of the uniformity of their distribution. The potential of a new local method for studying the parameters of local center using scanning electron microscopy (SEM), which is based on a method of photoelectric relaxation spectroscopy (PERS), is shown in this work in an example of investigation of semiinsulated gallium arsenide. 2 refs.

Govorkov, A.V.; Omel'yanovskii, E.M.; Polyakov, A.Ya.; Raikhshtein, V.I.; Fridman, V.A. *Bull Acad Sci USSR Phys Ser* v 51 n 3 1987, Mater of the Fifth All-Union Symp on Scanning Electron Microsc and Anal Methods for Invest Solids, Zvenigorod, USSR, May 1986 p 16-19.

## Microstructure

**094070 STRAIN MODEL FOR EL2 IN GaAs.** A strain model is proposed for the mechanism of formation of EL2 in GaAs and its dependence on dislocations. This model is similar to the stress model suggested by Holmes et al. but differences exist between these two models. By using the strain model, the formation of EL2 in In-doped, dislocation-free, SI LEC GaAs can be explained. (Edited



author abstract) 11 refs. In Chinese.

Zou Yuan-xi (Acad Sinica, Shanghai, China). *Xi You Jin Shu* v 5 n 4 Nov 1986 p 241-243.

**094071 ORIGIN OF MICROTWINNING IN ROOM TEMPERATURE INDENTED UNDOPED AND n-DOPED GaAs CRYSTALS.** The origin of microtwinning in room temperature indented GaAs crystals is analyzed. It is shown that microtwinning does not take place because of the non-centrosymmetry of the crystal structure but because the friction forces acting on the 30° partial dislocations are higher than those acting on the 90° partial dislocations:  $R_{30(g)} > R_{30(a)} > R_{90}$ . A new local method for studying the parameters of local center using scanning electron microscopy (SEM), which is based on a method of photoelectric relaxation spectroscopy (PERS), is shown in this work in an example of investigation of semiinsulated gallium arsenide. (Author abstract) 28 Refs.

Lefebvre, A. (Univ des Sciences et Technique, Villeneuve d'Ascq, Fr); Vanderschaeve, G. *Phys Status Solidi A* v 107 n 2 Jun 1988 p 647-653.

**Microwaves** See LASERS, SEMICONDUCTOR—Performance.

**Military Application** See INTEGRATED CIRCUITS—Millimeter Waves.

## Morphology

**094072 MORPHOLOGY OF GaAs AND InP (001) SUBSTRATES AFTER DIFFERENT PREPARATION PROCEDURES PRIOR TO EPITAXIAL GROWTH.** The morphology of (001) GaAs and (001) InP substrates after different preparation procedures prior to epitaxy has been studied. The effect of two commonly used polishing solutions were tested:  $\text{Br}_2\text{-CH}_3\text{OH}$  and  $\text{H}_2\text{SO}_4\text{:H}_2\text{O}_2\text{:H}_2\text{O}$ . These solutions remove a certain amount of material, but we have shown in previous papers that a residual oxide layer remains on the surface, resulting from preparation in air, which must be removed prior to epitaxial growth. The morphology of the surfaces after the above mentioned etchants and additional wet chemical deoxidation treatments was characterized using a phase contrast microscope equipped with a Nomarski interferometer. (Edited author abstract) 26 refs.

Saletes, A. (CNRS-Sophia Antipolis, Valbonne, Fr); Turco, F.; Massies, J.; Contour, J.P. *J Electrochem Soc* v 135 n 2 Feb 1988 p 504-509.

**Noise, Spurious Signal** See TRANSISTORS, FIELD EFFECT—Noise.

**Optical Properties** See Also CRYSTALS—Growing.

**094073 EXCITON BINDING ENERGY IN SMALL-PERIOD GaAs/Ga<sub>(1-x)Al<sub>x</sub>As</sub> SUPERLATTICES.** We report the optical determination of exciton binding energies in small-period GaAs/Ga<sub>0.7</sub>Al<sub>0.3</sub>As superlattices by means of low-temperature photoluminescence excitation spectroscopy and photoluminescence spectroscopy as a function of temperature. The heavy-hole exciton binding energy decreases with decreasing superlattice period. Our experimental findings are in reasonable agreement with a variational calculation. (Author abstract) 16 refs.

Chomette, A. (CNET, Lannion, Fr); Lambert, B.; Devaud, B.; Clerot, F.; Regreny, A.; Bastard, G. *Europhys Lett* v 4 n 4 Aug 15 1987 p 461-466.

**094074 TRANSIENT CHARACTERISTICS OF LUMINESCENCE FROM GaAs/Ga<sub>0.6</sub>Al<sub>0.4</sub>As MULTI-QUANTUM-WELL STRUCTURE UNDER RESONANT EXCITATION.** The transient characteristics of photoluminescence from the exciton band in a multi-quantum well have been examined under a resonant excitation condition of the exciton by using a time-correlated single-photon counting method. We have found that the delay, rise and decay times of the luminescence depend on wavelength of excitation and observation, and that the

dependencies disappear with increasing temperature from 20 to 50 K. These results could be well explained in terms of exciton relaxation through localized levels created by a fluctuation of the width of the multi-quantum well. (Author abstract) 5 refs.

Miyoshi, Tadaki (Yamaguchi Univ, Ube, Jpn); Aoyagi, Yoshinobu; Segawa, Yusaburo; Namba, Susumu. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1438-1441.

**094075 EFFECTS OF AN ELECTRIC FIELD ON THE DECAY TIME OF LUMINESCENCE FROM A GaAs/Ga<sub>0.6</sub>Al<sub>0.4</sub>As MULTI-QUANTUM-WELL STRUCTURE.** The decay time of luminescence from a multi-quantum well has been measured at 20 K by using a cw mode-locked Kr laser and a synchroscan-streak camera. The decay time was found to increase with applied electric field. The increase is considered to be attributable to a field-induced carrier separation. The decay time depends on the observed wavelength of luminescence. This dependence changes with the electric field, suggesting that the energy-decreasing rate of excitons becomes slower in the presence of an electric field. (Author abstract) 10 refs.

Miyoshi, Tadaki (Yamaguchi Univ, Ube, Jpn); Aoyagi, Yoshinobu; Segawa, Yusaburo; Namba, Susumu; Sano, Naokatsu. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1442-1446.

**094076 ELECTROLUMINESCENCE FROM A SHORT ASYMMETRIC GaAs/AlAs SUPERLATTICE.** The electroluminescence obtained from a GaAs p-n junction containing a short asymmetric GaAs/AlAs superlattice has been studied. In addition to the electroluminescence from the bulk GaAs, three more electroluminescence peaks are observed. These are due to the  $n=1$  electron-light hole states in the three narrowest wells. The electron confinement is found to be consistent with that of the  $\Gamma(\text{GaAs})$  to  $X(\text{AlAs})$  potential. (Author abstract) 11 refs.

Phillips, R.T. (Univ of Exeter, Exeter, Engl); Couch, N.R.; Kelly, M.J. *Semicond Sci Technol* v 2 n 12 Dec 1987 p 828-831.

**094077 OPTICAL PROPERTIES AND BAND STRUCTURE OF SHORT-PERIOD GaAs/AlAs SUPERLATTICES.** We have studied six GaAs/AlAs superlattices with periods ranging from 18 to 60 Å and different average aluminum composition. Three of these samples are shown to be direct bandgap materials whose band structure differs strongly from that of the corresponding alloy, but is correctly described by an envelope function calculation. The three remaining samples are shown to be indirect both in real and reciprocal space. Analysis of the time decay of the luminescence shows that this is a momentum-forbidden exciton mode allowed by disorder scattering, which leads to a luminescence efficiency comparable to that of the direct bandgap samples. Partial lifting of the degeneracy of the three X orbitals by the superlattice potential is also observed. Finally, we take advantage of the strong dependence of these indirect transition energies on the band discontinuities to estimate the valence band offset to be about 550 meV in this system. (Edited author abstract) 35 refs.

Finkman, E. (Bell Communities Research, Red Bank, NJ, USA); Sturge, M.D.; Meynadier, M.-H.; Nahory, R.E.; Tamargo, M.C.; Hwang, D.M.; Chang, C.C. *J Lumin* v 39 n 2 Dec II 1987 p 57-74.

**094078 OBSERVATION OF RESOLVED 2s EXCITON LINES IN (AlGa)As/GaAs QUANTUM WELL.** All the major electronic companies are investing heavily in gallium arsenide (GaAs) technology with a view to its commercial exploitation in the optic and electro-optic fields. Several articles have cataloged its possible uses, when combined with the mixed crystal aluminum gallium arsenide ((AlGa)As), in layered structures of atomic dimensions. Many technological and physical questions remained unanswered, in particular, one problem concerned with the binding energy of electron-hole pairs in quantum wells. The uncertainty arose from experimental

results which conflicted with each other by a factor of nearly two and it was left to calculation to attempt to resolve the difficulty. In this article we show how a study of the details of the photoluminescence from GaAs/(AlGa)As multiple quantum wells and the correct interpretation of the results has led to an unequivocal determination of this quantity. 6 refs.

Dawson, P.; Moore, K.J.; Duggan, G.; Ralph, H.I.; Foxon, C.T. *Annu Rev Philips Res Lab* 1986 p 22-24.

**094079 INTERVALLEY  $\Gamma$ -X SCATTERING RATE IN GALLIUM ARSENIDE CRYSTALS.** From hot photoluminescence depolarization the electron life-time ( $18 \pm 2$  fs) at electron energy  $\epsilon_0 = 0.57$  eV has been measured in GaAs crystals. From these data the  $\Gamma$ -X intervalley scattering time is estimated as  $30 \pm 10$  fs. (Author abstract) 4 refs.

Mirlin, D.N. (Acad of Sciences of the USSR, Leningrad, USSR); Karlik, I.Ya.; Saepa, V.F. *Solid State Commun* v 65 n 3 Jan 1988 p 171-172.

**094080 OPTICAL PROPERTIES OF GaAs.** The optical absorption coefficient and complex dielectric response function of pure GaAs is measured at ambient temperature in the range of  $100\text{-}20000\text{cm}^{-1}$  using two different techniques. The results reported are in agreement with results reported in other published work. In order to improve the efficiency of the GaAs to be used as a solar cell, we propose, on the basis of empirical formula and data available in the literature, the amount of doping, appropriate to increasing the efficiency of GaAs as a solar cell. (Edited author abstract) 13 refs.

Memon, A. (Univ of Bahrain, Bahrain); Fakhro, S.Q. *Int J Infrared Millim Waves* v 8 n 11 Nov 1987 p 1391-1397.

**094081 AlAs PHONON PARAMETERS AND HETEROSTRUCTURE CHARACTERIZATION.** Infrared and Raman spectra from an AlAs-GaAs heterostructure yield phonon parameters for non-oxidized pure AlAs at 300, 77 and 6 K, which have not been thoroughly established. Strong infrared interference effects in the heterostructure are identified and produce a large peak near the GaAs LO frequency. This explains an anomalous double peak previously observed in the infrared spectroscopy of  $\text{Al}_x\text{Ga}_{1-x}\text{As}$ -GaAs heterostructures. (Author abstract) 12 refs.

Perkowitz, S. (Emory Univ, Atlanta, GA, USA); Sudharasan, R.; Yom, S.S.; Drummond, T.J. *Solid State Commun* v 62 n 9 Jun 1987 p 645-647.

**094082 LIGHT SCATTERING IN GaAs PARABOLIC QUANTUM WELLS.** We report the observation of electronic light scattering in photoexcited parabolic GaAs- $\text{Al}_x\text{Ga}_{1-x}\text{As}$  quantum wells. The spectra show sharp peaks corresponding to transitions between sublevels in the conduction band. The precision of the measurements allows a test of the simple harmonic oscillator model for the energy level structure. The energy gap and alloy composition of the  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  layers are determined from resonance Raman scattering by optical phonons. We use these results to calculate the conduction band offset  $Q_c$ . We obtain  $Q_c$  approx. 0.7, in agreement with recent experiments in square quantum wells. (Author abstract) 12 refs.

Menendez, J. (AT&T, Murray Hill, NJ, USA); Pinczuk, A.; Gossard, A.C.; Lamont, M.G.; Cerdeira, F. *Solid State Commun* v 61 n 10 Mar 1987 p 601-605.

**094083 PHOTOQUENCHING AND RECOVERY EFFECTS OF EL2 ABSORPTION IN GaAs.** Optical absorption spectroscopy on the major midgap donor (EL2) in GaAs shows that the metastable state of the EL2 level ( $\text{EL2}^*$ ) can be optically recovered to the normal state ( $\text{EL2}^0$ ) at 11 K. On the basis of the transient properties of the photoquenching and recovery effects, we suggest



that these effects occur as a result of a dynamic balance between the  $EL2^0 \rightarrow EL2^*$  and  $EL2^* \rightarrow EL2^0$  transitions. (Author abstract) 10 refs.

Tajima, Michio (Optoelectronics Joint Research Lab, Kawasaki, Jpn); Saito, Hiroki; Iino, Takayuki; Ishida, Koichi. *Jpn J Appl Phys Part 2* v 27 n 1 Jan 1988 p 101-103.

**094084 PHOTO-HALL STUDY OF THE OPTICALLY ENHANCED PHOTOCURRENT IN SEMI-INSULATING LEC GaAs.** The photocurrent of semi-insulating GaAs is enhanced by long time excitation with photons of energy higher than 1 eV. Photo-hall experiments on the enhanced photocurrent reveal that this is mainly due to holes, and that the mobility is increased in conditions of strong photocurrent enhancement. This is discussed on the basis of metastability of midgap levels in GaAs. Thermal annealing experiments showed that likely EL6 is involved in this phenomenon. (Author abstract) 14 refs.

Jimenez, J. (Facultad de Ciencias, Valladolid, Spain); Alvarez, A.; Gonzalez, M.A.; de Saja, J.A.; Bonnafé, J. *Solid State Commun* v 63 n 10 Sep 1987 p 937-940.

**094085 OBSERVATION OF 1.13 (EV% POLARIZED) LUMINESCENCE BAND IN PLASTICALLY DEFORMED GaAs.** A luminescence band centered at 1.13 eV, with a width of 140 meV at 77 K, has been observed in GaAs after plastic deformation at 400°C by uniaxial compression. This band is polarized normally to the primary glide plane, which suggests that it comes from dislocations rather than from point defects. A configuration coordinate diagram for this dislocation level is proposed. (Edited author abstract) 11 refs.

Depraetere, E. (Univ of Lille, Villeneuve d'Ascq, Fr); Vignaud, D.; Farvacque, J.L. *Solid State Commun* v 64 n 12 Dec 1987 p 1465-1468.

**094086 MEASUREMENTS OF ABOVE-BANDGAP OPTICAL ANISOTROPIES IN THE (0 0 1) SURFACE OF GaAs.** We report on a detailed experimental study of above-bandgap optical anisotropies of the (0 0 1) surface of GaAs as a function of doping concentration and conductivity type. We conclude that the measured spectra have two components, a first one which depends on these two parameters and a second one which is independent of them. The first component is actually dependent on the surface electric field due to the pinning of the Fermi level at the sample surface states. (Author abstract) 7 refs.

Acosta-Ortiz, S.E. (Univ Autonoma de San Luis Potosi, San Luis Potosi, Mex); Lastras-Martinez, A. *Solid State Commun* v 64 n 5 Nov 1987 p 809-811.

**094087 IMAGE ANALYSIS OF EL2 DISTRIBUTIONS IN LEC GaAs SI MATERIALS.** In a recent paper we showed that EL2 centers are not especially concentrated on dislocations as is the usual stated opinion. Photoquenching experiments and the analysis of infrared transmission images enable the identification of the local EL2<sup>+</sup> contribution in the cell pattern; a profile of the calculated EL2<sup>+</sup> quenched center densities was deduced showing a lower density in the walls and a higher density in an intermediate zone surrounding the inner cell. In this letter we propose a confirmation of this schematic distribution by extending the calculation to the complete image. A quantitative image of the EL2<sup>+</sup> densities is presented. A discussion is introduced which compares this new point of view with previous results reported in the literature, especially the conclusions on infrared luminescence images. (Author abstract) 14 refs.

Fillard, J.P. (Univ des Sciences et Techniques du Languedoc, Montpellier, Fr); Montgomery, P.; Baroudi, A.; Bonnafé, J.; Gall, P. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 258-259.

**094088 RAMAN SCATTERING FROM LO-PHONON-PLASMON MODES IN GaAs<sub>1-x</sub>P<sub>x</sub> CRYSTALS.** The concentration and the mobility of the free carriers are obtained from the frequency shift  $\Delta\omega$  and halfwidth broadening  $\Delta b$  of the coupled mode  $\omega_+$  in

comparison with the pure LO<sub>2</sub> (GaP-like) phonon. The Raman spectra obtained in the backscattering geometry from (100) faces are presented and discussed. 7 refs.

Irmer, G.; Herms, M.; Monecke, J.; Bock, H. *Phys Status Solidi B* v 145 n 1 Jan 1988 p K79-K82.

**094089 DEEP LEVEL CHARACTERIZATION IN SEMI-INSULATING LEC GALLIUM ARSENIDE.** The temperature dependent Hall effect, photoconductivity, IR absorption, and C - U analysis are applied for characterizing semi-insulating undoped LEC gallium arsenide samples. It is shown that a combination of the different experimental techniques can give a satisfactory description of the physical properties of this material. In particular it is found that EL2 is the dominant deep level, although in particular cases the photoconductivity threshold can be lower than 0.7 eV. The activation energy from Hall effect measurements can be as low as 0.42 eV. (Author abstract) 20 refs.

Fornari, R. (CNR, Parma, Italy); Dozza, L. v 105 n 2 Feb 1988 p 521-530.

**094090 ENHANCEMENT OF HEAVY-HOLE-RELATED EXCITONIC OPTICAL TRANSITIONS IN (111)-ORIENTED QUANTUM WELLS.** Photoluminescence excitation spectra have been measured at low temperatures on high quality GaAs/Al<sub>0.3</sub>Ga<sub>0.7</sub>As and GaAs/AlAs multiple quantum wells grown by molecular beam epitaxy along the [111] and [100] crystallographic axes. Comparisons of these spectra have shown clear evidence of the enhancement of the heavy-hole-related excitonic optical transitions relative to the light-hole-related transitions in (111)-oriented quantum wells in comparison with (100)-oriented quantum wells. (Author abstract) 15 refs.

Hayakawa, Toshiro (Sharp Corp, Tenri, Jpn); Takahashi, Kosei; Suyama, Takahiro; Kondo, Masafumi; Yamamoto, Saburo; Hijikata, Toshiaki. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 300-303.

**094091 LIGHT ABSORPTION AND HYPER-RAMAN SCATTERING BY MANY-ELECTRON COMPLEXES IN QUANTUM WELL STRUCTURES.** In the absorption and luminescence spectra of GaAs/Al<sub>x</sub>Ga<sub>1-x</sub>As transitions to light-hole exciton and heavy-hole exciton states are detected. Also a broad luminescence band is ascribed to biexciton luminescence. However, more reliable methods of biexciton detection are two-photon absorption and hyper-Raman scattering. The authors report on estimations of the bihole dissociation energy and oscillator strengths due to bihole light absorption, the probability of intersubband optical transitions of heavy holes, the probability of bihole dissociation accompanied by LO phonon emission, the probability of two-photon Raman scattering with the participation of the biexciton, consisting of two electrons and two heavy holes. 11 refs.

Bobrysheva, A.I. (Acad of Sciences of the Moldavian SSR, Kishinev, USSR); Russu, S.S.; Zoloi, V.A. *Phys Status Solidi B* v 146 n 1 Mar 1988 p 329-334.

**094092 TRIPLY RESONANT SECOND-ORDER RAMAN SCATTERING IN GaAs.** We have achieved conditions for triply resonant second-order Raman scattering induced by the iterated electron - one-phonon interaction by applying uniaxial stress on bulk GaAs and thus producing an energy splitting between the light- and heavy-hole valence bands equal to the energy of two scattering phonons. We show that all three energies involved in this process, the incident and the outgoing photon energy, and also the intermediate energy, are simultaneously in resonance with an electronic transition. Under such conditions we observe, even for crossed polarizations, scattering intensities much larger than the ones seen in resonant 2LO-phonon Froehlich intraband Raman scattering for unstressed samples. (Author abstract) 15 refs.

Alexandrou, A. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Cardona, M. *Solid State Commun* v 64 n 7 Nov 1987 p 1029-1034.

**094093 PHOTOREFLECTANCE OF GaAs/AlGaAs MULTIPLE QUANTUM WELLS.** Room-temperature photoreflectance was studied in GaAs-AlGaAs quantum wells with well widths ranging from 40 to 144 Angstrom. The allowed ( $\Delta n = 0$ ) heavy hole to conduction ( $h_1, h_2, h_3$ ) and light hole to conduction ( $l_1, l_2$ ) transitions have been observed in a 144 Angstrom sample. (Edited author abstract) 4 refs.

Weihua, Zhuang (Int Cent for Theoretical Physics, Trieste, Italy); Da, Teng; Dianzhao, Sun; Desheng, Jiang. *Solid State Commun* v 65 n 12 Mar 1988 p 1581-1582.

**094094 OPTICAL EVIDENCE FOR THE IMPURITY BAND NATURE OF THE METAL-INSULATOR TRANSITION IN GaAs.** Far infrared magneto-transmission measurements on n-types GaAs doped near the metal-insulator transition show evidence for the impurity 1s-2p<sup>+</sup> optical transition in both the insulating and the metallic states and no cyclotron resonance at low temperatures. The 1s-2p<sup>+</sup> absorption line-shape varies smoothly through the magnetic field induced metal-insulator transition. (Author abstract) 21 refs.

Lee, Ming-Way (Univ of Maryland, College Park, MD, USA); Romero, D.; Drew, H.D.; Shayegan, M.; Elman, B.S. *Solid State Commun* v 66 n 1 Apr 1988 p 23-27.

**094095 PECULIARITIES OF RADIATIVE RECOMBINATION OF GALLIUM ARSENIDE DOPED WITH SHALLOW DONORS AND ACCEPTORS.** The photoluminescence of epitaxial n-GaAs:(Te+Ge) with an intermediate degree of compensation is studied as a function of excitation level. The parameters of a moving band were determined and compared with the theory. Discrepancies between theory and experiment can be understood if, when considering thermalization processes of non-equilibrium holes, their transitions between tail states passing by the valence band are taken into account. (Author abstract) 13 refs.

Domanevskii, D.S. (Byelorussian Polytechnical Inst, Minsk, USSR); Zhokhovets, S.V.; Prokopenya, M.V. *Phys Status Solidi A* v 106 n 1 Mar 1988 p 249-261.

**094096 ON THE ORIGIN OF CATHODOLUMINESCENCE CONTRAST PHENOMENA IN SEMI-INSULATING GaAs.** The microscopic origin of homogenization can be investigated by cathodoluminescence (CL) measurements on a micrometer scale. CL micrographs of as-grown and of annealed s.i.-GaAs show cellular structures with bright cell walls and dark cell interiors. CL micrographs of annealed material show additional island-like structures in the cell interiors which seem to be the microscopic origin for the homogenization. The observed CL properties can be explained in terms of a non-radiative recombination process which is coupled to gallium vacancies or to the intrinsic EL2 defect. Annealing of GaAs leads to an increase of the EL2 concentration. (Edited author abstract). 18 Refs.

Koschek, G. (Univ Duisburg, Duisburg, West Ger); Lakner, H.; Kubalek, E. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 651-658.

**094097 ELLIPSOMETRIC STUDIES OF NATURAL FILMS ON GaAs.** Ellipsometric angles  $\Delta$  and  $\psi$  of about 20 samples of GaAs single-crystals with natural thin films were studied for several angles of incidence at room temperature within a several years period at  $\lambda = 632.8$  nm.  $\Delta$  and  $\psi$  are used to determine the optical constants  $n$  and  $k$  and the thickness and refractive index of thin surface film. Also studied were the changes of  $\Delta$  and  $\psi$  with temperature during several consecutive heating-cooling cycles for two samples in the range from 20 to 201°C. The experimental results are interpreted in terms of the temperature coefficients  $dn/dT$  and  $dk/dT$  and desorption and adsorption of gases and vapours from and on the sample surface. (Author abstract). 20 Refs.

Lukes, F. (J.E. Purkyne Univ, Brno, Czech). *Phys Status Solidi A* v 107 n 1 May 1988 p 239-251.



**094098 TUNNELLING OF ELECTRON-HOLE PAIRS IN A RAMAN SCATTERING STUDY OF A THIN LAYER GaAs/AlAs SUPERLATTICE.** Resonant Raman scattering of a thin layer GaAs/AlAs superlattice has been studied as a function of the laser energy  $E_L$  over a broad energy range. The relative intensity of the phonon modes which belong to different composing layers has been found to be exponentially dependent on the incident photon energy. The observed behavior is interpreted in terms of the electron-hole pairs' tunneling through the AlAs barriers. (Author abstract). 9 Refs.

Gridin, Vladimir V. (Technion, Haifa, Isr); Beserman, Robert; Morkoc, H. *Solid State Commun* v 67 n 3 Jul 1988 p 317-319.

**094099 SHORT RANGE ASSOCIATION OF EL2 WITH DISLOCATIONS IN GaAs-In MATERIALS.** Laser scanning tomography coupled with infrared transmission images allow precise investigations on the micro environment of dislocations in GaAs-In materials. We present a study of the EL2 distribution in the central region of a wafer, using photoquenching experiments at liquid nitrogen temperature. It is found that a limited increase of the EL2 density is to be noted in the close vicinity of a dislocation. (Edited author abstract).

Fillard, J.P. (Cent d'Electronique de Montpellier, Montpellier, Fr); Gall, P.; Baroudi, A.; Bonnafé, J. *Solid State Commun* v 67 n 3 Jul 1988 p 321-323.

**094100 THEORY OF TRANSIENT ENERGY TRANSFER IN GALLIUM ARSENIDE.** Numerical calculations are given for optical two-beam coupling in undoped, semi-insulating GaAs using picosecond pulses. Absorption at the intrinsic defect EL2, two-photon absorption, free-carrier absorption, photorefractive gratings, free-carrier gratings, and absorption gratings are included. Results for normalized probe transmission as a function of pump fluence and as a function of pump-probe delay show that the major effects are energy transfer from pump to probe or from probe to pump (depending on crystal orientation) due to the photorefractive effect, two-photon absorption, and free-carrier transient energy transfer from the pump to the probe. 25 refs.

Valley, George C. (Hughes Research Lab, Malibu, CA, USA); Smirl, Arthur L. *IEEE J Quantum Electron* v 24 n 2 Feb 1988 p 304-310.

**094101 STUDY OF THE OPTICAL PROPERTIES OF SEMICONDUCTORS WITH SYNCHROTRON RADIATION FROM THE VEPP-2M STORAGE RING.** This paper reports on evaluation of measurements of reflectivity on III-V semiconductors GaAs for a broad spectral range. The measurements were made using both a classical source (from 4 to 13 eV) and synchrotron radiation from the VEPP-2M storage ring (from 14 to 26 eV). The method of evaluation is based on a fit of the relative reflectivities as obtained from Fresnel formulas to the measured data for 10 discrete angles of incidence. In the range from 19 to 26 eV, where the optical transitions from atomic 3d-states of Ga to the conduction band of the GaAs are predominant, the experimental results were compared with pseudopotential calculations. A good qualitative agreement with the experimental data was found. (Author abstract) 19 refs.

Pajasova, L. (Czechoslovak Acad of Sciences, Prague, Czech); Pajas, P.; Simunek, A.; Makarov, O.A. *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 131-137.

**094102 THEORETICAL STUDIES OF POLARIZATION DEPENDENT ELECTRO-OPTICAL MODULATION IN LATTICE MATCHED AND STRAINED MULTI-QUANTUM WELL STRUCTURES.** We report on polarization-dependent optical absorption for excitonic and interband transitions in lattice matched (GaAs/AlGaAs) and strained (biaxial tensile strain - GaAsP/AlGaAs; biaxial compressive strain - InGaAs/AlGaAs) multi-quantum-well structures

in the presence of transverse electric fields. The hole states are solved by using the Kohn-Luttinger Hamiltonian and using an eigenvalue technique. The effect of heavy-hole and light-hole mixing due to the strain, electric field and quantization is studied. Under biaxial tensile strain the heavy-hole and light-hole transition can coincide, leading to interesting polarization dependent effects. Results are presented for excitonic and interband transitions. (Author abstract) 21 refs.

Hong, Songcheol (Univ of Michigan, Ann Arbor, MI, USA); Singh, Jasprit. *Superlattices Microstruct* v 3 n 6 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 645-656.

**094103 ABSORPTION AND PHOTOLUMINESCENCE STUDIES OF THE TEMPERATURE DEPENDENCE OF EXCITON LIFE TIME IN LATTICE-MATCHED AND STRAINED QUANTUM WELL SYSTEMS.** We present systematic studies of the temperature dependence of linewidths and lifetimes of excitonic transitions in quantum wells grown by molecular beam epitaxy using both photoluminescence (PL) and optical absorption. The temperature ranged from 6K to room temperature. Samples under investigation were lattice-matched GaAs/AlGaAs and InGaAs/InAlAs, and strained InGaAs/GaAs and InGaAs/AlGaAs quantum well systems. In addition, the effects of well-size variations in GaAs/AlGaAs quantum wells were measured and analyzed. In all cases we were able to observe the excitonic transitions up to room temperature. The exciton lifetimes were calculated as a function of temperature using the Heisenberg uncertainty principle. We found the lifetime decreases significantly with temperature and increases with increasing well size. These results are interpreted in terms of the exciton-phonon interaction and are expected to be very useful for the design of semiconductor optical devices. (Edited author abstract) 24 refs.

Chen, Y. (Univ of Michigan, Ann Arbor, MI, USA); Kothiyal, G.P.; Singh, J.; Bhattacharya, P.K. *Superlattices Microstruct* v 3 n 6 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 657-664.

**094104 NONLINEAR OPTICS BELOW THE BANDEDGE IN GaAs QUANTUM WELL HETEROSTRUCTURES.** Most studies of the optical properties of GaAs/AlGaAs quantum wells have focussed on the wavelength region above the bandedge, where there exists a rich spectrum of sharp quasi-two-dimensional excitons. Much less attention has been paid to quantum well properties at incident photon energies less than the ground state exciton transition. This below-gap spectral region is of importance for several reasons. Recent experiments in GaAs quantum wells have revealed strong electro-optic and all-optical excitonic effects for light propagating in the transparent wavelength range of the crystal. 5 refs.

Zucker, J.E. (AT&T Bell Lab, Holmdel, NJ, USA). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 31-32.

**094105 EFFECTS OF ALLOYING AND HYDROSTATIC PRESSURE ON THE LUMINESCENCE OF Mn IN GaAs.** Manganese (Mn) in III-V semiconductors offers an interesting case where the d-like nature of transition metals is combined with the possibility of measuring charge-transfer luminescence. It is shown that Mn charge-transfer luminescence studied as a function of alloying may predict hetero-structure band off-sets and that the hydrostatic pressure dependence may separately determine deformation potentials of the two band edges of the host material. (Author abstract) 10 refs.

Samuelson, Lars (Univ of Lund, Lund, Swed); Nilsson, Stefan. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 127-128.

**094106 OPTICAL PROPERTIES OF EL2 FAMILY IN GaAs.** Optical properties of deep level EL2 in LEC,

HB and VPE GaAs have been investigated by using photocapacitance technique. It indicated that EL2 in various GaAs samples has slightly but definitely different optical properties. Such phenomena further demonstrate the reasonableness of the concept of 'EL2 family'. (Author abstract) 2 refs.

Zhou, B.L. (Acad Sinica, Shanghai, China); Hu, B.H. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 367-368.

**094107 MAGNETO-OPTICAL STUDY OF THE HEAVY-HOLE EXCITON IN GaAs-(GaAl)As QUANTUM WELLS.** Variational calculations considering the mixing of heavy- and light hole states are performed to explain the diamagnetic shift and binding energy of the heavy-hole exciton. (Edited author abstract) 6 refs.

Ossau, W. (Univ Wuerzburg, Wuerzburg, West Ger); Jäkel, B.; Weimann, G. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 723-724.

**094108 ENERGY RELAXATION IN p- AND n-GaAs QUANTUM WELLS: CONFINEMENT EFFECTS.** We have measured the energy relaxation of carriers in p- and n-type GaAs quantum wells using time-resolved photoluminescence. At low excitation densities low carrier temperatures the energy loss rate for holes is greater than for electrons, but it is not observed to depend on well width for values greater than 60 Angstrom. At high excitation densities the rate is found to increase significantly for narrow wells (25Angstrom). (Author abstract) 11 refs.

Tatham, M. (Clarendon Lab, Oxford, Engl); Taylor, R.A.; Ryan, J.F.; Wang, W.I.; Foxon, C.T. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 459-462.

## Order-Disorder

**094109 PAIRED TEMPERATURE SPECTROSCOPY (PATS) FOR GAP STATES IN ORDERED AND DISORDERED SEMICONDUCTORS: II. EXPERIMENTAL APPLICATIONS.** We present applications of paired temperature spectroscopy (PATS) to deep levels in liquid encapsulated Czochralski (LEC) grown and irradiated GaAs and InP. In GaAs, the level is near the midgap and appears to belong to the EL2 family of defects. In InP, we find two levels: one at 0.34 eV and the other at 0.42 eV. We have also carried out deep level transient spectroscopy (DLTS) on these levels. The agreement between PATS and DLTS is good. Our exercise establishes PATS as a successful near-isothermal technique for characterizing traps in semiconductors. (Author abstract) 5 refs.

Singh, Raj K. (SUNY/Albany, Albany, NY, USA); Singh, Vijay A.; Corbett, James W.; Magno, Richard. *Semicond Sci Technol* v 2 n 11 Nov 1987 p 726-731.

**094110 COMPOSITIONAL DISORDERING OF FOCUSED-SI-IMPLANTED GaAs/AlGaAs SUPERLATTICES BY RAPID THERMAL ANNEALING.** Compositional disordering of focused-Si-implanted GaAs/Al<sub>0.5</sub>Ga<sub>0.5</sub>As superlattices, followed by rapid thermal annealing (RTA), was investigated by means of sputtering Auger electron spectroscopy (AES) and Raman spectroscopy. Complete disordering was found to take place in the superlattices focused-Si-implanted with a dose of  $5 \times 10^{15} \text{ cm}^{-2}$  and annealed at 1000°C for 4 to 30 seconds, resulting in an Al<sub>0.25</sub>Ga<sub>0.75</sub>As alloy. The Raman spectra showed that this alloy had a higher quality as the implanted samples were annealed for longer periods of time. (Author abstract) 15 refs.

Uematsu, Masashi (NTT LSI Lab, Atsugi, Jpn); Yanagawa, Fumihiko. *Jpn J Appl Phys Part 2* v 26 n 12 Dec 1987 p 2101-2103.



## Oscillations

**094111 LOW FREQUENCY AND CHAOTIC CURRENT OSCILLATIONS IN SEMIINSULATING GaAs.** Low frequency current oscillations (LFO) in semiinsulating GaAs are studied as a function of illumination and applied electric field. A transition from LFO to chaotic oscillations is observed and its dependence on the values of the control parameters is investigated. It is found that the chaos is achieved by period doubling. (Author abstract) 13 refs.

Knap, W. (Univ of Warsaw, Warsaw, Pol); Jezewski, M.; Lusakowski, J.; Kusko, W. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 813-816.

## Oxidation

**094112 HIGH-PRESSURE THERMAL OXIDATION OF GALLIUM ARSENIDE AT 250°C.** It is shown that the native oxide of GaAs can be thermally grown easily at a temperature of 250°C using a high-pressure oxidation technique. The resulting oxide films are uniform, chemically stable and have a breakdown strength of  $6.8 \times 10^6$  v/cm and a bandgap energy greater than 6.5 eV. The chemical composition of the oxide films is studied using X-ray photoelectron spectroscopy, and it is found to contain oxides of both gallium and arsenic. (Author abstract) 9 refs.

Bhat, K.N. (Indian Inst of Technology, Madras, India); Basu, N. *Electron Lett* v 23 n 24 Nov 19 1987 p 1329-1330.

**094113 ARSENIC GROWTH ON THE GALLIUM ARSENIDE SURFACE DURING OXIDATION.** Crystalline arsenic was observed to grow on the surface of GaAs during exposure to continuous-wave laser radiation. A study of the time development of the arsenic growth as revealed by Raman backscattering indicated that a surface diffusion process was responsible for limiting the growth process. Temperature measurements were performed from which the diffusion barrier energies were obtained for various GaAs samples. From these results the diffusion process was shown to depend on the Fermi level of the sample. (Author abstract) 10 refs.

Martin, R. (Univ of California, Los Angeles, CA, USA); Braunstein, R. *J Phys Chem Solids* v 48 n 12 1987 p 1207-1212.

**094114 OPTICAL PROPERTIES OF THE THERMAL OXIDE - GaAs ROUGH INTERFACE.** The surface roughness of GaAs originating during thermal oxidation at a temperature of 450°C was studied using multiple-angle-of-incidence ellipsometry at 632.8 nm and reflectometry on samples after the dissolution of the oxide film. The rough surface is represented by an effective layer with optical constants determined in the Bruggeman effective medium approximation. Experimental data were used to determine the thickness of the effective layer and the volume factor of voids. The properties of the natural oxide film on the surface of the samples are also discussed. (Author abstract) 15 refs.

Gaillyova, Y. (J.E. Purkyne Univ, Brno, Czech). *Thin Solid Films* v 155 n 2 Dec 30 1987 p 217-255.

**094115 PLATINUM CONTAMINATION OF OXIDE GROWN BY PLASMA ANODIZATION OF GALLIUM ARSENIDE.** The contamination of oxide films caused by sputtering of the cathode (Pt) during the anodization of GaAs in an oxygen plasma was investigated. Platinum was found to accumulate near the surface of the oxide, its concentration decreasing rapidly towards the oxide-semiconductor interface. No correlation of Pt content with deep level spectra from GaAs could be established. The amount of platinum built into the oxide depends sensitively on growth conditions. (Author abstract) 9 Refs.

Lanyi, S. (Inst of Physics, EPRC SAS, Bratislava, Czech); Pavlyak, F.; Pincik, E. *Surf Interface Anal* v 11 n 11 Aug 1988 p 553-558.

## Performance

**094116 DEVELOPING THE NEXT GENERATION OF INTEGRATED CIRCUITS.** For more than two decades, the telecommunications industry has exploited the properties of silicon to produce increasingly faster, more powerful integrated circuits (ICs). Now these silicon chips - capable of shuttling electrons at high speeds across tightly populated chip surfaces - are being joined by a new, significantly faster generation of ICs, fabricated in gallium arsenide. An aggressive research and development program, is resulting in the design, fabrication, and testing of experimental gallium arsenide (GaAs) chips. In developing these experimental chips, BNR is exploiting the high-speed, low-power, and light-emitting properties of GaAs.

Jay, Paul; Streater, Rick. *Telesis* v 14 n 1 1987 p 4-13.

**094117 GALLIUM ARSENIDE DIGITAL TECHNOLOGY.** The features of GaAs digital technology are pointed out. Potential applications in electronic warfare, communications, electronic countermeasures, and radar are proliferating as people become aware of the capabilities of digital devices in this high-speed low-power high-temperature-tolerant material. New horizons in packing density, functional complexity, and system integration are opening up.

Smith, Irl W. *Electron Prog* v 28 n 3 1987 p 11-22.

**094118 GALLIUM ARSENIDE ON SILICON: A REVIEW.** Recent advances in the performance of electronic and optical devices fabricated in GaAs on Si substrates have led to the consideration of this hybrid technology for novel applications. These range from simply replacing GaAs substrates with large area, light weight, high strength Si substrates to highly desirable integration of GaAs and Si devices and circuits on the same chip. Other applications include the use of GaAs as an interlayer for subsequent growth of long wavelength compound semiconductors (III-V and II-VI) for focal plane arrays with built-in Si signal processors. (Author abstract) 42 refs.

Morkoc, H. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Unlu, H.; Zabel, H.; Otsuka, N. *Solid State Technol* v 31 n 3 Mar 1988 p 71-76.

**094119 SUBNANOSECOND SILICON ECL GATE ARRAYS FACE CHALLENGE FROM GaAs AND CMOS.** The mainstay of the fastest digital systems, silicon ECL gate arrays face competition from high-density CMOS, bipolar-CMOS, and gallium arsenide. It is pointed out that due to recent advances ECL's picosecond delays and gate complexity ensure its lead.

Bursky, Dave. *Electron Des* v 35 n 13 Jun 12 1986 p 74-80, 82, 84.

**094120 FASTER AND SMALLER WITH GALLIUM ARSENIDE.** The advantages of using gallium arsenide as semiconductor material over silicon are pointed out. Its most notable characteristic is that its electrons can be made to travel at speeds 5 times faster in GaAs than in silicon. This is specially significant wherever fast electronic switches are needed as in microwave and optical communications. GaAs can also be made to emit light and can be used to manufacture optical elements such as lasers and optical detectors. However, GaAs is a more difficult material to work with than silicon and its technology is less mature. Also, it is more expensive. It is unlikely to supplant silicon as the general semiconducting material and it is an alternative to silicon in some specialized applications such as telecommunications and optoelectronics.

Grad, Paul. *J Inst Eng Aust* v 60 n 17 Aug 19 1988 p 16-18.

**Photoconductivity** See Also OPTICAL GRATINGS.

**094121 VANADIUM IN GaAs: FOR A REVISION OF THE ENERGY LEVEL SCHEME.** Photoconductivity measurements performed at 4.2K on semi-insulating

V-doped GaAs, give support to identify the isolated vanadium ( $V_{Ga}$ ) as a double acceptor in gallium-arsenide. This behavior would explain all the known properties of the V-doped crystals including the semi-insulating character. The first transition would be at  $E_c - 0.65 \pm 0.03$  eV and the second at  $E_c - 0.16 \pm 0.01$  eV. (Author abstract) 14 refs.

Barrau, J. (CNRS, Toulouse, Fr); Sorba, A.; Brousseau, B.; Brousseau, M.; Leotin, J.; Binh, Phi Hoa; Reclus, G. *Solid State Commun* v 62 n 11 Jun 1987 p 753-755.

**094122 QUENCHING PHENOMENON OF PHOTOCONDUCTANCE IN INDIUM DOPED DISLOCATION FREE GaAs.** In photoconductance measurements on indium doped semi-insulating GaAs, we have found that the quenching phenomenon of photoconductance is enhanced with the reduction in the dislocation density due to the addition of a few percent indium atoms to GaAs. We propose that the enhancement in the quenching phenomenon associates with increasing the internal stress due to the decrease in dislocation density. The time dependence of photoconductance also suggests the existence of the state or the path assisting the transition from normal EL2 states to those metastable states in indium doped GaAs. (Author abstract) 18 Refs.

Satoh, M. (Hisci Univ, Tokyo, Jpn); Kawahara, H.; Kuriyama, K.; Kim, C. *Solid State Commun* v 67 n 2 Jul 1988 p 139-141.

**094123 EL2 IN PHOTOCONDUCTIVITY SPECTRA OF Cr-DOPED SI GaAs BULK CRYSTALS.** Extrinsic photoconductivity measurements at 70 and 293 K in Cr-doped Si GaAs bulk crystals have been carried out in order to characterize the deep levels in this material. The photoconductivity spectra reveal two characteristic structures extended in the low-energy and the high-energy regions, respectively. It is shown that low-energy structure is connected with the  $Cr^{2+}$  deep acceptor level and the high-energy one with the EL2 deep donor level. The spectrum measured after an intentionally photo-induced transfer of EL2 into its metastable state confirms our interpretation of the origin of the high-energy structure. We believe that our study is the first to identify the EL2 contribution to the photoconductivity spectra of Cr-doped Si GaAs. The optical ionization energy with respect to the conduction band and the Frank-Condon parameter of  $Cr^{2+}$  centers are obtained from the experimental results. (Author abstract) 25 refs.

Germanova, K. (Sofia Univ, Sofia, Bulg); Donchev, V.; Hardalov, Ch.; Nikolov, L. *J Phys D* v 20 n 11 Nov 1987 p 1507-1511.

**094124 PHOTOCONDUCTIVITY STUDY OF THE INTERACTION BETWEEN DISLOCATIONS AND EL2 COMPLEXES IN SEMIINSULATING GaAs.** Photoconductivity has been used to examine the EL2-center photoquenching rate in semiinsulating GaAs doped with chromium before and after plastic strain. Deductions are made on the nature of the centers in these crystals. (Author abstract) 13 refs.

Farvacque, G.L.; Gruson, B. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 13-18.

## Physical Properties

**094125 PHOTOINDUCED RECHARGING PHENOMENA AND VANADIUM-RELATED CENTRES IN GaAs:V.** Photoinduced recharging phenomena are studied at low temperatures ( $T < 80$  K) on n-type and semi-insulating GaAs:V by optical absorption, C-EPR, and TD-EPR. Illumination with  $h\nu_{exc} > 1.05$  eV into the photoionization absorption  $\alpha_{II}$  excites electrons into the conduction band and recharging takes place, which has been monitored by optical absorption and EPR. The center responsible for  $\alpha_{II}$  appears to be a V-containing complex of unknown structure, rechargeable under illumination from (V-X) into (V-X)<sup>+</sup>. The  $V^{2+}/(II)$  center measured by TD-EPR is shown to be a second V-containing



ing complex different from (V-X). The interpretation of all experiments does not require a V-related mid-gap level. (Edited author abstract) 20 refs.

Ulrici, W. (Akad der Wissenschaften der DDR, Berlin, East Ger); Kreissl, J.; Vasson, A.; Vasson, A.M.; En-Naquad, M. *Phys Status Solidi B* v 143 n 1 Sep 1987 p 195-206.

**094126 EFFECT OF SEMICONDUCTOR PARAMETERS ON SPECTRAL SENSITIVITY OF A GALLIUM ARSENIDE-ELECTROLYTE CONTACT.** The dependence of spectral sensitivity of a gallium arsenide contact with a 0.01 N KCl solution in dimethylformamide upon impurity concentration in the semiconductor and applied anode bias is studied. It is known that a decrease in dopant level increases spectra sensitivity in the long-wave region. Experimental results are compared with calculation and are found to agree satisfactorily. The results are relevant to solar cells. (Edited author abstract) 13 refs.

Kravchenko, S.N. (I.I. Mechnikov State Univ, Odessa, USSR); Musarova, V.F. *Sov Phys J* v 30 n 4 Apr 1987 p 270-273.

**094127 INFLUENCE OF MANY-BODY EFFECTS ON THE CYCLOTRON RESONANCE MASS OF TWO-DIMENSIONAL POLARONS WITH APPLICATION TO GaAs-Al<sub>1-x</sub>Ga<sub>x</sub>As% HETEROSTRUCTURES.** The influence of many-body effects on the cyclotron resonance mass of two-dimensional polarons is investigated. Firstly, the occupation effect is considered, which arises from the Fermi-Dirac statistics. It is found that (1) the occupation effect reduces the polaron effect, i.e. the cyclotron resonance mass renormalization due to the polaron effect is reduced over the whole magnetic field region, (2) for a fixed electron density the cyclotron resonance mass shows an oscillating behavior as a function of the magnetic field. Secondly, the effect of static screening on the polaron cyclotron resonance mass is examined. The electron screening is found to reduce further the cyclotron resonance mass renormalization. After taking into account the nonparabolicity of the electron energy band, the calculated cyclotron resonance mass is compared to the recent experimental data for GaAs-Al<sub>1-x</sub>Ga<sub>x</sub>As heterostructures. Good agreement is found for magnetic fields  $H > 12$  T. (Edited author abstract) 26 refs.

Wu, Xiaoguang (Univ of Antwerp, Antwerp, Belg); Peeters, F.M.; Devreese, J.T. *Phys Status Solidi B* v 143 n 2 Oct 1987 p 581-594.

**094128 INTERFERENCE EFFECTS OF RAMAN SCATTERING BY LO-PHONONS NEAR THE  $E_0 + \Delta_0$ -GAP STUDIED ON (1 $\bar{1}$ 1 $\bar{3}$ ), (111), AND (1 $\bar{1}$ 1 $\bar{1}$ ) FACES OF GaAs.** We have studied the interference of dipole-allowed deformation-potential Raman scattering and dipole-forbidden Froehlich-induced scattering by LO-phonons near the  $E_0 + \Delta_0$ -gap on the (1 $\bar{1}$ 1 $\bar{3}$ ) face of MBE-GaAs and on the (111) and (1 $\bar{1}$ 1 $\bar{1}$ ) faces of bulk GaAs at 100 K. Absolute values of the squared Raman tensor are displayed. A fit of the resonance profile reveals that the purity of the MBE-sample under investigation compares well with that of (001) LPE-samples studied previously. The (111) and (1 $\bar{1}$ 1 $\bar{1}$ ) faces of GaAs show opposite signs in the interference, in accordance with symmetry considerations. (Author abstract) 8 refs.

Kauschke, W. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Vorlicek, V.; Cardona, M.; Vina, L.; Wang, W.I. *Solid State Commun* v 61 n 3 Feb 1987 p 487-489.

**094129 THEORY OF THE SPECTRAL ACOUSTIC PHONON EMISSION INTENSITY OF HOT 2D ELECTRONS IN QUANTIZED n-INVERSION LAYERS.** The spectral acoustic phonon emission intensity of the hot quasi-two-dimensional electron gas (2DEG) in quantized n-Si(GaAs) inversion layers is calculated as a function of the phonon angular frequency  $\omega$  at different values of the carrier temperature  $T_c$  and density  $N_s$ . In the

long wave length limit ( $\hbar\omega \ll k_B T_c$ ) the emission intensity increases  $\propto \omega^s(\omega^s+1)$  for bulk- (surface-) modes where  $s=3$  for the unscreened acoustic deformation potential coupling. At  $\omega \approx v_j 2k_F$  ( $v_j$ : sound velocity of the phonon mode  $j$ ,  $k_F$ : radius of the Fermi-circle) the emission intensity reaches a maximum whose position is shifted to higher  $\omega$ -values if  $N_s$  increases. For given values of  $N_s$ ,  $T_c$  (lattice temperature) and  $\theta$  (emission angle) the emission intensity maximum of the n-GaAs inversion layer is found to be about one order of magnitude smaller than the intensity maximum of the n-Si inversion layer. (Author abstract) 14 refs.

Vass, E. (Univ of Innsbruck, Austria). *Solid State Commun* v 61 n 2 Jan 1987 p 127-131.

**094130 NON-PARABOLICITY AND ANISOTROPY IN THE CONDUCTION BAND OF GaAs.** The spin-doublet splitting and effective-mass shift of the cyclotron resonance in n-GaAs has been studied in high static magnetic fields applied along the (001), (011) and (111) crystal directions. A clear anisotropy of the conduction band has been observed in the orientation dependence of the spin-doublet splitting. Experimental results are described using a five-level k-p model. Comparison between the experimental data and this theoretical model allowed the determination of important band-structure parameters for GaAs, such as the interband momentum matrix element. (Author abstract) 18 refs.

Sigg, H. (Univ of Nijmegen, Nijmegen, Neth); Perenboom, J.A.A.J.; Pfeffer, P.; Zawadzki, W. *Solid State Commun* v 61 n 11 Mar 1987 p 685-689.

**094131 HOT PHOTOLUMINESCENCE SPECTROSCOPY INVESTIGATIONS OF L-VALLEY SPLITTING AND INTERVALLEY SCATTERING IN UNIAXIALLY STRESSED GALLIUM ARSENIDE.** Hot photoluminescence spectra (HPL) of uniaxially stressed GaAs are investigated. From the stress-induced shift and splitting in the HPL spectra, shear deformation potentials for the subsidiary minima have been determined with a good accuracy. From the stress dependence of the relative intensities in the split spectrum a value of the coupling constant for scattering between the L-valleys is obtained as  $D_{LL} = (5 \pm 1) \times 10^8$  eV cm<sup>-1</sup>. (Edited author abstract) 13 refs.

Mirlin, D.N. (USSR Acad of Sciences, Leningrad, USSR); Sapega, V.F.; Karlik, I.Ya.; Katilius, R. *Solid State Commun* v 61 n 12 Mar 1987 p 799-802.

**094132 INTERACTION OF OPTICAL PHONONS WITH ELECTRONS IN GaAs QUANTUM WIRES.** The energy and the effective mass of an electron in a quantum-well wire of GaAs surrounded by Ga<sub>1-x</sub>Al<sub>x</sub>As is calculated in the presence of electron-LO-phonon interaction using a variational approach. The polaron mass is found to be dependent on the sizes of the wire, its magnitude is greater than that in comparable two- and three-dimensional semiconductor structures. (Edited author abstract) 17 refs.

Degani, M.H. (Univ de Sao Paulo, Sao Carlos, Braz); Hipolito, O. *Solid State Commun* v 65 n 10 Mar 1988 p 1185-1187.

**094133 POLARON CYCLOTRON MASS IN GaAs-Al<sub>x</sub>Ga<sub>1-x</sub>As.** A theoretical analysis is made of the polaron cyclotron resonance mass in GaAs-Al<sub>x</sub>Ga<sub>1-x</sub>As heterostructures for different electron densities ( $n_e$ ). Agreement is found with existing experimental data in the magnetic quantum limit. The authors found that polaron corrections have to be included but for  $n_e > 1.4 \times 10^{11}$  cm<sup>-2</sup> they are found to be smaller than for bulk systems. (Edited author abstract) 18 refs.

Peeters, F.M. (Univ Instelling Antwerpen, Antwerp, Belg); Wu, Xiaoguang; Devreese, J.T. *Solid State Commun* v 65 n 12 Mar 1988 p 1505-1508.

**094134 HEATING OF COLD ELECTRONS BY A WARM GaAs LATTICE: A NOVEL PROBE TO CARRIER-PHONON INTERACTION.** The polar optical scattering of electrons and holes is studied by

picosecond luminescence in a GaAs/Al<sub>x</sub>Ga<sub>1-x</sub>As heterostructure and in 5 and 13nm thick GaAs/Al<sub>x</sub>Ga<sub>1-x</sub>As quantum wells. In contrast to earlier work we do not trace the cooling of hot carriers in a cold lattice but we look at the reverse process of heating of a cold electron-hole plasma by a warm lattice. The scattering rates prove to be independent of density, dimensionality, and quantum well thickness. (Author abstract) 15 refs.

Ruehle, W.W. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Pollard, H.-J.; Bauser, E.; Ploog, K.; Tu, C.W. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 407-412.

**094135 BALLISTIC ELECTRON TRANSPORT IN GaAs/AlGaAs TUNNELING JUNCTIONS WITH OPTICAL PHONON EMISSION.** Oscillatory current-voltage characteristic with period of longitudinal optical-phonon (LO-phonon) energy in Hickmott's experiment (Hickmott and coworkers 1984) is studied. The origin of this oscillation is attributed to a one-dimensional localization. It can cause considerable space charge in a fieldless undepleted region. This space charge may induce an additional electric field on the barrier and therefore influence the tunneling current. Sideband energy spectrum of a tunneling electron with LO-phonon emission is given by using the path integral method and WKB approximation. Experiments are discussed. (Edited author abstract) 16 refs.

Hu, P. (Univ of Houston, Houston, TX, USA); Ting, C.S. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 555-558.

**094136 DOUBLE RIDLEY-WATKINS-HILSUM-GUNN EFFECT IN COMPENSATED GaAs.** Our studies show that impurity scattering drastically reduces low-field electron mobility, peak velocity and negative differential mobility in compensated GaAs. Under certain conditions, such as at low temperature, high doping density and high compensation ratio, the electron velocity versus electric field relation may exhibit two maxima. The reason for the second maximum is the decrease in impurity scattering rate with an increase in the kinetic energy of L-valley electrons, and subsequent electron transfer into the X-valleys. We influence the characteristics of high field domains in compensated GaAs. (Edited author abstract) 13 refs.

Xu, Jingming (Univ of Toronto, Toronto, Can); Shur, Michael. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 607-610.

**094137 NORMAL AND HOT ELECTRON MAGNETO-PHONON RESONANCE IN A GaAs-HETEROSTRUCTURE.** Linear and nonlinear magneto-phonon resonances are investigated in a two-dimensional electron gas in a GaAs-Al<sub>x</sub>Ga<sub>1-x</sub>As heterostructure, within the momentum balance equation approach. The linear transverse resistivity as obtained from the present approach reduces to the high magnetic field result as based on the Kubo-formula. The Landau-level broadening is taken to be a Gaussian with a constant background. The effect of the broadening parameters on the shape of the magneto-phonon oscillations in the transverse resistivity  $\rho_{xx}$  and the energy relaxation rate is found to be appreciable and stronger than in the corresponding three dimensional case. The nonlinear momentum balance equation is solved for arbitrary average electron velocity. We find that the maxima at the linear magneto-phonon resonance evolve to minima (and the minima become maxima) when the average electron velocity is sufficiently large. (Author abstract) 18 refs.

Warmenbol, P. (Univ of Antwerp, Wilrijk-Antwerpen, Belg); Peeters, F.M.; Devreese, J.T. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 771-775.

**094138 LOCAL DENSITY VALENCE BAND OFFSET IN GaAs/AlAs: ROLE OF INTERFACE DIPOLE.** The valence band offset,  $\Delta E_v$ , at the lattice-matched GaAs/AlAs(001) interface is derived from



highly precise self-consistent all-electron local density band structure calculations of the  $(\text{GaAs})_n(\text{AlAs})_n(001)$  superlattices (with  $n < 3$ ). Using the core levels as reference energies, we find that  $\Delta E_v = 0.50 \pm 0.05$  eV, in agreement with recent experimental results ( $\Delta E_v = 0.45 - 0.55$  eV). The dependence of  $\Delta E_v$  on the superlattice thickness is studied and related to the interface charge redistribution which produces an interface dipole potential estimated to be approximately 0.14 eV. (Edited author abstract) 12 refs.

Massidda, S. (Northwestern Univ, Evanston, IL, USA); Min, B.I.; Freeman, A.J. *Superlattices Microstruct* v 4 n 1 1988, Chicago Conf, Pap, Chicago, IL, USA, 1987 p 15-17.

## Plasmas

**094139 INFLUENCE OF CARRIER LIFETIME ON THE COOLING OF A HOT ELECTRON-HOLE PLASMA IN GaAs.** The influence of carrier lifetime on the cooling of a hot electron-hole plasma in bulk GaAs is studied by time-resolved photoluminescence. We observe a reduced cooling rate for samples with short carrier lifetime and an enhanced cooling rate for samples with long lifetime at high densities. The cooling rate is independent of carrier lifetime at low densities. The experimental data are in agreement with theory if the degeneracy of the electron and hole Fermi gas is taken into account. (Author abstract) 9 refs.

Leo, K. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Ruehle, W.W. *Solid State Commun* v 62 n 9 Jun 1987 p 659-662.

**094140 ELECTRON PLASMA IN A NON-PARABOLIC CONDUCTION BAND.** The electron plasma in highly n-doped GaAs and InP is influenced by the nonparabolicity of the conduction band. Its properties for densities up to  $2 \cdot 10^{19} \text{ cm}^{-3}$  have been studied experimentally by Raman scattering of coupled plasmon-LO-phonon modes. The Raman spectra and the dispersion of the plasmon-phonon modes were described by evaluating the Lindhard-Mermin dielectric function including the nonparabolicity of the band structure with the carrier concentration and the electron collision time as the only free parameters. It turns out that this procedure is a very sensitive method to determine the carrier concentration of a sample. (Author abstract). 8 Refs.

Richter, R. (RWTH Aachen, Aachen, West Ger); Nowak, U.; Juergensen, H.; Roessler, U. *Solid State Commun* v 67 n 3 Jul 1988 p 199-204.

**094141 HIGH RESOLUTION STUDIES OF 2 D PLASMA TRANSPORT IN GaAs/GaAlAs QUANTUM WELLS.** A new time-of-flight method for lateral transport investigations capable of high spatial and temporal resolution is presented. Transport properties are studied by carrier density probing at the beginning and the end of a flight distance defined by masks. Ambipolar transport parallel to interfaces can be described completely by diffusion, while additional expansion effects accelerate the transport in directions perpendicular to interfaces. (Author abstract) 8 refs.

Hillmer, H. (Univ Stuttgart, Stuttgart, West Ger); Forchel, A.; Hansmann, S.; Lopez, E.; Weinmann, G. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 485-488.

## Protective Coatings

**094142 OXIDATION OF GaAs WITH A PbS LAYER ON ITS SURFACE.** Using the methods of IR spectroscopy, X-ray spectral analysis and mass spectrometry, it is shown that in the oxidation of GaAs-PbS structures the formation of  $\text{PbSO}_4$  occurs first and then that of  $\text{PbO}$ , which can then oxidize the gallium in the substrate. The rate of formation of oxide layers during thermal oxidation of GaAs-PbS structures and their electrical strength are higher than those of the oxide layers forming during thermal oxidation of GaAs. 13 refs. In Russian.

Mittova, I.Ya.; Semenov, V.N.; Verevkina, Zh.A.; Puk-

hova, V.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 5 May 1987 p 717-720.

## Purification

**094143 PHOTOLUMINESCENCE OF BULK AND EPITAXIAL GaAs.** Methods for donor identification in bulk and epitaxial GaAs and for quantitative determination of acceptors in bulk insulating GaAs are described. Sulphur and a previously unreported donor were present in a wide variety of commercial bulk GaAs. A new procedure for electronic Raman scattering in GaAs is demonstrated. Greatly improved sensitivity and flexibility for acceptor determination is shown. (Author abstract) 10 refs.

Harris, T.D. (AT&T Bell Lab, Murray Hill, NJ, USA). *J Cryst Growth* v 89 n 1 Jun 1988, Purif of Mater for Cryst Growth and Glass Process - Proc of the Second Workshop, Champion, PA, USA, Sep 28-Oct 1 1987 p 21-27.

## Radiation Damage

**094144 SCATTERING BY A RANDOM FIELD OF ELASTIC DEFORMATIONS IN NEUTRON-BOMBARDED GaAs.** The contribution to electron scattering due to a random field of elastic deformations produced by defects in GaAs caused by neutron irradiation is calculated. Under the assumption of smallness of the radius of correlation of the random field and the parameter values used earlier to interpret the optical absorption spectrum, the influence of this scattering mechanism on the mobility is estimated. (Author abstract) 3 refs.

Mironov, A.G. (M.V. Lomonosov Moscow State Univ, USSR). *Sov Phys J* v 30 n 6 Jun 1987 p 488-490.

**094145 ENERGY DEPENDENCE OF PROTON-INDUCED DISPLACEMENT DAMAGE IN GALLIUM ARSENIDE.** Nonionizing energy deposition in gallium arsenide (GaAs) has been calculated for protons with energies ranging from 1 to 1000 MeV. The calculations are compared with experimental results for ion-implanted GaAs resistors and Hall samples irradiated with protons in the energy range 1 to 60 MeV. Results are compared with recent studies of proton-induced displacement damage in silicon. 22 refs.

Burke, E.A. (US Naval Research Lab, Washington, DC, USA); Dale, C.J.; Campbell, A.B.; Summers, G.P.; Stapor, W.J.; Xapsos, M.A.; Palmer, T.; Zuleeg, R. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1220-1227.

**Radiation Effects** See Also SEMICONDUCTOR MATERIALS—Radiation Effects.

**094146 DEFECT FORMATION IN NUCLEAR-ALLOYED GALLIUM ARSENIDE.** Precision methods of measuring the lattice spacing and density of single crystals were used to examine the nature and behavior of point defects in nuclear-alloyed gallium arsenide. It is shown that the main part of the interstitial atoms is not concentrated in elongated clusters of the type of disordered regions and is distributed in the matrix in the form of complexes or small clusters. Satisfactory agreement was found between the dose dependence of the lattice spacing in the irradiated material and the results of calculations based on the given defect formation model. The lattice spacing and density of nuclear-alloyed gallium arsenide are restored at an annealing temperature of 500-600°C. (Author abstract) 7 refs.

Kolin, N.G.; Bublik, V.T.; Osvenskii, V.B.; Yarmolyuk, N.I. *Phys Chem Mater Treat* v 21 n 3 May-Jun 1987 p 223-226.

**094147 ENERGY DEPENDENCE OF THE SPUTTERING YIELD OF GALLIUM ARSENIDE BY ARGON ION BOMBARDMENT.** The sputtering yields of a GaAs single crystal with (100) orientation bombarded by 15-35 keV  $^{40}\text{Ar}^+$  for normal incidence are determined. The yield values are compared with different modifica-

tions of P Sigmund's sputtering yield formula in the elastic collision region. The atomic surface binding energy of GaAs is estimated using the measured yield values. The results are compared with that of metallic alloy sputtering and the qualitative differences are noted. (Author abstract) 14 refs.

Bhattacharya, S.R. (Saha Inst of Nuclear Physics, Calcutta, India); Ghose, D.; Basu, D. *Indian J Pure Appl Phys* v 25 n 9 Sep 1987 p 328-330.

**094148 PHONON SHIFTS IN ION BOMBARDED GaAs: RAMAN MEASUREMENTS.** When 15 MeV ions bombarded single crystal GaAs (111), (100), and (110) faces, they leave a strained, crystalline, surface layer with many defects (as well as a buried amorphous layer). Using Raman spectroscopy, we measure the shifts and line widths of the optic phonons of these strained crystalline layers. Using simple models, the possible sources of the phonon shifts are quantitatively considered. We conclude that the strains, and a change in the ionic plasma frequency (LO-TO splitting) due to a ratio of interstitials, or antisites, to atoms in the crystal of  $\approx 2\%$ -3% account for the major portion of the phonon shifts. These effects have been ascribed previously to phonon confinement. (Author abstract) 34 refs.

Burns, Gerald (IBM, Yorktown Heights, NY, USA); Dacol, F.H.; Wie, C.R.; Burstein, E.; Cardona, M. *Solid State Commun* v 62 n 7 May 1987 p 449-454.

**094149 TYPE-CONVERSION PHENOMENON IN ELECTRON-IRRADIATED GaAs.** The authors examine type-conversion in more detail. It is shown that the type-conversion data are consistent with the recent TDH conclusions only if E1 is a donor. It is shown that E2 is almost certainly a donor also. These results then lead to a more accurate value for the  $C_{AS}$  production rate,  $5.0 \pm 0.5 \text{ cm}^{-1}$ , under 1 MeV irradiation. Finally, it is shown that significant room-temperature acceptor annealing can be observed in p-type samples. The possible identification of the  $C_{AS}$  with Ga-sublattice damage is discussed. 13 refs.

Look, D.C. (Wright State Univ, Dayton, OH, USA); Farmer, J.W. *J Phys Chem Solids* v 49 n 1 1988 p 97-102.

**094150 ELECTRON TRAPS IN n-GaAs IRRADIATED WITH HIGH ELECTRON BEAM FLUXES AT HIGH TEMPERATURES.** High-temperature induced defects (HTID) in GaAs have been investigated after irradiation at 50°C and 400°C. DLTS spectra of vapor phase epitaxy grown (VPE) n-GaAs ( $n = (2 \text{ to } 4) \times 10^{15} \text{ cm}^{-3}$ ) have been studied after electron bombardment with subsequent post-irradiation annealing up to 400°C. P1 to P3 traps are the primary defects of electron bombardment which are masked by E3 to E5 traps. Post-irradiation annealing or high temperature irradiation manifests HTID. 6 refs.

Brudnyi, V.N. (VD Kuznetsov Siberian Physico-Technical Inst, Tomsk, USSR); Peshev, V.V. *Phys Status Solidi A* v 105 n 1 Jan 1988 p K57-K60.

**094151 POINT DEFECTS IN GaAs STUDIED BY CORRELATED POSITRON LIFETIME, OPTICAL, AND ELECTRICAL MEASUREMENTS. II. POINT DEFECTS IN GaAs IRRADIATED WITH FAST NEUTRONS.** The positron lifetime technique was used in combination with infrared absorption, photoluminescence, and photoreflection measurements to investigate defects created by irradiation of GaAs with fast neutrons. The integrated fluence ranged from  $5 \times 10^{14}$  to  $3.8 \times 10^{19} \text{ n}^+/\text{cm}^2$ . Geometrical size of the displacement cascades is estimated to be  $r = 5 \text{ nm}$ . The behavior of the carrier concentration  $n$  estimated from photoreflection experiments provides  $r = 20 \text{ nm}$ . This value is characteristic of the insulating region surrounding the cascade. Almost the same value is typical of the luminescence killer region and positron trapping. Evidence of positron trapping by vacancy-type irradiation defects is given. The vacancies disappear in an annealing stage at 500°C. The stage is



interpreted as a long-range migration of point defects resulting in a dissolution of the displacement cascades. A substage at 200°C observed in photoluminescence experiments is discussed as recombination of vacancy-interstitial close pairs in the As sublattice which are situated outside of displacement cascades. (Edited author abstract). 34 Refs.

Diubek, G. (Padagogischen Hochschule, Halle, East Ger); Diubek, A.; Krause, R.; Brummer, O. *Phys Status Solidi A* v 107 n 1 May 1988 p 111-121.

**094152 EFFECT OF ION BEAM MIXING ON THE EVOLUTION OF ARSENIC FROM THE Au-GaAs SYSTEM.** Gold and gold-based alloys are frequently used as contact materials to GaAs. The contact technology involves high temperature heat treatment. This temperature can be decreased using low dose ion beam mixing to break up the contaminating layer at the interface before annealing. The contact thus formed is more uniform and the gold does not penetrate so deep as in the non-implanted case. In this study a comparison of the arsenic loss from non-implanted and 700 keV  $10^{14}\text{Xe}^{2+}$  cm<sup>-2</sup> pre-implanted 40 nm Au-GaAs structures is presented. In investigating the interdiffusion of Au and GaAs by Rutherford backscattering spectrometry, different mechanisms were found for the two cases. 4 Refs.

Jaroli, E. (Central Research Inst for Physics, Budapest, Hung); Pecz, B.; Veresegyhazy, R.; Paszti, F.; Lohner, T.; Fried, M.; Mojzes, I.; Gyulai, J. *Phys Status Solidi A* v 107 n 1 May 1988 PK15-K17.

**Research** See ALSO INTEGRATED CIRCUITS, MONOLITHIC—Fabrication.

**094153 MINIBAND DISPERSION OF THE CONFINED AND UNCONFINED STATES OF COUPLED MULTIPLE QUANTUM WELLS.** In the photoreflectance spectra at 300K of a series of GaAs/Ga<sub>0.82</sub>Al<sub>0.18</sub>As multiple quantum wells with different barrier widths we have observed for the first time evidence for coupling between multiple wells (miniband dispersion) in several confined transitions above the fundamental transition. In addition, a number of unconfined transitions also exhibit coupling effects. Excellent agreement is found between experiment and a Bastard model calculation. (Author abstract) 27 refs.

Shen, H. (Brooklyn College, Brooklyn, NY, USA); Pan, S.H.; Hang, Z.; Pollak, Fred H.; Sacks, R.N. *Solid State Commun* v 65 n 9 Mar 1988 p 929-934.

**094154 SUPPRESSION OF RAMAN SCATTERING BY INTERFACE PHONONS IN QUANTUM WELLS UNDER HIGH PHOTOEXCITATION.** We report on the power-density dependence of resonant Raman scattering by interface phonons in GaAs-Al<sub>x</sub>Ga<sub>1-x</sub>As quantum wells. Strong photoexcitation leads to suppression of the nominally forbidden (defect-induced) scattering. The magnitude of the quenching is largest for laser energies in the vicinity of outgoing resonances. Alternative mechanisms which partially account for the experimental findings are discussed. We consider in particular the role of ionized impurities and effects due to screening by photoexcited carriers. (Author abstract) 19 refs.

Ambrzevicius, G. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Cardona, M.; Merlin, R.; Ploog, K. *Solid State Commun* v 65 n 9 Mar 1988 p 1035-1038.

## Soldering

**094155 SUCCESSFUL ALLOY ATTACHMENT OF GAAS MMIC'S.** Alloy attachment of GaAs monolithic circuits was examined after initial reflow, after environment bake, and after a stepped series of thermal cycles from 200 to 1000 cycles (-55 to +125°C). The variety of solders tested included both pastes and preforms. Monolithic assemblies alloyed with these solders were evaluated for changes in physical properties as well as for changes in electrical performance. It was noted during the study

that via fractures due to thermal expansion differences between the alloy and the GaAs monolithic device were a common occurrence and could become an inherent reliability risk. Based on this evidence, an investigation relating the frequency of fracturing to the size and the shape of the vias was undertaken. The results of the investigation led to the development of processing parameters which could minimize and control fracture occurrence; these parameters are presented.

Pavio, Jeanne S. (Texas Instruments Inc, Dallas, TX, USA). *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2616-2620.

## Solubility

**094156 SOLUBILITY OF GALLIUM ARSENIDE IN BISMUTH-GALLIUM MELTS.** The solubility of GaAs in melts of the Bi-Ge system was determined at 700, 800 and 850°C. All the liquidus isotherms were found to be characterized by the presence of a minimum at a Bi content in the solvent of approximately 85 at.% and a maximum at a Bi concentration of approximately 10 at.%. The experimental data do not agree with a calculation within the framework of a regular associated solution model. An expression is obtained for the solubility of As in the 600-900°C range for the quasi-binary system Bi-GaAs. In Russian. 13 refs.

Yakusheva, N.A.; Chikichev, S.I. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 10 Oct 1987 p 1607-1609.

**Space Applications** See SPACECRAFT—Communication Systems.

**Spectroscopic Analysis** See ALSO SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Electronic Properties.

**094157 STUDY ON DETECTIVE SENSITIVITY OF PHOTOTHERMAL RADIOMETRY SPECTROSCOPY.** The detective sensitivity of the photothermal radiometry (PTR) spectrum technique is discussed and the absorption edges of Cu<sub>2</sub>O and GaAs are measured. The absorption edge of Cu<sub>2</sub>O shows two shoulders obviously in 632nm and 641nm. The fundamental absorption edge of GaAs is measured with PTR. The signal amplitude of GaAs is an order of magnitude less than that of Cu<sub>2</sub>O. By comparison and analysis, it is found that the detective sensitivity of PTR can be improved obviously when the responsive wavelength range of infrared detector lies in the strong infrared radiation band of the specimen. (Author abstract) In Chinese. 7 refs.

Wang, Guifen (Nankai Univ, China); Wang, Xuan; Ma, Genyuan; Zhang, Guangyin. *Hongwai Yanjiu A-JI* v 6 n 5 1987 p 347-351.

**094158 ZEEMAN SPECTROSCOPY ON TI-DOPED GaAs AND GaP.** Zeeman spectroscopy measurements on the sharp line structure observed in the absorption and photoluminescence spectrum of GaP:Ti around 0.61 eV are interpreted as  $^2T_{2g}$   $^2E$  transitions of Ti<sup>3+</sup>(d<sup>1</sup>). A related system of lines at 0.57 eV in GaAs:Ti is similarly interpreted. (Author abstract) 11 refs.

Halliday, D.P. (Univ of Nottingham, Nottingham, Engl); Payling, C.A.; Saker, M.K.; Skolnick, M.S.; Ulrici, W.; Eaves, L. *Semicond Sci Technol* v 2 n 10 Oct 1987 p 679-682.

**094159 RAMAN PIEZOSPECTROSCOPIC STUDY OF INDIUM-HARDENED GaAs.** We have investigated the effect of a uniaxial stress on the transverse optical and longitudinal optical phonon frequencies of In-hardened GaAs using a cw Nd:YAG laser. We find that for a stress along [1 1 1] the singlet-doublet phonon frequency splittings are smaller in comparison with those in pure GaAs. A possible explanation of this effect may lie in a hardening of the internal stress parameter due, at least in part, to the increase in lattice constant. Plastic deformation and fracture at the highest stresses reached is also discussed and compared with observations for pure GaAs. (Author abstract) 27 refs.

Anastassakis, E. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Cardona, M. *Solid State Commun* v 64 n 4 Oct 1987 p 543-547.

**094160 VERY HIGH PURITY GaAs: FREE EXCITON DOMINATED 5K PHOTOLUMINESCENCE AND MAGNETOPHOTOLUMINESCENCE SPECTRA.** We report the observation of 5K photoluminescence (PL) spectra of undoped GaAs, grown by molecular beam epitaxy, which are dominated by free exciton (intrinsic) emission. The weakness of impurity related features is taken as an indication of very low levels of residual impurity contamination. The identification of the strong, narrow peak in the PL spectra with the free exciton emission has been confirmed using magnetophotoluminescence studies. Our results are in good agreement with magnetoreflectance data which are sensitive only to intrinsic (i.e. excitonic) features. (Author abstract) 9 refs.

Koteles, Emil S. (GTE Lab Inc, Waltham, MA, USA); Elman, B.S.; Zemon, S.A. *Solid State Commun* v 62 n 10 Jun 1987 p 703-706.

**094161 PHOTO-MODULATING ABSORPTION SPECTROSCOPY OF SEMICONDUCTORS UNDER HYDROSTATIC PRESSURE.** A technique for the photo-modulating optical absorption spectrum under hydrostatic pressure is developed. This new experiment method which combines the highly sensitive modulation spectroscopy with the diamond anvil cell technique is very useful for investigating the absorption of interband transitions in semiconductors under extreme conditions. The new technique has been used for GaAs and CdTe and shows superiorities of the sensitivity and accuracy to the conventional optical absorption spectroscopy under high pressure. (Author abstract) 11 refs.

Shan, Wei (Acad Sinica, Shanghai, China); Shen, Xuechu; Zhu, Haorong; Jiang, Shan. *Chin J Infrared Res Ser B (Engl Ed)* v 6 1987 p 27-31.

**094162 CHARACTERIZATION OF ELECTRICAL PROPERTIES OF SEMI-INSULATING GaAs USING ACOUSTO-ELECTRIC VOLTAGE SPECTROSCOPY BETWEEN 83 AND 300 K WITH SURFACE WAVE POWER AS AN ADDITIONAL PARAMETER.** Transverse acousto-electric voltage (TAV) measurements as a function of incident photon energy, surface acoustic wave (SAW) power and dc bias voltage of temperature range between 83 and 300 K are used to study the surface of semi-insulating, Cr-doped GaAs samples. A bound excitonic excitonic level around 1.506 eV is detected and it is observed that (i) raising the temperature, (ii) applying a dc bias voltage, (iii) increasing the SAW power, (iv) decreasing the spectral resolution of the incident photon beam and (v) illuminating by a bias light with energies between 1.55 and 0.89 eV all result in the quenching of the excitonic structure. The presence of a large band of interface traps, that considerably influences the field effect measurements, are detected and their radial distribution is studied by monitoring the TAV amplitude as a function of the spatial position of the incident beam. (Edited author abstract) 24 refs.

Tabib-Azar, M. (Case Western Reserve Univ, Cleveland, OH, USA). *Solid State Electron* v 31 n 7 Jul 1988 p 1197-1204.

**094163 PHOTOREFLECTANCE SPECTROSCOPY OF GaAs-AlAs MULTIPLE QUANTUM WELL STRUCTURES.** Photoreflectance (PR) spectra of GaAs-AlAs multiple quantum well (MQW) structures at room temperature are measured and compared with the photoluminescence excitation spectrum at 2K. The results show that the excitonic process is very important for GaAs-AlAs MQWs even at room temperature. The PR modulation mechanism of GaAs-AlAs MQW structures is discussed. It is pointed out that the PR modulation is mainly caused by the optical modulation of the surface electric field. In contrast to the case of bulk materials, the PR spectra of MQWs have mainly the first derivative functional lineshapes. Under the low field condition, they



are dominated by the stark shifts of quantized subbands and corresponding excitonic energy gaps. (Author abstract). 17 Refs. In Chinese.

Yinsheng, Tang (Univ of Science & Technology of China, China); Desheng, Jiang. *Hongwai Yanjiu A-Ji* v 7A n 3 1988 p 195-199.

**094164 RAMAN SCATTERING FROM PERIODIC & QUASIPERIODIC GAAS/GA<sub>1-x</sub>AL<sub>x</sub>AS SUPERLATTICES.** The Raman spectra of periodic and Fibonacci superlattices of GaAs/Ga<sub>1-x</sub>Al<sub>x</sub>As are reported. The superlattices were grown using similar bilayer building blocks involving layers of GaAs and Ga<sub>1-x</sub>Al<sub>x</sub>As of different thicknesses. Like the more usual superlattices grown from unilayer blocks, the frequencies of the longitudinal acoustic modes observed in the Raman spectra depend strictly on the superlattice periodicity (or quasiperiodicity). However, the Raman intensities of the acoustic modes in the bilayer superlattices differ from predictions based on theories for the unilayer cases. The optic-mode Raman spectra of the periodic and quasiperiodic superlattices are very similar apart from the intensity of the GaAs-layer longitudinal optic phonon at 290 cm<sup>-1</sup>. (Author abstract). 21 Refs.

Lockwood, D.J. (Nat'l Research Council, Ottawa, Ont, Can); Moore, W.T.; Devine, R.L.S. *Indian J Pure Appl Phys* v 26 n 2-3 Feb-Mar 1988 p 131-140.

**094165 MASS SPECTROSCOPIC STUDY OF THE PYROLYSIS OF ORGANOMETALLIC PRECURSORS USABLE IN GAAS VAPOR PHASE EPITAXY. I: THE FLUORINE-CONTAINING DERIVATIVES (C<sub>6</sub>F<sub>5</sub>)<sub>3</sub>-N<sub>2</sub>ME<sub>2</sub>GAASET<sub>3</sub>.** Thermal decomposition of the coordination compounds Rf<sub>3-n</sub>Me<sub>n</sub>GaAsEt<sub>3</sub> (Rf=C<sub>6</sub>F<sub>5</sub>; n=0, 2) in a CVD reactor has been investigated under helium and hydrogen atmosphere by a quadrupole mass analyzer. At 600°C, hydrogen facilitates the Rf elimination forming C<sub>6</sub>F<sub>5</sub>H but under inert atmosphere, decomposition of these cyclic groups generates HC≡CF and stable gallium fluoride entities which prevent, in the case of Rf<sub>3</sub>GaAsEt<sub>3</sub>, the growth of the layer. The ethyl elimination mechanism is a β elimination for RfMe<sub>2</sub>GaAsEt<sub>3</sub> in helium, hydrogenolysis and homolytic fission followed by disproportionation of Et radical for RfMe<sub>2</sub>GaAsEt<sub>3</sub> in hydrogen. The reaction mechanism becomes complicated for Rf<sub>3</sub>GaAsEt<sub>3</sub> in helium. The electroattractive Rf group stabilizes the donor-acceptor Ga-As bond as this is required for adducts used as a single source but its use as ligand in organometallic precursor for GaAs epitaxy must be limited according to its low thermal stability. (Author abstract). 18 Refs.

Maury, F. (CNRS, Toulouse, Fr); El Hammadi, A. *J Cryst Growth* v 91 n 1-2 Aug 1988 p 97-104.

**094166 MASS SPECTROMETRIC STUDY OF THE PYROLYSIS OF ORGANOMETALLIC PRECURSORS USABLE IN GAAS VAPOR PHASE EPITAXY. II: THE DIARSINE ADDUCTS [CIR<sub>2</sub>GAA-SET<sub>2</sub>]<sub>2</sub>CH<sub>2</sub> (R=Me, Et).** The thermal decomposition of adducts [CIR<sub>2</sub>GaAsEt<sub>3</sub>]<sub>2</sub>CH<sub>2</sub> (R=Me, Et) in helium and hydrogen atmosphere has been investigated by mass spectrometry. Using a simple analytical procedure, this paper reveals the importance of the alkyl elimination process in epitaxial growth. Hydrogen would favor homolytic fissions of M-Et bonds, whereas a β elimination would be dominant at higher temperatures. The first mechanism seems preferable in low temperature GaAs OMVPE to a β elimination which generates both hydride intermediates and a polycrystalline growth if the deposition temperature is not sufficiently high. Selection of useful new precursors requires thermolabile groups and must take in account these competitive alkyl elimination mechanisms. (Author abstract). 17 Refs.

Maury, F. (CNRS, Toulouse, Fr); El Hammadi, A. *J Cryst Growth* v 91 n 1-2 Aug 1988 p 105-110.

**094167 ANGLE-DEPENDENT X-RAY PHOTOELECTRON SPECTROSCOPY INVESTIGATION OF GAAS SURFACES.** Angle-dependent x-ray photoelectron spectroscopy (ADXPS) provides a method for investigat-

ing thin native oxides without the need for destructive depth profiling. In addition, surface chemical environments can be identified and their chemical shifts monitored as a function of angle. The ability to examine samples at very small angles is important if the types and extents of surface coverage are to be distinguished between. A study of the growth of native oxide on a GaAs surface by ADXPS shows the oxide to be gallium rich at the outermost surface. Comparison of the data with theoretical models for thickness and extent of coverage indicates that the oxides grow as patches of variable thickness. (Author abstract) 10 refs.

Stickle, William F. (Perkin-Elmer Physical Electronics Lab, Mountain View, CA, USA); Bomben, Kenneth D. *Thin Solid Films* v 154 n 1-2 Nov 12 1987, Pap Presented at the Int Conf on Metall Coat - Part II, San Diego, CA, USA, Mar 23-27 1987 p 301-307.

**094168 RAMAN SPECTROSCOPY OF ACOUSTIC PHONONS IN PERIODIC AND FIBONACCI SUPERLATTICES.** Results of Raman scattering experiments on (a) periodic superlattices made up of GaAs/In<sub>x</sub>Ga<sub>1-x</sub>As layers with high indium concentrations, (b) GaAs/Ga<sub>1-x</sub>Al<sub>x</sub>As Fibonacci superlattices, are presented. We discuss the observed peak positions and intensities using the continuum theory of acoustic wave propagation in layered media and the photo-elastic coupling model. (Author abstract) 14 refs.

Dharama-wardana, M.W.C. (Nat'l Research Council, Ottawa, Ont, Can); MacDonald, A.H.; Aers, G.C.; Lockwood, D.J.; Moore, W.T.; Devine, R.L.S. *Superlattices Microstruct* v 3 n 6 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 665-671.

**094169 OPTICAL SPECTROSCOPY OF EXCITONS IN QUANTUM WELLS.** Main aspects of the electric-field effects on excitons in GaAs-GaAlAs quantum wells by spectroscopic studies are presented, including thickness dependence and coupling between excitonic states. Based on our experimental results recently obtained with high-quality QW-embedded p-i-n samples, the main aspects of the field effects are presented; dependence of Stark shifts on the well thickness and coupling of the excited states of the heavy-hole exciton with the ground state of the light-hole exciton. 18 refs.

Esaki, L. (IBM Thomas J. Watson Research Cent, Yorktown Heights, NY, USA); Vina, L.; Mendez, E.E.; Chang, L.L. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 12-16.

**094170 INVESTIGATIONS OF THE ORIGIN OF THE DEEP CENTER RELATED LUMINESCENCE BANDS DUE TO NEUTRON-TRANSMUTATION DOPING (NTD) IN GAAS AFTER ANNEALING AND ITS INFLUENCE ON COMPENSATION.** Dopant incorporation after NTD and subsequent annealing is investigated by photoluminescence and electrical measurements. The free-carrier concentration intended can not be fully achieved because of V<sub>Ga</sub>D-complexes (D=Ge<sub>Ga</sub>, Se<sub>As</sub>) and Ge<sub>As</sub>-acceptors which partly compensate the donors introduced by NTD. (Author abstract) 5 refs.

Rentzsch, Rolf (Akad der Wissenschaften der DDR, Berlin, East Ger); Friedland, Juergen. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 357-358.

**094171 PHOTOLUMINESCENCE DECAY MECHANISM OF THE APPROXIMATELY 1.49 eV EMISSION IN LEC-GROWN SEMI-INSULATING GAAS.** In undoped liquid-encapsulated Czochralski-grown semi-insulating (LEC SI) GaAs, carbon acceptor, C<sub>As</sub>, is responsible for the approximately 1.49 eV donor-acceptor (D-A) pairs radiative recombination at low temperatures. A mechanism is proposed to explain the temperature dependence of the exponent of the power law: p(T) = -1 + βT of the approximately 1.49 eV emission in

semi-insulating GaAs. (Edited author abstract) 5 refs.

Teh, C.K. (Univ of Alberta, Edmonton, Alberta, Can); Weichman, F.L. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 359-360.

**094172 CHARACTERIZATION OF DEEP-LEVELS AROUND THE DISLOCATION IN GAAS MATERIALS BY CATHODOLUMINESCENCE.** The relationship between the dislocation distribution and deep-level distribution is demonstrated for the first time using a new multi-wavelength line tracing technique. Line tracing results show that the CL intensities of deep-level emission approximately coincide with those of near band edge emission. Also, there is an electron beam irradiation effect on the deep-levels. (Author abstract) 2 refs.

Ikeda, Kousuke (NTT, Electrical Communications Lab, Musashino, Jpn); Ishii, Yoshikazu. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 361-362.

**094173 FERMIL LEVEL EFFECT ON THE LUMINESCENCE FROM GAAS:Cr MATERIALS.** By investigating the luminescence spectra from GaAs:Cr samples with various Fermi levels, especially the spectral properties of n<sup>+</sup> material, a complete picture of luminescence spectra from GaAs:Cr materials varying from p-type, semi-insulating, to heavily doped n-type, corresponding to Cr ions with different charge states and their complexes, has been given. (Author abstract) 3 refs.

Ge, Weikun (Acad Sinica, Beijing, China). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 403-404.

**094174 INDIRECT EXCITONS IN SHORT PERIOD SUPERLATTICES.** We have studied the time-resolved photoluminescence (PL) and excitation (PLE) spectra of superlattices (SL) with approximately equal thicknesses of AlAs and GaAs and with periods 18 to 60 Å. Typical PL and PLE spectra at 2K are shown. The strongest PL feature, labelled X<sub>xy</sub>, shows slow non-exponential decay after pulse excitation. We attribute the 'X<sub>xy</sub>' PL to the recombination of a localized exciton consisting of an X-point electron in the AlAs and a T-point hole in the GaAs. 6 refs.

Sturge, M.D. (Dartmouth College, Hanover, NH, USA); Finkman, E.; Tamargo, M.C. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 425-426.

**094175 INTENSITY CORRELATION MEASUREMENT OF TIME-RESOLVED PHOTOLUMINESCENCE FROM GAAS MQWS.** We have measured the energy relaxation of hot carriers in p- and n-type GaAs/GaAlAs quantum wells by detecting time-resolved hot luminescence using two-pulse intensity correlation with 150fs resolution. In the former p = 7 × 10<sup>17</sup> cm<sup>-3</sup> and the well width d<sub>w</sub> = 60 Angstrom; the n-type sample has n = 2 × 10<sup>17</sup> cm<sup>-3</sup> and d<sub>w</sub> = 258 Angstrom. The excitation density is approximately 3 × 10<sup>16</sup> cm<sup>-3</sup>, and the photon energy hν = 2.0 eV. Assuming that the photon excess energy is shared evenly among the carriers, the initial mean carrier energy is approximately 14 meV for the p-type sample and 62 meV for the n-type sample. 4 refs.

Eakin, H.J.W. (Clarendon Lab, Oxford, Engl); Ryan, J.F. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 553-554.

**094176 THEORY OF RESONANTLY EXCITED HIGH-DENSITY EXCITON SYSTEMS.** Transient measurements on highly excited GaAs as a representative of a high density exciton system demonstrated that resonantly excited excitons are stable at pair-densities



much higher than the Mott-density. The latter is known as the limiting density in the case of excitation above the band edge. Optical spectra of resonantly excited high density exciton systems, self-consistently calculated on the basis of a recently developed many particle theory, are presented. 5 refs.

Schaefer, W. (Univ Dortmund, Dortmund, West Ger); Schudt, K.-H.; Binder, R.; Treusch, J. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 569-570.

**094177 HOT CARRIER RELAXATION PROCESSES IN GaAs-GaAlAs MULTIPLE QUANTUM WELL STRUCTURES.** Based on the nonlinear luminescence correlation technique, a new time resolved spectroscopy technique has been developed and applied to the study of hot carrier relaxation processes in GaAs-GaAlAs multiple quantum well structures. We have found that the well width has a significant effect on the relaxation processes. For a sample with  $L_z = 40$  Angstrom, the time constant of the LO-phonon relaxation is found to be as long as 42 ps. (Author abstract) 5 refs.

Xu, Zhongying (Acad Sinica, Beijing, China); Li, Yuzhang; Xu, Jizong; Zheng, Baozhen; Xu, Junying; Zhuang, Weihua; Ge, Weikun. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 585-586.

**094178 INFLUENCE OF PHONONS AND PLASMONS ON SEMICONDUCTOR BAND EDGE SPECTRA.** The band-tail absorption and gain spectra in polar semiconductors are calculated nonperturbatively by taking into account the interactions of the optically generated or annihilated electron-hole pair with the longitudinal optical phonons and the plasmons. In an unexcited crystal an Urbach tail is obtained due to the inter- and intraband exciton scattering by phonons. In an inverted crystal the gain spectra exhibit plasmon-phonon sidebands. (Author abstract) 5 refs.

Haug, H. (Univ Frankfurt, Frankfurt, West Ger); Mueller, J.F.; Liebler, J. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 605-606.

**094179 TUNNELING SPECTROSCOPY IN PHOTO-EXCITED SEMICONDUCTOR SUPERLATTICES.** In this work, the tunneling processes of carriers were studied in a photo-excited semiconductor superlattices. We studied GaAs-Al<sub>0.25</sub>Ga<sub>0.75</sub>As multi-quantum-wells (MQW); 100 alternate periods of 120 Angstrom -GaAs wells and 58 Angstrom -Al<sub>0.25</sub>Ga<sub>0.75</sub>As barriers embedded in pin diode structure grown by molecular beam epitaxy with the electric field applied in the direction of superlattices. 5 refs.

Masumoto, Yasuaki (Univ of Tsukuba, Sakura-mura, Jpn); Sasaki, Fumio. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 709-710.

**094180 EFFECT OF NONEQUILIBRIUM ACOUSTIC PHONONS ON THE LUMINESCENCE OF MULTIQUANTUM WELL STRUCTURES.** A study of the quenching of the band-acceptor emission in the spectrum of GaAs/AlGaAs multi-quantum wells induced by nonequilibrium phonon pulses has revealed characteristic features in the acoustic phonon interaction with 2D electron gas. (Author abstract) 4 refs.

Akimov, A.V. (USSR Acad of Sciences, Leningrad, USSR); Kaplyanskiy, A.A.; Kozub, V.I.; Kop'ev, P.S.; Meltzer, B.Ya. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 711-712.

**094181 DYNAMICS OF EXCITONS SINKING INTO AN ENLARGED WELL IN GaAs/AlAs SHORT-PERIOD SUPERLATTICE.** We have studied the dynamics of excitons using picosecond luminescence measurements of the GaAs/AlAs superlattice ( $L_B = 1.2$  nm and  $L_Z = 3.4$  nm) with an enlarged well ( $L_Z = 6.1$  nm),

which is intentionally introduced. The lateral transfer and the vertical transport are observed. (Author abstract) 4 refs.

Nakamura, A. (Nagoya Univ, Nagoya, Jpn); Fujiwara, K.; Tokuda, Y.; Nakayama, T.; Hirai, M. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 719-720.

**094182 PERIODICITY-DEPENDENT PHOTOLUMINESCENCE OF (GaAs)<sub>m</sub>(AlAs)<sub>n</sub> SUPERLATTICES.** The photoluminescence (PL) and excitation spectra (PLE) of GaAs/AlAs superlattices (SLs) with a series of period lengths are investigated. The direct-indirect-gap transition related to the SL periodicity is evidenced by comparing PL and PLE spectra and by analyzing the line shape of the excitation spectra. (Author abstract) 4 refs.

Jiang, Desheng (Max-Planck-Inst fuer Festkoeperforschung, Stuttgart, West Ger); Kelting, K.; Isu, T.; Ploog, K.; Queisser, H.J. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 721-722.

**094183 DYNAMIC BEHAVIOR OF TWO-DIMENSIONAL EXCITON IN GaAs SINGLE QUANTUM WELL UNDER A MAGNETIC FIELD.** Time-resolved photoluminescence spectra of two-dimensional excitons in a GaAs single quantum well were investigated in a magnetic field. The radiative life-time was independent of the magnetic field up to 6 T. The high density excitation effect on the photoluminescence spectrum was observed. The exciton temperature was decreased by applying the magnetic field. (Author abstract) 2 refs.

Segawa, Yusaburo (Inst of Physical & Chemical Research, Wako, Jpn); Kusano, Junichi; Aoyagi, Yoshinobu; Namba, Susumu. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 729-730.

**094184 EXCITON TRANSPORT PHENOMENON IN SUPERLATTICE CONFINED QUANTUM WELL.** Inserting a graded three-period superlattice between the AlGaAs and the GaAs quantum well at the bottom interface causes the intensity of the PL associated with free heavy-hole exciton recombination to increase intensely. Only the bottom interface plays an important role in the carrier transition and recombination processes. The dependence of PL on lattice temperature shows the exciton transport property and it is affected by both interfaces. (Author abstract) 2 refs.

Sun, Yali (Changchun Inst of Physics, Changchun, China). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 731-732.

**094185 DONOR-INTERFACE ACCEPTOR PAIR EMISSION IN THE ABRUPT HETEROINTERFACE.** The new photoluminescence (PL) line revealing a large blue shift with excitation intensity increase has been found in both undoped and lightly doped GaAs/AlGaAs heterojunction layers grown by LPE and MBE techniques. Some heterojunction energy band models which attempt to explain the occurrence in the GaAs spectrum of the PL line with peak energy ranging from that of the bound exciton to that of the donor-carbon acceptor pair emission involve carriers confinement and tunable transition. We have concluded that the main experimental data associated with the H-line are consistent with the distant donor-acceptor pair emission. 6 refs.

Kop'ev, P.S. (Acad of Sciences of the USSR, Leningrad, USSR); Kochereshko, V.P.; Uraltsev, I.N.; Efros, A.L.; Yakovlev, D.R. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 747-748.

**094186 CHARACTERISTICS OF PHOTOLUMINESCENCE AT GaAs/AlGaAs INTERFACE.** The unusual new spectrum, H-line, has been observed in low temperature photoluminescence (PL) spectra of GaAs

edge emission region from lightly or undoped GaAs/AlGaAs epilayers grown by liquid-phase epitaxy (LPE). This phenomena can be related to the energy band offset effect between GaAs and AlGaAs layers. In this paper, the pico-second(ps) life-time of H-line and the relation between H-line and heterojunction properties are reported by the PL and x-ray technology. 5 refs.

Yuan, Yourong (Acad Sinica, Changchun, China); Merz, J.L.; Vawter, G.A. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 755-756.

**094187 X-RAY TOPOGRAPHY AND PHOTOLUMINESCENCE (PL) AT GaAs/AlGaAs MBE AND LPE HETEROJUNCTION MATERIALS.** MBE and LPE heterojunction epitaxial GaAs/AlGaAs layers are studied by both X-ray and photoluminescence (PL) to profile the uniformity, defects and dislocations, and stress distribution for the material research. Heterojunction GaAs/AlGaAs epilayers are grown by general MBE and LPE technology. Among them there are MBE growth single quantum well layers with or without superlattice buffer layers, LPE double heterojunction wafers, and LPE AlGaAs waveguides. X-ray topography and measurements are carried out by the use of scanning type double crystal X-ray goniometer, D/MAX-rA Rigaku. 4 refs.

Feng, Yuchen (Acad Sinica, Changchun, China); Gao, Dachao; Yuan, Yourong; Eda, Kazuo. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 757-758.

**094188 PHOTOLUMINESCENCE FROM DEFECTS AND IMPURITIES IN GaAs/n-GaAlAs 2DEG STRUCTURE.** A great effort has been paid to improve the quality of the 2DEG structure. The growth defects and unintentional impurities such as carbon are regarded as two important factors to influence electron mobility and hard to be controlled in MBE technology. For analysing the type of defects and impurities and their relative concentrations, photoluminescence is a sensitive and very useful technique. The 2DEG sample was grown on (100) oriented Cr-doped GaAs substrate. The photoluminescence measurement was carried out at 4.2K by using Ar<sup>3+</sup> laser 5145 Angstrom emission with power density about 0.2w/mm<sup>2</sup>. 4 refs.

Jia, Weiye (Acad Sinica, Beijing, China); Huang, Yi; Zhou, Junming; Wang, Yanyun. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 761-762.

**094189 PHOTOLUMINESCENCE RELATED TO THE INTERFACE OF GaAs/(GaAl)As HETEROJUNCTIONS.** We have investigated an unusual new line observed in GaAs/(AlGa)As heterojunctions, referred to as the H-band, by low-temperature photoluminescence experiments in magnetic fields up to 9.5 T. The direction of the magnetic field was turned from perpendicular to parallel to the interface. From the energetic shift, the splitting-behaviour, the lineshape and the temperature dependence of the luminescence line, we conclude that the H-band is emitted by the recombination of a flat-band electron with a hole confined to an excited subband. (Author abstract) 2 refs.

Ossau, W. (Univ Wuerzburg, Wuerzburg, West Ger); Bangert, E.; Landwehr, G.; Weimann, W. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 763-764.

**094190 EVIDENCE FROM PHOTOLUMINESCENCE SPECTRA FOR THE FORMATION OF EXTREMELY LOW-COMPENSATED P- AND N-TYPE Ge-DOPED GaAs GROWN BY MOLECULAR BEAM EPITAXY.** Photoluminescence (PL) spectra of molecular beam epitaxially-grown GaAs doped by an amphoteric impurity (Ge) are reported. PL results re-



vealed that significantly low-compensated both n- and p-type samples can be reproducibly fabricated by precisely controlling As<sub>4</sub> to Ga flux ratio,  $\gamma$ . It was also explicitly demonstrated that along the increase of  $\gamma$ , a steep change from p- to n-type conduction occurs at  $\gamma$  about 1.6. (Author abstract) 2 refs.

Makita, Yunosuke (Electrotechnical Lab, Sakura-mura, Jpn); Mori, Masahiko; Tanaka, Hideki; Yokohama, Hideo; Irie, Katsuhiko; Ohnishi, Nobukazu; Shigetomi, Shigeru. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 907-908.

**Spectrum Analysis** See Also SEMICONDUCTOR MATERIALS—Spectrum Analysis.

**094191 DETECTION OF FIR RADIATION BY PHOTON DRAG OF FREE CARRIERS IN SEMI-METAL THIN FILM.** Fast ns. response with good sensitivity of far infrared radiation (FIR) is observed in anisotropic thin films of Bi and Sb evaporated at large angle. The signal in the wavelength region  $\lambda > 200 \mu\text{m}$  is assigned to the classical optical pressure on the free carriers while the signal in the 100 microns region can be assigned to a band transition. These detectors are currently used by us for time diagnostic of FIR laser Raman with a sensitivity 10-20 times larger than the best commercial Ge photon-drag detectors at wavelengths larger than 300 microns. (Author abstract) 23 refs.

Marchetti, S. (CNR, Pisa, Italy); Simili, R.; Bernardini, M.; Giorgi, M. *Phys Scr* v 37 n 5 May 1988 p 836-839.

## Strain

**094192 EFFECTS OF PLASTIC STRAIN ON THE ELECTRICAL PARAMETERS OF GaAs.** A logical explanation has been obtained for the experimental results for the EL2 centers produced on plastic strain. Our object has been to obtain a fuller picture of the conductivity of strain GaAs, where we have used semi-insulating s/i GaAs, as well as n-type and p-type specimens. An important point is the number of possible dislocation states, which is estimated as  $n_d = 2N_d/b$  ( $b$  is the Burgers vector). For each crystal, we used at least one specimen such that  $n_d$  was 10 times larger than the major-carrier concentration in the unstrained material. 17 refs.

Hertsen, D.; Haasen, P. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 56-60.

**Structure** See Also SEMICONDUCTING GALLIUM COMPOUNDS—Structure.

**094193 INVESTIGATION OF THE STRUCTURE OF THE  $2 \times 4$  RECONSTRUCTIONS OF GaAs (001) BY ANALYSIS OF RHEED INTENSITY DATA.** Rocking curves are computed for electrons incident in turn in three different azimuths for 512 different models of the reconstruction. Each model corresponds to a different arrangement of twisted tilted dimers. For each incident beam azimuth many of these distinct models give identical rocking curves. This is explained by the possible values of the structure factor for scattering by surface atoms. In particular it is shown that the incident electrons are insensitive to atomic displacements which are parallel to the incident beam azimuth. Preliminary models are presented for which the agreement with experiment is best for all three azimuths. The effects of tuning the displacements within the dimers are considered and finally the intensities of the non-specular beams are briefly discussed. (Edited author abstract) 10 refs.

Knibb, M.G. (Univ of Leicester, Leicester, Engl); Maksym, P.A. *Appl Phys A* v A46 n 1 May 1988 p 25-29.

**094194 RAMAN SPECTROSCOPY OF ACOUSTIC PHONONS IN FIBONACCI SUPERLATTICES.** We report on resonant and non-resonant Raman scattering by acoustic phonons in Fibonacci GaAs-AlAs superlattices. Spectra off-resonance show doublets centered at frequencies that follow a power-law behavior, in good agreement

with predictions of a continuum model. Resonant data show a weighted density of states revealing the expected rich structure of gaps in the phonon spectrum. It is proposed that the electronic excitation involved in the resonant process is a surface state of the superlattice. (Author abstract) 23 refs.

Bajema, K. (Univ of Michigan, Ann Arbor, MI, USA); Merlin, R. *Superlattices Microstruct* v 3 n 5 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 477-479.

**Substrates** See Also GOLD AND ALLOYS—Thin Films; IRON AND ALLOYS—Thin Films; METALS AND ALLOYS—Thin Films; MICROSTRIP DEVICES; NICKEL AND ALLOYS—Thin Films; SEMICONDUCTING CADMIUM COMPOUNDS—Vapor Deposition; SEMICONDUCTING INDIUM COMPOUNDS—Structure; SEMICONDUCTING INDIUM COMPOUNDS—Substrates; SEMICONDUCTING ZINC COMPOUNDS—Growth; SEMICONDUCTING ZINC COMPOUNDS—Vapor Deposition.

**094195 RAPID CONTROLLED THINNING OF GALLIUM ARSENIDE.** A method for thinning (100) gallium arsenide substrates using a wet chemical etch is described. An etchant of hydrofluoric acid, nitric acid, acetic acid, and deionized water in a 1:3:5:5 volumetric ratio was used to thin 400  $\mu\text{m}$  thick wafers to 150  $\mu\text{m}$ . Etch rates of 20  $\mu\text{m}/\text{min}$  were achieved with excellent uniformity across 2 in. wafers. The process was used to fabricate monolithic four-bit phase shifters. (Edited author abstract) 8 refs.

O'Connor, James M. (Allied-Bendix Aerospace Technology Cent, Columbia, MD, USA); Dvorsky, Edward F.; Hier, Harry S.; Reif, Warren P. *J Electrochem Soc* v 135 n 1 Jan 1988 p 190-193.

**094196 DECAPAGE IN SITU DE SUBSTRATS GaAs (001) PAR HCl GAZ.** [In Situ Cleaning of GaAs (001) Substrates Using HCl Gas]. In situ chemical etching of GaAs (001) by gaseous HCl before molecular beam epitaxy growth has been studied by X-ray Photoelectron Spectroscopy (XPS) and Secondary Ion Mass Spectrometry (SIMS). At low temperature (25°C) under high HCl partial pressure, HCl only removes the oxide layer of the substrate and does not react with the underlying GaAs crystal. At high temperature (> 400°C) under low pressure, the GaAs substrate is etched at a rate of 6  $\text{\AA}/\text{min}$ . However, SIMS analysis shows a highly contaminated substrate-layer interface after etching at 400°C. (Edited author abstract) 5 refs. In French.

Contour, J.P. (CNRS, Valbonne, Fr); Massies, J.; Huber, A.; Grattepail, C. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 167-168.

**094197 QUALIFICATION DE SUBSTRATS DE GaAs SEMI-ISOLANTS.** [Qualification of Semi-Insulating GaAs Substrates]. A brief review of different kinds of semi-insulating materials available and the suppliers presently on the market is given. The qualification is discussed in terms of wafer morphology, polishing quality and electrical properties; in all cases, a quantitative approach is proposed in order to avoid misunderstandings with the suppliers. Some other points such as subsurface-damages and thermal stability are discussed and analyzed as non-objective parameters. This qualification is presented as necessary but not sufficient. The future requires definition of more precise criteria based on a better understanding of semi-insulating GaAs. (Edited author abstract) 8 refs. In French.

Visentin, N. (THOMSON-CSF, Orsay, Fr). *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 155-162.

## Surface Properties

**094198 FREE SURFACES AND MULTILAYER INTERFACES IN THE GaAs/AlAs SYSTEM.** Semiempirical potential energy functions have been utilized for a variety of calculations in the Ga-Al-As system: (1) surface

energies have been calculated for several orientations of GaAs; (2) ledge energies for the GaAs(001) (As terminated) surface show long range interaction effects with the ledge energy increasing with spacing; (3) GaAs(001)/AlAs(001) superlattices have been simulated for a range of interlayer spacings with the excess interfacial energy per interlayer increasing from 5  $\text{erg}/\text{cm}^2$  at an interlayer spacing of 1 molecular layer (5.8  $\text{\AA}$ ) to 50  $\text{erg}/\text{cm}^2$  at an interlayer spacing of 18 molecular layers (103.8  $\text{\AA}$ ). (Author abstract) 9 refs.

Choi, D.K. (Stanford Univ, Stanford, CA, USA); Takai, T.; Erkoc, S.; Halicioglu, T.; Tiller, W.A. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 9-15.

**Surfaces** See Also LEAD AND ALLOYS—Thin Films; SEMICONDUCTING GALLIUM COMPOUNDS—Surfaces; SEMICONDUCTING GERMANIUM—Electronic Properties; SEMICONDUCTOR DEVICES—Semiconductor Metal Boundaries; SEMICONDUCTOR DEVICES, MIS—Electric Properties; SEMICONDUCTOR DEVICES, MOS—Semiconductor Insulator Boundaries.

**094199 SOLID-PHASE REACTIONS BETWEEN (100) GaAs AND THIN-FILM REFRACTORY METALS (Ti, Zr, V, Nb, Cr, Mo, AND W).** Recently, there has been an increased interest in the applications of refractory metals as gate materials for the self aligned gate process in the fabrications of GaAs field effect transistors. In this study, we systematically investigated the thermally induced interface interactions between (100) GaAs substrates and thin films of refractory metals (Ti, Zr, V, Nb, Cr, Mo, and W). Depth profilings of the M/GaAs interfaces were obtained using conventional and heavy ion Rutherford backscattering spectrometry. Phase identifications were achieved by X-ray diffraction. Results on the phase formation sequence, reaction kinetics, the distribution, composition and structure of the reacted phases and the interface reactivity of these contacts are presented. Correlations between metal properties (electronegativity and metal-metal bond strength) and kinetics of the reactions (activation energy and reactivity of the interfaces) are discussed. (Author abstract) 36 refs.

Yu, K.M. (Lawrence Berkeley Lab, Berkeley, CA, USA); Jaklevic, J.M.; Haller, E.E. *Appl Phys A* v A44 n 2 Oct 1987 p 177-190.

**094200 QUALITATIVE ANALYSIS OF INTERFACIAL PHENOMENA AT THE UNDOPED POLY-GaAs/KCl SOLUTION INTERFACE USING MICROELECTROPHORESIS MEASUREMENTS.** The author describes a relation between interfacial charges at undoped semiconductor/electrolyte interfaces and zeta potentials, and discuss the surface states and interfacial phenomena with reference to microelectrophoresis experiments. Experiments indicate that the effect of grain boundaries in poly-semiconductor is not important and can be neglected for colloidal semiconductors. The density of the slow surface states of the undoped poly-Si is greater than that of undoped poly-GaAs. The  $\text{K}^+$  and  $\text{Cl}^-$  ions at the undoped poly-GaAs/KCl solution interfaces are indifferent ions and the KCl solutions are indifferent electrolytes. The slow surface states of undoped poly-GaAs/KCl solution interfaces are dominated by the physically adsorbed  $\text{K}^+$  ions which act as positively charged donor surface states. 25 refs.

Chun, Jang H. (Kwangju Univ, Seoul, South Korea). *J Electrochem Soc* v 134 n 12 Dec 1987 p 3201-3204.

**094201 OXIDATION STATES AND FERMI-LEVEL PINNING ON GaAs(110) SURFACE.** Fermi-level pinning produced by oxygen adsorption on the GaAs(110) cleavage surface both at 300 (in chamber) and 77 K (in liquid  $\text{N}_2$ ) has been studied using the polarization modulated reflectivity technique. Specific transformations of spectra of doped samples have made it possible to follow the kinetics of barrier formation. It has been found that the creation of acceptor and donor pinning levels on the surface correlates with two essentially different oxida-



tion states. The first is the chemisorption of atomic oxygen. We suggest that it forms patches on the surface. The second phase is supposed to be a surface oxide. (Edited author abstract) 34 refs.

Berkovits, V.L. (Acad of Sciences of the USSR, Leningrad, USSR); Kiselev, V.A.; Minashvili, T.A.; Safarov, V.I. *Solid State Commun* v 65 n 5 Feb 1988 p 385-388.

**094202 ADSORPTION OF OXYGEN ON ALKALI METAL COVERED GaAs (1 1 1) SURFACES.** Na and Cs adlayers on GaAs (1 1 1) surfaces and their effect on oxygen uptake on the surfaces have been studied by LEED, XPS and UPS. An enhancement of two orders of magnitude in initial oxygen sticking coefficients was observed. Oxygen was found to sit on top of the alkali adatom at the initial stage of  $O_2$  exposure. (Author abstract) 7 refs.

Ding, Xumin (Fudan Univ, Shanghai, China); Dong, Guosheng; Hou, Xiaoyuan; Wang, Xun. *Solid State Commun* v 61 n 6 Feb 1987 p 391-393.

**094203 ELECTRONIC PROPERTIES AND MODELING OF LATTICE-MISMATCHED AND REGROWN GaAs INTERFACES PREPARED BY METALORGANIC VAPOR PHASE EPITAXY.** In order to study and model non-ideal semiconductor-semiconductor interfaces, three kinds of GaAs interfaces, i.e., (i) a slightly mismatched InGaAs/GaAs interface, (ii) a highly mismatched GaAs/InP interface and (iii) an air-exposed GaAs/GaAs interface, were prepared by MOVPE. Their electronic properties were studied through measurements of C-V characteristics, carrier concentration profiles, DLTS spectra and I-V characteristics. By a novel interpretation of C-V characteristics and DLTS spectra, all the experimental results were explained consistently by a common model involving a U-shaped interface state continuum. The origin of the interface state continuum is explained by the disorder induced gap state (DIGS) model recently proposed for insulator-semiconductor and metal-semiconductor interfaces. This model seems to serve as a universal model for non-ideal S-S interfaces. (Author abstract) 18 refs.

Ikeda, Eiji (Hokkaido Univ, Sapporo, Jpn); Hasegawa, Hideki; Ohtsuka, Shunsuke; Ohno, Hideo. *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 180-187.

**094204 GaAs SURFACE CLEANING WITH HCl GAS AND HYDROGEN MIXTURE FOR MOLECULAR-BEAM-EPITAXIAL GROWTH.** GaAs surface cleaning with a hydrogen chloride gas and hydrogen mixture prior to molecular-beam-epitaxial growth has been investigated as a means of reducing the carrier depletion at the substrate-epitaxial layer interface. Reactive gas etching was performed at a substrate temperature of 500°C. The amount of carrier depletion, measured by a capacitance-voltage carrier profiling technique, decreased significantly from  $1.2 \times 10^{12} \text{ cm}^{-2}$  to less than  $1 \times 10^{10} \text{ cm}^{-2}$ . (Author abstract) 8 refs.

Saito, Junji (Fujitsu Ltd, Atsugi, Jpn); Nanbu, Kazuo; Ishikawa, Tomonori; Kondo, Kazuo. *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 702-703.

**094205 OXYGEN ON AND BELOW THE 001 SURFACES OF GALLIUM ARSENIDE.** A tight binding slab model calculation is used to simulate the electronic structure about a layer of oxygen on and below the unrelaxed 001 surface of gallium arsenide. Comparison is made with photoemission data. The results lead to a simple interference model which could present an explanation as to why electrons are pinned about a constant energy position in the gap at high levels of oxygen exposure. (Author abstract) 9 refs.

Lowther, J.E. (Univ of Witwatersrand, Johannesburg, S Afr). *Solid State Commun* v 66 n 1 Apr 1988 p 75-77.

**094206 DETERMINATION DES ETATS DE SURFACE INDUITS PAR UN METAL ELECTRODEPOSE A LA SURFACE DE GaAs PAR MESURE DE PHOTOCAPACITE.** [Determination of Surface States Induced by Metal Electrodeposited on Sur-

faces of GaAs by Photocapacity Method]. The method of photocapacity used with electrochemical junctions is studied as the mechanism of formation of metal/semiconductor interfaces. The method is used for n-GaAs/metal-electrolyte interface. The electrolytic deposition of metal on GaAs substrate permits one to obtain Schottky barrier with electric characteristic comparable to ultra-high vacuum technique. 4 refs. In French.

Allongue, P. (CNRS, Paris, Fr). *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 259-260.

**094207 APPLICATION DE L'XPS ANGULAIRE A L'ETUDE DE LA PASSIVATION DE SEMI-CONDUCTEUR (Si -  $SiO_2$ , GaAs - OXYDES NATIFS).** [Application of Angle-Resolved X-Ray Photoelectron Spectroscopy to the Passivation of Semiconductors (Si- $SiO_2$ , GaAs - Native Oxide)]. Analysis by measurements under different take-off angles of photoemitted electrons excited by X-rays provides chemical information about the surface region of materials. It is possible to extract quantitative results about the concentration of elements as a function of depth. In a first step a series of experiments have been performed on samples of silicon thermally oxidized to check the validity of this analytical method. The experimental results for the interface thickness are found to be in good agreement with other results. The studies of GaAs were performed on the (001) face of the sample. The anisotropies in angular photoemission were found mainly for  $As_{3d}$  and  $As_{3d}/Ga_{3d}$ . An analysis by decomposition of experimental peaks by means of a curve-fitting routine gives a combination of gaussians. The comparison between the intensities of  $As_{3d}$ ,  $Ga_{3d}$  and  $O_{1s}$  peaks points out the presence in high proportion of Ga or As atoms non-combined with oxygen or in the form of suboxides. (Edited author abstract) 9 refs. In French.

Quemerais, A. (CNRS, Rennes, Fr); Lepert, S.; Gaudu, M.L.; Priol, M. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 277-278.

**094208 CONDUCTIVITE DE SURFACE SUR GaAs ET D'INTERFACE GaAs/NITRURE.** [Conductivity of the GaAs Surface and the GaAs/Nitride Interface]. The authors have investigated the conductance of  $Si_3N_4$ /GaAs interfaces between two types of contacts, ohmic and Schottky. The surface square resistance was found to be  $10^{10}$  ohms, about one order of magnitude below the square resistance of free GaAs surface, and it is poorly dependent on surface treatment and type of contact. The free surface conductance is recovered at low voltage when a recess is realized before the Schottky metallization. These results are qualitatively in good agreement with the discussion of conductance transient measurement on GaAs Mesfet previously published. (Author abstract) 3 refs. In French.

Gaonach, C. (Thomson-CSF, Orsay, Fr); Tardella, A. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 281-283.

**094209 CARACTERISATIONS PHYSICO-CHIMIQUES ET ELECTRIQUES DES INTERFACES GaAs-Si<sub>3</sub>N<sub>4</sub>.** [Physicochemical and Electrical Characterizations of GaAs-Si<sub>3</sub>N<sub>4</sub> Interfaces]. The influence of different GaAs surface treatments on the chemical composition and electrical behavior of the  $Si_3N_4$ -GaAs interface has been studied by X-Ray Photoelectron Spectroscopy (XPS), Secondary Ion Mass Spectroscopy (SIMS) and C-V measurements.  $Si_3N_4$  was deposited by Plasma Enhanced Chemical Vapor Deposition (PECVD) and by Reactive Sputtering (RS). It has been demonstrated that the chemical composition and the electrical behavior of the  $Si_3N_4$ -GaAs interface is drastically dependent on GaAs initial surface pretreatments, plasma nature, power and r.f. plasma excitation frequency. (Author abstract) 1 ref. In French.

Alnot, P. (Thomson-CSF, Orsay, Fr); Grattapain, C.;

Huber, A.; Wyczisk, F.; Bourgoin, J.; Vuillaume, D.; Joubart, R.; Peray, J.F. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 287-289.

**Testing** See Also TRANSISTORS, FIELD EFFECT—Reliability.

**094210 MONTE CARLO SIMULATION OF HOT ELECTRONS IN n-GaAs. EFFECT OF ELECTRON-ELECTRON SCATTERING ON DRIFT VELOCITY OVERSHOOT.** Monte Carlo simulation is presented to clarify the screening effect of the polar LO phonon scattering field by electrons on the high field transport in GaAs. The electron-electron scattering (short range force) is also examined, where the long range interaction, electron-plasmon scattering, is not considered. The conventional Monte Carlo simulation, single electron simulation, or Ensemble Monte Carlo simulation, does not take into account the simultaneous change of the two electrons' states. New Monte Carlo simulation is proposed in which simultaneous simulation of many electrons' states is made, where energy and momentum conservation is exactly taken into account. (Edited author abstract) 15 refs.

Hasegawa, Arata (Osaka Univ, Jpn); Miyatsuji, Kazuo; Hamaguchi, Chihiro. *Technol Rep Osaka Univ* v 37 n 1865-1888 Mar 1987 p 117-125.

## Thermal Effects

**094211 TEMPERATURE DEPENDENCE OF THE PHOTOLUMINESCENCE IN GaAs-GaAlAs MULTIPLE QUANTUM WELL STRUCTURES.** The temperature dependence of the photoluminescence (PL) of GaAs/GaAlAs multiple quantum wells is investigated. Emissions related to transitions between  $n=1,2,3$  electron and hole subbands are observed. Theoretical evaluation of the energy levels fits nicely the experimental data. The temperature dependence of peak position and photoluminescence intensity and the dependence of PL intensity on the power excitation show that there are three different temperature regions. At low temperatures (22 to 40 K) the main emission is ascribed to exciton recombination while at temperatures higher than 100 K it can be attributed to free carrier recombination. In the intermediate temperature region the PL involves both, excitonic and free carrier recombination. Thermally activated non-radiative recombination processes strongly reduce the luminescence quantum efficiency. (Author abstract). 14 refs.

Chiari, A. (Univ di Parma, Parma, Italy); Colocci, M.; Fermi, F.; Li, Yuzhang; Querzoli, R.; Vinattieri, A.; Zhuang, Weihua. *Phys Status Solidi B* v 147 n 1 May 1988 p 421-429.

## Thermal Properties

**094212 TEMPERATURE DEPENDENCE OF THE LATTICE CONSTANT IN DOPED AND NONSTOICHIOMETRIC GaAs, GaAl<sub>1-x</sub>P<sub>x</sub>, AND GaP.** The subjects of investigation were single crystalline GaAs and n-type GaAs plates doped with Te and p-type GaAs plates doped with Si, Zn, or Sn. Results of measurements of the lattice constants in the range 300 to 700 K are presented. The resulting values of the thermal expansion coefficient and their temperature changes are discussed. (Edited author abstract). 12 Refs.

Bak-Misiuk, J. (Polish Acad of Sciences, Warsaw, Pol); Bruhl, H.G.; Paszkowicz, W.; Pietsch, U. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 451-457.

## Thermoelasticity

**094213 THERMOELASTIC ANALYSIS OF GaAs IN LEC GROWTH CONFIGURATION: II. TEMPORAL EVOLUTION OF THE STRESS FIELD.** The temperature distribution in the growth system and the elastic thermal stress field in the growing crystal are calculated at three stages of the solidification process. Results indicate that at the early stages of growth



excessive stresses are generated as the cone emerges from the encapsulant, and at later times the maximum stresses occur close to the solidification interface and the region where the crystal emerges from the encapsulant. Adjustment of heater power for reduction of stresses associated with excessive cooling of the crystal is found to be inadequate and results in enhanced convexity of the growth interface and generation of large stresses in that region. (Author abstract) 16 refs.

Motakef, Shahryar (MIT, Cambridge, MA, USA). *J Cryst Growth* v 88 n 3 May 1988 p 341-352.

**Thin Films** See Also SEMICONDUCTOR MATERIALS—Thin Films; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, FIELD EFFECT—Noise.

**094214 EPITAXIAL, THERMODYNAMICALLY STABILISED METAL/III-V COMPOUND SEMICONDUCTOR INTERFACE: NiGa ON GaAs (001).** Crystalline thin films of the intermetallic compound NiGa have been grown by molecular beam epitaxy (MBE) on GaAs (001) substrate. The epitaxial NiGa films are chemically stable and continuous up to at least 500°C and present a resistivity of 10  $\mu\Omega\text{cm}$ , equivalent to that of the best silicide thin films. (Edited author abstract) 7 refs.

Guivarc'h, A. (CNET, Lannion, Fr); Guerin, R.; Secoue, M. *Electron Lett* v 23 n 19 Sep 10 1987 p 1004-1005.

**094215 PHOTOLUMINESCENCE STUDY OF GaAs GROWN DIRECTLY ON Si SUBSTRATES.** The photoluminescence (PL) spectra of heteroepitaxial GaAs layers grown on Si substrates by MOCVD and those of epitaxial GaAs films prepared by stripping off the Si substrates were observed at 77 K and 2 K in order to clarify the effect of internal stress in the GaAs layers. It was found that the shift of the PL peak position of the band-edge emission lines at these temperatures can be elucidated quantitatively by the strain due to the difference in the thermal expansion coefficients of GaAs and Si. (Author abstract) 14 refs.

Enatsu, Masao (Sharp Corp, Tenri, Jpn); Shimizu, Masafumi; Mizuki, Toshio; Sugawara, Kazushi; Sakurai, Takeshi. *Jpn J Appl Phys Part 2* v 26 n 9 Sep 1987 p 1468-1471.

**094216 NOTE ON THE BAND-FOLDING EFFECTS IN THE  $(\text{GaAs})_n/(\text{AlAs})_1$ ,  $(\text{GaAs})_1/(\text{AlAs})_n$  ( $n=1-10$ ) SUPERLATTICES.** The electronic band structures of  $(\text{GaAs})_n/(\text{AlAs})_1$  and  $(\text{GaAs})_1/(\text{AlAs})_n$  ( $n=1-10$ ) superlattices were investigated by means of an improved tight-binding method in which the overlap integrals up to the second nearest-neighbor atoms, including new parameters, were explicitly taken into account. Kroemer's rule for the band offset value was employed. The resulting band structure of superlattices in the extended zone scheme were compared with the bulk band structure while paying attention to the band-folding effect due to a periodic insertion of one atomic monolayer. A possibility of transforming an indirect-gap material into a direct-gap material by such artificial insertion of another material is discussed and the optical oscillator strength at the  $\Gamma$ -point is estimated for each  $n$ . (Author abstract) 16 refs.

Nara, Shigetoshi (ATR, Osaka, Jpn). *Jpn J Appl Phys Part 1* v 26 n 10 Oct 1987 p 1713-1718.

**094217 MODIFIED EXCITONIC RESONANCES IN GaAs/AlAs MULTIPLE QUANTUM WELL HETEROSTRUCTURES WITH ULTRATHIN BARRIERS.** Excitonic resonance structures in GaAs/AlAs multiple quantum well heterostructures with varying barrier-layer thicknesses  $L_B$  down to 1.3 nm are investigated for two sets of samples with the nominal well widths of  $L_Z=9.2$  and 6.4 nm, by 2K photoluminescence excitation spectroscopy. The observed resonance energies of the  $n=1$  heavy-hole (1 hh) and light-hole (1 lh) free excitons imply that quantum confinement effects persist at least down to the decreased barrier-layer thickness of  $L_B=1.3$  nm. This result is inconsistent with the red shifts expected from the simple well-coupling theory within the one-band Kronig-Penney model at the  $\Gamma$  point. Instead,

blue shifts of 6-8 meV (8-17 meV) are observed for the 1 hh (1 lh) excitonic resonance peaks when  $L_B$  is decreased from 10 to 2 nm. A relative decrease of the oscillator strength of the 1 lh transition compared to the 1 hh transition is also observed as  $L_B$  is decreased. These results manifest important effects of the indirect-gap barrier material for the actual wavefunction matching across the interface and the breakdown of the envelope function approach to GaAs/AlAs quantum well heterostructures with ultrathin barriers. (Author abstract) 25 refs.

Fujiwara, K. (Max-Planck-Institut fuer Festkoerperforschung, Stuttgart, West Ger); de Miguel, J.L.; Tapfer, L.; Ploog, K. *Appl Phys A* v A 44 n 4 Dec 1987 p 323-328.

**094218 ETCHING TECHNIQUE TO REVEAL DISLOCATIONS IN THIN GaAs FILMS GROWN ON Si SUBSTRATES.** Dislocations in GaAs and GaAs/Si are revealed by the etching technique at room temperature. The etchant is composed of  $\text{H}_2\text{O}$ ,  $\text{K}_2\text{Cr}_2\text{O}_7$ ,  $\text{HNO}_3$ ,  $\text{HCl}$  and  $\text{H}_2\text{SO}_4$ . The dislocation density of GaAs grown on Si by MOCVD using GaP and strained layer superlattices is about  $1 \times 10^6 \text{ cm}^{-2}$ . (Author abstract) 3 refs.

Nishikawa, Hironobu (Nagoya Inst of Technology, Nagoya, Jpn); Soga, Tetsuo; Mikuriya, Nobuo; Jimbo, Takashi; Umeno, Masayoshi. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 159-160.

**094219 INVESTIGATIONS OF THIN FILMS ON GaAs USING THE PROTON RESONANT SCATTERING TECHNIQUE.** We have characterized a number of thermally stable thin film/GaAs systems including thin films of refractory metal silicides and nitrides as well as dielectric films on GaAs substrates using a MeV proton scattering technique. Thin films of tungsten silicides, zirconium nitride and silicon dioxide on GaAs substrates are investigated. The enhanced proton scattering cross sections of nitrogen, silicon and oxygen at their corresponding resonant energies enable us to accurately measure the compositions of these films. The advantages and disadvantages of this technique regarding depth resolution, accessible depth, and mass resolution compared to the conventional Rutherford backscattering spectrometry for thin film analysis are discussed. (Author abstract) 28 refs.

Yu, Kin Man (Lawrence Berkeley Lab, Berkeley, CA, USA); Jaklevic, J.M.; Haller, E.E. *Nucl Instrum Methods Phys Res Sect B* v B30 n 4 Apr 1 1988 p 551-556.

**094220 ENERGY BAND STRUCTURE OF  $(\text{GaAs})_m(\text{AlAs})_n$  SEMICONDUCTOR SUPERLATTICES WITH ULTRATHIN LAYERS.** The local band structure of the  $(\text{GaAs})_m(\text{AlAs})_n$  superlattices is calculated within the framework of the cluster recursion method of Haydock-Heine-Kelly. The Hamiltonian is constructed in the  $\text{sp}^3\text{s}^*$ -basis of the tight-binding method. The diagonal matrix elements and orbital populations are calculated in a self-consistent way. The superlattice consists of alternate layers of GaAs and AlAs, each containing one to eight (110) layers of zincblende structure. The limiting cases of such a superstructure are the ideal heterojunction and a semiconductor material made up of alternate GaAs and AlAs layers. The paper presents the calculated densities of electron states for  $(\text{GaAs})_1 \cdot (\text{AlAs})_1$  and band discontinuities at the heterojunction. The dependence of the superlattice energy gap width on the alternate layer thickness derived here is in qualitative agreement with the experimental photoluminescence data. (Author abstract) 18 refs.

Gushchina, N.A. (Acad of Sciences of the USSR, Leningrad, USSR); Dunaevskii, S.M.; Nikulin, V.K. *Phys Status Solidi B* v 146 n 2 Apr 1988 p 511-516.

**094221 ENHANCEMENT OF THE CAPTURE RATE OF CARRIERS IN (111)-ORIENTED GaAs/Al-GaAs QUANTUM WELL STRUCTURES.** A detailed analysis of the dependence of the photoluminescence spectrum on the excitation density in (111)- and (100)-oriented single-quantum-well (SQW) structures is presented. The results show that the capture rate of photo-excited carriers in the barrier region by the SQW and the radiative

recombination rate in the SQW are enhanced in (111)-oriented SQW structures compared to those in (100)-oriented ones. (Author abstract). 15 Refs.

Hayakawa, Toshiro (Sharp Corp, Tenri, Jpn); Kondo, Masafumi; Suyama, Takahiro; Takahashi, Kosei; Yamamoto, Saburo; Hijikata, Toshiki. *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 762-765.

**Transport Properties** See Also SEMICONDUCTOR DEVICES—Mathematical Models; SEMICONDUCTOR DEVICES—Stability; TRANSISTORS, BIPOLAR—Heterojunctions.

**094222 ON THE INTERPRETATION OF THERMOPOWER MEASUREMENTS IN  $\text{GaAs-Al}_x\text{Ga}_{1-x}$  AS HETEROSTRUCTURES.** The authors present numerical results for the thermopower, in the degenerate limit, in quasi-two-dimensional quantum well structures and show that for a reasonable choice of parameters like volume concentration of electrons and thickness of the quantum well, their expression describes well the behavior of thermopower below 10 K. They discuss the conditions under which their expression reduces to the expression for a 2-D system used by other authors to interpret their data below 10 K. 12 refs.

Jali, V.M. (Karnatak Univ, Dharwad, Dharwad, India); Kubakaddi, S.S.; Mulimani, B.G. *Phys Status Solidi B* v 143 n 1 Sep 1987 p K25-K29.

**094223 PERCOLATIVE TRANSPORT IN GaAs AT 10T MAGNETIC FIELDS. INTERPRETATION VIA HYDROGEN WAVEFUNCTIONS AT MEGATESLA FIELDS.** An analytical WKB approximation of the numerical results of W. Roesner et al. for the hydrogen ground-state wavefunctions at megatesla fields is used to solve the percolation problem for transport involving donors in direct-gap semiconductors. We show that the transport coefficients thus obtained account for the magnetoresistance data in GaAs, to an accuracy comparable with previous theoretical work. (Author abstract) 8 refs.

Buczko, Ryszard (Scuola Normale Superiore, Pisa, Italy); Chroboczek, J.A.; Wunner, Guenter. *Phil Mag Lett* v 56 n 6 Dec 1987 p 251-258.

**094224 TRANSPORT PARAMETERS IN ILLUMINATED LAYERS OF SEMIINSULATING GaAs.** Measurements are reported on semi-insulating p-type gallium arsenide specimens illuminated with photons of energy greater than the energy gap. An excited layer is defined of thickness  $d$  given by the sum of the radiation penetration depth and the ambipolar diffusion length. Concentrations  $n$  and mobilities  $\mu$  of the carriers in this layer are determined from galvanomagnetic effects in light and in darkness. The concentration  $n$  shows a slow decrease with increasing wavelength out to the absorption edge, where it falls abruptly;  $\mu$  falls with rising photon energy. As a function of increasing intensity, the mobility remains constant, while  $n$  rises linearly with photon-excitation rate. The results are discussed in terms of the variations of  $d$ . Further an attempt has been made to find the dependence between electron and hole concentrations in the excited layer measuring the variations of short circuit photomagnetolectric current as a function of excess conductance. (Author abstract) 9 refs.

Euthymiou, P.C. (Athens Univ, Athens, Greece); Papaiannou, G.J.; Kourkoutsas, C.D.; Banbury, P.C. *Solid State Commun* v 62 n 6 May 1987 p 423-425.

**094225 UNIVERSAL MAGNETOCONDUCTANCE FLUCTUATIONS IN NARROW  $n^+$  GaAs WIRES.** We describe experimental results of the low-temperature magnetoresistance measurement in a nanometer-structure doped GaAs wire with the thickness of 200 Å, the width of 0.3  $\mu\text{m}$  and the length of 2  $\mu\text{m}$ . Aperiodic and reproducible magnetoconductance fluctuations are observed which arises from a quantum interference of



electron waves. The magnitude of the fluctuation is of the order of the universal conductance  $e^2/h$  and is compared with recent theories. (Author abstract) 19 refs.

Ishibashi, K. (Osaka Univ, Toyonaka, Jpn); Nagata, K.; Gamo, K.; Namba, S.; Ishida, S.; Murase, K.; Kawabe, M.; Aoyagi, Y. *Solid State Commun* v 61 n 6 Feb 1987 p 385-389.

**094226 MODULATION-DOPED  $\text{Al}_x\text{Ga}_{1-x}\text{As}$ /GaAs HETEROSTRUCTURES WITH PARALLEL CONDUCTING LAYER IN  $\text{Al}_x\text{Ga}_{1-x}\text{As}$ .** The transport properties of the 2-D electron gas with and without parallel conducting channel are studied in strong magnetic fields at low temperatures. The modulation-doped  $\text{n-Al}_x\text{Ga}_{1-x}\text{As}$ /GaAs heterostructures were grown by molecular beam epitaxy. Both dark and photoconductivity are measured. The behavior of the Hall coefficient is explained. 2 refs.

Jiang, P.H. (Chinese Acad of Sciences, Beijing, China); Zhu, Y.T.; Sun, D.Z.; Zeng, Y.P. *Phys Status Solidi B* v 145 n 2 Feb 1988 p K111-K114.

**094227 NEGATIVE MAGNETORESISTANCE OF NEUTRON-TRANSMUTATION-DOPED GALLIUM ARSENIDE AT VARIABLE-RANGE HOPPING.** Investigations of anomalous magnetoresistance (mr) in neutron-transmutation-doped GaAs are performed at  $T=0.05$  to  $4.2$  K in the vicinity of the metal-insulator transition (MIT). Without as well as with magnetic field a variable-range hopping law  $q(T)=q_0 \exp(T_1/T)^{1/2}$  is found where  $T_1$  approaches zero as  $n$  approaches  $n_c$ . At higher magnetic fields the negative mr saturates and eventually changes into a positive mr with  $T_1(H) > T_1(0)$ . The dependence of  $T_1$  on  $n$  as well as on  $H$  originates from the scaling behavior of the localization radius and the dielectric constant at the MIT. (Edited author abstract) 19 refs.

Rentsch, R. (Acad der Wissenschaften der DDR, Berlin, West Ger); Friedland, K.J.; Ionov, A.N. *Phys Status Solidi B* v 146 n 1 Mar 1988 p 199-206.

**094228 HYDRODYNAMIC HOT-ELECTRON TRANSPORT MODEL WITH MONTE CARLO-GENERATED TRANSPORT PARAMETERS.** A unique hot-electron transport model suitable for studying submicron GaAs device structures is presented. The model is based on the semiclassical 'hydrodynamic' conservation equations for the average electron density, momentum, and energy. The model includes electron relaxation times, momentum relaxation times, energy relaxation times, electron temperature tensors and heat flow vectors as a function of average electron energy for the  $\Gamma$ , X and L valleys of GaAs. The relaxation times represent rates of exchange of electrons between valleys and rates of loss of average momentum and average energy between and within the individual valleys. The electron temperature tensor and heat flow vector depend on the electron velocity distribution about the average electron velocity and ultimately affect transport when spatial variations in average velocity and average energy exist. Transport parameters are calculated using the Monte Carlo method and the ergodic principle applied directly to the integral definitions for the parameters. Therefore, the model includes nonequilibrium transport effects such as velocity overshoot and nonuniform average electron energy. The new model should prove instrumental in optimizing electron transport through submicron structures for high-speed devices. (Edited author abstract) 7 refs.

Woolard, D.L. (North Carolina State Univ, Raleigh, NC, USA); Trew, R.J.; Littlejohn, M.A. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 571-574.

**Vapor Deposition** See Also GALLIUM COMPOUNDS—Spectroscopic Analysis; PHOTOLUMINESCENCE.

**094229 MULTI-QUANTUM-WELL STRUCTURES PREPARED BY THE FLASH EVAPORATION TECHNIQUE: GROWTH, STRUCTURAL, AND OPTICAL CHARACTERIZATION.** The flash evaporation

technique under high-vacuum conditions is a possible method to produce multi-quantum-well structures and superlattices. Using this technique, epitaxial GaAs/GaP and, for the first time GaAs/Ca<sub>0.43</sub>Si<sub>0.57</sub>F<sub>2</sub> multi-quantum-well samples are grown. The structural characterization is performed by reflection high energy electron diffraction and Rutherford backscattering/channeling measurements. Optical investigations (absorption and light-induced grating measurements) show quantum confinement in both systems investigated and type II character for the GaAs/Ca<sub>0.43</sub>Si<sub>0.57</sub>F<sub>2</sub> heterostructures. (Author abstract) 17 refs.

Schumann, B. (Karl-Marx-Univ Leipzig, Leipzig, East Ger); Flaggmeyer, R.; Weinert, H. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 257-264.

**094230 HETEROEPITAXIE DE GaAs SUR Si (100) PAR EPVOM.** [Heteroepitaxy of GaAs on Si (100) by MOVPE]. This work deals with the metallorganic vapor phase epitaxy of GaAs on Si. Photoluminescence spectroscopy, double-crystal X-ray diffraction and secondary ion mass spectroscopy were used to illustrate a close correlation found between growth conditions and material properties. (Author abstract) 5 refs. In French.

Freundlich, A. (CNRS, Valbonne, Fr); Grenet, J.C.; Neu, G.; Leycuras, A.; Gibart, P.; Verie, C. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 195-196.

**X-Ray Analysis** See Also SEMICONDUCTING INDIUM COMPOUNDS—X-Ray Analysis; SEMICONDUCTOR MATERIALS—Etching.

**094231 X-RAY TOPOGRAPHIC INVESTIGATION OF CELLULAR STRUCTURE IN SEMI-INSULATING GaAs.** In the present work a high-purity semi-insulating GaAs single crystal grown by the LEC (liquid encapsulated Czochralski) technique has been studied by X-ray transmission topography. A  $<001>$  wafer, 370  $\mu\text{m}$  thick, has been investigated by the Lang method. Topographs were recorded on Ilford G5 50  $\mu\text{m}$  nuclear plates. Several topographs for various reflections were taken with Mo  $\text{K}\alpha_1$  radiation. These topographs suggest a very well pronounced cellular structure. (Edited author abstract) 15 refs.

Zielinska-Rohozinska, E. (Univ of Warsaw, Warsaw, Pol). *J Cryst Growth* v 87 n 1 Jan II 1988 p 154-156.

**094232 CHARACTERIZATION OF  $\text{Ga}_{1-x}\text{Al}_x\text{As}$ /GaAs SUPERLATTICES AND THIN SINGLE LAYERS BY X-RAY DIFFRACTION.** The optimization of the production conditions of laser materials on the basis of multiquantum structures as an active layer requires knowledge of the geometrical structure, chemical composition, and stress profile of the applied superlattice. These data can be established by X-ray diffraction since the periodic hyperstructure of the superlattice in the nanometer region has a detectable influence on the X-ray diffraction pattern. The characterization of superlattices by this technique is performed by an X-ray collimator. In principle it represents a double crystal diffractometer with a slit monolithic Si crystal which is an almost ideal collimator and monochromator. A theoretical consideration is given of the superlattice diffraction. Experimental results of X-ray diffraction measurements are presented. (Edited author abstract) 7 refs.

Baumbach, T. (Karl-Marx-Univ Leipzig, Leipzig, East Ger); Bruhl, H.-G.; Pietsch, U.; Terauchi, H. *Phys Status Solidi A* v 105 n 1 Jan 1988 p 197-205.

**094233 MEASUREMENTS OF LATTICE PARAMETERS AND HALF-WIDTHS OF THE ROCKING CURVE ON GaAs CRYSTAL BY THE X-RAY DOUBLE-CRYSTAL METHOD USING A  $\text{Cu K}\alpha$  DOUBLET.** GaAs wafers grown by HB and LEC techniques were appraised by the double-crystal method using a  $\text{Cu K}\alpha$  doublet. Distributions of lattice strains and defect density along the  $<110>$  radial direction on wafers have been obtained from measurements of lattice parameters and half-widths of the rocking curve, respectively. (Au-

thor abstract) 8 refs.

Fukumori, Taichiro (Miyazaki Univ, Miyazaki, Jpn); Futagami, Koji. *Jpn J Appl Phys Part 1* v 27 n 3 Mar 1988 p 442-443.

**SEMICONDUCTING GALLIUM COMPOUNDS** See Also CRYSTALS—Measurements; CRYSTALS—Physical Properties; INFRARED DETECTORS—Performance; INTEGRATED OPTICS—Switching; LASERS, SEMICONDUCTOR; LASERS, SEMICONDUCTOR—Design; LASERS, SEMICONDUCTOR—Electric Properties; LASERS, SEMICONDUCTOR—Modes; LASERS, SEMICONDUCTOR—Noise, Spurious Signal; LASERS, SEMICONDUCTOR—Performance; LASERS, SEMICONDUCTOR—Radiation Effects; LIGHT—Modulators; OPTICAL DEVICES—Performance; OPTOELECTRONIC DEVICES—Materials; PHOTODETECTORS—Multiplexing; SEMICONDUCTING GALLIUM ARSENIDE—Spectroscopic Analysis; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES—Junctions; SEMICONDUCTOR DEVICES, MISFET—Fabrication; TELECOMMUNICATION LINKS, OPTICAL—Performance; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, BIPOLAR—Performance; TRANSISTORS, FIELD EFFECT—Heterojunctions; TRANSISTORS, FIELD EFFECT—Performance; TRANSISTORS, FIELD EFFECT—Tunneling; WAVEGUIDE COMPONENTS—Couplers; WAVEGUIDES, OPTICAL—Performance.

**094234 CHARACTERISATION OF  $\text{Ga}_{1-x}\text{In}_x\text{As}/\text{Al}_{1-y}\text{In}_y\text{As}$  MULTIPLE QUANTUM WELLS BY RAMAN SCATTERING.** Two  $\text{Ga}_{1-x}\text{In}_x\text{As}/\text{Al}_{1-y}\text{In}_y\text{As}$  multiple quantum well structures are characterized using Raman spectroscopy. Raman scattering by zone folded longitudinal acoustic phonons is observed and analyzed using the elastic continuum theory to determine the superlattice periods of the structures. The energies of the optical phonons in the ternary alloy layers have also been measured and their relationship to the alloy compositions is discussed. (Author abstract) 16 refs.

Davey, S.T. (British Telecom Research Lab, Ipswich, Engl); Scott, E.G.; Wakefield, B.; Davies, G.J. *Semicond Sci Technol* v 2 n 10 Oct 1987 p 683-686.

**094235 PURE BLUE EL OF GaN:Zn.** GaN was epitaxially grown on (0001) sapphire by the vapor phase reaction of the  $\text{Ar-NH}_3\text{-HCl-Ga}$  system. The incorporation of Zn into the GaN was found to be critically dependent on growth conditions. Suitable conditions for obtaining blue EL were investigated. (Edited author abstract) In Chinese. 9 refs.

Xie, Jiang-feng (Chinese Acad of Science, China); Fu, Shu-qing; Sun, Ya-li; Zhang, Chuan-ping. *Xi You Jin Shu* v 6 n 1 Feb 1987 p 38-42.

**094236 OBSERVATION OF DONOR-RELATED DEEP LEVELS IN  $\text{Ga}_x\text{In}_{1-x}\text{P}$  ( $0.52 \leq x \leq 0.71$ ).** This paper reports donor-related deep levels in  $\text{Ga}_x\text{In}_{1-x}\text{P}$  ( $0.52 \leq x \leq 0.71$ ). S-, Se- and Si-doped GaInP grown by chloride-vapor-phase epitaxy was used for the measurements. At the Ga composition  $x$  of 0.52 that is lattice matched to GaAs, a deep level was observed for S-doped GaInP but not for Se- or Si-doped GaInP. Se-doped GaInP with larger  $x$  values was also studied, and the deep level was observed for  $x$  larger than 0.56. It is found that the behavior due to these donor-related deep levels, with effects such as persistent photoconductivity and Ga-composition dependence, is the same as for DX centers in AlGaAs. These results are relevant to the use of GaInP/GaAs heterostructures for high-speed electronic devices such as high-electron-mobility transistors. (Edited author abstract) 12 refs.

Kitahara, Kuninori (Fujitsu Lab Ltd, Atsugi, Jpn); Hoshino, Masataka; Ozeki, Masashi. *Jpn J Appl Phys Part 2* v 27 n 1 Jan 1988 p 110-112.

**094237 EXCESS ELASTIC ENERGY AND THE INSTABILITY OF  $(\text{GaAs})_1(\text{InAs})_1(001)$ ,  $\text{Ga}_2\text{InAs}_4$ ,  $\text{GaIn}_3\text{As}_4$  AND  $\text{Ga}_{1-x}\text{In}_x\text{As}$  ALLOYS.** Self-consistent ab initio pseudopotential calculations indicate that the  $(\text{GaAs})_1(\text{InAs})_1(001)$  superlattice and the  $\text{Ga}_2\text{InAs}_4$  and  $\text{GaIn}_3\text{As}_4$  cubic crystals are unstable against phase



segregation at zero temperature. Instability results from the excess elastic energy of stretched Ga-As and compressed In-As bonds, which is not compensated by the energy released in the distortion of the anion sublattice. A simple statistical scheme, based on the above results, predicts an even stronger instability of random  $\text{Ga}_{1-x}\text{In}_x\text{As}$  alloys. (Author abstract) 20 refs.

Boguslawski, P. (EPFL, Lausanne, Switz); Baldereschi, A. *Solid State Commun* v 66 n 6 May 1988 p 679-682.

## Aging

**094238 STUDY BY DDX AND SIMS OF EPVOM GROWN  $\text{Ga}_{1-x}\text{Al}_x\text{As}$ .** The aging of EPVOM grown  $\text{Ga}_{1-x}\text{Al}_x\text{As}$  layers has been studied by double X-ray diffraction in a first step. The evolution of strain measured by the radius of curvature varies from one layer to another for a same composition. The origin of this evolution is the oxidation of the layers. The oxidation can occur even for layers which are protected by a GaAs layer. In order to find a correlation between the oxidation rate and a chemical component, a SIMS study has been carried out. It shows a correlation between the carbon concentration and the oxidation rate of Al rich  $\text{Ga}_{1-x}\text{Al}_x\text{As}$  compounds. For a carbon concentration larger than a few  $10^{17} \text{ cm}^{-3}$  the oxidation rate is too small to be measured. (Author abstract) 2 refs. In French.

Leycuras, A. (CNRS, Valbonne, Fr); Grenet, J.C.; Freundlich, A.; Grattapain, C. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, Zemes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 201-202.

**Applications** See LASERS, SEMICONDUCTOR—Fabrication; SEMICONDUCTOR DIODES, LIGHT EMITTING—Research.

**Charge Carriers** See Also PARTICLE DETECTORS; SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers; SEMICONDUCTOR DEVICES—Heterojunctions.

**094239 DRIFT MOBILITIES OF PHOTOCARRIERS IN AMORPHOUS HYDROGENATED GaP MADE BY REACTIVE EVAPORATION.** The drift mobilities of photoelectrons and photoholes in a film of a-GaP:H at 300 K were estimated to be  $2.3 \times 10^{-3} \text{ cm}^2/\text{Vs}$  and  $1.3 \times 10^{-3} \text{ cm}^2/\text{Vs}$ , respectively, from a time-of-flight measurement in which the mole ratio of Ga to P, r, in the film was nearly equal to unity. Spectra of the ac photoconductivity for different hydrogenated films with different values of r were measured at 90 K and the results at low photon energies suggest an excitation of electrons and holes at the gap states to the mobility edges of the conduction and valence bands, respectively, owing to the transport of mobile holes as well as mobile electrons deduced from time-of-flight measurements. (Author abstract) 10 refs.

Onuki, Masami (Kumamoto Univ, Kumamoto, Jpn); Kubota, Hiroshi. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1404-1407.

**094240 NON-DESTRUCTIVE DETERMINATION OF FREE CARRIER DENSITY OF EPITAXIAL LAYERS OF GaSb BY IR REFLECTIVITY MEASUREMENT.** IR reflectivity measurements were made on thin epitaxial GaSb layers grown on n+ GaSb and semi-insulating GaAs substrates. The results were interpreted using a two-oscillator dielectric model and free carrier concentrations were determined and compared with electrical measurements. (Author abstract) 12 refs.

Schirar, S. (Univ des Sciences et Techniques du Languedoc, Montpellier, Fr); Bayo, L.; Melouah, A.; Bougnot, J.; Llinares, C.; Montaner, A.; Galtier, M. *Thin Solid Films* v 155 n 1 Dec 15 1987 p 125-132.

**094241 SCREENING EFFECTS IN TWO-DIMENSIONAL ELECTRON GAS.** The potential produced by a charged impurity at the interface of a highly doped GaAlAs and GaAs is calculated at a finite temperature. The electron gas formed at the interface is described as a two dimensional gas in which the impurity is assumed to

be dipped. Temperature dependence of the impurity potential is calculated in the random phase approximation (R.P.A.) as well as in the modified temperature-dependent Thomas-Fermi (M.T.T.F.) approximation which is defined to include temperature effects and to reduce to Thomas-Fermi result at zero temperature. The binding energy of the impurity for the ground state is calculated in R.P.A. and in M.T.T.F. It is shown that at temperature T, much larger than the Fermi temperature,  $T_F$ , M.T.T.F. gives binding energies close to R.P.A. results. (Author abstract) 10 refs.

Panat, P.V. (Lakehead Univ, Thunder Bay, Ont, Can); Paranjape, V.V. *Solid State Commun* v 62 n 12 Jun 1987 p 829-832.

**094242 HOT CARRIER-PHONON INTERACTION IN THREE- AND TWO-DIMENSIONAL  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$ .** The dependence of carrier-phonon interaction on dimensionality and on quantum well thickness is studied in bulk  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$  and in 3.4, 8.0, and 13.8 nm thick  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}/\text{Al}_{0.48}\text{In}_{0.52}\text{As}$  quantum well structures. The variation of carrier temperature with absorbed power in a steady-state photoluminescence experiment yields effective longitudinal optical phonon energies and carrier-polar optical scattering times, which are within experimental error independent of sample structure and agree with the theoretical value. (Author abstract) 12 refs.

Lobentanzer, H. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Ruehle, W.W.; Stolz, W.; Ploog, K. *Solid State Commun* v 62 n 1 Apr 1987 p 53-56.

**094243 OPTICAL INVESTIGATION OF THE HEAVY HOLE-LIGHT HOLE SPLITTING IN THIN GaAs/GaAlAs QUANTUM WELLS.** A study of the optical properties of thin GaAs/GaAlAs quantum wells shows that the heavy hole-light hole splitting reaches a maximum for a well thickness of  $\approx 9$  monolayers and decreases rapidly for smaller thicknesses. These results with calculations made in the envelope function approximation. (Edited author abstract) 8 refs.

Laruelle, F. (CNRS, Bagnex, Fr); Etienne, B. *Solid State Commun* v 65 n 7 Feb 1988 p 565-569.

**094244 CARRIER CONCENTRATION PROFILES ACROSS GAP GRAIN BOUNDARIES OBSERVED BY RAMAN MEASUREMENTS.** Raman measurements were performed on grain boundaries in n-type and p-type GaP grown by the SSD method. The high angle grain boundaries show a central region of carrier depletion which is attributed to dopant depletion. Broad ranges of carrier accumulation are not always clearly pronounced. Possible reasons of the formation of these profiles are discussed. (Edited author abstract) 20 refs.

Irmer, G. (Bergakademie Freiberg, Freiberg, East Ger); Siegel, W. *Phys Status Solidi A* v 105 n 2 Feb 1988 p 549-553.

**094245 FEMTOSECOND ABSORPTION SATURATION STUDIES OF HOT CARRIERS IN GaAs AND ALGaAs.** Femtosecond carrier dynamics in GaAs and AlGaAs thin films are studied by time-resolved pump-probe spectroscopy. Measurements are performed using identical pulses as well as a continuum probe. Observations of the ultrafast absorption saturation response are related to the excitation of the carriers into specific nonthermal distributions, to their rapid scattering out of these states, and to subsequent cooling of the quasi-thermal carrier distribution to the temperature of the lattice. A strong dependence of the initial scattering rates on the mole fraction of Al and the excess electron energy is observed. 34 refs.

Lin, Wei-Zhu (MIT, Cambridge, MA, USA); Schoenlein, Robert W.; Fujimoto, James G.; Ippen, E.P. *IEEE J Quantum Electron* v 24 n 2 Feb 1988 p 267-275.

**094246 HOT CARRIER ENERGY LOSS RATES IN GaInAs/InP QUANTUM WELLS.** We have measured the energy loss rates of hot carriers in bulk  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$  and in  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}/\text{InP}$  quantum wells of widths 154 Angstrom and 14 Angstrom. We find that the energy loss

rates are considerably lower than predicted by the unscreened carrier-LO phonon interaction. We show that the discrepancy may be resolved, at least in part, by invoking the presence of a non-equilibrium phonon distribution, the magnitude of the effect depending on the well width. (Author abstract) 15 refs.

Westland, D.J. (Clarendon Lab, Oxford, Engl); Ryan, J.F.; Scott, M.D.; Davies, J.I.; Riffat, J.R. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 431-434.

**094247 HOT CARRIER RELAXATION AND RECOMBINATION IN GaSb/AlSb QUANTUM WELLS.** We present picosecond time-resolved experiments on GaSb/AlSb quantum wells using a sum frequency generation technique. Recombination processes as well as relaxation and cooling processes of hot carriers in 2D GaSb/AlSb systems are studied. As a result, we find LO-phonon scattering times  $\tau_{LO}$  of about 12ps. (Author abstract) 10 refs.

Cebulla, U. (Univ Stuttgart, Stuttgart, West Ger); Zollner, S.; Forchel, A.; Subbanna, S.; Griffiths, G.; Kroemer, H. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 507-510.

**094248 ANALYSIS OF CARRIER DISTRIBUTION FUNCTION THROUGH SMITH-PURCELL EFFECT IN GaAs/GaAlAs HETEROSTRUCTURES.** We have observed the Smith-Purcell effect in GaAs-GaAlAs-heterostructures. A grating structure induces far infrared (FIR) emission from drifted carrier distributions, which is angle dependent and allows the determination of intrinsic carrier properties. (Edited author abstract) 11 refs.

Gornik, E. (Univ Innsbruck, Innsbruck, Austria); Christanell, R.; Lassnig, R.; Weimann, G. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 751-754.

**Chemical Vapor Deposition** See Also LASERS, SEMICONDUCTOR; SEMICONDUCTING INDIUM COMPOUNDS—Chemical Vapor Deposition.

**094249 GAS MIXING DEVICE FOR MOCVD.** Epitaxial layers of  $\text{Ga}_{1-x}\text{In}_x\text{As}$  have been grown in a horizontal, low pressure metalorganic chemical vapor deposition reactor, using a mixing manifold of radial symmetry. The effect of the inlet configuration of the reactant gases on the compositional uniformity of the layers has been investigated by photoluminescence spectroscopy. It was found that incomplete gas phase mixing of the reactants resulted in poor uniformity of the grown layers. By incorporating a mixing device in the gas line, which imparted a rotational component to the gas flow, epitaxial layer uniformities were markedly improved. (Author abstract) 6 refs.

Blaauw, C. (Bell-Northern Research, Ottawa, Ont, Can); Miner, C.J. *J Cryst Growth* v 84 n 2 Aug 1987 p 191-195.

**094250 CHEMICAL VAPOR DEPOSITION OF  $\text{CuGaS}_2$  USING CHLORIDE SOURCES.** The chemical vapor deposition of  $\text{CuGaS}_2$  using  $\text{CuCl}$ ,  $\text{GaCl}_3$  and S sources and  $\text{N}_2$  carrier gas has been studied for the first time. The synthesized deposits are characterized by an X-ray diffraction method and confirmed to be  $\text{CuGaS}_2$  with chalcopyrite structure.  $\text{CuGaS}_2$  layers are grown on GaAs(111) substrates at approximately 700°C and show green luminescence due to donor-acceptor pair recombinations at 2.299 eV at 4.2 K. (Author abstract) 10 refs.

Matsumoto, Takashi (Yamanashi Univ, Kofu, Jpn); Nakanishi, Hiroshi; Ishida, Tetsuro. *Jpn J Appl Phys Part 2* v 26 n 8 Aug 1987 p 1263-1265.

**094251 RAMAN SCATTERING ANALYSIS OF DISORDER IN HETEROGENEOUS  $(\text{GaAs})_{1-x}(\text{SiC}_2\text{:H})_x$  FILMS GROWN BY METAL-ORGANIC CHEMICAL VAPOUR DEPOSITION.** A chemical and structural analysis of  $(\text{GaAs})_{1-x}(\text{SiC}_2\text{:H})_x$  film is performed by using the Raman scattering probe. A multizone structural model is evidenced in accordance with previous



X-ray and electron diffraction experiments. The ability of a spatial correlation model to account for the lineshape evolution of the spectra of the GaAs phase is discussed for the first time for both longitudinal optical and transverse optical modes. The values of the 'Raman size' of the GaAs crystallites lie well below those deduced from diffraction experiments, revealing the presence of many internal defects which greatly influence the electron-phonon interactions. (Author abstract) 16 refs.

Maury, F. (CNRS, Toulouse, Fr); Carles, R.; Landa, G.; Renucci, J.B. *Thin Solid Films* v 155 n 2 Dec 30 1987 p 331-342.

**094252 COMPARATIVE STUDY OF Ga(CH<sub>3</sub>)<sub>3</sub>, Ga(C<sub>2</sub>H<sub>5</sub>)<sub>3</sub> AND Ga(C<sub>4</sub>H<sub>9</sub>)<sub>3</sub> IN THE LOW PRESSURE MOCVD OF GaAs.** Our study presents data on the growth of GaAs obtained in a low pressure (10<sup>4</sup> Pa) metal organic chemical vapor deposition (MOCVD) system using Ga(CH<sub>3</sub>)<sub>3</sub> [TMG], Ga(C<sub>2</sub>H<sub>5</sub>)<sub>3</sub> [TEG] or Ga(C<sub>4</sub>H<sub>9</sub>)<sub>3</sub> [TIBG]. The growth efficiencies for these gallium sources, calculated on the basis of our own vapor pressure measurements, are of comparable magnitude. Due to the lower thermal stability of TEG and TIBG growth of GaAs is possible at lower temperatures. High quality films with free carrier concentration below 10<sup>15</sup> cm<sup>-3</sup> were grown at 923 K with TMG, at 843 K with TEG. The TIBG grown films tended to be n-type, probably due to contamination in the source. The electrical properties of the films are independent of the arsine overpressure (V/III ratio) in a broad range using TEG or TIBG. This allows epitaxial deposition of GaAs at a low consumption of AsH<sub>3</sub>. (Author abstract) 47 refs.

Plass, C. (RWTH, Aachen, West Ger); Heinecke, H.; Kayser, O.; Lueth, H.; Balk, P. *J Cryst Growth* v 88 n 4 May II 1988 p 455-464.

## Contacts

**094253 OHMIC CONTACTS ON p-TYPE Ga<sub>0.47</sub>In<sub>0.53</sub>As/InP.** Ohmic contacts of Au and Ag based Zn containing alloys on p-type Ga<sub>0.47</sub>In<sub>0.53</sub>As have been studied using intermediate layers of Ti and Ni, respectively. Low specific contact resistance in the order of 10<sup>-5</sup> Ωcm<sup>2</sup> are achieved. In AuZn alloy, the Ti intermediate metal layer causes higher contact resistances together with a worse contact morphology in contrast to Ni intermediate layers. However for AgZn contacts Ti adherent layers improve the contact resistances, especially for lower alloying temperatures. These contacts exhibit smoother interfaces as revealed by TEM micrographs. Thus AgZn contacts apply best to low resistive contacting of very thin p-layers forming e.g. the base of a ballistic device. (Edited author abstract) 11 refs.

Allevato, C.E. (Aachen Univ of Technology, Aachen, West Ger); Selders, J.; Schulte, F.; Beneking, H. *Solid State Electron* v 30 n 10 Oct 1987 p 1039-1042.

**094254 LOW RESISTANCE METAL-SEMICONDUCTOR CONTACTS TO GALLIUM ANTIMONIDE.** The physics of current transport mechanisms for metal-semiconductor contacts on GaSb have been examined using the model of A.Y.C. Yu including the image-force barrier lowering. (Author abstract) 10 refs.

Heinz, C. (Univ Muenchen, Munich, West Ger). *Int J Electron* v 64 n 6 Jun 1988 p 923-927.

**094255 Au-Zn/Au-Sb/GaP OHMIC CONTACT OF GaP LED.** This paper presents some work on the mechanism of ohmic contact of Au-Zn/Au-Sb/GaP system. Good ohmic behavior can be obtained during 520-560 °C alloying temperature. The lowest specific contact resistance 3.2×10<sup>-3</sup> Ωcm<sup>2</sup> is obtained at about 537 °C alloying temperature. It seems that the electric behavior is affected by the small islands on the interface of sample alloyed. 2 refs.

Lu, Zihong (Zhejiang Univ, Hangzhou, China); Hua, Weimin; Ding, Zuchang. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 806-807.

## Crystal Lattices

**094256 LATTICE VIBRATIONS OF CuGaSe<sub>2</sub>, CuInSe<sub>2</sub> TERNARY COMPOUNDS, AND CuGa<sub>1-x</sub>In<sub>x</sub>Se<sub>2</sub> SOLID SOLUTIONS.** On the basis of IR reflection, transmission, and Raman spectra the frequencies of the vibrational modes of CuGaSe<sub>2</sub>, CuInSe<sub>2</sub>, and CuGa<sub>1-x</sub>In<sub>x</sub>Se<sub>2</sub> obtained and identified. It is shown that the lattice vibrations of the solid solutions display mixed type behavior. In the frequency range ω > 200 cm<sup>-1</sup>, the vibrational modes show two-mode behavior. Two relatively independent bands in this range are due to vibrations of Ga-Se atoms and In-Se, respectively, in antiphase. The vibrational modes in the low frequency range (ω > 200 cm<sup>-1</sup>) display one-mode behavior. (Author abstract) 7 refs.

Bodnar, I.V. (Radioengineering Inst, Minsk, USSR); Smirnova, G.V.; Smirnova, T.V.; Aleshchenko, Yu.A.; Vodopyanov, L.K. *Phys Status Solidi B* v 145 n 1 Jan 1988 p 117-122.

## Defects

**094257 DISLOCATION STRUCTURE OF GaP CRYSTALS AFTER 6-10° BENDING.** More than one thousand individual dislocations have been examined by TEM in S-doped LEC-GaP after three-point bending of (001) wafers at temperatures in the range 605-615°C. A linear variation of dislocation density with bending angle between 6 and 10° is observed. The role of different dislocation types is investigated. An increasing proportion of 60° dislocations in {111} planes develops during bending. Macroscopic curvature is discussed in terms of the dislocation density observed. Resolved shear stresses are derived from slip-band observation. (Author abstract) 38 refs.

Pauffer, P. (Karl-Marx-Univ, Leipzig, East Ger); Rotsch, P.; Wagner, G. *Philos Mag A* v 56 n 4 Oct 1987 p 533-551.

**094258 ALLOY DISORDER BROADENING OF DEFECT ENERGY LEVELS.** The deep level transient spectroscopy (DLTS) peaks are broader in alloys than the peaks in binary III-V compounds. This effect is related to substitutional disorder present in the alloy which changes the sharp energy levels into a distribution. We give relations between the broadened DLTS signal, defect energy level broadening and alloys disorder with particular reference to electron irradiation induced E3 defect in GaAs<sub>1-x</sub>Sb<sub>x</sub> alloys. (Edited author abstract) 14 refs.

Arora, B.M. (Tata Inst of Fundamental Research, Bombay, India). *Solid State Commun* v 61 n 2 Jan 1987 p 105-107.

**094259 TRANSITION-METAL ELECTRON STATES IN IMPERFECT Ga<sub>2</sub>S<sub>3</sub> CRYSTALS.** Resonance techniques and, in particular, electron paramagnetic resonance (EPR) and γ-resonance (GR) are informative for the interpretation of the impurity character in defect semiconductors. These methods give information on the spatial distribution of paramagnetic ions, the chemical bond nature, and charge state of the atoms and their electronic structure. Ga<sub>2</sub>S<sub>3</sub> defect crystals were studied by EPR and GR within the 77 to 300 K range to determine the electronic states of Mn and Fe impurity atoms. The analysis reveals that electrically inactive Fe atoms are incorporated as Fe<sup>2+</sup> into the lattice and form chemical bonds with S atoms. 10 refs.

Askerov, I.M. (Azerbaijani Civil Engineering Inst, Baku, USSR); Mekhrabov, A.O.; Aslanov, G.K.; Tagiev, B.G.; Nakhmetov, S.M. *Phys Status Solidi A* v 105 n 2 Feb 1988 p K151-K154.

**094260 POINT DEFECTS IN GaP SINGLE CRYSTALS INVESTIGATED BY MECHANICAL DAMPING.** The dependence of mechanical damping of LEC (liquid encapsulated Czochralski) crystals of GaP:S was measured in the temperature range 300 ... 600 K and at frequencies near 70 and 140 kHz, respectively. In samples of different stoichiometry two peaks could be observed:

Peak A at 350 K and peak B at 450 K. Peak A is attributed to the relaxation of point defects near the surface, peak B is probably due to Ga vacancies. (Author abstract) 28 refs.

Klimm, D. (Karl-Marx-Univ, Leipzig, East Ger); Pauffer, P. *Cryst Res Technol* v 22 n 8 Aug 1987 p 1023-1030.

**094261 INVESTIGATION OF DEEP DEFECTS IN GaAs<sub>1-x</sub>P<sub>x</sub> BY DOUBLE LIGHT SOURCE PHCAP.** The deep defects in GaAs<sub>1-x</sub>P<sub>x</sub>(N)/GaP (x=0.65,0.85) are investigated by double light source photoluminescence (PHCAP) method. The parameters of deep level (DL) are determined by the PHCAP spectra which are measured at the low temperature (T=100K). The nature of DL and the influence of As component on DL parameters are analyzed. (Author abstract) 5 refs.

Zhou, Bizhong (Xiamen Univ, Xiamen, China); Huang, Jingzhao; Chen, Shibou. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 335-336.

**094262 COMPLEX DEFECTS IN GaP STUDIED BY OPTICALLY DETECTED MAGNETIC RESONANCE (ODMR).** Optically detected magnetic resonance (ODMR) in the photoluminescence (PL) mode has recently been extensively applied to the study of the electronic structure and identity of complex defects in GaP, monitoring recombination of bound excitons (BEs) associated with these defects. In this paper we discuss evaluation and interpretation of ODMR data from recent studies on several neutral ('isoelectronic') complex defects related to Cu, Li, C and the P<sub>Ga</sub>-antisite in GaP. 12 refs.

Chen, W.M. (Linköping Univ, Linköping, Swed); Mone-mar, B. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 337-338.

**094263 INVESTIGATION OF DEFECTS IN GaP USING POSITRON ANNIHILATION LIFETIME SPECTRA.** The defects in LEC GaP(S) and their behaviour under thermal treatment have been investigated by positron annihilation technique (PAT). The positron lifetime of free state and trapped state in GaP(S) are obtained. The results are analyzed by a defect reaction. (Author abstract) 4 refs.

Zhou, Bizhong (Xiamen Univ, China); Fang, Jianling; Huang, Jingzhao. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 867-868.

**Doping.** See Also SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers; SEMICONDUCTING GALLIUM ARSENIDE—Doping; TRANSISTORS, FIELD EFFECT—Heterojunctions.

**094264 INTERACTION BETWEEN AN IMPURITY AND POINT DEFECT IN GaP AND GaAs CRYSTALS.** An analytical relation is established between the nonstoichiometry factor δ of a doped A<sup>III</sup>BV crystal and the equilibrium-liquids parameters of the crystal. The values of δ in the primary-crystallization range of GaP and GaAs are calculated along the equilibrium-liquidus isotherms in the Ga-P-Si, Ga-P-Zn, Ga-As-Si and Ga-As-Zn systems. It is shown that, qualitatively, the value of δ in highly doped GaP and GaAs crystals does not depend on the nature of the impurity or its state in the crystal. In Russian. 15 refs.

Barchuk, A.N.; Ivashchenko, A.I.; Kopanskaya, F.Ya. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 8 Aug 1987 p 1237-1240.

**094265 PRESSURE DEPENDENCE OF DONOR LEVELS IN GaP: ELECTRONIC RAMAN SCATTERING EXPERIMENTS.** Electronic Raman scattering experiments have been performed in S and Te doped GaP up to 47 kbar. We observe an increase of the energy of the 1S(T<sub>1</sub>)-1S(T<sub>12</sub>) interground state transition. Its pressure coefficient is very small and suggests that the



1S( $\Gamma_1$ ) donor ground state evaluate like a shallow level. The results are analyzed in terms of lattice parameter, screening, effective mass and umklapp parameter variations. (Author abstract) 28 refs.

Galtier, P. (CNRS, Grenoble, Fr); Martinez, G. *Solid State Commun* v 65 n 3 Jan 1988 p 193-197.

**094266 DEEP LEVELS IN NON-DOPED AND DONOR-DOPED GaP.** Four deep electron-rap levels were detected by DLTS from the non-doped and Te- or S-doped LEC-grown GaP. Some discussions are given regarding their origin. The density  $N_1$  of these levels increased linearly with the net donor density  $N_D$  for non-doped samples.  $N_1$  was reduced by doping Te with  $N_D$  approximately  $10^{17} \text{ cm}^{-3}$ , and then increased as  $N_D$   $10^{17}$  for  $N_D > 10^{17} \text{ cm}^{-3}$ . (Author abstract) 13 refs.

Endo, Tamio (Mie Univ, Tsu, Jpn); Uchida, Eiji; Hiro-saki, Yuushi; Sugiyama, Koichi. *Jpn J Appl Phys Part 1* v 27 n 1 Jan 1988 p 153-154.

**094267 CHARACTERIZATION OF DX CENTERS IN GaAlAs GROWN BY LIQUID-PHASE EPITAXY.** It is well known that n-type  $\text{Ga}_{1-x}\text{Al}_x$  solid solutions with  $x \geq 0.2$  doped with a group IV or VI element contain a large number of deep levels due to DX centers. This note reports on studies of p-n junctions prepared by growing an Sn-doped GaAlAs layer and a Ge- or Si-doped GaAs layer. The structures were grown for manufacturing of double heterostructure stripe geometry lasers. Two liquid phase epitaxial techniques were used for growing; the common sliding boat technique and a technique in which the solution used for the growth of the layer is pushed out by the solution for the subsequent layer. The p-n junctions were studied by measuring C-U and C-T characteristics, DLTS and DDLTS. 8 refs.

Zdansky, K. (Czechoslovak Acad of Sciences, Prague, Czech); Le Thanh, Binh. *Phys Status Solidi A* v 105 n 1 Jan 1988 p K51-K55.

**094268 INCORPORATION OF NITROGEN INTO GALLIUM ARSENIDE GROWN BY CHLORIDE VPE.** The incorporation of nitrogen into GaAs in the halide-VPE system using  $\text{NH}_3$  as the doping source is investigated. The concentration of incorporated N depends on the  $\text{NH}_3$  flow rate and increases with decreasing deposition temperature. Concentrations up to  $6 \times 10^{17} \text{ cm}^{-3}$  could be detected far above the calculated equilibrium value. By a comparison of SIMS-data with those obtained from IR it is found that most of the N-atoms are situated substitutionally on As lattice sites. Normal-pressure 2 K photoluminescence measurements show N-related luminescence peaks at 1.508 and 1.496 eV. Most probably this luminescence arises from complexes of N with undeliberately introduced impurities. For the 1.508 eV center a complex  $\text{Si}_{\text{Ga}}\text{-N}_{\text{As}}$  is discussed. (Edited author abstract) 13 refs.

Schwetlick, S. (Karl-Marx-Univ Leipzig, East Ger); Seifert, W.; Butter, E.; Hoerig, W.; Pickenhain, R.; Schwabe, R. *Cryst Res Technol* v 22 n 8 Aug 1987 p 999-1007.

**094269 DX-CENTER-FREE GaAs/N-AlGaAs HEMT STRUCTURES.** The DX centers in N-Al $_x$ Ga $_{1-x}$ As layers grown by MBE were investigated. The concentration ratio of DX centers to total donors was determined for various compositions of AlGaAs and doping concentrations of Si. Based on these results, DX-center-free selectively doped GaAs/N-AlGaAs heterostructures were proposed and successfully applied to HEMTs. (Author abstract) 15 refs.

Ishikawa, Tomonori (Fujitsu Lab, Kawasaki, Jpn); Kondo, Kazuo. *Fujitsu Sci Tech J* v 24 n 2 Summer 1988 p 143-149.

**094270 DIRECT OBSERVATION OF INTERSUBBAND RELAXATION IN NARROW MULTIPLE QUANTUM WELL STRUCTURES.** The intersubband relaxation in modulation doped GaAs/Al $_x$ Ga $_{1-x}$ As quantum well structures is studied by an infrared bleaching technique with picosecond time resolution. Typical intersubband relaxation times are measured to be in the

order of 10 ps at 300K for subband splittings between 120 and 150 meV. The time constants increase with subband separation. The experimental findings are consistent with a model where polar LO phonon scattering is assumed to be the most relevant relaxation mechanism. (Author abstract) 15 refs.

Seilmeier, A. (Technische Univ Muenchen, Munich, West Ger); Huebner, H.J.; Woerner, M.; Abstreiter, G.; Weimann, G.; Schlapp, W. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 767-770.

**094271 INCORPORATION DU Zn DANS UNE STRUCTURE GaInAs/InP LORS D'UNE CROISSANCE PAR MOCVD.** [Incorporation of Zn in a GaInAs/InP Structure During MOCVD Growth]. A paradoxical drop of the acceptor concentration in InP layers has been observed when p-type InP and p<sup>+</sup>-type GaInAs are consecutively grown. Two hypotheses of a neutral zinc formation and a fast out-diffusion have been investigated. The diffusion model predicts a zinc behavior consistent with the experiments. (Author abstract) 7 refs. In French.

Rose, B. (CNET, Bagneux, Fr); Kazmierski, C.; Robein, D. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 311-313.

**Electric Conductivity** See SEMICONDUCTOR MATERIALS—Electric Conductivity.

## Electric Field Effects

**094272 ELECTRIC FIELD INDUCED REFLECTION IN GaInAsP/InP MQW STRUCTURE.** Reflection of light due to the electric field effect was seen for the first time in GaInAsP/InP MQW structures through the observation of an interference pattern between the transmitted and reflected light; this was caused by a change in the refractive index and absorption coefficient in the MQW layers due to the partial application of an electric field to the MQW layers. The observed data were fitted with the theoretical simulations and the refractive index change was predicted to be about 0.025% at  $-5 \text{ V}$ . This is a promising step towards the realization of the intersectional optical switch. (Author abstract) 10 refs.

Kikugawa, Tomoyuki (Tokyo Inst of Technology, Tokyo, Jpn); Ravikumar, K.G.; Shimomura, Kazuhiko; Izumi, Akira; Arai, Shigehisa; Sumatsu, Yasuharu; Ohki, Yoshimasa. *Jpn J Appl Phys Part 2* v 26 n 8 Aug 1987 p 1268-1271.

**094273 VALENCE BAND DISPERSION IN FINITE QUANTUM WELLS WITH UNIFORM ELECTRIC FIELD.** Valence band dispersion of GaAs-Ga $_x$ Al $_{1-x}$ As single finite quantum well in presence of an external electric field is computed by means of the perturbed Luttinger Hamiltonian. When the field is perpendicular to the semiconductor layers. The authors use an iterative process to solve the set of coupled differential equations, taking into account only the mixing of the deepest bounded valence states. This situation is important for the second and third valence band levels in the k-space. (Author abstract) 15 refs.

Hernandez-Cabrera, A. (Univ de La Laguna, Tenerife, Canary Isl); Aceituno, P. *Solid State Commun* v 65 n 12 Mar 1988 p 1451-1455.

## Electric Properties

**094274 ELECTRO-OPTIC EFFECTS AND ELECTROABSORPTION IN A GaAs/AlGaAs MULTIPLE QUANTUM WELL HETEROSTRUCTURE NEAR THE BANDGAP.** We report phase difference measurements at 50 and 30 meV from the excitonic peak of a GaAs/AlGaAs multiple quantum well structure. We find pronounced dispersion of the quadratic effect; in contrast, we see no indication of dispersion in the linear effect even this close to the bandgap. (Author abstract) 9 refs.

Glick, M. (Ecole Polytechnique Federale de Lausanne, Lausanne, Switz); Pavuna, D.; Reinhart, F.K. *Electron*

*Lett* v 23 n 23 Nov 5 1987 p 1235-1237.

**094275 BREMSSTRAHLUNG ISOCHROMAT STUDIES OF CONDUCTION BAND STATES IN GaAs.** Using bremsstrahlung isochromat spectroscopy, we have studied the conduction band density of states of the prototypical layer compound GaSe. We find two main features in the lower conduction band density of states, in qualitative agreement with core-level reflectivity data. However, there is a large discrepancy between the energy positions of the optical and BIS peaks. This discrepancy is discussed in terms of excitonic effects and of self-energy corrections. (Edited author abstract) 19 refs.

Gao, Y. (Univ of Minnesota, Minneapolis, MN, USA); Smandek, B.; Nikaido, M.; Weaver, J.H.; Levy, F.; Margaritondo, G. *Solid State Commun* v 65 n 1 Jan 1988 p 11-13.

**094276 COMPARISON OF PHASE MODULATION OF GaAs/AlGaAs DOUBLE HETEROSTRUCTURES.** The performance of double-heterostructure GaAs/Al $_x$ Ga $_{1-x}$ As phase modulators with different doping profiles are compared. The largest phase modulation of 1.75 rad/V mm at a wavelength of 1.09  $\mu\text{m}$  was obtained with an active layer doped at  $n = 3 \times 10^{17} \text{ cm}^{-3}$ . However, an intrinsic active layer gives the lowest characteristic modulation energy needed for high-frequency modulation. (Edited author abstract) 4 refs.

Faist, J. (Ecole Polytechnique Federal de Lausanne, Lausanne, Switz); Reinhart, F.K.; Martin, D. *Electron Lett* v 23 n 25 Dec 3 1987 p 1391-1392.

**094277 ETCH PIT DENSITY VARIATION AND ELECTRICAL PROPERTIES OF GaSb SINGLE CRYSTALS GROWN BY THE BRIDGMAN METHOD.** GaSb single crystals were grown by the vertical Bridgman technique. The distributions of the dislocation density along the diameter and the length of the ingot were studied. The average etch pit density was found to be  $1.5 \times 10^5 \text{ cm}^{-2}$ , the lowest value reported so far for Bridgman grown crystals. The variation of electrical properties was also studied along the diameter and the length of the crystal. The resistivity was found to vary from 0.051 to 0.064  $\Omega \text{ cm}$ . (Author abstract) 16 refs.

Roy, U.N. (Indian Inst of Technology, Kharpur, India); Basu, S. *Mater Lett* v 6 n 7 Apr 1988 p 238-241.

**094278 PASSIVATION OF Ga $_{0.47}$ In $_{0.53}$ As BY a-Si:H.** The optical gap (0.75 eV) of Ga $_{0.47}$ In $_{0.53}$ As fits with the light used in optical fiber, but its surface states pin the Fermi level near the bottom of its conduction band and prevent its use in MESFET. S. Loualiche et al. have shown that when a thin film (500-2000 Angstrom) of a-Si:H is inserted between this III-V and the Pt, Schottky diodes with space charge zone in the III-V can be obtained at room temperature. This work is extended here by a study of the I(V) curve for various temperatures and as a function of the quality of the a-Si:H films. 1 ref.

Belkouch, S. (CNRS, Grenoble, Fr); Valentin, F.; Deneuville, A. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 249-250.

**Electronic Properties** See Also CALCIUM COMPOUNDS—Electronic Properties; SEMICONDUCTOR MATERIALS—Spectrum Analysis.

**094279 EXCITON-PHONON SYSTEM IN GaAs-Ga $_x$ Al $_{1-x}$ As QUANTUM WELLS.** The binding energies of light- and heavy-hole exciton-phonon systems in GaAs-Ga $_x$ Al $_{1-x}$ As quantum wells are calculated as a function of the well thickness for several values of the heights of the potential barriers. A comparison between these results and recent experimental measurements is presented. (Author abstract) 25 refs.

Degani, Marcos H. (Univ de Sao Paulo, Sao Paulo, Braz); Hipolito, Oscar. *Semicond Sci Technol* v 2 n 9 Sep 1987 p 578-581.



**094280 EFFECT OF ELECTRON-PHONON COUPLING ON THE QUANTUM-CONFINED STARK EFFECT.** On the basis of intermediate-coupling scheme applied to the electron-phonon system in GaAs-GaAlAs quantum well structures we have calculated the electric field induced eigen-energy shift. A quadratic Stark shift is found at weak fields. For large enough electric fields the corrections due to the electron-phonon coupling are significant. (Author abstract) 8 refs.

Xu, Wang (Neimenggu Univ, Huhhot, China); Xi, Xia Liang; Kan, Chang. *Solid State Commun* v 65 n 1 Jan 1988 p 83-85.

**094281 TUNNELING OF ELECTRONS IN QUANTUM WELLS WITH INDIRECT GAP SEMICONDUCTOR BARRIERS.** One of the features peculiar to GaAs-Ga<sub>1-x</sub>Al<sub>x</sub> As quantum wells with  $x \geq 0.43$  are barriers formed by an indirect gap semiconductor. We make use of a simple one-dimensional tight-binding model to study the tunneling properties of such a system. Wave-functions and probabilities associated with an electron in each spatial region as a function of time are computed and compared with the results of a simple square barrier model. It is shown that the states related to the indirect conduction band minima of the barrier act as a new channel and increase the tunneling current between the wells. We suggest that these states are the origin of an unexplained structure observed in photoemission from a double quantum well. The effect of an external electric field is analyzed. (Edited author abstract) 16 refs.

Brey, L. (Univ Autonoma, Madrid, Spain); Tejedor, C. *Solid State Commun* v 61 n 9 Mar 1987 p 573-576.

**094282 GaAs MONOLAYER SUPERLATTICES: A NEW CANDIDATE FOR A HIGHLY SPIN-POLARIZED ELECTRON SOURCE.** Using the results of an ab-initio self-consistent local density Dirac calculation of its electronic structure, we suggest that the GaAs/AlAs monolayer superlattice should be a good candidate for a high quality spin-polarized photoelectron source, giving a theoretical polarization of electrons of 100% together with favorable conditions for their extraction from the solid. (Author abstract) 20 refs.

Ciccacci, F. (Univ di Roma, Rome, Italy); Molinari, E.; Christensen, N.E. *Solid State Commun* v 62 n 1 Apr 1987 p 1-3.

**094283 RAMAN SCATTERING IN AlGaP ALLOYS.** Raman spectra of Al<sub>x</sub>Ga<sub>1-x</sub>P alloys with Al concentration ranging from  $x=0.10$  to  $x=0.79$  are presented. Two longitudinal optical (LO) bands have been observed, which are related to GaP and AlP respectively (two mode behavior). The compositional variation of the LO and TO phonon frequencies has been measured and explained in terms of the MREI model. (Author abstract) 11 refs.

Armelles, G. (CSIC, Madrid, Spain); Calleja, J.M.; Munoz, E. *Solid State Commun* v 65 n 8 Feb 1988 p 779-782.

**094284 OBSERVATION OF A GAP IN THE COUPLED INTERSUBBAND CYCLOTRON RESONANCE EXCITATIONS IN A QUASI TWO-DIMENSIONAL ELECTRON GAS.** Far-infrared magnetotransmission measurements are reported on the energies of the coupled intersubband-cyclotron resonance excitations in a GaAs-GaAlAs heterojunction in the presence of a large tilted magnetic field. It is experimentally found that the lowest lying coupled mode is pinned to an energy which is somewhat lower than the electric subband separation leading to an opening of a gap in the excitation energy spectrum. This is in qualitative agreement with a recent theoretical prediction. (Author abstract) 12 refs.

Huant, S. (CNRS, Grenoble, Fr); Grynberg, M.; Martine, G.; Etienne, B. *Solid State Commun* v 65 n 6 Feb 1988 p 457-461.

**094285 RESONANT DX CENTERS IN HIGHLY DOPED Sn-Ga<sub>1-x</sub>Al<sub>x</sub>As UNDER HYDROSTATIC PRESSURE IN A MAGNETIC FIELD.** We report

experimental evidence of deep impurity states producing a localized resonance in the  $\Gamma_{1c}$  band continuum in highly doped Sn-Ga<sub>1-x</sub>Al<sub>x</sub>As. At low temperatures and increasing pressure, electrons were transferred from the  $\Gamma_{1c}$  band to the deep Sn donor state; this transfer of carriers was directly related to the pressure dependence of Shubnikov de Haas oscillations. Persistent photoconductivity, due to the DX nature of this deep level, was observed through the increase in the  $\Gamma$  carrier density resulting from illumination with a light emitting diode. This is interpreted as a photoionization of the DX centers up to the  $\Gamma_{1c}$  valley. (Author abstract) 2 refs.

Basmaji, P. (CNRS, Valbonne, Fr); Portal, J.C.; Aulombard, R.L.; Gibart, P. *Solid State Commun* v 63 n 2 Jul 1987 p 73-76.

**094286 FEMTOSECOND COLLISION TIMES OF HOT ELECTRONS IN GaAs DETERMINED BY PICOSECOND TIME-RESOLVED LIGHT SCATTERING.** Picosecond laser pulses have been used to excite dense electron-hole plasmas in GaAs and to probe the dynamics of the plasmas by time-resolved Raman scattering from single particle excitations. The Raman lineshapes are explained by a theory which includes the electron collision time. For a plasma with density of  $5 \times 10^{18} \text{ cm}^{-3}$  the collision time is found to be about 20 femtoseconds. (Author abstract) 16 refs.

Huang, Y. (Univ of California, Berkeley, CA, USA); Yu, P.Y. *Solid State Commun* v 63 n 2 Jul 1987 p 109-111.

**094287 THERMOREFLECTANCE STUDY OF DIRECT AND INDIRECT EXCITONS NEAR THE FUNDAMENTAL EDGE OF GaSe.** Thermoreflectance spectra have been obtained on GaSe single crystals between 50 and 300 K and a theoretical model is developed to fit the experimental curves. The main feature of the spectra is due to the disappearance of the back reflection of the sample caused by the small absorption below the direct exciton. The direct excitonic structure is observed at higher energy. (Author abstract) 15 refs.

Bernier, G. (Univ de Sherbrooke, Que, Can); Gagnon, R.; Jandl, S.; Brebner, J.L. *Solid State Commun* v 63 n 5 Aug 1987 p 431-434.

**094288 DEEP LEVELS IN SUPERLATTICES.** The deep levels of substitutional  $\text{sp}^3$ -bonded point defects in GaSb/AlSb and GaAs/GaP(001) superlattices are predicted by using Green's function method in empirical tight-binding formalism. The corrections arising from the band offset and the strain effects induced by the lattice mismatch (up to 3.7% for GaAs/GaP) were included. 5 refs.

Huang, Ming-Zhu (Univ of Science & Technology of China, Hefei, China); Gu, Yiming; Shi, Xiangjun; Ren, Shangyuan. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 327-328.

**094289 PROPERTIES OF A MAGNETOPOLARON AT THE INTERFACE OF POLAR-POLAR CRYSTALS.** Using Larsen's method, we obtained the effective Hamiltonian of a magnetopolaron at the interface of polar-polar crystals and studied the relation between its behavior and magnetic field. The method in this paper is available in the case of weak-coupling and arbitrary magnetic field. Of course, the perturbational terms can be expanded to the higher order. However, it is needless to do because GaAs is taken as an example. 3 refs.

Gu, Shiwei (Shanghai Jiao-Tong Univ, Shanghai, China); Kong, Xiaojun; Wei, Chengwen. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 751-752.

**Etching** See Also LASERS, SEMICONDUCTOR—Resonators; TRANSISTORS, FIELD EFFECT—Etching.

**094290 LASER-INDUCED THERMOCHEMICAL MASKLESS-ETCHING OF III-V COMPOUND SEMICONDUCTORS IN CHLORIDE GAS ATMO-**

SPHERE. Thermochemical maskless etching of compound semiconductors (GaAs, InP, InSb, and GaP) has been performed by focused Ar-laser irradiation in chloride gas atmospheres. A controlled minimum linewidth of down to  $0.6 \mu\text{m}$  with a maximum etching rate of up to  $13 \mu\text{m/s}$  has been obtained. Minimum laser powers necessary for thermochemical etching in each of compound semiconductors were found to be 0.24, 0.56, and 0.06 W, corresponding to minimum local temperatures rises of 190, 515, and  $110^\circ\text{C}$  for GaAs, InP, and InSb, respectively. Etching rates exhibited Arrhenius behavior with activation energies of 3.6-3.9 kcal/mole. Etching at excessively higher laser powers than those minimum powers was found, by microprobe photoluminescence measurements, to degrade the optical quality of the etched substrate. (Author abstract) 36 refs.

Takai, M. (Osaka Univ, Toyonaka, Jpn); Tsuchimoto, J.; Tokuda, J.; Nakai, H.; Gamo, K.; Namba, S. *Appl Phys A* v A45 n 4 Apr 1988 p 305-312.

**Growth** See Also CRYSTALS—Whiskers; LASERS, SEMICONDUCTOR—Electric Properties; LASERS, SEMICONDUCTOR—Performance; LIGHT—Modulators; SEMICONDUCTOR DEVICES, MISFET—Fabrication; SEMICONDUCTOR DIODES—Fabrication; SEMICONDUCTOR DIODES, PHOTODIODE—Manufacture; SEMICONDUCTOR DIODES, PHOTODIODE—Reliability; SEMICONDUCTOR MATERIALS—Growth; SOLAR CELLS—Materials; SOLAR CELLS—Silicon; TRANSISTORS, FIELD EFFECT—Junctions.

**094291 BERYLLIUM DIFFUSION ACROSS GaAs/(Al, Ga)As HETEROJUNCTIONS AND GaAs/AlAs SUPERLATTICES DURING MBE GROWTH.** Beryllium diffusion during MBE growth of (Al, Ga)As layers, (Al, Ga)As/GaAs heterojunctions and GaAs/AlAs superlattices has been studied by electrochemical C-V and secondary ion mass spectrometry (SIMS) concentration profiling, in conjunction with transmission electron microscopy. Diffusion times were comparatively short since they were limited to part of the growth sequence, so non-equilibrium effects had a significant influence. The results are consistent with an interstitial-substitutional mechanism in which lattice site incorporation becomes more difficult with increasing band gap enthalpy. Incorporation involves a 'kick-out' reaction which leads to the observed disordering of the superlattices. (Author abstract) 15 refs.

Devine, R.L.S. (Philips Research Lab, Redhill, Engl); Foxon, C.T.; Joyce, B.A.; Clegg, J.B.; Gowers, J.P. *Appl Phys A* v A44 n 2 Oct 1987 p 195-200.

**094292 CRYSTAL GROWTH OF CuGaSe<sub>2</sub> FROM IN SOLUTIONS.** The phase relations of a CuGaSe<sub>2</sub>-In pseudobinary system have been studied and the conditions of preparation of the solid phase having the chalcopyrite crystal structure were obtained. On the basis of the data, CuGaSe<sub>2</sub> crystals were grown from In solutions, and their properties were examined. (Author abstract) 7 refs.

Sugiyama, Koichi (Mie Univ, Tsu, Jpn); Sawada, Atsushi; Ito, Koji; Iwasaki, Satoshi; Endo, Tamio. *J Cryst Growth* v 84 n 4 Oct 1987 p 673-675.

**094293 STUDY OF SUPERCOOLING BEHAVIOR OF InGaAsP SOLUTIONS FOR GROWTH OF HIGH QUALITY InGaAsP/InGaAs(P) LAYERS ON (100) InP.** The growth conditions for producing high quality InGaAsP ( $\lambda = 1.3 \mu\text{m}$ )/In<sub>0.53</sub>Ga<sub>0.47</sub>As interfaces on (100) oriented InP by liquid phase epitaxy were investigated in detail. Results on the variation of InGaAsP layer thickness, lattice mismatch and photoluminescence wavelength with growth temperature reveal that homogeneous nucleation of the quaternary growth melt occurs at a critical supercooling  $\Delta T_c$ . Four growth regimes,  $\Delta T > T_c$  and  $\Delta T < \Delta T_c$  in both the presence and absence of apparatus vibration were evaluated. High quality InGaAsP/InGaAs interfaces can be grown at melt cooling rates as low as  $0^\circ\text{C/min}$  for  $\Delta T < \Delta T_c$  in the absence of vibration, but vibration will slightly degrade interface quality. For  $\Delta T > \Delta T_c$ , melt cooling rates of approx.  $0.6^\circ\text{C/min}$  in the absence of apparatus vibration will yield



good interfaces; but melt cooling rates  $\leq 0.1^\circ\text{C}/\text{min}$  and/or apparatus vibration will result in very poor quality interfaces. (Edited author abstract) 16 refs.

Knight, D.G. (Bell-Northern Research Ltd, Ottawa, Ont, Can); Majeed, A. *J Cryst Growth* v 85 n 3 Nov II 1987 p 363-376.

**094294 THICKNESS CONTROL OF  $\text{Ga}_{1-x}\text{Al}_x\text{As}$  LAYERS GROWN BY LIQUID PHASE EPITAXY AT LOW GROWTH TEMPERATURE.** The uniformity of a  $\text{Ga}_{1-x}\text{Al}_x\text{As}$  layer grown by liquid phase epitaxy was investigated as a function of the growth temperature in the range of 600 to 800°C. Lowering the growth temperature causes the growth rate to decrease, which contributes to remarkable reductions in both the normalized edge growth height (H) and the thickness variation ( $\sigma$ ) over the wafer. At a growth temperature of 600°C, the flat  $\text{Ga}_{1-x}\text{Al}_x\text{As}$  (solid composition,  $x=0.45\pm 0.008$ ) layer of  $2.058\pm 0.07\text{ }\mu\text{m}$  ( $\sigma/d=3.4\%$ ) can be obtained with an edge growth height of  $2.92\text{ }\mu\text{m}$  ( $H=1.25$ ). On the other hand, at a short growth time of 0.3s, the variation of layer thickness of less than  $\pm 0.007\text{ }\mu\text{m}$  ( $\pm 8.9\%$ ) does not depend on the growth temperature. The probable lowest limit in a flat layer can be varied by the initial supersaturation. (Author abstract) 29 refs.

Todoroki, Satoru (Hitachi Ltd, Yokohama, Jpn); Ohbu, Isao; Kashiwada, Yasutoshi. *J Cryst Growth* v 85 n 3 Nov II 1987 p 461-468.

**094295 MODIFIED BRIDGMAN GROWTH AND ETCHING OF  $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$  CRYSTALS.** A modified Bridgman technique, in which both the furnace and growth ampul are kept stationary, is used for the first time to grow single crystals of  $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$ . Because of the stationary conditions, this method simplifies the conventional technique and minimizes vibrational disturbances which may interfere with the growth process. The Nagakawa etchant was found to produce etch pits on nonpolar (110) planes of  $\text{Cd}_{0.96}\text{Zn}_{0.04}\text{Te}$  crystals which are probably indicative of dislocations and the etch pit density was low. These observations, the very smooth cleavage planes, and well-defined Laue patterns show the single crystallinity of the material grown by this technique. 12 refs.

Trivedi, S.B. (Rensselaer Polytechnic Inst, Troy, NY, USA); Wiedemeier, H. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3199-3201.

**094296 OMVPE OF  $\text{GaInAs}$  ON A SPINNING SUBSTRATE.** It is shown that thickness uniformity of OMVPE layers can strongly be improved by rotation of the substrate during growth. A new susceptor assembly to achieve rotation is presented. The new principle of supporting and driving a substrate holder without shafts and seals is shown to be capable of growing layers of  $\text{GaInAs}$  with a uniformity of layer thickness required for modern semiconductor devices. It should be possible to construct susceptor assemblies with this principle, that will handle wafers with 2 inch diameter or even larger. This susceptor could be used even in low pressure systems. (Edited author abstract) 8 refs.

Woelk, E. (RWTH, Aachen, West Ger); Beneking, H. *J Cryst Growth* v 87 n 2-3 Feb 1988 p 201-204.

**094297 MOLECULAR BEAM EPITAXY OF  $\text{GaAs}_x\text{P}_{1-x}$  USING LOW-ENERGY  $\text{P}^+$  ION BEAM.** We describe the epitaxial growth of  $\text{GaAs}_x\text{P}_{1-x}$  ( $0 < x < 0.7$ ) on  $\text{GaAs}(001)$  substrates using mass-separated low-energy  $\text{P}^+$  ions, and  $\text{Ga}$  and  $\text{As}_4$  molecular beams. Epilayers have been obtained at growth temperatures ( $T_g$ ) ranging from 300 to 650°C at  $\text{P}^+$  ion energies ( $E_{p+}$ ) between 50 and 300 eV. We have investigated the growth rate as a function of  $E_{p+}$  and the film composition as a function of the flux ratio of  $\text{As}_4$  to  $\text{P}^+$ ,  $T_g$ , and  $E_{p+}$ . The sticking coefficient of phosphorus is markedly enhanced by using  $\text{P}^+$  ion, compared with that of  $\text{As}_4$ . As the flux ratio of  $\text{As}_4$  to  $\text{P}^+$  is increased from 0 to 8, the composition ratio  $x$  of  $\text{GaAs}_x\text{P}_{1-x}$  complex  $\text{SiGa-NAs}_3$  is discussed. (Edited —  $x$  films varies from 0 to 0.5. The composition ratio  $x$  decreases slightly with increasing  $T_g$  from 400 to 650°C,

and increases with increasing  $E_{p+}$ . Film surfaces are smooth at  $E_{p+}$  below 100 eV, and their morphology is degraded with increasing energy. (Author abstract) 8 refs.

Maruno, S. (Mitsubishi Electric Corp, Amagasaki, Jpn); Morishita, Y.; Ito, T.; Nomura, Y.; Ogata, H. *J Electron Mater* v 17 n 1 Jan 1988 p 21-24.

**094298 COMPOSITIONAL VARIATION RELATED TO THE GROWTH PROCESS IN  $\text{GaAlAs}$  EPITAXIAL LAYERS.** Compositional profiles of epitaxial  $\text{GaAlAs}$  layers grown by liquid phase epitaxy using the supersaturation technique were investigated in relation to the growth conditions by laser Raman spectroscopy. In the diffusion limited process with a flat temperature profile during epitaxial growth cycle, a uniform layer of  $1.26 \pm 0.017\text{ }\mu\text{m}$  ( $\pm 1.3\%$ ) with a small compositional variation of  $0.457 \pm 0.007$  ( $\pm 1.5\%$ ) can be accomplished. On the other hand, remarkable compositional variations ( $> \pm 10\%$ ) occur during an initial growth stage, which depends on the initial supersaturation. Compositional uniformity is improved to  $0.152 \pm 0.007$  ( $\pm 4.6\%$ ) by decreasing initial supersaturation to 2.5°C. (Author abstract) 26 refs.

Todoroki, Satoru (Hitachi Ltd, Yokohama, Jpn); Ohbu, Isao; Sekine, Yukari; Kashiwada, Yasutoshi. *J Electrochem Soc* v 135 n 4 Apr 1988 p 989-993.

**094299 CROSS-SECTIONAL TEM OBSERVATION OF NON-UNIFORMITY IN MULTIPLE QUANTUM WELL STRUCTURES.** Cross-sectional TEM observation of  $\text{GaAs-Al}_x\text{Ga}_{1-x}\text{As}$  multiple quantum well structure grown by molecular beam epitaxy has been carried out. The results show that broadened emission band of photoluminescence is probably due to non-uniform size of the wells. (Author abstract) 4 refs. In Chinese.

Fan, Tiwen (Acad Sinica, Beijing, China). *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 211-212.

**094300 HIGH QUALITY MBE  $\text{GaAs-AlGaAs}$  QUANTUM WELL STRUCTURES.** High quality  $\text{GaAs-AlGaAs}$  QW structures have been prepared by a MBE system. The linewidth of the PL spectrum of  $n=1$  electron-heavy hole free exciton recombination is narrow and its full width of half maximum (FWHM) is only 1.2 meV for well width 141 Angstrom at 10.5 K. It indicates that the fluctuation of well width and flatness of interface is less than one monolayer. The emission is kept to be excitonic from low to room temperature. (Author abstract) 9 refs. In Chinese.

Liang, Jiben (Acad Sinica, China); Kong, Meiyung; Sun, Dianzhao; Zheng, Yiping; Huang, Yunheng. *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 213-216.

**094301 GROWTH BY ANTIPHASE-DOMAIN-FREE  $\text{GaP}$  ON  $\text{Si}$  BY ORGANOMETALLIC VAPOR PHASE EPITAXY.** Heteroepitaxial growth of  $\text{GaP}$  on  $\text{Si}(100)$  substrates organometallic vapor phase epitaxy (OMVPE) is studied. The effects of substrate pretreatment procedures on antiphase-domain-free  $\text{GaP}$  film growth are also investigated. These procedures include final chemical treatment just before loading into an OMVPE reactor and increased preheating temperature just before growth. By optimizing these pretreatment procedures, antiphase-domain-free  $\text{GaP}$  films are successfully grown on nominally just-cut (100) substrates as well as (100) substrates with a  $4^\circ$  tilt toward [011] by optimizing these pretreatment procedures. A photoelectrochemical etching procedure is demonstrated as a new, convenient method for revealing antiphase domain (APD) structures in grown films. Advantages of the two-step growth method for obtaining  $\text{GaP}$  films with good surface morphology are also discussed. (Author abstract) 11 refs.

Sugo, Mitsuru (NTT, Electrical Communications Lab, Tokai, Jpn); Yamamoto, Akio; Yamaguchi, Masafumi. *J Cryst Growth* v 88 n 2 Apr II 1988 p 229-235.

**094302 RESONANT TUNNELLING IN  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}/\text{InP}$  DOUBLE-BARRIER STRUCTURES GROWN BY AP-MOCVD.** We report the observation of

negative-differential resistance in  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}/\text{InP}$  double-barrier structures grown by AP-MOCVD. The devices exhibit the largest peak/valley current ratios seen in this system; 1.2:1 (2.8:1) and 3.0:1 (5.5:1) at 77 K (4.2 K) for the  $n=1$  and  $n=2$  resonances, respectively. (Edited author abstract) 7 refs.

Higgs, A.W. (Royal Signals & Radar Establishment, Great Malvern, Engl); Taylor, L.L.; Apsley, N.; Bass, S.J.; Hutchinson, N.J. *Electron Lett* v 24 n 6 Mar 17 1988 p 322-323.

**094303 NEW APPROACH FOR DETERMINING THE LIQUIDUS AND SOLIDUS ISOTHERMS OF THE SYSTEMS  $\text{A}^{\text{III}}\text{-B}^{\text{III}}\text{-CV}$ .** Compounds of the type  $\text{A}^{\text{III}}\text{-B}^{\text{III}}\text{-CV}$  have found widespread application in the industrial production of different semiconductor devices. The phase diagrams of the systems they are realized from are the basis for the controllable synthesis of those compounds. The analytical relationships of the liquidus and solidus isotherms for the  $\text{A}^{\text{III}}\text{-B}^{\text{III}}\text{-CV}$  systems are represented in this article. They are compared with theoretical and experimental results which different authors have obtained for the  $\text{Ga-Al-As}$ ,  $\text{Ga-Al-P}$ ,  $\text{In-Ga-As}$  and  $\text{In-Ga-P}$  systems. The relationships obtained correspond very well with the results. (Author abstract) 14 refs.

Nedev, N.K. (Inst of Micro & Optoelectronics, Botevgrad, Bulg); Minkov, D.A. *J Cryst Growth* v 88 n 4 May II 1988 p 429-434.

**094304 OMVPE GROWTH OF UNIFORM  $\text{Ga}_{1-x}\text{In}_x\text{As}$ .** Because of its optical and electrical characteristics,  $\text{Ga}_{1-x}\text{In}_x\text{As}$  ( $x=0.53$ ) lattice-matched to  $\text{InP}$  is one of the most promising materials for the fabrication of such devices as high-speed transistors, light-receiving and light-emitting devices which operate in the wavelengths from 1.3 to 1.55- $\mu\text{m}$  used in long-wavelength optical transmission, and the optoelectronic ICs in which these discrete devices are used. As a thin-film epitaxial growth method for this  $\text{Ga}_{1-x}\text{In}_x\text{As}$ , Sumitomo Electric has introduced organometallic vapor phase epitaxy (OMVPE). By making improvements in existing technology, the authors have succeeded in developing OMVPE technology capable of growing, with excellent reproducibility,  $\text{Ga}_{1-x}\text{In}_x\text{As}$  thin films with a uniform alloy compositional distribution on a two-inch  $\text{InP}$  substrate. It was also confirmed through double-crystal x-ray diffractometry and photoluminescence measurements that the grown  $\text{Ga}_{1-x}\text{In}_x\text{As}$  thin film has excellent crystal quality. (Edited author abstract) 7 refs.

Kamei, Hidenori; Sasaki, Goro; Kato, Takashi; Murata, Michio; Maeda, Masahiro; Hayashi, Hideki; Yoshida, Ken-ichi. *Sumitomo Electr Tech Rev* n 27 Jan 1988 p 151-154.

**094305 MASS SPECTROMETRIC STUDY OF THE REACTION OF TRIETHYLINDIUM WITH ARSINE GAS.** A study of the premature room temperature gas-phase reactions involved in the growth of  $\text{GaInAs}$  using  $\text{Et}_3\text{In}$ ,  $\text{Me}_3\text{Ga}$ , and  $\text{AsH}_3$  was undertaken, using a specially designed mass spectrometer sampling system on a conventional, low pressure OMVPE (Organometallic Vapor Phase Epitaxy) reactor. It was shown that the reaction of the  $\text{Et}_3\text{In-AsH}_3$  mixture could be described by reversible bimolecular reaction kinetics within the limits of experimental error, and evidence for an adduct is presented. The equilibrium constant for this system was determined as 30 torr; the rates of forward and reverse reaction were  $5\text{ (torr-s)}^{-1}$  and  $0.15\text{ s}^{-1}$ , respectively. The implications of the reaction of this organometallic source with arsine on the growth mechanism is discussed. (Edited author abstract) 28 refs.

Agnello, Paul D. (Rensselaer Polytechnic Inst, Troy, NY, USA); Ghandhi, Sorab K. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1530-1534.

**094306 STUDIES ON X-RAY INTERFERENCE FRINGES IN  $\text{GaAlAs/GaAs}$  EPITAXIAL LAYERS.** X-ray interference fringes caused by polyamines have



been observed during the growth of GaAlAs/GaAs epitaxial layers by use of MBE and LPE methods. The interference fringes can be recorded and fringe images can be taken by use of X-ray double crystal goniometer. The results are discussed in the case of bending epitaxial GaAlAs/GaAs samples. The bending radius of the epitaxial sample can be calculated from the inter-space of the interference fringes of film image, and the thickness of different layers can be calculated from oscillating periods of their fringes in the rocking curves. (Author abstract) In Chinese. 12 refs.

Ga Dachao (Acad Sinica, Changchun, China); Feng Yuchen; Yuan Yourong. *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 262-268.

**094307 KINETIC ASPECTS OF ORDERING IN  $GaAs_{1-x}Sb_x$  GROWN BY ORGANOMETALLIC VAPOR PHASE EPITAXY.** Long range ordered structures have been studied in  $GaAs_{1-x}Sb_x$  alloys with  $x \approx 0.5$  grown by organometallic vapor phase epitaxy (OMVPE). The emphasis of this paper is on the kinetic effects leading to the occurrence of ordering. In particular, the effects of growth temperature, growth rate, and substrate orientation are reported. The ordered simple tetragonal CuAu-I ( $L1_0$ ) and the chalcopyrite ( $E1_1$ ) structures were observed at the highest growth temperatures from 580 to 660°C on (100) oriented InP substrates with both high and low growth rates. We also examined samples grown on (221) and (311) oriented InP substrates at 550°C. They showed very little ordering with only local observation of weak  $L1_0$  superlattice electron diffraction spots. (Edited author abstract) 33 refs.

Jen, H.R. (Univ of Utah, Salt Lake City, UT, USA); Jou, M.J.; Cherng, Y.T.; Stringfellow, G.B. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 175-181.

**094308 EPITAXIES SUR SUBSTRAT D'INP GRAVES PAR RIE-METHANE.** [Epitaxial Layers on an InP Substrate Etched by Reactive Ion-Methane Techniques]. The authors have grown InGaAs epitaxial layers on InP substrates which have been etched with plasma RIF technique based on methane, argon, hydrogen mixtures. X-rays diffraction measurements show the epitaxial layers are perfect. Due to manipulation of samples in air, SIMS analysis has revealed a pollution by sulfur at the InGaAs/InP interface. (Author abstract) 3 refs. In French.

Le Corre, A. (CNET, Lannion, Fr); Caulet, J.; Gauneau, M.; Henry, L.; Lecrosnier, D.; Vaudry, C. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 191-192.

**094309 EPITAXIE DE  $Ga_{1-x}In_xAs$  DESACCORDE SUR INP.** [Epitaxial Growth of  $Ga_{1-x}In_xAs$  Mismatched on InP]. The authors have studied the growth of  $In_{0.82}Ga_{0.18}As$  on InP substrate. This ternary can be used for detection or emission at  $\lambda = 2.55 \mu m$ . The lattice mismatch between these two materials is 1.9% and it induces the generation of dislocations. The quality of the samples has been improved by the use of a graded buffer layer. (Author abstract) 3 refs. In French.

Pavec, S. (CNET, Lannion, Fr); Caulet, J.; Gauneau, M.; Lambert, B.; Le Corre, A.; Lecrosnier, D. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 205-206.

**Impurities** See Also SEMICONDUCTING INDIUM COMPOUNDS—Impurities.

**094310 ELECTRON PARAMAGNETIC RESONANCE OF TITANIUM IN GaP.** EPR and photo-EPR experiments are reported performed on LEC-grown GaP:Ti with different Fermi-level positions. An isotropic signal with  $g=1.952$  and a linewidth of 20.0 mT is assigned. An acceptor level is located at  $(0.5 \pm 0.1)$  eV below the conduction band minimum. (Edited author

abstract) 17 refs.

Kreissl, J. (Akad der Wissenschaften der DDR, Berlin, East Ger); Gehlhoff, W.; Ulrici, W. *Phys Status Solidi B* v 143 n 1 Sep 1987 p 207-215.

**094311 LOCAL VIBRATIONAL MODE ABSORPTION OF HYDROGEN AND OXYGEN CENTRES IN LEC-GROWN GaP AND GaAs.** The authors report results of linear-vibrational mode absorption experiments on GaP and GaAs which strongly suggest the presence of hydrogen-related centers and centers containing interstitial oxygen, and their interdependence. The measured infrared absorption spectra are presented and discussed. 6 refs.

Ulrici, B. (Akad der Wissenschaften der DDR, Berlin, East Ger); Stedman, R.; Ulrici, W. *Phys Status Solidi B* v 143 n 2 Oct 1987 p K135-K139.

**094312 HOLE TRAPS IN GaSe:Co SINGLE CRYSTALS.** In order to clarify the nature of the cobalt related hole traps (CRHT) in GaSe single crystals, GaSe:Co single crystals were grown by the Bridgman method and the optical absorption spectra, the photoconductivity spectra and the thermally stimulated current (TSC) were investigated. The energy levels of the CRHT in GaSe:Co single crystals were located at 0.18, 0.28, 0.38, 0.49 and 0.57 eV above the valence band. The optical absorption peaks and the photoconductivity peaks corresponding to the CRHT were observed in the wavelength range from 650 to 950 nm and these peaks are respectively attributed to the carrier transitions from the CRHT to the indirect conduction band of GaSe:Co single crystals. (Author abstract) 6 refs.

Yoon, Chang-Sun (Sogang Univ, Seoul, South Korea); Lee, Byong-Hyuk; Kim, Wha-Tek. *Solid State Commun* v 62 n 8 May 1987 p 583-586.

**094313 NITROGEN BOUND ELECTRONS, EXCITONS, AND MULTIEXCITONS IN GaP.** By means of a simple effective mass model the density functional theory is used to calculate the ground state energy of the exciton at the isolated N impurity. For this purpose, the N potential is adjusted and provides the value known from experiment. This potential offers the basis for the computations of the bound multiexciton complexes at the isolated N impurity and of the electron binding energy at the N pairs. The results so obtained are in good qualitative agreement with the experimental ones. (Author abstract) 21 refs.

Haufe, A. (Karl-Marx-Univ Leipzig, Leipzig, East Ger). *Phys Status Solidi B* v 144 n 2 Dec 1987 p 733-738.

**094314 RAMAN SCATTERING STUDY OF GaP:IN EPITAXIAL LAYERS.** Raman spectra of VPE-grown GaP:In samples were investigated in the temperature range between 20 and 300 K, using five discrete lines of the Ar-ion laser. The nitrogen concentration ranged from  $2 \times 10^{17}$  to  $3.3 \times 10^{19} \text{ cm}^{-3}$ . Four nitrogen-related peaks were observed. While the origin of the high-frequency peak is unclear at present, the arguments are given to identify the remaining peaks with a defect-activated LO(X) mode, a nitrogen local vibrational mode, and with its first overtone, respectively. (Author abstract). 33 Refs.

Vorlicek, V. (Czechoslovak Acad of Sciences, Prague, Czech); Gregora, I.; Riede, V.; Neumann, H. *J Phys Chem Solids* v 49 n 7 1988 p 797-805.

**094315 DEEP STATES RELATED TO 3D-TRANSITION METAL IMPURITIES IN  $GaAs_{1-x}P_x$  ALLOY SYSTEM.** A spin-polarized tight-binding model is extended to 3d-impurity-doped  $GaAs_{1-x}P_x$  alloy system. The deep states of Ti, Mn, Fe and Cu, including trap levels, local charges and spin densities, are predicted for different composition x. The theoretical results show good agreement with the relevant experimental data and reveal their variation trends. (Author abstract) 10 refs.

Gu, Yiming (Univ of Science & Technology of China, Hefei, China); Huang, Ming-zhu; Wang, Kelin. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens

Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 417-418.

**094316 QUANTUM WELLS AND DEEP IMPURITY LEVELS UNDER HYDROSTATIC PRESSURE.** We present a cryogenic temperature study of confined transitions and deep impurity levels in a  $GaAs-Ga_{1-x}Al_xAs$  multiple quantum well under hydrostatic pressure. Photorefectance at 80 to 300K was used to study quantized states up to  $n=7$ . A sublinear pressure behavior was found, with pressure coefficients that decreased with increasing n. Indirect transitions from L and X conduction bands were observed. Photoluminescence at 18K was used to observe a deep level, and its phonon replica, that is resonant below 24 and above 80kbar. The level is observed both in bulk GaAs and the quantum well, and may be due to Si impurities. (Edited author abstract) 21 refs.

Chandrasekhar, Meera (Univ of Missouri, Columbia, MO, USA); Chandrasekhar, H.R.; Kangarlou, A.; Venkateswaran, U.; Chambers, F.A.; Meese, J.M. *Superlattices Microstruct* v 4 n 1 1988, Chicago Conf, Pap, Chicago, IL, USA, 1987 p 107-114.

## Ion Implantation

**094317 EFFECT OF HYDROGEN IMPLANTATION INDUCED STRESS ON GaP SINGLE CRYSTALS.** The fluence dependence of internal stress, of plastic deformation and of flaking are studied on GaP single crystals bombarded with 0.1-1.7 MeV protons at 300 and 650 K and annealed at 720 K in the range of fluences  $D=10^{15}$  to  $10^{18} \text{ cm}^{-2}$  using photoelastic stress measurements, cross sectional transmission electron microscopy, scanning electron microscopy and profilometry. It is demonstrated that the implanted hydrogen precipitates in planar form at higher concentrations. The proton bombarded region consists of a less damaged near-surface layer and of a highly damaged 'buried' layer. Within the 'buried' layer supersaturated with point-like defects thermal annealing makes simpler defects coagulate to Frank loops. At the interface between the implanted layer and the bulk material microcracks are formed due to lateral stresses. Stress increases with fluence and exhibits saturation behavior due to plastic deformations which lead to flaking at very high stresses. (Author abstract) 39 refs.

Ascheron, C. (Karl-Marx-Univ Leipzig, Leipzig, East Ger); Bartsch, H.; Setzer, A.; Schindler, A.; Paufler, P. *Nucl Instrum Methods Phys Res Sect B* v B28 n 3 Oct 1987 p 350-359.

**094318 DOPANT REDISTRIBUTION AND CRYSTALLINE DAMAGE REMOVAL DURING RAPID THERMAL ANNEALING OF Be AND Mg IMPLANTS IN  $Ga_{0.47}In_{0.53}As$ .** Secondary ion mass spectrometry (SIMS) and 1.5 MeV Rutherford backscattering (RBS) have been used to correlate redistribution of Be<sup>+</sup> and Mg<sup>+</sup> implants with the reordering of damaged crystal during rapid thermal annealing (RTA) of  $Ga_{0.47}In_{0.53}As$ . Studies were made of three different implant conditions:  $1 \times 10^{14} \text{ cm}^{-2}$  Be<sup>+</sup> and  $1 \times 10^{15} \text{ cm}^{-2}$  Mg<sup>+</sup>, implanted at room temperature, and also  $1 \times 10^{14} \text{ cm}^{-2}$  Mg<sup>+</sup> implanted at 200°C. In addition, a comparison was made of two different methods of surface protection, CVD Si<sub>3</sub>N<sub>4</sub> and a GaAsP 'proximity cap'. It is found that redistribution of Be<sup>+</sup> differs slightly for the two types of surface protection employed, but that the use of RTA suppresses excessive indiffusion effects observed during long time furnace anneals. It is proposed that regrowth in GaInAs occurs in a similar manner to that observed in GaAs and InP. Proximity annealing results in retention of all the implanted Mg<sup>+</sup> dose. (Edited author abstract) 25 refs.

Wilkie, J.H. (Univ of Surrey, Guildford, Engl); Spiller, G.D.T.; Henning, I.D.; Sealy, B.J. *J Cryst Growth* v 85 n 3 Nov II 1987 p 433-439.



**094319 ANNEALING BEHAVIOUR OF EXTREMELY LOW ENERGY BERYLLIUM IMPLANTATION INTO  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$ .** Low energy ion implantation (2-10 keV) of beryllium has been performed and annealing carried out by rapid thermal annealing at different temperatures. Secondary ion mass spectrometry measurements of implanted profiles showed a strong diffusion of the beryllium atoms towards the surface. For the lowest implantation energies this influence is so strong that no indiffusion could be measured. The resulting annealed profile is much narrower than the implanted profile. From diodes fabricated from these layers, a barrier enhancement of 0.42 eV has been determined. (Author abstract) 10 refs.

Fernholz, G. (RWTH, Aachen, West Ger); Breuer, U.; Beneking, H. *Thin Solid Films* v 156 n 2 Jan 30 1988 p 239-242.

**094320 PHOTOLUMINESCENCE STUDIES OF Mg AND Hg IMPLANTED  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$ .** Mg and Hg have been implanted in  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$ . These impurities behave as shallow acceptors in  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$ . Hg is particularly interesting because it does not diffuse towards the bulk. From systematic photoluminescence measurements as a function of excitation power, ion dose and temperature, the Mg and Hg acceptor binding energy are estimated to be, respectively,  $16 \pm 2$  and  $68 \pm \text{meV}$ . (Edited author abstract) 15 refs.

Louati, A. (Insa de Lyon, Villeurbanne, Fr); Charreaux, C.; Nouailhat, A.; Guillot, G.; Favenec, P.N.; Salvi, M. *Solid State Commun* v 62 n 1 Apr 1987 p 31-34.

**094321 GETTERING OF COPPER IN PROTON-AND HELIUM-BOMBARDED BURIED REGIONS OF GALLIUM PHOSPHIDE.** The effect of copper gettering was studied in buried damaged regions caused by proton ion implantation of 300 and 600 keV, respectively. During annealing procedures copper atoms implanted with 200 keV redistribute from the surface layer into buried damaged regions. It is demonstrated that this gettering procedure can be advantageous over the commonly used back side ion beam gettering. (Author abstract) 17 refs.

Ascheron, C. (Karl-Marx-Univ Leipzig, Leipzig, East Ger); Klose, H.A.; Frentrup, W.; Griepentrog, M. *Phys Status Solidi A* v 106 n 1 Mar 1988 p 73-79.

## Magnetic Field Effects

**094322 MAGNETO-OPTICAL TRANSITIONS IN GALLIUM PHOSPHIDE.** The structure of the magnetic levels of the GaP valence band has been calculated within the framework of the effective-mass method. We have determined the effective masses of holes in the direction of a field parallel to [001], the probabilities of magneto-optical transitions, and their dependence on the reduced wave vector. The distinctive features of the magneto-optical spectra of GaP are discussed. 6 refs.

Belov, N.P. (Inst of Fine Mechanics & Optics, Leningrad, USSR); Krylov, K.I.; Prokopenko, V.T.; Yas'kov, A.D. *Sov Phys J* v 30 n 7 Jul 1987 p 620-623.

**094323 HALL EFFECT STUDIES ON p-TYPE GaSb GROWN UNDER MICROGRAVITY CONDITIONS.** Undoped GaSb crystals are always p-type with hole concentration of about  $1 \times 10^{17} \text{ cm}^{-3}$  and Hall mobility of 600 to 800  $\text{cm}^2/\text{Vs}$  at room temperature. The residual acceptor responsible for this behavior is thought to be associated with lattice defects arising from deviations from stoichiometry, the lattice defect being probably a Ga vacancy and a Ga atom on a Sb lattice site. This note presents the results of Hall effect analysis of residual acceptors in a crystal grown under microgravity conditions and a control sample grown on earth. Hall data were measured between 300 and 20 K. The concentrations of both acceptors and donors are greater in the terrestrial samples than in the crystal grown under microgravity conditions. In accordance with the lower impurity concentrations and compensation degree, the Hall mobility at 77 K is higher in the crystal grown under microgravity

conditions. 22 refs.

Gyuro, I. (Hungarian Acad of Sciences, Budapest, Hung); Podor, B.; Popov, V.V.; Parfenov, R.V. *Phys Status Solidi A* v 105 n 2 Feb 1988 p K129-K133.

## Measurements

**094324 ELECTROREFLECTANCE AND PHOTOREFLECTANCE MEASUREMENTS OF GAAS/ALAS SHORT PERIOD SUPERLATTICES.** Electroreflectance and photorefectance measurements are reported for GaAs/AlAs short-period superlattice over the wavelength range 9000/3000 Å. Emphasis is on the spectral region of 4500-3000 Å where the observed structures have been associated with the  $E_1$  and  $E_1 + \Delta_1$  transitions of the superlattice. These transitions are shifted toward higher energies when the well-width decreases. The experimental results are compared with a simple calculation based on a Kronig-Penney model. (Edited author abstract). 10 refs.

Rodriguez, J.M. (CSIC, Madrid, Spain); Armelles, G.; Briones, F. *Solid State Commun* v 67 n 9 Sep 1988 p 859-862.

## Mechanical Properties

**094325 A DETERMINATION OF THE RELATIVE BULK MODULI OF  $\text{GaInAsP}$  AND  $\text{InP}$ .** Relative spectroscopic measurements of the bulk modulus of GaInAsP lattice-matched to InP yield a value within 1 percent of that of InP. This surprising result is not in agreement with accepted interpolated values but is predicted by Keyes' empirical scaling rule for elastic constants. It is concluded that it may not be necessary to take axial strain into account in analysing hydrostatic pressure measurements on lattice-matched III-V heterostructure. (Edited author abstract). 18 refs.

Prins, A.D. (Univ of Surrey, Guildford, Engl); Dunstan, D.J. *Philos Mag Lett* v 58 n 1 Jul 1988 p 37-44.

**Metallizing** See ELECTRIC CONTACTS, OHMIC—Lubrication.

**Microscopic Examination** See SEMICONDUCTOR MATERIALS—Defects.

**Microstructure** See SEMICONDUCTING INDIUM COMPOUNDS—Microstructure.

**Optical Properties** See Also CRYSTALS—Electron States; CRYSTALS—Optical Properties; SEMICONDUCTING CADMIUM COMPOUNDS—Optical Properties; SEMICONDUCTING GALLIUM ARSENIDE—Growth; TRANSISTORS, PHOTOSENSITIVE—Heterojunctions.

**094326 ROOM-TEMPERATURE  $1.55 \mu\text{m}$  OPTICAL BISTABILITY IN A  $\text{GaInAs/AlInAs}$  MULTIPLE-QUANTUM-WELL ETALON.**  $1.55 \mu\text{m}$  optical bistability has been observed in a GaInAs/AlInAs MQW etalon at room temperature. We have shown that the nonlinear mechanism responsible for the bistability is due to an electronic nonlinearity in the refractive index. (Edited author abstract) 6 refs.

Kawaguchi, H. (NTT, Atsugi, Jpn); Kawamura, Y. *Electron Lett* v 23 n 19 Sep 10 1987 p 1013-1014.

**094327 ON THE BLEACHING OF THE A-BOUND EXCITON ABSORPTION IN  $\text{GaP:N}$ .** The intensity dependence of the A-line absorption in GaP:N is investigated at various nitrogen concentrations and at different excitation conditions, i.e. for resonant and band-to-band excitation. For the intensity levels, which are necessary to saturate the absorption, simultaneous luminescence measurements have clearly shown the formation of an electron-hole liquid in the excited region. An explanation is given of the experimental findings which takes into account the presence of an electron-hole liquid in the sample. (Author abstract) 20 refs.

Woggon, Ulrike (Humboldt-Univ zu Berlin, Berlin, East Ger); Henneberger, F.; Weinert, H. *Phys Status Solidi B* v 143 n 2 Oct 1987 p 611-623.

**094328 OPTICAL INVESTIGATIONS OF A GaSb-ALSB SINGLE QUANTUM WELL.** We present a study of the low temperature electroreflectance and photoluminescence of GaSb-ALSB single quantum well heterostructure grown by molecular beam epitaxy. Our results evidence the important role of misfit strains in the electronic structure of this system. The luminescence, which is remarkably intense, arises from excitons bound to shallow defects which are most likely neutral acceptors. (Author abstract) 12 refs.

Raisin, C. (Univ des Sciences et Techniques du Languedoc, Montpellier, Fr); Lassabaterre, L.; Allibert, C.; Girault, B.; Abdel-Fattah, G.; Yoisin, P. *Solid State Commun* v 61 n 1 Jan 1987 p 17-19.

**094329 ANALYSIS OF THE EXCITONIC MOTT TRANSITION IN GaSe.** Detailed photoluminescence spectra of GaSe at a bath temperature of 2K were measured at electron-hole densities ranging from below to above the screening limit for the free direct excitons. Special care was used to reduce the effects of spatial carrier inhomogeneity. We observe a continuous transition from exciton recombination processes to an e-h plasma emission. We compare our observations with the results of a simplified first order theory which accounts for electron-hole correlation effects. The observed red shift of the fundamental direct exciton level is well reproduced by our theoretical calculations. (Author abstract) 21 refs.

Pavesi, L. (Univ di Trento, Italy); Staehli, J.L.; Capozzi, V. *Solid State Commun* v 61 n 5 Feb 1987 p 321-325.

**094330 USING DISPERSION THEORY TO INTERPRET THE POLARIZATION PROPERTIES OF THE BAND-EDGE EMISSION IN GaN CRYSTALS.** In this paper, we report the polarization properties of the near band-edge emission in GaN crystal wafers. When excitation intensity increases in the range of 0-0.1  $\text{Mw cm}^{-2}$ , the polarization of band-edge emissions increase quadratically, then, a saturation appears. These phenomena can be explained by the dispersion theory of exciton-exciton interaction. (Author abstract) 6 refs.

Bao, Qincheng. (Chinese Acad of Sciences, Changchun, China); Zhang, Fengling; Li, Duolu; Dai, Rensong; Xu, Xurong. *Solid State Commun* v 61 n 6 Feb 1987 p 381-384.

**094331 MAGNETO-OPTICAL STUDIES OF  $\text{GaInAs-InP}$  QUANTUM WELLS.** The optical properties of GaInAs-InP quantum wells are studied in magnetic fields of up to 16T. A comparison of the absorption and photoluminescence spectra of a series of multiple quantum wells provides evidence that the photoluminescence occurs from excitons in which the hole is localised. This localisation is shown to be present in a highly doped sample with a sheet carrier density of approximately  $10^{12} \text{ cm}^{-2}$ , indicating that the localisation is not screened out by high free carrier densities. A theoretical fit to measured Landau level transitions in a 100 Å multiple quantum well allows values for the carrier masses, electron non-parabolicity and exciton binding energy to be determined. (Author abstract) 21 refs.

Mowbray, D.J. (Univ of Oxford, Oxford, Engl); Singleton, J.; Skolnick, M.S.; Pulsford, N.J.; Bass, S.J.; Taylor, L.L.; Nicholas, R.J.; Hayes, W. *Superlattices Microstruct* v 3 n 5 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 471-475.

**094332 OPTICAL STUDIES OF GaAs QUANTUM WELLS.** Photoluminescence and excitation spectroscopy of the photoluminescence (XPL) are powerful tools to investigate the energy levels and relaxation mechanisms in semiconductor heterostructures. The present review is devoted to a brief presentation of some experimental and theoretical results obtained in GaAs-Ga(Al)As quantum



well structures. They evidence the size quantization, the enhanced excitonic binding, the bandgap renormalization and the impurity distribution profiles. 18 refs.

Bastard, Gerald (Ecole Normale Supérieure, Paris, Fr). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 33-36.

**094333 ELECTRON BEAM EFFECTS ON BLUE LUMINESCENCE OF ZINC-DOPED GaN.** It is well known that Zn in GaN plays an important role for forming blue luminescent centers. For device applications of the blue emission, it is necessary to increase the blue luminescent centers, as well as to decrease unintentionally introduced non-radiative recombination centers. 9-30kV electron-beam irradiation enhances the blue luminescence in zinc-doped GaN both at low temperature and room temperature. Dependence on irradiation conditions is studied in detail and the mechanism is discussed. 1 ref.

Amano, Hiroshi (Nagoya Univ, Nagoya, Jpn); Akasaki, Isamu; Kozawa, Takahiro; Hiramatsu, Kazumasa; Sawaki, Nobuhiko; Ikeda, Kousuke; Ishii, Yoshikazu. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 121-122.

## Order-Disorder

**094334 DISORDER OF A  $Ga_{1-x}In_xAs_{1-y}P_y$  INP QUANTUM WELL BY Zn DIFFUSION.** Data are presented showing for the first time that Zn diffusion into a  $Ga_{1-x}In_xAs_{1-y}P_y$  INP quantum well and superlattice (of 100 Å thickness) completely disorders the quantum well and superlattice layers. The photoluminescence wavelength of the quantum well and the superlattice increased after Zn diffusion, which can be attributed to the In-Ga interdiffusion at the hetero-interfaces, as a result of the interchange mechanism between the interstitials and substitutional zinc atoms. (Author abstract) 15 refs.

Razeghi, M. (Thomson-CSF, Orsay, Fr); Acher, O.; Launay, F. *Semicond Sci Technol* v 2 n 12 Dec 1987 p 793-796.

**094335 ORDERED STRUCTURE IN OMVPE-GROWTH  $Ga_{0.5}In_{0.5}P$ .** The ordered structure of Ga and In in GaInP grown on (00) GaAs by organometallic vapor phase (OMVPE) is investigated using high-resolution transmission electron microscopy (TEM). The orderings are sequences of (111) planes arranged in the order of Ga/P/In/P/Ga/P/InP along the [111] and  $\bar{1}\bar{1}\bar{1}$  directions, respectively. The ordered structure may be thermodynamically stable. The OMVPE growth mechanism may partly determine ordering direction in the crystal. (Edited author abstract) 8 refs.

Koindow, Masahiko (Hitachi Ltd, Kokubunji, Jpn); Kakibayashi, Hiroshi; Minagawa, Shigekazu. *J Cryst Growth* v 88 n 2 Apr II 1988 p 291-296.

## Oxidation

**094336 LONG-TIME AIR OXIDATION AND OXIDE-SUBSTRATE REACTIONS ON GaSb, GaAs AND GaP AT ROOM TEMPERATURE STUDIED BY X-RAY PHOTOELECTRON SPECTROSCOPY.** The room temperature oxidation behaviour of GaSb, GaAs and GaP has been monitored for a period of 3 years using X-ray photoelectron spectroscopy. By comparisons of the compositions of the growing oxide and the depth profiles of the 3-year oxide, information on the oxide-substrate interfacial reactions is obtained. The growing oxide surface consists of  $Ga_2O_3$  and  $Sb_2O_3$  (Sb:Ga  $\approx$  1) for GaSb, a metastable Ga-O-As complex (As:Ga  $\approx$  0.5) for GaAs, and  $P_2O_5$  and  $Ga_2O_3$  +  $GaPO_4$  (P:Ga  $\approx$  3) for GaP. The oxide-substrate reaction occurs for GaSb and GaAs, and the resulting interface shows three features: (1) increase in gallium oxide; (2) decrease in the  $B^V$  oxide; (3) deposition of elemental B<sup>v</sup>, even at room temperature, although a very long period of time is necessary. For GaP, no such reaction occurs. (Edited author abstract) 32 refs.

Mizokawa, Yusuke (Univ of Osaka Prefecture, Sakai,

Jpn); Komoda, Osamu; Miyase, Sunao. *Thin Solid Films* v 156 n 1 Jan 15 1988 p 127-143.

**094337 X-RAY PHOTOELECTRON SPECTRA OF AN ELECTRON-BEAM OXIDE LAYER ON GaSb.** A new oxidation method for GaSb that utilized a high energy electron-beam was investigated. The grown oxide layer was characterized by X-ray photoelectron spectroscopy (XPS) measurements. The oxidized Sb was distributed throughout the oxide layer and there was less pile-up of elemental Sb concentration at the oxide-semiconductor interface. (Author abstract) 17 refs.

Wada, Takao (Nagoya Inst of Technology, Nagoya, Jpn); Kitamura, Noboru. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 686-687.

## Performance

**094338 ROOM-TEMPERATURE OPERATION OF  $Ga_{0.47}In_{0.53}As/Al_{0.48}In_{0.52}As$  RESONANT TUNNELING DIODES.** Room-temperature operation of  $Ga_{0.47}In_{0.53}As/Al_{0.48}In_{0.52}As$  resonant tunnelling (RT) diodes is reported. The peak/valley ratio of the current is as high as 4:1 at room temperature and is 15:1 at 80K. The position of the peak in the current/voltage characteristic showed good agreement with that obtained from an electron tunnelling transmission calculation. (Edited author abstract) 16 refs.

Sen, S. (AT&T Bell Lab, Murray Hill, NJ, USA); Capasso, F.; Hutchinson, A.L.; Cho, A.Y. *Electron Lett* v 23 n 23 Nov 5 1987 p 1229-1231.

**094339 SINGLE-HETEROJUNCTION GaAlAs - A NEW TECHNOLOGY FOR INFRARED LEDs AND OPTOCOUPLERS.** This technology, originally developed to provide brighter hyper-red LEDs, offers a significant improvement over rival GaAs and GaAlAs homojunction technology for infrared emitters. Advantages include higher operating speed, better reliability, linear radiant intensity/forward-current relation and a higher radiant intensity where needed. (Edited author abstract)

Boissy, Marie Claude. *Electron Compon Appl* v 8 n 3 1988 p 153-155.

**Photoconductivity** See Also ELECTRODES, ELECTROCHEMICAL—Semiconductor Materials.

**094340 WAVELENGTH-DEPENDENT PHOTOCONDUCTION EFFECTS ON THE SECOND SUB-BAND OCCUPANCY IN (Al, Ga)As/GaAs HETEROJUNCTIONS.** We have used magneto-transport measurements with the magnetic field aligned perpendicular to, and then parallel to the interface of a number of (Al, Ga)As/GaAs two-dimensional electron-gas samples, to determine the populations of the first and second sub-bands in the interface potential well. The total carrier density in the samples has been gradually increased by pulsed illumination either with a red ( $h\nu=1.95$  eV) or infrared ( $h\nu=1.43$  eV) LED, and it has been found that the carrier density at which the second sub-band is first occupied is lower when the red LED is used. This difference is ascribed to the effect of electron-hole pairs generated in the GaAs altering the depletion charge, and hence the sub-band spacing; such a mechanism does not operate when the infrared LED is used. (Edited author abstract) 14 refs.

Harris, J.J. (Philips Research Lab, Redhill, Engl); Lacklison, D.E.; Foxon, C.T.; Seltin, F.M.; Suckling, A.M.; Nicholas, R.J.; Barnham, K.W.J. *Semicond Sci Technol* v 2 n 12 Dec 1987 p 783-789.

## Physical Properties

**094341 INVESTIGATION OF PROPERTIES OF THE GALLIUM PHOSPHIDE/INSULATOR INTERFACE.** The special physicochemical properties of III-V semiconductors are such that thermal oxidation cannot be used when building up the elements of opto- and microelectronics, and low-temperature processes must be

found to form insulating films. A highly promising method of this kind is anodic oxidation in electrolytes. Research workers have shown considerable interest in semiconductor/insulator interfaces of structures on the basis of GaAs and InP, but only a few papers have been concerned with systems consisting of GaP and an anodic oxide film (AOF). (Edited author abstract) 6 refs.

Kashkarov, P.K. (M.V. Lomonosov State Univ, Moscow, USSR); Nevzorov, A.N.; Sorokin, I.N.; Sosnovskikh, Yu.N.; Sygailo, A.I. *Sov Electrochem* v 23 n 2 Feb 1987 p 232-234.

**094342 OBSERVATION OF MONOLAYER FLUCTUATIONS IN THE EXCITED STATES OF  $GaAs-Al_xGa_{1-x}As$  MULTIPLE-QUANTUM-WELL STRUCTURES USING PHOTOCURRENT AND REFLECTION SPECTROSCOPIES.** Low temperature photocurrent and reflection spectra are described for  $GaAs-Al_xGa_{1-x}As$  multiple-quantum-well structures grown by molecular beam epitaxy. The spectra include well resolved multiple sharp components both in the ground-state exciton and higher-order allowed and forbidden exciton transitions. These multiple components are attributed to changes in well thickness of approximately one monolayer. The observed splittings both in the ground and excited states agree with calculated values. (Edited author abstract) 14 refs.

Yu, P.W. (Wright State Univ, Dayton, OH, USA); Reynolds, D.C.; Bajaj, K.K.; Litton, C.W.; Klem, J.; Huang, D.; Morkoc, H. *Solid State Commun* v 62 n 1 Apr 1987 p 41-44.

**094343 BAND LINEUPS AT THE  $GaSb-Al_xGa_{1-x}Sb$  HETEROJUNCTION: EXPERIMENTAL EVIDENCE FOR A NEW COMMON ANION RULE.** The valence band offset in  $GaSb-Al_xGa_{1-x}Sb$  quantum wells has been determined by a light scattering method and found to be nearly the same as in their  $GaAs-Al_xGa_{1-x}As$  counterparts. This result suggests the validity of a restricted form of the common anion rule, which can be stated as follows: the valence band offset in a common anion heterostructure tends to be independent of the particular anion chosen. This new rule is consistent with Tersoff's band lineup theory and also with a recent tight binding theory by Harrison and Tersoff. (Author abstract) 27 refs.

Menendez, J. (AT&T Bell Lab, Murray Hill, NJ, USA); Pinczuk, A.; Werder, D.J.; Valladares, J.P.; Chiu, T.H.; Tsang, W.T. *Solid State Commun* v 61 n 11 Mar 1987 p 703-706.

**094344 EXCITONIC PROPERTIES AND TEMPERATURE BEHAVIOUR OF THE PHOTOLUMINESCENCE FROM  $GaAs-GaAlAs$  MULTIPLE QUANTUM WELL STRUCTURES.** The temperature characteristics of the excitonic radiative recombination in multiple quantum well structures have been investigated and shown to be a good assessment phenomena of emissions from quantum wells with different widths in the same sample. (Edited author abstract) 6 refs.

Xu, Zhongying (Acad Sinica, Beijing, China); Xu Jizong; Ge Weikun; Zheng Baozhen; Xu Junying; Li Yuzhang. *Solid State Commun* v 61 n 11 Mar 1987 p 707-711.

## Plasmas

**094345 OPTICAL GAIN SPECTRA OF HIGH DENSITY ELECTRON-HOLE PLASMA IN GaSe AND InSe.** We have performed stimulated emission and unsaturated optical gain measurements at low temperature in the indirect semiconductors GaSe and InSe at excitation intensities above 0.5 MW/cm<sup>2</sup>, i.e., when the critical Mott density is overcome and an electron-hole plasma (EHP) is generated. In both GaSe and InSe the gain spectra show only the band due to zero phonon recombination of indirect plasma (IEHP). No optical gain due to direct plasma (DEHP) is observed. The comparison of experimental results with theoretical models is very satisfactory. In InSe it becomes also a tool for evaluating the consistence of proposed band structures with observed



data. (Author abstract) 16 refs.

Cingolani, R. (CNR, Bari, Italy); Ferrara, M.; Lugara, M. *Phys Scr* v 37 n 4 Apr 1988 p 583-586.

## Precipitation

**094346 PRECIPITATE IDENTIFICATION IN LEC-GROWN SI-DOPED GaAs.** It is shown that the phase which precipitates due to normal segregation in LEC-grown Si-doped GaAs, once the solid solubility of the dopant is exceeded, is elemental Si. The presence of high Si concentrations in the melt also promotes the formation of a further precipitate which appears at the melt-encapsulant interface and also becomes incorporated into the crystal surface. This precipitate has been identified as  $B_{13}As_2$ . (Author abstract) 13 refs.

Cockayne, B. (Royal Signals & Radar Establishment, Great Malvern, Engl); MacEwan, W.R.; Hope, D.A.O.; Harris, I.R.; Smith, N.A. *J Cryst Growth* v 87 n 1 Jan 11 1988 p 6-12.

## Pressure Effects

**094347 HYDROSTATIC PRESSURE EFFECTS ON Mn IN GaAs<sub>1-x</sub>P<sub>x</sub>.** Hydrostatic pressure has been applied to samples of Mn-doped GaAs and GaAs<sub>1-x</sub>P<sub>x</sub> ( $x = 0.04$ ). The charge transfer nature of the radiative recombination allows determination of the pressure derivative of the Mn acceptor level relative to the valence band edge. The pressure derivatives have been determined and are found to be identical for both the binary and ternary material, 1.1-1.2 meV/kbar. This number is only a small fraction of the total pressure derivative of the  $\Gamma_{1c}$   $\Gamma_{15v}$  energy gap which amounts to 10.7 meV/kbar. Using the Mn acceptor energy level as a reference we were able to determine the hydrostatic deformation potentials of the valence and conduction bands and found values of  $a_v = +0.9$  eV and  $a_c = -7.7$  eV respectively. (Edited author abstract) 24 refs.

Nilsson, S. (Univ of Lund, Lund, Swed); Samuelson, L. *Solid State Commun* v 65 n 12 Mar 1988 p 1477-1482.

## Radiation Effects

**094348 USING GaAs AND GaP FILMS WITH ABNORMAL PHOTOVOLTAGES FOR RECORDING X-RAYS.** The possibility of recording x-rays with films made for CdTe and Sb<sub>2</sub>Se<sub>3</sub> semiconductor compounds which upon illumination with visible light generate an abnormal photovoltage has been reported. These films are sensitive to x-rays only in air, whereas their sensitivity disappears in vacuum. This behavior is associated with the increase in the ion concentration in air where the films can be shunted by ion currents or by the interaction of ions with the surface of the films. It has also been shown that it is possible to use Si and Ge films with an abnormal photovoltage for recording x-rays in both air and vacuum. The author considers in the present work the possible application of films made from  $A_3B_5$  semiconductor compounds (GaAs and GaP) with an abnormal photovoltage for recording x-rays. 5 refs.

Abdullaev, N. *Sov At Energy* v 61 n 5 Nov 1986 p 927-929.

**094349 ELECTRICAL PROPERTIES AND FERMI LEVEL PINNING IN PROTON-IRRADIATED GaSb.** The effect of electron, fast neutron, and deuteron irradiations on the electrical properties of GaSb has been previously investigated. These irradiations convert n-type GaSb to p-type and shift the Fermi level into the lower half of the energy gap. The authors describe the effect of proton (5 MeV) bombardment on the electrical properties and Fermi level positions of the initial n-, p-, and p<sup>+</sup>-type bulk GaSb. The samples were irradiated using a cyclotron with current densities from  $(0.5 \text{ to } 5) \times 10^{-4} \text{ A/cm}^2$ . 6 refs.

Brudnyi, V.N. (Siberian V.D. Kuznetsov Physico-Technical Inst, Tomsk, USSR); Kamenskaya, I.V. *Phys Status Solidi A* v 105 n 2 Feb 1988 p K141-K144.

**094350 EFFECT OF ELECTRON RADIATION ON THE ELECTROPHYSICAL PROPERTIES OF GALLIUM NITRIDE.** The effect of electron radiation on the electrophysical properties of the i-layer in an i-n-structure of zinc-doped gallium nitride was investigated using a scanning electron microscopy induced current method. (Author abstract) 2 refs.

Obyden, S.K.; Perlovskii, G.A.; Saparin, G.V.; Nikolaev, A.G. *Bull Acad Sci USSR Phys Ser* v 51 n 3 1987, Mater of the Fifth All-Union Symp on Scanning Electron Microsc and Anal Methods for Invest Solids, Zvenigorod, USSR, May 1986 p 33-34.

Research See Also SEMICONDUCTING GALLIUM ARSENIDE—Research.

**094351 SPIN-ON SOURCE FOR ZINC DIFFUSION IN (100) GALLIUM ANTIMONIDE.** Spin-on diffusion of zinc in gallium antimonide in an open-tube furnace has been demonstrated, utilizing zinc silica films with different zinc concentrations. Diffusions were performed at temperatures of 630° and 680°C. For lower zinc concentrations in the source and longer diffusion times, the concentration in the semiconductor can fall below the substrate doping level due to depletion effects of the source. 12 refs.

Heinz, Christian (Univ Muenchen, Munich, West Ger). *J Electrochem Soc* v 135 n 1 Jan 1988 p 250-252.

Space Charge See SEMICONDUCTOR DEVICES—Tunneling.

Specific Heat See Also SEMICONDUCTOR MATERIALS—Specific Heat.

**094352 HEAT CAPACITY AND LATTICE ANHARMONICITY IN Cu<sub>3</sub>Sn<sub>2</sub>VI<sub>2</sub> CHALCOPYRITE COMPOUNDS.** The molar heat capacity at constant pressure is measured for CuGaS<sub>2</sub> in the temperature range from 300 to 600 K and for CuGaTe<sub>2</sub>, CuInS<sub>2</sub>, and CuInTe<sub>2</sub> from 300 to 500 K with an estimated accuracy of  $\pm 1 \text{ J/mol K}$ . The anharmonic contributions to the heat capacity at constant pressure and at constant volume are estimated and analyzed in terms of perturbation theory. The volume Grueneisen functions of the compounds are evaluated and compared with existing literature data. (Author abstract) 44 refs.

Neumann, H. (Karl-Marx-Univ Leipzig, Leipzig, East Ger); Kuehn, G.; Moeller, W. *Phys Status Solidi B* v 144 n 2 Dec 1987 p 565-573.

## Spectroscopic Analysis

**094353 INFLUENCE OF THE JAHN-TELLER EFFECT UPON ZERO-PHONON LINES IN OPTICAL SPECTRA.** A mechanism involving the Jahn-Teller effect is used to account for both strong and absent zero-phonon lines in optical spectra. The method is applied to explain why the 1.03 eV zero-phonon line of the GaP:Cr<sup>3+</sup> system is very strong, while no zero-phonon line is observed from the GaAs:Cr<sup>3+</sup> system. (Author abstract) 15 refs.

Dunn, J.L. (Univ Nottingham, Nottingham, Engl); Bates, C.A. *J Phys C Solid State Phys* v 20 n 36 Dec 30 1987 p L995-L998.

**094354 TIME-RESOLVED EXCITON PHOTOLUMINESCENCE IN GaSe AND GaTe.** Time-resolved photoluminescence measurements of the layered semiconductors GaSe and GaTe have been made using a mode-locked dye laser and a synchronously scanning streak camera. It is shown that at low excitation densities ( $10^{15}$ ,  $10^{17} \text{ cm}^{-3}$ ) exciton dynamics is dominated by trapping at defects. A rate equation model is developed that describes exciton formation, recombination and trapping. At 4 K we determine free-exciton recombination times of 200 ps for GaTe and 350 ps for GaSe. Trapping times of 200 and 900 ps yield capture cross sections of  $1.2 \times 10^{-14} \text{ cm}^2$  and  $3.6 \times 10^{-15} \text{ cm}^2$  for GaTe and GaSe respectively. (Author abstract) 17 refs.

Taylor, R.A. (Univ of Oxford, Oxford, Engl); Ryan, J.F.

*J Phys C Solid State Phys* v 20 n 36 Dec 30 1987 p 6175-6187.

**094355 POSSIBILITY OF A DIRECT OBSERVATION OF THE TIME EVOLUTION IN HETEROSTRUCTURE BARRIER TUNNELING.** By varying two design parameters, e.g., the width of a quantum well (QW) and its chemical composition, or by applying an external field, it is possible to implement two QW's with identical ground-state levels in the conduction band - but different in the valence band. This allows a selective 'preparation' of an initial electron state by interband photoexcitation. In a coupled QW system the electron will oscillate between the two wells, giving rise to an oscillating luminescence signal with a period directly related to the tunneling time. (Author abstract) 8 refs.

Luryi, Serge (AT&T, Murray Hill, NJ, USA). *Solid State Commun* v 65 n 8 Feb 1988 p 787-789.

**094356 LUMINESCENCE DECAY OF EXCITONS BOUND TO NITROGEN PAIRS IN GaP:N.** We report photoluminescence lifetime studies of excitons bound to  $NN_1$  and  $NN_3$  pair centres in GaP:N in the temperature range of 4.5-110 K. The experimental results show that the temperature dependence of the luminescence lifetime of  $NN_3$  centres is not very different from sample to sample, while that of  $NN_1$  centres is quite different for different sample. For  $T > 40 \text{ K}$ , in a sample with very small electron-escape probability of the bare electron state, it is observed that thermal release of the hole from  $NN_1$  center, and verifies the Hopfield-Thomas-Lynch (HLT) model of isoelectronic traps. (Author abstract) 11 refs.

Zheng, Jiansheng (Univ of Wisconsin, Madison, WI, USA); Yen, W.M. *J Lumin* v 39 n 5 Apr 1988 p 233-237.

**094357 POSSIBILITY OF GREEN LIGHT EMISSION FROM GaP/AIP (001) SUPERLATTICES.** Using ab initio band structure calculations based on the augmented spherical wave method and calculations of oscillator strengths based thereon, it is shown that monolayer type GaP/AIP (001) superlattices, in comparison to the earlier studied GaP and GaP:N materials, may show prospects for light emission in the green. (Author abstract) 20 refs.

Schuermans, M.F.H. (Philips Research Lab, Eindhoven, Neth); Rompa, H.W.A.M.; Eppenga, R. *J Lumin* v 37 n 5 Sep 1987 p 269-273.

**094358 SPECTROSCOPIC STUDIES OF THE LOCAL SYMMETRY OF NITROGEN PAIRS IN GaP.** We presented an investigation of the defect symmetry associated with nitrogen-nitrogen pairs in GaP. We only found defects associated with  $C_{2v}$  or  $C_s$  local-symmetry groups [(a, a, 0) or (a, a, b) orientations of two substitutional atoms]. This contradicts the standard assignment. Performing a model calculation which takes account of the conduction band structure of GaP. We show that specific features indeed exist in indirect band gap semiconductors. They prevent a simple assignment in terms of nitrogen-nitrogen separation. The change in exciton binding energy arises from the microscopic arrangement around the nitrogen atom. This is illustrated from hydrostatic pressure and uniaxial stress measurements; it also permits an analysis of the nitrogen related isoelectronic complexes found in the alloys. (Author abstract) 46 refs.

Gil, Bernard (CNRS, Montpellier, Fr). *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 84-98.

**094359 LOW TEMPERATURE TRANSIENT OF DEEP CENTRE Zn IN GaN.** Kinetics of the photoluminescence emitted from GaN:Zn was studied at temperature 2 K. A typical life-time of 300 ns is reported for the blue GaN:Zn emission peaking at about 2.89 eV. The



decay of PL intensity corresponds to a hyperbolic curve approximately and it is well described by the Bequerel type of relation. (Author abstract) 3 refs.

Gao, Ying (Acad Sinica, Changchun, China); Bergman, P.; Monemar, Bo.; Holz, P. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Mater, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 375-376.

**094360 PHOTOLUMINESCENCE OF Mn-, Cr-DOPED AND UNDOPED  $\epsilon$ -GaSe.** Photoluminescence (PL) of Mn-, Cr-doped and undoped  $\epsilon$ -GaSe single crystals was investigated. PL spectra showed broad bands of manganese and chromium related defects centered at 1.804 eV and 1.942, 1.876, and 1.787 eV, respectively. (Author abstract) 6 refs.

Chung, C.H. (Yonsei Univ, Seoul, South Korea); Hahn, S.R.; Park, H.L.; Kim, W.T.; Lee, S.I. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 405-406.

**094361 PHOTOLUMINESCENCE AND THERMAL QUENCHING OF FREE EXCITONS UNDER NORMAL PRESSURE IN GaP:N.** The free exciton of GaP:N under normal pressure has been observed for the first time with high density excitation. We have measured the value of binding energy of free exciton experimentally and discussed its binding energy. (Author abstract) 5 refs.

Dou, Kai (Acad Sinica, Changchun, China); Zhang, Xinyi; Hong, Qiang. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 487-488.

**094362 EXCITON TUNNELING IN  $\text{GaAs}_{1-x}\text{P}_x$ :N, A WEAKLY DISORDERED SEMICONDUCTOR.** The luminescence spectra of  $\text{GaAs}_{1-x}\text{P}_x$ :N ( $0 < x < 0.4$ ) are studied at  $T=2\text{K}$ , by selective excitation into the nitrogen-bound exciton band. The main spectral features are analyzed in terms of acoustic phonon-assisted exciton transfer between localized states. The energy of the excitonic mobility edge is determined spectroscopically and is found to vary as  $x(1-x)$ . (Author abstract) 6 refs.

Gershoni, D. (AT&T Bell Lab, Murray Hill, NJ, USA); Ron, Arza; Cohen, E.; Fried, A. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 489-490.

**094363 TRANSIENT STATE STUDY OF THE POLARIZATION PROPERTIES OF SIDEBAND RECOMBINATION EMISSIONS IN GaN CRYSTALS.** In this paper, we report that the polarizabilities of near sideband recombination emission  $I_1$  and  $I_3$  in GaN crystal change quadratically with density of bound excitons. The results of transient spectra agree with our previous results of steady state experiments and provides an experiment proof for the dispersion theory of exciton-exciton interaction. The excitation intensity in our experiments was  $1.2 \times 10^{19} \text{W/cm}^2$ , time precision was 10 ns and the temperature was  $77 \pm 0.5 \text{ K}$ . 4 refs.

Bao, Qingcheng (Acad Sinica, China); Zhang, Fengling; Pang, Shengmin; Li, Duoli; Tian, Nailing; Xu, Xurong. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 491-492.

**094364 STUDY ON THE LUMINESCENCE OF GaP:N UNDER SELECTIVE EXCITATION OF EXCITONS BOUND TO  $\text{NN}_i$  CENTERS.** The photoluminescence of excitons bound to isoelectronic traps in GaP:N has been studied for many years. Most of the properties of various  $\text{NN}_i$  centers are well known now. To our knowledge, in all the previous works the excitation photon energies are higher than the emission photon energies. Under selective excitation of excitons bound to  $\text{NN}_i$  centers, we observed and studied the luminescence of excitons bound to shallower  $\text{NN}_i$  ( $i=3, 4, 5$ ), isolated nitrogen centers and of free excitons. 3 refs.

Hong, Qiang (Acad Sinica, Changchun, China); Dou, Kai; Zhang, Xinyi. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 525-526.

**094365 HIGH RESOLUTION LUMINESCENCE DEPTH PROFILING OF ION ETCHED MULTIQUANTUM WELL STRUCTURES.** Luminescence spectroscopy is a very sensitive tool to determine the quality of the quantum well structures, but provides depth resolution only for the layers close to the sample surface. To overcome this limitation GaInAs/InP multi quantum well structures are stepwise ion-etched to different depths. The different layers are analyzed by luminescence spectroscopy with high depth resolution. (Edited author abstract) 2 refs.

Germann, R. (Univ Stuttgart, Stuttgart, West Ger); Forchel, A.; Scholz, F. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 733-734.

**094366 RESEARCH ON PHOTOVOLTAIC SPECTRA OF P/N/N+ GaP.** The photovoltaic spectra (PVS) of P/N/N+ GaP:N have been measured by the surface photovoltaic method and fitted well to our theoretical results in this paper. Six structure parameters and the nitrogen concentration have been obtained. (Author abstract) 5 refs.

Chen, Chao (Xiamen Univ, Xiamen, China); Liu, Shiyi. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 808-809.

#### Spectrum Analysis

**094367 BREAKDOWN ELECTROLUMINESCENCE SPECTRA IN STRUCTURES BASED ON THE SOLID SOLUTIONS  $\text{Ga}_{1-x}\text{Al}_x\text{P(As)}$ .** The basic characteristics of BEL in reverse-biased p-n structures based on  $\text{Ga}_{1-x}\text{Al}_x\text{P}$  and  $\text{Ga}_{1-x}\text{Al}_x\text{As}$  were studied. It is concluded that the use of  $\text{Ga}_{1-x}\text{Al}_x\text{P}$  and  $\text{Ga}_{0.62}\text{Al}_{0.38}\text{As}$  structures enables realization of thermally stable luminescence both with forward and reverse bias of p-n structures, and at the same time the maximum light intensity in structures with green and red luminescence equals 300 and 500  $\mu\text{cd}$  at 20 mA. 10 refs.

Ermakov, O.N. *J Appl Spectrosc* v 46 n 2 Feb 1987 p 150-154.

**094368 PLASMON AND PLASMON-LO PHONON COUPLING MODES IN MIXED CRYSTAL  $\text{GaAs}_{1-x}\text{P}_x$  GROWN BY LIQUID PHASE EPITAXY.** The plasma reflection spectra and the behaviours of the plasmon-LO phonon coupling modes for the mixed crystals  $\text{GaAs}_{1-x}\text{P}_x$  with different compositions grown by liquid phase epitaxy are reported. The behaviours are explained with a model of two valleys of conduction band in which a donor level associated with X conduction valley is considered. (Author abstract) 7 refs.

Ye, Hongjuan (Acad Sinica, Shanghai, China); Lu, Wei; Tao, Fengxiang; Shen, Xuechu. *Chin J Infrared Res Ser B (Engl Ed)* v 6 1987 p 55-60.

#### Structure See Also SEMICONDUCTING ZINC COMPOUNDS—Structure.

**094369 ELECTRONIC STRUCTURE OF TERNARY SEMICONDUCTOR ALLOYS: CPA CALCULATIONS USING  $\text{sp}^3\text{s}^*$  BANDSTRUCTURES.** Coherent potential approximation (CPA) calculations of the electronic structure of the III-V ternary alloys  $\text{GaAs}_{1-x}\text{P}_x$ ,  $\text{Ga}_x\text{In}_{1-x}\text{As}$ ,  $\text{Ga}_{1-x}\text{Al}_x\text{As}$ ,  $\text{Ga}_x\text{In}_{1-x}\text{P}$ , and  $\text{GaSb}_{1-x}\text{P}_x$  are reported. Results are presented for the CPA self-energies, state densities, and band-bowing functions for these materials. The calculations utilize the  $\text{sp}^3\text{s}^*$  bandstructures as input into the Chen and Sher CPA formalism. The present work is the first utilization of these bandstructures in CPA calculations for ternary alloys and the first CPA treatment of  $\text{GaSb}_{1-x}\text{P}_x$ . In qualitative agreement with previous studies, the results of these

calculations show that alloy disorder effects are small for  $\text{GaAs}_{1-x}\text{P}_x$ , of moderate importance for  $\text{Ga}_x\text{In}_{1-x}\text{As}$  and  $\text{Ga}_x\text{Al}_{1-x}\text{As}$ , and relatively large for  $\text{Ga}_x\text{In}_{1-x}\text{P}$ . (Edited author abstract) 23 refs.

Shen, Yu-Tang (Texas Tech Univ, Lubbock, TX, USA); Myles, Charles W. *J Phys Chem Solids* v 48 n 12 1987 p 1173-1184.

**094370 POLARITY DETERMINATION IN  $\langle 111 \rangle$ -ORIENTED GaSb BY HIGH-RESOLUTION TRANSMISSION ELECTRON MICROSCOPY AT 300 kV.** The polarity of orientations of  $\langle 110 \rangle$  projected single crystals of tetrahedral compound semiconductors has been determined by high-resolution electron microscopy (HREM) at 300 kV. The method has been applied to GaSb and computer simulations show that the image contrast is the reverse of that expected intuitively. Similar results are predicted for GaAs. (Author abstract) 5 refs.

Wright, A.C. (Univ of Manchester Inst of Science & Technology, Manchester, Engl); Ng, T.L.; Williams, J.O. *Phil Mag Lett* v 57 n 2 Feb 1988 p 107-111.

**094371 TEMPERATURE DEPENDENCE OF  $X_1$ - $X_3$  SPLITTING ENERGY IN LIGHTLY DOPED GaP.** The splitting energy  $\delta$  between the  $X_1$ -band with an effective mass  $m_1^*$  and the  $X_3$ -band with  $m_2^*$ , and the effective mass ratio  $m_2^*/m_1^*$  for the conduction band on n-GaP were determined as a function of the temperature T by measuring the infrared absorption and fitting theoretical curves of the  $X_1 \rightarrow X_3$  absorption band. As T rises,  $\delta$  decreases as  $0.349 \cdot 6.83 \times 10^{-5} T^2 / (T + 460) [\text{eV}]$ , which can be explained by a faster shift of the upper  $X_3$ -band than the lower  $X_1$ -band toward the valence band. This empirical equation gives  $\delta = 316 \text{ eV}$  at 773 K. The  $m_2^*/m_1^*$  increases, which indicates that the upward-bending of the  $X_1$ -band has a stronger T-dependence than the  $X_3$  band. (Author abstract) 22 refs.

Endo, Tamio (Mie Univ, Tsu, Jpn); Sawa, Kazuhiro; Okino, Yasushi; Itoh, Nobuhiko; Sugiyama, Koichi. *Jpn J Appl Phys Part 1* v 27 n 1 Jan 1988 p 72-77.

**094372 CRYSTAL STRUCTURE OF  $\text{Ga}_2\text{Se}_{3-3x}\text{Te}_3$ .** Up to now, the quaternary system  $\text{Ga}_2\text{Se}_{3-3x}\text{Te}_3$  has been considered as completely miscible in the solid state. Nevertheless, Woolley and Smith concluded from the nonlinear dependence of the cubic lattice constant on the concentration parameter x that there should be an ordered compound in the vicinity of  $x = 0.25$ . The authors reinvestigated the system  $\text{Ga}_2\text{Se}_{3-3x}\text{Te}_3$  in this concentration region by means of X-ray powder diffraction and microprobe analysis. Samples were prepared either by sintering of powder mixtures of  $\text{Ga}_2\text{Te}_3$  and  $\text{Ga}_2\text{Se}_3$  at elevated temperatures or by reaction between a  $\text{Ga}_2\text{Se}_3$  crystal and a  $\text{Ga}_2\text{Te}_3$ -rich gas phase at 1000 K. The diffuse zinc-blende pattern does not transform to a sharp one, but to the new pattern of the tetragonal lattice. 4 refs.

Bredol, M. (Univ Muenster, Muenster, West Ger); Leute, V. *Phys Status Solidi A* v 107 n 1 May 1988 p K7-K10.

#### Substrates See Also SEMICONDUCTING ZINC COMPOUNDS—Growth.

**094373 PREPARATION CHIMIQUE DES SUBSTRATS GaSb (100) EN VUE DE L'EPITAXIE.** [Effects of Chemical Preparation of GaSb (100) Substrates on Epitaxy]. This paper presents the results of the chemical etching of the GaSb substrates. Auger electron spectroscopy for surface characterization was used. The authors have tested several etchants and selected one of them which gives smooth surfaces free of etch pits with not too much antimony depleted and with controllable etch rates. (Author abstract) 5 refs. In French.

Silga, M. (CNRS, Montpellier, Fr); Da Silva, F.W.O.; Raisin, C.; Lassabatiere, L. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 163-164.



## Surfaces

**094374 POLARIZATION DEPENDENCE OF OPTICAL TRANSITIONS IN GaP(110) AND GaAs(110) SURFACES STUDIED WITH SURFACE DIFFERENTIAL REFLECTIVITY.** We present results on the polarization dependence of Surface Differential Reflectivity in GaP(110) and GaAs(GaAs(110) surfaces. GaP(110) shows a transition at 2.8 eV which is excited only with the light electric vector parallel to the  $[11\bar{0}]$  direction; for the optical transition above 3.0 eV there is not any marked polarization dependence. GaAs(110) shows optical transitions between 2.6 and 4.0 eV which have a weak dependence on light polarization. (Author abstract) 14 refs.

Selci, S. (Univ di Roma 'Tor Vergata', Rome, Italy); Cicciacci, F.; Cricenti, A.; Felici, A.C.; Goletti, C.; Chiaradia, P. *Solid State Commun* v 62 n 12 Jun 1987 p 833-834.

**094375 THEORETICAL CONTRIBUTION TO THE LATTICE DYNAMICS OF GALLIUM ANTIMONIDE (110) SURFACE.** We calculate the bulk and (110) surface r.m.s thermal vibrations amplitude in GaSb by a simple analytical method. The bulk values are in good agreement with experimental and other theoretical data. The calculated surface enhancement factor of these thermal vibrations agrees with experimental fit data. The effect of long-range Coulomb interactions is also analyzed. (Edited author abstract) 15 refs.

Masri, P. (CNRS, Montpellier, Fr). *Solid State Commun* v 64 n 6 Nov 1987 p 933-936.

**094376 INTERACTION BETWEEN TWO SURFACE EXCITATIONS IN DEGENERATE POLAR SEMICONDUCTORS.** A systematic study of the interaction of surface plasmons with surface optical phonons is made for III-V group polar semiconductors, namely, GaSb, InSb, GaAs, InAs, GaP, and InP, to find the factors which can influence the coupling between the two modes of vibrations. It is found that the extent of coupling depends upon the Szegedi effective charge or the ionicity of the compound. (Edited author abstract) 17 refs.

Srivastava, K.S. (Univ of Lucknow, Lucknow, India); Sinha, Achla; Srivastava, Reena; Tandon, Ajay. *Phys Status Solidi B* v 146 n 1 Mar 1988 p 141-143.

**094377 PROPRIETES ELECTRONIQUES DES SURFACES DE GaSb ET AISb PREPAREES PAR EXPITAXIE PAR JETS MOLECULAIRES.** [Surface Electronic Properties of GaSb and AISb Prepared by Molecular Beam Epitaxy]. This paper deals with MBE grown GaSb and AISb (100) surfaces. After a brief description of the growth conditions, the authors detail some results obtained by EELS (primary electron energy 100 eV - 500 eV) and discuss the modifications of the spectra induced by oxygen adsorption and by annealing. (Author abstract) 3 refs. In French.

Da Silva, F.W.O. (CNRS, Montpellier, Fr); Raisin, C.; Lassabatre, L. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 233-234.

**094378 ETUDE DES SURFACES DE GaSb PAR LA METHODE D'ETUDE EN SPECTROSCOPIE DE PERTES D'ENERGIE DES ELECTRONS LENTS ENTRE 293 K ET 523 K.** [Study of GaSb Surfaces by Electron Energy Loss Spectroscopy Between 293 K and 523 K]. Results obtained on UHV (110) GaSb cleaved surfaces by electron energy loss spectroscopy (EELS) and the Kelvin method in the 293-523 K temperature range are given. At 293 K the comparison between EELS spectra from freshly and oxidized cleaved surfaces reveals deep modifications of the loss structures relative to the 5-10 eV energy range and to the surface exciton. When increasing temperature on freshly cleaved n and p-type GaSb surfaces, their work functions begin to rise at 320 K. At the same time, on freshly cleaved surfaces the loss structure from Sb-4d gets a better defined doublet at 32.5

and 33.7 eV. This structure vanishes at higher temperatures and begins to reappear around 500 K. (Author abstract) 4 refs. In French.

Bonnet, J. (CNRS, Montpellier, Fr); Soonckindt, L.; Vieujot, E.; Lassabatre, L. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 273-275.

## Switching

**094379 IMPEDANCE SWITCHING EFFECTS IN GaAs/AlAs BARRIER STRUCTURES.** AlAs tunnel barriers in MBE-grown GaAs layers have been studied using pulsed and continuous I/V and swept temperature/capacitance measurements. Such layers demonstrate an impedance switching phenomenon which is persistent and repeatable. This impedance switching is manifested by the device as two distinct impedance modes: a high-impedance mode (of the order of 10 k $\Omega$  at dc for a 0.3 mm dot), and a low-impedance mode (of the order of 10  $\Omega$ ). Such a phenomenon may restrict the operation of some devices, but may lead to other novel applications. (Author abstract) 3 refs.

Campbell, A.C. (Univ of Texas at Austin, Austin, TX, USA); Kesan, V.P.; Crook, G.E.; Maziar, C.M.; Neikirk, D.P.; Streetman, B.G. *Electron Lett* v 23 n 18 Aug 27 1987 p 926-927.

**Thermal Effects See SEMICONDUCTING GALLIUM ARSENIDE—Thermal Effects.**

**Thermal Properties See SEMICONDUCTING GALLIUM ARSENIDE—Thermal Properties.**

## Thermodynamic Properties

**094380 LATTICE VIBRATION AND THERMODYNAMICAL PROPERTIES OF ZINC-BLENDE TYPE SEMICONDUCTOR COMPOUND (GAP).** A six parameter non-central dynamic model for zinc blende compounds is developed which takes into account the covalent nature of atomic bonds. It is considered that during rotation, angles between bonds remain the same and only energy changes due to rotation of valence bonds formed by overlap of hybrid directional wave functions of neighbouring atoms. The dispersion curves, specific heat and Debye characteristic temperatures of GaP are calculated and compared with experimental data. The agreement is satisfactory. (Edited author abstract) 26 refs.

Ram, R.K. (SGR Post-Graduate Coll, Dobhi, India). *Modell Simul Control B* v 12 n 4 1988 p 1-14.

**094381 THERMODYNAMIC ANALYSIS OF THE CuGaSe<sub>2</sub>-In SYSTEM.** Liquidus and solidus curves have been calculated for the CuGaSe<sub>2</sub>-In system by assuming CuGa<sub>x</sub>In<sub>1-x</sub>Se<sub>2</sub> chalcopyrite or Ga<sub>x</sub>In<sub>1-y</sub>Se<sub>2</sub> layer structure alloys as the solid phases. We use the liquidus interaction parameters derived from solubility parameters, molar volumes and electronegativities of elements, whereas the solidus interaction parameters are taken as adjustable parameters for fitting to the experimental data. The obtained results indicate that the calculated liquidus points for In solutions containing high concentrations of CuGaSe<sub>2</sub> solute correspond to the CuGa<sub>x</sub>In<sub>1-x</sub>Se<sub>2</sub> solid phase and are fitted fairly well to the experimental data, and that the Ga<sub>x</sub>In<sub>1-y</sub>Se<sub>2</sub> is stable as the solid phase associated with liquid solutions containing lower concentrations of CuGaSe<sub>2</sub>. (Author abstract). 17 Refs.

Sugiyama, Koichi (Mie Univ, Tsu, Jpn). *J Cryst Growth* v 89 n 4 7(I) 1988 p 579-584.

**Thin Films See Also RAMAN SCATTERING—Mathematical Models; SEMICONDUCTING INDIUM COMPOUNDS—Thin Films.**

**094382 DOUBLE CRYSTAL X-RAY ROCKING CURVES OF MULTIPLE LAYER STRUCTURES.** Interference effects in double crystal x-ray rocking curves arising from the existence of a sub-micrometer layer sandwiched between two layers of different composition

are studied by simulation and experiment. For GaInAs structures on InP with a quarter micrometer middle layer, composition and thickness could be determined to an accuracy of 50 ppm and 50 Å respectively. There is an excellent consistency between interference structures and layer parameters deduced from various reflections. The sensitivity of the interference structures to other layer parameter variations is investigated. (Author abstract) 16 refs.

Chu, X. (Univ of Durham, Durham, Engl); Tanner, B.K. *Semicond Sci Technol* v 2 n 12 Dec 1987 p 765-771.

**094383 DETERMINATION DU PROFIL DE CONCENTRATION DE LA COUCHE DE TRANSITION DE HETEROSTRUCTURES Ga<sub>1-x</sub>Al<sub>x</sub>As/GaAs PAR RENDEMENT DE PHOTOEMISSION X.** [Determination of the Concentration Profile for the Transition Layer in Ga<sub>1-x</sub>Al<sub>x</sub>As/GaAs by X-Ray Photoemission]. The experimental measurement of X-ray photoemission jumps is carried out for Ga<sub>1-x</sub>Al<sub>x</sub>As/GaAs epitaxial heterostructures where a superficial thin film is first corroded by various chemical treatments. Assessment of the composition profile of the GaAlAs-GaAs interface region is realized by the non-destructive X-ray photoemission jump method. It shows that the results obtained are compatible with the characteristics of photocurrent spectra. (Author abstract) In French. 12 refs.

Bouabellou, A. (Univ de Constantine, Algeria); Schemelev, V.N.; Tagirov, I.R. *Thin Solid Films* v 155 n 2 Dec 30 1987 p 285-294.

**094384 INFLUENCE OF ION SPUTTERING ON AUGER ELECTRON SPECTROSCOPY DEPTH-PROFILING OF GaAs/AlGaAs SUPERSTRUCTURE.** The resolution of depth profiling by Auger electron spectroscopy (AES) changes depending on ion sputtering conditions due to implanted ion effects such as knock-on and cascade mixing. To evaluate the influence of these effects on depth profiling, profile broadening due to ion sputtering was measured using different levels of energy and species of ions. In addition, the altered layer's thickness was estimated. (Author abstract) 3 refs.

Matsunaga, Fumiko (Hitachi Ltd, Tokyo, Jpn); Kakibayashi, Hiroshi; Mishima, Tomonori; Kawase, Susumu. *Jpn J Appl Phys Part 1* v 27 n 1 Jan 1988 p 149-150.

**094385 CHEMICAL MODIFICATION OF GaP-CI THIN FILM PHOTOELECTRODES.** Modification of chlorogallium phthalocyanine (GaPc-CI) thin film photoelectrodes with thin films of polyvinylferrocene (PVF), thin films of PVF with incorporated ferricyanide, and thin films of a coprecipitated ferricinium-ferricyanide salt is demonstrated. The analysis of the coprecipitated ferricinium-ferricyanide salt demonstrates the formation of a Prussian Blue (PB)-like electroactive film. PVF films on bare gold were first characterized to demonstrate incorporation of ferricyanide during formation of ferricinium ions. This was followed by demonstration of the direct interaction of ferrocenium and ferricyanide, without the polymer, on bare gold, and on the Pc surface. GaPc-CI films overlaid with PB thin films formed from ferrocenium/ferricyanide can produce either negative or positive photopotentials, depending upon the dopant condition of the Pc layer, relying only upon the photoelectrochemical redox activity of the PB layer. (Edited author abstract). 23 Refs.

Nanthakumar, A. (Univ of Arizona, Tucson, AZ, USA); Armstrong, N.R. *J Electroanal Chem Interfacial Electrochem* v 248 n 2 Jul 8 1988 p 349-362.

**094386 RAMAN SCATTERING FROM PERIODIC AND NONPERIODIC GaSb/AISb STRAINED-LAYER LATTICES.** Raman scattering measurements have been performed on a series of periodic and nonperiodic strained-layer GaSb/AISb lattices. In the optical frequency region quantum confined longitudinal optic phonons are observed in GaSb layers when the layer width



is less than 25 Angstrom. Spatially extended interface modes lying within the LO-TO regions for both GaSb and AlSb are also seen. The interface mode frequencies are not well fit by current macroscopic theories. The confinement-induced  $\Gamma$ -to-L crossover in GaSb manifests itself via the observation of a scattering structure which resembles the optical phonon density of states. In structures grown with supercell or nonperiodic symmetry, the acoustic spectra display zone folding as well as nominally forbidden modes whose frequencies lie close to but are not exactly coincident with zone boundary phonons. Acoustic phonons in a quasiperiodic Fibonacci lattice have been measured and compared to periodic rational approximant lattices with (ABAAB) or (ABAABAAB) repeat units. (Author abstract) 36 refs.

Schwartz, G.P. (AT&T Bell Lab); Gualtieri, G.J.; Sunder, W.A.; Farrow, L.A. *Superlattices Microstruct* v 3 n 5 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 523-533.

**094387 CHARACTERISATION PAR DIFFRACTION X DES SUPER-RESEAUX GaAlAs-GaAs. IMPORTANCE DES TECHNIQUES ET DE LA PROCEDURE UTILISEES.** [Characterization by X-Ray Diffraction of GaAlAs-GaAs Superlattices. Importance of Techniques and Procedures Used]. X-ray diffraction techniques are at the present time widely used to determine the structural parameters of artificial semiconductor based superlattices. They can also reveal most of the peculiarities, or 'defects', of these structures, namely lateral and/or vertical variations of composition and thicknesses, substrate warpage and misorientation, provided the right set-ups and procedures are used. These defects and their effects on the X-ray diagrams are described, together with the most adequate experiments to bring them into view. (Author abstract) 6 refs. In French.

Auvray, P. (CNET, Lannion, Fr); Baudet, M.; Caulet, J. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 255-256.

**Transport Properties** See Also SEMICONDUCTING GALLIUM ARSENIDE—Plasmas.

**094388 TUNNELING STUDIES OF THE MINIBAND STRUCTURE OF A SUPERLATTICE.** It is now known that electron transport in narrow barrier superlattices proceeds by miniband conduction. However, previous experiments have been limited to studying electrons in the bottom of the first miniband. We report tunneling measurements which have enabled us to inject electrons into any position in the superlattice miniband structure. The MBE grown GaAs/(AlGa) As samples consist of an electron injector, an AlGaAs tunnel barrier and a superlattice. By biasing the structure we are able to control the electron injection energy, and the corresponding tunnel current shows pronounced negative differential resistance associated with the presence of minibands and band gaps. Analysis of the I-V characteristic shows that Bloch transport and not sequential tunneling is occurring. (Author abstract) 8 refs.

England, P. (Bell Communications Research Inst, Redbank, NJ, USA); Hayes, J.R.; Harbison, J.P.; Hwang, D.M. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 735-737.

## Vapor Deposition

**094389 REACTIONS OF TRIETHYLINDIUM AND TRIMETHYLGALLIUM WITH ARSINE GAS.** A study of the premature room temperature gas-phase reactions involved in the growth of GaInAs using  $\text{Et}_3\text{In}$ ,  $\text{Me}_3\text{Ga}$  and  $\text{AsH}_3$  was undertaken, using a specially designed mass spectrometer sampling system on a conventional, low pressure organometallic vapor phase epitaxy reactor. It was shown that the reaction of the  $\text{Et}_3\text{In-AsH}_3$  mixture could be described by reversible bimolecular reaction kinetics within the limits of experimental error, and evidence for an adduct is presented. The equilibrium constant for this system was determined as 30 Torr; the

rates of forward and reverse reactions were  $5 \text{ (Torr s)}^{-1}$  and  $0.17 \text{ s}^{-1}$  respectively. The  $\text{Me}_3\text{Ga-AsH}_3$  reaction was found to occur at room temperature in less than 0.2 s; as a result, only lower bounds for the equilibrium constant and the rate of forward reaction could be determined. 11 refs.

Agnello, Paul D. (Rensselaer Polytechnic Inst, Troy, NY, USA); Ghandi, Sorab K. *Sol Cells* v 24 n 1-2 May-Jun 1988, Proc 8th Photovoltaic Adv Res Dev Proj Rev Meet, Denver, CO, USA, Nov 15-18 1987 p 117-126.

**SEMICONDUCTING GERMANIUM** See Also LENSES—Costs; PARTICLE DETECTORS; RAMAN SCATTERING—Efficiency; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTOR DEVICES, MOSFET; SEMICONDUCTOR MATERIALS—Amorphous; SPECTROMETERS, PARTICLE.

**094390 GERMANIUM ENTERS A NEW ERA.** With IR imaging on the rise, germanium - a near-perfect material for IR lenses and windows - is making a comeback. A basic production flowsheet for germanium manufacture is discussed. Applications of germanium in optical fibers, IR photodetectors, and IR optics are described. 7 refs.

de Ruijter, Ignace. *Photonics Spectra* v 21 n 7 Jul 1987 p 55-56, 58-59.

**Amorphous** See Also SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Magnetic Properties.

**094391 EXAFS OF DISORDERED SYSTEMS.** EXAFS is a new tool for structure determination of materials. It complements the standard diffraction techniques and opens up new possibilities for systems not amenable to other methods. In an application to amorphous Ge, EXAFS showed that its structure is a continuous random network and not a microcrystalline state. However, in transforming to the crystalline state amorphous Ge was found to pass through a mixed amorphous-microcrystalline state. The crystallization is a continuous transition extending over a  $T_g$  range of at least 70°C. Even at the highest  $T_g$  of 370°C the sample has not fully crystallized. EXAFS was able to discern the distinction between the microcrystalline and amorphous states because of high resolution due to its capability to detect data to higher k-values than diffuse x-ray scattering. This high resolution also led to a more accurate characterization of the first coordination shell relative to the crystalline state. 7 refs.

Stern, E.A. (Univ of Washington, Seattle, WA, USA). *Phys Prop of Amorphous Mater, Proc of a Lect Ser, Bloomfield Hills, MI, USA, 1982-1983* Publ by Plenum Press, New York, NY, USA & London, Engl, 1985 p 201-219.

**094392 PHOTO-INDUCED EFFECTS IN AMORPHOUS Ge-S.** The authors report the results of experiments on light induced ESR (LESER), photoluminescence and photodarkening in Ge-S films. From these results, they propose a model to explain the present and previous results. In this model, all the defect centers have negative-U, but they have a broad distribution of the activation energy for recovery from  $D^0$  to  $D^+$  and  $D^-$ . An interesting point in this model is that the value of the activation energy changes by illumination and annealing reversibly because of the structural change surrounding the defect. Such a structural change is probably related to the photodarkening. An inducing rate of  $D^0$  by illumination is assumed to be correlated with the activation energy of the defect center. The present model is in contrast to the suggestion by Biegelsen and Street that prolonged illumination introduces additional defects, which have a relation with the photo-darkening. 13 refs.

Shimizu, Tatsuo (Kanazawa Univ, Kanazawa, Jpn); Kawachi, Genshiro; Kumeda, Minoru. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 173-183.

**094393 SPECTROSCOPIC ELLIPSOMETRY STUDIES OF VOID STRUCTURE IN OBLIQUELY DEPOSITED AMORPHOUS Ge FILMS.** It has been

demonstrated that spectroscopic ellipsometry studies yield significant information on the microstructure and the dielectric properties of obliquely deposited amorphous Ge films. A correlation between dielectric properties, columnar structure and density of voids has been established. We have used the SE technique to study the radiation induced giant structural densification phenomenon in obliquely deposited a-Ge-Se based films and structural relaxation effects in glow discharge a-Si films. 20 refs.

Chopra, K.L. (Indian Inst of Technology, New Delhi, India); Kumar, Satyendra. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 327-337.

**094394 STRUCTURE AND EXISTENCE OF THE FIRST SHARP DIFFRACTION PEAK IN AMORPHOUS GERMANIUM PREPARED IN UHV AND MEASURED IN-SITU.** The structure of 'glassy' germanium films prepared by slow sublimation of germanium on heated substrates in ultra-high vacuum was investigated using in-situ high-energy transmission electron elastic scattering. It is shown that on the basis of the presently available experimental evidence, there exists a number of important physical constraints as to the structure of amorphous germanium. Furthermore, a diffraction pre-peak has been observed, the first such observation in tetrahedrally bonded elemental amorphous semiconductor. This result is discussed in the light of similar observations in other disordered systems. The significance of short- and medium-range real space correlations in disordered systems is pointed out. (Edited author abstract) 35 refs.

Viscor, Petr (Roskilde Univ Cent, Roskilde, Den). *J Non Cryst Solids* v 101 n 2-3 May 1988 p 156-169.

**094395 INFLUENCE OF BOND-ANGLE AND DIHEDRAL-ANGLE DISORDERS ON THE TOP OF THE VALENCE BAND OF AMORPHOUS GERMANIUM.** The electronic structure of amorphous germanium (a-Ge) is considered using a tight-binding scheme with all first-neighbor couplings in a continuous random network. The dihedral-angle and bond-angle disorders are found to be important at the valence-band-edge and responsible for the observed features near the top of the valence band. At the top of the valence band of a-Ge a tail of localized states  $\approx 0.4 \text{ eV}$  in width is found. (Author abstract) 24 Refs.

Ratag, V.M. (Bandung Inst of Technology, Bandung, Indonesia). *Phys Status Solidi B* v 147 n 1 May 1988 p 243-251.

**Applications** See SEMICONDUCTOR COUNTERS—Performance.

## Calculations

**094396 MICROSCOPIC CALCULATION OF THE LATTICE DYNAMICS OF GERMANIUM USING PSEUDO-ATOMS.** The phonon frequencies of germanium are calculated using a quantum-mechanical dynamical matrix and the pseudo-atom expression for the change in charge density. A model pseudo-atom is constructed from Phillips' bond charge model with the dimensions of the bond charge taken from the static crystal: each pseudo-atom moves rigidly with its ion and is taken to consist of a central part and half of each adjacent bond charge. Without exchange-correlation (XC) effects, the calculated phonon spectrum is unsatisfactory with several acoustic modes being unstable. Several modifications of the model are tried but do not rectify this. An expression for the energy contribution caused by the SC effects is derived using perturbation theory. The implications of the treatment of the XC effects is discussed and so are some possible improvements to the model pseudo-atom. (Author abstract) 26 refs.

Ball, M.A. (Univ of Liverpool, Liverpool, Engl). *J Phys C Solid State Phys* v 20 n 25 Sep 10 1987 p 3795-3807.



### Charge Carriers See Also INFRARED RADIATION—Sensors.

**094397 DRIFT VELOCITY AND DIFFUSIVITY OF HOT CARRIERS IN GERMANIUM: MODEL CALCULATIONS.** A simple analytical model with two adjustable parameters is employed in describing the drift velocity and longitudinal diffusion coefficient of charge carriers (electrons and holes) in purified germanium, over a wide range of electric field ( $10\text{--}10^4$  v/cm). The effects of the lattice temperature for the range 130–300 K are considered, and a comparison with experimental data is made. The model may be used for the simulation of the behavior of germanium devices. (Edited author abstract) 19 refs.

Omar, M. Ali (Kuwait Univ, Kuwait); Reggiani, Lino. *Solid State Electron* v 30 n 12 Dec 1987 p 1351–1354.

**094398 RADIATION SPECTRA OF A SUBMILLIMETRIC LASER IN CYCLOTRON HOT HOLE TRANSITIONS IN GERMANIUM.** The spectra of submillimetric radiation of a laser based on cyclotron hot hole transitions in germanium are measured for the first time. The radiation is observed in the form of a monochromatic line  $\delta\nu \leq 0.1\text{ cm}^{-1}$  whose frequency is linearly and monotonically returned in a range of  $30\text{--}50\text{ cm}^{-1}$ . Intensity oscillations are detected. A new generation mechanism is used in discussing the results. (Author abstract) 7 refs.

Mityagin, Yu. A.; Murzin, V.N.; Stoklitskii, S.A.; Trofimov, I.E.; Chebotarev, A.P. *Sov Phys Lebedev Inst Rep* n 8 1987 p 11–14.

**094399 GENERATION OF HOT CARRIERS IN A SEMICONDUCTOR ROD WITH A NOTCH.** The current transport mechanism of the SOGICON-type Ge device is studied. Current-voltage characteristics were measured by applying pulsed voltage. As the voltage was increased, there appeared first a sublinear region in the current-voltage characteristics, and then current oscillation. From the present experiments, it was verified that the appearance of the sublinear region is ascribed to the generation of the hot carriers. (Author abstract) 3 refs.

Kamigaki, Tetsuya (Tokai Univ, Hiratuka, Jpn); Choe, Il Yong; Akiba, Yukio; Kurosu, Tateki; Iida, Masamori. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 692–693.

**094400 EXTRINSIC SELF-TRAPPING AND NEGATIVE U OF OXYGEN-RELATED THERMAL DONORS IN GERMANIUM.** The occurrence of some types of configurationally bistable thermal donors with negative effective correlation energy ( $U < 0$ ), that are formed at initial stages of heat treatment at  $T \leq 673\text{ K}$  of the oxygen containing germanium crystals is presented. The study of the equilibrium electron occupation containing germanium crystals is presented. The study of the equilibrium electron occupation function of three transforming thermal donors types enables one to obtain the values of  $U$  and the probability of double electron occupancy. By means of the kinetics of thermal donor transformation processes between two equilibrium configurations the activation energy and the cross-section for extrinsic self-trapping of charge carriers are determined. The results obtained are discussed in terms of very large lattice relaxation phenomena. (Author abstract). 23 Refs.

Litvinov, V.V. (Byelorussian State Univ, Minsk, USSR); Palchik, G.V.; Urenev, V.I. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 311–321.

### Chemical Vapor Deposition

**094401 VAPORIZATION OF GERMANIUM DIOSIDE.** Germanium dioxide vaporizes decomposing as  $\text{GeCl}_4(\text{g})$  and germanium metal. We have found it useful to study this system and to measure a set of pressures by the Knudsen and torsion effusion methods. This letter summarizes, for each run, the vapor pressure-temperature equations calculated by least-squares treatment of the results. 14 refs.

Piacente, Vincenzo (Univ 'La Sapienza', Rome, Italy);

Stranges, Stefano; Scardala, Paolo. *J Mater Sci Lett* v 6 n 8 Aug 1987 p 972–974.

**094402 GROWTH AND ETCHING OF GERMANIUM FILMS BY CHEMICAL VAPOR DEPOSITION IN A  $\text{GeCl}_4\text{--H}_2$  GAS SYSTEM.** The etching and growth of germanium films are investigated using a  $\text{GeCl}_4\text{--H}_2$  gas system in the temperature range of  $490\text{--}565^\circ\text{C}$ . At relatively low  $\text{GeCl}_4$  partial pressures less than  $2 \times 10^{-3}$  torr, epitaxial growth of Ge is observed on Ge (100) surfaces, whereas at  $\text{GeCl}_4$  partial pressures higher than  $2 \times 10^{-3}$  torr, etching of the Ge film is found to occur. In the experiments utilizing patterned substrates, where the surface consists of defined areas of Ge and  $\text{SiO}_2$ , Ge is found to deposit selectively only on the exposed Ge regions. The growth reactions of Ge epitaxial films proceed through the Langmuir-Hinshelwood mechanism: the surface reaction takes place between two hydrogen atoms dissociatively adsorbed and a surface-adsorbed  $\text{GeCl}_2$  molecule. (Edited author abstract) 18 refs.

Ishii, Hiromu (NTT, Atsugi, Jpn); Takahashi, Yasuo. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1539–1543.

**094403 FORMATION OF AMORPHOUS SEMICONDUCTORS BY CHEMICAL VAPOUR DEPOSITION FROM ORGANOGERMANIUM COMPOUNDS.** Attention is focused on chemical vapor deposition (CVD) from organometallics (OM) to produce (by a process known as OM-CVD) amorphous, thin-layer semiconductors from organogermanium compounds. Deposits from thermolyses of precursors (diluted  $1:10^4$  with helium) at atmospheric pressure in a quartz tube are collected on wafers of monocrystalline silicon, silica or alumina set on a heated graphite plate, and gaseous products are analyzed. Thermal stabilities decrease, and the compounds decompose at lower temperatures ( $150\text{--}200^\circ\text{C}$ ) than do the corresponding organosilicon compounds. Thermolysis mechanisms, deduced from gaseous products, are consistent with the presence of germynes as intermediates. The most thermolabile compounds decompose cleanly to form amorphous and homogeneous layers. Optical gaps, deduced from absorption spectra, are between 0.8 and 1.50 eV. (Edited author abstract) 27 refs.

Mazerolles, P. (Univ Paul Sabatier, Toulouse, Fr); Moranchio, R.; Reynes, A. *Silicon Germanium Tin Lead Compd* v 9 n 2–3 1986, Fifth Int Conf on the Organometall and Coord Chem of Germanium, Tin and Lead, Padua, Italy, Sep 7–11 1986 p 155–183.

### Contamination

**094404 THERMODYNAMICS OF THE REACTION BETWEEN A GERMANIUM MELT AND QUARTZ GLASS.** The results of a thermodynamic calculation show that reduction of quartz glass may be the cause of its contaminating action during contact with a germanium melt. In the  $1300\text{--}1900\text{ K}$  range the main components of the vapor phase above the germanium melt/quartz glass system should be germanium monoxide, germanium and silicon monoxide. The silicon content in the germanium is determined by the oxygen partial pressure above the system, an increase in which should cause a decrease in the silicon content in the melt. 11 refs. In Russian.

Devyatich, G.G.; Krasnova, S.G.; Pronchatov, A.N. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 1027–1030.

### Crystallization

**094405 INFLUENCE OF THE INTERFACE ON THE CRYSTALLIZATION OF AMORPHOUS GE IN PD/GE MULTILAYERS.** The amorphous to crystalline phase transition of Ge in contact with Pb has been extensively investigated in Pb/Ge multilayers. We find that the Ge crystallizes at reduced temperatures in the range of  $100\text{--}200^\circ\text{C}$  depending on the thickness of the Ge and the Pb. Simultaneously the texture of the Pb improves and the layered structure completely disappears. It is suggested that the basis for the reduction of the crystallization temperature is the enhanced diffusion kinetics at

the interface, caused by the adjacent Pb layer. (Author abstract). 21 refs.

Sevenhans, W. (Katholieke Univ Leuven, Louvain, Belg); Locquet, J.-P.; Bruynseraede, Y.; Homma, H.; Schuller, Ivan K. *Phys Scr* v 38 n 3 Sep 1988 p 426–428.

### Defects

**094406 STACKING-FAULT ENERGIES IN SEMICONDUCTORS FROM FIRST-PRINCIPLES CALCULATIONS.** A procedure to calculate stacking-fault energies in semiconductors from first principles without the need to perform large supercell calculations is proposed. This procedure is applied to calculate the energies of extrinsic and intrinsic stacking faults in germanium and silicon carbide using recently published total-energy calculations as input. The sign of the extrinsic-stacking-fault energy is proposed as an indicator for the occurrence of polytypism, in accordance with a recently proposed explanation of polytypism based on an ANNNI model. (Author abstract) 13 refs.

Denteneer, P.J.H. (Eindhoven Univ of Technology, Eindhoven, Neth); van Haeringen, W. *J Phys C Solid State Phys* v 20 n 32 Nov 20 1987 p L883–L887.

**094407 INVESTIGATION OF DISLOCATION MOBILITIES IN GERMANIUM IN THE LOW-TEMPERATURE RANGE BY IN SITU STRAINING EXPERIMENTS.** The mobility of screw and  $60^\circ$  dislocations in thin, single-crystal foils of germanium has been studied by in situ tensile testing in a high-voltage electron microscope operating at 400 kV, at stresses around 40 MPa and temperatures around  $400^\circ\text{C}$ . The velocity of the dislocations was found to depend strongly on their length, and this is discussed in terms of a double-kink mechanism with a high lattice friction on kinks. Activation energies for kink formation and migration are deduced from fits of the velocity-length curves, and discussed in terms of core structures of partial dislocations. (Author abstract) 19 refs.

Louchet, F. (Domaine Univ, St. Martin d'Heres, Fr); Brechet, Y.; Pellissier, J.; Muchy, D. *Philos Mag A* v 57 n 2 Feb 1988 p 327–335.

**094408 ATOMIC STRUCTURES AND ELECTRON SPECTRAL OF (110) SMALL-ANGLE BOUNDARIES IN GERMANIUM BICRYSTALS.** An examination of the dislocation's structure and electronic parameters of small-angle boundaries can elucidate some features of the excitation structure and spectrum for the electron subsystem and can enable one to extrapolate the results to not excessively small inclination angle, including ones allowing of quasi-two-dimensional conductivity. One can examine DLTS spectra associated with these boundaries in n-type germanium bicrystals. The DLTS spectrum was measured by applying a regular train of voltage pulses, with the charge at the boundary relaxing in the intervals between pulses towards the equilibrium value on account of thermal ejection for electrons trapped during the pulses. The changes in level population at the boundary were determined by measuring the nonequilibrium capacitance and resistance. In both cases, the measured DLTS spectra were identical. 10 refs.

Belyavskii, V.I.; Orlov, A.N.; Shreter, Yu.G. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17–22 1986 p 133–137.

### Deformation

**094409 MAGNETISM OF PLASTICALLY DEFORMED Ge AND Si CRYSTALS.** Susceptibility  $\chi$  of plastically deformed Ge and Si single crystals was investigated. The plastic deformation leads to the appearance of dependence  $\chi$  on the magnetic field value and then to the decrease of Ge and Si single crystals diamagnetism. The peculiarities of the behavior are interpreted on the basis of the suggested ferromagnetic properties of dislocations. (Author abstract) 9 refs.

Tsmots, V.M. (Acad of Sciences of the Ukrainian SSR,



Kiev, USSR); Shakhovtsov, V.I.; Shindich, V.L.; Shpinar, L.I.; Shubak, M.I.; Stym, V.S.; Yaskovets, I.I. *Solid State Commun* v 63 n 1 Jul 1987 p 1-3.

## Density

**094410 IN-SITU MEASUREMENTS OF THE DENSITY OF AMORPHOUS GERMANIUM PREPARED IN ULTRA-HIGH VACUUM.** A non-destructive, in-situ technique has been used to determine the density of amorphous germanium films, prepared in ultra-high vacuum by slow sublimation onto heated single crystal sapphire substrates. Contrary to previous results, a density deficit with respect to the crystal has been observed. It is pointed out that the density deficit with respect to the crystalline phase (where such exists) is a general feature common to all bulk glasses and that it should be considered also as a characteristic structural feature of a stable state of amorphous germanium. The apparent thickness dependence of the measured density is discussed in terms of a single relaxation mechanism. (Author abstract) 14 refs.

Viscor, Petr (Roskilde Univ Cent, Roskilde, Den). *J Non Cryst Solids* v 101 n 2-3 May 1988 p 170-178.

## Doping See Also CRYSTALS—Growing.

**094411 BERYLLIUM-HYDROGEN AND ZINC-HYDROGEN SHALLOW ACCEPTOR COMPLEXES IN GERMANIUM.** New shallow acceptor complexes with hydrogenically-spaced excited states have been discovered in intentionally-doped crystals of otherwise ultra-pure germanium. The doping consists of  $> 10^{14}$  cm $^{-3}$  of group II impurities, and the crystal were grown under hydrogen atmosphere. The identification proposed is that of a hydrogen-group II impurity complex, with piezospectroscopic behavior of a  $\langle 111 \rangle$ -oriented defect. (Edited author abstract) 24 refs.

McMurray, Robert E. Jr. (Lawrence Berkeley Lab, Berkeley, CA, USA); Haegel, N.M.; Kahn, J.M.; Haller, E.E. *Solid State Commun* v 61 n 1 Jan 1987 p 27-32.

**094412 SOLID SOLUTIONS OF THE Ge-Si SYSTEM NEAR PURE GERMANIUM.** In a study of the electrophysical properties of solid solutions of the germanium-silicon system anomalies near pure germanium (0.04 at. % Si) were noted at high temperatures. These anomalies are attributed to structural transformations of the matrix occurring as a result of an interaction between atoms of the doping impurity and germanium point defects. In Russian. 9 refs.

Ugai, Ya.A.; Bondarev, Yu.M.; Goncharov, E.G.; Khoviv, A.M. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 12 Dec 1987 p 1945-1947.

## Electric Breakdown

**094413 HALL-EFFECT MEASUREMENTS DURING LOW-TEMPERATURE AVALANCHE BREAKDOWN OF p-GERMANIUM.** We have determined the electric transport properties in the pre- and post-breakdown regime of p-germanium at low temperatures from conductivity and Hall-effect measurements. The breakdown mechanism is demonstrated to involve a mobility which depends sensitively upon the density of the mobile charge carriers. (Author abstract) 8 refs.

Parisi, J. (Univ Tuebingen, Tuebingen, West Ger); Peinke, J.; Rau, U.; Mayer, K.M. *Phil Mag Lett* v 57 n 6 Jun 1988 p 311-314.

## Electric Properties

**094414 SPATIO-TEMPORAL INSTABILITIES IN THE ELECTRIC BREAKDOWN OF p-GERMANIUM.** Investigating the impact-ionization-induced avalanche breakdown in homogeneously doped p-germanium samples cooled to liquid-helium temperatures, we observed the spontaneous formation of current oscillations and current filaments in a highly nonlinear regime of the current-voltage characteristic. The spontaneous current

oscillations exhibit typical nonlinear dynamics as different routes to chaos under small variation of a control parameter. Self-organized emergence of quasiperiodic and mode-locked states can be ascribed to the simultaneous presence of two and more competing fundamental oscillatory modes intrinsic to our semiconductor system. Due to the coupling of the corresponding localized oscillation centers, typical nonlinear phenomena known from the circle-map formalism can be observed. We report on the spatially resolved observation of current filament patterns developing during avalanche breakdown. Two-dimensional imaging of the nucleation and the dynamics of the current filaments has been obtained by low-temperature scanning electron microscopy. These self-generated spatial structures are closely linked to the nonlinear shape of the current-voltage characteristic. Combining spatially and time-resolved measurements enables the localization of the temporal current instabilities in the boundary region of the current filaments. (Edited author abstract) 12 refs.

Peinke, J. (Univ Tuebingen, Tuebingen, West Ger); Parisi, J.; Roehricht, B.; Mayer, K.M.; Rau, U.; Huebener, R.P. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 817-820.

## Electromagnetic Field Effects

**094415 NEW RESULTS ON STIMULATED EMISSION FROM p-GERMANIUM IN CROSSED FIELDS.** The spectrum of the stimulated far infrared emission from p-germanium in crossed electric and magnetic fields is studied by means of a tunable narrowband GaAs-detector. A multimode spectrum is observed from mirrorless samples and quantitatively explained in terms of waveguide-like modes. (Author abstract) 11 refs.

Helm, M. (Univ of Innsbruck, Innsbruck, Austria); Unterrainer, K.; Gornik, E.; Haller, E.E. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 759-762.

## Electronic Properties

**094416 STUDIES ON THE ELECTRONIC ENERGY STATES OF GERMANIUM MICROCRYSTAL AND THE CHEMICAL SHIFT DUE TO SURFACE OXIDIZATION BY MEANS OF PHOTOELECTRON SPECTROSCOPY.** The energies of electronic states in the germanium microcrystals which were made by evaporation in inert gas (He) at low pressure were deduced from the photoelectron spectra induced by X-ray and ultraviolet irradiations. The valence band structure of the microcrystal which has the size ca. 4 nm in diameter was similar to that of the amorphous state. The origin may be due to a change in the many-body effect, an interaction between a hole and an electron, and/or multi-scattering of an electron originating in the imperfection in the structure of a microcrystal. The energies of inner-core electrons of a microcrystal which has size ca. 4 nm were the same as that of the bulk. The chemical shift due to oxidation of a powder-like microcrystal differs from that of the bulk surface. (Author abstract) 6 refs.

Arai, Toshihiro (Univ of Tsukuba, Sakura, Jpn); Tagawa, Reiji. *Jpn J Appl Phys Part 1*, v 26 n 11 Nov 1987 p 1850-1854.

**094417 QUANTUM LIMIT CYCLOTRON RESONANCE IN Ge - ACOUSTIC DEFORMATION POTENTIAL SCATTERING.** Electron cyclotron resonance linewidth in pure Ge has been studied for acoustic deformation potential scattering in the quantum limit. The relaxation time derived therefrom is obtained as a function of temperature (10 to 160 K) and magnetic field (17 to 75 kG). The inverse relaxation time for acoustic deformation potential scattering in the quantum limit is found to be proportional to temperature and to the square root of the magnetic field. These experimental results are explained qualitatively by Meyer's prediction. (Author abstract) 25 refs.

Kobori, H. (Osaka Univ, Toyonaka, Jpn); Ohya, T.; Otsuka, E. *Solid State Commun* v 64 n 1 Oct 1987 p 35-39.

## 094418 INELASTIC SCATTERING TIME OF

**ELECTRONS IN METALLIC Ge:Sb.** We measured the negative magnetoresistance in Ge:Sb at low temperatures, and derived the inelastic scattering time applying the localization theory. The inelastic scattering time shows, above liquid He temperatures,  $T^{-3/2}$  dependence which is due to the electron-electron interaction in a dirty medium. Below about 1 K temperature the dependence is weaker. It is not explained by the spin scattering independent of temperature, and indicates the inelastic scattering time or the spin scattering having weak temperature variation. (Author abstract) 14 refs.

Ootuka, Youiti (Univ of Tokyo, Tokyo, Jpn); Matsuoka, Hideyuki; Kobayashi, Shun-ichi. *Disord Semicond Publ* by Plenum Press, New York, NY, USA and London, Engl, 1987 p 91-96.

**094419 TWO TYPES OF GENERATION OF STIMULATED SUBMILLIMETRIC RADIATION OF HOT HOLES IN LIGHTLY DOPED GERMANIUM CRYSTALS.** Two types of generation of stimulated radiation of hot holes in intersubzone transitions and in cyclotron type transitions are recorded for the first time in the same p-Ge crystal. The characteristics of the phenomenon and a generation model, which considers the anti-intersection Landau levels, and movement of the wave functions of light and heavy holes in a state with an identical total energy with crossed E/H fields are discussed. (Author abstract) 11 refs.

Melnichuk, I.M.; Mityagin, Yu.A.; Murzin, V.N.; Stoklit-skii, S.A.; Trofimov, I.E.; Efimov, Yu.A. *Sov Phys Lebedev Inst Rep* n 12 1987 p 1-5.

**094420 EFFECT OF INTERACTION AND SEPARATION OF LANDAU LEVELS OF LIGHT AND HEAVY HOLES IN GERMANIUM IN CROSSED ELECTRICAL AND MAGNETIC FIELDS.** The energy spectrum of the valent zone of germanium is calculated in crossed electrical and magnetic fields. Separation of the Landau levels and formation of mixed states of the light and heavy holes at the level intersection points are discovered. The influence of these phenomena on the characteristics of laser generation of radiation in a system of hot carriers is discussed. (Author abstract) 8 refs.

Murzin, V.N.; Stoklit-skii, S.A. *Sov Phys Lebedev Inst Rep* n 12 1987 p 36-40.

**094421 TIGHT BINDING MODELS FOR NON IDEAL SEMICONDUCTOR INTERFACES.** The electronic structure of the (100) Ge-GaAs is studied for a non ideal model which assumes a stoichiometrically disordered interface. By using an empirical tight binding model with a 1s 3p basis, which suffices to describe reasonably the valence bands, and by employing a method of calculation based on the Surface Green Function Matching formalism a fairly simple calculation can be set up which explains adequately the experimentally established semiconductor nature of this interface. (Author abstract) 17 Refs.

Munoz, M.C. (CSIC, Madrid, Spain); Velasco, V.R.; Garcia-Moliner, F. *Prog Surf Sci* v 26 n 1-4 1987 p 117-133.

## Etching

**094422 CHEMICAL ETCHING OF GERMANIUM.** Epitaxial germanium is an important material for the fabrication of tandem solar cells and long wavelength photodetectors. The polishing of germanium substrates, prior to germanium epitaxy, is thus an important step. A series of etching experiments have been conducted to evaluate chemical etches for this approach. It is found that the most satisfactory surfaces are obtained with a 2-3 min treatment in  $\text{HNO}_3:\text{CH}_3\text{COOH}:\text{H}_2\text{O}$  in an 18:8:5 ratio by volume. (Author abstract) 7 Refs.

Ghandhi, S.K. (Rensselaer Polytechnic Inst, Troy, NY, USA); Ayers, J.E. *J Electrochem Soc* v 135 n 8 Aug 1988 p 2053-2054.



## Grain Boundaries

**094423 CHARACTERIZATION OF POLYCRYSTALLINE GERMANIUM BY EBIC.** The electron-beam-induced-current (EBIC) mode of a scanning electron microscope has been used to characterize the electrical activity of the grain boundaries in germanium. The boundaries have been characterized from a structural point of view using electron channeling patterns (ECP) and X-ray topography. The low-angle boundaries in Ge polycrystals show an EBIC contrast  $C$  which increases when the beam energy increases, while the  $\Sigma 3$  twins do not show a significant activity even when there is a deviation from the coincidence orientation. The collection efficiency of  $\eta$  of Schottky contacts has been measured. Both  $C$  and  $\eta$  measurements cannot be quantitatively analyzed using previously existing models. The basic ideas which should lead to a better modeling are discussed. (Author abstract) 20 refs.

Tabet, Nouar (CNRS, Meudon, Fr); Monty, Claude. *Philos Mag B* v 57 n 6 Jun 1988 p 763-776.

**094424 STRUCTURE AND ELECTRICAL PARAMETERS OF GRAIN-BOUNDARY DISLOCATIONS IN GERMANIUM.** Calculations have been performed on atomic structures by the use of various atomic potentials in examining grain boundaries close to boundaries with reversed densities of  $\Sigma=9$  coincidence nodes. (Author abstract) 18 refs.

Moller, H.J. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 138-143.

**094425 GRAIN-BOUNDARY CONDUCTIVITY IN GERMANIUM.** Measurements have been made on the two-dimensional conductivity for large-angle grain boundaries in germanium bicrystals. The bound-hole model originally devised for boundaries of various types is found to be applicable to these boundaries. (Author abstract) 12 refs.

Labusch, R.; Tumel, H. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 156-161.

**Impurities** See Also SEMICONDUCTING SILICON—Impurities.

**094426 ENHANCED RECOMBINATION THROUGH DEEP IMPURITIES WITHIN ELECTRON-HOLE LIQUID IN GERMANIUM.** Effect of deep double acceptors, Be and Zn, on electron-hole recombination in electron-hole liquid in Ge is studied by means of time-resolved photoluminescence measurements. Non-radiative recombination is strongly enhanced by the double acceptors. Recombination rate per impurity is  $7.2 \times 10^{10} \text{ cm}^3 \text{ s}^{-1}$  for Be, or  $2.6 \times 10^{-10} \text{ cm}^3 \text{ s}^{-1}$  for Zn, more than ten times as large as that for shallow acceptor In,  $2.2 \times 10^{-11} \text{ cm}^3 \text{ s}^{-1}$ . (Author abstract) 5 refs.

Ogaka, Kensuke (Osaka Univ, Toyonaka, Jpn); Ohyama, Tyuzi; Otsuka, Eizo. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 493-494.

## Ion Implantation

**094427 EFFECT OF  $\text{N}_2^+$ -ION IMPLANTATION ON ELECTRONIC PROPERTIES OF AMORPHOUS Ge.** The effect of introduction of large number of defects on the electrical properties of a-Ge film has been studied. Deposits of a-Ge of thickness 2000 Angstrom were obtained by evaporating 99.99% pure germanium from an Mo boat on to clean glass substrates with pre-deposited Al electrodes. After low temperature dc conductivity measurements, the samples were bombarded with  $\text{N}_2^+$  ions of 30 and 45 keV energy at room temperature and conductivity measurements repeated for bombarded films. The slopes of the plots of  $\ln \sigma_{dc}$  versus  $T^{-1/4}$  indicate that the density of localized states increase

considerably on ion implantation but return to the values before ion implantation on annealing at  $100^\circ\text{C}$  for 30 min, indicating the process of creation of defects is reversible. (Author abstract) 1 ref.

Hulsurkar, Ujwala V. (Marathwada Univ, Aurangabad, India); Chandole, S.V.; Shah, S.S. *Indian J Pure Appl Phys* v 25 n 3 Mar 1987 p 135-136.

## Ionization

**094428 ORIENTATION DEPENDENT SURFACE DIPOLE AND FERMI-LEVEL POSITION ON A CLEAN Ge CYLINDER.** Photoelectron spectroscopy was used to measure the orientation-dependent photoionization threshold  $\xi$  ( $\alpha$ ) and Fermi-level pinning position ( $E_v - E_F$ ) at the surface. A cylindrically shaped Ge sample was prepared to allow in situ investigations. The comparison between Ge, Si, GaAs and W data confirms that relaxation-induced dipoles determine  $\xi$  ( $\alpha$ ) on nonpolar semiconductors. The variation of the pinning position shows distinct features. (Edited author abstract) 11 refs.

Kuhr, H.J. (Max-Planck-Gesellschaft, Berlin, West Ger); Ranke, W. *Solid State Commun* v 61 n 5 Feb 1987 p 285-287.

## Low Temperature Properties

**094429 SPATIALLY RESOLVED OBSERVATION OF CURRENT FILAMENT DYNAMICS IN SEMICONDUCTORS.** Two-dimensional imaging of the nucleation and the dynamics of current filaments generated in homogenous p-doped germanium at 4.2 K during impurity impact ionization induced avalanche breakdown has been performed. The images were obtained by scanning the specimen surface with an electron beam and by recording the beam-induced current change in the voltage-biased samples. This new method is expected to identify in particular the filament configurations showing chaotic temporal resistance behavior. (Author abstract) 8 refs.

Mayer, K.M. (Univ Tuebingen, Tuebingen, West Ger); Gross, R.; Parisi, J.; Peinke, J.; Huebener, R.P. *Solid State Commun* v 63 n 1 Jul 1987 p 55-59.

## Marketing

**094430 SPECIAL FEATURES OF GERMANIUM AND GALLIUM SUPPLY AND DEMAND.** Gallium and germanium both find their main uses in the electrical and electronics sector, more than three-quarters of total world consumption of germanium and more than 90% of that of gallium being attributable to electronic and optoelectronic applications. An attempt has been made to identify the main features that govern supply and demand and to explain how these characteristics distinguish them from the tonnage base metals that are traded on the world's metal exchanges. Technological factors associated with their production and usage rather than the availability and supply of their mineral ores are the principal determinants of market stability for both germanium and gallium. 13 refs.

Jacobson, D.M. (GEC Hirst Research Cent, Wembley, Engl). *Trans Inst Min Metall Sect C* v 97 Mar 1988, Proc of the Twelfth Annu Comm Mod Meet of the Inst of Min and Metall, London, Engl, Dec 3 1987 p 45-48.

**Optical Properties** See Also SEMICONDUCTING SILICON—Optical Properties.

**094431 FAR-INFRARED OPTICAL CONSTANTS, QUANTUM EFFICIENCY AND INTERNAL QUANTUM YIELD OF DETECTOR-QUALITY GALLIUM-DOPED GERMANIUM.** The temperature variations of the optical constants of detector quality gallium doped germanium have been determined between 4.7 and 295 K in the spectral region from 30 to  $130 \text{ cm}^{-1}$ . The 4.7 K absorption and refraction spectra were used to calculate the expected quantum efficiency of a Ge:Ga photoconductor having similar geometric and electrical characteristics to those used in earlier detector studies. A

comparison of this with measurements of the photoconductive response of such a detector allowed the spectral variation, of the internal quantum yield of photoexcited free carriers to be studied. (Author abstract) 13 refs.

Leotin, J. (INSA, Toulouse, Fr); Barre, S.; Laverny, C.; Goiran, M.; Birch, J.R. *Infrared Phys* v 28 n 3 May 1988 p 165-172.

**094432 FAR-INFRARED OPTICAL PROPERTIES OF QUENCHED GERMANIUM. V: UNIAXIAL STRESS EFFECTS ON THE  $\text{SA}_1$  ACCEPTORS.** Far-infrared absorption spectra of quenched germanium were measured under a uniaxial stress along the  $\langle 100 \rangle$ ,  $\langle 110 \rangle$  and  $\langle 111 \rangle$  crystallographic orientations. It is concluded from the analyses of the number of the bands split with stress and from the feature of splitting of each band that the  $\text{SA}_1$  acceptor, which is the shallowest one in the quenched-in acceptors and has a ground state split into two levels without a uniaxial stress, is constructed from a defect in which the symmetric axis is along a  $\langle 111 \rangle$  crystallographic axis. (Edited author abstract) 20 Refs.

Hattori, Takeshi (Osaka Univ, Osaka, Jpn); Yamano, Koji; Mitsuishi, Akiyoshi; Kamiura, Yoichi. *Jpn J Appl Phys Part 1* v 27 n 5 May 1988 p 776-783.

**094433 PICOSECOND RAMAN SCATTERING FROM NON-EQUILIBRIUM LO AND TO PHONONS IN GERMANIUM.** The temporal evolution of non-equilibrium LO and TO phonon populations in photo-excited Ge was monitored at 77K and 300K using a picosecond Raman scattering technique. In addition to demonstrating that significant non-equilibrium populations are produced in non-polar semiconductors, the results also indicate that carrier-TO phonon interactions are of similar strength to carrier-LO phonon interactions. The phonon lifetimes and non-equilibrium populations are discussed and compared with data obtained by others in GaAs. (Author abstract) 17 refs.

Young, J.F. (Natl Research Council, Ottawa, Can); Wan, K.; van Driel, H.M. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 455-458.

**094434 FAR IR LUMINESCENCE OF HOT HOLES IN Ge: DIAGNOSTICS OF INTERSUBBAND POPULATION INVERSION AND EFFECTS OF UNIAXIAL STRESS.** The effect of 'flare up' of the far IR luminescence of hot holes in Ge with application of the magnetic field  $\vec{H} \parallel \vec{E}$  was used to diagnose the population inversion of h-1 transitions. The heating of p-Ge samples by the pulses of a strong electric field was used in temperature investigation of the luminescence. Threshold temperatures of far IR emission gain of hot holes at  $\vec{E} \perp \vec{H}$  fields were estimated. The effect of uniaxial stress on hot hole luminescence was investigated. (Author abstract) 8 refs.

Gavrilenko, V.I. (Acad of Sciences of the USSR, Gorky, USSR); Korotkov, A.L.; Krasyl'nik, Z.F.; Nikonov, V.V.; Pavlov, S.A. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 755-758.

## Oxidation

**094435 NATIVE OXIDES FORMED ON SINGLE-CRYSTAL GERMANIUM BY WET CHEMICAL REACTIONS.** The preparation of stable oxide films on single-crystal germanium surfaces by a room temperature 'wet' chemical oxidation technique is described. Characterization by IR-transmission, ellipsometry, x-ray photoelectron spectroscopy, Rutherford backscattering, and electron microscopy show that such films are dense, uniform, and free of defects. The oxides are a mixture of two germanium dioxide phases both of which have a cristobalite atomic configuration. Unlike hexagonal germania, these films are stable in both water and hydrofluoric acid. They can be totally converted to the hexagonal dioxide phase by heat-treatment in either oxygen or nitrogen ambient at  $600^\circ\text{C}$ . The growth kinetics, mechanisms and morphologies of the oxides formed by this method are presented. (Edited author abstract) 18 refs.



Gregory, O.J. (Univ of Rhode Island, Kingston, RI, USA); Pruitt, L.A.; Crisman, E.E.; Roberts, C.; Stiles, P.J. *J Electrochem Soc* v 135 n 4 Apr 1988 p 923-929.

## Physical Properties

**094436 EXPERIMENTAL STUDY OF THREE GROUND STATE COMPONENTS OF THE HYDROGEN-OXYGEN DONOR IN GERMANIUM.** Experimental results are presented which show the existence of a ground state manifold consisting of at least three (IS) levels associated with the hydrogen-oxygen donor D(H,O) in ultra-pure germanium. Photothermal ionization spectra were recorded as a function of temperature. In addition to the transitions arising from the stress-insensitive ground state (GS), at  $T = 6K$ , a low intensity hydrogenic series of lines is observed with energies 2.51 meV smaller than from the GS, arising from a (IS) energy level lying 1.57 meV above the GS. Above 7K a further weak transition is observed at 2.97 meV less than the GS series, arising from an energy level 1.94 meV above the GS. A multicomponent (IS) manifold has been predicted by two theoretical models. Our experimental results allow the determination of the model parameters and are consistent with the predictions of the tunneling hydrogen model when an excited state splitting of 0.98 meV due to two nuclear configurations is included. (Edited author abstract) 16 refs.

Navarro, H. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Griffin, J.; Haller, E.E.; McMurray, R.E. Jr. *Solid State Commun* v 64 n 10 Dec 1987 p 1297-1303.

**094437 DETERMINATION OF CNDO PARAMETERS FOR GERMANIUM AND THEIR APPLICATION TO SIMPLE GERMANIUM MOLECULES.** The authors have obtained a set of CNDO (Complete Neglect of the Differential Overlap) parameters for crystalline germanium that can reproduce, to high accuracy, the experimental values for the cohesive energy, the valence bandwidth and the equilibrium internuclear separation for a perfect Ge crystal. The CNDO method is then used to calculate the equilibrium bond lengths of simple molecules of Ge. The results are compared with experimental data. This set of parameters may be useful for defect studies in Ge. (Edited author abstract). 19 Refs.

Ong, C.K. (Nat'l Univ of Singapore, Singapore); Khoo, G.S. *J Phys Chem Solids* v 49 n 8 1988 p 883-886.

## Radiation Effects

**094438 HIGH CONTRAST LASER WRITING IN IN SITU TEXTURED GERMANIUM FILMS VIA A NOVEL CHEMICAL OXIDE FORMATION.** A high contrast laser wiring technique based on laser induced efficient chemical oxidation in situ textured Ge films is demonstrated. Free running Nd-YAG laser pulses are used for irradiating the films. The irradiating effects have been characterized using optical microscopy, electron spectroscopy and microdensitometry. The mechanism for the observed contrast has been identified as due to formation of GeO<sub>2</sub> phase upon laser irradiation using X-ray initiated Auger spectroscopy (XAES) and X-ray photoelectron spectroscopy (XPS). The contrast in the present films is found to be nearly five times more than that known due to GeO phase formation in similar films. (Author abstract) 9 refs.

Rao, L. Kameswara (Indian Inst of Science, Bangalore, India). *Opt Commun* v 65 n 4 Feb 15 1988 p 239-242.

**Recovery See SEMICONDUCTOR MATERIALS—Etching.**

**Specific Heat See SEMICONDUCTING SILICON—Thermal Properties.**

## Spectroscopic Analysis

**094439 PIEZO-SPECTROSCOPY OF THE C LINE OF GALLIUM IN GERMANIUM.** Experimental results are presented on the behavior of the C line of gallium

impurity in germanium under uniaxial compression along a  $\langle 100 \rangle$  direction. The C line stress spectrum is found to have ten components arising from the splitting of a complex final state consisting of the closely spaced combination:  $1\Gamma_7^- + 3\Gamma_8^- + 3\Gamma_8^+$ . The participation of the even parity state in the C transition has not been previously reported. Recent theoretical calculations are shown to give splitting values in agreement with these results. (Edited author abstract) 13 refs.

Vickers, R.E.M. (Univ of Wollongong, Wollongong, Aust); Fisher, P.; Freeth, C.A. *Solid State Commun* v 65 n 4 Jan 1988 p 271-274.

**094440 IR-SPECTROSCOPY OF IMPURITY COMPLEXES IN GERMANIUM.** A large number of impurity complexes which create shallow levels, have been discovered in pure and doped germanium single crystals. The structure and the composition of several of these complexes have been determined using far-infrared spectroscopy and information about crystal growth related residual impurities. In general, the complexes consist of a heavy substitutional impurity binding one or more light, interstitial impurities such as hydrogen or lithium. The coupling between the tunneling motion of the interstitial component and the electronic structure of the complexes can create complicated ground state manifolds which contain stress insensitive components. Spectroscopy further shows that multivalent centers, such as double or triple acceptors, become hydrogenic complexes upon binding one or two hydrogen atoms, respectively. Neutralization of shallow acceptors in silicon, which has recently attracted attention, appears to be the same phenomenon as the valency reduction of multiple acceptors in germanium. (Author abstract) 42 refs.

Haller, E.E. (Univ of California, Berkeley, CA, USA). *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond. Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 201-211.

## Spectrum Analysis

**094441 SATURATION OF INTERVALENCE-BAND TRANSITION IN P-TYPE GERMANIUM.** The nonlinear absorption saturation in P-Ge is investigated. Using the combined density of states for heavy and light hole valence bands and semiconductor energy band dispersion relation  $E(k)$ , from the imaginary part of the susceptibility, the absorption coefficient, which decreases with the increase of intensity in a manner similar to an inhomogeneously broadened two-level model, is obtained as  $\alpha(I, \omega) = \alpha_0(\omega) / [1 + I(\omega)/I_s(\omega)]^{1/2}$ . The quantitative relations between  $\alpha_0$ ,  $I_s$ , semiconductor parameters and the frequency of the incident light are deduced. The theoretical calculation is found to be in good agreement with the measured results. (Author abstract) 5 refs.

Wang Weili (Peking Univ, China); Xing Qijiang; Zhu Yinkang; Shi Shouxi. *Chin J Infrared Res Ser B (Engl Ed)* v 6 1987 p 81-84.

**094442 TIME-RESOLVED PICOSECOND INFRA-RED ABSORPTION INDUCED BY HIGH-DENSITY PHOTOGENERATED CARRIERS IN GE AND CDSE.** Picosecond time-resolved absorption at 2.2, 3.4, and 3.9  $\mu m$  produced by photogenerated carriers in intrinsic Ge and semi-insulating CdSe has been measured at room temperature. For Ge, the peak absorbance changes as the square of the probe wavelength. The absorption profile as a function of delay time relative to the excitation pulse rises with a resolution-limited risetime ( $< 10$  ps) and decays over the range from several hundred picoseconds to several nanoseconds. These observations can be accounted for by free-carrier absorption and Auger recombination. Intervalence transitions make a small contribution (approximately 17%) to the induced absorption only at 2.2  $\mu m$ . For CdSe, the absorption change with time exhibits a more complex profile, which is described and discussed. 25 refs.

Ockman, Nathan (City Coll, New York, NY, USA); Dorsinville, Roger; Wang, Wuobao; Alfano, Robert R.

*IEEE J Quantum Electron* v QE-23 n 11 Nov 1987 p 2008-2014.

**094443 PHOTOLUMINESCENCE AND INFRA-RED ABSORPTION STUDIES OF DOUBLE ACCEPTORS IN GERMANIUM.** Recent studies of double acceptors using near-, mid-, and far-infrared spectroscopy are reviewed, and new results are presented in each of these areas. Bound excitons and bound multiexciton complexes associated with these centers are investigated using photoluminescence and near-infrared absorption spectroscopy, and also measurements of the far-infrared absorption due to transitions between bound exciton states. Many bound exciton excited states are observed, and are well explained by a pseudo-donor model. The earlier predictions that the double acceptor ground states were split by hole-hole coupling, which were based upon near-infrared results and the temperature dependence of the mid-infrared neutral acceptor absorption, are verified by detailed uniaxial stress measurements of Ge:Be and Ge:Zn. (Author abstract) 47 refs.

Thewalt, M.L.W. (Simon Fraser Univ, Burnaby, BC, Can); Labrie, D.; Booth, I.J.; Clayman, B.P.; Lightowers, E.C.; Haller, E.E. *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond. Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 47-64.

**094444 ABSORPTION STRENGTHS IN THE FAR-IR SPECTRUM OF SHALLOW DONORS AND ACCEPTORS IN GERMANIUM.** The far-IR absorption spectrum of elemental shallow donors and acceptors in germanium has been studied as a function of the dopant concentration ( $10^{12}$ ,  $10^{14}$  at/cm<sup>3</sup>). The integrated absorption cross section and the oscillator strength have been determined for the main transitions from the ground state. The oscillator strength have been determined for the main transitions from the ground state. The oscillator strengths decrease gradually in the sequences Sb, P, As and B, Al, Ga, In, i.e. with the ground state becoming gradually deeper. Absorption spectra of compensated samples are also presented, illustrating the effect of band-gap illumination on the relative line strengths of the compensated as well as the compensating impurities. (Author abstract) 10 refs.

Rotsaert, E. (Rijksuniversiteit Gent, Ghent, Belg); Clauws, P.; Vennik, J.; Van Goethem, L. *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond. Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 75-79.

**094445 ZEEMAN SPECTROSCOPY OF IMPURITIES IN STRESS-INDUCED UNIAXIAL GERMANIUM.** A novel cryostat which permits the simultaneous application of a uniaxial compressive force and a uniform magnetic field to a crystalline solid has been used to study impurity spectra in semiconductors. The application of such a force along a  $\{100\}$  crystallographic direction, for example, converts germanium from cubic to tetragonal symmetry. The stress-modified line spectrum can then be studied using Zeeman spectroscopy. (Author abstract) 7 refs.

Fisher, P. (Univ of Wollongong, Wollongong, Aust); Freeth, C.A.; Vickers, R.E.M. *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond. Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 80-83.

**Substrates See GERMANIUM COMPOUNDS—Thin Films.**

## Thin Films

**094446 SOME ELECTRICAL PROPERTIES OF MIXED AMORPHOUS THIN FILMS OF GERMANIUM AND SILICON MONOXIDE BEFORE ELECTROFORMING.** The co-evaporated SiO<sub>2</sub>-Ge system was studied. Thin-film MIM sandwich structures were depos-



ited by vacuum evaporation at a pressure of  $\approx 10^{-4}$  Pa and were measured at a pressure of  $10^{-3}$  Pa. The conductivity at low temperature and under d.c. fields has been found to be governed by a combination of an electronic hopping process and free-band conduction. At fields greater than  $2 \times 10^6$  V m $^{-1}$ , it is concluded that the conduction process is governed by the Poole-Frenkel effect. Comparison with earlier results on SiO $_2$ -GeO $_2$  films showed small differences in activation energy for conduction for samples of broadly similar overall composition. (Author abstract) 7 refs.

Abeyasuriya, W.D.B.S. (Brunel Univ, Engl); Hogarth, C.A. *J Mater Sci* v 22 n 9 Sep 1987 p 3342-3348.

## Transport Properties

**094447 LOW-TEMPERATURE MAGNETORESISTANCE IN MEDIUM-ANGLE GRAIN BOUNDARIES IN GERMANIUM.** Magneto-transport properties of grain boundaries in germanium biocrystals are studied in the liquid helium temperature range. For samples with 7° and 9° tilt angle an exponential magnetic field dependence is observed, which is analyzed in terms of two-dimensional hopping conduction. The acceptor concentration N in the grain boundary can be deduced by comparing different magnetic field orientations. A surprising temperature dependence of N is obtained. In addition, the activation energy is determined as about 0.5 meV, typical for the hopping process, and decreases slightly with increasing magnetic field. (Author abstract) 8 refs.

Xia, Yi-ben (Univ Wuerzburg, Wuerzburg, West Ger); Bangert, E.; Landwehr, G. *Phys Status Solidi B* v 144 n 2 Dec 1987 p 601-608.

## SEMICONDUCTING GERMANIUM COMPOUNDS

### Amorphous

**094448 AMORPHOUS Ge $_{1-y}$ Se $_y$  ALLOYS: ESR STUDY OF GAP STATES.** We have measured the ESR spectra of evaporated amorphous Ge $_{1-y}$ Se $_y$  alloy films. We find that with the addition of Se to a-Ge the spin density drops, the g-value decreases from  $2.0233 \pm 0.0007$  to  $2.012 \pm 0.002$  and there is an increase in asymmetry and linewidth. The results indicate that the Fermi level shifts into the conduction band tail with the addition of as little as 5 at.% Se and that the introduction of Se permits a significant reduction in the dangling bond density. (Author Abstract) 6 refs.

Pooke, D. (DSIR, Lower Hutt, NZ); Buckley, R.G.; Devine, S.; Trodahl, H.J. *Solid State Commun* v 62 n 5 May 1987 p 341-343.

**094449 CONTRAST-MATCHING SMALL-ANGLE NEUTRON-SCATTERING EXPERIMENTS ON OBLIQUELY EVAPORATED AMORPHOUS GeSe $_3$  FILMS.** Small-angle neutron-scattering contrast-matching experiments have been performed on obliquely deposited amorphous GeSe $_3$  films. The films are found to have two types of void: one anisotropic with a ratio of major to minor axes of about five; the other isotropic and a factor of ten smaller in volume. Although the scattering data are difficult to interpret, there is reason to believe that surface (roughness) scattering does not play the dominant role. (Author abstract) 8 refs.

Verrall, D. (Univ of Cambridge, Cambridge, Engl); Spence, C.A.; Elliott, S.R. *Philos Mag B* v 57 n 4 Apr 1988 p 445-453.

**094450 INVESTIGATION OF MEDIUM RANGE ORDER BY PHOTOEMISSION, REFLECTIVITY, LASER-INDUCED CRYSTALLIZATION RAMAN SPECTROSCOPY IN AMORPHOUS GeSe $_2$ .** It is difficult to determine the structure of amorphous materials, since the long range order is completely destroyed, where the conventional crystallographic diffraction method becomes less powerful. The authors report recent investigations for intermediate structures in amorphous GeSe $_2$  both by laser-induced crystallization Raman spec-

troscopy and photoemission and reflectivity spectra. 30 refs.

Murase, Kazuo (Osaka Univ, Toyonaka, Jpn); Inoue, Koichi. *Disord Semicond Publ* by Plenum Press, New York, NY, USA and London, Engl, 1987 p 297-306.

**094451 BONDING AND SHORT RANGE ORDER IN a-Ge $_x$ Te $_{1-x}$  ALLOYS.** Central to an understanding of the properties of amorphous semiconductors is a knowledge of their bonding coordination. An additional factor in alloy systems (A $_x$ B $_{1-x}$ ) is the degree to which randomly distributed bonds are replaced by heteropolar (A-B) bonds. Vibrational and electronic spectroscopy have proven powerful tools to elucidate these aspects of the structure. The authors present the results of far infrared absorption measurements, supported by Raman spectroscopy, over a wide range of a-Ge $_x$ Te $_{1-x}$  alloy composition. The data provide estimates of the density of GeTe $_4$  and Te-Te units as a function of composition. These densities are well predicted by a random network model containing the following features: 1. 4-2 fold coordination at all compositions. 2. A weak but systematic chemical order, with the density of heteropolar bonds lying approximately one third of the way from the CRN to the COCRN densities. 18 refs.

Fee, M.G. (Victoria Univ of Wellington, Wellington, NZ); Trodahl, H.J. *Disord Semicond Publ* by Plenum Press, New York, NY, USA and London, Engl, 1987 p 307-315.

**094452 PHOTOACOUSTIC SPECTRA OF AMORPHOUS SEMICONDUCTORS Ge $_{20}$ S $_{80-x}$ Bi $_x$ .** A study of the amorphous semiconductors Ge $_{20}$ S $_{80-x}$ Bi $_x$  by photoacoustic spectroscopy in the spectroscopy in the spectral range 200 nm to 2600 nm has been undertaken for the first time. The three regions of the optical absorption edge of the semiconductors (i) Urbach's tail, (ii) the subband tail due to localized tail states, and (iii) the interband transition region above the fundamental absorption edge, have been observed. Bismuth impurity induced structural modification in the parent Ge-S glass, which is responsible for p-n transition in these semiconductors, is reflected in the optical absorption spectrum. (Author abstract) 17 Refs.

Bhatia, K.L. (Maharshi Dayanand Univ, Rohtak, India); Bhatnagar, V.K. *J Non Cryst Solids* v 104 n 1 Aug 1988 p 17-21.

**094453 STRUCTURAL MODELS OF AMORPHOUS GeS.** We have constructed two hand-built CRN structural models of a-GeS. We have assumed 4:2 coordination for the Ge and S atoms respectively, and allowed only Ge-S and Ge-Ge bonds. The models contain 430 and 350 atoms. They differ both by the statistics of the tetrahedra Ge(Ge $_{4-p}$ S $_p$ ) and by their medium-range order. The first model corresponds to a three-dimensional network with random statistics for the tetrahedra, the second one represents a layered structure built mainly of Ge(Ge $_2$ S $_2$ ) units. The models were relaxed with respect to the Keating potential. Comparison of the calculated and observed structural characteristics, density and radial distribution function (RDF), showed that the structure of a-GeS may be represented by the three-dimensional CRN, but not by the layered model. (Edited author abstract) 37 Refs.

Drchal, V. (Czechoslovak Acad of Science, Prague, Czech); Malek, J. *Philos Mag B* v 58 n 3 Sep 1988 p 303-317.

## Chemical Vapor Deposition

**094454 PREPARATION OF GERMANIUM NITRIDE FILMS BY LOW PRESSURE CHEMICAL VAPOR DEPOSITION.** Germanium nitride (Ge $_3$ N $_4$ ) was deposited onto polished germanium wafers by low pressure chemical vapor deposition (LPCVD). Depositions were performed in a hot-wall quartz tube system at temperatures from 450° to 600°C, using GeCl $_4$  and NH $_3$  reactants. Details of the deposition procedure and apparatus are reported. Deposition rates of 5-50 Å per min were obtained, yielding films having refractive indexes of

$2.05 \pm 0.05$ , as measured by ellipsometry. The dependence of deposition rate on temperature and gas flow parameters is reported. Infrared transmission data, as well as etch rate data, are also presented. (Edited author abstract) 21 refs.

Young, Andrew B. (Brown Univ, Providence, RI, USA); Rosenberg, James J.; Szendro, Istvan. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2867-2870.

## Crystallization

**094455 CRYSTALLIZATION KINETICS OF GLASSY GeSe $_2$ .** The crystallization kinetics of glassy GeSe $_2$  was investigated by non-isothermal heat flux differential scanning calorimetry (DSC) on both bulk and powder samples. It was shown that high-temperature modification of germanium disulphide crystallizes from an undercooled melt of composition GeSe $_2$ . The crystallization kinetics can be described by the Sestak-Berggren (SB) kinetic model, using the Arrhenius dependence of the rate constant. It was found that the Johnson-Mehl-Avrami (JMA) kinetic model is less suitable for the description of the studied crystallization process. A BASIC program has been written for both SB and JMA models to evaluate kinetic data from experimental DSC curves recorded with the Perkin-Elmer Thermal Analysis Data Station system. (Author abstract) 21 refs.

Malek, J. (Czechoslovak Acad of Sciences, Pardubice, Czech); Klokorka, J. *J Therm Anal* v 32 n 6 Nov-Dec 1987 p 1883-1893.

**Doping See SEMICONDUCTING SILICON COMPOUNDS—Doping.**

**Electric Conductivity See SEMICONDUCTING LEAD COMPOUNDS—Electric Conductivity.**

**Electronic Properties See SEMICONDUCTING SILICON COMPOUNDS—Electronic Properties.**

## Microscopic Examination

**094456 STRUCTURE OF IODINE-DOPED POLY-GeO-PHTHALOCYANINE EPITAXIAL FILM AND ITS LATTICE DEFECTS STUDIED BY DIRECT ATOM IMAGING.** The process of iodine doping into poly-GeO-phthalocyanine (GeOPc) thin films has been studied by high-resolution electron microscopy (2.0 Å resolution; 200 kv). The doped GeOPc is isomorphic with NiPc, CoPc, FePc, H $_2$ Pc-halogen complexes. The doping is initiated from the stacking fault plane and the expansion of the lattice due to the penetration of iodine is 2.6 Å at the faulted planes while it is only 0.2 Å in the regular part of the crystal. The molecular arrangement and iodine position at the defect are directly determined visually. (Author abstract) 11 refs.

Kobayashi, Takashi (Kyoto Univ, Uji, Jpn); Uyeda, Natsuo. *Philos Mag B* v 57 n 4 Apr 1988 p 493-504.

## Microstructure

**094457 PLANAR DEFECTS IN GeSe AND GeS CRYSTALS.** Planar defects in layered GeSe and GeS crystals grown by vapor transport were studied by transmission electron microscopy. The principal defects are (110) twins which appear as narrow parallel bands and (001) low-angle grain boundaries containing networks of boundary dislocations. In order to propose an atomistic model, the structure of the materials is described in terms of hexagonal rings and trigonal pyramids projected along the c-axis. These units are used for the construction of a model of the twin structure which is free of dangling bonds. The relationship of the defects with transport properties is discussed. (Author abstract) 12 Refs.

Karakostas, Th. (Aristotle Univ of Thessaloniki, Thessaloniki, Greece). *J Mater Sci* v 23 n 9 Sep 1988 p 3099-3105.

**Optical Properties See Also SEMICONDUCTING TIN COMPOUNDS—Optical Properties.**

## 094458 TEMPERATURE DEPENDENCE OF



**TWO-DIMENSIONAL OPTICAL ENERGY GAP FOR GERMANIUM SELENIDE SINGLE CRYSTALS.** The interband absorption coefficient of GeSe single crystals near the fundamental absorption edge is analyzed on the basis of a two-dimensional model and is found to correspond to an indirect forbidden transition. The optical energy gap at room temperature is found to be  $(1.066 \pm 0.011)$  and  $(1.078 \pm 0.010)$  eV for the a- and c-crystallographic axes, which lie in the plane of cleavage. The temperature dependence of the two-dimensional optical energy gap is studied from room temperature to near liquid nitrogen temperature. This dependence is found to be linear in the range from 96 to 250 K with a negative temperature coefficient  $dE_g/dT$  equal to  $-0.48$  and  $-0.46$  meV per K for the a- and c-axes, respectively. The results are compared with those obtained on basis of three dimensional model and agreement is found to be within the limits of experimental error. (Author abstract) 13 refs.

Elkorashy, A.M. (Military Technical Coll., Cairo, Egypt). *Phys Status Solidi B* v 146 n 1 Mar 1988 p 279-285.

## Order-Disorder

**094459 SHORT-RANGE ORDER IN SOME ALLOYS OF THE Ge-As-Te SEMICONDUCTING GLASSY SYSTEM BY X-RAY DIFFRACTION.** A study of short-range order in amorphous semiconducting alloys of the Ge-As-Te system has been carried out by x-ray diffraction. The different hypothesis on germanium coordination have been taken into account, following the different criteria cited in the literature for binary Ge-Te alloys. The result of this study shows the possibility of structural units based on tetra- or tricoordinated germanium atoms, which bonded together give way to short-range order in these alloys. It has also been found that, for these alloys, germanium dicoordination is not compatible with the data obtained experimentally. (Author abstract) 22 refs.

Ligero, R.A. (Univ de Cadiz, Cadiz, Spain); Vazquez, J.; Villares, P.; Jimenez-Garay, R. *J Mater Sci* v 22 n 12 Dec 1987 p 4357-4361.

## Physical Properties

**094460 STRUCTURE AND TRANSPORT PROPERTIES OF AMORPHOUS  $Ge_{1-x}C_x:H$  THIN FILMS OBTAINED BY ACTIVATED REACTIVE EVAPORATION.** Hydrogenated amorphous germanium-carbon ( $a-Ge_{1-x}C_x:H$ ) thin films have been prepared by an activated reactive evaporation technique. Germanium was evaporated from a resistively heated tungsten basket through an acetylene plasma. The films thus obtained were characterized for the compositional, structural, electrical and optical properties. The effects of substrate temperature, role of hydrogen and variation of optical energy gap with carbon content were also investigated. Typically, films deposited at 200°C showed a sharp absorption edge corresponding to an optical gap of about 1.3 eV and thermally activated electrical conduction over a wide range of temperatures. (Author abstract) 11 refs.

Kumar, Sunil (Indian Inst of Technology, New Delhi, India); Kashyap, Subhash C.; Chopra, K.L. *J Non Cryst Solids* v 101 n 2-3 May 1988 p 287-290.

## Radiation Effects See FILMS—Doping.

## Spectroscopic Analysis

**094461 INFRARED LATTICE VIBRATIONS IN  $Cu_2GeSe_3$ .** Infrared reflectivity spectra of  $Cu_2GeSe_3$  are measured at room temperature in the wave-number range from 180 to 4000  $cm^{-1}$ . From an analysis of the spectra the parameters of four vibrational modes are determined. The experimental results are compared with predictions from group theory. From a comparison of the results of  $Cu_2GeSe_3$  with the vibrational characteristics of other chalcogenides it follows that the force constants of cation-chalcogen bonds increase with increasing valence of the cation. (Author abstract) 14 refs.

Riede, V. (Karl-Marx-Univ, Leipzig, East Ger); Sharif, N.; Neumann, H.; Sobotta, H.; Omar, M.S.; Pamplin, B.R. *Cryst Res Technol* v 22 n 8 Aug 1987 p 1089-1093.

**094462 ON THE MASS TRANSPORT PROPERTIES OF THE GeSe-Ge<sub>4</sub> SYSTEM UNDER NORMAL AND REDUCED GRAVITY CONDITIONS.** With respect to the mass spectrometric observations by Buchan and Rosenberger, our earlier mass transport rate studies of the GeSe-Ge<sub>4</sub> system are re-evaluated considering the presence of GeSe(s) and GeSe<sub>2</sub>(s) phases in the source material. The previously derived dominance of the sublimation of GeSe at lower ( $<0.05$  atm) and of chemical vapor transport at higher ( $>0.1$  atm) pressures of Ge<sub>4</sub> has also been concluded from the current analysis of the transport system. The nature of the dominant CVT process(es) is apparently different from that proposed earlier, and is not known at this time. The experimentally observed flux anomalies are independent of a given model. The limitations of the previous and current models for the GeSe-Ge<sub>4</sub> system are discussed. (Author abstract) 26 refs.

Palosz, Witold (Rensselaer Polytechnic Inst, Troy, NY, USA); Wiedemeier, Heribert. *J Cryst Growth* v 89 n 2-3 Jun II 1988 p 242-250.

**094463 ELECTRON SPIN RESONANCE OF  $Mn^{2+}$  IN Bi DOPED n-TYPE AMORPHOUS GERMANIUM CHALCOGENIDE SEMICONDUCTORS.** Electron spin resonance of Bi doped  $Ge_{20}S_{79.5-x}Bi_xMn_{0.5}$  glassy semiconductors has been observed using transition metal Mn as a microprobe for the first time. At lower Bi concentrations ( $x=4$ ) one resonance line at  $g \approx 2$  is observed whereas in  $x=11$  &  $x=15$  composition another line at  $g \approx 4$  appears. It is suggested that Bi atoms in Sulfur rich germanium sulfide glass occupy two different types of sites in the material at low (4 at%) and high 11, 15 at%) Bi concentrations respectively. (Author abstract) 8 refs.

Bhatia, K.L. (Maharshi Dayanand Univ, Rohtak, India); Bhatnagar, V.K.; Gosain, D.P. *Key Eng Mater* v 13 pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 623-626.

## Surfaces

**094464 NATURAL SURFACE FILMS ON GeS.** GeS belong to a group of layer-like orthorhombic chalcogenides which have attracted considerable interest in recent years. The present note reports results on the growth of a natural surface film on the cleaved surface of a p-type single crystal. To get information about the properties of cleaved surfaces of this material with respect to possible contamination, the author studied the changes of the ellipsometric angles with time. 3 refs.

Lukes, F. (J.Ev. Purkyne Univ, Brno, Czech). *Phys Status Solidi A* v 106 n 1 Mar 1988 p K27-K30.

## Synthesis

**094465 EFFECT OF HEAT TREATMENT ON THE ELECTROPHYSICAL PROPERTIES OF  $GeAs_2$ .** Depending on the synthesis and heat-treatment conditions, it is possible to obtain germanium di-arsenide crystals with either hole-type or electron-type conductivity. The electron type of conductivity is observed only in crystals grown directly by the method of directional crystallization at arsenic vapor pressures of 4200-4500 GPa. If annealing occurs at temperatures below the eutectic temperature, then only p-type samples can be formed. 7 refs. In Russian.

Ugai, Ya.A.; Goncharov, E.G.; Evseeva, S.P.; Turkin, S.A.; Popov, A.E. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 5 May 1987 p 727-729.

## SEMICONDUCTING GLASS—See Also GLASS, METALLIC—Spectroscopic Analysis.

**Amorphous** See SEMICONDUCTOR MATERIALS—Amorphous.

**Applications** See SENSORS—Electrochemical.

## Crystallization

**094466 ELECTROPHYSICAL AND OPTICAL PROPERTIES OF THIN FILMS OF THE Ti-Ge-Te SYSTEM.** The special features of the process of crystallization of thin films of glassy semiconductors of the Ti-Ge-Te system have been revealed by measurements of the electric conductivity in the 90-470 K temperature range and by studies of the spectral dependences of the optical transmission. Among these special features processes of endothermal type were particularly noted. The electric conductivity parameters of the films and their refractive indices in the optical transparency range were determined. In Russian. 8 refs.

Bazakutsa, V.A.; Minaev, V.S.; Mussil, V.V.; Savchenko, K.V.; Fedorchenko, V.I. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 12 Dec 1987 p 1985-1987.

**094467 NON-ISOTHERMAL CRYSTALLIZATION OF  $Bi_2S_3$  FROM GLASSY  $(GeS_2)_{0.5}(Bi_2S_3)_{0.5}$ .** The non-isothermal kinetics of crystallization of  $Bi_2S_3$  from glassy  $(GeS_2)_{0.5}(Bi_2S_3)_{0.5}$  is examined using differential scanning calorimetry. Several kinetic models related to different mechanisms are tested. The best fit to the experimental data is obtained assuming that the transformation fulfills the equation  $f(\alpha) = \alpha^m(1 - \alpha)^n$ , where  $\alpha$  is the fraction of crystallized material. (Author abstract) 7 refs.

Tichy, L. (Univ of Chemical Technology, Pardubice, Czech); Nagels, P. *Phys Status Solidi A* v 107 n 2 Jun 1988 p 769-774.

**094468 PROPERTIES OF SEMICONDUCTIVE GLASSES IN THE  $V_2O_5$ -CuO SYSTEM.** In this work a range of rapidly quenched glassy films in the  $V_2O_5$ -CuO system were prepared and their crystallization processes, IR absorption spectra and electrical conductivities were investigated. The electrical conductivity of the quenched glassy films is discussed from the standpoints of the reduction of  $V^{5+}$  ion and the glass structure. With increase of CuO content, the amount of reduction increases, whereas the electron hopping paths through V-O-V bonds decreased. Overall, the electrical conductivity of the quenched films increased with the increase of CuO content, mainly due to the increase of  $V^{4+}$  ion. 10 refs.

Tsuzuki, A. (Government Industrial Research Inst, Nagoya, Jpn); Kawakami, S.; Awano, M.; Sekiya, T.; Torii, Y. *J Mater Sci Lett* v 7 n 7 Jul 1988 p 745-747.

## Defects

**094469 POSITRON ANNIHILATION STUDY OF DEFECTS AND MICROHETEROGENEITY OF CHALCOGENIDE GLASSY SEMICONDUCTORS.** Chalcogenide glassy semiconductors (CGS) - compounds of chalcogens (S, Se, Te) with the elements Ge, As, Si - are closely studied using various techniques because of the wide technical applications of these materials. A substantially new result of this positron annihilation (PA) study in comparison with previous investigations consists in identification of positron annihilation mechanisms in CGS and in demonstration of a very high sensitivity of PA-technique to CGS - defects responsible for their electric and optical properties. The typical positron annihilation lifetimes are found. A satisfactory explanation of both the lifetime and annihilation radiation angular correlation data using the so-called 'optical' model provides a test of the positron annihilation mechanism in CGS. (Edited author abstract)

Shantarovich, V.P. (Acad of Sciences of the USSR, Moscow, USSR); Kobrin, B.V. *Key Eng Mater* v 13 pt



3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 639-640.

## Dielectric Properties

**094470 DIELECTRIC PROPERTIES OF SEMI-CONDUCTING GLASSES.** The dielectric behavior or the response of a material under an applied ac signal has been considered in different ways by the workers from dielectric and semiconductor schools. This has resulted into different ways of the presentation of dielectric data, the correlation and advantages of these different representations are briefly discussed. The experimental data over a wide temperature and frequency region in transition metal oxide (TMO) glasses is critically examined to demonstrate two distinct regions of dielectric response. In the high frequency region both the dielectric constant and dielectric loss show little dependence on frequency. In the low frequency region the dielectric constant and dielectric loss show a large dispersion. A plausible qualitative model for explaining the dielectric behavior of semiconducting glasses over a wide frequency range is presented. (Edited author abstract)

Mansingh, Abhai (Univ of Delhi, Delhi, India). *Key Eng Mater* v 13 pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 895-896.

## Differential Thermal Analysis

**094471 NATURE OF DEFECTS IN AMORPHOUS Bi-Se ALLOYS.** Differential thermal analysis results concerning  $\text{Bi}_x\text{Se}_{1-x}$  alloys ( $0 < x < 0.27$ ) show that Bi atoms may be either three- or four-fold coordinated. Further measurements of dark conductivity show a sharp decrease in both resistivity and activation energy of conductivity between 1 and 2 at% Bi. Comparison with other Bi-based alloys and chalcogenide alloys without Bi leads to the conclusion that Bi plays a particular role when allied with chalcogenide materials. Consideration concerning the metallic character and electronegativity of Bi enable us to confirm that in Bi-based chalcogenide alloys the Bi defects are four-fold coordinated and positively charged. (Edited author abstract). 36 Refs.

Vautier, C. (Lab d'Etude des Couches Minces Amorphes et Polycristallines, Fr); Saiter, J.M.; Derrey, T. *J Non Cryst Solids* v 103 n 1 6(II) 1988 p 57-72.

## Doping See Also GLASS, METALLIC—Ionic Conduction.

**094472 ELECTRICAL CONDUCTIVITY OF SEMI-CONDUCTING BARIUM ALUMINOPHOSPHATE GLASSES CONTAINING SINGLE AND DOUBLE REDOX PAIRS.** In systems with TM (Transition Metal)-oxides incorporated in pairs the probability of hopping processes significantly depends on the oxidation potential or on the electrochemical series of the redox pairs, respectively, because the electronic charge carrier concentration depends on the mutual shift of the redox equilibria. Those hopping processes which are not conform to this shift have a very low probability. Therefore, increasing or decreasing conductivity in those mixed redox pairs containing systems depends primarily on the electrochemical series and on the initial redox situation of that redox pair and its redox shift, which dominates the electrical conductivity. (Edited author abstract) 39 refs.

Zirkelbach, Karl (Inst fuer Nichtmetallische Werkstoffe, Berlin, West Ger); Brueckner, Rolf. *Glastech Ber* v 61 n 1 Jan 1988 p 12-23.

**094473 EFFECT OF IRON IMPURITY ON ESR AND ELECTRICAL PROPERTIES OF BIS-MUTH-VANADATE GLASSES.** It is well known that the semiconducting properties of the transition metal ion glasses are due to the presence of transition elements in various valence states. The present work aims to study the interaction between vanadium and iron ions in  $\text{V}_2\text{O}_5$ - $\text{Bi}_2\text{O}_3$  glasses doped with  $\text{Fe}_2\text{O}_3$ . The electrical conductivity of the bismuth-vanadate glasses is greatly affected by the addition of  $\text{FeO}_3$ . For the glasses containing  $\text{Fe}_2\text{O}_3$

, content up to 10 mol %, the electrical conduction takes place due to the electron hopping between various TMI hopping centres. The conduction due to the hopping mechanism goes on decreasing as the  $\text{Fe}_2\text{O}_3$  content is increased to more than 10 mol %. This is because more of the iron ions are situated in some kind of clusters and interaction pairs due to the Fe-O-Fe and Fe-O-V bonds formations. 11 refs.

Ghosh, Aswini (Indian Assoc for the Cultivation of Science, Calcutta, India); Chaudhuri, B.K. *J Mater Sci Lett* v 7 n 4 Apr 1988 p 357-358.

**094474 EFFECT OF Cu DOPING ON THE DC CONDUCTIVITY AND THERMOELECTRIC POWER OF  $\text{As}_2\text{Se}_3$ -BASED GLASSES.** The dc conductivity and the thermoelectric power of  $\text{As}_2\text{Se}_3\text{Cu}_x$  and  $\text{As}_2\text{Se}_{1.5}\text{Te}_{1.5}\text{Cu}_x$  glasses ( $x = 1.0$  and  $1.67$ ) were measured as a function of temperature. Band-like conduction is observed with holes as dominant charge carriers. The addition of Cu leads a decrease in the activation energies for conduction which is correlated with the change in the density of states of the valence band. (Author abstract). 15 Refs.

Abe, H. (Hokkaido Univ, Sapporo, Jpn); Nakamura, Y. *Phys Status Solidi A* v 107 n 1 May 1988 p 315-319.

**094475 EFFECT OF COPPER AND LEAD ON THE PROPERTIES OF As-Ge-X(X/S, Se, Te) GLASSES -POSITRON ANNIHILATION STUDIES.** The positron annihilation and electron microscopy techniques as well as measurements of electroconductivity and density were used for studies of As-Ge-X (S=S, Se, Te) glassy semiconductor doped with copper and lead. The influence of doping appeared to be dependent on the dopant amount and on the type of chalcogen. New units of structure-three-component compounds of metal with elements of glass, were identified in some cases. The doping effects were different in the case of disordered distribution of these units in the glass matrix and for their associations. The positron annihilation data were used for interpretation of the results of conductivity measurements. (Author abstract) 1 ref.

Kobrin, B.V. (Acad of Sciences of the USSR, Moscow, USSR); Shantarovich, V.P.; Kim, T.I.; Mikhailov, M.D.; Borisova, Z.U.; Zaslavskii, B.I. *Key Eng Mater* v 13 pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 638.

## Electric Conductivity

**094476 ELECTRICAL CONDUCTION IN CADMIUM GERMANATE GLASSES.** Preliminary conductivity data are reported for a series of novel cadmium germanate glass compositions. All systems studies are electronic conductors with small activation energies. The highest in CdO-content sample,  $0.56\text{CdO} \cdot 0.44\text{GeO}_2$ , is found to exhibit  $\sigma_{300\text{K}} \approx 100$  mho/cm. Correlations are attempted between the transport properties and the structural characteristics of these glasses. (Author abstract) 11 refs.

Chrysikos, G.D. (Nat'l Hellenic Research Foundation, Athens, Greece); Kamitsos, E.I.; Swiatek, J. *Solid State Commun* v 63 n 7 Aug 1987 p 615-618.

**094477 ON ELECTRONIC CONDUCTION IN THE PRE-SWITCHING REGION OF GLASSY SEMI-CONDUCTING ALLOYS  $\text{As}_{40}\text{Se}_{30}\text{Te}_{30}$  AND  $\text{As}_{20}\text{Se}_{50}\text{Te}_{30}$ .** The off-state direct current I-V characteristics for glassy alloys  $\text{As}_{40}\text{Se}_{30}\text{Te}_{30}$  and  $\text{As}_{20}\text{Se}_{50}\text{Te}_{30}$  at different temperatures were studied. For this study of electrical conduction properties, two kinds of electrode configurations were used: a double-point contact on one surface and a sandwich device. It was found that current flow can be space-charge limited, producing non-ohmic behavior, which in turn reflects on the electrical switching effect that the materials exhibit. The influence of the selenium content on the electrical properties was also studied. The experimental results obtained were compared with those in the literature, and the differences justified by the method of material preparation. Lastly, the depen-

dence of ohmic resistance on temperature was analyzed, and the characteristic behavior of intrinsic semiconduction observed. (Author abstract) 20 refs.

Marquez, E. (Univ de Cadiz, Cadiz, Spain); Villares, P.; Jimenez-Garay, R. *Mater Sci Eng* v 100 Apr 1988 p 229-234.

**094478 ANOMALOUS CONDUCTIVITY AND OTHER PROPERTIES OF  $\text{V}_2\text{O}_5$ - $\text{P}_2\text{O}_5$  GLASSES WITH  $\text{Bi}_2\text{O}_3$  OR  $\text{Sb}_2\text{O}_3$ .** To characterize  $\text{V}_2\text{O}_5$ - $\text{P}_2\text{O}_5$  glasses with  $\text{Bi}_2\text{O}_3$  or  $\text{Sb}_2\text{O}_3$ , the dc and ac conductivities and dielectric constants were measured, and SEM, x-ray diffraction, and DTA studies were made. The electric properties were measured in the temperature range 80-420 K and in the frequency range 0.1-100 kHz. The dc conductivity of the  $50\text{V}_2\text{O}_5(50-x)\text{P}_2\text{O}_5\text{-xBi}_2\text{O}_3$  ( $x=5-40$  mol%) glasses is found to be always higher than that of the pure base glass  $50\text{V}_2\text{O}_5\text{-P}_2\text{O}_5$ , while the dc conductivity of the  $50\text{V}_2\text{O}_5(50-x)\text{P}_2\text{O}_5\text{-xSb}_2\text{O}_3$  glasses is always lower than that of the base glass. Above 200 K, the activation energy of the  $\text{V}_2\text{O}_5$ - $\text{P}_2\text{O}_5$ - $\text{Bi}_2\text{O}_3$  glass depends on the concentration of  $\text{Bi}_2\text{O}_3$ , while that of the  $\text{V}_2\text{O}_5$ - $\text{P}_2\text{O}_5$ - $\text{Sb}_2\text{O}_3$  glasses is almost independent of the  $\text{Sb}_2\text{O}_3$  concentration. However, both of these glasses show an interesting conductivity minimum for about 25-30 mol% of  $\text{Bi}_2\text{O}_3$  or  $\text{Sb}_2\text{O}_3$ . This behavior was not found earlier in any such transition metal oxide glasses. The anomalous behavior is also observed in the concentration ( $\text{Bi}_2\text{O}_3$  or  $\text{Sb}_2\text{O}_3$ ) dependence of the density, glass transition temperature  $T_g$ , ac conductivity, and dielectric constant data. (Edited author abstract). 29 Refs.

Ghosh, Aswini (Indian Assoc for the Cultivation of Science, Calcutta, India); Chaudhuri, B.K. *J Non Cryst Solids* v 103 n 1 6(II) 1988 p 83-92.

**094479 ELECTRICAL CONDUCTIVITY OF VANADIUM PHOSPHATE GLASSES CONTAINING ZNO OR  $\text{GeO}_2$ .** The conduction mechanism of vanadium phosphate glasses containing ZnO or  $\text{GeO}_2$  is discussed in comparison with that of  $\text{PbO-V}_2\text{O}_5\text{-P}_2\text{O}_5$  glasses. Especially, the effect of  $\text{V}_2\text{O}_5$  concentration on the conductivity and the glass structure is discussed. 17 Refs.

Hirashima, Hiroshi (Keio Univ, Yokohama, Jpn); Kurokawa, Haruki; Mizobuchi, Katsuo; Yoshida, Teturo. *Glastech Ber* v 61 n 6 Jun 1988 p 151-156.

**094480 CONDUCTIVITY MINIMUM OF THE  $\text{V}_2\text{O}_5$ - $\text{P}_2\text{O}_5$  GLASSES CONTAINING  $\text{Bi}_2\text{O}_3$  OR  $\text{Sb}_2\text{O}_3$ .** A minimum in the dc and ac conductivities, dielectric constant, glass transition temperatures and density observed in the glasses  $50\text{V}_2\text{O}_5(50-x)\text{P}_2\text{O}_5\text{-XMO}$  with  $\text{MO}=\text{Bi}_2\text{O}_3$  or  $\text{Sb}_2\text{O}_3$  at  $x \approx 25-30$  mol% of MO is found to be due to the lowest value of the ratio  $V^{5+}/V^{4+}$  appearing at the same concentration of MO. The conductivity data for a particular concentration could, however, be well fitted with the Mott's polaron theory. The glass forming oxides also affect the activation energy for hopping conduction. (Author abstract) 9 refs.

Ghosh, Aswini (Indian Assoc for the Cultivation of Science, Calcutta, India); Chaudhuri, B.K. *Key Eng Mater* v 13 pt 2 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 515-518.

**094481 ELECTRICAL CONDUCTIVITY IN ZINC-BORATE GLASSES CONTAINING TRANSITION METAL OXIDES.** Oxide glasses doped with paramagnetic transition metal oxides behave like semiconducting glasses. As part of a programme to study the effect of doping transition metal ions on the electrical conductivity in inorganic glasses, we have undertaken a study of the D.C. electrical conductivity in zinc-borate glasses doped



with  $\text{Fe}_2\text{O}_3$ ,  $\text{V}_2\text{O}_5$  and  $\text{Fe}_2\text{O}_3 + \text{V}_2\text{O}_5$  mixed together and we report in this communication the results obtained in the systems. (Author abstract) 4 refs.

Anavekar, R.V. (Bangalore Univ, Bangalore, India); Devaraj, N.; Ramakrishna, J. *Key Eng Mater* v 13 pt 1, pt 2 and pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 545-546.

**094482 IR SPECTROSCOPIC AND D.C. RESISTIVITY STUDIES OF BARIUM-VANADATE GLASSES.** Vanadium ions in  $\text{V}_2\text{O}_5$  are known to exist in two different valence states;  $\text{V}^{4+}$  and  $\text{V}^{5+}$ . The electrical conduction is believed to occur by electron hopping between  $\text{V}^{4+}$  and  $\text{V}^{5+}$  ions. Owing to the semiconducting nature, the glasses containing  $\text{V}_2\text{O}_5$  in amorphous state. In the present work systematic studies of barium-vanadate glasses containing iron are reported. A series of amorphous samples  $3\text{BaO} \cdot (0.9-Z) \text{V}_2\text{O}_5 \cdot 0.1\text{Fe}_2\text{O}_3$  with Z varying from 0.15 to 0.45 are prepared by pouring the melt on to a cold copper surface. The variations of resistivity and activation energy with composition are explained on the basis of the structure of these glasses. (Edited author abstract)

Bansal, T.K. (IIT Delhi, New Delhi, India); Bansal, Sadhana; Mendiratta, R.G. *Key Eng Mater* v 13 pt 2, 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 553.

## Electric Properties

**094483 MODEL FOR THE CHEMICAL MODIFICATION OF ELECTRICAL PROPERTIES OF CHALCOGENIDE GLASSES BY BISMUTH.** A mechanism is proposed to account for the ability of Bi to change the electrical properties of certain chalcogenide glasses. EXAFS experiments have shown that there is a significant change in the local structural environment of the Bi at compositions close to the critical concentration of Bi (10at.%) at which the p-n transition takes place. These structural changes are interpreted in terms of a model in which the type of bonding at the Bi sites changes from covalent to partially ionic. The presence of charged impurity centres upsets the equilibrium between native charged defects in the glass, and a p-n 'doping' transition subsequently occurs at a critical impurity concentration. (Author abstract) 47 refs.

Elliott, S.R. (Univ of Cambridge, Cambridge, Engl); Steel, A.T. *J Phys C Solid State Phys* v 20 n 27 Sep 30 1987 p 4335-4357.

**094484 STRUCTURAL AND ELECTRICAL PROPERTIES OF THE GLASSY SEMICONDUCTOR SYSTEM Cu-As-Te.** A method has been developed for measuring electrical conductivity in bulk samples of glassy semiconductors based on the procedure described by L.B. Valdes which is used to determine the conductivity of  $\text{Cu}_{0.05}\text{As}_{0.50}\text{Te}_{0.45}$  and  $\text{Cu}_{0.15}\text{As}_{0.40}\text{Te}_{0.45}$ . The experimental results are justified by structural models corresponding to the compositions. The estimates of the number of bonds of each of the possible types as well as their ionization energies are used for this purpose. This analysis is preceded by a description of an electrical conduction model. Results on the properties of electrical switching are given. (Edited author abstract) 23 refs.

Marquez, E. (Univ de Cadiz, Puerto Real, Spain); Vazquez, J.; de la Rosa-Fox, N.; Villares, P.; Jimenez-Garay, R. *J Mater Sci* v 23 n 4 Apr 1988 p 1399-1404.

## Electronic Properties

**094485 ELECTRONIC PROCESSES IN OXIDE GLASSY SEMICONDUCTORS AND THIN-FILM STRUCTURES BASED ON THEM.** The physical nature of electronic processes in oxide glassy semiconductors (OGS) based on  $\text{V}_2\text{O}_5$  is discussed on the basis of the theory of the small-radius polaron (SRP). The most important parameters of the process of charge transfer by polarons are determined from an analysis of the temperature dependence of the static conductivity by mathematical

modeling employing general theoretical expressions. A model of coupled SRP, presuming that they are localized by the Coulomb field of the charged defect centers, is proposed for describing the results on the effect of a strong electric field and dielectric relaxation. On the basis of the model, expressions describing the dependence of the current density and dielectric constant on the dc electric field strength and also a relation determining the dielectric relaxation time for the given model are obtained. The results of studies of the electric properties of OGS modified by additions of a second transition-metal oxide are also discussed. (Author abstract) 61 refs.

Gaman, V.I. (Tomsk State Univ, USSR); Kosintsev, V.I.; Kalygina, V.M. *Sov Phys J* v 30 n 6 Jun 1987 p 461-474.

**094486 EXPONENTIAL BAND TAILS AS A CONSEQUENCE OF THE GLASS TRANSITION.** A recently proposed theory for the glass transition is briefly reviewed. The theory predicts two different kinds of glass transitions, slow and fast. It is argued that glassy semiconductors prepared from a fast glass transition have exponential band tails of localized states. (Author abstract) 21 refs.

Dyre, J.C. (Roskilde Univ Cent, Roskilde, Den). *Key Eng Mater* v 13 pt 2 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 501-504.

**094487 POSITRONIUM PICK-OFF LIFE TIMES IN  $\text{V}_2\text{O}_5$ - $\text{TeO}_2$  CuO SEMICONDUCTING GLASSES.** The ternary glass system  $(\text{V}_2\text{O}_5)_{0.55-x}(\text{CuO})_x(\text{TeO}_2)_{0.45}$  exhibits a complex behavior due to the formation of  $\text{V}^{4+}$ ,  $\text{V}^{5+}$ ,  $\text{Cu}^+$  and  $\text{Cu}^{2+}$  ions. As  $\text{V}_2\text{O}_5$  is partially replaced by CuO, electron transfer can take place between  $\text{V}^{4+}$  ( $3d^1$ ) and  $\text{Cu}^{2+}$  ( $3d^9$ ) leading to a decrease in  $\text{V}^{4+}$  ion concentration. This is confirmed by ESR studies when at 5 mol % CuO the  $\text{V}^{4+}$  resonance is completely suppressed. Thus there is a change in the paramagnetic ion concentration with composition. Since one of the important quenching modes of positronium is pick-off through paramagnetic ions we expect the positron lifetime to reflect this variation. (Edited author abstract) 6 refs.

Veena, K. (Univ of Hyderabad, Hyderabad, India); Sunandana, C.S.; Bansal, C. *Key Eng Mater* v 13 pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 633-636.

**094488 STUDY OF SECONDARY ELECTRON EMISSION CHARACTERISTICS IN BISMUTH CONTAINING SEMICONDUCTING GLASSES.** A study of electron emissive characteristic is presented for bismuth containing vanadium pentoxide and silicate glasses. Measurements of yield in secondary electron emission (SEE) were performed incorporating a retarding field analyzer and the other related parameters such as work function and ionization potential were measured using a low energy electron gun. All measurements were made in ultra high vacuum conditions at pressure less than  $10^{-9}$  Torr. X-ray diffraction (XRD) was used to identify the metal contents in these glasses. On the basis of the experimental results, applications of these glasses in electron multipliers is proposed. (Author abstract)

Rajopadhye, N.R. (Univ of Poona, Poona, India); Bhorkar, S.V.; Chakravorty, D. *Key Eng Mater* v 13 pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 810.

## Heat Transfer

**094489 THERMAL INSTABILITY IN THE LASER-DRIVEN MELTING AND RECRYSTALLIZATION OF THIN SILICON FILMS ON GLASS SUBSTRATES.** This paper develops a conductive heat transfer stability theory for the laser-driven melting and recrystallization of thin silicon films deposited on conductive (glass) substrates. The important parameters are: laser power, laser intensity distribution, and beam scanning speed. Basic state temperature distributions are obtained for straight phase boundaries. These calculated temperature distributions show the origin of instability. A linear

perturbation analysis is used to obtain the leading order corrections to the basic-state temperature fields. The perturbation time rate of growth, as a function of the disturbance wavelength, is then predicted. (Author abstract) 18 refs.

Grigoropoulos, C.P. (Columbia Univ, New York, NY, USA); Buckholz, R.H.; Domoto, G.A. *J Heat Transfer Trans ASME* v 109 n 4 Nov 1987 p 841-847.

## Heat Treatment

**094490 QUANTUM SIZE EFFECTS IN HEAT TREATED, Cd(S,Se) DOPED GLASSES.** Fine semiconductor particles of different sizes can be grown in a doped glass by appropriate heat treatment. Changes in the corresponding optical absorption spectra result from quantum confinement effects. These changes are related to particle size and allow growth and coarsening kinetics to be determined. (Author abstract) 17 refs.

Fuyu, Yan (Sheffield Univ, Sheffield, Engl); Parker, J.M. *Mater Lett* v 6 n 7 Apr 1988 p 233-237.

## High Pressure Effects

**094491 HIGH-PRESSURE STUDIES ON Ge-Te GLASSES EVIDENCE FOR A CRITICAL COMPOSITION IN IV-VI CHALCOGENIDE GLASSY SYSTEMS.** The electrical resistivity of bulk  $\text{Ge}_x\text{Te}_{100-x}$  glasses has been measured as a function of temperature and pressure. Under high pressure, all the glasses were found to undergo sharp discontinuous transitions from glassy semiconductors to crystalline metal. Several of the observed properties such as the transition pressure, conductivity activation energy and pre-exponential factor, exhibit anomalous trends at a composition  $x = 20$ . These results suggest that the  $x = 20$  composition in the Ge-Te system should possess salient structural features. A model based on the unusual stability of certain structural units is proposed for explaining the anomaly at 20 at.% Ge concentration. (Edited author abstract) 41 refs.

Asokan, S. (Indian Inst of Science, Bangalore, India); Parthasarathy, G.; Gopal, E.S.R. *Philos Mag B* v 57 n 1 Jan 1988 p 49-60.

## Impurities

**094492 OPTICAL MONITORING OF PHOTODISSOLUTION KINETICS IN AMORPHOUS AS-S FILMS.** The kinetics of the photodissolution of silver into amorphous As-S films of various compositions in the range  $\text{As}_{40}\text{S}_{60}$  to  $\text{As}_{20}\text{S}_{80}$  has been investigated by monitoring the changes that occur in their reflectivity during the photodissolution process. As the S content was increased above 60 at.% the rate of photodissolution increased to a maximum at around  $\text{As}_{33}\text{S}_{67}$  and then decreased, the maximum rate being approximately double that for  $\text{As}_{20}\text{S}_{80}$ . This is attributed to the fact that only compositions within a few at.% of  $\text{As}_{33}\text{S}_{67}$  yield a homogeneous material when photodoped. The effect of using silver-copper alloys as the metal source instead of pure silver was found to increase the photodissolution rate by up to 12%. The photodissolution rate and the form of the time dependence of the process were dependent on the thickness of the silver layer used as the ion source. Thin silver films yield a slower rate and a diffusion-limited process whereas thick films yield a faster rate and a reaction-limited process. (Edited author abstract) 24 refs.

Ewen, P.J.S. (Univ of Edinburgh, Edinburgh, Scotl); Zakery, A.; Firth, A.P.; Owen, A.E. *Philos Mag B* v 57 n 1 Jan 1988 p 1-12.

## Magnetic Properties

**094493 MAGNETIC, SUSCEPTIBILITY AND SPECIAL FEATURES OF THE STRUCTURAL-CHEMICAL COMPOSITION OF GLASSES OF THE  $\text{As}_2\text{S}_3$ - $\text{AsI}_3$  SYSTEM.** It is established that the concentration dependence of the magnetic susceptibility of glasses of the  $\text{As}_2\text{S}_3$ - $\text{AsI}_3$  system is well explained by a model of the microheterogeneous structure of the glasses. It is shown



that small additions of elements differing with respect to their electronic structure (iodine and iron) lead to the appearance of features of various characters on the concentration dependences of the magnetic susceptibility. In Russian. 14 refs.

Pinzenik, V.P.; Kramarenko, A.N.; Khimnits, V.V.; Rosola, I.I. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 4 Apr 1987 p 654-657.

**094494 ELECTRONIC CONDUCTION IN BASALT GLASS AND GLASS-CERAMICS - CORRELATION WITH MAGNETITE CRYSTALLIZATION.** The dc conductivity measurements have been made in a wide range of temperature on a basalt glass heat-treated at different temperatures to form magnetite particles. Small polaron hopping mechanism is operative in the as-annealed glass between  $\text{Fe}^{2+}$  and  $\text{Fe}^{3+}$  ions in the isolated state. This mechanism is operative in the heat-treated samples between these ions in the magnetite grains. The dc conductivity at 473 K and the activation energy show significant changes around 700°C, when magnetite forms in the basalt glass, which has been correlated with the magnetic data on these samples. TSPC and TSDC data are interesting, but the data analysis is complicated by the possible occurrence of Verwey transition in the small particles of magnetite. Preliminary ac conductivity data support the small polaron hopping mechanism. (Author abstract) 15 refs.

Jurado-Egea, J.R. (Univ of Edinburgh, Edinburgh, Scotl); Owen, A.E.; Bandyopadhyay, A.K. *J Mater Sci* v 22 n 10 Oct 1987 p 3602-3606.

**094495 ELECTRON SPIN RESONANCE IN SOME VANADATE GLASSES.** Interpretation of the semiconductivity in these glasses requires a knowledge of the valency state of the transition metal ions that are present in the glass. The electron spin resonance (e.s.r.) technique provides a useful method for determining the concentration of a paramagnetic species present. The normal ions ( $\text{V}^{5+}$  in vanadate glasses) are diamagnetic hence cannot be detected directly by the e.s.r. technique while the reduced ions  $\text{V}^{4+}$ , which are paramagnetic and have spin  $s = 1/2$ , can be detected directly by e.s.r. leading to a single resonance line influenced by nuclear hyperfine interactions. The combined effect of this interaction and the interaction of adjacent paramagnetic centres results in a line shape which should be characteristic of each glass. 7 refs.

Hosseini, A.A. (Univ of Mazandaran, Babolsar, Iran); Hogarth, C.A. *J Mater Sci Lett* v 7 n 6 Jun 1988 p 593-595.

## Mathematical Models

**094496 FREQUENCY-DEPENDENT CONDUCTIVITY IN IONIC GLASSES: A POSSIBLE MODEL.** The frequency-dependent (ac) conductivity behavior of ionically conducting glasses is discussed. A critique is given of the treatment of Almond and West for this behavior. Two models are proposed instead to account for the observed ac loss data. One involves parallel relaxation processes and is a modification of a model originally developed for the case of large-polaron transport in amorphous semiconductors. The other is based on series relaxation, and is based on a model originally proposed by Glarum for the case of dielectric relaxation in molecular liquids. In the development given here, this model is modified so as to describe ionic transport, and a new microscopic transport mechanism is proposed - 'diffusion-controlled relaxation' - which satisfies the requirements of the Glarum theory and which naturally incorporates cooperative ionic motions. For this reason, it is intuitively more appealing. (Author abstract). 54 Refs.

Elliott, S.R. (Univ des Sciences et Techniques de Languedoc, Montpellier, Fr). *Solid State Ionics* v 27 n 3 Jul 1988 p 131-149.

## Optical Properties

**094497 RAMAN SCATTERING STUDY OF LASER INDUCED STRUCTURAL TRANSFORMATIONS IN GLASSY  $\text{As}_2\text{Se}_3$ .** Light induced transformations have been studied as a function of the irradiation time by the Raman scattering technique on the chalcogenide alloy glass  $\text{As}_2\text{Se}_3$ . As a function of the laser intensity we observe: (i) For very low laser intensities there are no detectable changes in the Raman spectra; (ii) For intermediate laser intensities the spectrum exhibits oscillatory changes as a function of the irradiation time; (iii) For high laser intensities crystallization starts after some time of irradiation, which depends on the power level. Our explanations are based on the assumption that the radiation pumps the material from the glassy state towards the crystalline state, through the formation of submicrocrystalline clusters, which can coalesce to form large clusters attaining microcrystalline size at high power levels. (Author abstract) 25 refs.

Abdulhalim, I. (Israel Inst of Technology, Haifa, Isr); Bersman, R. *Solid State Commun* v 64 n 6 Nov 1987 p 951-955.

**094498 OPTICAL ABSORPTION OF VANADIUM IN SODIUM DIBORATE GLASSES.** The optical absorption in blown films and bulk specimens of sodium diborate glasses containing vanadium oxide based on the system  $[\text{Na}_2\text{O}-2\text{B}_2\text{O}_3]_{1-x} [\text{V}_2\text{O}_5]_x$  where  $x=0, 0.05, 0.10, 0.15$  and  $0.20$  has been studied in the wavelength range 200 to 900 nm. The fundamental absorption edge has been analyzed in the light of existing models. Glasses containing a higher content of vanadium have fewer defects compared with those containing a low vanadium content. The absorption spectra are due solely to pentavalent vanadium. (Author abstract) 24 refs.

Khawaja, E.E. (King Fahd Univ of Petroleum & Minerals, Dhahran, Saudi Arabia); Al-Adel, F.F. *J Mater Sci* v 23 n 4 Apr 1988 p 1391-1394.

**094499 EFFECT OF TEMPERATURE ON THE OPTICAL ABSORPTION EDGE OF THE TITANIUM OXIDE-DOPED SODA-LIME SILICA GLASSES.** From the density of states model, the value of  $E_{\text{opt}}$  is decreased as the degree of disorder in the amorphous structure is increased. Also, as temperature increases, the disorder increases and the band tailing shifts to lower energies and extends further into the forbidden band. The absorption index  $K$  is calculated using data of the absorption coefficient ( $\alpha = 4\pi K/\lambda$ ). The results show the variation of this quantity with wavelength for five different temperatures. The increase in absorption index with increasing temperature arises from the higher transition probability of carriers across the smaller optical energy gap. 8 refs.

Higazy, A.A. (El-Monoufia Univ, Shebin El-Koam, Egypt); Hussein, A.; Ewaida, M.A.; El-Hofy, M. *J Mater Sci Lett* v 7 n 5 May 1988 p 453-456.

**094500 FAR INFRARED DIELECTRIC LOSS AND LOW FREQUENCY RAMAN SCATTERING IN CHALCOGENIDE GLASSES.** Important information about the nature of the ubiquitous low frequency Raman peak ('Bose peak'), which is commonly observed in network glasses, can be obtained from a detailed comparison of the Raman scattering of the far infrared dielectric loss. New dielectric loss data for vitreous  $\text{As}_2\text{Se}_3$  will be presented and interpreted in terms of a model for low frequency modes in this glass. (Author abstract). 8 Refs.

Strom, U. (US Naval Research Lab, Washington, DC, USA); Culbertson, J.C.; Freitas, J.A. Jr. *Int J Infrared Millim Waves* v 9 n 4 Apr 1988 p 321-324.

**094501 PHOTOACOUSTIC STUDIES ON SELENIUM-BASED SEMICONDUCTING GLASSES.** The optical energy gap of amorphous  $\text{Se}_{1-x}\text{Te}_x$  and  $\text{Se}_{1-x}\text{Sb}_x$  semiconducting alloys have been determined as a function of  $x$  using photoacoustic spectroscopy for the first time. The optical energy gap of amorphous selenium reduces drastically on substitution of 2% Sb. On annealing

the optical energy gap of amorphous selenium decreases linearly as a function of annealing temperature towards that of crystalline selenium. (Author abstract) 6 refs.

Venugopal Reddy, K. (Univ of Hyderabad, Hyderabad, India); Bhatnagar, A.K. *Key Eng Mater* v 13 pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 813-816.

**094502 PHOTOACOUSTIC STUDIES OF LEAD-VANADATE GLASSES.** Semiconducting lead vanadate glasses ( $\text{V}_2\text{O}_5$ )<sub>x</sub>(PbO)<sub>100-x</sub> glasses have been studied using photoacoustic absorption spectroscopy. It is found that the energy gap  $E_g$  decreases with increasing PbO concentration. Doping of ( $\text{V}_2\text{O}_5$ )<sub>50</sub>(PbO)<sub>50</sub> glass with  $\text{Fe}_2\text{O}_3$  decreases the energy gap, but increase in doping of  $\text{Fe}_2\text{O}_3$  results in the increase of  $E_g$ . (Author abstract) 5 refs.

Virataswaroop, U.N. (Univ of Hyderabad, Hyderabad, India); Bhatnagar, A.K. *Key Eng Mater* v 13 pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 817-820.

**094503 DARK RECOVERY OF FATIGUED PL CENTERS DURING FATIGUING IN AMORPHOUS Ge-SE SYSTEM.** Dark recovery of fatigued photoluminescence intensity have been studied. Two types of fatigued centers have been detected, one is dark-restorable, the other is not. These centers need different exposition to be fatigued. (Author abstract) 5 refs.

Koos, Margit (Central Research Inst for Physics, Budapest, Hung); Pocsik, Istvan; Kosa Somogyi, Istvan. *Key Eng Mater* v 13 pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 825-828.

Phase Transitions See GLASS—Physical Properties.

## Physical Properties

**094504  $\text{GeSnSe}_3$  GLASS - A NOVEL EXCEPTION TO THE IOFFE-REGEL RULE.** Glasses based on the  $\text{Ge}_{2-2x}\text{Sn}_{2x}\text{Se}_3$  ternary have been examined using scanning calorimetry, Mossbauer spectroscopy, and molar volume measurements. The origin of extensive glass formation, especially near  $x=0.5$ , is traced to a floppy molecular fragment based on the structure of  $\text{c-GeSnSe}_3$ .  $\text{c-GeSnSe}_3$  does not exist in a structure isomorphous to  $\text{c-GeSnS}_3$ , thus showing  $\text{g-GeSnSe}_3$  to be a novel exception to the Ioffe-Regel Rule. (Author abstract) 15 refs.

Enzweiler, R.N. (Univ of Cincinnati, Cincinnati, OH, USA); Boolchand, P. *Solid State Commun* v 62 n 3 Apr 1987 p 197-200.

**094505 ELASTIC CONSTANTS OF THE CHALCOGENIDES GLASSES ( $\text{Ge}_x\text{Se}_{1-x}$ ,  $\text{As}_y\text{Se}_{1-y}$  AND  $\text{Ge}_{2/3}\text{Se}_{1/3}$ ).** The elastic constants of the three different types of the chalcogenide glasses,  $\text{Ge}_x\text{Se}_{1-x}$  with  $x=0$  to  $0.3$ ,  $\text{As}_y\text{Se}_{1-y}$  with  $y=0$  to  $0.45$ , and  $\text{Ge}_{2/3}\text{As}_{1/3}\text{Se}_{1-z}$  with  $z=0$  to  $0.6$  have been measured. The results are compared with recent theories of the rigidity percolation in covalent networks. Contrary to previous reports, our results do not show any clear anomaly of the elastic constants at the rigidity percolation threshold around the average coordination of 2.4. The origin of the dependence of the anomaly on the experimental methods is discussed. (Edited author abstract) 18 refs.

Ito, Y. (Niigata Univ, Ikarashi, Jpn); Kashida, S.; Murase, K. *Solid State Commun* v 65 n 6 Feb 1988 p 449-452.

**094506 EFFECT OF MICROSTRUCTURE AND FUSION TEMPERATURE ON THE ELECTRICAL AND OPTICAL PROPERTIES OF VANADATE GLASSES.** The electrical and optical properties of binary semiconducting oxide glasses containing 45 mol%  $\text{V}_2\text{O}_5$  and 55 mol%  $\text{GeO}_2$  fused and equilibrated at various temperatures ( $T_d$ ) in air were measured.  $T_d$  was varied over the range from 1000 to 1350°C. Their electrical and optical properties are shown to be sensitive to microstruc-



ture and melt temperature. We suggest that the change in  $T_g$  caused progressive microstructure changes of these glasses, which dramatically affected the electronic conductivity and the activation enthalpy for conduction. (Author abstract) 20 refs.

Khan, M.N. (Bahrain Univ, Bahrain). *J Mater Sci* v 23 n 3 Mar 1988 p 847-851.

**094507 OPTICAL ABSORPTION AND THERMAL DIFFUSIVITY IN  $Ge_xTe_{100-x}$  GLASSES BY THE PHOTOACOUSTIC TECHNIQUE.** The variation in the optical energy gap with composition in the  $Ge_xTe_{100-x}$  system ( $15 \leq x \leq 28$ ) of glasses in bulk form has been studied using photoacoustic techniques. It is found that the optical energy gap increases with increasing composition factor  $x$ , with the rate of increase showing a slowing-down trend for compositions with  $x > 20$ . The composition dependence of the thermal diffusivity of these samples has also been measured. The thermal diffusivity is found to peak around the composition corresponding to  $x=20$ . The observed phenomena are explained on the basis of chemical bond formation in this system of glasses. The change in the short-range order and increase in the number of Te-Te bonds with decreasing  $x$  are interpreted as being responsible for the behaviour exhibited by these materials. (Author abstract). 23 Refs.

Madhusoodanan, K.N. (Cochin Univ Of Science & Technology, Cochin, India); Philip, Jacob; Parthasarathy, G.; Asokan, S.; Gopal, E.S.R. *Philos Mag B* v 58 n 1 Jul 1988 p 123-132.

**Pressure Effects** See GLASS—Pressure Effects.

#### Radiation Effects

**094508 PHOTOINDUCED CHANGES IN THE RATE OF DISSOLUTION OF  $As_2S_3$  AND  $AsSe$  FILMS.** Using the methods of IR spectroscopy and etching kinetics, a study was made of the photo- and thermo-induced changes in the structure of arsenic monoselenide and arsenic sulfide chalcogenide glass films. It was found that the short-range-order structure changes in all the cycles of action on  $AsSe$  films, in contrast to  $As_2S_3$  films, in which structural changes are observed only during irradiation or annealing of fresh films. 6 refs. In Russian.

Mamedov, S.B.; Mikhailov, M.D.; Pogoreva, V.G.; Yakovuk, O.A. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1804-1808.

**094509 STRUCTURAL MODIFICATION OF ARSENIC CHALCOGENIDE GLASSES UNDER  $\gamma$ -RADIATION.** The radiation-induced changes of the molecular structure and properties of chalcogenide glassy semiconductors are analysed. The effect of  $\gamma$ -radiation on the mechanical properties (Young's modules, internal friction) was investigated at various temperatures and radiation doses. At low temperatures the changes of the molecular structure and the corresponding changes of mechanical properties grow with decrease of the structural network rigidity. At higher temperatures the opposite dependence of the properties is found. (Edited author abstract). 8 Refs.

Popov, A.I. (Moscow Power Engineering Inst, USSR); Domoryad, I.A.; Michalev, N.I. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 333-337.

#### Spectroscopic Analysis

**094510 RAMAN SCATTERING IN Ge-S-Ga GLASSES.** We present a study by Raman spectroscopy of a new class of semiconducting glasses; ternary alloys of Ge, S and Ga. Both the high-frequency molecular-like modes and the low-frequency acoustic region have been investigated for various glass compositions and laser excitation wavelengths. The results throw some light on the molecular structure and dynamics of these glasses. (Author abstract) 25 refs.

Fontana, M.P. (Univ di Parma, Parma, Italy); Rosi, B.; Ivanova, Z.; Kirov, N. *Philos Mag B* v 56 n 4 Oct 1987

p 507-514.

**094511 APPLICATION OF MOESSBAUER SPECTROSCOPY AND DTA TO A STRUCTURAL STUDY OF SEMICONDUCTING  $P_2O_5-V_2O_5$  GLASSES.** A Moessbauer spectrum series of  $P_2O_5-V_2O_5$  glasses containing 5 mol%  $Fe_2O_3$  consists of a paramagnetic quadrupole doublet, the isomer shift of which varies from 0.37 to 0.32 mm  $s^{-1}$  when the  $P_2O_5$  content is changed from 5 to 40 mol%. This indicates that all the  $Fe^{3+}$  ions are surrounded by four oxygen atoms and that they are present at the substitutional sites of the  $V^{3+}$  or  $V^{4+}$  ions constituting  $VO_4$  tetrahedra. These results are quite different from the Moessbauer result of the  $95V_2O_5 \cdot 5Fe_2O_3$  glass, where the  $Fe^{3+}$  ions prove to be surrounded by six oxygen atoms at the interstitial sites of the layer structure composed of the  $VO_5$  tetragonal pyramids (or trigonal bipyramids). A distinct increase in the quadrupole splitting ranging from 0.71 to 0.90 mm  $s^{-1}$  in the same compositional region indicates an increased electric field gradient at the iron nucleus. (Edited author abstract) 42 refs.

Nishida, Tetsuaki (Kyushu Univ, Fukuoka, Jpn); Takashima, Yoshimasa. *J Non Cryst Solids* v 94 n 2 Nov 1987 p 229-237.

**094512 X-RAY K ABSORPTION EDGES OF Ge AND Se IN  $Ge_{22}Se_{78-x}Bi_x$  GLASSES AND AMORPHOUS FILMS.** The X-ray K absorption edges of Ge and Se in glassy  $Ge_{22}Se_{78-x}Bi_x$  with  $x=0, 2$  and 10 have been studied in bulk as well as in thin-film form. In both cases, we find that, at a low concentration of Bi ( $x=2$ ), the Se K edge shifts while that of Ge remains unchanged. On the other hand, at a higher concentration of Bi ( $x=10$ ), the reverse happens. The results indicate different kinds of bonding at low and high concentrations of Bi. The results are in agreement with those of other workers who drew similar conclusions from the electrical properties. (Author abstract) 14 refs.

Agnihotri, A.K. (Harcourt Butler Technological Inst, Kanpur, India); Kumar, A.; Nigam, A.N. *Philos Mag B* v 57 n 2 Feb 1988 p 319-324.

**094513 PHASE SEPARATION IN  $Ge_{1-x}Sn_xSe_2$  GLASSES.** Raman scattering and Moessbauer spectroscopy have been used to examine the structure of  $Ge_{1-x}Sn_xSe_2$  glasses in the composite range  $0 \leq x \leq 0.7$ . The Raman spectra can be separated into contributions from  $GeSe_2$  and  $SnSe_2$  units, and for  $x \geq 0.35$  a softening of the tetrahedral breathing modes and a shift in the polarizability of the structure are observed. For  $x=0.5$ , thermal annealing results in the precipitation of crystalline  $SnSe_2$ . These results are interpreted to indicate a phase separation of  $GeSe_2$  and  $SnSe_2$  in the amorphous state. (Author abstract) 9 refs.

McNeil, L.E. (Univ of North Carolina, Chapel Hill, NC, USA); Mikrut, J.M.; Peters, M.J. *Solid State Commun* v 62 n 2 Apr 1987 p 101-103.

**094514 MOESSBAUER SPECTROSCOPY - A REWARDING PROBE OF MORPHOLOGICAL STRUCTURE OF SEMICONDUCTING GLASSES.** In Section II, the author provides some background material on Moessbauer spectroscopy. The intention is to familiarize the reader with the method, thus making easier the interpretation of the spectra of chalcogenide network glasses. Section III presents experimental results on  $g-GeSe_2$ , first as revealed by diffraction measurements and vibrational spectroscopy, and then as extended by the Moessbauer results. This approach permits a structure discussion of the prototypical glass. 51 refs.

Boelchand, Punit (Univ of Cincinnati, Cincinnati, OH, USA). *Phys Prop of Amorphous Mater, Proc of a Lect Ser, Bloomfield Hills, MI, USA, 1982-1983* Publ by Plenum Press, New York, NY, USA & London, Engl, 1985 p 221-260.

**094515 X-RAY SPECTROSCOPIC STUDIES OF THE GLASSY  $Ge_{x-1}Se_{100-x}$  SYSTEM.** X-ray K-absorption edges of germanium and selenium have been studied in

glassy  $Ge_xSe_{100-x}$  ( $x = 10, 15, 22$  and 30). We find that the Ge K-absorption edge always shifts towards higher energies with respect to pure amorphous germanium whereas the Se K-absorption edge always shifts towards lower energies with respect to amorphous selenium. In both cases, the shift is found to be a minimum for the particular value  $x = 22$  which indicates some modifications in the structure at this composition. (Author abstract). 17 Refs.

Agnihotri, A.K. (Harcourt Butler Technological Inst, Kanpur, India); Kumar, A.; Nigam, A.N. *Philos Mag Lett* v 58 n 1 Jul 1988 p 63-67.

**094516 XANES AND EXAFS STUDY OF SEMICONDUCTOR GLASSES.** Semiconductor glasses like Se-Te, Te-Ge etc. are characterized by at least a half-filled outer electron shell with the bonding being described by the 8-N rule. These materials are represented by a model of continuous random network of atoms but the short range disorder differs in nature in various systems. This, in turn, influences the shape of density and electron states, in valence and conduction bands, also, it leads to localized electronic states in band tails. XANES and EXAFS techniques offer a very potential method of probing the electronic structure and local ordering as well as changes therein. Being atom specific, they can be tuned to a particular species of atoms present in the system. Of late, EXAFS, the XANES technique has also been showing signs of yielding quantitative data. (Edited author abstract)

Garg, K.B. (Univ of Rajasthan, Jaipur, India). *Key Eng Mater* v 13 pt 1 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 147.

**094517 EPR OF TELLURIUM-VANADATE GLASSES PARTIALLY SUBSTITUTED BY IRON-GROUP IONS.** EPR of  $5-TO_{50}V_{20}Fe_{20}O_2$  glasses ( $TO = TiO_2, Cr_2O_3, MnO_2, Fe_2O_3$  and  $Co_2O_3$ ) has been investigated in the temperature range 300-473 K. The results are discussed in terms of (i) the influence of  $Ti^{3+}$  and  $Co^{3+}$ -ions on the geometry of  $3d^1 (V^{4+})$  electron hopping and (ii) formation of and dissociation of clusters involving  $Fe^{3+}$  ( $Mn^{2+}$ ) and  $V^{4+}$ . (Author abstract) 3 refs.

Sunandana, C.S. (Univ of Hyderabad, Hyderabad, India). *Key Eng Mater* v 13 pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 627-632.

#### Structure

**094518 LAYER STRUCTURES IN CHALCOGENIDE GLASSES.** The composition dependence of various properties in chalcogenides glasses shows a transition when the average coordination number is 2.67. A constraint-counting analysis for two-dimensional systems suggests that layer structures are maximally stabilized at the critical composition. (Author abstract). 9 Refs.

Tanaka, Keiji (Hokkaido Univ, Sapporo, Jpn). *J Non Cryst Solids* v 103 n 1 6(II) 1988 p 149-150.

**094519 STRUCTURAL TRANSFORMATION IN N-TYPE Bi DOPED SEMICONDUCTING GLASSES  $Ge_{20}S_{80-x}Bi_x$ .** The problem of controlled doping (n-type/p-type) of amorphous germanium chalcogenides is of great importance due to their application in devices. In this investigation, we have applied techniques of DTA, X-ray diffractometry, electron-microscopy and measurement of electrical transport under high pressure to study the structural features of amorphous Bi doped  $Ge_{20}S_{80-x}Bi_x$  ( $x=0, 4, 11, 15$ ) with a view to understand the mechanism of doping in these semiconductors. The experiments reveal the presence of composite clusters of Ge-S-Bi which decompose into simpler units  $B_2S_3, GeS_2$



on annealing/applying pressure. This indicates the Bi impurity induced chemical modification of the semiconductor. (Author abstract) 6 refs.

Gosain, D.P. (Maharshi Dayananda Univ, Rohtak, India); Bhatia, K.L.; Parthasarathy, G.; Gopal, E.S.R. *Key Eng Mater* v 13 pt 2 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 351-354.

**094520 POSITRON ANNIHILATION FOR INVESTIGATION OF CHEMICAL BONDING IN THE STRUCTURES OF As-Se, As-Te AND Ge-Se.** Previous structural studies of Ge-Se, As-Se and As-Te glasses taking traditional techniques revealed some typical structures depending on the glass composition. Thus for the Ge-Se system the tetrahedral units  $\text{GeSe}_{4/2}$  ( $X=30$  at.%Ge) and finally to ethane-like units  $\text{Ge}_2(\text{Se}_2\text{O}_4)_6$  when  $x$  is about 40 at.%. Meanwhile the explanation of the dependence of glass forming temperature and photoluminescence energy on composition for  $\text{As}_x\text{B}_{1-x}$  ( $x > 30$  at.%) using such characteristic as chemical binding energy requires the assumption of existence (along with single Ge-Ge and Ge-Se bonds) of double and triple bonds between germanium (arsenic) atoms. Its validity is proved in this study for As-Se, As-Te and Ge-Se systems using the positron annihilation method. (Author abstract) 7 refs.

Kevdina, I.B. (Acad of Sciences of the USSR, Moscow, USSR); Kobrin, B.V.; Minaev, V.S.; Shantarovich, V.P. *Key Eng Mater* v 13 pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 637.

## Surfaces

**094521 ELECTRONIC PROCESSED ON THE SURFACE OF As-Se CHALCOGENIDE GLASSY SEMICONDUCTORS.** The paper is a survey of the results obtained in studies of surface processes. As a subject the model glassy semiconductor  $\text{As}_2\text{Se}_3$  was chosen, as well as other compositions in the As-Se system (with deviations from stoichiometry). Glassy  $\text{As}_2\text{Se}_3$  is used to illustrate the major results of these studies. Section 2 is an analysis of experimental data on the effect of mechanical and chemical surface treatment on the properties of glassy  $\text{As}_2\text{Se}_3$ . Section 3 considers the effects associated with adsorption on the surface of  $\text{As}_2\text{Se}_3$  and other compounds of the system. Section 4 sums up the results obtained and discusses the model concepts suggested by these studies. 68 Refs.

Mamontova, T.N. (Acad of Sciences of the USSR, Leningrad, USSR); Kochemirovskii, A.S.; Pivovarova, L.V. *Phys Status Solidi A* v 107 n 1 May 1988 p 11-43.

**Switching** See GLASS—Crystallization.

**Synthesis** See Also GLASS—Infrared Transmission.

**094522 SYNTHESIS AND STRUCTURAL STUDIES OF NOVEL CADMIUM GERMANATE GLASSES.** The synthesis of novel cadmium germanate glasses is reported in detail. Several representative samples, spanning the entire glass-forming region, have been studied by means of Raman and Fourier transform infrared spectroscopies, complemented by density measurements. The experimental results reveal the tetrahedral structure of the germania network, the large number of non-bridging-oxygens associated with germanium centers and the partial covalent character of the cadmium-oxygen interactions. (Author abstract) 16 refs.

Chrysoskos, G.D. (Natl Hellenic Research Foundation, Athens, Greece); Kamitsos, E.I. *Solid State Commun* v 63 n 7 Aug 1987 p 611-613.

**094523 PREPARATION AND SEMICONDUCTIVE PROPERTIES OF GLASSY FILMS IN THE  $\text{V}_2\text{O}_5\text{-MoO}_3$  SYSTEM.** Rapidly quenched glassy films in the  $\text{V}_2\text{O}_5\text{-MoO}_3$  system were prepared using a twin-roller type apparatus. The glass formation has a wide range of 0-70 mol%  $\text{MoO}_3$  content. Crystallization occurs in two or three steps, except for  $\text{V}_2\text{O}_5$ -rich glassy films. The electric

conductivity of the glassy films shows a maximum at a composition of about 20 mol%  $\text{MoO}_3$ . The electrical behavior and glass structure are discussed on the basis of IR spectral data. (Edited author abstract) 17 refs.

Tsuzuki, A. (Government Industrial Research Inst, Nagoya, Jpn); Kawakami, S.; Awano, M.; Sekiya, T.; Torii, Y. *Mater Res Bull* v 23 n 3 Mar 1988 p 327-332.

## Thermal Effects

**094524 ON THE JOULE SELF-HEATING CURRENT INCREASE CORRESPONDING TO A NON-SWITCHING VOLTAGE IN BULK GLASSY SEMICONDUCTORS.** This paper analyses the influence of Joule self-heating on the electrical conduction process in bulk glassy semiconductors, when non-switching square voltage pulses are applied; the dependence of the heating time constant on the ratio between steady-state current increase and the initial current; and the relationship between steady-state current increase, applied voltage and ambient temperature. (Author abstract) 13 refs.

Marquez, E. (Univ de Cadiz, Cadiz, Spain); Villares, P.; Jimenez-Garay, R. *Semicond Sci Technol* v 3 n 2 Feb 1988 p 161-164.

## Thermal Expansion

**094525 THERMAL EXPANSION OF SOME Ge-Se-Te GLASSES.** Results of measurements of the thermal expansion coefficient (from 50°C to the softening temperature) are reported for eight glass compositions of the Ge-Se-Te system. For  $(\text{GeSe}_2)_{100-2x}\text{Se}_x\text{Te}_x$  glasses, an increase in the glass transition temperature ( $T_g$ ) and in  $\Delta\alpha$  (the change in thermal expansion coefficient,  $\alpha$ , during the glass transition) is seen with decreasing SeTe content. For  $(\text{GeSe}_2)_{23.33}\text{Se}_{30-2x}\text{Te}_x$  glasses,  $\alpha$ ,  $T_g$  and  $\Delta\alpha$  are invariant with composition. These results, when examined along with those obtained for other chalcogenide glasses, indicate that chalcogenide glasses are not necessarily in a stage of isofree volume during glass transition. Values ranging from 0.024 to 0.167 are obtained for the free volume of some chalcogenide glasses. (Edited author abstract) 16 Refs.

Giridhar, A. (Natl Aeronautical Lab, Bangalore, India); Mahadevan, Sudha; Singh, A.K. *J Non Cryst Solids* v 103 n 1 6(II) 1988 p 73-78.

## Thermoelectric Effects

**094526 STUDY OF THE ELECTROTHERMAL SWITCHING EFFECT IN BULK GLASSY SEMICONDUCTORS BY A COMPUTER SIMULATION METHOD.** The electrical switching process in glassy semiconductors has been studied by a computer simulation method. The operation of a switching device has been considered from the stand-point of internal heat generation and the attendant rise in device temperature. A simple model has been chosen for an analysis in which the thermal and electrical parameters are related in a nonlinear manner through the exponential dependence of conductivity on temperature. Furthermore, field-dependence effects (space-charge formation) are introduced in order to complete the model, which could be called 'electronically assisted' thermal breakdown. The simulated current-voltage relationship exhibits a turnover voltage and conditions of negative differential resistance. To summarize, it is demonstrated that the application of a computer simulation is useful, in order to examine the switching phenomenon. (Author abstract) 22 refs.

Marquez, E. (Univ de Cadiz, Cadiz, Spain); Villares, P.; Jimenez-Garay, R. *J Mater Sci* v 22 n 12 Dec 1987 p 4434-4438.

## Thin Films

**094527 VIBRATIONAL SPECTROSCOPIC STUDY OF METAL CHALCOGENIDE SPIN-ON-GLASSES.** Thin films of germanium diselenide have been prepared by a spin-on-glass technique from ethylenediamine solutions. The solutions and the films at various

stages of processing have been characterized using infrared and Raman spectroscopies. The results indicate that amorphous  $\text{GeSe}_2$  films are formed after complete processing. At stages prior to the formation of the final film several chemically distinct species are observed. The identification of some of these species offers insight into the formation of solid  $\text{GeSe}_2$  networks. (Author abstract) 20 refs.

Ferris, Nancy S. (Eastman Kodak Co, Rochester, NY, USA); Lelental, Mark. *Mater Res Bull* v 23 n 5 May 1988 p 653-661.

**094528 SILVER PHOTODISSOLUTION AND OPTICAL PROPERTIES OF  $\text{GeSe}_3$  VITREOUS GLASS THIN FILMS.** The photodoping of Ag in thin layers of amorphous  $\text{GeSe}_3$  semiconductors was studied according to the intensity and wavelength of the radiation used. This study is based on the electrical resistance variation of the Ag layer deposited above (or underneath)  $\text{GeSe}_3$  for a given radiation. Optical measurements for wavelengths from 350 nm to 2.5  $\mu\text{m}$  were used to determine the absorption coefficient  $\alpha$  for transparency zones, the index of refraction, and the extinction coefficient of  $\text{GeSe}_3$ . (Author abstract) 45 Refs.

Konan, K. (Univ des Sciences et Techniques, Montpellier, Fr); Galibert, G.; Calas, J. *Phys Status Solidi A* v 107 n 1 May 1988 p 273-279.

**X-ray Analysis** See Also SEMICONDUCTING GERMANIUM COMPOUNDS—Order-Disorder.

**094529 TOPOLOGICAL FEATURES OF  $\text{Cu}_{15}\text{As}_{34}\text{Se}_{51}$  GLASSY SEMICONDUCTOR.** In a previous work the short-range order of  $\text{Cu}_{15}\text{As}_{34}\text{Se}_{51}$  has been studied by X-ray diffraction from analysis of its radial distribution function (RDF). A conclusion of this work was that the structure is made up of a tetrahedral framework centered on copper atoms, there also being some centered on arsenic atoms. On the basis of short-range order, a 1.07 nm radius spherical model has been built up by a random method. The model is made up of 200 atoms, of which 30 are copper, 70 arsenic, and 100 selenium, if we take into account the material composition. The geometrical fitting of the structure has been carried out by comparison between the RDF of the model and the experimental one, multiplied by a theoretical function, simulating the shape and finite size of the model. 10 refs.

De La Rosa-Fox, N. (Univ De Cadiz, Cadiz, Spain); Esquivias, L. *J Mater Sci Lett* v 7 n 2 Feb 1988 p 105-107.

**094530 STRUCTURAL AND ELECTRICAL PROPERTIES OF THE GLASSY SEMICONDUCTOR SYSTEM Cu-As-Te PART 2 STRUCTURAL ANALYSIS BY X-RAY DIFFRACTION AND SPACE MODELS.** An X-ray diffraction radial distribution study of  $\text{Cu}_{0.05}\text{As}_{0.50}\text{Te}_{0.45}$  and  $\text{Cu}_{0.15}\text{As}_{0.40}\text{Te}_{0.45}$  amorphous alloys obtained by the melt quench method has been performed. The short range order proposed from the radial distribution function (RDF) interpretation was calculated from a theoretical expression that takes into account the variation with  $s$  (scattering vector modulus) of the atomic scattering factor. The local order of both alloys presents a deviation from the covalent character of the arsenic and tellurium elements bound to copper, increasing the mean coordination and not fitting the octet rule. For study of the structural characteristics, tridimensional models were built by computer simulation of an X-ray diffraction experiment. Refinement was carried out by the Metropolis-Monte Carlo method with modifications. The basic structure of both models may be described by a network of tetrahedra centered on copper and arsenic atoms. As both clusters are intermingled, the network connectivity is increased. Both models present a certain number of tellurium atoms with dangling bonds with average bonding distances above the mean value which together with the copper concentration may be responsible for its decreased electrical resistivity. (Author abstract) 24 refs.

Vazquez, J. (Univ de Cadiz, Cadiz, Spain); Marquez, E.; De La Rosa-Fox, N.; Villares, P.; Jimenez-Garay, R. *J Mater Sci* v 23 n 5 May 1988 p 1709-1717.



## SEMICONDUCTING INDIUM

## Electric Conductivity

**094531 ELECTRICAL CONDUCTANCE OF INDIUM THIN FILMS IMMEDIATELY AFTER BEING DEPOSITED.** Several workers have studied the electrical conductance of indium thin films, but little has been reported on the effects on this property due to aging of samples in the form of polycrystalline aggregates. The authors carried out in situ measurements on samples ranging in thickness from 110 to 194 nm. At room temperature, indium films within this thickness range go through a transition from discontinuous (island structure) to continuous films. Electrical resistance measurements as a function of time were made to obtain information on this process. 10 refs.

Clark, N. (Univ de Costa Rica, San Jose, Costa Rica); Segnini, M. *Phys Status Solidi A* v 105 n 2 Feb 1988 p K125-K128.

## SEMICONDUCTING INDIUM COMPOUNDS

See Also ALUMINUM AND ALLOYS—Vapor Deposition; COLLOIDS—Materials; INFRARED DETECTORS—Efficiency; LASERS, SEMICONDUCTOR; LASERS, SEMICONDUCTOR—Accessories; LASERS, SEMICONDUCTOR—Analysis; LASERS, SEMICONDUCTOR—Chemical Vapor Deposition; LASERS, SEMICONDUCTOR—Degradation; LASERS, SEMICONDUCTOR—Design; LASERS, SEMICONDUCTOR—Electric Properties; LASERS, SEMICONDUCTOR—Performance; LASERS, SEMICONDUCTOR—Stability; MODULATORS; SEMICONDUCTING GALLIUM ARSENIDE—Electronic Properties; SEMICONDUCTING GALLIUM ARSENIDE—Growth; SEMICONDUCTING GALLIUM COMPOUNDS—Growth; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES—Measurements; SEMICONDUCTOR DEVICES—Semiconductor Insulator Boundaries; SEMICONDUCTOR DEVICES, CHARGE TRANSFER—Contacts; SEMICONDUCTOR DEVICES, MIS—Semiconductor Insulator Boundaries; SEMICONDUCTOR DEVICES, MISFET—Semiconductor Insulator Boundaries; SEMICONDUCTOR DIODES—Electric Properties; SEMICONDUCTOR DIODES, PHOTODIODE—Analysis; SEMICONDUCTOR DIODES, PHOTODIODE—Fabrication; SOLAR CELLS—Silicon; SOLAR CELLS—Thermal Effects; TRANSISTORS—Performance; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, FIELD EFFECT; TRANSISTORS, FIELD EFFECT—Doping; TRANSISTORS, FIELD EFFECT—Fabrication; TRANSISTORS, FIELD EFFECT—Heterojunctions; TRANSISTORS, FIELD EFFECT—Manufacture; TRANSISTORS, FIELD EFFECT—Optimization.

**094532 EXCITON ABSORPTION AND LUMINESCENCE OF INDIUM SELENIDE CRYSTALS.** By investigations of low-temperature photoluminescence (PL) spectra of InSe crystals the nature of emission lines in the region of indirect exciton transitions is determined and the energy diagram of optical direct and indirect transitions is offered. The pressure in  $\gamma$ -InSe of regions containing stacking faults results in the appearance of a fine structure in the PL spectra of an  $n = 1$  exciton state. Within the framework of a 'resonant exciton' model the causes of the growth of integrated intensity in the absorption spectra of an  $n = 1$  exciton state are discussed. (Author abstract) 18 refs.

Gnatenko, Yu.P. (Acad of Sciences of the USSR, Kiev, USSR); Zhirko, Yu.I. *Phys Status Solidi B* v 142 n 2 Aug 1987 p 595-604.

**094533 ELECTROCHEMICAL AND SPECTRO-ELECTROCHEMICAL ANALYSIS OF THE OXIDE/p-INDIUM PHOSPHIDE SEMICONDUCTOR SURFACE USING FOURIER TRANSFORM INFRARED AND RAMAN SCATTERING SPECTROSCOPES.** Raman scattering and FTIR reflectance spectroscopies have been used to examine p-InP/oxide surfaces. The thin anodic oxide film grown in pH 6 tartaric acid solutions is found to be primarily indium dihydrogen phosphate. This layer gives rise to an appreciable reduction in band bending (as much as 300 mV) which is similar to that obtained by open circuit photovoltage measurements. The photocurrent-voltage behavior of p-InP/oxide shows that the growth of anodic oxide at p-InP introduces significant surface states which act as surface recombination centers. (Author abstract) 34 refs.

Li, Jiango (Univ of Utah, Salt Lake City, UT, USA); Pons,

Stanley. *J Electroanal Chem Interfacial Electrochem* v 233 n 1-2 Sep 10 1987 p 1-18.

**094534 BAND STRUCTURE OF InN.** The energy band structure of wurtzite-structure semiconductive InN is predicted using empirical nearest-neighbor tight-binding theory. The tight-binding parameters are extrapolated from those of zincblende InP, InAs, and InSb by using empirical rules for the dependences of the parameters on bond length and on row of the Periodic Table. The predicted band gap is direct and agrees well with the data for this potential orange light-emitter. It is suggested that zincblende InN, if it can be grown, also will have a band-gap near 2 eV. (Author abstract) 19 refs.

Jenkins, David W. (Univ of Notre Dame, Notre Dame, IN, USA); Hong, Run-Di; Dow, John D. *Superlattices Microstruct* v 3 n 4 1987 p 365-369.

## Amorphous

**094535 LOW-TEMPERATURE WET-CHEMICAL SYNTHESIS OF AMORPHOUS INDIUM SULFIDE POWDERS.** Indium sulfide is a chalcogenide semiconductor useful in the preparation of green and red phosphors and the manufacture of picture tubes for color television. It was possible to prepare amorphous indium sulfide powders using the reaction between an acidified (pH=1.3) solution of indium chloride and sodium hydrosulfide (NaHS). The indium sulfide powders prepared by this process give a glass transition at 330°C and a crystallization exotherm on heating at 390°C in a DSC. Results of characterization of the amorphous and heat treated powders using electron microscopy (SEM, TEM), electron probe microanalysis (EMPA) and X-ray diffraction (XRD) are presented. (Edited author abstract) 11 refs.

Kumta, P.N. (Univ of Arizona, Tucson, AZ, USA); Phule, P.P.; Risbud, S.H. *Mater Lett* v 5 n 10 Sep 1987 p 401-404.

**094536 METAL-SEMICONDUCTOR TRANSITION IN AMORPHOUS InSb FILMS.** The metal-semiconductor transition takes place with the change of the substrate temperature  $T_s$  in amorphous InSb films which is formed by the vapor deposition. Amorphous InSb behaves like a metal for  $T_s > 120$  K, as semiconductor for  $T_s > 120$  K; superconductivity on one side of the metal was investigated. (Edited author abstract) 8 refs.

Cao Xiao-Wen (Acad Sinica, Hefei, China). *Solid State Commun* v 61 n 10 Mar 1987 p 627-630.

**094537 INNOVATIVE METHOD FOR PREPARING ANISOTROPIC InSb-NiSb RIBBON.** Amorphous ribbon with InSb-NiSb eutectic composition has been prepared by melt-spinning technique. Subsequent magnetic field annealing above its crystallization temperature caused it to crystallize with parallel aligned NiSb needles in InSb matrix. The effect of heating rate, annealing temperature and field strength on the resulting microstructure and magnetic properties was examined. This new method was shown to be more cost effective than conventional unidirectional eutectic solidification process. The magnetic properties will be compared to those produced by the conventional method. (Author abstract) 3 refs.

Chang, H.Y. (Chung Shan Inst of Science & Technology, Lung-Tan, Taiwan); Chian, C.I.; Yao, P.C.; Yang, S.J.; Hsu, S.H. *Key Eng Mater* v 13 pt 1 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 57.

**Applications** See CAPACITORS—Stability; LASERS, SEMICONDUCTOR—Materials; LASERS, SEMICONDUCTOR—Mathematical Models; SEMICONDUCTING SILICON COMPOUNDS—Chemical Vapor Deposition; SEMICONDUCTOR DEVICES; SEMICONDUCTOR DEVICES—Performance; SEMICONDUCTOR DEVICES—Semiconductor Insulator Boundaries; SEMICONDUCTOR DEVICES, MISFET—Analysis; SEMICONDUCTOR DIODES, LIGHT EMITTING; SEMICONDUCTOR DIODES, PHOTODIODE—Materials; SOLAR CELLS—Efficiency; TRANSISTORS, FIELD EFFECT—Fabrication; TRANSISTORS, FIELD EFFECT—Performance.

**Charge Carriers** See Also SEMICONDUCTOR DEVICES, MOS—Spectroscopic Analysis; SEMICONDUCTOR MATERIALS—Charge Carriers.

**094538 RAMAN SCATTERING BY GaInAs-InP QUANTUM WELLS: EFFECTS OF FREE CARRIERS AND IMPURITIES.** We report a Raman scattering study of the effects of free carriers, produced by both photo-excitation and remote doping, on the LO phonons in both bulk  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$  and  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As-InP}$  single quantum wells. In the bulk alloy high carrier densities cause both a weakening and a shift to lower energy of the dominant GaAs-like LO phonon. In the quantum-well structures this effect is greatly enhanced due to the efficient trapping of photo-excited carriers in the well. This behavior is in contrast to that of the InP capping layer where we observe a coupled LO-plasmon mode on the high-energy side of the LO phonon. Removal of the InP capping layer by selective etching allows us to study effects of this layer on the  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$  phonons. In addition, the quantum-well Raman spectra indicate the presence of impurities due to cross contamination during growth. (Author abstract) 21 refs.

Mowbray, D.J. (Univ of Oxford, Oxford, Engl); Hayes, W.; Bland, J.A.C.; Skolnick, M.S.; Bass, S.J. *Semicond Sci Technol* v 2 n 12 Dec 1987 p 822-827.

**094539 SUBBAND STRUCTURE CALCULATION FOR INVERSION LAYERS IN InAs AND InP.** The complete electronic subband structure of n-inversion layers of InAs- and InP-MIS systems is calculated using a new approximate self-consistent method. Remarkable agreement with recently published experimental results is obtained if the non-parabolicity of the conduction band is taken into account. Landau levels are calculated also for InP accounting for the non-parabolicity. (Author abstract) 12 refs.

Uebensee, H. (Technische Hochschule Ilmenau, Ilmenau, East Ger); Paasch, G.; Gobsch, G. *Solid State Commun* v 62 n 10 Jun 1987 p 699-701.

**094540 MEASUREMENT OF CHARGE-CARRIER CONCENTRATION IN INDIUM PHOSPHIDE BY MEANS OF AN ELECTROLYTE-SEMICONDUCTOR CONTACT.** An electrolyte-semiconductor contact is used to study the conductivity of epitaxial layers and single crystals of n-type indium phosphide obtained by gas transport. Some of the specimens were alloyed with tin and sulfur. The volt-farad characteristics are used to find the potentials of planar zones, which amount to 0.8-1.3 V for different electrolytes. Values of concentration of charge carriers calculated from measured values of capacitance of the electrolyte-indium-phosphide contact showed good agreement with measurements of the Hall effect on single crystals in the range  $10^{16}$ - $10^{18}$  cm<sup>-3</sup>. The use of measurements of the capacitance of the electrolyte-semiconductor contact with simultaneous etching of a local region made it possible to study the electron distribution in epitaxial layers of indium phosphide. (Author abstract) 12 refs.

Asanov, O.M.; Gaman, V.I.; Zorkal'tseva, N.N.; Korableva, T.V.; Petrova, N.G. *Sov Phys J* v 30 n 5 May 1987 p 421-424.

**094541 MAGNETOTRANSPORT PROPERTIES AND SUBBAND STRUCTURE OF THE TWO-DIMENSIONAL ELECTRON GAS IN THE INVERSION LAYER OF InSb BICRYSTALS UNDER HYDROSTATIC PRESSURE.** Magnetotransport properties of the n-inversion layer formed at the grain boundary in p-InSb bicrystals are investigated. Hydrostatic pressure up to 10<sup>3</sup> MPa is used to characterize the properties of the two-dimensional electron gas in the inversion layer. At atmospheric pressure in addition to previous results four series of quantum oscillations are revealed, indicating that four electric subbands are occupied. From quantum oscillations of the magnetoresistivity the characteristic parameters of the electric subbands and their pressure dependences are established. A strong decrease of the



carrier concentration in the inversion layer and of the corresponding subband population is observed when pressure is applied. A simple theoretical model is used to calculate the energy diagram of the quantum well and the pressure dependence of the subband parameters. (Edited author abstract) 26 refs.

Herrmann, R. (Humboldt-Universität zu Berlin, Berlin, East Ger); Kraak, W.; Handschack, S.; Schurig, Th.; Kusnick, D.; Schnackenburg, B. *Phys Status Solidi B* v 145 n 1 Jan 1988 p 157-166.

**094542 ON THE DEFORMATION POTENTIALS IN  $\text{CuInSe}_2$  TERNARY SEMICONDUCTORS.** From the analysis of the variation of the energy gap with temperature and pressure in the ternary compound  $\text{CuInSe}_2$ , the valence and conduction band deformation potentials are estimated to be 7.78 and 9.48 eV per unit dilation, respectively. It is found that both the valence and conduction band extrema move to higher energies on compression. It is also suggested that electron-electron scattering combined with polar optical modes has an important influence on the mobility in n-type  $\text{CuInSe}_2$ . (Author abstract) 22 refs.

Rincon, C. (Univ de Los Andes, Merida, Venez.). *J Phys Chem Solids* v 49 n 4 1988 p 391-393.

**094543 INTRINSIC AND DEEP CENTRE CHARGE CARRIERS IN INDIUM ANTIMONIDE.** In the temperature range 150 to 300 K the authors calculate  $n_{IC}$  for an ideal pure  $\text{InSb}$  crystal and also for doped  $\text{InSb:Cr}$  and  $\text{InSb:V}$  samples with deep impurity centres. They analysed the latest available experimental data on  $\text{InSb}$  band parameters and tried to make these data more exact by combining them with intrinsic carrier (IC) data. These results were used for analysis of the temperature dependences  $n(T)$ . The microscopic calculation of the IC concentration is a way to obtain information about deep centres even in cases where the transition to the exhaustion range is not observed. 11 Refs.

Kosarev, V.V. (Acad of Sciences of the USSR, Leningrad, USSR); Popov, V.V.; Vekshina, V.S.; Pepik, N.I. *Phys Status Solidi A* v 107 n 1 May 1988 pK43-K48.

**094544 PICOSECOND RAMAN LIGHT-SCATTERING STUDY OF HOT CARRIERS IN  $\text{InP}$ .** We demonstrate a novel method of using picosecond time-resolved Raman scattering to study the kinetics of nonequilibrium carriers in semiconductors. A pump-probe technique employing two separate lasers of different intensities, focal-spot sizes, and pulse durations is used to ensure that a plasma of uniform density is probed. The nonequilibrium-carrier density near the surface of a semi-insulating  $\text{InP}$  sample is estimated by fitting the photoexcited plasmon - longitudinal optical phonon coupled-mode peak in the Raman spectra. The dielectric function used in the calculation includes contributions from intraband transitions of electrons, light holes, and heavy holes as well as from interband transitions of the holes. The temporal evolution of the optically excited carrier population is modelled using a one-dimensional diffusion equation. The ambipolar diffusion constant and the surface-recombination velocity of the nonequilibrium carriers are found to be comparable to estimated values based on extrapolation of equilibrium properties. (Author abstract) 15 refs.

Wan, Kam (Nat'l Research Council of Canada, Ottawa, Ont, Can); Young, Jeff F.; SpringThorpe, A.J. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicon Technol Conf, Ottawa, Ont, Can p 831-837.

**094545 LASER INDUCED COOLING OF HOT ELECTRONS IN  $n\text{-InSb}$  BY FREE CARRIER ASSISTED TRANSITIONS.** Laser induced cooling (LIC) of the conduction electrons in  $n\text{-InSb}$  is observed with the simultaneous application of a non-ohmic electric field and CO laser radiation near the effective gap. A model based on free carrier assisted transitions (FCAT) is shown to explain the results. Experimental measurements of photoconductivity and the Shubnikov-de Haas effect are claimed to be consistent with LIC due to FCAT. (Edited

author abstract) 12 refs.

Hanes, L.K. (North Texas State Univ, Denton, TN, USA); Seiler, D.G. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 493-496.

**094546 MONTE CARLO INVESTIGATION OF MINORITY ELECTRON TRANSPORT IN  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ .** The transport of minority electrons in p-type  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$  has been investigated for doping levels of  $10^{17}$  and  $5 \times 10^{17} \text{ cm}^{-3}$ . It is found that the electrons exhibit smaller velocities at electric fields below 4 kV/cm when the electron-hole interaction is taken into account. The velocities at fields above 4 kV/cm are higher and reach a maximum at 5 kV/cm. The fraction of electrons that transfer to the upper valleys are significantly reduced for electric fields below 6 kV/cm. (Author abstract) 10 refs.

Osman, M.A. (Scientific Research Associates Inc, Glastonbury, CT, USA); Grubin, H.L. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 653-656.

## Chemical Reactions

**094547 LITHIUM INSERTION INTO INDIUM SEQUELENIDE.** The effects of lithium intercalation in  $\text{In}_2\text{Se}_3$  have been studied using different methods. Electrochemical properties of the non-stoichiometric  $\text{Li}_x\text{In}_2\text{Se}_3$  phase are given in the range  $0 \leq x \leq 1$  for either quenched or annealed compounds. Electronic conductivity has been measured during the insertion process in n-butyl lithium and suggests weak charge transfer. The relation between the morphology of samples and insertion mechanism have been discussed. (Author abstract) 25 Refs.

Julien, C. (CNRS, Paris, Fr); Samaras, I. *Solid State Ionics* v 27 n 1-2 Jun 1988 p 101-107.

**Chemical Vapor Deposition** See Also SEMICONDUCTING GALLIUM ARSENIDE—Chemical Vapor Deposition.

**094548 REACTOR DESIGN AND OPERATING PROCEDURES FOR  $\text{InP}$  BASED MOCVD.** Important technological difficulties inherent in the MOCVD of  $\text{InP}$  based materials are reviewed together with appropriate solutions. A reactor layout incorporating sophisticated gas switching and pressure control facilities is described, together with options for in situ reagent concentration monitoring. A safe and effective technique for dealing with pyrophoric by-products is discussed. The relative merits of growth at atmospheric pressure and low pressure are considered. Similar performance is noted for the two regimes when preparing low dimensional structures but high background purity has been easier to achieve at low pressure. Persistent photoconductivity has been observed in 'bulk' layers of very high purity  $\text{InP}$  grown at low pressure.  $\text{InP}$  grown at low temperatures exhibits superior morphology when grown with the triethyl rather than trimethyl indium precursor. (Author abstract) 13 refs.

Thrush, E.J. (STC Technology Ltd, Harlow, Engl); Cureton, C.G.; Trigg, J.M.; Stagg, J.P.; Butler, B.R. *Chemtronics* v 2 n 2 Jun 1987 p 62-68.

**094549 MOCVD GROWTH OF  $\text{InP}$  USING RED-PHOSPHORUS AND HYDROGEN PLASMA.**  $\text{InP}$  epitaxial layers have been grown by metalorganic chemical vapor deposition using red-phosphorus and hydrogen plasma alternative to  $\text{PH}_3$  gas cylinder. The carrier concentration was  $3.9 \times 10^{16} \text{ cm}^{-3}$  and the Hall mobility was  $3650 \text{ cm}^2/\text{Vs}$  at 300 K. Quadrupole mass spectrometer showed that the group V sources in this method were  $\text{PH}_3$  and phosphorus vapor. (Author abstract) 9 refs.

Naitoh, Masami (Nagoya Inst of Technology, Nagoya, Jpn); Umeno, Masayoshi. *Jpn J Appl Phys Part 2* v 26 n 9 Sep 1987 p 1538-1539.

**094550 PREPARATION OF  $\text{In}_2\text{O}_3$  SINGLE CRYSTALS BY CHEMICAL VAPOUR TRANSPORT METHOD.** The preparation of  $\text{In}_2\text{O}_3$  single crystals by chemical vapour deposition method with chlorine as a

transporting agent has been investigated. On the basis of thermodynamic calculations, the best temperature conditions of the transport process have been evaluated. Octahedral, transparent, and yellow single crystals of  $\text{In}_2\text{O}_3$  have been grown. (Author abstract) 14 refs.

Jozefowicz, M. (Polish Acad of Sciences, Warsaw, Pol); Piekarczyk, W. *Mater Res Bull* v 22 n 6 Jun 1987 p 775-780.

**094551 LOW-TEMPERATURE GROWTH OF  $\text{InSb}$  BY VACUUM MOCVD USING  $\text{TEIn}$  AND  $\text{SbH}_3$ .** This report describes the homo-epitaxial growth of  $\text{InSb}$  by the Metal-Organic Chemical Vapor Deposition Method (MOCVD) using triethylindium ( $\text{TEIn}$ ) and stibine ( $\text{SbH}_3$ ) for indium and antimony sources, respectively. Single crystal  $\text{InSb}$  layers were grown at  $400^\circ\text{C}$ . The gas flow rate ratio ( $=\text{SbH}_3/\text{TEIn}$ ) should be more than 8 in order to grow a layer with good morphology. The epitaxial layer was n-type, with a carrier density and mobility of  $1.5 \times 10^{16} \text{ cm}^{-3}$  and  $7.6 \times 10^4 \text{ cm}^2/\text{Vs}$ , respectively, at 77 K. By inserting a buffer layer grown at  $400^\circ\text{C}$ , the single crystal  $\text{InSb}$  layer was grown even at  $300^\circ\text{C}$ . (Author abstract) 5 refs.

Sugiura, O. (Tokyo Inst of Technology, Tokyo, Jpn); Kameda, H.; Shiina, K.; Matsumura, M. *J Electron Mater* v 17 n 1 Jan 1988 p 11-14.

**094552 SIMS AND DLTS MEASUREMENTS ON  $\text{Fe}$ -DOPED  $\text{InP}$  EPITAXIAL LAYERS GROWN BY MOCVD.** SIMS and DLTS measurements have been carried out on Fe-doped  $\text{InP}$  epitaxial layers grown by metalorganic chemical vapor deposition (MOCVD). Fe was doped with ferrocene  $\text{Fe}(\text{C}_5\text{H}_5)_2$  and smoothly distributed in the epitaxial layers. The solubility limit of Fe is  $7 \times 10^{16} \text{ cm}^{-3}$  at a growth temperature of  $650^\circ\text{C}$ . A new electrically active defect was observed in  $\text{InP}$  doped with the excess concentration of Fe over the solubility limit. (Author abstract) 10 refs.

Takanohashi, Tsugunori (Fujitsu Lab, Atsugi, Jpn); Nakai, Kenya; Nakajima, Kazuo. *Jpn J Appl Phys Part 2* v 27 n 1 Jan 1988 p 113-115.

**094553 HETEROEPITAXIAL GROWTH OF INDIUM PHOSPHIDE ON SILICON BY MOCVD USING ADDUCT SOURCE.** The heteroepitaxial growth of  $\text{InP}$  on Si by low pressure metalorganic chemical vapor deposition is reported. The trimethylindium-trimethylphosphine adduct was used as the In source in this study. From X-ray and SEM examinations, it can be seen that  $\text{InP}$  epilayers of good crystallinity with mirror-like surfaces can be grown directly on (100) and (111) p-type Si substrates. A carrier concentration profile shows that the carrier distribution in the  $\text{InP}$  epilayer is very uniform. The efficient photoluminescence compared with that of  $\text{InP}$  homoepitaxy shows the good quality of  $\text{InP}/\text{Si}$  epilayers. (Edited author abstract). 8 Refs.

Lee, Ming-Kwie (Nat'l Sun Yat-Sen Univ, Kaohsiung, Taiwan); Tung, Hsin-Hang. *Chung kuo Kung Ch'eng Hsueh K'an* v 11 n 3 May 1988 p 291-294.

**094554 INDIUM TRANSIENTS IN THE GROWTH OF  $\text{InGaAs}$  BY METAL-ORGANIC CHEMICAL VAPOR DEPOSITION.** A study of indium transients in the growth of  $\text{InGaAs-AlGaAs}$  and  $\text{InGaAs-GaAs}$  heterostructures is described for samples grown by atmospheric-pressure metal-organic chemical vapor deposition (MOCVD) using trimethylindium ( $\text{TMin}$ ) and an interrupted growth process. No evidence of large compositional transients and rapid decays in the indium signal are observed in analysis of secondary ion mass spectrometry (SIMS) and sputtered neutral mass spectrometry (SNMS) data taken at the interfaces of both  $\text{InGaAs-GaAs}$  strained-layer superlattice structures and  $\text{InGaAs-AlGaAs}$  laser structures. (Author abstract). 24 Refs.

Fernandez, G.E. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Bryan, R.P.; York, P.K.; Coleman, J.J. *Mater Lett* v 6 n 11-12 Jul 1988 p 409-412.



**094555 EFFICIENCIES OF InAs TRANSPORT AND EPITAXIAL GROWTH BY CHEMICAL VAPOUR DEPOSITION IN THE SYSTEM InAs-AsCl<sub>3</sub>-H<sub>2</sub>.** Efficiencies of InAs transport and epitaxial growth calculated on the basis of thermodynamic considerations and experimentally determined are compared. Parameters optimal with respect to productivity technology for the system InAs-AsCl<sub>3</sub>-H<sub>2</sub> are discussed. From the comparison of calculated and experimental results one can conclude that InAs is transported effectively from the source to the gas phase. This confirms the adequacy of the thermodynamic model to describe the processes taking place at the source zone. The experimental efficiency of InAs epitaxial growth is smaller than that calculated on the basis of the thermodynamic model because of the kinetically controlled growth regime at certain technological conditions. (Edited author abstract). 4 refs.

Trifonova, E.P. (Sofia Univ, Sofia, Bulg); Hitova, L. *Thin Solid Films* v 161 Jul 1988 p 257-261.

**094556 CROISSANCE MOCVD ET CARACTERISATION DE Puits QUANTIQUES InP/GaInAs/InP.** [MOCVD Growth and Characterization of InP/GaInAs/InP Quantum Wells]. X-ray microanalysis has been performed using a STEM at 100 keV allowing an incident electron probe size as small as 1 nanometer. With the experimental conditions, the spatial resolution of this technique is estimated to be about 3 nanometers. Good correlations between these two techniques are obtained on LP-MOCVD quantum wells (InP/GaInAs/InP), and the non-equivalence of the two heterojunctions is evidenced. (Edited author abstract) 3 refs. In French.

Chazelas, J. (Thomson-CSF, Orsay, Fr); Olivier, J.; Razeghi, M. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 197-198.

## Composition Effects

**094557 ELECTRON-MICROSCOPE STUDY OF A NON-STOICHIOMETRIC PHASE IN InSb HEATED IN A VACUUM.** When thin-foil specimens of InSb are heated in the vacuum of an electron microscope, a depletion of Sb takes place because of the preferential evaporation of Sb. This results in the formation of a novel non-stoichiometric (In-rich) solid phase having a cubic structure with a lattice parameter of 5.9 Angstrom, which is about 10% smaller than that of InSb. It has been shown that the twin-orientation relationship exists between the matrix and the non-stoichiometric phase. (Author abstract) 5 refs.

Saka, H. (Nagoya Univ, Nagoya, Jpn); Itoh, K.; Imura, T.; Kamino, T. *Phil Mag Lett* v 56 n 6 Dec 1987 p 225-230.

## Contacts

**094558 INFLUENCE OF INTERFACIAL MORPHOLOGY AND COMPOSITION ON THE BEHAVIOUR OF AuGeNi CONTACTS TO InP.** A correlation between electron microscopy, secondary-ion mass spectroscopy (SIMS) and electrical measurements is reported for AuGeNi alloyed contacts to InP. Changes in the morphology and in the composition of the material at the interface show strong trends as a function of the initial alloy temperature and of subsequent heat treatment to simulate accelerated device operation. Dramatic changes in the electrical properties of the contacts are shown to follow closely and consistently the changes in morphology. The principal factor controlling the stability of the contact appears to be the thickness and integrity of a new AuGeP phase at the interface. Growth of large particles of Au<sub>2</sub>P<sub>3</sub> occurs at high alloy temperatures or after prolonged heat treatment and is strongly associated with contact degradation. There was no evidence for preferential Ge diffusion. Various models for current transport across the metal-semiconductor interface are discussed as well as the implications for the control of contact resistance. (Author abstract) 30 refs.

Anderson, D.A. (Royal Signals & Radar Establishment,

Malvern, Engl); Graham, R.J.; Steeds, J.W. *Semicond Sci Technol* v 3 n 2 Feb 1988 p 63-76.

**094559 EFFECT OF THE SURFACE COMPOSITION OF INDIUM PHOSPHIDE ON THE BARRIER HEIGHT AT A P-InP-Ag CONTACT.** Metal-semiconductor contacts are now widely used in various semiconductor devices. This explains the interest in studying the barrier formation mechanism in such contacts and the influence of various factors on the height of this barrier. Such investigations are generally carried out on semiconductors whose surface is cleaned by chemical etching and is coated by a thin oxide layer or on the surface of semiconductors obtained by cleaving in an ultrahigh vacuum. This paper presents the results of an investigation of the p-InP-Ag contact, fabricated on the surface of epitaxial InP layers after they have been cleaned by heating in an ultrahigh vacuum. The effect of surface impurities on the height of the potential barrier at the contact is investigated. 6 refs.

Izreal'Yants, K.R.; Korotikh, V.L.; Musatov, A.L.; Filippov, S.L.; Kokhanyuk, M.B.; Russu, E.V. *Sov J Commun Technol Electron* v 32 n 6 Jun 1987 p 137-138.

## Corrosion

**094560 FORMATION AND CORROSION PROCESSES OF COLLOIDAL In<sub>2</sub>Se<sub>3</sub>.** Colloids of an In<sub>2</sub>Se<sub>3</sub> layered-type semiconductor were prepared in aqueous medium in the presence of sodium metaphosphate. Formation of the crystalline colloids was followed spectrophotometrically. The reactions of OH CO<sub>2</sub><sup>-</sup>, and (CH<sub>3</sub>)<sub>2</sub>COH radicals with In<sub>2</sub>Se<sub>3</sub> particles were investigated by pulse radiolysis. Both oxidation and reduction of the colloids led to bleaching of semiconductor absorption. The bleaching was much more pronounced in anodic (oxidative) than in cathodic (reductive) corrosion processes. Decomposition by both processes resulted in disappearance of the 'structured' absorption of small particles. Bleaching was also observed upon laser flash photolysis of semiconductor colloids in the absence of scavengers. (Author abstract) 26 refs.

Dimitrijevic, Nada M. (Univ of Notre Dame, Notre Dame, IN, USA); Kamat, Prashant V. *Langmuir* v 3 n 6 Nov-Dec 1987 p 1004-1009.

## Crystal Lattices See SEMICONDUCTING GALLIUM COMPOUNDS—Crystal Lattices.

## Crystallization

**094561 INFLUENCE OF DEPOSITION TEMPERATURE ON THE CRYSTALLIZATION OF THERMALLY EVAPORATED INDIUM SELENIDE THIN FILMS.** Thermal evaporation in vacuum of a stoichiometric bulk of InSe results in amorphous selenium-rich films when deposited at ambient temperature. The films may be obtained in crystalline form at a deposition temperature above 150°C. The films deposited above 200°C contain an additional In<sub>2</sub>Se phase along with indium selenide. 14 refs.

Rousina, Roughieh (Sardar Patel Univ, Gujarat, India). *J Mater Sci Lett* v 7 n 8 Aug 1988 p 893-894.

## Defects See Also CRYSTALS—Dislocations.

**094562 DEFECT STRUCTURES IN InP CRYSTALS BY LASER SCANNING TOMOGRAPHY.** Laser-beam scanning tomography (infrared light scattering tomography) images are taken from various InP crystals. They all display a distribution of bright points which are shown to be statistically arranged along the crystallographic axes <100> and <110>. These microdefects are likely distributed along dislocations in such a way that small volumes or 'cells' (typically 200-500 μm wide) are kept free from defects. It is shown that the density varies with the doping of the material; lower densities were observed in Fe-doped InP crystals. (Edited author abstract) 10 refs.

Fillard, J.P. (Univ de Sciences et Techniques du Languedoc,

Montpellier, Fr); Gall, P.; Baroudi, A.; George, A.; Bonnafé, J. *Jpn J Appl Phys Part 2* v 26 n 8 Aug 1987 p 1255-1257.

**094563 STUDY OF STATIC ATOMIC DISPLACEMENTS BY CHANNELLED-ELECTRON-BEAM-INDUCED X-RAY EMISSION: APPLICATION TO In<sub>0.53</sub>Ga<sub>0.47</sub>As ALLOYS.** A novel method for detecting and measuring the static atomic displacements from the perfect crystal sites existing in some alloys is investigated. The method uses the influence of the channeling of an electron beam on the ratio of the numbers of characteristic X-rays emitted by two atoms which are displaced differently with respect to the average lattice planes. Calculations taking into account the delocalization of the ionizing events and the atoms' thermal vibrations show that displacements smaller than 0.01 nm should be detectable. This is confirmed by an experimental STEM study of thin In<sub>0.53</sub>Ga<sub>0.47</sub>As epitaxial layers, where the arsenic atoms are shown to be displaced from the perfect crystal sites more than are the indium and gallium atoms. (Author abstract) 30 refs.

Glas, F. (CNET, Bagnex, Fr); Henoc, P. *Philos Mag A* v 56 n 3 Sep 1987 p 311-328.

**094564 OBSERVATION OF CELLULAR STRUCTURES OF DEFECTS IN SEMI-INSULATING InP-Fe.** GaAs semi-insulating materials reveal an organization of defects which appears in (001) wafers as a pattern of cells. This typical arrangement is displayed in surface etch images as well as X-ray topographies, infrared transmission and so on. It is shown that a similar organization also exists in InP wafers: its visualization is not easy because of a weak contrast in the image: their observation requires a strong contrast enhancement by numerical processing. The structure could be related to entangled dislocations along shear stress planes resulting from the post growth cooling process. They are observed as very bright points in laser scanning tomography. These cellular patterns are not as dependent on the origin of the crystal and the typical average dimensions are in the range of 200-300 μm (similar to GaAs) which means that they fit within the dimensions of most optoelectronic integrated circuits. The macrospecific arrangement of cells does not display the tetragonal symmetry often observed on GaAs materials. (Edited author abstract) 18 refs.

Fillard, J.P. (Univ des Sciences et Techniques du Languedoc, Montpellier, Fr); Baroudi, A.; Gall, P.; Bonnafé, J.; Favennec, P.N.; Coquille, R. *Solid State Commun* v 64 n 9 Dec 1987 p 1243-1246.

**094565 ON THE POSSIBILITY OF FORMATION OF ASSOCIATED IMPURITY CENTERS IN SEMI-INSULATING INDIUM PHOSPHIDE DOPED BY OXYGEN.** The purpose of the note is the investigation of the photoelectrical properties of indium phosphide doped by iron and oxygen simultaneously. The impurities were introduced into the melt as Fe or Fe+In<sub>2</sub>O<sub>3</sub>. The amount of iron was kept constant (0.08 wt. percent) whereas the In<sub>2</sub>O<sub>3</sub> content was changed (0.04 to 0.40 wt. percent). Investigations of the photoconductivity (PC) were carried out using standard synchronous detection techniques in the temperature range 80 to 300K. Double doping by iron and oxygen leads to a noticeable change in the photoelectric properties of the material. x Refs.

Kulikova, O.V. (Acad of Sciences of the Moldavian SSR, USSR); Kulyuk, L.L.; Nartya, N.M.; Radautsan, S.I.; Russu, E.V.; Siminel, A.V.; Strumban, E.E. *Eys Status Solidi A* v 107 n 1 May 1988 pK57-K60.

**094566 DISLOCATION MULTIPLICATION AND DISPLACEMENT SPEED IN INDIUM PHOSPHIDE.** Measurements have been made on dislocation speeds in indium phosphide by means of topographic



observations made with synchrotron radiation. Here we present results obtained recently at LURE-DCI by synchrotron topography. 14 refs.

George, A.; Jacques, A. *Bull Acad Sci USSR Phys Ser v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 162-167.*

## Deformation

**094567 DYNAMICAL RECOVERY AND SELF-DIFFUSION IN InP.** Single crystals of InP with <123> orientation have been deformed at constant strain rates at temperatures between 540 and 780°C. The resulting stress-strain curves are rather similar to those obtained for other semiconductors such as Ge, Si and InSb, and two stages of dynamical recovery can be clearly identified. From the strain-rate and temperature dependencies of the stress at the beginning of the first recovery stage, an activation energy of 2.3 eV is deduced. This may be regarded as a lower bound for the activation energy of self-diffusion of the slowest-moving species; for the pre-exponential factor  $D_0$  of the diffusion coefficient a value between  $10^{-3}$  and  $10^{-2}$  cm<sup>2</sup> s<sup>-1</sup> is estimated. (Author abstract) 37 refs.

Siethoff, H. (Univ Wuerzburg, Wuerzburg, West Ger); Ahlborn, K.; Brion, H.G.; Voelkl, J. *Philos Mag A v 57 n 2 Feb 1988 p 235-244.*

## Diffusion

**094568 SULPHUR DIFFUSION INTO InP BY AN OPEN TUBE PROCESS.** A technique is described for the diffusion of sulphur into InP by an open tube process, which gives highly reproducible results from run to run, as required for device applications. A vacuum-deposited layer of gallium sulphide (Ga<sub>2</sub>S<sub>3</sub>) was used as the source for sulphur diffusion, with a chemically vapor deposited SiO<sub>2</sub> cap layer of preventing decomposition of the InP surface during heat treatment. Diffusions were carried out at temperatures ranging from 585°C to 708°C. Diffused layers were characterized by the surface carrier concentration and diffusion constant. From these measurements the diffusion profile for sulphur in InP is estimated to be of the complementary error function type. The activation energy of the diffusion was estimated to be 1.94 eV. The technique is ideally suited for the fabrication of shallow n+p junctions in InP, and has been used successfully for space-borne solar cells. (Edited author abstract) 12 refs.

Parat, Krishna K. (Rensselaer Polytechnic Inst, Troy, NY, USA); Ghandhi, Sorab K. *Solid State Electron v 31 n 6 Jun 1988 p 1053-1056.*

**Doping** See Also SEMICONDUCTING GALLIUM ARSENIDE—Doping; SEMICONDUCTING GALLIUM ARSENIDE—Growth; SEMICONDUCTING GALLIUM COMPOUNDS—Doping; SEMICONDUCTOR DEVICES, MISFET—Fabrication; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, FIELD EFFECT—Millimeter Waves.

**094569 OUT-DIFFUSION AND REACTIVATION OF Zn IN InP SUBSTRATES.** The influence of temperature on p-doping in Zn-diffused InP substrates has been investigated. By cooling diffused InP samples slowly after diffusion or subjecting them to heat treatment, significant out-diffusion of Zn has been observed. By heat-treating with rapid cooling, a substantial fraction of the incorporated but electrically inactive Zn atoms can be reactivated, resulting in a drastically increased acceptor concentration. (Edited author abstract) 6 refs.

Jung, H. (AEG AG, Ulm, West Ger); Marschall, P. *Electron Lett v 23 n 19 Sep 10 1987 p 1010-1011.*

**094570 PREPARATION OF LOW DISLOCATION DENSITY InP CRYSTAL WITH CONTROLLED CARRIER CONCENTRATION BY MULTI-DOPING TECHNIQUE.** This paper reports that low dislocation density InP crystals with a controlled carrier concentration have been prepared by, doping with shallow level impurities and isoelectronic impurities or with deep level impurities and isoelectronic impurities. EPD of these

crystals can reach  $10^3$  cm<sup>-3</sup>. The results of electrical measurements show that isoelectronic impurities have no influence on electrical properties. The semi-insulating InP single crystals have good thermal stability. The influence of isoelectronic impurities on reducing dislocation density are discussed. (Edited author abstract) 11 refs. In Chinese.

Ye, Shi-zhong (Acad Sinica, China); Liu, Xun-lang; Jiao Jing-hua; Yang, Bao-hua; Zhao, Jian-qun. *Xi You Jin Shu v 5 n 4 Nov 1986 p 276-280.*

**094571 STUDY OF RESIDUAL BACKGROUND DOPING IN HIGH PURITY INDIUM PHOSPHIDE GROWN BY ATMOSPHERIC PRESSURE OMVPE.** High purity InP epilayers have been grown by OMVPE with 77 K mobilities as high as  $119000$  cm<sup>2</sup> V<sup>-1</sup> s<sup>-1</sup> using TMI<sub>n</sub> specially purified via the diphos route. The effect of growth rate, growth temperature and V/III ratio on background doping and mobility is reported. Silicon is identified as the residual impurity in the epilayers. (Author abstract) 17 refs.

Briggs, A.T.R. (STC Technology Ltd, Harlow, Engl); Butler, B.R. *J Cryst Growth v 85 n 3 Nov II 1987 p 535-542.*

**094572 PROPERTIES OF InP DOPED WITH 4d IONS.** We have grown InP crystals doped with elements from the second long period (Nb, Mo, Ru, Rh and Pd) by the high-pressure gradient freeze method or by the liquid encapsulated Czochralski technique. Samples have been characterized electrically by Hall effect measurements and chemically analyzed by spark source mass spectroscopy and secondary-ion mass spectrometry. We found the 4d impurities are introduced with a concentration of many  $10^{15}$  cm<sup>-3</sup>. Nevertheless by spectroscopic measurements (electron paramagnetic resonance, photoluminescence and optical absorption) we have detected no lines which could be related to a ground or an excited state of the 4d impurity in isolated form. By deep-level spectroscopy, we detect only one hole trap in the concentration range of a few  $10^{15}$  cm<sup>-3</sup> which can be related to the 4d doping. The energy position of this trap is independent of the impurity and is found at 0.15-0.2 eV from the valence band. (Edited author abstract) 28 refs.

Bremont, G. (CNRS, Villeurbanne, Fr); Nouailhat, A.; Guillot, G.; Toudic, Y.; Lambert, B.; Gauneau, M.; Coquille, R.; Deveaud, B. *Semicond Sci Technol v 2 n 12 Dec 1987 p 772-778.*

**094573 FLUORESCENCE EXAFS STUDY OF Zn-DOPED LEC InP CRYSTAL.** Interatomic distance between Zn impurity atom and P host atom in LEC InP:Zn was determined by extended X-ray absorption fine structure by monitoring the Zn K<sub>α</sub> fluorescence yield. The measured Zn-P interatomic distance remained the value of 2.42 Å, which was in excellent agreement with the distance 2.41 Å calculated from Pauling's tetrahedral radii for zincblende structure. From XANES spectra, strong lattice distortion was observed around the Zn atom. (Author abstract) 19 refs.

Kitano, Tomohisa (NEC, Kawasaki, Jpn); Watanabe, Hisao; Matsui, Junji. *Jpn J Appl Phys Part 2 v 27 n 1 Jan 1988 p 9-11.*

**094574 ELECTROCHEMICAL AND STRUCTURAL ASPECTS OF LITHIUM INSERTION INTO THE NEW LAYERED COMPOUND CdIn<sub>2</sub>S<sub>2</sub>Se<sub>2</sub>.** Electrochemical lithium insertion in pure and (PTFE-and/or C-) mixed CdIn<sub>2</sub>S<sub>2</sub>Se<sub>2</sub> has been investigated by galvanostatic discharge experiments. Structural changes induced by lithium insertion have been observed by powder X-ray diffraction measurements. The reversibility of the process is poor in the whole range explored, but differences in behaviour are noticed. Analyses of the results evidence that CdIn<sub>2</sub>S<sub>2</sub>Se<sub>2</sub> is a very interesting new compound, more significant for its fundamental properties than in view of its application as cathode material in aprotic solvent lithium cells. (Edited author abstract) 23 refs.

Bicelli, L. Peraldo (CNR, Milan, Italy); Maffi, S.; Tagliavini, P.; Zanotti, L. *Mater Chem Phys v 19 n 4 May*

1988 p 369-380.

**094575 EFFECT OF THE InP DOPING DENSITY ON THE ELECTRICAL PROPERTIES OF THE TWO-DIMENSIONAL ELECTRON GAS IN LPE-GROWN MODULATION-DOPED HETEROSTRUCTURES.** In<sub>0.53</sub>Ga<sub>0.47</sub>As/n-InP modulation-doped heterostructures have been grown by liquid phase epitaxy. Shubnikov-de Haas and quantum Hall effect measurements were taken for the confirmation of the existence of the two-dimensional electron gas (2DEG). Mobility enhancements were observed at low temperatures from the variable-temperature Hall measurements. When the doping density of InP layer was varied from  $2.1 \times 10^{17}$  to the  $5.2 \times 10^{18}$  cm<sup>-3</sup>, the sheet electron density and mobility of 2DEG at 10 K were changed from  $6.52 \times 10^{11}$  to  $1.01 \times 10^{12}$  cm<sup>-2</sup> and 49,500-43,600 cm<sup>2</sup>/v-s, respectively. From the recordings of high-field Hall plateaus, the channel densities were  $4.03 \times 10^{11}$  and  $6.03 \times 10^{11}$  cm<sup>-3</sup>, respectively. The corresponding Fermi energies were 20.1 and 29.9 meV measured from the lowest energy level in the potential well. (Author abstract) 29 refs.

Su, Y.K. (Nat'l Cheng Kung Univ, Tainan, Taiwan); Dai, T.A.; Chen, S.C. *Solid State Electron v 31 n 5 May 1988 p 953-958.*

**094576 DOPING INHOMOGENEITIES AND COMPENSATION IN n-TYPE LEC InP WAFERS.** Lateral scans of free carrier infrared absorption with lateral resolution of 100 μm and Hall effect measurements were performed across (001) wafers cut from Sn- and S-doped 111 direction crystals. Considerable microinhomogeneities as well as macroinhomogeneities are detected in the distributions of the concentrations of free carriers, donors, and compensating acceptors. The macroinhomogeneities are due to growth facets representing regions of increased carrier concentration, while the microinhomogeneities are growth striations appearing both in and outside of facets. This behaviour may be understood by considering the growth direction of the crystals. Reasons for differences between the optical and electrical values of the compensation ratio as well as possible origins of the compensating acceptors are discussed. (Edited author abstract) 16 Refs.

Wruck, D. (Zentralinst fuer Elektronenphysik, Berlin, East Ger); Knauer, A. *Phys Status Solidi A v 107 n 1 May 1988 p 321-328.*

**094577 EFFECT OF COOLING AMBIENT ON ELECTRICAL ACTIVATION OF DOPANTS IN MOVPE OF InP.** The electrical doping level of p-InP (Zn or Cd) cooled from typical MOVPE growth temperatures is strongly dependent on the gaseous cooling ambient. This is the result of electrical deactivation rather than loss of the dopant. Atomic H is found in samples cooled in AsH<sub>3</sub> or PH<sub>3</sub> and the possibility of an H passivation mechanism is discussed. (Author abstract) 6 Refs.

Cole, S. (British Telecom Research Lab, Ipswich, Engl); Evans, J.S.; Harlow, M.J.; Nelson, A.W.; Wong, S. *Electron Lett v 24 n 15 Jul 21 1988 p 929-931.*

## Electric Conductivity

**094578 ELECTRICAL TRANSPORT PROPERTIES OF INDIUM SELENIDE SINGLE CRYSTALS.** Electrical conductivity and Hall effect measurements were performed on InSe single crystals grown by the Bridgman Stockbarger method. The measurements were carried out both along the c-axis and perpendicular to it. The samples were of n-type nature in the whole temperature range from liquid nitrogen temperature up to 500 K. The anisotropy properties of n-type InSe crystals at temperatures 77-500 K were investigated. The electrical conductivity measured when the current was oriented at right angles to the c-axis ( $\sigma_{\perp}$ ) was found to be higher than the conductivity measured parallel to the c-axis ( $\sigma_{\parallel}$ ). The anisotropy in the electron mobility was also observed. It is seen that at room temperature the concentration of free carriers lies between  $10^{13}$  and  $10^{14}$  cm<sup>-3</sup>. (Edited author abstract) 12 refs.



Hussein, S.A. (Assiut Univ, Qena, Egypt); Nagat, A.T.; Hafez, A.M.; Gameel, Y.H.; Belal, A.A. *Indian J Pure Appl Phys* v 25 n 7-8 Jul-Aug 1987 p 278-281.

**094579 ELECTRICAL CONDUCTIVITY ANISOTROPY IN TIN-DOPED n-TYPE INDIUM SELENIDE.** Electrical conductivity anisotropy of n-type indium selenide samples doped with different concentrations of tin is studied between 30 and 300 K. The anisotropy ratio is found to depend exponentially on the inverse temperature, the activation energy  $E$ , and the pre-exponential factor varying with free carrier concentration. This behavior is explained by the existence of potential wells created by planar aggregates of ionized donor impurities screened by free electrons. A simple model in which the depth of these potential wells is calculated as a function of temperature, charge density in the planar defects, and electron concentration, gives account of the measured activation energies, but does not explain the high value of the anisotropy ratio. The existence of strictly two-dimensional electrons bound to planar defects not contributing to the electrical conduction across the layers is proposed to explain this result. (Author abstract) 17 refs.

Pomer, F. (Facultad de Fisica, Burjasot, Spain); Chevy, A.; Segura, A.; Bonet, X. *Phys Status Solidi B* v 145 n 1 Jan 1988 p 261-268.

**094580 FINITE FREQUENCY SCALING OF HOPPING CONDUCTIVITY IN n-IN5Sb.** Conductivity measurements on three disc-shaped n-In5Sb samples were carried out in magnetic fields up to 70 kG at temperatures down to 40 mK and over a frequency range of 0-10<sup>5</sup> Hz. A scaling formula was found for AC and DC conductivity in the hopping conduction region. The value of a parameter in the equation is found to agree with the value predicted by theory for some semiconductor materials with a constant density of states at the Fermi level. (Edited author abstract) 18 refs.

Abboudy, S. (Univ of London, Egham, Engl); Fozzoni, P.; Mansfield, R.; Lea, M.J. *Phil Mag Lett* v 57 n 5 May 1988 p 277-282.

**094581 HOPPING CONDUCTION IN n-TYPE INDIUM PHOSPHIDE.** Measurements of the resistivity of three samples of n-InP with  $N_D - N_A = 4.8, 5.9$  and  $7.8 \times 10^{15} \text{ cm}^{-3}$  in magnetic fields up to 70 kG and for temperatures down to 60 mK are described. The theoretical resistivity in zero magnetic field is in good agreement with experiment for both nearest-neighbor and variable-range hopping, provided that an enhanced dielectric constant is used, which is required to reduce the theoretical hopping activation energy to the measured  $\epsilon_3$ . It is found that the temperature dependence of the pre-exponential factor is significant and that  $\epsilon_3$  should be determined from  $\ln(\rho/T)$  against  $T^{-1}$  plots. This also applies to the determination of  $T_0$  in the variable-range hopping region. The magnetoresistance in the weak-field limit for the nearest-neighbor-hopping region confirms previously reported measurements, and the anisotropy of the magnetoresistance agrees closely with the expected  $(H/4H_c)^2$  dependence. (Edited author abstract) 16 refs.

Mansfield, R. (Univ of Brunel, Brunel); Abboudy, S.; Fozzoni, P. *Philos Mag B* v 57 n 6 Jun 1988 p 777-790.

## Electric Field Effects

**094582 ELECTRON GAS HEATING AND COOLING EFFECTS BY MICROWAVE ELECTRIC FIELDS IN COMPENSATED InSb.** Data of an experimental investigation of the electron gas cooling in compensated indium antimonide in a warming electric field are presented. The electron average energy was determined from the hot electron thermoelectromotive force arising on opposite ends of the graded n-n<sup>+</sup> junction placed in a microwave electric field. It is found that at liquid nitrogen temperature, in the samples with electron density  $n < 2 \cdot 10^{12} \text{ cm}^{-3}$ , the average energy of an electron decreases in comparison with the equilibrium value in a certain range of electric fields. The dependences of the longitudinal and transverse diffusion coefficients on the amplitude

of microwave electric field were deduced from the hot electron thermoelectromotive force. (Edited author abstract) 9 refs.

Asmontas, S. (Lithuanian Acad of Sciences, Vilnius, USSR); Pozela, J.; Subacius, L.; Valusis, G. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 701-703.

**Electric Properties** See Also SEMICONDUCTOR DIODES—Tunneling.

**094583 ELECTRICAL PROPERTIES OF Fe-DOPED SEMI-INSULATING InP AFTER PROTON BOMBARDMENT AND ANNEALING.** The effects of proton bombardment and subsequent 30-min annealing on the electrical properties of semi-insulating InP doped with Fe at concentrations from  $9 \times 10^{15}$  to  $2 \times 10^{17} \text{ cm}^{-3}$  have been measured for proton doses from  $1.0 \times 10^{12}$  to  $4.4 \times 10^{15} \text{ cm}^{-2}$  and for annealing temperatures from 80 to 750°C. Proton bombardment decreases the sheet resistivity to as low as  $3 \times 10^4 \Omega/\square$ . The sheet resistivity is further decreased by annealing at temperatures up to 200-250°C but is increased by annealing at higher temperatures. Semi-insulating behavior is restored by annealing at 450°C or above. These changes can be explained by the formation of donor and acceptor defects at relative rates that vary with proton dose and by the removal of these defects at relative rates that vary with annealing temperature, although a variation in the effectiveness of the Fe acceptors or a hopping contribution to the conductivity may also play a role. (Author abstract) 8 refs.

Woodhouse, J.D. (MIT, Lexington, MA, USA); Donnelly, J.P.; Iseler, G.W. *Solid State Electron* v 31 n 1 Jan 1988 p 13-16.

**094584 SCATTERING MECHANISMS OF THE HALL EFFECT AND TRANSVERSE MAGNETORESISTANCE IN NON-DEGENERATE PIEZO-ELECTRIC SEMICONDUCTORS.** The Hall effect and transverse magnetoresistance in the intrinsic non-degenerate semiconductors InSb and GaAs have been investigated according to the scattering processes of carriers in solids. These scattering processes include the acoustic phonon scattering, piezo-electric scattering and ionized-impurity scattering. The energy band structure of carriers is assumed to be non-parabolic. Results show that the Hall angle, the Hall coefficient, and the transverse magnetoresistance depend strongly on the dc magnetic field due to the energy-dependent relaxation time. A comparison between experimental work and theory for the Hall effect and transverse magnetoresistance in InSb has been made. The effect of non-parabolicity in InSb has also been discussed in comparison with the numerical results for the parabolic band structure. (Edited author abstract) 37 refs.

Wu, Chhi-Chong (Nat'l Chiao Tung Univ, Hsinchu, Taiwan); Lin, Chau-Jy; Tsai, Jenson. *Semicond Sci Technol* v 3 n 2 Feb 1988 p 90-100.

**094585 ELECTRICAL CONTACTS TO SEMICONDUCTING INDIUM TELLURIDE FILMS.** Thin films of indium telluride were prepared by thermal evaporation of the bulk compound in vacuum. When a stoichiometric bulk is evaporated in vacuum, the resulting film is often non-stoichiometric. Hence, a detailed analysis of the dependence of film composition on the composition of the bulk was carried out. The effect of temperature on the nature of the contacts was studied on an In-InTe-In structure. In order to study the mechanism of conduction, Al-InTe-In sandwich structures were prepared with aluminum and indium as the lower and upper contacts, respectively. The linear dependence of  $\log I$  on  $V^{1/2}$  indicates Schottky emission to be the dominant electron transfer mechanism. 10 refs.

Rousina, Roughieh (Sardar Patel Univ, Gujarat, India); Shivakumar, G.K. *J Mater Sci Lett* v 7 n 5 May 1988 p 463-465.

**094586 ELECTRICAL PROPERTIES OF Cd-DOPED p-InSe.** Results are presented on the temperature dependences of the hole concentration and the Hall mobility in Cd-doped p-InSe, and the acceptor level

related to Cd atoms is characterized. Furthermore, the relationship between the mobility and the impurity concentration is discussed. Single crystals of p-type InSe were grown by a conventional Bridgman technique. Cd of 99.99 percent purity was doped from 0.1 to 1 at percent to the stoichiometric melt of InSe. The results of x-ray measurements showed that these p-type InSe belong to the  $\gamma$ -polytype as in the case for not purposely doped n-type InSe. In conclusion, the carrier transport of Cd-doped p-InSe is dominated by the acceptor level at 0.45 eV above the valence band. The temperature dependence of the hole mobility can be well fitted by the combined mobility of the optical phonon and the ionized impurity scatterings. 13 Refs.

Shigetomi, S. (Kurume Univ, Kurume, Jpn); Ikari, T.; Koga, Y.; Shigetomi, S. *Phys Status Solidi A* v 108 n 1 Jul 1988 p K53-K57.

**094587 ELECTRICAL CHARACTERIZATION OF n-INP GROWN BY METAL-ORGANIC VAPOUR-PHASE EPITAXY.** At room-temperature, the Hall mobility observed in epitaxial n-InP samples grown by metal-organic vapour-phase epitaxy is often lower than predicted, with a corresponding rise in the electronic concentration. These effects are attributed to the presence of a residual deep donor center that both acts as a strong scatterer and provides the additional electronic excitation observed at high temperature as it ionizes. A binding energy of 215 meV is consistent with both electrical-transport measurements and the observed photoluminescence. (Author abstract) 21 refs.

Benzaquen, M. (McGill Univ, Montreal, Que, Can); Walsh, D.; Mazaruk, K.; Weissfloch, P.; Puetz, N.; Miner, C. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 846-849.

## Electronic Properties

**094588 LOCALISATION EFFECTS CAUSED BY THE REMOTE DONORS IN MODULATION-DOPED QUANTUM WELLS.** We have developed a theoretical model to determine the size and scale of potential fluctuations  $2\eta$  created in the 2D electron gas in the QW by the random distribution of ionized donors modeled as a 2D sheet. We show that for  $E_{FE} > \eta$  all electrons are localized at low temperature, while for  $E_{FE} < \eta$  there are both localized and free electrons. This behavior manifests itself in experimental results of mobility measurements using persistent photoconductivity which exhibit a mobility edge. Photoluminescence results where the oscillator strength for the localized electrons is suppressed compared with free electrons recombining with the few photo-excited localized holes also support this theory since the fluctuations separate the localized electrons and holes in real space. (Edited author abstract) 22 refs.

Rorison, J.M. (RSRE, Malvern, Engl); Kane, M.J.; Herbert, D.C.; Skolnick, M.S.; Taylor, L.L.; Bass, S.J. *Semicond Sci Technol* v 3 n 1 Jan 1988 p 12-17.

**094589 CYCLOTRON RESONANCE IN THE n-INVERSION LAYER OF InSb GRAIN BOUNDARIES.** We report the observation of the cyclotron resonance of electrons in a grain boundary inversion layer. We provide transmission measurements on a p-type InSb bicrystal at discrete wavelengths between  $\lambda = 70.6 \mu\text{m}$  and  $251 \mu\text{m}$  using an optically pumped molecular gas laser. The observed cyclotron resonance spectra consisting of the cyclotron resonance lines of at least three electric subbands do not allow a direct determination of the cyclotron masses of the different electric subbands because of the large linewidth of several lines. (Edited author abstract) 11 refs.

Mueller, H.-U. (Univ zu Berlin, Berlin, East Ger); Ludwig, F.; Herrmann, R. *Solid State Commun* v 65 n 7 Feb 1988 p 761-763.



**094590 CHARACTERISTICS OF DISORDER IN DEFECTIVE LAYERED SEMICONDUCTOR  $\alpha$ - $\text{In}_2\text{Se}_3$ .**  $\text{In}_2\text{Se}_3$  which crystallizes in layer structure has been studied at different post preparation temperatures. The presence of a large number of intrinsic defects affects strongly its electrical and optical properties. Our experiments aimed at measuring the influence of the post-preparation annealing on conductivity and anisotropy. From FIR spectroscopy the reflectivity spectrum is found to be included by crystal disorder. Photoluminescence measurements are also included and provide valuable information concerning the crystal degree of ordering. (Author abstract) 10 refs.

Kambas, K. (Aristotle Univ of Thessaloniki, Thessaloniki, Greece); Fotis, J.; Hatzikrantonis, E.; Julien, C. *Phys Scr* v 37 n 3 Mar 1988 p 397-400.

**094591 HIGH MOBILITY TWO-DIMENSIONAL ELECTRON GAS IN  $\text{InP}/\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$  HETEROJUNCTIONS GROWN BY LOW-PRESSURE ORGANOMETALLIC VAPOUR PHASE EPITAXY.** The two-dimensional electron gas in  $\text{InP}/\text{GaInAs}$  heterojunctions, grown by LP-OMVPE, showed Hall mobilities as high as 164 000 and 103 000  $\text{cm}^2/\text{Vs}$  at 4 K and 80 K, respectively. A maximum Hall mobility of 172 000  $\text{cm}^2/\text{Vs}$  was measured at 20 K. Shubnikov-de Haas oscillations measured at 200 mK in magnetic fields up to 20 T indicated the total absence of parallel conduction. By illuminating the sample it was possible to populate the second electrical sub-band at a total carrier density  $n_s = 4.4 \times 10^{11} \text{ cm}^{-2}$ . (Author abstract) 7 refs.

Thijs, P.I.A. (Philips Research Lab, Eindhoven, Neth); Lagemaat, J.M. *Electron Lett* v 24 n 4 Feb 18 1988 p 226-227.

**094592 MODEL FOR THE BAND GAP SHRINKAGE IN THE CHALCOPYRITE SEMICONDUCTOR  $\text{CuInSe}_2$ .** A model for the band gap shrinkage in ternary chalcopyrite compounds is proposed and applied to  $\text{CuInSe}_2$ . A reasonable agreement is found with the data for both n- and p-type bulk samples of this compound. The fact that nearly the same energy gap is observed in p-type samples of  $\text{CuInSe}_2$  while a wide range of  $E_g$  is found for n-type  $\text{CuInSe}_2$ , is also explained by this model. (Author abstract) 23 refs.

Rincon, C. (Univ de Los Andes, Merida, Venez). *Solid State Commun* v 64 n 1 Oct 1987 p 15-17.

**094593 DETERMINATION BY OPTICAL DLTS OF THE DISTRIBUTION OF STATES NEAR THE VALENCE BAND OF PLASMA OXIDIZED n-TYPE  $\text{InP}$ .** The purpose of this note is to study by low temperature optical DLTS the interface state distribution in the lower part of the energy gap on MIS structures elaborated with rf plasma oxidation. For such structures, the density of states near the conduction band has been studied by the conductance method and has pointed out the interest of the bilayer oxide. 11 Refs.

Lepley, B. (ESE, Metz, Fr); Bath, A.; Carabatos-Nedelec, C.; Papaioannou, G.J.; Euthymiou, P.C.; Ravelet, S. *Phys Status Solidi A* v 108 n 1 Jul 1988 p K41-K46.

**094594 COMPARISON OF THE ELECTRONIC PROPERTIES OF THIN-PERIOD (INAS)(GAAS) AND (INAS)(ALAS) SUPERLATTICES WITH COMPOSITIONALLY SIMILAR RANDOM ALLOYS.** A comparison is made between the electronic properties of the (InAs)(GaAs) and (InAs)(AlAs) superlattices with their compositionally similar random alloys. While the long-range order in the superlattice can dramatically reduce the effect of alloy scattering on both transport and excitonic linewidth, the electronic properties of the thin-period superlattice are similar to the alloy with major differences occurring only in the hole states. Since the band-edge lineup at strained heterointerfaces is largely unknown, the authors present the dependence of the bandgap, the electron and hole effective masses and the separation between the heavy and light hole bands at the center of the Brillouin zone with respect to the band-edge lineup. Calculations show that thin-period strained super-

lattices using these systems could have excellent potential for high-speed devices. 19 refs.

Jaffe, Mark (Univ of Michigan, Ann Arbor, MI, USA); Singh, Jasprit. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2540-2545.

**094595 DEEP LEVELS IN n- $\text{InP}$ .** Seven electron traps and two hole traps have been detected on various n- $\text{InP}$  samples of high-quality Au/ $\text{InP}$  Schottky barrier and p+n junction structures by using DLTS technique. We propose that electron trap  $\text{ME}_1$  ( $E_C$ -0.69eV) observed for the first time is related to impurity iron, and the commonly detectable electron trap  $\text{ME}_2$  ( $E_C$ -0.62eV) is probably caused by native defect or residual impurity other than iron. (Author abstract) 2 refs.

Hu, B.H. (Acad Sinica, Shanghai, China); Zhou, B.L.; Chen, Z.X. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 371-372.

**094596 ELECTRON TUNNELLING INTO INTERFACIAL LANDAU STATES IN SINGLE BARRIER n-TYPE  $(\text{InGa})\text{As}/\text{InP}/(\text{InGa})\text{As}$  HETEROSTRUCTURES.** A new type of tunnelling phenomenon in forward-biased single-barrier  $n^+(\text{InGa})\text{As}/n^-(\text{InGa})\text{As}/\text{InP}/n^+(\text{InGa})\text{As}/n^+(\text{InGa})\text{As}$  heterostructures has been observed when a quantizing magnetic field is applied in the plane of the  $\text{InP}$  barrier. The occurrence of two distinct series of resonances in the voltage- or field-dependence of the current is interpreted in terms of electron tunnelling from a 2DEG in the  $n^-$  layer into interfacial Landau states in the  $n^+(\text{InGa})\text{As}$ . These states correspond to classical skipping orbits of an electron along the tunnel barrier interface. For devices in which the  $n^+(\text{InGa})\text{As}/n^+\text{InP}$  interface at the back end of the gate is within approximately 0.3  $\mu\text{m}$  of the barrier, the interfacial Landau states are observed to evolve into box-quantized states as the magnetic field is reduced to zero. (Author abstract) 9 refs.

Chan, K.S. (Univ of Nottingham, Nottingham, Engl); Eaves, L.; Maude, D.K.; Sheard, F.W.; Snell, B.R.; Toombs, G.A.; Alves, E.S.; Portal, J.C.; Bass, S. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 711-716.

**Etching** See Also OPTICAL GRATINGS—Manufacture; SEMICONDUCTING GALLIUM ARSENIDE—Etching; SEMICONDUCTING GALLIUM COMPOUNDS—Etching.

**094597 NOVEL ETCH MASK PROCESS FOR THE ETCHING OF (011) ORIENTED FACET V-GROOVES IN  $\text{InP}$  (100) WAFERS.** A photoresist etch mask process has been developed for the etching of (110) direction, (111B) faceted v-grooves in  $\text{InP}$  (001) wafers. Etching rates are measured about 0.083 and 0.042  $\mu\text{m}/\text{s}$  for etching depth and undercutting, respectively. The undercutting mechanism is discussed. The deterioration of the etching solution and the resist mask have been studied. (Author abstract) 12 refs.

Huo, D.T.C. (AT&T Bell Lab, Murray Hill, NJ, USA); Wynn, J.D.; Napholtz, S.G.; Lenzo, F.R.; Wilt, D.P. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2850-2856.

**094598 PROPERTIES OF LASER-INDUCED THERMOCHEMICAL ETCHING OF  $\text{InP}$ .** The properties of laser-induced thermochemical etching of  $\text{InP}$  were investigated with a visible multiline  $\text{Ar}^+$  laser and reactant gas  $\text{Cl}_2$  for the first time. Two thresholds of light intensity were observed, respectively, in surfacial writing, etching and rapid penetrating etching. Explanations of the relationship between the etching rate and light intensity are given. (Author abstract) 12 refs.

Li, Ding (Shanghai Inst of Laser Technology, Shanghai, China); Qiu, Mingxin; Zhong, Kuang. *J Electron Mater* v 17 n 1 Jan 1988 p 29-32.

**094599 PREFERENTIAL PHOTOELECTROCHEMICAL ETCHING IN n- $\text{InP}$ .** A V-shaped groove was obtained on n- $\text{InP}$  with a maskless photoelectrochemical method by scanning a laser spot. The groove

profile changes with the number of scans, beginning with a flat bottom and ending with a V profile. All these etched shapes depend on the reactivity of the various crystallographic planes and on exposure time. (Author abstract) 7 refs.

Moutonnet, D. (CNET, Lannion, Fr). *Mater Lett* v 6 n 5-6 Mar 1988 p 183-185.

**094600 SURFACE ORIENTATION EFFECT ON PHOTOELECTROCHEMICAL ETCHING IN n-TYPE  $\text{InP}$ .** The effect of surface orientation on photoelectrochemical etching in n-type  $\text{InP}$  is studied. The (111) planes are of special interest because of their surface composition, only consisting of group III atoms (111) or of group V atoms ( $1\bar{1}\bar{1}$ ). A comparison with etching of the (100) face with acidic solution has shown the great dependence of etching morphology with P or In atom quantities. Following the different reactivities of group III and group V atoms, the etching seems to be always initiated by oxidizing of P atoms. These are directly apparent on the (100) and (111) faces and become apparent in surface defects on the (111) face. (Author abstract) 7 Refs.

Moutonnet, D. (CNET, Lannion, Fr). *Mater Lett* v 6 n 11-12 Jul 1988 p 433-435.

## Fracture

**094601 INDENTATION FRACTURE IN THE  $\text{In}_{1-x}\text{Ga}_x\text{As}_y\text{P}_{1-y}/\text{InP}$  SYSTEM AND ITS EFFECT ON MICROHARDNESS ANISOTROPY CHARACTERISTICS.** Knoop microhardness anisotropy measurements on the  $\text{In}_{1-x}\text{Ga}_x\text{As}_y\text{P}_{1-y}/\text{InP}$  system have disclosed an appreciable variation in hardness behaviour across the composition range of the alloy. This paper relates these variations to changes in the directional fracture characteristics of the system. The qualitative investigation of both Vickers and Knoop indentation fracture has established the emergence of a secondary  $<100>$  cleavage direction at high values of the composition parameter. The marked change in Knoop microhardness anisotropy characteristics with increasing y in the  $\text{In}_{1-x}\text{Ga}_x\text{As}_y\text{P}_{1-y}/\text{InP}$  system has been partially correlated to the emergence of  $<100>$  cleavage and the general increase in indentation fracture, highlighted by the quantitative fracture measurements. Thus, it is concluded that even at very low indentation loads, the effect of fracture on the measured hardness of crystalline materials cannot be ignored. (Edited author abstract) 32 refs.

Watts, D.Y. (Univ of Southampton, Southampton, Engl); Willoughby, A.F.W. *J Mater Sci* v 23 n 1 Jan 1988 p 272-280.

**Growing** See Also LASERS, SEMICONDUCTOR—Degradation.

**094602 LIQUID PHASE EPITAXY AND CHARACTERIZATION OF RARE-EARTH-ION (Yb, Er) DOPED  $\text{InP}$ .** Yb-doped  $\text{InP}$  was grown by liquid phase epitaxy (LPE). Results of photoluminescence (PL) and secondary ion mass spectroscopy (SIMS) measurements revealed that Yb ions are not uniformly dispersed in the crystals but rather incorporated in the crystals as micro particles of Yb-rich compounds. It results in low reproducibility of the epitaxially grown crystals, and relatively weak Yb-related luminescence in spite of the high average Yb concentration in the crystals. Preliminary experimental results on Er-doped  $\text{InP}$  and  $\text{InGaAsP}$  also revealed formation of Er-rich micro particles within the epitaxial crystals. This seems to be the reasons for reported difficulties in fabricating high quality, reproducible, Er-doped  $\text{InP}/\text{InGaAsP}$  double heterostructure lasers by LPE. (Author abstract) 8 refs.

Nakagome, H. (NTT, Musashino, Jpn); Takahei, K.; Homma, Y. *J Cryst Growth* v 85 n 3 Nov II 1987 p 345-356.



**Growth.** See Also LASERS, SEMICONDUCTOR; SEMICONDUCTOR DIODES, PHOTODIODE—Fabrication; SEMICONDUCTOR DIODES, PHOTODIODE—Micro-waves; SEMICONDUCTOR DIODES, PHOTODIODE—Millimeter Waves; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, FIELD EFFECT; TRANSISTORS, FIELD EFFECT—Materials.

**094603 COMPOSITIONAL HOMOGENEITY OF MOVPE-GROWN  $\text{In}_x\text{Ga}_{1-x}\text{As}$ : DEPENDENCE ON REACTOR WALL TEMPERATURE AND WORKING PRESSURE.** The compositional homogeneity of MOVPE-grown in  $\text{In}_x\text{Ga}_{1-x}\text{As}$  layers over an area of  $5.5 \times 10 \text{ cm}^2$  is investigated. The various conditions under which these layers were grown are atmospheric pressure and low pressure as well as cold and hot reactor walls. At atmospheric pressure a cold reactor wall initiates a convective vortex, a hot reactor wall yields parasitic depositions on the reactor wall. At low pressure the layer composition is found to be nearly independent of the wall temperature. Layers with a high compositional homogeneity of about 1% over an area of two 2 inch wafers can be grown at a total pressure of 100 mbar. (Author abstract) 6 refs.

Haspeklo, H. (AEG Research Cent, Ulm, West Ger); Buettner, U.; Sasse, E.; Koenig, U. *J Cryst Growth* v 84 n 2 Aug 1987 p 196-198.

**094604 ELECTROABSORPTIVE  $\text{In}_{1-x}\text{Ga}_x\text{As}_y\text{P}_{1-y}$  SUPERLATTICES GROWN BY LIQUID PHASE EPITAXY.** An automatically controlled liquid phase epitaxy process has been developed for the growth of superlattice structures with layers in the thickness range 50-300 nm. Homojunction structures in  $\text{InP}$  or  $\text{In}_{1-x}\text{Ga}_x\text{As}_y\text{P}_{1-y}$  have been grown with from 18 to 102 alternating p and n layers. Heterostructures with undoped layers of smaller band-gap separating the p and n layers have also been produced. A sideways offset of the position of the solutions allowed all p and n stacks to be deposited at opposite ends of the substrate in addition to the interleaved layers at the center. Simple ohmic contacts to the p and n ends enabled the electroabsorption characteristics of the central area to be measured for light travelling perpendicular to the junction planes. Only a few volts produced significant changes in absorption at wavelength from 1.2 to 1.3  $\mu\text{m}$ , in agreement with theory. (Author abstract) 14 refs.

Greene, P.D. (STC Technology Ltd, Harlow, Engl); Wheeler, S.A. *J Cryst Growth* v 84 n 2 Aug 1987 p 259-265.

**094605 CADMIUM DOPING OF  $\text{InP}$  GROWN BY MOCVD.** The use of Cd as a p-type dopant during the growth of  $\text{InP}$  by metalorganic chemical vapor deposition (MOCVD) has been investigated. Trimethylindium, phosphine and dimethylcadmium (DMCd) were used as sources of In, P and Cd, respectively. The effect of the DMCd flow rate and the reactor pressure on the  $\text{InP}$  doping level was determined. The concentration of Cd in the  $\text{InP}$  was found to be proportional to its partial pressure in the reactor and the deposition rate was independent of the total reactor pressure. These results are in agreement with theoretical considerations. Deterioration of the layer morphology was observed for depositions at low reactor pressure and high DMCd flow rate. The results demonstrate that Cd is not a suitable dopant for low pressure MOCVD for high p-type doping levels. (Author abstract) 9 refs.

Blaauw, C. (Bell-Northern Research, Ottawa, Ont, Can); Emmerstorfer, B.; SpringThorpe, A.J. *J Cryst Growth* v 84 n 3 Sep 1987 p 431-435.

**094606 GROWTH OF THIN  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$  LAYERS BY LIQUID PHASE EPITAXY.** The growth rate of thin ( $< 100 \text{ nm}$ )  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$  layers by step-cooled liquid phase epitaxy (LPE) is reported. Growth from  $\text{In-Ga-As}$  melts at approximately  $600^\circ\text{C}$  is shown to require growth times under one second to obtain layers less than 150 nm thick. In contrast adding the isoelectronic dopant aluminum to growth melt significantly reduces the observed growth rate, and layer thicknesses below 30 nm can be obtained for growth times on the

order of one second. Aluminum isoelectronic doping is therefore considered an important method for obtaining thin layers of  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$  by LPE. (Author abstract) 8 refs.

Whitney, Peter S. (MIT, Cambridge, MA, USA); Fomstad, Clifton G. *J Cryst Growth* v 84 n 4 Oct 1987 p 676-678.

**094607 MOCVD GROWTH OF  $\text{InP}$  ON 4-INCH SI SUBSTRATE WITH  $\text{GaAs}$  INTERMEDIATE LAYER.** This letter describes the heteroepitaxy of  $\text{InP}$  on Si by MOCVD. A new epitaxial structure with a thin  $\text{GaAs}$  intermediate layer ( $\text{InP}/\text{GaAs}/\text{Si}$ ) is proposed to alleviate the large lattice mismatch (8.4%) between  $\text{InP}$  and Si. Using this structure, a 4-inch  $\text{InP}$  single crystal with a mirror-like surface and good thickness uniformity ( $\Delta d/d = \pm 10\%$ ) was obtained. Residual stress in the  $\text{InP}$  film was  $5.7 \times 10^8 \text{ dyn/cm}^2$  for the  $\text{InP}/\text{GaAs}/\text{Si}$  structure, as compared to  $8.3 \times 10^8 \text{ dyn/cm}^2$  for the  $\text{InP}$  directly grown on Si. This shows that the  $\text{GaAs}$  intermediate layer is also effective in reducing the residual stress in the  $\text{InP}$  epilayer. (Author abstract) 9 refs.

Seki, Akiori (SHARP Corp, Tenri, Jpn); Konushi, Fumihiko; Kudo, Jun; Kakimoto, Seizo; Fukushima, Takashi; Koba, Masayoshi. *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1587-1589.

**094608 STRAIN-INDUCED SHIFT OF OPTICAL PHONON FREQUENCY IN  $\text{InGaP}$  LAYERS GROWN ON  $\text{GaAs}$  SUBSTRATES.** Raman spectra from  $\text{InGaP}$  epitaxial layers grown on  $\text{GaAs}$  (001) and (111)B substrates were studied. Both LO and TO phonon frequencies varied, not only with the alloy composition, but also with the lattice strain induced by the lattice mismatch between the epitaxial layer and the substrate. The amounts of these frequency variations agreed with the calculations, including a two-dimensional elastic strain in the epitaxial layer. (Author abstract) 21 refs.

Kato, Takamasa (Yamanashi Univ, Kofu, Jpn); Matsumoto, Takashi; Hosoki, Mitsuru; Ishida, Tetsuro. *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1597-1600.

**094609 INTERMIXING PROCESS OF  $\text{InGaAs}/\text{InP}$  MQW GROWN BY METALORGANIC MOLECULAR BEAM EPITAXY AT THERMAL ANNEALING.** The intermixing process of  $\text{InGaAs}/\text{InP}$  multiple-quantum-well (MQW) structure by thermal annealing at  $500\text{--}700^\circ\text{C}$  is investigated. Optical measurement appears to show that the MQW structure is unstable in the annealing above  $700^\circ\text{C}$ . SIMS and X-ray analysis, however, reveal that the MQW structure remains basically intact and that this intermixing process is mainly attributable to a minor diffusion of P atoms inducing a lattice-mismatched layer. The pronounced optical peak shifts can be roughly explained on the basis of this minor diffusion process. (Author abstract) 12 refs.

Nakashima, Kiichi (NTT, Atsugi, Jpn); Kawaguchi, Yuichi; Asahi, Hajime; Imamura, Yoshihiro. *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1620-1622.

**094610 LOCAL ATOMIC ARRANGEMENT IN AN  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$  QUASI-BINARY ALLOY GROWN BY LIQUID-PHASE EPITAXY.** Weak diffuse scattering was observed in the small-angle scattering region from the  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$  alloy, which is theoretically found to originate from an atomic configuration on the group III sublattice. The experimental results could be explained in terms of the existence of a short-range ordered configuration. Such a deviation from the randomness was limited in terms of the volume of a unit cell, but no long-range order correlation was observed. (Author abstract) 6 refs.

Osamura, Kozo (Kyoto Univ, Kyoto, Jpn); Sugahara, Mitsuru; Nakajima, Kazuo. *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1746-1748.

**094611 LARGE SCALE SYNTHESIS AND GROWTH OF POLYCRYSTALLINE  $\text{InP}$ .** An apparatus has been designed and constructed for the direct synthesis and growth of polycrystalline indium phosphide by injection of phosphorus through a layer of boron oxide

into indium. Two modes of operation were used. In the first, the whole charge was frozen out slowly to form a crucible-shaped ingot which was broken up for use in single crystal growth. A seed crystal was used to present supercooling of the melt. In the second, the seed crystal was used to initiate Czochralski growth and the product was removed as a polycrystalline ingot. Details are given of the design features of the apparatus. The electrical properties of the product are presented, as well as analytical results obtained by spark source mass spectrograph. (Author abstract) 6 refs.

Dowling, D.J. (MCP Electronic Materials Ltd, Windsor, Engl); Brunton, R.A.; Crouch, D.A.E.; Thompson, A.J.; Wardill, J.E. *J Cryst Growth* v 87 n 1 Jan 1988 p 137-141.

**094612 EPITAXIAL GROWTH OF MANGANESE-DOPED INDIUM PHOSPHIDE.** The successful preparation of iron-doped semi-insulating  $\text{InP}$  by organometallic vapor-phase epitaxy (OMVPE) has been recently reported. In this letter we report the preparation and characterization of manganese-doped  $\text{InP}$  OMVPE using an organometallic manganese source. Hall effect and photoluminescence measurements were used to assess the electrical and optical properties of the epitaxial layers. The grown layers were p-type and had carrier concentrations in the range  $7 \times 10^{14}$  to  $2 \times 10^{16} \text{ cm}^{-3}$ . 11 refs.

Huang, K. (Northwestern Univ, Evanston, IL, USA); Wessels, B.W. *J Mater Sci Lett* v 6 n 11 Nov 1987 p 1310-1312.

**094613 HETEROEPITAXIAL GROWTH OF  $\text{InP}$  ON GARNET.** In small areas  $\text{InP}$  has epitaxially been grown by organometallic vapor phase epitaxy on a synthetically grown lattice-adapted garnet substrate. Two one-dimensional lattice-matching relations have to be fulfilled. A high-resolution transmission electron micrograph shows that a somewhat inclined (001)  $\text{InP}$  surface is grown on a (111) garnet substrate in agreement with the matching relations. (Author abstract) 6 refs.

Haisma, J. (Philips Research Lab, Eindhoven, Neth); Cox, A.M.W.; Koek, B.H.; Mateika, D.; Pistorius, J.A.; Smeets, E.T.J.M. *J Cryst Growth* v 87 n 2-3 Feb 1988 p 180-184.

**094614 X-RAY CHARACTERIZATION OF  $\text{In}_x\text{Ga}_{1-x}\text{As}/\text{GaAs}$  QUANTUM WELLS.** X-ray diffraction patterns have been measured for pseudomorphic  $\text{In}_x\text{Ga}_{1-x}\text{As}/\text{GaAs}$  quantum well (QW) structures of widths 183, 121 and 61 Å, and composition x of about 0.28 grown by molecular beam epitaxy. The measured patterns show Pendellosung fringes due to the 513 Å  $\text{GaAs}$  barriers. These Pendellosung fringes are modulated by a broad weak peak mostly coming from the 183 Å  $\text{In}_x\text{Ga}_{1-x}\text{As}$  well layer. The X-ray diffraction fringe modulating patterns between  $32^\circ$  and  $33^\circ$  are fairly symmetric for a non-interrupted growth procedure. The diffraction pattern for the same structures with interrupted growth is less symmetric, since there is further modulation by another weaker peak. Layer thickness and In composition in thin layers (around 100 Å in the thickness) can be estimated by X-ray modeling and good agreement obtained between the measured and the calculated X-ray diffraction patterns. (Edited author abstract) 10 refs.

Jeong, Jichai (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Schlesinger, T.E.; Milnes, A.G. *J Cryst Growth* v 87 n 2-3 Feb 1988 p 265-275.

**094615 LPE GROWTH OF  $\text{InP}/\text{InGaAsP}/\text{InGaAs}/\text{InP}$  HETEROSTRUCTURE AT NORMAL COOLING RATE AT  $630^\circ\text{C}$ .** LPE growth conditions for  $\text{InGaAsP}/\text{InP}$  DH structures (approx.  $1.6 \mu\text{m}$ ) on (100)  $\text{InP}$  at  $630^\circ\text{C}$  are discussed.  $\text{InGaAsP}$  anti-meltback layers should be of  $\lambda \geq 1.3 \mu\text{m}$  for the active layers of  $\lambda = 1.6\text{--}1.66 \mu\text{m}$ . Control of the magnitude of the supersaturation of the melt for the anti-meltback layers and the upper cladding layers is very important in order to achieve the



meltback-free LPE growth. For the  $\lambda = 1.66 \mu\text{m}$  InGaAs active layer, it is also important to prevent circumferential dissolution of active layers. (Author abstract) 12 refs.

Ohtsuka, K. (Mitsubishi Electric Corp, Amagasaki, Jpn); Matsui, T.; Ogata, H. *J Cryst Growth* v 87 n 2-3 Feb 1988 p 338-342.

**094616 GROWTH AND CHARACTERIZATION OF LARGE SIZE, HIGH QUALITY,  $\text{InP}$  SINGLE CRYSTALS.** Single-crystal InP wafers grown by both the vertical gradient freeze (VGF) technique and the liquid encapsulated Czochralski (LEC) have been studied and compared in terms of overall quality. The techniques used to characterize the defect structure consist of (i) defect-revealing etch, (ii) transmission x-ray topography (TXRT), and (iii) transmission cathodoluminescence (TCL). Subsequent to etching, the VGF substrates were found to have a uniformly low ( $<100/\text{cm}^2$ ) EPD from the wafer edge to the center with no slip observed. The low defect density is independent of the sulfur doping level in the range  $2 \times 10^{17}$ – $3 \times 10^{18}/\text{cm}^3$  and is attributed to the reduced axial and radial temperature gradients during growth. In contrast, the Sn- and Fe-doped LEC material had overall EPD levels exceeding  $10^4/\text{cm}^2$ . (Edited author abstract) 13 refs.

Monberg, E.M. (AT&T, Engineering Research Cent, Princeton, NJ, USA); Gault, W.A.; Dominguez, F.; Simchok, F.; Chu, S.N.G.; Stiles, C.M. *J Electrochem Soc* v 135 n 2 Feb 1988 p 500-503.

**094617 USE OF TERTIARYBUTYLPHOSPHINE FOR THE GROWTH OF  $\text{InP}$  AND  $\text{GaAs}_{1-x}\text{P}_x$ .** A newly-developed phosphorus source, tertiarybutylphosphine (TBP), which is much less toxic than  $\text{PH}_3$ , has been used to grow InP and  $\text{GaAs}_{1-x}\text{P}_x$  by atmospheric pressure organometallic vapor phase epitaxy (MOVPE). Excellent morphologies are obtained for the growth of InP between 560 and  $630^\circ\text{C}$  for TBP partial pressures larger than  $0.5 \times 10^{-3}$ . For the first time, V/III ratios as low as 3 have been used to grow InP epilayers with featureless morphologies at  $600^\circ\text{C}$ . The use of TBP to replace  $\text{PH}_3$  in the growth of  $\text{GaAs}_{1-x}\text{P}_x$  results in a nearly linear relationship between vapor and solid composition at  $610^\circ\text{C}$ , i.e., the P distribution coefficient is nearly unity. This contrasts sharply with the very low P distribution coefficient obtained using  $\text{PH}_3$  at such low growth temperatures. (Edited author abstract) 29 refs.

Chen, C.H. (Univ of Utah, Salt Lake City, UT, USA); Cao, D.S.; Stringfellow, G.B. *J Electron Mater* v 17 n 1 Jan 1988 p 67-73.

**094618 HIGH-PURITY LPE GROWTH OF  $\text{InP}$  BY CO ADDITION TO AN  $\text{In-P}$  MELT.** High-purity InP layers are grown using an LPE technique with Co addition. In an In-P solution, Co combines with P to form a CoP precipitate. Solution impurities were removed by incorporation into the CoP precipitate and the In-P solution was purified as a result. High-purity InP layers with  $100,000$ – $110,000 \text{ cm}^2/\text{Vs}$  of Hall mobility at 77 K were obtained by a combination of adding the Co and baking the In-P solution in wet hydrogen. (Author abstract) 14 refs.

Kondo, Susumu (NTT, Atugi, Jpn); Amamo, Toshimasa; Nagai, Haruo. *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 1997-2001.

**094619 COMPARATIVE STUDY ON PROTECTION METHODS AGAINST  $\text{InP}$  SUBSTRATE DECOMPOSITION IN LIQUID PHASE EPITAXY.** The use of a Sn-In-P melt and of InP cover wafers of different orientations to prevent thermal surface decomposition of InP substrates in liquid phase epitaxy has been compared. An almost equivalent protection efficiency was found for the Sn-In-P solution and a (111B) wafer. However, with the melt approach a remarkable increase of residual impurity density was observed particularly at the interface of epitaxial InGaAs layers. (Author abstract) 5 refs.

Pfanner, K. (Heinrich-Hertz-Inst fuer Nachrichtentechnik Berlin GmbH, Berlin, West Ger); Franke, D.; Sartorius, B.; Schlak, M. *J Cryst Growth* v 88 n 1 Apr 1988 p 67-70.

**094620 CRACKS IN  $\text{InP}$ -BASED HETEROSTRUCTURES.** InGaAs/InP and InAlAs/InP single heterostructure grown by molecular beam epitaxy and InGaAsP/InP single heterostructures grown by liquid phase epitaxy under large negative lattice mismatch conditions have been investigated in order to clarify the physical mechanisms of crack formation and propagation. It has been found that cracks generated at the epilayer-substrate interface propagate into both the epilayer and the substrate. It has been observed that cracks parallel to the  $[11\bar{0}]$  direction have a higher mobility than cracks parallel to the  $[110]$  direction. The previously reported cracking model, involving glide, combination and lock up of misfit dislocations, has been confirmed. (Author abstract) 19 refs.

Franzosi, P. (CNR, Parma, Italy); Salvati, G.; Scaffardi, M.; Genova, F.; Pellegrino, S.; Stano, A. *J Cryst Growth* v 88 n 1 Apr 1988 p 135-142.

**094621 DIFFUSION-LIMITED GPE GROWTH OF MIXED CRYSTALS: APPLICATION TO  $\text{In}_{1-x}\text{Ga}_x\text{As}$  ON  $\text{InP}$ .** It is shown that for LPE at constant temperature in an  $(n+1)$  component system the layer thickness is proportional to  $\sqrt{t}$  and the solid composition is constant irrespective of the magnitude of the  $n^2$  diffusion coefficients  $D_{ij}$ . For a ternary system the crystallization path is determined by the ratio of the effective diffusion coefficients of the two dissolved components  $D_2/D_3$ . Growth experiments of the InGaAs lattice-matched to InP at  $600^\circ\text{C}$  prove the  $\sqrt{t}$  law. The crystallization path is derived by measuring the solid composition as a function of supersaturation. An analysis using the phase diagram in clouding strain energy yields  $D_{\text{Ga}}/D_{\text{As}} = 0.42$ . The effective diffusion coefficients of As and Ga in In are obtained. (Edited author abstract) 23 refs.

Traeger, G. (Univ Erlangen, Erlangen, West Ger); Kuphal, E.; Zschauer, K.-H. *J Cryst Growth* v 88 n 2 Apr II 1988 p 205-214.

**094622 ELECTRICAL AND OPTICAL PROPERTIES OF  $\text{InP}$  GROWN BY MBE USING  $\text{P}^+$  ION BEAM.** InP layers have been grown on Fe-doped semi-insulating InP substrates by molecular beam epitaxy using a low energy  $\text{P}^+$  ion beam under various conditions: V/III flux ratios were from 1.2 to 2.2, and growth temperatures were from 400 to  $490^\circ\text{C}$ . The electrical and optical properties of the epilayers are described. The unintentionally doped epilayers were n-type, and there existed two shallow donor levels with activation energies of 4 and 7 meV and two deep donor levels with activation energies of 125 and 175 meV. The carrier concentration and mobility increased with decreasing V/III flux ratio and/or increasing power temperature. The carrier concentration and mobility measured at 80 K were  $1.2 \times 10^{16} \text{ cm}^{-3}$  and  $21200 \text{ cm}^2/\text{Vs}$  for the sample grown at  $490^\circ\text{C}$  and with a V/III flux ratio of 1.9. Photoluminescence spectra and SIMS profiles showed that Fe atoms diffuse into epilayers from substrates and pile up near the surface. (Author abstract) 8 refs.

Morishita, Y. (Mitsubishi Electric Corp, Amagasaki, Jpn); Maruno, S.; Ito, T.; Nomura, Y.; Ogata, H. *J Cryst Growth* v 88 n 2 Apr II 1988 p 215-220.

**094623 LPE GROWTH OF  $\text{GeDOPED InGaAsP/InP}$  BY TWO-PHASE SOLUTION TECHNIQUE.** Germanium doping of  $\text{In}_{1-x}\text{Ga}_x\text{As}_y\text{P}_{1-y}$  ( $E_g \approx 0.95 \text{ eV}$ ) layers grown by LPE using two-phase solution technique produces n-type layers with distribution coefficient  $k_{\text{Ge}} \approx 4.5 \times 10^{-3}$ . In addition, Ge doping gives rise to a new band of luminescence. The experiments are carried out in a horizontal sliding boat system by using a two-phase solution technique in which an excess piece of undoped InP is kept floating on the growth solution. In most cases, the as-grown layers are smooth and shiny. At times, a clean wipe off does not occur and a metallic solution cover is found on the growth substrate at the end of the growth run. (Edited author abstract) 12 refs.

Chandvankar, S.S. (Tata Inst of Fundamental Research, Bombay, India); Rajalakshmi, R.; Srivastava, A.K.;

Arora, B.M. *J Cryst Growth* v 88 n 2 Apr II 1988 p 303-305.

**094624 EFFECT OF LATTICE MISMATCH BETWEEN EPITAXIAL LAYER AND SUBSTRATE ON IMMISCIBILITY OF  $\text{InGaAsP/GaAs}$  LPE LAYERS.** The liquid phase epitaxy (LPE) growth of InGaAsP on GaAs in the immiscible region has been studied in terms of the substrate induced stabilization. The results show that layers grown on (100) GaAs exhibit extraordinary behavior in the PL spectra as well as the surface morphology, while those on (111)A and (111)B GaAs do not. This suggests that the stabilization due to the substrate for the (111) orientation is stronger than that for (100), which is consistent with the theoretical prediction that the effect of strain energy induced by the substrate is greater for the growth on (111) than (100) oriented substrates. It is suggested, by examining the compositional variation at the onset of the LPE growth, that the effect which weakens the substrate induced stabilization for the (100) orientation is the presence of defects due to the lattice mismatch between the substrate and the transient layer, that grows within the initial short time of about 50 ms. (Author abstract) 35 refs.

Tanaka, Shigeyasu (Nagoya Univ, Nagoya, Jpn); Hiramatsu, Kazumasa; Habu, Yoshio; Akasaki, Isamu. *J Cryst Growth* v 87 n 4 Mar 1988 p 446-452.

**094625 METAL ORGANIC VAPOUR PHASE EPITAXY (MOVPE) OF HIGH PURITY  $\text{InP}$  AND THE ROLE OF RESIDUAL IMPURITIES.** InP epitaxial layers have been grown using an atmospheric pressure, metal-organic vapor phase epitaxy (MOVPE) reactor and various trimethylindium sources purified by different routes and analyzed by inductively coupled plasma emission spectrometry (ICP) and different phosphine sources. The inadvertent incorporation of residual impurities Zn and Si has been studied by electrical methods and photoluminescence (PL). The effect of growth temperature, V/III ratio, and growth rate is reported. High purity InP with  $n_{77\text{K}} < 3 \times 10^{14} \text{ cm}^{-3}$  and  $\mu_{77\text{K}} > 110,000 \text{ cm}^2/\text{Vs}$  has been prepared from the purest trimethyl indium and 100% phosphine sources at a temperature of  $600^\circ\text{C}$  and a V/III ratio of 34/1. This material also shows good surface morphology and the optical spectra are dominated by excitonic, near-band gap emissions at low temperatures. The Zn and Si impurities have a dramatic effect on the electrical and photoluminescence properties, lowering the carrier mobility and introducing deep centers associated with bound donors (Si) and acceptors (Zn, C). (Author abstract) 39 refs.

Gerrard, Neil D. (UMIST, Manchester, Engl); Nicholas, D. Julian; Williams, John O.; Jones, Anthony C. *Chemtronics* v 3 n 1 Mar 1988 p 17-30.

**094626 DEVELOPMENT OF LOW DISLOCATION  $\text{InP}$  SINGLE CRYSTALS DOPED SIMULTANEOUSLY WITH Ga AND As.** InP single crystals with low dislocation were developed using an improved LEC technique and simultaneous doping of Ga and As. Amounts smaller than  $10^{19}$ – $10^{20} \text{ cm}^{-3}$  of Ga and As in the melted material were sufficient to reduce the EPD of both N-type crystal doped with Sn and semi-insulating crystal doped with Fe to less than  $1000 \text{ cm}^{-2}$ . Doping of Ga and As had no influence on the electrical properties and IR absorption. The deviation of lattice parameter was less than  $4 \times 10^{-4}$  and no misfit dislocation was observed in the epitaxial layer. These crystals are expected to be used for the manufacture of OE-IC and other devices and further the development of such devices. (Author abstract) 5 refs.

Shimizu, Atsushi; Matsumoto, Kazuhisa; Morioka, Mikio; Koe, Kiyohiko. *Sumitomo Electr Tech Rev* n 27 Jan 1988 p 160-165.

**094627 EFFECT OF GROWTH TEMPERATURE ON  $\text{InGaAsP/GaAsP}$  EPITAXIAL GROWTH.** The epitaxial growth condition of InGaAsP on  $\text{GaAs}_{0.61}\text{P}_{0.39}$  is discussed in conjunction with a lattice latching effect



which is shown to have a relationship with the solid composition of the epilayer. The growth temperature dependence of this relation is also discussed in terms of a theoretical calculation. The PL FWHMs of the epilayers depend on the solid composition but not on the growth temperature. This behavior is attributed to the compositional fluctuation, lattice latching effect and binodal instability of the epilayers. (Author abstract) 27 refs.

Fujii, Sadao (Kanagafuchi Chemical Industry Co, Kobe, Jpn); Tobita, Manabu; Furuta, Shigeru; Sakai, Shiro; Umeno, Masayoshi. *Jpn J Appl Phys Part 1* v 27 n 3 Mar 1988 p 379-383.

**094628 SIMULATION AND GROWTH RATE UNIFORMITY OF MOVPE INP USING ADDUCTS.** InP was grown by MOVPE using phosphine and the adduct TMIIn-TEP. Growth rate and uniformity were measured for different growth conditions and reactor geometries, and were compared to finite difference computer simulations. Good agreement was found between experimental and simulated growth uniformity, except when gas phase depletion reactions occurred. These reactions are usually thought to be eliminated by the use of indium-adducts, but in this paper we demonstrate that these reactions still occur under certain growth conditions. Growth rate simulations were compared to experimental data to detect the onset of depletion reaction effects, and to find means to eliminate them. Simulations were also used to improve reaction chamber design for growth uniformity. (Author abstract) 25 refs.

Field, R.J. (Yale Univ, New Haven, CT, USA); Scholz, F. *J Cryst Growth* v 88 n 3 May 1988 p 371-378.

**094629 SOLUTION CHEMISTRY IN THE FORMATION OF SINGLE-PHASE  $\text{CuInSe}_2$  BY SPRAY PYROLYSIS.** Conditions for depositing single-phase degenerate  $\text{CuInSe}_2$  on molybdenum by chemical spray pyrolysis are provided. The chemistry of the initial spray solution is also discussed. Accurate control of pH and exclusion of oxygen during processing are most important for prevention of copper selenide and indium oxide second phases in the films. (Edited author abstract) 25 refs.

Brown, Brian J. (Stanford Univ, Stanford, CA, USA); Haba, Belgacem; Bates, Clayton W. Jr. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1559-1561.

**094630 SOLID COMPOSITION OF  $\text{In}_{1-x}\text{Ga}_x\text{As}$  GROWN BY THE HALOGEN TRANSPORT ATOMIC LAYER EPITAXY.** The growth of  $\text{In}_{1-x}\text{Ga}_x\text{As}$  by halogen transport atomic layer epitaxy (ALE) is described. The vapor-solid distribution relation for the group III elements is experimentally obtained. A model which assumes the Langmuir-type adsorption for the group III monochlorides is developed. It is shown that the solid composition grown by halogen transport ALE is determined by the competitive adsorption of GaCl and InCl on the substrate. (Author abstract). 16 Refs.

Koukitu, Akinori (Tokyo Univ of Agriculture & Technology, Tokyo, Jpn); Nakai, Hideo; Saegusa, Akihiko; Suzuki, Takeyuki; Nomura, Okio; Seki, Hisashi. *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 744-746.

**094631 HIGH QUALITY SINGLE CRYSTAL GROWTH OF LAYERED InSe SEMICONDUCTOR BY BRIDGMAN TECHNIQUE.** This paper concerns layered crystals of InSe semiconductor grown using the Bridgman technique from a nonstoichiometric melt of  $\text{In}_{0.52}\text{Se}_{0.48}$ . The segregation of excess In decreased by decreasing the temperature gradient of the solid-liquid interface and a good quality InSe single crystal could be grown in a temperature gradient as low as  $4^\circ\text{C}/\text{cm}$ . The value of electron mobility and photoluminescence spectra were greatly improved in comparison with the previously reported data. (Author abstract). 11 Refs.

Ishii, T. (NTT, Musashino, Jpn). *J Cryst Growth* v 89 n 4 7(I) 1988 p 459-462.

**094632 COMPOSITIONAL GRADIENTS IN InGaAs - A GROWTH MODEL AND THE ELECTRICAL EFFECTS ON PHOTODETECTORS.** PIN de-

vices have been grown by vapor phase epitaxy in which the InGaAs layer has either a depth compositional gradient, as determined by X-ray diffractometry, or in which the InGaAs layers exhibit no depth compositional gradient. The electrical properties of these devices have been measured. While the devices with ungraded InGaAs layers show a strong dependence of the dark current on the lattice mismatch (versus the underlying substrate), the devices with depth gradients in the InGaAs layer exhibit low dark currents (less than 10 nA) over a wide range of heterojunction mismatch conditions. We propose a model for the growth of the InGaAs layer which both accounts for the presence of the depth gradient and presents a scheme for growing depth-uniform (ungraded) material. We then extend this model to explain the differing electrical properties of devices with and without depth compositional gradients. (Author abstract). 12 Refs.

Longeway, P.A. (David Sarnoff Research Cent, Princeton, NJ, USA); Smith, R.T. *J Cryst Growth* v 89 n 4 7(I) 1988 p 519-526.

**094633 GROWTH OF IRON DOPED SEMI-INSULATING INP BY HYDRIDE VAPOR PHASE EPITAXY IN A NITROGEN AMBIENT.** The hydride vapor phase epitaxial (VPE) growth of semi-insulating (SI) InP:Fe using  $\text{N}_2$  as a carrier gas is reported. Iron doping was achieved by using  $\text{FeCl}_2$  generated in situ by reaction of HCl and powdered iron in a  $\text{N}_2$  carrier, and the transport of iron as  $\text{FeCl}_2$  was verified by optical absorption spectroscopy. In order to achieve InP growth in a  $\text{N}_2$  carrier input flowrates were adjusted to minimize the pyrolysis of  $\text{PH}_3$ . The thermodynamics of  $\text{FeCl}_2$  transport and InP growth in an inert carrier are discussed, and preliminary results showing the growth of  $10^8 \Omega \text{ cm}$  InP: Fe using this technique are presented. (Author abstract). 12 Refs.

Karlcek, R.F. Jr. (AT&T Bell Lab, Murray Hill, NJ, USA). *J Cryst Growth* v 91 n 1-2 Aug 1988 p 33-38.

**094634 INCLUSION-LIKE DEFECTS IN INP SUBSTRATES AND RELATED DEFECTS IN HETERO-EPI-TAXIAL AND ZN DIFFUSED LAYERS.** InP substrates grown by the liquid encapsulated Czochralski technique often contain typical inclusion-like defects which consist of a central core from which dislocation loops are punched out. The correlation between these defects present in InP substrates and the crystal quality of InGaAsP and InGaAs epilayers and Zn diffused InP layers has been studied. It has been found that the InGaAsP layers grown by liquid phase epitaxy exhibit roughly circular large hillocks, up to  $100 \mu\text{m}$  in diam, related to the inclusion-like defects. The propagation of dislocation loops from the substrate into the epilayers has been demonstrated. As for InGaAs layers grown by the molecular beam epitaxy, defects elongated in the [110] direction, up to  $50 \mu\text{m}$  in length and  $100 \mu\text{m}$  in width, have been observed to be in a one-to-one correspondence with the inclusion-like defects. Misfit dislocations within both InGaAs/ InP and InGaAsP/InP heterostructures and cracks within Zn diffused InP layers have been found to originate preferentially at the inclusion-like defects. (Edited author abstract). 12 Refs.

Franzosi, P. (CNR, Parma, Italy); Salvati, G.; Scaffardi, M. *J Cryst Growth* v 91 n 1-2 Aug 1988 p 90-96.

**094635 DESIGN OF THE OPTIMUM REACTOR CHAMBER FOR UNIFORM INP EPILAYER THICKNESS PROFILES GROWN BY MOVPE.** Gas flow control tubes were designed to obtain uniform epitaxial layers grown by metalorganic vapor phase epitaxy (MOVPE). Four tube-shape parameters for the reactor, the angle of inclination of the susceptor, the angle of inclination of the top wall of the tube, and the curvature and height of the top wall were varied and the uniformity of the InP epitaxial layers was studied. The inclined susceptor and inclined top wall improved the thickness uniformity in the direction of the gas flow. It was also found that the curvature of the top wall of the tube was effective in the control of the epitaxial layer thickness in the direction normal to the gas flow. Uniform epitaxial layers over entire 5 cm diam wafers could be obtained by

optimizing the design of the tube. (Edited author abstract). 10 Refs.

Takenaka, Chisato (Fujitsu Lab, Atsugi, Jpn); Fujii, Takuya; Kuramata, Akito; Yamazaki, Susumu; Nakajima, Kazuo. *J Cryst Growth* v 91 n 1-2 Aug 1988 p 173-179.

**094636 MASS SPECTROMETRIC STUDIES OF PHOSPHINE PYROLYSIS AND OMVPE GROWTH OF InP.** The mechanism of  $\text{PH}_3$  decomposition was studied by using  $\text{D}_2$  as a carrier gas and analyzing the reaction products with a mass spectrometer. The effects of InP and silica surfaces were investigated. The only gaseous product below  $600^\circ\text{C}$  is  $\text{H}_2$ . Since any gas phase H atoms would produce HD, the reaction occurs entirely on the surface. The slow step is the unimolecular removal of the first hydrogen atom, with an activation energy of  $36.0 \text{ kcal/mole}$  on InP surfaces. The reaction on InP is first order for  $\text{PH}_3$  concentrations as high as 15%, so the surface is not saturated at those conditions. When trimethylindium (TMIIn) is added to the gas mixture, the mechanism changes dramatically, probably proceeding via an unstable intermediate adduct of TMIIn and  $\text{PH}_3$  which eliminates  $\text{CH}_4$  upon formation. This concerted reaction lowers the pyrolysis temperatures of both  $\text{PH}_3$  and TMIIn. (Author abstract) 28 refs.

Larsen, C.A. (Univ of Utah, Salt Lake City, UT, USA); Buchan, N.I.; Stringfellow, G.B. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 148-153.

## Hardening

**094637 SOLUTION HARDENING DUE TO A NONRANDOM ATOM ARRANGEMENT IN III-V TERNARY ALLOY SEMICONDUCTORS.** Nonrandomness in the atomic arrangement impedes the motion of a dislocation. The extra resolved shear stress to move a dislocation,  $\tau$ , is calculated for III-V ternary alloy semiconductors on the basis of a thermodynamical analysis where the strain energy is considered as the mixing enthalpy. The  $\tau$  is large for a large lattice-mismatched alloy, e.g., InGaAs while negligible for a closely lattice-matched alloy, e.g., GaAlAs. The hardening in the alloy with the strain due to lattice mismatch can be significant at high temperatures or during the operation of devices and thus could elongate the device lifetime. (Author abstract) 13 refs.

Ichimura, Masaya (Kyoto Univ, Kyoto, Jpn); Sasaki, Akio. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 176-178.

## Heat Treatment

**094638 RAMAN STUDY OF DISORDER IN LASER-ANNEALED III-V SEMICONDUCTORS.** From Raman study of laser-annealed InP and GaAs semiconductors (both crystalline and ion implanted), the conclusion is drawn that under certain conditions a disordered polycrystalline phase rather than a monocrystalline one may be produced. The diagnostic of the disorder is based on the Raman polarization measurements as well as on phonon linewidths and frequency shifts and on plasmon-phonon damping. Calculations were performed on the ratios of phonon scattering intensities for a polycrystal with either random or preferential orientation of crystallites. The dependence of Raman line shape on crystallite size is evaluated. From comparison of calculated and measured data the degree of orientation and size is estimated. (Author abstract) 16 refs.

Reshina, I.I. (Acad of Sciences of the USSR, Leningrad, USSR). *Phys Status Solidi A* v 106 n 1 Mar 1988 p 261-270.



**094639 COMPUTER ANALYSIS OF EFFECTS OF ANNEALING ON  $\text{InP}$  INSULATOR-SEMICONDUCTOR INTERFACE PROPERTIES USING MIS C-V CURVES.** The effects of annealing on the distributions of interface states at the I-S interface were investigated by analyzing the C-V characteristics of as-grown and annealed  $\text{Al}_2\text{O}_3/\text{native oxide}/\text{InP}$  MIS capacitors using a self-consistent computer simulation program. It is shown that interface states form a continuum of donor-like and acceptor-like states continuously distributed both in energy and in space. The state density distribution before and after annealing maintains the same functional form, which is U-shaped in energy and exponentially decaying in space. The charge neutrality point dividing donor-like and acceptor-like states occurs at the U-shaped minimum. Annealing reduces the spatial extension of states, the U-shape curvature and the magnitude of density. However, the energy position of the charge neutrality point remains remarkably invariant. (Author abstract) 31 refs.

He, Li (Hokkaido Univ, Sapporo, Jpn); Hasegawa, Hideki; Sawada, Takayuki; Ohno, Hideo. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 512-521.

## Impurities

**094640 ACCEPTOR LEVELS IN INDIUM SELENIDE. AN INVESTIGATION BY MEANS OF THE HALL EFFECT, DEEP-LEVEL-TRANSIENT SPECTROSCOPY AND PHOTOLUMINESCENCE.** Acceptor levels related to I, II, IV and V group impurities in indium selenide are studied by means of the Hall effect, deep-level-transient spectroscopy (DLTS) and photoluminescence. Activation energies for hole concentrations in the range from 200 to 300 MeV have been measured. A reversible change of sign of the Hall voltage has been observed below 215 K. This behavior can be explained through a model in which acceptor levels are assumed to be shallow and interlayer planar precipitates of ionized shallow donors create potential wells that behave as deep donors and in which a low concentration of bidimensional free electrons can exist. This model also explains the capacitance-voltage characteristics of both  $\text{ITO}/\text{p-InSe}$  and  $\text{Au}/\text{p-InSe}$  barriers. A broad band whose intensity is related to p conductivity appears in the PL spectra of low resistivity p-InSe. The shape and temperature dependence of this band can be explained through self-activated photoluminescence in a complex center. (Edited author abstract) 40 refs.

Segura, A. (Dep de Fisica Aplicada, Valencia, Spain); Martinez-Tomas, M.C.; Mari, B.; Casanovas, A.; Chevy, A. *Appl Phys A* v A 44 n 3 Nov 1987 p 249-260.

**094641 DIFFUSION MECHANISM OF Cd IN  $\text{InP}$  AND  $\text{InGaAs}$ .** Cadmium was diffused into  $\text{InP}$  and  $\text{InGaAs}$  using  $\text{Cd}_3\text{P}_2+\text{P}$  or  $\text{Cd}_3\text{P}_2+\text{Cd}_3\text{As}_2$  as the diffusion sources. Two diffusion fronts were observed. The diffusion characteristics for  $\text{Cd}_3\text{P}_2+\text{P}$  sources are interpreted based on the interstitial-substitutional model, or its modification, the vacancy complex model. The charge state of the diffusing interstitial cadmium atom is a singly ionized donor. The chemical species of phosphorus which reacts with  $\text{InP}$  is  $\text{P}_2$  and gaseous Cd originates from solid-phase  $\text{CdP}_2$ . For  $\text{Cd}_3\text{P}_2+\text{Cd}_3\text{As}_2$  diffusion sources, the effective diffusion coefficient and the surface acceptor concentration decrease with increasing the  $\text{Cd}_3\text{As}_2$  weight fraction. The relative depth of the deeper diffusion front becomes more deep when the supply of vacancies is suppressed. (Author abstract) 13 refs.

Ohtsuka, Ken-ichi (Mitsubishi Electric Corp, Amagasaki, Jpn); Matsui, Teruhito; Ogata, Hitoshi. *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 253-259.

**094642 CALCULATION OF DISLOCATION PINNING FORCES IN  $\text{InP}$  WITH ISOVALENT IMPURITIES BY SOLID SOLUTION HARDENING MODEL.** Based on a solid solution hardening model, the authors have considered the solution of isovalent impurities in  $\text{InP}$  and the elastic misfit arising from the differences of the tetrahedral radii between added impurities and host atoms. For isovalent impurities in  $\text{InP}$ ,

pinning forces as large as  $10^9 - 10^{10}$  dynes/cm<sup>2</sup> have been calculated. Thus, the reduction in dislocation density in  $\text{InP}$  single crystals doped with isovalent impurities can be explained. (Author abstract) 15 refs. In Chinese.

Ye, Shizhong (Acad Sinica, Beijing, China); Yang, Baohua. *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 150-155.

**094643 TIN-RELATED SHALLOW DONOR IN INDIUM SELENIDE.** Hall-effect measurements in indium selenide samples doped with different amounts of tin are reported. The temperature dependence of free-electron concentration is interpreted through a single-donor single-acceptor model from which the ionization energy of the tin related shallow donor (22 meV) and the compensation ratio are obtained. At low temperature the electron concentration departs from activated behavior and tends to be constant. This can be interpreted through the existence of two-dimensional subbands related to interlayer planar aggregates of donor impurities that are located in energy below the tin-related donor level. (Author abstract) 15 refs.

Mari, B. (Univ of Valencia, Valencia, Spain); Segura, A.; Chevy, A. *Appl Phys A* v A46 n 2 Jun 1988 p 125-129.

**094644 NATURE OF THE ELECTRICAL INACTIVITY OF TIN AND IRON IMPURITY ATOMS IN  $\text{In}_2\text{Te}_3$  AND  $\text{Ga}_2\text{Te}_3$ .**  $\alpha\text{-In}_2\text{Te}_3$ ,  $\beta\text{-In}_2\text{Te}_3$ , and  $\text{Ga}_2\text{Te}_3$  crystals doped with iron or tin were studied. Iron and tin are found in divalent states in  $\beta\text{-In}_2\text{Te}_3$  and  $\text{Ga}_2\text{Te}_3$  by Moessbauer spectroscopy. Their electrical inactivity is explained by a compensation effect of  $\text{In}^+$  or  $\text{Ga}^+$  ions which pins the Fermi level to the middle of the energy gap. In  $\alpha\text{-In}_2\text{Te}_3$  doped with iron or tin some impurity enriched regions which results in additional conductivity at low temperature are found. (Author abstract) 13 Refs.

Nasredinov, F.S. (Acad of Sciences of the USSR, Leningrad, USSR); Masterov, V.F.; Saidov, CH.S.; Seregin, P.P.; Troitskaya, N.N.; Tschirner, H.U. *Phys Status Solidi A* v 107 n 1 May 1988 p 291-298.

**Ion Implantation.** See Also OPTOELECTRONIC DEVICES; SEMICONDUCTOR DEVICES—Junctions; TRANSISTORS, FIELD EFFECT—Fabrication.

**094645 PHOTOLUMINESCENCE ENHANCEMENT OF  $\text{InP}$  TREATED WITH ACTIVATED HYDROGEN.** A large enhancement of the photoluminescence intensity emitted by a (100)-oriented  $\text{InP}$  surface after exposure to activated hydrogen, indicating a sharp reduction of the surface recombination rate, is reported in this work. It is shown, using capacitance-voltage measurements performed on metal-insulator-semiconductor structures, that the hydrogen treatment also results in a strong pinning of the interface Fermi level. These phenomena are interpreted on the following basis: (i) neutralization by hydrogen species of active recombination centers which are deemed to be phosphorus-dangling bonds; and (ii) creation of pinning surface states due to the formation of volatile phosphorus hydride compounds freeing excess indium atoms. (Edited author abstract) 28 refs.

Viktorovitch, P. (CNRS, Ecully, Fr); Benyahia, F.; Santinelli, C.; Blanchet, R.; Leyral, P.; Garrigues, M. *Appl Surf Sci* (1985) v 31 n 3 Apr 1988 p 317-326.

**094646 LOCALIZED VIBRATIONAL MODES IN PROTON AND DEUTERON IMPLANTED  $\text{InP}$  SINGLE CRYSTALS.** Infrared absorption spectra of proton and deuteron implanted  $\text{InP}$  single crystals exhibit four localized vibrational modes with frequencies of 2197, 2212, 2308, 2335  $\text{cm}^{-1}$  and 1600, 1619, 1659, 1678  $\text{cm}^{-1}$ , respectively. From a comparison of these mode frequencies with those in other species containing In-H(D) and P-H(D) bonds it is concluded that all four modes observed are due to stretching vibrations of bonds formed between phosphorus and the implanted atoms. The number of vibrating bonds is found to be proportional to the damage density. Annealing experiments indicate a higher thermal stability of the defect configurations giving rise to the two high-energy localized modes. (Author abstract) 14 refs.

Riede, V. (Karl-Marx-Univ, Leipzig, East Ger); Neu-

mann, H.; Sobotta, H.; Ascheron, C.; Groetschel, R. *Solid State Commun* v 65 n 9 Mar 1988 p 1063-1067.

**094647 PROPERTIES OF  $\text{In}$  AND  $\text{P}$  SUBCASCADES IN A CRYSTALLINE ION-IMPLANTED  $\text{InP}$  TARGET.** Results of a Monte Carlo simulation of the damage formation in a crystalline  $\text{InP}$  target are reported. The simulation analyzes the features of the two recoil populations for different orientations of the target. (Author abstract) 11 refs.

Mazzone, A.M. (CNR, Bologna, Italy). *Philos Mag A* v 57 n 5 May 1988 p 741-747.

**094648 RESEARCH ON THE ION IMPLANTATION OF Be INTO  $\text{InGaAs}$ .** Ion implantation of Be into  $\text{InGaAs}$  and their annealing behavior have been studied by using SIMS, electrochemical C-V and Hall measurement. Results show that proximity cap annealing below 700°C with step temperature cycle results in high activation and good surface quality. Be-implant pn junctions with high breakdown voltage and low leakage current have been constructed, and have been used in the fabrication of monolithically integrated PIN-JFET photo-receivers. (Edited author abstract) In Chinese. 3 refs.

Zhang Yonggang (Acad Sinica, Shanghai, China); Fu Xiaomei; Pan Huizhen; Chen Ruyi; Zhang Huixing. *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 328-331.

**094649 1f NOISE IN ION-IMPLANTED INDIUM PHOSPHIDE LAYERS.** The frequency dependence of noise levels in ion-implanted devices of  $\text{InP}$  follows Hooke's relationship [Phys. Lett. A-29, 139 (1969)]. The noise levels vary in proportion to the square of the terminal voltages, and decrease linearly with the frequency and the total carriers throughout the ranges from 0.1 Hz to 100 kHz. The Hooke parameter is  $\alpha_H = 1.5 \times 10^{-4}$ . (Author abstract) 11 refs.

Tacano, Munecazu (Electrotechnical Lab, Tsukuba, Jpn); Ogawa, Kinya; Sugiyama, Yoshinobu. *Solid State Electron* v 31 n 8 Aug 1988 p 1243-1245.

**094650 ELECTRICAL PROPERTIES OF  $\text{InP:Fe}$  SINGLE CRYSTALS IMPLANTED BY PHOSPHORUS IONS.** This note is devoted to the investigations of phosphorus ion implantation and to the influence of the post-implantation annealing process upon the electrical properties of  $\text{InP:Fe}$  crystals grown by the liquid encapsulated Czochralski method under argon pressure. Iron doping has been performed during growth. To estimate the depth of donor levels arising during the post-implantation annealing of samples the temperature dependence of the surface Hall coefficient  $R_{HS}$  has been investigated in the range 100 to 400 K. The thermal electron activation energy has been determined to be 0.09 eV. 2 Refs.

Radautsan, S.I. (Acad of Sciences of the Moldavian SSR, Kishinev, USSR); Tiginyanu, I.M.; Pyshnaya, N.B. *Phys Status Solidi A* v 108 n 1 Jul 1988 p K59-K61.

**Laser Applications.** See LASERS, SEMICONDUCTOR—Fabrication.

## Low Temperature Effects

**094651 VARIABLE-RANGE HOPPING IN  $\text{InP}$  CLOSE TO THE METAL-INSULATOR TRANSITION.** Analysis of conductivity data taken over the temperature range 4.2-0.05 K for a compensated sample of  $\text{InP}$  on the insulating side of, but very close to, the metal-insulator transition in terms of the relation  $\sigma = \sigma_0 \exp[-(T_0/T)^s]$  gives  $s=0.25$  instead of  $s=0.5$  previously obtained for a sample at some distance from the transition. Application of a small magnetic field produces behavior characteristic of the metallic regime and so confirms the phase diagram proposed by Shapiro. (Author abstract) 6 refs.

Finlayson, D.M. (St. Andrews Univ, St. Andrews, Scotl); Mason, P.J.; Mohammad, I.F. *J Phys C Solid State Phys* v 20 n 25 Sep 10 1987 p L607-L610.



**094652 THERMAL EXPANSION COEFFICIENT AND GRUNEISEN PARAMETER OF INP CRYSTAL AT LOW TEMPERATURES.** The thermal expansion of the lattice constant of InP crystal has been measured in the range 4.2–300 K by the Bond method and the results are shown graphically. The thermal expansion coefficient  $\alpha$  calculated from the experimental results is negative between 15 and 80 K and positive below 15 K. The corresponding Gruneisen parameter  $\gamma$  closely follows the behaviour of  $\alpha$  and the values of  $\alpha$  and  $\gamma$  are tabulated and shown graphically. The results do not agree with the phenomenological theory in which only a negative  $\alpha$  is predicted for InP at low temperatures. (Author abstract) 13 refs.

Haruna, K. (Tamagawa Univ, Machida, Jpn); Maeta, H.; Ohashi, K.; Koike, T. *J Phys C Solid State Phys* V 20 n 32 Nov 20 1987 p 5275-5279.

**Low Temperature Properties** See Also SEMICONDUCTOR DEVICES, MOS—Surface Properties.

**094653 INTERPRETATION OF ULTRASONIC ATTENUATION IN n-InSb AT LOW TEMPERATURES.** Measurements of the ultrasonic attenuation in n-InSb at low temperatures are reported. A magnetic field-induced relaxation peak diminishing in height with decreasing temperatures is observed in the range 0.25–4.2 K. Both our data and other recent measurements can be interpreted in detail solely in terms of the Hutson and White model. (Author abstract) 10 refs.

Fernandez, B. (Univ de Sherbrooke, Sherbrooke, Que, Can); Guillon, F.; Cheeke, J.D.N. *Solid State Commun* v 64 n 5 Nov 1987 p 779-781.

**Magnetic Field Effects** See Also SEMICONDUCTOR DEVICES—Tunneling.

**094654 SHALLOW DONOR-LIKE IMPURITY STATES.** We present evidence of hydrogenic behavior of shallow donor-like impurity states in n-type InP ( $8.5 \times 10^{15} \text{ cm}^{-3} < N_d - N_a < 6.2 \times 10^{16} \text{ cm}^{-3}$ ) from magnetic freeze out experiments at magnetic fields up to 18 T. This occurs at  $T < 10$  K and at a magnetic field sufficiently high to induce a metal-insulator transition. At high fields, the reduction of the binding energy with respect to the hydrogenic model of D.M. Larsen can be well accounted for by the increasing overlap of the impurity wave functions as the donor concentration increases. (Author abstract) 18 refs.

Aulombard, R.L. (CNRS, Montpellier, Fr); Kadri, A.; Zitouni, K.; Konczewicz, L. *Solid State Commun* v 61 n 7 Feb 1987 p 419-422.

**094655 MAGNETOPHONON EFFECT IN N-InSb UNDER HYDROSTATIC PRESSURE.** The magnetophonon effect in nondegenerate N-InSb is investigated under hydrostatic pressure in the magnetic field up to 0.7 T at liquid nitrogen temperature. The magnetophonon oscillation in the Hall voltage for N-InSb under hydrostatic pressure is reported here for the first time. The experimental results and theoretical analysis show that both oscillations for the Hall coefficient and transverse magnetoresistance have a similar relationship with pressure, i.e., the periods of oscillation decrease with the increase of the pressure, which shows the similar physical mechanism, i.e., increase of the energy gap with increasing pressure. (Author abstract) 19 refs.

Li, Qiguang (Acad Sinica, Shanghai, China); Shen, Xuechu; Ju, Guanglin; Zheng, Guozhen. *Chin J Infrared Res Ser B (Engl Ed)* v 6 1987 p 39-45.

## Magnetic Properties

**094656 THE TWO-PHOTON MAGNETOABSORPTION IN n-InSb.** By measuring the photoconductivity (pc) and modulated pc, two-photon magnetoabsorption (TPMA) excited by a cw CO<sub>2</sub> laser in n-InSb at  $T = 15$  K in the Voigt configuration and magnetic field in  $<111>$  orientation up to 4.2 T was observed. The experimental results show that the TPMA process in InSb could be explained by the 'interband-intraband' transition

theory. Most of the absorptions observed are proved to be spherical transitions, while the remainders are induced from weaker inversion asymmetry transition, warping or K<sub>H</sub> transitions. TPMA coefficients are derived by calculating the imaginary part of the third nonlinear susceptibility. By comparing these coefficients with the changes in pc induced by TPMA the current TPMA theory is confirmed. (Edited author abstract). 13 Refs. In Chinese.

Wei, Tao (Peking Univ, China); Wang, Xuezhong. *Ban-daoti Xuebao* v 9 n 4 Jul 1988 p 380-387.

## Measurements

**094657 PHOTO HALL MEASUREMENTS OF BAND-TAIL ABSORPTION AND RECOMBINATION TIMES IN INDIUM ANTIMIDE.** Photo Hall measurements are reported for a n-type InSb sample at 77 K. A bulk recombination time of 350 ns and an effective surface recombination time of 20 ns, corresponding to a surface recombination velocity of  $2.8 \times 10^5 \text{ cm s}^{-1}$ , has been estimated from an analysis of the frequency dependence of the photocurrent generation. The measurements yield interband absorption coefficients in the band-tail which are systematically lower than the previous optical measurements, being up to an order of magnitude lower at  $100 \text{ cm}^{-1}$  below the band edge. The form of the band-tail is qualitatively described in terms of the convolution of an exponential edge and an acceptor impurity resonance. (Author abstract) 12 refs.

Mackenzie, H.A. (Heriot-Watt Univ, Riccarton, Scotl); Allan, G.R.; Hunter, J.J.; Hutchings, D.C.; Wherrett, B.S. *Opt Commun* v 63 n 2 Jul 15 1987 p 73-77.

**094658 FAR-INFRARED MAGNETOOPTICAL ABSORPTION IN  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ .** By observing far-infrared electron cyclotron resonance in photoexcited  $\text{In}_x\text{Ga}_{1-x}\text{As}$  ( $x = 0.53$ ) at 4.2 K, as well as the Zeeman absorption signal due to donor electrons, the electron transfer between the conduction band and donor states is investigated. Impact ionization of donor electrons by photoexcited electrons has been confirmed. From the time-resolved measurement, the apparent lifetime of conduction electrons is found to be  $17 \mu\text{s}$  and the momentum relaxation time  $6.7 \times 10^{-13} \text{ s}$ . The time-resolved absorption measurement gives a definite clue to the electron capture rate by a donor and the recombination rate at an acceptor center. (Author abstract) 9 refs.

Fujii, Ken-ichi (Osaka Univ, Toyonaka, Jpn); Ohyama, Tuzui; Otsuka, Eizo. *Solid State Commun* v 65 n 11 Mar 1988 p 1263-1265.

**Mechanical Properties** See Also SEMICONDUCTING GALLIUM COMPOUNDS—Mechanical Properties.

**094659 MICROHARDNESS OF  $\text{CuInSe}_2$ .** Vickers microhardness measurements have been performed on (112) faces of n- and p-type  $\text{CuInSe}_2$  single crystals at room temperature. In nearly stoichiometric samples, hardness values of  $2.33 \pm 0.06 \text{ GPa}$  and  $3.37 \pm 0.09 \text{ GPa}$  were found for n- and p-type material respectively. Preliminary results regarding hardness anisotropy and microhardness changes due to larger deviations from stoichiometry are given. At applied loads in the range 5–500 g no dependence of the microhardness on the load was found. (Author abstract) 20 refs.

Constantinidis, G. (Univ of Salford, Salford, Engl); Tomlinson, R.D.; Neumann, H. *Phil Mag Lett* v 57 n 2 Feb 1988 p 91-97.

## Microscopic Examination

**094660 LATTICE POSITION OF DIFFUSED Zn IN InP.** We have measured the substitutional fraction ( $f_s$ ) for Zn atoms diffused into InP crystals using the proton-induced X-ray excitation (PIXE) technique. Diffusion times ranged from 15–60 min at 425–650°C. For several samples with diffusion depths in the range 0.75–3.7  $\mu\text{m}$  (as determined by SIMS analysis), we find that the Zn impurity atoms reside almost totally on lattice sites:  $f_s = 0.9 \pm 0.1$ . Contrary to results of an earlier study, we find

no evidence for precipitates in the diffused layers. However, only approx.  $10^{-3}$ – $10^{-1}$  of the Zn is electrically active, consistent with Tuck and Hooper's suggestion of neutral  $V_P\text{Zn}_{1/2}V_P$  complexes. (Author abstract) 10 refs.

Lennard, W.N. (Univ of Western Ontario, London, Ont, Can); Swanson, M.L.; Eger, D.; Springthorpe, A.J.; Shepherd, F.R. *J Electron Mater* v 17 n 1 Jan 1988 p 1-3.

**094661 SEM STUDY OF THERMAL DEGRADATION OF INDIUM PHOSPHIDE SUBSTRATES.** SEM observations are reported with the aim of studying the thermal degradation of InP substrate surfaces decomposed at typical VPE and LPE growth temperatures in a hydrogen atmosphere. The surface morphology is shown to vary extensively with the variation of annealing temperature. (Author abstract) 7 refs.

Shrivastava, M.C. (Univ of Roorkee, Roorkee, India); Swaminathan, S. *Microelectron J* v 19 n 1 Jan-Feb 1988 p 48-51.

**094662 TRANSMISSION/SCANNING TRANSMISSION ELECTRON MICROSCOPY INVESTIGATION OF Au/Cr CONTACTS TO P-TYPE InP.** The change in contact resistance produced by the annealing of Au/Cr metallizations to p-type InP has been correlated with the microstructural changes examined by electron microscopy. The contacts were initially non-ohmic. Their resistance decreased, but remained non-ohmic, even after annealing to temperatures up to 450°C. Transmission and scanning transmission electron microscopy of cross-section samples revealed the formation, at elevated temperatures, of CrP and AuIn intermetallic layers at the contact/semiconductor interface. Chromium appeared to initiate compound formation through the dissociation of InP, although gold likely assisted in driving the reactions. CrP formed first, at temperatures below 350°C, as a polycrystalline, fine-grained layer between the Cr and InP. The formation of islands of AuIn followed at about 400°C and these grew into a continuous layer upon further annealing. (Author abstract) 14 refs.

Ivey, D.G. (Univ of Alberta, Edmonton, Alberta, Can); Bruce, R.; Piercy, G.R. *Solid State Electron* v 31 n 8 Aug 1988 p 1251-1258.

## Microstructure

**094663 AVERAGE BOND LENGTHS AND ATOM ARRANGEMENT IN  $\text{In}_{1-x}\text{Ga}_x\text{As}$  AND  $\text{GaAs}_{1-x}\text{P}_x$  III-V TERNARY ALLOY SEMICONDUCTORS.** Statistics for five different tetrahedra in  $\text{In}_{1-x}\text{Ga}_x\text{As}$  and  $\text{GaAs}_{1-x}\text{P}_x$  III-V ternary alloy semiconductors were derived through a thermodynamical analysis. Every bond length between nearest-neighbor atoms in each tetrahedron was calculated. Then, average bond lengths were obtained theoretically; they agree fairly well with experimental data from the extended X-ray absorption fine structure. Effects of the short-range order in atom arrangement on the average bond lengths were discussed. (Author abstract) 15 refs.

Ichimura, Masaya (Kyoto Univ, Kyoto, Jpn); Sasaki, Akio. *Jpn J Appl Phys Part 1* v 26 n 8 Aug 1987 p 1296-1299.

## Modification

**094664 SPECTROELLIPSOMETRIC STUDY OF THE ELECTROCHEMICAL MODIFICATION OF InP.** In the cathodic decomposition of InP, which occurs during hydrogen evolution, an indium rich film grows on the surface of the semiconductor. Subsequently this film undergoes transformations between oxidized and reduced forms following the electrode polarization. An in situ spectroellipsometric study of these transformations was carried out. From these measurements it is possible to obtain both the thickness and the dielectric function of the film. Using the effective medium approximation, the components of the two forms of film are identified: indium oxide and solution in the oxidized stage, indium and solution in the reduced one. These results show that spectroellipsometry is a method well suited to characterize



in situ the electrochemical surface modifications. (Author abstract) 14 refs.

Gagnaire, A. (Ecole Centrale de Lyon, Ecully, Fr); Joseph, J.; Etcheberry, A. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2475-2478.

**Morphology** See SEMICONDUCTING GALLIUM ARSENIDE—Morphology.

**Optical Properties** See Also INFRARED DETECTORS—Fabrication; LIGHT—Modulation; SEMICONDUCTING GALLIUM ARSENIDE—Optical Properties; SEMICONDUCTING GALLIUM COMPOUNDS—Optical Properties.

**094665 ELECTRONIC BAND STRUCTURE AND OPTICAL ANISOTROPY IN InS: I. EXPERIMENTAL STUDY.** Optical properties of InS on (001) surfaces are investigated using polarized absorptions near the fundamental gap (1.5 to 3.0 eV) and polarized reflectivity in the range of photon energy from 2 to 20 eV using a synchrotron radiation source. Detailed analyses of polarized absorption spectra reveal that the fundamental band gap of InS is an allowed indirect transition for each polarization in the (001) plane. The lowest direct-gap is allowed for b-polarization, but forbidden for a-polarization. Dielectric functions are derived from reflectivity spectra by Kramers-Kronig analysis and some features in spectra are assigned to interband transitions. (Author abstract) 17 refs.

Takarabe, K. (Okayama Univ of Science, Okayama, Jpn); Kawamura, H.; Wakamura, K. *Phys Status Solidi B* v 142 n 2 Aug 1987 p 605-615.

**094666 EXTRINSIC PHOTOLUMINESCENCE FROM InGa/GaAs PSEUDOMORPHIC SINGLE QUANTUM WELLS.** Extrinsic luminescence due to carbon and beryllium acceptors in InGaAs pseudomorphic single quantum wells has been studied. The relative intensity is found to be very weak, even for acceptor concentrations approximately  $10^{17} \text{ cm}^{-3}$ . Acceptor binding energies are obtained and compared with those for GaAs/AlGaAs quantum wells and InGaAs/GaAs multilayer structures. Despite the relatively large strains in the InGaAs/GaAs single quantum wells, we do not observe any significant effect on the binding energies. (Author abstract) 22 refs.

Devine, R.L.S. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Moore, W.T. *Solid State Commun* v 65 n 1 Jan 1988 p 19-21.

**094667 PHOTOLUMINESCENCE STUDIES ON THE LAYER SEMICONDUCTOR  $\text{In}_2\text{Se}_3$ .** Photoluminescence investigations of the layered  $\text{In}_2\text{Se}_3$  show clearly distinct results for two varieties of materials: pure  $\alpha$ - $\text{In}_2\text{Se}_3$  and mixture of  $\alpha$  and  $\gamma$ - $\text{In}_2\text{Se}_3$ . The pure  $\alpha$ - $\text{In}_2\text{Se}_3$  exhibits, at liquid helium temperature, two photoluminescence bands: one at higher energy 1.523 eV due to the radiative recombination of impurity bond excitons, and the other at lower energy 1.326 eV due to recombination on luminescence centers formed by intrinsic defects due to disorder in the cation sublattice. In the mixed  $\alpha$  and  $\gamma$ - $\text{In}_2\text{Se}_3$  only one broad band at 1.319 eV is observed related to the additional disorder in the cation sublattice coming from the alloying of the  $\alpha$ - and  $\gamma$ -phases. (Author abstract) 9 refs.

Balkanski, M. (CNRS, Paris, Fr); Julien, C.; Chevy, A.; Kambas, K. *Solid State Commun* v 59 n 7 Aug 1986 p 423-427.

**094668 PHOTOLUMINESCENCE OF InGaAs/GaAs PSEUDOMORPHIC SINGLE QUANTUM WELLS: EFFECT OF EXCITATION INTENSITY.** The effect of excitation intensity on the photoluminescence spectra of pseudomorphic InGaAs/GaAs single quantum wells grown by molecular beam epitaxy is examined. Even at moderate excitation intensities, saturation of the exciton population and band-filling is observed. The band-filling leads to luminescence involving higher sub-bands, and the energies obtained are used to estimate the band offsets at the quantum well interfaces. (Author

abstract) 20 refs.

Devine, R.L.S. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Moore, W.T. *Solid State Commun* v 65 n 3 Jan 1988 p 177-179.

**094669 REFLECTION SPECTRA OF  $\text{CuInSe}_2$  FROM 2 TO 100 eV.** We report, for the first time, reflectivity up to 100 eV of the chalcopyrite  $\text{CuInSe}_2$  using synchrotron radiation. P-like partial densities of states in the conduction band are identified from the sharp structures at 1 to 22 eV. These structures originate due to the transitions from the In  $4d_{5/2}$  core level to the conduction band. This material is promising for use in solar cells. (Edited author abstract) 4 refs.

Takarabe, Kenichi (Okayama Univ of Science, Okayama, Jpn); Irie, Taizou. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1828-1830.

**094670 OPTICAL BAND EDGE ABSORPTION IN  $\text{CuInSe}_2$ .** Optical properties are studied of (100) oriented  $\text{CuInSe}_2$  crystals near the absorption edge. The results suggest that the optical band edge absorption in  $\text{CuInSe}_2$  is dominated by electron-phonon interaction. Linear optical dichroism of the edge absorption in chalcopyrite-structure  $\text{CuInSe}_2$  is revealed and investigated.  $\text{CuInSe}_2$  is established to differ from the other chalcopyrite crystals in a negative linear dichroism near the absorption edge. (Author abstract) 27 refs.

Medvedkin, G.A. (Acad of Sciences of the USSR, Leningrad, USSR); Rud, Yu.V.; Tairov, M.A. *Phys Status Solidi B* v 144 n 2 Dec 1987 p 809-824.

**094671 OPTICAL PROPERTIES OF InS UNDER HIGH PRESSURE.** Pressure effects are studied on the fundamental indirect gap, direct gap, and next highest critical point in InS single crystals by using a diamond-anvil cell for the first time. A synchronized decrease of their energies is observed with pressure increasing up to 2 GPa. This unusual behavior is inferred partly due to a softening of In-In bond under pressure. (Edited author abstract) 12 refs.

Takarabe, K. (Okayama Univ of Science, Okayama, Jpn). *Phys Status Solidi B* v 145 n 1 Jan 1988 p 219-225.

**094672 EFFECTS OF HEAT TREATMENT ON THE OPTICAL AND STRUCTURAL PROPERTIES OF InSe THIN FILMS.** Thin films of indium selenide of different thicknesses were deposited on glass substrates by vacuum evaporation. The optical gaps were determined from the absorption spectra. The value increases with the thickness of the films and heat treatment temperature. The variation of valence band density of states with temperature is observed. A radial distribution function analysis of X-ray diffraction spectra is made to get an insight into structural information. A transition from the amorphous to the crystalline state takes place at 573 K. (Edited author abstract) 28 refs.

Biswas, S.K. (Univ of Kalyani, Nadia, India); Chaudhuri, S.; Choudhuri, A. *Phys Status Solidi A* v 105 n 2 Feb 1988 p 467-475.

**094673 OPTICAL SIGNAL AMPLIFICATION AT 1.3  $\mu\text{m}$  BY TWO-WAVE MIXING IN InP:Fe.** Two-wave mixing experiments demonstrate amplification of optical signals using the photorefractive effect in InP:Fe. Signal beam amplification was obtained at both 1.06  $\mu\text{m}$  and 1.32  $\mu\text{m}$  with gains of 13 dB/cm and 11 dB/cm, using alternating electric fields of up to  $\pm 10^4$  V/cm. Differential amplification at data rates exceeding the material response time is demonstrated. (Author abstract) 6 refs.

Bylsma, R.B. (AT&T, Holmdel, NJ, USA); Glass, A.M.; Olson, D.H. *Electron Lett* v 24 n 6 Mar 17 1988 p 360-362.

**094674 TIME RESOLVED PHOTOLUMINESCENCE FROM  $\text{Yb}^{3+}$  CENTERS IN InP:Yb.** The time dependence of the internal 4f-4f transitions of  $\text{Yb}^{3+}$  in InP has been studied as a function of temperature over the

range 10 to 110K. The quenching of both the photoluminescence intensity and the excited state lifetime is found to be thermally activated with  $E_A \approx 0.1$  eV. This is interpreted in terms of hole emission from the neutral Yb acceptor. At low temperature the lifetime appears dominated by weak coupling to resonant states in the valence band, while nonexponential contributions to the decay are interpreted as being due to the capture of nonequilibrium carriers by the neutral Yb acceptor. (Author abstract) 18 refs.

Klein, P.B. (Naval Research Lab, Washington, DC, USA). *Solid State Commun* v 65 n 10 Mar 1988 p 1097-1101.

**094675 REACTIVELY EVAPORATED FILMS OF INDIUM SULPHIDE.**  $\alpha$ - $\text{In}_2\text{S}_3$  films were prepared by reactively evaporating indium in an atmosphere of sulphur. X-ray diffraction studies show that the grains have no preferred orientation on the substrate surface. Film properties (surface smoothness, optical transmission, and refractive index) are optimized in the substrate temperature interval (425  $\pm$  50)K. Fundamental absorption starts at (2.01  $\pm$  0.01)eV and the transition leading to this is a direct forbidden one. Charge carriers are n-type and the activation energy for electronic conduction is (0.26  $\pm$  0.02)eV. (Edited author abstract) 22 refs.

George, J. (Cochin Univ of Science & Technology, Cochin, India); Joseph, K.S.; Pradeep, B.; Palson, T.I. *Phys Status Solidi A* v 106 n 1 Mar 1988 p 123-131.

**094676 MAGNETO-OPTICAL INVESTIGATIONS ON P-InSb BICRYSTALS IN THE SUBMILLIMETER WAVELENGTH RANGE.** The magneto-optical properties of p-type InSb bicrystals are investigated from  $\lambda = 57$  to 251  $\mu\text{m}$  at temperatures  $T \leq 4.2$  K and magnetic fields up to  $B = 6.5$  T. At 118.8 and 251  $\mu\text{m}$  the cyclotron resonance of the conduction electrons in the n-inversion layer adjacent to the grain boundary can be detected. At all other wavelengths strong magnetic field dependent absorption effects in the p-type bulk mask the relatively small absorption effects in the inversion layer. The acceptor excitation spectrum of the bulk is discussed. From the periodicity of quantum oscillations three occupied electric subbands are identified. The experimental cyclotron resonance spectra are modeled as the superposition of three cyclotron resonance lines belonging to the three occupied electric subbands. Cyclotron masses are obtained and compared to the experimental data. (Edited author abstract) 20 refs.

Ludwig, F. (Humboldt-Univ zu Berlin, Berlin, East Ger); Mueller, H.U.; Herrmann, R. *Phys Status Solidi B* v 148 n 1 Jul 1988 p 143-153.

**094677 RESONANT RAMAN SCATTERING OF Li INTERCALATED InSe.** Optical properties of  $\text{Li}_x\text{InSe}$  are presented as a function of the lithium concentration and temperature. Investigations of the photoluminescence and absorption measurements show that the presence of alternating sheets of lithium induces changes in the electronic band structure. The Raman spectrum does not change appreciatively unless it is modified by the presence of excitons near certain resonance conditions. (Author abstract) 7 refs.

Jouanne, M. (CNRS, Paris, Fr); Julien, C.; Beserman, R.; Balkanski, M. *Phys Scr* v 38 n 3 Sep 1988 p 471-473.

**094678 PICOSECOND  $\text{CO}_2$  LASER-INDUCED SELF-DEFOCUSING IN INSB.** Self-defocusing of 45-ps  $\text{CO}_2$ -laser pulses has been observed in InSb at intensities as low as 1 MW/cm<sup>2</sup>. It is caused by the two-photon absorption generated free carriers and the resulting self-phase modulation. In addition to demonstrating spatial beam modulation in this material at 10.6  $\mu\text{m}$ , the authors confirm directly that such a process occurs on a picosecond time scale. This suggests that the switching speed of infrared optical bistable devices can be increased to the picosecond regime. They also provide an



accurate determination of the two-photon absorption coefficient in InSb. Other applications to continuum and ultrashort pulse generation are discussed. 26 refs.

Sheik-Bahae, Mansoor (State Univ of New York at Buffalo, Amherst, NY, USA); Kwok, Hoi-Sing. *IEEE J Quantum Electron* v QE-23 n 11 Nov 1987 p 1974-1980.

**094679 INVESTIGATIONS OF RECOMBINATION MECHANISMS IN THE PULSED FAR IN-FRA RED PHOTO RESPONSE OF n-InP.** Narrow (10-50 ns) far infrared pulses ( $\lambda = 91 \mu\text{m}$ ) with sharp ( $\geq 1$  ns) cut-off are used to probe the recombination dynamics of electrons in high purity n-InP. The decay of the photosignal is investigated for a variety of laser intensities, sample bias voltages, temperatures and compensation ratios. A simple model is outlined to explain the observed linear dependence at low bias of the inverse decay time parameter,  $\tau^{-1}$ , on electric field. For higher impurity samples at higher intensities the decay exhibits an initial fast component. A more complete model, invoking Auger recombination, is outlined to explain this effect. (Author abstract) 15 refs.

Rikken, G.L.J.A. (Max-Planck-Institut fuer Festkörperforschung, Grenoble, Fr); Wyder, P.; Chamberlain, J.M.; Halliday, D.P.; Grimes, R.T. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 763-766.

## Oscillations

**094680 OSCILLATORY INTERBAND FARADAY ROTATION IN InSb.** Oscillations of interband Faraday rotation with applied magnetic field in InSb have been observed at low temperature using a cw CO laser. These oscillations are attributed to the electrons progressively excited to different Landau sublevels in the conduction band. The experimental measurements have been compared with theoretical estimates. (Edited author abstract) In Chinese. 3 refs.

Wang Weili (Peking Univ, Beijing, China). *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 315-317.

## Oxidation

**094681 KINETICS OF ANODIC OXIDE GROWTH.** The process of anodic oxide growth has been investigated. It is shown that the obtained experimental results confirm the Fehner-Mott oxidation model in the case of InSb, a typical compound of the III-V group. We also present a kinetic theory of the anion migration in the formed oxide. The theory is based on the following assumptions. (a) The only species which moves through the formed oxide is the OH<sup>-</sup> anion. (b) The chemical reactions of OH<sup>-</sup> with In<sup>3+</sup> and Sb<sup>3+</sup> cations take place simultaneously and independently, in a thin layer of the oxide/InSb interface. The resulting solution of the kinetic equations describes the anion distribution in the formed oxide. A simple expression for the rate of oxidation is obtained. Another possible application of the presented theory is suggested. (Author abstract) 10 refs.

Grinberg, S.P. (Tel-Aviv Univ, Ramat Aviv, Isr); Shapira, Yoram; Calahorra, Z. *Phil Mag Lett* v 55 n 6 Jun 1987 p 305-310.

**094682 NEW PLASMA OXIDATION OF InP FOR IGFET.** InP surfaces have been oxidized by reactive sputtering of InP target in a magnetically confined, dc excited, plasma of pure oxygen. Microprobe and Auger analyses have indicated a uniform composition with equal proportions of phosphorus and indium oxides. Measurement on MOS devices have shown a film resistivity of  $4.6 \times 10^{13} \Omega \cdot \text{cm}$  and minimum interface states density of  $1.2 \times 10^{12}/\text{cm}^2/\text{eV}$ . The MOSFET on p-InP has indicated an electron mobility of 400  $\text{cm}^2/\text{Vs}$  in the induced n-channel. (Author abstract) 30 refs.

Al-Refaie, S.N. (Univ of Kent, Canterbury, Engl). *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 273-279.

## Phase Diagrams

**094683 THERMODYNAMICS AND KINETICS OF THE QUASIBINARY SYSTEM  $\text{Hg}_{(3-3k)}\text{In}_{2k}\text{Te}_3$ .** I. INVESTIGATIONS BY X-RAY DIFFRACTION AND DIFFERENTIAL THERMOANALYSIS. The phase diagram of the quasibinary system  $\text{Hg}_3\text{Te}_3\text{-In}_2\text{Te}_3$  was investigated by Guinier X-ray measurements and by DTA experiments. It is shown that at the stoichiometry  $\text{Hg}_5\text{In}_2\text{Te}_8$  an ordered phase is formed, which undergoes a phase transition at 720 K. There are indications that the high-temperature phase of  $\text{Hg}_5\text{In}_2\text{Te}_8$  has a structure with a partially ordered cation sublattice, but the miscibility gaps between the high-temperature phase and the regions with defect zincblende lattice could not be detected. At the stoichiometric composition  $\text{Hg}_3\text{In}_2\text{Te}_6$ , for temperatures higher than 625 K, a solid solution with the defect zincblende structure is formed, whereas at lower temperatures a decomposition into the two phases,  $\text{Hg}_5\text{In}_2\text{Te}_8$  and  $\text{HgI}_2\text{Te}_4$ , occurs. Several proposals for the structures of the ordered phases are developed. (Edited author abstract) 17 refs.

Leute, Volkmar (Univ Muenster, Muenster, West Ger); Schmidtke, Heinrich Michael. *J Phys Chem Solids* v 49 n 4 1988 p 409-420.

**094684 PHASE DIAGRAM OF  $\text{CuIn}(\text{S}_x\text{Te}_{1-x})_2$ .** The phase diagram of the system  $\text{CuIn}(\text{S}_x\text{Te}_{1-x})_2$  was obtained from differential thermal analysis (DTA) and X-ray diffraction measurements. DTA measurements were carried out on each sample and the transition temperatures were plotted as a function of alloy composition. A miscibility gap was found in a wide range of the system. Values of lattice parameters were determined in all cases and the limits of single phase solid solution were estimated. For the range of single phase behavior, values of energy gap were obtained by optical absorption measurements. (Author abstract) 9 refs.

Grima, Pedro (Univ de Los Andes, Merida, Venez); Quintero, Miguel; Rincon, Carlos; Peres, G.S.; Wooley, John C. *Solid State Commun* v 67 n 2 Jul 1988 p 81-83.

## Phase Transitions

**094685 PHASE TRANSITION TEMPERATURE OF THE  $\alpha\text{-In}_2\text{Se}_3$  SINGLE CRYSTAL.** The variation of phase transition temperature was observed when the heating-cooling cycle of the stoichiometric  $\alpha\text{-In}_2\text{Se}_3$  single crystals was repeated under the vacuum of  $4 \times 10^{-5}$  torr. The critical temperature of  $\alpha \rightarrow \beta$ -phase transition decreased but the critical temperature of  $\beta \rightarrow \alpha$ -phase transition increased as the number of heating-cooling cycle increased. This phase transition temperature shift control can be understood when we consider the fact that the stoichiometric  $\alpha\text{-In}_2\text{Se}_3$  single crystal changes to the In-excess  $\alpha\text{-In}_2\text{Se}_3$  single crystal due to the evaporation of selenium atoms when the sample was in heating cycle. (Author abstract) 3 refs.

Kim, Hyung-Gon (Chosun Univ, Kwangju, South Korea); Min, In-Soen; Kim, Wha-Tek. *Solid State Commun* v 64 n 5 Nov 1987 p 819-822.

## Photochemical Reactions See PHOTOCATHODES—Efficiency.

## Photoconductivity

**094686 FIELD-INDUCED ENERGY SHIFT OF EXCITONIC ABSORPTION IN  $\text{InGaAs/InP}$  MULTIQANTUM WELLS GROWN BY METALORGANIC MOLECULAR BEAM EPITAXY.** Excitonic absorption features are observed at room temperature in  $\text{InGaAs/InP}$  multiquantum-well structures grown by metalorganic molecular beam epitaxy. The heavy-hole exciton peak was found to shift toward the lower-energy side as the result of an external electric field. These peak shifts showed good agreement with the results of an exact calculation using phase-shift analysis in the resonance-scattering theory for this quantum well. (Author abstract) 13 refs.

Nojima, Shunji (NTT Electrical Communications Lab, Atsugi, Jpn); Kawaguchi, Yoshihiro; Nakashima, Kiichi; Wakita, Koichi. *Jpn J Appl Phys Part 1* v 26 n 11 Nov 1987 p 1927-1928.

## Physical Properties See Also SEMICONDUCTING FILMS—Growth.

**094687 ELECTRONIC BAND STRUCTURE AND OPTICAL ANISOTROPY IN InS. II. THEORETICAL STUDY.** The electronic band structure of InS is calculated for the first time using the empirical pseudo-potential method. A group-theoretical study of the symmetry properties of InS is included. The resulting energy bands are then used to calculate the imaginary part of the dielectric function for each polarization along the principal axes of InS. The total and partial electronic densities are mapped on the (110) plane. Comparisons are made with previous experimental studies. (Author abstract) 19 refs.

Takarabe, K. (Okayama Univ of Science, Okayama, Jpn); Kawamura, H.; Wakamura, K. *Phys Status Solidi B* v 143 n 2 Oct 1987 p 519-538.

**094688 MULTIPHONON ABSORPTION IN InP.** IR absorption measurements have been made using a high resolution Fourier-transform spectrometer on crystals of InP in the region of  $(400-4000)\text{cm}^{-1}$  at temperature between 11-300 K. Very weak, new absorption bands, their absorption coefficients are of approx.  $10^{-1}\text{cm}^{-1}$ , were observed at  $996\text{cm}^{-1}$ ,  $965\text{cm}^{-1}$ ,  $932\text{cm}^{-1}$ ,  $838\text{cm}^{-1}$ ,  $776\text{cm}^{-1}$ ,  $742\text{cm}^{-1}$ ,  $718\text{cm}^{-1}$ ,  $590\text{cm}^{-1}$ ,  $558\text{cm}^{-1}$  and  $538\text{cm}^{-1}$ . The frequencies and temperature dependence of these weak bands indicate that they arise from three-phonon processes and appropriate assignments are given. We observed, using IR absorption technique, the boron contamination in LEC ( $\text{B}_2\text{O}_3$ )-CZ InP crystal. The content of boron contamination has been proved to be approx.  $10^{16}\text{cm}^{-3}$ . (Edited author abstract) 8 refs.

Zhang Yu-ai (Acad Sinica, Beijing, China); Jiang Dengsheng; Hsu Chen-Chia. *Solid State Commun* v 61 n 4 Jan 1987 p 213-216.

## Plasmas See SEMICONDUCTING GALLIUM ARSENIDE—Plasmas; SEMICONDUCTING GALLIUM COMPOUNDS—Plasmas.

## Processing

**094689 SPECIAL FEATURES OF PULSED PHOTO ANNEALING OF INDIUM ANTIMONIDE.** The structure and morphology of the surface of indium antimonide subjected to ion implantation and annealing with a noncoherent light pulse emitted by xenon lamps were examined. The examination was carried out in an optical microscope, in a microinterferometer, and by transmission electron microscopy. The results show that at a light energy density of approximately  $17\text{J}/\text{cm}^2$ , local melting changes to uniform melting of the indium antimonide surface. The depth of penetration is approximately 20 nm. (Edited author abstract) 5 refs.

Astakhov, V.P.; Danilov, Yu. A.; Dudnik, V. Ya.; Pitirimova, E.A. *Phys Chem Mater Treat* v 22 n 1 Jan-Feb 1988 p 25-28.

**094690 EVALUATION DE LA PERTURBATION APORTE PAR LE SCIAGE, LE RODAGE ET LE POLISSAGE DE MONOCRISTAUX D'InP AU MOYEN DE LA TECHNIQUE DE DOUBLE DIFFRACTION X.** [Evaluation of Damage Occurring During Sawing, Grinding, and Polishing of InP Monocrystals by Means of Double X-Ray Diffraction]. The authors have studied the damaged layers formed during the processing of InP wafers by double-crystal x-ray diffraction. The damaged layer for as-cut and as-lapped wafers



is of the order of 10  $\mu\text{m}$ . Consequently, it is not necessary to take off more than 10 to 20  $\mu\text{m}$  during the polishing stage. (Author abstract) In French.

Caulet, J. (CNET, Lannion, Fr); Coquille, R. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 175-176.

**094691 TRAITEMENT ET PASSIVATION D'INP (100) SOUS JETS MOLECULAIRES D'ARSENIC: APPLICATION A LA REALISATION DE MISFETs.** [Treatment and Passivation of InP (100) Surfaces Under Arsenic Molecular Beams: Application to MISFETs]. Arsenic stabilized InP (100) surfaces are prepared by heating InP under an arsenic molecular beam. The surface chemical composition as a function of the temperature (250-515°C) is studied by X-Ray Photoelectron Spectroscopy. (Author abstract) 1 ref. In French.

Hollinger, G. (CNRS, Ecullly, Fr); Blanchet, R.; Gendry, M.; Santinelli, C.; Viktorovitch, P. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 227-228.

## Radiation Effects

**094692 A.C. HOPPING CONDUCTANCE IN ELECTRON-IRRADIATED InSb.** Sufficient degree of damage induced by electron irradiation in n-type InSb allows the observation of hopping conductance having a frequency dependence approximately  $\omega^2$  at low temperatures. The temperature dependence of  $s$  is studied and discussed in terms of quantum-mechanical tunnelling and the correlated barrier hopping mechanisms. (Author abstract) 19 refs.

Kouimtzis, S.D. (Univ of Reading, Reading, Engl). *Solid State Commun* v 65 n 11 Mar 1988 p 1435-1438.

**094693 DYNAMIC BEHAVIOR AND RESPONSE-TIME CONTROL OF TWO-PHOTON OPTICAL BISTABILITY IN INSB AT 10.6  $\mu\text{m}$  WAVELENGTH.** A time-dependent theory has been developed to model the behavior of doped-InSb, optically bistable etalons operating at room temperature and illuminated by a pulsed  $\text{CO}_2$  laser. Good agreement is obtained between this semiempirical theory and experiment. The reduction of switching times to approximately 1 ns by n-type doping has been demonstrated experimentally. 9 refs.

Ji, Wei (Heriot-Watt Univ, Edinburgh, Scotl); Kar, Ajoy K.; Chua, Peter L.; Walker, Andrew C. *IEEE J Quantum Electron* v QE-23 n 11 Nov 1987 p 1986-1991.

## Research See SEMICONDUCTOR DEVICES—Research.

## Reviews

**094694 DEVELOPMENT OF HIGH-QUALITY INP SINGLE CRYSTALS.** In the manufacture of electronic devices there is a need for crystals with low dislocation densities for both conductive and semi-insulating substrates. GaInAsP semiconductor lasers for optical communication at the 1.55  $\mu\text{m}$  band and GaInAs avalanche photodiodes (APDs) employing InP substrates have appeared on the market. To realize an optoelectronic integrated circuit (OEIC), the development of a semi-insulating substrate crystal has been started. An OEIC has transistors and optical devices integrated on the same wafer. A semi-insulating wafer is considered to be the most suitable substrate for an OEIC because of the easy isolation of its devices. Furthermore, as the thermal resistivity of InP is small (two-thirds that of GaAs), high power dissipation is permissible. If semi-insulating InP wafers are applied to transistors, the fabrication of a metal insulator semiconductor field effect transistor (MISFET) is possible. The chapter covers methods for crystal growth and reduction of dislocation density. 23 refs.

Morioka, M. (Sumitomo Electric Industries, Hyogo, Jpn); Tada, K.; Akai, S. *Annu Rev Mater Sci* v 17 1987 p 75-100.

**Specific Heat** See SEMICONDUCTING GALLIUM COMPOUNDS—Specific Heat.

## Spectroscopic Analysis

**094695 FINE STRUCTURE IN THE FREE EXCITON REGION OF THE EMISSION SPECTRA OF  $\gamma$ -InSe.** The fine structure of the emission spectrum of  $\gamma$ -InSe in the free exciton region has been investigated. The complete behavior is given and the quantitative analysis is described in detail. Also, the doublet structure is examined and the possible stacking faults contribution is considered. It is found that the origin of the second peak is bound excitonic. The phonon modes involved in the temperature variation of the exciton energy are obtained from fitting the experimental data to previous theoretical calculations. An explanation is given for the temperature variation of the half width anomaly. (Author abstract) 16 refs.

Paraskevopoulos, K.M. (Univ of Thessaloniki, Thessaloniki, Greece); Julien, C.; Balkanski, M. *Phys Status Solidi B* v 143 n 2 Oct 1987 p 741-748.

**094696 POLARIZATION STUDIES OF POLAR PHONONS OF InSe.** Polarized Raman spectra of  $\gamma$ -InSe are given for two different scattering geometries,  $(k_i \parallel c)$  and  $(k_i \perp c)$ . This allows the experimental determination of the frequency of a doubly degenerated transverse optical mode. 9 refs.

Jouanne, M. (CNRS, Paris, Fr); Julien, C.; Balkanski, M. *Phys Status Solidi B* v 144 n 2 Dec 1987 p K147-K150.

**094697 VERIFICATION OF  $\text{CuInSe}_2$  DENSITY OF STATES FEATURES BY REFLECTION ELECTRON ENERGY LOSS SPECTROSCOPY.** Reflection electron energy loss measurements of  $\text{CuInSe}_2$  single crystals are reported and when possible, the losses are compared with previous results. Their identification of the transitions is confirmed and refined by spectrum simulations with total and partial densities of states from band structure calculations. New conduction-band maxima at energies not covered by the available calculations are proposed, and their consistency with the experimental loss energies is shown by another simulation with Lorentzian density peaks. (Edited author abstract) 26 refs.

Kleint, Ch. (Karl-Marx-Univ, Leipzig, East Ger); Funke, M.; Tomlinson, R.D. *Appl Phys A* v A46 n 2 Jun 1988 p 137-143.

**094698 PHOTOLUMINESCENCE SPECTRA OF LI-INTERCALATED INDIUM SELENIDE.** The photoluminescence (PL) spectra of pure and Li intercalated InSe using the n-butyl-lithium method are presented in the temperature range from 5 to 150 K and the effect of Li intercalation on the structure of the emission spectrum is examined. The new characteristics demonstrate the presence of new PL centers that modify the long-wavelength region of the spectrum. The observed modifications, which are analysed in detail, taking into account the dependence of the spectra on temperature optical excitation intensity and dose of intercalation, enable us to give an interpretation of their origin. (Author abstract) 18 Refs.

Paraskevopoulos, K.M. (Univ Pierre et Marie Curie, Paris, Fr); Julien, C.; Balkanski, M.; Porte, C. *J Lumin* v 42 n 1 Jun-Jul 1988 p 15-20.

**094699 EFFECT OF LOCAL ATOMIC ARRANGEMENT ON Co-RELATED LUMINESCENCE IN III-V ALLOY SEMICONDUCTORS.** We have measured Co-related luminescence spectra of a series of  $\text{In}_{1-x}\text{Ga}_x\text{P}$  and  $\text{GaAs}_{1-x}\text{P}_x$  alloy semiconductors. The spectra show several broad bands and their intensities vary systematically with the change in alloy composition. These behaviors are well explained by the local atomic arrangements of each constituent atom surrounding the Co luminescent center, based upon the calculated occupation probability of the atoms. (Author abstract) 6 refs.

Nishino, Taneo (Osaka Univ, Toyonaka, Jpn); Shirakata, Sho; Hamakawa, Yoshihiro. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int

Conf on Lumin, Beijing, China, Aug 17-21 1987 p 409-410.

**094700 STUDIES OF InP SURFACE AND InP-INSULATOR INTERFACE BY SPECTRAL PHOTOLUMINESCENCE.** In this work, we use photoluminescence (PL) spectrum measurements (4 K and 77 K) as a means of assessing modifications of the surface properties of InP crystals subjected to various chemical treatments, insulating layer deposition and annealing. We show that all of the above processes strongly affect the photoluminescence spectrum of the InP surface (interface). We observed, in particular, important modifications of the intensity ratio (R) of two peaks located at 1.41 eV (P1) and 1.1 eV (P3). On the basis of a simple model we show that the PL spectrum provides direct information on (i) process induced modifications of the surface velocity and (ii) creation of new radiative centers which are probably related to lattice non-stoichiometry and which are responsible for the 1.1 eV transition. 3 refs.

Leyral, P. (CNRS, Ecullly, Fr); Bouedoucen, H.; Commere, B.; Krawczyk, S. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 753-754.

**094701 PHOTOLUMINESCENCE CHARACTERIZATION OF RARE-EARTH (Er, Yb)-DOPED InP GROWN BY METALORGANIC CHEMICAL VAPOR DEPOSITION.** Er-doped and Yb-doped InP epitaxial crystals were grown by MOCVD and photoluminescence (PL) of intra-4f-shell transitions of the rare earth ions was observed. Rare-earth-ion-related PL intensities are observed to increase only sublinearly as a function of excitation photon density. Their decay time constants are about one order of magnitude smaller than those of corresponding rare earth ions in CdS. These results indicate that a strong nonradiative bimolecular decay mechanism is in effect in state-of-the-art crystals and that intra-4f-shell transitions of rare earth ions depend strongly on the host crystals in which the ions are incorporated. (Author abstract) 5 refs.

Takahei, Kenichiro (NTT Electrical Communications Lab, Musashino, Jpn); Uwai, Kunihiko; Nakagome, Hiroshi. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 901-902.

## Stability

**094702 MASS SPECTROMETRIC EVIDENCE OF INSTABILITY IN  $\text{In}_{1-x}\text{Ga}_x\text{As}$  COMPOUNDS: ACTIVITY MEASUREMENTS OF InAs.** Activity measurements in the  $\text{In}_{1-x}\text{Ga}_x\text{As}$  system are performed by mass spectrometry coupled with a multiple-Knudsen-cell furnace. The condition for reversible vaporization are first carefully analyzed as a function of the orifice to sample surface ratio, given the fact that the measurements of the partial pressure of Ga are doubtful, because equilibrium conditions are not established for this species in effusion cells. Activities of the InAs compound are deduced in the pseudo-binary section  $\text{In}_{1-x}\text{Ga}_x\text{As}$  from ionic intensities of  $\text{As}^{+2}$ ,  $\text{As}^{+4}$ , and  $\text{In}^{+}$ . The thermodynamic behavior of these solid solutions at 950 K shows an instable composition domain and consequently, at equilibrium, these mixtures present a miscibility gap. These thermodynamic results agree with all X-ray structure measurements showing that the usual elaborated compounds are homogeneous mixtures. Agreement between these data and previous calorimetric data is not good, and a lack of consistent thermodynamic data is still remaining for the GaAs-InAs pseudobinary system. (Author abstract) 36 Refs.

Tmar, Mohamed (CNRS, St. Martin d'Heres, Fr); Catillon, Christian. *J Cryst Growth* v 89 n 4 7(I) 1988 p 501-510.



## Strain

**094703 STRAIN EFFECTS IN InGaAs/AlAs SUPERLATTICES.** Estimates are made of the effect of strain on the conduction and valence bands of  $\text{In}_x\text{Ga}_{1-x}\text{As}$  wells confined by unstrained GaAs barriers. Strain leads to a large splitting between the heavy and light holes which enhances in-plane mobilities, while the heavy hole and itself remains fairly stationary. (Author abstract) 19 refs.

Dahl, D.A. (Lockheed Palo Alto Research Lab, Palo Alto, CA, USA). *Solid State Commun* v 61 n 12 Mar 1987 p 825-826.

## Structure

**094704 ATOMIC STRUCTURE OF ORDERED InGaP CRYSTALS GROWN ON (001)GaAs SUBSTRATES BY METALORGANIC CHEMICAL VAPOR DEPOSITION.** InGaP crystals grown on (001)GaAs substrates by metalorganic chemical vapor deposition are structurally evaluated by transmission electron microscopy. High-resolution electron microscopy observation and electron diffraction analysis of both the (110) and the (11 $\bar{0}$ ) cross-section specimens strongly suggest that ordering of column III atoms on only two sets of the (111) planes with doubling in periodicity of (111) layers, i.e.,  $\text{In/Ga/In/Ga/In/Ga}$ , is occurring in the crystal. The ordering of the crystal is not perfect, and the ordered regions are assumed to be plate-like microdomains. (Author abstract) 18 refs.

Ueda, Osamu (Fujitsu Lab Ltd, Atsugi, Jpn); Takikawa, Masahiko; Komeno, Junji; Umebu, Itsuo. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1824-1827.

**Substrates** See Also DIELECTRIC MATERIALS—Vapor Deposition; RUTHENIUM AND ALLOYS—Thin Films; SEMICONDUCTING GALLIUM COMPOUNDS—Growth; SILICA—Chemical Vapor Deposition; SILICA—Spectrum Analysis; SILVER AND ALLOYS—Thin Films.

**094705 InP (AND GaAs) SUBSTRATE STABILIZATION BY THE PRESENCE OF GaAs (AND InP) IN A METAL-ORGANIC VAPOUR-PHASE EPITAXY SYSTEM.** Metal-organic vapour-phase epitaxy (MOVPE) requires a stabilized substrate surface prior to growth to obtain a high-quality crystal. Here we show the effect of exposing GaAs and InP substrates to  $\text{AsH}_3$  and (or)  $\text{PH}_3$  in the temperature range from 550°C to 750°C, in an MOVPE reactor. The presence of a GaAs substrate partially stabilizes the InP substrate; the stabilized area decreases when either temperature of  $\text{AsH}_3$  flow increases. The presence of a stabilized InP substrate (under  $\text{PH}_3$  flow) also partially stabilizes the GaAs substrate. Surface analysis shows that the stabilized area contains column-V species coming from the neighbouring substrate. The V-hydride species active in the MOVPE environment are not dimers or tetramers. Annealing the substrates under both  $\text{AsH}_3$  and  $\text{PH}_3$  shows preference for As-species aggregation at the substrate surface. The simple model previously used to predict stabilization is extended to cover this mixed-hydride situation. (Edited author abstract) 17 refs.

Masut, Remo A. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Sacilotti, Marco A.; Roth, Alain P.; Williams, Digby F. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 1047-1052.

**094706 EVALUATION DES SUBSTRATS D'InP et de GaAs PAR IMAGERIE DE LA PHOTOLUMINESCENCE.** [Evaluation of InP and GaAs Substrates by Photoluminescence Imaging]. The authors present a photoluminescence imaging technique that can be used to obtain information about the quality and uniformity of the electronic properties of substrates, epitaxial films, and semiconductor/insulator boundaries. The method is particularly useful for evaluating InP and GaAs substrates. The presence of dislocations, extended near-surface defects, and process induced modifications of the surface recombination velocity can be easily assessed.

Krawczyk, S.K. (CNRS, Ecully, Fr); Garrigues, M.; Schohe, K.; Lallemand, C. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 171-173.

**094707 L'OXYNITRURE DE PHOSPHORE MAS-SIF PON: CANDIDAT A LA PASSIVATION DE InP.** [Phosphorus Oxynitride PON Material: Candidate for the Passivation of InP]. A possible way to passivate InP substrate surface consists in the deposition of an insulator containing phosphorus. Contrary to the classical techniques, the authors propose to grow low temperature deposition thin films by evaporating powdered PON material. In this paper, the original preparation of this material is described and characterized as a good candidate for the elaboration of thin insulator layers containing P, O and N. (Author abstract) 3 refs. In French.

Marchand, R. (CNRS, Rennes, Fr); Boukbir, L.; Falchier, P.; Laurent, Y.; Bonnaud, O.; Roul, G.; Favennec, P.N. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 231-232.

**094708 PHOTOLUMINESCENCE RESOLUE EN PROFONDEUR POUR CARACTERISER LES DEFAUTS CREES PENDANT LA PASSIVATION D'InP.** [Further Development of Photoluminescence for Characterization of Defects Created During the Passivation of InP]. Further developments of electrical and optoelectronic InP devices are strongly hampered by the poor electronic quality and insufficient stability of InP insulator interfaces. In this work the authors report on in-depth defect creation in InP substrate during the insulator deposition. The experimental approach is based on room temperature photoluminescence (PL) depth profiling and transient measurements. (Author abstract)

Krawczyk, S. (CNRS, Ecully, Fr); Schohe, K.; Longere, J.Y.; Leyral, P.; Hartnagel, H.L.; Schuetz, R. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 237-238.

**Surfaces** See Also INDIUM COMPOUNDS—Thin Films; SEMICONDUCTING GALLIUM ARSENIDE—Surfaces; SEMICONDUCTING GALLIUM COMPOUNDS—Surfaces.

**094709 REFLECTION HIGH-ENERGY ELECTRON DIFFRACTION STUDIES OF INDIUM PHOSPHIDE SURFACE.** Reflection high-energy electron diffraction studies of single-crystal indium phosphide substrates have been performed. It is shown that the substrates do not undergo any deleterious changes during chemical etching or the back contact sintering process. The low-power plasma exposure of the substrates is, however, responsible for structural modifications at the front surface and the performance of indium tin oxide/indium phosphide solar cells. (Author abstract) 5 refs.

Naseem, Shahzad (Univ of the Punjab, Lahore, Pak). *Jpn J Appl Phys Part 1* v 27 n 1 Jan 1988 p 145-146.

**094710 X-RAY PHOTOELECTRON SPECTROSCOPY ANALYSIS OF CHANGES IN InP AND InGaAs SURFACES EXPOSED TO VARIOUS PLASMA ENVIRONMENTS.** InP and InGaAs electronic devices are subject to deterioration of their properties upon exposure to air, moisture, and irradiation due to the instability of their surfaces. Attempts to protect device surfaces by overcoating them with a plasma deposited protective coating are frustrated by a marked deterioration of their electrical properties after deposition. Using x-ray photoelectron spectroscopy, we have examined InP and InGaAs surfaces exposed to hydrogen, nitrous oxide, nitrogen, and ammonia plasma. We observed that these surfaces change substantially upon plasma exposure to either oxygen or hydrogen containing plasmas. The observed changes qualitatively agree with the observed device electrical property changes. (Author abstract) 24 refs.

Thomas, J.H. III (David Sarnoff Research Cent, Prince-

ton, NJ, USA); Kaganowicz, G.; Robinson, J.W. *J Electrochem Soc* v 135 n 5 May 1988 p 1201-1206.

**094711 STABILISATION D'UNE SURFACE INP (100) PAR L'AZOTE OU PAR L'ANTIMOINE.** [Stabilization of an InP (100) Surface Using Nitrogen or Antimony]. For indium phosphide (InP), conventional cleaning procedures such as argon ion bombardment or vacuum annealing lead to the formation of metallic indium in the top layers. This negative effect may be reduced or balanced using special treatments based on the interaction of the surface with (V) elements closely related to phosphorus. In this AES-ELS study, some results are reported about the interaction of InP (100) with nitrogen ions and antimony atoms. From an initial surface including the usual contamination layer, bombardment of the sample with nitrogen ions of 300 eV energy induces the removal of carbon impurity; implantation of nitrogen in the top layers is simultaneously observed. At increasing N<sup>+</sup> dose, metallic In is detected in connection with etching effects on the surface oxide and on the N-implanted layer previously formed. Heat treatments of the InP sample with the presence of evaporated antimony atoms lead to the formation of In-Sb bonds, preventing the development of metallic In. Metallic Sb is not observed for the low coverages involved in the experiment. These results are deduced from the comparison of the AES-ELS spectra with those of pure In, Sb and InSb samples. (Author abstract) 6 refs. In French.

Bouslama, M. (Univ Claude Bernard Lyon I, Villeurbanne, Fr); Jardin, C. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 221-222.

**094712 INTERACTION DE L'OXYGENE AVEC InP PASSIVE PHOSPHORE: PREMIERS RESULTATS SUR LE ROLE D'UNE COUCHE INTERFACIALE D'Yb.** [Interaction of Oxygen with Passivated Phosphorus: Preliminary Results on the Role of Interfacial Yb Film]. The interaction of molecular oxygen with the phosphorus passivated (100) face of InP (denoted InP(P<sub>2</sub>)) has been studied using Auger electron spectroscopy (AES) and ultraviolet photoelectron spectroscopy (UPS). It is shown that the 2 or 3 N.L. of phosphorus in excess on the surface almost inhibit any reaction with O<sub>2</sub> up to 10<sup>12</sup> L (1 L = 10<sup>-6</sup> T.s.). This is tentatively associated to a dense interconnected network of phosphorus. In an attempt to stimulate the O<sub>2</sub>-InP(P<sub>2</sub>) interaction, a layer of Yb has been evaporated before the O<sub>2</sub> exposure. The preliminary results show a dramatic increase of the oxygen adsorption for related structures observable at exposures as low as 60 L. (Author abstract) 7 refs. In French.

Tardy, J. (CNRS, Villeurbanne, Fr). *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 235-236.

**094713 SUR LES MODIFICATIONS DES PROPRIETES STRUCTURALES, MORPHOLOGIQUES ET ELECTRONIQUES DE InP (110) INDUITES PAR LE CHAUFFAGE.** [On the Modification of Structural, Morphological, and Electronic Properties of InP (110) by Annealing]. In this paper the authors present results obtained by A.E.S., L.E.E.D., and work function measurements on the modifications induced by annealing InP (110) cleaved surfaces. When increasing the temperature (up to 800 K), the L.E.E.D. diagram remains practically unaltered, while the Auger peaks and the work function rapidly changes. These last modifications are correlated and explained in terms of P vacancies. (Author abstract) 5 refs. In French.

Dumas, M. (CNRS, Montpellier, Fr); Benkacem, M.; Palau, J.M.; Lassabaterre, L. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 241-244.



**094714 CHARACTERISATION DE L'INTERFACE InP-OXYDE ANODIQUE PAR UNE NOUVELLE TECHNIQUE DE MESURE DE CHARGES TRANSITOIRES.** [Characterization of the InP-Anodic Oxide Interface by a Novel Transient Charge Measurement Technique]. A new transient characterization technique is used to measure the surface potential shift, interface state density  $D_{it}$ , and state kinetics for n-InP MIS diodes with a double layer insulator (native anodic oxide-evaporated alumina). The surface Fermi level shift is limited at  $0.35 \pm 0.55$  eV from the conduction band by a steep increase of  $D_{it}$ . It is observed that this pinning level can be moved over 0.2 eV depending on the steady state bias conditions. This result can be explained by electrical-induced physical modifications of the interface in relation to phosphorous vacancy mobility. A secondary peak of states is observed close to the conduction band with a small capture cross section. (Edited author abstract) 4 refs. In French.

Garrigues, M. (CNRS, Ecully, Fr); Zencirci, N.; Mahdjoub, A. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 271-272.

## Synthesis

**094715 PREPARATION AND SINGLE CRYSTAL INVESTIGATION ON THE INTERCALATION COMPOUND  $\text{In}_{0.67}\text{TaS}_2$ .** A vapor-phase transport technique yielded single crystals of the intercalation compound  $\text{In}_{0.67}\text{TaS}_2$  starting with  $2\text{H-TaS}_2$  and In. The title compound is hexagonal, space group  $P6_3/m2$ , with  $a=3.332(2)$ ,  $c=7.983(5)$  Å and  $Z=1$ . Using 293 K diffractometer intensity data, the crystal structure has been determined by a single-crystal X-ray technique and refined to a final  $R_w$  of 0.029. Although electron diffraction experiments did not reveal a clustering of the In atoms, their very large temperature factors indicate a positional disorder around the refined position in the trigonal-prismatic holes between the  $\text{TaS}_2$  layers. (Edited author abstract) 20 refs.

Abriel, W. (Univ Hannover, Hanover, West Ger); Lerf, A. *Mater Res Bull* v 23 n 5 May 1988 p 673-678.

## Theory

**094716 THEORETICAL ANALYSES OF THE SHUBNIKOV-DE HAAS OSCILLATION IN InSb INVERSION LAYERS.** A calculation is presented of the subband and Landau energy levels in inversion layers adjacent to grain boundaries in InSb bicrystals. Within a simplified model the transverse magnetoresistance is calculated and compared with recent experiments. Some unexpected new features in the Shubnikov-de Haas oscillations are related to the occupation of several electric subbands. (Edited author abstract) 27 refs.

Gobsch, G. (Technische Hochschule Ilmenau, Ilmenau, East Ger); Paasch, G.; Schulze, D.; Handschack, S.; Fiedler, T. *Solid State Commun* v 65 n 12 Mar 1988 p 1583-1587.

## Thermal Effects

**094717 THERMAL STABILITY OF (Ti+Zn)-CO-DOPED SEMI-INSULATING InP SINGLE CRYSTALS.** (Ti+Zn)-doped semi-insulating InP crystals with resistivities above  $1 \times 10^6 \Omega \text{ cm}$  are grown by the liquid encapsulated Czochralski (LEC) method, and redistribution of Ti and Zn in the crystals annealed without encapsulant at 800 to 900°C is examined using secondary ion mass spectroscopy. The results show that no redistribution of Ti and Zn occurs in annealed semi-insulating crystals. (Author abstract). 6 Refs.

Katsui, Akinori (NTT, Tokai-mura, Jpn). *J Cryst Growth* v 89 n 4 7(1) 1988 p 612-613.

**Thin Films** See Also SOLAR ENERGY—Materials.

**094718 ELECTRICAL CHARACTERIZATION OF INDIUM TELLURIDE THIN FILMS.** The present

letter reports the growth of stoichiometric thin films of indium telluride and their electrical characterization. Stoichiometric films of indium telluride have been obtained by vacuum evaporation of a non-stoichiometric bulk compound with excess indium. The conductance resulting from the space-charge recombination process is proportional to the intrinsic carrier concentration and hence yields an activation energy equal to  $(E_g/2)$  and the conductance due to diffusion process being proportional to the square of the intrinsic carrier concentration yields an activation energy equal to  $E_g$ , the intrinsic band gap of the material. 7 refs.

Rousina, Roughieh (Sardar Patel Univ, Gujarat, India); Shivakumar, G.K. *J Mater Sci Lett* v 6 n 10 Oct 1987 p 1131-1132.

**094719 THERMAL DIFFUSIVITY MEASUREMENT OF MICRON-THICK SEMICONDUCTOR FILMS BY MIRAGE DETECTION.** We describe a method using the mirage detection technique for thermal diffusivity measurements of thin films. High frequency measurements are required for such materials. By determining the difference between two phase measurements, we have been able to avoid probe beam size effects which strongly affect the high frequency responses. The thermal diffusivity of a polycrystalline semiconductor thin film has been measured by using optical heating and compared with the corresponding single-crystal diffusivity. The thermal diffusivity of polymer semiconductor thin films has been obtained for various dopings by using electrical heating. (Author abstract) 20 refs.

Roger, J.P. (CNRS, Paris, Fr); Lepoutre, F.; Fournier, D.; Boccara, A.C. *Thin Solid Films* v 155 n 1 Dec 15 1987 p 165-174.

**094720 FORMATION OF InSe AND GaSe DEPOSITED FILMS AND THEIR ELECTRICAL PROPERTIES.** The appropriate substrate temperatures for the formation of InSe and GaSe films by the evaporation of  $\text{In}_2\text{Se}_3$ , InSe,  $\text{Ga}_2\text{Se}_3$  and GaSe have been found. Epitaxial films of InSe were obtained by the evaporation of InSe on mica substrates whose temperature were kept at 400°C, whereas films of GaSe could not be formed on mica. The electrical properties of the InSe and GaSe films obtained are also reported. (Author abstract) 30 refs.

Yudasaka, M. (Yokohama Natl Univ, Yokohama, Jpn); Nakanishi, K. *Thin Solid Films* v 156 n 1 Jan 15 1988 p 145-152.

**094721 EFFECTS OF OXYGEN PARTIAL PRESSURE ON THE PROPERTIES OF REACTIVELY EVAPORATED THIN FILMS OF INDIUM OXIDE.** Thin films of indium oxide were prepared by evaporating indium in the presence of oxygen. The effects of varying the oxygen partial pressure on the optical, electrical and structural properties were investigated. Films evaporated under the optimum oxygen partial pressure of 0.133 Pa exhibited a resistivity of  $4.8 \times 10^{-4} \Omega \text{ cm}$  and a transmittance of more than 80% at wavelengths of 600 nm and above, for a film thickness of 225 nm. All the films, in the range of partial pressure of oxygen used, were found to be n type. The films showed a b.c.c. structure with  $a_0 = 1.0118$  nm and a preferred orientation along the  $\langle 400 \rangle$  axis. (Author abstract) 31 refs.

Naseem, S. (Univ of the Punjab, Lahore, Pak); Rauf, I.A.; Hussain, K.; Malik, N.A. *Thin Solid Films* v 156 n 1 Jan 15 1988 p 161-171.

**094722 PROPRIETES ELECTRIQUES DES COUCHES MINCES  $\text{D'In}_2\text{O}_3$  PREPAREES PAR OXYDATION POSTERIEURE DE METAL EVAPORE.** [Electric Properties of  $\text{In}_2\text{O}_3$  Thin Films Prepared by Post-Oxidation of the Evaporated Metal]. We studied the electrical properties of non-doped or tin-doped  $\text{In}_2\text{O}_3$  (ITO) thin films. The films were prepared by coevaporation of indium and tin in an  $\text{O}_2$  atmosphere of  $10^{-3}$  Torr, followed by post-oxidation of amorphous films of  $\text{InO}_x$  by heat treatment in air. Under optimum conditions of tin doping, an n-type semiconducting ITO film with resistivity  $\rho = (5-6) \times 10^{-4} \Omega \text{ cm}$  was

obtained. The films were highly degenerated, which allows us to postulate scattering of carrier electrons due to ionized impurities. (Author abstract) 23 refs. In French.

Noguchi, S. (Asahi Glass Co, Yokohama, Jpn); Sakata, H. *Thin Solid Films* v 157 n 2 Feb 29 1988 p 181-188.

**094723 GROWTH AND CHARACTERIZATION OF INDIUM TELLURIDE THIN FILMS.** Thin films of indium telluride prepared by conventional vacuum evaporation techniques are often non-stoichiometric because of fractionation. Hence, in an attempt to obtain stoichiometric films, non-stoichiometric bulk was used. It is observed that a bulk with a composition  $\text{In:Te} = 55.7:44.3$  (atomic per cent) yields stoichiometric films. The effect of deposition temperature and annealing at elevated temperatures has been studied in detail. The results indicate that an increase in the deposition temperature results in the re-evaporation of tellurium from the films whereas indium-deficient films are obtained on annealing at elevated temperatures. (Author abstract) 22 refs.

Rousina, Roughieh (Sardar Patel Univ, Gujarat, India); Shivakumar, G.K. *Thin Solid Films* v 157 n 2 Feb 29 1988 p 345-350.

**094724 GROWTH AND CHARACTERIZATION OF  $\text{CuInSe}_2$  FILM BY CLOSE-SPACE EVAPORATION.**  $\text{CuInSe}_2$  thin films were prepared on mica substrates using an evaporation technique which involved varying the distance between the source and the substrate. Films evaporated on substrates at distances less than 1 cm from the source exhibited preferential orientation in the (112) direction. The grain size increased from 0.5 to 1.0  $\mu\text{m}$  as the source substrate distance decreased from 3 to 1 cm. The conductivity increased with a decrease in the distance between the source and substrate. Electron probe microanalysis of these films showed that films coated on substrates farther away from the source had a slight selenium deficiency and an excess of indium. Three characteristic energy gaps of 1.01, 1.25 and 2.4 eV were obtained from an analysis of the optical absorption spectrum. The optical transition probability for valence band to conduction band transitions was estimated to be 10.91 eV which gives an admixture of copper d states to the valence band of 32%. (Author abstract) 18 refs.

Murali, K.R. (Indian Inst of Technology, Madras, India); Viswanathan, S.K.; Gopalani, B.S.V. *Mater Sci Eng* v 100 Apr 1988 p 241-244.

**094725 EFFECT OF POST-DEPOSITION VACUUM ANNEALING ON PROPERTIES OF ITO LAYERS.** Indium tin oxide (ITO) films have been deposited on glass substrates by dc reactive magnetron sputtering. The rectangular  $127 \times 336 \text{ mm}^2$  cathode target 90 percent In + 10 percent Sn was sputtered in an Ar +  $\text{O}_2$  gas mixture at a total pressure of 0.2 Pa. Post-deposition annealing of ITO-coated substrates at a temperature of about 500-700 K for some 70 min in vacuum at  $5 \times 10^{-3}$  Pa caused the layers to crystallize. The crystallization results in the ITO electric resistivity decreasing by more than five orders. After vacuum annealing ITO layers were obtained with a resistivity of about  $10^{-4} \Omega \text{ cm}$ . (Edited author abstract). 6 Refs.

Libra, M. (Czechoslovak Acad of Sciences, Prague, Czech); Bardos, L. *Vacuum* v 38 n 6 1988 p 455-457.

**094726 EFFECT OF A TILTED MAGNETIC FIELD ON THE SIZE-QUANTIZED LEVELS OF QUANTUM WELLS IN ULTRATHIN FILMS OF NARROW-GAP SEMICONDUCTORS.** An attempt is made to investigate the effects of a tilted magnetic field on the size-quantized levels of quantum wells in ultrathin films of narrow-gap semiconductors, taking n-type InSb as an example. It is found that, in general, the energy eigenvalue of the lowest magneto-size-quantized level increases with increasing magnetic field and decreases both, with increasing film thickness and with increasing orientation of the magnetic field, for given values of the other parameters. Besides, it is observed that the difference of the energy



eigenvalues of the lowest two magnetic sub-levels of the lowest electric sub-band reaches a maximum at a given magnetic field, showing a decrease with its orientation, while it increases with the film thickness. (Author abstract). 17 refs.

Bose, M.K. (Univ Coll of Science & Technology, Calcutta, India); Majumdar, C.; Maity, A.B.; Chakravarti, A.N. *Phys Status Solidi B* v 148 n 1 Jul 1988 p 165-172.

**094727 PREPARATION OF EPITAXIAL InSb FILMS BY MAGNETRON SPUTTERING.** InSb demonstrates an extremely high electron mobility, up to 1 000 000  $\text{cm}^2 \cdot \text{V}^{-1} \cdot \text{s}^{-1}$  at 77 K, which makes it of particular interest for very high-speed circuit applications. The preparation of thin epitaxial films of InSb by magnetron sputtering is discussed. Using this technique, we have deposited good quality epitaxial InSb films on <100> InSb and <100> GaAs. The effects of substrate temperature and sputter pressure on film morphology, composition, and growth rate are examined. Preliminary measurement of the electrical characteristics of these layers and their crystal quality by X-ray diffraction and large-area electron-channelling pattern analysis are presented. (Edited author abstract) 12 refs.

Webb, J.B. (Div of Chemistry, Ottawa, Ont, Can); Halpin, C.; Ehrismann, J.; Noad, J.P. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 872-877.

**094728 INVESTIGATION OF ELECTRODEPOSITED CuInSe<sub>2</sub> FILMS.** After a brief review of CuInSe<sub>2</sub> films prepared using an electrophoretic technique, results obtained by an electrochemical deposition method will be described. The electrophoretic technique, which is simple, was first investigated and found to be unsuitable for CuInSe<sub>2</sub>-film deposition. Using the electrochemical deposition method, we obtained uniform and homogeneous CuInSe<sub>2</sub> films. The quality of the films was then determined by scanning electron microscopy, electron-probe microanalysis, X-ray diffraction, and secondary-ion mass spectroscopy. Heterojunction cells of the form CdS-CuInSe<sub>2</sub> were finally fabricated using the electrodeposited films. The devices showed an active-area AM1 short-circuit current density of more than 30  $\text{mA} \cdot \text{cm}^{-2}$  and a  $V_{oc}$  of about 0.2 V. (Author abstract) 4 refs.

Qiu, C.X. (McGill Univ, Montreal, Que, Can); Shih, I. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 1011-1014.

**094729 GROWTH AND ANNEALING OF AgInSe<sub>2</sub> THIN FILMS.** Amorphous thin films of AgInSe<sub>2</sub> were grown by rf magnetron sputtering and then crystallized using two forms of optical annealing: laser annealing using a raster-scanned argon laser and heat-pulse annealing using a quartz-halogen heat-lamp system. It was determined that laser annealing of films on amorphous substrates resulted in fine-grained polycrystalline chalcopyrite AgInSe<sub>2</sub> thin films with a preferred (112) orientation. The presence of weak X-ray diffraction peaks associated with nonchalcopyrite phases indicated that some segregation had occurred. Heat-pulse annealing of films on single-crystal substrates led to better results. The films were more highly oriented with no evidence of any segregation. (Author abstract) 8 refs.

Weir, R.D. (McMaster Univ, Hamilton, Ont, Can); Jessop, P.E.; Garside, B.K. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 1033-1036.

**094730 TRANSMISSION AND PHOTOREFLECTANCE SPECTRA IN HIGHLY STRAINED InGaAs-GaAs MULTIPLE QUANTUM WELLS.** Low temperature optical transmission spectra (TS) and room temperature photoreflectance (PR) spectra have been measured to investigate several  $\text{In}_x\text{Ga}_{1-x}\text{As}/\text{GaAs}$  strained multiple quantum wells (MQWs) grown by molecular beam epitaxy (MBE). Sharp PR features indicating excellent optical quality of these samples were observed. The excitonic transitions up to 3C-3H are observed. The band-to-band transitions are observed in

both TS and PR spectra, which are identified as 1C-1L transitions. The calculated transition energies, taking into account both the strain and the quantum well effects, are in good agreement with the TS and PR spectra. This shows that room temperature PR is a powerful and convenient tool to investigate the strained layer MQWs. A heavy-hole valence band discontinuity of 30% was obtained for  $0.13 \leq x \leq 0.193$ . We conclude that the light holes are in the GaAs barrier region (Type II MQWs) and the light hole transition 1C-1L is a sensitive parameter in determining the band offset in InGaAs/GaAs strained layer MQWs. (Edited author abstract) 21 refs.

Ji, G. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Reddy, U.K.; Huang, D.; Henderson, T.S.; Morokoc, H. *Superlattices Microstruct* v 3 n 5 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 539-545.

**094731 REACTIVE SPUTTERED CuInSe<sub>2</sub>.** The deposition of CuInSe<sub>2</sub> thin films by co-sputtering from copper and indium planar magnetron sputtering sources in a working gas of argon plus  $\text{H}_2\text{Se}$  is being investigated. Near-stoichiometric coatings deposited onto glass and molybdenum-coated substrates have been found to have resistivities, Hall mobilities, absorption coefficients, band gaps, surface topographies, grain sizes and oxygen heat treatment behavior comparable with those of films produced by the more common three-source evaporation method. However, it has not been possible by reactive sputtering to deposit indium-rich films ( $[\text{In}]/[\text{Cu}] \approx 1.5$ ) of the type commonly used as a top layer in the preparation of two-layer device quality films by the evaporation method. Apparently an indium-rejection behavior, which occurs during the deposition process in  $\text{H}_2\text{Se}$  reactive sputtering, makes it difficult to achieve indium compositions beyond the amount that can be incorporated into the CuInSe<sub>2</sub> chalcopyrite phase. Experiments are described which were conducted to examine the dependence of the indium-rejection behavior on the deposition conditions. (Author abstract) 17 refs.

Thornton, John A. (Univ of Illinois, Urbana, IL, USA); Lomasson, T.C.; Talieh, H.; Tseng, B.-H. *Sol Cells* v 24 n 1-2 May-Jun 1988, Proc 8th Photovoltaic Adv Res Dev Proj Rev Meet, Denver, CO, USA, Nov 15-18 1987 p 1-9.

**094732 EFFECTS OF COMPOSITION AND SUBSTRATE TEMPERATURE ON THE ELECTROOPTICAL PROPERTIES OF THIN-FILM CuInSe<sub>2</sub> AND CuGaSe<sub>2</sub>.** Polycrystalline thin films of CuInSe<sub>2</sub> and CuGaSe<sub>2</sub> deposited by thermal evaporation onto heated substrates of 7059 glass and  $\text{Al}_2\text{O}_3$  were studied. The data for CuInSe<sub>2</sub> indicates an absorption coefficient as high as  $1.5 \times 10^5 \text{ cm}^{-1}$ , though predominantly  $(2.0-8.0) \times 10^4 \text{ cm}^{-1}$ , and band-gap values ranging from 0.94 to 1.02 eV, with band-gap narrowing observed for films deposited at 350°C. The effect of high temperatures and lower copper concentrations in CuInSe<sub>2</sub> and CuGaSe<sub>2</sub> is to shift the onset of absorption to higher energies. The data for CuGaSe<sub>2</sub> thin films indicate absorption coefficients up to  $(1-2) \times 10^5 \text{ cm}^{-1}$  at 500 nm and band gaps ranging from 1.66 to 1.72 eV. The effect of higher substrate temperatures on CuGaSe<sub>2</sub> is to eliminate secondary phases and minimize residual absorption below the band gap. The electrical measurements on CuInSe<sub>2</sub> indicate activated conductivity and show the films to be highly compensated by donors and acceptors whose origins are the native defects arising from non-stoichiometry. (Edited author abstract) 14 refs.

Tuttle, J. (Solar Energy Research Inst, Golden, CO, USA); Albin, D.; Goral, J.; Kennedy, C.; Noufi, R. *Sol Cells* v 24 n 1-2 May-Jun 1988, Proc 8th Photovoltaic Adv Res Dev Proj Rev Meet, Denver, CO, USA, Nov 15-18 1987 p 67-79.

**094733 DEVICE QUALITY THIN FILMS OF CuInSe<sub>2</sub> BY A ONE-STEP ELECTRODEPOSITION PROCESS.** Fabrication of device quality polycrystalline thin films of CuInSe<sub>2</sub> with appreciable photovoltaic activity has been achieved by a simple one-step electrodeposition process from a single solution. Controlled by a personal computer, the thin film deposition process has been

upgraded to be semi-automatic with good accuracy, flexibility and reliability. The thin films are electrodeposited at constant potentials in unstirred solution. An innovative method employing a multi-potential procedure is used to produce the bilayer (indium-rich) thin films. Devices made from these films showed improved spectral response in the long wavelength region. The electron-beam-induced current measurement indicates a heterojunction device. (Edited author abstract) 16 refs.

Pern, F.J. (Solar Energy Research Inst, Golden, CO, USA); Goral, J.; Matson, R.J.; Gessert, T.A.; Noufi, R. *Sol Cells* v 24 n 1-2 May-Jun 1988, Proc 8th Photovoltaic Adv Res Dev Proj Rev Meet, Denver, CO, USA, Nov 15-18 1987 p 81-90.

## Transport Properties

**094734 DETERMINATION OF TRANSPORT PARAMETERS FOR InP DEVICE SIMULATIONS IN  $n^+nn^+$  STRUCTURES.** Phenomenological transport parameters in n-InP are derived from large scale, ensemble Monte Carlo particle simulations. These parameters are required in efficient numerical methods used to solve 'hydrodynamic-like' transport formulations which govern various physical models of bulk, unipolar InP devices. For an equivalent single-valley conduction band, a set of transport parameters in n-InP at 300 K is calculated from the Monte Carlo data. An example of the use of these parameters in a numerical simulation code is provided. (Author abstract) 7 refs.

Tait, Gregory B. (US Naval Research Lab, Washington, DC, USA); Krowne, Clifford M. *Solid State Electron* v 30 n 12 Dec 1987 p 1317-1322.

## Vapor Deposition See Also LASERS, SEMICONDUCTOR—Fabrication.

**094735 EFFECT OF GAS PHASE GROWTH PARAMETERS ON THE COMPOSITION OF InGaAs IN THE HYDRIDE VPE PROCESS.** A 1.4  $\mu\text{m}$  thick InGaAs layer exhibiting an X-ray diffraction linewidth of 18 arc S has been grown on an InP substrate. This is the best crystalline perfection ever reported for InGaAs, as far as the author is aware. The effect of gas composition on lattice mismatch has been investigated for InGaAs layers grown under a variety of conditions. An empirical equation has been developed which relates lattice mismatch ( $\Delta a/a$ ) to metals ratio, mole fraction of  $\text{AsH}_3$  and mole fraction of HCl. Values of ( $\Delta a/a$ ) calculated using this equation are in good agreement with experiment. The metals ratio for lattice match is shown to vary linearly with the growth rate. This observation is shown to be consistent with mass transfer limitation in the gas phase. As a further consequence, relationships between layer thickness uniformity and lattice mismatch uniformity and between growth rate and gas composition are derived. (Author abstract) 18 refs.

Buckley, D.N. (AT&T Bell Lab, Murray Hill, NJ, USA). *J Electron Mater* v 17 n 1 Jan 1988 p 15-20.

**094736 LOW-VACUUM METALORGANIC VAPOR PHASE EPITAXY OF InGaP AND ITS IMMISCIBLE GROWTH.** InP and InGaP crystal growth on GaAs(100) was carried out by low-vacuum (0.03 Torr) MOVPE. Single crystals of InGaP were obtained on GaAs when the substrate temperature was 670°C. In this low-vacuum MOVPE growth of InGaP, as in conventional MOVPE, the growth rate is limited by the supply of group-III metalorganics, and Ga-element is taken into the grown layer more effectively than In-element. In some cases, immiscible InGaP growth was observed as a compositional separation in the grown layers when the substrate temperature was below 620°C. A model for the



crystal growth in low-vacuum MOVPE, which can explain the occurrence of the immiscibility, is proposed. (Author abstract). 27 Refs.

Ozasa, Kazunari (Kyoto Univ, Kyoto, Jpn); Yuri, Masaaki; Nishino, Shigehiro; Matsunami, Hiroyuki. *J Cryst Growth* v 89 n 4 7(1) 1988 p 485-495.

**094737 EQUILIBRIUM ANALYSIS OF THE VPE-HYDRIDE METHOD USING A GALLIUM-INDIUM ALLOY SOURCE.** Recently, a new and simple method was developed where the equilibrium expression can be used directly to analyze the VPE-hydride system with the two metal sources. This new method has been applied in study to the VPE-hydride technique with the alloy source. Results of the study explain the previously reported experimental data and predict that the composition of the ternary is not only dependent on the partial pressure of arsine and alloy composition but also on the partial pressure of HCl. The equilibrium analysis also indicates that the same alloy can continually be used in the VPE technique to produce the lattice-matched  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ . 23 Refs.

Quinlan, Kenneth P. (Rome Air Development Cent, Hanscom Air Force Base, MA, USA). *J Electrochem Soc* v 135 n 8 Aug 1988 p 2108-2111.

**094738 VACUUM DEPOSITION PROCESSES FOR  $\text{CuInSe}_2$  AND  $\text{CuInGaSe}_2$  BASED SOLAR CELLS.** This paper reviews the vacuum deposition methods presently used at the Boeing High Technology Center for the preparation of each of the layers in the ternary based  $\text{CuInSe}_2/\text{CdZnS}$  and quaternary based  $\text{CuInGaSe}_2/\text{CdZnS}$  solar cells. This includes the sputter deposition of the molybdenum base electrode, physical vapor deposition of the selenide layers from three ( $\text{CuInSe}_2$ ) or four ( $\text{CuInGaSe}_2$ ) elemental sources, and deposition of the mixed sulfide using either resistively heated or electron-beam evaporation sources with CdS, ZnS or CdZnS as the starting material. (Author abstract) 7 refs.

Devaney, W.E. (Boeing Electronics Co, Seattle, WA, USA); Mickelsen, R.A. *Sol Cells* v 24 n 1-2 May-Jun 1988, Proc 8th Photovoltaic Adv Res Dev Proj Rev Meet, Denver, CO, USA, Nov 15-18 1987 p 19-26.

## X-Ray Analysis

**094739 CHARACTERIZATION OF  $\text{In}_{1-x}\text{Ga}_x\text{As}_{1-x}\text{Sb}_x$  GaAs STRAINED LAYER SUPERLATTICES BY ION BACKSCATTERING-CHANNELING AND X-RAY DIFFRACTION.** The combination of ion backscattering and X-ray diffraction can be used to study composition, crystalline quality, and tetragonal distortion in strained layer superlattices (SLs). The authors investigated various  $\text{In}_x\text{Ga}_{1-x}\text{As}/\text{GaAs}$  SLs/MBE grown on GaAs(100) substrates using RBS/channeling, X-ray diffraction, and TEM techniques. The samples are composed of 2 to 20 nm thick layers with 10 to 40 periods and x-values of 18 to 24 percent. The epitaxial films were grown from Ga, In, and  $\text{As}_4$  fluxes. Initially, a 70 nm thick GaAs buffer layer with a perfect RHEED controlled surface was grown under optimal growth and thermal annealing conditions. In some cases an alloy buffer layer  $\text{In}_{0.5x}\text{Ga}_{1-0.5x}\text{As}$  was deposited. 12 Refs.

Flaigmeier, R. (Karl-Marx-Univ Leipzig, Leipzig, East Ger); Lenkeit, K.; Baumbach, T.; Kanter, Yu.O.; Fedorov, A.A. *Phys Status Solidi A* v 107 n 1 May 1988 PK19-K24.

## SEMICONDUCTING INTERMETALLICS

### Magnetic Properties

**094740 HIGH-DENSITY PHOTOGENERATED FREE-CARRIER SPIN RELAXATION PROCESSES IN WURTZITE SEMICONDUCTORS:  $\text{CdSe}$  AND SEMIMAGNETIC SEMICONDUCTOR  $\text{Cd}_{1-x}\text{Mn}_x\text{Se}$ .** Picosecond time-resolved spin relaxation kinetics of high-density free carriers is investigated at low temperatures in  $\text{CdSe}$  ( $x = 0$ ) and in dilute semimagnetic semiconductor  $\text{Cd}_{1-x}\text{Mn}_x\text{Se}$  for  $x = 0.05$  and  $0.10$ . The

fast spin relaxation observed in  $\text{CdSe}$  results from a mechanism associated with the noncentrosymmetric character of the band structure for this material. This process is similar to the one proposed by M. I. D'yakonov and V. I. Perel' (1971) for the zinc blende crystal structures. The spin relaxation times in  $\text{CdSe}$  are on the order of 30 ps. The spin relaxation times are  $< 20$  ps in semimagnetic semiconductor  $\text{Cd}_{1-x}\text{Mn}_x\text{Se}$  and are consistent with spin-flip Raman scattering measurements. The increase in spin relaxation rate relative to  $\text{CdSe}$  is explained in terms of the carrier spin exchange between the carriers and the magnetic spin sites. A probable cause for the reduction in the observed spin polarization factor for carriers in  $\text{Cd}_{1-x}\text{Mn}_x\text{Se}$  ( $x \neq 0$ ) is presented. 42 refs.

Junnarkar, Mahesh R. (City Coll of New York, NY, USA); Alfano, R.R.; Furdyna, J.K. *IEEE J Quantum Electron* v 24 n 2 Feb 1988 p 315-324.

### Structures

**094741 NEUTRON DIFFRACTION AND MAGNETIC ANISOTROPY STUDY OF Y-Fe-Ti INTERMETALLIC COMPOUNDS.** High resolution neutron powder diffraction has been used to determine the crystal structures of  $\text{YFe}_{11}\text{Ti}$  and  $\text{YFe}_{10}\text{Ti}$  intermetallic compounds. Both compounds crystallize in the  $\text{ThMn}_{12}$  tetragonal structure (space group  $I_4/mmm$ ). The 8j and 8f sites are virtually fully occupied by Fe whilst the 8i site is partially occupied by Fe and Ti atoms. The temperature dependence of the magnetic anisotropy from 293 to 78 K has been measured by the singular point detection technique. The magnetic anisotropy is found to increase with decreasing temperature. The value of the anisotropy field is 37 KOe and 21 KOe at 78 K and 293 K respectively. (Author abstract) 10 refs.

Moze, O. (Istituto MASPEC, Parma, Italy); Pareti, L.; Solzi, M.; David, W.I.F. *Solid State Commun* v 66 n 5 May 1988 p 465-469.

### Thin Films

**094742 ELECTRICAL TRANSPORT PROPERTIES OF THALLIUM-DOPED P-TYPE  $\text{Pb}_{0.8}\text{Sn}_{0.2}\text{Te}$  THIN FILMS.** Hall coefficient and d.c. conductivity studies were made on p-type  $\text{Pb}_{0.8}\text{Sn}_{0.2}\text{Te}$  thin films doped with different concentrations of thallium in the temperature range 77 to 500 K. The Hall coefficient and Hall mobility are found to decrease with an increase in the doping concentration of thallium. Hall coefficient data have been analysed in the light of a double valence-band model. Various band parameters such as valence band separation, population ratio, mobility ratio and effective mass ratio have been calculated. Hall mobility data have been analysed in the light of lattice- and defect-limited scattering mechanisms. (Author abstract) 33 refs.

Jagadish, C. (Univ of Delhi, Delhi, India); Dawar, A.L.; Mathur, P.C. *J Mater Sci* v 23 n 3 Mar 1988 p 1002-1008.

## SEMICONDUCTING LEAD COMPOUNDS

See Also LEAD AND ALLOYS—Thin Films; LUMINESCENCE—Analysis; MAGNETIC SEMICONDUCTORS—Optical Properties; MAGNETIC SEMICONDUCTORS—Thermal Effects; SEMICONDUCTING FILMS—Growth; SEMICONDUCTING GLASS—Optical Properties.

Applications See LASERS, SEMICONDUCTOR—Fabrication.

Charge Carriers See Also RADIATION DETECTORS.

**094743 EFFECT OF REDUCTION OF PLZT ON CARRIER LIFETIME DETERMINED BY EBIC.** Lanthanum doped lead zirconate titanate (PLZT) behaves like an n-type semiconductor when reduced in vacuum. Steady state electron induced current was measured at different electron energies and lifetime of excess carriers was estimated at corresponding depths. The carrier lifetime decreased by one order of magnitude whereas the average sheet conduction increased by about four orders of magnitude due to reduction. (Author abstract) 11 refs.

Maurya, J.C. (Univ of Poona, Poona, India); Dixit, A.V.;

Manorama, Vardhreddy; Bhoraskar, S.V. *Solid State Commun* v 64 n 9 Dec 1987 p 1235-1240.

**094744 ACOUSTICAL DEFORMATION POTENTIAL AND EFFECTIVE MASS IN n-TYPE LEAD TELLURIDE BETWEEN 4 AND 300 K.** The acoustical deformation potential value is deduced for n-PbTe from low temperature electron mobility results. The value obtained is  $\Xi = (22 \pm 2)$  eV. Assuming  $\Xi$  independent of temperature T, the electron density of states effective mass at the conduction band edge follows the linear relation  $m^*(T) = 0.040 m_0 [1 + (4.7 \pm 0.3) \times 10^{-3} T]$  between 4 and 300 K. (Author abstract) 8 refs.

Pelletier, C.M. (CNRS, Rennes, Fr); Roland, S.; Granger, R.; Lasbley, A. *J Phys Chem Solids* v 49 n 2 1988 p 139-142.

### Doping

**094745 DOPING OF LEAD SELENIDE WITH THALLIUM.** A study was made of the properties of thallium-doped lead selenide as a function of the charge composition during crystal growth from vapor according to the vapor-liquid-solid mechanism. It is shown that thallium is an acceptor impurity, and from a charge of composition  $\text{Pb}_x\text{Te}_{1-x}\text{Se}_x$  with  $2 = 0.413$  and  $y \geq 0.018$  and with  $y = 0.01$  and  $x \leq 0.52$  a material with p-type conductivity is obtained. The dependence of the composition of thallium-doped lead selenide during diffusion annealing on the thallium vapor pressure at constant lead vapor pressure is determined. It is shown that at a lead vapor pressure of 1.3332 Pa and a thallium vapor pressure  $\geq 1.87 \cdot 10^{-3}$  Pa it is possible to obtain crystals with p-type conductivity. 14 refs. In Russian.

Surin, V.Yu.; Tamm, M.E.; Zlomanov, V.P. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1818-1821.

### Electric Conductivity

**094746 NON-LINEAR TRANSPORT PROPERTIES OF THE  $\text{PbTe-GeTe}$  SYSTEM.** The dependence of the resistivity on temperature for PbTe crystals alloyed with  $< 10\%$  GeTe shows a smooth resistivity hump at low temperatures, which indicates a phase transition. Below the resistivity hump the behavior of the system is non-ohmic. The I-V characteristics at these low temperatures are S shaped. At a critical current density the system oscillates. The resistivity anomaly and the critical temperature at which this anomaly occurs was found to depend on the current density. (Author abstract) 18 refs.

Valassiades, O. (Aristotle Univ of Thessaloniki, Thessaloniki, Greece); Pavlidou, E.; Economou, N.A. *Solid State Commun* v 62 n 7 May 1987 p 503-507.

Electric Properties See Also SUPERCONDUCTING MATERIALS—Impurities.

**094747 STRUCTURAL AND ELECTRICAL PROPERTIES OF  $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$  FILMS GROWN BY MOLECULAR BEAM EPITAXY.** Thin epitaxial layers of  $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$  were grown on (100) KCl substrates by molecular beam epitaxy using a single Knudsen source. A typical source temperature of 600°C and substrate temperatures of 250 to 350°C were used. Laue, X-ray, RHEED, SEM, and Van der Pauw techniques employed to characterize these films. Layers 4 to 5  $\mu\text{m}$  thick grown at a growth rate of 0.75  $\mu\text{m}/\text{h}$ . These layers are p-type having carrier concentrations in the range of  $10^{17}$  to  $10^{18} \text{ cm}^{-3}$  and mobilities on the order of  $10^3 \text{ cm}^2/\text{Vs}$  at 110 K. The composition x in the films is found to vary with the substrate temperature. Films grown at 325°C exhibit the same value of x as the source material. (Edited author abstract) 20 refs.

Ponnuraju, K. (Indian Inst of Technology, Madras, India); Vaya, P.R.; Sobhanadri, J. *Phys Status Solidi A* v 105 n 1 Jan 1988 p 161-169.



**094748 PHOTOINDUCED ELECTRIC PROPERTIES OF  $Pb_{1-x}Sn_xTe$  SINGLE CRYSTALS.** It was established that the simultaneous action of  $CO_2$ -laser radiation and an external electric field of frequency  $f \leq 10^5$  Hz and strength of the order of that of the laser wave electric field leads to a lowering of the hole concentration or an increase of the electron concentration of the same order as without an electric field but within a shorter time period. The influence of an electric field alone leads to no detectable changes in the electrical characteristics. Changes in the electrical properties upon variation of the orientation of the external electric field with respect to laser wave electric field direction were also established. 5 refs.

Plyatsko, S.V. (Acad of Sciences of Ukrainian SSR, Kiev, USSR); Sizov, F.F.; Darchuk, S.D. *Mater Lett* v 6 n 4 Feb 1988 p 116-118.

## Growth

**094749 PRECIPITATES IN  $PbTe:Cr$  CRYSTAL GROWN BY THE BRIDGMAN METHOD.** X-ray diffraction measurements and electron microprobe analysis were performed on  $PbTe$  crystals grown by the Bridgman method doped with 1.2 wt% Cr. Scanning electron microscopic observations and electron microprobe analysis carried out on the (110) oriented samples revealed needle-like precipitates enriched in chromium and tellurium. It was confirmed that the composition of the widest precipitates was equal to  $Cr_3Te_4$ . It corresponded to mixing of two compounds:  $Cr_2Te_3$  and  $CrTe$ . Using X-ray diffraction measurements, additional phases such as  $CrTe$  monoclinic,  $Cr_2Te_3$  hexagonal and  $CrTe$  hexagonal have been found in the samples. (Edited author abstract) 11 refs.

Golacki, Z. (Polish Acad of Sciences, Warsaw, Pol); Godwod, K.; Majewski, J.; Jasielek, G. *J Cryst Growth* v 84 n 3 Sep 1987 p 455-459.

**094750 ELECTRIC PROPERTIES OF  $PbSe$  FILMS ON A POLYIMIDE SUBSTRATE.** Using methods of mathematical experiment design, global polynomial models are constructed for the carrier mobility and concentration of lead selenide films obtained from the vapor phase by the 'hot wall' method on a polyimide substrate. It is shown that, by measuring the technological factors of the film growth process, it is possible to effectively control the electric parameters of the films. The conditions of growth of film material with maximum carrier mobilities and minimum carrier concentrations are optimized. In Russian. 3 refs.

Frenk, D.M.; Voropai, V.A.; Lopyanko, M.A.; Pavlyuk, M.F.; Prokopi, V.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 8 Aug 1987 p 1261-1264.

**094751 VORSTELLUNGEN ZUM SCHICHTWACHSTUM VON BLEIPHthalOCYANINDUENNSCHICHTEN.** [Considerations Regarding Lead Phthalocyanine Thin Film Growth]. The effect of the preparation conditions on the structure and properties of lead phthalocyanine thin films is investigated. By means of electron microscopic examination, the simultaneous appearance of the monocline and tricline crystal modification is demonstrated. For the first time, the absorption peaks are given in the visible and IR regions of the monocline modification. The results are summed up in a three-phase model of lead phthalocyanine thin film growth. (Translated author abstract) 17 refs. In German.

Mrwa, Axel; Reinhardt, Carola; Hamann, Claus. *Wiss Z Tech Univ Karl Marx Stadt* v 29 n 2 1987 p 298-305.

**094752 GROWTH OF  $PbTe$  DOPING SUPERLATTICES BY HOT WALL EPITAXY.** The doping behavior of different species for the growth of  $PbTe$  layers has been investigated. For doping with Te, a model calculation for the status of the Te source as a function of the temperature and time is presented and compared with experimental data. The doping of  $PbTe$  using  $Bi_2Te_3$  and  $Tl_2Te$  sources was studied and typical carrier concentrations and mobilities are given. Finally the differences

between the different dopants with respect to interdiffusion are discussed. These results are important for possible device application of  $PbTe$  nipi structures as IR detectors. (Author abstract) 22 refs.

Clemens, Helmut (Montanuniversitaet Leoben, Leoben, Austria). *J Cryst Growth* v 88 n 2 Apr II 1988 p 236-240.

**094753 INFLUENCE OF ELECTROMAGNETIC RADIATION ON THE FIELD OF HOMOGENEITY OF LEAD TELLURIDE.** A substantial reduction in the dimensions and a change in the configuration of the homogeneity region of a narrow gap telluride lead semiconductor grown in a wide temperature range of 450-830°C with photostimulated epitaxy are detected with the effect of laser radiation ( $\lambda = 0.35$  micron) on the growth zone. (Author abstract) 2 refs.

Aleksandrov, O.V.; Zaitsev, V.V.; Kalyuzhnaya, G.A.; Kiseleva, K.V. *Sov Phys Lebedev Inst Rep* n 9 1987 p 13-16.

## Impurities

**094754 IMPURITY LEVELS IN  $PbTe$  AND  $Pb_{1-x}Sn_xTe$ .** The doping characters of vacancies, the existence of impurity resonances, Fermi-level saturation and de-saturation, the sensitivity of the resonances to host chemistry, the behavior of In as both a donor and an acceptor in  $Pb_{1-x}Sn_xTe$ , and the occurrence of other apparently anomalous valences of impurities in IV-VI semiconductors are shown to be simple and direct consequences of a covalent defect theory. Several important defects are assigned to 'incorrect' or 'anti' sites. (Edited author abstract) 23 refs.

Lent, Craig S. (Univ of Notre Dame, Notre Dame, IN, USA); Bowen, Marshall A.; Allgaier, Robert S.; Dow, John D.; Sankey, Otto F.; Ho, Eliza S. *Solid State Commun* v 61 n 2 Jan 1987 p 83-87.

**094755 SPIN SPLITTING IN NARROW-GAP  $Pb_{1-x}Sn_xTe$  SEMICONDUCTORS.** The g factor in the solid solutions  $Pb_{1-x}Sn_xTe$  of the p and n type ( $x = 0, 0.1, 0.19, 0.2, 0.28, \text{ and } 0.38$ ), doped with germanium, cadmium, and bismuth, is determined from investigations of the quantum oscillations of the magnetoresistance. Comparison of the results obtained with theoretical calculations, taking into account the dependence of the matrix element of the momentum operator on the composition x, shows that the experiment agrees well with the theory within the framework of Dimmock's model. Analysis of the experimental results indicate that doping with nonmagnetic impurities does not affect the magnitude of the spin splitting. (Author abstract) 27 refs.

Dmitriyev, A.I. (Acad of Sciences of the Ukrainian SSR, USSR); Lashkarev, G.V. *Sov Phys J* v 30 n 8 Aug 1987 p 711-716.

## Magnetic Properties

**094756 ELECTRON PARAMAGNETIC RESONANCE OF MAGNETIC CLUSTERS IN  $Pb_{1-x}Gd_xTe$ .** Measurements of electron paramagnetic resonance (EPR) and of susceptibility with a superconducting quantum interference device (SQUID) have been performed on  $Pb_{0.995}Gd_{0.005}Te$  crystals from 4.2 to 300 K. The EPR spectra consist of two components, one showing the fine structure of  $Gd^{3+}$  ions in a cubic environment and the other a broad line, which we attribute to clusters of interacting Gd ions. The resonant field of the cluster line appears to be due to an exchange-narrowing mechanism. The ratio of cluster-line intensity to fine-structure intensity increases with decreasing temperature down to 10 K and then decreases. This decrease may be related to the spin freeze-out seen in ac susceptibility. The line-width broadening of the cluster and the single-ion lines are similar below 20 K, with a higher rate for the cluster line. The Curie-Weiss temperature is negative and small for both clustered and single spins, reflecting a weak antiferromagnetic interaction. (Edited author abstract) 15 refs.

Bartkowski, M. (Nat'l Research Council of Canada, Ottawa, Ont, Can); Northcott, D.J.; Park, J.M.; Reddoch,

A.H.; Williams, D.F.; Lamarche, G. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 1023-1026.

**Optical Properties** See Also LEAD COMPOUNDS—Optical Properties.

**094757 FUNDAMENTAL ABSORPTION EDGE OF  $PbGa_2S_4$ .** Optical absorption spectra of  $PbGa_2S_4$  were measured in the photon energy range from 2.0 to 3.2 eV and for temperatures between 32 and 300 K.  $PbGa_2S_4$  is found to be an indirect-gap semiconductor with a gap energy of 2.84 eV at room temperature. At slightly higher energies the fundamental edge is followed by a direct gap with an energy of 2.91 eV at 300 K. The results obtained are compared with previous measurements and with experimental data for  $CdGa_2S_4$  having similar near-edge optical properties. (Author abstract) 13 refs.

Neumann, H. (Karl-Marx-Univ, Leipzig, East Ger); Hoerig, W.; Nook, G.; Syrbu, N.N. *Solid State Commun* v 65 n 2 Jan 1988 p 155-157.

**094758 OPTICAL BISTABILITY IN  $PbSnTe$  AT 10  $\mu M$ .** Experimental evidence of optical hysteresis is found for the first time in  $Pb_{1-x}Sn_xTe$ . Thus, the possibility of optical bistability in lead chalcogenides by a continuous wave laser excitation is realized. Possible mechanisms of the observed nonlinear refraction in the sample due to the thermal effects or to the free carriers generation, are discussed. (Author abstract) 13 refs.

Paskov, P.P. (Inst of Electronics, Sofia, Bulg); Pavlov, L.I.; Atanasov, P.A.; Kushev, D.B.; Zheleva, N.N. *Opt Commun* v 65 n 2 Jan 15 1988 p 133-136.

**094759 NONLINERITIES IN EXCITONIC LUMINESCENCE OF DIRECT-GAP SEMICONDUCTORS UNDER VERY LOW OPTICAL EXCITATION LEVELS.** The dependences of peak luminescence intensity  $I_{lum}$  for free and bound excitons on the level  $I_{exc}$  of the above-gap optical exciton are studied in direct-gap semiconductors  $PbI_2$  and  $CdSe$  within a wide range  $10^{11} \leq I_{exc} \leq 10^{19}$  quanta  $cm^{-2} s^{-1}$ . The experimental dependences  $I_{lum} = f(I_{exc})$  are well represented by a nonlinear power law. The degree of nonlinearity increases gradually with the decrease of  $I_{exc}$  and also becomes higher with increasing of temperature. Linearity is sometimes observed only at sufficiently high  $I_{exc}$  above  $10^{16}$  quanta  $cm^{-2} s^{-1}$ . A phenomenological theoretical model is proposed which accounts for non-radiative surface recombination and non-uniform spatial distribution of the excited carriers and provides satisfactory qualitative agreement with the experimental findings. (Edited author abstract) 17 refs.

Brodin, M.S. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Gushcha, A.O.; Khodintsev, V.N.; Shevel, S.G.; Taranenko, L.V.; Tishchenko, V.V. *Phys Status Solidi B* v 144 n 2 Dec 1987 p 863-873.

## Oxidation

**094760 SPECIAL FEATURES OF THE REACTION BETWEEN TETRAGONAL  $PbO$  AND OXYGEN.** A study was made of the reaction between tetragonal lead monoxide and oxygen at 690-810 K and at  $O_2$  pressures exceeding the dissociation pressure of red lead up to  $1.10^5$  Pa. The existence of supersaturated solid solutions of oxygen in  $\alpha$ - $PbO$  is noted. These solutions form under conditions where the formation of a new condensed phase ( $Pb_3O_4$ ) for kinetic reasons, does not occur. 13 refs. In Russian.

Kochetov, I.A.; Vishnyakov, A.V.; Kortunenkov, P.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1863-1866.

**Phase Transitions** See LEAD AND ALLOYS—Radiation Effects.

## Photoconductivity

**094761 RESIDUAL PHOTOCONDUCTIVITY IN  $Pb_{0.78}Sn_{0.22}Te$  IN THE FAR INFRARED RANGE OF THE SPECTRUM.** No red boundary for the phenom-



non of residual photoconductivity is found to wavelengths of approximately 350 microns in  $\text{Pb}_{0.78}\text{Sn}_{0.22}\text{Te}:\text{In}$ . The nature of the temperature and time relaxation in the longwave range of the spectrum is found to be the same as in the shorter wave range. An explanation of the phenomenon within a model of Jahn-Teller electron capture centers is proposed. (Author abstract) 11 refs.

Voronova, I.D.; Semenova, E.V. *Sov Phys Lebedev Inst Rep* n 7 1987 p 24-28.

**Photovoltaic Effects** See CERAMIC MATERIALS—Thin Films.

### Physical Properties

**094762 FARADAY EFFECT APPROACH TO A STUDY OF  $\text{Al}^{\text{IV}}\text{B}^{\text{VI}}$  NARROW-GAP SEMICONDUCTOR BAND STRUCTURE.** The magnetooptical Faraday effect in the transparency range of  $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$  ( $0.9 \leq x \leq 0.23$ ) and  $\text{PbSe}$  single crystals with carrier concentrations from  $2 \times 10^{16}$  to  $2 \times 10^{18} \text{ cm}^{-3}$  is investigated under applied magnetic fields up to 6 T over the temperature range  $T = 4.2$  to 300 K. g-factors and effective masses of carriers are determined within the range of  $T = 4.2$  to 300 K. It is shown that the experimental results with or without quantization of the energy spectrum may be interpreted only under a particular condition. Some new values of Dimmock six-band model parameters are obtained taking this condition into account. (Edited author abstract) 21 refs.

Martynchuk, E.K. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Sizov, F.F. *Phys Status Solidi B* v 145 n 1 Jan 1988 p 309-318.

### Precipitation

**094763 PREPARATION OF BARIUM TITANYL OXALATE TETRAHYDRATE AND ITS UTILIZATION IN HIGH-CURIE-POINT BARIUM-LEAD TITANATE CERAMICS.** Barium titanyl oxalate tetrahydrate (BTOX) was prepared by coprecipitation method in which a mixture of barium-titanium chloride aqueous solution was slowly added to an ethanol solution of oxalic acid at room temperature. Aging after coprecipitation decreased the BET surface area of the precipitated barium titanyl oxalate tetrahydrate and the  $\text{BaTiD}_{20.5}$  second phase content of the calcined powder.  $\text{Ba}_{1-x}\text{Pb}_x\text{TiO}_3$  ceramics in which  $x = 0.50$  was synthesized by the reaction of BTOX,  $\text{PbO}$ ,  $\text{TiO}_2$  and dopants. A  $\text{Ba}_{0.5}\text{Pb}_{0.5}\text{TiO}_3$  ceramic with PTCR (positive temperature coefficient of resistivity) characteristics of 3.7 orders of magnitude, a minimum resistivity around 100 ohm/cm and a Curie point at 320°C was obtained. Factors such as the  $\text{Sb}_2\text{O}_3$ , MnO dopants contents, the Ti/(Ba+Pb) ratio, sintering temperature and microstructures which influence the PTCR characteristics were studied. (Author abstract) 7 refs.

Kao, Chih-Chun (Industrial Technology Research Inst, Hsinchu, Taiwan); Yang, Chun-Lien. *MRL Bull Res Dev* v 1 n 2 Sep 1987 p 57-62.

### Radiation Effects

**094764 CONTROL OF CARRIER LIFETIME IN  $\text{PbTe}$   $n\text{-ipi}$ -SUPERLATTICES BY EXTERNAL PHOTOINJECTION.** Photoexcitation of  $\text{PbTe}$  doping superlattices at different intensity levels can have a large influence on nonequilibrium carrier lifetime which in turn is determined both by  $\text{PbTe}$  bulk properties and details of the superlattice periodic potential. Such 'tunability' in the recombination rate is examined theoretically in a model which considers details of carrier tunneling and thermal excitation in the superlattice as well as the role of Auger recombination as a decay channel at high densities. Good agreement is obtained with experimental studies of transient photoconductivity in which picosecond pulses from a Nd:YAG laser have been used to vary the effective lifetime from less than 2 nsec up to 10 usec. We also show how the presence of 300 K background radiation has an important influence on practical recombination rates. (Author abstract) 11 refs.

Oswald, J. (Montanuniv Leoben, Leoben, Austria); Bauer, G.; Goltso, W.C.; Nurmikko, A.V. *Superlattices Microstruct* v 4 n 2 1988, Pap from the Chicago Conf, Chicago, IL, USA p 159-163.

### Spectroscopic Analysis

**094765 AUGER ELECTRON SPECTROSCOPY OF LASER-DEPOSITED  $\text{Pb}_{1-x}\text{Cd}_x\text{Se}$  FILMS.** Auger electron spectroscopy (AES) was applied for the film constitution investigation. Two groups of samples were prepared, one from a monolithic polycrystalline material and the other from tablets. The AES investigations show a lack of oxygen in both cases, despite the inevitable oxidation during the course of tablet preparation. The latter fact still remains open to discussion. Another important result from AES investigations is that there are no constitutional differences in the layers from pulse to pulse and there are no intermediate transitional layers, formed in the time (approx. 6 sec) between the pulses. 6 refs.

Sendova, M.S. (Sofia Univ, Sofia, Bulg); Maksimov, M.H.; Gaskov, A.M. *J Mater Sci Lett* v 7 n 2 Feb 1988 p 93-94.

**094766 DIRECT OBSERVATION OF GIANT DEVIATIONS FROM STOICHIOMETRY IN SINGLE CRYSTALLINE  $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$  BY MEANS OF THE MOSSBAUER EFFECT ON THE  $^{119}\text{Sn}$  NUCLEI.** The spectra of ordinary  $\text{Pb}_{0.77}\text{Sn}_{0.23}\text{Te}$  and metallic bare shown. The spectrum of the studied hyperstoichiometric samples consists of two lines which indicates the presence of two non-equivalent states of tin. Computer assisted determinations of the linewidth, isomer shift  $\delta$ , and magnitude of the effect were carried out as well as decomposition of the complex spectra into singlets. Not only tin but also lead occupies interstitial sites of the materials under investigation. The total concentration of interstitial metal atoms reaches values on the order of one atom per elementary cell. 2 Refs.

Baltrunas, D. (Acad of Sciences of the Lithuanian SSR, Vilnius, USSR); Zayachuk, D.M.; Motiejunas, S.; Starik, P.M. *Phys Status Solidi A* v 106 n 2 Apr 1988 p K173-K175.

**094767 ELECTRON SPIN RESONANCE STUDIES ON THE SUPERLATTICES  $\text{PbTe-Pb}_{1-x}\text{Eu}_x\text{Te}$  PREPARED BY HOT WALL EPITAXY.** Electron spin resonance spectra of the superlattices  $\text{PbTe-Pb}_{1-x}\text{Eu}_x\text{Te}$  prepared by a hot wall epitaxy technique have been examined, in which  $x$  denotes the fraction of europium or periodic monolayers of  $\text{Pb}_{1-x}\text{Eu}_x\text{Te}$  calculated by assuming no diffusion of europium(II) into the  $\text{PbTe}$  layer. For the spectra of the superlattices the linewidth was found to vary markedly over the range of  $x$  between 0.1 and 1, proving that most of the europium(II) exists on the monolayer of  $\text{Pb}_{1-x}\text{Eu}_x\text{Te}$ . In the case of randomly europium-doped crystalline  $\text{Pb}_{1-y}\text{Eu}_y\text{Te}$  of  $y = 0.003$ , in which  $y$  is the fraction of europium doped in the crystalline  $\text{PbTe}$ , the overall splitting of the ground state parameter of europium(II) in a cubic field surrounded by telluride ions as estimated to be  $1570 \times 10^{-4}$ . (Edited author abstract) 7 Refs.

Nakamura, Takato (Shizuoka Univ, Hamamatsu, Jpn); Ishida, Akihito; Fujiyasu, Hiroshi. *Thin Solid Films* v 161 Jul 1988 p 149-156.

**094768 DEPTH PROFILE OF THE ELEMENTS IN LEAD CHALCOGENIDE LAYERS.** The results of the quantitative X-ray electron spectroscopy and Auger electron spectroscopy of lead chalcogenide layers obtained by the hot wall technique are presented in this paper. The initial compounds  $\text{PbTe}$ ,  $\text{PbS}$ ,  $\text{PbSe}$ ,  $\text{PbS}_{1-x}\text{Se}_x$ ,  $\text{PbSe}_{1-x}\text{Te}_x$  and  $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$  were brought to  $P_{\text{min}}$  by the method of continuous and multiple sublimation-crystallization at the evaporation temperature. The layers were grown by congruent sublimation. The composition of the resulting layers was identical to that of the initial material. After sensitizing, polycrystalline films of  $\text{PbS}$  and  $\text{PbS}_x\text{Se}_{1-x}$  on photoglass supports displayed a non-homogeneous distribution of the elements across the near-surface

layer. The films that contained a larger amount of lead in the near-surface layer and had a better developed relief of the elemental distribution across the layer exhibited greater photosensitivity. (Edited author abstract) 9 Refs.

Kovalev, A.N. (Helsinki Univ of Technology, Helsinki, Finl); Korabiev, V.V. *Thin Solid Films* v 161 Jul 1988 p 281-287.

### Structure

**094769 ELECTRONIC STRUCTURE AND SYMMETRY PROPERTIES OF THE ENVELOPE FUNCTIONS IN  $\text{PbTe-Pb}_{1-x}\text{Sn}_x\text{Te}$  SUPERLATTICES.** In the framework of J.O. Dimmock's two band model and in the constant band edge approximation within each layer, the electronic structure for the  $\text{PbTe-Pb}_{1-x}\text{Sn}_x\text{Te}$  SL is studied. The study is carried out for the  $\langle 111 \rangle$  valley,  $k_1 = 0$ , and taking into account all the possible solutions for the effective Hamiltonian. A new dispersion relation and new zero energy gap conditions are derived. Numerical calculations reveal that the inclusion of the largest wave vector solutions do not substantially modify the energy spectrum obtained when such solutions are excluded. (Author abstract) 8 refs.

Gondar, J. Lopez (Univ of Havana, Havana, Cuba); de Dios Leyva, M. *Phys Status Solidi B* v 142 n 2 Aug 1987 p 445-453.

### Synthesis

**094770 SOLIDUS SURFACE OF THE SOLID SOLUTION  $\text{Pb}_{1-x}\text{S}_x\text{Se}_{1-x}$  ( $0.4 \leq x \leq 0.8$ ).** A study was made of the boundaries of the range of existence of the solid solution of lead sulfide and lead selenide, using the 'frozen-equilibrium' and 'first-crystal' methods. It was found that the maximum solubility of lead in the solid solution with  $x = 0.05$  is attained at 1140-1150 K and is equal to  $1.9 \cdot 10^{19} \text{ cm}^{-3}$ . The solidus surface of the  $\text{PbSe-PbS}$  system in the lead-rich region is displaced toward the lead side. In Russian. 7 refs.

Kuznetsova, L.A.; Shtanov, V.I.; Zlomanov, V.P. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 4 Apr 1987 p 537-539.

### Thermodynamic Properties

**094771 PARTIAL PRESSURES AND THERMODYNAMIC PROPERTIES FOR LEAD TELLURIDE.** The optical absorbance of the vapor over pure Te, over  $\text{Pb-Te}$  samples containing 49.01, 49.70, 51.26, and 55 atom percent (a/o) Te, and over a 1.56 mg crystal of  $\text{PbTe}$  is measured between 230 and 700 nm for optical cell temperatures of 1028, 1133, 1273, and 1353 K, and for a range of sample temperatures. The partial pressures of  $\text{Te}_2$ ,  $\text{P}_2$ , and of  $\text{PbTe}$  are extracted from the data. For  $\text{Te-saturated PbTe(c)}$ ,  $P_2$  reaches a maximum value of  $1.5$  to  $1.7 \times 10^{-2} \text{ atm}$  between 1064 and 1099 K and drops to  $2.6 \times 10^{-3} \text{ atm}$  at the 1197 K maximum melting point. (Edited author abstract) 32 refs.

Huang, Yu (Marquette Univ, Milwaukee, WI, USA); Brebrick, R.F. *J Electrochem Soc* v 135 n 2 Feb 1988 p 486-496.

**094772 PARTIAL PRESSURES AND THERMODYNAMIC PROPERTIES OF  $\text{PbTe-SnTe}$  SOLID AND LIQUID SOLUTIONS WITH 13, 20, AND 100 MOLE PERCENT  $\text{SnTe}$ .** The partial pressures of  $\text{Te}_2$ ,  $\text{PbTe}$ , and  $\text{SnTe}$  are determined for the solid solutions ( $\text{Pb}_{1-x}\text{Sn}_x\text{Te}$ ) with  $x = 0.13, 0$ , and 1.0 and for  $y$  values corresponding to  $\text{Pb-Sn}$  saturation, to  $\text{Te}$  saturation, and to compositions within the homogeneity range, as well as for the liquids forming from these solids. The partial pressures are extracted from measurements of optical absorbance of the coexisting vapor phase between 230 and 700 nm. A number of thermodynamic and phase



program data are obtained. The enthalpy of fusion of congruently melting, 50.4 a/o Te SnTe, is  $45.7 \pm 1.2$  kJ/mol. (Edited author abstract) 45 refs.

Huang, Yu (Marquette Univ, Milwaukee, WI, USA); Brebrick, R.F. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1547-1559.

## Thin films

**094773 EFFECT OF HYDROGEN ON THE ELECTRICAL PROPERTIES OF p-TYPE  $\text{Pb}_{0.8}\text{Sn}_{0.2}\text{Te}$  THIN FILMS.** D.C. conductivity and Hall Coefficient studies were made in the temperature range 77-300 K on p-type  $\text{Pb}_{0.8}\text{Sn}_{0.2}\text{Te}$  thin films exposed to molecular hydrogen gas at high pressures (150-500 PSI) for 2 h. The Hall Coefficient is found to increase with the increase in hydrogen pressure and reaches a maximum at about 250 PSI. With further increase in the gas pressure, the Hall Coefficient is found to decrease and to change its sign. Mobility however increases with the increase in the gas pressure. Hydrogen is found to stabilize the electrical properties of these films. (Author abstract) 8 refs.

Dawar, A.L. (Univ of Delhi, Delhi, India); Jagadish, C.; Shishodia, P.K.; Sharma, Sanjay; Kapoor, S.K.; Sachar, B.K.; Mathur, P.C. *J Phys Chem Solids* v 49 n 1 1988 p 113-114.

**094774 OXYGEN DIFFUSION TO THE BULK AND CRYSTALLITE BOUNDARIES IN PbTe FILMS.** Thermal oxygen diffusion to the bulk and at crystallite boundaries (CB) in PbTe films have been experimentally investigated. Ions  $\text{O}^{+}$  implanted in sub-surface layer of films served as source of diffusion to the bulk; this diffusion process was provided by annealing in vacuum. Diffusion along CB was stimulated by air annealing of the films. It was proved that changes of properties during diffusion in n-type PbTe films mainly occurred owing to localization of oxygen at CB. For investigated films oxygen diffusion constant and activation energy of the process have been obtained. (Author abstract) 8 refs.

Atakulov, Sh.B. (State Pedagogical Inst, Fergana, USSR); Kokanbaev, I.M. *Solid State Commun* v 61 n 6 Feb 1987 p 369-372.

**094775 BAND-GAP VARIATION IN TERNARY ALLOY FILMS.** Measurements of the optical absorption of thin films of  $\text{Pb}_{1-x}\text{Hg}_x\text{S}$  show a sharp increase in the optical band gap with a small addition of mercury to PbS. It is suggested that the band gap is increased in the films as a result of the formation of new conduction and valence bands. (Author abstract). 13 Refs.

Jain, Mukesh (Indian Inst of Technology, New Delhi, India). *Philos Mag Lett* v 58 n 1 Jul 1988 p 59-62.

**094776 INFLUENCE OF THE FILM HISTORY ON SOME ELECTROPHYSICAL PROPERTIES OF VE, CAD, AND COD PbSe FILMS.** The influence of the 'biography' of the PbSe films prepared by vacuum evaporation (VE) and chemical deposition selenosulfate based procedure - CAD - and selenourea based procedure - COD) on their structure, phase composition, resistivity, and photoconductivity is studied. The considered processes perturbing the film-air system are aging effects and different kinds of thermal treatments. It is evidenced that the number and the types of the active adsorption sites are the factors which differentiate between an 'as-grown' film and a film with a certain history. (Author abstract). 12 Refs.

Candea, Rodica M. (Inst of Isotopic & Molecular Technology, Cluj-Napoca, Rom); Biro, L.P.; Dadarlat, N.; Borodi, G.; Darabont, A.; Fitori, P.; Turcu, Rodica. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 233-240.

**094777 PROPERTIES OF VARIABLE BAND GAP II-VI-IV TERNARY ALLOY THIN FILMS.** Thin films of  $(\text{PbCH})_{1-x}(\text{HgCH})_x$  ( $\text{CH} = \text{S, Se and Te}$ ;  $0.07 \leq x \leq 0.93$ ) materials were deposited at different temperatures by flash evaporation. Structural and optical analyses indicate that under appropriate conditions of growth, the

films grow as single phase and the characteristics are sensitive to mercury concentration ( $x$ ) and substrate temperature. The direct optical band gap can be varied between 1.43-2.17 eV in  $\text{Pb}_{1-x}\text{Hg}_x\text{S}$ , 0.20-0.06 eV in  $\text{Pb}_{1-x}\text{Hg}_x\text{Se}$  and 0.27-0.09 eV in  $\text{Pb}_{1-x}\text{Hg}_x\text{Te}$  films by changing mercury concentration from 0.07 to 0.93. The observed characteristics of the films can be explained by considering that the new lattices form by atom-by-atom condensation of evaporated materials. (Author abstract) 13 refs.

Jain, Mukesh (Indian Inst of Technology, New Delhi, India); Sehgal, H.K. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 415-422.

Vapor Deposition See SEMICONDUCTING FILMS—Growth.

## SEMICONDUCTING LIQUIDS

### Physical Properties

**094778 SEMICONDUCTIVITY IN THE LIQUID Cu-TlTe SYSTEM.** Measurements of the electrical conductivity, the magnetic susceptibility, and the thermoelectric power for the liquid Cu-TlTe system are made in wide temperature and composition ranges. It is observed that the conductivity for the system falls abruptly at the composition of 50 mol percent Cu and the thermoelectric power changes its sign around this composition. The diamagnetic susceptibility also shows a sharp maximum at the corresponding composition. The experimental results of the present work are compared with the previous data of liquid telluride systems and are discussed in the light of current transport theories employed in amorphous and liquid semiconductors. (Author abstract). 19 Refs.

Satow, T. (Yamagata Univ, Yamagata, Jpn); Ishikawa, H.; Uemura, O. *Phys Status Solidi B* v 146 n 2 Apr 1988 p 661-669.

### Thermodynamic Properties

**094779 THERMAL EXPANSION AND STRENGTH CHARACTERISTICS OF THE INTER-ATOMIC BOND IN MELTS OF THE COMPOUNDS  $\text{Bi}_2\text{Se}_3$ ,  $\text{Sb}_2\text{Se}_3$  AND  $\text{Bi}_2\text{Te}_3$ .** A study was made of the temperature dependence of the specific volumes of bismuth and antimony chalcogenides in the liquid phase. The thermal expansion coefficients of melts of  $\text{A}_2\text{V}_3\text{VI}$  compounds were calculated at various temperatures. On the basis of these results, the characteristic Debye temperatures in the liquid phase at the melting point of each compound were estimated. It is noted that the melting process leads to a sharp increase in the thermal expansion coefficients (2.5-fold) and a decrease in the Debye temperature (1.6-fold), which attests to significant changes in the vibrational spectrum of atoms of  $\text{A}_2\text{V}_3\text{VI}$  compounds during the crystal-melt phase transition. In Russian. 11 refs.

Glazov, V.M.; Shchelikov, O.O. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 8 Aug 1987 p 1275-1277.

Thermodynamics See SEMICONDUCTING SILICON—Growth.

## SEMICONDUCTING MANGANESE COMPOUNDS

### Electric Conductivity

**094780 HIGH-TEMPERATURE ELECTRICAL TRANSPORT PROPERTIES OF MANGANESE TELLURIDE.** Electrical conductivity, thermoelectric power and dielectric constant of polycrystalline manganese telluride ( $\text{MnTe}$ ) have been measured in the temperature range 300-100 K, using pressed pellets of powdered samples.  $\text{MnTe}$  shows semiconducting behavior in the entire temperature range studied. It exhibits extrinsic conduction up to 600 K but is intrinsic in nature above 600 K. Low mobility of the charge carriers ( $\mu \approx 10^{-2}$

$-10^{-3} \text{ cm}^2 \text{ V}^{-1} \text{ s}^{1/2}$ ) and low value of the mean free path (0.039 Å) in the intrinsic region (600-1000 K) indicate localization of the charge carriers, due to strong electron-phonon interaction. (Author abstract) 25 refs.

Yadava, Y.P. (Indian Inst of Technology, Kanpur, India). *Mater Lett* v 6 n 8-9 May 1988 p 297-302.

**094781 RESISTIVITY CHANGE OF  $\gamma\text{-MnO}_2$  IN A  $\text{H}_2/\text{Ar}$  MIXED GAS ATMOSPHERE.** In the present letter a change in resistivity of unexpected direction in  $\gamma\text{-MnO}_2$  with N-type semiconduction behaviour in the  $\text{H}_2/\text{Ar}$  mixed gas atmosphere is reported. The anomalous behaviour of the  $\text{H}_2$ -gas sensing of  $\gamma\text{-MnO}_2$  was found to be due to  $\gamma\text{-MnO}_2$  behaving in reverse to a normal N-type semiconductor, showing a resistivity increase in the reducing mixed gas  $\text{H}_2/\text{Ar}$ , contrary to its polymorph  $\gamma\text{-MnO}_2$ . As for the practical application, the reactive behaviour of excellent gas sensing is to be expected for a gas sensor. 4 refs.

Li, Jian-Bao (Univ of Tokyo, Jpn); Koumoto, Kunihito; Yanagida, Hiroaki. *J Mater Sci Lett* v 7 n 4 Apr 1988 p 331-334.

### Magnetic Properties

**094782 NEAREST NEIGHBOR EXCHANGE CONSTANTS IN  $\text{Hg}_{1-x}\text{Mn}_x\text{Te}$ ,  $\text{Hg}_{1-x}\text{Mn}_x\text{Se}$  AND OTHER SEMIMAGNETIC SEMICONDUCTORS.** High field magnetization experiments ( $B \leq 35$  T) have been performed at 1.8 K in  $\text{Hg}_{1-x}\text{Mn}_x\text{Te}$  ( $x=0.056$ ) and  $\text{Hg}_{1-x}\text{Mn}_x\text{Se}$  ( $x=0.0650$ ). At  $B > 6$  T the magnetization exhibits step-like increases due to the magnetic field alignment of the antiferromagnetically coupled nearest neighbor Mn pairs and triangles. A theoretical fit of the magnetization curves provide a determination of NN exchange constants  $J_{\text{NN}}/k_B = (-5.1 \pm 0.5)$  K for  $\text{Hg}_{1-x}\text{Mn}_x\text{Te}$  and  $J_{\text{NN}}/k_B = (-6 \pm 0.5)$  K for  $\text{Hg}_{1-x}\text{Mn}_x\text{Se}$ . Analysis of all the presently available  $J_{\text{NN}}$  values for semimagnetic semiconductors is presented and the observed trends and discrepancies are discussed. (Author abstract) 27 refs.

Galazka, R.R. (Polish Acad of Medicine, Warsaw, Pol); Dobrowolski, W.; Lascary, J.P.; Nawrocki, M.; Bruno, A.; Broto, J.M.; Ousset, J.C. *J Magn Magn Mater* v 72 n 2 Apr 1 1988 p 174-180.

### Thin Films

**094783 SOLUTION GROWTH TECHNIQUE FOR THE DEPOSITION OF MANGANESE SULPHIDE THIN FILM.** Thin films of  $\text{MnS}$  were deposited by the solution growth technique using manganese acetate, triethanolamine, hydrazine, thioacetamide and ammonium chloride. Using x-ray diffraction, the film was shown to be amorphous. The optical band gap was found to be  $5.2 \times 10^{-19}$  J (3.25 eV). The activation energy of electrical conduction was observed to be  $2.4 \times 10^{-19}$  J (1.5 eV). The films were found to be p type using the thermoelectric probe method. The room temperature conductivity was found to be  $1.26 \times 10^{-5} \text{ S cm}^{-1}$ . The bath parameters were studied to optimize the film thickness. The terminal thickness of 260 nm is reached after  $2.88 \times 10^4$  s. (Author abstract) 13 refs.

Pramanik, P. (Indian Inst of Technology, Kharagpur, India); Akhter, M.A.; Basu, P.K. *Thin Solid Films* v 158 n 2 Apr 1988 p 271-275.

## SEMICONDUCTING ORGANIC COMPOUNDS See Also PHOTOCONDUCTING MATERIALS; TRANSISTORS, FIELD EFFECT—Thin Films.

**094784 APPLICATION OF PHOSPHINE TELLURIDES TO THE PREPARATION OF GROUP II-VI (2-16) SEMICONDUCTOR MATERIALS.** In order to find low-temperature routes to metal tellurides, we have investigated some of the reactions of phosphine tellurides. Via the phosphine telluride, tellurium is chemically transported by  $\text{PM}_3$  under very mild conditions. Triethylphosphine telluride reacts with Hg at room temperature and with  $\text{HgR}_2$  ( $\text{R} = \text{Et, Ph}$ ) at  $115^\circ\text{C}$ , in each case giving



HgTe as the sole solid-state product. We studied the reaction with  $\text{HgPh}_2$  in greater detail, showing that  $\text{Ph}_2\text{Te}$  and  $\text{Ph}_2\text{Te}_2$  are the major organic products. (Edited author abstract) 12 refs.

Steigerwald, M.L. (AT&T, Murray Hill, NJ, USA); Sprinkle, C.R. *Organometallics* v 7 n 1 Jan 1988 p 245-246.

## Charge Carriers

**094785 CARRIER DRIFT MOBILITIES IN SOME ORGANIC SOLIDS. A SEARCH FOR ORGANIC PHOTOVOLTAIC MATERIALS. II. CHARGE TRANSPORT CALCULATIONS IN s-TETRAZINE AND 4-PHENYLAZOAZOBENZENE.** Excess electron and excess hole mobilities of S-tetrazine and 4-phenylazoazobenzene are calculated using the tight binding approximation with SCF-AOs as a basis set. The applicability of the band model in these organic solids is discussed in the light of Munn and Siebrand's theory of charge transport in organic solids. The results show that these two organic solids may be good candidate materials for organic photovoltaic devices. (Author abstract) 19 refs.

Kumar, B. (Devi Ahilya Univ, Indore, India). *Phys Status Solidi B* v 143 n 2 Oct 1987 p 663-673.

## Electric Conductivity

**094786 TETRAKIS(METHYLTELURIO)TETRAETHIAFULVALENE ( $\text{TTeC}_4\text{-TTF}$ ), A HIGH-MOBILITY ORGANIC SEMICONDUCTOR.** The authors have found a class of highly conductive single-component organic semiconductors - the tetrakis(alkylthio)tetrathiafulvalenes - and have given these systems on the descriptive title of 'molecular fastener'. In a program to synthesize single-component molecular assemblies with high conductivity, they then discovered a new organic semiconductor, tetrakis(alkyltelluro)tetrathiafulvalene with an electric resistivity of  $8.1 \times 10^4$  ohm-cm and a high charge mobility,  $20\text{-}30 \text{ cm}^2 \text{V}^{-1} \text{s}^{-1}$ . This unusually low resistivity is explained in terms of the molecular packing and the manner of stacking within the crystal. (Edited author abstract) 11 refs.

Inokuchi, H. (Inst for Molecular Science, Okazaki, Jpn); Imaeda, K.; Enoki, T.; Mori, T.; Maruyama, Y.; Saito, G.; Okada, N.; Yamochi, H.; Seki, K.; Higuchi, Y.; Yasuoka, N. *Nature* v 329 n 6134 Sep 3-9 1987 p 39-40.

## Electric Properties

**094787 LOW DIMENSIONAL MOLECULAR SEMICONDUCTOR: THE RADICALAR BIS-PHTHALOCYANINATO LUTETIUM  $\text{Pc}_2\text{Lu:CHD 2Cl}_2$ .** Crystals of solvate bisphthalocyaninato-lutetium,  $\text{Pc}_2\text{Lu:CH}_2\text{Cl}_2$ , are shown to be intrinsic molecular semiconductors ( $\sigma_{R,T} = 6 \times 10^{-5} \Omega^{-1}$ ,  $E(\text{act.}) = 0.32 \text{ eV}$ ). Both crystallographic determinations and magnetic properties demonstrate the one-dimensional character of this radicalar material. While dioxygen has drastic and reversible effects on the magnetic properties, it has not any one on transport properties. This is characteristic of spin coupling between the adsorbed oxygen and the radicalar host molecule,  $\text{Pc}_2\text{Lu:CH}_2\text{Cl}_2$ . (Author abstract) 28 refs.

Petit, P. (Inst Charles Sadron, Strasbourg, Fr); Holczner, K.; Andre, J.-J. *J Phys (Paris)* v 48 n 8 Aug 1987 p 1363-1367.

**094788 BARRIER HEIGHTS AND INTERFACE STATES OF METAL/2, 4, 7-TRINITRO-9-FLUORENONE THIN FILM CONTACTS.** The purpose of this note is to present experimental results of determining the barrier height of contacts formed between Al, Cr, Ni, Cu, Ag, and Au and vacuum evaporated 2, 4, 7-trinitro-9-fluorenone (TnF) thin films. Plotting the measured barrier height against the metal electronegativity shows excellent correlation. The barrier height proportionally changes with the metal electronegativity, and the best-fit straight line to the plot has a slope of 0.75 which is numerically in good agreement with the value of  $E_g$

/3.5 = 0.76. This suggests that the contacts also related to the class of metal nonmetal contacts in which the interface states of MOIS type play a dominant role in Schottky barrier formation at metal-nonmetal interfaces. 5 refs.

Chot, T. (Cent for Scientific Research of Vietnam, Hanoi, Vietnam); Xuan, N.N.; Minh, L.Q. *Phys Status Solidi A* v 105 n 2 Feb 1988 p K121-K124.

**Electronic Properties** See ORGANOMETALLICS—Electric Properties; SEMICONDUCTING POLYMERS—Structure.

**Molecular Structure** See ORGANOMETALLICS—Synthesis.

**Optical Properties** See Also POLYACETYLENES—Optical Properties; SALTS—Optical Properties.

**094789 LUMINESCENCE AND RELAXATION OF ENERGY IN DISORDERED ORGANIC AND INORGANIC MATERIALS.** We consider the properties of excitons at and below the mobility edge where the stochastic Master equation approach is valid. An analogous formulation can be given before  $\epsilon_c$ . Takagahara has considered the relaxation of band excitons in quantum wells. For excitons diffusing in localized states, we can define an effective pair localized state. This description applies to a large category of problems and has in each case to be analyzed individually. Let us consider the case where the models are appropriate; this would, for example, apply to excitons in QWs and organic materials. 32 refs.

Movaghar, B. (GEC Research Lab, Wembley, Engl); Gruenewald, M.; Ries, B. *Disord Semicond Publ* by Plenum Press, New York, NY, USA and London, Engl, 1987 p 723-743.

**Physical Properties** See Also ORGANIC COMPOUNDS—Magnetic Field Effects.

**094790 PHYSICAL, THERMAL AND OPTICAL CHARACTERIZATION OF RHODIUM(III) ACETYLACETONATE.** Rhodium(III) acetylacetonate was investigated for its physical, thermal and optical properties. Ultraviolet-visible absorption spectra show absorptions at 320 nm, 260 nm, and 210 nm. Density measurements yielded a value of  $1.75 \text{ g/cm}^3$ . Thermal characteristics were evaluated using differential thermal analysis (DTA). It was found that the compound is not volatile, decomposing upon heating. If heating rates are rapid enough, e.g.  $> 2^\circ\text{C/min}$ , melting at  $267^\circ\text{C}$  can be observed. If heating rates are slower, decomposition is complete before the melting point. If the compound is annealed at  $267^\circ\text{C}$  for four hours decomposition is complete, yielding 99% pure rhodium metal. In an oxidizing atmosphere, on the other hand, the compound decomposes into a product containing 75% rhodium metal which appears to be  $\text{RhO}_2$ . (Author abstract) 13 refs.

Poston, S. (North Carolina State Univ, Raleigh, NC, USA); Reisman, A. *J Electron Mater* v 17 n 1 Jan 1988 p 57-61.

**094791 VALENCE BAND DENSITY-OF-STATES IN 7,7',8,8' TETRACYANOQUINODIMETHANE.** XPS measurements have been performed on the organic semiconductor TCNQ in order to have a measure of the valence band density of states. Agreement has been found between experimental and theoretical results obtained by means of a CNDO calculation. The high-lying  $\pi$ -orbitals of TCNQ have been assigned to a set of hybridized molecular states of carbon (mainly) and nitrogen p-like atomic character. (Edited author abstract) 33 refs.

Girlanda, R. (CNR, Messina, Italy); Martino, G.; Mezzasalma, A.M.; Mondio, G.; Saitta, G. *Solid State Commun* v 60 n 11 Dec 1986 p 873-876.

## Radiation Effects

**094792 PHOTOPLASTIC EFFECT IN ORGANIC SEMICONDUCTORS: ANTHRACENE AND NAPHTHALENE.** A detailed study has been made on many

features of the photoplastic effect in anthracene crystals doped with tetracene. PPE measurements have been made on naphthalene crystals, which have the same monoclinic structure as anthracene. (Author abstract) 21 refs.

Kojima, K. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 99-103.

**Thin Films** See Also SEMICONDUCTING LEAD COMPOUNDS—Growth.

**094793 INVESTIGATION OF CONDUCTIVITY IN METAL-SUBSTITUTED PHTHALOCYANINE LANGMUIR-BLODGETT FILMS.** Conductivity data for Langmuir-Blodgett films of cobalt, nickel, copper and zinc tetracumylphenoxy phthalocyanine complexes are presented as well as the changes in conductivity of the films induced by exposure to ammonia. An explanation is given for these results, supported by discrete variational X- $\alpha$  calculations of simple cobalt, nickel, copper and zinc phthalocyanine complexes and on calculations of these metals complexed with tetraazaporphyrin and ammonia. It was found that to some extent the conductivity can be correlated with the energy gap between the highest occupied and lowest unoccupied orbitals. (Author abstract) 29 refs.

Kutzler, Frank W. (US Naval Research Lab, Washington, DC, USA); Barger, William R.; Snow, Arthur W.; Wohltjen, Hank. *Thin Solid Films* v 155 n 1 Dec 15 1987 p 1-16.

**SEMICONDUCTING POLYMERS** See Also COPOLYMERS—Theory; POLYACETYLENES; POLYMERS—Conductive; POLYMERS—Synthesis.

**094794 ELECTRONIC STRUCTURE OF POLYISONAPHTHOTHIOPHENE: DESIGN OF A NEW CONJUGATED ORGANIC POLYMER.** Ab initio band structure results of polyisobenzothienophene (PINTP) are presented. Comparison of its electronic properties such as band gap, ionization potential and electron affinity with those of polyisobenzophenethene (PITN) and polythiophene (PTP) indicates PINTP to be the best intrinsic electrical conductor of these three polymers. PINTP is also predicted to be the most dopant-philic of them. The effect of the hetero substitution and the substitution at the naphthalene ring on the conduction properties of PINTP is also discussed. (Author abstract) 25 refs.

Bakhshi, A.K. (Friedrich-Alexander Univ Erlangen-Nuernberg, Erlangen, West Ger); Ladik, J. *Solid State Commun* v 63 n 12 Sep 1987 p 1157-1160.

**094795 ELECTRICAL PROPERTIES OF MOS AND MIS DIODES USING AN ELECTROCHEMICALLY PREPARED POLY(N-METHYLPYRROLE).** Organic semiconductor devices using electrochemically prepared poly(N-methylpyrrole) (PNP) were characterized by capacitance-voltage (C-V) measurements. A device with aluminum evaporated on the PNP behaved as a MOS (metal-oxide semiconductor) diode in vacuum. Assuming the oxide layer between the metal and the PNP to be pure  $\text{Al}_2\text{O}_3$ , the MOS parameters were calculated. The values obtained for depletion width  $W = 166 \text{ angstrom}$  and acceptor density  $N_A = 10^{18} \text{ cm}^{-3}$  in the PNP were reasonable by comparison with the previously reported values obtained by Schottky analysis. An indium/poly(p-phenylene)-1,3,4-oxadiazole (POD)/PNP diode was prepared, and C-V measurements were carried out in air. The diode behaved like an MIS (Metal-insulator semiconductor) device, but the characteristics showed large variation with frequency. We have proposed a schematic model for this mechanism on the basis of the results obtained by dielectric measurements of POD and the temperature dependence of the MIS characteristics. (Author abstract) 20 refs.

Tsunoda, S. (Mitsubishi Electric Corp, Amagasaki, Jpn); Koezuka, H.; Kurata, T.; Yanaura, S.; Ando, T. *J Polym Sci Part B* v 26 n 8 Aug 5 1988 p 1697-1710.



**Amorphous**

**094796 STRUCTURAL AND ELECTRONIC PROPERTIES OF POLYMERIC AMORPHOUS SEMICONDUCTORS  $Si_{1-x}C_x:H$ .** Preparation of polymeric hydrogenated amorphous semiconductors and their structural and electronic properties are discussed. These polymeric films  $Si_{1-x}C_x:H$  are situated between hydrogenated amorphous silicon films and polyacetylene. (Author abstract) 17 refs.

Nitta, S. (Gifu Univ, Gifu, Jpn); Nonomura, S.; Takagi, R.; Kojima, N.; Yasuda, A. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 469-478.

**Applications** See BIOSENSORS—Glucose Sensors; SEMICONDUCTOR DIODES—Research.

**Bonding**

**094797 DEVELOPMENT OF COPPER WIRE BONDING FOR PLASTIC MOULDED SEMICONDUCTOR PACKAGES.** Comparative studies of wire materials (impurities) as well as fundamental researches about the technology of the wire bonding process employing copper, aluminum, or silver have been made in the past several years. Against this background, the authors took note of the fact that the diffusion rate at the bonds between copper wire and aluminum pads is very slow as compared with that at conventional gold and aluminum bonds, and carried out research and development work on copper wire bonding but using a bonding machine designed for gold wire. Ball formation and ball bonding were the major subjects of development. In English and French. 7 refs.

Okuda, T. (Manufacturing Development Lab, Amagasaki, Jpn); Machida, K.; Hirota, J.; Yamamoto, I.; Kawanaka, R.; Shimotomai, M. *Weld World Soudage Monde* v 25 n 3-4 1987 p 46-53.

**Charge Carriers**

**094798 THERMALLY STIMULATED SURFACE POTENTIAL DECAY IN HDPE AND THE CROSS-OVER PHENOMENON.** The field strength dependence of thermally stimulated charge decay (TSCD) from corona charged high-density polyethylene (HDPE) was studied in the high temperature region above room temperature up to the melting point. The studies reveal the existence of a deep surface trap as well as a shallow and a deep bulk trap. Charge release from the deep bulk trap is enhanced by high electric fields and gives rise to a cross-over in surface potential decay curves. (Author abstract)

von Berlepsch, H. (Akad der Wissenschaften der DDR, Teltow-Seehof, East Ger); Pinnow, M. *Phys Status Solidi A* v 105 n 2 Feb 1988 p 485-492.

**094799 HOLE TRANSPORT IN CORONA-CHARGED  $12 \mu m$  SHELDAHL FEP SAMPLES INTERPRETED THROUGH A FIELD-DEPENDENT SCHUBWEG MODEL.** Potential build up and decay curves for positive corona charged Sheldahl FEP foils were measured and interpreted using the conventional field-dependent schubweg and a trap structure with shallow traps at the polymer surface (mean life time of  $10^3$  s) and quasi-deep traps (mean detrapping time of  $7 \times 10^3$  s) in the bulk. For this trap, only the product of the mobility by the trapping time is relevant (of the order of  $10^{-10} cm^2/V$ ). Comparison between measurements in pure  $N_2$ , dry air, and ambient air demonstrates that moisture has a not negligible effect on charge transport, decreasing the surface potential. Holes trapped at the surface are located a little beneath the polymer surface. (Edited author abstract) 18 refs.

Ferreira, G.F. Leal (Univ de Sao Paulo, Sao Carlos, Braz); Oliveira, O.N. Jr. *Phys Status Solidi A* v 105 n 2 Feb 1988 p 531-539.

**Doping** See Also BAND STRUCTURE—Calculations; POLYACETYLENES—Doping.

**094800 ION IMPLANTATION DOPING AND ELECTRICAL PROPERTIES OF HIGH-TEMPERATURE LADDER POLYMERS.** We report the first ion implantation doping studies on high-temperature ladder polymers and show that insulating films of the benzimidazobenzophenanthroline type ladder polymer (BBL) can be doped by boron, argon, and krypton implantation to conductivities as high as  $224 S/cm$  at a dose of  $4.0 \times 10^{16}/cm^2$  while retaining the excellent mechanical properties of the pristine films. Effects of dose (ions/ $cm^2$ ) and beam current density (microamps/ $cm^2$ ) on electrical conductivity at fixed ion energies are reported. The temperature dependence of the conductivity indicates that the implanted ladder polymer films are semiconductors. Spatially selective implantation, creating regions of conducting lines in an insulating matrix, which suggests microelectronic device applications of the ladder polymers, is demonstrated. (Author abstract) 14 refs.

Jenekhe, Samson A. (Honeywell Inc, Bloomington, MN, USA); Tibbetts, Stanley J. *J Polym Sci Part B* v 26 n 1 Jan 1988 p 201-209.

**094801 DIFFUSION PROCESSES IN THE DOPING OF POLYMER FILMS.** A critical review is presented of the various diffusion models and the associated experimental techniques that have been put forth to describe the mass transfer limitations on the overall processes by which polymer films are doped to develop enhanced electrical conductivity. The discussion emphasizes comparative features and their connections with data interpretation. The strengths and weaknesses associated with particular approaches are stressed in order to explain the wide range of diffusion coefficients reported by the many prior investigators, and to suggest further steps that may eventually resolve some contradictions and provide a more satisfactory understanding of the doping and undoping processes for conductive polymers. (Author abstract). 19 Refs.

Perlmutter, Daniel D. (Univ di Roma 'La Sapienza', Rome, Italy); Scrosati, Bruno. *Solid State Ionics* v 27 n 3 Jul 1988 p 115-123.

**Electric Conductivity**

**094802 FREQUENCY-DEPENDENT CONDUCTIVITY IN POLYANILINE.** Frequency(f) and temperature(T) dependence of electrical conductivity  $\sigma(f, T)$  and optical spectrum in polyaniline are presented. The behavior of  $\sigma(f, T)$  at low protonation levels is the same as the lightly doped polypyrrole. These results can be described by the slightly modified Kivelson model, that is, the interpolation hopping between the polaron and bipolaron. The behavior of  $\sigma(f, T)$  in highly protonated polyaniline is the same as in disordered semiconductors. (Author abstract) 19 refs.

Hayashi, Takafumi (Univ of Tokyo, Tokyo, Jpn); Hirai, Yoshinori; Tanaka, Hajime; Nishi, Toshio. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1800-1802.

**Electric Properties**

**094803 PHOTO-ELECTRICAL CHARACTERISTICS OF SEMICONDUCTING POLYMER P3MT/ELECTROLYTE INTERFACE AND CATALYSIS OF Pt ATOMS ON P3MT SURFACE.** The transient and static photoelectrical characteristics of one-dimensional semiconducting polymer poly(3-methyl thiophene)-P3MT/electrolyte and GaAs/electrolyte interfaces are reported. The differences between them have been observed; they result from the differences of energy band structure, elementary excitation state and the property of dopant. The catalysis of Pt atoms, which are plated on the P3MT surface by a photoelectrochemical method, has been observed and the optimum density of Pt atom has been found. The result of surface Auger spectrum analysis of Pt plated P3MT sample is reported. (Author abstract) 10 refs. In Chinese.

Yuan, R.K. (Nanjing Univ, Nanjing, China); Huang, Z.C.; Peramunage, D.; Tomkiewicz, M.; Ginley, D.S. *Pan Tao T'i Hsueh Pao* v 9 n 2 Mar 1988 p 156-162.

**094804 STUDIES OF SEMICONDUCTING ORGANIC POLYMER-GRAPHITE COMPOSITES FROM D.C. TO MICROWAVE FREQUENCIES.** The samples are mixtures consisting of particles of graphite dispersed within a matrix of a doped substituted polyacetylene. The electrical impedance spectra are discussed in terms of inhomogeneity and intrinsic contributions. The frequency dependence of the a.c. conductivity and permittivity has been measured at frequencies between 10 kHz and 12 GHz. The ac conductivity is given by the power-law relation  $\sigma(\omega) \propto \omega^n$  with  $0 < n < 0.4$  at frequencies below 30 MHz,  $0.5 < n < 1$  at frequencies between 30 MHz and 2 GHz and  $1 < n < 2$  at frequencies between 2 GHz and 8 GHz. A saturation occurs at approximately 8 GHz. Various theoretical approaches are presented in order to support such behavior. (Author abstract) 29 refs.

Fourrier-Lamer, A. (Univ Paris VI, Paris, Fr); Fizazi, A.; Belhadj-Tahar, N.; Fontanille, A.; Soum, A. *Synth Met* v 24 n 1-2 Apr 1988, Proc of the Second Fr-Pol Colloq on Low Dimens Org Conduct and Electroactive Polym, Nancy, Fr, May 12-15 1987 p 95-105.

**Electrodeposition**

**094805 APPLICATION OF SUPERCONDUCTING CERAMICS AS SUBSTRATES FOR THE ELECTROCHEMICAL DEPOSITION OF CONDUCTING POLYMERS AND METALS.** Superconducting ceramics of  $Y_1Ba_2Cu_3O_{8-\delta}$  are studied as electrode substrates for electrochemical deposition of conducting polymers (polythiophene, polypyrrole) and metals (Cu, Ag). The superconductivity of the ceramics is found to be insensitive to the electrochemical processes, and even to exposure to iodine vapor and  $\gamma$ -ray irradiation up to 100 Mrad. (Author abstract) 13 refs.

Kaneto, Keiichi (Osaka Univ, Suita, Jpn); Yoshino, Katsumi. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1842-1844.

**Electronic Properties**

**094806 ON THE ELECTRONIC STRUCTURE OF POLYTHIENEO [3,4-C] THIOPHENE: A POLYMER WITH VERY SMALL BAND GAP.** Results of ab initio band structure calculations aimed at designing an intrinsic electrically conducting polymer are presented. The electronic structure and conduction properties of a polythiophene derivative, polythieno [3, 4-C] thiophene (PTTP) obtained by fusing another thiophene ring on the  $\beta$ - $\beta'$  bond of each backbone thiophene ring of polythiophene are investigated. The results show that in comparison to polythiophene and its other derivatives, PTTP has (i) the smallest band gap (scaled theoretical value of 0.5 eV) and (ii) greater tendency to form conducting materials on doping with both electron acceptors and electron donors. The effect of hetero substitution and the substituent at the carbon skeleton on the conduction properties of PTTP is discussed. (Edited author abstract) 17 refs.

Bakhshi, A.K. (Univ of Delhi, New Delhi, India); Ladik, J. *Solid State Commun* v 65 n 10 Mar 1988 p 1203-1206.

**Microscopic Examination**

**094807 HIGH-RESOLUTION ELECTRON MICROSCOPY OF SOLUTION-GROWN CRYSTALS OF POLY(p-PHENYLENE SULPHIDE).** Crystals of poly(p-phenylene sulfide) were obtained from an  $\alpha$ -chloronaphthalene solution. The chain axis (the crystal c-axis) was usually normal to the support film. High resolution electron microscopic images were taken as the projection of the molecular chains on the ab plane along the chain axis. Occasionally it was observed that crystals took different orientations on the support film for undefined reasons. From such orientations, the high resolution image of a crystal rotated by  $28.7^\circ$  around the a-axis from the usual orientation was obtained. (Author abstract) 14 refs.



Uemura, Akio (Kyoto Univ, Uji, Jpn); Tsuji, Masaki; Kawaguchi, Akiyoshi; Katayama, Ken-Ichi. *J Mater Sci* v 23 n 4 Apr 1988 p 1506-1509.

## Optical Properties

**094808 PHOTO-EXCITATION IN CONJUGATED POLYMERS.** Conjugated polymers such as polyacetylene form a group of model semiconductors in which the 'one-dimensional' character of the polymer strongly modifies the behavior of charges added to the chains from that usually observed in three-dimensionally bonded semiconductors. The motion of charged excitations is highly anisotropic, with strong confinement to the chain through the 'polaronic' structural relaxation of the chain. This anisotropy strongly affects charge transport and charge separation following photo-excitation. In this paper we some of the recent work in this area and we present polarization-dependent measurements of photoluminescence (PL) and photo-induced absorption (PA) on highly oriented films of polyacetylene and poly(phenylenevinylene). (Edited author abstract) 94 refs.

Friend, R.H. (Cavendish Lab, Cambridge, Engl); Bradley, D.D.C.; Townsend, P.D. *J Phys D* v 20 n 11 Nov 14 1987, Pap Presented at the Polym Phys Group Meet on Electroact Polym, London, Engl, May 14 1987 p 1367-1384.

**Phase Transitions** See POLYACETYLENES—Phase Transitions; POLYMERS—Solutions.

## Photoconductivity

**094809 DYNAMICS OF PHOTOGENERATED SOLITONS IN TRANS-POLYACETYLENE.** Time-resolved absorption using pole wavelengths of 2.5-5.5  $\mu\text{m}$  has been used to study photoexcitations in the quasi-one-dimensional semiconductor, trans-polyacetylene. Present apparatus has 0.5-ps resolution, which is sufficient to observe the decay of the photogenerated charged soliton pairs which form after intrachain excitation of electron-hole pairs. The tunability of the apparatus permits the unambiguous identification of solitons and observation of spectral relaxation during their formation. 21 refs.

Rothberg, L. (AT&T Bell Lab, Murray Hill, NJ, USA); Jedju, T.M.; Etemad, S.; Baker, G.L. *IEEE J Quantum Electron* v 24 n 2 Feb 1988 p 311-314.

**Physical Properties** See ACETYLENE—Electric Conductivity; SEMICONDUCTING FILMS—Doping.

**Radiation Effects** See PLASTICS FILMS—Electrochemistry.

**Research** See Also POLYMERS—Electric Conductivity.

**094810 RECENT DEVELOPMENTS IN ELECTRO-ACTIVE POLYMERS.** Electro-active polymers may be defined as those polymers whose properties allow them to play an active role in the carrying, controlling, generation or utilization of electric currents. This includes intrinsically conducting, piezoelectric, electro-optic materials, and so on, but not polymers in their more traditional electrical use as insulators, important though their electrical properties are for the application. (Author abstract) 16 refs.

Brook, M.G. (Yarsley Technical Cent, Surrey, Engl). *Plast Rubber Process Appl* v 8 n 4 1987 p 235-238.

## Structure

**094811 STRUCTURE AND ELECTRONIC PROPERTIES OF POLYANILINE.** Degree of protonation and oxidation dependence of the spin-lattice relaxation time  $T_1$  ( $^1\text{H-NMR}$ ),  $^{13}\text{C-NMR}$  spectrum, FT-IR spectrum for polyaniline are presented. It is concluded that benzoid rings in the chain are transformed into quinoid rings by oxidation, and in oxidized polyaniline the degree of localization of electrons is dominated by the degree of protonation. (Author abstract) 11 refs.

Hayashi, Takafumi (Univ of Tokyo, Tokyo, Jpn); Hirai, Yoshinori; Tanaka, Hajime; Nishi, Toshio. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1803-1805.

## Synthesis

**094812 SYNTHESIS AND STUDIES OF POLY(3,9-CARBAZOLYL), A NEW CONDUCTIVE POLYMER DISPLAYING HIGH OPTICAL TRANSMITTANCE IN THE VISIBLE.** A polycarbazole consisting mostly of 3,9 linkages has been synthesized in a DMF solution by coupling 3,6-diiodocarbazole with an activated copper catalyst. Although this polymer cannot be oxidized by  $\text{I}_2$ , other acceptors such as iodine monochloride or NO will convert it to a p-type semiconductor with a conductivity as high as  $1\text{ ohm}^{-1}\text{ cm}^{-1}$ . A unique property of the oxidized polymer complex is that it displays a maximum transmittance in the visible at 600 nm and a broad near-i.r. band at 2300 nm. A large shift of the long-wavelength absorbance of the radical cation on the 3,9-linked polymer versus that found on the carbazole monomer suggests that a significant number of adjacent carbazole units are close to planarity. This must provide a significant pathway for electronic transport. (Edited author abstract) 26 refs.

Racchini, Joel R. (Univ of Minnesota, Minneapolis, MN, USA); Wellenhoff, Stephen T.; Schwab, Stuart T.; Herrera, Carlos D.; Jenekhe, Samson A. *Synth Met* v 22 n 3 Jan 1988 p 273-290.

**094813 CONDUCTING-POLYMER ELECTRONICS.** Polymers with electrical conductivities as good as those of metals are well known, but have yet to replace conventional electronic components because of difficulties in preparing and manipulating them. The development of soluble precursor polymers which can be unified and manipulated before being converted into a conductive form has invigorated the field. By using polyacetylene prepared by such a route, a research team at the Cavendish Laboratory in Cambridge has succeeded in fabricating polymeric semiconductor devices, transistors and diodes with characteristics superior to any previously reported. These devices operate via mechanisms intrinsically different from those in conventional semiconductor devices. Although the results obtained by this research team do not yet pose a threat to establish semiconductor technology, they offer the prospect of novel devices which cannot be constructed with conventional semiconductors.

Bloor, David (Queen Mary Coll, London, Engl). *Nature* v 335 n 6186 Sep 8 1988 p 115-117.

**094814 NEW SEMICONDUCTOR DEVICE PHYSICS IN POLYMER DIODES AND TRANSISTORS.** Semiconductor devices have been made from polyacetylene, a conjugated polymeric semiconductor. The device operates in a novel way: charge is stored in localized soliton-like excitations of the polymer chain, which are introduced not by doping or photoexcitation but by the presence of a surface electric field. The formation of charged solitons changes the optical properties of the polymer, introducing optical absorption below the band gap. Combined with the processibility of the polymer, these new electrooptical effects may be exploited technologically in electrooptical modulators. (Edited author abstract) 22 Refs.

Burroughes, J.H. (Cavendish Lab, Cambridge, Engl); Jones, C.A.; Friend, R.H. *Nature* v 335 n 6186 Sep 8 1988 p 137-141.

**Thin Films** See Also PROPORTIONAL COUNTERS—Materials.

**094815 ELEKTRISCHE EIGENSCHAFTEN SILBERHALTIGER GLIMMPOLYMERSCHICHTEN.** [Electric Properties of Glow Discharge Polymer Films Containing Silver Particles]. Composite glow polymer thin films containing silver particles have been produced by means of parallel glow polymerization and metal vaporization. TEM photographs show the three structural regions present. The structure of the test samples changes upon heating the test samples in a vacuum. Tunnel

conduction appears between metal islands separated from one another. The activation energy was determined experimentally from electric measurements as well as from the cluster size and cluster spacing. (Translated author abstract) 13 refs. In German.

Heilmann, Andreas; Kampfrath, Gerit; Schwab, Toralf; Van, Do Ngoc. *Wiss Z Tech Univ Karl Marx Stadt* v 29 n 2 1987 p 263-268.

## SEMICONDUCTING SAMARIUM COMPOUNDS

### Elasticity

**094816 TEMPERATURE DEPENDENCE OF ELASTIC PROPERTIES OF  $\text{Sm}_{1-x}\text{Gd}_x\text{S}$  SINGLE CRYSTALS IN THE VICINITY OF THE —BLACK-GOLD— PHASE TRANSITION.** The temperature dependences of Young's modulus  $E_{100}$  and the lattice parameter have been studied in the temperature range 20 to 1000°C on  $\text{Sm}_{1-x}\text{Gd}_x\text{S}$  crystals with  $x=0$ , 0.14, and 0.18. The Gd concentration in the alloys was close to the critical one ( $x_c=0.16$ ). Under normal conditions a crystal of composition with  $x=0.14$  was in the black (semiconducting) phase whereas a crystal of composition with  $x=0.18$  was in the gold (metallic) phase. Young's, and shear moduli were measured by the resonance method. 11 refs.

Nikanorov, S.P. (USSR Acad of Sciences, Leningrad, USSR); Burenkov, Yu.A.; Lebedev, A.B.; Golubkov, A.V.; Zhukova, T.B.; Smirnov, I.A. *Phys Status Solidi A* v 105 n 2 Feb 1988 p K103-K106.

### Phase Transitions

**094817 SEMICONDUCTOR-METAL PHASE TRANSITION UNDER UNIAXIAL COMPRESSION OF  $\text{Sm}_{1-x}\text{Gd}_x\text{S}$  SINGLE CRYSTALS.** In SmS under a hydrostatic pressure of  $P_c=650\text{ MPa}$  a valency transition has been observed retaining the NaCl-type lattice and implying an essential reduction in the lattice constant. There are data stating that a similar transition in SmS and  $\text{Sm}_{0.85}\text{Gd}_{0.15}\text{S}$  can occur under uniaxial compression. The note deals with some peculiarities of such a transition in  $\text{Sm}_{0.86}\text{Gd}_{0.14}\text{S}$  crystals. The nuclei of the new phase appear due to stress concentrations at the specimen ends and their development takes place by the motion of misfit dislocations under the action of external stress. 8 refs.

Golubkov, A.V. (USSR Acad of Sciences, Leningrad, USSR); Egorov, V.M.; Orlova, T.S.; Sergeeva, V.M.; Smirnov, B.I.; Smirnov, I.A. *Phys Status Solidi A* v 105 n 2 Feb 1988 p K93-K96.

## SEMICONDUCTING SELENIUM See Also SEMICONDUCTOR MATERIALS—Amorphous.

**Amorphous** See Also SEMICONDUCTING SILICON—Electronic Properties; SEMICONDUCTOR DIODES, PHOTODIODE—Ionization.

**094818 POLARIZED ELECTROABSORPTION SPECTRA OF AMORPHOUS SEMICONDUCTORS.** Transverse electroabsorption spectra of amorphous Se and hydrogenated amorphous Si (a-Si:H) are presented. These spectra are anisotropic, with fields  $F$  parallel to the polarization  $E$  of light, causing much larger signals than  $F$  perpendicular to  $E$ . At temperatures below 350 K the signal depends little on temperature. At higher temperatures the field-induced change  $\Delta\alpha$  depends on photon energy. At low energies the spectrum becomes isotropic and may arise from a quadratic Stark effect of tail states with rather large polarizabilities. The electroabsorption spectra cannot be explained by the Franz-Keldysh effect or by an exciton model. It is proposed that they arise from



field mixing of tail states which increases their dynamic polarizability. The mixing is most effective for states near the mobility edges. (Author abstract) 46 refs.

Weiner, G. (Fachbereich Physik der Univ Marburg, Marburg, West Ger); Dersch, U.; Thomas, P. *Philos Mag B* v 57 n 6 Jun 1988 p 721-735.

**094819 DENSITY OF STATE IN a-Se FROM COMBINED ANALYSIS OF XEROGRAPHIC POTENTIALS AND TRANSIENT TRANSPORT DATA.** The large-angle convergent-beam electron diffraction technique has been used to obtain 200 rocking curves from a  $1500 \text{ Al}_{0.4}\text{Ga}_{0.6}\text{As}/30 \text{ GaAs}/3500 \text{ Al}_{0.4}\text{Ga}_{0.6}\text{As}$  sample observed in plan view. It is demonstrated that the rocking curves are sensitive to the presence of the GaAs layer and are in good agreement with simulations calculated from a simple kinematical approach. It is shown that both the layer thickness and depth in the foil may be examined and that GaAs layer thicknesses less than 10 in the 5000 foil may be detectable. (Author abstract) 11 Refs.

Abkowitz, M. (Xerox Webster Research Cent, Webster, NY, USA). *Philos Mag Lett* v 58 n 1 Jul 1988 p 53-57.

## Charge Carriers

**094820 HOLE TRANSPORT IN SELENIUM-BASED AMORPHOUS XEROGRAPHIC PHOTO-RECEPTORS.** Xerographic time of flight (XTOF) and conventional time of flight (TOF) experiments were used to determine the response of various selenium-based amorphous monolayer photoconductors to short light pulses. From the observed flight time, the hole drift mobility,  $\mu_h$ , of charge carriers was deduced. For pure and lightly doped a-selenium, transient photocurrent signals at low field exhibit a decay during the time prior to transit time. This has been attributed to the loss of charge carriers from the propagation photoinjected charge packet and the time constant of the decay,  $\tau_h$ , has been taken as the hole lifetime. For a given composition, sample thickness, light intensity, substrate material and top contacts (in TOF only) were varied to ensure that the observed decay time constant  $\tau_h$  is a meaningful bulk parameter. Hole transport measurements support the assignment of  $\tau_h$  as hole lifetime.  $\mu_h$  and  $\tau_h$  were measured as a function of composition and applied field. Experimental data suggest that the hole transport mechanism is shallow trap controlled. Light doping of selenium with arsenic creates shallow traps and causes hole transport to deteriorate. Addition of chlorine promotes hole transport by increasing the lifetime but the hole drift mobility is reduced. Addition of tellurium in the range of 0-7 wt. percent progressively decreases hole drift mobility due to an increase in the density of the shallow traps. When chlorine is added to Se-Te alloys, it improves the hole transport by increasing  $\tau_h$  but the hole mobility falls. (Edited author abstract) 23 Refs.

Vaezi-Nejad, S.M. (Thames Polytechnic, London, Engl); Juhasz, C. *J Mater Sci* v 23 n 9 Sep 1988 p 3387-3392.

## Diffusion

**094821 DIFFUSION OF SELENIUM AND TELLURIUM IN SILICON.** Diffusion of selenium and tellurium in silicon has been investigated in the temperature range 1000°C to 1310°C by sheet conductivity. For Si:Se  $D_0 = 0.3 \pm 0.1 \text{ cm}^2/\text{s}$  and  $h = 2.6 \pm 0.1 \text{ eV}$ , and for Si:Te  $D_0 = 0.9 \pm 0.3 \text{ cm}^2/\text{s}$  and  $h = 3.3 \pm 0.1 \text{ eV}$  have been obtained. The surface concentrations for both dopants were of the order of  $5 \times 10^{13}$  to  $6 \times 10^{16} \text{ cm}^{-2}$ . The Hall coefficient leads to an energy level of  $300 \pm 15 \text{ meV}$  for selenium and  $200 \pm 20 \text{ meV}$  for tellurium. (Author abstract) 16 Refs.

Stuempel, H. (Univ Paderborn, Paderborn, West Ger); Vorderwuelbecke, M. *Appl Phys A* v 46 n 3 Jul 1988 p 159-163.

## Electric Properties

**094822 ELECTRICAL PROPERTIES OF AMORPHOUS SEMICONDUCTOR SELENIUM AND ITS ALLOYS: I. MONOLAYERS.** Various monolayer

a-Se-based photoreceptor devices were fabricated by vacuum evaporation and their electrical properties were investigated. Three experimental techniques, namely xerographic time of flight (XTOF), electroded time of flight (TOF) and xerographic discharge were used to determine the drift mobility, carrier lifetime, dark decay and residual voltage. Where possible, these measurements were carried out as a function of applied field and composition, namely As approx. 0.3 wt%, Te up to 17 wt% and Cl up to 60 ppm. The addition of As or Te alone reduced both hole and electron drift mobilities and increased the carrier lifetime. Both XTOF and TOF experiments showed a trap-limited response for electron transport in Se+Cl and Se:Te+Cl systems. The addition of As was found to restore the electron response in these photoreceptors. From the charge transport data and saturated residual voltage measurements, the hole capture coefficient in a-Se was estimated to be about  $1.0 \times 10^{-8} \text{ cm}^3 \text{ s}^{-1}$ . (Edited author abstract) 58 refs.

Vaezi-Nejad, S.M. (Kingston Polytechnic, Kingston upon Thames, Engl); Juhasz, C. *Semicond Sci Technol* v 2 n 12 Dec 1987 p 809-821.

## Photochemical Reactions

**094823 PHOTOELECTROCHEMISTRY IN PARTICULATE SYSTEMS. 8. PHOTOCHEMISTRY OF COLLOIDAL SELENIUM.** Selenium which exists in both crystalline and amorphous forms is an n-type semiconductor with a broad range of applications. Optical and photoelectrical properties of different forms of selenium have already been studied. In authors' continuing efforts to probe the corrosion processes of metal chalcogenides they have recently reported the laser flash photolysis and pulse radiolysis study of CdSe and  $\text{In}_2\text{Se}_3$  colloids. A major product of photoanodic corrosion of these semiconductors is elemental Se, which could be identified by the changes in the absorption spectrum. Se formed during the anodic corrosion process either exists in the colloidal form or precipitates on the surface of colloidal CdSe and  $\text{In}_2\text{Se}_3$ . The presence of Se, which is also photoactive, can influence the photoelectrochemical behavior of colloidal metal selenides. In view of this the authors have prepared colloidal particles of red amorphous Se in aqueous solution, and its photochemical and photoelectrochemical behavior is described here. 18 refs.

Dimitrijevic, Nada M. (Univ of Notre Dame, Notre Dame, IN, USA); Kamat, Prashant V. *Langmuir* v 4 n 3 May-Jun 1988 p 782-734.

## Thin Films

**094824 CRYSTALLIZATION AND MELTING OF  $\text{Se}_{0.99}\text{Bi}_{0.01}$  THIN FILMS BY MEANS OF D.T.A. TECHNIQUE.** The thermal properties of amorphous chalcogenide semiconductors can be changed by addition of some impurities: the effects of various kinds of foreign atoms on thermal phenomena have been studied. The  $\text{Se}_{0.99}\text{Bi}_{0.01}$  thin films deposited on aluminium and kapton substrates either by flash or by thermal evaporation have been characterized by means of the differential thermal analysis technique (D.T.A.). This paper deals with crystallization and melting of such films. Furthermore, in order to determine the activation energy associated with the crystallization and the frequency factor, three methods are considered. The values obtained do not vary more than 10%. The nature of the substrate and the method of evaporation seem to modify the thermal behavior. It is worth noting that a sharper peak of crystallization occurs in the case of  $\text{Se}_{1-x}\text{Bi}_x$  deposited on kapton substrates due to the small size of crystals. (Edited author abstract) 11 refs.

Atmani, H. (Lab d'Etude des Couches Minces Amorphes et Polycristallines, Mont-St.-Aignan, Fr). *Mater Chem Phys* v 19 n 3 Apr 1988 p 255-266.

**SEMICONDUCTING SELENIUM COMPOUNDS** See Also SEMICONDUCTING GLASS—Optical Properties; SEMICONDUCTOR MATERIALS—Chemical Vapor Deposition.

## Amorphous

**094825 ELECTRICAL CONDUCTION IN AMORPHOUS  $\text{Cu}_{10}\text{As}_{40}\text{Se}_{50}$  WITH POTENTIAL FLUCTUATIONS.** Hall measurements of amorphous and annealed  $\text{Cu}_{10}\text{As}_{40}\text{Se}_{50}$  samples are performed to evaluate the carrier density and to evaluate the mobility in the temperature range 300 to 580 K. It is found that the free hole density  $p_f$ , the Fermi level, and the mobility are functions of the annealing processes. The data are interpreted using the potential fluctuation theory. Differential thermal analysis (DTA) is performed. The endothermic changes of DTA have been attributed, in fact, to the shrinkage of the maximum height of the potential hills with temperature; while the exothermic changes have been regarded as a reason of the reduction of the disorder energy with annealing. (Author abstract) 12 refs.

Abdalla, S. (Qena-Asiut Univ, Asut, Egypt); Dongol, M.; Ibrahim, M.M. *Phys Status Solidi B* v 144 n 2 Dec 1987 p 745-752.

**094826 DECAY OF PHOTOCONDUCTIVITY IN AMORPHOUS  $\text{As}_2\text{Se}_3$  FOLLOWING REPETITIVE-PULSE EXCITATION.** Experimental results are presented for the decay of photoconductivity in amorphous  $\text{As}_2\text{Se}_3$  following single-pulse, repetitive-pulse and steady-state illumination, at various temperatures. The observed decays are compared with calculations using a discretized density of band-tail states decaying exponentially into the band gap. The connection between the decays after repetitive-pulse and steady-state illumination is described. It is shown that agreement between calculation and experiment requires a band tail which extends deep into the band gap, and that the presence of a deep band tail can be inferred from measurements made on relatively short time scales. (Author abstract) 21 refs.

Wolverson, D. (Univ of Exeter, Exeter, Engl); Phillips, R.T. *Philos Mag B* v 57 n 5 May 1988 p 635-647.

**094827 ELECTRICAL PROPERTIES OF THE AMORPHOUS SEMICONDUCTING Se-Te-In SYSTEM.** The measurement of DC electrical conductivity and thermoelectric power of the bulk samples of chalcogenide glasses of the system  $\text{Se}_{70-x}\text{Te}_{30-x}\text{In}_x$  ( $x=1, 3, 5, 7, 9\%$  atomic weight) are studied. The activation energies are obtained from conductivity and thermoelectric power measurements, using Mott, Davis and Fritzsche equations. The difference of activation energies  $E_0 = E_\sigma - E_s = 0.12 \text{ eV}$  is explained on the basis of long range electrostatic potential fluctuations, and this difference in activation energies is in agreement with the results reported by Overhof and Beyer for the chalcogenides. And it has also been observed that addition of indium in the samples increases the electrical conductivity. (Author abstract) 19 Refs.

Gadkari, A.B. (Shivaji Univ, Kolhapur, India); Zope, J.K. *J Non Cryst Solids* v 103 n 2-3 Jul 1988 p 295-299.

**094828 SHORT-RANGE ORDERED STRUCTURE IN AMORPHOUS SELENIUM FILMS BY X-RAY RADIAL DISTRIBUTION FUNCTION ANALYSIS.** By the word 'Structure' we would mean the short-range order (SRO) as well as the structural and compositional inhomogeneities. In this presentation, the SRO structure will be analyzed in vapour-deposited amorphous selenium films considering the radial distribution function (RDF), which is a Fourier transform of the X-ray diffractogram data recorded in a counter-diffractometer equipped with LiF monochromator. In applying RDF, various corrections are to be made and these are to be dealt with critically so as to evaluate the structural arrangement in a more reasonable manner. This presentation is concerned



with the development and applications of the correction procedures in vapour-deposited a-Se films. (Edited author abstract)

Nag, J. (Indian Assoc for the Cultivation of Science, Calcutta, India); Sen Gupta, S.P. *Key Eng Mater* v 13 pt 1 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 149.

**Charge Carriers** See SEMICONDUCTING SELENIUM—Charge Carriers.

**Corrosion** See SEMICONDUCTING SELENIUM—Photochemical Reactions.

## Crystallization

**094829 ZONAL RECRYSTALLIZATION OF SUPERIONIC  $\text{Cu}_{2-x}\text{Se}$  IN THE SOLID STATE.** Investigations were conducted into the redistribution of mobile copper in specimens of a nonstoichiometric semiconductor compound of copper selenide  $\text{Cu}_{2-x}\text{Se}$  during their zonal recrystallization in the solid state in the vicinity of the superionic phase transition ( $T_c = 291-413$  K). The superionic phase transition in  $\text{Cu}_{2-x}\text{Se}$  is complicated and includes the transformations of the eutectoid and peritectoid type, and the coefficient of diffusion of mobile copper ion in the material gives a value comparable with the diffusion coefficients in the liquid. (Edited author abstract) 6 refs.

Korzhev, M.A.; Abrikosov, N.Kh. *Phys Chem Mater Treat* v 1 n 5 Sep-Oct 1987 p 467-469.

**Defects** See SEMICONDUCTING BISMUTH COMPOUNDS—Doping.

## Doping

**094830 SYNTHESIS AND PROPERTIES OF HYDROGEN-INTERCALATED INDIUM AND GALLIUM MONOSELENIDES.** The possibility of intercalating hydrogen ions into indium and gallium monoselenides is established. The thermodynamic parameters of the intercalation reactions are calculated, and the coefficient of proton diffusion in Vander Waals spaces is determined. The effect of hydrogen intercalation on the resistivity perpendicular to the InSe and GaSe layers is ascertained. 10 refs. In Russian.

Koz'mik, I.D.; Grigor'chak, I.I.; Bakhmatyuk, B.P.; Kovalyuk, Z.D. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 5 May 1987 p 754-757.

## Growth

**094831 METAL-ORGANIC VAPOUR PHASE EPITAXIAL GROWTH AND CHARACTERIZATION OF WIDE BAND-GAP II-VI MATERIALS.** Recent progress in metal-organic vapour phase epitaxial growth and characterization of the wide band-gap II-VI materials  $\text{ZnSe}$ ,  $\text{ZnSe}_{1-y}\text{S}_y$  ( $0 < y < 1$ ) and  $\text{ZnS}$  is described. Attention is focussed on the nature of interfaces when these materials are grown on single crystalline III-V semiconductors where, in most cases, there is a lattice-mismatch between the epitaxial layer and substrate. The superior characteristics of the lattice-matched ternary  $\text{ZnSe}_{0.95}\text{S}_{0.05}$  grown on GaAs are highlighted. Difficulties with doping studies are indicated and future lines of research are outlined. (Author abstract) 26 refs.

Williams, J.O. (UMIST, Manchester, Engl). *Chemtronics* v 2 n 2 Jun 1987 p 43-48.

**Ion Implantation** See SEMICONDUCTING ZINC COMPOUNDS—Synthesis.

## Mechanical Properties

**094832 VARIATION OF THE MICROHARDNESS OF COPPER SELENIDE DURING THE TRANSITION TO THE SUPERIONIC PHASE.** A study was made of the microhardness of  $\text{Cu}_{2-x}\text{Se}$  samples ( $x = 0-0.3$ ) in the 220-470 K temperature range. An anomalous decrease in the microhardness of the samples

was observed during the transition to the superionic  $\beta$ -phase ( $T_c = 291-413$  K). This anomalous decrease is attributed to a singular state of the superionic phase which is intermediate between solid and liquid. In Russian. 8 refs.

Korzhev, M.A.; Korol'kova, I.G.; Abrikosov, N.Kh. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 12 Dec 1987 p 1962-1964.

## Optical Properties

**094833 EFFECT OF CHLORINE ON XEROGRAPHIC PROPERTIES OF a-SE:Te ALLOYS.** Amorphous selenium (a-Se) has an optical bandgap of 2.1 eV and a photogeneration efficiency close to unity at 2.7 eV which makes it sensitive to the blue region of the visible spectrum. Alloying with tellurium reduces the bandgap and increases the photosensitivity towards higher wavelengths. Experimental results have already been reported to show that charge acceptance, residual voltage, dark decay rate and drift mobility are sensitive to tellurium. Charge acceptance and carrier drift mobilities decrease with tellurium whereas dark decay rate increases. All these effects are undesirable in xerography. Transient photoconductivity and residual voltage measurements were carried out to investigate the effect of a small chlorine addition on the xerographic properties of a-Se:Te alloys. Chlorine improves the residual voltage and charge acceptance. Transient photoconductivity data on hole transport shows that the xerographically important parameter of carrier range is also improved. The results are interpreted in the framework of shallow trap controlled transport. (Edited author abstract) 16 refs.

Vaezi-Nejad, S.M. (Kingston Polytechnic, Kingston Upon Thames, Engl); Juhasz, C. *J Mater Sci* v 23 n 9 Sep 1988 p 3286-3289.

## Photoconductivity

**094834 STEADY STATE AND TRANSIENT PHOTOCONDUCTIVITY IN AMORPHOUS THIN FILMS OF  $\text{Se}_{0.8}\text{Te}_{0.2}$ .** The present paper reports on steady state and transient photoconductivity measurements in amorphous thin films of  $\text{Se}_{0.8}\text{Te}_{0.2}$ . The paper also reports the effect of crystallization on the photoconductive behavior. The photosensitivity ( $I_{ph}/I_d$ ) reduces by a factor of 5 and the decay of photocurrent becomes much slower in the films annealed above the crystallization temperature (state B) as compared to the films annealed below the crystallization temperature (state A). A detailed analysis of the photoconductive decay in the state B shows that the recombination within localized states may be the predominant recombination mechanism in this state. (Author abstract) 22 refs.

Tripathi, S.K. (Harcourt Butler Technological Inst, Kanpur, India); Kumar, A. *J Electron Mater* v 17 n 1 Jan 1988 p 45-51.

**Structure** See NIOBIUM COMPOUNDS—Structure.

## Switching

**094835 THRESHOLD SWITCHING EFFECTS IN  $\text{Ag}_2\text{TeSe}_2$  AND  $\text{CuTeSe}_2$  FILMS.** Switching effects in  $\text{Ag}_2\text{TeSe}_2$  and  $\text{CuTeSe}_2$  chalcopyrite semiconductors films have been investigated. The threshold switching voltage was found to increase linearly with the thickness, more-over  $V_{th}$  increases exponentially with the temperature. The rapid transition between the highly resistive and conductive states was attributed to an electrothermal origin from Joule's heating of a current channel. (Author abstract) 11 refs.

Affifi, M.A. (Ain Shams Univ, Cairo, Egypt); Labib, H.H.A.; Abou El Ela, A.H.; Sharaf, K.A. *Appl Phys A* v 44 n 2 Jun 1988 p 113-117.

## Synthesis

**094836 CRYSTAL STRUCTURE OF COPPER IODIDE TRISELENIDE  $\text{CuISe}_3$ , A REACTANT IN AN**

**n-CuInSe<sub>2</sub> BASED SOLAR CELL.** The crystal structure of  $\text{CuISe}_3$  has been determined.  $\text{CuISe}_3$  is a rhombohedral crystal with space group  $R\bar{3}m$  and lattice parameters  $a = 1407.9(6)$  pm,  $c = 1418.7(2)$  pm (hexagonal setting). The structure consists of six-membered Se rings in chain-type configuration, which are surrounded by rhombuses of  $\text{Cu}_2\text{I}_2$  units oriented parallel to the c-direction and alternating in height. A comparison with the crystal structure of  $\text{CuBrSe}_3$  is given. (Edited author abstract) 14 refs.

Milius, W. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Rabenau, A. *Mater Res Bull* v 22 n 11 Nov 1987 p 1493-1497.

**094837 KINETIC STUDY OF THE FORMATION OF COPPER SELENIDES BY COPPER SELENIZATION.** Copper-selenium compounds have received considerable attention in recent years due to their potential application in semiconducting systems. Copper electrodeposits of different thicknesses were obtained on titanium plates and corroded by a selenization process in selenous acid solutions. The change in the open circuit potential with time was followed and the records show one or two plateaus at different potential values. The transition times measured on those plateaus and their variations with selenous acid, proton and  $\text{Cl}^-$  ion concentrations, as well as with temperature were measured. Kinetic parameters were deduced, which allowed the formulation of reaction mechanisms for the copper corrosion reactions occurring on both plateaus. SEM micrographs and analysis of the obtained deposits and of the solutions resulting from the corrosion processes confirmed the postulated mechanisms. The most likely compounds formed were  $\alpha\text{-Cu}_2\text{Se}$  for high reaction rates and  $\alpha\text{-CuSe}$  mixed with  $\text{Cu}_{1.8}\text{Se}$  and  $\text{Cu}_{2-x}\text{Se}$  for slower rates. (Edited author abstract) 11 refs.

Villalvilla, J.M. (Univ Autonoma de Madrid, Madrid, Spain); Velasco, J. Gonzalez; Ortega, J. *Mater Chem Phys* v 19 n 4 May 1988 p 341-356.

**094838 CRYSTAL GROWTH AND CHARACTERIZATION OF  $\text{Mn}_x\text{Cd}_{1-x}\text{Ga}_2\text{Se}_4$ : A NEW FAMILY OF DILUTED MAGNETIC SEMICONDUCTORS.** Crystals of  $\text{Mn}_x\text{Cd}_{1-x}\text{Ga}_2\text{Se}_4$  ( $0.00 \leq x \leq 1.00$ ) were grown from the vapor phase by chemical transport, and all the samples were found to crystallize in the tetragonal defect chalcopyrite structure, space group  $I4^-$ . X-ray investigations suggested that  $\text{Mn}^{2+}$  ions replace  $\text{Cd}^{2+}$  ions on 2b positions of the lattice. EPR spectra were examined as a function of temperature and of the composition x. Evidence is presented that the magnetic interactions between manganese ions are predominantly antiferromagnetic down to  $T = 90$  K. (Edited author abstract) 20 refs.

Simeone, M.G. (ITSE-CNRS, Rome, Italy); Viticoli, S. *Mater Res Bull* v 23 n 8 Aug 1988 p 1219-1225.

## Thermodynamic Properties

**094839 ENTHALPY AND HEAT CAPACITY OF  $\text{NbSe}_2$ ,  $\text{NbSe}_{1.75}$  AND  $\text{MoSe}_2$  AT HIGH TEMPERATURES.** The enthalpies of  $\text{NbSe}_2$ ,  $\text{NbSe}_{1.75}$  and  $\text{MoSe}_2$  have been measured for the first time by a mixing method in a vacuum calorimetric device in the 1200-1800 K range. The temperature dependences of the enthalpy and heat capacity of the investigated materials have been calculated. It is shown that the enthalpy monotonically increases in the 1200-1800 K range, increases with a decrease in the selenium content in the Nb-Se system, and decreases when passing from  $\text{NbSe}_2$  to  $\text{MoSe}_2$ . 12 refs. In Russian.

Bolgar, A.S.; Trofimova, Zh.A.; Yanaki, A.A.; Kopylova, L.I.; Zaletilo, L.S. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 897-899.

**SEMICONDUCTING SILICON**—See Also ACETYLENE—Adsorption; ACOUSTIC SURFACE WAVE DEVICES; ALUMINUM AND ALLOYS—Purification; CATHODES—Performance; CRYSTALS—Growing; ELECTRIC CONTACTS—Metallizing; ELECTRIC SWITCHES, SEMICONDUCTOR—Materials; ELECTRONIC CIRCUITS, FREQUENCY DIVIDING—Microwaves; FILMS—Dielectric; GLASS—Physical Properties; INTEGRATED CIRCUIT



MANUFACTURE—Decontamination; INTEGRATED CIRCUIT MANUFACTURE—Efficiency; INTEGRATED CIRCUIT MANUFACTURE—Thermal Effects; INTEGRATED CIRCUITS—Computer Aided Design; INTEGRATED CIRCUITS, VLSI—Computer Aided Design; INTERFEROMETERS—Manufacture; IRON AND ALLOYS—Thin Films; NIOBIUM COMPOUNDS—Thin Films; OPTOELECTRONIC DEVICES—Millimeter Waves; ORGANIC COMPOUNDS—Desulfurization; OSCILLATORS, MICRO-WAVE—Fabrication; PRINTED CIRCUITS—Electric Wiring; RADIATION DETECTORS—Performance; SEMICONDUCTING FILMS—Growth; SEMICONDUCTING GALLIUM ARSENIDE—Applications; SEMICONDUCTING GALLIUM ARSENIDE—Doping; SEMICONDUCTING GALLIUM ARSENIDE—Growth; SEMICONDUCTING GALLIUM ARSENIDE—Performance; SEMICONDUCTOR DEVICE MANUFACTURE; SEMICONDUCTOR DEVICE MANUFACTURE—Laser Applications; SEMICONDUCTOR DEVICE MANUFACTURE—Quartz Applications; SEMICONDUCTOR DEVICES—Analysis; SEMICONDUCTOR DEVICES—Junctions; SEMICONDUCTOR DEVICES—Radiation Effects; SEMICONDUCTOR DEVICES—Semiconductor Insulator Boundaries; SEMICONDUCTOR DEVICES, MOS—Computer Aided Design; SEMICONDUCTOR DEVICES, MOS—Semiconductor Insulator Boundaries; SEMICONDUCTOR DEVICES, MOSFET—Electric Conductivity; SEMICONDUCTOR DEVICES, MOSFET—Fabrication; SEMICONDUCTOR DEVICES, MOSFET—Noise; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Electric Properties; SEMICONDUCTOR DIODES; SEMICONDUCTOR DIODES—Electric Properties; SEMICONDUCTOR DIODES, PHOTODIODE—Performance; SEMICONDUCTOR MATERIALS—Amorphous; SEMICONDUCTOR MATERIALS—Charge Carriers; SEMICONDUCTOR MATERIALS—Etching; SENSORS—Performance; SILICON AND ALLOYS—Photolithography; SILVER AND ALLOYS—Thin Films; SOLAR CELLS—Silicon; SPECTROMETERS, PARTICLE; SUBSTRATES—Materials; TITANIUM COMPOUNDS—Thin Films; TRANSISTORS—Materials; TRANSISTORS—Mathematical Models; TRANSISTORS, BIPOLAR—Electric Properties; TRANSISTORS, BIPOLAR—Fabrication; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, FIELD EFFECT—Noise; TUNGSTEN CARBIDE—Thin Films.

**094840 RECLAIMED SILICON WAFERS AND SURFACE CONTAMINATION: A COMPARATIVE STUDY.** The study presented demonstrates the potential of SSIMS analysis for probing and evaluating silicon surface contamination. Though direct quantitation is very difficult, comparisons of contaminants to matrix-ion intensities can produce reproducible ratios for use in comparing different materials. In terms of the levels of cleaning contaminants on wafers, the study clearly shows that the cleanliness of reclaimed wafers compares favorably with that of virgin silicon surfaces. Thus, the use of reclaims as process monitors should not result in a greater potential for product cross-contamination. 6 refs.

Karwacki, Eugene J. Jr.; Magnotta, Vincent L.; McCullough, A.W.; McGregor, Charles. *Microcontamination* v 5 n 11 Nov 1987 p 62-64.

**094841 INTERACTION BETWEEN LOCALIZED AND DELOCALIZED STATES INDICATED FROM TEMPERATURE-DEPENDENT ESR STUDY OF SUBMETALLIC P-DOPED SI.** A K-band electron spin resonance (ESR) analysis has been carried out on submetallic Si:P powders containing  $(1.7 \pm 0.1) \times 10^{18}$  P atoms  $\text{cm}^{-3}$ . As expected, only one signal, generally referred to as the central pair line (CPL), is observed. Accurate data of the peak-to-peak linewidth  $\Delta B_{pp}$  and g-value are presented for the temperature range  $1.6 \text{ K} \leq T \leq 300 \text{ K}$ . The implication of the experimental results regarding the physical model of the P-in-Si behavior is discussed. In the range  $\leq 4.2 \text{ K}$ , comparison to other data reveals the existence of a significant different T dependence of g and  $\Delta B_{pp}$  between the high and low observational-frequency situations. In the higher T range, the data are indicative of the presence of an s-d like interaction between localized donor spins and delocalized electrons, which gradually increases with T. (Edited author abstract) 27 refs.

Stesmans, A. (Katholieke Univ Leuven, Louvain, Belg). *Phys Status Solidi B* v 143 n 2 Oct 1987 p 733-740.

**094842 ENERGY BAND DIAGRAM OF THE a-Si:H/c-Si INTERFACE AS DETERMINED BY INTERNAL PHOTOEMISSION.** The internal photoemission of electrons from the valence band of crystalline silicon into the conduction band of amorphous hydrogenated silicon has been studied experimentally. The photoemission process in the case of the interface between two

semiconductors raised specific problems in the treatment of data, and these are analyzed. The results indicate that the energy difference between the amorphous and crystalline valence band edges at the interface is close to zero, and is not affected by the hydrogen-induced widening of the optical gap in amorphous silicon. (Author abstract) 17 refs.

Cuniot, M. (CNRS, Meudon, Fr); Marfaing, Y. *Philos Mag B* v 57 n 2 Feb 1988 p 291-300.

**094843 SEMI-EMPIRICAL TOTAL ENERGY METHOD FOR ELEMENTAL CLUSTERS AND SOLIDS: APPLICATION TO THE STRUCTURAL PROPERTIES OF SILICON CLUSTERS.** A semi-empirical pseudopotential method to determine the structural properties of small atomic clusters is presented. The method combines a linear combination of Gaussian orbitals, an atomic-like pseudopotential and a valence force field description to determine the structural energies of small clusters. This procedure is easy to implement and accurately reproduces the structural properties of silicon clusters as determined from more rigorous techniques. (Author abstract) 14 refs.

Chelikowsky, J.R. (Exxon Research & Engineering Co, Annandale, NJ, USA); Redwing, R. *Solid State Commun* v 64 n 5 Nov 1987 p 843-846.

**094844 PHOTOEMISSION FROM THE Si/La INTERFACE.** We present photoemission results from the Si/La interface prepared by depositing increasing amount of La on Si(111)  $2 \times 1$  at room temperature. The interface appears to be reacted in the La coverage region 0.1-2 ML. Further deposition of La results in the growth of pure metal. A valence and core states analysis suggests that the chemical bond is more ionic at the lowest coverage and becomes silicide-like at 2 ML. (Author abstract). 11 Refs.

Puppin, E. (Stanford Univ, Stanford, CA, USA); Guyot, H.; Shen, Z.X.; Hwang, J.; Lindau, I. *Solid State Commun* v 67 n 1 Jul 1988 p 23-27.

**094845 HYDROGENATED AMORPHOUS SILICON FILMS OBTAINED BY A LOW PRESSURE DC GLOW DISCHARGE.** Films of a-Si:H have been deposited by means of a dc hot cathode discharge of  $\text{SiH}_4$  with electrostatic confinement at a pressure as low as 0.4 Pa. The plasma used is quite quiescent as has been observed by means of reproducible Langmuir probe measurements. Substrates have been placed at different locations in between the electrodes, some of them facing the anode and the others facing the cathode. Films deposited on substrates facing the cathode present a granular, non-columnar, structure, an IR spectrum with only SiH absorption peaks, and a very low photoresponse. Films deposited on substrates facing the anode have a similar IR spectrum but are homogeneous, have lower hydrogen content, and present a high photoresponse. (Edited author abstract). 24 Refs.

Delgado, J.C. (Univ de Barcelona, Barcelona, Spain); Andreu, J.; Sardin, G.; Esteve, J.; Morenza, J.L. *Appl Phys A* v 46 n 3 Jul 1988 p 207-213.

## Ablation

**094846 ULTRAVIOLET LASER ABLATION OF A SILICON WAFER.** Pulsed laser irradiation at 248 nm can ablate Si atoms from a Si(100) wafer. The mechanism of this photoablation has been examined by a laser-induced fluorescence analysis of the Si products. The measured Si atoms were shown to leave the wafer surface with an average translational energy of 2.5 kcal/mol. The distribution of the translational energy is well described by a theoretical model for non-cascade ablation processes. (Author abstract) 8 refs.

Kawasaki, Masahiro (Mie Univ, Tsu, Jpn); Sato, Hiroyasu; Inoue, Gen. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1604-1605.

## Absorption

**094847 SEMIEMPIRICAL CNDO INVESTIGATIONS OF H, F AND Cl CHEMISORBED ON Si (111).** In a previous paper, the semiempirical CNDO SCF molecular orbital method has been applied to clusters  $\text{X}_3$ ,  $\text{X}'_{12}$  modeling covalent semiconductors. X and X' stand for semiconductor atom and the corresponding fictitious one, respectively. The results obtained from CNDO/2 calculations can be used to describe the properties of silicon, diamond and germanium, after redetermining the bonding parameters and choosing the reasonable electronegativities of boundary atoms. We report the results of H, F and Cl chemisorbed on Si(111). These results are obtained by use of the mentioned calculating scheme. Comparing with the results of other theoretical calculations, it is shown that our calculating scheme is also suitable for studying chemisorptions on covalent semiconductor surfaces. (Author abstract) 11 refs. In Chinese.

Wu, Ji'an (Acad Sinica, China). *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 205-207.

## Acoustic Wave Effects

**094848 PERTURBATION OF SAW PHASE VELOCITY IN THE n-Si/YZ-LiNbO<sub>3</sub> STRUCTURE.** The overall phase velocity change of SAW for n-Si thin layer on YZ-LiNbO<sub>3</sub> substrate is calculated considering mechanical and electrical perturbations in the case of low-kd limit. The mechanical perturbation is modified to include the dependence of electron concentration in Si. The variation of overall SAW velocity with electron concentration, layer thickness, and frequency show markedly different dependence from that of both mechanical and electrical perturbations. The rapid decreases of overall SAW velocity at low and high electron concentrations are attributed to electrical perturbation and carrier concentration effect on mechanical perturbation respectively. (Author abstract) 25 refs.

Park, H.K. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Kim, H.C. *J Phys D* v 21 n 1 Jan 14 1988 p 219-222.

## Adsorption

**094849 SELF-CONSISTENT CALCULATION OF BOND ORBITAL FOR OXYGEN ADSORPTION ON Si SURFACE.** A self-consistent calculation of bond orbital, which takes the variation of atomic wave functions by charge transfer into account is proposed for the investigation of oxygen adsorption on Si(111) surface. In the head-on position adsorption model, a suitable selection of bond length can produce the relative energies of all main peaks in the valence band photoelectron emission spectra. The results indicate the bond length between Si and O atoms is not close to that in  $\text{SiO}_2$  as usually conjectured, but a little less than that of Si-Si bond in bulk. The calculations also gives the energy of Si-O bond under the surface after oxidation. (Author abstract) 16 refs. In Chinese.

Zhong Xuifu (Acad Sinica, Beijing, China); Xing Yirong. *Pan Tao Ti Hsueh Pao* v 9 n 1 Jan 1988 p 23-26.

**Amorphous** See Also CRYSTALS—Physical Properties; METALS AND ALLOYS—Amorphous; RAMAN SCATTERING; SEMICONDUCTING FILMS—Chemical Vapor Deposition; SEMICONDUCTING FILMS—Electronic Properties; SEMICONDUCTING FILMS—Silicon; SEMICONDUCTING GALLIUM COMPOUNDS—Electric Properties; SEMICONDUCTING SELENIUM—Amorphous; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR MATERIALS—Amorphous; SEMICONDUCTOR MATERIALS—Spectroscopic Analysis; SENSORS—Materials; SILICON AND ALLOYS—Thin Films; SOLAR CELLS—Arrays; SOLAR CELLS—Silicon; SOLAR CELLS—Stability; SOLIDS—Hydrogen Determination; TRANSISTORS—Analysis; TRANSISTORS—Fabrication; TRANSISTORS—Thermal Effects; TRANSISTORS, FIELD EFFECT—Thin Films.



**094850 MICROWAVE-EXCITED PLASMA CVD OF a-Si:H FILMS UTILIZING A HYDROGEN PLASMA STREAM OR BY DIRECT EXCITATION OF SILANE.** The microwave-excited plasma CVD of a-Si:H films, in which SiH<sub>4</sub> was decomposed by a plasma stream of hydrogen or by direct excitation at low pressures ( $10^{-4}$  to  $10^{-3}$  Torr), was examined and compared with a previously studied Ar plasma stream method. It was clarified that an Ar plasma stream was not necessary to obtain highly photoconductive a-Si:H films. However, the deposition characteristics in these deposition methods were different from the Ar plasma stream method. On the other hand, the influence of the hydrogen plasma stream was not apparent when the SiH<sub>4</sub> flow rate was high, suggesting an ionization cross-section dependence of the plasma discharge. (Author abstract) 14 refs.

Watanabe, Takeshi (Hitachi Ltd, Yokohama, Jpn); Tanaka, Masahiro; Azuma, Kazufumi; Nakatani, Mitsuo; Sonobe, Tadashi; Shimada, Toshikazu. *Jpn J Appl Phys Part 1* v 26 n 8 Aug 1987 p 1215-1218.

**094851 HYDROGEN DIFFUSION IN AMORPHOUS SILICON.** Hydrogen diffusion in doped and compensated a-Si:H has been measured by secondary-ion mass spectrometry profiling in the temperature range 155-300°C. Doping reduces the activation energy and enhances the diffusion coefficient by up to three orders of magnitude at 200°C, and a correlation between the diffusion coefficient and the dangling-bond density is found. An analysis of three different diffusion models indicates that the breaking of weak Si-Si bonds by hydrogen may be an important process. The relation between the diffusion results and the thermal equilibration of the electronic structure is discussed. (Author abstract) 21 refs.

Street, R.A. (Xerox Palo Alto Research Cent, Palo Alto, CA, USA); Tsai, C.C.; Kakalios, J.; Jackson, W.B. *Philos Mag B* v 56 n 3 Sep 1987 p 305-320.

**094852 DENSITY OF STATES OF SPUTTERED a-Si:H STUDIED BY THE SPACE-CHARGE-LIMITED CURRENT TECHNIQUE. THE INFLUENCE OF DEPOSITION PARAMETERS, LIGHT AND keV-ELECTRON IRRADIATION.** The space-charge-limited current (SCLC) technique has been used to determine the density of states (DOS) near the Fermi level for a-Si:H films prepared by magnetron sputtering under various experimental conditions. From a study of the thickness dependence it can be concluded that surface or interface states might significantly contribute to the DOS. A minimum DOS of  $5.5 \times 10^{15} \text{ cm}^{-3} \text{ eV}^{-1}$  at  $E_c - E = 0.75 \text{ eV}$  was determined for well passivated films. The generation of metastable defects by light soaking and keV electron irradiation has been directly observed by the change in the DOS. For the same energy deposited, defect creation by electrons is a factor of 3300 higher than that by light. In addition, the generation process is found to be different. A model is suggested that explains the creation of defects by electrons via a direct electronic excitation process. (Author abstract) 44 refs.

Gangopadhyay, S. (Univ Kaiserslautern, Kaiserslautern, West Ger); Schroeder, B.; Geiger, J. *Philos Mag B* v 56 n 3 Sep 1987 p 321-333.

**094853 DEPOSITION OF a-Si:H BY MAGNETRON SPUTTER-ASSISTED PLASMA-CVD: PREPARATION AND PHYSICAL PROPERTIES.** Thin a-Si:H layers were deposited by sputter-assisted plasma (SAP)-CVD. The magnetron used combines the sputter technique with the plasma-assisted CVD and enables to shift the deposition from sputtering over SAP-CVD to the pure PCVD regime by variation of the process parameters. The physical properties (deposition rate, dark and photoconductivity, ESR and IR absorption) of the layers have been correlated with the deposition regime and the special process parameters for finding out the optimal deposition parameters in the SAP-CVD regime. The dependence of the growth rate on the growing regime has been described by a model based on a linear superposition of the partial growth rates in the sputtering and PCVD regime. (Edited author abstract) 14 refs.

Kottwitz, A. (Technical Univ Dresden, Dresden, East Ger); Fuchs, M.; Schade, K.; Bindemann, R.; Druessedau, T.; Gerlach, W. *J Non Cryst Solids* v 93 n 2-3 Sep 1987 p 230-240.

**094854 LIGHT-INDUCED CHANGES IN THE FIELD-EFFECT CONDUCTANCE OF HYDROGENATED AMORPHOUS SILICON.** The effects of illumination with white light and annealing to 180-200°C on the field-effect conductance of a-Si:H FETs have been investigated. The effects produced by illumination are completely reversed by annealing. We find that illumination produces two types of change in the field-effect conductance; first, a maximum decrease in the off-conductance of about 300%, with a positive shift of the threshold voltage, and secondly a horizontal displacement of the conductance characteristic in the pre-threshold region with no change in the off-conductance. In both cases there is a movement of the bulk Fermi level with respect to the conduction band mobility edge. These two effects may be produced in a single silicon film sample. (Author abstract) 10 refs.

Manookian, W.Z. (Heriot-Watt Univ, Edinburgh, Scotl); Wilson, J.I.B. *Semicond Sci Technol* v 2 n 10 Oct 1987 p 649-653.

**094855 PHYSICAL PROPERTIES OF AMORPHOUS HYDROGENATED SILICON FILMS OBTAINED BY MAGNETRON SPUTTERING.** A study was made of the optical and electric properties of amorphous hydrogenated silicon films obtained by magnetron sputtering of a silicon target in an argon-hydrogen dc plasma at a deposition temperature of 250-300°C and a relative hydrogen partial pressure of 40% or more. It is shown that with respect to their optical properties, dark conductivity, and quantity and form of bound hydrogen these films are similar to those obtained by silane decomposition, but their photoconductivity is inferior to that of films obtained by silane decomposition. 13 refs. In Russian.

Svanbaev, E.A.; Zherzdev, A.V.; Taurbaev, T.M.; Terukov, E.I.; Zhdanovich, N.S. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 5 May 1987 p 709-713.

**094856 DOPING EFFICIENCY IN R.F.-SPUTTERED HYDROGENATED AMORPHOUS SILICON.** The efficiency of B and As in gas-phase doping of hydrogenated amorphous silicon (a-Si:H) prepared by r.f. sputtering has been experimentally evaluated. The dopant incorporation, i.e., the solid-phase concentration, was found to be linear with gas-phase concentration for both dopants, and independent of the substrate temperature. The creation of defects with doping has been investigated by electron spin resonance and photothermal deflection spectroscopy. The results suggest that a dangling bond is created for each fourfold-coordinated dopant atom, in agreement with the general concept of the modified 8-N rule. However, the variations of the doping efficiency with the solid-phase concentrations differ from the expected values. It is concluded that the laws of mass action cannot be applied under conditions of sputtering and that the incorporation of dopant atoms occurs in a non-equilibrium process at the growing surface. (Edited author abstract) 17 refs.

Jousse, D. (CNRS, Grenoble, Fr); Bruyere, J.C.; Bustarret, E.; Deneuille, A. *Phil Mag Lett* v 55 n 1 Jan 1987 p 41-46.

**094857 TRANSITION FROM DIFFUSIVE TO BALLISTIC CAPTURE RELATED TO HYDROGEN INCORPORATION IN AMORPHOUS SILICON.** We have shown in previous work that, in triode dc sputtered amorphous silicon, the value of the capture cross-section  $\sigma$  of deep gap states depends strongly on the hydrogen content of the material. Here we analyze the influence of such an effect on the transport properties of a set of samples whose hydrogen content  $C_H$  varies between 8 and 20%. For this purpose, we have measured at room temperature the mobility-lifetime product for electrons,  $\mu_n \tau_n$ , the density of states at the Fermi level  $N(E_F)$  and the defect density  $N_d$  derived from photothermal deflection

spectroscopy experiments. Log-log plots of the  $\mu_n \tau_n N(E_F)$  and  $\mu_n \tau_n N_d$  products against  $\sigma$  show two regimes with a transition corresponding to a hydrogen content of about 12%. These two regimes are related to different modes of capture controlled either by a diffusive process (low  $C_H$ ) or by a ballistic process (high  $C_H$ ). (Edited author abstract) 14 refs.

Mencaraglia, D. (CNRS, Gif-sur-Yvette, Fr); Kleider, J.P. *Phil Mag Lett* v 55 n 2 Feb 1987 p 63-68.

**094858 MOBILITY-LIFETIME ESTIMATES IN AMORPHOUS HYDROGENATED SILICON (a-Si:H).** Estimates of the majority photocarrier mobility-lifetime ( $\mu\tau$ ) product obtained from time-of-flight transient photoconductivity and from steady-state photoconductivity are compared. It is shown that in principle both experiments measure the integral of the transient drift mobility. Estimates of  $\mu\tau$  for undoped amorphous hydrogenated silicon (a-Si:H) based on the two techniques disagree by a factor of approximately 100 in comparable specimens. Possible origins of the discrepancy are discussed in relation to experimental procedures, optical bias effects and surface inhomogeneity. It is concluded that in undoped a-Si:H the dangling-bond defect observed in electron-spin resonance acts predominantly as a photocarrier trap and not as a simple recombination center. (Edited author abstract) 14 refs.

Schiff, E.A. (Syracuse Univ, Syracuse, NY, USA). *Phil Mag Lett* v 55 n 2 Feb 1987 p 87-92.

**094859 MICROSCOPIC MOBILITY IN HYDROGENATED AMORPHOUS SILICON.** It has recently been proposed that the electron microscopic mobility in hydrogenated amorphous silicon is of the order of  $100 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ , and that the observed lower mobility values result from scattering by potential fluctuations arising from defect centers which have a negative effect correlation energy. We show that such potential fluctuations cannot lower the mobility to its observed value of  $10 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ . Moreover, we find that the experimental evidence used to support the claim of a higher mobility can be adequately explained by the lower of the accepted values. (Author abstract) 17 refs.

Kakalios, J. (Xerox Palo Alto Research Cent, Palo Alto, CA, USA). *Phil Mag Lett* v 55 n 3 Mar 1987 p 129-134.

**094860 ENERGY LEVELS OF DANGLING-BOND CENTRES IN a-Si:H STUDIED BY PHOTOCAPACITANCE TRANSIENT SPECTROSCOPY.** The energy level spectrum of gap states in P-doped a-Si:H has been determined using photo-isothermal capacitance transient spectroscopy (ICTS) with sub-bandgap excitation. Photocapacitance transients were observed in the range from the bandgap energy down to 0.5 eV. It has been deduced that two gap-state features exist in the mobility gap; one is 0.5-0.6 eV below the mobility edge ( $E_c$ ) of the conduction band, and the other 1.0-1.2 eV below  $E_c$ . These results are consistent with our previously reported results on ICTS as well as with defect PL, which were explained in terms of 'isolated' and 'charge-coupled' doubly occupied dangling bonds ( $D^-$ ,  $D^+$ ). (Author abstract) 27 refs.

Okushi, Hideyo (Electrotechnical Lab, Sakura-mura, Jpn); Tanaka, Kazunobu. *Phil Mag Lett* v 55 n 3 Mar 1987 p 135-141.

**094861 TRANSIENT PHOTOCONDUCTIVITY IN N-TYPE a-Si:H.** The long-time transient photocurrent decay in annealed and light-exposed P-doped a-Si:H is examined experimentally and by numerical modeling. The decay is a dispersive power law with sublinear index, extending to times longer than 1s, and the decay rate increases with temperature. Light exposure dramatically decreases the decay amplitude but does not affect the rate of decay. The phenomenon is discussed in terms of a comprehensive multiple-trapping model in which transport of thermalized electrons is essentially non-dispersive, and recombination of free carriers via defects is dispersive,



owing to continued thermalization of excess holes. The index of the excess photoelectron decay provides information on the valence-band tail states, which are exponentially distributed, with a characteristic energy estimated as 0.06 eV. (Edited author abstract) 22 refs.

Main, C. (Dundee Coll of Technology, Dundee, Scotl); Russell, R.; Berkin, J.; Marshall, J.M. *Phil Mag Lett* v 55 n 4 Apr 1987 p 189-195.

**094862 INFLUENCE OF MECHANICAL STRESS ON LIGHT-INDUCED CREATION OF DEFECTS IN HYDROGENATED AMORPHOUS SILICON.** The effect of mechanical stress on light-induced changes in photoconductivity has been studied in films of plasma-deposited hydrogenated amorphous silicon on different substrates. The experimental results reveal no correlation between the degradation of the photoconductivity and the mechanical stress in these films. These findings contradict the observations of M. Stutzmann but agree with those of S. Guha et al. (Author abstract) 9 refs.

Ghaith, A. (Univ of Chicago, Chicago, IL, USA). *Phil Mag Lett* v 55 n 4 Apr 1987 p 197-200.

**094863 MICROSCOPIC MOBILITY IN HYDROGENATED AMORPHOUS SILICON.** A recent letter by J. Kakalios has criticized our suggestion that the microscopic mobility of hydrogenated amorphous silicon increases under high-level double injection. In this Letter, we show that Kakalios misinterpreted our model and misrepresented our data. (Author abstract) 44 refs.

Adler, David (MIT, Cambridge, MA, USA); Silver, Marvin. *Phil Mag Lett* v 56 n 3 Sep 1987 p 113-119.

**094864 FREQUENCY-DEPENDENT LOSS IN SANDWICH SAMPLES OF HYDROGENATED AMORPHOUS SILICON.** Measurements of the a.c. conductivity of intrinsic sandwich samples of a-Si:H with  $n^+$  contact layers made between 1.3 and 360 K are described. Effects arising from the series impedance of the  $n^+$  layers are described by a simple geometrical model, demonstrating that the losses observed are representative of the bulk material. At low temperatures, the loss is small and fairly independent of temperature, but above 80 K it increases rapidly with temperature. The low-temperature loss is ascribed to deep states, and that occurring at higher temperatures to band-tail relaxation. Evidence in favor of this view is presented from the changes in loss observed under illumination. (Author abstract) 13 refs.

Shimakawa, K. (Univ of Glasgow, Glasgow, Scotl); Long, A.R.; Imagawa, O. *Phil Mag Lett* v 56 n 2 Aug 1987 p 79-84.

**094865 INTERPRETATION OF THE LOW-TEMPERATURE PHOTOCONDUCTIVITY IN a-Si.** The paper is concerned with the interpretation of steady-state photoconductivity results on undoped a-Si at temperatures of 50 K and below which lead to an essentially constant value of the (photogeneration efficiency  $\times$  mobility  $\times$  lifetime) product  $\eta\mu\tau \approx 10^{-11} \text{ cm}^2\text{V}^{-1}$ . Measurements on  $p^+i-n^+$  junctions and Cr- $i-n^+$  barriers were carried out to determine the parameters separately: (i) steady-state reverse saturation currents gave a generation efficiency of  $\eta \approx 5 \times 10^{-2}$  below 50 K, suggesting that geminate recombination limits the generation process; (ii) the electron drift mobility  $\mu_e$  through the tail states and the charge extracted from the absorption region of the incident light were investigated by transient experiments, these showed that  $\mu_e\tau_a$  is limited to about  $3 \times 10^{-10} \text{ cm}^2\text{V}^{-1}$  at low T. (Edited author abstract) 9 refs.

Spear, W.E. (Univ of Dundee, Dundee, Scotl); Cloude, Carolyn S. *Phil Mag Lett* v 55 n 6 Jun 1987 p 271-276.

**094866 STAEBLER-WRONSKI EFFECT IN a-Si:H FILMS IMPLANTED WITH BORON AND PHOSPHORUS IONS.** It is established in experiments in a-Si:H films implanted with boron and phosphorus ions that with total concentrations of the implanted B and P ions  $N_B$  and  $N_P$  of less than  $5 \cdot 10^{19} \text{ cm}^{-3}$  the Staebler-Wronski effect, a change in the dark conductivity and

its energy of activation after illumination of the films by white light, is observed. At  $N_B, N_P > 5 \cdot 10^{19} \text{ cm}^{-3}$  there is no such effect. The nature of the observed patterns is discussed. (Author abstract) 11 refs.

Kurova, I.A.; Akimchenko, I.P.; Chitaya, K.B. *Moscow Univ Phys Bull* v 42 n 2 1987 p 116-119.

**094867 EXPERIMENTAL DETERMINATION OF THE DENSITY OF GAP STATES IN AMORPHOUS SILICON BY SCHOTTKY BARRIER ADMITTANCE.** Experimental admittance measurements are presented for an n-type doped amorphous-silicon Schottky barrier. The measurements are shown to be quite consistent with the theory described by I.W. Archibald and R.A. Abram and, using this theory, an estimate of the density of states in the upper half of the mobility gap is calculated. The average value is approximately  $10^{17} \text{ cm}^{-3} \text{ eV}^{-1}$ , and there is a minimum situated approximately 0.4 eV below the conduction-band mobility edge. The test-fit value for the gap-state capture/emission time constant  $\tau_0$  is found to be  $10^{-12} \text{ s}$ . (Edited author abstract) 16 refs.

Archibald, I.W. (Univ of Durham, Durham, Engl); Abram, R.A. *Philos Mag B* v 56 n 4 Oct 1987 p 429-441.

**094868 THERMALIZATION AND RADIATIVE RECOMBINATION OF PHOTO-EXCITED CARRIERS IN a-Si:H.** The thermalization and recombination of photo-excited carriers in a-Si:H have been studied by transient photoluminescence. The time decay of the photoluminescence after pulsed photo-excitation was measured for temperatures between 50 and 120 K and for different optical bias intensities. It is shown that the experimental results can be understood in the framework of an extended multiple-trapping model which, in contrast to the conventional multiple-trapping model, allows for transitions between the localized tail states and for electron-hole recombination. Thus, the model presented can be understood as a first step toward a common description of the transient optical and transport properties of a-Si:H. The validity of the basic assumptions made in the conventional multiple-trapping model as well as in our extended version are discussed, and possible extensions are pointed out. (Author abstract) 17 refs.

Maschke, K. (Ecole Polytechnique Federale de Lausanne, Lausanne, Switz); Merk, E.; Czaja, W. *Philos Mag B* v 56 n 4 Oct 1987 p 457-470.

**094869 OPTICAL CHARACTERIZATION OF UNDOPED a-Si:H PREPARED BY PHOTO-CVD AND GD TECHNIQUES.** We have optically characterized undoped a-Si:H films prepared by photo-CVD and GD techniques under various deposition conditions. Photoluminescence (PL) and transmission spectra were measured at 77 K, from which the peak energy  $E_p$  of the main PL band and the optical absorption edge  $E_{opt}$  could be deduced. We have obtained the Urbach energy  $E_0$  by means of photothermal deflection spectroscopy (PDS) at room temperature. The differences  $\Delta E$  between  $E_p$  and  $E_{opt}$  were plotted against  $E_0$  for films prepared under various conditions, from which it was found that the same linear relation holds between  $\Delta E$  and  $E_0$  commonly for films prepared by both techniques. We conclude that the increase of  $\Delta E$  in films deposited at a low substrate temperature is mainly caused by a broadening of the tail states owing to disorder in the amorphous network. (Author abstract) 8 refs.

Kawasaki, Satoshi (Tokyo Univ of Agriculture & Technology, Koganei, Jpn); Sato, Katsuaki; Suzuki, Kazuhiko; Takeuchi, Hiroshi; Kuroiwa, Koichi; Tarui, Yasuo. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1400-1403.

**094870 LIGHT-INDUCED EFFECT OF a-Si FILMS FABRICATED USING THE SUPER CHAMBER.** The light-induced effect in a-Si films with low impurity concentrations fabricated in the super chamber was investigated. It was confirmed that a reduction of impurity reduces the light-induced effect over a range of more than  $10^{18} \text{ cm}^{-3}$  for oxygen. Furthermore, other factors come to have an influence on the light-induced effect in the

low-impurity region. We believe that there are at least two types of light-induced defects, one related to impurities, which may be located below the midgap, and one related to structural properties, which may be located around the midgap. For a further reduction of the light-induced degradation in a-Si films, it is necessary to reduce the impurities in a-Si films and to suppress the creation of dangling bonds around the midgap. (Author abstract) 12 refs.

Ohnishi, Michitoshi (SANYO Electric Co, Moriguchi City, Jpn); Tsuda, Shinya; Takahama, Tsuyoshi; Isomura, Masao; Nakashima, Yukio; Nakamura, Noboru; Nakano, Shoichi; Yazaki, Takehito; Kuwano, Yukinori. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1408-1412.

**094871 ON THE REACTION KINETICS IN A MERCURY PHOTOSENSITIZED CVD OF a-Si:H FILMS.** The reaction kinetic processes for mercury photosensitized CVD ( $\text{Hg}^*\text{-CVD}$ ) in silane were analyzed using a time-dependent, one-dimensional calculation based on mass-, momentum- and energy-conservation equations, including simplified surface reactions such as radical adsorption and hydrogen elimination from the substrate. A good agreement between the measured and the calculated time-varying concentrations of species provides sufficient validity regarding the present model. It is also shown that the saturation of the  $\text{SiH}_4$  decomposition observed by many authors in closed systems can be explained by the abstraction of  $\text{SiH}_4$  from the surfaces by radicals peculiar to the  $\text{Hg}^*\text{-CVD}$  (e.g.,  $\text{HgH}$ ); gas-phase reactions are significantly influenced by surface reactions when the volume-to-surface ratio becomes small. (Author abstract) 20 refs.

Matsui, Yasuji (Mitsubishi Electric Corp, Amagasaki, Jpn); Yuuki, Akimasa; Morita, Noriko; Tachibana, Kunihide. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1575-1581.

**094872 DEPENDENCE OF THE PERSISTENT PHOTOCONDUCTIVITY IN DOPING-MODULATED a-Si:H MULTILAYERS ON THE EXPOSURE TEMPERATURE.** We find that the photo-induced excess conductivity (persistent photoconductivity, PPC) in doping-modulated hydrogenated amorphous silicon (a-Si:H) is thermally activated for exposure temperatures above 220 K. However, we find a temperature regime between 80 and 220 K in which the PPC measured at 300 K is independent of excitation temperature. Whether the PPC is excited in the thermally activated regime above 220 K or in the temperature-independent regime, the annealing occurs at 410 K. The pre-exponential factor and the activation energy of PPC are related by the Meyer-Neldel rule independent of the excitation temperature. (Edited author abstract) 13 refs.

Vomvas, A. (Univ of Chicago, Chicago, IL, USA); Fritzsche, H. *Phil Mag Lett* v 56 n 5 Nov 1987 p 197-201.

**094873 CHARACTERISTICS OF RECOMBINATION PROCESSES IN DOPED HYDRATED AMORPHOUS SILICON FILMS.** The results of measurements of the temperature dependences of the dark conductivity and photoconductivity of a-Si:H films, doped from the gas phase or by implantation of phosphorus or boron ions, as well as the effect of preillumination with white light with different duration on the photoconductivity are presented. A model is proposed for carrier recombination in doped films, taking into account the broadening of the levels of dangling bonds and the difference in the coefficients trapping of electrons and holes on neutral and charged dangling bonds. The dependence of the stationary interband photoconductivity on the equilibrium Fermi level and the appearance of the temperature-induced quenching of the photoconductivity in doped films after preillumination are studied on the basis of this model. (Author abstract) 13 refs.

Zvyagin, I.P. (M.V. Lomonosov Moscow State Univ, USSR); Kurova, I.A.; Ormont, N.N.; Chitaya, K.B. *Sov Phys J* v 30 n 6 Jun 1987 p 451-460.



**094874 EQUILIBRIUM DANGLING BOND DENSITIES IN a-Si:H AND ITS RELATED THIN-FILM ALLOYS.** The equilibrium density of dangling bonds is calculated without resort to kinetic arguments. We find that this density depends on temperature and the position of the Fermi energy within the mobility gap. Comparing our results to experimental data on the defect density in doped and light-soaked a-Si:H and to data on related thin-film alloys we are able to distinguish equilibrium from non-equilibrium defect structures. Our considerations suggest that enhanced carrier densities not only drive the equilibrium towards higher defect densities but also enhance the speed of those kinetic processes that establish equilibrium on the microscopic scale. (Author abstract) 27 refs.

Mueller, G. (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Ger). *Appl Phys A* v A45 n 2 Feb 1988 p 103-107.

**094875 ESR AND CONSTANT PHOTOCURRENT STUDIES OF SURFACE AND BULK DEFECTS IN a-Si:H.** Surfaces and bulk defect densities in undoped a-Si:H films on a quartz substrate are estimated from the thickness dependence of the defect density by ESR and constant photocurrent method (CPM). For the first time, the thickness of a defective surface layer in a-Si:H is determined by ESR to be about 200 Å. The decrease in surface spin density by HF etching treatment and the difference in photoconductivities measured by illumination from different sides suggest that the free surface layer is more defective than the interface layer on a quartz substrate. (Author abstract) 7 refs.

Xu, Xixiang (Kanazawa Univ, Kanazawa, Jpn); Morimoto, Akiharu; Kumeda, Minoru; Shimizu, Tatsuo. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1818-1820.

**094876 TRANSIENT PHOTOCURRENT STUDY OF THE DANGLING BOND CENTRE IN UNDOPED AMORPHOUS SILICON.** The spectra of all four cross-sections for optical transitions associated with a correlated dangling bond centre in undoped amorphous silicon have been derived by combining transient and modulated photocurrent measurements. Analysis of the spectral shape of these cross-sections yields the energies of transitions between extended band states and the dangling bond centres with single and double occupancy, providing a unique energy placement of the dangling bond states. The results show that the singly and doubly occupied dangling bond states are located about 0.88 and 0.62 eV below the conduction-band edge, respectively, and the effective correlation energy is around 0.26 eV. Lattice relaxation energies are found to be between 0.09 and 0.13 eV. This implies a negligible role for lattice relaxation in the dangling bond transitions. (Author abstract) 39 refs.

Hattori, Kiminori (Osaka Univ, Toyonaka, Jpn); Okamoto, Hiroaki; Hamakawa, Yoshihiro. *Philos Mag B* v 57 n 1 Jan 1988 p 13-29.

**094877 CHARACTERIZATION OF THE STRUCTURE IN HYDROGENATED AMORPHOUS SILICON BY MEANS OF  $^{119}\text{Sn}$  MOSSBAUER SPECTROSCOPY.** The network structure in hydrogenated amorphous silicon (a-Si:H) films including a small amount of tin has been investigated by means of Mossbauer spectroscopy. The quadrupole splitting  $\Delta$  of  $^{119}\text{Sn}$  nuclei in a-Si:H films is very sensitive to the difference in the hydrogen bonding configuration, and is concluded to be a useful parameter for the characterization of the amorphous structure. The relation between  $\Delta$  and the IR spectra shows that the over-constrained region is formed in the a-Si:H network by the SiH group. (Author abstract) 21 refs.

Myoren, Hiroaki (Hiroshima Univ, Higashi-Hiroshima, Jpn); Shrestha, Purushottam; Imura, Takeshi; Osaka, Yukio. *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 1967-1970.

**094878 PRODUCTION OF EXCESS INTERSTITIALS BY PRE-AMORPHISATION.** Single-crystal silicon has been amorphized by bombardment with  $\text{Si}^+$ ,

$\text{Ge}^+$  or  $\text{Sn}^+$  ions. After conventional annealing (900°C, 30 min) some disorder remained. The amount was measured by ion channelling and transmission electron microscopy and compared with the quantity of excess interstitials predicted by the Monte Carlo computer program TRIM. Both the predicted and measured integral disorder fell as the atomic weight of the projectile increased. Because lattice strain also leads to a reduction in ion channelling this had to be taken into account when estimating residual damage from back-scattering analysis. Our results indicate that there are six scattering centers per interstitial. (Author abstract) 10 refs.

Thornton, J. (Univ of Surrey, Guildford, Engl); Paus, K.C.; Webb, R.P.; Wilson, I.H.; Booker, G.R. *J Phys D* v 21 n 2 Feb 14 1988 p 334-338.

**094879 AMPLIFICATION OF PHOTOCONDUCTIVE GAIN WITH SPACE CHARGE DOPING IN MINI MULTILAYERED STRUCTURE.** Optoelectrical properties of a-Si:H(F) multilayers consisting of alternating intrinsic and phosphorus doped layers (mini structure) have been investigated as a function of sublayer thickness by steady state and transient photocurrent measurements. The modulation of the band potential by space charge doping leads to high photoconductivity of the order  $10^{-3}$  S/cm under an illumination of  $10^{14}$  photons/cm<sup>2</sup>s, while maintaining a dark conductivity as low as that of  $10^{-10}$  S/cm. A high photoconductive gain above 10 is obtained for the reverse-biased Schottky diode by controlling the ratio of its thickness and doping level. (Author abstract) 12 refs.

Shirai, Hajime (Tokyo Inst of Technology, Yokohama, Jpn); Nakamura, Tetsuro; Shimizu, Isamu. *Jpn J Appl Phys Part 2* v 26 n 12 Dec 1987 p 1937-1940.

**094880  $^{31}\text{P}$  NUCLEAR MAGNETIC RESONANCE STUDY OF LOCAL BONDING CONFIGURATION OF PHOSPHORUS IN AMORPHOUS SILICON-HYDROGEN-PHOSPHORUS ALLOYS.**  $^{31}\text{P}$  nuclear magnetic resonance (NMR) spectra have been measured for amorphous hydrogenated silicon heavily doped with phosphorus. Phosphorus is enriched in the film during glow-discharge decomposition of the  $\text{SiH}_4$ - $\text{PH}_3$  mixture at a substrate temperature of 250°C by a factor of 3.  $^{31}\text{P}$  NMR results demonstrate that almost all the phosphorus atoms are bonded to three silicon atoms, and not to hydrogen or to other phosphorus. (Author abstract) 10 refs.

Hayashi, Shigenobu (Natl Chemical Lab for Industry, Tsukuba, Jpn); Hayamizu, Kikuko; Yamasaki, Satoshi; Matsuda, Akihisa; Tanaka, Hazunobu. *Jpn J Appl Phys Part 2* v 26 n 12 Dec 1987 p 2041-2043.

**094881 ON THE ZERO TEMPERATURE STATISTICS FOR THE DENSITY OF GAP STATES OF HYDROGENATED AMORPHOUS SILICON.** It is shown that one may obtain much larger value of density-of-states in the gap of hydrogenated amorphous silicon than real value if the zero temperature statistics are used in studying that material. So care must be taken when one employs zero temperature statistics in studying the density-of-states of amorphous materials. (Author abstract) 8 refs.

Yoon, Byung-Gook (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Lee, Choochun. *Solid State Commun* v 64 n 4 Oct 1987 p 583-584.

**094882 ANOMALOUS CHANGE OF d.c. CONDUCTIVITY WITH AMBIENT CONDITIONS IN SLOWLY-DEPOSITED SPUTTERED  $\alpha$ -Si AND  $\alpha$ -Si:H.** Electrical d.c. conductivity  $\sigma$  of sputtered  $\alpha$ -Si and weakly-hydrogenated  $\alpha$ -Si:H has been measured between 77 and 400 K, both in dry helium and vacuum ambient. Although the former ambient condition led exactly to the well-known  $\sigma \propto T^{-1/4}$  law, significant deviation from this law has been observed in vacuum at low temperatures. Both behaviours show up reproducibly and interchangeably by varying the ambient conditions. This is believed to arise from the particular microvoid structure of the films studied, depending on which the

ambient condition has a physical influence on the measured d.c. conductivity. This relates to the question about which ambient condition shows up most reliable to measure  $\sigma$  in and what is meant by 'bulk' conductivity. (Author abstract) 12 refs.

Stesmans, A. (Katholieke Univ Leuven, Louvain, Belg); Wu, Y. *Solid State Commun* v 62 n 6 May 1987 p 435-439.

**094883 EFFECT OF BOND-ANGLE AND DIHEDRAL-ANGLE DISORDERS ON THE TOP OF THE VALENCE BAND OF AMORPHOUS SILICON.** We have considered the electronic structure of amorphous silicon using a tight-binding method with all first-neighbor couplings in a continuous random network. The effects of bond-angle and dihedral-angle disorders were examined keeping only the nearest-neighbor interactions in the Hamiltonian. The dihedral-angle and bond-angle disorders were found to be important at the valence-band edge and responsible for the observed features near the top of the valence band. We find the same results as J. Singh et al., i.e. that in the top of the valence-band there is a tail of localized states  $\approx 0.5$  eV in width. (Author abstract) 22 refs.

Ratag, Victor M. (Bandung Inst of Technology, Bandung, Indonesia). *J Phys Chem Solids* v 49 n 1 1988 p 9-14.

**094884 NEW MODEL FOR THE STAEBLER-WRONSKI EFFECT.** A new model for the formation of metastable Staebler-Wronski (SW) defects in a-Si:H is proposed. The phonons of local Si-H vibrational modes released in the non-radiative recombination of photoexcited electrons and holes through weak Si-H bonds may break the Si-H bonds themselves and result in an increase of Si dangling bonds, that is, SW defects. The model provides a reasonable qualitative explanation of all the important experimental results related to the phenomenon. (Author abstract) 27 refs.

Qin, Guo-Gang (Peking Univ, Peking, China); Kong, Guang-Lin. *Phil Mag Lett* v 57 n 2 Feb 1988 p 117-122.

**094885 EXTENDED-STATE HOLE MOBILITY IN AMORPHOUS SILICON.** The hole drift mobility in a-Si:H p-i-n junction specimens has been investigated between 250 and 455 K. It is shown that effects associated with anomalous dispersion disappear above 360 K. In the range between 360 and 455 K results have been fitted to the multi-trapping transport model, making it possible to deduce the extended-state hole mobility  $\mu_v$ . Assuming a temperature dependence of the form  $\mu_v \propto T^{-n}$  (with  $n=0.5$  and 1.0), analysis of the data leads to  $\mu_v$  values between 0.4 and 0.8 cm<sup>2</sup> V<sup>-1</sup> s<sup>-1</sup> at 295 K. (Author abstract) 13 refs.

Goldie, D. (Univ of Dundee, Dundee, Scotl); Spear, W.E. *Phil Mag Lett* v 57 n 2 Feb 1988 p 135-141.

**094886 DEFECT AT THE SURFACE OF a-Si:H FILMS AS ELUCIDATED BY PHOTOCURRENT.** From the dependence of thermal quenching of photocurrent on the excitation photon energy, a 0.36-eV-deep hole trap is found near the surface in a-Si:H. It is suggested that the defect exists in the Si/SiO<sub>2</sub> interface. The decrease in the normalized photocurrent at large absorption coefficient is probably caused by the defect. (Author abstract) 11 refs.

Yamaguchi, M. (Univ of Tokyo, Tokyo, Jpn). *Solid State Commun* v 61 n 1 Jan 1987 p 9-12.

**094887 PARTIAL SATURATION OF THE CONDUCTION BAND TAIL IN DOPED a-Si:H.** The temperature and excitation density dependence of transient photocurrents in lightly doped a-Si:H reveals partial saturation of an exponential conduction band tail with a characteristic width of 40 meV. (Author abstract) 6 refs.

Kristensen, I.K. (Odense Univ, Odense M, Den); Hvam, J.M. *Solid State Commun* v 65 n 5 Feb 1988 p 415-417.



**094888 THEORETICAL ANALYSIS OF INFRARED STIMULATED CURRENT IN  $\alpha$ -Si:H.** The infrared stimulated current (IRSC) in amorphous semiconductors is interpreted in terms of a model of two-step excited processes. The photoconductivity behavior with the excitation of two successive light beams, a visible light beam at an early time and an i.r. beam at a later time, is analyzed based on the same model. (Edited author abstract) 5 refs.

Xu, Zhengyi (Acad Sinica, Beijing, China); Gu, Benyuan; Han, Daxing. *Solid State Commun* v 62 n 2 Apr 1987 p 125-128.

**094889 ELECTRON-NUCLEAR DOUBLE RESONANCE OF DANGLING-BOND CENTRES IN  $\alpha$ -Si:H.** We have observed the ENDOR spectra of dangling bonds in  $\alpha$ -Si:H at 15K which are due to the hyperfine interaction with the  $^{29}\text{Si}$  isotope at the dangling bond site and also due to that with the  $^{29}\text{Si}$  isotope occupying one of its neighboring sites. The hyperfine splitting associated with the above interactions are 71 G and 26 G, respectively. The nature of the dangling-bond center is discussed on the basis of these results. (Author abstract) 10 refs.

Yokomichi, H. (Univ of Tokyo, Tokyo, Jpn); Hirabayashi, I.; Moigaki, K. *Solid State Commun* v 61 n 11 Mar 1987 p 697-701.

**094890 OCCUPANCY OF DANGLING BOND DEFECTS IN DOPED HYDROGENATED AMORPHOUS SILICON.** The occupancy of dangling bond defects in doped hydrogenated amorphous silicon is examined using a combination of electron spin resonance, sub-bandgap absorption, and transport measurements. A corrected value of  $U = +0.2$  eV ( $\pm 0.1$  eV) is obtained for the dangling bond correlation energy in state-of-the-art material. The importance of potential fluctuations caused by inhomogeneous defect distributions is demonstrated for the case of boron doping in non-optimized samples. (Author abstract) 8 refs.

Stutzmann, Martin (Max-Planck-Institut fuer Festkörperforschung, Stuttgart, West Ger); Jackson, Warren B. *Solid State Commun* v 62 n 3 Apr 1987 p 153-157.

**094891 DIRECT OBSERVATION OF  $\alpha$ -Si:H/ $\alpha$ -Si $_{1-x}$ C $_x$ H MULTILAYERS AND THEIR ELECTRICAL PROPERTIES.** Very clear transmission electron microscopy (TEM) patterns of ultrathin  $\alpha$ -Si:H/ $\alpha$ -Si $_{1-x}$ C $_x$ H multilayers have been observed. TEM photographs show rapidly increasing interface roughness as the number of multilayers increases. The  $\alpha$ -Si:H/ $\alpha$ -Si $_{1-x}$ C $_x$ H heterojunction interfaces are the main causes of this roughness. In addition, the dependence of the optical gap, activation energy, and conductivity on  $\alpha$ -Si:H well layer thickness is investigated. These results cannot be explained by the quantum effect alone. (Author abstract) 15 refs.

Itoh, Haruo (Hitachi Ltd, Kokubunji, Jpn); Matsubara, Sunao; Muramatsu, Shin-ichi; Nakamura, Nobuo; Shimada, Toshikazu; Shimotsu, Teruo. *Jpn J Appl Phys Part 2* v 27 n 1 Jan 1988 p 24-27.

**094892 CHARACTERISTICS OF  $\alpha$ -Si FILMS PREPARED BY COMPRESSED MAGNETIC FIELD (CMF)-MAGNETRON SPUTTERING.** The compressed magnetic field magnetron sputtering system has been developed to minimize the damage to the substrate and to enable film deposition at low temperature. High-quality  $\alpha$ -Si:H film has been formed by using He whose atomic radius is smaller than that of Ar. In this paper, the characteristics of the compressed magnetic field-magnetron sputtering system are described. The  $\alpha$ -Si:H film is characterized by using the partial pressure of hydrogen as a parameter. Moreover, the characteristics and thermoproperty of the film by He sputtering are compared with those of the film by Ar sputtering. (Edited author abstract) 13 refs.

Hata, Tomonobu (Kanazawa Univ, Kanazawa, Jpn); Kamide, Yukihiro; Nakagawa, Shigeki; Hattori, Kouji. *Electron Commun Jpn Part 2* v 71 n 2 Feb 1988 p 9-18.

**094893 IDENTIFICATION OF ELECTRON AND**

**HOLE PICOSECOND TRAPPING PROCESSES IN DOPED  $\alpha$ -Si:H.** Using the picosecond pump and probe technique we identify the electron and hole contributions to the photomodulation response in doped  $\alpha$ -Si:H. We have found that electron trapping in doping related defects is about 50 times faster than hole trapping regardless of doping type and concentration, temperature, light exposure or the energy level of the traps. This is an intrinsic property of  $\alpha$ -Si:H which originates from a larger electron hopping rate among localized states in the conduction band-tail due to a larger extent of the electron wave function. (Author abstract) 20 refs.

Vardeny, Z. (Brown Univ, Providence, RI, USA); Thomsen, C.; Tauc, J. *Solid State Commun* v 65 n 7 Feb 1988 p 601-604.

**094894 THICKNESS AND DOPING DEPENDENCE OF THE OPTICAL GAP IN AMORPHOUS HYDROGENATED SILICON FILMS.** The optical energy gap and refractive index has been determined by analysis of absorption curves of device-type amorphous hydrogenated silicon films of various thickness and doping. The gap is essentially independent of thickness and P doping, but is slightly reduced by B doping. The refractive index is independent of doping. (Edited author abstract) 17 refs.

Chacorn, V. (Univ of New South Wales, Kensington, Aust); Haneman, D. *Solid State Commun* v 65 n 7 Feb 1988 p 609-611.

**094895 HOLE CARRIER DRIFT-MOBILITY MEASUREMENTS IN  $\alpha$ -Si:H, AND THE SHAPE OF THE VALENCE-BAND TAIL.** A detailed study has been performed concerning the temperature and electric-field dependence of hole carrier time-of-flight pulses in amorphous silicon. Various aspects of the experimental behavior are employed in the estimation of the energy distribution of other characteristics of localized states in the films. Over the depth range 0.2 to 0.45 eV, the trap concentration is found to vary more rapidly than the exponential form assumed in earlier studies, and a Gaussian tail is in better agreement with the data. Localized-state capture cross-sections are calculated as  $1.3 \times 10^{-16}$  cm<sup>2</sup>, and are essentially independent of depth over the range studied. Taking the present data in conjunction with the energy distribution of states as determined by other techniques allows an estimation of the mobility of free holes. The value of about  $10 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$  thus obtained is an order of magnitude larger than the previous estimate from time-of-flight measurements, but is comparable to the figures suggested by other transport data. (Author abstract) 18 refs.

Marshall, J.M. (Univ Coll of Swansea, Swansea, Wales); Street, R.A.; Thompson, M.J.; Jackson, W.B. *Philos Mag B* v 57 n 3 Mar 1988 p 387-397.

**094896 DRIFT MOBILITY IN n- AND p-CONDUCTING  $\alpha$ -Si:H.** The drift mobility of a series of undoped and doped  $\alpha$ -Si:H films has been determined from their steady-state photoconductivity and response time. The drift mobilities at 300 K were  $0.1 \text{ cm}^2 \text{ V}^{-1}$  and  $5 \times 10^{-4} \text{ cm}^2 \text{ V}^{-1}$  for electrons and holes, respectively. The activation energies were 0.13 and 0.27 eV. There is no influence of doping up to a doping level of 1000 ppm of either  $\text{PH}_3$  or  $\text{B}_2\text{H}_6$ . The temperature dependence of the response time reflects changes in the dominant recombination path. At low temperatures tunnelling processes prevail but with increasing temperature direct capture of free carriers by dangling bonds becomes predominant. (Author abstract) 25 refs.

Hoheisel, M. (Siemens AG, Munich, West Ger); Fuhs, W. *Philos Mag B* v 57 n 3 Mar 1988 p 411-419.

**094897 ATOMIC STRUCTURE OF AMORPHOUS SILICON.** A supercell configuration and the self-consistent pseudopotential method are applied to study the structural properties of amorphous silicon ( $\alpha$ -Si). Starting from a random atomic arrangement in the supercell, a local equilibrium structure is obtained by minimizing the total energy of the system. In the equilibrium, a short

range order is formed. Most atoms are 4-fold coordinated, but also appear 3-fold, and 5-fold coordinated atoms. In addition, 3-membered rings are found. The calculated total energy variations due to volume changes explain the pressure induced phase changes of  $\alpha$ -Si. (Author abstract) 23 refs.

Uda, Tsuyoshi (Hitachi Ltd, Kokubunji, Jpn). *Solid State Commun* v 64 n 5 Nov 1987 p 837-841.

**094898 MICROSCOPIC MECHANISM FOR THE PHOTO-CREATION OF DANGLING BONDS IN  $\alpha$ -Si:H.** We present a microscopic model for the photo-creation of silicon dangling bonds, taking into account the combined effects of breaking of weak bonds, Si-H bond switching, and H-tunneling which occur under intense optical excitation. We also discuss the kinetics of the photo-creation of silicon dangling bonds, taking into account that the other defects than dangling bonds are photocreated. (Author abstract) 26 refs.

Morigaki, Kazuo (Univ of Tokyo, Tokyo, Jpn). *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 163-168.

**094899 ESR IN P/I HETEROJUNCTIONS BASED ON  $\alpha$ -Si:H.** Amorphous silicon ( $\alpha$ -Si:H) solar cells have been rapidly coming into practical use. The conversion efficiency of  $\alpha$ -Si:H solar cells has been improved to 11.5% in a small area ( $1 \text{ cm}^2$ ) and 9.3% in a large area ( $100 \text{ cm}^2$ ). Electron spin resonance (ESR) has provided useful information concerning deep levels in undoped hydrogenated amorphous silicon. The authors report the first ESR study of P/I structures which closely simulate photovoltaic devices. The influence of carbon content in the p-layer and the illumination time on the spin density ( $N_s$ ), g-value, and peak to peak linewidth ( $\Delta H_{pp}$ ) was investigated. 6 refs.

Chen, Guanghua (Lanzhou Univ, Lanzhou, China); Sun, Guosheng; Zhang, Fangqing. *Phys Status Solidi A* v 105 n 1 Jan 1988 p K41-K43.

**094900 MICROSCOPIC MECHANISM FOR ANNEALING OF PHOTOCREATED DANGLING BONDS IN  $\alpha$ -Si:H.** A microscopic mechanism for annealing of photocreated dangling bonds in  $\alpha$ -Si:H is presented taking into account hydrogen plays an important role in annealing of dangling bonds. This model can account for the experimental fact that photocreated dangling bonds as well as thermally created dangling bonds are annealed at relatively low temperatures such as  $100\text{-}150^\circ\text{C}$  in  $\alpha$ -Si:H. (Author abstract) 18 refs.

Morigaki, Kazuo (Univ of Tokyo, Tokyo, Jpn). *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 138-140.

**094901 INVESTIGATION OF UV-UV-IR SPECTRA FOR AMORPHOUS SEMICONDUCTOR SUPERLATTICES.** We have successfully made amorphous semiconductor superlattices of  $\alpha$ -Si:H/ $\alpha$ -Si $_{1-x}$ C $_x$ H films consisting of 28-102 periods of 10-200 Angstrom thick  $\alpha$ -Si:H and 60 Angstrom  $\alpha$ -Si $_{1-x}$ C $_x$ H by periodic alternating the plasma gas mixture in single reaction chamber of plasma deposition system. The results of TEM and XPS show smooth and sharp boundaries between the layers. The vibration modes of (Si-H)N stretchbonds and extra hydrogen bonded at the interface have been discovered by analysing the fine structure of the (Si-H) stretch mode in the wavenumber of  $2400\text{-}1800 \text{ cm}^{-1}$ . The results of investigation of UV-UV spectra indicate that the shift of optical energy gap in  $\alpha$ -Si:H/ $\alpha$ -Si $_{1-x}$ C $_x$ H superlattices is induced by quantum well effect. (Author abstract) 16 refs. In Chinese.

Mao, Guomin (Nanjing Univ, Nanjing, China); Chen, Kunji; Du, Jiafang; Li, Zhiheng; Chen, Hong. *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 181-188.

**094902 EFFECT OF INTERRUPTING FILM GROWTH ON THE PROPERTIES OF  $\alpha$ -Si:H.** This paper compares photoluminescence, optical absorption, H-evolution, and infrared vibrational spectra of glow-discharge deposited hydrogenated amorphous silicon,



a-Si:H, prepared in three different ways: continuous deposition and deposition interrupted hundreds of times either by a shutter or by shutting off the plasma power. The latter yields an excess hydrogen content, a blue shift of the optical gap, and a decrease in the photoluminescence intensity. The results are related to the initial non-equilibrium plasma chemistry. (Author abstract) 11 refs

Wang, Shu-Lin (Acad Sinica, Shanghai, China); Cheng, Ru-Guang; Fritzsche, H. *Phil Mag Lett* v 57 n 4 Apr 1988 p 241-245.

**094903 DENSITY OF STATES IN NONCRYSTALLINE SOLIDS.** The paper considers the energies of all the electrons in a semiconductor and all the possible energies electrons can attain after they have been given some additional energy, for instance, by absorption of sunlight or by heating the material. The problem is difficult because there are about  $10^{24}$  electrons in  $1 \text{ cm}^3$  of amorphous (or crystalline) silicon. That is as many electrons as there are sand grains in one million cubic yards of sand. The investigative method used by the author is to deduce the electronic states from chemical arguments and a few experiments. 40 refs.

Fritzsche, H. (Univ of Chicago, Chicago, IL, USA). *Phys Prop of Amorphous Mater, Proc of a Lect Ser, Bloomfield Hills, MI, USA, 1982-1983* Publ by Plenum Press, New York, NY, USA & London, Engl, 1985 p 313-341.

**094904 GEMINATE RECOMBINATION AND INJECTION CURRENT: DIAGNOSTICS FOR EXTENDED STATE MOBILITY.** In this paper the author raises the question, Is the extended state mobility in a-Si:H low ( $10 \text{ cm}^2/\text{V}\cdot\text{s}$ ) or high ( $> 200 \text{ cm}^2/\text{V}\cdot\text{s}$ )? This will be treated by examining two seemingly independent phenomena: (1) geminate recombination and (2) injection currents. The former refers to a primary photo-excitation process leading to a production of free carriers. This process involves the probability of escape of an excited pair from each other. Among the various factors governing this primary yield is the extended state mobility which determines how far apart the pair will be when they become thermalized. If the mobility is low, the mean free path is small and they diffuse apart during thermalization. On the other hand, if the mobility is high, the mean free path is large and they move apart ballistically in the range of the Coulomb interaction. In the former case, the separation is generally small and the yield would be expected to be small. In the latter case, the separation would be large and the yield approaches unity. 21 refs.

Silver, M. (Univ of North Carolina, Chapel Hill, NC, USA). *Phys Prop of Amorphous Mater, Proc of a Lect Ser, Bloomfield Hills, MI, USA, 1982-1983* Publ by Plenum Press, New York, NY, USA & London, Engl, 1985 p 397-421.

**094905 LIGHT-INDUCED EFFECTS IN HYDROGENATED AMORPHOUS SILICON ALLOYS.** The author reviews the experimental observations of light-induced effects in a-Si:H and discusses various models in the light of the experimental observations. By suitable annealing in vacuum and carrying out measurements in situ, one may minimize or eliminate surface effects. The discussions consider the experimental results which reflect changes in the bulk properties only. The observations concern dark conductivity, photoconductivity, photoluminescence, determination of gap state distribution, origin of the light-induced states and role of impurities. 45 refs.

Guha, S. (Energy Conversion Devices Inc, Troy, MI, USA). *Phys Prop of Amorphous Mater, Proc of a Lect Ser, Bloomfield Hills, MI, USA, 1982-1983* Publ by Plenum Press, New York, NY, USA & London, Engl, 1985 p 423-438.

**094906 RECOMBINATION AT DANGLING BONDS AND BAND TAILS: TEMPERATURE DEPENDENCE OF PHOTOCONDUCTIVITY IN HYDROGENATED AMORPHOUS SILICON.** The theory of recombination of dangling bonds and band tails is

developed. The statistics for correlated defects are included and the Shockley-Read formalism is extended to asymmetric exponential distributions of tail states. Parametrical representations of the photoconductivity and the charge densities are obtained. A comparison of the results explains the thermal quenching of the photoconductivity experimentally observed. At low temperatures, the photoconductivity is determined by the balance between the two band-tail charge densities. At higher temperatures, one band-tail density becomes negligible compared with the dangling-bond charge density and the photoconductivity is controlled by the latter. Finally, the variations in photoconductivity with the density-of-states parameters are discussed. (Edited author abstract) 28 refs.

Vaillant, F. (CNRS, Grenoble, Fr); Jousse, D.; Bruyere, J.-C. *Philos Mag B* v 57 n 5 May 1988 p 649-661.

**094907 DEPENDENCE OF HYDROGEN DIFFUSION ON GROWTH CONDITIONS IN HYDROGENATED AMORPHOUS SILICON.** The dependence of the hydrogen diffusion coefficient on the material growth conditions in doped hydrogenated amorphous silicon has been measured, using secondary-ion mass spectrometry. A greatly enhanced diffusion was found in material with a columnar microstructure because of the preferential motion of hydrogen along the columns. Increasing the deposition temperature in noncolumnar material results in a higher diffusion coefficient and a lower hydrogen concentration. No significant change in the diffusion was found with different n-type dopants. (Author abstract) 13 refs.

Street, R.A. (Xerox Palo Alto Research Cent, Palo Alto, CA, USA); Tsai, C.C. *Philos Mag B* v 57 n 5 May 1988 p 663-669.

**094908 INTRINSIC STRESS OF PHOSPHORUS- AND BORON-DOPED AMORPHOUS SILICON FILMS.** The relationship between the intrinsic stress and hydrogen-bonding configuration for plasma-produced hydrogenated amorphous silicon (a-Si:H) films doped with phosphorus and boron has been studied in the gas-phase doping ratios from 0 to  $5 \times 10^{-3}$  prepared with different substrate temperatures. We found the same strong correlation between the sign and strength of intrinsic stress  $\sigma_i$  and the infrared stretching-mode absorption ratio  $I(\text{SiH}_2)/I(\text{SiH})$  ( $=R$ ) as in a previous study on undoped films. (Edited author abstract) 8 refs.

Kakinuma, Hiroaki (Oki Electric Industry Co, Hachioji, Jpn). *Philos Mag B* v 57 n 5 May 1988 p 671-676.

**094909 TEMPERATURE DEPENDENCE OF PHOTODEGRADATION IN AMORPHOUS HYDROGENATED SILICON.** This paper reports on the results of steady-state photoconductivity measurements, which change continuously during the photodegradation. Since the light exposure need not be interrupted for these measurements, this procedure can be used for investigating the time evolution of metastable defect generation in a-Si:H. The measurements show that the power index of the time evolution (long-term observation) of the photodegradation is determined by the exposure temperature and the material. (Edited author abstract) 14 refs.

Sun, Y.M. (Siemens Research Lab, Munich, West Ger); Kruehler, W.; Nebel, C.E.; Bauer, G.H. *Appl Phys A* v A46 n 1 May 1988 p 5-8.

**094910 DEVICE APPLICATION OF AMORPHOUS SILICON.** Some unique advantages of tetrahedrally bonded amorphous semiconductors are discussed, along with some concrete evidences demonstrated from recent technologies. Current state of the arts in industrial device R&D efforts and their industrialization are overviewed. Some unique physical properties and remarkable advantages of a-Si alloys as a new optoelectronic material are pointed out from both basic physics and technological viewpoints. 9 refs.

Hamakawa, Yoshihiro. *Noncryst Semicond* Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 229-255.

**094911 PREPARATION AND APPLICATIONS OF**

**AMORPHOUS SILICON.** This chapter is concerned with the preparation, properties, and possible applications of amorphous silicon (a-Si) prepared by the glow-discharge (gd) decomposition of silane. It was discovered that a-Si prepared by the gd technique possesses a low density of states in the mobility gap, probably the most important single factor in its applied potential. A direct result of this has been the development of the a-Si field-effect transistor (FET) which could find applications in large-area addressable displays, in addressable image-sensing arrays, and in logic circuits. Various additional developments and discoveries are reported and discussed. 33 refs.

LeComber, P.G. (Univ of Dundee, Dundee, Scotl). *Cryst Semicond Mater and Devices, Trieste, Italy, 1984* Publ by Plenum Press, New York, NY, USA, 1988 p 623-639.

**094912 DENSITY OF STATES IN a-Si:H<sub>2</sub>Cl<sub>2</sub> DETERMINED BY SPACE-CHARGE-LIMITED CURRENTS.** Space-charge-limited current measurements have been performed on samples deposited by a glow discharge in an  $\text{SiCl}_4 + \text{H}_2$  mixture. The resulting density-of-states distribution  $N(E)$  is compared with those found by den Boer and Weisfield in hydrogenated amorphous silicon films. The structure of the  $N(E)$  distribution is influenced by the presence of chlorine in the network of the films. (Author abstract) 20 refs.

Ligonzo, Teresa (Univ di Bari, Bari, Italy); Murri, Roberto; Augelli, Vincenzo; Schiavulli, Luigi. *Thin Solid Films* v 158 n 2 Apr 1988 p 217-223.

**094913 UTILISATION DU SILICIUM AMORPHE HYDROGENE DANS LA REALISATION DE MIROIRS POUR LASERS HAUTE ENERGIE A  $\lambda = 10.6 \mu\text{m}$ .** [Utilization of Hydrogenated Amorphous Silicon to Realize Mirrors for High-Energy Lasers at  $\lambda = 10.6 \mu\text{m}$ .] Hydrogenated amorphous silicon thin films are hard, with low porosity and have a high refractive index. Owing to its mechanical and chemical properties, this material is attractive to be used as a thin protective film for  $\text{CO}_2$  laser mirror coatings. Unfortunately the low absorption at  $10.6 \mu\text{m}$  is too high for quarter-wave layer at that wavelength in enhanced metallic coatings. Nevertheless, when associated with a classical transparent but softer high index material such as  $\text{ZnS}$  or  $\text{ZnSe}$ , hydrogenated amorphous silicon can be used in order to design the last composite high index quarter-wave layer. Theoretical calculations predict an optimum reflectance for a fixed a-Si:H thickness. The silicon is thin enough to obtain a high reflectivity coating but thick enough to provide a good chemical and mechanical protection. (Edited author abstract) 10 refs. In French.

Mouchart, J. (Lab De Marcoussis, Marcoussis, Fr); Villela, G.; Dutois, F.; Pointu, B. *Vide Couches Minces* v 42 n 239 Nov-Dec 1987 p 465-477.

**094914 RADIATION INDUCED CRYSTALLIZATION OF AMORPHOUS Si:H ALLOY.** The microcrystalline phase of hydrogenated silicon ( $\mu\text{c-Si:H}$ ) has recently drawn interest as a new phase material for applications in thin film solar cells. Two stage radiation-enhanced nucleation has been observed in thin films of hydrogenated amorphous silicon. A microcrystalline-amorphous ( $\mu\text{c-a}$ ) mixed phase can be produced at room temperature from RF glow discharge amorphous thin films by using neutron irradiation with a dose of  $2 \times 10^{16}$  neutrons/ $\text{cm}^2$ . The subsequent annealing at  $150^\circ\text{C}$  using a built-in heating stage in a transmission electron microscope (TEM) can produce a high volume fraction of  $\mu\text{c}$  phase with an average grain size of 150 Angstroms. According to the in situ annealing data, the neutron irradiated film exhibits a nucleation controlled phase transformation. (Author abstract) 23 refs.

Koo, Y.C. (Univ of Toronto, Toronto, Ont, Can); Perrin, R.; Aust, K.T.; Zukotynski, S. *Metall Trans A* v 19 n 5 May 1988 p 1345-1349.



**094915** <sup>29</sup>Si DYNAMIC NUCLEAR POLARIZATION OF DEHYDROGENATED AMORPHOUS SILICON. <sup>29</sup>Si NMR spectra were obtained on a dehydrogenated amorphous silicon sample by means of dynamic nuclear polarization (DNP). The dependence of the DNP enhancement factor, which peaked at about 40, upon the microwave frequency offset ( $\omega - \omega_0$ ) from the electron spin Larmor frequency is essentially antisymmetric about  $\omega - \omega_0 = 0$ , which corresponds to a  $g$  value of 2.0059. This observation shows that the paramagnetic centers are fixed, immobile on the time scale of electron spin Larmor precession, requiring a reexamination of recently advanced models of the paramagnetic defects. Prospects for the application of DNP in the study of amorphous silicon materials are discussed. (Author abstract) 20 refs.

Lock, H. (Colorado State Univ, Fort Collins, CO, USA); Wind, R.A.; Maciel, G.E.; Zumbulyadis, N. *Solid State Commun* v 64 n 1 Oct 1987 p 41-44.

**094916** THERMAL-EQUILIBRIUM PROCESSES AND ELECTRONIC TRANSPORT IN UNDOPED HYDROGENATED AMORPHOUS SILICON. The temperature and time dependence of the d.c. conductivity of undoped hydrogenated amorphous silicon is presented. Measurements of the electronic transport are reported, with particular emphasis on the effects of annealing and cooling the samples. Two regimes of behaviour are observed. When samples are rapidly cooled from 200°C below a temperature  $T_E$  approximately 145°C a non-equilibrium dark conductivity, higher than that corresponding to slow cooling, is observed. The electronic and atomic structure then slowly relax and the time dependence of the excess conductivity is well described by a stretched exponential function. The second regime above  $T_E$  corresponds to a relaxation time short compared to experimental times and the conductivity is independent of which order the annealing temperature is chosen. Thus the thermal equilibrium processes observed in undoped samples are qualitatively very similar to those observed in doped samples as recently reported in the literature. (Author abstract) 15 refs.

Meaudre, R. (Univ Claude Bernard Lyon I, Villeurbanne, Fr); Meaudre, M.; Jensen, P.; Guiraud, G. *Phil Mag Lett* v 57 n 6 Jun 1988 p 315-320.

**094917** DRIFT MOBILITY UNDER SINGLE AND DOUBLE INJECTION IN HYDROGENATED AMORPHOUS SILICON. To test the effect of charged defect centers in a-Si:H we have performed drift-mobility measurements using a small-voltage-step technique in p-i-n and M-i-n samples already under strong forward bias. These measurements have been made as a function of forward bias and temperature. The drift mobility under double injection was of the order of one decade larger than that under single injection. The respective activation energies were approximately 0.13 and 0.17 eV while the activation energies for the forward-bias currents were approximately 0.45 and 0.64 eV. We suggest that the differences in drift mobility are a result of an increase in the extended-state mobility arising from neutralization of the charge defects under double injection, which is not possible under single injection. (Author abstract) 7 refs.

Xu, L. (Univ of North Carolina at Chapel Hill, Chapel Hill, NC, USA); Winborne, G.; Silver, M.; Cannella, V.; McGill, J. *Philos Mag B* v 57 n 6 Jun 1988 p 715-720.

**094918** ELECTRON DIFFRACTION STUDY OF THE STRUCTURE OF BORON- AND PHOSPHORUS-DOPED HYDROGENATED AMORPHOUS SILICON. The effect of gas-phase doping with boron and phosphorus on the structure of glow-discharge amorphous hydrogenated silicon has been studied by means of energy-filtered electron diffraction. The reduced density function was calculated and the network was found to contract upon doping. At levels of less than 20 at% neither boron nor phosphorus segregated from the network. At high phosphorus doping levels an amorphous chemically ordered structure corresponding to  $Si_2P$  was formed. At high boron doping levels, evidence for the presence of boron icosahedra was obtained. (Author abstract) 12 refs.

Liu, Z.Q. (Univ of Sydney, New South Wales, Aust); McKenzie, D.R.; Cockayne, D.J.H.; Dwyer, D.M. *Philos Mag B* v 57 n 6 Jun 1988 p 753-761.

**094919** DENSITY OF MID-GAP STATES FOR UNDOPED a-Si<sub>1-x</sub>Ge<sub>x</sub>H AND a-Si:H DETERMINED BY STEADY-STATE HETEROJUNCTION-MONITORED CAPACITANCE METHOD. A simple technique has been described for determining the density of mid-gap states of highly resistive amorphous semiconductors, using amorphous/crystalline heterojunction structures. The technique has been tested and applied on undoped hydrogenated amorphous silicon films and silicon-germanium alloy films, covering the optical gap range of 1.30 to 1.76 eV. Those densities obtained from this technique have been found to be densities of singly-occupied dangling bonds. (Author abstract) 8 refs.

Matsuura, Hideharu (Electrotechnical Lab, Tsukuba, Jpn). *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 513-515.

**094920** DENSITY-OF-STATE DISTRIBUTION FOR UNDOPED a-Si:H AND a-Si<sub>1-x</sub>Ge<sub>x</sub>H DETERMINED BY TRANSIENT HETEROJUNCTION-MONITORED CAPACITANCE METHOD. A novel technique has been proposed for determining the density-of-state (DOS) distribution in the mobile highly resistive amorphous semiconductors, using amorphous/crystalline heterojunction structures. This technique has been tested and applied on undoped hydrogenated amorphous silicon (a-Si:H) films and silicon-germanium alloy Ge<sub>x</sub>H films, covering the optical gap range ( $E_g$ ) of 1.55 eV to 1.76 eV. For undoped a-Si:H ( $E_g = 1.76$  eV), the mid-gap DOS distribution has been located at 0.85 eV below the conduction band mobility edge, with a  $5.6 \times 10^{15} \text{ cm}^{-3} \text{ eV}^{-1}$ . (Author abstract) 10 refs.

Matsuura, Hideharu (Electrotechnical Lab, Tsukuba, Jpn). *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 516-518.

**094921** EVIDENCE FOR THERMAL DEFECT CREATION IN AMORPHOUS SILICON. Comparison of contactless time-resolved photoconductivity experiments at 200°C and at 23°C yields evidence for a thermal defect creation in the network of hydrogenated amorphous silicon (a-Si:H). In undoped a-Si:H these defects act mainly as hole traps and lead to an increased effective electron lifetime. In p- and n-type samples the effective majority carrier lifetime is reduced at higher temperatures due to the thermal generation of recombinative states. (Author abstract) 11 refs.

Werner, A. (Hahn Meitner Inst, Berlin, West Ger); Kunst, M. *Solid State Commun* v 65 n 12 Mar 1988 p 1501-1503.

**094922** PROPERTIES OF AMORPHOUS Si:H FILMS PREPARED BY DUAL ION BEAM SPUTTERING. The Ion Beam Sputtering (IBS) and the Dual Ion Beam Sputtering (DIBS) allow independent control of the deposition kinetics and the hydrogenation of hydrogenated amorphous silicon (a-Si:H) films. This makes it possible to investigate the correlations between the disorder in the amorphous matrix and the optical parameters, such as optical gap and Urbach energy. Data were taken for samples grown at different substrate temperatures, having different hydrogen content, or presenting damage induced by argon bombardment. In addition, an experimental evaluation of the shift in optical gap due to the alloying with H was carried out and gave  $6.63 \times 10^{-3} \text{ eV/at\%}$ . (Author abstract) 10 refs.

Rudolf, P. (Univ La Sapienza, Rome, Italy); Coluzza, C.; Mariucci, L.; Frova, A. *Phys Scr* v 37 n 5 May 1988 p 828-830.

**094923** LOW PRESSURE CHEMICAL VAPOUR DEPOSITION AMORPHOUS SILICON BEHAVIOUR UNDER ANNEALING. Four types of amorphous silicon materials were grown in a low pressure chemical vapour deposition (LPCVD) system and their differences in colour, adherence, and smoothness, as well as crystallinity of the derived materials were investigated as a function of annealing temperature. Experimental results indicate that amorphous silicon growth can occur either

through a heterogeneous mechanism on the substrate surface or through homogeneous nucleation in the vapour phase. In general, surface-grown amorphous silicon renders high quality polysilicon after annealing. This is not the case for amorphous silicon nucleated in the vapour phase, which produces poor quality polysilicon under similar temperature conditions. (Author abstract) 17 refs.

Pastor, G. (Inst de Electronica de Comunicaciones, Madrid, Spain); Tejedor, P.; Jimenez, I.; Dominguez, E.; Torres, M.; Garcia-Ramos, J.V. *Phys Status Solidi A* v 106 n 1 Mar 1988 p 11-16.

**094924** PICOSECOND PHOTOMODULATION STUDIES OF CARRIER TRAPPING IN a-Si:H. Subnanosecond trapping in gap states of photogenerated carriers in doped, compensated and undoped a-Si:H, and a-Si:H/a-Si<sub>3</sub>N<sub>4</sub>/H multilayer structures, was studied by the picosecond pump and probe technique. In undoped a-Si:H the photoexcited carriers are trapped in band-tail states and in compensated a-Si:H in impurities introduced by doping. In singly doped a-Si:H the photoexcited majority carriers are trapped in impurities while the minority carriers are trapped in charged dangling bonds introduced by doping. In a-Si:H/a-Si<sub>3</sub>N<sub>4</sub>/H superlattices photocarriers are trapped in interface related defects. The transport dynamics of the trapping process is in all cases dispersive. (Author abstract) 28 refs.

Vardeny, Z. (Brown Univ, Providence, RI, USA); Taue, J. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 339-348.

**094925** PHOTOLUMINESCENCE STUDIES OF BAND-TAIL STATES IN a-Si:H. There is general agreement that the 1.4 eV emission band in a-Si:H arises from recombination of carriers trapped within the valence and conduction-band tails. Time-resolved measurements of this emission suggest that at low temperatures the carriers thermalize within the tails by direct hopping to lower-energy states, and that only one species is moving. The high transfer rates imply that these states may not be as localized as previously thought. During thermalization the recombination is dominated by radiative processes which are reaction rather than diffusion limited. Non-radiative processes are found to be operative on very short (ps) and long ( $\mu$ s) time scales, but do not appear important during this regime of rapid thermalization. (Edited author abstract) 24 refs.

Wilson, B.A. (AT&T Bell Lab, Murray Hill, NJ, USA). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 349-356.

**094926** RECOMBINATION IN a-Si:H BASED MATERIALS: EVIDENCE FOR TWO SLOW RADIATIVE PROCESSES. New time resolved photoluminescence measurements show that two radiative processes contribute to the approx. 1.3 eV emission band seen in a-Si:H. These processes are distinguished by their different lifetimes. Similar lifetime distributions are seen in a-Si<sub>3</sub>N<sub>4</sub>/H alloys and also in a-Si:H based multilayers. Time resolved electroluminescence and photoconductivity also have similar lifetime distributions. The temperature and excitation intensity dependence of the lifetime distributions provide evidence for saturation effects. Together with spectral measurements, these data reveal a range of radiative slow processes below approx. 20  $\mu$ s, and a predominantly nonradiative channel with a lifetime of about 8  $\mu$ s. (Edited author abstract) 11 refs.

Searle, T.M. (Univ of Sheffield, Sheffield, Engl); Hopkinson, M.; Edmeades, M.; Kalem, S.; Austin, I.G.; Gibson, R.A. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 357-368.

**094927** THERMAL AND OPTICAL QUENCHING OF THE PHOTOCONDUCTIVITY IN a-Si:H FILMS. It is shown that there are major inconsistencies in the current interpretations of optical and thermal quenching of the photoconductivity in a-Si:H. The quenching phenomena are studied in differently doped



samples and in the accumulation layer of a field effect transistor where the occupancy of the centers can be controlled by the gate potential. It is found that optical and thermal quenching arise from different excitation processes: Thermal quenching, which is only observed in samples where the Fermi level is close to midgap, is attributed to the temperature enhanced transfer of holes to D<sup>-</sup> states; optical quenching is suggested to arise in all kinds of samples from the excitation of electrons from D<sup>-</sup> states, and its temperature dependence is shown to originate from the competition of direct capture of electrons in neutral dangling bonds with tunneling transitions of band tail electrons. (Edited author abstract) 19 refs.

Carius, R. (Philipps-Univ, Marburg, West Ger); Fuhs, W.; Weber, K. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 369-379.

**094928 RECOMBINATION AND THE STANDARD MODEL IN AMORPHOUS HYDROGENATED SILICON (a-Si:H): AN ESSAY.** Non-radiative photocarrier recombination in amorphous hydrogenated silicon (a-Si:H) is reviewed. Emphasis is given to undoped material in the room temperature regime and to the effects upon photocarrier processes of the D center observed in electron spin resonance. The measurements include electron spin resonance, transient and steady-state photoconductivity, spin-dependent photoconductivity, and surface photovoltage. Three issues are addressed: (i) Is the electron recombination process due to tunneling or to free-to-bound transitions? (ii) Is there an important electron trap, and is the D<sup>0</sup> such a trap? (iii) Is electron capture by the D<sup>0</sup> center and hole capture by the D<sup>-</sup> the dominant recombination channel? (Edited author abstract) 21 refs.

Schiff, E.A. (Syracuse Univ, Syracuse, NY, USA). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 379-388.

**094929 OPTICAL AND PHOTOELECTRICAL PROPERTIES OF a-Si:H IMPLANTED BY Mg IONS.** The authors studied the photoluminescence and the spectral dependence of photoconductivity of a-Si:H layers with various concentrations of implanted Mg ions after subsequent anneal at 350 and 500°C. The aim was to clarify the possibility of preparation of weakly doped a-Si:H layers of p-type with stable properties. 8 refs.

Akimchenko, I.P. (Acad of Sciences of the USSR, Moscow, USSR); Zavetova, M.; Karriyev, A.N.; Krasnopetsev, V.V. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 395-400.

**094930 DETERMINATION OF THE ELECTRONIC DENSITY OF STATES OF N-TYPE HYDROGENATED AMORPHOUS SILICON FROM TRANSIENT SWEEP-OUT EXPERIMENTS.** We analyze the forward-bias transient response of hydrogenated amorphous silicon (a-Si:H)  $i/n/i$  structures in terms of the space-charge and emission limited currents. It is shown that the initial space-charge limited current in the thicker  $i$  layer gives way at later times to an emission-limited current from the  $n$  layer. The temporal dependence of the current depends upon the density of states and the position of the Fermi level in the  $n$  layer as well as upon the applied voltage and characteristics of the  $i$  layer. Comparison with the experimental data suggests that the electronic density of states in  $n$ -type a-Si:H has a peak within 0.3 eV below the conduction-band mobility edge. (Author abstract) 4 refs.

Silver, Marvin (Univ of North Carolina, Chapel Hill, NC, USA); Adler, David; Branz, Howard M. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 401-406.

**094931 ELECTRON CORRELATION ENERGIES IN HYDROGENATED AMORPHOUS SILICON.** The existence of defects with a negative correlation energy in amorphous silicon is still a question of controversy. Basically, two classes of defect models exist for this material. The first model states that the bulk of the

available experimental data can be explained by considering three major defect states (valence band tail states, dangling bonds, and conduction band tail states), all of which have positive-U character. The second class of models agrees with the existence of some positive-U defect states but, in addition, postulates the existence of some positive-U defect states, but, in addition, postulates the existence of an even larger density of negative-U defects, especially dangling bonds. The authors report some new experimental results which might help resolve part of the discrepancy between these two models. 23 refs.

Stutzmann, M. (Xerox Palo Alto Research Cent, Palo Alto, CA, USA); Jackson, W.B.; Street, R.A.; Biegelsen, D.K. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 407-414.

**094932 DEFECTS IN a-Si:H.** Defects in a-Si:H play an important role in its electronic properties because they give rise to gap states acting as either trapping centers or recombination centers. However, knowledge of them is still lacking. The authors discuss the nature of some defects in a-Si: H, particularly deep gap states and light-induced ESR (LESR) centers exhibiting ESR of  $g$ -values either  $g=2.004$  or  $g=2.013$  in undoped a-Si:H as well as similar centers in doped a-Si:H. The authors present evidence that some of the deep gap states are correlated with nitrogen impurities and discuss their role in photoinduced phenomena as well as their microscopic nature. The authors discuss the nature of LESR centers in undoped a-Si:H as well as those of similar centers and other defects in doped a-Si:H in the light of our recent ESR and ODMR measurements. 37 refs.

Morigaki, K. (Univ of Tokyo, Tokyo, Jpn); Yamaguchi, M.; Hirabayashi, I.; Hayasi, R. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 415-424.

**094933 OPTICAL ABSORPTION EDGE OF HYDROGENATED AMORPHOUS SILICON.** In earlier work the authors reported the shape of the absorption edge of a-Si:H using photoacoustic spectroscopy (PAS), from which the slope of the valence-band tail as well as the defect-state profile was determined. In this paper, a recent PAS technique is described for determining the optical absorption spectrum of a-Si:H in the temperature range of 10 K < T < 300 K. The optical absorption edge ( $1 < \alpha < 10^3 \text{ cm}^{-1}$ ) of a-Si:H is presented as a function of the measurement temperature, substrate temperature and post-annealing temperature. On the basis of the results, it is demonstrated that not only the disorder, thermal (dynamical) as well as structural (frozen-in), but also the bonded-hydrogen content determine the optical bandgap of a-Si:H. 15 refs.

Tanaka, Kazunobu (Electrotechnical Lab, Sakura-mura, Jpn); Yamasaki, Satoshi. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 425-434.

**094934 PREPARATION OF a-Si AND ITS RELATED MATERIALS BY HYDROGEN RADICAL ENHANCED CVD.** A novel method of preparing a-Si and its related materials from fluorides, i.e., Hydrogen Radical Enhanced CVD (HRCVD), is proposed. This method is based on control over the chemistry both in the gas phase and in the growing surface with the aid of hydrogen atoms. The high quality of the films is achieved due to a reduction in the density of states both in the midgap and in the valence band tail, resulting in the high photoelectric properties and the nondispersive hole transport, while the network structure in the Si films is controlled intentionally from the amorphous form to the crystalline form under the epitaxial growth by the new technique. (Author abstract) 48 refs.

Hanna, Jun-ichi (Tokyo Inst of Technology, Yokohama, Jpn); Shibata, Naoki; Fukuda, Kaichi; Ohtoshi, Hirokazu; Oda, Shunri; Shimizu, Isamu. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 435-446.

**094935 APPLICATION OF IN SITU ELLIPSO-**

**TRY TO THE GROWTH OF HYDROGENATED AMORPHOUS SILICON.** The physics of hydrogenated amorphous silicon (a-Si:H) has been studied for a number of years. The knowledge of the fundamental growth mechanisms continues to expand, however, through more detailed measurements of sample microstructure and its connection with plasma processing. In situ ellipsometry is one such measurement which the authors believe holds considerable promise in this regard. The paper provides a review of the current status of the interpretation of ellipsometry measurements of thin film semiconductors. This background material is presented so that the reader will recognize the novel capabilities of in situ ellipsometry for the study of the microstructural evolution of a-Si:H. The paper covers applications of the in situ technique to investigations of (1) the nucleation and interface properties of a-Si:H deposited under different conditions and (2) the effects of N<sub>2</sub> plasma exposure on the a-Si:H surface. 21 refs.

Collins, R.W. (Standard Oil Research & Development, Cleveland, OH, USA); Cavese, J.M.; Clark, A.H. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 447-458.

**094936 DENSITY OF GAP STATES IN UNDOPED AND DOPED AMORPHOUS HYDROGENATED SILICON OBTAINED BY OPTICAL SPECTROSCOPY.** Density of states (DOS) in the mobility gap of amorphous hydrogenated silicon (a-Si:H) is important since it influences the electrical and photoelectrical properties of this material. The silicon dangling bond is a basic deep defect in a-Si:H, the energy position of which is a function of its electron occupation. This defect has been studied by electron spin resonance, luminescence, optical absorption, photoconductivity, conductivity and capacitance techniques, but there exists still disagreement about the position of the silicon dangling bond within the gap. The authors present an approach based on photoconductivity technique used for measuring small optical absorption in subgap region. Measurement of the subgap absorption spectra by means of the constant photocurrent method (CPM), together with the measurement of the photothermopower and the mobility gap value, have enabled the authors to determine the density and position of the dangling bond in a different charge state within the mobility gap for undoped and doped a-Si:H. A new model for the density of gap states in doped a-Si:H is presented. 27 refs.

Triska, Ales (Czechoslovak Acad of Sciences, Prague, Czech); Kocka, Jan; Vanecek, Milan. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 459-468.

**094937 STRUCTURAL CHARACTERIZATION OF AMORPHOUS SILICON AND GERMANIUM.** We have derived a simple relationship between the measured TO-phonon frequency and the square of the TO-phonon Raman linewidth. The minimum strain energy calculated from the minimum  $\Delta\theta$  prior to crystallization compares favorably with the enthalpy of crystallization, being 15 KJ/mole for a-Si and 9.4 KJ/mole for a-Ge. The variation of  $\Delta\theta$  with T<sub>a</sub> may be fitted to an activated process resulting in an energy barrier of approximately 0.19 eV and 0.18 eV for a-Si and a-Ge, respectively. We have also derived an expression allowing the determination of  $\Delta\theta$  from optical absorption, thereby opening the door for many investigators regarding a quantitative measure of  $\Delta\theta$ . Since  $\Delta\theta$  affects the distance between the second nearest neighbors, the minimum hydrogen content for strain relieving is 6%, although it is more probable that 12% is required if two hydrogen atoms are bonded to two adjacent atoms. (Author abstract) 31 refs.

Tsu, Raphael (Solar Energy Research Inst, Golden, CO, USA). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 479-488.

**094938 RESONANT TUNNELING THROUGH QUANTIZED STATES IN a-Si:H.** Ultra-thin multilayer structures consisting of amorphous silicon (a-Si:H) and



silicon-based materials such as amorphous silicon nitride ( $a\text{-Si}_{1-x}\text{N}_x\text{:H}$ ), silicon carbide ( $a\text{-Si}_{1-x}\text{C}_x\text{:H}$ ), or silicon germanium ( $a\text{-Si}_{1-x}\text{Ge}_x\text{:H}$ ) have been extensively studied. The layer thickness can be controlled on an atomic scale and hence the optical and electrical properties have been interpreted by assuming the quantized states in the conduction and valence bands of the potential well layers, as in the case of crystalline semiconductor superlattices. However, there has been a current question whether or not the quantum size effect is really existing in ultra-thin amorphous semiconductor multilayers. We report on the resonant tunneling phenomena through  $a\text{-Si}_3\text{N}_4\text{:H}/a\text{-Si:H}/a\text{-Si}_3\text{N}_4\text{:H}$  double barrier structures. This is direct evidence of the quantization effect in an amorphous silicon well layer sandwiched with stoichiometric silicon nitride barriers. 10 refs.

Hirose, Masataka (Hiroshima Univ, Hiroshima, Jpn); Ihara, Yohji; Miyazaki, Seichi. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 511-518.

**094939 PERSISTENT PHOTOCONDUCTIVITY IN AMORPHOUS SILICON ALLOYS.** We have reviewed the present status of the enhanced conductivity observed in various  $a\text{-Si:H}$  structures upon a brief light exposure. It is pointed out that this effect is larger and persists longer in the doping modulated multilayers and compensated films of  $a\text{-Si:H}$  as compared with doped and undoped single layers and  $a\text{-Si:H}/a\text{-SiN}_x\text{:H}$  multilayers. The large effect in doping modulated and compensated films can be explained by assuming the presence of special centers with barriers, which are either already present or are created by light exposure in the upper half of the gap and are related to the presence of P and B, or B alone. 20 refs.

Agarwal, S.C. (Energy Conversion Devices Inc, Troy, MI, USA); Guha, S. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 519-527.

**094940 THERMAL EQUILIBRATION MODEL FOR PERSISTENT PHOTOCONDUCTIVITY IN DOPING MODULATED AMORPHOUS SILICON.** The persistent photoconductivity effect in doping modulated amorphous silicon is compared to the light-induced conductivity changes in compensated amorphous silicon. The recent proposal that the defect structure of doped amorphous silicon is in metastable thermal equilibrium is able to account for the metastable excess conductivity in both systems, and for the several orders of magnitude difference in exposure times needed. 19 refs.

Kakalios, J. (Xerox Palo Alto Research Cent, Palo Alto, CA, USA); Street, R.A. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 529-539.

**094941 BAND EDGE ALIGNMENT AND QUANTUM SIZE EFFECTS IN HYDROGENATED AMORPHOUS SILICON GERMANIUM SUPERLATTICE STRUCTURES.** We deduce conduction and valence band alignments in hydrogenated amorphous silicon/germanium superlattices from the layer thickness dependence of coplanar conductivity and thermoelectric power, Schottky barrier height, and optical absorption. We find that the amorphous germanium conduction band edge lies approx. 0.5 eV below and the valence band edge approx. 0.15 eV above the corresponding amorphous silicon edge. (Author abstract) 12 refs.

Persans, P.D. (Exxon Research & Engineering Co, Annandale, NJ, USA); Wronski, C.; Abeles, B. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 541-550.

**094942 JUNCTION CAPACITANCE STUDIES OF HYDROGENATED AMORPHOUS SILICON DOPING SUPERLATTICE FILMS.** We report junction capacitance measurements of amorphous silicon nini doping superlattice samples. By analyzing capacitance-voltage measurements at a series of temperatures we have deduced the densities of both shallow and deep states in each of the constituent layers. We conclude that the

deep defect density in the intrinsic regions is nearly equal to that in the n-type regions and thus much greater than that in bulk intrinsic material. These measurements disclose the existence of distinct interface states at the n-i and i-n boundaries with energies that strongly suggest that they are dangling bond defects. Both results have implications regarding mechanisms of dangling bond formation in amorphous silicon. (Edited author abstract) 12 refs.

Cohen, J. David (Univ of Oregon, Eugene, OR, USA); Michelson, Carol E.; Harbison, James P. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 577-583.

**094943 EFFECTS OF BAND BENDING ON THE OPTICAL, ELECTRICAL AND PHOTOELECTRONIC PROPERTIES OF  $a\text{-Si:H}$  THIN FILMS IN SURFACE CELL STRUCTURES.** We have studied the optical, electrical and photoelectronic properties of  $a\text{-Si:H}$  thin films in surface cell structures and have concluded that band bending at dry nitrogen  $a\text{-Si:H}$  surfaces and oxide glass  $a\text{-Si:H}$  interfaces makes many of these properties appear to be thickness dependent. We show that the  $a\text{-Si:H}$  alloys are homogeneous, and that the thickness dependence can be deduced from a model that includes an upward band bending, i.e., depletion regions, at both thin film surfaces. (Edited author abstract) 20 refs.

Parsons, G.N. (North Carolina State Univ, Raleigh, NC, USA); Kusano, C.; Lucovsky, G. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 587-602.

**094944 HYDROGEN MOTION AND THE STAEBLER-WRONSKI EFFECT IN AMORPHOUS SILICON.** In 1977 Staebler and Wronski discovered that prolonged illumination could induce reversible changes in the photoconductivity and dark conductivity of hydrogenated amorphous silicon ( $a\text{-Si:H}$ ). Subsequently, similar reversible changes have been observed in the photoluminescence, electron spin density, photovoltaic parameters, and density of gap states in  $a\text{-Si:H}$ . We describe a model for the Staebler-Wronski effect that is based on the assumption that hydrogen is induced to move by the recombination or trapping of carriers and that local bond reconstruction then creates a metastable state. 42 refs.

Carlson, D.E. (Solarex Thin Film Div, Newtown, PA, USA). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 613-620.

**094945 DANGLING BONDS AND METASTABILITY IN SEMICONDUCTORS.** All semiconductors have dangling bonds. In crystals they are found on the surface, in grain boundaries, in dislocations, in point defects, near impurities and in vacancies. In amorphous semiconductors, there is a much greater opportunity to form dangling bonds. The author reviews various major observations of metastability in  $a\text{-Si:H}$ , summarizes the main models to be tested, shows that the breaking of weak bonds model is compatible with the charge redistribution model, and presents a perspective on what remains to be done. 32 refs.

Pankove, Jacques I. (Solar Energy Research Inst, Golden, CO, USA). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 625-633.

**094946 RECOMBINATION-ENHANCED DEFECT FORMATION AND ANNEALING IN  $a\text{-Si:H}$ .** Despite efforts to elucidate the light-induced (or current-induced) instability in  $a\text{-Si:H}$ , one approach has been largely neglected. This approach is the exploitation of analogies between the formation and annealing of metastable defects (MSDs) in  $a\text{-Si:H}$  and the recombination-induced defect reactions in crystalline semiconductors. Defect reactions are any bond rearrangements around a defect, including the motion or creation of a defect. Recent efforts using this approach have (1) produced a conclusion that the light-induced effects in  $a\text{-Si:H}$  are probably of extrinsic origin, in disagreement with current intrinsic models; and (2) shown that a class of physical processes has been overlooked in kinetic analyses of MSD densities. This paper summarizes this approach and its results to date. 17 refs.

Redfield, David (Stanford Univ, Stanford, CA, USA). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 635-640.

**094947 COMPOSITION AND THERMAL STABILITY OF GLOW-DISCHARGE  $a\text{-Si:C:H}$  AND  $a\text{-Si:N:H}$  ALLOYS.** Reported are results of a broad-scaled investigation of  $a\text{-Si:C:H}$  and  $a\text{-Si:N:H}$  films prepared at laboratories from a wide range of different gases. We characterize the composition of such films with respect to the gas mixture used, employing Auger electron spectroscopy (AES), electron probe microanalysis (EPMA), infrared (IR) absorption and gas effusion experiments. The latter two techniques are applied as a sensitive tool for structural effects in the amorphous material. Gas effusion experiments are also used to elucidate the mechanisms of thermal decomposition of the amorphous films with consequences both for the choice of optimum deposition conditions and for high-temperature applications of the amorphous alloys. The optical band-gap is related to the compositional and structural film properties. 25 refs.

Beyer, W. (Inst fuer Grenzlaechenforchung, Juelich, West Ger); Mell, H. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 641-658.

**094948 INVESTIGATION OF THE ELECTRONIC STRUCTURE OF AMORPHOUS SILICON BASED ON STUDIES OF THE AMORPHOUS-TO-CRYSTALLINE TRANSITION.** We discuss features in the electronic density of states (EDOS) of amorphous silicon ( $a\text{-Si}$ ) based on studies of the velocity of the conversion of  $a\text{-Si}$  to crystalline ( $c\text{-Si}$ ) silicon. The discussion adopts a model where charged dangling bonds in the  $a\text{-Si}$  matrix diffuse to the  $a\text{-c}$  interface where they allow conversion of atoms from  $a\text{-to-c}$  configurations. Features in the EDOS are identified and placed in the energy pseudogap. (Edited author abstract) 22 refs.

Paesler, M.A. (Philipps-Univ Marburg, Marburg, West Ger); Mosley, L.E. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 659-672.

**094949 STATISTICAL SHIFT OF THE FERMI ENERGY AND THE PREFACTOR OF THE DC CONDUCTIVITY IN  $a\text{-Si:H}$ .** We show that recent models of the density of states distribution lead to large values for the statistical shift of the Fermi level. These agree with transport models which consider transport in extended states only if the rather high prefactor  $\sigma_0 = 2000 \Omega^{-1} \text{cm}^{-1}$  for the dc conductivity is assumed. This is in contradiction to the values proposed recently by Mott and by Fenz et. al. (Edited author abstract) 31 refs.

Overhof, Harald (Univ of Paderborn, Paderborn, West Ger). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 713-722.

**094950 OPTICAL DEGRADATION OF  $a\text{-Si:H}$  FILMS WITH DIFFERENT MORPHOLOGY.** The optical degradation (Staebler-Wronski (SW) effect) of  $a\text{-Si:H}$  films prepared by plasma CVD has been studied in connection with the morphological inhomogeneity of the films. The relative degradation rate of cubic photoconductivity  $\alpha$  widely varied with deposition substrate temperature  $T_s$  and had its maximum at  $T_s = 200$  to approx.  $250^\circ\text{C}$ . In the films of both the lower and higher  $T_s$ ,  $\alpha$  decreased due to the increase of stable dangling bonds in the former and the decrease of weak bonds in the latter. The SW effect was hardly observed in  $\mu\text{-Si:H}$  deposited from highly diluted silane with hydrogen. (Author abstract) 14 refs.

Ohagi, Hideki (Kinki Univ, Osaka, Jpn); Yamazaki, Motoharu; Nakata, Jun-ichi; Imao, Shozo; Shirafuji, Junji; Fujibayashi, Keiji; Inuishi, Yoshio. *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 916-918.



**094951 THERMAL CONDUCTIVITY OF AMORPHOUS Si AT LOW TEMPERATURES.** Measurements of thermal conductivity of amorphous Si films from 2 to 50 K are presented. The qualitative and quantitative behavior is similar to thermal conductivity of other amorphous dielectrics. The temperature range of the plateau of  $\gamma(T)$  correlates with the maximum  $T_m = 30$  K of the function  $c/T^3(T)$ . An analysis of the effective free path of phonons in dependence on the reduced temperature  $T/\theta_D$  results in a remarkable coincidence for amorphous As, Se, Si, Ge, and  $\text{SiO}_2$ ,  $\text{GeO}_2$  in the plateau range. This fact leads to a restriction of hypotheses for explanation of the plateau of thermal conductivity at amorphous materials. (Author abstract). 26 Refs.

Pompe, G. (Technischen Univ Dresden, Dresden, East Ger); Hegenbarth, E. *Phys Status Solidi B* v 147 n 1 May 1988 p 103-108.

**094952 ION-BEAM-INDUCED EPITAXIAL CRYSTALLISATION (IBEC) OF AMORPHOUS SILICON LAYERS PRODUCED BY CHEMICAL VAPOUR DEPOSITION.** Amorphous silicon layers deposited by chemical vapor deposition on monocrystalline silicon substrates were epitaxially recrystallized by ion beam induced epitaxial crystallization at 400°C after preamorphization of the transition region layer/substrate. In this manner, a layer with a thickness of 400 nm was recrystallized by implanting silicon ions at 330 keV with a dose of about  $1 \times 10^{17} \text{ cm}^{-2}$ . (Author abstract). 6 Refs.

Skorupa, W. (Acad of Sciences of the GDR, Dresden, East Ger); Voelskow, M.; Matthai, J.; Knothe, P. *Electron Lett* v 24 n 14 Jul 7 1988 p 875-876.

**094953 LACK OF CHEMICAL INTERACTION OF HYDROGENATED AMORPHOUS SILICON WITH INDIUM-DOPED ZINC OXIDE TRANSPARENT CONDUCTIVE FILMS.** Indium-doped zinc oxide films have been prepared by the spray pyrolysis technique using air as a carrier gas at atmospheric pressure. These films show the excellent optical and electrical characteristics of a transparent conductive coating, with a sheet resistance of  $15 \Omega/\square$  and an average optical transmission of about 88%. All the studied films show the wurtzite hexagonal crystalline structure. The results of Auger electron spectroscopy show that there was no reduction of the oxide film when an a-Si:H film was deposited by the plasma decomposition of silane at substrate temperatures in the range 150-300°C. A steep interface between the transparent conductive film and the hydrogenated amorphous silicon was observed. Also, it was found that the depth distribution of the constituent atoms zinc, oxygen and indium in the ZnO:In film was homogeneous. (Author abstract). 18 Refs.

Ortiz, A. (UNAM, Mexico City, Mex); Sanchez, A.; Falcony, C.; Farias, M.H.; Hirata, G.A.; Cota-Araiza L. *J Non Cryst Solids* v 103 n 1 6(II) 1988 p 9-13.

**094954 SELECTIVE WET AND DRY ETCHING OF HYDROGENATED AMORPHOUS SILICON AND RELATED MATERIALS.** The etch rate in aqueous KOH solutions and in  $\text{CF}_4\text{-O}_2$  plasmas was measured for hydrogenated amorphous silicon (a-Si:H) as a function of preparation conditions, and was compared to that of silicon in the hydrogen-free amorphous, poly-crystalline, and crystalline form. The rate depends strongly on the hydrogen content in wet etching and moderately in plasma etching. In analogy to crystalline silicon, the plasma etch rate of a-Si:H exhibits a strong dependence on the Fermi level. (Author abstract). 28 Refs.

Haller, I. (IBM, Yorktown Heights, NY, USA); Lee, Y.H.; Nocera, J.J.; Jaso, M.A. *J Electrochem Soc* v 135 n 8 Aug 1988 p 2042-2045.

**094955 APPLICATION OF THE EXTENDED PAIR APPROXIMATION TO HOPPING CONDUCTION IN r.f. SPUTTERED AMORPHOUS SILICON.** The real and imaginary parts of the frequency-dependent conductivities of amorphous silicon and hydrogenated amorphous silicon samples prepared by r.f. sputtering have been measured over temperatures between 40 and

200 K, where variable-range hopping is the dominant conduction mechanism. The data are interpreted using the extended pair approximation (EPA). This model gives an excellent qualitative fit to the data, describing well the scaling with the reduced frequency and the loss peak observed at the transition from non-dispersive to dispersive conduction. Quantitatively the agreement is less good. The discrepancies suggest that the conduction mechanism is not adequately described by electron tunnelling in a constant density of localized states. Various recent modifications to this basic model are discussed in the light of the data. (Edited author abstract). 35 Refs.

Long, A.R. (Univ of Glasgow, Glasgow, Scotl); McMillan, J.; Balkan, N.; Summerfield, S. *Philos Mag B* v 58 n 2 Aug 1988 p 153-169.

**094956 GAP STATES IN UNDOPED AMORPHOUS SILICON STUDIED BY BELOW-GAP MODULATED PHOTOCURRENT SPECTROSCOPY.** The energetic distribution and nature of dangling-bond states in undoped a-Si:H have been investigated by a newly developed gap-state spectroscopy which is based on the frequency-resolved spectrum of modulated photocurrent with below-gap photoexcitation. The energy scale is directly specified by the energy of the below-gap light populating the particular gap states. The result has led to the conclusion that the peak of the gap-state distribution associated with doubly occupied dangling bonds ( $D^-$ ) is located about 0.5 eV below the conduction band edge. The analysis for the pre-exponential factor of the thermal emission rate of electron from the  $D^-$  center suggests that the emission occurs in two stages through excited states. (Author abstract). 29 Refs.

Abe, K. (Osaka Univ, Toyonaka, Jpn); Okamoto, H.; Nitta, Y.; Tsutsumi, Y.; Hattori, K.; Hamakawa, Y. *Philos Mag B* v 58 n 2 Aug 1988 p 171-184.

**094957 ELECTRON MOBILITY IN AMORPHOUS SILICON UNDER DOUBLE INJECTION.** The transport of a pulse of photogenerated excess electrons has been investigated in a-Si  $p^+i-n^+$  junctions under forward bias in the presence of strong double injection. It is found that the electron drift mobility is completely independent of forward current densities of up to  $0.33 \text{ A cm}^{-2}$ . The results disagree with previous work of Silver et al., who observed an appreciable increase in electron mobility in the same range of current densities. It is suggested that the experimental disagreement arises from problems inherent in the voltage-step technique of mobility measurement used by these authors. (Author abstract). 10 Refs.

Goldie, D. (Univ of Dundee, Dundee, Scot); LeComber, P.G.; Spear, W.E. *Philos Mag Lett* v 58 n 2 Aug 1988 p 107-112.

**094958 MOBILITY ACTIVATION ENERGY OF HYDROGENATED AMORPHOUS SILICON.** Recent experimental results indicate that the density of conduction band tail states  $g(E)$  in a-Si:H below the mobility edge  $E_c$  initially decreases linearly with increasing depth  $E_c - E$  and subsequently, below an energy  $E_0$ , decreases at an exponential rate. We examine the temperature range in which such a density of states may be expected to lead to a mobility activation energy  $E_\mu$  close to  $E_c - E_0$  and how  $E_\mu$  will behave at other temperatures. (Author abstract).

Halpern, V. (Bar-Ilan Univ, Ramat-Gan, Isr). *Philos Mag Lett* v 58 n 2 Aug 1988 p 113-116.

**094959 NON-OHMIC CONDUCTION IN GLOW-DISCHARGE A-Si:H FILMS.** Non-Ohmic conduction in undoped glow-discharge a-Si:H films has been studied using sandwich configurations. It is found that the conductivity at low temperatures is field-dependent and varies with field in the manner  $\sigma = \sigma_0 (T \exp(AeV/kT))$  over most of the field range used in the experiment, where A is a weak function of temperature T and V is the applied voltage. For voltages less than 1 V, the electric field does not change the temperature dependence of conductivity and the Mott  $T^{-1/4}$  law is obeyed

at low temperatures. The effect of light soaking is also described in this Letter and the results show that the low-temperature non-Ohmic conductivity remains almost unchanged after illumination while the high-temperature Ohmic conductivity drops significantly. (Author abstract). 22 Refs.

Zhou, J.H. (Chinese Acad of Sciences, Beijing, China); Zhang, D.L. *Philos Mag Lett* v 58 n 2 Aug 1988 p 117-122.

**094960 PHOTOCONDUCTIVITY MEASUREMENTS AS A TOOL FOR THE EVALUATION OF THE DENSITY OF STATES IN AMORPHOUS SILICON.** Photoconductivity measurements as a function of the temperature and light intensity were carried out on samples of hydrogenated and halogenated silicon films. The samples were deposited by rf glow discharge starting from a mixture of silicon tetrachloride and hydrogen. Experimental data were analyzed by using a theoretical model which assumes a density of states distribution having two exponential band tails and two gaussian distribution of states in the mobility gap. The model predicts a dependence of the photoconductivity as a function of the light intensity which agrees very well with the experimental one. (Author abstract). 10 Refs.

Augelli, V. (Univ di Bari, Italy); Berardi, V.; Murri, R.; Sschiavulli, L. *Phys Scr* v 38 n 2 Aug 1988 p 188-190.

**094961 INTERBAND OPTICAL ABSORPTION IN AMORPHOUS SILICON.** The interband optical absorption characteristics of amorphous silicon films prepared by various techniques have been investigated. Above the main absorption edge, the absorption coefficient  $\alpha$  can be fitted to the 'Tauc' model  $(\alpha\hbar\omega)^{1/2} = C_0^{1/2} (\hbar\omega - E_g)$ . The experimental  $(\alpha\hbar\omega)^{1/2}$  versus  $\hbar\omega$  plots are generally piecewise linear, with an increase in slope above an energy  $E_u$ . Structure in the 'Tauc' plots is correlated with preparation conditions; the experimental results are consistent with a broadening of the density of states distribution at the band edges within a gap defined by  $E_u$ . The incorporation of bonded hydrogen into the a-Si network results in compositional disorder and deeper potential fluctuations that widen  $E_u$ . The bonded hydrogen increases both extrapolated energy gaps; the blue shift is proportional to the line density of hydrogen atoms over a wide range of bonded hydrogen concentrations. A unified model for the interband absorption edge in a-Si and a-Si:H is presented. (Author abstract). 4 Refs.

Kruzelecky, R.V. (Univ of Toronto, Toronto, Ont, Can); Ukah, C.; Racansky, D.; Zukotynski, S.; Perz, J.M. *J Non Cryst Solids* v 103 n 2-3 Jul 1988 p 234-249.

**094962 ELECTRON EQUILIBRATION IN A-SI:H BANDTAILS FOLLOWING PULSE EXCITATION.** The dynamic of excess carriers in hydrogenated amorphous silicon is investigated by a novel 'photoconductivity versus photoabsorption' analysis which combines cw and transient measurements. The technique enables one to establish experimentally whether and at which time excess carriers created by a light pulse reach a steady state equilibrium distribution. For a representative sample we find that the equilibrium is reached in about 40  $\mu\text{sec}$  and that the recombination and trapping rates are comparable. A theoretical model describing the dynamics is also presented. (Edited author abstract). 17 Refs.

Zeldov, E. (Technion-Israel Inst of Technology, Haifa, Isr); Weiser, K. *Solid State Commun* v 67 n 9 Sep 1988 p 903-906.

**094963 MODULATED OPTICAL REFLECTANCE MEASUREMENTS ON AMORPHOUS SILICON LAYERS AND DETECTION OF RESIDUAL DEFECTS.** Modulated optical reflectance measurements on amorphous silicon layers are presented and a sample theoretical model, which is in good agreement with the experiment, is proposed. Further, the correlation between defects remaining after recrystallization of the amorphous layers and the measured modulated optical reflectance is



established. This measurement technique turns out to be useful for characterizing amorphous Si layers produced by ion implantation, for controlling the recrystallization of such layers, and for detecting residual defects. (Author abstract). 27 Refs.

Wurm, S. (Siemens AG, Munich, West Ger); Alpern, P.; Savignac, D.; Kakoschke, R. *Appl Phys A* v 47 n 2 Oct 1988 p 147-155.

**094964 HIGH RATE PRIMARY ION BEAM DEPOSITION OF A-Si:H FILMS.** Hydrogenated amorphous silicon films have been prepared by primary ion beam deposition with a new electrodeless rf ion source. The design of the ion source is described. The composition of the a-Si:H films has been determined by Rutherford backscattering, and the photoconductivity by the constant photocurrent method (CPM). The best a-Si:H films show photoconductivities of  $5 \times 10^{-5} (\Omega \text{ cm})^{-1}$ . The deposition rates were between 0.7 and 1.2 nm s<sup>-1</sup>. (Author abstract). 24 Refs.

Frey, H. (Lot-und Schweissgerate GmbH, Aichwald, West Ger). *Appl Phys A* v 47 n 2 Oct 1988 p 193-197.

**094965 GAP-STATE DISTRIBUTION IN a-Si: H BY MODULATED PHOTOCURRENT: SHALLOW-STATE-DEEP-STATE CONVERSION AND TEMPERATURE SHIFT OF THE ELECTRON-TRANSPORT PATH.** The distribution of localized states in a-Si:H above the Fermi energy has been determined by phase-shift analysis of modulated photocurrents. By use of a novel experimental technique the modulation frequency range could be greatly extended compared to conventional mechanical light chopping, revealing the gap-state distribution over an energy interval from 0.25 to 0.7 eV below the conduction-band edge. A shoulder at 0.35 eV and a peak at 0.55 eV below the band edge have been detected. Defect creation by strong illumination increases the peak and quenches the shoulder, indicating a shallow-state-deep-state conversion, and also proves the high sensitivity of this method. Data taken over a large temperature range from 110 to 480 K indicate an energy shift of the dominant electron-transport path with temperature. (Author abstract). 19 Refs.

Schumm, G. (Univ Stuttgart, Stuttgart, West Ger); Nitsch, K.; Bauer, G.H. *Philos Mag B* v 58 n 4 Oct 1988 p 411-420.

**094966 EFFECT OF HYDROGEN PLASMA ON THE PROPERTIES OF a-Si: H/a-Si<sub>1-x</sub>N<sub>x</sub>:H SUPERLATTICES.** A hydrogen plasma introduced during the interrupting interval when alternating two gases affects the properties of a-Si:H/a-Si<sub>1-x</sub>N<sub>x</sub>:H superlattices resulting in the creation of fewer interface defects than the superlattices prepared without the hydrogen plasma. (Author abstract). 17 Refs.

Yamaguchi, M. (Univ of Tokyo, Tokyo, Jpn); Yatabe, K.; Ohta, H.; Morigaki, K. *Philos Mag Lett* v 58 n 4 Oct 1988 p 213-218.

**094967 AMORPHOUS SILICON AS A RESIST MATERIAL.** Lithographic properties of amorphous silicon films exposed to glow-discharge hydrogen plasma and ion beams have been investigated. The rate of film etching by a CF<sub>4</sub> plasma is lowered by exposure, giving rise to a negative resist behavior of the material. The sensitivity and contrast are approximately  $10^{18}$  ions/cm<sup>2</sup> and 1.1, respectively. The effect of exposure time on etching characteristics was also studied. 9 Refs.

Gupta, P.K. (Indian Inst of Technology, New Delhi, India); Chopra, K.L. *IEEE Electron Device Lett* v 9 n 1 Jan 1988 p 17-19.

**094968 DEPOSITION OF AMORPHOUS SILICON FILMS FROM AN ELECTROSTATICALLY CONFINED SILANE PLASMA.** Amorphous silicon films have been deposited by means of a low pressure silane dc discharge within a reactor provided with a hot cathode and an electrostatic confinement. The plasma density is five times larger in the confined regime than in the unconfined one. The characterization of the films

shows good optical and electrical properties. (Author abstract) 5 Refs.

Andreu, J. (Univ de Barcelona, Barcelona, Spain); Sardin, G.; Delgado, J.C.; Canillas, A.; Esteve, J.; Morenza, J.L. *Vacuum* v 37 n 5-6 1987, VI Span Conf on Vac and Its Appl, Madrid, Spain, Dec 1985 p 443-444.

**094969 a-Si:N:H PREPARED BY REACTIVE EVAPORATION IN AMMONIA VAPOUR.** The reactive evaporation of Si in an ammonia ambient has been used to produce a-Si:N:H thin films. These films are 'intrinsic-like' with low room-temperature conductivities ( $< 10^{-12} \text{ S cm}^{-1}$ ), high activation energies (0.9 eV), and high optical bandgaps (1.9 eV). Films prepared in this manner have been doped using co-evaporation of antimony (n type) and indium (p type). The addition of 2 at.% indium or antimony results in an increase in the room-temperature conductivity by eight and six orders of magnitude respectively. The undoped and doped samples are photoconductive when illuminated with a quartz-halogen source. (Author abstract) 8 Refs.

Audas, R.D. (Univ of Waterloo, Waterloo, Ont, Can); Brodie, D.E. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicon Technol Conf, Ottawa, Ont, Can p 1020-1022.

**094970 DOPING GLOW-DISCHARGE AMORPHOUS SILICON BY METAL COEVAPORATION.** We report here on the further development of a new technique for doping plasma-deposited amorphous silicon by thermal evaporation of metal into the plasma from which the film is grown. We show that the dc bias applied to the substrate has an important effect on the incorporation of the metal into the film, and on the doping efficiency. We also report on our efforts to monitor and control the evaporation by mass spectroscopy. (Author abstract) 4 Refs.

Perluzzo, G. (Ecole Polytechnique, Montreal, Que, Can); Aktik, C.; Currie, J.F.; Poulin-Dandurand, S.; Yelon, A. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicon Technol Conf, Ottawa, Ont, Can p 1027-1029.

**Applications** See Also ELECTRODES—Materials; INTEGRATED CIRCUIT MANUFACTURE; SEMICONDUCTOR COUNTERS—Research; SENSORS—Materials; SOLAR CELLS—Materials; SOLAR CELLS—Silicon; TRANSISTORS—Fabrication; TRANSISTORS—Research; TRANSISTORS, FIELD EFFECT.

**094971 SILICON MICROSTRUCTURES LET MANUFACTURERS IMPLEMENT A VARIETY OF SENSORS ON CHIP.** By taking advantage of techniques developed and refined by semiconductor makers over the past two decades, manufacturers of a variety of sensors - such as chemical-sensitive devices, airflow sensors, and thermometers - are mass-producing silicon microstructures that mimic the functions of conventional sensors, yet are inexpensive to the point of being disposable. The pricing of these sensors will let one incorporate sensing capabilities in applications that previously wouldn't have justified the added expense. 3 Refs.

Mosley, J.D. (EDN, Newton, MA, USA). *EDN* v 32 n 24 Nov 26 1987 p 75-78, 80, 82.

**Charge Carriers** See Also ELECTRONS—Scattering; LASER BEAMS—Effects; SEMICONDUCTING CADMIUM COMPOUNDS—Charge Carriers; SEMICONDUCTOR DEVICES, CHARGE COUPLED; SEMICONDUCTOR DEVICES, MOSFET; SEMICONDUCTOR MATERIALS—Semiconductor Insulator Boundaries; SOLAR CELLS—Silicon; TRANSISTORS, BIPOLAR—Electronic Properties; TRANSISTORS, BIPOLAR—Measurements.

**094972 ANALYTIC DESCRIPTION OF VALENCE BAND NONPARABOLICITY IN SILICON.** Setting out from our solutions of the Kane equation for hole energies in the  $\epsilon < \Delta_0$  and  $\Delta_0 < \epsilon \leq \epsilon_g$  regions and using the method of continuous fractions we obtain simple dispersion relations which accurately describe the valence bands in the non-parabolic region  $\epsilon \approx \Delta_0$ . We also examine the change in the constant energy surfaces of heavy, light, and spin-split holes as the energy increases. (Author abstract) 11 Refs.

Gritsyuk, P.M. (Chernovtsy State Univ, USSR); Shitvel'-

man, K.Ya.; Prudius, A.G. *Sov Phys J* v 30 n 4 Apr 1987 p 286-290.

**094973 SAMPLE THICKNESS DEPENDENCE OF MINORITY CARRIER LIFETIMES MEASURED USING AN ac PHOTOVOLTAIC METHOD.** When Si wafer thickness is much smaller than the minority carrier diffusion length, the carrier lifetime, estimated by an ac photovoltaic method previously reported, has been shown to be restricted by the wafer thickness. The thickness dependence of the lifetime was measured on n-type Si wafers with thickness from 0.6 to 4 mm. The observed lifetimes ranged from 72.3  $\mu$ s to 1.1 ms and were in good agreement with those estimated theoretically. It was demonstrated that the bulk lifetime can be obtained with less than a 10% error when the sample thickness is 3.6 times larger than the diffusion length of the minority carriers. (Author abstract) 16 Refs.

Honma, Noriaki (Hitachi Ltd, Kokubunji, Jpn); Munakata, Chusuke. *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 2033-2036.

**094974 MINORITY CARRIER TRANSPORT IN HEAVILY DOPED SILICON: FUNDAMENTAL EQUATIONS.** From fundamental principles, the equations that govern minority carrier transport and recombination in a heavily doped semiconductor are derived. The equations are based on three physically meaningful doping-dependent material parameters: minority carrier lifetime, mobility, and equilibrium concentration. To completely describe the problem, there is no need to use nonphysical entities like 'effective doping level' or 'apparent bandgap narrowing', as has become common in the silicon device literature. Under steady state, only two parameters, which are combinations of the three fundamental ones, are relevant to minority carrier transport and recombination. These findings have important implications for parameter measurements and for the modeling of heavily doped regions in devices. (Author abstract) 34 Refs.

Del Alamo, Jesus A. (Stanford Univ, Stanford, CA, USA); Swanson, Richard M. *Jpn J Appl Phys Part 1* v 26 n 11 Nov 1987 p 1860-1866.

**094975 EFFECT OF RADIATION DAMAGE ON CARRIER MOBILITY IN NEUTRON-TRANSMUTATION-DOPED SILICON.** The effect of radiation damage on neutron-transmutation-doped silicon of initially low- and high-resistivity materials has been studied by electrical property measurements. The materials were irradiated with a moderate thermal ( $0.45-1.0 \times 10^{18}$  neutrons cm<sup>-2</sup>) and fast ( $0.45-8.1 \times 10^{16}$  neutrons cm<sup>-2</sup>) neutron fluences. After irradiation, a small reduction of carrier mobility of the initially low-resistivity materials was observed, while the reduction of conductivity was large. The annealing behavior and temperature dependence of mobility of the materials indicate that the mechanism of carrier scattering is dominated by ionized impurities acting as point defects. The conductivity of those materials was recovered after annealing at 560°C for 60 min. In the range of annealing temperatures below 600°C, the carrier mobility of initially high-resistivity materials decreased together with the conductivity. The last result can tentatively be explained by a defect cluster model for fast-neutron-induced lattice damage. (Author abstract) 25 Refs.

Maekawa, T. (Chiba Inst of Technology, Chiba, Jpn); Inoue, S.; Aiura, M.; Usami, A. *Semicon Sci Technol* v 3 n 2 Feb 1988 p 77-83.

**094976 IDENTIFICATION OF THE NEUTRAL CHARGE STATE OF PLATINUM IN SILICON.** A comparison of optical cross sections of platinum in silicon obtained from Fourier photoconductivity and photoelectron paramagnetic resonance (photo-EPR) measurements shows that the detailed structure in the high-resolution



Fourier spectra is caused by the neutral  $\text{Pt}^0$  defect. The hole ionization of  $\text{Pt}^0$  leads to the  $\text{Pt}^-$  defect observed in EPR. (Author abstract) 13 refs.

Omring, P. (Univ of Lund, Lund, Swed); Kleverman, M.; Emanuelsson, P.; Olajos, J.; Grimmeiss, H.G. *Solid State Commun* v 65 n 7 Feb 1988 p 557-560.

**094977 CHEMICAL/MICROWAVE TECHNIQUE FOR THE MEASUREMENT OF BULK MINORITY CARRIER LIFETIME IN SILICON WAFERS.** A chemical/microwave technique for the measurement of bulk minority carrier lifetime in silicon wafers is described. This method consists of a wet chemical treatment (surface cleaning, oxidation in solution, and measurement in HF solution) to passivate the silicon surfaces, a laser diode array for carrier excitation, and a microwave bridge measuring system which is more sensitive than the microwave systems used previously for lifetime measurement. Representative experimental data are presented to demonstrate this technique. The result reveals that this method is useful for the determination of bulk lifetime of commercial silicon wafers. (Author abstract) 14 refs.

Luke, Keung L. (JPL, Pasadena, CA, USA); Cheng, Li-Jen. *J Electrochem Soc* v 135 n 4 Apr 1988 p 957-961.

**094978 TRAPPING OF MINORITY CARRIERS IN THERMAL  $\text{U}^-$ -DONORS IN n-Si.** Theoretical studies are made on the trapping behavior of the semiconductor containing  $\text{U}^-$ -donors. The traps are divalent bistable thermal donors (BTD) with occupancy level inverted order of the first and second electrons ( $\text{U}^-$ -center). These results require the development of a new model of photoconductivity, which should involve both the existence of multiple-charge conditions for these centers and their inverted level order. This paper is mainly concerned with the analysis of the kinetics of the long-time component of photoconductivity (PC) related to the charge change of BTD. The theoretical analysis results are compared with the experimental data for the two sets of bistable thermal donors in n-Si. (Edited author abstract) 14 refs.

Makarenko, L.F. (Acad of Sciences of the Belorussian SSR, Minsk, USSR); Murin, L.I. *Phys Status Solidi B* v 145 n 1 Jan 1988 p 241-253.

**094979 TRANSITION PROBABILITY OF IMPACT IONIZATION BY HOLES IN SILICON.** An analytical expression is developed for the transition probability per unit time for impact ionization by holes. The approach is based upon time dependent perturbation calculations and the Bloch functions for the states of electrons and holes. The threshold energy of ionization by holes is calculated for the valley  $L_1$  for the electron band structure of silicon. The results obtained for the probability are in good agreement with experimental results for threshold energy and theoretical results for the ionization probability. (Author abstract) 10 refs.

Gautam, D.K. (Central Electronics Engineering Research Inst, Pilani, India); Khokle, W.S.; Garg, K.B. *Phys Status Solidi B* v 145 n 1 Jan 1988 p 269-275.

**094980 DIFFUSION LENGTH STUDIES IN SILICON BY THE SURFACE PHOTOVOLTAGE METHOD.** Diffusion lengths of minority carriers in the range 1-1200  $\mu\text{m}$  were measured in n and p type silicon single crystals with a wide range of resistivities by the surface photovoltage (SPV) method. Optimum measurement conditions were established by studying the dependence of measured diffusion length on the experimental conditions. The published absorption coefficient ( $\alpha$ ) data of Dash and Newman and Runyan were found inadequate, and a new determination of  $\alpha$  was made. (Edited author abstract) 35 refs.

Saritas, M. (Univ of Manchester Inst of Science & Technology, Manchester, Engl); McKell, H.D. *Solid State Electron* v 31 n 5 May 1988 p 835-842.

**094981 MEASUREMENT OF GENERATION LIFETIME IN THIN SILICON LAYERS.** This paper describes an improved capacitance method for the mea-

surement of the minority carrier generation lifetime in the near surface region in thin silicon layers. The technique provides a simple experimental means for evaluating interferences in the leakage current, such as diffusion from the quasi-neutral bulk and peripheral generation, permitting a more accurate determination of the lifetime. Additional, related capacitance measurements are performed on adjacent circular capacitors of differing radii to quantify the extent of peripheral generation. Results are presented demonstrating application of the method and illustrating the magnitude of these interferences. These results indicate that the accurate determination of the generation lifetime in current, high quality silicon necessitates the use of experimental means, such as the technique described, in order to quantify interference components in the leakage current. Assumptions underlying the technique and limitations in its use are discussed. (Edited author abstract) 20 refs.

Hof, T.E. (Univ of Cincinnati, USA); Morthorst, T.J.; Roenker, K.P. *Solid State Electron* v 31 n 5 May 1988 p 937-944.

**094982 SURFACE AND VOLUME DECAY PROCESSES IN SEMICONDUCTORS STUDIED BY CONTACTLESS TRANSIENT PHOTOCONDUCTIVITY MEASUREMENTS.** Excess charge carrier kinetics in moderately doped pSi wafers were investigated with a contactless transient photoconductivity method, i.e. the time-resolved microwave conductivity (TRMC) method. The surface structure of the wafers was changed by etching and polishing, the volume structure by irradiation with high-energy electrons. Comparison of the photoconductivity decay after excitation by strongly absorbed light and by weakly absorbed light was used to distinguish between surface and volume decay processes. The experimental results deviate from predictions based on a linear surface decay rate. These results are discussed and suggestions are made for the use of transient photoconductivity measurements to characterize semiconductor wafers. (Author abstract) 15 refs.

Kunst, M. (Hahn-Meitner-Inst, Glienickestrasse, Berlin, East Ger); Mueller, G.; Schmidt, R.; Wetzel, H. *Appl Phys A* v A46 n 2 Jun 1988 p 77-85.

**094983 MAGNETIC PROPERTIES OF DONORS AND ACCEPTORS IN SILICON: SIMILARITIES AND DIFFERENCES.** The authors summarize experimental results obtained for the susceptibility and nonlinear magnetization of insulating n-type and p-type silicon. The behavior of donors and of acceptors is found to be quite similar, and agrees with predictions of the scaling theory of Bhatt and Lee. They also present and discuss some differences which are not yet fully understood. (Edited author abstract) 11 refs.

Roy, A. (City Univ of New York, NY, USA); Levy, M.; Turner, M.; Sarachik, M.P.; Isaacs, L.L. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 65-71.

**094984 IMPROVED METHOD TO DETERMINE THE CAPTURE CROSS-SECTION OF MAJORITY CARRIERS FROM THE PULSE-FILLING MEASUREMENT.** A method is proposed to determine the capture cross-section of majority carriers from a change in the capacitance due to trap filling without any influence of slow capture in the depletion edge region. The difference in the capacitance under two bias conditions is measured by microcomputer-based isothermal capacitance transient spectroscopy. The capture cross-section of an electron on Au-acceptor level in Si is obtained to verify this method. (Author abstract) 8 refs.

Tomokage, Hajime (Fukuoka Univ, Fukuoka, Jpn); Morita, Shunya; Miyamoto, Tokuo. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 688-689.

**094985 DETERMINATION OF MINORITY CARRIER MOBILITY IN SILICON FROM STATIONARY AND TRANSIENT LIFETIME MEASUREMENT.** The minority carrier diffusion coefficient in Si as a function of dopant density is evaluated by comparing the

diffusion length as obtained by a steady state method (using a combination of the photoelectromagnetic (PEM) effect and the steady state photoconductivity (PC) effect) and a lifetime obtained by the photoconductivity decay (PCD) method. Within the limits of the experimental data dispersion, the electron minority diffusion coefficients are comparable to the majority ones in the doping range  $3 \times 10^{14} < N_A \text{ LS } 3 \times 10^{17} \text{ cm}^{-3}$ . The minority hole diffusion coefficients are about 36 percent higher than the majority hole coefficients in the doping range  $6.1 \times 10^{13} < N_D < 7.1 \times 10^{16} \text{ cm}^{-3}$ . (Author abstract). 21 Refs.

Susi, Enrichetta (CNR, Bologna, Italy); Passari, L.; Merli, M.; Carotta, Maria Cristina. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 583-587.

**094986 SURFACE-RECOMBINATION AND DOPING EFFECTS ON THE MINORITY CARRIERS IN POLYCRYSTALLINE SILICON.** A scanning laser microscope was used in a spatially resolved photoconductivity experiment to determine the minority-carrier diffusion length ( $L$ ) and surface-recombination velocity at grain boundaries ( $S_{GB}$ ) in (i) n- and p-type Wacker polysilicon and (ii) neutron-transmutation-doped Metron polysilicon as a function of beam intensity. Different values of  $L$  were measured on opposite sides of the grain boundaries. For the Metron samples,  $L$  was measured at the same grain boundary using a series of samples doped to different levels. These samples had dopant concentrations between  $10^{13}$  and  $10^{17} \text{ atoms/cm}^3$ .  $L$  was found to decrease from 50 to 5  $\mu\text{m}$ , with decreasing beam intensity, reaching a constant value at low beam intensities.  $L$  was also found to remain relatively unchanged for low dopant concentrations. The  $S_{GB}$  values were found to increase with increasing beam intensity in both Wacker and Metron samples, ranging between  $10^4$  and  $10^5 \text{ cm/s}$ .  $L$  was also measured with a light-beam-induced-current technique (perpendicular geometry) and found to be in close agreement with values obtained using the photoconductivity technique. (Author abstract). 17 Refs.

Damaskinos, S. (Univ of Waterloo, Waterloo, Ont, Can); Dixon, A.E. *Can J Phys* v 66 n 3 Mar 1988 p 200-205.

**094987 INJECTION AND RECOMBINATION CURRENTS IN a-Si:H STRUCTURES.** Both, theoretical and experimental investigations of current-voltage characteristics of a-Si:H structures (Pt-i-n, p-i-n) are carried out. A choice in favor of the double-carrier injection mechanism is substantiated. A theory of G-R currents is applied to a semiconductor with a continuous density of localized states in the mobility gap. (Author abstract). 10 Refs.

Golikova, O.A. (Acad of Sciences of the USSR, Leningrad, USSR); Mezdrogina, M.M.; Feoktistov, N.A.; Sorokina, K.L.; Kazanin, M.M.; Karageorgiy-Alkalaev, P.M.; Leiderman, A.Yu. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 323-329.

**094988 TEMPERATURE DEPENDENCE OF MINORITY ELECTRON MOBILITY AND BANDGAP NARROWING IN P+ SI.** By fabricating wide-base-width lateral and vertical bipolar transistors with uniformly heavily doped p-type bases, both bandgap narrowing (BGN) and minority electron mobility ( $\mu$ ) have recently been measured. These measurements have been extended to temperatures from 90 to 390 K. Minority-electron mobility increases strongly as temperature decreases, the most heavily doped layers exhibiting the strongest mobility increase with decreasing temperature. Bandgap narrowing decreases linearly with decreasing temperature down to roughly 240 K and levels off. For a sample doped  $2 \times 10^{19} \text{ cm}^{-3}$ , the BGN is 15 meV lower at 100 K and 25 meV higher at 390 K than at room temperature. Both these results suggest that it is possible



to construct higher performance n-p-n bipolar transistors (with heavily doped bases), for low-temperature operation, than was previously believed. 2 refs.

Swirhun, S.E. (Stanford Univ, CA, USA); Kane, D.E.; Swanson, R.M. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2385.

**094989 MINORITY-CARRIER LIFETIME ANALYSIS OF SILICON EPITAXY AND BULK CRYSTALS WITH NONUNIFORMLY DISTRIBUTED DEFECTS.** Existing analyses of the pulsed response of a MOS capacitor for minority-carrier lifetime determination result in a lifetime value averaged over most of the depletion region width. The authors present an analysis of MOS capacitance-versus-time data that enables minority-carrier generation lifetime to be plotted as a function of depletion-region depth. The technique is shown to be useful for samples with bulk or buried interfacial layer defects that have defect-free surfaces. Data are presented for intrinsically getterd bulk crystals and extrinsically getterd Si (2% Ge) epitaxial layers with misfit dislocations. For samples that do have uniform lifetimes, the measurement time required for determining carrier lifetime is reduced by more than an order of magnitude. 11 refs.

Radzinski, Zbigniew (North Carolina State Univ, Raleigh, NC, USA); Honeycutt, Jeffrey; Rozgonyi, George A. *IEEE Trans Electron Devices* v 35 n 1 Jan 1988 p 80-84.

**094990 N-TYPE SIPOS AND POLY-SILICON EMITTERS.** N-type SIPOS and poly-silicon emitters on silicon show potential for improved minority carrier blocking properties over conventional diffused emitters. This paper discusses experiments designed to elucidate the physical mechanisms responsible for this improvement and to optimize the process conditions. Emitters both with and without an intentionally grown chemical oxide under the SIPOS or poly-silicon film are investigated. Both poly-silicon and SIPOS emitters, in their optimized form, can achieve  $J_{oc}$  of less than  $2 \times 10^{-14}$  A/cm<sup>2</sup>, an improvement of several decades over shallow diffused emitters. (Author abstract) 6 refs.

Kwark, Y.H. (Stanford Univ, Stanford, CA, USA); Swanson, R.M. *Solid State Electron* v 30 n 11 Nov 1987, New Dev in the Phys of Homo- and Heterojunctions, US-Belg Jt Semin, Louvain, Belg, May 28-30 1986 p 1121-1125.

**094991 MODELLING OF MINORITY-CARRIER TRANSPORT IN HEAVILY DOPED SILICON EMITTERS.** The transport and recombination of minority carriers in heavily doped emitters plays a crucial role in the performance of silicon bipolar transistors and solar cells. In the past, only order-of-magnitude prediction of the value of the current injected into a heavily doped emitter was possible. The limitations to a more accurate modelling stemmed from: (1) the incomplete understanding of the physics of minority carriers in heavily doped semiconductors; (2) the lack of precise measurements of the relevant material parameters; (3) the difficulties encountered with the modelling of transport and recombination in non-homogeneously doped regions; and (4) problems with the characterization of 'real' emitters of bipolar devices. This paper reviews recent experimental and theoretical efforts that addressed some of these issues, with the goal of being able to achieve accurate modelling of the current injected into an arbitrary heavily doped region in a silicon device. (Author abstract) 67 refs.

del Alamo, Jesus A. (NTT, Atsugi, Jpn); Swanson, Richard M. *Solid State Electron* v 30 n 11 Nov 1987, New Dev in the Phys of Homo- and Heterojunctions, US-Belg Jt Semin, Louvain, Belg, May 28-30 1986 p 1127-1136.

**094992 TUNING THE EFFECTIVE BANDGAP OF A SILICON DOPING SUPERLATTICE.** In this paper, we examine the tunability of the effective bandgap and carrier concentration in a silicon-doping superlattice with narrow n<sup>+</sup>-doped layers and wide p-doped layers. Quanti-

tative tunability parameters are defined and their variation with dopant concentration and temperature are calculated self-consistently in the effective mass and Hartree approximations. It is found that the tunabilities increase as doping is increased or as temperature is decreased. (Author abstract) 9 refs.

Schmidt-Weinmar, H.G. (Univ of Alberta, Edmonton, Alberta, Can); Teo, K.H.; McMullin, J.N.; McKinnon, G.H. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicon Technol Conf, Ottawa, Ont, Can p 1064-1068.

**094993 MICRO-DEFECT EFFECTS ON MINORITY CARRIER LIFETIME IN HIGH PURITY DISLOCATION-FREE SILICON SINGLE CRYSTALS.** The effects of various kinds of micro-defects on minority carrier lifetime in high purity dislocation-free silicon single crystals were studied by float-zoning, photoconductivity attenuation and copper decoration combined with selective etching, X-ray topography and electron-beam-induced-current analysis. We found that swirl defects (A or B type) and unidentified frozen-in defects are responsible for limiting minority carrier lifetimes in high purity silicon crystals. The A-type defect was found to be a recombination center with an effective diameter of approximately 30-40  $\mu$ m. By altering crystal growth conditions such as growth rate and diameter, various thermal gradients and cooling rates were attained. These affected the micro-defect characteristics and hence the lifetimes of the crystals grown. (Author abstract) 17 refs.

Wang, T.H. (Solar Energy Research Inst, Golden, CO, USA); Ciszek, T.F.; Schuyler, T. *Sol Cells* v 24 n 1-2 May-Jun 1988, Proc 8th Photovoltaic Adv Res Dev Proj Rev Meet, Denver, CO, USA, Nov 15-18 1987 p 135-145.

**Chemical Deposition** See INTEGRATED CIRCUIT MANUFACTURE—Laser Applications.

#### Chemical Reactions

**094994 APPLICATION OF AUGER ELECTRON SPECTROSCOPY AND PRINCIPAL COMPONENT ANALYSIS TO THE STUDY OF THE Pd/c-Si AND Pd/a-Si INTERFACES.** An analysis is made of Pd/c-Si and Pd/a-Si interfaces using principal-component analysis (PCA) of the Auger line shapes combined with a technique known as target transformation (TT), which, when used after PCA, allows the extraction of spectra for unidentified compounds in a depth profiling. The results obtained reveal the existence of a Si-rich compound in both interfaces, while Pd<sub>2</sub>Si was found to be spontaneously formed (i.e., without annealing) only at the Pd/a-Si interface. 24 refs.

Vidal, R. (CONICET, Santa Fe, Argent); Ferron, J. *Appl Surf Sci* (1985) v 31 n 2 Feb-Mar 1988 p 263-276.

**Chemical Vapor Deposition** See ALSO SEMICONDUCTING FILMS—Chemical Vapor Deposition; SEMICONDUCTOR DEVICES, MOSFET—Manufacture.

**094995 SOLID PHASE EPITAXY OF LPCVD AMORPHOUS SILICON FILMS.** Solid phase epitaxy of 190 nm amorphous silicon films deposited by LPCVD at 545°C on silicon substrates was studied. A single silicon implantation at 190 keV was performed to initiate the SPE<sup>1</sup> process. The effect of the silicon dose in the range  $1 \times 10^{15}$ - $1 \times 10^{16}$  cm<sup>-2</sup> on the quality of the epitaxial layer was studied by TEM. Epitaxial crystallization of the amorphous silicon was obtained for a silicon dose greater than  $4 \times 10^{15}$  cm<sup>-2</sup> after annealing for 65h at 650°C. The main defects in the film were dislocations and microtwins. The density of defects decreased after annealing at 950°C for 30 min. In addition to defects in the epitaxial layer a residual dislocation band was observed in the substrate. The depth and width of this dislocation band is determined by the silicon dose. (Author abstract) 26 refs.

Hatalis, Miltiadis K. (Carnegie-Mellon Univ, Pittsburgh, PA, USA); Greve, David W. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2536-2540.

**094996 DIFFUSION LENGTH MEASUREMENTS ON PLASMA-SPRAYED POLYCRYSTALLINE SIL-**

**ICON SUBSTRATES AND ON SILICON GROWN ON THEM BY CHEMICAL VAPOUR DEPOSITION.** The plasma spray technique was used to obtain p-type polycrystalline silicon deposits 200  $\mu$ m-2 mm thick and of area 1 cm<sup>2</sup>. Silicon layers 50  $\mu$ m thick were grown on these deposits by chemical vapor deposition. The electronic diffusion length of plasma-sprayed silicon was found to be in the range 9-16  $\mu$ m whereas it increased to 28  $\mu$ m in the layer grown by chemical vapor deposition. (Author abstract) 8 refs.

Akani, M. (CNRS, Meudon, Fr); Boree, J.E.; Suryanarayanan, R.; Rodot, M.; Brun, G.; Caymax, M. *Sol Cells* v 22 n 2 Oct 1987 p 97-101.

**094997 THERMODYNAMIC EQUILIBRIA IN THE Si-H-Cl AND Si-H-Br SYSTEMS.** Equilibrium calculations were performed for the Si-H-Cl and Si-H-Br systems. Gibb's free energy of formation data from the JANAF tables were used for all species, with the exception of that for SiCl<sub>3</sub>(g). Three conditions of interest to the electronics industry were examined: epitaxial silicon deposition, polysilicon deposition, and conversion of SiX<sub>4</sub>(g) to SiH<sub>3</sub>X<sub>3</sub>(g). Calculated results are presented graphically: partial pressures as a function of temperature; and silicon content of the gas phase as a function of initial starting concentrations. (Edited author abstract) 23 refs.

Hunt, Lee P. (Hunt Associates, Bridgewater, NJ, USA). *J Electrochem Soc* v 135 n 1 Jan 1988 p 206-209.

**094998 CO<sub>2</sub>-LASER-INDUCED CHEMICAL VAPOUR DEPOSITION OF POLYCRYSTALLINE SILICON FROM SILANE.** Silicon dots have been deposited on silicon-coated quartz substrates by continuous wave CO<sub>2</sub>-laser-induced decomposition of silane. The deposited material was determined by micro Raman scattering to be polycrystalline silicon. The height of the silicon dots was measured as a function of output laser power and irradiation time. The growth rate of silicon dots having a gaussian profile was found to be proportional to silane pressure and laser power. The laser power required for silicon melting (1683 K) was measured under specific experimental conditions. The substrate temperature could be calculated for any laser power assuming a linear temperature dependence on this power. The growth rate of silicon dots was found to be proportional to the substrate temperature. The growth kinetics of silicon dots may be limited by the number of collisions between 'cold' silane molecules and the heated zone of substrates. A reaction mechanism based on this assumption is proposed in this paper. (Author abstract) 22 refs.

Tonneau, D. (CNET, Meylan, Fr); Auvert, G.; Pauleau, Y. *Thin Solid Films* v 155 n 1 Dec 15 1987 p 75-86.

**094999 INITIAL STEPS IN THE PHOTOCHEMICAL VAPOUR DEPOSITION OF AMORPHOUS SILICON.** The overall process of chemical vapour deposition (CVD) is divided into reaction steps in the gas phase and on the solid-state surface. Energy input and primary reaction of the gas phase educt molecules constitute the initial steps considered in this paper. Special emphasis is placed on the photochemical vapour deposition (photo-CVD) of amorphous silicon from SiH<sub>4</sub> and Si<sub>2</sub>H<sub>6</sub> including uv single photon and ir multiple-photon activation. Experimentally convenient excitation processes and energetically possible primary decomposition pathways are summarized, compared, and discussed with respect to the selectivity of the chemical reactions. Finally the current status of photo-CVD is briefly presented. (Author abstract) 66 refs.

Stafast, H. (Inst fuer Physikalische und Theoretische Chemie, Frankfurt, West Ger). *Appl Phys A* v A45 n 2 Feb 1988 p 93-102.

**095000 THREE-DIMENSIONAL FLOW EFFECTS IN SILICON CVD IN HORIZONTAL REACTORS.** Numerical modeling of Si homoepitaxial deposition from SiH<sub>4</sub> in the horizontal reactor has been undertaken employing the steady-state, fully parabolic flow approxi-



mation for the heat, momentum, and mass-transfer equations. Reactants are assumed to be dilute in their carrier gas. The resulting set of partial differential equations are discretized using finite elements and solved using the method of lines. The effect of a third dimension, the side temperature boundary conditions, and natural convection are explored. Given recent kinetics data on the silane decomposition and silylene insertion reactions, it is shown that a quasi-thermodynamic equilibrium exists in the heated region above the surface, at least for hydrogen gas ambients. (Edited author abstract) 63 refs.

Moffat, H.K. (Univ of Minnesota, Minneapolis, MN, USA); Jensen, K.F. *J Electrochem Soc* v 135 n 2 Feb 1988 p 459-471.

**095001 INITIAL STAGE OF LASER-INDUCED SELECTIVE CHEMICAL VAPOR DEPOSITION OF SILICON.** Spatially selective chemical vapor deposition has been achieved by ArF excimer laser (193 nm) irradiation through a metal mask in a  $\text{Si}_2\text{H}_6 + \text{He}$  gas mixture. The selective deposition kinetics has been found to be controlled by a nonthermal process and has been explained in terms of the Langmuir-Hinshelwood mechanism. Both surface migration of adsorbed radicals and desorption of reaction products appear to be enhanced with the laser irradiation, leading to a selective nucleation of silicon. (Author abstract) 9 refs.

Tanaka, Takeshi (Hiroshima Univ, Higashihiroshima, Jpn); Deguchi, Koji; Hirose, Masataka. *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 2057-2060.

**095002 CONVECTION AND MASS-TRANSPORT IN LASER-INDUCED CHEMICAL VAPOR DEPOSITION.** Gas flow and energy and species transport in laser-induced chemical vapor deposition (LICVD) of amorphous silicon films by silane pyrolysis are analyzed by finite element analysis of a two-dimensional model for the process. Spatial nonuniformity of the deposited film is shown to result from diffusion controlled transport of products between the beam and substrate. Deposition profiles are affected by buoyancy-driven convection only at increased gas pressures. Horizontal orientation of the reactor with respect to gravity is optimal because the stagnation-like flow, that results adjacent to the substrate, enhances mixing, and smoothes the film profile. (Author abstract) 40 refs.

Patnaik, S. (MIT, Cambridge, MA, USA); Brown, R.A. *J Electrochem Soc* v 135 n 3 Mar 1988 p 697-706.

**095003 PREPARATION AND PROPERTIES OF a-Si FILMS DEPOSITED AT A HIGH DEPOSITION RATE UNDER A MAGNETIC FIELD.** An rf plasma decomposition of  $\text{SiH}_4$  under a magnetic field was investigated. It was confirmed by the optical emission spectra that a high-electron-density plasma can be produced under a magnetic field. High-quality a-Si films with a photosensitivity of  $\sigma_{ph}/\sigma_d$  of  $7 \times 10^5$  were obtained at a high deposition rate of  $10 \text{ Å/s}$  under the magnetic field. The a-Si solar cells with i-layers deposited at a high deposition rate under a magnetic field have a higher open-circuit voltage and a higher recombination efficiency than those without the magnetic field; a conversion efficiency of 10.1% under AM1 ( $100 \text{ mW/cm}^2$ ) illumination was obtained at a deposition rate of  $10 \text{ Å/s}$ . The rf plasma decomposition of  $\text{SiH}_4$  under a magnetic field is thought to be very suitable for fabricating a-Si solar cells with a high conversion efficiency at a high deposition rate. (Author abstract) 9 refs.

Ohnishi, Michitoshi (Sanyo Electric Co, Moriguchi City, Jpn); Nishiwaki, Hidenori; Uchihashi, Kenji; Yoshida, Kazuhiro; Tanaka, Makoto; Ninomiya, Kunimoto; Nishikuni, Masato; Nakamura, Noboru; Tsuda, Shinya; Nakano, Soichi; Yazaki, Takehito; Kuwano, Yukinori. *Jpn J Appl Phys Part 1* v 27 n 1 Jan 1988 p 40-46.

**095004 PROCESS CHARACTERIZATION AND MECHANISM FOR LASER-INDUCED CHEMICAL VAPOR DEPOSITION OF a-Si:H FROM  $\text{SiH}_4$ .** The dependence of a-Si:H film deposition by laser-induced decomposition of  $\text{SiH}_4$  on the different process variables

is studied. The gas phase temperature in the beam center, produced by  $\text{CO}_2$  laser irradiation in parallel configuration, is estimated using a simple energy and balance model. The surface temperature is measured with high accuracy employing a Ni sensor ( $250^\circ\text{--}400^\circ\text{C}$ ). The deposition rate and film properties such as the hydrogen content and the optical energy gap are determined as a function of these parameters. The production of  $\text{H}_2$  (approximately 10%),  $\text{Si}_2\text{H}_6$  (approximately 2%), and  $\text{Si}_3\text{H}_8$  in the gas phase during laser irradiation is proved by a mass spectrometric analysis. The chemical reaction processes induced in the gas phase and at the surface are discussed. A mechanism explaining the main features of the complicated chemistry involved is developed. (Author abstract) 31 refs.

Metzger, D. (Univ of Heidelberg, Heidelberg, West Ger); Hesch, K.; Hess, P. *Appl Phys A* v A45 n 4 Apr 1988 p 345-353.

**095005 NEW HIGH PURITY DOPING SOURCE FOR CVD Si-Ga EPITAXY.** A new CVD growth chemistry has been developed for producing very pure and high crystalline-quality gallium-doped silicon epitaxy. Gallium trichloride,  $\text{GaCl}_3$ , has been employed as an improved precursor to the currently accepted organometallic gallium source, trimethyl gallium,  $(\text{CH}_3)_3\text{Ga}$ . In contrast to trimethyl gallium, this metal halide doping source does not cause carbon contamination of the epitaxial layer. Much more abrupt layer-to-layer transition regions have been demonstrated. Data on the electrical and crystalline characteristics of  $\text{GaCl}_3$ -grown Si:Ga layers are presented. The current doping limit of  $4 \times 10^{17} \text{ cm}^{-3}$  obtained with this chemistry under normal CVD growth conditions is well below the solubility limit and is indicative of the unusual surface chemistry involved in doping. Results of experiments to elucidate the doping mechanism are discussed. (Author abstract) 13 refs.

Huffman, J.E. (Rockwell Int, Anaheim, CA, USA). *J Cryst Growth* v 87 n 4 Mar 1988 p 425-430.

**095006 PREFERRED ORIENTATION OF SILICON FILMS GROWN BY LPCVD AT RELATIVELY LOW TEMPERATURES.** Polycrystalline silicon thin films prepared by low pressure chemical vapour deposition (LPCVD) are of great interest in integrated circuitry. The most recent interest was motivated by relatively low temperature processes for obtaining silicon films on insulators for active matrix addressing of liquid crystal displays. This paper presents studies concerning the exact orientational relationship of the grains and a detailed view of the initial stages of growth following pyrolysis. Transmission electron microscopy investigations to define the structure were performed. 8 refs.

Karakostas, Th. (Aristoteles Univ of Thessaloniki, Thessaloniki, Greece); Meakin, D.; Migliorato, P.; Stoemenos, J.; Economou, N.A. *J Mater Sci Lett* v 7 n 3 Mar 1988 p 247-250.

**095007 VERY-LOW-TEMPERATURE SILICON EPITAX BY PLASMA-CVD USING  $\text{SiH}_4\text{-PH}_3\text{-H}_2$  REACTANTS FOR BIPOLAR DEVICES.** A novel plasma-CVD process has been developed for growing specular silicon epitaxial layers at very low temperatures of approximately  $200^\circ\text{C}$ . The epitaxial layers were deposited from  $\text{SiH}_4\text{-PH}_3$  gases diluted with  $\text{H}_2$  on single-crystal substrates just after being etched in a HF dip. The highest electron mobility and lowest resistivity of the  $n^+$ -layers were  $30 \text{ cm}^2/\text{V}\cdot\text{s}$  and  $4 \times 10^{-4} \Omega\cdot\text{cm}$ , respectively. This technology has been successfully applied to fabricate bipolar transistors with a high current gain of 370. (Author abstract) 9 refs.

Uematsu, Tsuyoshi (Hitachi Ltd, Kokubunji, Jpn); Matsubara, Sunao; Kondo, Masao; Tamura, Masao; Saitoh, Tadashi. *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 493-495.

**095008 GROWTH OF ORIENTED Si FILM ON QUARTZ FROM  $\text{Si}_2\text{H}_6$  BY THERMAL AND PHOTO-CVD USING A  $\text{D}_2$  LAMP.** Polycrystalline Si films have been grown on fused quartz plates at  $500\text{--}650^\circ\text{C}$

from  $\text{Si}_2\text{H}_6$  by thermal CVD and photo-CVD using a  $\text{D}_2$  lamp. The thermal and photo-CVD films prepared above  $575^\circ\text{C}$  are highly  $\langle 100 \rangle$ -oriented but the films at  $545$  and  $560^\circ\text{C}$  are  $\langle 110 \rangle$ -oriented. This tendency is more remarkable in the photo-CVD than in the thermal CVD. These orientations change little in depth, but the orientation horizontal to the film plane is random. (Author abstract) 16 refs.

Okuyama, Masanori (Osaka Univ, Toyonaka, Jpn); Fujiki, Noriaki; Inoue, Kohji; Hamakawa, Yoshihiro. *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 499-501.

**095009 IN SITU IR SPECTROSCOPIC STUDY OF a-Si:H FILMS GROWING UNDER PHOTO-CHEMICAL VAPOR DEPOSITION CONDITION.** Polarization modulation infrared spectroscopy has been successfully applied for in situ observations of a-Si:H films growing under photo-chemical vapor deposition conditions. The thin films exhibited absorption bands arising from  $\text{SiH}_3$  or  $\text{SiH}_2$  species, depending upon the substrate temperature. Whereas the mass thickness of the film deposited at  $293 \text{ K}$  increased in proportion to the deposition time, the IR absorption intensity of  $\text{SiH}_3$  species decreased in rate when the film grew beyond  $15 \text{ Å}$  in thickness, showing that the concentration of the  $\text{SiH}_3$  species becomes reduced with the deposition time. Although the band ascribable to the Si-O stretching vibration could not be observed during the deposition, it grew when the film was exposed to air. This fact suggests that the origin of the oxygen incorporated in the film is mainly atmospheric oxidizing agents. (Author abstract) 17 refs.

Wadayama, Toshimasa (Tohoku Univ, Sendai, Jpn); Suetaka, Wataru; Sekiguchi, Atsushi. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 501-505.

**095010 ANALYTICAL STUDY ON INTERFACE OF EPITAXIAL Si IN Si SUBSTRATE GROWN BY  $\text{CO}_2$  LASER CVD.** The Si epitaxial films were grown on (100) Si substrates at  $650^\circ\text{C}$  by  $\text{CO}_2$  laser CVD using  $\text{SiH}_4$  gas. The authors discuss the initial stage of Si epitaxial growth by the crystallinity measurements of the region near the interface and the effect of the concurrent radiation of UV light onto Si substrate during the epitaxial growth by the  $\text{CO}_2$  laser CVD. The improvement of crystallinity of the epitaxial films is also discussed. The crystallinity measurement was carried out by Rutherford backscattering spectrometry (RBS) and transmission electron microscopy (TEM). The high density defect region of approximately  $150 \text{ nm}$  in thickness from the interface was observed in the case of the films grown by  $\text{CO}_2$  laser CVD at  $700^\circ\text{C}$ , and this kind of region was eliminated by the coradiation of UV light during the epitaxial growth. (Edited author abstract) 13 refs.

Meguro, T. (Waseda Univ, Tokyo, Jpn); Ikeda, N.; Itoh, T. *J Electrochem Soc* v 135 n 8 Aug 1988 p 2046-2049.

**095011 EPITAXIAL GROWTH OF IN SITU DOPED SILICON BY LPCVD.** This paper analyzes the first results obtained in the deposition of in situ doped epitaxial silicon under low pressure conditions. A LPCVD system at high temperatures using a hot wall reactor was used for the experiments. The results obtained on the impurity concentration in the grown layers indicate its strong dependence on the partial pressure of diborane and hydrogen. Furthermore, a difference in the growth rate has been found when diborane is introduced into the initial mixture, which depends on the source used and appears to be due to the presence of HCl in the gas phase. (Author abstract) 8 refs.

Dominguez, C. (CSIC, Madrid, Spain); Pastor, G.; Dominguez, E. *Vacuum* v 37 n 5-6 1987, VI Span Conf on Vac and Its Appl, Madrid, Spain, Dec 1985 p 407-409.

**095012 LOW PRESSURE SILICON EPITAXY IN A HOT-WALL REACTOR.** An attempt has been made to elucidate the mechanism followed during silicon epitaxial deposition at low pressures and high temperatures



when varying the silicon source. Although a similar reaction for both sources appears to exist, i.e. pyrolysis decomposition in the gas phase, the heterogeneous deposition mechanism may be different, for the different sources. This is due to the fact that, in the case of trichlorosilane, the co-generation of HCl with SiCl<sub>2</sub> in the gas phase makes possible a competition between etching and growth, whereas, in the case of dichlorosilane, the absence of HCl in the gas phase permits a single deposition mechanism. In order to explain the actual mechanism for each of the sources it is necessary to carry out an in-depth study of the various parameters governing deposition. 9 refs.

Dominguez, C. (CSIC, Madrid, Spain); Dominguez, E. *Vacuum* v 37 n 5-6 1987, VI Span Conf on Vac and Its Appl, Madrid, Spain, Dec 1985 p 419-421.

**095013 LOW-TEMPERATURE CRYSTALLIZATION OF IN SITU PHOSPHORUS-DOPED LOW-PRESSURE CHEMICAL-VAPOUR DEPOSITED AMORPHOUS SILICON.** A method has been developed for producing low-resistivity phosphorus-doped polysilicon films with a minimum thermal budget. The method involves low-pressure chemical-vapor deposition of amorphous silicon at 500°C followed by crystallization at 650°C. Films formed in this manner are compared to films deposited polycrystalline at 627°C. In both cases, in situ doping is achieved by addition of PH<sub>3</sub> diluted in SiH<sub>4</sub> to the gas mixture. For a given SiH<sub>4</sub>:PH<sub>3</sub> flow ratio, the phosphorus concentration determined from secondary-ion mass spectroscopy is four times larger in the amorphous-deposited material. Moreover, the resistivity is substantially lower in this material even when the dopant concentrations are similar. The latter result may be due in part to reduced dopant segregation to grain boundaries. The internal strain determined from the Raman line width is larger in the polycrystalline-deposited material but could be reduced by high-temperature annealing. (Author abstract) 7 refs.

Wachter, D. (Carleton Univ, Ottawa, Ont, Can); Tarr, N.G. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicon Technol Conf, Ottawa, Ont, Can p 1030-1032.

**Cleaning** See Also SEMICONDUCTING GALLIUM ARSENIDE—Growth.

**095014 SI SURFACE CLEANING BY Si<sub>2</sub>H<sub>6</sub>-H<sub>2</sub> GAS ETCHING AND ITS EFFECTS ON SOLID-PHASE EPITAXY.** Si surface cleaning with Si<sub>2</sub>H<sub>6</sub>-H<sub>2</sub> was studied for lateral solid-phase epitaxy (L-SPE) of CVD a-Si films. The cleaning was performed at 850°C, which is considerably lower than the previously-reported H<sub>2</sub>-cleaning temperature (1100°C). This is because etching of native oxide is enhanced by a reaction between oxide and Si-atoms dissociated from Si<sub>2</sub>H<sub>6</sub>. The effects of Si<sub>2</sub>H<sub>6</sub>-cleaning on L-SPE were studied using a Si (100) wafer with SiO<sub>2</sub> stripes. After Si<sub>2</sub>H<sub>6</sub>-cleaning or H<sub>2</sub>-cleaning at 850°C, CVD a-Si films are deposited on the wafers, then crystallized by annealing (575°C). An H<sub>2</sub>-cleaned sample showed imperfect L-SPE because of a residual native-oxide layer at the a-Si/substrate interface. In the Si<sub>2</sub>H<sub>6</sub>-cleaned sample, the native-oxide layer was removed, and L-SPE growth was observed uniformly in the wafer. Si<sub>2</sub>H<sub>6</sub>-cleaning at 850°C is applicable for substrates with abrupt impurity distribution. (Author abstract) 18 refs.

Kunii, Yasuo (NTT LSI Lab, Atsugi, Jpn); Sakakibara, Yutaka. *Jpn J Appl Phys Part 1* v 26 n 11 Nov 1987 p 1816-1822.

**Contacts** See Also INTEGRATED CIRCUITS, VLSI—Contacts.

**095015 CHANGES IN ELECTRICAL CHARACTERISTICS OF Al-Ti CONTACTS ON SILICON.** The electrical characteristics of Al-Ti metallization on p, n, p<sup>+</sup> and n<sup>+</sup> silicon were studied. The contact specific resistance or the electron and hole energy barriers were determined. The conductance-reverse voltage measurement technique was used to reveal the contact non-uniformities (microplasma-type effects). SEM micrographs provided a picture of the contacts surface geometry. All these

results showed that when the Ti barrier disappears due to the Al-Ti interaction the entire contact behavior resembles that of an Al/Si contact. This drastic change of the contacts properties, as well as the surface degradation, are therefore confirmed by a consistent investigation of the electrical characteristics. The paper presents the results of some investigations on Ti and Ag-Ti metallization systems. (Edited author abstract) 23 refs.

Brezeanu, G. (Polytechnic Inst of Bucharest, Bucharest, Rom); Dascau, D.; Dan, P.A.; Negru, S.; Traistaru, V. *Microelectron Reliab* v 28 n 2 1988 p 205-211.

**Contamination** See Also INTEGRATED CIRCUITS, VLSI.

**095016 ANALYSIS OF COINCIDENCE LOSSES FOR A MONITOR OF PARTICLE CONTAMINATION ON SURFACES.** A widely used instrument (manufactured by InspeX, Incorporated) for detecting, sizing, and counting particles on silicon wafer surfaces determines particle size by the number of pixels on a vidicon-type screen that are activated by light scattered from particles during oblique observation of perpendicular illumination. The authors present a method for estimating the fraction of the particles that are not involved in coincidence. The full solution for the fraction of particles in any size category overlapped by those in any other category is presented. Two limits are developed: one for particles all the same size (that is, each giving the same response) and one for particles of very different sizes, the smallest being much more numerous. (Edited author abstract) 5 refs.

Cooper, Douglas W. (IBM, Yorktown Heights, NY, USA); Miller, Robert J. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2871-2875.

**095017 REMOVAL PROCESSES FOR DAMAGE AND CONTAMINATION AFTER CF<sub>4</sub>/40% H<sub>2</sub> REACTIVE ION ETCHING OF SILICON.** State of the art of RIE reactors, nature of damage and contamination introduced, their effects and controls are reviewed. The defect model as conceived on this basis is presented. The highly selective etching of SiO<sub>2</sub> relative to Si is done by reactive ion etching with CF<sub>4</sub>/40% H<sub>2</sub>. The damage and contamination introduced in Si are characterised by Al/p-Si Schottky diodes fabricated on dry etched Si wafers. The dry etching is found to convert an Al/p-Si ohmic contact into a rectifying one. Various removal processes of damage and contamination after dry etching are tried to restore the original behaviour of the diodes. The results indicate that ashing, (RF sputter etching in N<sub>2</sub> ambient) followed by HF dip are sufficient to restore the surface. The effects of omissions of RF sputter etching in N<sub>2</sub> ambient and HF dip are discussed. An alternative process of thermal oxidation of dry etched Si wafers in an O<sub>2</sub>/TCE ambient at 1000°C for 15 mins followed by HF dip is seen to recover the surface. This is confirmed by lifetime studies made on post-oxidised Si wafers. The latter process consumes more silicon. The suitability of the process for VLSI fabrication is discussed. (Edited author abstract) 54 refs.

Singh, Awatar (CEERI, Pilani, India). *Microelectron J* v 18 n 5 Sep-Oct 1987 p 13-24.

**095018 INVESTIGATION OF SURFACE CONTAMINATION ON SILICON WAFERS WITH SIMS.** An analytical approach for investigation of surface contaminants with SIMS (secondary ion mass spectrometry) is proposed. The major problem is the presence of the contaminants only in the native oxide (thickness approximately 1.5 nm). This means that analysis has to be performed in a surface zone smaller than the implantation depth of the primary ions. Chemical matrix effects and a changing erosion rate are encountered owing to the native oxide and the dynamic process of primary ion implantation and sputtering. Owing to the necessity of analyzing extremely thin surface layers very slow sputtering has to be applied (1-10 monolayers per min.). As a consequence the secondary ion intensities are low and hydrocarbon species interfere with the elements to be analyzed. For the identification of the secondary ion signals the evaluation

of isotopic ratios determined with low mass resolution ( $M/\Delta M \approx 350$ ) is combined with measurement of high resolution mass spectra. (Author abstract) 20 refs.

Stingeder, G. (Technical Univ Vienna, Vienna, Austria); Grundner, M.; Grasserbauer, M. *Surf Interface Anal* v 11 n 8 May 1988 p 407-413.

**095019 CONTAMINATION OF SILICON SURFACES EXPOSED TO CHF<sub>3</sub> PLASMAS AN XPS STUDY OF THE FILM AND THE FILM-SURFACE INTERFACE.** Si surfaces previously exposed to CHF<sub>3</sub> plasmas (RIE mode) have been characterized by x-ray photoelectron spectroscopy (XPS). Plasma exposure of a clean Si surface leads to the deposition of a C,F containing film. The C<sub>1s</sub> XPS spectrum reveals various bonding states of carbon, including CF<sub>3</sub>, CF<sub>2</sub>, CF, C-CF<sub>x</sub>. The [C]/[F] ratio and the relative concentrations of the different carbon species do not depend on exposure time. For very short exposure times (approximately 1s) the polymer deposition is instantaneous and the film substrate interface is accessible. It consists of a SiO<sub>x</sub> layer - probably the remains of the native oxide layer existing on the substrate - and C- and Si-F species implanted within or below the SiO<sub>x</sub> layer. The ion bombardment is thus proved to be an essential parameter of the polymer deposition initial mechanism. (Author abstract) 37 refs.

Cardinaud, C. (CNRS, Nantes, Fr); Rhounna, A.; Turbon, G.; Grolleau, B. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1472-1477.

**095020 SURFACE CONTAMINATION DETECTION BELOW THE ppb RANGE ON SILICON WAFERS.** The atomic absorption technique has been used to detect trace impurity contamination in silicon wafers at different stages of processing. Suitable wafer etching by quantitative silicon removal followed by impurity concentration made it possible to reach significant detection limits for all the interesting contaminants, including Fe, Cr, Cu, Ni, K, Zn, Co, Mn, each present at levels below 10<sup>12</sup> atoms/cm<sup>2</sup>. The number of contaminant species can be further increased and the detection limits improved. The extent to which correlations are possible with other less direct methods is discussed. (Author abstract) 2 refs.

Corradi, A. (Dynamit Nobel Silicon, Novara, Italy); Domenici, M.; Guaglio, A. *J Cryst Growth* v 89 n 1 Jun 1988, Purif of Mater for Cryst Growth and Glass Process - Proc of the Second Workshop, Champion, PA, USA, Sept 28-Oct 1 1987 p 39-42.

**Crack Propagation** See DIES—Ceramic.

**Crystal Lattices**

**095021 REMEASUREMENT OF A SILICON LATTICE PERIOD.** Optical interferometry of a silicon lattice period is an important link between macroscopic and microscopic lengths as well as between low-energy and high-energy spectroscopies. An evident discrepancy between two pre-1982 measurements has limited the effective application of these results. Very recent results are reported in a preliminary way that appear to further understanding and to remove this discrepancy. 11 refs.

Deslattes, Richard D. (NBS, Gaithersburg, MD, USA); Tanaka, Mitsuru; Greene, Geoffrey L.; Henins, Albert; Kessler, Ernest G. Jr. *IEEE Trans Instrum Meas* v IM-36 n 2 Jun 1987, Sel Pap - Conf on Precise Electromagn Meas (CPEM/86), Gaithersburg, MD, USA, Jun 23-27 1986 p 166-169.

**Crystalline** See Also SEMICONDUCTOR DEVICES, MOSFET—Mathematical Models.

**095022 DEPTH DEPENDENCE OF NUCLEATION IN IMPLANTED POLYCRYSTALLINE SILICON FILMS ON SiO<sub>2</sub>.** Silicon films can be prepared for silicon-on-insulator (SOI) applications by amorphizing a polycrystalline silicon film by ion implantation and then crystallizing it by a subsequent low-temperature anneal. Crystallization of a 1500 Å polycrystalline silicon film



self-implanted at an energy of 100 keV and a dose of  $2 \times 10^{15}$  ions/cm<sup>2</sup> is found to be due to the nucleation of crystallites at or near the top surface. Nucleation is believed to be due to small crystalline regions (clusters) which survive implantation. Such clusters will exist predominantly at the depth corresponding to the least implant damage which, for this implantation-target combination, is at the top surface. 13 refs.

Iverson, R.B. (MIT, Cambridge, MA, USA); Reif, R. *Mater Lett* v 6 n 11-12 Oct 1987 p 460-462.

#### Crystallization See Also TRANSISTORS—Thin Films.

**095023 LARGE SPONTANEOUS NUCLEATION RATE IN IMPLANTED POLYCRYSTALLINE SILICON FILMS ON SiO<sub>2</sub>.** One method of preparing silicon films for silicon-on-insulator (SOI) applications is to amorphize a polycrystalline film by implantation and then crystallize it by a low temperature anneal. The experiment examined crystallization behavior to determine whether the grains in the annealed film grow from seed grains (grains which survived the implant). Crystallization of a silicon film self-implanted at a dose of  $2 \times 10^{15}$  ions/cm<sup>2</sup> due to the nucleation of crystallites and not due to the growth of grains that survived the implant. The nucleation rate was more than three orders of magnitude faster than that for either amorphous silicon or polycrystalline silicon self-implanted at  $5 \times 10^{15}$  ions/cm<sup>2</sup>. (Edited author abstract) 16 refs.

Iverson, R.B. (MIT, Cambridge, MA, USA); Reif, R. *Mater Lett* v 5 n 10 Sep 1987 p 393-395.

**095024 PROPERTIES OF DIFFUSED RESISTORS IN SOLAR-GRADE SEMICRYSTALLINE SILICON.** The transport properties of diffused p<sup>+</sup>-layers in n-type semicrystalline solar-grade silicon have been examined. It has been found that the grain boundary slightly increases the resistance of the majority carrier flow. A simple method is proposed to determine the average grain size, the barrier height and the effective trapping density at the grain boundary. Resistors made of these diffused layers show anomalous behavior concerning their voltage and temperature dependence. This anomaly is caused by the soft I-V characteristics of the isolation p-n junction. (Author abstract) 13 refs.

El-Emawy, A. (Ain Shams Univ, Cairo, Egypt); Zekry, A.; El-Koosy, M.; Fikry, H. *Solid State Electron* v 31 n 7 Jul 1988 p 1179-1185.

#### Cutting

**095025 WAFER SLICING BY INTERNAL DIAMETER SAWING.** Internal Diameter Sawing (IDS) is the commonly used technique for slicing hard and brittle materials such as semiconductive silicon and germanium or ceramics and glasses. Nevertheless, productivity and yield are relatively low on account of difficulty in handling the flexible tool. Increasing workpiece dimensions leads to greater problems in realizing quality requirements, such as high flatness, low roughness, and low crystal damage. This paper deals with basic relationships in IDS, applying to all workpiece materials. (Edited author abstract) 10 refs.

Struth, W.F. (Fraunhofer-Inst fuer Produktionstechnologie, Aachen, West Ger); Steffens, K.; Koenig, W. *Precis Eng* v 10 n 1 Jan 1988 p 29-34.

#### Decontamination

**095026 CLEAN MODULE: ADVANCED TECHNOLOGY FOR PROCESSING SILICON WAFERS.** Modern IC fabrication technology is placing increasing demands on silicon material manufacturing. Polished silicon wafers must meet rigid criteria relative to bulk crystal parameters, mechanical dimensions and surface cleanliness. The twin demands of quality and productivity have been addressed in the Clean Module (CM), a fully integrated and automated manufacturing system for cleaning, inspecting and packaging silicon substrates. Utilizing the latest in clean room technology, robotics,

computer control and just-in-time (JIT) manufacturing, the CM delivers silicon wafers that meet the needs of the VLSI industry. 6 refs.

Golland, D.I. (Monsanto Electronic Materials Co, St. Peters, MO, USA); Albrecht, P.D.; Krussell, W.C.; Puerto, F.A. *Semicond Int* v 10 n 10 Sep 1987 p 184-187.

**Defects See Also CRYSTALS—Defects; CRYSTALS—Dislocations; MICROSCOPES—Design; SEMICONDUCTOR MATERIALS—Defects.**

**095027 NITROGEN RELATED DONORS IN SILICON.** Electrical characteristics of identified N-related defects in Si are investigated by conductivity and Hall effect measurements. Results are presented for N-ion implanted layers which were annealed to introduce off-center substitutional N, N-N pair centers, and N aggregates. Neither off-center substitutional N nor the more predominant N-N pair center introduces the shallow donor activity previously reported for N-implanted Si. Shallow donor activity is observed, however, after annealing for 1h at 800°C and is attributed to N aggregates. The donor concentration increases rapidly with dose between  $2 \times 10^{14}$  and  $10^{15}$  cm<sup>-2</sup> (N concentrations  $\approx 1.5 \times 10^{19}$  cm<sup>-3</sup>), and then decreases at higher doses. (Edited author abstract) 16 refs.

Stein, H.J. (Sandia Natl Lab, Albuquerque, NM, USA). *J Electrochem Soc* v 134 n 10 Oct 1987 p 2592-2596.

**095028 INFLUENCE OF CARBON CONTENT ON INTRINSIC GETTERING PROCESS.** The authors studied the influence of carbon on oxygen precipitation and defect formation in P type CZ silicon. During the oxygen intrinsic gettering (IG) process, it was found that IG defects were fewer for wafers with carbon content up to  $1 \times 10^{17}$ /cm<sup>3</sup> although the precipitation rate of oxygen at 750°C was higher for the same samples. During the heat treatment at 750°C, the wafers with high carbon content appear to precipitate oxygen and carbon simultaneously and to create new donors. The thermal donors created at 450°C are the heterogeneous nucleation sites of IG defects. (Edited author abstract) In Chinese. 19 refs.

Tan, Song-sheng (Acad Sinica, China); Xu, Xue-min; Li, Yue-zhen. *Xi You Jin Shu* v 6 n 2 May 1987 p 91-96.

**095029 BASIC TYPES OF NONUNIFORMITIES AND THEIR MANIFESTATION IN THE GALVANOMAGNETIC PROPERTIES OF ESPECIALLY PURE SILICON.** A method is proposed for analyzing the type of nonuniformities in a single-crystalline pure material based on the changes in the 'asymmetry resistances,' determined from the magnitudes of the external potentials on the Hall contacts, in a magnetic field. By comparing their magnetic-field dependences with the analogous dependences of the Hall constant and of the resistivity, measured with different polarities of the voltage applied to the sample, it is shown that the asymmetry resistances are the parameters which are most sensitive to nonuniformity. It was found that nonuniformities of the 'compensation' type, i.e., space-charge regions in which the minority carriers make an appreciable contribution to the Hall constant, are systematically manifested in crystals of especially pure high-resistance silicon. The effective Hall factors were calculated under the conditions of Hall bipolarity of the impurity conductivity and the results are compared with the experimental data. (Author abstract) 13 refs.

Ostrobodova, V.V. (M.V. Lomonosov Moscow State Univ, USSR). *Sov Phys J* v 30 n 6 Jun 1987 p 498-509.

**095030 SYSTEMATIC ANALYSIS OF DEFECTS IN ION-IMPLANTED SILICON.** A classification scheme for the different forms of implant-related damage which arise upon annealing consisting of five categories is presented. Category I damage is 'subthreshold' damage or that which results prior to the formation of an amorphous layer. If the dose is increased sufficiently to result in the formation of an amorphous layer then the defects which form beyond the amorphous/crystalline (a/c) interface are classified as category II ('end of range') damage. Category III defects are associated with the solid phase epitaxial

growth of the amorphous layer. It is possible to produce a buried amorphous layer upon implantation. If this occurs, then the defects which form when the two a/c interfaces meet are termed category IV ('clamshell', 'zipper') defects. Finally, category V defects arise from exceeding the solid solubility of the implanted species in the substrate at the annealing temperature. In addition to presenting examples of this classification scheme, new results emphasizing category II, IV, and V defects are presented. (Edited author abstract) 137 refs.

Jones, K.S. (Univ of California, Berkeley, CA, USA); Prussin, S.; Weber, E.R. *Appl Phys A* v A45 n 1 Jan 1988 p 1-34.

**095031 REVELATION OF MICROPORES IN a-Si-H FILMS.** Glow discharge a-Si:H has been studied regarding micropore density in the films. These defects have been visualized by means of field-assisted silver ion exchange. It has been shown that a  $5 \times 10^3$  cm<sup>-2</sup> micropore density is an intrinsic feature of the studied films and is not affected by the thermal and field treatment during the ion diffusion. (Author abstract) 7 refs.

Danesh, P. (Bulgarian Acad of Sciences, Sofia, Bulg); Pantchev, B.G. *Sol Energy Mater* v 17 n 2 Feb-Mar 1988 p 95-98.

**095032 NEW PHOTOLUMINESCENCE DEFECT SPECTRA IN SILICON IRRADIATED AT 100 K: OBSERVATION OF INTERSTITIAL CARBON.** We report photoluminescence spectra of defects in irradiated silicon which are stable below room temperature. No-phonon lines (ST1)<sup>0</sup> at approx. 856 meV, ST2 at approx. 1115 meV, and ST3 at approx. 1126 meV are observed, along with a broad emission band extending from 0.7 to 1 eV. The ST1 defect studies is a deep hole trap at approx. E<sub>v</sub> + 0.25 eV, which, in addition, can bind an electron loosely. Piezospectroscopy shows that the defect is essentially <100> axial symmetric with slight distortion to C<sub>1h</sub>. The absence of Zeeman splittings confirms the deep hole binding in an axially symmetric potential. The independence of dopants, the annealing behavior, and comparison to EPR and IR active defects suggest a correlation of the ST1 defect with interstitial carbon. (Edited author abstract) 18 refs.

Thonke, K. (Univ Stuttgart, Stuttgart, West Ger); Teschner, A.; Sauer, R. *Solid State Commun* v 61 n 4 Jan 1987 p 241-244.

**095033 EPR STUDY ON A NEW TRICLINIC SYMMETRY DEFECT IN NEUTRON-IRRADIATED FZ-SILICON.** A new defect, labeled as Si-PK1, has been observed with EPR (Electron Paramagnetic Resonance) in neutron irradiated FZ-Si grown in argon, hydrogen and vacuum. Its symmetry has been determined to be triclinic symmetry, the lowest possible symmetry. Si-PK1 has not been observed in CZ-Si. It is not related to any common impurities in Si, like oxygen, carbon, phosphorus and boron. It is claimed to be an intrinsic defect. Combining with the empirical classification of g tensor, it is concluded that Si-PK1 may be a multivacancy cluster. (Edited author abstract) 14 refs.

Wu En (Peking Univ, Beijing, China); Wu Shu-xian; Mao Jin-Chang; Yan Mao-Xun; Qin Guo-gang. *Solid State Commun* v 61 n 3 Jan 1987 p 199-202.

**095034 THEORETICAL STUDY OF THE ELECTRONIC STRUCTURE FOR TWIN STACKING FAULTS IN SILICON.** The electronic structure and atomic relaxation of twin stacking fault along [111] direction in silicon are studied within the local density approximation with first principle cluster model self-consistent calculations. The atomic relaxation obtained from the viewpoint of total energy is in agreement with



experiments. The electronic structure, defect levels, and fault energy of twin stacking faults in silicon are discussed. (Edited author abstract) 10 refs.

Gong, Xin-gao (Acad Sinica, Hefei, China); Zheng, Qing-qi; Han, Ru-shan; Yang, Wei-sheng. *Solid State Commun* v 62 n 2 Apr 1987 p 65-68.

**095035 PHOTOMODULATION SPECTROSCOPY OF DANGLING BONDS IN DOPED AND UNDOPE a-Si:H.** The energy levels and the effective correlation energy  $U_{\text{eff}}$  of dangling bond defects in doped and undoped a-Si:H were determined by the steady state and transient photomodulation spectroscopy. We found that in undoped a-Si:H the two dangling bond levels ( $D\pm$ ) are symmetrically located around midgap with  $U_{\text{eff}}$  of  $0.5 \pm 0.1$  eV, whereas in P(B) doped a-Si:H the states  $D-(D+)$  are pushed away from the conduction (valence) band toward midgap and  $U_{\text{eff}} = 0.4 \pm 0.1$  eV. (Author abstract) 20 refs.

Vardeny, Z. (Brown Univ, Providence, RI, USA); Zhou, T.X.; Stoddart, H.A.; Tauc, J. *Solid State Commun* v 65 n 9 Mar 1988 p 1049-1053.

**095036 CLUSTERS OF RADIATION DEFECTS IN SILICON WITH DISLOCATIONS.** The influence of dislocations ( $N_D = 1 \times 10^4$  to  $1 \times 10^7 \text{ cm}^{-2}$ ) on the radiation defect cluster formation by 640 mev proton irradiation was investigated in n-type silicon. The temperature dependences of Hall coefficient and conductivity obtained in the temperature interval of 80 to 400 K demonstrate that the production rate and thermal ionization energy of divacancies as well as the potential barrier for their aggregation are independent on the dislocation density  $N_D$ . In the case of A-centers these parameters appear to vary with  $N_D$ . Dislocation strain fields affect the formation of complexes of primary defect-impurity atom-type which are accumulated near the dislocations and create the impurity-defect atmosphere. The strain fields do not alter the processes of intrinsic defect cluster formation which occur in the region of the primary displacement cascade. (Edited author abstract) 6 refs.

Kazakevich, L.A. (VI Lenin State Univ, Minsk, USSR); Kuznetsov, V.I.; Lugakov, P.F. *Phys Status Solidi A* v 105 n 1 Jan 1988 p 97-100.

**095037 NATURE OF LATTICE DEFECTS INDUCED BY EXCIMER LASER IRRADIATION FOR EXTRINSIC GETTERING.** Structure and thermal behavior of lattice defects in silicon induced by excimer laser irradiation, which is expected to be adopted as a new extrinsic gettering technique, were examined by transmission electron microscopy. Stacking fault tetrahedra and a peculiar type of dislocations which appeared in a V-shape were found in a melted and regrown layer of an as-irradiated sample. After subsequent heat treatment, slip dislocations were generated from the traces of laser beam shot and the stacking fault tetrahedra were mostly transformed into the V-shaped dislocations. These V-shaped dislocations were proved to be thermally stable and were expected to work as effective extrinsic gettering centers. (Author abstract) 13 refs.

Sakai, Akira (NEC, Kawasaki, Jpn); Ono, Haruhiko; Ohshita, Yoshio; Matsui, Junji. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 155-158.

**095038 THERMAL GENERATION OF FRENKEL PAIR IN SILICON.** A basic concept in thermodynamics states that, if an isolated system is left standing, it comes eventually to a final state which does not change. This final state is called the thermal equilibrium state. If vacancies and self-interstitials coexist, it is sure that they recombine with each other. Greatest importance is given to the basic concept in the thermodynamics mentioned above. Therefore, regardless of whether or not the thermal generation of the Frenkel pair is energetically possible, the Frenkel pair should be generated thermally as a reverse reaction of the recombination, to get the thermal equilibrium state. (Author abstract) 13 refs.

Yoshida, Masayuki (Kyushu Inst of Design, Fukuoka, Jpn); Matsumoto, Satoru. *Keio Sci Technol Rep* v 40 n

2 Dec 1987 25p.

**095039 DEFECT PROPERTIES IN SILICON INDUCED BY RF PLASMA IRRADIATION.** The effects of rf room temperature air plasma irradiation on Si surface have been studied by the C-V and DLTS measurements. It is found that a thin oxide film is formed on the Si surface by the air plasma anodization. The DLTS measurements show a continuously distributed interface state and a single energy level at  $E_C - E_B = 0.54$  eV which is a kind of localized defect existed in the oxide layer near the interface. In addition, there are two energy levels in the bulk Si induced by the plasma interaction. They behave as the divacancy usually observed in the electron beam irradiated Si. The cross section of these defect levels are measured and their isochronal annealing behaviours have been investigated. (Author abstract) 7 refs.

Xu, Jian-Guo (Fudan Univ, Shanghai, China); Sun, Heng-Hui. *Solid State Commun* v 66 n 7 May 1988 p 751-753.

**095040 DISLOCATION CURVATURE BY KINK MIGRATION IN A NON-UNIFORM STRESS FIELD: APPLICATION TO DISLOCATION LOOPS IN SILICON.** The radius of curvature of dislocations in the thermally activated regime of glide, and in a non-uniform stress field, is derived from two characteristic times related to kink velocity. The result is compared to experimental values of the radius of curvature at the corner of stress-induced dislocation loops in silicon. (Author abstract) 5 refs.

Pichaud, B. (CNRS, Marseilles, Fr); Minari, F. *Phil Mag Lett* v 57 n 6 Jun 1988 p 299-303.

**095041 THEORETICAL STUDIES OF THE NATURE OF 2210  $\text{cm}^{-1}$  IR ABSORPTION PEAK IN SILICON CRYSTAL CONTAINING HYDROGEN (I): VALENCE FORCE FIELD CALCULATIONS OF THE OSCILLATOR FREQUENCIES.** Starting from the idea of the Urey-Bradley force field, the authors have calculated the vibrational frequencies with a valence force field method for two models of the defect complexes corresponding to the 2210  $\text{cm}^{-1}$  peak in a silicon crystal containing hydrogen, vacancy + 4H and interstitial silane. Based on analysis of the calculated results and reasonableness of the force constant adjustments, it is concluded that the vacancy + 4H model is preferable. In addition, a reliable method is described in which the two models can be discriminated between experimentally. (Edited author abstract) 25 refs.

Guoren, Bai (Acad Sinica, China); Jiankun, Zhou; Jianmin, Chen; Tianshen, Shi; Mingwei, Qi; Leiming, Xie. *Sci Sin Ser A* v 31 n 4 Apr 1988 p 499-512.

**095042 NEW EPR DEFECT IN NEUTRON-IRRADIATED FZ-SILICON AND HYDROGEN PASSIVATION EFFECT.** A new EPR center having  $C_{2v}$  symmetry and  $S=1$ , labeled as Si-Pk3, has been observed for the first time in neutron-irradiated silicon. The spectra start to appear after a 150°C annealing and disappear at 500°C. The principal values of tensor g and D are determined. The microscopic model is proposed to be a trivacancy chain along the direction with an oxygen atom situated in the middle. The annealing temperature in hydrogen-containing samples is at least 150°C lower than that of other samples. (Author abstract) 15 refs.

Shuxiang, Wu (Peking Univ, China); Maoxun, Yan; Huiying, Xu; Jinchang, Mao; En, Wu. *Sci Sin Ser A* v 31 n 1 Jan 1988 p 98-104.

**095043 INVESTIGATION OF RADIATION DEFECTS IN HYPERABRUPT p-n JUNCTIONS.** Distribution profiles for the levels of radiation defects in hyperabrupt implanted p-n junctions irradiated by electrons with a dose up to  $5 \times 10^{15} \text{ cm}^{-2}$  were studied using admittance spectroscopy (AS). Besides a general tendency of the defect density to decrease towards the surface, the distribution of defects is correlated with the profile of the doping impurity (phosphorus). It is associated with the reduced energy of defect formation in the

layer implanted. The effect is measured of an electric field ranging within  $\epsilon \approx 10^4$  to  $5 \times 10^5 \text{ V/cm}$  on the activation energy for the emission rate of electrons from A- and E-centers. (Edited author abstract). 24 Refs.

Marchishin, I.V. (Acad of Sciences of the USSR, Novosibirsk, USSR); Ovsyuk, V.N.; Sevastianov, S.B. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 557-568.

**095044 DEFECT GENERATION AND GETTING DURING RAPID THERMAL ANNEALING.** The generation of crystallographic defects induced by metallic impurities diffusing from the back side of silicon wafers is observed during rapid thermal annealing. The type of defect generated depends on both the type and concentration of metal used. Saucer-pits, hillocks, and oxidation induced stacking faults are observed after oxidation in the time range 40-180s. These defects can be annihilated by gettering with a heavily doped P layer diffused into the back side of the wafers. The effectiveness of this annihilation depends upon the order of the gettering and defect-generating processes. It also depends on the type and concentration of metal used. (Author abstract). 56 Refs.

Zagodzdzon-Wosik, W. (Univ of Houston, Houston, TX, USA). *J Electrochem Soc* v 135 n 8 Aug 1988 p 2065-2069.

**095045 ROD-LIKE DEFECTS IN SILICON: COESITE OR HEXAGONAL SILICON?** The crystallographic nature of rod-like defects in silicon, as observed by high resolution electron microscopy after low temperature annealings of high oxygen content Czochralski silicon, ion implantation, or electron irradiation is discussed. The interpretation of the HREM images of the rod-like defects is critically examined in view of the two models recently proposed in the literature, i.e., hexagonal silicon or coesite  $\text{SiO}_2$  precipitates. It is shown that the interpretation as hexagonal silicon instead of coesite precipitates is very favourable. (Author abstract). 33 Refs.

Bender, H.; Vanhellemont. *Phys Status Solidi A* v 107 n 2 Jun 1988 p 455-467.

**095046 PROS AND CONS FOR DANGLING BONDS AT DISLOCATION CORES IN SI.** Some peculiar results of deep-level transient spectroscopy (DLTS) measurements on plastically deformed hydrogenated Si are explained in terms of a model for the driven reconstruction of dislocations. Driven reconstruction may be responsible for the reduction in the density of high-temperature electron paramagnetic resonance (EPR) centres after predeformation and after deformation during heat treatment in a hydrogen atmosphere. The model for driven reconstruction is based on the assumption that the non-reconstructed state is the lowest energy state of the dislocation core. Together with numerous results concerning electrical conduction along dislocation cores, the considerations presented in this Letter strongly indicate that dangling bonds exist within dislocation cores in Si. The absence of a dislocation-related EPR signal suggests that there must be a reason, intrinsic to the dislocation core, by which dangling bonds in dislocations do not carry unpaired electrons. (Author abstract). 13 Refs.

Pohoryles, B. (Polish Acad of Sciences, Warsaw, Pol). *Philos Mag Lett* v 58 n 1 Jul 1988 p 7-10.

**095047 DEFECT ENGINEERING FOR VLSI EPITAXIAL SILICON.** The control of dopants, impurities and defects for very large scale integration of silicon integrated circuits requires a complex set of crystal and processing conditions to be satisfied simultaneously. In order to achieve the maximum yield and highest level of electrical performance for a given device design, we have manipulated the lattice constant and boron doping levels in CVD epitaxial silicon layers co-doped with germanium. By adjusting the ratios of germane and diborane in a dichlorosilane/hydrogen CVD reactor we can achieve extrinsic gettering using controlled introduction of interfacial misfit dislocations with Si(Ge), and buried high conducting layers which are strain-free and lattice



matched to the Si substrate. A variety of these structures have been characterized using gated-diode leakage, spreading resistance profiling, MOS lifetime, cross-sectional TEM, SEM-EBIC and SIMS depth profiling. (Author abstract) 16 refs.

Rozgonyi, G.A. (North Carolina State Univ, Raleigh, NC, USA); Salih, A.S.M.; Radzinski, Z.; Kola, R.R.; Honeycutt, J.; Bean, K.E.; Lindberg, K. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 300-307.

**095048 ON THE NATURE AND ENERGY DISTRIBUTION OF DEFECT STATES CAUSED BY HOT ELECTRONS IN SI.** We consider the temperature dependence of hot-carrier induced degradation effects in MOS devices. Using a 2D device simulator program capable of handling temperatures in the range 40-300 K, it is shown that the degradation is caused by interface states near the drain. The states have an energy dependent density peaked strongly at the conduction band edge. (Author abstract) 7 refs.

Asenov, A. (Technische Univ Muenchen, Garching, West Ger); Bollu, M.; Koch, F.; Scholz, J. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 319-324.

**095049 SPIN-DEPENDENT RECOMBINATION AND CONDUCTIVITY AS MEANS OF EXAMINING DISLOCATIONS IN SEMICONDUCTORS.** Dislocations in silicon have been examined by spin-dependent recombination methods for photoexcited electrons and holes together with combined spin resonance for electrons trapped in a one-dimensional band corresponding to one of the types of reconstructed dislocation. (Author abstract) 16 refs.

Kveder, V.V.; Osip'yan, Yu.A. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 1-7.

**095050 PHOTO-ESR STUDIES ON SILICON CONTAINING DISLOCATIONS.** We have applied photo-ESR to define the positions of the energy levels for Si Kl centers. The method has certain advantages: high sensitivity and scope for determining the energy positions of broken bonds. It can assist in identifying the states of defects observed by other methods. Erdmann and Alexander first used this method to determine energy levels related to Si Kl centers. ESR measurements also make it possible to determine the microscopic symmetry of the broken bonds, as well as to identify defects having such bonds. 18 refs.

Suezawa, M.; Sumino, K. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 8-12.

**095051 RECTILINEAR DISLOCATION PHOTO-LUMINESCENCE FOR SILICON.** Two-stage silicon crystal strain produces long rectilinear 60° dislocations and ones of screw orientation. A new photoluminescence spectrum appears. This is transformed on annealing to the familiar spectrum for crystals strained in the usual way. (Author abstract) 8 refs.

Sauer, R.; Kisielowski-Kemmerich, C.; Alexander, H. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 13-17.

**095052 DEEP DISLOCATION AND POINT-DEFECT LEVELS IN PLASTICALLY DEFORMED SILICON.** Nonstationary capacitance spectroscopy has been applied to deep defect levels introduced by plastic strain in n-type and p-type silicon. The observed features of these levels lead to the suggestion that two different types of defects are formed. (Author abstract) 28 refs.

Weber, E.R.; Omling, P.; Kisielowski-Kemmerich, C.;

Alexander, H. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 18-23.

**095053 CALCULATION OF BOUND ELECTRON STATES AT RECONSTRUCTED 90° PARTIAL DISLOCATIONS IN SILICON BY LCAO METHODS IN THE FOUR COORDINATION-SPHERE APPROXIMATION.** A theoretical study is made on bound electron states in dislocations in Si. The bound states are calculated by a recursion form of the strong-coupling method, which also employs the translational symmetry along a dislocation line. (Author abstract) 11 refs.

Teichler, H.; Marheine, C. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 34-38.

**095054 OPTICAL NUCLEAR-MOMENT POLARIZATION IN PLASTICALLY STRAINED SILICON SINGLE CRYSTALS.** In research on broken bonds in semiconductors, the following points must be borne in mind: 1) a broken bond is a complicated electron-vibrational system having several charge states and local multiplet spin correlation, 2) electron-electron correlations in each broken bond are responsible for producing the Mott-Hubbard insulator with narrow bands, and 3) the carrier mobility in the broken-bond system reflects the degree of strain disorder and the polaron effects, and it is dependent on the type of magnetic ordering in the chain on account of the spin correlations. 14 refs.

Bagraev, N.T.; Vlasenko, L.S.; Mashkov, V.A. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 44-50.

**095055 NONSTATIONARY-CAPACITANCE SPECTROSCOPY OF 60° DISLOCATIONS IN SILICON.** Deep-level transient spectroscopy DLTS has been used to examine a group of 60° dislocation in n-type silicon. It is found that this type of dislocation is associated with a level in the middle of the forbidden band. (Author abstract) 8 refs.

Kronewicz, J.; Schroter, W. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 51-55.

**095056 ARE THERE RECONSTRUCTION SOLITONS AT PARTIAL DISLOCATIONS IN SILICON?** Deposits may accumulate at dislocation cores and produce additional acceptor levels. This is possible if an acceptor dopant takes up the positions of atoms having three nearest neighbors rather than four. This may imply that solitons occur in reconstructed dislocations. (Author abstract) 25 refs.

Heggie, M. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 61-65.

**095057 INDUCED-CURRENT STUDY OF DEFECTS IN STRAINED SILICON.** It has been found that the dislocation contrast increases with heat-treatment temperature, whereas the electrical activities determined from the Hall effect, DLTS, and thermally stimulated depolarization fall as the temperature and time of heat treatment increase. To elucidate the reasons for this conflict, we have examined how the EBIC contrast is dependent on defects produced by plastic strain, heat treatment, and impurity composition. The results are compared with those on the electrophysical properties of the same crystals obtained by other methods. 13 refs.

Bondarenko, I.E.; Yakimov, E.B. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 70-74.

**095058 FORMATION KINETICS AND BEHAV-**

**IOR FOR NONLINEAR EXCITATIONS LIMITING DISLOCATION MOBILITY IN SEMICONDUCTOR SINGLE CRYSTALS.** The experiments were performed with n-type silicon specimens cut from dislocation-free crystals grown by crucible-free zone melting and doped during growth with phosphorus to a resistivity of 1.5  $\Omega$ -m. The specimens were rectangular prisms having edge orientation of dimensions 35×4×1.5 mm. Individual dislocations were introduced from a scratch and detected by selective chemical etching. We examined three types of dislocation on the compression side: screw ones and two types of 60° dislocation with opposite sequences for the partial ones. We considered only dislocations not having subsurface kinks. 12 refs.

Nikitenko, V.I.; Farber, B.Ya.; Iunin, Yu.L. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 81-86.

**095059 EFFECTS OF EXCITATIONS ON DISLOCATION MOBILITY IN ELEMENTAL SEMICONDUCTORS.** Measurements have been made on the effects of electron excitation on dislocation mobility in elemental semiconductors; there was no effect for germanium, whereas silicon showed an increase in mobility below 700°C. (Author abstract) 24 refs.

Maeda, K.; Kimura, K.; Takeuchi, S. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 93-98.

**095060 DYNAMIC RECOVERY IN SI AND Ge DUE TO SLIP LEADING TO SCREW-DISLOCATION NETS AND STAGE IV IN WORK HARDENING.** A study is made on the new stage IV of work hardening in Si and Ge at high temperatures on the basis of a dislocation-cell model. The dislocations move within the cell (without transverse slip), and edge dislocations annihilate by climb in the cell walls. (Author abstract) 6 refs.

Haasen, P.; Alborne, C.; Schroter, W. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 111-114.

**095061 HIGH-RESOLUTION ELECTRON MICROSCOPY APPLIED TO PHASE TRANSITIONS CAUSED BY INDENTING SILICON.** Hexagonal silicon has been used having almost ideal c/a ratio, with layers produced on indenting the crystals in the range 450-700°C. High-resolution electron microscopy can be applied to configurations where the habit plane is perpendicular to the surface, which throws some light on the structure of the cubic-hexagonal boundary. Here we describe such measurements. 17 refs.

Pirouz, P.; Chaim, R.; Samuels, J. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 115-122.

**095062 ROOM-TEMPERATURE DISLOCATION MIGRATION IN SILICON SINGLE CRYSTALS.** Here we report some direct observations on dislocation motion in Si crystals at room temperature, where we discuss the thermally activated characteristics of the motion and consider the effects of dislocation mobility on macroscopic features. We used n-type silicon crystals grown along by Czochralski's method or by crucible-free zone melting. The crystals were dislocation-free or contained growth dislocations (up to  $5 \cdot 10^4 \text{ cm}^{-2}$ ) and had resistivities of 30-200  $\Omega$ -cm. 24 refs.

Shepizman, V.V.; Smirnov, V.I.; Sointseva, I.Yu. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 128-132.



**095063 TWIN BOUNDARIES AS BARRIERS TO DISLOCATION GLIDE AND EFFECTS ON THE PROPERTIES OF SOLAR-BATTERY SILICON.** Estimates are made of the energy barriers for reactions of dissociated gliding dislocations with twin boundaries. It is shown that the latter provide considerable obstacles to dislocation glide. (Author abstract) 6 refs.

Gleichmann, R. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 144-149.

**095064 THERMAL STABILITY OF STRAIN-INDUCED DEFECTS IN SILICON.** A study has been made by electron microscopy of the effects of plastic-strain and annealing temperatures on the numbers and distributions of defects introduced into silicon by strain. (Author abstract) 13 refs.

Yonenaga, I.; Sumino, K. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 23-26.

**095065 INTERACTIONS OF DISLOCATIONS AND POTENT DEFECTS IN HYDROGENATED SILICON AND DISLOCATION CORE STUDIES.** A study has been made of the effects on the DLTS spectra from hydrogenation and subsequent annealing for plastically strained silicon, which leads to the suggestion that the various point defects are related to particular dislocation types. (Author abstract) 8 refs.

Pohoryles, B. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 27-30.

**095066 PROBLEMS IN INTERPRETING SILICON EBIC MEASUREMENTS.** Problems are discussed in determining recombination parameters from EBIC diffusion-length and measurements. Results on the electrical parameters of defects are discussed in relation to impurity doping and temperature effects. (Author abstract) 33 refs.

Kittler, M.; Seifert, W.; Richter, H. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 82-88.

**095067 PLASMA EFFECTS ON EBIC SIGNALS FROM SILICON.** The maximal plasma losses and the maximum contrast at dislocations occur at almost the same bias, and they give similar graphs as functions of beam current, so the different parts on the contrast-bias curve are ascribed to differences in recombination at defects: within the depleted layer, under the depleted layer, and within the neutral plasma during drift and diffusion. The lower limit to the bias  $V_1$  is ascribed to the plasma dimensions approaching the Debye length, while the upper limit  $V_h$  agrees qualitatively with predictions from a plasma erosion model, i.e., the value of  $V_h$  is linearly related to the beam current. 7 refs.

Toth, A.L. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 89-92.

**095068 DISLOCATION RECOMBINATION THEORY FOR SILICON AND INTERPRETATION OF EBIC CONTRAST IN TERMS OF FUNDAMENTAL DISLOCATION PARAMETERS.** A new theory is proposed for recombination at charged dislocations in semiconductors. This is applied to EBIC contrast from individual dislocations. (Author abstract) 6 refs.

Wilshaw, P.R.; Booker, G.R. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 109-113.

**095069 ROD DEFECTS IN SILICON: STRUC-**

**TURE AND ANNEALING BEHAVIOR.** The authors describe the formation of rod defects in silicon and their transformation to various elongated defects via well-defined dislocation reactions during thermal annealing. They first discuss only the agglomeration of the interstitial atoms. The geometrical constructions are extended to include the effects of impurities, particularly oxygen, in a forthcoming paper. Boron-implanted silicon was examined in the high-voltage electron microscope after thermal annealing. The specimens were thinned down by the usual chemical polishing method. 22 refs.

Bartsch, H.; Heydenreich, J.; Hoehl, D.; Kastner, G.; Werner, P. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 125-129.

## Deformation

**095070 DISLOCATIONS AT GRAIN BOUNDARIES IN DEFORMED SILICON.** Regions adjacent to  $\Sigma = 9$  and  $\Sigma = 25$  boundaries in silicon bicrystals are found to be in an advanced stage of hardening. Electron microscopy shows multiple slip, cross-slip, network formation and some transmission of slip across the boundary. (Author abstract) 28 refs.

Martinez-Hernandez, M. (Ecole des Mines, Nancy, Fr); Kirchner, H.O.K.; Korner, A.; George, A.; Michel, J.P. *Philos Mag A* v 56 n 5 Nov 1987 p 641-658.

**Degradation** See SEMICONDUCTOR DEVICES, MOS—Electronic Properties.

**Dielectric Properties** See Also LIQUID METALS—Dielectric Properties.

**095071 DETERMINATION OF THE COMPLEX DIELECTRIC FUNCTION OF Si(111) 2 X 1, GaAs(110) AND GaP(110) SURFACES BY POLARIZED SURFACE DIFFERENTIAL REFLECTIVITY.** We present a determination of the complex dielectric function of Si(111) 2X1, GaAs(110) and GaP(110) surfaces by using polarized Surface Differential Reflectivity technique. The effective number of electrons per atom participating in the optical transitions is calculated for energies up to 4.0 eV for each surface. (Author abstract). 15 Refs.

Cricenti, A. (Inst di Struttura della Materia, Italy); Selci, S.; Cicciacci, F.; Felici, A.; Goletti, C.; Yong, Zhu; Chiarotti, G. *Phys Scr* v 38 n 2 Aug 1988 p 199-203.

## Diffusion

**095072 NEW MODEL FOR THE DETERMINATION OF POINT DEFECT EQUILIBRIUM CONCENTRATIONS IN SILICON.** In this paper the boundary conditions for point defect distributions in monocrystalline silicon are investigated. These boundary conditions are established by simple thermodynamic considerations. A circle process is used including vacancy, interstitial and Frenkel pair generation which yields a simple relationship between the vacancy and interstitial equilibrium concentrations at the surface. A new OED model is also presented which explains the  $t^{-1/4}$  behavior for the interstitial supersaturation. This model is used to simulate experiments of Mizuo and Higuchi. In this way values for the equilibrium concentrations and the diffusion coefficients of vacancies and interstitials are obtained. (Author abstract) 9 refs.

Budil, M. (Technical Univ Vienna, Vienna, Austria); Guerrero, E.; Brabec, T.; Selberherr, S.; Poetzel, H. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 1 Mar 1987 p 37-44.

**Doping** See Also INFRARED DETECTORS—Performance; METALS AND ALLOYS—Impurities; OXIDES—Thermal Effects; PARTICLE DETECTORS—Performance; SEMICONDUCTING FILMS—Growth; SEMICONDUCTING GALLIUM—Ion Implantation; SEMICONDUCTOR DEVICES—Materials; SEMICONDUCTOR DIODES, PHOTODIODE—Junctions; SEMICONDUCTOR MATERIALS—Ion Implantation; SOLAR CELLS—Silicon; TRANSISTORS—Thin Films; TRANSISTORS, BIPOLAR—

Transport Properties; WAVEGUIDES, OPTICAL.

**095073 INFLUENCE OF NUCLEATION ON THE KINETICS OF BORON PRECIPITATION IN SILICON.** A study of the precipitation of boron implanted into pre-amorphized silicon has been carried out following several thermal processes in the temperature range between 550 and 900°C. It will be shown that the formation of inactive boron takes place even during a low-temperature solid-phase epitaxy of the regrowing layer, when the starting concentration level exceeds about  $3.5 \times 10^{20}$  atoms/cm<sup>3</sup>. The presence, at the beginning of the annealing process, of inactive atoms in the form of small aggregates which behave as nucleation centers, markedly affects the precipitation kinetics during the thermal treatments. In these conditions the experimental data follow F.S. Ham's theory of precipitation. On the contrary, if all the dopant is incorporated in the lattice side, nucleation is the limiting factor for boron deactivation. (Author abstract) 30 refs.

Landi, E. (CNR, Bologna, Italy); Guimaraes, S.; Solmi, S. *Appl Phys A* v A44 n 2 Oct 1987 p 135-141.

**095074 ODMR STUDIES ON NEW DONORS IN SILICON.** The ODMR (Optically Detected Magnetic Resonance) studies of the characteristic spectral line K (0.902eV) of ND (new donors) in Si show that the corresponding luminescence center is a neutral isoelectronic trap and the luminescence transition is the radiative recombination of bound excitons of the trap. An isotropic  $g_R = 1.997 \pm 0.001$  band is observed, which implies a hole-attractive local potential of the center. The result supports the author's previous suggestion about the luminescent mechanism of line K. (Author abstract) In Chinese. 9 refs.

Ge, Weikun (Acad Sinica, China). *Hongwai Yanjiu A-Ji* v 6 n 5 1987 p 329-333.

**095075 VAPOUR-PHASE DIFFUSION OF ALUMINIUM INTO SILICON.** The purpose of this letter is to report a study of experimental conditions which can affect the aluminium surface concentration in silicon throughout the vapor-phase diffusion cycle. The present investigations were carried out for different experimental conditions under which the aluminium surface concentration remains effective throughout the diffusion cycle. The present results show that the source temperature must be optimized around 1025°C, under a vacuum of  $10^{-6}$  torr. Above 1030°C, the surface concentration begins to decrease as the aluminium source temperature increases. This unexpected observation can be attributed to a decrease of the partial pressure of the aluminium vapor due to the vapor oxidation by the residual water vapor and oxygen in the system. Higher diffusion temperatures (above 1150°C) yield lower surface concentrations which are partly due to the increase of the aluminium vapor oxidation, and moreover, can create a reproducibility problem. 10 refs.

Azimi-Nam, S. (Materials & Energy Research Cent, Tehran, Iran). *J Mater Sci Lett* v 6 n 9 Sep 1987 p 1073-1075.

**095076 VARIATION OF Sb CONCENTRATION IN MELT DURING THE GROWTH OF HEAVILY Sb-DOPED Si SINGLE CRYSTALS.** A mathematical model has been established for characteristics of the variation of Sb concentration in the melt during the growth process of heavily Sb-doped Si single crystals. The calculated curve drawn with the model is in good agreement with the experimental one. As a result of the segregation of the solute during pulling, the concentration of Sb in the melt increases. It is found from the calculated curves that the increase of Sb concentration can be brought under control while the pulling process was carried out under a reduced pressure. Thus, the formation of a cellular interface could be postponed. As the pressure



in a furnace decreases to 2.7 kPa, the Sb concentration will be kept almost unchanged. (Edited author abstract) 8 refs. In Chinese.

She, Siming (Central-South Univ of Technology, Changsha, China); Cheng, Jun. *Chin Shu Hsueh Pao* v 23 n 3 Jun 1987 p A188-A194.

**095077 EFFECT OF BORON AND PHOSPHORUS IMPURITIES ON MICRODEFECT FORMATION DURING HEAT TREATMENT OF SILICON.** A study was made of the effect of doping with boron or phosphorus on microdefect formation during the growth and subsequent heat treatment of silicon crystals. It was found that defect formation during growth and heat treatment of the crystals are influenced by a combination of parameters, such as the oxygen content in the crystal, the crystal growth rate, and the concentration and type of doping impurity. 3 refs. In Russian.

Gulyaeva, A.S.; Lainer, L.V.; Slobodova, S.V.; Shusheblina, N.Ya. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 880-882.

**095078 LOCAL BORON DOPING OF SILICON UNDER THE EFFECT OF SCANNING RADIATION FROM A CO<sub>2</sub> LASER.** Laser doping of silicon by boron is performed with irradiation by continuous-wave scanning radiation by a CO<sub>2</sub> laser of a thin boron film (approximately 100 Å) applied to the surface of a silicon plate. The profiles of distribution of the B admixture in the Si are studied using mass-spectroscopy of secondary ions. (Author abstract) 4 refs.

Kiyak, S.G.; Krechun, V.; Manenkov, A.A.; Mikhailescu, I.; Mikhailova, G.N.; Prokhorov, A.M.; Ursu, I. *Sov Phys Lebedev Inst Rep* n 3 1987 p 11-14.

**095079 FABRICATION OF HEAVILY-DOPED POLYCRYSTALLINE SILICON FILM USING A LASER-DOPING TECHNIQUE.** A structure composed of alternating layers of hydrogenated amorphous silicon (a-Si:H) film and either phosphorus or boron film was used to fabricate low-resistivity polycrystalline silicon (poly-Si) film at low temperature. This structure was formed by a radio-frequency glow discharge process at 230°C and then irradiated by a pulsed XeCl excimer laser at room temperature. Simultaneous crystallization and uniform diffusion of the dopant atoms was achieved. The 240 nm-thick boron-doped poly-Si film had a sheet resistivity of 23 Ω/unit area ( $p=5.5 \times 10^{-4}$  Ωcm). (Author abstract) 9 refs.

Sameshima, Toshiyuki (Sony Corp Research Cent, Yokohama, Jpn); Usui, Setsuo; Tomita, Hisashi. *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1678-1680.

**095080 BIAS EFFECTS ON PREPARATION OF DOPED AMORPHOUS SILICON IN A TRIODE GLOW DISCHARGE.** Bias effects on the preparation of doped amorphous silicon are investigated using a triode glow discharge. The negative bias improves the quality of the phosphorus-doped amorphous silicon films, while it does not improve the quality of boron-doped films. (Author abstract) 18 refs.

Aozasa, Masao (Osaka City Univ, Jpn); Pyon, Ryun Gill; Ando, Keichi. *Mem Fac Eng Osaka City Univ* v 27 Dec 1986 p 53-65.

**095081 ELECTRIC RESISTIVITY DISTRIBUTION IN SILICON SINGLE CRYSTALS.** A study was made of the effect of the degree of compensation on the microinhomogeneity of the radial distribution of the electric resistivity in n-type silicon single crystals grown by the floating zone melting method along the [111] and [100] directions. It was established that the microinhomogeneity of the electric resistivity increases with an increase in the degree of compensation, and for given growth conditions is higher in single crystals grown along the [111] direction. (Translated author abstract) In Russian. 5 refs.

Kravitsov, A.A.; Chervonyi, I.F.; Shklyar, B.L. *Tsvet Met* n 7 Jul 1987 p 76-77.

**095082 INVESTIGATION OF THE MAJORITY CARRIERS DIFFUSION COEFFICIENTS BEHAVIORAL PATTERN IN DEGENERATELY-DOPED SILICON.** For electron and hole concentrations equal to or larger than the corresponding density of states in the conduction and valence bands, the ratio of the majority carriers diffusion coefficient-to-drift mobility increases with the power of (2/3) of the corresponding majority carriers concentration. It is shown that the majority carriers diffusion coefficient in degenerately-doped silicon increases sharply with the dopant level in the  $10^{19}$  to  $5 \times 10^{21}$  cm<sup>-3</sup> range of the latter, regardless of the ambient temperature. Exact values of diffusion coefficients in phosphorus-, arsenic- and boron-doped silicon are presented up to carrier densities one order of magnitude higher than the solid solubility. Implications of the presented results for the physics of silicon-based electron devices are also outlined. (Edited author abstract) 16 refs.

Silard, Andrei P. (Polytechnic Inst, Bucharest, Rom); Duta, Miron J. *Int J Electron* v 63 n 5 Nov 1987 p 723-731.

**095083 DEPTH DISTRIBUTIONS OF Au RECOIL ATOMS IN SILICON.** The depth distributions of Au recoil atoms in Si have been investigated for Ar, Kr, and Xe ions implantation in 25-30 nm of an Au-Si system. The profiles were measured by means of RBS and radioactive techniques. The experimental results were compared with theoretical Gras-Marti analytical expressions and Monte-Carlo simulated depth distributions. (Author abstract) 14 refs.

Paprocki, K. (UMCS, Lublin, Pol); Brylowska, I.; Syszko, W. *Appl Phys A* v A45 n 2 Feb 1988 p 109-112.

**095084 ON THE Sb REDISTRIBUTION IN Si DURING POST-IMPLANTATION ANNEALING.** Some useful data concerning the impurity redistribution after implantation in semiconductors may be obtained by an appropriate comparison between accurate experimental data and some proper theoretical results describing both the implantation process and the following diffusion phenomena during the redistribution step. In this paper an analytic expression giving the redistribution of the dopant concentration after the implantation processes is presented as a useful means of discussing the impurity redistributed profile, particularly that of the antimony during post-implantation annealing. 6 refs.

Gaiseanu, F. (CCSIT, Bucharest, Rom); Badila, M.; Postolache, C.; Dima, I. *Rev Roum Phys* v 32 n 4 1987 p 429-433.

**095085 LOWER LIMIT OF DETECTABILITY AT HIGH SPATIAL RESOLUTION OF As IMPLANTED INTO Si USING THE JEOL 200CX IN THE STEM-EDX MODE.** The objective of this study is to determine the accuracy and detectability of STEM X-ray dopant profiling using a conventional W-filament-equipped, general-user instrument by direct comparison of the STEM profile with that determined by both Rutherford backscattering (RBS) and secondary ion mass spectroscopy (SIMS). To this end, therefore, a Si wafer was implanted at 100 keV,  $5 \times 10^{15}$  cm<sup>-2</sup> with As and was made into both a cross-sectional TEM specimen and planar, approximately 1 cm<sup>2</sup> RBS and SIMS specimens. Difficulties of STEM-EDX dopant profiling arise from drift, contamination, beam size, beam spreading within the sample, specimen damage, and diffraction effects. For each factor we have described a method of compensation in the JEOL 200CX case. 30 refs.

Renteln, P. (Cornell Univ, Ithaca, NY, USA); Ast, D.G. *Ultramicroscopy* v 24 n 1 1988 p 37-44.

**095086 CONTROLLED ATOMIC LAYER DOPING AND ALD MOSFET FABRICATION IN Si.** Controlled atomic layer doping (ALD) is obtained, combining the adsorption and desorption behaviors of Sb in Si molecular beam epitaxy and solid phase epitaxy. SIMS and C-V measurements confirm the sharp doping profile. It is shown by Hall measurements that the carrier concentration varies from  $9 \times 10^{11}$  to  $8 \times 10^{13}$  cm<sup>-2</sup> and

the mobility from 250 to 60 cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup> when the Sb concentration is changed from 0.0015 to 1 monolayer. The first ALD-MOSFET, with a gate length of 8 μm and a gate oxide thickness of 100 nm, is made using the ALD layer as the conducting channel, and has a transconductance of 7 mS/mm. (Author abstract) 14 refs.

van Gorkum, Aart A. (Hitachi Ltd, Kokubunji, Jpn); Nakagawa, Kiyokazu; Shiraki, Yasuhiro. *Jpn J Appl Phys Part 2* v 26 n 12 Dec 1987 p 1933-1936.

**095087 OXYGEN-DOPED Si EPITAXIAL FILM (OXSEF).** We propose a new wide-gap material, an oxygen-doped Si epitaxial film (OXSEF), for applications to Si heterobipolar transistors (HBTs). OXSEF containing several tens of at.% of oxygen can be grown on a Si substrate by depositing Si in about  $10^{-6}$  Torr O<sub>2</sub>. OXSEF is literally almost a single crystal with an identical crystalline structure to Si, although it includes {111} twins as defects caused by oxygen. Temperature and O<sub>2</sub> pressure dependences of oxygen concentration in OXSEF are dominated by oxygen adsorption on the Si surface. Oxygen atoms in OXSEF segregate to some extent to form incomplete oxides like SiO<sub>1.5</sub>, but complete phase separation as a mixture of Si and SiO<sub>2</sub> regions does not occur, probably because of non-equilibrium conditions in MBE growth. Valence band discontinuity at the Si/OXSEF interface is deduced to be 0.26 eV based on photoelectrical measurements. (Author abstract) 23 refs.

Tabbe, Michiharu (NTT Electrical Communication Lab, Atsugi, Jpn); Takahashi, Mitsutoshi; Sakakibara, Yutaka. *Jpn J Appl Phys Part 1* v 26 n 11 Nov 1987 p 1830-1837.

**095088 DOPING OF POLYSILANE ALLOYS.** In order to control the conductivity of plasma-prepared wide-optical-gap binary Si:H alloys containing a number of (SiH<sub>2</sub>)<sub>n</sub> groups (polysilane alloys), boron and phosphorus doping are performed using pre-mixed Si<sub>2</sub>H<sub>6</sub>+B<sub>2</sub>H<sub>6</sub> and Si<sub>2</sub>H<sub>6</sub>+PH<sub>3</sub> gases. The conductivity can be controlled by about nine and six orders of magnitude for p and n type alloys, respectively, even when prepared at 300 K. The low substrate temperature of 300 K provides the condition suitable for forming linear-chained (SiH<sub>2</sub>)<sub>n</sub> groups, and all the doped alloys have wide optical gaps of greater than 2.0 eV due to the incorporation of (SiH<sub>2</sub>)<sub>n</sub>. The doping mechanism of the polysilane alloys is also discussed, and is compared with that of conventional hydrogenated amorphous silicon. (Author abstract) 7 refs.

Furukawa, Shoji (NTT, Musashino, Jpn). *Solid State Commun* v 62 n 8 May 1987 p 539-541.

**095089 ANALYSIS OF POLYSILICON DIFFUSION SOURCES.** Diffusion of boron and arsenic from implantation doped polycrystalline silicon films into single-crystal silicon was investigated as a function of various process parameters. The effects of interface treatment prior to poly-Si deposition and of the poly-Si grain size are analyzed. New data on dopant segregation are presented. Limitations of present process modeling tools are discussed and improved values for several input parameters are proposed. (Author abstract) 20 refs.

Probst, V. (Siemens AG, Munich, West Ger); Boehm, H.J.; Schaber, H.; Oppolzer, H.; Weitzel, I. *J Electrochem Soc* v 135 n 3 Mar 1988 p 671-676.

**095090 PRESSURE DEPENDENCE OF THE DIAMAGNETIC SUSCEPTIBILITY OF SHALLOW DONORS IN SILICON.** A theory of the diamagnetic susceptibility ( $\chi_{dia}$ ) of a shallow donor in Si is given incorporating the many valley structure of the conduction band minimum. This theory is used for the computation of  $\chi_{dia}$  for various uniaxial stresses applied along [100], [110] and [111] directions. The effect of the uniaxial stress on the donor states is considered by following the valley repopulation model of Wilson and Feher. It is found that



the directional dependence is negligible and diamagnetism increases with the value of pressure. (Edited author abstract) 22 refs.

Devaraj, T. Vincent (Madurai Kamaraj Univ, Madurai, India); Sukumar, B.; Navaneethakrishnan, K. *Solid State Commun* v 61 n 11 Mar 1987 p 727-730.

**095091 IMPURITY INDUCED VIBRATIONS IN LIGHT DOPED SILICON.** The local densities of states (LDOSs) are calculated by use of the recursion method for the lithium or phosphorous-compensated boron-doped crystalline silicon. The impurity induced local and quasi-local vibrational modes are studied. Agreement between experiments and calculation is achieved. (Edited author abstract) 7 refs.

Fu Ying (Acad Sinica, Shanghai, China); Xu Wenlan; Zheng Zhaobo. *Solid State Commun* v 62 n 3 Apr 1987 p 163-167.

**095092 DSC STUDIES OF GLASSY BEHAVIOR IN P-DOPED a-Si:H.** Differential scanning calorimetry (DSC) studies of P-doped hydrogenated amorphous silicon (a-Si:H) show characteristic behaviors of glass transition phenomena as frequently found in conventional melt-quenched glasses. The glass transition temperature ( $T_g$ ) detected by DSC agrees well with the equilibration temperature ( $T_E$ ) determined by the temperature dependence of dc conductivity. Regarding the influence of hydrogen content,  $T_g$  decreases as hydrogen content increases. (Author abstract) 6 refs.

Matsuo, Shinji (Hiroshima Univ, Higashi-Hiroshima, Jpn); Nasu, Hiroyuki; Akamatsu, Chikashi; Hayashi, Ryo; Imura, Takeshi; Osaka, Yukio. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 132-133.

**095093 PHOSPHORUS DOPING INTO SILICON USING ArF EXCIMER LASER.** In this work we perform impurity doping using ArF excimer laser with a doping gas that is absorbed at 193 nm, and investigate the influence of photochemical decomposition on doping characteristics. Since we compare doping in gas ambients with that using only the adsorbed layers at the same laser wavelength, we are able to separate the effect that photochemical decomposition of a doping gas has on dopant incorporation. From the experiments of doping in  $\text{POCl}_3$  ambients and that using the adsorbed layers formed on the silicon surface, it is shown that dopant atoms produced by photochemical decomposition of  $\text{POCl}_3$  influence the doping characteristics. The surface concentration of carrier concentration profiles in doping using  $\text{POCl}_3$  adsorbed layers increases with the number of pulses, indicating that the supply of dopant atoms from the adsorbed layers to the silicon surface is rate limiting. 15 refs.

Kato, Shin-ichi (Keio Univ, Hiyoshi, Jpn); Saeki, Hideo; Wada, Jun-ichi; Matsumoto, Satoru. *J Electrochem Soc* v 135 n 4 Apr 1988 p 1030-1032.

**095094 DETERMINATION OF Pt-GROUP METAL DOPANTS IN SILICON BY GRAPHITE FURNACE ATOMIC ABSORPTION SPECTROMETRY.** Pt-group metal determinations were investigated. The sensitivities (1% absorption) were  $5.8 \times 10^{-11}$ ,  $2.8 \times 10^{-11}$ ,  $2.6 \times 10^{-11}$ ,  $2.8 \times 10^{-10}$  and  $1.8 \times 10^{-10}$  g for Ru, Rh, Pd, Ir, and Pt, respectively. Around these sensitivities, the relative standard deviation for each element were not more than 9%. The method developed is sensitive and accurate, so it is suitable for the analysis of traces of Pt-group metal dopants in microsamples of Si. (Author abstract) 7 refs. In Chinese.

Cui, Xianhang (Acad Sinica, Beijing, China); Ma, Hui-min. *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 129-134.

**095095 SURFACE DOPING OF SEMICONDUCTORS BY PULSED-LASER IRRADIATION IN REACTIVE ATMOSPHERE.** Intense pulsed-laser irradiation in a suitable chemical atmosphere can produce a significant incorporation of chemical species from the environment to the surface molten layer. This process has been used to produce p-n junctions in silicon and GaAs

irradiated, respectively, in  $\text{PCl}_3$  and  $\text{SiH}_4$  atmospheres. A modeling of the incorporation process, taking into account the solid-liquid-solid transition of the surface layer, has been developed following both a numerical and a semi-analytical approach. The modeling of the doping process gives results in a reasonably good agreement with the experimental doping profiles, obtained by irradiating Si samples in  $\text{PCl}_3$  atmosphere. (Author abstract) 22 refs.

Bentini, G.G. (CNR, Bologna, Italy); Bianconi, M.; Summonte, C. *Appl Phys A* v A45 n 4 Apr 1988 p 317-324.

**095096 EFFECT OF DOPING ON THE BEHAVIOR OF MICRODEFECTS IN DISLOCATION-FREE SILICON.** The concentration of metallographically revealed microdefects in highly doped samples in the initial state is, on the average, an order of magnitude less than in weakly doped samples. Regardless of the type and concentration of doping element, after heat treatment the microdefects create displacement fields corresponding to defects with a specific atomic volume greater than that of the matrix. The doping of silicon with various impurities (B, As, Sb, Ge) causes the process of microdefect development to be slowed down. The size of microdefects in highly doped samples, all other conditions being equal, in 2 to 3 times less than in weakly doped samples. The introduction of a doping impurity in amounts no less than  $5 \cdot 10^{18} \text{ cm}^{-3}$  leads to a slowing down of the development of growth-type microdefects. 9 refs. In Russian.

Postolov, V.G.; Bublik, V.T.; Kov'ev, E.K.; Litvinov, Yu.M. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 11 Nov 1987 p 1765-1768.

**095097 NITROGEN DOPING IN HYDROGENATED AMORPHOUS SILICON.** A direct evidence of substitutional doping in ion beam deposited amorphous hydrogenated silicon by nitrogen is presented. From the analysis of infrared (IR) absorption spectra and Si-2p core level shape, measured with X-ray photoelectron spectroscopy (XPS), the preferential tendency of nitrogen to go in for three-fold coordination at higher concentration and tetrahedral bonding at lower concentration ( $\leq 4 \text{ at}\%$ ) is established. XPS technique has been used for the first time to deduce the upper limit for substitutional solid solubility of the impurity. (Author abstract) 18 refs.

Singh, Jagriti (Indian Inst of Technology, New Delhi, India); Budhani, R.C. *Solid State Commun* v 64 n 3 Oct 1987 p 349-352.

**095098 ROLE OF HYDROGEN IN DOPING MECHANISM FOR a-Si:H ALLOYS.** Calculations of electronic energies for structural clusters simulating phosphorus and boron substitutional doped and undoped pure and hydrogenated silicon have been performed using CNDO/2 quantum chemical molecular orbital method. The results show that more energy for implanting impurities is required in hydrogenated Si cluster than that in pure Si cluster, and a band of shallow gap states is induced by the substitutional doping in the hydrogenated system. From the results, it is concluded that the hydrogenation is a key factor of efficient substitutional doping in the a-Si:H alloys. (Edited author abstract) 9 refs.

Zhang, Rui-qin (Shandong Univ, Jinan, China); Dai, Guo-cai; Cai, Zheng-ting; Guan, Da-ren. *Solid State Commun* v 65 n 12 Mar 1988 p 1625-1627.

**095099 CHEMICALLY INDUCED GRAIN BOUNDARY MIGRATION IN DOPED POLYCRYSTALLINE SILICON FILMS.** Chemically induced grain-boundary migration is demonstrated in polycrystalline silicon films. Growth of anomalously large grains, along with dopant depletion, is observed in P-doped polycrystalline Si films annealed at  $700^\circ\text{C}$  in the presence of a neighboring  $\text{TiSi}_2$  film. We propose a novel driving mechanism for migration, an electrostatic force on the interface due to inhomogeneous dopant depletion. (Edited author abstract) 17 refs.

Tu, K.N. (IBM T.J. Watson Research Cent, Yorktown Heights, NY, USA); Tersoff, J.; Chou, T.C.; Wong, C.Y. *Solid State Commun* v 66 n 1 Apr 1988 p 93-97.

**095100 CURRENT UNDERSTANDING OF EPITAXIAL CVD SILICON LAYER DOPING IN THE LIGHT OF MODELLING AND THEORY DEVELOPMENT (V).** In the  $\text{SiH}_4\text{-HCl-AsH}_3\text{-H}_2$  system of depositing epitaxial silicon doped with arsenic an equilibrium-like doping process has been obtained by way of experiments not only as a limiting case at high deposition temperatures, as had been shown formerly, but also in the range of lower temperatures when the layer growth rate falls below a critical value. By means of introducing the term of a critical rate the theory of dopant incorporation, published in the Parts I-IV of the present report, has been extended to full completeness. (Author abstract) 13 refs.

Kuehne, H. (Akad der Wissenschaften der DDR, Frankfurt, East Ger); Morgenstern, Th. *Cryst Res Technol* v 22 n 8 Aug 1987 p 989-997.

**095101 EFFECT OF INHOMOGENEOUS DOPANT PROFILES ON THE ELECTRON ENERGY LOSS SPECTRA OF Si(100).** Surface plasmon excitations are measured by high resolution electron energy loss spectroscopy (HREELS) on highly n-doped, clean Si(100) wafers. After different annealing cycles at  $900^\circ\text{C}$  the plasmon loss shifts to lower loss energy. This effect can be quantitatively described by out-diffusion of the phosphorus dopant. The assumption of diffusion profiles and fits of calculated loss spectra to the experimental data allow a determination of the diffusion constant of phosphorus in silicon. (Author abstract). 9 Refs.

Foerster, A. (RWTH, Aachen, West Ger); Layet, J.M.; Lueht, H. *Appl Phys A* v 47 n 1 Sep 1988 p 95-97.

**095102 EXPERIMENTAL EVIDENCE FOR BORON-HYDROGEN INTERACTION IN BORON-DOPED SILICON PASSIVATED WITH HYDROGEN.** The infrared absorption of silicon implanted with  $^{10}\text{B}$  and  $^{11}\text{B}$  isotopes passivated with  $^1\text{H}$  or  $^2\text{H}$  reveals a boron-related shift of the H vibrational line associated with the passivating complex. The small shift observed for  $^1\text{H}$  is expected from a model of bond-centered hydrogen interacting weakly with boron. The boron shift for  $^2\text{H}$  is 4 times larger. This can be explained qualitatively by assuming that there are two equilibrium positions for hydrogen in the hydrogen bond between Si and B and that the relative energy minima are not the same for  $^1\text{H}$  and  $^2\text{H}$ . (Author abstract). 20 Refs.

Pajot, B. (Groupe de Physique des Solides de l'ENS, Paris, Fr); Chari, A.; Aucouturier, M.; Astier, M.; Chantre, A. *Solid State Commun* v 67 n 9 Sep 1988 p 855-858.

**095103 EFFECT OF DOPING DENSITY AND INJECTION LEVEL ON MINORITY-CARRIER LIFETIME AS APPLIED TO BIFACIAL DENDRITIC WEB SILICON SOLAR CELLS.** The measured short-circuit current density in bifacial dendritic web silicon solar cells has been found to decrease with decreasing base resistivity, particularly under back illumination. In addition, the ratio of short-circuit current under back illumination to short-circuit current under front illumination was observed to vary with light intensity. These observations reflect the fact that the minority-carrier lifetime in the base of these cells is a function of the base resistivity and the illumination level. The dopant was assumed to play only an indirect role in determining lifetime. This decrease in lifetime is shown to follow from a distribution of defect levels in the bandgap. These levels are a consequence of extended defects that have been observed in the web material. The dopant, acts only in the indirect role of moving the Fermi level over an existing background distribution of defect levels that arise from the extended defects. Assuming a parabolic distribution of defect levels in the bandgap, the minority-carrier lifetime was calculated as a function of doping density and excess carrier concentration (illumination level) using the Shockley-Read-Hall theory. The short-circuit current densities



that were calculated using these lifetimes agreed reasonably well with measured values for bifacial dendritic web silicon solar cells 26 refs.

Meier, Daniel L. (Westinghouse Corp, Pittsburgh, PA, USA); Hwang, Jeong-Mo; Campbell, Robert B. *IEEE Trans Electron Devices* v 35 n 1 Jan 1988 p 70-79.

**095104 IMPROVED MEASUREMENTS OF DOPING PROFILES IN SILICON USING CV TECHNIQUES.** One of the problems of doping profile measurements using CV techniques is that numerical differentiation is required. This can, under certain circumstances, result in very noisy profiles. A method is presented for obtaining noise-free profiles by choosing a step size that takes account of the resolution of the capacitance meter to ensure that the maximum profile detail is retained. A range of other factors that can affect profiling accuracy are also reviewed. 19 refs.

McGillivray, Ian G. (Univ of Edinburgh, Scotl); Robertson, John M.; Walton, Anthony J. *IEEE Trans Electron Devices* v 35 n 2 Feb 1988 p 174-179.

**095105 NUMERICAL SIMULATION OF THE GAS IMMERSION LASER DOPING (GILD) PROCESS IN SILICON.** A simulation program that models the gas immersion laser doping (GILD) process is described. This program, which is called LASERMELT, first solves for the silicon melt depth and melt time versus laser energy fluence, and then the impurity dopant profiles using a dopant incorporation and impurity diffusion model. Experimental and simulated dopant profiles and sheet resistance values are given as functions of the laser energy fluence and number of pulses. The determination of liquid phase impurity diffusion coefficients in molten silicon is also described. 39 refs.

Landi, Ettore (Stanford Univ, CA, USA); Carey, Paul G.; Sigmon, Thomas W. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 2 Feb 1988 p 205-214.

**095106 DOPING OF AMORPHOUS SEMICONDUCTORS.** The purpose of this talk is to review our present understanding of the doping process in a-Si:H and a-Ge:H, based on recent investigations of the chemical composition and the electronic properties of these materials. Using electron spin resonance, it has been possible to directly observe phosphorus and arsenic donor states and to deduce a fairly detailed model for the electronic density of states near the conduction band mobility edge in n-type samples. The common experimental features observed in the various dopant-host pairs are used to discuss possible microscopic mechanisms for the doping process. (Edited author abstract)

Stutzmann, Martin (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger). *Key Eng Mater* v 13 pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 894.

**095107 PLASMA EDGE IN AMORPHOUS SILICON FILMS DOPED BY METAL ATOMS.** Valence electron collective excitations show themselves in the reflectance spectra of amorphous silicon films in the vacuum ultraviolet region. It is found, that the plasma resonance frequency of valence electrons decreases and the resonance width increases under amorphous silicon doping by metal atoms. (Author abstract) 4 refs.

Bizyaev, S.L. (Acad of Sciences of the USSR, Novosibirsk, USSR); Makarov, O.A.; Sinyukov, M.P. *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 126-127.

**095108 HEAVY DOPING EFFECTS IN SILICON.** Different mechanisms causing bandgap narrowing in heavily doped silicon are reviewed. A distinction is made between many-body effects and the effects due to random impurity distribution. The values of bandgap narrowing, calculated using a theoretical model, are compared with the experimental results. Recombination in heavily-doped silicon is discussed and the different recombination mechanisms, present at high doping levels, are explained.

Experimental values for the minority-carrier lifetime as a function of the doping level are given. Surface recombination at the heavily doped Si/SiO<sub>2</sub> interface is discussed, the transport equations in the case of a position dependent bandgap are derived, and the influence of heavy-doping effects on the performance of several devices is discussed. (Edited author abstract) 39 refs.

Van Overstraeten, Roger J. (IMEC vzw, Louvain, Belg); Mertens, Robert P. *Solid State Electron* v 30 n 11 Nov 1987, New Dev in the Phys of Homo- and Heterojunctions, US-Belg Jt Semin, Louvain, Belg, May 28-30 1986 p 1077-1087.

**095109 OPTICAL CHARACTERIZATION OF HEAVILY DOPED SILICON.** Out of a variety of optical techniques used to characterize heavily doped semiconductors photoluminescence and Raman spectroscopy are discussed as tools to study heavy doping effects. Photoluminescence spectroscopy is sensitive to electronic transitions between the conduction and valence band whereas electronic Raman scattering probes transitions within either band. Parameters relevant to device physics such as the band gap shrinkage due to heavy doping are extracted from these measurements. It is shown that both techniques are applicable to the characterization of thin heavily doped implanted or epitaxial layers. (Edited author abstract) 28 refs.

Wagner, Joachim (Fraunhofer Inst fuer Angewandte Festkoerperphysik, Freiburg, West Ger). *Solid State Electron* v 30 n 11 Nov 1987, New Dev in the Phys of Homo- and Heterojunctions, US-Belg Jt Semin, Louvain, Belg, May 28-30 1986 p 1117-1120.

**095110 POSSIBILITY OF TRANSMUTATION DOPING OF SILICON BY MEANS OF PROTON IRRADIATION.** The possibility of the transmutation doping of silicon with aluminum using the nuclear reaction induced accelerated protons was studied. 15-30 MeV protons were used for Al-acceptor doping of silicon. Irradiation of silicon with 20-25 Mev energy protons enabled its doping with Al atoms. The rate of Al atoms implantation, with the proton energy range of 20-25 Mev, constituted more than  $2 \cdot 10^{-2}$  per one incident proton. Mg doping compensation degree  $k=0.4$ . The acceptor level corresponding to Al was  $E_v + 0.069 \pm 0.001$  ev. 7 refs.

Pavlenko, A. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Tokarevsky, V.; Struk, Yu.; Kurilo, P.; Baransky, P.; Gaydar, G. *Radiat Phys Chem* v 31 n 1-3, Progr in Radiat Process, Proc of the 6th Int Meet, Ottawa, Ont, Can, May 31-Jun 5 1987 p 333-335.

**095111 ELECTRICAL DOPING PROFILES ON TEXTURIZED SURFACES.** The texture etching on (100) Si surfaces produces an array of pyramids of 1-10  $\mu$ m base dimension. Texturized surfaces are used as wideband anti-reflection structures in Si solar cell technology. Doping techniques are then performed on the so obtained non-planar surfaces. For a complete characterization of solar cells it is important to measure the electrically active dopant concentration vs depth. To determine this profile, the authors used an automatic apparatus that combines differential Hall effect and resistivity measurement with anodic stripping of successive layers. This technique implies the knowledge of the angle between the vectors of carrier drift velocities and magnetic field in which the sample is placed. In texturized samples this angle is not constant. The aim of the work is to show the applicability of the technique on these kinds of samples. 2 refs.

Pozzato, G. (CNR, Bologna, Italy); Rizzoli, R.; Summonte, C. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, Zemes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 291-292.

**095112 INFRARED MEASUREMENTS OF INTERSTITIAL OXYGEN IN HEAVILY DOPED SILICON.** A technique, based on the original approach of Series and Griffiths, has been developed for infrared (IR) measurements of interstitial oxygen concentrations in

heavily doped silicon. The new procedure uses a short baseline and thin wafer samples. Our results show that this method can be used at resistivities down to 0.015  $\Omega$  cm for n-type silicon and near to 0.05  $\Omega$  cm for p-type. Measurements of the oxygen content of the same samples by secondary ion mass spectroscopy are in good agreement with the IR data. (Author abstract) 11 refs.

Oates, A.S. (AT&T Bell Lab, Allentown, PA, USA); Lin, W. *J Cryst Growth* v 89 n 1 Jun 1988, Purif of Mater for Cryst Growth and Glass Process - Proc of the Second Workshop, Champion, PA, USA, Sept 28-Oct 1 1987 p 117-123.

**Electric Conductivity** See Also ELECTRIC CONTACTS, OHMIC—Low Temperature Effects; ELECTRIC MEASUREMENTS—Resistance.

**095113 MOBILITY EDGE IN SiP.** By assuming that the conduction band in SiP contains a mobility edge, we are able to account in detail for the temperature and stress dependences of the electrical conductivity in the vicinity of the metal-insulator transition. Most of the temperature dependence is found to result directly from the thermal redistribution of electrons among states with a strongly energy-dependent relaxation time. The model reproduces the previously unexplained T<sup>2</sup> slope, which has been observed experimentally at stresses just below the critical value. (Author abstract) 19 refs.

Meyer, J.R. (US Naval Research Lab, Washington, DC, USA); Bartoli, F.J. *Phil Mag Lett* v 56 n 2 Aug 1987 p 69-77.

**095114 MEYER-NELDEL RULE IN FIELD-EFFECT MEASUREMENTS AND THE MICROSCOPIC PREFACTOR OF THE CONDUCTIVITY IN a-Si:H.** The temperature dependence of the field-effect characteristic is studied. The data are analyzed on the basis of the effective density of states function obtained from the data at a single temperature. It is shown that there are four reasons for the Meyer-Neldel-like behavior: the statistical shift of the bulk Fermi-level, the temperature shift of the conduction band, the breakdown of the interface approximation, and as the most important effect the explicit temperature dependence of the Fermi distribution. The energetic position of the dominant transport path, the temperature coefficients of the Fermi level and of the conduction band energies are obtained by fitting the entire set of measurements. An analysis allows the determination of the microscopic prefactor of the flat-band conductivity. (Edited author abstract) 14 refs.

Schumacher, R. (Philipps-Univ Marburg, Marburg, West Ger); Thomas, P.; Weber, K.; Fuhs, W. *Solid State Commun* v 62 n 1 Apr 1987 p 15-17.

**095115 FIELD-EFFECT ANALYSIS FOR THE DETERMINATION OF GAP-STATE DENSITY AND FERMIL-LEVEL TEMPERATURE DEPENDENCE IN POLYCRYSTALLINE SILICON.** The field-effect conductance has been used in two distinct ways to determine the gap-state density in polycrystalline silicon. The relationship between the surface potential and the gate voltage, which determines the gap-state density, has been deduced according to the incremental method, already proposed by T. Suzuki et al., and a new method. The new method is based on the temperature dependence of the derivative of the field-effect conductance with respect to the gate voltage. The results from the two methods are in good agreement and show a rapidly increasing gap-state density in the upper half of the gap. The temperature analysis of the field-effect conductance indicates that the position of the Fermi level is temperature dependent. (Edited author abstract) 19 refs.

Fortunato, G. (GEC, Wembley, Engl); Meakin, D.B.; Migliorato, P.; Le Comber, P.G. *Philos Mag B* v 57 n 5 May 1988 p 573-586.

**095116 AC CONDUCTIVITY IN n-TYPE SILICON BELOW THE METAL-INSULATOR TRANSITION.** The purpose of this paper is to compare the experimental



studies of  $\sigma(N, \omega, T)$  for  $0.3N_c < N < N_c$  with the various theoretical predictions for  $\sigma(N, \omega, T)$ . We limit our discussion to doped n-type crystalline semiconductors although many significant studies of amorphous semiconductors, superionic conductors, and 1d-organic conductors have also been made. The data presented are for Si:P and Si:As. 43 refs.

Castner, T.G. (Univ of Rochester, Rochester, NY, USA); Deri, R.J. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 73-82.

**095117 CHAOTIC CONDUCTIVITY OSCILLATION IN N-TYPE SI BY IMPACT-IONIZATION IN FREEZEOUT TEMPERATURE RANGE.** Chaotic conductivity oscillation induced by hot electron impact-ionizations from donor levels was observed in a narrow temperature range between 22 K and 26 K and in an electric field range between 130 V/cm and 180 V/cm in n-Si. (Author abstract) 10 refs.

Yamada, K. (Saitama Univ, Urawa, Jpn); Takara, N.; Imada, H.; Miura, N.; Hamaguchi, C. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 809-812.

## Electric Field Effects

**095118 X-RAY INTERFEROMETRIC INVESTIGATIONS OF STRUCTURAL DISTORTIONS IN SEMICONDUCTOR CRYSTALS CAUSED BY CONSTANT ELECTRIC AND MAGNETIC FIELDS.** The effect of constant electric and magnetic fields on silicon semiconductor crystals was investigated experimentally. Electric and magnetic fields create structural distortions leading to changes in X-ray interferometric pictures which depend on the magnitude of the applied field. At certain values of the intensity of the electric field and induction of the magnetic field, the moire pictures disappear. (Author abstract) 12 refs.

Arshakyan, E.Z. (Erevan Polytechnic Inst, Erevan, USSR); Aboyan, A.O.; Bezirganyan, P.A. *Phys Status Solidi A* v 106 n 1 Mar 1988 p 41-47.

**095119 IMPACT IONIZATION AND ELECTRIC FIELD QUENCHING OF PHOTOLUMINESCENCE IN SILICON.** The photoluminescence intensity at 1.8 K of deep and shallow bound excitons, free excitons and electron-hole droplets in silicon is investigated in a weak electric field. The photoluminescence as well as the photocurrent was detected with simultaneous pulsed excitation of both laser light and electric field. The luminescence is quenched due to impact ionization by field accelerated hot electrons and holes starting around 50-100 V/cm for the shallow bound excitons, depending on sample purity and excitation intensity. The deeply bound excitons increase in intensity with applied field and are difficult to completely quench before the electrical breakdown of the sample. The impact ionization of the free excitons is sensitive to the presence of the electron-hole droplet phase. No significant difference between n- and p-type samples was observed. (Edited author abstract)

Weman, H. (Linköping Univ, Linköping, Swed); Zhao, Q.X.; Monemar, B. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 791-794.

**Electric Properties** See Also SEMICONDUCTOR DEVICES; MIS—Tunneling; SEMICONDUCTOR DEVICES; MOS—Semiconductor Insulator Boundaries; SOLAR CELLS—Processing.

**095120 Si HETEROJUNCTION BIPOLAR TRANSISTORS WITH SINGLE-CRYSTALLINE  $\beta$ -SiC EMITTERS.** The electrical characteristics of single-crystalline  $\beta$ -SiC grown on a Si substrate and the SiC/Si heterojunction system have been investigated to determine their suitability for the application to heterojunction bipolar transistors. Arsenic and phosphorus ion implantation and subsequent furnace annealing were found to provide n-type SiC layers with the sheet resistivity of several hundred ohm/square. The current-voltage characteristics can be given as  $J = J_0 \exp(qV/nkT)$ , where the value of  $n$  is around 1.35. Heterojunction bipolar transistors using SiC as a wide-gap emitter were realized for the

first time and compared with previously reported Si-based HBT's. The performance of our wide-gap emitter becomes superior to others at large Gummel numbers. (Author abstract) 11 refs.

Sugii, T. (Fujitsu Lab Ltd, Atsugi, Jpn); Ito, T.; Furumura, Y.; Doki, M.; Mieno, F.; Maeda, M. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2545-2549.

**095121 GENERATION LIFETIME IN HIGH RESISTIVITY SILICON.** The dark current at 295 K in some large area n+p diodes with gold base contacts has been analyzed to show the quality of the high resistivity wafers was generally very good. Estimates of the generation lifetime in the processed wafers ranged from 5 to 30 ms. The diffusion current injected at the base contact was often larger than the generation component and both were spatially variable. The behavior of the diffusion component implied a base contact interface generation velocity falling to values near  $10^4$  mm/s or lower in places. (Author abstract) 44 refs.

Rawlings, K.J. (Harwell Lab, Engl). *Nucl Instrum Methods Phys Res Sect A* v A260 n 1 Oct 1 1987 p 201-209.

**095122 STUDY OF ELECTRICAL INSTABILITY IN DETECTOR-GRADE NTD SILICON.** Electrical measurements have been used to investigate air quenching effects. Some instabilities of electrical properties were observed over the temperature range  $450 \pm 50^\circ\text{C}$ , i.e., a conduction type conversion (n  $\rightarrow$  p) follows the gradual rise in resistivity as a function of the time after quenching. The experiments indicate that this is a property peculiar to mixed NTD silicon. A large effect can be noted in sample pre-annealed at  $650^\circ\text{C}$ . The instability is reversible and can remain at liquid nitrogen temperature for a long time. (Edited author abstract) 3 refs. In Chinese.

Du, Guang-ting (Tsinghua Univ, China); Zhao, Jin-liang; Meng, Xiang-ti; Wang, Jia-ying; Xu, Xiao-lin; Yang, Qi-ji; Guo, Jin; Wang, Xi-min; Jiang, Jian-guo. *Xi You Jin Shu* v 5 n 2 May 1986 p 95-99.

**095123 FREQUENCY-DEPENDENT PHOTOVOLTAGE-GENERATING AREAS IN A STRONGLY-INVERTED OXIDIZED p-TYPE SILICON WAFER.** Surface photovoltages (SPVs) excited with a chopped 632.8 nm-wavelength photon beam (PB) were measured with a transparent electrode that covered half of a sample wafer 76 mm in diameter. The PB diameter was kept at  $120 \mu\text{m}$  and the PB power at  $1 \mu\text{W}$ . Since the wafer resistivity was  $0.29 \Omega\text{m}$ , the wafer surface was considered to be strongly inverted after forming a dry oxide layer  $280 \text{ nm}$  thick. SPVs were observed by changing the PB-irradiating positions so that the beam both did and did not pass through the transparent electrode. When the PB-chopping frequency was as low as 2 Hz, the SPV appeared across the entire wafer surface. However, the SPV-generating area decreased around the PB-irradiated point as the frequency became high. This can be explained by a distributed resistance and capacitance network model, previously reported by others. (Author abstract) 19 refs.

Munakata, Chusuke (Hitachi Ltd, Kokubunji, Jpn); Honma, Noriaki. *Jpn J Appl Phys Part 1* v 26 n 10 Oct 1987 p 1663-1666.

**095124 MODEL FOR THE STAEBLER-WRONSKI EFFECT.** Based on experimental results of transient photoresponse and photo-induced reversible changes for the same a-Si:H pin-type solar cell structure, a model is proposed for the Staebler-Wronski effect, by which reversible changes of the photo-induced dangling-bond density can be interpreted. We show that the origin of the effect is a space-charge redistribution caused by the corresponding reversible changes of internal electric fields in a-Si:H. A discussion is given of the reversible transitions during illumination and annealing. (Edited author abstract) 11 refs.

Dai Guo-Cai (Shandong Univ, Jinan, China); Gao Guang; Zheng Zhen-Xun. *Phil Mag Lett* v 56 n 6 Dec 1987 p 265-269.

**095125 VARIABLE-RANGE HOPPING AND THE HALL COEFFICIENT IN Si:As.** Conductivity and Hall measurements were made on Si:As samples on the barely-insulating side of the metal-insulator transition. Both conductivity and Hall coefficient obey variable-range hopping behavior ( $\ln \sigma \propto -(T_0/T)^{1/4}$  and  $\ln R_H \propto (T_0H/T)^{1/4}$ ), with the quantity  $(T_0H/T_0)^{1/4}$  equal to  $0.63 \pm 0.02$  in the limit of low magnetic field at the critical concentration,  $N_c$ . This is the first experimental verification of the theoretical predictions of Gruenewald et al. for  $R_H$  in the variable-range hopping regime.  $(T_0H/T_0)^{1/4}$  decreases somewhat with both increasing field and decreasing donor density. The prefactor for the Hall coefficient gives a value for  $\lim(1/NeR_H)$  as  $N \rightarrow N_c$  consistent with the corresponding results in this system on the metallic side of the transition. (Author abstract) 16 refs.

Koon, D.W. (Univ of Rochester, Rochester, NY, USA); Castner, T.G. *Solid State Commun* v 64 n 1 Oct 1987 p 11-14.

**095126 STRUCTURAL AND PHOTOELECTRICAL PROPERTIES OF A THIRD-ORDER TWIN BOUNDARY ( $\Sigma = 27$ ) IN SILICON.** In contrast to the joint the boundary displayed structural instability. On annealing it faceted and dissociated forming lower energy defects of twin boundaries of first and second orders. The  $\Sigma = 27$  boundary is of high electrical activity in the symmetrical  $\{552\}/\{552\}$  and faceted (parallel to the plane  $\{111\}$  of one of the grains) orientations. Surface recombination velocities ( $s$ ) equal  $6.6 \times 10^5$  and  $1.3 \times 10^6 \text{ cm s}^{-1}$  at 300 K, respectively. The value  $s$  increases approximately twice during faceting which agrees with geometrical models for the  $\Sigma = 27$  boundary in a diamond lattice. The electrical activity of the tetrajoints and the regions of the intersection of electrically inactive first order twin boundaries is revealed. (Edited author abstract) 16 refs.

Andreeva, A.V. (Acad of Sciences of the USSR, USSR); Bazhenov, A.V.; Bulenkov, N.A.; Firsova, A.A. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 351-362.

**095127 DC AND AC CHARACTERIZATION OF GRAIN BOUNDARIES IN FLOAT ZONE SILICON.** A grain boundary (GB) in a float-zone (FZ) silicon bicrystal was studied by, current-voltage characteristics and admittance spectroscopy. For both methods a common model is used which takes into account potential fluctuations in the GB plane. A unique deconvolution scheme for the experimental data is presented. Within that model all measurements, dc and ac, over the whole temperature ( $200 \text{ K} \leq T \leq 300 \text{ K}$ ) and doping ( $5 \times 10^{12} \text{ cm}^{-3} \leq N_D \leq 10^{15} \text{ cm}^{-3}$ ) range studied can be described by a common density of states in the GB. Additionally, information about the inhomogeneity of the barrier height in the GB plane and traps in the space charge zone is obtained. (Author abstract) 13 refs.

Petermann, G. (Univ Goettingen, Goettingen, West Ger). *Phys Status Solidi A* v 106 n 2 Apr 1988 p 535-549.

**095128 MEASUREMENT OF HALL MOBILITY IN N-CHANNEL SILICON INVERSION LAYER.** The Hall mobility of electrons in silicon inversion layers is determined from measurements of the magnetic-field sensitivity of dual-drain n-channel metal oxide semiconductor transistors and comparison with numerical device-modeling results. The variation of the Hall mobility with bias conditions is discussed. These data are needed for the design, test, and modeling of magnetic-field-sensitive field-effect transistors (MAGFET) used as integrated magnetic-field sensors. 13 refs.

Briglio, D.R. (Univ of Alberta, Edmonton, Alberta, Can); Nathan, A.; Baltes, H.P. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 842-845.

**Electronic Properties** See Also ELECTRONS—Density Measurement; SEMICONDUCTING FILMS—Electronic Properties.



**095129 NEW EXPERIMENTAL DETERMINATION OF THE RELATIONSHIP BETWEEN THE HALL MOBILITY AND THE HOLE CONCENTRATION IN HEAVILY DOPED p-TYPE SILICON.** The relationship between the Hall mobility and the hole concentration in p-type silicon were experimentally investigated. Boron and gallium were used as dopants; their doping was done by either the ion implantation or the diffusion technique. It was found that the relationships for boron-doped specimens and for gallium-doped specimens for the heavily doped range are considerably different from each other. Both of these relationships are also different from the so-called Irvin curve which is well known as a standard relationship between the mobility of carriers and the impurity concentration, but the relationship for boron doping is almost consistent with that of Thurber et al., if the Hall mobility factor is reasonably taken into account. (Author abstract) 17 refs.

Sasaki, Y. (Gunma Univ, Kiryu, Jpn); Itoh, K.; Inoue, E.; Kishi, S.; Mitsuishi, T. *Solid State Electron* v 31 n 1 Jan 1988 p 5-12.

**095130 KILOVOLT ELECTRON ENERGY LOSS DISTRIBUTION IN Si.** Using the electron-beam-induced barrier current and the Monte Carlo simulation it was possible to determine the depth-dose function as well as the distribution function of the generation source for electron-hole pairs perpendicular to the injection direction. The depth-dose function was compared with results obtained by Everhart and Hoff. By fitting the simulated barrier current profile to the measured one we could estimate the relatively small width of the space charge region of the p-n junction employed for the measurements. Furthermore, the spatial dose distribution of Si was described in an analytic approximation of the Monte Carlo simulation using two Gaussian functions concerned with the spreading of the penetrating electron beam and the diffusion of the primary electrons within the target, respectively. This approximation was based on treatments of the scattering process of the primary electrons given by Bethe and co-workers, Bothe and Archard. (Author abstract) 16 refs.

Werner, U. (Inst fuer Festkoerperphysik und Elektronenmikroskopie der AdW der DDR, Halle, East Ger); Koch, F.; Oelgart, G. *J Phys D* v 21 n 1 Jan 14 1988 p 116-124.

**095131 ENERGY SPECTRUM AND MATRIX ELEMENTS OF INTERSUBZONE HOLE TRANSITIONS IN SILICON IN CROSSED ELECTRICAL AND MAGNETIC FIELDS.** Luttinger's Hamiltonian is the basis for calculating the energy spectrum and matrix elements of intersubzone hole transitions in germanium in crossed electrical and magnetic fields. A feature in the frequency relation of the matrix elements caused by the tunneling effect is discovered. (Author abstract) 10 refs.

Stoklitskii, S.A. *Sov Phys Lebedev Inst Rep* n 7 1987 p 50-54.

**095132 BOUND EXCITON RECOMBINATION AT Mn-Zn PAIR CENTERS IN SILICON.** The low temperature photoluminescence of silicon doped with manganese and zinc consists of a broad vibronic band with zero-phonon lines at  $944.80 \pm 0.1$  meV and  $945.8 \pm 0.1$  meV. The spectrum is assigned to isoelectronic bound exciton recombination at neutral Mn-Zn pair centres known to exist in the samples. (Author abstract) 11 refs.

Henry, M.O. (Nat'l Inst for Higher Education, Dublin, Irel); McGuigan, K.G.; Barklie, R.C. *Solid State Commun* v 64 n 1 Oct 1987 p 31-33.

**095133 PRESSURE EFFECTS ON ELECTRONIC STRUCTURES OF AMORPHOUS SEMICONDUCTORS.** Pressure-induced changes in electronic structures have been studied for a-Si:H and a-Se films at pressure up to 80 kbar. By using the Wemple-DiDomenico relationship for the refractive-index dispersions, it is speculated that the electronic change induced in a-Si:H is much less than that in a-Se. The results for a-Se are consistent with a model assuming enhanced intermolecular interactions by hydrostatic compression. (Author abstract) 7 refs.

Tanaka, K. (Hokkaido Univ, Sapporo, Jpn); Murayama, H. *Solid State Commun* v 64 n 1 Oct 1987 p 125-127.

**095134 ON THE CROSS SECTION OF ELECTRON CAPTURE INTO THE DEEP STATE OF THERMAL U<sup>-</sup> DONORS IN Si.** To understand the mechanism of electrical activity of the thermal donor (TD) in Si:O crystals, data on the properties of the first species of the successively formed TD complexes are essential. These complexes are donors with inverse ordering of occupancy levels (U<sup>-</sup> donors). One of the main parameters of the thermal U<sup>-</sup> donors is the cross section of electron capture into the deep state. The aim of this note is to determine the deep state variation with growing of the TD complex. 6 refs.

Makarenko, L.F. (Acad of Sciences of the Byelorussian SSR, Minsk, USSR). *Phys Status Solidi A* v 106 n 2 Apr 1988 p k153-k155.

**095135 IN SITU WORK FUNCTION MEASUREMENTS IN EVAPORATED AMORPHOUS SILICON.** In situ contact potential difference measurements have been used to determine the work function of evaporated amorphous silicon (a-Si). The work function of unhydrogenated a-Si is found to be  $(4.66 \pm 0.02)$  eV. It is increased by 0.1 eV in hydrogenated amorphous silicon (a-Si:H). The work function is insensitive to variations in substrate temperature between 60 and 250+20 °C. The results are correlated with optical absorption and conductivity data. Limitations of the contact potential difference methods of monitoring changes in the bulk Fermi level are discussed. (Author abstract) 16 refs.

Ukah, Clement I. (Univ of Toronto, Toronto, Ont, Can); Kruselecky, Roman V.; Racansky, Daria; Zukotynski, Stefan. *J Non Cryst Solids* v 103 n 1 6(II) 1988 p 131-136.

**095136 TRAP-AUGER EFFECT IN RELATIVELY PURE SILICON.** By interpreting published lifetime curves for relatively pure silicon it is shown that the trap-Auger effect can be significant. It is estimated to be  $10^{-24}$  cm<sup>6</sup> s<sup>-1</sup>. At low carrier densities one would not expect the Auger effect to be important. The band-band effect goes at the rate of  $(B_1 + B_2)pnp$  (cm<sup>-3</sup> s<sup>-1</sup>) and this is small if n and p are small. A standard value of  $B_1 + B_2$  is  $3.9 \times 10^{-31}$  cm<sup>6</sup> s<sup>-1</sup>. On the whole, however, the numerical estimates and the fit are very satisfactory, showing that the trap-Auger effect, i.e. the term  $\beta n$ , is important even though the defect density is so small. 3 refs.

Landsberg, Peter T. (Univ of Southampton, Southampton, Engl). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 587-588.

## Encapsulation

**095137 EFFECT OF Si<sub>3</sub>N<sub>4</sub> ENCAPSULATION ON THE THERMAL PROCESSING OF HYDROGENATED AMORPHOUS SILICON.** The properties of annealed hydrogenated amorphous silicon (a-Si:H) with and without Si<sub>3</sub>N<sub>4</sub> encapsulation have been studied using Rutherford backscattering spectrometry, forward recoil analysis and scanning electron microscopy. Thermal processing of a-Si:H results in loss of hydrogen at temperatures above 375°C with or without Si<sub>3</sub>N<sub>4</sub> thin film encapsulation. With no encapsulation, the loss of hydrogen is preceded by the formation of bubbles which eventually break to form pinholes on the substrate. However, with Si<sub>3</sub>N<sub>4</sub> encapsulation in the structure Si<sub>3</sub>N<sub>4</sub>/a-Si:H/Si no pinhole formation is observed. (Author abstract) 12 refs.

Olowolafe, J.O. (Obafemi Awolowo Univ, Nigeria). *Thin Solid Films* v 161 Jul 1988 p 181-185.

**Etching** See Also INTEGRATED CIRCUIT MANUFACTURE—Etching; INTEGRATED CIRCUITS—Masks; SEMICONDUCTOR DEVICES, MOS—Manufacture.

**095138 HYDROGEN PLASMA ETCHING OF AMORPHOUS AND MICROCRYSTALLINE SILICON.** The etching of amorphous and microcrystalline

silicon films in a hydrogen plasma has been investigated. For amorphous silicon an etch rate of 2-4 Å/s was found. Microcrystalline silicon is etched at a rate of 0.3 Å/s. Microcrystalline silicon consists of two phases. The amorphous part is removed preferably. (Author abstract) 6 refs.

van Oort, R.C. (Technical Univ of Delft, Delft, Neth); Geerts, M.J.; van den Heuvel, J.C.; Metselaar, J.W. *Electron Lett* v 23 n 18 Aug 27 1987 p 968-970.

**095139 SILICON TRENCH ETCH IN A HEX REACTOR.** The fabrication of trench structures in single crystal silicon substrates for dielectric isolation or buried capacitors is readily achievable in a hexagonally configured, low pressure plasma etch system using chlorine chemistry. A number of process concerns are discussed. (Author abstract) 11 refs.

Herb, G.K. (AT&T Bell Lab, Allentown, PA, USA); Rieger, D.J.; Shields, Kathleen. *Solid State Technol* v 30 n 10 Oct 1987 p 109-115.

**095140 APPLICATION OF PHOTO-ASSISTED ETCHING TECHNOLOGY TO PREFERENTIAL ETCHING OF Si FOR DIELECTRICALLY ISOLATED STRUCTURE.** A fabrication sequence of a dielectrically isolated structure by field-assisted bonding of oxidized wafer pairs and preferential etch-back process utilizing a photo-assisted etching technology is presented. The etching technique utilizes the high etch selectivity between an epitaxially grown moderate resistivity layer and a low resistivity n-type substrate. The photochemically etched surface is specular and the thickness variations of the epitaxial layer can be controlled to less than  $\pm 20$  nm across a 3-inch diameter wafer. The process controllability is superior to conventional methods because of the simple etch mechanism. The technique has shown considerable promise for the fabrication of a practical SOI substrate. (Author abstract) 16 refs.

Ozawa, Kiyoshi (Fujitsu Lab Ltd, Morinosato-Wakamiya, Jpn); Ito, Takashi; Ishikawa, Hajime. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1509-1512.

**095141 ETCHED SHAPE CONTROL OF SINGLE-CRYSTAL SILICON IN REACTIVE ION ETCHING USING CHLORINE.** The trench shape formation mechanism is examined during reactive ion etching (RIE) of single-crystal silicon using chlorine for the etching gas, and shape control is achieved through the mixing of the depositing gas. One problem with RIE is undercutting of the sidewall due to divergent ions from ion-molecule collisions. Furthermore, sharp crevices are formed at the trench bottom edges because of the increase in radical concentration at these edges. From the experiment using chlorine, it is found that these problems are suppressed by a simultaneous deposition. Experimentation also showed that the etched depth is independent of the trench width for trenches wider than 0.7 μm, although the sidewall slope only slightly decreased with increasing trench width. (Edited author abstract) 19 refs.

Sato, Masaaki (NTT, Atsugi-shi, Jpn); Arita, Yoshinobu. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2856-2862.

**095142 X-RAY PHOTOELECTRON SPECTROSCOPY STUDY OF CF<sub>4</sub>/H<sub>2</sub> REACTIVE ION ETCHING RESIDUE ON SILICON.** CF<sub>4</sub>/H<sub>2</sub> reactive ion etching residue deposited on silicon was studied using x-ray photoelectron spectroscopy (XPS) and grazing angle XPS. Deposits are shown to be primarily a CHF<sub>x</sub> polymer consisting of CF<sub>2</sub>, CHF, and CH/CC functionalities. The polymer surface appears rich in graphite which is produced by ion bombardment of the polymer surface. This film is deposited on an oxide-coated silicon surface. (Author abstract) 14 refs.

Thomas, J.H. III (RCA Lab, Princeton, NJ, USA); Mu, X. Chun; Fonash, S.J. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3122-3125.



**095143 LIMITATIONS OF ORIENTATION DEPENDENT MICROSTRUCTURE ETCHING IN SILICON.** In this note, we report on an attempt to employ the ODE technique for batch fabrication of cavities suitable for vertically coupling optical fibers to silicon circuitry. The authors' results indicate that it is impossible to select such a limited subset of these planes (e.g., by masking their traces) and neglect the effect of the others. This approach succeeds in one-dimensional trench etching applications because the effect of the oblique {111} planes is seen only at the ends of the long trenches, which may be removed by cleaving. However, the two-dimensional shape of a small mask opening cannot be projected vertically into (110) Si, because of the interference of the non-vertical {111} planes. 9 refs.

Ade, R.W. (Columbia Univ, New York, NY, USA); Fossum, E.R. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3192-3194.

**095144 MASK DEPENDENT ETCH RATES III: THE EFFECT OF A SILVER ETCH MASK ON THE PLASMA ETCH RATE OF SILICON.** The authors report their findings using Ag as an etch mask in RIE etching of Si. Silver also enhances the etch rate of Si, and this enhancement is even more dramatic than that observed with Al. It is shown that the mask dependence of plasma etch rates is not limited to Al masks but is also observed with Ag masks. The enhancement of the etch rate with Ag is dramatic, with etch rates many times that of resist. That fact that two different metal masks give different enhancements of the Si etch rate show that the metal mask is responsible for the different rates. The larger enhancement with Ag masks can be partially explained by increased Ag surface area. 2 refs.

Fedynshyn, T.H. (Olin Research Cent, Cheshire, CT, USA); Grynkewich, G.W.; Dumas, R.H. *J Electrochem Soc* v 135 n 1 Jan 1988 p 268-269.

**095145 REACTIVE AND CHEMICALLY ASSISTED ION BEAM ETCHING OF SI AND SiO<sub>2</sub>.** Results are presented for the etching of thermal SiO<sub>2</sub> and single crystal Si by two ion beam sources of widely different characteristics, viz., a cold cathode saddle field source and a heated filament source. Reactive ion beam etching in SF<sub>6</sub> is described for both sources and chemically assisted ion beam etching (using a specially constructed inlet system) in SF<sub>6</sub>/Ar<sup>+</sup> using the heated filament source. Etching rates of Si in the latter mode are dependent on reactive gas partial pressure. Reactive and chemically assisted ion beam etching work in CF<sub>4</sub> using the heated filament source is reported. Changes in etch selectivity between Si and SiO<sub>2</sub> are observed. (Author abstract) 50 refs.

Carter, M.A. (Middlesex Polytechnic, London, Engl); Goldspink, G.F. *Vacuum* v 38 n 1 1988 p 5-10.

**095146 EINFLUSS DER FREQUENZ EINER CF<sub>4</sub>-GLIMMENTLADUNG AUF DAS PLASMA-ÄTZEN VON SILICIUM.** [Effect of Frequency on Plasma Etching of Silicon in a CF<sub>4</sub> Glow Discharge]. In plasma etching of Si, an increase of the excitation frequency of a CF<sub>4</sub> discharge in the region of 10 to 1000 kHz results in a decrease in the Si etching rate. Evaluations of the motion of ions in the space discharge layer of the Si substrate and the discharge voltage, which changes in the course of frequency variation lead, in the discussion of the etching rate progress, to the conclusion that the etching process takes place with the support of ions and the ion energy, is of decisive importance for the etching effect. (Translated author abstract) In German. 13 refs.

Hille, Norbert; Poll, Hans-Ulrich. *Wiss Z Tech Univ Karl Marx Stadt* v 29 n 4 1987 p 540-545.

**095147 EXPERIMENTAL STUDIES ON THE POLISHING MECHANISM OF HP-NONBAKED SiO<sub>2</sub> POLISHING AGENT FOR SILICON WAFERS (PART II).** A rapid removal of the fragments of the oxidic films is a key point to both polishing rate and the polished surface quality. Thus authors further investigated the reductions with use in  $\zeta$ -potential HP colloidal particles

and the surface tension of the polishing agent respectively. Several experiments show that the particles and the solution both exhibit a large capacity to adsorb the fragments, same as the ability toward some metal impurities. To sum up, the authors believe that the polishing mechanism of the HP polishing agent is the comprehensive actions of chemical action, mechanical action, complexing action, adsorption and rinsing, which is most suitable for offering high-quality polished silicon wafers for LSI and VLSI. (Edited author abstract) In Chinese. 11 refs.

Wang, Guang-yu (Acad Sinica, China); Liu, Feng-wei. *Xi You Jin Shu* v 6 n 4 Nov 1987 p 269-274.

**095148 POLYSILICON DRY ETCHING BY A LARGE-AREA ELECTRON BEAM.** Dry etching using a novel large-area electron beam has been obtained on polysilicon over SiO<sub>2</sub>/Si samples in the pressure range 0.1-0.4 Torr. The dependence of etching rate upon electron-beam power density, total pressure of the CF<sub>4</sub>/He mixture, and the ratio of CF<sub>4</sub>/He pressure has been determined. An etching rate of 150 nm/min without any addition of O<sub>2</sub> has been achieved with a low-energy density electron beam for poly-Si dry etching. (Author abstract) 9 refs.

Du, Y.C. (Fudan Univ, Shanghai, China); Wang, H.; Sun, D.C.; Li, F.M. *Appl Phys A* v A45 n 2 Feb 1988 p 165-168.

**095149 ETCHING OF Si THROUGH SiO<sub>2</sub> IN CF<sub>4</sub>/N<sub>2</sub>O PLASMA.** The etching behavior of CF<sub>4</sub>/N<sub>2</sub>O on silicon and its compounds has been investigated over a wide range of plasma conditions. A peculiar 'tunnel effect' was discovered during this study. That is, when using a mixture of CF<sub>4</sub> and N<sub>2</sub>O operated under high pressure and power conditions, one can etch deeply into silicon through a silicon dioxide layer, resulting in patterned tunnels in the underlying silicon substrate. In contrast, no such effect was observed in a CF<sub>4</sub>/O<sub>2</sub> or a CF<sub>4</sub>/(N<sub>2</sub>+O<sub>2</sub>) plasma under otherwise identical etching conditions. A model for the observations will be discussed. (Author abstract) 8 refs.

Wang, X.W. (Yale Univ, New Haven, Ct, USA); Liu, M.D.; Ma, T.P.; Barker, R.C. *J Electrochem Soc* v 135 n 2 Feb 1988 p 442-445.

**095150 MICROWAVE MULTIPOLAR PLASMA FOR ETCHING AND DEPOSITION.** Microwave Multipolar Plasmas (MMP) are plasmas which are confined by multipolar magnetic fields and excited by 2.45 GHz microwaves. Two main features distinguish MMPs from conventional plasmas: the decoupling of plasma excitation from plasma-surface interactions and the absence of self-bias, allowing independent control of substrate bias and ion impact energy. Microwave excitation is applied in three ways: localized (i.e., conventional) electron cyclotron resonance (ECR), surface wave, and distributed ECR (DECR). All three methods have been used to investigate silicon etching by fluorine, but only DECR seems technologically promising. Silicon homoepitaxy has been done on 100 mm wafers at temperatures down to 400°C in silane MMPs excited by DECR. (Author abstract) 27 refs.

Burke, Rudolf R. (CNRS, Meylan, Fr); Pomot, Claude. *Solid State Technol* v 31 n 2 Feb 1988 p 67-71.

**095151 EXCIMER-LASER ETCHING ON SILICON.** Studies have been made of poly- and single-crystal Si etching induced by excimer-laser irradiation of the silicon surfaces in halogenated gases. Etching was investigated for different conduction types, impurity concentrations and crystallographic planes. The n<sup>+</sup>-type Si is etched spontaneously by Cl<sup>-</sup> as a result of the availability of conduction electrons. Easy F<sup>-</sup> ion penetration into Si causes spontaneous etching in both types. Anisotropic etching for n<sup>+</sup> poly-Si is investigated because of its importance to microfabrication technology. Pattern transfer etching for n<sup>+</sup> poly-Si has been realized using reflective optics. The problems involved in obtaining finer resolution etching are discussed. (Edited author abstract) 26 refs.

Horiike, Y. (Toshiba Research & Development Cent, Kawasaki, Jpn); Hayasaka, N.; Sekine, M.; Arikado, T.; Nakase, M.; Okano, H. *Appl Phys A* v A44 n 4 Dec 1987 p 313-322.

**095152 SINGLE SILICON ETCHING PROFILE SIMULATION.** Single Si etching profiles by Cl<sub>2</sub> and a mixture of Cl<sub>2</sub> and CHF<sub>3</sub> are discussed in terms of experimentation and simulation. A microprobe Auger analysis of a trench side wall has proven that the bombardment of obliquely impinging ions to a side wall leads to both concave and tailed features. In the case of a mixture of Cl<sub>2</sub> and CHF<sub>3</sub> protects the side wall from species impinging from an inclined direction. Furthermore, the difference in the polymer sputtering rate, resulting from subsequently impinging ions between the tailed part and the flat bottom regions improves the tailed part of the rectangular bottom. A profile simulation supports the idea that obliquely impinging species, polymer deposition and sputtering of a polymer are important factors in determining the single Si etching profile. (Author abstract) 8 refs.

Arikado, Tsunetoshi (Toshiba VLSI Research Cent, Kawasaki, Jpn); Horioka, Keiji; Sekine, Makoto; Okano, Haruo; Horiike, Yasuhiro. *Jpn J Appl Phys Part 1* v 27 n 1 Jan 1988 p 95-99.

**095153 STUDY OF REACTIVE ION ETCHING OF SI AND SiO<sub>2</sub> FOR CF<sub>x</sub>Cl<sub>4-x</sub> GASES.** A parametric study of the etching of Si and SiO<sub>2</sub> by reactive ion etching (RIE) was carried out to gain a better understanding of the etching mechanisms. The Si etch rate uniformity across the wafer as a function of the temperature of the wafer and the Si load, the optical emission as a function of the temperature of the load, the etch rate of SiO<sub>2</sub> as a function of the sheath voltage, and the mass spectra for each of the FCs were measured. (Edited author abstract)

Fortuno, Guadalupe (IBM, Hopewell Junction, NY, USA). *Plasma Chem Plasma Process* v 8 n 1 Mar 1988 p 19-34.

**095154 RECOVERY OF SI SURFACES SUBJECTED TO REACTIVE ION ETCHING USING RAPID THERMAL ANNEALING.** In a recent report, we demonstrated that rapid thermal annealing (RTA) can be successfully used to recover the surface properties of silicon exposed to reactive ion etching (RIE) in a case where there was no substantial residue (non-silicon) layer produced by the RIE. The RIE process, for which RTA was successful, was CCl<sub>4</sub> blanket etching of bare Si wafers. In that report we suggested that RTA could be successfully employed for the recovery of Si surfaces exposed to other RIE processes, if residue layers were removed prior to rapid thermal annealing. In this study we substantiate that assertion for the case of silicon exposed to CClF<sub>3</sub>/H<sub>2</sub> RIE. It is pointed out that the complete evolution of Au/Si contact (1 mm, 1000 Angstrom thick Au dots) electrical behavior for three various processing steps is presented. Shown are the I-V data for a dot to a control surface (curve a), a dot to an RIE-exposed surface (curve b), a dot to an RTA/O<sub>2</sub> ashed/RIE-exposed surface, and a dot to an HF etched/RTA/O<sub>2</sub> ashed/RIE-exposed surface. 7 refs.

Fonash, S.J. (Pennsylvania State Univ, University Park, PA, USA); Mu, X.C.; Chakravarti, S.; Rathbun, L.C. *J Electrochem Soc* v 135 n 4 Apr 1988 p 1037-1038.

**095155 LASER-INDUCED CHEMICAL ETCHING OF SILICON IN CHLORINE ATMOSPHERE.** Laser-induced chemical etching of single-crystalline (100) Si in Cl<sub>2</sub> atmosphere has been investigated for continuous Ar<sup>+</sup> and Kr<sup>+</sup> laser irradiation at around 351 nm, and at 457.9, 488.0, 514.5 and 647.1 nm. For laser irradiances below 10<sup>5</sup> W/cm<sup>2</sup> the etching mechanism is non-thermal, and is based on photo-generated electron-hole pairs within



the Si surface and Cl atoms produced within the gas phase. The experimental results are compared with model calculations. (Author abstract) 23 refs.

Mogyorosi, P. (Johannes-Kepler-Univ Linz, Linz, Austria); Kullmer, R.; Bauerle, D. *Appl Phys A* v A45 n 4 Apr 1988 p 293-299.

**095156 CHEMICAL ETCHING OF SILICON BY CO<sub>2</sub>-LASER-INDUCED DISSOCIATION OF NF<sub>3</sub>.** The pulsed infrared laser dissociation of NF<sub>3</sub> is reported for the first time, and is used to investigate silicon etching. The role played by collision-enhanced multiple-photon absorption and dissociation is considered, with data on the nonlinear decrease of the absorption cross-section with increasing pulse energy and increasing pressure presented. Using an experimental arrangement in which the laser beam is focussed parallel to the surface, the dissociation process induces spontaneous etching of silicon. Etching was monitored by use of a quartz-crystal microbalance upon which a thin film of amorphous silicon was deposited. For a surface with no previous exposure to the photolysis products, dissociation causes the formation of a surface layer prior to the onset of etching. X-ray photoelectron spectroscopy demonstrates this to be a fluorosilyl layer possessing a significant concentration of SiF<sub>3</sub> and SiF<sub>4</sub>. In contrast, a surface already thickly fluorinated does not form a thicker layer once laser pulsing commences again. In this case, etching starts immediately with the first pulse. The etch yield dependencies on several parameters were obtained using silicon samples possessing a thick fluorosilyl surface layer. Attempts at etching SiO<sub>2</sub> under identical conditions were unsuccessful. (Edited author abstract) 42 refs.

Brannon, J.H. (IBM, Hopewell Junction, NY, USA). *Appl Phys A* v A46 n 1 May 1988 p 39-50.

**095157 Nb REDEPOSITION ON SI DURING PLASMA ETCHING OF Nb/SiO<sub>2</sub>/SI LAYERS INVESTIGATED BY RBS.** The redeposition of electrode material (Ni, Cr, Al) and material of a Nb layer on silicon surface during plasma etching of Nb, SiO<sub>2</sub> and Si by a CF<sub>4</sub> plasma has been investigated by Rutherford Back Scattering spectrometry. It is shown that a steady state (NbF<sub>x</sub>)<sub>gas</sub> ↔ (Nb)<sub>ads</sub> + xF exists, what causes a Nb contamination of etched Si surfaces. Obviously this steady state concentration (Nb)<sub>ads</sub> is influenced by additional redeposition of non-etchable electrode material as Ni, Cr and Al. (Author abstract) 6 refs.

Schelle, D. (Friedrich-Schiller-Univ, Jena, East Ger); Tiller, H.J. *Cryst Res Technol* v 22 n 8 Aug 1987 p 1009-1014.

**095158 ETCH RATE DISTRIBUTION OVER SILICON WAFERS IN EPW SOLUTIONS.** Anisotropic etching of silicon wafers in ethylenediamine-pyrocatechol-water (EPW) solutions was carried out to reveal the distribution of etch rates over the wafer. The etch depth, i.e., the etch rate on the wafers, was found to vary within a few percent about the average value, and the standard deviation depended on the etch conditions such as temperature and flow patterns in the solution. The distribution was shown as a map and statistically analyzed. The major factor affecting the distribution was found to be the mass transfer in the solution via flow patterns in the solution. (Author abstract). 7 refs.

Matsuka, Masakuni (Tokyo Univ of Agriculture & Technology, Tokyo, Jpn); Arai, Yasushi; Yoshida, Yukoh. *Jpn J Appl Phys Part 1* v 27 n 5 May 1988 p 784-789.

**095159 TRENCH ETCHES IN SILICON WITH CONTROLLABLE SIDEWALL ANGLES.** This paper describes the role of the temperature of the silicon wafer in controlling a deep trench etch sidewall angle and also the etch rate. In addition, it discusses the role of pressure in controlling etch rate and selectivity. This work was performed in a Tegal 1500 Test Bench. The temperature of the wafer could be held fixed as a function of time at any temperature between 20° and 200°C. Our chemistry is chloroform, CHCl<sub>3</sub> with O<sub>2</sub> and N<sub>2</sub> as additives. We have

found that the sidewall angle of the trench (the angle that the sidewall makes with a normal to the wafer surface) could be varied continuously from about 32° at 40°C to 7° at 190°C. The sidewalls are typically planar and relatively smooth. The bottom of the etch becomes increasingly planar as sidewall angle decreases. (Edited author abstract). 10 refs.

Carlile, Robert N. (Univ of Arizona, Tucson, AZ, USA); Liang, Victor C.; Palusinski, Olgierd A.; Smadi, Mithkal M. *J Electrochem Soc* v 135 n 8 Aug 1988 p 2058-2064.

**095160 ELECTRON CYCLOTRON RESONANCE MICROWAVE-PLASMA ETCHING.** Electron cyclotron resonance microwave-plasma etching of Si and SiO<sub>2</sub> using a (CF<sub>4</sub> + O<sub>2</sub>) gas mixture is investigated in a magnetically confined plasma. High etch rates have been obtained at 0.8 Torr pressure, where the etching mechanism may be due primarily to neutral active species (1 Torr = 133 Pa). The high etch rate can be explained by a high dissociation efficiency of the ECR microwave plasma, and the directionality by carbon deposits associated with it. The magnetic confinement is likely to play a role similar to that of ion and electron screening. (Author abstract) 8 refs.

Mejia, S.R. (Univ of Manitoba, Winnipeg, Manit, Can); Chau, T.; Mcleod, R.D.; Kao, K.C.; Card, H.C. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 856-858.

**095161 RIE ETCHING OF DEEP TRENCHES IN Si USING CBrF<sub>3</sub> AND SF<sub>6</sub> PLASMA.** A two step RIE etch process offers the capability to form deep trenches with ideal profiles in bulk silicon. The first step in CBrF<sub>3</sub> transfers the pattern of the structured tri-level system into the silicon. Because the sidewalls are not smooth and the corners at the bottom of the 4 to 6 µm deep trenches are relatively sharp, a further short etch step in SF<sub>6</sub> was introduced. The RIE with CBrF<sub>3</sub> results in an anisotropic etch of Si compared to SF<sub>6</sub> which leads due to the isotropic etch behavior to smooth and slightly tapered sidewalls and to a rounded bottom. (Author abstract) 8 refs.

Krings, A.M. (Aachen Technical Univ, Aachen, West Ger); Eden, K.; Beneking, H. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microthogr, Jouy-en-Josas, Fr, Sep 22-25 1987 p 553-558.

**095162 FRACTAL MICROPATTERNS GENERATED BY ANODIC ETCHING.** The anodic etching of single crystal silicon as a method to produce a three dimensional channel system was studied. The geometry of the channel labyrinth was revealed by microscopy (optical, SEM and TEM). The crystallographic behavior of porous silicon was investigated by X-ray and electron diffraction. (Author abstract) 8 refs.

Harsanyi, J. (Max-Planck-Institut fuer Festkoerperforschung, Stuttgart, West Ger); Habermeier, H.-U. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microthogr, Jouy-en-Josas, Fr, Sep 22-25 1987 p 575-580.

**095163 ANISOTROPIC ETCHING OF SILICON IN HYDRAZINE.** This paper contains a detailed discussion of the practical issues related to the anisotropic etching of single crystal silicon using a 50-50 hydrazine-water solution. Characteristics of the etchant, etching reactor design, etch procedures, safety precautions, etch rate data for typical samples and appropriate etch-masks are among the topics discussed. The etching process is carried out in an atmospheric reflux reactor, continuously purged with nitrogen. The etch rate of (100) silicon at 115°C in this hydrazine solution is nearly 3 µm/min, which is much higher than that of ethylenediamine-pyrocatechol-water (EDP) solutions. Silicon dioxide, silicon nitride and most metallic thin films, except aluminium, can be used to mask the etching process. The etch rate is reduced significantly in highly-boron-doped silicon; a boron concentration of  $1.5 \times 10^{20} \text{ cm}^{-3}$  practically stops the etch. The use of the hydrazine

solution for micromachining thin silicon diaphragms, cantilevers and fibers is demonstrated. (Author abstract) 68 refs.

Mehregany, Mehran (MIT, Cambridge, MA, USA); Senturia, Stephen D. *Sens Actuators* v 13 n 4 Apr 1988 p 375-390.

## Fracture

**095164 DYNAMICS OF DISLOCATION GENERATION AT CRACK TIPS AND THE DUCTILE-BRITTLE TRANSITION.** During the last few years there has been interest in the phenomena which control whether crystalline solids containing cracks deform in a brittle or ductile manner. One of the main conclusions is that the role of dislocations generated from external sources, as compared with that of dislocations nucleated at and emitted from the crack tip, in controlling T<sub>c</sub> is not understood. The purpose of the present paper is to report on some recent experiments on Si and theoretical computations which address this and other problems covering the ductile-brittle transition of intrinsically brittle materials. Fracture experiments were carried out using 4-point bend tests on rectangular bars of float zone Si. 15 refs.

Hirsch, P.B. (Univ of Oxford, Oxford, Engl); Roberts, S.G.; Samuels, J. *Scr Metall* v 21 n 11 Nov 1987 p 1523-1528.

**095165 INFLUENCE OF PRECIPITATED OXYGEN ON THE BRITTLE-DUCTILE TRANSITION OF SILICON.** The degree of brittleness of silicon during cutting depends on oxygen content and previous heat treatment. The authors report on the ductile-brittle transition of three grades of Si in various stages of oxide precipitation but at one particular crack opening rate ( $\dot{\delta} = 50 \text{ µm/min}$ ). They analyzed the ductilization process by scanning electron microscopy. 8 refs.

Behrensmeier, R. (Univ Goettingen, West Ger); Brede, M.; Haasen, P. *Scr Metall* v 21 n 11 Nov 1987 p 1581-1585.

**095166 FRACTURE OF SILICON WAFERS.** This paper examines the fracture strength of a wide range of silicon material both as-grown and after processing. The wafers tested were from crystals grown by float-zone and Czochralski techniques and the effects of oxidation, ion-implantation and annealing in various environments have been studied. The technique used to measure the fracture stress involved simply supporting the wafer on an aluminum ring concentric to the load axis. The load was gradually increased until the wafer fractured. In the first part of the study, the role of the surface on the fracture behavior has been investigated in detail. Results can be analyzed in terms of surface controlled defects under conditions where surface defects are dominant and bulk controlled defects where these defects are dominant. (Edited author abstract) 18 refs.

McLaughlin, J.C. (Southampton Univ, Southampton, Engl); Willoughby, A.F.W. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 83-90.

**Grain Boundaries** See Also SOLAR CELLS—Efficiency; SOLAR CELLS—Silicon.

**095167 INTERACTION OF DISLOCATIONS WITH Σ=9 GRAIN BOUNDARIES IN SILICON BICRYSTALS.** Studies have been made on the core structures for grain-boundary dislocations by means of models based on springs and spheres. These dislocations arise in elemental semiconductors on absorption of lattice dislocations by symmetrical boundaries having Σ=9 or when such dislocations pass through them. (Author abstract) 8 refs.

George, A.; Jacques, A. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 150-155.



Growing See TRANSISTORS, BIPOLAR—Fabrication.

**Growth** See Also CRYSTALS—Defects; CRYSTALS—Growth; SEMICONDUCTOR DEVICES—Junctions; SEMICONDUCTOR DEVICES, MOSFET—Electric Properties; SEMICONDUCTOR MATERIALS—Processing; TRANSISTORS—Fabrication.

**095168 RADIOACTIVE-TRACER STUDY OF THE DISSOLUTION OF GASES IN SILICON.** A radioactive-tracer method of studying the distribution of inert gases and hydrogen in silicon single crystals grown by floating zone melting has been developed. The dependence of the specific activity and the thickness of the activated layer on the crystal growth rate was determined. The possibility of dissolving Krypton and Tritium in silicon crystals is shown. (Translated author abstract) In Russian. 7 refs.

Trubitsyn, Yu.V.; Neimark, K.N.; Zakharov, O.A. *Tsvet Met* n 4 Apr 1987 p 68-70.

**095169 BEHAVIOR OF CARBON DURING THE GROWTH OF SILICON SINGLE CRYSTALS.** The results of an experimental study of the carbon content and distribution in silicon single crystals with diameters of 100-150 mm grown by the Czochralski method are presented. A study is made of the effect of certain parameters of the growth of such crystals on the carbon content and distribution - namely, the charge composition, the gas flow rate in the working chamber of the crystal growth reactor, and also factors determining the degree of mixing of the melt in the crucible. (Translated author abstract) In Russian. 8 refs.

Sal'nik, Z.A.; Levshin, E.A. *Tsvet Met* n 4 Apr 1987 p 70-72.

**095170 SILICON MOLECULAR BEAM EPITAXY ON GaP AND GaAs.** Thin silicon films have been epitaxially grown on GaP and GaAs by molecular beam epitaxy (MBE). Films and interfaces have been investigated by surface analysis and transmission electron microscopy. Both the surface and the bulk of the films are contaminated by atoms from the substrate; this is attributed mainly to surface diffusion and exchange between Si and Ga atoms. On GaP, films thinner than 75 nm are subject to tensile stress because of the lattice mismatch (0.36%), without the appearance of crystal imperfections. Thicker films contain dislocation and stacking faults, related to strain-induced atomic rearrangements. The critical thickness for dislocation formation is significantly larger than is predicted from elasticity theory. On GaAs, the lattice mismatch of 4% gives a greater reduction in crystal quality. (Author abstract) 27 refs.

Zalm, P.C. (Philips Research Labs, Eindhoven, Neth); Bulle-Lieuwma, C.W.T.; Maree, P.M.J. *Philips Tech Rev* v 43 n 5-6 May 1987 p 154-165.

**095171 GaAs ON Si TECHNOLOGY.** High quality GaAs layers were grown on Si(100) wafers by the heat treatment of the substrates at high temperatures and a subsequent two-step growth sequence at low temperature and then at the conventional growth temperature. The grown layers showed a high quality, single domain structure, a mirror-like surface, high electron mobility, fairly high photoluminescence intensity and low etch pit density. A small offset angle from (100) was necessary to grow a single domain GaAs layer. (Author abstract) 36 refs.

Kaminishi, Katsuzo (Oki Electric Industry Co, Tokyo, Jpn). *Solid State Technol* v 30 n 11 Nov 1987 p 91-97.

**095172 INVESTIGATION OF VARIOUS SUBSTRATE DOPANTS AND EPITAXIAL GROWTH TECHNIQUES FOR PRODUCING SHARP TRANSITION EPITAXIAL WAFERS.** Arsenic, antimony, phosphorus, boron, and gallium doped silicon substrates were used for the fabrication of n/n+ or p/p+ epitaxial wafers to study autodoping effects in a horizontal induction heated atmospheric pressure epitaxial reactor. Using the 'high-low' technique which uses a high temperature prebake (without HCl etching) followed by a relatively

low temperature and slow growth rate deposition, sharp n/n+ transition on arsenic material was achieved. This method appears to produce an epitaxial layer of more uniform resistivity out to the beginning of the transition region for all of the n-type substrates used. Results show that when the epitaxy employs the high-low technique at a temperature of 1050°C, heavily doped arsenic substrates offer unique transition and defect density advantages over either antimony or phosphorus material. (Edited author abstract) 11 refs.

Schmidt, Dennis N. (Westinghouse Research & Development Cent, Pittsburgh, PA, USA). *J Electrochem Soc* v 134 n 11 Nov 1987 p 2845-2850.

**095173 SELECTIVE DOPED POLYSILICON GROWTH: EFFECT OF CARBON ON THE SELECTIVE DOPED SILICON FILM GROWTH.** We previously discussed selective polysilicon growth technology based on selective epitaxial growth technology. In this paper, we report the influence of CH<sub>4</sub>-introduction on the crystallinity of silicon, the doping control with PH<sub>3</sub>, and the selective growth of silicon. It has become possible to control the transition from epitaxial silicon to polysilicon and  $\beta$ -SiC. By achieving a definite doping control, the resistivity can be lowered to  $1 \times 10^{-3} \Omega \cdot \text{cm}$ . A combination of these technologies made it possible to grow selectively doped polysilicon with a flat surface. (Edited author abstract) 8 refs.

Mieno, F. (Fujitsu Ltd, Kawasaki, Jpn); Furumura, Y.; Nishizawa, T.; Maeda, M. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2862-2867.

**095174 GROWTH AND CHARACTERIZATION OF SINTERED POLYCRYSTALLINE SILICON.** p-Type polycrystalline large grain Si specimens were grown in vacuum and inert atmosphere by sintering. By means of a morphological characterization of the specimens, the three theoretical sintering steps were observed using a scanning electron microscope (SEM). The influence of mechanical pressure, temperature and sintering time on the specimen mobility was investigated. Correlation between the grain dimension and the mobility variation was studied. The temperature dependence of the resistivity, mobility and carrier concentration was also investigated. (Author abstract) 9 refs.

Gombia, E. (MASPEC-CNR Inst, Parma, Italy); Panizieri, R.; Salvati, G.; Vidal, J. *J Cryst Growth* v 84 n 4 Oct 1987 p 621-628.

**095175 PROPERTIES OF SILICON CRYSTALS GROWN UNDER THE ACTION OF A VERTICAL MAGNETIC FIELD.** The possibility of obtaining 100-mm-diam silicon single crystals with a low oxygen content (up to  $2 \cdot 10^{17} \text{ cm}^{-3}$ ) at relatively low magnetic field strengths is shown. In crystals grown under magnetohydrodynamic action, a more ordered distribution of microdefects is formed, which is attributed to the nature of the temperature fluctuations in the melt. The electrical and structural parameters of these crystals are thermally stable. (Translated author abstract) In Russian. 10 refs.

Gel'gat, Yu.M.; Levshin, E.S.; Pogodin, A.I.; Sal'nik, Z.A.; Smirnov, B.V.; Eidenzon, A.M. *Tsvet Met* n 7 Jul 1987 p 72-76.

**095176 MELT MOTION IN A CZOCHRALSKI CRYSTAL PULLER WITH AN AXIAL MAGNETIC FIELD: UNCERTAINTY IN THE THERMAL CONSTANTS.** For a Czochralski silicon puller with a uniform axial magnetic field of at least 0.2 T (2000 G), the melt velocities are so small that the inertial effects can be neglected and viscous effects are confined to thin layers. Analytical solutions of the momentum equation are possible and provide physical insights into the melt motions. The asymptotic analysis for strong magnetic fields is used to treat the effects of changing the values of the thermal conductivity, coefficient of volumetric expansion and thermal gradient of surface tension. With a particular choice for the characteristic velocity, the dimensionless stream functions for the melt motions are relatively independent of the thermal conductivity and depend

on the thermal expansion coefficient and surface tension gradient only through a single parameter reflecting the ratio of these two thermal constants. Variations with magnetic field strengths from 0.2 to 1.7 T are discussed as well. (Author abstract) 14 refs.

Hjellming, L.N. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Walker, J.S. *J Cryst Growth* v 87 n 1 Jan II 1988 p 18-32.

**095177 EXAMINATION OF NATURAL CONVECTION IN THE MELT WITH VERTICAL SUBSTRATES IN LIQUID PHASE EPITAXIAL GROWTH OF SILICON.** The results are presented of examination of dissolution of vertical silicon substrates in Sn-Si melts. Natural convective motion in the melt is analyzed and the conditions of uniform dissolution of the substrates are determined. It is recommended to use the results for inspecting the hydrodynamic behavior of the melt during liquid-phase epitaxy of silicon. (Author abstract) 7 refs.

Volkov, M.P.; Burov, S.V. *Phys Chem Mater Treat* v 21 n 4 Jul-Aug 1987 p 418-421.

**095178 MONTE CARLO SIMULATION OF CRYSTAL GROWTH FROM SILICON MELT.** Monte Carlo simulations were carried out to study the rapid crystal growth rates of crystalline silicon in (100) and (111) orientations from pulsed-laser-induced melt. Growth rates were obtained above and below the surface-roughening transition temperature by means of a non-solid-on-solid model. The growth rates for the (100) direction were found to be much higher than those for (111). No roughening transition could be observed in (100) orientation and random growth was shown for this atomically rough surface. (Author abstract) 12 refs.

Tan, A.K. (Natl Univ of Singapore, Singapore); Ong, C.K.; Tan, H.S. *Semicond Sci Technol* v 3 n 1 Jan 1988 p 1-5.

**095179 SUBMICRON PMMA/W/SiO<sub>2</sub> LITHOGRAPHY FOR Si LOCALIZED EPITAXY.** The micro-electronic process we propose in this paper has been developed in order to bury a metallic grating in silicon material. A good control of dimensions in the 0.5- $\mu\text{m}$  period range and an excellent crystallinity of the embedded semiconductor are the two major characteristics of this process. Using this technique, permeable base transistors have been made, the characteristics of which are given and briefly discussed. (Author abstract) 12 refs.

Glastre, G. (CNET, Meylan, Fr); Vincent, G.; Vaireille, A.; Normandon, P.; Puissant, C.; Rosencher, E. *Microelectron Eng* v 7 n 1 1987 p 1-10.

**095180 FORMATION OF NUCLEI OF OXYGEN PRECIPITATES IN CZ SILICON CRYSTALS DURING CRYSTAL GROWTH PROCESS.** The effects of the thermal history during CZ process conformation of the nuclei of the oxygen precipitates are investigated by the annealing experiments on as-grown crystals and a special crystal growth experiment. In the annealing experiments, the thermal histories similar to those during crystal growth are given to the specimens and their effects on oxygen precipitation are examined. In the growth experiment, the crystal is subjected to the duplicated in situ annealing in the crystal puller and the effect of the thermal history, particularly that in the intermediate temperature range, is examined. On the basis of the present results, the formation process of the nuclei during crystal growth is summarized. (Edited author abstract) 13 refs.

Furuya, H. (Mitsubishi Metal Corp, Jpn); Suzuki, I.; Shimanuki, Y.; Murai, K. *J Electrochem Soc* v 135 n 3 Mar 1988 p 677-682.

**095181 PREGROWTH AMBIENT GAS ANALYSIS OF CZOCHRALSKI Si CRYSTAL PULLER.** The nature of the ambient gas during vacuum bakeout of a Czochralski silicon crystal puller was investigated by



using a commercially available residual gas analyzer. The ambient pressure changes observed during bakeouts were correlated with the relevant gas profiles generated from the residual gas analyzer. The partial pressures and the percent compositions of the ambient gas species were then calculated. Among the major species found during vacuum bakeouts were CO, CH<sub>4</sub>, H<sub>2</sub>O, and Ar. CH<sub>4</sub> and H<sub>2</sub>O completely vanished within 2-4h into the bakeout, and the steady-state ambience was composed mostly of CO gas. The prime source of CO was apparently the reduction of the fused quartz crucible by its graphite holder. (Edited author abstract) 15 refs.

Choe K.S. (IBM, Hopewell Junction, NY, USA); Strudwick, T.H. *J Electrochem Soc* v 135 n 3 Mar 1988 p 706-710.

**095182 OBSERVATION OF THE  $n=2$  EXCITED STATES OF THE LIGHT AND HEAVY HOLE EXCITONS IN GaAs GROWN DIRECTLY ON Si BY OMVPE.** Using photoluminescence excitation spectroscopy and selective photoluminescence excitation at low temperatures, the evidence for  $n=2$  excited states of both the light hole ( $m_j = \pm 3/2$ ) and the heavy hole ( $m_j = \pm 1/2$ ) excitons is presented for GaAs grown directly on Si by OMVPE. The excited states are about 3 meV above the corresponding  $n=1$  ground states, similar to exciton results for homoepitaxial GaAs. Using selective excitation a spectral width of  $\approx 2$  meV is observed for the  $n=1$  transition of the light hole exciton. (Edited author abstract) 13 refs.

Zemon, S. (GTE, Waltham, MA, USA); Jagannath, C.; Shastri, S.K.; Lambert, G. *Solid State Commun* v 65 n 7 Feb 1988 p 553-556.

**095183 EDDY CURRENT MONITORING SYSTEM AND DATA REDUCTION PROTOCOL FOR CZOCHRALSKI SILICON CRYSTAL GROWTH.** A computer controlled eddy current system for the in situ monitoring of Czochralski silicon crystal growth is introduced. A scheme to reduce eddy current sensor data to temperature values and thermal profiles in the growing crystal is presented. The principle of eddy current testing involves the behavior of electromagnetic radiation penetrating the silicon crystal and its subsequent reflection. This behavior is outlined by Maxwell's equations, and it is the solution of the electromagnetic field boundary-value problem that relates voltage measurements from the eddy current probe to the changing electrical conductivity of the crystal. Due to a strong temperature dependence of the electrical conductivity in solid silicon, it is then possible to determine thermal profiles within the growing crystal. (Author abstract) 27 refs.

Stefani, J.A. (Columbia Univ, New York, NY, USA); Tien, J.K.; Choe, K.S.; Wallace, J.P. *J Cryst Growth* v 88 n 1 Apr 1988 p 30-38.

**095184 EDDY CURRENT MEASUREMENT OF CRYSTAL AXIAL THERMAL PROFILES DURING CZOCHRALSKI SILICON CRYSTAL GROWTH.** The axial thermal profiles of silicon crystals during the Czochralski crystal growth process were measured experimentally by using an eddy current technology. The intrinsic conductivity changes in the crystal resulting from cooling were measured in terms of the eddy current amplitude and phase responses, and the axial thermal profiles of the growing crystal were subsequently derived from the results. The experimental results indicate that the axial thermal profile in the region is nearly linear and quite transient during the initial phase of body growth. As the crystal gets longer, the increasing heat loss by radiation from the crystal surface causes the overall profile to shift downward. When the crystal reaches 200-250 mm in length, a steady state condition is achieved, and the overall axial thermal profile stays nearly invariant for the remainder of the growth. The steady state axial thermal gradient in the region is estimated to be about 4-6°C/mm. (Edited author abstract) 25 refs.

Choe, K.S. (IBM Corp, Hopewell Junction, NY, USA); Stefani, J.A.; Tien, J.K.; Wallace, J.P. *J Cryst Growth* v 88 n 1 Apr 1988 p 39-52.

**095185 THIN EPITAXIAL SILICON REGROWTH USING ION IMPLANTATION AMORPHIZATION TECHNIQUES.** An ion implantation amorphization technique for the preparation of thin epitaxially regrown silicon layers has been studied. <sup>28</sup>Si<sup>+</sup> ions are implanted into low pressure chemical vapor deposition (LPCVD) silicon films which have been deposited on silicon wafers. This causes amorphization of the films and dispersal of the buried native oxide layer on the wafers. Subsequent thermal annealing results in epitaxial regrowth of the amorphized films. The resultant crystal quality of the regrown films and substrates was studied by x-ray, Raman, Rutherford backscattering, wet chemical etching, and electrical measurements. Improvements to the process are discussed. (Edited author abstract) 16 refs.

Cole, R.C. (Aerospace Corp, El Segundo, CA, USA); Knudsen, J.F.; Bowman, R.C. Jr.; Adams, P.M.; Hurrell, J.P.; Halle, L.; Newman, R.; Jamieson, D. *J Electrochem Soc* v 135 n 4 Apr 1988 p 974-979.

**095186 EFFECT OF THE NATURE OF THE IMPURITIES ON THE RATE OF AXIAL GROWTH OF FILAMENTARY SILICON CRYSTALS.** A study was made of the kinetics of axial growth, of filamentary silicon crystals in a standard once-through chloride system according to the vapor-liquid-solid mechanism, using various initiating impurities. It was found that the effect of these impurities on the growth rate is determined by the edge wetting angle of the drop at the tip of the filamentary crystal and by the solubility of the material being crystallized in the initiator metal. In Russian. 6 refs.

Shchetinin, A.A.; Bubnov, L.I.; Kozhenkov, O.D.; Tatarentov, A.F. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 10 Oct 1987 p 1589-1592.

**095187 REACTION BETWEEN THE COMPONENTS IN MELTS OF THE Sn-Ga-Si SYSTEM.** On the basis of experimental data concerning the density of melts of the Sn-Ga-Si system, the partial molar volumes of tin, gallium and silicon at 1470 and 1570 K were calculated. In an analysis of the dependences of the partial molar volumes of the components on the melt composition and temperature the presence of a tendency toward phase separation is noted. In Russian. 7 refs.

Timoshin, A.S.; Kozhitov, L.V.; Morgunov, I.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 12 Dec 1987 p 1948-1951.

**095188 GETTEROWANIE WEWNETRZNE W KRZEMIE OTRZYMYWANYM METODA CZOCHRALSKIEGO.** [Internal Gettering in Silicon Obtained by Czochralski Method]. Problems connected with internal gettering technique of impurities in silicon wafers have been discussed. Practical conclusions relative to the method of controlling parameters of internal getters are obtained. Criteria are established in selecting properties of silicon and conditions of preliminary heat treatment to ensure effective gettering of impurities. (Edited author abstract) 34 refs. In Polish.

Kucharski, Krzysztof (Inst Technologii Elektronowej, Warsaw, Pol). *Elektronika* v 28 n 9 1987 p 3-8.

**095189 EPITAXIAL GROWTH OF CrSi AND CrSi<sub>2</sub> ON Si(111).** The possibility of epitaxial growth of chromium silicides upon thermal processing of thin Cr deposits ( $\leq 30$  monolayers (ML)) on Si(111) is demonstrated using low energy electron diffraction (LEED) and angle resolved X-ray (XPS) and ultra-violet (UPS) photoemission. For coverages  $\theta \geq 4$  ML epitaxial CrSi with a lattice misfit of  $\approx 1.6\%$  can be grown upon annealing at 350°C. Thermal treatment at 450°C for  $\theta \geq 6$  ML results in epitaxial CrSi<sub>2</sub> formation with two kinds of domains rotated by 30° with respect to each other around the surface normal. LEED intensities indicate essentially equal formation probabilities for both orientations despite the large difference in lattice misfit of  $\approx 0.1$  and  $\approx 3.8\%$ , respectively. (Author abstract) 6 refs.

Wetzel, P. (Lab de Physique et de Spectroscopie Electronique, Mulhouse, Fr); Pirri, C.; Peruchetti, J.C.; Bolmont, D.; Gewinner, G. *Solid State Commun* v 65 n 10

Mar 1988 p 1217-1220.

**095190 UHV-PROZESSTECHNOLOGIE FUER DIE SILIZIUM-MOLEKULARSTRAHLEPITAXIE (Si-MBE).** [UHV Processing Technology for Silicon Molecular Beam Epitaxy (Si-MBE)]. Silicon-molecular beam epitaxy (Si-MBE) places stringent demands on the generation and handling of the ultrahigh vacuum (UHV). An industrial production system suitable for a small series production is presented. Necessary prerequisites in designing sub-systems for perfect crystal growth are discussed. Conditioning and processing influence process-vacuum and wafer throughput. Typical vacuum problems in connection with Si-MBE are discussed. (Author abstract) 8 refs. In German.

Kibbel, H. *Vak Tech* v 37 n 2 Mar 1988 p 35-40.

**095191 GROWING SILICON SINGLE CRYSTALS BY THE METHOD OF VERTICAL DIRECTED CRYSTALLIZATION IN GRAPHITE CRUCIBLES.** The advantages of the method of vertical direct crystallization (VDC) over the widely used Czochralski method is the low cost of the crystals, high productivity, and simplicity in control of the process, as well as the possibility of obtaining ingots of any cross section. In our study we show that it is possible to grow single crystals of silicon by the VDC method in inexpensive crucibles made from modified graphite. A thermal assembly has been developed that contains a heater, a crucible, and heat insulation. The crucible is installed within the heater on a graphite rod. To control the structure of the crystal being grown it is necessary to act on the shape of the crystallization front (CF). This is done most simply by varying the relationship of the heat fluxes from center and from the periphery of the bottom of the crucible. In the thermal assembly developed the CF shape was regulated by varying the thermal resistance of the rod.

Basovskii, A.A.; Kats, E.A.; Chertov, B.N.; Rogailin, M.I. *Sov Electr Eng* v 58 n 11 1987 p 113.

**095192 DIRECT OBSERVATION BY X-RAY RADIOGRAPHY OF CONVECTION OF MOLTEN SILICON IN THE CZOCHRALSKI GROWTH METHOD.** Convection of molten silicon during Czochralski single crystal growth was directly observed using X-ray radiography. The melt flow pattern was monitored using a tracer method. The tracer, whose density and wettability were adjusted to that of the molten silicon, was developed. The observed convection of the molten silicon in the crucible was not only steady but also transient, and not axisymmetric but asymmetric. This asymmetry is attributed to the asymmetric temperature distribution within the crucible. The flow velocity of the molten silicon in the 75 mm diameter crucible was 10 to 20 mm/s. (Author abstract) 16 refs.

Kakimoto, Koichi (NEC Corp, Kawasaki, Jpn); Eguchi, Minoru; Watanabe, Hisao; Hibiya, Taketoshi. *J Cryst Growth* v 88 n 3 May 1988 p 365-370.

**095193 ELECTRICAL SIZE EFFECTS OF THIN C54-TiSi<sub>2</sub> FILMS GROWN ON SILICON SUBSTRATES.** The temperature dependences of the Hall constant  $R_H$  and resistivity at various thicknesses for C54-TiSi<sub>2</sub> films grown on (111) and (100) silicon substrates were measured. The resistivity increases as temperature increases with a character incongruent with the Bloch-Grüneisen equation as followed by normal metals. The magnitude of  $R_H$  has a flat appearance at high temperatures (for  $T > 400$  K), and increases as the temperature decreases and reaches a maximum value near 360 K, and then decreases to reverse the sign at low temperatures. The thinner the film thickness, the higher the temperature for sign reversal. The experimental data can be satisfactorily explained by the classical size effect and two-band model. (Author abstract) 14 refs.

Yang, Jeng-Rern (Nat'l Tsing Hua Univ, Hsinchu, Taiwan); Lue, Juh Tzeng. *Solid State Commun* v 65 n 12 Mar 1988 p 1613-1616.



**095194 HIGH DEPOSITION RATE GROWTH OF a-Si:H BY PHOTO-CHEMICAL VAPOR DEPOSITION USING VACUUM ULTRA-VIOLET LIGHT.** The promotion of chemical reaction by Hg sensitization, or the use of high power light source are examined to increase the deposition rate. The source gas is effectively decomposed by vacuum ultraviolet (UV) light whose wavelength is much shorter than the absorption edge of the source gas. By the appropriate combination of the source gas and the light, the author has successfully achieved a high deposition rate by the direct decomposition using incoherent light. (Edited author abstract) In Chinese. 6 refs.

Du Kaiying (Sichuan Univ, Chengdu, China). *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 278-282.

**095195 SCIENCE AND ENGINEERING OF LARGE-DIAMETER CZOCHRALSKI SILICON CRYSTAL GROWTH.** Silicon is the major semiconductor material used in solid state electronics. To keep pace with the growth in integrated circuit size and complexity, silicon has to be prepared in single crystal form with continued increases in size and improvements in perfection. Modern integrated circuits called VLSI (for Very Large Scale Integration) and future circuits called ULSI (for Ultra Large Scale Integration) depend upon the availability of highly perfect single crystals which are prepared almost exclusively from silicon pulled from the melt by the Czochralski (CZ) technique. In this review the major advances in the understanding and engineering of this technology are discussed for crystals of 100 mm in diameter and approximately 20 kg in mass. 50 refs.

Lin, Wen (AT&T, Allentown, PA, USA); Benson, K.E. *Annu Rev Mater Sci* v 17 1987 p 273-298.

**095196 INFLUENCE OF DIFFERENT DEPOSITION PARAMETERS ON THE PROPERTIES OF HYDROGENATED AMORPHOUS SILICON FILMS PREPARED BY MAGNETRON SPUTTERING.** Hydrogenated amorphous silicon films have been reactively sputtered with different flow rates of hydrogen in an Ar-H<sub>2</sub> gas mixture. The films have been characterized with respect to optoelectronic and structural properties. The susceptibility to light-induced changes has been studied. The effects of variation of the rf power density and the total pressure on the film properties have also been examined. Each of the deposition parameters has been found to exercise considerable control on the film characteristics. Parametric optimization has yielded encouraging results in terms of film quality. (Edited author abstract). 12 Refs.

Das, Debajyoti (Indian Assoc for the Cultivation of Science, Calcutta, India); Banerjee, Ratnabali; Batabyal, A.K.; Barua, A.K. *J Non Cryst Solids* v 103 n 1 6(II) 1988 p 143-148.

**095197 CORRELATIONS BETWEEN THERMAL DONOR FORMATION, ROD-LIKE DEFECT FORMATION, AND OXYGEN REDUCTION DURING LOW-TEMPERATURE ANNEALING OF CZ-GROWN SILICON.** Complex investigations of the oxygen reduction, TD and RLD formation are described for annealing at temperatures from 440 up to 500°C for 200 to 1500 h. The measurements of the TD activity refer to different species which only partially correspond to the double donors. The oxygen reduction as well as the TD activity point to the existence of silicon self-interstitials. The strong influence of self-interstitials is also derived from the defect formation during annealing at these temperatures. It is found that besides RLD's also isolated defects parallel to {111} habit planes exist showing contrasts which indicate an analogous crystalline structure as previously described for RLD's. Supposing that self-interstitials are the dominant point defect type for the TD and RLD formation, a model of precipitation processes in the low-temperature region is discussed. (Edited author abstract). 29 Refs.

Reiche, M. (Acad der Wissenschaften, Halle, East Ger); Reichel, J.; Nitzsche, W. *Phys Status Solidi A* v 107 n 2 Jun 1988 p 851-865.

**095198 MASS TRANSPORT IN A CZOCHRALSKI PULLER WITH A STRONG MAGNETIC FIELD.** This paper treats the mass transport of oxygen in a Czochralski silicon crystal puller with an extremely strong, uniform, axial magnetic field. The problem is intrinsically unsteady and the oxygen concentration of a crystallizing particle depends on its trajectory since the beginning of crystal growth. The results provide the base solution for the mass transport problem with much weaker magnetic fields. (Author abstract) 5 refs.

Hjellming, L.N. (Univ of Illinois, Urbana, IL, USA); Walker, J.S. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 25-31.

**095199 NUMERICAL ANALYSIS OF OXYGEN TRANSPORT IN MAGNETIC CZOCHRALSKI GROWTH OF SILICON.** A series of numerical analyses was executed in order to interpret the different kinds of behavior between the transverse MCZ and the axial MCZ on oxygen contents in Si crystals, which are low in the transverse MCZ but very high in the axial MCZ; such a tendency was reproduced by the calculations. The reasons of the different kinds of behavior between the two fields are discussed. (Author abstract) 9 refs.

Kobayashi, Sumio (Sumitomo Metal Industries Ltd, Amagasaki, Jpn). *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 69-74.

**095200 EFFECTS OF BORON CONCENTRATION UPON OXYGEN PRECIPITATION IN CZ SILICON.** Effects of boron concentration upon oxygen precipitation were studied in Czochralski (CZ) silicon annealed from 2 to 128 h between 450 and 1050°C. In this investigation Bragg line profile (BLP), high resolution diffuse X-ray scattering (DXS) and transmission electron microscopy (TEM) were employed. The BLP and DXS data have shown that the nature of the predominant defects depend upon annealing time and temperature, as well as, on dopant concentration. The long range displacement field of these defects, however, does not seem to be affected by these parameters. The TEM results have shown a dependence of precipitate growth kinetics, as well as, structure upon dopant concentration, and annealing temperature and time. Differences in oxide precipitate growth kinetics between lightly and heavily doped materials and a correlation between DXS parameters and TEM images are discussed. (Author abstract) 16 refs.

Bulla, D.A.P. (Univ de Sao Paulo, Sao Paulo, Braz); Castro, W.E. Jr.; Stojanoff, V.; Ponce, F.A.; Hahn, S.; Tiller, W.A. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 91-96.

**095201 GROWTH OF HIGH QUALITY CoSi<sub>2</sub>/Si SUPERSTRUCTURES ON Si (111).** Using a newly developed solid phase epitaxy technique (SPE) it is shown that ultrathin essentially pinhole-free CoSi<sub>2</sub> layers can be grown epitaxially on Si (111). These form the basis of a number of short period metal/semiconductor superlattices that have been grown by combining SPE-grown CoSi<sub>2</sub> with MBE-grown Si. Substrate temperatures for Si-MBE have to be chosen very low ( $\approx 350^\circ\text{C}$ ) in order to avoid a roughening of the layers. (Author abstract) 18 refs.

von Kaenel, H. (ETH, Zurich, Switz); Henz, J.; Ospelt, M.; Wachter, P. *Superlattices Microstruct* v 4 n 1 1988, Chicago Conf, Pap, Chicago, IL, USA, 1987 p 27-31.

## Heat Treatment

**095202 EFFECT OF HEAT TREATMENT ON THE STATE OF THE IMPURITIES IN SINGLE-CRYSTAL SILICON.** The changes occurring in a silicon solid solution under the action of heat treatment in the 300-1300°C temperature range were studied by the IR

absorption method. It was found that in the temperature range in which changes in the structural and electrical parameters occurred. There was a simultaneous decrease in the oxygen, carbon, boron and phosphorus concentrations in the silicon solid solution. (Translated author abstract) In Russian. 9 refs.

Guskina, L.G.; Fal'Kevich, E.S. *Tsvet Met* n 9 Sep 1987 p 58-59.

**095203 HIGH-TEMPERATURE TREATMENT OF HEM POLY-SI.** Polycrystalline silicon (poly-Si) is one of the prospective materials for solar energy conversion. The author studied the high-temperature effects on HEM-type poly-Si. Thermal treatment was carried out in a nitrogen atmosphere so that nitrogen caused dislocation locking close to the surfaces and prevented out-diffusion of oxygen and carbon. Therefore, out-diffusing impurities were precipitated close to the surface forming [C, O] complexes and amorphous SiO<sub>2</sub> phase and giving rise to the observed infrared spectra. 6 refs.

Pivac, B. (Ruder Boskovic Inst, Zagreb, Yugosl); Urli, N. *J Mater Sci Lett* v 7 n 1 Jan 1988 p 9.

**095204 NUCLEATION KINETICS OF PLATE-LIKE OXIDE PRECIPITATES IN Cz-SILICON.** A quantitative model of nucleation kinetics of platelike oxide precipitates in Czochralski-grown silicon is presented. Some features of the precipitate formation neglected in previous models are taken into consideration, i.e., the shape of precipitates, large volume misfit of Si matrix and oxide precipitates as well as partial relaxation of resulting strain energy by the emission of self-interstitials. The results are in good agreement with experimental findings such as 1) the dependence of the oxide precipitate nucleation rate on the interstitial oxygen content in silicon and 2) the shape of precipitates and the rate of self-interstitial emission determined by HREM and infrared spectroscopic investigations, respectively. (Edited author abstract) 28 refs.

Jablonski, J. (Inst of Electron Technology CEMI, Warsaw, Pol); Wojciechowski, J.; Kucharski, K. *Phys Status Solidi A* v 105 n 1 Jan 1988 p 113-121.

**095205 ONE- AND TWO-DIMENSIONAL NON-LINEAR DOPANT DIFFUSION IN CRYSTALLINE SILICON - SOME ANALYTICAL RESULTS.** The diffusion of dopant in crystalline silicon during heat treatment is dependent on the dopant concentration; in particular it is enhanced at high concentrations. Simple mathematical models of this process result in a nonlinear diffusion equation. This paper considers such a model with an initial 1-D Gaussian implant profile and for a simple 2-D implant near a mask edge. Non-dimensional parameters are identified which represent the amount of enhancement, the depth of the implant and the time of the heat treatment relative to physical parameters in the problem. Analytical expressions are presented for the concentration showing junction depths and local structure for various limiting cases of the parameters. Of particular interest is the case of large enhancement when the results include not only those derived elsewhere for the high concentration region but also the detailed structure of the steep front near the junction. Comparison with numerical results is also included. (Author abstract) 9 refs.

Please, C.P. (Univ of Reading, Engl); King, J.R. *Solid State Electron* v 31 n 2 Feb 1988 p 299-305.

## Hydrogenation

**095206 PHYSICAL PROPERTIES AND MICROSTRUCTURE OF AMORPHOUS HYDROGENATED SILICON FILMS.** The technological parameters largely determine the microstructure and composition of an amorphous hydrogenated silicon film. With an increase in the monosilane concentration in the gas mixture and a constant rate of film deposition there is a decrease in the localized-state density at the Fermi level, in the photoconductivity activation energy, in the hydrogen content, and in the SiH<sub>2</sub>/SiH ratio, which, in turn, leads to a decrease in the size of the microinhomogeneities



in the film. Films with a high SiH<sub>2</sub>/SiH ratio have a columnar microstructure and a developed surface relief. In films with a homogeneous structure the monohydride bond type is dominant. The relative photosensitivity and the band gap in films with a homogeneous structure vary very little during variation of the deposition parameters. 9 refs. In Russian.

Mezdrogina, M.M.; Kudoyarova, V.Kh.; Bardamid, A.P.; Novosel'skaya, A.I. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 883-887.

## Imaging Techniques

**095207 NEW MECHANISM FOR SUBSURFACE IMAGING IN SILICON.** We report the use of photo-thermal radiometric microscopy to image through silicon wafers. Experimental results are presented which show that the signal obtained decreases as the normal emissivity of the material on the back surface increases. The theory for the emissivity of partially transparent objects has been extended to explain these findings. We conclude that the contrast is due to photon-induced switching of the infra-red transmission coefficient of the silicon. (Author abstract) 6 refs.

Sheard, S.J. (Univ Coll London, London, Engl); Somekh, M.G. *Electron Lett* v 23 n 21 Oct 8 1987 p 1134-1136.

**Impurities** See ALSO CRYSTALLIZATION—Laser Applications; SEMICONDUCTOR DEVICES; SCHOTTKY BARRIER—Impurities.

**095208 SELECTIVE TRAPPING OF SELF-INTERSTITIALS BY INTERSTITIAL CARBON IMPURITIES IN ELECTRON IRRADIATED SILICON.** Float-zone silicon doped with carbon ( $1.6 \times 10^{17} \text{ cm}^{-3}$ ) has been irradiated with 2 mev electrons below 220 K up to a dose of  $1.9 \times 10^{18} \text{ electrons cm}^{-2}$  leading to a monotonic decrease in the concentration of the substitutional impurity. Interstitial carbon is produced but its concentration saturates and then falls because the defects trap mobile self interstitials. New infrared absorption lines at 966 and  $959 \text{ cm}^{-1}$  (77 K) are ascribed to a C<sub>2</sub>-Si<sub>2</sub> pair defect which also acts as a nucleation site for agglomeration of Si<sub>1</sub> atoms. The latter reactions appear to occur during irradiations at 300 K. (Author abstract) 24 refs.

Chappell, S.P. (Univ of Reading, Reading, Engl); Newman, R.C. *Semicond Sci Technol* v 2 n 10 Oct 1987 p 691-694.

**095209 INTRODUCTION TO GOLD GETTERING IN SILICON AND A DISCUSSION OF INTRINSIC GETTERING.** Metals, and particularly gold, introduce electrical states into silicon which act as traps for charge carriers. While this is desirable in some devices, in others it degrades performance and must be removed by gettering. This paper discusses the problem and presents experimental studies on the mechanism of intrinsic gettering of gold. 30 refs.

Baginski, Thomas A. (Auburn Univ, Auburn, AL, USA). *Gold Bull* v 20 n 3 Sep 1987 p 47-53.

**095210 CALCULUL UNOR NIVELE ADINCI PEN-TRU IMPURITATI INTERSTITIALE IN SILICIU.** [Calculation of Deep Levels for Interstitial Impurities in Silicon], a method is proposed to calculate deep levels for interstitial impurities in Si. The crystal potential is supposed to be a small perturbation for the self consistent Hartree-Fock potential of free impurity atom. A complete computational work is performed for some elements in the first order of perturbation theory. The obtained levels are compared with the experimental ones and a good agreement is found. (Edited author abstract) In Romanian. 10 refs.

Nigulescu, E.C. (Inst Politehnic Bucuresti, Bucharest, Rom); Marian, P.; Popescu, I.M. *Bul Inst Politeh Bucuresti Ser Electroteh* v 46-47 1984-1985 p 65-69.

**095211 TRANSMISSION ELECTRON MICROSCOPY (TEM) STUDY OF OXYGEN PRECIPITATION INDUCED BY INTERNAL GETTERING IN**

**LOW AND HIGH OXYGEN WAFERS.** Czochralski silicon wafers with high (34-40 ppm) and low (22-28 ppm) oxygen content were used to compare the precipitation characteristics of both types of wafers subjected to a four-step getter anneal procedure. TEM observations from the bulk of the wafers that received the full simulated thermal treatment revealed a precipitation regime that began with the nucleation of needle-shaped fundamental precipitates and evolved by coalescence and defect colony generation into the formation of octahedral precipitates. (Author abstract) 24 refs.

Rivaud, L. (Eastman Kodak Co, Rochester, NY, USA); Anagnostopoulos, C.N.; Erikson, G.R. *J Electrochem Soc* v 135 n 2 Feb 1988 p 437-442.

**095212 INVESTIGATION OF ELECTRONIC STRUCTURES FOR INTERSTITIAL 4D TRANSITION-METAL IMPURITIES IN SILICON.** Electronic structure calculations of interstitial 4d transition-metal impurities in silicon have been performed within the framework of Scattered-Wave X $\alpha$  method. The cluster Si<sub>10</sub>Si<sub>16</sub>, which is centered on the tetrahedral interstitial position, is used to simulate the bulk of silicon, where sixteen Si<sup>+</sup> represent the atoms at the cluster surface. In order to eliminate the dangling bond effects, the Si<sup>+</sup> atom is assumed to be the hydrogen atom with the statistical exchange parameter  $\alpha_{\text{Si}}$ . Placing a neutral 4d impurity atom (Pd, Rh, Ru, Tc or Mo) at the center of the cluster Si<sub>10</sub>Si<sub>16</sub>, the new cluster XS<sub>10</sub>Si<sub>16</sub> (X stands for one of the mentioned impurity atoms) simulating the crystal locally perturbed by interstitial impurity atom is constructed. (Edited author abstract) 19 refs. In Chinese.

Wu Ji'an (Acad Sinica, Beijing, China); Tang Jiuyao. *Pan Tao Ti Hsueh Pao* v 9 n 1 Jan 1988 p 27-33.

**095213 GOLD SILICIDE PRECIPITATES IN SILICON.** This letter describes the precipitation of gold in silicon from a highly supersaturated solution. After saturation of float-zone at 1275°C with gold, annealing experiments were performed at 850°C for various annealing times. By means of high-resolution electron microscopy, small particles (10-20 nm diameter) consisting of a metastable gold silicide were found. From selected-area diffraction patterns we deduce an orthorhombic unit cell with  $a=0.960$ ,  $b=0.768$  and  $c=0.690 \text{ nm}$ . (Author abstract) 3 refs.

Baumann, F.H. (Univ Goettingen, Goettingen, West Ger); Schroeter, W. *Phil Mag Lett* v 57 n 2 Feb 1988 p 75-80.

**095214 EVALUATION OF INTRINSIC GETTERING OF GOLD BY OXIDE PRECIPITATION IN CZOCHRALSKI SILICON.** Intrinsic gettering of gold in Czochralski single-crystal silicon was evaluated using neutron activation analysis and electron beam microprobe analysis. Silicon wafers were subjected to oxygen denuding and heat-treatment cycles which produced a defect structure, adjacent to a defect-free region, of either oxide particles, oxide particles and stacking faults at mixed ratios, or stacking faults alone. These were produced to evaluate the possibility of gettering of gold from the defect-free region by mechanisms of dislocation-metal interactions, dislocations associated with stacking faults, stacking faults, or interstitial-metal interactions. None of these mechanisms were found to cause gettering. (Edited author abstract) 23 refs.

Pietila, Doug A. (Boeing Electronics, Seattle, WA, USA); Masson, D. Bruce. *J Electrochem Soc* v 135 n 3 Mar 1988 p 686-690.

**095215 NATURE OF NITROGEN-OXYGEN COMPLEXES IN SILICON.** The nature of nitrogen-oxygen complexes acting as shallow donors in silicon was investigated by measuring the optical absorptions due to the electronic transitions associated with donor electrons. The complexes were eliminated by heat treatment at temperatures higher than 1100°C. The generation processes of nitrogen-oxygen complexes of several kinds were traced by means of both isochronal and isothermal annealings. An analysis of the result led to a picture in which the

complexes of the dominant type consist (each) of one oxygen atom and two or three pairs of nitrogen atoms. (Author abstract) 9 refs.

Suezawa, Masashi (Tohoku Univ, Sendai, Jpn); Sumino, Koji; Harada, Hirofumi; Abe, Takao. *Jpn J Appl Phys Part 1* v 27 n 1 Jan 1988 p 62-67.

**095216 PARAMAGNETIC RESONANCE OF A Se-AL COMPLEX IN SILICON.** In selenium diffused, aluminium doped silicon a new electron paramagnetic resonance (EPR) spectrum, Si-NL31, was observed as a broad structure superposed on the selenium pair resonance. The EPR spectrum could not be analyzed directly, but an intense <sup>27</sup>Al electron nuclear double resonance (ENDOR) spectrum of trigonal symmetry was found to be related to it. The small hyperfine interaction combined with the large quadrupole effect are evidence for a negatively charged, substitutional Al acceptor, with a donor at the nearest neighbour position. By field scanned ENDOR the EPR spectrum could be analysed. The small anisotropy and shift of the g-value with respect to the free electron value is circumstantial evidence for the presence of a selenium double donor. The nearly vanishing contact density on the <sup>27</sup>Al nucleus is evidence for a doublet ground state, for which the defect axis lies in a nodal plane. This explains why the EPR spectrum shows no resolved <sup>77</sup>Se hyperfine structure. The connection to the infrared complex Si:Se(X<sub>1</sub>), which also has a doublet groundstate, is discussed. (Author abstract) 26 refs.

van Oosten, A.B. (Univ van Amsterdam, Amsterdam, Neth); Ammerlaan, C.A.J. *Solid State Commun* v 65 n 9 Mar 1988 p 1039-1044.

**095217 ELECTRON PARAMAGNETIC RESONANCE OF THE Mn<sub>4</sub><sup>0</sup> CLUSTER IN SILICON.** In high-resistivity p-type and n-type silicon doped with manganese the Mn<sub>4</sub><sup>0</sup> cluster is identified by EPR. The spectrum shows a characteristic hyperfine structure and an angular dependence of fine structure at 20 K. The analysis of the spectrum yield the assumption of the following cluster model: the cluster consists of four Mn<sup>0</sup> atoms on nearest interstitial sites; it has cubic/tetrahedral symmetry; spin multiplets with S=0,1,2,3,4,5, and 6 are produced by dominant exchange coupling where the multiplet with S=6 is the ground state observed by the EPR experiments. The photo-EPR results suggest a donor level (Mn<sub>4</sub>)<sup>0/30</sup> near midgap. (Author abstract) 14 refs.

Kreissl, J. (Akad der Wissenschaften der DDR, Berlin, East Ger); Gehlhoff, W. *Phys Status Solidi B* v 145 n 2 Feb 1988 p 609-617.

**095218 CORRELATION OF DIFFUSIVITIES OF VARIOUS ELEMENTS IN SILICON.** In a recent review of thermodynamics of point defects in solids P. Varotsos and K. Alexopoulos considered the case of various (foreign) atoms, diffusing in the same bulk material. In order to confirm their results the authors collected the diffusion constants published by various workers and subjected them to a least squares fitting. 38 refs.

Hadjicantis, V. (Univ of Athens, Athens, Greece); Londos, C.A.; Eftaxias, K. *Phys Status Solidi A* v 105 n 2 Feb 1988 p K87-K92.

**095219 ORIENTATION DEPENDENCE OF OXYGEN THERMAL DONORS IN SILICON UNDER STRESS.** Pre-heat-treated or as-provided p-type Cz-silicon samples were stressed along <011> or <010> direction during 450°C annealing. The generated oxygen thermal donor concentrations were obtained by resistivity measurements. We found that the thermal donor formation rate is not only dependent upon the thermal history of the sample and the stress on the sample, but also depends on the orientation of the sample under stress. (Author abstract) 17 refs.

Wang, Paul W. (SUNY at Albany, Albany, NY, USA); Zhang, Ying; Corbett, James W. *Mater Lett* v 6 n 1-2 Nov 1987 p 1-4.



**095220 CONTRIBUTII LA STUDIUL NIVELELOR ADINCI DE IMPURITATI DINTR-UN SEMICONDUCTOR PRIN DETERMINAREA RATELOR DE EMISIE OPTICA.** [About Deep Impurity Centers in a Semiconductor from Optical Emission Rates]. The results on the optical emission rates and the optical cross sections for the deep level Au impurities in Si from the transient junction current in adequate experimental conditions are presented. (Author abstract) 5 refs. In Romanian.

Cone, Gabriela F.; Popescu, I.M.; Stanciu, Gh.A. *Bul Inst Politeh Bucuresti Electron* v 48 1986 p 9-17.

**095221 NITROGEN-OXYGEN COMPLEXES IN CZOCHRALSKI-SILICON.** Infrared spectra of nitrogen doped Czochralski-grown silicon indicate absorption lines in addition to the well-known lines of local modes of oxygen, carbon and nitrogen centers. The most prominent lines can be shown to be correlated with certain oxygen and nitrogen concentrations. These lines are, therefore, thought to arise from N-O complexes and are discussed in the context of an O-induced disturbance of N<sub>2</sub>-pair vibrations. The results of preliminary investigations on the stability of such complexes are also reported. (Author abstract) 8 refs.

Wagner, P. (Heliotronic GmbH, Burghausen, West Ger); Oeder, R.; Zulehner, W. *Appl Phys A* v A46 n 2 Jun 1988 p 73-76.

**095222 IMPURITY CONCENTRATION DEPENDENCE OF THE 1/f NOISE PARAMETER  $\alpha$  IN SILICON.** A model for mobility fluctuations is applied to calculate numerically the 1/f noise parameter  $\alpha$  as a function of impurity concentration in n- and p-type silicon at room temperature (T=300 K). It is found that  $\alpha(N)$  and  $\alpha(P)$  show minima in the impurity range from  $10^{19}$  -  $10^{20}$  cm<sup>-3</sup>. (Author abstract) 14 refs.

Jevtic, M.M. (Inst of Physics, Zemun, Yugosl). *Solid State Electron* v 31 n 6 Jun 1988 p 1049-1052.

**095223 IMPURITY BANDS IN SILICON AND GERMANIUM.** An account is given of some of the developments which have led to a better understanding of conduction in impurity bands, since the work of Hellmut Fritzsche opened up the subject. (Author abstract) 35 refs.

Mott, Nevill (Cavendish Lab, Cambridge, Engl). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 3-10.

**095224 EXPERIMENTAL SET-UP COMBINED WITH A FOURIER TRANSFORM SPECTROMETER FOR SIMULTANEOUS DETERMINATION OF CONCENTRATIONS OF BOTH SHALLOW ACCEPTORS AND DONORS IN SEMICONDUCTORS.** An experimental set-up combined with a Nicolet 200SXV Fourier transform spectrometer used for simultaneous determination of concentrations of both shallow acceptors and donors in semiconductor samples under the illumination of an external light beam ( $h\nu \geq E_g$ ) is reported. As an example, the concentrations of both boron and phosphorus impurities in silicon have been simultaneously measured using this set-up. (Author abstract). 6 Refs. In Chinese.

Jincai, Xiao (Acad Sinica, China); Zhiyi, Yu; Wei, Lu; Hongjuan, Ye; Jichang, Zhang. *Hongwai Yanjiu A-Ji* v 7A n 3 1988 p 237-240.

**095225 LATTICE DISTORTIONS INDUCED BY CARBON IN SILICON.** X-ray double-crystal diffraction has been used to investigate the lattice distortions in silicon crystals containing carbon impurities. Precise lattice-spacing measurements have been carried out with a double-source double-crystal transmission technique. A linear correlation between the absolute value of lattice spacing and the carbon concentration was observed. X-ray double-crystal reflection topography was used to measure residual minute lattice strains also as a function of the carbon atom number density. A similar relationship was found. A comparison of the results of the lattice-spacing measurements and of the topographic investigations indicates that the lattice consists of consecutive layers

which are alternately more and less carbon enriched. The observed lattice deformations arise from the substitutional exchange of silicon and carbon atoms. (Author abstract). 15 Refs.

Windisch, D. (Physikalisch-Technische Bundesanstalt, Braunschweig, West Ger); Becker, P. *Philos Mag A* v 58 n 2 Aug 1988 p 435-443.

**095226 NON-LOCAL THEORY OF THE METAL-INSULATOR TRANSITION IN Si:P.** In the presence of localized states the Kubo-Greenwood formula for electrical conductivity assumes kinetic asymmetry generated by dissipation. When this asymmetry is combined with topological freedom, the density dependence of the metallic conductivity near threshold is correctly obtained. Anderson localization of electronic states in a random impurity potential is topologically equivalent to domain formation in random-field Ising models. The separable extended states postulated by the theory simply explain recent observations of the Hall effect in one-dimensional wires. (Author abstract). 22 refs.

Phillips, J.C. (AT&T, Murray Hill, NJ, USA). *Philos Mag B* v 58 n 4 Oct 1988 p 361-367.

**095227  $\gamma$ -RAY AND SMALL-ANGLE NEUTRON SCATTERING STUDY OF OXYGEN PRECIPITATION IN SILICON SINGLE CRYSTALS.** Oxygen precipitation in heat-treated Czochralski-grown silicon single crystals has been investigated using  $\gamma$ -ray diffraction combined with small-angle neutron scattering and infrared absorption measurements. Diffuse scattering around the diffraction peaks was observed using  $\gamma$ -rays and this is associated with oxygen precipitation in the silicon lattice. The analysis of the diffuse scattering produces an average precipitate size in agreement with small-angle neutron scattering measurements. (Author abstract). 14 refs.

Kinder, S.H. (Univ of Reading, Reading, Engl); Mes-soloras, S.; Stewart, R.J. *Philos Mag Lett* v 58 n 4 Oct 1988 p 183-188.

**095228 HYDROGEN IN Si: DIFFUSION AND SHALLOW IMPURITY DEACTIVATION.** We analyze the total H profiles obtained from secondary ion mass spectrometry data (SIMS) using (a) the model of H diffusion in the presence of strong trapping, which is the most widely accepted today, and (b) a new electric field enhanced diffusion (drift) model which is supported by recent experimental observations and theoretical predictions of a H-donor state in the band gap. The second model gives excellent fits of the SIMS data over the entire explored temperature range and accounts for the observed dependence of the H penetration depth on impurity type. 63 refs.

Capizzi, M. (Univ di Roma 'La Sapienza', Rome, Italy); Mittiga, A. *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986. p 19-29.

**095229 OXYGEN DONOR IN SILICON.** The effect of uniaxial stress upon the helium-like infrared absorption spectrum of the oxygen donor in Si has been examined for both the neutral and singly ionized charge states. Contrary to the well-known results for substitutional donors in Si, no splittings of the spectral features were observed for a 001 stress direction. Small splittings were observed for 110 and 111 stress directions that are a characteristic of a C<sub>2v</sub> anisotropy. Our results are consistent with an effective-mass-like ground state wave function that is constructed from the single pair of conduction band valleys along the C<sub>2</sub> axis of the oxygen donor defect. Recent deep level transient spectroscopy and electron paramagnetic resonance experiments made with uniaxial stress have also been explained by a ground state wave function constructed from a single pair of conduction band valleys. The relationship between the various measurements is discussed. Outstanding problems for the oxygen donor are also described. (Author abstract) 38 refs.

Stavola, Michael (Bell Lab, Murray Hill, NJ, USA). *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 187-200.

**095230 REMOVAL OF CARBON FROM MOLTEN SILICON.** Various processes have been proposed for the production of solar grade silicon which is not required to have the same purity as that of semiconductor grade. One of the most prominent processes is the reduction of high purity silica with high purity carbon, which yields silicon with metal impurities less than 1ppm but with several hundreds ppm of carbon. Possibilities of reducing carbon content with simple processes have been investigated in this study. The results suggest that the rate of decarburization may be determined by the rate of SiC dissolution into the silicon melt. The effects of filtering tubes was also studied. 2 refs.

Sakaguchi, Koichi (Univ of Tokyo, Jpn); Maeda, Masafumi. *Trans Iron Steel Inst Jpn* v 28 n 1 1988, Prepr for the 114th ISIJ Meet, Part I, Kumamoto, Jpn, Oct 9-11 1987 p B.33.

**095231 PASSIVATION IN SILICON.** We summarize recent results in hydrogen passivation in silicon, and present the first comprehensive diffusion profiles, i.e. profiles in floating zone n-type and p-type vs. temperature and vs. resistivity. Domination of hydrogen diffusion by impurity trapping is clearly indicated for part of the profile in low resistivity p-type silicon. Also discussed are the current models of hydrogen passivation of dangling bonds, shallow acceptors, shallow donors and hyper-deep defects. (Author abstract) 14 refs.

Corbett, J.W. (Univ at Albany, Albany, NY, USA); Lindstrom, J.L.; Pearton, S.J.; Tavendale, A.J. *Sol Cells* v 24 n 1-2 May-Jun 1988, Proc 8th Photovoltaic Adv Res Dev Proj Rev Meet, Denver, CO, USA, Nov 15-18 1987 p 127-133.

**Ion Implantation** See Also ELECTRON BEAMS—Applications; INTEGRATED CIRCUITS; SEMICONDUCTING BORON—Activation; SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers; SEMICONDUCTOR DEVICES—Imaging Techniques; SEMICONDUCTOR DEVICES, MOS; SEMICONDUCTOR DEVICES, MOSFET; SEMICONDUCTOR MATERIALS—Radiation Effects; SEMICONDUCTOR MATERIALS—Thermal Effects; SILICON COMPOUNDS—Forming; SOLIDS—Ion Implantation; TITANIUM AND ALLOYS—Ion Implantation.

**095232 THERMAL REDISTRIBUTION OF FLUORINE IN BF<sub>2</sub><sup>+</sup>-IMPLANTED SiO<sub>2</sub>/Si STRUCTURES.** Concentration profiles of fluorine is isochronal vacuum-annealed single-crystal Si and SiO<sub>2</sub>/Si structures implanted with  $2 \times 10^{15}$  111 keV <sup>11</sup>B<sup>19</sup>F<sub>2</sub><sup>+</sup> ions cm<sup>-2</sup> have been studied by the nuclear resonance broadening technique through the reaction <sup>19</sup>F(p,  $\alpha$ )<sup>16</sup>O. No loss of redistribution of fluorine was observed in either the Si or SiO<sub>2</sub>/Si samples for 30 min anneals up to 700°C. Annealing the Si targets above this temperature led to loss and redistribution (up to 80% at 1000°C) of fluorine. Annealing of the SiO<sub>2</sub>/Si samples at 900°C and above led to lower loss (10% at 1000°C) and agglomeration of the fluorine, most probably at the SiO<sub>2</sub>/Si interface. (Author abstract) 36 refs.

Whitlow, Harry J. (Royal Inst of Technology, Stockholm, Swed); Keinonen, Juhani; Zaring, Carina; Petersson, C. Sture. *Semicond Sci Technol* v 2 n 9 Sep 1987 p 625-627.

**095233 STUDY OF DEFECTS IN PHOSPHORUS ION-IMPLANTED SILICON.** Defects in phosphorus implanted silicon with doses from  $5 \times 10^{14}$  to  $1 \times 10^{16}$  cm<sup>-2</sup>, thermally annealed in a tube furnace at 900°C, have been studied by transmission electron microscopy. A dislocation network with regular distribution was observed for the sample with dose  $1 \times 10^{16}$  cm<sup>-2</sup>. For samples with doses  $5 \times 10^{15}$  cm<sup>-2</sup>, different density dislocation loops were observed. The formation mechanism of



the dislocations is due to the release of misfit stress under the action of thermal annealing. (Edited author abstract) 11 refs. In Chinese.

Shen, Hou-yun (Wuhan Univ, China); Pan, Xian-zheng; Guo, Huai-xi; Jian, Jin-chen. *Xi You Jin Shu* v 5 n 2 May 1986 p 105-108.

**095234 INVESTIGATION OF THE THERMAL STABILITY OF ION-IMPLANTED AND LASER ANNEALED SILICON LAYERS.** Laser annealing of ion-implanted layers of silicon permits the production of supersaturated solutions of substitution of various impurities in silicon. On the basis of studying the thermal stability of supersaturated solutions of substitution of antimony in silicon, obtained by ion-implantation and pulsed laser annealing, the causes of their thermal instability are manifested and the conditions providing for improved thermal stability of such supersaturated solutions are determined. 10 refs.

Batische, S.A.; Danilovich, N.I.; Mostovnikov, V.A.; Pristrem, A.M.; Tatur, G.A. *J Appl Spectrosc* v 46 n 4 Apr 1987 p 364-368.

**095235 X-RAY TOPOGRAPHY STUDY OF THE EFFECTS OF  $\text{Cl}^+$  AND  $\text{F}^+$  IMPLANTATION IN SILICON ON OXIDATION INDUCED STACKING FAULTS AND DISLOCATION.** Oxidation accompanies the fabrication of almost every silicon integrated circuit device. As a consequence, crystallographic defects are frequently generated. In particular, the presence of oxidation-induced stacking faults have a deleterious effect on the electrical performance of bipolar charge-coupled imaging devices. To study this, the effect of  $\text{Cl}^+$  and  $\text{F}^+$  ion implantation on oxidation-induced stacking faults in floating zone grown silicon was investigated using double-crystal x-ray topography. Chloride ion implantation resulted in the shrinkage of oxidation-induced stacking faults after annealing at  $1200^\circ\text{C}$  in  $\text{O}_2$  atmosphere. (Edited author abstract) In Chinese 11 refs.

Xu, Jing-yang (Acad Sinica, China); Bronsveld, P.M.; Boom, G.; De Hosson, J.Th.M. *Xi You Jin Shu* v 6 n 1 Feb 1987 p 15-21.

**095236 INVESTIGATION OF SILICIDE FORMATION FROM Nb/Si MULTILAYER FILM AND As OUT-DIFFUSION DURING  $\text{NbSi}_2$  FORMATION.** The formation of  $\text{NbSi}_2$  from Nb/Si multilayer film, its properties and the out-diffusion of implanted As atoms during  $\text{NbSi}_2$  formation were investigated. Rutherford backscattering of nine layers of silicon and eight layers of niobium evaporated alternatively on a silicon substrate. After annealing at  $900^\circ\text{C}$  for 30 minutes, the Nb/Si multilayer films became a silicide film of good quality. In comparison with the silicide formed from a single metal layer, the multilayer structure shows less As out-diffusion and loss during silicide formation. In comparison with routine  $900^\circ\text{C}$  30 minutes oven annealing for silicide formation, scanning electron beam annealing further decreases the out-diffusion and loss of implanted As atoms due to its transient annealing character. In Chinese 8 refs.

Wu, Ming-fang (Peking Univ, China); Xia, Zong-huan; Yao, Shu-de; Zhang, Guo-bing; Wang, Yang-yuan. *Xi You Jin Shu* v 6 n 1 Feb 1987 p 32-37.

**095237 ANOMALOUS CHANNELLING EFFECTS IN ION-IMPLANTED SILICON.** In this work results of a Monte Carlo simulation of the ion penetration in a crystalline silicon target are reported. It is shown that, contrary to the common expectation, channeling is sustained by a non-vanishing divergency of the ion beam for a nominally random orientation of the target. (Author abstract) 13 refs.

Mazzone, A.M. (CNR, Bologna, Italy). *Phil Mag Lett* v 55 n 5 May 1987 p 235-238.

**095238 APPLICATION OF THE TRUNCATED TWO-PIECE NORMAL DISTRIBUTION TO THE MEASUREMENT OF DEPTHS OF ARSENIC IMPLANTS IN SILICON.** The truncated two-piece normal

distribution is applied to data obtained from backscattering experiments in order to investigate the depth of arsenic implants in silicon. (Author abstract) 13 refs.

Kimber, A.C. (Univ of Surrey, Guildford, Engl); Jaynes, C. *Appl Stat* v 36 n 3 1987 p 352-357.

**095239 LATTICE DAMAGE, BORON DIFFUSION, AND DOPANT ACTIVATION IN  $\text{BF}_2$  IMPLANTED LAYERS.** The properties of boron-doped silicon layers obtained by ion implantation using  $\text{BF}_2^+$  molecular ions are studied with Rutherford backscattering spectrometry, transmission electron microscopy, secondary ion mass spectrometry, and with incremental sheet resistance and sheet Hall coefficient measurements by the anodic sectioning method. The implantation step is responsible for the formation of interstitial aggregates at the amorphous/crystal interface. The size of these aggregates, and hence the total number of defects involved, depends on the implant conditions, and is different for samples implanted in the two systems used (a medium current and a high current implanter). (Edited author abstract) 17 refs.

Queirolo, G. (SGS Microelettronica, Agrate, Italy); Caprara, P.; Meda, L.; Guareschi, C.; Anderle, M.; Ottaviani, G.; Armigliato, A. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2905-2910.

**095240 DAMAGE CREATED BY HIGH-CURRENT-DENSITY IMPLANTS OF PHOSPHORUS INTO  $\langle 100 \rangle$  AND  $\langle 111 \rangle$  SILICON WAFERS.** The damage left by high-current-density implants of 120 keV phosphorus into  $\langle 100 \rangle$  and  $\langle 111 \rangle$  silicon oriented substrates was investigated as a function of the fluence in the range  $4 \times 10^{15}$ – $1.5 \times 10^{16}/\text{cm}^2$ . The samples were analyzed by 2 MeV  $\text{He}^+$  channeling and transmission electron microscopy. The results are compared with the ion assisted regrowth of amorphous layers at well defined temperatures in the  $250^\circ\text{C}$ – $400^\circ\text{C}$  range. (Edited author abstract) 17 refs.

Servidori, M. (CNR-LAMEL, Bologna, Italy); Cannavo, S.; Ferla, G.; La Ferla, A.; Rimini, E. *Appl Phys A* v 44 n 3 Nov 1987 p 213-218.

**095241 ATOMIC STRUCTURE OF DISLOCATIONS AND DIPOLES IN SILICON.** Dislocations of the  $a/2 \langle 110 \rangle$  Burgers vector lying in  $\{001\}$  and  $\{111\}$  planes in the form of cross-grids are often observed in ion-implanted and thermally annealed specimens of diamond cubic materials. In order to assess the mechanism of formation of these dislocations, we have calculated the energies and determined the atomic core structures of  $a/2 \langle 110 \rangle \{001\}$  edge dislocations and their dipoles, and of  $a/2 \langle 110 \rangle \{111\}$  dislocations in silicon by minimizing the total configurational energy. The calculations were made using Keating potentials and these results are compared with those obtained using more recent ideas. The results indicated that non-equilibrium effects must prevail during the formation of observed dislocation dipoles. (Edited author abstract) 18 refs.

Nandedkar, A.S. (North Carolina State Univ, Raleigh, NC, USA); Narayan, J. *Philos Mag A* v 56 n 5 Nov 1987 p 625-639.

**095242 TEMPERATURE AND TIME DEPENDENCE OF DOPANT ENHANCED DIFFUSION IN SELF-ION IMPLANTED SILICON.** Diffusion experiments for boron, phosphorus, arsenic, and antimony were performed in the presence of lattice defects produced by silicon ion implantation. The effects of transient enhanced diffusion were revealed by beveling and staining measurements on selectively implanted samples and by SIMS determinations of dopant profiles. The annealing of the doped implanted specimens ranged from  $700^\circ$  to  $1100^\circ\text{C}$ , the last treatment having been made by electron beam. The low temperatures allowed the following of the kinetics of the anomalous diffusion: it was ascertained that the enhanced diffusion coefficient is nearly constant until a time value is reached which decreases with the temperature increase, after which it tends gradually to the equilibrium value. (Edited author abstract) 32 refs.

Angelucci, R. (CNR, Bologna, Italy); Cembali, F.; Negri, P.; Servidori, M.; Solmi, S. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3130-3134.

**095243 EFFECT OF BEAM CURRENT ON THE CRYSTAL QUALITY OF THE RESIDUAL SILICON LAYER IN BURIED NITRIDE STRUCTURE FORMED BY NITROGEN IMPLANTATION WITH A STATIONARY BEAM.** The authors demonstrate that the crystal quality of the residual silicon layer in buried silicon nitride structure produced by nitrogen implantation with a stationary beam apparently depends on the beam current. When the beam current is low (0.05–0.15 mA) and, hence, the local peak temperature during implantation is low ( $300^\circ$ – $600^\circ\text{C}$ ), the residual silicon layer is highly defective. When the beam current is sufficiently high (0.2 and 0.4 mA), albeit there is a large temperature cycling effect, a superior quality surface can be formed due to the high temperature in situ heating during implantation. 17 refs.

Poon, M.C. (Chinese Univ of Hong Kong, Hong Kong); Wong, S.P.; Lam, Y.W.; Kwok, H.L. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3190-3191.

**095244 RESISTANCE CHANGES IN SILICON BY MeV PROTON IMPLANTATION.** Protons were implanted into the phosphorus-doped ( $6 \times 10^{13} \text{ cm}^{-3}$ ) epitaxial region of insulated gate transistors at MeV energies and doses ( $3 \times 10^{11}$ – $10^{13} \text{ cm}^{-2}$ ) in the range of those used for lifetime control in silicon power devices. Spreading resistance depth profiles were used to study changes in resistance after implantation and subsequent annealing. After implantation, the largest resistance increase occurs near the proton range; the resistance profile is similar to the expected displaced atom profile. The resistance increase is attributed to carrier compensation rather than to a decreased mobility. At a dose of  $10^{13} \text{ cm}^{-2}$  1.5 MeV protons, the resistance increase is observed to saturate. (Edited author abstract) 15 refs.

Mogro-Campero, A. (GE, Schenectady, NY, USA); Chang, M.F.; Benjamin, J.L. *J Electrochem Soc* v 135 n 1 Jan 1988 p 172-176.

**095245 STUDY OF POSTANNEALING AND IN SITU ANNEALING OF SILICON WAFERS IMPLANTED WITH A HIGH DOSE OF OXYGEN.** The effects of postannealing and in situ annealing on the reduction of oxygen ion implantation damage in silicon wafers were investigated by means of scanning electron microscopy, Rutherford backscattering spectrometry, and transmission electron microscopy. The results of this study, which utilized an etch-pit technique in a conjunction with the SEM, showed that a high postannealing temperature ( $> 1000^\circ\text{C}$ ) was needed to effectively lower the imperfection density in the top surface region of silicon wafers. A postannealing time of 2h at a high temperature ( $> 1000^\circ\text{C}$ ) was sufficient to significantly reduce the implantation damage in the top silicon surface region. (Edited author abstract) 10 refs.

Wang, Ping (Univ of Arizona, Tucson, AZ, USA); Sjoreen, T.P.; Chang, Li; Demer, L.J. *J Electrochem Soc* v 135 n 1 Jan 1988 p 186-190.

**095246 INCORPORATION OF ION-IMPLANTED ALUMINUM IN SILICON ANNEALED AT HIGH TEMPERATURES.** In this paper a case study of Al implanted in  $\langle 111 \rangle$ -Si and annealed at high temperatures ( $\geq 1200^\circ\text{C}$ ) is presented. At such high temperatures, deep junctions ( $\geq 10 \mu$ ) were easily achieved using Al as a p-type dopant. Our Al profiles for samples annealed at  $1200^\circ\text{C}$  are qualitatively similar to those reported in the literature. Precipitates of aluminum oxide having a crystalline structure were found in the implanted region and associated with the anomalous redistribution of Al observed in SIMS analysis. This is the first time that the



presence of precipitates of aluminum oxide having a crystalline structure in Al-implanted and annealed Si has been reported. 9 refs.

Chang, H.R. (GE, Schenectady, NY, USA); Lewis, N.; Smith, G.A.; Hall, E.L.; Temple, V.A.K. *J Electrochem Soc* v 135 n 1 Jan 1988 p 252-257.

**095247 BEEINFLUSSUNG DER  $\text{MoSi}_2$ -SILICIERUNG AUF KRISTALLINER UNTERLAGE INFOLGE IONENIMPLANTATION DURCH DUENNE MO-SCHICHTEN.** [Influence of Ion Implantation Through Thin Mo Layers on Molybdenum Silicide Formation on a Crystalline Base]. It is shown that ion implantation by thin molybdenum layers on crystalline silicon with sufficiently large ion doses results in the formation of hexagonal silicide phases. This modification does not encompass, however, the entire Mo layer of the appropriate thickness. The profiles of the dopants as well as a self-aligning diode technology are presented. (Translated author abstract) In German. 11 refs.

Gessner, Thomas; Tolonics, Johann; Vetter, Egbert. *Wiss Z Tech Univ Karl Marx Stadt* v 29 n 4 1987 p 512-520.

**095248 AI-RECOIL IMPLANTATION INTO n-TYPE Si USING DIFFERENT PRIMARY IONS.** Al/Si is probably the most widely investigated metal semiconductor structure ever examined. This work studied the effects of Al-recoil implantation into n-type Si using  $\text{Ar}^+$ ,  $\text{B}^+$  and  $\text{BF}_2^+$  as the primary ions. At different implant dosages, simulated profiles, sheet resistances, I-V curves were measured to determine the properties of the implanted surface layers. It was found that the activation of the recoiled Al was much lower compared with that of B. At low implant dosages, Schottky barriers were formed. They became p-n junctions at the higher implant dosages. Transitional properties were affected by the recombination mechanisms and damage. The  $\text{Ar}^+$ -implanted samples produced p-n junctions with somewhat inferior characteristics. (Author abstract) 10 refs.

Kwok, H.L. (Chinese Univ of Hong Kong, Hong Kong); Wong, W.C.; Wong, S.C. *Semicond Sci Technol* v 3 n 1 Jan 1988 p 6-11.

**095249 DISTRIBUTIONS OF BORON AND PHOSPHORUS IMPLANTED IN SILICON IN THE ENERGY RANGE 0.1-1.5 MeV.** Boron and phosphorus were implanted in p-type and n-type silicon wafers in the energy range from 0.1 to 1.5 MeV. Three different methods were used to determine the distribution of the ions: SIMS, CV and NRA. The results were fitted to a Pearson IV distribution in order to extract moments for describing the distributions analytically. The projected ranges agree well with the theoretical values. Deviations are observed at higher energies. Projected range standard deviations are significantly greater than the tabulated values. The skewness clearly deviates from available tabulated data, although the same trend is observed. (Author abstract) 22 refs.

Oosterhoff, S. (Twente Univ of Technology, Enschede, Neth). *Nucl Instrum Methods Phys Res Sect B* v B30 n 1 Feb 1988 p 1-12.

**095250 PROPERTIES OF CLUSTERED INTERSTITIALS IN ION-IMPLANTED SILICON: COMPARISON BETWEEN A MONTE CARLO SIMULATION AND X-RAY DIFFRACTION MEASUREMENTS.** In this letter a dynamical Monte Carlo method is used to calculate the strain induced in a silicon lattice by the disorder caused by implantation. The model is based on the prevailing role of clustered interstitials. Comparison with experiments shows that the disorder which survives spontaneous annealing is attributable to the few interstitial clusters formed within the cascade volume. (Author abstract) 16 refs.

Mazzoni, A.M. (Centro Nazionale Ricerche-Istituto Lab Materiali e Componenti Elettronica, Bologna, Italy); Servidori, M. *Phil Mag Lett* v 57 n 2 Feb 1988 p 85-90.

**095251 EFFECT OF A TEMPERATURE GRADI-**

**ENT ON ARSENIC DIFFUSION IN SILICON.** The effect of a temperature gradient on arsenic diffusion was investigated. Arsenic-implanted silicon wafers were subjected to temperature gradients in the order of  $100^\circ\text{C cm}^{-1}$  in a rapid thermal anneal apparatus. No measurable differences were observed in the arsenic profiles by changing the direction of the temperature gradient in the low dose ( $1 \times 10^{14} \text{ cm}^{-2}$ ) Si(111) and Si(100). The calculations agree well with measured results for the low and high dose Si(100). However, there is disagreement for the high dose Si(111). It is proposed that the defect-enhanced Soret effect, which couples arsenic diffusion flux to the heat flux in the highly disordered crystal, may cause the observed temperature gradient dependence in arsenic penetration. (Edited author abstract) 20 refs.

Feynson, A. (AT&T Bell Lab, Reading, PA, USA); Zemel, J.N. *Thin Solid Films* v 157 n 1 Feb 15 1988 p 49-57.

**095252 CONDUCTIVITY OF ION IMPLANTED AND RAPID THERMAL ANNEALED SEMI-INSULATING POLYCRYSTALLINE SILICON.** Semi-insulating polycrystalline silicon (SIPOS) films of various oxygen content have been deposited on silicon dioxide. The films were implanted with As, B, and P and were annealed with a tungsten-halogen lamp rapid thermal annealing furnace. A low temperature forming gas anneal was included as a last step. The sheet resistance was found to be a function of oxygen content of the film, ion implantation dose, type of dopant implanted, and annealing conditions. Sheet resistances could be controlled over five orders of magnitude by controlling the above parameters. Boron gave a lower sheet resistance with arsenic and phosphorus giving larger values for the same fabrication conditions. (Edited author abstract) 29 refs.

Ozguz, V.H. (North Carolina State Univ, Raleigh, NC, USA); Wortman, J.J.; Hauser, J.R.; Littlejohn, M.A.; Rozgonyi, G.A.; Curran, P. *J Electrochem Soc* v 135 n 3 Mar 1988 p 665-671.

**095253  $\text{BF}_2^+$  ION IMPLANTATION IN SILICON.** In the present work we study the effect of the ion post-acceleration on the boron depth profile in  $\text{BF}_2^+$ -implanted silicon layers. Experiments show that SIMS boron depth profiles show two boron peaks: a first one, closer to the surface, is well described by a gaussian distribution, as modeled for an amorphous matrix; and a deeper second one, due to dissociated  $\text{BF}_2^+$ , is well described by a Pearson IV distribution plus exponential tail. The dissociation of  $\text{BF}_2^+$  takes place just after the mass analysis, before the post-acceleration, with an efficiency of the order of 2-5% for the DF-3000 Varian implanter; however, this result depends on the particular experimental arrangement. 12 refs.

Queirolo, G. (SGS Microelettronica SpA, Agrate, Italy); Bresolin, C.; Meda, L.; Anderle, M.; Canteri, R. *J Electrochem Soc* v 135 n 3 Mar 1988 p 777-780.

**095254 HALL ELEMENT YIELDING A PRECISE FIELD-LINEAR HALL VOLTAGE UP TO A HIGH-FIELD REGION.** A Hall element yielding a precise field-linear output up to 8 tesla has been developed using heavily As-ion implanted Si. The deviation from the linear relationship was less than 0.1% from 1.5 to 8 tesla at 4.2 K. The material design was so made that the conducting surface layer was thinner than 1 micron and the mobility and field product were smaller than 0.04 at 8 tesla. (Author abstract) 7 refs.

Oguro, Isamu (Univ of Tokyo, Tokyo, Jpn); Sasaki, Yoshisato; Itoh, Kazuo; Tanuma, Sei-ichi. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 263-265.

**095255 DETERMINATION OF DOPING PROFILES FOR LOW BORON ION IMPLANTATIONS IN SILICON.** A method for determination of doping profiles from the silicon surface to the deep bulk using a high frequency C-V technique is presented. Experimental results using Ziegler's method for obtaining the profile near the surface are compared with theoretical calculations assuming Gauss type distribution and using spread-

ing resistance measurements. Doping profiles of boron implanted at 60 keV with doses in the range of  $6 \times 10^{10}$  -  $3 \times 10^{12} \text{ cm}^{-2}$  were investigated. The obtained peak value of the profile  $N(x)$  and its linear dependence on the implanted dose  $N_d$  can be used for the determination of low boron doses in p-type silicon substrates during MOS device fabrication. (Author abstract) 12 refs.

Kinder, R. (Technical Univ of Bratislava, Bratislava, Czech); Frank, H. *Solid State Electron* v 31 n 2 Feb 1988 p 265-268.

**095256 STUDY OF LATTICE DAMAGE IN ION-IMPLANTED SILICON WAFERS BY PHOTOACOUSTIC SPECTROSCOPY.** The effect of boron or phosphorus implantation on silicon wafers and the annealing behaviour of ion-implanted silicon wafers are studied by photoacoustic spectroscopy (PAS). Lattice damage induced by ion-implantation with doses  $10^{12} \text{ cm}^{-2}$  to approximately  $10^{15} \text{ cm}^{-2}$  is observed. After annealing, the residual defects in the damage region are examined. It is concluded that the rapid thermal annealing is more effective than the conventional one in removing the defects in ion-implanted layers of silicon wafers under certain circumstances. (Edited author abstract) 10 refs.

Su Jiuling (Fudan Univ, China); Bao Zongming. *Chin J Infrared Res Ser B (Engl Ed)* v 6 1987 p 73-80.

**095257 OPTICAL PROFILE ANALYSIS OF DIFFUSED AND ION-IMPLANTED SILICON.** In doping profiles used by modern semiconductor technology there are large gradients of the complex refractive index which produce significant spectra of integral optical reflectivity and transmission by internal reflection. In this case the calculus of geometrical optics approximation cannot be used. It is shown that it is possible to calculate the spatial distribution of the optical constants and the local free carrier concentration, respectively, using the matrices calculation of multilayer structures and the Drude theory. The concentration profiles which are used for as an example are present in boron diffused (surface concentration up to  $N_0 = 3.4 \times 10^{20} \text{ cm}^{-3}$ ) and ion implanted (fluence of implanted boron ions:  $N_{D,0} = 10^{16} \text{ ions/cm}^2$  at 150 keV) silicon samples. After successive isochronally annealing (700 to  $950^\circ\text{C}$ ) the implanted ions are activated as an increasing modified Gauss profile. Another aspect is the question of transmission and reflectance if the direction of wave propagation is changed in connection with the theorem of reciprocity. In agreement with theory the integral transmission is symmetrical, but the integral reflection is asymmetrical. (Edited author abstract) 14 refs.

Kessler, F.R. (Technische Univ Braunschweig, Braunschweig, West Ger); Barkow, U.; Nies, R.; Unzner, N. *Phys Status Solidi A* v 105 n 2 Feb 1988 p 627-635.

**095258 STUDY ON  $\text{Fe}^+$  IMPLANTED IN SILICON.**  $\text{Fe}^+$  implanted in silicon is studied by way of the conversion electron Moessbauer spectroscopy, together with the second ion microprobe spectroscopy, and the measurements of the electrical and optical parameters of the implanted layer. The results show that before and after low temperature annealing, the high dose of the implanted iron in silicon is concentrated in many small zones in the implanted layer rather than uniformly distributed in it. The iron is in substitutional positions in these densely concentrated zones. After low temperature annealing the iron is still in electrically inactive state. The view that Fe-Si compound phase may form after high temperature annealing is further supported by the results of ion probe analysis. (Edited author abstract) 7 refs. In Chinese.

Honglin, Zhao (Tianjin Univ, China); Bingqiao, Li; Ji, Pan. *Tianjin Daxue Xuebao* n 1 1988 p 17-22.

**095259 TRANSIENT EFFECTS DURING SIMS DEPTH PROFILING WITH OXYGEN.** Before a steady state is reached in a SIMS experiment with oxygen primary ions, transient effects occur due to the build-up of an oxygen profile in the sample. We studied profiles in the



situation in which the variation of ionization yield, radiation enhanced diffusion, and radiation enhanced segregation are assumed to be the relevant process. Low energy As and Sb implantations (4 keV to 10 keV) as well as homogeneously doped wafers are studied. In the transient region attention is paid to the As or Sb ion as well as to a high intensity molecular compound (AsSiO or SbSiO). Experiments were carried out using an electron beam to irradiate the sample during sputter profiling. The changes in the profile shape with varying primary energy, oxygen partial pressure and electron beam impact conditions lead to the description of a model of the enhanced redistribution due to segregation. (Edited author abstract). 20 Refs.

Avau, D. (IMEC vzw, Louvain, Belg); Vandervorst, W.; Maes, H.E. *Surf Interface Anal* v 11 n 10 Jul 1988 p 522-528.

**095260 MONTE CARLO SIMULATION OF ION IMPLANTATION IN CRYSTALLINE SILICON USING MARLOWE.** The Monte Carlo program MARLOWE is used to simulate ion implantation in semiconductors, i.e., boron and phosphorus implanted into crystalline silicon. Unlike most programs of its kind which require amorphous targets, MARLOWE is able to simulate ion collisions in crystalline targets. It thus provides a more satisfactory treatment of channeling and damage cascades. Simulations are performed under varying conditions and the results are compared with experiment. In addition, the effects of various parameters (beam divergence, lattice temperature, etc.) are investigated. The adequacy of the theories used in the program, in particular the treatment of inelastic losses, is evaluated, and recommendations for further development are made. Post-processors written for the program are described. (Author abstract). 17 Refs.

Moore, J.S. (IBM East Fishkill Lab, Hopewell Junction, NY, USA); Srinivasan, G.R. *J Electrochem Soc* v 135 n 8 Aug 1988 p 2034-2038.

**095261 STUDY OF THE SHEET CONDUCTANCE PROFILES FOR RECOIL-IMPLANTED n-P T%YPE SILICON.** Recoil implantation provides an alternative means to form very shallow and highly doped surface layers. The thickness of these layers depends on the implant conditions as well as the activity of the dopant atoms. Under appropriate recoil implant conditions, very shallow surface layers could be formed. This work examined the recoil implanted sheet conductance profiles in n-Si. Both Co and Al dopants were used. The sheet conductances were measured using the standard four-point probe technique and the profiles were obtained by successive anodic oxidation and etching of the implanted layers. The data were compared with simulated results based on reported recoil dopant profiles suggested by L.A. Christel et al (1981). The sheet conductances appeared to provide a reasonable estimation of the surface carrier densities. 7 refs.

Kwok, H.L. (Chinese Univ of Hong Kong, Hong Kong); Wong, W.C. *Solid State Electron* v 31 n 8 Aug 1988 p 1343-1345.

**095262 RTA PROCESS OF ARSENIC-IMPLANTED SILICON.** The RTA process with an rf induced graphite as an irradiation heat source is investigated. It is found that the complete process of RTA can be divided into two steps. When the temperature is in the range of 800-900°C, a solid phase is grown epitaxially, and then at 1000°C and higher temperatures, damages and defects are annealed out. (Author abstract). 6 Refs. In Chinese.

Xi Li (Qinghua Univ, China); Tsien, Peihsin; Li, Zhijian. *Bandaoti Xuebao* v 9 n 4 Jul 1988 p 395-402.

**095263 RAPID THERMAL ANNEALING OF ARSENIC-PHOSPHORUS (n<sup>+</sup>-n<sup>-</sup>) DOUBLE-DIFFUSED SHALLOW JUNCTIONS.** Double-diffused shallow junctions have been formed by ion implantation of both phosphorus and arsenic ions into silicon substrates followed by rapid thermal annealing. Experimental results

on defect removal, impurity activation and redistribution, effects of silicon pre-amorphization and electrical characteristics of titanium-silicided junctions are presented. (Author abstract). 17 Refs.

Kwong, D.L. (Univ of Texas at Austin, Austin, TX, USA); Ku, Y.H.; Alvi, N.S. *Thin Solid Films* v 161 Jul 1988 p 131-137.

**095264 MODELLING OF <sup>18</sup>O TRACER STUDIES OF THE OXYGEN REDISTRIBUTION DURING FORMATION OF SiO<sub>2</sub> LAYERS BY HIGH DOSE IMPLANTATION.** The modelling of buried SiO<sub>2</sub> layer formation by high dose implantation is extended to simulate new experimental data. The experiments involved the implantation of two different oxygen isotopes (<sup>16</sup>O and <sup>18</sup>O) followed by subsequent analysis by secondary ion mass spectroscopy (SIMS) to determine the isotope distributions. Using the model, isotope depth distributions have been generated for comparison with the experimental data. For doses lower than the critical dose needed for layer formation, profiles have been calculated showing the distribution of the two isotopes. For the case where the combined dose is greater than this critical dose good agreement is found between the experimental data and the distributions calculated. Some discrepancies are apparent especially at the edges of the buried layer which originate in the non-linearity of the SIMS signals. (Edited author abstract). 17 Refs.

Jager, H.U. (Zentralinst fuer Kernforschung, Dresden, East Ger); Kilner, J.A.; Chater, R.J.; Hemment, P.L.F.; Peart, R.F.; Reeson, K.J. *Thin Solid Films* v 161 Jul 1988 p 333-342.

**095265 ELLIPSOMETRIC AND ION BACKSCATTERING MEASUREMENTS OF THE PROPERTIES OF SILICON-ON-INSULATOR STRUCTURE FORMED BY THERMALLY ACTIVATED REDISTRIBUTION OF HIGH-DOSE ION IMPLANTED NITROGEN.** This note reports the formation of SOI structure consisting of a buried layer of silicon nitride and the results of measurement of the refractive indices and the thicknesses of SOI layers by multiple-angle-of-incidence (MAI) ellipsometry, which is fast, contactless, non-destructive, and inexpensive. Moreover, the refractive index can be used as a quality control parameter of the silicon nitride layer. Finally the results are compared of ellipsometry measurements with other methods. 17 Refs.

Khanh, N.Q. (Hungarian Acad of Sciences, Budapest, Hung); Fried, M.; Battistig, G.; Laczik, Z.; Lohner, T.; Jaroli, E.; Schiller, V.; Guylai, J. *Phys Status Solidi A* v 108 n 1 Jul 1988 p K35-K40.

**095266 TWO-DIMENSIONAL MODELING OF ION IMPLANTATION INDUCED POINT DEFECTS.** An analytical model for the description of ion-implantation-induced damage profiles is presented. The model is based on extensive Monte Carlo simulations of B-, P-, As-, and Sb-implantations in Si. One-dimensional profiles are described by a Gaussian function and an exponential function joined together continuously with continuous first derivatives. The two-dimensional model has previously been developed by the authors for dopant profiles and is demonstrated to apply well to point defect distributions. Parameters have been obtained for the four ions by fitting the model to the Monte Carlo results, and they are provided in the form of tables for the energy range of 10-300 keV (for the ID model 1-300 keV). The Monte Carlo simulations are based on the binary collision approximation, the assumption of a random target, and the validity of the linear collision cascade theory. The importance of energy transport by recoils is pointed out. 23 refs.

Hobler, Gerhard (Technical Univ of Vienna, Austria); Selberherr, Siegfried. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 2 Feb 1988 p 174-180.

**095267 TRANSIENT ELECTRON BEAM ANNEALING OF ARSENIC IMPLANTED SILICON.** Single crystal silicon, doped by implantation of arsenic ions (maximum concentrations between  $3 \times 10^{20}$  and

$5 \times 10^{20} \text{ cm}^{-3}$ ) was annealed by irradiation with a raster scanned beam at power density of about  $100 \text{ W cm}^{-2}$ . Arsenic redistribution and substitutionality were studied by Rutherford backscattering and channeling techniques. Sheet resistance was measured by a four-point probe. Using thermal cycles lasting about 1s, full activation with little dopant movement was observed for the higher energy implants while the best result for the 5 keV implants was 90% substitutionality. (Author abstract) 16 refs.

Maydell-Ondrusz, E.A. (Univ of Surrey, Guildford, Engl). *Vacuum* v 37 n 3-4 1987 p 253-256.

**095268 BURIED OXIDE FORMATION IN Si BY HIGH-DOSE IMPLANTATION OF OXYGEN.** The formation of a buried oxide film in Si by high-dose implantation of oxygen and subsequent annealing has been studied. It has been shown that this method can render good quality silicon-on-insulator with a dislocation density lower than  $10^5 \text{ cm}^{-2}$  and sharp interfaces. The microstructure after annealing was demonstrated to depend strongly on that in the as-implanted state. Silicon point defects have been argued to play an important role in the determination of the microstructure. (Author abstract) 10 refs.

Van Ommen, A.H. (Philips Research Lab, Eindhoven, Neth); Viegars, M.P.A. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 383-389.

**095269 OPTICAL AND COMPOSITIONAL STUDIES OF BURIED OXIDE LAYERS IN SILICON FORMED BY HIGH DOSE IMPLANTATION.** Samples of standard SIMOX material, dose  $2.4 \times 10^{18} \text{ cm}^{-2}$  at 200 keV have been examined in the as-implanted and annealed condition. The samples were prepared by wet-chemical etching with the silicon overlayer being removed first. Samples were then etched to remove the buried oxide, revealing and successively exposing the interface. These samples were then examined by ellipsometry and SIMS with an emphasis on the optical properties and compositional nature of the interfaces. Ellipsometry results indicate that a final layer of the buried oxide with refractive index 2.5 to 3 and thickness 150 to 250 Å is very resistant to the oxide etch. This may be correlated with the compositional profile of the interfacial region obtained by SIMS. The interface between the buried oxide and bulk silicon includes two layers, the first of silicon with SiO<sub>2</sub> precipitates and the second of entirely SiO<sub>2</sub>. (Author abstract) 9 refs.

Chater, R.J. (Imperial Coll, London, Engl); Kilner, J.A.; Scheid, E.; Cristolovenau, S.; Hemment, P.L.F.; Reeson, K.J. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 390-396.

## Ionization

**095270 DRIFT VELOCITY AND IONIZATION COEFFICIENT FOR HOLES IN SINGLE-VALLEY SEMICONDUCTORS.** An analytical theory has been developed for drift velocity ( $V_d$ ) and ionization coefficient ( $\alpha_h$ ) of holes in silicon. Based on Boltzmann transport equation, expressions for drift velocity ( $V_d$ ) and ionization coefficient ( $\alpha_h$ ) are derived. The theoretical approach is based on calculation of the collision operator for ionization probability, approximated by a delta function. It is observed that the values drift velocity ( $V_d$ ) and ionization coefficient ( $\alpha_h$ ) agree with experimental results for ionization length ( $l_{io} = 70 \text{ Å}$ ) and ionization energy ( $\epsilon_i = 2.5 \text{ eV}$ ). This confirms the validity of the developed theoretical model. (Edited author abstract) 19 refs.

Gautam, D.K. (Central Electronics Engineering Research Inst, Rajasthan, India); Khokle, W.S.; Garg, K.B. *Solid State Electron* v 30 n 12 Dec 1987 p 1271-1275.



**Laser Applications** See ACOUSTIC GENERATORS; SEMICONDUCTOR DEVICES, MOS—Etching.

**Machining** See Also SENSORS.

**095271 CONTACT DAMAGE IN SINGLE-CRYSTALLINE SILICON INVESTIGATED BY CROSS-SECTIONAL TRANSMISSION ELECTRON MICROSCOPY.** Cross-sectional transmission electron microscopy (TEM) is demonstrated as a powerful tool for investigating subsurface damage in the micrometer and submicrometer ranges in brittle materials, and applications to a wide variety of contact damage in silicon are discussed and illustrated with TEM images. Regions of plasticity and different types of cracking are identified and characterized for various contact situations: indentation, scribing, solid-particle impacts, and polishing/grinding. (Edited author abstract) 28 refs.

Johannsson, Stefan (Uppsala Univ, Uppsala, Swed); Schweitz, Jan-ake. *J Am Ceram Soc* v 71 n 8 Aug 1988 p 617-623.

## Magnetic Field Effects

**095272 TUNING CORRELATION AND LOCALIZATION LENGTHS WITH HIGH MAGNETIC FIELDS NEAR THE METAL-INSULATOR TRANSITION.** Various experiments at low-temperatures on Si:As in the critical regime ( $0.8 < N/N_c < 1.2$ ) near the metal-insulator transition have yielded information on magnetic-field-induced changes in the correlation and localization lengths. The measurements include magnetoresistance of metallic samples, magnetocapacitance, ac magnetocapacitance, and the field dependence of Mott variable-range hopping conduction for insulating samples. The field-induced changes in  $\xi(N, H)$  are interpreted in terms of field-induced changes in the critical density  $N_c$  and the correlation-localization-length exponent  $\nu(H)$ . The implications of the results for the Shapiro phase diagram are discussed. (Author abstract) 57 refs.

Castner, T.G. (Univ of Rochester, Rochester, NY, USA); Shafarman, W.N.; Koon, D. *Philos Mag B* v 56 n 6 Dec 1987, Second Bar-Ilan Conf on the Phys of Disordered Syst, Ramat-Gan, Isr, Jan 5-7 1987 p 805-820.

**Magnetic Properties** See Also MAGNETISM—Diamagnetism.

**095273 ELECTRON PARAMAGNETIC RESONANCE OF AN Fe-Fe PAIR IN SILICON.** The electron paramagnetic resonance spectrum Si-NL24, which is associated with an iron-iron impurity pair and was earlier observed in electron-irradiated silicon, was produced as a quenched-in defect spectrum. Contrary to previous work we could resolve the complete angular dependence of the spectrum and found that it has monoclinic  $I$  symmetry. Two possible atomic models with the iron atoms at interstitial sites are presented. The EPR spectrum can be described as a paramagnetic system with  $S = \frac{1}{2}$  and rather unusual  $g$ -values, as well as by  $S = \frac{5}{2}$  and  $g$ -values close to  $g = 2$ . Hyperfine interactions with two equivalent  $^{57}\text{Fe}$  nuclei could be determined. This Fe-Fe pair and the  $\text{Fe}_2$  complex are the only intermediate states in the thermal clustering process of interstitial iron which are observed in electron paramagnetic resonance. (Author abstract) 21 refs.

van Kooten, J.J. (Univ van Amsterdam, Amsterdam, Neth); Sieverts, E.G.; Ammerlaan, C.A.J. *Solid State Commun* v 64 n 12 Dec 1987 p 1489-1494.

**095274 MAGNETIC SUSCEPTIBILITY OF AMORPHOUS SEMICONDUCTORS.** We analyze the diamagnetic susceptibility ( $\chi$ ) of a model two-dimensional semiconductor both in crystalline and amorphous phases using a linear combination of hybrids model. We show that the large diamagnetic enhancement in am-Si and Ge is due to the reduction of Van Vleck type paramagnetic term. (Author abstract) 14 refs.

Sahu, T. (Berhampur Univ, Berhampur, India); Panigrahi, N.; Misra, P.K. *Key Eng Mater* v 13 pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad,

India, Dec 16-20 1986 p 693-696.

**Manufacture** See Also FURNACES, MELTING—Solar.

**095275 FURNACE DIFFUSION OF SI WAFERS USING SOLID SOURCE WAFERS OF VARIOUS MATERIALS.** Solid source wafer technology facilitates the production of silicon wafers in the manufacture of semiconductors. This planar diffusion source (PDS) method provides a high degree of doping uniformity with mass transport of dopant to all silicon surfaces. The process is safe and its cleanliness and reliability virtually eliminates manufacturing downtime. In use, the solid source and silicon wafers are edge stacked in furnace carriers so that each source wafer is followed by two back-to-back silicon wafers. Wafer transfer robots facilitate this stacking arrangement and automatically load wafers into the furnace. A number of solid source dopants such as multi-temperature phosphorus, boron nitride and arsenic can be used. Process specifics are described. 2 refs.

Anon. *Ind Heat* v 54 n 12 Dec 1987 p 32-33.

**Mathematical Models** See Also ELECTRIC SWITCHES, SEMICONDUCTOR; SEMICONDUCTOR DEVICES, MOSFET—Noise.

**095276 MODELING FOR COUPLED DOPANT DIFFUSION IN SILICON.** The simulation of coupled dopant diffusion in silicon is becoming increasingly important in integrated circuit technology, as device dimensions are reduced and efforts are made to reduce process complexity. Thus a need exists for accurate simulation over a wide range of diffusion conditions, based on necessity on well tested, predictive physical models. (Author abstract) 5 refs.

Cowern, N.E.B. (GEC Research Ltd, Wembley, Engl); Godfrey, D.J. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 1 Mar 1987 p 59-63.

## Measurements

**095277 STUDY OF AN 'IN LINE' MINORITY CARRIER LIFETIME OF SILICON WAFER MONITOR FOR DEVICES PROCESSING.** This paper has solved a continuous equation for silicon wafers whose thickness are 0.01 cm and 0.10 cm and in which two surface recombination velocities  $S_1$  and  $S_2$  are different. Application of the minority carrier lifetime monitoring method in semiconductor device processing is also reported. (Edited author abstract) In Chinese. 4 refs.

Ju, Jian-hua (Univ of Science & Technology, China); Cao, Ze-chun. *Xi You Jin Shu* v 6 n 2 May 1987 p 124-126.

**095278 KINETICS OF OXYGEN DIFFUSION TO THE GRAIN BOUNDARY IN OXYGEN-RICH DIRECTIONALLY CAST SILICON BICRYSTALS.** The electron beam induced current mode of a scanning electron microscope has been used to measure the minority carrier recombination velocity at the depletion layer edge of the grain boundary as a function of annealing time (30-240 min) and temperature (600-900°C) in oxygen-rich directionally cast silicon bicrystals. The minority carrier recombination velocity at the grain boundary has been found to increase significantly with increasing annealing time and temperature. The grain boundary barrier potential has been determined from the zero-bias capacitance as a function of annealing time and temperature. A theoretical model has been proposed whereby the diffusivity of oxygen in silicon can be computed from the increase in grain boundary interface trap density, calculated from the grain boundary recombination velocity and barrier potential. (Edited author abstract) 16 refs.

Kumar, Rajesh (Nat'l Physical Lab, New Delhi, India); Kotnala, R.K.; Arora, N.K.; Das, B.K. *Sol Cells* v 23 n 3-4 Apr 1988 p 173-179.

## Mechanical Properties

**095279 STUDY OF INDENTATION ANNEALING OF (111) P-TYPE SINGLE CRYSTAL SILICON.** The indentation rosette size in (111) p-type Czochralski grown

silicon was measured as a function of annealing temperature (450 to 1100°C), time (600 to 9300 sec) and indentation load (0.147 to 2.94 N). The indentations were made with the silicon surface immersed in an electrolytic solution containing NaI with concentrations in the range of  $10^{-5}$  to  $10^{-1}$  Ml $^{-1}$ . The indentation rosette size  $<2L>$  increases with annealing time and temperature, and indentation load. The indentation rosette size has three stages as the temperature increased. The indentation rosette size increases with increasing indentation load. The concentration of NaI solution, in contact with silicon surface during indentation influenced the indentation rosette size. The maximum in rosette size is obtained in  $4 \times 10^{-4}$  Ml $^{-1}$ . 22 refs.

Lee, S.W. (Univ of Illinois at Chicago, Chicago, IL, USA); Danyluk, S. *J Mater Sci* v 23 n 1 Jan 1988 p 55-60.

**095280 AVOGADRO CONSTANT - RECENT RESULTS ON THE MOLAR VOLUME OF SILICON.** The density  $\rho$  of two silicon crystals has been determined by precision hydrostatic weighing, based on very accurate solid density standards (SDSs). Densities of additional crystals were gained from density differences measured by the temperature-of-floatation method. The molar mass  $M$  of the crystals was determined by comparing the isotopic abundances against the known abundances of the National Bureau of Standards (NBS) reference material SRM 990 using activation analysis and mass spectroscopy. Combining the measured values for  $M$  and  $\rho$  leads to  $M/\rho = (12.058\,822 \pm 0.000\,013)$  cm $^3$ /mol. With the known volume of the unit cell the following value for the Avogadro constant was calculated:  $N_A = (6.022\,137 \pm 0.000\,007) \times 10^{23}$  mol $^{-1}$ . 18 refs.

Seyfried, Peter (Physische Technische Bundesanstalt, Braunschweig, West Ger); Balhorn, Reiner; Kochsiek, Manfred; Kozdon, Andrzej F.; Rademacher, H.-J.; Wagenbreth, Helmut; Peuto, Anna M.; Sacconi, Attilio. *IEEE Trans Instrum Meas* v IM-36 n 2 Jun 1987, Sel Pap - Conf on Precise Electromagn Meas (CEPM/86), Gaithersburg, MD, USA, Jun 23-27 1986 p 161-165.

**Medical Applications** See BIOSENSORS—Glucose Sensors.

**Melting** See Also SEMICONDUCTING GLASS—Heat Transfer; SEMICONDUCTOR DEVICES—Measurements.

**095281 MELTING THRESHOLD OF CRYSTALLINE AND AMORPHIZED Si IRRADIATED WITH A PULSED ArF (193 nm) EXCIMER LASER.** Modifications induced by a pulsed ArF excimer laser at surface of implanted silicon were investigated by a new and simple method which consists to follow the evolution of solid reflectivity, at 633 nm wavelength, resulting from the amorphous-polycrystalline (or monocrystalline) transition during the laser melting process. These results, which have been compared to those obtained using time resolved reflectivity experiments have demonstrated the capability of this simple technique to determine the melting threshold of implanted silicon. (Author abstract) 13 refs.

Foulon, F. (CNRS, Strasbourg, Fr); Fogarassy, E.; Slaoui, A.; Fuchs, C.; Unamuno, S.; Siffert, P. *Appl Phys A* v A45 n 4 Apr 1988 p 361-364.

## Metallizing

**095282 UNTERSUCHUNGEN ZUR OBERFLÄCHENVORBEREITUNG VOR DER MO-SI-MISCHSCHICHTABSCHIEDUNG.** [Investigation of Techniques for Cleaning Silicon Surface Prior to MoSi Mixed Layer Deposition]. The effect of different surface preparation techniques prior to the deposition of metal or mixed layers in integrated circuit manufacture is investigated. Determination of the contact resistance between the transit path and the semiconductor materials offers a sufficiently sensitive measurement method for the evaluation of different variants. A wet chemical etching method with optimized process control has proved itself to be an advantageous surface preparation technique. (Translated author abstract)



Krauss, Dietmar; Kaufmann, Christian; Raschke, Thomas. *Wiss Z Tech Univ Karl Marx Stadt* v 29 n 4 1987 p 546-552.

**Microanalysis** See SEMICONDUCTOR MATERIALS—Microanalysis.

### Microscopic Examination

**095283 MEASUREMENTS OF SMALL ELASTIC STRAINS USING ELECTRON CHANNELING PATTERNS.** A silicon single-crystal slab 0.15 mm in thickness was bent to produce small, nonuniform surface strains of the order of 0.2 percent. The electron channeling patterns were observed in a JSM 840 SEM (scanning electron microscope) at an accelerating voltage close to 25 kV. Proper choice of the triangles formed by intersecting channeling lines of zero-order and of higher-order Laue zones allows one to measure the changes in their dimensions caused by imposed strain. It was estimated that the lower limit of detectable elastic strain is close to 0.1 percent. The possibilities of using this method for estimation of the average elastic strains in thin epitaxial layers are discussed. (Author abstract) 16 Refs.

Kozubowski, J.A. (Univ of Minnesota, Minneapolis, MN, USA); Gerberich, W.W.; Stefanski, T. *J Mater Sci* v 3 n 4 Jul 8 1988 p 710-713.

### Microstructure

**095284 FABRICATION OF SILICON MICROSTRUCTURES BASED ON SELECTIVE FORMATION AND ETCHING OF POROUS SILICON.** A process is described for use in silicon microstructures. This process consists of selective anodization of silicon in concentrated HF solution to form porous silicon and etching of the porous silicon in dilute NaOH solution to obtain desired microstructures. Proton implantation is employed to produce a thicker anodizable high donor concentration layer in lightly doped n-type silicon substrates, and nitrogen ion implantation is employed to create thinner highly resistive islands in the high donor concentration layer. 19 Refs.

Tu, Xiang-Zheng (Texas A&M Univ, College Station, TX, USA). *J Electrochem Soc* v 135 n 8 Aug 1988 p 2105-2107.

**Millimeter Waves** See TELECOMMUNICATION LINES, STRIP—Mathematical Models.

### Morphology

**095285 EFFECT OF ARGON PRESSURE ON THE MORPHOLOGY OF THE SURFACE OF SILICON UNDER THE EFFECT OF LASER RADIATION.** Investigations were conducted into the effect of the argon pressure in the range 1-80 atm on the morphology of the surface of silicon at a laser radiation flux density of approximately  $10^6$  W/cm<sup>2</sup>. The results show that a system of cracks forms after completion of the effect of the laser pulse. They can be regarded as an instability caused by movement of the strain wave. (Author abstract) 5 refs.

Selishchev, S.V.; Byalyi, A.V. *Phys Chem Mater Treat* v 21 n 5 Sep-Oct 1987 p 488-489.

**095286 MORPHOLOGY AND ELECTRONIC PROPERTIES OF PHOSPHORUS-DOPED HYDROGENATED AMORPHOUS AND MICROCRYSTALLINE SILICON DEPOSITED BY DC DISCHARGE IN SiH<sub>4</sub>/PH<sub>3</sub>.** n-Type Si:H films have been prepared by DC discharge decomposition of SiH<sub>4</sub>/PH<sub>3</sub> gas mixtures to investigate the effects of the discharge current density ( $J_{DC}$ ) and voltage ( $V_{DC}$ ) on film structure and dark electrical transport characteristics. Examination of the resulting Si:H films by transmission electron microscopy (TEM) indicates a discernible microstructure that depends on the discharge parameters. Film growth can be interpreted in terms of the effect of the deposition parameters on nucleation and surface diffusion. Increasing  $V_{DC}$  enhances the nucleation density resulting in a homogeneous, fine-grained structure that is largely amor-

phous. In contrast, increasing  $J_{DC}$  enhances surface mass transport, resulting in a two-phase structure consisting of crystallites, as large as 1000 Å in diameter, interconnected by an amorphous tissue. For a given impurity level, the resulting electrical transport characteristics are correlated with microstructure; higher dark conductivities are associated with deposition conditions that enhance microcrystallization. (Author abstract) 23 Refs.

Kruzelecky, R.V. (Univ of Toronto, Toronto, Ont, Can); Zukotynski, S.; Perz, J.M. *J Non Cryst Solids* v 103 n 2-3 Jul 1988 p 221-233.

### Noise, Spurious Signal

**095287 SPATIAL CORRELATION MEASUREMENTS OF 1/f NOISE IN SEMICONDUCTORS.** One of the proposed models for 1/f noise, thermal fluctuations theory, involves a diffusive mechanism which implies spatial correlation of the fluctuating quantity within a frequency-dependent correlation length. In order to test this prediction, we have performed spatial correlation measurements on p-type conductive diffused strips of silicon at temperatures between 20 and 295 K. The frequency span was from 10 Hz to 10 kHz. We have not found any correlation between the 1/f fluctuations in two different segments of the strip separated by 2.5 mils, making diffusion mechanism an unlikely origin of the noise. (Author abstract) 11 refs.

Celik-Butler, Zeynep (Univ of Rochester, Rochester, NY, USA); Hsiang, Thomas Y. *Solid State Electron* v 31 n 2 Feb 1988 p 241-244.

### Nondestructive Examination

**095288 NONDESTRUCTIVE NONCONTACT TESTING OF SILICON WAFERS AND DEVICES MADE FROM THEM BY INDUCTIVE CHARGE EMF IN A SCANNING ELECTRON MICROSCOPE.** Information concerning local electric nonuniformities and the electrophysical parameters of the original semiconductor wafers and structures, upon which the functional characteristics of integrated circuits made from them ultimately depend, is very important. The problem of developing noncontact and nondestructive methods for testing the raw materials and fabricated elements of semiconductor devices is real. We will examine the possibilities and a new method of investigating local electrophysical parameters in the surface and subsurface layers of silicon structures based on scanning the change in surface deflection of the zones in the charge states at the radiation points and the surface barrier (inductive charge) emf associated with them. 8 refs.

Gostev, A.V. (M.V. Lomonosov Moscow State Univ, USSR); Kleinfeld, Yu.S.; Rau, E.I.; Spivak, G.V. *Sov Microelectron* v 16 n 4 Jul-Aug 1987 p 183-189.

**Optical Properties** See Also SEMICONDUCTOR DEVICES—Junctions.

**095289 DETERMINATION OF THE THICKNESS AND OPTICAL PROPERTIES OF AMORPHOUS SILICON FILM BY TRANSMISSION SPECTRA.** The thickness  $d$  and optical constants  $n$ ,  $k$  of amorphous silicon film have been determined simultaneously by transmission spectra. The accurate formulae for transmittance and reflectance as well as the detailed processes are given. The optical properties of GD-grown amorphous silicon films are studied. (Author abstract) In Chinese. 9 refs.

Li, Guoguang (Fudan Univ, China); Yang, Henqing; Huang, Jiaming; Chen, Junyi; Zong, Xiangfu. *Hongwai Yanjiu A-Ji* v 6 n 5 1987 p 321-328.

**095290 TEMPERATURE DEPENDENCE OF THE OPTICAL DISPERSION PARAMETERS IN Si AND Ge.** In Si and Ge, the optical dispersion parameters (single-oscillator energy  $E_0$ , dispersion energy  $E_d$  and bond energy gap  $E_g$  developed by Wemple and S.H. DiDomenico, and M. Phillips) have been analyzed in the temperature range 100-300 K using data obtained by H.

W. Icenogle et al.  $E_0$  and  $E_g$  exhibit a very small temperature dependence in both materials. The thermal coefficients of the dispersion energy,  $dE_d/dT$ , have opposite signs (Si,  $-41.9 \times 10^{-4}$  eV K<sup>-1</sup>; Ge,  $+37.7 \times 10^{-4}$  eV K<sup>-1</sup>). (Author abstract) 7 refs.

Toyoda, T. (Nippon Mining Co, Toda, Jpn). *Phil Mag Lett* v 55 n 3 Mar 1987 p 143-146.

**095291 OPTICAL ABSORPTIVITY OF ION-BEAM IRRADIATED SILICON.** Single-crystal layers of silicon on sapphire have been irradiated with Ne and Kr ions at room temperature. The concomitant changes in optical absorption have been measured as a function of photon energy. The absorptivity of the amorphized silicon is about one order of magnitude higher as compared to the crystalline state in the photon energy interval of 1.5-3 eV. This is sufficient for generating optical patterns of high contrast by irradiation of selected parts of the wafer. (Author abstract) 14 refs.

Bhatia, K.L. (Max-Planck-Institut fuer Kernphysik, Heidelberg, West Ger); Kraetschmer, W.; Kalbitzer, S. *Appl Phys A* v A45 n 1 Jan 1988 p 69-72.

**095292 CARS PROBING OF THE Si RAMAN MODE TRANSFORMATION DURING STRONG PICOSECOND PULSED-LASER IRRADIATION.** We report on picosecond coherent anti-Stokes Raman scattering (CARS) probing of the Si optical phonon spectrum transformation during picosecond pulsed-laser irradiation. CARS spectra were obtained in reflection at various laser fluences up to melting. The observed spectrum broadening is theoretically explained in terms of phonon heating and laser-induced mechanical stress build-up on a time scale of 10 ps. (Author Abstract) 9 refs.

Govorkov, S.V. (Moscow State Univ, Moscow, USSR); Koroteev, N.I.; Shumay, I.L.; Zadkov, V.N. *Solid State Commun* v 62 n 5 May 1987 p 331-334.

**095293 OPTICALLY INDUCED CHANGES IN THE SUB-BAND GAP ABSORPTION OF HYDROGENATED AMORPHOUS SILICON.** Measurements of infrared absorption in thin (120 nm) films of amorphous hydrogenated silicon subjected to light soaking were performed by Fourier transform infrared spectroscopy. Light exposure increased absorption in the region 0.3 to 0.4 eV but reduced it between 0.40 and 0.43 eV. These effects, which were room temperature annealable, indicate that at least two kinds of electronic states are involved. (Author abstract) 8 refs.

Gal, M. (Univ of New South Wales, Kensington, Aust); Haneman, D.; Paul, G.L. *Solid State Commun* v 62 n 7 May 1987 p 509-511.

**095294 DEPENDENCE OF THE PHOTOLUMINESCENCE FATIGUE ON THE ILLUMINATION TEMPERATURE FOR a-Si:H.** Effects of strong illumination at temperatures between 8 K and room temperature on the photoluminescence intensity in a-Si:H were measured between 8 K and 100 K. The photoluminescence fatigue is more prominent by illumination at 8 K than at temperatures above 50 K. This result appears to contradict the usually accepted mechanism of the photo-degradation. Creation of two kinds of defects by illumination is proposed to solve the contradiction. (Author abstract) 19 refs.

Kumeda, Minoru (Kanazawa Univ, Kanazawa, Jpn); Ohta, Toyokazu; Shimizu, Tatsuo. *Solid State Commun* v 64 n 3 Oct 1987 291-294.

**095295 FATIGUE AND LOW TEMPERATURE SELF-RECOVERY OF PHOTOLUMINESCENCE IN a-Si:H.** During a short exposure at 80 K it was observed that the photoluminescence (PL) intensity decreases by 14-50% of its original value to a steady-state by a  $t^{1/3}$  time process. The fatigued PL intensity spontaneously returns to its starting value if the excitation light is turned off and the sample is kept in the dark for a few minutes at the original temperature. The dark recovery



shows an exponential time dependence with time constants of about one minute. The fatigue of PL depends on the substrate temperature during preparation and has a maximum at  $T_S = 300^\circ\text{C}$  (50% fatigue). The results are interpreted by the transition: weak bonds  $\leftrightarrow$  dangling bonds. (Author abstract) 9 refs.

Koos, M. (Hungarian Acad of Sciences, Budapest, Hung); Pocsik, I.; Somogyi, I. Kosa. *Solid State Commun* v 65 n 12 Mar 1988 p 1509-1512.

**095296 MEASUREMENTS OF OPTICAL PROPERTIES OF YTTRIUM- $\alpha$ -DOPED a-Si:H FILMS BY USING NULL ELLIPSOMETRIC SPECTRUM METHOD.** The dependences of the optical properties on the wavelength  $\lambda$  for yttrium-doped a-Si:H films with different doping concentrations have been measured. The volume fraction of dopant yttrium in the sample has been calculated in terms of the effective medium approximate theory, and the result is compared with that by the energy spectrum method. Both results are consistent with each other. (Author abstract) 7 Refs. In Chinese.

Zhang, Shuzhi (Shandong Univ, Shandong, China); Wei, Aijian; Shao, Xue; Cheng, Xingui. *Hongwai Yanjiu A-Ji* v 7A n 4 1988 p 301-306.

**095297 LUMINESCENCE IN SILICON IN ELECTRIC AND MAGNETIC FIELDS.** The low temperature photoluminescence of free excitons, electron-hole droplets and bound excitons in silicon is investigated as a function of electric and magnetic fields. The luminescence is quenched due to impact ionization by field-accelerated electrons and holes. (Author abstract) 5 refs.

Zhao, Q.X. (Linköping Univ, Linköping, Sweden); Weman, H.; Monemar, B. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 151-152.

**095298 OPTICAL PROPERTIES OF GD a-Si:H/a-Si<sub>1-x</sub>C<sub>x</sub>:H SUPERLATTICES.** The blue-shifts of optical bandgap appear in compositional amorphous superlattices. Besides, infrared transmission and Raman scattering measurements can be used to investigate the interface properties. Persistent photoconductivity (PPC) after a brief illumination was observed in some doping superlattices. Here we mainly present our experimental results to show the optical properties of a-Si:H/a-Si<sub>1-x</sub>C<sub>x</sub>:H superlattices. 8 refs.

Zhang, Fangqing (Lanzhou Univ, Lanzhou, China); Xu, Xixiang; Sun, Guosheng; Zhang, Yafei; Chen, Guanghua. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 727-728.

## Order-Disorder

**095299 ORIENTATIONAL DISORDER IN AMORPHOUS SILICON PROBED BY XANES (X-RAY ABSORPTION NEAR EDGE STRUCTURE).** The difference between the K-edge XANES spectra of crystal and amorphous silicon is discussed. We show that the multiple scattering signal gives a large contribution to the total absorption in crystalline silicon in an energy range of about 70 eV. The double scattering term probing the triplet distribution function gives the major contribution to the XANES. We show that the difference between the crystalline and amorphous absorption spectra is due mainly to the crystalline multiple scattering signal which is quenched in the amorphous spectrum. The suppression of the signal due to the triplet distribution function in the amorphous silicon is assigned to the large orientational disorder. (Author abstract) 23 refs.

Di Cicco, A. (Univ di Roma 'La Sapienza', Rome, Italy); Bianconi, A.; Benfatto, M.; Marcelli, A.; Natoli, C.R.; Pianetta, P.; Woicik, J. *Phys Scr* v 38 n 3 Sep 1988 p 408-411.

**Oxidation** See Also DIFFUSION—Computer Simulation; INTEGRATED CIRCUITS, VLSI—Radiation Protection; SEMICONDUCTOR DEVICES, MOSFET—Radiation Effects; SOLAR CELLS—Silicon.

**095300 KINETICS AND MECHANISM OF THE ELECTROCHEMICAL FORMATION OF POROUS SURFACE LAYERS ON SILICON IN HYDROFLUORIC ACID. SPECIFIC KINETIC FEATURES OF POROUS-LAYER FORMATION ON n- AND p-TYPE SILICON.** In the region of linear kinetics in the dark, the rate of formation of the porous layer (PL) is 6-7 times higher on the n-type than on the p-type material. The amount of silicon dissolved increases linearly with time for both types, under these conditions, but the dissolution rate of the p-type material is 1.2-1.3 times higher than that of the n-type material. The differences in the structure and formation kinetics of the porous layer and in silicon dissolution arise from the fact that, in the case of p-type material, PL formation occurs on account of silicon oxidation to compounds of lower valency, while at n-type material a mixed dissolution mechanism is operative which involves a predominant oxidation to the tetravalent state. (Author abstract) 19 refs.

Izidinov, S.O. (V.I. Lenin All-Union Electrotechnical Inst, Moscow, USSR); Blokhina, A.P.; Martynova, T.S. *Sov Electrochem* v 22 n 12 Dec 1986 p 1494-1500.

**095301 SURFACE EFFECTS CONTROLLING ELECTRON-STIMULATED OXIDATION OF SILICON.** Previously reported experimental results on the electron-stimulated oxidation of Si are quantitatively described. The framework of the analysis is a macroscopic continuum model which includes transport processes through the oxide layer, and surface effects mainly connected to the  $O_2$  sticking coefficient. The existence of the chemisorbed precursor states is pointed out and a simple picture of the potential energy experienced by the  $O_2$  molecule approaching the surface of the oxide layer is proposed. (Author abstract) 21 refs.

Miotello, A. (Istituto per la Ricerca Scientifica e Tecnologica, Trento, Italy); Toigo, F. *Phil Mag Lett* v 55 n 1 Jan 1987 p 53-58.

**095302 EFFECTS OF STRESS ON THE DRY OXIDATION OF SILICON. THEORY OF MOLECULAR-OXYGEN DIFFUSION IN SILICA.** We extend our previous quantum-chemical calculations of the incorporation and motion of interstitial molecular oxygen in silica. Our results based on CNDO calculations for an  $\alpha$ -quartz cluster show how the key energies vary with strain along the c axis and normal to it. The results show how the overall Arrhenius energy varies. We compare the predictions with experiment and discuss implications for silicon oxidation. (Edited author abstract) 18 refs.

Hagon, J.P. (Univ of Newcastle upon Tyne, Newcastle upon Tyne, Engl); Stoneham, A.M. *Phil Mag Lett* v 56 n 1 Jul 1987 p 41-45.

**095303 EFFECT OF THERMAL OXIDATION OF SILICON ON BORON DIFFUSION IN EXTRINSIC CONDITIONS.** Boron diffusion during extrinsic conditions in silicon has been investigated under both oxidizing and inert atmospheres for different temperatures (950-1100°C) and times. Oxidation-enhanced diffusion (OED) was found. This result is opposite to the oxidation-retarded diffusion of arsenic case. (Author abstract) 13 refs.

Ishikawa, Yutaka (Nippon Inst of Technology, Saitama, Jpn); Nakamichi, Ichiro; Matsumoto, Satoru; Nimi, Tatsuya. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1602-1603.

**095304 IN SITU MEASUREMENT OF SILICON OXIDATION KINETICS BY MONITORING SPECTRALLY EMITTED RADIATION.** When a highly polished silicon wafer is thermally oxidized, its spectral emittance fluctuates systematically, as the protective silica film grows thicker. If the spectral intensity of the emitted radiation at a wavelength where silica is transparent is monitored, the film thickness can be obtained. (Author

abstract) 15 refs.

Schiroky, Gerhard H. (GA Technologies Inc, San Diego, CA, USA). *J Mater Sci* v 22 n 10 Oct 1987 p 3595-3601.

**095305 WET HYDROGEN OXIDATION IN THE PRESENCE OF MOLYBDENUM AND TUNGSTEN FOR VLSI APPLICATIONS.** Oxidation of Si in the presence of Mo or W can be performed in an atmosphere of  $H_2$  with a low partial pressure of  $H_2O$ . A pyrogenic version of this process was established. The quality of oxide grown by this method is found to be comparable to that of dry thermal oxides. However, Si oxidation is observed to occur underneath Mo and W layers on the Si surface, as well as under Mo and W layers capped with phosphosilicate glass. Additionally, oxidation is observed within several microns of the periphery of  $Si_3N_4$ -capped Mo and W layers, leading us to conclude that modification of the gate structure or material is required to make WHO practical for source/drain reoxidation in refractory Mo or W gate VLSI. (Author abstract) 7 refs.

Kwasnick, R.F. (GE, Schenectady, NY, USA); Gorczyca, T.B.; Woodruff, D.W. *J Electrochem Soc* v 135 n 1 Jan 1988 p 176-179.

**095306 CHARGE TRAPPING IN OXIDE GROWN ON POLYCRYSTALLINE SILICON LAYERS.** Shifts in tunneling I-V characteristics are used to study electron trapping in oxides thermally grown on silicon layers deposited in both amorphous and polycrystalline phases. The electron trapping resulted from charge injection by tunneling from either the bottom or top electrodes of capacitors constructed of two deposited silicon layers separated by thermal oxide. It is observed that upon injection from the top electrode, the resulting trapped-charge centroid is located close to the middle of the oxide layer. On the other hand, injection from the bottom electrode results in an apparent trapped-charge centroid which is located near the bottom silicon-oxide interface. (Edited author abstract) 28 refs.

Avni, E. (Hebrew Univ of Jerusalem, Jerusalem, Isr); Abramson, O.; Sonnenblick, Y.; Shappir, J. *J Electrochem Soc* v 135 n 1 Jan 1988 p 182-186.

**095307 BLOCKING OF SILICON OXIDATION BY LOW-DOSE NITROGEN IMPLANTATION.** The oxidation characteristics of silicon implanted with a low dose of nitrogen ( $1.3 \times 10^{15} \text{ cm}^{-2}$ ) have been studied for dry oxidation conditions at  $1020^\circ\text{C}$ . The wafers were subjected to a pre-oxidation annealing. Complete inhibition of the oxide growth occurs in the initial stage of oxidation, while the oxidation rate for prolonged oxidation is identical to that for pure silicon. The oxidation resistance increases with the implantation dose. The resistance is attributed to the formation of a nitrogen-rich surface film during annealing. This layer, which consists of only a few monolayers, is presumably composed of oxynitride. The electrical characteristics of MOS capacitors formed on implanted wafers show that the interface state density is not significantly increased by the low-dose N implantation. (Author abstract) 21 refs.

Schott, K. (Univ Erlangen, Erlangen, West Ger); Hofmann, K.C.; Schulz, M. *Appl Phys A* v A45 n 1 Jan 1988 p 73-76.

**095308 ANODIC OXIDATION OF HYDROGENATED AMORPHOUS SILICON AND PROPERTIES OF OXIDE.** Anodic oxidation in an ethylene glycol solution of potassium nitrate is shown to be capable of forming uniform amorphous  $SiO_2$  layers on hydrogenated amorphous silicon (a-Si:H) films at room temperature at a rate of 5.5 Å/V up to the maximum thickness of about 2500 Å. The process is stable, reproducible, and electrically controllable. The oxidation process and the properties of the anodic oxide films are described, and a detailed comparison is made with the anodization of single-crystal silicon. The anodization accompanies electroluminescence. The effect of illumination of the anode and the behavior of luminescence from the anode



are discussed in detail in an attempt to clarify the electrical behavior of the anode during anodization. (Edited author abstract) 28 refs.

Hasegawa, Hideki (Hokkaido Univ, Sapporo, Jpn); Arimoto, Satoshi; Nanjo, Junji; Yamamoto, Hidekazu; Ohno, Hideo. *J Electrochem Soc* v 135 n 2 Feb 1988 p 424-431.

**095309 VISCOELASTIC BEM FOR MODELING OXIDATION.** A viscoelastic boundary element method has been developed to model the motion of silicon dioxide and silicon nitride during thermal oxidation of silicon. This technique uses Kelvin's solution reformulated according to the correspondence principle on viscoelasticity. Constant-velocity loading is chosen to ensure smooth variations in displacement and stress behavior for a wide range of relaxation times. (Author abstract) 7 refs.

Tung, Thy-Lai (MIT, Cambridge, MA, USA); Connor, Jerome; Antoniadis, Dimitri A. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 2 Jun 1987 p 115-121.

**095310 HIGH PRESSURE OXIDATION OF Si(100) FOR PRODUCTION OF ULTRATHIN OXIDE METAL-INSULATOR-SEMICONDUCTOR DIODES.** It is shown here that ultrathin oxides can be grown with excellent control by a low temperature, high pressure oxidation process. The I-V characteristics of tunneling melt-insulator-semiconductor diodes fabricated using this process demonstrate that the interface state density can be reduced by an order of magnitude compared with low temperature, atmospheric pressure oxidation. (Author abstract) 9 refs.

Basu, Nandita (Indian Inst of Technology, Madras, India); Bhat, K.N. *Thin Solid Films* v 156 n 2 Jan 30 1988 p 243-257.

**095311 ANALYSIS OF THE TECHNICAL ACCURACY OF THE PROCESS OF THERMAL OXIDATION OF A SILICON SURFACE IN DRY AND WET OXYGEN.** An equation is obtained for the technical accuracy of the process of thermal oxidation of silicon in dry and wet oxygen. The dependences of the relative technical spread in growth of the thickness of the SiO<sub>2</sub> film on the basic process factors are analyzed and synthesized. An interactive program has been developed for modeling the technical accuracy of the thermal-oxidation process. (Author abstract) 5 refs.

Sinekop, Yu.S.; Tsurin, O.F.; Bonat, E.E. *Radioelectron Commun Syst* v 30 n 9 1987 p 43-46.

**095312 GROWTH OF NATIVE OXIDE ON SILICON.** R.J. Archer has described the growth of a film on silicon at room temperature in air. F. Lukes and S.I. Raider et al. have also studied the growth of films at room temperature. With the shrinking of silicon device dimension, there is renewed interest today in the mechanisms of the growth of thin oxides. In thermal oxides, the concept of an abrupt interface between silicon and silicon dioxide has received general acceptance. This paper describes an experiment similar to that of Archer or Lukes but notes the apparent step growth in the formation of the native oxide on silicon. It is shown that the native oxide grown on a clean silicon substrate at room temperature tends to form one layer at a time. The layer thickness measured is compatible with that calculated for a monolayer of oxide. 10 refs.

Taft, E.A. (GE, Schenectady, NY, USA). *J Electrochem Soc* v 135 n 4 Apr 1988 p 1022-1023.

**095313 ANALYSIS OF RAPID DRY OXIDATION OF SILICON.** By analyzing the most recent models on rapid initial oxidation and the experimental data at low temperatures we prove unambiguously that neither enhanced nor retarded oxygen diffusion nor any kind of additional oxygen transport flux can account for anomalous initial regime of silicon dry oxidation. The rapid growth is mainly due to the enhanced oxygen solubility and partly to the enhancement of the reaction rate constant  $k_p$ . We argue that the reaction rate depends linearly on the oxygen solubility for low solubilities

pertinent to dry oxidation but that it saturates at high solubilities characteristic for the wet oxidation. (Author abstract) 12 refs.

Orlowski, M. (Siemens AG, Munich, West Ger); Pless, V. *Appl Phys A* v A46 n 1 May 1988 p 67-71.

**095314 ENHANCEMENT OF THE KINETICS OF THERMAL OXIDATION OF SILICON USING 1,1,1-TRICHLOROETHANE.** In this investigation the effects of 1,1,1-trichloroethane (TCA) on the silicon oxidation rate enhancement have been studied over a temperature range of 800°-1100°C along with thermodynamic considerations of the oxidation ambient. These studies have shown that, similar to the case of oxidation in HCl containing ambients, an oxide growth rate enhancement is also brought about by addition of TCA, and that this enhancement is not merely due to the presence of water vapor which is expected to exist in equilibrium in the TCA ambient. 14 refs.

Flemish, J.R. (Pennsylvania State Univ, University Park, PA, USA); Tressler, R.E.; Monkowski, J.R. *J Electrochem Soc* v 135 n 5 May 1988 p 1192-1194.

**095315 EXOELECTRON EMISSION OF THERMALLY OXIDIZED SILICON.** The current methods of production of semiconductor devices and integrated circuits are based on the formation of a dielectric film on the surface of the crystal. The authors examine the effect of preliminary machining of the surface of single crystal silicon with subsequent oxidation in various conditions on the extent of thermally stimulated exoemission and its relation with the structure of the surface layer and defectiveness of the oxide film. They reach the following conclusions: (1) The method of exoelectron emission yields additional information on the quality of the grown oxide and also on the number of defects in it. (2) The increase of the density of the defects in the oxide increases the concentration of the emission-active centres and, consequently, the intensity of exoemission. (3) Mechanical treatment of the surface of silicon preceding the oxidation process has a strong effect on the defectiveness of the oxide and the intensity and nature of thermally stimulated emission. 6 refs.

Devochkin, O.V.; Ivanov, L.A. *Phys Chem Mater Treat* v 21 n 6 Nov-Dec 1987 p 615-617.

**095316 GENERATION-ANNEALING OF OXIDE AND INTERFACE TRAPS AT 150 AND 298 K IN OXIDIZED SILICON STRESSED BY FOWLER-NORDHEIM ELECTRON TUNNELING.** Generation and thermal annealing of oxide and interface traps at 150 and 298 K are investigated by Fowler-Nordheim electron tunneling stress. Experiments indicate that the generation rate of positive oxide changes is higher at 150 than 298 K. This could be accounted for by the higher density of energetic electrons in the oxide and at gate/oxide interface at lower temperatures due to the larger electron-phonon scattering mean free path. The annealing rates of interface traps and negative oxide traps are higher at 298 than 150 K. The higher annealing rate of the interface traps by hydrogen at higher temperatures could be interpreted by the larger hydrogen arrival rate at the interface due to the larger hydrogen diffusivity in the silicon dioxide at higher temperatures. The higher annealing rate of negative oxide traps at higher temperatures is attributed to a higher emission rate of electrons trapped at the shallow neutral electron traps at higher temperatures. (Author abstract) 29 refs.

Hsu, Charles Ching-Hsiang (Univ of Illinois, Urbana, IL, USA); Sah, C. Tang. *Solid State Electron* v 31 n 6 Jun 1988 p 1003-1007.

**095317 LOW TEMPERATURE OXIDATION OF SILICON.** Oxidation of silicon in dry oxygen ambient at temperatures between 25°C to 500°C, with a point-to-plane corona discharge is studied. The oxidation rate for this case is a strong function of temperature and is found to increase significantly in comparison to the conventional thermal oxidation rate. For the thicker films, refractive index of the grown oxide layer approaches the

value obtained for high-temperature thermally grown oxide. (Author abstract). 4 Refs.

Madani, M.R. (Louisiana State Univ, Baton Rouge, LA, USA); Ajmera, P.K. *Electron Lett* v 24 n 14 Jul 7 1988 p 856-857.

**095318 MICROWAVE-DISCHARGE PLASMA OXIDATION OF SILICON IN A CUSP MAGNETIC FIELD.** The role of oxygen radicals and ions in the plasma oxidation of silicon is investigated using microwave-discharge oxygen plasma ignited in a cusp magnetic field. The cusp magnetic field forces streaming plasma to stop its progress resulting in a plasma boundary formation. Probe measurement of argon plasma reveals that the original plasma density of  $2 \times 10^{10} \text{ cm}^{-3}$  decreases to one-third,  $6 \times 10^9 \text{ cm}^{-3}$ , across the boundary. Thus, the cusp magnetic field achieves an oxygen plasma with fewer ambient charged particles. However, it is found that oxide growth rate on silicon does not change across the boundary. (Edited author abstract). 14 Refs.

Kimura, Shin-ichiro (Hitachi Ltd, Tokyo, Jpn); Murakami, Eiichi; Warabisako, Terunori; Sunami, Hideo. *J Electrochem Soc* v 135 n 8 Aug 1988 p 2009-2012.

**095319 KINETICS OF THE ROOM-TEMPERATURE AIR OXIDATION OF HYDROGENATED AMORPHOUS SILICON AND CRYSTALLINE SILICON.** An X-ray photoelectron spectroscopy determination of the room-temperature air oxidation of both hydrogenated amorphous silicon and crystalline silicon has shown that the log-log (complex order) kinetics depend on the method of surface preparation. For HF-etched surfaces, the slope is identical with those measured at significantly higher temperatures (about 1000°C). For Ar-etched surfaces, the structural damage thereby incurred gives significantly higher rates. (Author abstract). 20 refs.

Lu, Z.H. (Ecole Polytechnique de Montreal, Montreal, Que, Can); Sacher, E.; Yelon, A. *Philos Mag B* v 58 n 4 Oct 1988 p 385-388.

**095320 TWO-DIMENSIONAL THERMAL OXIDATION OF SILICON - II: MODELING STRESS EFFECTS IN WET OXIDES.** The authors propose that the stress from two-dimensional oxide deformation affects the kinetic parameters in the Deal-Grove model. In particular, the viscous stress associated with the nonuniform deformation of the oxide is identified as the fundamental force of retardation. In this model, the stress normal to the Si-SiO<sub>2</sub> interface reduces the surface reaction rate in both convex and concave surfaces, whereas the stress in the bulk of the oxide (compressive for concave and tensile for convex surfaces) is responsible for the thinner oxides on the concave structures. The model is described by a simplified mathematical formulation made possible by the symmetry in cylindrical structures. Comparisons with experimental data, possible applications, and limitations of the model are also discussed. 33 refs.

Kao, Dah-Bin (Stanford Univ, CA, USA); McVittie, James P.; Nix, William D.; Saraswat, Krishna C. *IEEE Trans Electron Devices* v 35 n 1 Jan 1988 p 25-37.

**095321 THERMAL OXIDATION OF SILICON: NEW EXPERIMENTAL RESULTS AND MODELS.** Most studies of Si oxidation commence with a discussion of the linear-parabolic oxidation model developed by a number of workers in the 1960's. The limits of the model are pure diffusion of oxidant for thick SiO<sub>2</sub> films and a surface reaction limitation for thin films. The steady state picture of this series reaction scheme is discussed and used to explain new experimental results. New data relevant to Si oxidation is presented on the following subjects: five orientations of Si; photonic excitation; intrinsic film stress; silicide oxidation. The role of electrons on the



oxidation kinetics is elucidated. A thermionic emission model for the initial stages of oxidation is proposed. (Author abstract) 44 refs.

Irene, Eugene A. (Univ of North Carolina, Chapel Hill, NC, USA); Ghez, R. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 1-16.

**095322 EFFECT OF SILICON SURFACE CLEANING PROCEDURES ON OXIDATION KINETICS AND SURFACE CHEMISTRY.** The effect of surface cleaning procedures on the kinetics of thermal oxide growth on silicon is presented. The goal is to relate the properties of the cleaned surface (composition, chemistry, impurity content) to the changes in oxide growth mechanisms. Experimentally, silicon (100) wafers were given different variations of an RCA clean, and then oxidized in dry  $O_2$  at 900°C producing oxides with thicknesses between 170 and 3900 Å. The results, in general agreement with earlier studies, show that the percentage difference in thickness is strongly dependent on oxide thickness. The data, which are explained in terms of the predictions of a linear-parabolic and a parallel oxidation model suggest that the surface cleans do not alter the diffusion of molecular oxygen in the oxide. Auger analysis of the surfaces shows that there is a substantial carbon contamination on the HF stripped wafer which is considerably reduced after a 5 min  $N_2$  anneal. (Author abstract) 17 refs.

Delarios, J.M. (Stanford Univ, Stanford, CA, USA); Helms, C.R.; Kao, D.B.; Deal, B.E. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 17-24.

**095323 HIGH TEMPERATURE REACTION AND DEFECT CHEMISTRY AT THE  $Si/SiO_2$  INTERFACE.** The generation of structural and electrical defects in  $Si/SiO_2$  structures upon high temperature annealing by the oxide decomposition reaction  $Si + SiO_2 \rightarrow 2SiO$  has been studied using scanning electron microscopy (SEM) and ramped current-voltage measurements. The  $SiO$  decomposition is nucleated at crystalline defects in the substrate and results in the formation of voids in the oxide. The voids grow laterally with annealing time, independent of the nature of the defect. Prior to the formation of physical voids in the oxide, defects become electrically active, leading to low field dielectric breakdown. The breakdown degradation is prevented when the  $O_2$  pressure in the annealing ambient is sufficient to reverse the decomposition reaction by reoxidizing the  $SiO$  product at the interface. (Author abstract) 9 refs.

Hofmann, K. (IBM, Yorktown Heights, NY, USA); Rubloff, G.W.; Liehr, M.; Young, D.R. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 25-31.

**095324 CONSTANT CURRENT VERSUS CONSTANT VOLTAGE PLASMA ANODIZATION TECHNIQUES.** In this paper a comparison is made between two basic techniques of plasma anodization, i.e. constant current and constant voltage methods. The comparison is based on new mathematical-physical models of both plasma anodization techniques, in which the condition of oxide growth during the process is expressed in terms of fluxes (oxygen ions and electrons) and/or voltages. Detailed analysis of these parameters, their changes during the oxide growth and their comparison enabled the confirmation of some of the experimentally observed effects and to predict others, unnoticed until now. Based on this analysis it is concluded that the oxide growth during the constant current plasma anodization is not only easier to be monitored and controlled, but also should result in much better anodic oxide electrophysical properties, their better control and repeatability. (Author abstract) 5 refs.

Beck, Romuald B. (IMEC vzw, Louvain, Belg). *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the

Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 32-39.

**095325 OXIDATION OF SILICON IN THE AFTERGLOW OF MICROWAVE INDUCED PLASMAS.** In this work the influence is described of various experimental parameters on the oxidation process of silicon in the afterglow of microwave induced plasmas in oxygen/argon mixtures. It was found that the oxidation is independent of the flow velocity of the reagents and of the wafer position in the fast flow reactor. By a chemical titration technique it is shown that oxygen atoms ( $^3P$ ) are the major oxidation precursors. They also form the explanation for the observed effect of the plasma composition and the reactor pressure on the silicon oxidation rate. Additionally, chlorine has only a minor effect on the oxidation rate which can be explained on the basis of a kinetic mechanism for the chlorine transformation. (Author abstract) 10 refs.

Vinckier, C. (KU Leuven, Louvain, Belg); Coeckelberghs, P.; Stevens, G.; De Jaegere, S. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 40-46.

**095326 EFFECTS OF LOW TEMPERATURE ANNEALING ON THE ELECTRICAL PROPERTIES OF PLASMA GROWN OXIDES.** The effects of low temperature annealing on the electrical properties of plasma grown oxides have been investigated. In conjunction with a trichloroethylene/oxygen plasma it is found that plasma oxides with good electrical properties can be obtained at annealing temperatures below 600°C. (Author abstract) 8 refs.

Barlow, K.J. (Univ of Liverpool, Liverpool, Engl); Eccleston, W.; Taylor, S. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 47-51.

**095327 SILICON OXIDATION.** Today's VLSI technology is to a large extent based on the excellent properties of thermally grown silicon dioxide layers.  $SiO_2$  is used as gate dielectric in MOS devices, as implantation or doping mask, and for device isolation purposes. This paper focuses on the mechanisms and kinetics of thermal oxidation. Various oxidation techniques are reviewed and the properties of the oxides are discussed. It is emphasized that thermal oxidation of the silicon strongly affects the properties of the underlying silicon bulk material. Phenomena like oxidation-enhanced diffusion and oxidation-induced stacking faults are explained, and other silicon dioxide properties important for VLSI applications are reviewed. (Edited author abstract) 113 refs.

Declerck, G.J. (IMEC, Louvain, Belg). *Acta Polytech Scand Electr Eng Ser* n 58 1987, Proc of the Adv Summer Sch on Microelectron: Phys and Technol for VLSI, Espoo, Finl, Jun 8-12 1987 p 57-105.

## Phase Transitions

**095328 EFFECT OF SPIN-ORBIT INTERACTION ON THE METAL-INSULATOR TRANSITION IN DOPED SILICON.** We show that in disordered metallic systems, spin-orbit interactions lead to the existence of two metallic phases separated in temperature. The low-temperature metallic phase arises from spin-orbit interactions. The crossover temperature is proportional to  $(Z-Z')^2$  ( $Z$  is the atomic number of the donor and  $Z'$  that of the matrix) and is expected to be observable for donors with large atomic numbers. The presence of two metallic phases implies two mobility edges, existing at different temperatures, and affecting the conductivity when the Fermi energy  $E_F$  lies below the mobility edge  $E_c$ . We thus predict anomalies in the conductivity in this range of concentration, consistent with the measurements of A.P. Long and M. Pepper on Si:Sb. (Author abstract) 16 refs.

Kaveh, M. (Bar-Ilan Univ, Ramat-Gan, Isrl); Mott, N.F. *Phil Mag Lett* v 56 n 3 Sep 1987 p 97-102.

**095329 CHARACTERIZATION OF a-Si:H PHASE TRANSFORMATION AND CRYSTALLIZATION BY ISOTHERMAL ANNEALING.** Hydrogenated amorphous silicon (a-Si:H) thin films have been prepared by plasma-enhanced low-pressure chemical vapor deposition (PE-LPCVD) from monosilane ( $SiH_4$ ) in hydrogen carrier gas. The variation of electrical conductivity with time at various isothermal annealing conditions have been used to study the phase transformation and crystallization kinetics. For the first time, it has been observed that the drop in the electrical conductivity in the early annealing stage is caused by hydrogen out-diffusion with different activation energies under various substrate temperatures. Transmission electron microscope (TEM) diffraction patterns, which directly measure crystallization, were also obtained. Furthermore, perpendicular crystallization rates for different activation energies under various substrate temperatures have been obtained. An empirical model to explain the phase transformation and crystallization kinetics of hydrogenated amorphous silicon thin films has been proposed. (Author abstract) 41 refs.

Chou, Jung-Chuan (Nat'l Chiao Tung Univ, Hsin-Chu, Taiwan); Hsiung, Shen-Kan; Lu, Chih-Yuan. *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 1971-1977.

**095330 ROLE PLAYED BY MECHANICAL STRESSES AND ELASTIC WAVES IN STRUCTURAL TRANSFORMATIONS IN CRYSTALS IN ION BOMBARDMENT AND SUBSEQUENT ANNEALING.** The authors present experimental data on the effect of static and dynamic elastic fields on the nature of structural transformations taking place in the subsystem of defects on single crystal and epitaxial silicon in irradiation with ions of medium energy and in postimplantation annealing. The results show that these effects can be explained on the basis of the considerations regarding the mechanism of interaction between the defects and target atoms with the stress field as a collective process in which a relatively large number of elementary defects and atoms take part. (Author abstract) 16 refs.

Pavlov, P.V.; Skupov, V.D.; Tetel'baum, D.I. *Phys Chem Mater Treat* v 21 n 6 Nov-Dec 1987 p 555-559.

Photoconductivity See Also ELECTRODES, ELECTROCHEMICAL—Chemical Modification.

**095331 PHOTOCONDUCTIVE CHARACTERISTICS AND STABILIZATION OF HYDROGENATED AMORPHOUS SILICON FILMS.** This paper describes the changes in the photoconductive characteristics under elevated environmental conditions and presents a stabilizing method of hydrogenated amorphous silicon (a-Si:H) thin films. a-Si:H is decomposed from silane in a PCVD (Plasma Chemical Vapor Deposition) apparatus. The results of high-temperature and high-humidity storage tests reveal that the photocurrent increased by about two orders of magnitude over the initial value, followed subsequently by a gradual decrease. The characteristics were stabilized through coating the film surface with a silicon nitride film deposited at room temperature by ECR (Electron Cyclotron Resonance) plasma CVD. (Edited author abstract) 13 refs.

Takahashi, Minoru (NTT Electrical Communications Lab, Musashino, Jpn); Nozawa, Toshinori. *Electron Commun Jpn Part 2* v 70 n 10 Oct 1987 p 26-34.

**095332 EFFECT OF INTERNAL STRESS ON PERSISTENT PHOTOCONDUCTIVITY IN a-Si:H/a-Si<sub>3</sub>N<sub>4</sub> LAYERED STRUCTURE.** Effects of internal stress on persistent photoconductivity (PPC) in a-Si:H/a-Si<sub>3</sub>N<sub>4</sub> layered structure are presented. Experiments have shown that PPC effect increases as internal stress is decreased. The results are explained in terms of hydrogen content and interface in the films. (Author abstract) 8 refs.

Wang, Wanlu (Lanzhou Univ, China); Liao, Kejun. *Solid State Commun* v 62 n 11 Jun 1987 p 749-751.



**095333 PHOTOCONDUCTIVE a-Si:H WITH DOMINANT MONOHYDRIDE BONDING PREPARED BY DC-MAGNETRON SPUTTERING.** A description is given of a dc-magnetron sputtering apparatus used for deposition of hydrogenated amorphous silicon (a-Si:H) by reactive sputtering in an argon/hydrogen discharge. The physical properties of the deposited a-Si:H films are determined by measuring the photo and dark conductivity, the Tauc gap, the IR absorption and by ESR and RBS measurements. The influence of the main deposition parameters (hydrogen partial pressure, dc-power) on the film properties is discussed. The films reveal a minimal value of dark conductivity of  $\sigma_D = 10^{-11} (\Omega\text{cm})^{-1}$  and a four decade higher photoconductivity even for samples prepared at growth rates of 7  $\mu\text{m}/\text{h}$ . In all films the hydrogen is predominantly bound in monohydride complexes (Si-H). (Author abstract). 19 Refs.

Druesdau, T. (Technische Univ 'Otto von Guericke' Magdeburg, Magdeburg, East Ger); Eckler, M.; Bindemann, R. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 285-293.

**Physical Properties** See Also SEMICONDUCTOR DEVICES—Physical Properties; SEMICONDUCTOR MATERIALS—Transport Properties.

**095334 TRANSFERABILITY OF TIGHT-BINDING PARAMETERS: THE SiN CASE.** We show that an alternative and more realistic procedure of tight-binding parametrization of 'host-impurity' interactions in the impurity problem is to take that one from the interactions of 'host-impurity perfect solid' (if any) followed by an appropriate scaling with the distance. We use this idea in the on-center Si:N case, taking the Si-N interactions from the tight-binding parametrization of  $\text{Si}_3\text{N}_4$  perfect crystal, using the  $d^{-2}$  scaling law to transfer the interactions to the impurity problem. This procedure can be useful to treat the distorted N impurity and suggestions are made to extend it to other impurity problems. (Edited author abstract) 18 refs.

Sferco, S.J. (Inst de Desarrollo Tecnológico para la Industria, Santa Fe, Argent); Passeggi, M.C.G. *Solid State Commun* v 61 n 4 Jan 1987 p 217-220.

**095335 SPHERICAL WAVE EXAFS ANALYSIS OF THE SILICON K-EDGE X-RAY ABSORPTION SPECTRUM.** The silicon K-edge EXAFS (extended X-ray absorption fine structure) spectrum has been analyzed by spherical wave formalism. The agreement between the experimental EXAFS spectrum in the energy range above 50 eV beyond the K-threshold and the theoretical one has been obtained using experimental values of the mean free path and of the different Debye-Waller factors for each shell. Seven shells around the absorbing atom have been considered in the calculation, but the amplitude due to the distant shells decreases rapidly with the distance, and above 80 eV only the contribution of the first three shells is important. We show that the single scattering contribution  $\chi_2(k)$  using the spherical wave approach can explain the experimental  $\chi(k) = (\mu(k) - \mu_0(k))/\mu_0(k)$  spectrum only above 50 eV. At lower energies there are strong multiple scattering effects and it is necessary to take account of other terms  $\chi_n(k)$  (with  $n > 2$ ) of given expansion. (Edited author abstract) 26 refs.

Di Cicco, A. (Univ di Roma, Rome, Italy); Bianconi, A.; Pavel, N.V. *Solid State Commun* v 61 n 10 Mar 1987 p 635-639.

**095336 TWO-PHONON FREQUENCY DIFFERENCE ABSORPTION IN Si AND Ge.** We measured the infrared absorption of crystalline silicon and germanium up to the one-phonon Raman frequency for temperatures between 10 and 300 K. We observed several peaks whose strength increases with increasing temperature. Calculations of the absolute two-phonon frequency difference absorption using Weber's adiabatic bond charge model and a local charge transfer ansatz based on phonon-induced bond length distortions to model the dipole moments yield agreement with experimental spectra. (Edited author abstract) 14 refs.

Winer, K. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Cardona, M. *Solid State Commun* v 64 n 12 Dec 1987 p 1461-1464.

**095337 PARTIAL DENSITY OF UNOCCUPIED STATES AND  $L_{2,3}$ -X-RAY ABSORPTION SPECTRUM OF BULK SILICON AND OF THE Si(111)  $2 \times 1$  SURFACE.** The  $L_{2,3}$  surface absorption spectrum of the clean Si(111)  $2 \times 1$  surface has been measured and compared with the bulk spectrum. The results are interpreted by comparison with tight binding calculations of the s density of states. The 2p core hole final state effect is shown to shift all absorption features in the bulk up to 3 eV above threshold by about 0.3 eV. A surface feature 2.3 eV above the conduction band bottom has been identified. (Author abstract) 18 refs.

Bianconi, A. (Univ degli Studi di Roma 'La Sapienza', Rome, Italy); Del Sole, R.; Selloni, A.; Chiaradia, P.; Fanfoni, M.; Davoli, I. *Solid State Commun* v 64 n 10 Dec 1987 p 1313-1316.

**095338 TUNNELING SPECTROSCOPY OF SURFACE AND BULK LANDAU LEVELS IN Si(001) ELECTRON ACCUMULATION LAYERS.** Magneto-oscillations in the tunneling characteristics of Ti/SiO<sub>2</sub>/n-Si(001) junctions with accumulated Si surface reflect the Landau-level structure of the  $E_0$  and  $E_1$  subbands and of bulk electrons belonging to the [100] and [010] valley pairs. The result is the effective cyclotron masses of the subbands and the principal masses of the bulk ellipsoids. (Author abstract) 19 refs.

Kunze, U. (Technische Univ Braunschweig, Braunschweig, West Ger). *Solid State Commun* v 64 n 10 Dec 1987 p 1325-1328.

**095339 CALCULATION OF THE OPTICAL PROPERTIES OF THE ISOLATED DANGLING BOND IN SILICON.** The optical ionization cross section for transitions between the level  $\epsilon(0, +)$  of the isolated silicon dangling bond and the valence band is calculated. Comparison with experiment shows that the purely electronic contribution has the correct order of magnitude. It is demonstrated that its shape can be accurately described by including the broadening due to the electron-lattice interaction with a Franck-Condon shift of 0.3 eV. The predicted correlation energy (0.65 eV) and localization of the wave function are consistent with experiment. (Edited author abstract) 28 refs.

Petit, J. (CNRS, Lille, Fr); Lannoo, M.; Allan, G. *Solid State Commun* v 60 n 11 Dec 1986 p 861-865.

**095340 AMORPHOUS SILICON.** We point out the qualitative features of amorphous silicon, particularly in relation to the crystalline form. The gap states of amorphous silicon are dealt with. The quasi-continuous distribution of such localized states in the band-gap region makes amorphous semiconductors substantially different from their crystalline counterpart. These localized states affect significantly the electrical and optical properties of amorphous silicon. The authors treat the structure and the growth kinetics of amorphous silicon, particularly a-Si:H. Photoinduced effects are surveyed, particularly on conductivity and on luminescence, from the current physics and application points of view. 181 refs.

Morigaki, K.; Nitta, S. *Noncryst Semicond* Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 53-96.

**095341 CALCULATION OF THE ISOTOPE FREQUENCY SHIFTS OF LOCAL MODE CAUSED BY INTERSTITIAL OXYGEN IN SINGLE CRYSTAL SILICON.** A calculation of the isotope frequency shifts of local mode caused by interstitial oxygen in silicon is presented by using a 9-atom cluster model based on the force constant approach. We find that the calculated result is not better than that of a single Si<sub>2</sub>O molecular model. Even if the effects of noncentral force and local distortion of lattice are taken into account, the result is still not satisfactory. In order to obtain the best fit with the experimental isotopic shifts, it is necessary to introduce the variation of the Si-O force constant with the different

isotopes. It turns out that the Si-O force constant increases with increasing the mass of silicon atom but decreases with increasing the mass of oxygen atom. (Edited author abstract) 13 refs.

Xu, Zhengyi (Acad Sinica, Beijing, China); Ge, Peiwen; Gu, Benyuan. *Solid State Commun* v 65 n 10 Mar 1988 p 1247-1251.

**095342 DEEP LEVEL INVESTIGATION OF N-DOPED FZ Si CRYSTALS.** The deep levels related to nitrogen in N-doped FZ Si crystals were studied by DLTS. A level located at  $E_c - 0.57$  eV related to nitrogen was observed besides the two levels,  $E_c - 0.20$  eV and  $E_c - 0.28$  eV, observed by others. After annealing at 400°C for 0.5 hr, the three levels vanished and three new levels related to nitrogen were formed. They were located at  $E_c - 0.17$  eV,  $E_c - 0.37$  eV and  $E_c - 0.50$  eV. Their annealing behavior was studied. (Author abstract) In Chinese. 6 refs.

Luan Hongfa (Acad Sinica, Beijing, China); Liang Junwu; Deng Lisheng; Zheng Hongjun; Huang Dading. *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 312-314.

**095343 COMPENSATION TUNING STUDY OF METAL INSULATOR TRANSITION IN Si:P.** Low temperature transport properties in doped semiconductors have attracted interest of solid state physicists, and many important achievements have been obtained. The problems of impurity conduction are divided into three categories: the hopping conduction, the metallic conduction, and the metal-insulator transition. Research activities in this field are discussed. 28 refs.

Sasaki, W. (Toho Univ, Funabashi, Jpn); Nishio, Y.; Kajita, K. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 37-44.

**095344 MELTING TEMPERATURE OF AMORPHIZED SILICON HEATED BY NANOSECOND LASER RADIATION.** The optical pyrometry technique for measuring the melting temperature of an amorphized silicon (a-Si),  $T_{ma}$  was applied. Values of  $T_{ma}$  given in the literature differ by 200 to 300 K. It is found that a-Si melts at a temperature which is only about 200 K lower than  $T_{mc}$  and not 500 K as was considered earlier. Therefore, homogeneous initiation of the solid phase in the metastable melt is hardly probable and can be neglected in considering the pre-history of formation of the fine-grained polycrystal. 15 Refs.

Ivlev, G.D. (Acad of Sciences of the Byelorussian SSR, Minsk, USSR); Malevich, V.L.; Zhidkov, V.V. *Phys Status Solidi A* v 106 n 2 Apr 1988 p k123-k127.

## Plasmas

**095345 PICOSECOND TIME-RESOLVED DETECTION OF PLASMA FORMATION AND PHASE TRANSITIONS IN SILICON.** Picosecond time-resolved reflectivity and transmission changes have been measured to study the electron-hole plasma formation and phase transitions in silicon, induced by 0.53  $\mu\text{m}$ , 30 ps laser pulses. The experimental results provide evidence of ultrafast energy transfer from the laser pulse to the lattice and of lattice heating and phase transition within a time less than 30 ps. It has been pointed out that Auger recombination can limit the increment of electron-hole plasma density. Some electron-hole plasma parameters under high excitation are deduced from the experimental data. (Author abstract) 9 refs. In Chinese.

Ma, Haiming (Fudan Univ, Shanghai, China); Liu, Yixian; Li, Fuming. *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 163-168.

## Polishing

**095346 EXPERIMENTAL STUDIES ON POLISHING MECHANISM OF HP-NONBAKED SiO<sub>2</sub> POLISHING AGENT FOR SILICON WAFERS (I).** SiO<sub>2</sub> polishing agent has been developed by means of a special technology from the hyperpure SiCl<sub>4</sub> recovered in the vent gas of a polysilicon reactor. In order to shed some light on its polishing mechanism, the authors determined the



physicochemical properties of the colloidal particles (diameter, hardness, surface charge and photo-electron energy spectroscopy) and the polishing agent itself (viscosity, specific gravity and conductivity). This paper also reports the surface quality and polishing rate compared to several commercial baked SiO<sub>2</sub> polishing agents. (Edited author abstract) In Chinese. 8 refs.

Wang, Guang-yu (Acad Sinica, China); Liu, Feng-wei. *Xi You Jin Shu* v 6 n 3 Aug 1987 p 207-211, 216.

**095347 AUTOMATED POLISHING SYSTEM.** The Model 372 polisher is a fully automated, cassette-to-cassette machine that operates under full computer control. In this manner, all operator-related variables are eliminated from the process. By carefully controlling polishing temperatures, pressure, and surface speeds, flat, uniform, haze-free wafers can be produced. The machine can not only be used for conventional preparation of substrate materials, but also has applications in the production of high density packaging systems and state-of-the-art integrated circuit production. The polisher is suited for both production quantities and small lot sizes. A capability for water reclaim, or rework from batch processes, can result in increased process yields.

Anon. *Solid State Technol* v 31 n 1 Jan 1988 p 153-154.

**Pressure Effects** See SEMICONDUCTING GALLIUM ARSENIDE—Doping.

**Processing** See Also SEMICONDUCTOR DEVICE MANUFACTURE.

**095348 SELECTIVE MASKING EFFECTS OF WO<sub>3</sub> RESIST ON IMPURITY DIFFUSION AND OXIDATION IN SILICON.** Selective masking effects of a WO<sub>3</sub> electron resist on phosphorus diffusion and oxidation in silicon at 1000°C are described. Though the diffusion coefficient of phosphorus in the WO<sub>3</sub> layer is about twice as large as that in the SiO<sub>2</sub> layer, the WO<sub>3</sub> resist is useful as a masking film for phosphorus diffusion at elevated temperatures around 1000°C. On the other hand, the masking effect of the WO<sub>3</sub> layer on the oxidation of a silicon substrate is insufficient, since the diffusion coefficient of O<sub>2</sub> molecules in the WO<sub>3</sub> layer is about eight times as large as that in the SiO<sub>2</sub> layer. (Author abstract) 7 refs.

Baba, Mamoru (Iwate Univ, Morioka, Jpn); Abe, Susumu; Ikeda, Toshio. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1561-1564.

**095349 INTERACTIVE COMPUTER SIMULATION OF HEATING AND COOLING A ROW OF SILICON WAFERS.** We present herein a computer simulation describing the heating or cooling of a row of silicon wafers in a quartz 'boat' undergoing a prescribed thermal cycle. The simulation includes the effects of conduction, convection, and radiation. A novel part of the simulation is the introduction of an 'effective viewfactor' that enables the radiative losses from the wafers to be easily calculated. Using this simulation we have predicted the rates at which wafers of a given radius and thickness can be cooled without producing unacceptable thermal stresses. (Author abstract) 7 refs.

Tavel, M.A. (Vassar Coll, Poughkeepsie, NY, USA); Hearn, E.W. *J Electrochem Soc* v 135 n 5 May 1988 p 1266-1271.

**095350 ANODIC PASSIVATION OF.** As part of a comprehensive electrochemical investigation of silicon etching and anodic passivation in KOH, chronoamperometric experiments were performed on precisely oriented {111} silicon to elucidate the mechanistic course of silicon {111}RTBC passivation. The resulting current vs. time relationships display multiple current maxima that obey two-dimensional nucleation and first-order reaction rate laws. Each current peak has been associated with either the formation of an anodic oxide or the dissolution of an open-circuit oxide film. Data analysis confirms previous results which show that anodic oxide formation on {111} silicon consumes a fixed quantity of charge of approximately  $2.4 \times 10^{-3}$  C/cm<sup>2</sup> for both n- and p-type silicon. (Author abstract). 31 Refs.

Smith, R.L. (MIT, Cambridge, MA, USA); Kloeck, B.; Collins, S.D. *J Electrochem Soc* v 135 n 8 Aug 1988 p 2001-2008.

**095351 CARBON FILM OXIDATION-UNDERCUT KINETICS.** A process is presented for fabricating micro-mechanical structures or freestanding shapes such as sheets of polysilicon. A sacrificial layer of carbon is deposited on a substrate, followed by a top layer of a second material. After oxidation of the carbon, the top layer is left free. The kinetics of the diffusion-limited oxidation process are modeled and compared to experimental data for the undercut of large (17×8.6 cm) sheets of polysilicon. (Author abstract). 7 Refs.

Bernstein, Johnathan (Charles Stark Draper Lab, Cambridge, MA, USA); Koger, T. Bruce. *J Electrochem Soc* v 135 n 8 Aug 1988 p 2086-2090.

**095352 SOI TECHNOLOGY USING BURIED LAYERS OF OXIDIZED POROUS SI.** A process to form large defect-free silicon-on-insulator structures on 4-in wafers, without warpage, using a layer of oxidized porous silicon in an n/n<sup>+</sup>/n structure is presented. CMOS devices have been fabricated in insulated single-crystal silicon islands. Mobilities comparable to bulk silicon have been measured and low-leakage junctions were realized. The advantages and limitations of the process are discussed. 9 refs.

Barla, Kathy (CNET, Grenoble, Fr); Bomchil, Guillermo; Herino, Roland; Monroy, Augustin. *IEEE Circuits Devices Mag* v 3 n 6 Nov 1987 p 11-15.

#### Protective Coatings

**095353 SYNTHESIS OF AN FeO<sub>x</sub> PROTECTIVE COATING ON A SILICON SURFACE BY THE REACTIVE EVAPORATION METHOD.** Heterostructure electrodes of FeO<sub>x</sub>/m-Si type for photoelectrochemical light converters, obtained by reactive evaporation of iron in an oxygen atmosphere, are characterized by a high quantum high conversion efficiency. A solid coating of FeO<sub>x</sub> ensures protection of the silicon surface from photoelectrocorrosion at thicknesses less than 10 nm. The photoactivity of the electrodes is caused by the generation of photocurrent carriers in the silicon and the transport of holes toward the electrode surface through the iron oxide/silicon interface. In Russian. 11 refs.

Salitra, G.S.; Pivovarov, A.P.; Baldokhin, Yu.V.; Borod'ko, Yu.G. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 12 Dec 1987 p 1941-1944.

#### Purification

**095354 SILICON PURIFICATION BY THE VAN ARKEL-DE BOER TECHNIQUE USING A Cu<sub>3</sub>Si:Si COMPOSITE ALLOY SOURCE.** Production of 99.9999% pure silicon by the Van Arkel-De Boer technique is described. The purification method is based on an HCl chemical vapor transport process using a Cu<sub>3</sub>Si:Si composite alloy as the silicon source. The concentration, origin, and behavior of the major impurities (Al, B, Ba, Ca, Cr, Fe, Mg, Mn, Mo, Ni, P, Ti, V, and Zr) involved in the process were studied by Atomic Absorption-Inductively Coupled Plasma (AA-ICP), Spark Source Mass Spectrometry (SSMS), and X-ray Fluorescence Analysis (XFA). Finally, the purification mechanisms and their relative importance in the overall process are discussed for these impurities. (Author abstract) 12 refs.

Tejedor, P. (Solar Energy Research Inst, Golden, CO, USA); Olson, J.M. *J Cryst Growth* v 89 n 2-3 Jun II 1988 p 220-226.

**095355 GLOW DISCHARGE MASS SPECTROMETRY - THE NEWEST TOOL FOR HIGH PURITY MATERIALS ANALYSIS.** Glow Discharge Mass Spectrometry (GDMS) is the latest application of mass spectrometry to the analysis of high purity materials. This technique exhibits high sensitivity (to 1 ppb) and quantitative accuracy using standards for a wide variety of materials. The utility of GDMS to both starting materials

and finished crystals is demonstrated for gallium arsenide, silicon and other electronic materials. The high sensitivity of GDMS allows the determination of uranium and thorium at sub part per billion levels in microelectronic manufacturing materials. Using cell cooling it is possible to analyze carbon, nitrogen, and oxygen to 1 part per million or less in many materials. When standards are available analytical accuracy of 5% is easily attained. Calibration curves are linear over at least six orders of magnitude. (Author abstract) 4 refs.

Guidoboni, Richard J. (Northern Analytical Lab, Amherst, NH, USA); Leipziger, Frederic D. *J Cryst Growth* v 89 n 1 Jun 1988, Purif of Mater for Cryst Growth and Glass Process - Proc of the Second Workshop, Champion, PA, USA, Sep 28-Oct 1 1987 p 16-20.

**095356 PURITY CONSIDERATIONS FOR AMORPHOUS SILICON THIN FILMS.** Contamination control is essential to prepare high quality amorphous silicon thin films for device applications such as solar cells and thin film transistors. Topics included in this paper are vacuum system preparation and reduction of residual gases, silane gas purity considerations, dopant contamination control, and particulate contamination control. The first topic, vacuum system preparation, considers the design and construction of vacuum systems and common vacuum practice used to minimize contamination in deposited films of amorphous silicon. The use of residual gas analyses and the measurement of desorption rates to reduce system contamination is discussed in detail. Next, gas chromatography/mass spectrometer analyses of silane and other feedstock gases from major producers are presented. Two methods, gas flushing and gas flow isolation, illustrate the techniques used to prevent dopant contamination. Finally, because most amorphous silicon deposition systems produce particulates which reduce the yields of fabricated devices, methods are discussed which minimize unwanted particulate production. (Author abstract) 11 refs.

Dickson, C.R. (Solarex Thin Film Div, Newtown, PA, USA); Fieselmann, B.F.; Oswald, R.S. *J Cryst Growth* v 89 n 1 Jun 1988, Purif of Mater for Cryst Growth and Glass Process - Proc of the Second Workshop, Champion, PA, USA, Sep 28-Oct 1 1987 p 49-61.

**Radiation Damage** See Also TRANSISTORS, BIPO-LAR—Radiation Damage.

**095357 INFLUENCE OF IRRADIATION TEMPERATURE ON RADIATION DEFECT ACCUMULATION IN SILICON.** The processes of radiation defect formation in n-type silicon are studied at various irradiation temperatures ( $T_{irr}=20$  to  $400^\circ\text{C}$ ) during 640 MeV proton or 10 MeV electron bombardment. The results are obtained from the analysis of the temperature dependences of charge carrier concentration in crystals irradiated at various temperatures and investigating samples (which are not irradiated but subjected to similar thermal treatment). It is established that production efficiencies for main radiation defects (A-, E-centers, divacancies, complexes of carbon-oxygen-divacancy) are complicated functions of  $T_{irr}$ , however the form of these functions appears to be different for the two types of irradiation used. The results obtained are interpreted. (Edited author abstract). 18 Refs.

Kuznetsov, V.I. (V.I. Lenin Byelorussian State Univ, Minsk, USSR); Lugakov, P.F.; Lukyanitsa, V.V. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 143-148.

**095358 NEUTRON DAMAGE EQUIVALENCE FOR SILICON, SILICON DIOXIDE, AND GALLIUM ARSENIDE.** Displacement-energy and ionization-energy transfers to Si, SiO<sub>2</sub>, and GaAs as functions of incident neutron energy were calculated using cross-section data and fine group structure in the NJOY code system. Neutron spectra determinations for several reactor neutron environments were made using activation cross sections and a novel technique with the SAND II code. Measurements of carrier-removal rates in GaAs and



of Si transistor gain degradation were made in representative neutron environments. Experimental results are compared to damage ratios predicted with the spectra and NJOY displacement functions. For fission-like spectra, calculated Si damage ratios are in good agreement with those determined with ASTM E722-85 and with measured transistor damage ratios. Significant differences are found between Si NJOY and ASTM E722-85 for 14-MeV-to-reactor neutron damage ratios; NJOY gives better agreement with experimental data reported in the literature. In GaAs, 14-MeV-to-reactor experimental damage ratios are smaller than predicted by calculated displacement ratios. This suggests that a more complex model of damage for majority carrier removal in GaAs is required. 26 refs.

Luera, Theodore F. (Sandia Natl Lab, Albuquerque, NM, USA); Kelly, John G.; Stein, Herman J.; Lazo, Maximo S.; Lee, Clarence E.; Dawson, L. Ralph. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1557-1563.

**Radiation Effects** See Also SEMICONDUCTING FILMS—Optical Properties; SEMICONDUCTOR DEVICES, BIPOLAR—Radiation Effects; SEMICONDUCTOR DEVICES, MOS—Radiation Effects.

**095359 INVESTIGATION OF SIH IR ABSORPTION PEAKS IN NEUTRON-IRRADIATED FZ-SI CRYSTAL CONTAINING HYDROGEN AT LOW TEMPERATURE.** The Si-H IR absorption peaks in the neutron-irradiated FZ-Si crystal containing hydrogen are investigated using the low-temperature (10 K) Fourier transform infrared absorption spectroscopy. More hydrogen-related IR peaks than those in the case of room-temperature spectroscopy including the fine structure of the 1980  $\text{cm}^{-1}$  peak and the correlation between the 1839  $\text{cm}^{-1}$  and 817  $\text{cm}^{-1}$  peaks have been found. The annealing behavior of above-mentioned low-temperature peaks is shown more definitely than that at room temperature. The configurations of these peaks are discussed. (Author abstract) In Chinese. 9 refs.

Qi, Mingwei (Acad Sinica, China); Shi, Tiansheng; Cai, Peixing; Bai, Guoren; Xie, Leiming; Gao, Jijing; Li, Shiling. *Hongwai Yanjiu A-JI* v 6 n 5 1987 p 363-368.

**095360 EFFECT OF IRRADIATION WITH ELECTRONS ON THE ETCHING OF SILICON SINGLE CRYSTALS.** In silicon single crystals irradiated with fast electrons, a microrelief reflecting the shape of the crystallization front, not visible in unirradiated crystals, was revealed by selective etching. In addition, in dislocation-free crystals after irradiation a change in the shape of the etching pits caused by the presence of A-defects in the investigated material was observed. The appearance of a microrelief attests to a nonuniform distribution of radiation defects, while the change in the shape of the etching pits is apparently the result of an interaction between primary radiation defects and growth microdefects. In Russian. 13 refs.

Garnyk, V.S.; Gorin, S.N.; Eidenzon, A.M.; Stryukov, V.A. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 9 Sep 1987 p 1413-1417.

**095361 TEMPERATURE RISE OF SMALL SILICON PARTICLES DURING LASER IRRADIATION.** The temperature of small silicon particles during laser irradiation was estimated from the Raman spectra of the particles. The relationship between the peak frequency shift and the linewidth of the experimental data was compared with a theoretical calculation made by Balkanski et al. This comparison has enabled us to determine the temperature of the silicon particles during laser irradiation. (Author abstract) 6 refs.

Okada, Tadashi (Tsuyama Natl Coll of Technology, Tsuyama, Jpn); Yamamoto, Keichi. *Jpn J Appl Phys Part I* v 26 n 12 Dec 1987 p 2134-2135.

**095362 HOPPING CONDUCTION IN ELECTRON-IRRADIATED PH-DOPED SI.** Hopping conduction is studied in n-type Ph-doped Si at low tempera-

tures. Sufficient degree of damage induced by electron irradiation of 1.5 MeV allows the observation of conduction by nearest neighbour hopping, or variable range hopping. Evidence of electron-electron interaction in the hopping conductance is presented. (Author abstract) 17 refs.

Kouimtz, S.D. (Univ of Reading, Reading, Engl). *Solid State Commun* v 65 n 11 Mar 1988 p 1439-1443.

**095363 DIVACANCIES PRODUCTION IN IRRADIATED N-TYPE SILICON.** Measurements of loss factor and capacitance made on single crystals of P-doped n-type silicon are reported. Samples are irradiated with  $(1.00 \pm 0.20)$  MeV electrons at temperatures  $< 12$  K. The production of divacancies in the irradiated samples is monitored using hopping conductivity changes at 4.2 K. Higher divacancy production is observed in Czochralski-grown samples and samples containing appreciable concentrations of group III impurities. This suggests that oxygen and group III impurities trap the self interstitials, mobile under irradiation conditions, thus inhibiting divacancy-self-interstitials annihilation. Effects of irradiation on the free carriers conductivity of the samples are also investigated. (Author abstract) 13 refs.

Awadelkarim, O.O. (Univ of Reading, Reading, Engl). *Physica B & C* v 150 n 3 Jun 1988 p 312-318.

**095364 CEMS ANALYSIS OF  $\text{Ar}^+$  IRRADIATED  $\text{Fe}/\text{SiO}_2$  SYSTEM.** Ion-beam induced mixing effects on metal/insulator systems have been recently studied to shed light on the different physical mechanisms responsible for the atomic transport process at the interface. When a Mossbauer isotope is present as a constituent of the system or as a probe, conversion electron Mossbauer spectroscopy (CEMS) can investigate some microstructural aspects of the mixed layer such as chemical environment, local atomic arrangement, magnetic ordering, etc. The authors report preliminary results on CEMS characterization of the  $\text{Fe}/\text{SiO}_2$  interface after  $\text{Ar}^+$  irradiation. It is possible to evaluate the iron areal density from each CEM spectral component by combining the Rutherford backscattering spectrometry absolute value of the areal density with the relative amount of the Mossbauer component. 12 refs.

Principi, G. (Univ Padova, Padua, Italy); Zhang, P.Q.; Battaglin, G.; Lo Russo, S.; Paccagnella, A. *J Mater Sci Lett* v 7 n 5 May 1988 p 484-486.

**095365 KINETICS OF THE FORMATION OF THE THERMAL DONORS IN SILICON. EFFECT OF VARIOUS PARAMETERS.** Annealing at 450 °C of oxygen rich silicon generates nine hydrogenic double donors (thermal donors whose ionization energies are about 60 meV for neutral states and 145 meV for ionized states. New kinetics of thermal donor formation are reported and the effect of various parameters is discussed. The essential role of the initial characteristics of the material and its thermal history are pointed out. Experiments of electron irradiation performed at room temperature before the generation of thermal donors rule out the contribution of intrinsic defects like single- and multivacancies to the clustering process leading to thermal donor formation. (Author abstract) 31 Refs.

Henry, A. (CEN, Grenoble, Fr); Saminadayar, K.; Paustrat, J.L.; Magnea, N. *Phys Status Solidi A* v 107 n 1 May 1988 p 101-110.

**095366 DYNAMICS OF OPTICAL PARAMETERS OF SILICON AND GERMANIUM SINGLE CRYSTALS DURING TWO-PULSED NANOSECOND LASER IRRADIATION.** The behaviour of the reflectivity and ellipsometric parameters  $\psi$  and  $\Delta$  of silicon and germanium single crystals was investigated experimentally during two-pulsed laser irradiation. A comparison of the experimental data with the results obtained in solving Stefan's nonlinear problem and with the temperature dependences of the measured optical quantities shows that the maximum temperature of the melt surface of a semiconductor is lower than the value predicted by the simple model of laser annealing. The absence of surface

overheat may be attributed to hydrodynamic phenomena which can develop in liquid phase in the process of the melting front movement. (Edited author abstract) 29 Refs.

Gusakov, G.M. (Moscow Inst of Electronic Technology, Moscow, USSR); Komarnitskii, A.A.; Em, A.S. *Phys Status Solidi A* v 107 n 1 May 1988 p 261-271.

**095367 HIGH-RESOLUTION ELECTRON MICROSCOPY OF SI CONES FORMED ON  $\text{Ar}^+$ -BOMBARDED SI WAFERS.** Conical Si projections generated on Si wafers bombarded with obliquely incident  $\text{Ar}^+$  ions were studied by high-resolution transmission electron microscopy. The cones were composed of an [111]-oriented bulk phase covered with a disordered thin layer, but the bulk phase was not perfectly ordered, containing an amorphous domain underneath the outermost area. Such a multi-phase structure is inexplicable in terms of ion erosion, suggesting interplay of the redeposition of sputtered Si atoms on the bombarded area with the ion-erosion process so as to promote cone evolution. The cones were also characterized by the development of web-like platelets at their acute angles, an indication of a crystal growth process involved in the surface phenomenon observed. (Author abstract) 26 Refs.

Morishita, S. (Nagoya Inst of Technology, Nagoya, Jpn); Tanemura, M.; Fujimoto, Y.; Okuyama, F. *Appl Phys A* v 46 n 4 Aug 1988 p 313-321.

**095368 RADIATION EFFECTS IN  $\text{SiO}_2/\text{Si}$  STRUCTURES.** In this paper, differences of the radiation effects by X-ray and  $\gamma$ -ray were examined. The device characteristics of an Si MOS transistor are strongly dependent on the Si surface, that is, the  $\text{SiO}_2$  film and the  $\text{SiO}_2/\text{Si}$  bipolar transistor are dependent on both the Si crystalline properties and the Si surface. Therefore, bipolar transistors were used in this study. As a result, there was no noticeable difference between radiation effects by X-ray and  $\gamma$ -ray and the effects were due mainly to the property change at the Si/ $\text{SiO}_2$  interface. The radiation effects in the  $\text{SiO}_2$  Si structures were studied by the capacitance-voltage (C-V) characteristics of MOS diodes. The dependence of the radiation effects on the MOS diode fabrication processes was also examined. 23 Refs.

Watanabe, Kikuo (Hitachi Ltd, Kokubunji, Jpn); Kato, Masataka; Nagata, Minoru; Okabe, Takahiro. *Electron Commun Jpn Part 2* v 71 n 5 May 1988 p 83-92.

**095369 RADIATION AND PROCESSING INDUCED EFFECTS IN SIMOX: A SPECTROSCOPIC STUDY.** The SIMOX formation process has been studied with electron spin resonance (ESR), IR spectroscopy, and photoluminescence. Samples were implanted with doses from  $0.5 \times 10^{18}/\text{cm}^2$  to  $2.6 \times 10^{18}/\text{cm}^2$  and annealed at 600°C to 1275°C. The  $\text{P}_b$  and radiation induced  $\text{E}'$  centers were measured with ESR. By measuring the  $\text{P}_b$  concentration, it is shown that oxide precipitates are concentrated in the superficial silicon layer and that they coalesce into the buried oxide with annealing. The stoichiometry of the buried layer is examined with IR. At 600°C the stoichiometry,  $\text{SiO}_x$ , ranges from  $x = 1.4$  to  $x = 1.6$  depending upon the implant dose. The stoichiometry approaches that of thermal oxide,  $\text{SiO}_2$ , at 1150°C and above. Photoluminescence from the D lines, caused by dislocations, is observed and the structural implications are discussed. 27 refs.

Stahlbush, R.E. (US Naval Research Lab, Washington, DC, USA); Carlos, W.E.; Prokes, S.M. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1680-1685.

**095370 RECOMBINATION CENTERS AND ELECTRICAL CHARACTERISTICS IN SILICON POWER P-I-N DIODES IRRADIATED WITH HIGH ENERGY ELECTRONS.** Recombination centers introduced by irradiation with 12 MeV electrons in large area silicon diodes with p-i-n structure are studied by the Deep



Level Transient Spectroscopy technique (DLTS). The effects of these levels on the electrical characteristics of the devices are related to their position  $E_t$  in the silicon forbidden gap, their concentration and their electron capture cross section. Changes of defect configuration during an annealing process at 360°C have been observed and a detailed analysis of the DLTS spectra has shown a complex defect pattern. The complex structure of the centers has been studied and demonstrated with the aid of proper modelling implemented on a set of numerical simulation tools. (Edited author abstract) 24 refs.

Fuochi, P.G. (CNR, Bologna, Italy); Martelli, A.; Bisio, G.M.; Di Zitti, E.; Motto, M.G.; Passerini, B.; Zambelli, M. *Radiat Phys Chem* v 31 n 4-6 1988, Progr in Radiat Process, Proc of the 6th Int Meet, Vol II, Ottawa, Ont, Can, May 31-Jun 5 1987 p 809-819.

**095371 LIGHT-INDUCED METASTABLE STATE IN DOPING-MODULATED AMORPHOUS SILICON SUPERLATTICES.** Photo-induced decrease in conductance after long light exposure has been observed for hydrogenated amorphous silicon (a-Si:H) npn... doping-modulated superlattices showing large persistent photoconductivity (PPC). The initial increase in PPC is taken over by the decrease even to the negative PPC after long illumination. This light-induced, metastable conductance can be recovered completely by 160°C annealing, which is independent of exposure time. In particular, the metastable defects created in the p-layers are found to be annealed out at 100°C. These results strongly suggest the creation and annealing of dangling bonds by light-soaking and annealing in doping-modulated superlattices. (Edited author abstract) 14 refs.

Yoo, Byung-Su (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Choi, Suk-Ho; Lee, Choochong; Jang, Jin. *Superlattices Microstruct* v 4 n 2 1988, Pap from the Chicago Conf, Chicago, IL, USA. p 133-137.

## Recrystallization

**095372 CW ARGON-LASER INDUCED ZONE-MELTING RECRYSTALLIZATION OF THIN SILICON ON OXIDE.** This paper describes a CW argon laser-induced zone-melting recrystallization technique. Large areas of single-crystalline silicon films on SiO<sub>2</sub> were obtained. The main features of this technique are the combination of seeding structures, a specially-shaped laser-beam spot and a locally-altered capping layer. Single-crystal silicon islands of 50  $\mu\text{m} \times 165 \mu\text{m}$  with the same <100> orientation as the silicon substrate have been successfully obtained. p-Channel depletion MOSFETs ( $w/L = 40 \mu\text{m}/10 \mu\text{m}$ ) were fabricated in the recrystallized film. The  $I_D-V_D$  characteristics of the devices were excellent. The surface hole mobility was 170  $\text{cm}^2/\text{V}\cdot\text{s}$ . 15 refs.

Xu, Qixia (Acad Sinica, Beijing, China); Ryssel, H.; Goetzlich, J.; Steinberger, H. *J Cryst Growth* v 88 n 3 May 1988 p 383-390.

## Reviews

**095373 SILICON WAFERS FOR THE 1990'S.** This review covers the status, trends and characteristics of silicon wafers which will be needed for future fabrication of microelectronic devices. The most pervasive silicon use will be for standard CMOS and possibly BiCMOS, for ASIC with mature design rule technologies. Larger diameter wafers, e.g. 6-8 inches with pp+ and p- substrates will become more common. A number of topics and issues important in today's research and development are discussed. (Author abstract) 39 refs.

Seidel, Thomas E. (Univ of California, Santa Barbara, CA, USA). *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 97-105.

**Spectroscopic Analysis** See Also SOLIDS—Purification; SPECTROPHOTOMETERS, INFRARED—Equipment.

**095374 ANOMALOUS FEATURE ON THE DLTS SPECTRUM OF SILICON.** The behavior of a very curious feature arising on the DLTS spectrum of LN<sub>2</sub> electron-irradiated pulled silicon is studied. It is shown that this behavior is not consistent with a normal DLTS peak caused by the trapping and emission of carrier from a deep level. However, it is almost certain that this feature is a result of the low-temperature irradiation of the pulled silicon. A model is proposed based on the oxygen trapping at abnormal sites in the silicon lattice. (Author abstract) 11 refs.

Londos, C.A. (Univ of Athens, Athens, Greece). *Solid State Commun* v 62 n 10 Jun 1987 p 719-722.

**095375 CHARACTERIZATION OF SMALL DIFFERENCES IN SURFACE POLISHING QUALITY OF SILICON WAFERS BY SPECTROSCOPIC ELLIPSOMETRY.** The surface trace imperfection of silicon wafers resulting from different polishing technologies has been quantitatively characterized by use of spectroscopic ellipsometry. The dielectric function  $\epsilon = \epsilon' + i\epsilon''$  for the residual damaged thin layer at the surface was calculated from the ellipsometric parameters  $\Psi$  and  $\Delta$  on the basis of a four-phase model. Results show that (i) A diagnosis for very small differences between various conventionally adopted polishing processes can be realized in the  $E_1$  spectroscopic structure of the silicon interband transition region, rejecting the necessity of  $E_2$ -structure which emerges from a shorter UV range. (ii) It seems that for silicon, a higher sensitivity for the surface imperfection may be obtained with the real part  $\epsilon'$  of the dielectric function than its imaginary  $\epsilon''$  the wavelength range of  $E_1$ . (Author abstract) 13 refs. In Chinese.

Chen, Zai (Fudan Univ, Shanghai, China); Qian, Youhua. *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 175-180.

**095376 SECOND ISOELECTRONIC MULTIEXCITON CENTER IN ANNEALED CZOCHRALSKI SILICON.** A recently reported group of photoluminescence lines observed in thermally annealed Czochralski silicon is studied using photoluminescence, excitation, and transient spectroscopies. The properties of these lines are remarkably similar to those of another, higher energy, series reported earlier. As for this previous case, we conclude that the new lines result from bound exciton and bound multiexciton complex recombination on an inhomogeneously broadened distribution of isoelectronic binding centers. (Author abstract) 6 refs.

Steele, A.G. (Simon Fraser Univ, Burnaby, BC, Can); Thewalt, M.L.W.; Watkins, S.P. *Solid State Commun* v 63 n 2 Jul 1987 p 81-84.

**095377 FAR-INFRARED ABSORPTION AND NEAR-INFRARED EXCITATION SPECTROSCOPY OF ISOELECTRONIC BOUND EXCITONS IN Si-Be + C.** Intense photoluminescence from the axial isoelectronic center formed by a pair of Be atoms occupying a Si vacancy is often accompanied by a weaker set of lines lying at higher energy. A correlation between the intensity of these lines and the concentration of C in the sample led to the suggestion that the new center is a Be-Be center perturbed by a nearest-neighbor C. Our measurements reveal strong similarities between the excited states of both systems, supporting this model. (Author abstract) 9 refs.

Labrie, D. (Simon Fraser Univ, Burnaby, BC, Can); Booth, I.J.; Watkins, S.P.; Thewalt, M.L.W. *Solid State Commun* v 63 n 2 Jul 1987 p 115-118.

**095378 SIMS ANALYSIS, UNDER CAESIUM BOMBARDMENT, OF Si IN GaAs/(Al, Ga) AS SUPERLATTICES: DETECTION LIMIT AND DEPTH RESOLUTION.** The secondary ion mass spectrometry technique has been revealed as a very powerful method for such a determination. But, in this particular case, some difficulties are encountered at low doping levels because of the presence of ions interfering with the main silicon isotope at mass 28. This paper deals with the search

for satisfactory experimental conditions for such a silicon analysis under cesium primary ion bombardment, the main requirements being the detection limit and the depth resolution. It will be shown that AJH molecular ions are the interfering species and two approaches have been explored to avoid this interference: use of high mass resolving power facilities of a double focusing mass spectrometer, or experimentation at low vacuum conditions. A compromise is inevitable between maximum sensitivity in the  $1-2 \times 10^{15} \text{ cm}^{-3}$  range by detecting negative secondary ions and good depth resolution, equal to about 40 angstrom, by using positive secondary ion collection. The ultimate performances of the technique are limited by the silicon surface segregation process. (Edited author abstract). 19 Refs.

Gauneau, M. (CNET, Lannion, Fr); Chaplain, R.; Regreny, A.; Salvi, M.; Guillemot, C.; Azoulay, R.; Duhamel, N. *Surf Interface Anal* v 11 n 11 Aug 1988 p 545-552.

**095379 SPECTROSCOPIC STUDIES OF DOUBLE DONORS IN SILICON.** We briefly review optical excitation spectroscopy of isolated double donors in silicon. We discuss how energies of optically forbidden states may be determined, either i) from phonon-assisted Fano resonances above the ionization limit; or ii) by shifting forbidden states into resonance with allowed transitions through the application of uniaxial stress. For neutral donors with two bound electrons, the importance of many-body effects has recently been demonstrated by a first study of spin-triplet states under uniaxial stress. We discuss the implications for the electronic structure of double donors and the question whether these systems may be viewed as solid-state analogues of helium. Finally, for singly ionized double donors, we find that the behavior of the deepest excited states under uniaxial stress cannot be accounted for within effective-mass theory and the deformation-potential approximation. (Author abstract) 48 refs.

Grossmann, G. (Univ of Lund, Lund, Swed); Bergman, K.; Kleverman, M. *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 30-46.

**095380 PHOTOLUMINESCENCE FATIGUE EFFECT IN GD a-Si:H:O.** Photoluminescence fatigue effect in GD a-Si:H:O films was observed at 77K. This effect was shown to be sensitive to deposition power. These results are interpreted in terms of non-radiative recombination associated with dangling bonds created by prolonged light irradiation. This interpretation is verified by ESR measurements of the films. (Author abstract) 4 refs.

Dong, Mianyu (Zhejiang Univ, Hangzhou, China); Wu, Xiaoping; Han, Gaorong; Ding, Zishang. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 197-198.

**095381 STUDY OF LOCAL VIBRATIONAL MODE ABSORPTIONS OF A DEFECT RELATED TO EL2 IN SI-GaAs.** This paper reports a careful infrared absorption investigation which reveals a pair of local vibration mode (LVM) whose two component bands are explicitly related to the metastable state and the ground state of EL2 respectively. The samples measured in this experiment were LEC (liquid encapsulated Czochralski) grown undoped and HB (horizontal Bridgman) grown Cr-doped Si-GaAs crystals. 4 refs.

Song, Chunying (Acad Sinica, Beijing, China); Ge, Weikun; Jiang, Desheng; Xu, Chenchia. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 363-364.



**095382 THERMALIZATION OF PHOTOEXCITED CARRIERS IN a-Si:H.** The transient photoluminescence properties of a-Si:H are explained within the framework of an extended multiple trapping model. The model gives a satisfactory description of our experimental results for the time decay of the photoluminescence after a pulsed photoexcitation, as well as of the dependence on the temperature and on the intensity of an external bias. The same model can be used for the description of the transient phototransport properties of a-Si:H. (Author abstract) 6 refs.

Czaja, Wolfgang (Inst de Physique Appliquee, Lausanne, Switz); Maschke, Klaus; Merk, Eric. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 559-560.

**095383 NON-RADIATIVE TRANSITION RATES: ACCEPTING AND PROMOTING PHONON MODES IN AN N-MODE MODEL.** The emission rate from deep levels due to multiphonon processes is calculated in the presence of an electric field adopting an N-mode model for the lattice vibrations. A closed analytical formula is obtained for any number of promoting and accepting modes. Experimental data on Si:Au are interpreted by means of this formula. (Author abstract) 2 refs.

Schenk, A. (Humboldt-Univ zu Berlin, Berlin, East Ger); Suisky, D.; Enderlein, R. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 609-610.

**095384 INJECTION ELECTROLUMINESCENCE IN ITO/a-Si:H STRUCTURE.** Visible electroluminescence in p/a-Si:H/ITO device has been observed for the first time with the naked eyes at room temperature. The emission peak located around 1.17eV and 1.28eV at 300K and 77K, respectively. Visible-light comes from the short wave-length tail of the whole spectra. Therefore the visible EL intensity is very low at room temperature. (Author abstract) 5 refs.

Zhang, Fangqing (Lanzhou Univ, Lanzhou, China); Zhang, Yafei; Li, Yahong; Chen, Guanghua. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 773-774.

## Spectrum Analysis

**095385 ZINC-RELATED ISOELECTRONIC BOUND EXCITON IN SILICON.** Photoluminescence (PL), photoluminescence excitation (PLE), and photoluminescence lifetime measurements are reported for a newly-discovered optical centre in a silicon sample diffused with iron and zinc. The PL spectrum consists of two thermalizing no-phonon lines, each with sharp low energy local mode phonon replicas in addition to a broad multiphonon sideband. The no-phonon lines, at  $1059.93 \pm 0.05$  and  $1075.12 \pm 0.05$  meV, are attributed, respectively, to transitions from the spin triplet and singlet states of an isoelectronic bound exciton (IBE). Other states of the IBE are observed at  $1108.4 \pm 0.5$ ,  $1110.0 \pm 0.5$  and  $1133.2 \pm 0.5$  meV in the PLE spectrum, which also shows sharp local mode phonon replicas. The energy level structure is consistent with IBE states formed by a hole and an electron subject to a large ground state valley-orbit splitting, and bound at the centre by approximately 82 meV. (Author abstract) 21 refs.

Henry, M.O. (Simon Fraser Univ, Burnaby, BC, Can); Beckett, D.J.; Steele, A.G.; Thewalt, M.L.W.; McGuigan, K.G. *Solid State Commun* v 66 n 7 May 1988 p 689-694.

**Stresses** See Also CRYSTALS—Defects; SEMICONDUCTOR DEVICES—Metallizing.

**095386 NAPREZENIA WPROWADZANE DO PLYTEK KRZEMOWYCH W CZASIE PROCESU WYTWARZANIA PRZYRZĄDÓW POLPRZEWODNIKOWYCH I UKŁADÓW SCALONYCH.** [Stresses Introduced into Silicon Layers During Manufacturing

Process of Semiconductor Devices and Integrated Circuits]. The origins of mechanical stresses in silicon plates during a manufacturing process of semiconductor devices and integrated circuits are considered. Particular attention is paid to stress originating during high-temperature processes, manufacturing processes of films on surface of a silicon layer and introduction of impurity atoms into the surface layer of silicon. (Edited author abstract) In Polish. 18 refs.

Kasjanik, Slawomir (Inst Technologii Elektronowej CEMI w Warszawie, Pol). *Elektronika* v 27 n 9 1986 p 11-16.

## Structure

**095387 CONSTRUCTION OF BOND-CENTERED WANNIER FUNCTIONS FOR SILICON VALENCE BANDS.** Bond-centered Wannier functions are constructed for the valence bands of silicon by a direct superposition of the Bloch functions whose phases are chosen on physical grounds. The Bloch functions are calculated using the linear muffin-tin orbitals method within the local density approximation. The resulting four Wannier functions per unit cell are equivalent to one another. Each is localized on a bond-center, has the  $\Gamma_1$  symmetry of the  $D_{3d}$  group, and falls off exponentially. (Author abstract) 29 refs.

Satpathy, S. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Pawlowska, Z. *Phys Status Solidi B* v 145 n 2 Feb 1988 p 555-565.

**095388 EFFECT OF HYDROGEN DILUTION ON STRUCTURE OF a-Si:H PREPARED BY SUBSTRATE IMPEDANCE TUNING TECHNIQUE.** The effect of hydrogen dilution of a source gas,  $\text{SiH}_4$ , on structural inhomogeneity has been studied for hydrogenated amorphous silicon films prepared under the mode involving a high deposition rate by the substrate impedance tuning technique. As the silane fraction decreases from 100% to 1% with hydrogen dilution, the SiH bonding configuration gradually changes into the dihydride ( $\text{SiH}_2$ ) group; finally, the films become microcrystalline. On the other hand, the state density in the mid gap and the spin density, related to the structural disorder, have minima at silane fractions of 100% and 10%. These results seem to be consistent with a two-phase model suggested for high rate films, with an emphasis on a different medium range disorder between the films prepared at high and low deposition rates. (Author abstract) 15 refs.

Matsuo, Shinji (Hiroshima Univ, Higashi-Hiroshima, Jpn); Ueda, Masato; Imura, Takeshi; Osaka, Yukio. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 475-479.

**095389 CALCULATED BAND GAPS AND EXCITED STATES IN SEMICONDUCTORS.** A method of treating the screening by valence electrons in a semiconductor which takes account of the lower and more uniform charge density in the regions between atoms is applied to silicon and cadmium sulphide. Improved values of the band gap are obtained and these results along with the densities of states and energy bands in the region of the gap are discussed. (Author abstract). 10 refs.

Ali Dahr, A.-I. (Univ of Lancaster, Lancaster, Engl); Lee, P.M. *Phys Scr* v 38 n 3 Sep 1988 p 441-443.

**095390 MODELING THE STRUCTURE OF AMORPHOUS SI BY SIMULATED ANNEALING.** We have developed a computer algorithm to generate models for tetrahedrally coordinated random networks, the prototypical example being a-Si. The method is easily extended to many other systems, a-SiO<sub>2</sub> being an example. The starting point is a supercell in the diamond cubic structure. Periodic boundary conditions are imposed so as to eliminate surface effects. The algorithm uses an elementary topological rearrangement that is randomly and progressively introduced into the diamond cubic structure until a random network has been generated. This is followed by an 'annealing' process that allows topological relaxation of the structure, leading to a structural model in agreement with experiment. We also describe a solution

to the traveling salesman problem that is identical in all important respects to modeling the structure of a-Si. The simple topology and the two-dimensional character of the traveling salesman problem make it possible to give an explicit example of a metastable state. (Edited author abstract) 11 refs.

Wooten, F. (Univ of California, Livermore, CA, USA); Weaire, D. *Key Eng Mater* v 13 pt 1 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 109-117.

**Substrates** See Also ANTIMONY AND ALLOYS—Thin Films; LASERS, SEMICONDUCTOR—Performance; SEMICONDUCTING GALLIUM ARSENIDE—Defects; SEMICONDUCTING GALLIUM ARSENIDE—Growth; SEMICONDUCTING GALLIUM ARSENIDE—Vapor Deposition; SEMICONDUCTOR DEVICES, MOSFET—Junctions; SEMICONDUCTOR DEVICES, MOSFET—Radiation Effects; SILICA—Thin Films; SILICON AND ALLOYS—Chemical Vapor Deposition; SILICON COMPOUNDS—Thin Films; SILVER AND ALLOYS—Thin Films.

**095391 EVALUATION OF DISLOCATION GENERATION IN U-GROOVE ISOLATION.** The density of dislocations generated on a silicon substrate in a groove structure is measured. In addition, the effects of the topographical structure and isolation groove oxidation conditions are investigated. Results show that the generation of dislocations greatly depends on the shape of the groove and the oxidation temperature. These results can be interpreted as being due to both the effect so the stress concentration during selective oxidation in the groove and the viscous flow of a  $\text{SiO}_2$  film. Also studied are suitable structure and process conditions for U-groove isolation by making use of the experimental results and stress analysis. (Edited author abstract) 17 refs.

Tamaki, Yoichi (Hitachi Ltd, Kokubunji, Jpn); Isomae, Seiichi; Sagara, Kazuhiko; Kure, Tokuo; Kawamura, Masao. *J Electrochem Soc* v 135 n 3 Mar 1988 p 726-730.

**095392 MOLECULAR BEAM HOMOEPITAXY ON Si(100) SUBSTRATES.** Molecular beam homoepitaxy of silicon on Si (100) and Si (111) substrates has been done with a UHV electron beam evaporation system. It is found that, after the substrate is chemically cleaned, a flat and ordered surface can be obtained by heating the substrate at UHV at a relatively low temperature (800-814°C). The epitaxial films of Si on Si (100) and Si (111) are deposited at the substrate temperature of 520°C and 714°C, respectively. The crystal structure and electrical properties of the epitaxial films are fairly satisfactory. (Edited author abstract). 2 Refs. In Chinese.

Zhou, Keming (Fudan Univ, China); Jiang, Weidong; Sheng Chi; Zhou, Guoliang; Zhang, Xiangjiu. *Bandaoti Xuebao* v 9 n 4 Jul 1988 p 435-438.

## Surface Properties

**095393 THEORY OF TWO-CENTER BOND FOR ON-TOP SITE ADSORPTION ON SILICON (111) SURFACE.** The theory of two-center bond has been applied to the on-top site adsorption of atomic H, O, F and Cl on Si (111) surface. The theory gives a systematic analysis for their bond length, charge population, force constant and, by a simple molecular model, local vibrational frequency. The adatom-induced valence band PES is discussed from a self-consistent calculation of bond orbitals in a previous paper. The results are comparable to ab initio and CNDO calculations for the same problem. For O and Cl adsorptions, the theory leads to agreement with experiments. (Author abstract). 10 Refs. In Chinese.

Zhong, Xuefu (Acad Sinica, Beijing, China); Xing, Yirong. *Bandaoti Xuebao* v 9 n 4 Jul 1988 p 358-363.

**Surfaces** See Also SEMICONDUCTOR DEVICES—Semiconductor Insulator Boundaries; SILICON COMPOUNDS—Forming.



**095394 ANALYSIS OF THE ATOMIC STRUCTURE OF THE Si(111)  $\sqrt{3}\times\sqrt{3}$ -Bi SURFACE BY X-RAY PHOTOELECTRON DIFFRACTION.** It is found by X-ray photoelectron spectroscopy and LEED that the saturation coverage of Bi is one monolayer for the Si(111) $\sqrt{3}\times\sqrt{3}$ -Bi surface. Azimuthal dependence of Bi 4d photoelectron diffraction has been measured for the Si(111) $\sqrt{3}\times\sqrt{3}$ -Bi surface and analyzed kinematically. The results of the analysis have confirmed the presence of Bi-triplets with sides of 3.1 Å as proposed by X-ray diffraction. It is further found that the Bi-triplets form an overlayer on the substrate. (Author abstract) 14 refs.

Park, Chong Yun (Tohoku Univ, Sendai, Jpn); Abukawa, Tadashi; Higashiyama, Kazuyuki; Kono, Shozo. *Jpn J Appl Phys Part 2* v 26 n 8 Aug 1987 p 1335-1337.

**095395 SILICON [113] SURFACE AS A TEST FOR SURFACE-ENERGY CALCULATIONS.** Surface-energy calculations have, in the past, been undertaken for a wide range of silicon surfaces with a degree of success that remains unclear. They suggest, for example, that the {113} face has a particularly high energy, but this is in direct conflict with the results of thermal etching. Simulated profile images of the theoretically derived silicon {113} surface and of a reconstruction based upon 'rebonding at steps' are here compared with recent observations. It is concluded that the former model may be discounted, while the latter, hitherto dismissed on theoretical energy grounds, gives good qualitative agreement with experiment. The practical implications of this are discussed briefly. (Edited author abstract) 13 refs.

Saisbury, I.G. (Uiv of Liverpool, Liverpool, Engl); Huxford, N.P. *Phil Mag Lett* v 56 n 1 Jul 1987 p 35-40.

**095396 ROLE OF STRUCTURAL DEFECTS AND ADMIXTURES IN RECONSTRUCTING A (100) SILICON SURFACE.** The (100) facet of silicon is investigated using methods of diffraction of slow electrons and electron Auger spectroscopy. (2 by 1), p(2 by 2) and c(4 by 4) superstructures are noted as the surface admixtures are removed from the sample. The c(4 by 4) superstructure is shifted into a (4 by 1) superstructure with subsequent electron effects ( $T=450^\circ\text{C}$ ,  $E=3\text{ keV}$ , and  $D=5\cdot 10^{19}\text{ electrons/cm}^2$ ). A model of the mutual transition of the cited elementary cells with each other is constructed using a quantum-chemical approximation of valent bonds. (Author abstract) 17 refs.

Burmistrov, V.V.; Dubinina, E.M.; Elovikov, S.S.; Ivanikov, V.P. *Moscow Univ Phys Bull* v 42 n 2 1987 p 76-82.

**095397 ON THE INTERACTION OF HALOGEN ATOMS WITH (111) AND (100) SURFACES OF SILICON.** The chemisorption of F, Cl, Br, and I atoms on the (111) and (100) surfaces of silicon has been studied by the MNDO method and using clusters of Si atoms to simulate the substrate. In the case of the adducts  $\text{F-Si}_4\text{H}_9$  and  $\text{Cl-Si}_4\text{H}_9$  the MNDO results are in close agreement with previous ab-initio ones concerning both the equilibrium distance and the chemisorption energies. For all the cases considered, the binding energy decreases in the order  $\text{F} > \text{Cl} > \text{Br} > \text{I}$ . The most stable adduct is always obtained upon chemisorption at the bridge position on the (100) surface. Chemisorption at on-top positions leads to slightly less stable adducts and is nearly isoenergetic on (100) and (111) surfaces. All the results are essentially insensitive to the dimensions of the clusters used to simulate the substrate. (Author abstract) 21 refs.

Barone, Vincenzo (Univ di Napoli, Italy); Leij, Francesco; Russo, Nino; Toscano, Marirosa. *Solid State Commun* v 59 n 7 Aug 1986 p 433-436.

**095398 ELECTRON-BEAM-INDUCED CURRENT OBSERVATION OF MISFIT DISLOCATIONS AT  $\text{Si}_{1-x}\text{Ge}_x/\text{Si}$  INTERFACES.** The electron-beam-induced current (EBIC) method has been applied to observing the misfit dislocations at  $\text{Si}_{1-x}\text{Ge}_x/\text{Si}$  interfaces in order to determine directly the dependence of critical layer thickness  $h_c$  on mole fraction  $x$ . The EBIC images show square-grid patterns that agree with a

chemical etched pattern. The typical dislocation image width obtained by EBIC is about 0.5  $\mu\text{m}$ , which approximately agrees with the resolution introduced from the lateral-dose function. It has been found that the dependence of  $h_c$  on  $x$  judged from whether or not the misfit dislocations generate cannot be explained by the theory presented by R. People and J.C. Bean. (Author abstract) 8 refs.

Kohama, Yoshitaka (NTT Applied Electronics Lab, Musashino, Jpn); Watanabe, Yoshio; Fukuda, Yukio. *Jpn J Appl Phys Part 2* v 26 n 12 Dec 1987 p 1944-1946.

**095399 HIGH RESOLUTION INVESTIGATION OF THE ROD-SHAPED SCATTERING FROM A (111) Si SURFACE BY A SYNCHROTRON RADIATION SOURCE.** By using a high resolution X-ray spectrometer in conjunction with a synchrotron radiation source, the rod-shaped scattering due to crystal truncation (RSCT), which is elongated along the normal of a crystal surface through a Bragg point, was investigated for two (111) silicon wafers of which the surfaces were differently processed. It is shown that the characterization of a crystal surface, on the basis of surface roughness on an atomic scale and the misorientation of mosaic blocks, is really possible by the precise measurement of the RSCT. (Author abstract) 7 refs.

Kashiwagura, Nobuo (Gifu Univ, Gifu, Jpn); Kashiwara, Yasuharu; Sakata, Makoto; Harada, Jimpei; Wilkins, Stephen W.; Stevenson, Andrew W. *Jpn J Appl Phys Part 2* v 26 n 12 Dec 1987 p 2026-2029.

**095400 IMPEDANCE STUDY OF THE SILICON-SOLUTION INTERFACE UNDER ILLUMINATION.** Surface states at the semiconductor-electrolyte interface under illumination have been determined. The Faradaic reaction involved at the interface is the hydrogen evolution. An equivalent circuit is proposed which is chosen as giving the best fit to the impedance data among six possible arrangements consistent with present models of the interface. Surface states act as recombination centers decreasing the Faradaic efficiency for the hydrogen evolution reaction. Surface state density at a given bias potential has been calculated to be  $\approx 10^{12}\text{ cm}^{-2}$ . Adsorbed ions induce surface states. Helmholtz double layer resistance is larger than the space charge resistance in the Tafel region; hence, the rate determining step for hydrogen evolution on Si lies in the double layer region. (Author abstract) 51 refs.

Chandrasekaran, K. (TX A&M Univ, College Station, TX, USA); Kainthla, R.C.; Bockris, J.O'M. *Electrochim Acta* v 33 n 3 Mar 1988 p 327-336.

**095401 DISLOCATION MEDIATED PSEUDO-MELTING AT SILICON-METAL INTERFACES.** The silicide formation between silicon and transition as well as noble metals occurs at 0.3-0.4 of the melting temperature of silicon. It is proposed that the chemical reaction is preceded by an interfacial melting process due to defect generation (dislocation or disclination) via the Koestertiz-Thouless mechanism. This is possible at temperatures lower than the melting temperature due to overall softening of the shear vibration mode of the surface silicon layers and may lead to the low temperature chemical reaction observed. The softening mechanism of atoms on the (111) surface of silicon due to the metal overlayer is suspected to be both elastic and electronic in origin, and leads to the breaking of the strong covalent silicon bonds at low temperatures. 13 refs.

Chakraverty, B.K. (Lab d'Etudes des Propriétés Electroniques des Solides, Grenoble, Fr). *Phys Prop of Amorphous Mater, Proc of a Lect Ser, Bloomfield Hills, MI, USA, 1982-1983* Publ by Plenum Press, New York, NY, USA & London, Engl, 1985 p 261-275.

**095402 USING PULSED HOLOGRAPHIC INTERFEROMETRY FOR EXAMINING THE DYNAMICS OF DEFORMATION OF THE SILICON SURFACE IN LASER IRRADIATION.** The authors developed a method of using pulsed holographic interferometry for measuring mechanical displacements of the surface of

solids under the effect of pulses of laser radiation. The profiles of displacement of the surface of the irradiated and adjacent zones in relation to the energy and passage time of the laser radiation pulse are constructed. It is shown that the high-speed heating and cooling of the material plays the controlling role in formation of the mechanical displacements of the surface of silicon. (Author abstract) 7 refs.

Bakharev, M.S.; Mirkin, L.I.; Khazen, A.M. *Phys Chem Mater Treat* v 21 n 6 Nov-Dec 1987 p 574-576.

**095403 IN SITU STUDY OF AQUEOUS HF TREATMENT OF SILICON BY CONTACT ANGLE MEASUREMENT AND ELLIPSOMETRY.** The application of in situ ellipsometry and in situ contact angle measurement to semiconductor surfaces is introduced. It should be recognized that the techniques discussed are applicable to all semiconductor surfaces in any ambient liquid phase. Experimental and instrumental considerations for the use of these techniques are discussed as well as experimental results for analysis of silicon and silicon dioxide surfaces. These results pertain to Si surfaces in ambient aqueous HF and yield evidence of a fluorocarbon film present on the Si surface following etch of a  $\text{SiO}_2$  film. (Author abstract) 31 refs.

Gould, G. (Univ of North Carolina, Chapel Hill, NC, USA); Irene, E.A. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1535-1539.

**095404 OSCILLATIONS OF THE SPIN AND VALLEY SPLITTINGS IN THE 2D-ELECTRON ENERGY SPECTRUM ON THE (100) SURFACE OF SILICON.** A spectroscopic method based on measurements of the luminescence spectra related to the radiative recombination of two-dimensional electrons with photo-excited nonequilibrium holes was applied for direct determination of the intervalley and spin splittings in the energy spectrum of two-dimensional electrons in a perpendicular magnetic field. Strong oscillatory dependences of these splittings on the filling factor have been observed. It is shown that the splittings increase by almost an order of magnitude due to the electron-electron interaction. (Edited author abstract) 18 refs.

Kukushkin, I.V. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger). *Solid State Commun* v 65 n 12 Mar 1988 p 1473-1476.

**095405 LEED INVESTIGATIONS ON PURE AND METAL TREATED VICINAL SILICON(111).** The structure of vicinal Si(111) surfaces as a function of misorientation was studied by LEED measurements. We find significant differences in morphology dependent on the step orientation. In part drastic changes of the structure have been observed after evaporation of small amounts of Ni or Pd, and after additional high temperature heat treatment. For Ag/Si(111) no changes were observed. (Edited author abstract) 15 refs.

Jentzsch, F. (Univ Hannover, Hannover, West Ger); Henzler, M. *J Appl Phys A* v A46 n 2 Jun 1988 p 119-123.

**095406 ORIGIN OF THE ROOM TEMPERATURE ALLOYED INTERFACE FORMATION (RTAIF) AT METAL-SEMICONDUCTOR INTERFACES THROUGH STUDIES USING SYNCHROTRON RADIATION (SR): THE CHEMICAL BONDING MODEL.** The room temperature alloyed interface formation at metal-semiconductor contacts is discussed. Au- and Ag- atoms behave differently on a clean Si surface from the viewpoint of RTAIF in spite of the fact that they belong to the same group in the periodic table. Several models for the phenomenon are compared where special attention is paid to photoemission studies performed on Au- and Ag-Si(111):2 $\times$ 1 systems at room temperature



using synchrotron radiation. The chemical bonding model explains the experimental observations. (Edited author abstract) 31 refs.

Iwami, Motohiro (Okayama Univ, Okayama, Jpn). *Rep Res Lab Surf Sci Okayama Univ* v 6 n 3 Nov 1987 p 37-47.

**095407 ABOUT THE SENSITIVITY OF IN SITU DIFFRACTION MEASUREMENTS WITH X-RADIATION OF A LASER-PRODUCED PLASMA.** Investigations were made of the angular resolution suitable for the temperature determination of a heated surface layer on (111)-oriented silicon by means of X-ray diffraction experiments with characteristic line emission of a laser-produced silicon-plasma. To model the thermally expanded layer a silicon crystal was implanted with  $1 \times 10^{15}$ ,  $0.2 \times 10^{15}$ , and  $2.1 \times 10^{15}$  boron-ions/cm<sup>2</sup> at 60, 100, and 150 keV, respectively. The maximum deformation obtained by the implantation process amounts to approx.  $3 \times 10^{-4}$  in an approx. 0.5  $\mu$ m thick surface layer. This deformation corresponding with a temperature increase of about 100 K may be detected by means of in situ X-ray diffraction methods. (Author abstract) 18 refs.

Forster, E. (Friedrich-Schiller-Univ, Jena, East Ger); Glas, P.; Goetz, K.; Joksche, St.; Nickles, P.V.; Schnurer, M.; Will, I. *Phys Status Solidi A* v 107 n 1 May 1988 p 85-93.

**095408 COMPUTER SIMULATION OF LEDGE FORMATION AND LEDGE INTERACTION FOR THE SILICON (111) FREE SURFACE.** Both strip and triangular clusters, composed of  $\langle 211 \rangle$  ledges, have been simulated on the Si (111) surface. The long range ledge-ledge interaction and the surface stress tensor distribution have been evaluated for these two pill-box geometries using a semi-empirical potential energy function that incorporates both two-body and three-body contributions. The consequences of the ledge-ledge interaction on two-dimensional nucleation for Si(111) has been evaluated as a function of Si adatom supersaturation and shows to differ significantly from conventional theory where such interaction is neglected. (Author abstract) 8 refs.

Balamane, H. (Stanford Univ, Stanford, CA, USA); Halicioglu, T.; Tiller, W.A. *J Cryst Growth* v 85 n 1-2 Nov 1 1987, Amer Cryst Growth 1987, Proc of the Seventh Amer Conf on Cryst Growth, Monterey, CA, USA, Jul 12-17 1987 p 16-24.

**095409 PHASE TRANSFORMATIONS AT A NICKEL-SILICON INTERFACE UNDER TRANSCIENT ANNEALING.** We use intense incoherent light pulses of approximately 60  $\mu$ s duration to induce reactions at a Ni-Si interface. Changes in morphology, composition, and electrical characteristics of the interfaces are studied. The diagnostics include scanning electron microscopy, Auger spectroscopy, X-ray analysis, and diffusion analysis. After annealing for a total of approximately 1 ms, the Si surface is found to support an intermixed and disordered Ni-Si layer consisting of mixed islands and flat structures. On further irradiation, after a certain threshold Ni density is reached in the Si, silicide growth takes place at the interface through an amorphous-to-crystalline transformation of this intermixed layer. The first phase to nucleate is mononickel silicide with a (200) orientation. This is attributed to kinetic effects, which optimize the heat of formation in the presence of excess Si. (Author abstract) 18 refs.

John, P.K. (Univ of Western Ontario, London, Ont, Can); Rastogi, A.C.; Tong, B.Y.; Wu, X.W.; Wong, S.K. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 1037-1043.

**095410 SCANNING TUNNELING SPECTROSCOPY ON SI.** An overview is given of various methods for applying tunneling microscopy to obtain information on the electronic structure of surfaces. Results are presented for clean Si(111) $\times 7$  and for a Si(111) $\times 7$  surface on which 1/3 monolayer was deposited. The interrelation between constant current topographies and current im-

ages is discussed. It is shown that the current characteristics obtained at a fixed sample-tip distance contain both influences of the local density of states and the transmission probability of the tunneling electrons. Information on the local density of states is not only of fundamental importance but is needed for an accurate interpretation of the constant current topographies and may be used to study the electronic effects upon metal atom adsorption. (Author abstract) 25 refs.

Neddermeyer, H. (Ruhr-Univ Bochum, Bochum, West Ger); Tosch, St. *Ultramicroscopy* v 25 n 2 1988, Scanning Tunneling Microsc, Sel Contrib from the Meet of the Ger Soc for Electron Microsc, Bremen, West Ger, Sep 1987 p. 135-147.

## Synthesis

**095411 SPECIAL FEATURES OF THE PROCESS OF HYDROGEN REDUCTION OF TRICHLOROSILANE IN THE PRESENCE OF WATER VAPOR.** A thermodynamic analysis is made of the process of hydrogen reduction of trichlorosilane in the presence of a residual quantity of water vapor. The equilibrium yield of silicon and silicon dioxide is determined as a function of temperature and trichlorosilane and moisture content in the Si-H-Cl-O system. It is established that the presence of moisture in the hydrogen does not lead to a decrease in the equilibrium yield of silicon. The optimally admissible moisture content, which does not lead to impairment of the structure of the polycrystalline silicon films being grown, is determined. (Translated author abstract) In Russian. 5 refs.

Bogomaz, A.V.; Galkin, P.N.; Levinzon, D.I.; Pravdina, O.V.; Tokarev, V.P. *Tsvet Met* n 1 Jan 1988 p 56-58.

**095412 SILICON FROM MICROWAVE PLASMAS: OPTICAL PROPERTIES AND THEIR RELATION TO STRUCTURE.** Amorphous and microcrystalline silicon films have been fabricated by microwave plasmas in a silane-hydrogen gas mixture under electron cyclotron resonance conditions. Optical properties of these films have been measured for photon energies in the range from 2.0 to 3.5 eV. The results show that the optical gap decreases from 1.70 to 1.40 eV as the structure changes from an amorphous network into a microcrystalline-amorphous mixture. The amorphous to microcrystalline transition is clearly indicated by the spectra of the refractive index  $n$ , and the imaginary part of the dielectric constant  $\epsilon_2$ . The measurements of the  $n$  and  $\epsilon_2$  spectra provide an alternative technique to x-ray diffraction in the investigation of microcrystalline structure, and would be particularly useful for thin films. (Edited author abstract) 31 refs.

Herak, T.V. (Univ of Manitoba, Winnipeg, Manit, Can); Schellenberg, J.J.; Shufflobotham, P.K.; Kao, K.C.; Card, H.C. *J Non Cryst Solids* v 103 n 1 6(II) 1988 p 125-130.

## Testing

**095413 NEW METHOD OF DETECTING PINHOLES EXISTING IN a-Si:H FILMS.** Pinholes are often inevitably formed in hydrogenated amorphous silicon (a-Si) film by a plasma CVD method, and they sometimes spoil the performance of the a-Si solar cells. For the a-Si films prepared on stainless steel, the stainless steel substrates were found to corrode at the points of contact with the pinholes of a-Si films by the electrochemical treatment of the a-Si covered plates. The currents flowing during the treatment can be utilized as a measure of the density of pinholes existing in the a-Si films. Many pits were observed on the substrates after the treatment, showing the places where the pinholes existed in a-Si films. By use of this method, the relation between the surface roughness of the stainless steel substrates and the formation of pinholes was clarified. (Author abstract) 9 refs.

Sakai, Yuichi (Osaka Univ, Toyonaka, Jpn); Yae, Shinji; Matsumura, Michio; Nakato, Yoshihiro; Tsubomura, Hiroshi. *Sol Energy Mater* v 17 n 2 Feb-Mar 1988 p 89-94.

**095414 INFLUENCE OF A GATE OXIDE ON THE 1/f NOISE IN SI.** The noise of thin Si samples with a large oxide layer is measured. 1/f noise sources in the bulk and near the semiconductor-oxide interface are observed. The 1/f noise parameter  $\alpha$  of the noise sources in the bulk is lower by a factor of 10 at least than those near the interface. The McWhorter model can explain the gate voltage dependence of the  $\alpha$ -value only at 300 K and its temperature dependence only above 160 K. The gate voltage dependence can also be explained in terms of mobility fluctuations by assuming two parallel layers, a surface layer with a higher  $\alpha$ -value and a lower mobility than the bulk layer. (Author abstract) 8 refs.

Clevers, R.H.M. (Eindhoven Univ of Technology, Eindhoven, Neth). *Physica B & C* v 147 n 2-3 Jan-Feb 1988 p 305-310.

## Thermal Properties

**095415 ANHARMONIC EFFECT ON THE THERMAL PROPERTIES OF SI AND GE.** The temperature dependence of specific heat  $C_N$  and thermal expansion coefficient  $\alpha$  for Si and Ge are studied theoretically from first principle by using the lattice dynamical method based on pseudopotentials. The obtained results of  $C_N$  and  $\alpha$  in the harmonic approximation are self-consistent with the observed data of these crystals at low temperatures. At high temperatures, the anharmonic contributions to the specific heat  $C_N^{\text{anh}} = C_N(1 + AT)$  are calculated by using the expression by Trivedi et al. The temperature dependence of the bulk modulus  $B_T$  are quantitatively obtained by considering the lattice vibrational contributions in addition to the static crystal energy. Then, the anharmonic corrections to the thermal expansion coefficient are estimated at high temperatures. The anharmonic coefficient  $A$  for the specific heat and the temperature-dependent decrease of  $B_T$  are quantitatively important at high temperatures for Si and Ge. (Author abstract) 51 refs.

Kagaya, Hiroko-Matsuo (Akita Univ, Akita, Jpn); Shoji, Naomichi; Soma, Toshinobu. *Solid State Commun* v 65 n 11 Mar 1988 p 1445-1450.

## Thermoelasticity

**095416 THERMOELASTIC RESPONSE OF POLYCRYSTALLINE SI TO AN INTENSE CW LASER BEAM.** We have used analytic methods to obtain closed forms for the thermal strains induced on polycrystalline Si when a cw visible laser beam is focused on its surface. The material is treated as isotropic with appropriately chosen elastic constants. The solution is expressed in terms of the Galerkin vectors for a semi-infinite bulk medium under point dilatation. The results show that considerable strains (corresponding to typical compressive stresses up to 0.5 GPa) are produced even for laser power densities lower than the threshold for melting. Three-dimensional graphical representations are given for the elastic displacements, the strain, and stress components, as a function of appropriate geometrical coordinates. (Author abstract) 27 refs.

Liarokapis, E. (Nat'l Technical Univ, Athens, Greece); Anastassakis, E. *Phys Scr* v 38 n 1 Jul 1988 p 84-89.

## Thick Films

**095417 GENERATION AND CHARACTERIZATION OF THICK SILICON-ON-INSULATOR FILMS.** Seeded recrystallization of thick (up to 25  $\mu$ m) polycrystalline silicon on SiO<sub>2</sub> using a zone melting technique provides films which contain no grain boundaries and exhibit large areas without subgrain boundaries (mm<sup>2</sup>). The results, especially the comparison of the two irradiation systems used (laser and strip heater), indicate the dominating role of the thermal gradient at the crystallization front for the origin and arrangement of defects. The electrical properties measured in CMOS transistors and diodes are comparable to a bulk reference preparation. (Author abstract) 23 refs.

Tillack, B. (Acad der Wissenschaften, Frankfurt, East



Ger); Banisch, R.; Richter, H.H. *Phys Status Solidi A* v 107 n 1 May 1988 p 281-289.

**Thin Films** See Also DISPLAY DEVICES—Liquid Crystal; RESISTORS—Electric Properties; SEMICONDUCTING SILICON COMPOUNDS—Chemical Vapor Deposition; SILANES—Purification; SOLID STATE DEVICES, MIM—Electric Conductivity; TRANSISTORS—Performance.

**095418 KINETICS AND MECHANISM OF ELECTROCHEMICAL FORMATION OF POROUS SURFACE LAYERS ON SILICON IN HYDROFLUORIC ACID. INFLUENCE OF ILLUMINATION ON THE KINETICS AND MECHANISM OF ANODIC POROUS-LAYER FORMATION ON n-TYPE SILICON.** The author discusses results obtained when studying the effect of light on the laws of PL growth and of silicon dissolution as the process that is basic to pore formation. Illumination lowers the rate of porous-layer formation under galvanostatic polarization, so that the linear and parabolic kinetics found in the dark is transformed to linear kinetics. Under the effect of light, oxidation of silicon to the divalent state is the predominant reaction; this promotes formation of a more porous structure because of inhibition of the growth of macropores taking place in the dark when silicon dissolves to tetravalent compounds. (Edited author abstract) 13 refs.

Izidinov, S.O. (V.I. Lenin All-Union Electrotechnical Inst, Moscow, USSR); Blokhina, A.P.; Martynova, T.S. *Sov Electrochem* v 23 n 1 Jan 1987 p 66-70.

**095419 CONSTRAINED FACET CRYSTAL GROWTH OF THIN FILMS ON AMORPHOUS SUBSTRATES.** The crystallization of thin silicon films by scanning with laser-shaped hot zones has been investigated. Large single crystals were obtained on silicon dioxide layer substrates by controlling the shape of the trailing edge of the traveling liquid zone. A model based on thermodynamic driving forces and geometrically limited kinetics within the undercooled region is proposed to describe the mechanism by which the geometry of the hot zone controls the crystallization of thin films on amorphous substrates. (Author abstract) 16 refs.

Aklufi, M. (US Naval Ocean Systems Cent, San Diego, CA, USA); Cadoff, I. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2511-2517.

**095420 EFFECT OF LOW PRESSURE ON THE STRUCTURE OF LPCVD POLYCRYSTALLINE SILICON FILMS.** Structure and crystal growth of undoped silicon films prepared by low pressure chemical vapor deposition (LPCVD) have been investigated by x-ray diffraction, and transmission and scanning electron microscopy. We show that for films deposited in silane partial-pressure range  $2 \times 10^{-4} \leq P \leq 1$  torr and temperature range  $580^\circ\text{C} \leq T \leq 700^\circ\text{C}$ , the pressure is a determining factor for crystallite size, texture, and surface roughness. At a fixed temperature, the crystallite size decreases when the pressure increases. At very low pressures the films have a random orientation. At intermediate pressures the films are characterized by a  $\langle 100 \rangle$  dominant texture and at high pressure, by a strong  $\langle 110 \rangle$  preferred orientation. (Edited author abstract) 22 refs.

Joubert, P. (CNET, Lannion, Fr); Loisel, B.; Chouan, Y.; Haji, L. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2541-2545.

**095421 MECHANISM OF SILICON FILM DEPOSITION IN THE RF PLASMA REDUCTION OF SILICON TETRACHLORIDE.** Plasma-chemical reduction of  $\text{SiCl}_4$  in mixtures with  $\text{H}_2$  and Ar has been studied by optical emission spectroscopy (OES) and laser interferometry techniques. It has been found that the Ar:  $\text{H}_2$  ratio strongly affects the plasma composition as well as the deposition ( $r_D$ ) and etch ( $r_E$ ) rates of Si: H, Cl films and that the electron impact dissociation is the most important channel for the production of  $\text{SiCl}_x$  species, which are the precursors of the film growth. Chemisorption of  $\text{SiCl}_x$  and the reactive surface reaction  $\text{SiCl}_x + \text{H} \rightarrow \text{SiCl}_{(x-1)} + \text{HCl}$  are important steps in the deposition process. The sug-

gested deposition model gives  $r_D \propto [\text{SiCl}_x][\text{H}]$ , in agreement with the experimental data. (Edited author abstract) 29 refs.

Bruno, G. (CNR, Bari, Italy); Capezzuto, P.; Cicala, G.; Cramarossa, F. *Plasma Chem Plasma Process* v 6 n 2 Jun 1986 p 109-125.

**095422 CHARACTERISTICS FOR a-Si:H FILMS PREPARED BY MERCURY-SENSITIZED PHOTO-CHEMICAL VAPOR DEPOSITION.** The density of states in a-Si:H, prepared by mercury-sensitized photo-CVD, was measured by the space-charge-limited current method. The density of Si dangling bonds ( $N_D$ ) was measured by the electron spin resonance method.  $N_D$  and a minimum of the density-of-state near the Fermi level ( $N_{\text{min}}$ ) indicated the same tendency versus substrate temperature, which showed a good correlation between  $N_D$  and  $N_{\text{min}}$ . Both  $N_D$  and  $N_{\text{min}}$  showed a minimum value near substrate temperature of  $200^\circ\text{C}$ . Photosensitivity reached more than  $1 \times 10^6$  for the sample. (Author abstract) 8 refs.

Kamimura, Takaaki (Toshiba Corp, Kawasaki, Jpn); Nozaki, Hidetoshi. *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1573-1575.

**095423 PROPERTIES OF POLYCRYSTALLINE SILICON GROWN ON INSULATING SUBSTRATES BY ELECTRON BEAM GUN EVAPORATION.** Growth of polycrystalline silicon on insulating substrates such as glass, silicon dioxide and fused quartz was studied using an electron beam gun evaporation technique. Growth characteristics were studied as a function of substrate temperature. The results of scanning electron microscopy, secondary ion mass spectrometry and X-ray diffraction studies on various films are presented. Hall mobility, resistivity and carrier concentration measurements are also presented. Growth of polycrystalline films (as determined by X-ray diffraction studies) on glass substrates at as low a temperature as  $525^\circ\text{C}$  were observed. Below this substrate temperature, films became amorphous. The grain size increased with the increase in the substrate temperature. The highest value of the Hall mobility measured was about  $10 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ . Both n-type and p-type films were obtained. (Author abstract) 15 refs.

Annamalai, N.K. (RADCE-ESR, Hanscom AFB, MA, USA); Meyyappan, Nara; Khondker, A.N. *Thin Solid Films* v 155 n 1 Dec 15 1987 p 97-113.

**095424 CHARACTERIZATION OF MICROCRYSTALLINITY IN HYDROGENATED SILICON THIN FILMS.** The characterization of microcrystallinity in undoped hydrogenated silicon thin films by means of X-ray diffraction and Raman spectroscopy is discussed in detail. We present experimental results for glow discharge films prepared under a wide range of conditions. Microcrystallinity is characterized in terms of crystalline volume fraction and crystallite size, and it is correlated with deposition rate and substrate temperature. A systematic discrepancy appears between the crystalline fractions determined from X-ray diffraction and Raman scattering and is discussed according to two possible origins: the different Raman cross-sections or the microcrystalline and amorphous phases, and the inhomogeneity of crystallinity as a function of thickness. We show that the accuracy can be improved by using fully recrystallized samples as a reference. (Author abstract) 35 refs.

Godet, C. (Univ Paris-Sud, Orsay, Fr); Marchon, B.; Schmidt, M.P. *Thin Solid Films* v 155 n 2 Dec 30 1987 p 227-242.

**095425 SIMPLE METHOD OF SPECTROSCOPIC REFLECTOMETRY FOR THE COMPLETE OPTICAL ANALYSIS OF WEAKLY ABSORBING THIN FILMS: APPLICATION TO SILICON FILMS.** A new reflectometric method enabling the complete optical analysis of weakly absorbing thin films deposited onto absorbing or non-absorbing substrates is described. The interpretation of the envelopes of the extrema present in the spectral dependence of the reflectance characterizing

the film can be performed by means of explicit formulae which allow the spectral dependences of both the optical constants of the film to be determined. The thickness of the film can also be found by an explicit formula. The method is employed for analysing silicon thin films deposited onto glass plates. A comparison of the new method with a similar method using the envelopes in the spectral dependence of the transmittance is performed. (Author abstract) 10 refs.

Ohlidal, I. (Purkyne Univ Brno, Brno, Czech); Navratil, K. *Thin Solid Films* v 156 n 2 Jan 30 1988 p 181-189.

**095426 CHARACTERIZATION OF MICROCRYSTALLINE SILICON FILMS PREPARED BY THE GLOW DISCHARGE METHOD UNDER DIFFERENT DEPOSITION CONDITIONS.** Microcrystalline silicon thin films have been prepared by rf glow discharge decomposition of silane mixed with hydrogen under different deposition conditions. Rf power, substrate temperature and the dilution of silane with hydrogen have been varied. Structural studies have been based on transmission electron microscopy, X-ray diffraction patterns and Raman spectra. The hydrogen content and its bonding configuration with silicon have been investigated from IR vibrational spectra. Dark conductivity and photoconductivity have been measured and correlated with the structural properties. (Author abstract) 16 refs.

Ray, Swati (Indian Assoc for the Cultivation of Science, Calcutta, India); De, S.C.; Barua, A.K. *Thin Solid Films* v 156 n 2 Jan 30 1988 p 277-285.

**095427 PREPARATION AND PROPERTIES OF a-SiGe:H FILMS FABRICATED WITH A SUPER CHAMBER (SEPARATED ULTRA-HIGH VACUUM REACTION CHAMBER).** High-quality a-SiGe:H films with low impurity concentrations were studied using a separated ultra-high vacuum reaction chamber system called the super chamber. The ESR spin density and the tail characteristic energy of the a-SiGe films ( $E_{\text{opt}} 1.5 \text{ eV}$ ) were  $6.5 \times 10^{15} \text{ cm}^{-3}$  and 46 meV, respectively. These values were much lower than those for films fabricated in a conventional chamber as well as those for a-Si films. Structural properties, such as the refractive indices and thermal effusion of hydrogen, were also measured. The results suggest that impurity reduction contributed not only to an improvement in the optoelectrical properties, but also the formation of a rigid a-SiGe network. (Author abstract) 7 refs.

Haku, Hisao (SANYO Electric Co, Hirakata, Jpn); Sayama, Katsunobu; Nakashima, Yukio; Takahama, Tsuyoshi; Isomura, Masao; Tarui, Hisaki; Hishikawa, Yoshihiro; Tsuda, Shinya; Nakano, Shiochi; Ohnishi, Michitoshi; Kuwano, Yukinori. *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 1978-1982.

**095428 MODELE PRZEWODNICTWA CIENKICH POLIKRYSTALICZNYCH WARSTW KRZEMU.** [Models of Conductivity of Thin Polycrystalline Silicon Films]. The latest models of conductivity of thin polycrystalline silicon films are presented. The development of the carrier's trapping theory is discussed in detail. Much space is dedicated to the new, phenomenal Mandurah et al. model, which is based on the combination of three effects: carrier's trapping, segregation of dopants and carriers detachment from the potential barriers. The model makes it possible to foresee and interpret the dependences of film electric features on thermal processes to which the films are subjected in their production as well as their dependences on dopants. (Author abstract) In Polish. 32 refs.

Pawlak, Edmund Z. (Politechnika Warszawska, Pol). *Rozpr Elektrotech* v 33 n 1 1987 p 71-105.

**095429 SILICON THIN FILMS FOR OPTOELECTRONIC TEMPERATURE SENSORS.** The optical transmission characteristics of polycrystalline thin films of silicon are reported with a view to fabricating a compact, intensity-modulated, optoelectronic temperature sensor



for real-time temperature measurement in industrial environments and inside high-voltage electrical machines. (Author abstract) 10 refs.

Agarwal, Rajendra P. (Univ of Roorkee, Roorkee, India); Kajanto, Isko; Friberg, Ari T. *Thin Solid Films* v 158 n 1 Mar 1988 p 1-5.

**095430 PERCOLATION MODEL FOR MICROCRYSTALLINE SILICON FILMS.** A percolation model is described which has application to many of the measurable properties of microcrystalline silicon thin films. The application of this model is based on the assumption of a random spatial distribution of the crystallites and an essentially two phase structure. The behavior of the photoconductivity and optical absorption spectra as a function of volume fraction are discussed in terms of interface and bulk properties. (Author abstract) 17 refs.

Schellenberg, J.J. (Univ of Manitoba, Winnipeg, Manit, Can); McLeod, R.D. *Solid State Commun* v 66 n 2 Apr 1988 p 159-162.

**095431 STUDY OF THE OPTOELECTRONIC AND STRUCTURAL PROPERTIES OF GLOW-DISCHARGE-DEPOSITED FLUORINATED, HYDROGENATED AMORPHOUS SILICON THIN FILMS.** The optoelectronic and structural properties of a-Si:F:H films prepared by the RF glow discharge decomposition of mixtures of silicon tetrafluoride and hydrogen have been studied as a function of the deposition parameters, viz. the hydrogen concentration in the gas mixture, the RF power density and the substrate temperature. It has been found that the deposition parameters can be optimized to prepare photosensitive fluorinated material having a band gap of approximately 1.65 eV. The photoinduced changes in the properties are quite small. Under suitable deposition conditions highly conducting ( $\sigma_D = 10^{-3} \text{ S cm}^{-1}$ ) films can also be produced. (Author abstract) 10 refs.

Ganguly, Gautam (Indian Assoc for Cultivation of Science, Calcutta, India); Ray, Swati; Barua, A.K.; De, S.C. *Sol Energy Mater* v 17 n 4 Jun 1988 p 237-245.

**095432 QUANTITATIVE MODEL FOR SILICON YIELD STRESS CALCULATIONS AT THIN FILM EDGES.** The results are presented of a theoretical study on the yield stress of dislocation-lean silicon. The obtained yield formula, which expresses the dependence of the external yield force on the intrinsic point defect concentration, is applied to the case of film edge induced dislocation generation in silicon substrates. A generally valid expression for the critical film thickness resulting in homogeneous defect nucleation is derived. The case of an inert anneal of dislocation-lean, oxygen-rich Czochralski silicon is studied more in detail. The theoretical results explain both the qualitative and the quantitative experimental results found in the literature. (Author abstract) 31 refs.

Vanhellemont, J. (Interuniversity Micro-Electronics Cent, Leuven, Belg); Claeys, C. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1509-1517.

**095433 PHOTOELECTRIC PROPERTIES OF AMORPHOUS SILICON THIN FILMS.** This report describes the photoelectric properties of hydrogenated amorphous silicon films deposited by the plasma chemical vapor deposition method. By the use of a newly established apparatus, it became possible to deposit films with photoconductivity as high as approximately  $3.9 \times 10^{-4} \Omega^{-1} \text{ cm}^{-1}$  in AM1 (100mW) illumination. The energy conversion efficiency was investigated for multi-layer solar cells consisting of both doped (p- and n-types) and undoped (i-type) layers. It was found that the maximum efficiency of 7.8% was attained by the use of a p-i-n structure. The current-voltage characteristics of the fabricated solar cells suggest that the same layer structure is applicable to high-performance photosensors. (Author abstract) 10 refs. In Japanese.

Nakaue, Akimitsu; Kajikawa, Hiroshi; Ohnishi, Yoshihiko; Hirai, Yo. *R&D Res Dev Kobe Steel Ltd* v 38 n 2 Apr 1988 p 69-72.

**095434 OXIDISE-ETCH-OXIDISE AND ANNEAL METHOD FOR GROWING HIGH QUALITY ULTRATHIN  $\text{SiO}_2$ .** Silicon wafers if both n- and p-types with orientations (100) and (111) and resistivities in the range of 5 to 6  $\Omega \text{ cm}$  were used. Ultrathin  $\text{SiO}_2$  in the range of 3 to 10 nm grown after subjecting the wafers to dry oxidation in a double walled furnace and HF etching at 1000°C in dry  $\text{O}_2$  and annealed at the same temperature for 30 to 40 min results in lowest fixed oxide charge, fast surface states, and high breakdown voltage which is a linear function of the square root of oxide thickness. This behaviour is attributed to structural and chemical bond modifications introduced by the treatment. 15 Refs.

Singh, A. (CEERI, Rajasthan, India). *Phys Status Solidi A* v 106 n 2 Apr 1988 p k139-k142.

**095435 HYDRIDE FORMATION OF EVAPORATED SILICON FILM OBSERVED BY INELASTIC ELECTRON TUNNELING SPECTROSCOPY.** Inelastic electron tunneling spectroscopy has been used for the characterization of thin films of evaporated silicon on alumina surfaces. The analysis of the tunneling spectra of the silicon films showed the formation of SiH species. The hydride formation is related to the residual water in the vacuum during the evaporation. (Author abstract) 11 Refs.

Higo, Morihide (Kagoshima Univ, Kagoshima, Jpn); Hayashi, Hiroki; Kamata, Satsuo. *Appl Surf Sci* (1985) v 32 n 3 Jul 1988 p 338-341.

**095436 KINETICS OF SOLID PHASE CRYSTALLIZATION IN AMORPHOUS SILICON.** Measurements of the kinetics of solid phase crystallization in amorphous silicon thin films are reviewed. Emphasis is placed on characterizing solid phase epitaxy (SPE) and random nucleation and growth (RNG) over a wide temperature range, and on comparing the behavior of intrinsic (undoped) amorphous silicon (a-Si) to that of films containing impurities. Using a combination of laser heating and in situ time-resolved reflectivity measurements, the temperature range over which solid phase crystallization processes can be studied has been greatly extended, allowing temperatures close to the melting point to be explored. Authors review how these techniques are used to characterize the temperature-dependent interplay between solid phase crystallization in a-Si and competitive processes such as impurity segregation, precipitation, and enhanced nucleation. SPE in intrinsic films is shown to be a thermally activated process characterized by a single activation energy, 2.7 eV, over the entire temperature range from 470 to 1350°C. (Edited author abstract) 138 Refs.

Olson, G.L. (Hughes Research Lab, Malibu, CA, USA); Roth, J.A. *Mater Sci Rep* v 3 n 1 Jun 1988 77p.

**095437 INFLUENCE OF HYDROGEN SURFACE REACTIONS ON THE GROWTH OF EVAPORATED a-Si:H FILMS.** Thin a-Si:H films are deposited by a direct reaction of evaporated silicon with atomic hydrogen. It is shown that a definite ratio of the number of incoming Si and H atoms is necessary to obtain material without microstructure and with a clear dominance of diluted monohydride bonding configurations. An adequate hydrogen etching process has to take place at the surface of the growing film in order to produce high quality material by the evaporation technique. A steric model is presented which explains the selective etching of  $\text{SiH}_2$  and  $\text{SiH}_3$  bonding sites by atomic hydrogen. (Author abstract) 19 Refs.

Iselborn, S. (Univ Kaiserslautern, Kaiserslautern, West Ger); Schroeder, B.; Geiger, J. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 275-284.

**095438 FRENKEL EFFECT IN SIPOS FILMS.** Semi-insulating polycrystalline silicon (SIPOS) has been of great interest in power and device passivation. Such layers inhibit the insurgence of high electric fields at the silicon surface because the equipotential lines are relaxed with respect to the case of an  $\text{SiO}_2$  passivation. The leakage current depends on the electric field and when it

approaches the breakdown value, the behavior is well described by the Frenkel model. In this work this process is investigated in films of different oxygen content and a model is proposed which explains the voltage dependence of the current in the region near breakdown. The question relative to the contribution of this effect to the lowering of the dielectric strength is presented and discussed. 11 Refs.

Manfredotti, C. (Univ Degli Studi, Turin, Italy); Fizzotti, F.; Amato, G. *Phys Status Solidi A* v 108 n 1 Jul 1988 p K25-K30.

**095439 LOW DEFECT-DENSITY POLYCRYSTALLINE SILICON FOR HIGH PERFORMANCE THIN FILM TRANSISTORS.** Polysilicon films formed by the decomposition of silane in a LPCVD reactor at temperatures around 630°C have been used to make thin film transistors. It has been found that deposition of the polysilicon at lower pressures than previously results in improved performance and this is related to the crystallographic structure of the material. The structure of polysilicon deposited at pressures down to 2.5 mTorr has been investigated and the results presented. (Author abstract) 11 refs.

Meakin, D.B. (GEC Research Ltd, Wembley, Engl); Economou, N.A.; Coxon, P.A.; Stoemenos, J.; Lowe, A.; Migliorato, P. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond. Louvain, Belg, Apr 13-15 1987 p 372-382.

**095440 PHOTOLUMINESCENCE PROPERTIES IN MICROCRYSTALLINE SILICON FILMS.** The photoluminescence properties of microcrystalline Si ( $\mu\text{-Si}$ ) films are investigated. The dissociation energy of photo-generated electron-hole pairs in band tail states decreases and the non-radiative recombination increases as the crystallization of a-Si:H is enhanced. This is explained as a result of the increase of neutral dangling bonds, which arises from the evolution of hydrogen while the deposition temperature rises. (Author abstract) 5 refs.

Liu, Hsiangna (Acad Sinica, China); Tang, Wenguo; Feng, Xiaomei; Li, Zhiyuan. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 143-144.

## Trace Analysis

**095441 METHODS FOR DETERMINATION OF TRACE ELEMENTS IN SEMICONDUCTOR FILMS.** Atomic absorption and spectrophotometric methods have been developed for analysis of trace impurities in stripping layers and films of semiconductor materials. The following items have been studied: determination of trace phosphorus in phosphorus implanted silicon, determination of trace sodium in thermal grown  $\text{SiO}_2$  on silicon substrates, determination of trace phosphorus in phosphorus silicon glass on silicon substrates; and determination of doping Te in vapor phase epitaxial GaAs on GaAs (Te) substrates and liquid phase epitaxial InSb on InSb substrates. The composition of silicon nitride has also been investigated. (Edited author abstract) In Chinese. 2 refs.

Cui, Xian-hang (Chinese Acad of Sciences, China); Xu, Xue-min; Liang, Zhi-cheng; Yan, Xing-tian. *Xi You Jin Shu* v 6 n 3 Aug 1987 p 231-232.

## Transport Properties

**095442 METAL-INSULATOR TRANSITION IN COMPENSATED SILICON.** We have measured dc electrical transport properties of compensated silicon, Si:P,B, near the metal-insulator transition at temperatures down to 1.35 K. We have used the variation of the coefficients of the T and  $T^{1/2}$  terms in the temperature dependence of the conductivity to determine  $n_c$ , the critical value of the electron concentration, n. In this temperature range these coefficients appear to be a more sensitive indicator of  $n_c$  than the variation of the zero temperature conductivity with n. The values of  $n_c$  ob-



tained are supported by estimates of  $n_c$  derived from the ratio of values of the Hall coefficient at room temperature and 4.2 K. We find that  $n_c$  increases with increasing compensation, in qualitative agreement with results in previous studies of compensated Ge. However, the increase in  $n_c$  is substantially less than that given by a current theoretical model. (Author abstract) 28 refs.

Hirsch, M.J. (Cornell Univ, Ithaca, NY, USA); Holcomb, D.F. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 45-56.

**095443 EFFECT OF POLYSILICON-SILICON INTERFACE RECOMBINATION VELOCITY ON CURRENT TRANSPORT PROPERTIES OF POLY-EMITTER TRANSISTORS.** Arsenic-implanted polysilicon contact layers show higher current gains than regular arsenic-implanted devices without polysilicon contacting the emitters. The increase in the current gain in polysilicon emitter transistors is due to the reduction in hole (base) current. A practical model has been developed and an analytical expression derived to characterize the hole (base) current transport through an n-type polysilicon emitter in terms of thermionic emission acting in parallel with drift diffusion incorporating the high low junction phenomenon of the poly-silicon-monosilicon interface. 11 Refs.

Srivastava, A. (State Univ of New York, NY, USA). *Phys Status Solidi A* v 106 n 2 Apr 1988 p K203-K207.

## Vapor Deposition

**095444 CHANNELING OF 20-100 eV Si ATOMS ABOVE THE Si(111) SURFACE.** The interaction of low-energy silicon atoms with an unreconstructed (111) silicon surface has been studied using molecular dynamics techniques and an accurate description of the covalent Si-Si interaction. For angles of incidence below a critical value, a new phenomenon of 'surface channeling' is observed. In 'surface channeling', the trajectory of the incoming particle is steered by short-range repulsive and long-range attractive interactions with the surface atoms parallel to and roughly 2 Angstrom above, the surface of the substrate. Such surface channeling trajectories offer considerable promise for precision control of beam-induced growth. (Author abstract) 8 refs.

Dodson, Brian W. (Sandia Natl Lab, Albuquerque, NM, USA). *Appl Surf Sci* (1985) v 29 n 3 Nov 1987 p 334-340.

**095445 COMPARATIVE STUDY OF SILICON DEPOSITION FROM  $\text{SiCl}_4$  IN COLD PLASMA USING ARGON,  $\text{H}_2$  OR  $\text{Ar} + \text{H}_2$ .** The deposition of silicon by cold plasmas using  $\text{SiCl}_4$  as the starting gas was studied using argon, hydrogen or a mixture of both as carrier gases. Electron temperatures and densities in these plasmas, as well as plasma species and growth rates, are compared. A good correlation was found between the reaction rates for the decomposition of the reactant and the growth rates of the films in each kind of plasma. The optimal values were measured when a mixture of argon and hydrogen was used. The differences observed between the three plasmas are attributed to the differences in plasma constituents, as detected by the double floating probes system and by mass spectrometry. A schema for the homogeneous (gas phase) and heterogeneous (plasma-surface) interactions in these plasmas is described. (Author abstract) 26 refs.

Manory, R.R. (Ben Gurion Univ of the Negev, Beer Sheva, Isr); Carmi, U.; Avni, R.; Grill, A. *Thin Solid Films* v 156 n 1 Jan 15 1988 p 79-92.

**Welding** See WELDING—Ultrasonic.

## X-Ray Analysis

**095446 MEASUREMENT OF THE STATIC DEBYE-WALLER FACTOR OF SILICON CRYSTALS BY THE PENDELLOESUNG FRINGE METHOD.** The static Debye-Waller factor of Czochralski-grown silicon crystals heat-treated at a high temperature has been measured by X-ray section topography. The static

Debye-Waller factor was determined through the variations in the Pendelloesung fringes in a topograph. The measured static Debye-Waller factor was proportional to the square of the scattering vector used, as expected from the theory. From an analysis of the experimental results the average size of the micro-defects formed by the heat treatment could be estimated. (Author abstract) 10 refs.

Sugita, Yoshimitsu (Toyama Univ, Toyama, Jpn); Sugiyama, Hiroshi; Iida, Satoshi; Kawata, Hiroshi. *Jpn J Appl Phys Part 1* v 26 n 11 Nov 1987 p 1903-1906.

**095447 X-RAY STANDING WAVES UNDER THE CONDITIONS OF MULTIPLE DIFFRACTION.** Equations are obtained for calculating the angular dependence of the secondary radiation yield (the photoelectron emission or fluorescence radiation) under the conditions of multiple dynamical X-ray diffraction. For a small yield depth  $L_{yi}$  the intensity of secondary radiation is proportional to the intensity of X-rays at the atomic sites of a surface layer of the single crystal. If  $L_{yi} > L_A$ , where  $L_A$  is the X-ray penetration depth, then the secondary radiation intensity is proportional to the total absorbed energy of X-rays. Computer simulation of the three-wave case (444, 335, Bragg geometry,  $\text{CuK}\alpha$ , Si) shows that the angular dependence of the photoelectron emission yield can be described as a repulsion interaction of two crossing two-wave maxima. A new possibility of observing the two-wave X-ray standing waves is discussed where the angular dependence of the induced second reflected wave with a small intensity is analysed instead of the secondary radiation yield within the total reflection domain for the first reflected wave. (Author abstract) 17 refs.

Kohn, V.G. (I.V. Kurchatov Inst of Atomic Energy, Moscow, USSR). *Phys Status Solidi A* v 106 n 1 Mar 1988 p 31-39.

**095448 GRAZING INCIDENCE X-RAY DIFFRACTION FROM SI WITH AN IMPLANTATION INDUCED AMORPHOUS SURFACE LAYER.** Si single crystals are implanted with As ions of 80 keV to a dose of  $1 \times 10^{15} \text{ cm}^{-2}$ . Under conditions of total external reflection Bragg diffraction of X-rays is measured. Intensity distributions  $I_H$  as a function of angles of grazing exit  $\alpha_H$  are determined with high resolution at different angles of grazing incidence  $\alpha$ . The experimental results are compared to calculations on the basis of dynamical diffraction theory. Complete agreement is achieved only if a variation in  $t_{am}$  of 10 percent across the sample is allowed for. At incidence angles smaller than the critical angle amorphous diffuse scattering is observed. (Edited author abstract) 8 Refs.

Wallner, G. (Ludwig-Maximilians-Universität, Munich, West Ger); Burkel, E.; Metzger, H.; Peisl, J. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 129-133.

## SEMICONDUCTING SILICON COMPOUNDS

See Also FILMS—Dielectric; PHOTORESISTS—Focusing; SEMICONDUCTING GERMANIUM—Defects; SEMICONDUCTING POLYMERS—Amorphous; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES—Materials; TRANSISTORS, BIPOLAR—Heterojunctions.

**095449 ARGON PLASMA TREATMENT EFFECTS ON  $\text{Si-SiO}_2$  STRUCTURES.** Combining measurements of inversion channel I-V and high frequency C-V characteristics it is shown that argon plasma treatment leads to an increase of positive fixed oxide charge and generation of deep acceptor-type interface states (with a charge density of about  $10^{11} \text{ cm}^{-2}$ ) accompanied by a reduction of the density of shallow acceptor-type interface states and a decrease of the inversion layer mobility. The radiation induced oxide charge is in the order of  $(1-3.5) \times 10^{11} \text{ cm}^{-2}$  depending on the oxide thickness. The mobility decrease and the plasma-introduced charges in the  $\text{Si-SiO}_2$  structures are assumed mainly to be trivalent Si and non-bridging oxygen due to the radiation-induced fracture of weak and strained bonds in the oxide and at the interface. The temperature behavior of the mobility indicates a dominance of Coulomb and surface potential fluctuation scattering. Hence a severe degradation of  $\text{Si-SiO}_2$  structures after low-temperature argon

plasma treatment is found. (Author abstract) 45 refs.

Kassabov, J. (Bulgarian Acad of Sciences, Sofia, Bulg); Atanasova, E.; Dimitrov, D.; Goranova, E. *Solid State Electron* v 31 n 2 Feb 1988 p 147-154.

**095450 DETERMINATION OF  $\text{Si-SiO}_2$  INTERFACE RECOMBINATION PARAMETERS USING A GATE-CONTROLLED POINT-JUNCTION DIODE UNDER ILLUMINATION.** A novel method is presented to determine  $\text{Si-SiO}_2$  interface recombination parameters. The device used is a polysilicon-oxide-semiconductor capacitor with a microscale central junction (a gate-controlled point-junction diode). Data analysis has been performed using a numerical scheme to find a quasi-exact solution for the current combining at the interface. It was found that the interface recombination parameters depend only weakly on trap energy in a wide range around midgap. The cross-section for capturing electrons was found to exceed the cross-section for capturing holes by a factor of  $10^2$  to  $10^3$ . 40 refs.

Girisch, Reinhard B.M. (Katholieke Univ Leuven, Heverlee, Belg); Mertens, Robert P.; De Keersmaecker, Roger F. *IEEE Trans Electron Devices* v 35 n 2 Feb 1988 p 203-222.

**Amorphous** See Also SEMICONDUCTING SILICON—Amorphous; SILICON CARBIDE—Lattice Vibrations.

**095451 KINETICS OF NATURAL OXIDATION OF HYDROGENATED AMORPHOUS SILICON.** Hydrogenated amorphous silicon (a-Si:H) has been investigated for applications in solar batteries, xerography, thin film transistors, etc. The a-Si:H surfaces are known to physically and chemically absorb various particles immediately after they are taken out of the growth chamber in air. The a-Si:H surfaces exposed in air have been covered always with very thin oxide films, because oxygen within the adsorbed particles reacts vigorously and chemically with silicon. The contamination and the oxide layer on the a-Si:H surfaces give undesirable effects to properties of these devices. 8 refs.

Yokota, Katsuhiko (Kansai Univ, Osaka, Jpn). *Technol Rep Kansai Univ* n 29 Mar 1987 p 35-40.

**095452 ELECTRON-HOLE RECOMBINATION IN  $\text{a-Si:H/a-Si}_{1-x}\text{N}_x\text{:H}$  SUPERLATTICES.** Time-resolved luminescence and ODMR experiments have been carried out at 2 K for a-Si:H/ $\text{a-Si}_{13}\text{N}_x\text{:H}$  superlattices and  $\text{a-Si}_{1-x}\text{N}_x\text{:H}$  bulk films. Experimental results on the superlattices are interpreted in terms of a quantum-well model. (Author abstract) 10 refs.

Ogihara, C. (Univ of Tokyo, Roppongi, Jpn); Takenaka, H.; Morigaki, K. *Solid State Commun* v 61 n 7 Feb 1987 p 431-435.

**095453 PHOTOLUMINESCENCE OF QUASI-ONE DIMENSIONAL AMORPHOUS  $\text{Si}_{1-x}\text{C}_x\text{:H}$  PREPARED BY THE GLOW DISCHARGE METHOD.** Glow discharge deposited  $\text{a-Si}_{1-x}\text{C}_x\text{:H}$  from disilane and acetylene with low substrate temperature has been studied for various gas mixing ratio  $M_g$  by photoluminescence measurement. The spectrum of a-C:H consists of two bands of 2.05 and 1.53 eV peak energies. The band at 2.05 eV shows the molecular-like radiative recombination and is also observed in  $\text{a-Si}_{1-x}\text{C}_x\text{:H}$  above  $m_g=40\%$ . These results are explained by one-dimensional structure constructing from polysilane and polyacetylene. (Author abstract) 12 refs.

Nonomura, S. (Gifu Univ, Gifu, Jpn); Hattori, S.; Nitta, S. *Solid State Commun* v 64 n 10 Dec 1987 p 1261-1264.

**095454 WHY THE PHOTOCONDUCTIVITY DECREASES IN  $\text{a-SiC:H}$  AND  $\text{a-SiGe:H}$  WHEN THE AMOUNT OF ALLOYING INCREASES.** IR, photoconductivity, Raman and photothermal deflection spectroscopy measurements were used to probe the relationship between material quality and the amount of microstructure in glow discharge deposited a-SiC:H and



a-SiGe:H films. We find that the microstructure is directly responsible for the decrease in photoconductivity observed in both alloys as a function of increased alloy content. The microstructure does this by causing a decrease in the steepness of the Urbach tail, thus allowing for an increase in both carrier trapping at the wider band edges and carrier recombination at or near the band tails. (Author abstract) 17 refs.

Mahan, A.H. (Solar Energy Research Inst, Golden, CO, USA); Raboisson, P.; Menna, P.; Mascarenhas, A.; Tsu, R. *Sol Cells* v 24 n 1-2 May-Jun 1988, Proc 8th Photovoltaic Adv Res Dev Proj Rev Meet, Denver, CO, USA, Nov 15-18 1987 p 195-203.

**Applications** See SEMICONDUCTOR FILMS; SEMICONDUCTOR DEVICES—Amorphous; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Measurements; SOLAR CELLS—Silicon.

**Charge Carriers** See Also SEMICONDUCTOR DEVICES, MOS—Spectroscopic Analysis; SILICON CARBIDE—Chemical Vapor Deposition.

**095455 HOT-ELECTRON TRAPPING IN THIN LPCVD SiO<sub>2</sub> DIELECTRICS.** The electron-trapping and surface-state generation characteristics of thin LPCVD (liquid-phase chemical vapor deposition) SiO<sub>2</sub> dielectrics have been studied using avalanche hot-electron injection. Layered structures of thermal and LPCVD oxide have been examined as a function of anneal time and temperature. After a 1000°C anneal, bulk trapping in the LPCVD oxide was reduced to levels comparable to those in a high-quality dry thermal oxide. Sensitivity to remaining traps was reduced by the presence of a thermal oxide layer on the semiconductor surface. After a postdeposition anneal, these layered surfaces demonstrated hot-electron performance equal to that of thermal oxide, within measurable limits. Also, layered structures generally demonstrated better resistance to surface-state generation than thermal oxides alone. 12 refs.

Kawamoto, Galen H. (Intel Corp, Hillsboro, OR, USA); Magyar, Gregory R.; Yau, Leopoldo D. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2450-2455.

## Chemical Vapor Deposition

**095456 LOW TEMPERATURE PYROLYTIC DEPOSITION OF HIGH QUALITY SiO<sub>2</sub>.** A pyrolytic process for the deposition of high quality silicon dioxide at temperatures of 100°-330°C is reported. Deposition is achieved by reacting silane and oxygen in the 2-12 torr pressure range, yielding deposition rates of 140 Å/min at 300°C and 50 Å/min at 120°C. Measurements of refractive index (1.45-1.46), field strength ( $3 \times 10^6$  V/cm), and resistivity ( $10^{13}$ - $10^{16}$  Ω-cm) indicate that the oxides are near-stoichiometric SiO<sub>2</sub>. Fixed oxide charge densities are as low as  $3 \times 10^{10}$  cm<sup>-2</sup> on <111> silicon. This technology appears promising for Group IV and Group III-V device applications. (Author abstract) 22 refs.

Bennett, B.R. (Rome Air Development Cent, Bedford, MA, USA); Lorenzo, J.P.; Vaccaro, K.; Davis, A. J. *Electrochem Soc* v 134 n 10 Oct 1987 p 2517-2521.

**095457 DOWNSTREAM PLASMA INDUCED DEPOSITION OF SiN<sub>x</sub> ON Si, InP, AND InGaAs.** Silicon nitride (SiN<sub>x</sub>) films have been deposited on Si, InP, and In<sub>0.47</sub>Ga<sub>0.53</sub>As using a downstream microwave plasma technique. Active nitrogen from a 2 torr N<sub>2</sub> plasma is used to chemically dissociate SiH<sub>4</sub> at the heated substrate located 60 cm downstream of the discharge. Films 50 nm thick were deposited in the temperature range 250°-400°C with SiH<sub>4</sub> to N<sub>2</sub> ratio of 0.03:1. For films deposited at 300°C, ellipsometer measurements gave a refractive index of  $1.90 \pm 0.05$  and Auger analysis showed an Si to N ratio of 0.71:1 with less than 0.1 atom percent oxygen. IR analysis of the films showed a decrease in the Si-H content after annealing. MIS capacitors were used to evaluate the bulk dielectric and insulator-semiconductor interface properties. C-V measurements were made at 10 MHz, 1 MHz, and 10 kHz. (Edited author abstract) 18 refs.

Dzioba, Steven (Bell-Northern Research Ltd, Ottawa, Ont, Can); Meikle, S.; Streater, R.W. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2599-2603.

**095458 FABRICATION OF a-Si:H FILMS BY CO-AXIAL LINE TYPE MICROWAVE HYDROGEN PLASMA CVD.** A double tube coaxial line type microwave plasma CVD system has been developed for a-Si:H film deposition using hydrogen and argon gases with pure SiH<sub>4</sub> gas as the material gas. The film quality was evaluated as a function of the plasma condition. A high-quality film can be fabricated under hydrogen plasma because a large amount of hydrogen radicals covers the film surface, thereby causing a thermal structural relaxation of silane radicals. This relaxation results when the silane radicals increase their surface mobility after the soft landing on the film surface. (Edited author abstract) 25 refs.

Kato, Isamu (Waseda Univ, Tokyo, Jpn); Ueda, Tetsuya; Hatanaka, Kazuhisa. *Electron Commun Jpn Part 2* v 70 n 11 Nov 1987 p 73-84.

**095459 LOW-PRESSURE PHOTOCHEMICAL VAPOUR DEPOSITION OF SILICON DIOXIDE ON InP SUBSTRATES.** Silicon dioxide films deposited on InP substrates are obtained from a mixture of silane and oxygen gases irradiated with a UV lamp. Deposition rates compatible with industrial processes are obtained for substrate temperatures well below the degradation threshold of InP. Optical and electrical characterizations are performed for InP MISFET applications. (Author abstract) 8 refs.

Nissim, Y.I. (CNET, Bagneux, Fr); Regolini, J.L.; Bensahel, D.; Licoppe, C. *Electron Lett* v 24 n 8 Apr 1988 p 488-489.

## Cleaning

**095460 WAY TO CLEAN WAFERS FAST - WITHOUT OXYGEN.** To speed up the cleaning of metallic contaminants from the critical top layers of a silicon wafer researchers at the Massachusetts Institute of Technology, with help from Texas Instruments Inc., are exploring a promising new method of purifying the material in seconds. To shorten the time needed, the MIT team collects the contaminants around butterfly-shaped deformities in the lattice structure of the silicon itself.

Angiolillo, Paul. *Electronics* v 60 n 18 Sep 3 1987 p 38.

## Crystalline

**095461 PHOTOLUMINESCENCE STUDY OF MICROCRYSTALLINE SILICON.** The photoluminescence characteristics of the crystallized amorphous silicon (microcrystalline Si) prepared by raising the substrate temperature (from 300°C to 520°C) during the deposition of amorphous Si with r.f. GD method are investigated. The luminescence peaks at about 1.35 eV in the photoluminescence spectra similar to a-Si,  $\mu$ -Si films are obtained. It can be concluded from the temperature dependence of the luminescence intensity and the photoacoustic spectra (PAS) that 1) the band tail width is narrowed, which indicates the decrease of the localization of the carriers in an amorphous phase in two-phase  $\mu$ -Si, 2) the dissociation energy of the photoinduced electron-hole pairs in the band tail states is reduced and 3) the non-radiative recombination is increased as the crystallization is enhanced. (Edited author abstract) 13 refs.

Liu, Xiangna (Acad Sinica, Shanghai, China); Feng, Xiaomei; Tang, Wenguo; Li, Zhiyuan. *Chin J Infrared Res Ser B (Engl Ed)* v 6 1987 p 7-14.

**Defects** See Also SEMICONDUCTOR DEVICES, MOS—Analysis.

**095462 ON THE GENERATION AND ANNEALING OF DANGLING BOND DEFECTS IN HYDROGENATED AMORPHOUS SILICON.** We show that, through the diffusive re-arrangement of Si-H bonds, the a-Si:H lattice is able to establish thermal equilibrium

between the densities of band tail trapped charge carriers and dangling bond defects. When this equilibrium is disturbed by changes in temperature, carrier injection or illumination, dangling bond defects have to be generated or annealed out via H-diffusion processes. Based on the concept of charge-induced bond breaking, we develop a mathematical formalism for the diffusive re-arrangement of Si-H bonds and show that our formalism can account for a variety of observations that have been made in the content of defect-generation and annealing experiments. (Author abstract) 26 refs.

Mueller, G. (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Ger). *Appl Phys A* v A45 n 1 Jan 1988 p 41-51.

**095463 LIGHT-INDUCED METASTABLE DEFECTS IN a-Si:H AS ELUCIDATED BY OPTICALLY DETECTED MAGNETIC RESONANCE MEASUREMENTS AT 2K.** We observed a gradual increase of a nonradiative recombination channel in a-Si:H by strong light exposure at 2 K, i.e., an increase in the intensity of the quenching optically detected magnetic resonance (ODMR) line at  $g=2.005$  and no change of the other quenching lines at  $g=2.004$  and  $g=2.013$ . The sample with previous light soaking at 300 K still showed a degradation of photoluminescence (PL) efficiency as much as that for the sample without previous light soaking, but no obvious change of the quenching ODMR lines. An increase of silicon dangling bond (db) density and the other nonradiative recombination process are suggested to explain the experimental results. (Author abstract) 17 refs.

Han, Daxing (Univ of Tokyo, Tokyo, Jpn); Yoshida, M.; Morigaki, K. *Solid State Commun* v 63 n 12 Sep 1987 p 1083-1086.

## Diffusion

**095464 MICROSTRUCTURE OF RuO<sub>2</sub> LAYER AS DIFFUSION BARRIER BETWEEN Al AND Si SUBSTRATE.** The microstructure of samples consisting of a 40 nm thick RuO<sub>2</sub> film reactively sputtered on a Si <111> substrate and covered with 20 nm of Al (<Si>/RuO<sub>2</sub>/Al) is investigated by high-resolution cross-sectional electron microscopy. The depth distributions of elements are studied by Rutherford backscattering spectrometry and electron probe microanalysis. In the as-deposited sample, the RuO<sub>2</sub>/Al interface is sharp, but a thin (3 nm) SiO<sub>2</sub> layer is observed at the <Si>/RuO<sub>2</sub> interface. After annealing at temperatures ranging from 450 to 700°C for 1-6 h, that layer remains unchanged, but a crystalline compound layer forms at the RuO<sub>2</sub>/Al interface. No diffusion of Si and Al into RuO<sub>2</sub> is detectable. The possible mechanisms for the barrier characteristics are discussed. We believe that the presence of the thin SiO<sub>2</sub> layer and the formation of an additional compound layer is intimately related to the good barrier performance of RuO<sub>2</sub>. (Author abstract) 14 refs.

Nieh, C.W. (California Inst of Technology, Pasadena, CA, USA); Kolawa, E.; So, F.C.T.; Nicolet, M.-A. *Mater Lett* v 6 n 5-6 Mar 1988 p 177-180.

**Doping** See Also SEMICONDUCTOR DEVICES, MOS—Thin Films; TRANSISTORS, FIELD EFFECT—Ion Implantation.

**095465 EFFECT OF HIGH TEMPERATURE ANNEALING ON THE MICROSTRUCTURE AND THERMOELECTRIC PROPERTIES OF GaP DOPED SiGe.** Annealing of GaP-doped SiGe will significantly alter the thermoelectric properties of the material resulting in increased performance as measured by the figure of merit, Z, and the power factor, P. The microstructures and corresponding thermoelectric properties after annealing in the 1100 to 1300°C temperature range have been examined to correlate performance improvement with annealing history. The figure of merit and power factor were both improved by homogenizing the material and limiting the amount of cross-doping. Annealing at 1215°C for 100 hr resulted in the best combination



of thermoelectric properties with a resultant figure of merit exceeding  $1 \times 10^{-3} \text{ } ^\circ\text{C}^{-1}$  and a power factor of  $44 \text{ } \mu\text{W cm}^{-2} \text{ } ^\circ\text{C}^{-2}$  for the temperature range of interest for space power: 400 to  $100^\circ\text{C}$ . (Author abstract) 14 refs.

Draper, Susan L. (NASA, Cleveland, OH, USA). *NASA Tech Memo* 100164 Oct 1987 22p.

**095466 CHARACTERIZATION OF THE HEAVILY (NON-DEGENERATE) BORON-DOPED  $\text{Si-SiO}_2$  INTERFACE.** The influence of doping, crystallographic orientation and oxide thickness on the parameters of the boron-doped  $\text{Si-SiO}_2$  interface up to  $3 \times 10^{18} \text{ cm}^{-3}$  for oxides thermally grown in a wet  $\text{O}_2$  ambient is investigated. The fundamental surface recombination velocity, which is proportional to the product of the density of the effective recombination centers and of the associated capture cross section is nearly constant in the range of doping studied. The fixed-oxide charge density increases with doping concentration; this is probably due to the increasing importance of boron atoms segregating in the oxide and/or to the excess silicon interstitials increasing in density with dopant concentration. (Author abstract) 9 refs.

Ghannam, Moustafa Y. (Stanford Univ, CA, USA). *Solid State Electron* v 30 n 11 Nov 1987, New Dev in the Phys of Homo- and Heterojunctions, US-Belg Jt Semin, Louvain, Belg, May 28-30 1986 p 1147-1152.

## Electronic Properties

**095467 ELECTRONIC STRUCTURE OF STRAINED  $\text{Si}_n/\text{Ge}_n(001)$  SUPERLATTICES.** Using the empirical tight binding method, we have investigated the electronic properties of the  $\text{Si}_n/\text{Ge}_n(001)$  strained superlattices as a function of the superlattice periodicity and the band misfit. For  $n \geq 4$  we have found that first and second conduction band states are localized in Si. The hole states localized in Ge appear for  $n \geq 4$ . The difference between the direct and indirect band gaps is reduced from 2.01 eV for bulk Si to 0.01 eV for  $n = 6$  which can be considered to be quasi-direct. For the cases  $n = 6$  and  $n = 8$ , the band gap might become direct for large values of band misfit. (Author abstract) 14 refs.

Ciraci, S. (Bilkent Univ, Ankara, Turk); Guelseren, O.; Ellialtioglu, S. *Solid State Commun* v 65 n 11 Mar 1988 p 1285-1290.

**095468 NATURE OF TRAPPED HOLE CENTRES (A CENTRES) IN  $\text{a-Si:H}$ : INVESTIGATION OF OPTICALLY DETECTED MAGNETIC RESONANCE AND PHOTOINDUCED ABSORPTION MEASUREMENTS ON  $\text{a-Si:H/a-Si}_{1-x}\text{N}_x\text{H}$  SUPERLATTICES.** The nature of the trapped hole centers (A centers) has been elucidated by optically detected magnetic resonance and photoinduced absorption (PA) measurements on  $\text{a-Si:H/a-Si}_{1-x}\text{N}_x\text{H}$  superlattices. The superlattice films reported here were of two types, i.e.,  $x=0.4$  and  $L_B$  (barrier-layer thickness) = 40 Angstrom and  $x=0.57$ ,  $L_B = 25$  Angstrom with various well-layer thickness,  $L_w$ , ranging from 6 to 36 Angstrom. The ODMR measurements were carried out at 9.6 GHz and 2 K, using a microwave spectrometer whose detail has been described in a previous article. The ODMR signal was detected by monitoring either total emitted light or monochromatized emission light with use of a cooled Ge detector. The optical excitation source was unfocused argon ion laser light at either 514.5 nm or 488 nm, depending on the optical gap energy of the film. The PA measurements were also carried out at 2 K using unfocused argon ion laser light as an excitation light. The results are discussed in terms of a model of self-trapped holes for the A centers. (Edited author abstract) 13 refs.

Ohta, H. (Univ of Tokyo, Tokyo, Jpn); Yamaguchi, M.; Ogihara, C.; Morigaki, K. *Solid State Commun* v 66 n 8 May 1988 p 797-800.

**095469 HOT ELECTRONS IN  $\text{SiO}_2$ : BALLISTIC TO STEADY-STATE TRANSPORT.** We present experimental and theoretical review of the properties of electron transport in thermally grown  $\text{SiO}_2$ . In thick films ( $\geq 10$

nm), steady-state transport is controlled by polar electron-phonon scattering at electric fields below  $2 \times 10^6 \text{ V/cm}$ . At higher fields, nonpolar scattering prevents the electrons from 'running away' and allows steady-state transport to occur at average electron energies of a few eV. In thinner films ( $\leq 6 \text{ nm}$ ), the 'vacuum emission' technique performed at room temperature and 80 K allows the observation of ballistic transport and phonon replicas, in agreement with Monte Carlo simulations. These results are used to investigate the electron-lattice coupling constants that result from the almost ideal structural and electronic properties of thermally grown  $\text{SiO}_2$  films. (Edited author abstract) 34 refs.

Fischetti, M.V. (IBM, Yorktown Heights, NY, USA); DiMarzio, D.J. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 629-636.

## Growth

**095470 AES AND FACTOR ANALYSIS STUDY OF SILICIDE GROWTH AT THE Pd/c-Si INTERFACE.** The authors measured the evolution of a palladium/silicon interface under consecutive annealing periods, performed at  $200^\circ\text{C}$  in UHV conditions. The interface was analyzed by means of Auger electron spectroscopy combined with factor analysis applied in a sequential way. It was found that silicide appears only after annealing and evolves until all the palladium is consumed. A silicon compound different from silicide, identified as  $\text{Pd}_3\text{Si}$  with  $x < 2$  is found at the Pd/Si and  $\text{Pd}_2\text{Si/Si}$  interfaces, before and after annealing respectively. (Edited author abstract) 13 refs.

Steren, Laura (Univ Nacional de Rosario, Rosario, Argent); Vidal, Ricardo; Ferron, Julio. *Appl Surf Sci* (1985) v 29 n 4 Dec 1987 p 418-426.

High Temperature Effects See SEMICONDUCTOR DEVICES, MOSFET—Degradation.

Ion Implantation See Also TRANSISTORS, FIELD EFFECT.

**095471 RAPID THERMAL ANNEALING OF SI-IMPLANTED LEC Si-GaAs AND ITS USE FOR GaAs VHSIC.** Rapid Thermal Annealing (RTA) of single and dual Si-implanted Si-GaAs has been investigated using a RF graphite heating apparatus. The Si-GaAs substrate used for direct implant was grown by LEC method. Si ion implant was performed at room temperature. Single implant was made at 100 keV with a dose between  $5 \times 10^{12} \text{ cm}^{-2}$  and  $5 \times 10^{14} \text{ cm}^{-2}$ ; dual implants were at 100 keV and 40 keV energy levels with doses of  $5 \times 10^{12} \text{ cm}^{-2}$  and  $1 \times 10^{14} \text{ cm}^{-2}$ , respectively. The GaAs wafer to be annealed was placed on a Si wafer with the polished surfaces facing each other to reduce the As loss of GaAs. The annealing temperature was between  $900^\circ\text{C}$  and  $1050^\circ\text{C}$  with overall annealing time varying from 5s to 15s. For both single and dual implants good results have been obtained compared with  $\text{SiO}_2$  capped furnace annealing. The dual Si-implanted RTA material has been used for the development of GaAs VHSIC and good results have been obtained. For example, the gate delay of 11-stage ring oscillator can be as small as 75.8 ps and the clock rate of frequency divider can reach 2.1GHz. (Edited author abstract) In Chinese. 2 refs.

Yang, Yao-zhong (Hebei Semiconductor Inst, China); Li, Bing-hui; Guo, Wen-shen. *Xi You Jin Shu* v 6 n 4 Nov 1987 p 275-278.

**095472 NITROGEN PROFILE MODIFICATION IN HIGH DOSE IMPLANTATION SYNTHESIS OF SILICON NITRIDE.** A model for the formation of buried nitride in the process of high dose nitrogen implantation into silicon is presented. The model takes into account the target volume swelling as well as the change in ion range profiles due to the formation of  $\text{Si}_3\text{N}_4$ . In target depths where the nitrogen to silicon ratio exceeds that for silicon nitride, any unbounded nitrogen atom is given a specific volume. (Author abstract) 21 refs.

Sobeslavsky, E. (Akad der Wissenschaften der DDR, Dresden, East Ger); Jaeger, H.U.; Kreissig, U.; Skorupa,

W.; Wollschlaeger, K. *Phys Status Solidi A* v 105 n 2 Feb 1988 p 387-396.

## Microstructure

**095473 DISTRIBUTION OF EL2 AND DISLOCATION AND THEIR CORRELATION IN Si-GaAs.** The radial distributions of EL2 concentration, dislocation density and carbon concentration in specimens of different carbon content grown by the LEC method were measured. The distribution of the carbon concentration is random. The average EL2 concentration increases after 2 hour annealing at  $800^\circ\text{C}$  in  $\text{H}_2$  atmosphere. The correlation between the distribution of EL2 and dislocations and the mechanism of annealing are discussed. (Edited author abstract) 21 Refs. In Chinese.

Yang, Rui-Xia (Hebei Inst of Technology, China); Li, Guang-Ping; Hua, Qing-Heng. *Xiyou Jinshu* v 7 n 1 Feb 1988 p 46-50.

## Optical Properties

**095474 OPTICAL PROPERTIES OF AMORPHOUS  $\text{SiN}_x$  (H) FILMS.** The optical absorption edges and the dispersion behaviour of the refractive index have been determined as a function of composition x for thin films of  $\text{a-SiN}_x(\text{H})$ , prepared (i) by glow-discharge decomposition of a gaseous mixture of silane and ammonia and (ii) by radio-frequency sputtering of silicon in an argon-nitrogen-(hydrogen) atmosphere. The data for films with and without hydrogen have been used to evaluate certain characteristic energies and these are then related to other experimental results, in particular those from photo-emission measurements. (Author abstract) 17 refs.

Davis, E.A. (Univ of Leicester, Leicester, Engl); Piggins, N.; Bayliss, S.C. *J Phys C Solid State Phys* v 20 n 27 Sep 30 1987 p 4415-4427.

Oxidation See DIELECTRIC MATERIALS—Synthesis.

## Photoconductivity

**095475 MEASUREMENT OF THE DENSITY OF ELECTRONIC STATES IN AQUEOUS ELECTROLYTES USING OXIDE-COVERED Pt-SILICIDE ELECTRODES.** A method of overcoming the difficulty in observing charge-transfer-limited current is to use a metal electrode covered with an insulator film which is thin enough to allow direct tunneling of electrons, but thick enough to avoid diffusion-controlled current. In this study an experimental investigation was made of the electrochemical charge transfer kinetics occurring with an oxide-covered Pt-silicide electrode. The effective electronic density states of ions in aqueous electrolytes was determined experimentally for the first time. The results for ferrocyanide ions showed excellent agreement with the classical theory of the Marcus-Gerischer model. 10 refs.

Morisaki, H. (Univ of Electro-Communications, Chofu, Jpn); Ono, H.; Yazawa, K. *J Electrochem Soc* v 135 n 2 Feb 1988 p 381-383.

## Physical Properties

**095476 SIMPLE METHOD TO DETERMINE THE  $\text{Si/SiO}_2$  FAST INTERFACE TRAP DENSITY CHANGE AFTER HIGH FIELD STRESS ON SILICON-ON-INSULATOR SUBSTRATES.** A simple method based on quasistatic capacitance-voltage measurements is described to determine the change in the  $\text{Si/SiO}_2$  fast interface trap distribution after high field stress. The method is independent of substrate type and enables the density of states distribution to be determined in the bandgap. However, the absolute energy of the traps is only known within an additive constant of comparable magnitude to the effective flatband voltage. Examples of the method are presented for a nonuniformly doped substrate and a high resistivity silicon-on-sapphire substrate. (Author abstract) 4 refs.

Calligaro, R.B. (GEC, Wembley, Engl). *IEE Proc Part I* v 134 n 5 Oct 1987 p 156-158.



## Pressure Effects

**095477 PRESSURE STUDIES OF QUASI-ONE DIMENSIONAL AMORPHOUS Si:H FILMS.** Pressure dependences of the optical absorption edge and the linear compressibility have been investigated up to approx. 100 kbar for quasi-one dimensional  $\alpha$ -Si:H films prepared by glow-discharge decomposition of disilane. The dependences behave in a different way in the high and low pressure regions. When pressure is lower than approx. 60 kbar, the material is compressed greatly and the pressure coefficient of the energy gap is  $-1 \text{ meV kbar}^{-1}$ . Above this pressure, the material becomes more rigid and the coefficient is  $-8 \text{ meV kbar}^{-1}$ . These results are discussed on the basis of a structural model which assumes a film structure consisting of polysilane molecules and  $\alpha$ -Si clusters. (Author abstract) 10 refs.

Tanaka, K. (Hokkaido Univ, Sapporo, Jpn); Nitta, S. *Solid State Commun* v 66 n 8 May 1988 p 827-830.

## Radiation Effects

**095478 RADIATION HARDNESS PROPERTY OF DRY OXIDE GROWN BY POSTOXIDATION COOLING IN OXYGEN AMBIENT.** The radiation behavior of silicon oxides prepared under various postoxidation conditions is studied by  $^{60}\text{Co}$  irradiation with a total dose of  $10^6$  rad. Before irradiation, it was shown that the sample obtained by postoxidation cooling in  $\text{N}_2 + \text{O}_2$  exhibited more positive initial oxide charges and larger negative charge-temperature instability than that obtained by postoxidation annealing in  $\text{N}_2$ . But after considering the initial oxide field effect on the irradiation result, the former one is less sensitive to irradiation than the latter one. Surprisingly, this hardness ability is significantly enhanced when the orientation of silicon substrate is gradually tilted from [100] to [011]. Possible explanations are given for these observations. It is supposed that the postoxidation cooling in  $\text{N}_2 + \text{O}_2$  provides a possible way for the oxide to become more radiation hard. (Author abstract) 20 refs.

Hwu, Jenn-Gwo (Nat'l Taiwan Univ, Taipei, Taiwan); Fu, Shyh-Liang. *Appl Phys A* v 46 n 3 Jul 1988 p 221-227.

## Spectroscopic Analysis

**095479 OPTICAL MODULATION SPECTROSCOPY IN  $\alpha$ -Si:H AT ROOM TEMPERATURE.** Optical Modulation Spectroscopy was studied at room temperature in three  $\alpha$ -Si:H films with different deposition temperatures. The gap density of states is largely influenced by this parameter. The results may be explained with a sharp distribution of  $\text{D}^0$  (neutral dangling bond) states and a broad distribution of  $\text{D}^-$  (negatively charged dangling bond) states. (Author abstract) 14 refs.

Grevendonk, W. (KU Leuven, Louvain, Belg); Dauwen, J.; Adriaenssens, G.J.; Seynhaeve, G.; Strauven, H.; Nagels, P.; Smeets, J. *Solid State Commun* v 66 n 8 May 1988 p 801-803.

## Stresses See SEMICONDUCTING SILICON—Oxidation.

## Surfaces

**095480 MODIFYING  $\text{SiO}_2$  SURFACE STATE.** A novel technique for modifying  $\text{SiO}_2$  surface state is presented. After the  $\text{SiO}_2$  surface is bombarded by electrons under certain energy, the variation of etching rate is observed. The etch rate of unbombarded  $\text{SiO}_2$  is about 700 - 1000 Å/min. However, no etching is observed for bombarded samples. (Author abstract) 2 refs. In Chinese.

Han, Jieping (Acad Sinica, Beijing, China); Wang, Peida; Xu, Weidong; Jin, Zhongyuan; Chen, Mengzhen. *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 221-223.

## Synthesis

**095481 SILICON CARBIDE FILMS OBTAINED IN A HIGH-FREQUENCY DISCHARGE PLASMA.**

Using IR spectroscopy and ultrasoft X-ray emission spectroscopy, a study was made of silicon carbide films obtained by evaporating quartz in a high-frequency induction discharge plasma at atmospheric pressure. In the general case, the films contain a large number of Si-C, Si-N and Si-O groups. The silicon carbide concentration in these films exceeds 50 wt.% (with organ as the plasma-forming gas). The complex spectral contour of the absorption band, with a maximum at  $825 \text{ cm}^{-1}$  in the IR spectrum of the SiC films, is decomposed into individual components; bands with maxima at 750, 820 and  $940 \text{ cm}^{-1}$  are obtained. 5 refs. In Russian.

Makeeva, N.N.; Sarovtsev, I.S.; Terekhov, V.A.; Anokhin, V.Z. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 924-926.

**095482 COMPARATIVE AES AND RHEED STUDY OF THE FORMATION OF Pd SILICIDE ON CLEAN AND OXIDE COVERED Si(100) AND (111) SURFACES.** The formation and epitaxial orientation of Pd silicide on clean and native oxide covered Si(100) and (111) surfaces was studied by Auger electron spectroscopy (AES) and reflection high energy electron diffraction (RHEED). Pd was vapor-deposited in UHV onto the substrates up to thicknesses of about 6 nm. On clean Si substrates, ultra thin Pd deposits reacted to form  $\text{Pd}_2\text{Si}$  even at room temperature. However, a polycrystalline structure with very small crystallite sizes was indicated by diffuse ring patterns in RHEED. During annealing of room-temperature deposits of Pd, the (100) and (111) substrates behaved differently. Larger crystallites formed on Si(100), but the films remained polycrystalline, though textured. On Si(111), virtually perfect epitaxial re-orientation of the silicide was found. When the substrates were initially covered with native oxide of about 2 nm thickness, silicide formation started at about  $200^\circ\text{C}$ , resulting in polycrystalline, but strongly textured  $\text{Pd}_2\text{Si}$ . (Edited author abstract) 10 refs.

Anton, R. (Univ Hamburg, Hamburg, West Ger); Neukirch, U. *Appl Surf Sci* (1985) v 29 n 3 Nov 1987 p 287-299.

**095483 CONCENTRATION CHANGES OF Pt AND Si IN A Pt/POLY-Si THIN LAYER SYSTEM BETWEEN  $750$  AND  $1000^\circ\text{C}$ .** A Pt/poly-Si/ $\text{SiO}_2$ /Si(100) multilayer system was annealed at  $750^\circ\text{C}$  in order to grow a PtSi layer on the poly-Si layer. Upon subsequent annealing at  $820^\circ\text{C}$ , the unreacted poly-Si diffuses partly into the PtSi. When equilibrium was reached at  $880^\circ\text{C}$ , the poly-Si and PtSi layers were almost completely separated with the Si nearer to the surface. After annealing at  $1000^\circ\text{C}$  for 10 min, the Pt and Si concentrations were constant throughout the top layer. (Author abstract) 7 refs.

Berning, G.L.P. (Univ of Orange Free State, Bloemfontein, S Afr); Louw, C.W. *Appl Surf Sci* (1985) v 31 n 4 May 1988 p 420-425.

## Thin Films See Also SEMICONDUCTOR DEVICES—Heterojunctions.

**095484 D.C. CONDUCTION IN THIN FILMS OF  $\text{SiO}/\text{In}_2\text{O}_3$  BEFORE AND AFTER ELECTROFORMING.** Electrical measurements on thin co-evaporated  $\text{SiO}/\text{In}_2\text{O}_3$  films before and after electroforming are reported. The high-field conduction (expressed in terms of circulating current  $I_c$  and bias voltage  $V_b$ ) in thin film sandwich structures of Al-SiO/ $\text{In}_2\text{O}_3$ -Al and Cu-SiO/ $\text{In}_2\text{O}_3$ -Cu is found to obey a relation of the form  $\log I_c \propto V_b^{1/2}$ . The electroformed samples show voltage-controlled negative resistance, voltage memory, thermal-voltage memory and pressure-voltage memory effects and the results are explained in terms of the filamentary model of electrical conduction. (Author abstract) 14 refs.

Al-Dhhan, Z.T. (Brunel Univ, Uxbridge, Engl); Hogarth, C.A. *J Mater Sci* v 22 n 10 Oct 1987 p 3698-3702.

**095485 ELECTRICAL CONTACTS TO BETA SILICON CARBIDE THIN FILMS.** Ohmic and rectifying electrical contacts to n- or p-type semiconducting  $\beta$ -SiC thin films were developed and characterized. Upon an-

nealing for 300s at  $1523 \text{ K}$ , Ni, Au-Ta, and Cr were ohmic on n-type material.  $\text{TaSi}_2$ , similarly heated to  $1123 \text{ K}$ , and as-deposited Al also showed ohmic character.  $\text{TaSi}_2$  had the lowest room-temperature contact resistivity of  $2.0 \times 10^{-2} \Omega\text{-cm}^2$ . For p-type  $\beta$ -SiC, Al-Ta $\text{Si}_2$  annealed for 1800s at  $1473 \text{ K}$  and Al annealed for 180s at  $1150 \text{ K}$  exhibited ohmic behavior. Al was the better of the two, having a room temperature contact resistivity of  $3.1 \times 10^{-2} \Omega\text{-cm}^2$ . High-temperature measurements of Al and  $\text{TaSi}_2$  contacts showed that these contacts are stable during electrical operation to at least  $673 \text{ K}$  for 8h in air. At this temperature the contact resistivity of  $\text{TaSi}_2$  and Al on  $\beta$ -SiC decreased by a factor of two and ten, respectively. Contacts of Au were shown to be rectifying on n-type  $\beta$ -SiC with a barrier height of  $1.20 \text{ V}$ . (Author abstract) 23 refs.

Edmond, J.A. (North Carolina State Univ, Raleigh, NC, USA); Ryu, J.; Glass, J.T.; Davis, R.F. *J Electrochem Soc* v 135 n 2 Feb 1988 p 359-362.

**095486 MICROPORE DENSITY IN  $\alpha$ -Si:H AND  $\alpha$ -Si:HCl FILMS.**  $\alpha$ -Si:H films deposited from various silane-containing gas mixtures have been studied regarding their porosity. Micropore densities of  $2.0 \times 10^2 \text{ cm}^{-2}$ ,  $5.0 \times 10^3 \text{ cm}^{-2}$  and  $5.0 \times 10^4 \text{ cm}^{-2}$  were determined for  $\alpha$ -Si:H:Cl,  $\alpha$ -Si:H(H+2) and  $\alpha$ -Si:H(Ar) films, respectively. It is suggested that these values correlate with the structural properties of the films, so that  $\alpha$ -Si:H:Cl films seem to be the most uniform on the microstructural scale. (Author abstract) 7 refs.

Danesh, P. (Bulgarian Acad of Sciences, Sofia, Bulg); Pantchev, B. *Mater Lett* v 6 n 3 Dec 1987 p 89-91.

**095487 PREPARATION AND TRANSPORT PROPERTIES OF AMORPHOUS SiGe ALLOYS.** The efficiency of solar energy conversion into electric power by means of the photovoltaic effect depends crucially on the bandgap of the light-absorbing semiconductor. It can be tailored to an optimum value with silicon-germanium alloys, whose bandgap can be varied along with their composition between  $1.8 \text{ eV}$  and  $1.0 \text{ eV}$ . These alloys were deposited as thin films on glass substrates by RF glow discharge. Their transport properties (mobility and lifetime) were determined by stationary and transient photoconductivity (time-of-flight technique). (Author abstract) 10 refs.

Karg, F.H. (Siemens AG, West Ger); Guenzel, E.; Grabmaier, J.G. *Siemens Forsch Entwicklungsber* v 17 n 3 1988 p 131-137.

**095488 POST-NITRIDATION ANNEALING - AN EFFECTIVE METHOD TO IMPROVE THE CHARACTERISTICS OF ULTRATHIN THERMAL NITRIDED OXIDE FILM.** The characteristics of ultrathin (approx. 100 Å) thermal nitrided  $\text{SiO}_2$  film was investigated. A new post-nitridation annealing technique was presented. The obtained thin film has several advantages compared to the thin  $\text{SiO}_2$  film, such as excellent oxidation-resistant characteristics; less positive charge and electron trap generation under high electric field stress; superior electrical breakdown characteristics; better irradiation-hard performance, etc. Its fixed charge and interface density are comparable to those of thin  $\text{SiO}_2$  film. It is a kind of ultra thin dielectric film of high performance. (Edited author abstract). 10 Refs. In Chinese.

Wu, Lifeng (Tsinghua Univ, China); Xiong, Daqing; Gu, Zuyi; Jin, Dongming; Liu, Litan; He, Xiaoyin. *Bandaoti Xuebao* v 9 n 4 Jul 1988 p 412-420.

**095489 HYDROGENATED AMORPHOUS SILICON FILMS DEPOSITED BY DC PLANAR MAGNETRON REACTIVE SPUTTERING.** Reactive sputtering has the advantage in hydrogenated amorphous silicon ( $\alpha$ -Si:H) deposition that it permits wide control of the hydrogen content in the films. This paper describes  $\alpha$ -Si:H films with high photo-to-dark conductivity ratios ( $10^5$ - $10^6$ ) and low midgap densities of states (approx.  $5 \times 10^{15} \text{ cm}^{-3}\text{-eV}^{-1}$ ) that we have deposited by DC



magnetron sputtering onto borosilicate glass substrates. Particular attention is given to the influence of the hydrogen partial pressure on the film properties such as the hydrogen content and bonding, the photo- and dark-conductivity, and the optical bandgap. (Edited author abstract) 30 refs.

Pinarbasi, Mustafa (Univ of Illinois at Urbana-Champaign, IL, USA); Lih Hsin Chou; Maley, Nagi; Myers, Alan; Leet, David; Thornton, John A. *Superlattices Microstruct* v 3 n 4 1987, Pap Presented at the Am Vac Soc Meet, Urbana-Champaign, IL, USA, Apr 1987 p 331-340.

## Vapor Deposition

**095490 PHOTOENHANCED DEPOSITION OF SILICON OXIDE THIN FILMS USING A NOVEL WINDOWLESS INTERNAL NITROGEN DISCHARGE LAMP.** This paper reviews the production of silicon oxide thin films using a novel photoenhanced deposition technique incorporating a windowless nitrogen discharge lamp contained within the deposition vessel. The use of an internal lamp obviates the need for a window between the lamp and reaction chamber and thus overcomes the problems of attenuation of short wavelength ultraviolet radiation by the window. Thin films of silicon oxide have been deposited onto single crystal silicon wafers from nitrous oxide-silane gas mixtures. Thin film transistors (TFTs) have been fabricated using the material (and an active layer of amorphous silicon deposited in the same system) and characteristics of these TFTs are also presented. (Edited author abstract). 14 refs.

Baker, S.D. (Cambridge Univ Engineering Dept, Cambridge, Engl); Milne, W.I.; Robertson, P.A. *Appl Phys A* v 46 n 4 Aug 1988 p 243-248.

**Viscoelasticity See MATHEMATICAL TECHNIQUES—Boundary Element Method.**

## SEMICONDUCTING SILVER COMPOUNDS

### Ionic Conduction

**095491 SOUND VELOCITY IN SILVER CHALCOGENIDES.** In this note, the authors investigate the sound propagation in a silver chalcogenide using a continuum model and calculate the shift of sound velocity, which is caused by the deviation from a stoichiometric ratio. It is shown that the deviation dependences due to excess ions and electrons are different. 9 Refs.

Kobayashi, M. (Niigata Univ, Niigata, Jpn); Yonashiro, K. *Solid State Ionics* v 27 n 3 Jul 1988 p 169-174.

### Optical Properties

**095492 NEGATIVE PHOTOCONDUCTIVITY IN AgGaSe<sub>2</sub> SINGLE CRYSTALS DUE TO THE NEGATIVE PHOTOGALVANIC EFFECT.** The report deals with the results of an investigation of the negative photogalvanic effect (NPGE) observed by the authors for the first time, and the impact of this effect on the negative photoconductivity (NP) in AgGaSe<sub>2</sub> single crystals. In order to study the photogalvanic effect, the crystals were exposed to linearly polarized light. In the wavelength range where NPGE are observed, the NPGE modes coincide with the infrared quenching of intrinsic photoconductivity. Hence it can be concluded that the negative PGE and negative PC are likely to be associated with R-centres of slow recombination characterized by energies of  $E = 0.68$  eV. 13 Refs.

Kasumov, T.K. (Acad of Sciences of the Azerbaidzhan SSR, Baku, USSR); Mamedov, F.I.; Gasyimov, I.K. *Phys Status Solidi A* v 107 n 1 May 1988 pK49-K52.

**Phase Diagrams See MAGNETIC SEMICONDUCTORS—Order-Disorder.**

**Phase Transitions See ELECTRONS—Emission.**

### Spectrum Analysis

**095493 SHALLOW BOUND EXCITONS IN SILVER HALIDES.** Luminescence and excitation experiments in AgBr and AgCl are described and interpreted for weakly bound excitons associated with divalent metal and chalcogen impurities like Cd<sup>2+</sup>, S<sup>2-</sup> etc. In the analysis, data on corresponding donors are used and central cell effects considered. The results are essentially in agreement with the assumption of recombination of (D<sup>0</sup>, X) complexes. Additional results are presented for crystals containing higher impurity concentrations or thermally treated. Experiments on excitons weakly bound at randomly fluctuating potentials due to compositional disorder in AgBr<sub>1-x</sub>Cl<sub>x</sub> alloys are also reported. Temperature variation, time-resolved resonant light scattering and hydrostatic pressure are employed to study emission specific to the alloy, the results proving that it is due to this type of localized exciton state. (Author abstract) 35 refs.

Von Der Osten, W. (Univ-GH Paderborn, Paderborn, West Ger). *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 240-255.

### Thermal Effects

**095494 ANOMALOUS TEMPERATURE DEPENDENCE OF FUNDAMENTAL GAP OF AgGaS<sub>2</sub> AND AgGaSe<sub>2</sub> CHALCOPYRITE COMPOUNDS.** We have studied the temperature variation of the fundamental gap energy of the chalcopyrite-like ternary semiconductors AgGaS<sub>2</sub> and AgGaSe<sub>2</sub> from reflectivity measurements performed between 5 K and room temperature. The temperature evolution of the gap energy is found to be different from that observed for the II-VI and III-V zincblende-like binary semiconductors. The temperature coefficients are positive under 80 K and negative above 100 K with values smaller than those encountered for the II-VI and III-V binaries. Results are discussed taking into account the hybridization between the d orbitals of Ag and the p orbitals of anion (S or Se). (Edited author abstract) 20 refs.

Artus, L. (Univ de Barcelona, Spain); Bertrand, Y. *Solid State Commun* v 61 n 11 Mar 1987 p 733-736.

### Thin Films

**095495 LATTICE CONTRACTION IN SILVER MONOLAYERS.** Ag films were prepared by evaporation onto (Al(111) at 520 K and studied by Spot-Profile-Analysis-LEED (SPA-LEED). The Ag monolayer grows pseudomorphically i.e. its lattice constant is contracted by 0.9% with respect to bulk Ag. With the onset of cluster growth in the second layer, the monolayer is contracted by 3.4%. At higher Ag coverages the contraction within the monolayer, which still exists besides three-dimensional clusters, reaches 5.4%. (Author abstract) 14 refs.

Frick, B. (Max-Planck-Gesellschaft, Berlin, West Ger); Jacobi, K.; Meyer, G.; Henzler, M. *Solid State Commun* v 63 n 6 Aug 1987 p 475-479.

## SEMICONDUCTING TELLURIUM

### Amorphous

**095496 STUDY OF CRYSTALLIZATION IN AMORPHOUS TELLURIUM FILMS USING RESISTIVITY MEASUREMENTS.** A rapid and drastic decrease in resistivity as a result of the crystallization of amorphous tellurium films deposited onto a glass substrate at 10-40°C was measured. On combining the above results with a model proposed for the change in resistivity of the crystallizing film, the activation energy for crystallization was evaluated to be 0.86 eV for pure tellurium films. A higher value of the activation energy was obtained for

gold-nucleated tellurium films. (Author abstract) 10 refs.

Okuyama, K. (Yamagata Univ, Yonezawa, Jpn); Kumagai, Y. *Thin Solid Films* v 156 n 2 Jan 30 1988 p 345-350.

**Transport Properties See SEMICONDUCTOR MATERIALS—Transport Properties.**

### Vapor Deposition

**095497 PREPARATION OF Te FILMS BY HOT WALL EPITAXY.** Hot wall epitaxy technique has been used to deposit tellurium films on to glass and freshly cleaved mica substrates. Environmental conditions are optimized to obtain better crystallinity and deposition rate. Grain size as large as 12.0 µm on glass and 6.4 µm on mica substrate has been obtained. Structure of the films was analyzed by X-ray diffraction and scanning electron microscopy. (Author abstract) 10 refs.

Athwal, I.S. (Guru Nanak Dev Univ, Amritsar, India); Bedi, R.K. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1413-1415.

## SEMICONDUCTING TELLURIUM COMPOUNDS

### Composition Effects

**095498 PROPERTIES OF Hg<sub>1-x</sub>Cd<sub>x</sub>Te SINGLE CRYSTALS GROWN BY THM.** It is well known that mercury cadmium tellurides (Hg<sub>1-x</sub>Cd<sub>x</sub>Te, MCT) are important materials for use in infrared detectors. In this letter we report the variation of cadmium composition, x, along the axial and radial directions of an MCT single crystal grown by the seedless traveling-heater method (THM) using tellurium solvent, as well as results on the temperature dependence of the Hall effect for p-type as-grown MCT samples which have classical behavior. 14 refs.

Kim, K.M. (Yonsei Univ, Seoul, South Korea); Hahn, S.R.; Noh, S.K.; Park, H.L.; Chung, C.H. *J Mater Sci Lett* v 6 n 10 Oct 1987 p 1205-1206.

**Crystalline See SEMICONDUCTING CADMIUM COMPOUNDS—Crystalline.**

### Defects

**095499 MEAN SQUARE DISPLACEMENTS OF NEIGHBOURS AND PHONON RESONANCE DUE TO A VACANCY IN HgTe AND CdTe.** The mean square displacements (MSD) of the neighbors around a vacancy in HgTe and CdTe are worked out using Green's function technique and scattering wave formalism. The results are compared with the values of the perfect systems. The phonon resonance due to the vacancy for the above systems are also simultaneously worked out. (Author abstract) 7 refs.

Madhavan, Y. (Madurai Kamaraj Univ, Madurai, India); Ramachandran, K.; Haridasan, T.M. *Phys Status Solidi B* v 145 n 1 Jan 1988 p 139-144.

**Electric Conductivity See SEMICONDUCTING MANGANESE COMPOUNDS—Electric Conductivity.**

**Electric Properties See SEMICONDUCTING ANTIMONY COMPOUNDS—Doping.**

### Mass Transfer

**095500 MASS TRANSFER OF HgTe IN THE SYSTEMS HgTe-NH<sub>4</sub>Br(D).** The process of mass transfer of HgTe in the closed systems HgTe-NH<sub>4</sub>Br and HgTe-NH<sub>4</sub>I is considered using a one-dimensional model of diffusion in a multicomponent gaseous mixture. It is assumed that transfer of material occurs between opposite ends of a quartz vial with a temperature gradient. A theoretical and experimental study of the rate of mass transfer of HgTe in these systems for temperature regimes of 743-753 K and 786-801 K showed that mass transfer of HgTe has a diffusion character. In Russian. 12 refs.



Ivanov-Omskii, V.I.; Akhromenko, Yu.G.; Il'chuk, G.A.; Pavlishin, S.P.; Krasnozhenov, E.P. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 9 Sep 1987 p 1457-1462.

## Thin Films

**095501 PYROELECTRICITY OF Cd-DOPED TEL-LURIDE THIN FILM.** The crystalline structure, electrical conductivity and pyroelectricity of freshly prepared  $\text{Hg}_{0.7}\text{Cd}_{0.3}\text{Te}$  thin film have been investigated in detail. In the initial heating stages, the pyroelectric current slowly falls, followed by abrupt decreases corresponding to the breaks in the curves at temperatures depending on the poling temperature, as a general trend in common. Thus 70° is the best poling temperature for attainment of a high generated pyroelectric current, holding up to relatively high working temperatures for the investigated  $\text{HgCdTe}$  films in the electronic and engineering industries. 13 Refs.

Tawfik, A. (Tanta Univ, Tanta, Egypt); El Mekawey, F.M. *J Therm Anal* v 34 n 1 Jan-Feb 1988 p 297-303.

## SEMICONDUCTING TIN COMPOUNDS

See Also GAS ANALYSIS—Sensors; HYDROGEN—Sensors; SOLAR CELLS.

## Crystallization

**095502 EFFECT OF Sn/Sb RATIO IN DETERMINING CRYSTALLITE SIZE OF  $\text{SnO}_2\text{-Sb}_2\text{O}_5$  SEMI-CONDUCTORS.** Six  $\text{SnO}_2\text{-Sb}_2\text{O}_5$  semiconductors with different Sn/Sb ratios were prepared by the gel method. The samples, heated at different temperatures in the range 250 to 1100°C, were characterized by X-ray analysis, surface area determination, TG-DTA studies and SEM observations. Results indicate that the crystallite size of  $\text{SnO}_2$  doped by antimony oxide is affected by the Sb/Sn ratio, smaller crystallites being obtained at lower antimony oxide loadings. The presence of a  $\text{Sb}_2\text{O}_4$  phase separated from  $\text{SnO}_2$  and the effect of antimony doping on  $\text{SnO}_2$  are the main parameters ruling  $\text{SnO}_2$  crystallite dimensions. (Author abstract) 13 Refs.

Carturan, G. (Univ of Trento, Trento, Italy); Giordano Orsini, P.; Scardi, P.; Di Maggio, R. *J Mater Sci* v 23 n 9 Sep 1988 p 3156-3160.

## Defects

**095503 INVESTIGATIONS OF THE BULK DEFECT CHEMISTRY OF POLYCRYSTALLINE TIN (IV) OXIDE.** The bulk defect chemistry of polycrystalline  $\text{SnO}_2$  has been investigated systematically by impedance spectroscopy. Nominally pure and In- and Sb-doped materials were shown to be stable in the rutile structure over the entire temperature range (500-900°C). Lattice constants were determined as a function of temperature. Defect chemistry can be described consistently by assuming fully ionized oxygen vacancies and conduction electrons as native defects. In the  $\text{O}_2$  partial pressure range between 0.02 and 1 bar, intrinsic behavior was observed with a characteristic exponent of  $-1/6$  of  $T > 800^\circ\text{C}$  in nominally pure oxides, whereas at lower temperatures acceptor impurities dominate the conductivity with a characteristic exponent of  $-1/4$ . (Edited author abstract) 21 refs.

Maier, J. (Max-Planck-Institut fuer Festkoerperforschung, Stuttgart, West Ger); Goepel, W. *J Solid State Chem* v 72 n 2 Feb 1988 p 293-302.

## Doping

**095504 CHEMICAL REACTION IN SnTe-BASED SOLID SOLUTIONS IN THE Sn-In-Te SYSTEM.** The results of a theoretical calculation of the concentration dependences of the elementary-cell parameter in various solid solution models were compared with experimental data. It was found that in SnTe-based solid solutions doped with In a deviation from stoichiometry leads to a qualitative change in the structure of the solid solution which is related to a chemical reaction between In atoms and atoms of the matrix to form  $\text{In}_2\text{Te}_3$  complexes. In Russian. 10 refs.

Gorne, G.V.; Zhigareva, N.K.; Ivanova, A.B.; Rogacheva, E.I. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 8 Aug 1987 p 1298-1302.

**095505 DOPING TIN-OXIDE FILMS BY ION IMPLANTATION.** A postdeposition method of doping tin-oxide ( $\text{SnO}_2$ ) films that includes ion implantation and a subsequent anneal has been developed. The method offers the advantage of being simpler and more reproducible than in situ doping techniques. Electrical conductivity can be controlled by adjusting dose and energy. Annealing at 700°C or above for 30 min is adequate to activate the dopants. Diffusion of the dopants such as phosphorus, arsenic, and fluorine in tin oxide is negligible at 900°C or below. Thus dopant distribution is essentially dependent on implant straggle. Electrical conductivity of 400  $\text{mho-cm}^{-1}$  can be routinely obtained with phosphorus implant. The highest conductivity achieved was 700  $\text{mho-cm}^{-1}$  with a combination of phosphorus and  $\text{BF}_2$  implants. (Author abstract) 4 refs.

Wan, C.F. (Texas Instruments, Dallas, TX, USA); McGrath, R.D.; Keenan, W.F.; Tung, Y.S.; Frank, S.N. *J Electrochem Soc* v 135 n 4 Apr 1988 p 985-988.

## Electric Conductivity

**095506 MECHANISMS OF DETECTION ON TIN OXIDE GAS SENSORS.** One of the most critical constraints in the full exploitation of automation in a variety of technological applications is the availability of suitable sensors. The design, fabrication and testing of such devices is therefore a compulsory prerequisite. Besides, the development at industrial level of these kind of devices could not be fulfilled unless reliable and low cost sensors are available, which must be selective to a variety of chemical species present in gas phase. In this paper, we intend to show a review of some important mechanisms of detection in these kind of sensors. Some data about accuracy, selectivity, response time and limits of detecting species are also reported. Finally, two methods of obtaining sensors are also reported; the first consists of a pyrolysis of organometallic compounds and the latter evaporation of metallic tin followed by a controlled oxidation process. (Author abstract) 11 refs.

Gutierrez, J. (IEC Lab Metrologia-Sensores, Madrid, Spain); Cebollada, F.; Elvira, C.; Millan, E.; Agapito, J.A. *Mater Chem Phys* v 18 n 3 Nov 1987 p 265-275.

**095507 INFLUENCE OF ADSORBED HYDROXYL SPECIES ON THE ELECTRICAL CONDUCTANCE OF  $\text{SnO}_2$ .** The origin of the electrical conductance maximum observed on tin dioxide with different gases has been studied. An interpretation of the high conductance value observed at low temperature is proposed and it has been found that the grain boundaries are very sensitive to gas adsorption. The contribution of water vapor to the electrical model has also been considered. (Author abstract) 12 refs.

Pijolat, C. (Ecole Natl Supérieure des Mines de St-Etienne, St-Etienne, Fr); Lalauze, R. *Sens Actuators* v 14 n 1 May 1988 p 27-33.

## Electric Properties

**095508 VARIATION IN ELECTRICAL PROPERTIES OF SnTe THIN FILMS WITH SUBSTRATE TEMPERATURE.** The influence of substrate temperature (300 to 460 K) on the electrical resistivity and thermoelectric power of thin films of SnTe and SnTe doped with 10% excess tin was investigated. The observed variation cannot be attributed to the improvement in crystallinity alone. The results are explained by considering the reduction in carrier concentration and the two-valence band structure of SnTe. (Author abstract) 13 refs.

Ganesan, N. (Indian Inst of Technology, Madras, India); Sivaramakrishnan, V. *Phys Status Solidi A* v 105 n 2 Feb 1988 p 461-466.

**095509 EFFECT OF EXCESS TIN ON THE ELEC-**

**TRICAL PROPERTIES OF SnTe THIN FILMS.** The influence of temperature and thickness on the electrical transport properties of 10% excess tin-doped polycrystalline SnTe thin films were investigated. From the observed variation of electrical resistivity and Seebeck coefficient it is concluded that the material exhibits a p-type degenerate behavior. Using the size effect data, different physical parameters such as Fermi energy, effective mass and scattering parameter were evaluated and compared to understand the effect of excess tin. (Author abstract) 33 refs.

Ganesan, N. (Indian Inst of Technology, Madras, India); Sivaramakrishnan, V. *J Mater Sci* v 23 n 4 Apr 1988 p 1237-1242.

## Optical Properties

**095510 OPTICAL PROPERTIES OF THE ALLOY SYSTEM SnTe-GeTe FROM REFLECTANCE MEASUREMENTS.** The reflectance spectra of bulk samples of the alloy series  $\text{Sn}_{1-x}\text{Ge}_x\text{Te}$  are measured at room temperature in the wavelength range 0.2 to 50  $\mu\text{m}$ . The principal optical constants are obtained using Kramers-Kronig analysis. The variations of the optical dielectric constant, the carrier effective mass, the optical mobility, and the optical energy gap are given as functions of the alloy fraction x. For the Sn-rich alloys ( $x < 0.3$ ) the energy gap and the dielectric constant do not follow the trends established for the series at the Ge-rich side, and are possibly related to the cubic-rhombohedral phase transition that occurs in this system. The mobility and effective mass, though, behave reasonably for all alloy fractions. (Author abstract) 37 refs.

Lewis, J.E. (State Univ of New York, Plattsburgh, NY, USA). *Phys Status Solidi B* v 143 n 1 Sep 1987 p 307-315.

**095511 OPTICAL PROPERTIES OF BROMINE-DOPED  $\text{SnO}_2$  COATINGS FOR SOLAR APPLICATIONS.** Bromine doped  $\text{SnO}_2$  coatings were prepared using spray pyrolysis. The absorption coefficient is calculated in the fundamental absorption region. The absorption coefficient data are analysed and interpreted in terms of direct and indirect allowed transitions. Solar spectrum transmittance, reflection coefficient, refractive index, and figure of merit are estimated. (Author abstract) 16 Refs.

Abass, A.K. (Univ of Basrah, Basrah, Iraq); Al-Liabi, N.A.; Taha, W.A. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 613-618.

## Phase Transitions

**095512 EFFECTS OF A DEVIATION FROM STOICHIOMETRY ON THE MOSSBAUER PARAMETERS OF  $\text{Sn}_{0.8}\text{Ge}_{0.2}\text{Te}$  DURING THE PHASE TRANSITION.** The system of solid solutions ( $\text{Sn}_{0.8}\text{Ge}_{0.2}$ ) $_{1-y}\text{Te}_y$  with the values of  $y=0.499$ ; 0.505; 0.510 is investigated by means of the Mossbauer effect on the  $^{119}\text{Sn}$  nucleus within the temperature range 160 to 300 K. The effective Debye temperature and mean-square displacements of tin atoms from equilibrium are calculated. In the region of phase transition (about 200 K) fractures on the temperature dependencies of the isomer shift and Debye temperature are observed, while no anomalies of the Mossbauer effect probability are noticed. No quadrupole interaction is observed with the symmetry decrease in the lattice. A correlation between the isomer shift and interatomic distance is revealed. The ionicity of the chemical bond in the system  $\text{Sn}_x\text{Ge}_{1-x}\text{Te}$  is  $\approx 54$  percent when  $x=0.9$ , and about 40 percent when  $x=0.1$ . (Author abstract) 20 Refs.

Balrunas, D. (Acad of Sciences of the Lithuanian SSR, Vilnius, USSR); Vengalis, B.; Motiejunas, S.; Shiktorov, N. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 197-204.

## Photoconductivity

**095513 DYE SENSITIZATION OF VAN DER WAALS SURFACES OF  $\text{SnS}_2$  PHOTOANODES.** The sensitization of the Van Der Waals surface of  $\text{SnS}_2$  ( $E_g =$



2.22 eV) with over 30 different dyes is studied. The van der Waals surface of this material has several advantages of studying sensitization. It is renewable via cleavage and lacks an oxide layer under ambient conditions. The relevance of the electrochemical properties of the dyes to their sensitization behavior is discussed. Adsorption isotherms for many of the dyes were measured by relating quantum yield for electron injection to surface coverage. Both J and H aggregates and monomeric dye species sensitize n-SnS<sub>2</sub>. The photocurrent-voltage behavior of the dye is interpreted by using Spilner's theory of electron injection into semiconductors. Sensitized photocurrents are also studied as a function of light intensity and supersensitizer concentration to aid the qualitative theoretical analysis. Several unusual effects associated with the layered structure of the semiconductor are observed including dye intercalation, total internal reflection of the incident light, and surface phase changes. (Author abstract). 25 Refs.

Parkinson, B.A. (DuPont, Wilmington, DE, USA). *Langmuir* v 4 n 4 Jul-Aug 1988 p 967-976.

## Preparation

**095514 PREPARATION AND ELECTROCHEMICAL BEHAVIOUR OF SOME METAL OXIDE FILMS.** Antimony, tin and titanium oxides are very attractive materials for spectroscopic studies, solar energy applications and other industrial purposes. In this work oxide films of these metals were prepared on glass, glassy carbon or platinum using a combined chemical vapor deposition-spraying technique. The variation in the physical properties of the film with its thickness and preparation parameters was studied. The electrochemical properties of the prepared electrodes were studied in different redox systems. The charge transfer reaction between the oxide film electrode and the redox electrolyte seems to occur via electron tunnelling through the barrier formed by the space charge layer of the semiconducting oxide. (Author abstract) 22 refs.

Badawy, W.A. (Univ of Cairo, Giza, Egypt); El-Taher, E.A. *Thin Solid Films* v 158 n 2 Apr 1988 p 277-284.

## Switching

**095515 MECHANISM FOR NONLINEAR I - V BEHAVIOUR AND THE TEMPERATURE DEPENDENCE OF THRESHOLD SWITCHING IN THE Se-Te-Sn SYSTEM.** The nonlinear I-V behavior and threshold switching of the bulk Se-Te-Sn system have been experimentally studied at various temperatures. It is observed that the curves are linear for low voltages and become superlinear at higher voltages. After a certain voltage  $V_{th}$ , the current through the material shoots to a very high value and the potential across the material drops to a low value. It is also found that there is a decrease in  $V_{th}$  with increase in percentage of tin and temperature. An attempt is made to explain the nonlinear I-V behavior and threshold switching on the basis of a microcrystallite model. A study of Se-Te-Sn system reveals that our results are in concurrence with the theoretical predictions. (Author abstract). 24 Refs.

Muragi, B.D. (Shivaji Univ, India); Zope, M.J.; Zope, J.K. *Appl Phys A* v 46 n 4 Aug 1988 p 299-303.

## Synthesis

**095516 PYROELECTRIC PROPERTIES OF Sn<sub>2</sub>P<sub>2</sub>S<sub>6</sub> CRYSTALS.** A study was made of the pyroelectric properties of crystals of the ferroelectric semiconductor Sn<sub>2</sub>P<sub>2</sub>S<sub>6</sub>. It was established that at room temperature the pyroelectric properties of these crystals are comparable to those of the most widely known pyroactive materials. It is shown that variations of the technological conditions of growth of the crystals affect the stability of their domain structure. 16 refs. In Russian.

Bravina, S.L.; Kladkevich, M.D.; Morozovskii, N.V.; Samoilov, V.B.; Maior, M.M.; Gurzan, M.I.; Vysochanskii, Yu.M.; Slivka, V.Yu.; Kremenchugskii, L.S. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 5 May 1987 p

733-738.

**095517 STRUCTURAL DETERMINATION AND TRANSPORT PROPERTIES OF A NEW PHASE WITH APPROXIMATE COMPOSITION Sn<sub>1.2</sub>Ti<sub>0.8</sub>S<sub>3</sub>.** A new compound, Sn<sub>1.2</sub>Ti<sub>0.8</sub>S<sub>3</sub>, has been characterized. The unit cell is orthorhombic, space group Pnma, a = 8.899(4) Å, b = 3.605(2) Å, c = 13.506(6) Å. Its crystal structure has been determined and yielded a reliability R factor of 0.025. This structure is reminiscent of that of Sn<sub>2</sub>S<sub>3</sub>, where part of Sn IV has been substituted with Ti. The band gap determined from electrical conductivity is found to be 0.05 eV. (Edited author abstract) 10 refs.

Gressier, P. (CNRS, Nantes, Fr); Meerschaut, A.; Rouxel, J. *Mater Res Bull* v 22 n 11 Nov 1987 p 1573-1580.

**Thermodynamic Properties** See SEMICONDUCTING LEAD COMPOUNDS—Thermodynamic Properties.

## Thin Films

**095518 THICKNESS DEPENDENCE OF H<sub>2</sub> GAS SENSOR IN AMORPHOUS SnO<sub>x</sub> FILMS PREPARED BY ION-BEAM SPUTTERING.** Amorphous semiconducting SnO<sub>x</sub> films were deposited by ion-beam sputtering on sintered alumina substrates. Amorphous film sensors were prepared by annealing the films at 300°C for 2 h in air. The thickness dependence of resistivity and hydrogen gas sensitivity were measured at 150°C over the thickness range ca. 1 to 700 nm. A resistivity maximum was observed in ultrathin films. Resistivity increased by three orders of magnitude with increasing film thickness from 0.9 to 7.4 nm and then decreased by five orders of magnitude from 7.4 to 35 nm. Ultrathin film sensors showed sensitivity maxima around a thickness of 10 nm. Sensitivity and resistivity of ultrathin films were significantly influenced by the thermal expansion coefficient and the surface state of the substrate. (Author abstract) 15 refs.

Suzuki, Takeyuki (Tokyo Univ of Agriculture & Technology, Koganei, Jpn); Yamazaki, Tsutomu; Yoshioka, Hiroshi; Hikichi, Kuniyuki. *J Mater Sci* v 23 n 1 Jan 1988 p 145-149.

**095519 HIGHLY CONDUCTING AND TRANSPARENT SnO<sub>2</sub> THIN FILMS PREPARED BY RF MAGNETRON SPUTTERING ON LOW-TEMPERATURE SUBSTRATES.** Highly conducting and transparent thin films of undoped tin oxide (SnO<sub>2</sub>) are prepared on unheated substrates (<90°C) by rf magnetron sputtering under an applied external dc magnetic field. The lowest resistivity obtained is  $1.9 \times 10^{-3} \Omega \text{cm}$ . The SnO<sub>2</sub> films with a sheet resistance below 200  $\Omega/\text{sq}$  and an average visible transmittance (between 400 and 700 nm) above 85%, and below 300  $\Omega/\text{sq}$  and above 80% (including organic film substrate) can be obtained for the films deposited on glass substrates and organic film substrates, respectively. (Author abstract) 18 refs.

Minami, Tadatsugu (Kanazawa Inst of Technology, Jpn); Nanto, Hidehito; Takata, Shinzo. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 287-289.

**095520 HIGH MOBILITY POLYCRYSTALLINE SnTe:Ge FILMS.** High mobility polycrystalline SnTe:Ge films have been prepared by co-evaporation of tin and germanium from a single source in an atmosphere of tellurium vapour for different weight percentages of germanium. It has been found that SnTe:Ge films with germanium content around 0.8 weight percent have maximum mobility (approximately  $1150 \text{ cm}^2 \text{V}^{-1} \text{s}^{-1}$  at room temperature) and minimum carrier concentration (approximately  $3 \times 10^{19} \text{ cm}^{-3}$  at room temperature). (Author abstract) 11 refs.

George, J. (Cochin Univ of Science & Technology, Cochin, India); Palson, T.I.; Joseph, K.S. *Solid State Commun* v 64 n 1 Oct 1987 p 161-164.

**Vacuum Applications** See SEMICONDUCTING INDIUM COMPOUNDS—Thin Films.

## SEMICONDUCTING ZINC COMPOUNDS

See Also MAGNETIC SEMICONDUCTORS—Physical Properties; RADIATION DETECTORS; SEMICONDUCTING CADMIUM COMPOUNDS; SEMICONDUCTING GALLIUM ARSENIDE—Defects; SEMICONDUCTOR DIODES; PHOTO DIODE—Heterojunctions; SEMICONDUCTOR MATERIALS; SOLAR CELLS—Cadmium Sulfide; ZINC COMPOUNDS—Sputtering.

**095521 CORRELATION BETWEEN THE 1.1 AND 1.45 eV EMISSION BANDS AND THE F<sup>+</sup> OPTICAL ABSORPTION BANDS IN ZnS CRYSTALS.** Zinc sulfide crystals are fired successively in a Zn liquid at 1184°C and annealed isochronally. The emission spectra between 700 and 1200 nm and the optical absorption bands ascribed to F<sup>+</sup> centers are measured in the specimens. The Zn treatments introduce emission bands with peaks at 1.1 and 1.45 eV, which are reported by other workers. These bands are annealed in company with F<sup>+</sup> centers. Therefore it is proposed that these emission bands are due to F<sup>+</sup> centers. (Author abstract) 21 refs.

Matsuura, K. (Tottori Univ, Koyama, Jpn); Kishida, S.; Fukata, Y.; Tsunumi, I. *Phys Status Solidi B* v 143 n 1 Sep 1987 p 275-280.

**095522 PHOTOCHEMISTRY AND RADIATION CHEMISTRY OF COLLOIDAL SEMICONDUCTORS. 23. ELECTRON STORAGE ON ZnO PARTICLES AND SIZE QUANTIZATION.** Improved methods for the preparation of colloidal ZnO solutions of different particle size are described, and the relation between absorption threshold and particle size is reported. CH<sub>2</sub>OH radicals, radiolytically generated, transfer electrons to ZnO particles. The electrons are long-lived and cause a substantial blue shift of the absorption spectrum of ZnO in a wavelength range of 60 nm below the threshold. The wavelength of maximum bleaching is shifted to shorter wavelengths with decreasing particle size (size quantization effect). Maximum bleaching occurs with a negative absorption coefficient of  $1.1 \times 10^5 \text{ M}^{-1} \text{cm}^{-1}$ . Electrons are also stored upon UV illumination of colloidal ZnO. The stored electrons react rather slowly with oxygen, the rate constant becoming lower with increasing particle size, and more rapidly with peroxy radicals. (Author abstract) 17 refs.

Haase, Markus (Hahn-Meitner-Inst Berlin, Berlin, West Ger); Weller, Horst; Henglein, Armin. *J Phys Chem* v 92 n 2 Jan 28 1988 p 482-487.

**Applications** See SEMICONDUCTOR DEVICES, MOS—Photovoltaic Effects; VARISTORS—Materials.

## Charge Carriers

**095523 CARRIER CONCENTRATION AND TRANSPORT IN Hg<sub>1-x</sub>Zn<sub>x</sub>Te FOR x NEAR 0.15.** Experimental measurements of concentration and mobility for as-grown Hg<sub>1-x</sub>Zn<sub>x</sub>Te, and after 'stoichiometric' annealing, are presented. Results are presented on the kinetics of changes in conductivity type and mobility in both types. A comparison of experimental mobility values with calculated ones indicates that the usual Kane model describes fairly well the structure of the electronic states in the conduction band, although the impurity concentration of the samples studied remains high, and since no effective mass measurement has been performed at the present time. 22 refs.

Granger, R. (CNRS, Rennes, Fr); Lasbley, A.; Rolland, S.; Pelletier, C.M.; Triboulet, R. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 682-688.

## Chemical Vapor Deposition

**095524 GROWTH RATE ENHANCEMENT BY XENON LAMP IRRADIATION IN ORGANOMETALLIC VAPOR-PHASE EPITAXY OF ZnSe.** The growth rate of ZnSe in organometallic vapor-phase epitaxy (OMVPE) using dimethylzinc (DMZ) and dimethyl-



selenide (DMSe) as the source materials was substantially increased by irradiation from a xenon lamp. The growth temperature was reduced from 500°C to 300°C by keeping a constant growth rate of 1-2  $\mu\text{m}/\text{h}$ . Promotion of surface reaction due to irradiation was considered as one of the factors for the growth rate enhancement. The density of defects which causes deep level emissions was also successfully reduced. We suggest that this technique is very effective to obtain high-quality epilayers. (Author abstract) 10 refs.

Fujita, Shigeo (Kyoto Univ, Kyoto, Jpn); Tanabe, Akira; Sakamoto, Takao; Isemura, Masashi; Fujita, Shizuo. *Jpn J Appl Phys Part 2* v 26 n 12 Dec 1987 p 2000-2002.

**095525 EFFECTS OF LATTICE MISMATCH ON CRYSTALLOGRAPHIC PROPERTIES OF ZnS GROWN ON GaP AND GaAs BY MOCVD.** The unusual phenomenon that largely lattice-mismatched ZnS layers grown on GaAs by MOCVD show better surface morphology and crystalline quality than less mismatched ZnS layers on GaP has been investigated by X-ray diffraction measurements. The results indicate that this phenomenon can be ascribed to the strain-relaxation taking place at an earlier stage of epitaxial growth on GaAs than on GaP substrates. (Edited author abstract) 10 refs.

Mitsuishi, Iwao (Tokyo Inst of Technology, Yokohama, Jpn); Mitsuhashi, Hiroshi; Kukimoto, Hiroshi. *Jpn J Appl Phys Part 2* v 27 n 1 Jan 1988 p 15-17.

**095526 PHOTOLUMINESCENCE PROPERTIES OF LI-DOPED ZnSe FILMS GROWN BY METAL-ORGANIC CHEMICAL VAPOR DEPOSITION.** Lithium-doped ZnSe films have been grown by atmospheric metalorganic chemical vapor deposition. Dimethylzinc and dimethylselenide were used as source materials and cyclopentadienyl lithium was used as a dopant. The films have been characterized by a low-temperature photoluminescence. It is shown that the lithium acts as a shallow acceptor in ZnSe with an activation energy of about 101-118 meV. Furthermore, it is shown that the intensity of emission from deep centers, such as so-called self-activated and copper-green emission, is remarkably reduced in lithium-doped ZnSe films. (Author abstract) 10 refs.

Yoshikawa, Akihiko (Chiba Univ, Chiba, Jpn); Muto, Shin-ichiro; Yamaga, Shigeki; Kasai, Haruo. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 260-262.

**095527 ZnTe LAYERS GROWN ON GaAs SUBSTRATES BY LOW PRESSURE MOCVD.** ZnTe epitaxial layers have been grown on [001] oriented GaAs substrates by low pressure MOCVD. All ZnTe layers grew in the [001] direction with a slight misorientation with respect to the underlying substrate. The layers exhibited an elongated surface structure directed along the [110] direction. The FWH value of the rocking curves was found to reduce with increasing layer thickness, saturating toward the value of 250°. Beyond approximately 2.5  $\mu\text{m}$  the layer quality does not improve very much with increasing thickness. (Author abstract) 17 refs.

Shtrikman, Hadas (Soreq Nuclear Research Cent, Yavne, Isr); Raizman, A.; Oron, M.; Eger, D. *J Cryst Growth* v 88 n 4 May 1988 p 522-526.

**095528 EFFECT OF ANNEALING ON PHOTOLUMINESCENCE PROPERTIES IN Ar<sup>+</sup>-ION IRRADIATED MOCVD-GROWN ZnSe FILMS.** Ion irradiation and subsequent thermal annealing effects have been investigated on photoluminescence properties at 4.2 K of ZnSe films grown on (100) GaAs and Ge substrates by metalorganic chemical-vapor deposition (MOCVD). After irradiation of Ar<sup>+</sup>-ion beams with a total dose of about 10<sup>15</sup> cm<sup>-2</sup> at 50 KeV, the deep-level emission bands newly appear in the vicinity of about 570 nm, while the excitonic emission lines become extremely weak in intensity or vanish completely. The photoluminescence spectra in ZnSe/Ge are almost completely recovered by annealing at 350°C. On the contrary, in the case of ZnSe/GaAs, the deep-level emission bands around 570

nm become much greater in intensity after the anneal. It is suggested that the 550, 570 and 600 nm bands which occur in the irradiated ZnSe/GaAs, are derived from complex defects associated with radiation-induced Zn vacancies and/or donor impurities out-diffused from the substrate. (Edited author abstract) 8 refs.

Sekoguchi, Maki (Osaka Univ, Suita, Jpn); Taguchi, Tsunemasa; Hiraki, Akio. *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 699-701.

**095529 EXCITONIC AND EDGE EMISSIONS IN MOCVD-GROWN ZnS FILMS AND ZnSe-ZnS SUPERLATTICES.** Excitonic lines and edge-emission bands in metalorganic chemical vapor deposition (MOCVD) heteroepitaxially-grown ZnS films on (100) GaAs substrates have been extensively investigated at 4.2 K using He-Cd (325 nm) and Xe-Cl excimer (308 nm) lasers. Distinct edge-emission bands were observed; the LO-phonon-replicated 3.641 and 3.666 eV bands are ascribed to a donor-acceptor pair and free-to-bound acceptor transition, respectively, from time-resolved spectral measurements. The Na acceptor level is tentatively assigned to be about 170 meV above the valence band. ZnSe-ZnS and ZnSe-ZnS<sub>0.99</sub> superlattices, which were for the first time prepared by low-pressure MOCVD, have been characterized by the well-width dependence of the excitonic lines and by optical absorption. We observed heavy-hole and light-hole excitons in the absorption spectra of the ZnSe-ZnS superlattices. (Author abstract) 11 refs.

Kawakami, Yoichi (Osaka Univ, Suita, Jpn); Taguchi, Tsunemasa; Hiraki, Akio. *J Cryst Growth* v 89 n 2-3 Jun 1988 p 331-338.

**095530 ELECTRICAL AND OPTICAL PROPERTIES OF DONOR DOPED ZnS FILMS GROWN BY LOW-PRESSURE MOCVD.** The growth and properties of donor impurity doped ZnS films prepared using low-pressure MOCVD have been examined. Trimethyl-aluminum (TMAI) and hydrogenchloride (HCl) were used as donor dopant sources. With Al doping, ZnS films, with resistivities as low as about 1  $\Omega\text{cm}$ , can be grown. In the photoluminescence of Al-doped ZnS, a near-band-edge emission and an SA emission are observed. A correlation between the resistivity and the SA emission intensity was found through which the resistivity decreases with an increase in the SA emission intensity. With Cl doping, films with resistivity as low as 0.2  $\Omega\text{cm}$  can be grown. It was found, however, that when the HCl flow rate was relatively high, the crystallinity tended to be poor, because of the reaction between HCl and the Zn-source material. (Author abstract) 20 refs.

Yamaga, S. (Chiba Univ, Chiba, Jpn); Yoshikawa, A.; Kasai, H. *J Cryst Growth* v 86 n 1-4 Jan 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 252-256.

**095531 DEPENDENCE ON GROWTH TEMPERATURE OF THE PHOTOLUMINESCENCE PROPERTIES OF NITROGEN-DOPED ZnSe GROWN BY MOCVD.** Growth of nitrogen-doped ZnSe films by low pressure MOCVD using dimethylzinc and hydrogen selenide as reactants has been carried out, and the dependence of low-temperature photoluminescence properties of nitrogen-doped films on growth temperature has been examined. It is shown that the nitrogen atoms act as shallow acceptors in ZnSe, with an activation energy of about 100-110 meV. However, some deep centers related to the nitrogen impurity are also introduced into highly nitrogen-doped ZnSe films, and the resistivity of nitrogen-doped ZnSe films remains high. (Author abstract) 27 refs.

Yoshikawa, A. (Chiba Univ, Chiba, Jpn); Muto, S.; Yamaga, S.; Kasai, H. *J Cryst Growth* v 86 n 1-4 Jan 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 279-284.

**095532 SUPERIORITY OF GROUP VII ELEMENTS OVER GROUP III ELEMENTS AS DONOR**

**DOPANTS IN MOCVD ZnSe.** Comparison of group III and group VII elements as donor species in ZnSe MOCVD growth has been studied from the viewpoint of their electrical properties, luminescence qualities and their controllabilities. Low resistivity high quality blue emitting ZnSe has been grown by doping a group VII donor chlorine, in atmospheric MOCVD. The superiority of group VII elements over group III elements with regard to carrier concentration controllability and carrier producing efficiency has been predicted. (Author abstract) 11 refs.

Kamata, Atsushi (Toshiba Corp, Kawasaki, Jpn); Uemoto, Tsutomu; Okajima, Masaki; Hirahara, Keijiro; Kawachi, Masaru; Beppu, Tatsuro. *J Cryst Growth* v 86 n 1-4 Jan 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 285-289.

**095533 STABILITY AND INTERDIFFUSION AT MOCVD GROWN ZnSe/GaAs INTERFACES.** ZnSe-/GaAs interface stability and its relation with the misfit-induced film degradation which occurs above a critical thickness of the ZnSe epilayer have been studied using Rutherford backscattering (RBS). The minimum backscattering yield  $X_{\text{min}}$  along the  $\langle 110 \rangle$  channeling direction increased from 6% to 12% with the increase of the ZnSe film thickness from 1800 to 3600 Angstrom, which may indicate an increase in the density of misfit dislocations above the critical thickness. Diffusion effects at the ZnSe/GaAs interface were observed for the thicker ZnSe film samples after thermal annealing at 600°C for 5 h as evidenced by the variations of the RBS random spectra. A marked contrast was observed in the lattice matched ZnSe/GaAs system, i.e., the interface was extremely stable even after thermal annealing. This indicates the importance of the lattice matching for the thermal stability of the heterointerface. (Author abstract) 6 refs.

Ohmi, K. (Hiroshima Univ, Hiroshima, Jpn); Suemune, I.; Kanda, T.; Kan, Y.; Yamanishi, M.; Nishiyama, F.; Hasai, H. *J Cryst Growth* v 86 n 1-4 Jan 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA Jul 12-17 1987 p 467-470.

## Composition Effects

**095534 COMPOSITION FAULTS IN  $\text{Zn}_{1-x}\text{In}_x\text{S}_{3-x}$  CRYSTALS.** Five members of the family  $\text{Zn}_{1-x}\text{In}_x\text{S}_{3-x}$  are studied by means of electron microscopy. It is found that all the compounds present hexagonal structures, with the same a-lattice parameter. The c-lattice constant depends on the stoichiometry, following a certain formula. In all the examined materials, composition faults are found, mainly as isolated faults and with an m-value smaller than the bulk material. Several polytypic forms, corresponding to the same composition, also exist. ZnS-rich crystals present no superstructure, most probably because of a random distribution of the cations in their sublattice. (Author abstract) 7 refs.

Frangis, N. (Univ of Thessaloniki, Thessaloniki, Greece); Manolikas. *Phys Status Solidi A* v 107 n 2 Jun 1988 p 589-595.

## Computation

**095535 COMMENT ON THE PIEZOPOLARON BOUND STATES IN SEMICONDUCTORS.** Following the perturbation theory of Bajaj et al. the ground state energy of a bound piezopolaron is computed for ZnS, ZnSe, ZnTe and CdTe. Extending this theory to the excited states, the L.A. phonon contributions to the Lamb-shifts in these piezoelectric semiconductors are obtained. It is found that these contributions are smaller by seven to eight orders when compared to the L.O. phonon contributions. (Author abstract) 14 refs.

Sivakumar, V. (Madurai Kamaraj Univ, Madurai, India); Sukumar, B.; Navaneethakrishnan, K. *J Phys Chem Solids* v 48 n 7 1987 p 683-685.



## Crystal Lattices

**095536 LATTICE IMAGES OF ZnSe CRYSTALS.** Using a 300 kV transmission electron microscope, lattice images of ZnSe projected on the (110) plane have been obtained. A detailed comparison between experimental and simulated images is made. The traditional simulation obtained by the superposition of free-atom potentials does not provide a fit to the elongation of close spots corresponding to adjacent columns of zinc and selenium atoms. It is also found that the difference in spot intensities for a through-focus series is not completely reproduced from such calculations. These deviations from experiment can be remedied by taking account of screening by valence-charge electrons. (Author abstract) 11 refs.

Watanabe, K. (Tokyo Metropolitan Technical Coll, Tokyo, Jpn); Hiratsuka, K.; Kikuchi, Y.; Yamaguchi, H. *Phil Mag Lett* v 56 n 2 Aug 1987 p 51-55.

**095537 EFFECT OF SCREENING IMAGES ON THE LATTICE OF ZnSe AND GaAs.** The crystal potentials of ZnSe and GaAs have been constructed by considering the reconstruction of valence charge electrons due to the crystallization. These potentials differ significantly from those obtained by the traditional method, consisting of the superposition of neutral atoms, in the low-order crystal potential components such as 111, 200, 220 and 311, especially in ZnSe. As a result, the distinctions in the image between the constituent atoms are more apparent in our results than in the traditional results. It is concluded that the lattice image calculation of these compounds needs to use the crystal potential which takes account of the accurate valence state and even thin crystals. (Author abstract) 16 refs.

Kikuchi, Y. (Science Univ of Tokyo, Tokyo, Jpn). *Philos Mag B* v 57 n 4 Apr 1988 p 547-556.

## Defects

**095538 DEFECTS AND STRESSES IN ZnSe FILMS PRODUCED FROM ELEMENTOORGANIC COMPOUNDS (MOCVD) ON (100) GaAs SUBSTRATES.** The structural perfection and elastic state of a ZnSe/GaAs structure are investigated. The ZnSe films, which have a larger lattice parameter than the GaAs, are in an elongated state. The causes of the widening of the diffraction peaks of the film and the substrate are established and an explanation of the formation of a negative curvature radius of the structure is advanced. (Author abstract) 9 refs.

Kuznetsov, P.I.; Martovitskii, V.P.; Pechenov, A.N.; Skorbut, S.D.; Talenskii, O.N. *Sov Phys Lebedev Inst Rep* n 3 1987 p 1-6.

**095539 THERMODYNAMICAL CONSIDERATION OF DEFECT CONCENTRATIONS IN ZnSe.** The growth conditions of n and p type ZnSe crystals are clarified from thermodynamical analysis of the defect and carrier concentrations as a function of growth temperature and Zn vapor pressure. It is found that the hole concentration at 300°C is by  $10^{-4}$  -  $10^{-6}$  lower than a doped acceptor and that highly doping of an acceptor under a saturated Se pressure is necessary to get p type low resistivity crystals. On the other hand, n type crystals are easily obtained by doping a donor under saturated Zn pressure. (Author abstract) 8 refs. In Japanese.

Ido, Toshiyuki; Matsushita, Yuji. *Chubu Daigaku Kogakubu Kiyo* v 23 Oct 1987 p 33-36.

## Density

**095540 EFFECT OF ADDITIVES ON THE HOT PRESSING OF ZINC SULPHIDE.** Zinc sulphide is a promising chalcogenide semiconductor for electro-optic applications. The material is currently developed in the form of powder, thin film and single crystals. Ceramics having a high density with controlled dopant content is the fundamental requirement for application of the material in this field. This letter reports the preparation of high-density zinc sulphide ceramics containing various

additives by hot pressing. The result suggests achievement of nearly full density at 800°C at 40 MPa for undoped material. The larger grains in specimens doped with  $\text{Li}_2\text{S}$  and  $\text{Bi}_2\text{S}_3$  show that these dopants enhanced grain growth. 6 refs.

Uematsu, Keizo (Nagaoka Inst of Technology, Nagaoka, Jpn); Sawada, Kazuhiko; Kato, Zenji; Uchida, Nozomu; Saito, Katsuchi. *J Mater Sci Lett* v 7 n 5 May 1988 p 473-474.

## Doping See Also VARISTORS—Stability.

**095541 LITHIUM AND PHOSPHORUS IMPURITIES IN ZnTe.** ZnTe crystals doped with Li or P in the range  $10^{16}$ - $10^{19} \text{ cm}^{-3}$  were characterized using electrical and luminescence measurements. The hydrogenic behavior of the acceptor centers was investigated using Hall measurements in the temperature range  $30 \leq T \leq 300 \text{ K}$ . The ionization energies at maximum dilution were found to be 0.048 eV and 0.042 eV for Li and P acceptors respectively. The effect of an annealing atmosphere (Zn or Te) on impurity concentration was studied. The results were found to be consistent with the segregation-diffusion model which invokes a three-phase equilibrium (Te precipitates)-(ZnTe matrix)-(vapor). In the ZnTe matrix, Li and P act as amphoteric impurities. The acceptors and donors are attributed to the substitutional ( $\text{Li}_{\text{Zn}}$ ,  $\text{P}_{\text{Te}}$ ) and the interstitial ( $\text{Li}_i$ ,  $\text{P}_i$ ) defects respectively. These defects initiate luminescence transitions in the near-band-edge region at 4 K. For nominally pure crystals, the excitonic nature of the principal band edge (PBE) line (due to residual Li acceptors) was principal band edge (PBE) line (due to residual Li acceptors) was confirmed through intensity versus temperature measurements. In Li- and P-doped crystals, further evidence was obtained for the assignment of the PBE line to a donor-to-valence-band transition. (Edited author abstract) 32 refs.

El Akkad, F. (NRC, Cairo, Egypt). *Semicond Sci Technol* v 2 n 10 Oct 1987 p 629-635.

**095542 INDIUM-DOPED ZINC OXIDE FILMS PREPARED BY d.c. MAGNETRON SPUTTERING.** Transparent and conductive films of indium-doped zinc oxide have been prepared by reactive sputtering of Zn-In alloy targets with a conventional d.c. magnetron technique in controlled Ar +  $\text{O}_2$  gas mixtures. The films were deposited onto glass substrates at a constant discharge current of 50 mA. Indium-doped films were polycrystalline with small crystal grains (5-15 nm) exhibiting low Hall mobility of  $1.4 \times 10^{-4} \text{ m}^2 \text{Vs}^{-1}$ , high carrier concentration of  $1.3 \times 10^{20} \text{ m}^{-3}$  and optical transmittance of 70-80% in the wavelength range from 400 to 800 nm. A correlation between the electrical, optical and structural properties of these films was also investigated. (Author abstract)

Czernastek, H. (Pedagogical Univ, Cracow, Pol); Brudnik, A.; Jachimowski, M. *Solid State Commun* v 65 n 9 Mar 1988 p 1025-1029.

**095543 EFFECT OF COPPER IMPURITY ON THE EDGE EMISSION OF ZnTe CRYSTALS.** The results are given of studies on the edge emission of undoped and copper-doped ZnTe crystals in the temperature range 4.2-300°K. The copper impurity has been found to increase the intensity of the principal edge emission band substantially. Analysis of the structure of this emission band indicated that a temperature below 160°K the main role is played by the emission from excitons that are most probably bound in  $\text{Cu}_{\text{Zn}}$  and  $\text{Li}_{\text{Zn}}$  centers while at higher temperatures it is played by emission during the transition of free electrons to these centers. An appreciable role is played over the entire range of temperatures by emission from free electrons with an energy of 13 MeV. The luminescence quenching energy below 160 K has a value of 7 MeV (the binding energy of a bound exciton) and at higher temperatures it is 78 MeV. (Author abstract) 14 refs.

Andronik, I.K. (V.I. Lenin State Univ, Kishinev, USSR); Vavilov, V.S.; Zoan Mien, Vu; Mikhailash, P.G.; Chukichev, M.V. *Sov Phys J* v 30 n 8 Aug 1987 p 702-706.

**095544 GALLIUM-DOPING EFFECTS ON THE MOLECULAR BEAM EPITAXIAL ZnS ON GaAs.** Twin-free ZnS:Ga epilayers were grown on (100)GaAs by MBE. The epilayers showed a smooth surface morphology. The PL spectrum exhibited a blue emission at 425 nm and a broad emission at 640 nm. The former was due to incorporated gallium and the latter may be a defect-related emission. When a post-annealing at 500°C for 30 min was carried out on the ZnS:Ga epilayers, the surface of the layer was slightly degraded due to a difference in the lattice constants of ZnS and GaAs. The intensity of the blue emission at 425 nm was increased about 50 times and the emission at 640 nm disappeared. 21 refs.

Ohta, Shin-Ichi (Nippon Seiki Co, Nagaoka, Jpn); Kashiro, Ko-Ichi; Yokoyama, Meiso. *J Mater Sci Lett* v 7 n 5 May 1988 p 506-508.

**095545 VERTICAL ZONE GROWTH AND CHARACTERIZATION OF UNDOPED AND Na, P AND Mn DOPED ZnSe.** We report the results of vertical zone growth of undoped and doped ZnSe of 50g charge sizes. Dopants studied were Na, P and Mn in the concentration range  $10^{18}$ - $10^{20} \text{ ions/cm}^3$ . The objective of the work was to study the influence of growth conditions and doping on the occurrence of twinning and to obtain material suitable for fabrication into (100) substrates. Sliced and polished wafers were studied by X-ray, optical and RHEED techniques. In undoped samples, clusters of twins occasionally interspersed with small twin free regions were commonly seen. Codoping with Na and P, resulted in a small increase in the quantity of twin free areas and a darkening of the ingots. Best results were achieved with Mn doping where twin free volumes up to  $3.5 \text{ cm}^3$  were obtained and which yielded (100) substrates for MBE. Not all Mn doped growth runs have led to twin free ZnSe crystals and the role of Mn is currently being investigated. (Author abstract) 9 refs.

Shone, Michael (Philips Corp, Briarcliff Manor, NY, USA); Greenberg, Berton; Kaczinski, Marie. *J Cryst Growth* v 86 n 1-4 Jan 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 132-137.

**095546 NITROGEN AND PHOSPHORUS DOPING IN ZnS LAYERS GROWN BY VAPOR PHASE EPITAXY ON GaAs SUBSTRATES.** Electrical and photoluminescence (PL) properties have been examined for N-doped and P-doped ZnS layers grown by vapor phase epitaxy on GaAs substrates at about 700°C. Nitrogen doping was done during growth by adding ammonia in the hydrogen flow of an open tube growth system using a ZnS powder source. Phosphorus doping was done by thermal diffusion after growth in a sealed quartz ampoule kept at 500°C. Compared to undoped samples, notable changes of PL spectra at 77 K include the appearance of a new UV emission at 390 nm and the disappearance of the Cu-related emissions but only for N-doped samples, not for P-doped samples. Concerning the trap levels measured by transient thermoluminescence (TTL) method, no difference was found between doped and undoped samples, except their concentrations. Discussions on these results are given in terms of substitutional nitrogen forming compensating acceptors and associated centers with Cu impurities. (Edited author abstract) 11 refs.

Zhang, S. (Technological Univ of Nagaoka, Nagaoka, Jpn); Kinto, H.; Yatabe, T.; Iida, S. *J Cryst Growth* v 86 n 1-4 Jan 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 372-376.

**095547 OPTICALLY DETECTED MAGNETIC RESONANCE STUDY OF STRONGLY COUPLED SHALLOW DONOR-DEEP GOLD CENTRE PAIRS IN ZnSe.** We describe ODMR experiments in which the 575 nm emission from gold-doped ZnSe is shown to consist of two contributions. The first contribution is due to recombination in which an electron from a shallow



donor is transferred to a complex which we have previously denoted Au-3 and which is believed to consist of substitutional divalent gold associated with a perturbing ion X. The impurity X is required to be positive with respect to the lattice, and interstitial gold  $\text{Au}^{+1}$  is a likely candidate. The second contribution to the 575 nm band involves a donor electron which is strongly coupled to the  $\text{Au}^{2+}\text{Zn}$  ion of the Au-3 centre by the spin exchange interaction, and we suggest that this part of the emission is due to a charge transfer or excitonic recombination process within the Au-3 complex itself. The isotropic component of the exchange splitting is measured directly to be of magnitude  $1.13 \text{ cm}^{-1}$  (0.140 meV). (Author abstract) 12 refs.

Poolton, N.R.J. (Univ of Hull, Hull, Engl); Nicholls, J.E.; Davies, J.J. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 609-614.

## Electric Conductivity

**095548 CONDUCTION MECHANISM IN ZINC TELLURIDE FILMS.** Electrical conductivity of vacuum evaporated ZnTe films of different thicknesses (2000 Angstrom to 5000 Angstrom) has been investigated as a function of electrical field at different temperatures (77K and 307-353K). Observed non-ohmic conduction has been explained on the basis of modified Poole Frankel effect. The observed thermal activation energy (0.3-0.5eV) of electrical conduction is in agreement with the results of other workers. (Author abstract) 26 refs.

Parakh, N.C. (MLV Government Coll, Bhillwara, India); Garg, J.C. *Indian J Pure Appl Phys* v 25 n 3 Mar 1987 p 110-113.

**095549 SOME STUDIES ON ZINC PHOSPHIDE FILMS GROWN BY HOT WALL EPITAXY.** Zinc phosphide ( $\text{Zn}_3\text{P}_2$ ) films were grown by the hot wall epitaxy technique on mica substrates in the temperature range 170 to 240°C. The surface morphology indicates that the grain size increases with the increase of substrate temperature corresponding to an activation energy of 0.32 eV. An analysis of the optical absorption spectrum indicates two direct transitions at 1.34 and 1.45 eV. The electrical conductivity varies from  $2 \times 10^{-5} (\Omega\text{cm})^{-1}$  in the temperature range 163 to 300 K. Minority carrier lifetime  $\tau = 1.23 \text{ ms}$  was measured using the photoconductivity technique. (Author abstract) 12 refs.

Vaya, P.R. (Indian Inst of Technology, Madras, India); Murali, K.R.; Sundaram, M. *Phys Status Solidi A* v 105 n 2 Feb 1988 p 477-484.

**095550 EFFECT OF VACUUM HEAT TREATMENT OF THE ELECTRIC CONDUCTIVITY OF ZINC OXIDE.** It is established that the effective bulk conductivity of powdered zinc oxide is determined by chemisorption effects on the surface of the oxide particles. An analysis of thermovacuum electric conductivity curves, together with dielectric measurements, made it possible to estimate the energy distance from the Fermi level to the level of occurrence of an adsorption-type trap, i.e. the energy of the transition from a charged form of chemisorption to a neutral form. It is shown that the main difference between the zinc oxide samples studied lies in the different locations of the Fermi level relative to the bottom of the conduction band, i.e., in different degrees of deviation from stoichiometry. Zinc oxide with a greater degree of nonstoichiometry is less suitable for the fabrication of nonlinear resistors. In Russian. 8 refs.

Makarov, V.O.; Tonkoshkur, A.S.; Chernenko, I.M. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 12 Dec 1987 p 2016-2020.

## Electric Properties See Also SEMICONDUCTOR MATERIALS—Growth.

**095551 PHOTOELECTRIC PROPERTIES OF UNDOPED AND Cd-DOPED  $\text{Zn}_3\text{P}_2$ -Mg JUNCTIONS.** Photovoltaic (PV) response curves for  $\text{Zn}_3\text{P}_2$ -Mg diodes have been measured over the spectral range from 0.5 to 2.5

$\mu\text{m}$ . The differences in the PV spectra between Cd-doped and undoped samples were analyzed. Electrical properties of the junctions are presented from the viewpoint of solar energy converters. (Author abstract) 12 refs.

Mirowska, N. (Technical Univ of Wroclaw, Wroclaw, Pol); Szatkowski, J.; Gumienny, Z. *Infrared Phys* v 28 n 2 Mar 1988 p 97-99.

**095552 EFFECT OF VACUUM ANNEALING ON THE ELECTRICAL PROPERTIES OF  $\text{Zn}_3\text{P}_2$  THIN FILMS.**  $\text{Zn}_3\text{P}_2$  is one of the most promising alternatives for photovoltaic applications, and also for laser applications. Some results on the effect of post-deposition annealing on the electrical properties of  $\text{Zn}_3\text{P}_2$  films are presented. The dc conductivity measurements were made in the temperature range 100 to 300 K. The low temperature data have been analyzed on the basis of Mott's variable range hopping conduction process and the high-temperature data have been examined for the thermionic emission of the carriers over the grain boundaries. 17 refs.

Murali, K.R. (Indian Inst of Technology, Madras, India); Gopalam, B.S.V. *J Mater Sci Lett* v 7 n 2 Feb 1988 p 125-129.

**095553 INFLUENCE OF INTERFACE STATES ON THE ELECTRICAL PROPERTIES OF  $\text{Mg-Zn}_3\text{P}_2$  JUNCTIONS.** Zinc phosphide ( $\text{Zn}_3\text{P}_2$ ) has become a promising semiconductor for application in photovoltaic solar energy conversion. It has an energy gap equal to 1.5 eV close to the optimum value for photovoltaic solar energy conversion at room temperature. The value of the minority carrier diffusion length suggests a reasonable high energy conversion efficiency. This has led to an investigation of metal-Schottky barriers on  $\text{Zn}_3\text{P}_2$ , particularly  $\text{Mg-Zn}_3\text{P}_2$  junctions. To explain the bias dependence of the ideality factor the authors consider a simple model with one band of interface states on the  $\text{Zn}_3\text{P}_2$  surface. 12 refs.

Szatkowski, J. (Technical Univ of Wroclaw, Wroclaw, Pol); Sieranski, K. *Phys Status Solidi A* v 106 n 1 Mar 1988 p K31-K34.

**095554 TEMPERATURE AND COMPOSITION DEPENDENCES ON THE ELECTRICAL PROPERTIES OF As-GROWN  $\text{ZnHgTe}$  CRYSTALS GROWN BY THE TRAVELLING HEATER METHOD.** Temperature dependence on the electrical properties of unintentionally-doped  $\text{ZnHg}_{1-x}\text{Te}$  bulk crystals, grown by the traveling heater method with a Te solvent, has been investigated by means of the Hall measurements at temperatures in the range 77 to 300 K. The crystals grown from  $x=0.02$  to 0.8 at about 700°C exhibited typically n-type conduction at 300 K. In particular, the electron Hall mobility of  $x=0.2$  was about  $10^4 \text{ cm}^2/(\text{V}\cdot\text{s})$  at about 150 K, and from its temperature dependence a donor level was located at about 12 meV below the conduction band. The electron mobility at 300 K decreased remarkably due to alloy scattering with increasing composition  $x$ . We observed anomalous behavior in the temperature dependence of the hole mobility above  $x=0.33$ ; a maximum value was reached at about  $4 \times 10^3 \text{ cm}^2/(\text{V}\cdot\text{s})$  at 77 K. (Author abstract). 8 Refs.

Sasaki, Tokuhito (Osaka Univ, Osaka, Jpn); Taguchi, Tsunemasa; Hiraki, Akio. *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 913-915.

**095555 ELECTRICAL PROPERTIES OF  $\text{Zn}_x\text{Cd}_{1-x}\text{Se}$ .** The variation in bandgap energy with composition was determined for single crystals of  $\text{Zn}_x\text{Cd}_{1-x}\text{Se}$  at 300 and 90 K.  $\text{Au-ZnCd}_{1-x}\text{Se}$  ( $x < 0.45$ ) diodes were fabricated and used to determine the dependence of barrier height and uncompensated donor density on composition. Deep levels were also investigated in these diodes using photocapacitance, which revealed the presence of two dominant levels with activation energies of 0.55-0.6 and 1.14-1.16 eV (referred to the valence band edge) that were independent of the composition. (Author abstract) 11 refs.

Al Bassam, A. (Univ of Durham, Durham, Engl); Brink-

man, A.W.; Russell, G.J.; Woods, J. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 667-672.

## Electronic Properties

**095556 ELECTRONIC PROPERTIES OF CERTAIN CHROMIUM SPINELS.** Some electronic properties of the following spinel series:  $\text{Zn}_{1-x}\text{Cr}_x\text{Cr}_2\text{Se}_4$ ,  $\text{Zn}_{1-x}\text{Ga}_{2x/3}\text{Cr}_2\text{Se}_4$  and  $\text{Co}_{0.55}\text{Cu}_{0.45}\text{Cr}_2\text{S}_4-y\text{Se}_y$  are presented. Using Slater's ideas on non-integer occupation numbers, the numbers of 3d holes (as the carriers of magnetism in these spinels) per Cr atom with spins up and down have been obtained. From the condition of self-consistency for the magnetic moment the number of occupied states at the Fermi level with given spin projection and the Pauli spin paramagnetic susceptibility have been calculated and compared with other terms of the total high field susceptibility. According to the Stoner-Edwards-Wohlfarth theory a set of important exchange and band parameters of these compounds was calculated for the first time. (Author abstract) 22 refs.

Juszczak, S. (Silesian Univ, Katowice, Pol). *J Magn Magn Mater* v 73 n 1 May 1988 p 18-26.

**095557 SUPEREXCHANGE IN HELICAL  $\text{Zn}_{1-x}\text{Ga}_{2x/3}\text{Cr}_2\text{Se}_4$ .** The exchange interactions in insulating, helical spinels have been explained on the basis of the Anderson-Kanamori theory of superexchange. The value of the exchange constants  $J_{BB}$  in the first three spheres of coordinations between the  $\text{Cr}^{n+}$  ions via  $\text{Se}^{2-}$  ligands have been estimated after taking into account the experimental data of the saturation field, the paramagnetic Curie-Weiss temperature and the assumption that the spin spiral angle increases linearly with increasing of Ga concentration. From the observed values of the exchange constants the transfer and direct integrals have been obtained which on further analysis yield the values of the covalency parameters. These parameters are found to be consistent with the chemical theory of covalency. (Author abstract) 18 refs.

Juszczak, S. (Silesian Univ, Katowice, Pol). *J Magn Magn Mater* v 73 n 1 May 1988 p 27-32.

**095558 STUDY OF s-d EXCHANGE INTERACTION IN  $\text{ZnFeSe}$  SEMIMAGNETIC SEMICONDUCTOR.** The magnetorefractivity and magnetic susceptibility was measured in  $\text{Zn}_{1-x}\text{Fe}_x\text{Se}$  ( $x < 0.07$ ). Large spin splitting was observed due to exchange interaction between band electrons and  $\text{Fe}^{2+}$  localized electrons. The exchange integrals are estimated for the first time for this iron-type material:  $\text{No}\alpha = 0.22\text{eV}$  and  $\text{No}\beta = -1.57\text{eV}$ . (Author abstract) 13 refs.

Twardowski, A. (Warsaw Univ, Warsaw, Pol); Glod, P.; de Jonge, W.J.M.; Demianiuk, M. *Solid State Commun* v 64 n 1 Oct 1987 p 63-67.

**095559 ELECTRONIC STRUCTURE OF CATIONIC CORE EXCITONS IN II-VI SEMICONDUCTORS.** The electronic structure of cationic core excitons in ZnS, ZnSe, ZnTe, and CdTe was analyzed by means of self-consistent-field multiple scattering  $X\alpha$  molecular cluster calculations. The exciton level introduced in the gap by the core hole is found to be weakly localized with a charge distribution similar to that of an isocoric single donor level. Core exciton binding and formation energies and also core ionization energies were calculated. The binding energies of the core excitons in ZnS are found to be almost independent of the depth of the core level involved. This behavior seems to be a general property of core excitons in semiconductors. Trends for core exciton binding energies, core level shifts and charge distributions are analyzed in the  $\text{ZnX}$  ( $X=\text{S}, \text{Se}, \text{Te}$ ) series and also in CdTe. (Author abstract). 19 Refs.

Chacham, H. (Univ Federal De Minas Gerais, Belo Horizonte, Brazil); Alves, J.L.A.; De Siqueira, M.L.; Leite, Jose R. *J Phys Chem Solids* v 49 n 8 1988 p 969-973.



**095560 COMMENTS ON THE INTERPRETATION OF THERMALLY STIMULATED LUMINESCENCE AND CONDUCTIVITY IN CONDUCTIVE ZnSe CRYSTALS.** Recently Oczkowski presented new results of calculations of the shape and the position of the TL and the thermally stimulated conductivity (TSC) curves applying the modified kinetic model with metastable state of donor-acceptor pairs (MDA) and shallow donor. It is well-known that the characteristic values of the capture cross-sections of the recombination center for the free electron ( $S_n$ ) and hole are helpful for the determination of the nature of this center. This note presents a simple estimation of the  $S_n$  value for the center (unidentified H-center, possibly MDA, or deep hole trap, or other center) which keeps the captured hole for a long time after removing the optical excitation from the conductive n-type ZnSe crystal at 77 K. 13 Refs.

Opanowicz, A. (Technical Univ of Lodz, Lodz, Pol.). *Phys Status Solidi A* v 108 n 1 Jul 1988 p K47-K51.

**095561 DETERMINATION OF  $x$  IN  $Hg_{1-x}Zn_xTe$  SINGLE CRYSTALS BY THE TEMPERATURE COEFFICIENT OF THE ENERGY GAP.** In this short communication, authors present the determination of composition,  $x$ , in  $Hg_{1-x}Zn_xTe$  single crystals using the temperature coefficient of the energy gap, i.e.,  $dE_g/dT$ . A tungsten-iodine lamp was employed as a light source for transmission measurements. A cryostat (Air Product Displex) was used for low temperature measurements and a Spex 3/4 monochromator was also used to obtain the transmission spectra. 9 Refs.

Jeon, H.W. (Yonsei Univ, Seoul, South Korea); Kim, K.M.; Kim, H.K.; Park, H.L.; Chung, C.H. *Phys Status Solidi A* v 108 n 1 Jul 1988 p K77-K79.

**095562 PHOTOLUMINESCENCE OF EXCITONS BOUND AT Te ISOELECTRONIC TRAPS IN ZnSe.**  $ZnSe_{1-x}Te_x$  belongs to the interesting class of semiconductor alloys in which Te acts both as an isoelectronic trap and as a constituent of the alloy. We have grown ZnSe single crystals having various concentrations of Te atoms from a mixture of Te and Se solutions. We observe an emission band having phonon structure and peaking at 2.67 eV in slightly Te-doped specimens ( $x < 0.008$ ), and a broad band at 2.48 eV in rather heavily Te-doped specimens ( $x \geq 0.046$ ). These two bands can be attributed respectively to recombination of excitons bound at  $Te_1$  atoms and  $Te_n$  ( $n \geq 2$ ) clusters. The results are interpreted in terms of intermediate electron-phonon coupling, and relevant optical processes are also discussed. (Author abstract) 14 refs.

Yao, T. (Electrotechnical Lab, Sakura-mura, Jpn); Kato, M.; Davies, J.J.; Tanino, H. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 552-557.

**095563 ALLOY-TRAPPED EXCITONS IN A NEW II-VI SEMICONDUCTOR SOLID SOLUTION  $Hg_{1-x}Zn_xTe$ .** Luminescence and reflectivity experiments were performed on Zn-rich  $Hg_{1-x}Zn_xTe$  crystals grown by THM. For compositions  $x > 0.90$ , the low temperature luminescence spectra are dominated by a broad line  $I_{L1}$  located a few meV below the free exciton ground state deduced from reflectivity. Selective excitation of luminescence within the  $I_{L1}$  band on an  $x = 0.94$  sample shows a narrowing line effect in the LO phonon luminescence replica. The behaviour of this line as a function of excitation energy and temperature indicates that it is due to radiative recombination of excitons localized in the potential wells associated with composition fluctuations. On samples richer in mercury ( $x < 0.90$ ) the luminescence spectra become dominated by a deeper band  $I_{L2}$  we attribute to excitons trapped on non-identified defects. (Author abstract) 18 refs.

Mariette, H. (CNRS, Meudon, Fr); Triboulet, R.; Marfaing, Y. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 558-563.

**095564 ELECTRONIC STRUCTURE OF  $ZnS$ ,  $ZnSe$  AND  $ZnS_{1-x}Se_x$  USING LMTO METHOD.** The electronic structures, total and partial density of states of II-VI semiconductors  $ZnS$ ,  $ZnSe$  and their alloy  $ZnS_{1-x}Se_x$  have been studied using a linear muffin-tin-orbital (LMTO) method. The computations are performed in two different exchange-correlation potentials, their results are compared to those of other theoretical calculation and XPS experiment. (Author abstract) 7 refs.

Zeng, Xu (Xiamen Univ, China); Huang, Meichun. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 913-914.

## Grain Boundaries

**095565 TRANSIENT RESPONSE OF ELECTRICALLY ACTIVE GRAIN BOUNDARIES IN POLYCRYSTALLINE SEMICONDUCTORS.** In many polycrystalline semiconductors, the current transport is controlled by potential barriers formed at the grain boundaries. We investigate the response of  $ZnO$  grain boundaries to high-voltage pulses with risetime of less than 1  $\mu s$ . The experimental results, in particular the voltage overshoot effect, cannot be explained by the dynamics of electrons (majority carriers) alone. A model which includes holes (generated by hot electrons in the depletion regions) yields an appreciable overshoot when the steady state is close to a current-voltage bistability. In this case, the approach to equilibrium is altered by the delayed response of the barriers to the presence of holes. Further implications of the model are also discussed. (Author abstract) 26 refs.

Tua, Patrizio F. (Brown Boveri Research Cent, Baden, Switzerland); Rossinelli, Marco; Greuter, Felix. *Phys Scr* v 38 n 3 Sep 1988 p 491-497.

**Growth** See Also SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR MATERIALS—Elasticity; SEMICONDUCTOR MATERIALS—Growth.

**095566 VAPOUR PHASE EPITAXY OF WIDE GAP II-VI COMPOUNDS.**  $ZnS$  and  $ZnSe$  epitaxial layers of high crystallographic perfection have been grown by open-tube chemical vapor transport in the temperature range from 650 to 700°C at gas flows lower than 20 l/h. Low-temperature epitaxial growth (450 to 600°C) has been realized with halogen containing systems. VPE methods have been successfully applied to grow low resistivity  $ZnSe$  probes on GaAs (Zn excess, autodoping by Ga). Photoluminescence spectra show more gap-near emission than deep level luminescence. 28 refs.

Hartmann, H. (Akad der Wissenschaften der DDR, Berlin, East Ger); Mach, R.; Testova, N. *J Cryst Growth* v 84 n 2 Aug 1987 p 199-206.

**095567 THERMODYNAMICAL ANALYSES AND LUMINESCENCE PROPERTIES OF VAPOR-GROWN  $ZnS_{1-x}Se_x$ .** Vapor phase transport analyses are presented regarding the epitaxial growth of  $ZnS_{1-x}Se_x$  on GaP. It has been predicted from a thermodynamical calculation and experimentally confirmed that the solid composition  $x$  can be controlled over a wide range by varying the source and/or the substrate temperature. The photoluminescence of epitaxial layers of  $ZnS_{1-x}Se_x$  ( $0.44 \leq x \leq 0.92$ ) grown on GaP exhibits a strong edge emission at room temperature, showing that the epitaxial layers are of high quality. (Author abstract) 10 refs.

Goto, Hideo (Nagoya Univ, Nagoya, Jpn); Zhou, Jun; Sawaki, Nobuhiko; Akasaki, Isamu. *Jpn J Appl Phys Part I* v 26 n 8 Aug 1987 p 1300-1304.

**095568 HIGH-QUALITY  $ZnSe$  FILM GROWTH BY 0.1-ATM MOVPE UNDER THE DIETHYLZINC DIFFUSION-LIMITED CONDITION.** The effects of the growth conditions on the growth rate, crystallographic and luminescence properties were investigated for  $ZnSe$  film growth by metalorganic vapor phase epitaxy at 0.1 atm using diethylzinc and  $H_2Se$ . It was shown that high-quality epitaxial layers can be grown under the diethylzinc diffusion-limited condition over temperatures ranging from 250 to 500°C. These layers exhibit dominant

blue photoluminescence at 77 K. However, the optimum growth temperature for  $ZnSe$  layers having a smooth surface and high crystallographic properties is restricted to within the region between 300 and 400°C. (Author abstract) 17 refs.

Shibata, Noriyoshi (NTT, Tokai-mura, Jpn); Ohki, Akira; Zembutsu, Sakae. *Jpn J Appl Phys Part I* v 26 n 8 Aug 1987 p 1305-1309.

**095569 ELECTRICAL AND LUMINESCENT PROPERTIES OF In-DOPED  $ZnSe$  GROWN BY LOW-PRESSURE VAPOR-PHASE EPITAXY.** In-doped  $ZnSe$  layers have been grown for the first time by low-pressure vapor-phase epitaxy using metallic Zn, Se and In as source materials on GaAs(100) substrates. The carrier concentration increases significantly with increasing In cell temperature, and is controlled in the range of  $10^{16}$ - $10^{18}$   $cm^{-3}$ . The near-band-gap emission also increases with In cell temperature. The highest carrier concentration achieved is  $1.3 \times 10^{18}$   $cm^{-3}$ , and even the most highly doped sample shows a photoluminescence spectrum dominated by the near-band-gap emission. (Author abstract) 10 refs.

Matsumoto, Takashi (Yamanashi Univ, Kofu, Jpn); Iijima, Takayuki; Katsumata, Yoshihito; Ishida, Tetsuro. *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1736-1739.

**095570 LATTICE-MISMATCH ENHANCED DIFFUSION AT A  $ZnSe/GaAs$  INTERFACE - INCREASE OF THERMAL STABILITY IN A LATTICE-MATCHING SYSTEM.**  $ZnSe/GaAs$  interface diffusion, especially at an elevated temperature, was investigated. For  $ZnSe$  films of which stoichiometry was not completely maintained at the interface, the enhancement of Zn diffusion into GaAs was observed with an increase of film thickness. With preheating of GaAs substrates prior to growth,  $ZnSe$  films are stably deposited on GaAs. However, for thick  $ZnSe$  films of 7200 Å, the original n- $ZnSe/n$ -GaAs interface turned out to be converted to p-type at the interface after thermal annealing at 650°C for three hours. These interface diffusions which depend on the film thickness are estimated to be related with the misfit-induced lattice relaxation caused above a critical thickness. This hypothesis was confirmed by the extreme thermal stability found in the lattice-matched  $ZnS_{0.96}Se_{0.04}/GaAs$  interface. (Author abstract) 12 refs.

Ohmi, Koutoku (Hiroshima Univ, Higashihiroshima, Jpn); Suemune, Ikuo; Kanda, Takashi; Kan, Yasuo; Yamanishi, Masamichi. *Jpn J Appl Phys Part 2* v 26 n 12 Dec 1987 p 2072-2075.

**095571 EFFECTS OF IODINE-DOPING ON THE HETERO-EPITAXIAL GROWTH OF  $ZnS$  ON GaP SUBSTRATES.** Single-crystalline  $ZnS$  layers have been grown on GaP substrates using an open-tube hydrogen transport system. By the addition of iodine to the reactant agents, the growth rate of  $AnS$  on GaP (111)A decreased and that on GaP (111)B increased. These changes of the growth rates caused by the iodine-doping process were characterized as the opposite behavior compared with those for the indium-doping case. For the growth on the GaP (100) plane, the deposition region has largely shifted to lower temperatures, and higher growth rates, such as  $\mu m/h$ , were obtained at considerably lower temperatures, such as 580°C. From an X-ray diffraction analysis, it was found that a significant improvement in the crystallinity of the grown layers on (100) substrates was caused by the doping of iodine. An improvement in the surface morphology for these layers was also clearly observed. (Author abstract) 7 refs.

Imai, Tetsuji (Shizuoka Univ, Hamamatsu); Fuke, Shunro; Watanabe, Masahiko; Araki, Hitosi; Kuwahara, Kazuhiro. *Jpn J Appl Phys Part I* v 27 n 1 Jan 1988 p 68-71.

**095572 GROWTH AND CHARACTERIZATION OF ZINC PHOSPHIDE CRYSTALS.** Zinc phosphide crystals ( $Zn_3P_2$ ) having a large grain size were grown with



purified source materials, using a necked quartz ampoule in order to control the transport rate of the nutrients. The electrical characteristics of the sliced wafer were measured as a function of both of the position along the growth direction of the ingot and the phosphorus composition  $x$  in the  $\text{Zn}_{1-x}\text{P}_x$ . The carrier concentration was found to vary along the growth direction. The electrical resistivity decreased from  $10^3$  to  $10^2 \Omega \text{ cm}$  simultaneously with an increase in the phosphorus composition of the grown crystal. (Author abstract) 11 refs.

Fuke, Shunro (Shizuoka Univ, Hamamatsu, Jpn); Takatsuka, Yuuji; Kuwahara, Kazuhiro; Imai, Tetsuji. *J Cryst Growth* v 87 n 4 Mar 1988 p 567-570.

**095573 USE OF METHYLSELENOL FOR ORGANOMETALLIC VAPOR-PHASE EPITAXY OF ZnSe.** Heteroepitaxial films of ZnSe on GaAs substrates have been grown by atmospheric-pressure organometallic vapor-phase epitaxy using a new selenium source, methylselenol,  $\text{CH}_3\text{SeH}$  (MSeH). Gas-phase prereaction with a group-II source material was suppressed compared with hydride sources, e.g.,  $\text{H}_2\text{Se}$ . The practical growth temperature was 300-400°C, which was sufficiently lower than 500°C used in the growth with dialkyl compounds. The epilayers exhibited a fairly smooth surface morphology and good crystallographic properties. Higher quality epilayers can be expected with source repurification or synthesis via purer chemical processes. (Author abstract) 11 refs.

Fujita, Shizuo (Kyoto Univ, Kyoto, Jpn); Sakamoto, Takao; Isemura, Masashi; Fujita, Shigeo. *J Cryst Growth* v 87 n 4 Mar 1988 p 581-584.

**095574 INTERFACE STRESS AT OMVPE-GROWN  $\text{ZnS}_x\text{Se}_{1-x}$ /GaAs:Cr HETEROSTRUCTURE.** The interface stress at OMVPE-grown  $\text{ZnS}_x\text{Se}_{1-x}$ /GaAs:Cr ( $x=0.03$  to approx. 0.14) heterostructures has been investigated the Cr-related photoluminescence line at 0.839 eV from GaAs:Cr substrates. From analysis of the shift of the related luminescence line, it has been found that the GaAs substrates at the heterointerface suffer compressive almost independent of the composition of  $\text{ZnS}_x\text{Se}_{1-x}$  epitaxial layers. Such compressive stress at the GaAs substrates be explained as being due to the difference between the thermal expansion coefficients of  $\text{ZnS}_x\text{Se}_{1-x}$  and GaAs; thermal stress introduced in cooling from the growth temperature (500°C) of  $\text{ZnS}_x\text{Se}_{1-x}$  on GaAs. (Author abstract) 18 refs.

Tonami, Yoshiyuki (Osaka Univ, Toyonaka, Jpn); Nishino, Taneo; Hamakawa, Yoshihiro; Sakamoto, Takao; Fujita, Shigeo. *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 506-508.

**095575 VARIATION OF MISFIT STRAIN IN ZnSe HETEROEPITAXIAL LAYERS WITH TEMPERATURE, LAYER THICKNESS AND GROWTH TEMPERATURE.** The temperature variation of misfit strain in ZnSe layers grown on GaAs(100) substrates has been measured at 80 to approx. 600 K for layer thicknesses of 0.2 to approx. 4.0  $\mu\text{m}$  by X-ray diffraction. Layers as thin as 0.2  $\mu\text{m}$  grow coherently on the substrate and the coherency holds even for low temperatures. Strain-free layers at room temperature include those with two-dimensional expansive strain. Layers with two-dimensional compressive strain with  $\epsilon \approx +0.03$  percent at room temperature become strain free at 80 K. The X-ray analysis is consistent with low-temperature reflection spectra. (Edited author abstract) 21 Refs.

Matsumoto, Takashi (Yamanashi Univ, Takeda, Jpn); Iijima, Takayuki; Ishida, Tetsuro. *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 892-895.

**095576 NOVEL ATMOSPHERIC PRESSURE TECHNIQUE FOR THE DEPOSITION OF ZNS BY ATOMIC LAYER EPITAXY USING DIMETHYLZINC.** We report on the results of a novel atomic layer epitaxy (ALE) deposition system which performs deposition at atmospheric pressure. Polycrystalline thin films of ZnS have been deposited using the gaseous sources dimethylzinc and hydrogen sulfide. Depositions were

carried out at substrate temperatures in the range 25 to 500°C. The results of several bulk and surface analytical techniques are presented which suggest that the films are stoichiometric and of high purity and crystal quality. The methodology of system operation is discussed as is the dependence of film quality upon process parameters. (Author abstract) 12 Refs.

Hunter, Adolph (McMaster Univ, Hamilton, Ont, Can); Kitai, Adrian H. *J Cryst Growth* v 91 n 1-2 Aug 1988 p 111-118.

**095577 ZnSe-ZnTe STRAINED-LAYER SUPERLATTICES: A NOVEL MATERIAL FOR THE FUTURE OPTOELECTRONIC DEVICES.** ZnSe-ZnTe strained-layer superlattices (SLSs) were grown by molecular beam epitaxy (MBE). The optical properties of the ZnSe-ZnTe SLS were evaluated by photoluminescence (PL). The PL peak position was shifted by tailoring the structure of the superlattice. The luminescence color in the visible changed from blue-green to red. In order to obtain both p- and n-type conduction in wide-bandgap II-VI compound semiconductors, we have prepared ZnSe-ZnTe superlattices with a modulation doping technique. When Sb was selectively doped in ZnTe layers, all the samples exhibited p-type conductivity with hole concentrations of  $(0.5-1.0) \times 10^{14} \text{ cm}^{-3}$ . On the other hand, Ga-doped SLSs were type with electron concentrations of  $(2-7) \times 10^{13} \text{ cm}^{-3}$ . Furthermore, the growth of ZnSe-ZnS SLSs was also demonstrated by metalorganic molecular beam epitaxy (MOMBE). Blue luminescence related to the quantized levels in the SLS was detected. (Author abstract) 14 refs.

Konagai, Makoto (Tokyo Inst of Technology, Tokyo, Jpn); Kobayashi, Masakazu; Kimura, Ryuei; Takahashi, Kiyoshi. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 290-295.

**095578 MOLECULAR BEAM EPITAXIAL GROWTH AND CHARACTERIZATION OF ZnTe AND CdTe ON (001) GaAs.** Investigations of elemental diffusion in (001) and (111) oriented CdTe and ZnTe layers grown by molecular beam epitaxy on (001) GaAs substrates show high Ga diffusion along dislocations and defects generated at the substrate-epitaxial interface. The use of CdTe/ZnTe superlattice buffer layers and nucleation on near-atomically planar GaAs surfaces is shown to suppress Ga diffusion to background detection levels. (Author abstract) 9 refs.

Wagner, B.K. (Georgia Tech Research Inst, Atlanta, GA, USA); Oakes, J.D.; Summers, C.J. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 296-302.

**095579 MOLECULAR BEAM EPITAXIAL GROWTH AND STRUCTURAL CHARACTERIZATION OF ZnS ON (001) GaAs.** The effect of surface nucleation processes on the quality of ZnS layers grown on (001) GaAs substrates by molecular beam epitaxy is reported. Reflection high energy electron diffraction indicated that nucleation at high temperatures produced more planar surfaces than nucleation at low temperatures, but the crystalline quality as assessed by X-ray double crystal diffraction is relatively independent of nucleation temperature. A critical factor in layer quality was the initial roughness of the GaAs surfaces. (Author abstract) 21 refs.

Benz, R.G. II (Georgia Tech Research Inst, Atlanta, GA, USA); Huang, P.C.; Stock, S.R.; Summers, C.J. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 303-310.

**095580 MBE GROWTH OF HIGH QUALITY LATTICE-MATCHED  $\text{ZnS}_x\text{Se}_{1-x}$  ON GaAs SUBSTRATES.** We present the optimum growth conditions of lattice-matched  $\text{ZnS}_x\text{Se}_{1-x}$  ( $x$  approximately 0.055) by MBE on (100) GaAs substrates. Surface morphology, X-ray diffraction and photoluminescence were investi-

gated, and the optimum growth conditions were revealed as follows: The molecular beam intensity ratio of the group VI to II element is around 2.0 and the substrate temperature is 340°C. This molecular beam ratio means that the surface coverage fractions of the group II and group VI atoms are the same during growth. It is shown by comparing the photoluminescence spectra that the quality of the  $\text{ZnS}_x\text{Se}_{1-x}$  epilayers was higher than that of ZnSe. (Author abstract) 13 refs.

Matsumura, Nobuo (Kyoto Inst of Technology, Kyoto, Jpn); Tsubokura, Mitsutaka; Sarai, Junji; Yodogawa, Yutaka. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 311-317.

**095581 HOMO-EPITAXIAL GROWTH OF ZnSe BY MBE.** Homo-epitaxial growth of ZnSe on melt-grown ZnSe single crystals with (110) or {111} surfaces orientation has been performed to obtain strain-free layers. Epitaxial growth was successful only on  $(\bar{1}11)$  and (110) substrate surfaces, which were prepared by chemical etching using a chromic acid mixture or a mixture of ammonia and hydrogen peroxide solution. Photoluminescence spectra measured at 4 K showed the strong Y and S lines and a broad band on the low energy side. While the layers of ZnSe grown on GaAs substrates with smooth surfaces showed only strong and sharp excitonic lines, growth on the rough ZnSe surface introduced disorder in the epitaxial layer degrading the luminescence response. (Author abstract) 6 refs.

Ohishi, M. (Okayama Univ of Science, Okayama, Jpn); Ohmori, K.; Fujii, Y.; Saito, H.; Tiong, S. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 324-328.

**095582 MOLECULAR BEAM EPITAXIAL GROWTH OF NITROGEN-DOPED ZnSe WITH ION DOPING TECHNIQUE.** Nitrogen-doped ZnSe layers on GaAs substrates have been prepared by an ion doping with nitrogen during molecular beam epitaxial growth of ZnSe in an attempt to obtain p-type crystals. The preliminary work using a simple ion source without a mass separator indicated that a considerable contamination of donor species occurred, together with the doping of nitrogen acceptors. The low-temperature photoluminescence (PL) was dominated by a strong donor-acceptor pair (DAP) emission. The best result obtained was with an N-doped layer exhibiting a PL spectrum dominated by a strong acceptor-bound-exciton emission  $I_1$  whose peak intensity was 40 times greater than that of the DAP emission. The optimum condition for ion doping was investigated in terms of ion energy and ion current density. A temperature dependence of the PL spectrum was also reported. (Edited author abstract) 8 refs.

Ohkawa, K. (Matsushita Electric Industrial Co, Osaka, Jpn); Mitsuyu, T.; Yamazaki, O. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 329-334.

**095583 ZnSe AND ZnSe/Ge EPI-LAYERS GROWN ON (100) Si BY MOLECULAR BEAM EPITAXY.** ZnSe layers in the thickness range 2 to 3  $\mu\text{m}$  were grown on (100) Si substrates with intermediate Ge epi-layer buffers. Ge epi-layers (approximately 0.5  $\mu\text{m}$  thick) were grown by Knudsen evaporation of Ge from a FBN crucible at Si substrate temperatures around 330°C. The Ge layer growth-rate being typically 0.33  $\mu\text{m/h}$  ( $2 \times 2$ ) reconstructed Ge surfaces were observed during Ge deposition by RHEED, the RHEED patterns being indicative of extremely smooth Ge surfaces. ZnSe layer quality was assessed using photoluminescence, SEM and cross-sectional TEM analyses, with layer quality achieved using superlattice buffers and single Ge epi-layer buffers being compared to that obtained by growing ZnSe directly on (100) Si. Cross-sectional TEM analysis showed the



layers grown with a two-period superlattice buffer to contain a significantly reduced concentration of structural defects. (Edited author abstract) 5 refs.

Park, R.M. (3M Canada Inc, Downsview, Ont, Can); Mar, H.A.; Kleiman, J. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 335-341.

**095584 ZnSe HOMO-EPITAXIAL GROWTH BY MOLECULAR BEAM EPITAXY.** High-quality undoped ZnSe homo-epitaxial growth by molecular beam epitaxy was demonstrated. A chemical etchant  $\text{H}_2\text{O}_2$ ,  $\text{NH}_4\text{OH}$  and  $\text{H}_2\text{O}$ , combined with a new thermal cleaning process, has been found promising for obtaining good initial ZnSe substrate surfaces necessary for high-quality homo-epitaxial growth by molecular beam epitaxy. The photoluminescence (PL) result is compared to that of a hetero-epitaxial layer on GaAs (001) substrate. A free excitonic PL emission line has been distinctly observed on the homo-epitaxial ZnSe layer grown on (001) substrate. A dominant emission line  $I_2$  in the 4.2 K PL spectrum of the homo-epitaxial ZnSe layer has been ascribed to In donors introduced by the In solder used to adhere the substrate to the molybdenum holder. (Author abstract) 10 refs.

Menda, Kazunori (Sumitomo Metal Mining Co, Ohme, Jpn); Takayasu, Ichiro; Minato, Tetsuo; Kawashima, Mitsuo. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 342-347.

**095585 LUMINESCENCE PROPERTIES OF ZnS/GaAs GROWN BY GAS SOURCE MBE.** High purity cubic ZnS films were grown on GaAs(100) by the gas source MBE method using  $(\text{CH}_3)_2\text{Zn}$  and  $\text{H}_2\text{S}$  as source materials. Photoluminescence studies of these films by the excitation of an  $\text{N}_2$  or an Xe-Cl excimer laser have shown that the intensity of self-activated emission depends on the  $[\text{S}]/[\text{Zn}]$  ratio and the substrate temperature. No SA emission was observed for ZnS films grown at 400°C or more with an  $[\text{S}]/[\text{Zn}]$  ratio of 2.3. Band edge emission consists of four sharp lines. The one at the highest photon energy, 3.797 eV, can be assigned to the recombination of a free exciton. (Author abstract) 10 refs.

Kanehisa, O. (Hitachi Ltd, Kokubunji, Jpn); Shiiki, M.; Migita, M.; Yamamoto, H. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 367-371.

**095586 CRYSTAL GROWTH OF ZnO BY CHEMICAL TRANSPORT.** Crystal growth of ZnO has been carried out by chemical transport in a closed tube using ammonium halides ( $\text{NH}_4\text{X}$ ), Zn,  $\text{ZnCl}_2$ , etc. as transport agents. Prismatic crystals of ZnO up to 1.5 mm in diameter and 8 mm in length were grown when  $\text{NH}_4\text{Cl}$  was used. The transport rate depended nearly proportionally on the undercooling, but not markedly on the amount of  $\text{NH}_4\text{Cl}$  added. When Zn and  $\text{ZnCl}_2$  were used, prismatic crystals were grown as well. The crystals grown were colorless or light-brown colored, and showed blue-green or yellow-green photoluminescence under UV excitation. When  $\text{NH}_4\text{Br}$  or  $\text{NH}_4\text{I}$  was used, however, only few crystals were obtained. (Author abstract) 23 refs.

Matsumoto, Koichi (Shizuoka Univ, Hamamatsu, Jpn); Shimaoka, Goro. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 410-414.

**095587 PHOTOLUMINESCENCE AND CYCLOTRON RESONANCE STUDIES ON HIGHLY PURIFIED ZnSe SINGLE CRYSTALS.** In order to prepare low resistivity p-type crystals with good reproducibility for practical use, the development of preparation procedures for high purity single crystals and also the research of their physical properties and of the impurity effect on them should be done. For this reason, we have prepared high purity ZnSe single crystals and evaluated the grown crystals by photoexcited cyclotron resonance and photo-

luminescence (PL) measurements. In the present paper, our recent results obtained on highly purified ZnSe single crystals are reviewed and some discussions are given. 38 refs.

Isshiki, Minoru (Tohoku Univ, Sendai, Jpn). *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 615-624.

**095588 MATERIALS GROWTH AND ITS IMPACT ON DEVICES FROM WIDE BAND GAP II-VI COMPOUNDS.** The progress made in the materials preparation and characterization of ZnSe in the last few years is reviewed. The recent results on MOVPE and MBE grown ZnSe show promise of achieving a p-n junction by reliable control of the quality of the material and the dopant incorporation. The impact of superlattices and multiquantum-well structures on the injection devices, electron beam pumped lasers, passivation of III-V compounds by II-VI compounds and nonlinear optical devices is briefly discussed. (Author abstract) 49 refs.

Bhargava, R.N. (Philips Corp, Briarcliff Manor, NY, USA). *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 873-879.

**Impurities** See Also SOLIDS—Impurities.

**095589 TIGHT-BINDING DESCRIPTION OF ISOVALENT IMPURITY CLUSTERS. APPLICATIONS TO Te IMPURITIES IN II-VI COMPOUND SEMICONDUCTORS.** For centers of several Te substitutionals in nearest-neighbor anion position in the host crystals ZnS, ZnSe, CdS, and CdSe a tight-binding description is given. The matrix of the Hamiltonian in the  $sp^3$ -representation includes all interactions up to the second-nearest neighbors and is based upon a charge self-consistent parametrization. All Te centers suitable in a tetrahedrally coordinated five-atom cluster are considered. Using the Koster-Slater scattering theory the off-diagonal matrix elements of the impurity potential have to be included. Thereby the results of the calculation are in good agreement with experimental data for the energy levels of complex Te impurities in II-VI semiconductors. (Author abstract) 10 refs.

Hanke, M. (Humboldt-Univ zu Berlin, Berlin, East Ger); Hennig, D.; Kaschte, A. *Phys Status Solidi B* v 143 n 2 Oct 1987 p 655-661.

**095590 ALKALI ATOMS AS ACCEPTOR IMPURITIES IN ZnSe.** The electronic structure of Li, Na, and K substitutional impurities in ZnSe are calculated within the framework of the self-consistent-field multiple-scattering molecular cluster model. The Li and Na impurities induce an  $a_1$  resonance in the valence band and at  $t_2$  state in the band gap. According to our results, the Li and Na acceptor states originate from the  $t_2$  orbital in the gap. The degree of localization of the gap state increases with atomic number, as a result from core repulsion effects and from the orthogonality between the impurity states. We suggest that the latter mechanism could be applied to Li and Na acceptors in other II-VI compounds. (Author abstract) 15 refs.

Chacham, Helio (Univ Federal de Minas Gerais, Belo Horizonte, Brazil); Alves, J.L.A.; De Siqueira, M.L. *Solid State Commun* v 64 n 6 Nov 1987 p 863-866.

**095591 DETECTION AND CONTROL OF IMPURITY INCORPORATION IN MBE-GROWN ZnSe.** Intentionally- and unintentionally-doped ZnSe films were grown on (100)-oriented GaAs substrates by molecular beam epitaxy. The incorporation of intentional and unintentional dopants in these films was investigated through the use of photoluminescence, selectively-excited photoluminescence, secondary ion mass spectrometry and Hall measurements. Gallium and chlorine were detected in the undoped epilayers and these impurities were found to be associated with the well-known  $I_x$  and  $I_{20}$  donor-bound excitonic emissions seen in the photoluminescence. Furthermore, it was found that extrinsic impurities

appeared to be responsible for the electrically active donors in the undoped films and these impurities originated from the Se source material. The results of our initial attempts at doping with sodium and phosphorus are also reported here. (Edited author abstract) 15 refs.

DePuydt, J.M. (3M Co, St. Paul, MN, USA); Smith, T.L.; Potts, J.E.; Cheng, H.; Mohapatra, S.K. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 318-323.

**095592 DECAY OF INTERNAL LUMINESCENCE TRANSITIONS OF 3d IMPURITIES IN II-VI COMPOUNDS - RECENT EXPERIMENTS AND REFINED INTERPRETATIONS.** The decay of the infrared emission of various 3d transition metal impurities (V, Cr, Fe, Co, Ni, Cu) in II-VI compounds (ZnS, ZnSe, CdS, CdSe) is studied in low-temperature experiments and by advanced model calculations. (Author abstract) 6 refs.

Goetz, Gertrud (Fritz-Haber-Inst der Max-Planck-Gesellschaft, Berlin, West Ger); Schulz, Hans-Joachim. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 415-416.

**Ion Implantation**

**095593 PERSISTENT PHOTOENHANCEMENT OF HYDROGEN-IMPLANTED QUANTIZED ACCUMULATION LAYERS ON ZnO SURFACES.** Strong hydrogen-implanted accumulation layers on ZnO surfaces, produced and maintained at 80 K, can be further enhanced by illumination with visible light. The attainable enhancement is surprisingly large, resulting in an enormous surface electron density of up to  $6 \times 10^{14} \text{ cm}^{-2}$ , and persists indefinitely after the light is switched off. The photoenhancement layer is practically identical in width (10-20 Å) and transport characteristics to the implanted layer upon which it is based. The photoenhancement effect is not fully understood. Various aspects of this effect are studied in an attempt to gain some insight into the processes involved. On the basis of the results presented we tentatively suggest that latent centers consisting of  $\text{H}_2^+$  species are introduced by the hydrogen implantation, in addition to the fully ionized proton donors responsible for the implanted accumulation layer. (Edited author abstract). 16 Refs.

Yaron, G. (Hebrew Univ, Jerusalem, Israel); Goldstein, Y.; Many, A.; Weisz, S.Z.; Resto, O. *J Phys Chem Solids* v 49 n 8 1988 p 887-895.

**Magnetic Properties**

**095594 HIGH FIELD MAGNETIZATION STEP IN  $\text{Zn}_{1-x}\text{Mn}_x\text{Te}$ .** Low temperature and high field magnetization experiments ( $H \leq 19 \text{ T}$ ) were carried out in diluted  $\text{Zn}_{1-x}\text{Mn}_x\text{Te}$  alloys ( $x = 0.03$ ). At 1.3 K, the first magnetization step, corresponding to the level crossing for pairs of nearest-neighbors (NN) is observed around  $H \approx 15 \text{ T}$ . Magnetization data are analyzed including, within the molecular field approximation (MFA), interactions between Mn ions distributed in small clusters (singles, pairs, triangles) with more distant neighbors than NN. Both the saturation value observed at  $H \approx 10 \text{ T}$  and the magnitude of the step agree with a random Mn distribution. Theoretical fits of the magnetization step provide a determination of the NN exchange constant  $J/k = -9.25 \pm 0.3 \text{ K}$ . (Author Abstract) 15 refs.

Barilero, G. (L'Ecole Normale Supérieure, Paris, Fr); Rigaux, C.; Hau, Nguyen Hy; Picoche, J.C.; Giriat, W. *Solid State Commun* v 62 n 5 May 1987 p 345-350.

**095595 MAGNETIC PROPERTIES OF  $\text{Zn}_{1-x}\text{Mn}_x\text{S}$ .** The low temperature ac susceptibility and specific heat of the diluted magnetic semiconductor  $\text{Zn}_{1-x}\text{Mn}_x\text{S}$  has been measured for Mn concentrations below  $x = 0.10$ . A paramagnetic to spin-glass transition has been observed for all concentrations. The concentration dependence of the



freezing temperature,  $T_F(x)$ , is compatible with a radial decay of the antiferromagnetic d-d interaction. The magnetic contribution to the specific heat can be described in the pair-approximation using  $J_{NN}/k_B = -16$  K for the nearest neighbor and  $J(R)/k_B = -10R^{-7.6}$  K for the long range part of the interaction. For these parameters also a fair agreement with reported high-field magnetization and high temperature susceptibility data can be obtained. (Edited author abstract) 15 refs.

Swagten, H.J.M. (Eindhoven Univ of Technology, Eindhoven, Neth); Twardowski, A.; de Jonge, W.J.M.; Demianiuk, M.; Furdyna, J.K. *Solid State Commun* v 66 n 8 May 1988 p 791-795.

**Measurements** See SEMICONDUCTING CADMIUM COMPOUNDS—Measurements.

**Optical Properties** See Also MAGNETIC SEMICONDUCTORS—Optical Properties.

**095596 AUGER QUENCHING OF LUMINESCENCE IN ZnSe: Mn.** The Auger coefficient for quenching of manganese luminescence by free carriers in ZnSe:Mn has been measured. Its value is  $5 \times 10^{-10} \text{ cm}^3 \text{ s}^{-1}$ . This value is similar to that found for ZnS:Mn and is anomalously large. A possible explanation involving energy band matching is discussed. (Author abstract) 15 refs.

Ayling, S.G. (Univ of St. Andrews, St. Andrews, Scotl); Allen, J.W. *J Phys C Solid State Phys* v 20 n 26 Sep 20 1987 p 4251-4257.

**095597 OPTICAL BLEACHING OF THE F+ OPTICAL ABSORPTION BANDS IN ZnS CRYSTALS.** The optical bleaching of the 2.3 and 2.9 eV bands related to the F+ centers in the electron-irradiated and Zn-treated ZnS crystals are measured from 25 K to room temperature under illumination of light from 395 to 702 nm. It is found that the 2.9 eV band is bleached in exactly the same manner as the 2.3 eV band. These bands are confirmed to be due to the same defects. It is deduced that the 2.3 eV absorption band is due to the transition of electrons from the ground state to the lower excited state located (49±5) meV below the conduction band, while the 2.9 eV band is due to the transition to the higher excited state located in or closely below the conduction band. (Edited author abstract) 20 refs.

Matsuura, K. (Tottori Univ, Tottori, Jpn); Kishida, S.; Yoshida, K.; Tsurumi, I. *Phys Status Solidi B* v 142 n 2 Aug 1987 p 617-627.

**095598 EDGE AND SELF-ACTIVATED HIGH BAND EMISSION OF ZnS<sub>1-x</sub>Se<sub>x</sub> SINGLE CRYSTAL EPITAXIAL LAYERS.** Intense edge and self-activated (SA) emissions have been observed in the ZnS<sub>1-x</sub>Se<sub>x</sub> ( $x > 0.41$ ) epitaxial layers grown on (100) GaP substrates. The edge emission shows a peak shift to the high-energy side with an increase in the ZnS molar fraction  $x$  and/or a decrease in the temperature. This emission is attributed to the donor (Al)-acceptor (Na) pair emission. The binding energies of the donor and acceptor were determined from thermal quenching curves. The SA band shows a peak shift to the low-energy side with a decrease in the temperature. Its peak energy increases with an increase of  $x$ , and is about 0.25 eV higher than that expected for the usual SA emission, showing that this band is due to the SA high band emission. (Author abstract) 31 refs.

Zhou, Jun (Nagoya Univ, Nagoya, Jpn); Goto, Hideo; Sawaki, Nobuhiko; Akasaki, Isamu. *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 229-234.

**095599 TRANSIENT BEHAVIORS OF THE 2.5 eV EMISSION BAND IN Se-TREATED ZnSe CRYSTALS.** ZnSe has been widely studied because of its potential as an efficient blue light emitter. However, it is difficult to make conducting n-type and p-type ZnSe because of the compensation effects by residual impurities and/or intrinsic defects. This work was done to clarify the nature of intrinsic defects induced by heat treatments. The transient behavior of the 2.5 eV emission band were

measured from 5 to 135 ns and emission mechanisms are discussed. 19 refs.

Kishida, S. (Tottori Univ, Tottori, Jpn); Matsuura, K.; Matsuoka, A.; Tsurumi, I. *Phys Status Solidi A* v 105 n 2 Feb 1988 p K165-K168.

**095600 INTRA-MANGANESE ABSORPTION AND LUMINESCENCE IN Zn<sub>1-x</sub>Mn<sub>x</sub>Se SEMI-MAGNETIC SEMICONDUCTOR.** Optical absorption and luminescence of Zn<sub>1-x</sub>Mn<sub>x</sub>Se ( $0 < x < 0.53$ ) is measured at T = 10, 77 and 300 K below fundamental absorption edge. Three absorption and one luminescence bands are observed and are attributed to the intra-ion transitions of Mn<sup>2+</sup> in 3d<sup>5</sup> configuration. Crystal field parameter Dq and Racah parameters B and C are derived as well as stabilization energy. (Author abstract) 21 refs.

Oczkiewicz, B. (Warsaw Univ, Warsaw, Pol); Twardowski, A.; Demianiuk, M. *Solid State Commun* v 64 n 1 Oct 1987 p 107-111.

**095601 2.5 eV EMISSION BAND IN THE Se-TREATED ZnSe CRYSTALS.** Zinc selenide crystals grown by sublimation methods were treated in Se and/or Zn vapor of 400 to 660°C. Photoluminescence spectra were measured from 16 to 200 K. A new emission band near 2.5 eV is induced by Se treatments. This band is enhanced by increasing the time of Se treatment and decreased by Zn treatment. No shift in the peak energy of this band was observed with increasing excitation intensity delay time, so the 2.5 eV band is not due to donor-acceptor pair recombination. It is proposed that this band is related to Se-excess defects. (Edited author abstract) 23 refs.

Kishida, S. (Tottori Univ, Tottori, Jpn); Matsuura, K.; Mori, H.; Yanagawa, T.; Tsurumi, I.; Hamaguchi, C. *Phys Status Solidi A* v 106 n 1 Mar 1988 p 283-289.

**095602 LOW TEMPERATURE PHOTOLUMINESCENCE IN Zn<sub>3</sub>P<sub>2</sub>.** Zinc phosphide, Zn<sub>3</sub>P<sub>2</sub>, has been studied to its promising photovoltaic properties. It has become one of the high-efficiency semiconductors used on solar energy conversion. This compound has a direct optical bandgap of approximately 1.5 eV at 300K, 1.645 eV at 80 K, and 1.685 eV at 5 K. In the present note measurements of photoluminescence in the 1.48 to 1.70 eV range are reported at liquid helium temperature. 12 Refs.

Misiewicz, J. (Technical Univ of Wroclaw, Wroclaw, Pol). *Phys Status Solidi A* v 107 n 1 May 1988 p K65-K68.

**095603 ELECTROLUMINESCENCE IN AG- OR CU-DOPED ZnSe MIS STRUCTURE.** ZnSe having a direct band gap of 2.71 eV at room temperature is one of the promising semiconducting materials for preparing visible light emitting electroluminescent devices. This was directed to studying the blue EL in a forward-biased undoped ZnSe MIS structure. It is found that the red band at 650 nm is obtained at RT, and the Cu-R and Cu-G bands at 630 nm and 530 nm, respectively, are obtained at liquid nitrogen temperature. This is the first time that the green EL band at 562.5 nm is obtained at RT. (Edited author abstract). 10 Refs. In Chinese.

Wang, Xin-Lin (Acad Sinica, China); Gong, Ting-Gan; Zhang, Ji-Ying; Li, Wei-Zhi. *Xiyu Jishu* v 7 n 1 Feb 1988 p 42-45.

**095604 JAHN-TELLER EFFECT AND OPTICAL PROPERTIES OF ZnSe:Fe<sup>2+</sup>.** Zeroth-order vibronic wave functions are built in the Born-Oppenheimer limit as symmetrized products of electronic functions and vibronic functions corresponding to up to N vibrational quanta. A linear Jahn-Teller Hamiltonian is then added to the spin-orbit and static crystal-field contributions which are taken as fixed parameters in accordance with their established properties. The diagonalization of the whole Hamiltonian predicts the energies and intensities of the absorbed lines which are then compared with the spectra. Good agreement with experiment is obtained when the energy of the coupling phonon  $\hbar\omega$  is 65 cm<sup>-1</sup> (good correspondence with the lattice dynamics of ZnSe) and the Jahn-Teller energy  $E_{JT}$  is 230 cm<sup>-1</sup> (in the same range of the reported values for ZnS:Fe<sup>2+</sup> and CdTe:Fe<sup>2+</sup>). It is

found that good stability is reached for N ≥ 8. The values of  $\hbar\omega$  and  $E_{JT}$  reported above correspond to the case N = 10. (Edited author abstract) 12 refs.

De Orue, Manuel A. (Univ de Concepcion, Concepcion, Chile); Rivera-Iratchet, Juan; Vogel, Eugenio E. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 28-32.

**095605 OPTICAL INVESTIGATION OF THE DILUTED MAGNETIC SEMICONDUCTOR Zn<sub>1-x</sub>Mn<sub>x</sub>Te.** Zn<sub>1-x</sub>Mn<sub>x</sub>Te alloys ( $0 \leq x \leq 0.72$ ) have been investigated by photocurrent spectroscopy, electroreflectance in the electrolyte configuration and under vacuum by absorption and reflectivity measurements. Electroreflectance enables one to accurately determine the fundamental gap as a function of the alloy composition. We find  $E_0(x) = (2.28 + 0.53x)$  eV, a linear law which is in good agreement with previously published results. In the case of thermally treated samples with x approximately 0.70 electroreflectance, photocurrent and absorption spectroscopy indicate that the fundamental transition may be totally different from what is expected depending on the part of the ingot from which the samples the originate ( $E_0 = 1.854$  eV instead of 2.65 eV). It is assumed on the basis of complementary investigations that the complete band structure of the anomalous samples is shifted towards lower energy values. (Author abstract) 22 refs.

Lemasson, P. (CNRS, Thiais, Fr); Nguyen Van Huong, C.; Benhida, A.; Lascaray, J.P.; Triboulet, R. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 564-569.

**095606 ELECTROCHEMICAL AND ELECTRO-OPTICAL PROPERTIES OF Hg<sub>1-x</sub>Zn<sub>x</sub>Te.** An experimental study of Hg<sub>1-x</sub>Zn<sub>x</sub>Te (ZMT) over the whole composition range is carried out, using an electrochemical technique, electrolyte electroreflectance (EER) and photocurrent spectroscopy. ZMT alloys exhibit good electrochemical stability in aqueous as well as in aprotic solution. Well-featured EER spectra are obtained. By analysis of EER lineshape and photocurrent spectra, interband transition energies  $E_0$  and  $E_1$  are determined. The results show that Hg rich ZMT alloys, grown by THM have a good chemical stability, low defect density and thus are very promising for infrared detector devices. (Author abstract) 18 refs.

Nguyen Van Huong, C. (CNRS, Meudon, Fr); Triboulet, R.; Lemasson, P. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 570-575.

**095607 ELECTRONIC STATES AND PAIR EMISSION IN ZnSe.** In this brief review the luminescent properties of shallow impurities in pure ZnSe are discussed. From this study it is shown that control of background impurities has significantly improved and sufficient incorporation of the shallow donors and acceptors is expected to lead to p-n junction in ZnSe and other wide energy band gap II-VI superconductors. 27 refs.

Bhargava, R.N. (North American Phillips Corp, Briarcliff Manor, NY, USA). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 24-27.

## Oxidation

**095608 SURFACE OXIDATION OF ZnHgTe AND ITS INTERFACE REACTION WITH METALS.** Migration processes of the constituent atoms and the interface properties in p- and n-type ZnHgTe crystals subjected to thermal oxidation or to metal deposition have for the first time been investigated by means of X-ray photoelectron spectroscopy (XPS) and Auger electron spectroscopy (AES) measurements in combination with ion-depth profile technique. The significant evaporation of Hg and Zn migration during oxidation have been observed and both play an important role for the oxidation process. As in the case of oxidation of CdHgTe, ZnTeO<sub>3</sub>



resulting from ZnO and TeO<sub>2</sub> formation may be considered to be one of the major constituents on the oxide surfaces. We have found both out-diffusion of Te and in-diffusion of Au at room temperature in Au/ZnHgTe and Au/ZnTe. A tentative interdiffusion model is proposed. (Author abstract) 12 refs.

Taguchi, Tsunemasa (Osaka Univ, Suita, Jpn); Sasaki, Tokuhito; Terada, Toshiyuki; Ekawa, Mitsuru; Hiraki, Akio. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 819-825.

## Phase Transitions

**095609 THERMODYNAMIC ANALYSIS AND PHASE EQUILIBRIA CALCULATIONS FOR THE Zn-Te, Zn-Se AND Zn-S SYSTEMS.** The available thermodynamic and phase equilibria data for the binary systems Zn-Te, Zn-Se and Zn-S have been analyzed using an 'associated solution model' for the liquid phases and considering the ZnTe, ZnSe and ZnS phases as line compounds. The phase diagrams and thermodynamic properties calculated from the optimized phase parameters agree well with the experimental data. (Author abstract) 58 refs.

Sharma, Ramesh C. (Indian Inst of Technology, Kanpur, India); Chang, Y. Austin. *J Cryst Growth* v 88 n 2 Apr II 1988 p 193-204.

## Photoconductivity

**095610 ON THE PHOTOCONDUCTIVITY RELAXATION IN ZnIn<sub>2</sub>S<sub>4</sub>.** The relaxation process of photoconductivity in ZnIn<sub>2</sub>S<sub>4</sub> is investigated together with optical quenching and thermally stimulated current. Photocurrent decays are processed by four-gate technique of photoinduced current transient spectroscopy (PICTS). A non-exponential behavior of the decays, due to a non-linear multichannel recombination mechanism, leads to 'anomalous' PICTS spectra that in the temperature range 200 to 300 K allow to evidence a thermal emission from a center with a repulsive potential barrier. The photoconductivity relaxation in the 80 to 200 K range is attributed to two competitive recombination channels. Models for the relaxation through both radiative and non-radiative recombination channels are proposed on the basis of optical quenching effect. (Edited author abstract). 19 Refs.

Serpi, A. (CNR, Cagliari, Italy); Zielinger, J.P. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 351-362.

## Physical Properties

**095611 PREPARATION AND CHARACTERIZATION OF SEVERAL II-IV-V<sub>2</sub> CHALCOPYRITE SINGLE CRYSTALS.** Single crystals of ZnSiP<sub>2</sub>, ZnGeP<sub>2</sub>, ZnGeP<sub>1.8</sub>As<sub>0.2</sub>, and ZnGeP<sub>1.6</sub>As<sub>0.4</sub> have been grown by several techniques and their electronic and optical properties were compared. For ZnSiP<sub>2</sub> there are marked absorption bands at 10 and 11.5 μm, and at 13 μm for ZnGeP<sub>2</sub>. Upon substitution of 10 mole% of arsenic for phosphorus, the latter band does not shift to higher wavelengths. Further substitution of arsenic for phosphorus in ZnGeP<sub>2</sub> showed a weak second band at 9.8 μm. (Author abstract) 16 refs.

Shen, He-Sheng (Brown Univ, Providence, RI, USA); Yao, Guang-Qing; Kershaw, Robert; Dwight, Kirby; Wold, Aaron. *J Solid State Chem* v 71 n 1 Nov 1987 p 176-181.

**095612 AMORPHOUS THIN FILMS OF Zn<sub>3</sub>P<sub>2</sub>.** Thin amorphous and crystalline films of Zn<sub>3</sub>P<sub>2</sub> have been prepared by direct evaporation. The structure and surface morphology of these films have been studied by X-ray and electron diffraction techniques. The optical and electrical properties of both types of films have been measured and compared. The absorption edge of a-films is red shifted in comparison to c-Zn<sub>3</sub>P<sub>2</sub> films. The activation energies are determined for both films and discussed. (Author abstract) 16 refs.

Deiss, J.L. (CNRS, Strasbourg, Fr); Eli-Drissi, B.; Robino, M.; Tapiero, M.; Zielinger, J.P.; Weil, R. *Phys Scr* v 37 n 4 Apr 1988 p 587-592.

**095613 RADIATIVE RECOMBINATION IN HIGHLY EXCITED ZnSe.** Photoluminescence spectra and lifetime measurements are obtained at 1.8 K on high purity zinc selenide single crystals for different excitation intensities. At high power densities, two new luminescent bands at 2800 meV and 2798.5 meV are observed. The spectral position of these emission bands, combined with their transient behavior, suggest that these peaks are due to the biexciton recombination line and to the biexciton-biexciton collision line. (Author abstract). 13 Refs.

Charbonneau, S. (Simon Fraser Univ, Burnaby, BC, Can); Thewalt, M.L.W.; Isshiki, M.; Masumoto, K. *Solid State Commun* v 67 n 3 Jul 1988 p 187-191.

## Pressure Effects

**095614 PRESSURE DEPENDENCE OF THE LOWEST DIRECT ABSORPTION EDGE OF ZnTe.** The dependence of the lowest direct absorption gap E<sub>0</sub> of ZnTe on hydrostatic pressure has been measured at room temperature with a diamond anvil cell for pressures up to the second phase transition (11.9 ± 0.3 GPa). The energy gap E<sub>0</sub> (eV) = 2.27 + 10.4 · 10<sup>-2</sup> · P - 28 · 10<sup>-4</sup> · P<sup>2</sup> (P in GPa) exhibits a sublinear dependence on P up to the first phase transition at 9.4 ± 0.3 GPa. However, if the gap is plotted as a function of the relative change of lattice constant (-Δa/a<sub>0</sub>) it shows, within error, a linearity with E<sub>0</sub> (eV) = 2.266 + 16.2 (-Δa/a<sub>0</sub>). The experimental results are compared to theoretical calculations based on a local empirical pseudopotential and with recently published ab initio LMTO calculations. (Author abstract) 22 refs.

Stroessner, K. (Max-Planck-Institut fuer Festkoerperforschung, Stuttgart, West Ger); Ves, S.; Kim, Chul Koo; Cardona, M. *Solid State Commun* v 61 n 5 Feb 1987 p 275-278.

## Recrystallization

**095615 GROWTH OF HgZnTe BY CAST-RECRYSTALLIZATION.** The growth of large-grained (Hg, Zn)Te ingots with mole fraction, x, of ZnTe (0.05 < x < 0.15) has been achieved by a modified cast-recrystallization (CR) technique. The recrystallization step of the CR process is performed using a high temperature gradient (10-100 K/cm), perpendicular to the ampoule axis. The homogeneity and structural, optical and photoelectrical properties of as-grown material and of material low-temperature annealed in Hg vapors have been studied. It was shown that the influence of low-temperature anneal on the properties of the material is essentially similar to that of (Hg, Cd)Te. The as-grown p-type layers are readily converted to n-type with the final donor concentrations in the mid 10<sup>15</sup> cm<sup>-3</sup> range, reflecting an uncontrolled doping level. The rate of the p-to-n-type conversion is, however, lower compared to (Hg, Cd)Te of the same band gap. The use of (Hg, Zn)Te grown by CR for IR detectors has been demonstrated. (Author abstract) 15 refs.

Nowak, Z. (Inst of Technical Physics, Warsaw, Pol); Piotrowski, J.; Rutkowski, J. *J Cryst Growth* v 89 n 2-3 Jun II 1988 p 237-241.

## Spectroscopic Analysis

**095616 TIME-RESOLVED SPECTROSCOPY OF THE LOW-ENERGY EMISSION BANDS OF HIGHLY DOPED Zn<sub>1-x</sub>Mn<sub>x</sub>S.** The luminescence excitation and emission spectra of Zn<sub>1-x</sub>Mn<sub>x</sub>S with high Mn concentration (0.01 ≤ x ≤ 0.25) is studied by time-resolved laser spectroscopy at temperatures 10 K ≤ T ≤ 300 K. Besides of the emission bands peaking at 17,000 cm<sup>-1</sup>, 15,750 cm<sup>-1</sup>, and = 13,500 cm<sup>-1</sup> a fourth band peaking in the IR at 10,600 cm<sup>-1</sup> is registered. This IR band is closely connected to two excitation bands in the UV peaking at 26,900 cm<sup>-1</sup> and 28,750 cm<sup>-1</sup> (T = 10 K, x = 0.034). Four different Mn dominated centers are distinguished, which are partly

connected by energy transfer. (Author abstract) 9 refs.

Benecke, C. (TU Berlin, Berlin, West Ger); Busse, W.; Gumlich, H.-E.; Moros, H.-J. *Phys Status Solidi B* v 142 n 1 Jul 1987 p 301-309.

**095617 NEW EMISSION BAND IN THE NEAR BAND EDGE REGION IN ZnSe SINGLE CRYSTAL.** An emission band with FWHM of 2.7 meV has been observed at 2.8002 eV. Its emission intensity is proportional to the 1.2 power of the excitation intensity. The excitation spectrum and selective excitation spectrum do not show any additional spectral structure. It is proposed that the origin of this emission is the scattering of excitons by other free particles at a structural defect with slightly lower potential for free particles and free excitons. (Author abstract) 7 refs.

Isshiki, M. (Tohoku Univ, Sendai, Jpn); Kyotani, T.; Masumoto, K.; Uchida, W.; Suto, S. *Solid State Commun* v 62 n 7 May 1987 p 487-490.

**095618 NMR STUDY OF THE ZINC CHALCOGENIDES (ZnX, X = O, S, Se, Te).** A nuclear magnetic resonance investigation of the solid zinc chalcogenides ZnX (X = O, S, Se, Te) is carried out, using the following nuclei as probes, <sup>67</sup>Zn, <sup>17</sup>O, <sup>33</sup>S, <sup>77</sup>Se, and <sup>125</sup>Te. The spectra yield nuclear quadrupole coupling constants and chemical-shift parameters for polycrystalline ZnO and ZnS in the wurtzite (hexagonal) form, and chemical shifts and linewidths for polycrystalline ZnS, ZnSe, and ZnTe in the sphalerite (cubic) form. A single crystal of ZnO is used to obtain an accurate measurement of the quadrupole coupling constant for <sup>67</sup>Zn, |e<sup>2</sup>qQ/h| = 2.4065(15) MHz at 296 K, in agreement with a recent Moessbauer-effect measurement. The electric field gradient of the wurtzite structures is analyzed with a simple ionic model, and the results are found to be in semiquantitative agreement with experiment. (Author abstract) 20 refs.

Bastow, T.J. (CSIRO, Clayton, Aust); Stuart, S.N. *Phys Status Solidi B* v 145 n 2 Feb 1988 p 719-728.

**095619 EXCITATION SPECTROSCOPY OF DONOR-ACCEPTOR PAIR LUMINESCENCE IN ZnSe<sub>x</sub>S<sub>1-x</sub>.** Luminescence of a donor-acceptor pair band in ZnSe<sub>x</sub>S<sub>1-x</sub> (0.85 < x < 1) prepared by sublimation method was investigated. The energies of Al donor, Na acceptor and optical phonons LO and TO for ZnSe<sub>0.94</sub>S<sub>0.06</sub> were determined as 25.5, 122.6, 31.3 and 26.4 meV, respectively, by means of excitation spectroscopy. (Author abstract) 4 refs.

Ohishi, Masakazu (Okayama Univ, Okayama, Jpn); Hiramatsu, Makoto; Ohmori, Kenzo; Saito, Hiroshi; Tiong, Shirley R. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 123-124.

**095620 STUDY OF TWO DEEP ELECTRON TRAPS IN ZnSe CRYSTALS.** The properties of two deep electron traps with activation energies E<sub>c</sub>-0.29 eV and E<sub>c</sub>-0.33 eV in ZnSe crystals are studied by ODLTS and DLTS techniques. The former trap is attributed to a defect and the latter is ascribed to an impurity or a complex center associated with an impurity. (Author abstract) 6 refs.

Wang, Shouyin (Acad Sinica, Changchun, China); Fan, Xiwu. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 333-334.

**095621 RESONANCE FLUORESCENCE OF LOCALIZED EXCITONS IN ZnSe<sub>1-x</sub>Te<sub>x</sub>.** From luminescence under spectrally selective excitation, in ZnSe<sub>1-x</sub>Te<sub>x</sub> for low Te-concentrations excitons are shown to localize at small Te-clusters. The energy spectrum of these



excitons, characterized by inhomogeneous broadening, and details of their exciton-lattice interaction are revealed. (Author abstract) 2 refs.

Permogorov, S. (A.F. Ioffe Physico-Technical Inst, Leningrad, USSR); Reznitsky, A.; Naumov, A.; Stolz, H.; Von Der Osten, W. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 483-484.

**095622 INTERACTION BETWEEN EXCITONS IN ZnSe EPILAYERS UNDER DIFFERENT EXCITATION INTENSITY.** ZnSe is one of the most promising materials for application to the blue EL devices. In highly excited semiconductors the interaction between excitons plays significant roles to the near band edge emission. In this paper a decreasing of intensity ratio of  $E_g$  band, associated with free exciton, to FB band, attributed to free-bound transition, can be explained by the interaction between excitons in ZnSe epilayer under high excitation intensity. 4 refs.

Ma, Li (Acad Sinica, Changchun, China); Tang, Zikang; Fan, Xiwu. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 523-524.

**095623 PICOSECOND DYNAMICS OF SECONDARY EMISSIONS OF EXCITONIC POLARITON IN HIGH PURITY ZnTe.** The relation between light scattering and luminescence under resonant optical excitation is studied in high purity ZnTe by picosecond spectroscopy. Direct experimental display is reported of the transformation from the Raman scattering to the luminescence in the excitonic polariton region. (Author abstract) 5 refs.

Oka, Yasuo (Tohoku Univ, Sendai, Jpn); Nakamura, Ken'ichi; Fujisaki, Haruo. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 577-578.

**095624 RESONANT SECONDARY EMISSION SPECTRA OF OPTICALLY ALIGNED HOT EXCITONS IN ZnTe: EFFECT OF THE EXCITATION INTENSITY.** The variation of the multiphonon LO-lines polarization degree and the sublinear dependence of their intensity on the pumping level have been established. The results explained in view of both the transverse and the longitudinal relaxation of the real intermediate states. (Author abstract) 5 refs.

Lisitsa, M.P. (Ukrainian Acad of Sciences, Kiev, USSR); Valakh, M.Ya.; Litvinchuk, A.P. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 607-608.

**095625 PHOTOLUMINESCENCE PROPERTIES OF ZnTe-ZnSe SUPERLATTICES GROWN BY HOT-WALL EPITAXY.** We have observed for the first time, the exciton luminescence lines from ZnTe-ZnSe superlattices (SLs), prepared by hot-wall epitaxy (HWE). Their structure dependence will be given with the calculation results. (Author abstract) 7 refs.

Yang, H. (Shizuoka Univ, Hamamatsu, Jpn); Fujiyasu, H.; Wu, Y.; Ishida, A.; Kuwabara, H. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 717-718.

**095626 HOT ELECTRON MECHANISMS DETERMINED FROM COMPARATIVE STUDIES OF ELECTROLUMINESCENCE.** Electroluminescence (EL) observations of Mn and Er implanted ZnS and ZnSe are consistent with hot electrons in a non-ballistic mode, complexes of large scattering cross-section and an exchange mechanism for manganese. (Author abstract) 3 refs.

Bryant, F.J. (Hull Univ, Hull, Engl); Hagston, W.E.; Swift, M.J.R. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on

Lumin, Beijing, China, Aug 17-21 1987 p 767-768.

**095627 EFFECT OF ANNEALING ZnSe CRYSTAL IN MOLTEN ZINC ON ITS ELECTRICITY AND LUMINESCENCE.** With annealing ZnSe crystal in molten Zinc, the mobility ( $\mu$ ) and the carrier concentration ( $n$ ) increase, as well as the blue exciton emission also increases in ZnSe crystal, it indicates that the quality of ZnSe crystal and the blue electroluminescence (EL) emission in ZnSe MIS diodes at RT can be improved. (Author abstract) 5 refs.

Zhang, Jiying (Acad Sinica, Changchun, China); Fan, Xiwu. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 798-799.

**095628 INVESTIGATION ON EXCITATION PROCESSES OF ELECTROLUMINESCENCE SPOTS IN FORWARD-BIASED ZnSe MIS DIODES.** Using an optical microscope with different filters, it is observed that the blue electroluminescence (EL) spots correspond to the yellow-orange EL spots in the site in forward-biased ZnSe MIS diodes. A model of blue EL excitation process is proposed in ZnSe MIS diode. The intrinsic blue EL spots can be obtained by hole injection, which is produced by impact ionization at high electric field region of I layer in the ZnSe MIS diode. (Author abstract) 5 refs.

Wang, Shouyin (Acad Sinica, Changchun, China); Fan, Xiwu. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 800-801.

**095629 INVESTIGATION OF DEEP LEVELS IN HEAT-TREATED ZnSe CRYSTALS BY ODLTS TECHNIQUE.** Three deep acceptor levels, formed by heat-treated undoped ZnSe crystals in vacuum are found by ODLTS method. Two deep acceptor levels of them,  $E_a + 0.30\text{eV}$ ,  $E_v + 0.72\text{eV}$ , are attributed to the deep acceptor levels related to the Cu-G and Cu-R centers, respectively, which could be produced by existence of the residual copper impurity in ZnSe crystal. (Author abstract) 6 refs.

Wang, Shouyin (Acad Sinica, Changchun, China); Fan, Xiwu. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 802-803.

**095630 PHOTO - AND ELECTROLUMINESCENCE OF ZnSe GROWN BY OMVPE.** Undoped ZnSe epilayers have grown on (100) GaAs substrates by atmospheric pressure organometallic vapor phase epitaxy (OMVPE) with dimethylzinc (DMZ) and hydrogen selenide ( $\text{H}_2\text{Se}$ ) as source. The epilayers grown under 270-325°C exhibit low resistivity of about  $1\Omega\cdot\text{cm}$ . The carrier concentration and mobility are of the order of  $10^{16}\text{cm}^{-3}$  and  $300\text{-}400\text{cm}^2\text{V}^{-1}\text{s}^{-1}$  respectively at RT. A strong NBE emission of PL and EL spectra are observed at 77K and RT respectively. (Author abstract) 5 refs.

Yang, Baojun (Acad Sinica, Changchun, China); Zhang, Jiying; Wessels, Bruce W. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 804-805.

**095631 EFFECT OF HEAT TREATMENT ON PHOTOLUMINESCENCE AND INTERFACE PROPERTIES IN MOCVD-GROWN ZnSe ONTO GaAs AND Ge.** The effect of heat treatment on 4.2 K photoluminescence spectra in MOCVD-grown ZnSe layers onto Ga As and Ge substrates has been presented. Excitonic-emission lines in ZnSe/GaAs are markedly affected by heat treatment in  $\text{H}_2$  atmosphere and gradually shift towards lower photon energies with temperature. In contrast to that, principal bound-exciton ( $1\text{GM}$ ) line in ZnSe/Ge was not changed up to 400°C. The interdiffusion between the epitaxial layer and substrate was significantly observed. (Author abstract) 4 refs.

Sekoguchi, Maki (Osaka Univ, Suita, Jpn); Hayamizu, Shunichi; Murase, Takashi; Taguchi, Tsunemasa; Hiraki, Akio. *J Lumin* v 40-41 Feb 1988, Excited State Processes

in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 838-839.

**095632 BLUE ELECTROLUMINESCENCE FROM ZnSe LANGMUIR-BLODGETT FILM MIS DIODES.** We report for the first time, the electrical and electroluminescent properties of Au/substituted silicon phthalocyanine LB film/MOCVD ZnSe MIS diodes. Underforward bias, and at room temperature the devices exhibited blue-white electroluminescence. Further investigation revealed two peaks in the spectrum. The 460nm peak coincides with the maximum output in the PL spectrum and is attributed to band-to-band recombination. (Author abstract) 4 refs.

Hua, Yulin (Acad Sinica, Changchun, China); Petty, M.C.; Roberts, G.G.; Ahmad, M.M.; Yates, H.M.; Maung, N.; Williams, J.O. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 861-862.

## Spectrum Analysis

**095633 RAMAN PROBING OF ZnTe-ZnS STRAINED-LAYER SUPERLATTICES.** ZnTe-ZnS strained-layer superlattices grown by Hot Wall Epitaxy are investigated by Raman spectroscopy. The formation of the superlattice structure is clearly observed. The line profile and the frequency shifts of LO and TO Raman modes due to elastic strain in the superlattice layers depend remarkably on the layer thickness and appear to be in compliance with theoretical calculation within the critical values of layer thicknesses. The spectra of ZnTe 10A-ZnS 10 A superlattices give an indication of folded LA phonon modes caused by the new periodicity. (Author abstract) 14 refs.

Shon, Le Hong (Osaka Univ, Toyonaka, Jpn); Inoue, Koichi; Murase, Kazuo. *Solid State Commun* v 62 n 9 Jun 1987 p 621-625.

**095634 LATTICE MODES OF  $\text{Zn}_3\text{P}_2$ .** Optical spectra of  $\text{Zn}_3\text{P}_2$  in the far infrared region ( $40\text{-}700\text{cm}^{-1}$ ) have been measured at room temperature and at 8 K. By means of Kramers-Kronig analysis, the optical constants and the energies of the zone-center TO and LO phonons have been determined. Two-phonon effects were observed and correlated with the energies of the TO and LO phonons. (Author abstract) 13 refs.

Misiewicz, J. (Technical Univ of Wroclaw, Wroclaw, Pol); Wrobel, J.M.; Clayman, B.P. *Solid State Commun* v 66 n 7 May 1988 p 747-750.

**095635  $\text{Zn}_3\text{P}_2$  AS INFRARED-TO-ULTRAVIOLET PHOTONCONVERTER.** The optical, electronic and other fundamental properties of zinc phosphide,  $\text{Zn}_3\text{P}_2$ , are briefly reviewed. Photoelectric properties of  $\text{Zn}_3\text{P}_2$ -based devices are discussed in various geometrical configurations. Technological problems are considered briefly and the potential application of  $\text{Zn}_3\text{P}_2$  as a solar photovoltaic conversion device is shown. (Author abstract) 28 refs.

Pawlikowski, J.M. (Indian Inst of Technology, Madras, India). *Infrared Phys* v 28 n 3 May 1988 p 177-182.

## Structure

**095636 DIFFERENT COORDINATION GEOMETRIES OF Co(II) ION IN  $\text{Co}_x\text{Zn}_{1-x}\text{In}_2\text{S}_4$  AND  $\text{Co-GaIn}_4$  LAYER COMPOUNDS: A QUANTITATIVE DETERMINATION BY XPS.** A quantitative determination of tetrahedral and octahedral cobalt ions in layer ternary compounds is obtained by the analysis of the photoelectronic spectra. This method can be of general application for computing a quantitative distribution of paramagnetic ions between different coordination geometries. (Author abstract) 24 refs.

Battistoni, C. (ITSE-CNR, Rome, Italy); Mattogno, G.; Viticoli, S. *Solid State Commun* v 63 n 4 Jul 1987 p 273-275.



**095637 EXAFS IN  $Zn_xCd_{1-x}Ga_2S_4$  DEFECT CHALCOPYRITE SOLID SOLUTION.** The structure of the nearest neighbors environment in the mixed defect chalcopyrite  $Zn_xCd_{1-x}Ga_2S_4$  is investigated by the EXAFS (extended X-ray absorption fine structure) spectroscopy at the Zn and Ga K-edges. The bond distances in the end member crystals and for different compositions in the alloy are determined. In addition to a conservation of the tetrahedral bond lengths with composition, the EXAFS analysis suggests an internal distortion in the  $ZnGa_2S_4$  compound, in contradiction with literature data. (Author abstract) 17 refs.

Lottici, P.P. (CNR, Parma, Italy); Antonioli, G.; Razzetti, C. *Phys Status Solidi B* v 145 n 2 Feb 1988 p 401-407.

**095638 ON THE STRUCTURE OF  $ZnIn_2Se_4$ .** The crystal structure of  $ZnIn_2Se_4$ , originally described in space group  $I\bar{4}$ , is properly described in  $I\bar{4}2m$ . In the revised description, four of the (disordered) metal atoms lie in equivalent sites of symmetry  $\bar{4}$ , two lie in sites of symmetry  $\bar{4}2m$ , and the Se atoms lie on mirror planes; the Laue symmetry is  $4/mmm$  rather than  $4/m$ . (Author abstract) 3 refs.

Marsh, Richard E. (California Inst of Technology, Pasadena, CA, USA); Robinson, William R. *J Solid State Chem* v 73 n 2 Apr 1988 p 591-592.

## Surfaces

**095639 RHEED OBSERVATION ON (001)ZnSe SURFACE: MBE SURFACE PHASE DIAGRAM AND KINETIC BEHAVIOR OF Zn AND Se ADATOMS.** Reflection high-energy electron diffraction (RHEED) studies have been performed on epitaxial (001)ZnSe surfaces. The phase diagram on the surface grown by molecular beam epitaxy (MBE) was obtained by observing changes of RHEED patterns as a function of beam flux ratio and substrate temperature. The desorption time of Se atoms and the adsorption time of Zn atoms were also obtained by measuring the time taken for the surface structure to change from a Se-stabilized surface to a Zn-stabilized one. The activation energy for the desorption of Se atom from a Se-stabilized surface was 1.02 eV. (Author abstract) 8 refs.

Menda, Kazunori (Sumitomo Metal Mining Co, Ohme, Jpn); Takayasu, Ichiro; Minato, Tetsuo; Kawashima, Mitsuo. *Jpn J Appl Phys Part 2* v 26 n 8 Aug 1987 p 1326-1329.

## Synthesis

**095640 INTERCALATES OF COMPOSITION  $ZnNb_{1+y}Se_2$ .** Intercalates of composition  $Zn_xNb_{1+y}Se_2$  ( $0 < x \leq 0.39$ ) have been synthesized for the first time by intercalating zinc from the vapor phase into niobium diselenide. The ranges of existence of these intercalates were determined by x-ray and quantitative chemical analyses. From the results of calculations of the electron density distribution it is shown that the intercalated zinc atoms have the coordinates (0,0,0). The statistical character of the filling of octahedral vacancies with intercalated zinc atoms is established. In Russian. 9 refs.

Kulikov, L.M.; Semenov-Kobzar', A.A.; Yanaki, A.A.; Akse'rud, L.G.; Koshel', O.S. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 12 Dec 1987 p 1968-1970.

**095641 INTERCALATION PROCESS AND THERMAL STABILITY IN AIR OF  $Zn_xNb_{1+y}Se_2$  INTERCALATES.** During the intercalation of niobium diselenide with zinc from the vapor-gas phase the implanting of the zinc is accompanied by the liberation of selenium into the vapor-gas phase and, in addition to intercalation with zinc, self-intercalation occurs. The intercalation process occurs in two states: the formation of intercalates with a zinc content  $x=0.27-0.33$  in the surface region and subsequent advancement of the intercalate front into the bulk of the microcrystal to form a homogeneous intercalate. It is established for the first time in the case of transition metal dichalcogenide intercalates such as  $Zn_xNb_{1+y}Se_2$  that the limit of their thermal stability in air

increases linearly with an increase in the quantity of intercalated zinc. In Russian. 5 refs.

Kulikov, L.M.; Semenov-Kobzar', A.A.; Yanaki, A.A.; Zaletilo, L.S.; Akse'rud, L.G.; Koshel', O.S. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 12 Dec 1987 p 1971-1975.

**095642 THERMODYNAMICS ANALYSIS OF THE REDUCIBILITY OF ZINC PHOSPHATE AND CADMIUM PHOSPHATE TO CORRESPONDING PHOSPHIDES.**  $Al^{11}_3B^{11}_2$  compound semiconductors, particularly Zn/Cd phosphides and arsenides have exhibited interesting properties for very promising application in devices such as solar cells, IR detectors, lasers and transducers. In this study, the reduction of  $Zn_3(PO_4)_2$  was done in vacuum at 600°C for 16h. The present note describes a critical assessment of the thermodynamics of oxidation reduction behaviour of CdO, ZnO and  $P_2O_5$  systems at various temperatures. Also taking into consideration the corresponding vapour pressure data, it has been shown that in the case of  $Zn_3(PO_4)_2$ ,  $P_2O_5$  gets reduced to phosphorus which then reacts with zinc to form  $Zn_3P_2$  in the boat while in the case of  $Cd_3(PO_4)_2$ , CdO gets reduced to cadmium and volatilizes off the system before  $P_2O_5$  could be reduced to elemental phosphorus. 21 refs.

Sundaram, S.K. (Indian Inst of Technology, Kharapur, India); Rao, D.R.; Paul, A. *J Mater Sci Lett* v 7 n 4 Apr 1988 p 417-421.

## Thermal Expansion

**095643 LOW-TEMPERATURE THERMAL EXPANSION OF  $ZnSiAs_2$ .** The thermal expansion coefficients  $\alpha_a$  and  $\alpha_c$  of the lattice parameters a and c of  $ZnSiAs_2$  are measured in the temperature range from 30 to 300 K using the X-ray Bond method. Both  $\alpha_a$  and  $\alpha_c$  decrease with temperature and become negative at about 45 K. The results are compared with thermal expansion data for other chalcopyrite semiconductors and are discussed in terms of the principal Grüneisen parameters of these compounds. (Author abstract). 42 Refs.

Deus, P. (Bergakad Freiberg, Freiberg, East Ger); Voland, U.; Neumann, H. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 225-231.

## Thermal Properties See SEMICONDUCTING ALUMINUM COMPOUNDS—Thermal Properties.

## Thick Films

**095644 PHYSICAL AND ELECTRICAL PROPERTIES OF SCREEN-PRINTED  $Zn_xCd_{1-x}S$  THICK FILMS.**  $Zn_xCd_{1-x}S$  films are of considerable interest for heterojunction solar cells because their use in place of CdS permits a greater open-circuit voltage. In the present paper we report results obtained with  $Zn_xCd_{1-x}S$  films prepared by the screen-printing technique in the entire composition range of  $0 \leq x \leq 1.0$ . The lattice parameters a and c vary with x in accordance with Vegard's law. Scanning electron micrographs reveal an enhancement in porosity with increasing x. The dark electrical resistivity of the film increases with x in the range  $0 \leq x \leq 0.6$ , but beyond this range it starts decreasing. Photoconductivity is studied as a function of x. An effect of  $H_2$  annealing on the dark resistivity and photosensitivity is established. (Edited author abstract) 16 refs.

Padam, G.K. (Nat'l Physical Lab, New Delhi, India); Shanker, V.; Ghosh, P.K. *J Mater Sci* v 23 n 3 Mar 1988 p 1064-1067.

## Thin Films See Also ELECTROLUMINESCENCE; LASERS, SEMICONDUCTOR—Design; MANGANESE AND ALLOYS—Spectroscopic Analysis.

**095645 STRUCTURAL PROPERTIES OF NON-STOICHIOMETRIC ZINC OXIDE FILMS.** Authors report a study of the crystal structure and microstructure of sputtered non-stoichiometric  $ZnO_x$  thin films for which  $0.7 < x < 1$ . A substrate rf discharge was used to control film stoichiometry during deposition. All

films had a columnar microstructures, and the film surface progressed from rough to smooth with increased oxidation. X-ray diffraction analysis detected no presence of crystalline zinc in any film. The crystallite size, strain and orientation of  $ZnO$ , detected in all films, was dependent on film composition and substrate rf discharge power. A model of film structure incorporating the competing effects of ion bombardment (causing amorphization) and increased oxygen content (creating improved crystallinity and orientation) is used to explain the observed variation of  $ZnO_x$  crystal structure. (Author abstract) 15 refs.

Brett, M.J. (Univ of Alberta, Edmonton, Alberta, Can); Parsons, R.R. *J Mater Sci* v 22 n 10 Oct 1987 p 3611-3614.

**095646 ELECTRICAL AND OPTICAL PROPERTIES OF VACUUM-DEPOSITED AMORPHOUS  $Zn_3P_2$  THIN FILMS.** Amorphous  $Zn_3P_2$  thin films were prepared by vacuum deposition. Reproducible electrical and optical properties were obtained by annealing the samples in the same way immediately after the deposition. Conductivity and thermopower measurements were performed and explained using the N.F. Mott and E.A. Davis model, and a long-range potential fluctuation suggested by H. Overhof and W. Beyer. (Author abstract) 11 refs.

Arsenault, C.J. (Univ of Waterloo, Waterloo, Ont, Can); Brodie, D.E. *Can J Phys* v 65 n 7 Jul 1987 p 756-759.

**095647 CRYSTALLOGRAPHIC CHARACTERIZATION OF  $ZnS_{1-x}Se_x$  PITAXIAL FILMS.** Crystalline quality of  $ZnS_{1-x}Se_x$  films grown on GaAs substrates has been investigated in detail using the X-ray double-crystal method. Respective fluctuations in orientation and spacing of lattice planes are measured separately. It is shown that the crystalline quality of  $ZnS_{1-x}Se_x$  films is noticeably affected by the fluctuation in orientation caused by lattice mismatch and partly by the fluctuation in spacing which may be associated with an inhomogeneous distribution of Se and S atoms. Improvement of the quality by lattice matching is due to a reduction of fluctuation in orientation. (Author abstract). 7 Refs.

Okamoto, Keiichi (Univ of Osaka Prefecture, Kyoto, Jpn); Itoh, Nobuo; Ogawa, Haruki; Toshiharu, Kawabata; Koike, Susume. *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 756-758.

**095648 EFFECT OF HEAT TREATMENT ON THE CRYSTALLINE QUALITY OF ZnSe EPILAYERS GROWN BY METALORGANIC VAPOR PHASE EPITAXY.** Thermal stability of ZnSe epilayers grown at the low growth temperatures of 250-300°C by MOVPE depends heavily on growth conditions, particularly the reactor pressure. The high density of deep centers is generated from the surface and diffuses into the epilayer by treating the epilayer at a temperature above 600°C under  $H_2$  atmosphere only. However, the increase of deep centers is effectively prevented by mixing dimethylzinc (DMZ) in the atmosphere even at the high temperature of 700°C. It is probable that the partial pressure of Zn vapor in the ambience would suppress the generation of Zn vacancies at the high temperature. (Edited author abstract). 8 Refs.

Yodo, Tokuo (Nippon Sheet Glass Co, Tsukuba city, Jpn); Yamashita, Ken. *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 903-905.

**095649 NITROGEN DOPED p-TYPE ZnSe LAYER GROWN BY METALORGANIC VAPOR PHASE EPITAXY.** Nitrogen-doped ZnSe layers have been grown on (100) GaAs substrates by metalorganic vapor phase epitaxy using  $NH_3$  as the doping material. The N-doped layers exhibit a strong free-to-acceptor transition emission at 77 K and a strong acceptor bound-exciton emission line at 15 K. The layers with a high doping level, which exhibit broader excitonic emission lines, indicate p-type conduction with low resistivities from  $10^2$  to  $10^3 \Omega \cdot cm$ , carrier concentrations of the order of  $10^{14} cm^{-3}$  and mobilities



from 20 to 50 cm<sup>2</sup>/Vs. Current-voltage characteristics of the N-doped ZnSe/n-GaAs heterojunctions conform to the p-type conduction. (Author abstract). 8 Refs.

Ohki, Akira (NTT, Tokai, Jpn); Shibata, Noriyoshi; Zembutsu, Sakae. *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 909-912.

**095650 GROWTH OF HEXAGONAL ZnS THIN FILMS BY MOCVD USING CS<sub>2</sub> GAS AS A SULFUR SOURCE.** High-quality ZnS films have been grown on glass and (111)Si substrates in the temperature range of 300-450°C by a low-pressure MOCVD technique using carbon disulfide (CS<sub>2</sub>) as a sulfur source. The diethylzinc-CS<sub>2</sub> (DEZ-CS<sub>2</sub>) system did not exhibit a premature reaction. The reaction process in this system is described. Films grown on glass substrates were hexagonal ZnS with a high degree of c-axis orientation. The full width at half maximum of the X-ray diffraction peak of 0.18° was obtained for the films grown at a substrate temperature of 400°C with a [CS<sub>2</sub>]/[DEZ] flow rate ratio of 10. Bright orange electroluminescence was observed in a thin film electroluminescent device with a manganese-doped MOCVD-grown ZnS emitting layer. (Author abstract) 13 refs.

Takata, S. (Kanazawa Inst of Technology, Kanazawa, Jpn); Minami, T.; Miyata, T.; Nanto, H. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 257-262.

**095651 ZINC PHOSPHIDE THIN FILMS GROWN BY RF SPUTTERING.** Zinc phosphide (Zn<sub>3</sub>P<sub>2</sub>) thin films have been prepared by RF sputtering in either Ar, H<sub>2</sub>, or PH<sub>3</sub> atmospheres. The Zn<sub>3</sub>P<sub>2</sub> films were deposited on glass substrates at RF power P<sub>s</sub> of 50-300 W, substrate temperature T<sub>s</sub> of 60-250°C, and total pressure up to 1 Torr. The Zn<sub>3</sub>P<sub>2</sub> films grown in PH<sub>3</sub> show a strongly preferred orientation; the c-axis is aligned perpendicular to the glass substrates, whereas the films grown in Ar and H<sub>2</sub> are amorphous. The crystallinity of Zn<sub>3</sub>P<sub>2</sub> films grown in PH<sub>3</sub> depends strongly on both PH<sub>3</sub> pressure P<sub>p</sub> and RF power: below P<sub>s</sub> = 150 W the films are amorphous while they are polycrystalline above it; the Zn<sub>3</sub>P<sub>2</sub> films are polycrystalline below P<sub>p</sub> = 0.6 Torr, whereas they are amorphous above it. The X-ray fluorescence analysis and EPMA indicate Zn<sub>3</sub>P<sub>2.03</sub> for the films deposited at P<sub>p</sub> = 0.2 Torr, P<sub>s</sub> = 200 W, and T<sub>s</sub> = 100°C. Optical measurements show that film has a 1.5 eV direct bandgap. (Author abstract) 11 refs.

Suda, Toshikazu (Inst of Vocational & Technical Education, Sagami-hara, Jpn); Miyakawa, Tadashi; Kurita, Shoichi. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 423-429.

**095652 ZINC PHOSPHIDE THIN FILMS GROWN BY LOW PRESSURE VAPOR PHASE DEPOSITION.** Zinc phosphide (Zn<sub>3</sub>P<sub>2</sub>) thin films have been grown by a low pressure vapor phase deposition technique at a pressure of 5-10 Torr. The Zn<sub>3</sub>P<sub>2</sub> thin films deposited at the optimum substrate temperature T<sub>s</sub> of 300-350°C show good crystallinity and stoichiometry; the Zn<sub>3</sub>P<sub>2</sub> films are preferentially oriented in the [004] direction on glass substrates. EPMA indicates a composition of Zn<sub>3</sub>P<sub>1.95</sub> for the Zn<sub>3</sub>P<sub>2</sub> films deposited at T<sub>s</sub> = 350°C with a grain size of 3-5 μm. A fundamental direct absorption edge of Zn<sub>3</sub>P<sub>2</sub> films has been deduced from optical transmission and reflection measurements, and is 1.45 eV at room temperature. (Author abstract) 8 refs.

Suda, Toshikazu (Inst of Vocational & Technical Education, Sagami-hara, Jpn); Nishimoto, Toshiaki; Kurita, Shoichi. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 430-435.

**095653 EFFECT OF CO-EVAPORATION ON ZnS:Mn ELECTROLUMINESCENT CHARACTERISTICS.** We present a discussion of the brightness-voltage (B-V) response of thin-film electroluminescent (TFEL) devices prepared by the simultaneous evaporation of ZnS

and Mn (or MnS) using two separate sources. Crystal structure, threshold voltage, saturation brightness, and memory margin of the B-V characteristics have been studied as a function of the deposition rate of dopant material relative to ZnS. Optimum annealing conditions of the devices are also given. These results indicate that co-evaporation can be advantageously employed to fabricate memory TFEL display devices with excellent characteristics. (Author abstract) 14 refs.

Fuh, A. (Ontario Research Foundation, Mississauga, Ont, Can); Gallinger, R.P.; Caporaletti, O. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 1060-1063.

## Vapor Deposition

**095654 USE OF ETHYLIODIDE IN PREPARATION OF LOW-RESISTIVITY N-TYPE ZnSe BY METALORGANIC VAPOR PHASE EPITAXY.** Ethyl iodide is shown to be useful as a dopant for growing high-quality n-type ZnSe layers by metalorganic vapor phase epitaxy. Low-resistivity ZnSe single-crystal layers with  $\rho < 0.002 \Omega \cdot \text{cm}$  and  $n > 10^{19} \text{ cm}^{-3}$  have been grown on (100) GaAs substrate. The grown layers, with an appropriate doping level ( $n$  approximately  $10^{18} \text{ cm}^{-3}$ ), show a strong blue near-band-edge photoluminescence at room temperature. The emission intensity from the layer is several hundred times stronger than that from the undoped ZnSe. (Author abstract) 7 refs.

Shibata, Noriyoshi (NTT, Tokai, Jpn); Ohki, Akira; Zembutsu, Sakae. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 251-253.

**095655 PHOTOLUMINESCENCE DUE TO LATTICE-MISMATCH DEFECTS IN HIGH-PURITY ZnSe LAYERS GROWN BY METALORGANIC VAPOR PHASE EPITAXY.** High-purity ZnSe layers grown by metalorganic vapor phase epitaxy exhibit an unusually strong luminescence band at 2.60 eV (Y band), which is extremely sensitive to residual impurity concentration. Y emission depends on the lattice mismatch between the epilayer and substrate. The emission decreases with the use of a lattice-matched In<sub>x</sub>Ga<sub>1-x</sub>As substrate. With the GaAs substrate, the emission intensity varies with layer thickness reflecting lattice relaxation in the ZnSe/GaAs structure. (Author abstract) 9 refs.

Shibata, Noriyoshi (NTT, Tokai, Jpn); Ohki, Akira; Zembutsu, Sakae; Katsui, Akinori. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 441-443.

**095656 THERMOELASTIC STRAIN IN ZnSe FILMS GROWN ON GaAs BY METALORGANIC VAPOR PHASE EPITAXY.** It has been observed that ZnSe lattices grown on (100) GaAs by metalorganic vapor phase epitaxy deform as growth temperature increases. The lattice parameter variation corresponds to calculated thermoelastic strain due to a mismatch in the thermal expansion coefficient between ZnSe and GaAs. In-plane tensile strain in ZnSe films is found to cause a spectral position shift in photoluminescence to longer wavelengths with increasing growth temperature. This shift can be explained by the dependences of energy gap variation on thermoelastic strain. (Author abstract) 12 refs.

Shibata, Noriyoshi (NTT, Tokai, Jpn); Ohki, Akira; Zembutsu, Sakae; Katsui, Akinori. *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 487-489.

**095657 OMVPE OF Zn-BASED II-IV SEMICONDUCTORS USING METHYLMERCAPTAN AS A NOVEL SULFUR SOURCE.** The use of a novel sulfur source, methylmercaptan, CH<sub>3</sub>SH (MSH), for OMVPE growth of ZnS and Zn(S,Se) has been developed for the first time. Gas-phase prereaction was not observed, and the growth temperature of ZnS was successfully reduced, compared with growth using dialkyl-compounds. Zn(S,Se) alloy epilayers lattice-matched to GaAs substrates had specular surface morphology, excellent crystallographic properties, and showed strong excitonic emissions but weak intensities of deep level emissions. (Author abstract) 12 refs.

Fujita, Shigeo (Kyoto Univ, Kyoto, Jpn); Isemura, Masashi; Sakamoto, Takao; Yoshimura, Naomichi. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 263-267.

**095658 EFFECTS OF LATTICE-MATCHED In<sub>x</sub>Ga<sub>1-x</sub>As SUBSTRATES ON ZnSe GROWTH BY METALORGANIC VAPOR PHASE EPITAXY.** Zinc selenide (ZnSe) epitaxial layers have been grown by metalorganic vapor phase epitaxy on lattice-matched In<sub>x</sub>Ga<sub>1-x</sub>As substrates with component values of  $x$  ranging from 0.034 to 0.047. It has been shown that a lattice mismatch reduction is essential for growing high-quality epilayers. Crystallographic properties of the layers are improved over those of ZnSe/GaAs structures. Intensities of excitonic emissions in the photoluminescence spectra increase with lattice matching. The energy position of the excitonic emission lines is almost constant for different thicknesses of the ZnSe layers. (Author abstract) 9 refs.

Shibata, Noriyoshi (NTT, Tokai, Jpn); Ohki, Akira; Nakanishi, Hideo; Zembutsu, Sakae. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 268-272.

**095659 GROWTH OF HIGH-QUALITY ZnSe BY MOVPE ON (100) ZnSe SUBSTRATE.** In this paper, we report the MOVPE growth of undoped ZnSe layers on (100) ZnSe substrates cut from ingots grown by iodine vapor transport. The purpose of the present paper is to show the effects of heat treatment of the substrates before growth under various atmospheres, on the morphological, crystallographic and photoluminescent properties, and the optimum cleaning procedure of the substrates to remove surface contaminants and oxide layers. 14 refs.

Yodo, T. (Nippon Sheet Glass Co, Toyosatomachi, Jpn); Koyama, T.; Yamashita, K. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 273-278.

**095660 EFFECT OF SUBSTRATE AUTODOPING ON MOVPE-GROWN ZnS<sub>1-x</sub>Se<sub>x</sub> AND ZnSe ANALYSIS BY PHOTOLUMINESCENCE (PL) AND SECONDARY ION MASS SPECTROMETRY (SIMS).** The effect of substrate outdiffusion on the optical properties and compositional integrity of high quality ZnSe and ZnS<sub>1-x</sub>Se<sub>x</sub> ( $0 < x < 1$ ) grown by atmospheric pressure metalorganic vapour phase epitaxy (MOVPE) was investigated by low temperature photoluminescence (PL) and secondary ion mass spectrometry (SIMS) depth profiling analyses. Substrate outdiffusion was found to occur in the ZnSe/GaAs and lattice mismatched ZnS<sub>1-x</sub>Se<sub>x</sub> ( $0 < x < 1$ )/GaAs systems but not appreciably in the ZnSe/Ge and lattice matched ZnS<sub>1-x</sub>Se<sub>x</sub> ( $x = 0.06$ )/GaAs as indicated by diffuse and abrupt compositional SIMS depth profiles respectively. Low temperature PL measurements indicated changes in the main excitonic recombination transitions for ZnSe/GaAs. In particular the emphasis changes from the I<sub>2</sub><sup>Ga</sup> donor bound exciton emission for thin layers to the I<sub>x</sub> native donor bound exciton emission for thicker layers. The I<sub>2</sub><sup>Ga</sup> donor bound exciton peak is also dominant in the lattice mismatched ZnS<sub>1-x</sub>Se<sub>x</sub> ( $0 < x < 1$ ). (Author abstract) 20 refs.

Maung, Nicholas (UMIST, Manchester, Engl); Williams, John O. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 629-633.

## Vibrations

**095661 HYDROGEN-INDUCED LOCALIZED VIBRATIONAL MODE IN PROTON IMPLANTED ZnSe SINGLE CRYSTALS.** Infrared transmission spectra of proton implanted ZnSe single crystals exhibit a localized vibrational mode at 2116 cm<sup>-1</sup> which is ascribed to Se-H bond vibrations. The dependence of the integrated absorption A of this mode on the proton fluence D follows the relation  $A \approx D^n$  with  $n=0.46$ . The results of ZnSe are compared with previous measurements



on proton implanted III-V compounds. (Author abstract) 9 refs.

Riede, V. (Karl-Marx-Univ, Leipzig, East Ger); Neumann, H.; Sobotta, H.; Ascheron, C.; Novikov, B.V. *Solid State Commun* v 61 n 2 Jan 1987 p 113-115.

## SEMICONDUCTOR COUNTERS See Also PARTICLE DETECTORS; PARTICLE DETECTORS—Radiation Damage; RADIATION DETECTORS.

### Accessories

**095662 C-V METER FOR SEMICONDUCTOR RADIATION DETECTORS.** A schematic diagram of a C-V meter for semiconductor detectors of nuclear radiation is proposed. The comparatively simple network ensures high accuracy at a low measuring signal level, good temperature stability, a wide range of measured capacity and stray capacity compensation. High voltage can be applied to the detector and its reverse current can be quite high. (Author abstract) 2 refs.

Mikhailov, M.A. (Inst for Nuclear Research & Nuclear Energy, Sofia, Bulg). *J Phys E* v 20 n 11 Nov 1987 p 1426-1427.

### Performance

**095663 TIME AND POSITION RESOLUTION OF A COAXIAL GERMANIUM DETECTOR BY THE LEAST-SQUARES FITTING OF THE WAVEFORM.** The time resolution of a coaxial Ge(Li) detector was improved by determining the time of interaction by a least-squares fitting of the digitized waveform. An FWHM of 14.6 ns was obtained for 122 keV  $\gamma$ -rays by a 42 mm-diameter detector. Position information was simultaneously obtained by this method. (Author abstract) 4 refs.

Toyoshima, Kouichi (Saga Univ, Saga, Jpn). *Jpn J Appl Phys Part 1* v 26 n 10 Oct 1987 p 1740-1744.

### Research

**095664 THICK AND LARGE ACTIVE AREA Si(Li) DETECTOR.** A 5-inch-diameter, 3-mm-thick silicon detector has been fabricated using a nondepleted grade crystal. The authors describe fabrication method and the characteristics of the device. From experimental data obtained with infrared light as well as a hadron beam, they conclude that a nondepleted grade silicon crystal will become applicable to radiation detectors as the result of the development of a suitable compensation technique. (Edited author abstract) 6 refs.

Miyachi, Takashi (Univ of Tokyo, Tokyo, Jpn); Ohkawa, Shoichi; Emura, Tsuneo; Nishimura, Makoto; Nitoh, Osamu; Takahashi, Kaoru; Kitamura, Shoichi; Kim, Yongcha; Abe, Takao; Matsuzawa, Hidemi. *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 307-310.

## SEMICONDUCTOR DEVICE MANUFACTURE

See Also ACTUATORS; ALUMINUM COMPOUNDS—Chemical Vapor Deposition; ELECTRON BEAMS—Applications; FILMS—Dielectric; FURNACES, ELECTRIC—Diffusion; INTEGRATED CIRCUIT MANUFACTURE—Laser Applications; INTEGRATED CIRCUIT MANUFACTURE—Vacuum Applications; INTEGRATED CIRCUITS—Computer Aided Design; PARTICLE SIZE ANALYSIS; RESISTORS—Thick Films; SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers; SEMICONDUCTING GALLIUM ARSENIDE—Performance; SEMICONDUCTING SILICON—Manufacture; SEMICONDUCTING SILICON—Oxidation; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES—Protection; SEMICONDUCTOR DEVICES, CHARGE COUPLED—Microscopic Examination; SEMICONDUCTOR MATERIALS—Etching; SEMICONDUCTOR MATERIALS—Growth; SEMICONDUCTOR MATERIALS—Ion Implantation; SEMICONDUCTOR MATERIALS—Thin Films; SILICA—Impurities; SILICA—Ion Implantation; SOLAR CELLS—Silicon; THYRISTORS—Electronics Packaging; TRANSISTORS, BIPOLAR—Processing; TRANSISTORS, FIELD EFFECT—Electric Properties; WATER POLLUTION.

**095665 PLASMA ETCHING IN SEMICONDUCTOR FABRICATION.** This book reviews and reports on research studies of plasma etching used in the fabrication

of semiconductor devices. The etching characteristics of materials widely used in device fabrication, such as silicon, silicon dioxide, photoresist and aluminum films, have been given most attention. An extensive review is made of etching mechanisms in halogenated plasmas and of reactor architecture. The book provides process information and an introduction to plasma generation, probe theory and photoresist chemistry. Details are given of plasma etching processes and the effects of changes of such parameters as rf applied frequency, gas flow, gas pressure and oxygen/hydrogen additions. The work is based on the original thesis submitted to the University of Sussex for a post-graduate degree and is presented as a book for more widespread interest.

Morgan, Russ A. (Univ of Sussex, Brighton, Engl). *Plasma Etching in Semicond Fabr* Publ by Elsevier (Plasma Technol, v 1), Amsterdam, Neth and New York, NY, USA, 1985 316p.

**095666 PROSPECTS FOR DEVELOPMENT OF HEAVY-CURRENT SEMICONDUCTOR DEVICES.** The state of the art and immediate prospects for development of basic classes of discrete heavy-current semiconductor devices are discussed. The limiting characteristics that have now been achieved for devices based on silicon, gallium arsenide, and silicon carbide are cited. (Author abstract) 13 refs.

Grekhov, I.V. *Sov Electr Eng* v 57 n 8 1986 p 1-5.

**095667 EFFECT OF POLYSILICON GATE PATTERN/DOPING SEQUENCE ON GATE OXIDE DEGRADATION.** This work was done to determine the extent to which gate oxide degradation could be prevented by doping the polysilicon before patterning, thus eliminating the edge effect during the doping process. That is, dope the polysilicon before patterning. Such a process would have utility in cases where the doping level or type is different in the gate as opposed to the source/drain and could therefore be done before patterning the gate. Capacitor yields were investigated in this regard to show the extent to which they were affected by the doping/patterning sequence. Benefits were achieved by patterning the polysilicon after the doping process. 9 refs.

Taylor, Martin A. (Motorola Inc, Phoenix, AZ, USA); Flowers, Dervin L.; Cosway, Richard. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2935-2937.

**095668 SELF-ALIGNED CONTROLLED COLLAPSE CHIP CONNECT (SAC4).** The authors have developed a self-aligned controlled collapse chip connect (SAC4) scheme for the precise positioning of device chips on a Si interconnect wafer, which has the following advantages: (i) The self-alignment is maintained in all three dimensions so that the chip to wafer spacing is established lithographically instead of depending on the critical control of the solder collapse. (ii) Patterning in the active area on both the chip and the wafer is planar with no inherent steps or gaps to be bridged. (iii) Because of the precise control of the chip to wafer distance, there can be direct access to any spot on a chip for I/O solder pads eliminating the need to bring all I/O pads to the chip edge which is implicit in the C4 scheme. This scheme is not limited to Si devices and boards. 6 refs.

Pfeiffer, L. (AT&T Bell Lab, Murray Hill, NJ, USA); West, K.W.; Wong, Y.H. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2940-2941.

**095669 DEPOSITION AND SINTERING OF PARTICLE FILMS ON A RIGID SUBSTRATE.** Experimental techniques for the deposition and sintering of ceramic particle films on a rigid substrate have been investigated. Three representative systems ( $\text{SiO}_2$ ,  $\text{ZnO-Bi}_2\text{O}_3$ , and  $\text{Al}_2\text{O}_3$ ) were chosen to determine the validity of the conceptual processing model. Crack-free, sintered films were produced using single or multiple deposition/sintering cycles. (Edited author abstract) 12 refs.

Garino, Terry J. (MIT, Cambridge, MA, USA); Bowen, H. Kent. *J Am Ceram Soc* v 70 n 11 Nov 1987 p C.315-C.317.

**095670 FLUID DYNAMIC PROBLEMS IN THE SEMICONDUCTOR INDUSTRY.** In the semiconductor industries, control of the manufacturing environment has become important because of rapid changes in device miniaturization and the utilization of wafers with large diameters. New problems have arisen, such as how to prevent minute dust particles from diffusing over wafers, or how to form thin films with a uniform thickness over large area wafers. To cope with such problems, the establishment of new analytical and control techniques is required. This report discusses various fluid dynamic problems involved with semiconductor fabrication. These problems are compared with situations treated with conventional fluid dynamic approaches. Our discussion focuses on (1) analysis of the air flow in clean rooms and inside semiconductor manufacturing apparatus, (2) predicting the thickness of a film formed on a wafer, (3) analysis of the behavior of dust particles in air flows with different levels of pressure, and (4) applicable methods to measure particle size and motion. (Edited author abstract) 21 refs.

Kobayashi, T. (Univ of Tokyo, Jpn); Kobayashi, S.; Kobayashi, J. *J Fluid Control* v 17 n 4 1987 p 20-37.

**095671 EFFECTS OF CONTAMINATION ON SEMICONDUCTOR MANUFACTURING YIELD.** The challenges associated with controlling particulate and chemical contamination to achieve high semiconductor device yields are demonstrated with data showing the influence of cleanroom air, semiconductor processes and tools, gases, chemicals, and DI water. Because typical film thicknesses are much smaller than pattern feature sizes, defects that are as small as one hundredth of the lithographic dimension must be controlled. Scaling device dimensions by a factor of 1/3 to 1/2 will require almost a factor of 10 reduction of particulate levels in order to maintain the prescaling yield. To achieve a 78 percent yield of (0.25 defects/cm<sup>2</sup>) in a typical submicron, process containing 250 process steps, each step must contribute no more than 0.001 killer defects/cm<sup>2</sup> on average. Storage of wafers for 1 hr in a Class 1 vertical laminar flow cleanroom is sufficient to reach this level. Considerably more defects are introduced in other process steps involving automated tools or chemical/gas exposure. As device dimensions are reduced, the contamination associated with liquids will become relatively more important than that from gases and cleanroom air. (Author abstract) 67 refs.

Osburn, Carlton M. (North Carolina State Univ, Raleigh, NC, USA); Donovan, Robert P.; Berger, Henry; Jones, Gary W. *J Environ Sci* v 31 n 2 Mar-Apr 1988 p 45-57.

**095672 SILO ISOLATION TECHNIQUE: A STUDY OF ACTIVE AND PARASITIC DEVICE CHARACTERISTICS WITH SEMI-RECESSED AND FULLY-RECESSED FIELD OXIDES.** A typical NMOS process with Sealed Interface Local Oxidation (SILO) technology as the device isolation technique was used to fabricate active and parasitic devices. The electrical characteristics are presented. The influence of the boron channel stop lateral diffusion into the active region on the narrow channel effect, the effective channel width, and the subthreshold current is discussed. The low leakage current of the subthreshold characteristics demonstrates the integrity of the isolation technique. Electrical measurements on N+P diodes with different perimeters reveal a weak defect generation during field oxidation. The results indicate that the fully-recessed SILO process is capable of replacing the conventional LOCOS technique in the micron and submicron technologies, with advantage in the planarity of the isolation process. (Author abstract) 17 refs.

Coppee, J.-L. (Univ Catholique de Louvain, Louvain-La-Neuve, Belg); Van de Wiele, F. *Solid State Electron* v 31 n 5 May 1988 p 887-891.

**095673 FABRICATION OF NANOMETER WIDTH GaAs/AlGaAs AND InGaAs/InP QUANTUM WIRES.** Starting from GaAs/AlGaAs and InGaAs/InP quantum well structures, we have produced quantum wires with



lateral dimensions down to 30 nm, using direct electron beam writing and several dry etching techniques. Investigating the photoluminescence efficiency of wire structures as a function of the linewidth, we find a steep decrease with decreasing linewidth in the case of the GaAs/Al-GaAs system, whereas for InGaAs/InP the decrease is much smaller. This luminescence decay can be interpreted as a result of the surface recombination at the sidewalls, which gains growing influence with decreasing linewidth. (Author abstract) 10 refs.

Maile, B.E. (Univ Stuttgart, Stuttgart, West Ger); Forchel, A.; German, R.; Menschig, A.; Streubel, K.; Scholz, F.; Weimann, G.; Schlapp, W. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microlithogr, Jouy-en-Josas, Fr, Sep 22-25 1987 p 163-168.

**095674 NATURE OF TITANIUM-CONTAINING FILMS FORMED ON POLYMER SURFACES BY REACTIONS OF SORBED WATER WITH  $TiCl_4$ .** This paper reports the reactions of gaseous  $TiCl_4$  with various polymers equilibrated at 50% and 0% RH. The reactions were studied using thickness measurements,  $O_2$  RIE rates, Rutherford backscattering spectroscopy (RBS) and X-ray photoelectron spectroscopy (XPS). The results show that at 0% RH, hydrophilic polymers such as hard-baked HPR-206 resist (HB206) have very little ( $< 2 \times 10^{14}$  atoms/cm<sup>2</sup>) Ti at the polymer surface and are readily etched by  $O_2$  RIE. In contrast, hydrophobic polymers such as polystyrene (PS) react readily with  $TiCl_4$  to give a measurable thickness increased, are etched at a reduced  $O_2$  RIE rate and appear to have Ti distributed throughout the film. (Edited author abstract) 13 refs.

Stillwagon, L.E. (AT&T, Murray Hill, NJ, USA); Vasile, M.J.; Baiocchi, F.A.; Silverman, P.J.; Taylor, G.N. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microlithogr, Jouy-en-Josas, Fr, Sep 22-25 1987 p 381-392.

**095675 USE OF ORGANOSILICON POLYMERS IN MULTILAYER PLASMA RESIST PROCESSING.** The unique resistance of organosilicon polymers to oxygen plasmas has led to their widespread use in multilayer resist processing. A study of their etching properties shows a correlation between their structure and etching characteristics. Often, these characteristics are obtained by means of laser interferometric techniques. Using a model of this laser signal we have identified various processes which combine to form an oxygen plasma resistant layer atop these organosilicon polymers. In particular, we have discovered that the etching characteristics of these polymers are relatively independent of the specific structure. Rather, the silicon content of these polymers plays the dominant role in providing resistance to these plasmas. For polymers having a high silicon content, the laser signal is regular and sinusoidal; for lower concentrations ( $< 10\%$ ), the laser signal shows irregularities which can be explained by means of the model. (Edited author abstract) 9 refs.

Paraszczak, J. (IBM, Yorktown Heights, NY, USA); Babich, E.; McGouey, R.; Heidenreich, J.; Hatzakis, M.; Shaw, J. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microlithogr, Jouy-en-Josas, Fr, Sep 22-25 1987 p 453-460.

## Chemical Vapor Deposition

**095676 HAZARDOUS GAS CONVERSION EFFICIENCY USING DYNAMIC FLAME COMBUSTION.** This article discusses dynamic flame combustion, which utilizes state of the art technology for hazardous waste gas disposal. The gas conversion efficiency of the system when tested using silane, phosphine and arsine gases is shown. (Author abstract) 7 refs.

Thomson, Mariste (Hoechst Celanese Corp, Sunnyvale, CA, USA). *Solid State Technol* v 31 n 2 Feb 1988 p 93-97.

**Cleaning** See INTEGRATED CIRCUIT MANUFACTURE—Cleaning.

## Computer Aided Manufacturing

**095677 LOW-THERMAL-BUDGET PROCESS MODELING WITH THE PREDICT COMPUTER PROGRAM.** Low-thermal-budget processing models have been developed that are applicable to a broad range of ion-implantation and annealing conditions. The cases discussed here include low-temperature furnace annealing of B implants, preamorphization or postamorphization using  $Si^+$  or  $Ge^+$  implants, and rapid thermal annealing of low-dose and high-dose implants. Annihilation of implant damage is accounted for through activated annealing models. Damage type and location in depth are important in understanding enhanced or retarded diffusion of dopants. Damage and diffusion models have been incorporated in the PREDICT program, and example calculations are compared with measurements. 28 refs.

Fair, Richard B. (Microelectronics Cent of North Carolina, Research Triangle Park, NC.). *IEEE Trans Electron Devices* v 35 n 3 Mar 1988 p 285-293.

## Computer Applications

**095678 MAP/SECS NETWORK FOR AUTOMATED SEMICONDUCTOR MANUFACTURING.** Although it boasts some of the world's most sophisticated equipment, the semiconductor industry has only recently begun to prepare for implementation of communication networks on the factory floor. This paper discusses an investigation under the auspices of SEMI (Semiconductor Equipment and Materials Institute) which has the semiconductor industry looking to MAP to satisfy its communication needs.

Moyne, James (Univ of Michigan, Ann Arbor, MI, USA); Birchak, John; McAfee, Leo; Brehm, Frederic. *Gateway* v 4 n 3 May-Jun 1988 p 20-23.

## Computer Simulation

**095679 MICROCOMPUTER SIMULATION IMPROVES PRODUCTION SCHEDULING FOR MICROELECTRONICS MANUFACTURERS.** A simulation model was designed and implemented with the purpose of improving the scheduling, control, and production management of the manufacturing line for a medium size silicon wafer manufacturer. The simulation model was designed to be interactive on a microcomputer, easily adaptable to other similar manufacturing environments, and readily usable at various decision levels ranging from manufacturing floor supervisors to upper management. It can easily interface with other decision analysis packages to assist in a variety of decision processes throughout the plant. (Edited author abstract) 19 refs.

Economides, Spyros (California State Univ, Hayward, CA, USA); Cunningham, Frank. *J Manuf Syst* v 6 n 4 1987 p 267-275.

**095680 MULTIPLE-ZONE SINGLE-MASK JUNCTION TERMINATION EXTENSION - A HIGH-YIELD NEAR-IDEAL BREAKDOWN VOLTAGE TECHNOLOGY.** The junction termination extension (JTE) technique is investigated by computer simulation and experimentally. A multiple-zone JTE can be fabricated with a well-controlled single ion-implantation through a single mask with laterally variable transparencies. Analog I-V trace records of over 40,000 samples were obtained for analysis. By grouping 49 JTE designs on separate regions of the wafer, the effects of the JTE variations and the material variations are separated. The measured JTE performance agrees well with the computer results. A multiple-zone JTE of sufficient size achieves an essentially ideal breakdown voltage unaffected by even a factor of two in ion-implant dose variations. The JTE performs well on both p-type and n-type wafers. A best design has been applied to several lots of power devices, and a yield of 99.5% having breakdown-voltage values within 10% of the ideal has been obtained. 6 refs.

Tantraporn, Wirojana (GE, Schenectady, NY, USA); Temple, Victor A.K. *IEEE Trans Electron Devices* v ED-34 n.10 Oct 1987 p 2200-2210.

**Contamination** See Also INTEGRATED CIRCUIT MANUFACTURE—Contamination; SEMICONDUCTING SILICON.

**095681 ULTRA-PURE WATER FOR THE SILICON CHIP INDUSTRY.** The author attempts to define and explain the constraints placed on the species and levels of impurities in ultra-pure water and to suggest how they may vary in the future. Turning to the contaminants, they are categorised. The contaminants include ionic species, organics, particulates, bacteria and pyrogens. The design of a very clean water distribution system is given.

McCartney, Bill (Motorola Semiconductor Div, East Kilbride, Scotl). *Chem Eng (London)* n 432 Jan 1987 p 24-26.

**095682 CLEANING A CLEANROOM.** The authors examine cleaning methods and solutions. The ideal solutions for removal of particles and chemicals are outlined along with the properties of commonly used disinfectants. Methods for cleaning a cleanroom are presented. Antistatic agents are also discussed. 2 refs.

Whyte, W.; Donaldson, Norman. *Microcontamination* v 5 n 11 Nov 1987 p 49-53.

**095683 TREND TOWARD CLASS 10 - 100 CLEANROOMS CHALLENGES CONSTRUCTION CONTRACTORS.** The purpose of this study is to highlight some of the difficulties and trends in the cleanroom construction industry. Overall, the underlying trend is toward additional and cleaner space, but in smaller segments. This is seen in a variety of circumstances. First, both small and large companies are planning or contemplating additional space. The smaller end-user is more often considering space at a higher particle level; the larger company, particularly in the microelectronics industry, is looking at cleaner space (Class 100 or better). The various stages of cleanroom construction are examined. It is shown that the construction of the cleanroom interior can be achieved only by using proven cleanroom construction techniques and quality control measures. Since this fact is becoming better known within the industry, owners are adjusting their approach to cleanroom construction services.

Baillargeon, Paul (Environmental Interiors Inc, Hudson, NH, USA). *Microcontamination* v 6 n 7 Jul 1988 p 26-32.

**095684 SUPER CLEANROOM TECHNOLOGY: A HIGH-TECH BALANCING ACT.** Results are presented of recent air filtration and airflow control technology R&D, both of which are key factors in super cleanroom design. Total uniform downflow and clean tunnel flow are discussed. The super cleanroom (SCR) system is outlined. The SCR system is an example of the new technologies being applied to the actual designing and engineering of super cleanrooms in semiconductor facilities. The ability to pretest cleanroom components and to simulate particular cleanroom setups or conditions prior to engineering and construction is a major advantage of the cleanroom laboratory facility. To maintain back-end price competitiveness and reliable production, two key requirements of future cleanroom systems will be localization of super-clean spaces and automation of wafer handling.

Suzuki, Yoshinobu (Shimizu Corp, Tokyo, Jpn); Oikawa, Susumu; Sekiguchi, Takeshi. *Microcontamination* v 6 n 9 Sep 1988 p 59-65.

**095685 IS THERE A LIGHT AT THE END OF THE TUNNEL?** The author outlines factors that need to be considered when determining the type, properties and materials that are suitable for cleanroom garments. Garment function, fabric evaluation are examined along with garment drying and evaluation. It is shown that there is no question that the PTFE material is best in terms of low particle shedding. However, PTFE garments are



expensive, and users will have to determine whether the difference between the nonwoven polyolefin and the PTFE is cost effective. The best of garments will be of limited value if the masks, gloves, and head coverings are not properly designed and used. It might be possible to improve the performance of the woven polyester garment by providing a small battery-driven suction blower to remove hot air and moisture. 5 Refs.

Hoenig, Stuart A. *Microcontamination* v 6 n 9 Sep 1988 p 18,20-24.

## Doping

**095686** AVTOMATIZIRANO DOLOCANJE IMPLANTACIJSKEGA PROFILA S CU METODO. [Automatic CV Measuring Technique for Ion Implanted Profiles]. An automatic on-line capacitance-voltage (CV) doping profile measuring technique is described, that allows measurements of concentration profiles in depths below the silicon surface greater than 2 Debye lengths. Despite its limitations, which are described, the method allows characterization of water fabrication processes during implantation. (Edited author abstract). 4 Refs. In Slovenian.

Belic, Andrej; Osredkar, Radko. *Elektroteh Vestn* v 55 n 1 Jan-Mar 1988 p 21-23.

**Encapsulation** See SEMICONDUCTOR MATERIALS—Encapsulation.

**Equipment** See Also INTEGRATED CIRCUIT MANUFACTURE—Contamination.

**095687** WAFER FABRICATION EQUIPMENT FIVE YEAR FORECAST. Concerning year-to-year trends for the industry as a whole, the five-year forecast in January 1988 is fundamentally the same as the picture presented last January. We had expected the turnaround in wafer fab equipment to occur earlier than it actually appeared, and we had predicted a 14 percent increase in 1987 spending for front end equipment. Because of the delayed turnaround, it looks like 1987 spending will actually be up about 5 percent. Last year we projected strong growth for the years 1988-1991 with the exception of a low growth period in 1989. At present we see no fundamental change in this scenario. Indeed, our optimistic five year forecast stands on even firmer ground this January. The semiconductor industry has emerged from its recession, the slack in capacity is being taken up and, in fact, new capacity has to be added to meet the world's voracious appetite for semiconductor devices.

Grenier, Joseph. *Solid State Technol* v 31 n 1 Jan 1988 p 67-70.

**095688** INFRARDECE ZGANJE DEBELOPLASTNIH MATERIALOV. [Infrared Firing of Thick Film Materials]. Thick film conductors and resistors were fired in an infrared belt furnace. Sheet resistivities of conductors were similar to resistivities of samples, fired in a 'conventional' belt furnace while the adhesion strength, measured by a peel test, was lower. Sheet resistivities of IR fired resistors were different and TCRs higher than those of 'conventional' fired resistors while the resistivity drift of aged resistors was similar. With different times at the highest temperature the TCRs can be optimized. (Edited author abstract). 8 Refs. In Slovenian.

Hrovat, Marko (Inst Jozef Stefan, Ljubljana, Yugoslavia); Belavic, Darko; Jan, Franc; Plevnik, Franc; Klemencic, Peter. *Elektroteh Vestn* v 55 n 1 Jan-Mar 1988 p 53-57.

**Etching** See Also PLASMAS—Etching; SEMICONDUCTING SILICON—Etching; TRANSISTORS, FIELD EFFECT—Contacts.

**095689** PRELIMINARY INVESTIGATION OF THE CONTAMINATION OF SEMICONDUCTOR PROCESS PUMP OIL BY HALOGENATED ORGANIC COMPOUNDS. Plasma etching is the controlled, preferably uniform, removal of layers of the material from a silicon wafer. In a plasma etcher, the wafers are placed in a vacuum with a controlled flow of

process gases. The mixture of process gases is irradiated with radio frequency radiation, usually at 13.56 MHz. Upon irradiation with the rf energy, the process gases are converted to a plasma, 'an ionized gas containing neutrals, ions and electrons'. There are many types of vacuum oils currently used in the semiconductor industry, including the perfluoroalkyl-polyethers (PFAPE) and the perfluoropolyethers (PFPE), which were the oils investigated in this paper. The chemistry of the vacuum oil decomposition and contamination is an area which requires further investigation due to the potential for worker exposure during pump maintenance. This paper reports on a study to determine the identity and quantity of organic vacuum oil contaminants in used plasma etch process pump oils. 13 refs.

Strang, C.R. (AT&T Technologies, Summit, MO, USA); Levine, S.P. *Solid State Technol* v 30 n 4 Apr 1987 p 69-70.

**095690** ANHYDROUS HF ETCHING OF NATIVE SiO<sub>2</sub>: APPLICATIONS TO DEVICE FABRICATION. A gaseous anhydrous HF/water vapor process has been developed that etches native oxide films at ambient temperature and pressure, without plasmas, and without the need for a subsequent rinse/dry. It is an isotropic etch with properties similar to a wet HF process. Using high purity gases and components, particles are controlled to levels that are known to obtain hydrophobic surfaces. Metallic impurities are not added by this process, but neither are they significantly reduced since volatile species are not formed at this temperature. The process can be used in applications where there is a need to remove the native oxide of silicon and where it is presently done with diluted HF dip and a rinse/dry. 16 refs.

Novak, Richard E. (FSI Int Inc). *Solid State Technol* v 31 n 3 Mar 1988 p 39-41.

**095691** CONTROLLED UNDERCUTTING OF V-GROOVE CHANNELS FOR INP BY PHOTORESIST ETCH MASK. A photoresist etch mask process has been developed for the etching of v-grooves in InP (001) for channelled substrate laser growth. The relationship between the photoresist (PR) mask undercutting and the dehydration bake temperatures, the postbake temperatures, and the photoresist thicknesses were studied. The native oxide growth during the bake processes was believed to give the extra large undercut. (Author abstract) 14 refs.

Huo, D.T.C. (AT&T Bell Lab, Murray Hill, NJ, USA); Wynn, J.D.; Napholtz, S.G.; Wilt, D.P. *J Electrochem Soc* v 135 n 5 May 1988 p 1231-1234.

**High Temperature Effects** See SEMICONDUCTING SILICON—Stresses.

**Inspection** See IMAGE PROCESSING—Industrial Applications.

## Ion Implantation

**095692** HIGH ENERGY ION IMPLANTATION. Still limited to R&D at all but a handful of companies, high energy ion implantation is emerging as powerful technique for implanting dopants 2 μm or more below the wafer surface. In the fabrication of deep CMOS wells, for example, high energy ion implantation is much more efficient than the traditional pre-dep and drive-in, and can also produce retrograde wells. The ability to produce such wells, where the doping concentration increases from the value at the surface to a peak below the device region, is significant, since such wells strongly reduce the susceptibility to latch-up. 13 refs.

Singer, Peter H. (Semiconductor Int, Newton, MA, USA). *Semicond Int* v 10 n 10 Sep 1987 p 92-96.

## Ion Sources

**095693** FURTHER IMPROVEMENTS IN END POINT DETECTION USING A WIDE ANGLE ION BEAM SOURCE. In the fabrication of multilayer or hybrid semiconductor devices, it is often necessary for

connections to be made vertically through the structure to predetermined depths and at precise locations on the device. This paper outlines the improvements in end point detection resolution that can now be achieved with the development of an axial filter and the inclusion of a particle counter to increase sensitivity. (Author abstract).

Dean, A.B. (RSREE, Malvern, Engl); Heath, M.; Brayford, M. *Vacuum* v 38 n 6 1988 p 499-502.

**Laser Applications** See Also CHEMICALS—Laser Applications.

**095694** LASER-BEAM-INDUCED RECRYSTALLIZATION OF SILICON AND ITS APPLICATION TO SILICON-ON-INSULATOR TECHNOLOGY. In this approach to semiconductor device fabrication technology a thin film of polycrystalline silicon deposited on an insulating substrate is converted to a uniform monocrystalline layer by means of laser-induced micro-zone melting. By control of experimental conditions it is possible to obtain device-quality dielectrically-isolated thin films of silicon. The defects normally found in the recrystallized material are periodic arrays of dislocations forming low-angle subgrain boundaries. The origin and control of these defects, which have only minor effects on the majority-carrier transport properties, are described. The properties of MOS transistors fabricated in this material are comparable to those of devices fabricated in single-crystal silicon wafers. (Edited author abstract) 34 refs.

Arnold, E. (North American Philips Corp, Briarcliff Manor, NY, USA); Baumgart, H.; Khan, B.; Ramesh, S. *Philips J Res* v 42 n 3 1987 p 253-280.

**095695** LASER DEPOSITION OF SEMICONDUCTORS FROM GAS MEDIUM PHASE. The possibility of initiating and controlling heterogeneous chemical processes of Si, Fe deposition onto the semiconductor surfaces by the pyrolytic action of IR laser radiation is experimentally investigated. (Author abstract) 5 refs.

Karlov, N.V.; Lukyanchuk, B.S.; Sisakyan, E.V.; Shafiev, G.A. *Bull Acad Sci USSR Phys Ser* v 51 n 6 1987, Proc of an All-Union Symp on Nonequilibrium Physicochem Processes in the Interact of Laser Radiat with Matter, Tashkent, USSR, Jun 1986 p 160-164.

**Materials** See Also INTEGRATED CIRCUIT MANUFACTURE—Optimization; SEMICONDUCTING SILICON COMPOUNDS—Chemical Vapor Deposition.

**095696** CONTROLLING COSTS IN CHEMICAL DISTRIBUTION SYSTEMS. The author discusses the cost advantages of purchasing chemicals in 55-gallon drums or even larger tanker-truck bulk loads instead of the standard one-gallon glass or polyethylene bottle. A typical front-end facility operating at 2500 four-inch wafer starts a week could realize potential savings of more than \$1500 a day in direct product cost savings and related labor expenditures by purchasing chemicals in 55-gallon drums. Savings would be even more impressive when factoring in tanker-truck bulk load prices. The major disadvantages of using bottles are discussed. The use of low-particulate chemicals in the semiconductor industry is increasing, although the cost of the submicron-filtered, prepackaged chemicals has limited their use in high volumes. Low-particulate materials generally are priced at two to three times the cost of semi-grade materials. However, equipment has recently been developed that totally eliminates the need for bottles. Instead, a continuous pipeline carries chemicals from the supplier to the wafer using fluoropolymer piping, baths, and wafer carriers.

Castellano, Robert N. (Information Network, San Francisco, CA, USA). *Microcontamination* v 5 n 11 Nov 1987 p 30, 32, 34.

**095697** WAFER PROCESSING AND MATERIALS. Despite the recent severe downturn in the semiconductor industry, improvements in device, circuit and process technologies have accelerated over the last two years.



Examples of this remarkable progress are milestones of the recent past and harbingers for the immediate future. This forecast article is limited to major trends and changing requirements, over the next five years, in the mainstream of semiconductor manufacturing, and to related materials and equipment issues; we focus on the areas of greatest need or opportunity. Our premise is: What modifications and innovations will likely continue or follow from changes in device and integrated circuit (IC) structures?

Kopp, Robert J. (Kopp Semiconductor Engineering, Albuquerque, NM, USA). *Semicond Int* v 11 n 1 Jan 1988 p 44-47.

**095698 CONTINUOUS MONITORING OF GASEOUS CARBON IMPURITIES IN ELECTRONIC-GRADE BULK GASES.** This article first gives a brief overview of current monitoring techniques, and it then describes a new method for monitoring inert-gas purity with respect to CO, CO<sub>2</sub>, and hydrocarbons. The gas-purity monitoring technique described is particularly suitable for continuous monitoring of CO, CO<sub>2</sub>, and hydrocarbons. Since the catalyst has a high methanation activity and low metal and support-surface areas, CO and CO<sub>2</sub> are converted efficiently, with rapid response time achieved due to minimal product retention. This technique will enable semiconductor device manufacturers to record instantaneous variations in inert-gas purity that could not otherwise be monitored, and to do so with greater accuracy and reliability than are now possible. 2 refs.

Whitlock, Walter H. (BOC Group Inc, Murray Hill, NJ, USA); Tamhankar, Satish S.; LaCava, Alberto I. *Microcontamination* v 6 n 5 May 1988 p 43-45.

## Mathematical Models

**095699 EMPIRICAL EVALUATION OF A QUEUEING NETWORK MODEL FOR SEMICONDUCTOR WAFER FABRICATION.** The congestion problems that plague wafer fabrication facilities are described in general terms, and several years' operating data from one particular facility are summarized. A simple queueing network model of that facility is constructed, and the model is used to predict certain key system performance measures. The values predicted by the model are found to be within about 10% of those actually observed. These results suggest that queueing network models can provide useful quantitative guidance to designers of wafer fabrication facilities, and we discuss refinements and extensions of our elementary model that are likely to be important in other settings. An important benefit gained from queueing theory is that congestion and delay in wafer fabrication are caused by variability in the operating environment. (Edited author abstract). 24 refs.

Chen, Hong (Stanford Univ, Stanford, CA, USA); Harrison, J. Michael; Mandelbaum, Avi; Ackere, Ann Van; Wein, Lawrence M. *Oper Res* v 36 n 2 Mar-Apr 1988 p 202-215.

**Monitoring** See SEMICONDUCTING SILICON—Measurements.

**Polishing** See SEMICONDUCTING SILICON—Spectroscopic Analysis.

## Process Control

**095700 SPATIALLY RESOLVED ELLIPSOmetry FOR SEMICONDUCTOR PROCESS CONTROL: APPLICATION TO GaInAs MIS STRUCTURES.** A new assessment technique, a spectroscopic ellipsometry system with high lateral resolution (10×10 μm spot), is introduced. Its high surface sensitivity is used at each step of a typical technological process, the fabrication of GaInAs metal-insulator-semiconductor structures, namely oxide removal, etching, and dielectric deposition. The measured nonuniformity of the Si<sub>3</sub>N<sub>4</sub>/GaInAs interface quality over the wafer is directly correlated to the electrical characteristics of the devices. This is a direct proof of the influence of the native oxide at this interface upon the electrical drift of MIS structures. (Author abstract) 19 refs.

Erman, M. (Lab d'Electronique et de Physique Appliquee, Limeil-Brevannes, Fr); Renaud, M.; Gourrier, S. *Jpn J Appl Phys Part 1* v 26 n 11 Nov 1987 p 1891-1897.

**Production Control** See INVENTORY CONTROL—Scheduling; SCHEDULING—Mathematical Models.

**Quality Control** See INTEGRATED CIRCUIT MANUFACTURE—Quality Control.

## Quartz Applications

**095701 SILICON ON QUARTZ BY SOLID-STATE DIFFUSION BONDING (SSDB) TECHNOLOGY.** Silicon wafer and quartz have been successfully bonded together by a two-step thermal treatment process. SIMS measurements shows that after molecular surface activated solvent treatment, the amount of OH on the silicon or quartz surface, which is essential to the first step (low-temperature) bonding strength, is one order of magnitude higher than that on the original silicon or quartz surface. After a high-temperature (850-1250°C) solid-state diffusion process, the bonding strength between silicon and quartz is increased to 150-185 kg/cm<sup>2</sup>. The material and electrical properties of the silicon on quartz substrate compares favourably with those of the bulk silicon wafer. (Edited author abstract) 4 refs.

Xu, X.-L. (Nanjing Inst of Technology Nanjing, China); Zhan, J.; Tong, Q.-Y. *Electron Lett* v 24 11 May 26 1988 p 691-692.

**Reliability** See TRANSISTORS, BIPOLAR—Electric Properties.

**Research** See Also PHOTORESISTS; SEMICONDUCTING SILICON—Ion Implantation.

**095702 MASK FABRICATION BY USING AN ELECTRON BEAM RESIST, CHLOROMETHYLATED POLYSTYRENE, AND DRY ETCHING PROCESS.** The relation between electron beam sensitivity and resolution of chloromethylated polystyrene (CMS) was investigated with respect to molecular weight and dry etching characteristics of chromium thin films in a carbon tetrachloride/oxygen mixed gas plasma in a planar type reactor. The CMS of large molecular weight shows high sensitivity, 0.26 μC/cm<sup>2</sup>, to electron beam exposure and good resistance to dry etching under certain chromium etching conditions. Moreover, detecting the end point of chromium dry etching is possible by measuring the change of electrode voltage during the chromium etching. (Edited author abstract) 15 refs.

Saeki, H. (Mitsubishi Electric Corp, Itami, Jpn); Shigetomi, A.; Watakabe, Y. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3134-3138.

**Silicon on Sapphire Technology** See Also PHOTORESISTS—Applications; SEMICONDUCTING SILICON COMPOUNDS—Physical Properties; SEMICONDUCTOR DEVICES, MOS—Radiation Effects; TRANSISTORS, FIELD EFFECT.

**095703 SAPPHIRE - THE LEADING SOI TECHNOLOGY.** Marconi Electronic Devices (MEDL) in association with the GEC Hirst research centre has been carrying out parallel research programmes into SOI technologies for some years. The view from our vantage point is that the only viable SOI technology is Silicon on Sapphire. The reasoning behind this involves the merits of the fabrication process itself; good yields and competitive production costs are not yet available in other SOI techniques. The main considerations are the criteria for radiation resistance evaluated by the US Department of Defense for VHSIC (very high speed integrated circuits). The article is a short report on the new SOS technology products.

Mead, Dave (Marconi Electronic Devices); Hine, John. *New Electron* v 20 n 4 Feb 17 1987 p 35.

**095704 GROWTH AND PROPERTIES OF TIN AND TiO<sub>2</sub>N<sub>x</sub> DIFFUSION BARRIERS IN SILICON ON SAPPHIRE INTEGRATED CIRCUITS.** The usefulness of titanium nitride thin films deposited under

different sputter deposition conditions as a diffusion barrier in silicon-to-aluminum contacts was examined. In particular, the effect of oxygen in the barrier film was investigated. The films were r.f. sputter deposited from a titanium target in an Ar-N<sub>2</sub> or Ar-N<sub>2</sub>-O<sub>2</sub> gas mixture under varying conditions of applied d.c. substrate bias voltage. The variations in film oxygen content, resistivity, film stress and deposition rate are presented as functions of nitrogen and oxygen partial pressures, and applied substrate bias. The diffusion barrier properties of dark brown films (B films) deposited under no-bias conditions, bright golden films (G films) deposited under proper substrate bias, and oxygen-containing golden films (Ox films) were tested by Rutherford backscattering spectrometry and optical measurements at temperatures of 450-600°C. (Edited author abstract) 35 refs.

Kumar, N. (Drexel Univ, Philadelphia, PA, USA); Fissel, M.G.; Pourrezaei, K.; Lee, B.; Douglas, E.C. *Thin Solid Films* v 153 Oct 26 1987, Pap Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 287-301.

**South Korea** See SEMICONDUCTOR DEVICES—Marketing.

**Testing** See INSPECTION—Automation.

## United States

**095705 NATIONAL SECURITY AND THE SEMICONDUCTOR INDUSTRY.** Since 1979 the US share of world semiconductor market has been steadily dropping while that of Japan has been rising sharply and has now overtaken the US market share. Implications for the national security of the USA of the international collaboration in chip manufacture are discussed. The efforts made by the Sematech Corporation supported by DOD to recover America's lead in the microelectronics industry are described and evaluated.

Dallmeyer, Dorinda G. *Technol Rev* v 90 n 8 Nov-Dec 1987 p 47-52, 55.

**SEMICONDUCTOR DEVICE TESTING** See Also AUTOMATIC TESTING; INTEGRATED CIRCUITS—Microscopic Examination; MICROSCOPIC EXAMINATION—Scanning Electron Microscopy; SEALS—Leak Detection; SEMICONDUCTOR DEVICES—Reliability; SEMICONDUCTOR DEVICES, MOSFET—Performance; SEMICONDUCTOR DEVICES, MOSFET—Switching; SEMICONDUCTOR DIODES—Reliability; TRANSISTORS, FIELD EFFECT—Testing.

**095706 IN-PROCESS WAFER TEST AND MEASUREMENT.** Major investments in equipment development, traditionally directed toward improvements in wafer processing equipment, are increasingly going into development of instrumentation for better ways of monitoring and controlling wafer-processing production. The reasons for this trend are rooted in both economics and technology: Process control is cost-effective because it increases device yields and performance. It also enables semiconductor manufacturers to produce more complex integrated circuits that, in turn, require more process control.

Dey, Jim (Micro Image Techniques, Los Gatos, CA, USA). *Semicond Int* v 11 n 1 Jan 1988 p 52-55.

**095707 RING TESTING OF DISCRETE DEVICES IMPLEMENTING POLYNOMIAL FORMS.** A method for synthesis of systems for diagnostic testing is described. It is based on transformation of a discrete testing object into a follower or an automatic device. The functions of the objects are assumed to be expressed by polynomial forms. Self-testing offers a simple implementation of tests by software and hardware and a compact representation of tests and output responses of the discrete devices (DD) being tested. In addition, on the basis of polynomial forms of DD functions, diagnostic tools of self-testing can be constructed. This approach is used in the present paper. 8 refs.

Litkov, I.P. *Cybernetics* v 23 n 3 May-Jun 1987 p 395-401.



**Automatic Testing** See INTEGRATED CIRCUIT TEST-ING—Equipment.

**Computer Aided Analysis** See SEMICONDUCTOR DEVICES, MOSFET—Radiation Effects.

## Computer Interfaces

**095708 SMD TESTING: UPDATE ON DEVICE HANDLERS AND BOARD FIXTURES.** With surface-mounted devices (SMDs), engineers can design more functions into less space than ever was possible with so-called conventional components. The culmination of this technology is products with improved performance at lower costs. Design for testability is considered that forces the designer and the test engineer, closely working together, to develop a product that, quite simply, can be reliably and efficiently tested.

Anon. *Eval Eng* v 26 n 12 Dec 1987 7p between 26 and 40.

**Laser Applications** See SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Junctions.

**Nondestructive Examination** See SEMICONDUCTOR DEVICES, MOSFET—Nondestructive Examination; SEMICONDUCTOR DEVICES, MOSFET—Radiation Effects.

## Radiation Effects

**095709 DOSIMETRY AND TOTAL DOSE RADIATION TESTING OF GAAS DEVICES.** Damage to GaAs devices from energetic electrons is shown to rise rapidly above 600 keV. Therefore, methods of dosimetry that are more sensitive to low-energy electrons (i.e., that determine deposited energy rather than atomic displacement) could be inappropriate for GaAs. For example, a 1-MeV electron irradiation requires an order-of-magnitude lower dose (in rad) to cause the same degradation as a  $^{60}\text{Co}$  source in a GaAs FET. Such considerations are used by the authors to argue against the use of rad dose to define mission radiation requirements and laboratory source calibration for GaAs devices. 7 refs.

Meulenberg, A. (COMSAT, Clarksburg, MD, USA); Dozier, C.M.; Anderson, W.T.; Mittleman, S.D.; Zuglich, M.H.; Caefer, C.E. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1745-1750.

**Standards** See MICROELECTRONICS—Radiation Effects.

**Thermal Effects** See Also SEMICONDUCTOR DEVICES—Reliability.

**095710 THERMAL TRANSIENT TESTING OUT OF THE LAB AND INTO PRODUCTION.** It is a well known fact that junction operating temperature is one of the key factors in determining the operational life of a semiconductor device, as the thermal resistance from the junction to the case is affected most significantly by the die bond. The methods for monitoring the integrity of the die bond or die attachment evaluation (DAE) in production and techniques commonly used for production monitoring of DAE are considered.

Ribble, William A. (Sage Enterprises Inc, Mountain View, CA, USA). *Eval Eng* v 26 n 11 Nov 1987 p 150-151.

**SEMICONDUCTOR DEVICES** See Also AM-MONIA—Sensors; CARBON MONOXIDE—Sensors; CONTROL EQUIPMENT, ELECTRIC—Performance; ELECTRIC POWER SYSTEMS—Control; ELECTRONIC CIRCUITS, SWITCHING—Components; GALLIUM COMPOUNDS—Chemical Vapor Deposition; INFRARED DETECTORS—Performance; INTEGRATED CIRCUITS—Applications; INTEGRATED CIRCUITS, VLSI; INTEGRATED CIRCUITS, VLSI—Testing; LASERS, SEMICONDUCTOR—Modes; LASERS, SEMICONDUCTOR—Performance; LASERS, SEMICONDUCTOR—Resonators; LASERS, SEMICONDUCTOR—Tuning; LIGHT—Modulators; LITHOGRAPHY—Photolithography; LOGIC DEVICES—Performance; MEMBRANES; MICROWAVE DEVICES; MOLYBDENUM AND ALLOYS—Microstructure; PHOTODETECTORS; RADIATION DETECTORS—Performance; SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers; SEMICONDUCTING GALLIUM ARSE-

NIDE—Growth; SEMICONDUCTING GERMANIUM—Charge Carriers; SEMICONDUCTING INDIUM COMPOUNDS—Doping; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Charge Carriers; SEMICONDUCTING SILICON—Doping; SEMICONDUCTOR MATERIALS; SEMICONDUCTOR MATERIALS—Doping; SEMICONDUCTOR MATERIALS—Electric Conductivity; SEMICONDUCTOR MATERIALS—Ion Implantation; SENSORS—Performance; SYSTEMS SCIENCE AND CYBERNETICS—Neural Nets; TRANSDUCERS—Calibration; TRANSISTORS, FIELD EFFECT; TRANSISTORS, FIELD EFFECT—Mathematical Models.

**095711 QUERSCHLIFF-PRAEPARATION VON METALL-ISOLATOR-METALL DUENNSCHICHTKATHODEN FUER DIE HOCHAUFGELOESTE ABBILDUNG MIT DEM TEM.** [Cross-Sectional Preparation of MIM Systems]. Metal insulator metal (MIM) systems of thin layers are of interest in many applications and physical investigations. In this context it is important to dispose of exact statements on the composition of such systems and its change during activity. An important direct method producing such statements is the cross-sectional examination developed in the latest years based on the preparation of thin cross-sections by mechanical polishing and ion milling until the thickness of the central region of the specimens is reduced to electron transparency, and high resolution electron optical imaging becomes possible. We are describing a method of cross-sectional work which we have successfully applied to MIM systems. (Author abstract) In German. 2 refs.

Kienzer, M. (Univ Tuebingen, Reutlingen, West Ger); Nisch, W.; Joensson, C. *Optik (Stuttgart)* v 77 n 2 Sep 1987 p 62-66.

**095712 SPATIAL PIXEL CROSSTALK IN A CHARGE-INJECTION DEVICE.** An optical multichannel detector system based on a charge-injection device (CID) sensor has been designed and constructed. This system is intended for use in a variety of spectroscopic studies, including atomic emission spectrometry (AES), in the ultraviolet to near-infrared spectral region. A General Electric Co. CID11B was selected as the sensor because preliminary research indicated that this device has excellent characteristics for detection of the very wide dynamic range signals encountered in AES. During initial characterization of this detection system, a phenomenon was observed in which the signal obtained from reading a pixel of the array was affected by the quantity of charge in orthogonally located pixels. Investigations indicate that this spatial crosstalk effect is not caused by charge migration among pixels ('blooming') as in many other types of imaging detectors. (Edited author abstract) 19 refs.

Sims, Gary R. (Univ of Arizona, Tucson, AZ, USA); Denton, M. Bonner. *Opt Eng* v 26 n 10 Oct 1987 p 999-1007.

**095713 ENERGY-BAND OFFSET OF  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As-In}_{0.52}(\text{Ga}_{1-x}\text{Al}_x)_2$  48As HETEROSTRUCTURES, DETERMINED BY PHOTOLUMINESCENCE EXCITATION SPECTROSCOPY OF QUASI-PARABOLIC QUANTUM WELLS GROWN BY MBE.** The conduction-band discontinuity,  $\Delta E_c(x)$ , of the heterostructure was determined to be  $(0.73 \pm 0.03)\Delta E_g(x)$  ( $0 \leq x \leq 1$ ), by a comparison of the electron (and hole) energy levels in quasi-parabolic (multi-stepped) quantum wells observed by photoluminescence excitation spectroscopy, with numerical solutions of Schrodinger's equation, with non-parabolicity of the conduction band was considered. (Edited author abstract) 25 refs.

Sandhu, Adarsh (Fujitsu Lab Ltd, Morinosato-Wakamiya, Jpn); Nakata, Yoshiaki; Sasa, Sigehiko; Kodama, Kunihiko; Hiyanizumi, Satoshi. *Jpn J Appl Phys Part 1* v 26 n 10 Oct 1987 p 1709-1712.

**095714 CAPACITANCE-VOLTAGE CHARACTERISTICS OF P-N JUNCTION OF THE NARROW BAND-GAP SEMICONDUCTORS  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$ .** The measuring technique of capacitance is improved so that the capacitance of P-N junction with low resistance can be made. The measurements of the C-V characteristics of P-N junction of  $\text{Hg}_{1-x}\text{Cd}_x\text{Te}$  ( $0.195 < x < 0.28$ ) are presented. It is found that the C-V curve of these P-N

junctions has a maximum and some 'negative' values, which can not be explained by the usual mechanism of diffusion capacity and the barrier-layer capacity. In comparing with the theory of indirect tunnelling capacity, these abnormal phenomena can be attributed to the tunnelling process between the deep impurity level and the conduction or/and valance bands. (Author abstract) 7 refs. In Chinese.

Lin He (Acad Sinica, Shanghai, China); Tang Dingyuan. *Pan Tao Ti Hsueh Pao* v 9 n 1 Jan 1988 p 60-66.

**095715 POSITION SENSITIVE DETECTORS USING HYDROGENATED AMORPHOUS SILICON.** Hydrogenated amorphous silicon (a-Si:H) offers some technical advantages over crystalline silicon for optical position sensing devices since it can be grown on a large variety of substrates at approx.  $250^\circ\text{C}$ , over large areas and at lower cost than crystalline Si. Its transparency to red light makes it suitable for applications which require superimposed detectors. We have examined a variety of layered a-Si:H structures using gold or Nichrome resistive contact layers and found that a multiple sequence of n-type/undoped/n-typed thin films offers the best positional linearity and the minimum change by the Staebler-Wronski effect. (Author abstract) 11 refs.

Al Sabbagh, S.K. (Heriott-Watt Univ, Edinburgh, Scotl); Wilson, J.I.B.; Manookian, W.Z. *J Phys D* v 21 n 2 Feb 14 1988 p 359-363.

**095716 POWER SEMICONDUCTORS HIT STRIDE.** In terms of sheer numbers and technical complexity, power electronics has been largely eclipsed by integrated circuit in the international marketplace. Yet without extensive prior work in power semiconductors, microelectronics would scarcely have advanced as far and fast as it now has. The author tells how this trend is reversing itself. (Edited author abstract)

Stein, Karl-Ulrich (Siemens AG, Munich, West Ger). *Siemens Compon* v 22 n 6 Dec 1987 p 218-220.

**095717 IMPLEMENTATION OF A NEW METHOD FOR THERMAL ANALYSIS OF PLANE MULTILAYERED SYSTEMS.** This paper reports the implementation of a new method for temperature calculations in plane multilayered systems. The method involves both analytical and numerical approaches to heat flow analysis and is well suited for power semiconductor systems where plane power dissipation can be assumed. The general case of an N-layered system is presented and some examples of calculations are given. The method, which involves short computation times, is usable on small computer systems and offers an alternative to finite-difference or finite-element methods as long as plane multilayered systems are considered. (Author abstract) 10 refs.

Dorkel, J.M. (CNRS, Toulouse, Fr); Napieralski, A.; Leturcq, Ph. *Numer Heat Transfer* v 13 n 3 1988 p 319-336.

**095718 FINDING REPLACEMENT SEMICONDUCTORS.** Electricians in modern facilities are adding repair of solid-state devices to their list of responsibilities. Being knowledgeable about the cross-referencing process enables these individuals to purchase replacement devices locally instead of buying original parts from the equipment manufacturer. This keeps downtime to a minimum and usually reduces the cost of the replacement parts. Semiconductors such as diode rectifiers, transistors, silicon-controlled rectifiers, and integrated circuits are used in all types of manufacturing equipment and in all phases of power control. The maintenance electricians must not only know how to test these devices as part of their troubleshooting responsibility, but in many instances they must select replacements for failed devices.

Huseman, John M. (Goodyear, Lincoln, NE, USA). *ECM Electr Constr Maint* v 86 n 13 Dec 1987 p 77-79.



**095719 NEW DEVELOPMENTS IN THE PHYSICS OF HOMO- AND HETEROJUNCTIONS, UNITED STATES-BELGIUM JOINT SEMINAR.** Proceedings incorporates 19 papers that emphasized the fundamental properties and devices based on silicon as well as type III-V and II-VI compound materials. All of the papers are indexed and abstracted separately. Topics considered include: heterostructures, modeling, high-electron mobility transistors (HEMT), MODFET's, optoelectronic devices, bipolar and field-effect transistors, semiconducting silicon and silicon compounds, heavy doping effects, microcrystalline emitters, VLSI's, charge carriers, polysilicon emitters, the band-band Auger effect in semiconductors, MESFET's, and solar cells. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10818 in the Ei Engineering Meetings (TM) database produced by Engineering Information Inc.

Van Overstraeten, R.J. (Ed.) (Interuniversity Microelectronics Cent, Louvain, Belg); Mertens, R.P. (Ed.); Neugroschel, A. *Solid State Electron* v 30 n 11 Nov 1987, New Dev in the Phys of Homo- and Heterojunctions, US-Belg Jt Semin, Louvain, Belg, May 28-30 1986 p 1077-1220.

**095720 PAPERS FROM THE 1987 NATIONAL CONFERENCE ON SEMICONDUCTOR DEVICES AND MATERIALS IEICE.** The conference materials contain 21 papers concerned with a wide scope of electronic and semiconductor devices. Plasma waveguides; high-resolution full-color displays; A/D and D/A converters; lead chromate ceramic photovoltaic properties; soft errors in DRAM's; semiconductor lasers; phase-shifted DFB lasers; optoelectronics and optical waveguides; optical fibers and couplers; optical fiber submarine cables; holographic pattern measuring method; and 3-d shape measurements using position-sensitive device are the main topics covered. All the papers are abstracted and indexed separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10928 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Ueki, Atsumi (Ed.) (Inst of Electronic, Information & Communications Engineers, Electronics Group, Tokyo, Jpn). *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 11 Nov 1987, Pap from the 1987 Natl Conf on Semicond Devices and Mater IEICE, Kumamoto, Jpn, Nov 1-4 1987 p 1035-1091.

**095721 BAND-GAP ENGINEERING FOR NEW PHOTONIC AND ELECTRONIC DEVICES.** Band-gap engineering is a powerful technique for the design of new semiconductor materials and devices. Heterojunctions and modern growth techniques, such as molecular beam epitaxy, allow band diagrams with nearly arbitrary and continuous band-gap variations to be made. A new generation of devices with unique capabilities, ranging from solid-state photomultipliers to resonant tunneling transistors and spin polarized electron sources, is emerging from this approach. (Author abstract) 42 refs.

Capasso, Federico (AT&T Bell Lab, Murray Hill, NJ, USA). *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 112-119.

**095722 COLLOQUIUM ON MULTI-QUANTUM WELL DEVICES - PHYSICS, ENGINEERING AND APPLICATIONS.** Proceedings incorporates nine papers dealing with the theory, performance and application of multiquantum well semiconductor devices. Topics considered include: semiconductor growth using molecular beam epitaxy, optical waveguides, semiconductor lasers grown by MOCVD, optoelectronic logic gates, strained layer superlattices, optical logic arrays, multilayer semiconductor structures, scattering mechanisms in 2-D electron-gas structures, and measurement of various parameters. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 09863 in the Ei Engineering Meetings (TM) database

produced by Engineering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig* n 1986/128, Colloq on Multi-Quantum Well Devices - Phys, Eng and Appl, London, Engl, Dec 8 1986. Publ by IEE, London, Engl, 1986 var pagings.

**095723 INTERNATIONAL ELECTRON DEVICES MEETING.** This proceedings contains 226 papers by various authors. The following topics are dealt with: selective epitaxy and merged bipolar-CMOS technology; hot-carrier effects; heterojunction electron devices; high-speed/high-density integrated circuits; image sensor technology; electron tubes; advanced bipolar devices; interconnect technology; optoelectronics and integration; Si/GaAs device and process simulation; microsensor technology; millimeter-wave devices; dynamic memories; CMOS and BIPOLAR process integration; low-temperature device operation; pseudomorphic heterostructure FETs; solid-state display and detector technology; traveling-wave tubes; hot-electron, current crowding and alpha-particle models; static and nonvolatile memories; dielectrics and shallow junctions; high-speed III-V devices; MOS modeling; discrete power devices; cathodes; MOSFET scaling; isolation and lithography; high-voltage ICs and lateral power devices; lasers; and fast wave devices. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11305 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEEE, Electron Devices Soc, New York, NY, USA). *Tech Dig Int Electron Devices Meet* 1987, Int Electron Devices Meet, Washington, DC, USA, Dec 6-9 1987. Publ by IEEE, New York, NY, USA, 1987. Available from IEEE Service Cent (Cat n 87CH2515-5), Piscataway, NJ, USA 936p.

**095724 ADVANCED PROCESSING OF SEMICONDUCTOR DEVICES.** Proceedings incorporates 44 papers that are grouped in five sessions. These deal with frontiers in silicon technologies of rapid thermal annealing (RTA), silicon-on-silicon (SOI), and silicides; plasma, laser and wet chemical processing of semiconductors; ion-beam and high-temperature processing of III-V and II-VI semiconductors; epitaxial regrowth and optoelectronic devices; and high-speed electron device technologies. Topics considered include: heterojunctions; bipolar transistors, FET, GaAs, AlGaAs, MOCVD, resonant tunneling bipolar transistors (RBT) permeable base transistors, high-electron-mobility transistors (HEMT), logic devices, MESFET, MOS capacitors, ternary semiconductors, CdTe films, IR detectors, quantum well lasers, reactive ion etching (RIE), distributed feedback (DFB) lasers; surface emitting semiconductor lasers, optoelectronic IC's, ion implantation, MODFET, superlattices, single crystals, silicon nitride films, and amorphous materials. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11659 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Mukherjee, Sayan D. (Ed.) (GE, USA). *Proc SPIE Int Soc Opt Eng* v 797, Adv Process of Semicond Devices, Bay Point, FL, USA, Mar 23-25 1987. Publ by SPIE, Bellingham, WA, USA, 1987 362p.

**Aging** See SEMICONDUCTOR DEVICES, MOSFET—Defects.

#### Amorphous

**095725 HYDROGENATED AMORPHOUS SILICON ELECTRONIC DEVICES AND THEIR ARRAYS.** The physics, fundamental limitations, and applications of amorphous devices are discussed. The most attractive application of a-Si:H electronic devices is in an active matrix. Examples are large-area flat-panel displays in portable television sets and video display terminals, as well as large-area contact-type image sensors in facsimile transducers. Current efforts are directed to developing arrays having more than 200×200 pixels. It is already evident that a-Si:H FETs have satisfactory characteristics for such applications, and that the important remaining

problems are to reduce production costs while maintaining long-term stability. An alternative technology, which is based on the polysilicon FET, is competing increasingly with the amorphous device technology. The potential usefulness of a-Si:H devices has been clearly demonstrated, but their practical importance has not been finally established, since further improvement of their performance and fabrication is required. This chapter, therefore, describes both the state-of-the-art technologies and performance of a-Si:H devices, and various technological trends aimed at achieving still further improvement. 63 refs.

Matsumura, Masakiyo (Tokyo Inst of Technology, Tokyo, Jpn). *Plasma Deposited Thin Films* Publ by CRC Press Inc, Boca Raton, FL, USA, 1986 p 205-235.

**Analogies** See SEMICONDUCTOR DIODES—Junctions.

**Analysis** See Also CRYSTALS—Composition Effects; LASERS—Tuning; MATHEMATICAL TECHNIQUES—Differential Equations; SEMICONDUCTOR DEVICES, BIPOLAR—Transport Properties; SEMICONDUCTOR DEVICES, MOS—Mathematical Models.

**095726 NUMERICAL SIMULATION OF THE DYNAMICS OF FIELD IMPROVISHMENT MODES.** The possibility of low field and reversed step domains in multivalley semiconductors was suggested over 20 years ago by J.A. Copeland and was re-examined more recently by a different method. Both refer only to the possibility stationary domains, which, once formed, propagate along an infinite device. Appropriate initial and cathode conditions are established for GaAs by numerical simulation using Boltzmann's transport equation and assuming constant voltage at the terminals. These conditions may lead to the repeated formation of these domains, giving rise to transmit time modes and seem promising in providing a higher power transfer than traditional ones, because the sign of the bulk charge is reversed while domain velocity and field directions remain opposite to each other. Hot electron launching which is indispensable to the process, might be achieved by suitable heterojunctions, namely at the cathode.  $Al_xGa_{1-x}As/GaAs$  is a possibility. (Edited author abstract) 14 refs.

Fernandes, C.F. (Inst Superior Tecnico, Lisbon, Port); Abreu Santos, H. *IEE Proc Part I* v 134 n 5 Oct 1987 p 148-152.

**095727 NEW INTEGRAL REPRESENTATIONS OF CIRCUIT MODELS AND ELEMENTS FOR THE CIRCUIT TECHNIQUE FOR SEMICONDUCTOR DEVICE ANALYSIS.** New integral representations of the distributed and one-lump circuit models and their circuit elements, accurate to mesh-size cubed ( $\Delta x$ )<sup>3</sup> using the trapezoidal approximation, are presented for large-signal transient, dc and small-signal numerical and analytical simulations of semiconductor devices. (Author abstract) 12 refs.

Sah, C.T. (Univ of Illinois, Urbana, IL, USA). *Solid State Electron* v 30 n 12 Dec 1987 p 1277-1281.

**095728 EIGENSTATE CALCULATION OF QUANTUM WELL STRUCTURES USING FINITE ELEMENTS.** The finite-element technique based on a Galerkin method is applied to the eigenstate problem of semiconductor quantum wells with arbitrary potential profiles. In the present formulation, finite elements are employed only within the well region, and the contribution of the semi-infinite barrier region is evaluated analytically. Self-consistent solutions are obtainable by solving a matrix eigenvalue problem iteratively. (Author abstract) 4 refs.

Hayata, K. (Hokkaido Univ, Sapporo, Jpn); Koshiba, M.; Nakamura, K.; Shimizu, A. *Electron Lett* v 24 n 10 May 12 1988 p 614-616.



**095729 IMPORTANCE OF THE N-BASE IN P-N-P-N-LIKE STRUCTURES SUBJECTED TO DV/DT RAMPS.** A simple yet thorough analysis of physical effects induced in p-n-p-n-like silicon structures by the high rate of the OFF-state forward anode voltage rise (dV/dt) is discussed. The importance of n-base parameters in shaping the faulty triggering of thyristors subjected to dV/dt ramps is clearly demonstrated. The main implications of the findings for thyristor physics and design are also outlined. 8 refs.

Silard, Andrei P. (Polytechnic Inst, Bucharest, Rom); Duta, Miron J. *IEEE Electron Device Lett* v 9 n 5 May 1988 p 197-199.

**Applications** See Also AMPLIFIERS, POWER TYPE—Analysis; BOLOMETERS—Applications; DATA PROCESSING—Data Acquisition; ELECTRIC DRIVE—Variable Speed; ELECTRIC POWER SUPPLIES TO APPARATUS; ELECTRIC UTILITIES—Electronic Equipment; FLOWMETERS; MICROWAVE DEVICES—Analysis; STORAGE BATTERY VEHICLES—Electric Drive; WELDING, ELECTRIC ARC—Equipment.

**095730 SINGLE-ELEMENT CHARGE-INJECTION DEVICE AS A SPECTROSCOPIC DETECTOR.** The need for a single-element charge-transfer device as a spectroscopic detector is discussed. Such a detector promises to offer superior performance compared to current photomultiplier tubes over a wide range of illumination levels. As a detector to address this need, the prototype CID75 manufactured by General Electric Co. is described and characterized. The CID75 is a single-element charge-injection-device sensor with a 1 mm by 1 mm photoactive area and a readout rate adjustable from 0 to 20 kHz. The electro-optical characteristics reported in this study include linearity, read noise, full-well capacity, dark count rate, and quantum efficiency. The sensors have good photometric linearity with a full-well capacity in excess of  $1.2 \times 10^8 e^-$ . The read noise of the detector can be lowered to  $80 e^-$  when its nondestructive readout mode is employed. The quantum efficiency of the CID75 is reported for the wavelength range from 200 to 1000 nm. (Edited author abstract) 27 refs.

Sweedler, Jonathan V. (Univ of Arizona, Tucson, AZ, USA); Denton, M. Bonner; Sims, Gary R.; Aikens, Richard S. *Opt Eng* v 26 n 10 Oct 1987 p 1020-1028.

**095731 SYSTEMS APPLICATIONS OF GaAs DEVICES AND ICS.** Gallium arsenide (GaAs) is now being considered by the semiconductor industry as a serious challenger to the dominance of silicon in high-speed digital circuits. In addition, with the accelerated progress in developing GaAs ICs for microwave and optoelectronics applications, major future markets are projected. This paper surveys the product areas and associated system applications for GaAs and related III-V compound semiconductor devices and ICs. Particular attention is given to the three main IC product areas of digital, analogue and optoelectronics and their applications to both military and civil systems. The strongest market currently is for military analogue devices. The projected digital market in the 1990s, however, dominates the other IC product areas. (Author abstract) 7 refs.

Oxley, Terry (GEC, Research Ltd, Chelmsford, Engl); Corbey, Colin. *Microprocessors Microsyst* v 11 n 8 Oct 1987 p 443-449.

**095732 POTENTIAL OF SINGLE-CHIP RECEIVERS FOR PROFESSIONAL RADIO APPLICATIONS.** Receivers for professional radio applications such as Private Mobile Radio (PMR) and Cellular Radio have reaped few of the benefits which integration has brought to other products. This article describes research which has been carried out into the application of new architectures which should facilitate the realization of single-chip receivers for these applications. 6 refs.

Moore, P.A.; Perry, C.L.; Thorn, S.R.J. *Annu Rev Philips Res Lab* 1986 p 94-96.

**095733 POWER SEMICONDUCTORS HIT STRIDE.** In terms of sheer numbers and technical complexity, power electronics has been largely eclipsed by

integrated circuits in the international marketplace. Yet without extensive prior work in power semiconductors, microelectronics would scarcely have advanced as far and fast as it now has. Now, however, this trend is starting to reverse itself. This article tells how. (Edited author abstract)

Stein, Karl-Ulrich (Siemens AG, Munich, West Ger). *Siemens Rev* v 54 n 5 Sep-Oct 1987 p 4-6.

**095734 THEORETISCHE UND EXPERIMENTELLE UNTERSUCHUNG EINES NEUARTIGEN GaAs-MeSFET-FREQUENZVERDOPPLERS.** [Theoretical and Experimental Characterization of a Novel GaAs-MeSFET Frequency Doubler]. GaAs-MeSFETs with large gatewidth ( $W = 1000 \mu m$ ) and connecting pads at both ends of the gate and drain electrodes were fabricated. A maximum doubler output power of 10 dBm was obtained under optimum bias and circuit conditions. Theoretical analysis of the frequency doubler as a four-port device using generalized Volterra series approach predicted well the output power/input power and output power versus reflection coefficients characteristics. The influence of the distinct parameters of the doubler is outlined. (Edited author abstract) In German. 7 refs.

Krozer, Viktor (Technische Hochschule Darmstadt, West Ger); Fricke, Klaus. *Frequenz* v 42 n 1 Jan 1988 p 24-28.

**Bonding** See METALS AND ALLOYS—Bonding; SEMICONDUCTOR DEVICE MANUFACTURE.

**Computer Aided Analysis** See Also INTEGRATED CIRCUIT TESTING—Computer Aided Analysis.

**095735 EFFICIENT SMOOTHING ALGORITHM FOR SPREADING RESISTANCE CALCULATIONS.** The need for a good smoothing algorithm before applying a more elaborate correction algorithm to spreading resistance data is illustrated. The important requirements for such a scheme are formulated. A new efficient smoothing scheme has been implemented and tested. It is shown that this scheme substantially improves the generated carrier concentration profiles and makes their interpretation easier. (Author abstract) 16 refs.

Claressy, T. (IMEC, Louvain, Belg); Vandervorst, W. *Solid State Electron* v 31 n 1 Jan 1988 p 53-63.

**095736 SENSITIVITY ANALYSIS FOR DEVICE DESIGN.** A sensitivity analysis technique for device design is proposed. By this method, the linearized variations of the device terminal characteristics are derived following some change either in the impurity distribution, or in device geometry, such as channel length an oxide thickness. This technique has been implemented in a general-purpose two-dimensional device-analysis program, and proved to be very efficient. It is believed that the present method can be profitably used for both deterministic and statistical device design. 20 refs.

Gnudi, A. (Univ of Bologna, Italy); Ciampolini, P.; Guerrieri, R.; Rudan, Massimo; Baccarani, G. *IEEE Trans Comput Aided Des Integr Circuits Syst* v CAD-6 n 5 Sep 1987, 1986 Int Conf on Comput-Aided Des of Integr Circuits, 1986 p 879-885.

**Computer Aided Design** See Also INTEGRATED CIRCUITS, VLSI—Computer Aided Design; SEMICONDUCTOR DEVICES, BIPOLAR; THYRISTORS—Computer Aided Design; TRANSISTORS, BIPOLAR—Mathematical Models.

**095737 EFFICIENT TRANSFERRED ELECTRON DEVICE SIMULATION METHOD FOR MICROWAVE AND MILLIMETER WAVE CAD APPLICATIONS.** A set of hydrodynamic transport equations, which govern a physical model for GaAs transferred electron devices, are formulated using phenomenological transport parameters derived from large scale Monte Carlo particle simulations. A fast and efficient numerical solution method is developed, allowing inexpensive investigations of a wide variety of TED samples under many operating conditions. The method not only permits insight into important semiconductor transport processes, but also permits the identification of candidate device samples

for microwave and millimeter wave circuit applications. (Edited author abstract) 19 refs.

Tait, Gregory B. (US Naval Research Lab, Washington, DC, USA); Krowne, Clifford M. *Solid State Electron* v 30 n 10 Oct 1987 p 1025-1036.

**095738 SUPERVISED SIMULATION SYSTEM FOR PROCESS AND DEVICE DESIGNS BASED ON A GEOMETRICAL DATA INTERFACE.** A supervised simulation system for two-dimensional simulation has been developed that covers the range from pattern layout to process and device simulation. The major aim is to provide a topography data format that allows automatic data treatment between topography simulation and implantation-diffusion simulation, and also between process and device simulation. Another important feature is job and file management by the system controller, which controls the module programs. Using a novel data format, the total fabrication process (deposition, etching, reflow, implantation, diffusion including oxidation) and device simulation is automatically completed by the system controller without any intricate treatment. 20 refs.

Kato, Koichi (Toshiba Corp, Kawasaki, Jpn); Shigyo, Naoyuki; Wada, Tetsunori; Onga, Shinji; Konaka, Masami; Taniguchi, Kenji. *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2049-2058.

## Computer Aided Engineering

**095739 INTEGRATED AUTOMATION OF THE PRODUCTION-PLANNING PROCESS FOR POWER SEMICONDUCTOR DEVICES.** The functional capabilities of the second stage of a CAD system for power semiconductor devices are analyzed; it was developed and placed into commercial service during the Eleventh Five-Year Plan. (Author abstract) 6 refs.

Grigorenko, V.P. *Sov Electr Eng* v 58 n 2 1987 p 87-92.

**Computer Simulation** See Also ELECTRIC GENERATORS, SYNCHRONOUS—Analysis; SEMICONDUCTOR DEVICES, MOSFET—Mathematical Models; SEMICONDUCTOR DEVICES, MOSFET—Stability.

**095740 COMPREHENSIVE TRANSPORT MODEL FOR SEMICONDUCTOR DEVICE SIMULATION.** In this paper a comprehensive carrier dynamical transport model for semiconductor device simulation is presented. The model consists of carrier, carrier momentum and carrier energy conservation relations derived using a perturbation solution for the carrier distribution function. Carrier degeneracy, multiple conduction sub-bands and ellipsoidal constant energy surfaces are accounted for, and the effective masses and band edges are assumed to be spatially inhomogeneous. The new formulation overcomes modelling inaccuracies of previous energy transport models based on a drifted Maxwellian distribution function, and for spatially homogeneous, non-degenerate semiconductors offers several computational advantages. (Author abstract) 14 refs.

McAndrew, C.C. (Univ of Waterloo, Waterloo, Ont, Can); Heasell, E.L.; Singhal, K. *Semicond Sci Technol* v 2 n 10 Oct 1987 p 643-648.

**095741 INTERCHANGE FORMAT FOR PROCESS AND DEVICE SIMULATION.** A standard format for transmitting profiles of semiconductor structures between sites and between tools is described. The standard, called the profile interchange format (PIF), is a flexible and hierarchical format, capable of storing descriptions of semiconductor structures such as those produced and used by process and device simulators. It can store detailed descriptions of the geometry, attribute profiles, material properties, and transient behavior of a single structure or a collection of structures. Two equivalent forms of the PIF are proposed to resolve conflicting demands placed on the format by its two primary uses, which are transmitting profiles between sites and local use as a database for process and device simulation. The 'intersite' form of the PIF, which can be viewed as an



extension of the electronic design interchange between sites, most importantly, portability. The 'intertool' form of the PIF is, in concept, equivalent in descriptive capabilities to the intersite form, but is intended to accommodate the needs of profile interchange between tools, most importantly, efficient storage and access of data. The PIF in both modes can be extended and modified to accommodate local needs. 10 refs.

Duvall, Steven G. (Intel Corp, Santa Clara, CA, USA). *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 7 Jul 1988 p 741-754.

**095742 RECENT APPLICATIONS OF MONTE CARLO METHODS FOR SEMICONDUCTOR MICRODEVICE SIMULATION.** Monte Carlo simulations for semiconductor devices are time consuming. We have investigated ways to speed up calculations on supercomputers and a method to incorporate overshoot effects in simple drift-diffusion models for submicron devices, using coefficients obtained from Monte Carlo experiments. An ensemble Monte Carlo algorithm, suitable for self-consistent device simulation, has been vectorized, and in preliminary testing runs three times faster on a CRAY X/MP 48 supercomputer. The inclusion of overshoot terms in a drift-diffusion simulation for a MESFET structure shows that the main overshoot effects can be incorporated in a simple model suitable for circuit simulation. Increased problems in stability, however, reduce the efficiency of traditional finite difference schemes and require further refinement in the numerical methods. (Edited author abstract) 10 refs.

Shapo, B. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Ball, C.; Kizilyalli, I.; Ravaioli, U. *Superlattices Microstruct* v 4 n 1 1988, Chicago Conf, Pap, Chicago, IL, USA, 1987 p 39-43.

**Contacts** See Also ELECTRIC CONTACTS, OHMIC—Analysis; ELECTRIC CONTACTS, OHMIC—Spectroscopic Analysis; INTEGRATED CIRCUITS—Fabrication; PRINTED CIRCUITS—Manufacture; SEMICONDUCTING GALLIUM COMPOUNDS—Contacts; SEMICONDUCTING INDIUM COMPOUNDS—Contacts; SEMICONDUCTING SILICON—Surfaces; SEMICONDUCTING SILICON COMPOUNDS—Thin Films; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER; SEMICONDUCTOR DIODES—Fabrication.

**095743 PRELIMINARY STUDIES OF Al-Ge-Ni OHMIC CONTACTS TO p- AND n-TYPE GaAs.** The authors have performed electrical measurements (I-V characteristics) and transmission electron microscopy (TEM) investigations of the contact with the aim of correlating contact microstructure with electrical behavior to understand the contact and optimize its performance. It is found that all Al-Ge-Ni contacts to p-type GaAs were found to be ohmic, whereas only 3 and 4 minute annealed contacts on n-type material were ohmic. There is a large difference in microstructure between contacts on n- and p-type material, suggesting this may be affected by the nature of the semiconductor. In spite of this, contact ohmicity appears to be accompanied by the presence of a well developed amorphous layer with a web-like structure consisting mainly of Al and some Ni. 2 refs.

Graham, R.J. (Arizona State Univ, Tempe, AZ, USA); Erkaya, H.H.; Roedel, R.J. *J Electrochem Soc* v 135 n 1 Jan 1988 p 266-267.

**095744 DEGRADATION OF THE Mg/SiO<sub>2</sub>/p-Si CONTACT.** Magnesium is a widely-used contact metal in semiconductor device applications, especially in high-efficiency silicon solar cell investigations. P-type float-zone wafers were used in this study. We have shown that the degradation of the Mg/SiO<sub>2</sub>/p-Si contact is governed by a low activation energy of 1.64 eV and the main cause for degradation is saturation current degradation. Extrapolation of the Arrhenius plot indicated that the degradation rate is still negligible at low temperature. 5 refs.

Poon, M.C. (Chinese Univ of Hong Kong, Hong Kong). *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1377-1378.

**095745 FORMATION OF OHMIC CONTACTS TO n-GaAs BY ION BEAM MIXING AND ANNEALING.**

A study carried out by the authors has shown that by using ion beam mixing on the Au-Ge/Ni/GaAs system, followed by an annealing step, an ohmic contact to n-GaAs can be formed. The morphology of the contacts fabricated in this way was better than the contacts without the ion implantation step. From Auger depth profiles, it follows that a region of uniformly mixed nickel/germanium/arsenic system formed, which spread uniformly throughout the metallization layer. In contrast, contacts which were only annealed exhibited regions of non-uniformly mixed Ni and Ge and of Ni and As. An Auger study revealed that more Ni diffused into the GaAs for the ion implanted contacts, and this helps to trap more Ge in the substrate, which is beneficial for doping purposes. (Edited author abstract) 20 refs.

Barnard, W.O. (CSIR, Pretoria, S Afr); Malherbe, J.B.; Lacquet, B.M. *Appl Surf Sci* (1985) v 31 n 4 May 1988 p 437-444.

**095746 RAPID THERMAL ANNEALING OF Al-Si CONTACTS.** A simple and direct method by utilizing rapid thermal annealing for 30 sec of conventional furnace instead of conventional sintering, is reported. AES, SEM, specific contact resistance and PN junction reverse current investigations show that Al-Si interdiffusion phenomenon which causes the failure for shallow junctions can be restricted effectively; therefore ohmic contact with good junction property can be achieved. (Edited author abstract) In Chinese. 11 refs.

Chen Cunli (Nanjing Univ, China); Peng Hui; Li Lianzhu. *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 318-320.

**095747 CONTACT RESISTANCE CALCULATIONS BASED ON A VARIATIONAL METHOD.** Noble's variational method is used to solve the contact resistance problem that arises when a circular disc source electrode is in contact with a semiconductor slab through an infinitesimally thin layer of resistive material. The method assumes that the source current density distribution  $J(r)$  has the form  $K_1(1-r^2) - \mu + K_2(1-r^2)^{3/2} + K_3(1-r^2)^{3/2}$ , where the parameters  $K_1$ ,  $K_2$ ,  $K_3$  and  $\mu$  are determined by variational principles. Calculations of the source current density and the total slab resistance, performed for a wide range of contact resistivities, show that the results are practically indistinguishable from those derived from an exact mixed boundary value method proposed earlier by us. While this method of using an optimized  $\mu$  is accurate, it is computationally slow. By fixing  $\mu$  at a constant value of 1/4, the authors find that they can reduce the computation time for each calculation of the total slab resistance to 1.5 s on an Apple II microcomputer, and still achieve an overall accuracy of 1%. Tables of the abscissas and weights required for implementation of the numerical scheme are provided. (Edited author abstract) 13 refs.

Leong, M.S. (Natl Univ of Singapore, Kent Ridge, Singapore); Choo, S.C.; Tan, L.S.; Goh, T.L. *Solid State Electron* v 31 n 7 Jul 1988 p 1187-1195.

**095748 COMBINED EBIC-AUGER ANALYSIS OF AuGeNi/ n-GaAs OHMIC CONTACT FORMATION.** Electron beam induced current imaging has been used to monitor the dynamic changes of the metal-semiconductor interface of AuGeNi/n-GaAs during annealing at 300°C. The reacted interface was then revealed by argon ion etching of the metal overlayer, and analyzed by secondary electron and Auger electron imaging. The combined EBIC-Auger imaging of the reacted interface indicates that the formation of the ohmic contact starts at localized areas where small Ni- and As-rich grains are formed. The results also show that this combined EBIC-Auger imaging technique is particularly suitable for investigating the mechanism of degradation of Schottky contacts. (Author abstract) 7 refs.

Hill, I.R. (Univ of Western Ontario, London, Ont, Can); Lau, W.M.; Yang, G.R.; North, R.A. *Surf Interface Anal* v 11 n 12 Sep 1988 p 596-598.

**Contamination** See Also SEMICONDUCTING SILICON COMPOUNDS—Cleaning.

**095749 HEAVY METAL CONTAMINATION FROM RESISTS DURING PLASMA STRIPPING.** A new mode of heavy metal contamination has been investigated. Generally used commercial positive photoresists containing heavy metal less than 0.5 ppm decreased minority carrier lifetime of the silicon substrate under the resist layer during resist stripping with a plasma asher. Since this contamination is induced by direct plasma exposure, it can be avoided by using plasmaless resist removal methods, such as wet stripping or down flow ashing. However, even in such resist stripping methods, a wafer temperature higher than 300°C introduces this problem. This contamination is reduced by both covering the silicon surface with a silicon oxide layer and by purifying the resists. Neither of these methods are perfect. (Author abstract) 20 refs.

Fujimura, Shuzo (Fujitsu Ltd, Kawasaki, Jpn); Yano, Hiroshi. *J Electrochem Soc* v 135 n 5 May 1988 p 1195-1201.

**Corrosion** See Also INTEGRATED CIRCUITS—Corrosion.

**095750 SCANNING ELECTRON MICROSCOPY IN THE STUDY OF CORROSION ON ALUMINIZED SEMICONDUCTOR DEVICES.** A study of the influence of the structural quality of the original Al film and the purity of chemical reagents used on the surface film morphology, using a scanning electron microscope, has established that the color change observed when aluminumized surfaces are etched is associated with the presence of heavy-metal impurities (Fe, Ni, Cr, Co and Zn ions). If the Al film structure is defective, excessive concentrations of these ions promote corrosion and the devices will fail in service. Blackening or coloration occurs when the defective areas are etched with contaminated agents. The heavy-metal ions produce localized electrochemical potential peaks; corrosion is locally accelerated because of the large difference between the work functions of Al and the impurities. Ways are proposed for minimizing the damage to Al-coated semiconductor devices. (Edited author abstract) 9 refs.

Medvetskii, S.P.; Zarubin, I.M.; Tsurkan, A.E. *Sov Surf Eng Appl Electrochem* n 5 1986 p 34-37.

**Defects** See Also SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Radiation Effects; SEMICONDUCTOR MATERIALS—Impurities.

**095751 MULTIPLICATION OF DEFECTS IN SEMICONDUCTORS DURING MULTIPLE PASSAGE OF SHOCK WAVES.** Investigations were conducted into the relationships governing the pile-up of point defects in crystals in multiple passage of nondestructive shock waves with a short leading edge. The probability and coefficient of multiplication of defects are determined. In the case of formation of defects of the same type (inherent defects), it is shown that the measurements of electrical conductivity, the life of current carriers, and their mobility can be used to determine the concentration of defects, the coefficients of multiplication of defects on the inherent defects and solutes, and the energy level of defects and their contribution to scattering of the charge carriers. (Author abstract) 8 refs.

Polyaninov, A.V.; Yanushkevich, V.A. *Phys Chem Mater Treat* v 21 n 4 Jul-Aug 1987 p 351-354.

**095752 VERIFICATION OF ANALYTIC POINT DEFECT MODELS USING SUPREM-IV.** Two-dimensional process modeling has been complicated by the increasing complexity of the physical models needed to characterize modern processes. Present physical models for diffusion favor modeling of both the vacancies and interstitials as well as the dopant impurities. These vacancies and interstitials are important in two dimensions since the lateral characteristic lengths are on the order of a few microns, which is comparable to device



dimensions. Hence, full two-dimensional solutions of the point defect equations are required to accurately model two-dimensional diffusion. Since the defects diffuse many orders of magnitude faster than the impurities, the problem of solving the coupled equations is numerically stiff and the numerical techniques become critical. The numerical methods in SUPREM-IV are described. Since the numerical solutions are time consuming, suitable analytic solutions are considered as an alternative. These analytic solutions are compared to the numerical results to test the limits of the assumptions used in the analytic formulation. The comparison forces the conclusion that analytic solutions are of limited use in prediction of point defect profiles in two dimensions. 18 refs.

Law, Mark E. (Stanford Univ, CA, USA); Dutton, Robert W. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 2 Feb 1988 p 181-190.

**095753 X-RAY TOPOGRAPHY AND TRANSMISSION ELECTRON MICROSCOPY APPLIED TO SEMICONDUCTOR DEVICE DEFECTS ARISING DURING MANUFACTURE.** When single-crystal silicon devices are being made, dislocations may arise from slip, point-defect condensation, stress relaxation around the impurity clumps, and tensile-stress relaxation at the edges of windows in the silicon oxide. The main purpose of these studies has been to determine whether there is a correlation between these manufacturing defects on the one hand and the electrical parameters of the transistors on the other. Two types of experiment have been performed: 1) X-ray topography applied during the manufacture of epitaxial planar transistors and 2) emitter injection-coefficient measurement for bipolar transistors in relation to defects detected by transmission electron microscopy. The main results are: 1) low dope concentrations in the emitter region produce a structure free from defects with a very high emitter injection coefficient; and 2) an increase in dope concentration causes defects to form in the emitter region, which in turn reduces the injection coefficient. 5 refs.

Auleytny, J.; Mizera, E. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struc and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 121-124.

**Design** See Also SEMICONDUCTOR DEVICES, MOSFET—Fabrication; SEMICONDUCTOR DEVICES, MOSFET—Simulation.

**095754 STRUCTURAL SYNTHESIS OF SEMICONDUCTOR DEVICES.** Our aim here is to find and formulate an algorithm for generating fundamentally new semiconductor devices. The knowledge about the device is represented in the form of three information arrays that contain information about the physical properties of the layers of material. This knowledge is formulated as a graph of the discrete computational environment (DCE). It is shown that any known devices may be obtained from the DCE with the aid of formal procedures. The concepts of an operator and an objective function are introduced. The problem of structural synthesis is formulated as an integral combinatorial problem. A generation algorithm is given. (Author abstract) 4 refs.

Gloriozov, E.L.; Orlov, O.M.; Tsarev, M.V. *Radioelectron Commun Syst* v 30 n 6 1987 p 20-25.

**095755 CHARGE WAVEFORM OF A NEW TWO-DIMENSIONAL POSITION-SENSITIVE SILICON DETECTOR.** The operation principles of the two-dimensional position-sensitive silicon detector newly developed by T. Doka et al. were studied using a simple model. This model treats the detector as an area of continuously distributed capacitance  $C$  and resistance  $R_s$  of position surface layer. A linear relationship can then be obtained between the position of the incident particle and charge collected at the corner contacts of the detector. The kinetics of charge collected at corner contacts, ballistic deficit and noise were calculated. Rise time of the charge pulse (10-90 percent) was found to vary with the position of incidence up to about  $R_s C/8$ . It was found that a shaping time constant longer than  $R_s C/3$  is required for

pulse shaping with single CR-differentiation and single CR-integration in order to obtain a ballistic deficit of less than 1 percent. (Author abstract). 14 Refs.

Hasebe, Nobuyuki (Ehime Univ, Matsuyama, Jpn); Ezawa, Yasuo; Yoshi, Hisashi; Yanagimachi, Tomoki. *Jpn J Appl Phys Part 1* v 27 n 5 May 1988 p 816-820.

**095756 POWER SEMICONDUCTOR DEVICES: AN OVERVIEW.** Advances in power semiconductor devices are discussed, focusing on the adaptation of silicon integrated circuit wafer processing methods to the design and fabrication of power devices. Some basic properties of power devices are reviewed, along with recent adaptations of wafer processing technology. Two trends are discerned: increasing use of self-aligned, double diffused MOS gate structures to achieve devices with low-current drive requirements; and movement toward an ideal one-dimensional device, thereby making more efficient use of the available area. Different devices are compared: Techniques that have potential for use in power devices are discussed: use of trenches, direct wafer bonding, cellular bipolar transistors, and junction termination. The combination of power switches with control logic on the same chip is briefly considered. 33 refs.

Hower, Philip L. (Unitrode Corp, Watertown, MA, USA). *Proc IEEE* v 76 n 4 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 335-342.

## Electric Conductivity

**095757 DEVICE FOR MEASUREMENT OF RESISTANCE OF SEMICONDUCTORS IN HEATING ELECTRIC FIELDS.** A device for measurement of the resistance of low-resistance semiconductors in heating electric fields is described. To simplify calculation of carrier mobility, an analog device is used to measure resistance for a fixed input power of up to 15 w. The device measures resistance in the temperature range of 77-300 K and magnetic-field range of 0-8 T. (Author abstract) 6 refs.

Loshkarev, V.V. *Instrum Exp Tech* v 30 n 4 pt 2 Jul-Aug 1987 p 975-977.

**095758 QUICK MEASUREMENT OF NONLINEAR CONDUCTION WITH A SINGLE PULSED FIELD.** A method of quickly measuring the nonlinear conduction of a semiconductor is developed where a single triangular pulsed field is used. The warm electron coefficient larger than  $4 \times 10^{-7} \text{ cm}^{-2}/\text{V}^2$  can be measured when it is well defined up to a sufficiently high field, for instance approx. 20 V/cm. Field dependence of the conductivity of pure InSb is measured at 50 and 63, where the nonlinear signal is small and the dependence is complicated. (Author abstract). 4 Refs.

Okazaki, Taizo (Shizuoka Univ, Shizuoka, Jpn). *Jpn J Appl Phys Part 1* v 27 n 5 May 1988 p 863-864.

**Electric Field Effects** See Also ELECTROOPTICAL DEVICES—Electric Field Effects; SEMICONDUCTOR DEVICES, MOS—Computer Simulation; SEMICONDUCTOR DEVICES, MOSFET—Thin Films.

**095759 TWO-DIMENSIONAL NUMERICAL ANALYSIS OF ELECTRIC FIELD PROFILE FOR HIGH VOLTAGE SEMICONDUCTOR DEVICES.** A two-dimensional numerical analysis of electric field profile for high-voltage devices using a computer simulation program is presented. The program is based on a finite element method. A simple empirical formula for calculation of surface electric field in an abrupt planar junction is derived and compared with the cylindrical approximation and simulation results. Electric field profiles are also given for high-voltage devices with terminal structure of ion implantation, plate and extension of gate. (Edited author abstract) In Chinese. 10 refs.

Chen Xingbi (Chengdu Inst of Radio Engineering, China); Li Zhaoji; Jiang Xu. *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 255-261.

**095760 EFFECT OF REFLECTING CONTACTS ON HIGH FIELD TRANSPORT.** There has been

interest in semiconductor device structures which take advantage of high velocity, high field transport. The high electron velocity in devices that take advantage of such transport is degraded if electrons are reflected at collecting contacts. This was demonstrated quantitatively by Brennan and coworkers (1983) who modeled the collecting contact with a constant, arbitrary reflection coefficient. For a real contact, however, the probability of an electron being reflected depends on its energy and momentum. We present a study of the effect of contacts on high field transport by Monte Carlo simulations of transport in an  $n^-$  GaAs region which terminates in an  $n^+$  GaAs/metal contact (Arnold 1987). (Edited author abstract) 4 refs.

Arnold, D. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Hess, K. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 593-594.

**Electric Power** See SOLID STATE DEVICES—Testing.

**Electric Properties** See Also TRANSISTORS—Fabrication; TRANSISTORS, BIPOLAR—Mathematical Models.

**095761 USE OF A COMPUTER SIMULATION TO INVESTIGATE THE INFLUENCE OF NONLINEAR PHYSICAL EFFECTS OF THE CURRENT-VOLTAGE CHARACTERISTIC OF SILICON MULTILAYER STRUCTURES.** The results of a mathematical computer simulation to investigate the influence of electron-hold scattering (EHS), Auger recombination, and the reduction of the kinetic coefficients and Shockley-Read lifetime of charge carriers in the heavily doped layers on the forward branch (FB) of the current-voltage characteristics (CVC) of multilayer silicon structures are presented. A numerical model of the CVC is constructed, in which the contribution of the above effects is taken into account for the first time. It is shown that the incorrect consideration of EHS in previous papers has led to an exaggerated contribution from EHS and, as a consequence of this, to a decrease in the contribution of the other effects. (Author abstract) 18 refs.

Mnatsakanov, T.T.; Rostovtsev, I.L.; Filatov, N.I. *Sov J Commun Technol Electron* v 32 n 1 Jan 1987 p 99-104.

**095762 RESONANT TUNNELING DEVICE WITH MULTIPLE NEGATIVE DIFFERENTIAL RESISTANCE: DIGITAL AND SIGNAL PROCESSING APPLICATIONS WITH REDUCED CIRCUIT COMPLEXITY.** A novel way to obtain multiple peaks in the current-voltage characteristic of a resonant-tunneling (RT) device is demonstrated. The peaks are generated using only the ground-state resonance of the quantum well rather than several states, as in conventional RT devices. The separation between the peaks is voltage-tunable, and the peak currents can be made nearly equal, which is necessary to use the device in a variety of circuit applications. A functional device operating at 100 K with two peaks in the I-V has been fabricated. The first practical demonstration of circuits for frequency multiplication by a factor of five, a three-state memory and a 4-b parity generator using a single functional RT device each, is also reported. The use of multiple-peak RT devices in these circuits results in an order-of-magnitude reduction in the number of components per function over conventional techniques. 18 refs.

Sen, Susanta (AT&T Bell Lab, Murray Hill, NJ, USA); Capasso, Federico; Cho, Alfred Y.; Sivo, Debbie. *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2185-2191.

**095763 RANDOM QUANTUM INTERFERENCE IN MICRODEVICES.** The conductance of small electronic devices at low temperatures is affected by random quantum interference of a universal character that can represent large fractional effects. Would-be designers of small quantum-effect devices should be prepared either to 'fix it' by obtaining unprecedented control over the



microscopic details of the device structure, or 'feature it' by figuring out ways to take advantage of these interference effects. (Edited author abstract) 30 refs.

Skoepol, W.J. (AT&T Bell Lab, Holmdel, NJ, USA). *Superlattices Microstruct* v 4 n 1 1988, Chicago Conf, Pap, Chicago, IL, USA, 1987 p 23-26.

## Electrochemistry

**095764 MODULATED LIGHT STUDIES OF THE ELECTROCHEMISTRY OF SEMICONDUCTORS: THEORY AND EXPERIMENT.** The photoelectrochemistry of three different semiconductors, p-GaP, n-CdS, and p-InP has been studied using a sinusoidally modulated light source. The results obtained for the resulting modulated photocurrent agree well with a theoretical model based upon surface reactions governed by dispersed rate constants arising from a gaussian distribution of free energies at the electrode solution interface. The technique gives information about the amount of surface recombination occurring as well as values of the rate constants and the surface coverage of intermediates. (Author abstract) 12 refs.

Albery, W.J. (Imperial Coll, London, Engl); Bartlett, P.N.; Wilde, C.P. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2486-2491.

**Electronic Properties** See Also SEMICONDUCTOR MATERIALS—Physical Properties; TRANSISTORS—Mathematical Models.

**095765 ON ELECTRON CONFINEMENT EFFECTS AND THE ULTIMATE SIZE REDUCTION IN SEMICONDUCTOR DEVICES.** Three-dimensional electron confinements cause a blue shift of the fundamental band gap and a size-induced metal-insulator transition. These quantum-size effects are expected in confinements with diameters up to the order of 10 and 100 nm at room temperature, in metals and semiconductors, respectively. The size effect can markedly be enhanced by an additional phonon confinement which is omnipresent in isolated sub-micrometer crystals. Confinement effects represent the limitation for the ultra-large-scale integration. (Author abstract) 8 refs.

Marquardt, Peter (Univ zu Koeln, Cologne, West Ger); Nimtz, Guenter. *Semicond Sci Technol* v 2 n 12 Dec 1987 p 833-834.

**095766 INVERSION DOMAINS AND DENSITIES OF STATES IN GAPLESS SEMICONDUCTORS IN A QUANTISING MAGNETIC FIELD.** Gapless semiconductors with the linear electron spectrum are considered taking into account a quantising magnetic field. Deformation potential interactions with phonons are shown to induce the spontaneous destruction of the zero-gap state due to the lowering of the effective space dimension in the magnetic field. The interaction with impurities is shown to shift the band inversion point. The Bogoliubov-de Gennes equations are derived; their inhomogeneous solutions are kinks linking the normal and inverted band domains. The electronic densities of states for two- and three-dimensional zero-gap states in a magnetic field are exactly calculated taking into account the Gaussian random potential and their singularities in the vicinity of band crossing points are studied. Possible consequences of these results for experiments with narrow-gap semiconductors near the inversion point are discussed. (Author abstract) 28 refs.

Ktitorov, S.A. (Acad of Science of the USSR, Leningrad, USSR); Petrov, Yu. V. *Semicond Sci Technol* v 3 n 1 Jan 1988 p 18-28.

**095767 DISCRETE COUPLED PLASMON-PHONON MODES IN FINITE SEMICONDUCTOR MULTI-LAYERS.** The coupled intra subband plasmon-phonon dispersion in N equally spaced quasi two-dimensional electron gas layers embedded in a polar semiconductor is analysed. The interactions of the Giuliani-Quinn surface plasmon excitations with surface and bulk phonons are also investigated. (Author abstract) 14 refs.

Liu, Y. (Ohio State Univ, Columbus, OH, USA); Sooryakumar, R. *Solid State Commun* v 64 n 7 Nov 1987 p 1081-1084.

**095768 MESOSCOPIC COHERENCE PHENOMENA IN SEMICONDUCTOR DEVICES.** Semiconductor devices have several attractive properties which make them useful in the study of electronic coherence phenomena such as universal conductance fluctuations. The use of gated devices allows the Fermi level, and thus the electronic wavelength, to be adjusted in order to study energy correlation effects. The two-dimensional electron gas formed beneath the gate can be tilted with respect to the magnetic field to reveal that the field correlation length of the fluctuations obeys a cosine law. This suggests that the fluctuations are caused by quantum interference in the same way that the Aharonov-Bohm effect arises in metallic rings. The energy range over which electrons are correlated in these materials is generally larger than in metals. This allows one to study these conductance fluctuations at much higher temperatures than are feasible in metallic conductors. For the same reason, larger source-drain voltages can be applied to observe asymmetry and nonlinear effects in the conductance. (Edited author abstract) 57 Refs.

Kaplan, S.B. (IBM, Yorktown Heights, NY, USA); Hartstein, Allan M. *IBM J Res Dev* v 32 n 3 May 1988 p 347-358.

**095769 ANALYSIS OF ELECTRON WAVE REFLECTIVITY AND LEAKAGE CURRENT OF MULTI-QUANTUM BARRIER: MQB.** In this paper, a multi-quantum barrier (MQB) made of super lattices is proposed. First, as a measure for indicating a possibility of improving the efficiency of carrier confinement by an MQB structure, the electron wave reflectivity for the electron energy in such a structure is derived. Next, the leakage current transmitted through the MQB is calculated. By such calculations, it is demonstrated theoretically that the height of the effective potential barrier can be increased from that of a classical barrier. 10 Refs.

Uenohara, Hiroyuki (Tokyo Inst of Technology, Yokohama, Jpn); Iga, Kenichi; Koyama, Fumio. *Electron Commun Jpn Part 2* v 71 n 5 May 1988 p 53-60.

**Encapsulation** See Also EPOXY RESINS—Curing.

**095770 NEW PROFILE OF ULTRA LOW STRESS RESIN ENCAPSULANTS FOR LARGE CHIP SEMICONDUCTOR DEVICES.** Internal stress, as a result of temperature cycle testing (TCT), causes package cracking, passivation film cracking, aluminum pattern deformation, etc. To reduce the internal stress, the authors previously (1987) determined that it is effective to introduce small silicone domains into the epoxy matrix and to create a strong interaction layer between the domain/matrix interface in a heterogeneous structure where soft polymer particles are dispersed as domains in the epoxy matrix as a continuous phase. To date, research efforts have yielded epoxy resins having about 0.1-μm domains with a strong interaction layer at the domain/matrix interface using special silicone modifiers. Comparisons were made between silicone-modified epoxy resins having 2.5-μm domains and smooth domain/matrix interfaces with versions having 0.1-μm domains. 6 refs.

Nakamura, Yoshinobu (NITTO Electric Industry Co, Kameyama, Jpn); Unishi, Shinjiro; Kunishi, Teruo; Miki, Kazuyuki; Tabata, Haruo; Kuwada, Kazuyuki; Suzuki, Hideto; Matsumoto, Tsunetaka. *IEEE Trans Compon Hybrids Manuf Technol* v CHMT-10 n 4 Dec 1987, Contrib from the 37th Electr Compon Conf, Boston, MA, USA, May 1987 p 502-506.

**Etching** See Also SEMICONDUCTOR MATERIALS—Etching.

**095771 EFFECT OF POTENTIAL FIELD ON ION DEFLECTION AND SHAPE EVOLUTION OF TRENCHES DURING PLASMA-ASSISTED ETCHING.** A mathematical model was developed to study shape evolution of trenches during plasma-assisted etch-

ing. A two-region sheath model was used to determine the effect of local potential distribution on ion deflection and on the ion flux and energy distribution along the walls of the trench. The potential field in the near-trench region was found by using the boundary integral method which, coupled with a moving boundary scheme, allowed the time evolution of etch profiles to be computed. The effect of important variables affecting ion deflection and sidewall etching was combined in a dimensionless group  $\Omega$ . For values of  $\Omega \leq 0.1$  and for positive mask potentials, less than 10% of the bombarding ion flux struck the sidewall of a rectangular trench. (Edited author abstract) 25 refs.

Economou, Demetre J. (Univ of Illinois, Urbana, IL, USA); Alkire, Richard C. *J Electrochem Soc* v 135 n 4 Apr 1988 p 941-949.

## Evaluation

**095772 EVALUATION OF MQW WAFER FOR SURFACE-EMITTING LASER BY X-RAY DIFFRACTION.** Wide-angle double-crystal X-ray diffraction was utilized to characterize a multi-quantum well (MQW) structure designed for a surface-emitting MQW laser. A precise measurement of the period was achieved and an evaluation of the abruptness of a hetero-interface is presented. (Author abstract) 4 refs.

Onda, Haruka (Tokyo Inst of Technology, Yokohama, Jpn); Uenohara, Hiroyuki; Koyama, Fumio; Iga, Kenichi. *Jpn J Appl Phys Part 1* v 27 n 3 Mar 1988 p 438-439.

**Fabrication** See INTEGRATED CIRCUITS, LSI—Design; SEMICONDUCTING CADMIUM COMPOUNDS—Surfaces; SEMICONDUCTING GALLIUM ARSENIDE—Etching; SEMICONDUCTING GALLIUM ARSENIDE—Ion Implantation; SEMICONDUCTING SILICON—Etching; SENSORS—Fabrication.

**Heterojunctions** See Also ACOUSTIC SURFACE WAVE DEVICES—Oscillations; ALUMINUM COMPOUNDS—Chemical Vapor Deposition; CAPACITORS—Electronic Properties; ELECTRIC CONTACTS, OHMIC—Performance; ELECTRIC SPACE CHARGE—Mathematical Models; ELECTRIC SWITCHES, SEMICONDUCTOR—Design; ELECTRONS—Transport Properties; HALL EFFECT DEVICES; LASERS, SEMICONDUCTOR—Design; LASERS, SEMICONDUCTOR—Performance; OPTICAL INSTRUMENTS; OPTOELECTRONIC DEVICES—Fabrication; OPTOELECTRONIC DEVICES—Performance; PHOTOVOLTAIC CELLS—Research; RADIATION DETECTORS—Research; SEMICONDUCTING ALUMINUM COMPOUNDS—Analysis; SEMICONDUCTING ALUMINUM COMPOUNDS—Electric Field Effects; SEMICONDUCTING ALUMINUM COMPOUNDS—Electric Properties; SEMICONDUCTING ALUMINUM COMPOUNDS—Electronic Properties; SEMICONDUCTING ALUMINUM COMPOUNDS—Growth; SEMICONDUCTING ALUMINUM COMPOUNDS—Physical Properties; SEMICONDUCTING ALUMINUM COMPOUNDS—Transport Properties; SEMICONDUCTING GALLIUM ARSENIDE—Electric Conductivity; SEMICONDUCTING GALLIUM ARSENIDE—Electronic Properties; SEMICONDUCTING GALLIUM ARSENIDE—Growth; SEMICONDUCTING GALLIUM ARSENIDE—Magnetic Field Effects; SEMICONDUCTING GALLIUM ARSENIDE—Physical Properties; SEMICONDUCTING GALLIUM COMPOUNDS—Electronic Properties; SEMICONDUCTING GALLIUM COMPOUNDS—Photoconductivity; SEMICONDUCTING GALLIUM COMPOUNDS—Physical Properties; SEMICONDUCTING GALLIUM COMPOUNDS—Thin Films; SEMICONDUCTING INDIUM COMPOUNDS—Chemical Vapor Deposition; SEMICONDUCTING INDIUM COMPOUNDS—Electronic Properties; SEMICONDUCTING INDIUM COMPOUNDS—Growth; SEMICONDUCTING SILICON—Surfaces; SEMICONDUCTOR MATERIALS; SEMICONDUCTOR MATERIALS—Analysis; SEMICONDUCTOR MATERIALS—Growth; SEMICONDUCTOR MATERIALS—Impurities; SEMICONDUCTOR MATERIALS—Photoconductivity; SEMICONDUCTOR MATERIALS—Physical Properties; SEMICONDUCTOR MATERIALS—X-Ray Analysis; SOLAR CELLS—Cadmium Sulfide; SOLAR CELLS—Materials; SOLAR CELLS—Performance; TITANIUM COMPOUNDS—Spectroscopic Analysis; TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, FIELD EFFECT; TRANSISTORS, PHOTOSENSITIVE—Heterojunctions.



**095773 ON THE FACTORS IMPAIRING THE COMPOSITIONAL TRANSITION ABRUPTNESS IN HETEROJUNCTIONS GROWN BY VAPOUR-PHASE EPITAXY.** The compositional transition abruptness in a heterojunction is impaired by after-supply of reactants adsorbed at certain surfaces or stored in various types of stagnant volumes (for the case of 'turn-off'). These volumes are found near valves, in vortices and in the boundary layer on the substrate. Expressions are derived for the shapes of the composition profiles to be expected from each of these factors separately, both after turn-off and after turn-on. These make it possible to estimate which factor is dominant and to suggest measures for improvement. In our growth apparatus, modification of the valves and reduction of the entry vortex in the reactor (by using a vertical 'chimney reactor' with bottom inlet) have led to very considerable improvements. (Author abstract) 15 refs.

van Oordorp, C. (Philips Research Lab, Eindhoven, Neth); Leys, M.R. *J Cryst Growth* v 84 n 2 Aug 1987 p 271-288.

**095774 ELECTRON TRANSPORT OF (Al, Ga)Sb/InAs HETEROJUNCTIONS PREPARED BY MOLECULAR BEAM EPITAXY.** Molecular beam epitaxial growth of (Al, Ga)Sb/InAs heterostructures is described. Electron transport studies indicate that these heterojunctions are of high quality. Shubnikov-de Haas measurement of the AlSb/InAs/GaSb quantum well shows a two-dimensional electron gas of concentration  $2 \times 10^{12} \text{ cm}^{-2}$  and a low-temperature mobility approaching  $10^5 \text{ cm}^2/\text{Vs}$ . Low-temperature capacitance/voltage measurement indicates that the thin AlSb barrier is a classical Mott-type barrier. (Author abstract) 8 refs.

Chiu, T.H. (AT&T, Holmdel, NJ, USA); Tsang, W.T.; Levi, A.F.J. *Electron Lett* v 23 n 17 Aug 13 1987 p 917-919.

**095775 ELECTROLUMINESCENT PARAMETERS OF ZnTe-InP HETEROJUNCTIONS.** We made zinc telluride-indium phosphide heterojunctions by epitaxial deposition of ZnTe in a quasiclosed volume on variously oriented InP substrates; film thicknesses about 100  $\mu\text{m}$ . We examined the electroluminescence (EL) spectra of the p-ZnTe-n-InP junctions with direct current up to  $1 \text{ A}\cdot\text{cm}^{-2}$  and in pulsed mode up to about  $10^2 \text{ A}\cdot\text{cm}^{-2}$ . The measurements were made at 77 and 300°K with forward and reverse bias. These heterojunctions emit in the green region, with quantum yields higher by two orders of magnitude than those obtained previously with other structures of  $\text{A}^{\text{III}}\text{B}^{\text{V}}\text{-A}^{\text{II}}\text{B}^{\text{V}}$  type. 14 refs.

Radautsan, S.I.; Rebrov, S.A.; Tsurkan, A.E. *J Appl Spectrosc* v 46 n 3 Mar 1987 p 267-269.

**095776 CYCLOTRON RESONANCE INVESTIGATIONS IN GaInAs(P)/InP HETEROJUNCTIONS GROWN BY LOW-PRESSURE METAL-ORGANIC CHEMICAL VAPOUR DEPOSITION.** We report in this letter the study of the cyclotron resonance spectrum of a two-dimensional electron gas at the  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}/\text{InP}$  interface, grown by low-pressure metal-organic chemical vapor deposition. Quantum oscillations that are clear consequences of the two dimensionality of the system have been evidenced in the region of cyclotron resonance. By tilting the sample, a second absorption peak added to the normal cyclotron resonance has been observed; it has been connected with the fact that two electric sub-bands were occupied at the heterojunction. (Author abstract) 16 refs.

Maurel, P. (Thomson-CSF, Orsay, Fr); Razeghi, M.; Guldner, Y.; Vieren, J.P. *Semicond Sci Technol* v 2 n 10 Oct 1987 p 695-699.

**095777 MAGNETOPHONON RESONANCE OF TWO-DIMENSIONAL ELECTRON GAS IN AlGaAs/GaAs HETEROSTRUCTURE.** The theory of magnetophonon resonance of the two-dimensional electrons in AlGaAs/GaAs single heterojunction is presented, where the electronic states are calculated self-consistently and the transverse magnetoresistance is calculated by Kubo formula taking into account 3 subbands

and 10 Landau levels in each subband. (Edited author abstract) 16 refs.

Mori, Nobuya (Osaka Univ, Jpn); Hamaguchi, Chihito. *Technol Rep Osaka Univ* v 37 n 1865-1888 Mar 1987 p 127-133.

**095778 HETEROJUNCTIONS OBTAINED USING SEMICONDUCTING METAL SULFIDE-POLYMER COMPOSITE FILMS.** Heterojunctions were prepared using transparent organosols containing colloidal metal sulfide and polymer. For example, spreading of an N,N-dimethylformamide (DMF) organosol containing colloidal cadmium sulfide and an 80:20 copolymer of vinylidene chloride and acrylonitrile on a copper sulfide substrate and removing DMF under vacuum gave a heterojunction which showed rectification of electric current (rectification ratio=44). Preparation of other heterojunctions and their rectification effect are also reported. (Author abstract) 5 refs.

Kubota, Etsuo (Tokyo Inst of Technology, Yokohama, Jpn); Yamamoto, Takakazu. *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1601-1602.

**095779 GROWING PERFECT VERTICAL LAYERS OF  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  WITH A BAND GAP INCREASING TOWARD THE SURFACE.** Using statistical methods of experiment design, a mathematical model is constructed which makes it possible to adequately describe the dependence of the dislocation density on the technological parameters of the process of growth of vertical  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  layers by the temperature-gradient zone melting method. The optimal values of these technological parameters (the process temperature, the thickness of the liquid zone, the duration of forward motion of this zone, and the initial concentration of aluminum in the liquid phase), at which the grown vertical  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  layers have a minimum dislocation density of  $4 \cdot 10^{13} \text{ cm}^{-2}$ , are determined. In Russian. 6 refs.

Gaponenko, V.N.; Lunin, L.S.; Lunina, O.D. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 8 Aug 1987 p 1247-1250.

**095780 ON A TWO-DIMENSIONAL ELECTRON GAS MODULATED BY A PERIODIC POTENTIAL.** After a brief introduction to the semiconductor heterojunction devices in which a two-dimensional electron gas can be realized and can be subjected to a periodic potential through a grating, the linear response function for this periodically modulated system is calculated in the random-phase approximation. Two solvable models have been considered, based on the anisotropic electron kinematics arising from the periodic potential. For the first model, approximate and exact results are obtained when (the Fermi level)  $E_F > 2t$  (half the band width) while, for the second model, exact results are obtained when  $E_F > 2t$  as well as  $E_F < 2t$ . Results for the static polarizability and the plasmon dispersion are explicitly displayed. (Author abstract) 16 refs.

Das, Amal K. (Dalhousie Univ, Halifax, NS, Can); Glasser, M.L.; Payne, S.H. *J Phys C Solid State Phys* v 21 n 2 Jan 20 1988 p 357-366.

**095781 OPTICAL LIMITATION IN A SYMMETRICAL PbS/PbSSe/PbSnSe HETEROSTRUCTURE.** A comparative analysis is performed of the waveguide properties of PbS/PbSSe/PbSnSe twin heterostructures with separate electron and optical limitation and PbSSe/PbSnSe twin heterostructures. It is shown that a reduction in the generation limit of lasers based on the twin heterostructures with separate electronic and optical limitation is caused by the optical limitation which is more effective than in the twin heterostructure. (Author abstract) 5 refs.

Selivanov, Yu.G.; Shotov, A.P. *Sov Phys Lebedev Inst Rep* n 4 1987 p 33-37.

**095782 TEMPERATURE DEPENDENCE OF THE MOBILITY IN HETEROSTRUCTURES MODIFIED BY MULTI-SUBBAND EFFECTS.** Recent experimental studies of the temperature dependence of the electron

mobility for GaAs-GaAlAs heterostructures in the low temperature range have been reported. The authors observed both an increase and a decrease of the mobility (or, equivalently, of the normalized resistance) with increasing temperature in dependence on several sample parameters. This behavior is explained by an interplay between scattering due to ionized impurities (positive temperature dependence) and acoustic phonons (negative temperature dependence). It is shown that intersubband scattering can significantly influence the temperature dependence of the mobility in heterostructures. 7 refs.

Suhrke, M. (Humboldt-Univ Berlin, Berlin, East Ger); Keiper, R.; Ziep, O. *Phys Status Solidi B* v 144 n 1 Nov 1987 p K7-K12.

**095783 ELECTRON-LO-PHONON INTERACTION IN SEMICONDUCTOR QUANTUM-Well HETEROSTRUCTURES.** The authors have reconsidered electron-LO-phonon interaction in the frame of a model suitable to incorporate LO-phonon confinement. This model has been worked out for the case of longwave dispersive phonons in a QWH. They briefly report the main results obtained and the basic assumptions of their approach. 13 refs.

Trallero Giner, C. (Univ de la Habana, Havana, Cuba); Comas, F. *Phys Status Solidi B* v 144 n 1 Nov 1987 p K19-K22.

**095784 CLOSED-FORM METHOD FOR SOLVING THE STEADY-STATE GENERALIZED ENERGY-MOMENTUM CONSERVATION EQUATIONS.** The Boltzmann transport equation applied to electron transport in a heterostructure semiconductor is discussed. The closed-form methods for solving the heterostructure energy-momentum conservation equations are considered and the energy flux conservation equation is suggested as an additional equation to be solved in the hydrodynamic hot electron transport model. Suitable numeric stable discretization schemes for the conservation equations are presented. (Author abstract) 13 refs.

Azoff, E.M. (Rutherford Appleton Lab, Didcot, Engl). *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 1 Mar 1987 p 25-30.

**095785 EFFECT OF SURFACE ENCAPSULATION AND  $\text{As}_4$  OVERPRESSURE ON Si DIFFUSION AND IMPURITY-INDUCED LAYER DISORDERING IN GaAs,  $\text{Al}_x\text{Ga}_{1-x}\text{As}$ , AND  $\text{Al}_x\text{Ga}_{1-x}\text{As-GaAs}$  QUANTUM WELL.** Data are presented demonstrating that the surface encapsulant and the  $\text{As}_4$  overpressure strongly affect Si diffusion in GaAs and  $\text{Al}_x\text{Ga}_{1-x}\text{As}$ , and thus are important parameters in impurity-induced layer disordering. Increasing  $\text{As}_4$  overpressure results in an increase in diffusion depth in the case of GaAs, and a decrease in diffusion depth for  $\text{Al}_x\text{Ga}_{1-x}\text{As}$ . In addition, the band-edge excitation is observed in absorption on an  $\text{Al}_x\text{Ga}_{1-x}\text{As-GaAs}$  superlattice that is diffused with Si and is converted to bulk crystal  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  via impurity-induced layer disordering. In contrast, the excitation is not observed in absorption on GaAs diffused with Si in spite of the high degree of compensation. These data indicate that the Si diffusion process, and the properties of the diffused material, are different for GaAs and for  $\text{Al}_x\text{Ga}_{1-x}\text{As-GaAs}$  superlattices converted into uniform  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  ( $0 \leq x \leq 1$ ) via impurity-induced layer disordering with the amphoteric dopant Si. 12 refs.

Guido, L.J. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Plano, W.E.; Nam, D.W.; Holonyak, N. Jr.; Baker, J.E.; Burnham, R.D.; Gavrilovic, P. *J Electron Mater* v 17 n 1 Jan 1988 p 53-56.

**095786 ELECTRICAL PROPERTIES OF INTERFACIAL TRAPS IN SELECTIVELY DOPED AlGaAs/GaAs HETEROSTRUCTURES.** A hole-trap-like peak appears in the drain current DLTS spectra recorded from a high-electron-mobility transistor fabricated with a selectively doped AlGaAs/GaAs heterostructure grown by



molecular-beam epitaxy. The peak is caused by traps which strongly affect the mobility. The emission and the capture activation energy of the traps increases as the gate bias increases. This shows that the traps which remain at a fixed energy level relative to the GaAs conduction band edge exchange electrons with the sub-bands in the accumulation layer. Based on the above characteristics, an analysis of the spectra indicates that interface-traps with a density of  $3.8 \times 10^{10} \text{ cm}^{-2}$  are located at 0.01 eV above the conduction band edge of GaAs, in the potential well of the accumulation layer. (Author abstract) 21 refs.

Takikawa, Masahiko (Fujitsu Lab Ltd, Atsugi, Jpn). *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 2026-2032.

**095787 NEW LOOK AT ZnSe/GaAs HETEROSTRUCTURES.** Contrary to some expectations for n-ZnSe/n-GaAs heterostructures, optical and electrical measurements indicate that the GaAs side of the junction is depleted of electrons, while the ZnSe side accumulates them. The low T conductance of the n-ZnSe exhibits two-dimensional metallic behavior: activated conduction is observed from 1.4 to 6 K, and a logarithmic variation of the conductance with temperature is observed between 14 and 45 K. A 0.75 V photovoltage under 5 mW  $\text{cm}^{-2}$  of white light with the GaAs negative is consistent with the theoretical predictions of Ihm and Cohen. (Author abstract) 17 refs.

Walsh, D. (McGill Univ, Montreal, Que, Can); Mazuruk, K.; Benzaquen, M.; Weissfloch, P. *Semicond Sci Technol* v 3 n 2 Feb 1988 p 116-119.

**095788 REMOTE IMPURITY SCATTERING IN HETEROJUNCTIONS.** The commonly used formalism for the ionized remote impurity scattering of electrons in a 2D electron gas contains the following inconsistency. The potential of the donors (e.g. the Si donors in the AlGaAs in the case of a GaAs-AlGaAs heterojunction) is accounted for twice: first in the self-consistent calculation of the envelope function and second in the calculation of the scattering rate. Instead, only the scattering as due to the fluctuations in the average field of the donors should be accounted for. We have developed expressions for this scattering amplitude and have applied them to a few GaAs-AlGaAs samples with very high mobilities. These samples posed the problem of a serious underestimation of the experimental mobility by the theory. This problem now can be resolved and a better agreement between experiment and theory has been obtained. (Author abstract) 24 refs.

van Hall, P.J. (Eindhoven Univ of Technology, Eindhoven, Neth); Klaver, T.; Wolter, J.H. *Semicond Sci Technol* v 3 n 2 Feb 1988 p 120-123.

**095789 OBSERVATION OF REAL SPACE TRANSFER IN GaAs-AlGaAs HETEROSTRUCTURE GROWN BY LPE.** Negative differential resistance (NDR) and oscillation was observed in GaAs-AlGaAs heterostructure grown by LPE. It was concluded that NDR resulted from real space transfer of hot electrons in the heterojunction. (Author abstract) 6 refs.

Jiang, Xiao-song (Peking Univ, Beijing, China); Yu, Li-sheng; Wang, Shu-min; Liu, Hong-xun; Zhang, Bei. *Solid State Commun* v 62 n 9 Jun 1987 p 597-598.

**095790 TUNNELING THROUGH SEMICONDUCTOR HETEROJUNCTION BARRIERS.** A five-level k.p-theory is presented for the description of single-particle tunneling through semiconductor barriers. The influence of the band structure is described using a local, energy-dependent effective mass  $\mu(\epsilon, z)$ . Within the barrier, the resulting 'tunneling' mass is smaller than the band edge mass of the barrier material, since the particle energy is closer to the valence band than the barrier band edge is. For GaAs-GaAlAs-GaAs structures, this effect can influence transmission rates by orders of magnitude. (Author abstract) 6 refs.

Lassnig, R. (Univ Innsbruck, Innsbruck, Austria). *Solid State Commun* v 61 n 9 Mar 1987 p 577-580.

**095791 CHARACTERISTICS OF A TRANSISTOR**

**BASED ON A HETEROSTRUCTURE WITH A QUANTUM TWO-DIMENSIONAL ELECTRON CHANNEL.** In recent years there has been great interest in the study of physical processes at the interface of heterojunctions and structures based on them. This is attributable primarily to the possibility of improving the characteristics of semiconductor devices based on GaAs. The development of structures with modulated doping of the heterojunction GaAs-Ga<sub>x</sub>Al<sub>1-x</sub>As with the help of the method of molecular-beam epitaxy has made it possible not only to obtain nearly ideal interfaces, but also to achieve values of the electron mobility exceeding  $10^6 \text{ cm}^2/\text{V}\cdot\text{sec}$ . Special interest in such structures has been simulated also by the experimental observation of fractional quantization of the Hall resistance. The characteristics of a transistor based on heterostructure have been described with the help of simplified models, on the voltage and of the current on the drainage potential. The paper discusses filling of size-quantization levels with electrons and characteristics of a transistor based on a heterostructure. 5 refs.

Zykov, N.V. *Sov Microelectron* v 16 n 3 May-Jun 1987 p 126-128.

**095792 PHASES OF THE RESISTIVITY AND THERMOPOWER OSCILLATIONS IN GaAs-Ga<sub>1-x</sub>Al<sub>x</sub>As HETEROJUNCTIONS.** We have examined the absolute and relative phases of the oscillations (at low magnetic fields) in the resistivity and thermopower of three GaAs-Ga<sub>1-x</sub>Al<sub>x</sub>As heterojunctions. The experimental value for the absolute phase of the resistivity oscillations agrees with the predicted result. We see virtually no phase difference between the resistivity and thermoelectric oscillations contrary to theoretical predictions based on the assumption that the thermopower is due to diffusion effects. This null result reinforces the view that the thermopower is mainly due to phonon drag rather than diffusion effects. (Author abstract) 13 refs.

D'Iorio, M. (Nat'l Research Council, Ottawa, Ont, Can); Stoner, R.; Fletcher, R. *Solid State Commun* v 65 n 7 Feb 1988 p 697-700.

**095793 REMOTE ION SCATTERING IN GaAs-GaAlAs HETEROSTRUCTURES.** A theoretical model of remote ion scattering in heterostructures is developed, based on the evaluation of the correlation function of the impurity potential. The method enables the consistent description of interference effects of the remote ion potentials, which are demonstrated to be particularly strong in such structures. Calculated mobilities demonstrate the invalidity of previously derived 'inherent mobility limits' motivating new considerations of relevant scattering sources. (Author abstract) 6 refs.

Lassnig, R. (Univ Innsbruck, Innsbruck, Austria). *Solid State Commun* v 65 n 7 Feb 1988 p 765-768.

**095794 SPECTRAL RESPONSE OF (CH)<sub>x</sub>-CdZnS HETEROJUNCTION: APPLICATION OF ON-SAGER'S THEORY OF GEMINATE RECOMBINATION.** The Onsager theory of geminate recombination is used to fit experimental photoresponse of (CH)<sub>x</sub>-CdZnS heterojunctions. This model, which depends upon three adjustable parameters, gives good agreement between experimental and calculated spectral response in zero bias conditions and lead to a simple interpretation of the change of spectral response under reverse bias. (Author abstract) 19 refs.

Laplace, D. (Lab des Semi-conducteurs & Energie Solaire, Dakar, Senegal); Youm, I.; Cohen-Solal, G.W.; Cadene, M. *Solid State Commun* v 64 n 11 Dec 1987 p 1379-1382.

**095795 RADIATIVE RECOMBINATION OF A 3D-ELECTRON WITH A 2D-HOLE IN P-TYPE GaAs/(Ga)AlAs HETEROJUNCTIONS.** We have investigated an unusual new line observed in p-type GaAs/(AlGa)As heterojunctions, referred to as the H-band, by low-temperature photoluminescence experiments in magnetic fields up to 9.5 T. The direction of the magnetic field was turned from perpendicular to parallel to the interface. From the energetic shift, the splitting-behaviour, the

lineshape and the temperature dependence of the luminescence line we conclude that the H-band is emitted by the recombination of a flat-band electron with a hole confined in an excited subband. (Author abstract) 6 refs.

Ossau, W. (Univ Wuerzburg, Wuerzburg, West Ger); Bangert, E.; Weimann, G. *Solid State Commun* v 64 n 5 Nov 1987 p 711-715.

**095796 CHARACTERIZATION OF ULTRATHIN CaF<sub>2</sub> FILMS HETEROEPITAXIALLY GROWN ON Si(111) SURFACES.** Ultrathin CaF<sub>2</sub> films heteroepitaxially grown on Si(111) substrates have been characterized by low-energy electron energy loss spectroscopy and Auger electron spectroscopy. The measured specimens were transferred from the growth chamber to an analyzing chamber located at a distant facility without suffering any contamination by use of a newly developed portable vacuum chamber. It has been proved from the measurements that a CaF<sub>2</sub> film of good quality grows even from the very initial stage of epitaxy. (Author abstract) 10 refs.

Ando, Koji (Univ of Tokyo, Tokyo, Jpn); Saiki, Koichiro; Sato, Yasuhiro; Koma, Atsushi; Asano, Tanemasa; Ishiura, Hiroshi; Furukawa, Seijiro. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 170-172.

**095797 ALLOY SCATTERING MOBILITY OF TWO DIMENSIONAL ELECTRON GAS IN RECTANGULAR AND DELTA DOPED QUANTUM WELLS IN QUATERNARIES.** The present authors have reported the calculation of alloy scattering mobility in HJs by assuming the scattering potential to be a spherically symmetric square well. This form of potential, which is the most appropriate in the presence of alloy clustering, has already been employed for bulk electrons, and for 2-DEG in ternaries. A simple analytic expression for the mobility may further be obtained when the radius of the cluster is small. In the present work, we shall extend our theory for the calculation of mobility of 2-DEG in the usual rectangular QWs and also in delta doped QWs. 15 refs.

Bhattacharyya, K. (Inst of Radio Physics & Electronics, Calcutta, India); Basu, P.K. *Solid State Electron* v 31 n 2 Feb 1988 p 309-310.

**095798 PHOTO-MODULATED REFLECTANCE SPECTROSCOPY OF HETERO NIPI STRUCTURES.** The room temperature photo-modulated reflectance and its dependence on the modulation intensity of hetero-NIPI structures are reported. The modulation mechanism in such structures is discussed. (Edited author abstract) 8 refs. In Chinese.

Tang, Yinsheng (Univ of Science & Technology of China, Hefei, China); Jiang, Desheng. *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 217-220.

**095799 CARRIER INJECTION AT GRADED HETEROJUNCTIONS.** Carrier injection was investigated on Ga<sub>1-x</sub>Al<sub>x</sub>As single heterostructures whose chemical composition changes near the heterojunction over an extended region. A model of the dependence of the energy bands on the coordinates allows discussion of the measured quantities, cathodoluminescence intensity and electron beam induced current (EBIC) in the context of generation, recombination, and transport of electron-hole pairs in the drift field of heterojunction. A determination of the p-n junction position is possible using the equation of continuity for EBIC. The transport of carriers from the p-n junction to the light emitting region (injection efficiency) was investigated. (Edited author abstract) 7 refs.

Stegmann, R. (Humboldt Univ of Berlin, Berlin, East Ger); Jacobs, B.; Kamleh, H.; Albani, M.; Heider, M.; Monzer, F. *Phys Status Solidi A* v 105 n 2 Feb 1988 p 661-670.



**095800 DETERMINATION OF BAND DISCONTINUITY IN AMORPHOUS SILICON HETEROJUNCTIONS.** A new procedure of determining the band offset in semiconductor heterojunctions has been developed. The valence band spectra for ultrathin amorphous silicon nitride ( $a\text{-Si}_{1-x}\text{N}_x\text{:H}$ ) or silicon carbide ( $a\text{-Si}_{1-x}\text{C}_x\text{:H}$ ) deposited on hydrogenated amorphous silicon ( $a\text{-Si:H}$ ) have been measured by X-ray photoelectron spectroscopy. It is demonstrated that the empirical deconvolution of measured spectra yields the valence band discontinuity in  $a\text{-Si}_{1-x}\text{N}_x\text{:H}/a\text{-Si:H}$  and  $a\text{-Si}_{1-x}\text{C}_x\text{:H}/a\text{-Si:H}$  systems. (Author abstract) 12 refs.

Hayashi, Tsukasa (Hiroshima Univ, Hiroshima, Jpn); Miyazaki, Seiichi; Hirose, Masataka. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 314-316.

**095801 SYNTHESIS OF EPITAXIAL BUFFER LAYERS OF GERMANIUM AND GERMANIUM-SILICON SOLID SOLUTIONS ON A SILICON SUBSTRATE (REVIEW).** Research concerning the synthesis of Ge and  $\text{Ge}_x\text{Si}_{1-x}$  buffer layers during the fabrication of devices based on GaAs/Si structures is reviewed. Various methods of obtaining epitaxial films of germanium and germanium-silicon solid solutions on a silicon substrate are described. (Translated author abstract) 20 refs. In Russian.

Gurevich, V.M.; Moskalev, L.L.; Novikova, E.N. *Tsvet Met* n 11 Nov 1987 p 81-85.

**095802 ENSEMBLE MONTE CARLO SIMULATION OF SEMICLASSICAL NONLINEAR ELECTRON TRANSPORT ACROSS HETEROJUNCTION BAND DISCONTINUITIES.** An ensemble Monte Carlo simulation code has been developed to study nonlinear electron transport across heterojunction interfaces in strong electric fields. The evolution of electron energy and momentum distribution in space and time has been investigated in two AlGaAs/GaAs single well heterostructures under various operating conditions. It is found that overheating, enhanced energy relaxation, and carrier confinement as a consequence of the structure in real space have a pronounced influence on the energy and momentum distribution. As a result, the energy distribution can have a structure which directly reveals the band structure (of the material). The influence of the structure in real space and the band structure of neighboring layer on the ionization rate is discussed along with the possibility of a new overshoot effect. (Edited author abstract) 17 refs.

Kim, K. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Hess, K. *Solid State Electron* v 31 n 5 May 1988 p 877-885.

**095803 ANALYTICAL INVESTIGATION OF HETEROJUNCTIONS FORMED BY VACUUM DEPOSITION.** Heterojunctions formed on the surface of the II-VI materials ZnTe, ZnSe, ZnS, CdS, ZnO and  $\text{Zn}_{0.22}\text{Cd}_{0.78}\text{S}$  have been fabricated by the vacuum deposition of copper chloride. A solid state reaction has been observed to take place at the surface of each of these materials. A detailed study of this reaction has been made by energy dispersive X-ray microanalysis and reflection electron diffraction. For some of the materials a limited reaction was observed to occur at room temperature. A complete reaction was only attained by annealing in the 150°C to 200°C temperature range. The use of a variable incident electron beam energy in X-ray microanalysis as a technique for the detection of heterojunction diffusion and film thickness assessment is demonstrated. (Author abstract) 9 refs.

Fitzgerald, A.G. (Univ Dundee, Dundee, Scotl); Potrous, S.M. *Sol Energy Mater* v 17 n 4 Jun 1988 p 299-309.

**095804 BAND EDGE OFFSETS IN STRAINED  $(\text{InGa})_{1-x}(\text{AlGa})_x$  HETEROSTRUCTURES.** The excitonic transitions between the ground electron and hole quantum well sublevels in strained  $\text{In}_x\text{Ga}_{1-x}\text{As}/\text{Al}_y\text{Ga}_{1-y}\text{As}$  multiple quantum well structures ( $x = 0.12\text{-}0.35$  and  $y = 0.2\text{-}0.35$ ) have been investigated by means of photoluminescence and photoconductivity measurements. The molecular beam epitaxy grown structures

contained an  $\text{Al}_y\text{Ga}_{1-y}\text{As}$  matrix with one unstrained GaAs and three strained  $\text{In}_x\text{Ga}_{1-x}\text{As}$  quantum wells one of which was in the GaAs cladding layers. The ratio of the conduction band edge line up to the band gap offset for the strained  $\text{In}_x\text{Ga}_{1-x}\text{As}$ -unstrained  $\text{Al}_y\text{Ga}_{1-y}\text{As}$  interface has been found to be  $0.67 \pm 0.08$  for the studied regions of  $x$  and  $y$ . (Author abstract) 13 refs.

Andersson, T.G. (Chalmers Univ of Technology, Goteberg, Sweden); Chen, Z.G.; Kulakovskii, V.D.; Uddin, A.; Vallin, J.T. *Solid State Commun* v 64 n 3 Oct 1987 p 379-382.

**095805 DEEP TRAP PARAMETERS IN  $\text{ZnSiAs}_2$  USING HETEROJUNCTION CAPACITANCE MEASUREMENTS.** Capacitance-voltage (C-V) relationship of an  $n^+0\text{-CdS}/p\text{-ZnSiAs}_2$  heterojunction has been analyzed over the frequency range of 10 Hz to 1 MHz and a temperature range of  $-20^\circ\text{C}$  to  $+60^\circ\text{C}$ , to find the deep trap parameters in  $p\text{-ZnSiAs}_2$  (hole concentration,  $p = 5 \times 10^{16}$ ). These films were grown on low resistivity Si substrates by the metal-organic chemical vapor deposition (MOCVD) technique. An electron trap was identified 0.60 eV below the conduction band edge, with a capture cross Section ( $\sigma$ ) of  $2 \times 10^{-12} \text{ cm}^2$ . Such a large value of  $\sigma$  indicates that this may be a positively charged donor-type trap. Its concentration was estimated to be about  $3 \times 10^{16} \text{ cm}^{-3}$ . (Author abstract) 13 refs.

Naseem, H.A. (Univ of Arkansas, Fayetteville, AR, USA); Burton, L.C.; Andrews, J.E. Jr. *Appl Phys Commun* v 8 n 1 Mar 1988 p 75-87.

**095806 CATION AND ANION DISPLACEMENTS AT HETERO-INTERFACES OF  $(\text{GaAs})_{28}(\text{AlAs})_{24}$  SUPERLATTICE LAYERS.** By developing a new method of Fourier analysis the local cation and anion displacements in a superlattice, especially near the hetero-interface boundary between the GaAs and the AlAs, were determined from the X-ray integrated intensities of the satellite reflections observed around the two fundamental Bragg reflections, namely the 002 and 004 reflections. The interlayer distance of successive cation layers was found to be 2.827 Angstrom in the GaAs region and 2.835 Angstrom in the AlAs region, except near the hetero-interface boundary. The anion layers are, therefore, located at the mid-point between the cation layers in these regions. However, near the hetero-interface region, which consists of eight molecular layers, anion layers are not located at the mid-point between them but are slightly shifted to the GaAs side. The value of the shift at the boundary between GaAs and AlAs was 0.016 Angstrom. (Author abstract) 3 refs.

Kashihara, Yasuharu (Nagoya Univ, Nagoya, Jpn); Harada, Jimpei. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 522-527.

**095807 EFFECT OF HALL CONDUCTIVITY OF A TWO-DIMENSIONAL ELECTRON LAYER ON THE PROPERTIES OF ELASTIC WAVES PROPAGATING NEAR THE HETEROJUNCTION IN HIGH MAGNETIC FIELDS.** The modification of elastic waves propagating near a heterojunction is analyzed on the basis of a set of the low-frequency dynamics equations for solid-state structures containing a two-dimensional 2D-conducting layer in high magnetic field. The cases are considered of the arrangement of 2D-conducting channel near a crystal free surface as well as in the bulk. (Author abstract) In Russian. 6 refs.

Kosevich, Yu.A.; Syrkyn, E.S. *Fiz Nizkikh Temp* v 14 n 1 Jan 1988 p 85-89.

**095808 ION CHANNELING STUDIES OF HETEROEPITAXIAL STRUCTURES FORMED BY MOLECULAR BEAM.** Epitaxial growth of  $\text{CaF}_2$  films onto Si(111) substrates and the subsequent growth of Si or Ge films onto the  $\text{CaF}_2/\text{Si}(111)$  structure have been conducted with heteroepitaxial structures of Si/ $\text{CaF}_2$ /Si(111) or Ge/ $\text{CaF}_2$ /Si(111), and then investigated by the Rutherford backscattering and ion channeling measurements. It is found that the Si film deposited on the  $\text{CaF}_2$  layer consists of the crystallites of two kinds: one with the

orientation either the same as that of silicon substrate (A type) or rotating  $180^\circ$  to the normal of the substrate surface (B type), indicating the mixture of A- and B-type crystallites in the top Si film. (Edited author abstract) 10 refs.

Jianliang, Peng (Nanjing Univ, China); Guanghou, Wang. *Sci Sin Ser A* v 31 n 7 Jul 1988 p 818-830.

**095809 STUDY ON THE TRANSIENT CAPACITANCE IN HETEROJUNCTION.** The authors' theoretical analysis for the phenomenon of transient capacitance in heterojunction  $\text{CdS}/\text{CuInSe}_2$  reveals that donors are ionized by adding a reverse D. C. bias  $V_{dc}$  after a forward-biased electrical pulse  $V_p$  is switched off, and then some of the electrons produced by ionization are captured by traps and recombined with the ionized donors again via tunneling. This recombination process and the electron drifting in heterojunction region lead to the transient capacitance phenomenon. The theoretical results are in good agreement with the experimental ones. (Author abstract). 18 refs. In Chinese.

Wenku, Yang (Changchun Coll of Optics & Fine Mechanics, China); Wenrong, Deng. *Hongwai Yanjiu A-Ji* v 7A n 3 1988 p 185-194.

**095810 BAND OFFSETS IN  $\text{Si-Si}_{1-x}\text{Ge}_x$  AND  $\text{Ge-Si}_{1-x}\text{Ge}_x$  TRAINED HETEROJUNCTIONS.** We have used a tight-binding scheme to compute valence band offsets in  $\text{Si-Si}_{1-x}\text{Ge}_x$  and  $\text{Ge-Si}_{1-x}\text{Ge}_x$  strained heterojunctions. Strain effects are taken into account by means of a scaling of atomic levels and interactions. Both a self-consistent method and a simple alignment of charge neutrality levels give good results when comparing with the available experimental and theoretical values. We obtain valence bands offsets which are a linear function of the relative composition  $x$ . (Author abstract). 13 refs.

Munoz, A. (Univ de la Laguna, Tenerife, Spain); Brey, L.; Tejedor, C. *Solid State Commun* v 67 n 4 Jul 1988 p 445-447.

**095811 SMALL-SIGNAL IMPEDANCE OF  $\text{GaAs-Al}_x\text{Ga}_{1-x}$  AS RESONANT TUNNELING HETEROSTRUCTURES AT MICROWAVE FREQUENCY.** The microwave impedance of high current drivability  $\text{GaAs-Al}_x\text{Ga}_{1-x}$  resonant tunneling heterostructures in negative differential resistance conditions is measured. Using an equivalent circuit model that accounts for the frequency variation of the impedance, circuit elements corresponding to physical phenomena present in the device are identified. (Author abstract). 5 refs.

Lippens, D. (CNRS, Fr); Mounaix, P. *Electron Lett* v 24 n 18 Sep 1 1988 p 1180-1181.

**095812 SOME PROPERTIES OF SEMICONDUCTOR SUPERLATTICES.** Some of the results obtained on semiconductor superlattices from optical and magnetooptical experiments are presented. These investigations give interesting information on the electronic properties of these two-dimensional systems which have opened up a new field of investigations in semiconductor physics. In particular, optical studies of  $\text{GaAs-AlGaAs}$  and  $\text{InAs-GaSb}$  superlattices and magnetic-absorption experiments in  $\text{HgTe-CdTe}$  superlattices are reported. 38 refs.

Voos, Michel (CNRS, Paris, Fr). *Ann Telecommun* v 43 n 7-8 Jul-Aug 1988 p 357-364.

**095813 OPTICAL STUDIES OF SHALLOW IMPURITIES IN SEMICONDUCTOR QUANTUM WELL STRUCTURES.** The main theoretical properties of hydrogenic impurities in quantum wells are discussed.



Their incidence on optical properties are shown, especially in the case of GaAs-GaAlAs and some other III-V systems. (Author abstract) 35 refs.

Delalande, C. (Ecole Normale Supérieure, Paris, Fr). *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 112-120.

**095814 PAPERS PRESENTED AT THE AMERICAN VACUUM SOCIETY MEETING.** The conference proceedings contains three papers dealing with magnetron reactive sputtering technique for deposition of hydrogenated amorphous silicon films, semiconductor interfaces with synchrotron radiation, and investigations of the Sb/CdTe(100)-(2×1) interfacial structure with photoemission. All the papers are abstracted and indexed separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10841 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Dow, John D. (Ed.). *Superlattices Microstruct* v 3 n 4 1987, Pap Presented at the Am Vac Soc Meet, Urbana-Champaign, IL, USA, Apr 1987 p 331-455.

**095815 INVESTIGATIONS OF THE Sb/CdTe(100)-(2×1) INTERFACIAL STRUCTURE WITH PHOTOEMISSION.** Clean CdTe(100) surfaces were generated by molecular beam epitaxy (MBE). High energy electron diffraction (HEED) and photoemission were used to determine surface quality and to make comparisons with surfaces generated via cycles of ion sputtering and annealing. Photoemission, HEED, and Auger electron spectroscopy were used to study the properties of the Sb/CdTe(100)-(2×1) interface. The Sb 4d core level spectrum showed a large shift (0.72 eV) in binding energy in converting from polycrystalline to the (2×2) surface. A model is proposed for the (2×2) surface structure in which Sb atoms are bonded to two Cd atoms, and Cd atoms are bonded to only one Sb atom. In order to satisfy dangling bonds, the Sb atoms also form dimer bonds with each other. (Edited author abstract) 12 refs.

John, P. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Leible, F.M.; Miller, T.; Hsieh, T.C.; Chiang, T.-C. *Superlattices Microstruct* v 3 n 4 1987, Pap Presented at the Am Vac Soc Meet, Urbana-Champaign, IL, USA, Apr 1987 p 347-355.

**095816 EFFECTIVE-MASS HAMILTONIAN FOR ABRUPT HETEROJUNCTIONS.** Recent work by Morrow and Brownstein has indicated that no derivation exists which would uniquely specify the form of the effective mass theory kinetic energy operator in the neighborhood of an abrupt heterojunction. Present work starts from a basic principle, i.e. the Lagrange equation of motions and provides such a derivation of a uniquely determined effective mass kinetic energy operator. The result is an operator introduced long ago by BenDaniel and Duke. (Author abstract) 8 refs.

Liu, H.C. (Univ of Pittsburgh, Pittsburgh, PA, USA). *Superlattices Microstruct* v 3 n 4 1987 p 413-415.

**095817 DIRECT-INDIRECT BAND GAP CROSS-OVER IN TWO-DIMENSIONAL GaSb/AlSb-QUANTUM-Well-STRUCTURES.** using excitation and time-resolved spectroscopy we have investigated the size-dependent change from direct to indirect band structure in two-dimensional GaSb/AlSb structures. In the indirect regime ( $L_p < 38$  Å) we observe L- and  $\Gamma$ -point transitions, whereas in the direct-gap samples only the  $\Gamma$ -point emission occurs. Direct evidence for the crossover is provided by the increase of the carrier life-time from less than 1 ns in direct-gap samples to more than 100 ns in indirect-gap samples. (Author abstract) 13 refs.

Cebulla, U. (Univ Stuttgart, Stuttgart, West Ger); Forchel, A.; Traenkle, G.; Griffiths, G.; Subbanna, S.; Kroemer, H. *Superlattices Microstruct* v 3 n 4 1987 p 429-434.

**095818 TRANSPORT EQUATIONS FOR HIGHLY**

#### DOPED DEVICES AND HETEROSTRUCTURES.

An overview of the transport equations describing electron and hole motion and density in solids with nonuniform band structure is presented. This includes materials with graded composition, like heterojunctions, and devices with highly doped regions, like the emitter region of modern bipolar transistors and solar cells. Effects due to carrier degeneracy, changes in the energy band edges, and changes in the density of states produce terms in the carrier- and current-density equations in addition to those found in the conventional Shockley model. These new terms are derived and discussed. The general energy-band diagram relating the electrostatic potential, electron affinity and bandgap is given. The current densities are written in terms of gradients of quasi-Fermi level and the carrier densities in terms of normalization integrals. The concepts of generalized drift and diffusion are discussed. Connections to the work by Van Overstraeten et al. and to Lundstrom et al. are given. The transport equations in the nondegenerate limit are presented. The special case of minority-carrier flow in quasi-neutral material is given. Approximations used in device analysis are discussed. (Edited author abstract) 15 refs.

Marshak, Alan H. (Louisiana State Univ, Baton Rouge, LA, USA). *Solid State Electron* v 30 n 11 Nov 1987, New Dev in the Phys of Homo- and Heterojunctions, US-Belg Jt Semin, Louvain, Belg, May 28-30 1986 p 1089-1093.

**095819 REVIEW OF MODELS FOR HETEROJUNCTION BAND OFFSETS.** A description and analysis is given of the theories governing the nature and magnitude of the conduction and valence band discontinuities in heterojunctions. These range from the original Anderson model of 1962 to the recently published position-dependent calculations of the present authors. (Author abstract) 39 refs.

Unlu, Hilmi (Univ of Minnesota, Minneapolis, MN, USA); Nussbaum, Allen. *Solid State Electron* v 30 n 11 Nov 1987, New Dev in the Phys of Homo- and Heterojunctions, US-Belg Jt Semin, Louvain, Belg, May 28-30 1986 p 1095-1098.

**095820 HETEROJUNCTIONS: SOME KNOWN AND UNKNOWN.** Aspects of heterojunctions that are discussed are the limitations of models and the accuracy of experimental measurements of barriers. Lattice matching and interface states are discussed and some recent bandgap engineering concepts are mentioned. (Author abstract) 34 refs.

Milnes, A.G. (Carnegie-Mellon Univ, Pittsburgh, PA, USA). *Solid State Electron* v 30 n 11 Nov 1987, New Dev in the Phys of Homo- and Heterojunctions, US-Belg Jt Semin, Louvain, Belg, May 28-30 1986 p 1099-1105.

**095821 OPTIMIZATION OF II-VI BASED HETEROJUNCTIONS.** The performance of heterojunction devices can be optimized by proper choice of characteristics of the two semiconductors forming the junction and by proper design. One important element in design is the termination of the active volume of the device with surfaces of low, preferably zero surface recombination velocity. This paper discusses the rules governing the choice of ratios of energy gaps, electron affinities, doping levels, minority carrier lifetimes, lattice constants, etc. for the semiconductors comprising the pair. It also discusses the use of heterostructures to produce the low surface recombination velocity surfaces bounding the active volume of the device. The paper reviews principles of materials science which govern the choice of semiconductors for the active regions of the device and the heterostructure 'encapsulants'. Attempts to realize electronic structures having the properties required by optimization theory are described. (Edited author abstract) 7 refs.

Loferski, Joseph J. (US Embassy, Warsaw, Pol). *Solid State Electron* v 30 n 11 Nov 1987, New Dev in the Phys of Homo- and Heterojunctions, US-Belg Jt Semin, Louvain, Belg, May 28-30 1986 p 1205-1213.

**095822 II-VI HETEROJUNCTION DEVICE PHYSICS.** II-VI compounds are mainly used for their

large bandgap. They serve as host materials in electroluminescent devices and as collector or window materials in thin film solar cells. Besides the band discontinuities, the physics of II-VI heterojunctions depends on the presence of deep trap levels within the large bandgap. As a typical example we treat the crossover phenomenon, which can be observed in heat-treated  $\text{Cu}_2\text{S}/\text{CdS}$  thin film solar cells. (Edited author abstract) 24 refs.

De Visschere, P. (State Univ of Ghent, Ghent, Belg); Burgelman, M.; Pauwels, H. *Solid State Electron* v 30 n 11 Nov 1987, New Dev in the Phys of Homo- and Heterojunctions, US-Belg Jt Semin, Louvain, Belg, May 28-30 1986 p 1215-1220.

**095823 THEORETICAL ASPECTS OF ELECTRON TRANSPORT IN MODULATED STRUCTURES.** We have studied transport both perpendicular and parallel to the heterojunction interfaces. For perpendicular transport we have investigated models for tunneling through double barriers and find that resonant tunneling and sequential tunneling lead to the same expression for the current as long as the width of the energy distribution of the injected electrons is larger than the width of the resonant level in the diode. We present results for phonon-assisted tunneling between two wells in a model which remains valid even when the barrier shrinks and the tunneling probability becomes very high. For parallel transport we show that very satisfactory agreement with extensive measurements of the mobility in modulation doped structures in the whole temperature range from 4 K to 300 K can be obtained if one takes into account the complete quasi-two-dimensional subband structure and all the relevant scattering mechanisms. For systems with more complicated double channel structures it is shown how one can tailor the conductivity of a channel in which perpendicular resonant tunneling affects parallel transport. (Edited author abstract) 11 refs.

Vinter, B. (Thomson-CSF, Orsay, Fr); Weil, T. *Superlattices Microstruct* v 3 n 5 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 481-484.

**095824 TRANSIENT AND STEADY-STATE RESPONSE OF THE TWO-DIMENSIONAL ELECTRON GAS IN HETEROJUNCTIONS SUBJECT TO AN EXTERNAL ELECTRIC FIELD.** The time-dependent linearized Boltzmann equation is solved accurately by a new self-consistent algorithm to obtain the time-dependent subband distribution functions in response to a step-wise electric field applied parallel to the AlGaAs-GaAs heterojunction interface. This study is for the polar optical phonon-electron scattering only. Both intra- and inter-subband scatterings are included. It is found that the energy-dependent subband relaxation time oscillates with a period equal to the polar optical phonon energy of 36 meV as the relaxation time is plotted against energy. The short time transport behavior is found to be restricted to within a few picoseconds. The electrons drift in a free-streaming fashion in a time scale of a few hundred femtoseconds. The time-dependent mobility begins to saturate at the steady state value in one picosecond at 300 K and 50 picoseconds at 77 K. (Author abstract) 12 refs.

Tang, D.S. (Univ of Texas at Austin, Austin, TX, USA). *Superlattices Microstruct* v 3 n 5 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 573-578.

**095825 FABRICATION OF GaAs HETEROJUNCTION RING STRUCTURES.** Micron-sized loops of two-dimensional electron gas have been made on GaAs-AlGaAs heterostructures using high-voltage electron beam lithography, for the investigation of the physics of low-dimensional structures, such as quantum interference (weak localization), the Aharonov-Bohm (AB) effect and the Quantum Hall effect. The fabrication procedure has been designed to minimize the effects of electron



irradiation. Marked AB oscillations have been observed at low temperatures ( $T < 100$  mK). (Author abstract) 10 refs.

Ford, C.J.B. (Cambridge Univ, Cambridge, Engl); Ahmed, H. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microthogr, Jouy-en-Josas, Fr, Sep 22-25 1987 p 169-174.

**095826 PRESSURE DEPENDENCE STUDY OF THE EFFECTIVE MASS IN  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As/InP}$  HETEROJUNCTIONS.** A study of the effective mass in  $\text{GaInAs/InP}$  heterojunctions under hydrostatic pressure up to 15 kbars is presented. Magnetophonon resonance experiments are performed to work out the increase of mass with pressure in our samples. The effective mass at atmospheric pressure is deduced from high temperature cyclotron resonance experiments and then used to calculate the frequency of the phonon interacting with the 2D electron gas ( $w_0$ ). The value of  $w_0$  is found to be dependent on the carrier concentration of the measured samples. The lowest value is found for the highest carrier concentration sample. A band edge effective mass increase of  $1 \pm 1\%$  kbar is found in the highest carrier concentration sample. (Edited author abstract) 13 refs.

Gauthier, D. (CNRS, Toulouse, Fr); Dmowski, L.; Portal, J.C.; Leadley, D.; Hopkins, M.A.; Brummell, M.A.; Nicholas, R.J.; Razeghi, M.; Maurel, P. *Superlattices Microstruct* v 4 n 2 1988, Pap from the Chicago Conf, Chicago, IL, USA p 201-206.

**095827 REAL SPACE TRANSFER: GENERALIZED APPROACH TO TRANSPORT IN CONFINED GEOMETRIES.** Research on transfer of electrons between semiconductor heterolayers is reviewed and its importance and applications in new forms of heterolayer-structures are discussed. It is shown that the massive transfer of hot electrons transversal to the layers is interesting from both a device and a physics point of view due to the high speed of the effect and due to its dependence on the details of the electron energy distribution under conditions far away from equilibrium. Less visible is the spreading of hot electrons in confining fields such as the gate field in field effect transistors. This spreading can be viewed as a real space transfer effect and causes additional mobility degradation and generally the enhancement of effects of nonlinear transport, notably impact ionization. The transfer of minute electron numbers from silicon into silicon dioxide appears as a special case of real space transfer from this point of view. It is shown that a complete understanding of this latter effect involves complex quantum-transport principles. Details of nonlinear transport of electrons over a well structure is discussed. It is shown that interesting combinations of k-space and real space transfer effects can be achieved which have new applications. The effects demonstrate the influence of the band-structure (band-gap engineering) on the energy distribution function of the electrons. (Edited author abstract) 18 refs.

Hess, K. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA). *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 319-324.

**095828 MICROSCOPIC HIGH FIELD TRANSPORT IN GRADED HETEROSTRUCTURES.** A new transport formulation has been developed for hot electron in graded and abrupt compound semiconductor heterostructures based on the ensemble Monte Carlo method. Semiclassical electron dynamics has been derived from the position dependent k.p. Hamiltonian. The validity for this is established from perturbation theory and the correspondence principle. A new model for open thermodynamic boundaries is constructed. Space charge effects on high energy electron injection across heterojunctions are discussed. (Author abstract)

Al-Omar, A. (Cornell Univ, Ithaca, NY, USA); Krusius, J.P. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 329-332.

**095829 ON THE ANALYTICAL APPROACH TO**

**THE REAL SPACE ELECTRON TRANSFER IN  $\text{GaAs-AlGaAs}$  HETEROSTRUCTURES.** Real space electron transfer (RSET) in modulation-doped heterostructures is analyzed in the frame of the analytical model for large layer widths ( $\geq 0.04 \mu$ ) proposed by Shichijo and co-workers (1980). It is shown that in high electric field parallel to the interface there is a discontinuity in electron temperature at the boundary between two materials. The model of Shichijo and co-workers is therefore modified using an appropriate boundary condition for electron temperature. In order to compare the modified model with Shichijo and co-workers' results their calculations are reexamined. We obtained different results which are qualitatively much closer to Monte Carlo results of Glisson and co-workers (1980). Taking into account the nonparabolicity of the central valley the influence of the electron temperature discontinuity was found to be apparent. Our analytical approach with Monte Carlo calculations. The approach for heterostructures consisting of central valley dominated materials is discussed. (Edited author abstract) 7 refs.

Mosko, Martin (Slovak Acad of Sciences, Bratislava, Czech); Novak, Ivo; Quittner, Pavol. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 363-366.

**095830 DIFFUSION COEFFICIENTS OF TWO-DIMENSIONAL ELECTRON GAS IN HETEROJUNCTIONS.** This paper presents a Monte Carlo study of diffusion and noise in Two-Dimensional Electron Gas (2DEG) in  $\text{AlGaAs-GaAs}$  heterojunctions. This is achieved by the calculation of the velocity fluctuations correlation functions of the gas subjected to a driving field applied along the channel. It is found that at low fields when the carriers have a real two-dimensional motion, the parallel correlation functions show oscillations which we analyse in terms of scattering rates. This gives rise to resonant noise spectra whose resonance frequency is nearly proportional to the driving field strength. At higher fields the behavior is similar to what occurs with bulk electrons. (Edited author abstract) 19 refs.

Zimmermann, J. (CNRS, Villeneuve d'Ascq, Fr); Wu, Y. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 367-370.

**095831 REDUCED INTERVALLEY TRANSFER IN A  $\text{GaAs-AlGaAs}$  HETEROJUNCTION.** In a Monte Carlo calculation aimed at studying the electron transport along the interface of a  $\text{GaAs-AlGaAs}$  heterojunction the electrons in the conducting channel have been found to exhibit higher steady-state velocities than in bulk  $\text{GaAs}$ , although effects such as degeneracy, subband scattering or remote impurity scattering were not taken into account. The effect is ascribed to the strong transverse electric field near the interface which reduces intervalley scattering, resulting in the higher velocities. (Author abstract) 7 refs.

Nederveen, K. (Univ of Technology, Eindhoven, Neth); van de Roer, T.G. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 375-377.

**095832 ULTRAFAST S-TYPE NDC AND SELF-OSCILLATIONS UNDER VERTICAL TRANSPORT IN MULTILAYER HETEROSTRUCTURES.** The dynamics of electron gas heating in multilayer bulk barrier heterostructures is considered. The response times of S-shaped I-U characteristic of heterostructures are investigated in the framework of balance equations. It is shown that under optimum condition the cut-off frequency of the current self-oscillations in the heterostructures is determined by the cooling time of hot electrons into potential wells. (Author abstract) 12 refs.

Belyantsev, A.M. (Acad of Sciences of the USSR, Gorky, USSR); Gavrilenko, V.I.; Ignatov, A.A.; Piskarev, V.I.; Shashkin, V.I.; Andronov, A.A. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 379-382.

**095833 ELECTRON TRANSPORT IN  $\text{GaAs/Al}_x$**

**$\text{Ga}_{1-x}\text{As}$  HETEROJUNCTIONS AT LOW TEMPERATURES.** We have performed Monte Carlo studies of transient and steady-state low temperature (10 K) transport for electrons in  $\text{GaAs/Al}_x\text{Ga}_{1-x}\text{As}$  single-well heterojunction structures. Besides polar optical, acoustic phonon (coupled by the deformation potential potential or piezoelectrically), and ionized impurity scattering we account for the interactions between the electrons through the effect of plasmons and single pair collisions. Results of ensemble Monte Carlo simulations for several values of the electric field are shown, pointing out the effect of the various scattering mechanisms on the electron velocity and distribution function. Our results do not confirm theoretical reports of scattering induced negative differential resistance. (Edited author abstract) 15 refs.

Artaki, M. (Univ of Illinois, Urbana, IL, USA); Hess, K. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 383-386.

**095834 WARM ELECTRON COEFFICIENT OF TWO DIMENSIONAL ELECTRON GAS IN A  $\text{GaAs-AlGaAs}$  HETEROJUNCTIONS AT LOW TEMPERATURES.** The warm electron coefficient of two dimensional electron gas in  $\text{GaAs}$  has been calculated by assuming an electron temperature. Calculated results are, however, in sharp disagreement with the experimental data and localised states are thought to play important roles in conduction. (Author abstract) 11 refs.

Basu, P.K. (CAS in Radio Physics & Electronics, Calcutta, India); Bhattacharyya, Keya. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 391-394.

**095835 HOT ELECTRON ENERGY RELAXATION VIA ACOUSTIC PHONON EMISSION IN  $\text{InP/In}_{0.53}\text{Ga}_{0.47}\text{As}$  HETEROSTRUCTURES AND SINGLE QUANTUM WELLS.** A study of the electron heating processes in modulation doped  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As/InP}$  heterostructures (SHJ) and single quantum wells (SQW) by magnetotransport measurements at low temperatures is presented. For electron temperatures below 20K both the SHJ and SQW show a power loss  $P_p$  ranging between  $P \propto T_e^{-3}$  and  $P \propto T_e^{-5}$  suggesting that energy relaxation occurs by acoustic phonon emission via mixed unscreened piezoelectric and deformation-potential interactions. In SHJ samples above  $T_e \geq 10\text{K}$  an extra inelastic scattering mechanism appears. (Edited author abstract) 11 refs.

Barlow, M.J. (Univ of Essex, Malvern, Engl); Ridley, B.K.; Kane, M.J.; Bass, S.J. *Solid State Electron* v 31 n 3/4 Mar-Apr 1988 p 501-505.

**095836 NONEQUILIBRIUM PHONON EFFECTS ON HOT CARRIER TRANSPORT AND THERMAL NOISE IN SEMICONDUCTOR HETEROSTRUCTURES.** Hot carrier steady state and transient transport in bulk semiconductors and heterostructures is analyzed using a general balance equation with nonequilibrium phonon occupation and an ambient magnetic field of arbitrary strength. Carrier-carrier Coulomb interactions are also incorporated dynamically, and for superlattices both intraplanar and interplanar interactions are included. We have examined the thermal noise temperature for hot electrons at a nonzero bias. (Edited author abstract) 13 refs.

Lei, X.L. (Stevens Inst of Technology, Hoboken, NJ, USA); Horing, N.J.M. *Solid State Electron* v 31 n 3/4 Mar-Apr 1988 p 531-534.

**095837 BREAKDOWN OF COHERENCE IN RESONANT TUNNELING THROUGH DOUBLE-BARRIER HETEROSTRUCTURES.** We report measurements of current-voltage characteristics of symmetric and asymmetric  $\text{AlGaAs/GaAs}$  double-barrier resonant tunneling structures (DBRTS) which exhibit intrinsic bistability. We interpret the data within a self-consistent model which takes into account the space-charge formation in



DBRTS and show that the intrinsic bistability is due to the feedback of the electrostatic field of the electrons in the well on the tunneling current density. We argue that the electron-electron interaction in the well destroys the coherence of tunneling. (Author abstract) 10 refs.

Goldman, V.J. (Princeton Univ, Princeton, NJ, USA); Tsui, D.C.; Cunningham, J.E. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 731-734.

**095838 MEASUREMENTS OF HOT ELECTRON MAGNETOPHONON RESONANCE IN GaAs/GaAlAs HETEROSTRUCTURES.** Hot electron magnetophonon resonances have been directly observed in GaAs/GaAlAs heterojunctions between 30 and 100K and their temperature and electric field dependences studied. The oscillation amplitude is seen to have a maximum at 60K, which is attributed to the influence of temperature dependent level broadening on the electron flow through energy space. The resonance positions indicate phonon frequencies close to the bulk TO value, as observed in normal magnetophonon resonances in heterojunctions, rather than the expected LO frequency. In samples of higher electron concentrations a second series of resonances is observed at low electric fields which we believe to be due to inter-subband scattering. (Author abstract) 13 refs.

Leadley, D.R. (Clarendon Lab, Oxford, Engl); Brummell, M.A.; Nicholas, R.J.; Harris, J.J.; Foxon, C.T. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 781-784.

**095839 MODULATION, PHOTOLUMINESCENCE, AND RAMAN SPECTROSCOPY OF SEMICONDUCTOR HETEROSTRUCTURES.** Using illustrative examples from the investigations of the author and his collaborators, it is shown that (1) piezo-modulated reflectivity (2) photoluminescence and (3) Raman spectroscopy can be used in the study of collective and localized excitations in semiconductor heterostructures. Results on epilayers of  $Cd_{1-x}Mn_xTe$  and  $ZnSe$  and quantum well structures of  $GaAs/Al_xGa_{1-x}As$ ;  $Cd_{1-x}Mn_xTe/Cd_{1-y}Mn_yTe$ ;  $Cd_{1-x}Mn_xTe/CdTe$ ;  $Cd_{1-x}Mn_xTe/In/CdTe$  are discussed. (Edited author abstract) 21 refs.

Ramdas, A.K. (Purdue Univ, West Lafayette, IN, USA). *Superlattices Microstruct* v 4 n 1 1988, Chicago Conf, Pap, Chicago, IL, USA, 1987 p 69-76.

**095840 ROLE OF THE ELECTRON-HOLE COULOMB INTERACTION IN QUANTUM CONFINED STARK EFFECT.** The luminescence peak energy and tunneling lifetime of an exciton in a semiconductor quantum well with a small valence band offset in the presence of a perpendicular electric field is calculated by generalizing the variational approach of quantum confined Stark effect normally used for systems of GaAs/Al-GaAs quantum wells. At a finite electric field, the electron-hole Coulomb interaction provides additional confinement to each of the carriers and enhances the Stark shift and the exciton lifetime against field ionization. Numerical results are presented for  $ZnSe/Zn_{1-x}Mn_xSe$  heterostructures in recent experiments. (Edited author abstract) 11 refs.

Wu, Ji-Wei (Indiana Univ, Bloomington, IN, USA); Nurmikko, A.V. *Superlattices Microstruct* v 4 n 1 1988, Chicago Conf, Pap, Chicago, IL, USA, 1987 p 81-85.

## Imaging Techniques

**095841 HIGH-FREQUENCY DIFFERENTIAL PIEZOELECTRIC PHOTOACOUSTIC INVESTIGATION OF ION-IMPLANTED (100) SILICON WAFERS VIA LASER BEAM POSITION MODULATION.** An exploratory application of position-modulation photoacoustic imaging of ion-implanted (100)-oriented Si wafers was undertaken to assess its potential as a diagnostic probe in semiconductor processing. Wafer scans were performed using acoustooptic modulation of a 1.06- $\mu m$  Nd<sup>3+</sup>:YAG laser beam up to 0.2 MHz with piezoelectric photoacoustic detection. Sensitivity ranges to ion-implanted parameters (ionic species and fluences)

were studied and the capability of the technique to monitor processing-induced damage was established. Results indicate that position-modulated photoacoustic detection offers higher sensitivity than single-beam photo-thermal imaging and has distinct advantages over other analytical techniques. 45 refs.

Zuccon, Johnny F. (Optical Recording Corp, Toronto, Ont, Can); Mandelis, Andreas. *IEEE Trans Ultrason Ferroelectr Freq Control* v 35 n 1 Jan 1988 p 5-13.

**Ion Implantation** See ION BEAMS—Applications; SEMICONDUCTOR MATERIALS—Ion Implantation.

**Junctions** See Also DATA STORAGE, DIGITAL—Random Access; ELECTRIC MEASUREMENTS—Performance; PRINTED CIRCUITS—Cooling; SEMICONDUCTING CADMIUM COMPOUNDS—Ion Implantation; SEMICONDUCTING FILMS—Electric Conductivity; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Electronic Properties; SEMICONDUCTING SILICON—Impurities; SEMICONDUCTING SILICON—Ion Implantation; SEMICONDUCTOR DEVICE TESTING—Thermal Effects; SEMICONDUCTOR DEVICES, MOS—Mathematical Models; SEMICONDUCTOR MATERIALS—Spectroscopic Analysis; SEMICONDUCTOR MATERIALS—Theory; SENSORS—Processing; SUPERCONDUCTIVITY—Mathematical Models; THERMOCOUPLES; TRANSISTORS, FIELD EFFECT—Performance; TRANSISTORS, PHOTOSENSITIVE.

**095842 ANALYSIS OF ELECTRIC FIELD DISTRIBUTIONS IN ULTRA-SHALLOW SILICON JUNCTIONS UNDER THERMODYNAMIC EQUILIBRIUM CONDITIONS.** A comprehensive analysis of electric field distributions in ultra-shallow, heavily-doped, strongly-asymmetric silicon n-p junctions is performed under thermodynamic equilibrium conditions. The physical deficiencies of previous approaches to the built-in electric field computations in such very steep junctions are examined on the grounds of semiconductor fundamentals. It is shown that in the surface-controlled region of ultra-shallow silicon junctions the built-in field  $E$  calculations depart from the bulk-type computations precisely in view of the peculiar physical features of the semiconductor surface (discontinuities of impurities, surface states, etc.). The results of this work suggest that all processes in the surface-controlled region of the heavily doped layer in ultra-shallow silicon junctions are being shaped by the peculiar interplay of the bulk field  $E$  created by the impurity gradients with the field  $E_{surf}$  originated in the surface states. (Edited author abstract) 24 refs.

Silard, Andrei P. (Polytechnic Inst, Bucharest, Rom). *Int J Electron* v 63 n 4 Oct 1987 p 587-600.

**095843 SCIENCE DES SURFACES: RECHERCHE FONDAMENTALE ET TECHNOLOGIES.** [Science of Surfaces: Basic Research and Technologies]. Characteristic properties of surfaces and interfaces are briefly outlined. The problems encountered in developing a junction that implements current research and technology are discussed. Unusual mineral surfaces are taken into account. Examples are given. In French.

Boiziau, C. (CEN, Gif-sur-Yvette, Fr). *Vide Couches Minces* v 42 n 237 1987 p 259-261.

**095844 FULLY ION-IMPLANTED ABRUPT PN JUNCTION ON SEMI-INSULATING InP.** We report an ion-implanted pn junction using Si for n-implant and P/Be co-implant for a shallow p<sup>+</sup> surface layer. C/V measurements indicate abrupt junction behavior. Mesa diodes were fabricated and showed an ideality factor of two, small leakage current and avalanche breakdown at reverse bias greater than 40 v. (Author abstract) 5 refs.

Wang, K.-W. (AT&T Bell Lab, Murray Hill, NJ, USA); Cheng, C.L.; Zima, S.M. *Electron Lett* v 23 n 20 Sep 24 1987 p 1040-1041.

**095845 NUMERICAL EVALUATION OF THE SCANNING METHOD FOR THE DETERMINATION OF MINORITY CARRIER DIFFUSION LENGTH IN p-n JUNCTIONS.** A numerical model for the scanning method for determining minority carrier diffusion length is presented to include the effect of the

built-in field and high-level injection. A numerical simulation is presented which shows that the scanning method for diffusion length measurements will not give accurate results for minority carrier diffusion length in the region where the presence of a built-in field is significant. No matter how poor the junction is made, the accuracy of the measurement method increases away from the depletion region. The problem of low magnitude in the induced short circuit current away from the physical junction could be overcome by increasing the generation level. For substrate dopant concentrations between  $2.0 \times 10^{15} \text{ cm}^{-3}$  and  $6.0 \times 10^{16} \text{ cm}^{-3}$  the distance into the device from the surface where the error of the measurement will be greater than 10% is expressed as a semi-empirical formula relating dopant concentration. (Edited author abstract) 10 refs.

Premaratne, L.P.J. (Univ of Queensland, St. Lucia, Aust); Yeow, Y.T. *Solid State Electron* v 30 n 10 Oct 1987 p 1017-1024.

**095846 PHOTOCONVERSION IN A p-n JUNCTION BASED ON POLYCRYSTALLINE SILICON.** Photocells with efficiencies of 9% have been fabricated on the basis of polycrystalline silicon. Their volt-ampere characteristics have been investigated, together with the photoelectric parameters of the p-n junctions as functions of grain size. (Author abstract) 4 refs.

Tkachenko, N.N.; Perova, V.I.; Fal'kevich, E.S.; Berenzko, L.E.; Kagan, M.B.; Kholev, B.A. *Sov Electr Eng* v 57 n 8 1986 p 25-26.

**095847 DEFECTS AND LEAKAGE CURRENTS IN PRE-AMORPHISED SHALLOW BF<sub>2</sub> IMPLANTED JUNCTIONS IN SILICON.** In this work it has been confirmed that pre-amorphization using <sup>28</sup>Si<sup>+</sup> can be successfully employed to make shallow BF<sub>2</sub> implanted p<sup>+</sup> junctions ( $x_j \approx 75\text{-}100\text{nm}$ ), but there is an important inter-relationship between annealing temperature, amorphous layer thickness and junction depth which must be optimized if low leakage junctions are to be realized. Two significant sources of leakage current have been identified as being due to deep level donors at the end of the silicon range and extended crystallographic defects at the original amorphous/crystalline interface. 5 refs.

Brotherton, S.D.; Gowers, J.P.; Young, N.D.; Clegg, J.B.; Ayres, J.R. *Annu Rev Philips Res Lab* 1986 p 36-38.

**095848 TECHNIQUE FOR DELINEATION OF PN JUNCTIONS IN CUBIC SILICON CARBIDE.** The authors describe a highly precise technique for delineating pn junctions in beta SiC grown on silicon substrates. It is shown that during the anodization process, a source of surface ions from the n and p regions of the SiC are required to combine with (OH)<sup>-</sup> to form a hydroxide (6). The n-type layer is biased positive and the oxide-semiconductor interface behaves as a reverse biased Schottky contact (7). Current in this region results from avalanche breakdown. In the p-type region, the oxide-semiconductor diode is forward biased, producing its source of ions. 7 refs.

Harris, G.L. (Howard Univ, Washington, DC, USA); Fekade, K. *J Electrochem Soc* v 135 n 2 Feb 1988 p 405-407.

**095849 SELF-ALIGNED TITANIUM SILICIDED JUNCTIONS FORMED BY RAPID THERMAL ANNEALING IN VACUUM.** New self-aligned silicided junctions have been developed by rapid thermal annealing in vacuum for applications to VLSI technology. These silicided junctions were investigated in regard to sheet resistance, junction depth, junction leakage current, and impurity depth profiles. After Ti film (35 nm) was deposited by dc magnetron sputtering, Si<sup>+</sup> was implanted for interface mixing and rapid thermal annealing (RTA) in vacuum (approximately  $10^{-1}$  Pa) was performed in temperature range of 550<sup>o</sup>-750<sup>o</sup>C. In these temperature ranges, the lateral growth of titanium silicide was prevented. After Si<sup>+</sup> implantation through the titanium



silicide layer to amorphize the Si substrate, As<sup>+</sup> and + ions were implanted for n<sup>+</sup>/p junction, and p<sup>+</sup>/n junction, respectively. (Edited author abstract) 19 refs.

Yoshida, T. (Matsushita Electric Industrial Co, Moriguchi, Jpn); Fukumoto, M.; Ohzone, T. *J Electrochem Soc* v 135 n 2 Feb 1988 p 481-486.

**095850 LASER 'DIRECT WRITING' OF SILICON pn JUNCTIONS.** Rectifying pn junctions have been deposited by a focused argon laser beam from silane and dopant gases on to oxidized silicon wafers. The characteristics depend on the deposition conditions and on the dopant gas content, but are not those of ideal junctions, probably due to a nonabrupt interface from the present growth parameter values. (Author abstract) 8 refs.

Milne, D. (Heriot-Watt Univ, Edinburgh, Scotl); Black, A.; Wilson, J.I.B.; John, P. *Electron Lett* v 24 n 1 Jan 7 1988 p 19-20.

**095851 100 NM DEEP p<sup>+</sup>/n JUNCTIONS WITH SELF-ALIGNED SILICIDED CONTACTS.** Shallow p<sup>+</sup>/n junctions have been formed with CoSi<sub>2</sub> contact layers. Specifically, an 11 nm thick Co film sputter deposited onto <100> Si that has been pre-amorphized with Sn<sup>+</sup> and implanted with BF<sub>2</sub><sup>+</sup>, is rapidly thermally annealed for 1 sec at 100°C. The result, after selective wet chemical etching, is a self-aligned 39 nm thick CoSi<sub>2</sub> layer on a 73 nm deep p<sup>+</sup>/n junction. The junctions have the following characteristics: sheet resistance of 8.6Ω/sq, electrical activity exceeding 1×10<sup>20</sup> carriers cm<sup>-3</sup>, reverse-bias leakage of -2na cm<sup>-2</sup> at -5 v and a forward-bias ideality factor of 1.08 from 5×10<sup>-12</sup> to 1×10<sup>-4</sup>A. Some reduction of SiO<sub>2</sub> by Co occurs during annealing. Identical results and essentially no reduction of SiO<sub>2</sub> are achieved using a two-step annealing: 10 sec at 700°C, prior to selective etching, followed by 1 sec at 1000°C. (Author abstract) 21 refs.

Delfino, M. (Signetics Corp, Sunnyvale, CA, USA); Morgan, A.E.; Sadana, D.K.; Maillot, P.; Broadbent, E.K. *Philips J Res* v 42 n 5-6 1987 p 593-607.

**095852 IMPROVING REVERSE RECOVERY TIME OF PN JUNCTION MEASUREMENTS: (PART 3).** Part 1 of this series (January 1988 PCIM) dealt with the errors caused by using an inductive current viewing resistor. Part 2 presented a method for determining minority carrier lifetime and the equations for predicting  $Q_{rr}$ ,  $t_{ba}$  and  $I_{rr}$  from the lifetime value. In this part, a practical way for determining lifetime and independent evidence of the validity of the lifetime equations are outlined.

Leinfelder, B.A. (Bermar Corp). *Powerconvers Intell Motion* v 14 n 3 Mar 1988 p 52-54.

**095853 SUSCEPTIBILITE RADIOFREQUENCE D'UNE JONCTION VIS-A-VIS D'UN CHAMP ELECTRIQUE PARALLELE AU PLAN METALLURGIQUE.** [Radio Frequency Susceptibility of a Junction to Electric Field Parallel to Its Metallurgical Plane]. When an alternating electric field is applied parallel to a junction, the radiofrequency susceptibility gives an absorption having a maximum versus the direct current polarization of the junction; the real part of the susceptibility is negative. The explanation of both features involves an internal field parallel to the alternating field. The experiment allows the measurement of the concentration of minority carriers. (Author abstract) In French. 10 refs.

Blanc, Francois (Univ de Clermont II, Aubiere, Fr); Fanguin, Rene; Raoult, Gaston; Labrune, Jean-Claude; Lomaggio, Germaine; Theobald, Jean-Gerard. *Can J Phys* v 66 n 1 Jan 1988 p 11-16.

**095854 COHERENT VOLTAGE OSCILLATIONS IN SMALL NORMAL TUNNEL JUNCTIONS AND THE Crossover TO THE INCOHERENT REGIME.** We discuss the possibility of charge oscillations in a normal tunnel junction, driven by an external current source ( $I_{ex}$ ), in the coherent limit. In that limit the dephasing time  $t_d$  is larger than the period  $t_p = e/I_{ex}$ . This

behavior is modified when  $t_d$  decreases. (Author abstract) 19 refs.

Gefen, Yuval. *IBM J Res Dev* v 32 n 1 Jan 1988 p 103-106.

**095855 CORRELATED DISCRETE TRANSFER OF SINGLE ELECTRONS IN ULTRASMALL TUNNEL JUNCTIONS.** Recent theoretical and experimental studies have revealed a new family of effects taking place in very small tunnel junctions at low temperatures. The effects have a common origin, the correlated discrete tunneling of single electrons and/or Cooper pairs resulting from their electrostatic ('Coulomb') interaction. This paper presents a brief review of the single-electron part of the family, including discussion of the background physics, methods of theoretical description of the new effects, experimental results, and possible applications of the new effects in analog and digital electronics. (Author abstract) 47 refs.

Likharev, K.K. *IBM J Res Dev* v 32 n 1 Jan 1988 p 144-158.

**095856 CIRCUIT TECHNIQUE FOR SEMICONDUCTOR-DEVICE ANALYSIS WITH JUNCTION DIODE OPEN CIRCUIT VOLTAGE DECAY EXAMPLE.** The application history of the circuit technique for semiconductor-device analysis is reviewed with a discussion of its specific application advantages, including providing accurate solutions. An illustration of the use of this technique for the time dependence of the open circuit voltage decay across an initially forward biased p/n junction is given. The illustration also presents a new solution method of the lumped model which gives the correct time dependence for the initial transient. (Edited author abstract) 46 refs.

Lindholm, Frederik A. (Univ of Florida, Gainesville, FL, USA); Sah, C. Tang. *Solid State Electron* v 31 n 2 Feb 1988 p 197-204.

**095857 PHOTON EMISSION FROM REVERSE-BIASED SILICON P-N JUNCTIONS.** An analytical theory has been developed for the light emission of a reverse-biased silicon p-n junction. Based on the theory of ionization and indirect recombination of electrons and holes under high-field conditions, the relative intensity of emitted light has been derived. It is observed that the normalized results of intensity are in good agreement with the experimental results for an electron ionization length  $l_{ioe} = 60$  Å, and a hole ionization length  $l_{ioh} = 70$  Å. Thus it confirms the validity of this theoretical model for light emission in a reverse-biased silicon p-n junction. (Author abstract) 16 refs.

Gautam, D.K. (Central Electronics Engineering Research Inst, Pilani, India); Khokle, W.S.; Garg, K.B. *Solid State Electron* v 31 n 2 Feb 1988 p 219-222.

**095858 ANOMALOUS TENSOELECTRIC EFFECTS IN GALLIUM ARSENIDE TUNNEL DIODES.** Anomalous tensorial phenomena induced in a tunnel p-n junction by a concentrated load and by hydrostatic compression were studied. The anomalous tensorial effects are caused by the action of concentrators of mechanical stresses in the vicinity of the p-n junction, giving rise to local microplastic strain. Under the conditions of hydrostatic compression prolate inclusions approximately 100-200 Å long play the role of concentrators. Analysis of irreversible changes in the current-voltage characteristics of tunnel p-n junctions made it possible to separate the energy levels of the defects produced with plastic strain of gallium arsenide. (Author abstract) 18 refs.

Alekseeva, Z.M. (Tomsk State Univ, USSR); Vyatkin, A.P.; Krivorotov, N.P.; Shchegol', A.A. *Sov Phys J* v 30 n 8 Aug 1987 p 716-720.

**095859 APPLICABILITY LIMIT OF THE DIFFUSION APPROXIMATION IN THE THEORY OF MULTILAYER SEMICONDUCTOR STRUCTURES.** The influence of nonlinear effects such as electron-hole scattering, Auger recombination, and a reduction of the

injection coefficients of emitter p-n junctions on the realizability of the diffusion regime of operation of multilayer semiconductor structures at a high charge-carrier injection level is investigated. A successive change in the operating regime of the structure is shown to be possible with an increase in the amount of current flowing through it as a function of the ratio of characteristic parameters - the thickness of the base layer, the diffusion length of charge carriers in it, the saturation currents of the emitter layers, etc. (Author abstract) 2 refs.

Mnatsakanov, T.T. *Sov J Commun Technol Electron* v 32 n 5 May 1987 p 86-90.

**095860 CONCISE AND COMPLETE SOLUTION FOR LINEARLY GRADED p-n JUNCTIONS.** We present a highly condensed solution consisting of the profiles for potential, electric field, net charge density and net mobile to net fixed charge density ratio, all as functions of distance for linearly graded p-n junctions. The condensed representation results from the use of the transformations for the potential and the distance variables proposed earlier. The important features of this solution are discussed and compared with the results of the depletion approximation. The method of using this solution to extract numerical results in specific situations is demonstrated. The new scaling length used successfully in the distance transformation is compared with those previously used in the literature and some general relationships connecting them are established. The depletion widths under different normalizations are compared. (Edited author abstract) 7 refs.

Jindal, C. (Rutgers State Univ of New Jersey, Piscataway, NJ, USA); Panayotatos, P. *Solid State Electron* v 31 n 5 May 1988 p 893-897.

**095861 EFFECTS OF TITANIUM SILICIDE FORMATION ON DOPANT REDISTRIBUTION.** This paper reports on boron and arsenic redistribution during the TiSi<sub>2</sub> self-aligned silicide process as applied to shallow (<0.2 μm) junctions. Dopant loss was seen to occur through evaporation from the silicide surface, segregation into the Ti-rich outer layer which is subsequently removed, and diffusion into the silicide layer. Depending on the silicide and junction annealing temperatures, up to 99% of the implanted dopant dose can be lost via these three mechanisms. Dopant loss is particularly acute when the silicide is formed concurrently with recrystallization annealing of the junction implant, before the dopant diffuses into the silicon. (Edited author abstract) 56 refs.

Osburn, C.M. (Microelectronics Cent of North Carolina, Research Triangle Park, NC, USA); Brat, T.; Sharma, D.; Griffiths, D.; Corcoran, S.; Lin, S.; Chu, W.K.; Parikh, N. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1490-1504.

**095862 STEADY STATE PHOTOCAPACITANCE STUDY OF SEMICONDUCTOR/AQUEOUS ELECTROLYTE JUNCTIONS: I. INTEREST AND DIFFICULTIES IN THE CASE OF n-GaAs.** The photocapacitance (PC) technique allows the determination of deep-level as well as surface states at semiconductor/electrolyte (SC/EL) contacts. Expressions of the PC signal, given in several peculiar cases, help in the understanding of the results obtained with GaAs in contact with an aqueous electrolyte. It is found that relevant experimental conditions of band bending and/or incident photon flux are required to detect transitions which have a small magnitude compared to the large response due to EL2 in GaAs. A quantitative interpretation of the spectrum is also given. (Author abstract) 6 refs.

Allongue, P. (CNRS, Paris, Fr); Cachet, H. *Ber Bunsenges Phys Chem* v 92 n 5 May 1988 p 566-572.

**095863 EFFECT OF ABSORPTION ON PHOTON EMISSION FROM REVERSE-BIASED SILICON P-N JUNCTIONS.** An analytical expression for the intensity of the emitted light has been derived from reverse-biased silicon p-n junction. Based on the theory of ionization and recombination, the intensity of light has



been calculated by taking the emission and absorption phenomena simultaneously. It is observed that the normalized results of the intensity agree with the reported experimental results in all the energy ranges of photons. Thus it confirms the validity of the developed theoretical model for light emission in a reverse-biased silicon p-n junction. 11 refs.

Gautam, D.K. (Central Electronics Engineering Research Inst, Pilani, India); Khokle, W.S.; Garg, K.B. *Solid State Electron* v 31 n 6 Jun 1988 p 1119-1121.

**095864 QUANTUM OSCILLATIONS IN COUPLED SINGLE ELECTRON TUNNEL JUNCTIONS.** It has been proposed that the frequency of the voltage oscillations associated with single electron tunneling (SET) in ultra-small junctions can be used for measuring electrical current at a higher degree of accuracy and resolution than earlier methods. To get rid of parasitic capacitances these SET junctions are made in pairs, coupled in series. A coupled nonlinear system is often expected to have a complex behavior. Such complex behavior will inhibit the function as a current meter. Therefore a detailed analysis of the coupled system is necessary and has been done here. We use an equivalent model to study the time dependence of the voltage oscillations across such a pair. Measurements on a test circuit as well as numerical studies of the corresponding theoretical model show that there is a large current interval where there is a simple functional relationship between the current driven through the circuit and the oscillation frequency. Multiperiodic behavior is also observed in the lower part of the current interval where oscillations are possible. (Edited author abstract) 6 refs.

Salmi, Lars-Allan (Chalmers Univ of Technology, Goteborg, Sweden); Russberg, Gunnar. *Solid State Commun* v 66 n 9 Jun 1988 p 909-912.

**095865 EFFECTIVE RECOMBINATION VELOCITY OF LOW-HIGH JUNCTIONS.** A simple general analytical expression is derived for the effective recombination velocity of low-high junctions where the highly doped region is assumed to have an arbitrary doping profile. The analytical results are compared with an 'exact' computer simulation program, BIPOLE. Agreement is found over wide choices of high and low region parameters. 17 refs.

Anon. *Solid State Electron* v 31 n 8 Aug 1988 p 1346-1348.

**095866 STEADY STATE PHOTOCAPACITANCE STUDY OF SEMICONDUCTOR/ELECTROLYTE JUNCTIONS II. SURFACE STATE DISTRIBUTION AND CHARGE TRANSFER MECHANISMS.** GaAs/electrolyte junctions are characterized by steady state photocapacitance measurements without (single beam experiment) or with added interband illumination (dual beam experiment). This original approach allows to give unambiguously the surface state distribution and to follow its evolution during electrochemical processes; results show the presence of two corrosion related states at  $E_c - 0.98$  eV and  $E_c - 1.14$  eV which behave differently under corrosion or photocorrosion conditions. It is shown that surfaces modified by electro-deposition of discontinuous and metal films exhibit metal-induced surface states responsible for charge transfers. (Author abstract). 41 refs.

Allongue, P. (CNRS). *Ber Bunsenges Phys Chem* v 92 n 8 Aug 1988 p 895-903.

**095867 CHARGE TRANSPORT IN SEMICONDUCTOR MICROJUNCTIONS.** P-n junctions of silicon-wedge microcontacts with variable constrictions down to 0.1  $\mu$ m diameter exhibit current transport behavior completely different from the conventional large-area junctions. Generation and recombination dominate for junctions larger than 1  $\mu$ m diameter; smaller junctions show a predominance of space charge and resistive effects. (Author abstract). 15 refs.

Trzcinski, R. (Max-Planck-Institut fuer Festkoerperforschung, Stuttgart, West Ger); Queisser, H.J. *Appl Phys A*

v 47 n 2 Oct 1988 p 119-122.

**095868 BIDIRECTIONAL BLOCKING JUNCTIONS IN SOI.** Back-to-back junction (n-p-n) structures were fabricated in silicon-on-sapphire (SOS), in polysilicon-on-SiO<sub>2</sub>, and in silicon-on-insulator (SOI) prepared by high-dose oxygen ion implantation. Since the structure is actually a bipolar transistor operated with an open base, the geometry and doping levels were adjusted to spoil its gain and thereby achieve symmetrical bidirectional blocking. In all three cases, ideal plane-junction breakdown was observed for both polarities of applied voltage when precautions were taken to avoid local field-enhancing geometries. 1 ref.

MacIver, Bernard (GM, Warren, MI, USA); Jain, Kailash C.; Valeri, Stephen J. *IEEE Circuits Devices Mag* v 3 n 6 Nov 1987 p 27-30.

**095869 APPROXIMATE-ANALYTIC SOLUTION FOR THE FORWARD-BIASED STEP JUNCTION.** Approximate-analytic methods for analyzing semiconductor samples containing junctions complement purely numerical solutions by providing added physical insight. These methods have proved useful, but have been applicable primarily to samples at equilibrium. A technique for applying these methods to forward-biased junctions is described. The equations obtained are compatible with previously published work. 10 refs.

Schrimp, R.D. (Univ of Arizona, Tucson, AZ, USA); Warner, R.M. Jr. *IEEE Trans Electron Devices* v 35 n 5 May 1988 p 698-700.

**095870 ELECTRICAL CHARACTERIZATION OF IN-SITU EPITAXIALLY GROWN SI P-N JUNCTIONS FABRICATED USING LIMITED REACTION PROCESSING.** Forward current ideality factors of  $1.01 \pm 0.3\%$  were obtained over a large current range extending down to 1 pA. Reverse current densities measured  $3.5 \pm 1.2$  nA/cm<sup>2</sup> at a reverse bias of -5V. Breakdown occurred at the expected value of -22 V and displayed a very sharp current rise of 30 decades/V. Extremely uniform light emission from the junction was observed under a microscope at breakdown; this phenomenon is a visual indication that the material is of high quality and suitable for high-performance minority-carrier devices. 11 refs.

King, C.A. (Stanford Electronics Lab, Stanford, CA, USA); Gronet, C.M.; Gibbons, J.F.; Wilson, S.D. *IEEE Electron Device Lett* v 9 n 5 May 1988 p 229-231.

**095871 CURRENT GENERATION MECHANISMS IN SMALL BAND GAP HgCdTe p-n JUNCTIONS FABRICATED BY ION IMPLANTATION.** A detailed study has been made of the current-voltage characteristics of Hg<sub>1-x</sub>Cd<sub>x</sub>Te ion-implanted p-n junctions with  $x \approx 0.224$ . It is found that the dark currents, for diodes of high quality, can be represented over a broad range of voltage and temperature by three current components. A diffusion current dominates in the small bias region at temperatures > 50 K. This current component is also observed at sufficiently high forward biases at low temperatures. At temperatures of  $30 < T < 50$  K in the small bias region, a current component with a positive temperature coefficient is observed. This component, which we call Type II tunneling, has a logarithmic voltage dependence in forward bias and some of the properties of this current can be accounted for by trap-assisted tunneling models for excess current in Esaki diodes. (Edited author abstract) 14 refs.

DeWames, R.E. (Rockwell Int Science Cent, Thousand Oaks, CA, USA); Williams, G.M.; Pasko, J.G.; Vanderwyck, A.H.B. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987; Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 849-858.

**095872 STUDY OF A DEEP CENTRE WITH AN EXCITED STATE: PHOTO-THERMAL EXCITATION BEHAVIOUR BY JUNCTION CAPACITANCE TECHNIQUES.** A procedure for constructing a configuration coordinate diagram for the centre based on

the results obtained by junction capacitance techniques is described and illustrated taking GaP:Ni(d<sup>2</sup>-d<sup>8</sup>) as an example. The shape of the optical cross section spectrum consists of a main threshold and a low energy sub-peak. From fitting the sub-peak to a Gaussian, the temperature-independent ZPL was found to be  $E_1 = 0.66$  eV, and  $\hbar\omega = 81$  meV. The main threshold energy  $E_2$  is 0.92 eV at 95 K. At higher temperatures the thresholds may be obtained by subtracting the sub-peak from the spectra. 3 refs.

Yang, Xizhen (Beijing Normal Univ, Beijing, China); Allen, J.W. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condensed Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 373-374.

**Low Temperature Effects See SEMICONDUCTOR DEVICES, MOSFET—Mathematical Models; TRANSISTORS—Noise.**

## Magnetic Field Effects

**095873 NUMERICAL SIMULATION AND DESIGN OPTIMIZATION OF MAGNETIC-FIELD-SENSITIVE MOS DEVICE.** A magnetic-field-sensitive MOS device is simulated using a computer. A two-dimensional numerical analysis is proposed by dividing the regions leading to savings of computational costs. The device is optimized by using the BFGS method. The theoretical results indicate that the device of aspect ratio (W/L) of 0.82 has the highest sensitivity. (Edited author abstract) In Chinese. 5 refs.

Ho Yie (Nanjing Inst of Technology, Nanjing, China); Wei Tongli; Shen Kechang. *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 294-299.

## Manufacture

**095874 SUCCESSFUL CLEAN ROOM DESIGN.** Manufacturing semiconductor chips with submicron line widths requires an ultra clean environment. This minute geometry is extremely sensitive to any type of contamination, and the denser the circuit on the chip, the more stringent are its cleanliness and temperature control requirements. The key to meeting these requirements is the HVAC system with vertical laminar flow (VLF) characteristics. 2 refs.

Schafer, Norman; Kotz, Donald A. *ASHRAE J* v 29 n 9 Sep 1987 p 25-28.

**095875 COMPARISON OF TWO WAFER INSPECTION METHODS FOR PARTICLE MONITORING IN SEMICONDUCTOR MANUFACTURING.** The two methods examined differ in the procedure used to select wafers for inspection. In the first, or fixed-policy, method, the same number of wafers is inspected regardless of defect density. In the second method a variable policy is used. It is found that in a superclean production environment these inspection methods are not equivalent in defect density estimation: estimates obtained by the variable policy may be biased, while those obtained with the fixed policy are always unbiased. Fundamental reasons for such a phenomenon are discussed and recommendations are made. 3 refs.

Pesotchinsky, Leon L. (San Jose State Univ, CA, USA); Fichtenholz, Zinoviy. *IEEE Trans Semicond Manuf* v 1 n 1 Feb 1988 p 16-22.

## Marketing

**095876 SEMICONDUCTORS GO TO KOREA.** The role played by US manufacturers in South Korea's entrance into the global semiconductor market is discussed. Technology transfer through joint ventures, licensing, and other kinds of agreements is examined. The difficulties encountered by the major South Korean companies, both individually and as a group, are discussed.

Perry, Tekla S. *IEEE Spectrum* v 24 n 12 Dec 1987 p 34-38.



**Materials** See Also CERAMIC MATERIALS—Thermal Conductivity; INTEGRATED CIRCUITS, VLSI—Thin Films; SEMICONDUCTING GALLIUM ARSENIDE—Applications; SEMICONDUCTING GALLIUM ARSENIDE—Ion Implantation.

**095877 ZIRCON PHOSPHATE MATERIAL FOR COATING VITREOUS SILICA.** A method involving the photocolometric determination of zirconium and phosphorus was developed at the State Scientific-Research Institute of Vitreous Silica for the investigation of the chemical composition of a coating containing 60% zirconium and 10% phosphorus. The method is based on the fact that zirconium forms with arsenic III a colored complex compound in the acidity range of 1-3 relative to HCl. The x-ray phase analysis showed that with an increase in the concentration of  $P_2O_5$  in the original material, the amount of zirconium pyrophosphate in the coating increases after heat treatment. In this case the strength of the zircon phosphate material increases. Thus, the compressive strength of specimens with a concentration of 20% of  $ZrP_2O_7$  was 30 MPa. The use of the results of the reported studies has made it possible to optimize the production process of applying zircon phosphate coatings to articles made of vitreous silica to be used in the semiconductor industry. 1 ref.

Zhuravlev, G.I. (Lensovet Leningrad Technological Inst, USSR); Kostrova, V.I.; Sokolova, A.P.; Khotimchenko, V.S. *Glass Ceram* v 43 n 7-8 Jul-Aug 1986 p 343-345.

**095878 HEAVY METAL GETTERING IN BURIED NITRIDE SILICON-ON-INSULATOR STRUCTURES.** Using Rutherford backscattering spectrometry the redistribution and gettering of implanted gold was investigated in silicon-on-insulator structures produced by high-dose nitrogen implantation. The gettering efficiency of a structure annealed at 1000°C containing a highly damaged silicon region near to the buried compound layer is more pronounced than that of a 1200°C-annealed structure with a lightly damaged silicon top layer. Gettering takes place at the interregion between silicon and silicon nitride. (Author abstract) 8 refs.

Skorupa, W. (Acad of Sciences of GDR, Dresden, East Ger); Knothe, P.; Groetzschel, R. *Electron Lett* v 24 n 8 Apr 1988 p 464-465.

**095879 DOPANT DIFFUSION IN SELF-ALIGNED SILICIDE/SILICON STRUCTURES.** Modern micro-electronic devices employ transition metal silicides in self-aligned structures on highly doped silicon material. Thermal treatments during or following silicide formation can significantly alter the dopant concentration in the underlying silicon layer. This paper discusses various diffusion mechanisms in self-aligned silicide structures and their effect on device performance. (Author abstract). 22 Refs.

Wittmer, Marc (IBM, Yorktown Heights, NY, USA). *J Electrochem Soc* v 135 n 8 Aug 1988 p 2049-2053.

**095880 POROUS SILICON TECHNIQUES FOR SOI STRUCTURES.** The two principal silicon-on-insulator fabrication techniques are examined. The first is by buried porous Si formation; areas surrounding device islands are converted into porous Si by proper tailoring of the wafer dopant profile. It is known as FIPOS (full insulation by porous oxidized silicon). The second is by epitaxy on porous Si; a uniform surface porous Si layer is used as a seeding layer for low-temperature epitaxy of the device Si. Oxidation of the underlying porous Si layer, via trenches in the device Si, has been improved to the point that defect generation and wafer warpage are avoided. Fabrication of advanced devices on the FIPOS material has shown that the porous silicon technology is among the front-runners for high-performance CMOS LSIs. 27 refs.

Tsao, Sylvia S. (Sandia Natl Lab, Albuquerque, NM, USA). *IEEE Circuits Devices Mag* v 3 n 6 Nov 1987 p 3-7.

**Mathematical Models** See Also SEMICONDUCTING GALLIUM ARSENIDE; SEMICONDUCTING GALLIUM ARSENIDE—Mathematical Models; SEMICONDUCTOR DEVICES, MOSFET—Computer Simulation; SEMICONDUCTOR MATERIALS—Charge Carriers.

**095881 MODELLISTICA DEI DISPOSITIVI A SEMICONDUCTORE.** [Modeling of Semiconductor Devices]. Physical models, numerical methods and potentialities of modern programs of simulation of electronic semiconductor devices are presented, with special reference to the system developed in the course of the last five years at the University of Bologna. The problems of analysis under static, dynamic and small-signal conditions are examined in detail from the numerical point of view, and some examples are illustrated in which use is made of the algorithms described. A method of analysis of sensitivity of the electric characteristics to the variations of the physical (impurity profiles), and geometric structure of the devices is presented. Finally, a model of transport in semiconductors based on the first and second order moments of the Boltzmann equation is illustrated. This is the so-called 'hydrodynamic' model which overcomes some limitations of the classic transport model based on 'drift' and diffusion. (Translated author abstract) In Italian. 23 refs.

Baccarani, G. (Univ di Bologna, Bologna, Italy); Ciampolini, P.; Gnudi, A.; Guerrieri, R.; Rudan, M. *Alta Freq* v 56 n 5 Jul 1987 p 59-71.

**095882 NON-QUASI-STATIC CAPACITANCE OF P/N JUNCTION SPACE-CHARGE REGIONS.** The effect of the free-carrier delay time on the space-charge-region capacitance is investigated and a method of finding such capacitance is developed. The method, which is based on a comprehensive quasi-static space-charge-region capacitance model and on the concept of the delay time in the region, describes the non-quasi-static capacitance for all voltages, all frequencies, and for both step and linear-graded junction profiles. The method requires a simple numerical iterative procedure. The results from the present method show good agreement when compared with a numerical method based on Sah's transmission-line equivalent circuit model and with measured dependencies. The method provides a tool for more accurate semiconductor device modeling and for integrated circuit simulations. (Author abstract) 16 refs.

Liou, J.J. (Univ of Central Florida, Orlando, FL, USA). *Solid State Electron* v 31 n 1 Jan 1988 p 81-86.

**095883 EVOLUTION SYSTEMS IN SEMICONDUCTOR DEVICE MODELING: A CYCLIC UNCOUPLED LINE ANALYSIS FOR THE GUMMEL MAP.** The initial/boundary-value problem for isothermal, lattice, semiconductor device modeling is described and analyzed. This nonlinear elliptic/parabolic system of reaction/diffusion/convection type is determined by a Maxwell equation, relating space/charge and the electric field, and by two continuity equations for the free electron and hole carrier concentrations. The Einstein relations for Brownian motion are not assumed in this analysis, so that the electrostatic potential,  $u$ , and the carrier concentrations,  $n$  and  $p$ , are the fundamental dependent variables of the system. The boundary conditions are Dirichlet conditions for dependent variable values on the contact portions of the device, and homogeneous Neumann conditions, expressing insulation, on the complement. Complicating the analysis are the transition singularity points between the mixed boundary conditions, and the field dependence of the mobility and diffusion coefficients. By means of a physically motivated analysis of the convective current component, we are able to uncouple the system by a cyclic horizontal line analysis, without an unreasonable time step restriction. (Edited author abstract) 21 refs.

Jerome, J.W. *Math Methods Appl Sci* v 9 n 4 1987 p 455-492.

**095884 SECOND ORDER DIFFERENCE SCHEME FOR TRANSIENT SEMICONDUCTOR DEVICE SIMULATION.** A second order scheme for the solution of the transient fundamental semiconductor device equations is presented which does not suffer from

timestep restrictions due to the stiffness of the analytical problem. The second order accuracy as well as the stability properties are demonstrated on the simulation of a p-n-junction diode. (Author abstract) 12 refs.

Ringhofer, Christian A. (Arizona State Univ, Tempe, AZ, USA). *Trans Soc Comput Simul* v 3 n 4 Oct 1986 p 253-278.

**095885 NUMERICAL SOLUTION OF THE HYDRODYNAMIC MODEL FOR A ONE-DIMENSIONAL SEMICONDUCTOR DEVICE.** A numerical implementation of a discretization scheme of the hydrodynamic model for submicron devices is described and applied to a one-dimensional ballistic diode. The performance of the numerical method and the physical results of the simulation for different biases and lattice temperatures, and a brief comparison to Monte Carlo simulations, are also given. (Author abstract) 16 refs.

Rudan, M. (IBM, Yorktown Heights, NY, USA); Odeh, F.; White, J. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 3 Sep 1987 p 151-170.

**095886 ANALYSIS OF A DISCRETIZATION ALGORITHM FOR TIME-DEPENDENT SEMICONDUCTOR MODELS.** A new algorithm is presented for the discretization of semiconductor models in one space dimension plus time. A complete error analysis is given, showing that the discretization errors do not depend on any derivatives of ill-behaved quantities such as carrier densities. In this algorithm, the electrostatic potential is updated from a discretization of the equation of total current continuity, and parabolic equations for the current densities are discretized, rather than those for the carrier densities. Projection methods, e.g. simple finite-element methods, are used for the space discretization. The equations for the current densities are similar to the familiar Scharfetter-Gummel expressions in the stationary limit. This method is fully compatible with recently developed methods for uncoupling the discrete systems to be solved at each time step, for an individual device or when a given problem involves multiple, coupled devices. (Edited author abstract) 13 refs.

Sever, Michael (Hebrew Univ, Jerusalem, Isr). *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 3 Sep 1987 p 171-189.

**095887 NUMERICAL ANALYSIS OF THE TRANSPORT PHENOMENON IN SEMICONDUCTOR DEVICES AND STRUCTURES. 5. THREE-DIMENSIONAL MODELING OF VLSI ELEMENTS.** A change in the configuration of the components in the plane of the crystal, i.e., their topology, is the approach approved in practice for improving the characteristics of LSI and VLSI elements. In this case, despite the possible significant machine time expenditures, the three-dimensional modeling of transport processes occurring in the elements is necessary in principle. The high efficiency of a multidimensional numerical analysis of semiconductor devices is confirmed in an example of three-dimensional modeling of bipolar integral circuit structures. (Edited author abstract) 17 refs.

Abramov, I.I. (Belorussian Inst of Railroad Transport Engineers, Gomel, USSR); Kharitonov, V.V. *J Eng Phys* v 53 n 1 Jul 1987 p 849-854.

**095888 BOUNDARY LIMITED HIGH FIELD TRANSPORT IN ULTRA SMALL DEVICES.** Boundary limited transport in small compound semiconductor devices is studied within the self-consistent Monte Carlo method. New stable microscopic models fully accounting for stochastic carrier exchange at boundaries have been developed for ohmic, tunneling, and Schottky barrier boundaries. These new models are demonstrated with



applications to the one-dimensional GaAs resistor,  $N^+ - N - N^+$  diode and the  $N^+ - N$  Schottky diode. (Author abstract) 5 refs.

Al-Omar, A. (Cornell Univ, Ithaca, NY, USA); Krusius, J.P. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 1 Mar 1987 p 3-9.

**095889 ON THE CONDITIONING OF THE STEADY STATE SEMICONDUCTOR DEVICE PROBLEM.** In this paper we carry out a conditioning analysis for the steady state semiconductor device problem. We consider various quasilinearizations as well as Gummel-type iterations and obtain stability bounds which may allow ill-conditioning in general. These bounds are exponential in the potential variation, and are sharp e.g. for a thyristor. But for devices where each smooth subdomain has an Ohmic contact, e.g. a pn-diode, moderate bounds guaranteeing well-conditioning are obtained. Moreover, the analysis suggests how various row and column scaling should be applied in order for the measured condition numbers of the linearized discrete problem to correspond more realistically to the true loss of significant digits in the calculations. (Author abstract) 7 refs.

Ascher, U. (Univ of British Columbia, Vancouver, BC, Can); Markowich, P.A.; Steinrueck, H.; Weiss, R.; Schmeiser, C. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 1 Mar 1987 p 19-23.

**095890 SELF-CONSISTENT I-V CHARACTERISTICS OF ULTRA-SMALL DEVICES.** A method is presented for the incorporation of space-charge effects into the analysis of one-dimensional devices. At each bias, solutions of Schrodinger's and Poisson's equations are performed iteratively, until the solutions converge. Some difficulties in the calculation of electron density are noted, and an algorithm is described to insure an accurate computation. Finally, the current-voltage characteristic of a recently fabricated resonant tunneling device is presented, to stress the importance of space-charge effects. (Author abstract) 6 refs.

Cahay, M. (Purdue Univ, West Lafayette, IN, USA); McLennan, M.; Datta, S.; Lundstrom, M.S. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 1 Mar 1987 p 53-57.

**095891 ADAPTIVE MESHING APPLIED TO A TWO-DIMENSIONAL DEVICE SIMULATOR.** The purpose of using an adaptive meshing strategy is to define the problem well with as few nodes as possible. The extent to which the discrete system adequately represents the problem being solved depends on the positioning of the grid points. It is the intention to show here that adding badly placed nodes to the region of interest in a mesh can reduce the accuracy of the resulting solution. A practical refinement strategy is presented where such problems are avoided. (Author abstract) 3 refs.

Edwards, S.P. (IMEC, Heverlee, Belg); De Meyer, K.; De Wilde, Ph. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 2 Jun 1987 p 65-70.

**095892 SIMPLIFIED DEVICE EQUATIONS AND TRANSPORT COEFFICIENTS FOR GaAs DEVICE MODELING.** In the analysis of submicrometer GaAs devices, consideration of hot-electron effects is imperative. A generalized current equation suggested by K.K. Thornber (1982) allows the inclusion of some of the hot-electron effects into standard drift/diffusion device models, and hence does not require too large computational resources. Here the authors report gradient and rate coefficient tables (graphs) that are necessary to complement the standard approach for electrons in GaAs at 300 K as calculated by Monte Carlo methods. 14 refs.

Kizilyalli, I.C. (Univ of Illinois, Urbana, IL, USA); Hess, K. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2352-2354.

**095893 CHARGE-INJECTION DEVICES - II: MULTIPLE-PIXEL SOLUTIONS WITH ROW IN-**

**JECTION.** The original 1-pixel theory has been reformulated for many pixels and solved numerically, almost exactly. Applicability to multiple-pixel charge-injection devices (CIDs) is supported by the consistency of the theory and comparison with measurements. Row-injection is only a small subset of possible multiple-pixel CID problems, but others may be relatively straightforward with the present calculations as an example. With these accurate results, approximations can be evaluated. 6 refs.

Weinberg, Donald L. (US Naval Research Lab, Washington, DC, USA). *IEEE Trans Electron Devices* v 35 n 1 Jan 1988 p 48-55.

**095894 MODIFIED GUMMEL METHOD FOR THE BASIC SEMICONDUCTOR DEVICE EQUATIONS.** A modification of H.K. Gummel's (1964) method for the iterative solution of the basic semiconductor device equations is presented. The method uses an approximation of an appropriately preconditioned Jacobian matrix and is designed to improve the convergence of Gummel's method for large currents. Performance is tested on a model problem. 4 refs.

Ringhofer, Christian (Arizona State Univ, Tempe, AZ, USA); Schmeiser, Christian. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 2 Feb 1988 p 251-253.

**Measurements** See Also ELECTRIC MEASUREMENTS—Microwaves; SEMICONDUCTOR DIODES—Radiation Effects; TRANSISTORS—Mathematical Models.

**095895 AUTOMATIC MEASUREMENT OF MINORITY CARRIER LIFETIMES IN SILICON FOR NONUNIFORM DOPED SAMPLES USING THE ZERBST METHOD.** One of the problems of automatically measuring lifetime using the Zerbst technique is the estimation of the total time required for measurement. The paper addresses this problem, and the proposed method is applicable to both uniformly and nonuniformly doped samples. This enables the data to be measured in a manner which ensures that noise free plots are obtained. (Author abstract) 35 refs.

McGillivray, Ian G. (Univ of Edinburgh, Scotl); Robertson, John M.; Walton, Anthony J. *IEE Proc Part I* v 134 n 6 Dec 1987 p 161-167.

**095896 LATTICE PARAMETER MEASUREMENT OF SUB-MICRON DEVICE STRUCTURES IN COMPOUND SEMICONDUCTORS VIA CONVERGENT-BEAM ELECTRON DIFFRACTION.** Dynamical diffraction effects prevent direct extraction of changes in the lattice parameter from convergent-beam electron diffraction (CBED) patterns which are obtained from high atomic number materials such as compound semiconductors. Therefore, in order to measure the relative lattice mismatch of a quaternary (InGaAsP) device structure grown on InP, we have opted to calibrate the relative position of CBED features with X-ray lattice parameter measurements which were obtained from planar quaternary layers grown on InP substrates. Three parameters from bright-field CBED patterns were measured as a function of the X-ray determined lattice mismatch in order to establish three separate calibration curves. CBED measurements taken from a device structure were found to produce similar values of lattice mismatch when interpreted using the calibration curves. The close correspondence of these three values of the lattice mismatch  $((4.541 \pm 2.119) \times 10^{-4})$ ,  $(5.158 \pm 2.881) \times 10^{-4}$ , and  $(4.819 \pm 4.021) \times 10^{-4}$ , enhances the credibility of this approach for the characterization of sub-micron device structures. (Edited author abstract) 9 refs.

Twigg, M.E. (AT&T Bell Lab, Murray Hill, NJ, USA); Chu, S.N.G.; Joy, D.C.; Maher, D.M.; Macrander, A.T.; Chin, A.K. *Mater Lett* v 6 n 1-2 Nov 1987 p 5-10.

**095897 ELECTRICAL MEASUREMENTS OF DEVICES FABRICATED IN PULSED ARC LAMP RAPID-ZONE-RECRYSTALLIZED SILICON ON INSULATOR.** A seeded polysilicon-coated sample is rapidly preheated and scanned by a linear translation table under the zone; speed is of the order of 35 cm/s. The lamp energy is collimated by a plate optic to a 0.5-mm line

with 8-kW-cm<sup>-2</sup> power density. A single lamp pulse melts the top film and the sample then cools by radiation. The sample is above room temperature for less than 15 s. Three-inch Si wafers with 0.5- $\mu$ m-thick seeded SOI islands (50  $\mu$ m by 2.5 cm) were prepared by this method. MOSFETs, resistors, capacitors, lateral junction diodes, Schottky diodes, and MESFETs were fabricated; standard CMOS LOCOS process technology was used. Measurements reveal electron mobilities averaging 670 cm<sup>2</sup>-V-s in implanted channels 915% higher than in bulk monitor samples). Unpassivated backchannel leakage averaged 80 nA- $\mu$ m<sup>-2</sup>. Minority-carrier lifetimes over 10  $\mu$ s (comparable to line e-beam recrystallized samples) exceed the values commonly seen in ZMR material. The electrical results confirm the material quality suggested by scanning electron microscopy, transmission electron microscopy, and Nomarski observations. The process, with significantly higher throughput than one requiring a vacuum, has application to high-speed, dense, radiation-hard CMOS. 4 refs.

Hunt, Charles E. (Univ of California, Davis, CA, USA). *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2362.

**095898 CHANNEL-LENGTH MEASUREMENT TECHNIQUE BASED ON A FLOATING-GATE DEVICE.** By measuring the threshold voltage of the structure for several drawn channel lengths,  $\Delta L$  is extracted. This technique is the translation of a capacitance measurement into a threshold measurement and as such is accurate and simple to perform. Since the technique does not involve a current flow through the transistor under test, it is especially advantageous for  $L_{eff}$  measurements on lightly-doped drain (LDD) and double-diffused drain (DDD) short-channel devices. 5 refs.

Eitan, Boaz (WaferScale Integration Inc, Fremont, CA, USA). *IEEE Electron Device Lett* v 9 n 7 Jul 1988 p 340-342.

**095899 4th ANNUAL IEEE SEMICONDUCTOR THERMAL AND TEMPERATURE MEASUREMENT SYMPOSIUM.** The proceedings contains 26 papers. The following topics are dealt with: thermal measurement systems and techniques; thermal modeling; thermal characterization of IC packages; thermal analysis; effects of radiation on enhanced electronic cooling; thermal design of ICs; wind tunnels; semiconductor device thermal factors; and diamond heat sinks. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11491 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEEE, Components, Hybrids & Manufacturing Technology Soc, New York, NY, USA). *4th Annu IEEE Semicond Thermal & Temperature Measurement Symp Publ* by IEEE, New York, NY, USA. 158p.

**Metallizing** See Also ELECTRIC CONTACTS, OHMIC—Manufacture.

**095900 SELF-ALIGNED COBALT DISILICIDE FOR GATE AND INTERCONNECTION AND CONTACTS TO SHALLOW JUNCTIONS.** A novel gate and interconnection and contact metallization technology that uses cobalt disilicide for both purposes is presented. Cobalt disilicide, with a thin polycrystalline film resistivity of 15-20  $\mu\Omega$ -cm, offers a 0.5-1- $\Omega/\square$  sheet resistance at the gate level in the silicide/polysilicon gate metal scheme. It also offers an excellent contact metallization scheme to shallow junctions. The scheme described utilizes self-aligned patterning features and low-temperature processing and shows stability up to 900°C. Various other features of the processing and characteristics of the silicide are presented. 28 refs.

Murarka, S.P. (Rensselaer Polytechnic Inst, Troy, NY, USA); Fraser, David B.; Sinha, Ashok K.; Levinstein, Hyman J.; Lloyd, Edward J.; Liu, R.; Williams, D.S.; Hillenius, S.J. *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2108-2115.



**095901 METALLURGICAL TOPICS IN SILICON DEVICE INTERCONNECTIONS: STRESSES.** Some of the problems encountered in thin film metallizations are presented in chronological order with references given to the literature dealing with a variety of topics, such as e.g. electromigration. The material which follows has been limited to the issue of stresses in thin films. A consideration of the general equilibrium of forces between films and substrates is extended to the measurement of stresses in uniform continuous films. In practical conditions with edges at via holes and along narrow conductors the stress distributions become more complicated. Intrinsic and extrinsic stresses are discussed with respect to both their origin and to what they mean for technological applications. Stress relaxation causes the formation of hillocks and holes. The implications of stresses with respect to adhesion and other practical effects are reviewed. (Edited author abstract) 107 refs.

d'Heurle, F.M. (IBM, Yorktown Heights, NY, USA). *Acta Polytech Scand Electr Eng Ser* n 58 1987, Proc of the Adv Summer Sch on Microelectron: Phys and Technol for VLSI, Espoo, Finl, Jun 8-12 1987 p 27-56.

**095902 WAFER BACK METALLIZATION FOR SEMICONDUCTOR PACKAGING.** Among the candidate metallurgical schemes, gold is still the material of choice in many applications although a number of multilayer metallization processes are being used or developed to meet special application requirements. Material requirements are described in this paper and material selection for wafer back metallization and its impacts on the performance of microelectronic devices are discussed. The significance of Au-Si contact is also discussed and a new observation on the low temperature behavior of gold-p-type silicon is reported. (Edited author abstract) 11 refs.

Kim, Namsoo P. (Gould Semiconductors, Santa Clara, CA, USA); Cooley, Richard F. *Thin Solid Films* v 153 Oct 26 1987, Pap Presented at the Int Conf on Metall Coat - Part I, San Diego, CA, USA, Mar 23-27 1987 p 447-457.

**Microstructure Examination** See Also SEMICONDUCTING SILICON—Nondestructive Examination.

**095903 EFFECT OF LOW-ENERGY ELECTRON IRRADIATION IN A SCANNING ELECTRON MICROSCOPE ON THE PARAMETERS OF SEMICONDUCTOR DEVICES.** The increase in the complexity and degree of integration of integrated circuits has made exceedingly urgent the problem of measurements of their elements, monitoring of the functioning, and analysis of faults by the methods of scanning electron microscopy (SEM). It is well known, however, that irradiation with electrons can substantially alter then electrophysical parameters of the elements and circuits. In this work the effect of irradiation in SEM on the parameters of some types of semiconductor devices is studied, and it is shown that even very sparing observation regimes can give rise to significant degradation of the parameters, the possibility of which must be taken into account in the analysis of results obtained with the help of SEM, and therefore SEM in application to semiconductor devices must in the general case be regarded as a destructive method. 9 refs.

Meiler, B.L. (Tallinn Polytechnic Inst, USSR); Kropman, D.I.; Levchenkova, A.A. *Sov Microelectron* v 16 n 2 Mar-Apr 1987 p 101-104.

**095904 OBSERVATION OF RARELY REPEATING, RAPIDLY OCCURRING PROCESSES IN SEMICONDUCTOR INSTRUMENTS USING SCANNING ELECTRON MICROSCOPY.** The use of a scanning electron microscope for observing rarely repeating, rapidly occurring processes in semiconductor instruments in a stroboscopic model with an on-off time ratio of up to  $10^6$  is described. (Author abstract) 3 refs.

Zlobin, V.A.; Kostysheva, U.V. *Bull Acad Sci USSR Phys Ser* v 51 n 3 1987, Mater of the Fifth All-Union Symp on Scanning Electron Microsc and Anal Methods for Invest Solids, Zvenigorod, USSR, May 1986 p 35-37.

**095905 ANISOTROPY OF THE ENERGY SPECTRUM OF REFLECTED ELECTRONS IN A HETEROTRANSITION.** Scanning electron microscopy (SEM) is an effective method for testing the geometrical and electrophysical parameters of semiconductor instruments of microelectronics and electrooptics. Development of new types of instruments with characteristic dimensions of the working regions up to several dozen angstroms requires development of new research methods based on mathematical processing of SEM signals with consideration of their distribution function in the investigated subject. For this purpose, the physical mechanism of formation of signals must be determined in turn and an adequate theoretical model must be created. This work examines the experimentally detected effect of anisotropy of the energy spectrum of reflected electrons (RE) near a heteroboundary when investigating heterostructures in SEM. A simple theoretical model, which agrees well with the experimental data, is proposed to explain the effect. (Author abstract) 4 refs.

Bakaleinikov, L.A.; Konnikov, S.G.; Solov'ev, V.A.; Umanski, V.E. *Bull Acad Sci USSR Phys Ser* v 51 n 3 1987, Mater of the Fifth All-Union Symp on Scanning Electron Microsc and Anal Methods for Invest Solids, Zvenigorod, USSR, May 1986 p 38-41.

**095906 ELECTRON-ACOUSTIC MICROSCOPIC STUDY ON DISLOCATION LINES IN THE BASE REGION OF npn Si-Tr.** Using an npn Si-Tr chip, bias voltage was applied between the collector and the base for in situ observation of SEM and electron-acoustic microscopy (EAM) in the same area. The results disclosed the following. (1) The contrast of electron acoustic image (EAI) of EAM varied with the bias conditions. (2) Dislocation lines were observed in the base region but not in the emitter region. (3) The dislocation lines in the EAI were not observed at bias voltage of 0 v but appeared at 0.4 V to the collector. (4) By using at acceleration voltage of 30 kV and Si as a specimen, the observation depth by EAM was about 10  $\mu$ m. EAM study of another type of Tr chips was also undertaken. (Author abstract) 14 refs.

Takenoshita, Hiroshi (Univ of Osaka Prefecture, Sakai, Jpn). *Jpn J Appl Phys Suppl* v 25 suppl 25-1, 1986 Proc 6th Symp on Ultrason Electron, Tokyo, Jpn, Dec 10-12 1985 p 194-196.

## Microstructure

**095907 INFLUENCE OF DIFFERENT SEM PARAMETERS ON CD MEASUREMENT RESULTS.** The increasing complexity and the resulting reduction in feature dimensions mean that the already wide field of application of a Scanning Electron Microscope (SEM) is extended to that of metrology. In many cases, due to its higher lateral resolution and the increased depth of focus, Critical dimension (CD) data can only be acquired using a SEM instead of optical systems. The correct evaluation of the obtained results requires a detailed knowledge about the influence of different SEM parameters, such as primary electron (PE) energy, beam diameter, focus, etc., on the video profiles. Up to now, the complexity of the profile variations due to a change in SEM parameters do not allow a fast and convenient compensation by the software. This makes it necessary to calibrate the system after a variation of SEM settings. (Author abstract) 4 refs.

Tollkamp-Schierjott, C. (Philips Analytical, Eindhoven, Neth). *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microolithogr, Jouay-en-Josas, Fr, Sep 22-25 1987 p 673-678.

**095908 LMS 2000 - A NEW METROLOGY TOOL.** The author has recently developed a new metrology system dedicated for nanometer precision microscopic and macroscopic dimensional measurements. The system uses latest technology high resolution laser interferometry and a novel optical scanning method designed for simultaneous x- and y-measurements.

Paul, H.-H. (Ernst Leitz Wetzlar GmbH, Wetzlar, West Ger). *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microolithogr,

Jouay-en-Josas, Fr, Sep 22-25 1987 p 689-691.

## Microstructures

**095909 USE OF S.E.M. FOR LINEWIDTH MEASUREMENTS.** By studying the cross-section of the lines to be measured we show that the absolute measurement of Critical Dimension is not provided by S.E.M. dedicated to metrological applications. A calibration for each layer is needed. (Author abstract) 1 ref.

Burlet, Daniel (CNET, Meylan, Fr); Martin, Herve. *Microelectron Eng* v 6 n 1-4 Dec 1987, Microcircuit Eng 87, Proc of the Int Conf on Microolithogr, Jouay-en-Josas, Fr, Sep 22-25 1987 p 679-681.

**Microwaves** See Also INTEGRATED CIRCUITS, MONOLITHIC—Microwaves.

**095910 NEW SITS CHALLENGE EXISTING POWER SEMICONDUCTORS.** The SIT is a FET in which the height of the potential barrier in the channel controls the main current flowing between the drain and the source. Sandwiched between the paired gates and the height of the potential barrier, the channel region is capacitively controlled by the gate and drain voltage through electrostatic induction. The power (static induction) SI family of devices covers the dc to 10GHz range with the ability to control power levels of 10 to 1 megawatt. SIT status is reviewed and the devices are compared with other power semiconductors. 17 refs.

Nishizawa, Jun-ichi (Tohoku Univ, Sendai, Jpn). *Power-convers Intell Motion* v 13 n 10 Oct 1987 9p between p 15 and 28.

**095911 MICROWAVE SEMICONDUCTORS FOR SMT.** Surface mounting technology is very much concerned with costs in electronics manufacturing. This mainly applies to entertainment electronics where the greatest numbers of SMDs (surface mounted devices) are used. But also in communications engineering a wide field is being opened up for surface mountable microwave semiconductors.

Anon (Siemens AG, Munich, West Ger). *Siemens Com-pen* v 23 n 2 Apr 1988 p 64-67.

**Millimeter Waves** See INTEGRATED CIRCUITS—Microwaves.

**Modeling** See Also INTEGRATED CIRCUIT MANUFACTURE; SEMICONDUCTING INDIUM COMPOUNDS—Transport Properties; SEMICONDUCTOR DIODES—Junctions; SOLIDS—Thermal Effects.

**095912 CRITICAL PLASMONS OF A QUASIPERIODIC SEMICONDUCTOR SUPERLATTICE.** Based on a versatile model, plasma excitations of the quasiperiodic semiconductor superlattice are studied through the rational approximation method. An universal condition is obtained. Thus not only a series of results in several references can be reproduced easily, but also the dispersion relations of the second type of quasiperiodic semiconductor superlattice and quasiperiodic superlattice of the II-VI compounds can be determined. A method is suggested to calculate the surface plasma modes of the semi-infinite quasiperiodic superlattice. (Author abstract) 11 refs. In Chinese.

Guoyi Qin (Nanjing Univ, China). *Pan Tao T'i Hsueh Pao* v 9 n 1 Jan 1988 p 15-22.

**095913 PHYSICS AND MODELING OF SUBMICRON SEMICONDUCTOR DEVICES.** The modeling of semiconductor devices almost always is done in order to try to explain or understand the underlying physics that produces an observed set of terminal characteristics. Thus, the model must incorporate the relevant physical processes, and good model development must rely on both intuition (of the theoretician) and experimental observations. We discuss the approaches used in developing



models and the special problems that arise in submicron semiconductor devices. (Edited author abstract) 15 refs.

Ferry, David K. (Arizona State Univ, Tempe, AZ, USA). *Acta Polytech Scand Electr Eng Ser n* 58 1987, Proc of the Adv Summer Sch on Microelectron: Phys and Technol for VLSI, Espoo, Finl, Jun 8-12 1987 p 131-150.

**Noise** See Also SEMICONDUCTING GALLIUM ARSENIDE—Growth; SEMICONDUCTING INDIUM COMPOUNDS—Ion Implantation; SEMICONDUCTING SILICON—Testing; SEMICONDUCTOR DIODES, PHOTODIODE—Junctions; TRANSISTORS, FIELD EFFECT—Electronic Properties.

**095914 STUDY OF SECONDARY EMISSION 1/f NOISE.** The secondary emission 1/f noise observed by Schwantes and Van der Ziel has been investigated in more detail. The new experiments were prompted by Van der Ziel's application of Handel's theory to Schwantes's 1960 secondary emission noise data. To that end we measured the spectrum  $S_{I_a}(f)$  versus  $(V_a - V_d)^{3/2}$  at constant current  $I_a$  and constant  $\delta$  and the noise spectrum versus  $I_a \delta^2$  at constant voltage  $(V_a - V_d)$  both for a large resistance  $R_c$  in the cathode lead. The results show good agreement with Handel's prediction, i.e. Handel's expression for the Hooke parameter  $\alpha_H$  is here verified. We finally discuss the meaning of these results and show that the Bremsstrahlung hypothesis can explain most of the data. (Author abstract) 5 refs.

Fang, P. (Univ of Minnesota, Minneapolis, MN, USA); Van der Ziel, A. *Physica B & C* v 147 n 2-3 Jan-Feb 1988 p 311-315.

**095915 VELOCITY FLUCTUATION NOISE MEASUREMENTS ON AlGaAs-GaAs INTERFACES.** Experiments performed to determine the dc, ac, and noise properties in the hot-electron regime of AlGaAs-GaAs heterojunction interfaces are discussed. With the use of noise temperature data, the diffusion coefficient can be determined as a function of electric field for transport parallel to the AlGaAs-GaAs interface. Two device structures with different characteristics, such as length, fraction of aluminum content, sheet-carrier concentration, etc., are used in the experiments. The experimental results are attributed to the field-dependent charge-transport properties of the quasi-two-dimensional electron gas formed at the interface. 14 refs.

Whiteside, Christopher F. (Univ of Florida, Gainesville, FL, USA); Bosman, Gijs; Morkoc, Hadis. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2530-2534.

**095916 1/F NOISE MEASUREMENT IN SEMI-CONTINUOUS METAL FILMS.** The noise of gold and aluminum films are measured. All noise spectra are the 1/f type. The noise of the gold films increases in proportion to the fifth power of the resistance in the high-resistance range and to the cube of the resistance in the low-resistance range. The noise of thin films is qualitatively characterized. The resistance dependences were explained by a static-contact model and granular-resistor model, respectively. 10 refs.

Takagi, Keiji (Kyushu Inst of Technology, Kitakyushu, Jpn); Mizunami, Toru; Masuda, Satoshi. *IEEE Trans Compon Hybrids Manuf Technol* v CHMT-10 n 4 Dec 1987, Contrib from the 37th Electr Compon Conf, Boston, MA, USA, May 1987 p 687-689.

**095917 UNIFIED PRESENTATION OF 1/F NOISE IN ELECTRON DEVICES: FUNDAMENTAL 1/F NOISE SOURCES.** 1/f noise in semiconductors, semiconductor devices, and collision-free devices (like vacuum tubes) is presented from a unified point of view, using an extended version of the F. N. Hooke equation (Physica, vol. 83b, p. 9, 1976), which is generalized to all collision-dominated systems involving mobility, diffusion, and cross-section fluctuations. It also applies to collision-free processes involving vacuum tubes, Schottky barrier diodes operating in the thermionic mode, and in devices such as p-i-n diodes in which collision processes are not the

determining factor. A generalized schematic is given for expressing the noise spectrum  $S_I(f)$  in the external circuit in terms of distributed noise sources of the nonuniform devices in terms of  $\alpha_H$ , so the latter can be determined from the former. It is then found that the Hooke parameter,  $\alpha_H$ , introduced by this equation can be used as a general measure of the noisiness of a system or device. Several cases in which the noise does not obey the quantum 1/f noise theory are discussed. Measurements on many different devices are examined, and an attempt is made to correlate measured values of the Hooke parameter with the values calculated from P. H. Handel's quantum theory of 1/f noise (1975, 1980). 97 refs.

van der Ziel, Aldert (Univ of Florida, Gainesville, FL, USA). *Proc IEEE* v 76 n 3 Mar 1988 p 233-258.

**Nondestructive Examination** See RADIOGRAPHY—X-Ray.

**Optical Properties** See Also LIGHT—Amplifiers; SEMICONDUCTOR MATERIALS—Amorphous.

**095918 NEW STEP IMPACT ELECTROLUMINESCENT DEVICES.** The step impact electroluminescent devices (SIED) and the multistep photon amplifier converted (SPAC) are proposed. The devices are a multilayered heterojunction structures in which the acceleration and collision excitation processes are spatially separated and permits independent optimization of each function in different materials. In collision excitation region, ballistic electrons excite the rare earth ions by direct impact. By changing conduction band step  $\Delta E_c$  we can tune up the energy of excited electrons to the resonance condition of a particular excited state of  $RE^{3+}$  ions. The emission from the rare earth ions with transition wavelength shorter than semiconductor's band edge emission can be generated. The emission will contain narrow lines with gradual change in wavelength with temperature. The advantages of the new devices and excitation mechanism are discussed in detail. (Edited author abstract) 42 refs.

Lozykowski, H.J. (Ohio Univ, Athens, OH, USA). *Solid State Commun* v 66 n 7 May 1988 p 755-759.

**095919 ELIMINATION OF PHOTO-INDUCED DEGRADATION IN SEMICONDUCTOR DEVICES.** Hydrogenated amorphous silicon and related alloys ordinarily exhibit photo-induced changes that degrade device behavior, particularly in solar-cell applications. On the basis of a recently developed theory for the electronic structure of such alloys, two approaches for elimination of these changes are proposed. (Author abstract) 7 refs.

Joannopoulos, J.D. (MIT, Cambridge, MA, USA); Adler, D.; Bar-Yam, Y. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 621-623.

**Performance** See Also SEMICONDUCTOR DEVICES, FIELD EFFECT—Ion Implantation.

**095920 THERMAL COMPOUNDS CUT POWER LOSS.** This paper deals with high power electronics that use semiconductor devices rated above 100A and/or 1000V. The paper is aimed at designers of power distribution, transportation, power supplies and power controller systems. (Edited author abstract)

Longenecker, Kenneth G. *Powerconvers Intell Motion* v 14 n 2 Feb 1988 p 20-21.

**095921 POWER MODULES CONTINUE TO GROW IN SIZE, POWER AND APPLICATIONS.** Current trends in power modules are reported. They include combinations of various semiconductor devices and new packages with higher power ratings. (Edited author abstract)

Smith, Marvin W. (Adree Technical Services). *Powerconvers Intell Motion* v 14 n 2 Feb 1988 p 22, 24.

**095922 HIGH-CURRENT PULSE-DOPED GaInAs MESFET.** We report the DC and microwave performance of pulse-doped GaInAs power MESFETs. For a 0.7  $\mu$ m

gate-length device, a maximum drain-current density of 870 mA/mm and a peak transconductance of 325 mS/mm were measured. A maximum stable gain of 11.7 dB at 26 GHz, and an extrapolated  $f_t$  of 33 GHz were obtained. These values are the highest reported for MESFETs having gates as long as 0.7  $\mu$ m. (Author abstract) 6 refs.

Fathimulla A. (Allied-Signal Aerospace Co, Columbia, MD, USA); Hier, H.; Abrahams, J. *Electron Lett* v 24 n 8 Apr 1988 p 498-499.

**Photovoltaic Effects** See PHOTOVOLTAIC CELLS—Applications.

**Physical Properties** See Also SOLIDS—Electric Conductivity.

**095923 SPACE-CHARGE LAYERS AT SEMICONDUCTOR INTERFACES.** We discuss the common features of interface band structures and the physical properties of space-charge layers associated with interfaces. Special emphasis is placed on the insulator-semiconductor interface, which is the basis for MOS devices, and the metal-semiconductor. 174 refs.

Schulz, M. (Inst fuer Angewandte Physik, Erlangen, West Ger). *Cryst Semicond Mater and Devices, Trieste, Italy, 1984* Publ by Plenum Press, New York, NY, USA, 1988 p 425-481.

**095924 BASIC PROPERTIES IN SEMICONDUCTOR DEVICES.** This chapter provides an introduction to the main physical phenomena occurring in semiconductor devices. Because of the dominant position of silicon as a semiconducting material in present-day devices, most of the phenomena discussed relate to effects occurring in silicon devices. However, attention is also paid to other materials, such as III-V compounds, which are especially important for semiconductor optical devices. 20 refs.

Pals, J.A. (Philips Research Lab, Eindhoven, Neth). *Cryst Semicond Mater and Devices, Trieste, Italy, 1984* Publ by Plenum Press, New York, NY, USA, 1988 p 507-548.

**Plastics Applications**

**095925 APPLICATION OF POLYIMIDE RESIN TO SEMICONDUCTOR DEVICES IN JAPAN.** Polyimide resins that have been developed and marketed for semiconductor applications by Japanese companies are reviewed. Test results for devices in which polyimide resins are used as the interlayer insulator, alpha-ray shielding, or buffer coating film are presented. The status of the development of new polyimides for semiconductors is discussed. 19 refs.

Makino, Daisuke (Hitachi Chemical Co, Jpn). *IEEE Electr Insul Mag* v 4 n 2 1988 p 15-23.

**Processing**

**095926 FOCUSED-ION-BEAM FUSE CUTTING FOR REDUNDANCY TECHNOLOGY.** Fuse cutting with focused ion beams to activate redundancy circuits is proposed, and experiments are reported that verify its potential usefulness. Aluminum fuses covered with a thin passivation layer, which are difficult to cut by conventional laser-beam technology due to the material's high reflectivity, were cut in 5 s. Ga ion beams with 30-kV acceleration voltage, 0.8- $\mu$ m beam diameter, and 0.3-A/cm<sup>2</sup> current density were used. No change in device properties due to focused-ion-beam irradiation was observed unless the focused ion beams were incident directly on the device. It is concluded that the focused-ion-beam programming technique will be useful for redundancy circuit programming. 13 refs.

Komano, Haruki (Toshiba Corp, Kawasaki, Jpn); Ohmura, Yamichi; Takigawa, Tadahiho. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 892-903.

**Protection**

**095927 SEMICONDUCTOR CHIP PROTECTION - PART 2.** The previous issue in this series introduced the



United States semiconductor chip protection legislation (SCAPA) and discussed what works are eligible for protection, the rights granted by registration and ownership. This issue deals with how a mask work is protected, including the application and the deposit requirements. (Author abstract)

Burshtein, S. *Eng Dig (Toronto)* v 33 n 8 Sep 1987 p 28-29.

#### 095928 SEMICONDUCTOR CHIP PROTECTION

- PART 1. In today's computer age, one of the most valuable forms of intellectual property is the right to prohibit reproduction of a semiconductor chip. Computers were originally developed without semiconductor chips. With the miniaturization of circuits and the development of semiconductor chips, computers have become more valuable tools. Behind the manufacture of any chip there is an extremely elaborate 3D design. The first step in the production of a chip is the making of 'masks' that are in the nature of photographic templates and are used in a way somewhat reminiscent of a photographic process to etch or deposit microscopic circuits and components on a silicon chip. A different mask is needed to produce each layer making up the chip. (Author abstract)

Burshtein, Sheldon (Blake, Cassels & Graydon, Toronto, Ont, Can). *Eng Dig (Toronto)* v 33 n 7 Aug 1987 p 10-11.

#### 095929 SEMICONDUCTOR CHIP PROTECTION

- PART 4. In the previous parts in this series the protection afforded by the US semiconductor chip protection legislation (SCPA) was discussed. This concluding part deals with the national scope of the legislation and in what circumstances it may extend to Canadians. Also discussed is the state of Canada's progress in connection with mask work protection at the time of writing. (Author abstract)

Burshtein, S. *Eng Dig (Toronto)* v 34 n 2 Apr 1988 p 33, 36-37.

#### Protective Coatings See SEMICONDUCTING INDIUM COMPOUNDS—Surfaces.

#### Radiation Effects See Also INTEGRATED CIRCUITS, VLSI—Radiation Effects.

095930 RADIATION HARD CIRCUITS. The development of basic device technologies with a high degree of tolerance to various radiation environments is essential for many new strategic and space-based military systems. The basic mechanisms of radiation effects on Si and GaAs devices have been identified. Examples of how fabrication processes can be tailored to significantly improve the resistance of advanced silicon bipolar circuits to total ionizing dose and GaAs MESFET technology to transient ionizing radiation have been presented. 5 refs.

Collins, Steven R.; Tabatabaie-Alavi, Kamal. *Electron Prog* v 28 n 3 1987 p 23-30.

#### 095931 SIMULATION OF HEAVY CHARGED PARTICLE TRACKS USING FOCUSED LASER BEAMS.

A laboratory system utilizing a Q-switched Nd-doped YAG laser is used to simulate the ionization track produced as energetic heavy ions traverse a semiconductor device (resulting in single-event upset effects). Details of the optical design for producing the precisely focused spot, and the requirements for fast pulses, are described. The advantages and disadvantages of the use of this laboratory simulation are discussed. Laser tests on p-n diodes, p-n junctions, bipolar memories, and power MOSFETs are described and compared to high-energy particle test results. 14 refs.

Richter, A.K. (Boeing Aerospace Co, Seattle, WA, USA); Arimura, I. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1234-1239.

#### 095932 ANGULAR DEPENDENCE OF CHARGE FUNNELING IN SI AND GAAS DEVICES. Charge collection and transient current measurements on n-type

GaAs and Si Schottky diodes bombarded with single alpha particles reveal a strong dependence on angle of incidence. Prompt recombination is evident in both materials. The magnitude of charge collected by funneling is proportional to the charge generated in the depletion region. An alternative interpretation of the data is that charge generated to a certain depth below the junction, proportional to the depletion width, is collected by funneling. The increased collection of charge with increasing angle appears to be due to a longer collection time. These measurements indicate that dynamic processes occur during charge funneling which are not fully described by existing phenomenological models. 19 refs.

Shanfield, Z. (Northrop Research & Technology Cent, Palos Verdes Peninsula, CA, USA); Kitazaki, K.S.; Moriaki, M.M.; Campbell, D.E. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1341-1347.

#### 095933 COMPARISON OF NEUTRON, PROTON AND GAMMA RAY EFFECTS IN SEMICONDUCTOR DEVICES.

Interest in proton radiation effects has intensified in recent years. A prime focus is the relationship between proton displacement and ionization effects and the separate consideration of neutron-induced displacement and gamma-ionization effects in TREE characterization. Recent work on proton and neutron displacement damage in silicon in terms of nonionizing energy loss has laid the groundwork for comparison of proton effects with the TREE database. Device radiation susceptibilities in neutron and gamma environments are summarized. Proton interactions in silicon devices are presented in terms of dose deposition and nonionizing energy loss. This leads to a neutron-proton damage equivalence factor and enables the development of a simple correspondence. The device susceptibility charts are then combined so that both displacement damage and ionization damage can be schematically examined relative to proton dose. These susceptibility charts demonstrate the dominance of ionization effects for damage in a proton environment for silicon microcircuit technologies. This approach is presented as a means of interpreting effects for both proton exposures and TREE simulators. It is concluded that TREE characterization can be used as a good first-order estimate of proton damage effects. 25 refs.

Raymond, J.P. (Mission Research Corp, San Diego, CA, USA); Petersen, E.L. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1622-1628.

#### Reliability See Also COMMUNICATION SATELLITES—Components; COMMUNICATION SATELLITES—Reliability; SEMICONDUCTOR DIODES, LIGHT EMITTING—Testing.

#### 095934 RELIABILITY DESIGN OF SEMICONDUCTOR DEVICES FOR CS-3 COMMUNICATION SATELLITE.

Semiconductor devices used in the CS-3 communication satellite are required to have higher reliability than the devices in the CS-2 satellite, because of the long-life and large communication capacity design of the CS-3 satellite. This paper presents the technologies for improving the reliability of the semiconductor devices used in the CS-3 transponders. Lifetime lengthening for GaAs power MESFETs is accomplished by applying Ti/Al Schottky gate metallization. Long-term stress testings of a large number of samples were undergone. Radiation hardness of Si devices is assured through selection. (Author abstract) In Japanese. 6 refs.

Wada, Yoshinori (NTT, Jpn); Ueki, Takemi; Shiono, Noboru. *Denki Tsubin Kenkyusho Kenkyu Jitsuyoka Hokoku* v 36 n 9 1987 p 1287-1293.

#### 095935 MECHANICAL DECAPSULATION TECHNIQUE FOR EPOXIDE-PACKAGED SEMICONDUCTOR COMPONENTS.

A novel mechanical technique for decapsulating plastic semiconductor components has been developed. The technique is extremely easy to use, has a high success rate, and is superior in all respects to previously-described mechanical techniques

which give inconsistent results. A significant advantage over alternative chemical techniques is that corrosion products on the die surface are retained. This paper describes the new technique and shows examples of new and corroded components that have been successfully decapsulated. (Author abstract) 7 refs.

Chwastek, E.J. (British Telecom Research Lab, Ipswich, Engl); Holland, I.A. *Qual Reliab Eng Int* v 4 n 1 Jan-Mar 1988 p 7-10.

#### 095936 EARLY LIFE FAILURES.

Device failures can be classified as event-dependent, time-dependent, and a combination of the two, event/time-dependent failures. Early life failure are dominated by event-dependent failures, i.e. Electrostatic Discharge (ESD) failures, and mechanical failures (bonds, cracks, etc.) that result from a stress event. Test and failure analysis results supporting the above are reviewed. This paper was presented at the 1985 Semiconductor Device Reliability North Atlantic Treaty Organization (NATO) Workshop. (Edited author abstract) 10 refs.

Unger, Burton A. (Bell Communications Research Inc, Red Bank, NJ, USA). *Qual Reliab Eng Int* v 4 n 1 Jan-Mar 1988 p 27-34.

#### 095937 SUBSURFACE BURNOUT MECHANISMS IN GALLIUM ARSENIDE (GaAs) ELECTRONIC DEVICES.

Subsurface burnout has been observed in GaAs power field-effect transistors (FET), GaAs planar transferred electron devices (TED) biased at sufficiently high voltages<sup>7,8</sup> and in some cases when GaAs FETs<sup>9</sup> and modulation doped FETs (MODFETs)<sup>10</sup> are irradiated with alpha particles. This paper attempts to access the present state of theoretical models to explain the physical mechanisms responsible for subsurface burnout in these devices with the aid of recent experimental results. The results of the work should assist in the creation of more reliable devices with greater radiation hardness. (Edited author abstract). 55 Refs.

Anderson, W.T. (US Naval Research Lab, Washington, DC, USA); Morgan, D.V.; Buot, F.A.; Christou, A. *Qual Reliab Eng Int* v 4 n 3 Jul-Sep 1988 p 255-268.

#### 095938 YIELD IMPLICATIONS AND SCALING LAWS FOR SUBMICROMETER DEVICES.

Yield scaling laws are developed that are applicable to VLSI (very large-scale integration) devices with features of minimum dimension smaller than that at which the defect-size probability density function peaks. Expressions for the fault-probability kernel of reduced-size devices are derived in terms of the full-size or prototype device. The role of the defect-size probability density function with respect to the average fault probability is explained and expressions for it are developed. The ensuing scaling laws are utilized to obtain expressions for the expected number of faults, and then applied to the evaluation of the yield for several different cases. The implications of the results for yield and productivity are examined. 19 refs.

Ferris-Prabhu, Albert V. (IBM, Essex Junction, VT, USA). *IEEE Trans Semicond Manuf* v 1 n 2 May 1988 p 49-61.

#### Research See Also ANTENNAS—Fabrication.

#### 095939 PSEUDOMORPHIC In<sub>0.53</sub>Ga<sub>0.47</sub>As/AlAs

RESONANT TUNNELING BARRIER WITH A PEAK-TO-VALLEY CURRENT RATIO OF 14 AT ROOM TEMPERATURE. We have studied the effect of barrier height on the negative differential resistance characteristics of In<sub>0.53</sub>Ga<sub>0.47</sub>As-based resonant tunneling barriers (RTBs), lattice-matched to an InP substrate, and In<sub>0.53</sub>Ga<sub>0.47</sub>As/AlAs pseudomorphic RTBs also grown on InP substrates. A peak-to-valley current ratio of 14 (300 K) and 35 (77 K) with a high peak-current density of 2.3 × 10<sup>4</sup> A/cm<sup>2</sup> was achieved for a resonant tunneling barrier structure of In<sub>0.53</sub>Ga<sub>0.47</sub>As (15 atomic layers)/AlAs (9 atomic layers). (Edited author abstract) 16 refs.

Inata, Tsuguo (Fujitsu Lab Ltd, Atsugi, Jpn); Muto, Shunichi; Nakata, Yoshiaki; Sasa, Shigehiko; Fujii, Toshio; Hiyanizu, Satoshi. *Jpn J Appl Phys Part 2* v 26



n 8 Aug 1987 p 1332-1334.

## Seals

**095940 EXISTENCE OF PLATING LAYER AT THE SURFACE AND ITS EFFECTS ON JOINING CHARACTERISTICS: MICRO-PARALLEL SEAM JOINING AND DEVELOPMENT OF JOINING EQUIPMENT (1ST REPORT).** The authors studied micro-parallel seam joining (MPSJ) used for the hermetic seal of ceramic packages for semiconductor devices. Attention was paid to the relationship between plated materials on the package and lid and its seam joining characteristics. It is necessary to use Fe-Ni-Co Kovar as a lid material because it has a similar thermal expansion coefficient to the ceramic substrate ( $\text{Al}_2\text{O}_3$ ). The lid and seal frame are joined by brazing under pressure of the plating material. (Edited author abstract) 12 refs.

Aono, Susumu (Nippon Avionics Co, Jpn); Satoh, Hidenori; Tanaka, Kazutoshi; Ishihara, Reiji. *Trans Jpn Weld Soc* v 17 n 2 Oct 1986 p 171-176.

Selection See ELECTRONIC CIRCUITS—Selection.

**Semiconductor Insulator Boundaries.** See Also FILMS—Electric Conductivity; SEMICONDUCTING SILICON—Ion Implantation; SEMICONDUCTING SILICON—Oxidation; SILICA—Chemical Vapor Deposition; STRONTIUM COMPOUNDS—Thin Films; TITANIUM COMPOUNDS—Chemical Vapor Deposition.

**095941 ANALYSIS OF ATOMIC SCALE STRUCTURE OF  $\text{Si}/\text{SiO}_2$  INTERFACE BY COMPUTER SIMULATION.** Atomic scale structure of  $\text{Si}/\text{SiO}_2$  interface has been constructed using crystal models. By assuming an appropriate interatomic potential, various structural properties have been deduced by computer simulation. The results of the calculation have shown a reasonable coincidence with various experimental results reported so far. A detailed understanding of the atomic scale structure of the  $\text{Si}/\text{SiO}_2$  interface has been obtained. (Author abstract). In Japanese. 39 refs.

Ohdomari, Iwao (Waseda Univ, Jpn); Akatsu, Hiroyuki. *Bull Cent Inf Waseda Univ* v 5 Spring 1987 p 24-31.

**095942 QUANTITATIVE MODELING OF  $\text{Si}/\text{SiO}_2$  INTERFACE FIXED CHARGE: I. EXPERIMENTAL RESULTS.** Fixed-oxide charge density ( $N_f$ ) at the  $\text{Si}/\text{SiO}_2$  interface for (100) and (111) wafers oxidized in dry  $\text{O}_2$  and annealed in argon has been studied as a function of the argon anneal temperature. In contrast to previous qualitative results, the annealed  $N_f$  value was found to be dependent on the anneal temperature. Wafers thermally cycled in argon showed reproducible, steady-state  $N_f$  values, which also cycled with temperature. These results may indicate that the residual charge densities after annealing represent an equilibrium state of the  $\text{Si}/\text{SiO}_2$  interface. The dependence of  $N_f$  on annealing time was found to be an exponential decay with a thermally activated time constant. As-grown fixed oxide charge  $N_f$  has also been characterized as a function of oxidation temperature and oxygen partial pressure. (Edited author abstract) 33 refs.

Akinwande, A.I. (Stanford Univ, Stanford, CA, USA); Plummer, J.D. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2565-2573.

**095943 QUANTITATIVE MODELING OF  $\text{Si}/\text{SiO}_2$  INTERFACE FIXED CHARGE: II. PHYSICAL MODELING.** The fixed-oxide charge density of  $N_f$  at the  $\text{Si}/\text{SiO}_2$  interface has been studied as a function of process variables. The process parameters used were temperature, time, ambient, and oxidation cycle. To explain the experimental data, it is postulated that oxide charges are located at specific interface sites, perhaps, the kinks and steps thought to be associated with the oxidation process. It is also postulated that silicon interstitials generated at the  $\text{Si}/\text{SiO}_2$  interface recombine with kinks and steps via a monatomic surface regrowth process. Using these concepts, the process dependence of oxide charges is modeled quantitatively in oxidizing and nonoxidizing ambients. The model, which is physically based, can be

used to predict  $N_f$  in the temperature range of 700°-1100°C, and in the oxidant partial-pressure range of 0-100%  $\text{O}_2$  in Ar. (Edited author abstract) 40 refs.

Akinwande, A.I. (Stanford Univ, Stanford, CA, USA); Plummer, J.D. *J Electrochem Soc* v 134 n 10 Oct 1987 p 2573-2580.

**095944 PROCESS DEPENDENCE OF THE  $\text{Si}-\text{SiO}_2$  INTERFACE TRAP DENSITY FOR THIN OXIDES.** The intrinsic interface traps associated with thin (approx. 100-400 Å) thermal oxides on silicon have been characterized with reference to different oxidation and annealing conditions using the quasi-static capacitance-voltage technique. For unannealed oxides, the interface trap distribution profiles exhibit peak structures in the lower half of silicon bandgap. A systematic dependence of the interface trap density on the oxidation variables was observed. A lower midgap density results for higher oxidation temperature, lower oxygen partial pressure in the ambient, and thicker oxide. For thin oxides, postoxidation annealing in nitrogen may decrease or increase the interface trap density depending on the anneal temperature. (Edited author abstract) 29 refs.

Hung, K.K. (Univ of Hong Kong, Hong Kong); Cheng, Y.C. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2814-2819.

**095945 SUB-BAND STRUCTURE FOR ELECTRONS AND HOLES IN INVERSION AND ACCUMULATION LAYERS AT THE  $\text{InGaAs-InP}$  INTERFACE.** In this paper we present the results of self-consistent sub-band calculations for the modulation-doped  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As-InP}$  interface. We give results both for the 2D EG and for the 2D HG and in both cases we consider n-type and p-type background doping in the  $\text{InGaAs}$ . The treatment of the 2D hole gas is more complicated because of the degeneracy of the bulk valence band. We use the  $4 \times 4$  Luttinger Hamiltonian to describe the coupling between heavy-hole and light-hole bands. 30 refs.

Ekenberg, U. (Dep of Theoretical Physics, Oxford, Engl). *Semicond Sci Technol* v 2 n 12 Dec 1987 p 802-808.

**095946 INTERFACE ANALYSIS OF  $\text{Al}_2\text{O}_3/\text{InP}$  STRUCTURE PREPARED BY MOLECULAR BEAM DEPOSITION.** We have applied disorder-sensitive high-energy ion scattering together with the C-V method to an interface study of  $\text{Al}_2\text{O}_3/\text{InP}$ , which was prepared with well-controlled molecular beam deposition. Low interface state densities (the minimum value near the midgap is approximately  $1 \times 10^{11} \text{ cm}^{-2} \text{ eV}^{-1}$ ) have been obtained in the present work. Measurements of the interface disorder for these samples suggest that there is a correlation between the interface state density and the interface disorder. It is necessary to lower the interface disorder to obtain low interface state densities. (Author abstract) 16 refs.

Ohyama, Hideaki (Science Univ of Tokyo, Tokyo, Jpn); Narusawa, Tadashi; Nakashima, Hisao; Takagi, Shin-ichi; Sugano, Takuo. *Jpn J Appl Phys Part 1* v 26 n 10 Oct 1987 p 1615-1621.

**095947 SURFACE ELECTROSTATIC OSCILLATIONS AT A MAGNETIZED SEMICONDUCTOR-DIELECTRIC BOUNDARY.** The spectrum of resonant frequencies of surface oscillations on a semiconductor-dielectric boundary is found for the case of arbitrary wave propagation direction relative to a constant external magnetic field, oriented parallel to the plane separating the media. Conditions are found under which solutions of the surface wave type are absent, i.e., a gap appears in the surface oscillation resonant frequency spectrum. It is shown that presence of this gap correspond to nontransmission of surface oscillations within a definite angular sector. The dependence of gap position and width on the magnitude of the external magnetic field and the semiconductor and dielectric parameters is found. (Author abstract) 10 refs.

Beletskii, N.N. (Acad of Sciences of the Ukrainian SSR, USSR); Gasan, E.A.; Yakovenko, V.M. *Radiophys Quantum Electron* v 30 n 3 Mar 1987 p 335-340.

**095948 THEORY OF  $1/f$  NOISE IN SEMICONDUCTOR-DIELECTRIC STRUCTURES WITH AN INVERSION CHANNEL AT THE INTERFACE.** One of the best known models for  $1/f$  noise is that of McWhorter, according to which this noise is due to the randomness of the processes of electron and hole exchange between a bulk semiconductor and traps located in an oxide film at its surface. Despite the physical simplicity and naturalness of the McWhorter model, up to the present time there has been no correct calculation of the spectral density of the noise which occurs within the framework of this model. Here the errors tolerated in the literature are not of a partial nature: The very widely accepted scheme for calculating  $1/f$  noise is invalid in principle. In the present work, based on the McWhorter model, a systematic calculation of the spectral density of the fluctuations in the number of free carriers in an inversion channel at a semiconductor-dielectric boundary is carried out. 22 refs.

Neustroev, L.N.; Osipov, V.V.; Panashchenko, O.N. *Sov Microelectron* v 16 n 4 Jul-Aug 1987 p 167-176.

**095949 XPS STUDY OF THE PASSIVATING OXIDE LAYER PRODUCED ON  $\text{GaAs}$  (001) SUBSTRATE BY HEATING IN AIR ABOVE 200°C.** The passivating oxide layer resulting from a high-temperature (250°C in air)  $\text{GaAs}$  substrate preparation procedure has been analysed by X-ray photoelectron spectroscopy. It is shown that the protective film obtained from heating a semi-insulating substrate in clean air to 250°C is mainly gallium oxide whereas it is an arsenic-rich mixture of As and Ga oxides after the standard preparation procedure. At this temperature, the oxidation steady-state conditions are reached after 5 minutes of heating. The higher the passivating temperature, the lower the arsenic content of the oxide layer. (Author abstract) 12 refs.

Contour, J.P. (CNRS, Valbonne, Fr); Massies, J.; Fronius, H.; Ploog, K. *Jpn J Appl Phys Part 2* v 27 n 2 Feb 1988 p 167-169.

**095950 SUB-BAND-GAP SURFACE PHOTOVOLTAGE IN  $\text{Si}/\text{SiO}_2$  STRUCTURES WITH QUASI-CONTINUOUSLY DISTRIBUTED INTERFACE TRAPS AND A DEEP IN LEVEL IN THE SEMICONDUCTOR BULK.** Computer simulation studies of sub-band-gap surface photovoltage (SPV) spectra of  $\text{Si}/\text{SiO}_2$  structures with optically active quasi-continuously distributed interface traps (ITs) and an In deep bulk level (DBL) are presented. The calculations have been carried out at  $T=93 \text{ K}$  for a variety of exciting light intensities. In order to separate the IT and DBL contributions to the SPV spectra, two  $\text{Si}/\text{SiO}_2$  structures have been considered separately. The substrate in the first structure contains only shallow B acceptors and that in the second structure only deep In acceptors. In the  $(\text{Si:B})/\text{SiO}_2$  case the SPV spectrum has been explained in terms of a proper model for the IT optical behavior. The theoretical results have been experimentally verified and the IT photoionization cross-sections have been determined. In the  $(\text{Si:In})/\text{SiO}_2$  case the conditions have been found under which both IT and In DBL influence the SPV spectra behavior. The possibility of determining basic DBL optical parameters has been shown. (Author abstract) 21 refs.

Germanova, K. (Sofia Univ, Sofia, Bulg); Hardalov, Ch.; Gergov, B. *Philos Mag B* v 57 n 6 Jun 1988 p 703-713.

**095951 INFOS 87: PROCEEDINGS OF THE FIFTH INTERNATIONAL CONFERENCE ON INSULATING FILMS ON SEMICONDUCTORS.** The proceedings contains 52 papers. The papers are grouped under following headings: oxidation of silicon; compound semiconductors; characterization of insulator-semiconductor structures; multilayer dielectrics; nitrides and oxynitrides; impurities in  $\text{SiO}_2$ ; conduction in insulators; insulator degradation; polysilicon; and semiconductor-on-insulator. All papers are separately indexed and abstracted. Technical and professional papers from this



conference are indexed and abstracted with the conference code no. 10687 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Declerck, G. (Ed.) (Interuniv Microelectronics Cent, Louvain, Belg); De Keersmaecker, R. (Ed.). *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 439p.

**095952 InGaAs/Si<sub>3</sub>N<sub>4</sub> INTERFACE OBTAINED IN ULTRAHIGH VACUUM MULTIPOLAR PLASMA: IN-SITU CONTROL BY ELLIPSOMETRY AND ELECTRICAL CHARACTERIZATION.** A multipolar plasma passivation scheme controlled by in-situ ellipsometry has been developed to produce a high electrical quality InGaAs/Si<sub>3</sub>N<sub>4</sub> interface. We have demonstrated the possibility to remove all native oxides at the InGaAs surface by heating the sample at 240°C, then using the action of a multipolar H<sub>2</sub> plasma at 185°C, without optical degradation of the surface. The passivation by a native nitride layer is then performed using a N<sub>2</sub> plasma, and Si<sub>3</sub>N<sub>4</sub> is deposited. The treatment induces a reduction of the density of interface states N<sub>SS</sub>(E), and also a change of the nature of these interface states as shown by a reduction in the capture cross section  $\sigma_n$ (E). (Author abstract) 14 refs.

Boher, P. (Lab d'Electronique et de Physique Appliquee, Limeil-Brevannes, Fr); Renaud, M.; Lopez-Villegas, J.M.; Schneider, J.; Chane, J.P. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 100-107.

**095953 PHOTOLUMINESCENCE TRANSIENT RESPONSE AS A TOOL TO 'TRACK' THE ORIGIN OF DRIFT PHENOMENA AT THE InP/INSULATOR INTERFACE.** We show that the shape of long-term photoluminescence (PL) transients from InP crystal is strongly affected by charge exchange processes between the semiconductor bands and slow traps situated at or near to the semiconductor surface. We show that the PL transients depend on chemical treatments of the surface and on the insulating layer deposition. We propose an electrical model of InP surface (interface) which explains the obtained experimental results. (Author abstract) 12 refs.

Krawczyk, S.K. (CNRS, Ecully, Fr); Schohe, K. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 108-113.

**095954 TIME-DEPENDENT RESPONSE OF INTERFACE STATES DETERMINED BY USING DIFFERENTIAL ISOTHERMAL TRANSIENT SPECTROSCOPY.** A method based on the differential analysis of the isothermal transients is proposed to study the dynamical properties of the charging and discharging of interface states, and several possible ties of using this method are shown. The results obtained in SiO<sub>2</sub>/Si and Si<sub>3</sub>N<sub>4</sub>/SiO<sub>2</sub>/Si samples are in agreement with the existence of a spatial and energy distribution of interface states within the insulator. From the experimental data, the concentration of traps within the insulator at 35 A is estimated to be  $5 \times 10^9 \text{ cm}^{-2} \text{ eV}^{-1}$ , with a tunneling cross section about  $10^{-19} \text{ cm}^2$ , at  $E_c \approx 0.2 \text{ eV}$ . (Author abstract) 8 refs.

Esteve, J. (Univ de Barcelona, Barcelona, Spain); Samitier, J.; Altelaarrea, H.; Herms, A.; Morante, J.R. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 120-126.

**095955 LOW-TEMPERATURE ESR STUDY OF P<sub>b0</sub> DEFECTS RESIDING IN THE (111) Si/NATIVE OXIDE INTERFACE.** A K-band electron spin resonance (ESR) study of the (111) Si/native SiO<sub>2</sub> structure has been carried out in the temperature range  $2.4 < T < 30 \text{ K}$ . The ESR signal of the interfacial [111]P<sub>b0</sub> center was observed, exhibiting in general similar properties to the well-documented [111]P<sub>b0</sub> signal observed on firmly thermally-oxidized (TO) Si. Apart from the [111]P<sub>b0</sub>

center, also the signals of the P<sub>b0</sub> defects with their dangling orbital parallel to [111], [111] or [111] have been observed; as yet, these signals have not been observed; as yet, these signals have not been observed on TO structures. The saturation behavior has been examined showing the P<sub>b0</sub> Si/native oxide interface center to be much less saturable than the P<sub>b0</sub> in TO structures. The observations are related to the particular physicochemical interface structure. (Author abstract) 16 refs.

Stesmans, A. (Katholieke Univ Leuven, Louvain, Belg). *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 134-141.

**Semiconductor Metal Boundaries** See Also INTEGRATED CIRCUITS, VLSI; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Transport Properties; VACUUM TECHNOLOGY—Applications.

**095956 STUDY OF METAL-SEMICONDUCTOR INTERFACE STATES USING DEEP LEVEL TRANSIENT SPECTROSCOPY.** This paper describes the principle of the determination of interface-state parameters by deep level transient spectroscopy (DLTS) and presents a new, simple and exact method to discriminate the DLTS signal due to the emission from interface states from that from bulk traps. The n-type Au-GaAs and Cr-GaAs interfaces have been investigated by the technique. The results obtained in the investigation have revealed the dependences of the energy position, density and capture cross section for the interface states on the metal deposited onto the semiconductor surface, which is consistent with the theoretical prediction by Yndurain and the experimental results obtained by other authors. (Author abstract) 17 refs.

Zhang, H. (Inst of Physical & Chemical Research, Wako, Jpn); Aoyagi, Y.; Iwai, S.; Namba, S. *Appl Phys A* v A 44 n 3 Nov 1987 p 273-277.

**095957 ON THE FERMIL LEVEL PINNING AT Ge/GaAs(110) INTERFACE.** By semi-empirical TB method and saturated slab model, the electronic states on the GaAs(110) surface adsorbed by Ge atoms in different coverages have been calculated. Combining with previous theoretical and experimental studies, an idea on the problem of Fermi level pinning on the Ge/GaAs(110) interface is suggested. (Author abstract) 8 refs. In Chinese.

Xu Zhizhong (Fudan Univ, Shanghai, China). *Pan Tao T'i Hsueh Pao* v 9 n 1 Jan 1988 p 82-85.

**095958 INTERFACIAL PROPERTIES OF METAL OVERLAYERS ON III-V COMPOUNDS.** This paper gives a short review of the interfacial properties of a few metal/III-V systems prepared under atomically clean conditions. The author focuses on a few representative interfacial layers with distinctly different electronic structural properties. A description is given of the Cr/InP (110), In/GaAs (110), and Yb/GaAs (110) interfaces. It is shown that a detailed understanding can now be obtained on an atomic scale about both the interfacial growth and the compositions of reaction products. 25 refs.

Lindau, I. (Stanford Univ, Stanford, CA, USA). *Vacuum* v 37 n 5-6 1987, VI Span Conf on Vac and Its Appl, Madrid, Spain, Dec 1985 p 385-390.

**095959 CHARACTERIZATION OF SEMICONDUCTOR INTERFACES WITH SYNCHROTRON RADIATION.** Photoemission spectroscopy and other techniques based on synchrotron radiation are extensively used to investigate the formation of metal-semiconductor interfaces, heterojunction interfaces and gas chemisorption on semiconductor surfaces. We review the present status and the predicted future development of this active area of research. In particular, we discuss the interplay of factors such as interface defects and metal-induced gap states in the establishment of Schottky barriers and of heterojunction band discontinuities. We also discuss the future use of photoemission in an 'integrated' production-characterization technology for solid-state devices, based on synchrotron radiation. Finally, we comment on the predicted impact of the new, ultrabright synchrotron

radiation sources under development at Berkeley and Trieste. (Author abstract) 31 refs.

Margaritondo, G. (Univ of Wisconsin, Madison, WI, USA). *Superlattices Microstruct* v 3 n 4 1987, Pap Presented at the Am Vac Soc Meet, Urbana-Champaign, IL, USA, Apr 1987 p 341-345.

**095960 PHOTOVOLTAIC PROPERTIES OF METAL-Pb<sub>2</sub>CrO<sub>5</sub> CONTACT.** Photovoltaic properties of a Pb<sub>2</sub>CrO<sub>5</sub> ceramic disk with a pair of planar electrodes are described. Open circuit photovoltage of the devices with Au or Ag electrodes is shown as functions of the light intensity and the wavelength, which is related with a metal-semiconductor contact. (Author abstract) 7 refs.

Yoshida, Shinzo (Nat'l Defense Acad, Yokosuka, Jpn); Toda, Kohji. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 11 Nov 1987, Pap from the 1987 Nat'l Conf on Semicond Devices and Mater IEICE, Kumamoto, Jpn, Nov 1-4 1987 p 1056-1057.

**095961 DISTRIBUTIONS ELECTRONIQUES AUX INTERFACES PROFONDES.** [Distribution of Electrons at Deep Interfaces]. It is shown that X-ray emission spectroscopy induced by electrons can be used for the determination of the valence and conduction states at deep solid-solid interfaces. Two metal semi-conductor examples are presented: Al/InP and Ag/Si. (Author abstract) 9 refs. In French.

Vergand, F. (Univ Pierre et Marie Curie, Paris, Fr); Jonnard, P.; Maaref, H.; Senemaud, C.; Roulet, H.; Dufour, G.; Bonnelle, C. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 223-225.

**095962 ESSAIS DE STABILISATION DE L'INTERFACE METAL/III-V PAR UNE MINCE COUCHE D'ANTIMOINE.** [Experiments on the Stabilization of Metal/III-V Interfaces Using a Thin Antimony Film]. Previous papers have pointed out that the first Sb monolayer is strongly fixed to the (110) III-V semiconductor surfaces. For InP and GaP, the authors have tested the effect of Sb: (i) on the electronic surface properties; (ii) on the intermixing process when used as an interlayer; and (iii) on the properties of Schottky diode achieved with Al and Ag. (Author abstract) 7 refs. In French.

Benkacem, M. (CNRS, Montpellier, Fr); Dumas, M.; Palau, J.M.; Lassabatre, L. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 245-248.

**Sensors** See Also CARBON MONOXIDE—Sensors; GAS ANALYSIS—Sensors; SENSORS—Reviews; VAPORES—Sensors.

**095963 PROGRESS IN SMART SENSORS.** This paper discusses the progress in smart sensors. It discusses the advantages of using silicon in sensors. Further a fully smart sensor as a focusing device, employing two photodetectors is presented. The current developments are discussed.

S. Middelhoek (Technische Univ Delft, Neth). *New Electron* v 21 n 4 Apr 1988 p 39-40.

**095964 COLLOQUIUM ON SOLID STATE AND SMART SENSORS.** This colloquium proceedings contains eight papers. The topics covered include: semiconductor gas sensors; biomedical applications of ISFETs; Solid state ion sensors; smart sensors; sensors and microprocessors; time encoded sensors for microprocessor applications; MOS structures for humidity and tactile sensing, and robot tactile array sensing. Technical and professional papers from this conference are indexed and



abstracted with the conference code no.07426 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig* n 1985/54, Colloq on Solid State and Smart Sens, London, Engl, May 14 1985. Publ by IEE, London, Engl, 1985 var pagings.

**Soldering** See Also PRINTED CIRCUITS—Manufacture.

**095965 TLM MODELING OF SOLDER JOINTS IN SEMICONDUCTOR DEVICES.** The transmission-line matrix (TLM) is used to model heat flow in semiconductor devices. Unlike some other numerical methods, a sense of the physical nature of the problem is retained and irregular boundaries, inhomogeneities, and temperature-dependent thermal parameters can be easily incorporated. The inclusion of a layer of solder between a device and its package has a substantial influence on the temperature distribution. The effects of solder joint perfection are investigated theoretically, and the extent to which topographical methods such as infrared thermal imaging can give useful experimental results is indicated. 18 refs.

Henini, Mohamed (Univ of Nottingham, Engl); De Cogan, Donard. *IEEE Trans Compon Hybrids Manuf Technol* v CHMT-10 n 3 Sep 1987, Second Int Electron Manuf Technol (IEMT) Symp, San Francisco, CA, USA, Sep 15-17 1986 p 440-445.

**Space Applications** See INTEGRATED CIRCUIT TESTING—Radiation Effects.

**Space Charge**

**095966 SPACE CHARGE EFFECTS IN RESONANT TUNNELING.** The effect of space charge accumulation in resonant tunneling devices is investigated. It is shown that the resonant current through a symmetric double-barrier device flows immediately after opening the resonant tunneling channel and does not require an exponentially long time to reach its steady-state value. It is also shown that space charge effects increase the width of the resonant peak in the I-V characteristic of a double-barrier device which tends to reduce the magnitude of the negative differential resistance. (Author abstract) 14 refs.

Payne, M.C. (Cavendish Lab, Cambridge, Engl). *Semicond Sci Technol* v 2 n 12 Dec 1987 p 797-801.

**095967 ON THE IMPEDANCE ASSOCIATED WITH ELECTRON-HOLE RECOMBINATION IN THE SPACE CHARGE LAYER OF AN ILLUMINATED SEMICONDUCTOR/ELECTROLYTE INTERFACE.** The impedance associated with recombination of free electrons and freeholes in the space charge layer has been calculated. It has been shown that this impedance corresponds to a parallel-equivalent circuit of a capacitance and a resistance in parallel with the space charge layer capacitance. It has been calculated that the recombination capacitance has almost the same voltage dependence as the space charge layer capacitance, and that the recombination resistance is inversely proportional to the recombination rate in the space charge layer. The impedance associated with recombination in the space-charge layer has been compared with the surface recombination impedance and with experimental results obtained at illuminated GaAs electrodes. (Author abstract) 17 refs.

Vanmaekelbergh, D. (Rijksuniv Gent, Ghent, Belg); Cardon, F. *Semicond Sci Technol* v 3 n 2 Feb 1988 p 124-133.

**Spectroscopic Analysis** See Also SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Thermal Effects.

**095968 RAMAN SCATTERING IN-DEPTH EVALUATION OF RECRYSTALLIZED SILICON-OXIDE USING DIFFERENT WAVELENGTH EXCITATION.** Recrystallized silicon-on-oxide were ana-

lyzed by laser Raman scattering spectroscopy. By changing the excitation laser wavelength, the in-depth stress profile was obtained. The in-depth stress change was strongly dependent on recrystallization power. Recrystallized silicon structures were confirmed by cross sectional TEM observations. Dependent on recrystallization power, silicon film structures changed from small grain or small and large two grain layers to continuous large grain films. (Author abstract) 4 refs.

Kanamori, M. (NEC, Kanagawa, Jpn); Tsuya, H. *J Electron Mater* v 17 n 1 Jan 1988 p 33-37.

**095969 RAMAN MICROPROBE STUDY OF SILICON- AND GERMANIUM-ON-INSULATOR STRUCTURES.** A Raman microprobe has been used to detect the changes in crystallinity, stress and homogeneity of thin films of silicon-on-insulator and germanium-on-insulator (GOI) structures. Silicon films recrystallized with a graphite strip heater at a substrate temperature of 1200°C show little or no stress, but those recrystallized with a continuous wave laser at a substrate temperature of 500°C have a residual stress of  $4 \times 10^9$  dyn  $\text{cm}^{-2}$ . Some of the strip-heater-recrystallized samples consist of large crystals of different orientations. As-deposited GOI is found to be unstressed. (Author abstract) 9 refs.

Campbell, I.H. (Princeton Univ, Princeton, NJ, USA); Fauchet, P.M.; Lee, E.H.; Awal, M.A. *Thin Solid Films* v 154 n 1-2 Nov 12 1987, Pap Presented at the Int Conf on Metall Coat - Part II, San Diego, CA, USA, Mar 23-27 1987 p 249-255.

**Stability** See Also IRON COMPOUNDS—Physical Chemistry.

**095970 COMPUTER SIMULATION AND EXPERIMENTAL OBSERVATION OF FEATURES AND STABILITY FOR FOUR KINDS OF STATIONARY DOMAINS IN TRANSFERRED ELECTRON DEVICES.** The features and the stability of four kinds of stationary domains in transferred electron devices have been investigated. Computer simulation and experimental observation are carried out. The four kinds of stationary domains are: (1) A domain is triggered near the cathode, and travels toward the anode where it is trapped as a stationary domain, (2) A domain is triggered directly near the anode where it grows without traveling, and then settles as a stationary domain, (3) A domain is triggered near the cathode; then because the bias voltage increases further, the domain extends over the notch near the cathode, and so a stationary domain occurs, and (4) A stationary domain is formed due to a large inhomogeneous active layer. The stability, the current drop, the dependence between frequency and negative resistance, and ability to a support a voltage of four kinds of stationary domain have also been studied. (Author abstract) 6 refs.

Yiyang, Zheng (Acad Sinica, Beijing, China). *Model Simul Control A* v 12 n 3 1987 p 47-56.

**Standards** See ELECTRONIC CIRCUITS—Standards.

**Stresses** See Also INTEGRATED CIRCUIT TESTING—Thermal Expansion.

**095971 MEASUREMENT OF STRESSES IN SILICON WAFER WITH INFRARED PHOTOELASTIC METHOD.** An infrared photoelastic system for measuring stresses in silicon wafers and its measurement method are presented in this paper. The experiment of exerting pressure on a silicon wafer is made on a model of simply supported beam subjected to four concentration forces. The result of stress measurement basically accords with that based on the theory. And stresses induced in silicon wafers during the simulated processing of semiconductor devices are measured. (Author abstract) 7 refs. In Chinese.

Qin, Ganming (South China Inst of Technology, China); Liang, Hancheng; Zhao, Shounan; Yin, Honghui. *Hong-wai Yanjiu A-jì* v 7A n 2 1988 p 109-112.

**Structures** See Also HALL EFFECT—Analysis; INTEGRATED CIRCUITS, VLSI.

**095972 RESONANT LEVEL LIFETIME IN GaAs-AlGaAs DOUBLE-BARRIER STRUCTURES.** The lifetime of the lowest quasi-bound state localized between the barriers of a GaAs/AlGaAs double-barrier structure is calculated as a function of barrier and well dimensions. The results are consistent with high-frequency experiments by Sollner et al. (1983) up to  $f=2.5$  THz. (Edited author abstract) 11 refs.

Bahder, Thomas B. (Harry Diamond Lab); Morrison, Clyde A.; Bruno, John D. *Harry Diamond Lab Tech Rep HDL TR* 2125 Aug 1987 8p.

**095973 TEM-QUERSCHNITTS-PRAEPARATION VON SOI-STRUKTUREN. [TEM Cross Section Preparation of SOI Structures].** A method of preparation of TEM cross section structures is described. The silicon-on-insulator (SOI) cross sections produced by this method have been examined by electron microscopy methods. As a result, a defect structure was detected in the SiO<sub>2</sub> boundary plane-adjacent regions of the silicon substrate and the recrystallized layer. Precipitations at the grain boundaries were observed during the recrystallization of the implanted Si layers. (Translated author abstract) In German. 7 refs.

Nagdajev, Jevgeni N.; Hoepfner, Kristina; Scharff, Wolfram. *Wiss Z Tech Univ Karl Marx Stadt* v 29 n 4 1987 p 573-580.

**095974 INFLUENCE OF MULTILAYER-STRUCTURE AREA ON THE PARAMETERS OF POWER SEMICONDUCTOR DEVICES.** The way in which several parameters: diode breakdown voltage, impact current, du/dt stability, and thyristor turn-off time depend on multilayer-structure area is analyzed. It is shown on the basis of extremal-value statistics that the area dependence for these parameters should be of logarithmic nature. (Author abstract) 7 refs.

Bartanov, A.B.; Kuz'min, V.A. *Sov Electr Eng* v 58 n 8 1987 p 102-105.

**095975 ELEMENTARY ELECTRONIC EXCITATIONS AT THE SURFACE OF A SEMICONDUCTOR SUPERLATTICE AND THEIR COUPLING TO EXTERNAL PROBES.** Advances in Molecular Beam Epitaxy (MBE) and other growth techniques over the last decade have made it possible to grow materials consisting of alternating layers of two or more semiconductors. The thickness of each layer can be varied from several Å to several hundred Å, and the sharpness of the interface is of the order of one atomic layer. The semiconductor materials chosen usually have a similar lattice constant but different electronic properties. GaAs and GaAlAs systems are the best known at the moment. Electrons are free to move in the plane of the layers but are localized in a given layer and can have a discrete energy spectrum. These discrete levels are called subbands. When the energy of the barrier is low and the barrier width is narrow, electrons can tunnel between different GaAs regions (quantum wells) and these discrete energy levels broaden to form minibands. A periodic array of layers is called a semiconductor superlattice. The study of the intrasubband plasma excitations in quantum wells and superlattices is carried out. 36 refs.

Giuliani, Gabriele (Purdue Univ, West Lafayette, IN, USA); Hawrylak, P.; Quinn, J.J. *Phys Scr* v 36 n 6 Dec 1987 p 946-959.

**095976 BINDING ENERGY OF HYDROGENIC IMPURITY IN QUANTUM WELL STRUCTURES.** We have studied the anisotropic effects on the hydrogenic impurity states in a quantum well. The variation of the binding energy of the ground state as a function of the well thickness for quantum wells with isotropic or anisotropic effective masses are calculated. The dependence of the longitudinal and transverse effective radii on the well size



and the mass ratio  $m_1/m_2$  is also discussed. A simple approximation method proposed recently by Lee and Mei is also used to study the binding energy of the hydrogenic impurity in the finite quantum well. (Author abstract) 17 refs.

Chou, W.C. (Nat'l Chiao Tung Univ, Hsinchu, Taiwan); Huang, W.J.; Chu, P.Y.; Han, C.S.; Chuu, D.S. *Physica B & C* v 150 n 3 Jun 1988 p 361-368.

**095977 SCANNING LOW ENERGY ELECTRON LOSS MICROSCOPY (SLEELM): Au ON Si.** High-resolution scanning low energy electron loss imaging of a well characterized system of Au on Si is demonstrated in reflection geometry at a primary electron energy  $E_p$  of 680 eV and spatial resolution of 3  $\mu$ m. Characteristic losses below 30 eV are chosen to examine the contrast between two regions (gold and silicon dominated) respectively. By differencing between a maximum in a loss intensity and an adjacent trough, high-quality Si images are obtained with contrast superior to  $L_{2,3}$  VV Auger electron images produced in comparable times. It should be noted that, in contrast to scanning Auger microscopy, the spatial resolution of SLEELM is limited only by the profile of the incident beam. An advantage of low electron energy loss imaging is that the depth resolution may be varied by altering the primary electron energy, with the possibility of bridging the gap between Auger microscopy and the X-ray microprobe analyser. Disadvantages of the technique lie in the weakness of the elastic backscattering which is essential to observe the losses in reflection geometry, and the possibility of overlapping low energy characteristic loss peaks. (Edited author abstract) 17 Refs.

El Gomati, M.M. (Univ of York, York, Engl); Matthew, J.A.D. *Appl Surf Sci* (1985) v 32 n 3 Jul 1988 p 320-331.

**095978 MONTE CARLO SIMULATIONS OF REPEATED VELOCITY OVERSHOOT STRUCTURES.** We have performed self-consistent Monte Carlo simulations on repeated velocity overshoot structures. From our calculations, we may assess the potential of such structures to enhance the average drift velocity of electrons. We find that there is no enhancement for uniformly doped structures. For spike-doped structures there is a small enhancement, but this is gained at the expense of a drop in current density. In both structures the velocity enhancement is limited by intervalley scattering. (Author abstract) 5 Refs.

Beton, P.H. (GEC, Wembley, Engl); Long, A.P.; Kelly, M.J.; Matthews, P.M. *Electron Lett* v 24 n 13 Jun 23 1988 p 817-818.

**095979 CONDUCTION AND CHARGE TRAPPING IN POLYSILICON-SILICON NITRIDE-OXIDE-SILICON STRUCTURES UNDER POSITIVE GATE BIAS.** Carrier conduction and trapping in silicon-nitride-oxide-silicon SNOS structures has been studied under positive gate bias using current-field (I vs. E) characteristics and flat-band voltage shift-fluence ( $\Delta V_{FB}$  vs. F) for structures with a thick bottom oxide (>100 angstrom). Under these conditions evidence is found of electrons tunneling from the Si through the bottom oxide, and holes injected from the gate moving through the nitride with recombination occurring in the nitride layer. Trapping of both electrons and holes is significant and the saturation value of the flat-band voltage shift is shown to depend parabolically on the thickness of the nitride layer. A simple two-carrier conduction model is proposed to explain the observed conduction and trapping characteristics. It is also shown that holes are the dominant conduction carriers in polysilicon-silicon nitride-silicon (SNS) structures under both positive and negative gate-bias conditions. 16 refs.

Aminzadeh, Mehran (Oregon State Univ, Corvallis, OR, USA); Nozaki, Shinji; Giridhar, R.V. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 459-467.

**Surfaces** See Also ALUMINUM AND ALLOYS—Thin Films.

**095980 DETERMINATION OF CONCENTRATION OF SURFACE STATES AT THE ILLUMINATED SEMICONDUCTOR-ELECTROLYTE INTERFACE.** Surface states at the semiconductor-electrolyte interface under illumination have been determined. The faradaic reaction involved at the (CdTe and GaP) interface is the photo-electrochemical reduction of carbon dioxide to carbon monoxide in dimethylformamide-water mixtures. A new equivalent circuit has been proposed to account for the impedance data. Surface states act as faradaic mediators for the reduction of carbon dioxide. Surface state density at a given bias potential has been calculated to be of the order of  $10^{14}$  cm<sup>-2</sup>. Adsorbed ions induce surface states. Surface state density induced by tetraalkylammonium ions decrease with increase of alkyl chain length. The number of surface states increases with water concentration. (Edited author abstract) 35 refs.

Chandrasekaran, K. (Texas A&M Univ, College Station, TX, USA); Bockris, J.O'M. *Electrochim Acta* v 32 n 9 Sep 1987 p 1393-1402.

**095981 ELECTRON BEAM STIMULATED REACTIONS ON SEMICONDUCTORS.** This paper discusses the quantitative Auger methods employed to obtain the oxide growth kinetics as well as the simultaneous observation of shifting in Auger peaks and their possible relationship with the Mott-Cabrera theory. Nevertheless, the dependence of the phenomenon on the current density seems to be contradictory to this theory. Other possibilities, such as Coulombian explosion induced by an Auger final state, are also considered. The possible applications in microelectronics especially in uhv processing are reviewed. (Edited author abstract)

Sacedon, J.L. (CSIC, Madrid, Spain). *Vacuum* v 37 n 5-6 1987, VI Span Conf on Vac and Its Appl, Madrid, Spain, Dec 1985 p 492.

**095982 ELEMENTARY EXCITATIONS IN A SEMICONDUCTOR-ADSORBED-MOLECULE SYSTEM.** The mechanism of the transfer of energy in systems consisting of a semiconductor and electronically and vibrationally excited molecules has been considered. The influence of excitations of the electronic and phonon subsystems of a semiconductor on adsorption and catalytic processes on its surface has been discussed. The possibility of the use of excited molecular probes for the diagnostics of charged defects and the study of their spatial and energy distribution on a surface has been analyzed. (Author abstract) 64 refs.

Kiselev, V.F. (M.V. Lomonosov State Univ, Moscow, USSR); Plotnikov, G.S.; Bepalov, V.A.; Zoteev, A.V.; Fomin, Yu.D. *Kinet Catal* v 28 n 1 pt 1 Jan-Feb 1987, Proc of the Sixth All-Union Conf on the Mech of Catal React, Moscow, USSR, 1986 p 14-27.

**Switching** See Also ELECTRIC MOTORS, AC; SEMICONDUCTING GALLIUM COMPOUNDS—Switching; SEMICONDUCTOR DIODES—Electric Properties; SEMICONDUCTOR MATERIALS—Charge Carriers.

**095983 NEW STRUCTURE OF THREE-TERMINAL GaAs  $p^+-n^--\delta(p^+)-n^--n^+$  SWITCHING DEVICE PREPARED BY MOLECULAR BEAM EPITAXY.** The concept to modulate the internal barrier of a regenerative switching device is proposed. A new structure of three-terminal GaAs  $p^+-n^--\delta(p^+)-n^--n^+$  switching device prepared by molecular beam epitaxy was developed. The third terminal was directly contacted to the  $\delta(p^+)$  barrier using the V-groove etching technique, in which the  $\delta(p^+)$  barrier height can be directly modulated by the external voltage. It is a voltage-controlled device. (Edited author abstract) 8 refs.

Wang, Y.H. (Nat'l Cheng Kung Univ, Tainan, Taiwan); Yarn, K.F.; Chang, C.Y.; Jame, M.S. *Electron Lett* v 23 n 17 Aug 13 1987 p 873-875.

**095984 NUMERICAL ANALYSIS OF SWITCHING PHENOMENA IN POWER SEMICONDUCTOR**

**DEVICES.** Switching phenomena in high power devices such as turn-off thyristors are analyzed numerically, based on two-dimensional model. Basic partial differential equations describing carrier transport in semiconductor are transformed into difference equation forms over finite difference rectangular meshes. To reduce computational time, irregular mesh scheme is utilized. As an example, analytical results with GTO thyristor are presented. (Edited author abstract) In Japanese. 2 refs.

Masada, Eisuke (Univ of Tokyo, Jpn); Tamura, Minoru. *J Fac Eng Univ Tokyo Ser A* n 24 1986 p 28-29.

**095985 DER IDEALE SCHALTER RUECKT NAEHER: LEISTUNGSHALBLEITER MIT  $\mu$ M-STRUKTUREN.** [Ideal Switch Comes Closer: Power Semiconductors with  $\mu$ m Structures]. The development of power semiconductor devices with many desirable features at ever-decreasing costs is reported. Although we are still far from the truly ideal switch, nevertheless remarkable achievements have been realized as a result of recent progress in the manufacture of IC's. Certain trends are described. 11 refs. In German.

Lemme, Helmuth. *Elektronik* v 36 n 9 Apr 30 1987 p 100-102, 104-106.

**095986 THREE-TERMINAL BISTABLE SWITCHES IN EFFECTIVE-MASS SUPERLATTICES.** Three-terminal bistable switching devices based on effective-mass superlattices are proposed and analyzed. The essential feature of the device is the presence of negative resistance controlled by the small gate voltage. The threshold voltage of negative resistance is much lower and the current density is much higher than those in the resonant tunnelling diodes. Such properties are desirable for achieving low-power and ultrafast three-terminal bistable switches. (Edited author abstract) 8 refs.

Aishima, A. (Hiroshima Univ, Higashi-Hiroshima, Jpn); Fukushima, Y. *Electron Lett* v 24 n 1 Jan 7 1988 p 64-65.

**095987 BIMOS CASCODE USING SIPMOS AND SIRET TRANSISTORS AS HIGH-BLOCKING, FAST SEMICONDUCTOR SWITCHES.** The described BIMOS-cascode circuit makes use of the benefits of both bipolar and MOS transistors. It employs a bipolar high-blocking SIRET (Siemens ring emitter transistor) and a SIPMOS device as low-blocking MOSFET in the emitter circuit. In addition, another SIPMOS is used as a high-blocking Darlington driver for the SIRET. This arrangement provides the feature of a voltage-controlled MOSFET in the control circuit and the features of the unsaturated, bipolar SIRET with low forward voltage in the output circuit without the restriction of a second breakdown. (Author abstract)

Herfurth, Michael (Siemens AG, Munich, West Ger). *Siemens Compon* v 22 n 6 Dec 1987 p 221-224.

## Temperature Measurement

**095988 TEMPERATURE DISTRIBUTION IN SQUARE-SHAPED SEMICONDUCTOR CHIPS.** Advantages and disadvantages of both, the eigenvalue and the Green's function methods for the evaluation of temperature distributions in square-shaped homogeneous hetero-layer semiconductor chips are analyzed. Combining the eigenvalue and Green's function techniques in order to overcome the particular disadvantages of both the methods a new procedure is proposed which allows a fast three-dimensional temperature modelling of integrated circuits. The new mixed method is applied to the calculation of temperature profiles of a power GaAs MESFET. (Author abstract) 7 Refs.

Henniger, U. (VEB, Berlin, East Ger); Schmidt, B.; Tempel, R.; Moeller, H. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 469-478.

**Theory** See Also MATHEMATICAL TECHNIQUES—Differential Equations; SEMICONDUCTOR MATERIALS—Amorphous; THYRISTORS—Mathematical Models.



**095989 MULTIPLE STEADY STATES IN ONE-DIMENSIONAL ELECTRODIFFUSION WITH LOCAL ELECTRONEUTRALITY.** This paper concerns itself with construction and study of multiple steady states, occurring in one-dimensional ambipolar electrodiffusion with local electroneutrality, constant and equal charge carrier mobilities in the absence of generation-recombination. Piecewise constant fixed charge density with four sign alterations is assumed. Multiple solution branches are constructed via a numerical and asymptotic solution of a system of nonlinear equations, resulting from an explicit integration of the appropriate boundary value problem. The parameter range in which multiplicity occurs is determined with the aid of asymptotic procedures. Existence of the appropriate multiple solutions follows from the Newton-Kantorovich Theorem. (Author abstract) 15 refs.

Rubinstein, I. (Weizmann Inst of Science, Rehovot, Isr). *SIAM J Appl Math* v 47 n 5 Oct 1987 p 1076-1093.

**095990 INITIAL BOUNDARY VALUE PROBLEMS FROM SEMICONDUCTOR DEVICE THEORY.** This paper is concerned with the basic equations for carrier transport in semiconductors in case of boundary conditions allowing the electrostatic potential at a contact to depend on the total current through this contact. An existence-uniqueness result is proved and, under additional assumptions, the global boundedness and the asymptotic behavior of solutions are investigated. (Author abstract) 10 refs.

Groeger, K. *Z Angew Math Mech* v 67 n 8 1987 p 345-355.

**095991 STABILITY OF THE LINEARIZED TRANSIENT SEMICONDUCTOR DEVICE EQUATIONS.** We present a stability analysis of the linearized transient semiconductor device equations by means of semigroup theory. Central to the developed theory is an estimate for the real parts of the eigenvalues of the linearized device problem with an upper bound which only depends on the biasing situation of the device. Under realistic assumptions we show that the device problem and its implicit Euler time discretization are uniformly (with respect to an intrinsic singular perturbation parameter) stable 'in the linearized sense'. (Author abstract) 22 refs.

Markowich, P.A. (Technische Univ Wien, Vienna, Austria); Ringhofer, Ch.A. *Z Angew Math Mech* v 37 n 7 1987 p 319-332.

## Thermal Effects

**095992 ON A PETROV-GALERKIN METHOD FOR THE ELECTRICAL AND THERMAL BEHAVIOUR OF SEMICONDUCTOR DEVICES IN TWO DIMENSIONS.** We consider the equations governing the electrical and thermal behavior of a semiconductor device in two dimensions. A non-standard Petrov-Galerkin method is used to obtain a discretisation of the equations for stationary problems. The resulting scheme is a generalization to the two-dimensional case and to the full set of equations of the well-known Scharfetter-Gummel scheme, which is the most successful discretisation for one-dimensional problems. The dependent variables used are the carrier densities, the electrostatic potential and the absolute temperature. (Author abstract) 5 refs.

Miller, John J.H. (Trinity Coll, Dublin, Ire). *Math Comput Simul* v 29 n 5 Oct 1987 p 367-372.

**Thin Films** See MOLYBDENUM AND ALLOYS—Electric Properties.

**Transport Properties** See Also HALL EFFECT—Mathematical Models; HALL EFFECT DEVICES—Calculations; SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers; SEMICONDUCTOR MATERIALS—Transport Properties; TRANSISTORS—Heterojunctions.

**095993 THEORY AND APPLICATIONS OF NEAR BALLISTIC TRANSPORT IN SEMICONDUCTORS.** A review of electronic transport in semiconductors in the near ballistic regime is presented. Recent experiments and

theories are discussed in detail. It is shown that the basic physics of ballistic transport is qualitatively well understood. Quantitatively much work remains to be done, especially with respect to device applications. Some problems related to applications are discussed in context with hot-electron- and high-electron-mobility-transistors. 42 refs.

Hess, Karl (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Iafraite, Gerald J. *Proc IEEE* v 76 n 5 May 1988 p 519-532.

**095994 CURRENT TRANSPORT OVER PARABOLIC POTENTIAL BARRIERS IN SEMICONDUCTOR DEVICES.** Current transport over the potential barrier of an  $n^+-p-n^+$  structure is studied using the diffusion theory and the thermionic-diffusion theory of current transport. Thermionic emission over the barrier is shown to be the asymptotic isothermal diffusion current. The J-V characteristics are derived for both the diffusion and thermionic-diffusion models. In particular, when the Bethe and the thermionic-diffusion (T-D) models are compared, both with and without backscattering effects, it is seen that the T-D model with backscattering is preferable to the Bethe approach and requires a relatively lower dopant concentration to be applicable. It is shown that two characteristic velocities are needed for the transport analysis: an effective collection velocity to terminate the region in which current is driven by diffusion and an emission velocity associated with carrier injection beyond the potential energy maximum. For a typical situation, the emission velocity can be as much as a factor of four greater than the collection velocity, showing that the velocity of injected carriers beyond the maximum can appreciably exceed the scatter-limited velocity. 18 refs.

Crowell, Clarence R. (Univ of Southern California, Los Angeles, CA, USA); Hafizi, Madij. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1087-1095.

**Tunneling** See Also SEMICONDUCTING GALLIUM ARSENIDE—Optical Properties; SEMICONDUCTING GALLIUM COMPOUNDS—Electronic Properties; SEMICONDUCTING GALLIUM COMPOUNDS—Growth; SEMICONDUCTING GALLIUM COMPOUNDS—Spectroscopic Analysis; SEMICONDUCTOR MATERIALS—Zener Effect.

**095995 SIMULATIONS OF THE CURRENT-VOLTAGE CHARACTERISTICS OF SEMICONDUCTOR TUNNEL STRUCTURES.** A method of calculating the current-voltage characteristics of semiconductor devices in which the current is controlled by tunneling through a series of potential barriers is presented. Its predictive powers allow it to be used as a design aid for such devices. (Author abstract) 19 refs.

Davies, R.A. *GEC J Res* v 5 n 2 1987 p 65-75.

**095996 INDIRECT TUNNELING CAPACITY OF THE  $p-n$  JUNCTION OF THE NARROW BAND-GAP SEMICONDUCTORS.** The expression of the capacity caused by the indirect tunneling process is derived by using the detailed balance between the process of indirect tunneling via deep impurity level and the process of thermal excitation and trapping. This capacity appears only in a narrow range of bias voltage around zero bias voltage. The C-V characteristic is not the usual monotonous function of voltage, but has a maximum and negative values in a range of bias voltage. Numerical calculations are made. The shape of the calculated C-V curves is similar to that of the measured C-V curves obtained on the  $p-n$  junctions of narrow gap semiconductors  $Hg_{1-x}Cd_xTe$ . (Author abstract) 8 refs. In Chinese.

Lin He (Shanghai Inst of Technical Physics, Shanghai, China); Tang Dingyuan. *Pan Tao Ti Hsueh Pao* v 9 n 1 Jan 1988 p 48-59.

**095997 TUNNELING RESISTANCE AND MAGNETORESISTANCE OF  $Al-Oxide-Al$  TUNNEL JUNCTIONS.** The temperature and magnetic field dependence of the tunnel resistance ( $R_T$ ) of  $Al-O-Al$  junctions have been studied for temperatures below 4.2 K. It is demonstrated that below 2.0 K  $R_T$  increases suddenly

and shows a negative magnetoresistance. The magnitude of this increase depends on the absolute value of  $R_T$  and is the smaller the larger  $R_T$  is. The effect corresponds to the behavior of 'weak localization' in thin disordered metallic films. (Author abstract) 6 refs.

Steiner, R. (Univ Wuerzburg, Wuerzburg, West Ger); Keck, K.; Wiesner, H. *Solid State Commun* v 63 n 6 Aug 1987 p 485-488.

**095998 POSSIBILITY OF CREATING ANALOG AND DIGITAL INTEGRATED CIRCUITS USING THE DISCRETE, ONE-ELECTRON TUNNELING EFFECT.** It was shown previously that in tunneling junctions of small area between metals (or grown semiconductors) at low temperatures a new effect - discrete tunneling by isolated current carriers through the tunneling barrier - is observed. It has become worthwhile to evaluate the possibility of using the discrete, one-electron tunneling effect in microelectronics. It is the purpose of this paper to perform such a preliminary analysis by combining tunneling junctions of small area with resistors and capacitors, a whole series of devices can be created in which analog information is stored and/or processes as individual electrons, and these devices may exhibit exceptionally high values of the useful characteristics. 28 refs.

Likharev, K.K. (M.V. Lomonosov Moscow State Univ, USSR). *Sov Microelectron* v 16 n 3 May-Jun 1987 p 109-121.

**095999 NEW SCATTERING-THEORETIC APPROACH TO ELASTIC ONE-ELECTRON TUNNELING THROUGH SPATIALLY LOCALIZED BARRIERS: APPLICATION TO SCANNING TUNNELING MICROSCOPY.** One-electron elastic tunneling through nonseparable, localized barriers is treated as a problem in Potential Scattering Theory, using the technique of localized Green functions. The method is illustrated by the calculation of the current in a model plano-spherical junction representative of the Scanning Tunneling Microscope whose lateral resolution is discussed. The new technique is applicable to several other localized barrier problems and allows one to test the accuracy of approximate, one-electron tunneling theories. (Author abstract) 13 refs.

Lucas, A.A. (IBM, San Jose, CA, USA); Morawitz, H.; Henry, G.R.; Vigneron, J.-P.; Lambin, Ph.; Cutler, P.H.; Feuchtwang, T.E. *Solid State Commun* v 65 n 11 Mar 1988 p 1291-1294.

**096000 OBSERVATION OF INTRINSIC BISTABILITY IN RESONANT TUNNELING DEVICES.** We report the observation of intrinsic bistability due to space charge build-up in an asymmetric  $GaAs/(AlGa)As$  double-barrier resonant tunneling device. (Edited author abstract) 4 refs.

Alves, E.S. (Univ of Nottingham, Nottingham, Engl); Eaves, L.; Henini, M.; Hughes, O.H.; Leadbeater, M.L.; Sheard, F.W.; Toombs, G.A.; Hill, G.; Pate, M.A. *Electron Lett* v 24 n 18 Sep 1 1988 p 1190-1191.

**096001 TIME-DEPENDENT TUNNELING IN HETEROSTRUCTURES.** We review various aspects of perpendicular transport in heterostructures focusing on time-dependent and resonant phenomena. The topics include: conventional theory of resonant tunneling, tunneling times, wave-packet tunneling through multi-barrier systems, life-times of resonant states and coherent vs. sequential tunneling. We outline the difficulties in including scattering in the theory. (Edited author abstract) 55 refs.

Jauho, A.P. (Univ of Copenhagen, Copenhagen, Den). *Acta Polytech Scand Electr Eng Ser* n 58 1987, Proc of the Adv Summer Sch on Microelectron: Phys and Technol for VLSI, Espoo, Finl, Jun 8-12 1987 p 192-221.



**096002 MAGNETIC FIELD STUDIES OF NEGATIVE DIFFERENTIAL CONDUCTIVITY IN DOUBLE BARRIER RESONANT TUNNELLING STRUCTURES BASED ON  $n^+ \text{InP}/(\text{InGa})\text{As}$ .** Negative differential conductivity (NDC) with a peak valley ratio of 4.5:1 (4 K) and 2:1 (150 K) is observed in double barrier resonant tunnelling devices based on  $n^+ \text{InP}/(\text{InGa})\text{As}$ . A transverse magnetic field applied in the plane of the tunnelling barriers ( $J \perp B$ ) significantly changes the current-voltage characteristics and eliminates the NDC for fields above -10 T. This behaviour is explained qualitatively in terms of the effect of the magnetic vector potential on the tunnelling electrons. The magneto-oscillations in the tunnelling current for  $J \parallel B$  are discussed in terms of a simple model of resonant tunnelling. (Author abstract) 12 refs.

Leadbeater, M.L. (Univ of Nottingham, Nottingham, Engl); Eaves, L.; Simmonds, P.E.; Toombs, G.A.; Sheard, F.W.; Claxton, P.A.; Hill, G.; Pate, M.A. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 707-710.

**096003 TUNNELING TIMES FOR WAVE PACKETS NARROW IN WAVE-NUMBER SPACE.** The tunneling times for wave packets narrow in  $k$ -space are considered for an arbitrary, localized potential barrier in one dimension. To zeroth order the classic phase times are derived. Corrections are discussed. An identity between the dwell time and the phase times is presented. We give an exact expression for the transmission time at resonance for a symmetric double barrier. (Edited author abstract) 10 refs.

Hauge, E.H. (NTH, Trondheim, Norw); Falck, J.P.; Fjeldly, T.A. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 747-748.

## Ultrasonic Effects

**096004 EFFECT OF ULTRASOUND ON THE ABSORPTION AND EMISSION SPECTRA OF LIGHT IN SEMICONDUCTORS.** Interest in studying the effect of low-frequency ultrasound on the absorption and emission spectra of light in semiconductors results from the possible use of this effect for controlling the parameters of optoelectronic semiconductor devices. Ultrasound causes a change in the forbidden energy gap and the permittivity of a semiconductor; in turn, this must affect the absorption of light in the semiconductor as well as its emitter characteristics. 8 refs.

Gulyayev, Yu.V.; Chusov, I.I.; Yaremchenko, N.G.; Nikitchenko, G.V.; Bugayeva, T.V. *Sov J Commun Technol Electron* v 32 n 2 Feb 1987 p 182-185.

## SEMICONDUCTOR DEVICES, BIPOLAR

See Also DATA STORAGE, DIGITAL—Random Access; ELECTRIC CONVERTERS—Design; ELECTRIC FILTERS, SWITCHED—Design; HALL EFFECT TRANSDUCERS—Performance; INTEGRATED CIRCUITS—Reliability; INTEGRATED CIRCUITS, LSI—Manufacture; INTEGRATED CIRCUITS, MONOLITHIC—Performance; INTEGRATED CIRCUITS, VLSI—Fabrication; INTEGRATED CIRCUITS, VLSI—Metallizing; LOGIC DEVICES—Gates; SEMICONDUCTOR DEVICES, MOS—Performance.

**096005 BIPOLAR GATE ARRAY THAT RUNS FAST ON LOW POWER.** The combination of a bipolar technology and a logic scheme called differential logic is spawning a new generation of Ferranti Electronics Ltd. high-density gate arrays that run at speeds competitive with the fastest bipolar VLSI circuit. The combination of collector-diffusion isolation and differential logic yields devices that achieve power dissipation ratings in the CMOS class. Capable of gate delays in the 1-ns range, clock frequencies up to 250 MHz, and system speeds as high as 100 MHz, the new FAB3 devices are able to achieve power dissipation ratings ranging between 55 and 750  $\mu\text{W}$ . In addition, this third-generation, 1.5- $\mu\text{m}$  version of Ferranti's decade old CDI process requires only six to eight masking steps, compared with the 12 to 15 steps required for competitive bipolar and CMOS VLSI processes.

Anon. *Electronics* v 59 n 32 Oct 2 1986 p 68-71.

**096006 LSI LOGIC ARRAYS BOOST BOTH DRIVE AND DENSITY.** LSI Logic Corp. has introduced a new family of bipolar complementary MOS (biCMOS) gate arrays. By merging its established CMOS technology with an entirely new bipolar I/O structure, the company boasts nearly 50,000 usable equivalent gates, the highest gate density of any biCMOS array, as well as a drive current of 24 mA.

Weber, Samuel. *Electronics* v 61 n 3 Feb 4 1988 p 63-64.

**096007 PROCEEDINGS OF THE 1987 BIPOLAR CIRCUITS AND TECHNOLOGY MEETINGS.** The proceedings contains 57 papers. The following topics are dealt with: bipolar modeling, advanced structures, design techniques, heterostructures, device measurement and characterization, digital circuits, linear circuits, bipolar device physics, and CAD (computer-aided design) and modeling. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10696 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Jopke, Janice (Ed.). *Proc of the 1987 Bipolar Circuits and Technol Meet, Minneapolis, MN, USA, Sep 21-22 1987* Publ by IEEE, New York, NY, USA, 1987. Available from IEEE Service Cent (Cat n 87CH2509-8) Piscataway, NJ, USA 205p.

## Applications See Also PRINTING—Color.

**096008 LOW-POWER 128-MHZ VCO FOR MONOLITHIC PLL IC'S.** The phase-locked loop (PLL) is implemented by 2- $\mu\text{m}$  bipolar-CMOS (BiCMOS) technology. The power dissipation of the PLL and the voltage-controlled oscillator (VCO) are 100 mW at 64 MHz and 25 mW for 1-128 MHz clock frequencies, respectively. The linearity of the VCO is  $\pm 0.5\%$  and the temperature stability is  $\pm 50$  ppm/ $^{\circ}\text{C}$ . The center frequency of the VCO is accurately set by using one fixed external resistor. The VCO has an advantage of noise insensitivity. To achieve these features, the VCO design uses an emitter-coupled multivibrator with a built-in timing capacitor and a controlled oscillation loop gain. The PLL can be applied not only to timing recovery for data transmission, but also to frequency synthesis and self-clocking for data recording. 9 refs.

Kato, Kazuo (Hitachi Ltd, Hitachi, Jpn); Sase, Takashi; Sato, Hideo; Ikushima, Ichiro; Kojima, Shun'ichi. *IEEE J Solid State Circuits* v 23 n 2 Apr 1988 p 474-479.

**Computer Aided Analysis** See TRANSISTORS, BIPOLAR—Computer Aided Analysis.

**Computer Simulation** See TRANSISTORS, BIPOLAR—Transients.

**Design** See DATA CONVERSION, ANALOG TO DIGITAL; INTEGRATED CIRCUITS, DIGITAL—Design.

**Doping** See CRYSTALS—Epitaxial Growth; TRANSISTORS, BIPOLAR.

**Electric Properties** See Also TRANSISTORS, BIPOLAR—Fabrication.

**096009 EFFECT OF THIN INTERFACIAL OXIDES ON THE ELECTRICAL CHARACTERISTICS OF SILICON BIPOLAR DEVICES.** The effect of thin interfacial oxides on the impurity diffusion from polysilicon to the silicon substrate has been studied in detail. Polysilicon films were deposited on the silicon substrate under two different process conditions to control the thickness of interfacial oxides. Results show that the presence of about 1-nm-thick oxides retarded the impurity diffusion by about 10 nm. An increase of the sheet resistance of about 10% has been observed. Bipolar devices, which are sensitive to the impurity profiles, were fabricated with identical processing, apart from the polysilicon deposition conditions. A detailed analysis of their electrical characteristics shows the difference of collector current components and hence the increase of current gain by about two times. These results indicate that the effect of interfacial oxides on the impurity profile

is expressed by the segregation coefficient  $m$ , which is the ratio of  $C_{\text{Si}}/C_{\text{PolySi}}$  at the interface. The sensitivity of  $m$  for the device characteristics was calculated by a process-device simulator, and it is demonstrated that the current gain is a strong function of  $m$  for shallow emitters. 17 refs.

Sagara, Kazuhiko (Hitachi Ltd, Kokubunji, Jpn); Nakamura, Tohru; Tamaki, Yoichi; Shiba, Takeo. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2286-2290.

**Fabrication** See Also TRANSISTORS, BIPOLAR—Heterojunctions; TRANSISTORS, BIPOLAR—Switching.

**096010 1.3- $\mu\text{m}$  CMOS/BIPOLAR STANDARD CELL LIBRARY FOR VLSI COMPUTERS.** The CMOS/bipolar standard cell library has been enhanced from 2 to 1.3  $\mu\text{m}$  for application to VLSI computers, such as 32-bit supermini- and microcomputers. This library has macrosells such as a 256-kb/8.4-ns ROM, 32-bit/4.5-ns carry propagation circuits for a 32-bit ALU, 4-kbyte/17-ns cache memory including an address translation function, and a 64-bit/37-ns multiplier. High integration density is obtained by using CMOS-based circuits and fast operation is achieved by using CMOS/bipolar sense circuits and drivers. In the cache memory, a functional sense amplifier, in which a conventional sense amplifier and a comparator are merged, is used. How to combine CMOS and bipolar devices in the macrosells along with application of the library to the VLSI computers is discussed. 23 refs.

Hotta, Takashi (Hitachi Ltd, Hitachi, Jpn); Kurita, Kouzaburo; Maejima, Hideo; Iwamura, Masahiro; Tanaka, Shigeo; Bandoh, Tadaaki; Yamauchi, Tatsumi; Hotta, Atsuo. *IEEE J Solid State Circuits* v 23 n 2 Apr 1988 p 500-506.

**Heterojunctions** See Also TRANSISTORS, BIPOLAR—Electric Properties; TRANSISTORS, BIPOLAR—Fabrication; TRANSISTORS, BIPOLAR—Performance; TRANSISTORS, BIPOLAR—Transport Properties.

**096011 GaAs/AlGaAs HETEROJUNCTION EMITTER-DOWN BIPOLAR CIRCUITS FABRICATED ON GaAs-ON-Si SUBSTRATES.** Small-scale GaAs HBT (heterojunction bipolar transistor) integrated circuits on silicon substrate are reported to demonstrate the potential of GaAs bipolar circuits fabricated on low-cost and large-diameter Si wafers. These circuits are 15-stage ring-oscillators and 256-b read-only-memories (ROMs). A maximum current gain of 25 was measured at a collector current density of 6250 A/ $\text{cm}^2$ . The ring oscillator consists of 15 inverters in series, and one output buffer. Each inverter is one transistor with four Schottky collectors for fan-out of four. This loaded ring oscillator showed a minimum gate-delay time of 200 ps at 10-mW/gate power dissipation. The delay increases to 400 ps at 4 mW/gate. Functional 256-b ROM circuits have also been obtained. The ROM uses emitter-down HBTs and double-level metals for interconnection. It is mask programmable and fully decoded. This circuit consists of approximately 120 gates. 2 refs.

Tran, L.T. (Texas Instruments Inc, Dallas, TX, USA); Matyi, R.J.; Shichijo, H.; Yuan, H.T.; Lee, J.W. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2369-2370.

**Junctions** See TRANSISTORS, BIPOLAR—Mathematical Models.

**Mathematical Models** See Also SEMICONDUCTOR DEVICES, MOS—Mathematical Models; TRANSISTORS, BIPOLAR—Heterojunctions.



**096012 EFFICIENT ALGORITHM FOR PHYSICAL-TOPOLOGICAL MODELING OF BIPOLAR SEMICONDUCTOR DEVICES WITH ALLOWANCE FOR THE NONLINEAR EFFECTS OF HEAVY DOPING AND HIGH INJECTION LEVEL.** General expressions are proposed for the electron and hole currents; they describe charge-carrier transport in an indirect-band semiconductor for an arbitrary doping level and any injection level. An efficient algorithm is described for physical-topological modeling of bipolar devices with allowance for recombination through deep levels, Auger recombination, electron-pole scattering, narrowing of the band gap, and other effects of heavy doping. The contribution made by nonlinear physical effects to the electrical characteristics of the structure is established. It is shown that electron-hole scattering, which is extremely important in calculation of the static volt-ampere characteristic, need not be taken into account in calculations for the process of reverse recovery in a diode. (Author abstract) 19 refs.

Mnatsakanov, T.T.; Rostovtsev, I.L.; Filatov, N.I. *Radiation Electron Commun Syst* v 30 n 6 1987 p 26-31.

**096013 EXTENDED PHOTOCURRENT MODELING WITH APPLICATION TO LATCHUP ANALYSIS.** Nonlinear departure from low injection and bipolar device modeling are introduced into TRISPACE circuit simulation software. These features and other advanced aspects of TRISPACE photocurrent representation are used to study latchup. Results are compared with those obtained using standard SPICE for modeling, as well as with results obtained using a linear photocurrent source. 11 refs.

Ishaque, A. (Rensselaer Polytechnic Inst, Troy, NY, USA); Becker, M.; Block, R.C. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1376-1380.

**Measurements** See Also TRANSISTORS, BIPOLAR—Electric Field Effects; TRANSISTORS, BIPOLAR—Low Temperature Effects.

**096014 MEASUREMENT TECHNIQUE TO OBTAIN THE RECOMBINATION LIFETIME PROFILE IN EPI LAYERS AT ANY INJECTION LEVEL.** The modulation measurement technique proposed by the authors (1985) to obtain a high injection recombination lifetime profile is extended to any injection level in order to obtain both the majority-carrier and minority-carrier lifetimes as well as its profile along the epi layer. The technique is simulated by numerically solving the relevant equations and the extraction of a varying lifetime profile is demonstrated both at low and high injection levels. Some experimental results on n-n<sup>+</sup> epi layers of different doping and thicknesses are reported that demonstrate the possibilities of this measurement technique. Both minority-carrier and majority-carrier lifetimes are obtained from the measurements of lifetime as a function of the injection level. 13 refs.

Spirito, Paolo (CNR, Naples, Italy); Cocorullo, Giuseppe. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2546-2554.

#### Microscopic Examination

**096015 WAVEFORM MEASUREMENTS IN HIGH-SPEED SILICON BIPOLAR CIRCUITS USING A PICOSECOND PHOTOELECTRON SCANNING ELECTRON MICROSCOPE.** A description is given of a noncontact waveform measurement technique for the characterization of high-speed LSI and VLSI circuits using a picosecond photoelectron scanning electron microscope with 5-ps temporal resolution, 0.1-μm spatial resolution, and a voltage resolution of 3 mV/√Hz. The ability of the technique to measure and monitor the internal waveforms and to resolve the different contributions of the delay in the circuit without any loading effect is demonstrated by its application to the full characterization of sub-100-ps silicon bipolar ECL (emitter-coupled

logic) circuits. 6 refs.

May, Paul (IBM, Yorktown Heights, NY, USA); Halbout, Jean-Marc; Chuang, C.T.; Li, G.P. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1126-1129.

**Microwave** See TRANSISTORS, BIPOLAR—Fabrication.

**Military Applications** See INTEGRATED CIRCUITS—Radiation Protection.

**Modeling** See TRANSISTORS, BIPOLAR—Heterojunctions.

**Performance** See LOGIC DEVICES—Gates; SEMICONDUCTOR DEVICES, MOS—Applications; TRANSISTORS, BIPOLAR—Performance.

**Processing** See SEMICONDUCTOR DEVICES, MOSFET—Reliability.

#### Production

**096016 BICMOS HITS VOLUME PRODUCTION AT SARATOGA.** A new family of bipolar complementary MOS (BiCMOS) devices is introduced that uses a second generation 1.5 μm process, called Sabic III. The family is characterized by 64-Kbit, TTL-compatible SRAMs with speeds ranging from 25 to 35 ns and chip power consumption of only 500 mW active and 150 mW standby.

Cole, Bernard C. *Electronics* v 61 n 3 Feb 4 1988 p 67.

**Radiation Effects** See Also DATA STORAGE, SEMICONDUCTOR—Radiation Effects.

**096017 LASER SIMULATION OF SINGLE EVENT UPSETS.** A pulsed picosecond laser was used to produce upsets in both a commercial bipolar logic circuit and a specially designed CMOS static RAM test structure. A comparison of the laser energy necessary for producing upsets in transistors that have different upset sensitivities with the single-event upset (SEU) level predicted from circuit analysis showed that a picosecond laser could measure circuit sensitivity to SEUs. The technique makes it possible not only to test circuits rapidly for upset sensitivity but also, because the beam can be focused down to a small spot size, to identify sensitive transistors. 7 refs.

Buchner, S.P. (Martin Marietta Lab, Baltimore, MD, USA); Wilson, D.; Kang, K.; Gill, D.; Mazer, J.A.; Raburn, W.D.; Campbell, A.B.; Knudson, A.R. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1228-1233.

**096018 INTRINSIC SEU RADIATION FROM USE OF HETEROJUNCTIONS IN GALLIUM ARSENIDE BIPOLAR CIRCUITS.** Use of GaAs/AlGaAs heterojunctions at the base-emitter junction in molecular-beam epitaxy (MBE)-type GaAs bipolar circuits reduces the thickness of the SEU (single-event upset)-sensitive volume associated with each transistor to about 0.2 μm. This results in a sharply reduced charge collection and a correspondingly sharp reduction in SEU sensitivity, even for low values of the critical charge. The effect is illustrated with an H<sup>12</sup>L (heterojunction inverted transistor integrated logic) gate array in which shift registers do not exhibit upsets on exposure to heavy ions with LET (linear energy transfer) values of up to 20 MeV-cm<sup>2</sup>/mg(GaAs), which is equivalent to over 30 MeV-cm<sup>2</sup>/mg(Si). A low-current version of the same shift registers exhibits an upset cross section of only 3 × 10<sup>-13</sup> cm<sup>2</sup>/b at an LET of 20 MeV-cm<sup>2</sup>/mg and zero at 11 MeV-cm<sup>2</sup>/mg(GaAs). Neither of the devices could be upset by exposure to 63-MeV protons at a fluence of 1 × 10<sup>12</sup> p/cm<sup>2</sup>, in agreement with the predictions made using CUPID simulation code. 10 refs.

Salzman, James F. (Texas Instruments Inc, Dallas, TX, USA); McNulty, Peter J.; Knudson, A.R. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1676-1679.

**096019 PREDICTION OF DOSE TO FAILURE VERSUS DOSE RATE FOR A RECESSED OXIDE DIGITAL BIPOLAR MICROCIRCUIT.** The author reports on measurements made of microcircuit performance at different, low dose rates over extended periods of time in an attempt to assess the suitability of using the microcircuit in the satellite-mission radiation environment. It was planned to use Fairchild 54F251 parts in a 2.3-rad(Si)/h satellite environment for a five-year mission, in which they would accumulate 100 krad(Si). An initial test at 10,000 rad(Si)/h resulted in values of the input current high, I<sub>IH</sub>, which greatly exceeded the specified limit of 20 μA after the first radiation exposure at a level of 10 krad(Si). Typically, input currents above 20 μA are considered failures. Subsequent tests at lower dose rates resulted in total doses to failure which were much greater than 10 krad(Si), and allowed a prediction of successful operation for the mission duration. The analysis used to predict performance at low mission dose rates is applicable to other part types that experience similar radiation-induced effects. 11 refs.

Schiff, Daniel (Assurance Technology Corp, Carlisle, MA, USA). *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1742-1744.

**096020 WAFER MAPPING OF TOTAL DOSE FAILURE THRESHOLDS IN A BIPOLAR RECESSED FIELD OXIDE TECHNOLOGY.** Ionizing radiation failure thresholds were measured across a silicon wafer using 10-keV X-rays to determine the success of hardened process modifications and to examine wafer-level hardness-assurance screening techniques. Topological wafer maps of the total-dose failure response for Signetics 74F00 circuits are presented. 3 refs.

Titus, Jeffrey L. (US Naval Weapons Support Cent, Crane, IN, USA); Platteter, Dale G. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1751-1756.

**Research** See TRANSISTORS.

**Switching** See SEMICONDUCTOR DEVICES, MOS—Computer Interfaces; TRANSISTORS, BIPOLAR—Fabrication; TRANSISTORS, FIELD EFFECT—Switching.

#### Theory

**096021 INFLUENCE OF RECOMBINATION CENTERS ON THE RELAXATION PROCESS OF A 2D PHOTOEXCITED HOT ELECTRON PLASMA.** The effect of recombination centers on the relaxation process of photo-excited 2D electron systems in polar semiconductors is studied theoretically. Our analysis takes into account the most important mechanisms of relaxation. We find that under certain conditions recombinations to centers can drastically modify the e-ph interaction via reduction of screening. Consequently, the time behavior of the energy exchange rate between the electronic system and the lattice can also be altered. Our results indicate that recombination to centers affects, in different ways, the time evolution of the carrier temperature and the rate of energy exchange rate. Qualitative agreement with some experimental data lends support to the model and allows us to make some predictions. (Author abstract) 28 refs.

Carrillo, J.L. (Int Cent for Theoretical Physics, Trieste, Italy); Luna-Acosta, G.; Arriaga, J.; Rodriguez, M.A. *Solid State Commun* v 63 n 9 Sep 1987 p 773-778.

#### Transport Properties

**096022 NUMERICAL ANALYSIS AND INTERPRETATION OF THE SMALL-SIGNAL MINORITY-CARRIER TRANSPORT IN BIPOLAR DEVICES.** A simple and efficient one-dimensional numerical technique is presented that determines the small-signal minority-carrier transport in the quasineutral regions of bipolar devices, such as diodes and transistors, under sinusoidal excitation. The technique is applied to study small-signal properties of p-n junction diodes and bipolar



transistors. Examples treated include the frequency dependence of transistor current gain, the diffusion capacitance of a quasineutral base or emitter, and base-layer carrier propagation delay. 27 refs.

Park, Jong-Sik (Univ of Florida, Gainesville, FL, USA); Neugroschel, Arnost; Lindholm, Fredrik A. *IEEE Trans Electron Devices* v 35 n 2 Feb 1988 p 195-202.

## SEMICONDUCTOR DEVICES, CHARGE COUPLED

See Also ASTRONOMY—Imaging Techniques; COATINGS—Antireflection Coatings; ELECTRONIC CIRCUITS, DELAY TYPE—Applications; IMAGE SENSORS; IMAGE SENSORS—Noise, Spurious Signal; IMAGE SENSORS—Performance; LOGIC CIRCUITS; NONDESTRUCTIVE EXAMINATION—Ultrasonic Applications; OSCILLOSCOPES, CATHODE RAY—Performance; PARTICLE DETECTORS; PHOTODETECTORS; PHOTODETECTORS—Control; SPECTROSCOPY, X-RAY—Equipment; TELEVISION EQUIPMENT—Cameras.

**096023 USE OF A CHARGE-COUPLED DEVICE FOR QUANTITATIVE OPTICAL MICROSCOPY OF BIOLOGICAL STRUCTURES.** The properties of a charge-coupled device (CCD) and its application to the high-resolution analysis of biological structures by optical microscopy are described. The CCD, with its high resolution, high sensitivity, wide dynamic range, photometric accuracy, and geometric stability, can provide data of such high quality that quantitative analysis on two- and three-dimensional microscopic images is possible. This description of the imaging properties of the microscope, and the high-quality image data provided by the CCD, allow sophisticated computational image processing methods to be used that greatly improve the effective resolution obtainable for biological structures. Image processing techniques revealed fine substructures in *Drosophila* embryonic diploid chromosomes in two and three dimensions. The same approach can be extended to structures as small as chromosomes. (Edited author abstract) 34 refs.

Hiraoka, Yasushi (Univ of California at San Francisco, San Francisco, CA, USA); Sedat, John W.; Agard, David A. *Science* v 238 n 4823 Oct 2 1987 p 36-41.

**096024 CCD AREA ARRAY DEVELOPMENTS.** There are a number of problems associated with CCD technology, and there is an emphasis on the development of device enhancements, especially in the field of 'area arrays' i.e. CCD sensing devices in which the pixels are grouped in a two-dimensional format. The article reviews CCD area array developments resulting in noise reduction, image uniformity, and elimination of a 'blooming' phenomenon.

Hickleton, Andrew. *New Electron* v 20 n 13 Jun 23 1987 p 16, 18.

**096025 VARIABLE IMAGE FORMAT FROM A CCD: ARE YOU LOCKED INTO THE 4:3 IMAGE FORMAT OF TELEVISION-COMPATIBLE CCD ARRAYS?** Most two-dimensional CCD arrays available in the marketplace today are configured in a 4:3 format to be compatible with television standards. Others are not. One of the others is the Texas Instruments TC211 device, which has 165 rows of pixels with 192 pixels per row and can be gated to use only certain portions of the chip as an active image area. The latter capacity is the result of a dump drain designed into the chip. This enables the user to clear unwanted charges from the CCD array quickly.

Profaizer, Rudy (Texas Instruments, Dallas, TX, USA). *Lasers Optonics* v 6 n 11 Nov 1987 p 86-87.

**096026 COMPENSATION FOR GAIN NONUNIFORMITY AND NONLINEARITY IN HgCdTe INFRARED CHARGE-COUPLED-DEVICE FOCAL PLANES.** Infrared CCD arrays generally require a compensation for the effect of gain and offset variation among the individual detectors of the array. Linear compensation techniques do not suffice for focal planes that exhibit a large nonlinearity of response combined with order-of-magnitude variations in threshold and saturation flux levels. This situation is common among hybrid architecture CCDs, particularly when HgCdTe is

the detector material. This paper reports on a multipoint piecewise-linear correction scheme employed on a HgCdTe infrared CCD focal plane. This technique allows a compensated response to be obtained in a computationally efficient manner. An experimental relationship between the number of calibration points and the amount of residual fixed-pattern noise is presented and compared to previous analytical models. (Author abstract) 3 refs.

Boreman, Glenn D. (Univ of Central Florida, Orlando, FL, USA); Costanzo, Christopher. *Opt Eng* v 26 n 10 Oct 1987 p 981-984.

**096027 ULTIMATE SENSITIVITY AND RESOLUTION OF PHOSPHOR/FIBER/CHARGE-COUPLED-DEVICE SYSTEMS.** Charge-coupled-device imagers have great potential to replace photographic film for recording cathode ray tube (CRT) displays. The basic problem, detection of electrons impacting with variable densities on a sensing screen, implies high sensitivity for single-electron detection. Few data have been published on CCD performance in this regime, especially as one component of a complete readout system. We report on the basic sensitivity and resolution of one possible system, the electron beam and phosphor coupled with fiber optics to a thermoelectrically cooled CCD camera. Observed performance indicates that present sensitivity is several CRT beam electrons per pixel and that resolutions of 25  $\mu\text{m}$  trace width present no problem. Improved experiments are expected to yield single-electron detection capability in the near future. The outlook for broad use of this readout in oscilloscopes, streak tubes, and imagers is discussed with regard to this performance. (Author abstract) 8 refs.

Dunham, Mark E. (EG&G Energy Measurements Inc, Los Alamos, NM, USA); Sanchez, Philip G. *Opt Eng* v 26 n 10 Oct 1987 p 1035-1042.

**096028 ALIGNMENT OF A CCD DEVICE INTO THE IMAGE PLANE.** Methods and instruments for the alignment of the optical sensors in the spacelabs Vega I and II are shown in this article. The determination of the best position of the CCD plane had become more exact applying OTF measurements in the focal plane. (Author abstract) 2 refs.

Abraham, Gy. (Technical Univ, Budapest, Hung). *Period Polytech Mech Eng* v 31 n 2-3 1987 p 209-213.

**096029 FREQUENCY FILTERING OF A SIGNAL BY INPUT CHARGE-COUPLED DEVICE UNITS.** It is shown that the frequency properties of input units employing charge-coupled devices (CCD) make it possible to impose the functions of frequency filtering on the input units, thereby simplifying the construction of a number of analogous units employing CCDs. It is shown for the example of two types of input units (with charge extrusion and with background current stabilization) that input units can accomplish a quasi-optimum passband filtering of signals. Mechanisms are examined for forming the lower and upper cutoff frequencies in these input units, their amplitude-frequency characteristics (AFC) are determined, and the influence of time quantization is examined. Experimental verifications of the proposed AFC model are presented. (Author abstract) 7 refs.

Vinetskiy, Yu.R. *Sov J Commun Technol Electron* v 32 n 5 May 1987 p 77-85.

**096030 CHARACTERISTICS OF OPTICAL CCD AS AN X-RAY IMAGE SENSOR.** We report here on the characteristics of a CCD for optical use in the several keV region. The CCD we used was an interline-transfer type device. We took X-ray images at energies of about 8 and 1.5 keV for various objects. We found that this device could yield sufficient information for a two-dimensional image. The spatial resolution is up to the individual pixel size ( $23 \times 27 \mu\text{m}$ ). The efficiency for X-rays is much superior to that of film. We measured the pulse-height distribution of X-rays in a photon-counting mode. We obtained a linear relation between the incident photon energy and the pulse height, while the energy resolution was kept constant. The effective depth of the depletion

layer of this device was calculated as being about 3  $\mu\text{m}$  from these measurements. We discuss the problems which must be faced in fabricating the CCD for X-ray use. (Author abstract) 8 refs.

Tsunemi, Hiroshi (Osaka Univ, Toyonaka, Jpn); Mizukata, Katsuya; Hiramatsu, Makoto. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 670-674.

**096031 COUNTING OF DEEP-LEVEL TRAPS USING A CHARGE-COUPLED DEVICE.** Quantization in dark current generation has been observed, using a virtual-phase charge-coupled device. Two sites for bulk silicon dark current have been identified with capture cross sections of  $1.8 \times 10^{-15} \text{ cm}^2$  and  $5.4 \times 10^{-16} \text{ cm}^2$ , and concentrations of  $1.3 \times 10^9 \text{ cm}^{-3}$  and  $1.5 \times 10^8 \text{ cm}^{-3}$ , respectively. 8 refs.

McGrath, R.D. (Texas Instruments Inc, Dallas, TX, USA); Doty, J.; Lupino, G.; Ricker, G.; Vallerger, J. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2555-2557.

**096032 FIRST TESTS WITH FULLY DEPLETED PN-CCD'S.** The authors have fabricated 280- $\mu\text{m}$ -thick fully depletable p-n charge-coupled devices (CCDs) on high-resistivity silicon (2.5 k $\Omega\text{-cm}$ ). Their operation is based on the semiconductor drift-chamber principle. They are designed as energy- and position-sensitive radiation detectors for (minimum) ionizing particles and X-ray imaging. Two-dimensional semiconductor device modeling demonstrates the basic charge-transfer mechanisms. Prototypes of the detectors have been tested in static and dynamic conditions. A preliminary charge-transfer inefficiency was determined to be  $6 \times 10^{-3}$ . The charge loss during the transfer is discussed, and an improved design, which is now being produced, is presented. 4 refs.

Struder, L. (Max-Planck Inst fuer Physik und Astrophysik, Munich, West Ger); Lutz, G.; Sterzik, M.; Holl, P.; Kemmer, J.; Prechtel, U.; Ziemann, T.; Rehab, P. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 372-376.

## Analysis

**096033 SIGNAL ANALYSIS OF MTF OF CCAID.** Signal analysis of the charge coupled area imaging devices (CCAID) working in the frame transfer manner is presented. The effects of the photo-integration, the transfer inefficiency and the width of the output pulses on the signal frequency spectrum are discussed. The corresponding modulation transfer functions (MTF) are derived. (Author abstract) In Chinese. 3 refs.

Zhou Weizhen (Northwest Telecommunications Engineering Inst, China). *Hongwai Yanjiu, A-ji* v 6 n 6 1987 p 407-412.

**Applications** See Also IMAGE PROCESSING; SATELLITES—Control Systems; SEMICONDUCTOR DEVICES, CHARGE TRANSFER—Applications.

**096034 LONG SLIT CHARGE-COUPLED-DEVICE OBSERVATIONS OF ACTIVE AND NORMAL GALAXIES.** We describe the acquisition, reduction, and analysis of long slit spectra of active and normal galaxies using the Steward Observatory Texas Instruments TI 3PCCD system on the University of Arizona Observatory 2.3 m telescope. We also present fully reduced data for one Seyfert and one normal galaxy to illustrate the scientific motivations for using such a detector system. (Author abstract) 13 refs.

Carone, T.E. (Univ of Arizona, Tucson, AZ, USA); Morris, Simon L.; Leach, Robert W. *Opt Eng* v 26 n 10 Oct 1987 p 1043-1047.



**096035 IMAGING AND NONDISPERSIVE SPECTROSCOPY OF SOFT X RAYS USING A LABORATORY X-RAY CHARGE-COUPLED-DEVICE SYSTEM.** This paper describes the design and performance of a laboratory instrument for imaging and nondispersive spectroscopy of soft x rays (300 eV to 10 keV) utilizing the Texas Instruments TI-4849 vital-phase CCD. This instrument has achieved a spatial resolution of 22  $\mu\text{m}$  (limited by pixel size) with an overall array area of 584  $\times$  390 pixels. It has achieved an energy resolution of approximately 140 eV FWHM for single-pixel  $^{55}\text{Fe}$  x-ray events (5.9 keV) with the CCD operated at  $-30^\circ\text{C}$ . We have operated the CCD in photon-counting mode at room temperature and have obtained x-ray spectra with an energy resolution of approximately 450 eV at 5.9 keV. The low energy x-ray sensitivity of the CCD also has been demonstrated by detecting carbon  $K_{\alpha}$  x rays (277 eV). (Author abstract) 6 refs.

Luppino, Gerard A. (MIT, Cambridge, MA, USA); Ceglie, Natale M.; Doty, John P.; Ricker, George R.; Vallerga, John V. *Opt Eng* v 26 n 10 Oct 1987 p 1048-1054.

**096036 ANALYSIS OF MTF OF CCD PUSH-BLOOM IMAGING SYSTEM IN ITS FLYING DIRECTION AND SELECTION OF THE OPTIMUM SUPERPOSED SAMPLING COEFFICIENT.** For a linear array CCD in a push-bloom imaging system, on condition that the input signal is a sine pattern with single frequency, the output signal spectrum is analyzed. The MTF expression of CCD in its flying direction is derived on certain conditions, which is then expressed as a product of  $\text{MTF}_1$ ,  $\text{MTF}_{\text{si}}$ ,  $\text{TF}_{\text{so}}$ . The effects of push-bloom coefficient  $\eta$  and superposed sampling coefficient  $\xi$  on MTF curves are analyzed. In general the value of  $\xi$  could be chosen as 2, at most as 4. (Author abstract) In Chinese. 8 refs.

Shen Yexin (Huazhong Univ of Science & Technology, China); Zhang Shouyi. *Hongwai Yanjiu, A-j* v 6 n 6 1987 p 401-406.

**096037 CHOOSING CCDs FOR MACHINE VISION APPLICATIONS.** When using a charge-coupled device (CCD) camera, many critical camera parameters must be understood and matched to the requirements of the particular machine vision or robotic application. The final choice of a sensor depends on requirements in optics, sensitivity, resolution and dynamic range, as well as cost. In addition, the question of standard versus non-standard video formats must be addressed. The author reviews the three major solidstate imaging technologies: frame transfer (FT), x,y-addressed metal-oxide semiconductor (XY-MOS) and interline transfer (IL). Each has its advantages and disadvantages. 7 refs.

Martins, Ed (North American Philips Corp, Slatersville, RI, USA). *Lasers Optonics* v 7 n 6 Jun 1988 p 65-69.

## Cooling

**096038 GENERALIZED APPROACH TO COOLING CHARGE-COUPLED DEVICES USING THERMOELECTRIC COOLERS.** This paper is concerned with the use of thermoelectric coolers (TECs) to cool charge-coupled devices (CCDs). Heat inputs to the CCD from the warmer environment are identified, and generalized graphs are used to approximate the major heat inputs. A method of choosing and estimating the power consumption of the TEC is discussed. This method includes the use of TEC performance information supplied by the manufacturer and equations derived from this information. Parameters of the equations are tabulated to enable the reader to use the TEC performance equations for choosing and estimating the power needed for specific TEC applications. (Author abstract) 2 refs.

Petric, Walter S. (JPL, Pasadena, CA, USA). *Opt Eng* v 26 n 10 Oct 1987 p 965-971.

**Design** See Also ELECTRON TUBES, TELEVISION CAMERA.

**096039 DESIGN OF LOW NOISE, HIGH PERFORMANCE X-RAY CHARGE-COUPLED-DEVICE CAMERAS.** In general, attention to a multitude of details is essential when designing low noise CCD cameras. This paper describes some of the critical details of the MIT x-ray CCD camera design. Special attention is given to those portions of the system that deviate from conventional practice in the design of CCD cameras. Furthermore, an attempt has been made to generalize the design so that both optical and x-ray requirements can be satisfied whenever possible. Currently, noise levels of  $< 8 \text{ e}^-/\text{rms}$  are routinely achieved with this design, and even lower levels ( $< 5 \text{ e}^-$ ) should be realizable. (Author abstract) 10 refs.

Doty, John P. (MIT, Cambridge, MA, USA); Luppino, Gerard A.; Ricker, George R. *Opt Eng* v 26 n 10 Oct 1987 p 1055-1060.

**096040 OPTIMIZING CHARGE-COUPLED-DEVICE DETECTOR OPERATION FOR OPTICAL ASTRONOMY.** We have operated two types of CCD detectors over the past several years: the three-phase thinned Texas Instruments 800  $\times$  800 and the thinned RCA 320  $\times$  512. Both detectors are operated in a slow-scan, cooled camera behind a variety of optical instruments at ground-based observatories, often involving low light levels. Emphasis is placed on optimizing the camera's operation with respect to quantum efficiency, readout noise, charge-transfer efficiency, dark current, full-well saturation, bias image flatness, residual image, and on-chip binning. Techniques for optimizing these properties are discussed. Our camera system is described, and information about the performance of our five operational CCDs is given. (Author abstract) 9 refs.

Leach, Robert W. (Univ of Arizona, Tucson, AZ, USA). *Opt Eng* v 26 n 10 Oct 1987 p 1061-1066.

**096041 FAST MEGAPIXEL CHARGE-COUPLED-DEVICE IMAGE ACQUISITION AND ANALYSIS SYSTEM FOR HIGH ENERGY NUCLEAR PHYSICS.** A two-camera system has been developed for photographing and analyzing images consisting of particle tracks from high energy collisions in a streamer chamber track detector. The charge-coupled-device (CCD) cameras view the collision region, with typical images consisting of more than 100 tracks. Each camera consists of a 1024  $\times$  1024 pixel CCD array. Up to three cameras can be read out simultaneously, at a rate of  $5 \times 10^5$  pixels/s/camera digitized to 9 bits, through a custom-designed multiplexing interface into an integer array processor, computer, and color display station. A software system has been developed that allows multiple asynchronous computer processes to record, analyze, and display the streamer chamber images. The system has been used in a high energy nuclear physics experiment for on-line analysis, digital data acquisition, and storage of streamer chamber events, with subsequent off-line image and physics analyses. (Author abstract) 7 refs.

Tincknell, M.L. (Lawrence Berkeley Lab, Berkeley, CA, USA); Chase, S.I.; Dinh, T.; Harris, J.W.; Teitelbaum, L. *Opt Eng* v 26 n 10 Oct 1987 p 1067-1076.

**096042 64X64 PIXEL TWO-LAYER STRUCTURE INS-IRCCD.** A 64 $\times$ 64 pixel InSb-IRCCD two-layer structure has been developed. It is constructed with a back-illuminated InSb  $p^+n$  photodiode array and a buried Si-CCD  $p$ -channel. The photodiode array was manufactured using ion-implantation and anodic oxide/sputtered  $\text{Al}_2\text{O}_3$  double layer passivation processes, by which  $R_0A$  values of more than  $1 \times 10^5 \Omega\text{cm}^2$  were obtained. The photodiode array, polished to 20  $\mu\text{m}$  thickness, and the CCD are interconnected by a special In-bump technique involving electroplating and reforming to conical shapes, which assures complete electrical connections. Signal charges in the CCD storage gate containing the background ingredient are partitioned to two parts or skimmed. By these techniques, CCD gate capacities are minimized. The output signals are corrected

to form the IR image. Good system linearities, where  $\gamma = 1.00 \pm 0.01$ , and excellent responses,  $D_{\lambda\text{peak}} = 6.0 \times 10^{11} \text{ cm Hz}^{1/2} \text{ W}^{-1}$  and  $\text{NETD} = 0.05\text{-}0.06 \text{ deg}$ , have been obtained. (Edited author abstract). 9 Refs. In Japanese.

Tsunoda, Reikichi (Japan Defense Agency, Tokyo, Jpn); Kanno, Toshio; Tsuji, Takafumi; Shirouzu, Shunji; Harada, Nozomu; Aihara, Satoshi; Sado, Tetsuo. *Terebijon Gakkaishi* v 42 n 5 May 1988 p 76-84.

## Heterojunctions

**096043 DARK CURRENT IN SELECTIVELY DOPED N-ALGaAs/GaAs CCDs.** The dark current of Schottky-barrier-gate charge-coupled devices (CCDs) utilizing selectively doped N-ALGaAs/GaAs structures grown by molecular beam epitaxy was investigated. The generation rate of carriers in the CCD channel, i.e. the dark current, and its temperature dependence were measured in detail. The dark current was dominated by the reverse current of the Schottky barrier gate and consisted of the reverse current of the operating gate as well as that of the neighboring two gates. The reverse current was shown to be dominated either by the thermionic-field emission current or by the field emission current because of the high doping of ALGaAs. A measure of the reduction of the reverse current is also presented. (Author abstract) 12 refs.

Akatsu, Yuji (Hokkaido Univ, Sapporo, Jpn); Ohno, Hideo; Hasegawa, Hideki; Sano, Naokatsu. *Jpn J Appl Phys Part 1* v 27 n 1 Jan 1988 p 78-82.

## Imaging Techniques

**096044 FLASH TECHNOLOGY FOR CHARGE-COUPLED-DEVICE IMAGING IN THE ULTRAVIOLET.** The introduction of the flash gate has made possible the fabrication of backside-illuminated CCDs with high sensitivity and stability throughout a wide range of ultraviolet and visible wavelengths (100 to 5000 Å). It had been determined previously that the characteristics of the oxide layer beneath the gate are critical to the ultimate achievable CCD performance. However, by creating an improved oxide layer in conjunction with the flash gate, we are now able to produce CCDs with near-ideal uv performance. We present recent results and related background theory that optimize the flash gate specifically for application in the uv. (Edited author abstract) 15 refs.

Janesick, James R. (JPL, Pasadena, CA, USA); Campbell, Dave; Elliott, Tom; Daud, Taher. *Opt Eng* v 26 n 9 Sep 1987 p 852-863.

**096045 ULTRAVIOLET AND EXTREME ULTRAVIOLET RESPONSE OF CHARGE-COUPLED-DEVICE DETECTORS.** We present results of a program to enhance the ultraviolet and extreme ultraviolet response of charge-coupled devices. The ultimate goal of our program is to develop a large format device with both high and stable quantum efficiency from 100 to 3000 Å that can be used as a windowless imaging detector in a space environment. Ultraviolet quantum efficiency measurements have been made for several ion-implanted and laser-annealed test CCDs specially fabricated for this program. Quantum efficiencies as high as 22% at 2500 Å, where the absorption depth in silicon is approx. 55 Å, have been observed in one such test CCD. Quantum efficiency measurements of standard back-illuminated RCA and Tektronix CCDs are presented. (Edited author abstract) 18 refs.

Stern, R.A. (Lockheed Palo Alto Research Lab, Palo Alto, CA, USA); Catura, R.C.; Kimble, R.; Davidsen, A.F.; Winzenread, M.; Blouke, M.M.; Hayes, R.; Walton, D.M.; Culhane, J.L. *Opt Eng* v 26 n 9 Sep 1987 p 875-883.



**096046 LOW LIGHT LEVEL IMAGING WITH COMMERCIAL CHARGE-COUPLED DEVICES.** Low light level imaging with commercially available CCDs has been limited by CCD availability as well as by poor performance at low signal levels by many devices constructed for consumer applications. These performance limitations usually take the form of poor charge-transfer efficiency at the low temperatures and/or high noise levels associated with charge-detection schemes that normally need to operate only near room temperature. This paper describes a commercial virtual-phase CCD and associated operating mode that allow high performance low light level imaging at low temperatures. This capability makes the device ideally suited to both scientific and military low light level imaging applications. (Edited author abstract) 7 refs.

Hsieh, S.M. (Texas Instruments Inc, Dallas, TX, USA); Hosack, H.H. *Opt Eng* v 26 n 9 Sep 1987 p 884-889.

**096047 420×420 CHARGE-COUPLED-DEVICE IMAGER AND FOUR-CHIP HYBRID FOCAL PLANE.** We have designed and fabricated a 420×420 pixel front-illuminated CCD imager. The device was designed to be used both individually and as part of a four-chip focal plane consisting of four chips closely abutted in a 2×2 array, for a total resolution of 840×840 pixels. Attention has been paid to achieving low noise operation, and noise levels of less than 20 e<sup>-</sup> at a 1.0 MHz data rate have been achieved. We describe special focal plane assembly techniques with which we have achieved 1 μm relative positional accuracy between the chips. (Edited author abstract) 14 refs.

Burke, Barry E. (MIT, Lexington, MA, USA); Mountain, Robert W.; Daniels, Peter J.; Harrison, David C. *Opt Eng* v 26 n 9 Sep 1987 p 890-896.

**096048 LARGE AREA FOCAL PLANE COMPRISING CHARGE-COUPLED DEVICES AND FIBER OPTICS.** Driven by a requirement for an 80 mm square sensor, we have combined CCD and tapered fiber optic technologies to create a large area focal plane. Seven custom low noise CCD imagers are assembled onto four tapered fiber optic bundles to match the physical characteristics of a tube camera used in an operational system. Two taper ratios are used in the focal plane to meet requirements for broad search and high accuracy measurements in a single device. The entire focal plane is cooled to -40°C to reduce dark current to insignificance at an integration time of 0.6 s. The focal plane has been integrated into a camera head that has an all-digital interface. The camera preserves the low noise characteristics of the focal plane in a multichannel assembly. (Author abstract) 2 refs.

Harrison, David C. (MIT, Lexington, MA, USA); Burke, Barry E. *Opt Eng* v 26 n 9 Sep 1987 p 897-901.

**096049 THOMSON-CSF FRAME-TRANSFER CHARGE-COUPLED-DEVICE IMAGERS: DESIGN AND EVALUATION AT VERY LOW FLUX LEVEL.** A slow-scan, cooled CCD camera system, similar to that used for astronomical observations, was constructed and used for testing CCD chips. Several devices were tested. This paper describes the design and performance of some Thomson-CSF solid-state area-array CCD sensors. These sensors use a frame-transfer organization adapted to operate in a double-interlaced-field readout mode with a memory zone (sensor TH 7861) or adapted to operate in a single-field mode without a memory zone (sensors TH 7882, TH 7883, TH 7884). We describe the system and the evaluation of the photometric performance of these chips, including quantum efficiency, readout noise, transfer efficiency, linearity, dark current, and field uniformity. Some projected developments of Thomson-CSF chips for scientific applications, such as the TH X31156 (1024×1024 pixels) and the buttable TH 7882 (TH X31157), are also presented. (Edited author abstract) 11 refs.

Beal, G. (Thomson-CSF, Boulogne-Billancourt, Fr); Boucharlat, G.; Chabbaï, J.; Dupin, J.P.; Fort, B.; Mellier, Y. *Opt Eng* v 26 n 9 Sep 1987 p 902-910.

**096050 OPTICAL TRACKING USING CHARGE-COUPLED DEVICES.** Techniques and instruments developed for extracting precise positional information from CCD images of point-source and extended optical targets are described. With the use of thinned, backside-illuminated devices, performance levels close to those expected from straightforward geometric considerations are obtained. For ideal point sources (i.e., stars outside of the earth's atmosphere), centerfinding accuracy of 1/100 pixel and measurement jitter of less than 1/250 pixel have been obtained. Tests showed that the main factor limiting tracker accuracy is small variation in the optical image shape rather than CCD noise or response nonuniformity. Methods of searching the entire field for the desired targets are described, along with windowing techniques for tracking. Also discussed are three examples of flight instruments previously developed or now being developed at the Jet Propulsion Laboratory. (Edited author abstract) 11 refs.

Stanton, Richard H. (JPL, Pasadena, CA, USA); Alexander, James W.; Dennison, Edwin W.; Glavich, Thomas A.; Hovland, Larry F. *Opt Eng* v 26 n 9 Sep 1987 p 930-938.

## Marketing

**096051 HIGH FRAME-RATE CCDs FIND A MID-MARKET NICHE.** In the last ten years, CCD imagers have gained widespread acceptance in two divergent markets - video cameras and specialized scientific applications. This article describes new applications for CCDs with performance positioned between these two segments.

Heidtmann, Denis; Smith, Paul; Yorsz, Jeff; Baran, Bruce. *Photonics Spectra* v 22 n 3 Mar 1988 p 127-128.

## Measurements

**096052 SIMPLE HIGH-FREQUENCY CHARACTERIZATION OF A THREE-PHASE CCD BY CONTROLLED FREE-CHARGE TRANSFER.** In this communication a technique is suggested where it is possible to characterize the charge-transfer inefficiency (ε) of a 3-phase CCD at high frequencies (1) without having to change the clock frequency and (2) with the clocks input and output circuitry operating at low frequency. This was achieved by the use of a simple virtual 2-phase clocking [2] of the CCD. Charge transfer under virtual 2-phase clocking of a 3-phase P-channel CCD is considered for demonstrating the effectiveness of the approach. 5 refs.

Shankar Narayanan, L. (Philips Research Lab, Eindhoven, Neth); Bhattacharyya, A.B.; Chandra, Sudhir. *Solid State Electron* v 31 n 1 Jan 1988 p 121-123.

## Microscopic Examination

**096053 RESEARCH ON APPLICATION OF DOUBLE GETTERING TECHNIQUE ON CCD AND ITS INCREASED GETTERING EFFECT.** The application of double gettering in the fabrication of CCD is introduced and its general applicability has been proved. Based on the observation on the etched defect patterns and the study of the microimage by electron microscopy, it has been shown that the gettering effect of the phosphorus is greater than that of the defects. This result has also been proved by estimation using the ion pair model. It is argued that the double gettering process is a technique which can greatly increase the gettering effect. (Edited author abstract) 16 refs. In Chinese.

Zhou, Shiren (Harbin Inst of Technology, Harbin, China); Ye, Yizheng; Ye, Shuichi; Mai, Zhenhong; Dai, Daoyang; Yang, Jiade; Chen, Muzhang. *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 169-174.

## Multiplexing

**096054 64×64-ELEMENT HgCdTe IRCCD FOR 3-5 μm BAND.** A 64×64-element HgCdTe IRCCD for 3-5 μm band has been successfully fabricated. Improvements in dynamic range and nonuniformity compensation are required to utilize maximum performance of a two-dimen-

sional IRCCD which consists of a HgCdTe photovoltaic array and a SiCCD multiplexer. The CCD multiplexer uses a new chip organization with an interlaced readout scheme and a storage/transfer common electrode configuration. Using these techniques, the IRCCD has 2.6 times greater dynamic range than conventional IRCCD, and 54 dB dynamic range is obtained for all 64×64 elements with 8% offset variation against 300 K background radiation. Mean detectivity  $D^*_{\lambda}$  is  $1.8 \times 10^{11}$  cmHz<sup>1/2</sup>W<sup>-1</sup> at peak wavelength of 4.7 μm. The nonuniformity compensation circuit which uses a digital signal processor (DSP) can execute both DC offset and responsivity compensation in real time. (Author abstract) 6 refs. In Japanese.

Tsunoda, Reikichi (Japan Defence Agency, Tokyo, Jpn); Kanno, Toshio; Ito, Yuichiro; Ishizaki, Hiroyuki; Tanikawa, Kunihiko. *Terebijon Gakkaishi* v 41 n 11 Nov 1987 p 1011-1018.

## Noise, Spurious Signal

**096055 CHARGE PARTITION NOISE IN CHARGE-COUPLED DEVICES.** In this paper we describe and analyze the internal noise sources of a signal charge partitioning circuit and indicate techniques for minimizing the internal noise of the circuit. Two noise sources are identified and described as a function of the circuit architecture and operating speeds: noise due to the trapping of thermal charge-density fluctuations (Johnson noise) and noise due to electrons scattered by the action of the partitioning gate. The noise due to the trapping of thermal charge-density fluctuations is dependent on the time it takes to divide the charge; at most, it is equal to the thermal Johnson noise of the integration well times the partition ratio. Noise due to the closing of the partitioning gate is dependent on the division ratio, the length of the spectrum gate, and its closure speed; it is, however, independent of the size of the charge packet being divided. With small division ratios (<10) and optimal operating speeds, the partition noise can be limited to fewer than 100 e<sup>-</sup>. (Author abstract) 6 refs.

Colquitt, Leroy Jr. (Westinghouse Electric Corp, Baltimore, MD, USA); Bluzer, Nathan; McKee, Richard. *Opt Eng* v 26 n 10 Oct 1987 p 992-998.

## Performance See Also CAMERAS—Space Applications.

**096056 DUAL-CHANNEL CHARGE-COUPLED DEVICE FOR HIGH SPEED SIGNAL ACQUISITION.** The paper describes the design and development of a CCD shift register that can take analog samples of an electrical signal at rates up to  $1 \times 10^8$  samples/s and provide temporary storage for 1024 samples. It is intended for operation in a fast-in, slow-out mode for capturing high speed electrical transients. The requirements of fast clocking and moderate clock driver power led to the choice of a serial-parallel-differential channels. Differential operation provides good linearity. The two channels can be used independently or multiplexed for sampling at the highest rate. The CCD is of the buried-channel type and uses four-process, with two polysilicon layers to provide an overlapping transfer together with its behavior in an instrument. (Edited author abstract)

Hayes, Raymond (Tektronix Inc, Beaverton, OR, USA); Heidtmann, Denis L. *Opt Eng* v 26 n 9 Sep 1987 p 829-836.

**096057 HIGH PERFORMANCE VISIBLE AND NEAR-INFRARED CHARGE-COUPLED-DEVICE ARRAY FOR SPECTROSCOPY APPLICATIONS.** This paper describes the design and performance of a scientific CCD array for use in NASA's Shuttle Image Spectrometer Experiment. The device is a four-phase, buried-channel CCD structure that operates in the frame-transfer mode. The sensor consists of 64×404 pixels (each 52 μm×52 μm), has a 100% fill factor, and operates in the visible and near-infrared spectral regions. In operation, the 404 horizontal elements provide spatial information, while the 64 vertical elements gives spectral



information covering the wavelength range of 400 to 1000 nm in 10 nm increments. The high full-well capacity of each pixel ( $> 2 \times 10^6$  electrons) and low noise floor ( $< 30$  electrons rms) yield a dynamic range of more than 95 db. The device has been designed to have good linearity characteristics. The unique dual-output structure allows a horizontal row to be read out to the right or to the left, or it can be split from the middle to both right and left output circuits simultaneously for high speed applications. The power dissipation of the device is about 60 mw. (Edited author abstract) 11 refs.

Wang, Weng-Lyang (EG&G Reticon, Sunnyvale, CA, USA); Hudson, Leland R.; Tseng, Hsin-Fu. *Opt Eng* v 26 n 9 Sep 1987 p 844-851.

**096058 CURRENT STATUS OF THE 800×800 CHARGE-COUPLED-DEVICE IMAGE SENSOR.** This paper presents an updated version of an earlier paper describing the Texas Instruments three-phase 800×800 charge-coupled-device image sensor [800×800 charge-coupled device image sensor', *Opt. Eng.* 22(5), 607-614(1983)]. Although this device was originally designed to be used as the sensor for the Wide Field/Planetary Camera on the Hubble Space Telescope, it is now being used as the detector of choice on many ground-based telescope. We review the performance of the device and indicate the contributions it has made to the understanding of general CCD performance. (Edited author abstract) 32 refs.

Blouke, Morley M. (Texas Instruments Inc, Dallas, TX, USA); Janesick, James R.; Elliott, Tom; Hall, Joseph E.; Cowens, Marvin W.; May, Patrick J. *Opt Eng* v 26 n 9 Sep 1987 p 864-874.

**096059 CHARGE-COUPLED COMPUTING FOR FOCAL PLANE IMAGE PREPROCESSING.** A new class of charge-coupled devices called charge-coupled-computing devices is described. These analog circuits perform arithmetic functions such as addition, subtraction, and magnitude comparison in the charge domain. The circuits are compact and are designed to be insensitive to rail voltages, simplifying their utilization. These devices, in conjunction with input, output, and analog memory circuits, can be combined to form a simple but general-purpose and fully programmable charge-coupled computer. A prototype charge-coupled computer has been fabricated and tested. Prospects for forming a large array of computers (e.g., 1000 to 10,000) on a single chip for spatially parallel image preprocessing are discussed. Such image plane preprocessing of data would find use in real-time mobile robot vision systems, in which low power, lightweight computing is critical for economical viability. (Author abstract) 8 refs.

Fossum, Eric R. (Columbia Univ, New York, NY, USA). *Opt Eng* v 26 n 9 Sep 1987 p 916-922.

**096060 CHARGE-COUPLED-DEVICE CHARGE-COLLECTION EFFICIENCY AND THE PHOTON-TRANSFER TECHNIQUE.** The charge-coupled device has shown unprecedented performance as a photon detector in the areas of spectral response, charge transfer, and readout noise. Recent experience indicates, however, that the full potential for the CCD's charge-collection efficiency (CCE) lies well beyond that realized in currently available devices. In this paper we present a definition of CCE performance and introduce a standard test tool (the photon-transfer technique) for measuring and optimizing this important CCD parameter. We compare CCE characteristics for different types of CCDs, discuss the primary limitations in achieving high CCE performance, and outline the prospects for future improvement. (Author abstract) 7 refs.

Janesick, James R. (JPL, Pasadena, CA, USA); Klaasen, Kenneth P.; Elliott, Tom. *Opt Eng* v 26 n 10 Oct 1987 p 972-980.

## Radiation Damage

**096061 EXTREME DAMAGE EVENTS PRODUCED BY SINGLE PARTICLES.** Recent measure-

ments of permanent displacement damage produced in charge-coupled devices by single neutron and proton interactions revealed that some of the events exceeded the mean value by more than a factor of ten. These extreme events cannot be readily explained in terms of calculated recoil spectra. In view of this finding, the authors estimate the probability of exceeding a given level of damage as the particle fluence is increased and multiple events occur. Analytical methods applicable to this problem are described and applied to the reported displacement damage data. The results indicate that the character of the damage distributions will change rapidly as the particle fluence is increased and a transition is made from single to multiple events. Although the damage distribution approaches a Gaussian form, the extreme events will persist up to exposure levels 100 times higher than that used in the reported experiments.

Burke, E.A. (Mission Research Corp, San Diego, CA, USA); Summers, G.P. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1575-1579.

## Space Applications

**096062 STAR MAPPER USING A LINEAR CHARGE-COUPLED-DEVICE ARRAY.** A star mapper using a Fairchild 2048-element linear CCD array (CCD 143) has been developed for the Indian Remote Sensing Satellite (IRS-1A), which is scheduled for launch in 1987. The star mapper is designed to scan stars up to 5th magnitude by using the orbital motion of the sun synchronous satellite, with a swath of 8° across the scan direction. Design details of the star mapper along with some test results of the qualification model are presented. (Author abstract) 2 refs.

Jain, Y.K. (ISRO, Bangalore, India); Koteswara Rao, V.; Rao, D.V.B. *Opt Eng* v 26 n 9 Sep 1987 p 939-943.

**096063 APPLICATION OF TEXAS INSTRUMENTS TC-104 LINEAR CHARGE-COUPLED-DEVICE ARRAYS IN SPACEBORNE CAMERA SYSTEMS.** The Texas Instruments TC-104 linear CCD array with 3456 elements per line has been investigated for applications in spaceborne imaging systems for multispectral and stereoscopic earth observation. Of special importance are parameters such as linearity, pixel nonuniformity, dynamic range, and calibratability. The TC-104 was found to be suitable for imaging systems with a radiometric resolution of up to 12 bits. (Author abstract) 9 refs.

Seige, Peter (DFVLR, Oberpfaffenhofen, West Ger); Rees, Gisbert. *Opt Eng* v 26 n 10 Oct 1987 p 1029-1034.

## SEMICONDUCTOR DEVICES, CHARGE TRANSFER See Also SEMICONDUCTOR MATERIALS—Photoconductivity.

### Applications

**096064 CHARGE TRANSFER DEVICE DETECTORS FOR ANALYTICAL OPTICAL SPECTROSCOPY - OPERATION AND CHARACTERISTICS.** In this paper, charge transfer devices (CTDs) are described. Detector characteristics pertinent to spectroscopic application - including quantum efficiency, read noise, dark count rate, and available formats - are emphasized. Unique capabilities, such as the ability to nondestructively read out the detector array and the ability to alter the effective detector element size by a process called binning, are described. CTDs with peak quantum efficiencies over 80% and significant responsivity over the wavelength range of 0.1 nm to 1100 nm are discussed. (Edited author abstract) 24 refs.

Bilhorn, R.B. (Univ of Arizona, Tucson, AZ, USA); Sweedler, J.V.; Epperson, P.M.; Denton, M.B. *Appl Spectrosc* v 41 n 7 Sep-Oct 1987 p 1114-1125.

**096065 SPECTROCHEMICAL MEASUREMENTS WITH MULTICHANNEL INTEGRATING DETECTORS.** This article covers three major topics related to the optimum use of integrating detectors in analytical

spectroscopy. The advantages of employing integrating multichannel detectors in analytical spectroscopy, rather than a single detector in a wavelength scanning system or an interferometer, are discussed. Included are detector read noise considerations. When one is employing an integrating detector in luminescence, absorption, and emission applications, achievable sensitivity is dependent on differing detector parameters. (Edited author abstract) 23 refs.

Bilhorn, R.B. (Univ of Arizona, Tucson, AZ, USA); Epperson, P.M.; Sweedler, J.V.; Denton, M.B. *Appl Spectrosc* v 41 n 7 Sep-Oct 1987 p 1125-1136.

## Contacts

**096066 INFLUENCE OF CATHODE CONTACTS ON NEAR-MICRON INP TRANSFERRED ELECTRON DEVICES.** We have performed an experimental investigation of twenty-five 1.5 to 2.0  $\mu$ m long InP TED's in tunable resonant structures at frequencies in the 75-100 GHz regime, and have simulated their behavior, and that of shorter devices. We have found that the cathode boundary condition determine the operation of near-micron InP TED's in following ways: it controls the threshold conditions; it controls the required dc bias power; it affects the transit-time frequency of the device; and it influences the electric field profile for an appreciable distance from the cathode. (Edited author abstract) 8 refs.

Czekaj, J. (Wayne State Univ, Detroit, MI, USA); Shaw, M.P. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 599-602.

Tunneling See SEMICONDUCTING SILICON COMPOUNDS—Photoconductivity.

## SEMICONDUCTOR DEVICES, FIELD EFFECT See Also AMPLIFIERS, OPERATIONAL; DATA STORAGE UNITS—Transients; INTEGRATED CIRCUITS, MONOLITHIC—Computer Aided Design; LOGIC CIRCUITS—Performance; TRANSISTORS, FIELD EFFECT.

**096067 PROCEEDINGS - IEEE/CORNELL CONFERENCE ON ADVANCED CONCEPTS IN HIGH SPEED SEMICONDUCTOR DEVICES AND CIRCUITS.** This proceedings contains 43 papers by various authors. The following topics are dealt with: MOSFETs; electrooptic sampling; insulating heterostructure FETs; atomic layer epitaxy; ultra-high performance MESFETs; novel processing heterojunction bipolar transistors; vertical transistors; resonant-tunneling diodes and millimeter-wave diodes. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11301 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEEE, Electron Devices Soc, New York, NY, USA). *Proc - IEEE/Cornell Conf on Adv Concepts in High Speed Semicond Devices and Circuits, Ithaca, NY, USA, Aug 10-12, 1987* Publ by IEEE, New York, NY, USA, 1987. Available from IEEE Service Cent (Cat n 87CH2526-2), Piscataway, NJ, USA 399p.

Analysis See TRANSISTORS, FIELD EFFECT—Mathematical Models.

Applications See TRANSISTORS, FIELD EFFECT—Applications.

Computer Aided Design See TRANSISTORS, FIELD EFFECT—Mathematical Models; TRANSISTORS, FIELD EFFECT—Modeling.

## Degradation

**096068 EFFECT OF IMPACT IONIZATION INDUCED BIPOLAR ACTION ON N-CHANNEL HOT-ELECTRON DEGRADATION.** The relationship between the total impact ionization rate and the measured substrate current is analyzed, using short-channel NMOS devices. It is shown that holes that are injected into the source and turn on the parasitic source-bulk-drain bipolar may actually be a significant portion of the total impact



ionization current. The authors explain how the commonly used model, which ignores this bipolar effect, can lead to incorrect predictions regarding hot-electron degradation. A related criterion for maximum source-drain voltage during accelerated stress is discussed and justified. 4 refs.

Krieger, Gadi (VLSI Technology Inc, San Jose, CA, USA); Cuevas, Peter P.; Misheloff, Michael N. *IEEE Electron Device Lett* v 9 n 1 Jan 1988 p 26-28.

**Doping** See TRANSISTORS, FIELD EFFECT—Materials.

**Efficiency** See TRANSISTORS, FIELD EFFECT—Millimeter Waves.

**Electric Conductivity** See TRANSISTORS, FIELD EFFECT—Thermal Effects.

**Electronic Properties** See Also TRANSISTORS, FIELD EFFECT—Mathematical Models.

**096069 VELOCITY OVERSHOOT IN ULTRA-SHORT-GATE-LENGTH GaAs MESFET'S.** GaAs MESFETs with ultrashort gates between 0.035 and 0.065  $\mu\text{m}$  were fabricated to determine trends in their DC transconductance as a function of gate length. It is found that overshoot in the channel causes a considerable increase in the average electron velocity. An approximation based on the gradual channel approximation becomes valid at ultrashort gate lengths due to an increased percentage of the channel that is velocity-saturated. 20 refs.

Bernstein, Gary (Arizona State Univ, Tempe, AZ, USA); Ferry, David K. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 887-892.

**Fabrication** See Also TRANSISTORS, FIELD EFFECT—Heterojunctions; TRANSISTORS, FIELD EFFECT—Ion Implantation; TRANSISTORS, FIELD EFFECT—Performance.

**096070 RELIABLE METHOD FOR 0.25-MICRON GATE MESFET FABRICATION USING OPTICAL PHOTOLITHOGRAPHY.** GaAs MESFETs with  $\frac{1}{4}$  micron ( $\mu\text{m}$ ) gate lengths recently have become commercially available. We have avoided costly and slow direct-write e-beam by developing a reliable optical lithography process with which we reproducibly make 0.25  $\mu\text{m}$  gate length MESFETs. Fabrication involves a bilayer technique incorporating positive photoresist image reversal and subsequent creation of an Al lift-off mask. The critical process step involves the controlled erosion of a reverse polarity 0.65  $\mu\text{m}$  positive photoresist line to 0.25  $\mu\text{m}$ . The final line length is reproducible to within  $\pm 10\%$ . We fabricated  $0.25 \times 300$ , 200 and 150  $\mu\text{m}$  gate MESFETs. The typical wafer yield is 50% with a gate length uniformity of  $\pm 10\%$  across a 2 inches diameter wafer. Using this process, we obtained 12 dB gain @ 24 GHz for  $0.25 \times 150 \mu\text{m}$  FETs. 9 refs.

Cantos, B.D. (Watkins-Johnson Co, Palo Alto, CA, USA); Remba, R.D. *J Electrochem Soc* v 135 n 5 May 1988 p 1311-1312.

**096071 GAAS MESFET LASER-DRIVER IC FOR 1.7-GBIT/S LIGHTWAVE TRANSMITTER.** GaAs monolithic integrated circuits for modulating junction lasers (laser drivers) have been developed for a 1.7-Gb/s lightwave communication system. The modulation currents can be varied continuously from a few mA up to 50 or 100 mA, depending on the types of laser drivers. It has been demonstrated that devices of the low-current type are capable of driving a 50- $\Omega$  load with a 50-mA modulation current with pulse rise and fall times (10% to 90%) less than 200 ps, and the high-current devices are capable of driving a 25- $\Omega$  load with up to 100-mA modulation current with pulse rise and fall times less than 250 ps. Nearly temperature-independent performance has been achieved from 0°C to 70°C. The laser drivers are also capable of providing output DC currents proportional to the duty cycle of input data for the purpose of duty-cycle-independent feedback control of junction lasers. The circuit designs and performance of these devices are

described. 5 refs.

Chen, F.S. (AT&T Bell Lab, Murray Hill, NJ, USA); Bosch, F. *J Lightwave Technol* v 6 n 3 Mar 1988 p 475-479.

**Heterojunctions** See TRANSISTORS, FIELD EFFECT—Millimeter Waves.

**Ion Implantation** See Also TRANSISTORS, FIELD EFFECT—Fabrication.

**096072 IMPROVED MODFET PERFORMANCE THROUGH ION IMPLANTATION IN THE GATE REGION.**  $\text{Al}_x\text{Ga}_{1-x}\text{As}/\text{GaAs}$  modulation-doped FETs (MODFETs) are reported which utilize low-dose p-type implantation under the gate region to improve the source-drain breakdown voltage. The gate-channel forward turn-on and reverse breakdown voltages are also improved due to this construction. Extremely low output conductances of less than 0.2 mS/mm were obtained with open-circuit voltage gains exceeding 250. Such improvements are important for achieving high RF power in microwave device applications, and have similarly significant implications for digital circuitry. The enhanced gate characteristics are thought to arise because the net donor concentration under the gate region is reduced due to the implanted p-type ions. The improved output conductance and drain breakdown may in part also be due to the fact that during annealing, the implanted ions diffuse laterally to the drain region. This results in a further reduction and grading of the net donor concentration in the region between the gate and the drain. 11 refs.

Lam, Christine S. (MIT, Cambridge, MA, USA); Fonstad, Clifton G. *IEEE Electron Device Lett* v EDL-8 n 12 Dec 1987 p 563-565.

**Junctions** See TRANSISTORS, FIELD EFFECT.

**Low Temperature Effects**

**096073 GALLIUM-ARSENIDE E- AND D-MESFET DEVICE NOISE CHARACTERISTICS OPERATED AT CRYOGENIC TEMPERATURES WITH ULTRALOW DRAIN CURRENT.** The low-frequency noise characteristics of GaAs MESFETs operating at very low power and at cryogenic temperatures of 77 and 10 K as well as at room temperature are discussed. A self-aligned gate and a buried p-layer were incorporated to maximize device gain and minimize low-frequency noise. Measurements at 77 K show a noise voltage spectral density of 1.0-2.0  $\mu\text{V}/\sqrt{\text{Hz}}$  at 1.0 Hz (referred to the transistor input) with a drain current of 1.0  $\mu\text{A}$ . 9 refs.

Sato, R.N. (Hughes Aircraft Co, El Segundo, CA, USA); Sokolich, M.; Doudounopoulos, Nicholas; Duffey, J.R. *IEEE Electron Device Lett* v 9 n 5 May 1988 p 238-240.

**Manufacture**

**096074 UNIFORMITY OF THRESHOLD VOLTAGE FOR MESFETs FABRICATED ON VGF GaAs SUBSTRATES.** Improved uniformity of threshold voltage is shown for MESFETs fabricated on GaAs substrates grown by a novel vertical gradient freeze technique when compared to devices fabricated on LEC GaAs substrates. The improved uniformity is most likely related to the decreased dislocation density and reduced impurity clustering in the VGF material. (Author abstract) 17 refs.

Reynolds, C.L. (AT&T, Reading, PA, USA); Gibson, W.C.; Clemans, J.E. *Electron Lett* v 23 n 23 Nov 5 1987 p 1222-1223.

**Mathematical Models** See Also TRANSISTORS, FIELD EFFECT—Electronic Properties; TRANSISTORS, FIELD EFFECT—Ion Implantation; TRANSISTORS, FIELD EFFECT—Noise.

**096075 TWO-DIMENSIONAL NUMERICAL MODELING OF HEMT USING AN ENERGY TRANSPORT MODEL.** A two-dimensional numerical computer simulation based on the analysis of the first three moments of the Boltzmann equation, known as the

energy-transport model, has been used to study various two-dimensional effects on the performance of  $\text{AlGaAs}/\text{GaAs}$  heterostructure field-effect transistor. The results are presented for half-micron gate length. The calculation reveals significant electron current contribution coming from the  $\text{AlGaAs}$  region between the source and gate, contributing to the reduction of access resistance. As the electrons acquire large energies near the drain side edge of the gate, real-space transfer to the  $\text{AlGaAs}$  region from the 'two-dimensional' electron gas channel occurs. However, at the drain end, the electron current is confined at the  $\text{GaAs}$  side of the heterointerface. The result shows insignificant current contribution from regions of depth greater than 0.048  $\mu\text{m}$  into the undoped  $\text{GaAs}$  bulk. (Edited author abstract) 14 refs.

Buot, F.A. (US Naval Research Lab, Washington, DC, USA). *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 1 Mar 1987 p 45-52.

**096076 IMPROVED MODFET PERFORMANCE THROUGH GATE CURRENT CONTROL.** Using an improved physical theory of the gate current in MODFETs the authors were able to decrease the gate current in the devices. By using an  $\text{AlAs}$  spacer layer, the turn-on voltage of the devices (i.e., the voltage at which the gate current density reaches  $5 \mu\text{A}/\mu\text{m}^2$ ) was increased to 1.2 V. This improvement increased the noise margin in an inverter with a fanout of one to greater than 500 mV at room temperature, and greater than 300 mV at 170°C. The lower gate current allowed the extrinsic transconductance ( $G_m$ ) to peak at a higher gate voltage, which resulted in a higher peak  $G_m$ . The average  $G_m$  for a 1- $\mu\text{m}$  FET over a 3-in. wafer reached 286 mS/mm. Here, the model for the gate current in MODFET devices and data from MODFETs fabricated with  $\text{AlAs}$  spacer layers are presented.

Ruden, P.P. (Honeywell Physical Science Cent, Bloomington, MN, USA); Han, C.J.; Chen, C.H.; Baier, S.; Arch, D.K. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2356.

**096077 DEFORMABLE-CHANNEL MODEL - A NEW APPROACH TO HIGH-FREQUENCY MESFET MODELING.** A model is presented for the ac response of a GaAs MESFET under saturated-channel conditions. High-frequency small-signal circuit parameters are evaluated by including transit-time effects in a rigorous way through a study of induced shape changes in the saturated-channel regions. Results agree well with empirical equivalent-circuit parameters for a physical MESFET. 12 refs.

Crowne, Frank (Martin Marietta Lab, Baltimore, MD, USA); Eskandarian, Abdollah; Sequeira, Brian; Jakhete, Rajendra. *IEEE Trans Microwave Theory Tech* v MTT-35 n 12 Dec 1987, 1987 MTT-S Int Microwave Symp, Las Vegas, NV, USA, Jun 9-11 1987 p 1199-1207.

**096078 LARGE-SIGNAL, ANALYTIC MODEL FOR THE GAAS MESFET.** An analytic, large-signal model for the GaAs MESFET is presented. The device model is physics-based and describes the conduction and displacement currents of the FET as a function of instantaneous terminal voltages and their time derivatives. The model allows arbitrary doping profiles in the channel and is thus suitable for the optimization of ion-implanted and buried-channel FETs. It also accounts for charge accumulation in the conducting channel at high electric fields and the associated capacitance in a self-consistent manner. Theoretical predictions of the model are correlated with experimental data on X-band power FETs and excellent agreement is obtained. 20 refs.

Khatibzadeh, M. Ali (North Carolina State Univ, Raleigh, NC, USA); Trew, Robert J. *IEEE Trans Microwave Theory Tech* v 36 n 2 Feb 1988 p 231-238.



**096079 MODELING OF BISTABLE DEVICE I-V CHARACTERISTIC RESULTING FROM CONDUCTIVITY MODULATION IN SEMICONDUCTORS.** The bistable I-V characteristic in a diode-like device structure that resembles the double-base diode is predicted by numerical solution. This bistable characteristic results from the conductivity modulation effect coupled with an ohmic voltage drop produced by the current through a shunt resistor. The back-surface field effect has a significant influence on the minority-carrier transport of this type of bistable I-V characteristic. A two-dimensional numerical simulation is performed to explore the steady-state bistable I-V characteristic including a negative dynamic conductance region. To better understand this mechanism, a DC equivalent circuit based on a one-dimensional current-flow model is proposed. The I-V characteristic obtained by this equivalent circuit agrees well with an exact two-dimensional numerical simulation result. 10 refs.

Son, Ilhun (Univ of Massachusetts, Amherst, MA, USA); Tang, Ting-Wei; Navon, David H. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 450-458.

**096080 COMPENSATION EFFECTS ON THE ELECTRON VELOCITY IN SUBMICROMETER GAAS MESFET'S.** The transient overshoot of the electron velocity for compensated GaAs is calculated using the Monte Carlo method. The transient electron velocity characteristics are compared for various compensation ratios. The influence of the compensation ratio on the GaAs MESFET structure was simulated using a two-dimensional Monte Carlo simulator. The drain current, transconductance, and channel electron velocity of submicrometer MESFETs are presented for various compensation ratios. 5 refs.

Grotjohn, Timothy A. (Michigan State Univ, E Lansing, MI, USA). *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1144-1145.

**Measurements** See SEMICONDUCTING SILICON—Electric Conductivity; TRANSISTORS, FIELD EFFECT—Electronic Properties.

**Microwaves** See Also TRANSISTORS, FIELD EFFECT—Fabrication.

**096081 TWO-DIMENSIONAL SIMULATION OF SUBMICROMETER GAAs MESFET'S: SURFACE EFFECTS AND OPTIMIZATION OF RECESSED GATE STRUCTURES.** The surface potential effect in GaAs MESFETs causes a depleted zone to form not only between the source and gate, but also between the gate and drain. The consequences of this phenomenon on the device behavior, the DC and AC characteristics, and the expected performance are studied. For this purpose, a two-dimensional resolution of the basic semiconductor equations is used. This model takes into account relaxation effects by including an energy relaxation equation. The dependence of MESFET characteristics such as transconductance, output conductance, and capacitance on the dimensions of the zone where surface potential effects occur is given. Some interesting conclusions concerning the optimization of recessed-gate structures are drawn. 21 refs.

Heliodore, Frederic (Cent Hyperfrequencies et Semiconducteurs, Villeneuve d'Ascq, Fr); Lefebvre, Marc; Salmer, Georges; El-Sayed, Osman L. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 824-830.

**Millimeter Waves**

**096082 ULTIMATE SCALING LIMITS FOR HIGH-FREQUENCY GAAs MESFET'S.** The scaling relationships of GaAs MESFETs are investigated by examining the dimensions and material parameters of devices fabricated over the past 22 years. Scaling rules are suggested that will account for the collected data. Extrapolation of the extracted scaling rules to very small geometries along with consideration of basic physical principles, suggests ultimate scaling limits for millimeter-wave GaAs MESFETs. 18 refs.

Golio, J. Michael (Motorola Government Electronics Group, Chandler, AZ, USA). *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 839-848.

**Modeling** See TRANSISTORS, FIELD EFFECT—Mathematical Models.

**Noise** See Also AMPLIFIERS—Theory.

**096083 MICROWAVE NOISE CHARACTERIZATION OF GAAS MESFET'S: EVALUATION BY ON-WAFER LOW-FREQUENCY OUTPUT NOISE CURRENT MEASUREMENT.** A simplified noise equivalent circuit is presented for submicrometer-gate-length MESFETs, in the common-source configuration, consisting of five linear circuit elements: the gate-to-source capacitance, the total input resistance, the transconductance, the output resistance, and a noise current source of spectral density at the output port. All of these elements can be determined by on-wafer measurements, and the noise current can be measured at a low frequency. The minimum noise figure of the device calculated from this model and bias and frequency dependence of the noise figure are shown to be in agreement with microwave noise figure measurements. This technique is then used for determination of the minimum noise figure of a device solely by on-wafer measurements rather than by microwave measurements. The proposed technique can be utilized rapidly, conveniently, without the need for tuning, and at the wafer stage of device fabrication. 21 refs.

Gupta, Madhu S. (Univ of Illinois, Chicago, IL, USA); Pitzalis, Octavius Jr.; Rosenbaum, Steven E.; Greiling, Paul T. *IEEE Trans Microwave Theory Tech* v MTT-35 n 12 Dec 1987, 1987 MTT-S Int Microwave Symp, Las Vegas, NV, USA, Jun 9-11 1987 p 1208-1218.

**096084 GATE CURRENT 1/F NOISE IN GAAS MESFET'S.** Gate current 1/f has been investigated on commercial GaAs MESFETs. It is found that devices with slight differences in drain current noise can have quite a difference on type of  $I_g$  versus  $V_{ds}$  and  $V_{gs}$  and even greater differences in the gate current noise. The 1/f part in the spectrum of the gate current is a better diagnostic tool for characterizing the quality of the junction than the drain current noise. A model that is based on a Schottky barrier shunted by edge currents are proposed to explain the experimental results. 7 refs.

Vandamme, Lode K.J. (Eindhoven Univ of Technology, Eindhoven, Neth); Rigaud, Dominique; Peransin, Jean-Marie; Alabedra, Robert; Dumas, Jean-Michel. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1071-1075.

**Optimization** See TRANSISTORS, FIELD EFFECT—Electric Properties.

**Performance** See TRANSISTORS, FIELD EFFECT—Microwaves.

**Radiation Effects**

**096085 IONIZING RADIATION HARDNESS OF GAAS TECHNOLOGIES.** The radiation response of several GaAs technologies to ionizing radiation has been investigated. Self-aligned gate (SAG) enhancement-depletion (E/D) GaAs metal semiconductor field-effect transistor (MESFET), SAG AlGaAs/GaAs modulation-doped FET (MODFET), and complementary-AlGaAs/GaAs heterostructure insulated gate FET (C-HIGFET) devices and circuits all demonstrated minimal sensitivity to total dose effects to 250 Mrad(GaAs). The heterostructure-based technologies showed superior tolerance to high-dose-rate exposures, with upset levels exceeding  $1 \times 10^{10}$  rad(GaAs)/s. 8 refs.

Listvan, M.A. (Honeywell Inc, Bloomington, MN, USA); Vold, P.J.; Arch, D.K. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1664-1668.

**096086 TRANSIENT RADIATION EFFECTS IN**

ALGAAS/GAAS MODFET'S. Transient radiation effects were measured in AlGaAs/GaAs MODFETs. The temperature dependence of the long-term transients was measured using 3-ns flash X-ray pulses, allowing the observation of trapping levels. These long-term transients were similar to those observed in conventional GaAs FETs, with the exception that persistent photoconductivity was observed in some devices. 16 refs.

Anderson, W.T. (US Naval Research Lab, Washington, DC, USA); Simons, M.; Tseng, W.F.; Herb, J.A.; Bandy, S. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1669-1675.

**Simulation**

**096087 ERROR INDICATION AND ADAPTIVE REFINEMENT IN SEMICONDUCTOR DEVICE SIMULATION.** Two error indicators for an elliptic problem are presented. The first is based on the solution of a local Neumann problem, and the second is the error in the gradient field. For semiconductor device simulation a hybrid error indicator with three components is presented. The first component arises from the discretization of the Poisson equation by the finite element method, and the other two components are the  $L_2$  norm of the error in the current densities. Examples of the adaptive scheme are provided for a p-n diode, a MESFET and a MOSFET. (Author abstract). 23 Refs.

Deljouie-Rakhsandeh, K. (STC Technology Ltd, Harlow, Engl); Deeley, E.M. *Int J Electron* v 65 n 2 Aug 1988 p 175-192.

**Spectrum Analysis**

**096088 OBSERVATION OF LARGE ABSORPTION MODULATION IN A QUANTUM-WELL FIELD-EFFECT DEVICE.** Deep quenching of absorption ( $\Delta\alpha > 10^4 \text{ cm}^{-1}$ ) over a 90-meV spectral range brought about by field-induced carriers has been observed directly for the first time at room temperature in a special AlInAs/GaInAs/AlInAs single quantum-well (SQW) MODFET for a modest gate voltage change from -0.6 to 1.5 V. Optical measurements were carried out in the 1.0- $\mu\text{m}$ -to-1.7- $\mu\text{m}$  range using the focused output from a monochromator. Photocurrent spectrum taken at zero bias shows characteristic absorption steps due to 2-D subbands. To investigate the effect of gate bias on the absorption spectrum, the light was focused onto the optical test pad through the substrate, reflected off the Cr/Au electrode, and was detected by a PbS photodetector. The gate-voltage induced modulation in the reflected light was measured using a lock-in amplifier. The measured difference spectrum clearly shows a large change at the position of  $n_s = 1$  exciton peaks with a maximum  $\Delta I/I$  of approximately 2%. This amounts to  $\Delta\alpha$  approximately  $10^4 \text{ cm}^{-1}$ , which corresponds to total quenching of the excitonic absorption. The observed absorption change is primarily due to the filling of the generalized phase space by free carriers. It is strong enough for detecting the logic state in SQW devices. 4 refs.

Chang, T.Y. (AT&T Bell Lab, Holmdel, NJ, USA); Kuo, J.M.; Bar-Joseph, I.; Miller, D.A.B.; Chemla, D.S. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2362-2363.

**Stresses** See TRANSISTORS, FIELD EFFECT—Electric Properties.

**Thermal Effects**

**096089 ENHANCED TEMPERATURE DEPENDENCE OF MESFET CHARACTERISTICS BY BACKGATE AND SIDEGATE BIASING.** An enhanced temperature dependence of drain saturation current as well as threshold voltage is observed for ion-implanted GaAs MESFET's when backgate or sidegate bias voltage is applied. By performing conductance DLTS measurement based on backgating effect of FETs, three kind of traps, namely Cr, HL4 and HL8, are



identified for the substrate prepared by Horizontal Bridgman method. Also three kind of traps, namely EL2, HL4 and HL8, are identified for the non-doped Liquid Encapsulated Czochalski (LEC) substrate. Simulation of the stationary characteristics of FETs is made at various temperature using a device model which includes both the depletion region at the n-i (channel-substrate) junction and influence of the deep traps. (Edited author abstract) 15 refs.

Ogawa, Matsuo (Kobe Univ, Kobe, Jpn). *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 9 Sep 1987 p 847-856.

## SEMICONDUCTOR DEVICES, GUNN EFFECT See SEMICONDUCTING GALLIUM ARSENIDE—Physical Properties.

## SEMICONDUCTOR DEVICES, MIS See Also DISPLAY DEVICES—Thin Films; INFRARED DETECTORS; OPTICAL DATA PROCESSING; SEMICONDUCTING GALLIUM COMPOUNDS; SEMICONDUCTING SILICON—Oxidation; SEMICONDUCTOR DIODES—Etching; SEMICONDUCTOR DIODES—Radiation Effects; SILICON COMPOUNDS—Chemical Vapor Deposition; SILICON NITRIDE—Chemical Vapor Deposition; SILICON NITRIDE—Thin Films; SOLAR CELLS—Silicon; TELECOMMUNICATION LINES—Microwaves.

Amorphous See SEMICONDUCTOR DIODES, TUNNEL—Testing.

## Applications

**096090 SENSING BEHAVIOR OF Pd-SnO<sub>x</sub> MIS STRUCTURE USED FOR OXYGEN DETECTION.** A new type of oxygen sensor with a Pd-SnO<sub>x</sub>-Si<sub>3</sub>N<sub>4</sub>-SiO<sub>2</sub>-Si-Al MIS structure has been developed, and is capable of detecting partial pressures of less than 0.1 Torr of O<sub>2</sub> at 300 K. The detection principle of this device is based on the changes in ionic charge of the SnO<sub>x</sub> film during oxygen adsorption and consequent changes in the flat-band voltage. Device fabrication processing, SnO<sub>x</sub> film composition, structure and electrical characterization are described briefly. The experimental results for the steady-state and transient behavior of the device are presented. The concentration of oxygen ions adsorbed in the MIS structure at a given temperature and oxygen pressure are measured by the triangular voltage sweep method, which confirmed a postulated detection mechanism. (Author abstract) 10 refs.

Kang, W.P. (Rutgers Univ, Piscataway, NJ, USA); Xu, J.F.; Lalevic, B.; Poteat, T.L. *Sens Actuators* v 12 n 4 Nov-Dec 1987, Pap Presented at the 2nd Int Meet on Chem Sens, Bordeaux, Fr, Jul 7-10 1986 p 349-366.

Degradation See TRANSISTORS, FIELD EFFECT—Degradation.

## Electronic Properties

**096091 ELECTROLUMINESCENCE OF CdS/LANGMUIR-BLODZHE/Au STRUCTURES.** Electroluminescence is discovered in metal-dielectric-semiconductor structures based on CdS and Langmuir films of stearic acid. A tunnel-injection mechanism of its excitation is established. The specific resistance of the substrate material is about 10 Ω·cm. The ohmic contact to the CdS was created by burning in indium, while the contact to the Langmuir layer was formed by spraying on gold in a vacuum of at least 10<sup>-6</sup> mm Hg. (Edited author abstract) 2 refs.

Georgobiani, A.N.; Rambidi, N.G.; Todua, P.A.; Sheshtakova, E.F.; Eltzazarov, B.T. *Sov Phys Lebedev Inst Rep* n 9 1987 p 60-62.

**096092 IMPROVEMENT OF THE ELECTRICAL PROPERTIES OF THE AlN/GaAs MIS SYSTEM AND THEIR THERMAL STABILITY BY GaAs SURFACE STOICHIOMETRY CONTROL.** The GaAs surface pre-treatment conditions for the MOCVD-AlN/GaAs MIS diodes are investigated. An AsH<sub>3</sub> pre-treatment just prior to the AlN deposition degraded the C-V characteristics of AlN/n-GaAs MIS diodes in the accu-

mulation side. The characteristics and their stability were drastically improved by a pure H<sub>2</sub> pre-treatment at 500°C. It was confirmed that the free As at the interface generates surface states near the conduction band edge and that control of the surface stoichiometry and atomic structure is necessary to improve the MIS characteristics. (Author abstract) 9 refs.

Fujieda, Shinji (NEC Corp, Kawasaki, Jpn); Mizuta, Masashi; Matsumoto, Yoshishige. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 296-299.

**096093 CAPACITANCE-VOLTAGE CHARACTERISTICS OF Hg<sub>1-x</sub>Cd<sub>x</sub>Te MIS DEVICES.** The C-V characteristics of N- and P-type Hg<sub>1-x</sub>Cd<sub>x</sub>Te (x=0.2~0.56) MIS devices fabricated with double dielectric layers consisting of anodic oxide and ZnS are studied. The nonparabolicity and degeneracy of Hg<sub>1-x</sub>Cd<sub>x</sub>Te conduction band are taken into account in the theoretical treatment based on Kane model. In calculating high frequency capacitance, the redistribution of minority carriers in the inversion layer is also considered. The C-V measurements are carried out within the frequency range of 20Hz ~ 10MHz and the temperature range of 26~200K. For Hg<sub>0.7</sub>Cd<sub>0.3</sub>Te MIS device, the results at 80K show that the fixed positive charge density is 8~10×10<sup>11</sup>cm<sup>-2</sup>, slow interface trap density 4~10×10<sup>10</sup>cm<sup>-2</sup>, and minimum fast surface state density 1.72×10<sup>11</sup>cm<sup>-2</sup>eV<sup>-1</sup>. (Author abstract) 9 refs. In Chinese.

Huang, He (Acad Sinica, China); Tong, Feiming; Tang, Dingyuan. *Hongwai Yanjiu A-Ji* v 7A n 2 1988 p 89-95.

## Electronic Properties

**096094 HOT HOLE CREATION DUE TO IMPACT EXCITATION IN THE METAL ELECTRODE OF A FORWARD BIASED MIS STRUCTURE.** A theoretical investigation is made of the process by which hot electrons in a metal cause impact excitation of the electrons in the Fermi sea to create a hot hole population. Expressions for the energy and velocity distributions of the holes are obtained for a metal with a spherical Fermi surface, assuming Thomas-Fermi screening. A simple model is used to calculate the probability that an electron injected into the metal, from the insulator of a metal-insulator-semiconductor (MIS) diode, can create a hole capable of reaching the MI interface. The theory is applied to an electroluminescent Au/i-ZnS/n-ZnS MIS structure and the hole flux at the metal-insulator interface is calculated. The results show that the impact excitation model provides a plausible explanation of the behavior of the electroluminescent efficiency of such MIS diodes. (Author abstract) 24 refs.

Jones, R.E. (Univ of Durham, Durham, Engl); Abram, R.A. *Solid State Electron* v 31 n 5 May 1988 p 989-997.

Fabrication See OXIDES—Electronic Properties; SEMICONDUCTOR DEVICE MANUFACTURE—Process Control.

Heterojunctions See LASERS, SEMICONDUCTOR—Materials; TRANSISTORS, BIPOLAR—Heterojunctions.

## Mathematical Models

**096095 BULK LEVELS AND INTERFACE CALCULATIONS FOR NARROW BAND-GAP SEMICONDUCTORS.** Accurate small-signal low and high frequency capacitance-voltage characteristics of Metal-Insulator-Semiconductor (MIS) devices in narrow band-gap semiconductors are presented. The unique physical features of narrow band-gap semiconductors are incorporated simultaneously in the calculations: the nonparabolicity of the conduction band, degeneracy in the occupancy of the free carriers and compensated and partially ionized impurities or defects. Accurate high frequency characteristics are calculated by taking into account minority carriers redistribution which causes polarization of the inversion layer. The analysis presented describes MIS capacitance curves in terms of the detailed bulk band structure. This approach is important for defect

semiconductors such as HgCdTe. (Author abstract) 8 refs.

Bloom, I. (Technion-Israel Inst of Technology, Haifa, Isr); Nemirovsky, Y. *Solid State Electron* v 31 n 1 Jan 1988 p 17-25.

## Measurements

**096096 MEASUREMENT OF THE PARAMETERS OF MIS STRUCTURES WITH COMPENSATION OF THE EFFECT OF THE CAPACITANCE OF THE DIELECTRIC.** A scheme for measuring the parameters of an MIS structure excited by a low-amplitude impulsive signal is described. The measurements are performed under conditions of compensation of the capacitance of the dielectric. The scheme enables measurement of the capacitance of a semiconductor in the range 2-2000 pF with the capacitance of the dielectric varying from 5 to 500 pF and a surface state recharging time of the constant states varying from 30 to 300 μsec with a reduced error of ±3%. (Author abstract) 5 refs.

Chaikovskii, V.M. (Penza Polytechnic Inst, USSR). *Instrum Exp Tech* v 30 n 3 pt 2 May-Jun 1987 p 709-712.

## Modeling

**096097 USING THE METHOD OF INTEGRAL DYNAMIC VOLT-AMPERE CHARACTERISTICS TO STUDY IONIC INSTABILITY IN MIS DEVICES.** The method of dynamic volt-ampere characteristics (DVAC) is one of the most popular for measuring electrical relaxation and ion drift in the insulating layers of MIS devices. With this method the basic current that arises when a linear voltage is applied to an MIS device is measured and the number of mobile ions in the insulator is found by integrating the measured current with respect to voltage. An improved method of recording a DVAC is examined here and consists of measuring the integral of current with respect to voltage directly (integral DVACs, or IDVACs). The IDVAC method is used to measure the number of mobile ions at elevated temperatures in SiO<sub>2</sub> and SiO<sub>2</sub>+fluorine-bearing layers on silicon and corrosion-resistant alloys with aluminum and polysilicon electrodes. 6 refs.

Volkov, S.A. (Acad of Sciences of the USSR, USSR); Kol'tsov, B.B.; Lutsenko, G.N.; Ovsyuk, V.N. *Sov Microelectron* v 16 n 3 May-Jun 1987 p 144-147.

## Optical Properties

**096098 REFLECTOMETRY MEASUREMENT OF OPTICAL PARAMETERS OF Au/SiO<sub>2</sub>/Si FILMS.** A new insight into the analysis of multiple-angle reflectometry measurements has led to unambiguous measurements of the thickness and optical constants of thin films. These were deposited as the metal layer of metal/oxide/silicon structures. The method involves finding suitable wavelength(s) and angles for which variations in the calculated reflectivity ratio (R<sub>p</sub>/R<sub>s</sub>), caused by assuming different thicknesses, cannot be compensated for by assuming different optical constants. For each condition, the thickness is determined from measurements made at one wavelength. The gold thickness determinations are believed to be accurate to ±0.3 nm and the optical constants are consistent with those of other workers using simple gold-substrate systems. (Author abstract) 15 refs.

Miller, L.S. (Coventry Polytechnic, Coventry, Engl); Walder, A.J.; Linsell, P.; Blundell, A. *Thin Solid Films* v 156 n 1 Jan 15 1988 p 11-20.

Performance See Also TRANSISTORS, FIELD EFFECT—Heterojunctions.

**096099 GaAs MIS STRUCTURES WITH SiO<sub>2</sub> USING A THIN SILICON INTERLAYER.** The introduction of a pseudomorphic Si interlayer, about 1.0 nm thick, is found to improve the MIS characteristics of the SiO<sub>2</sub>/GaAs system. Quasistatic and high-frequency capacitance/voltage data from such a novel capacitor structure on n-GaAs indicate that the surface of the GaAs is swept from inversion to accumulation. X-ray photoelectron



spectroscopy and ion scattering spectroscopy confirm the presence of the Si layer and its complete coverage of the GaAs surface. The Si layer minimizes the formation of any detrimental native oxides and thus controls the chemical nature of the GaAs surface. This approach has implications in the development of metal-insulator-semiconductor systems in general. (Edited author abstract.) 11 Refs.

Fountain, G.G. (Research Triangle Inst, Research Triangle Park, NC, USA); Hattangady, S.V.; Vitkavage, D.J.; Rudder, R.A.; Markunas, R.J. *Electron Lett* v 24 n 18 Sep 1 1988 p 1134-1135.

## Physical Properties

**096100 ELECTROPHYSICAL PROPERTIES OF METAL-DIELECTRIC-SEMICONDUCTOR STRUCTURES OF CdS LANGMUIR-BLODZHE FILM/Au.** The electrophysical properties of metal-dielectric-semiconductor structures with an insulating multimolecular layer of stearic acid formed on CdS through the Langmuir-Blodzhe technology are investigated. The volt-ampere and volt-Faraday characteristics of the structures point to a tunnel-injection mechanism for current flow. (Author abstract) 4 refs.

Georgobiani, A.N.; Rambidi, N.G.; Todua, P.A.; Sheshtakova, E.F.; Eltazarov, B.T. *Sov Phys Lebedev Inst Rep* n 9 1987 p 55-59.

**Semiconductor Insulator Boundaries** See Also SEMICONDUCTING INDIUM COMPOUNDS—Heat Treatment.

**096101 InP NATIVE OXIDE: A DRIFT FACTOR IN InP-MIS.** It is shown that a native oxide in a InP-MIS structure is a key parameter in the time instability of the device. This is demonstrated in experiments on Al/SiO<sub>2</sub>/native oxide/InP structures with different native oxide thicknesses. A minimum of the flat-band voltage drift is observed for thicknesses close to 30 Å. A model which considers traps distributed as a continuum of states in the insulator and tunneling with the InP surface channel is consistent with these results. (Author abstract) 14 refs.

Pham, V.V. (Lab d'Automatique et d'Analyse des Systemes, Toulouse, Fr); Esteve, D.; Farre, J.; El Mahdy, A.; Ronda, M.; Simonne, J.J. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 83-88.

**096102 REDUCTION OF THE CONCENTRATION OF SLOW INSULATOR STATES IN SiO<sub>2</sub>/InP-MIS STRUCTURES.** In this paper we will discuss the influence of the deposition temperature, the spatial separation of sample and plasma ('indirect plasma method'), and the addition of phosphorus into the reaction chamber during the initial period of insulator deposition on the properties of n-type and p-type InP-MIS capacitors. Plasma-enhanced chemical vapor deposited silicon dioxide is used as insulator. The samples were characterized by means of capacitance/voltage (C(V)) and deep level transient spectroscopy (DLTS) measurements. Only minor hysteresis of the C(V) curves and concentrations of slow insulator states of only  $(1-2) \times 10^{11} \text{ cm}^{-2} \text{ eV}^{-1}$  are measured for the best of our samples. (Edited author abstract) 4 refs.

Kulisch, W. (Univ of Kassel, Kassel, West Ger); Rombach, H.; Kassing, R. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 89-94.

**096103 Hg<sub>0.7</sub>Cd<sub>0.3</sub>Te/SiO<sub>2</sub>-PHOTOX INTERFACE PROPERTIES STUDIED BY PHOTO- AND BIAS-INDUCED CHARGING.** We have investigated the effects of light illumination in the wavelength range 1 μm to 2200 Angstrom (with and without DC bias) on the Hg<sub>0.7</sub>Cd<sub>0.3</sub>Te (n-type)/SiO<sub>2</sub>-Photox interface at 77 K in the metal-insulator-semiconductor device configuration. Illumination of wavelength λ without bias produced a flatband shift ( $\Delta U_{fb}$ ) towards positive values. The saturation value of  $\Delta U_{fb}$  has a pronounced peak at λ = 2800 Angstrom and is negligible for λ ≥ 5100 Angstrom. The

light-induced charge is maintained for at least 8 h at 77 K but leaks off if the device is heated briefly to 300 K. We propose a model to explain these results involving light-induced charging and discharging of very slow trap states in the Si 2-Photox (at or near the interface) with an energy distribution centered about 4.5 eV above the oxide valence band. (Edited author abstract) 9 refs.

Ksendzov, A. (Brooklyn Coll, Brooklyn, NY, USA); Pollak, Fred H.; Wilson, J.A.; Cotton, V.A. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 834-839.

## Spectroscopic Analysis

**096104 InP-SiO<sub>2</sub> METAL-INSULATOR-SEMICONDUCTOR STRUCTURE PARAMETERS INVESTIGATED WITH DLTS AND OTHER CAPACITANCE TECHNIQUES.** In this paper, we report the study of an n-type InP-SiO<sub>2</sub> Metal-Insulator-Semiconductor structure by means of Deep Level Transient Spectroscopy and two complementary techniques: Capacitance versus Voltage and Conductance versus Frequency measurements. We have observed two bulk traps probably related to impurities in the InP crystal. Majority carrier interface states have been studied: the three methods bring similar density profiles showing a minimum value about  $10^{12} \text{ eV}^{-1} \text{ cm}^{-2}$  in the energy range 0.4-0.7 eV below the conduction band edge. Moreover, we have detected a 'missing Phosphorus' interface level at 0.3 eV below the conduction band with a density about  $4 \times 10^{10} \text{ cm}^{-2}$ . (Author abstract) 15 refs.

Bogdanski, P. (Univ de Caen-ISMRA, Caen, Fr); Murray, F.; Piel, J.P. *Solid State Commun* v 64 n 4 Oct 1987 p 411-416.

**Theory** See TRANSISTORS, FIELD EFFECT—Theory.

**Transport Properties** See TRANSISTORS, FIELD EFFECT—Transport Properties.

**Tunneling** See Also TRANSISTORS—Analysis.

**096105 INELASTIC ELECTRON TUNNELING SPECTROSCOPY OF Si MIS STRUCTURES WITH ULTRATHIN THERMAL SILICON NITRIDE AND THERMAL SILICA.** Inelastic electron tunneling spectroscopy (IETS) has proved useful for the study of the vibrational spectra of a range of molecular group compounds. In this technique the interaction between tunneling electrons and phonons including longitudinal and local-mode ones is used. Tunneling in boron-doped p-type silicon-insulator-semiconductor (MIS) tunnel junctions was studied at low temperatures by measuring the second derivative ( $d^2I/dU^2$ ) of the current voltage characteristics as a function of applied bias voltage (U). The vibrational spectra of the thermal silica and thermal silicon nitride was studied. (Edited author abstract.) 36 Refs.

Kovchayev, A.P. (Acad of Sciences of the USSR, Novosibirsk, USSR); Kurishev, G.L.; Postnikov, K.O.; Sokolov, R.A.; Subbotin, I.M. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 669-674.

## SEMICONDUCTOR DEVICES, MISFET

### Analysis

**096106 STUDIES ON AN In<sub>0.53</sub>Ga<sub>0.47</sub>As/In<sub>0.52</sub>Al<sub>0.48</sub>As SINGLE-QUANTUM-WELL QUASI-MISFET.** The authors describe the properties of a novel InGaAs/InAlAs quasi-MISFET in which an inverted modulation-doped single quantum well forms the channel and an undoped semi-insulating InAlAs constitutes the gate barrier. The entire structure is grown lattice-matched to InP continuously by molecular-beam epitaxy in a single step. Rapid thermal annealing of implanted semiconductors and ohmic contacts have been investigated and have been used successfully in the fabrication of the MISFETs. Improved performance is obtained with the incorporation of Ti in the source-drain metallization, with which contact resistances as low as 0.1 Ω mm are measured. 31 refs.

Seo, Kwang S. (Univ of Michigan, Ann Arbor, MI, USA); Bhattacharya, Pallab K. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2221-2231.

**Applications** See INTEGRATED CIRCUITS—Fabrication.

### Fabrication

**096107 Ga<sub>0.47</sub>In<sub>0.53</sub>As DEPLETION MODE MISFETs WITH NEGLIGIBLE DRAIN CURRENT DRIFT.** Ga<sub>0.47</sub>In<sub>0.53</sub>As depletion-mode metal insulator semiconductor field-effect transistors with a transconductance in the range 100-140 mS/mm and with no significant current drift (less than 3 percent in 30 hours) have been fabricated on epitaxial layers grown by MOCVD. This high performance has been achieved using an efficient passivation of the GaInAs surface which associates in situ native oxide removal by a hydrogen multipolar plasma and a Si<sub>3</sub>N<sub>4</sub> film deposition. (Author abstract.) 7 Refs.

Renaud, M. (Lab d'Electronique et de Physique Appliquee, Limeil Brevannes, Fr); Heyen, M.; Schmitz, Boher, P.; Schneider, J.; Barrier, J. *Electron Lett* v 24 n 12 Jun 9 1988 p 750-752.

**096108 In<sub>0.52</sub>Al<sub>0.48</sub>As/N<sup>+</sup>-In<sub>0.53</sub>Ga<sub>0.47</sub>As MISFET WITH A HEAVILY DOPED CHANNEL.** An In<sub>0.52</sub>Al<sub>0.48</sub>As/n<sup>+</sup>-In<sub>0.53</sub>Ga<sub>0.47</sub>As MIS-type field-effect transistor (FET) with a channel doped at a  $7 \times 10^{17} \text{ cm}^{-3}$  level has been fabricated on an InP substrate. A device with a 2-μm channel length has yielded a maximum transconductance of 152 mS/mm,  $f_T = 12.4 \text{ GHz}$ , and  $f_{max} = 50 \text{ GHz}$ . At 10 GHz, the maximum available gain is 17.4 dB. The performance of this device shows that heavily doped channel FETs are very promising for high-frequency operation. 17 refs.

Del Alamo, Jesus A. (NTT, Atsugi, Jpn); Mizutani, Takashi. *IEEE Electron Device Lett* v EDL-8 n 11 Nov 1987 p 534-536.

**096109 PSEUDOMORPHIC ZnSe/GaAs MISFET DEVICES.** ZnSe (a zincblende semiconductor with a room temperature bandgap of 2.7 eV) is used as the insulator in a working GaAs MISFET device. A coherent, dislocation-free ZnSe/GaAs heterointerface has been obtained by molecular-beam epitaxy (MBE) of pseudomorphic ZnSe onto as-grown GaAs MBE epilayers. The small (0.25%) lattice constant mismatch between ZnSe and GaAs allows for the growth of 1000-angstrom insulating layers devoid of strain-relieving misfit dislocations. Nucleation on MBE-grown epilayers results in a layer-by-layer growth. High-resolution transmission electron microscopy examining the interfacial region of the pseudomorphic ZnSe/GaAs epilayer heterojunction confirms the existence of the coherent interface such that the lattice constant in the plane of the layers is the same for the two materials. Having the capability of achieving a nearly perfect epitaxial interface has allowed for the fabrication of a GaAs MISFET device. MIS capacitors were used to determine the n-channel thickness and doping. The I-V characteristics of the MISFET devices were measured at room temperature and 77K. This II-VI/III-V heteroepitaxial interface has all the potential of the AlGaAs/GaAs structure with the additional advantage of larger band discontinuities.

Studtmann, G.S. (Purdue Univ, West Lafayette, IN, USA); Gunshor, R.L.; Kolodziejczyk, L.A.; Mellock, M.R.; Otsuka, N.; Munich, D.P.; Cooper, J.A.; Pierret, R.F. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2378.

**096110 HIGH-TRANSCONDUCTANCE HETEROSTRUCTURE Ga<sub>0.47</sub>In<sub>0.53</sub>As/InP METAL-INSULATOR-SEMICONDUCTOR FIELD-EFFECT TRANSISTORS GROWN BY CHEMICAL BEAM EPITAXY.** The SiO<sub>2</sub> insulator is on top of an InP layer; current transport occurs, however, in an adjacent n-type



Ga<sub>0.47</sub>In<sub>0.53</sub>As:Sn layer. A transconductance of  $g_m = 300$  mS/mm is obtained from depletion-mode MISFETs with a gate length of 1.2  $\mu$ m. This MIS (metal-insulator-semiconductor) junction has a symmetric current-voltage characteristic and a low leakage current of 10 nA at  $\pm 2$  V. High-frequency S-parameter measurements performed by probing devices on the wafers yield a unity current gain frequency of  $F_t = 22.2$  GHz and a maximum frequency of oscillation  $f_{max} = 27$  GHz. 8 refs.

Schubert, E. Frederic (AT&T Bell Lab, Murray Hill, NJ, USA); Tsang, W.T.; Feuer, M.D.; Mankiewicz, P.M. *IEEE Electron Device Lett* v 9 n 3 Mar 1988 p 145-147.

**096111 p-CHANNEL QUANTUM-WELL HETEROSTRUCTURE MISFET.** A p-channel heterostructure MISFET-like device based on a quantum well with an underlying impurity layer is discussed. The device is based on an AlGaAs/GaAs heterostructure with a recessed-gate geometry and uses Zn-diffused refractory-metal contacts. The 4100 cm<sup>2</sup>/V-s hold mobility obtained in this inverted-interface structure at 77 K is comparable to that achieved in normal-interface AlGaAs/GaAs heterostructures. Transconductance and K-factor values as high as 52 mS/mm and 140 mS/V-mm, respectively, are obtained at 77 K in p-channel FETs with 2.0- $\mu$ m gate lengths and 6.0  $\mu$ m source-drain spacings, representing state-of-the-art values for p-HFETs at similar dimensions. 12 refs.

Kiehl, Richard A. (IBM, Yorktown Heights, NY, USA); Tiwari, Sandip; Wright, Steven L.; Olson, M.A. *IEEE Electron Device Lett* v 9 n 6 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 309-311.

## Heterojunctions

**096112 HIGH-PERFORMANCE WN-GATE MISFETs FABRICATED FROM MOVPE WAFERS.** WN-gate heterojunction MISFETs with an AlGaAs layer as insulator have been fabricated on MOVPE wafers; they exhibit high transconductance (up to 460 mS/mm) and high  $V_t$  uniformity. (Author abstract) 5 refs.

Wolny, M. (Lab d'Electronique et de Physique Appliquee, Limel-Brevannes, Fr); Aguilu, T.; Deconinck, P.; Moroni, D.; Andre, J.P. *Electron Lett* v 23 n 21 Oct 8 1987 p 1127-1128.

## Materials

**096113 SHORT- AND LONG-TERM RELIABILITY OF NITRIDED OXIDE MISFETs.** The short- and long-term reliability of thin nitrided oxide (oxynitride) films is studied. Tests conducted on several oxynitride films fabricated under various nitridation conditions show that (1) the defect density of thin (5-nm) oxynitride film is very low; (2) oxynitride MISFETs exhibit less transconductance degradation due to hot-carrier injection than oxide MISFETs; (3) these thin films have superior time-dependent dielectric breakdown characteristics; and (4) the electron traps in oxynitride film are drastically reduced by annealing in an O<sub>2</sub> gas atmosphere. 4 refs.

Kaga, Toru (Hitachi Ltd, Kokubunji, Jpn); Hagiwara, Takaaki. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 929-934.

## Radiation Effects

**096114 IONIZING RADIATION EFFECTS IN N-CHANNEL (HG,Cd)TE MISFETs WITH ANODIC SULFIDE PASSIVATION.** The effect of ionizing radiation, up to a dose of  $1.6 \times 10^5$  rad(ZnS), on n-channel (Hg,Cd)Te MISFETs, fabricated using anodic sulfide/ZnS insulators, has been investigated. Devices were irradiated under dc bias at 78K. Radiation-induced threshold-voltage shifts, degraded transconductance, and decreased subthreshold current gate voltage slopes were observed. For all but the most negative biases during irradiation threshold voltage shifts (a maximum of  $-6.0$  V at  $1.6 \times 10^5$  rad(ZnS)) are associated with net hole trapping with evidence for trapping near the interface for zero applied field during irradiation. Evidence of electron

trapping was observed for large negative biases during irradiation. The radiation-induced degradation in transconductance is attributed to surface mobility reduction (30% after  $1.6 \times 10^5$  rad(ZnS)) associated with scattering from interface charge. The decreased subthreshold slope (82 mV/decade at 50K after  $1.0 \times 10^5$  rad(ZnS)) is attributed to modification of the preirradiation gate voltage-surface-potential relationship by radiation-induced interface traps. 22 refs.

Waterman, James R. (US Naval Research Lab, Washington, DC, USA); Schiebel, R.A. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1597-1601.

## Semiconductor Insulator Boundaries

**096115 InP METAL-INSULATOR-SEMICONDUCTOR FIELD-EFFECT TRANSISTORS USING VACUUM-EVAPORATED FILMS.** Because of high electron mobility in FETs using III-V compound semiconductors, extensive research has been made on these devices for high-speed logic circuits. Among these compound semiconductors, InP is suitable for the MIS FET unlike GaAs. This is because in InP the interface state is lower than  $10^{12}$  cm<sup>-2</sup> eV<sup>-1</sup> and the Fermi level at the interface is located near the conduction band. The characteristics of the interface between InP and an insulator was investigated using an MIS structure on an InP substrate fabricated by using vacuum-evaporated SiO or ZnS for the gate insulator and vacuum-evaporated aluminum for the gate electrode. The mobility of the device was influenced strongly by the activation temperature of the ion-implanted substrate. When the activation temperature was increased from 660°C to 700°C, the mobility decreased. This mobility decrease is considered to be due to Coulomb scattering in the channel. (Edited author abstract) 9 refs.

Takagi, Shinichi (Tokyo Univ, Tokyo, Jpn); Sugano, Takuo. *Electron Commun Jpn Part 2* v 71 n 2 Feb 1988 p 106-112.

**SEMICONDUCTOR DEVICES, MOS** See Also AUTOMOBILES—Electronic Equipment; COMPUTERS—Multiplying Circuits; COMPUTERS, ANALOG—Multiplying Circuits; COMPUTERS, MICROCOMPUTER; COMPUTERS, MICROCOMPUTER—Design; DATA CONVERSION, ANALOG TO DIGITAL—Components; DATA CONVERSION, ANALOG TO DIGITAL—Sampling; DATA CONVERSION, DIGITAL TO ANALOG—Random Access; DATA STORAGE, DIGITAL—Fixed; DATA STORAGE, DIGITAL—Random Access; DATA STORAGE, SEMICONDUCTOR—Design; DATA STORAGE, SEMICONDUCTOR—Fabrication; DATA STORAGE, SEMICONDUCTOR—Storage Devices; ELECTRIC FILTERS—Design; ELECTRIC FILTERS, LOW PASS—Design; ELECTRIC SWITCHES, SEMICONDUCTOR; ELECTRONIC CIRCUITS, COMPARATOR; ELECTRONIC CIRCUITS, MULTIVIBRATOR—Design; FILMS—Dielectric; FLOW OF FLUIDS—Sensors; IMAGE SENSORS—Electronics Packaging; INTEGRATED CIRCUIT MANUFACTURE—Performance; INTEGRATED CIRCUIT TESTING—Efficiency; INTEGRATED CIRCUITS; INTEGRATED CIRCUITS—Design; INTEGRATED CIRCUITS—Microscopic Examination; INTEGRATED CIRCUITS—Radiation Protection; INTEGRATED CIRCUITS, DIGITAL—Attenuation; INTEGRATED CIRCUITS, DIGITAL—Performance; INTEGRATED CIRCUITS, DIGITAL—Synthesis; INTEGRATED CIRCUITS, MONOLITHIC; INTEGRATED CIRCUITS, MONOLITHIC—Mathematical Models; INTEGRATED CIRCUITS, MONOLITHIC—Performance; INTEGRATED CIRCUITS, VLSI; INTEGRATED CIRCUITS, VLSI—Analysis; INTEGRATED CIRCUITS, VLSI—Computer Aided Design; INTEGRATED CIRCUITS, VLSI—Fabrication; INTEGRATED CIRCUITS, VLSI—Performance; INTEGRATED CIRCUITS, VLSI—Testing; LOGIC CIRCUITS—Performance; LOGIC CIRCUITS—Testing; LOGIC DEVICES; LOGIC DEVICES—Gates; MICROSCOPIC EXAMINATION—Scanning Electron Microscopy; MULTIPLEXING EQUIPMENT; OSCILLATORS—Performance; OSCILLATORS, SOLID STATE—Mathematical Models; REFRACTORY METALS—Transport Properties; RESISTORS—Design; SEMICONDUCTING FILMS—Chemical Vapor Deposition; SEMICONDUCTING GALLIUM ARSENIDE—Electric Properties; SEMICONDUCTOR DEVICES—Switching; SEMICONDUCTOR DEVICES, BIPOLAR; SEMICONDUCTOR DEVICES, FIELD EFFECT—Degradation; SEMICONDUCTOR DEVICES, MOSFET; SEMICONDUCTOR MATERIALS—Doping; SEMICONDUCTOR MATERIALS—Impurities; SILICA—Ion Implantation; THYRISTORS—Computer Simulation; THYRISTORS—Control; THYRISTORS—Performance; THYRISTORS—Space Applications; TRANSISTORS, BIPOLAR; TRANSISTORS, FIELD EFFECT—Analysis; TRANSISTORS,

FIELD EFFECT—Fabrication; TRANSISTORS, FIELD EFFECT—Noise; TRANSISTORS, FIELD EFFECT—Physical Properties; TRANSISTORS, FIELD EFFECT—Stability; TRANSISTORS, FIELD EFFECT—Switching.

**096116 INTEL'S RADICAL REDESIGN DOUBLES 8096 THROUGHPUT.** Among various 16-bit microcontrollers a radically redesigned CMOS version of Intel's 8096 chip is introduced. The new 80C196 will double the performance of the 8096 in many applications, while adding new features that broaden design options. And for many math-intensive operations, throughput is tripled. The 1.5- $\mu$ m double-metal-CMOS 80C196 is a major departure from the earlier eight-bit 8051 and 16-bit 8096 - as severe as was the shift at the general-purpose microprocessor level from the 8- and 16-bit 8088/8086 to the present 16- and 32-bit 80286/80386 architectures. Pin- and code-compatible with the earlier 8096, the new 12-MHz 80C196 keeps many of the same features as its predecessors.

Anon. *Electronics* v 60 n 20 Oct 1 1987 p 59-60.

**096117 CAPACITANCE-VOLTAGE PROPERTIES OF THIN Ta<sub>2</sub>O<sub>5</sub> FILMS ON SILICON.** A comprehensive study of the high frequency (1 MHz) capacitance-voltage (C-V) properties of Al/Ta<sub>2</sub>O<sub>5</sub>/p-Si capacitors is described. The dependence of the dielectric constant of thermally oxidized Ta<sub>2</sub>O<sub>5</sub> on the oxidation temperature and the silicon substrate temperature during the deposition of tantalum metal was studied. Charge trapping or generation processes in the Ta<sub>2</sub>O<sub>5</sub> bulk or in the Ta<sub>2</sub>O<sub>5</sub>-Si interface region were investigated on the basis of shifts in the flat-band voltage of 1 MHz C-V curves. The Ta<sub>2</sub>O<sub>5</sub> thin films on p-type silicon substrates were prepared by thermal oxidation at 430-675°C of electron-beam-deposited tantalum. (Edited author abstract) 18 refs.

Oehrlin, Gottlieb S. (IBM, Yorktown Heights, NY, USA). *Thin Solid Films* v 156 n 2 Jan 30 1988 p 207-229.

**096118 GENERATION CURRENTS FROM INTERFACE STATES IN SELECTIVELY IMPLANTED MOS STRUCTURES.** The ability to model the effects of doping on the depleted MOS surface velocity is particularly important for scaled devices because of high doping levels and high device susceptibility to generation currents. However, it is difficult to find detailed measurements of the influence of ion implantation on surface generation in the doping range  $3 \times 10^{16}$  to  $5 \times 10^{17}$  cm<sup>-3</sup>, and the data that have been reported are not all in agreement. This doping range is of practical importance for charge coupled devices. By careful design of test structures and by accurate 2-D modeling, we have investigated the effects of selective implantation on surface and bulk generation parameters for some arsenic and boron implants in this range into <100> p-type silicon. The principal results are that for arsenic implants below roughly  $6 \times 10^{12}$  cm<sup>-2</sup>, typical of buried channel implants, no enhancement of surface state generation is observed to within 20% of the nominal surface generation, despite concerns of arsenic segregation at the interface. Also, for boron implants below  $3 \times 10^{12}$  cm<sup>-2</sup>, typical of compensation implants in device active areas, no significant increase is observed. (Edited author abstract) 35 refs.

Hawkins, G.A. (Eastman Kodak Co, Rochester, NY, USA). *Solid State Electron* v 31 n 2 Feb 1988 p 181-196.

**096119 EFFECT OF GATE MATERIAL ON OXIDE DEGRADATION DUE TO CHARGE-INJECTION IN METAL-OXIDE-SEMICONDUCTOR CAPACITORS.** Aluminum and polycrystalline silicon gate metal-oxide-semiconductor (MOS) capacitors were studied in order to investigate the effect of the gate electrode material on the surface state generation and oxide trapping under tunneling injection of electrons into the oxide. Combined I-V and C-V measurements lead to the conclusion that the main differences between the two types of capacitors are in the surface states generation rate and saturation values and in the bulk trapping sites generation rate. The two types of devices display a remarkable similarity in the



behavior of the occupation probability of bulk oxide traps and in the initial number of trapping sites in fresh samples. (Author abstract) 21 refs.

Avni, E. (Hebrew Univ of Jerusalem, Jerusalem, Isr); Sonnenblick, Y.; Nissan-Cohen, Y. *Solid State Electron* v 31 n 2 Feb 1988 p 245-250.

**096120 SICHTBARE LICHTEMISSION BEI CMOS-KURZKANAL-INVERTERN.** [Visible Light Emission of Short-Channel CMOS Inverters]. Visible light emission of both, the n-channel and the p-channel field-effect transistor of a short-channel CMOS inverter has been observed. The emitted light has a very weak intensity and appears quite uniform along the drain ends of the channels. A direct correlation between the emitted light intensity and the anomalous transfer behavior is shown, as it occurs in CMOS circuits at higher supply voltages. (Author abstract) In German. 7 refs.

Graf, Alfons (Technische Muenchen, Munich, West Ger). *AEU Arch Elektron Uebertrag Electron Commun* v 42 n 2 Mar-Apr 1988 p 124-127.

**096121 CHARACTERISTICS OF A SET OF 12.7-MM PROCESSOR CHIPS.** A 1.0- $\mu$ m CMOS technology with three layers of metal is used to implement a high-density master image that contains logic and RAM's. The image allows the use of more than 1,000,000 transistors. A hierarchical design methodology is described. This chip offers variable-sized physical partitions and RAM macros. Fixed area sizes and locations for partitions and macros are not necessary. Density and performance of custom chips are approached by the described methodology with significantly lower development cost and time. 4 refs.

Klein, Klaus (IBM, Boeblingen, West Ger); Koetzle, Gunther; Miersch, Ekkehard F.; Schettler, Helmut; Schulz, Uwe; Wagner, Otto. *IEEE J Solid State Circuits* v SC-22 n 5 Oct 1987 p 783-789.

**096122 553K-TRANSISTOR LISP PROCESSOR CHIP.** The authors describe a LISP microprocessor which includes over 550K transistors, has 114K of on-chip RAM, and runs instructions in a single 30-ns clock cycle. The chip is implemented in 1.25- $\mu$ m double-level-metal (DLM) CMOS, has 224 pins, and is packaged in a custom pin-grid array. The microinstruction and macroinstruction sets of this chip are compatible with an existing LISP processor. An extensive discussion of test features designed into the processor chip is given. 11 refs.

Bosshart, Patrick W. (Texas Instruments Inc, Dallas, TX, USA); Hewes, C. Robert; Ales, Michael D.; Chang, Mi-Chang; Chau, Kwok Kit; Fasham, Kingsley; Hoac, Charles C.; Houston, Theodore W.; Kalyan, Vibhu; Lusky, Stephen L.; Mahant-Shetti, Shivaling S.; Matzke, Douglas J.; Ruparel, Kamalash N.; Sexton, Joe F.; Shaw, Ching-Hao; Shridhar, Thirumalai. *IEEE J Solid State Circuits* v SC-22 n 5 Oct 1987 p 808-819.

**096123 RECOMBINATION LIFETIME OF SHORT-BASE-WIDTH DEVICES USING THE PULSED MOS CAPACITOR TECHNIQUE.** The authors point out that the technique of D.K. Schroder, J.D. Whitfield, and C.J. Varker for the determination of recombination lifetime using pulsed MOS capacitors at elevated temperatures does not consider lateral quasi-neutral bulk generation and the time dependence of the width of the space-charge region in short-base-width devices (i.e., epitaxial wafers). Consequently, calculations using this technique indicate that the recombination lifetime is a function of device diameter. A simple one-dimensional approach is proposed in which bulk generation in the lateral area of the device is taken into consideration resulting in a fairly uniform recombination lifetime that is independent of the device diameter for short-base-width devices. 5 refs.

Aminzadeh, Mehran (Oregon State Univ, Corvallis, OR, USA); Forbes, Leonard. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 518-521.

**096124 CHARACTERISTICS OF CMOS DEVICES**

**IN OXYGEN-IMPLANTED SILICON-ON-INSULATOR STRUCTURES.** The characteristics of CMOS devices fabricated in oxygen-implanted silicon-on-insulator (SOI) substrates with different oxygen doses are studied. The results show that transistor junction leakage currents are improved by orders of magnitude when the oxygen dose is decreased from  $2.25 \times 10^{18} \text{ cm}^{-2}$  to  $1.4 \times 10^{18} \text{ cm}^{-2}$ . The floating-body effect, i.e., transistor turn-on at lower gate voltage with dramatic improvement in subthreshold slope when the drain voltage is increased, is enhanced by the reduction in leakage current and hence the oxygen dose. In SOI substrates implanted with  $1.4 \times 10^{18} \text{ cm}^{-2}$  oxygen dose and annealed at 1150°C, back-channel mobilities are decreased by several orders of magnitude compared to the mobilities in the precipitate-free silicon film. These device characteristics are correlated with the microstructure at the silicon-buried-oxide interface, which is controlled by oxygen implantation and post-oxygen-implantation anneal. 17 refs.

Mao, Bor-Yen (Texas Instruments Inc, Dallas, TX, USA); Sundaresan, Ravishankar; Chen, C.-E. Daniel; Matloubian, Misha; Pollack, Gordon. *IEEE Trans Electron Devices* v 35 n 5 May 1988 p 629-633.

**096125 CMOS TEMPERATURE-COMPENSATED CURRENT REFERENCE.** A temperature-compensated current reference for CMOS integrated circuits based on a MOSFET as current-defining element, is described. To minimize the mass-production cost, it uses no external components nor trimming procedures. Comparison with classical current references with a resistor as a current-defining element shows a considerable improvement of the relative tolerance on the current. Theoretical expressions are presented and compared with experimental results from an integrated prototype. For devices from the same batch, the standard deviation is measured to be 2.5%, and the temperature dependence is 3% from 0 to 80°C. From theoretical equations, the standard deviation of devices from different batches is expected to be about 15%. 7 refs.

Sansen, Willy M. (Katholieke Univ Leuven, Heverlee, Belg); Op't Eynde, Frank; Steyaert, Michiel. *IEEE J Solid State Circuits* v 23 n 3 Jun 1988, Thirteenth Eur Solid-State Circuits Conf 87, Bad Soden, West Ger, Sep 1987 p 821-824.

**096126 ADVANCED OSELO ISOLATION WITH SHALLOW GROOVES FOR HIGH-SPEED SUBMICROMETER ULSI'S.** A submicrometer (0.7- $\mu$ m) isolation structure using processes that are compatible with the LOCOS processes has been developed. This novel isolation structure, called OSELO II, is fabricated using modified local oxidation technology and an offset structure. The offset structure is characterized by a framed Si<sub>3</sub>N<sub>4</sub> mask for bird-beak-free oxidation, formation of shallow self-aligned Si grooves, and two-step boron-ion implantation that decreases current leakage along the isolation sidewall. This isolation technology provides (1) an active MOS transistor having a mask-defined 0.8- $\mu$ m channel width giving 60% more drain current than the conventional transistor with LOCOS isolation, (2) 0.6- $\mu$ m minimum isolation length, which equals the isolation length between the two adjacent active transistors and is also defined by the mask length, and (3) 20% lower parasitic junction capacitance compared with the LOCOS structure. These results demonstrate that the process is promising for high-speed submicrometer ultralarge-scale integrated devices. 8 refs.

Kaga, Toru (Hitachi Ltd, Kokubunji, Jpn); Kawamoto, Yoshifumi; Ijima, Shinpei; Sudoh, Yoshimi; Sakai, Yoshio. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 893-898.

**096127 LOW NOISE MONOLITHIC CMOS FRONT END ELECTRONICS.** Design considerations for low noise charge measurement and their application in CMOS electronics are described. The amplifier driver combination whose noise performance has been measured in detail as well as the analog multiplexing silicon strip detector readout electronics are designed with low power consumption and can be operated in pulsed mode so as to

reduce heat dissipation even further in many applications. (Author abstract) 7 refs.

Lutz, G. (Max-Planck-Inst fuer Physik und Astrophysik, Munich, West Ger); Buttler, W.; Bergmann, H.; Holl, P.; Hosticka, B.J.; Manfredi, P.F.; Zimmer, G. *Nucl Instrum Methods Phys Res Sect A* v A263 n 1 Jan 1 1988, Front Detect for Front Phys, Proc of the Third Pisa Meet on Adv Detect, Castiglione della Pescaia, Italy, Jun 3-7 1986 p 163-173.

**Analysis** See Also ELECTRONIC CIRCUITS, TRIGGER—Mathematical Models; INTEGRATED CIRCUITS, DIGITAL—Analysis; TRANSISTORS, FIELD EFFECT—Electric Properties.

**096128 THREE-DIMENSIONAL ANALYSIS PROGRAM FOR MOS DEVICES AND THE VIRTUAL NODE METHOD.** A three-dimensional finite difference program has been developed for the analysis of steady-state characteristics of MOS devices with arbitrary geometric boundary shapes. A self-consistent solution of Poisson's equation and the current continuity equations by use of Gummel's approach has been carried out. The Newton-Raphson algorithm was used for the linearization of the discretized Poisson equation, and an ICCG method was employed for the solution of the resulting linear equations. By reasonably controlling the number of Newton iterations, selecting a suitable LU decomposition for the linearized system matrix by use of the ICCG method, and by using the results of a two-dimensional analysis as initial values, the required computational time can be kept acceptably short. In order to use the finite difference method for MOS devices with complex shapes, a new approach called the Virtual Node Method was developed. Theoretical analysis and the computational results indicate that this approach works satisfactorily for MOS devices with arbitrary shapes. (Author abstract) 7 refs.

Chen, Datong (Tsinghua Univ, Beijing, China); Wang, Zeyi; Wu, Qiming; Li, Zhijian. *Math Comput Simul* v 29 n 6 Dec 1987 p 461-475.

**096129 COMMON ORIGIN FOR ELECTRON AND HOLE TRAPS IN MOS DEVICES.** Experimental evidence is provided to show that many electron and hole traps found in ultraclean and annealed SiO<sub>2</sub> layers are related to intrinsic oxygen-deficiency defects. These trapping sites are found to play a dominant role in low-field oxide breakdown, radiation sensitivity, and interface state generation in MOS devices. The saturation of SiO<sub>2</sub> with oxygen leads to the elimination of a large number of these traps and to the stabilization of SiO<sub>2</sub> layers for use in submicrometer devices. 22 refs.

Aslam, Mohammad (Wayne State Univ, Detroit, MI, USA). *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2535-2539.

**Applications** See Also AMPLIFIERS, OPERATIONAL—Measurements; COMPUTERS, MICROCOMPUTER—Design; DATA CONVERSION, ANALOG TO DIGITAL; DATA STORAGE, DIGITAL—Random Access; DATA STORAGE, SEMICONDUCTOR—Storage Devices; DISPLAY DEVICES—Liquid Crystal; ELECTRIC FILTERS, DIGITAL; INTEGRATED CIRCUITS—Layout; INTEGRATED CIRCUITS, LINEAR—Design; INTEGRATED CIRCUITS, VLSI—Applications; INTEGRATED CIRCUITS, VLSI—Design; LOGIC CIRCUITS—Fabrication.

**096130 CMOS VLSI SETS THE DIRECTION FOR NEW ICS.** A few years ago, CMOS was just a curiosity. A technology developed primarily to meet extremely low power consumption and radiation-tolerance requirements, CMOS became infamous for its high cost, its tendency to latch up, and its insatiable appetite for real estate. Then US and Japanese manufacturers began to work on 1-Mbit DRAMS. CMOS is reborn, reaching skyrocketing speed and unprecedented density and spawning new classes of



function-, application-, and user-defined ICs. Meanwhile, emphasis for designers is shifting from process to applications expertise.

Wilson, Ron (Computer Design, Littleton, MA, USA). *Comput Des* v 26 n 22 Dec 1987 p 79-82, 86-91.

**096131 BICMOS FOR HIGH PERFORMANCE, HIGH DENSITY APPLICATIONS.** The applicability of BICMOS is investigated with respect to technology, circuit design and system aspects. Based on a n-well CMOS technology, process extensions like buried layer and polysilicon emitter are discussed with regard to bipolar device performance. The Totem Pole buffer, a basic BICMOS circuit, is investigated in detail. Finally we point out the advantages of BICMOS compared to both Bipolar and CMOS using more complex circuits (SRAMs). (Edited author abstract) 5 refs.

Klar, Heinrich (Siemens AG, Munich, West Ger); Heimsch, Wolfgang; Klose, Helmut; Krebs, Roland; Pfaffel, Bruno; Stegherr, Michael; Winerl, Josef; Ziemann, Klaus. *AEU Arch Elektron Uebertrag Electron Commun* v 42 n 2 Mar-Apr 1988 p 65-74.

**096132 IS BICMOS THE NEXT TECHNOLOGY DRIVER?** BICMOS, a process combining bipolar and CMOS transistors on the same die, has been the subject of extensive research and development that now appears to be bearing fruit. It is becoming a favorite candidate for mainstream products: interface logic, static random-access memories, mixed analog/digital circuits, and gate arrays. It is even being considered for high-performance microprocessors and dynamic RAMs. Some observers say the process will be the main technology driving virtually all functions in the next decade; others believe it will always remain in niche applications.

Cole, Bernard C. *Electronics* v 61 n 3 Feb 4 1988 p 55-57.

**096133 ALTERA'S SPEEDY WAY TO TAILOR ADD-ONS TO IBM'S PS/2.** Add-on board suppliers will soon get an all-in-one programmable interface chip that will help them quickly enter the potentially huge market for plug-in peripheral cards serving IBM Corp's Personal System/2. Altera Corp. is launching the industry's first erasable programmable logic device aimed at providing complete interface to the IBM Micro Channel bus. Not only will the new CMOS EPLD save time in turning out the add-on boards, but it will save board space as well. Accompanying development software will cut the time to market even more, and vendors will be able to put their add-on PS/2 interface functions into four reserved programmable spaces on the EPLD.

Lineback, J. Robert. *Electronics* v 61 n 4 Feb 18 1988 p 99-100.

**096134 DEVICE CHARACTERISTICS OF THE Pd-SnO<sub>x</sub> MIS OXYGEN SENSORS.** An oxygen sensor has been developed in the device configuration Pd-SnO<sub>x</sub>-Si<sub>3</sub>N<sub>4</sub>-SiO<sub>2</sub>-Si-Al with highly resistive SnO<sub>x</sub> film as oxygen absorptive element. The device operation is based on a shift in flat-band voltage  $\Delta V_{fb}$  of a MIS (metal-insulator-semiconductor) capacitor on oxygen adsorption. The device sensitivity, i.e.,  $\Delta V_{fb}$  shift, was investigated as a function of structural and chemical composition of the absorptive SnO<sub>x</sub> film. Typical results for the columnar SnO<sub>x</sub> film showed  $\Delta V_{fb}$  to be 100 mV at T = 19°C in 0.5-torr O<sub>2</sub> partial pressure, and at T = 80°C  $\Delta V_{fb}$  increased to 200 mV. Under the same condition, devices with continuous SnO<sub>x</sub> film had  $\Delta V_{fb}$  of 15 and 50 mV, respectively, indicating much higher sensitivity for columnar SnO<sub>x</sub> film. The effect of external field on oxygen adsorption clearly indicates that O<sub>2</sub> adsorption is almost completely suppressed at the external bias of +18 V for the investigated range of O<sub>2</sub> pressure. This property eliminates the necessity of keeping the device under vacuum or encapsulation before use.

Xu, J.F. (Rutgers Univ, Piscataway, NJ, USA); Kang, W.P.; Lalevic, B.; Poteat, T.L. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2383.

**096135 MOS IMPLEMENTATION OF TOTALLY SELF-CHECKING CHECKER FOR THE 1-OUT-OF-3 CODE.** The problem of designing a totally self-checking (TSC) checker for the 1-out-of-3 code using combinational logic alone has not yet been solved. It is shown, however, that it is feasible to design such a checker in MOS technology. Analysis and simulation show that the proposed checker is a TSC checker for the 1-out-of-3 code with respect to a set of physical defects which occur frequently in MOS technology. 10 refs.

Tao, D.L. (Syracuse Univ, NY, USA); Lala, Parag K.; Hartmann, Carlos R.P. *IEEE J Solid State Circuits* v 23 n 3 Jun 1988, Thirteenth Eur Solid-State Circuits Conf 87, Bad Soden, West Ger, Sep 1987 p 875-877.

**096136 PALLADIUM-GATE MOS DEVICES FOR ARSINE DETECTION.** Pd-MOS structures with holes in the gate metal have been prepared for detecting arsine, and investigated in a flow system. The samples show a reversible decrease of threshold voltage on admixtures of arsine to an air stream (temperature range 350 K to 470 K). A change of threshold voltage of 34 mV is found for 0.1 ppm arsine in air (T = 433 K). For arsine concentrations of 2.5 ppm, a response time of 40 s and a recovery time of 300 s are observed at 450 K. The response of the same structures to small concentrations of H<sub>2</sub> has also been investigated. Sensitivity and response are comparable to the results found for arsine. This similarity points to a decomposition of arsine at the Pd surface, with subsequent diffusion of hydrogen to the metal-oxide interface. (Author abstract) 13 refs.

Mokwa, W. (Fraunhofer Inst fuer Mikroelektronische Schaltungen und Systeme, Duisburg, West Ger); Dobos, K.; Zimmer, G. *Sens Actuators* v 12 n 4 Nov-Dec 1987, Pap Presented at the 2nd Int Meet on Chem Sens, Bordeaux, Fr, Jul 7-10 1986 p 333-339.

**Automatic Testing** See DATA STORAGE, DIGITAL—Random Access.

**Computer Aided Analysis** See Also INTEGRATED CIRCUITS, VLSI—Mathematical Models; INTEGRATED CIRCUITS, VLSI—Radiation Effects.

**096137 PARAMETRIC FORMULATION OF CMOS LATCH-UP AS A FUNCTION OF CHIP LAYOUT PARAMETERS.** The relationship between the CMOS latch-up characteristics and the chip layout parameters such as the location and spacing of the well and substrate tie-ups (straps) is studied. By measuring the strap current  $I_s$  at varying distances from the well-substrate boundary, it is found that placing these straps at the boundary is most effective. The holding current  $I_h(x, N)$  at a point in the circuit is quantitatively related to 1) the distance x of the well-substrate strap from this point, and 2) the doping level N of the respective region. An analytical expression of the form  $I_h(x, N) = e^{a-bx} = I_{oc} - bx$  is developed to predict the required frequency of strapping for a particular process technology, where coefficients a and b are functions of the doping. The impact of a strapping scheme on latch-up is explained in terms of a simple engineering model. 12 refs.

Lohia, Ramesh (Rockwell Int, Newport Beach, CA, USA); Ali, Akhtar. *IEEE J Solid State Circuits* v 23 n 1 Feb 1988, 1987 Symp on VLSI Circuits, Karuizawa, Jpn, May 22-23 1987 p 245-250.

**Computer Aided Design** See Also INTEGRATED CIRCUITS, VLSI—Computer Aided Design.

**096138 TWO-STAGE CHANNEL ROUTING FOR CMOS GATE ARRAYS.** A two-stage channel routing technique for CMOS gate arrays is proposed. In the first stage, certain nets are routed on two sides of the channel so that channel density is reduced. A single-side O(N) optimum algorithm is presented for this stage. The algorithm can choose one set with maximum weight from among the possible sets of routing nets. The second stage can be general channel routing. An efficient algorithm for a one-and-a-half-layer routing model that is based on one metal mask and a fixed poly-crossunder layer is presented. This router scans the channel in a left-to-right,

zone-by-zone manner, using a multilevel prediction to guide wiring and a greedy approach for nets to contend for limited crossunders. Implementation results are provided to indicate the efficiency of the technique. 16 refs.

Song, Jian-Ning (Tsinghua Univ, Beijing, China); Chen, Yun-Kang. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 4 Apr 1988 p 439-450.

**096139 CMOS GATE FOREST: AN EFFICIENT AND FLEXIBLE HIGH-PERFORMANCE ASIC DESIGN ENVIRONMENT.** The basic concepts of the second-generation gate arrays are described. The most important architectures that were used to implement the different concepts are discussed. An overview of the current status of a number of typical sea-of-gates masters is given. A number of quality marks have been defined along which the different architectures can be evaluated. These quality marks range from microarchitecture aspects such as isolation techniques and connectability of the core cells, to macro aspects such as distribution functions. Using these quality marks for reference, the Gate Forest is discussed. The Gate Forest is seen as a major extension of the sea-of-gates principle. It differs from the extant sea-of-gates concept in several important aspects. It is based on a hierarchical concept, both in architecture and design. It combines flexibility and efficiency in one environment by providing transistor-level optimization together with cell library support for different logic design styles. It furthermore supports the efficient implementation of different types of memory in any desired location. The current status of the second generation of the Gate Forest is also briefly described. 28 refs.

Beunder, Michiel A. (Inst for Microelectronics, Stuttgart, West Ger); Kernhof, Juergen P.; Hoefflinger, Bernd. *IEEE J Solid State Circuits* v 23 n 2 Apr 1988 p 387-399.

**096140 DETERMINISTIC ALGORITHM FOR AUTOMATIC CMOS TRANSISTOR SIZING.** A model which offers a closed-form equation for determining device size, based on speed and load, has been developed. The need for circuit simulation is eliminated in most cases. This model is used in a system for automatically producing performance-tuned cell layouts. 6 refs.

Richman, Bruce A. (Gould Inc, Pocatello, ID, USA); Hansen, James E.; Cameron, Kelly. *IEEE J Solid State Circuits* v 23 n 2 Apr 1988 p 522-526.

**096141 MOSIS - A GATEWAY TO SILICON.** The MOSIS Service, a low-cost prototyping service for standard-cell and full-custom VLSI circuit development, is discussed. MOSIS (an acronym for MOS Implementation System) has developed a methodology that allows the merging of many different projects from various organizations onto one wafer. This cost-sharing gives designers opportunities that might be prohibitive at regular commercial prices. Since designs are combined on a single mask set, MOSIS users pay for only the fraction of the silicon that they use. Runs are scheduled on a regular basis for 3.0-, 2.0-, 1.6-, and 1.2- $\mu$ m double-metal CMOS/bulk technologies. MOSIS quality control and access to MOSIS are described.

Tomovich, Christine (Univ of Southern California, Los Angeles, CA, USA). *IEEE Circuits Devices Mag* v 4 n 2 Mar 1988 p 22-23.

**Computer Interfaces**

**096142 TI TO ROLL OUT ITS FIRST FAMILY OF PRODUCTS MADE WITH BICMOS.** A brand new family of interface chips is introduced by Texas Instruments that are notable for two important reasons: These ICs run cooler than any other high-performance interface chips, delivering bipolar speeds at CMOS power levels. The devices are made with a new process based on Impact, TI's mainstream high-performance bipolar technology, which has been modified to accept CMOS on the same substrate. The result is Impact CS. The company has big plans for its biCMOS process: it will use it across the board, building memories, gate arrays, application-specific ICs and even linear circuits.



Weber, Samuel. *Electronics* v 60 n 20 Oct 1 1987 p 81-82.

**Computer Simulation** See Also LOGIC CIRCUITS—Mathematical Models.

**096143 THRESHOLD VOLTAGE PREDICTIONS FROM MICROMOS: A 3-D MOS SIMULATOR.** This paper provides predicted values of threshold voltage for the full recessed MOS structure obtained from the 3-D code called MICROMOS. Uniform and implanted channel cases are considered. Short channel, narrow width and small geometry effects are automatically included. Results for these conditions as well as variable oxide thickness and substrate doping are shown. All results indicate the correct tendency of change for threshold voltage. Values for threshold voltage prediction are obtained from 3-D computer generated drain current vs gate voltage characteristics. (Edited author abstract) 9 refs.

DeMassa, T.A. (Arizona State Univ, Tempe, AZ, USA); Hsueh, K.L. *Solid State Electron* v 30 n 10 Oct 1987 p 1063-1068.

**096144 MOS DIGITAL CIRCUITS SIMULATOR USING A NEWLY DEVELOPED LOGIC SIMULATOR.** The authors have introduced modeling techniques in the conventional logic simulators. This allows the use of a newly developed logic simulator to be used for MOS circuits which finds a wide acceptability for realizing VLSI circuits. The simulator is developed on the IBM-PC computer. 2 refs.

Salama, Aly E. (Cairo Univ, Giza, Egypt); Khalil, Ahmed H. *Modell Simul Control A* v 16 n 1 1988 p 37-43.

**096145 LATCHUP PERFORMANCE OF RETROGRADE AND CONVENTIONAL N-WELL CMOS TECHNOLOGIES.** The static and transient latchup performance of conventional and retrograde n-well CMOS technologies is compared. Both technologies are optimized for 1- $\mu$ m design-rule circuit applications and have comparable well depths under the active area. The devices are fabricated on both bulk silicon and p-on-p+ epitaxial silicon substrates, allowing the influence of the n-well doping profile and the effect of the interaction between the fabrication schedule and the epitaxial material to be studied. The retrograde n-well structures are shown to have superior latchup immunity, due primarily to reduced n-well sheet resistance and greater tolerance to thin p on p+ epitaxial material. 15 refs.

Lewis, Alan G. (Xerox Palo Alto Research Cent, CA, USA); Martin, Russel A.; Huang, Tiao-Yuan; Chen, John Y.; Koyanagi, Mitsumasa. *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2156-2164.

**096146 EFFICIENT NUMERICAL SIMULATION OF THE HIGH-FREQUENCY MOS CAPACITANCE.** An enhancement of the MOSCAP C-V simulation program that permits efficient evaluation of the high-frequency MOS capacitance, including inversion-charge-redistribution effects, is presented. The measured C-V characteristics of a buried-channel MOS structure have been modeled successfully using the modified MOSCAP program. It has been found that neglect of inversion-charge rearrangement in response to the high-frequency ac signal leads to a significant underestimation of the semiconductor space-charge capacitance in strong inversion for the buried-channel device. 10 refs.

Watt, Jeffrey T. (Stanford Univ, CA, USA); Plummer, James D. *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2214-2216.

## Control

**096147 EVOLUTION OF MOS-BIPOLAR POWER SEMICONDUCTOR TECHNOLOGY.** A review of the innovations that have led to the evolution of a power transistor technology based on MOS gate control is provided. This technology offers the advantage of very high input impedance, which allows the control of the devices using low-cost integrated circuits. The physics of operation of the two types of devices in this category,

power MOSFETs and power MOS-bipolar devices, are described. Trends in process technology and device ratings are analyzed. Based on the superior performance of these devices, it is projected that they will completely displace the power bipolar transistor in the future. 29 refs.

Baliga, B. Jayant (GE, Schenectady, NY, USA). *Proc IEEE* v 76 n 4 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 409-418.

**Degradation** See Also SEMICONDUCTING SILICON—Defects.

**096148 MNOS DEGRADATION MECHANISM.** For over 10 years, there has been much research on MNOS structure degradation in connection with developments in energy-independent MOS memory components with stable characteristics. Degradation makes itself felt in metal-silicon nitride (SN)-ultrathin oxide-semiconductor (MNOS) structures in that there are changes in charge-accumulation characteristics for electrons and holes at the trapping centers (TC) as well as in the charge flow characteristics in repeated read-write cycles, as well as on UV irradiation (the accumulated charge is less, as is the storage time). In this paper conductivity changes have been observed in SN MNOS structures as related to the charge passing. The rates of conductivity change in the two materials are determined by the nonequilibrium-carrier concentrations in the bulk and are dependent on the manufacturing conditions. 22 refs.

Maslovskii, V.M. *Sov Microelectron* v 16 n 4 Jul-Aug 1987 p 202-204.

**096149 TIME-DEPENDENT EVOLUTION OF INTERFACE TRAPS IN HOT-ELECTRON DAMAGED METAL/SiO<sub>2</sub>/SI CAPACITORS.** Results are reported which indicate that the interface traps generated by hot-electron injection undergo significant changes with time at room temperature. Immediately after injection, a peak of the interface trap distribution appears above the midgap energy about 0.75 eV above the valence-band energy level (approx.  $E_v + 0.75$  eV) in all of the samples studied. This peak, along with its background, increases or decreases with time at room temperature, depending on the gate bias polarity during injection, the initial damage level, the gate-induced stress, and the presence of certain chemical impurities in the gate oxide. In the cases where this peak decreases with time, a second peak below midgap (approx.  $E_v + 0.35$  eV) develops, and this peak grows with time at the expense of the first peak. The important factors that affect the time-dependent behavior of the interface traps are discussed. 9 refs.

Nishioka, Yasuhiro (Yale Univ, New Haven, CT, USA); Da Silva, Eronides F. Jr.; Wang, Yu; Ma, Tso-Ping. *IEEE Electron Device Lett* v EDL-8 n 12 Dec 1987 p 566-568.

**096150 NEW HOT-CARRIER-INDUCED DEGRADATION PHENOMENA IN HALF-MICROMETER MOS TRANSISTORS.** The degradation magnitude is one to two orders larger than that of the severest stress condition ever reported, and increases rapidly with decreasing gate length. This phenomenon limits the applicable voltage for 0.5- $\mu$ m MOSFETs. The mechanism of this large degradation has been determined using experimental data and simulation results. The large degradation is due to the highly efficient injection of hot electrons into the gate oxide. The degradation magnitude has a positive strong correlation with gate currents instead of substrate currents over a wide range of bias voltage. From these results and two-dimensional two-carrier device simulations, it has been determined that the large degradation is caused by the large impact ionization just at the Si/SiO<sub>2</sub> interface in the source high-resistivity region (source impact), and by the high electric field enhancing the hot-electron injection of hot electrons into the gate oxide, resulting in the large degradation. Moreover, the magnitude of the new degradation mode increases rapidly with decreasing the gate length to 0.5  $\mu$ m. So, it becomes extremely important to suppress this degradation mode in the design of reliable 0.5- $\mu$ m MOSFETs. Some methods of suppressing this degradation are presented and discussed. 4 refs.

Nitayama, Akihiro (Toshiba Corp, Kawasaki, Jpn); Takenouchi, Naoko; Hamamoto, Takeshi; Oowaki, Yukihito. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2384.

**096151 DRAMATIC IMPROVEMENT OF HOT-ELECTRON-INDUCED INTERFACE DEGRADATION IN MOS STRUCTURES CONTAINING F OR CL IN SiO<sub>2</sub>.** The effects of F and Cl incorporated in SiO<sub>2</sub> on the susceptibility of the metal/SiO<sub>2</sub> (MOS) interface to hot-electron damage have been studied. It has been found that, by introducing a very small amount of F or Cl in the thermal SiO<sub>2</sub>, the generation of interface traps by Fowler-Nordheim tunneled hot electrons can be greatly suppressed. In addition, the gate-size dependence of hot-electron-induced interface traps, which is normally observed in samples made of dry oxides, does not appear in such chlorinated or fluorinated samples. When excess amounts of F or Cl are introduced into SiO<sub>2</sub>, however, the benefits mentioned will diminish. The possible roles that F and Cl play that lead to the experimental observations are discussed. 10 refs.

Nishioka, Yasuhiro (Yale Univ, New Haven, CT, USA); Da Silva, Eronides F. Jr.; Wang, Yu; Ma, Tso-Ping. *IEEE Electron Device Lett* v 9 n 1 Jan 1988 p 38-40.

**096152 CHARGE STORAGE IN MOS STRUCTURES AS AFFECTED BY AVALANCHE- AND PHOTOINJECTION.** Experimental data are presented for charge storage in dry SiO<sub>2</sub> of silicon MOS structures, which accompanies electron avalanche- and photoinjection. Dependencies of the effect on prehistory, temperature and field were investigated. Dominant positive charging of nonhydrated structures at 300 K and a field  $\geq 2$  MV/cm were observed. Its characteristic time was found by means of pulse photoinjection. The results obtained are discussed in terms of indirect energy dissipation of hot electrons in SiO<sub>2</sub>. (Author abstract) 6 refs.

Kuznetsov, S.N. (Petrozavodsk State Univ, Petrozavodsk, USSR); Gurtov, V.A. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 347-352.

**Density** See LOGIC DEVICES—Gates.

**Design** See Also COMPUTER GRAPHICS—Design; COMPUTERS, DIGITAL—Multiplying Circuits; COMPUTERS, MICROCOMPUTER—Control; DIGITAL COMMUNICATION SYSTEMS—Voice/Data Integrated Services; ELECTRONIC CIRCUITS, MULTIVIBRATOR—Spectrum Analysis; MAGNETIC FIELDS—Sensors.

**096153 CMOS LATCHUP MODELLING: A NEW APPROACH.** In this paper, a new lumped element latchup model which includes two extra bipolar transistors is proposed. The divergence between the results of the conventional and the proposed model is explained in terms of the circuit parameters. The output behavior of CMOS latchup and the output latchup mode are discussed in connection with the proposed model and the predictions of the model are compared to the results of the conventional model using SPICE. (Author abstract) 10 refs.

Li, Wei (Univ of Pittsburgh, Pittsburgh, PA, USA); El Nokali, M. *Int J Electron* v 64 n 2 Feb 1988 p 269-282.

**096154 WALLS COME TUMBLING DOWN.** Next year an increasing number of semiconductor firms will begin to introduce standard, semicustom and custom products based on next-generation CMOS processes with 0.8- to 1- $\mu$ m design rules, blurring the demarcation between exotic high-performance technology and standard commercial applications. Also coming soon are the first samples of 4-Mbit dynamic RAMs, and the first



experimental 16-Mbit designs. Merging of logic and bit memory blocks is contemplated that will help boost system performance.

Cole, Bernard C. *Electronics* v 60 n 21 Oct 15 1987 p 95-97.

**096155 OPTIMIZED LAYOUT OF MOS CELLS.** A design method using both logical optimization and optimized topological arrangements is described. Starting from a minimized Boolean function, a synthesis of an optimized well-structured network is obtained. The most original aspect of this approach is a transistor merging procedure leading to a nonseries-parallel network while maintaining a systematic layout. An extension to the synthesis of several functions relies on transistor mergings between functions and allows comparisons to a PLA implementation. Gains in both area and performance are obtained. 16 refs.

Thuau, Ghislaine (Inst Natl Polytechnique de Grenoble, Fr); Saucier, Gabriele. *IEEE Trans Comput* v 37 n 1 Jan 1988 p 79-87.

**096156 SELF-TERMINATING LOW-VOLTAGE SWING CMOS OUTPUT DRIVER.** A CMOS output pad driver circuit is described that automatically series-terminates a driven line in the line's characteristic impedance. The circuit has advantages in speed, power, and size over conventional designs. The key idea is the use of emitter-coupled logic (ECL)-compatible low-voltage swings for signaling, combined with the use of the driver transistor as both a switch and as a termination resistor. An on-chip measurement circuit dynamically adjusts the impedance of the driver to match the impedance of an external reference impedance standard, allowing the circuit to compensate for both chip and board level fabrication variations. 6 refs.

Knight, Thomas F. Jr. (Symbolics Inc, Cambridge, MA, USA); Krymm, Alexander. *IEEE J Solid State Circuits* v 23 n 2 Apr 1988 p 457-464.

**096157 DESIGN AND IMPLEMENTATION OF A CMOS VCXO FOR FM STEREO DECODERS.** A circuit technique to simulate large variable capacitance of both positive and negative polarities over a given frequency range is discussed. The simulated capacitance can be varied by voltage control from  $-60$  to  $+100$  pF. The capacitor-simulating circuit is connected in parallel with a resonator to tune its parallel resonance. An oscillator with grounded resonator is also developed. Together with the variable capacitor, a voltage-controlled crystal oscillator (VCXO) is realized. The oscillation frequency of the oscillator can be varied  $\pm 1\%$  by voltage control. Detailed analyses to completely characterize the oscillator with simple expression are presented. The prototype of the VCXO has been fabricated in a  $4\text{-}\mu\text{m}$  standard CMOS process. 7 refs.

Huang, Qiuting (Katholieke Univ Leuven, Heverlee, Belg); Sansen, Willy M.C.; Steyaert, Michiel S.J.; Van Peteghem, Peter M. *IEEE J Solid State Circuits* v 23 n 3 Jun 1988, Thirteenth Eur Solid-State Circuits Conf 87, Bad Soden, West Ger, Sep 1987 p 784-793.

## Electric Breakdown

**096158 ULTRA-THIN SILICON-DIOXIDE BREAKDOWN CHARACTERISTICS OF MOS DEVICES WITH  $N^+$  AND  $P^+$  POLYSILICON GATES.** The authors investigated the effect of the gate material on the breakdown characteristics of ultrathin silicon dioxide films at low voltages ( $< 6$  V). When MOS capacitors were stressed with a positive gate voltage, the charge-to-breakdown and time-to-breakdown at a fixed oxide-voltage drop were significantly smaller in  $p^+$  polysilicon-gate capacitors than  $n^+$  polysilicon-gate capacitors. The results are interpreted in terms of a simple model of hole tunneling resulting from hot-hole generation in the anode by hot electrons entering from the silicon dioxide. Extrapolation of high-voltage-breakdown life-time measurements for relatively thick-oxide devices to low voltages may be complicated by this mechanism. 12 refs.

Holland, S. (Univ of California, Berkeley, CA, USA); Chen, I.C.; Hu, Chenming. *IEEE Electron Device Lett* v EDL-8 n 12 Dec 1987 p 572-575.

**Electric Properties** See Also CAPACITORS—Contacts; INTEGRATED CIRCUITS—Microscopic Examination; SEMICONDUCTING SILICON—Radiation Effects; TRANSISTORS, FIELD EFFECT—Analysis.

**096159 ON THE INFLUENCE OF THE THIN INTERFACIAL OXIDE LAYER ON THE ELECTRICAL AND PHOTOVOLTAIC PROPERTIES OF Au/OXIDE/ $p$ -InP DIODES.** Au/thermal oxide/ $p$ -InP structures were investigated for the oxide layer thickness,  $\delta$ , ranging from 1.8 to 13.5 nm. For increasing  $\delta$ , the forward dark-current mechanism changed from thermionic emission into recombination, and tunneling became dominant in reverse current. Under illumination the short-circuit current remained almost independent of  $\delta$  up to 10 nm and an important increase of the open-circuit voltage occurred at  $\delta \geq 4.5$  nm. Auger spectroscopy revealed that the outer part of the interfacial layer was  $\text{In}_2\text{O}_3$  while the inner part contained In, O and P. An energy band scheme was proposed for this two-layer model, which allowed us to explain the electrical characteristics. (Author abstract) 20 refs.

Song, Y.P. (Rijksuniversiteit Gent, Ghent, Belg); Van Meirhaeghe, R.L.; Lafiere, W.H.; Cardon, F. *Semicond Sci Technol* v 2 n 11 Nov 1987 p 736-741.

**096160 PARAMETER ESTIMATION IN MOS CONDUCTANCE STUDIES.** An accurate and reliable method for the analysis of MOS conductance is presented. Interfacial trap densities and time-constants and band-bending variance are obtained with estimates of their likely errors and covariance, and statistics are presented to test the goodness-of-fit and validity of the conductance model used. (Author abstract) 14 refs.

Noras, James M. (Univ of Bradford, Bradford, Engl). *Solid State Electron* v 31 n 5 May 1988 p 981-987.

**096161 PSEUDOCOLLECTOR EFFECT IN A CMOS INVERTER.** The pseudocollector effect in a CMOS inverter is demonstrated by analyzing the current distribution in the latchup state. The decoupling of the current flow from the latchup feedback loop is controlled by the input voltage applied to the gates of  $n$ -channel and  $p$ -channel MOSFETs, which results in a reduction of latchup susceptibility. Latchup in a CMOS inverter is influenced by the effects of input voltage through a pseudocollector and potential modulation. It is shown that a simple SCR structure cannot reflect adequately these phenomena. 5 refs.

Lee, Chun-Teh (Advanced Micro Devices, Sunnyvale, CA, USA). *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2212-2214.

**Electronic Properties** See Also TRANSISTORS, FIELD EFFECT—Electric Properties.

**096162 HOT ELECTRON EFFECTS IN NARROW WIDTH MOS DEVICES.** Narrow channel NMOSFET device degradation is explored by measuring the effect of hot-carrier stress on the current-voltage characteristics, the transconductance, field-effect mobility and surface scattering factor. Under conditions of substrate electron injection, the degradation mechanism can be explained as being interface charge generation, resulting in an increase on the surface scattering factor. This effect is more pronounced in narrow channel devices due to an excess hot-electron activity along the edges of the channel where the in-diffusion of field implant creates a region with higher impurity concentration. (Author abstract) 10 refs.

Petrova, R.S. (Inst of Microelectronics, Sofia, Bulg); Kamburova, R.S.; Vitanov, P.K.; Stefanov, E.N. *Microelectron J* v 18 n 6 Nov-Dec 1987 p 25-30.

**096163 DEVELOPMENT OF HOT-CARRIER SIMULATOR  $\text{H}_2$ -CAST AND ITS APPLICATION TO LDD.** A hot-carrier simulator ( $\text{H}_2$ -CAST) is developed using the 'effective electron temperature model,' and with

this simulator, the lightly doped drain (LDD) structure is analyzed. This simulator is based on a 3-D device simulator, where the carrier motion in the oxide film is also considered. The model equation for the channel hot electron region and the avalanche hot electron region in the NMOS single-drain structure is evaluated. It is found that the model is valid for an analysis of the hot-carrier injection phenomena in both regions. From the analysis of the LDD structure, it is apparent that the injection of the avalanche hot-holes is responsible for the degradation of the device characteristic. This simulator is considered to be an effective tool in designing a device with an effective channel length  $L_{\text{eff}}$  less than  $0.8\text{ }\mu\text{m}$ . (Edited author abstract) 15 refs.

Hamada, Akemi (Hitachi Ltd, Tokyo, Jpn); Toyabe, Toru; Takeda, Eiji. *Electron Commun Jpn Part 2* v 71 n 5 May 1988 p 75-82.

**096164 REDUCED OXIDE CHARGE TRAPPING AND IMPROVED HOT-ELECTRON RELIABILITY IN SUBMICROMETER MOS DEVICES FABRICATED BY TITANIUM SALICIDE PROCESS.** The effects of the titanium salicide (self-aligned silicide) process on the reliability of very-thin-gate-oxide MOSFETs have been studied. It is shown that the titanium salicide process, as compared to the conventional poly-Si gate process, has reduced electron and hole trapping in the oxide and improved hot-electron reliability. It is shown that these phenomena are related to the reduced hydrogen content in the oxide as revealed by a secondary ion mass spectrometry (SIMS) analysis. 10 refs.

Chang, Shuo-Tung (Hewlett-Packard Lab, Palo Alto, CA, USA); Chiu, Kuang Yi. *IEEE Electron Device Lett* v 9 n 5 May 1988 p 244-246.

**096165 EFFECT OF HYDROGEN ON TRAP GENERATION, POSITIVE CHARGE TRAPPING, AND TIME-DEPENDENT DIELECTRIC BREAKDOWN OF GATE OXIDES.** The effect of high-temperature ( $\approx 900^\circ\text{C}$ ) hydrogen on the gate oxides of MOS devices is studied. Hydrogen is introduced into devices by either high-temperature anneal or conventional process steps such as low-pressure chemical vapor deposition (LPCVD) of  $\text{Si}_3\text{N}_4$ . In all cases, measurements of high-field stress behavior show that high-temperature hydrogen steps reduce time to breakdown and increase bulk and interface trap generation, but do not affect the generation of positive charge. These results indicate that the wear-out mechanism of gate oxides at high fields is related to trap generation rather than to accumulation of positive charge. 10 refs.

Nissan-Cohen, Y. (GE, Schenectady, NY, USA); Gorczyca, T. *IEEE Electron Device Lett* v 9 n 6 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 287-289.

**096166 VALENCE BAND ELECTRON TUNNELING IN METAL-OXIDE-SILICON STRUCTURES.** Experimental results are presented for the substrate current appearing in thin oxide metal-oxide-silicon capacitors with a shallow  $n/p$  junction beneath the gate when a positive gate voltage in the tunneling regime is applied. The analysis of the current-voltage characteristics shows that for an oxide voltage drop lower than about 5 V the substrate current is due to electron tunneling from the silicon valence band. The dispersion relation in the energy range extending 3 eV below the oxide conduction band is determined from the voltage dependence of the current in the direct tunneling regime. An effective mass of about  $0.8m_0$  is found near the edge of the oxide conduction band, while for lower energies a strong decrease of the effective mass is observed. (Author abstract) 6 refs.

Modelli, A. (SGS Microelettronica, Agrate, Italy). *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 298-303.



**096167 MODELS AND EXPERIMENTS ON DEGRADATION OF OXIDIZED SILICON.** The concepts of electronic and protonic traps are introduced to delineate and classify the fundamental mechanisms of charging, generation, annealing and hydrogenation of electronic or electron and hole traps located in the interfacial (gate-conductor/oxide, oxide/nitride and oxide/silicon), insulator (oxide, nitride and oxynitride) and semiconductor surface layers of silicon MOS transistors and integrated circuits. Two matrix tables, one without tunneling ( $3 \times 3$ ) and one with tunneling ( $3 \times 4$ ) are used to classify the trap charging and electronic injection mechanisms according to the initial and final (band or bound) states of the electronic transition and the energy exchange mechanisms (thermal, optical and Auger-impact). The importance of tunneling to and from traps (TTT) as an oxide charge build-up mechanism is discussed. Examples at three DC bias conditions to delineate the dominant degradation mechanisms in silicon MOS transistors are given. (Edited author abstract)

Sah, C.T. (Univ of Illinois, Urbana, IL, USA). *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 311-312.

**096168 EVALUATION OF CHANNEL HOT CARRIER EFFECTS IN n-MOS TRANSISTORS AT 77 K WITH THE CHARGE PUMPING TECHNIQUE.** With the charge pumping technique, the role of hot holes in the channel hot carrier degradation of short channel n-MOS transistors is shown to be less pronounced at 77 K than at 300 K. Also fewer fast interface states are generated at 77 K for the same substrate current level in the low gate bias regime. Furthermore, the dominant device degradation is found to be in the high gate bias regime. Furthermore, the dominant device degradation is found to be in the high gate bias regime at 77 K, in contrast to the case of 300 K. This is due to the presence of negative charge in the oxide or in acceptor-type interface states. (Author abstract) 6 refs.

Heremans, P. (IMEC, Louvain, Belg); Sun, Y.-C.; Groeseneken, G.; Maes, H.E. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 313-318.

**Electronics Packaging** See Also DATA STORAGE, DIGITAL—Electric Power Supplies; INTEGRATED CIRCUITS—Mathematical Models.

**096169 CMOS CHIP PAIR FOR DIGITAL TV.** A two-chip digital TV with the potential for 650 horizontal lines of resolution and implemented with 195K transistors has been described. Both are fabricated in 1.5- $\mu$ m double-metal CMOS technology and assembled in plastic packages. The video processor with a 2H one-transistor cell dynamic RAM line memory contains 140K transistors in a 62-mm<sup>2</sup> chip, operates up to 50 MHz, and dissipates 250 mW at 14.3 MHz. The synchronous processor dissipates 110 mW at 14.3 MHz. 2 refs.

Suzuki, Seigo (Toshiba Corp, Kawasaki, Jpn); Kawai, Kiyoyuki; Muramatsu, Kunio. *IEEE J Solid State Circuits* v SC-22 n 5 Oct 1987 p 835-840.

## Etching

**096170 OXIDE BREAKDOWN DUE TO CHARGE ACCUMULATION DURING PLASMA ETCHING.** Charge accumulation on an insulating gate oxide may cause electrostatic breakdown. Exposing a wafer containing MOS devices to a plasma discharge during patterning of poly gate structures may, under certain conditions, cause damage to the device due to such a charge accumulation. At 13.56 MHz the charge that can be transferred to the wafer is so small that it is unlikely that the gate will reach a level where electrical breakdown will occur. If, however, the frequency is low or a dc supply is used, breakdown of the oxides may appear. Samples subjected to a low frequency or dc plasma also exhibit an increase in the density of states at the oxide semiconductor interface. (Edited author abstract) 9 refs.

Ryden, K.-H. (Inst of Microwave Technology, Stockholm, Swed); Norstrom, H.; Nender, C.; Berg, S. *J Electrochem Soc* v 134 n 12 Dec 1987 p 3113-3118.

**096171 ELECTRICAL PROPERTIES OF DEVICES FABRICATED ON LASER-ETCHED SILICON.** Focused laser etching has been investigated for use in limited area processing (LAP) of silicon wafers. The electrical properties of the etched material have been characterized for the first time by fabricating several different test structures, including isolation trenches, Schottky barrier diodes, and MOS trench capacitors. The etched material is suitable for many applications. 14 refs.

Treyz, G.V. (Columbia Univ, New York, NY, USA); Osgood, Richard M. Jr. *IEEE Electron Device Lett* v 9 n 5 May 1988 p 262-264.

## Evaluation

**096172 HOW TO EVALUATE MICROPOWER ELECTRONICS.** The sheer number of capabilities of the new high-tech devices is one of the forces driving the integration of electronics into gas distribution instrumentation. The rapid development of these devices creates competitive struggles for market share that reduces costs and increases available options. The article discusses power; handling; and safety of complimentary metal oxide semiconductor devices (CMOS) as guides to the evaluation of such devices.

Anon. *Gas Ind (Park Ridge IL)* v 32 n 10 Aug 1988 p 25-26.

**Fabrication** See Also DATA PROCESSING—Data Acquisition; INTEGRATED CIRCUITS, LINEAR—Fabrication; INTEGRATED CIRCUITS, LSI—Fabrication; INTEGRATED CIRCUITS, VLSI—Fabrication; SEMICONDUCTOR DEVICES, BIPOLAR—Fabrication; SEMICONDUCTOR DEVICES, MOSFET—Fabrication; TELEPHONE EXCHANGES—Electronic Equipment.

**096173 INTERFACE PROPERTIES OF THERMAL SiO<sub>2</sub> USING 1,1,1,TRICHLOROETHANE(TCA). TRICHLOROETHANE(TCA).** 1,1,1,Trichloroethane (TCA) has been used as a chlorine source in growing gate oxides for MOS devices. These oxides were grown with varying molar concentrations of TCA. Interface trap density ( $D_{it}$ ) was evaluated as a function of molar concentration of TCA. Results were compared with trichloroethylene (TCE) oxides, grown under identical conditions, to assess the feasibility of substituting a TCA source for the TCE. It was found that TCA oxides showed reduced interface trap density,  $D_{it}$ , for an optimum molar concentration of TCA, as compared to TCE oxides. In addition, interface trap density  $D_{it}$  vs. molar concentration of TCA shows a broadened minimum. It was also found that TCA is a better source for p-type silicon, than for n-type silicon. (Author abstract) 12 refs.

Bhan, R.K. (Solid State Physics Lab, Delhi, India); Lomash, S.K.; Basu, P.K.; Chabra, K.C. *J Electrochem Soc* v 134 n 11 Nov 1987 p 2826-2828.

**096174 HIGH-PERFORMANCE BICMOS TECHNOLOGY WITH DOUBLE-POLYSILICON SELF-ALIGNED BIPOLAR DEVICES.** A high-performance BiCMOS (bipolar complementary MOS) technology is described which incorporates 12-GHz double-polysilicon self-aligned bipolar, fully silicided CMOS devices and 1- $\mu$ m features. This process is applied to a BiCMOS gate design, called transistor feedback logic, to fabricate a divide-by-16 frequency divider with a maximum operating frequency of 364 MHz. Availability of uncompromised MOS and bipolar transistors allows a free mix of pure CMOS, pure bipolar, or BiCMOS gates on the same chip. 16 refs.

Rajkaran, Kamal (Unisys Corp, Eagan, MN, USA); Gheewala, Tushar R.; Diedrick, J. *IEEE Electron Device Lett* v EDL-8 n 11 Nov 1987 p 509-511.

**096175 SI-GATE CMOS DEVICES ON A Si/CaF<sub>2</sub>/Si STRUCTURE.** Si-gate CMOS inverter chains and 1/8 dynamic frequency dividers have been fabricated on a

Si/CaF<sub>2</sub>/Si structure. A high-quality heteroepitaxial Si/CaF<sub>2</sub>/Si structure was formed by successive molecular-beam epitaxy of CaF<sub>2</sub> and Si. Transistors have been fabricated with an improved CMOS process that prevents crystal degradation during the fabrication process as much as possible. The maximum effective mobilities are about 570 and 240 cm<sup>2</sup>/V-s for n-channel and p-channel transistors, respectively. The inverter chain, with an effective channel length of 2.0  $\mu$ m, has a delay time per gate of 360 ps. A maximum operating frequency of 300 MHz is obtained in the divider with an effective channel length of 2.5  $\mu$ m at a supply voltage of 5 V. These results indicate that the Si/CaF<sub>2</sub>/Si structure has potential for the fabrication of high-speed silicon-on-insulator devices. 13 refs.

Onoda, Hiroshi (Oki Electric Industry Co, Hachioji, Jpn); Sasaki, Masayoshi; Katoh, Teruo; Hirashita, Norio. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2280-2285.

**096176 MODELING AND CHARACTERIZATION OF CMOS-COMPATIBLE HIGH-VOLTAGE DEVICE STRUCTURES.** The design, implementation, and modeling of high-voltage MOS transistors in a standard CMOS technology is described. High voltage n-channel and p-channel transistors, with breakdown voltages of 50 and 180 V, respectively, have been fabricated. A SPICE-compatible model for these transistors is described, and its accuracy verified by comparison with experimental results. 18 refs.

Parpia, Zahir (Univ of Toronto, Ont, Can); Salama, C. Andre T.; Hadaway, Robert A. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2335-2343.

**096177 THREE-DIMENSIONAL HIGH-VOLTAGE CMOS UTILIZING A LASER-RECRYSTALLIZED SOI LAYER.** A flat-panel display driver fabricated with a 3-D IC technology which integrates a low-voltage bulk CMOS control-unit with high-voltage offset-gate SOI-MOS output circuits with a simple fabrication process is described. Performance results are given. 3 refs.

Sasaki, N. (Fujitsu Ltd, Kawasaki, Jpn); Kawamura, S.; Kawai, S.; Shirato, T.; Aneha, M.; Nakano, M. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2361.

**096178 UPMOS - A NEW APPROACH TO SUBMICROMETER VLSI.** A self-aligned, raised contact structure, UPMOS, which provides shallow junctions, low series resistance, and minimizes the source/drain (S/D) junction capacitance for MOS circuits is described. In this process, a composite gate structure with a 'reaction layer' and SiO<sub>2</sub> sidewalls is patterned by conventional RSE techniques. A layer of undoped polysilicon  $\approx 0.2 \mu$ m-0.3  $\mu$ m thick is then deposited over the entire wafer. This polysilicon layer is removed from areas other than the S/D in two steps. The S/D junctions are formed by ion implantation into the polysilicon followed by a diffusion anneal. A selective CoSi<sub>2</sub> layer is then formed on the polysilicon to reduce sheet resistance. This produces a MOSFET structure with raised S/D regions that extend over the field oxide for contact to first-level metal. Contacts to the S/D junction made on the polysilicon over the field oxide provide a more reliable contact scheme by avoiding aluminum spiking and relaxing alignment tolerances. This structure greatly reduces the S/D junction area and thus reduces the junction capacitance. In



addition, the formation of shallow junctions without implant damage is made possible with the UPMOS structure. 1 ref.

Foo, P.D. (Bell Lab, Murray Hill, NJ, USA); Liu, R.; Lebowitz, J.; Orlowsky, K.J.; Hillenius, S.J.; Lynch, W.T. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2368-2369.

**096179 PROCESS FOR A CMOS CHANNEL-STOP IMPLANTATION SELF-ALIGNED TO THE P-WELL AND P-WELL ACTIVE AREA.** A simplified isolation process for test CMOS LSI chip fabrication is proposed. In the process, channel-stop implantation is self-aligned to the p-well and the p-well active area. It is shown that a CMOS device with a one-level metallization can be fabricated with only seven photomasks using the process. 5 refs.

Yamauchi, Noriyoshi (NTT, Tokai, Jpn). *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2562-2563.

**096180 PROCESS FOR THE COMBINED FABRICATION OF ION SENSORS AND CMOS CIRCUITS.** A novel process for the fabrication of ion-selective field-effect transistors (ISFETs) together with CMOS circuits on the same chip is reported. The process is based on a standard 2- $\mu$ m, n-well, CMOS process, which is only modified starting at the metal interconnect step. The interconnect layer used is tungsten silicide. ISFETs are fabricated with floating polysilicon gates, which are exposed to photolithographic masking and HF etching before silicon nitride is deposited on the wafer. This layer of  $\text{Si}_3\text{N}_4$  acts both as the pH-sensitive insulator for the ISFETs and as a protection layer for the on-chip circuitry buried beneath it. A source-follower circuit is described that provides an output voltage dependent on the threshold-voltage variations of the sensing transistor. 15 refs.

Bousse, Luc (Stanford Univ, CA, USA); Shott, John; Meindl, James D. *IEEE Electron Device Lett* v 9 n 1 Jan 1988 p 44-46.

## Heat Treatment

**096181 EFFECT OF 1300-1380°C ANNEAL TEMPERATURES AND MATERIAL CONTAMINATION ON THE CHARACTERISTICS OF CMOS/SIMOX DEVICES.** The characteristics of CMOS transistors fabricated on silicon implanted with oxygen (SIMOX) materials were measured as a function of the silicon superficial layer contamination levels. In addition, postimplant anneal temperatures of 1300°C, 1350°C, and 1380°C were examined. It is found that the transistor leakage currents as well as the integrity of the gate oxide and implanted SIMOX oxide are functions of the carbon content in the starting material. Leakage currents below  $1.0 \times 10^{-12}$  A/ $\mu$ m of channel width have been measured when the carbon concentration is reduced to  $2 \times 10^{18}$  /cm<sup>2</sup>. In addition, the integrity of the transistor gate dielectric, SIMOX implanted oxide, and oxygen precipitate density are seen to be a function of the postimplant anneal temperature. A gate dielectric breakdown field of 10 MV/cm has been achieved when the postimplant temperature is increased to 1380°C. 8 refs.

Jastrzebski, L. (David Sarnoff Research Cent, Princeton, NJ, USA); Ipri, Alfred C. *IEEE Electron Device Lett* v 9 n 3 Mar 1988 p 151-153.

## Hysteresis

**096182 HYSTERESIS CYCLE IN THE LATCH-UP CHARACTERISTIC OF WIDE CMOS STRUCTURES.** Experimental results are interpreted in terms of a simple lumped-element model that is also used to reproduce the hysteresis phenomenon with discrete components. The hysteresis is related to a three-dimensional (3-D) nonuniformity in the current distribution. Such hysteresis can lead to an erroneous evaluation of latchup parameters, such as the holding current density. 2 refs.

Selmi, L. (Univ of Bologna, Italy); Sangiorgi, Enrico; Crisenza, G.; Re, D.; Ricco, Bruno. *IEEE Electron Device Lett* v 9 n 5 May 1988 p 214-216.

Impurities See INTEGRATED CIRCUITS—Design.

## Ion Implantation

**096183 EFFECTS OF FIELD IMPLANTS ON SMALL GEOMETRY CMOS DEVICES.** Various aspects of field implants have been studied with reference to a 3  $\mu$ m CMOS p-well process. It has been found that p-field (adjacent to p-channel transistors) implant is not required for a low voltage (1.5 v) process. Both p- and n-field implants are, however, essential for a high voltage (5 v) process. The threshold voltage or a narrow width n-channel transistor is found to be increased from 0.3 v to 2.5 v as compared to that of a large width transistor if the field implant is followed by a long high temperature step. The increase in threshold in the case of a narrow p-channel transistor is observed to be from 0.35 to 1.65 v under the same conditions. Such a large increase in the threshold voltage can be prevented by a proper design of the process. It has also been observed that arsenic is an unsuitable species of p-field implants. (Edited author abstract) 18 refs.

Roy, J.N. (Semiconductor Complex Ltd, Punjab, India); Chaudhury, Harish K.; Zarabi, M.J. *Microelectron Reliab* v 27 n 6 1987 p 953-957.

**096184 ADJUSTMENT OF THRESHOLD VOLTAGE OF MOS DEVICES BY ION IMPLANTATION.** We report the effect of oxide thickness, implant energy and dose on threshold voltage shift  $\Delta V_t$ . The implant parameters e.g. stopping power, projected range, straggle and the energy loss per micron for an ion in the substrate lattice are calculated using WKB potential. The junction depth beneath the oxide semiconductor surface is calculated using a two layer model. The parameters are used in theoretical calculation of threshold shift of MOS devices. Experimental threshold voltages for unimplanted and implanted samples were obtained from C-V plots, showing good agreement with theory. (Edited author abstract) 7 refs.

Virdi, G.S. (Central Electronics Engineering Research Inst, Pilani, India); Singh, S.; Pathak, B.C.; Khokle, W.S. *Microelectron J* v 19 n 1 Jan-Feb 1988 p 19-33.

## Junctions

**096185 INTERFACE STATES AND IMPURITIES IN MOS STRUCTURES WITH VERY THIN TUNNELING BARRIERS.** Electron tunneling spectroscopy was used to investigate MOS junctions with very thin silicon oxide or silicon oxynitride layers (2-5 nm) as tunneling barriers. For the tunneling measurements at 4.2 K highly degenerate P-doped ( $3 \times 10^{20}$  cm<sup>-3</sup>) Si substrates, oxidized in dry oxygen at 600°C were used. Silicon oxynitride layers were prepared by plasma nitridation in an  $\text{NH}_3$  discharge. As gate electrodes evaporated films of Al, Au or Pb were utilized. Changes in the tunneling conductivity were attributed to changes in the density of interface states, caused by hydrogen annealing or by high field stress. The results indicate a correlation between the generation of interface states and the removal of Si-H configurations. Vibrational modes of phonons, dopants and impurities were detected by inelastic electron tunneling spectroscopy. (Author abstract) 16 refs.

Balk, P. (Technical Univ Aachen, Aachen, West Ger); Do Thanh, L.; Ewert, S.; Kuball, M.; Schmitz, S. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 304-310.

## Manufacture

**096186 ETCHING OF PHOSPHORUS DOPED POLYSILICON FILMS.** A new technique for etching phosphorus doped polysilicon has been developed, based on a chlorine chemistry and contained in a triode configured reactor. Process results for various high and

low frequency and pressure are described. 4 refs.

Chambers, Andrew A. (Electrotech, Bristol, Engl); Davies, Simon V.; Lovett, Mostyn. *Semicond Int* v 11 n 1 Jan 1988 p 69-79.

**096187 AUTOMATIC CHANNEL ROUTING AND PHYSICAL DESIGN WITH TWO-DIRECTIONAL UNEQUAL GRID.** The automatic channel routing problem concerning two-directional unequal grid used in single-metal MOS technology is discussed. The authors propose an approach to deal with the routing in which vias are placed on adjacent tracks, and give the application results. The results show that nearly all the adjacent vias problems can be solved without additional routing area. (Author abstract) 4 refs. In Chinese.

Zhuang, Wenjun (Acad Sinica, Beijing, China); Gao, Chunhua. *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 200-204.

**096188 BiCMOS SHRINKS BELOW A MICRON.** This paper discusses briefly the technological achievements in manufacturing sub-micron high speed BiCMOS devices. It also discusses the development in CMOS memories.

Henley, Simon. *New Electron* v 21 n 4 Apr 1988 p 35.

Mathematical Models See Also AMPLIFIERS, OPERATIONAL—Fabrication; MATHEMATICAL STATISTICS—Monte Carlo Methods; TRANSISTORS—Hysteresis; TRANSISTORS—Temperature Effect.

**096189 TIME PERTURBATION ANALYSIS FOR THE MOS SYSTEM.** The development of a numerical implementation of the small signal response of the MOS (Metal-Oxide-Silicon) capacitor using time perturbation analysis is discussed. The effects of nonconstant doping profiles and interface and bulk traps are included. The model uses Fermi-Dirac statistics to describe the occupancy of the interface and bulk traps. The oxide region is considered to have no mobile carriers and any fixed oxide charge distribution is modeled as a charge sheet at the Si-SiO<sub>2</sub> interface. This technique can be used to find the small signal response of the device from the static solution. (Author abstract) 10 refs.

Gaitan, Michael (NBS, Gaithersburg, MD, USA); Mayergoyz, Isaac D. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 2 Jun 1987 p 77-83.

**096190 EXTRACTION OF TERMINAL CHARGES FROM TWO-DIMENSIONAL DEVICE SIMULATIONS OF MOS TRANSISTORS.** Quasi-static models of n-terminal semiconductor devices usually express terminal currents as the sum of steady-state and transient components. We consider here the formulation where these transient components are assumed to be time derivatives of charges associated with the terminals and these charges are completely specified by the terminal voltages applied to the device. This paper describes a method for extracting these terminal charges from two-dimensional device simulations of MOS transistors. The technique was used to obtain terminal charges for an n-channel MOS transistor and some results are presented. In addition, charge tables were generated and used in a table model for MOS transistors. The transient behavior of a circuit using this table model is compared with a physical time-domain simulation. (Author abstract) 10 refs.

Prendergast, E.J. (AT&T Bell Lab, Allentown, PA, USA); Lloyd, P.; Dirks, H. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 2 Jun 1987 p 107-114.

**096191 DESIGN OPTIMIZATION OF JCMOS STRUCTURES.** JCMOS structures are based on merging an MOS capacitance, a JFET, and a bipolar transistor in the area of a single MOS transistor. The structure performs the basic operations of temporary storage, writing, and sensing of stored data and is used in DRAM, serial dynamic memory, and dynamic logic applications.



A JCMOS structure implementation using a retrograde p-well CMOS process is presented. An analytical model relating terminal voltages and currents to device dimensions and doping levels is derived. Simulation results are presented for both reading and writing modes of operation. A test cell was successfully fabricated to verify the principle of operation, and experimental and theoretical results are compared. A simplified lumped component equivalent circuit, to be used in circuit simulators such as SPICE, is presented, and its validity is investigated. The structure design requirements and procedure are presented. The model is used to optimize the design of the structure. 17 refs.

Eldin, Ali G. (Univ of Waterloo, Ont, Can); Elmasry, Mohamed I. *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2136-2145.

**096192 EFFECT OF CHANNEL IMPLANTS ON MOS TRANSISTOR CHARACTERIZATION.** MOS device characterization involves the extraction of parameters from electrical measurements. A nonuniform channel doping profile can make such characterization ambiguous since device parameters are usually based upon a uniform doping profile model. The authors solve the one-dimensional Poisson's equation for several doping profiles and show the impact of a nonuniform doping profile on the threshold surface potential, threshold voltage, normal field mobility degradation, and transconductance. Five methods - the linear extrapolation, transconductance peak, Fowler and Hartstein, constant current, and split C-V methods - for obtaining the threshold voltage are compared. 22 refs.

Booth, Richard V. (Lehigh Univ, Bethlehem, PA, USA); White, Marvin H.; Wong, Hon-Sum; Krutsick, Thomas J. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2501-2509.

**096193 APPLIED FIELD AND TOTAL DOSE DEPENDENCE OF TRAPPED CHARGE BUILDUP IN MOS DEVICES.** A rate equation for charge buildup is developed that includes carrier sweep out, geminate recombination, hole/electron trapping, and effects of internal fields. The first moment of the resulting charge distribution is calculated to yield the midgap voltage shift as a function of irradiation time. The initial midgap voltage shift per dose and the maximum midgap voltage shift are derived. The field dependence of these quantities is shown to be a consequence of the field dependence of the hole/electron capture cross sections and geminate recombination escape probability. The results of this formulation show that the  $E^{-1/2}$  decrease in the midgap shift per dose with field described in the literature is due to the decrease of the hole capture cross section with increasing applied field. The theory is validated by comparison with experimental results obtained on 225-angstrom thermal oxide on p-type silicon test capacitors irradiated under bias at room temperature. 26 refs.

Krantz, Richard J. (Aerospace Corp, El Segundo, CA, USA); Aukerman, Lee W.; Zietlow, Thomas C. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1196-1201.

**096194 COMMENTS, WITH REPLY, ON 'CHARACTERIZATION AND MODELING OF MISMATCH IN MOS TRANSISTORS FOR PRECISION ANALOG DESIGN' BY K. R. LAKSHMIKUMAR, ET AL.** In a recently published paper by K. R. Lakshmikummar, et al. (ibid, vol. SC-21, no. 6, pp. 1057-1066, 1986) the yield of a digital-to-analog converter (DAC) as a function of component matching is estimated analytically. Here, an assumption inherent to that derivation, namely, that the DAC outputs are independent, is questioned and is demonstrated to be inconsistent with Monte-Carlo simulations. The reply of the authors of the original paper is also included. 8 refs.

Conroy, Cormac S.G. (Univ Coll, Cork, Irel); Lane, William A.; Moran, Michael A. *IEEE J Solid State Circuits* v 23 n 1 Feb 1988, 1987 Symp on VLSI Circuits,

Karuizawa, Jpn, May 22-23 1987 p 294-296.

**096195 METHODOLOGY FOR SUBMICRON DEVICE MODEL DEVELOPMENT.** Two-dimensional (2-D) device analysis is coupled into a new model development environment. An improved set of 2-D analytical boundary conditions for submicron MOS technology is developed through using exact information from numerical simulations. In addition to the accurate modeling of 2-D potential boundary conditions, the model provides a framework for further enhancements in the context of technology evolution. Specifically, the methodology is general and can be extended to a variety of technologically complex submicron structures, for example, source/drain tip implants (LDD-type devices) and a variety of other blanket and locally implanted structures. 12 refs.

Marash, Vered (Stanford Univ, CA, USA); Dutton, Robert W. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 2 Feb 1988 p 299-306.

**096196 COMPUTATION OF STEADY-STATE CMOS LATCHUP CHARACTERISTICS.** Robust computational techniques are presented for steady-state characterization of CMOS latchup via numerical device simulation. Of specific interest are efficient means of accurately evaluating knees in I-V characteristics, corresponding to latchup triggering and holding points. Making use of predictor-corrector continuation procedures and special initial-guess strategies, more than an order of magnitude improvement in computational efficiency is achieved over previous approaches. It is shown that for some latchup problems, these methods are essential due to their unique ability to trace characteristics that are multivalued in both I and V. Simulated results for both triggering and holding characteristics of a VLSI CMOS process are presented, from which primary structural dependencies are identified and new physical insight is obtained. 38 refs.

Coughran, William M. Jr. (AT&T, Murray Hill, NJ, USA); Pinto, Mark R.; Smith, R. Kent. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 2 Feb 1988 p 307-323.

**096197 MOS TRANSISTOR CHARGE MODEL FOR VLSI DESIGN.** The development of an MOS transistor charge and capacitance model for the analysis and design of VLSI circuits is described. The total stored charge in each of the gate, bulk, and channel regions is obtained by integrating the distributed charge densities over the thin-oxide area. Charge conservation is guaranteed in this model by using the terminal charges as the state variables. The capacitance expressions have the nonreciprocal property. Partition of channel charge into the drain and source components is 40/60 in the saturation region. In the triode region, this partition changes asymptotically to 50/50 as the gate voltage increases. The carrier-velocity saturation effect is incorporated through both the modification of channel quasi-Fermi level and the determination of drain saturation voltage. Implementation of the model in the SPICE circuit simulator has been achieved. Modeled results compare well with experimental data for transistors with channel lengths as small as 0.75  $\mu$ m. 30 refs.

Sheu, Bing J. (Univ of Southern California, Los Angeles, CA, USA); Hsu, Wen-Jay; Ko, Ping K. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 4 Apr 1988 p 520-527.

**096198 ANALYSIS AND CHARACTERIZATION OF BICMOS FOR HIGH-SPEED DIGITAL LOGIC.** A combined bipolar and CMOS (BiCMOS) logic gate, capable of driving large capacitive loads at high speed, is analyzed and characterized. A simple analytical model which accurately predicts the transient response of the BiCMOS gate is described. At moderate and large loads, saturation of the bipolar transistors due to collector resistance can dominate the transient response. Device scaling issues are discussed for minimizing gate delay at various loading conditions. 8 refs.

Greeneich, Edwin W. (Arizona State Univ, Tempe, AZ, USA); McLaughlin, Kevin L. *IEEE J Solid State Circuits* v 23 n 2 Apr 1988 p 558-565.

**096199 NEW ANALYTICAL MODEL FOR THE TWO-TERMINAL MOS CAPACITOR ON SOI SUBSTRATE.** An analytical model for the two-terminal metal-oxide-semiconductor-oxide-semiconductor (MOS-OS) structure, which takes into account the width of the accumulation layer in the SOI film and the space-charge region in the underlying Si substrate, is presented. The results of the model are compared with results one-dimensional (1-D) numerical simulations for a uniformly doped Si film and substrate, showing considerable improvement in accuracy compared to traditional models. 5 refs.

Flandre, Denis (Catholic Univ of Louvain-la-Neuve, Belg); Van de Wiele, Fernand. *IEEE Electron Device Lett* v 9 n 6 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 296-299.

**Measurements** See Also CAPACITORS—Measurements; SEMICONDUCTOR DEVICES, MOSFET; SEMICONDUCTOR MATERIALS—Spectroscopic Analysis.

**096200 OXIDE-THICKNESS DETERMINATION IN THIN-INSULATOR MOS STRUCTURES.** A technique to electrically determine the oxide thickness (and, in some cases, the flat-band voltage and surface doping as well) of thin-insulator MOS structures is discussed. This method does not require a model for either the accumulated or inverted semiconductor interface but assumes only that the classical MOS theory holds for zero surface band bending. By means of numerical simulations and comparison with high-resolution measurements obtained with transmission-electron microscopy, the technique is found to be valid well beyond the conditions for which it has been mathematically derived and to be applicable in almost all cases of practical interest. 9 refs.

Ricco, Bruno (IBM, Yorktown Heights, NY, USA); Olivo, Piero; Nguyen, Thao N.; Kuan, Tung-Shen; Ferriani, Guido. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 432-438.

**096201 TRANSIMPEDANCE PREAMPLIFIER WITH 70-DB AGC RANGE IN FINE-LINE NMOS.** The test results for an NMOS transimpedance preamplifier with 50- $\Omega$  drive capability and built-in automatic gain control (AGC) function are presented. Measurements at 0.88 Gb/s using  $\lambda = 1.3 \mu$ m and a p-i-n photodiode yield an average output power of -26 dBm with bit error rate (BER) =  $10^{-9}$ . A method to estimate the receiver sensitivity from noise-figure measurements is also proposed. This provides a relatively simple complementary technique to optical bit error rate (BER) measurements. 6 refs.

Jindal, Renuka P. (AT&T, Murray Hill, NJ, USA). *IEEE J Solid State Circuits* v 23 n 3 Jun 1988, Thirteenth Eur Solid-State Circuits Conf 87, Bad Soden, West Ger, Sep 1987 p 867-869.

**Modeling** See Also INTEGRATED CIRCUITS—Production Control; TRANSISTORS, FIELD EFFECT—Modeling.

**096202 ACCURACY OF CONVENTIONAL INVERSION CHARGE MODELING IN SCALED DOWN MOS DEVICES.** The density of surface inversion charge in MOS structures is typically calculated using the relation  $Q = \text{cox} (V_G - V_T)$ . We try to quantitatively assess the goodness of this relation in MOS devices scaled down according to constant field scaling and constant voltage scaling principles by comparing the inversion charge given by this relation to the inversion charge obtained by numerically solving the Poisson equation in one dimension. It turns out that while in the case of constant field scaling the conventional relation for inver-



sion charge becomes progressively erroneous, the same is not true for devices scaled down according to constant voltage scaling. (Edited author abstract) 5 refs.

Bose, S.C. (Central Electronics Engineering Research Inst, Pilani, India); Srivastava, S.; Shekhar, Chandra; Khokle, W.S. *Microelectron Reliab* v 28 n 1 1988 p 15-17.

**096203 LOGARITHMIC KINETIC FOR THE ACCUMULATION OF IONIC CHARGE IN  $\text{SiO}_2$  DIELECTRIC FILMS.** Ion drift and accumulation of an ionic charge  $Q$  in dielectric films of  $\text{SiO}_2$ , as a rule, correspond to diffusion theory which gives a time dependence of the form  $Q \propto (t/\tau)^{1/2}$ , where  $t$  is the time of action of the polarizing voltage and  $\tau$  is a constant of the process. Hofstein observed an exponential dependence  $Q \propto 1 - \exp(-t/\tau)$  which was explained by the emission of ions from traps near the dielectric-metal interface. In the present work it was found that charge accumulation in  $\text{SiO}_2$  films can follow a law  $Q \propto \ln(t/\tau)$ . A modification of the existing models is needed for an explanation of such kinetics. 4 refs.

Volkov, S.A. (Acad of Sciences of the USSR, USSR); Kol'tsov, B.B.; Lutsenko, G.N.; Ovsyuk, V.N. *Sov Microelectron* v 16 n 3 May-Jun 1987 p 148-151.

**096204 CMOS DELAY TIME MODEL BASED ON WEIGHTED PEAK CURRENT.** We propose a new CMOS delay time model with the configuration ratio, the input slope and the load condition taken into account. This model is based on the optimally weighted switching peak current. The delay equations are computationally effective and the error is typically within 10 percent of SPICE results. (Author abstract). 5 Refs.

Kim, K.H. (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Park, S.B. *Electron Lett* v 24 n 18 Sep 1 1988 p 1128-1129.

**Noise** See Also TELEVISION EQUIPMENT—Cameras.

**096205 GOOD DESIGN METHODS QUIET HIGH-SPEED CMOS NOISE PROBLEMS.** Today's high-speed CMOS logic is creating a big controversy over the issue of ground-bounce noise and the problems it creates in digital system design. Using some constructive design techniques can minimize the effects of ground-bounce noise. Minimize is a key word here, because designers do not have total control over the problem - chip manufacturers have to provide some help, too. Several noise minimizing methods are considered.

Tripp, Tim (Fairchild Semiconductor Corp, Portland, ME, USA); Hall, Bill. *EDN* v 32 n 22 Oct 29 1987 p 229-232, 234, 236.

**Noise, Spurious Signal**

**096206 INFLUENCE OF THE INTERFACE AND OF THE CHANNEL VOLUME OF  $1/f$  NOISE OF MOS TRANSISTORS BIASED IN THE LINEAR REGION AT STRONG INVERSION.** The paper is concerned with  $1/f$  noise of MOS transistors operating in the linear region at strong inversion. It is assumed that the  $1/f$  noise can be caused by carrier density fluctuations and/or carrier mobility fluctuations in the channel. A theoretical analysis and experimental investigation indicate that in general the equivalent input noise voltage level  $S_{Vg}$  and the shape of the characteristics of  $S_{Vg}$  vs the effective gate voltage  $V_{GT}$  depend on the transistor geometry, on the surface state density vs energy distribution  $N_t(E_f)$ , and on the scattering centre density vs channel depth  $N_s(x)$ . In the case of larger transistors (long channel and large oxide thickness) carrier density fluctuations determine the  $S_{Vg}$  level and the distribution  $N_t(E_f)$  determines the shape of  $S_{Vg}$  vs  $V_{GT}$ . In the case of smaller transistors, the shape of the characteristics  $S_{Vg}$  vs  $V_{GT}$  can also be determined by carrier mobility fluctuations. (Author abstract) 15 refs.

Grabowski, Franciszek (Technical Univ of Rzeszow, Rzeszow, Pol). *Solid State Electron* v 31 n 1 Jan 1988 p 115-120.

**096207 SIMULATION-ORIENTED NOISE MODEL FOR MOS DEVICES.** A formula for the noise in MOS devices particularly suited to general-purpose circuit simulation programs is described. It is valid in every part of the MOS  $I$ - $V$  curves. The expression for the thermal noise is derived from a theoretical analysis, and the flicker-noise expression is empiric. 9 refs.

Nicollini, Germano (SGS Microelettronica, Milan, Italy); Pancini, Davide; Pernici, Sergio. *IEEE J Solid State Circuits* v SC-22 n 6 Dec 1987, 1987 Int Solid-State Circuits Conf (ISSCC), New York, NY, USA, Feb 1987 p 1209-1212.

**Optimization**

**096208 LINEAR ALGORITHMS FOR OPTIMIZING THE LAYOUT OF DYNAMIC CMOS CELLS.** In many CMOS design styles the basic building blocks are complex (static or dynamic) CMOS gates with up to a few dozen transistors. The layout optimization for such gates takes the shape of graph optimization problems. Two such graph problems, corresponding to different layout styles for basic cells composed of dynamic CMOS gates, are considered. Both problems are solved in linear time; the number of gates in the cell is considered. 16 refs.

Lengauer, Thomas (Univ Gesamthochschule Paderborn, West Ger); Muller, Rolf. *IEEE Trans Circuits Syst* v 35 n 3 p 279-285 Mar 1988.

**096209 OPTIMIZED  $1.0\text{-}\mu\text{m}$  CMOS TECHNOLOGY FOR NEXT-GENERATION CHANNELLESS GATE ARRAYS.** An optimized 5-V  $1.0\text{-}\mu\text{m}$  CMOS technology has been developed to achieve high speed and high packing density for channelless gate arrays. In addition to the downward scaling of CMOS device geometry, reduction of the parasitic resistances is essential for next-generation channelless gate arrays. The technology utilizes sidewalled PMOS and lightly doped drain (LDD) NMOS structures with  $1.0\text{-}\mu\text{m}$  actual physical gate lengths and  $20\text{-nm}$  gate-oxide thickness. Tungsten metal is selectively deposited on the source and drain regions to reduce sheet resistivity, thus gaining extra speed improvement. This technology was applied to a large-scale gate array of over 40K usable gates; high-speed (290-ps) operation has been achieved for a two-input NAND gate with a fan-out of 2 and  $2\text{-mm}$  Al. An advanced graphic processor with over 35K used gates has been successfully demonstrated. 11 refs.

Ushiku, Yukihiko (Toshiba Corp, Kawasaki, Jpn); Kobayashi, Teruo; Yoshida, Akito; Itoh, Nobuyuki; Nishiyama, Akira; Nakata, Rempai. *IEEE J Solid State Circuits* v 23 n 2 Apr 1988 p 507-513.

**Performance** See Also COMPUTERS, MICROCOMPUTER—Design; ELECTRONICS PACKAGING—Degradation; IMAGE PROCESSING—Components; LOGIC DESIGN—Computer Aided Design.

**096210 ANALOG/DIGITAL BCD MOS TECHNOLOGY WITH DIELECTRIC ISOLATION - DEVICES AND PROCESSES.** A dielectrically isolated bipolar-CMOS-DMOS (BCD MOS) integrated-circuit technology that has been successfully developed for high-voltage applications (150-500 V) is reported. This technology integrates bipolar, CMOS, DMOS, p-n-p-n, JFET, and DGD MOS (dual-gate DMOS) devices on a single chip. The core BCD MOS process is chosen to be an optimized poly-gate n-channel DMOS process; additional levels and their relative sequences were chosen on the basis of their effects on the performance of the various kinds of devices in the chip and the trade-offs among those performances. The characteristics of the major devices in solid-state switches for telecommunication applications are demonstrated. 27 refs.

Lu, Chih-Yuan (AT&T Bell Lab, Reading, PA, USA); Tsai, Nun-Sian; Dunn, Charles N.; Riffe, Pamela C.; Shibib, M. Ayman; Furnage, Richard A.; Goodwin, C.A. *IEEE Trans Electron Devices* v 35 n 2 Feb 1988 p 230-239.

**Photovoltaic Effects**

**096211 ON THE INFLUENCE OF GAMMA RADIATION DOSE ON SELECTED PHOTOELECTRIC PROPERTIES OF ZnSe MOS STRUCTURES.** The results of investigations on the possibilities of application of ZnSe MOS detectors for the measurements of gamma radiation dose are presented. It is shown that variations of photocurrent and induced photoelectromotoric force can be related to the dose of gamma radiation acting on the material of the detector. Investigated detectors can find applications in radiation technique and radiotherapy where they can be used for monitoring of high doses of gamma radiation. (Author abstract) 7 refs.

Warkocki, Stanislaw (Higher Officer Sch of Chemical Army, Cracow, Pol); Zmija, Jozef; Demianiuk, Mieczyslaw. *Electron Technol (Warsaw)* v 19 n 1-2 1987 p 101-111.

**Physical Properties**

**096212 EFFECTS OF HYDROGEN CHLORIDE ON THE ANNEALING KINETICS OF INTERFACE AND OXIDE TRAPS IN OXIDIZED SILICON STRESSED BY AVALANCHE ELECTRON INJECTION.** Effects of HCl during oxidation on the room temperature annealing kinetics of interface and oxide traps are investigated in aluminum/poly-silicon/oxide/silicon capacitors after avalanche electron injection (AEI) from silicon. A turn-around phenomenon in the interface trap annealing kinetics is observed in the HCl oxides, which may be associated with the activation of a chlorine-related interface trap after the AEI ceases. HCl reduces or retards the anneal of the interface traps but enhance the anneal of the oxide traps. In a  $200\text{ A}$  oxide, an exposure to  $10^{15}\text{ e/cm}^2$  of 8-keV electrons gave much larger annealed densities of oxide and interface traps than in an oxide stressed by avalanche injected electrons of  $10^{18}\text{ e/cm}^2$  of an equivalent amount of energy with initial gate voltage in the 22-25 V range. (Edited author abstract) 18 refs.

Lin, Wallace Wan-Li (Univ of Illinois, Urbana, IL, USA); Sah, Chih-Tang. *Solid State Electron* v 31 n 7 Jul 1988 p 1151-1156.

**Processing** See Also SEMICONDUCTOR DEVICES, BIPOLAR—Production; TRANSISTORS, BIPOLAR—Performance.

**096213 TI'S BLAZING-FAST CMOS LOGIC TAKES ON SCHOTTKY BIPOLAR.** A new advanced complementary MOS (CMOS) logic (ACL) family of parts is introduced by Texas Instruments, Inc. Sharing the credit for the performance of the TI ACL parts are an innovative twin-well process that builds  $1\text{-}\mu\text{m}$ -long gates and a novel pinout. Also important for performance is the close attention given to fighting off latchup and electrostatic discharge.

Anon. *Electronics* v 59 n 31 Sep 18 1986 p 78-81.

**096214 BURIED-OXIDE ISOLATION WITH ETCH-STOP (BOXES).** A buried-oxide (BOX) isolation process which has greatly improved submicrometer MOS manufacturability has been developed. The process, BOXES (BOX with etch-stop) isolation, incorporates an etch-stop layer over active area down to which the field oxide is etched, rather than to the active-area surface as in BOX. Nonuniformities inherent to the BOX process do not then cause the field oxide to be recessed below the active-area surface. Furthermore, by a brief overetch of the etch-stop during its patterning, the field oxide is made to controllably encroach laterally over the active-area edges. Measurements of NMOS devices demonstrate that BOXES isolation with lateral encroachment has greatly reduced sidewall and edge parasitic conduction. 7 refs.

Kwasnick, Robert F. (GE, Schenectady, NY, USA); Kaminsky, E.B.; Frank, P.A. *IEEE Electron Device Lett* v 9 n 2 Feb 1988 p 62-64.



## Radiation Damage

**096215 CORRELATION BETWEEN MECHANICAL STRESS AND HYDROGEN-RELATED EFFECTS ON RADIATION-INDUCED DAMAGE IN MOS STRUCTURES.** Polycide-gate MOS capacitors were investigated as a function of gate-oxide thickness. The compressive stress magnitude was altered by varying the silicide (TiSi<sub>2</sub> or WSi<sub>2</sub>) thickness in the polycide-gate electrode, and hydrogen introduction into gate-SiO<sub>2</sub> film was carried out by diffusion from plasma-deposited silicon-nitride passivation film (SiN-cap). In a MOS capacitor without passivation film (no-cap sample), it was found that compressive stress on gate-SiO<sub>2</sub> reduces both positive charge build-up ( $\Delta Q_p$ ) and interface-trap generation ( $\Delta D_{it}$ ). Radiation induced shift,  $Q_{ox}$  exhibits a smaller stress effect as compared with  $D_{it}$ . As gate-SiO<sub>2</sub> thickness decreases, the stress effect on  $\delta Q_{ot}$  increases, while this effect on  $D_{it}$  remains nearly constant. Both stress effects of  $Q_{ox}$  and  $D_{it}$  in SiN-cap samples show a gate-oxide-thickness dependence similar to that on  $Q_{ox}$  in no-cap samples. The stress effect observed in no-cap samples can be explained on the basis of the bond reformation process at the SiO<sub>2</sub>/Si interface and near the electrode/SiO<sub>2</sub> interface. 22 refs.

Kasama, K. (NEC, Sagami-hara, Jpn); Tsukiji, M.; Kobayashi, K. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1202-1207.

**096216 CHARGE COLLECTION EFFICIENCY RELATED TO DAMAGE IN MOS CAPACITORS.** Absolute charge collection efficiencies of undamaged and radiation-damaged MOS capacitors have been measured as a function of applied collection bias and related to device damage. The measurements were performed on devices irradiated to various particle fluences, under different bias conditions, and with both lightly and heavily damaging particles. The measurements allow characterization and separation of damage effects due to flatband voltage shifts and atomic displacements in the substrate, and are sensitive indicators of both kinds of damage. Using this technique in conjunction with a microbeam, possibilities exist for investigating damage at a highly localized level, ion per ion, as the damage occurs. This technique is not limited to MOS devices. 8 refs.

Xapsos, Michael A. (US Naval Research Lab, Washington, DC, USA); Campbell, Arthur B.; Knudson, Alvin R.; Stapor, William J.; Shapiro, Phillip; Palmer, Tawanna; McDonald, Patrick T.; Swickert, Suzanne L. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1214-1219.

**Radiation Effects** See Also INTEGRATED CIRCUITS, VLSI—Radiation Effects; RADIATION EFFECTS—Computer Simulation; SEMICONDUCTOR DEVICE MANUFACTURE—Silicon on Sapphire Technology.

**096217 FREQUENCY DISPERSION OF GAMMA RAY IRRADIATED MOS C-V CURVES.** A large frequency dispersion of MOS C-V characteristics after Co-60 gamma ray irradiation was observed. The difference between flatband voltage shift and midgap voltage shift are discussed herein. The recovery of the interface states density and positive charge is also presented. (Author abstract) 4 refs.

Ohnishi, Kazunori (Nihon Univ, Funabashi, Jpn); Ushirokawa, Akio. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 9 Sep 1987 p 804-806.

**096218 TOTAL-DOSE EFFECTS OF GAMMA-RAY IRRADIATION ON CMOS/SIMOX DEVICES.** Radiation-hardened CMOS/SIMOX (separation by implanted oxygen) devices have been developed using a combination of vertical isolation structures obtained by SIMOX technology and recently developed lateral isolation structures. The n-channel MOSFET is vertically isolated by multilayers of highly-oxygen-doped polysilicon and buried SiO<sub>2</sub>; it is laterally isolated by multilayers of thin sidewall SiO<sub>2</sub>, sidewall polysilicon, and

thick field SiO<sub>2</sub>. The p-channel MOSFET has the same vertical isolation structure as that of the n-channel MOSFET, but has no sidewall polysilicon layer and uses a thick field SiO<sub>2</sub> layer for lateral isolation. Highly-oxygen-doped polysilicon and sidewall polysilicon layers act to shield radiation-induced positive charges trapped in the buried SiO<sub>2</sub> and field SiO<sub>2</sub> layers, respectively. 9 refs.

Ohno, Terukazu (NTT, Atsugi, Jpn); Izumi, Katsutoshi; Shimaya, Masakazu; Shiono, Noboru. *IEEE Circuits Devices Mag* v 3 n 6 Nov 1987 p 21-26.

**096219 NATURE OF THE DEEP HOLE TRAP IN MOS OXIDES.** The authors investigated hole and electron trapping events at E' deep hole traps in metal-oxide-semiconductor oxides. Using a sequence of ultraviolet irradiation, electron spin resonance measurements, and capacitance-versus-voltage measurements, results were obtained that are consistent with a simple oxygen vacancy model for the hole trap. However, these results are inconsistent with the bond strain gradient model proposed by F. J. Grunthaner et al. (1982). 40 refs.

Witham, Howard S. (Pennsylvania State Univ, University Park, PA, USA); Lenahan, Patrick M. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1147-1151.

**096220 ROLE OF HYDROGEN IN RADIATION-INDUCED DEFECT FORMATION IN POLYSILICON GATE MOS DEVICES.** The role of hydrogen in the generation of radiation-induced interface-trap and oxide-trapped charge in MOS polysilicon gate capacitors has been investigated. The concentration of radiation-induced interface-trap and oxide-trapped charge measured both immediately after irradiation and after postirradiation anneal increases if high-temperature anneals are performed in hydrogen. These results were analyzed in the context of several models of interface-trap and oxide-trapped charge formation. The mutual increase in the concentration of oxide-trapped charge and the early-time (1-ms to 10-sec) component of interface-trap charge with the amount of hydrogen used during processing suggests that the breaking of Si-H or Si-OH bonds may be responsible for much of the defect formation at or near the silicon/silicon dioxide interface. 30 refs.

Schwank, J.R. (Sandia Natl Lab, Albuquerque, NM, USA); Fleetwood, D.M.; Winokur, P.S.; Dressendorfer, P.V.; Turpin, D.C.; Sanders, D.T. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1152-1158.

**096221 CRITICAL EVALUATION OF THE MIDGAP-VOLTAGE-SHIFT METHOD FOR DETERMINING OXIDE TRAPPED CHARGE IN IRRADIATED MOS DEVICES.** The validity of using midgap voltage shifts to determine radiation-induced oxide-trapped charge is examined using thermally stimulated current (TSC), conductance, and C-V techniques. The assumption behind the midgap technique that all interface states are amphoteric P<sub>b</sub> centers is shown to be not generally valid. Conductance measurements revealed a donor interface state in the upper half of the bandgap. Results obtained by combining data from TSC and high-frequency C-V measurements show the existence of three types of radiation-induced interface states: the P<sub>b</sub> center, a donor state in the upper half of the bandgap, and an acceptor state in the lower half. No single surface potential exists that is the neutral point for N<sub>it</sub> for all processes and radiation doses. Midgap voltage shifts do not generally correlate with oxide-trapped charge determined from thermally stimulated current (TSC) measurements. The magnitude of the fractional deviation is typically less than a factor of unity but in some cases is as large as a factor of four. The significance of these errors needs to be determined for each application. Arguments and tests supporting the validity of using TSC measurements for determining oxide-trapped charge are presented. 21 refs.

Shanfield, Z. (Northrop Research & Technology Cent,

Palos Verdes Peninsula, CA, USA); Moriwaki, M.M. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1159-1165.

**096222 RADIATION-INDUCED INTERFACE TRAPS IN MO/SiO<sub>2</sub>/SI CAPACITORS.** The radiation induced interface traps in molybdenum-gate metal/SiO<sub>2</sub>/Si (MOS) capacitors over a wide range of radiation doses have been investigated. It has been found that: (1) high-temperature (900°C) annealing in H<sub>2</sub> after Mo deposition increases the radiation sensitivity significantly, especially for dose levels above 1 Mrad(Si); (2) gate-size dependence of the radiation sensitivity is observed in samples without the hydrogen anneal, but not in samples annealed in hydrogen; (3) a characteristic interface trap peak above midgap appears immediately after irradiation, which, along with its background, decreases with time after irradiation over a long period (over 1000 h) at room temperature; (4) the rate of decrease of this peak is a function of the initial damage level, the gate bias during sample storage, and the storage temperature; (5) while this peak is decreasing, a second peak below midgap will develop and grow with time, and the rate of growth of the second peak is correlatable to the reduction of the first peak, suggesting the possibility of defect transformation process at the interface; (6) the defect transformation process is strongly influenced by the gate bias and sample temperature after irradiation. 11 refs.

Nishioka, Yasuhiro (Yale Univ, New Haven, CT, USA); da Silva, Eronides F. Jr.; Ma, T.-P. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1166-1171.

**096223 GROWTH AND ANNEALING OF TRAPPED HOLES AND INTERFACE STATES USING TIME-DEPENDENT BIASES.** Defect growth and annealing mechanisms in MOS devices have been studied. Biases were changed during irradiations. Significant radiation-induced annealing of trapped holes was observed. Apparent room-temperature annealing of interface states was also observed. A consistent explanation of this apparent annealing is presented, i.e., an effect of LNUs (lateral nonuniformities) on the results of the sub-threshold analysis technique. A possible physical mechanism for the creation of LNUs due to inhomogeneous energy deposition is explored. 29 refs.

Freitag, R.K. (US Naval Research Lab, Washington, DC, USA); Dozier, C.M.; Brown, D.B. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1172-1177.

**096224 RADIATION RESPONSE OF MOS CAPACITORS CONTAINING FLUORINATED OXIDES.** By introducing small amounts of fluorine into the gate oxide, the radiation response of metal/SiO<sub>2</sub>/Si(MOS) capacitors and their subsequent time-dependent behavior were altered. It was observed that compared with their control capacitors, which had no fluorine introduced into the oxide, the fluorinated samples exhibit the following major differences: (1) the densities of radiation-induced oxide charge and interface traps are reduced, (2) the gate-size dependence of the radiation-induced interface traps is suppressed, and (3) the overall density of the radiation-induced interface traps continues to decrease with time for many hours after irradiation before a turnaround trend is observed. Possible mechanisms involving the roles that fluorine may play in relieving the oxide strain near the SiO<sub>2</sub>/Si interface and in the postirradiation defect-reaction chemistry are discussed. 17 refs.

da Silva, Eronides F. Jr. (Yale Univ, New Haven, CT, USA); Nishioka, Yasuhiro; Ma, T.-P. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1190-1195.



**096225 COMPARISON OF POSITIVE CHARGE GENERATION IN HIGH FIELD STRESSING AND IONIZING RADIATION ON MOS STRUCTURES.** The effects of ionizing radiation and high field stressing on metal-oxide-silicon oxides are compared. Using electron spin resonance, the authors compare the point defects responsible for the positive charge generated by ionizing radiation and high field stressing. The two processes have been found to be different in that the positive charge generated by ionizing radiation is almost entirely due to E' centers in the oxide; however, less than half the positive charge generated by high field stressing can be accounted for by E' centers. 17 refs.

Warren, W.L. (Pennsylvania State Univ, University Park, PA, USA); Lenahan, P.M. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1355-1358.

**096226 RADIATION HARD 1.0- $\mu$ M CMOS TECHNOLOGY.** Test results are presented of a radiation-hard CMOS technology with 1.0- $\mu$ m-minimum geometry features. The radiation goals of this technology are to ensure the MOS devices are functional after 10 Mrad total dose irradiation, are single-event-upset hardened to less than  $10^{-10}$  errors/pbit-day, are transient-upset-immune to  $10^9$  rad/s, and are latchup-free. 8 refs.

Lee, K.H. (AT&T Bell Lab, Allentown, PA, USA); Desko, John C.; Kohler, Ross A.; Lawrence, Cris W.; Nagy, William J.; Shimer, Julie A.; Steenwyk, Steven D.; Anderson, Richard E.; Fu, Julia S. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1460-1463.

**096227 MEASUREMENT OF LOW-ENERGY X-RAY DOSE ENHANCEMENT IN MOS DEVICES WITH METAL SILICIDE GATES.** A photocurrent technique was used to accurately measure dose enhancement in the gate oxide of MOS devices with tungsten or titanium silicide over various thicknesses of poly-Si exposed to low-energy X-irradiation. The results show that the dose enhancement is strongly dependent on the type of metal/silicide used and the thickness of the poly-Si layer between the metal/silicide and the SiO<sub>2</sub> gate insulator. A straightforward procedure for calculating the equal damage dose equivalence for metal/silicide over poly-Si gate MOS structures is presented. 10 refs.

Benedetto, J.M. (US Army Lab Command, Adelphi, MD, USA); Boesch, H.E. Jr.; Oldham, T.R.; Brown, G.A. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1540-1543.

**096228 VARIATIONS IN SEMICONDUCTOR DEVICE RESPONSE IN A MEDIUM-ENERGY X-RAY DOSE-ENHANCING ENVIRONMENT.** Experiments were undertaken to investigate the response of semiconductor devices to medium-energy X-ray irradiation under conditions in which dose-enhancement effects are important. It has been found that the response of MOS capacitors to the same dose-enhanced radiation depends not only on the increased dose, but also on the incident radiation spectra, device temperature and processing, and/or oxide thickness and electric field. In many cases, these dependencies cannot be explained simply in terms of existing knowledge of basic mechanisms of radiation effects on MOS devices (for example, electron-hole recombination and hole transport and trapping), or by present Monte Carlo electron/photon transport codes such as the Integrated Tiger Series (ITS). The response of semiconductor diodes to the dose-enhanced radiation appears to be qualitatively different from that of MOS capacitors, and differs markedly in value from the ITS code predictions. These results demonstrate that an improved understanding of semiconductor device response to enhanced irradiation is needed to assure simulation fidelity of tests of devices to be used in dose-enhancing environments. 26 refs.

Beutler, D.E. (Sandia Natl Lab, Albuquerque, NM,

USA); Fleetwood, D.M.; Beezhold, W.; Knott, D.; Lorence, L.J. Jr.; Draper, B.L. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1544-1550.

**096229 SINGLE EVENT UPSET IN SOS INTEGRATED CIRCUITS.** Single-event upset (SEU) by argon and krypton ions has been observed in 1.25- $\mu$ m CMOS-SOS (complementary metal-oxide-semiconductor-silicon-on-sapphire) integrated circuits. Mixed-mode PISCES-SPICE circuit-device simulations were conducted and the calculated (linear energy transfer) threshold compared favorably to experimental data. Analysis with the two-dimensional finite-element PISCES code revealed the upset-charge-collection mechanism involves charge multiplication due to bipolar action. 8 refs.

Rollins, J.G. (Aerospace Corp, Los Angeles, CA, USA); Choma, J. Jr.; Kolasinski, W.A. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1713-1719.

**096230 EFFECTIVENESS OF CMOS CHARGE REFLECTION BARRIERS IN SPACE RADIATION ENVIRONMENTS.** Single-event upsets in microelectronic circuits follow the collection of more than some critical amount of charge at certain reverse-biased junctions. Reducing charge collection at the junctions lowers the upset rate without requiring performance tradeoff. Three mechanisms for reducing the fraction of charge collected at a junction can be incorporated in the use of CMOS-type wells. For illustration, the CHMOS-III-D process used in Intel's P51C256 is shown to lower the error rate to be expected in deep space by an order of magnitude from that calculated for an equivalent dynamic RAM of standard design. 8 refs.

McNulty, P.J. (Clarkson Univ, Potsdam, NY, USA); Lynch, J.E.; Abdel-Kader, W.G. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1796-1799.

**096231 RESIDUAL CHARGES EFFECT ON THE ANNEALING BEHAVIOR OF Co-60 IRRADIATED MOS CAPACITORS.** It was experimentally observed that the residual charges of an MOS capacitor after C-V testing can exist for a long time. These charges include a nonzero field at the SiO<sub>2</sub>/Si interface, and subsequently affect the annealing behavior due to a charge-temperature effect if the MOS capacitor is left floating during annealing. This problem is solved by a flat-band condition annealing method based on a charge-temperature technique. The annealing kinetics of a Co-60 irradiated MOS capacitor are then studied. A power-law behavior of the annealing kinetics has been obtained for oxide charges annealed at 300°C. Possible explanations are given for this observation. 20 refs.

Hwu, Jenn-Gwo (Nat'l Taiwan Univ, Taipei, Taiwan); Lee, Guang-Sheng; Lee, Si-Chen; Wang, Way-Seen. *IEEE Trans Nucl Sci* v 35 n 1 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 960-965.

**096232 ELECTRON BEAM IRRADIATION EFFECTS ON MOS-TRANSISTORS AND ITS SIGNIFICANCE TO E-BEAM TESTING.** The aim of this paper is to show the effects of e-beam irradiation on both passivated and un-passivated MOS transistors down to lum geometries. In particular, the shift in threshold and leakage current under different exposure conditions have been investigated and a mechanism for the observed changes explored. Finally, some guide lines within which e-beam testing could be done with minimum change in the performance of the device are given. (Author abstract) 14 refs.

Ranasinghe, D.W. (British Telecom Research Lab plc, Ipswich, Engl); Machin, D.J.; Proctor, G. *Microelectron Eng* v 7 n 2-4 1987, Proc of the First Euro Conf on Electron and Opt Beam Test of Integr Circuits, Grenoble, Fr, Dec 9-11 1987 p 397-403.

## Radiation Protection

**096233 RADIATION HARDNESS IN CMOS DEVICES.** Ionizing radiation, which can be electromagnetic (charged particles or gamma rays and other photons) or particulate (fast neutrons), causes most of the problems associated with the irradiation of CMOS components. The author describes several approaches to achieve true, accurately defined radiation hardness of CMOS components.

Main, Gordon (Harris Systems). *New Electron* v 20 n 12 Jun 9 1987 p 16, 18, 22.

**Reliability See Also INTEGRATED CIRCUITS—Reliability; SUBSTRATES—Electric Properties.**

**096234 HARDNESS ASSURANCE BASED ON SYSTEM RELIABILITY MODELS.** The problem of determining a piece-part test program based on system reliability objectives is considered. It is shown how conventional single-sample plans can be extended to include a demonstration of system reliability by numerical simulation of system tests. A theoretical basis for test planning is suggested which may be of use to both producers and consumers of radiation-hardened piece parts. 15 refs.

Browning, J.S. (Sandia Natl Lab, Albuquerque, NM, USA); Gover, J.E. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1775-1781.

**Research See OXIDES—Thin Films.**

## Semiconductor Insulator Boundaries

**096235 OBSERVATION OF FERMIL LEVEL PINNING AT THE GaAs-PLASMA-OXIDE INTERFACE.** Small-signal charge transient spectroscopy (CTS) measurements of GaAs MOS diodes with plasma oxide insulating layers point to two dominant trapping levels responsible for the steady-state Fermi level pinning at the GaAs-oxide interface. The E<sub>c</sub>-0.70 eV discrete surface trap is identified with the defect level observed in fundamental studies of III-V surfaces; this defect is due to missing As. The second level, positioned at E<sub>c</sub>-0.67 eV, has not been reported previously. It is argued that the 0.67 eV defect is characteristic of the transition layer between the moderately doped (N<sub>D</sub> to about 10<sup>15</sup>-10<sup>16</sup> cm<sup>-3</sup>) GaAs substrate and the oxide. (Author abstract) 18 refs.

Thurzo, I. (Slovak Acad of Sciences, Bratislava, Czech); Pinick, E.; Morvic, M.; Gorog, T. *Semicond Sci Technol* v 2 n 10 Oct 1987 p 636-642.

**096236 STUDY OF ELECTRON TRAPS IN SILICON DIOXIDE DUE TO MOBILE SODIUM IONS AT THE Si-SiO<sub>2</sub> INTERFACE.** We have studied electron trapping due to mobile sodium ions in silicon dioxide near the Si-SiO<sub>2</sub> interface using MOS capacitors. After doing a bias-temperature stress, hot electrons were injected into SiO<sub>2</sub> by avalanche injection. The number of trapped electrons, as measured by shifts in flat-band voltage of high frequency C-V curves, is proportional to the sodium ion density. The depth of these electron traps was found by a thermal detrapping experiment to be about 1.2 eV. A possible model for the origin of the mobile sodium-related electron trap is presented. (Author abstract) 16 refs.

Ramesh, K. (Indian Inst of Technology, Bombay, India); Chandorkar, A.N.; Vasi, J. *J Inst Electron Telecommun Eng* v 33 n 1 Jan-Feb 1987 p 38-40.

**096237 ELECTRICAL PROPERTIES OF Si-SiO<sub>2</sub> STRUCTURES TREATED IN HELIUM PLASMA.** Experimental data are presented for the influence of helium plasma on the electrical properties of Si-SiO<sub>2</sub> structures with dry thermal oxide (d = 16 - 72 nm). It is found that for strongly damaged structures low temperature helium plasma introduces acceptor-type interface



states near the conduction band edge and has an annealing effect on the deep acceptor-type states. It has also shown that the initial characteristics of the Si-SiO<sub>2</sub> structures and the gas used are critical for the plasma-forming of both the interface and inversion channel properties. (Author abstract) 20 refs.

Kassabov, J. (Bulgarian Acad of Sciences, Sofia, Bulg); Atanasova, E.; Dimitrov, D.; Goranova, E. *Microelectron J* v 18 n 5 Sep-Oct 1987 p 5-12.

**096238 ELECTRONIC PROPERTIES OF A PHOTOCHEMICAL OXIDE-GaAs INTERFACE.** The properties of a GaAs-oxide interface formed by recently proposed photochemical oxidation in water were studied. Remarkable photoluminescence intensity enhancement was observed after oxidation which previously was interpreted as 'unpinning' of the Fermi level. However, the surface current transport and capacitance-voltage measurements consistently indicated a strong Fermi level pinning with an increased surface depletion. These apparently contradictory results can be explained by a new model in which photochemical oxidation does not unpin, but shifts the pinning position of the Fermi level towards the valence band edge. (Author abstract) 17 refs.

Sawada, Takayuki (Hokkaido Univ, Sapporo, Jpn); Hasegawa, Hideki; Ohno, Hideo. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1871-1873.

**096239 ELECTRICAL SWITCHING AND NOISE SPECTRUM OF Si-SiO<sub>2</sub> INTERFACE DEFECTS GENERATED BY HOT ELECTRONS.** We observe at low temperatures the noise caused by switching the occupancy of individual interface defect states that have been created during electrical stress with high drain voltages. These results are compared with measurements of traps present in undamaged n-channel Si(100) MOSFETs. (Author abstract) 6 refs.

Bollu, M. (Technische Univ Muenchen, Garching, West Ger); Koch, F.; Madenach, A.; Scholz, J. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 142-147.

**096240 INDIVIDUAL INTERFACE STATES AND THEIR IMPLICATIONS FOR LOW-FREQUENCY NOISE IN MOSFETs.** We show that the wide distribution of time constants required to explain 1/f noise in MOSFETs arises as a natural consequence of the multi-phonon model of carrier trapping into individual Si-SiO<sub>2</sub> interface states. A new class of random telegraph signal found in the drain current of small-area silicon MOSFETs is described. These signals are a result of defect metastability and are shown to be a source of non-Gaussian noise. (Author abstract) 15 refs.

Kirton, M.J. (Royal Signals & Radar Establishment, Malvern, Engl); Uren, M.J.; Collins, S. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 148-152.

**096241 IMPROVEMENT OF THE Si-SiO<sub>2</sub> INTERFACE STRESS RESISTANCE OF THIN GATE OXIDES AFTER CHANNEL ION IMPLANTATION.** The effect of phosphorus and boron ion implantation into silicon dioxide films is examined with regard to the resistance of the Si-SiO<sub>2</sub> interface under high field constant current stress conditions. Phosphorus and boron ions of various doses and energies have been implanted through a approx. 35 nm thick oxide. The interface stress resistance is found to decrease with increasing ion dose and increase with implant energy. However, at high energies, the stress resistance of the boron implanted samples is significantly less than the phosphorus equivalents due to the creation of a second interface trap level. Post-implant annealing increases the interface stress resistance but the best performance is observed for the case of sacrificial oxidation. (Author abstract) 6 refs.

Calligaro, R.B. (GEC Research Ltd, Wembley, Engl). *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond,

Louvain, Belg, Apr 13-15 1987 p 339-346.

**096242 SOME MATERIAL STRUCTURAL PROPERTIES OF SOI SUBSTRATES PRODUCED BY SDB TECHNOLOGY.** SOI substrates have been produced by silicon direct bonding (SDB) technology. Thermal oxides ranging in thickness from native oxide to anjnm or even more, on either or both wafers have been bonded successfully. The fracture strength of the SOI layer is 130-200 kg/cm<sup>2</sup> which is similar to the value of intrinsic bulk silicon. Dislocations have been shown to be concentrated on the backsides of the substrate and no additional defects have been developed within 80 μm of the Si-SiO<sub>2</sub> bonding area. Mobility and minority carrier lifetime similar to that of the original bulk silicon have been obtained after annealing. (Author abstract) 3 refs.

Li, Hui (Nanjing Inst of Technology, Nanjing, China); Sun, Guo-Liang; Zhan, Juan; Tong, Qin-Yi. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 397-401.

## Semiconductor Metal Boundaries

**096243 DETERMINATION OF Si-SiO<sub>2</sub> INTERFACE TRAP PROPERTIES OF p-MOS STRUCTURES WITH VERY THIN OXIDES BY CONDUCTANCE MEASUREMENT.** The interface traps of as-oxidized p-MOS structures with very thin (88-434 Å) oxides are characterized by conductance technique. The interface trap density is found to increase inversely with the oxide thickness. The hole capture cross sections  $\sigma_p$  show no obvious dependence on the oxide thickness, but decrease exponentially with energy towards the midgap. The dispersion parameters  $\sigma_s$  are compared with the theoretical predictions based on the patchwork model. Both the magnitude and bias dependence of the measured  $\sigma_s$  are much larger than the theory predicts. With numerical simulation, it is shown that the width of the conductance peak can be strongly influenced by the behavior of the capture cross section. By incorporating the energy dependence of  $\sigma_p$  into the patchwork model, good agreement between the experimental values and theoretical estimations of  $\sigma_s$  is obtained. (Author abstract) 5 refs.

Hung, K.K. (Univ of Hong Kong, Hong Kong); Cheng, Y.C. *Appl Surf Sci* (1985) v 30 n 1-4 Oct II 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 114-119.

## Sensors See HYDROCARBONS—Sensors.

## Space Charge See Also SILICON NITRIDE—Space Charge.

**096244 STUDY OF QUASIEQUILIBRIUM AND NONEQUILIBRIUM PROCESSES IN p-Cd<sub>x</sub>Hg<sub>1-x</sub>Te BASED MOS STRUCTURES.** Studies of quasiequilibrium and nonequilibrium voltage-capacitance characteristics (VCC's) of MOS structures provides information on the volume and surface properties of the material: the mechanism of majority carrier generation in the space charge region of the semiconductor and the surface state density on the semiconductor-dielectric boundary and in the equilibrium zone inflection. The studies were performed with bulk single-crystals of undoped Cd<sub>x</sub>Hg<sub>1-x</sub>Te with x=0.215 [ $E_g$  (77K) = 110 meV] and x=0.3 [ $E_g$  (77K) = 250 meV]. The material with p-type conductivity was obtained by generation of intrinsic point defects by thermal heating. 10 refs.

Nikitin, M.S.; Nikiforov, A.Yu.; Troshina, E.V. *Sov Microelectron* v 16 n 2 Mar-Apr 1987 p 95-98.

## Spectroscopic Analysis

**096245 GATE CHARGE RELAXATION MECHANISM OF MOS STRUCTURE WITH ZERO BIASED SOURCE AND TRANSIENT SPECTROSCOPIC MEASUREMENT OF Si/SiO<sub>2</sub> INTERFACE STATE DISTRIBUTION NEAR MINORITY CARRIER BAND EDGE.** The gate charge relaxation mechanism of MOS structure with zero biased source region is investi-

gated under a small gate square pulse. It is demonstrated that when the Fermi level goes to the surface minority carrier energy band edge, this mechanism will turn from carrier capturing and emitting of interface states to minority carrier diffusing and drifting delayed by interface state trapping. The theoretically predicted behaviors of such a minority carrier transportation are verified by experiments. Based on this theory a new measurement principle for Si/SiO<sub>2</sub> interface state density near minority carrier band edge is proposed and the  $D_{it}(E)$  formula is deduced. The  $D_{it}(E)$  distributions show some important and common features. Even in the energy position 0.05 eV, apart from the minority carrier edge, reasonable  $D_{it}(E)$  measurement is also obtainable by this method. (Author abstract) 8 refs. In Chinese.

Zheng, Xinyu (Tsinghua Univ, Beijing, China); Li, Zhijian. *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 189-199.

**096246 SPECTROSCOPY OF ONE-DIMENSIONAL SUBBANDS ON InSb.** By means of high-resolution optical lithography two-dimensional (2D) electron inversion layers in metal-oxide-semiconductor (MOS) structures on InSb are laterally confined to narrow channels. The widths of the channels ( $w \approx 100$  nm) are comparable to the de-Broglie wavelength of the electrons and formation of one-dimensional (1D) subbands results. This is verified by direct spectroscopy of intersubband transitions between the 1D subbands at far-infrared frequencies. Cyclotron resonance experiments also show the importance of the lateral confining potential. In particular, the transition from 1D to 2D electronic behavior is observed when the magnetic field strength is increased and the cyclotron radius  $l$  becomes much less than the channel width  $w$ . (Author abstract) 21 refs.

Merkt, U. (Univ Hamburg, Hamburg, West Ger); Sikorski, Ch.; Kotthaus, J.P. *Superlattices Microstruct* v 3 n 6 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 679-684.

## Stresses See TRANSISTORS—Degradation.

## Structure See Also TRANSISTORS—Structure.

**096247 INVESTIGATION OF THE HYDROGENATED Si-SiO<sub>2</sub> INTERFACE BY X-RAY DIFFRACTION.** An asymptotic Bragg diffraction method is applied for the first time to the investigation of a hydrogenated Si-SiO<sub>2</sub> interface. It appears that the method may be useful for physical and chemical characterization of Pd-SiO<sub>2</sub>-Si type sensor systems. (Author abstract) 3 refs.

Rzhanov, A.E. (I.V. Kurchatov Inst of Atomic Energy, Moscow, USSR); Filippov, V.I.; Chaplanov, V.A.; Yakimov, S.S. *Mater Lett* v 6 n 5-6 Mar 1988 p 170-172.

## Substrates

**096248 CHARACTERISTICS OF CMOS DEVICES IN HIGH-ENERGY BORON-IMPLANTED SUBSTRATES.** CMOS devices on substrates subject to high-energy implantation of boron for buried-layer fabrication are examined. FET device characteristics, threshold voltage, and breakdown characteristics are investigated, along with mobility and minority-carrier lifetime. In addition, well leakage and breakdown are studied in an effort to provide guidelines for well design in a megaelectronvolt-implanted substrate. It is seen that MOSFET transistor characteristics are virtually unaffected by the implant. Latchup behavior improves with the incorporation of the buried layer, and the holding voltage increases as the well and implant depths decrease. 12 refs.

Zappe, Hans P. (Univ of California, Berkeley, CA, USA); Hu, Chenming. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1029-1034.

## Surface Properties

**096249 INVESTIGATION OF INTERFACE PECULIARITIES IN ANODIZED p-InSb MOS STRUCTURES.**



**TURES.** C-U measurements are made on p-InSb MOS structures in an extended frequency range (2 Hz to 50 kHz) at temperatures of 4.2 and 77 K. The effect of illumination with different intensities and also of stationary magnetic fields up to 5 T on the C-U characteristic are analyzed. The surface photoelectric electromotive force and its dependence of the illumination intensity are measured. The density of the localized surface states ( $10^{12} \text{ eV}^{-1} \text{ cm}^{-2}$ ) and a state density peak ( $10^{13} \text{ eV}^{-1} \text{ cm}^{-2}$ ) near the conduction band edge are determined from the measured dependences. The effect of magnetic field on the C-U characteristic without illumination is explained qualitatively and quantitatively. The results of the surface photoelectric emf measurements are analyzed qualitatively yielding to a special barrier mechanism for its formation. (Author abstract). 15 Refs.

Berezovets, V.A. (Acad. of Sciences of the USSR, Leningrad, USSR); Braune, W.; Kubicki, N.; Smirnov, A.O. *Phys Status Solidi A* v 108 n 1 Jul 1988 p 303-309.

**Switching** See INTEGRATED CIRCUITS—Design; INTEGRATED CIRCUITS, LINEAR—Mathematical Models.

## Temperature Effect

**096250 CRYOGENIC TEMPERATURE DEPENDENCE OF THE VOLTAGE TRANSFER CHARACTERISTICS OF CMOS INVERTERS.** The voltage transfer characteristics of CMOS inverters have been studied as a function of temperature between 77 and 300 K and supply voltages between 2 and 20 v. The logic levels, maximum gain, unity gain points, noise margins and other parameters, such as ( $V_H - V_L$ ), all showed improvement as the temperature was lowered. For one inverter with a supply of 5 v, the maximum gain increased from 57 to 105, ( $V_{IH} - V_{IL}$ ) decreased from 0.50 to 0.28 v and ( $V_H - V_L$ ) increased from 4.46 to 4.75 v on decreasing the temperature from 300 to 77 K. For all inverters, these and other parameters showed a smooth monotonic improvement as the temperature was lowered. These and other results obtained can be qualitatively explained as due to an increase in the absolute values in the threshold voltages of the PMOS and NMOS transistors and to an increase in the carrier mobility as the temperature was lowered. (Edited author abstract). 31 refs.

Deen, M.J. (Simon Fraser Univ, Burnaby, BC, Can). *Solid State Electron* v 31 n 8 Aug 1988 p 1299-1308.

**Testing** See Also DATA STORAGE, DIGITAL—Random Access; INTEGRATED CIRCUIT TESTING; INTEGRATED CIRCUIT TESTING—Failure.

**096251 CMOS MOBILITY DEGRADATION COEFFICIENTS AT LOW TEMPERATURES.** An AC measurement technique is applied to NMOS and PMOS devices fabricated using a 1.25  $\mu\text{m}$  CMOS process. The parasitic resistance and mobility degradation coefficients have been extracted for temperatures between 25 K and 300 K. The NMOS parasitic resistance stays flat with temperature while the PMOS resistance rises sharply below 200 K, probably due to the light source/drain diffusion doping. The mobility reduction parameter  $\theta$ , shows a clear 1/T behavior between 100 K and room temperature, with  $\theta$  approaching unity for the PMOS devices. This may have serious implications for the performance of highly scaled devices which operate at high transverse electrical fields. (Author abstract) 12 refs.

Campbell, S.A. (Univ of Minnesota, Minneapolis, MN, USA); Andersen, P. *IEE Proc Part I* v 135 n 1 Feb 1988 p 17-19.

**096252 UNIVERSAL TEST SET FOR CMOS CIRCUITS.** A universal test set for CMOS circuits is demonstrated that can be derived from the functional description of the circuit alone. It is shown that for a restricted class of CMOS circuits, the gate-level universal test set (UTS<sub>g</sub>) consisting of maximal false vectors and minimal true vectors can sensitize every detectable stuck-open fault in the circuit. A universal initialization set (UIS) is defined which can also be derived from just

the functional description, and which contains initialization vectors for each of the test vectors. This set consists of maximal true vectors and minimal false vectors. It is shown that a test set on UTS<sub>g</sub> and UIS can be guaranteed to detect every detectable stuck-open fault in both redundant and irredundant CMOS implementation of the function, even in the presence of arbitrary delays and timing-skews. The size of the test set is also investigated. 14 refs.

Gupta, Gopal (SILC Technologies, Waltham, MA, USA); Jha, Niraj K. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 5 May 1988 p 590-597.

## Theory

**096253 NEW CAPABILITIES OF THE CMOS INVERTER.** Capabilities of the CMOS inverter are introduced that are based on the theory that for  $V_{Tn} = |V_{Tp}| \approx 2/3V_{SS}$ , a third high-impedance (HI) valid logic state is created between the zero and one states. By the generation of a 'HALF' level ( $= 1/2V_{SS}$ ), the inverter can be used as a tristate inverter. Circuit techniques to propagate the HALF level are given. This enables the general design of tertiary logic circuits and possibly tertiary arithmetic circuits. Two application examples are given. Illustrative experiments based on commercial ICs have been carried out, and results that verify the theory are given. This should open the way for digital circuits and applications. Improvements on the HALF propagation are needed which, in addition to the circuit level, may be thought of on the process and/or the device levels. 4 refs.

Talkhan, Elsayed A. (Cairo Univ, Giza, Egypt). *IEEE J Solid State Circuits* v 23 n 3 Jun 1988, Thirteenth Eur Solid-State Circuits Conf 87, Bad Soden, West Ger, Sep 1987 p 872-875.

## Thermal Properties

**096254 TEMPERATURE DEPENDENCE OF THE MOS MOBILITY DEGRADATION.** The mobility of carriers in a MOS inversion layer appears to decrease as the degree of inversion increases. An investigation using Kelvin contact specimens has separated the extrinsic effect caused by the parasitic contact resistances to the channel and the intrinsic, surface scattering effect. The temperature dependence of the intrinsic effect is reported. The intrinsic effect appears to be process-dependent. (Author abstract). 5 Refs.

Jones, B.K. (Univ of Lancaster, Lancaster, Engl); Russell, P.C. *IEE Proc Part I* v 135 n 4 Aug 1988 p 94-96.

**Thick Films** See SEMICONDUCTING FILMS—Growth.

**Transients** See TRANSISTORS, BIPOLAR—Modeling.

## Transport Properties

**096255 NEW METHOD FOR THE SIMULTANEOUS DETERMINATION OF THE SURFACE-CARRIER MOBILITY AND THE METAL-SEMICONDUCTOR WORK-FUNCTION DIFFERENCE IN MOS TRANSISTORS.** The method consists of simple measurements of the drain conductance in the linear region of output characteristics for a series of MOS transistors with gate oxides of different thicknesses. Provided the effective mobility does not depend on oxide thickness, both the mobility and the work-function difference can be determined without the need of determining the threshold voltage. The reduced work-function difference  $\phi^*_{MS}$  can be determined even if substrate impurity concentration is unknown. A practical verification of the method is done by reanalysis of experimental data in the literature. 11 refs.

Majkusiak, Bogdan (Technical Univ of Warsaw, Pol); Jakubowski, Andrzej. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 439-443.

## Tunneling

**096256 MODIFICATION TO THE FOWLER-NORDHEIM TUNNELING CURRENT CALCULATION FOR THIN MOS STRUCTURES.** This paper presents a new computer modeling of Fowler-Nordheim (F-N) tunneling current from an inverted silicon surface to the metal gate of the thin oxide MOS structures. In this model the tunneling current through the oxide is taken to be proportional to the product of the gate oxide field and the inversion layer carrier concentration. Within the semiconductor the standard semiconductor equations are solved to ensure electron current at the semiconductor surface is equal to the tunneling current through the oxide. The computational results indicate that the current-voltage characteristics of the structure would saturate if it is limited by carrier generation in the space-charge region of the silicon. (Edited author abstract) 9 refs.

Oh, Seog-Ju (Univ of Queensland, St. Lucia, Aust); Yeow, Y.T. *Solid State Electron* v 31 n 6 Jun 1988 p 1113-1118.

**096257 TUNNELING LEAKAGE IN GE-PREAMORPHIZED SHALLOW JUNCTIONS.** CMOS shallow junctions with depths less than 0.2  $\mu\text{m}$  were fabricated using Ge-preamorphization and rapid thermal annealing. A low bulk generation current ( $< 1 \text{ nA/cm}^2$ ) for both poly-gated and Al-gated diodes was obtained by placing the extended end-of-range defects inside the heavily doped junction. However, gated diode characterization shows a large tunneling current component in addition to the bulk generation current when the surface is accumulated by the gate. By comparing preamorphized with nonpreamorphized junctions for both poly-gated and Al-gated diodes, it is concluded that the tunneling effect is due to the presence of the midgap states within or near the depletion region at the surface of the junction edge. These midgap states are a result of the crystal damage associated with Ge preamorphization. PISCES simulations of this tunneling current show good agreement with the experimental results, which show that gate-induced drain leakage in N<sup>+</sup> poly-gate PMOS devices at high drain voltages is strongly dependent on removal of junction implantation damage. 24 refs.

Wen, Duen-Shun (North Carolina State Univ, Raleigh, NC, USA); Goodwin-Johansson, Scott H.; Osburn, Carlton M. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1107-1115.

## SEMICONDUCTOR DEVICES, MOSFET

See Also DATA STORAGE UNITS—Electric Power Supplies; ELECTRIC CONVERTERS, POWER TYPE—Performance; ELECTRIC CONVERTERS, STATIC; ELECTRIC DRIVE—Performance; ELECTRIC FILTERS—Fabrication; ELECTRIC HEATING, INDUCTION—Electric Power Supplies; ELECTRONIC CIRCUITS—Performance; ELECTRONIC CIRCUITS, POWER SUPPLY—Switching; INTEGRATED CIRCUITS; LITHOGRAPHY—Applications; LOGIC CIRCUITS—Synthesis; MICROELECTRONICS—Electric Power; SEMICONDUCTOR DEVICES, MOS—Substrates; TRANSISTORS, FIELD EFFECT—Junctions; TRANSISTORS, FIELD EFFECT—Transport Properties.

**096258 SELF-CONSISTENT MONTE CARLO SIMULATION FOR TWO-DIMENSIONAL ELECTRON TRANSPORT IN MOS INVERSION LAYER.** Hot electron transport in a MOS inversion layer on a (100) silicon surface was analyzed by using a rigorous Monte Carlo method while taking into account changes in subband structures due to electron repopulation. An iterative procedure of the method consisted of a self-consistent calculation of the Schroedinger and Poisson's equations as well as a Monte Carlo calculation for electron scattering. The calculated relative electron population in each subband significantly differed from the results of a conventional Monte Carlo calculation in a tangential electric field higher than 10 kV/cm, above which carrier heating effects greatly influence the subband structures.



The calculated electron drift velocity is in reasonable agreement with the experimental data. (Author abstract) 16 refs.

Shirahata, Masayoshi (Osaka Univ, Suita City, Jpn); Taniguchi, Kenji; Hamaguchi, Chihiro. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1447-1452.

**096259 THIS SMART POWER CHIP BREAKS THE 100-V BARRIER.** Smart power MOSFET devices were sought that can be rated at more than 400 volts. By putting low-power control logic and a high-voltage power device on a single chip, much of the processing that would otherwise have to be done by an external microprocessor is offloaded onto the chip. Thus the sensitive control circuitry is isolated from the high voltages in the power circuit. A first silicon chip that can operate at 500 volts is introduced, with the logic circuitry implemented in CMOS.

Anon. *Electronics* v 59 n 32 Oct 2 1986 p 89-91.

**096260 COMPARISON OF MINIMUM PROPAGATION DELAY AND UNITY POWER TRANSFER FREQUENCY OF SUBMICRON MOSFETS.** The object of this communication is to demonstrate a relationship between the maximum small-signal frequency of operation and the large-signal propagation delay of a submicron MOSFET. A figure of merit for the MOSFET is derived as the frequency for which the ratio of power transferred between stages of identical amplifiers equals unity. This frequency (unity power transfer frequency) is determined for submicron MOSFETs with resistive loads and is compared with the propagation delay of a ring oscillator comprising identical devices. 6 refs.

Simmons, J.G. (AT&T Bell Lab, Murray Hill, NJ, USA); Taylor, G.W. *Solid State Electron* v 31 n 2 Feb 1988 p 314-316.

**096261 OUTPUT CHARACTERISTIC STABILIZATION OF POWER MOSFETS.** The saturation current of a biased MOS transistor decreases as the temperature is raised. Thus self-heating results in a negative equilibrium output conductance and the possibility of instability in the circuit. Experiments are reported to show that this effect can be relieved over a wide range of bias conditions using a controlled substrate bias driven from an integrated MOS sensor. (Author abstract). 3 Refs.

Abdala, M.A. (Univ of Lancaster, Lancaster, Engl); Jones, B.K. *IEE Proc Part I* v 135 n 4 Aug 1988 p 91-93.

**096262 PUNCHTHROUGH CURRENT FOR SUBMICROMETER MOSFETS IN CMOS VLSI.** Simulated and measured data show that drain-induced barrier lowering (DIBL) in buried-channel MOSFETs is different from that in surface channel (SC) MOSFETs. This is explained by the differences between channel current paths and channel potential distribution. A new parameter, defined as the incremental voltage that the drain can sustain before the punchthrough current increases by an order of magnitude, is used to indicate the rate of increase of punchthrough current and is a measure of DIBL. 9 refs.

Zhu, Jun (Xerox Palo Alto Research Cent, CA, USA); Martin, Russel A.; Chen, John Y. *IEEE Trans Electron Devices* v 35 n 2 Feb 1988 p 145-151.

**096263 STUDY OF GATE OXIDE LEAKAGE AND CHARGE TRAPPING IN ZMR AND SIMOX SOI MOSFETS.** Characterization of gate oxides grown on zone-melting-recrystallized (ZMR) and silicon-implanted-with-oxygen (SIMOX) films indicates oxide leakage and charge trapping to be several orders of magnitude greater than their bulk silicon counterparts. Electron trapping is the primary trapping mechanism for constant current injection in the gate oxides of these SOI (silicon-on-insulator) films. Similar type of traps are observed in ZMR and SIMOX oxides. 8 refs.

Lee, Chun-Teh (MIT, Lexington, MA, USA); Burns, James A. *IEEE Electron Device Lett* v 9 n 5 May 1988 p 235-237.

**096264 IMPROVED MOSFET SHORT-CHANNEL DEVICE USING GERMANIUM IMPLANTATION.** Germanium doping in silicon tends to suppress any enhancement in dopant diffusion due to excess point defects. By performing a dual implantation of germanium and the normal source-drain dopant, lateral diffusion of the source-drain profile can be controlled, thus resulting in improved short-channel device behavior. 7 refs.

Pfister, James R. (Motorola Inc, Austin, TX, USA); Law, Mark E.; Dutton, Robert W. *IEEE Electron Device Lett* v 9 n 7 Jul 1988 p 343-346.

**096265 COLLOQUIUM ON HOT CARRIER DEGRADATION IN SHORT CHANNEL MOS.** This colloquium proceeding contains 11 articles on hot carrier degradation in short channel MOS devices. Among the topics covered are: N-MOS and P-MOS short channel transistors; Parameter extraction of locally damaged MOSFETs; Hot carriers in MOSFETs; Submicron p-MOSFETs; N-channel lightly doped drain devices; Phosphorus source drains; N-channel silicon on sapphire transistors; Surface state creation by dynamic aging; and Hot carriers and gate current in CMOS devices. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11330 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (IEE, Electronics Div, London, Engl). *IEE Colloq Dig* n 1987/15, Colloq on Hot Carrier Degrad in Short Channel MOS, London, Engl, Jan 27 1987. Publ by IEE, London, Engl, 1987.

**Analysis** See Also INTEGRATED CIRCUITS, VLSI—Analysis.

**096266 MOSFET ANALYSIS THROUGH NUMERIC SOLUTION OF POISSON'S EQUATIONS BY THE METHOD OF MOMENTS.** A new numerical approach to solve Poisson's equation using the method of moments is described. The approach specified would convert the partial differential equation (Poisson's equation) into an integral equation which is then reduced to a system of simultaneous equations. For a large system of such linear equations, the application of the method of moments would yield stable, reliable consistent and accurate results. 17 refs.

Arvas, E. (Rochester Inst of Technology, Rochester, NY, USA); Turkman, R.I.; Neelakantaswamy, P.S. *Solid State Electron* v 30 n 12 Dec 1987 p 1355-1357.

**096267 SIMPLE EXPLICIT EXPRESSIONS FOR THE MODERATE INVERSION LIMITS IN LONG CHANNEL MOSFETS FOR ANALOG APPLICATIONS.** For the long-channel MOSFET, which is extensively employed in analog integrated circuits, explicit expressions are proposed for the weak/moderate inversion and moderate/strong inversion limit points. Empirical expressions are suggested that describe the variation of these limits with temperature for a variety of process parameters and bias conditions. A way of modeling the drain current in the moderate inversion region is suggested. 7 refs.

Bagheri, Mehran (Bell Communications Research Inc, Red Bank, NJ, USA). *Solid State Electron* v 30 n 12 Dec 1987 p 1357-1359.

**096268 THRESHOLD VOLTAGE OF SHORT-CHANNEL BC-MOSFET IN THE ENHANCEMENT MODE.** The buried-channel MOSFET (BC-MOSFET) has received considerable interest because the carrier mobility in a buried channel is higher than the surface mobility. A BC-MOSFET normally operates in the depletion mode, i.e. a remaining channel exists in the bulk after the top and bottom of the implant region are depleted by the gate voltage and the substrate-channel junction. The threshold voltage of a short-channel BC-MOSFET in the depletion mode has been studied in the past. However in devices where the channel-implant concentrations are low or the reverse bias at the substrate is high enough, the depletion region due to the sub-

strate-channel junction can reach the semiconductor surface, and conduction is due to the accumulation of majority carriers at the surface induced by the gate electric field. This is defined as the enhancement mode. We derive the threshold voltage of a short-channel BC-MOSFET considering both the depletion and enhancement modes. 7 refs.

Tong, K.Y. (Hong Kong Polytechnic, Hung Hom, Hong Kong). *Solid State Electron* v 30 n 12 Dec 1987 p 1359-1361.

**096269 HOT-CARRIER ANALYSIS OF SUBMICROMETER MOSFETS.** Based on Monte Carlo (MC) device simulations, an analysis of hot-carrier effects in submicrometer n-MOSFETs is presented that provides detailed insight because the high-energy electrons are treated directly. The dc stress characteristics of both lightly-doped drain (LDD) and conventional As source/-drain devices are found to correlate with the surface hot-electron concentration, and agreement with experimental data shows that the electron flux above 3 eV, integrated along the channel, can be used to predict device degradation. The simulations indicate that the whole dc stress characteristic can be attributed to hot electrons, while the holes generated by impact ionization have a very small probability of gaining enough energy to be injected over the oxide barrier. 15 refs.

Sangiorgi, Enrico (AT&T Bell Lab, Murray Hill, NJ, USA); Pinto, Mark R.; Venturi, Franco; Fichtner, Wolfgang. *IEEE Electron Device Lett* v 9 n 1 Jan 1988 p 13-16.

**096270 THREE-DIMENSIONAL ANALYSIS OF SUBTHRESHOLD SWING AND TRANSCONDUCTANCE FOR FULLY-RECESSED-OXIDE (TRENCH) ISOLATED 1/4-μm-WIDTH MOSFETS.** The dependence of MOSFET gate controllability on the field-isolation scheme is investigated using three-dimensional simulation. It is found that a fully-recessed-oxide (trench) isolated MOSFET has a steep subthreshold characteristic and high transconductance in comparison with a non-recessed device. These features result from the small depletion capacitance due to the crowding of the gate's fringing field at the channel edge. It is also found that the gate and diffused line capacitances in the case of fully-recessed-oxide isolation are small, so that high-switching-speed operation can be expected. These features are enhanced with a reduction in the channel width, especially for lower-submicrometer-width MOSFETs. A drawback of a fully-recessed-oxide MOSFETs is its low threshold voltage. However, the leakage current is not as large as that inferred from the inverse narrow-channel effect because of its steep subthreshold characteristic. Several countermeasures for this low threshold voltage are discussed. 17 refs.

Shigyo, Naoyuki (Toshiba Corp, Kawasaki, Jpn); Fukuda, Sanae; Wada, Tetsunori; Hieda, Katsuhiko; Hamamoto, Takeshi; Watanabe, Hidehiro; Sunouchi, Kazumasa; Tango, Hiroyuki. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 945-951.

**096271 SEMI-ANALYTICAL APPROACH TO THE EVALUATION OF THRESHOLD VOLTAGE IN DEPLETION MOS'S WITH NONUNIFORMLY DOPED SUBSTRATES.** D.A. Antoniadis' algorithm (1984) is extended to cover the computation of threshold voltage for depletion or buried-channel MOSFETs. It is shown that a key factor in its evaluation, of the derivative of the integral charge of the mobile minority carriers in the substrate with respect to the gate-source bias, can easily be calculated using the concept of flat-band capacitance. The threshold voltage is thus computed without requiring strict numerical solution of Poisson's equation, yet the accuracy is very good. This modified algorithm has been



implemented in SUPREM III, and good agreement between simulation and experimental results has been achieved. 5 refs.

Yu, Zhiping (Tsinghua Univ, Beijing, China); Zhao, Xijun. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 993-998.

**096272 TWO-DIMENSIONAL NUMERICAL ANALYSIS OF THE FLOATING REGION IN SOI MOSFETS.** Results of simulating SOI/MOSFET (silicon-on-insulator/ metal-oxide-semiconductor field-effect-transistor) devices using the full two-dimensional numerical solution of the classical semiconductor equations are presented. Particular attention has been paid to the role of the floating region, and it is demonstrated that removal of this phenomenon is important for the improvement of the performance of SOI/MOSFET devices. Several methods, such as applying a back gate bias or using thinner (100-nm) films, are investigated as a means of controlling this undesirable feature. It is shown that the use of thin films has major advantages. It is concluded from a study of the effect of lifetime on device performance that improved film quality can have an adverse effect on the  $I_d-V_d$  characteristics, giving an enhanced kink and earlier breakdown on 0.3- $\mu$ m silicon films. 11 refs.

Edwards, Susan P. (IMEC, Heverlee, Belg); Yallup, Kevin J.; De Meyer, Kristin M. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1012-1020.

**096273 INFLUENCE OF THE EPITAXIAL LAYER ON THE CURRENT-VOLTAGE CHARACTERISTICS IN HIGH VOLTAGE VDMOS DEVICES. ANALYSIS OF THE QUASI-SATURATION POINT.** In this paper, the influence of the epitaxial layer on the current-voltage characteristics,  $I_D(V_D)$ , for high voltage VDMOS (vertical double-diffused MOS transistor devices) is analyzed. The quasi-saturation point of the  $I_D(V_D)$  curve and its evolution with the drain bias are studied. The epitaxial layer resistance is considered in the saturation and quasi-saturation operation modes. (Author abstract) 8 refs.

Rebollo, J. (CSIC, Barcelona, Spain); Millan, J.; Paredes, J.; Lora-Tamayo, E.; Serra-Mestres, F. *Vacuum* v 37 n 5-6 1987, VI Span Conf on Vac and Its Appl, Madrid, Spain, Dec 1985 p 399-401.

**Applications See AMPLIFIERS, POWER TYPE—Design; AUTOMOBILE ENGINES—Ignition; ELECTRONIC CIRCUITS, POWER SUPPLY—Switching; HYDROGEN SULFIDE—Sensors; SEMICONDUCTOR DEVICES, MOS.**

## Automatic Testing

**096274 CURVE TRACERS ADVANCE MOSFET TECHNOLOGY.** In a typical curve tracer application, the device-under-test (DUT) can range from a two-, three-, or four-terminal device (i.e., diodes, transistors, and thyristors) to multipin optoelectronic devices and ICs. Rather than testing singlepoint parameters, the curve tracer shows what actually happens in a device over its full range of operation. By exercising each pin of the device, the curve tracer can provide a family of output curves representing the dc (static) parameters that characterize the entire operational range of the DUT. This makes curve tracers ideal for checking the success of a particular stage of processing, or for characterizing the device after it has been completed. It is reported how the curve tracer has accelerated development of a revolutionary MOSFET power device.

Dierberger, Ken (Adanced Power Technology, Bend, OR, USA). *Semiconduct Int* v 11 n 2 Feb 1988 p 88-90.

## Calculations

**096275 MODELLING DC CHARACTERISTICS OF MOSFET.** An empirical formula is presented for the current-voltage characteristics of the metal oxide semiconductor field effect transistor (MOSFET). The three parameters of the formula can be calculated easily from separate regions in the device dc characteristics without recourse to special electrical measurements or global curve-fitting

techniques. By using this formula, the implementation of a new MOSFET model into the source code of Spice is feasible. (Author abstract) 17 refs.

Abuelma'atti, Muhammad Taher (Univ of Bahrain, Isa Town, Bahrain). *Comput Aided Des* v 19 n 7 Sep 1987 p 380-382.

## Charge Carriers

**096276 STRESS-BIAS DEPENDENCE OF HOT-CARRIER-INDUCED DEGRADATION IN MOSFETS.** The stress-bias dependence of hot-carrier-induced degradation in short N-channel MOSFETs is examined. A positive stress electric field ( $V_{gs} > V_{ds}$ ) across the gate oxide results in a characteristic  $g_m$  shift to the positive  $V_{gs}$  direction and a large  $V_t$  degradation with a low rate of shift. In contrast, a negative stress field ( $V_{gs} < V_{ds}$ ) causes a reduction in magnitude in  $g_m$  with a negligible peak shift and a small initial  $V_t$  degradation with a fast shift rate. The effect of stress-bias on the turn-on characteristics has also been investigated. It is proposed that the degradation observed in the case of positive electric-field stress is essentially due to the localized electron trapping in the oxide near the drain, whereas the case of negative E-field stress is mainly due to interface-trap generation localized near the drain. (Author abstract) 11 refs.

Trocino, Michael R. (Motorola Inc, Austin, TX, USA); Fu, Kuan-Yu; Teng, Ker-Wen. *Solid State Electron* v 31 n 5 May 1988 p 873-875.

## Computer Aided Design

**096277 UPDATING MOSFET MODELS IN SPICE-PART II.** In the article, the authors outline deviation of the parameters for the modified model of a modern power MOSFET in SPICE II. The results obtained are listed.

Wheatley, Frank; Ronan, Harold. *Electron Prod Des* v 8 n 8 Aug 1987 p 23-26, 29-30.

**096278 COMPUTER ANALYSIS AND DESIGN OPTIMIZATION OF MAGNETIC-FIELD SENSITIVE MOS DEVICE.** In this paper, a two-dimensional numerical simulation for a Magnetic-Field-Sensitive device (split-drain MOSFET) is presented. Different model equations for the subthreshold and normal regions are given. The computation cost is low. In order to optimize the design of the device, the BFGS optimization method is adopted. The theoretical results indicate that the highest sensitivity of the device occurs at an aspect ratio of 0.8. This is in good agreement with the experimental work. (Author abstract) 5 refs.

Wei Tongli (Nanjing Inst of Technology, China); He Yie. *Solid State Electron* v 31 n 2 Feb 1988 p 237-240.

**096279 DESIGN OF MOS NETWORKS IN SINGLE-RAIL INPUT LOGIC FOR INCOMPLETELY SPECIFIED FUNCTIONS.** If a logic gate in a logic network of MOS transistors expresses a negative function, which is a logic function that can be expressed as the complement of a disjunctive form of only noncomplemented variables, it is called a negative gate. An algorithm, DIMN, for the design of a MOS logic network with a minimum number of negative gates and irredundant connections among negative gates for a completely specified function was published by the authors in 1985. DIMN is extended here to the case of an incompletely specified function, and an example is given. 9 refs.

Lai, Hung Chi (Univ of Illinois, Urbana, IL, USA); Muroga, Saburo. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 3 Mar 1988 p 339-345.

## Computer Simulation

**096280 AUTOMATIC EXTRACTION SYSTEM FOR MOSFET MODEL PARAMETERS IN CIRCUIT SIMULATION.** The MOSFET model of SPICE2 circuit simulator is studied. This model requires about thirty parameters, and the accuracy of the simulation

depends on these parameters. Therefore, in order to make a MOSFET model available, these parameters must be precisely and efficiently extracted. For this reason, a simple and useful computer-controlled extraction system for MOSFET model parameters has been developed. This system measures I-V characteristics required for parameter extraction automatically and calculates each parameter with small error. The validity of the extracted parameters produced by this system was verified by comparing simulated MOSFET characteristics with the measured ones. Good agreement has been obtained, and the system has been proved very useful and practical. This paper describes the system and discusses the extraction method used. 4 refs.

Aida, Tahito (NHK, Tokyo, Jpn). *NHK Lab Note* n 330 Mar 1986 14p.

**096281 CMOS DEVICE MODEL FOR ACCURATE CIRCUIT SIMULATION APPLICATION.** This paper proposes a submicron CMOS device model which is used in the charge oriented circuit simulation to achieve higher-accuracy circuit analysis. The features of this model are: (1) continuity of drain conductance at the pinch-off voltage ensures accurate expression of the drain conductance which is especially important in designing analog circuits; (2) minority carriers in the pinch-off region are considered to express accurately the current and capacitance characteristics in the saturation region. (Edited author abstract) 16 refs.

Sano, Eiichi (NTT, Atsugi, Jpn); Kimura, Tadakatsu. *Electron Commun Jpn Part 2* v 70 n 11 Nov 1987 p 94-102.

**096282 MODIFIED SPICE II MODELS MODERN POWER MOSFETS.** The SPICE II simulation software package is a widely available, well understood design tool for i.c. modeling and analysis; however, it has its limitations. Since SPICE II's internal device models can't be easily changed for all existing copies, the authors updated the capabilities of this simulation package by adding a 'subcircuit' of external components that complement the devices within the SPICE II software, so as to form a true, equivalent circuit of a power MOSFET. The subcircuit works with the standard SPICE II software, providing a model with all the terminal characteristics of a power MOSFET. Parameters of the subcircuit model can be determined from simple terminal measurements or from standard data sheets, using the algorithm and empirical approach described in the article. 3 refs.

Ronan, Harold; Wheatley, Frank; Dolny, Gary. *Electron Prod Des* v 8 n 7 Jul 1987 p 25-26.

**096283 DEVELOPMENT AND APPLICATION OF A GATE CAPACITANCE SIMULATOR IN MOSFET.** A one-dimensional device simulator has been developed for calculating MOS gate capacitance. The Poisson equation is solved numerically using a finite difference method. Simulated results are in good agreement with experimental data for the case of a nonuniform profile in an ion-implanted MOSFET. (Edited author abstract). In Japanese.

Akiyama, Yutaka; Sano, Yoshiyuki; Emura, Yuya; Matsushita, Ken-ichi; Kouso, Masakazu; Dang, Ryo. *Bull Coll Eng Hosei Univ* n 24 Mar 1988 p 23-33.

## Defects

**096284 TWO-DIMENSIONAL MODELING AND PARAMETER EXTRACTION OF AGED MOSFETS.** The effect of stress induced defects on the ohmic region characteristics of short channel MOSFETs is analyzed by means of a two dimensional device simulator. The device aging is summarized in the formation of a narrow defective interface region whose nature, length and position above the channel are the parameters of our investigation. The channel conductance and transconductance degradations were found to be greatly influenced by the position of the defective region and its length. Also, fundamental differences were observed between the effects of interface states and fixed oxide charges. The interaction between the



defective and defect-free channel regions was found to produce a transconductance overshoot which attenuates the aging effects. Finally, a parameter extraction method based on a two-piece analytical model of locally damaged MOSFETs is elaborated and validated by means of a 2-D simulation. (Author abstract) 8 refs.

Haddara, H. (CNRS, Grenoble, Fr); Cristoloveanu, S. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 2 Jun 1987 p 85-91.

## Degradation

**096285 DEGRADATION OF SUBMICRON MOSFETs AFTER AGING.** The degradation was investigated after electrical stress. New methods for the aging investigation based on field effect mobility measurements are presented. The correlations between the different degradation parameters are analysed by one-dimensional modelling that takes into account the potential fluctuations induced by the surface state and charge generation. The degradations increase with the bias parameter  $K = U_g/U_d$  applied during stress. In addition, the partial reversibility of degradations shows that electron trapping is the main cause of aging. (Edited author abstract) 21 Refs.

Cabon, B. (CNRS, Grenoble, Fr); Ghibaudo, G. *Phys Status Solidi A* v 107 n 1 May 1988 p 393-404.

**096286 HOT-ELECTRON EFFECTS IN SILICON-ON-INSULATOR N-CHANNEL MOSFETs.** Hot-electron degradation has been measured in short-channel bulk and SOI MOSFETs. The presence of a floating substrate in the SOI devices appears to increase the drain-saturation voltage and therefore to reduce the drain electric field. This effect is further enhanced when thin fully depleted films are considered. Electrical stress measurements and device modeling suggest that hot-electron degradation will be smaller in SOI MOSFETs than in their bulk counterparts. 8 refs.

Coline, Jean-Pierre (Hewlett-Packard Lab, Palo Alto, CA, USA). *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2173-2177.

**096287 TRAPPED-ELECTRON AND GENERATED INTERFACE-TRAP EFFECTS IN HOT-ELECTRON-INDUCED MOSFET DEGRADATION.** An experimental method is proposed to distinguish the electron-trapping effect in the gate oxide from the interface-trap generation effect in hot-electron-induced MOSFET degradation. In this method, by selecting the appropriate bias conditions, hot electrons and/or hot holes are intentionally injected into the oxide region above the channel outside the drain layer, which affects MOSFET characteristics such as threshold voltage and transconductance. The negative charges of electrons trapped in the oxide during hot-electron injection are completely compensated for by the positive charges of subsequently injected and trapped holes, and the trapped electron effect in the degradation is eliminated. Using this method, the causes for hot-electron-induced transconductance degradation ( $\Delta g_m/g_m$ ) are analyzed. As the degradation increases, the trapped-electron effect decreases, and the generated interface-trap effect increases. A relationship between  $g_m$  degradation due to generated interface-traps and  $\Delta g_m/g_m$  is established. 15 refs.

Tsuchiya, Toshiaki (NTT, Atsugi, Jpn). *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2291-2296.

**096288 HOT-CARRIER-INDUCED DEGRADATION IN MOSFETs STUDIED BY RECOVERY TEMPERATURE SPECTROSCOPY (RTS).** After electrical stress, the MOSFET was quickly heated up to the first temperature of the RTS, kept for a constant time (e.g., 3 min.), and quenched. Then the device characteristics, for example, transconductance, were measured. The procedure is repeated with the temperature raised step by step by a constant value. The temperature derivative of the measured characteristics, i.e., the recovery temperature spectrum, yields information on the activation energy ( $E_a$ )

) and frequency factor ( $f$ ) of the thermal recovery reaction. The authors used an ALDD n-channel MOSFET which is essentially the same structure as the ITLDD, the LDD MOSFET free from spacer-induced degradation. Two hot-electron-related peaks and one hot-hole-related peak were identified in the recovery temperature spectra. As a result, the usefulness of the RTS in hot-carrier-induced degradation studies has been confirmed.

Saitoh, Mitsuchika (Toshiba Corp, Kawasaki, Jpn); Kinugawa, Masaaki; Hashimoto, Hazuhiko. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2384.

**096289 RELATIONSHIP BETWEEN OXIDE CHARGE AND DEVICE DEGRADATION: A COMPARATIVE STUDY OF N- AND P-CHANNEL MOSFETs.** The experimentally determined features of degradation of conventional n-channel and p-channel MOSFETs are investigated with a 2-D simulation. Fast and slow interface states, as well as channel mobility degradation due to Coulomb scattering off these charges, are considered. Three different models concerning kind and spatial distribution of degradation are studied. The authors also present a model that self-consistently describes the observed experimental features in the pentode and subthreshold regimes of the device. Furthermore, the substrate current is included in this analysis. 19 refs.

Schwerin, Andreas (Siemens AG, Munich, West Ger); Hansch, Wilfried; Weber, Werner. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2493-2500.

**096290 INTERFACE TRAP EFFECTS ON THE HOT-CARRIER INDUCED DEGRADATION OF MOSFETs DURING DYNAMIC STRESS.** Foundry and hardened n-channel MOSFETs were stressed with dynamic ac pulses and with static dc voltages. The preradiation hot-carrier induced degradation is identical for devices from both processes when subjected to static stress, but when subjected to dynamic stress, the degradation is much more severe for the hardened devices. The data suggest that the degradation is strongly influenced by the pulse structure. It is proposed that the initial density of interface traps may be responsible for the enhancement in degradation exhibited by the hardened devices following dynamic stress. 16 refs.

Suehle, J.S. (NBS, Gaithersburg, MD, USA); Russell, T.J.; Galloway, K.F. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1359-1365.

**096291 HOT-ELECTRON DEGRADATION OF N-CHANNEL POLYSILICON MOSFETs.** The stability of the hydrogen passivation in hydrogenated n-channel polysilicon MOSFETs has been studied under thermal stress and hot-electron stress at elevated temperatures. Although the hydrogen passivation is stable at 150°C, channel hot-electron stress at high temperatures appears to create additional grain boundary traps, presumably by breaking the Si-H bonds at the grain boundaries. This mechanism is in addition to the creation of acceptor-type fast interface states that occur in bulk MOSFETs. 11 refs.

Banerjee, Sanjay (Texas Instruments Inc, Dallas, TX, USA); Sundaresan, Ravishankar; Shichijo, Hisashi; Malhi, Satwinder. *IEEE Trans Electron Devices* v 35 n 2 Feb 1988 p 152-157.

**096292 GATE OXIDE CHARGE-TO-BREAKDOWN CORRELATION TO MOSFET HOT-ELECTRON DEGRADATION.** Substrate current by itself is found not to be a sufficient indicator of degradation. Experiments using active-area test capacitors with and without poly edges confirm that the gate-oxide trap density beneath the poly edges is equally important in determining the degradation. Certain processing steps have been identified as being responsible for gate-oxide degradation. An optimization of these steps has resulted in improved hot-electron degradation behavior. 11 refs.

Davis, Marshall (Natl Semiconductor Corp, Puyallup, WA, USA); Lahri, Rajeeva. *IEEE Electron Device Lett* v 9 n 4 Apr 1988 p 183-185.

**096293 HOT-CARRIER-INDUCED DEGRADATION IN P-MOSFETs UNDER AC STRESS.** Lifetimes under AC stress are calculated with a quasistatic model using parameters extracted from DC stress data. For inverter-like waveforms, the measurement data show reasonable agreement with the simulation results. For waveforms with turnoff transient occurring in the presence of high drain voltage, more degradation than the model predicts is found if the transient is short ( $\leq 10$  ns) and gate voltage is high. 9 refs.

Ong, T.-C. (Univ of California, Berkeley, CA, USA); Seki, Kouichi; Ko, P.K.; Hu, Chenming. *IEEE Electron Device Lett* v 9 n 5 May 1988 p 211-213.

**096294 HOT-ELECTRON-INDUCED DEGRADATION OF CONVENTIONAL, MINIMUM OVERLAP, LDD AND DDD N-CHANNEL MOSFETs.** Substrate current characteristics of conventional minimum overlap, DDD (double-diffused drain), and LDD (lightly doped drain) (n-channel MOSFETs with various LDD n<sup>+</sup> doses have been studied. Threshold voltage shift, transconductance degradation, and change of substrate current for these devices after stressing were also investigated. The minimum gate/drain overlap devices had the highest substrate current and the worst hot-electron-induced degradation. The amount of gate-to-n<sup>+</sup> drain overlap in LDD devices was an important factor for hot-electron effects, especially for devices with low LDD n<sup>+</sup> doses. The injection of hot holes into gate oxide in these devices at small stressed gate voltages was observed and was clearly reflected in the change of substrate current. The device degradation of low-doped LDD n-channel MOSFETs induced by AC stress was rather severe. 18 refs.

Liou, Tian-I (Natl Semiconductor Corp, Santa Clara, CA, USA); Teng, Chih-Sieh; Merrill, Richard B. *IEEE Circuits Devices Mag* v 4 n 2 Mar 1988 p 9-15.

**096295 SIMULATION OF MOSFET LIFETIME UNDER AC HOT-ELECTRON STRESS.** A substrate current model and a quasistatic hot-electron-induced MOSFET degradation model have been implemented using the Substrate Current And Lifetime Evaluator (SCALE) package. It is shown that quasistatic simulation is valid for a class of waveforms that includes those encountered in inverter-based logic circuits. The validity and limitations of the model are illustrated with experimental results. SCALE is linked to SPICE externally in a pre- and postprocessor fashion to form an independent simulator. The preprocessor interprets the input deck and requests SPICE to output the transient node voltages of the user-selected devices. The postprocessor then calculates the transient substrate current and makes a lifetime prediction. 11 refs.

Kuo, Mary M. (Univ of California, Berkeley, CA, USA); Seki, Koichi; Lee, Peter M.; Choi, Jeong Yeol; Ko, Ping K.; Hu, Chenming. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1004-1011.

**096296 SUPPRESSION OF HOT-CARRIER EFFECTS IN SUBMICROMETER SURFACE-CHANNEL PMOSFETs.** Hot-carrier-induced degradation in surface-channel (p-type polysilicon gate) PMOSFETs is investigated. Hot-electron-induced punchthrough is found to limit the lifetime of these devices. Although these surface-channel devices are observed to be more reliable than conventional buried-channel transistors, a lightly doped drain design is found to be necessary to provide adequate suppression of hot-carrier generation in 0.8- $\mu$ m-gate-length ( $L_{eff} = 0.5 \mu$ m) transistors operated at 5 V. 7 refs.

Brassington, Michael P. (Natl Semiconductor, Palo Alto, CA, USA); Poulter, Mark W.; El-Diwan, Monir. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1149-1151.



**096297 MECHANISM OF DEGRADATION OF LDD MOSFET'S DUE TO HOT-ELECTRON STRESS.** The dominant degradation mechanism in n-channel lightly doped drain (LDD) MOSFETs following hot-electron injection is identified. While there is no shift in the threshold voltage or any change in the subthreshold slope (implying no significant interface state generation), the peak value of the transconductance is found to degrade with stress time. This degradation is attributed to the increase in the source-drain series resistance, which is measured as a function of stress time. In addition, it is found that for any stress time, the measured series resistance is a strong function of the gate voltage, implying a modulation of the depletion width in the lightly doped region with change in the gate voltage. 8 refs.

Bhattacharyya, Anjan (Philips Research Lab, Sunnyvale, CA, USA); Shabde, Sunil N. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1156-1158.

## Efficiency

**096298 NEW TECHNOLOGY MAKES POWER MOSFETS FASTER, MORE EFFICIENT.** Using a totally new approach, a family of high-power MOSFETs exhibit the lowest input capacitance and lowest ON resistance of any comparable device. These improvements allow power supplies to use higher switching frequencies and motor control circuits to run faster with less drive current and better efficiency. This permits designers to use power MOSFETs in applications previously restricted to power bipolar transistors and thyristors.

Daly, Tom (Advanced Power Technology). *Powerconverters Intell Motion* v 14 n 1 Jan 1988 p 14, 16-18.

**Electric Breakdown** See Also INTEGRATED CIRCUITS—Mathematical Models; TRANSISTORS, FIELD EFFECT—Electric Breakdown.

**096299 AVALANCHE-INDUCED DRAIN-SOURCE BREAKDOWN IN SILICON-ON-INSULATOR n-MOSFET'S.** A proposed breakdown model includes the effects of floating substrate and finite silicon thickness. The calculated I-V characteristics in the breakdown region agree well with the experimental results. The results show that 1) the drain-source breakdown voltage of silicon-on-insulator (SOI) n-MOSFETs increases with increasing channel length, increasing positive substrate voltage, and decreasing silicon film thickness; and 2) SOI n-MOSFETs have higher breakdown voltage than their bulk-silicon counterparts at large gate bias, but lower breakdown voltage at small gate bias. 9 refs.

Young, K. Konrad; Burns, James A. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 426-431.

## Electric Conductivity

**096300 CONDUCTANCE FLUCTUATIONS IN ULTRA-SHORT-CHANNEL SI MOSFETS.** Conductance fluctuations with gate voltage near threshold are observed at temperatures up to 10 K in metal-oxide-semiconductor field-effect transistors (MOSFETs) with wide (44  $\mu\text{m}$ ) but short ( $\leq 0.15 \mu\text{m}$ ) channels. The reproducible variations are consistent with the universal conductance fluctuations predicted by Lee and Stone. (Author abstract) 9 refs.

Chou, S.Y. (MIT, Cambridge, MA, USA); Antoniadis, D.A.; Smith, H.I.; Kastner, M.A. *Solid State Commun* v 61 n 9 Mar 1987 p 571-572.

**096301 LOCALIZED INTERFACE TRAP GENERATION IN SILO-ISOLATED MOSFET'S DURING PECVD NITRIDE PASSIVATION.** The authors report the generation of interface traps during the plasma-enhanced chemical vapor deposition of silicon nitride passivation in MOS structures that utilize a sealed-interface local oxidation scheme (SILO) for device isolation. These traps are highly localized at the boundaries between gate and field oxides, causing enhanced subthreshold conduction. Localized interface traps of this type were not observed in identical MOS structures that use conventional LOCOS (local oxidation of silicon) isolation and

were eliminated by thermal anneals at 450°C. Anneals in hydrogen ambients resulted in enhanced rates of hot-carrier-induced degradation. The high densities and localized nature of these anomalous traps make possible a novel mode of device operation in which source-drain conduction is strongly modulated by substrate bias. 12 refs.

Brassington, Michael P. (Fairchild Research Cent, Palo Alto, CA, USA); Razouk, Reda R.; Hu, Chenming. *IEEE Trans Electron Devices* v 35 n 1 Jan 1988 p 96-100.

**096302 NOVEL TRENCH-INJECTOR POWER DEVICE WITH LOW ON RESISTANCE AND HIGH SWITCHING SPEED.** A power MOSFET device structure that has been developed to optimize the tradeoff between ON resistance and switching speed is discussed. The device structure features a trench injector that injects a controlled quantity of minority carriers into the drift path of the MOSFET current to modulate the conductivity of the device during the ON state. This conductivity-modulated MOSFET device (CMDMOS) has been fabricated and characterized. The device structure has demonstrated low ON resistance and high switching speed. It can be implemented along with logic circuitry to allow programmable electrical control of the switching-speed/ON-resistance tradeoff. 7 refs.

Liu, David K.Y. (Stanford Univ, CA, USA); Plummer, James D. *IEEE Electron Device Lett* v 9 n 7 Jul 1988 p 321-323.

## Electric Properties

**096303 SUBTHRESHOLD TRANSCONDUCTANCE IN THE LONG-CHANNEL MOSFET.** The transconductance-current ratio of the long-channel MOSFET approaches the ideal value of  $q/kT$  under subthreshold conditions. This behavior has previously been explained using a BJT-like model. It is shown that such a model is inappropriate, and that this phenomenon can be explained by the diffusive nature of the subthreshold current, the law governing the density gradient, and the existence of a quasi high-low junction between the source region and channel. A general expression for subthreshold transconductance is developed. It is also demonstrated analytically that the bulk and inversion-layer capacitances that enter into this expression are equal at the threshold of strong inversion, a demonstration that avoids approximations employed in a previous treatment of the matter. (Author abstract) 23 refs.

Schrimpf, R.D. (Univ of Minnesota, Minneapolis, MN, USA); Ju, D.-H.; Warner, R.M. Jr. *Solid State Electron* v 30 n 10 Oct 1987 p 1043-1048.

**096304 INFLUENCE OF HOT-ELECTRON-INDUCED AGING ON THE DYNAMIC CONDUCTANCE OF SHORT-CHANNEL MOSFETS.** An analysis of the dynamic conductance of a nonuniform MOSFET operating in weak inversion is presented. A new method for the determination of the interface state density accounting for nonuniformity and of DIBL effects is proposed. This method is suitable for the study of hot-electron-induced aging in submicron MOS transistors. It is demonstrated that the interface state density near the drain increases drastically with stress duration whereas the interface state density near the source remains almost unchanged after aging. (Edited author abstract) 15 refs.

Ghibaudo, G. (ENSERG, Grenoble, Fr); Cabon, B. *Solid State Electron* v 30 n 10 Oct 1987 p 1049-1052.

**096305 NEW METHOD FOR THE EXTRACTION OF MOSFET PARAMETERS.** A new method for the extraction of the MOSFET parameters is presented. The method, which relies on combining drain current and transconductance transfer characteristics, enables reliable values of the threshold voltage  $V_t$ , the low field mobility  $\mu_0$  and the mobility attenuation coefficient  $\theta$  to be obtained. (Author abstract) 8 refs.

Ghibaudo, G. (Sachs & Freeman Associates Inc, Landover, MD, USA). *Electron Lett* v 24 n 9 Apr 28 1988 p 543-545.

**096306 ELECTRON ENERGY DISTRIBUTION FOR CALCULATION OF GATE LEAKAGE CURRENT IN MOSFETS.** A new equation, which does not require any fitting parameters, has been developed to predict gate leakage current density in MOSFETs. The equation is based upon a non-Maxwellian hot-electron distribution function derived from the Boltzman transport equation, and utilizes a physically calculated local electron temperature. The model predicts gate currents for a sample submicron MOSFET that are in good agreement with experiment. (Author abstract) 14 refs.

Goldsman, N. (Univ of Maryland, College Park, MD, USA); Frey, J. *Solid State Electron* v 31 n 6 Jun 1988 p 1089-1092.

**096307 MODELLING THE LOCAL DAMAGE OF SHORT-CHANNEL MOSFETS DUE TO HOT ELECTRON INJECTION USING RESULTS FROM PHOTOINJECTION MEASUREMENTS ON MOS CAPACITORS.** As dimensions of MOS transistors are reduced higher lateral and transverse electric fields lead to carrier heating in the channel of the transistor. The injection of hot carriers into the insulator of a MOS device causes a change in the electrical properties due to generation of fast surface states and generation or filling of oxide traps. To obtain the kinetics of charge building up at the Si-SiO<sub>2</sub> interface and in the bulk of the insulator after electron injection, photoinjection investigations on semitransparent MOS capacitors were carried out at a field of  $1 \times 10^6$  V/cm (injection from the semiconductor). A xenon arc lamp was used for irradiation of the samples. The change of the mid-gap voltage and the increase of the concentration of fast surface states after photoinjection were determined by applying high frequency C-U measurements. 3 refs.

Januschewski, F. (Akad der Wissenschaften der DDR, Frankfurt, East Ger); Erzgraber, H.J.; Fuessel, W. *Phys Status Solidi A* v 106 n 2 Apr 1988 p k215-k220.

**096308 CONDUCTANCE TECHNIQUE IN MOSFETS: STUDY OF INTERFACE TRAP PROPERTIES IN THE DEPLETION AND WEAK INVERSION REGIMES.** A new and accurate approach to a.c. conductance measurements on MOSFETs is presented. It is shown that the conductance technique can be used to study interface trap properties in most of the silicon band-gap by direct measurement on a single MOSFET. The equivalent circuit is analyzed and the influence of the channel length on the inversion layer response is discussed. It is shown that the channel time constant is mainly determined by the channel length. For small channel lengths  $L < 5 \mu\text{m}$  the channel time constant is generally smaller than  $10^{-8}$  s. As a result rapid response, the interface traps can easily interact with the minority carrier band in inversion. Therefore, such traps can be studied in a similar way as those interacting with the majority carrier band in depletion. (Edited author abstract) 15 refs.

Haddara, Hisham S. (ENSERG, Grenoble, Fr); El-Sayed, Mohamed. *Solid State Electron* v 31 n 8 Aug 1988 p 1289-1298.

**096309 ELECTRICAL CHARACTERISTICS OF MOSFET'S UTILIZING OXYGEN-ARGON SPUTTER-DEPOSITED GATE OXIDE FILMS.** A study is presented of the electrical characteristics of MOSFETs utilizing oxygen-argon. The gate-oxide films deposited at low temperature (200°C) by oxygen-argon sputtering of an SiO<sub>2</sub> target. The MOSFETs formed are confirmed to have triode characteristics. Oxygen mixing makes it possible to improve considerably the MOSFET field-effect mobility and subthreshold slope over those of argon-only sputter-deposited film to 700 cm/V-s and 170 mV/decade. These improvements are the result of a large reduction in



surface-state density. The results confirm the usefulness of oxygen-argon sputter-deposited gate-oxide films for fabrication at low temperature. 11 refs.

Suyama, Shiro (NTT, Musashino, Jpn); Okamoto, Akio; Serikawa, Tadashi. *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2124-2128.

**096310 SUBBREAKDOWN DRAIN LEAKAGE CURRENT IN MOSFET.** Significant drain leakage current can be detected at drain voltages much lower than the breakdown voltage. This subbreakdown leakage can dominate the drain leakage current at zero  $V_G$  in thin-oxide MOSFETs. The mechanism is shown to be band-to-band tunneling in Si in the drain/gate overlap region. In order to limit the leakage current to 0.1 pA/ $\mu\text{m}$ , the oxide field in the gate-to-drain overlap region must be limited to 2.2 MV/cm, which may set another constraint for oxide thickness or power supply voltage. 5 refs.

Chen, J. (Univ of California, Berkeley, CA, USA); Chan, T.Y.; Chen, I.C.; Ko, P.K.; Hu, Chenming. *IEEE Electron Device Lett* v EDL-8 n 11 Nov 1987 p 515-517.

**096311 ANOMALOUS SUBTHRESHOLD CURRENT-VOLTAGE CHARACTERISTICS OF N-CHANNEL SOI MOSFET'S.** The abnormally high slopes of the subthreshold current-voltage characteristics exhibited by n-channel silicon-on-insulator (SOI) MOSFETs are experimentally related to defect density (off-state leakage current) as well as drain voltage and channel length, and a theoretical physical description of the measured relations is presented and supported. The anomalous subthreshold behavior is attributed analytically to the (floating) body effect due to charging (biasing) by impact ionization at the drain. 6 refs.

Fossum, Jerry G. (Univ of Florida, Gainesville, FL, USA); Sundaresan, Ravishankar; Matloubian, Mshel. *IEEE Electron Device Lett* v EDL-8 n 11 Nov 1987 p 544-546.

**096312 HIGH-QUALITY CMOS IN THIN (100 NM) SILICON ON SAPPHIRE.** Electrical characteristics of enhancement-mode n-channel and p-channel MOSFETs in 100-nm-thick silicon-on-sapphire (SOS) are reported. Channel mobilities (linear operation) of 500 and 200  $\text{cm}^2/\text{V}\cdot\text{s}$ , respectively, have been measured in double solid-phase epitaxially (DSPE) improved material. Deep trap levels associated with the Si-sapphire interface were measured in concentrations as low as  $1 \times 10^{11} \text{ cm}^{-2}$ . These results indicate that DSPE-improved SOS films thinned to 100 nm are suitable for application to high-performance down-scaled CMOS circuitry. 15 refs.

Garcia, G.A. (US Naval Ocean Systems Cent, San Diego, CA, USA); Reedy, Ronald E.; Burgener, M.L. *IEEE Electron Device Lett* v 9 n 1 Jan 1988 p 32-34.

**096313 ELECTRICAL CHARACTERISTICS OF MOSFET'S USING LOW-PRESSURE CHEMICAL-VAPOR-DEPOSITED OXIDE.** The electrical characteristics of MOSFETs and MOS capacitors utilizing thin (80-230 angstrom) low-pressure chemical-vapor-deposited (LPCVD) oxide films deposited at 12 angstrom/min are presented. MOSFETs using CVD oxides show good electrical characteristics with 70-90% of the surface mobility of conventional MOSFETs. The CVD oxides exhibit the same low leakage current and high breakdown fields as the thermal oxides, and significantly lower trapping and trap generation rates than thermally grown oxides. Interface state densities of  $\leq 3 \times 10^{10} \text{ cm}^{-2}\text{eV}^{-1}$  are obtained from CVD devices by using a short annealing in oxygen ambient following the deposition. These results indicate that these LPCVD oxide films may be promising dielectrics for MOS device application. 13 refs.

Lee, Jack (Univ of California, Berkeley, CA, USA); Hegarty, Chris; Hu, Chenming. *IEEE Electron Device Lett* v 9 n 7 Jul 1988 p 324-327.

**096314 RECOVERY OF THRESHOLD VOLTAGE AFTER HOT-CARRIER STRESSING.** The recovery of threshold voltage due to high drain or gate voltage and the

effects of hot-carrier stressing on the drain breakdown voltage of MOSFETs have been studied. A high oxide field causes slow recovery through tunneling detrapping of electrons in both p- and n-MOSFETs. For n-MOSFETs the mechanism of fast recovery is low-level hole injection at high  $V_D$ . Hot-carrier stressing at high  $V_G$  causes the drain breakdown voltage to decrease (walk-in). This results in enhanced hole injection, thus increasing the rate of subsequent recovery of  $V_t$ . The breakdown voltage increases and then decreases when stressed at low gate voltages. 20 refs.

Ong, Tong-Chern (Univ of California, Santa Clara, CA, USA); Levi, M.; Ko, Ping-Keung; Hu, Cheming. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 978-984.

**Electronic Properties** See Also PLASMAS—Oscillations.

**096315 TECHNIQUE FOR THE OBSERVATION OF INTERFACE TRAP DENSITIES IN MOSFET DEVICES.** An experimental technique is described that permits the direct measurement of interface trap densities. The measurements may be carried out at fixed, controlled values of the surface potential or surface electric field. Results obtained by this technique are compared with those found by conventional methods. (Author abstract) 8 refs.

Heasell, E.L. (Univ of Waterloo, Waterloo, Ont, Can). *Semicond Sci Technol* v 3 n Jan 1988 p 35-39.

**Fabrication** See Also SEMICONDUCTING SILICON—Doping; TRANSISTORS, FIELD EFFECT—Junctions.

**096316 NOVEL SELF-ALIGNED POLYSILICON-GATE MOSFETS WITH POLYSILICON SOURCE AND DRAIN.** A novel self-aligned technique is described for self-aligning a polysilicon gate in devices with polysilicon source and drain regions. The technique is demonstrated for two types of polysilicon source and drain devices. In one type of device, the polysilicon serves as the source of dopant for diffused source and drain junctions. In the second type, the polysilicon, together with an underlying interfacial oxide, forms a tunneling CIS (conductor-thin-insulator-semiconductor) structure. The characteristics of devices of both types fabricated under almost identical conditions using the new self-alignment technique are compared. (Author abstract) 11 refs.

Moravvej-Farshi, M.K. (Univ of New South Wales, Kensington, Aust); Green, M.A. *Solid State Electron* v 30 n 10 Oct 1987 p 1053-1062.

**096317 SILICON-ON-INSULATOR MOS DEVICES FOR INTEGRATED CIRCUIT APPLICATIONS.** Several techniques for fabricating regions of crystalline silicon on insulating (SOI) substrates are available. These methods are described briefly and device design considerations introduced by the use of SOI are discussed. The advantages of SOI devices are described; these are absence of latch-up, process simplicity, radiation resistance, and reduction of parasitic capacitance. The physics of an SOI MOS transistor are presented. 7 refs.

Coline, Jean-Pierre. *Hewlett Packard J* v 39 n 1 Feb 1988 p 87-93.

**096318 SELF-ALIGNED UMOSFET'S WITH A SPECIFIC ON-RESISTANCE OF  $1 \text{ m}\Omega \times \text{cm}^2$ .** An improved UMOSFET with an ultralow specific on-resistance is described. This device utilizes a self-aligned process that permits closely spaced vertical trench gates with a unit cell of 6  $\mu\text{m}$ . This allows for a large increase of channel density and, therefore, reduces the on-resistance per unit area significantly. Experimental devices have been fabricated, and a specific on-resistance of  $1.0 \text{ m}\Omega \text{ cm}^2$  with a breakdown voltage of 30 V has been achieved. This specific on-resistance is the lowest value ever reported for FETs. 10 refs.

Chang, H.R. (GE, Schenectady, NY, USA); Black, R.D.; Temple, V.A.K.; Tantraporn, Wirojana; Baliga, B. Jayant. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA,

USA, Jun 22-24 1987 p 2329-2334.

**096319 FABRICATION OF THIN GATE OXIDE MOSFET'S USING LOW-TEMPERATURE PLASMA-ENHANCED CHEMICAL-VAPOR-DEPOSITED  $\text{SiO}_2$ .** The fabrication and device performance of large-area ( $9.7 \times 10^{-4} \text{ cm}^2$ ), thin-gate-oxide ( $t_{ox} \leq 200 \text{ angstrom}$ ) n-channel MOSFETs using this PECVD (plasma-enhanced chemical vapor deposition) gate oxide process are discussed. Measurements made on these MOSFETs show that they compare well to equivalently prepared thermally oxidized devices. For example, the transconductance of a 100-angstrom PECVD MOSFET was  $215 \times 10^{-9} \text{ S}$ , compared to  $275 \times 10^{-9} \text{ S}$  for a 100-angstrom thermally oxidized sample. The field effect mobilities were 352 and 460  $\text{cm}^2/\text{V}\cdot\text{s}$ , respectively; thresholds were 0.04 V for the PECVD device and  $-0.08 \text{ V}$  for the thermal device. These results were obtained from devices which received only a  $400^\circ\text{C}$  (postmetal) anneal after gate oxide deposition. This demonstrates that PECVD can be a viable candidate for reducing the number of high-temperature steps in VLSI processing. 2 refs.

Stasiak, J. (IBM, Yorktown Heights, NY, USA); Batey, J.; Tierney, E.; Li, J. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2367.

**096320 FLOATING-GATE CURRENT SENSOR.** The theory and experimental results for a concept for sensing wideband currents by utilizing a MOS floating-gate device structure are described. The experimental device structure consists of a dual-gate n-channel MOSFET with the gate next to the source controlling the current injection into the channel and the gate next to the drain acting as the floating gate. The sensing of the current results from the capacitive coupling of mobile carriers in the channel to the input gate of an on-chip MOS electrometer amplifier as they pass beneath the floating gate. A difference between the floating gate current sensing concept and the more conventional resistor sensing approach is that the floating-gate current sensor is ac coupled so that dc components of the current are filtered out. Also, the floating gate current sensor has a current-to-voltage transfer function with a linear characteristic at low signal currents and a square-root characteristic at high signal currents. In addition, the floating gate frequency response is determined by the carrier transport time in the region beneath the floating gate rather than an RC time constant, as in the resistor sensing approach. The latter feature allows long current integration times without the use of high-value resistors.

Kub, F.J. (Westinghouse Electric Corp, Baltimore, MD, USA); Lin, H.C. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2383.

**096321 DEEP-SUBMICROMETER MOS DEVICE FABRICATION USING A PHOTORESIST-ASHING TECHNIQUE.** A photoresist-ashing process has been developed which, when used in conjunction with conventional g-line optical lithography, permits the controlled definition of deep-submicrometer features. The ultrafine lines were obtained by calibrated ashing of the lithographically defined features in oxygen plasma. The technique has been successfully used to fabricate MOSFETs with effective channel length as small as  $0.15 \mu\text{m}$  that show excellent characteristics. An NMOS ring oscillator with  $0.2\text{-}\mu\text{m}$  devices has been fabricated with a room-temperature propagation delay of 22 ps/stage. Studies indicate that the thinning is both reproducible and uniform so that it should be usable in circuit as well as device fabrication. Since most polymer-based resist materials are etchable with an oxygen plasma, the basic technique could be



extended to supplement other lithographic processes, including e-beam and X-ray processes, for fabricating both silicon and nonsilicon devices and circuits. 5 refs.

Chung, J. (Univ of California, Berkeley, CA, USA); Jeng, M.-C.; Moon, J.E.; Wu, A.T.; Chan, T.Y.; Ko, P.K.; Hu, Chenming. *IEEE Electron Device Lett* v 9 n 4 Apr 1988 p 186-188.

**096322 LDD MOSFET'S USING DISPOSABLE SIDEWALL SPACER TECHNOLOGY.** A technology for fabricating lightly doped drain (LDD) MOSFET devices based on disposable sidewall spacers is presented. Using a thin polysilicon buffer layer between the low-temperature oxide (LTO) sidewall spacers and the oxidized polysilicon gate, a single masking step can be used to form the n<sup>+</sup> and n<sup>+</sup> or p<sup>+</sup> and p<sup>+</sup> source/drain implants for the NMOS and PMOS devices, respectively. In addition, the LTO sidewall spacers may be removed by a wet HF strip, thus minimizing additional damage to the gate oxide that may be caused by reactive ion etch removal. The disposable sidewall spacer technology is easily adaptable to a CMOS process as demonstrated by the fabrication of a 4K × 4 SRAM circuit using a conventional 1.5-μm CMOS technology. 4 refs.

Pfister, James R. (Motorola, Austin, TX, USA). *IEEE Electron Device Lett* v 9 n 4 Apr 1988 p 189-192.

**096323 EFFECTS OF ION-BEAM MIXING ON THE PERFORMANCE AND RELIABILITY OF DEVICES WITH SELF-ALIGNED SILICIDE STRUCTURE.** The uniformity of Ti silicide resistance has been greatly improved by using an ion-beam mixing technique. The integrity of both MOS capacitors and p-n junction diodes has been improved. N-channel MOS field-effect transistors fabricated with this technique show better electrical characteristics, less electron trapping in the gate oxide, and better hot-carrier resistance than with devices made without the use of ion-beam mixing. 10 refs.

Ku, Y.H. (Univ of Texas, Austin, TX, USA); Lee, S.K.; Kwong, Dim-Lee; Lee, C.-O.; Yeagain, John R. *IEEE Electron Device Lett* v 9 n 6 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 293-295.

**096324 NEW MOSFET WITH LARGE-TILT-ANGLE IMPLANTED DRAIN (LATID) STRUCTURE.** The LATID device features the elimination of the sidewall spacer and self-alignment of n<sup>+</sup> large tilt angle (LAT) and n<sup>+</sup> implants to the same gate edge. Even without a spacer and a heavy drive-in, the LATID can achieve both a sufficiently long L<sub>eff</sub> and an n<sup>+</sup> gate overlap. The LATID achieves improved current drive by more than 50% and improved hot-carrier lifetime by more than three orders of magnitude as compared with a conventional lightly doped drain. The LATID technique is most promising for applications to submicrometer ULSI under 5-V operation. 11 refs.

Hori, Takashi (Matsushita Electric Industrial Co, Moriguchi, Jpn); Kurimoto, Kazumi. *IEEE Electron Device Lett* v 9 n 6 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 300-302.

**096325 COMPLEMENTARY METAL OXIDE SEMICONDUCTOR COMPATIBLE HIGH-VOLTAGE TRANSISTORS.** The purpose of this work was to study the implementation of high-voltage transistors using standard 3-5 μm complementary metal oxide semiconductor (CMOS) technology with a minimum of additional photolithographic or implant steps. A fabrication process was designed to accommodate a variety of high-voltage transistors with greater than 450 V breakdown voltage and low-voltage CMOS. Extensive use was made of a two-dimensional device model and a one-dimensional process model to determine suitable process parameters. The necessary conditions to produce a high-voltage double-diffused metal oxide semiconductor (DMOS) structure, as well as both n-well and p-well regions for CMOS transistors, and a thick gate oxide required to sustain the full blocking voltage were the main determinants of the process flow. Lateral DMOS (LDMOS),

vertical DMOS (VDMOS), conductivity modulated FET (COMFET), and MOS triac (TRIMOS) devices were fabricated on the same chip as standard CMOS transistors using the developed fabrication sequence. (Edited author abstract) 10 refs.

Kempf, P. (Northern Telecom Electronics Ltd, Ottawa, Ont, Can); Hadaway, R.; Kolk, J. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicon Technol Conf, Ottawa, Ont, Can p 1003-1008.

## Ionization

**096326 ACCURATE ANALYSIS OF IMPACT IONIZATION EFFECTS IN SUBMICROMETER MOSFET DEVICES.** The substrate current due to electron initiated impact ionization in submicrometer n-channel MOSFETs is calculated using a Monte Carlo (MC) simulation which uses the electrical field and current density distributions given by the PISCES conventional 2-D device modeling program. This method couples the physical precision of the MC technique with a conventional device modeling program based on the drift-diffusion approach. The MC simulation is therefore computationally efficient while still treating the details of high field transport correctly, and leads to an efficient and precise method for modeling submicrometer MOSFETs. 5 refs.

Hwang, Chang C. (Stanford Univ, CA, USA); Dutton, R.W.; Higman, J.M.; Hess, K. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2384.

**Junctions** See Also ELECTRIC SWITCHES, SEMICONDUCTOR—Electric Power.

**096327 PLANAR p-n JUNCTION WITH NEAR IDEAL BREAKDOWN VOLTAGE.** MOSFETs are increasingly used as power devices and an important requirement of such a device is its ability to withstand high voltage. Since many MOS transistors have planar configuration, it is essential that the actual breakdown voltage of a planar junction is made to reach the bulk breakdown voltage. By using concentration profiling, a breakdown voltage of 91% of the bulk breakdown value is achieved. Numerical techniques were adopted to evaluate the field and the multiplication factor in the junction. The superiority of the method lies in its simplicity. (Edited author abstract) 9 refs.

Jog, Sujata (Indian Inst of Technology, Bombay, India); Sundar Singh, V.P. *Microelectron J* v 19 n 1 Jan-Feb 1988 p 41-47.

**096328 IMPROVING PN JUNCTION REVERSE RECOVERY MEASUREMENTS. PART 1.** Significant errors occur in measurement of the reverse recovery time of ultrafast rectifiers and Power MOSFETs. A primary cause is the inductance of the current-sampling resistor. A pertinent analysis is presented.

Leinfelder, Bernard A. (Bernar Corp). *Powerconverters Intell Motion* v 14 n 1 Jan 1988 p 41-44.

**096329 FORMATION OF SHALLOW p<sup>+</sup>-n JUNCTIONS USING BORON-NITRIDE SOLID DIFFUSION SOURCE.** The authors describe how shallow p<sup>+</sup>-n junctions on the order of 0.1 μm deep were fabricated using boron-nitride solid diffusion sources. The process used combines the hydrogen-injection method and rapid thermal processing. Sheet resistivities, in ranges from 50 to 130 Ω/sq with junction depths from 0.1 to 0.19 μm, are possible with this technique. Diode characteristics of 0.11-μm junctions show low reverse leakage current (of the order of 10 nA/cm<sup>2</sup>) indicating the possibility of this method's use to form PMOS source-drain contacts. 10 refs.

Kim, Kyeong-Tae (Korea Advanced Inst of Science & Technology, Seoul, South Korea); Kim, Choong-Ki. *IEEE Electron Device Lett* v EDL-8 n 12 Dec 1987 p 569-571.

**096330 OPTIMIZATION OF THE GERMANIUM PREAMORPHIZATION CONDITIONS FOR SHAL-**

**LOW-JUNCTION FORMATION.** Shallow p<sup>+</sup>-n and n<sup>+</sup>-p junctions were formed in germanium preamorphized Si substrates. Germanium implantation was carried out over the energy range of 50-125 keV and at doses from 3 × 10<sup>14</sup> to 1 × 10<sup>15</sup> cm<sup>-2</sup>. p<sup>+</sup>-n junctions were formed by 10-keV boron implantation at a dose of 1 × 10<sup>15</sup> cm<sup>-2</sup>. Arsenic was implanted at 50 keV at a dose of 5 × 10<sup>15</sup> cm<sup>-2</sup> to form the n<sup>+</sup>-p junctions. Rapid thermal annealing was used for dopant activation and damage removal. Rutherford backscattering spectrometry was used to study the dependence of the amorphous layer formation on the energy and dose of germanium ion implantation. Cross-sectional transmission electron microscopy was used to study the residual defects formed due to preamorphization. Complete elimination of the residual end-of-range damage was achieved in samples preamorphized by 50-keV/1 × 10<sup>15</sup> cm<sup>-2</sup> germanium implantation. Areal and peripheral leakage current densities of the junctions were studied as a function of germanium implantation parameters. The results show that high-quality p<sup>+</sup>-n and n<sup>+</sup>-p junctions can be formed in germanium preamorphized substrates if the preamorphization conditions are optimized. 40 refs.

Ozturk, Mehmet C. (North Carolina State Univ, Raleigh, NC, USA); Wortman, Jimmie J.; Osburn, Carlton M.; Ajmera, A.; Rozgonyi, George A.; Frey, Eric; Chu, Wei-Kan; Lee, Clinton. *IEEE Trans Electron Devices* v 35 n 5 May 1988 p 659-668.

## Low Temperature Effects

**096331 50-ANGSTROM GATE-OXIDE MOSFET'S AT 77 K.** The mobility degradation and hot-carrier-induced degradation at 77 and 300 K in MOSFETs with very thin gate oxides are studied. Four oxide thicknesses, 52 angstrom, 92 angstrom, 152 angstrom, and 254 angstrom, are investigated, with an emphasis on 52 angstrom and 152 angstrom. All the devices are conventional n-channel MOSFETs without threshold adjustment implants. It is found that hot-carrier-induced degradation may not be the limiting factor in choosing the power-supply voltage, and special drain structures may be necessary for very thin gate MOSFETs even at 77 K. However, mobility reduction at high V<sub>G</sub> is more severe both at lower temperatures and for thinner oxides. Electron mobility appears to be oxide-thickness-dependent at 77 K. The dependence of the electron mobility on the normal field is so strong that it results in unusual I-V characteristics such as negative transconductance at 77 K for an oxide field above 3 MV/cm. The I-V characteristics have been modeled for 52 angstrom devices. 25 refs.

Ong, Tong-Chern (Univ of California, Berkeley, CA, USA); Ko, Ping K.; Hu, Chenming. *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2129-2135.

## Magnetic Field Effects

**096332 PHONON EMISSION BY A HOT TWO-DIMENSIONAL ELECTRON GAS IN A QUANTIZING MAGNETIC FIELD.** A detailed analysis is made of the acoustic phonon emission spectrum of a heated 2DEG in (0 0 1) n-Si inversion layer, when a quantizing magnetic field B is applied perpendicular to the layer. Particular attention is given to the case of high magnetic fields when only a few Landau levels are occupied. The emitted power is then quasimonochromatic at the cyclotron frequency. Both longitudinal and transverse modes are considered and the transition to zero field is discussed. (Edited author abstract) 19 refs.

Toombs, G.A. (Univ of Nottingham, Nottingham, Engl); Sheard, F.W.; Neilson, D.; Challis, L.J. *Solid State Commun* v 64 n 4 Oct 1987 p 577-581.

## Manufacture

**096333 MOSFET'S IN POLYCRYSTALLINE Si RECRYSTALLIZED WITH THE PROCESS OF SSIC - SEED SELECTION THROUGH ION CHANNELING.** This letter demonstrates the optimization for large grain poly-Si formation by Si ion implantation and subsequent recrystallization. When SSIC (seed selection



through ion channeling) occurs, the grain size becomes largest. A high quality poly-Si MOSFET was fabricated using SSIC process. (Author abstract) 5 refs.

Mizushima, Ichiro (Keio Univ, Yokohama, Jpn); Ohori, Kiyoshi; Itoh, Kenichi; Kuwano, Hiroshi. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 11 Nov 1987, Pap from the 1987 Natl Conf on Semicond Devices and Mater IEICE, Kumamoto, Jpn, Nov 1-4 1987 p 1062-1064.

## Materials

**096334 VERTICAL-TYPE AMORPHOUS-SILICON MOSFET IC'S.** The performance of vertical-type amorphous-silicon (a-Si) MOSFETs has been improved significantly by using native silicon dioxide as the gate insulator. The maximum field-effect mobility was  $1.2 \text{ cm}^2/\text{V}\cdot\text{s}$ . An E/E-type inverter and a seven-stage ring oscillator have been fabricated by integrating the vertical-type a-Si MOSFET. The minimum propagation delay time was 95 ns/stage. The characteristics of a flip-flop circuit are also described. 10 refs.

Okada, Hiroyuki (Tokyo Inst of Technology, Tokyo, Jpn); Uchida, Yasutaka; Arai, Kazumasa; Oda, Shunji; Matsumura, Masakiyo. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 919-922.

**096335 CHARACTERISTICS OF MOSFET'S ON LARGE-GRAIN POLYSILICON FILMS.** Polysilicon transistors with improved characteristics are reported. Solid-phase crystallization of evaporated amorphous silicon is used to grow grains in the film up to  $3.5 \mu\text{m}$ . MOSFETs fabricated on this poly-Si film exhibit a carrier mobility of  $165 \text{ cm}^2/\text{V}\cdot\text{s}$  for electrons and  $69 \text{ cm}^2/\text{V}\cdot\text{cm}$  for holes. CMOS 100-stage inverter chains with propagation delay times of 400 ps/stage are demonstrated. The dependence of electrical characteristics on channel length is found and explained by the number of grain boundaries in the channel region. The results indicate that the characteristics of MOSFETs are improved if the grain size of the poly-Si film is as large as the device dimensions. All the devices fabricated are applicable to high-density VLSIs. 15 refs.

Katoh, Teruo (Oki Electric Ind Co, Hachioji, Jpn). *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 923-928.

## Mathematical Models See Also ELECTRONS—Electric Field Effects.

**096336 OPTIMUM DESIGN OF VERTICAL POWER MOSFET WITH THICK DRAIN OXIDE.** The optimum design of a vertical power MOSFET with thick drain oxide is described, taking into account such characteristics as the on-resistance and breakdown voltage. Introducing the empirical ideality of the edge-termination which determines the breakdown voltage of the device, the optimum doping density and thickness of the epitaxial layer have been determined to minimize the on-resistance. Using two-dimensional simulation to evaluate the optimum design of the device, the thickness of the drain oxide and the relationship between the layout pitch and the product of on-resistance and active area have been determined. (Edited author abstract) 18 refs.

Ueda, Daisuke (Matsushita Electronics Corp, Takatsuki, Jpn); Takagi, Hiromitsu; Kano, Gota; Kuroda, Keiji. *Electron Commun Jpn Part 2* v 70 n 8 Aug 1987 p 68-79.

**096337 MODELING OF OHMIC MOSFET OPERATION AT VERY LOW TEMPERATURE.** A model for the ohmic operation of a MOS transistor at very low temperature (4-40 K) is presented. The model is based on a quantum treatment of the inversion layer and on a specific low temperature mobility law. It enables a good description of the MOSFET transfer characteristics (field effect mobility, drain current) as a function of gate voltage and predicts the temperature dependence of the maximum field effect mobility and of the threshold voltage. (Author abstract) 14 refs.

Ghibaudo, G. (CNRS, Grenoble, Fr); Balestra, F. *Solid State Electron* v 31 n 1 Jan 1988 p 105-108.

**096338 COMPARISON OF SOME METHODS FOR THE SOLUTION OF THE NONLINEAR POISSON EQUATION IN SEMICONDUCTOR DEVICE MODELLING.** This paper examines several modifications to Newton's method for the numerical solution of the nonlinear Poisson equation which describes the electrostatic potential distribution in a semiconductor device. Two methods for a more efficient solution of the equation when the device is a Metal-Oxide-Semiconductor Field Effect Transistor are proposed. Their extension to the solution of the fully coupled system of equations is also discussed. The modifications to Newton's method are also compared numerically. (Author abstract) 14 refs.

Fitzsimons, Conor J. (Trinity Coll, Dublin, Ire). *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 4 Dec 1987 p 197-209.

**096339 IMPROVED HOT-ELECTRON-EMISSION MODEL FOR SIMULATING THE GATE-CURRENT CHARACTERISTIC OF MOSFETS.** This paper presents a possible explanation for the shoulder behavior in the gate-current characteristic of a MOSFET. The change of emission population from the bulk toward the surface was found responsible for this phenomenon. (Author abstract) 3 refs.

Wang, Cheng T. (Device Research Inst, Torrance, CA, USA). *Solid State Electron* v 31 n 2 Feb 1988 p 229-231.

**096340 PSEUDO-TWO-DIMENSIONAL ANALYSIS OF SHORT CHANNEL MOSFETS.** A new version of a pseudo-two-dimensional analysis for the drain region of short channel MOSFETs is proposed. Second order effects such as mobility degradation, velocity saturation, and short channel effects are included in the analysis and the dependence on the processing parameters is taken into consideration. The model proposed in this paper guarantees the continuity of the output conductance and its derivative with respect to the drain voltage at the point of transition from the linear to the saturation region. The predictions of the model are confirmed by a comparison with the experimental data available in the literature. (Author abstract) 10 refs.

El Banna, M. (Univ of Pittsburgh, Pittsburgh, PA, USA); El Nokali, M. *Solid State Electron* v 31 n 2 Feb 1988 p 269-274.

**096341 EFFECTIVE GAIN AND EFFECTIVE EXCESS NOISE FACTOR ASSOCIATED WITH DARK CURRENT IN SUPERLATTICE APDs.** Formulae are derived for the effective gain and effective excess noise factor associated with dark current in superlattice avalanche photodiodes (SAPDs) taking into account the influence of residual hole ionization. These indicate that the effect of dark current on receiver performance increases with the electron ionization probability and the number of stages. (Author abstract)

Fyath, R.S. (Univ Coll of North Wales, Bangor, Wales); O'Reilly, J.J. *Solid State Electron* v 31 n 2 Feb 1988 p 275-277.

**096342 MOSFET MODEL WITH SUBSTRATE BIAS FOR CAD.** A simplified three-terminal MOSFET model for CAD is obtained by incorporating the black box method into the physical model of MOSFET, and then expanded to be a four-terminal MOSFET model by taking into account the effects of substrate bias, the modeling of which is also simplified. A computer program with optimization algorithms and least-square curve fitting technique has been used to determine the model parameters automatically. Only simple experimental measurements are required for parameter extraction. Simulated results obtained from the model with experimental data. (Edited author abstract) 9 refs. In Chinese.

Sun, Xingchu (Shanghai Univ of Science & Technology, China). *Pan Tao Ti Hsueh Pao* v 9 n 2 Mar 1988 p 120-128.

**096343 THRESHOLD VOLTAGE MODELS OF THE NARROW-GATE EFFECT IN MICRON AND SUBMICRON MOSFETS.** Modeling of the narrow gate

effect on the threshold voltage shift ( $\Delta V_T$ ) and the effective channel width ( $W_{CE}$ ) by Ji and Sah, based on the solution of the Poisson equation for the two-dimensional (2-D) potential distribution using the depletion approximation, has been improved by removing the depletion approximation. A simple two-parameter analytical formula for predicting the threshold voltage shift of a narrow gate MOSFET with gate width ( $W_G$ ) in the micron and submicron ranges, was proposed and tested against 2-D numerical results. Both parameters can be extracted easily from the theoretical 2-D computed or experimental drain conductance-gate voltage characteristics. The new model shows that the threshold voltage shift of any given MOSFET with a known  $W_{CE}$  can be determined based only on one test device. Therefore, in applications, computation time can be reduced considerably by using the proposed analytical formula to compute the threshold voltage of any given MOSFET. (Edited author abstract) 25 refs.

Chung, Steve Shao-Shiun (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Sah, Chih-Tang. *Solid State Electron* v 31 n 6 Jun 1988 p 1009-1021.

**096344 THREE-PIECE MODEL OF CHANNEL LENGTH MODULATION IN SUBMICROMETER MOSFETS.** A simple model for the linear region of submicrometer n-channel MOSFETs is proposed in which the effective channel length of the device is considered as a function of applied gate and drain voltages, channel doping and temperature. The MOSFET channel is supposed to have three regions with different values of surface state density and oxide charge to take into account the processing-induced damages at its edges. The model is compared with the experimental results of device transconductance at room and low temperatures. It allows understanding of various results unaccounted for by standard models and offers a physical basis for more sophisticated modelling. (Edited author abstract) 23 refs.

Nguyen-Duc, Chien (CNRS, Grenoble, Fr); Cristoloveanu, Sorin; Ghibaudo, Gerard. *Solid State Electron* v 31 n 6 Jun 1988 p 1057-1063.

**096345 ANALYTICAL MODELING OF TRANSFER ADMITTANCE IN SMALL MOSFETS AND APPLICATION TO INTERFACE STATE CHARACTERISATION.** A simple analytical model for the transfer admittance (dynamic transconductance) of MOS transistors is presented. This model establishes a direct correlation between the transfer admittance and the interface state admittance in an explicit analytical form. Experimental measurements have been performed and the obtained results with our theory. We present a new method for characterising interface states in MOS transistors of channel lengths less than  $10 \mu\text{m}$  from the measurement of the imaginary part of the inverse of the transfer admittance. (Edited author abstract) 11 refs.

Haddara, Hisham (CNRS, Grenoble, Fr); Ghibaudo, Gerard. *Solid State Electron* v 31 n 6 Jun 1988 p 1077-1082.

**096346 THRESHOLD-VOLTAGE VARIATIONS IN VLSI MOSFETS DUE TO SHORT CHANNEL LENGTHS.** A simple model is derived for the threshold voltage of a MOSFET in a CMOS n-well or p-well process. The model includes the short-channel effects and considers a Gaussian distribution of the n-type implant in the n-well. An expression is derived based on the charge conservation principle for a case of low drain-source voltage  $V_{DS}$ , which geometrically takes into account the two-dimensional edge effects. The model is in agreement with the measured threshold voltages of typical CMOS (p-channel) transistors. The model is also in agreement with L.D. Yau's model (1974) in the limiting case of uniform channel doping. 4 refs.

Nataraj, B.S. (Santa Clara Univ, CA, USA); Kumar, Rajendra. *IEEE J Solid State Circuits* v SC-22 n 5 Oct 1987 p 905-908.



**096347 SUBTHRESHOLD MODEL OF THE NARROW-GATE EFFECT IN MOSFETS.** The subthreshold softening characteristic of MOSFETs due to the narrow-gate effect has been investigated based on device physics and the two-dimensional (2-D) numerical solution of the Poisson equation. Numerical results taken on stepped-oxide MOSFETs with different gate widths show that a narrower-gate-width device tends to give higher cutoff voltage. Two parameters account for the softening of the subthreshold characteristics: the subthreshold slope of the drain conductance-gate voltage characteristic and the effective channel width. Both parameters can be extracted easily from the theoretical 2-D computed or experimental drain conductance-gate voltage characteristics. A two-parameter analytical approximation formula for narrow-gate MOSFETs operating in the subthreshold range is proposed and tested against exact 2-D numerical results, showing good accuracy. 20 refs.

Chung, Steve Shao-Shiun (Univ of Illinois, Urbana, IL, USA); Sah, Chih-Tang. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2521-2529.

**096348 IMPROVING THE NON-QUASI-STATIC WEAK-TO-STRONG-INVERSION FOUR-TERMINAL MOSFET MODEL.** The recently proposed non-quasistatic dc-to-high-frequency weak-to-strong-inversion model for the four-terminal MOSFET is improved in such a way that closer agreement with exact and experimental results can be obtained. It is shown that the modification of a single parameter leads to significant improvement in the model characteristics. 8 refs.

Bagheri, Mehran (Bell Communications Research, Red Bank, NJ, USA). *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2558-2560.

**096349 INFLUENCE OF DEGENERACY IN THE CHANNEL ON LONG-CHANNEL MOSFET CHARACTERISTICS.** Fermi-Dirac statistics are incorporated into the Pao-Sah model of the MOS transistor. This modification changes the description insignificantly. The comparison of characteristics computed with the use of Fermi-Dirac and Maxwell-Boltzmann statistics shows that the use of the latter causes small errors even in the case of transistors with extremely thin gate oxides. 4 refs.

Majkusiak, B. (Technical Univ of Warsaw, Pol); Jakubowski, A.; Lukasiak, L. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2560-2561.

**096350 NEW DISCRETIZATION STRATEGY OF THE SEMICONDUCTOR EQUATIONS COMPRISING MOMENTUM AND ENERGY BALANCE.** A discretization scheme is applied to the hydrodynamic model for semiconductor devices that generalizes the Scharfetter-Gummel method to both the momentum-conservation and the energy-conservation equations. The major advantages of the scheme are: (1) the discretization is carried out without neglecting any terms, thus providing a satisfactory description of such effects as velocity overshoot and carrier heating; and (2) the resulting equations lend themselves to a self-consistent solution procedure similar to those currently used to solve the simpler drift-diffusion equations. Two-dimensional steady-state simulations of an n-channel MOSFET and of an n-p-n BJT (bipolar junction transistor) have been carried out by means of an improved version of the program HFIELDS. Carrier-temperature plots have been obtained with a reasonable computational effort, demonstrating the efficiency of this technique. The results have been compared with those obtained with the standard drift-diffusion model and significant differences in the electron concentration have been found, especially at the drain end of the MOSFET channel. 29 refs.

Forghieri, Alessandro (Univ of Bologna, Italy); Guerrieri, Roberto; Ciampolini, Paolo; Gnudi, Antonio; Rudan,

Massimo; Baccarani, Giorgio. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 2 Feb 1988 p 231-242.

**096351 ADAM: A TWO-DIMENSIONAL, TWO-CARRIER MOSFET SIMULATOR BASED ON GENERALIZED STREAM FUNCTIONS.** ADAM, a static MOSFET simulator based on a generalized stream function approach which automatically satisfies the continuity equations for full two-carrier transport, is described. This approach introduces a stream potential to account for source/sink terms in the continuity equations. The coupled, nonlinear equations are solved sequentially using H.K. Gummel's (1964) algorithm while the individual linear systems are solved using H.L. Stone's (1968) SIP method. Rectangular MOSFET geometries, which can include substrate insulation (SOS/SOI), can be simulated. Impurity profiles can be input from the SUPREM-3 (1-D) or ROMANS (2-D) process simulators. A multicomponent stream vector approach is used to treat the multiterminal current flow. Convergence of terminal currents occurs rapidly and leads to an efficient simulator in spite of the extra equations to be solved. The generalized stream function approach is described, along with boundary conditions and discretization. Simulation results are presented and the interpretation of the calculated stream functions discussed. 13 refs.

Williams, Ross A. (Rockwell Int, Newport Beach, CA, USA); Pattanayak, Deva N. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 2 Feb 1988 p 243-250.

**096352 NONSTATIONARY CARRIER DYNAMICS IN QUARTER-MICRON SI MOSFETS.** An application of Monte Carlo particle and relaxation time approximation modeling to quarter-micron Si MOSFETs is presented. Through a comparison between these two nonstatic models and a conventional model, nonstationary carrier transport is shown to dominate in  $0.4 \mu\text{m}$  or less channel devices, with peak velocities exceeding  $1.0 \times 10^7 \text{ cm/s}$ . It is shown that the relaxation time approximation model tends to overestimate nonstationary carrier dynamics, especially the energy distribution. 10 refs.

Tomizawa, Masaaki (NTT, Atsugi, Jpn); Yokoyama, Kiyoyuki; Yoshii, Akira. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 2 Feb 1988 p 254-258.

**096353 VOLTAGE-DOPING TRANSFORMATION: A NEW APPROACH TO THE MODELING OF MOSFET SHORT-CHANNEL EFFECTS.** It is shown that the influence of the drain-source field on the potential barrier height is physically equivalent to and can be replaced by a reduction in channel doping concentration according to a formula derived from the two-dimensional Poisson equation. The actual barrier height for any drain bias and channel length, on which the derived equation depends, can be calculated easily using well-known one-dimensional (long-channel) solutions. This simple but general procedure, called the voltage-doping transformation (VDT), is shown to lead to analytically calculated potential distributions in fairly good agreement with two-dimensional numerical simulation. An application of the VDT to threshold voltage ( $V_{th}$ ) calculations also is shown. The  $V_{th}$  model is compared with measurements taken on implanted n-MOSFETs with various channel lengths. Good agreement demonstrates the accuracy of both the VDT and the new  $V_{th}$  model. 9 refs.

Skotnicki, Tomasz (CNET-CNS, Meylan, Fr); Merckel, Gerard; Pedron, Thierry. *IEEE Electron Device Lett* v 9 n 3 Mar 1988 p 109-112.

**096354 INVERSE-NARROW-WIDTH EFFECTS AND SMALL-GEOMETRY MOSFET THRESHOLD VOLTAGE MODEL.** An analytical threshold voltage model is developed based on the results from a three-dimensional MOSFET simulator, called MICROMOS. The model is derived by solving Poisson's equation analytically and is used to predict the threshold voltage of MOSFETs with fully recessed oxide isolation (the trench structure). Coupling was observed between the short-channel effect and the inverse-narrow-width effect. The coupling results from the mutual modulation of the depletion depth and is used to extend the analytical

inverse narrow-width model to small-geometry devices. The model is compared with experimental data obtained from the literature as well as with the three-dimensional simulator. Satisfactory agreement for channel lengths down to  $1.5 \mu\text{m}$  and channel widths down to  $1 \mu\text{m}$  has been obtained. 16 refs.

Hsueh, Kelvin Kuey-Lung (Arizona State Univ, Tempe, AZ, USA); Sanchez, Julian L.; Demassa, Thomas A.; Akers, Lex A. *IEEE Trans Electron Devices* v 35 n 3 Mar 1988 p 325-338.

**096355 TWO-DIMENSIONAL ANALYTICAL MODEL OF THRESHOLD VOLTAGES OF SHORT-CHANNEL MOSFETS WITH GAUSSIAN-DOPED CHANNELS.** A two-dimensional analytical model for the threshold voltage of a short-channel MOSFET with a Gaussian-doped channel has been developed. The Gaussian profile has been simulated by a novel integrable function. This makes possible a purely analytical solution of the two-dimensional Poisson's equation in the channel region of the MOSFET. 6 refs.

Dasgupta, A. (Indian Inst of Technology, Kharagpur, India); Lahiri, S.K. *IEEE Trans Electron Devices* v 35 n 3 Mar 1988 p 390-392.

**096356 AUTOMATED PARAMETER EXTRACTION AND MODELING OF THE MOSFET BELOW THRESHOLD.** A subthreshold model for use in circuit simulation software is described. The model includes representation of nonuniform substrate impurity concentrations and short-channel and narrow-channel effects, while being simple in form. It has been developed in concert with an automated parameter-extraction methodology. The model adds only one parameter to the existing strong inversion model with which it is fully integrated. The accuracy and computational efficiency are suitable for circuit simulation. The results of an extraction carried out on nMOS transistors with channel widths from  $70$  to  $0.9 \mu\text{m}$  and channel lengths from  $35$  to  $1.25 \mu\text{m}$  over a wide range of bias conditions are described. 10 refs.

Silburt, Allan L. (Mosaid Inc, Carp, Ont, Can); Boothroyd, A.R.; Digiovanni, Mario. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 4 Apr 1988 p 484-488.

**096357 MODEL SELECTION FOR SOI MOSFET CIRCUIT SIMULATION.** A method for experimentally selecting proper silicon-on-insulator MOSFET models for circuit simulation is described, verified, and demonstrated. The selection criteria are derived from steady-state current-voltage characteristics predicted by thin-film and (semi-)bulk models. The necessity for proper model selection is emphasized by revealing significant simulation errors that result from seemingly valid but actually empirical models. 13 refs.

Fossum, J.G. (Univ of Florida, Gainesville, FL, USA); Veeraraghavan, S.; Fitzpatrick, D. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 4 Apr 1988 p 541-544.

**096358 SEMI-EMPIRICAL MODEL FOR THE FIELD-EFFECT MOBILITY OF HYDROGENATED POLYCRYSTALLINE-SILICON MOSFETS.** The quantitative relationship between field-effect mobility ( $\mu_{FE}$ ) and grain-boundary trap-state density ( $N_t$ ) in hydrogenated polycrystalline-silicon (poly-Si) MOSFETs is investigated. The focus is on the field-effect mobility in MOSFETs with  $N_t$   $1 \times 10^{12} \text{ cm}^{-2}$ . It is found that reducing  $N_t$  to as low as  $5 \times 10^{11} \text{ cm}^{-2}$  has a great impact on  $\mu_{FE}$ . MOSFETs with  $N_t$  of  $4.2 \times 10^{11} \text{ cm}^{-2}$  show an electron mobility of  $185 \text{ cm}^2/\text{V}\cdot\text{s}$ , despite a mean grain size of  $0.5 \mu\text{m}$ . The three principal factors that determine  $\mu_{FE}$ , namely, the low-field mobility, the mobility degradation factor, and the trap-state density  $N_t$  are clarified. 15 refs.

Seki, Shunji (NTT, Atsugi, Jpn); Kogure, Osamu; Tsujijima, Bunjiro. *IEEE Trans Electron Devices* v 35 n 5 May 1988 p 669-674.



**096359 POLYNOMIAL SPLINES FOR MOSFET MODEL APPROXIMATION.** The approximation of MOSFET nonlinearities by use of polynomial splines was investigated for reducing both circuit model development time and model simulation cost. After a brief tutorial on spline functions, it is shown how the number of independent variables for the MOSFET simulation models in digital circuits is reduced by their use. A tableau formulation for generating splines is presented along with a storage-reduction technique for polynomial spline coefficients. Mathematical programming problems for one-, two-, and three-dimensional splines are given that result in accurate monotonic splines using few segments. Two spline segments are shown to provide sufficient accuracy in the one-dimensional case, while  $4 \times 4$  and  $2 \times 5 \times 5$  segments provide sufficient accuracy in the two- and three-dimensional cases, respectively. 38 refs.

Barby, James A. (Univ of Waterloo, Ont, Can); Vlach, Jiri; Singhal, Kishore. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 5 May 1988 p 557-566.

**096360 STATIC CHARACTERISTICS OF 2.3-NM GATE-OXIDE MOSFETS.** The static characteristics of experimentally fabricated 2.3-nm gate-oxide MOSFETs were reasonably fitted from the subthreshold to postthreshold region by a Pao-Sah double-integral MOSFET model modified with field-dependent mobility. Gate leakage current was negligibly small compared to drain current at the threshold voltage. 12 refs.

Nagai, Kiyoko (Electrotechnical Lab, Tsukuba, Jpn); Hayashi, Yutaka. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1145-1147.

**096361 CONSIDERATION OF DOPING PROFILES IN MOSFET MOBILITY MODELING.** The channel mobility of a MOSFET in the strongly inverted, linear regime is an important parameter in this modeling process and depends on the effective normal electric field. It is shown that the general form of this field is  $E_{eff} = (\eta Q_c + \zeta Q_b)/\epsilon_{Si}$ , where  $Q_c$  and  $Q_b$  are the inversion- and bulk-charge area densities, respectively, and the coefficient  $\eta$  and  $\zeta$  determine the weighting of these charge densities. A recent study of p-channel MOSFET transistors indicates that  $\eta \approx 1/3$  and  $\zeta = 1$ , which implies that the inversion charge contribution is different for electrons and holes in MOSFETs. It is shown theoretically, by quantum mechanical arguments, that  $\zeta = 1/2$  for both n- and p-channel MOSFETs and the coefficient of the bulk-charge contribution  $\zeta$  depends on the doping profile in the near-surface region. A uniform doping profile produces a value of  $\zeta = 1$ , while a nonuniform profile near the interface leads to  $\zeta > 1$  (accumulation) or  $\zeta < 1$  (depletion). Experimental results to support these conclusions are reported. 8 refs.

Krutsick, Thomas J. (Lehigh Univ, Bethlehem, PA, USA); White, Marvin H. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1153-1155.

**096362 ERROR ESTIMATION OF A CHARGE SHEET MODEL IN CALCULATING THE DRAIN CURRENT OF A THIN GATE OXIDE MOSFET.** The error in the charge sheet model proposed by Brews for the approximation of the drain current of a long channel MOSFET has been analyzed. Percent error curves are presented as a function of surface potential with doping concentration and oxide thickness as parameters. (Author abstract) 4 refs.

Nagai, Kiyoko (Electrotechnical Lab, Jpn); Hayashi, Yutaka. *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 11 Nov 1987 p 1104-1105.

**096363 IMPROVING THE ACCURACY OF THE CHARGE-SHEET MODEL FOR THE LONG-CHANNEL METAL-OXIDE SEMICONDUCTOR FIELD-EFFECT TRANSISTOR.** It is shown that the accuracy of the charge-sheet model for the long-channel metal-oxide-semiconductor field-effect transistor can be improved by allowing for the small potential drop across the inversion layer, and by using a more accurate analytic approximation for the charge stored in the depletion

region. These changes bring charge-sheet model to better than 1% agreement with the Pao-Sah model for typical devices and operating conditions. The proposed modifications do not significantly increase the computational complexity of the charge-sheet model. 9 refs.

Tarr, N.G. (Carleton Univ, Ottawa, Ont, Can). *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicon Technol Conf, Ottawa, Ont, Can p 995-998.

## Measurements

**096364 DIRECT DEPLETION CAPACITANCE MEASUREMENT TECHNIQUE TO DETERMINE THE DOPING PROFILE UNDER THE GATE OF A MOSFET.** A technique to measure directly the depletion capacitance between the inversion layer and the substrate in the determination of the doping profile under the gate of a MOS device is described. The measurement technique is less sensitive to stray capacitance and can be carried out under steady-state conditions. The technique therefore lends itself to direct measurement on small-area devices, avoiding the need for large-area devices as in other techniques. Doping profiles obtained using this method on MOS transistors as small as  $W \times L = 18.8 \times 3.1 \mu m^2$  are compared with profiles obtained by the pulse method on large-area MOS capacitors. The comparison shows good agreement in the range where the technique is applicable. 11 refs.

Wikstrom, J.A. (Univ of California, Los Angeles, CA, USA); Viswanathan, C.R. *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2217-2219.

**096365 INVESTIGATION OF ELECTRON DRIFT VELOCITY IN MOSFETS USING A GRATING GATE ELECTRODE.** A technique was developed for measuring electron drift velocity versus lateral electric field in MOSFET inversion layers with normal electric field as an adjustable parameter. This technique uses MOS transistors whose gates consist of an aluminum grating with period (pitch)  $< 1.75 \mu m$ , spanning the width of the device. Each of the electrodes of the grating is independently accessible, allowing arbitrary voltages to be applied to them. In this manner, any gate voltage as a function of distance along the channel can be approximated discretely. A thick gate dielectric facilitates the smearing of the surface potentials due to each of the gate electrodes at the semiconductor surface making the potential variation smooth. With the ability to apply any arbitrary gate potential as a function of position, the surface potential and thus the inversion layer can be modulated so as to create a nearly uniform inversion charge for any given drain-to-source voltage, implying a nearly uniform tangential electric field. The normal field is then adjustable by adjusting the common offset voltage applied to all electrodes.

Bair, L.A. (MIT, Cambridge, MA, USA); Antoniadis, D.A.; Sodini, C.G. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2385-2386.

**096366 GATE-VOLTAGE-DEPENDENT EFFECTIVE CHANNEL LENGTH AND SERIES RESISTANCE OF LDD MOSFETS.** A measurement algorithm to extract the effective channel length and source-drain series resistance of MOSFETs is presented. This extraction algorithm is applicable to both conventional and LDD (lightly doped drain-source) MOSFETs. It is shown that the effective channel length and the source-drain series resistance of an LDD device are gate-voltage dependent. The effective channel length of an LDD device is not necessarily the metallurgical junction separation between the source and drain, as it is in a conventional device. A more generalized interpretation of effective channel length is introduced to understand the physical meaning of this gate-voltage dependence. The result also indicates that the effective channel length and source-drain resistance are two inseparable device parameters regardless of whether the devices in question are LDD or conventional FETs. 16 refs.

Hu, Genda J. (Sierra Semiconductor Corp, San Jose, CA,

USA); Chang, Chi; Chia, Yu-Tai. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2469-2475.

**096367 CHARACTERIZATION OF THE INVERSE-NARROW-WIDTH EFFECT.** The inverse-narrow-width effect - the reduction in the threshold voltage with decreasing device width - is modeled and experimentally measured. A fringing gate capacitance model is extended to include the effects of the sidewall interface charge. Two-dimensional and three-dimensional simulations are used to illustrate the enhanced sidewall potential and current, and also the effect of sidewall interface charge on the electrical behavior of MOSFETs with fully recessed isolation oxides. The authors compare the closed-form analytical threshold voltage expression developed with experimental data from small-geometry NMOS devices and find very good agreement. 13 refs.

Akers, Lex A. (Arizona State Univ, Tempe, AZ, USA); Sugino, Michael; Ford, Jenny M. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2476-2484.

**096368 MEASUREMENT AND NUMERICAL MODELING OF SHORT-CHANNEL MOSFET GATE CAPACITANCES.** The gate-to-source and gate-to-drain capacitance of long-channel and short-channel n-MOSFETs were measured experimentally and simulated using a two-dimensional numerical simulator that allows different inversion-layer carrier mobility models to be used. Comparison of the experimental and simulated data demonstrates the velocity saturation effect in the capacitance data of the short-channel devices. Transverse-field dependence of the mobility is also found to be necessary to account for the experimental data. 28 refs.

Yeow, Yew-Tong (IBM, Yorktown Heights, NY, USA). *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2510-2520.

**096369 EFFECTS OF ARSENIC DRAIN PROFILE ON SUBMICROMETER SALICIDE MOSFETS.** The performance and reliability tradeoffs with source-drain implant energy were examined on n-channel MOSFETs with 0.5- $\mu m$  physical gate lengths and fully silicided sources, drains, and gates. Platinum silicide was used over structures with self-aligned arsenic source-drain implants with energies ranging from 40 to 220 keV at a constant dose of  $1 \times 10^{14} cm^{-2}$ . Shallow implants showed low diode reverse breakdowns due to depletion layer interactions, but yielded low series resistance and underdiffusion ( $\Delta L$ ) values, and high device gains. Deeper implants ( $> 70 keV$ ) showed improved diode characteristics, but devices exhibited increased series resistance,  $\Delta L$ , and reduced gains. Only minor short-channel effects were noted on threshold voltage and subthreshold swings for channel devices with  $L = 0.5 \mu m$  over the range of implants examined, although the higher-energy implants did show more severe drain modulation effects. Significantly improved immunity to hot-carrier degradation was noted with the deeper implants. The drains implanted at 145 keV showed the best immunity to hot-electron degradation, small gain, and short-channel effects, giving a good balance between device performance and reliability. 23 refs.

Ford, Jenny M. (Motorola Bipolar Technology Cent, Mesa, AZ, USA); Stemple, Donald K. *IEEE Trans Electron Devices* v 35 n 3 Mar 1988 p 302-308.

**096370 RELATIONSHIP BETWEEN GATE BIAS AND HOT-CARRIER-INDUCED INSTABILITIES IN BURIED- AND SURFACE-CHANNEL MOSFETS.** For accurate predictions of device reliability with respect to hot-carrier effects, it is necessary to establish worst-case stress bias conditions. Detailed measurements of hot-carrier-induced instabilities in short-channel pMOSFETs have revealed that stress gate bias conditions corresponding to peak gate currents result in maximum



shifts in device parameters. However, for some parameters, notably those measured at low drain bias, comparable shifts are observed for stress gate bias conditions that correspond to peak substrate currents. These observations are valid for both buried-channel (n-type polysilicon gate) and surface-channel (p-type polysilicon gate) pMOSFETs. An interpretation of these results based on the generation of trapped oxide charge and interface traps is proposed. 6 refs.

Brassington, Michael P. (Nat'l Semiconductor, Palo Alto, CA, USA); Razouk, Reda R. *IEEE Trans Electron Devices* v 35 n 3 Mar 1988 p 320-321.

**096371 ON THE EFFECT OF HOT-CARRIER STRESSING ON MOSFET TERMINAL CAPACITANCES.** The hot-carrier effect on the MOSFET is studied by measuring the terminal capacitances of a MOSFET before and after bias voltage stressing. It is concluded that under DC bias stressing, hot electrons are trapped near the drain end of the device. Capacitance observations can be understood in terms of a model in which the trapped-electron distribution peaks very close to the drain-channel metallurgical junction. 6 refs.

Yao, C.T. (Sachs/Freeman Associates, Landover, MD, USA); Peckerar, M.; Friedman, D.; Hughes, H. *IEEE Trans Electron Devices* v 35 n 3 Mar 1988 p 384-386.

## Microwaves

**096372 EXPLOIT ADVANTAGES OF POWER FETs FOR L-BAND USE.** A double diffused MOSFET (DMOSFET) fabricated in silicon has been developed that brings real power to L-band frequencies for the first time. The DMOSFET's linear common-source operation makes simple control of gain and power output possible since the device can deliver linear broadband amplification of waveforms with complex modulation schemes. Ease of bias and resistance to thermal runaway make the DMOSFET a superior building block for complex military system applications. (Edited author abstract)

Leighton, William (M/A-COM PHI Inc, Torrance, CA, USA); Meyer, Jeff; Sedigh, Kazem; Zurkowski, Hanan. *Microwaves RF* v 27 n 4 Apr 1988 p 131-132.

## Modeling

**096373 MOSFET MODEL CONTINUOUS FROM WEAK TO STRONG INVERSION.** A simple analytical model is proposed for long-channel MOSFETs. The model describes MOSFET operation in all regions from weak to strong inversion by a single exponential equation. This makes its implementation in CAD easy and time-saving. Predicted and experimental data are in good agreement. (Author abstract) 4 refs.

Abu-Zeid, M.M. (Eindhoven Univ of Technology, Eindhoven, Neth); De Jong, G.G. *Electron Lett* v 23 n 24 Nov 1987 p 1299-1300.

**096374 NEW BORON IMPLANTATION MODEL SUITABLE FOR ANALYTICAL MODELING OF THRESHOLD VOLTAGE OF MOSFETS.** The boron implantation profile in silicon is usually simulated by the Pearson-IV distribution function with some modifications, as in SUPREM. But this function is complex from the point of view of analytical modeling. New functions which fit well with SUPREM simulated implantation profiles for boron in silicon have been proposed. These functions, being analytically integrable, allow us to formulate accurate analytical models of threshold voltages of MOSFETs with implanted channels. Models for the threshold voltages of both long channel and short channel NMOSFETs have been presented. For the long channel case, the results agree with those obtained from numerical computations with considerable saving of computation time. The results of the short channel model also show good agreement with available experimental data. (Edited author abstract) 10 refs.

Das Gupta, A. (Indian Inst of Technology, Kharagpur, India); Lahiri, S.K. *Solid State Electron* v 30 n 12 Dec 1987 p 1283-1287.

**096375 MODELIRANJE NAPONA PRAGA OSIROMASENOG MOSFETA S PROIZVOLJNOM KONCENTRACIJOM PRIMJESA U KANALU.** [Threshold Voltage Modeling of Depletion MOSFET with Arbitrary Channel Impurity Distribution]. Mathematical model for the threshold voltage estimation of depletion MOSFET with arbitrary channel impurity distribution is described. The algorithm for threshold voltage calculation based on this model is derived and computer program is written. A typical example of threshold voltage calculation illustrates accepted procedure. (Author abstract) In Serbo-Croatian. 7 refs.

Butkovic, Z.; Biljanovic, P.; Divkovic-Puksec, J. *Elektrotehnika (Zagreb)* v 30 n 5-6 Sep-Dec 1987 p 233-237.

## Noise

**096376 DETERMINATION OF INTERFACE STATE DENSITY ESPECIALLY AT THE BAND EDGES BY NOISE MEASUREMENTS ON MOSFETS.** There are several experimental methods of measuring interface state densities on Si/SiO<sub>2</sub> interfaces. Up to now none of them has been able to provide information about the states within 0.1 eV near the band edges. However measurements of flicker or 1/f noise on MOSFETs allow interface state densities to be determined not only in the whole band gap but also within the bands. (Author abstract) 18 refs.

Jaentsch, O. (Siemens AG, Munich, West Ger); Borchert, B. *Solid State Electron* v 30 n 10 Oct 1987 p 1013-1015.

**096377 SIMPLE DERIVATION OF REIMBOLD'S DRAIN CURRENT SPECTRUM FORMULA FOR FLICKER NOISE IN MOSFETS.** A simple derivation of Reimbold's drain current spectrum formula is obtained from the usual input voltage spectral density for flicker noise in MOS transistors. The demonstration relies on a general expression of the MOSFET transconductance. Complete equivalence between approaches based on drain current or input voltage noise spectral densities is emphasized. (Author abstract) 7 refs.

Ghibaudo, Gerard (ENSERG, Grenoble, Fr). *Solid State Electron* v 30 n 10 Oct 1987 p 1037-1038.

**096378 EXCESS NOISE IN BURIED-CHANNEL MOS TRANSISTORS.** A definitive experiment is described on the excess noise in a buried-channel MOS transistor. The specimen was biased with a uniform, Ohmic, channel. With the surface enhanced 1/f noise is produced. With the surface depleted or inverted the noise drops by more than two orders of magnitude and takes on the character of the 1/f noise observed in JFETs. Also seen is a large generation-recombination noise peak involving the fast surface states. The implications for excess noise theory and device design are discussed. (Author abstract) 8 refs.

Hayat, S.A. (Univ of Lancaster, Lancaster, Engl); Jones, B.K. *Semicond Sci Technol* v 2 n 11 Nov 1987 p 732-735.

**096379 THERMAL ACTIVATION MODEL FOR 1/f NOISE IN SI-MOSFETS.** Measurements of the temperature dependence of noise power spectra in a series of commercial p-channel MOSFETs are presented. It was found that both the magnitude and the functional form of the voltage noise power spectral density varied greatly in the range between 60 and 260 K. The experimental results were compared to first-principle calculations which showed that the noise was due to the capture and emission of carriers by oxide traps through thermal activation. The process caused fluctuations in both the density and the surface mobility of the channel carriers through the modulation of the surface potential and the scattering rate, respectively. (Author abstract) 18 refs.

Surya, Charles (Univ of Rochester, Rochester, NY, USA); Hsiang, Thomas Y. *Solid State Electron* v 31 n 5 May 1988 p 959-964.

**096380 1/f NOISE IN (100) n-CHANNEL SI-MOSFETS FROM T=4.2 K TO T=295 K.** We have measured the 1/f-noise in the drain current of n-channel (100)

Si-MOSFET in the temperature range 4.2 K-295 K as a function of drain voltage. At T=4.2 K the 1/f-noise has also been measured as a function of gate voltage. At temperatures above T=130 K two noise sources contribute to the 1/f-noise: a McWhorter-like number fluctuations noise source and a mobility fluctuations noise source. We distinguished between the two sources on the basis of the different dependences of the noises on the electric field. Between 4.2 and 130 K the 1/f-noise is interpreted as number fluctuations noise. A maximum is observed between 50 and 70 K. At T=4.2 K we could not distinguish between the two sources. At low drain voltages there is a linear relationship between the gate voltage and the ratio of the square of the drain current to the 1/f-noise. The 1/f-noise as a function of drain voltage at T=4.2 K could be analyzed with the same two-valley model as that used for the analysis of the drain current-drain voltage characteristics. (Author abstract) 22 refs.

Hendriks, E.A. (Rijksuniversiteit Utrecht, Utrecht, Neth); Zijlstra, R.J.J. *Solid State Electron* v 31 n 6 Jun 1988 p 1105-1111.

## Noise, Spurious Signal

**096381 DIFFUSION AND INTER-VALLEY NOISE IN (100) n-CHANNEL SI-MOSFETS FROM T=4.2 TO 295 K.** Noise in the drain current of (100) n-channel Si-MOSFETs was investigated as a function of both source-drain voltage and gate voltage, from T=4.2 to 295 K. The frequency range covered was from 1 to 250 kHz. Three contributions to the noise could be distinguished: 1/f-noise, generation-recombination noise and white noise. This paper deals mainly with the white noise component. The current-voltage characteristics at T=295 K can be described by simple MOSFET-theory, but at T=4.2 K hot carrier effects and field-induced transitions occur, and theory has to be amended accordingly. The white noise was measured at room temperature in diffusion noise. We also observed extra white noise at intermediate temperatures but it was less pronounced. We have developed a model which interprets this extra noise as the frequency-independent part of generation-recombination noise caused by inter-valley transitions between three groups of valleys. There is good agreement between the model and our experimental results. (Author abstract) 27 refs.

Hendriks, E.A. (Utrecht Univ, Utrecht, Neth); Zulstra, R.J.J. *Solid State Electron* v 31 n 2 Feb 1988 p 171-180.

## Nondestructive Examination

**096382 NON-DESTRUCT TESTER DETERMINES POWER MOSFETS UIS LIMITS. PART 2.** A UIS non-destruct test fixture is described whose new crowbar response time is much faster than the previous design, 50 nsec relative to 200 nsec. Preliminary testing shows that the UIS failure mode for older high voltage power MOSFETs is apparently due to an instantaneous, critical drain current phenomenon independent of the size of the unclamped inductance. (Author abstract) 4 refs.

Pshaenich, Al (Motorola). *Powerconverters Intell Motion* v 13 n 10 Oct 1987 p 35-36, 38, 40-41.

**096383 ANALYSIS OF NONPLANAR DSA MOS (V-MOS) TRANSISTOR BY CAPACITANCE MEASUREMENTS.** A nondestructive method to determine the parameter of the DSA transistor by capacitance measurement is proposed. Determined parameters are the gate oxide thickness the drain impurity density, the drain area, the drain flat-band voltage, and the lateral profile along the channel which is one of the features of the DSA MOS transistor. In this method, both depletion and inversion characteristics of gate-drain capacitance are analyzed mainly by fitting them to the measured characteristics. (Edited author abstract) 7 refs.

Ohashi, Hiroshi (Tokyo Univ of Agriculture & Technology, Koganei, Jpn); Fujita, Takeshi; Tarui, Yasuo. *Electron Commun Jpn Part 2* v 70 n 12 Dec 1987 p 47-58.



## Optimization

**096384 OPTIMIZATION OF THE DRIFT REGION OF POWER MOSFET'S WITH LATERAL STRUCTURES AND DEEP JUNCTIONS.** The electric field profile in the drift region of power MOSFETs with lateral structures and deep junctions has been found analytically. From the analysis, the best uniform surface doping density and depth of the drift region in offset-gate power MOSFETs that introduces the minimum series resistance and sustains a given junction breakdown voltage is derived. Design guidelines for such MOSFETs are proposed. Comparison with computer simulation results has shown that it is reasonable for some practical structures. 12 refs.

Chen, X.B. (Chengdu Inst of Radio Engineering, Chengdu, China); Song, Z.Q.; Li, Z.J. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2344-2350.

**096385 OPTIMIZATION OF LDD MOSFET'S USING COUPLED 2-D SIMULATIONS.** During the design of p-channel LDD (lightly doped drain) devices for a CMOS technology, it was discovered that conventional LDD spacer design used for n-devices fails to give LDD structure to p-devices. Much wider spacers are required to create LDD p-channel devices. Detailed study of anisotropic etching of oxide used to define the LDD spacers showed that the spacers are not completely vertical and boron implant used in p+ source-drain region of p-devices scatters underneath the spacers. A complete two-dimensional computer simulation of the process and resulting device structure was done using SAMPLE (etching and lithography simulator), MEMBRE (two-dimensional process simulator) and PISCES (two-dimensional device simulator) in coupled form. Implant doses, temperature cycles, and spacer widths were optimized for breakdown voltage, Miller capacitance, and  $ID_{SAT}$  for both n- and p-devices simultaneously. Experimental data agreed well with the simulations. 2 refs.

Husain, Asim (Intel Corp, Santa Clara, CA, USA); Mathur, Rajiv; Wu, Sheldon. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2386.

## Performance

**096386 INSTRUMENTATION AMP IS FAST AND VERY ACCURATE.** Finding an instrumentation amplifier that can handle fast millivolt-level signals accurately, especially when the signals are floating on high common-mode voltages at high impedances, usually leaves system designers feeling exasperated. They have to resort either to in-house designs or to hybrid, modular, or even rack-mounted devices. A JFET-input instrumentation amplifier chip is reported.

Goodenough, Frank. *Electron Des* v 34 n 4 Feb 20 1986 p 59-60, 62.

**096387 MOSFET'S MIT VLSI-STRUKTUREN: Bessere Eigenschaften durch Erhöhung der Zelldichte. [MOSFET with VLSI Structures: Better Characteristics by Increasing the Cell Density].** The development of MOSFET's belonging to the so-called third generation is reported in which the cell density was multiplied by a factor of 3 reaching a value of 450,000/cm<sup>2</sup>. These devices feature a considerably lower specific turn-on impedance. At similar size of chips, a higher current density is reached at a lower price. In German.

Dumsky, Georg. *Elektronik* v 36 n 9 Apr 30 1987 p 110-112.

**096388 1,800 V BIPOLAR-MODE MOSFETs (IGBT).** Adopting the silicon wafer direct-bonding (SDB) technique, Toshiba has developed 1800 V bipolar-mode MOSFETs (metal oxide semiconductor field effect transistors). The SDB technique, which eliminates the problems accompanying conventional epitaxy, easily produces lay-

ers having a resistivity higher than 100  $\Omega\text{cm}$ , for a high voltage on a low resistivity substrate. By a new device geometry, parasitic thyristor latch-up was successfully suppressed, resulting in a maximum current capability of more than 150 A and a fast switching time. (Edited author abstract) 8 refs.

Nakagawa, Akio (Toshiba Corp, Jpn); Imamura, Kaoru; Furukawa, Kazuyoshi. *Toshiba Rev (Int Ed)* n 161 Autumn 1987 p 34-37.

**096389 MOSFET POWER MODULE HANDLES 1000V, 200A.** A new approach provides a Power MOSFET module with better electrical and thermal characteristics and easier packaging than multiple, discrete devices. (Author abstract)

Lorch, Yiftach (Semikron Int). *Powerconverters Intell Motion* v 14 n 2 Feb 1988 p 38, 40, 42.

**096390 SIPMOS DEPLETION TRANSISTORS CONDUCT WITHOUT GATE SIGNALS.** SIPMOS depletion-type transistors, also called normally on transistors, conduct without a gate signal applied. The relatively abrupt transition from the resistive to the pentode region allows many circuit designs to be greatly simplified by use of this transistor type. The device is ideal for use as a current limiter, constant power source or dc and ac current switch. (Author abstract)

Kaifler, Erich (Siemens AG, Munich, West Ger). *Siemens Compon* v 22 n 3 Jun 1987 p 104-107.

**096391 CRITERIA FOR ESTIMATING THE IMPACT OF SERIES RESISTANCE ON MOSFET PERFORMANCE.** We derive simple engineering criteria which may be used as a guideline in MOSFET design. In particular, with respect to series resistance it is clear that a too high  $R_S$  value is detrimental to device performance. On the other hand, pressing for a value which is lower than necessary may call for other unwelcome features (e.g. too deep junctions). Hence, a means for estimating the allowed  $R_S$  values is of prime importance. We show how such criteria may be obtained and used for estimating the necessary quantities. (Author abstract) 12 refs.

Gildenblat, G.Sh. (Pennsylvania State Univ, University Park, PA, USA); Cohen, S.S. *Solid State Electron* v 31 n 2 Feb 1988 p 261-263.

**096392 POWER MOSFETs IMPROVE BRUSHLESS DC MOTOR DRIVES.** Improvements in the drain-source diode of fourth-generation Power MOSFETs have enhanced the use of these devices in brushless DC motor drives. The drain-source diode's reverse-recovery time is now reduced to that of discrete diodes. Better ruggedness now virtually eliminates Commutating SOA limitations. Accompanying the diode improvements are ON-resistances below 40m $\Omega$  in TO-220 packages, which will significantly influence the use of power transistors in motor-drive output stages. In low-voltage brushless drives, the new device characteristics tip the balance of tradeoffs for power-device selection. As opposed to PNP bipolars or P-channel MOSFETs, N-channel MOSFETs are now the best choice for upper half-bridge positions. Similarly, SENSEFETs are the devices of choice for lower half-bridge positions.

Schultz, Warren (Motorola Inc). *Powerconverters Intell Motion* v 14 n 1 Jan 1988 p 52-54, 56.

**096393 POWER MOSFETs UNDERGO 60V GATE-RUPTURE TEST.** A markedly increased gate-rupture voltage capability is the result of a process improvement that Motorola applies to its TMOS Series products. It is also a major technological achievement in the power MOSFET realm. The process has been dubbed 'Bullet-Proof' to indicate the added ruggedness and to induce an inherently higher user confidence in the reliability of power MOSFET components. The gate-voltage improvements result in more reliable devices, because their gate-rupture voltage is higher.

Schulz, Werner (PCIM, Ventura, CA, USA). *Powerconverters Intell Motion* v 14 n 1 Jan 1988 p 58.

**096394 DYNAMIC PERFORMANCE OF CURRENT-SENSING POWER MOSFETs.** Errors in the output of current-sensing MOSFETs during switching are either perceived, due to measurement difficulties, or real, due to a change in sense ratio as the device passes from the linear to the fully enhanced region. Transformer action within the device package also produces transients and limits bandwidth. (Author abstract). 1 Ref.

Grant, D. (Univ of Bristol, Bristol, Engl); Pearce, R. *Electron Lett* v 24 n 18 Sep 1 1988 p 1129-1131.

**096395 POWER MOSFET PACKAGES TAKE NEW DIRECTIONS.** Higher voltages, lower on-resistances and new fabrication processes have captured most of the spotlight in power MOSFETs the past few years. It is pointed out that in the last year, developments in packages for these semiconductors have also come to share center stage. The packages have become smaller, more amenable to modern assembly processes, more thermally efficient, and better able to maximize the parts' performance potential for many applications. User demands for switching more power at higher frequencies - such as in the military - call for even better heat dissipation and control of factors like parasitic inductance than traditional power MOSFETs can handle. To squeeze out the higher speed and power, MOSFET makers are now turning to the package.

Chin, Spencer (Electronic Products, Garden City, NY, USA). *Electron Prod (Garden City NY)* v 31 n 8 Sep 15 1988 p 35-38.

**096396 ON THE PERFORMANCE LIMIT FOR SI MOSFET'S: EXPERIMENTAL STUDY.** Short-channel MOSFETs fabricated by direct-write electron-beam lithography have been examined with regard to parameters such as channel length, oxide thickness, and substrate doping concentration. A simple relationship between channel length and transconductance in the saturated region has been derived from the experimental results, and the performance of MOSFETs with zero channel lengths has been evaluated as a function of oxide thickness. The ultimate performance of MOSFETs with both zero channel length and zero oxide thickness has been estimated to be about 3000 mS/mm. This limitation is attributed to the saturation velocity and the finite inversion layer thickness. The electron saturation velocity in the inversion layer has been confirmed experimentally to be  $1.0 \times 10^7$  cm/s. 12 refs.

Toriumi, Akira (Toshiba Corp, Kawasaki, Jpn); Iwase, Masao; Yoshimi, Makoto. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 999-1003.

## Radiation Damage

**096397 RADIATION DAMAGE IN MOS TRANSISTORS AS A FUNCTION OF THE ANGLE BETWEEN AN APPLIED ELECTRIC FIELD AND VARIOUS INCIDENT RADIATIONS (PROTONS, ELECTRONS, AND CO-60 GAMMA RAYS).** Data are presented that show that ionizing radiation damage produced by 2-to-16-MeV protons in MOS transistors, with applied electrical fields across the gate oxides, is dependent on the angle between the fields and the incident protons. This angular dependency can be explained by the columnar recombination mode. For <sup>60</sup>Co photons and 5-to-20-MeV electrons, the data show no angular dependency. 8 refs.

Tallon, R.W. (US Air Force Weapons Lab, Kirtland AFB, NM, USA); Kemp, W.T.; Ackermann, M.R.; Owen, M.H.; Hoffland, A.H. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1208-1213.

**Radiation Effects** See Also MICROELECTRONICS—Radiation Effects; SEMICONDUCTOR DEVICES—Radiation Effects.



**096398 COMPARISON OF PROTON AND NEUTRON CARRIER REMOVAL RATES.** Displacement-damage-induced carrier removal rates for proton irradiations in the energy range 10-175 MeV were compared to 1-MeV-equivalent neutrons using power MOSFETs as a test vehicle. The results showed that, within experimental error, the degradation mechanisms were qualitatively similar and that the ratio of proton-to-neutron carrier removal rates as a function of proton energy correlate with a calculation based on nonionization energy loss in silicon. For exposures under junction bias, p-type silicon was found to have a smaller carrier removal rate for both proton and neutron irradiations, whereas, for n-type silicon, junction bias had little effect on the carrier removal rate. 8 refs.

Pease, R.L. (Mission Research Corp, Albuquerque, NM, USA); Enlow, E.W.; Dinger, G.L.; Marshall, Paul. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1140-1146.

**096399 REEVALUATION OF WORST-CASE POSTIRRADIATION RESPONSE FOR HARDENED MOS TRANSISTORS.** The worst-case postirradiation response of hardened n-channel transistors following Co-60 exposure to total dose levels of system interest is demonstrated to occur for 0-V bias during radiation, and positive bias during a subsequent anneal. This observation is explained in terms of oxide-trapped and interface-state charge buildup and anneal. Additional results are presented which suggest that, for future technologies with very thin gate oxides, worst-case device leakage during irradiation may well occur for 0-V irradiations. The authors discuss the importance of periodically reevaluating the response of MOS devices during and after irradiation to determine worst-case test conditions, particularly as technologies advance and gate insulators become thinner. 33 refs.

Fleetwood, D.M. (Sandia Natl Lab, Albuquerque, NM, USA); Dressendorfer, P.V.; Turpin, D.C. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1178-1183.

**096400 POST-IRRADIATION EFFECTS IN FIELD-OXIDE ISOLATION STRUCTURES.** The authors have studied experimentally the time dependence of leakage currents in six CMOS (complementary metal-oxide semiconductor) processes using LOCOS (local oxidation of silicon) isolation structures. These six process lines represent six different US semiconductor companies. In their radiation response, these processes range from very hard to very soft. In the softer processes, the radiation-induced leakage currents are due to the turning on of a leakage path either under the thick field oxide or along the transistor edge (bird's beak) region. In the hardest process, the field oxide did not turn on, and the leakage was entirely due to subthreshold current in the gate region. These different mechanisms have qualitatively different time dependences, which are discussed along with the implications of the results for hardness assurance testing. 17 refs.

Oldham, T.R. (US Army Lab Command, Adelphi, MD, USA); Lelis, A.J.; Boesch, H.E.; Benedetto, J.M.; McLean, F.B.; McGarrity, J.M. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1184-1189.

**096401 ANALYTICAL MODEL FOR THE SINGLE EVENT BURNOUT OF POWER MOSFETS.** The processes causing single-event burnout in power MOSFETs are modeled analytically, describing the evolution of the plasma filament from an ion traversing the structure and the processes constituting the triggering mechanism of second breakdown. Analytically tractable models are achieved by using simplifying approximations in common use in established semiconductor device theory, and by using initial conditions and parameters typical for simulations of single-event upset phenomena. Comparative simplicity and tractability is favored over accuracy to gain

lucid relationships between pertinent parameters, which can guide device design and optimization, aid the interpretation of results from simulation and experiment, and help in the development of simulation software. 12 refs.

Hohl, Jakob H. (Univ of Arizona, Tucson, AZ, USA); Galloway, Kenneth F. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1275-1280.

**096402 GENERATION OF INTERFACE STATES BY IONIZING RADIATION AT 80K MEASURED BY CHARGE PUMPING AND SUBTHRESHOLD SLOPE TECHNIQUES.** Generation of fast interface states  $D_i$  by ionizing radiation has been measured in MOS transistors at 80K and 295K using charge pumping and subthreshold slope techniques. Using charge pumping, the more sensitive and reliable technique, it has been found that  $D_i$  are not formed by radiation at 80K. In contrast, subthreshold slope measurements appear to show an increase in  $D_i$  in MOSFETs irradiated at 80K. This is shown to be an artifact caused by lateral nonuniformities (LNU) in the radiation-induced fixed charge. 27 refs.

Saks, N.S. (US Naval Research Lab, Washington, DC, USA); Ancona, M.G. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1348-1354.

**096403 TEMPERATURE-INDUCED REBOUND IN POWER MOSFETS.** Enhancement-mode n-channel power MOSFETs were investigated for rebound. They received a 300 krad(Si) dose of gamma radiation under positive gate bias with source and drain grounded. The irradiated transistors were thermally annealed with all terminals shorted or under positive gate bias with drain and source shorted, at temperatures from 60°C to 150°C. Threshold-voltage rebound was observed for some transistor types under certain experimental conditions. 19 refs.

Singh, Gurbax (NBS, Gaithersburg, MD, USA); Galloway, Kenneth F.; Russell, Thomas J. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1366-1371.

**096404 MODELING TRANSIENT RADIATION EFFECTS IN POWER MOSFETS.** Using standard device specifications and simple assumptions, the transient radiation response of vertical-conduction double-diffused metal-oxide-semiconductor (VDMOS) MOSFETs can be modeled in a standard circuit analysis program. The device model consists of a body diode, a parasitic bipolar transistor, and elements to simulate high-current reduced breakdown. The proposed photocurrent model emulates response to any pulse shape and accounts for bias-dependent depletion regions. The model can be optimized to best fit available test data. 8 refs.

Hoffman, J. Russell (Martin Marietta Aerospace, Denver, CO, USA); Hall, Wallace E.; Dunn, Douglas E. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1381-1385.

**096405 PROPAGATION DELAY MEASUREMENTS FROM A TIMING SAMPLER INTENDED FOR USE IN SPACE.** A 3- $\mu$ m CMOS timing sampler is described which is a test circuit designed into the Jet Propulsion Labs' CRRES chip to be flown on the Combined Release and Radiation Effects Satellite (CRRES). The timing sampler consists of 64 inverter-pair stages with sampling latches and decoder circuitry. The sampler is used to measure inverter-pair propagation delays, which are nominally 2.5 ns, with a resolution of 100 ps. A simple model was developed to explain the radiation-induced inverter-pair delay shifts in terms of radiation-induced MOSFET threshold-voltage shifts and effective modal capacitances. The magnitude of the shift in pair delay with radiation was estimated at the point where the n-MOSFET threshold voltage became zero. For a 0.7-V-threshold shift, the pair delay increased from its preradiation value by 360 ps for a rising step input and

decreased by 190 ps for a falling step input. 11 refs.

Blaes, B.R. (JPL, Pasadena, CA, USA); Buehler, M.G.; Lin, Y.-S. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1470-1473.

**096406 EVALUATION OF LOW-ENERGY X-RAY AND COBALT-60 IRRADIATIONS OF MOS TRANSISTORS.** An evaluation of methodologies for irradiating MOS transistors with low-energy X-ray and  $^{60}\text{Co}$  sources has been performed. It has been found that comparisons of voltage shifts produced by bulk trapped-charge and interface states in MOS transistors irradiated using two different low-energy X-ray sources (an ARACOR 10-keV W source and an 8-keV Cu source) agree to within better than 30%. This quality of agreement is similar in magnitude to that between MOS devices irradiated by different  $^{60}\text{Co}$  sources. In contrast, the measurements indicate that interlaboratory comparisons of ratios of shifts produced by X-ray and  $^{60}\text{Co}$  sources can lead to differences in ratios as large as a factor of approximately 1.7. Improved electron-hole recombination data for oxides is presented. This recombination correction, in conjunction with a correction for interface dose enhancement, is used to predict the ratios of shifts produced by X-ray and  $^{60}\text{Co}$  sources. However, the results show that corrections for electron-hole recombination and interface dose enhancement do not, by themselves, adequately predict the field-dependent behavior of these transistors. 20 refs.

Dozier, C.M. (US Naval Research Lab, Washington, DC, USA); Fleetwood, D.M.; Brown, D.B.; Winokur, P.S. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1535-1539.

**096407 RADIATION EFFECTS IN LDD MOS DEVICES.** The purpose of this work is to investigate the response of lightly doped drain (LDD) n-channel transistors to ionizing radiation. Transistors were fabricated with conventional (non-LDD) and LDD structures using both standard (nonhardened) and radiation-hardened gate oxides. Characterization of the transistors began with a correlation of the total-dose effects due to 10-keV X-rays and  $^{60}\text{Co}$  gamma rays. It was determined that the radiation response of LDD transistors is similar to that of conventional transistors. Both standard and radiation-hardened transistors subjected to hot-carrier stress before irradiation show a similar radiation response. After exposure to  $1.0 \times 10^6$  rads(Si), nonhardened transistors show increased susceptibility to hot-carrier degradation, while the radiation-hardened transistors exhibit similar hot-carrier degradation to nonirradiated devices. The authors demonstrated a fully-integrated radiation hardened process that is solid to  $1.0 \times 10^6$  rads(Si), and shows promise for achieving  $1.0 \times 10^7$  rad(Si) total-dose capability. 11 refs.

Woodruff, Richard L. (United Technology Microelectronics Cent, Colorado Springs, CO, USA); Adams, James R. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1629-1634.

**096408 MODEL DESCRIBING HOT-CARRIER AND RADIATION EFFECTS IN MOS TRANSISTORS.** Data that describe the magnitude and type of damage created in MOS transistors by hot-carrier and ionizing-radiation environments are presented. The interaction of the effects of these types of damage is described by a qualitative model that divides the damage into two damage regions. 6 refs.

McBrayer, J.D. (Sandia Natl Lab, Albuquerque, NM, USA); Pastorek, R.A.; Jones, R.V.; Ochoa, A. Jr. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1647-1651.



**096409 RADIATION-TOLERANT, SIDEWALL-HARDENED SOI/MOS TRANSISTORS.** Total dose radiation effects were measured for sidewall-hardened n-channel silicon-on-insulator (SOI)/MOS transistors, fabricated in zone-melt-recrystallized (ZMR) and oxygen-implanted (SIMOX) SOI materials. The radiation responses of transistors are compared with three types of sidewall or edge configurations: island transistors with passivated edges, island transistors without passivated edges, and edgeless (enclosed-gate) transistors. Data from these three test devices allow clear separation of front-, back-, and edge-channel conduction. Passivated edge channels were hard to  $^{60}\text{Co}$  doses in excess of 24 Mrad(Si). The overall hardness of the passivated-edge transistors is limited only by the radiation-induced threshold voltage shifts (about  $-1\text{ V}$  at  $1.0\text{ Mrad}$ ) of the top channel. No significant differences in total-dose response of ZMR and SIMOX devices were observed under the radiation conditions used. 21 refs.

Tsao, S.S. (Sandia Natl Lab, Albuquerque, NM, USA); Fleetwood, D.M.; Weaver, H.T.; Pfeiffer, L.; Celler, G.K. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1686-1691.

**096410 TOTAL DOSE HARDENING OF BURIED INSULATOR IN IMPLANTED SILICON-ON-INSULATOR STRUCTURES.** Total dose characteristics of the buried insulator in implanted silicon-on-insulator (SOI) substrates have been studied using MOS transistors. The threshold-voltage shift of the parasitic back-channel transistor, which is controlled by charge trapping in the buried insulator, is reduced by lowering the oxygen dose as well as by an additional nitrogen implant, without degrading the front-channel transistor characteristics. The improvements in the radiation characteristics of the buried insulator are attributed to the decrease in the buried oxide thickness or to the presence of the interfacial oxynitride layer formed by the oxygen and nitrogen implants. 12 refs.

Mao, Bor-Yen (Texas Instruments Inc, Dallas, TX, USA); Chen, Cheng-Eng; Pollack, Gordon; Hughes, Harold L.; Davis, Gracie E. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1692-1697.

**096411 FIRST NONDESTRUCTIVE MEASUREMENTS OF POWER MOSFET SINGLE EVENT BURNOUT CROSS SECTIONS.** A novel technique to nondestructively measure single-event burnout cross sections for n-channel power MOSFETs is presented. Previous measurements of power MOSFET burnout susceptibility have been destructive and thus not conducive to providing statistically meaningful burnout probabilities. The nondestructive technique and data for various device types taken at several accelerators, including the Lawrence Berkeley Labs' Bevalac, are documented. Several phenomena are observed. 8 refs.

Oberg, Dennis L. (Boeing Aerospace Co, Seattle, WA, USA); Wert, Jerry L. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1736-1741.

**096412 PROGRAMMABLE TEST SYSTEM FOR TRANSIENT ANNEALING CHARACTERIZATION OF IRRADIATED MOSFETS.** A current-programmable, computer-controlled transient annealing test system (TATS) for making complete MOSFET I-V measurements is described. The system forces source currents from  $100\text{ pA}$  to  $10\text{ mA}$  and measures corresponding gate voltages starting at times as early as  $100\text{ }\mu\text{s}$  after a radiation pulse. Features of the system include multiple independent test channels, temperature control over the full military range, and completely programmable test/bias sequences. Applications of the system include: a) transient-failure-mechanism studies, b) in-source testing, and c) high-throughput wafer-level hardness-assurance testing. 5 refs.

Tausch, H.J. (Design Engineering Inc, Albuquerque, NM, USA); Wemhoner, R.; Pease, R.L.; Schwank, J.R.; Maier, R.J. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987

Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1763-1768.

**096413 HEAVY-ION-INDUCED, GATE-RUPTURE IN POWER MOSFETS.** A heavy-ion-induced burnout mechanism has been experimentally observed in power metal-oxide-semiconductor field-effect transistors (MOSFETs). This mechanism occurs when a heavy charged particle passes through the gate oxide region of n-channel or p-channel devices having sufficient gate-to-source or gate-to-drain bias. The gate rupture leads to significant permanent degradation of the device. A proposed failure mechanism is discussed and experimentally verified. The absolute immunity of p-channel devices to heavy-ion-induced semiconductor burnout is demonstrated and discussed along with nondestructive burnout testing methods. 3 refs.

Fischer, Thomas A. (Sandia Natl Lab, Albuquerque, NM, USA). *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1786-1791.

**096414 SEU SENSITIVITY OF POWER CONVERTERS WITH MOSFETS IN SPACE.** Results of an investigation into the survivability of power MOSFETs in space are reported. 72 of these devices are presently in geosynchronous orbit aboard six communications spacecraft, and operating at  $70\text{ V}$ , which is 70% of the nominal breakdown voltage. No failures have occurred after 94536 device-days in space. The irradiation of discrete parts as well as the prototype flight power converter, containing the same part types, by iron particles with a LET (linear energy transfer) of  $10\text{ MeV-cm}^2\text{mg}$ , and an iron spectrum with a maximum LET of 26 showed these high-reliability flight parts to be relatively harder than the same type of devices previously ground tested. This appears to be the explanation for the lack of failures in space. 4 refs.

Brucker, G.J. (RCA/GE, Princeton, NJ, USA); Measel, P.; Oberg, D.; Wert, J.; Criswell, T. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1792-1795.

**Reliability** See Also SEMICONDUCTOR DEVICES, MOS—Electronic Properties.

**096415 RUGGEDNESS TESTING BOLSTERS POWER MOSFET RELIABILITY IN HIGH-STRESS CIRCUITS.** Circuit design and process control must account for parasitic bipolar transistors and avalanche energy in power MOSFETs. It is pointed out that both may cause second-breakdown failures.

Carlson, Peter J. (6 GE, Syracuse, NY, USA). *Electron Des* v 33 n 6 Mar 13 1986 p 147-150, 152.

**096416 HOW NATIONAL BUILDS IN RELIABILITY FOR ITS BICMOS.** The National Semiconductor Corp. reliability program in the processing of its bipolar complementary MOS (BiCMOS) III devices is described. Seven different areas affecting reliability were identified and attacked during process development: soft-error rate, hot-electron degradation of MOS transistors, hot-carrier effects in bipolar transistors, electromigration effects in the metalization, passivation integrity, latchup, and electrostatic discharge. After process development vigorous strife testing uncovered subtle weaknesses in the active MOS FET and bipolar devices, oxides, metal interconnects, and passivation techniques.

Runyon, Stan. *Electronics* v 61 n 3 Feb 4 1988 p 61-62.

#### Semiconductor Insulator Boundaries

**096417 THERMIONIC EMISSION PROBABILITY FOR SEMICONDUCTOR-INSULATOR INTERFACES.** Simulation of hot-carrier gate-current effects in either MOSFET or MODFET devices requires knowledge of the carrier-emission probability over the semiconductor-insulator barrier. Several recent studies have relied on a limiting form for this probability that can lead to significant errors for large fields in the Si-SiO<sub>2</sub> system. It

is shown that the result for emission probability can be expressed as an error function, leading to simple implementation in the numerical 2-D simulators commonly used in device analysis. The result is compared to the commonly used limiting form for both large and small values of the normalized barrier height. 9 refs.

Henning, Albert K. (Stanford Univ, CA, USA); Plummer, James D. *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2211-2212.

#### Simulation

**096418 TWO-DIMENSIONAL SHORT CHANNEL MOSFET STEADY STATE AND SUBSTRATE CURRENT SIMULATION.** Using total quantity of carrier analysis method, a new numerical model for two-dimensional short channel steady state MOSFET is presented. The Poisson equation, the continuity equations for electrons and holes are solved via two-dimensional MOSFETs simulator LADES1-A (Lishan Advance Device Simulation Version no. 1-A). The LADES1-A can be used to design and predict the effect of different process conditions and geometric structures of the devices. This simulator is very useful for device designer to study the phenomena inside the device aiming at decreasing the short channel effect by the optimum method. In order to illustrate the application of the simulator, some of our simulation results of short channel MOSFET are presented. The substrate current produced by hot carriers and the generation-recombination rate of nonequilibrium carriers are discussed in detail. (Author abstract) 11 refs. In Chinese.

Du Min (Shanxi Lishan Microelectronics Corp, Shanxi, China); Huang, Chang. *Pan Tao Ti Hsueh Pao* v 9 n 1 Jan 1988 p 1-6.

**Space Applications** See COMMUNICATION SATELLITES—Electric Power Supplies.

#### Spectroscopic Analysis

**096419 LOW FREQUENCY NOISE AND DLTS AS SEMICONDUCTOR DEVICE CHARACTERIZATION TOOLS.** The technique of low-frequency noise vs temperature measurements is shown to be a powerful diagnostic technique for determining Generation Recombination (GR) trapping parameters in MOSFETs. From computer controlled measurements of low frequency noise vs temperature, the trapping parameters are extracted in a manner similar to that of Deep Level Transient Spectroscopy (DLTS). The trapping parameters are also extracted by curve fitting of the low frequency noise vs temperature curves. These noise-determined trapping parameters are compared with those measured by DLTS. The agreement between parameters determined by the spot frequency noise Arrhenius plot with those determined by DLTS is close, while the agreement between those determined by noise curve fitting is reasonable for noise peaks near room temperature, but becomes poor for low temperature noise peaks. By the use of PECVD silicon nitride as a passivation material, the sensitivity to measure GR traps by the low frequency noise vs temperature technique can be increased. (Edited author abstract) 7 refs.

Scholz, F. (Northern Telecom Electronics Ltd, San Diego, CA, USA); Hwang, J.M.; Schroder, D.K. *Solid State Electron* v 31 n 2 Feb 1988 p 205-217.

#### Stability

**096420 INCOMPATIBILITY OF REQUIREMENTS FOR OPTIMIZING SHORT CHANNEL BEHAVIOUR AND LONG TERM STABILITY IN MOSFETS.** An analytical approach is presented which predicts that the requirements for minimizing short channel effects and long term degradation due to hot carrier trapping lead to incompatible requirements on the design of short channel MOSFETs. Model predictions are compared with experimental data and with the results of 2-D simulations. An asymmetrical MOSFET structure is proposed to circumvent this design problem. (Author



abstract) 14 refs.

Bauer, F. (RWTH Aachen, Aachen, West Ger); Jain, S.C.; Korec, J.; Lauer, V.; Offenberger, M.; Balk, P. *Solid State Electron* v 31 n 1 Jan 1988 p 27-33.

## Switching

**096421 HIGH FREQUENCY SWITCHING OF POWER MOSFETS.** A great deal of attention has focused on optimizing the switching performance of the power MOSFET. Recent developments in the use of distributed power conditioning for logic circuits, pulse power applications and high frequency power conversion have resulted in an increase in switching frequencies. A series of tests on a 'topless' power MOSFET investigate high frequency switching performance, in particular the effect of source terminal parasitic inductance. (Edited author abstract) 5 refs.

Hobson, L. (Loughborough Univ of Technology, Engl); Hinchliffe, S. *Powerconverters Intell Motion* v 14 n 4 Apr 1988 p 70, 72-74, 76-77.

**096422 HIGH FREQUENCY SWITCHING OF POWER MOSFETS.** The effect of the source terminal parasitic inductance on the switching performance of power MOSFETs has been investigated. Results are given of the improvement in switching times produced when an IRF450 in a TO3 package is modified to include a second source lead for drive purposes. (Author abstract) 5 refs.

Hinchliffe, S. (Loughborough Univ of Technology, Loughborough, Engl); Hobson, L. *Int J Electron* v 65 n 1 Jul 1988 p 127-138.

**096423 ADVANCED 50-V HIGH-SIDE SWITCH TECHNOLOGY.** The advanced high-side switch (AHSS) technology integrates a high-density 50-V DMOSFET as a power switch and 5-V dense CMOS for digital ICs and up to 50-V CMOS output drivers. The 50-V DMOSFET has half the specific on-resistance of commercially available devices due to aggressive cell design and short channel approach. With this technology 3 million cell/sq in DMOSFET has also been demonstrated. The high-voltage CMOS utilizes a special lightly doped drain (LDD) structure. The doping profile and geometry layout of this LDD region has been highly optimized through field simulation and intensive experiments. The peak electric field under and around the gate oxide was drastically reduced to enhance gate strength and reliability. Study and attention were also paid to the layout and doping profiles to expand the CMOS safe operating area without running into latching problem before exceeding the rated blocking voltage, even at high temperature (150°C). By taking advantage of various diffusions associated with the DMOSFET, this complicated but high-performance AHSS was able to be realized through only 10 mask steps. The nature of this process allows the low-voltage CMOS portion to be shrinkable without changing the process. 3 refs.

Chang, M. (GE, Research Triangle Park, NC, USA); Yilmaz, H.; Gauffreau, G.; Hsieh, I.; Hodgins, R.; Wrathall, R.; Owyang, K.; Pattanayak, D. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2360-2361.

## Theory

**096424 SUBSTRATE BIAS DEPENDENCE OF SHORT-CHANNEL MOSFET THRESHOLD VOLTAGE - A NOVEL APPROACH.** A simple theory to predict the threshold voltage variation of short-channel MOS transistors with substrate bias is proposed. While the basis of the model is vertical field perturbations due to the source-drain, its uniqueness depends on a definition of threshold voltage based on the amount of total free charge in the channel rather than inversion of the entire channel. The theory has been verified for transistors of three channel lengths, namely, 2.70, 1.70, and 0.70  $\mu\text{m}$ , fabricated with a p-well CMOS process. A comparison is made with an earlier model based on field perturbation. The

validity of the arguments underlying the theory has been demonstrated by 2-D device simulations with MINIMOS. 16 refs.

Roychoudhuri, A. (Semiconductor Complex Ltd, Punjab, India); Jha, M.; Sharma, S.K.; Govindacharyulu, P.A.; Zarabi, M.J. *IEEE Trans Electron Devices* v 35 n 2 Feb 1988 p 167-173.

**096425 HOT-ELECTRON EFFECTS ON SHORT-CHANNEL MOSFET'S DETERMINED BY THE PIEZORESISTANCE EFFECT.** The piezoresistance effect of n-inversion layers in the hot-electron regime is discussed. The measurements were performed on short-channel n-MOSFETs at both 77 and 300 K. From the data at 77 K, clear evidence is obtained for different saturation velocities of electrons in Si depending on the occupation of the subbands. By application of this effect to 300 K, good agreement between theory and experiment is achieved. Furthermore, the mechanical prestress inside the transistor has been estimated to reach values of up to 150 N/mm<sup>2</sup>. 14 refs.

Borchert, Bernd (Siemens AG, Munich, West Ger); Dorda, Gerhard E. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 483-488.

## Thin Films

**096426 THIN-FILM, ACCUMULATION-MODE p-CHANNEL SOI MOSFETS.** Electrical characteristics of thin-film (100 nm), accumulation-mode SOI p-channel MOSFETs are reported and compared to simulation. In the OFF regime, the p-type channel is fully depleted. As a result, low values of leakage current are obtained. Good threshold voltage control is obtained. (Author abstract) 5 refs.

Coline, J.P. (Hewlett Packard Ct R&D, Palo Alto, CA, USA). *Electron Lett* v 24 n 5 Mar 3 1988 p 257-258.

**096427 GATE COUPLING AND FLOATING-BODY EFFECTS IN THIN-FILM SOI MOSFETS.** Thin-film, silicon-on-insulator (SOI) MOSFETs exhibit bias-dependent suppression of the kink effect. For zero or positive back gate bias, the kink effect is suppressed but the threshold reports depends strongly on back gate bias. For sufficiently negative back gate bias (as might be the for total-dose radiation-hard applications), the kink effect re-emerges and the threshold voltage depends instead on the applied drain voltage. (Edited author abstract) 9 refs.

Tsao, S.S. (Sandia Natl Lab, Albuquerque, NM, USA); Myers, D.R.; Eller, G.K. *Electron Lett* v 24 n 4 Feb 18 1988 p 238-239.

**096428 SOME PROPERTIES OF THIN-FILM SOI MOSFETS.** The properties that can be expected from thin-film silicon-on-insulator transistors are described. Simple qualitative modeling shows that improvements of different parameters, such as subthreshold slope, hot-electron effects, and short-channel effects, can be obtained when thin, fully depleted films are used. The potential advantages of using these devices for future small-geometry CMOS applications are highlighted. 11 refs.

Coline, Jean-Pierre (Hewlett Packard Lab, Palo Alto, CA, USA). *IEEE Circuits Devices Mag* v 3 n 6 Nov 1987 p 16-20.

**096429 INVERSION-MODE MOSFET'S IN POLY-CRYSTALLINE SILICON THIN FILMS: CHARACTERIZATION AND MODELING.** The performance of MOSFETs in LPCVD (liquid-phase chemical vapor deposited) polysilicon is characterized. Specifically, the transistor I-V behavior, transconductance, channel mobility, and leakage current are discussed in detail. These observed device characteristics are quantitatively analyzed, based on a polysilicon MOSFET theory that is presented. The model utilizes the concept of the effective doping level and is analytic, tractable, and analogous to conventional bulk silicon MOSFET theory. Additionally, the adverse role of the grain boundary for device performance and the effect of grain-boundary hydrogenation in increasing the ON/OFF current ratio are described. 24 refs.

Qian, Feng (Oregon Graduate Cent, Beaverton, OR, USA); Kim, Dae M.; Park, Hee Kyun; Sachitani, Jack L. *IEEE Trans Electron Devices* v ED-34 n 12 Dec 1987, 1987 IEEE Microwave and Millimeter-Wave Monolithic Circuits Symp, Jun 8-9 1987 p 2439-2449.

**096430 REDUCTION OF KINK EFFECT IN THIN-FILM SOI MOSFET'S.** Numerical simulation is used to show that potential and electric field distribution within thin, fully depleted SOI devices is quite different from that observed within thicker, partially depleted devices. Reduction of drain electric field and of source potential barrier brings about a dramatic decrease of kink effect. 7 refs.

Coline, Jean-Pierre (Hewlett-Packard Co, Palo Alto, CA, USA). *IEEE Electron Device Lett* v 9 n 2 Feb 1988 p 97-99.

## Transport Properties

**096431 ELECTRON VELOCITY OVERSHOOT AT ROOM AND LIQUID NITROGEN TEMPERATURES IN SILICON INVERSION LAYERS.** Effective electron velocities in silicon MOSFETs exceeding the bulk saturation values of  $10^7$  cm/s at room temperature and  $1.3 \times 10^7$  cm/s at liquid-nitrogen temperature are inferred. This conclusion suggests that electron velocity overshoot occurs over a large portion of the device channel length. To infer this phenomenon, submicrometer-channel-length Si MOSFETs with lightly doped inversion layers were fabricated. These devices have low field mobility of 450 cm<sup>2</sup>/V-s and showed only slight short-channel effects. Effective carrier velocities are calculated from the saturated transconductance  $g_m$  at  $V_{DS} = 1.5$  V after correction for parasitic resistances of source and drain. 11 refs.

Shahidi, G.G. (MIT, Cambridge, MA, USA); Antoniadis, Dimitri A.; Smith, Henry I. *IEEE Electron Device Lett* v 9 n 2 Feb 1988 p 94-96.

**096432 INVESTIGATION AND MODELING THE SURFACE MOBILITY OF MOSFET'S FROM -25 TO +150°C.** The surface mobility of n- and p-channel MOS transistors with varying densities of oxide charge and interface states has been investigated at low drain voltage in the temperature range from -25 to 150°C. Mobility values were extracted from DC transfer characteristics using the Pao-Sah drain current model and taking into account interface-state charge and short-channel effects. The dependence of the surface mobility is calculated using a partly diffuse scattering model. The influence of oxide and interface state charges on current transport is modeled by screened Coulomb potential scattering and by surface potential fluctuation, which saturates for charge densities larger than  $6.25 \times 10^{10}$  cm<sup>-2</sup>. 30 refs.

Soppa, Winfried M. (Technical Univ Berlin, Berlin, West Ger); Wagemann, Hans-Gunther. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 970-977.

## Tunneling

**096433 EFFECT OF FOWLER-NORDHEIM TUNNELING CURRENT STRESS ON MOBILITY IN N-CHANNEL MOSFET'S.** The electron effective mobility in n-channel MOSFETs has been investigated under Fowler-Nordheim (F-N) tunneling current stress at room temperature. With F-N current stress, mobilities become smaller than of the prestress mobilities over the whole region of inversion carrier density  $N_{inv}$  and the  $N_{inv}$ -dependence of the mobility almost disappears. 9 refs.

Akizawa, Mitsuru (Keio Univ, Hiyoshi, Jpn); Matsumoto, Satoru. *IEEE Trans Electron Devices* v 35 n 2 Feb 1988 p 245-246.

**SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER** See Also INFRARED DETECTORS—Materials; LOGIC DEVICES—Gates; SEMICONDUCTING GALLIUM ARSENIDE—Electric Properties; SEMICONDUCTING INDIUM COMPOUNDS—Electronic Properties; SEMICONDUCTOR DIODES—Electric Properties; SEMICONDUCTOR MATERIALS.



**096434 CORRELATION BETWEEN CURRENT TRANSPORT MECHANISMS AND ETCH FEATURES IN Au-CdS SINGLE-CRYSTAL SCHOTTKY DIODES.** The effects of surface features on chemically etched (0001) planes of single-crystal CdS on the dark current transport mechanisms in Schottky diodes prepared on them by vacuum evaporation of gold are investigated. By combining scanning electron microscope (SEM) observations of these surface features with measurements of current-voltage (I-V) characteristics, the diode behavior of the Schottky barriers is demonstrated to be strongly influenced by the surface topography. The temperature dependence of I-V, capacitance-voltage (C-V) and photo-electric measurements are also studied in an attempt to correlate the junction parameters with surface features. (Author abstract) 13 refs.

Oktik, S. (Univ of Durham, Durham, Engl); Russell, G.J.; Woods, J. *Semicond Sci Technol* v 2 n 10 Oct 1987 p 661-665.

**096435 SCHOTTKY DIODES ON ZnIn<sub>2</sub>S<sub>4</sub> SINGLE CRYSTALS.** Schottky diodes have been prepared on ZnIn<sub>2</sub>S<sub>4</sub> single crystal ternary compounds by using Au as the barrier contact. Compared with theoretical models, these diodes show majority carrier tunnel and interface state effects. The influence of chemical etching on the electrical properties is also reported. (Edited author abstract) 10 refs.

Vigil, O. (CNR, Parma, Italy); Lopez, S.; Morris, E.; Calzadilla, O.; Leccabue, F. *Sol Energy Mater* v 16 n 4 Oct 1987 p 315-318.

**096436 ADVANCED SCHOTTKY TTL PROCESS EXTENDED.** Fast is a family of TTL circuits, manufactured using the Isoplanar process. They are designed to offer the switching speed and output drive capability of Schottky TTL, with superior noise margins and only one-fourth the power consumption. There are now 120 FAST device types. The latest development is FAST LSI. This extension of the process allows for higher density, higher performance functions. The article is a short review of the FAST family products.

Pusey, Ernie (Fairchild). *New Electron* v 20 n 4 Feb 17 1987 p 40.

**096437 ANOMALOUS BEHAVIOUR IN THE CAPACITANCE OF SELENIUM SCHOTTKY DIODES.** Measurements on Se-Tl, Se-Bi, and Se-Au Schottky diodes, fabricated by evaporation of thallium, bismuth, or gold respectively, on a layer of crystallized selenium have shown an anomalous minimum of incremental capacitance with variation of applied voltage at a frequency below about 1 kHz. The voltage of the minimum varies consistently with the estimated barrier height of the junctions and suggests that it arises from a deep level located some 0.4 eV above the valence band of trigonal selenium. The disappearance of the effect with increasing frequency, while qualitatively consistent with this interpretation, indicates the level to be at 0.6 eV. (Author abstract) 9 refs.

Champness, C.H. (McGill Univ, Montreal, Que, Can); Pan, J. *Can J Phys* v 66 n 2 Feb 1988 p 168-174.

**096438 REDUCTION OF SCHOTTKY BARRIER HEIGHTS BY SURFACE OXIDATION OF GaAs AND ITS INFLUENCE ON DLTS SIGNALS FOR THE MIDGAP LEVEL EL2.** The barrier heights of Al-Schottky diodes formed on surface oxidized GaAs have been found to be smaller than those on as-etched GaAs. They recovered to the as-etched value when the samples were annealed, probably due to reduction of the surface oxide layer by Al. The barrier height of Au-Schottky diodes formed on surface oxidized GaAs depend on the oxidation conditions. These variations of the barrier height can be explained by differences of the oxide compositions and bonding strengths of the metal oxides (Al<sub>2</sub>O<sub>3</sub>, Ga<sub>2</sub>O<sub>3</sub> etc.). In accordance with decrease of the barrier height, the DLTS (Deep Level Transient Spectroscopy) signal of the midgap level EL2 decreased and the signal peak shifted to a lower temperature even for

the Au-GaAs Schottky barrier. The decrease of the DLTS signal can be explained by a change of the occupation factor due to change of the reverse saturation current density. (Author abstract) 14 refs.

Hasegawa, Fumio (Univ of Tsukuba, Tsukuba, Jpn); Onomura, Masaaki; Mogi, Chikako; Nannichi, Yasuo. *Solid State Electron* v 31 n 2 Feb 1988 p 223-228.

**096439 INTERFACE EFFECTS ON Mg-Zn<sub>3</sub>P<sub>2</sub> SCHOTTKY DIODES.** Cd-doped Mg-Zn<sub>3</sub>P<sub>2</sub> diodes with Au ohmic back contacts have been investigated experimentally. The I-V and C-V characteristics have been interpreted by taking into account an interfacial layer with states in equilibrium with the semiconductor. (Author abstract) 20 refs.

Szatkowski, J. (Technical Univ of Wroclaw, Pol); Sieranski, K. *Solid State Electron* v 31 n 2 Feb 1988 p 257-260.

**096440 METAL d-LEVEL INDUCED MID-GAP FERMIL LEVEL PINNING ON GaAs(110).** The transport properties of a diverse range of metal/GaAs(110) Schottky diodes have been examined using the conventional current-voltage and capacitance-voltage techniques. The data are used to test for correlations between the Schottky barrier height and the interface heat of reaction, the metal work function and the metal electronegativity. Central transition metals, situated between groups Va-VIII of the periodic table, pin the Fermi level near mid-gap. The barrier heights obtained from most other metals exhibit a near-linear dependence on electronegativity. (Author abstract) 38 refs.

McLean, A.B. (Univ Coll, Cardiff, Wales); Williams, R.H.; McGill, J.F. *Solid State Commun* v 65 n 11 Mar 1988 p 1415-1418.

**096441 GaAs SCHOTTKY DIODE'S LATERAL SURFACE POTENTIAL DISTRIBUTION.** A high resolution scanning Auger microprobe was used to determine the potential on the GaAs surface as a function of the lateral distance from the Schottky electrode edge. The voltage varies nearly linearly with distance. For a hard breakdown case, the surface field is approximately 1.2E5 V/cm, similar to that in a computer simulated JTE case with bound charges approximately 1.2E12 cm<sup>-2</sup> extending laterally to twice the space charge layer thickness. For a leaky junction, the surface field is in 1E4 V/cm range, with small variations as a function of the current, similar to a SIPOS case. (Author abstract) 7 refs.

Tantraporn, W. (GE, Schenectady, NY, USA); McConnell, M.D. *J Electrochem Soc* v 135 n 5 May 1988 p 1229-1231.

**096442 ELECTRICAL AND PHOTOVOLTAIC PROPERTIES OF Au/n-CuInSe<sub>2</sub> SCHOTTKY BARRIER DIODES.** The results of electrical and photovoltaic measurements taken with Au/n-CuInSe<sub>2</sub> contacts are presented and discussed. The electron conductivity of the samples was about 10<sup>-1</sup> Ω<sup>-1</sup> cm<sup>-1</sup>, and the electron mobility was 260 cm<sup>2</sup>V<sup>-1</sup> s<sup>-1</sup> at room temperature. The rectifying Au and the ohmic In contacts were prepared by vacuum evaporation on the opposite surfaces of the n-CuInSe<sub>2</sub> plate. The dark and light current-voltage characteristics at T = 298 K are shown. 14 Refs.

Opanowicz, A. (Technical Univ of Lodz, Lodz, Pol); Koscielniak-Mucha, B.; Boros, G. *Phys Status Solidi A* v 106 n 2 Apr 1988 p K197-K201.

**096443 BORON IMPLANTATION EFFECTS ON Au-GaAs SCHOTTKY BARRIER.** In this work, we analyse the use of boron implantation in order to change the barrier height of GaAs Schottky contacts. The dependence on the annealing temperature and implantation dose of the barrier height variation, as well as of the diode quality factor are also reported. In both cases, the observed behavior is related to the presence of defects created by implantation in the surface layer, and their annealing kinetics. (Author abstract) 12 refs.

Perez, A. (Univ de Barcelona, Barcelona, Spain); Roura, P.; Esteve, J.; Altelaar, H.; Anton, J.A.; Cornet, A.;

Morante, J.R. *Vacuum* v 37 n 5-6 1987, VI Span Conf on Vac and Its Appl, Madrid, Spain, Dec 1985 p 415-417.

**096444 GaAs SCHOTTKY DEVICES FOR SUB-MILLIMETER WAVELENGTHS.** The objective of this paper is to determine the extent of Schottky barrier diode operation as a mixer element at submillimeter wavelengths. To this end, the most recent theoretical treatments are surveyed in order to determine: (a) the maximum frequency of device operation from basic physical principles, (b) intrinsic conversion loss limitations to the minimum anode size, (c) total conversion loss limits, and (d) projected mixer noise temperature values as a function of specific device parameters. The equivalent circuit considered throughout this analysis is presented. Minimum conversion loss in the THz range occurs for mixer diode with the smallest possible junction capacitance. This capacitance can be reduced along with the R<sub>s</sub>, C<sub>j</sub>(0) product by decreasing the device area and increasing the active layer impurity concentration. It is concluded on the basis of the four analyses of device mixer noise temperature and conversion loss that reasonable Schottky barrier mixer diode operation can be expected to at least 10 THz. 12 refs.

Mattauch, R.J. (Univ of Virginia, Charlottesville, VA, USA); Crowe, T.W. *Int J Infrared Millim Waves* v 8 n 10 Oct 1987, Pap Presented at the Submillimeter (Terahertz) Receiver Technol Conf, Lake Arrowhead, CA, USA, Apr 7-8 1987 p 1235-1241.

## Analysis

**096445 PHOTOEMISSION SPECTROSCOPY STUDIES OF Cu-GaAs (110) INTERFACE USING SYNCHROTRON RADIATION.** The Cu-GaAs (110) interface and Schottky barrier formation have been studied with synchrotron radiation photoemission spectroscopy for Cu overlayers deposited at room temperature. The evolution of the Ga3d and As3d spectra shows that strong interactions occur between Cu and GaAs substrate during the interface formation. For less than 0.5 monolayer (ML) Cu only rigid band bending was observed, but no interfacial reaction could be appreciated; for Cu more than 1 ML apparent interfacial reaction appeared, by which metallic Ga formed at the interface, and some As segregated on the metal; there were evidences of clustering or island growth of the Cu overlayers observed. Using deconvolution technique it has been found that the interfacial Fermi level lies at about 0.9 eV below the conduction band maximum. The mechanism of the Cu-GaAs (110) interface and Schottky barrier formation is discussed. (Author abstract) 19 refs. In Chinese.

Pan Shihong (Nankai Univ, Tianjing, China). *Pan Tao Ti Hsueh Pao* v 9 n 1 Jan 1988 p 67-73.

## Contacts

**096446 CHARACTERISTICS OF WSi<sub>x</sub> FILMS AND ITS CONTACT TO GaAs.** The resistances and stresses of MSi<sub>x</sub> and WSi<sub>x</sub>/n-GaAs Schottky contacts using rf sputtered films with a variety of compositions have been investigated before and after annealing. Experimental results show that the characteristics of the films and Schottky contacts depend significantly on X. When X=0.62, WSi<sub>0.62</sub>/n-GaAs Schottky contact exhibits a high temperature stability after annealing at 800°C. (φ<sub>B</sub>=0.8 eV, n=1.1). A self-aligned GaAs MESFET has been fabricated using rf sputtered WSi<sub>x</sub>-gate. (Author abstract). 7 Refs. In Chinese.

Weng, Juewei (Shanghai Jiaotong Univ, China); Xin, Shanghai; Shi, Changxin; Chen, Yixin. *Bandaoti Xuebao* v 9 n 4 Jul 1988 p 421-428.

## Electric Properties

**096447 SCHOTTKY DIODES WITH HIGH SERIES RESISTANCE: A SIMPLE METHOD OF DETERMINING THE BARRIER HEIGHTS.** The forward I-V characteristic of a Schottky diode is strongly affected by the series resistance. At low barriers and high resistances it is difficult to determine the diode param-



ters. I-V measurements at extremely low voltages enable the barrier height to be derived. In the case of indium tin oxide or palladium on a-Si:H, consistent results were obtained. (Author abstract) 18 refs.

Brutscher, N. (Siemens AG Research Lab, Munich, West Ger); Hoheisel, M. *Solid State Electron* v 31 n 1 Jan 1988 p 87-89.

**096448 INTERPRETATION OF NON-LINEAR SCHOTTKY BARRIER  $C^{-2}$ -V CHARACTERISTICS.** An analysis has been made of the non-linear  $C^{-2}$ -V characteristics exhibited by n-CdTe Schottky barriers. The empirical data are shown to be explained satisfactorily assuming the existence of deep traps at 0.8 eV below the conduction band. The shallow donor concentration inferred from this analysis is close to that calculated by a simpler method which treats the real junction as an equivalent ideal Schottky diode in parallel with a voltage independent capacitance. The latter procedure is shown to be invalid in this instance and an explanation is given for its apparent success. (Author abstract) 8 refs.

Bryant, F.J. (Univ of Hull, Hull, Engl); Majid, J.M.; Scott, C.G.; Shaw, D. *Solid State Commun* v 63 n 1 Jul 1987 p 9-12.

**096449 STUDY OF THE ELECTRICAL AND INTERFACIAL PROPERTIES OF SPUTTERED Ti/Si AND SPUTTERED  $TiSi_2$ /Si SCHOTTKY BARRIERS.** Schottky diodes were made by sputtering of Ti or  $TiSi_2$  on a hot Si substrate at a temperature  $T_s$  between room temperature and 760°C. For the  $TiSi_2$  sputtered samples I-V characteristics were obtained, which could be attributed to the abrupt metal-semiconductor interface (confirmed by Auger measurements). Due to the unreactive nature of the  $TiSi_2$  the native  $SiO_x$  layer is not converted. Therefore the barrier height  $\Phi_B$  hardly depends on  $T_s$  and is always larger than the corresponding  $TiSi_2$ /Si value. We also found that sputter deposition of Ti and  $TiSi_2$  creates donor-type defects into the Si substrate with concentrations depending on surface pretreatment, sputter power and substrate temperature. Most of these defects could be annealed at 200°C. For the sputtered Ti/Si diodes the sputter-induced defects together with the conversion of the native  $SiO_x$  layer (by Ti into  $TiO_x$  and  $Ti_2Si_3$ ) determines the  $\Phi_B$ - $T_s$  behavior. For  $T_s > 550^\circ\text{C}$  a  $\Phi_B$  value typical for a titanium disilicide/Si contact was measured. (Author abstract) 21 refs.

De Bosscher, W. (Rijksuniversiteit Gent, Ghent, Belg); Van Mierhaeghe, R.L.; De Laere, A.; Laflere, W.H.; Cardon, F. *Solid State Electron* v 31 n 5 May 1988 p 945-951.

**096450 CHARGE TRANSPORT STUDY IN THIN FILM Au-CdTe SCHOTTKY DIODES.** Au-CdTe diodes were prepared on CdTe thin layers deposited electrochemically. Measurements of dark I-V characteristics at several temperatures and C-U characteristics at room temperature in darkness were used for the study of charge transport in the diodes. The results can be explained by a model consisting of the series connection of an Au-CdTe Schottky barrier, several intergranular (IG) barriers in the CdTe layer, and a relatively small series resistance of bulk of the grains. Some parameters of transport such as the quality factor of the diode and barrier heights of Schottky, and IG barriers are obtained and the impurity concentration and number of grain boundaries are estimated by comparison of theory with experiment. (Author abstract) 5 refs.

Kindl, D. (Charles Univ, Prague, Czech); Touskova, J. *Phys Status Solidi A* v 106 n 1 Mar 1988 p 297-304.

**096451 INTERFACE ANALYSIS AND ELECTRIC CHARACTERISTICS OF PALLADIUM SILICIDE-P-TYPE SILICON SCHOTTKY BARRIER DIODE.** The interface property of palladium silicide-silicon (P-type) Schottky Barrier Diode (SBD) has been studied by AES spectrum and EBIC image. The thickness of  $Pd_xSi_y$  layer and the deepness of schottky 'junction' are estimated. At room temperature, the response time ( $< 1\text{ns}$ ) of SBD to 1.06  $\mu\text{m}$  laser is roughly read out from

an oscillograph. By using DLTS, the position of the deep level in SBD surface space charge region  $E_T - E_v = 0.33\text{ eV}$ , the capture cross section  $\sigma_p$  ( $248\text{ K}$ )  $= 4.4 \times 10^{-18}\text{ cm}^2$  and the average impurity concentration of deep level  $N_T = 0.085(N_A - N_D)$  are made out. A 'lagging edge' of the pulsed response to laser resulting from the deep level is discussed. (Author abstract) 2 refs. In Chinese.

Xie, Baixing (Kunming Inst of Physics, China); Lin, Youshen; Xu, Xiaohua; Zhang, Jingshao; Fan, Dianyuan. *Hongwai Yanjiu A-Ji* v 7A n 2 1988 p 81-87.

**096452 ELECTRICAL CHARACTERIZATION OF SCHOTTKY DIODES ON VERY LOW ENERGY ION-ETCHED GaAs SURFACES.** A study of the electrical behavior of Al and Au-GaAs Schottky diodes on ion-etched n- and p-type material in the energy range 0-200 eV is reported. The main results are: (i) the Schottky barrier height deduced from I-V characteristics decreases on n-type and increases on p-type material as the ion energy increases. (ii) The barrier becomes independent of the nature of the metal. (iii) The recovery of the initial barrier height by thermal annealing is more imperfect as the ion energy increases. (iv) A 50 eV ion etching followed by a 400°C annealing step is a good way to obtain quasi-ideal diodes. (v) Unlike previous explanations attributing electrical degradations of Schottky diodes on ion-etched semiconductors to the creation of donor-like defects, the observation of the C-V results shows that, in this low energy range, acceptor-like defect levels must be taken into account. (Edited author abstract). 38 refs.

Neffati, T. (CNRS, Orsay, Fr); Lu, G.N.; Barret, C. *Solid State Electron* v 31 n 8 Aug 1988 p 1335-1342.

**096453 DEPENDENCE OF PtSi SCHOTTKY DIODE ELECTRICAL BEHAVIOUR ON THE PLATINUM FILM THICKNESS AND ON THE ANNEALING PROCESS.** The current-voltage characteristics were measured in Schottky diodes prepared by the deposition of 30 and 60 nm platinum films onto Si  $< 111 >$  wafers and annealing of 520°C for 1/2 h. The current density in the thin platinum diodes is nearly an order of magnitude higher than that in the thick platinum diodes. In the former the current density also increases with increasing perimeter-to-area ratio. This behavior has been associated with the formation of a narrow cylindrical silicidic region penetrating inside the silicon substrates deeper than that flat internal interface and caused by the vertical diffusion of platinum at the  $SiO_2$  sidewalls. The experimental I-V characteristics are fitted by accounting for the effects of the deep silicidic both on the tunnelling contribution and on the lowering of the Schottky barrier height. (Author abstract). 22 Refs.

LaVia, F. (SGS Microelettronica Spa, Catania, Italy); Lanza, P.; Viscuso, O.; Ferla, G.; Rimini, E. *Thin Solid Films* v 161 Jul 1988 p 13-20.

**096454 NEW RICHARDSON PLOT FOR NON-IDEAL SCHOTTKY DIODES.** The influence of operating temperature on the I-V and C-V characteristics of Al/n-GaAs Schottky diodes was studied. Diode parameters such as the ideality factor n and barrier height  $\Phi_{Ba}$  were found to be dependent on the temperature. For these diodes the usual Richardson plot  $\log(I_s/ST^2)$  as well as the modified plot  $I_s/ST^2$  vs.  $1/n(T)$  did not yield the true value for the effective Richardson constant  $A^*$  and barrier height  $\Phi_{Ba}$ . A new Richardson plot  $n(T)\log(I_s/ST^2)$  vs.  $1/T$  presented here results in a better estimation of  $A^*$  and  $\Phi_{Ba}$ . (Author abstract). 18 Refs.

Bhuiyan, A.S. (CNRS, Toulouse, Fr); Martinez, A.; Esteve, D. *Thin Solid Films* v 161 Jul 1988 p 93-100.

## Electronic Properties

**096455 SPECTROSCOPY OF DELAYED ELECTRONIC TRANSITIONS IN GaAs SCHOTTKY DIODES.** Dielectric spectroscopy of semiconductors (DSS) reveals in frequency spectra of delayed electronic transitions in semi-insulating systems and it may be used to study the trapping/de-trapping processes in the space charge regions of Schottky diodes and at the metal-semi-

conductor interfaces. We report measurements for two types of diodes with different bulk doping, in the frequency range 0.01 Hz to 10 kHz, with the temperature and bias as variable parameters. The trapping processes in the space charge region are shown to have non-exponential time dependence, and the interfacial processes give strong deviations from the classically expected behavior at very low frequencies and high temperatures, with a strong dependence on external bias. Certain phenomena appear to point to many-body interactions having a role in determining the rate processes in these Schottky diodes. (Author abstract) 18 refs.

Zaidi, Shahid H. (Bedford New Coll, Egham, Engl); Jonscher, Andrew K. *Semicond Sci Technol* v 2 n 9 Sep 1987 p 587-596.

**Fabrication** See SEMICONDUCTOR DIODES—Fabrication.

**Heterojunctions** See SEMICONDUCTOR DEVICES, CHARGE COUPLED—Heterojunctions; TRANSISTORS, FIELD EFFECT—Mathematical Models.

## Impurities

**096456 INVESTIGATION OF DEEP IMPURITIES IN SCHOTTKY DIODES ON HIGH-RESISTIVITY SILICON.** It is shown that in a Schottky Au-Si diode formed on high-resistivity n-type silicon the quasi-Fermi levels are not flat in the greater part of the space charge region. A procedure is given to determine the parameters of the space charge distribution and the energy levels of deep impurities from C-U and C-f characteristics. A model with a single deep impurity level and with uniform distribution of shallow and deep impurity concentrations is assumed. The method is demonstrated for an Au-Si diode used as a nuclear radiation detector. 14 refs.

Dabrowski, W. (Univ of Mining & Metallurgy, Cracow, Pol). *Phys Status Solidi A* v 105 n 2 Feb 1988 p 511-520.

**096457 CHARACTERIZATION OF ENHANCED BARRIER SCHOTTKY DIODES IMPURITY PROFILING IN THE PUNCH-THROUGH REGION.** We have established a theoretical basis for impurity profiling of the punch-through p-layer in metal-p<sup>+</sup>-n structures and have successfully applied this to Au/n-GaAs enhanced barrier diodes having a shallow Be implant under the metal. The theory uses the thermionic emission model for electron conduction over the barrier. Use of our model to interpret Schottky diode current-voltage characteristics and capacitance-voltage data yields the spatial dependence of the activated Be implant. Normal capacitance-voltage analysis can profile only part of the n-region and not the p-region in punch-through. Our results scale with the SIMS profile of the annealed 5 keV Be implant. (Edited author abstract) 12 refs.

Crowell, C.R. (Univ of Southern California, Los Angeles, CA, USA); Stanchina, W.E.; Vaidyanathan, K.V. *J Electrochem Soc* v 135 n 6 Jun 1988 p 1543-1547.

## Junctions

**096458 ANALYSIS OF THE PHOTOCURRENT INDUCED IN A SEMI-INFINITE SCHOTTKY BARRIER BY A TIME VARYING FOCUSED LASER BEAM.** General expressions are derived for the photocurrent induced in a semi-infinite Schottky barrier diode due to excitation by a focussed convergent light beam. A simple repeated transform technique using the Hankel and Laplace transformations is used to solve the diffusion equation. Special cases are considered where the excitation can be described by  $\delta$  functions, step functions, and harmonic modulation of the beam. The effects of beam focusing and cases where a simpler treatment may be used are discussed. (Author abstract) 15 refs.

Pester, P.D. (Univ of Oxford, Oxford, Engl); Wilson, T. *Phys Status Solidi A* v 105 n 2 Feb 1988 p 649-660.



**096459**  $n$ - $V_{oc}$  DIAGRAM AND THE PHYSICS OF NATIVE INTERFACIAL LAYER OF THE SCHOTTKY BARRIER. A method of investigating an interface of the Schottky barrier by a photovoltaic effect is examined in a complex analysis of the interfacial layer effects in Cu/Cu<sub>2</sub>O junctions. This approach assumes construction of the  $n$ - $V_{oc}$  (nonideality factor vs open circuit voltage) diagram for the devices studied and its analysis in terms of theoretical model of the tunnel MIS Schottky diode. Two interesting cases from a tutorial viewpoint are considered: the case of native interfacial layer (A) and that of intentionally modified native interfacial layer (B). (Edited author abstract) 12 refs.

Iwanowski, R.J. (Polish Acad of Sciences, Warsaw, Pol). *Phys Scr* v 37 n 5 May 1988 p 790-794.

**096460** NEW METHOD FOR MEASURING CARRIER CONCENTRATION PROFILE NEAR A GAAS SURFACE THROUGH A NETWORK ANALYZER. A method based on S-parameter measurement which precisely obtains the junction capacitance of the Schottky gate of GaAs MESFETs is proposed. In this method, the junction capacitance is derived from a diode circuit simulation based on S-parameter measurements. Determination of the junction capacitance under forward-biased voltage and the carrier concentration profile near the channel surface of Schottky gates are possible with this method. 4 refs.

Fukai, Y.K. (NTT, Musashino, Jpn); Muraguchi, Masahiro. *IEEE Electron Device Lett* v 9 n 2 Feb 1988 p 74-76.

## Mathematical Models

**096461** PHYSICAL EQUIVALENT CIRCUIT MODEL FOR PLANAR SCHOTTKY VARACTOR DIODE. A physical equivalent circuit model for the planar GaAs Schottky varactor diode is presented. The model takes into account the distributed resistance and capacitance of the active layer, the sidewall capacitance, and the parasitic resistances and accurately accounts for the high series resistance observed near the pinch-off voltage. The dependence of the maximum series resistance of varactor size, frequency, and doping profile has been theoretically investigated, and the results agree well with experimental data. The proposed model can be easily used for optimization of planar Schottky varactor diodes with regard to broad-band monolithic VCO constraints. 4 refs.

Phillippe, Pascal (Lab d'Electronique et de Physique Applique, Limell-Brevannes, Fr); El-Kamali, Walid; Pauker, Vlad. *IEEE Trans Microwave Theory Tech* v 36 n 2 Feb 1988 p 250-255.

## Measurements

**096462** EXPERIMENTAL INVESTIGATION OF THE DEPENDENCE OF BARRIER HEIGHT ON METAL WORK FUNCTION FOR METAL-SiO<sub>2</sub>-p-Si (MIS) SCHOTTKY-BARRIER DIODES IN THE PRESENCE OF INVERSION. The dependence of barrier height on the metal work function of metal-SiO<sub>2</sub>-p-Si Schottky barrier diodes was investigated and nonlinearity was found. This is explained by the theoretical model proposed recently by Chattopadhyay and Daw. The values of interface trap density and fixed charge density of the insulating layer of the diodes were calculated using this model and found to be appreciably different from those estimated by the usual method. (Author abstract) 13 refs.

Chattopadhyay, P. (Indian Inst of Science, Bangalore, India); Kumar, V. *Solid State Electron* v 31 n 2 Feb 1988 p 143-146.

**Millimeter Waves** See SIGNAL RECEIVERS—Low Temperature Effects.

## Noise

**096463** POMIARY SZUMOW MIESZANIA I STRAT PRZEMIANY DIOD SCHOTTKY'EGO TYPU BADP17. [Measurement of Mixing Noise and

Transformation Losses of Schottky Diodes Type BADP17]. Measurement procedure of mixer noise coefficient with partial rejection of a signal with mirror frequency is presented. Structure of a single diode measuring mixer is described. Results of measurements of the noise coefficient and transformation losses of the mixer with Schottky diodes type BADP17 are discussed. (Edited author abstract) 4 refs. In Polish.

Lobzowski, Andrzej (Politechniki Warszawskiej, Pol); Zaklikiewicz, Andrzej M.; Zebrowski, Zbigniew F. *Elektronika* v 28 n 9 1987 p 16-20.

**Noise, Spurious Signal** See SEMICONDUCTOR DEVICES—Noise, Spurious Signal.

**Performance** See Also SEMICONDUCTOR DIODES—Performance.

**096464** ON THE FORMATION OF NEAR IDEAL QUASI-SCHOTTKY BARRIERS BETWEEN INDIUM TIN OXIDE AND GALLIUM ARSENIDE. The formation of good quality diodes between indium tin oxide and gallium arsenide is explained in terms of existing metal-semiconductor theory. A characterization of the devices using capacitance-voltage and current-voltage techniques is presented. Diodes have demonstrated near-ideal behavior with ideality factors of less than 1.02 and barrier heights of  $(0.85 \pm 0.05)$  eV, suggesting the formation of a quasi-Schottky barrier, the height of which is pinned by surface-state effects. (Author abstract) 22 refs.

Parker, D.G. *GEC J Res* v 5 n 2 1987 p 116-123.

## Processing

**096465** EFFECT OF SCANNING ELECTRON BEAM ANNEALING ON THE REVERSE CURRENT IN Ti-GaAs SCHOTTKY DIODES. The effects of scanning electron beam annealing of Ti-GaAs Schottky diodes on the reverse diode characteristics are observed and discussed. Significant reductions in the values of the saturation current, the generation current and the shunt current are attributed to the low-energy secondary excitations generated by electron bombardment. (Author abstract) 11 refs.

Meglicki, Zdzislaw (Univ of Western Australia, Nedlands, Aust); Nener, Brett D.; Prasad, Krishnamachar; Sharda, Hemlata; Faraone, Lorenzo; Nassibian, Armenag G. *Jpn J Appl Phys Part 2* v 27 n 4 Apr 1988 p 704-706.

**Radiation Effects** See Also SEMICONDUCTOR DEVICES—Radiation Effects.

**096466** EFFECT OF BIAS ON OPTICAL BEAM INDUCED CURRENT IMAGING OF DEFECTS IN PLANAR AND SCHOTTKY JUNCTION DEVICES. We derive general expressions for the optical beam induced current that is obtained as a light beam scans across a subsurface defect in a semiconductor device. We then specialize to the cases of Schottky barrier and p-n junction devices and discuss the effect of various parameters such as reverse bias and surface recombination velocity on the resolution and contrast that is obtained. (Author abstract) 11 refs.

Wilson, T. (Univ of Oxford, Oxford, Engl); McCabe, E.M. *Optik (Stuttgart)* v 78 n 2 Jan 1988 p 59-63.

**Semiconductor Metal Boundaries** See CATHODES, THERMIONIC; SEMICONDUCTOR DIODES—Heat Treatment.

## Spectroscopic Analysis

**096467** DIELECTRIC SPECTROSCOPY OF SILICON BARRIER DEVICES. Dielectric studies, equivalent in many respects to the familiar admittance spectroscopy, are reported on three silicon barrier devices: a Schottky diode on 10 $\Omega$ cm n-type (A), a surface barrier diode on 10 $\Omega$ cm n-type (B) and an n<sup>+</sup>-p junction on 3  $\times$  10 $\Omega$ cm material (C). The response in the frequency range 0.01-10 $\Omega$ Hz and in the temperature range 10-325 K

shows three principal features in A and B: the d.c. conductance, a strongly dispersive behaviour at low frequencies and high temperatures, a secondary loss peak associated with the d.c. conduction, and a high-frequency loss peak which is distinctly broader than Debye. The dispersive process which is known as Low-Frequency Dispersion (LFD) and which may go over into negative capacitance under forward bias, is seen only in interfacial devices. The n<sup>+</sup>-p junction shows only the d.c. process and the high-frequency loss peak which is almost Debye-like. Several of these features have been seen previously in other devices, especially LFD in GaAs and it is significant that they are now seen in silicon barrier devices implying that they are not simply a consequence of the compound nature of the material. They are related to the presence of electrochemical interaction in the oxide layer under the metal contact. (Author abstract) 23 refs.

Jonscher, Andrew K. (Univ of London, London, Engl); Robinson, Mark N. *Solid State Electron* v 31 n 8 Aug 1988 p 1277-1288.

## Surfaces

**096468** EFFECT OF STRUCTURE TREATMENT ON Al-Si SCHOTTKY STRUCTURE. There is no unique theory to explain the anomalies in the theoretical and experimental I-V characteristics. The formation of the surface space charge region and the bending of the energy bands at the semiconductor surface for a given surface treatment is complex. This introduces uncertainties in the barrier height ( $\phi_B$ ) and ideality factor ( $\eta$ ) in a Schottky diode. In the present note the effect of different surface treatments and the annealing temperature on the  $\phi_B$  and  $\eta$  values of Al-Si Schottky diodes is studied. 9 refs.

Vava, P.R. (Indian Inst of Technology, Madras, India); Majhi, J. *Phys Status Solidi A* v 106 n 2 Apr 1988 p k209-k213.

## Temperature Effect

**096469** TEMPERATURE DEPENDENCE OF BARRIER HEIGHTS OF Au/ $n$ -CdTe SCHOTTKY DIODES. The temperature dependence of the barrier heights of Au/ $n$ -CdTe Schottky diodes has been investigated by measuring the I-V characteristics at different temperatures. The results show that the apparent barrier heights increase linearly with increasing temperature and a rising rate of  $9 \times 10^{-4}$  eV/K is obtained. These results agree with those of K. Hattori and others on InP. (Edited author abstract) 6 refs. In Chinese.

Zhang, Shibiao (Nankai Univ, Tianjin, China); Shi, Shangyu. *Bandaoti Xuebao* v 9 n 4 Jul 1988 p 443-445.

## Testing

**096470** STRUCTURAL NONUNIFORMITY OF EPITAXIAL GALLIUM ARSENIDE FILMS AND THE ELECTROPHYSICAL CHARACTERISTICS OF SCHOTTKY DIODES MADE FROM THEM. The current level of development in microelectronics is characterized by intensive research into the electrophysical properties of semiconductor devices fabricated from binary semiconductor compounds, namely gallium arsenide. However, gallium arsenide has not been widely used for devices that operate at high temperatures and power levels because of the high density of crystal lattice defects. The basic parameters of these devices largely depend on the uniformity of the structure and the impurity in the source material. It is also assumed that defects in the crystal construction and nonuniformity of the impurity compound in microvolumes of the device structure are responsible for the appearance of domains and current pinches. We will examine the principles of a new noncontact, nondestructive method for making electrically active defects visible and the features of surface and volume defects in epitaxial gallium arsenide films. 14 refs.

Gostev, A.V. (M.V. Lomonosov Moscow State Univ, USSR); Kleinfeld, Yu.S.; Rapoport, B.M.; Rau, E.I.; Sinkevich, V.F. *Sov Microelectron* v 16 n 4 Jul-Aug 1987 p 176-183.



Theory See TRANSISTORS—Electric Properties.

## Thermal Effects

**096471 EFFECTS OF THERMAL SILICIDATION ON THE CURRENT TRANSPORT CHARACTERISTICS OF  $Ti / <111>Si$  SCHOTTKY-BARRIER CONTACTS.** Using the interfacial-layer theory we present a systematic study on the effects of thermal silicidation on the current transport characteristics of  $Ti-nSi$  and  $Ti-pSi$  Schottky-barrier contacts. Based on the developed theory, the experimentally observed deviations from ideal thermionic-emission I-V model can be interpreted by the progressive variations of typical parameters such as thermal-equilibrium barrier height  $\phi_{B0}$ ,  $\phi(\phi_{Bp}, \phi)$ , interfacial-layer capacitance per unit area ( $C_i$ ), diode ideality-factor ( $n$ ) at a certain forward-bias voltage, and interface-state-apparent-spectrum (ISAS) obtained by both I-V and constant-temperature-Schottky-capacitance-spectroscopy (CTSCS) methods. We found that associated with the formation of stoichiometric  $TiSi_2$  at the  $Ti/Si$  interface, there is a drastic change of barrier height as well as diode ideality-factor without a prominent degradation of the soft reverse I-V characteristics. The changes happened in the interface-state spectra can be further interpreted in terms of real interface-state density and effective minority-carrier to majority-carrier capture rate ratio of the interface states. 16 refs.

Tseng, Hsun-Hua (Nat'l Chiao-Tung Univ, Hsin-Chu, Taiwan); Wu, Cheng-Yuan. *Solid State Electron* v 31 n 1 Jan 1988 p 35-44.

## Transients

**096472 TRANSIENT ANALYSIS OF SCHOTTKY-BARRIER DIODES.** The turnon and turnoff transients of a Schottky-barrier diode are determined by an analysis based on thermionic emission across the metal-semiconductor barrier and a displacement current within the space charge region. The results of the analysis are compared to those from a device simulator and are shown to be in excellent agreement. 10% time constants for both turnon and turnoff transients are shown to be strongly controlled by the SBDs depletion capacitance in reverse bias. (Author abstract) 8 refs.

McCowan, A. (Univ of Wales, Swansea, Wales); Shaari, S.B.H.; Board, K. *IEE Proc Part I* v 135 n 3 Jun 1988 p 71-75.

## Transport Properties

**096473 CURRENT TRANSPORT MECHANISMS IN ATOMICALLY ABRUPT METAL-SEMICONDUCTOR INTERFACES.** A comprehensive model for electron transport mechanisms across a fully formed Schottky-barrier junction is proposed in which the metal-semiconductor interface is approximated as an abrupt quantum mechanical transition. Improved formulations of the barrier-lowering mechanisms and carrier tunneling effects are derived where the dipole barrier lowering is modeled as a single exponential decay of the total surface charge density. Quantum calculations follow a two-band model in which the imaginary component of the electron wave vector in the semiconductor energy gap is obtained by including the effect of both conduction and valence states. The energy band profile effects are included in the calculation of tunneling current, and it is shown that the finite negative charge residing at the metal-semiconductor interface considerably modulates the tunneling transmission probability of carriers. Experimental results obtained from atomically clean  $Al-n+GaAs-nGaAs$  interfaces fabricated by in situ molecular-beam epitaxy (MBE) are shown to be in excellent agreement with the transport calculations. 50 refs.

Shenai, Krishna (Stanford Univ, CA, USA); Dutton, Robert W. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 468-482.

**096474 HOT CARRIER TRANSPORT EFFECT IN SCHOTTKY-BARRIER DIODE GROWN BY MBE.** Hot-electron transport effects in Schottky-barrier diodes

grown by molecular-beam epitaxy (MBE) were investigated. Comparisons with experimental results for an  $Al-n+GaAs$  diode shows that terminal currents obtained using the Monte Carlo (MC) method agree well with experiment and are higher than those of conventional analysis for the forward-bias condition. A much higher thermionic-emission velocity at the Schottky contact was obtained using the MC analysis compared to previously published results. It is argued that these hot-electron transport effects should be included when analyzing device physics and current-voltage characteristics of Schottky-barrier diodes grown by MBE. 10 refs.

Hwang, Chang G. (Stanford Univ, USA); Dutton, Robert W. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 5 May 1988 p 578-583.

## SEMICONDUCTOR DEVICES, TRANSIT TIME See Also OSCILLATORS, SOLID STATE—Analysis.

### Mathematical Models

**096475 EFFICIENCY AND POWER OUTPUT OF THE QUANTUM-WELL INJECTION TRANSIT-TIME DEVICE.** A theoretical analysis is presented of the efficiency and power capability of the quantum-well injection transit-time (QWITT) device. When compared with traditional semiconductor sources such as TED (transferred-electron device) or IMPATT (impact avalanche and transit time) devices, the results show that the QWITT is a far better source at millimeter wavelengths. The superior performance of the QWITT is due to its high intrinsic frequency response time, as well as to the extremely localized carrier injection mechanism and the utilization of the high transient velocity of carriers at small distances. Computer simulations that took these effects into account clearly confirmed these merits. For example at 300 GHz, a single QWITT provides an output power of 1.2 mW at 7.4% efficiency when it is matched to a resonant circuit with about 1- $\Omega$  resistance. 9 refs.

Song, Inchee (Univ of California, Los Angeles, CA, USA); Pan, Dee-Son. *IEEE Electron Device Lett* v EDL-8 n 12 Dec 1987 p 560-562.

**SEMICONDUCTOR DIODES** See Also ACCELERATORS—Radiation Effects; ELECTRIC MEASUREMENTS—Power; ELECTRONIC CIRCUITS—Performance; ELECTRONIC CIRCUITS, FREQUENCY CONVERTER—Performance; ELECTRONIC CIRCUITS, FREQUENCY MULTIPLYING—Millimeter Waves; ELECTRONIC CIRCUITS, SWITCHING—Measurements; GLASS—Electric Properties; LASERS, INJECTION—Mathematical Models; LASERS, INJECTION—Spectrum Analysis; LASERS, SEMICONDUCTOR; LASERS, SEMICONDUCTOR—Accessories; LASERS, SEMICONDUCTOR—Analysis; LASERS, SEMICONDUCTOR—Chemical Vapor Deposition; LASERS, SEMICONDUCTOR—Design; LASERS, SEMICONDUCTOR—Efficiency; LASERS, SEMICONDUCTOR—Fabrication; LASERS, SEMICONDUCTOR—High Temperature Effects; LASERS, SEMICONDUCTOR—Measurements; LASERS, SEMICONDUCTOR—Optical Pumping; LASERS, SEMICONDUCTOR—Performance; LASERS, SEMICONDUCTOR—Reliability; LASERS, SEMICONDUCTOR—Stability; LASERS, SEMICONDUCTOR—Switching; LASERS, SEMICONDUCTOR—Tuning; OPTICAL COMMUNICATION—Laser Applications; OSCILLATORS—Millimeter Waves; SCINTILLATION COUNTERS—Testing; SEMICONDUCTING GALLIUM ARSENIDE—Metallizing; SEMICONDUCTOR DEVICES, FIELD EFFECT—Simulation; SEMICONDUCTOR DEVICES, MOS—Electric Properties; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Noise; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Transport Properties; SIGNAL DETECTION—Microwaves; THYRISTORS—Overvoltage Protection.

**096476 SIGNAL, RECOMBINATION EFFECTS AND NOISE IN AMORPHOUS SILICON DETECTORS.** Some properties of hydrogenated amorphous silicon diodes are described. Back biased diodes of the Schottky, p-i-n type, in thicknesses ranging from 5-15  $\mu m$ , have been tested with 6 MeV alpha particles and with 1 and 2 MeV protons. Large signal saturation, due to electron-hole recombination, occurs for high LET particles. Diodes have been exposed to fast neutron fluences up to  $10^{13} cm^{-2}$  and shown to have better radiation resistance than similarly exposed crystalline silicon detec-

tors. From our measurements we extrapolate that minimum ionizing particles can be detected with stacked layers 100-120  $\mu m$  thick, with adequate signal/noise levels. (Author abstract) 13 refs.

Perez-Mendez, V. (Univ of California, Berkeley, CA, USA); Ward, W.; Qureshi, S.; Street, R.A.; Kaplan, S.N. *Nucl Instrum Methods Phys Res Sect A* v A260 n 1 Oct 1 1987 p 195-200.

**096477 DIFFUSION LENGTH MEASUREMENTS IN BULK AND EPITAXIALLY GROWN III-V SEMICONDUCTORS USING CHARGE COLLECTION MICROSCOPY.** Diffusion lengths and surface recombination velocities were measured in GaAs diodes and InP finished solar cell. The basic technique used was charge collection microscopy also known as electron beam induced current (EBIC). The normalized currents and distances from the pn junction were read directly from the calibrated curves obtained while using the line scan mode in an SEM. These values were then equated to integral and infinite series expressions resulting from the solution of the diffusion equation with both extended generation and point generation functions. (Edited author abstract) 5 refs.

Leon, R.P. (NASA, Lewis Research Cent, Cleveland, OH, USA). *NASA Tech Memo* 100128 1987 7p.

**096478 THERMAL PARAMETERS OF MICRO-WAVE DIODES AND TRANSISTORS.** In this paper the most widely used methods of thermal resistance measurements of diodes, as well as UHF and microwave transistors, are described. The advantages and drawbacks of these methods are discussed and the results of measurements of typical devices are presented in order to compare the applicability of these methods to the measurements of devices manufactured at the Institute. A brief outline of the theory of heat conduction and of the numerical analysis of semiconductor structures together with calculations are also presented. (Author abstract) 3 refs.

Szczesny, Juliusz (Inst of Electron Technology, Warsaw, Pol); Jelenki, Andrzej. *Electron Technol (Warsaw)* v 19 n 1-2 1987 p 3-22.

**096479 DIODE AS AN ENERGY-CONTROLLED, NOT A CHARGE-CONTROLLED DEVICE.** The conventional notion of electricity as electrons jostling their way down a wire cannot, according to the author's theory be the thing that arrives at and controls the operation of a diode. His developing analysis of the behavior and of a diode is totally at odds with the traditional view, based on electrons, holes and energy barriers across the p-n interface.

Catt, Ivor. *Electron Wireless World* v 93 n 1619 Sep 1987 p 903-904.

**096480 P-N JUNCTION DIODE CAPABLE OF WORKING AT 650°C.** The National Institute's semiconductor has been made possible by growing large crystals of cubic boron nitride (c-BN), which has the same crystal structure as diamond and shows similarities in hardness and thermal conductivity. The Institute succeeded not only in making c-BN, p and n semiconductors but also in producing a c-BN junction diode. The junction diode was successfully shown to operate at a high temperature of 650°C. The diode manufacturing process is described.

Anon. *JEE J Electron Eng* v 25 n 253 Jan 1988 p 77-79.

**096481 SURFACE-MOUNT P-I-N DIODES OPERATE BEYOND 2GHz.** Until recently, p-i-n diode switches with good performance beyond the few hundred of megahertz range have been difficult and expensive to manufacture. With the introduction of triple p-i-n diodes in a surface-mount package, Siemens claims to have overcome both these problems.

Anon. *Electron Wireless World* v 93 n 1622 Dec 1987 p 1261-1262.



**096482 BULK-BARRIER-DIODE.** Bulk-barrier-diodes (BB-diodes) are majority-carrier devices and can, therefore, be used up to frequencies in the microwave region. Similar to Schottky-barrier diodes, charge-carrier transportation is determined by an energy barrier. In Schottky-barrier diodes, charge-carrier transportation is determined by an energy barrier. In Schottky-barrier diodes the barrier is located at the metal/semiconductor boundary, whereas in BB-diodes it is found inside the semiconductor and is the result of a space-charge zone in a three-layered npn- or pnp-structure with a very thin base region. The height of the barrier is determined by technological parameters such as doping density and layer thickness. As the current in BB-diodes, just as in Schottky-barrier-diodes, is an exponential function of barrier height, the current-voltage-characteristic can be adjusted by technological means. BB-diodes can be used up to frequencies in the microwave region as rectifier for small voltages and as frequency mixer. BB-Diodes are very sensitive thermal and optical detectors from infrared until ultraviolet. (Author abstract) In German. 23 refs.

Mader, Hermann (Fachhochschule Muenchen, Munich, West Ger). *AEU Arch Elektron Uebertrag Electron Commun* v 42 n 2 Mar-Apr 1988 p 118-123.

**096483 DOSE-VOLTAGE DEPENDENCE OF CO-AXIAL BREMSSTRAHLUNG DIODES.** The relations  $D \propto IV^{2.65}$  is widely used to estimate the on-axis radiation-dose rate for flash x-ray sources,  $D$ , as a function of diode current,  $I$ , and voltage,  $V$ , 1 m downstream of an optimized bremsstrahlung target. This relation is valid only for pencil beams. In this paper, we show that for diodes having beams with finite spatial and angular extent, this relation can still be used if the power 2.65 is modified. Using particle-in-cell and radiation-transport codes, this modification is evaluated for a diode proposed for the 20-MeV HERMES III accelerator that is currently under construction. (Edited author abstract). 21 refs.

Sanford, T.W.L. (Sandia Natl Lab, Albuquerque, NM, USA); Halbleib, J.A.; Poukey, J.W.; Heath, C.E.; Mock, R. *Nucl Instrum Methods Phys Res Sect B* v B34 n 3 Sep 1988 p 347-356.

**Analysis** See LASERS, SEMICONDUCTOR—Analysis; LASERS, SEMICONDUCTOR—Mathematical Models.

**Applications** See Also ELECTRONIC CIRCUITS, FREQUENCY MULTIPLYING; ELECTRONIC CIRCUITS, LIMITER—Design; WAVEGUIDE ATTENUATORS—Testing; WAVEGUIDES, OPTICAL—Fabrication.

**096484 CALCULATING THE SQUARE LAW DETECTOR SIGNAL-TO-NOISE OUTPUT.** Diode detectors are used in a variety of applications from squelch circuits to radar receivers. When the signal-to-noise ratio (SNR) at the input of a diode detector is low, calculation of the output SNR is important in determining overall system performance. In the article, the diode detector is modeled as an ideal square law detector. In addition, calculator programs are mentioned for an HP-41 series calculator, displaying the output SNR in db. 4 refs.

Fivash, Matthew J. (Honeywell Inc, Annapolis, MD, USA). *Microwaves RF* v 26 n 6 Jun 1987 p 133-134, 136.

**Computer Simulation** See Also LASERS, SEMICONDUCTOR—Computer Simulation; SEMICONDUCTOR DEVICES—Mathematical Models.

**096485 COMPUTER SIMULATION OF THE JUNCTION FIELD IN DOUBLE MESA HIGH VOLTAGE DIODES.** In order to fabricate high breakdown voltage diodes, the junction field must be properly controlled. This paper deals with a new junction termination geometry which can reduce the surface field, and achieves a high breakdown voltage in the junction. The new method is called the double mesa etch method (DMEM). These devices yield a good high-voltage junction rectifying property. The fabrication processes developed in this study are believed to be important for fabricating high power devices for the future. (Edited author abstract) 12 refs.

Jwo, S.C. (Natl Yuen-Lin Inst of Technology, Yuen-Lin,

Taiwan). *Modell Simul Control A* v 13 n 1 1987 p 31-41.

**Dielectric Properties** See SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Spectroscopic Analysis.

**Electric Properties** See Also ELECTRIC ATTENUATORS—Microwaves; ELECTRIC CONTACTS—Electric Properties; SEMICONDUCTING GALLIUM ARSENIDE—Charge Carriers; SEMICONDUCTING POLYMERS.

**096486 EFFECTS OF INTERFACIAL STATES ON THE CAPACITANCE-VOLTAGE CHARACTERISTICS OF Pd/SiO<sub>2</sub>/n-Si SCHOTTKY DIODES.** The shape of the  $1/C^2$  vs reverse voltage characteristic of a MIS device, with an ultrathin insulating layer, was theoretically examined taking into account interface states effects. The model foresees a linear behavior with a lower slope with respect to the ideal MS curve if interface states in communication with the semiconductor are present.  $1/C^2$ -V curves of Pd/SiO<sub>2</sub>/n-Si MIS Schottky diodes were measured under nitrogen and in two hydrogen/nitrogen mixtures, and were compared with Pd/n-Si curves. Changes of slope and the appearance of nonlinear behavior observed in hydrogenated devices are interpreted in terms of interactions between hydrogen atoms and interface states. Pd-gate MIS structures were shown to be an interesting experimental system to observe the effects of interfacial states on the electrical properties of the SiO<sub>2</sub>/n-Si interface. (Author abstract) 21 refs.

Bagnoli, P.E. (Univ di Pisa, Pisa, Italy); Nannini, A. *Solid State Electron* v 30 n 10 Oct 1987 p 1005-1012.

**096487 INFRA-RED SENSITIVITY OF BULK-BARRIER DIODES DUE TO LATTICE DEFECTS.** Bulk-barrier diodes (BBDs) are majority carrier Si devices; their electrical characteristics can be adjusted by process design. Measurements of the quantum efficiency have been made in the wavelength range of 1.4-2.0  $\mu$ m. The infrared sensitivity of a BBD in this region is explained by the excitation of carriers from deep traps produced by ion implantation. (Author abstract) 9 refs.

Georgoulas, N. (Univ of Thrace, Xanthi, Greece). *IEE Proc Part I* v 134 n 5 Oct 1987 p 153-155.

**096488 CURRENT OSCILLATION RELATED TO N=3 SUBBAND LEVELS UP TO ROOM TEMPERATURE IN InGaAs/InAlAs MQW DIODES.** A clear current oscillation related to the  $n=3$  subband levels was observed up to room-temperature in the forward I-V characteristic of the InGaAs/InAlAs MQW diodes, as well as a current oscillation related to the  $n=2$  subband levels. A significant hysteresis characteristic was also observed for the current oscillation related to the  $n=3$  subband levels at 77 K. The energy difference between the  $n=1$  and  $n=2$  subband levels estimated from the I-V characteristic agrees with that obtained from the absorption spectrum. (Author abstract) 8 refs.

Kawamura, Yuichi (NTT, Atsugi, Jpn); Wakita, Koichi; Oe, Kunishige. *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1603-1605.

**096489 NOISE, BREAKDOWN, AND DYNAMIC RANGE OF DIODES WITH HOT CHARGE CARRIERS.** Investigations of diodes with hot charge carriers (HCCD) have shown that their most promising applications are in measurement of low levels of cw and pulsed microwave power. Another important area of application for these devices may be apparatus for counting high-frequency pulses. In this connection such an HCCD characteristic as the dynamic range is of interest. 7 refs.

Starikov, A.I.; Razovskii, N.P.; Svetlichnyi, V.M. *Radioelectron Commun Syst* v 30 n 3 1987 p 94-96.

**096490 FIELD AND ELECTRON FIELD EMISSION CURRENT IN A DIODE WITH A SPHEROIDAL ANODE CHAMBER.** Various field-emission systems, in which the anode is a nearly closed surface with a small opening for the entry of the field-emission cathode (FEC), are now being investigated. A typical example of such a system is the FEC placed in a microwave resonator. An investigation of the dependence of the electric field

intensity  $E$  and the emission current  $I$  of such a diode on its geometrical parameters is of practical interest. No analytical methods exist for calculating  $E$  and  $I$  in such systems. The use of numerical methods is hampered by the fact that the dimensions of the typical geometrical parameters of the system differ by three to five orders of magnitude. A simple method is proposed for calculating  $E$  and  $I$  of a field-emission system in the static regime. 7 refs.

Chernykh, L.M.; Baskin, L.M. *Sov J Commun Technol Electron* v 32 n 6 Jun 1987 p 141-143.

**096491 FORWARD CURRENT-VOLTAGE CHARACTERISTICS OF GALLIUM ARSENIDE POWER DIODES AT HIGH CURRENT DENSITIES.** The forward current-voltage characteristics of power gallium arsenide diodes were investigated at the current density range of  $j$  approximately  $10^{-10}$  A/cm<sup>2</sup>. The ratio  $w/L$  ( $w$  is the width of the undoped  $N_0$  base,  $L$  is the diffusion length) was varied in a wide range by irradiation of the p-n structures with  $\gamma$ -quants of 1.25 Mev energy. Experimental data were compared with theoretical calculations taking into account the reduction of p-n junction injection coefficients. It has been shown that experimental data fit well with the theory if saturation current density is approximately  $10^{-18}$ - $10^{-16}$  A/cm<sup>2</sup>. There is no necessity to consider the reabsorption of the radiative recombination (RRR) effect to explain the experimental results. Simple analytical expressions for the current-voltage characteristics of GaAs diodes are proposed for a wide range of  $j$ ,  $w$  and  $w/L$  values. (Author abstract) 14 refs.

Delimova, L.A. (A.F. Ioffe Physical-Technical Inst, Leningrad, USSR); Zhilyaev, Yu.V.; Kachorovsky, V.Yu.; Levinstein, M.E.; Rossin, V.V. *Solid State Electron* v 31 n 6 Jun 1988 p 1101-1104.

**096492 SOME INTERESTING CHARACTERISTICS OF GaAs VERTICAL p<sup>+</sup>in<sup>+</sup> DIODES.** GaAs vertical p<sup>+</sup>in<sup>+</sup> diodes have been studied in the temperature range 187-373 K. The voltage and temperature dependence of the experimental results indicates that the transport mechanism is dominated by leakage in the low voltage and by high-injection diffusion in the high voltage regions. The temperature variation of the ambipolar diffusion length ( $L_i$ ) and the minority carrier lifetime ( $T$ ) has been evaluated and corresponding empirical relations have been obtained. A theoretical analysis gives  $T = 5$  ns at room temperature. (Author abstract). 11 refs.

Khan, W.I. (Univ of Leeds, Leeds, Engl). *Solid State Electron* v 31 n 8 Aug 1988 p 1265-1268.

**096493 SWITCHING MECHANISM IN THE HETEROSTRUCTURE HOT-ELECTRON DIODE.** In the heterostructure hot-electron diode (H<sup>2</sup>ED) two possible conduction mechanisms exist. At low fields, the current is limited by tunneling through a wide-bandgap heterostructure barrier, resulting in a relatively large device series resistance. At higher fields, electrons are heated to sufficient energies so that thermionic emission over the barrier becomes dominant and the series resistance in this region become negligible. Since the energy distribution of electrons is confined to a narrow range of energies, one or the other of these modes will dominate conduction. The transition between these current conduction modes is shown to result in a negative differential resistance (NDR) and switching speeds that may be extremely fast. Results of both theoretical and experimental investigations of the H<sup>2</sup>ED that verify the proposed mechanism and determine more precisely the underlying physical phenomena involved are presented. It is shown using an analytical theory that the field switching mechanism previously proposed is consistent with the NDR observed in the H<sup>2</sup>ED. In addition to the tunneling and



thermionic emission of hot electrons, the accumulation of electrons at the heterointerface is identified as an important mechanism in the operation of the device. 1 ref.

Higman, T.K. (Univ of Illinois, Urbana, IL, USA); Higman, J.M.; Emanuel, M.A.; Hess, K.; Coleman, J.J.; Kolodzey, J. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2381.

## Electronic Properties

**096494 HIGH-FIELD, NONLINEAR ELECTRON TRANSPORT IN LIGHTLY DOPED SCHOTTKY-BARRIER DIODES.** The high-field transport of electrons in an n-type Schottky barrier diode is analyzed in relation to the existing synthesis of drift-diffusion (DD) and thermionic emission (TE) theories. Energy relaxation is shown to play a significant role in allowing the DDTE theory to encompass as wide an applicability as it does in spite of its underlying assumptions. The transport equations for energy and momentum balance are solved for the electrostatic potential distribution of a Schottky diode while including quasi-ballistic effects of the inertia of the energy and momentum fluxes. Relaxation of both momentum and energy is included through scattering with ionized impurities, acoustic phonons and optical phonons. The model is applied to a silicon Schottky barrier and the results related to the existing theories. (Author abstract) 44 refs.

Darling, Robert B. (Univ of Washington, Seattle, WA, USA). *Solid State Electron* v 31 n 6 Jun 1988 p 1031-1047.

## Etching

**096495 EFFECT OF PHOTOCHEMICAL ETCHING ON INTERFACE STATE DENSITY OF  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$  METAL/INSULATOR/SEMICONDUCTOR DIODES.** A metal/insulator/semiconductor (MIS) structure of  $\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$  has been prepared by applying an excimer laser photo-CVD process to depositing a  $\text{SiN}_x$  insulating layer. It is found that interface state densities can be remarkably reduced by in situ photochemical etching with  $\text{CCl}_4$  or  $\text{CH}_3/\text{Br}$  gases prior to  $\text{SiN}_x$  deposition. A minimum value of the U-shape profile of the interface state density as low as  $5 \times 10^{11} \text{ cm}^{-2} \text{ eV}^{-1}$  is attained. (Author abstract) 11 refs.

Aoki, A. (Osaka Univ, Suita, Jpn); Miyoshi, S.; Shirafuji, J. *Electron Lett* v 23 n 17 Aug 13 1987 p 891-892.

**Fabrication** See Also LASERS, SEMICONDUCTOR—Efficiency; LASERS, SEMICONDUCTOR—Performance.

**096496 EFFECT OF PHOTOCHEMICAL SURFACE PASSIVATION ON REVERSE CURRENT IN Ti-GaAs SCHOTTKY DIODES.** The effect of photochemical surface passivation on Ti-GaAs diodes is demonstrated and discussed. The procedure described can be used to prepare a stable and repeatable GaAs surface for device processing. It is also compatible with lift-off technique. (Author abstract) 8 refs.

Meglicki, Zdzislaw (Univ of Western Australia, Nedlands, Aust); Nener, Brett D.; Prasad, Krishnamachari; Sharda, Hemlata; Faraone, Lorenzo; Nassibian, Armenag G. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 290-292.

**096497 MONOLITHICALLY INTEGRATED LASER/PHOTODETECTOR.** The fabrication and performance characteristics of a laser structure with monolithically integrated monitoring photodiode are described. The structure utilizes semi-insulating Fe doped InP layers for confinement of the current to the active region of the laser and for the separation of the laser and the photodetector sections. The lasers have threshold currents in the range 30-40 mA and emit in a single frequency by virtue of frequency selective feedback, provided by a grating etched on the substrate. The photodetector provides approx. 300  $\mu\text{A}$  of photocurrent per mW of laser power which is comparable to the value for a large area Ge photodiode generally used to monitor laser power. The new structure

also minimizes the unwanted reflection effects on laser performance caused by light reflected from the photodiode interface. (Author abstract) 7 refs.

Dutta, N.K. (AT&T, Murray Hill, NJ, USA); Cella, T.; Zilko, J.L.; Piccirilli, A.B.; Brown, R.L. *Electron Lett* v 24 n 6 Mar 17 1988 p 335-336.

**096498 GaAs/alGaAs MULTIPLE QUANTUM WELL PIN DIODES GROWN BY SELECTIVE AREA EPITAXY.** We have investigated the selective growth of GaAs/AlGaAs MQW pin diodes by atmospheric pressure MOCVD. A patterned spin-on silica film was used to restrict single-crystal growth to the exposed areas of the substrate. We have found that high-quality material can be grown by selective area epitaxy although edge effects currently limit the device performance. (Author abstract). 4 Refs.

Roberts, D.A. (Univ of Sheffield, Sheffield, Engl); David, J.P.R.; Hill, G.; Houston, B.A.; Pate, M.A.; Roberts, J.S.; Robson, P.N. *Electron Lett* v 24 n 14 Jul 7 1988 p 896-898.

**096499 SHANNON CONTACT FORMATION ON GaAs WITH INTERFACIAL NITROGEN INCORPORATION.** The family of refractory metal nitrides (TiN, ZrN, NbN, and WN) exhibits enhanced rectifying barrier heights on n-GaAs after high-temperature annealing and the diodes have electrical characteristics of Shannon contacts (i.e., metal-p-n structure). A further enhancement of the barrier height can be achieved by implanting nitrogen into n-GaAs substrates with a negative substrate bias (up to  $-400 \text{ V}$ ) prior to sputter-deposition of TiN, ZrN, or  $\text{W}_5\text{Si}_3$  gates. After rapid thermal annealing at temperatures above  $700^\circ\text{C}$ , the I-V characteristics of the diodes follow the voltage dependence of the Shannon energy barrier  $\Phi_B(V)$  and a positive is developed after the onset of Shannon contact formation. A reduction of gate current (by more than four orders of magnitude) and a twofold reduction of diode capacitance can be obtained. Annealing between  $500$  and  $700^\circ\text{C}$  shows a vertical shift of the  $\Phi_B(V)$  curves, which indicates the reduction of interface states. With increasing nitrogen implantation energy, and hence the nitrogen penetration depth, the diode reverse breakdown voltage increases from  $-10$  to  $-18 \text{ V}$  and the breakdown characteristics changes from a 'soft' breakdown to avalanche breakdown. 1 ref.

Zhang, L.C. (Univ of California, Berkeley, CA, USA); Cheung, S.K.; Liang, C.L.; Cheung, N.W. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2376.

## Heat Treatment

**096500 ANNEALING EFFECT ON Au/a-Si:H/a-Si:H(n-TYPE)/Cr SCHOTTKY DIODES PREPARED BY AN RF MAGNETRON SPUTTERING TECHNIQUE.** The annealing effect on Au/a-Si:H/a-Si:H(n-type)/Cr-type Schottky diodes has been investigated. Thin films of amorphous silicon were prepared by an RF magnetron sputtering technique on a glass substrate with Cr contacts and then gold electrodes (area =  $7.85 \times 10^{-3} \text{ cm}^2$ ) were fixed under a vacuum of  $10^{-5}$  Torr. Measured current-voltage characteristics, before and after annealing at about  $70-200^\circ\text{C}$ , show significant differences and therefore it has been concluded that the rectification ratio increases and the ideality factor decreases with increasing annealing temperature. The barrier height  $\phi_{Bn}$  and density of surface states  $D_s$  were found to be  $\phi_{Bn} = 0.641$  and  $0.726 \text{ eV}$  and  $D_s = 3.47 \times 10^{13}$  and  $3.30 \times 10^{13} \text{ states cm}^{-2} \text{ eV}^{-1}$  employing Crowell-Sze's and Cowley-Sze's theories respectively. The changes in the current-voltage characteristics were explained by means of surface states at the metal/semiconductor interface. (Author abstract) 28 refs.

Serin, T. (Univ of Kaiserslautern, West Ger); Uraz, A.A.; Serin, N. *Semicond Sci Technol* v 2 n 11 Nov 1987 p 742-746.

**Heterojunctions** See Also LASERS, SEMICONDUCTOR; LASERS, SEMICONDUCTOR—Fabrication; LASERS, SEMICONDUCTOR—Mathematical Models; LASERS, SEMICONDUCTOR—Measurements.

**096501 CHARACTERISTICS OF THE HYDROGENATED AMORPHOUS SILICON-CRYSTALLINE CADMIUM TELLURIDE HETEROJUNCTION DIODE.** The current-voltage characteristics and visible and x-ray photocurrent characteristics have been investigated for a heterojunction diode constructed of plasma-deposited hydrogenated amorphous silicon (a-Si:H) and single crystal cadmium telluride (c-CdTe). Devices showed low reverse bias saturation current, a photoresponse spectrum ranging from approximately 400-800 nm and a 3-decade increase in reverse bias saturation current when exposed to 40 keV x-rays. (Author abstract) 8 refs.

Meikle, Scott G. (Shizuoka Univ, Hamamatsu, Jpn); Hatanaka, Yoshinori. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1812-1814.

**096502 ISOTYPE  $\text{Al}_{0.05}\text{Ga}_{0.95}\text{As}/\text{Al}_{0.35}\text{Ga}_{0.65}\text{As}$  INTERFACE OF THE LPE-GROWN DOUBLE HETEROSTRUCTURE AT ELEVATED TEMPERATURE.** The isotype interface of a double heterostructure is studied by measuring the capacitance-voltage characteristic (C/V technique). For the LPE-grown  $\text{Al}_{0.05}\text{Ga}_{0.95}\text{As}/\text{Al}_{0.35}\text{Ga}_{0.65}\text{As}$  system it is shown that the effective barrier height of the p-type heteroboundary can be estimated even in the range below 25 meV by recording the C/V characteristic at lower than room temperature. Experimental evidence is given that the effective barrier height at the isotype p/p interface of the NpP-type heterostructure may be raised after treatment at elevated temperature. This reaction at the heteroboundary depends on the mechanical stress additionally introduced by the solder. The gradual increase in light output often observed in AlGaAs double heterostructure diodes during operation at elevated temperature can be approximated by a step-like function of the operation time and a characteristic delay time. The process is mainly thermally controlled with an activation energy of about 0.53 eV. A correspondence is found between the microscopic process at the p/p interface and the gradual increase in light output. It is suggested that the reaction at the isotype interface of LPE-grown AlGaAs heterojunctions is at least partly the origin of the increase in light output during operation at elevated temperature. Both phenomenon are not dependent on the operation current and are more effective at low external compressive stress. (Edited author abstract) 8 refs.

Krispin, P. (GDR Acad of Sciences, Berlin, East Ger); Beister, G.; Maeger, J. *Solid State Electron* v 31 n 5 May 1988 p 921-927.

**096503 THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THE HETEROSTRUCTURE HOT ELECTRON DIODE.** Experimental data are presented on the heterostructure hot electron diode ( $\text{H}^2\text{ED}$ ), a two-terminal device that exhibits S-shaped negative differential resistance due to a field dependent transition between the current conduction modes of tunneling and thermionic emission of hot electrons in a two-layer AlGaAs heterostructure. Results are presented on various single and multiple period  $\text{H}^2\text{ED}$  structures fabricated from wafers grown by metalorganic chemical vapor deposition (MOCVD). Preliminary microwave characterization of the  $\text{H}^2\text{ED}$  on non-optimized structures have resulted in test-fixture-limited oscillation at frequencies greater than 17 GHz. (Edited author abstract) 6 refs.

Emanuel, M.A. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Higman, T.K.; Higman, J.M.; Kolodzey, J.M.; Coleman, J.J.; Hess, K. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 589-592.

**Impurities** See SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Impurities.



**Junctions** See Also SEMICONDUCTING SILICON COMPOUNDS; SEMICONDUCTOR DEVICES, MOS—Tunneling; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER.

**096504 HIGH-TEMPERATURE CUBIC BORON NITRIDE P-N JUNCTION DIODE MADE AT HIGH PRESSURE.** A p-n junction diode of cubic boron nitride was made by growing an n-type crystal epitaxially on a p-type seed crystal at a pressure of 55 kilobars and a temperature of about 1700°C. A temperature-difference solvent method was used for the crystal growth, and beryllium and silicon were doped as acceptors and donors, respectively. Formation of the p-n junction was clearly confirmed at 1 bar by rectification characteristics and by existence of a space charge layer of the junction as observed by electron beam induced current measurement. This diode operated at 530°C. (Author abstract) 14 refs.

Mishima, Osamu (Nat'l Inst for Research in Inorganic Materials, Sakura-mura, Jpn); Tanaka, Junzo; Yamaoka, Shinobu; Fukunaga, Osamu. *Science* v 238 n 4824 Oct 9 1987 p 181-183.

**096505 ROOTS AND RAMIFICATIONS OF A UNIFIED THEORY OF ELECTRICAL CONDUCTION IN p-n JUNCTIONS, HETEROJUNCTIONS, AND SOLAR CELLS.** Conduction in various types of p-n junctions, heterojunctions, and Schottky diodes, and in homojunction and heterojunction solar cells have been explained by numerous different theories, whose applicability often depends on current and temperature ranges and device material and junction type. This paper, however, reviews the results of a unified theory of dc conduction, which reflect all physical and geometric parameters of the device just described, and which accurately agree with extensive experimental data reported by some 27 authors over a period exceeding a quarter of a century. The underlying concepts of this general dc theory of diodes pertain to what may be called the thermodynamic formulation of generalized fields (TFGF). This paper reviews, as applied to diodes, some fundamental aspects of the TFGF. In addition, the paper presents some new findings pertaining to the historic, thermodynamic, and quantum-mechanical roots of the TFGF. To be included in this paper are brief accounts of new possible extensions and applications of the TFGF. These will include the generalization of this interfacial transport theory to the area of time-varying fields, and the possible realization of absolute theoretical predictability of electronic, and optoelectronic, solid state device characteristics. (Edited author abstract) 42 refs.

Melehy, M.A. (Univ of Connecticut, Storrs, CT, USA). *Int J Electron* v 63 n 4 Oct 1987 p 555-571.

**096506 NEW THEORETICAL MODEL FOR A p-n JUNCTION REALISTIC DIODE.** Attempts have been made to give a new theoretical model for semiconductor bipolar realistic diodes. The fact that the realistic devices are not completely free from the effects of traps, defects, band to band radiative and non-radiative (Auger effect) transitions etc., leads to the mathematical solutions which show oscillatory variations (between two positive values) in the carrier density distributions. This leads to the deviation of a diode characteristics from those of the ideal diode. An application of the model has been made to a p-n junction. Experimental evidence of this deviation in Schottky heterostructures found in the literature can act as a direct support of the model. (Edited author abstract) 14 refs.

Khan, W.I. (Univ of Leeds, Leeds, Engl). *Solid State Electron* v 30 n 12 Dec 1987 p 1221-1225.

**096507 FABRICATION OF P-N JUNCTION DIODES USING HOMOEPITAXIALLY GROWN 6H-SiC AT LOW TEMPERATURE BY CHEMICAL VAPOR DEPOSITION.** Homoepitaxial growth on a 6H-SiC (0001)Si face was carried out successfully at 1500°C by chemical vapor deposition. This temperature is 300°C lower than typical well-known growth temperatures. The p-n junction diodes were fabricated with the grown layers and showed very good rectification. The breakdown electric field was estimated to be  $2.4 \times 10^6$

V/cm using the characteristics of the p-n junction diodes. This value is comparable with high-temperature grown layers. The fabricated p-n junction diodes showed blue light emission in the forward-biased region. (Author abstract) 16 refs.

Shibahara, Kentaro (Kyoto Univ, Kyoto, Jpn); Kuroda, Naotaka; Nishino, Shigehiro; Matsunami, Hiroyuki. *Jpn J Appl Phys Part 2* v 26 n 11 Nov 1987 p 1815-1817.

**096508 DOUBLE HETEROSTRUCTURE GaAs TUNNEL JUNCTION FOR A AlGaAs/GaAs TANDEM SOLAR CELL.** A double hetero (DH) GaAs tunnel diode which consists of a GaAs tunnel junction sandwiched between  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  layers has been grown by molecular beam epitaxy, and its annealing characteristics studied. DH tunnel diodes have the advantage that a decrease in the tunnel peak current density due to annealing is greatly suppressed compared to conventional GaAs diodes without AlGaAs layers. In-depth profiles of dopants indicate that the AlGaAs layers act as blocking layers against Be diffusion, which causes a degradation of the diodes. An  $\text{Al}_{0.4}\text{Ga}_{0.6}\text{As}/\text{GaAs}$  tandem solar cell incorporating the DH tunnel junction as interconnectors has achieved a conversion efficiency of 20%. (Author abstract) 10 refs.

Sugiura, Hideo (NTT, Tokai-mura, Jpn); Amano, Chikao; Yamamoto, Akio; Yamaguchi, Masafumi. *Jpn J Appl Phys Part 1* v 27 n 2 Feb 1988 p 269-272.

**096509 HIGH-SPEED NON-LINEAR CIRCUIT MODELS FOR p-n JUNCTION DIODES.** Circuit models for both long-base and short-base p-n junction diodes which are valid for non-linear high-speed and high-frequency operations are presented. The diode model consists of a parallel connection of higher-order dynamic elements and includes the conventional diffusion model as a special case. The new dynamic model can be used for simulating arbitrary p-n junction diode circuits under all operating conditions. In particular, it is capable of simulating realistically the diode's reverse transient behaviour and providing an increasingly accurate approximation to the diffusion equation as the order of the model gets higher. The model is also shown to be capable of reproducing the frequency-dependent small-signal characteristics of p-n junction diodes. (Edited author abstract) 18 refs.

Chua, Leon O. (Univ of California, Berkeley, CA, USA); Chang, Chwen-Cher. *Int J Circuit Theory Appl* v 16 n 2 Apr 1988 p 157-190.

## Laser Applications

**096510 AlGaAs VISIBLE LASER DIODE EMT-TING AT 780 nm.** Room temperature cw operation V-grooved laser diode emitting at 780 nm has been successfully fabricated by two-step liquid phase epitaxy method. Extremely good internal current confinement is achieved by using an n-type current blocking layer grown on the p-type substrate. The threshold currents are uniformly distributed between 35 and 50 mA. Owing to the simple fabrication process, lasing yield as high as 75% can be easily obtained. (Author abstract) 7 refs.

Lu, S.C. (Industrial Technology Research Inst, Hsinchu, Taiwan); Wang, D.C.; Chen, C.N.; Shry, W.F. *MRL Bull Res Dev* v 1 n 2 Sep 1987 p 29-32.

## Low Temperature Effects

**096511 LOW-TEMPERATURE CHARACTERISTICS OF CdS/CuInSe<sub>2</sub> DIODES.** The current-voltage characteristics, relative spectral response and the electron-beam-induced current (EBIC) for CdS/CuInSe<sub>2</sub> devices were measured in the 40-300 K temperature range. The results indicate that, at temperatures below 220 K, two space-charge regions are present and a reversal in the photocurrent, which shows spectral dependence, takes place under forward bias. The characterization of the device junction(s) by EBIC measurements is consistent with the spectral response. (Author abstract) 13 refs.

Noufi, R. (Solar Energy Research Inst, Golden, CO,

USA); Ramanathan, V.; Matson, R.J. *Sol Cells* v 24 n 1-2 May-Jun 1988, Proc 8th Photovoltaic Adv Res Dev Proj Rev Meet, Denver, CO, USA, Nov 15-18 1987 p 11-17.

## Materials

**096512 SILICON NITRIDE PASSIVANT FOR HgCdTe n+p DIODES.** A  $\text{SiN}_x$  film deposited by electron cyclotron resonance plasma CVD has been successfully applied as a surface passivant for  $\text{Hg}_{0.7}\text{Cd}_{0.3}\text{Te}$  n+p diodes. The ECR-plasma CVD assures low temperature deposition of  $\text{SiN}_x$  film on HgCdTe. The  $\text{SiN}_x$  has an excellent interface with HgCdTe with a surface-state density as low as  $1 \times 10^{11} \text{ cm}^{-2} \text{ eV}^{-1}$  and a low fixed charge of  $-1.4 \times 10^{11} \text{ cm}^{-2}$ . Measurement of flatband shifts after exposure to humidity verify that the  $\text{SiN}_x$  is more moisture resistant than the conventional ZnS passivant. A diode ( $\lambda_{co} = 5.4 \mu\text{m}$ ) passivated with  $\text{SiN}_x$  had a zero bias resistance of  $4 \times 10^{10} \Omega$  (diode area =  $4.8 \times 10^{-5} \text{ cm}^2$ ) at 77 K. (Author abstract) 9 refs.

Kajihara, N. (Fujitsu Lab Ltd, Atsugi, Jpn); Sudo, G.; Miyamoto, Y.; Tanikawa, K. *J Electrochem Soc* v 135 n 5 May 1988 p 1252-1255.

**Mathematical Models** See Also LASERS, SEMICONDUCTOR—Theory.

**096513 FREQUENCY DEPENDENCE OF THE INPUT IMPEDANCE OF A DIODE IN A FREQUENCY MULTIPLIER.** A system of equations is obtained showing that the input impedance of a diode in a frequency multiplier (FM) depends on the impedance of the multiplier output matching circuit (MC). Frequency functions of the input impedance of a diode in a FM are calculated for a single- and double-circuit MC. It is noted that optimum matching with a real input impedance in a FM can be achieved with smaller losses than that achieved with the RC equivalent to the input impedance of a multiplier diode with a given frequency band. (Author abstract) 6 refs.

Savchenko, S.M. *Sov J Commun Technol Electron* v 32 n 2 Feb 1987 p 95-100.

**096514 SIMULATION OF GaAs p-i-n DIODES.** GaAs p-i-n diodes have been modeled using numerical simulation, and the theoretical results have been compared to those of experiment. The simulations predict that with a lifetime of the carriers of  $10^{-7}$  s, devices that have good i-layer modulation may be built. This is in agreement with currently available commercial devices. 12 refs.

Gopinath, A.; Atwater, H. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 414-417.

**096515 NEW DEVICE - A POWER SEMICONDUCTOR DIODE WITH AN INTEGRATED THERMAL SENSOR.** A power semiconductor diode with an integrated thermal sensor is introduced. Means for producing such a device are presented, and the resulting device is analyzed. The theoretical model agrees with the experimental results within 10%. The practical conditions in which the sensor can be used are discussed. 2 refs.

Manduteanu, George V. (IPRS Banasa, Bucharest, Rom). *IEEE Trans Electron Devices* v 35 n 5 May 1988 p 700-703.

**Measurements** See Also ELECTRIC MEASUREMENTS—Capacitance; SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER; SEMICONDUCTOR DIODES, TUNNEL—Oscillations.

**096516 CHARGE COLLECTION IN SURFACE BARRIER DIODES.** 340 keV protons and 5.5 MeV alpha particles have been employed to measure the window thickness of silicon surface barrier diodes that have undergone oxidation in potassium dichromate solution, steam oxidation and oxygen gas aging. It has been found that the window thickness is independent of the silicon resistivity (300-11,000  $\Omega\text{cm}$ ) and that the dead layer part of the window cannot be treated as a simple geometric



layer. A model has been developed to explain this by considering charge collection and loss mechanisms. The model considers the creation of a plasma along the track of the particle; the expansion and erosion time of the plasma constitute the total time during which recombination of carriers may take place at the surface. The window thickness is given by  $W_x = -A \ln E_0 + B$ , where  $E_0$  is the maximum field in the depletion layer and A, B are constants. The constants A and B have been extracted from the experimental results and compared with the calculated ones. (Author abstract) 10 refs.

Haque, A.K.M.M. (South Bank Polytechnic, London, Engl); Hasko, D.G. *J Phys D* v 20 n 10 Oct 14 1987 p 1284-1290.

**096517 MEASUREMENT OF PULSE VOLTAGE IN HIGH-CURRENT DIODE BY MEANS OF GERMANIUM SENSORS.** A method for measurement of voltage directly in the gap of a high-current diode is described. The method is based on measurement of bremsstrahlung attenuation in absorbing filters. An algorithm is described for calculation of the bremsstrahlung attenuation on which the method is based. The time resolution was 7 nsec and was determined by the frequency response of the recording apparatus. (Author abstract) 2 refs.

Krasik, Ya.E. (Scientific-Research Inst of Nuclear Physics, USSR); Matvienko, V.M.; Sinebryukhov, A.A. *Instrum Exp Tech* v 30 n 2 pt 2 Mar-Apr 1987 p 370-372.

**096518 VERTICAL STORAGE TRENCH GATED DIODE LEAKAGE.** A vertical gated diode structure is inherent in the DRAM trench capacitor. A leakage mechanism of considerable magnitude, associated with this structure, is described. The leakage is due to minority carrier generation which occurs at the heavily doped silicon-substrate trench-oxide interface. The carriers are transported in the trench sidewall channel along the dielectric interface to the nearest reverse-biased junction. In a cell design without a well, minority carriers travel vertically in the trench sidewall channel to the storage node diffusion, reducing the DRAM cell retention time. In a cell within a well, the carriers are collected at the well-substrate junction instead of the storage node. 3 refs.

Voldman, Steven H. (IBM, Essex Junction, VT, USA); Bryant, Andres; Noble, Wendell P. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2373.

**096519 MEASURING BEAM LEADED DIODES NONDESTRUCTIVELY.** A nondestructive technique for measuring the capacitance and forward-biased resistance of beam-leaded diodes (BLDs) is introduced. The method involves the use of vacuum hold-down rather than permanent attachment of the diode, permitting its removal. The results of measurements on a p-i-n diode are given, but similar utility exists for Schottky detector and mixer BLDs. The calculations demonstrate the sensitivity of the circuit contributions to the effective installed capacitance of a BLD in a microwave transmission line. This suggests the desirability of utilizing not only a microwave circuit characterization of candidate beam-leaded diodes but also one which uses as similar a transmission-line topology as possible to that of the intended end use. 5 refs.

White, Joseph F. (M/A-COM Inc, Burlington, MA, USA); Parisi, Samuel J. *IEEE Trans Microwave Theory Tech* v MTT-35 n 12 Dec 1987, 1987 MTT-S Int Microwave Symp, Las Vegas, NV, USA, Jun 9-11 1987 p 1414-1418.

## Microanalysis

**096520 HELIUM MICROPROBE ANALYSIS OF NICKEL SILICIDE DIODES.** In this paper we present RBS and channeling measurements made on microscopic nickel silicide diode structures. These were obtained by using the helium ion microprobe at the University of Surrey. We also show that the new pre-lens deflection system enables measurements to be made with a 10  $\mu$ m

diameter probe over a 2x2 mm area without significant dechanneling or increase in the probe's diameter. (Author abstract) 7 refs.

Thornton, J. (Univ of Surrey, Guildford, Engl); Harper, R.E.; Albury, D.M. *Nucl Instrum Methods Phys Res Sect B* v B29 n 3 Dec 1987 p 515-520.

**Microwaves** See Also OSCILLATORS, MICROWAVE ANALYSIS; OSCILLATORS, MICROWAVE—Performance; OSCILLATORS, MICROWAVE—Stability; SEMICONDUCTOR DIODES, IMPATT—Fabrication.

**096521 SEMICONDUCTOR DIODES IN MICROWAVE CONTROL DEVICES. A SURVEY.** The state of the art and the problems that arise in utilization of microwave switching and limited diodes are discussed. Impedance characteristics of microwave p-n diodes are analyzed. Problems associated with increasing the working power, speed, and maximum frequency are considered together with the prospects for the paths toward further improvement in control devices for the centimeter and millimeter wavebands. (Author abstract) 55 Refs.

Lebedev, I.V.; Shnitnikov, A.S. *Radioelectron Commun Syst* v 30 n 10 1987 p 3-10.

**096522 BEHAVIOR OF A MICROWAVE LIMITER DIODE WITHIN THE WORKING FREQUENCY BAND AND OUTSIDE THE BAND.** Limiter diodes with p-n structures that have a thin lightly doped base region are widely employed to protect high-sensitivity input stages of microwave radio receivers. These devices are subject to inconsistent requirements for operation in sharply differing low- and high-power regimes with rapid transition from one to another. The physical processes that take place in a semiconductor structure under the action of a microwave signal with high power level are complicated and have not been adequately studied. We report results of an analysis of the operation of a limiter diode at different frequencies. The influence of the avalanche-multiplication effect on the parameters of the device is considered. 4 Refs.

Shnitnikov, A.S.; Filatov, N.I. *Radioelectron Commun Syst* v 30 n 10 1987 p 99-101.

**096523 MICROWAVE FREQUENCY OPERATION OF THE HETEROSTRUCTURE HOT-ELECTRON DIODE.** The generation of microwave frequencies by the heterostructure hot-electron diode (H<sup>2</sup>ED) is discussed. At 77 K, self-oscillation has been produced over a broad frequency range from direct current to 10.5 GHz, limited by the parasitic series resistance and capacitance. Considerations of the bias polarity required to produce oscillations and of their high-frequency response support a model of switching from tunneling to thermionic emission. 10 refs.

Kolodzey, J. (Univ of Illinois, Urbana, IL, USA); Laskar, J.; Higman, T.K.; Emanuel, M.A.; Coleman, James J.; Hess, Karl. *IEEE Electron Device Lett* v 9 n 6 Feb 1988, 34th Nucl Sci Symp, San Francisco, CA, USA, Oct 21-23 1987 p 272-274.

## Millimeter Waves

**096524 LARGE-SIGNAL CHARACTERIZATIONS OF UNIPOLAR III-V SEMICONDUCTOR DIODES AT MICROWAVE AND MILLIMETER-WAVE FREQUENCIES.** Large-signal characterizations are performed for n-GaAs and n-InP diodes operating in oscillator circuits at microwave and millimeter-wave frequencies. A CAD approach, consisting of a physical device model and an efficient numerical solution method, is used to analyze several sample diode structures with different material properties and geometries. The large-signal simulation results are reported for X-band and Q-band diodes, and are found to correlate well with results obtained from both laboratory experiment and large-scale ensemble Monte Carlo calculations. 8 refs.

Tait, Gregory B. (US Naval Research Lab, Washington, DC, USA); Krowne, Clifford M. *IEEE Trans Electron Devices* v 35 n 2 Feb 1988 p 223-229.

**Modeling** See TRANSISTORS, BIPOLAR—Modeling.

**Noise** See Also NOISE, SPURIOUS SIGNAL—Mathematical Models.

**096525 MEASUREMENT OF THE FLICKER NOISE PARAMETERS OF MIXER AND VARACTOR DIODES.** Flicker noise, the spectral density of which varies approximately inversely as the frequency, is observed in all semiconductor devices. No single theoretical model exists for flicker noise. Because of modulation effects this noise has a significance influence on the spectral characteristics of self-excited oscillators, power amplifiers, frequency multipliers, mixers and autodyne receivers. No single theoretical model exists for flicker noise. This paper presents the results of measurements of the flicker noise characteristics of widely used gallium-arsenide Schottky-barrier mixer diodes 3A110A and 3A111A and the 2A605A, 2A605E and 2A609A silicon multiplier diodes. 14 refs.

Zubov, P.T.; Leshchikov, B.Ye.; Khotuntsev, Yu.L. *Sov J Commun Technol Electron* v 32 n 2 Feb 1987 p 190-192.

## Noise, Spurious Signal

**096526 NOISE FIGURE PERFORMANCE OF A MICROWAVE MIXER DIODE WITH THE COMPLETE DIODE MODEL.** An analysis of thermal and Schottky noise generated in a microwave mixer diode has been made, based on the complete model which describes the diode in a more accurate manner than hitherto. In order to show the effects of the linear and nonlinear diode parasitic reactances on noise figure of a mixer diode which is in either series or shunt configuration with the image termination either open- or short-circuited, the performances of the three diode models (which are the complete, purely resistive and small-signal resistive) were compared. For a low-noise mixing process, the questions of which configuration and which image termination were answered. (Edited author abstract) 3 refs.

Gunes, Zeynep Filiz (Yildiz Univ, Istanbul, Turk). *Bull Tech Univ Istanbul* v 38 n 3 1985 p 353-375.

**096527 FLICKER NOISE IN HYDROGENATED AMORPHOUS-SILICON SCHOTTKY DIODES.** Noise measurements have been performed on a-Si:H Schottky diodes with Au and Pt metal contacts. The noise was found to exhibit 1/f behavior with  $0.7 < n < 1.3$ . The theory of flicker noise in intrinsic a-Si:H is further developed for Schottky diodes. The dependence of the noise on temperature and mean d.c. current is explained on the basis of this theory. It is shown that the measurements provide a means of calculating the density and distribution of the gap states. The results are found to be in good agreement with other techniques. They also suggest the presence of a peak in the gap-state density, around 0.4 eV below  $E_c$ . (Author abstract) 9 refs.

Bathaci, F.Z. (Imperial Coll, London, Engl); Anderson, J.C. *Philos Mag B* v 57 n 2 Feb 1988 p 259-269.

**Performance** See Also LASERS, SEMICONDUCTOR—Performance; MICROWAVE LIMITERS—Computer Simulation.

**096528 DEPENDENCE OF MIXING PERFORMANCE OF A SCHOTTKY DIODE ON ITS PARASITICS.** Conversion loss and noise figure variations of a Schottky diode which is in the series configuration with the short-circuited image termination, have been analyzed against its parasitics, which are nonlinear junction capacitance, the spreading resistance, the reverse limit resistance, the lead inductance and the packaging capacitance and the computed results are presented. It has been pointed out that the parasitic reactances are most effective on the performance of the series diode in the most negative bias region; effect of the spreading resistance depends upon the



biasing level, and the diode performance does not depend upon the reverse limit resistance unless it is smaller than 100 K. (Edited author abstract) 9 refs.

Gunes, Zeynep Filiz (Yildiz Univ, Besiktas, Turk). *Bull Tech Univ Istanbul* v 38 n 4 1985 p 435-446.

**096529 BARRIER HEIGHT ENHANCEMENT OF InP-BASED  $n\text{-Ga}_{0.47}\text{In}_{0.53}\text{As}$  SCHOTTKY-BARRIER DIODES GROWN BY MOLECULAR BEAM EPITAXY.** Barrier height enhancement of an InP-based  $p^+-n\text{-Ga}_{0.47}\text{In}_{0.53}\text{As}$  Schottky diode grown by MBE has been demonstrated for infra-red photodetector applications. A barrier height of 0.35 eV for  $n\text{-Ga}_{0.47}\text{In}_{0.53}\text{As}$  Schottky barrier diodes, was increased to the effective barrier height of 0.55 eV, with a  $p^+-\text{Ga}_{0.47}\text{In}_{0.53}\text{As}$  surface layer of 30 nm thick. The results show a reverse leakage current density of  $1.5 \times 10^{-3}$  A/cm<sup>2</sup> and a junction capacitance of 0.3 pF, which are comparable to those of  $p\text{-Ga}_{0.47}\text{In}_{0.53}\text{As}$  Schottky-barrier diodes at a reverse bias voltage of 5 V. (Author abstract) 6 refs.

Kim, J.H. (JPL, Pasadena, CA, USA); Li, S.S.; Figueroa, L. *Electron Lett* v 24 11 May 26 1988 p 687-689.

**096530 PERFORMANCE OF SCHOTTKY DIODES AS FAR-INFRARED MODULATORS.** We analyze the performance as a terahertz-frequency modulator of a small-area Schottky diode mounted in a corner-cube antenna. The analysis includes the effects of carrier inertia and dielectric relaxation as modeled by K.S. Champlin and G. Eisenstein. It also includes the effect of the vanishing of the depletion region above the flat-band potential, as modeled by T.W. Crowe and R.J. Matlack. Baseline calculation refers to a 1.4  $\mu\text{m}$  diameter diode operated at a carrier frequency of 2.52 THz and a modulation frequency of 8 GHz, as was used in the experiments of D.M. Watson, E.N. Grossman, and T.G. Phillips. The effects on reflectivity modulation, and therefore on sideband-generation efficiency, of varying the diode parameters are investigated. (Edited author abstract) 16 refs.

Grossman, Erich N. (California Inst of Technology, Pasadena, CA, USA). *Int J Infrared Millim Waves* v 8 n 10 Oct 1987, Pap Presented at the Submillimeter (Terahertz) Receiver Technol Conf, Lake Arrowhead, CA, USA, Apr 7-8 1987 p 1293-1312.

**Processing** See Also SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Processing.

**096531 EFFECTS OF PROCESSING CONDITIONS ON THE CHARACTERISTICS OF PLATINUM SILICIDE SCHOTTKY BARRIER DIODES.** A study has been carried out to determine the effects of various processing conditions on the formation of PtSi Schottky barrier diodes. Various surface preparation techniques were experimented. Comparisons were made between oxide etching by wet etch (BHF) and reactive ion etching (RIE) predeposition cleaning by wet etch or in situ Ar sputter cleaning, and the use of different thicknesses of Pt. The interaction between PtSi and the contact metallurgy during subsequent annealing was examined. The study shows that each component has a distinct effect on the quality of the PtSi film. The results indicate that oxide etching by wet etch is probably incomplete, leaving residues or suboxides on the surface of Si substrates which interfere with subsequent PtSi formation. Though RIE seems more effective in removing the oxide, data support the view that a damaged layer of Si is formed, which should be consumed by the PtSi formation for optimum electrical characteristics. Even if the formation of the PtSi is ideal, interaction between the PtSi and a commonly used Ti/Al-Cu/Si contact metallurgy at elevated temperatures could degrade the PtSi film qualities if a suitable diffusion barrier is not used. (Edited author abstract) 20 refs.

Moy, D. (IBM, Yorktown Heights, NY, USA); Basavaiah, S.; Chuang, C.T.; Li, G.P.; Hackbarth, E.; Brodsky, S.B.; Polcari, M.R. *Solid State Electron* v 31 n 5 May 1988 p 843-849.

## Radiation Effects

**096532 INVESTIGATION OF  $\text{H}^-$  PRODUCTION IN A PULSED POWER DIODE AT 10 GW.** Several experimental runs on the investigation of  $\text{H}^-$  production in various types of pulsed power diodes (reflex and magnetically insulated) at a power level of 10 GW and electron cathode surface current density in the (0.5–) kA/cm range with different prepulse conditions in the anode-cathode (A-C) gap were carried out. The scheme with intermediate ion charge exchange ( $\text{H}^- \rightarrow \text{H}^+$ ) and two stage acceleration was used to identify the  $\text{H}^-$  (or  $\text{D}^-$ ) ions and estimate their relative concentration in the plasma formed at the cathode surface. The measured activation yield of  $^{13}\text{N}$  in the  $^{12}\text{C}(p, \gamma)^{13}\text{N}$  reaction gave values of  $\text{H}^-$  current densities equal to  $(0.25 \pm 0.15) \text{ A/cm}^2$ , which corresponded to (0.5–2)% of  $\text{H}^-$  percentage in the cathode plasma in our experimental conditions. (Author abstract) 7 refs.

Bistritsky, V.M. (Inst of Nuclear Physics, Tomsk, USSR); Volkov, S.N.; Krasik, Ya.E.; Matvienko, V.M.; Tolmacheva, V.G. *Nucl Instrum Methods Phys Res Sect B* v B28 n 1 Aug 1987 p 131-134.

**096533 EFFECTS OF THE SPACE ENVIRONMENT ON LASER DIODES.** Laser diodes have been irradiated to investigate their behavior in the space environment. The InGaAsP/InP laser diodes used are manufactured by a technology projected to have high-output-power potential. The principal parameters of the devices, which included InP p-n junctions and double-heterostructure lasers with broad and narrow stripe-geometries, measured during 1 MeV electron irradiation, did not degrade appreciably. The partial annealing of irradiation-induced defects that takes place reduces the ultimate degradation induced by radiation. (Author abstract) 24 refs.

Roux, M. (ONERA-CERT, Toulouse, Fr). *ESA J* v 11 n 2 1987 p 167-183.

**096534 USING RADIATION TECHNOLOGY TO PRODUCE FAST-RECOVERY POWER DIODES.** The influence of electron-irradiation regimes and subsequent thermal annealing on the basis parameters of fast-recovery silicon diodes has been investigated. Concern here is to investigate radiation defects (RD) and to develop a regime for a radiation technology process (RTP) in order to improve a combination of parameters of fast-recovery diodes made of Soviet-produced silicon in accordance with the base technology. 9 refs.

Asina, S.S.; Kuznetsov, V.M.; Surma, A.M. *Sov Electr Eng* v 57 n 5 1986 p 74-78.

**096535 EFFECT OF ELECTRON IRRADIATION ON INTERFACE STATES OF InP MIS SCHOTTKY DIODES.** The effect of 2 MeV electron irradiation on interface states of a Au/Langmuir-Blodgett film/InP MIS diode has been studied. It was found by deep-level transient spectroscopy measurement that a broad peak induced by the interface states decreased significantly after electron irradiation. Moreover the surface photovoltaic measurement showed two orders of magnitude reduction of the surface recombination velocity. All this evidence shows that electron irradiation could reduce the density of interface states between InP and the Langmuir-Blodgett film. (Author abstract) 8 refs.

Peng, Chen (Fudan Univ, Shanghai, China); Sun, Heng-Hui. *Semicond Sci Technol* v 2 n 12 Dec 1987 p 779-782.

**096536 TRANSIENT MEASUREMENTS OF ULTRAFAST CHARGE COLLECTION IN SEMICONDUCTOR DIODES.** Funneling-current transients produced in semiconductor devices are predicted to occur on a picosecond time scale. These transients were measured by using a high bandwidth sampling system. Measurements were made on 1-, 3-, and 10- $\Omega$ -cm silicon low-capacitance diodes and  $10^{16} \text{ cm}^{-3}$  Te-doped GaAs diodes. The data are compared to the Hsieh, Murley and O'Brien, the McLean and Oldham, and the Messenger

models. Risettime versus doping density, peak current, total charge, and amplitude versus bias were measured. Current transients and prompt charge versus energy are presented. 15 refs.

Wagner, Ronald S. (Los Alamos Natl Lab, NM, USA); Bradley, Jeffrey M.; Bordes, Nicole; Maggiore, Carl J.; Sinha, Dipen N.; Hammond, Robert B. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1240-1245.

**096537 ETUDE DES INTERFACES Al-GaAs ET InP PREPAREES PAR BOMBARDEMENT IONIQUE DE TRES BASSE ENERGIE (0-200 eV).** [Study of the Al-GaAs and -InP Interfaces Prepared by Low-Energy-Ion Bombardment (0-200 eV)]. A systematic study of the electrical behavior of Schottky diodes using Al-ion cleaned GaAs (InP) was done in the ion energy range 0-200 eV. The main results are: (i) The Schottky barrier height  $\Phi_B$  deduced from I-V characteristics decreases on n-type material and increases on p-type as the ion energy increases. (ii) Thermal annealing becomes less and less efficient as the ion energy increases. (iii) The study of interface states by Schottky capacitance spectroscopy shows the creation of new states, specific to ion etched interfaces. These states are responsible for  $\Phi_B$  modification. (Edited author abstract) 12 refs. In French.

Neffati, T. (CNRS, Orsay, Fr); Maeref, H.; Barret, C. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 267-269.

## Reliability

**096538 DEATH BY A THOUSAND CUTS: THE PHYSICS OF DEVICE FAILURE THROUGH A SERIES OF ACTIVATED, MICROSCOPIC EVENTS.** A physical model describes device failure in terms of a series of n microscopic events (such as defect creation) which are describable in terms of an identifiable activation energy. The results show a 'Weibull like' time dependence, but the temperature dependence is not of the simple Arrhenius form. Application is made to the 'dark' leakage current in a PIN photodiode and to the deviation in threshold voltage in a MOSFET. In particular the threshold voltage is shown to depend on a series of activated processes, and the required number of such processes to cause failure increases with the width of the gate electrode. (Author abstract) 8 refs.

Holden, A.J. (Plessey Research Caswell Ltd, Towcester, Engl); Allen, R.W.; Beasley, K.; Parker, D.R. *Qual Reliab Eng Int* v 4 n 3 Jul-Sep 1988 p 247-254.

**Research** See Also SEMICONDUCTOR MATERIALS—Spectroscopic Analysis.

**096539 METAL-POLYMER SCHOTTKY BARRIERS ON CAST FILMS OF SOLUBLE POLY(3-ALKYLTHIOPHENES).** We present the results of a study of strong rectification by metal-polymer (Schottky) diodes made by evaporating metal contacts onto films of a soluble semiconducting polymer cast from solution. Poly(3-hexylthiophene), a soluble alkyl derivative of poly(thiophene), and indium contacts form the Schottky diodes. Current-voltage characteristics exhibit rectification ratios in the range 100:1 to 1000:1; the forward current increases exponentially over several decades, whereas a relatively small leakage current flows under reversed bias. Capacitance-voltage data indicate nearly uniform dopant concentration over a depth of about 1500 angstrom. (Author abstract) 14 refs.

Tomozawa, H. (Univ of California, Santa Barbara, CA, USA); Braun, D.; Phillips, S.; Heeger, A.J.; Kroemer, H. *Synth Met* v 22 n 1 Nov 1987 p 63-69.

**Simulation** See SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Transients.



## Spectroscopic Analysis

**096540 FAST CAPACITANCE METER FOR DEEP-LEVEL SPECTROMETERS.** A high-precision fast capacitance meter based on a 2T bridge for studying fast (up to 1  $\mu$ sec) relaxation of the capacitance of semiconductor diode structures is described. A theoretical analysis is performed and the conditions under which the maximum fast-response of the meter is achieved while preserving its high accuracy, are calculated. (Author abstract) 15 refs.

Puzin, I.B. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Khrounzhii, A.I. *Instrum Exp Tech* v 30 n 3 pt 2 May-Jun 1987 p 701-704.

**Spectrum Analysis** See LASERS, SEMICONDUCTOR; LASERS, SEMICONDUCTOR—Spectrum Analysis.

**Substrates** See LASERS, SEMICONDUCTOR—Mathematical Models.

**Switching** See ANTENNAS—Phased Arrays.

**Temperature Effect** See SEMICONDUCTOR DEVICES, SCHOTTKY BARRIER—Temperature Effect.

## Temperature Measurement

**096541 CRYOGENIC THERMOMETRY AND LEVEL DETECTION WITH COMMON DIODES.** Common silicon diodes, manufactured for room temperature electronics, have been used successfully both for thermometry down to 4 K and for liquid helium level monitoring. Ageing has been checked and a novel level detector is fully described. It is the purpose of the present work to report properties of the glass-encapsulated switching diode 1N914 and the plastic-encapsulated rectifier diode 1N4002 when used as cryogenic thermometers. The common gallium arsenide LED has also been investigated. 8 refs.

Talpe, J. (Univ de Buenos Aires, Argent); Stolovitzky, G.; Bekeris, V. *Cryogenics* v 27 n 12 Dec 1987 p 693-695.

**Theory** See MATHEMATICAL TECHNIQUES—Algorithms.

**Tunneling** See Also SEMICONDUCTING GALLIUM COMPOUNDS—Performance.

**096542 BULK TUNNELING CONTRIBUTION TO THE REVERSE BREAKDOWN CHARACTERISTICS OF  $\text{InSb}$  GATE CONTROLLED DIODES.** This work presents measurements and analysis of optimized reverse breakdown characteristics of  $\text{InSb}$   $p^+n$  gate controlled mesa diodes. Surface current contributions were minimized by adjusting the potential of the peripheral gate electrode. The resulting measured breakdown currents are found to be proportional to the junction area and exhibit diode bias and temperature dependence that fit quantitatively to direct band-to-band tunneling theory of one sided abrupt junction devices. The agreement between theory and experiment, achieved without any fitting parameter, confirms that bulk band-to-band direct tunneling mechanism is the fundamental limit for the diodes reverse bias performance. (Author abstract) 11 refs.

Adar, R. (Technion-Israel Inst of Technology, Haifa, Isr); Nemirovsky, Y.; Kidron, I. *Solid State Electron* v 30 n 12 Dec 1987 p 1289-1293.

**096543 ELEVEN-BIT PARITY GENERATOR WITH A SINGLE, VERTICALLY INTEGRATED RESONANT TUNNELING DEVICE.** A vertically integrated diode (VID) with five negative differential resistance regions has been developed by stacking five resonant tunneling structures. This device can be used for processing both analogue and digital signals. An 11-bit parity checker was demonstrated using the VID. In this approach, a single device replaced a large number of exclusive-OR gates in a conventional parity checker. (Author abstract) 4 refs.

Lakhani, A.A. (Allied-Signal Aerospace Co, Columbia,

MD, USA); Potter, R.C.; Hier, H.S. *Electron Lett* v 24 n 11 May 26 1988 p 681-683.

**096544 QUANTUM TRANSPORT MODELING OF RESONANT-TUNNELING DEVICES.** A form of quantum transport theory has been developed to model the resonant-tunneling diode and similar devices in which quantum interference effects play a significant role. The internal state of the device is represented by the Wigner distribution function, with boundary conditions which model the effects of the electrical contacts to the device. Inelastic scattering processes are approximated by a classical Boltzmann collision operator, and the effects of different scattering processes on the device characteristics are evaluated numerically. (Author abstract) 11 refs.

Frenseley, William R. (Texas Instruments Inc, Dallas, TX, USA). *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 739-742.

**096545 QUANTUM TUNNELING PROPERTIES FROM A WIGNER FUNCTION STUDY.** We use a Wigner function description of a Gaussian wave packet to study tunneling through single and double quantum barriers. We note a tunneling time proportional to  $1/k$  and a constant delay time associated with tunneling for the single barrier. The resonant structure gives rise to peaks in tunneling time associated with the resonant energy of the system. We study the initial distribution for the resonant tunneling diode. This is computed from a scattering state basis. Time evolution of the resonant tunneling system is then performed, yielding transient and steady-state results for the I-V curves. (Author abstract) 15 refs.

Kluksdahl, N.C. (Arizona State Univ, Tempe, AZ, USA); Krizan, A.M.; Ringhofer, C.; Ferry, D.K. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 743-746.

**SEMICONDUCTOR DIODES, AVALANCHE** See Also OPTICAL COMMUNICATION EQUIPMENT; PHOTODETECTORS; PHOTONS—Measurements; SEMICONDUCTOR DIODES, PHOTODIODE—Analysis; SEMICONDUCTOR DIODES, PHOTODIODE—Heterojunctions; SEMICONDUCTOR DIODES, PHOTODIODE—Mathematical Models; SEMICONDUCTOR DIODES, PHOTODIODE—Performance; TRANSISTORS, BIPOLAR—Analysis.

**Analysis** See SEMICONDUCTOR DIODES, PHOTODIODE—Mathematical Models.

**Diffusion** See SEMICONDUCTOR DIODES, PHOTODIODE—Noise.

**Fabrication** See SEMICONDUCTOR DIODES, PHOTODIODE—Fabrication.

## Heterojunctions

**096546 MILLIMETER-WAVE HETEROJUNCTION MITATT DIODES.** An approximate large-signal design theory, fabrication techniques, and experimental results for millimeter-wave transit-time devices are described. The approximate large-signal analysis is used to investigate the power and efficiency of heterojunction and transit-time devices. The analysis results show that significant improvement can be achieved for MITATT (mixed tunnel-avalanche transit-time) and TUNNETT (tunnel transit-time) devices by using heterostructures for velocity modulation. A device fabrication process that uses a novel wafer-thinning technique is presented in detail. This technique allowed the fabrication of millimeter-wave diodes with GaAs thickness of 1.5  $\mu$ m with excellent yield. Both double-drift GaAs IMPATT (impact ionization avalanche transit-time) and heterojunction MITATT diodes were fabricated. The diodes were operated as oscillators between 65 and 93 GHz. A typical power output of 45 mW at 72 GHz for a 1%-duty-cycle, 1- $\mu$ s-pulsewidth operation was obtained. 14 refs.

Dogan, Numan S. (Washington State Univ, Pullman, WA, USA); East, Jack R.; Elta, Michael E.; Haddad, George I. *IEEE Trans Microwave Theory Tech* v MTT-35 n 12 Dec 1987, 1987 MTT-S Int Microwave Symp, Las Vegas, NV, USA, Jun 9-11 1987 p 1308-1316.

**Ion Implantation** See SEMICONDUCTOR DIODES, PHOTODIODE—Fabrication.

**Ionization** See SEMICONDUCTOR DIODES, PHOTODIODE—Ionization; SEMICONDUCTOR DIODES, PHOTODIODE—Noise.

## Microstructure

**096547 DEFECT MICROSTRUCTURE AND MICROPLASMAS IN SILICON AVALANCHE PHOTODIODES.** Soft, noisy silicon avalanche photodiodes were studied using the SEM electron beam induced current technique and transmission electron microscopy. They were found to contain varying concentrations of (i) diffusion-induced misfit dislocations, (ii) precipitates and (iii) cusps (lines of shallower penetration) in ragged  $p-n^+$  junctions due to dislocation-retarded diffusion. The noise was of classical microplasma form but the sites of this breakdown did not correlate with the precipitates as in most previous cases, but occurred at favored points along the cusps in the  $p-n^+$  junction. Low and intermediate densities of misfit dislocations were found to produce microplasmas with lower breakdown voltages than very high densities. The shallowest misfit dislocations produced the greatest diffusion retardation, suggesting that removal of atoms from the diffusing flux by segregation to the dislocation is the mechanism responsible. (Author abstract) 37 refs.

Lesniak, M. (Imperial Coll of Science & Technology, London, Engl); Holt, D.B. *J Mater Sci* v 22 n 10 Oct 1987 p 3547-3555.

**Noise** See SEMICONDUCTOR DIODES, PHOTODIODE—Noise.

## Radiation Effects

**096548 MEASUREMENTS OF NATURAL RADIATION EFFECTS IN LOW NOISE AVALANCHE PHOTODIODE.** Low-noise avalanche photodiodes (APDs) were irradiated to determine their sensitivity to the natural space environment. Radiation effects on important APD parameters were determined by exposure to 1.5-MeV electrons from a Van de Graaf generator and to gamma rays from a  $^{60}\text{Co}$  source, both to a total dose of 300 krad (Si). During irradiation, the dc dark current and an associated  $1/f$  noise were found to increase linearly with dose only if bias voltage was applied. A  $t^{-x}$  annealing behavior was observed. Radiation-damage coefficients, threshold dose rates, and threshold fluences are calculated. 8 refs.

Swanson, Eric A. (MIT, Lexington, MA, USA); Arnau, Elaine R.; Walther, Frederick G. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1658-1663.

**SEMICONDUCTOR DIODES, GUNN** See Also NOISE GENERATORS—Research; OSCILLATORS, GUNN—Analysis; WAVEGUIDES, DIELECTRIC—Accessories; WAVEGUIDES, RECTANGULAR.

**Applications** See SIGNAL GENERATORS—Design.

## Design

**096549 USE OF THE QUASI-HYDRODYNAMIC METHOD TO CALCULATE THE IMPEDANCE OF GUNN DIODES WITH BALLISTIC ELECTRON MOTION.** Generalized relations are obtained for the propagation constants of spacecharge waves in semiconductors with negative differential mobility using the quasi-hydrodynamic method. An analytical expression is obtained for the microwave impedance of GaAs Gunn diodes having a structure of the type  $n^+-n-n^+$ . It is shown that unlike existing relations, this relation enables the ballistic or noncollisional nature of the motion of the charge carriers in a Gunn diode to be taken into account in the millimeter wave band. (Author abstract) 10 refs.

Rozdobud'ko, V.V. *Radioelectron Commun Syst* v 30 n 5 1987 p 13-17.



## Electric Properties

**096550 EXPERIMENTAL DETERMINATION OF THE DEPENDENCE OF THE ADMITTANCE OF A GUNN DIODE ON THE AMPLITUDE OF THE A-C VOLTAGE AND THE FREQUENCY.** The dependence of the admittance of the active region of an AA-703 diode on the amplitudes of the ac voltage across it are investigated for several frequencies (9.0, 9.1, 9.2, 9.3, 9.4, 9.5 and 9.8 GHz) by the self-excited oscillator method with a varying load. The parameters of the equivalent circuit of the diode case, the load impedance in the plane of the diode and the power absorbed by this load are measured. The results obtained are used to calculate the admittance of the diode and the voltage amplitude. The measurement method is described and the results obtained are presented and discussed. (Author abstract). 10 Refs.

Grigor'Yev, M.A.; Kolosov, V.V.; Navrotskaya, Yu.N. *Sov J Commun Technol Electron* v 32 n 10 Oct 1987 p 169-177.

## Junctions

**096551 EXPERIMENTAL STUDY OF JUNCTIONS WITH A LOW n-GaAs BARRIER.** A simple method is described for measuring a low potential barrier on the cathode of a Gunn diode. Measurements of the characteristics of junctions with a barrier height of 0.1-0.2 eV are presented. The temperature-dependence of the barrier height is determined. (Author abstract) 11 refs.

Dubrovskiy, V.N.; Karasev, A.S.; Kireyev, O.A. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 38-42.

**Millimeter Waves** See OSCILLATORS, GUNN—Millimeter Waves.

**Noise** See OSCILLATORS, GUNN—Design.

## Testing

**096552 NONRECIPROCALITY IN A GUNN DIODE IN CROSSED STATIONARY ELECTRIC AND MAGNETIC FIELDS.** The effect of a magnetic field on the characteristics of Gunn diodes has been investigated by a number of research workers. It was found, in particular, that there is a change in the threshold electric field when the diode is placed in a stationary magnetic field. The observed changes in the characteristics are due to the magnetoresistive effect. Only the dependence of the characteristics of the Gunn diode on the value of the magnetic field were investigated, and the dependence of the characteristics on the direction of the magnetic field was ignored. 7 refs.

Usanov, D.A.; Skripal, A.V. *Radioelectron Commun Syst* v 30 n 5 1987 p 53-55.

**096553 FEATURES OF THE OSCILLATORY CHARACTERISTICS OF MILLIMETER-BAND GUNN DIODES.** An investigation of the form of the oscillatory characteristics of Gunn diodes enables one to explain the features of the oscillation build up process, and enables one to make recommendations for choosing the optimum value of the load admittance and the supply voltage of a Gunn-diode generator. The results of the investigation enable us to explain why it is possible in practice to obtain self-excited oscillations when a Gunn diode operates in a series-oscillatory circuit. 1 ref.

Knyazeva, L.P.; Murav'ev, V.V.; Shalatonin, V.I. *Radioelectron Commun Syst* v 30 n 5 1987 p 67-69.

## Thermal Effects

**096554 THERMAL STUDY OF A GUNN DIODE IN MICROSTRIP CIRCUITS.** The steady-state thermal behavior of a microstrip Gunn diode circuit is studied with the goal of reducing the device temperature by varying microstrip thicknesses. The temperature increases in the device and in the heat sink are considered separately. The device temperature is analyzed by the finite element technique. The heat sink resistance is calculated by

simplified analytical schemes. (Author abstract). 16 Refs.

Tseng, A.A. (Drexel Univ, Philadelphia, PA, USA). *Arch Elektrotech (Berlin)* v 71 n 5 1988 p 349-355.

**SEMICONDUCTOR DIODES, IMPATT** See Also OSCILLATORS—Analysis; OSCILLATORS—Millimeter Waves; OSCILLATORS—Testing; OSCILLATORS, MICROWAVE; SEMICONDUCTING GALLIUM ARSENIDE—Growth.

**096555 PULSE DRIVEN MBE GaAs IMPATT DIODES FOR MM WAVES.** First results on MBE grown pulse driven GaAs Impatt diodes for V-band frequencies are reported. The diode design is based on recent investigations on the electron drift velocity in highly doped GaAs. 6.5 W peak rf-output power at 68 GHz are obtained from single-drift flat-profile diodes. Some aspects on further optimization are discussed. (Author abstract) 20 refs.

Pierzina, Reinert (Technische Univ Muenchen, Munich, West Ger); Grothe, Helmut. *AEU Arch Elektron Uebertrag Electron Commun* v 41 n 4 Jul-Aug 1987 p 242-245.

**096556 EXPERIMENTAL AND THEORETICAL INVESTIGATIONS ON A DISC-TYPE RESONANT STRUCTURE FOR IMPATT DIODES AT D-BAND FREQUENCIES.** The tuning behaviour of IMPATT diodes in a disc-type resonant cap structure is experimentally investigated between 130 GHz and 150 GHz for different load parameters. The measured results are compared with theoretical curves obtained from an IMPATT impedance expression and the resonator impedance analysed by a field matching technique. An encouraging agreement of theoretical predictions and experimental results can be observed. (Author abstract). 6 Refs.

Wenger, Josef (Technische Univ Muenchen, Munich, West Ger); Guettich, Ulrich. *AEU Arch Elektron Uebertrag Electron Commun* v 42 n 3 May-Jun 1988 p 203-205.

## Analysis

**096557 SIMPLIFIED FIELD ANALYSIS OF A DISTRIBUTED IMPATT DIODE USING MULTIPLE UNIFORM LAYER APPROXIMATION.** A small-signal field analysis of a distributed IMPATT (impact avalanche and transit time) diode is presented. The active region of the diode is assumed to consist of a uniform avalanche layer and avalanche-free drift layers. The propagation constant and field distributions are obtained without numerical solution of differential equations. The effects of losses caused by the presence of inactive layers are included in the analysis. Numerical examples of GaAs double-Read distributed IMPATT diodes are given which show the dependence of the amplification characteristics on the thicknesses of the avalanche and drift layers. 11 refs.

Matsumoto, Masayuki (Osaka Univ, Suita, Jpn); Tsutsumi, Makoto; Kumagai, Nobuaki. *IEEE Trans Microwave Theory Tech* v 36 n 8 Aug 1988 p 1283-1285.

## Calculations

**096558 COMPUTATION OF LARGE SIGNAL GaAs IMPATT DIODE PARAMETERS FROM CLOSED FORM ANALYTICAL SOLUTION.** The paper discusses the computation of the large signal admittance and power in Read and abrupt junction structures based on the approximate closed form solution and considering the basic device structure parameters. The results have been compared with the simulation results on the more realistic Read model and found satisfactory throughout a fairly large RF voltage range. The applicability of the analysis for optimum device design is as good as the simulation, with the advantages of lower cost and greater simplicity in terms of the computer program involved. (Author abstract) 11 refs.

Shukla, S.R. (Government of India, Delhi, India); Swarup, Prem; Sen, M.N. *IEE Proc Part I* v 135 n 1 Feb 1988 p 13-16.

**Electric Properties** See OSCILLATORS, MICRO-WAVE—Space Charge.

## Fabrication

**096559 NEAR STATE-OF-THE-ART POWER IN P<sup>+</sup>-N-N<sup>+</sup> D-BAND IMPATT DIODE ON A WAFER WITH RAMPED N-N<sup>+</sup> INTERFACE.** The fabrication of a near state-of-the-art ( $P_0 = 110$  mW,  $\pi = 4.85\%$  p<sup>+</sup>-n-n<sup>+</sup> D band ( $f = 124$  GHz) Si IMPATT diode on a wafer with ramped n-n<sup>+</sup> interface is described. The introduction of a critical annealing step, prior to p<sup>+</sup> diffusion, in the fabrication sequence of the diode has been found to yield the above results. Possible reasons for power and efficiency enhancement has been discussed. 5 refs.

Singh, J.K. (CEERI, Rajasthan, India); Gokgor, H.S.; Howard, A.M.; Myers, F.A. *Proc IEEE* v 75 n 12 Dec 1987 p 1688-1690.

**Heterojunctions** See SOLID STATE DEVICES—Millimeter Waves.

## Measurements

**096560 MEASUREMENT OF LOSS RESISTANCE AND AVALANCHE FREQUENCY OF IMPATT DIODES.** Direct methods for measuring loss resistance and the avalanche frequency  $\Omega$  of IMPATT diodes involve difficulties associated with analysis of measurement-chamber parameters and processing of the experimental results. As the frequency goes up these difficulties increase. It is precisely at the shortwave end of the microwave range that the advantages of IMPATT diodes over other types of semiconductor devices are particularly apparent, however. A technique for measuring avalanche frequency and loss resistance of IMPATT diodes is outlined. Its principal advantages are as follows: the possibility of employing simple measurement sections requiring no calibration; the improved frequency range of measurements; the possibility of measuring the parameters of caseless diodes; universality; and the greater ease of determining and processing the experimental results. 4 Refs.

Skachko, V.I.; Kosinskii, V.S.; Gorlachev, V.E. *Radioelectron Commun Syst* v 30 n 10 1987 p 89-91.

## Millimeter Waves

**096561 ANALYSIS OF A MILLIMETER-WAVE IMPATT DIODE BY A MODIFIED READ MODEL.** A modified Read model analysis is proposed for millimeter-wave IMPATT diodes. The energy relaxation time and the ionization rates which have been obtained from the microscopic model are taken into account in this modified analysis. The validity of applying this analysis to millimeter-wave IMPATT diodes is examined. (Author abstract) 4 refs.

Fukushima, Makoto (Shimane Univ, Matsue, Jpn). *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 8 Aug 1987 p 709-711.

## Testing

**096562 IMPACT IONIZATION RATES IN (100)-GaAs AT HIGH ELECTRIC FIELDS DERIVED FROM AVALANCHE BREAKDOWN OF SUBMICRON PIN-DIODES.** From measured breakdown-voltages of GaAs-pin-diodes fabricated with MBE the average ionization rate is deduced for fields up to  $10^6$  V/cm, taking into account deadspaces and field penetration into the cladding p- and n-layer. (Author abstract) 7 refs.

Claassen, Manfred (Technische Univ Muenchen, Munich, West Ger); Grothe, Helmut; Pierzina, Reinert; Harth, Wolfgang. *AEU Arch Elektron Uebertrag Electron Commun* v 41 n 6 Nov-Dec 1987 p 380-381.



**SEMICONDUCTOR DIODES, LIGHT EMITTING**

See Also ALUMINUM COMPOUNDS—Optical Properties; DISPLAY DEVICES—Liquid Crystals; LASERS, SEMICONDUCTOR—Mathematical Models; OPTICAL COMMUNICATION EQUIPMENT; OPTICAL DEVICES—Measurements; OPTICAL FIBERS; OPTICAL FIBERS—Measurements; OPTOELECTRONIC DEVICES; SCALES AND WEIGHING—Stability; SEMICONDUCTING GALLIUM ARSENIDE; SEMICONDUCTING GALLIUM ARSENIDE—Doping; TELECOMMUNICATION LINKS, OPTICAL—Modular Construction.

**096563 BACK LIGHTING USING ARGUS LEDS.**

Based on proven production techniques Siemens has developed a new LED with an extremely wide viewing angle. Together with reflector and diffuser, ARGUS LEDs are ideal for evenly illuminated large areas. Background lighting of display systems is easily done with the new light emitting diodes. (Author abstract)

Kristufek, Peter (Siemens AG, Munich, West Ger). *Siemens Compon* v 22 n 5 Oct 1987 p 180-182.

**096564 1.3μm WAVELENGTH InGaAsP/InP LIGHT EMITTING DIODES.** A 1.3μm wavelength InGaAsP/InP light emitting diode has been developed as a light source for optical fiber transmission systems. High-radiance and high-speed performance are achieved by the use of double heterostructure and current confinement structure. When this light emitting diode is coupled to a 50μm core 0.2-NA graded-index fiber, the optical power is 15μW at 50mA current. The cut-off frequency at -3db optical output power is 100 MHz at 50 mAdc with 10% modulation. The diode has a high reliability with an estimated half-power lifetime of 10<sup>7</sup> hours at room temperature. (Author abstract) In Japanese. 8 refs.

Sawa, Kazuhiro (Matsushita Electronics Corp, Jpn); Hirayama, Kenji; Otsuka, Yasuhiro; Matsuda, Toshio; Nagao, Shigeru; Koike, Susumu. *Natl Tech Rep Matsushita Electr* v 34 n 1 Feb 1988 p 20-26.

**096565 COUPLING EFFICIENCY OF SURFACE-EMITTING LED'S TO SINGLE-MODE FIBERS.** Using coherent-mode representation, the light emission of a surface-emitting LED (SELED) with a Lambertian far-field and a uniform near-field intensity is expressed by coherent modes. The coupling efficiency of the SELED to a single-mode fiber is calculated as the weighted sum of the coupling efficiencies of the coherent modes to the fiber mode. The absolute maximum achievable efficiency is found to be the inverse of the number of the coherent modes, and is equal to  $(\lambda^2/\pi A)$ , where  $\lambda$  is the LED emission area and  $A$  is the emission wavelength. This efficiency can be obtained by butt coupling if the LED area  $A$  is about equal to or larger than the fiber mode size. The theoretical prediction agrees well with published experimental data. 19 refs.

Chen, Kuo-Liang (Hewlett Packard Co, San Jose, CA, USA); Kerps, Dieter. *J Lightwave Technol* v LT-5 n 11 p 1600-1604.

**Applications** See Also ELECTRIC SWITCHES—Applications; FIBER OPTICS—Performance; OPTICAL FIBERS—Measurements; TELEVISION BROADCASTING—Synchronization.

**096566 LIEHTEMITTERDIODE ALS STRAHLUNGSQUELLE DER NICHTMECHANISCHEN DRUCKTECHNIK.** [Light Emitting Diode as Radiation Source for the Non-Mechanical Printing Technique]. Light emitting diodes have been internationally used for picture tracing since 1971. The paper presents application possibilities of LEDs being suitable for non-mechanical picture tracing by means of application cases and test results. (Author abstract) 13 refs. In German.

Deter, C. (Kombinat VEB Carl Zeiss Jena, East Ger); Rothe, S. *Feingeraetetechnik* v 36 n 6 1987 p 266-268.

**096567 LED-ZEILEN-MODULE.** [LED Line Modules]. LED line modules can be used favourably in the areas of reprographics, alphanumeric marking, optical display and scanning. Such modules contain 256 monolithically integrated LED's and the triggering IC's re-

quired. The emission lies within the red spectrum range, the resolution is of 16 luminous spots per millimetre. (Author abstract) 4 refs. In German.

Nather, Heinz (Univ Stuttgart, West Ger); Schairer, Werner. *F&M Feinwerktech Messtech* v 96 n 4 Apr 1988 p 144-146.

**Degradation** See SEMICONDUCTING GALLIUM ARSENIDE—Electronic Properties.

**Efficiency**

**096568 RED AlGaAs LIGHT-EMITTING DIODES.** HP has recently released indicator and display products containing a new type of red light-emitting diode (LED) based on the aluminum gallium arsenide (AlGaAs) materials system. These LEDs offer a significant improvement in efficiency over the red LEDs that have previously been available but cost only slightly more. This paper provides an overview of the different types of AlGaAs devices that are available and compares their performance to that of the other red LED technologies. (Edited author abstract).

Steranka, Frank M.; DeFever, Dennis C.; Camras, Michael D.; Tu, Chin-Wang; McElfresh, David K.; Rudaz, Serge L.; Cook, Louis W.; Snyder, Wayne L. *Hewlett Packard J* Aug 1988 p 84-88.

**Electric Properties**

**096569 SQUARE-PULSE SHAPER FOR LIGHT-EMITTING DIODE.** A power supply for a light-emitting diode is described that reduces by a factor of  $\approx 10$  the rise time of the radiation pulse (as compared with the certificate data) by correcting the shape of the current pulse that flows through the light-emitting diode. (Author abstract) 1 ref.

Dideikin, A.T. (Acad of Sciences of the USSR, Leningrad, USSR). *Instrum Exp Tech* v 30 n 2 pt 2 Mar-Apr 1987 p 481-482.

**Fabrication**

**096570 PREPARATION OF GAP RED LED'S BY LIQUID PHASE EPITAXY.** A liquid phase epitaxy system with rotation boat design has been developed to grow GaP epitaxial layers for red light emitting diode applications. The optimum growth condition was determined by optimizing both the light emission intensity and the uniformity of diodes fabricated from each wafer. Gap red light emitting diodes with an average quantum efficiency of 2.9% were routinely obtained. The maximum quantum efficiency was 3.5% for an uncoated diode driven with a current density of 6.3 A/cm<sup>2</sup>. (Author abstract) 8 refs.

Liu, R.S. (ITRI, Hsinchu, Taiwan); Chen, C.L.; Nee, C.Y.; Cheng, K.Y. *MRL Bull Res Dev* v 1 n 1 Mar 1987 p 27-33.

**096571 ERBIUM-DOPED GaAs LIGHT-EMITTING DIODES EMITTING ERBIUM f-SHELL LUMINESCENCE AT 1.54 μm.** GaAs light-emitting diodes emitting at 1.54 μm have been fabricated using Er-doped GaAs grown by metal organic chemical vapour deposition, and the output characteristics are reported. Characteristic emission from the internal 4f-shell transitions of erbium is observed even at room temperature, and the wavelength shifts by less than the measurement resolution of 1 nm over the temperature range from 180 K to 296 K. These results confirm the possibility of fabricating stable light sources using rare earth doped semiconductors. (Author abstract). 10 Refs.

Whitney, P.S. (NTT, Tokyo, Jpn); Uwai, K.; Nakagome, H.; Takahei, K. *Electron Lett* v 24 n 12 Jun 9 1988 p 740-741.

**Heterojunctions** See Also LASERS, RING—Mode Locking; SEMICONDUCTING GALLIUM COMPOUNDS—Performance.

**096572 DETERMINATION OF TEMPERATURE-DEPENDENT CARRIER LOSSES IN 1.3 μm InGaAsP/InP DOUBLE-HETEROSTRUCTURES.** This note describes a procedure for the experimental determination of the total carrier loss in the active region of light-emitting InGaAsP/InP DHS. This method is based on the temperature dependence of the relative intensity of the light emitted in a direction normal to the junction planes and measured in a current range typical for device operation conditions. Some experimental results are given. 8 refs.

Rheinlaender, B. (Karl-Marx-Univ, Leipzig, East Ger); Heilmann, R.; Oelgart, G. *Phys Status Solidi A* v 106 n 1 Mar 1988 p K113-K116.

**Junctions**

**096573 CARRIER INJECTION MECHANISM IN AN A-SIC P-I-N JUNCTION THIN-FILM LED.** A systematic study has been done on the carrier injection mechanism and electroluminescent properties of an amorphous silicon-carbide p-i-n junction thin-film light-emitting diode (a-SiC TFLED). The analysis of the junction characteristics reveals that the main contribution to the junction current comes from electrons injected by tunneling from the n-layer through the i-n interface notch barrier, while the electroluminescent property of the TFLED is determined by the injection process of holes. This process also takes place by tunneling, in this case from the p-layer through the p-i interface notch barrier. On the basis of the results of the analysis, a method to improve the LED performance using a hot-carrier-tunneling injector structure is proposed. With this structure, the brightness of the TFLED is increased by more than one order of magnitude to about 20 cd/m<sup>2</sup>, with an injection current density of 600 mA/cm<sup>2</sup>. 10 refs.

Kruangam, Dusit (Osaka Univ, Toyonaka, Jpn); Deguchi, Masahiro; Toyama, Toshihiko; Okamoto, Hiroaki; Hamakawa, Yoshihiro. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 957-965.

**Mathematical Models**

**096574 MONTE-CARLO MODEL OF A LIGHT-EMITTING DIODE.** The first complete Monte-Carlo model of a surface light-emitting diode is presented in this paper. In the model all important phenomena (including the two-dimensional diffusion of minority carriers before their recombination in the active region and the re-emission of radiation) are taken into account. The influence of various construction parameters on the external quantum efficiency of the homojunction GaAs diode is examined. (Author abstract) 30 refs.

Pufal, Slawomir (Technical Univ of Lodz, Lodz, Pol); Nakwaski, Wlodzimierz. *Opt Quantum Electron* v 19 n 5 Sep 1987 p 289-292.

**Optical Properties**

**096575 MINORITY-CARRIER GENERATION AND RECOMBINATION IN 1.35 μm InGaAsP/InP DOUBLE HETEROSTRUCTURE DIODES.** In mesostructure diodes with differently spaced p-n and heterojunctions the electron-beam induced current and cathodoluminescence, C-U characteristics, DLTS, and photoreponse as well as the injection luminescence as functions of the wavelength, temperature, and time were measured. The InP-interlayer suppresses the collection of the photogenerated holes by means of the valence band offset-induced pile-up effect at low illumination levels and low temperatures, delays the motion of the holes during the collection at high illumination levels and reduces the hole injection into the n-type quaternary active layer at low temperatures. Due to the separation of the p-n junction from the active layer, the content of nonradiative recombination centres in the active layer is reduced. (Edited author abstract). 20 Refs.

Rheinlander, R. (Karl-Marx-Univ Leipzig, Leipzig, East Ger); Grummt, G.; Kovac, J.; haefer, H.; Heilmann, R. *Phys Status Solidi A* v 107 n 1 May 1988 p 405-418.



**096576 PROPERTIES OF RED LIGHT EMITTING (Al,Ga)As DOUBLE HETEROSTRUCTURE DIODES.** Using the spectral response of the photocurrent, various modes of a scanning electron microscope, photo and injection luminescence as well as the capacitance-voltage technique, the characteristic parameters of GaAlAs diode structure and material properties were investigated and compared with the brightness of the LEDs. The experiments involving different temperatures reveal insights into the injection properties at the heterobarriers. The metallurgical transition position outside the active layer near the heterojunction simultaneously ensures a high injection and material efficiency in the active region. The internal efficiency of the best diodes is about 55 percent at room temperature and is limited by the population of the indirect gap minima of the conduction band with rising AlAs-content. (Author abstract). 9 refs.

Grummt, G. (Karl-Marx-Univ Leipzig, Leipzig, East Ger); Haefner, H.; Oelgart, G.; Thielemann, W.; Pickenhain, R.; Jacobs, B. *Phys Status Solidi A* v 107 n 1 May 1988 p 419-428.

**Packaging** See OPTOELECTRONIC DEVICES—Packaging.

## Performance

**096577 BUTT COUPLING EFFICIENCY OF LONG-WAVELENGTH EDGE-EMITTING LEDs TO SINGLE-MODE FIBERS.** Butt coupling efficiency between edge-emitting LEDs operating at 1.3 and 1.55  $\mu\text{m}$  wavelengths and single-mode fibers, has been investigated using far-field pattern data. (Author abstract) 18 refs.

Ghafoori-Shiraz, H. (Anritsu Corp, Atsugi, Jpn). *Trans Inst Electron Inf Commun Eng Sect E (Engl)* v E70 n 7 Jul 1987 p 617-620.

**096578 BACK LIGHTING USING ARGUS LEDs.** Argus LEDs were developed for applications requiring homogeneous light over large areas, since their light emission covers a fairly large solid angle. With this special feature, Argus LEDs further extend the wide range of standard LEDs which are mainly suitable for switching or operating status indication, because their radiation is concentrated in the axial direction. The benefits of Argus LEDs can be fully utilized if an external reflector and a diffuser are used. In this arrangement, an even level of light from areas, symbols and characters is achieved.

Kristufek, Peter (Siemens AG, Munich, West Ger). *Displays* v 9 n 2 Apr 1988 p 85-87.

## Reliability

**096579 RELIABILITY OF LEDs AND QUATERNARY PHOTODIODES.** The reliability of GaAlAs and InGaAsP LEDs, and InGaAsP photodiodes, which have been used in the fiber-optic video distribution system, is studied. All devices are found to be sufficiently reliable. The study also showed that: (a) GaAlAs LEDs with Al content as large as 0.78  $\mu\text{m}$  band-gap have reliability comparable to the usual 0.8  $\mu\text{m}$  band-gap LEDs, (b) homogeneous degradation of InGaAsP LEDs is caused by electrode migration, (c) InGaAsP photodiodes do not endure electrical-surge as well as Ge photodiodes, and (d) discontinuous bias application improves device reliability. (Author abstract) 9 refs. In Japanese.

Uehara, Shingo (NTT, Jpn); Fukuda, Mitsuo; Sudo, Hiromi; Kaizu, Katsumi. *Denki Tsushin Kenkyusho Kenkyu Jitsuyoku Hakoku* v 36 n 8 1987 p 1097-1102.

## Research

**096580 PHOTOCONDUCTIVE INFRARED EXCITATION SPECTRUM OF GaP DIODE WAFERS AND APPLICATION AS AN INFRARED IMAGING SYSTEM.** The photoconductive excitation spectrum of GaP:N (ZnTe) diodes was measured irradiating the samples from p- and n-side under forward and reverse bias conditions. The ionization thresholds of S and Te donors as well as transitions from their ground states to excited

bound levels with subsequent ionization by the electric field can be observed. The observed minima in the continuum above the ionization threshold are due to phonon assisted fast recombination. (Edited author abstract) 9 refs.

Moser, K. (Univ Regensburg, Regensburg, West Ger); Brechter, M.; Pretti, W. *Int J Infrared Millim Waves* v 8 n 11 Nov 1987 p 1399-1410.

**096581 ENERGY TRANSFER INTO AND OUT OF MANGANESE IN THE ELECTROLUMINESCENCE OF ZnS:Mn AND ZnSe:Mn.** The response of electroluminescent Schottky diodes of ZnS:Mn and ZnSe:Mn to short drive pulses has been investigated. There is evidence for energy transfer into the manganese from centres which can be more efficiently excited, in addition to the impact excitation of the manganese centres themselves, and for energy transfer out of manganese into non-radiative centres. In ZnS:Mn the transfer processes into and out of manganese can be treated as being independent, and at low concentrations the decay follows the Forster law. In ZnSe:Mn the transfer into and out of manganese is correlated and there is no simple form for the decay curve. (Author abstract). 17 refs.

Rigby, N.E. (Univ of St. Andrews, St. Andrews, Scotl); Allen, J.W. *J Lumin* v 42 n 3 Sep 1988 p 143-148.

**Semiconductor Metal Boundaries** See SEMICONDUCTING GALLIUM COMPOUNDS—Contacts.

## Testing

**096582 LIFETIME TEST FOR HIGH-CURRENT-INJECTION STRAINED-LAYER SUPERLATTICE LIGHT-EMITTING DIODE.** The successful long-term operation of  $\text{GaAs}_{1-y}\text{P}_y\text{-In}_x\text{Ga}_{1-x}\text{As}$  strained-layer superlattice (SLS) light-emitting diodes under high constant current injection is discussed. This SLS can be grown ( $y \approx 2x$ ) with average lattice constant that matches that of the GaAs substrate. The LED structure grown by MOCVD (metalorganic chemical vapor deposition) on n-GaAs substrate consists of 10 periods of undoped  $\text{GaAs}_{1-y}\text{P}_y\text{-In}_x\text{Ga}_{1-x}\text{As}$  SLS sandwiched between p<sup>+</sup>- and n-GaAs films. A 3000-angstrom  $\text{SiO}_2$  layer was deposited by plasma-assisted CVD to make a 6- $\mu\text{m}$ -wide stripe structure. Diodes with typical dimensions of  $25 \times 300 \mu\text{m}^2$  were fabricated and showed ideality factor in the range between 2 and 3. Room-temperature lifetime tests were carried out for several devices ( $x = 0.1, y = 0.2$ ) at current injection of  $4000 \text{ A/cm}^2$ , for diodes emitting at 0.94  $\mu\text{m}$ . No degradation in the optical intensity was observed after more than 2000 h of operation. The EL spectral peak position remained unchanged while the spectral line width increased by about 5.7 meV during the test period. By varying the value of x, LEDs emitting at wavelength in the range from 0.9 to 1.1  $\mu\text{m}$  were achieved. The emission properties and lifetime of these LEDs are discussed.

Katsuyama, T. (North Carolina State Univ, Raleigh, NC, USA); Yang, Y.J.; Moore, D.; Karam, N.; Bedair, S.M. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2379.

**SEMICONDUCTOR DIODES, PHOTODIODE** See Also ACCELERATORS, SYNCHROTRON—Accessories; CALORIMETERS—Performance; CALORIMETERS—Readout Systems; IMAGE SENSORS; INTEGRATED CIRCUITS, MONOLITHIC; INTEGRATED OPTICS—Mathematical Models; LASER BEAMS—Effects; OPTICAL COMMUNICATION EQUIPMENT; OPTICAL COMMUNICATION EQUIPMENT—Performance; OPTICAL DEVICES—Performance; OPTICAL VARIABLES MEASUREMENT; OPTOELECTRONIC DEVICES—Performance; PARTICLE DETECTORS—Testing; PHOTODETECTORS—Applications; SCINTILLATION COUNTERS; SIGNAL RECEIVERS—Design.

**096583 TWO-DIMENSIONAL PHOTODIODE USING a-Si PIN DIODES.** This paper proposes a two-dimensional photodiode composed of an a-Si pin junction. The photodiode is constructed on the glass substrate. The pixel of the sensor is of a simple structure

composed of two photodiodes connected in opposite directions between the vertical and the horizontal signal lines. The photodiode constructed by a-Si pin junction has the function of the blocking diode, preventing the crosstalk in reading out the signal, in addition to the photoelectric conversion. A two-dimensional  $5 \times 5$  photosensor was constructed experimentally, and the basic operation was verified. (Edited author abstract) 10 refs.

Senda, Kohji (Matsushita Electronics Corp, Takatsuki, Jpn); Susa, Masahiro; Hiroshima, Yoshimitsu; Takamura, Tohru. *Electron Commun Jpn Part 2* v 70 n 10 Oct 1987 p 9-15.

**096584 MBE GROWN MONOLITHIC INTEGRATED InGaAlAs/InP RIDGE WAVEGUIDE PHOTODIODES.** The first monolithic integration of a low loss InGaAlAs Ridge waveguide with a low leakage InGaAs photodiode is demonstrated. The structure has been grown by molecular beam epitaxy on a n<sup>+</sup>-InP substrate, using an InGaAlAs layer with a bandgap of 1.29  $\mu\text{m}$ , suitable for waveguiding at 1.55  $\mu\text{m}$  wavelength. Absorption of the guided light is provided by leaky coupling from the InGaAlAs guiding layer into the higher index InGaAs absorbing region containing a p/n junction. The devices showed external quantum efficiencies as high as 20% for operation at 1.55  $\mu\text{m}$  wavelength. This is the first demonstration of a monolithic integrated waveguide device in the InGaAlAs/InP material system. (Author abstract) 28 refs.

Cinguino, P. (CSELT, Turin, Italy); Genova, F.; Rigo, C.; Cacciatori, C.; Stano, A. *CSELT Tech Rep* v 15 n 6 Oct 1987 p 421-424.

**096585 LIGHT SENSING WITH OPTICAL ICS.** Traditionally photodiodes have been used in conjunction with hybrid amplifier circuitry to perform certain signal processing applications, e.g. light current amplification, light threshold detection and light demodulation. But because photodiodes can be built out of silicon, this has given the IC designer the ability to fabricate both the hybrid circuitry and the photodiode on the same silicon substrate. The article reviews optical sensor applications, absolute light measurement, optocouplers-optoisolators, and rotary position encoding using optical emitter-detector assemblies.

Cook, Derek. *New Electron* v 20 n 17 Sep 1 1987 p 33-35.

**096586 NEGATIVE RESISTANCE WITH AUGER SUPPRESSION IN NEAR-INTRINSIC, LOW-BANDGAP PHOTO-DIODE STRUCTURES.** The theory of PIN diodes made with narrow band gap material possessing appreciable Auger generation processes predicts negative resistance effects in reverse bias, accompanied by Auger suppression. The presence of moderate impurity concentrations in the intrinsic region can modify the behavior so that a complete family of Auger-suppressed devices is revealed with interesting variations in the modes of operation. Practical IR detectors and other devices will require heterostructure technology to minimize contact generation currents. (Author abstract) 6 refs.

White, A.M. (Royal Signals & Radar Establishment, Malvern, Engl). *Infrared Phys* v 27 n 6 Nov 1987 p 361-369.

**096587 DIODE LASER A HETEROSTRUCTURE ENFOUÏE OPTIMISEE POUR APPLICATION AU DELA DE 2 GBIT/S.** [Optimized Buried Heterostructure Laser Diode for Application Above 2 Gbit/s]. A 1300 nm InGaAsP buried heterojunction structure used in single-mode fiber optical transmission systems developed by les Laboratoires de Marcoussis and manufactured by Alcatel-CIT, has been optimised by partially suppressing the parasitic capacitances of the reverse biased binary junctions located on both sides of the active layer. A significant decrease of the chip capacitance allows one to modulate laser diodes with a series resistance larger than  $10 \Omega$  at 2 Gbit/s NRZ. With such a high bit-rate 1300 nm laser source, an optical transmission experiment at 2.6



Gbit/s has been achieved by Alcatel Transmission at Lannion, showing the high bit-rate performances of the new structure. (Author abstract) 5 refs. In French.

Carriere, Claude (Alcatel, La-Ville-du-Bois, Fr); Renard, Jean; Doll, Andre; Ceurjolly, Christian. *Ann Telecommun* v 43 n 1-2 Jan-Feb 1988 p 78-82.

**096588 ULTRA-WIDE-BAND LONG-WAVELENGTH P-I-N PHOTODETECTORS.** The authors compare several designs for very high-speed (millimeter-wave) long-wavelength photodetectors, materials for such detectors, and ways of characterizing the speed of these devices. Experimental results are given, showing high-speed response with bandwidths beyond 50 GHz, impulse responses less than 10 ps, and detection sensitivities to 0.1 fJ in packaged devices. The inherent bandwidth-efficiency limit in conventional p-i-n detectors is discussed and compared to theoretical and experimental results for waveguide-geometry detectors. 56 refs.

Bowers, John E. (AT&T Bell Lab, Holmdel, NJ, USA); Burrus, Charles A. Jr. *J Lightwave Technol* v LT-5 n 10 p 1339-1350.

**096589 MULTIGIGABIT-PER-SECOND AVALANCHE PHOTODIODE LIGHTWAVE RECEIVERS.** The authors review theoretical and experimental performance of high-speed III-V avalanche photodiodes (APDs) and of multigigabit-per-second lightwave receivers using FET and bipolar amplifiers. Particular attention is given to the APD gain-bandwidth product and its effect on high-speed receiver sensitivity. Comparisons between measured receiver sensitivities and calculated performance are presented for bit rates up to 8 Gb/s. 69 refs.

Kasper, Bryon L. (AT&T Bell Lab, Holmdel, NJ, USA); Campbell, Joe C. *J Lightwave Technol* v LT-5 n 10 p 1351-1364.

**096590 FAST DIFFUSION-DRIVEN PHOTODETECTOR: THEORY AND EXPERIMENT.** A high-speed photodetector has been demonstrated. Prototype silicon devices have detection bandwidths of 5 GHz and are limited by neither the saturation-velocity transit time nor the carrier lifetime. These detectors use a combination of the Dember effect and the ease of generating fine photocarrier gratings, and scale to bandwidths of several hundred gigahertz. 9 refs.

Kostenbauder, Adnah (Stanford Univ, CA, USA); Yoo, S.J.B.; Siegman, A.E. *IEEE J Quantum Electron* v 24 n 2 Feb 1988 p 240-244.

**096591 TUNABLE SUPERLATTICE P-I-N PHOTODETECTORS: CHARACTERISTICS, THEORY, AND APPLICATIONS.** Extended measurements and theory on the recently developed monolithic wavelength demultiplexer consisting of voltage-tunable superlattice p-i-n photodetectors in a waveguide configuration are discussed. It is shown that the device is able to demultiplex and detect two optical signals with a wavelength separation of 20 nm directly into different electrical channels at a data rate of 1 Gb/s and with a crosstalk attenuation varying between 20 and 28 dB, depending on the polarization. The minimum acceptable crosstalk attenuation at a data rate of 100 Mb/s is determined to be 10 dB. The feasibility of using the device as a polarization angle sensor for linearly polarized light is also demonstrated. A theory for the emission of photogenerated carriers out of the quantum wells is included, since this is potentially a speed limiting mechanism in these detectors. It is shown that a theory of thermally assisted tunneling by polar optical phonon interaction is able to predict emission times consistent with the observed temporal response. 61 refs.

Larsson, Anders (Chalmers Univ of Technology, Goteborg, Sweden); Andrekson, Peter A.; Eng, Sverre T.; Yariv, Amnon. *IEEE J Quantum Electron* v 24 n 5 May 1988 p 787-801.

## Analysis

**096592 ANALYSIS OF A PIN PHOTODIODE WITH INTEGRATED WAVEGUIDE.** The absorption coefficient of an InGaAs PIN photodiode integrated with an InGaAsP-InP waveguide is analyzed by means of the mode-matching technique. The results compare excellently to published data for  $\lambda = 1.3 \mu\text{m}$ . It is shown that by an optimized device structure the absorption coefficient can be increased to about 0.15 dB/ $\mu\text{m}$ , enabling reduced detector length and smaller capacitance. (Author abstract) 5 refs.

Amann, M.-C. (Siemens AG, Munich, West Ger). *Electron Lett* v 23 n 17 Aug 13 1987 p 895-897.

**096593 MULTILAYER APDs PRODUCING UP TO TWO IMPACT IONISATIONS PER CARRIER PER STAGE: OPTICAL RECEIVER PERFORMANCE ANALYSIS.** Previous analyses of the gain and noise properties of superlattice avalanche photodiodes (APDs) are extended to allow for the production of up to two impact ionizations per initiating carrier per stage. The sensitivity of optical receivers employing these advance APD structures is determined, allowing for the influence both of residual hole ionization and dark current. These devices are found to have higher gain and noise figures than their single ionization electron counterparts. Receiver sensitivity studies are reported, which indicate that dark current and residual hole ionization are of increased significance, but that provided these effects are small, improved performance is obtained. (Author abstract) 42 refs.

Fyath, R.S. (Univ Coll of North Wales, Bangor, Wales); O'Reilly, J.J. *IEE Proc Part J* v 135 n 2 Apr 1988 p 101-108.

**096594 InP/Ga<sub>0.47</sub>In<sub>0.53</sub>As SUPERLATTICE AVALANCHE PHOTODIODE.** The article reports a theoretical study on the photoresponse characteristics of an InP/Ga<sub>0.47</sub>In<sub>0.53</sub>As superlattice p<sup>+</sup>i-n<sup>+</sup> APD for operation in the 1-1.6  $\mu\text{m}$  wavelength region. It has been found that the  $\beta/\alpha$  ratio for the structure is 16 for an electric field  $E = 3 \times 10^7/\text{m}$ . The device is thus expected to become an attractive low-noise detector for fiber-optic communication systems. The device has a quantum efficiency of 60% at  $\lambda = 1.3 \mu\text{m}$ . The bandwidth of the response curve is approximately 100 MHz. (Author abstract). 6 Refs.

Batra, S. (Birla Inst of Technology, Mesra, India); Lahiri, A.; Chakrabarti, P. *Electron Lett* v 24 n 15 Jul 21 1988 p 964-965.

**Applications** See Also INTERFEROMETRY, HOLOGRAPHIC; OPTOELECTRONIC DEVICES—Design.

**096595 MONOLITHIC PIN/AMPLIFIER PHOTORECEIVER.** An InGaAs/InP monolithic photoreceiver, in which a pin photodiode and a preamplifier are integrated, has been developed. The 8610 type photoreceiver (IMSO8610) has been developed so as to be applied to the systems with bit rates up to 400 Mb/sec. It operates with a single 5v power supply. A transimpedance of 965 ohms and a 3db cut-off frequency of 240 MHz have been obtained. The photoreceiver is so reliable that it can be used practically. In addition, a self-aligned FET with a cut-off frequency of 3 GHz has been developed to fabricate a higher-speed photoreceiver. (Author abstract) In Japanese. 9 refs.

Matsuda, Kenichi (Matsushita Electric Industrial Co, Jpn); Kubo, Minoru; Tojo, Masaaki; Ohnaka, Kiyoshi; Shibata, Jun. *Natl Tech Rep Matsushita Electr Ind Co* v 34 n 1 Feb 1988 p 35-40.

**096596 SIMPLE DATA LINK FOR PLASTIC FIBERS.** A simple data link which employs single-chip integrated photodetectors consisting of photodiodes and amplifiers has been developed. The link is of the single direction type and the twin direction type, with the features of open-collector output, small size and low cost. The simple data link makes possible easy development of

optical signal transmission system in new-medium communications, factory automation and office automation, as well as miniaturization of the equipment. The paper describes the design, characteristics and reliability test results of the optical connector modules comprising optical components. Also, it discusses the main characteristics of the simple data links in which these modules are employed. (Author abstract) In Japanese. 2 refs.

Nagata, Sadao (Matsushita Electronics Corp, Jpn); Taniguchi, Masaki; Yamaguchi, Masayuki. *Natl Tech Rep Matsushita Electr* v 34 n 1 Feb 1988 p 86-93.

**096597 INVESTIGATION OF AN OPTOELECTRONIC NONLINEAR EFFECT IN A GaInAs PHOTODIODE, AND ITS APPLICATION IN A COHERENT OPTICAL COMMUNICATION SYSTEM.** A nonlinear mixing effect has been predicted theoretically, and measured using a GaInAs PIN photodiode. The nonlinear effect has been simulated using a small signal finite difference model. The variation of the effect has been measured over the frequency range 1.2-15 GHz for a number of bias voltages from 5 to 20 v, and the effect has been shown to be optoelectronic in origin. A high frequency heterodyne experiment has been performed with the optical and local oscillator signals in the range 10-20 GHz. The difference beat frequency was observed at 500 MHz and 2 GHz. The measured conversion loss was between 27 and 40 db for a 0 dbm local oscillator signal. The application of the optoelectronic mixing effect to optical fiber frequency domain multiplex systems for the dissemination of frequency standards has been considered. (Author abstract) 18 refs.

Humphreys, D.A. (NPL, Teddington, Engl); Lobbett, R.A. *IEE Proc Part J* v 135 n 1 Feb 1988 p 45-51.

**096598 LOW ENERGY X-RAY AND GAMMA SPECTROSCOPY USING SILICON PIN PHOTODIODES.** An energy resolution of 1.43 keV (FWHM) for the 59.55 keV <sup>241</sup>Am  $\gamma$ -ray line at 19°C was obtained by using low-cost silicon PIN photodiodes. The dependence of energy resolution on detector and preamplifier temperature was investigated. At -40°C a FWHM of 1.04 keV was reached. Low energy Mn and Ti K X-ray spectra were also taken, and the 5.9 and 4.5 keV peaks were clearly resolved from the noise. Our measurements show that silicon PIN photodiodes are comparable in performance with the best room temperature silicon detectors which are considerably more expensive. (Author abstract) 5 refs.

Markevich, N. (Technion, Haifa, Israel); Gertner, I.; Felsteiner, J. *Nucl Instrum Methods Phys Res Sect A* v A269 n 1 Jun 1 1988 p 219-221.

**096599 H<sup>+</sup> AND He<sup>+</sup> SPECTROSCOPY USING SILICON PIN PHOTODIODES.** Silicon PIN photodiodes have been used in detecting H<sup>+</sup> and He<sup>+</sup> ions from a 1 Mev accelerator. Energy resolutions (FWHM) from 20 keV (at 16 keV) to 4.7 keV (at 1 Mev) for H<sup>+</sup> and from 3.4 keV (at 22 keV) to 9.8 keV (at 700 keV) for He<sup>+</sup> have been measured at room temperature. Resolution measurements over this energy range using a premium PIPS detector have also been performed. A comparison between the two detectors shows that the photodiodes exhibit better energy resolution over the whole energy range for H<sup>+</sup>, and comparable resolution for He<sup>+</sup>. It is argued that the resolution of the photodiode can be further improved by manufacturing a device with thinner entrance window. (Author abstract) 9 refs.

Markevich, N. (Technion Israel Inst of Technology, Haifa, Israel); Gertner, I.; Felsteiner, J. *Nucl Instrum Methods Phys Res Sect A* v A269 n 3 Jun 20 1988 p 599-602.

**096600 MINIATURE VACUUM PHOTODIODES FOR CALORIMETERS.** Data are presented on the performance of flat vacuum photodiodes 30 mm in diameter and 8 mm in height and with a quantum



efficiency of the photocathode of 24% for NaI(Tl) crystals. The effects of magnetic fields up to 2.3 T have been measured. (Author abstract) 5 refs.

Anashin, V.V. (Inst of Nuclear Physics, Novosibirsk, USSR); Aksenov, V.A.; Bagduyev, R.I.; Beschastnov, P.M.; Golubev, V.B.; Goldberg, I.I.; Mironenko, L.A.; Redko, I.Yu.; Serebnyakov, S.I.; Tikhonov, Yu.A. *Nucl Instrum Methods Phys Res Sect A* v A265 n 1-2 Mar 1988, Adv in Exp Methods for Colliding Beam Phys, Stanford, CA, USA, Mar 9-13 1987 p 301-302.

**Computer Aided Analysis** See Also PHOTOVOLTAIC CELLS—Mathematical Models.

**096601 MONTE CARLO SIMULATION OF BLOOMING AND CROSSTALK IN AN RL1024G DIODE ARRAY.** The RL1024G, a 2-in.-long linear array of 1024 photosensitive diodes, has been modeled by the Monte Carlo method. Good agreement has been obtained with experimental data using a simple model depending on a few parameters. Since the model can predict the signals from the array for a given illumination pattern, it describes the nonlinear response function of the array. Such a description is a prerequisite for the construction of a restoration method that calculates the true illumination from the registered one. 4 refs.

Philip, Johan (Royal Inst of Technology, Stockholm, Sweden); Carlsson, Kjell. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2260-2264.

**Defects** See SEMICONDUCTOR DIODES, AVALANCHE—Microstructure.

**Design** See Also RADIATION DETECTORS—Calibration.

**096602 ILLUMINATED BALLISTIC CAMEL DIODE: A NEW OPTOELECTRONIC NEGATIVE RESISTANCE DEVICE.** An appropriately designed illuminated ballistic camel diode (IBCD) should exhibit a negative resistance range of its current/voltage characteristics by the decrease of temporarily trapped, photoelectrically released minority carriers with increasing applied voltage. Integration with a pn light-emitting diode in a heterostructure provides a bistable memory element. (Author abstract). 4 refs.

Lehovec, K. *Electron Lett* v 24 n 13 Jun 23 1988 p 803-804.

## Electric Properties

**096603 SHORT WAVELENGTH RESPONSIVITY IMPROVEMENT AND LONG WAVELENGTH RESPONSIVITY DEGRADATION IN PHOTODIODES AS A RESULT OF GAMMA IRRADIATION.** Changes in surface and bulk properties of United Detector Technology pin-05D photodiodes as a result of 1.3 Mrad gamma irradiation are compared. Changes in surface properties are seen experimentally to significantly alter overall device characteristics. Changes in device properties include increases in surface conductivity, improved quantum efficiency at visible wavelengths, decreased infrared response, and decreased minority carrier lifetime. The first four results are new and permit differentiation between surface and bulk effects. A model consistent with all of these measurements is presented to explain the changes. The model is based upon gamma ray photodesorption of surface impurities. (Edited author abstract) 11 refs.

Hava, S. (Ben-Gurion Univ of the Negev, Beer Sheva, Isr); Kopeika, N.S. *Opt Eng* v 26 n 9 Sep 1987 p 959-962.

## Fabrication

**096604 SMALL-JUNCTION-AREA GaInAs/InP PIN PHOTODIODE WITH MONOLITHIC MICROLENSES.** We report on a back-illuminated GaInAs/InP photodiode with a monolithic microlens that we have fabricated. The photodiode has both an ultrabroad bandwidth of 18 GHz and a high quantum efficiency of about 84%. It achieves this by using a small pin junction area

while maintaining a large fibre alignment tolerance by incorporating an InP microlens. The photodiode capacitance was 20 fF for a junction diameter of approximately 15  $\mu\text{m}$ . (Author abstract) 8 refs.

Makiuchi, M. (Fujitsu Lab Ltd, Atsugi, Jpn); Wada, O.; Kumai, T.; Hamaguchi, H.; Aoki, O.; Oikawa, Y. *Electron Lett* v 24 n 2 Jan 21 1988 p 109-110.

**096605 InGaAs PIN PHOTODIODES ON RECESSED SEMI-INSULATING GaAs SUBSTRATES.** Low leakage current  $\text{Ga}_{1-x}\text{In}_x\text{As}$  pin photodiodes have been fabricated on GaAs substrates by incorporating an  $\text{GaAs/Ga}_{1-x}\text{In}_x\text{As}$  superlattice buffer to accommodate the lattice mismatch. Devices fabricated from  $\text{Ga}_{0.65}\text{In}_{0.35}\text{As}$  on  $n^+$  substrates exhibited leakage currents below 1 nA at  $-10\text{ V}$ , and external uncoated quantum efficiencies of approx. 47% at 1.15  $\mu\text{m}$ . A growth and processing sequence for fabricating devices in recesses on semi-insulating GaAs substrates with a coplanar geometry, to allow subsequent GaAs circuit processing, has been identified, and shown not to introduce a significant leakage penalty. (Author abstract) 8 refs.

Hodson, P.D. (Plessey Research Caswell Ltd, Towcester, Engl); Wallis, R.H.; Davies, J.I.; Shephard, H.E. *IEE Proc Part J* v 135 n 1 Feb 1988 p 2-4.

**096606 FABRICATION OF MONOLITHIC TWIN-GaInAs PIN PHOTODIODE FOR BALANCED DUAL-DETECTOR OPTICAL COHERENT RECEIVERS.** A monolithic twin-GaInAs/InP pin photodiode with planar, embedded structure has been fabricated for optical coherent receiver applications. High-uniformity ( $\pm 1.5\%$ ) quantum efficiency and low capacitance (0.3 pF) have been achieved, and its advantage has been demonstrated by the intensity noise suppressions of a dual-detector balanced heterodyne receiver (better than  $-15\text{ dB}$  up to 4.2 GHz). (Author abstract) 5 refs.

Wada, O. (Fujitsu Lab Ltd, Atsugi, Jpn); Miura, S.; Mikawa, T.; Aoki, O.; Kiyonaga, T. *Electron Lett* v 24 n 9 Apr 28 1988 p 514-516.

**096607 DESIGN AND PERFORMANCE OF VERY HIGH-SPEED  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}/\text{In}_{0.52}\text{Al}_{0.48}\text{As}$  P-I-N PHOTODIODES GROWN BY MOLECULAR BEAM EPITAXY.** High-speed  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}/\text{In}_{0.52}\text{Al}_{0.48}\text{As}$  photodiodes were grown by molecular beam epitaxy (MBE) on semi-insulating InP substrates. The measured impulse response characteristics for the photodiodes are very close to the analytically calculated ones. The temporal response to pulsed optical excitation is characterized by a rise time of 21 ps and a width (FWHM) of 27 ps. The  $25 \times 20\text{-}\mu\text{m}^2$  diodes have a junction capacitance  $<0.1\text{ pF}$ , a dark current approx. 1 nA, and a peak responsivity of 0.35 A/W. These characteristics are comparable or better than most epitaxial InGaAs photodiodes reported to date, and made the devices suitable for high-speed applications and monolithic integration. 13 refs.

Zebda, Yousef (Univ of Michigan, Ann Arbor, MI, USA); Bhattacharya, Pallab; Tobin, Mary S.; Simpson, Thomas B. *IEEE Electron Device Lett* v EDL-8 n 12 Dec 1987 p 579-581.

**096608 PLANAR InP/InGaAsP THREE-DIMENSIONAL GRADED-JUNCTION AVALANCHE PHOTODIODE.** A planar InP/InGaAsP avalanche photodiode, which is fabricated by  $\text{Be}^+$  implantation through a dish-shaped InGaAs mask, has been developed. A three-dimensional graded junction is obtained and a uniform gain as high as 30 is achieved without edge or surface breakdown. The dish-shaped InGaAs implantation mask is formed by a photoelectrochemical etching technique. Device modeling indicates that the graded junction and low doping concentration can prevent edge breakdown and greatly suppress the surface field. The diode has a separated absorption and multiplication structure grown by hydride vapor-phase epitaxy. These devices exhibit low primary dark currents ( $\approx 1\text{ nA}$ ), and high quantum efficiencies close to that of an InGaAs p-i-n at 1.3- $\mu\text{m}$  wavelength. Sensitivity measurements at bit

rates of 1.7 Gb/s give a minimum average receiver power required for  $10^{-9}$  BER of  $-35.5\text{ dBm}$ . 12 refs.

Chi, Gou-Chung (AT&T Bell Lab, Murray Hill, NJ, USA); Muehner, D.J.; Ostermayer, F.W. Jr.; Freund, J.M.; O'Brien, K.J.; Pawelek, R.; McCoy, R.J.; Smith, R.C.; Mattera, Vincent D. Jr. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2265-2269.

**096609 InP/InGaAsP/InGaAs AVALANCHE PHOTODIODES GROWN BY CHEMICAL-BEAM EPITAXY.** With the chemical-beam epitaxy-grown In/InGaAsP/InGaAs avalanche photodiodes (APDs) described, bandwidths as high as 6 GHz in the low-gain regime ( $M < 4$ ) were achieved. This is comparable to the highest bandwidth reported to date for this type of APD. For higher multiplication values, a gain-bandwidth-limited response was observed; the gain-bandwidth product was in the range 25 to 30 GHz. The frequency response of the APDs is explained in terms of five effects: carrier diffusion, the transit time through the depletion region, the RC time constant, charge accumulation at the heterojunction interfaces, and the avalanche buildup time. For example, to minimize hole trapping at the heterojunction interfaces, three thin ( $\leq 700\text{ Å}$ ) InGaAsP ( $E_g = 1.13, 0.95$ , and  $0.80\text{ eV}$ ) transition layers, were incorporated. The other device parameters can be summarized as follows: the total dark current was as low as 3.6 nA at 90% of breakdown and the primary multiple dark current was 1.5 nA. Useful avalanche gains as high as 30 were achieved. The quantum efficiency of uncoated devices at 1.3  $\mu\text{m}$  was approximately 55%. The device capacitance ( $\text{diam} = 40\text{ }\mu\text{m}$ ) was  $<0.1\text{ pF}$  at the operating voltage. 2 refs.

Campbell, J.C. (AT&T Bell Lab, Holmdel, NJ, USA); Tsang, W.T.; Qua, G.J.; Johnson, B.C. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2380.

**096610 HIGH-PERFORMANCE GaInAs INTERDIGITATED METAL-SEMICONDUCTOR-METAL (IMSM) 1.3- $\mu\text{m}$  PHOTODETECTOR GROWN ON A GaAs SUBSTRATE.** High-performance photodetectors have been fabricated on GaInAs layers grown on GaAs semi-insulating substrates by MBE (molecular-beam epitaxy). A high-performance detector sensitive to radiation at the low fiber dispersion, 1.3- $\mu\text{m}$  wavelength was fabricated on a nonlattice matched, semi-insulating, GaAs substrate by growing a 0.5- $\mu\text{m}$ -thick undoped GaAs buffer layer followed by an intermediate 0.5- $\mu\text{m}$ -thick GaInAs layer with an indium concentration less than that needed to absorb 1.3- $\mu\text{m}$  radiation. This was then followed by the active GaInAs layer designed to absorb the 1.3- $\mu\text{m}$  radiation and a 500-angstrom layer which was graded back to GaAs at the surface. The metal fingers for the IMSM detector were then fabricated on the surface using a gold lift-off process. The graded gap layer serves two purposes: 1) to provide a high Schottky barrier at the surface making possible the IMSM detector and 2) to provide an electric field that repels electrons and holes from surface preventing their trapping there. Low-frequency gain, which usually limits the performance of IMSM detectors, was not observed. Responsivities of 0.5 A/W were measured at 1.3  $\mu\text{m}$  and a bandwidth of 3.2 GHz was estimated for the detector from the response to a 48-ps laser pulse at 0.8  $\mu\text{m}$ . 1 ref.

Rogers, D.L. (IBM, Yorktown Heights, NY, USA); Woodall, J.M.; Pettit, G.D.; McInturff, D. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2383-2384.

**Heterojunctions** See Also LASERS, SEMICONDUCTOR.

**096611 InGaAs/InP SAGM AVALANCHE PHOTODIODES INCORPORATING A PSEUDOQUATERNARY SUPERLATTICE GRADED HETEROJUNCTION GROWN BY ATMOSPHERIC-PRESSURE**



**MOCVD.** We have demonstrated a high-speed GaInAs-InP SAGM avalanche photodiode grown by atmospheric-pressure MOCVD which incorporates a graded-bandgap GaInAs/InP superlattice layer to overcome hole pile-up effects inherent in interface design flexibility without recourse to GaInAsP quaternary compositions. High-speed operation has been demonstrated without compromising the dark current or gain by the inclusion of the multiple heterojunctions of the superlattice. (Edited author abstract) 3 refs.

Moseley, A.J. (Plessey Research Caswell Ltd, Towcester, Engl); Urquhart, J.; Hodson, P.D.; Riffat, J.R.; Davies, J.I. *Electron Lett* v 23 n 17 Aug 13 1987 p 914-916.

**096612 PHOTOELECTRIC RESPONSE OF A  $n\text{ZnSe-pGaAs}$  HETEROSTRUCTURE WITH ILLUMINATION BY LIGHT AT TWO DIFFERENT WAVELENGTHS.** The photoelectric properties of an  $n\text{ZnSe-pGaAs}$  heterostructural photodiode are studied and a theoretical model of the photoresponse with illumination by light at two different wavelengths is constructed. It is shown that such a photodiode may be used to process images formed in different spectral ranges. (Author abstract) 1 ref.

Zhuk, B.V.; Zhukov, I.A.; Zlenko, A.A.; Razov, E.N.; Chernyavskii, V.D. *Sov Phys Lebedev Inst Rep* n 7 1987 p 10-13.

## Ionization

**096613 STUDIES ON IONIZATION COEFFICIENTS OF TARGETS IN AN AMORPHOUS SELENIUM APD FOR PICK-UP TUBES BY NEW TYPE LEAST SQUARES.** The ionization coefficient of electrons and holes (i.e.  $\alpha$  and  $\beta$ ) have been determined only by the voltage and current characteristics of targets of an a-Se APD in the operation state of pick-up tubes. These determinations were based on self-consistently solving 12 simultaneous transcendental Webb's equations by using random numbers and linear approximations. The authors explain the methods of determining  $\alpha$  and  $\beta$ , and discuss excess noise factors. (Edited author abstract) 3 refs.

Taketoshi, Kazuhisa (NHK, Tokyo, Jpn); Tanioka, Kenkichi; Kawamura, Tatsuro. *Jpn J Appl Phys Part 1* v 26 n 10 Oct 1987 p 1648-1652.

**096614 CURRENT NOISE IN N-TYPE  $\text{Al}_x\text{Ga}_{1-x}\text{As}$ .** Current noise in Si-doped  $\text{Al}_x\text{Ga}_{1-x}\text{As}$ , grown by means of M.O.V.P.E., was investigated in the frequency range 1 Hz-100 kHz and in the temperature range 80-340 K. The measured noise over and above thermal noise was found to depend quadratically on the applied electric field, which means that it was caused by resistivity fluctuations. The noise consisted typically of two types of components:  $1/f$  noise and one or two generation-recombination (g-r) components with Lorentzian-shaped frequency dependence. From the temperature dependence of the g-r noise relaxation times, it was possible to calculate the activation energies and capture cross sections of two different deep electron traps. (Author abstract) 7 refs.

Hofman, F. (Rijksuniversiteit Utrecht, Utrecht, Neth); Zijlstra, R.J.J.; Henning, J.C.M. *Solid State Electron* v 31 n 2 Feb 1988 p 279-282.

## Junctions

**096615 CASCADED HOMOJUNCTION AVALANCHE PHOTODIODES.** The structure and the performance of a cascaded avalanche photodiode (APD) based on cascaded homojunctions are discussed. Similar to the hetero-structure superlattice APD, such a device has a lower excess noise and a higher gain at lower bias voltages than conventional APDs. In addition to the ionization ratio, several parameters also affect the device's performance. (Author abstract) 19 refs.

Choa, F.S. (State Univ of New York at Buffalo, Amherst, NY, USA); Liu, P.L. *Fiber Integr Opt* v 7 n 1 1988 p 1-15.

**096616 INTEGRATED ALL-SILICON COLOR FILTERING ELEMENT WITH AN ENHANCED**

**WAVELENGTH TUNABILITY.** A method for applying the wavelength-dependent response of silicon photodiodes for the integration of an electronically tunable optical filtering element with the photodetector in silicon is presented. Previous sensors suffered from a limited tunable spectral range. Here, the filter tunability is extended by enhancing the long-wavelength tunability using an extra implantation for realizing a higher doped buffer layer underneath a shallow junction to reduce the built-in depletion layer. Also, an independent electronically programmable short-wavelength cutoff is introduced. The latter is based on the control of the surface space-charge region. The flexibility obtained allows the electronic shaping of clearly distinguishable responses using a single photodiode. 6 refs.

Wolffenbuttel, R.F. (Delft Univ of Technology, Neth). *IEEE Electron Device Lett* v 9 n 7 Jul 1988 p 337-339.

## Manufacture

**096617 GaInAs PIN PHOTODIODES GROWN ON SILICON SUBSTRATES FOR 1.55  $\mu\text{m}$  DETECTION.** We report GaInAs PIN photodiodes to be fabricated on silicon substrates. Superlattice buffer layers were used to accommodate the lattice parameter mismatch. Reverse leakage currents of approximately 70 nA at  $-1$  V bias were measured for 105  $\mu\text{m}$ -diam mesa diodes. The uncoated external quantum efficiency at a wavelength of 1.55  $\mu\text{m}$  was 30%. (Author abstract) 2 refs.

Hodson, P.D. (Plessey Research Caswell Ltd, Towcester, Engl); Bradley, R.R.; Riffat, J.R.; Joyce, T.B.; Wallis, R.H. *Electron Lett* v 23 n 20 Sep 24 1987 p 1094-1095.

## Materials

**096618 HIGH-SPEED FRONT-ILLUMINATED GaInAsP/InP pin PHOTODIODE.** We have developed a high-speed front-illuminated GaInAsP/InP pin photodiode for use at the optical wavelength of 1.3  $\mu\text{m}$ . The device is grown on an  $n^+$ -InP substrate and uses polyimide both as a passivation layer and as a bonding pad holder to reduce parasitic capacitance. An optoelectronic sampling measurement of the impulse response shows a pulsewidth (FWHM) of 28 ps. A 3 dB bandwidth in excess of 18 GHz has been achieved. (Author abstract) 7 refs.

Yi, M.B. (California Inst of Technology, Pasadena, CA, USA). *Electron Lett* v 24 n 8 Apr 1988 p 455-456.

**096619 DIELECTRICS FOR PASSIVATION OF PLANAR InP/InGaAs DIODES.** We have investigated dielectrics for passivating planar InP or InGaAs photodiodes thermally evaporated  $\text{Al}_2\text{O}_3$  and  $\text{SiO}_2$ , sputtered  $\text{Si}_3\text{N}_4$  and  $\text{SiO}_2$  and also  $\text{SiO}_2$  using chemical vapor deposition. The measured bulk and field-effect properties of all dielectrics excluding sputtered  $\text{SiO}_2$  were suitable for this application. In planar InGaAs diodes with Cd diffused or Mg implanted  $p^+$ -region a disordered dielectric/semiconductor surface led to high reverse current densities above 1 mA/cm<sup>2</sup>. In InP diodes with  $p^+$ -diffusion and dielectrics exhibiting positive flatband voltages, e.g.  $\text{Si}_3\text{N}_4$  and  $\text{Al}_2\text{O}_3$ , reverse current densities of 10  $\mu\text{A}/\text{cm}^2$  were measured probably caused by a slight inversion of the semiconductor surface. With a  $\text{SiO}_2$  or CVD- $\text{SiO}_2$  passivating layer on n-InP lowest leakage current densities (10 nA/cm<sup>2</sup>) were achieved. Very low dark-current planar photodiodes InP/InGaAsP/InGaAs have been fabricated using  $\text{SiO}_2$  passivation (30 nA/cm<sup>2</sup>). (Author abstract) 6 refs.

Unterboersch, G. (Heinrich-Hertz-Inst fuer Nachrichtentechnik Berlin GmbH, Berlin, West Ger); Bach, H.G.; Schmitt, F.; Schmidt, R.; Schlaak, W. *Appl Surf Sci* (1985) v 30 n 1-4 Oct 1 1987, INFOS 87: Proc of the Fifth Int Conf on Insul Films on Semicond, Louvain, Belg, Apr 13-15 1987 p 76-82.

## Mathematical Models

**096620 NEW INFRARED AVALANCHE PHOTODIODE FOR LONG DISTANCE FIBER OPTIC**

**COMMUNICATION.** Theoretical studies are presented for the response characteristics and quantum efficiency of a new infrared avalanche photodiode (APD) for the 3-4  $\mu\text{m}$  wavelength range. The device structure is a photo-DOVATT (Double Velocity Avalanche Transit Time) made of  $\text{InAsSb}_{1-x}/\text{InAs}$ ,  $\text{InAsSb}_{1-x}$  being lattice matched to InAs. We expect it to be used in long distance fiber-optic communication. The calculated gain-bandwidth product is around 20 GHz and the calculated quantum efficiency is 75% near 3  $\mu\text{m}$  wavelength. (Edited author abstract) 8 refs.

Chakrabarti, P. (Birla Inst of Technology, Ranchi, India); Pal, B.B. *Solid State Electron* v 31 n 1 Jan 1988 p 1-3.

**096621 THEORY OF AVALANCHE DIODE HARMONIC OPTOELECTRONIC MIXER.** A simple empirical model is proposed for the multiplication factor of the avalanche photodiode (APD). Using this model closed-form expressions are derived for the conversion loss of APD optoelectronic mixers. The model is valid over a wider range of APD reverse-bias voltage. Using the new model, expressions are derived for the conversion loss of the APD harmonic optoelectronic mixing. (Edited author abstract) 4 refs.

Abuelma'atti, Muhammad Taher (Univ of Bahrain, Isa Town, Bahrain). *IEE Proc Part J* v 135 n 2 Apr 1988 p 183-186.

**096622 FIELD AND SPATIAL GEOMETRY DEPENDENCIES OF THE ELECTRON AND HOLE IONIZATION RATES IN GaAs/AlGaAs MULTIQUANTUM WELL APD'S.** Numerical calculations are presented of the electron and hole ionization rates in GaAs/AlGaAs multiquantum-well APDs (avalanche photodiodes) as a function of the applied electric field and the spatial geometries, i.e., the barrier- and well-layer widths, respectively. The model is calibrated to existing experimental data on bulk GaAs material and then extrapolated to the multiquantum well structure. It is found that at high electric field strengths the net ionization rate approaches the weighted average of the constituent bulk rates; the potential discontinuity is relatively insignificant. The potential discontinuity most greatly affects the electron ionization rate at low applied electric field strengths within a spatially symmetric structure. It is further determined that the electron-to-hole ionization rate ratio is greatest at low applied electric fields within a spatially symmetric structure with equal well and barrier widths. 38 refs.

Brennan, Kevin F. (Georgia Inst of Technology, Atlanta, GA, USA); Wang, Yang. *IEEE Trans Electron Devices* v 35 n 5 May 1988 p 634-641.

## Microwaves

**096623 HIGH-SPEED InP/InGaAsP/InGaAs AVALANCHE PHOTODIODES GROWN BY CHEMICAL BEAM EPITAXY.** High-performance InP/InGaAsP/InGaAs avalanche photodiodes (APDs) grown by chemical beam epitaxy are described. These APDs exhibit low dark current (less than 50 nA at 90% of breakdown), good external quantum efficiency (greater than 90% at a wavelength of 1.3  $\mu\text{m}$ ), and high avalanche gain ( $\approx 40$ ). In the low-gain regime, bandwidths as high as 8 GHz have been achieved. At higher gains, a gain-bandwidth-limited response is observed; the gain-bandwidth product is 70 GHz. 24 refs.

Campbell, J.C. (AT&T Bell Lab, Holmdel, NJ, USA); Tsang, W.T.; Qua, G.J.; Johnson, B.C. *IEEE J Quantum Electron* v 24 n 3 Mar 1988 p 496-500.

## Millimeter Waves

**096624 TOP-ILLUMINATED InGaAs/InP P-I-N PHOTODIODES WITH A 3-DB BANDWIDTH IN EXCESS OF 26 GHz.** Top-illuminated InGaAs p-i-n photodiodes have been fabricated from metal organic vapor-phase epitaxy (MOVPE) material, grown on semi-insulating InP substrates. A flat frequency response to 26 GHz has been measured, which is the highest figure



yet reported for such devices. The predicted 3-dB bandwidth of these devices is 35 GHz. 6 refs.

Wake, D. (British Telecommunications Research Lab, Ipswich, Engl); Blank, L.C.; Walling, R.H.; Henning, I.D. *IEEE Electron Device Lett* v 9 n 5 May 1988 p 226-228.

## Noise

**096625 IMPROVED FIGURE OF MERIT FOR NOISE IN AVALANCHE PHOTODIODES.** We propose a new noise figure for avalanche photodiodes (APDs). This new noise figure overcomes the difficulty of estimating the internal multiplication and quantum efficiency in complex APD structures, such as III-V SAM APDs. Measurements of the new noise figure are presented for two commercial SAM APDs and we show theoretically that it represents a more complete figure of merit for comparing the performance of one APD with another, and with the ideal. (Author abstract) 3 refs.

Westbrook, L.D. (British Telecom Research Lab, Ipswich, Engl); MacBean, M.D.A.; Rodgers, P.M. *Electron Lett* v 24 n 14 Jul 7 1988 p 853-854.

**096626 Hg<sub>0.4</sub>CD<sub>0.6</sub>TE 1.55-μM AVALANCHE PHOTODIODE NOISE ANALYSIS IN THE VICINITY OF RESONANT IMPACT IONIZATION CONNECTED WITH THE SPIN-ORBIT SPLIT-OFF BAND.** The authors describe the electrical and optical characterization of three Hg<sub>1-x</sub>Cd<sub>x</sub>Te avalanche photodiodes manufactured using planar technology with composition parameter  $x$  near 0.6. This alloy composition leads to devices that are well suited for 1.55-μm detection. From the noise analysis under multiplication, the authors show the tight dependence of the ratio  $\beta/\alpha$  (of the hole and electron ionization coefficient, respectively) upon  $x$  and the ratio  $\Delta/E_g$  where  $\Delta$  is the spin-orbit splitting energy and  $E_g$  is the bandgap energy. It turns out that in these alloys around  $x = 0.6$ ,  $\Delta$  is very close to bandgap energy so  $\beta/\alpha$  reaches its maximum value. Owing to this property, which is characteristic of II-VI compounds, Hg<sub>1-x</sub>Cd<sub>x</sub>Te is a good candidate for 1.3-μm to 1.6-μm avalanche photodiodes. 12 refs.

Orsal, Bernard (Univ des Sciences et Technique du Languedoc, Fr); Alabedra, Robert; Valenza, Matteo; Lecoy, Gilles P.; Meslage, J.; Boisrobert, C.Y. *IEEE Trans Electron Devices* v 35 n 1 Jan 1988 p 101-107.

**096627 1/f NOISE IN SHORT n-p<sup>+</sup> DIFFUSION-CURRENT-DOMINATED (HgCd)Te AVALANCHE PHOTODIODES.** The observed 1/f noise from Hg<sub>0.56</sub>Cd<sub>0.44</sub>Te avalanche n<sup>+</sup>-n<sup>+</sup> p<sup>+</sup> photodiodes in the forward and reverse current shows the following regions: i) ohmic, ii) diffusion-dominated short diode, iii) series-resistance dominated, iv) diffusion-dominated short diode with reverse-bias-dependent length, and v) multiplication. The interpretation is based on Hooge's empirical 1/f noise formula and Kleinpenning's model for 1/f noise in short diodes. 24 refs.

Vandamme, Lode K.J. (Eindhoven Univ of Technology, Neth); Orsal, B. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 502-506.

## Optical Properties

**096628 OPTICAL DETECTION UP TO 2.5 Gbit/s WITH A STANDARD HIGH-SPEED SELF-ALIGNED SILICON BIPOLAR TRANSISTOR.** Recent progress in optical fibre communication has encouraged the development of fast and sensitive photodetectors. In this letter we report on the photoresponse of the BC diode of a vertical npn transistor fabricated using a self-aligning silicon bipolar process. This technology allows the large scale integration of bipolar devices. The base-collector (BC) diode showed optical detection capabilities up to 2.5 Gbit/s. 6 refs.

Bock, W. (Siemens AG, Munich, West Ger); Prettl, W. *Electron Lett* v 24 n 13 Jun 23 1988 p 808-810.

**096629 HIGH RESPONSIVITY LONG-WAVELENGTH ( $\lambda = 10 \mu\text{M}$ ) GaAs/Al<sub>x</sub>Ga<sub>1-x</sub>As MUL-**

**TIQUANTUM WELL SUPERLATTICE TUNNELING DETECTOR.** The structure considered consists of 50 periods of 72-angstrom GaAs quantum wells doped  $n = 1.5 \times 10^{18} \text{ cm}^{-3}$  separated by Al<sub>0.38</sub>Ga<sub>0.62</sub>As barriers, with n<sup>+</sup> ohmic contacts on both sides. The quantum well is designed to contain only two bound states separated in energy by  $E_2 - E_1 = 124 \text{ meV}$  (corresponding to  $\lambda = 10 \mu\text{m}$ ). The ground state of one well aligns with the excited state of the neighboring well due to sequential resonant tunneling. This band alignment ensures that the incident infrared radiation is strongly absorbed by the intersubband resonance and photoexcites an electron. The electron then rapidly and efficiently tunnels out of the well and travels a hot-electron mean free path  $L$ , and thereby produces a large photocurrent. The responsivity  $R = 1.9 \text{ A/W}$ , while  $L = 4500 \text{ angstrom}$ . These results are a consequence of the thicker and higher tunneling barriers, which lowers the dark current and thus allows the use of higher bias voltages. These detectors have an advantageous narrow bandwidth ( $\Delta\lambda/\lambda = 10\%$ ) and an estimated high-speed response of over 10 GHz. These devices have been used to measure novel hot-electron superlattice transport physics. 3 refs.

Levine, B.F. (AT&T Bell Lab, Murray Hill, NJ, USA); Choi, K.K.; Bethua, C.G.; Walker, J.; Malik, R.J. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2382.

## Oscillations

**096630 CURRENT OSCILLATIONS IN THE PLANAR BALLISTIC PHOTODIODE.** The possibility of current oscillations to occur in a thin layer of an intrinsic semiconductor at the charge carrier interband photogeneration was shown in previous papers. Current oscillations in a hypothetical semiconductor have been observed by simulation using the macroparticle technique. In the present paper the instability is considered and further results of investigation of the instability in a planar photodiode are presented. 3 refs.

Junevicius, D. (Lithuanian Acad of Sciences, Vilnius, USSR); Reklaitis, A. *Modell Simul Control A* v 15 n 1 1988 p 37-43.

## Performance

**096631 EFFICIENT PHOTODIODE-WAVEGUIDE COUPLING FOR HYBRID INTEGRATED OPTICAL CIRCUITS.** A GaInAsP edge-detecting photodiode was coupled with an SiO<sub>2</sub>-TiO<sub>2</sub> single-mode waveguide in a simple hybrid integration scheme. The newly developed edge-detecting photodiode with a window region was used to improve photodiode durability. (Author abstract) 6 refs.

Yamada, M. (NTT, Tokai, Jpn); Terui, H.; Yamada, Y.; Himeno, A.; Kobayashi, M. *Electron Lett* v 23 n 20 Sep 24 1987 p 1056-1057.

**096632 DEVELOPMENT OF A P-I-N HgCdTe PHOTOMIXER FOR LASER HETERODYNE SPECTROMETRY.** An improved HgCdTe photomixer technology was demonstrated which employs a p-i-n photodiode structure. The i-region was near intrinsic n-type HgCdTe; the n-region was formed by B<sup>+</sup> ion implantation; and the p-region was formed either by a shallow Au diffusion or by a Pt Schottky barrier. Experimental devices in a back-side illuminated mesa diode configuration were fabricated, tested and delivered. The best photomixer was packaged in a 24-hour LN<sub>2</sub> dewar along with a cooled GaAs FET preamplifier. Testing was performed by mixing black-body radiation with a CO<sub>2</sub> laser beam and measuring the IF signal, noise, and signal-to-noise ratio in the GHz frequency range. Signal bandwidth for this photomixer was 1.3 GHz. The heterodyne noise equivalent power (NEP) was  $4.4 \times 10^{-20} \text{ W/Hz}$  out to 1 GHz, increasing to  $8.6 \times 10^{-20} \text{ W/Hz}$  at 2 GHz. Other photomixers delivered on this program had heterodyne NEPs at 1 GHz ranging from  $8 \times 10^{-20}$  to  $4.4 \times 10^{-19} \text{ W/Hz}$  and NEP bandwidths from 2 to 4 GHz. (Edited author abstract) 13 refs.

Bratt, Peter R. (Hughes Aircraft Co, Goleta, CA, USA). *NASA Contract Rep* 4094 Sep 1987 54p.

**096633 P-TYPE PROCESSING PROVIDES SILICON PHOTODIODE'S ENHANCED LONG-WAVELENGTH PERFORMANCE.** Large-area planar photodiodes fabricated with p-type silicon can provide high response with good speed at wavelengths beyond 1 μm. When properly processed, such devices can outperform n-type devices in applications such as YAG-based targeting systems. (Author abstract) 3 refs.

Flood, Colin J. (Antel Optronics Inc, Burlington, Ont, Can); Yamazaki, Tsuneo. *Laser Focus (Littleton Mass)* v 23 n 12 Dec 1987 p 112, 114, 116.

**096634 InGaAs PHOTODIODES FOR LONG-WAVELENGTH FIBEROPTIC COMMUNICATIONS.** In single-mode telecommunications, InGaAs detectors have become widely accepted for meeting high sensitivity and bandwidth requirements. Now, this technology continues to progress as device manufacturers introduce improved detectors and package more functions into their receiver modules. (Author abstract)

Mack, Richard (Laser Focus, Tulsa, OK, USA). *Laser Focus (Littleton Mass)* v 23 n 12 Dec 1987 p 136, 138-141.

**096635 GAIN REGULATOR FOR AVALANCHE PHOTODIODE.** A device for correction of the bias voltage of an avalanche photodiode is described that fixes the operating point with a specified avalanche multiplication. The device has periodic-pulse action. The correction time is 0.1 sec and the accuracy of gain setting is 5%. (Author abstract)

Bochkhar, E.P. (Moscow State Univ, USSR); Zakharov, A.I.; Titae, A.A.; Shirokov, P.P. *Instrum Exp Tech* v 30 n 2 pt 2 Mar-Apr 1987 p 391-394.

**096636 PHOTOCURRENTS IN p-n Si DIODES UNDER HIGH INTENSITY (PULSED-LASER) ILLUMINATION: QUANTUM YIELDS AND KINETIC EVALUATION.** The photoelectric response of p-n Si photodiodes under pulsed laser illumination (half width 10 ns) at 532 nm was studied as a function of dose, which was varied over 6 orders of magnitude. The photocurrent transients are dominated by a plateau-like feature due to the build up of space charge at the intensities used. Increasing bias voltage increases the height of the plateau and decreases its length. In the low-dose range the length of the transient increases linearly with dose and the collected charge reaches a constant value. At high doses considerable charge loss (decrease in quantum yields) is accompanied by a less than proportional increase of the transient lifetime. From model calculations the dose and voltage dependence of the quantum yield of charge collection is shown to be the result of competition between current flow and first and higher order recombination. The model calculations are consistent with experimental results. (Edited author abstract) 8 refs.

Neumann-Spallart, M. (Inst fuer Theoretische Chemie und Strahlenchemie, Vienna, Austria); Schwarz, A.; Grabner, G. *Appl Phys A* v A46 n 1 May 1988 p 9-12.

**096637 HIGH-SPEED GaInAs/InP MULTIQUANTUM WELL AVALANCHE PHOTODIODES GROWN BY ATMOSPHERIC-PRESSURE MOCVD.** We report the performance of a high speed GaInAs/InP multi-quantum well avalanche photodiode grown by atmospheric pressure MOCVD. The multi-quantum well avalanche region of the device consists of 50 periods of 150 Å wells and barriers forming the intrinsic region of a pin structure. Avalanche multiplication up to a factor of 25 has been measured at dc together with high-speed



response giving a maximum measured rf gain of 16 and a gain-bandwidth product in excess of 25 GHz. (Edited author abstract) 5 refs.

Moseley, A.J. (Plessey Research Caswell Ltd, Towcester, Engl); Urquhart, J.; Riffat, J.R. *Electron Lett* v 24 n 6 Mar 17 1988 p 313-315.

**096638 PERFORMANCE EVALUATION OF GaAlAsSb/GaInAsSb SAM-APDSS FOR HIGH BIT RATE TRANSMISSIONS IN THE 2.5  $\mu$ m WAVELENGTH REGION.** A theoretical evaluation of separate absorption and multiplication photodiodes made from GaAlAsSb/GaInAsSb/GaSb heterostructures suitable for detection in the 2.5  $\mu$ m wavelength region is presented. Receiver sensitivities as low as -50.5 dBm at 0.66 Gbit/s and -46.4 dBm at 2 Gbit/s are expected from the use of such devices cooled at 190 K with optimum gains higher than 100. (Author abstract). 4 Refs.

Benoit, J. (CNRS, Montpellier, Fr); Boulou, M.; Soulage, G.; Joulle, A.; Mani, H. *J Opt Commun* v 9 n 2 Jun 1988 p 55-58.

**Radiation Effects** See Also SEMICONDUCTOR DIODES, AVALANCHE—Radiation Effects.

**096639 GAMMA RADIATION RESPONSE OF MWIR AND LWIR HgCdTe PHOTODIODES.** Results of an experimental investigation of the gamma radiation response of HgCdTe photodiodes are reported. The devices were fabricated in material grown by liquid-phase epitaxy; the p-n junctions were made by ion implantation and passivated with ZnS. The MWIR (medium-wave infrared) devices, tested at 120K, showed transient response in reasonable agreement with existing theory and total dose hardness greater than 1 Mrad(Si). The LWIR (long-wave infrared) detectors, tested at 40K, showed a degradation threshold at 10 Krad(H<sub>2</sub>O). This degradation is not a result of surface inversion resulting from charge trapping in the insulator. 3 refs.

Williams, G.M. (Rockwell Int Science Cent, USA); Vanderwyck, A.H.B.; Blazejewski, E.R.; Ginn, R.P.; Li, C.C.; Nelson, S.J. *IEEE Trans Nucl Sci* v NS-34 n 6 Dec 1987, 1987 Annu Conf on Nucl and Space Radiat Eff, Snowmass Village, CO, USA, Jul 28-31 1987 p 1592-1596.

**Reliability** See Also SEMICONDUCTOR DIODES, LIGHT EMITTING—Reliability.

**096640 HIGHLY RELIABLE PLANAR GaInAs/InP PHOTODIODES WITH HIGH YIELD MADE BY ATMOSPHERIC PRESSURE MOVPE.** A process for making GaInAs/InP pin photodiodes based on atmospheric pressure MOVPE is described. The technique gives devices with low dark currents ( $< 1$  nA) and capacitances ( $< 0.2$  pF). Yields on large area wafers greater than 80% can be achieved and good reliability has been demonstrated ( $< 0.4$  FIT at 20°C). (Author abstract) 2 refs.

Robertson, M.J. (British Telecom Research Lab, Ipswich, Engl); Ritchie, S.; Sargood, S.K.; Nelson, A.W.; Davis, L.; Walling, R.H.; Skrimshire, C.P.; Sutherland, R.R. *Electron Lett* v 24 n 5 Mar 3 1988 p 252-254.

**096641 RELIABILITY EVALUATION AND PREDICTION FOR SILICON PHOTODETECTORS.** The electrical parameters of silicon detectors were measured under various external influences (temperature cycling, humidity, salt atmosphere, etc.). The tests were designed and the data were analyzed by using the randomized block design method from the SAS software package. To estimate the lifetime of the detectors, an accelerated lifetime was implemented. Using plots of inspected interval data based on the maximum-likelihood technique (using the software package CENSOR), it was found that the Weibull distribution fit the lifetime test data. The CDF (cumulative distribution function) and the acceleration factor were calculated; the median lifetime of the silicon detector at room temperature was  $8.94 \times 10^6$  hours, and the 95% s-confidence interval was  $(7.16-10.6) \times 10^6$  hours. 25 refs.

Weis, E.A. (Tel-Aviv Univ, Isr); Caldaranu, D.; Snyder, M.M.; Croitoru, Nathan. *IEEE Trans Reliab* v 37 n 1 Apr 1988 p 14-23.

**096642 RELIABILITY OF VAPOR-GROWN PLANAR In<sub>0.53</sub>Ga<sub>0.47</sub>As/InP P-I-N PHOTODIODES WITH VERY HIGH FAILURE ACTIVATION ENERGY.** The mean time to failure (MTTF) was measured for a statistically significant population of planar In<sub>0.53</sub>Ga<sub>0.47</sub>As/InP heterostructure p-i-n photodetectors at several elevated temperatures. The probability for failure is fit to a log-normal distribution, with the result that the width of the failure distribution is  $\sigma = 0.55 \pm 0.2$ , and is roughly independent of temperature. From the temperature dependence of MTTF data, it is found that the failure mechanism is thermally activated, with an activation energy of less than  $1.5 \pm 0.2$  eV measured in the temperature range of 170-250°C. This extrapolates to a MTTF of less than 0.1 failure in 10<sup>9</sup>h (or  $< 0.1$  FIT) at 70°C, indicating that such devices are useful for systems requiring extremely high reliable components, even if operated at elevated temperatures for significant time periods. This activation energy is the highest value reported for In<sub>0.53</sub>Ga<sub>0.47</sub>As/InP photodetectors, and is significantly higher than the energies of approximately 0.85 eV often suspected for these devices. 5 refs.

Forrest, Stephen R. (Univ of Southern California, Los Angeles, CA, USA); Ban, V.S.; Gasparian, G.; Gay, Daniel; Olsen, Gregory H. *IEEE Electron Device Lett* v 9 n 5 May 1988 p 217-219.

**Sensors** See IMAGING TECHNIQUES—Sensors.

**Spectrum Analysis**

**096643 ANALYSIS OF THE R<sub>0A</sub> PRODUCT IN n<sup>+</sup>-p Hg<sub>1-x</sub>Cd<sub>x</sub>Te PHOTODIODES.** The influence of different junction current components (diffusion current for radiative and Auger 7 recombination mechanisms, tunneling and depletion layer currents) on the R<sub>0A</sub> product of n<sup>+</sup>-p-Hg<sub>1-x</sub>Cd<sub>x</sub>Te photodiodes is considered. The considerations are carried out for the 77-300 K temperature region and 1-15  $\mu$ m cutoff wavelength. Optimum doping concentrations in the p-type region of n<sup>+</sup>-p abrupt junctions are determined, taking into account the influence of the tunneling current and of a fixed surface charge density of the junction passivation layer. Results of calculations are compared with experimental data reported by many authors. An attempt is made to explain the discrepancy between theoretical calculations and experimental data. (Author abstract) 57 refs.

Rogalski, A. (Inst of Technical Physics, Warsaw, Pol). *Infrared Phys* v 28 n 3 May 1988 p 139-153.

**Theory**

**096644 GaInAs PHOTODIODES AS TRANSFER STANDARDS FOR PICOSECOND MEASUREMENTS.** GaInAs photodiodes are developed for use as pulsed transfer standards at the optical fiber communications wavelengths. The concept and requirements for a transfer standard photodiode are discussed. The photodiode and mount are theoretically modelled, results indicate that there is an optimum epitaxial layer thickness and diode series resistance for a particular device diameter and mount inductance. Measurements are made of an unoptimized 45  $\mu$ m diameter device mounted on a prototype reverse terminated coplanar holder. A measured FWHM of 40 ps was obtained at 1146 nm, and the 3 dB frequency response is measured as 10.8 GHz at 1060 nm. (Author abstract) 16 refs.

Humphreys, D.A. (NPL, Teddington, Engl); Moseley, A.J. *IEE Proc Part J* v 135 n 2 Apr 1988 p 146-152.

**Thermal Effects**

**096645 METHOD FOR STABILIZING THE MULTIPLICATION OF AN AVALANCHE PHOTODIODE.** In this paper we describe a new and effective method for stabilizing the working point and the multiplication factor of an avalanche photodiode. This method

sharply reduces the thermal instability of a photodetector. The method can be summarized as follows: a bias voltage with constant and varying components is applied to the diode. Since the avalanche multiplication factor M is a nonlinear function of the temperature and the bias voltage, a change in the temperature is accompanied by a change in the shape of the current signal from the diode, which is determined by the variable component of the bias voltage. As a result, the relation between the current signals from the diode averaged over the period and over the half-period of the alternating bias voltage can be used to identify the mismatch signal, which depends on the temperature. As this signal varies as a result of variations in the temperature and other factors, the constant bias voltage E and the amplitude (u<sub>M</sub>) of the alternating bias voltage change in equal degrees, until the value of the signal is restored. 3 refs.

Chernov, E.I. *Optoelectron Instrum Data Process* n 3 1987 p 115-118.

**SEMICONDUCTOR DIODES, TUNNEL** See Also ELECTROLUMINESCENCE; OSCILLATORS—Synchronization.

**Electronic Properties**

**096646 MULTIPLE-STATE MEMORY CELL BASED ON THE RESONANT TUNNELING DIODE.** The device consists primarily of several molecular-beam-epitaxy (MBE)-grown GaAs/(AlGa)As resonant tunneling diodes connected in parallel. This device exhibits multiple peaks in the I-V characteristic. When a load resistor is connected, the circuit can be operated in a multiple stable mode. With this concept, implementation of three-state and four-state memory cells are made. In the three-state case the operating points at voltages V<sub>0</sub> = 0.27 V, V<sub>1</sub> = 0.42 V, and V<sub>2</sub> = 0.53 V represent the logic levels 0, 1, and 2. Similarly for the four-state memory cell the logic levels voltages are V<sub>0</sub> = 0.35 V, V<sub>1</sub> = 0.42 V, V<sub>2</sub> = 0.54 V, and V<sub>3</sub> = 0.59 V. A suggestion of an integrated device structure using this concept is also presented. 12 refs.

Soderstrom, Jan (Chalmers Univ of Technology, Goteberg, Swed); Andersson, Thorvald G. *IEEE Electron Device Lett* v 9 n 5 May 1988 p 200-202.

**Heterojunctions**

**096647 IMPROVED Al<sub>x</sub>Ga<sub>1-x</sub>As/Ga<sub>1-y</sub>In<sub>y</sub>As/GaAs STRAINED-LAYER DOUBLE BARRIER RESONANT TUNNELING STRUCTURE.** We report the observation of differential negative resistance in a resonant tunnelling diode which consists of Al<sub>0.35</sub>Ga<sub>0.65</sub>As barriers and a Ga<sub>0.80</sub>In<sub>0.20</sub>As quantum well, grown on GaAs substrate by molecular beam epitaxy (MBE) at a constant substrate temperature of 550°C, for the entire structure. The current peak/valley ratio at resonance is 6 to 1 at 77 K. Our result demonstrates the feasibility of preparing device-quality MBE Al<sub>x</sub>Ga<sub>1-x</sub>As layers at low substrate temperature and fabricating quantum devices involving heterojunctions with severe strain. (Author abstract) 23 refs.

Yang, C.H. (Texas Instruments Inc, Dallas, TX, USA); Shih, H.D. *Electron Lett* v 24 n 9 Apr 28 1988 p 553-555.

**096648 TUNNELING TIME THROUGH HETEROJUNCTION DOUBLE BARRIER DIODES.** The quantum mechanical tunneling time through a heterojunction double barrier diode (DBD) is calculated for all incident electron energies (on-resonance and off-resonance). The well-known result of Eisenbud and Wigner is used, and simple analytical results are obtained. The longest time delay occurs at the on-resonance incident energy due to the electron bouncing back-and-forth in the well region of a DBD. In addition to the exact result for the transmission coefficient and time delay, a Breit-Wigner resonant form is also used to model tunneling amplitude in the neighborhood of a resonance. The tunneling time delay consider-



ation indicates that the ultimate device response of DBDs utilizing GaAs-AlGaAs alloy system is in the sub-picosecond or picosecond regime. (Author abstract) 21 refs.

Liu, H.C. (Univ of Pittsburgh, Pittsburgh, PA, USA). *Superlattices Microstruct* v 3 n 4 1987 p 379-382.

**Mathematical Models** See ELECTRONIC CIRCUITS—Mathematical Models; MICROWAVE DEVICES.

**Millimeter Waves** See SEMICONDUCTOR DIODES, AVALANCHE—Heterojunctions.

## Oscillations

**096649 FUNDAMENTAL OSCILLATIONS UP TO 200 GHz IN A RESONANT-TUNNELING DIODE.** The physical basis for these oscillations is the negative dynamic conductance (NDC) associated with the resonant tunneling of electrons through a quantum well bounded by two tunnel barriers. A key to achieving the present results was the use of thin (1.5 nm) AlAs barriers and moderate doping ( $N_D = 2 \times 10^{17} \text{ cm}^{-3}$ ) in the n-GaAs outside barriers. Another key to these results was the development of rectangular waveguide resonators capable of providing greater-than-unity circuit Q at frequencies where the terminal negative resistance of the diode is rapidly approaching zero. The diodes were mounted in the gap between the waveguide floor and the bottom of a post that protruded roughly halfway into the guide. The contact to the individual diodes was made with a whisker whose length (approx. 0.18 mm) was as short as practically possible to minimize parasitic inductance in the circuit. A WR-6 resonator yielded oscillations between 102 and 112 GHz with peak power of about 5  $\mu\text{W}$  in this band. The frequency tuning was accomplished primarily with bias voltage. A scaled-down version of this resonator in WR-3 waveguide achieved oscillations between 192 and 201 GHz, again tunable mostly by bias voltage. The peak power in this range was about 0.2  $\mu\text{W}$ .

Brown, E.R. (MIT, Lexington, MA, USA); Sollner, T.C.L.G.; Goodhue, W.D.; Parker, C.D. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2381.

## Testing

**096650 POTENTIAL BARRIER HEIGHT OF AMORPHOUS MIS TUNNEL DIODES.** Expressions for the potential barrier height of amorphous MIS tunnel diodes are derived and solved numerically both at thermal equilibrium and in the presence of applied voltages. The results presented show the effects of localized gap states, semiconductor surface states, and the metal work function on the potential barrier height and its voltage dependence. (Author abstract) 10 refs.

Shousha, A.H.M. (Cairo Univ, Cairo, Egypt). *Solid State Commun* v 64 n 5 Nov 1987 p 831-835.

**SEMICONDUCTOR DIODES, ZENER** See Also ELECTRONIC CIRCUITS, VOLTAGE STABILIZING—Design.

## Applications

**096651 BRINGING SIMPLICITY TO ZENER BARRIERS.** Several hundred thousand shunt-diode safety barriers are installed every year to protect electrical circuits in hazardous areas; the number has been growing for a quarter of a century. Yet users frequently still have to select what they want from a confusing variety of options. Manufacturers still define barriers in electrical-component terms rather than by their instrumentation function, and offer more models than is necessary. This is not the case with the more recent isolating interface devices where users are presented with only a handful of designs, each carefully tailored for an application, and thus making selection simplicity itself. The author argues that seven modules now cover most needs.

Hutcheon, Ian. *Control Instrum* v 19 n 10 Oct 1987 p 64-65, 67.

**Measurements** See ELECTRIC MEASUREMENTS—Voltage.

## Performance

**096652 VOLTAGE REFERENCES.** The zener diode, bandgap reference, and gas tubes, with an emphasis on breakdown voltage are considered. In the discussion emphasis is on breakdown voltage and temperature characteristics. (Edited author abstract) 14 refs.

Sum, K. Kit (Summit Electronics Inc). *Powerconverters Intell Motion* v 14 n 2 Feb 1988 p 58-60.

## Standards

**096653 ASSESSMENT OF THE PERFORMANCE OF ZENER REFERENCES OF THE HIGHEST QUALITY.** Zener diodes are now playing an important part in the development of transfer voltage standards. The computer-controlled equipment that is described is capable of measuring these devices to 1 part in  $10^7$  at the 6-V level. A technique is described for characterizing the data obtained at various currents and temperatures in order to produce quantitative figures for the important parameters of Zener diodes. The results and application of this method are discussed. 4 refs.

Roberts, Derek E. (Univ of Cambridge, Engl). *IEEE Trans Instrum Meas* v IM-36 n 4 Dec 1987, IMTC/1987: The Fourth IEEE Instrum and Meas Technol Conf, Boston, MA, USA, Apr 27-29 1987 p 913-917.

**SEMICONDUCTOR MATERIALS** See Also ACOUSTIC SURFACE WAVE DEVICES—Applications; BARIUM TITANATE—Thermal Effects; CATHODOLUMINESCENCE; COMPOSITE MATERIALS—Microstructure; COPPER AND ALLOYS—Amorphous; COPPER SELENIUM ALLOYS—Physical Properties; CRYSTALS—Electron States; CRYSTALS—Growth; ELECTRONS—Tunneling; GALLIUM AND ALLOYS—Thin Films; GAS DETECTORS—Performance; GLASS—Optical Properties; GLASS—Physical Properties; GLASS, METALLIC—Doping; INDIUM AND ALLOYS—Phase Transitions; INFRARED DETECTORS—Materials; INTERMETALLICS; LIQUID METALS—Electronic Properties; LITHIUM COMPOUNDS—Electric Conductivity; MICROSCOPIC EXAMINATION—Transmission Electron Microscopy; MOLYBDENUM COMPOUNDS—Electric Properties; OPTOELECTRONIC DEVICES—Reviews; ORGANIC COMPOUNDS—Magnetic Properties; PALLADIUM SILICON ALLOYS—Thin Films; RARE EARTH ELEMENTS; SEMICONDUCTING GALLIUM ARSENIDE—Ion Implantation; SEMICONDUCTING SILICON—Etching; SEMICONDUCTING SILICON COMPOUNDS—Surfaces; SEMICONDUCTOR DEVICES; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES, MOS—Ion Implantation; SEMICONDUCTOR DEVICES, MOSFET—Analysis; SEMICONDUCTOR DEVICES, MOSFET—Performance; SILICON CHROMIUM ALLOYS—Electric Conductivity; SOLAR CELLS; SOLAR CELLS—Efficiency; SOLIDS; SOLIDS—Physical Properties; SUPERCONDUCTING MATERIALS—High Temperature Effects; SURFACES—Adsorption; TRANSISTORS, FIELD EFFECT—Electric Properties; TRANSISTORS, FIELD EFFECT—Heterojunctions; TRANSISTORS, FIELD EFFECT—Modeling; ULTRASONIC WAVES—Absorption; X-RAYS—Diffraction.

**096654 RECTIFICATION PROPERTIES OF ASYMMETRICAL SUPERLATTICES.** A rectifying superlattice which can be used for detecting THz waves is proposed. The device is created by using an effective-mass superlattice in which the superlattice cycle is gradually changed. The operating principle is based on the fact that the quantum mechanical transmission coefficient with asymmetrical geometry is asymmetrical with respect to the applied voltage. The forward current is several orders in magnitude greater than the reverse current at a relatively low applied voltage. This feature is potentially useful for detecting and mixing small signals at THz frequencies. (Author abstract) 12 refs.

Aishima, Asuo (Hiroshima Univ, Hiroshima, Jpn); Fukushima, Yoshifumi. *Jpn J Appl Phys Part 1* v 26 n 8 Aug 1987 p 1310-1319.

**096655 PHOTO-EPITAXY OF NARROW BAND GAP II-VI MATERIALS - THE WAY AHEAD.** The present status of photo-epitaxy in relation to narrow band gap II-VI materials is outlined. Epitaxial layers of  $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$  and related binaries have been grown in the

temperature range 200°-300°C. Reaction mechanisms are discussed and include the Hg photosensitized decomposition of diethyltelluride, free radical mechanisms and the effect on alloy composition. The current problems of photo-epitaxy and the influences that solutions to these problems will have on future developments are considered. Greater tailoring of the precursors and u.v. wavelengths is anticipated and reaction paths selected for surface heterogeneous reactions. The future objective for photo-epitaxy of II-VI materials is to achieve in situ fabrication technology where the epitaxial growth only occurs on pre-selected areas of the substrate and is combined with other laser processing techniques. (Author abstract) 20 refs.

Irvine, S.J.C. (Royal Signals & Radar Establishment, Malvern, Engl); Mullin, J.B. *Chemtronics* v 2 n 2 Jun 1987 p 54-61.

**096656 KINETICS OF PHOTOCONDUCTIVITY IN A SEMICONDUCTOR UNDER STRONG INTERBAND OPTICAL EXCITATION (POSSIBLE STOCHASTICITY).** Stationary states and the kinetics of charge carriers are studied in an 'almost intrinsic' semiconductor containing deep levels of one kind and subjected to exposure under photon energy greater than the forbidden bandwidth. The exposure intensity is assumed sufficiently large, such that the concentration of the photoexcited charge carriers would exceed equilibrium significantly. Taken into account are both the charge carrier heating by the light and the dependence of the forbidden bandwidth on the electron and hole concentration and temperature. The conditions are mentioned for which stochastic or periodic electron and hole temperature and concentration self-oscillations should occur in the specimen. (Author abstract) 12 refs.

Bonch-Bruевич, V.L. (M.V. Lomonosov Moscow State Univ, USSR). *Sov Phys J* v 30 n 6 Jun 1987 p 517-523.

**096657  $\text{A}^{\text{I}}\text{B}^{\text{III}}\text{C}_2\text{VI}$ -HALBLEITER MIT CHALCOPYRITSTRUKTUR. [ $\text{A}^{\text{I}}\text{B}^{\text{III}}\text{C}_2\text{VI}$ -Semiconductors with Chalcopyrite Structure].** The ternary  $\text{A}^{\text{I}}\text{B}^{\text{III}}\text{C}_2\text{VI}$  chalcopyrite semiconductors are of technological interest since they show promise for applications in such areas as solar cells and non-linear optics. In this paper we give a survey of the crystal chemistry of these compounds, including the structure of the epitaxial layers, and discuss some new results concerning their thermal properties. Furthermore, the influence of the p-d hybridization of the uppermost valence band on the band gap and the nature of the intrinsic defects in  $\text{CuInSe}_2$  are considered. (Author abstract) In German. 156 refs.

Kuehn, Guenther (Karl-Marx-Univ Leipzig, Leipzig, East Ger); Neumann, Hans. *Z Chem* v 27 n 6 Jun 1987 p 197-206.

**096658 LIOUVILLE SPACE REVISITED: EXCITATION AND RELAXATION OF MULTIPLE-QUANTUM NUCLEAR SPIN COHERENCE IN DIPOLEAR SYSTEMS.** Dominant trends in the nuclear spin dynamics of large, strongly coupled systems are predicted using a model that treats coherence transfer as a multisite exchange process in Liouville space. The problem is broken into two parts. First, the formation of multiple-quantum coherences under a nonsecular Hamiltonian is examined for a system of N spin-1/2 nuclei. These coherences then are allowed to evolve under a secular Hamiltonian, during which time there occurs a redistribution into new multiple-spin modes. Throughout both phases, the system is driven to a steady state where most of the coherence is shared by modes involving approximately 75% of the spins. The effects of different initial distributions in Liouville space are investigated. (Author abstract) 8 refs.

Munowitz, M. (Amoco Corp, Naperville, IL, USA); Mehring, M. *Solid State Commun* v 64 n 4 Oct 1987 p 605-608.



**096659 AB INITIO EXPLANATION OF THE INCOMMENSURATE PHASE TRANSITION IN  $\text{BaMnF}_4$ .** Results of an a priori theoretical study of the origins of the incommensurate instability in  $\text{BaMnF}_4$  are presented. The most unstable vibrational mode lies at  $q_1 = (0.32, 0.5, 0.5)$  (in fractions of the reciprocal lattice vectors for the orthorhombic lattice), while the observed value is  $(0.392, 0.5, 0.5)$ . These findings are interpreted in terms of our previously introduced concept of an imperfect, or 'latent' symmetry which is extended into a general explanation of incommensurate behavior. A further possible consequence of this is that some strongly incommensurate systems could, in a specific and restricted sense, be novel states of matter. (Author abstract) 15 refs.

Edwardson, P.J. (Univ of Nebraska-Lincoln, Lincoln, NE, USA); Katkanant, V.; Hardy, J.R.; Boyer, L.L. *Solid State Commun* v 64 n 4 Oct 1987 p 625-629.

**096660 BRILLOUIN SCATTERING STUDY OF PHASE TRANSITIONS IN  $\text{TiInS}_2$ .** The temperature dependence of the elastic coefficients of  $\text{TiInS}_2$  has been investigated by Brillouin scattering measurements. For longitudinal phonons propagating in the (001) plane the variation of  $\Delta C_{11} \approx (T_c - T)$  was found below the ferroelectric transition point ( $T_c = 189$  K). For propagation perpendicular to the (001) plane ( $C_{33}$  mode) clear anomalies were observed at  $T = 213$  K and  $T = 195$  K. Between these temperatures the Brillouin peaks show broadening, which is attributed to a coupling between the acoustic mode and an overdamped mode. (Author abstract) 15 refs.

Laiho, R. (Univ of Turku, Turku, Finl); Levola, T.; Sardar, R.M.; Allakhverdiev, K.R.; Sadikov, I.Sh.; Tagiev, M.M. *Solid State Commun* v 63 n 12 Sep 1987 p 1189-1192.

**096661 CYLINDRICAL QUANTUM WELL WITH POSITION DEPENDENT MASS.** Using the envelope function approximation and a one-band model, the cylindrical quantum well with position dependent mass problem is studied. The boundary conditions to be fulfilled by the radial wave functions are deduced. The transcendental equation for the energy levels, the normalized wave functions, and the confinement are obtained in the flat band approximation considering a sectionally constant mass profile. Also numerical results are given for the  $\text{GaAs-Al}_{0.32}\text{Ga}_{0.68}\text{As}$  cylindrical quantum well. (Author abstract) 15 refs.

Perez-Alvarez, R. (Havana Univ, Havana, Cuba); Parra-Santiago, J.L.; Pajon-Suarez, P. *Phys Status Solidi B* v 144 n 2 Dec 1987 p 639-644.

**096662 THREE-BRANCH EXCITONIC POLARITONS IN DIRECT BAND GAP CUBIC SEMICONDUCTORS.** The transition is studied between a photon and 'heavy' and 'light' excitons in direct-band gap cubic semiconductors with a fourfold degenerated highest valence band at the center of the Brillouin zone. The transition matrix elements are calculated in the second-order approximation of the perturbation series with respect to a small constant proportional to the difference of the mass of the heavy and light holes. The algebraic equation determining the dispersion of the three-branch polaritons is derived. The spin structure of the wave functions of the corresponding excitons is established. (Author abstract) 7 refs.

Khamsasy, Ch. (Acad of Sciences of Vietnam, Hanoi, Vietnam); Nguyen Van Hieu; Nguyen Ai Viet. *Phys Status Solidi B* v 144 n 2 Dec 1987 p 645-652.

**096663 ON PHOTOEMISSION FROM QUASI-ONE-DIMENSIONAL STRUCTURES OF NARROW-GAP SEMICONDUCTORS HAVING RECTANGULAR CROSS-SECTIONS.** An attempt is made to investigate for the first time the photoemission from quasi-one-dimensional (Q1D) structures of narrow-gap semiconductors having rectangular cross-sections, taking n-type  $\text{InSb}$  as a typical example. It is found that for Q1D structures having square cross-sections, the variation of the photocurrent density with the transverse dimensions is significantly influenced by the photo ener-

gies. For photon energies close to the electron affinity, the emission current exhibits an oscillatory character (with an increasing average) with the increasing transverse dimensions of the submicron structure. For photon energies significantly lower than the electron affinity, the emission could become forbidden over a narrow range of the transverse dimensions. 10 refs.

Maity, A.B. (Univ Coll of Science & Technology, Calcutta, India); Majumdar, C.; Chakravarti, A.N. *Phys Status Solidi B* v 144 n 2 Dec 1987 p K93-K98.

**096664 PHOTOELECTRON EMISSION AND SURFACE STATE BANDS IN III-V SEMICONDUCTORS.** The possibility of applying the method of external photoemission for detection of filled surface states in three III-V semiconductors is discussed. In the first part of the paper Kane's and Ballantyne's theories are presented. In the second part, experimentally obtained spectral distributions of derivatives of quantum yield  $Y'$  ( $\epsilon$ ) for  $\text{InSb}$  or  $\text{InAs}$  'real' and atomically clean surfaces are given, as well as those obtained with the use of theoretical Ballantyne's functions. Comparison of the peaks or 'shoulders' in these distributions led to conclusion, that photoemission yield curves reflect volume, electron features of crystals, and the observed peaks do not originate from surface states overlapping the valence bands. The similar result was obtained for  $\text{GaAs}$  crystals, however, in this case, the proportion of peak height in the respective figures does not give an obvious explanation (distribution  $Y'$  ( $\epsilon$ ) for  $\text{GaAs}$  with the surface orientation (100) and (110) were compared). The whole set of experimental data gave rise to conclude that, for the examined semiconductors the commonly used dependence  $Y'$  ( $\epsilon$ ) approx.  $N_0$  ( $\epsilon$ ) is improper. (Author abstract) 15 refs.

Seroczynska-Wojas, Bozena (Warsaw Technical Univ, Warsaw, Pol). *Electron Technol (Warsaw)* v 19 n 3-4 1987 p 103-113.

**096665 ON THE MECHANISMS OF PHOTOREFLECTANCE IN MULTIPLE QUANTUM WELLS.** Mechanisms of photoreflectance of MQW structures are studied. The photomodulation of the built-in surface electric field is analyzed. It is argued that in MQW structures unlike to bulk crystals the electric field does not result in a Franz-Keldysh-effect but rather in a Stark effect of subbands and excitons and a corresponding change of wavefunctions and oscillator strengths. The photoreflectance line shape is not of third derivative but of first derivative type in the case of MQW structures. Experimental photoreflectance spectra are reported which confirm these conclusions and allow the derivation of sublevel energies, broadening parameters, and exciton binding energies. (Author abstract) 17 refs.

Enderlein, R. (Beijing Univ, Beijing, China); Jiang, Desheng; Tang, Yinsheng. *Phys Status Solidi B* v 145 n 1 Jan 1988 p 167-180.

**096666 DETERMINATION OF THE ELECTRON LIFETIME IN  $\text{P-CuInS}_2$  FROM A PHOTOVOLTAIC STUDY OF  $\text{In/p-CuInS}_2$  SCHOTTKY BARRIER DIODES.** The chalcopyrite  $\text{CuInS}_2$  semiconductor with the direct band gap  $E_g$  1.5 eV at  $T = 300$  K has been suggested as a useful material for electrooptical devices and photovoltaic conversion. The determination of the lifetime of minority carriers and their diffusion length is therefore important for analysis of the photovoltaic performance of this material. The results of a study of single crystals grown from the melt by the Bridgman method are presented. The crystals displayed p-type conductivity of about  $10^{-4} \Omega^{-1} \text{cm}^{-1}$  and hole mobility of about  $20 \text{ cm}^2 \text{V}^{-1} \text{s}^{-1}$ . From the typical capacitance-voltage characteristic of the diode the diffusion potential  $U_D = 0.34$  and width of the space charge layer  $w = 60 \text{ nm}$  were found at  $T = 300 \text{ K}$ . 12 refs.

Opanowicz, A. (Technical Univ of Lodz, Lodz, Pol); Koscielniak-Mucha, B. *Phys Status Solidi A* v 105 n 2 Feb 1988 p K135-K139.

**096667 DEVICE FOR CHARGE AND CURRENT RELAXATION SPECTROSCOPY OF LEVELS IN**

**SEMICONDUCTORS.** A device is described for determination of level parameters in semiconductors and semiconductor structures by charge and current relaxation spectroscopy. The device permits measurement of the relaxation of a leaking charge or a discharge current with a time constant of from approximately 1  $\mu\text{sec}$  to 10 sec. Level occupation is changed by a voltage or light pulse. The method permits determination of the energy state, capture cross section, and concentration profile of deep levels, the energy spectrum of surface states, and the concentration profile of uncompensated fine levels. The device allows study of specimens with  $R_c C_c \geq 1 \mu\text{sec}$ , where  $R_c$  is the leakage resistance and  $C_c$  is the equivalent capacitance of the specimen. (Author abstract) 9 refs.

Rukovichnikov, A.I. (Acad of Sciences of the USSR, Moscow, USSR); Polyakov, V.I.; Perov, P.I.; Ignatov, B.G.; Ermakov, O.N.; Aleksandrov, A.A. *Instrum Exp Tech* v 30 n 5 pt 2 Sep-Oct 1987 p 1226-1230.

**096668 NONCRYSTALLINE SEMICONDUCTORS.** This book incorporates 17 papers that focus on processes and materials on the insulating (or semiconducting) side of the Anderson transition. An attempt is made to give the reader a deeper understanding of noncrystalline semiconductors by contrasting the similarities and major differences exhibited by these material systems. The articles introduce the major concepts, describe our present understanding, and emphasize which questions remain unresolved and what needs to be done in the future. Comprehensive lists of references are included. Topics considered include: amorphous semiconductors, their optical, electronic and physical properties, magnetic effects, the Hatt effect, transport properties, vibrational spectra of amorphous solids, semiconductor devices, amorphous silicon, amorphous chalcogenides, amorphous group V semiconductors (P, As, Sb), oxide glasses, amorphous molecular solids, biological polymers, and impurity conduction in semiconductors. All papers are separately indexed and abstracted.

Pollak, Michael (Ed.) (Univ of California, Riverside, CA, USA). *Noncryst Semicond* Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 3 v, 605p.

**096669 CRYSTALLINE SEMICONDUCTING MATERIALS AND DEVICES.** This book which contains 16 contributions by various authors, is concerned primarily with the fundamental theory underlying the physical and chemical properties of crystalline semiconductors. After basic introductory material on chemical bonding, electronic band structure, phonons, and electronic transport, some emphasis is placed on surface and interfacial properties, as well as effects of doping with a variety of impurities. Against the background, the use of such materials in device physics is examined and aspects of materials preparation are discussed. The level of presentation is suitable for postgraduate students and research workers in solid-state physics and chemistry, materials science, and electrical and electronic engineering. Topics considered include: amorphous silicon, ion implantation, annealing, optical-communication devices, theory of surface waves, space-charge layers at semiconductor interfaces, electronic structure of surface and interfaces, impurity bands, electronic states and structural properties of deep centers in semiconductors, shallow impurity states, localized phonon modes, electron transport, phonons, electronic band structure as well as bonds and bands in semiconducting materials. All papers are separately indexed and abstracted.

Butcher, Paul N. (Ed.) (Univ of Warwick, Coventry, Engl); March, Norman H. (Ed.); Tosi, Mario P. (Ed.). *Cryst Semicond Mater and Devices*, Trieste, Italy, 1984 Publ by Plenum Press, New York, NY, USA, 1988 645p.

**096670 CHARACTERISTICS OF  $\text{ZnO/CuInS}_2$  HETEROJUNCTIONS.** Heterojunctions of the form  $\text{ZnO/CuInS}_2$  have been fabricated by sputtering a layer of thin film n-type  $\text{ZnO}$  on p- or n-type monocrystalline Bridgman-grown  $\text{CuInS}_2$  samples. Dark and illuminated current-voltage and dark capacitance-voltage characteris-



tics have been investigated and the energy band diagrams have been proposed for the heterostructures. (Author abstract) 18 refs.

Qiu, C.X. (McGill Univ, Montreal, Que, Can); Shih, I.; Champness, C.H. *Sol Energy Mater* v 17 n 4 Jun 1988 p 289-297.

**096671 HOT ELECTRON MAGNETOPHONON RESONANCES IN CONDUCTION AND NOISE FOR A NONDEGENERATE SEMICONDUCTOR.**

The nonlinear transverse magnetoresistivity of conduction electrons subject to inelastic scatterings by longitudinal optical phonons in a non-degenerate semiconductor is determined using a balance equation approach. Magnetophonon resonances are examined in both, the linear and nonlinear transverse magnetoresistivities; and the electron temperature in an intense electric field is calculated as a function of the magnetic field, showing significant electron resonant cooling. The nonlinear current saturation in a high electric field is also studied, and is shown to be independent of the magnetic field. The thermal noise temperature for hot electrons at a nonzero bias is also examined, and exhibit its oscillatory behavior as a function of magnetic field. (Author abstract) 18 refs.

Cui, H.L. (Stevens Inst of Technology, Hoboken, NJ, USA); Lei, X.L.; Horing, N.J.M. *Phys Status Solidi B* v 146 n 1 Mar 1988 p 189-197.

**096672 DISORDERED SEMICONDUCTORS.** This volume incorporates 76 papers divided into eight sections addressing current issues relevant to the electronic and structural properties of heavily-doped crystalline and amorphous semiconductors. Topics considered include: metal-insulator transitions, chalcogenide glasses, hydrogenated amorphous silicon, multilayers, heterojunctions, interfaces, polaron formation, density of states, dc conductivity, localization effects, amorphous-to-crystalline transitions, defect formation, dangling bonds, metastability, band tail effects, polar cells, junction capacitance measurement, charge carriers, quantum effects, persistent photoconductivity, resonant tunneling, polymeric semiconductors, doping, spectroscopic analysis, optical absorption, photoelectric properties, spontaneous emission, thermal and optical quenching, photoluminescence, carrier trapping, spectroscopic ellipsometry, photoemission, energy gaps, contacts, photo-induced effects, and neutron scattering in graphite. All papers are separately indexed and abstracted.

Kastner, Marc A. (Ed.) (MIT, Cambridge, MA, USA); Thomas, Gordon (Ed.); Ovshinsky, Stanford R. (Ed.). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 760p.

**096673 AB-INITIO DETERMINATIONS OF SEMICONDUCTOR SPIN-ORBIT SPLITTINGS FROM ASW.** We demonstrate that the spin-orbit splittings of the valence and conduction bands at the  $\Gamma$ , L and X symmetry points in the Brillouin zone of a series of IV-IV, III-V, II-VI and I-VII semiconductors can be obtained accurately, to within 15 percent, from the Augmented Spherical Wave (ASW) method. The expression required for the evaluation of the matrix elements of the spin-orbit operator within the ASW basis set is derived and discussed. Our results imply that the earlier experimental assignment of  $\Delta_0$  for AlSb and InP should be reconsidered. (Author abstract). 16 Refs.

Eppenga, R. (Philips Research Lab, Eindhoven, Neth); Schuurmans, M.F.H.; Rempah, H.W.A.M. *J Phys Chem Solids* v 49 n 9 1988 p 1119-1124.

**096674 LES SEMICONDUCTEURS II-VI PARTICULAIRES ET APPLICATIONS. [Group II-VI Semiconductors: Specific Features and Applications].** II-VI compounds form a particularly class of semiconductor materials owing to their specific physical properties. Yet, they can be compared with the III-V semiconductors (GaAs-InP) for their band gap engineering facilities. Up to now, their development was essentially bound with the needs of the infrared detection and imaging in the windows of atmospheric transmission from 8 to 12  $\mu\text{m}$

and 3 to 5  $\mu\text{m}$ , and more recently in the wavelength range which correspond to the optical fiber transmissions. High quality monocrystal are difficult to obtain with classical growing methods. However, with the aid of epitaxial technologies it is possible to realize new devices. The electronic structure of these materials reveals a few original characteristics in comparison with other semiconductor: large band gap range, metal/semiconductor transition, spin-orbit resonance, specific effects with magnetic ions in the crystal lattice etc. In this paper, the author describes some of the most significant properties of these materials, their technology and preparation and some of the most promising applications. (Edited author abstract). 53 Refs. In French.

Le Traon, Jean-Yves (CNET, Lannion, Fr). *Ann Telecommun* v 43 n 7-8 Jul-Aug 1988 p 378-391.

**096675 EXTENDED ABSTRACTS OF THE 19TH CONFERENCE ON SOLID STATE DEVICES AND MATERIALS.** Proceedings incorporates 136 papers. These are grouped according to the following subjects: MOS memories; silicon devices; III-V semiconductor processing; optical devices and materials; characterization of III-V type semiconductors; epitaxial growth; SOI; gate dielectrics; silicon materials technology; high-speed devices; microfabrication; isolation; bipolar devices; quantum size effects; modeling and simulation; metallization and multilevel interconnects; characterization and manipulation of devices and materials. Topics considered include: semiconductor and excimer lasers; FET's, MOSFET's, MESFET's, MIS devices, epitaxial growth, molecular beam epitaxy (MBE), chemical vapor deposition (CVD), etching, microscopic examination, spectroscopic analysis, ion and electron beams, photoluminescence, dielectrics, superconductors, electric discharges, heterojunctions, Schottky barriers, integrated circuits, LSI, VLSI, Monte Carlo simulation, and crystals. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10533 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Japan Soc of Applied Physics, Tokyo, Jpn). *Conf Solid State Devices Mater* 19th, Tokyo, Jpn, Aug 25-27 1987. Publ by Japan Soc of Applied Physics, Tokyo, Jpn, 1987 565p.

**096676 II-VI COMPOUNDS 1987: PROCEEDINGS OF THE THIRD INTERNATIONAL CONFERENCE ON II-VI COMPOUNDS (ORGANIZED IN ASSOCIATION WITH THE SEVENTH TRIANNUAL MEETING OF THE AMERICAN ASSOCIATION FOR CRYSTAL GROWTH).** The proceedings contains 140 papers. The papers are grouped under the following section headings: theory; growth from liquids; growth from the vapor; characterization; materials processing (ion implantation, diffusion, passivation); and devices. Some of the specific topics discussed are: size-induced metal-insulator transition in metals and semiconductors; (Hg, Zn) Te - a new material for IR detection; growth of high-quality ZnSe by MOVPE on (100) ZnSe substrate; dislocations and electrical characteristics of HgCdTe; diffusion mechanisms in II-VI materials; and electroplated  $\text{Cu}_x\text{S-CdS}$  photovoltaic cells. All papers are separately indexed and abstracted.

Ruth, R.P. (Ed.) (SBRC, Goleta, CA, USA); Marfaing, Y. (Ed.); Mullin, J.B. (Ed.); Woods, J. (Ed.). *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 959p.

**096677 THIRD CANADIAN SEMICONDUCTOR TECHNOLOGY CONFERENCE.** This issue contains 52 conference papers. The topics covered include: semiconductor materials growth; materials and device characterization; materials and device processing; device fabrication and performance; solar cells; lasers. All of the papers are in English except one which is in French. All of the papers are abstracted and indexed separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11127 in the Ei Engineering Meetings (TM) database produced by

Engineering Information, Inc.

Anon (Nat'l Research Council of Canada, Ottawa, Ont, Can). *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 814-1068.

**096678 THIRD INTERNATIONAL CONFERENCE ON SUPERLATTICES, MICROSTRUCTURES AND MICRODEVICES.** This issue contains 9 conference papers, all of the papers are abstracted and indexed separately. The topics covered include: helicon wave propagation; multi-quantum-well structures; feriodic and fibonacci superlattices; nonideal superlattices; band structure. Most of the papers deal with GaAs and related compounds. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11057 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *Superlattices Microstruct* v 3 n 6 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 641-700.

**096679 DIALECTRIC LAYERS IN SEMICONDUCTORS: NOVEL TECHNOLOGIES AND DEVICES 1986 (PAPERS PRESENTED AT E-MRS SPRING MEETING, SYMPOSIUM XII).** This conference proceedings contains 48 papers. Topic covered include: silicon on insulator; fundamentals of laser and electron induced oxidation and nitridation; interface and thin oxides; and semiconducting compounds. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11424 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Bentini, G.G. (Ed.) (CNR, Bologna, Italy); Fogarassy, E. (Ed.); Golanski, A. (Ed.). *Dialectr Layers in Semicond: Novel Technol and Devices 1986*, Strasbourg, Fr, Jun 17-20 1986 Publ by Les Editions de Physique, Les Ulis, Fr, 1986 406p.

**096680 HOT CARRIERS IN SEMICONDUCTORS, PROCEEDINGS OF THE FIFTH INTERNATIONAL CONFERENCE.** Proceedings incorporate 111 papers of which three are presented in the form of summary/abstract. The papers are grouped into ten chapter dealing with: real space transfer/heterostructures, ultrafast studies, optical studies, transport theory, devices, ballistic transport, scattering processes and hot phonons, tunneling, far IR and magnetic field studies as well as impact ionization/noise/chass. Topics considered include: electric breakdown, germanium, silicon, GaAs, semiconducting gallium and aluminum compounds, current simulations, quantum wells, magnetic and electric field effects, spectroscopic analysis, phonon, hot electrons, magneto-phonon resonance, heterostructures, luminescence and photoluminescence, bipolar and field-effect transistors, semiconductor diodes, charge carriers, Wigner function, superlattices, donors, and bulk semiconductors, ensemble Monte Carlo simulation, umpolar hot electron transistors, MODFET, photoconductivity, carrier mobility, plasmas, Raman scattering, and relaxation processes. All papers are separately indexed and abstracted. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11243 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Shah, Jagdeep (Ed.) (AT&T, Bell Lab, Holmdel, NJ, USA); Iafate, G.J. (Ed.). *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 319-820.

**096681 METALS FOR THE ELECTRONICS INDUSTRY - 1.** The paper discusses three aspects of the use of metals. The first part deals with metals in semiconductors. Most of the paper deals with two recent develop-



ments - the attempt to return to the electronic valve using semiconductor technology and the emergence of high-temperature superconductors.

Hilsum, C.; Lee, R.A. *Trans Inst Min Metall Sect C* v 97 Mar 1988, Proc of the Twelfth Annu Comm Meet of the Inst of Min and Metall, London, Engl, Dec 3 1987 p 31-34.

**Acoustic Effects** See CRYSTALS—Acoustic Properties.

#### Acoustic Properties

**096682 SOUND ABSORPTION IN HIGHLY INHOMOGENEOUS SEMICONDUCTORS.** The sound wave propagation in piezosemiconductors with inhomogeneously distributed carrier density has been previously studied assuming the inhomogeneities to be small. In the present study this restriction is removed. The procedure of solving the sound absorption problem reduces to the deduction of the dispersion equation as a result of solving the elasticity theory equations combined with Maxwell ones. 4 refs.

Chaikovskii, I.A. (Inst of Applied Physics, Kishinev, USSR); German, A.I. *Phys Status Solidi B* v 143 n 1 Sep 1987 p K53-K56.

#### Acoustic Wave Effects

**096683 PHONON-PLASMON INTERACTION WITH ZINNER TUNNELING IN AN ALTERNATING ELECTRICAL FIELD AND WAVEFRONT REVERSAL OF SOUND.** The possibility of wavefront reversal of sound in piezosemiconductors based on phonon-plasmon interaction is examined in conditions of periodic change in the balanced concentration of the electron-hole plasma with Zinner tunneling in an external electrical field. (Author abstract) 4 refs.

Brysev, A.P.; Strel'tsov, V.N. *Sov Phys Lebedev Inst Rep* n 5 1987 p 34-37.

**096684 WAVEFRONT REVERSAL OF SONIC BEAMS IN PIEZOSEMICONDUCTORS WITH MODULATION OF THE ELECTRON MOBILITY BY AN EXTERNAL ELECTRICAL FIELD.** A new mechanism for wavefront reversal of sound in piezosemiconductors is examined. It is based on phonon-plasmon interaction with periodic modulation of the electron mobility in an external alternating electrical field. (Author abstract) 2 refs.

Brysev, A.P.; Strel'tsov, V.N. *Sov Phys Lebedev Inst Rep* n 9 1987 p 9-12.

**Adsorption** See METALS AND ALLOYS—Electronic Properties.

**Amorphous** See Also ARSENIC—Amorphous; ELECTRIC CONDUCTIVITY; METALS AND ALLOYS—Amorphous; SEMICONDUCTING FILMS—Electric Properties; SEMICONDUCTING GERMANIUM—Amorphous; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Order-Disorder.

**096685 AMORPHOUS SEMICONDUCTORS.** In contrast to crystalline solids, which are characterized by the long-range periodic order of their constituent atoms, the properties of amorphous solids are determined by the electronic configuration and chemical bonding of adjacent atoms. The research efforts of physical scientists over the past twenty years have helped secure a promising commercial future for amorphous semiconductors, in areas as diverse as solar power and sub-micron optics. (Edited author abstract) 7 refs.

Reynolds, S. (Univ of Edinburgh, Scotl); Belford, R.E. *Phys Technol* v 18 n 5 Sep 1987 p 193-203.

**096686 ROLE OF DANGLING BONDS IN THE TRANSPORT AND RECOMBINATION OF a-Si:Ge:H ALLOYS.** Measurements are reported of the luminescence, time-of-flight photoconductivity and electron spin resonance (ESR) in a-Si:Ge:H alloys. In the

alloys it is found that the luminescence intensity varies with defect density according to a tunneling model similar to that in a-Si:H. However, the tunnelling distance decreases with Ge concentration up to about 30% and then increases. This nonmonotonic behavior is attributed to the additional chemical disorder of the alloys. Time-of-flight experiments confirm that the dangling bonds are the dominant deep trap in the alloys. We find that the capture cross-sections for electrons and holes are very similar to those measured in a-Si:H, and are independent of whether the trap is a Ge or Si dangling bond. (Author abstract) 20 refs.

Street, R.A. (Xerox Palo Alto Research Cent, Palo Alto, CA, USA); Tsai, C.C.; Stutzmann, M.; Kakalos, J. *Philos Mag B* v 56 n 3 Sep 1987 p 289-303.

**096687 A.C. CONDUCTION IN AMORPHOUS CHALCOGENIDE AND Pnictide SEMICONDUCTORS.** The various origins of a frequency-dependent conductivity in amorphous semiconductors are reviewed, stressing particularly recent advances and the influences that factors such as correlation and non-random spatial distributions of electrically active centres can have on the a.c. conductivity. A comprehensive survey is given of the experimental a.c. data for two types of amorphous semiconductor, namely chalcogenide and pnictide materials. It is concluded that the a.c. behaviour at intermediate to high temperatures is well accounted for by the correlated-barrier-hopping model, whereas the low-temperature behaviour is probably due to atomic tunneling. (Author abstract) 140 refs.

ELLIOTT, S.R. (Univ of Cambridge, Cambridge, Engl). *Adv Phys* v 36 n 2 Mar-Apr 1987 p 135-218.

**096688 CALCULATION OF LOCALIZED-STATE ENERGY DISTRIBUTIONS FROM TRANSCIENT-PHOTO RESPONSE DATA.** Time-of-flight studies of carrier transport through films of an amorphous semiconductor may be used to explore the energy distribution of shallow localized states in such materials. In this paper, we describe a new and computationally straightforward procedure for this purpose. The effectiveness of both this and previous techniques is evaluated using computer-generated time-of-flight data for model semiconductor films having known energy distributions of localized states. The procedures are also assessed in relation to recent experimental data for electron transport in amorphous silicon. (Author abstract) 11 refs.

Marshall, J.M. (Univ Coll Swansea, Swansea, Wales); Berkin, J.; Main, C. *Philos Mag B* v 56 n 5 Nov 1987 p 641-652.

**096689 NOVEL DEPOSITION CONCEPT FOR AMORPHOUS SUPERLATTICES.** Cumulative layered structures of amorphous semiconductors have attracted much interest in recent years, as they make it possible to use quantum effects to improve semiconductor properties. There is, however, a serious disadvantage in using such superstructures in practical devices, because the conventional process requires mechanical alternation of source gases and evacuation of the system for each layer deposition. As an alternative to this inefficient physically controlled method, the authors have developed an efficient photochemically controlled method which facilitates the continuous deposition of various superlattices. In combination with two modes of excitation, at least one of which is operated in a pulsed mode, an appropriately selected pair of source gases accumulates continuously binary layers of amorphous semiconductors. As an example of verification of this novel process, an amorphous superlattice composed of an amorphous silicon carbide barrier layer and an amorphous silicon well layer was prepared from a mixture of disilane and carbon tetrafluoride. (Edited author abstract) 7 refs.

Kawasaki, M. (Univ of Tokyo, Tokyo, Jpn); Matsuzaki, Y.; Fueki, K.; Nakajima, K.; Yoshida, Y.; Koinuma, H. *Nature* v 331 n 6152 Jan 14 1988 p 153-155.

**096690 Dc CONDUCTIVITY OF AMORPHOUS CuInSe<sub>2</sub> FILMS.** CuInSe<sub>2</sub> is one of ternary chalcopyrite

semiconductors of the II-III-VI<sub>2</sub> group with an energy gap around 1.00±0.02 eV for polycrystalline materials, and is a strong contender for terrestrial solar cells fabrication. In this letter results of dc conductivity, its temperature dependence, the effect of thermal cycling on the films, the activation energies and the annealing effects on flash evaporated and co-evaporated amorphous CuInSe<sub>2</sub> films on alumina substrates, are reported. Above 200 K, the conduction seems to be by the process where the carriers are excited beyond the mobility edges into non-localized states. 4 refs.

Venkataraman, S. (Univ of Hyderabad, Hyderabad, India); Bhatnagar, A.K. *J Mater Sci Lett* v 6 n 12 Dec 1987 p 1374-1376.

**096691 MULTIPLE TRAPPING MODEL: APPROXIMATE AND EXACT SOLUTIONS.** Approximate methods of analysis of the multiple trapping model for amorphous semiconductors, which is based on the concept of demarcation energy between the two fractions of shallow and deep traps, are comparatively considered. The necessity is shown to take into account the real trap energy distribution function to obtain the results adequate to exact analytical solution of the problem. (Author Abstract) 7 refs.

Arkhipov, V.I. (Moscow Engineering Physics Inst, Moscow, USSR); Iovu, M.S.; Rudenko, A.I.; Shutov, S.D. *Solid State Commun* v 62 n 5 May 1987 p 339-340.

**096692 COMPUTER SIMULATION STUDIES OF RADIATION INDUCED AMORPHIZATION.** The molecular dynamics results reported here show the amorphization of a pure Lennard-Jones crystal under the introduction of point defects, either Frenkel pairs or isolated interstitials. The requirement of both critical concentration and introduction rate of the defects is evidenced, in agreement with laboratory results on metallic systems. The high value of the critical rate found is explained by the occurrence of a new migration mechanism, an athermal one, for the interacting interstitials, leading to a very fast elimination by clustering. (Author abstract) 13 refs.

Limoge, Y. (CEN, Gif-sur-Yvette, Fr); Rahman, A.; Hsieh, Horngming; Yip, Sidney. *J Non Cryst Solids* v 99 n 1 1988 p 75-88.

**096693 METAL-SEMICONDUCTOR TRANSITION IN AMORPHOUS Si<sub>1-x</sub>C<sub>x</sub> FILMS: DETECTION OF THE TRANSITION BY ROOM-TEMPERATURE MEASUREMENTS.** The relation between  $\sigma$  and  $d\sigma/dT$  is studied at room-temperature. All samples investigated which show activated conduction at low temperatures fulfill  $\sigma(293\text{ K}) < 300\ \Omega^{-1}\text{ cm}^{-1}$ , whereas all samples with metallic conduction at low temperatures fulfill  $\sigma(293\text{ K}) > 440\ \Omega^{-1}$ . Within the regions 100 to 360  $\Omega^{-1}\text{ cm}^{-1}$  and 440 to 1400  $\Omega^{-1}\text{ cm}^{-1}$  nearly linear relations between  $\sigma$  and  $d\sigma/dT$  are observed. It appears likely that  $d\sigma/dT$  as a function of  $\sigma+0$  exhibits a knee at about 420  $\omega^{-1}\text{ cm}^{-1}$  indicating the presence of a sharp metal-semiconductor transition at room temperature. The experimental results confirm quantitatively a phenomenological model of  $\sigma(T, x)$  in the semiconducting region, which is developed mainly on the basis of low-temperature measurements in two preceding papers. (Edited author abstract) 13 refs.

Moebius, A. (Akad der Wissenschaften der DDR, Dresden, East Ger). *Phys Status Solidi B* v 144 n 2 Dec 1987 p 759-766.

**096694 ALLOYING EFFECTS ON THE OPTICAL ABSORPTION EDGE AND PHOTOCONDUCTANCE OF RF SPUTTERED a-Sn<sub>1-x</sub>Si<sub>x</sub>:H FILMS.** Hydrogenated amorphous Sn-Si alloy films were prepared by reactive co-sputtering at 220 and at 110°C. The tin content of the films varied between 0.3 and 4.7 at.%. The optical absorption and photoconductivity were measured as a function of wavelength and film composition. The energy gap, as evaluated from these measurements, de-



creases with increasing tin content, more strongly for samples prepared at the lower temperature. The photoconductance response varies strongly, by about three orders of magnitude, as the Sn concentration increases to 4.7 at.% and is quite different for the two kind of samples. (Edited author abstract) 20 refs.

Perez, R. (Univ of Puerto Rico, Rio Piedras, PR, USA); Resto, O.; Weisz, S.Z.; Goldstein, Y. *Appl Phys Commun* v 7 n 4 Dec 1987 p 291-300.

**096695 PHONONS IN a-SiC:F ALLOYS.** A theoretical study of the vibrational excitations induced by F atoms in amorphous SiC has been made in a cluster Bethe lattice method formalism. The calculated results are in agreement with the available infrared data. However, two predicted peaks near 200 and 1000  $\text{cm}^{-1}$  have not been detected so far. (Author abstract) 10 refs.

Ghosh, B.K. (Allahabad Univ, Allahabad, India); Agrawal, Bal K. *Solid State Commun* v 65 n 8 Feb 1988 p 815-818.

**096696 PHYSICAL PROPERTIES OF AMORPHOUS MATERIALS, PROCEEDINGS OF A LECTURE SERIES.** The 14 papers in this volume are arranged in five parts. Part one, dealing with all aspects of the materials, can serve as a general introduction to the whole field. Part two is concerned with the structure of amorphous solids. Part three deals with the analysis of phonon modes in amorphous materials. The problem of electronic structure is the basis of both parts four and five. Part four is primarily concerned with the density of states available to electrons as they move through the disordered system. Part five is devoted to several aspects of nonequilibrium phenomena.

Adler, David (Ed.) (MIT, Cambridge, MA, USA); Schwartz, Brian B. (Ed.); Steele, Martin C. (Ed.). *Phys Prop of Amorphous Mater, Proc of a Lect Ser, Bloomfield Hills, MI, USA, 1982-1983* Publ by Plenum Press, New York, NY, USA & London, Engl, 1985 443p.

**096697 CHEMISTRY AND PHYSICS OF COVALENT AMORPHOUS SEMICONDUCTORS.** The author reviews the fundamentals of solid state physics adopting an approach in which periodicity is not fundamental and the theory of crystalline materials represents a subset of the general development. The current viewpoint is that the foremost consideration in any analysis of the properties of a particular material is the composition, which determines the chemistry and average coordination and thus, the local structure. The preparation conditions primarily affect the morphology but can also influence the local chemical bonding. The creation energy and effective correlation energy of the low-energy defects involve not only the nominal constituents but also the unintentional impurities. In addition, it is vital to analyze the surface and interface states as well as the space-charge conditions. Both chalcogenides and chalcogenides exhibit similar transient behavior, including dispersive transport, photoluminescence, photo-induced absorption, metastable phases, and photo-induced ESR. Many of these phenomena are now being observed and studied in crystalline semiconductors after having been first understood in amorphous phases. 167 refs.

Adler, David (MIT, Cambridge, MA, USA). *Phys Prop of Amorphous Mater, Proc of a Lect Ser, Bloomfield Hills, MI, USA, 1982-1983* Publ by Plenum Press, New York, NY, USA & London, Engl, 1985 p 5-103.

**096698 FUNDAMENTALS OF AMORPHOUS MATERIALS.** The author discusses the 'key' to making the nature of amorphous materials clear and to understanding their physical properties. First, there is an average coordination number which defines the structural integrity of the material and its gap and is determined only by the chemistry of the constituent atoms. This is called its normal structural bonding (NSB). Second, it is the deviations from the optimal coordination number, the deviant electronic configurations (DECs), that are essential to the understanding of the important phenomena in amorphous materials. It is these DECs which determine

the transport properties of amorphous materials and are responsible for the states in the gap. Third, there need not be corresponding crystal structures. The ability to design and synthesize a great variety of amorphous materials depends on the fact that many do not have corresponding crystal structures. The paper also describes new devices based on the application of these concepts. 115 refs.

Ovshinsky, Stanford R. (Energy Conversion Devices Inc, Troy, MI, USA). *Phys Prop of Amorphous Mater, Proc of a Lect Ser, Bloomfield Hills, MI, USA, 1982-1983* Publ by Plenum Press, New York, NY, USA & London, Engl, 1985 p 105-155.

**096699 STRUCTURAL STUDIES OF AMORPHOUS MATERIALS.** This paper is concerned with the progression from the initial studies of atomic arrangements in amorphous materials to those which have become possible recently as a result of the availability of synchrotron radiation. Regarding the last named, in principle it should be possible to use anomalous scattering to get the individual partial distribution functions. It should also be possible to determine atomic arrangements and their changes in real time for amorphous materials. Fractions of a second time scale are being evolved for EXAFS studies. There is reason to believe that these time-resolved studies will yield understanding of the rearrangements which take place as glasses go through the glass transition. The paper also includes a discussion on amorphous semiconductors. 24 refs.

Bienenstock, Arthur (Stanford Univ, Stanford, CA, USA). *Phys Prop of Amorphous Mater, Proc of a Lect Ser, Bloomfield Hills, MI, USA, 1982-1983* Publ by Plenum Press, New York, NY, USA & London, Engl, 1985 p 171-200.

**096700 PROBLEMS RELATING TO THE ELECTRONIC STRUCTURE OF AMORPHOUS SEMICONDUCTORS.** This paper deals with several problems related to the theory of amorphous semiconductors, some of which have remained unsolved despite the magnitude of the effort devoted to basic and applied research on these materials. The author reviews recent progress, attempts to identify the essential remaining difficulties, and summarizes new results. The topics covered are band tails, the Lloyd model, shallow impurity levels, deep levels, excitons, electronic transport, and optical absorption. 37 refs.

Cohen, Morrel H. (Exxon Research & Engineering Co, Annandale, NJ, USA). *Phys Prop of Amorphous Mater, Proc of a Lect Ser, Bloomfield Hills, MI, USA, 1982-1983* Publ by Plenum Press, New York, NY, USA & London, Engl, 1985 p 343-359.

**096701 NONEQUILIBRIUM TRANSPORT PROCESSES IN AMORPHOUS AND OTHER LOW CONDUCTIVITY MATERIALS.** The author discusses macroscopic transport theory. Microscopic transport theory is able to fix the constants of the material more or less arbitrarily. Of course, this is not actually correct; everything depends on everything else. Macroscopic transport theory, as such, does not know about this which means that models must be handled with care. There are two important time constants. One of them ( $\tau_0$ ) is the minority carrier lifetime which governs the rate at which a nonequilibrium concentration decays; it is called the carrier lifetime. The other ( $\tau_D$ ) is the dielectric relaxation time; it governs the decay of the charge, not the decay of free carrier concentration. Phenomena that are governed primarily by carrier concentration are controlled by  $\tau_0$ ; phenomena which are primarily governed by space charge are controlled by  $\tau_D$ . 20 refs.

Henisch, Heinz K. (Pennsylvania State Univ, University Park, PA, USA). *Phys Prop of Amorphous Mater, Proc of a Lect Ser, Bloomfield Hills, MI, USA, 1982-1983* Publ by Plenum Press, New York, NY, USA & London, Engl, 1985 p 361-379.

**096702 PECULIAR MOTION OF ELECTRONS IN AMORPHOUS SEMICONDUCTORS.** An introduction summarizes the basic concepts which are used to describe the electronic properties of amorphous semicon-

ductors. The next section discusses some experiments which have been useful in testing these ideas and providing detailed information about amorphous semiconductors. These experiments concern a time of flight technique in transient photoconductivity and a multiple trapping model of dispersive transport. 8 refs.

Kastner, Marc A. (MIT, Cambridge, MA, USA). *Phys Prop of Amorphous Mater, Proc of a Lect Ser, Bloomfield Hills, MI, USA, 1982-1983* Publ by Plenum Press, New York, NY, USA & London, Engl, 1985 p 381-396.

**096703 BEHAVIOR OF PHOTOCONDUCTIVITY DURING THE APPROACH TO STEADY STATE IN AMORPHOUS SEMICONDUCTORS.** The behavior of photoconductivity during the approach towards steady state in amorphous semiconductors is examined based on the rate equations governing both the occupancy function of localized states and the density of excess free carriers in the extended states. Assuming a shape for the time-dependent trap occupancy function and in an exponential distribution of localized states, under the consideration of recombination term as a perturbation, a power-series solution to an approximate form of the nonlinear multiple-trapping problem including diffusion-limited bimolecular recombination is obtained. The calculated photocurrent is predicted to rise as  $t^\alpha$  at an early stage of photoexcitation, where  $\alpha$  is a dispersive parameter, then to exceed the steady state value by a factor before settling down to the steady level. (Author abstract) 11 refs.

Gu, Benyuan (Acad Sinica, Beijing, China). *Solid State Commun* v 60 n 11 Dec 1986 p 889-892.

**096704 DEPLETION-DISCHARGE TRANSIENT SPECTROSCOPY: DIRECT DETERMINATION OF THE DENSITY OF DEEP EMISSION STATES IN AMORPHOUS SEMICONDUCTORS.** An analysis was made of the depletion-discharge process observed in amorphous semiconductors, where the dark decay of the surface potential  $V$  was caused by a sweep out from the bulk of only one sign of the charge carriers thermally generated from deep states in the bulk and a simultaneously progressive formation of the space charge of the opposite sign. It is shown that the distribution of the density of deep emission states can be directly determined from a plot of  $t|dV/dt|$  for  $t < t_d$  ( $t_d$ : the depletion time) and  $t[d(1/V)/dt]$  for  $t > t_d$  vs  $\ln(t)$  using a deconvolution technique. (Author abstract) 12 refs.

Nakayama, Yoshikazu (Univ of Osaka Prefecture, Sakai, Jpn); Akita, Seiji; Kawamura, Takao. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 320-322.

**096705 NOTE ON VITRIFICATION OF SEMICONDUCTORS.** Conditions are formulated for obtaining semiconductors and spin systems in the glassy state. It is shown that the electronic subsystem plays an important role during vitrification of semiconductors. The author discusses briefly the anomalous influence of weak electromagnetic fields on semiconducting melts at the time of their relaxation. (Author abstract) 27 refs.

Savransky, S.D. (Pedagogical Inst, Novgorod, USSR). *J Non Cryst Solids* v 101 n 1 Apr 1988 p 130-132.

**096706 SEMICONDUCTING AMORPHOUS FILM CONTAINING CARBON NITROGEN AND BORON.** A semiconductor amorphous film containing carbon, nitrogen, and boron was deposited on a variety of substrates through the pyrolysis, in a closed system, of a borazine derivative. Physical and physicochemical characterization revealed a carbonaceous material having an amorphous matrix similar to vitreous carbon, but denser, with embedded crystallites of boron nitride. The film is highly reflective, adherent, hard, and behaves as a narrow band semiconductor. The bandgap is susceptible to modification by chemical treatment. (Author abstract) 18 refs.

Maya, Leon (Oak Ridge Natl Lab, Oak Ridge, TN, USA). *J Electrochem Soc* v 135 n 5 May 1988 p 1278-1281.



**096707 ELECTRONIC PROPERTIES OF AMORPHOUS SEMICONDUCTORS.** We review our understanding of the electronic states in amorphous semiconductors. The materials upon which we concentrate are the group IV semiconductors and Se. Experimental probes of the density of states and theoretical interpretations are reported. 58 refs.

Weaire, D.; O'Reilly, E. *Noncryst Semicond* Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 v 1, p 1-17.

**096708 LOCALIZED STATES IN THE BAND GAP OF AMORPHOUS SEMICONDUCTORS.** Transient photoconductivity (TPC), transient photoinduced optical absorption (PA), and transient photoluminescence (PL) are considered. Using TPC it has become possible to map out the density of states in the band-tails. The transient optical experiments as well as TPC provide information about deeper gap states arising from defects. The current model for the important defects in chalcogenide glasses and information about defect states coming from TPC, PA, and PL is reviewed. It is shown how the defect and band-tail states interact in some of the experiments. 54 refs.

Kastner, M.A. *Noncryst Semicond* Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 45-67.

**096709 TETRAHEDRALLY BONDED AMORPHOUS SEMICONDUCTORS.** This review concentrates on amorphous Ge and Si. The author discusses the different methods of preparation and describes the relaxation and crystallization processes. Structure studies of both local atomic arrangement and medium-range inhomogeneities are presented. Vibrational and electronic densities of states in the presence of disorder, which are related to the intrinsic network characteristics with little influence of defects, are dealt with. Optical and transport properties, which are largely influenced by the presence of defects, and are dependent on preparation conditions are considered, along with the nature of the defects and their associated localized states. 291 refs.

Theye, Marie-Luce. *Noncryst Semicond* Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 v 2, p 1-51.

**096710 AMORPHOUS CHALCOGENIDES.** The term —chalcogenides—, as used here, comprises the elements S, Se, Te as well as their compounds. We restrict ourselves to a few members of the family such as Se and the As chalcogenides which have received the greatest attention either because they have found applications in xerography or because of interesting scientific phenomena. Structure and structural defects, optical and electrical properties, recombination of excess carriers, and interaction with light are dealt with. 142 refs.

Weiser, K. *Noncryst Semicond* Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 97-131.

**096711 AMORPHOUS GROUP V SEMICONDUCTORS: P, As, AND Sb.** The group V amorphous semiconductors of P, As, and Sb exhibit a number of special characteristics that differentiate them from other elemental amorphous systems. Of particular interest is the strong evidence for intermediate range structural order, particularly in a-P and a-As. Emphasis is placed on recent studies on a-P, particularly with a focus on structural, vibrational, and optical properties. The special aspect of variable order in the group V systems is further emphasized. The presence of intermediate range order in amorphous group V systems makes these systems of interest to parallel studies in Ge and As chalcogenide systems. 78 refs.

Lannin, Jeffrey S. *Noncryst Semicond* Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 133-160.

**096712 RAMAN RESEARCH OF AMORPHOUS SEMICONDUCTOR MODULATED STRUCTURE.** Raman research of amorphous semiconductor modulated structure is introduced, which gives a certain quantity of angle disorder and the method of determining the size of crystallite from the frequency shift of TO-like peak. Emphasis is placed on the frequency spectra of modulated

structures and some clear and definite conclusions are drawn. (Edited author abstract) In Chinese. 3 refs.

Chen Guangxu (Nanjing Univ, Nanjing, China); Zhang Xingku; Chen Kunji. *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 321-324.

**096713 PHASE SHIFT ANALYSIS OF MODULATED PHOTOCURRENT: DETERMINATION OF THE ENERGY SCALE.** For the determination of the density of states in the mobility gap of amorphous semiconductors using the —phase shift analysis of modulated photocurrent— this paper suggests that making use of the magnitude of the induced photocurrent helps to remove arbitrariness in the energy scale. The working equations for the density of states and the corresponding energy position are expressed in terms of the intensity of the photocurrent. A simulation is made for a specific distribution, to investigate the validity of the procedure. The results show that the profile of the energetic distribution of localized states and the exact energy position of each state are consistent with the original distribution considered. (Author abstract) 10 refs.

Aktulga, E. (Mimar Sinan Univ, Istanbul, Turk); Aktas, G. *Appl Phys A* v A45 n 3 Mar 1988 p 221-224.

**096714 OPTICAL DETERMINATION OF THE FUNDAMENTAL ENERGY GAP OF AMORPHOUS MoS<sub>3</sub>.** The fundamental energy gap of amorphous MoS<sub>3</sub> has been determined from a study of the absorption ( $1.24 \pm 0.05$  eV) and electrolyte electroreflectance ( $1.30 \pm 0.05$  eV) spectra of thin films prepared by an electrodeposition procedure. This is claimed to be the first report of thin films of this amorphous material. (Edited author abstract) 15 refs.

Bhattacharya, R.N. (Brooklyn Coll of CUNY, Brooklyn, NY, USA); Lee, C.Y.; Pollak, Fred H.; Schleich, D.M. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 247-255.

**096715 STRUCTURE OF AMORPHOUS SEMICONDUCTORS.** The structure of several amorphous semiconductors is now known with considerable precision on a scale of 3-1000 Angstrom. Crucial experiments in this area are discussed. (Edited author abstract) 13 refs.

Phillips, J.C. (AT&T Bell Lab, Murray Hill, NJ, USA). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 257-259.

**096716 HIGH BRILLIANCE X-RAY SOURCES AND THE STUDY OF AMORPHOUS MATERIALS.** The impact of the availability of x-ray synchrotron radiation on the study of atomic arrangements in amorphous materials was reviewed previously. Since that time, it has become apparent that orders of magnitude increases in the x-ray spectral brilliance will soon become available as a result of the use of undulators on the 16 GeV storage ring PEP at Stanford University and proposed 6-8 GeV storage rings. In this paper, the author reviews the new characteristics which the radiation will have, relative to that obtained from bending magnets and wigglers. He discusses the manner in which the studies of atomic arrangements may be expected to be affected by these changes. 7 refs.

Bienenstock, Arthur (Stanford Univ, Stanford, CA, USA). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 269-272.

**096717 X-RAY ABSORPTION STUDIES OF AMORPHOUS ARSENIC CHALCOGENIDE SEMICONDUCTORS.** An important family of amorphous (a-) semiconductors is chosen to demonstrate current state-of-the-art techniques in x-ray absorption spectroscopy (XAS). The authors review recent developments in XAS methods before discussing applications to amorphous arsenic trisulfide (a-As<sub>2</sub>S<sub>3</sub>) and related systems. Investigations of XAS on a-As<sub>2</sub>S<sub>3</sub> are shown to result in: an ability to use XAS to measure bond strengths; a better understanding of reversible photo-darkening; and development of a technique for crystallizing pure As<sub>2</sub>S<sub>3</sub> from the bulk glass. (Edited author abstract) 16 refs.

Sayers, D.E. (North Carolina State Univ, Raleigh, NC, USA); Yang, C.Y.; Paesler, M.A. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 273-282.

**096718 ELECTRICAL CONDUCTIVITY OF NON-HYDROGENATED AMORPHOUS TETRACORDINATED SEMICONDUCTORS.** The authors present the results of conductivity measurements as a function of temperature performed on a series of flash-evaporated a-III-V compounds, in comparison with those previously obtained on evaporated a-Ge. All samples have been deposited under controlled conditions and their global composition has been checked. They have also been studied by other methods, which brings additional information for the analysis of the data. Yet, the dispersion of the results remains too large, and the information appears too restricted, for proposing a unified model of transport in a-compounds. The authors, however, show that one must call for conduction mechanisms different from those admitted in a-Ge and a-Si, because the localized states in the pseudo-gap are not distributed in the same way. 26 refs.

Theye, Marie-Luce (CNRS, Paris, Fr); Gheorghiu, Adriana; Rappeneau, Therese; Udron, Dominique. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 489-497.

**096719 CARRIER RECOMBINATION KINETICS IN AMORPHOUS DOPING SUPERLATTICES.** Research activities on nipi structures are reported, along with conductivity measurements as a function of layer thickness. The salient features of these measurements are discussed. The authors consider the kinetics of photocarrier recombination in nipi samples below 20 K, as well as persistent photoconductivity. 15 refs.

Ley, L. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Hundhausen, M. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 551-561.

**096720 MATERIAL DESIGN BY STRUCTURAL MODULATION OF AMORPHOUS SEMICONDUCTORS.** A new concept in material design based on the structural modulation of amorphous semiconductors is described. Near-infrared sensitive photoconductors with high photoresponse are designed by employing stacked multilayers of a-Si:H(F)/a-SiGe<sub>x</sub>H(F) prepared by hydrogen radical enhanced chemical vapor deposition. Measurements of conductivity perpendicular to the layers have indicated that structural modulation suppresses dark conductivity without sacrificing photoconductivity. Studies of transient photocurrent suggest the presence of artificially-produced shallow trapping states in the modulated structure. (Author abstract) 17 refs.

Oda, S. (Tokyo Inst of Technology, Yokohama, Jpn); Shirai, H.; Tanabe, A.; Hanna, J.; Shimizu, I. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 563-575.

**096721 THEORY OF COVALENT AMORPHOUS SEMICONDUCTORS.** Amorphous-semiconductor theory has undergone a continual evolution over the past 20 years. A modern view is discussed. (Edited author abstract) 34 refs.

Adler, David (MIT, Cambridge, MA, USA). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 673-680.

**096722 LOCALIZATION EFFECTS IN AMORPHOUS SEMICONDUCTORS.** On the basis of recently developed theories of transport and optical properties of amorphous semiconductors the question is discussed whether localization effects manifest themselves in the transport and optical data of these materials. It is argued that strong static disorder is responsible for the fact that quite generally  $Q_0 \approx 10$ , where  $Q_0$  is the intercept of



$Q = \ln(\sigma/\Omega cm) + |eS/k|$  vs.  $T^{-1}$ . Optical properties, matrix elements in particular, are hardly influenced by localization. (Edited author abstract) 20 refs.

Dersch, U. (Philipps-Univ, Marburg, West Ger); Thomas, P. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 697-704.

**096723 BAND-EDGE CONDUCTION IN AMORPHOUS SEMICONDUCTORS.** Experiments have shown that the conduction process near the band edges of amorphous semiconductors differs from that in crystals. Three possible explanations for the anomalies have been proposed: long-range potential fluctuations, hopping in band tails, and polaron formation. The transport energy description is used to show how band-tail hopping may cause the anomalous transport. Transient measurements provide additional evidence for hopping. In the band-tail-hopping regime, the mobility edge plays no direct role in transport phenomena. (Edited author abstract) 41 refs.

Monroe, Don (AT&T Bell Lab, Murray Hill, NJ, USA). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 705-712.

**096724 MECHANICAL STRESS IN THE CRYSTALLIZATION PROCESS OF AMORPHOUS SEMICONDUCTORS BY PULSE ACTION.** Rapid heating of amorphous materials by pulse annealing gives the possibility of avoiding solid phase ordering processes and of exceeding the temperature  $T_{AM}$  at which melting, supercooled melt formation, and crystallization take place. The high rate of cooling gives a glass-like state. The kinetics of these processes allows for crystal nucleation and growth. The mechanical stress energy decreases the time of liquid and crystalline nucleus formation and accelerates the beginning of crystallization. 12 refs.

Aleksandrov, L.N. (Acad of Sciences of the USSR, Novosibirsk, USSR). *Phys Status Solidi A* v 106 n 2 Apr 1988 p k135-k138.

**096725 THEORETICAL CALCULATION OF THE EFFECTIVE CORRELATION ENERGY OF THE HYDROGENATED AMORPHOUS GERMANIUM DANGLING BOND BY THE SELF-CONSISTENT-FIELD X-ALPHA SCATTERED-WAVE METHOD AND COMPARISON OF RESULTS BETWEEN A-Si:H AND A-Ge:H.** The authors have performed the self-consistent-field x-alpha scattered-wave (SCF-X $\alpha$ -SW) calculations on a 13-atom cluster Ge $4$ (sat) $9$  which is used to model the dangling bond defect center in hydrogenated amorphous germanium (a-Ge:H). The transition state concept of the SCF-X $\alpha$ -SW method was applied to the model cluster to determine the effective correlation energy  $U_{eff}$ . The effects of local atomic relaxations around the positively ( $T_3^+$ ) and negatively ( $T_3^-$ ) charged dangling bond defect centers were examined. The results yield a positive effective correlation energy (0.027 eV). Also a comparison of the results for the Si and Ge dangling bonds, so made, and its implications are discussed. (Edited author abstract). 11 refs.

Lo, C.F.; Adler, D.; Johnson, K.H. *J Non Cryst Solids* v 103 n 1 6(II) 1988 p 3-8.

**096726 CONDUCTION BAND IN NON-CRYSTALLINE SEMICONDUCTORS.** Following investigations by P. Thomas and co-workers, the energy of the current path in the conduction band of noncrystalline semiconductors and its relation to the calculated mobility edge is investigated. Delocalization is assumed to occur when  $L_i < \xi$ , where  $\xi$  is the localization length and  $L_i$  the inelastic diffusion length. For a non-degenerate gas we believe that localization is never complete, in contrast to the situation in metals. Both amorphous silicon and impurity bands in crystalline materials are discussed. The relationship of the pre-exponential factor in the conductivity to the predictions of scaling theory is investigated. No evidence is found for any error in the latter. (Author abstract). 74 refs.

Mott, N.F. (Univ of Cambridge, Cambridge, Engl). *Philos Mag B* v 58 n 4 Oct 1988 p 369-384.

**096727 STRUCTURAL STUDY BY ELECTRON DIFFRACTION ON AMORPHOUS Se $_{100-x}Bi_x$  FILMS.** Amorphous and homogeneous thin films of the Se $_{100-x}Bi_x$  system were obtained by a controlled co-evaporation technique in the region dilute in Bi ( $x < 5$ ). A structural study has been carried out on the basis of electron diffraction experiments. The maximum entropy method was used to minimize the effects of truncation of data ( $S < 8$  angstrom $^{-1}$ ). Details of the distribution functions in the direct space are analyzed in relation to that of pure selenium. Problems of the real coordination of Bi in these alloys and the role played by Bi as a modifier element in the amorphous matrix of selenium. (Edited author abstract). 38 refs.

Munoz, A. (Dep de Fisica de la Materia Condensada, Seville, Spain); Cumbreira, F.L.; Marquez, R. *Mater Lett* v 7 n 4 Oct 1988 p 138-142.

**096728 THEORY OF AMORPHOUS SEMICONDUCTORS.** A thermodynamic view of the structure of covalent amorphous semiconductors is presented in which local configurations of higher free energy that are accessible at high temperatures are frozen in below the glass transition temperature. It is shown how this leads to exponential band tails, defect states, and the possibility of doping. Given the resulting density of states, the possible mechanisms of electronic transport are analyzed. (Author abstract) 16 refs.

Adler, David (MIT, Cambridge, MA, USA). *Key Eng Mater* v 13 pt 1 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 11-17.

**096729 MULTILAYERED AMORPHOUS SEMICONDUCTORS: PERIODIC AND QUASIPERIODIC SUPERLATTICES.** A brief description of the electronic properties of amorphous superlattices is presented within a comparison with their crystalline counterparts. Some examples are given to demonstrate that these new materials, beyond their proper peculiarities related to the multilayered structures, provide possibilities to obtain information about properties of amorphous bulk materials. Emphasis is put on the investigation of thermal relaxation, kinetics and mechanism of mixing operations as evidenced in diffraction approaches. Quasiperiodic superlattices, with layers deposited in a Fibonacci sequence, are also mentioned in relation with the understanding of the usual physical properties of true quasicrystals. (Author abstracted) 58 refs.

Janot, Chr. (Inst Laue-Langevin, Grenoble, Fr). *Key Eng Mater* v 13 pt 2 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 417-442.

**096730 ELECTRONIC TRANSPORT IN AMORPHOUS CHALCOGENIDE SEMICONDUCTORS.** Charge transport in the relatively simple amorphous chalcogenide semiconductors such as Se and As $_2$ Se $_3$  most likely involves trap-limited processes. Carriers migrate via extended states or via states at or close to the mobility edges,  $E_c$  and  $E_v$ . The evidence from a variety of experiments is consistent with the view that the traps which limit carrier mobilities are located at relatively well-defined energies within the mobility gap, and that these traps originate from structurally-related electronic defects characteristics of various bonding abnormalities associated with the chemistry of chalcogenide elements and compounds. 51 refs.

Owen, E.A. (Univ of Edinburgh, Edinburgh, Scotl). *Key Eng Mater* v 13 pt 2 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 443-466.

**096731 THEORETICAL STUDIES OF OPTICAL ABSORPTION IN AMORPHOUS SEMICONDUCTORS.** Optical properties and matrix element effects of amorphous semiconductors are studied theoretically on the basis of a simple two-band model. We consider the tight-binding-Hamiltonian of Abe and Toyozawa including short ranged disorder. Two different approaches to

calculate the imaginary part of the dielectric constant  $\epsilon_2(\omega)$  are used. Both allow to go in a systematic manner beyond the zeroth order for  $\epsilon_2$  which is the convoluted density of States. (Edited author abstract) 4 refs.

Dersch, U. (Univ of Marburg, Marburg, West Ger); Grunewald, M.; Thomas, P. *Key Eng Mater* v 13 pt 3 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 835-836.

**Analysis** See Also MASS SPECTROMETERS—Applications; SEMICONDUCTOR DEVICES—Analysis.

**096732 ATOM ARRANGEMENT IN III-V QUATERNARY ALLOY SEMICONDUCTORS OF (ABCD) TYPE.** The nonrandomness in atom arrangement has been estimated for III-V quaternary alloys of (ABC)D type through a thermodynamical analysis. As in ternary alloys, the strain energy is considered to be the mixing enthalpy. Calculations were carried out for (In-GaAl)As and Ga(SbAsP), and the results are represented in terms of short-range order parameters of second-nearest pairs. The number of pairs increases compared with a random arrangement if composed of larger and smaller atoms than the average; however, the number of pairs of larger or smaller atoms decreases. When the lattice constant of a constituent binary compound coincides with that of an alloy, there appears in the alloy a preference for compound clustering. The results are compared with those for ternary alloys. (Author abstract) 26 refs.

Ichimura, Masaya (Kyoto Univ, Kyoto, Jpn); Sasaki, Akio. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 642-648.

**096733 LATTICE DISTORTIONS AROUND ATOMIC SUBSTITUTIONS IN II-VI ALLOYS.** We address the problem of the configurational disorder in several pseudobinary II-VI solid solutions by studying the local order around a given species by means of the Extended-X-ray-Absorption-Fine Structure (EXAFS) technique. We present our EXAFS results and we introduce the structural model for their interpretation. 46 refs.

Balzarotti, A. (Univ di Roma, Rome, Italy). *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity, Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 150-175.

**096734 PAPERS FROM THE CHICAGO CONFERENCE.** This issue contains 23 conference papers by various authors dealing with super lattices. Major topics covered are semiconductor superlattices, multiple quantum wells, quantum tunneling resonant tunneling, ohmic contacts, and metastable states. All papers are abstracted and indexed separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11557 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *Superlattices Microstruct* v 4 n 2 1988, Pap from the Chicago Conf, Chicago, IL, USA. p 121-250.

**Anisotropy** See SEMICONDUCTING INDIUM COMPOUNDS—Mechanical Properties.

## Applications

**096735 GaInAs MISFETS SHOW PROMISE IN POWER APPLICATIONS.** Metal-insulator-semiconductor FETs (MISFETs) fabricated from GaInAs have characteristics that make them potentially superior in some respects to GaAs MESFETs when used in power amplifiers. For this reason, researchers are making concentrated efforts to produce devices that demonstrate their performance potential. Insulated-gate FET technology unlocks the potential of this new material for high-frequency devices. 18 refs.

Gardner, Peter D. (SRI David Sarnoff Research Cent, Princeton, NJ, USA). *Microwaves RF* v 27 n 1 Jan 1988 p 99-100, 102-103.



## Calculations

**096736 SCATTERING OF EXCITONS BY EXCITONS IN SEMICONDUCTING QUANTUM WELL STRUCTURES.** We have theoretically investigated the scattering of excitons by excitons in a two-dimensional semiconducting quantum well system. The scattering cross sections have been calculated using the Born approximation for both the elastic and inelastic scattering of the excitons by excitons. The threshold for inelastic scattering is increased over the value in a bulk semiconductor because of the enhancement of the exciton binding energy by its confinement. The behavior of the scattering cross section as a function of the energy of relative motion of the excitons is different than in the bulk and the cross section is a more sensitive function of the ratio of the electron and hole masses than in the bulk. (Author abstract) 31 refs.

Feng, Yuan-Ping (Illinois Inst of Technology, Chicago, IL, USA); Spector, Harold N. *J Phys Chem Solids* v 48 n 12 1987 p 1191-1196.

**096737 PHONON DENSITY OF STATES CALCULATION FOR SUPERLATTICE SYSTEMS.** Based on the fundamental Recursion method, a calculational method in real space for the phonon density of states of three-dimensional semiconductor superlattice systems is presented. The application of this method to the diatomic superlattice system is successful. (Author abstract) 5 refs. In Chinese.

Fu, Ying (Shanghai Inst of Technical Physics, China); Xu, Wenlan. *Hongwai Yanjiu A-Ji* v 7A n 1 1988 p 1-6.

**Charge Carriers** See Also BISMUTH AND ALLOYS—Thin Films; CRYSTALS—Dislocations; CRYSTALS—Electron States; CRYSTALS—Physical Properties; DATA STORAGE, SEMICONDUCTOR—Storage Devices; FERRITES—Dielectric Properties; PHOTOCONDUCTING DEVICES—Switching; PHOTOCONDUCTING MATERIALS—Spectrum Analysis; PHOTOCONDUCTING MATERIALS—Temperature Effects; PHOTOELECTRIC CELLS—Transients; SEMICONDUCTING BISMUTH COMPOUNDS—Phase Equilibria; SEMICONDUCTING GALLIUM ARSENIDE—Spectrum Analysis; SEMICONDUCTING SELENIUM COMPOUNDS—Amorphous; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Photoconductivity; SEMICONDUCTING SILICON—Spectroscopic Analysis; SEMICONDUCTING SILICON COMPOUNDS—Defects; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES—Junctions; SEMICONDUCTOR DEVICES—Mathematical Models; SEMICONDUCTOR DEVICES—Measurements; SEMICONDUCTOR DEVICES—Semiconductor Insulator Boundaries; SEMICONDUCTOR DEVICES, CHARGE COUPLED—Measurements; SEMICONDUCTOR DEVICES, MIS—Spectroscopic Analysis; SEMICONDUCTOR DEVICES, MOS—Electronic Properties; SEMICONDUCTOR DEVICES, MOS—Mathematical Models; SEMICONDUCTOR DEVICES, MOS—Radiation Effects; SEMICONDUCTOR DEVICES, MOSFET; SEMICONDUCTOR DEVICES, MOSFET—Analysis; SEMICONDUCTOR DEVICES, MOSFET—Electric Conductivity; SEMICONDUCTOR DEVICES, MOSFET—Electric Properties; SEMICONDUCTOR DIODES—Electric Properties; SOLAR CELLS—Electric Properties; SOLAR CELLS—Fabrication; SOLAR CELLS—Thermal Effects; TRANSISTORS, BIPOLAR—Electric Properties; TRANSISTORS, FIELD EFFECT—Models; TRANSISTORS, FIELD EFFECT—Stability.

**096738 SCATTERING OF EXCITONS BY FREE CARRIERS IN SEMICONDUCTING QUANTUM WELL STRUCTURES.** We have theoretically investigated the scattering of excitons by free electrons and holes in a two-dimensional semiconducting quantum well system. The scattering cross-sections have been calculated using the Born approximation for both the elastic and inelastic scattering of the excitons by the free carriers. The threshold for inelastic scattering is increased over the value in a bulk semiconductor because of the enhancement of the exciton binding energy by its confinement. The behavior of the scattering cross-section as a function of the energy of relative motion of the free carriers and the excitons is different than in the bulk and the cross-section is a more sensitive function of the ratio of the electron and hole masses than in the bulk. (Edited author abstract) 36 refs.

Feng, Yuan-Ping (Illinois Inst of Technology, Chicago, IL, USA); Spector, Harold N. *J Phys Chem Solids* v 48

n 7 1987 p 593-601.

**096739 TWO-PARTICLE MONTE-CARLO METHOD FOR WARM ELECTRONS IN A HIGH-FREQUENCY ELECTRIC FIELD.** A two-particle Monte-Carlo method for the numerical simulation of the nonhomogeneous kinetic equations useful for the treatment of warm electron properties in the case of ac fields is given. The method is based on the solution of the Green function equation by the Monte-Carlo Technique. The electric field time dependence is taken into account by the simulation of the motion of particles with variable weights. Making use of the proposed method the frequency dependence of the nonlinearity coefficient for p-Ge is calculated. (Author abstract) 8 refs.

Kancelis, Z. (Acad of Sciences of the Lithuanian SSR, Vilnius, USSR); Matulis, A. *Phys Status Solidi B* v 142 n 1 Jul 1987 p 247-254.

**096740 BAND-TO-BAND RECOMBINATION IN  $Ga_xIn_{1-x}Sb$ .** The carrier lifetimes in  $Ga_xIn_{1-x}Sb$  for radiative and Auger recombination are calculated for the temperature range 77-300 K and the composition range  $0 \leq x \leq 1$ . The possible band-to-band Auger recombination mechanisms in direct-gap semiconductors are investigated. The Auger rates are calculated, including Boltzmann Statistics and nonparabolic bands, using the Kane-band model. In the low temperature range, for lightly doped material, the carrier lifetime is determined by radiative recombination. At higher temperatures the CHCC process is dominant in n-type  $Ga_xIn_{1-x}Sb$  but in p-type material the CHLH process is dominant. The influence of CHSH processes on the carrier lifetime is appreciable in p-type  $GaSb$ . The calculations are compared with experimental data reported by other authors. (Author abstract) 42 refs.

Rogalski, A. (Inst of Technical Physics, Warsaw, Pol). *Infrared Phys* v 27 n 6 Nov 1987 p 353-360.

**096741 INFLUENCE OF MINORITY CARRIER DIFFUSION LENGTH IN DETERMINING THE EFFECTS OF BASE LAYER THICKNESS OF AN  $n^+p$  SILICON SOLAR CELL AND A BSF CELL BY NUMERICAL ANALYSIS.** A systematic study on the performance of a diffused cell with base width has been carried out for three different minority carrier lifetimes in the base. The numerical analysis shows that the diode is mainly controlled by the diffusion of minority carriers in the base rather than the recombination process. It is sufficient to choose the thickness of the device to be about its minority carrier diffusion length. The reflection of the charge carriers by the back-surface-field in the BSF cell enhances the performance of the conventional diffused cell to a greater extent. Again the peak efficiency with thickness in BSF cell efficiency shows that it is sufficient to have base thickness half of its minority carrier diffusion length. 10 refs

Dhanasekaran, P. Caleb (Indian Inst of Technology, Madras, India); Gopalam, B.S.V. *J Mater Sci Lett* v 6 n 10 Oct 1987 p 1156-1160.

**096742 INTERACTION OF A LOCALIZED SPIN MOMENT WITH PHONONS DUE TO THE EXCHANGE SCATTERING OF VIRTUAL CARRIERS IN SEMICONDUCTORS.** A new theory of the spin-lattice interaction mechanism is developed for localized spins in semiconductors. In this mechanism, the coupling with phonons results from exchange scattering on a localized spin of the electron-hole pairs accompanying the phonons. The process leads to a relaxation flip of the localized spin, provided the intermediate-state carrier spins are flipped by spin-orbit interaction. A detailed analysis of the mechanism is carried out in the approximation of the isotropic band structure of the semiconductor and the deformation electron-phonon interactions. The experimental manifestations of the mechanism are discussed. (Author abstract) 15 refs.

Semenov, Yu.G. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR). *Phys Status Solidi B* v 143 n 2 Oct 1987 p 717-726.

**096743 INFLUENCE OF INTERELECTRON INTERACTION ON THE FORBIDDEN BANDWIDTH OF NONDEGENERATE NARROWBAND SEMICONDUCTORS.** The dependence of the forbidden bandwidth on the charge carrier concentration and temperature is computed for nondegenerate narrowband semiconductors. Conditions are indicated for the intensity and frequency of the light absorbed between the bands for which the system becomes unstable and periodic self-oscillations in the electron and hole concentration and temperature occur. (Author abstract) 12 refs.

Vinke, E.E. (M.V. Lomonosov Moscow State Univ, USSR). *Sov Phys J* v 30 n 6 Jun 1987 p 539-543.

**096744 DIFFUSION-DRIFT MODELING OF STRONG INVERSION LAYERS.** By generalizing the equation of state of the conduction electron gas in a semiconductor to include a dependence not only on electron density but also on the density gradient we show that the standard diffusion-drift description can be extended to describe much of the quantum mechanical behavior exhibited by strong inversion layers. (Author abstract) 7 refs.

Ancona, M.G. (US Naval Research Lab, Washington, DC, USA). *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 1 Mar 1987 p 11-18.

**096745 NOVEL METHOD FOR SOLVING THE CONTINUITY EQUATIONS.** This paper examines methods for the numerical solution of the continuity equations with the carrier concentrations as dependent variables. The emphasis is on the use of the preconditioned conjugate gradient method to solve the linear system arising from the discretization of a continuity equation. This is achieved by a simple symmetrization of the system matrix, which symmetrization can be used for most discretizations arising from the Scharfetter-Gummel method. (Author abstract) 10 refs.

Fitzsimons, C.J. (Trinity Coll, Dublin, Ire). *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 2 Jun 1987 p 71-76.

**096746 ON THE DIFFUSIVITY-MOBILITY RATIO OF THE CARRIERS IN n-CHANNEL INVERSION LAYERS ON TERNARY CHALCOPRYTE SEMICONDUCTORS.** An attempt is made to study the Einstein relations for the diffusivity-mobility ratios of the carriers in n-channel inversion layers on ternary chalcopryte semiconductors under both weak and strong electric field limits, taking n-channel inversion layers on  $CdGeAs_2$  as an example. It is found, on the basis of newly derived 2D  $E-k_x$  dispersion relations of the conduction electrons for both the limits by considering the various types of anisotropies in the energy band, that the ratios increase with increasing surface electric fields for both the limits and the theoretical results are in qualitative agreement with the suggested experimental method of determining the Einstein relation in degenerate semiconductors having arbitrary dispersion law. The corresponding well-known results for isotropic two-band Kane model are also obtained from the expressions derived. (Author abstract) 32 refs.

Ghatak, K.P. (Univ Coll of Science & Technology, Calcutta, India); Chattopadhyay, N.; Mondal, M. *Appl Phys A* v 44 n 4 Dec 1987 p 305-312.

**096747 OPTICAL DAMPING CONSTANT DUE TO FREE CARRIERS IN NARROW GAP SEMICONDUCTORS.** Far infrared reflection spectra of narrow gap semiconductors ( $HgSe$ ,  $Zn_xHg_{1-x}Se$  and  $Cd_xHg_{1-x}Se$ ) are measured by a Fourier transform system in the range of 20 to 500  $cm^{-1}$  at 5 K. The spectra of these materials are analyzed by using the dynamic dielectric function as a sum of interband and intraband transitions and phonon contributions. Damping constants of free carriers are estimated from best fitting with experimental reflectivity curves. The frequency dependence of the damping constant for  $HgSe$  shows the Drude type in lower



frequency than the plasma frequency. That in higher than the plasma frequency is explained well by the impurity scattering including single and collective excitations and the effect of the electron-LO phonon polar coupling. The dependence of the damping constant on the frequency for  $\text{Zn}_x\text{Hg}_{1-x}\text{Se}$  and  $\text{Cd}_x\text{Hg}_{1-x}\text{Se}$  shows the similar tendency for HgSe. The compensation in our samples is about 30% for doubly ionized impurities (donors and acceptors). (Author abstract) 14 refs.

Kumazaki, K. (Hokkaido Inst of Technology, Sapporo, Jpn). *Solid State Commun* v 64 n 4 Oct 1987 p 567-571.

**096748 ELECTRON DENSITY CORRELATION OF A SUPERLATTICE WITH WAVE FUNCTION OVERLAPS.** A calculation of RPA electron-electron density correlation function of a type I superlattice is presented. The electron tunneling between adjacent quantum wells is taken into consideration. A formal expression of density correlation function is explicitly given within single band tight binding approximation. (Author abstract) 8 refs.

Lu Xiao-jia (Chinese Acad of Sciences, Shanghai, China); Xie Lei-ming; Lei Xiao-ling. *Solid State Commun* v 64 n 4 Oct 1987 p 593-595.

**096749 LATTICE-SCATTERING MOBILITY OF TWO DIMENSIONAL ELECTRON GAS IN SEMICONDUCTOR QUANTUM WELLS.** Electron mobility in a quantum well is calculated over the temperature range 30-300 K including the effects of polar optical phonon, deformation-potential acoustic and piezoelectric scattering. A direct iterative solution of the Boltzmann equation is used without employing Matthiessen's rule. The mobility for a sheet carrier concentration of  $2 \times 10^{15} \text{ m}^{-2}$  in a GaAs channel of width 160 Angstrom is found to be greater than the bulk mobility. (Author abstract) 17 refs.

Chattopadhyay, D. (Inst of Radio Physics & Electronics, Calcutta, India). *Solid State Commun* v 62 n 6 May 1987 p 395-397.

**096750 NOTE ON THE PLASMON DISPERSION IN SEMICONDUCTOR SUPERLATTICES.** The plasmon dispersion relation in semiconductor superlattices is derived by taking into account energy band curvature due to charge transfer. The result is in nice agreement with experimental data. (Author abstract) 10 refs.

Yang, Rui-Qing (Nanjing Univ, Nanjing, China); Tsai, Chien-Hua. *Solid State Commun* v 63 n 12 Sep 1987 p 1081-1082.

**096751 CURRENT RELAXATION PROCESSES IN HIGHLY EXCITED SEMICONDUCTORS.** We compare the conductivity relaxation time due to electron-hole scattering to the one due to electron-phonon scattering. We first calculate the variations of both scatterings with the electron-hole plasma density from the dilute to the metal-like regime, using the appropriate screenings of the interaction potentials; we find that, unexpectedly, the electron-hole collisions dominate the electron-phonon scattering, not at very large density, but instead, at intermediate density, when the plasma becomes degenerate. (Author abstract) 14 refs.

Combescot, M. (Groupe de Physique des Solides de l'Ecole Normale Supérieure, Paris, Fr). *Solid State Commun* v 62 n 8 May 1987 p 587-590.

**096752 MAGNETIC SUSCEPTIBILITY OF A TWO-DIMENSIONAL ELECTRON GAS IN THE STRONG MAGNETIC FIELD LIMIT AND FOR NON-ZERO TEMPERATURES.** Analytic expressions are derived for the magnetic susceptibility and the Fermi energy of a non-interacting two-dimensional electron gas in the strong field limit and for non-zero temperatures. The results at zero temperature agree with existing calculations but the results at finite temperature are different from those obtained recently by other authors. The results are relevant to studies of MOSFET inversion layers and GaAs/AlGaAs heterojunctions. (Edited author abstract) 13 refs.

Wang, L. (Louisiana State Univ, Baton Rouge, LA, USA); O'Connell, R.F. *Phys Status Solidi B* v 144 n 2 Dec 1987 p 781-786.

**096753 BAND STRUCTURE ENGINEERING FOR MAXIMAL LIGHT-HOLE BEHAVIOUR IN STRAINED QUANTUM WELL SYSTEMS.** We show that the highest valence subband can be light-hole-like over a significant energy range (50-100 meV) in the plane of a strained layer superlattice where (i) the light hole and heavy hole confinement wells are in different regions of the superlattice and (ii) the heavy hole confinement well is deeper than the light hole confinement well. The separate confinement minimizes the interaction between light hole and heavy hole zone center states, thus reducing subband non-parabolicity due to state mixing, while the different well depths enhance the splitting between the highest heavy hole and light hole states. (InAlGa)As-(GaAl)As should be an ideal material system to demonstrate maximal light-hole behavior, behavior of significant benefit for high hole mobility and optoelectronic applications. (Author abstract) 17 refs.

O'Reilly, E.P. (Univ of Surrey, Guildford, Engl); Witchlow, G.P. *Solid State Commun* v 62 n 9 Jun 1987 p 653-656.

**096754 NEW, MORE ACCURATE METHODS FOR THE INVESTIGATION OF THE FREE CARRIER CONCENTRATION AND MOBILITY BY 1/NOISE MEASUREMENTS.** The proposed new method can be applied to materials that obey the Hooge-Vandamme relation. The result for  $n$ , given by the method, is independent of the actual mobility  $\mu$ , and weakly depends on the noise factor  $\alpha_H$ . Almost the same procedure can be applied for the investigation of  $\mu$ . The problem of temperature dependence investigations is considered. (Edited author abstract) 10 refs.

Kiss, L.B. (JATE Univ Szeged, Hung); Torok, M.I.; Hevesi, I. *Solid State Commun* v 61 n 11 Mar 1987 p 731-732.

**096755 EFFECT OF ANISOTROPY AND WARPING ON THE AUGER LIFETIME OF DIRECT GAP SEMICONDUCTORS.** We show that the result  $\tau^{-1}$  approximately equals  $(k_B T/E_g)^{3/2} \exp(-\lambda E_g/k_B T)$  for the Auger rate of direct gap semiconductors is only valid for electrons and holes having a dispersion relation with spherical symmetry. Although the exponential term is still given by the threshold energy for the Auger process, the prefactor has to be multiplied by  $(k_B T/E_g)^{1-p/2}$  where  $p = 0, 1$  or  $2$  is essentially the dimensionality of the dispersion relation symmetry. If the valence band warping is taken into account, we have  $p = 0$ . (Edited author abstract) 8 refs.

Combescot, M. (Groupe de Physique des Solides de l'Ecole Normale Supérieure, Paris, Fr); Combescot, R. *Solid State Commun* v 61 n 12 Mar 1987 p 821-823.

**096756 DENSITY OF STATES OF A TWO DIMENSIONAL ELECTRON GAS IN A HIGH MAGNETIC FIELD STUDIED WITH PHOTOLUMINESCENCE.** The density of states of a quasi-two-dimensional electron gas in magnetic fields up to 25 T is determined directly from photoluminescence measurements and can be described by Gaussian broadened Landau levels superimposed on a constant background. A model for electron-acoustic phonon scattering is presented to explain the observed filling factor ( $\nu$ ) dependence of the width of the partially filled first Landau level  $\Gamma_1$ , while it is suggested that the  $\nu$  dependence of the width of the completely filled zeroth Landau level  $\Gamma_0$  can be attributed to long range impurity scattering. The background is found to be independent of  $\nu$  and is assumed to have the same origin as  $\Gamma_0$  because of the resemblance in their dependence on electron temperature. (Edited author abstract) 25 refs.

Berendschot, T.T.J.M. (Univ of Nijmegen, Nijmegen, Neth); Reinen, H.A.J.M.; Bluyssen, H.J.A. *Solid State Commun* v 63 n 10 Sep 1987 p 873-876.

**096757 BIPOLARON EFFECTS ON THE LAT-**

**TICE ENERGY OF  $\text{Ti}_4\text{O}_7$ .** Taking into account the electron-phonon interactions proposed by P.W. Anderson, the lattice energy in semiconducting  $\text{Ti}_4\text{O}_7$ , below the metal-to-semiconductor transition temperature, in which bipolarons are formed, is calculated, using the polarizable point ion shell model developed by G.J. Dienes et al. The electron-phonon coupling constants ( $\lambda$ ) which represent the strengths of the electron-phonon interactions are estimated by fitting the ionic spacings calculated theoretically to the experimental ones. The coupling constant between the electron trapped at a  $\text{Ti}^{3+}$  site and the phonon of the nearest cation ( $\lambda_{+}$ ) and that due to the phonon of the nearest anion ( $\lambda_{-}$ ) are found to have values of  $-107.0 \text{ eV nm}^{-1}$  and  $14.0 \text{ eV nm}^{-1}$ , respectively. (Edited author abstract) 21 refs.

Iguchi, E. (Yokohama Natl Univ, Yokohama, Jpn); Yamamoto, T.; Tilley, R.J.D. *J Phys Chem Solids* v 49 n 2 1988 p 205-212.

**096758 MONTE CARLO INVESTIGATION OF THE NEAREST-AVAILABLE-NEIGHBOR DISTRIBUTION IN THREE DIMENSIONS: A MODEL FOR ELECTRON-HOLE RECOMBINATION IN SEMICONDUCTORS.** A Monte Carlo calculation is presented of the range-dependent survival probability of an initially randomly distributed electron-hole population recombining according to a nearest-available-neighbor rule. It confirms a previous prediction of an asymptotic power-law behavior in three dimensions, with exponent  $-3/2$ . The distribution of surviving electrons and holes in the asymptotic region takes the form of two interlacing electron and hole networks. The relevance of the nearest-available-neighbor recombination model as an approximation to real systems is discussed. (Author abstract) 10 refs.

Bishop, J.E.L. (Univ of Sheffield, Sheffield, Engl); Searle, T.M. *Philos Mag B* v 57 n 3 Mar 1988 p 329-342.

**096759 COHERENT AND SEQUENTIAL TUNNELING IN SERIES BARRIERS.** A simple approach which can describe both coherent tunneling and sequential tunneling is applied to resonant tunneling through a double-barrier structure. This approach models phase-randomizing events by connecting to the conductor a side branch leading away from the conductor to a reservoir. The reservoir does not draw or supply a net current, but permits inelastic events and phase randomization. A conductance formula is obtained which contains contributions due to both coherent and sequential tunneling. We discuss the limiting regimes of completely coherent tunneling and completely incoherent transmission, and discuss the continuous transition between the two. Over a wide range of inelastic scattering times tunneling is sequential. The effect of inelastic events on the peak-to-valley ratio and the density of states in the resonant well is investigated. We also present an analytic discussion of the maximum peak conductance  $e/k$  of an isolated resonance in a many-channel conductor. (Author abstract) 34 refs.

Buttiker, M. *IBM J Res Dev* v 32 n 1 Jan 1988 p 63-75.

**096760 ELECTRON AND PHONON TEMPERATURE FIELDS IN BOUNDED SEMICONDUCTORS IN A MAGNETIC FIELD.** The electron and phonon temperature distributions in a semiconductor sample with finite dimensions, placed in a thermostat with an arbitrary, fixed temperature profile, were studied. Heat transfer between the thermostat and the electrons and phonons through the wall is assumed to be arbitrary, while the magnetic field is assumed to be weak. (Author abstract) 3 refs.

Bochkov, V.S. (Acad of Sciences of the Uzbek SSR, USSR); Gurevich, Yu. G.; Shekhtman, L.A. *Sov Phys J* v 30 n 8 Aug 1987 p 707-711.

**096761 SIMPLE MODEL FOR THE ORIGIN OF CHAOS IN SEMICONDUCTORS.** It is shown how a simple model for chaos in semiconductors results from a



three-fold argument: (a) One starts with a Chapman-Kolmogorov equation for the generation-recombination processes. These are assumed in the simplest case (considered here) to be uniform in space and to involve only holes. A recurrence relation for the average hole concentration at successive discrete time intervals is derived by averaging the Chapman-Kolmogorov equation. (b) One sets up a generation-recombination rate for a specific model. (c) The possibility of chaos then follows by combining (a) and (b) and hence finding a recurrence relation of the type  $x_{k+1} = f(x_k)$  with quadratic maximum, which is known to produce a period doubling route to chaos. (Author abstract) 25 refs.

Landsberg, P.T. (Univ of Southampton, Southampton, Engl); Schoell, E.; Shukla, P. *Physica D* v 30 n 1 & 2 Feb-Mar 1988 p 235-243.

**096762 THERMODYNAMICS OF THE COULOMB LATTICE GAS WITHIN THE MEAN SPHERICAL APPROXIMATION.** The free energy of the classical two-component three-dimensional Coulomb lattice gas is derived in the explicit form within the mean spherical approximation. The model exhibits three important features: the onset of the condensation into the NaCl-like ordered phase, the critical point which is probably connected with condensation effects and the critical point of the 'gas-liquid' type at the low concentration. (Author abstract) 17 refs.

Mitas, L. (EPRC SAS, Bratislava, Czech). *Solid State Commun* v 65 n 11 Mar 1988 p 1401-1404.

**096763 MECHANISM FOR TWO-ELECTRON CAPTURE AT DEEP LEVEL DEFECTS IN SEMICONDUCTORS.** We have studied two-electron capture in nonradiative recombination when the energy of recombining charge carriers is transferred to the lattice via the deep level defect's local vibration mode. Unlike recombination due to electron-phonon interaction, the proposed model is based on the electron-electron integration in the conduction band with simultaneous excitation of the deep level defect's local vibration mode. We also consider the spin-dependent, field- and temperature-induced effects relevant to the present two-electron capture mechanism, and demonstrate the existence of the gigantic capture cross section provided that both deep level defects responsible for recombination are correlated in distribution with shallow donors and a multiphonon transition is most favored. In the context of the local negative-U concept, the two-electron capture mechanism can account for the observed dynamics of rapid recombination due to (i) deep level double-charged centers at the sites of Si lattice, (ii) antisite defects in III-V compounds, and (iii) 'interstitial atom + vacancy' type elastic defects stabilized by internal strain in silicon. (Author abstract) 13 refs.

Bagraev, N.T. (A.F. Ioffe Physico-Technical Inst, Leningrad, USSR); Mashkov, V.A. *Solid State Commun* v 65 n 10 Mar 1988 p 1111-1117.

**096764 PREDICTION OF LINE INTENSITIES AND INTERPRETATION OF ACCEPTOR SPECTRA IN SEMICONDUCTORS.** The optical absorption strength of acceptors in semiconductors is calculated in the effective-mass approximation. The spherical-model description of acceptor states explains the main features of the experimental IR spectra. The strength of intensity of the D and C lines ( $2P_{3/2}$  final states) relative to that of the G line ( $2P_{3/2}$  final state) results from the presence of a d-like component in the acceptor ground state. The line intensities in Si and Ge are calculated beyond the spherical model including valence-band warping, coupling to the split-off valence band and q-dependent screening. The results reproduce available experimental data and provide useful additional information for the interpretation of those data. (Edited author abstract) 11 refs.

Binggeli, N. (EPF, Lausanne, Switz); Baldereschi, A. *Solid State Commun* v 66 n 4 Apr 1988 p 323-328.

**096765 CARRIER KINETICS IN A SEMICONDUCTOR WITH LIGHT-INDUCED GAPS.** Due to the influence of a strong electromagnetic field an induced gap

is expected to occur in the band structure of a semiconductor. In this paper the influence of the damping by electron-phonon collisions and by recombination on the new band structure is investigated. Taking into account damping kinetic equations for the electrons are derived and discussed with the help of calculations. (Author abstract) 11 refs.

Hartmann, M. (Acad der Wissenschaften der DDR, Berlin, East Ger); Zimmermann, R.; Stolz, H. *Phys Status Solidi B* v 146 n 1 Mar 1988 p 357-369.

**096766 GREEN'S FUNCTION APPROACH TO NONEQUILIBRIUM CHARGE CARRIERS IN DIRECT GAP SEMICONDUCTORS GENERATED BY SHORT LIGHT PULSES.** In the present paper the Green's function approach to nonequilibrium quasi-free charge carriers in highly excited semiconductors is applied. In doing this a system of kinetic equations for generalized Wigner distributions of renormalized quasi-electrons and holes is obtained, that takes into account (additionally to well-known published results) the interaction of the longitudinal optical phonons and the intraband interaction of the radiation field with the electron-hole plasma. Thus, utilizing the corresponding field equations and the suitable boundary conditions, relaxation processes in the semiconductor after excitation by a short laser pulse and a laser probe beam experiment may be described. (Author abstract) 16 refs.

Glaeske, H. (Univ Jena, Jena, East Ger); Schubert, M. *Phys Status Solidi B* v 146 n 1 Mar 1988 p 385-391.

**096767 DETECTION OF FIR RADIATION BY PHOTON DRAG OF FREE CARRIERS IN SEMI-METAL THIN FILM.** Fast ns. response with good sensitivity of far infrared radiation (FIR) is observed in anisotropic thin films of Bi and Sb evaporated at large angle. The signal in the wavelength region  $\gamma > 200 \mu\text{m}$  is assigned to the classical optical pressure on the free carriers while the signal in the 100 microns region can be assigned to a band transition. These detectors are currently used by us for time diagnostic of FIR laser Raman with a sensitivity 10-20 times larger than the best commercial Ge photon-drag detectors at wavelengths larger than 300 microns. (Author abstract) 16 refs.

Marchetti, S. (CNR, Pisa, Italy); Simili, R.; Bernardini, M.; Giorgi, M. *Phys Scr* v 37 n 5 May 1988 p 820-822.

**096768 NUMERICAL ANALYSIS OF THE EVOLUTION OF DYNAMIC GRATINGS IN SEMICONDUCTORS.** A method for numerically simulating the excitation and relaxation of photoinduced dynamic gratings of nonequilibrium charge carriers in semiconductors is described. Results calculated on the evolution of nonequilibrium carriers described by a system of equations consisting of the continuity equation and the Poisson equation, with nonlinear recombination, are reported. Writing pulses in the nanosecond range are considered. The effect of diffusion and recombination on the relaxation of the nonequilibrium carriers is determined for various grating periods. (Author abstract) 13 refs.

Kudryashov, N.A.; Kucherenko, S.S.; Mazur, E.A. *Optoelectron Instrum Data Process* n 6 1987 p 59-64.

**096769 UEBER DIE LOESUNG VON EINDIMENSIONALEN MODELGLEICHUNGEN DES LADUNGSTRAEGERTRANSPORTES IN HALBLEITERN MIT EINER QUADRATURFORMELMETHODE.** [Solution of One-Dimensional Model Equations for Carrier Transport in Semiconductors with a Quadrature Formula Method]. The topic of the investigation is a class of linear integro-differential equations for the carrier transport in semi-conductors under the influence of constant electric fields. Quadrature methods for the solution of this equation - reformulated as an integral equation (Fredholm integral equation of the second kind with discontinuous kernel) - are considered. A complete solution algorithm which is based on a multiple interpolatory quadrature formula is given and demonstrated by numerical examples. (Author abstract) 11 refs. In German.

Micke, A. (Akad der Wissenschaften der DDR, Berlin, East Ger); Wendt, W. *Z Angew Math Mech* v 68 n 2 1988 p 79-87.

**096770 ELECTRON AND HOLE CYCLOTRON RESONANCE IN SEMIMETALLIC GaSb/InAs/GaSb QUANTUM WELLS.** Far-infrared magneto-transmission studies are reported on GaSb/InAs/GaSb quantum wells using circular polarized light. Electron and hole Landau level transitions are observed and identified by their selection rules. The effective masses and densities of both kinds of carriers are determined as a function of magnetic field and the InAs layer thickness. We find that the hole cyclotron resonance disappears at high magnetic fields due to depopulation of the holes when the ground hole Landau level crosses the Fermi level. (Author abstract) 9 refs.

Kim, L.S. (Univ of Maryland, College Park, MD, USA); Drew, H.D.; Muneke, H.; Chang, L.L.; Esaki, L. *Solid State Commun* v 66 n 8 May 1988 p 873-876.

**096771 TIME-RESOLVED PHOTOLUMINESCENCE SYSTEM WITH SUBNANOSECOND RESOLUTION AT WAVELENGTHS UP TO 1.65  $\mu\text{m}$ .** A system for measuring carrier lifetimes as short as 100 ps at luminescence wavelengths up to 1.65  $\mu\text{m}$  has been developed. This uses the photoluminescence phase shift technique and is based around a guided-wave lithium niobate modulator with a high (5 GHz) bandwidth. Measurements have been performed on an MBE grown sample consisting of 25 angstrom thick quantum wells of Ga<sub>0.47</sub>In<sub>0.53</sub>As with 100 angstrom thick barriers of InP, the lifetime was found to be 3 ns. (Author abstract) 8 Refs.

Marsh, J.H. (Univ of Glasgow, Glasgow, Scotl); Dickson, G.; Claxton, P.A. *Electron Lett* v 24 n 12 Jun 9 1988 p 744-746.

**096772 NON-PARABOLICITY AS A CAUSE OF OSCILLATIONS IN 2D CYCLOTRON RESONANCE.** Non-parabolicity in conjunction with occupation number effects is shown to produce an oscillatory behaviour of CR mass, line width, and amplitude. Numerical calculations are performed for an InAs quantum well and a GaAlAs hetero-junction. The results have resemblances to the experimental findings, but the amplitudes are smaller and the resonance positions do not correspond to the densities quoted for the samples. (Author abstract) 15 Refs.

Hansen, E.B. (Univ of Copenhagen, Copenhagen, Den); Hansen, O.P. *Solid State Commun* v 66 n 11 Jun 1988 p 1181-1184.

**096773 EFFECT OF BROADENING OF TRAIL STATES ON THE EINSTEIN RELATION IN HEAVILY DOPED COMPENSATED SEMICONDUCTORS.** An attempt is made to study the dependence of the Einstein relation on carrier concentration in heavily doped compensated semiconductors with broadened tail states, both in the presence and absence of a quantizing magnetic field, taking n-InSb as an example. It is found that, corresponding to a given free electron concentration, the broadening of the tail states modifies the Einstein relation by enhancing the diffusivity-mobility ratio in the absence of magnetic quantization while the reverse is observed in the presence of a quantizing magnetic field. Besides, the ratio of decrease of the ratio with increasing magnetic field in the quantum limit is found to be independent of such broadening effects. (Author abstract) 14 Refs.

Ghosh, S. (Univ Coll of Science & Technology, Calcutta, India); Chakravarti, A.N. *Phys Status Solidi B* v 147 n 1 May 1988 p 355-360.

**096774 QUASIELASTIC LIGHT SCATTERING FROM FREE CARRIERS IN SEMICONDUCTORS WITH NON-PARABOLIC ENERGY BONDS.** Theory of quasielastic electron light scattering for non-parabolic semiconductors is developed. The scattering spectra are



shown to have Lorentzian profiles in doped semiconductors. The width of the Lorentzian is defined in terms of the thermal conductivity of the electron sub-system in case of light scattering from energy density fluctuations. The width of the Lorentzian in case of light scattering from spin density fluctuations is decided by electron diffusion. Frequency-dependent expressions for the coefficients of electronic diffusion, thermal diffusion and thermal conductivity coefficients are derived. (Author abstract). 11 refs.

Ipatova, I.P. (A.F. Ioffe Physical Technical Inst, Leningrad, USSR); Subashiev, A.V.; Voitenko, V.A. *Indian J Pure Appl Phys* v 26 n 2-3 Feb-Mar 1988 p 246-251.

**096775 TEMPERATURE AND CARRIER INJECTION-DEPENDENT CHARACTERISTICS OF BULK UNIPOLAR(BARRIER) SWITCHES.** The current/voltage characteristics of two-state homojunction barrier devices between 270K and 330K were investigated. Two new gated regenerative switching devices (the gated camel switch and the gated p plane barrier switch) are introduced. Carrier injection-dependent operational parameters, including switching voltage  $V_{SW}$ , switching current density  $J_{SW}$ , holding voltage  $V_H$  and holding current density  $J_H$  were studied. It is found that with increasing the injected electron or hole current density  $V_{SW}$  decreases while  $J_{SW}$  increases. The two holding point parameters  $V_H$  and  $J_H$  remain constant over the carrier injection range. A comparison between theoretical and available experimental results is included. (Edited author abstract). 6 refs.

Al-Bustani, A. (Lancashire Polytechnic, Preston, Engl). *Electron Lett* v 24 n 18 Sep 1 1988 p 1185-1187.

**096776 THEORY OF CONDUCTANCE OSCILLATIONS OF NARROW 2D ELECTRON SYSTEMS IN HIGH MAGNETIC FIELDS.** The size and magnetic field quantization of electron motion in narrow 2D systems is investigated. The confining potential is approximated by an irregular set of parabolic quantum wells of various width connected in series. The conductivity is given the form which reflects the magnetic crossover in quantisation under high magnetic fields. It is shown that each 1D subband with the index  $n$ , which originates from size quantisation, is continuously transformed into a Landau level with the same index under the influence of magnetic field, i.e., the number of nodes of corresponding eigenfunctions is conserved. Thus, due to the magnetic field, all zero field conductance peaks pertaining to one subband index are grouped into one Landau level. The application of a magnetic field may serve as a useful tool for the determination of the number of 1D subbands in the system, which can otherwise be masked by universal conductance fluctuations. (Author abstract). 20 refs.

Havlova, H. (Czechoslovak Acad of Sciences, Prague, Czech); Smreka, L.; Ishihara, A. *Phys Scr* v 38 n 3 Sep 1988 p 468-470.

**096777 ANALYSIS OF TIME-OF-FLIGHT TRANSIT TIMES BASED ON THE MULTIPLE-TRAPPING MODEL OF CHARGE-CARRIER TRANSPORT.** Within the context of the multiple-trapping model, we discuss different theoretical ways of defining a transit time in the time-of-flight experiment. A new definition based on the first moment with respect to space of the free-carrier distribution is proposed. At the same time various experimentally used definitions of transit time are identified and the corresponding operational values are extracted from Monte Carlo simulated time-of-flight current traces for different field strengths and temperatures, with either an exponential or a linear density of tail states. The theoretical and Monte Carlo results for the different approaches are compared. Definitions of transit time that emphasize the fastest of the drifting carriers exhibit a larger electric field dependence and a smaller apparent activation energy than definitions based on the totality of excess charge carriers. Consequently, to analyse drift-mobility data in the multiple-trapping framework, one has to use a theoretical definition compatible with the procedure used in extracting the experimental transit times. (Edited author ab-

stract). 27 refs.

Seynhaeve, G. (KU Leuven, Louvain, Belg); Adriaenssens, G.J.; Michiel, H.; Overhof, H. *Philos Mag B* v 58 n 4 Oct 1988 p 421-432.

**096778 PERCOLATIVE TRANSPORT IN AMORPHOUS SEMICONDUCTORS.** For phonon-assisted transport between localized electronic states in amorphous semiconductors, the conductance of the medium is known to be the same as that of an equivalent resistor network. If the impedances of the resistors between adjacent sites vary over several orders of magnitude, this conductance is determined mainly by the magnitude of the critical impedance  $Z_c$  such that a percolation path through the system of resistors with impedance less than  $Z_c$  exists only if  $Z_0 \geq Z_c$ . Various methods for calculating  $Z_c$  and its dependence on the parameters of the system, are compared for a model system in which all the states have one of two discrete energies. Our main conclusion is that in the calculation of  $Z_c$  from the mean number of bonds per site, it can be very important to optimize the range of sites and bonds that are considered. (Edited author abstract) 14 refs.

Halpern, V. (Bar-Ilan Univ, Ramat-Gan, Isr). *Philos Mag B* v 56 n 6 Dec 1987, Second Bar-Ilan Conf on the Phys of Disordered Syst, Ramat-Gan, Isr, Jan 5-7 1987 p 861-871.

**096779 LASER BEAM INDUCED CURRENT MEASUREMENTS OF MINORITY CARRIER DIFFUSION LENGTH.** Techniques for extracting values of bulk diffusion length from experimental LBIC (laser-beam-induced current) curves are presented for both parallel and perpendicular barrier-beam geometries and for both thick and thin samples. Experimental tests of each technique compare diffusion length results obtained for samples of different geometries with each other, with confirmation of results by measuring the minority carrier lifetime by photoconductivity decay in samples cut from the same wafers and then calculating the diffusion length. The LBIC techniques presented are shown to allow practical and meaningful determination of diffusion length, and to have significant advantages over the techniques from which they evolved. (Edited author abstract) 16 refs.

Oliver, B.A. (Univ of Waterloo, Waterloo, Ont, Can); Dixon, A.E. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 814-820.

**096780 EXCITON LINEWIDTH DUE TO SCATTERING FROM FREE CARRIERS IN SEMICONDUCTING QUANTUM WELL STRUCTURES.** The contribution to the exciton linewidth in semiconducting quantum well structures due to the scattering of excitons by free carriers is calculated. It is found that this contribution becomes very important in limiting the exciton linewidth when a high density of free carriers is present or at low temperatures where the scattering of the excitons by optical and acoustic phonons is reduced. This contribution to the linewidth in quantum well structures is found to increase with the free carrier concentration and to extremely broaden the exciton peak at high carrier concentrations. At lower carrier concentrations, where the carrier behave as a nondegenerate gas of particles, the contribution to the exciton linewidth due to scattering by free carriers increases with temperature. (Author abstract) 13 refs.

Feng, Yuan-ping (Illinois Inst of Technology, Chicago, IL, USA); Spector, Harold N. *Superlattices Microstruct* v 3 n 5 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 459-461.

**096781 EFFECT OF CONTINUUM RESONANCES ON HOT CARRIER TRANSPORT IN QUANTUM WELLS.** In addition to bound states, quantum wells also produce resonant states in the continuum. While bound states have received considerable attention and are now the basis of device applications, the corresponding virtual states have hardly been studied. We investigate the

influence of these resonant states on hot electron transport in quantum wells. We find that the matrix elements which determine scattering rates exhibit structure at the resonant energies. This leads to suppression of scattering by polar optical phonons relative to nonpolar optical and acoustic phonon scattering. We discuss the effect that these states have on the capture and release of carriers by the quantum well. (Edited author abstract) 10 refs.

Porod, Wolfgang (Univ of Notre Dame, Notre Dame, IN, USA); Lent, Craig S. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 359-362.

**096782 INTERSUBBAND RELAXATION OF PHOTOEXCITED HOT CARRIERS IN QUANTUM WELLS.** We have probed the dynamics of hot electrons in undoped GaAs/(GaAl)As quantum wells using time-resolved Raman techniques. By tuning the photon energy of a time-delayed weak probe, we study the  $n=1$  to  $n=2$  or  $n=2$  to  $n=3$  intersubband transitions by electronic Raman scattering. The lifetime and the intersubband scattering time of the electrons photoexcited on the lowest electronic subbands are determined separately. Calculation of the rate of intersubband scattering by longitudinal acoustical phonons accounts for the observation of relatively long lived electrons on the second subband of a 215 Angstrom MQWS. When the well is narrower, so that the  $n=2$  to  $n=1$  transition can occur with emission of a longitudinal optical phonon, we find that the lifetime of carriers in the  $n=2$  band is too short to measure with our technique. (Edited author abstract) 19 refs.

Oberli, D.Y. (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Wake, D.R.; Klein, M.V.; Henderson, T.; Morkoc, H. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 413-418.

**096783 SECONDARY EMISSION STUDIES OF HOT CARRIER RELAXATION IN POLAR SEMICONDUCTORS.** The details of the initial relaxation of optically injected hot carriers in polar semiconductors are studied by Raman scattering from nonequilibrium LO phonons and anti-Stokes hot luminescence. Experiments on intrinsic and doped GaAs reveal carrier-phonon and carrier-carrier interaction times, the wavevector dependence of the hot phonon distribution, and the influence of holes on the LO phonon lifetime. Studies in  $Al_xGa_{1-x}As$  probe the influence of alloy disorder on the generation of hot phonons. Because there are two optic phonon modes in  $Al_xGa_{1-x}As$ , we can experimentally measure the effect of ionicity (the frequency difference between LO and TO phonons) on the generation rate for the hot phonons. (Edited author abstract) 16 refs.

Kash, J.A. (IBM, Yorktown Heights, NY, USA); Tsang, J.C. *Solid State Electron* v 31 n 3-4 Mar-Apr 1988, Hot Carriers in Semicond, Boston, MA, USA, Jul 20-24 1987 p 419-424.

**096784 HOT CARRIER RELAXATION IN HIGHLY EXCITED III-V COMPOUNDS.** The transition from nonthermal to thermalized carrier distributions and their subsequent cooling via phonon emission is investigated in III-V compounds by time resolved optical measurements with femtosecond laser pulses. (Author abstract) 3 refs.

Kurz, H. (RWTH Aachen, Aachen, West Ger); Kuett, W.; Seibert, K.; Strahnen, M. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 447-450.

**096785 ELECTRON-ELECTRON SCATTERING DURING FEMTOSECOND PHOTOEXCITATION IN QUANTUM WELLS.** We model the dynamics of carriers injected into a semiconductor quantum well during femtosecond photoexcitation using an ensemble Monte Carlo simulation which includes two-dimensional electron-electron scattering. The time evolution of the nonequilibrium electron distribution is used to calculate



the time dependence of the multi-subband dielectric matrix during the simulation so that transient effects in the screening are incorporated into the inter-carrier scattering rate. Our results show that band filling occurs within 200fs for small injection energies, the rate of which increases with increasing injection density. (Author abstract) 7 refs.

Goodnick, S.M. (Oregon State Univ, Corvallis, OR, USA); Lugli, P. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 463-466.

**096786 NONLINEAR MODULATION OF HOT CARRIER MOBILITY AND OPTICAL ABSORPTION IN PHOTOEXCITED POLAR SEMICONDUCTORS.** The nonlinear interaction between the steady state carrier distribution in a photoexcited polar semiconductor and the population generated by a second light source is studied theoretically. We analyze the changes in mobility and optical absorption as a function of the intensities and energies of the light sources and as a function of the intensity of an applied electric field. We find that the interaction between the two carrier populations generated by the light sources can serve as a mechanism of modulation for the carrier mobility and optical absorption. (Author abstract) 8 refs.

Rodriguez, M.A. (Univ Autonoma de Puebla, Puebla, Mex); Carrillo, J.L. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 511-514.

**096787 QUANTUM CORRECTIONS TO THE MONTE CARLO SOLUTION OF HOT-ELECTRON TRANSPORT IN SEMICONDUCTORS.** By using the generalized Kadanoff-Baym method, we construct a computational scheme which can be included in an ensemble Monte Carlo program to give quantitative estimates of the intra-collisional field effect and/or of collisional broadening. The central quantity in our theory is the joint spectral density  $K(k,k')$  which describes the relation between the initial and final kinetic momenta in a scattering event. (Edited author abstract) 20 refs.

Jauho, Antti-Pekka (Univ of Copenhagen, Copenhagen, Den); Reggiani, Lino. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 535-538.

**096788 NONLINEAR ENERGY RELAXATION OSCILLATIONS AND CHAOTIC DYNAMICS OF HOT CARRIERS.** It is shown that recently observed complex chaotic behavior associated with low temperature impurity breakdown can be understood by introducing the mean energy per carrier  $E$  as an additional dynamic variable besides the carrier densities. A set of coupled nonlinear evolution equations for the carrier density and mean energy is derived by a moment expansion of the Boltzmann equation including impact ionization. This process leads to a novel, strongly nonlinear relaxation term in the dynamic energy balance equation. The simplest, spatially homogeneous version of the model yields hysteretic or non-hysteretic static current-voltage characteristics, and spontaneous self-sustained current oscillations. It can also be used to explain the coupling of the oscillations in two spatially separated hot carrier subsystems via energy exchange. (Edited author abstract) 14 refs.

Schoell, Eckehard (Rheinisch-Westfälische Technische Hochschule Aachen, Aachen, West Ger). *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 539-542.

**096789 GENERATION-RECOMBINATION NOISE OF HOT CARRIERS IN SEMICONDUCTORS.** We present an original Monte Carlo procedure to account for generation-recombination noise through impurity centers in semiconductors. An exact decomposition procedure of the current spectral density evidences the importance of a cross-correlation contribution coming from velocity and number fluctuations. (Author abstract) 12 refs.

Reggiani, Lino (Univ di Modena, Modena, Italy); Lugli, Paolo; Mitin, Vladimir. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 543-546.

**096790 ELECTRON-HOLE DRAG IN SEMICON-**

**DUCTORS.** Transport of minority carriers in semiconductor plasmas can be strongly affected by electron-hole scattering. In high-mobility carrier systems not only the presence of one carrier type, but also its drift velocity determines the transport of the other carrier type via electron-hole scattering. This effect is known as 'carrier drag'. In modulation-doped quantum well structures the carrier drag is strong enough to cause 'negative absolute mobility' of both minority electrons and holes. We describe all-optical transport measurements, from which momentum relaxation times by electron-hole scattering are quantitatively determined. Extremely short scattering times result for minority electrons in a hole plasma (40 to 100 fs) in contrast to the reverse case of holes in an electron plasma (2-5 ps). The physical reasons (mass ratio, degeneracy, two-dimensionality) are discussed, as well as new phenomena as negative photoconductivity and plasma instabilities in the presence of strong electron-hole drag. (Edited author abstract) 30 refs.

Hoepfel, R.A. (Univ Innsbruck, Innsbruck, Austria); Shah, J. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 643-648.

**096791 SCATTERING PROCESSES IN SEMICONDUCTORS.** We give the variation with temperature and carriers density of the electron-phonon (e-ph) and electron-hole (e-h) collision times from the nondegenerate to the degenerate limits. We show that the e-h collision time is minimum not at very large density but when the plasma becomes degenerate. We also show that the collision time with acoustical phonons has a minimum in the degenerate domain. The corresponding density can be reached experimentally only for low temperature. We give an expression for the screening of the e-ph interaction, which was up to now taken incorrectly similar to the one for Coulomb interaction. (Edited author abstract) 5 refs.

Combescot, Monique (Ecole Normale Supérieure, Paris, Fr). *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 657-661.

**096792 HOT PHONON DYNAMICS.** The paper illustrates theoretical results on nonequilibrium phonon effects based on a novel Monte Carlo algorithm. No assumptions on the form of the phonon or the electron distributions are required. The emphasis is given to the study of LO phonon perturbation as a result of the relaxation of photoexcited carriers in polar semiconductors. Agreement is found with available experimental results from time resolved luminescence and Raman measurements. (Edited author abstract) 20 refs.

Lugli, Paolo (Univ di Modena, Modena, Italy). *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 667-672.

**096793 NONEQUILIBRIUM CARRIER-PHONON COUPLING IN A SEMICONDUCTOR QUANTUM WELL.** We discuss an approach proposed recently by us for the description of hot phonon dynamics in heterolayers. The nonequilibrium phonons are described as excitations localized near the carrier layer and a kinetic equation for these 'phonon wavepacket' is obtained. Calculation of the cooling rate and mobility of hot electrons are compared with recent experiments. (Author abstract) 18 refs.

Marchetti, M.C. (Univ of Illinois at Chicago, Chicago, IL, USA); Cai, W.; Lax, M. *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 677-681.

**Chemical Analysis** See THALLIUM AND ALLOYS—Solvent Extraction.

**Chemical Vapor Deposition** See Also CHEMICAL EQUIPMENT—Reactors; CRYSTALS—Growing; SEMICONDUCTING SILICON—Amorphous.

**096794 MOCVD FOR THE GROWTH OF WIDE BAND-GAP II-VI COMPOUNDS.** MOCVD offers many potential advantages for the growth of wide band-gap II-VI compounds (band-gaps  $> 2$  eV), the initial key factor being growth at lower temperatures and, consequently, improved properties. Progress has been made in areas such as purity and interface control but

several important objectives, in particular, better control of doping and thickness uniformity, need to be achieved. The current position is reviewed for the growth of the zinc compounds, cadmium sulfide, and several ternary alloys and some of the successes and problems are highlighted. Possible exploitation of these materials in devices is discussed, together with the likely materials parameters which need to be controlled. (Author abstract) 18 refs.

Wright, P.J. (Royal Signals & Radar Establishment, Malvern, Engl); Cockayne, B. *Chemtronics* v 2 n 2 Jun 1987 p 49-53.

**096795 BOUNDARY LAYER MODEL FOR THE MOCVD PROCESS IN A VERTICAL CYLINDER REACTOR.** The transport process in metalorganic chemical vapor deposition (MOCVD) is investigated for a vertical reactor where two kinds of reactants are mixed just above the horizontally-attached substrate. A boundary layer model is developed and the epitaxial growth of the compound semiconductor is described. The model predicts that the growth rate is a function of reactant partial pressure, boundary layer thickness and the degree of mixing. It also predicts that uniformity in thickness is obtained by controlling the homogeneity of mixing. Results of experimental studies on ZnSe epitaxial growth rate agree well with the calculated growth rate. (Author abstract) 12 refs.

Shibata, Noriyoshi (NTT, Tokyo, Jpn); Zembutsu, Sakae. *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1416-1421.

**096796 OXIDATION OF Si-RICH CHEMICAL-VAPOR-DEPOSITED FILMS OF TUNGSTEN SILICIDE.** We have studied dry oxidation characteristics of Si-rich  $WSi_x$  thin films prepared by LPCVD directly on  $SiO_2$  with  $x=2.7$  for as-deposited films. It has been reported previously that thin (less than 100 nm) CVD tungsten silicide adheres well to  $SiO_2$ . Using Auger depth profiling and Rutherford backscattering spectroscopies, we find that silicon in excess of stoichiometric  $WSi_2$  diffuses through the silicide toward the surface to form a  $SiO_2$  passivating overlayer. The extracted activation energy for this oxidation process is  $E_a=1.2$  eV, consistent with oxygen diffusion in  $SiO_2$ . A similar value of  $E_a$  is found for  $WSi_x$  deposited on polysilicon. During the anneal, the stoichiometry  $x$  of  $WSi_x$  decreases monotonically with the annealing temperature, reaching  $x=2$  after 30 min at 900°C or 20 min at 950°C. Longer times or higher temperatures result in silicon depletion, with  $x=1.7$  after 30 min at 1000°C. (Edited author abstract) 13 refs.

Krusin-Elbaum, L.; Joshi, R.V. *IBM J Res Dev* v 31 n 6 Nov 1987 p 634-640.

## Chemistry

**096797 CHEMICAL POTENTIAL OF AN INTRINSIC SEMICONDUCTOR NEAR  $T=0$ .** It is confirmed that the Fermi level of an intrinsic semiconductor goes to the bottom of the conduction band as  $T \rightarrow 0$ . However the loss of one electron is sufficient to make it go to the top of the valence band, and for some purposes it may be adequate to take an average of the two values. (Author abstract) 2 refs.

Landsberg, P.T. (Univ Southampton, Southampton, Engl); Browne, D.C. *Solid State Commun* v 62 n 3 Apr 1987 p 207-208.

**Composition Effects** See SEMICONDUCTING GLASS—Structure; SEMICONDUCTING ZINC COMPOUNDS—Electric Properties.

## Computer Simulation

**096798 COMPUTER SIMULATION OF HOPPING CONDUCTIVITY IN LIGHTLY DOPED TWO-DIMENSIONAL SEMICONDUCTORS.** We present the results of a numerical simulation of a two-dimensional lightly doped compensated semiconductor. We choose a flat density of states with width  $\Delta\epsilon$ . We model the semiconductor as a Miller and Abrahams type resistor network: we use the full form of the resistance and do not



take the low-temperature asymptotic form because we carry out the simulation at temperatures for which  $kT$  is of order  $\Delta\epsilon$ . (Edited author abstract) 18 refs.

Shegelski, Mark R.A. (Dalhousie Univ, Halifax, NS, Can); Barrie, Robert. *Can J Phys* v 66 n 2 Feb 1988 p 150-154.

**Contacts** See Also SEMICONDUCTOR DEVICES—Contacts.

**096799 ACOUSTOELECTRONIC INTERACTION IN A SEMICONDUCTOR WITH PERIODICALLY ARRANGED CONTACTS IN A VARYING ELECTRIC FIELD.** Acoustoelectronic effects in semiconductors and layered piezoelectric-semiconductor structures with a periodic system of ohmic contacts, which produces an electric field in the semiconductor that varies in space and time, are investigated. Interest in a systematic investigation of acoustoelectronic effects in such structures has been stimulated by the discovery of a whole series of effects in them: frequency conversion and multiplication and synchronous signal detection. The use of periodic arrays of ohmic contacts opens up the possibility for the direct observation of electron waves, excited through the simultaneous stimulus of the piezoelectric field of the acoustic wave and the varying drift field. Formulas are given and analyzed in this paper that describe electron absorption and the velocity of acoustic waves in a varying field when its phase is taken into consideration; expressions are also given for the acoustoelectric current, detected by the periodic array of contacts. (Author abstract) 10 refs.

Gulyayev, Yu.V.; Mansfel'd, G.D.; Boritko, S.V. *Sov J Commun Technol Electron* v 32 n 1 Jan 1987 p 83-89.

**096800 CURRENT TRANSIENT STUDIES OF Al-a-As<sub>2</sub>Se<sub>3</sub> CONTACTS.** Results are reported of current transients after a voltage step is applied to an a-As<sub>2</sub>Se<sub>3</sub> sample with an oxidized Al contact. Most of the results can be explained using the multiple-trapping model if it is assumed that there is a hole-accumulation region near the contact. (Author abstract) 18 refs.

Gibson, D.G. (MIT, Cambridge, MA, USA); Kastner, M.A. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 237-246.

**Contamination** See SEMICONDUCTOR DEVICE MANUFACTURE.

## Cooling

**096801 HOT CARRIER COOLING IN GaAs QUANTUM WELLS.** The cooling of a hot electron-hole plasma in undoped, p-doped, and n-doped GaAs/Al-GaAs quantum wells of three different thicknesses (3, 9, and 20 nm) is investigated by picosecond luminescence spectroscopy. The energy loss of holes due to the Froehlich interaction is at low excitation densities independent of well width and close to the value obtained by a simple theory. The rate strongly decreases with increasing excitation density. For electrons, the energy loss is even at low densities strongly reduced compared to the simple theory of the Froehlich interaction. The reduction of the energy loss at high densities is independent of dimensionality and well width and not caused by screening or degeneracy effects. The energy loss due to acoustic deformation potential scattering depends on well width. (Author abstract) 25 refs.

Leo, K. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Rühle, W.W.; Queisser, H.J.; Ploog, K. *Appl Phys A* v A45 n 1 Jan 1988 p 35-39.

## Crack Propagation

**096802 CONDITION OF CRACK PROPAGATION IN A BRITTLE FILM WITH CONSIDERATION OF ITS PENETRATION INTO THE SUPPORT MATERIAL.** Conditions of crack propagation in a brittle film applied to the support when tensile stresses exist in the latter are considered. It is shown that under definite conditions the crack penetrates to the support. An

expression is obtained for critical thickness of the film beginning from which the appeared crack propagates along the support. It is shown that critical thickness of the film depends on the fracture toughness of both the support material and the film. (Edited author abstract) 11 refs. In Russian.

Frantsuzova, L.P.; Frantsuzov, A.A. *Probl Prochn* n 2 Feb 1988 p 22-25.

**Crystal Lattices** See Also PHOTOLUMINESCENCE—Analysis.

**096803 ELECTRON-PHONON INTERACTION IN SEMICONDUCTOR SUPERLATTICES.** The single-particle Hamiltonian of the electron-long-wave optical phonon interaction is discussed for semiconductor superlattices—the dispersion relations of long-wave optical phonons, i.e., the interface-like bulk phonons (IBPs) and longitudinal optical (LO) phonons of the polar semiconductor superlattice, are analyzed in detail. The IBPs are composed from ordinary interface phonons on adjacent interfaces coupling through their macroscopic electric fields to form a collective excitation of the superlattice. The coupling functions describing the modified Froehlich interaction of a single electron with the continuous field of polarization of the IBPs and LO phonons are discussed and presented in graphical form. (Edited author abstract) 27 refs.

Wendler, L. (Univ Jena, Jena, East Ger); Haupt, R. *Phys Status Solidi B* v 143 n 2 Oct 1987 p 487-510.

**096804 LATTICE DYNAMICS FOR SUPERLATTICES.** The acoustic and optic modes of a one-dimensional model of a diatomic superlattice are considered. By employing a microscopic theory it is possible to explore the zone-folding characteristics. The treatment is based on linear lattice dynamics with nearest neighbour interactions. The equations of motion for the different atoms (on either side) at two superlattice interfaces replace the boundary conditions used in continuum theories. This microscopic approach has the advantage that both optic and acoustic branches are described within a single formulation and without recourse to the long wavelength limit. The algebra, which is otherwise quite involved, is simplified by the use of transfer matrix techniques. The spectrum contains a number of interesting features whose underlying physical principles are discussed. (Author abstract) 17 Refs.

Albuquerque, E.L. (Univ Federal do Rio Grande do Norte, Natal, Braz); Fulco, P.; Tilley, D.R. *Phys Status Solidi B* v 146 n 2 Apr 1988 p 449-456.

**096805 ELECTRON-PHONON SCATTERING IN SEMICONDUCTOR SUPERLATTICES IN A QUANTIZING MAGNETIC FIELD.** Total electron-phonon scattering rates are obtained in an ideal superlattice in a quantizing magnetic field. The dispersion of an electron along the superlattice axis is assumed to be of a tight-binding type. Compact analytical expressions are possible for acoustic and nonpolar optical phonon scattering. The numerical results for acoustic and nonpolar optical phonon scattering rates are presented for the GaAs/Ga<sub>1-x</sub>Al<sub>x</sub>As superlattice and the effect of miniband width parameters on these scattering rates is discussed. (Author abstract) 11 Refs.

Kubakaddi, S.S. (Karnatak Univ, India); Mulimani, B.G.; Sankeshwar, N.S. *Jpn J Appl Phys Part 1* v 27 n 5 May 1988 p 730-733.

**096806 ELECTROSTATIC AND MAGNETOSTATIC MODES IN SEMICONDUCTOR SUPERLATTICES.** We present a study of interface optical phonons and magnetostatic modes in semiconductor superlattices. We first review the propagation of longitudinal waves propagating parallel to the superlattice axis in order to show the similarities and differences between these and the interface modes just mentioned. The interface modes are discussed with the aim to interpret experiments carried out with superlattices of diluted magnetic semiconductors. (Author abstract) 13 refs.

Rodriguez, Sergio (Purdue Univ, West Lafayette, IN, USA); Camacho, Angela; Quiroga, Luis. *Superlattices Microstruct* v 3 n 4 1987 p 371-377.

## Crystalline

**096807 SURFACE POLARITY AND SYMMETRY IN SEMICONDUCTING COMPOUNDS. PART I - MACROSCOPIC EFFECTS OF POLARITY.** The polarity of the crystallographic surfaces of semiconducting compounds with the sphalerite and wurtzite structures results in gross differences in macroscopic chemical, mechanical and crystal growth behaviour which are reviewed. The surface polarity index and the singular surface polyhedra for sphalerite- and wurtzite-structure semiconducting compounds are introduced. (Edited author abstract) 61 refs.

Holt, D.B. (Imperial Coll of Science & Technology, London, Engl). *J Mater Sci* v 23 n 3 Mar 1988 p 1131-1136.

## Crystallization

**096808 THEORY OF ELECTRICAL TRANSPORT AND RECOMBINATION IN POLYCRYSTALLINE SEMICONDUCTORS UNDER OPTICAL ILLUMINATION.** A method for describing electrical transport in polycrystalline material has been developed by solving a current continuity equation that involves drift, diffusion and nonuniform generation rate of electron-hole pairs. By taking the recombination current at the grain boundary interface, at the grain boundary space-charge region, and at the bulk into consideration a theoretical method for grain boundary recombination has been developed. The author includes the effects of Shockley-Read-Hall recombination statistics, of trap-assisted recombination statistics, and of the heavy dopings of the semiconductor region(s). On the basis of the present theory the dependence of the grain-boundary potential-barrier height  $V$  on the grain size, doping concentrations, and carrier generation rate has been studied. It is found that the effective recombination velocity at the edge of the grain boundary space-charge region is a function of  $V$ , and that it increases with grain size until it attains a peak value. (Edited author abstract) 34 refs.

Mohammad, S. Noor (Case Western Reserve Univ, Cleveland, OH, USA); Rogers, Charles E. *Solid State Electron* v 31 n 7 Jul 1988 p 1157-1167.

**Defects** See Also CRYSTALS—Dislocations; ELECTRIC MEASUREMENTS—Capacitance; INTEGRATED CIRCUITS, LSI—Testing; SEMICONDUCTING INDIUM COMPOUNDS—Growth; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Impurities; SEMICONDUCTING SILICON—Ion Implantation.

**096809 THEORY OF ELECTRON BEAM INDUCED CURRENT AND CATHODOLUMINESCENCE CONTRASTS FROM STRUCTURAL DEFECTS OF SEMICONDUCTOR CRYSTALS; STEADY-STATE AND TIME-RESOLVED PROBLEMS.** Electron-beam-induced current and cathodoluminescence are powerful tools for revealing and characterizing point-like defects, dislocations, and grain boundaries in semiconductor crystals. This paper reviews the theoretical studies of electron-beam-induced current and cathodoluminescence contrasts from local structure defects of semiconductor crystals (the geometrical aspects of both contrasts, the assessment of the defect properties from the contrast, the evaluation of bulk parameters in the presence of defects, and time-resolved characterization of defects), including recent developments in this area. (Author abstract) 80 refs.

Jakubowicz, A. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger). *Scanning Microsc* v 1 n 2 Jun 1987 p 515-533.



**096810 LATTICE DISTORTION ASSOCIATED WITH ISOLATED DEFECTS IN SEMICONDUCTORS.** A semi-empirical tight-binding method is used to investigate the lattice relaxation around isovalent impurities and its effect on the vibrational properties of semiconductors. In terms of the revised Hartree-Fock atomic-term values, this technique provides simple analytical expressions for the change in the impurity-host bond energy and suggests a computationally efficient and reasonable method to estimate the bond-length distortions. Numerical calculations for the symmetric lattice relaxations are reported for eighty cases of impurity-host systems in nineteen elemental and compound semiconductors. The frequencies of the impurity modes in the dilute limit of mixed II-VI and III-V compounds are derived and the results are compared and discussed with the existing optical experiments and full lattice dynamical (Green's function) calculations. (Edited author abstract) 43 refs.

Talwar, D.N. (Texas A&M Univ at Galveston, Galveston, TX, USA); Suh, K.S.; Ting, C.S. *Philos Mag B* v 56 n 5 Nov 1987 p 593-609.

**096811 EFFECT OF DISORDERED REGIONS ON SEMICONDUCTOR JOULE HEATING.** The effect of radiation-induced disordered regions (DR) on the Joule heating of semiconductor is theoretically investigated. It is shown that both overheating and cooling of semiconductor near DR are possible depending on relation between DR and bulk thermal and electrical properties. Hence the existence of regions with different thermal and electrical properties in semiconductor material may both increase and decrease the probability of thermal breakdown. (Author abstract) 4 refs.

Sokolov, G.V. (Moscow Engineering Physics Inst, Moscow, USSR); Arkhipov, V.I.; Rudenko, A.I. *Solid State Commun* v 64 n 4 Oct 1987 p 549-551.

**096812 ATOMIC RADII IN TERNARY ADAMANTINES.** Bonded radii are derived for eight electropositive and four electronegative elements from line plots of total valence electron densities for 10 ternary chalcopyrites, in order to aid in understanding the defect chemistry of such compounds. They scale well with tetrahedral sulfide crystal radii, when a spherical atom approximation is made, in which case they are significantly closer to these than to covalent tetrahedral radii, as illustrated for several ternary chalcogenides. Their derivation confirms that the electronegative elements in these tetrahedrally bonded ternaries are better described by tetrahedrally distorted spheres. Still, models using these radii are to be preferred over the usual ball-and-stick types. (Edited author abstract) 28 refs.

Cohen, David (Weizmann Inst of Science, Rehovot, Isr). *J Phys Chem Solids* v 49 n 1 1988 p 103-111.

**096813 EVIDENCE OF A RADIATION-INDUCED DEFECT LEVEL IN n-TYPE InSb.** Capacitance bridge measurements of loss on irradiated n-type InSb specimens at low temperatures are reported. A peak in ac conductance at 51 K is seen after irradiation and it is attributed to a radiation induced level. (Author abstract) 12 refs.

Kouimtzis, S.D. (Univ of Reading, Reading, Engl). *Solid State Commun* v 64 n 8 Nov 1987 p 1171-1173.

**096814 ACCEPTOR IMPURITY BAND CONDUCTANCE IN ZERO-GAP  $Hg_{1-x}Cd_xTe$ .** The authors studied the transport process of zero-gap  $Hg_{1-x}Cd_xTe$  and the influence of the presence of acceptor levels. The anomalous dips  $A_1A_2$  on mobility versus temperature curves were studied in different magnetic fields. The experimental results show that  $A_1A_2$  are caused by the acceptor band conductance when the acceptor density in the conduction band is sufficiently high, and  $A_1$  is caused by mercury vacancies. (Edited author abstract) 14 refs.

Yong, Liang (Shanghai Inst of Technical Physics, China); Guozhen, Zheng; Dingyuan, Tang. *Sci Sin Ser A* v 31 n 1 Jan 1988 p 46-56.

**096815 POSITRON STUDY OF VACANCY DEFECTS IN PROTON AND NEUTRON IRRADIATED**

**GaP, InP, AND Si.** The annealing and fluence dependent concentration of defects produced by irradiation with fast neutrons and protons was studied by means of the positron annihilation technique (measurements of the positron lifetime and Doppler broadening lineshape of annihilation photons) and internal friction measurements. In proton bombarded GaP a two-stage annealing process is observed (stage I near 200°C and stage II near 600°C) and attributed to the annealing of point-like and extended defects, respectively. In neutron irradiated GaP all positron sensitive radiation defects disappear after annealing at 700°C. In all materials the positron lifetime and S-parameter increase with rising proton and neutron fluence. Elemental semiconductors exhibit stronger increases than compound semiconductors. (Author abstract) 32 refs.

Dlubek, G. (Paedagogischen Hochschule Halle, East Ger); Ascheron, C.; Krause, R.; Erhard, H.; Klimm, D. *Phys Status Solidi A* v 106 n 1 Mar 1988 p 81-88.

**096816 DETERMINATION OF TRAP CONCENTRATIONS AND ENERGY LEVELS IN INSULATORS AND SEMICONDUCTORS FROM STEADY-STATE SPACE-CHARGE-LIMITED CURRENTS.** A method to determine trap concentrations and discrete trap energy levels in insulators and semiconductors from the experimental  $j(U)$  (current density-voltage) characteristic of one-carrier steady-state space charge limited currents measured at constant temperature is described. The procedure for the experimental  $j(U)$  characteristic evaluation is presented. An analysis of trap parameter errors is carried out and the requirements for accuracy of the measurements are deduced. (Author abstract) 7 refs.

Hrebicek, J. (Acad of Sciences, Brno, Czech); Cech, V.; Brablec, A. *Phys Status Solidi A* v 106 n 1 Mar 1988 p 167-172.

**096817 POLARIZATION AND TEMPERATURE RELATIONS OF LUMINESCENCE ASSOCIATED WITH A BINARY COMPLEX OF DEFECTS IN SEMICONDUCTORS.** Radiative recombination of carriers in complex defects in semiconductors is investigated. A relation between the microscopic parameters of the complex (the distance between the defects, their energy positions, etc.) and the characteristics of its luminescence is established. (Author abstract) 7 refs.

Georgobiani, A.N.; Gruzintsev, A.N.; Zayats, A.V.; Tiginyanu, I.M. *Sov Phys Lebedev Inst Rep* n 11 1987 p 59-62.

**096818 DISTRIBUTION OF DEEP LEVEL PARAMETERS IN SPECTRAL ANALYSIS OF DLTS (SADLTS).** It is shown that one can estimate the broadening parameters of both the capture cross section  $\sigma$  and the activation energy  $E$  of a deep level from the emission rate spectrum  $S(\lambda, T)$  of the transient capacitance  $\Delta C(t, T)$  obtained in a spectral analysis of the DLTS (SADLTS) proposed in our previous paper. Numerical examples are given to illustrate typical cases of interest for an idealized model of independent Gaussian distributions,  $f(\sigma)$  and  $g(E)$ . In general,  $S(\lambda, T)$  is a convolution of  $f$  and  $g$  with its higher and lower  $\lambda$  side characterized by broadening parameters for  $\sigma$  and  $E$ , respectively. A simple formula is derived in order to obtain the central value  $E$  of the activation energy. (Author abstract) 25 refs.

Tahira, Kenichiro (Natl Defense Acad, Yokosuka, Jpn); Morimoto, Jun; Miyakawa, Toru. *Jpn J Appl Phys Part I* v 27 n 4 Apr 1988 p 556-562.

**096819 THERMODYNAMICS OF DEFECT FORMATION AND DEFECT INTERACTION IN COMPOUND SEMICONDUCTORS.** Based on the Gibbs canonical distribution, a number of physical quantities is related to crystal growing conditions such as various point defect densities (intrinsic, vacancies, antistructural, complex of some point defects), high-temperature density of free carriers, homogeneity region width, and impurity distribution factor. It is discussed how to calculate the Gibbs partial potential from experimental data. The

results can be now used for solving a variety of problems of point defects in semiconductors including effects of complex formation. (Author abstract). 12 Refs.

Bulyarskii, S.V. (Kishinev Polytechnical Inst, Kishinev, USSR); Oleinikov, V.P. *Phys Status Solidi B* v 146 n 2 Apr 1988 p 439-447.

**096820 STUDY OF MICRODEFECTS IN NEAR-SURFACE AND INTERIOR OF III-V COMPOUND WAFERS BY DARK-FIELD TRANSMISSION MICROSCOPY.** The application of dark field transmission microscopy is reported for observing microdefects in III-V compound wafers. Using near infra-red imaging with a video camera, high contrast results are obtained of micro-precipitates of  $1 \mu m$  and smaller in the subsurface and interior of wafers of indium-doped GaAs and an epitaxial layer of GaAs on GaAs. (Author abstract). 4 Refs.

Montgomery, P.C. (Univ des Sciences et Techniques du Languedoc, Montpellier, Fr); Fillard, J.P. *Electron Lett* v 24 n 13 Jun 23 1988 p 789-790.

**096821 APPROPRIATE PULLING AXIS ORIENTATION TO SUPPRESS SLIP DISLOCATION GENERATION DURING CZOCHRALSKI GROWTH OF SEMICONDUCTOR CRYSTALS.** The pulling axis orientation effect on dislocation density reduction is considered, based on the Schmid factor calculation under a uniform tangential stress field. The maximum Schmid factor converges at the 0.4536 value at  $\langle 110 \rangle$  orientation. The  $\langle 110 \rangle$  pulling axis is the best orientation to suppress slip dislocation generation. The feature of slip dislocation in a (110) wafer is also clarified from the calculation. (Author abstract). 14 Refs.

Kitano, tomohisa (NEC Corp, Kawasaki, Jpn); Matsui, Junji. *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 740-743.

**096822 INTERATOMIC POTENTIALS IN SEMICONDUCTORS AND THEIR VALIDITY FOR DEFECT CALCULATIONS.** We discuss the validation of interatomic forces for defect calculations in semiconductors like silicon. Our tests include estimates of lattice response functions, defect steric energies, and relaxed atomic positions near defects. We find the variation from one potential to another to be substantial, notably because of the dominance of the bond-angle terms in the energy. Differences are less serious in the predicted geometries than in the predicted energies, which indicates preferred strategies for finding relaxed geometries. (Author abstract). 56 Refs.

Stoneham, A.M. (Harwell Lab, Oxon, Engl); Torres, V.T.B.; Masri, P.M.; Schober, H.R. *Philos Mag A* v 58 n 1 Jul 1988 p 93-106.

**096823 PARAMETER-FREE CALCULATIONS OF TOTAL ENERGIES, INTERATOMIC FORCES AND VIBRATIONAL ENTROPIES OF DEFECTS IN SEMICONDUCTORS.** We discuss calculations from first-principles (using the local-density approximation for exchange and correlation) of defect total energies, vibrational modes, internal energies and entropies. Results are presented for the defect-induced distortion field of an arsenic impurity in silicon and for the vibrational entropy of a silicon vacancy. We also discuss the important role of electron and atom chemical potentials, presenting results for the Ga vacancy in the GaAs bulk and at the (111) surface. (Author abstract). 38 Refs.

Scheffler, Matthias (Max-Planck-Gesellschaft, Berlin, West Ger); Dabrowski, Jaroslaw. *Philos Mag A* v 58 n 1 Jul 1988 p 107-121.

**096824 DRIVEN RECONSTRUCTION OF DISLOCATION CORES IN SEMICONDUCTORS.** The conditions necessary for driving the reconstruction of a dislocation core by means of helium atoms diffusing along a dislocation pipe are examined. It is shown by a simple model that, unlike in Ge, in which such reconstruction has



been achieved, the chances of driving such a reconstruction in Si by helium are rather small. Some hopes may be focused on hydrogen, which is known to diffuse effectively into deformed Si. (Author abstract). 5 Refs.

Pohoryles, B. (Polish Acad of Sciences, Warsaw, Pol). *Philos Mag Lett* v 58 n 1 Jul 1988 p 1-5.

**096825 PROCEEDINGS OF THE FIFTH INTERNATIONAL CONFERENCE ON THE PROPERTIES AND STRUCTURES OF DISLOCATIONS IN SEMICONDUCTORS.** The proceedings contains 32 papers. Some of the specific topics discussed are: photo-ESR studies on silicon containing dislocations; deep levels due to dislocations in CdS; effects of plastic strain on the theoretical parameters of GaAs; an induced-current study of defects in strained silicon; and grain-boundary conductivity in germanium. All papers are separately indexed and abstracted. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10743 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 179p.

**096826 TOPOLOGICAL DISORDER AND ELECTRON STATES IN PLASTICALLY STRAINED ONE-COMPONENT SEMICONDUCTORS.** Semiconductors represent extremely convenient materials for researching the electronic parameters of topologically disordered crystals, since the strong-bond approximation operates well for them. An example of such a crystal is taken here as a one-component semiconductor containing a dislocation time. Here we discuss characteristic features of the electron states in crystals containing dislocations by means of a simple model that, however, retains the main features identified previously in more realistic but more complicated ones. 9 refs.

Kawamura, K. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 24-27.

**096827 THEORETICAL STUDY OF CHARGE TRANSFER AND BOUND ELECTRON STATES AT DISLOCATIONS IN SEMICONDUCTING COMPOUNDS.** A study is made of the consequences of charge transfer occurring at dislocation cores containing unpaired bonds in compounds of elements of groups II-VI and III-V. Preliminary calculations have been performed on electronic levels in dislocations in GaAs and CdTe by other authors. 17 refs.

Teichler, H.; Grollich, M. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 28-33.

**096828 EFFECTS OF POINT DEFECTS ON DISLOCATION MOBILITY IN PEIERLS POTENTIAL RELIEF.** Measurements on dislocation mobility over a wide enough temperature range can in principle detect changes in the activation energy for the dislocation speed corresponding to the transition from kink generation at point defects (low temperatures) to free generation at higher ones. Such a transition has been observed in measurements on the mobilities of individual dislocations in silicon, namely from 2.3 C ev at  $T < 1050^\circ\text{C}$  to 4 ev at  $T > 1050^\circ\text{C}$ . 12 refs.

Petukhov, B.V. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 75-80.

**096829 MICROHARDNESS ANISOTROPY AND POLARITY IN ELEMENTAL SEMICONDUCTING AND IN  $A^{III}B^V$  SEMICONDUCTOR COMPOUNDS.** Microhardness measurements have been made on faces of Ge, GaAs, and InSb single crystals at 20-400°C by means of Vickers and Knoop indentors. It is concluded that the experiments on microhardness anisotropy and polarity

can be used to provide semiquantitative information on dislocation speeds in semiconductors, particularly the relative speeds of A(g) and B(g) dislocations in  $A^{III}B^V$  compounds. Experiments on microhardness anisotropy are more sensitive at low temperatures possibly because of the slower fall in the stresses with distance produced by a Knoop indenter. 13 refs.

Warren, P.D.; Roberts, S.G.; Hirsch, P.B. *Bull Acad Sci USSR Phys Ser* v 51 n 4 1987, Proc of the Fifth Int Conf on the Prop and Struct of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 168-172.

**096830 ELECTRONIC STRUCTURE OF COMPLEX DEFECTS IN SEMICONDUCTORS FROM LUMINESCENCE PERTURBATION SPECTROSCOPY.** The electronic structure of complex defects, in particular their bound excitons, is discussed for neutral 'isoelectronic' complexes as well as donors and acceptors. The experimental data referred to are from photoluminescence in magnetic and/or microwave fields. (Author abstract) 13 refs.

Monemar, B. (Linköping Univ, Linköping, Swed); Chen, W.M. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 59-63.

**096831 NONRADIATIVE ELECTRON-HOLE RECOMBINATION THROUGH DEEP CENTERS IN SEMICONDUCTORS.** Dynamical processes associated with nonradiative multiphonon capture of injected minority carriers by a deep-level defect are described, including the capture itself, the recombination enhanced defect reaction and the coherent electron-hole capture. A simple formula is given their rates with a standard basis put on the adiabatic limit for electron transition much faster than lattice motion. (Author abstract) 7 refs.

Sumi, Hitoshi (Univ of Tsukuba, Sakura-mura, Jpn). *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 76-79.

**096832 PROCEEDINGS OF THE FIFTH INTERNATIONAL CONFERENCE ON THE STRUCTURE AND PROPERTIES OF DISLOCATIONS IN SEMICONDUCTORS.** This conference proceedings contains 35 papers. Among the subjects covered are the following: configuration defects in plastically strained CdS crystals, interaction of dislocations and indium in GaAs, strain-induced defects in silicon, scanning DLTS study of GaAs defect distributions and energy levels, effects of space-charge cylinders on dislocation EBIC profiles, EBIC and cathodoluminescence contrast due to individual dislocations, silicon EBIC measurements, EBIC dislocation contrast, high-resolution electron microscopy, dislocation recombination X-ray topography and laser interferometers with WFR mirrors. All of the papers are abstracted and indexed separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11230 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 175p.

**096833 ANISOTROPIC DEFECTS IN  $A^{III}B^V$  SEMICONDUCTING COMPOUNDS.** Various types of defect influence the operation of optoelectronic devices. Dislocations act as sources of dark-line defects (DLD) and are important in optical-element degradation. Also, microdefects act as radiationless recombination centers. A new type of line defect has been identified in  $A^{III}B^V$  semiconductor compounds, which is of vacancy type and is oriented in  $[11\bar{0}]$  directions. (Edited author abstract) 3 refs.

Leipner, H.S.; Hoche, H.R.; Schreiber, J. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 31-33.

**096834 DIFFRACTION ELECTRON MICROSCOPY IN SEMICONDUCTOR DEFECT RESEARCH.** Effects of two types were examined: a) image displacement, and b) amplitude changes in the intensity oscillations (including additional oscillations lacking from focused pictures). The displacement directions were determined by the signs of the defect-plane inclinations, and they are most clearly seen in dark-field pictures produced with large excitation errors. The intensity variations and the new oscillations are most prominent on pictures corresponding to small errors. The signs of the defects can be determined by examining the displacements and intensity variations on defocusing. 27 refs.

Maksimov, S.K. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 49-53.

**096835 EFFECTS OF SPACE-CHARGE CYLINDERS ON DISLOCATION EBIC PROFILES.** The calculation method has been proposed for deriving the dependence of the EBIC contrast on the radius of the space-charge cylinder for various values of parameters such as dislocation depth and diffusion length. Profiles have been examined for the current density passing through parts of a dislocation. The results of this study and others show that the space-charge cylinder radius is determined by the screening atmosphere of the space charges compensating the charge on the dislocation. There are some discrepancies between the measured contrast and the values found in the calculations. 13 refs.

Cavallini, A.; Gondi, P. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 54-59.

**096836 EBIC AND CATHODOLUMINESCENCE CONTRAST DUE TO INDIVIDUAL DISLOCATIONS.** A mathematically exact solution has been obtained for the EBIC contrast for a dislocation perpendicular to the surface of a Schottky diode. A theoretical study has been made of the cathodoluminescence contrast from a defect. (Author abstract) 8 refs.

Pasemann, L. (Karl Marx Univ, Leipzig, East Ger); Hergert, W. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 60-66.

**096837 IRBIC SEMICONDUCTOR DEFECT PICTURES.** A new method is described for imaging defects, particularly dislocations, in scanning electron microscopy by recording the infrared-beam induced current. The apparatus built in the authors' laboratory has very high sensitivity and enables one to perform the following: a) to measure infrared beam induced currents (IRBIC) and to obtain infrared images (IRBIC is analogous to the electron-beam induced current EBIC method), b) to perform traditional photoconductivity-spectrum measurements, and c) to check the filling of levels in the forbidden band on monochromatic illumination during local photoconductivity measurement. The IRBIC data have been examined to confirm the type of radiation defect produced in the scanning electron microscope (SEM). The results for the photocurrents and infrared contrast due to dislocation lines are at least in partial agreement with the DLTS data from various sources. (Edited author abstract) 11 refs.

Castaldini, A.; Cavallini, A.; Gondi, P. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 77-81.

**096838 HIGH-RESOLUTION ELECTRON MICROSCOPY AND X-RAY METHODS APPLIED TO  $A^{III}B^V$  CRYSTALS.** Defect images have been formed for  $\text{Cd}_{1-x}\text{Mn}_x\text{Te}$  ( $0 < x < 0.7$ ) and ZnS by X-ray diffraction



and electron microscopy. Pictures are presented of dislocations, packing defects, and twins in these crystals. (Author abstract) 25 refs.

Mizera, E. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 103-108.

## Deformation

**096839 EFFECTS OF PLASTIC DEFORMATION ON THE ELECTRICAL CONDUCTIVITY OF S<sub>m</sub>S SINGLE CRYSTALS.** Single crystals of semiconducting S<sub>m</sub>S, grown by a Bridgman method, have been compressed at room temperature by a few percent, and the effects of deformation on the electrical conductivity have been investigated between room and liquid-helium temperatures. For deformed crystals, the conductivity measured below 20 K in a direction parallel to the edge dislocations is orders of magnitude larger than that of the undeformed crystals. This increase is interpreted in terms of the existence of a metallic region along the core of the edge dislocation. The activation energy of the conductivity at around liquid-nitrogen temperature exhibits an anisotropy after deformation, which is explained by segregation of donor S<sub>m</sub> interstitials in the strain field of edge dislocations. (Author abstract) 15 refs.

Iwamoto, K. (Univ of Tokyo, Jpn); Kimura, K.; Takeuchi, S. *Philos Mag B* v 57 n 4 Apr 1988 p 467-472.

## Degradation See Also SEMICONDUCTING SILICON—Amorphous.

**096840 DISLOCATIONS OR POINT DEFECTS: A STUDY OF DEEP LEVELS IN MECHANICALLY STRESSED GaP p-n JUNCTIONS.** Degradation is a very important effect for devices made from Al<sub>III</sub>B<sub>V</sub> compounds; major parts are played by dislocations and stress inhomogeneities, but the mechanism is not entirely clear. The authors have examined the behavior of deep levels associated with degradation in order to elucidate it. Further research has shown that a family of such deep levels can arise without substantial degradation, but in that case the spectra obtained by deep-level transient spectroscopy DLTS are very much dependent on the illumination, minority injection, and heat treatment. These levels have been detected here in a light-emitting diode. 7 refs.

Dozza, L.; Ferenczi, G. *Bull Acad Sci USSR Phys Ser* v 51 n 9 1987, Proc of the Fifth Int Conf on the Struct and Prop of Dislocat in Semicond, Moscow, USSR, Mar 17-22 1986 p 130-133.

## Dielectric Properties

**096841 NOVEL METHOD OF CALCULATING THE RPA DIELECTRIC FUNCTION FOR A SEMICONDUCTOR AT REAL ENERGIES.** We demonstrate a novel method for direct calculation of the Random Phase Approximation (RPA) dielectric function for a semiconductor at real energies based on a special point integration procedure. The method is relevant in the context of model-free ab initio calculations of dielectric properties and self-energies in semiconductors. (Author abstract) 17 refs.

Farid, B. (Eindhoven Univ of Technology, Eindhoven, Neth); Lenstra, D.; van Haeringen, W. *Solid State Commun* v 67 n 1 Jul 1988 p 7-11.

**096842 ON THE STATIC DIELECTRIC CONSTANT AND PLASMON ENERGY OF TiS<sub>2</sub> AND TiSe<sub>2</sub>.** A simple extreme-tight binding scheme is proposed to evaluate the long-wavelength dielectric constant and main plasmon energy of the titanium dichalcogenide compounds TiS<sub>2</sub> and TiSe<sub>2</sub>. Both compounds are assumed to be semiconductors. The model presented, although very simple, provides a reasonable picture concerning the main plasmon peak in these compounds. (Edited author abstract) 28 refs.

Oliveira, L.E. (Unicamp, Campinas, Braz). *Phys Status*

*Solidi B* v 147 n 1 May 1988 p 223-228.

**096843 ACOUSTOELECTRIC INTERACTION IN LAYERED NON-UNIFORM STRUCTURES.** The effective dielectric permittivity of a layered structure is calculated for transverse non-uniformity in conductivity with diffusion neglected. It is shown that this type of structure can be represented as a two-layer semiconductor. (Author abstract) 13 refs.

Kunigelis, V. (Vilnius State Univ, USSR); Kvetkus, V.; Adomaitis, V. *Russ Ultrason* v 18 n 1 1988 p 41-46.

## Diffusion

**096844 SINGULARITIES IN DETERMINATION OF THE DIFFUSION COEFFICIENTS OF COMPONENTS IN MELTS OF A<sup>III</sup>B<sup>V</sup> SYSTEMS.** A critical analysis is performed of the mathematical expressions used to compute the diffusion coefficients of components on the basis of data on the growth rate or dissolution of crystals of A<sup>III</sup>B<sup>V</sup> compounds. It is shown that neglect of high-order terms of the series that are the solution of the mass transport differential equations will result in substantial errors during processing of the experimental results. To simplify the computations and eliminate mathematical inaccuracy, it is proposed to use the analytic solution of the diffusion mass transport equations in the approximation of a semi-infinite medium. The diffusion coefficients of arsenic in liquid indium in the 550-750° C temperature range is computed on the basis of experimental results on the rate of InAs dissolution in an unsaturated In-As melt by using the method proposed. (Author abstract) 12 refs.

Moskvin, P.P. (V.I. Ul'yanov (Lenin) Electrotechnical Inst, Leningrad, USSR); Sorokin, V.S. *Sov Phys J* v 30 n 4 Apr 1987 p 281-286.

**096845 ONE-DIMENSIONAL MODELLING OF DIFFUSION IN SEMICONDUCTORS DURING CRYSTAL GROWTH.** A simple approach is developed for modeling the distribution of dopant in crystals grown by the Czochralski technique. Allowance is made for the temperature dependence of the diffusivity and for the diffusion of dopant behind the moving boundary. It is found that the effect can make a significant difference to the final dopant distribution. The diffusion process is modeled using a discrete method, previously developed for situations in which the boundary is static. (Author abstract) 9 refs.

Hearne, M.T. (Univ of Nottingham, Engl); Rogers, T.G.; Tuck, B. *COMPEL Int J Comput Math Electr Electron Eng* v 6 n 4 Dec 1987 p 211-225.

**096846 FINITE-ELEMENT ANALYSIS OF CONVECTIVE DIFFUSION EQUATION FOR SEMICONDUCTOR PROBLEMS USING CONJUGATE GRADIENT METHOD.** By means of a finite-element method, the nonsteady-state convective diffusion equation describing the diffusion problem in a semiconductor is discretized. A conjugate gradient method is applied to the resultant matrix for analysis of the problem. A technique is applied to the equation before discretization so that a windward discretization is applied. As a result, suppression of the parasitic spatial oscillation and improvement of convergence have been attained. Both these points are problems in conventional finite-element methods. However, by means of the improvement herein, both the accuracy and the computation time have been improved. The result has been applied to the semiconductor diffusion equation and the convective diffusion equation, and the effectiveness of the method has been confirmed. (Author abstract) 7 refs.

Ono, Masashi (Keio Univ, Yokohama, Jpn); Hane, Masami; Hane, Kunio; Suzuki, Tokio. *Electron Commun Jpn Part 2* v 71 n 5 May 1988 p 93-99.

**096847 EFFECTS OF DRIFT AND DIFFUSION IN SEMICONDUCTORS ON PLANE WAVE INTERACTION AT INTERFACES.** The field solution for a semiconductor material is presented in terms of gradient

and curl components based on a drift-diffusion model. This is done for both biased and unbiased semiconductors where the bias causes a drift current. A simple demonstration of the field representation is given for plane-wave scattering at a dielectric-semiconductor interface when the incident field used is either TM<sup>z</sup> or TE<sup>z</sup>. 10 refs.

Davis, William A. (Virginia Polytechnic Inst & State Univ, Blacksburg, VA, USA); Krowne, Clifford M. *IEEE Trans Antennas Propag* v 36 n 1 Jan 1988 p 97-103.

**096848 DIFFUSION MECHANISMS IN II-VI MATERIALS.** Diffusion processes play a crucial role in the growth and subsequent processing stages of semiconductors, not least in the II-VI semiconductor materials. The present situation with respect to self-, impurity and inter-diffusion is considered. Chalcogen self-diffusion shows a consistent pattern for all of the II-VI materials and involves a single diffusion mechanism over most of the composition range. Metal self-diffusion however reveals a more complex situation with simultaneous contributions from several different defects. The metal self-diffusivity can be enhanced by impurity doping. Impurity diffusivities exhibit a variety of features whose interpretation at present is limited to the simplest cases. Empirical correlations are found between the pre-exponential factors ( $D_0$ ) and the activation enthalpies ( $Q$ ) for diffusion which have value in the interpolation or extrapolation of data. (Author abstract) 119 refs.

Shaw, D. (Univ of Hull, Hull, Engl). *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 778-796.

## Dissolution See COLLOIDS—Testing.

**Doping See Also BARIUM TITANATE—Electric Conductivity; CERIUM COMPOUNDS—Spectroscopic Analysis; CRYSTALS—Dislocations; FILMS—Electric Conductivity; GLASS—Electric Properties; IRON COMPOUNDS—Magnetic Properties; MASS SPECTROMETERS—Ion Sources; POLYACETYLENES—Physical Chemistry; POLYACETYLENES—Physical Properties; SEMICONDUCTING CADMIUM COMPOUNDS—Growth; SEMICONDUCTING CADMIUM COMPOUNDS—Photoconductivity; SEMICONDUCTING GALLIUM ARSENIDE—Optical Properties; SEMICONDUCTING GALLIUM ARSENIDE—Photoconductivity; SEMICONDUCTING SILICON—Amorphous; SEMICONDUCTING SILICON—Electronic Properties; SEMICONDUCTING SILICON—Mathematical Models; SEMICONDUCTING SILICON—Phase Transitions; SEMICONDUCTING SILICON—Thin Films; SEMICONDUCTOR DEVICES—Transport Properties; SEMICONDUCTOR DEVICES, BIPO-LAR—Measurements; SEMICONDUCTOR DEVICES, MIS—Electronic Properties; SOLID SOLUTIONS—Phase Transitions; SUPERCONDUCTING MATERIALS—Mathematical Models; TRANSISTORS, BIPO-LAR—Degradation; TRANSISTORS, BIPO-LAR—Processing; TRANSISTORS, FIELD EFFECT—Electronic Properties; TRANSISTORS, FIELD EFFECT—Mathematical Models.**

**096849 SOLUBILITY OF ZINC IN INDIUM ANTIMONIDE OVER VARIOUS SECTIONS OF THE TERNARY SYSTEM In-Sb-Zn.** It is established that the solubility of zinc in indium antimonide over various sections of the ternary system In-Sb-Zn is of retrograde character. This retrogradation is most clearly expressed over the In-Sb-Zn section, on which the maximum solubility of zinc in indium antimonide is 1.51 at.% at 480°C. On all the sections studied the maximum solubility of zinc is observed at one and the same temperature of 480°C and amounts to 1.30 at.% for the InSb-ZnSb section, 1.29 at.% for the InSb-Zn<sub>3</sub>Sb<sub>2</sub> section and 0.76 at.% for the InSb - (0.51 In+0.5 Zn) section. The zinc content in a solid solution of Zn in InSb at the eutectic melting point of 280°C coincides with literature data. In Russian. 5 refs.

Lapkina, I.A.; Sorokina, O.B.; Voloshin, A.E.; Shcherbovskii, E.Ya.; Viryasova, T.B. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 4 Apr 1987 p 533-536.



**096850 DIFFUSION OF RADIOACTIVE  $^{204}\text{Ti}$  IN LEAD TELLURIDE AND THE SOLID SOLUTIONS  $\text{Pb}_{0.8}\text{Sn}_{0.2}\text{Te}$  AND  $\text{PbSe}_{0.08}\text{Te}_{0.92}$ .** Measurements were made of the coefficients of diffusion of  $^{204}\text{Te}$  in p-type  $\text{PbTe}$ ,  $\text{Pb}_{0.8}\text{Sn}_{0.2}\text{Te}$  and  $\text{PbSe}_{0.08}\text{Te}_{0.92}$ . In the 550–700°C range the dependence of the thallium diffusion coefficient on temperature is governed by the Arrhenius equation, and the activation energies of thallium diffusion in  $\text{PbTe}$ ,  $\text{PbSe}_{0.08}\text{Te}_{0.92}$  and  $\text{Pb}_{0.8}\text{Sn}_{0.2}\text{Te}$  are equal, respectively, to 83, 114 and 156 J/mol. In  $\text{Pb}_{1-y}(\text{Sn}_{0.08}\text{Te}_{0.92})_y$  the values of the thallium diffusion coefficients are proportional to the hole concentration to the  $-0.38$  power. 6 refs. In Russian.

Firsova, L.P.; Simirskaya, G.P. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 916-919.

**096851 ON THE SEMICONDUCTIVITY AND VERY HIGH DIELECTRIC CONSTANT OF THE  $\text{Ba}_{1-x}\text{Ti}_x\text{CoO}_2$  SYSTEM.** The aim of the present work is to determine a system with a very high dielectric constant with low resistivity to be used in electronic application at low fields. A  $\text{BaO-CoO}$  system was prepared from  $\text{BaCO}_3$  and high purity  $\text{CoO}$ . Donor doping was accomplished by blending the prepared  $\text{BaCoO}_2$  with  $\text{TiO}_2$ . The adding of titanium to the  $\text{BaO-CoO}$  system increased the dielectric constant to optimum value at 10 at% Ti. This can be explained on the basis of the substitution mechanism. 13 refs.

Tawfik, A. (Tanta Univ, Tanta, Egypt). *J Mater Sci Lett* v 6 n 10 Oct 1987 p 1224-1226.

**096852 MATHEMATISCHE MODELLE DER DOPANTENDIFFUSION IN THEORIE UND ANWENDUNG.** [Theory and Application of Mathematical Dopant Diffusion Models]. Mathematical models of dopant diffusion are discussed, their discretization by means of difference methods is considered and applications in microelectronics are pointed out. (Translated author abstract) 12 refs. In German.

Feudel, Thomas; Meier, Mathias; Ulbricht, Steffen; Stephan, Rolf; Windisch, Guenther. *Wiss Z Tech Univ Karl Marx Stadt* v 29 n 2 1987 p 193-199.

**096853 ORIGIN OF LASER-ASSISTED AND DOPING-ASSISTED PHENOMENA IN SEMICONDUCTORS.** Transfer of energy from a laser beam to a semiconductor takes place via excitation of the electronic system. Criteria for the occurrence of electronic effects are discussed. A model of localised electronic excitation is presented and compared with experimental data obtained on doped and laser irradiated semiconductors. (Author abstract) 41 refs.

Wautelet, M. (Univ de l'Etat, Mons, Belg); Quenon, P.; Jadin, A. *Semicond Sci Technol* v 3 n Jan 1988 p 54-59.

**096854 SPECTRAL RESPONSE OF PERSISTENT PHOTOCONDUCTIVITY IN MODULATION-DOPED  $\text{Al}_x\text{Ga}_{1-x}\text{As/GaAs}$  HETEROSTRUCTURES.** We have measured the spectral response of persistent photoconductivity (PPC) in modulation doped  $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As/GaAs}$  heterostructures at low temperature (77 K). The observed two thresholds (0.8 and 1.1 eV) indicate that there are two independent mechanisms responsible for PPC. They are (1) electron photoexcitation from Cr deep level in Si  $\text{GaAs:Cr}$  substrate; (2) photoionization of DX center in  $\text{AlGaAs}$ . (Author abstract) 9 refs. In Chinese.

Dong Mouqun (Acad Sinica, Beijing, China); Ge Weikun; Jiang Pihuan; Sun Dianzhao; Cheng Zonggui. *Pan Tao Ti Hsueh Pao* v 9 n 1 Jan 1988 p 92-95.

**096855 ELECTRONIC STRUCTURE OF PURE AND DOPED ORTHORHOMBIC  $\text{La}_2\text{CuO}_4$ .** The electronic structure of orthorhombic  $\text{La}_2\text{CuO}_4$  has been investigated by first principles pseudofunction band calculations and group theoretical analysis. We find that pure as well as doped compounds remain metallic at all finite temperatures as a consequence of the  $\text{Cmca}$  ( $D_{2h}^{18}$ ) space group symmetry. The experimentally observed rapid rise in resistivity below 30 K suggests a structural transition to a lower symmetry space group that could be driven

electronically or magnetically. One possible candidate is monoclinic  $\text{C2/m}$  ( $C_{2h}^3$ ) which is a subgroup of  $\text{Cmca}$  and can be obtained by distorting the Cu-O bonds or rotating the  $\text{CuO}_6$  octahedra. Implications for superconductivity are discussed. (Author abstract) 16 refs.

Kasowski, Robert V. (DuPont, Wilmington, DE, USA); Hsu, William Y.; Herman, Frank. *Solid State Commun* v 63 n 12 Sep 1987 p 1077-1080.

**096856 INTERCALATION OF Mg IN  $\text{V}_2\text{O}_5$ .** The intercalation produced by the insertion of  $\text{Mg}^{2+}$  into  $\text{V}_2\text{O}_5$  was investigated by XRD. It was found that there were three phases similar closely to that of Li in  $\text{V}_2\text{O}_5$  and one of them was a more stable state. (Author abstract) 3 refs.

Yu, Wen-hai (Univ of Science & Technology of China, Hefei, China); Wang, Da-zhi; Zhu, Bin; Zhou, Gui-en. *Solid State Commun* v 63 n 11 Sep 1987 p 1043-1044.

**096857 ELECTRON-MOBILITY ENHANCEMENT AND ELECTRON-CONCENTRATION ENHANCEMENT IN  $\delta$ -DOPED n-GaAs AT  $T=300$  K.** The electron-mobility of  $\delta$ -doped GaAs grown by molecular-beam epitaxy is determined for two-dimensional doping concentrations ranging from  $10^{10} \text{ cm}^{-2}$  to  $10^{13} \text{ cm}^{-2}$ . A mobility-enhancement (of up to a factor of four) of  $\delta$ -doped epitaxial layers over their corresponding homogeneously doped layer is found in highly doped layers at  $T=300$  K. Temperature-dependent Hall-measurements are performed to clarify the physical origin of the mobility-enhancement. The electron-mobility is roughly constant in the range  $4\text{K} \leq T \leq 300$  K. The Hall-mobility measurements confirm that (i) high degeneracy of the two-dimensional electron-gas, (ii) spatial electron-donor separation in  $n=1,3,\dots$  subbands, as well as (iii) screening are the origins of high room-temperature mobility of  $\delta$ -doped GaAs. Extremely high free-electron-concentrations of  $n_{2\text{DEG}}=2 \times 10^{13} \text{ cm}^{-2}$  can be obtained in  $\delta$ -doped GaAs, corresponding to three-dimensional concentrations  $9 \times 10^{19} \text{ cm}^{-3}$ . This electron-concentration enhancement is assumed to be due to a reduced Si-autocompensation. (Author abstract) 14 refs.

Schubert, E.F. (AT&T, Holmdel, NJ, USA); Cunningham, J.E.; Tsang, W.T. *Solid State Commun* v 63 n 7 Aug 1987 p 591-594.

**096858 PHOTOREFLECTANCE SPECTROSCOPY OF GaAs DOPING SUPERLATTICES.** Room temperature photoreflectance of molecular beam epitaxy GaAs doping superlattices was measured. Additional structures corresponding to forbidden transitions ( $\Delta n \neq 0$ ) were observed at very low pump beam intensity. Experimental results show that the dominant modulation mechanism of photoreflectance of doping superlattices is different from that of bulk materials. We suggest that the photoreflectance spectrum of doping superlattices have mainly first derivative functional lineshapes, which is caused by the subband shift in doping superlattices. The experiments are well explained by this mechanism. (Author abstract) 12 refs.

Tang, Yinsheng (Univ of Science & Technology of China, Hefei, China); Wang, Bingshen; Jiang, Desheng; Zhuang, Weihua; Liang, Jiben. *Solid State Commun* v 63 n 9 Sep 1987 p 793-796.

**096859 INFLUENCE OF PHOTO-MODULATION ON REFLECTANCE OF HETERO NIPI SUPERLATTICES.** The effect of room temperature photo-modulation on the reflectance of GaAs/AlGaAs hetero NIPI superlattices is reported. We propose a modulation mechanism which produces first derivative functional lineshapes in weak modulation limit. This model gives a good explanation of all the experimental phenomena. (Author abstract) 14 refs.

Yinsheng, Tang (Univ of Science & Technology of China, Hefei, China); Desheng, Jiang; Ploog, Klaus. *Solid State Commun* v 64 n 5 Nov 1987 p 655-657.

**096860 HYPERFINE INTERACTION IN PHOSPHORUS-DOPED AMORPHOUS SILICON-GERMANIUM ALLOYS.** We present a study of the hyperfine

structure in the electron spin resonance spectra of phosphorus-doped  $\text{a-Si}_{0.7}\text{Ge}_{0.3}\text{H}$ . Electron bombardment and annealing are used to vary the defect density and to shift the Fermi level in the range  $0.45 < E_C - E_F < 0.75$  eV. The main observation is that electron bombardment causes an enhancement of the density of hyperfine centers and a major decrease of the hyperfine splitting from 265 to 200 G. The data show that phosphorus introduces two hyperfine centers: the well known fourfold coordinated phosphorus atoms and a deep state the density of which can be enhanced by electron bombardment and hydrogen effusion. We suggest that the latter is a dangling-bond state on a twofold coordinated phosphorus. (Author abstract) 8 refs.

Finger, F. (Philipps-Univ Marburg, Marburg, West Ger); Fuhs, W.; Carius, R. *Phil Mag Lett* v 57 n 4 Apr 1988 p 235-240.

**096861 EFFECT OF DOPING ON PARAMETRIC AMPLIFICATION IN PIEZOELECTRIC SEMICONDUCTORS.** Using the straightforward coupled-mode theory, the parameter amplification is analytically investigated in a doped piezoelectric semiconductor. The origin of the nonlinear interaction is taken to be in the second-order optical susceptibility  $\chi^{(2)}$  arising from the nonlinear induced current density. The threshold value of the pump electric field  $E_{0h}$  and the corresponding excitation intensity are obtained for crystals for various concentrations.  $E_{0h}$  is found to decrease with rise in doping concentration. The investigation also reveals that the phenomena of self-focusing and self-defocusing can be enhanced in these crystals. The parametric gain constant is obtained for both lightly and highly doped semiconductors. (Edited author abstract) 17 refs.

Aghamkar, P. (Bhopal Univ, Bhopal, India); Sen, P.; Sen, P.K. *Phys Status Solidi B* v 145 n 1 Jan 1988 p 343-349.

**096862 BOLOMETRIC ABSORPTION SPECTRA OF DOPED  $\text{TaS}_3$ .** We have taken bolometric infrared spectra of the charge-density-wave conductor orthorhombic  $\text{TaS}_3$ , doped with niobium and titanium. For transverse polarization, the bolometric signal is roughly proportional to the absorptivity. Niobium doping (approx. 200 ppm) greatly increases the charge-density-wave depinning field and broadens the Peierls transition, while Ti doping (approx. 10 ppm) has negligible effect. Nevertheless, both types of samples have similar spectra: a large decrease of absorption above the Peierls gap (i.e. smearing of the absorption threshold) and no significant increase in absorption below the gap. The 'midgap' absorption line at  $500 \text{ cm}^{-1}$  is not affected by doping. Results are discussed in terms of the model of Tutto and Zawadowski. (Author abstract) 16 refs.

Minton, G. (Univ of Kentucky, Lexington, KY, USA); Brill, J.W. *Solid State Commun* v 65 n 10 Mar 1988 p 1069-1072.

**096863 IMPURITY PAIRING IN THE OPTICAL ABSORPTION OF DOPED SEMICONDUCTORS.** We developed a theoretical approach based on the alternant molecular orbital model for the hydrogen molecule to predict the optical absorption spectrum of donor pairs in doped semiconductors. The fundamental absorption line has been obtained through the density of states in the pair approximation while the interaction between the lattice and the electron excitation has been considered in terms of the Franck-Condon model. (Author abstract) 15 refs.

Guimaraes, P.S. (Univ Federal da Sao Carlos, Sao Carlos, Brazil); Ferreira de Silva, A. *Solid State Commun* v 66 n 2 Apr 1988 p 119-121.

**096864 VIBRONIC INTERACTION IN THE ABSORPTION SPECTRA OF VANADIUM-DOPED  $\text{Al}^{\text{III}}$  B $^{\text{VI}}$  SEMICONDUCTORS.** The vibronic interaction in  $\text{Al}^{\text{III}}\text{B}^{\text{VI}}$  semiconductors doped with 3d-impurities is investigated. Ham's reduction parameter for vanadium in  $\text{Al}^{\text{III}}$



B<sup>VI</sup> semiconductors is calculated. Comparison is made of the calculated absorption spectra with available experimental data. (Author abstract). 8 Refs.

Melnichuk, S.V. (Chernovtsy State Univ, Chernovtsy, USSR); Kramar, V.M.; Tovstuyk, K.D. *Phys Status Solidi B* v 146 n 2 Apr 1988 p 613-617.

**096865 FORMATION AND ANALYSIS OF SHALLOW ARSENIC PROFILES.** Shallow arsenic implants were activated by furnace and rapid thermal annealing (RTA). Comparisons of junction depths measured by secondary ion mass spectrometry (SIMS) and spreading resistance (SR) showed SIMS values 50-90 nm deeper than SR values, due to ion knock-on during SIMS profiling. (Author abstract). 7 Refs.

Clayton, S. (Naval Ocean System Cent, San Diego, CA, USA); Springer, L.; Offord, B.; Sedgwick, T.; Reedy, R.; Michel, A.; Scilla, G. *Electron Lett* v 24 n 14 Jul 7 1988 p 831-833.

**096866 INFLUENCE OF EXPERIMENTAL CONDITIONS ON MATRIX EFFECT IN SIMS.** The influence of the experimental conditions on the matrix effect in secondary ion mass spectrometry (SIMS) of Be ions in AlGaAs was investigated with a Cameca IMS-3f ion microanalyzer. In this study the nature and energy of the primary ion beam was varied, as well as the energy filtering and contrast aperture in the secondary optics. A strong influence of the nature of the primary ion and the energy filtering on the matrix effect was found, while the matrix effect was weakly affected by the primary energy and the contrast apertures. The optimum experimental conditions under which the matrix effect was reduced is discussed. 16 Refs.

Gao, Y. (CNET, Bagneux, Fr). *Appl Surf Sci* (1985) v 32 n 4 Aug 1988 p 420-430.

**096867 COUNTERDOPING OF MOS CHANNEL (CDC) - A NEW TECHNIQUE OF IMPROVING SUPPRESSION OF LATCHING IN INSULATED GATE BIPOLAR TRANSISTORS.** A novel technique of improving suppression of latching in insulated-gate bipolar transistors (IGBTs) is proposed and experimentally verified. By counterdoping the channel of the DMOS cell, the doping of the p-base can be increased up to a factor of two. Dynamic latching improvement of 40-80%, corresponding to the p-base doping increase, has been obtained. The degradation in forward blocking voltage was observed when the counterdoping dosage exceeds about  $2 \times 10^{12} \text{ cm}^{-2}$  for 600-V devices. 10 Refs.

Chow, T.P. (GE, Schenectady, NY, USA); Baliga, B.J.; Pattanayak, Deva N. *IEEE Electron Device Lett* v 9 n 1 Jan 1988 p 29-31.

**096868 EXTENSION OF THE C-V DOPING PROFILE TECHNIQUE TO STUDY THE MOVEMENTS OF ALLOYED JUNCTION AND SUBSTRATE OUT-DIFFUSION, THE SEPARATION OF JUNCTIONS, AND DEVICE AREA TRIMMING.** Digital data acquisition provides accurate data on capacitance vs. voltage (C-V) measurement and facilitates incorporation of improved analyses based on more complete models. The avalanche field check is an independent means of determining the junction area, and can be used as a quality-control indicator in device production or as a monitoring tool during area trimming of diodes hidden from view. Iterative fitting techniques can yield accuracies sufficient for studying alloyed junction movement from the C-V data. The nature of the doping profile in a nonabrupt junction can be inferred. The profile in the middle layer of a back-to-back junction structure in many practical cases can also be determined. Experimental examples are shown to support the interpretations. 5 Refs.

Tantraporn, W. (GE, Schenectady, NY, USA); Glover, G.H. *IEEE Trans Electron Devices* v 35 n 4 Apr 1988 p 525-529.

**096869 NEW PUNCHTHROUGH CURRENT MODEL BASED ON THE VOLTAGE-DOPING TRANSFORMATION.** The punchthrough phenomenon

is investigated by a 2-D numerical analysis. A physical interpretation that relates this phenomenon to the drain-field-induced reduction in doping concentration is proposed. This interpretation allows a better understanding of the mechanism of surface and bulk punchthrough flows and provides a guideline for the quantitative solution to the problem. The relation between the reduced N<sup>+</sup> and real N dopings (called the voltage-doping transformation, or VDT) is derived from the two-dimensional Poisson equation. It is shown that as a result of the VDT, it is possible to accurately calculate the actual barrier heights as a function of applied voltages and channel length using the well-known long-channel expressions where N is substituted by N\*. 16 Refs.

Skotnicki, Tomasz (CNET, Meylan, Fr); Merckel, Gerard; Pedron, Thierry. *IEEE Trans Electron Devices* v 35 n 7 Jul 1988 p 1076-1086.

**096870 BAND-BAND AUGER EFFECT IN SEMICONDUCTORS.** Theoretical and experimental work on the band-band Auger effect is discussed with special reference to recent work. (Author abstract) 69 Refs.

Landsberg, Peter T. (Univ of Florida, Gainesville, FL, USA). *Solid State Electron* v 30 n 11 Nov 1987, New Dev in the Phys of Homo- and Heterojunctions, US-Belg Jt Semin, Louvain, Belg, May 28-30 1986 p 1107-1115.

**096871 SUPERLATTICE DOPING INTERFACES.** The effect of background doping on current transport in quantum well structures is investigated by the use of n<sup>+</sup>-n junctions superimposed on superlattices. Data are presented which show that the applied bias appears across only lightly doped and depleted regions. Current vs. voltage characteristics are observed which are consistent with expected electron barriers for these superlattice structures. Negative differential resistance effects and conductance oscillation effects are also observed, and are shown to originate from movement of bias-dependent depletions. (Author abstract) 10 Refs.

Kirchoefer, S.W. (US Naval Research Lab, Washington, DC, USA); Newman, H.S. *Superlattices Microstruct* v 4 n 1 1988, Chicago Conf, Pap, Chicago, IL, USA, 1987 p 87-95.

**096872 CRITICAL EVALUATION OF CALIBRATION PROCEDURES FOR DISTRIBUTION ANALYSIS OF DOPANT ELEMENTS IN SILICON AND GALLIUM ARSENIDES.** Strategies for highly accurate quantitative distribution analysis of the most important dopant elements in silicon (B, As) and gallium arsenide (Si) by combination of various methods with different systematic errors are discussed. Analytical figures of merit are given for the methods applicable to a specific problem evaluating Secondary Ion Mass Spectrometry (SIMS), Rutherford Backscattering Spectrometry (RBS), Neutron Activation Analysis (NAA), Charged Particle Activation Analysis (CPAA), electrical and magnetic measurements. (Author abstract) 57 Refs.

Grasserbauer, M. (Technical Univ Vienna, Austria). *Pure Appl Chem* v 60 n 3 Mar 1988, Invited Lect Presented 30th Microsymp on Macromol-Polym Supported Org Reagents and Catal, Prague, Czech, Jul 6-9 1987 p 437-444.

## Drying

**096873 CRITICAL EXAMINATION OF A CRY-CHEMICAL METHOD FOR THE PREPARATION OF HIGH SURFACE AREA SEMICONDUCTING POWDERS.** The effect of the nature of precursor salts on the surface area of mixed metal chlorides and mixed metal oxides prepared by freeze-drying was studied in the following systems: MgCl<sub>2</sub>·6H<sub>2</sub>O-KCl, acetates and nitrates of lanthanum, strontium and cobalt, nitrates of nickel and cobalt. The intermediates as well as the final products were studied by electron microscopy. X-ray powder diffraction, thermogravimetric analysis and differential scanning calorimetry. Dehydration of MgCl<sub>2</sub>·6H<sub>2</sub>O-KCl occurred with an increase in surface area, but any further effects due to the formation of the perovskite phase

were not seen because of sintering. (Edited author abstract) 22 Refs.

Hibbert, B.D. (Royal Holloway & Bedford New Coll, Egham, Engl); Lovegrove, J.; Tseung, A.C.C. *J Mater Sci* v 22 n 10 Oct 1987 p 3755-3761.

## Elasticity

**096874 ELECTRICAL PROPERTIES OF P-TYPE AND N-TYPE ZnSe-ZnTe STRAINED-LAYER SUPERLATTICES.** We have grown ZnSe-ZnTe strained-layer superlattices (SLSs) on InP substrates by molecular beam epitaxy. In addition to undoped SLSs, two kinds of modulation doped SLS samples were prepared in this study. Van der Pauw measurements of the SLS samples at room temperature showed that their electrical properties can be controlled by using the modulation doping technique. The undoped sample and the Ga-doped sample exhibited n-type conduction, whereas p-type conduction was observed for the Sb-doped sample. Interdiffusion profiles of dopants were measured by secondary ion mass spectroscopy, and significant Ga redistribution was observed. Finally, we have fabricated p-n junctions from ZnSe-ZnTe SLSs, and measured their current-voltage characteristics. (Edited author abstract) 12 Refs.

Kobayashi, Masakazu (Tokyo Inst of Technology, Tokyo, Jpn); Dosho, Shiro; Imai, Akira; Kimura, Ryuhei; Kona-gai, Makoto; Takahashi, Kiyoshi. *Superlattices Microstruct* v 4 n 2 1988, Pap from the Chicago Conf, Chicago, IL, USA p 221-225.

**Electric Conductivity** See Also IRON COMPOUNDS—Electric Conductivity; LITHIUM COMPOUNDS—Ionic Conduction; SEMICONDUCTING FILMS—Doping; SEMICONDUCTING LEAD COMPOUNDS—Doping; SEMICONDUCTING TIN COMPOUNDS—Defects.

**096875 RESISTIVITY CORRECTION FACTOR FOR FOUR-PROBE METHOD ON CIRCULAR SEMICONDUCTORS - I.** A resistivity correction factor is described for a system consisting of a thick, circular semiconductor and a four-probe array. The electric potentials in the interior of the sample were obtained by solving Poisson's equation analytically. Expressions for the resistivity correction factor are presented for three cases of the probe position. The resistivity correction factors of a circular sheet, calculated by the present method, coincides with that obtained from the conformal transformation method. Numerical evaluations were carried out as a function of the thickness and radius of the sample and the spacing and position of the probe array. (Author abstract) 8 Refs.

Yamashita, Masato (Ibaraki Univ, Hitachi, Jpn). *Jpn J Appl Phys Part 1* v 26 n 9 Sep 1987 p 1550-1554.

**096876 HIGH-FREQUENCY CONDUCTIVITY OF METALS IN DEGENERATE SEMICONDUCTORS WITH EXTRINSIC ELECTRON STATES.** Spatial dispersion is taken into account in calculations of the dissipative part of the transverse conductivity of weakly alloyed semiconductors. Local and resonant states of the electrons are considered. The maxima of the conductivity are observed for transitions between local, resonant, and band electron states. (Author abstract) 7 Refs.

Ermolaev, A.M. (A.M. Gorkii State Univ, Khar'kov, USSR). *Sov Phys J* v 30 n 4 Apr 1987 p 274-277.

**096877 THERMAL BREAKDOWN IN A PLANE SEMICONDUCTOR SAMPLE INFLUENCED BY A STRONG CURRENT PULSE.** The conditions of thermal breakdown appearance and evolution in a plane semiconductor sample, containing impurities, are theoretically investigated. Approximate analytical and numerical solutions of the non-linear non-stationary thermal conductivity problem, corresponding to one of the possible models of thermal breakdown are obtained. Using the results, obtained in the paper, it is possible, in particular,



to estimate time of safe operation of a semiconductor element under given thermal and electrical conditions. (Author abstract) 4 refs.

Olchak, A.S. (Moscow Engineering Physics Inst, Moscow, USSR); Rudenko, A.I.; Sokolov, G.V. *Int J Electron* v 64 n 3 Mar 1988 p 417-420.

**096878 DETERMINATION OF DEGREE OF NON-UNIFORMITY OF RESISTIVITY OVER THICKNESS OF HIGH-RESISTANCE LAYERS.** High-resistance semiconductor layers (i-type layers) are finding wider use, especially in GaAs. They are successfully used as insulation for semiconductor devices and individual components of integrated circuits and as an active region in a number of devices. A method is described for determination of the degree of nonuniformity of resistivity over the thickness of a high-resistance layer that is based on measurement of the frequency dependence of specimen impedance. A computer-based method is proposed for calculation of the resistivity distribution. A circuit is given for measurement of capacitance and loss tangent in the frequency range of  $20\text{--}10^7$  Hz, from which specimen impedance is measured with an error of approximately 15% for R and 5% for X. A graph is given for the resistivity distribution in an i-type layer formed by proton irradiation of n-type GaAs. (Edited author abstract) 7 refs.

Kogan, V.M.; Pavlov, P.V. *Instrum Exp Tech* v 30 n 5 pt 2 Sep-Oct 1987 p 1235-1238.

**096879 PERCOLATION ELECTROCONDUCTIVITY OF TWO-COMPONENT BARRIER-DISORDERED POLYCRYSTALLINE COMPOSITES.** The dependence of electroconductivity on composition in binary composites that are mixtures of different polycrystalline semiconductors characterized by a wide distribution of intercrystallite barrier heights, has been studied theoretically. A number of limits have been analyzed when the passing of the current carriers between two adjacent crystallites that belong to different components is either permitted or prohibited. (Author abstract) 20 refs.

Sukharev, V.Ya. (Karpov Inst of Physical Chemistry, Moscow, USSR); Chistyakov, V.V.; Myasnikov, I.A. *J Phys Chem Solids* v 49 n 4 1988 p 333-338.

**096880 BISTABILITY OF NON-LINEAR CONDUCTIVITY IN INSULATORS WITH SLIDING CHARGE DENSITY WAVES.** At low temperatures in semiconducting compounds with a sliding charge density wave (CDW), it is shown that the nonlinear d.c. current voltage characteristic should be bistable. The high velocity branch describes free sliding of the CDW, motion which becomes undamped at zero temperature ('Froehlich superconductivity'). In the low-velocity branch the CDW is highly deformed, with a velocity low enough that backflow currents of thermally excited quasiparticles can screen the local electric fields produced by the moving CDW. The results are compared with recent experiments on the blue bronze  $\text{K}_{0.3}\text{MoO}_3$ . (Author abstract) 19 refs.

Littlewood, P.B. (AT&T, Murray Hill, NJ, USA). *Solid State Commun* v 65 n 11 Mar 1988 p 1347-1350.

**096881 NEW METHOD FOR CONTACTLESS CONDUCTIVITY MEASUREMENT OF A SEMICONDUCTOR LAYER.** A semiconducting layer, placed on an insulating substrate which contains paramagnetic impurities, distorts the electron paramagnetic resonance (EPR) lineshape of the impurities. This distortion can be used to monitor the conductivity of the semiconducting layer. The method is demonstrated on p-type InSb crystals on a ruby ( $\text{Al}_2\text{O}_3$ ;  $\text{Cr}^{3+}$ ) substrate. The results are in good agreement with independent direct resistivity measurement. (Author abstract) 4 refs.

Zevin, V. (Hebrew Univ of Jerusalem, Jerusalem, Isr); Suss, J.T.; Zemel, A.; Rotter, S. *Solid State Commun* v 66 n 5 May 1988 p 553-555.

**096882 LOW FREQUENCY CONDUCTIVITY ANOMALIES OF STRONGLY DISORDERED SEMICONDUCTORS.** Various alternatives for the asymptotic behavior of conductivity, polarizability, and

current spectrum of disordered semiconductors near the mobility edge are discussed within a self-consistent theory for current relaxations and density fluctuations. (Author abstract) 20 refs.

Goetze, W. (Technische Univ Muenchen, Garching, West Ger). *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 83-90.

**096883 DC ELECTRICAL CONDUCTIVITY OF HIGHLY DISORDERED ELEMENTAL SEMICONDUCTORS.** The authors report experimental data on hopping conduction in six elemental amorphous semiconductors in which some control has been exercised over the degree of disorder without the incorporation of active additives such as hydrogen or fluorine. Some attempts to model the dc conductivity theoretically are reviewed. 18 refs.

Yoffe, A.D. (Cavendish Lab, Cambridge, Engl); Phillips, R.T. *Disord Semicond* Publ by Plenum Press, New York, NY, USA and London, Engl, 1987 p 499-509.

**096884 NEW EFFECTS IN THE NON LINEAR REGIME OF CHARGE-DENSITY WAVE SYSTEMS.** New effects have been recently found by Salva et al. in the non-linear conductivity of CDW systems at high electric fields. We propose a possible interpretation based on the CDW interaction with some internal degree of freedom associated with the pinning centers. It is shown that this coupling leads to deformed Shapiro steps as experimentally observed. (Author abstract) 5 refs.

Ortiz, G. (Centro Atomico Bariloche, Argent); Nunez Regueiro, M.D.; Balseiro, C.A. *Solid State Commun* v 67 n 2 Jul 1988 p 89-91.

**096885 RESISTIVITY OF SEMICONDUCTOR, SPLIT-ELECTRODE THERMISTORS.** By using Fourier Series Boundary Condition, as well as a standard Fourier series approach to solving Laplace's Equation, an exact solution for the thermistor model was obtained. Then, a PASCAL program was written for a VAX 11/750 computer to evaluate the slowly convergent Fourier series - it being found that fifty terms were required for each resistivity value. Finally, a series of measurements were performed on thermistors of various sizes, and it was found that resistivities calculated with the aid of said resistance measurements were almost invariant, the standard deviation being  $9.148 \text{ ohm-cm}$ , with a mean value of  $\rho = 9.1148 \times 10^2 \text{ ohm-cm}$ . It is clear, that the thermistor model and the methods of solution of the problem were of value. (Edited author abstract) 4 Refs.

Jones, Roger C. (Univ of Arizona, Tucson, AZ, USA). *Trans Soc Comput Simul* v 5 n 2 Apr 1988 p 153-158.

**096886 LOCALISATION EFFECT IN THERMO-POWER AND RESISTIVITY OF QUASI 1D SEMICONDUCTING COMPOUND  $[(\text{Nb}_{1-x}\text{Ta}_x\text{Se}_4)_3\text{I}]$ .**  $(\text{NbSe}_4)_3\text{I}$  has a quasi 1D structure consisting of  $\text{NbSe}_4$  chains parallel to the c axis. The Nb-Nb distance within the chain is approx. 3 Å whereas the interchain distance is much larger (6.7 Å). Electrical resistivity and thermoelectric power measurements were carried out in the temperature range 130 K-350 K. For some crystals the low activation energy persists up to the lowest temperature investigated. This was designated type I. For some crystals the activation energy increases once again to a higher value (0.11 eV) at lower temperatures. These crystals were designated type II although X-ray diffraction is unable to distinguish the two types of crystals. The effect of introducing disorder in the chain by introduction of Ta is investigated in the present work. 5 refs.

Bansal, C. (Univ of Hyderabad, Hyderabad, India); Surendranath, K.; Srivastava, V. *Key Eng Mater* v 13 pt 2 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 537-541.

**096887 ADDITION EFFECT OF TI ON THE ELECTRICAL AND THERMAL TRANSPORTS OF  $\alpha\text{-As}_2\text{Se}_3$ .** The addition effect of Ti on the electrical and thermal properties of the binary chalcogenide semiconductor  $\text{As}_2\text{Se}_3$  in the homogeneous glass-forming region, i.e. of Ti levels up

to about  $10^{22} \text{ cm}^{-3}$ , are reported and discussed. The increase of thallium is found to decrease the glass transition and melting temperatures as well as the dc conductivity. (Edited author abstract) 2 refs.

Kotkata, M.F. (Ain Shams Univ, Cairo, Egypt); El-Fouly, M.H.; Fayek, S.A.; El-Hakim, S.A. *Key Eng Mater* v 13 pt 2 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 551-552.

**096888 CARACTERISATION DES COMPOSES III-V AU MOYEN DE LA MESURE DE RESISTIVITE RESISTIVITE PAR POINTES.** [Characterization of III-V Compounds by Means of Point Resistivity Measurement]. The 4 D model 880 GaAs four point probe meter is used to measure sheet resistance of ion-implant layers, epitaxial layers and doped substrates of GaAs, GaAlAs and other III-V compounds. A description of the meter and its use is given. The use of the meter for process monitoring, process equipment characterization, and boule characterization is examined.

Genet, P. (MB Electronique-Buc). *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composes III - V, Fr, Apr 27-28 1988 p 293-294.

**Electric Field Effects** See Also ELECTRONICS—Transport Properties; SEMICONDUCTOR DEVICES—Electric Conductivity.

**096889 STEADY STATE AND NON-STEADY STATE OF A SEMICONDUCTOR-FERROELECTRIC IN THE PRESENCE OF AN ELECTRIC FIELD.** The behavior of the light mode in a semiconductor-ferroelectric with an electric field is considered. A qualitative investigation of the obtained third-order dynamic system is made. Depending on the system parameters, there may be either three singular points or one singular point. Instability is possible at the first of these points, and, therefore, stochastic auto-oscillations may exist in addition to the regular auto-oscillations of the polarization and electric field intensity vectors. Hysteresis may arise under certain conditions, depending on the initial conditions of a given mode. (Author abstract) 9 refs.

Kachlishvili, T.Z. (M.V. Lomonosov State Univ, Moscow, USSR). *Sov Phys J* v 30 n 6 Jun 1987 p 524-538.

**Electric Properties** See Also COPPER COMPOUNDS—Ionic Conduction; PYRITES—Flotation; SALTS—Structure; SEMICONDUCTING GLASS—Doping; SEMICONDUCTOR DEVICES—Tunneling.

**096890 ELECTRIC PROPERTIES OF ANTIMONY SELENIDE SINGLE CRYSTALS.** A study was made of the electric conductivity of stoichiometric and selenium-doped antimony selenide single crystals along the cleavage planes and in the direction perpendicular to them, using both direct and alternating current. In addition, the thermoelectric power in these directions was determined in the 300-500 K range. Possible conductivity mechanisms, including hop-type are considered. It is proven that electron hops at defects are determined by 'dangling' bonds and occur primarily along Sb-Se-Sb chains. In Russian. 13 refs.

Gribnyak, L.G.; Ivanova, T.B. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 4 Apr 1987 p 540-544.

**096891 QUANTUM CORRECTIONS TO THE HALL EFFECT IN III-V SEMICONDUCTORS.** We have measured the temperature dependence of the low-temperature Hall effect coefficient,  $R_H$ , and resistance, R, of various III-V semiconductors. In 3D when the magnetic field suppresses the quantum interference correction,  $R_H$  and R vary with temperature T as  $T^{1/2}$  in the manner predicted for the electron interaction correction. In samples with a short elastic scattering length, and in the presence of small magnetic fields, we have found a correction to  $R_H$  of approximately the same size but opposite sign to the correction to R. This appears to be a quantum interference correction, which is in disagreement



with theory predicting the absence of such an effect. We suggest that theories of the quantum corrections to the Hall effect require reevaluation in 3D as well as in 2D. (Edited author abstract) 12 refs.

Newson, D.J. (Cambridge Univ, Engl); Pepper, M.; Hall, E.Y.; Hill, G. *J Phys C Solid State Phys* v 20 n 27 Sep 30 1987 p 4369-4376.

**096892 ELECTRIC CONDUCTIVITY AND THERMOELECTRIC POWER OF RARE-EARTH ORTHOCHROMITES OF THE CERIUM SUBGROUP.** Measurements were made of the electric conductivity and thermoelectric power of rare-earth orthochromites in the 870-1270 K range in various gaseous media. It was established that in the  $10^4$ - $10^{12.5}$  Pa, oxygen partial pressure range rare-earth orthochromites remain p-type semiconductors and their electric conductivity depends very little on the oxygen partial pressure in the gaseous phase. It is shown that electrical transport in rare-earth chromites is realized by hole motion (predominantly by electron hopping between chromium ions of different valences). For the first time, a dependence of the electric properties of light rare-earth orthochromites on the atomic number of the lanthanide was noted. 8 refs. In Russian.

Gil'derman, V.K.; Zemtsov, V.I.; Pal'gaev, S.F. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 1001-1004.

**096893 QUICK COMPUTATION OF POTENTIAL DISTRIBUTION IN A HIGHLY CONDUCTIVITY-MODULATED SEMICONDUCTOR AND ITS APPLICATION TO PCD DEVICES.** The plasma-coupled device (PCD), which is a bipolar type functional device, has been applied to various image sensors. However, the PCD patterns cannot be designed by computer simulation because of the difficulty in calculating three-dimensional potential distribution in a highly-injected, highly conductivity-modulated semiconductor body. This letter proposes a new but practical simulation method in which some simple assumptions are employed. It is shown that the shape of the potential distribution and the conductivity modulation region around the ON-element of the PCD are consistent with the experimental observation. (Author abstract) 9 refs.

Kusuda, Yukihiisa (Nippon Sheet Glass Co, Toyosato-machi, Jpn); Tanaka, Shuhei; Asai, Takahiro. *Jpn J Appl Phys Part 2* v 26 n 10 Oct 1987 p 1626-1628.

**096894 ELECTRICAL PROPERTIES OF ANTIMONY-DOPED P-TYPE  $Hg_{0.78}Cd_{0.22}Te$  LIQUID-PHASE-EPITAXY FILMS.** Hall measurements have been performed on antimony-doped p-type  $Hg_{0.78}Cd_{0.22}Te$  LPE (Liquid-Phase-Epitaxy) films between 20 and 150 K. The ionization energy of isolated shallow acceptors was estimated to be about 11 MeV. From the analysis of the Hall coefficient and the hole mobility data, we found that compensation in the films is not enough to explain the typically low hole mobility at low temperatures. (Author abstract) 22 refs.

Chen, M.C. (Texas Instruments Inc, Dallas, TX, USA); Dodge, J.A. *Solid State Commun* v 59 n 7 Aug 1986 p 449-452.

**096895 THERMOEMF IN RELAXATIONAL CONDITIONS.** A relaxational semiconductor with an injective contact is considered. It is shown that a term that is activationally dependent on the temperature may appear in the expression for the thermoemf of the sample, in the given conditions. (Author abstract) 5 refs.

Drozhzhov, Yu.P. *Moscow Univ Phys Bull* v 42 n 4 1987 P 80-83.

**096896 MODELLING CURRENT/VOLTAGE CHARACTERISTICS OF SPACE-CHARGE-LIMITED CURRENTS WITH NONLINEAR VELOCITY-FIELD RELATIONSHIPS.** A simple empirical equation is presented to describe the current/voltage characteristic of space-charge-limited currents in semiconductor materials with a nonlinear velocity-field relationship. The equation covers the entire current/voltage

characteristic and yields asymptotic behavior in good agreement with previously published results. (Author abstract) 2 refs.

Abuelma'atti, M.T. (Univ of Bahrain, Isa Town, Bahrain). *Electron Lett* v 24 n 1 Jan 7 1988 p 23-24.

**096897 QUANTUM THEORY OF THERMOPOWER IN QUANTUM WELL WIRES.** A quantum theory for thermopower in quantum well wires is presented. Expressions for thermopower are obtained, both in the longitudinal and transverse configurations where the temperature gradient is parallel and perpendicular to the wire, respectively. The expression obtained in the longitudinal configuration agrees with that obtained from the conventional Boltzmann transport equation in the relaxation time approximation. (Author abstract) 12 refs.

Jali, V.M. (Karnatak Univ, Dharwad, India); Kubakaddi, S.S.; Mulimani, B.G. *Phys Status Solidi B* v 144 n 2 Dec 1987 p 739-744.

**096898 ELECTRICAL AND OPTICAL PROPERTIES OF n-TYPE  $Hg_{1-x}Cd_xTe$ .** Carrier concentration, mobility, and resistivity were over the temperature range 90 to 300 K. The room temperature carrier concentration is  $1.5 \times 10^{17} \text{ cm}^{-3}$  with a mobility of  $150 \text{ cm}^2/\text{Vs}$ . The ionization energy of the principle donor is 0.07 eV below the conduction band. The optical absorption coefficient was measured as a function of photon energy and indicates an indirect energy gap of 0.78 eV. Schottky barrier devices were formed on the material by evaporating gold as rectifying contact and indium as an ohmic contact. (Edited author abstract) 7 refs.

Eshraghi, S.A. (Univ of California, Los Angeles, CA, USA); Kianian, S.; Ostrom, B.; Stafsudd, O.M.; Gentile, A.L. *Phys Status Solidi A* v 105 n 2 Feb 1988 p 563-566.

**096899 ELECTRICAL CHARACTERISATION OF SI-DOPED  $GaAs_{0.5}Sb_{0.5}$  ON  $InP$  GROWN BY MOLECULAR BEAM EPITAXY.** Between the growth temperatures of 490-520°C Si-doped  $GaAs_{0.5}Sb_{0.5}$  changes from  $1 \times 10^{17} \text{ cm}^{-3}$  n-type to  $2 \times 10^{17} \text{ cm}^{-3}$  p-type. The scattering mechanisms of the n and p-type epilayers are investigated. The reproducibility and potential applications of the observed conduction type change are demonstrated by the fabrication of a pn diode. (Author abstract) 9 refs.

Sandhu, A. (Fujitsu Lab Ltd, Atsugi, Jpn); Fujii, T.; Nakata, Y.; Sugiyama, S.; Miyauchi, E. *Electron Lett* v 24 n 8 Apr 1988 p 451-452.

**096900 ANNEALING EFFECTS ON THE ELECTRICAL PROPERTIES OF  $Hg_{1-x}Cd_xTe$  GROWN BY TWO DIFFERENT TECHNIQUES.** Epitaxial layers of  $Hg_{1-x}Cd_xTe$  (x is the mole fraction of CdTe) have been studied extensively because of their use in infrared detectors. HgTe has been used as source material and CdTe single crystals as substrate for isothermal closed-tube preparations. The interdiffusion coefficient and rate of transport of material from the source to the substrate depend on the used isothermal techniques, especially the Hg pressure. In the present work, electrical measurements were carried out on annealed layers to get the effects of annealing on the transport parameters of layers grown by vapor phase and liquid phase epitaxy. 5 Refs.

Hady, A.A.A. (Cairo Univ, Giza, Egypt). *Phys Status Solidi A* v 107 n 1 May 1988 PK25-K28.

## Electrochemistry

**096901 PHOTOELECTROCHEMICAL BEHAVIOR OF  $LaCoO_3$  CERAMIC AND SINGLE CRYSTAL.** We report in this paper the electrochemical and photoelectrochemical behavior of  $LaCoO_3$  ceramics and single crystals, as they have recently attracted much attention due to catalytic properties and electrocatalytic influence on oxygen evolution from aqueous solutions. Potentiodynamic sweepings give rise to n-p reversible transitions. Correlations have been established between electrochemical, photoelectrochemical, conductivity mea-

surements and action spectra. Schematic band diagrams have been deduced for n- and p-type material. 13 refs.

Joirot, S. (CNRS, Talence, Fr); Campet, G.; Claverie, J. *Mater Lett* v 6 n 11-12 Oct 1987 p 468-474.

**096902 ORBITAL-ENERGY-RESOLVED PARTIAL CHARGE TRANSFER IN CHEMISORPTION AND ELECTROCHEMICAL PROCESSES ON SEMICONDUCTORS.** The distribution of multi-electron partial charge transfer over the orbital energy scale in chemisorption or electrochemical processes, as revealed by difference density of states calculations, provides basic information about interfacial chemical bonds and is particularly relevant for semiconductors, due to the relation of semiconductor interfacial processes to the band structure and band-gap. A short synopsis of the quantum-chemical approach to electronic structures at electrode interfaces is given in the first part of this paper. In the second part, density of states calculations of the chemisorption on semiconductors at the level of Green's functions of tight-binding Hamiltonians are continued, and the case of chemisorption of water dissociation products ( $H$ ,  $OH$ ) at Ga-terminated GaAs (111)A and (100)A surfaces and their displacement by a halide is reported in some detail. This study contributes data for qualitative distinction of energy-resolved partial charge transfer and surface charging on semiconductor electrodes which is essential for understanding the origin of the dipolar Helmholtz potential. 19 Refs.

Lorenz, W. (Karl-Marx-Univ, Leipzig, East Ger); Rommel, K. *J Electroanal Chem Interfacial Electrochem* v 250 n 1 Aug 10 1988 p 37-59.

## Electrodeposition

**096903 IONIC ELECTRODEPOSITION OF II-VI AND III-V COMPOUNDS. IV. DEPOSITION OF BOTH ELEMENTS AND  $1:1$  COMPOUND POSITIVE OF THE PURE ELEMENT REVERSIBLE POTENTIALS: PURE UNDERPOTENTIAL DEPOSITION.** A description is given of theoretical modeling and computer simulation of electrodeposition of compound semiconductors and addresses the underpotential deposition of both elements and the  $M_1X_1$  compound positive of the free element reversible potential. This is named pure underpotential deposition (PUD) and correspond to Class II compounds as described by F.A. Kroger. PUD occurs when the two reversible (Nernst) potentials are sufficiently close that the elemental activity reductions and free energy change provided by the reaction  $M(s) + X(s) = M_1X_1$ , ( $\Delta G_{MX}^\circ$ ) decrease the anodic terms in the Butler-Volmer equations sufficiently so that the cathodic components cause net deposition of both elements, at comparable rates, positive of where either element individually plates. (Edited author abstract) 16 refs.

Engelken, Robert D. (Arkansas State Univ, Jonesboro, AR, USA). *J Electrochem Soc* v 135 n 4 Apr 1988 p 834-839.

## Electrodes

**096904 CONTACT RESISTANCE OF THE ELECTRODES ON SEMICONDUCTING CERAMICS.** The electrical contact resistances of several different kinds of electrode on a semiconducting  $BaTiO_3$  ceramic body were measured by 2-probes method using the thickness varying and the complex impedance method. These two methods are easily available and agreed well with each other in the case of lower ohmic contact electrode, but for the higher ohmic contact resistances the contact resistances could be obtained by the complex impedance method only. (Author abstract) 6 refs.

Yoon, Sang-Ok (KAIST, Seoul, South Korea); Jung, Hyung-Jin; Yoon, Ki-Hyun. *Solid State Commun* v 64 n 4 Oct 1987 p 617-619.



**Electromagnetic Field Effects** See Also LIQUID METALS—Electromagnetic Field Effects.

**096905 INTERACTION OF SEMICONDUCTORS WITH A STRONG RESONANCE ELECTROMAGNETIC FIELD.** A procedure is developed of constructing an effective Hamiltonian, which makes it possible to reduce the nonstationary problem of interaction between a semiconductor and a strong resonance electromagnetic field to a corresponding problem of equilibrium statistical mechanics. Criteria are obtained when the proposed approach is valid. A corresponding effective Hamiltonian has been found taking into account the electron and hole acceleration by the field as well as different relaxation processes, which permits the investigation of both, the energy spectrum of a semiconductor in a strong field and its thermodynamical properties. (Author abstract) 18 refs.

Kruglov, V.I. (Acad of Sciences of the Belorussian SSR, Minsk, USSR). *Phys Status Solidi B* v 142 n 1 Jul 1987 p 165-178.

**Electronic Properties** See Also BIOCHEMISTRY—Theory; ELECTRONICS—Mathematical Models; HALL EFFECT—Measurements; PHOSPHORUS—Physical Properties; SEMICONDUCTING GERMANIUM—Thin Films; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES, MOS—Space Charge; TRANSISTORS, BIPOLAR—Tunneling.

**096906 ELECTRON-HOLE LIQUID IN SEMICONDUCTOR SUPERLATTICES OF THE III TYPE.** The coupling energy and the balanced density of an electron-hole liquid are calculated in semiconductor superlattices of the III type which are characterized by an indirect energy slot in the space of the coordinates. (Author abstract) 11 refs.

Markova, N.V.; Silin, A.P. *Sov Phys Lebedev Inst Rep* n 3 1987 p 72-76.

**096907 ELECTRONIC STRUCTURE OF 3D TRANSITION-ATOM IMPURITIES IN SEMICONDUCTORS.** The effects of 3d impurities in semiconductors have preoccupied the field since the invention of the transistor. Reliable experimental data for germanium and silicon became available quite early. Theoretical explanations of the properties of such impurities have lagged behind, in part, because of the inherent complexity of the problem. The article presents an in-depth review of the present status of the field. This review contains a most careful and detailed exposition of various aspects of the subject, presented, as the author states, using 'the combined points of view of theoretical solid-state physics, semiconductor physics, and classical inorganic chemistry'. While all outstanding theoretical issues have not yet been resolved, the article illuminates the great progress that has been made. It should serve as a basic reference and summary to all interested in this subject. 290 refs.

Zunger, Alex (Solar Energy Research Inst, Golden, CO, USA). *Solid State Phys* v 39. Publ by Academic Press, Orlando, FL, USA, 1986 p 275-464.

**096908 SELF-ENERGY CORRECTIONS TO THE LOCAL DENSITY BAND STRUCTURE OF SEMICONDUCTORS AND INSULATORS.** A formalism is proposed that allows an efficient computation of the exchange-correlation functional including the nonlocal exchange and dynamical screening correctly. In combination with LDA band structures this functional leads to remarkably good results for semiconductors and even wide gap insulators. The model furthermore provides a qualitative understanding of electronic many-body effects. (Author abstract) 28 refs.

von der Linden, W. (Max Planck Inst fuer Festkoerperforschung, Stuttgart, West Ger); Horsch, P.; Lukas, Wolf-Dieter. *Solid State Commun* v 59 n 7 Aug 1986 p 485-490.

**096909 GROUND STATE OF THE SHALLOW ACCEPTOR IN HIGHLY DOPED P-TYPE  $Hg_{1-x}Mn_xTe$ .** The binding energies of shallow acceptors in  $Hg_{1-x}Mn_xTe$  have been found for several values of  $x$  (from 0.15 to 0.085) using the variational procedure. With a decrease

in composition  $x$  the energy values are slowly decreasing, simultaneously the estimated values of the acceptor polarizability in the ground state are increasing. The Clausius-Mossotti relation and the Castner model of electrostatic impurity-impurity interaction have been applied to evaluated the influence of the polarizability and the neutral acceptor concentration on the reduction of the ground state energy. This influence is significant for high concentrations, especially for smaller values of  $x$ . (Author abstract) 9 refs.

Buczko, R. (Polish Acad of Sciences, Warsaw, Pol). *Solid State Commun* v 59 n 7 Aug 1986 p 495-497.

**096910 ELECTRONIC INTERBAND RAMAN SCATTERING IN SEMICONDUCTORS IN A STATIC MAGNETIC FIELD NON-LOCAL EFFECTS.** Since the Hamiltonian describing the electronic states in the effective mass approximation contains non-local potentials, the interaction with the electromagnetic field has to be modified in order to preserve the gauge independence of physical quantities. The interband Raman efficiency using the modified interaction is evaluated and the difference with previous calculations is discussed. (Author abstract) 16 refs.

De Salvo, E. (Ecole Polytechnique Federale de Lausanne, Lausanne, Switz); Quattropani, A.; Girlanda, R. *Solid State Commun* v 63 n 2 Jul 1987 p 159-162.

**096911 ELECTRONIC DENSITY-OF-STATES NEAR A ROUGH SURFACE.** We use the infinite-barrier model in conjunction with the coherent potential approximation to treat the problem of a rough surface. The local densities of states near the surface are calculated. (Author abstract) 9 refs.

Hong, K.M. (Univ of Hong Kong, Hong Kong). *Solid State Commun* v 66 n 2 Apr 1988 p 241-243.

**096912 MONTE CARLO STUDY OF HOT ELECTRON TRANSPORT IN QUANTUM WELLS.** Monte Carlo simulations of hot electron transport in  $AlGaAs/GaAs/AlGaAs$  quantum wells were carried out in order to clarify the drift velocity overshoot and steady state drift velocity versus the electric-field relation. In the simulations, we took into account the nonparabolic isotropic energy band structures. Results are given for  $GaAs$  well widths of 500 and 100 Angstrom and an electron sheet density of  $1.0 \times 10^{12} \text{ cm}^{-2}$  at 77 K. The drift-velocity overshoot reaches about  $7 \times 10^7 \text{ cm/s}$  at an electric field of 10 kV/cm in both quantum well structures. A negative differential mobility appears beyond 3 kV/cm in both structures due to electron transfer from the  $\Gamma$  valley to the L valleys. (Author abstract) 32 refs.

Tanimoto, Hiroyoshi (Osaka Univ, Suita, Jpn); Yasuda, Naoki; Taniguchi, Kenji; Hamaguchi, Chihiro. *Jpn J Appl Phys Part 1* v 27 n 4 Apr 1988 p 563-571.

**096913 PIEZORESISTANCE ANISOTROPY OF THE FERROMAGNETIC SEMICONDUCTOR  $HgCr_2Se_4$ .** The spinel  $HgCr_2Se_4$  is a ferromagnetic semiconductor (Curie temperature  $T_C \approx 106K$ ) in which the connection between magnetic and semiconducting properties is notable. Although it has interesting physical properties and a good perspective of practical applications its band structure has not been established up to now. This note report the results of measurements of the anisotropy of the piezoresistance effect in single crystals of n- and p-type  $HgCr_2Se_4$ . These measurements were performed in order to obtain information about the symmetry of the conduction and valence bands in the para- and ferromagnetic regions. 4 Refs.

Galdikas, A. (Acad of Sciences of the Lithuanian SSR, Vilnius, USSR); Grebinkskii, S.; Michkevicius, S. *Phys Status Solidi A* v 107 n 1 May 1988 pK53-K55.

**096914 TEMPERATURE-INDEPENDENT ELECTRON TRANSFER: RHODAMINE B/ OXIDE SEMICONDUCTOR DYE-SENSITIZATION SYSTEM.** The fluorescence spectrum and decay of rhodamine B (Rh B) adsorbed on insulator ( $SiO_2$ ) and oxide semiconductors ( $ZrO_2$ ,  $TiO_2$  (anatase)) were measured in

vacuo at temperatures in the range 4-300 K. The effect of temperature on both the intensity and decay rates of the fluorescence is very weak, indicating that the electron transfer (ET) from Rh B in the excited state to those semiconductors (SC) is almost an activationless process. The results lead to the conclusion that continuous levels in the conduction band of the SC serve as the electron acceptor state. (Author abstract). 18 Refs.

Hashimoto, K. (Inst for Molecular Science, Okazaki, Jpn); Hiramoto, M.; Sakata, T. *J Phys Chem* v 92 n 15 Jul 28 1988 p 4272-4274.

**096915 MODEL SPECTRAL DENSITY FOR HOT-ELECTRON QUANTUM TRANSPORT.** Quantum transport theory indicates that a proper treatment of high-field transport in semiconductors should include collisional broadening and intracollisional field effects. By using the Generalized Kadanoff-Baym method, we construct a computational scheme which includes both of these effects. The central quantity in our theory is the joint spectral density  $K(k, k')$  which describes the relation between the initial and final kinetic momenta in a scattering event. Analytical and numerical analyses for several models of interest are presented and discussed. (Author abstract). 20 Refs.

Reggiani, Lino (Univ di Modena, Modena, Italy); Lugli, Paolo. *Phys Scr* v 38 n 1 Jul 1988 p 117-121.

**096916 ELECTRONIC STRUCTURE OF (001) FACE CENTERED CUBIC QUASI-PERIODIC SUPERLATTICE.** We study the electronic structure of a (001) face centered cubic quasi-periodic superlattice within a tight binding model using the transfer matrix method and a perturbative approach. The band gaps are found to vary strongly within the two dimensional Brillouin zone and there are a few eigenvalues for each  $k_{11}$  for which the eigenstates appear to be extended in the quasi-periodic direction also. (Author abstract) 6 refs.

Kumar, Vijay (Indira Gandhi Cent for Atomic Research, Kalpakkam, India); Ananthakrishna, G. *Key Eng Mater* v 13 pt 2 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 527-532.

**096917 PARITY VIOLATION AND ELECTRON-SPIN RESONANCE OF DONORS IN SEMICONDUCTORS.** This paper presents a theory of the g-factors and the intensities of the electric dipole spin-resonance absorption for conduction electrons and electrons bound to donors in zinc blende and wurtzite semiconductors. The results of the theory are compared with relevant data on  $InSb$  and  $Cd_{1-x}Mn_xSe$ . The best fits of the theory to the experimental results yield values for the strength of the spin-orbit coupling in the conduction band of these materials as well as parameters describing the anisotropic Zeeman splitting of the electron energy levels. (Author abstract) 20 refs.

Rodriguez, Sergio (Purdue Univ, West Lafayette, IN, USA). *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 212-233.

**096918 ELECTRONIC STRUCTURE OF BOUND EXCITONS IN SEMICONDUCTORS.** A brief theoretical description of the framework used in the description of the BE electronic structure in the different cases is presented. A general description of the BE electronic structure of neutral ('isoelectronic') defects is attempted, with a number of key experimental examples from different semiconductors. Some general aspects of BEs for



the case of donors and acceptors, where at least three particles are contained in the BE excitation are briefly accounted. 151 refs.

Monemar, B. (Linköping Univ, Linköping, Swed); Lindefelt, U.; Chen, W.M. *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 256-285.

**096919 ELECTRONIC STRUCTURE OF II-VI COMPOUNDS AND THEIR ALLOYS - ROLE OF CATION d BANDS.** Traditionally the electronic structure of II-VI compounds was treated theoretically through tight-binding or pseudopotential models, neglecting the cation d bands, despite the fact that they are located less than approximately 10 eV below the valence band maximum (VBM). Applying first-principle all-electron band structure and total energy methods to ZnTe, CdTe, and HgTe and their ordered alloys, we show that inclusion of cation d states on the same footing as other valence states leads to a number of qualitative and quantitative changes in the predicted electronic structure. These include effects on: (i) the predicted band gaps, (ii) the spin-orbit splitting at the VBM, (iii) the band offset between two II-VI compounds, (iv) the cohesive energy, and (v) the direction of charge transfer in an alloy. (Author abstract) 38 refs.

Wei, Su-Huai (Solar Energy Research Inst, Golden, CO, USA); Zunger, Alex. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 1-7.

**096920 OPTICAL AND ELECTRONIC PROPERTIES OF HgTe-CdTe SUPERLATTICES.** A survey of current issues concerning the electronic and optical properties of HgTe-CdTe superlattices is given. The superlattice has been conjectured to provide certain advantages relative to the HgCdTe alloy for infrared detectors. A comparison of theoretical predictions with recent measurements is made. The conduction electrons are expected to be partially localized near the HgTe-CdTe interfaces, to a degree dependent on the superlattice band gap. The valence band offset between HgTe and CdTe is still not determined precisely. Measurements of the optical absorption coefficient as a function of photon energy indicates that expected structure due to energy subbands does occur, indicating the presence of abrupt interfaces. Recent measurements of resonant tunneling currents through double barrier structures also imply abrupt interfaces, and may help in determining the valence band offset. (Author abstract) 11 refs.

Schulman, J.N. (Hughes Research Lab, Malibu, CA, USA). *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 25-27.

**096921 BALLISTIC TRANSPORT IN II-VI SEMICONDUCTOR COMPOUNDS AND ALLOYS.** Realistic band structures are used in calculating the group velocity and scattering rates for electrons with injection energies up to 1 eV in ZnTe, CdTe, and the low-effective-mass alloy  $\text{Hg}_{0.7}\text{Cd}_{0.3}\text{Te}$ . Scattering from longitudinal optical phonons, ionized impurities, and alloy disorder have been included in our full band-structure calculation, which automatically includes both intra- and intervalley scattering. Of the II-VI materials considered, at 77 K HgCdTe is superior for low injection energies (up to 0.25 eV) while CdTe is superior at higher injection energies (1 eV) at room temperature. The attainable mean free paths ( $\geq 1000$  Angstrom) and group velocities ( $\geq 10^8$  cm/s) for both systems are comparable to values found in III-V systems. (Author abstract) 4 refs.

Berding, M.A. (SRI Int, Menlo Park, CA, USA); Krishnamurthy, S.; Sher, A.; Chen, A.-B. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 33-38.

**096922 EXCITON COMPLEXES IN II-VI MATE-**

**RIALS.** Creation and recombination channels of free and bound exciton complexes as well as their interaction mechanisms are discussed for different II-VI compounds to get a survey of general properties of such complexes in these materials. It will be shown that creation of bound excitons in a manifold of excited electronic states plays a dominant role in spectra taken for high excitation densities. The observation of the buildup of biexcitons in two-step processes via bound-exciton levels is demonstrated to be a valuable means to distinguish between these processes and exciton-exciton scattering in II-VI compounds. (Author abstract) 35 refs.

Gutowski, J. (Technischen Univ Berlin, Berlin, West Ger). *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 528-535.

**096923 HOLE SUBBANDS IN QUANTUM WELLS AND SUPERLATTICES.** Results of theoretical investigations on hole subbands in quantum wells and superlattices are reviewed. Topics covered include: hole subband calculation by an expansion method; pseudopotential calculation by a two-step procedure; heavy and light hole mixing and Coulomb energy of excitons; other applications of the expansion method. (Author abstract) 13 refs.

Huang, Kun (Chinese Acad of Sciences, Beijing, China); Xia, Jianbai; Zhu, Bangfen; Tang, Hui. *J Lumin* v 40-41 Feb 1988, Excited State Processes in Condens Matter, Proc of the Int Conf on Lumin, Beijing, China, Aug 17-21 1987 p 88-91.

**096924 WIGNER FUNCTION SIMULATION OF QUANTUM TUNNELING.** The quantum mechanical phenomenon of tunneling time has been the subject of much debate. We use a Wigner function description of a Gaussian wave packet to study the tunneling process. By adjusting the parameters of the barrier and wave packet, a variety of cases can be studied. For the multiple barrier case, the tunneling time shows peaks at energies corresponding to resonant states of the system. This charge storage within the well is also found to be significant in studying the resonant tunneling diode, giving rise to kinks in the negative differential conductivity region of the I-V characteristic. (Author abstract) 14 refs.

Kluksdahl, N.C. (Arizona State Univ, Tempe, AZ, USA); Kriman, A.M.; Ferry, D.K. *Superlattices Microstruct* v 4 n 2 1988, Pap from the Chicago Conf, Chicago, IL, USA. p 127-131.

## Electroplating

**096925 LASER NICKEL PLATING OF SEMICONDUCTORS.** The action of laser radiation on the semiconductor-electrolyte system leads to acceleration of the reduction of nickel and/or ordering of the residue structure. The mechanism of increase in the deposition rate is associated with a set of thermal and electrical influences of laser radiation on the given system. (Author abstract) 7 refs.

Eremenko, A.A.; Zade, V.V.; Zaitseva, A.K.; Kozlova, E.K.; Portnyagin, A.I.; Romanchenko, A.N.; Filippov, A.E. *Moscow Univ Phys Bull* v 42 n 4 1987 p 57-61.

## Encapsulation

**096926 EFFECT OF HEATING ON THE STRUCTURE OF Au/GaAs ENCAPSULATED WITH  $\text{SiO}_2$ .** The structural effects of heating 1500 Å Au/GaAs (001) encapsulated with 2000 Å of  $\text{SiO}_2$  were examined by scanning electron microscopy and X-ray diffraction. It was observed that  $\text{SiO}_2/\text{Au/GaAs}$  (capped) in vacuum up to 500°C remained shiny and gold in color, whereas similar heating of Au/GaAs (uncapped) caused a change of color from shiny gold to dull silver. Mass spectroscopy showed that the amount of arsenic vapor evolved was much less for the capped sample. However, X-ray diffraction showed that  $\text{Au}_7\text{Ga}_2$  formed abundantly in both types of samples after heating at 500°C, though the epitaxial relationship was mainly  $\text{Au}_7\text{Ga}_2$  (001) || GaAs (001) for capped and  $\text{Au}_7\text{Ga}_2$  (100) || GaAs (001) for uncapped.

SEM revealed gold-rich aligned rectangular protrusions on the surfaces of  $\text{SiO}_2/\text{Au/GaAs}$  as well as Au/GaAs after heating at 500°C, though the average length of these rectangles was 1.5  $\mu\text{m}$  for the capped sample and 6.7  $\mu\text{m}$  for the uncapped sample. New morphological features absent in Au/GaAs were observed in  $\text{SiO}_2/\text{Au/GaAs}$ . These features are a gold-rich maze with a line width of 6  $\mu\text{m}$  and gold-rich protruded lines with a line width of 9  $\mu\text{m}$ . The gold-rich protruded lines were formed by the growth and joining together of some gold-rich aligned rectangular protrusions. The gold-rich maze was observed in  $\text{SiO}_2/\text{Au/GaAs}$  after heating in vacuum, but was not observed in  $\text{SiO}_2/\text{Au/GaAs}$  after heating in nitrogen. (Edited author abstract) 6 refs.

Zeng, X.-F. (Carnegie Mellon Univ, Pittsburgh, PA, USA); Chung, D.D.L.; Lakhani, Amir. *Solid State Electron* v 30 n 12 Dec 1987 p 1259-1266.

**Energy Gap** See Also SEMICONDUCTING SILICON COMPOUNDS—Spectroscopic Analysis.

**096927 CHARGE STATES OF VACANCIES IN IV-VI SEMICONDUCTORS.** Within the analytical tight-binding model of IV-VI semiconductor's band structure, the restricted Hartree-Fock calculation of the electron structure of vacancies is carried out. Many-electron effects are shown to play a critical role in the formation of bound states. For example, the Pb vacancy possesses the energy level in a fundamental gap, which is absent in one-electron Parada and Pratt theory. The filling levels of the various charge states of vacancies versus chemical composition of the host crystal are calculated. (Author abstract) 17 refs.

Pankratov, O.A. (USSR Acad of Sciences, Moscow, USSR); Povarov, P.P. *Solid State Commun* v 66 n 8 May 1988 p 847-853.

**096928 CHARACTERISTICS OF DOUBLE INJECTION IN WIDE-GAP SEMICONDUCTORS.** Double injection of carriers in wide-gap semiconductors, when the main charge is localized at levels interacting with the minority current-carrier band, is studied. It is shown that in this case double injection of carriers can lead to a cubic current-voltage characteristic (CVC). The possibility of the appearance of two-cubic sections, on the CVC separated by a quadratic region is also pointed out. (Author abstract) 11 refs.

Zyuganov, A.N.; Koren', N.N.; Smertenko, P.S. *Sov J Commun Technol Electron* v 32 n 8 Aug 1987 p 42-47.

**Etching** See Also ION BEAMS—Applications; OPTOELECTRONIC DEVICES—Etching; SEMICONDUCTING SILICON—Contamination.

**096929 EFFECT OF DOPANTS CONCENTRATION ON RESOLUTION AND RATE OF LIGHT INDUCED ETCHING - PART I: THEORETICAL ANALYSIS.** Resolving power of light-induced etching (photoetching) for n-type semiconductors is to be understood as including the space-charge region at the surface. The injection modulation characteristic  $\zeta$  is introduced in the proposed model of photoetching. This characteristic is derived from the stationary concentration of holes in case of nonuniform injection; it depends on the semiconductor material characteristics ( $\tau_b$ ,  $N_D$ ,  $L$ ,  $s$ ) and on the light grating period. (Edited author abstract) 14 refs.

Marsik, Jaroslav (TESLA Electronics Research Inst, Prague, Czech). *Tesla Electron* v 18 n 3 Sep 1985 p 73-78.

**096930 PHOTO-INITIATED DEPOSITION AND ETCHING OF MATERIALS RELEVANT TO SEMICONDUCTOR DEVICES.** This review discusses the chemical and physical reactions which can be induced in various organometallic species, at or close to a surface, by light in the near infrared to ultraviolet range, and which result in technologically useful film deposition. Photon-induced etching processes are also covered. The review is concerned with both the physics and chemistry



of the photon interaction, and with the materials and structural properties of the resulting films. (Author abstract) 427 refs.

Haigh, J. (British Telecom Research Lab, Martlesham Heath, Eng); Aylett, M.R. *Prog Quantum Electron* v 12 n 1 1988 p 1-85.

**096931 REACTION BETWEEN CdTe AND AQUEOUS SOLUTIONS OF NITRIC ACID.** It is established that the degree of dissolution of CdTe in aqueous solutions of  $\text{HNO}_3$  at 25°C can be judged either from the accumulation of nitric acid reduction products or from the diffusion of oxidation products from the surface of the dissolving plate into the bulk of the solution. On the surface of the plate a film forms which consists of Te,  $\text{TeO}_2$  and, possibly,  $\text{CdTeO}_3$  with a thickness of the order of 1  $\mu\text{m}$ . The formation of a film during the action of nitric acid is attributed to the transfer of  $\text{Cd}^{2+}$  ions of cadmium telluride into the solution and to oxidation of  $\text{Te}^{2-}$  to  $\text{Te}^0$  and  $\text{Te}^{4+}$ . It is concluded that the heterogeneous chemical reaction between CdTe and  $\text{HNO}_3$  may be regarded as the sum of the combined processes of anodic dissolution of tellurium and cathodic reduction of nitric acid. In Russian. 13 refs.

Sava, A.A.; Tomashik, V.N.; Mizetskaya, I.B. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 10 Oct 1987 p 1639-1642.

**096932 EXTRACTION OF GERMANIUM FROM FLUORINE-CONTAINING PEROXIDE ETCHING SOLUTIONS.** A study was made of the possibility of recovering germanium from fluorine-containing peroxide etching solutions by precipitating it with calcium-containing reagents (phosphogypsum, lime milk) or with aluminum and ferrous salts. Optimal results were obtained by using ferrous sulfate, a titanium production waste, as the precipitator. A technological scheme for recovering germanium from spent etching solutions used in the semiconductor industry is proposed. 5 refs. In Russian.

Poladyan, V.E.; Arlasovich, L.M.; Andrianov, A.M. *Tsvet Met* n 12 Dec 1987 p 58-60.

**096933 ETCH PIT PATTERNS OF MISFIT DISLOCATIONS IN  $\text{AlGaAs/GaAs}$  HETEROSTRUCTURE.** Misfit dislocations at the  $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As/GaAs}$  heterojunction have been revealed by an etching technique on the cleaved interface. On the  $(11\bar{0})$  cleaved surfaces, the dislocation etch pits are revealed as upright pyramids, while on the  $(110)$  surfaces, i.e. parallel to the primary flat, they are revealed as inverted pyramids. (Author abstract) 1 ref.

Tseng, W. (Naval Research Lab, Washington, DC, USA); Prokes, S.; Wilkins, B.; Fatemi, M.; Christou, A. *Mater Lett* v 6 n 8-9 May 1988 p 281-283.

**096934 DISTRIBUTION OF ORIGINS AND EXITS OF SPUTTERED ATOMS.** The distribution of origins and exits of Al and Si sputtered atoms under  $\text{O}^+$  and  $\text{Ar}^+$  ion bombardment has been studied by simulation program TCISIS. Concerning the width of sputtering location distribution, radial locations of sputtered particles around ion beam axis in the solid surface have been recorded. Evidence that most of the sputtered atoms eject from the first two surface layers has been provided. The given width of sputtering location distribution is available for superfine sputtering etching and SIMS design. (Author abstract) In Chinese. 10 refs.

Zheng Liping (Acad Sinica, Shanghai, China); Cui Fuzhai. *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 288-293.

**096935 REACTIVE ION ETCHING OF III-V COMPOUNDS USING  $\text{C}_2\text{H}_6/\text{H}_2$ .** Reactive ion etching of InP, GaInAs and GaAs using a mixture of ethane and hydrogen,  $\text{C}_2\text{H}_6/\text{H}_2$ , is demonstrated for the first time. It has been found that by choosing optimum etching parameters we can obtain excellent vertical sidewalls as well as very smooth surfaces, keeping the etching rate at a convenient value of 20-60 nm/min. (Author abstract). 7 Refs.

Matsui, T. (Mitsubishi Electric Corp, Amagasaki, Jpn); Sugimoto, H.; Ohishi, T.; Ogata, H. *Electron Lett* v 24 n 13 Jun 23 1988 p 798-800.

**096936 WET-CHEMICAL ETCHING OF III-V SEMICONDUCTORS.** III-V semiconductors like GaAs can be wet-chemically etched by three mechanisms: electrochemically with an external voltage source, electrochemically using an oxidizing agent (electroless), and chemically with a reactive compound. In some cases the etching process only proceeds when the semiconductor is exposed to light. The etch rate depends on the relative reaction rate at the semiconductor surface and the mass transfer in the solution. Other important factors are the effect of the crystal planes, the orientation of a mask with respect to these planes, and the electrical contact with other materials. It is pointed out that wet-chemical etching of III-V semiconductors can be used on a large scale for various applications, including the detection of crystallographic defects, the fabrication of special profiles and the selective dissolution of closely related materials in multilayer structures. (Edited author abstract). 16 Refs.

Kelly, J.J. (State Univ of Utrecht, Utrecht, Neth); van den Meerakker, J.E.A.M.; Notten, P.H.L.; Tiburg, R.P. *Philips Tech Rev* v 44 n 3 Jul 1988 p 61-74.

**096937 PROCEEDINGS OF THE SIXTH SYMPOSIUM ON PLASMA PROCESSING.** This conference proceedings contains 60 papers arranged in eight sections. The sections are: processing and degradation; processing, magnetic confinement, reactor design; spectroscopic diagnostics; modeling; damage and deposition; etching of silicon and metals, deposition; surface analysis and interaction and novel applications of plasmas. The topics discussed are dry etching, reactive ion etching, resist etching, sloped contact etch process in a single wafer, multilevel VLSI metallizations, plasma processing, surface modifications produced by etching, chemical sputtering of semiconductors, ion suppression, and laser assisted plasma etching. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10842 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Mathad, G.S. (Ed.) (IBM, East Fishkill, NY, USA); Schwartz, G.C. (Ed.); Gottscho, R.A. (Ed.). *Proc Electrochem Soc* v 87-6, Proc of the Sixth Symp on Plasma Process, San Diego, CA, USA, Oct 19-24 1986. Publ by Electrochemical Soc Inc, Pennington, NJ, USA, 1987 754p.

**096938 PREPARATION DE SURFACE DES COMPOSES III-V PAR GRAVURE IONIQUE REACTIVE DANS UN MELANGE GAZEUX A BASE DE METHANE.** [Surface Preparation of III-V Compounds by Reactive Ion Etching in a Methane-Based Gas Mixture]. Dry etching techniques are becoming increasingly important, and recently a Metal Organic Reactive Ion Etching (MORIE) process usable in micro-opto-electronic technology has been reported. This process appears usable also for surface treatments; for example, before epitaxial growth. (Author abstract) 4 refs. In French.

Henry, L. (CNET, Lannion, Fr); Vaudry, C.; Alnot, P.; Olivier, J. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composes III - V, Fr, Apr 27-28 1988 p 169-170.

## Evaporation

**096939 THERMOGRAVIMETRIC AND MASS-SPECTROMETRIC STUDIES OF  $\text{Cd}_4\text{GeSe}_6$  AND  $\text{Cd}_4\text{GeSe}_5$ .** A thermogravimetric study of the  $\text{Cd}_4\text{GeSe}_6$  and  $\text{Cd}_4\text{GeSe}_5$  powders showed that these materials are stable during heating in air to 680 and 740 K, respectively. Evaporation of the compounds is of incongruent character, and the degree of dissociation depends on the temperature of the evaporator. In the vapor phase of the compounds  $\text{CdS}$ ,  $\text{CdSe}$ ,  $\text{GeSe}_2$  and  $\text{GeSe}$  molecules are observed which are elements of the crystal structure. Molecules which include germanium and cadmium atoms simultaneously are not presented. In Russian. 6 refs.

Motrya, S.F.; Svitlits, V.P.; Semrad, E.E.; Dovgoshei, N.I. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 9 Sep 1987 p 1543-1546.

## Friction

**096940 FRICTION AND WEAR OF SEMICONDUCTORS IN SLIDING CONTACT WITH PURE METALS.** The friction and wear of the semiconductors silicon and gallium arsenide in contact with pure metals was studied. Friction experiments were conducted at room temperature in air and in a vacuum of  $2.0 \times 10^{-7}$  Pa. Five transition and two nontransition metals - titanium, tantalum, nickel, palladium, platinum, copper, and silver - were slid on a single crystal of silicon. Four metals - indium, nickel, copper, and silver - were slid on a single crystal of gallium arsenide. Furthermore, experiments on the wear of silicon in sliding contact with titanium, nickel, and copper were conducted in a vacuum of  $1.0 \times 10^{-5}$  Pa. The results indicated that the friction and wear of the semiconductors were dependent on the contacting metal. The effect of the contacting metal on the friction and wear was considered to arise from the interactions at the metal-semiconductor interface. (Edited author abstract) 22 refs.

Mishina, H. (Inst of Physical & Chemical Research, Wako, Jpn). *Tribol Int* v 21 n 2 Apr 1988 p 76-82.

## Grain Boundaries

**096941 TRANSIENT PHOTOCONDUCTIVITY ANALYSIS NEAR A GRAIN BOUNDARY OF POLYCRYSTALLINE SEMICONDUCTORS.** The effect of grain boundary recombination on the photoconductance transient response, after excitation with a delta function light pulse near a grain boundary, is studied here. An analytical expression is derived for this decay which can be readily computed numerically. The photoconductance turns out to be a non-exponential function of time even at large decay times. A practical method, based on such non-experimental decay curves obtained with the light beam positioned away or near a grain boundary, is developed to deduce accurate values of the bulk lifetime and in the grain boundary recombination velocity. (Author abstract) 16 refs.

Dimitriadis, C.A. (Univ of Thessaloniki, Thessaloniki, Greece). *Solid State Commun* v 64 n 6 Nov 1987 p 851-854.

## Growing See Also CRYSTALS—Growing.

**096942 MOVPE GROWN  $\text{GaAlAs/GaAs}$  DH DEVICES OPERATING AS LASER DIODES AND BIPOLAR TRANSISTORS FOR OPTOELECTRONIC INTEGRATION.** In these devices, a structural similarity between DH (double-heterostructure) laser diodes and DH bipolar transistors has been taken full advantage of, since both laser diodes and electronic devices can be fabricated simultaneously in the same process, using an epitaxial wafer grown in one step. The function of the devices is described. A maximum current gain of 5000 was observed with typical values in the range of 200-1000 for a collector current density  $J_c$  of 2  $\text{kA/cm}^2$ . This result is a substantial improvement over results previously reported. This is because the setback layers avoid the displacement of the emitter-base p-n junction. When the device operates as a laser diode between the emitter-base junction, a lasing characteristic with a minimum threshold current  $I_{th}$  of 170 mA and a differential quantum efficiency of about 10% at room temperature are obtained. The main reason for the rather high  $I_{th}$  is the leakage current through the  $\text{GaAlAs}$  p<sup>+</sup>-n homojunction. Optimization of the device structure - for example, by increasing the aluminum content in the cladding layers and using the quantum well base structure is expected to produce a lower lasing threshold current. 1 ref.

Temmyo, Jiro (NTT, Atsugi, Jpn); Hasumi, Yuji; Kozen, Atsuo. *IEEE Trans Electron Devices* v ED-34 n 11 Nov 1987, 45th Annu Device Res Conf, Santa Barbara, CA, USA, Jun 22-24 1987 p 2364.



**Growth** See Also CRYSTALS—Structure; MOLECULAR BEAM EPITAXY; MOLECULAR BEAM EPITAXY—Equipment; ORGANOMETALLICS—Vapor Pressure; SEMICONDUCTING GALLIUM ARSENIDE—Chemical Vapor Deposition; SEMICONDUCTING GALLIUM ARSENIDE—Electric Properties; SEMICONDUCTING INDIUM COMPOUNDS—Chemical Vapor Deposition; SEMICONDUCTING SILICON—Doping; SEMICONDUCTING SILICON—Growth; SEMICONDUCTING SILVER COMPOUNDS—Thin Films; SEMICONDUCTOR DEVICES—Heterojunctions; SOLID STATE DEVICES.

**096943 GROWTH AND STRUCTURAL CONSIDERATIONS ON SINGLE TIBISE<sub>2</sub> CRYSTALS.** TIBISE<sub>2</sub> single crystals were grown in an adequate size (2 cm long and 1 cm diameter). The material was characterized by X-ray powder diffraction and electron microscopy. TIBISE<sub>2</sub> crystallizes with rhombohedral symmetry, forming a slightly distorted cubic lattice with a nonprimitive unit cell of  $a=6.162$  Å and  $\alpha=87.21^\circ$ . Ordering of Ti and Bi layers perpendicular to the [111] direction leads to superstructure reflections, only observed in the electron diffraction patterns. A high density of regularly arranged or movable dislocations was also observed. (Author abstract) 23 refs.

Toubektsis, S.N. (Univ of Thessaloniki, Thessaloniki, Greece); Polychroniadis, E.K. *J Cryst Growth* v 84 n 2 Aug 1987 p 316-322.

**096944 CASSETTE FOR LIQUID-PHASE EPITAXIAL GROWTH OF MULTILAYER PERIODIC STRUCTURES.** A cassette with a spiral channel is described for growing multilayer semiconductor structures by liquid-phase epitaxy. A structure with alternating n<sup>+</sup>- and n-type layers based on GaAs is prepared using the cassette. The layer thicknesses are 2.5-3.2 µm for a free-carrier concentration of  $2.10^{16}$  cm<sup>-3</sup> in the n-type layer. (Author abstract) 8 refs.

Krasovitsov, S.N. (Acad of Sciences of the USSR, USSR); Kuznetsov, A.G.; Medvedev, A.L. *Instrum Exp Tech* v 30 n 1 pt 2 Jan-Feb 1987 p 231-233.

**096945 GROWTH AND SOME PROPERTIES OF Zn<sub>2</sub>In<sub>2</sub>S<sub>8</sub> SINGLE CRYSTAL.** Zn<sub>2</sub>In<sub>2</sub>S<sub>8</sub> has been synthesized in the form of single hexagonal platelets. This compound is the fifth member of the layered semiconductor family Zn<sub>x</sub>In<sub>2-x</sub>S<sub>8</sub>. Optical measurements are used for the evaluation of the energy gap at room temperature. This was found equal to 2.84 eV. The presence of extended composition faults was indicated by the a<sup>2</sup>-hv diagrams and proved by electron microscopy techniques. Some electrical properties have been studied and an electron trap at  $E_t=E_c-0.4$  eV, with a concentration of about  $10^{12}$  cm<sup>-3</sup> was found to exist. An anisotropy of about  $10^6$  was measured in the two directions: parallel to the layers and vertical to them. (Edited author abstract) 13 refs.

Kalomiros, J.A. (Aristoteles Univ of Thessaloniki, Thessaloniki, Greece); Anagnostopoulos, A.N.; Spyridelis, J. *Mater Res Bull* v 22 n 10 Oct 1987 p 1307-1314.

**096946 METAL-ORGANIC VAPOUR-PHASE EPITAXY OF MULTILAYER STRUCTURES WITH III-V SEMICONDUCTORS.** Vapor-phase epitaxy with metal-organic reactants (MO-VEP) is a method for growing multilayer structures of III-V semiconductor materials such as GaAs and Al<sub>x</sub>Ga<sub>1-x</sub>As. Precise control of the growth parameters can give interfaces that are abrupt on an atomic scale. The quality of the interfaces and the depth profiling have been assessed by spectroscopic ellipsometry and confirmed by photoluminescence experiments on quantum wells consisting of a thin GaAs layer between two Al<sub>x</sub>Ga<sub>1-x</sub>As layers with a larger band gap. The emission wavelength of these wells can be varied in a controlled manner from 800 to 620 nm by decreasing the well width or incorporating aluminum in the well, or both. Laser operation has been obtained for quantum wells with emission wavelengths down to 730 nm. In modulation-doped heterostructures with GaAs and Al<sub>x</sub>Ga<sub>1-x</sub>As a two-dimensional electron gas is formed on the GaAs side near the heterojunction. The spatial separation of carriers and donor impurities gives high electron mobilities, particularly at low temperatures. This favors the application of such structures for obtaining transistors

with a good high-frequency performance. At low temperatures the presence of a two-dimensional electron gas is responsible for the 'quantized Hall effect.' (Edited author abstract) 23 refs.

Frijlink, P.M. (Lab d'Electronique et de Physique Appliquee, Limeil-Brevannes, Fr); Andre, J.P.; Erman, M. *Philips Tech Rev* v 43 n 5-6 May 1987 p 118-132.

**096947 METAL-ORGANIC VAPOUR-PHASE EPITAXY WITH A NOVEL REACTOR AND CHARACTERIZATION OF MULTILAYER STRUCTURES.** A novel type of reactor has been developed for making MO-VEP multilayer structures, in which sharp transitions can be obtained between layers of different composition. The perfection of the structures produced is demonstrated by means of transmission electron microscopy. It is demonstrated for instance that the transition regions are no thicker than approximately one monolayer. The optical quality of the quantum wells is determined by measuring the decay time of the luminescence. It appears that the decay time in quantum wells is less dependent on temperature than in bulk material, so that the threshold current for laser operation is also less temperature-dependent. (Edited author abstract) 10 refs.

Leys, M.R. (Philips Research Lab, Eindhoven, Neth); Viegiers, M.P.A.; 't Hooft, G.W. *Philips Tech Rev* v 43 n 5-6 May 1987 p 133-142.

**096948 MOLECULAR BEAM EPITAXY OF MULTILAYER STRUCTURES WITH GaAs AND Al<sub>x</sub>Ga<sub>1-x</sub>As.** The growth of thin films of GaAs and Al<sub>x</sub>Ga<sub>1-x</sub>As on GaAs substrates by molecular beam epitaxy (MBE) has been investigated. High-quality films and multilayer structures with controlled thickness and composition have been deposited. Information has been obtained on the surface chemistry and the dynamics of growth. It is possible to produce abrupt interfaces between GaAs and Al<sub>x</sub>Ga<sub>1-x</sub>As layers, where the compositional changes occur over no more than one monolayer. GaAs layers have been grown with low background impurity concentrations ( $2 \times 10^{14}$  cm<sup>-3</sup>) and this has enabled us to achieve high electron mobilities at low temperatures ( $3 \times 10^6$  cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup> at 4 K) in two-dimensional electro-gas structures. Multiple quantum-well structures prepared by growing very thin GaAs wells between Al<sub>x</sub>Ga<sub>1-x</sub>As barriers showed laser emission at wavelengths down to 704 nm. (Edited author abstract) 27 refs.

Joyce, B.A. (Philips Research Lab, Redhill, Engl); Foxon, C.T. *Philips Tech Rev* v 43 n 5-6 May 1987 p 143-153.

**096949 TEM INVESTIGATIONS OF THE TUNGSTEN SILICIDE FILMS ON SILICON.** Tungsten silicide thin films were prepared by electron beam evaporation techniques. Tungsten films of 900 Å thick were evaporated onto the silicon substrates. The as-deposited films were subsequently annealed in a quartz diffusion furnace under an N<sub>2</sub> atmosphere. X-ray diffraction and transmission electron microscopy were used to determine the structure of the annealed thin films. Grain coarsening and epitaxial silicides were observed on the as-deposited tungsten film on (100) silicon after furnace annealing at 800°C for 1 hour. (Author abstract) 12 refs.

Tjong, S.C. (Nat'l Sun Yat-Sen Univ, Kaohsiung, Taiwan); Hsieh, I.C. *Mater Res Bull* v 22 n 6 Jun 1987 p 841-847.

**096950 SPARK SOURCE MASS SPECTROGRAPHIC ANALYSES OF α-HgI<sub>2</sub>.** The concentrations of both inorganic and organic impurities in α-HgI<sub>2</sub> single crystals grown in different laboratories, in solution or from the vapor phase, have been analyzed by SSMS. The total content of carbon in hydrocarbons is very high, ranging from about 30 up to 50,000 at.ppm, most crystals containing several thousands of ppm. Li, Bi, C, F, Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Co, Cu, Zn, As, Br and Ag are characteristic inorganic impurities. Al, Cl and K have the highest concentrations of up to hundreds of at.ppm. Na, Mg, Si, S, Ca, Fe and Br concentrations reach tens of ppm. The others have concentrations of the order of ppm. Most impurities are concentrated in clusters. There is a straightforward

correlation between the SSMS data and the nuclear detector quality of crystals. (Author abstract) 32 refs.

Nicolau, Y.F. (CEA, Grenoble, Fr); Andreani, A.M. *J Cryst Growth* v 87 n 1 Jan II 1988 p 117-128.

**096951 ON THE GROWTH OF CoSi<sub>2</sub>/Si HETEROSTRUCTURES ON Si(111).** Thin epitaxial, perfectly smooth and pinhole-free CoSi<sub>2</sub> layers of type B orientation could be grown on top of Si(111) wafers for the first time, by using a novel solid phase epitaxy (SPE) technique. Due to the high perfection of these layers and a lowering of the substrate temperature during subsequent Si-MBE, single type A Si overgrowth was achieved. This represents the basis for the fabrication of Si/CoSi<sub>2</sub>/Si superstructures. (Author abstract) 15 refs.

Henz, J. (ETH Zurich, Zurich, Switz); Ospelt, M.; von Kanel, H. *Solid State Commun* v 63 n 6 Aug 1987 p 445-449.

**096952 ISOTHERMAL MOTION IN A LIQUID-ENCAPSULATED CZOCHRALSKI CRYSTAL PULLER WITH AN AXIAL MAGNETIC FIELD.** During the growth of a semi-conductor crystal in a Czochralski crystal puller, the time periodic convection and turbulence are suppressed by an applied magnetic field. The velocities in the molten material are decreasing functions of the magnetic field strength. For the growth of gallium arsenide, a liquid bulk encapsulant is added over the free surface of the melt to prevent the evaporation of arsenic. The encapsulant and melt motion are coupled through the boundary conditions at the liquid-liquid interface, providing a mechanism for meridional circulations in the melt which are not present in non-encapsulated systems. This paper presents analytical solutions for an isothermal liquid-encapsulated GaAs system with a strong, uniform axial magnetic field. (Author abstract) 6 refs.

Hjellming, L.N. (Univ of Illinois, Urbana, IL, USA); Walker, J.S. *PCH PhysicoChem Hydrodyn* v 10 n 1 1988 p 107-131.

**096953 ESTIMATION OF MINIMUM GROWTH TEMPERATURE FOR CRYSTALS GROWN FROM THE GAS PHASE.** It is proposed that the limiting temperature,  $\theta$ , for single crystal growth from the gas phase is the temperature at which the kinetic rate of arrival at each surface site is equal to the rate of removal by surface diffusion. An expression is derived for  $\theta$  at atmospheric pressure. Surface diffusion is considered for the cases of covalent, ionic and metallic solids, and simple models used to allow the estimation of activation energy for surface diffusion in each case. Results are presented for 33 crystals including group IV elements, III-V compounds ionic solids and metals. Agreement with experimental results is shown to be satisfactory in those cases where results are available from the literature. (Edited author abstract) 20 refs.

Dryburgh, P.M. (Univ of Edinburgh, Edinburgh, Scotl). *J Cryst Growth* v 87 n 4 Mar 1988 p 397-407.

**096954 GaInAsP ALLOYS AND LOW DIMENSIONAL STRUCTURES GROWN BY ATMOSPHERIC PRESSURE METAL ORGANIC VAPOUR PHASE EPITAXY (MOVPE).** The growth conditions for MOVPE of GaInAs and GaInAsP lattice-matched to InP are described and factors affecting composition and crystallinity are discussed. Compositional uniformity as a function of reactor cell temperature, and results on low dimensional structures grown in both the GaInAs/InP system and in the GaInAsP/InP system are reported. Results are given on all-MOVPE double heterostructure and ridge waveguide lasers operating at 1.3 µm wavelength. (Author abstract) 13 refs.

Butler, B.R. (STC Technology Ltd, Harlow, Engl); Briggs, A.T.R.; Thrush, E.J.; Garrett, B.; Stagg, J.P. *Chemtronics* v 3 n 1 Mar 1988 p 31-34.



**096955 ALTERNATIVE PRECURSORS FOR THE MOVPE GROWTH OF WIDE BAND GAP II-VI COMPOUNDS.** The use of conventional precursors such as dialkylzinc compounds and group VI hydrides has traditionally caused serious pre-reaction problems in the growth of wide band gap II-VI materials, (e.g., ZnSe and ZnS), by MOVPE. There is thus a need for alternative source materials. One solution has been to employ alkyl- or heterocyclic derivatives of the group VI elements and this work is briefly reviewed here. An alternative approach is to modify the group II source to make it less susceptible to pre-reaction with the group VI hydride. We now report the successful use of the 1,4-dioxan and 1,4-thioxan adducts of dimethylzinc as precursors for high quality ZnSe. In addition to reducing significantly the pre-reaction with 2Se the use of these adducts allows epitaxial growth of ZnSe at temperatures as low as 200°C. (Author abstract) 21 refs.

Jones, A.C. (Epichem Ltd, Wirral, Engl); Wright, P.J.; Cockayne, B. *Chemtronics* v 3 n 1 Mar 1988 p 35-37.

**096956 PURIFICATION OF GROUP III METAL ALKYLs USING NITROGEN DONOR LIGANDS.** Increased understanding of the factors affecting adduct formation between group III metal alkyls (Lewis acids) and group V Lewis bases, and their subsequent thermal behavior, have led directly to the discovery of a new process for the purification of group III metal alkyls e.g.  $\text{Me}_3\text{M}$  (M=Al, Ga and In) and  $\text{Et}_3\text{In}$ . This process involves the formation of involatile adducts of the metal alkyls with the involatile diamine 4,4'-methylenebis(N,N'-dimethylaniline) (Arnold's base,  $[\text{Me}_2\text{N}(\text{C}_6\text{H}_4)]_2\text{CH}_2$ , MBDA) which dissociate on heating in vacuo to liberate the high purity metal alkyl. Samples of the alkyls have been analyzed for microimpurities by Inductively Coupled Plasma Emission Spectroscopy (ICP) before and after purification in order to probe the effectiveness of the new process. Vapor pressure measurements of trimethylindium over the adduct  $(\text{Me}_3\text{In})_2\text{MBDA}$  have been carried out in order to investigate the potential of this adduct for the delivery of trimethylindium by the modified entrainment method. (Author abstract) 24 refs.

Foster, Douglas F. (Univ of St. Andrews, St. Andrews, Scotl); Rushworth, Simon A.; Cole-Hamilton, David J.; Jones, Anthony C.; Stagg, John P. *Chemtronics* v 3 n 1 Mar 1988 p 38-43.

**096957 REAGENT CONCENTRATION MEASUREMENTS IN METAL ORGANIC VAPOUR PHASE EPITAXY (MOVPE) USING AN ULTRASONIC CELL.** An ultrasonic cell for measuring gas composition is described. Measurements were made of steady-state partial pressures of trimethyl gallium (TMG) and trimethyl indium (TMI), at  $25\text{ cm}^3\text{ min}^{-1}$  hydrogen flow-rate, as a function of temperature of the sources. The following partial pressure equations were found to apply. For TMG:  $\log_{10} P$  (Torr)  $8.05-1710/T(\text{K})$  for  $-10.6^\circ\text{C} < T(\text{K}) < 11.0^\circ\text{C}$  TMI:  $\log_{10} P$  (Torr)  $= 11.14-3240/T(\text{K})$  for  $-7.7^\circ\text{C} < T < 70.4^\circ\text{C}$ . The ratio of principal specific heats, for the two alkyl vapors were found to be:  $\gamma(\text{TMG})=1.103\pm 0.003$  and  $\gamma(\text{TMI})=1.12\pm 0.025$ . Observations that the partial pressure can depend on the temperature at which the TMI was condensed suggest dimorphism of TMI. (Author abstract) 25 refs.

Stagg, J.P. (STC Technology Ltd, Harlow, Engl). *Chemtronics* v 3 n 1 Mar 1988 p 44-49.

**096958 DISSOCIATION PRESSURES OF SOME GROUP III TRIALKYLs OVER THEIR ADDUCTS WITH 1,2-BIS(DIPHENYLPHOSPHINO) ETHANE.** The dissociation pressures of trimethyl aluminum ( $\text{Me}_3\text{Al}$ ), trimethyl gallium ( $\text{Me}_3\text{Ga}$ ), deuterotrimethyl gallium ( $\text{CD}_3)_3\text{Ga}$  and trimethyl indium ( $\text{Me}_3\text{In}$ ), over their respective adducts with 1,2-bis(diphenylphosphino) ethane  $\text{Ph}_2\text{P}(\text{CH}_2)_2\text{PPh}_2$  have been determined by Knudsen mass loss effusion. The enthalpy changes for these processes were found to be in the order  $\text{Me}_3\text{Al} > \text{Me}_3\text{In} > \text{Me}_3\text{Ga} \approx (\text{CD}_3)_3\text{Ga}$ . (Author abstract) 15 refs.

Bradley, D.C. (Queen Mary Coll, London, Engl); Faktor, M.M.; Frigo, D.M.; Zheng, D.H. *Chemtronics* v 3 n 1 Mar 1988 p 53-55.

**096959 CRYSTALLIZATION AND CHARACTERIZATION OF AsSeI.** Glassy AsSeI has been crystallized as polycrystalline boules and the surface studies of AsSeI have also been done using scanning electron microscopic analysis. Crystallization of AsSeI depends on the time of isothermal annealing. Microhardness studies have also been reported on polycrystalline AsSeI. (Author abstract) 13 refs.

Ariuvoli, D. (Anna Univ, Madras, India); Gnanam, F.D.; Ramasamy, P. *J Cryst Growth* v 88 n 3 May 1988 p 353-357.

**096960 SIMULATION OF III-V TERNARY COMPOUND SEMICONDUCTOR MATERIAL GROWTH BY LIQUID PHASE EPITAXIAL TECHNIQUE.** A calculation method is developed to simulate the liquid phase epitaxial (LPE) growth of III-V compound semiconductors. The semiconductors under simulation are the ternary materials  $\text{AlGaAs}$ ,  $\text{InGaAs}$  and  $\text{InAsSb}$ . There are melt back and lattice mismatch problems to grow a  $\text{InAs}_{0.35}\text{Sb}_{0.65}$  epilayer on  $\text{InSb}$  substrate. Simulation results suggest that this can be achieved by proper preparation of melt and temperature programming. (Author abstract). 24 Refs.

Cheng, Chih-ho (Nat'l Tsing Hua Univ, Hsin-Chu, Taiwan); Hsueh, Kan-Lin; Yang, Chien-Wen; Lien, Chen-sin. *Chemtronics* v 3 n 2 Jun 1988 p 94-98.

**096961 MICROSCOPY OF BULK-GROWN III-V SEMICONDUCTOR MATERIALS.** Compounds formed by the combination of one or more of the elements from Group IIIA (Al, Ga, or In) and Group VA (P, As, or Sb) are known as III-V materials. These materials have attractive semiconductor properties, but much of their potential has yet to be realized because they are difficult to produce in high-quality single crystal form. The purpose of this review is to describe how microscopy based studies have influenced the development of III-V materials, with particular emphasis on the impact such studies have had on materials applications. The review is concerned with materials produced by bulk growth methods in which large volumes of single crystal material are grown. The currently important materials are discussed with reference to the specific material properties that are attractive for a particular application. 126 refs.

Brown, G.T. (Ministry of Defence, Malvern, Engl). *Annu Rev Mater Sci* v 17 1987 p 123-148.

**096962 NEW DEVELOPMENTS IN IIa-VIb (ALKALINE-EARTH CHALCOGENIDE) BINARY SEMICONDUCTORS.** Single crystals of Ca, Sr and Ba monochalcogenides have been grown by a floating melt-zone method. Reflection, luminescence and other optical spectra have been measured on these high quality crystals. From experimental and theoretical studies on the band structure, it is concluded that most of these IIa-VIb crystals are indirect gap semiconductors (except BaO) with the minimum gap between the X-point conduction band and the  $\Gamma$ -point valence band. This indirect gap is predicted to be dipole-forbidden from the symmetry of the X-point phonons. Such a specific feature in the band structure of IIa-VIb crystals is supposed to have a significant influence on the optoelectronic properties of IIa-VIb compound semiconductors. (Author abstract) 12 refs.

Kaneko, Yoshio (Univ of Tokyo, Tokyo, Jpn); Koda, Takao. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 72-78.

**096963 GROWTH AND CHARACTERIZATION OF  $\text{Cd}_{1-x}\text{Zn}_x\text{Te}$  AND  $\text{Hg}_{1-x}\text{Zn}_x\text{Te}$ .** We describe the modified vertical Bridgman conditions required for bulk growth of  $\text{Cd}_{1-x}\text{Zn}_x\text{Te}$  and  $\text{Hg}_{0.87}\text{Zn}_{0.13}\text{Te}$ . Good quality single crystals were obtained, with dislocation densities of approximately  $4 \times 10^4$  to  $1 \times 10^5\text{ cm}^{-2}$ . No

precipitates were observed under IR microscopic examination. The  $\text{Hg}_{0.87}\text{Zn}_{0.13}\text{Te}$  crystal exhibited n-type behavior after a 250°C mercury saturated post-anneal, with a carrier density of  $8 \times 10^{15}\text{ cm}^{-3}$  and mobility of  $1.5 \times 10^5\text{ cm}^2/\text{V}\cdot\text{s}$  at 77 K. X-ray lattice constant measurements and atomic absorption analysis were used to establish accurately the zinc mole fraction in the crystals. The structural properties were studied using X-ray diffraction and topography; photoreflectance, a contactless form of the electric field modulated reflectivity technique, was used for optical characterization. (Author abstract) 13 refs.

Kennedy, J.J. (US Army Cent for Night Vision & Electro-Optics, Fort Belvoir, VA, USA); Amirtharaj, P.M.; Boyd, P.R.; Qadri, S.B.; Dobbyn, R.C.; Long, G.G. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 93-99.

**096964 INTERNAL TEMPERATURE GRADIENT OF ALLOY SEMICONDUCTOR MELTS FROM INTERRUPTED GROWTH EXPERIMENTS.** Interrupted growth experiments on  $\text{Hg}_{0.8}\text{Cd}_{0.2}\text{Se}$  alloys were performed in an attempt to estimate the actual internal temperature gradient in the melt during directional solidification. The results have been analyzed in terms of a theoretical model which assumes an axial composition profile characteristic of diffusion controlled solute redistribution during growth. A comparison of the calculated and measured values suggests a reduction in the applied (empty furnace) temperature gradient by about a factor of three. Values of the interface segregation coefficient ( $k$ ) determined from the phase diagram, predict values of solute concentration build up in the solid during growth interruptions which are inconsistent with measured results. It appears that the  $k$  values used tend to underestimate the actual  $k$  values for higher alloy compositions and overestimate  $k$  for the lower alloy compositions. (Author abstract) 8 refs.

Andrews, R.N. (Univ of Alabama at Birmingham, Birmingham, AL, USA); Szofran, F.R.; Lehoczy, S.L. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 100-105.

**096965 REVIEW OF THE BULK GROWTH OF HIGH BAND GAP II-VI COMPOUNDS.** A wide variety of methods has been applied to the bulk growth of high band gap II-VI compounds. This is due in part to the differences between the compounds, but more importantly, to the great difficulty of achieving single crystal material of significant size. Melt, solution, and vapor methods have all yielded material useful for small-scale experimental studies; however, significant progress in skill needs to be made in growth techniques for future applications of II-VI compounds to become effective. (Author abstract) 48 refs.

Fitzpatrick, B.J. (Philips Corp, Briarcliff Manor, NY, USA). *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 106-110.

**096966 RECENT DEVELOPMENTS IN  $\text{HgCdTe}$  AND  $\text{HgZnTe}$  GROWTH FROM Te SOLUTIONS.** Growth of  $\text{HgCdTe}$  by liquid phase epitaxy (LPE) from Te-rich solutions has become a widely used approach to produce large-area films with good crystalline quality. This approach offers several advantages, namely, a low Hg overpressure, simplicity of growth chamber design, and reduced solute depletion from the melt. This paper briefly reviews some of the recent progress in growing LPE from Te rich melts and compares it with alternative epitaxial growth techniques. In addition, it will address doping



HgCdTe LPE with group Va impurities and growth of HgZnTe as a possible emerging alternative to HgCdTe. (Author abstract) 19 refs.

Castro, C.A. (Texas Instruments Inc, Dallas, TX, USA); Tregilgas, J.H. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 138-145.

**096967 INFINITE-MELT VERTICAL LIQUID-PHASE EPITAXY OF HgCdTe FROM Hg SOLUTION: STATUS AND PROSPECTS.** Liquid-phase epitaxy (LPE) has emerged as the predominant materials growth technology for the fabrication of HgCdTe infrared (IR) detectors in the IR community over the past decade. This paper reviews the current status as well as the evolution of one modification of LPE technology, specifically, 'infinite-melt' vertical LPE (VLPE) from Hg-rich solutions. The backside-illuminated hybrid focal plane array (HFPA) approach for IR detection has been established in the past few years as the most attractive one for both scanning and staring modes in either tactical or strategic applications. Knowledge of fundamental material properties for the Hg-Cd-Te system is reviewed in three main areas: phase diagram, defect chemistry, and impurity doping. The review concludes with a discussion of the prospects for use of the VLPE technology for investigating fundamental material properties of HgCdTe as well as fabricating advanced device structures of high performance. (Edited author abstract) 54 refs.

Tung, Tse (Santa Barbara Research Cent, Goleta, CA, USA). *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 161-172.

**096968 TERRACING IN HgCdTe LPE FILMS GROWN FROM Te SOLUTION.** Terracing in HgCdTe films grown by LPE from Te solution is influenced by many factors. These include melt-back of the substrate, substrate holder design, rotation rate of the substrate, thermal gradients, and growth rates. Many of the variables which influence terracing are interdependent and can be related to their effects on the supersaturation. Variables which tend to level the solute and/or thermal fields would tend to reduce terracing. (Author abstract) 12 refs.

Parker, S.G. (Texas Instruments Inc, Dallas, TX, USA); Weirauch, D.F.; Chandra, D. *J Cryst Growth* v 86 n 1-4 Jan I 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 173-182.

**096969 SEMICONDUCTOR QUANTUM WELL STRUCTURES AND SUPERLATTICES, SYMPOSIUM.** This conference proceedings contains 37 papers, 2 are in abstracted form only. The main subjects are thin-film growth techniques, molecular beam epitaxy (MBE), metalorganic vapor phase epitaxy (MOVPE), hot wall epitaxy (HWE), ultrathin multilayer structures, quantum well heterostructures, artificial superlattices, strained-layer superlattices, bandgap engineering and band structure, integrated optics, and magnetic epitaxial structures. Assessment techniques of ultrathin multilayer structures are also presented, of particular importance is the microscopic structure at the interface of the constituent layers. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11465 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Ploog, K. (Ed.) (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Linh, N.T. (Ed.). *Semicond Quantum Well Struct and Superlattices, Symp, Strasbourg, Fr, May 13-15 1985* Publ by Editions de Physique, Les Ulis, Fr, 1986 265p.

**096970 CARACTERISATION PAR DIFFRACTION DE PHOTOELECTRONS X, DES ETAPES SUCCESSIVES DE L'EPITAXIE DES MATERIAUX III-V.** [Characterization by X-Ray Photoelectron Diffraction of the Successive Layers of Epitaxially Grown III-V Materials]. Electron scattering and diffraction in X-ray photoelectron spectroscopy (XPD) are used to characterize III-V

semiconducting layers. Their crystallinity degree is evaluated and experimental conditions required to measure the actual stoichiometry are described. Finally, XPD is compared to other techniques. (Author abstract) 4 refs. In French.

Olivier, J. (Thomson-CSF, Orsay, Fr); Alnot, P.; Guizot, J.L.; Wyczisk, F. *Vide Couches Minces* v 43 n 241 Mar-Apr 1988, 2emes Journ Etud sur L'Epitaxie et la Passivation des Composés III - V, Fr, Apr 27-28 1988 p 285-286.

**Heat Treatment** See Also SEMICONDUCTING GALLIUM ARSENIDE—Defects.

**096971 T<sub>2</sub>-ALICu STRUCTURE AND ITS PHASE TRANSITION UNDER HEAT TREATMENT.** The variation of electrical resistivity with temperature of rapidly quenched T<sub>2</sub>-ALiCu thin ribbons and the X-ray powder diffraction study of the phase transition under heat treatment are presented. We obtained that the quasi-lattice parameter is equal to 5.045 Å and the T<sub>2</sub>-ALiCu icosahedral phase will transform into T<sub>B</sub> phase and T<sub>1</sub> phase under heat treatment. (Author abstract) 11 refs.

Huang, Zhao-rong (Acad Sinica, China); Pan, Guang-zhao; Yang, Da-yu; Chen, Xi-shen. *Solid State Commun* v 63 n 11 Sep 1987 p 951-954.

**Heterojunctions**

**096972 ANALYSIS OF THERMIONIC EMISSION CURRENT OVER THE AL<sub>1-x</sub>Ga<sub>x</sub>1-xAs BARRIER IN A GaAs/Al<sub>1-x</sub>Ga<sub>x</sub>1-xAs/GaAs (x > 0.45) STRUCTURE.** Thermionic emission (TE) current over the Al<sub>1-x</sub>Ga<sub>x</sub>1-xAs barrier in a GaAs/Al<sub>1-x</sub>Ga<sub>x</sub>1-xAs/GaAs (x > 0.45) structure has been analyzed taking into account the conduction band structures of GaAs and Al<sub>1-x</sub>Ga<sub>x</sub>1-xAs. Assumption of a noninteracting electron model leads to the conclusion that the L valley governs the TE current. This is true for x > 0.45, but contradicts recent experiments when x approaches 1. The model has been modified to include the  $\Gamma \rightarrow X \rightarrow \Gamma$  current which arises from the mixing between  $\Gamma$  and X wave functions at heterojunction interfaces. On the basis of the modified model, the competition between the L current and the  $\Gamma \rightarrow X \rightarrow \Gamma$  current is discussed. (Author abstract) 10 refs.

Zohta, Yasuhiro (Toshiba Corp, Kawasaki, Jpn). *Jpn J Appl Phys Part 2* v 27 n 5 May 1988 p 906-908.

**High Pressure Effects** See SEMICONDUCTING INDIUM COMPOUNDS—Optical Properties; SEMICONDUCTOR DEVICES—Heterojunctions.

**High Temperature Effects**

**096973 PRESENCE OF Cu<sub>2</sub>O IN MBa<sub>2</sub>Cu<sub>3</sub>O<sub>6</sub> (M=Sm, Ho), SEMICONDUCTING MODIFICATION OF HIGH TEMPERATURE SUPERCONDUCTORS.** The presence of traces of Cu<sub>2</sub>O in MBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-x</sub> for x=1 has been detected by resonance Raman scattering in the vicinity of the blue exciton of Cu<sub>2</sub>O. The intensities of the Raman lines due to Cu<sub>2</sub>O are sensitive to temperature and to the photon energy of the laser in the green-violet range. The Raman lines of Cu<sub>2</sub>O have not been observed in the superconducting phase of these compounds (x=0). (Edited author abstract) 20 refs.

Liu, R. (Max-Planck-Inst fuer Festkoerperforschung, Stuttgart, West Ger); Thomsen, C.; Cardona, M.; Matztausch. *Solid State Commun* v 65 n 1 Jan 1988 p 67-70.

**096974 STUDY ON COPPER VALENCY OF HIGH-T<sub>c</sub> SUPERCONDUCTOR YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-y</sub> BY HIGH TEMPERATURE X-RAY ABSORPTION SPECTROSCOPY.** The X-ray absorption spectra of the Cu K-edge have been obtained for a high-T<sub>c</sub> superconductor YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-y</sub> by in-situ high temperature measurements between room temperature and 600°C and for quenched samples prepared by rapid cooling from various temperatures up to 880°C. The results indicate that the copper valency is predominantly 2+ and the monovalent state appears as the oxygen contents decrease with

increasing temperature. The Cu K-edge X-ray absorption spectra of lanthanide compounds with oxygen-deficient triperovskite structure LnBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-y</sub> (Ln=Nd, Sm, Eu, Gd, Dy, Ho, Er, Tm, Yb or Lu) were also reported. (Author abstract) 29 refs.

Iwazumi, Toshiaki (Univ of Tsukuba, Sakura-mura, Jpn); Nakai, Izumi; Izumi, Mitsuru; Oyanagi, Hiroyuki; Sawada, Hideaki; Ikeda, Hiroshi; Saito, Yosuke; Abe, Yoshihito; Takita, Koki; Yoshizaki, Ryozo. *Solid State Commun* v 65 n 3 Jan 1988 p 213-217.

**096975 OXYGEN EVOLUTION FROM YBa<sub>2</sub>Cu<sub>3</sub>O<sub>6.85</sub> HIGH T<sub>c</sub> SUPERCONDUCTORS.** Neutron and X-ray diffraction experiments showed the relation between the oxygen content and the structural phase transition in high temperature superconductors. We report on measurements of the oxygen desorption in YBa<sub>2</sub>Cu<sub>3</sub>O<sub>6.85</sub> using high temperature oxygen evolution techniques, and find quantitative agreement with neutron diffraction data. Below 800°C the expansion coefficient is related to the evolution rate. Using desorption relations we assign a value of 0.16 eV to the oxygen-oxygen repulsion energy, responsible for the order-disorder transition in the linear Cu-O chains. Above 800°C several sharp oxygen escape peaks are observed. (Edited author abstract) 16 refs.

Strauven, H. (Katholieke Univ Leuven, Louvain, Belg); Locquet, J.P.; Verbeke, O.B.; Bruynseraede, Y. *Solid State Commun* v 65 n 4 Jan 1988 p 293-296.

**096976 HALL EFFECT MEASUREMENTS IN La<sub>2-x</sub>Sr<sub>x</sub>CuO<sub>4</sub>.** We present Hall effect measurements in the normal state of the high temperature superconducting ceramics La<sub>2-x</sub>Sr<sub>x</sub>CuO<sub>4</sub> (x=0, 0.05, 0.08, 0.1, 0.15, 0.2, 0.25 and 0.30). The Hall constant (R<sub>H</sub>) is positive and it is a decreasing function of x. Every Sr gives approximately 1 hole to the conduction band. For x=0, R<sub>H</sub> has semiconductor-like temperature dependence, while for the other Sr concentrations, R<sub>H</sub> is constant in temperature. The Hall mobility ( $\mu_H$ ) decreases with x at high temperatures. For x=0  $d\mu_H/dT > 0$  and with doping it changes to  $d\mu_H/dT < 0$ . We give a simple model calculation which qualitatively accounts for the observed behavior of the resistivity, Hall constant and Hall mobility as a function of Sr concentration. (Author abstract) 12 refs.

Petravic, M. (Univ of Zagreb, Zagreb, Yugosl); Tutis, E.; Hamzic, A.; Forro, L. *Solid State Commun* v 65 n 7 Feb 1988 p 573-576.

**High Temperature Properties** See SEMICONDUCTING SAMARIUM COMPOUNDS—Elasticity.

**Impurities** See Also ELECTRONS—Scattering; REFRACTORY METALS—Impurities; SEMICONDUCTING CADMIUM COMPOUNDS—Charge Carriers; SEMICONDUCTING GERMANIUM—Spectrum Analysis; SEMICONDUCTING INDIUM COMPOUNDS—Growth; SEMICONDUCTING SILICON—Spectroscopic Analysis; SEMICONDUCTOR DEVICES—Heterojunctions; SEMICONDUCTOR DEVICES, MOSFET—Mathematical Models; SPECTROSCOPY, INFRARED.

**096977 LO-PHONON MODES BOUND TO NEUTRAL IMPURITIES IN POLAR SEMICONDUCTORS: II. SPECIAL CASES AND EXPERIMENTAL RESULTS.** In a previous paper the Froehlich interaction between charge carriers bound at impurities and LO-phonons in polar semiconductors was considered within second-order perturbation theory. Here special cases including the possibilities of degenerate electronic ground and excited states are discussed. Jahn-Teller like splittings of degenerate ground states as well as Lamb-Rutherford like splittings of degenerate excited states are obtained. Besides renormalized electronic excitations the solution of the eigenvalue problem yields phonons bound to neutral impurities (dielectric modes). Results of Raman spectroscopic determinations of these modes in GaP, Si, and



Sn are presented and their experimental binding energies are compared with theoretical results. (Author abstract) 18 refs.

Monecke, J. (Bergakad Freiberg, Freiberg, East Ger); Cordts, W.; Irmer, G.; Baimarov, B.H.; Toporov, V.V. *Phys Status Solidi B* v 142 n 1 Jul 1987 p 237-246.

**096978 THEORETICAL INVESTIGATION OF DEEP-LEVEL IMPURITIES IN SEMICONDUCTORS CHROMIUM AND MANGANESE IN GaAs.** A general theoretical discussion is given of the properties of defect atoms in semiconducting crystals. The calculations begin from a Hamiltonian of the electrons in a perfect semiconductor crystal containing one defect atom. By a series of transformations, it is found that the admixtures of the band and defect states are small when the electron defect states are in the middle of the band gap. In contrast, when the electron energies of the defect states are close to those of the band, much admixing takes place and the localized states become delocalized. The results are used to illustrate in a qualitative way the differences in properties between  $Mn^{3+}$  and  $Cr^{3+}$  ions in GaAs, and to re-examine the luminescence properties of chromium-doped GaAs. (Author abstract) 22 refs.

Sigmund, E. (Univ of Nottingham, Nottingham, Engl); Bates, C.A. *Philos Mag B* v 56 n 5 Nov 1987 p 611-623.

**096979 SEMIEMPIRICAL ASSIGNMENT OF THE ELECTRON TRANSITIONS IN MANGANESE(II)-DOPED II-VI COMPOUNDS.** The electron transitions in manganese (II)-doped II-VI compounds have been assigned by the Angular Overlap Model (AOM). The extracted AOM and electron repulsion parameters are applied to assess the covalency of the respective manganese-ligand bonds. A comparison with Crystal Field Theory (CFT) is made in order to demonstrate the advantages offered by the AOM. The Dq values for Mn (II) in CdS and CdSe were found by interpolation from the Dq vs  $R_{ML}^{-3}$  relation. (Author abstract) 30 refs.

Stavrev, K. (Univ of Sofia, Sofia, Bulg); Kynev, K.; Nikolov, G.St.; Dyakovitch, V.A. *J Phys Chem Solids* v 48 n 9 1987 p 841-844.

**096980 TWO-DIMENSIONAL ELECTRON GAS OF VERY HIGH MOBILITY IN PLANAR DOPED HETEROSTRUCTURES.** We demonstrate how it is possible to optimize the reduction of remote ionized impurity scattering in modulation doped heterostructures. This can be obtained by a novel implementation of the doping in the barrier using two planar doped layers separated by a large spacer. We have verified this prediction in GaAs/GaAlAs heterojunctions and obtained in preliminary studies very high mobilities reaching a peak value of  $3.7 \times 10^6 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$  at a sheet electron density of  $1.8 \times 10^{11} \text{ cm}^{-2}$ . (Author abstract) 10 refs.

Etienne, B. (CNRS, Bagneux, Fr); Paris, E. *J Phys (Paris)* v 48 n 12 Dec 1987 p 2049-2052.

**096981 ISOELECTRONIC SUBSTITUTIONAL IMPURITY-INDUCED OPTICAL ABSORPTION IN AN NaCl-TYPE SEMICONDUCTOR.** The structures in the complex dielectric function of an isoelectronic substitutional dilute alloy have been analyzed in terms of extra and missing wavevector conserving transitions. Wavevector non-conserving transitions have not been pointed out for an s conduction band and a p valence band with NaCl structure. The transitions are related to the modification of the host density of states due to the impurity potential. The lowest-energy direct transitions give rise to a structure which can be used to determine or to confirm the band gap energy. The other transitions serve to investigate critical points in the Brillouin zone. (Author abstract) 4 refs.

Hugel, J. (Univ de Metz, Metz, Fr); Chetouane, K.; Parlebais, J.C. *Semicond Sci Technol* v 3 n 2 Feb 1988 p 146-149.

**096982 QUANTUM TRANSPORT FOR BLOCH ELECTRONS IN HOMOGENEOUS TIME DEPENDENT ELECTRIC FIELDS.** Quantum transport equa-

tions for Bloch electrons interacting with randomly distributed impurities in the presence of a homogeneous electric field of arbitrary strength and time dependence are derived. The equations account for all possible quantum effects to lowest nonzero order in the scattering strength, including intra and interband scattering, interband Zener tunneling and nonlinear transient transport, and contain effects previously not anticipated, such as coherent impurity scattering, and field and time dependent scattering matrix elements. (Author abstract) 9 refs.

Krieger, J.B. (Electronics Technology & Devices Lab, Fort Monmouth, NJ, USA); Iafate, G.J. *Solid State Commun* v 61 n 2 Jan 1987 p 97-100.

**096983 DENSITY-OF-STATES DUE TO PAIRING OF IMPURITIES IN SEMICONDUCTOR SYSTEMS.** We study the pair formation of hydrogen-like impurities in 3-D and 2-D systems. The density-of-states is obtained for the ground state of the  $H_2$ -like molecule and  $H_2^+$ -like ion for concentrations realizable in doped semiconductors and MOS structures. The joint density-of-states for the transition  $H_2 \rightarrow H_2^+$  is also obtained. The calculated bandwidth shows that pair formation is relevant in those systems. (Author abstract) 8 refs.

de Andrada e Silva, E.A. (Ministerio de Ciencia e Tecnologia, Sao Jose dos Campos, Brazil); da Cunha Lima, I.C.; Ferreira de Silva, A. *Solid State Commun* v 61 n 12 Mar 1987 p 795-798.

**096984 HALL COEFFICIENT FOR ELECTRONS IN A NEARLY FULL IMPURITY BAND.** At 3 K a change of sign of the Hall coefficient  $R_H$  of a 35% compensated n-InP crystal is observed where the variable-range hopping regime dominates the conductivity. This effect is not observed for a more compensated sample and is consistent with hopping conduction by holes in a nearly full band of localized donor impurity states. (Author abstract) 13 refs.

Benzaquen, M. (McGill Univ, Montreal, Que, Can); Walsh, D.; Mazuruk, K. *Solid State Commun* v 61 n 12 Mar 1987 p 803-805.

**096985 IMPURITY CONDUCTION IN SEMICONDUCTORS.** The role of the electron-electron interaction in impurity conduction which is crucial in determining the density of states for most compensations is considered. These new developments are discussed somewhat sketchily. We focus mainly on what is currently understood best: the physics of impurity conduction in lightly doped Ge and Si at small compensations. Discussions are also presented of a few other semiconductors where impurity conduction was reported (InSb, GaAs, and InP) and of other systems, such as semiconductors with magnetic ions and two dimensional systems with localized states. These offer new opportunities to study impurity conduction phenomena. 222 refs.

Chroboczek, J.A. *Noncryst Semicond* Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 109-167.

**096986 PRORACUN KOREKCIJSKOG FAKTORA ZA POSTUPAK RASPODIJELJENOG OTPORA.** [Calculation of Spreading Resistance Correction Factor]. The spreading resistance method is one of the most widely used methods of resistivity profile evaluation, and consequently, the impurity profile evaluation in semiconductors. The measured resistivity profile is corrected by the use of one of the existing models, the most often used one proposed by Schumann and Gardner. In this article, a few existing methods of correction factor calculation have been compared; a faster and more accurate method than the methods compared, has been developed. (Author abstract) In Serbo-Croatian. 11 refs.

Zelic, G.; Sribar, J.; Butkovic, Z. *Elektrotehnika (Zagreb)* v 30 n 5-6 Sep-Dec 1987 p 227-232.

**096987 SHALLOW IMPURITY STATES IN SEMICONDUCTORS: THEORETICAL ASPECTS.** We give a self-contained and updated account of the theory of shallow impurity states in semiconductors. We focus on two essential building blocks of the theory. One is the

impurity potential, which is discussed according to our present understanding of the dielectric response in semiconductors. The second block is the effective-mass approximation (EMA), about which we discuss applications to physical cases, accuracy, limitations, and possible extensions. 56 refs.

Resta, R. (Int Sch for Advanced Studies, Trieste, Italy). *Cryst Semicond Mater and Devices, Trieste, Italy, 1984* Publ by Plenum Press, New York, NY, USA, 1988 p 217-242.

**096988 ELECTRONIC STATES AND STRUCTURAL PROPERTIES OF DEEP CENTERS IN SEMICONDUCTORS.** We present some general aspects and list some open problems in the field of pointlike deep centers in semiconductors that require an accurate knowledge of the short-range part of the impurity or defect potential, i.e., the details of its behavior in real space within the first few shells of nearest neighbors. We sometimes need a realistic theoretical description of the local electronic structure of a deep center even to get just a qualitative understanding of its experimental behavior. This review is focused on theoretical methods designed to study these challenging cases. A few simple qualitative ideas and general physical arguments, which provide a useful conceptual reference frame are reviewed. 189 refs.

Bachelet, G.B. (CNR, Trento, Italy). *Cryst Semicond Mater and Devices, Trieste, Italy, 1984* Publ by Plenum Press, New York, NY, USA, 1988 p 243-304.

**096989 IMPURITY BANDS.** The concept of impurity band and the phenomena of impurity conduction characteristic of the impurity band are described. In connection with the analysis of impurity conduction, in particular the metal-insulator transition in doped semiconductors, the historical development of localization theory from the paper by Anderson in 1958 entitled 'Absence of Diffusion in Certain Random Lattices' to the scaling theory in 1979 is surveyed. The current status of theoretical investigations for the interplay between disorder and electron-electron interaction in the impurity bands of doped semiconductors is reviewed. 74 refs.

Kamimura, H. (Univ of Tokyo, Tokyo, Jpn). *Cryst Semicond Mater and Devices, Trieste, Italy, 1984* Publ by Plenum Press, New York, NY, USA, 1988 p 305-354.

**096990 BASIC PROGRAM ESTIMATING REDISTRIBUTED IMPURITY DISTRIBUTION ON HIGH TEMPERATURE SEMICONDUCTOR PROCESSES.** It is difficult to obtain the impurity distribution from an analytic solution, but the redistribution can be evaluated by a personal computer. This paper describes a fabrication method of a BASIC program for the impurity redistribution. The prepared program sets an assumed symmetrical impurity distribution for an initial condition, and obtains a numerical solution from a difference equation, which is made from the diffusion equation with the Crank-Nicolson's method, by the Gauss-Seidel's repetition method. An estimation for a transistor-base-impurity redistribution affected by an oxidation and emitter-diffusion-processes is illustrated. (Edited author abstract) 9 refs. In Japanese.

Ito, Susumu. *Tohoku Gogyo Daigaku Kiyo* 1 n 8 Mar 1988 p 177-183.

**096991 IMPURITY-BOUND ELECTRON IN QUANTUM WELL-HETEROSTRUCTURE-TYPE SYSTEMS.** The ground-state binding energy of a hydrogenic impurity is retrieved as a function of the effective dimensionality in a quantum well confinement. The geometry the authors use is a rectangular box, the dimensions of which can be tuned so as to yield a unified description interpolating between the bulk, the quasi-two- and one-dimensional limits as well as the quantum well box case. An interesting feature concerning the variation of the binding energy with the change in the geometry of the system is that  $E_B$  does not always increase monotonically as the dimensionality is reduced. For instance, when



either a or b is held fixed at a value comparable with  $\alpha^*$  and the remaining parameter is varied the authors observe that  $E_B$  goes through a minimum. (Edited author abstract). 7 Refs.

Ercelevi, A. (Middle East Technical Univ, Ankara, Turk); Ozdinger, U. *J Phys Chem Solids* v 49 n 7 1988 p 769-772.

**096992 EFFICIENT SIMULATION OF COUPLED POINT DEFECT AND IMPURITY DIFFUSION.** A program has been developed which efficiently solves the coupled diffusion of interstitials, vacancies, and multiple impurity species in two dimensions. Due to the vast differences in diffusivities of the point defects and impurities, two separate spatial grids are used. A coarse grid is sufficient to represent the rapidly diffusing point defects, whereas a much finer grid is necessary to resolve the details of the impurity profile. Independent time steps are automatically selected for each species, permitting this extremely stiff system of diffusion equations to be solved in acceptable CPU time on a minicomputer. The simulation results are used to study the coupled diffusion of point defects and impurities under local oxidation conditions. Comparison with lap and stain measurements on structures with various widths of oxidizing and nitride-masked regions allows accurate values for numerous point defect diffusion parameters to be extracted. 42 refs.

Kump, Michael R. (Technological Modeling Associates, Palo Alto, CA, USA); Dutton, Robert W. *IEEE Trans Comput Aided Des Integr Circuits Syst* v 7 n 2 Feb 1988 p 191-204.

**096993 SHALLOW IMPURITY CENTERS IN SEMICONDUCTORS, PROCEEDINGS OF THE SECOND INTERNATIONAL CONFERENCE ON SHALLOW IMPURITY CENTERS/FOURTH TRIESTE IUPAP-ICTP SEMICONDUCTOR SYMPOSIUM.** This publication contains 22 papers by various authors dealing with shallow impurity centers in semiconductors. All of the papers are abstracted and indexed separately. Major topics covered are research activity in the early years and the most relevant subsequent developments, novel phenomena, recent experimental and theoretical techniques and the behavior of impurities in new semiconductor materials. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 10758 in the Ei Engineering Meeting (TM) database produced by Engineering Information, Inc.

Baldereschi, A. (Ed.) (Univ di Trieste, Trieste, Italy); Resta, R. (Ed.). *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 305p.

**096994 SHALLOW IMPURITY STATES IN SEMICONDUCTORS - THE EARLY YEARS.** This paper presents the author's recollections of the early years (roughly the early and middle 1950's) of the science of shallow impurity states, with emphasis on the theoretical aspects. It concludes with some reflections from the vantage point of today. (Author abstract)

Kohn, Walter (Univ of California, Santa Barbara, CA, USA). *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 1-5.

**096995 SHALLOW IMPURITY INTERACTIONS AND THE METAL-INSULATOR TRANSITION.** A review is given of our current understanding of the interactions between shallow impurities in semiconductors at intermediate concentrations, particularly as seen through optical (far-infrared), dielectric and magnetic properties. Interpreted in terms of models appropriate for the non-metallic phase, these results point out the importance of randomness in the dopant distribution. Connection with the recent scaling approach to the metal-insulator transition, based on perturbative expansions about the high density metallic (weak-coupling) limit, is discussed.

(Author abstract) 65 refs.

Bhatt, R.N. (AT&T Bell Lab, Murray Hill, NJ, USA). *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 99-111.

**096996 LATTICE RELAXATIONS AT SUBSTITUTIONAL IMPURITIES IN SEMICONDUCTORS.** The positions of the crystal nuclei in the surrounding of substitutional impurities in Si and GaAs have been calculated using density-functional theory together with the local-density approximation for exchange and correlation and the total-energy gradient approach. These investigations give a qualitative explanation of the mechanism which drives the impurity-induced lattice relaxations as well as quantitative predictions of relaxation amplitudes up to far away from the defect. Both, the electronic screening charge at the impurity, and the long-range distortion pattern of the nuclei are found to be highly anisotropic, propagating mostly along the zigzag bonding chains of the (110) planes. Comparisons of the calculated distortions for Si:As<sup>+</sup> and GaAs:S<sup>+</sup> with two recent EXAFS analyses and for Si:S<sup>+</sup> with an EPR analysis show good agreement. (Author abstract) 57 refs.

Scheffler, Matthias (Physikalisch Technische Bundesanstalt, Braunschweig, West Ger). *Physica B & C* v 146 n 1-2 Sep 1987, Shallow Impurity Cent in Semicond, Proc of the Second Int Conf on Shallow Impurity Cent/Fourth Trieste IUPAP-ICTP Semicond Symp, Trieste, Italy, Jul 28-Aug 1 1986 p 176-186.

**Ion Implantation** See ALSO CRYSTALS—Microstructure; INTEGRATED CIRCUIT MANUFACTURE; INTEGRATED CIRCUITS, VLSI—Fabrication; LOGIC CIRCUITS, INTEGRATED INJECTION—Design; MATERIALS—Ion Implantation; SEMICONDUCTING SILICON—Defects; SEMICONDUCTING SILICON—Growth; SEMICONDUCTING SILICON—Optical Properties; SEMICONDUCTING SILICON—Oxidation; SEMICONDUCTOR DEVICE MANUFACTURE—Doping; SEMICONDUCTOR DEVICES, MOS—Ion Implantation; SEMICONDUCTOR DEVICES, MOSFET—Modeling.

**096997 ION IMPLANTATION DISTRIBUTIONS IN CRYSTALLINE MULTILAYER TARGETS.** Range distributions of Bi in Si/Ge multilayer structures and N in Au/Si double-layer structures have been calculated using the computer simulation code COSIPO. Various combinations of amorphous, random, polycrystalline and monocrystalline structures were studied. Good agreement with existing experimental data was found. The crystalline structure is predicted to have measurable effect on the distributions, but in the case of N in Au/Si the discontinuity in the distribution is more sensitive on the layer thickness. (Author abstract) 24 refs.

Hautala, M. (Univ of Helsinki, Helsinki, Finl); Koponen, I. *Nucl Instrum Methods Phys Res Sect B* v B28 n 2 Sep 1987 p 237-241.

**096998 ION IMPLANTATION AND LOW TEMPERATURE PROPERTIES OF METAL-SEMICONDUCTOR ALLOYS.** We review the experimental work on ion implantation with respect to superconductivity and electrical resistivity of metal-semiconductor alloys carried out at the Institute of Physics of Academia Sinica. Samples studied included liquid-quenched Al-Si-Ge ribbons and Al thin films. The liquid-quenched ribbons with a superconducting transition temperature  $T_c$  of 3.2 K were implanted with H or H<sub>2</sub> ions at room temperature and a decrease of  $T_c$  was observed. The ribbons were also implanted with Si ions at liquid nitrogen temperature, resulting in a higher onset of transition at about 4 K. We also implanted Si ions into Al thin films at room temperature up to 5 at.% Si. The  $T_c$  of the films increased from 1.5 to 1.9 K and the temperature-dependence of resistivity was changed from  $T^5$  to a  $T^3$ -dependence within 30-50 K. The superconductivity of Al-semiconductor alloys was proved to be strongly influenced by the disorder, which depends crucially on the implantation temperature. (Author abstract) 12 refs.

Xi, Xiao-Xing (Peking Univ, Beijing, China); Zhou, Da-Wei; Zhao, Guang-Lin; Ran, Qi-Ze; Liu, Jia-Rui;

Guan, Wei-Yan. *Nucl Instrum Methods Phys Res Sect B* v B28 n 2 Sep 1987 p 247-250.

**096999 MONITORING OF SIMOX LAYER PROPERTIES AND IMPLANTATION TEMPERATURE BY OPTICAL MEASUREMENTS.** Infrared absorption and Raman scattering measurements of SIMOX structures implanted at various temperatures yield information on the structure and the strain in both the top silicon and the buried oxide layers. Both techniques can also be used to monitor the implant temperature after the implantation. (Author abstract) 17 refs.

Harbeke, G. (RCA Ltd, Zurich, Switz); Steigmeier, E.F.; Hemment, P.; Reeson, K.J.; Jastrzebski, L. *Semicond Sci Technol* v 2 n 10 Oct 1987 p 687-690.

**097000 OBSERVATION OF STACKING-FAULT TETRAHEDRA IN III-V COMPOUNDS.** The first observations of stacking-fault tetrahedra in ion-implanted III-V compounds are reported. The structure and orientation of the stacking-fault tetrahedra are briefly described. The tetrahedra are present in the near-surface region that recrystallized during the annealing. High-resolution images suggest that the stacking-fault tetrahedra are of the vacancy type. (Author abstract) 16 refs.

De Cooman, B.C. (Cornell Univ, Ithaca, NY, USA); McKernan, S.; Carter, C.B.; Ralston, J.R.; Wicks, G.W.; Eastman, L.F. *Phil Mag Lett* v 56 n 3 Sep 1987 p 85-90.

**097001 MOLECULAR-ORBITAL METHOD FOR EVALUATING COMPOUND SEMICONDUCTOR RANGE PARAMETERS.** Using a molecular-orbital method, the range parameters of compound semiconductors are treated. The calculated results indicate that all III-V compounds and II-VI compounds deviate positively and negatively, respectively from Bragg's rule, and that the deviation coefficient does not depend on the implant energy but depends on the chemical bonding of the compounds. In addition, the calculated electronic stopping power of range parameters in negatively deviating systems ( $\text{He}^+ \rightarrow \text{CdS}$  and  $\text{CdTe}$ , and  $\text{B}^+ \rightarrow \text{HgCdTe}$ ) and positively deviating systems ( $\text{Li}^+ \rightarrow \text{Al}_2\text{O}_3$ ,  $\text{Si}^+ \rightarrow \text{GaAs}$ ,  $\text{Be}^+ \rightarrow \text{InP}$  and  $\text{N}^+ \rightarrow \text{GaP}$ ) are in good agreement with experimental results. The theoretical model and the method used for calculating are discussed. (Author abstract) 22 refs.

Wang, Dening (Acad Sinica, Shanghai, China); Wang, Weiyan. *Nucl Instrum Methods Phys Res Sect B* v B28 n 4 Nov 1 1987 p 488-492.

**097002 RESONANT NUCLEAR REACTIONS IN ANALYZING ION-IMPLANTED LAYERS.** Ion implantation is widely used to dope semiconductors, to modify solid surfaces, for gettering, to synthesize compounds, and for various purposes in radiation materials science. The bombardment itself and the subsequent operations distort the theoretical implanted-atom distributions. Nondestructive concentration profile monitoring is sometimes required in developing techniques. Resonant nuclear reaction methods are most suitable for light ions, which can be implemented with low-energy electrostatic accelerators ESA operating up to 2 Mv. Here the authors consider a universal method of determining concentration profiles without the resonance width constraint, which can be realized by means of standard ESA and a gamma spectrometer based on the Vektor system. 10 refs.

Barit, I.Ya. (Acad of Sciences of the USSR, Moscow, USSR); Kuz'min, L.E.; Kazantsev, A.M. *Ind Lab (USSR)* v 53 n 6 Jun 1987 p 532-535.

**097003 CHEMICAL TRENDS IN LATTICE LOCATION OF IMPLANTED IMPURITIES IN A<sup>III</sup>B<sup>V</sup> COMPOUNDS.** The lattice location and the electronic configuration of various groups of nontransition elements of the Periodic Table implanted in A<sup>III</sup>B<sup>V</sup> semiconductor compounds are discussed on the assumption that the local chemical bond plays the dominant role. Using this



scheme, a simple explanation is proposed for the discrepancy in the electrical activity of high-dose n- and p-type implants in GaAs. (Author abstract) 35 refs.

Antonicik, E. (Univ of Aarhus, Aarhus, Den). *Nucl Instrum Methods Phys Res Sect B* v B29 n 3 Dec 1987 p 490-499.

**097004 DOSE EFFECTS IN ION IMPLANTED COMPOUND SEMICONDUCTORS.** In this work a Monte-Carlo method of dynamical type is used to simulate the alteration of compound semiconductor targets of the III-V group, that is GaAs in InP, bombarded with Bi<sup>+</sup> and Si<sup>+</sup>. In the model account is taken of the presence of strains in the lattice and the results describe their effects on the behavior of the ions and on the formation of point defects and of concentration imbalances. (Author abstract) 22 refs.

Mazzone, A.M. (CNR, Bologna, Italy). *Appl Phys A* v A45 n 2 Feb 1988 p 113-118.

**097005 ION IMPLANTERS: CHEMICAL AND RADIATION SAFETY.** Recommendations to reduce chemical and radiation hazards for ion implanters are described along with pertinent regulations. Data are presented on production and maintenance operations. Routine chemical and radiation exposures during production operations are at least an order of magnitude below allowable limits. Airborne exposures during maintenance operations can be easily controlled by local exhaust ventilation and by keeping residues wet during cleaning operations. Without these controls, excessive exposure to airborne arsenic can occur, particularly when personnel clean source housing chambers of solid source arsenic implanters. (Author abstract) 27 refs.

Baldwin, David G. (Nat'l Semiconductor Corp, Santa Clara, CA, USA); King, Bruce W.; Scarpace, Lewis P. *Solid State Technol* v 31 n 1 Jan 1988 p 99-105.

**097006 STUDIES OF DEPTH PROFILES OF FLUORINE IN <sup>19</sup>F<sup>+</sup> ION IMPLANTED Pb<sub>1-x</sub>Sn<sub>x</sub>Te, CdTe AND Si.** The <sup>19</sup>F(P,  $\alpha$ )<sup>16</sup>O resonance nuclear reaction at E<sub>R</sub> = 872.1 keV, with width  $\Gamma$  = 4.2 keV, is used to measure the fluorine depth profiles in <sup>19</sup>F<sup>+</sup> ion implanted Pb<sub>1-x</sub>Sn<sub>x</sub>Te, CdTe and Si samples. Deconvoluting the experimental excitation curves by use of a reference function and parameter optimization procedure, the fluorine depth profiles are obtained, while the projected range distribution parameters, R<sub>p</sub>,  $\Delta R_p$  and SK for <sup>19</sup>F<sup>+</sup> ion implantation in Pb<sub>1-x</sub>Sn<sub>x</sub>Te, CdTe and Si are determined. These range distribution parameters are also calculated theoretically. The comparison between the experimental and theoretical results shows that the experimental R<sub>p</sub> and  $\Delta R_p$  agree well with the theoretical values. The possibility of studying the stopping powers of heavy ions at low velocities in solids by using resonance nuclear reaction technique is discussed. (Author abstract) 17 refs. In Chinese.

Xia Yueyuan (Shandong Univ, Jinan, China); Tan Chunyu; Yang Hong; Hu Xierong; Chen Lixin; Wang Yihua; Sun Xiufang; Zheng Zongshuang; Zhang Qichu; Zhu Peiran; Liu Jiarui. *Pan Tao Ti Hsueh Pao* v 9 n 1 Jan 1988 p 74-81.

**097007 COMPUTER SIMULATION ANALYSIS OF THE PLANAR CHANNELING EFFECT IN PRACTICAL ION IMPLANTATION.** The planar channeling effect in ion implantation was studied using computer simulation. The simulation code was a modified MARLOWE code which enabled dynamic processes of amorphization due to high-dose ion implantation to be simulated. The authors simulated the practical ion implantation of 100 keV Si<sup>+</sup> ions in a 3 inch wafer of GaAs. Since an ion beam scans over a wide area, the angle of incidence of the ion beam changes from point to point on the wafer and results in considerable deterioration of uniformity in the ion-implanted depth, even though the angle of incidence was chosen so as to prevent the channeling condition from occurring during ion implantation. The result clearly indicates that a marked inhomogeneity in ion implantation takes place in the practical manufacturing processes. (Author abstract) 7 refs.

Kimura, Yoshihide (Osaka Univ, Suita, Jpn); Kang, Hee Jae; Shimizu, Ryuichi. *Jpn J Appl Phys Part 2* v 27 n 3 Mar 1988 p 444-447.

**097008 ION IMPLANTATION DOPING OF SEMICONDUCTORS.** An overview of the use of ion implantation to dope silicon and gallium arsenide is presented. The problems associated with epitaxial regrowth in the solid phase and annealing, including rapid thermal annealing, are discussed in detail. Channeling, prior amorphisation, very high energy (MeV) implants, and silicon-on-insulator structures are highlighted as topics that could influence the fabrication of future integrated circuits. The applications of ion implantation to device fabrication are also briefly reviewed. (Author abstract) 61 refs.

Sealy, B.J. (Univ of Surrey, Guildford, Engl). *Int Mater Rev* v 33 n 1 1988 p 38-52.

**097009 ION IMPLANTATION AND ANNEALING.** Ion implanters and ion sources are considered, along with Current Measurement. Range distribution and penetration anomalies are discussed. Furnace annealing, rapid thermal annealing and laser annealing are compared. Ion damage is dealt with. 47 refs.

Rimini, E. (Univ di Catania, Catania, Italy). *Cryst Semicond Mater and Devices, Trieste, Italy, 1984* Publ by Plenum Press, New York, NY, USA, 1988 p 591-622.

**097010 IMPROVED MODEL AND NUMERICAL SIMULATION FOR TWO DIMENSIONAL ION IMPLANTATION.** A new two-dimensional ion implantation model is presented. The two-dimensional distribution of the implanted impurity near an arbitrary shaped mask edge is described by a two half-Gaussian profile or a modified Pearson-IV distribution in the vertical direction and by a complementary error function in the lateral direction. The different stopping powers of the various mask materials for multi-layer mask have been considered. Using this model, an implantation process simulator has been developed which can continuously calculate the impurity profile for several times with different energy, dose and impurity. The effects of the various mask edges have been taken into account. (Edited author abstract) In Chinese. 8 refs.

Xu Chenxi (Fudan Univ, Shanghai, China); Ruan Gang; Wang Jianwei. *Pan Tao Ti Hsueh Pao* v 9 n 3 May 1988 p 269-277.

**097011 ON-LINE MEASUREMENT OF THE SPATIAL DOSE UNIFORMITY IN ION IMPLANTATION PROCESSES.** A method is described which enables the on-line monitoring of the uniformity of an ion implantation. The position on the target-wafer where a fixed amount of dose is implanted is inferred from the two values of the scanning voltages. The procedure includes the correction for finite beam size. The method neither interrupts nor disturbs the ion beam and provides an immediately available record of the implant uniformity. An example of application is demonstrated. (Author abstract) 6 refs.

Stiehler, Thomas (Acad der Wissenschaften der DDR, Dresden, East Ger). *Nucl Instrum Methods Phys Res Sect B* v B31 n 4 Jun 1 1988 p 563-566.

**097012 ION BEAM APPLICATION ON MATERIALS MODIFICATION.** Ion beam applications in solid materials modification are reported. Introduction of defects and excess atoms are described with examples of ion implantation in semiconductors, superconductors and high T<sub>C</sub> superconductors. Ion implantation of oxygen to high T<sub>C</sub> superconductors such as YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-x</sub> followed by thermal annealing at 900-950°C was performed without losing high T<sub>C</sub> superconducting characteristics up to a dose of  $1 \times 10^{17}/\text{cm}^2$  which adds about one excess oxygen. (Edited author abstract). 10 Refs. In Japanese.

Masuda, Kohzoh. *J Jpn Soc Powder Powder Metall* v 35 n 3 Apr 1988 p 157-162.

**097013 ION IMPLANTATION DOPING OF SEMICONDUCTORS.** An overview of the use of ion implanta-

tion to dope silicon and gallium arsenide is presented. The problems associated with epitaxial regrowth in the solid phase and annealing, including rapid thermal annealing, are discussed in detail. Channeling, prior amorphisation, very high energy (MeV) implants, and silicon-on-insulator structures are highlighted as topics that could influence the fabrication of future integrated circuits. The applications of ion implantation to device fabrication are also briefly reviewed. (Author abstract). 61 Refs.

Sealy, B.J. (Univ of Surrey, Guildford, Engl). *Mater Sci Technol* v 4 n 6 Jun 1988 p 500-512.

**097014 NONDESTRUCTIVE ION-IMPLANT MONITORING USING LASER RAMAN SPECTROSCOPY.** A new Raman technique for monitoring low-dose ion implants is described. The capability for detection of implants of 20-50 keV B<sup>+</sup> (or equivalent BF<sub>2</sub><sup>+</sup> energies) at doses as low as approximately  $10^{10} \text{ cm}^{-2}$  is of particular interest. The feasibility of using the technique for monitoring V<sub>i</sub>-adjust implants is demonstrated. Low-energy B<sup>+</sup> and BF<sub>2</sub><sup>+</sup> ion implants in silicon were studied to determine the detection limits of the technique. Samples were analyzed immediately after implantation, without annealing. Implant doses in the range from  $3 \times 10^{16} \text{ cm}^{-2}$  to the detection limit of  $3 \times 10^{10} \text{ cm}^{-2}$  were characterized in this way. The technique is intended for application to in situ process monitoring for VLSI technology. 22 refs.

De Wilton, A.C. (Northern Telecom Electronics Ltd, Ottawa, Ont, Can); Simard-Normandin, M.; Wong, P.T.T. *Can J Phys* v 65 n 8 Aug 1987, Third Can Semicond Technol Conf, Ottawa, Ont, Can p 821-830.

**097015 APPLICATION OF HIGH ENERGY IMPLANTATION IN SEMICONDUCTORS.** A short survey of MeV ion implantation (I/I) is given. In the first part, we present measurements of ion ranges and profiles, the damage induced by high energy deposition, material modifications, and the annealing behavior. The second section presents device improvements or fabrication by high energy I/I: waveguides, cosmic ray simulation, SOI isolation, thyristors, magnetic bubbles, latch up and SEU prevention, ion lithography, retrograde p-wells and collectors, gridists and PROM customization. The last part deals with technical problems: availability, costs, and handling. (Author abstract) 26 refs.

Fahrner, W.R. (Hahn-Meitner-Inst, Berlin, West Ger); Laschinski, J.R.; Braeunig, D. *Nucl Instrum Methods Phys Res Sect A* v A268 n 2-3 May 20 1988, Seventh Tandem Conf, Proc, Berlin, West Ger, Apr 6-10 1987 p 579-588.

## Ionization

**097016 EFFECT OF PRIMARY IONIZATION IN AMORPHOUS SILICON DETECTORS.** The characteristics of the signal produced in amorphous silicon detectors have been studied with alphas and protons of energy in the range 400 keV to 5.8 MeV. The detectors are p-i-n structures fabricated by plasma decomposition of silane. They are operated under inverse polarization from 0 to 100 V. The collected charge is studied as a function of the energy deposited in the detectors. The mechanisms involved in the charge collection are analyzed and the consequences over future detector development are discussed. (Author abstract). 21 Refs.

Equer, B. (CNRS, Palaiseau, Fr); Karar, A. *Nucl Instrum Methods Phys Res Sect A* v A271 n 3 Sep 1988 p 574-584.

Laser Applications See SEMICONDUCTING SILICON—Doping.

## Machining

**097017 MACHINING ELECTRONICS MATERIALS.** Hard materials for electronics components can usually be machined efficiently with diamond tools. For most applications, however, the available data has to be supplemented by in-house tests in the interests of devising the optimum and most cost-effective machining method.



Ultrahigh precision and minimum sub-surface damage are critical requirements. 4 refs.

Cesak, F. (Siemens AG, Munich, West Ger). *Ind Diamond Rev* v 46 n 513 Feb 1986 p 72-75.

**Magnetic Field Effects** See Also METALS AND ALLOYS—Magnetic Field Effects; SEMICONDUCTING INDIUM COMPOUNDS—Thin Films.

**097018 QUANTIZED PHOTOEMISSION FROM QUASI-TWO-DIMENSIONAL STRUCTURES OF WIDE-GAP SEMICONDUCTORS IN A STRONG MAGNETIC FIELD.** MBE and MOCVD techniques have made it possible to fabricate almost defect-free quasi-two-dimensional structures of sub-micron dimensions. The quantized photoemission from such structures in the presence of a quantizing magnetic field is investigated for the first time by considering a quasi-two-dimensional film of a degenerate wide-gap semiconductor, taking n-type GaAs as a typical example. 9 refs.

Majumdar, C. (Univ Coll of Science & Technology, Calcutta, India); Maity, A.B.; Chakravarti, A.N. *Phys Status Solidi B* v 144 n 1 Nov 1987 p K13-K18.

**097019 STUDY OF INTERBAND TUNNELING IN A SEMICONDUCTOR IN THE PRESENCE OF A MAGNETIC FIELD.** The purpose of the paper is to carry out a theoretical study of the effect of a longitudinal magnetic field on interband tunneling in a semiconductor. We have made use of the crystal momentum representation and considered tunneling for a two-band semiconductor with non-parabolic band structure. We have indicated the circumstances under which our results are likely to be significantly different from similar ones obtained by others. (Edited author abstract) 13 refs.

Chakraborty, P.K. (Indian Inst of Technology, Kharapur, India); Biswas, J.C.; Roy, C.L. *J Phys Chem Solids* v 49 n 2 1988 p 125-132.

**097020 BREAKDOWN OF CYCLOTRON RESONANCE IN SEMICONDUCTOR SUPERLATTICES.** The authors observed breakdown of cyclotron resonance in large magnetic fields oriented perpendicular to the growth direction in semiconductor superlattices. At small magnetic fields conventional cyclotron resonance is observed with the mass related to the miniband mass. At large magnetic fields, when the cyclotron diameter approaches the superlattices period, the resonance frequency appears to saturate and is determined by orbits impaled on the barrier. A model calculation gives good account of the magnetic field dependence of the resonance position and line width. (Author abstract) 10 refs.

Duffield, T. (Bell Communications Research Inc, Redbank, NJ, USA); Bhat, R.; Kozma, M.; Hwang, D.M.; DeRosa, F.; Grabbe, P.; Allen, S.J. Jr. *Solid State Commun* v 65 n 12 Mar 1988 p 1483-1487.

**097021 INFLUENCE OF QUANTIZING MAGNETIC FIELD ON PARAMETERS OF ELECTRONS IN  $\text{Bi}_{1-x}\text{Sb}_x$  ALLOYS.** Pronounced influence of quantizing magnetic field  $H$  in ultraquantum limit on spin splitting factor  $\gamma = \Delta_{\text{spin}}/\Delta_{\text{orb}}$  and cyclotron mass  $m_c$  of electrons at  $L$  in n-type semiconductor  $\text{Bi}_{0.91}\text{Sb}_{0.09}$  alloy is observed. The decrease of cyclotron mass  $m_c$  and tending of  $\gamma$  to 1 with increasing  $H$  is explained by the decrease of the Fermi energy in ultra-quantum limit. Experimental results are in qualitative and quantitative agreement with the McClure and Choi theory. (Author abstract) 4 refs. In Russian.

Arutyunov, K.Yu.; Mironova, G.A.; Ponomarev, Ya.G. *Fiz Nizkikh Temp* v 13 n 9 Sep 1987 p 973-976.

**097022 ON ELECTRON STATES OF QUANTUM WELLS IN ULTRATHIN FILMS OF WIDE-GAP SEMICONDUCTORS IN AN ORIENTED MAGNETIC FIELD.** An attempt is made to investigate the effects of a tilted magnetic field on the size-quantized levels of quantum wells in ultrathin films of wide-gap semiconductors, taking n-GaAs as an example. It is found that the energy eigenvalue of the lowest Landau level

corresponding to a given electric subband increases with increasing magnetic field, and reaches a maximum corresponding to a given orientation of the field, the dependence being increasingly prominent with increasing size quantum numbers. Besides, the eigenvalue corresponding to the lowest electric subband decreases with increasing film thickness, the rate of decrease being significantly dependent on the magnetic field and its orientation. (Author abstract) 13 refs.

Bose, M.K. (Univ Coll of Science & Technology, Calcutta, India); Majumdar, C.; Maity, A.B.; Chakravarti, A.N. *Phys Status Solidi B* v 146 n 2 Apr 1988 p 525-530.

**097023 NONLOCAL EFFECTS IN HELICON WAVE PROPAGATION IN A SUPERLATTICE.** Dispersion relations have been obtained on the basis of linear response theory for helicon waves propagation parallel to a magnetic field applied along the axis of a superlattice. Numerical applications have been made to a Kronig-Penney model and the preliminary results clearly indicate nonlocal effects. (Author abstract) 11 refs.

Achar, B.N. Narahari (Memphis State Univ, Memphis, TN, USA). *Superlattices Microstruct* v 3 n 6 1987. Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 641-643.

**097024 IMPACT IONIZATION AND CHAOTIC STATES IN NARROW-GAP SEMICONDUCTORS UNDER A STRONG MAGNETIC FIELD.** A model for recombination instability of a narrow-gap semiconductor in the freeze-out regime is investigated. It is shown that the thermal transition probability for the phonon-assisted generation and recombination of electrons from the excited donor states plays the dominant role for the occurrence of the bistable states in the conduction electron density and the current instability among the various rate coefficients in the region of post-breakdown. (Author abstract) 16 refs.

Abe, Yutaka (Hokkaido Univ, Sapporo, Jpn). *Solid State Electron* v 31 n 3/4 Mar/Apr 1988 p 795-798.

**Magnetic Properties** See Also MAGNETIC SEMICONDUCTORS—Electronic Properties; POLYETHYLENE TEREPHTHALATE—Thick Films; SUPERCONDUCTING MATERIALS—Magnetic Properties.

**097025 CRYSTALLOGRAPHIC AND MAGNETIC PROPERTIES OF THE SYSTEM  $(\text{AgInCd})_2(\text{CuIn})_2\text{Mn}_4\text{Te}_4(x+y+z=1)$  WITH  $x=3y$ .** Samples of the alloy system  $(\text{AgInCd})_2(\text{CuIn})_2\text{Mn}_4\text{Te}_4$  ( $x+y+z=1$ ) with  $x=3y$  were prepared by a melt and anneal technique. Lattice parameter values are measured and the limit of single phase behavior determined. Magnetic susceptibility measurements are made in the temperature range between 80 and 300 K. Values of the Curie-Weiss temperature and Curie constant are obtained from the susceptibility results. (Author abstract) 12 refs.

Quintero, M. (Univ de Los Andes, Merida, Venez); Sagredo, V.; Tovar, R.; Grima, P.; Perez, G.S. *Solid State Commun* v 64 n 4 Oct 1987 p 407-410.

**097026 ON THE INDUCED COBALT MOMENT IN  $\text{RCO}_4\text{B}$ -TYPE COMPOUNDS.** The results of magnetic measurements performed on  $(\text{Gd}_x\text{Y}_{1-x})\text{Co}_4\text{B}$  compounds in the temperature range 4.2-900 K are reported. The compounds with  $x \geq 0.2$  are ferrimagnetically ordered. The mean cobalt moment is dependent on composition. Above the Curie temperatures, the reciprocal susceptibilities obey a nonlinear dependence as function of temperature. By using a two sublattice model, the mean values of the molecular field coefficients characterizing the magnetic interactions inside and between sublattices are determined. The mean cobalt moments are linearly dependent on the exchange fields acting on these atoms. (Author abstract) 12 refs.

Burzo, E. (Central Inst of Physics, Bucharest, Rom); Creanga, I.; Ursu, M. *Solid State Commun* v 64 n 4 Oct 1987 p 585-587.

**097027 MAGNETIZATION AND SUSCEPTIBILITY OF  $\text{Pb}_{1-x}\text{Mn}_x\text{Se}$ .** Susceptibility and magnetization have been measured in samples of  $\text{Pb}_{1-x}\text{Mn}_x\text{Se}$  with small values of  $x$  over a temperature range from 2 to 300 K. The high temperature susceptibility followed the Curie-Weiss relation with a small paramagnetic Curie temperature that indicated a weak antiferromagnetic coupling among Mn ions. The high field magnetization could be fitted to a modified Brillouin function. (Author abstract) 6 refs.

Gorska, M. (Univ of Maryland, College Park, MD, USA); Anderson, J.R. *Solid State Commun* v 63 n 11 Sep 1987 p 1055-1058.

**097028 STUDY OF THE NATURE AND PROPERTIES OF  $\text{V}_{1-x}\text{Cu}_x\text{O}_2$  SOLID SOLUTIONS ( $0 \leq x \leq 0.04$ ).** It is shown that for  $x \leq 0.02$   $\text{V}_{1-x}\text{Cu}_x\text{O}_2$  solid solutions ( $0 \leq x \leq 0.04$ ) are isostructural with pure vanadium dioxide. In the investigated samples a semiconductor-metal phase transition is observed. For  $x > 0.02$  a redistribution of the copper ions occurs. Copper additives lower the semiconductor-metal phase transition temperature and stabilize the intermediate insulating phase. The temperature dependence of the magnetic susceptibility of the semiconducting phase of  $\text{V}_{1-x}\text{Cu}_x\text{O}_2$  attests to the formation of paramagnetic centers as a result of breakage of  $\text{V}^{4+}-\text{V}^{4+}$  bonds due to charge compensation. The number of paramagnetic centers is proportional to the copper concentration in the solid solution for  $x \leq 0.02$ . In Russian. 12 refs.

Kellerman, D.G.; Gorshkov, V.S.; Belysheva, G.M.; Khodos, M.Ya.; Perelyaev, V.A. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 10 Oct 1987 p 1678-1682.

**097029 MAGNETIC EFFECTS IN NONCRYSTALLINE SEMICONDUCTORS.** The normal diamagnetic behavior of amorphous semiconductors is discussed along with paramagnetic effects such as those due to native defects or impurities or to optically induced changes in the material. Relaxation mechanisms for electronic spins via the atoms in the lattice (spin-lattice relaxation) are summarized. Results of NMR and NQR measurements in amorphous semiconductors are discussed. These results include the use of NMR and NQR as probes of local bonding arrangements and the use of nuclear spin-lattice relaxation to probe low energy vibrational excitations or impurity species in amorphous semiconductors. Applications of Mossbauer and ODMR spectroscopy to amorphous semiconductors are summarized. 159 refs.

Taylor, P. Craig. *Noncryst Semicond* Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 69-110.

**097030 MAGNETORESISTANCE OF LOW STAGE GRAPHITE ACCEPTOR COMPOUNDS.** The angular dependences of magnetoresistance (ADM)  $\Delta\rho/\rho_0$  versus the angle  $\Theta$  between the magnetic field direction and the sample c-axis of the graphite intercalation compound (GIC) are calculated. Comparison of the obtained theoretical dependences with the experimental data is carried out for the stage-2  $\text{C}_{10}\text{CuCl}_2$  and  $\text{C}_{10}\text{ICl}$  compounds, and also for the stage-1 heterointercalated compound  $\text{C}_{10}\text{CuCl}_2 \cdot 0.6 \text{ ICl}$ . It is shown that three dimensional model with the c-axis dispersion of the current carriers is in much better correspondence with the experimental data than two dimensional one. (Author abstract) 12 refs.

Davydov, V.N. (Moscow State Univ, Moscow, USSR); Koubatchinski, V.A. *Solid State Commun* v 66 n 7 May 1988 p 695-699.

## Manufacture

**097031 NEW WAY TO MAKE CRYSTALS FOR SEMICONDUCTOR USES.** In the competitive world of substrate manufacturing, some firms are trying less-costly and more-manageable changes in methods to obtain silicon and gallium arsenide crystals. Some of the topics discussed are crystal growing, doping; Czochralski growth; pressure factor; and semiconductor material economics.

Parkinson, Gerald (Chemical Engineering, New York,



NY, USA); Ushio, Shota; Lewald, Roon; Hunter, David. *Chem Eng (New York)* v 94 n 8 May 25 1987 p 14-15, 17.

**097032 IMPULSIVE THERMOPROCESSING OF SEMICONDUCTOR PLATES.** Impulsive thermoprocessing of materials has played an ever-increasing role in the technology of semiconductor production in recent years. Use of impulsive heating methods permits reduction to a minimum of negative affects associated with long-term high-temperature processing, as well as a reduction in the amount of time required for various technological operations. Thermal processing of semiconductors by short pulses producing the adiabatic regime, for example, when laser radiation is used, has a number of serious drawback. Among these are significant mechanical stresses produced upon local heating of the crystal, as well as high temperature gradients and cooling rates, which produce inadmissible concentrations of point defects which require subsequent low temperature annealing in the furnace. Therefore the adiabatic regime will not be considered in the present study. This paper discusses the processes occurring within the plate in the thermal balance regime. 14 refs.

Vol'f, B.E.; Kobrin, B.V. *Sov Microelectron* v 16 n 3 May-Jun 1987 p 152-156.

## Marketing

**097033 PROCEEDINGS OF THE TWELFTH ANNUAL COMMODITY MEETING OF THE INSTITUTION OF MINING AND METALLURGY.** This issue of the journal contains five papers presented at a meeting. The subjects covered include metals in electronics, geological occurrence of these elements, factors affecting availability, features of germanium and gallium supply and demand, and gallium arsenide from mine to microcircuit. All papers are abstracted separately. Technical and professional papers from this conference are indexed and abstracted with the conference code no. 11652 in the Ei Engineering Meetings (TM) database produced by Engineering Information, Inc.

Anon (Inst of Mining & Metallurgy, London, Engl). *Trans Inst Min Metall Sect C* v 97 Mar 1988, Proc of the Twelfth Annu Commodity Meet of the Inst of Min and Metall, London, Engl, Dec 3 1987 p C31-C52.

**097034 FACTORS AFFECTING AVAILABILITY OF ELECTRONIC METALS.** It is the author's contention that the development of markets for electronic metals is hampered by uncertainties about their availability and price. The biggest single problem facing the potential new user is the lack of definitive information on production, consumption and stocks. The paper covers sources, trade policy, stockpiles and pricing. Comments are addressed to the case of gallium arsenide.

Fickling, M. *Trans Inst Min Metall Sect C* v 97 Mar 1988, Proc of the Twelfth Annu Commodity Meet of the Inst of Min and Metall, London, Engl, Dec 3 1987 p 42-44.

**Mathematical Models** See Also DIELECTRIC MATERIALS—Electromagnetic Field Effects; ELECTRIC CONDUCTIVITY—Mathematical Models; ELECTRONS—Tunneling; FERROMAGNETIC METALS—Magnetic Field Effects.

**097035 DEFORMABLE SEMICONDUCTORS WITH INTERFACES: BASIC CONTINUUM EQUATIONS.** A conceptually simple, but nonetheless nonlinear, rotationally invariant and thermodynamically admissible, continuum theory of deformable semiconductors is presented on the basis of (1) general principles of continuum physics including the effects of singular surfaces and energy-carrying interfaces and (2) a systematic use of the principle of virtual power for finite velocity fields. The presence of a singular 'thermodynamic' surface provides proper boundary conditions at the interface, so that no restrictions need to be made concerning the value of surface electric entities in problems dealing with surface-wave propagation. The primitive nonlinearity is essential in that it guarantees obtaining a consistent set of linearized equations about a state exhibiting bias fields.

(Author abstract) 36 refs.

Daher, N. (CNRS, Besancon, Fr); Maugin, G.A. *Int J Eng Sci* v 25 n 9 1987 p 1093-1129.

**097036 NONLINEAR ELECTROACOUSTIC EQUATIONS IN SEMICONDUCTORS WITH INTERFACES (RELATION BETWEEN THE MACROSCOPIC AND THE QUASI-MICROSCOPIC DESCRIPTIONS).** Relations between the present macroscopic theory and conventional quasi-microscopic descriptions based on statistical mechanics are discussed. The present work consists of a derivation of nonlinear electroacoustic equations and constitutive relations, in view to studying, linear, linearized about an initial state and nonlinear wave-propagations problems in different elastic semiconductors (extrinsic, intrinsic,...) with various interfaces such as metal-semiconductor, insulator-semiconductor, semiconductor-semiconductor or simply free space-semiconductor. 38 refs.

Daher, Naoum (CNRS, Besancon, Fr); Maugin, Gerard A. *Int J Eng Sci* v 26 n 1 1988 p 37-58.

**097037 ON-STATE MODELLING OF SEMICONDUCTOR FLOATING REGIONS USING GUMMEL'S ALGORITHM.** A somewhat heuristic, but effective, procedure has been described that results in convergence of the Gummel algorithm when solving the three semiconductor equations for a problem containing PN junction isolated non-contacted regions. Further the importance of employing the correct, i.e., second order, boundary conditions at reflecting boundary conditions at reflecting boundaries has been emphasized. 5 refs.

Whight, K.R.; Gough, P.A. *Annu Rev Philips Res Lab* 1986 p 32-36.

**097038 BAND-MIXING AND BOUND STATES IN NARROW-GAP SEMICONDUCTORS.** We calculate the bound states and effective masses in the surface layers on the narrow-gap semiconductors  $Hg_{1-x}Cd_xTe$  and  $InSb$ , self-consistently taking the split-off band  $\Gamma_7$  into account. The eight-band Kane's Hamiltonian, which describes the interaction of the conduction and valence bands, is diagonalized numerically using the boundary conditions for the envelope wave functions which originate from the model. (Author abstract) 7 refs.

Nachev, Ivo S. (Inst of Microelectronics, Sofia, Bulg). *Phys Scr* v 37 n 5 May 1988 p 825-827.

**097039 SPACE-CHARGE-LIMITED CURRENTS IN MATERIALS WITH NONLINEAR VELOCITY-FIELD RELATIONSHIPS.** A general parametric form of the current-voltage characteristic of space-charge-limited currents (SCLC) is derived in the virtual cathode approximation. The result is used to obtain several exact solutions for the trap-free insulator that is characterized by a nonlinear velocity-field (v-F) relationship. The solutions describe the gradual transition from the regime of constant mobility to that of the field-independent drift velocity. The first-order and second-order corrections to the Mott-Gurney law are then obtained in a closed form for an important class of velocity-field relationships. Exact solutions are also obtained for v-F models that exhibit negative differential mobility behavior. The theory is in good agreement with existing experimental data. The general result is used to specify the condition that allows the anode field as well as the v-F dependence to be extracted from experimental current-voltage characteristics without assuming any a priori v-F relation. 25 refs.

Gildenblat, Gennady Sh. (Pennsylvania State Univ, University Park, PA, USA); Rao, Ashwin R.; Cohen, Simon S. *IEEE Trans Electron Devices* v ED-34 n 10 Oct 1987 p 2165-2172.

**097040 INDUCED CURRENT IN P-N-STRUCTURES WITH LOCAL RECHARGING OF THE DEEP LEVELS.** Theoretical models are proposed which make it possible to associate the current density with a fixed position of a probe and the local value of the electrical field intensity in the region of generation of

electron-hole pairs. (Author abstract) 7 refs.

Konnikov, S.G.; Sobolev, M.M.; Dmitriev, A.P.; Yasyevich, I.N. *Bull Acad Sci USSR Phys Ser* v 51 n 3 1987, Mater of the Fifth All-Union Symp on Scanning Electron Microsc and Anal Methods for Invest Solids, Zvenigorod, USSR, May 1986 p 9-15.

**097041 DEPENDENCE OF LIFETIME ON DESIGN PARAMETERS OF AN nipi DOPING SUPERLATTICE: RESULTS OF SELF-CONSISTENT CALCULATIONS.** This paper presents a scheme for calculating recombination lifetimes in a doping superlattice at arbitrary temperatures and forward biases. The scheme involves the self-consistent calculation of sub-band energies, populations and envelope functions, followed by the calculation of lifetime using overlap integrals. Results of these calculations are then presented for a variety of combinations of layer thicknesses and dopings, all at a temperature of 300 K and a forward bias of 1 V. Our results give room temperature lifetimes as high as approximately 30 ms for n and p layer thicknesses of 750 Angstrom each, i-layer thickness of 50 Angstrom, and dopings in the n and p layers of  $2 \times 10^{18} \text{ cm}^{-3}$ . (Author abstract) 7 refs.

Clark, Ralph O. (Cleveland State Univ, Cleveland, OH, USA); Goradia, Chandra; Brinker, David J. *Superlattices Microstruct* v 4 n 2 1988, Pap from the Chicago Conf, Chicago, IL, USA p 187-193.

**097042 EXCITATIONS OF A SUPERLATTICE WITH A COMPLEX UNIT CELL AND EFFECT OF BACKGROUND CHARGE DYNAMICS IN AN EXTERNAL MAGNETIC FIELD.** A semiconductor superlattice with a complex unit cell in an external magnetic field is considered. The effect of background charge dynamics is also discussed. The cyclotron-acoustic plasmons have been found. (Author abstract) 5 refs.

Yun, Zhu (Fudan Univ, Shanghai, China); Shixun, Zhou. *Superlattices Microstruct* v 4 n 2 1988, Pap from the Chicago Conf, Chicago, IL, USA p 195-196.

**Measurements** See Also BAND STRUCTURE—Mathematical Models; CERAMIC MATERIALS—Piezoelectric.

**097043 AUTOMATIC EQUIPMENT FOR MEASURING TRANSPORT PARAMETERS OF SEMI-INSULATING MATERIALS.** The measurement of resistivity and of Hall constant is difficult due to high resistances and a strong temperature dependence of resistivity. Equipment has been constructed which solves the mentioned problems using suitable electronic circuitry, precise temperature stabilization and automatic data processing. (Edited author abstract) 5 refs.

Karlovsky, Jaroslav (Tesla Electronics Research Inst, Prague, Czech). *Tesla Electron* v 18 n 4 1985 p 113-116.

**097044 EXTREME SPIN EXCHANGE NARROWING IN A NEUTRAL PHTHALOCYANINE RADICAL: THE LITHIUM PHTHALOCYANINE [1].** The lithium phthalocyanine radical  $PcLi$  is a molecular semiconductor ( $\sigma(300 \text{ K}) \sim 10^{-3} \Omega^{-1} \text{ cm}^{-1}$ ,  $\Delta E = 0.2 \text{ eV}$ ) whose dynamical magnetic properties are exceptional: extremely narrowed EPR line. Both EPR and static susceptibility measurements show a complex magnetic behavior which is attributed to competing ferromagnetic and antiferromagnetic interactions very sensitive to the presence of oxygen. (Author abstract) 20 refs.

Turek, Ph. (Inst Charles Sadron, Strasbourg, Fr); Andre, J.-J.; Simon, J. *Solid State Commun* v 63 n 8 Aug 1987 p 741-744.

## Mechanical Properties

**097045 PREPARATION AND MICRO-HARDNESS STUDIES ON SOME V-VI-VII GLASSY COMPOUNDS.** V-VI-VII group compounds are semiconductors and some of them show ferroelectric, photoelectric, piezoelectric properties. Glassy materials of these group compounds show interesting optical and magnetic optical



properties. The glasses of these materials are used as IR detectors and also as memory storage devices. The initial compounds SbSi, BiSeI and AsSeBr were prepared from elements of Antimony (99.999%), Bismuth (99.999%), Arsenic (99.999%), Sulphur (99.999%), Selenium (99.999%) and resublimed analar grade (99.9%) iodine, taken stoichiometrically by vacuum fusion. Micro hardness studies were done using Leitz pyramidal indenter. The loads were varied from 2 to 100 gms. The effect of varying indentation time for different loads and effect of annealing time with hardness will be discussed. (Edited author abstract)

Ariuvoli, D. (Anna Univ, Madras, India); Gnanam, F.D.; Ramasamy, P. *Key Eng Mater* v 13 pt 1 1987, Int Conf on Met and Semicond Glasses (MSG-86), Hyderabad, India, Dec 16-20 1986 p 58.

**097046 MODELING OF MECHANICAL PROPERTIES OF II-VI MATERIALS.** This paper reviews some new developments in the theory of alloy correlations, order-disorder transitions, and solidus phase-transition curves. It is argued that semiconductor alloys are never truly random, and the various phenomena that drive deviations from random arrangements are introduced. Likely consequences of correlations on the ability to fine-tune the lattice match of epitaxial layers to substrates, on vacancy formation, on diffusion, and on vapor-phase crystal growth are discussed. Examples are chosen for the alloys  $Hg_{1-x}Cd_xTe$ ,  $Hg_{1-x}Zn_xTe$ ,  $Cd_{1-y}Zn_yTe$ , and  $CdSe_{1-y}Te_y$ . (Author abstract) 16 refs.

Sher, A. (SRI Int, Menlo Park, CA, USA); Berding, M.A.; Van Schilfgaarde, M.; Chen, A.-B.; Patrick, R. *J Cryst Growth* v 86 n 1-4 Jan 1 1988, II-VI Compd 1987: Proc of the Third Int Conf on II-VI Compd, Monterey, CA, USA, Jul 12-17 1987 p 15-24.

## Microanalysis

**097047 ION MICROBEAM APPLICATIONS IN SEMICONDUCTORS.** Microbeam techniques and applications to semiconductor analysis are briefly reviewed. Special microbeam requirements and limitations for channeling analysis using MeV He microbeams are discussed, including conditions to minimize beam damage to Si and GaAs. Finally, channeling contrast microscopy is described, together with the application of this technique to the analysis of phase transformations and impurity redistribution in locally laser annealed Si. (Author abstract) 10 refs.

Williams, J.S. (MIT, Melbourne, Aust); McCallum, J.C.; Brown, R.A. *Nucl Instrum Methods Phys Res Sect B* v B30 n 3 Mar II 1988, Nucl Microprobe Technol and Appl, Proc of the First Int Conf, Oxford, Engl, Sep 1-4 1987 p 480-485.

**Microscopic Examination** See Also MEMBRANES—Materials; MICROSCOPIC EXAMINATION—Scanning Electron Microscopy; SEMICONDUCTING SILICON—Doping; SEMICONDUCTOR DEVICES—Heterojunctions.

**097048 IN SITU HIGH-RESOLUTION ELECTRON MICROSCOPY REACTIONS IN SEMICONDUCTORS.** An assessment has been made of the feasibility of performing in situ electron microscopy experiments, under high-resolution imaging conditions at high temperature. The particular field of interest is that of interface reactions in semiconductor systems. It is found that the image quality is sufficiently good, especially with new medium-voltage instruments, that changes in the specimens can be followed by extensive periods of time. Results on the solid phase epitaxial regrowth of silicon compare well with those obtained from high-voltage electron microscopy and Rutherford backscattering spectroscopy studies on the same materials. The behavior of some metal-gallium arsenide reactions (specifically Ti-GaAs and Ni-GaAs) has also been investigated. The influence of extremely thin foils is unpredictable at present. (Author abstract) 32 refs.

Sinclair, R. (Stanford Univ, Stanford, CA, USA); Parker, M.A.; Kim, K.B. *Ultramicroscopy* v 23 n 3-4 1987 p 383-395.

**097049 DIRECT OBSERVATION OF ATOMIC COLUMNS IN SEMICONDUCTORS BY HREM AT 400 kV.** The different viewing axes of cubic diamond and zincblende type structures observable by HREM at 400 kV are investigated. Complete dynamical calculations are presented for the four orientations  $\langle 100 \rangle$ ,  $\langle 111 \rangle$ ,  $\langle 110 \rangle$ , and  $\langle 013 \rangle$  in Si, Ge, and several III-V and II-VI compounds. It is shown both experimentally and theoretically that true atomic imaging is possible in the  $\langle 100 \rangle$ ,  $\langle 111 \rangle$ , and  $\langle 013 \rangle$  orientations. Moreover atomic species can be identified in favourable compounds with rather different Z-values for the two  $\langle 100 \rangle$  and  $\langle 013 \rangle$  orientations. (Author abstract) 23 refs.

Bourret, A.; Rouviere, J.L.; Spender, J. *Phys Status Solidi A* v 107 n 2 Jun 1988 p 481-501.

**097050 CHARACTERISTICS OF LOCAL CATHODE LUMINESCENCE OF NARROW-BAND SEMICONDUCTOR MATERIALS.** This paper demonstrates the high potential of the method of local cathode luminescence in investigating narrow band materials and the expedience of its further development for a wavelength region above 5.5  $\mu m$ , for which special photoreceivers with high sensitivity and greater dimensions of the receiver surface are required. 24 refs.

Petrov, V.I. *Bull Acad Sci USSR Phys Ser* v 51 n 3 1987, Mater of the Fifth All-Union Symp on Scanning Electron Microsc and Anal Methods for Invest Solids, Zvenigorod, USSR, May 1986 p 42-47.

**Microstructure** See Also SEMICONDUCTING SILICON—Etching.

**097051 BOND LENGTHS IN III-V TERNARY ALLOY SEMICONDUCTORS.** An analysis was applied to 18 different III-V ternary alloy semiconductors. A thermodynamical approach was taken in order to derive relative numbers or statistics of tetrahedron cells, and then the average bond lengths were theoretically calculated. To this extent, they would give us a basic idea of the microstructure of alloy semiconductors. The theoretical results of  $In_{1-x}Ga_xAs$  and  $GaAs_{1-x}P_x$  agree fairly well with experimental data from extended X-ray absorption fine structures. (Author abstract) 17 refs.

Sasaki, Akio (Kyoto Univ, Kyoto, Jpn); Ichimura, Masaya. *Jpn J Appl Phys Part 1* v 26 n 12 Dec 1987 p 2061-2066.

**097052 HIGH-TEMPERATURE LATTICE THERMAL EXPANSION OF SOME MIXED CRYSTALS OF THE  $CuGe_2P_3$ - $Cu_2GeS_3$  SYSTEM.** In the compounds  $CuGe_2P_3$  and  $Cu_2GeS_3$  the anion sites are occupied by phosphorus and sulphur respectively, and the cation sites are shared by copper and germanium in both the compounds. Therefore, when  $Cu_2GeS_3$  is added to the  $CuGe_2P_3$ , the phosphorus atoms would be replaced by sulphur atoms at the anion sites and germanium by copper at the cation sites. Thus  $Cu_2GeS_3$  forms a continuous series of solid solution with  $CuGe_2P_3$  especially when the former is in the cubic form. As a part of a general programme of X-ray diffraction studies on zinc-blende type semiconductors, the authors have reported data on lattice parameters and thermal expansion of  $CuGe_2P_3 + 0.5 Cu_2GeS_3$  and  $CuGe_2P_3 + 0.8 Cu_2GeS_3$ . This letter reports similar work on  $CuGe_2P_3 + 0.2 Cu_2GeS_3$  and a comparison of the data on thermal expansion of all the compounds. 15 refs.

Bhikshamaiah, G. (Osmania Univ, Hyderabad, India); Suryanarayana, S.V.; Omar, M.S. *J Mater Sci Lett* v 7 n 5 May 1988 p 433-434.

**097053 CATHODE LUMINESCENCE INVESTIGATIONS OF  $InGaAsP/InP$  HETEROSTRUCTURES.** This work presents the results of cathode luminescence (CL) investigations of single layers  $InGaAsP/InP$  heterostructures with a composition of a quadruple solid solution at wavelengths of 1.2 and 1.5  $\mu m$ . The authors previously investigated the effect of noncorrespondence of the parameters of the lattice on the hetero-boundary on the defect structure of epitaxial layer. This

work investigates heterostructures in which the condition of isoperiodicity is met sufficiently well and the noncorrespondence of the lattice parameters had no great effect on the defect formation process. 5 refs.

Petrov, V.I. (Dvoryankin, V.F.); Karachevtseva, M.V.; Strakhov, V.A.; Telegin, A.A.; Shabalin, A.V.; Yaremenko, N.G. *Bull Acad Sci USSR Phys Ser* v 51 n 3 1987, Mater of the Fifth All-Union Symp on Scanning Electron Microsc and Anal Methods for Invest Solids, Zvenigorod, USSR, May 1986 p 29-32.

**097054 X-RAY TOPOGRAPHY OF  $Al^{III}B^V$  SEMICONDUCTOR EPITAXIAL STRUCTURES ON THE VEPP-4 SR BEAM.** Exposures of strongly absorbing single crystals and epitaxial structures of the  $Al^{III}B^V$  semiconductors in Laue reflection have been made on the experimental station Topography and Diffractometry on the VEPP-4 storage ring white SR beam. The aim of the work was to ascertain the influence of doping on the structural perfection of the crystals as well as the role of the inheritance of defects in the substrate by epitaxial layers grown on them. Of course, the defects acquired by the structures in the process of growing of them were also of interest. 3 refs.

Kulipanov, G.N. (Inst of Nuclear Physics, Novosibirsk, USSR); Litvinov, Yu.M.; Mazurenko, S.N.; Mikhailov, M.A.; Panchenko, V.E.; Vasenkov, A.A. *Nucl Instrum Methods Phys Res Sect A* v A261 n 1-2 Nov 1 1987, Synchrotron Radiat Util, Proc of the Seventh USSR Natl Conf, Novosibirsk, USSR, Jun 3-5 1986 p 257-259.

**097055 SCATTERING THEORY FOR QUASI-ONE-DIMENSIONAL TUNNELING STRUCTURES.** Quantum theoretical studies of semiconductor microstructures are most naturally done in terms of one-dimensional scattering states, which are characterized far from a structure by k-dependent reflection and transmission amplitudes. We have investigated these states using integral forms such as the Lippmann-Schwinger equation. These allow us to obtain global properties of the states and provide the basis for a formal scattering theory of the kind that has been developed for the conventional problem of three-dimensional potential scattering. We find orthonormality relations for the scattering states, the one-dimensional analogues of Wigner's inequality and Levinson's theorem, and associated properties of the complex-momentum transmission amplitude. (Author abstract) 10 refs.

Kriman, A.M. (Arizona State Univ, Tempe, AZ, USA); Ferry, D.K. *Superlattices Microstruct* v 3 n 5 1987, Third Int Conf on Superlattices, Microstruct and Microdevices, Chicago, IL, USA, Aug 17-20 1987 p 503-507.

**Microwaves** See TRANSISTORS, FIELD EFFECT—Microwaves.

**Millimeter Waves** See Also SEMICONDUCTOR DEVICES—Computer Aided Design.

**097056 FEATURES OF THE USE OF SEMICONDUCTOR STRUCTURES WITH A SUPERLATTICE IN THE MILLIMETER BAND.** The results of an experimental study of semiconductor structures with a superlattice, constructed in the form of heteroepitaxial elements  $Ge-Ge_{1-x}Si_x$  ( $x$  approximately 0.05, period approximately 175 Angstrom), in states of detection and mixing of signals in the 8-mm band, are presented. It is shown that the high-frequency characteristics of the structures studied are different from the analogous characteristics of known nonlinear elements. (Author abstract) 9 refs.

Kechiyev, M.M.; Kostenko, A.A.; Kuznetsov, O.A.; Filatov, O.N.; Khlopov, G.I.; Shestopalov, V.P. *Sov J Commun Technol Electron* v 32 n 6 Jun 1987 p 102-105.

**Modification** See SEMICONDUCTING GLASS—Radiation Effects.



**Morphology** See SEMICONDUCTING GALLIUM ARSENIDE—Substrates.

### Noise, Spurious Signal

**097057 STATISTICAL STUDY OF NARROW-BAND NOISE IN  $\text{NbSe}_3$ .** Transient records of narrow-band noise in the charge density wave material  $\text{NbSe}_3$  have been analyzed. The statistics are those of Gaussian noise, not those of a coherent signal. The amplitudes of the various harmonics are found to be uncorrelated. These results are incompatible with some present models of narrow-band noise. (Author abstract) 16 refs.

Link, G. Lee (Univ of Illinois at Urbana-Champaign, Urbana, IL, USA); Mozurkewich, George. *Solid State Commun* v 65 n 1 Jan 1988 p 15-17.

**Nondestructive Examination** See HELICONS—Propagation.

**Optical Properties** See Also CRYSTALS—Electron States; MERCURY AND AMALGAMS—Optical Properties; POTASSIUM COMPOUNDS—Doping; SEMICONDUCTING SILICON—Amorphous.

**097058 LASER-INDUCED OSCILLATORY INSTABILITIES IN AMORPHOUS MATERIALS.** An oscillatory behavior of the optical properties of amorphous materials is observed as a function of time, when the samples are irradiated by CW laser beams. The Raman TO peak and line width have a quasi-periodic behavior parallel to that of the transmitted light, which indicate a structural oscillation between metastable states. A kinetic model is proposed, which is based on the generation of hot mobile electrons by the laser and on thermally activated atomic transitions between the metastable states assisted by the transient local energy release caused by the electron trapping. (Author abstract) 20 refs.

Abdulhalim, I. (Israel Inst of Technology, Haifa, Isr); Beserman, R.; Khait, Yu.L. *Europhys Lett* v 4 n 12 Dec 15 1987 p 1371-1377.

**097059 ANALYTICAL PROPERTIES OF MEAN TWO-PARTICLE DENSITY MATRIX.** The analytical properties of the mean two-particle density matrix  $Z(t)$  in the right-hand half-plane of the complex variable  $t$  is considered. It is proved that in the case of a Gaussian field, the function  $Z(t)$  is analytical in the region  $\text{Re } t > 0$ . It is shown that the frequency dependence of the light-absorption coefficient in disordered semiconductors is determined by the asymptote of the function  $Z(t)$  as  $t$  approaches  $\infty$ . (Edited author abstract) 6 refs.

Arbuzov, Yu.D. (All-Union Scientific-Research Inst of Fuel Processing & Utilization, USSR); Kolenkin, M.Yu. *Sov Phys J* v 30 n 6 Jun 1987 p 484-488.

**097060 GIGANTIC NONLINEAR OPTICAL POLARIZABILITY OF SEMICONDUCTOR MICROCRYSTALLITES.** We analyze theoretically the nonlinear optical properties of semiconductor box so small that quantum confinement effect works in all three dimensions. It is shown for the first time that the third order optical polarizability of an assembly of such quantum boxes is enhanced by a number of unit cells in the box through the effect of the giant oscillator strength when the box size satisfies the conditions given in terms of size-quantization energy, exciton binding energy, interaction energy of two excitations and the off-resonance energy. Microcrystallites of CuCl look a promising material to observe this effect. (Author abstract) 6 refs.

Hanamura, Eiichi (Univ of Tokyo, Tokyo, Jpn). *Solid State Commun* v 62 n 7 May 1987 p 465-469.

**097061 INDIRECT ABSORPTION EDGE OF  $\text{ZrS}_2$  AND  $\text{HfS}_2$ .** The transmission spectra and the wavelength-modulated transmission spectra of  $\text{ZrS}_2$  and  $\text{HfS}_2$  were measured simultaneously over the temperature range from 1.9 to 300K, and structures in the spectra due to the indirect allowed transitions including excitonic effects were clearly observed. Comparing with the band structure calculations, these correspond to  $\Gamma_2^-$  to  $L_1^+$  and  $\Gamma_2^-$

to  $M_1^+$  transitions. (Author abstract) 7 refs.

Terashima, K. (Univ of Tokyo, Tokyo, Jpn); Imai, I. *Solid State Commun* v 63 n 4 Jul 1987 p 315-318.

**097062 CPA CALCULATIONS OF  $E_1$  OPTICAL GAPS IN III-V TERNARY ALLOYS.** The  $E_1$  critical-point energies are calculated for the ternary alloys  $\text{Ga}_x\text{In}_{1-x}\text{P}$ ,  $\text{Ga}_x\text{In}_{1-x}\text{As}$ ,  $\text{GaAs}_{1-x}\text{P}_x$  and  $\text{InAs}_{1-x}\text{P}_x$  in coherent-potential approximation using tight-binding Hamiltonian and neglecting spin-orbit effects. Good agreement, to within a few percent, is obtained between the calculated values of the  $E_1$  energy gap and the corresponding experimental values, for all ternary systems studied. (Edited author abstract) 14 refs.

Gupta, R. (Indian Inst of Technology, New Delhi, India); Gera, V.B.; Jain, K.P. *Solid State Commun* v 61 n 4 Jan 1987 p 253-255.

**097063 LO-PHONON INSTABILITY DUE TO INDIRECT INTERBAND ABSORPTION OF A LASER FIELD IN SEMICONDUCTORS.** We investigate the possibility of excitation and amplification of longitudinal optical (LO) lattice vibrations by electrons due to interband absorption of a laser field in semiconductors. We show that under certain conditions the phonon excitation rate may become greater than the rate of relaxation and the LO-phonon system may reach instability. (Edited author abstract) 10 refs.

Sakai, J.W. (Univ of Brasilia, Brasilia, Braz); Nunes, O.A.C. *Solid State Commun* v 64 n 11 Dec 1987 p 1393-1396.

**097064 REGENERATIVE OSCILLATIONS, SPATIAL-TEMPORAL SINGLE PULSES AND STATIC INHOMOGENEOUS STRUCTURES IN OPTICALLY BISTABLE SEMICONDUCTORS.** The results are presented of a numerical simulation of the spatial-temporal dynamics of a semiconductor interferometer with competing carrier-density and thermal mechanisms of nonlinear dispersion and absorption rising with temperature. Single traveling pulses and static inhomogeneous structures (layers), which arise due to diffusion of kinetic variables and represent the novel type of transverse effects in optical bistability, are numerically found. The investigated phenomena are: self-formation of layers on the background of regenerative oscillations; excitation and propagation of traveling pulses under plane wave interferometer pumping; spontaneous emergence of traveling pulses under Gaussian pumping, as well as new homogeneous regimes; regenerative oscillations around various equilibrium states and switchings between corresponding limit cycles, generation of single pulses in response to small external signals (regime of a single-shot optical multivibrator) and nontrivial transient processes in the course of switching. (Author abstract) 19 refs.

Balkarei, Yu.I. (Acad of Sciences of the USSR, Moscow, USSR); Grigor'yants, A.V.; Rzhano, Yu.A.; Elinson, M.I. *Opt Commun* v 66 n 2-3 Apr 15 1988 p 161-166.

**097065 OPTICAL PROPERTIES OF NONCRYSTALLINE SEMICONDUCTORS.** The models developed to describe localized electronic states in amorphous semiconductors are discussed along with the nature of the optical band edge in amorphous semiconductors, and the photoinduced shift of this edge in the group VI materials. The optical properties of amorphous semiconductors in the interband region are considered. The nature of the electronic states deep in the gap and free carrier absorption are reported. 72 refs.

Taylor, P. Craig. *Noncryst Semicond* Publ by CRC Press Inc, Boca Raton, FL, USA, 1987 p 19-44.

**097066 RESONATORLESS DISSIPATIVE OPTICAL BISTABILITY. INFLUENCE OF EXTERNAL FIELDS AND SAMPLE THICKNESS.** The influence of sample thickness and carrier surface recombination on the characteristics of resonatorless dissipative optical bistability (RDOB) is investigated. The RDOB under consideration is caused by the excitation density nonlinearities of band-edge absorption of laser radiation in semiconduc-

tors. The diversity of multivalued spatial carrier distributions in the sample of thickness  $d$  with arbitrary velocity of surface recombination  $S$  are considered. It is established that strong recombination can considerably affect the structure and properties of possible carrier distributions and hysteresis of the transmission. (Author abstract) 12 refs.

Kochelap, V.A. (Acad of Sciences of the Ukrainian SSR, Kiev, USSR); Sokolov, V.N. *Phys Status Solidi B* v 146 n 1 Mar 1988 p 311-317.

**097067 NONLINEAR OPTICS AND THE MOTT TRANSITION IN SEMICONDUCTORS.** Optical spectra below and above the Mott transition of excitons have to be calculated from the inhomogeneous integral equation for the polarization function including self-energy, screening, and band filling. Results for gap shifts, exciton shift, exciton bleaching, and continuum enhancement are critically reviewed and extended. (Author abstract) 26 refs.

Zimmermann, R. (Acad der Wissenschaften der DDR, Berlin, East Ger). *Phys Status Solidi B* v 146 n 1 Mar 1988 p 371-384.

**097068 INFRARED PROPERTIES OF THE OXYGEN-DEFICIENT TRIPEROVSKITE  $\text{YBa}_2\text{Cu}_3\text{O}_y$  COMPOUND.** Infrared absorption spectra have been evaluated for the  $\text{YBa}_2\text{Cu}_3\text{O}_y$  compound samples prepared after rapid cooling from various temperatures in order to maintain the composition existing at the quench temperature. The absorption spectra for the samples with tetragonal symmetry and the reflection spectra for the samples with the orthorhombic symmetry have been determined. The superconducting energy gap was evaluated for an orthorhombic sample. (Author abstract) 14 refs.

Saito, Yosuke (Univ of Tsukuba, Sakura, Jpn); Sawada, Hideaki; Iwazumi, Toshiaki; Abe, Yoshihito; Ikeda, Hiroshi; Yoshizaki, Ryozo. *Solid State Commun* v 64 n 7 Nov 1987 p 1047-1050.

**097069 ELECTROREFRACTION IN  $\text{GaInAs/InP}$  MULTIPLE QUANTUM WELL HETEROSTRUCTURES.** We report the first absolute measurement of electric-field-induced changes in refractive index in  $\text{GaInAs}$  quantum well heterostructures. Even for wavelengths as far as 40 meV below the absorption edge, excitonic effects dominate electrooptic phase modulation. This effect close to resonance yields index changes two orders of magnitude larger than in bulk material. We find that the size of the index change, its dependence on applied voltage, and its behaviour with wavelength are well described in terms of the quantum confined Stark effect on excitonic absorption. (Author abstract) 15 refs.

Zucker, J.E. (AT&T Bell Lab, Holmdel, NJ, USA); Bar-Joseph, I.; Sucha, G.; Koren, U.; Miller, B.I.; Chemla, D.S. *Electron Lett* v 24 n 8 Apr 1988 p 458-459.

**097070 PHOTOLUMINESCENCE IN  $\text{p-Hg}_{0.42}\text{Cd}_{0.58}\text{Te}$ .** Photoluminescence (PL) is a standard technique for examining the quality of samples and studying basic properties of semiconductor materials. The authors investigated PL and photoconductivity (PC) spectra of  $\text{Hg}_{0.42}\text{Cd}_{0.58}\text{Te}$  at 30 K. The effects of the crossing point between the regions of excitonic character of the high energy line on one side and interband character on the other side are discussed. 8 refs.

Werner, L. (Humboldt-Univ zu Berlin, Berlin, East Ger); Tomm, J.W. *Phys Status Solidi A* v 106 n 1 Mar 1988 p K83-K87.

**097071 TIME-DEPENDENT INFORMATION DEPTH IN OPTICAL PROBING OF SEMICONDUCTOR MATERIALS AND DEVICES.** The authors consider the interaction of a time varying focused light beam with a semi-infinite semiconductor. The volume which the photogenerated carriers probe as a function of time after the light beam is switched on is considered by



introducing an information depth within which the majority of the carriers are generated. The effects of surface recombination velocity and absorption on the information depth are discussed. (Edited author abstract). 20 Refs.

Pester, P.D. (Univ of Oxford, Oxford, Engl); Wilson T. *Phys Status Solidi A* v 106 n 2 Apr 1988 p 577-582.

**097072 OPTICAL STUDY OF  $Hg_{1-x}Cd_xTe$  GRADED GAP MATERIAL.** Layers of the ternary compound  $Hg_{1-x}Cd_xTe$  are often graded band gap II-VI semiconducting systems. Epitaxial layers of this compound are obtained by depositing  $HgTe$  from the gaseous phase on  $CdTe$  single crystals under controlled  $Hg$  pressure. The energy gap of this compound changes as a function of layer thickness and thus composition. The molar composition  $x = 0.2$  is required for devices working in the infrared region. The collection efficiency is high enough for photovoltaic application. Optical measurements for selected layers have been performed to get information about the composition and energy gap gradient with layer thickness. 6 Refs.

Hady, A.A.A. (Cairo Univ, Giza, Egypt). *Phys Status Solidi A* v 106 n 2 Apr 1988 p k191-k195.

**097073 ON THE BAND GAP DEPENDENCE OF REFRACTIVE INDICES OF SOME QUATERNARY III-V AND II-VI COMPOUNDS OF DEVICE INTEREST.** With increasing applications of ternary and quaternary alloys of III-V and II-VI compounds in optoelectronic devices like emitters, detectors, modulators and mixers, the materials given are promising candidates. Of the attempts to predict the refractive indices of mixed semiconductor crystals, the model proposed by D.K. Ghosh et al. has been found to be fairly successful. This note demonstrates the credibility of the model in predicting the refractive indices of those crystalline alloys within their miscibility range and compares them with experimental values. 13 Refs.

Ghosh, D.K. (Burdwan Univ, West Bengal, India); Chatterjee, U.; Samanta, L.K. *Phys Status Solidi A* v 107 n 1 May 1988 p K79-K81.

**097074 ON THE OPTICAL STARK EFFECT OF EXCITONS IN SEMICONDUCTORS.** The so-called optical or dynamical Stark effect of excitons in semiconductors is studied by applying a two-band density matrix approach. It is found that the effect of a Stark-like field induced modification of the excitonic envelope function can be neglected. A pump pulse below the exciton resonance leads to a blue-shift and a bleaching. These two effects are linked in such a way that the shift can at most be of the order of the dephasing rate. The essential features of the effect are found to be present already in the two-level approximation where other resonances and the absorption continuum are neglected. (Author abstract). 10 Refs.

Balslev, I. (Odense Univ, Odense, Den); Stahl, A. *Solid State Commun* v 67 n 2 Jul 1988 p 85-88.

**097075 NONLINEAR REFRACTION AND INCREASING ABSORPTION IN  $HgCdTe$  OPTICAL BISTABILITY AT ROOM TEMPERATURE: AN EXPERIMENTAL STUDY.** The effects of nonlinear absorption in optical bistability as observed at room temperature in  $Hg_{0.815}Cd_{0.185}Te$  s investigated. As intensity is increased, a new feature for  $HgCdTe$  is observed, namely the transition in transmission from anticlockwise hysteresis loops. This transition is not present in reflection. Our observations are consistent with the assumption of thermally induced changes in the nonlinear optical properties of the semiconductor. (Author abstract). 12 Refs.

Cecchi, S. (Istituto Nazionale di Ottica, Florence, Italy); Coppo, P.M.; Salieri, P.; Arecchi, F.T. *Opt Commun* v 67 n 4 Jul 1988 p 305-310.

**097076 LMTO CALCULATION OF THE OPTICAL-PHONON DEFORMATION POTENTIALS OF CUBIC SEMICONDUCTORS.** The optical-phonon deformation potentials of the cubic semiconductors GaP and GaAs have been investigated by LMTO-ASA approach

within the frozen-phonon approximation. Some of the different treatments in frame of the LMTO method are examined and compared with the nonlocal empirical pseudopotential method (NEPM). The investigation indicates that the results of the frozen-potential model, in which the displacement of empty spheres is synchronized with the vibration of atomic spheres, are closest to that of the NEPM in a variety of LMTO treatments. The agreement between this approach and experiment is not inferior to one of the NEPM, thus providing the optical deformation potentials of zinc-blende semiconductors with a feasible ab initio calculation. (Author abstract). 7 Refs. In Chinese.

Wang, Renzhi (Xiamen Univ, China); Huang, Meichun. *Bandaoti Xuebao* v 9 n 4 Jul 1988 p 352-357.

**097077 DETERMINATION OF THE OPTICAL CONSTANTS  $n$ ,  $k$  OF  $Zn_3In_2S_6$  AND  $Zn_5In_2S_8$  FROM TRANSMISSION MEASUREMENTS.** Thin layers of  $Zn_3In_2S_6$  and  $Zn_5In_2S_8$  laminated compounds are used to obtain interference modulated transmission spectra at normal incidence with unpolarized light. An analysis based on the use of the extremes of the fringes in the transparent region is applied in order to determine the real and imaginary parts of the refractive index, as well as the thickness of the specimens. The equation  $2nd = m\lambda$ , helps to estimate  $n$  in the region of strong absorption so that the optical constants are finally determined in the spectral region 450 to 700 nm. Ellipsometric measurements are used to crosscheck the results at  $\lambda = 632.8$  nm. (Author abstract). 5 Refs.

Kalomiros, J.A. (Aristotle Univ of Thessaloniki, Thessaloniki, Greece); Spyridelis, J. *Phys Status Solidi A* v 107 n 2 Jun 1988 p 633-637.

**097078 OPTICAL PROPERTIES OF  $TiB_2$  MONOCRYSTALS.** Above some temperature, rhombohedral phases of  $TiB_2$  have a disordered cubic structure with respect to cations, that allows their treatment as  $Al^{IV}B^{VI}$  pseudocompounds ( $PbTe$ ,  $PbSe$ ,  $PbS$ ). The wide regions of solid solutions that form  $TiB_2$  with  $Al^{IV}B^{VI}$  compounds confirm the above statement. According to the theoretical investigations rhombohedral phases of  $TiB_2$  on the basis of antimony have an inverse spectrum, but the latter of those based on bismuth is normal. Owing to this there are systems among the solid solutions based on  $TiB_2$  and  $Al^{IV}B^{VI}$  compounds, in which a transition through the gapless state is realized. This stimulates interest in an experimental investigation of the optical properties of rhombohedral phases ( $D_{3d}$ ) of  $TiB_2$ -group semiconductors. In the present note the results of transmission and reflection measurements of n- $TiB_2$  are reported. 10 Refs.

Veis, A.N. (Inst of Applied Physics, Kishinev, USSR); Koditsa, D.D.; Popovich, N.S. *Phys Status Solidi A* v 107 n 2 Jun 1988 p K169-K173.

**097079 RADIATIVE AND NON-RADIATIVE POLARITON STRUCTURE OF SUPERLATTICES.** Optical properties of multilayered materials are considered. We emphasize polaritons of semi-infinite superlattices, that is, superlattices which exhibit a free surface. In these thin-film structures, the accumulation of interfaces gives rise to peculiar electromagnetic eigenmodes, distributed as continuous frequency bands. The termination of the superlattice at the surface modifies the density of these modes. In particular, one notices the appearance of isolated branches analogous to surface polariton modes of semi-infinite homogeneous materials. We describe radiative and non-radiative modes, including finite life-time effects, from the point of view of scattering theory, using a Green's function technique. The local density of states of the polariton modes is calculated and provides a complete information on the allowed electromagnetic excitations, as a function of wavelength, at any depth in the superlattice. The results are used to discuss reflectance and attenuated total reflection experiments on superlattices. (Edited author abstract). 18 Refs.

Dereux, Alain (Facultes Universitaires ND de la Paix, Namur, Belg); Vigneron, Jean-Pol; Lambin, Philippe;

Lucas, Amand A. *Phys Scr* v 38 n 3 Sep 1988 p 462-467.

**097080 ELECTROREFRACTION AND ELECTROABSORPTION IN  $InP$ ,  $GaAs$ ,  $GaSb$ ,  $InAs$ , AND  $InSb$ .** Effective-mass theory is used to calculate electric-field-induced changes in optical refraction and absorption (the Franz-Keldysh effect) in five direct-gap III-V semiconductors:  $InP$ ,  $GaAs$ ,  $GaSb$ ,  $InAs$ , and  $InSb$ , covering the 0.88-to-10- $\mu$ m wavelength range. The magnitude of the effect is determined by fitting experimental absorption data. Results are given for photon energies from the bandgap to 100 meV below the gap for applied electric fields from  $3 \times 10^3$  to  $3 \times 10^5$  V/cm. Values of  $\Delta n$  and  $\Delta k$  as large as  $10^{-3}$  to  $10^{-2}$  are found. The results are applicable to integrated-optic devices including switches and modulators. 39 Refs.

Bennett, Brian R. (Rome Air Development Cent, Hanscom AFB, MA, USA); Soref, Richard A. *IEEE J Quantum Electron* v QE-23 n 12 p 2159-2166.

Order-Disorder See Also METALS AND ALLOYS—Order-Disorder.

**097081 PAIRED TEMPERATURE SPECTROSCOPY (PATS) FOR GAP STATES IN ORDERED AND DISORDERED SEMICONDUCTORS - I. THEORETICAL ANALYSIS.** Paired temperature spectroscopy (PATS) is a recently proposed transient-capacitance-based technique to characterize trap parameters in semiconductors. One constructs a PATS signal by subtracting the capacitance transients at two distinct temperatures. The extrema of this signal contain the information of the trap parameters. We present a detailed theoretical analysis of PATS. The analysis includes studies of the sharpness of the PATS extrema, error estimation and the ability of PATS to resolve traps with proximal activation energies. The analysis is extended to disordered semiconductors where one has a distribution of activation energies. The suitability of PATS is established, particularly, for analyzing metastable defect centers. (Author abstract) 14 Refs.

Singh, Raj K. (SUNY/Albany, Albany, NY, USA); Singh, Vijay A.; Corbett, James W. *Semicond Sci Technol* v 2 n 11 Nov 1987 p 716-725.

**097082 THERMOELECTRIC EFFECTS IN THE QUANTUM HALL REGIME.** The transport properties of a disordered two-dimensional semiconductor system are investigated in the limit of high magnetic fields. The longitudinal thermopower as a function of the electron concentration is shown to vanish in the plateau regimes of the Hall conductivity - in agreement with experiments. Similar to the quantum Hall effect, this low temperature phenomenon is due to localization by a random potential. (Author abstract) 26 Refs.

Grunwald, A. (Univ zu Koeln, Cologne, West Ger); Hajdu, J. *Solid State Commun* v 63 n 4 Jul 1987 p 289-292.

Oscillations See Also SEMICONDUCTOR DIODES, PHOTODIODE—Oscillations.

**097083 RADIAL OSCILLATIONS OF AN ELASTIC SEMICONDUCTOR.** We consider the radial oscillations of a cylindrical tube, under an applied traction on its inner and outer surfaces which are carrying charges and are maintained at constant temperature, the relaxation times and coupling coefficients having been neglected. The material of the tube is taken to be a deformable, transversely isotropic, heat conducting and polarized semiconductor in the presence of an electric field. We look for the interaction of mechanical, thermal and electric fields in the tube. Stress distribution, the velocity and acceleration of the oscillation, temperature field, free electrons and hole charge distribution, the electric intensity distribution at any point inside the tube are determined. That one of the shear stresses, when compared with the purely elastic solutions, does no longer vanish is due to the interaction of the various fields. Oscillations are, on the whole, damped. (Edited author abstract) 3 Refs.

Verma, P.D.S. (Kurukshetra Univ, Kurukshetra, India);



Rana, O.H.; Verma, Meenu. *Int J Eng Sci* v 26 n 1 1988 p 27-36.

## Oxidation

**097084 LOW-TEMPERATURE OXIDATION KINETICS OF CdTe AND COMPOSITION OF THE REACTION PRODUCTS.** Using a thermogravimetric method, a study was made of the kinetics of the reaction between cadmium telluride and atmospheric oxygen. It was established that the oxidation process occurs at a noticeable rate at temperatures above 600 K. The oxidation of CdTe is governed by a linear law. The main kinetic parameters of the process are calculated. 2 refs. In Russian.

Fedorova, T.B.; Vishnyakov, A.V.; Kovtunenkov, P.V. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 912-915.

**097085 DEPENDENCE OF LAYER THICKNESS ON FINAL CELL VOLTAGE FOR ANODIC OXIDE FILMS GROWN GALVANOSTATICALLY ON  $Hg_{1-x}Cd_xTe$  ( $x=0.02, 0.16, 0.20, 0.22, 0.34, 1.00$ ).** Anodic oxidation is an established technology for manufacturing insulating layers on the alloy semiconductor  $Hg_{1-x}Cd_xTe$ . Because of the high relative dielectric constant of the anodic oxide, it can be successfully applied in MIS and MISFET devices where a high insulator capacitance for layers thick enough to diminish breakdown effects and technological failure is needed. In order to obtain an oxide layer with a desired thickness, the relation between thickness and process parameters must be known. It was the aim of the present note to investigate the dependence of the anodic oxide thickness on  $Hg_{1-x}Cd_xTe$  on the final cell voltage in the galvanostatic regime over a wide range of  $x$ . 7 refs.

Pfeffer, S. (Humboldt Univ of Berlin, Berlin, East Ger); Schubert, B. *Phys Status Solidi A* v 105 n 2 Feb 1988 p K115-K119.

**097086 OBSERVATION OF IN SITU AND EX SITU OXIDATION PROCESSES FOR ZnTe SURFACES BY HIGH-RESOLUTION ELECTRON MICROSCOPY.** The oxidation of ZnTe surfaces, both in situ and ex situ, is studied by high-resolution electron microscopy. For in situ oxidation, the oxidation sequence involved amorphization of the ZnTe crystal as Te is removed by a non-thermal electron stimulated process, with subsequent formation of hexagonal ZnO by oxygen diffusion into the sample. In ex situ oxidation, the main phases present are crystals of ZnO and Te metal, which usually give rise to layered surface regions, in the sequence ZnTe/Te/ZnO, with the large crystals (up to 100 nm) of Te in an epitaxial relationship with the bulk ZnTe and the small ZnO crystals (5 nm) in random orientations. This process involves the diffusion of Zn from the bulk ZnTe to the surface followed by reaction with oxygen in air to form ZnO. (Edited author abstract). 21 Refs.

Lu, Ping (Arizona State Univ, Tempe, AZ, USA); Smith, David J. *Phys Status Solidi A* v 107 n 2 Jun 1988 p 681-691.

**Performance** See Also SENSORS—Materials.

**097087 LOCAL CATHODOLUMINESCENCE OF GRADED-GAP SEMICONDUCTORS.** An expression is obtained for the spatial distribution of nonequilibrium carriers in a graded-gap semiconductor excited by a focused electron probe. Comparison between calculated and experimental spectra is used to estimate the diffusion length and the reduced surface recombination rate. (Author abstract) 6 refs.

Petrov, V.I.; Skvortsova, E.E.; Shabalin, A.V. *Moscow Univ Phys Bull* v 42 n 6 1987 p 81-83.

## Phase Diagrams

**097088  $PbIn_2Se_4$ - $PbGa_2Se_4$  SECTION OF THE QUASI-TERNARY SYSTEM  $PbSe$ - $In_2Se_3$ - $Ga_2Se_3$ .** Using methods of physicochemical analysis, a study was

made of the interaction over the  $PbIn_2Se_4$ - $PbGa_2Se_4$  section of the  $PbSe$ - $In_2Se_3$ - $Ga_2Se_3$  system, and the phase diagram of this section was plotted. It was established that the range of  $PbIn_2Se_4$ -based solid solutions at 300 K amount to 2 mol.%  $PbGa_2Se_4$ . The electrophysical properties of the solid solutions were studied in a wide temperature range. Alloys of  $PbIn_2Se_4$ -based solid solutions are p-type semiconductors with an electric-conductivity activation energy of 1.22-1.00 eV. 3 refs. In Russian.

Alidzhanov, M.A.; Rustamov, P.G.; Melikova, Z.D. *Izv Akad Nauk SSSR Neorg Mater* v 23 n 6 Jun 1987 p 900-901.

**097089 PHASE DIAGRAM OF  $CuAl_xIn_{1-x}S_2$  SOLID SOLUTIONS.** The  $CuInS_2$  and  $CuAlS_2$  semiconducting compounds are promising materials for fabricating solar cells.  $CuAlS_2$  a candidate for blue to ultraviolet light emitting diode applications. The aim of the note is to plot the phase diagram of system and to carry out a thermodynamic analysis of the phase equilibrium. The concentration dependences of the heats of mixture both in the solid and liquid phases are sign changing functions with a flex point which is indicative of the complex character of interatomic interactions. 7 refs.

Aksenov, I.A. (Acad of Sciences of the Byelorussian SSR, Minsk, USSR); Makovetskaya, L.A.; Popelnuyk, G.P.; Shilovich, I.P. *Phys Status Solidi A* v 105 n 2 Feb 1988 p K97-K102.

**097090 PHASE RELATIONS AND THE EFFECTS OF ORDERING IN  $(AgIn)_{1-x}Mn_{2x}Te_2$  AND  $CuIn_{1-x}Mn_{2x}Te_2$  ALLOYS.** Polycrystalline samples of the semimagnetic semiconductor alloys  $(AgIn)_{1-x}Mn_{2x}Te_2$  and  $(CuIn)_{1-x}Mn_{2x}Te_2$  were used in lattice parameter, optical energy gap  $E_0$ , and differential thermal analysis (DTA) measurements. The results indicate that in the zinc blende and chalcopyrite ranges of composition, ordering of the manganese can occur at lower temperatures, and a combination of the results is used to delineate the composition and temperature ranges in which disordered  $\alpha$  and ordered  $\alpha'$  chalcopyrite and disordered  $\beta$  and ordered  $\beta'$  zinc blende is the equilibrium structure. While the manganese ordering has little effect on the lattice parameter, it has an appreciable effect on the values of  $E_0$ . This is demonstrated by the different aiming points at  $z = 1.0$  for the  $E_0$  vs.  $z$  lines in the different fields, the values being 2.8 eV for  $\beta$ , 1.95 eV for  $\beta'$ , and 1.35 eV for  $\alpha'$ . (Author abstract). 17 Refs.

Quintero, M. (Univ de los Andes, Merida, Venez); Grima, P.; Tovar, R.; Perez, G.S.; Woolley, J.C. *Phys Status Solidi A* v 107 n 1 May 1988 p 205-211.

**Phase Transitions** See Also SEMICONDUCTING CADMIUM COMPOUNDS—Surfaces; SEMICONDUCTING SELENIUM COMPOUNDS—Crystallization; SEMICONDUCTING SILICON—Magnetic Field Effects; SUPERCONDUCTING DEVICES—Josephson Junctions; SUPERCONDUCTING MATERIALS—Phase Transitions.

**097091 IONOGRAPHIC PATTERNS WITH AMORPHOUS/CRYSTALLINE CONTRAST.** Ion irradiation of thin layers of crystalline semiconductors induces a phase transition to the amorphous state. The concomitant optical contrast between unirradiated, crystalline, and irradiated, amorphous material may be used for pattern fabrication in the submicron range. This process is explained by the example of silicon single-crystal layers on sapphire. (Author abstract) 3 refs.

Kalbitzer, S. (Max-Planck-Inst fuer Kernphysik, Heidelberg, West Ger). *Appl Phys A* v A44 n 2 Oct 1987 p 153-155.

**097092 PRESSURE-INDUCED TRANSITIONS IN AMORPHOUS  $Tl_xSe_{100-x}$  ALLOYS.** The electrical resistivity of bulk semiconducting amorphous  $Tl_xSe_{100-x}$  alloys with  $0 \leq x \leq 25$  has been investigated up to a pressure of 14 GPa and down to liquid-nitrogen temperature by use of a Bridgman anvil device. All the glasses undergo a discontinuous pressure-induced semiconducting-to-metal transition. X-ray diffraction studies on the pressure-recovered samples show that the high-pressure

phase is the crystalline phase. The pressure-induced crystalline products are identified to be a mixture of Se having a hexagonal structure with  $a=4.37$  Angstrom and  $c=4.95$  Angstrom and TlSe having a tetragonal structure with  $a=8.0$  Angstrom and  $c=7.0$  Angstrom. (Author abstract) 15 refs.

Parthasarathy, G. (Univ-GH-Paderborn, Paderborn, West Ger). *Phil Mag Lett* v 56 n 5 Nov 1987 p 191-195.

**097093 DIELECTRIC ANOMALY AT THE METAL-INSULATOR TRANSITION AS SEEN BY ELECTRON SPIN RESONANCE. 1. ANALYSIS OF THE ESR LINE SHAPE FOR POOR CONDUCTORS.** The shape of the electron spin resonance (ESR) line for itinerant electrons is asymmetric. The asymmetry is due to a microwave phase shift inside the sample. A complete equation for the power absorbed in conducting media is derived in this paper; it includes spin diffusion, sample size and displacement-current effects. This new formalism is appropriate to study the ESR of heavily doped semiconductors. It is shown that ESR may be a powerful technique to measure the dielectric constant in these media. (Edited author abstract) 18 refs.

Leclercq, Francoise (CNRS, Lille, Fr); Damay, Pierre. *Philos Mag B* v 57 n 1 Jan 1988 p 61-74.

**097094 APPARATUS AND METHOD OF DETERMINING THE THERMAL EFFECTS OF PHASE TRANSFORMATIONS BY DIFFERENTIAL THERMAL ANALYSIS.** A variety of calorimeters with differing accuracies, complexities, ease of use, and expense are commonly used to determine thermal effects. In a number of cases an express determination of the phase transformation thermal effects, such as melting, is needed. There is practically no information about the thermal effects in complex semiconducting systems in the literature, and available data on the heat of fusion of semiconducting III-V compounds differ by 2-3 times. Consequently, an apparatus and a method for the express determination of thermal effects are proposed in this paper on the basis of a differential thermal analysis apparatus similar to those found in many research laboratories. 6 refs.

Evgen'ev, S.V. (M.V. Lomonosov Inst of Precise Chemical Technology, Moscow, USSR). *Ind Lab (USSR)* v 53 n 7 Jul 1987 p 602-605.

**097095 THERMAL EXPANSIVITY OF  $\alpha$ ,  $\gamma$  AND  $\beta$ - $LiO_3$  BY NEUTRON THERMODIFFRACTOMETRY.** We describe neutron powder diffraction experiments and show how thermodiffractionograms obtained by means of a position-sensitive-detector diffractometer can be used to determine accurately the thermal variations of cell parameters and the principal linear expansion coefficients of materials. The case of the three phases  $\alpha$ ,  $\gamma$  and  $\beta$  of lithium iodate is investigated, results are subsequently compared to previously published ones. (Author abstract) 17 refs.

Coquet, E. (Univ de Bourgogne, Dijon, Fr); Cretet, J.M.; Bestaoui, A.; Pannetier, J.; Bouillot, J. *Solid State Commun* v 63 n 6 Aug 1987 p 557-560.

**097096 ON THE ORDER-DISORDER PHASE TRANSITION IN TERNARY COMPOUNDS.** The phase transition from the chalcopyrite to the sphalerite structures observed in ternary compounds semiconductors  $Al^{III}B^{IV}C_2^V$  and  $Al^{III}B^{III}C_2^{VI}$  is analyzed by using a semi-empirical model. The difference in the band-gap between the ordered chalcopyrite and the disordered sphalerite phases, and the critical temperature for the phase transition are determined. The results are compared with the available experimental data. (Author abstract) 13 refs.

Rincon, C. (Univ de Los Andes, Merida, Venez). *Solid State Commun* v 64 n 5 Nov 1987 p 663-665.

























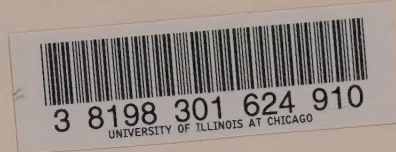












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